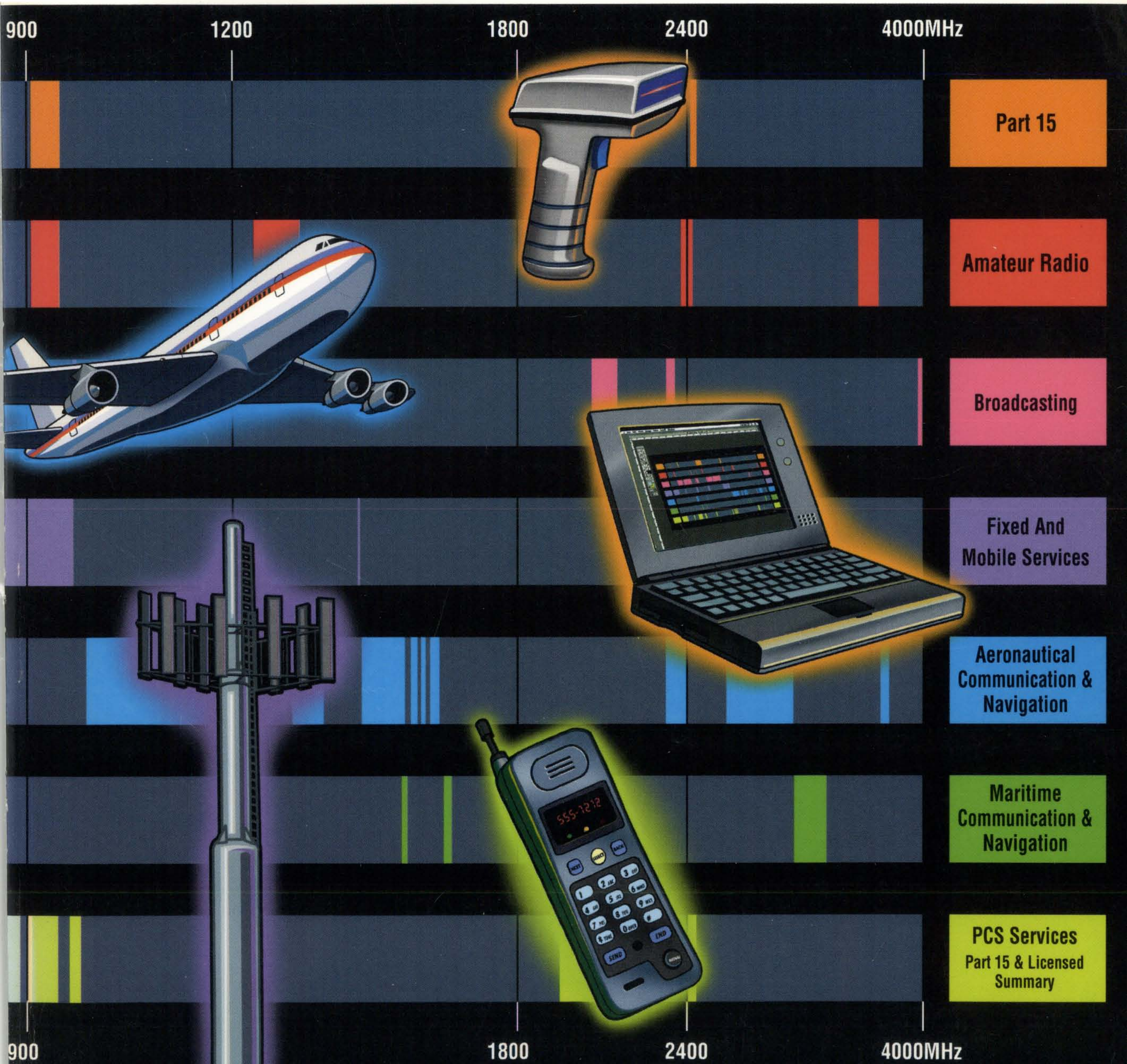
MOTOROLA

DL110/D
REV 7

RF
Device Data



MOTOROLA

RF Device Data

This publication presents technical information for the several product families that comprise the Motorola portfolio of RF Products. The product families include bipolar, LDMOS, MOSFET RF Power, and gallium arsenide chip technologies in a variety of ceramic and plastic surface mount packages. Discrete components, hybrid modules, and integrated circuits provide different levels of complexity in an effort to provide RF solutions to our customers' RF needs.

This edition encompasses a considerable number of changes that have occurred since our last printing. Many devices have been removed from this book due to package eliminations, aging technology, low sales, or new technology replacements. The changes are detailed in "About this revision" on the following page.

All devices are in alphanumeric order in the **Device Index** of this book. Just turn to the appropriate page for technical details of the known device. If you are seeking a "closest replacement" for a competitor's part, then turn to the **Cross Reference** section for information. Finally, if you need to identify a device that meets your functional performance requirements of frequency, output power, gain, or other parameters, then utilize the **Selector Guide** section of the book.

The information in this book has been carefully checked and is believed to be accurate; however, no responsibility is assumed for inaccuracies. Please consult your nearest Motorola Semiconductor sales office for further assistance regarding any aspect of Motorola RF Products.

Motorola reserves the right to make changes, without further notice, to any products herein. Motorola makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any consequential or incidental damages. "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and Ⓜ are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

© Motorola, Inc. 1996
Previous Edition © 1995
"All Rights Reserved"

Printed in U.S.A.

ABOUT THIS REVISION

- The RF Device Data Book is contained in one volume. All data sheets for Low and High Power Discrete Transistors, Hybrid Circuits for Power Amplifiers, Linear Amplifiers and Monolithic Integrated Circuits have been combined into one section. These data sheets are in alphanumeric order. Application notes are contained in the RF Application Reports handbook which is available through Literature and Printing Distribution center by ordering HB215/D.

- New Products introduced since our last printing have been added to the portfolio.

- Many devices have been removed due to package eliminations, aging technology, or low sales.

- Many dated devices have been added to our “Not Recommended for New Design” list.

- The Tuning, Hot Carrier, and PIN Diode Data Sheet information can be obtained by contacting the Signal Products Division’s Product Marketing organization.

- The Cross Reference identifies Motorola replacement devices as a “closest replacement.” Functional similarity best defines the meaning of closest replacement.

DATA CLASSIFICATION

ADVANCE INFORMATION

Data sheets herein contain information on new products. Specifications and information are subject to change without notice.

FORMAL

For a fully characterized device, there must be devices in the warehouse and price authorization.

RF DEVICE INDEX

RF DEVICE INDEX — continued

RF DEVICE INDEX — continued

RF DEVICE INDEX — continued

Section One

Selector Guide

How to Use This Selector Guide

Introduction

This new selector guide combines the RF products of Motorola Phoenix, Motorola Toulouse (France), and Motorola Hong Kong.

General

The products in this guide are separated FIRST into major categories such as Power FETs, Power Bipolar, Small Signal, Monolithic Integrated Circuits, and Low and High Power Amplifiers. SECOND, within each category parts are listed by frequency band, except for small signal transistors and monolithic integrated circuits, which are divided by application. Small signal transistor applications are low noise, linear amplifiers, switches, and oscillators. Monolithic integrated circuit application groupings are switching, receiver functions and transmitter functions. THIRD, within a frequency band, transistors are further grouped by operating voltage and, finally, output power.

To Replace Devices in an Existing Design

Consult the Index and Cross Reference to determine Motorola's closest replacement device.

To Replace Devices Not Recommended for New Design

Consult the Index and Cross Reference to determine Motorola's closest replacement device.

Parts listed in the Index and Cross Reference followed by an asterisk are devices Not Recommended for New Design. These are products that are outmoded or have a technology or package that has reached the end of its life cycle.

Remember

Applications assistance is only a phone call away — call the nearest Semiconductor Sales office or 1-800-521-6274.

Table of Contents

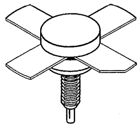
Page

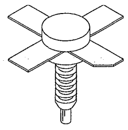
RF Discrete Transistors

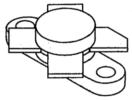
In the following pages, the reader will find the most extensive group of RF Discrete Transistors offered by any semiconductor manufacturer anywhere in the world today.

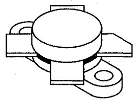
From Bipolar to FET, from Low Power to High Power, the user can choose from a variety of packages. They include plastic, metal can and ceramic that are microstrip circuit compatible or surface mountable. Many are designed for automated assembly equipment.

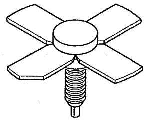
Major sub–headings are MOSFETs, Power Bipolar and Small Signal.

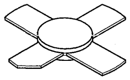

CASE 145A–09
STYLE 1
(.380″ STUD)

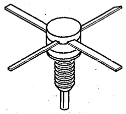

CASE 145D–02
STYLE 1
(.380 SOE)

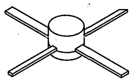

CASE 211–07
STYLE 1, 2
(.380″ FLANGE)

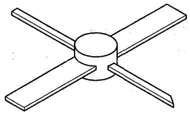

CASE 211–11
STYLE 1, 2
(.500″ FLANGE)

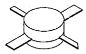

CASE 244
STYLE 1
(.280″ STUD)

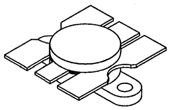

CASE 249
STYLE 1, 3
(.280″ PILL)

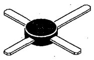

CASE 305
STYLE 1
(.204″ STUD)

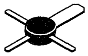

CASE 305A
STYLE 1, 2
(.204″ PILL)

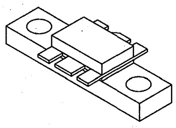

CASE 305C
STYLE 1

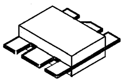

CASE 305D
STYLE 1

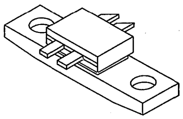

CASE 316–01
STYLE 1, 3
(.500″ CQ)

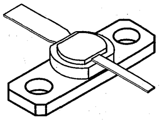

CASE 317
STYLE 1, 2
(MACRO–X)

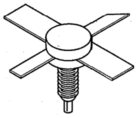

CASE 317D
STYLE 2

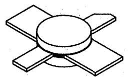

CASE 319
STYLE 1, 2, 3
(CS–12)

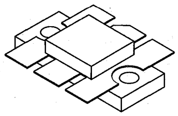

CASE 319A
STYLE 2

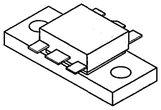

CASE 319B
STYLE 1

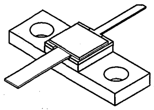

CASE 328A–03
STYLE 1

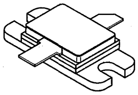

CASE 332–04
STYLE 1, 2
(.280″ STUD)

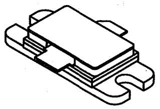

CASE 332A
STYLE 2
(.280″ PILL)

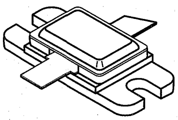

CASE 333
STYLE 1


CASE 333A
STYLE 1, 2
(MAAC PAC)

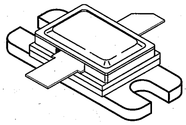

CASE 336E
STYLE 1


CASE 355C
STYLE 1

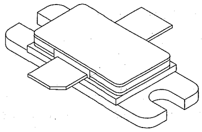

CASE 355D
STYLE 1



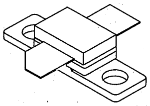
CASE 355E
STYLE 1



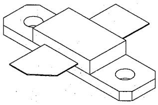
CASE 355G
STYLE 1



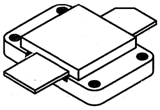
CASE 355H–01
STYLE 1



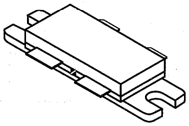
CASE 360A
STYLE 1



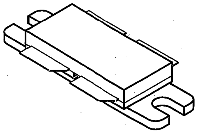
CASE 360B
STYLE 1



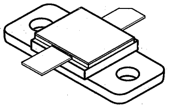
CASE 368
STYLE 2
(HOG PAC)



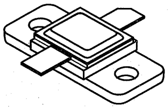
CASE 375
STYLE 2



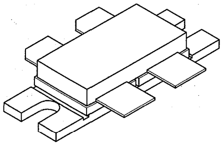
CASE 375A
STYLE 1



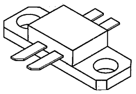
CASE 376B
STYLE 1



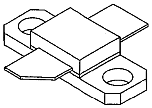
CASE 376C
STYLE 1



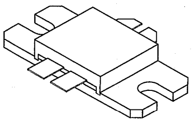
CASE 390B
STYLE 1



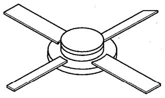
CASE 395B
STYLE 1



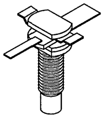
CASE 395C
STYLE 1, 2



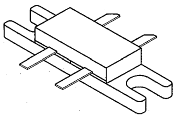
CASE 398
STYLE 1



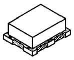
CASE 400
STYLE 1



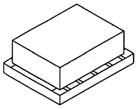
CASE 401
STYLE 1



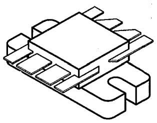
CASE 412
STYLE 1



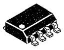
CASE 430
STYLE 2



CASE 430B
STYLE 1



CASE 744A
STYLE 1, 2



CASE 751
STYLE 1
(SO–8)

RF Power MOSFETs

Motorola RF Power MOSFETs are constructed using a planar process to enhance manufacturing repeatability. They are *N–channel field effect transistors* with an oxide insulated gate which controls vertical current flow.

Compared with bipolar transistors, RF Power FETs exhibit higher gain, higher input impedance, enhanced thermal stability and lower noise. The FETs listed in this section are specified for operation in RF Power Amplifiers and are grouped by frequency range of operation and type of application. Arrangement within each group is first by order of voltage then by increasing output power.

Table 1. To 150 MHz HF/SSB

For military and commercial HF/SSB fixed, mobile and marine transmitters.

Device	P_{out} Output Power Watts	P_{in} Input Power Typical Watts	G_{ps} Typical Gain dB @ 30 MHz	Typical IMD		θ_{JC} °C/W	Package/Style
				d_3 dB	d_{11} dB		
V_{DD} = 28 Volts, Class AB							
MRF138	30	0.6	17	−30	−60	1.5	211–07/2
MRF140	150	4.7	15	−30	−60	0.6	211–11/2
V_{DD} = 50 Volts, Class AB							
MRF148	30	0.5	18	−35	−60	1.5	211–07/2
MRF150	150	3	17	−32	−60	0.6	211–11/2
MRF154	600	12	17	−25	—	0.13	368/2
MRF157	600	6	20	−25	—	0.13	368/2

Table 2. To 225 MHz VHF AM/FM

For VHF military and commercial aircraft radio transmitters.

Device	P_{out} Output Power Watts	P_{in} Input Power Typical Watts	G_{ps} (Typ)/Freq. dB/MHz	η Efficiency Typical %	θ_{JC} °C/W	Package/Style
V_{DD} = 28 Volts, Class AB						
MRF134	5	0.2	14/150	55	10	211–07/2
MRF136	15	0.38	16/150	60	3.2	211–07/2
MRF136Y	30	1.2	14/150	54	1.8	319B/1
MRF137	30	0.75	16/150	60	1.8	211–07/2
MRF171	45	1.4	15/150	60	1.5	211–07/2
MRF173	80	4	13/150	65	0.8	211–11/2
MRF175LV	100	4	14/225	65	0.65	333/1
MRF174	125	8.3	11.8/150	60	0.65	211–11/2
MRF141	150	15	10/175	55	0.6	211–11/2
MRF175GV	200	8	14/225	65	0.44	375/2
MRF141G	300	30	10/175	55	0.35	375/2
V_{DD} = 50 Volts, Class AB						
MRF151	150	7.5	13/175	45	0.6	211–11/2
MRF176GV	200	4	17/225	55	0.44	375/2
MRF151G	300	7.5	16/175	55	0.35	375/2

Table 3. To 500 MHz VHF/UHF AM/FM

For VHF/UHF military and commercial aircraft radio transmitters.

Device	P_{out} Output Power Watts	P_{in} Input Power Typical Watts	G_{ps} (Typ)/Freq. dB/MHz	η Eff., Typ %	θ_{JC} °C/W	Package/Style
V_{DD} = 28 Volts, Class AB						
MRF158	2	0.02	20/400	55	13.2	305A/2
MRF160	4	0.08	17/400	50	7.2	249/3
MRF166C	20	0.4	17/400	55	2.5	319/3
MRF164W	20	0.4	16.5/400	50	1.5	412/1
MRF166W	40	2	13/400	50	1.0	412/1
MRF175LU	100	10	10/400	55	0.65	333/1
MRF177	100	6.4	12/400	60	0.65	744A/2
MRF177M	100	6.4	12/400	60	0.65	390B/1
MRF175GU	150	9.5	12/400	55	0.44	375/2
V_{DD} = 50 Volts, Class AB						
MRF176GU	150	6	14/400	50	0.44	375/2

Table 4. To 520 MHz

Designed for broadband VHF & UHF commercial and industrial applications. The high gain and broadband performance of these devices make them ideal for large–signal, common–source amplifier applications in 12.5 volt mobile and base station operation.

Device	P_{out} Output Power Watts	P_{in} Input Power Typical Watts	G_{ps} (Typ)/Freq. dB/MHz	η Eff., Typ %	θ_{JC} °C/W	Package/Style
V_{CC} = 7.5 Volts, Class AB						
MRF5003(18a)	3	0.27	10.5/512	50	14	430/2
MRF5007(18a)★	7	0.5	11.5/512	55	5	430B/1
V_{CC} = 12.5 Volts, Class AB						
MRF5015	15	1.1	11.5/512	55	3.5	319/3
MRF5035	35	6.3	7.5/512	55	1.8	316–01/3
MRF255★	55	0.8	16/54	45	1.0	211–11/2

Table 5. To 1.0 GHz

For HF/VHF/UHF military and commercial radio transmitters.

Device	P_{out} Output Power Watts	P_{in} Input Power Typical Watts	G_{ps} (Typ)/Freq. dB/MHz	η Eff., Typ %	θ_{JC} °C/W	Package/Style
V_{DD} = 28 Volts, Class AB						
MRF182	30	1.5	13/1000	55	1.5	360B/1
MRF183	45	2.8	12/1000	55	1.25	360B/1

(18) Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

★New Product

RF Power Bipolar Transistors

Motorola's broad line of bipolar RF power transistors are characterized for operation in RF power amplifiers. Typical applications are in military and commercial landmobile, avionics and marine radio transmitters. Groupings are by frequency band and type of application. Within each group, the arrangement of devices is by major supply voltage rating, then in the order of increasing output power. All devices are NPN polarity except where otherwise noted.

HF Transistors

Table 6. 1.5 – 30 MHz, HF/SSB

Designed for broadband operation, these devices feature specified Intermodulation Distortion at rated power output. Applications include mobile, marine, fixed station, and amateur HF/SSB equipment, operating from 12.5, 13.6, 28, or 50 volt supplies.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min) Gain @ 30 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 12.5 or 13.6 Volts, Class AB					
MRF421	100 PEP/CW	10	10	0.6	211–11/1
V_{CC} = 28 Volts, Class AB					
MRF426	25 PEP/CW	0.16	22	2.5	211–07/1
MRF422	150 PEP/CW	15	10	0.6	211–11/1
V_{CC} = 50 Volts, Class AB					
MRF429	150 PEP/CW	7.5	13	0.8	211–11/1
MRF448	250 PEP/CW	15.7	12	0.6	211–11/1

Table 7. 14 – 30 MHz, CB/Amateur Band

These HF transistors are designed for economical, high–volume use in CW, AM and SSB applications.

V_{CC} = 12.5 or 13.6 Volts, Class AB

MRF455	60	3	13	1	211–07/1
MRF454	80	5	12	0.7	211–11/1

Table 8. 27 – 50 MHz, Low–Band FM Band

For use in the FM "Low–Band," for Mobile communications.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min) Gain @ 50 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 12.5 or 13.6 Volts, Class AB					
MRF492	70	5.6	11	0.7	211–11/1

VHF Transistors

Table 9. 30 – 200 MHz Band

Designed for Military Radio and Commercial Aircraft VHF bands, these 28–volt devices include the all–gold metallized MRF314/16/17 high–reliability series.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
V_{CC} = 28 Volts, Class AB					
MRF314	30	3	10/150	2.2	211–07/1
MRF316(2)	80	8	10/150	0.8	316–01/1
MRF317(2)	100	12.5	9/150	0.65	316–01/1

(2) Internal Impedance Matched

VHF Transistors (continued)

Table 10. 136 – 174 MHz High Band

The "workhorse" VHF FM High–Band is served by Motorola with the broadest range of devices and package combinations in the industry.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min) Gain @ 175 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 12.5 Volts, Class C					
MRF4427(18b)	1	0.016	18(19)	125(1)	751/1
MRF553	1.5	0.11	11.5	25	317D/2
MRF2628	15	0.95	12	4	244/1
MRF1946	30	3	10	1.6	211–07/1
MRF1946A	30	3	10	1.8	145A–09/1
MRF224	40	14.3	4.5	2.2	211–07/1
MRF240	40	5	9	2.2	145A–09/1
MRF247(2)	75	15	7	0.7	316–01/1

UHF Transistors

Table 11. 100 – 400 MHz Band

Stringent requirements of the UHF Military band are met by MRF325, 326, 327, 329 and 2N6439 types, with all–gold metal systems, specified ruggedness and programmed wirebond construction, to assure consistent input impedances for internally matched parts.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min) Gain @ 400 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 28 Volts, Class C					
MRF325(2)	30	4.3	8.5	2.2	316–01/1
MRF326(2)	40	5	9	1.6	316–01/1
2N6439(2)	60	10	7.8	1.2	316–01/1
MRF327(2)	80	14.9	7.3	0.7	316–01/1
MRF329(2)	100	20	7	0.7	333/1
MRF392(3)	125	19.8	8	0.7	744A/1

Table 12. 400 – 500 MHz Band

Similar to the 100–400 MHz transistors, these devices have bandwidth capabilities operating up to 500 MHz. All have nitride passivated die, gold metal systems, specified ruggedness and controlled wirebond construction to meet the stringent requirements of military space applications.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
V_{CC} = 28 Volts, Class C					
MRF313	1	0.03	15/400	28.5	305A/1
MRF321	10	0.62	12/400	6.4	244/1
MRF323	20	2	10/400	3.2	244/1
MRF393(3)	100	18	7.5/500	0.7	744A/1

(1) $R_{\theta JA}$. Thermal Resistance Junction to Ambient.

(2) Internal Impedance Matched

(3) Internal Impedance Matched Push-Pull Transistors

(18) Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

(19) Typical

UHF Transistors (continued)

Table 13. 470 – 512 MHz Band

Higher power output devices in this UHF power transistor series feature internally input–matched construction, are designed for broadband operation, and have guaranteed ruggedness under output mismatch and RF overdrive conditions. Devices are specified for handheld, mobile and base station operation.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
V_{CC} = 12.5 Volts, Class C					
MRF581(4)	0.6	0.03	13/500	40	317/2
MRF555	1.5	0.15	10/470	25	317D/2
MRF652	5	0.5	10/512	7	244/1
MRF652S	5	0.5	10/512	7	249/1
MRF653	10	2	7/512	4	244/1
MRF653S	10	2	7/512	4	249/1
MRF641(2)	15	2.5	7.8/470	4	316–01/1
MRF654(2)	15	2.5	7.8/512	4	244/1
MRF644(2)	25	5.9	6.2/470	1.7	316–01/1
MRF650(2)	50	15.8	5.0/512	1.3	316–01/1
MRF658(2)	65	25	4.15/512	1	316–01/1

Device	P_{out} Output Power Watts	Class	P_{in} (Max) Input Power Watts	G_{PE} (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
V_{CC} = 24 Volts						
TP5002S	1.5	A	0.075	13/470	21	249/1
TP5051	50	AB	6	9/470	1.2	333A/2

900 MHz Transistors

Table 14. 870 – 960 MHz Band

Designed specifically for the 900 MHz mobile radio band, MRF840 through MRF847 devices offer superior gain and ruggedness, using the unique CS–12 package, which minimizes common–element impedance, and thus maximizes gain and stability. Devices are listed for mobile and base station applications.

Device	P_{out} Output Power Watts	P_{in} (Max) Input Power Watts	G_{PE} (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
V_{CC} = 12.5 Volts — Class C — Si Bipolar					
MRF559(5)	0.5	0.08	8/870	50	317/2
MRF581(5)	0.6	0.06	10(19)/870	40	317/2
MRF837(5)	0.75	0.11	8/870	40	317/1
MRF8372(5) (18a,b)	0.75	0.11	8/870	45	751/1
MRF557(5)	1.5	0.23	8/870	25	317D/2
MRF839F(5)	3	0.46	8/870	9	319/2
MRF840(2)(6)	10	2.5	6/870	3.1	319/1
MRF842(2)(6)	20	5	6/870	1.5	319/1
MRF844(2)(6)	30	9	5.2/870	1.5	319/1
MRF847(2)(6)	45	16	4.5/870	1	319/1

(2) Internal Impedance Matched

(4) Small signal gain. P_o is Typ.

(5) Common Emitter Configuration

(6) Common Base Configuration

(18) Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

(19) Typical

900 MHz Transistors (continued)

Table 14. 870 – 960 MHz Band (continued)

Device	P_{out} Output Power Watts	Class	P_{in}(Max) Input Power Watts	Gp (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
V_{CC} = 24 Volts — Si Bipolar						
MRF890	2	C	0.25	9/900	25	305/1
TP3007S	2	AB	0.25	9/960	21	305C/1
MRF857	2.1 (CW)	A	0.4	12.5/900	8.4	305/1
MRF857S	2.1 (CW)	A	0.4	12.5/900	8.4	305D/1
MRF896	3	AB	0.3	10/900	7	305/1
MRF858	3.6 (CW)	A	0.29	11/900	6.9	319/2
MRF858S	3.6 (CW)	A	0.29	11/900	6.9	319A/2
TP3008	4	AB	0.28	11.5/960	5	319/2
MRF891	5	AB	0.63	9/900	7	319/2
MRF891S	5	C	0.63	9/900	7	319A/2
MRF859★	6.5 W (CW)	A	0.46	11.5/900	3.9	319/2
MRF859S★	6.5 W (CW)	A	0.46	11.5/900	3.9	319A/2
MRF860	13.7 (CW)	A	1.1	11/900	1.9	395B/1
MRF892(2)	14	C	2	8.5/900	3.5	319/1
MRF861	27 (CW)	A	8	9.5/900	0.92	375A/1
MRF894(2)	30	C	6	7/900	1.5	319/1
MRF897(3)	30	AB	3	10/900	1.7	395B/1
MRF897R(3)★	30	AB	3	10.5/900	1.7	395B/1
TP3034	35	AB	7	7/960	2.3	319/2
MRF862	36 (CW)	A	4.5	9/900	0.75	375A/1
MRF898(2)	60	C	12	7/900	1	333A/1
V_{CC} = 26 Volts — Si Bipolar						
MRF880(3)	90	AB	12.7	8.5/900	1.3	375A/1
TP3069	100	AB	18	7.5/960	0.7	375A/1
MRF899(3)	150	AB	24	8/900	0.8	375A/1

(2) Internal Impedance Matched

(3) Internal Impedance Matched Push-Pull Transistors

★New Product

1.5 GHz Transistors

Table 15. 1400 – 1640 MHz Band

Device	P_{out} Output Power Watts	Class	P_{in}(Max) Input Power Watts	Gp (Min)/Freq. Power Gain dB/MHz	θ_{JC} °C/W	Package/Style
MRF16006	6	C	1.09	7.4/1600	6.8	395C/2
MRF15030	30	A, AB	3.8	9/1490	1.4	395C/1
MRF16030	30	C	5.33	7.5/1600	1.7	395C/2
MRF15090	90	A, AB	16	7.5/1490	0.7	375A/1

Microwave Transistors

Table 16. L–Band Pulse Power

These products are designed to operate in short pulse width, 10 µs, low duty cycle, 1%, power amplifiers operating in the 960–1215 MHz band. All devices have internal impedance matching. The prime application is avionics equipment for distance measuring (DME), area navigation (TACAN) and interrogation (IFF).

Device	P_{out} Output Power Watts	P_{in}(Max) Input Power Watts	Gp (Min) Gain @ 1090 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 18 Volts — Class A & AB Common Emitter					
MRF1000MA	0.2	0.02	10	25	332–04/2
MRF1000MB	0.2	0.02	10	25	332A/2
V_{CC} = 50 Volts — Class C Common Base					
MRF1150MA	150	25	7.8	0.3	332–04/1
MRF1375	375	80	6.7	0.12	355G/1

Table 17. L–Band Long Pulse Power

These products are designed for pulse power amplifier applications in the 960–1215 MHz frequency range. They are capable of handling up to 10 µs pulses in long pulse trains resulting in up to a 50% duty cycle over a 3.5 millisecond interval. Overall duty cycle is limited to 25% maximum. The primary applications for devices of this type are military systems, specifically JTIDS and commercial systems, specifically Mode S. Package types are hermetic.

Device	P_{out} Output Power Watts	P_{in}(Max) Input Power Watts	G_{PB} (Min) Gain @ 1215 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 28 Volts — Class C Common Base					
MRF10005	5	0.71	8.5	8	336E/1
V_{CC} = 36 Volts — Class C Common Base					
MRF10031	30	3	10	3	376B/1
MRF10120	120	19	8	0.6	355C/1

Table 17. L–Band Long Pulse Power, Class C Common Base (continued)

Device	P_{out} Output Power Watts	P_{in}(Max) Input Power Watts	G_{PB} (Min) Gain @ 1215 MHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 50 Volts					
MRF10070	70	7	10(7)	0.4	376C/1
MRF10150	150	15	10(7)	0.25	376B/1
MRF10350	350	44	9(7)	0.11	355E/1
MRF10500	500	63	9(7)	0.12	355D/1
MRF10501	500	63	9(7)	0.12	355H/1

Table 18. 2 GHz Narrowband CW

The MRW2000 Series of NPN Silicon microwave power transistors are designed for common base service in amplifier or oscillator applications in the 1–2.3 GHz frequency range.

Device	P_{out} Output Power Watts	P_{in}(Max) Input Power Watts	G_{PB} (Min) Gain @ 2 GHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 28 Volts — Class B & C Common Base					
MRW2001	1	0.13	9	35	328A–03/1
MRW2005	5	0.8	8	8.5	328A–03/1

Table 19. 3 GHz Narrowband CW, Class B & C Common Base

The MRW3000 Series are the industry's first 100% VSWR tolerant 3 GHz devices. They are common–base configured in hermetic packages and rated for 28 volt operation.

Device	P_{out} Output Power Watts	P_{in}(Max) Input Power Watts	G_{PB} (Min) Gain @ 3.0 GHz dB	θ_{JC} °C/W	Package/Style
V_{CC} = 28 Volts					
MRW3001	1	0.2	7	35	328A–03/1
MRW3003	3	0.75	6	17	328A–03/1
MRW3005	5	1.6	5	8.5	328A–03/1

(7)Typical @ 1090 MHz

Linear Transistors

The following sections describe a wide variety of devices specifically characterized for linear amplification. Included are medium power and high power parts covering frequencies from 100 MHz–4 GHz.

Table 20. To 1 GHz, Class A

These devices offer a selection of performance and price for linear amplification to 1 GHz. The “MRA” prefix parts are input matched and feature high overdrive and extreme ruggedness capability.

Device	P_o @ 1 dB Comp. Point Watts	G_{SS} (Min)/Freq. Small Signal Gain dB/MHz	Bias Point (Vdc/A)	θ_{JC} °C/W	Package/Style
V_{CC} = 19 Volts					
MRA1000–7L	7	9/1000	19/1.2	4	145D–02/1
MRA1000–14L	14	8/1000	19/2.4	2.1	145D–02/1
V_{CC} = 25 Volts					
MRF1029(9)	1.5	8/1000	25/0.2	12	244/1
MRF1032(9)	6	6.5/1000	25/0.85	3.5	244/1

Table 21. To 2 GHz, Class A

These parts offer low cost alternatives to matched devices used primarily as pre–drivers to 2 GHz.

Device	P_o @ 1 dB Comp. Point Watts	G_{SS} (Min)/Freq. Small Signal Gain dB/MHz	Bias Point (Vdc/A)	θ_{JC} °C/W	Package/Style
V_{CC} = 20 Volts					
MRF3094(9)	0.5	10.5/2000	20/0.12	40	328A–03/2
MRF3104(9)	0.5	10.5/2000	20/0.12	40	305A/1
MRF3095(9)	0.8	9/2000	20/0.12	35	328A–03/2
MRF3105(9)	0.8	9/2000	20/0.12	35	305A/1
MRF3096(9)	1.6	9/2000	20/0.24	22	328A–03/2
MRF3106(9)	1.6	9/2000	20/0.24	22	305A/1
MRF2000–5L(10)	5	7/2000	19/0.6	10	360A/1

Table 22. UHF Ultra Linear For TV Applications

The following devices have been characterized for ultra–linear applications such as low–power TV transmitters in Band IV and Band V. Each features diffused ballast resistors and an all–gold metal system to provide enhanced reliability and ruggedness.

Device	P_{ref}(Min) Watts	Gp (Min)/Freq. Small Signal Gain dB/MHz	3 Tone IMD(8) dB	θ_{JC} °C/W	Package/Style
V_{CC} = 20 Volts, Class A					
TPV596A	0.5	11.5/860	–58	20	244/1
TPV597	1	10.5/860	–58	9	244/1
TPV598	4	7/860	–60	5	244/1
V_{CC} = 25 Volts, Class A					
TPV695A	14	9.5/860	–47	2.5	395B/1
TPV7025	25	8.5/860	–45	1.5	398/1
TPV6030	20/35(11)	9.5/860	–51/–	1.1	375A/1
V_{CC} = 26 Volts, Class AB					
MRF6414★	—	8.5/960	—	1.3	333A/2
V_{CC} = 28 Volts, Class AB					
TPV8100B	100(11)	8.5/860	—	0.7	398/1

(8) Vision Carrier: – 8 dB; Sound Carrier: – 7 dB; Sideband Carrier: – 16 dB

(9) Former Prefix was “RF”

(10) Former Prefix was “MRA.”

(11) Output power at 1 dB compression in Class AB

★New Product

Table 23. Microwave Linear For PCN Applications

The following devices have been developed for linear amplifiers in the 1.5–2 GHz region and have characteristics particularly suitable for PCN base station applications.

Device	P_{out} Watts	Class	Bias Point Vdc/mA	Gain (Typ)/Freq dB/MHz	θ_{JC} °C/W	Package/Style
MRF6401(12)	0.5	A	20/80	10/1880	30	305C/1
MRF6402(13)	4.5	AB	26/40	10/1880	5	319/2
MRF6404(16)	30	AB	26/150	8.5/1880	1.4	395C/1

Table 24. Microwave Linear Power

Common emitter microwave devices are offered for a wide variety of uses in small and medium signal, Class A, AB and C applications up to 4 GHz. The use of all–gold metal systems, diffused ballast resistors and hermetic packaging results in devices that display excellent reliability even in a military environment.

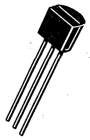
Device	G_{SS} (Min) @ Freq. Small Signal Gain dB/GHz	1 dB Comp. Watts	P_{sat} Watts	−30 dB IMD Watts	Emitter Current mA	Package/Style
V_{DD} = 20 Volts						
MRW53502	5/3	1.6	2	1.5	230	401/1
MRW53601	6/3	0.8	1	0.8	120	328A–03/1
MRW54001	5/4	0.5	0.8	0.5	120	400/1
MRW54601	6/4	0.5	0.8	0.5	120	328A–03/1

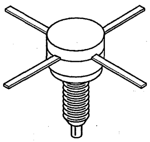
(12)Formerly known as "TP4001S"
(13)Formerly known as "TP4004"
(16)Formerly known as "TP4035"

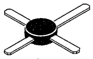
RF Small Signal Transistors

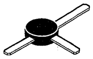
Motorola's broad line of RF Small Signal Transistors includes NPN and PNP Silicon Bipolar Transistors characterized for low noise amplifiers, mixers, oscillators, multipliers, non–saturated switches and low–power drivers.

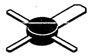
These devices are available in a wide variety of package types: plastic Macro–X and Macro–T, ceramic and surface mounted. Most of these transistors are fully characterized with s–parameters.

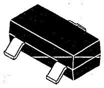

CASE 29–04
STYLE 2
(TO–226AA)

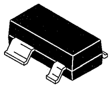

CASE 244A
STYLE 1

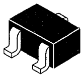

CASE 317
STYLE 2
(MACRO–X)

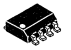

CASE 317A
STYLE 2
(MACRO–T)


CASE 317D
STYLE 2
(POWER MACRO)


CASE 318–08
STYLE 6
(SOT–23)


CASE 318A
STYLE 1
LOW PROFILE
(SOT–143)

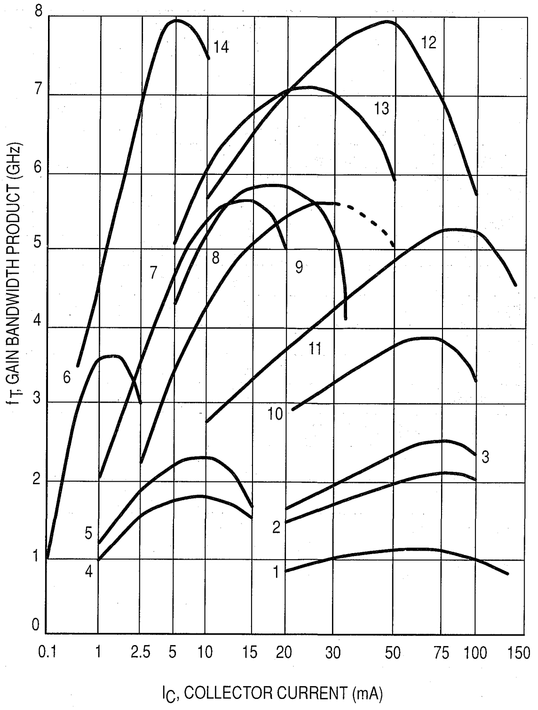

CASE 419
STYLE 3, 6
(SC–70/SOT–323)


CASE 751
STYLE 1
(SO–8)

RF Small Signal Transistors

RF Small Signal Transistor Gain Characteristics

Curve numbers apply to transistors listed in the subsequent tables.

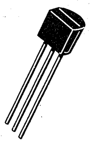


Selection by Package

In small–signal RF applications, the package style is often determined by the end application or circuit construction technique. To aid the circuit designer in device selection, the Motorola broad range of RF small–signal amplifier transistors is organized by package. Devices for other applications such as oscillators or switches are shown in the appropriate preceding tables. **These devices are NPN polarity unless otherwise designated.**

Plastic SOE Case

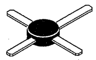
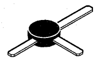
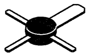
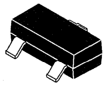
Table 1. Plastic SOE Case

Device	Gain–Bandwidth @ f_T Typ GHz	I_C mA	Curve No. Page 1–15	NF @ f Typ dB	MHz	Gain @ f Typ dB	MHz	Maximum Ratings $V_{(BR)CEO}$ Volts	I_C mA	Package
Case 29–04/1,2, TO–226AA										
LP1001	5	10	—	2.7	500	12.5	1000	15	—	
LP1001A	5	10	—	3.2	1000	12.5	1000	15	—	
MPS901(29)	4.5	15	7	2.4	900	12	900	15	30	
MPS911(29)	7	30	8	1.7	500	16.5	500	12	40	
MPS571	8	50	12	2	500	14	500	10	80	
MPS3866	0.8	50	1	—	—	10	400	30	400	

(29)Packaging Options Available in Tape and Reel and Fan Fold Box

Selection by Package **(continued)**

Table 1. Plastic SOE Case (continued)

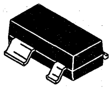
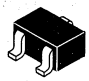
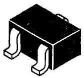
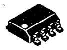
	Gain–Bandwidth							Maximum Ratings		
Device	**@ f_T Typ GHz**	**I_C mA**	**Curve No. Page 1–15**	**NF @ f Typ dB**	**MHz**	**Gain @ f Typ dB**	**MHz**	**$V_{(BR)CEO}$ Volts**	**I_C mA**	**Package**
Case 317/2 — MACRO–X										
MRF901	4.5	30	7	2	1000	12	1000	15	30	
MRF941	8	50	—	2.1	2000	12.5	2000	10	50	
MRF571	8	50	12	1.5	1000	12	1000	10	70	
MRF951	7.5	100	—	2.1	2000	12.5	2000	10	100	
MRF559	3	150	10	—	—	13	512	18	150	
MRF581	5	200	11	2	500	15.5	500	18	200	
MRF581A	5	200	11	1.8	500	15.5	500	15	200	
MRF837	5	200	11	—	—	10	870	16	200	
Case 317A/2 — MACRO–T										
BFR90	5	14	7	2.4	500	18	500	15	30	
BFR96	4.5	50	9	2	500	14.5	500	15	100	
Case 317D/2										
MRF553	—	—	—	—	—	13	175	16	500	
MRF555	—	—	—	—	—	12.5	470	16	400	
MRF557	—	—	—	—	—	9	870	16	400	
Case 318–08/6 — SOT–23										
MMBR521LT1(17)(18c)	3.4	–70	—	1.5	500	15	500	–10	–70	
MMBR931LT1(18c)	3	5	6	4.3	1000	10	1000	5	5	
MMBR5031LT1(18c)	1	20	—	2.5	450	17	450	10	20	
BFS17LT1(18c)	1.3	25	—	5	30	—	—	15	—	
BFR92ALT1(18c)	3.4	25	—	3.0	500	15	—	15	25	
MMBR901LT1(18c)	4	30	7	1.9	1000	12	1000	15	30	
BFR93ALT1(18c)	3.4	35	—	2.5	30	—	—	12	35	
MMBR920LT1(18c)	4.5	35	—	2.4	500	15	500	15	35	
MMBR5179LT1(18c)	1.4	50	4	4.5	200	15	200	12	50	
MMBR941LT1(18c,d)	8	50	—	2.1	2000	8.5	2000	10	50	
MMBR941BLT1(18c,d)	8	50	—	2.1	2000	8.5	2000	10	50	
MMBR911LT1(18c)	6	60	8	2	500	17	500	12	40	
MMBR571LT1(18c)	8	70	12	2	500	16.5	500	10	80	
MMBR951LT1(18c)	8	100	—	2.1	2000	7.5	2000	10	100	
MMBR951ALT1(18c)	8	100	—	2.1	2000	7.5	2000	10	100	

(17)PNP

(18)Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

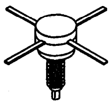
Selection by Package (continued)

Table 1. Plastic SOE Case (continued)

Device	Gain–Bandwidth		Curve No. Page 1–15	NF @ f		Gain @ f		Maximum Ratings		Package
	f_T Typ GHz	@ I_C mA		Typ dB	MHz	Typ dB	MHz	$V_{(BR)CEO}$ Volts	I_C mA	
Case 318A/1 — SOT–143										
MRF5711LT1(18c)	8	–70	12	1.6	1000	13.5	1000	10	70	
MRF5211LT1(17)(18c)	4.2	–50	—	2.8	1000	11	1000	–10	–70	
MRF9331LT1(18c)	5	2	—	2.5	1000	12.5	1000	8	1	
MRF9011LT1(18c)	3.8	30	7	2.3	1000	10.2	1000	15	30	
MRF9411LT1(18c)	8	50	—	2.1	2000	9.5	2000	10	50	
MRF9411BLT1(18c)	8	50	—	2.1	2000	9.5	2000	10	50	
MRF0211LT1(18c)	5.5	70	12	1.8	1000	9.5	1000	15	70	
MRF5811LT1 (18c)★	5	75	11	2.0	500	18.4	500	18	200	
MRF9511LT1(18c)	8	100	—	2.1	2000	9	2000	10	100	
MRF9511ALT1(18c)	8	100	—	2.1	2000	9	2000	10	100	
Case 419/3 — SC–70/SOT–323										
MRF927T1(18c)★	8	5	14	1.7	1000	9.8	1000	10	10	
MRF947T1(18c,d)	8	50	—	2.1	1500	10.5	1500	10	50	
MRF947AT1(18c)	8	50	—	2.1	1500	10.5	1500	10	50	
MRF947BT1(18c,d)	8	50	—	2.1	1500	10.5	1500	10	50	
MRF957T1(18c)	8	30	—	2.0	1500	9	1500	10	100	
Case 419/6 — SC–70/SOT–323										
MRF947RT3(18d)	8	50	—	2.1	1500	10.5	1500	10	50	
Case 751/1 — SO–8										
MRF5943(18a,b)	1.5	35	2	3.4	200	12	250	30	400	
MRF3866R2(18b)	0.8	50	1	—	—	10.5	400	30	400	
MRF4427(18b)	1.6	50	1	—	—	18	175	20	400	
MRF5812(18a,b)	5.5	75	11	2	500	15.5	500	15	200	
MRF8372(18a,b)	5	75	11	—	—	10	870	16	200	

Ceramic SOE Case

Table 2. Ceramic SOE Case

Device	Gain–Bandwidth		Curve No. Page 1–15	N @ f		Gain @ f		Maximum Ratings		Package
	f_T Typ GHz	@ I_C mA		Typ dB	MHz	Typ dB	MHz	$V_{(BR)CEO}$ Volts	I_C mA	
Case 244A/1										
MRF587	5.5	90	11	3	500	13	500	15	200	

(17) PNP

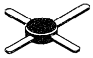
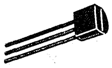
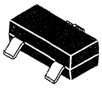
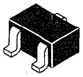
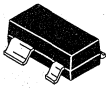
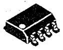
(18) Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

★New Product

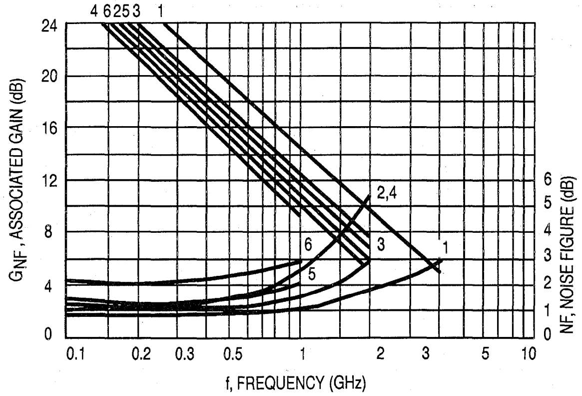
Selection by Application

Table 3. Low Noise

The Small–Signal devices listed are designed for low noise and high gain amplifier mixer, and multiplier applications. Each transistor type is available in various packages. **Polarity is NPN unless otherwise noted.**

Package	Name	Case Number	Curve Number (See figure below)					
			1	2(17)	3	4	5	6
	MACRO–X	317/2	MRF941 MRF951(20)	—	MRF571	MRF581	MRF901	—
	TO–226AA	29–04/2	—	—	MPS571	—	MPS901	MPS911
	SOT–23	318–08/6	MMBR941LT1 MMBR941BLT1 MMBR951LT1(20)	MMBR521LT1	MMBR571LT1	—	MMBR901LT1	MMBR911LT1
	SC–70/ SOT–323	419/3, 6	MRF927T1 MRF947AT1 MRF947T1 MRF947BT1 MRF947RT3 MRF957T1(20)	—	—	—	—	—
	SOT–143	318A/1	MRF9411BLT1 MRF9411LT1 MRF9511LT1(20) MRF9511ALT1	MRF5211LT1	MRF5711LT1 MRF0211LT1	MRF5811LT1	MRF9011LT1	—
	SO–8	751/1	—	—	—	MRF5812	—	—

(17)PNP
(20)Higher Current Version



Gain and Noise Figure versus Frequency

Selection by Application **(continued)**

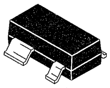
Table 4. CATV, MATV and Class A Linear

For Class A linear CATV/MATV applications. Listed according to increasing gain bandwidth (f_T).

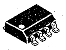
			Noise Figure	Distortion Specifications					
Device	Nominal Test Conditions V_{CE}/I_C Volts/mA	f_T Typ MHz	Typ/Freq. dB/MHz	2nd Order IMD dBc	3rd Order IMD dBc	12 Ch. Cross–Mod. dBc	Output Level dBmV	$V_{(BR)CEO}$ V	Package/ Style
MMBR5179LT1(18c)	6/5	1500	4/450					12	318–08/6
MRF5943(18a,b)	15/50	1500	3.4/200					30	751/1
MMBR5031LT1(18c,d)	6/5	2000	1.9/450					10	318–08/6
MMBR920LT1(18c,d)	10/14	4500	2.4/500					15	318–08/6
BFR96	10/50	4500	2/500					15	317A/2
BFR90	10/14	5000	2.4/500					15	317A/2
MRF581	10/75	5000	2.7/300		–65		+50	18	317/2
MRF581A	10/75	5000	1.8/500		–65		+50	15	317/2
MRF5812(18a,b)	10/75	5000	1.8/500		–65		+50	15	751/1
LP1001		5000	2.7/500					15	29–04/2
LP1001A		5000	3.2/1000					15	29–04/2
MRF587	15/90	5500	3/500	–52	–72		+50	17	244A/1

(17) PNP

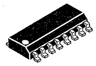
(18) Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.



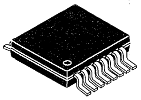
CASE 318A–05
(SOT–143)



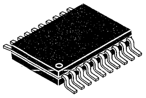
CASE 751
(SO–8)



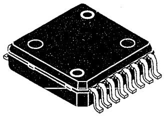
CASE 751B
(SO–16)



CASE 948C
(TSSOP–16)



CASE 948D
(TSSOP–20)



CASE 978
(PFP–16)

Monolithic Integrated Circuits

Motorola's RF monolithic integrated circuit devices provide an integrated solution for the personal communications market. These devices are available in plastic SOIC–8, SOIC–16, SOT–143, TSSOP–16, TSSOP–20 or PFP–16 packages.

Evaluation Boards

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

RF Monolithic Integrated Circuits

Switching

Antenna Switches

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current µA (Typ)	P_{in}, 1 dB Compression dBm (Typ)	Insertion Loss dB (Typ)	Isolation dB (Typ)	Package	System Applicability
MRFIC2003(18b)	100–1000	2.8–6.0	<10	21	0.5	20	SO–8	CT2, ISM
MRFIC1801(18b)	1500–2500	2.7–5.5	300	29	0.6	20	SO–8	DECT, PHS, PCS, ISM
MRFIC0903(18b)★	100–2000	0–5.0	60	35.5	0.65	21	SO–8	AMPS, Class 4 & 5 GSM, DCS1800, PHS, PCS

Receiver Functions

900 MHz Front End

LNA + Mixer

Device	RF Freq. Range MHz	IF Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Conv. Gain dB (Typ)	Output Level, 1 dB Comp. dBm (Typ)	Package	System Applicability
MRFIC2001(18b)	500–1000	0–250	2.7–5.0	4.7	23	–10	SO–8	CT2, ISM

General Purpose Cascode Amplifier

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Small Signal Gain @ 900 MHz dB (Typ)	Noise Figure dB (Typ)	Reverse Isolation dB (Typ)	Package	System Applicability
MRFIC0916(18c)★	100–2000	2.7–5.0	4.7	18.5	1.9	44	SOT–143	AMPS, CT1, CT2, GSM, IS–54, ISM, DECT, PHS, PCS

1.9 GHz Front End

Integrated LNA

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Small Signal Gain dB (Typ)	Noise Figure dB (Typ)	Reverse Isolation dB (Typ)	Package	System Applicability
MRFIC1808(1,18b)★	1700–2100	2.7–4.5	4.2	17	1.6	37	SO–8	DECT, PHS, PCS

Integrated LNA/Downconverter

Device	RF Freq. Range GHz	IF Freq. Range GHz	Supply Volt. Range Vdc	Supply Current RX Mode mA (Typ)	Mixer Conv. Gain dB (Typ)	LNA Gain dB (Typ)	LNA Noise Figure dB (Typ)	Package	System Applicability
MRFIC1804(18b)	1.8–1.925	70–325	2.7–3.3	10	4	14	2.3	SO–16	DECT, PHS, PCS
MRFIC1814(1,18b)★	1.8–2.0	70–300	2.7–4.5	10	9	17	2.5	TSSOP–16	DECT, PHS, PCS

(1)To be introduced in 1Q96

(18)Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

★New Product

Receiver Functions (continued)

2.4 GHz Front End

Integrated LNA/Downconverter

Device	RF Freq. Range MHz	IF Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Conv. Gain dB (Typ)	LNA Noise Figure dB (Typ)	Isolation Lo to RF, Lo to IF dB (Typ)	Package	System Applicability
MRFIC2401(18b)	2400–2500	100–350	4.75–5.25	9.5	21	1.9	20	SO–16	WLAN, MMDS, ISM

Transmitter Functions

General Purpose Integrated Circuits

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Gain Control dB (Typ)	Lo Leakage dBm (Typ)	SSB P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC0001(18b)★	50–260	2.7–5.5	10	30	–55	–10	TSSOP–20	DCS1800, GSM, NADC PDC, PHS

General Purpose Cascode Amplifier

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Small Signal Gain @ 900 MHz dB (Typ)	Noise Figure dB (Typ)	Reverse Isolation dB (Typ)	Package	System Applicability
MRFIC0916(18c)★	100–2000	2.7–5.0	4.7	18.5	1.9	44	SOT–143	AMPS,CT1,CT2,GSM,IS–54, ISM,DECT,PHS,PCS

900 MHz Transmit Chain

Transmit Mixer

Device	RF Freq. Range MHz	IF Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Standby Current µA (Typ)	Conv. Gain dB (Typ)	Output Level, 1 dB Comp. dBm (Typ)	Package	System Applicability
MRFIC2002(18b)	500–1000	0–250	2.7–5.0	5.5	0.1	10	–18	SO–8	AMPS,CT1,CT2, GSM, IS–54, ISM
MRFIC2101(18b)	800–1000	0–250	3–4.75	45	2	26.5	4.5	SO–16	AMPS,CT1,CT2, GSM, IS–54, ISM

Driver and Ramp

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Standby Current mA (Typ)	Small Signal Gain dB (Typ)	Gain Control dB (Typ)	P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC2004(18b)	800–1000	2.7–4.0	11	0.7	21.5	34	–1	SO–16	AMPS,CT1,CT2, GSM,ISM
MRFIC0904(18b)★	800–1000	2.7–5.0(47)	280	0.05	27	24.5	25.5	SO–16	AMPS,GSM,ISM

(18) Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

(47) Negative supply required

★New Product

Transmitter Functions (continued)

900 MHz Transmit Chain (continued)

Power Amplifier

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Small Signal Gain dB (Typ)	Return Loss Input/Output dB (Typ)	P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC2006(18b)	500–1000	1.8–4.0	46	23	15	15.5	SO–8	AMPS,CT1,CT2, GSM,ISM

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Standby Current mA (Typ)	Small Signal Gain dB (Typ)	P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC2101(18b)	800–1000	4.75	38	2	16	18	SO–16	ISM, CT1, CT2

Device	Freq. Range MHz	Supply Volt. Range Vdc	Power Added Efficiency (%)	Power Gain dB	Harmonic Output 2fo dBc	P_{out}/P_{in} dBm (Typ)	Package	System Applicability
MRFIC0913(1)★	880–915	4.8(47)	50	25	–30	34.5/10	PFP–16	GSM

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Power Gain dB	Harmonic Output 2fo dBc	P_{out}/P_{in} dBm (Typ)	Package	System Applicability
MRFIC0914(1)★	890–950	4.8–6.0	586	28	–45	30.5/2.5	SO–16	Paging/ISM

1.9 GHz Transmit Chain

UpMixer, Exciter and LO Amp

Device	RF Output Freq. Range GHz	Supply Volt. Range Vdc	Supply Current TX Mode mA (Typ)	Standby Current μA (Typ)	Conv. Gain dB (Typ)	Recommended IF Input MHz (Typ)	P_{out}, 1 dB Comp. dBm (Typ)	Package	System Applicability
MRFIC1803(18b)	1.7–2.5	2.7–3.3	28	100	10	70–350	–2	SO–16	DECT,PHS, PCS
MRFIC1813(1,18b)★	1.7–2.5	2.7–4.5	24	25	15	70–350	2	TSSOP–16	DECT,PHS, PCS

PA Driver and RAMP

Device	RF Output Freq. Range GHz	Supply Volt. Range Vdc(47)	Supply Current mA (Typ)	Standby Current mA (Typ)	Small Signal Gain dB (Typ)	P_{out}/P_{in} dBm (Typ)	1 dB Compression dBm (Typ)	Pkg	System Applicability
MRFIC1806(18b)★	1.5–2.5	3.0–5.0	115	0.25	23	19.5/–3	+21	SO–16	DECT,PHS, PCS

(1)To be introduced 1Q96

(18)Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

(47)Negative supply required

★New Product

Transmitter Functions (continued)

1.9 GHz Transmit Chain (continued)

Power Amplifier and TX/TR Switch

Device	RF Output Freq. Range GHz	Supply Volt. Range Vdc	PA Supply Current TX Mode mA (Typ)	Standby Current mA (Typ)	Small Signal Gain dB (Typ)	Insertion Loss Rx Mode dB (Typ)	P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC1807(18b)★	1.5–2.2	3.0–5.0	325	0.06	8	1	25	SO–16	DECT, PHS, PCS

2.4 GHz Transmit Chain

Exciter Amplifier

Device	Freq. Range GHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Small Signal Gain dB (Typ)	Noise Figure dB (Typ)	P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC2404(18b)	2.0–3.0	4.75–5.25	9	17	4.3	5	SO–8	WLAN, MMDS, ISM

Power Amplifier

Device	Freq. Range MHz	Supply Volt. Range Vdc	Supply Current mA (Typ)	Small Signal Gain dB (Typ)	Power Control Range dB (Typ)	P_{out}, 1 dB Compression dBm (Typ)	Package	System Applicability
MRFIC2403(18b)	2200–2700	4.75–5.25	95	23	20	19	SO–16	WLAN, MMDS, ISM

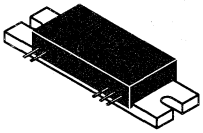
(18)Tape and Reel Packaging Option Available by adding suffix: a) R1 = 500 units; b) R2 = 2,500 units; c) T1 = 3,000 units; d) T3 = 10,000 units.

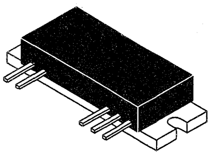
★New Product

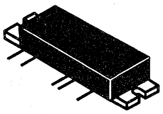
RF Amplifiers

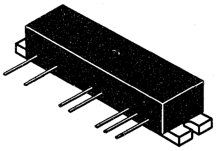
Motorola's line of RF amplifiers designed and specified for use in land mobile radios, CATV distribution systems and general purpose wideband amplification applications. They feature small size, matched inputs and outputs, high stability and guaranteed performance specifications. For the user, they offer the benefits of smaller and less complex system designs in less time and at lower overall cost.

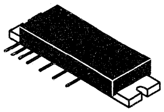
Each amplifier uses modern transistor chips which are gold metallized and have silicon nitride passivation for increased reliability and long life. Chip and wire construction features MOS capacitors and laser trimmed nichrome resistors. Circuit substrates and metallization have been selected for optimum performance cost and reliablity.

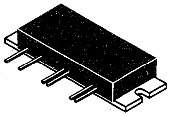

CASE 301AA
STYLE 1

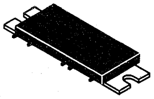

CASE 301AB
STYLE 1

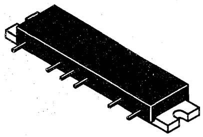

CASE 301E
STYLE 1

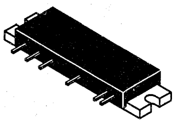

CASE 301F
STYLE 1

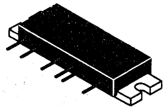

CASE 301J
STYLE 1

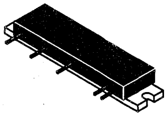

CASE 301K
STYLE 3

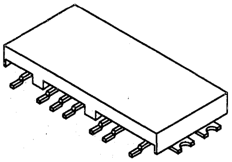

CASE 301N
STYLE 1

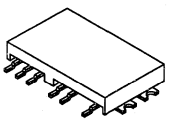

CASE 301R
STYLE 1

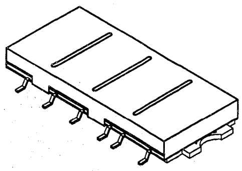

CASE 301T
STYLE 1

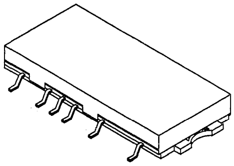

CASE 301V
STYLE 1

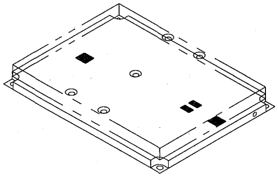

CASE 301Y
STYLE 1


CASE 420
STYLE 1

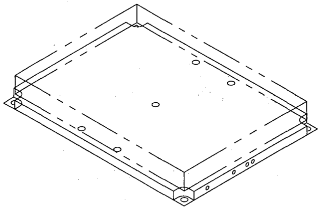

CASE 420A
STYLE 1


CASE 420L
STYLE 1

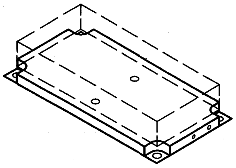

CASE 420U
STYLE 1



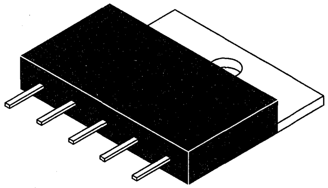
CASE 429A
STYLE 1



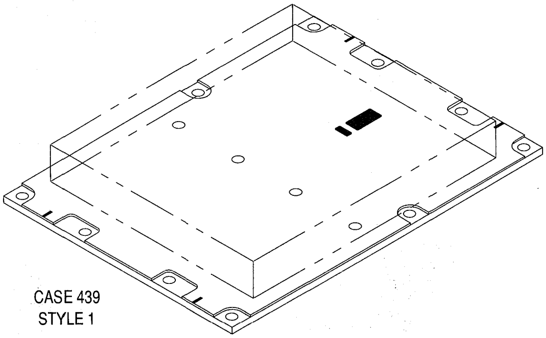
CASE 429C
STYLE 1



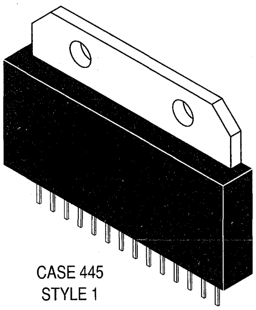
CASE 429E
STYLE 1



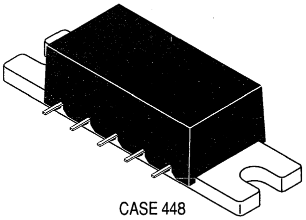
CASE 431A
STYLE 1



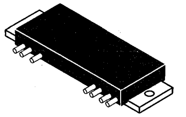
CASE 439
STYLE 1



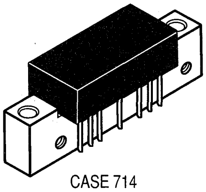
CASE 445
STYLE 1



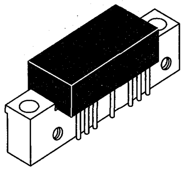
CASE 448
STYLE 1, 2



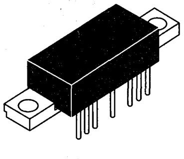
CASE 700
STYLE 2



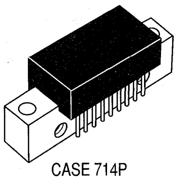
CASE 714
STYLE 1



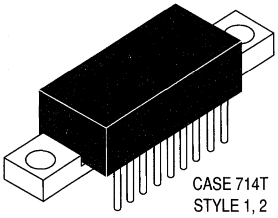
CASE 714F
STYLE 1



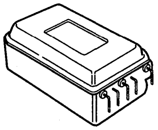
CASE 714G
STYLE 1



CASE 714P
STYLE 2, 3



CASE 714T
STYLE 1, 2



CASE 825A
STYLE 1

RF Amplifiers

High Power

Complete amplifiers with 50 ohm in/out impedances are available for a variety of applications including land mobile radios, base stations, TV transmitters and other uses requiring large–signal amplification, both linear and Class C. Frequencies covered range from 68–1785 MHz with power levels extending to 180 watts.

Land Mobile/Portable

The advantages of small size, reproducibility and overall lower cost become more pronounced with increasing frequency of operation. These amplifiers offer a wide range in power levels and gain, with guaranteed performance specifications for bandwidth, stability and ruggedness.

Table 1. VHF/UHF, Class C

Device	P_{out} Output Power Watts	P_{in} Input Power Watts	f Frequency MHz	G_P Power Gain, Min dB	V_{CC} Supply Voltage Volts	Package/Style
68–210 MHz, VHF Band — Class C (Silicon Bipolar Die)						
MHW105	5	0.001	68–88	37	7.5	301K/3
MHW607–1	7	0.001	136–150	38.4	7.5	301K/3
MHW607–2	7	0.001	146–174	38.4	7.5	301K/3
MHW607–3	7	0.001	174–195	38.4	7.5	301K/3
MHW607–4	7	0.001	184–210	38.4	7.5	301K/3
400–512 MHz, UHF Band — Class C (Silicon Bipolar Die)						
MHW704–1	3	0.001	400 – 440	34.8	6.0	301J/1
MHW704–2	3	0.001	440 – 470	34.8	6.0	301J/1
MHW707–1	7	0.001	403 – 440	38.4	7.5	301J/1
MHW707–2	7	0.001	440 – 470	38.4	7.5	301J/1
MHW707–3	7	0.001	470 – 500	38.4	7.5	301J/1
MHW707–4	7(23)	0.001	490 – 512	38.4(23)	7.5	301J/1
MHW720A1(22)	20	0.15	400 – 440	21	12.5	700/2
MHW720A2(22)	20	0.15	440 – 470	21	12.5	700/2
806–940 MHz, UHF Band — Class C (Silicon Bipolar Die)						
MHW851–1	1.6	0.001	820–850	32	6	301N/1
MHW851–2	1.6	0.001	870–905	32	6	301N/1
MHW851–3	2	0.001	890–915	33	6	301N/1
MHW851–4	1.6	0.001	915–925	32	6	301N/1
MHW803–1	2	0.001	820–850	33	7.5	301E/1
MHW803–2	2	0.001	806–870	33	7.5	301E/1
MHW803–3	2	0.001	870–905	33	7.5	301E/1
MHW804–1	4	0.001	800–870	36	7.5	301F/1
824 – 915 MHz, UHF Band — Class C (GaAs FET Die)						
MHW9002–1(22)	1.4	0.005	824–849	24.5	5.8	420A/1
MHW9002–2(22)	1.4	0.005	870–905	24.5	5.8	420A/1
1710 – 1785 MHz, UHF Band — (GaAs FET Die)						
MHW9014★	2.1	0.001	1710–1785	33.2	6.0	420/1

(22) Designed for Wide Range P_{out} Level Control

(23) P_o @ f = 490 MHz. P_o = 6.5 W @ f = 512 MHz

★New Product

High Power: Land Mobile/Portable (continued)

Table 2. UHF, Linear

Device	P_{out} Output Power Watts	P_{in} Input Power Watts	f Frequency MHz	G_p Power Gain, Min dB	V_{CC} Supply Voltage Volts	Package/Style
824–849 MHz, UHF Band — Class AB (Silicon Bipolar Die)						
MHW920★	0.8(24)	0.001	824–849	29	6	420U/1
MHW927B(22)	6(24)	0.001	824–849	37.8	12.5	301AA/1
880–960 MHz (for GSM) — Class AB (Silicon Bipolar Die)						
MHW2902★	3.2	0.001	890–915	32	6.0	420L/1
MHW953(22)	3.5	0.001	890–915	35.4	7.2	301V/1
MHW954(22)	3.5	0.1	890–915	15.4	7.2	301Y/1
MHW909(22)	9	0.1	890–915	19.5	7.2	301T/1
MHW915(22)	14	0.1	890–915	21.4	12.5	301T/1
880–960 MHz (for GSM) — Class AB (LDMOS Silicon FET)						
MHW913	14	0.1	880–915	21.5	12.5	301AB/1
MHW914(22)	14	0.001	890–915	41.4	12.5	301R/1
MHW916	16	0.036	925–960	26.5	26	301AB/1

TV Transmitters

Table 3. UHF Ultra Linear for TV Applications

These amplifiers are characterized for ultra–linear applications in Band IV and Band V TV transmitters.

Device	Frequency MHz	P_{ref} Watts	G_p (Min)/Freq. Power Gain dB/MHz	3 Tone(8) IMD 1 dB	3 Tone(25) IMD 2 dB	V_{CC} Volts	Class	Package/Style
MRFA2600(26)	470–860	20	10.5/860	–50	–53	26.5	A	429A/1
MRFA2602(28)	470–860	40	9/860	–50	–53	25.5	A	429C/1
RFA8090B	470–860	95(11)	8/860	—	—	28	AB	429E/1
MRFA2604★	470–860	180(11)	8/860	—	—	28	AB	439/1

(8) Vision Carrier: – 8 dB; Sound Carrier: – 7 dB; Sideband Carrier: – 16 dB
(11) Output power at 1 dB compression in Class AB
(22) Designed for Wide Range P_{out} Level Control
(24) Average Power; Peak Power is twice average power
(25) Vision Carrier: – 8 dB; Sound Carrier: – 10 dB; Sideband Carrier: – 16 dB
(26) Formerly known as "RFA6031"
(28) Formerly known as "RFA6060"
★New Product

Low Power

The following categories describe a wide range of complete amplifier assemblies both hybrid and monolithic for use in CATV distribution systems, instrumentation, communications and military equipment. A variety of power levels and frequencies of operation is offered for many applications.

CATV Distribution

Motorola Hybrids are manufactured using the latest generation technology which has set new standards for CATV system performance and reliability. These hybrids have been optimized to provide premium performance in all CATV systems up to 152 channels.

Table 1. To 50 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nominal) dB	Channel Loading Capacity	Maximum Distortion Specifications				Noise Figure @ 50 MHz dB	Package/ Style
			Output Level dBmV	2nd Order Test(30) dB	Composite Triple Beat dB 4 CH	Cross Modulation dB 4 CH		
Low Current Amplifiers								
MHW1184L	18	4	+50	–70	–73	–64	5	714/1
MHW1224L	22	4	+50	–70	–72	–63	5	714/1
MHW1254L	25	4	+50	–70	–70	–62	4.5	714/1
MHW1304L	30	4	+50	–70	–66	–57	4.5	714/1

Table 2. 5–200 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nominal) dB	Channel Loading Capacity	Maximum Distortion Specifications						Noise Figure @ 175 MHz dB	Package/ Style
			Output Level dBmV	2nd Order Test(30) dB	Composite Triple Beat dB		Cross Modulation dB			
					22 CH	26 CH	22 CH	26 CH		
High–Split Reverse Amplifiers										
MHW1134	13	22	+50	–72	–73	–71(19)	–65	–65(19)	7	714/1
MHW1184	18	22	+50	–72	–72	–70(19)	–64	–64(19)	5.5	714/1
MHW1224	22	22	+50	–72	–69	–68.5(19)	–62	–62(19)	5.5	714/1
MHW1244	24	22	+50	–72	–68	–67.5(19)	–61	–61(19)	5	714/1

(19)Typical

(30)Channels 2 and A @ 7

Low Power: CATV Distribution (continued)

Table 3. 40−450 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nominal)	Channel Loading Capacity	Maximum Distortion Specifications				Noise Figure @ 450 MHz	Package/ Style
			Output Level	2nd Order Test	Composite Triple Beat dB	Cross Modulation dB	dB	
	dB		dBmV	dB	60 CH	60 CH	Typ	
Conventional Hybrids								
MHW5142A	14	60	+46	−74(31)	−61	−62	6	714/1
MHW5182A	18	60	+46	−72(31)	−61	−59	5.5	714/1
MHW5183	18	60	+46	−62(31)(32)	−58	−57	4.5	714/1
MHW5222A	22	60	+46	−72(31)	−60	−59	4.5	714/1
MHW5272A	27	60	+46	−72(31)	−59	−60	5.5	714/1
MHW5342A	34	60	+46	−72(31)	−59	−59	6.0	714/1
MHW5382A	38	60	+46	−70(31)	−59	−59	4	714/1
CA97901	21.2(44)	30	+46	−65	−65	−65	5.5	714F/1
Power Doubling Hybrids								
MHW5185B	18	60	+46	−67(32)	−67	−67	5.5	714/1
MHW5205	20	60	+46	−58(33)	−64	−64	5.5	714/1
MHW5225	22	60	+46	−69(31)	−62	−62	5	714/1
Feedforward Hybrids								
MFF124B	24	60	+46	−84(31)	−79	−75	10(34)	825A/1

Table 4. 40−550 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nom.)	Channel Loading Capacity	Maximum Distortion Specifications						Noise Figure @ 550 MHz	Package/ Style
			Output Level	2nd Order Test	Composite Triple Beat dB		Cross Modulation dB		dB	
	dB		dBmV	dB	77 CH	87 CH	77 CH	87 CH	Typ	
Conventional Hybrids										
MHW6122	12	77	+44	–74(35)	–56	—	–62	—	7	714/1
MHW6142	14	77	+44	–72(35)	–59	—	–62	—	6.5	714/1
MHW6172	17	77	+44	–70(35)	–59	—	–62	—	6	714/1
MHW6182	18	77	+44	–72(35)	–58	—	–62	—	6	714/1
MHW6183	18	77	+44	–58(36)	–58	—	–58	—	5	714/1
MHW6222	22	77	+44	–66(35)	–57	—	–57	—	5	714/1
MHW6272	27	77	+44	–64(35)	–57	—	–57	—	6	714/1
MHW6342	34	77	+44	–64(35)	–57	—	–57	—	5.5	714/1
Power Doubling Hybrids										
MHW6185B	18	77	+44	–65(36)	–65	—	–68	—	6	714/1
MHW6205	20	77	+44	–60(36)	–64	—	–67	—	7.5	714/1
MHW6225	22	77	+44	–55(36)	–62	—	–63	—	7.0	714/1
Feedforward Hybrids										
MFF224B	24	77	+44	–86(35)	–75	—	–70	—	11(34)	825A/1

(31)Channels 2 and M13 @ M22

(32)Composite 2nd order; V_{out} = +46 dBmV/ch

(33)Composite 2nd order IMD, 60 channel flat

(34)Maximum

(35)Channels 2 and M30 @ M39

(36)Composite 2nd order; V_{out} = +44 dBmV/ch

(44)Hi-Slope Trunk Amplifier. The specified gain is at 450 MHz.

Low Power: CATV Distribution (continued)

Table 5. 40–600 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nom.) dB	Channel Loading Capacity	Maximum Distortion Specifications						Noise Figure @ 600 MHz dB Typ	Package/ Style
			Output Level dBmV	2nd Order Test dB	Composite Triple Beat dB		Cross Modulation dB			
					85 CH	87 CH	85 CH	87 CH		
Conventional Hybrids										
MHW6182–6	18	87	+44	–56(36)	—	–57	—	–55	6(34)	714/1
MHW6222–6	22	87	+44	–56(36)	—	–56	—	–56	6(34)	714/1
Power Doubling Hybrids										
MHW6185–6	18	87	+44	–60(36)	—	–62	—	–66	6.5	714/1
MHW6185–6A★	18	87	+44	–64(36)	—	–64	—	–66	7(34)	714/1
MHW6205–6A★	20	87	+44	–63(36)	—	–63	—	–65	6.5(34)	714/1
Feedforward Hybrids										
MFF324B	24	85	+44	–86(38)	–73	—	–68	—	12.5(34)	825A/1

Table 6. 40–860 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nom.) dB	Channel Loading Capacity	Maximum Distortion Specifications						Noise Figure Typ dB		Package/ Style
			Output Level dBmV	2nd Order Test dB	Composite Triple Beat dB		Cross Modulation dB		@ 750 MHz	@ 860 MHz	
					110 CH	128 CH	110 CH	128 CH			
Conventional Hybrids											
MHW7142	14	110	+40	–60	– 62	—	– 66	—	—	7.5(34)	714/1
MHW8142	14	128	+38	–60	—	– 61	—	– 66	—	8.0(34)	714/1
MHW7182	18	110	+44	–62(39)	– 62	—	– 64	—	5.5	—	714/1
MHW8182	18	128	+38	–60(40)	—	– 60	—	– 60	—	6	714/1
MHW7222	22	110	+40	–55(39)	– 60	—	– 60	—	5.5	—	714/1
MHW8222	22	128	+38	–56(40)	—	– 60	—	– 60	—	6.4	714/1
MHW7272★	27	110	+40	–60(39)	– 60	—	– 60	—	6.5(34)	—	714/1
MHW8272★	27	128	+38	–58(40)	—	– 60	—	– 60	—	7.0(34)	714/1
MHW7292★	29	110	+40	–60(39)	– 60	—	– 60	—	6.5(34)	—	714/1
MHW8292★	29	128	+38	–56(40)	—	– 60	—	– 60	—	7.0(34)	714/1

Device	Hybrid Gain (Nom.) dB	Channel Loading Capacity	Maximum Distortion Specifications							Noise Figure Typ dB		Package/ Style
			Output Level dBmV	2nd Order dB		Composite Triple Beat dB		Cross Modulation dB		@ 750 MHz	@ 860 MHz	
				77 CH	110 CH	77 CH	110 CH	77 CH	110 CH			
Power Doublers												
MHW7185	18	77/110	+44	–62	–56	–65	–56	–68	–65	—	8.5(34)	714/1
MHW7185A★	18	110	+44	—	–58		–58	—	–65	8.5(34)	—	714/1
MHW7205A★	20	110	+44	—	–56		–57	—	–64	8.5(34)	—	714/1
Feed Forward Hybrids												
MFF424B★	24	110	+44	—	–70(37)	—	–65(37)	—	—	13(34)	—	825A/1

(34) Maximum

(36) Composite 2nd order; V_{out} = +44 dBmV/ch

(37) Flat

(38) Channels 2 and M39 @ M48

(39) Composite 2nd order; V_{out} = +40 dBmV/ch

(40) Composite 2nd Order; V_{out} = +38 dBmV/ch

★New Product

Low Power: CATV Distribution (continued)

Table 7. 40–860 MHz Hybrids

Device	Gain dB Typ	Frequency MHz	V_{CC} Volts	2nd Order IMD @ V_{out} = 50 dBmV/ch Max	DIN45004B @ f=860 MHz dBμV Min	Noise Figure @ 860 MHz dB Max	Package/ Style
Conventional Hybrids							
CA901	17	40 – 860	24	–60	120	8	714P/2
CA901A	17	40 – 860	24	–64	120	8	714P/2
Power Doubling Hybrids							
CA902	17	40 – 860	28	–63	123	9.5	714P/2
CA902A	17	40 – 860	28	–67	123	9.5	714P/2
CA922	17	40 – 860	24	–63	123	9.5	714P/2
CA922A	17	40 – 860	24	–67	123	9.5	714P/2
CA912	17	40 – 860	15	–63	123	9.5	714P/3
CA912A	17	40 – 860	15	–67	123	9.5	714P/3

Table 8. 40/1000 MHz Hybrids, V_{CC} = 24 Vdc, Class A

Device	Hybrid Gain (Nom.) dB	Channel Loading Capacity	Maximum Distortion Specifications						Noise Figure @ 860 MHz dB Typ	Package/ Style
			Output Level dBmV	2nd Order Test dB	Cross Modulation dB 128 CH	Cross Modulation dB 152 CH	Composite Triple Beat dB 128 CH	Composite Triple Beat dB 152 CH		
Conventional Hybrids										
MHW9142	14	152	+38	–59(40)	—	–63	—	–59	8.5(34)	714/1
MHW9182	18	152	+38	–59(40)	—	–59	—	–59	6.5	714/1

Table 9. Standard Linear Hybrids

The CA series of RF linear hybrid amplifiers consists of a family of medium power, broadband gain blocks in the CATV industry standard "CA" package. These amplifiers were designed for multi–purpose RF applications where linearity, dynamic range and wide bandwidth are of primary concern. Each amplifier is available in various package options. Six parts are available as indicated in a low profile package. Arrangement within the group is in order of increasing maximum frequency.

Device	V_{CC} (Nom.) Volts	BW MHz	Gain Flatness Typ ±dB	Gain/Freq. Typ dB/MHz	P_{1dB} Typ dBm	NF/Freq. Typ dB/MHz	3rd Order Intercept Point/Freq. Typ dBm/MHz	VSWR Max 50 Ω/75Ω	V_S/I_S Typ V/mA	Case/ Style
CA5815C(41)	15	10–1000	1	15.5/1000	30	8.5/1000	40.5/1000	2.6/—	15/700	714P/3
MHL8015★	15	40–1000	1	18.5/900	26	7.5/1000	38/879	2.6/—	15/380	448/2
MHL8115★	15	5–1000	1	17.5/900	30	8.5/1000	41.5/879	2.6/—	15/700	448/2
MHL9125★	15	800–960	0.5	20/900	31	7.5/960	43/879	1.5/—	15/700	448/2
CA2830C	24	5–200	0.5	34.5/100	29	4.7/200	46/200	2/—	24/300	714F/1
CA2833C	24	5–200	0.5	34.5/100	29	4.7/200	46/200	2/—	24/300	714G/1
CA2842C	24	10–400	0.5	22/100	32	4/100	44/300	1.5/—	24/230	714F/1
CA2810C	24	10–450	1.5	34/50	30	—/300	43/300	2/1.3	24/310	714F/1
CA2818C	24	10–400	0.5	18.5/50	30	5/200	45/200	2/—	24/205	714F/1
CA4800C(41)	24	10–1000	1	17.5/1000	26	7.5/1000	38/1000	2.6/—	24/220	714P/2
CA4812C(41)	24	10–1000	1	17.5/1000	26	7.5/1000	38/1000	2.6/—	12/380	714P/3
CA4815C(41)	24	10–1000	1	17.5/1000	26	7.5/1000	38/1000	2.6/—	15/380	714P/3
CA2832C	28	1–200	0.5	35.5/100	33	5/200	47/200	2/—	28/435	714F/1
CA5800C(41)	28	10–1000	1	15.5/1000	30	8.5/1000	40.5/1000	2.6/—	28/400	714P/2
CA5801(41)	28	50 – 1000	1	17.5/1000	30	8.5/1000	41.5/1000	2.6/—	28/400	714P/2
MHL8018★	28	40–1000	1	18.5/900	26	7.5/1000	38/879	2.6/—	28/210	448/1
MHL8118★	28	5–1000	1	17.5/900	30	8.5/1000	41.5/879	2.6/—	28/400	448/1
MHL9128★	28	800–960	0.5	20/900	31	7.5/960	43/879	1.5/—	28/400	448/1

(34) Maximum

(40) Composite 2nd Order; V_{out} = +38 dBmV/ch

(41) Available in thin flange package (714T) by adding suffix "S" after part number, i.e. CA4800CS.

★New Product

CRT Drivers

Table 10. Video Amplifiers

These complete hybrid amplifiers are specifically designed for CRT driver applications requiring high frequency response and high voltage, such as high resolution color graphics video monitors. Gold metallized die and substrates are used to insure high reliability and improved ruggedness.

Device	V_{CC} (nom) Volts	Gain(42) (Typ) V/V	t_r/t_f (Typ)(43) nsec	3 dB BW (Typ)(43) MHz	Video Clock Freq. MHz	V_{out} (Max) Volts	Load	Package/Style
CR2428	60	12	2.0	145	290	50 P–P	6 to 20 pF	431A/1
MHW2528(45) ★	60	12	2.8	100	200	50 P–P	6 to 20 pF	445/1
CR3428	80	12	2.2	130	260	70 P–P	6 to 20 pF	431A/1
MHW3528(45) ★	80	12	2.7	120	240	70 P–P	6 to 20 pF	445/1

(42)Insertion Gain; 50 Ohm Source

(43)Capacitive Load 8.5 pF, V_{out} = 40 V P-P

(45)Triple Video Amplifiers

★New Product

Section Two

RF Device Data Sheets

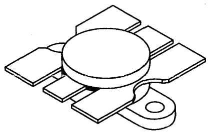
The RF Line
NPN Silicon RF Power Transistor

. . . designed primarily for wideband large–signal output amplifier stages in the 225 to 400 MHz frequency range.

- Guaranteed Performance in 225 to 400 MHz Broadband Amplifier @ 28 Vdc
  Output Power = 60 Watts over 225 to 400 MHz Band
  Minimum Gain = 7.8 dB @ 400 MHz
- Built–In Matching Network for Broadband Operation Using Double Match Technique
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability Applications

2N6439

60 W, 225 to 400 MHz
CONTROLLED "Q"
BROADBAND RF POWER
TRANSISTOR
NPN SILICON



CASE 316–01, STYLE 1

MAXIMUM RATINGS*

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	33	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	146 0.83	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	°C/W

ELECTRICAL CHARACTERISTICS* (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	33	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	2.0	mAdc

(continued)

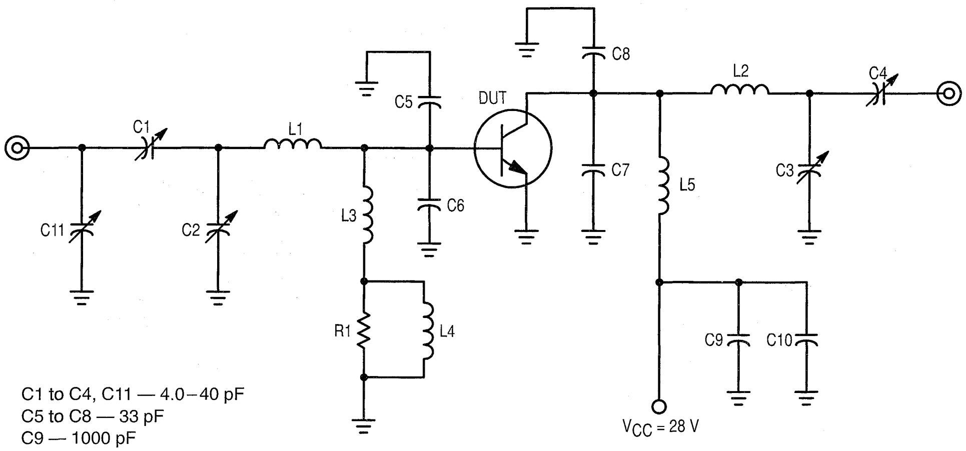
NOTE:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

* Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS* — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	67	75	pF
BROADBAND FUNCTIONAL TESTS (Figure 6)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 60 W, f = 225–400 MHz)	G_{PE}	7.8	8.5	—	dB
Electrical Ruggedness (P_{out} = 60 W, V_{CC} = 28 Vdc, f = 400 MHz, VSWR 30:1 all phase angles)	ψ	No Degradation in Output Power			—
NARROW BAND FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 60 W, f = 400 MHz)	G_{PE}	7.8	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 60 W, f = 400 MHz)	η	55	—	—	%

* Indicates JEDEC Registered Data.



C1 to C4, C11 — 4.0–40 pF
C5 to C8 — 33 pF
C9 — 1000 pF
C10 — 5.0 µF
R1 — 15 Ω
L1, L2 — 3/16″ x 1″ Copper Strap
L3 — 1.5 µH
L4 — 10 µH
L5 — 1 Turn #16 AWG, 5/16″ I.D.

Figure 1. 400 MHz Test Amplifier (Narrow Band)

NARROW BAND DATA

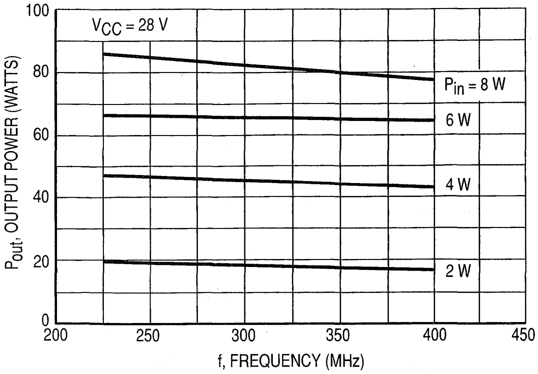


Figure 2. P_{out} versus Frequency

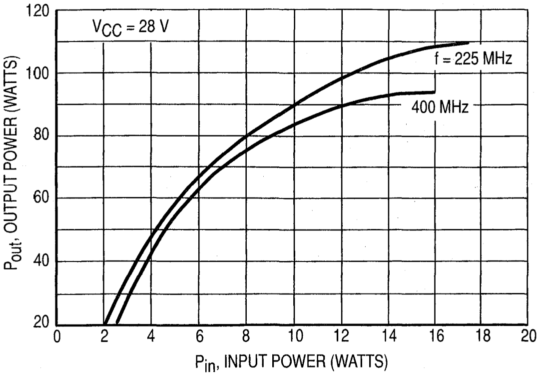


Figure 3. Output Power versus Input Power

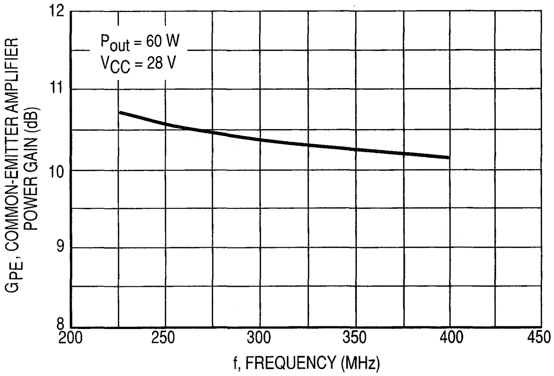


Figure 4. Power Gain versus Frequency

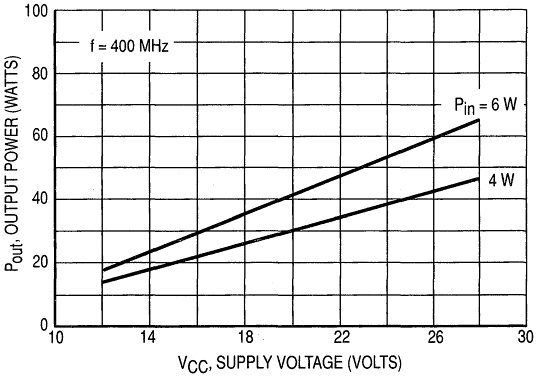


Figure 5. Output Power versus Supply Voltage

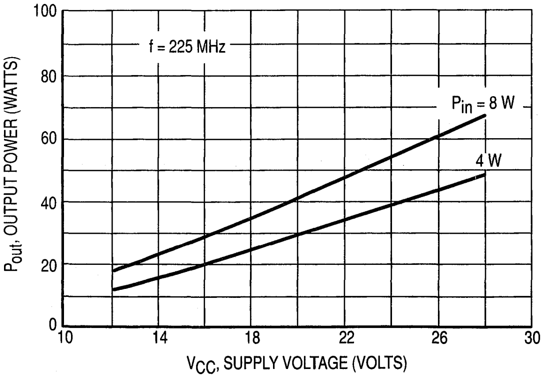
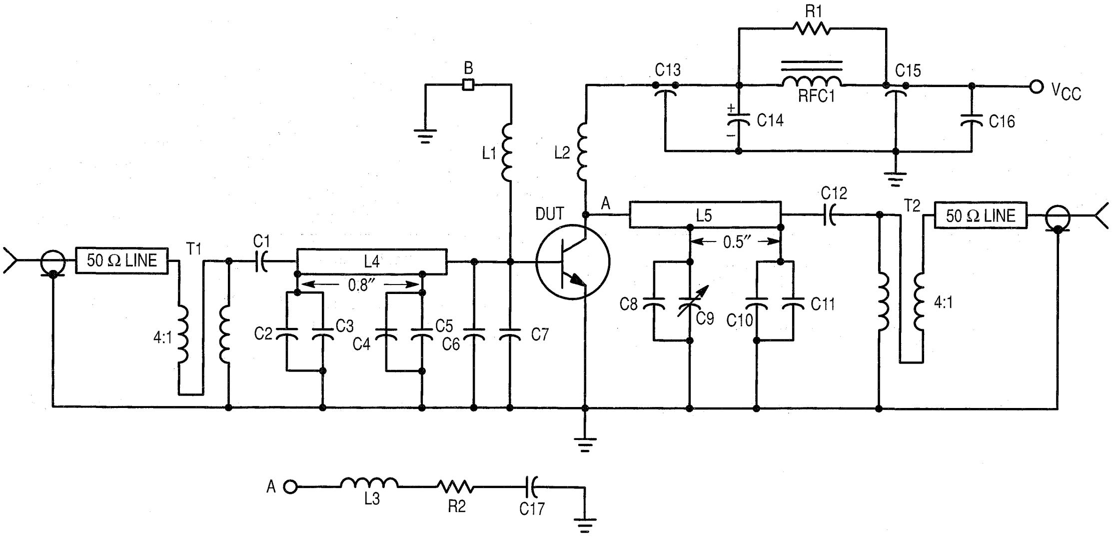


Figure 6. Output Power versus Supply Voltage



C1 — 68 pF
C2, C4, C8, C10 — 27 pF
C3, C5, C11 — 10 pF
C6, C7 — 51 pF
C9 — 1.0–10 pF JOHANSON
C12 — 100 pF
C13, C15 — 680 pF
C14, C16 — 1.0 µF, 35 V Tantalum
C17 — 0.1 µF, ERIE Red Cap

RFC1 — Ferrite Bead Choke, Feroxcube VK200 19/4B
B — Ferroxcube 56-590-65/4B Ferrite Bead
T1, T2 — 25 Ohms (UT25) Miniature Coaxial Cable, 1 turn
R1 — 11 Ω, 1.0 W
R2 — 20 Ω, 1/4 W
L1 — 10 Turns, #22 AWG, 1/8″ I.D.
L2 — 4 Turns, #16 AWG, 1/4″ I.D.
L3 — 6 Turns, #24 AWG, 1/8″ I.D.
L4, L5 — 1″ x 0.25″ Microstrip Line
Board Material 0.031″ Thick Teflon-Fiberglass

Figure 7. 225 to 400 MHz Broadband Test Circuit Schematic

BROADBAND DATA (Circuit, Figure 7)

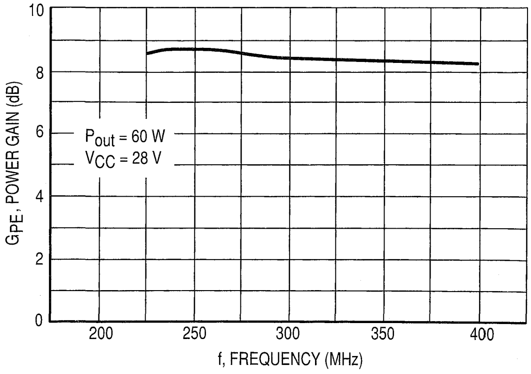


Figure 8. Power Gain versus Frequency

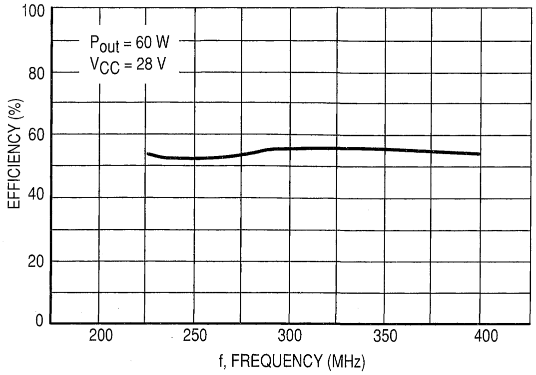


Figure 9. Efficiency versus Frequency

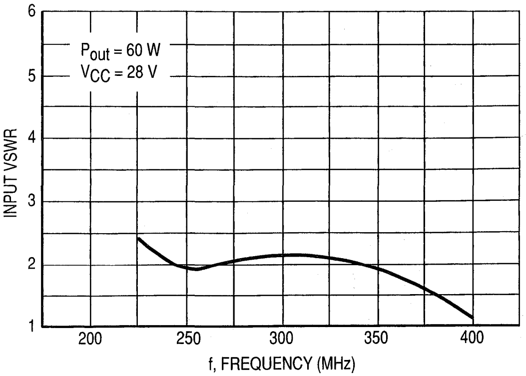
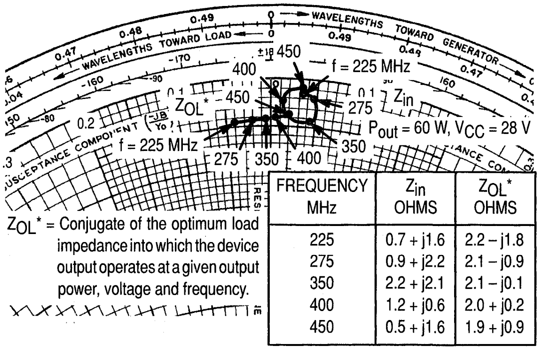


Figure 10. Input VSWR versus Frequency



Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

FREQUENCY MHz	Z_{in} OHMS	Z_{OL}^* OHMS
225	0.7 + j1.6	2.2 – j1.8
275	0.9 + j2.2	2.1 – j0.9
350	2.2 + j2.1	2.1 – j0.1
400	1.2 + j0.6	2.0 + j0.2
450	0.5 + j1.6	1.9 + j0.9

Figure 11. Series Equivalent Input-Output Impedance

The RF Line

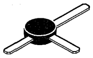
NPN Silicon High-Frequency Transistor

BFR90

Designed primarily for use in high–gain, low–noise, small–signal amplifiers. Also used in applications requiring fast switching times.

- High Current–Gain — Bandwidth Product —
  f_T = 5.0 GHz (Typ) @ I_C = 14 mA
- Low Noise Figure —
  NF = 2.4 dB (Typ) @ f = 0.5 GHz
  = 3.0 dB (Typ) @ f = 1.0 GHz
- High Power Gain —
  G_{max} = 18 dB (Typ) @ f = 0.5 GHz
  = 12 dB (Typ) @ f = 1.0 GHz

f_T = 5.0 GHz @ 14 mA
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON



CASE 317A–01, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	250 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	500	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 14 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—

(continued)

NOTE:
1. Device mounted on .062″ 2 oz. copper G10 board material, collector pad area 110 X 700 mils.

REV 1

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	5.0	—	GHz
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.5	1.0	pF
FUNCTIONAL TESTS					
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	NF	 — —	 2.4 3.0	 — —	dB
Power Gain at Optimum Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	G_{NF}	 — —	 15 10	 — —	dB
Maximum Available Power Gain (1) (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	G_{max}	 — —	 18 12	 — —	dB

NOTE: 1. $G_{max} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

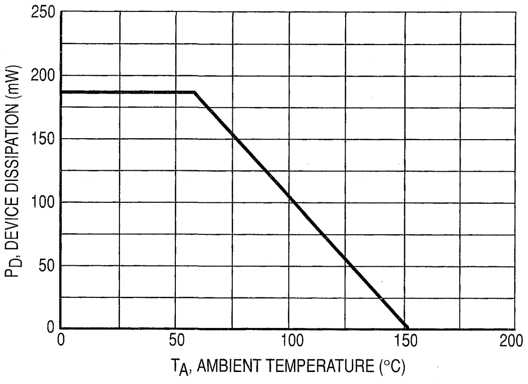


Figure 1. Power Derating

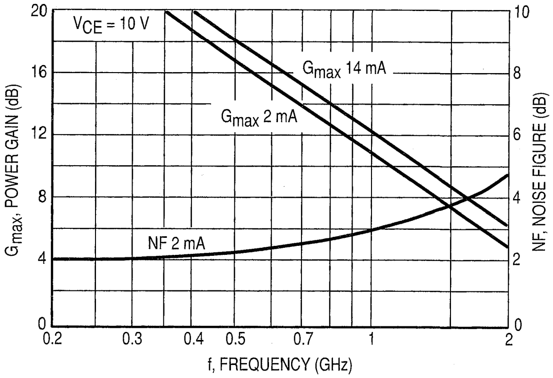


Figure 2. Power Gain and Noise Figure versus Frequency

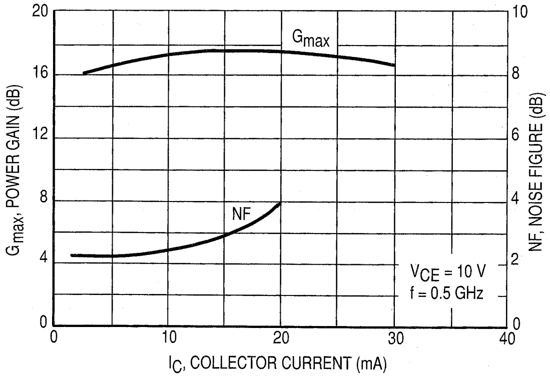


Figure 3. Power Gain and Noise Figure versus Collector Current

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S_{11}	∠ φ	S_{11}	∠ φ	S_{11}	∠ φ	S_{11}	∠ φ	S_{11}	∠ φ
5.0	2.0	0.77	−45	0.48	−90	0.33	−125	0.27	−160	0.28	170
	5.0	0.52	−60	0.25	−110	0.18	−150	0.18	170	0.21	145
	10	0.33	−75	0.15	−125	0.13	−175	0.15	150	0.20	130
	20	0.20	−95	0.12	−155	0.14	165	0.17	145	0.22	130
	30	0.17	−116	0.14	−170	0.17	160	0.21	145	0.26	130
10	2.0	0.79	−40	0.50	−80	0.33	−115	0.26	−150	0.25	175
	5.0	0.56	−55	0.27	−95	0.16	−135	0.13	−175	0.17	150
	10	0.39	−65	0.16	−105	0.10	−150	0.10	165	0.15	140
	20	0.25	−75	0.10	−120	0.09	−175	0.12	150	0.18	130
	30	0.25	−75	0.10	−120	0.09	−175	0.12	150	0.18	130

Table 1. S_{11} Parameters

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S_{22}	∠ φ	S_{22}	∠ φ	S_{22}	∠ φ	S_{22}	∠ φ	S_{22}	∠ φ
5.0	2.0	0.89	−20	0.69	−30	0.61	−35	0.55	−35	0.52	−45
	5.0	0.75	−25	0.55	−30	0.50	−30	0.47	−30	0.43	−40
	10	0.64	−25	0.49	−25	0.45	−25	0.43	−30	0.40	−35
	20	0.57	−25	0.47	−20	0.44	−25	0.43	−25	0.40	−35
	30	0.55	−20	0.47	−20	0.46	−20	0.44	−25	0.42	−35
10	2.0	0.91	−15	0.74	−25	0.66	−30	0.62	−35	0.59	−40
	5.0	0.79	−20	0.61	−25	0.56	−25	0.54	−30	0.51	−35
	10	0.70	−20	0.56	−20	0.53	−25	0.51	−25	0.48	−35
	20	0.63	−20	0.54	−25	0.53	−20	0.51	−25	0.49	−35
	30	0.63	−15	0.56	−15	0.55	−20	0.54	−25	0.52	−35

Table 2. S_{22} Parameters

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S_{21}	∠ φ	S_{21}	∠ φ	S_{21}	∠ φ	S_{21}	∠ φ	S_{21}	∠ φ
5.0	2.0	5.76	140	3.81	105	2.73	90	2.20	75	1.70	60
	5.0	9.92	125	5.24	95	3.50	80	2.80	70	2.10	60
	10	12.33	115	5.82	90	3.79	75	2.90	65	2.20	55
	20	13.62	105	6.00	85	3.88	75	2.95	65	2.25	55
	30	13.41	105	5.80	80	3.74	75	2.85	65	2.15	55
10	2.0	5.77	145	3.88	110	2.80	90	2.25	75	1.75	60
	5.0	10.05	130	5.42	95	3.60	80	2.85	70	2.10	60
	10	12.56	115	6.00	90	3.90	80	3.05	70	2.25	55
	20	13.77	110	6.13	85	3.92	75	3.05	65	2.20	55
	30	13.23	105	5.79	85	3.70	75	2.85	65	2.15	55

Table 3. S_{21} Parameters

Frequency (MHz)		200		500		800		1000		1500	
V_{CE} (Volts)	I_C (mA)	S_{12}	∠ φ	S_{12}	∠ φ	S_{12}	∠ φ	S_{12}	∠ φ	S_{12}	∠ φ
5.0	2.0	0.06	65	0.10	55	0.12	55	0.14	55	0.17	60
	5.0	0.05	65	0.08	65	0.12	65	0.15	65	0.19	65
	10	0.04	65	0.08	70	0.12	70	0.15	70	0.20	65
	20	0.04	75	0.08	75	0.12	75	0.15	70	0.20	70
	30	0.03	75	0.07	75	0.11	75	0.15	75	0.19	70
10	2.0	0.05	70	0.03	55	0.11	55	0.12	55	0.15	60
	5.0	0.04	65	0.07	65	0.10	65	0.13	65	0.17	70
	10	0.04	65	0.07	70	0.10	70	0.13	70	0.17	70
	20	0.03	70	0.07	75	0.10	75	0.13	75	0.17	70
	30	0.03	75	0.06	75	0.10	75	0.13	75	0.17	70

Table 4. S_{12} Parameters

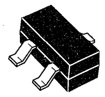
The RF Line
NPN Silicon High-Frequency Transistors

Designed primarily for use in high–gain, low–noise, small–signal UHF and microwave amplifiers constructed with thick and thin–film circuits using surface mount components.

- T1 suffix indicates tape and reel packaging of 3,000 units per reel.

BFR92ALT1

RF TRANSISTORS
NPN SILICON



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	25	mAdc
Maximum Junction Temperature	T_{Jmax}	150	°C
Power Dissipation, T_{case} = 75°C Derate linearly above T_{case} = 75°C @	$P_{D(max)}$	0.273 3.64	W mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	−55 to +150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	275	°C/W

DEVICE MARKING

BFR92ALT1 = P2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (1) (I_C = 10 mA)	$V_{(BR)CEO}$	15	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	20	—	Vdc
Emitter–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (I_C = 14 mA, V_{CE} = 10 V)	h_{FE}	40	—	—
Collector–Emitter Saturation Voltage (1) (I_C = 25 mA, I_B = 5.0 mA)	$V_{CE(sat)}$	—	0.5	Vdc
Base–Emitter Saturation Voltage (1) (I_C = 25 mA, I_B = 5.0 mA)	$V_{BE(sat)}$	—	1.2	Vdc

NOTE:
1. Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(continued)

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Typ	Unit
SMALL–SIGNAL CHARACTERISTICS			
Current–Gain — Bandwidth Product (I_C = 14 mA, V_{CE} = 10 V, f = 500 MHz)	f_T	4.5	GHz
Noise Figure (V_{CE} = 1.5 V, I_C = 3.0 mA, R_S = 50 Ω, f = 500 MHz)	NF	3.0	dB
Capacitance–Collector to Base (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	0.7	pF

The RF Line

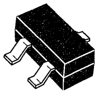
NPN Silicon High-Frequency Transistors

BFR93ALT1

Designed primarily for use in high–gain, low–noise, small–signal UHF and microwave amplifiers constructed with thick and thin–film circuits using surface mount components.

- T1 Suffix Indicates Tape and Reel Packaging of 3,000 Units per Reel.

RF TRANSISTORS
NPN SILICON



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	12	Vdc
Collector–Base Voltage	V_{CBO}	15	Vdc
Emitter–Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	35	mAdc
Maximum Junction Temperature	T_{Jmax}	150	°C
Power Dissipation, T_{case} = 75°C (2) Derate linearly above T_{case} = 75°C @	$P_{D(max)}$	0.306 4.08	W mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	–55 to +150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	245	°C/W

DEVICE MARKING

BFR93ALT1 = R2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (1) (I_C = 10 mA)	$V_{(BR)CEO}$	12	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 μA)	$V_{(BR)CBO}$	15	—	Vdc
Emitter–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)EBO}$	2.0	—	Vdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	50	nA
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	50	nA
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 30 mA, V_{CE} = 5.0 V)	h_{FE}	40	—	—
Collector–Emitter Saturation Voltage (1) (I_C = 35 mA, I_B = 7.0 mA)	$V_{CE(sat)}$	—	0.5	Vdc
Base–Emitter Saturation Voltage (1) (I_C = 35 mA, I_B = 7.0 mA)	$V_{BE(sat)}$	—	1.2	Vdc

NOTE:
1. Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
2. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

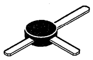
Characteristic	Symbol	Min	Max	Unit
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product (I_C = 30 mA, V_{CE} = 5.0 V, f = 500 MHz)	f_T	3.0	—	GHz
Noise Figure (V_{CE} = 5.0 V, I_C = 2.0 mA, R_S = 50 Ω, f = 30 MHz)	NF	—	3.0	dB

The RF Line
NPN Silicon High-Frequency Transistor

The BFR96 transistor uses the same state–of–the–art microwave transistor chip which features fine–line geometry, ion–implanted arsenic emitters and gold top metallization. This transistor is intended for low–to–medium power amplifiers requiring high gain, low noise figure, and low intermodulation distortion. The BFR96 is particularly suitable for broadband MATV/CATV amplifiers.

BFR96

f_T = 4.5 GHz @ 50 mA
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON



CASE 317A–01, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_C = 100°C (1) Derate above T_C = 100°C	P_D	0.5 10	Watts mW/°C
Storage Temperature	T_{stg}	–55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector–Base Capacitance (V_{CB} = 10 Vdc, Emitter Guarded)	C_{cb}	—	1.2	1.5	pF

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

(continued)

REV 1

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	NF	—	2.0	—	dB
Maximum Unilateral Gain/Insertion Gain (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	G_U(max)/ $\lvert S_{21}\rvert^2$	—/12	14.5/13	—	dB

NOTE: 2. $G_U(\text{max}) = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

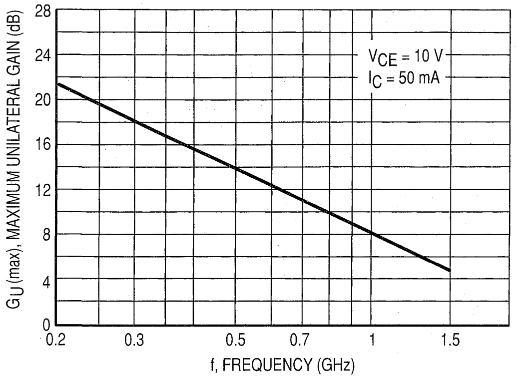


Figure 1. Maximum Unilateral Gain versus Frequency

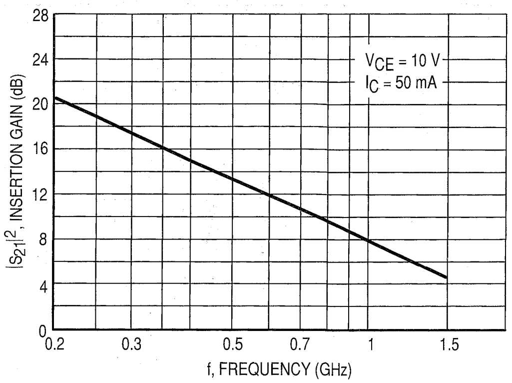


Figure 2. $|S_{21}|^2$ versus Frequency

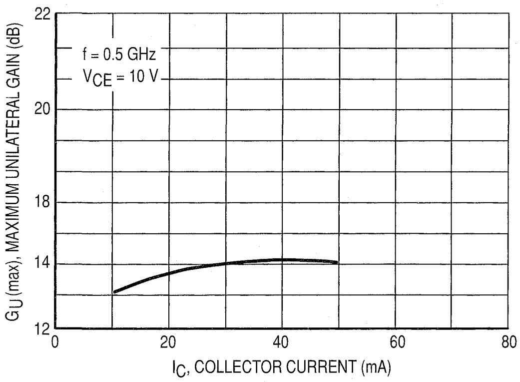


Figure 3. Maximum Unilateral Gain versus Collector Current

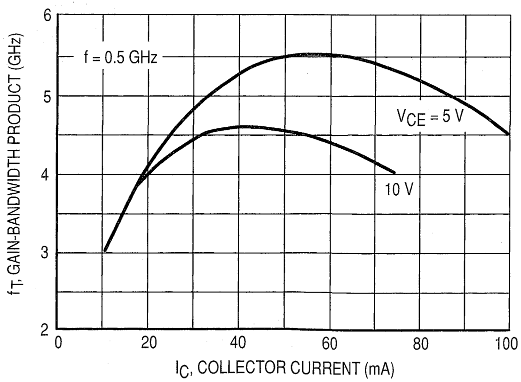


Figure 4. Gain–Bandwidth Product versus Collector Current

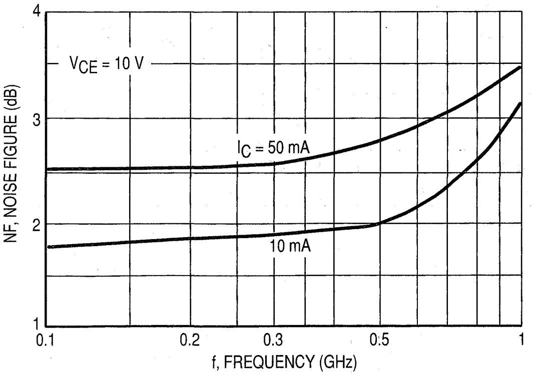


Figure 5. Noise Figure versus Frequency

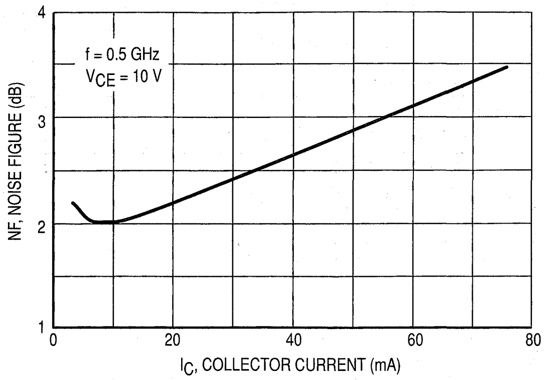


Figure 6. Noise Figure versus Collector Current

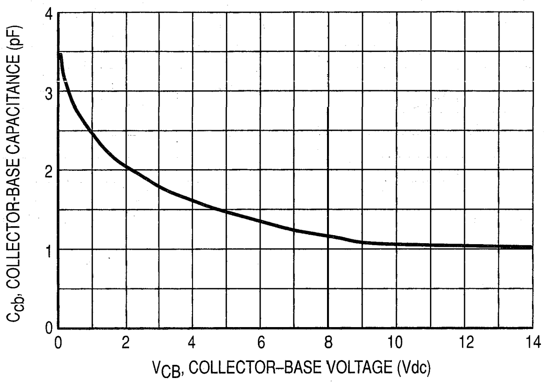


Figure 7. Collector–Base Capacitance versus Collector–Base Voltage

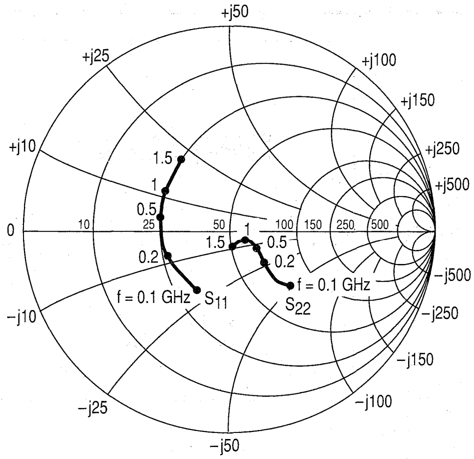


Figure 8. Input/Output Reflection Coefficients versus Frequency (V_{CE} = 10 V, I_C = 50 mA)

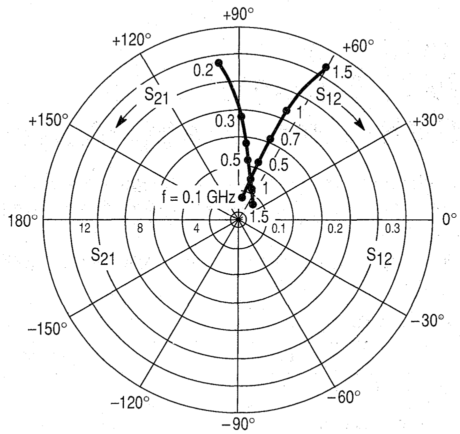


Figure 9. Forward/Reverse Transmission Coefficients versus Frequency (V_{CE} = 10 V, I_C = 50 mA)

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
5.0	10	100	0.51	−95	15.04	121	0.047	54	0.58	−48
		300	0.43	−163	5.87	92	0.082	58	0.26	−63
		500	0.46	174	3.61	79	0.120	63	0.19	−63
		700	0.48	162	2.65	68	0.161	63	0.15	−64
		1000	0.48	146	1.92	57	0.220	63	0.12	−79
		1500	0.54	121	1.40	43	0.320	58	0.13	−118
	25	100	0.39	−122	19.41	112	0.037	60	0.42	−68
		300	0.39	−176	6.81	89	0.079	68	0.16	−94
		500	0.42	166	4.11	78	0.129	70	0.10	−103
		700	0.44	156	3.05	69	0.176	68	0.06	−119
		1000	0.44	142	2.20	59	0.244	64	0.06	−159
		1500	0.49	118	1.62	45	0.348	57	0.10	177
	50	100	0.35	−140	21.10	106	0.032	64	0.33	−81
		300	0.38	176	7.11	88	0.081	72	0.13	−116
		500	0.42	162	4.28	78	0.133	72	0.09	−136
		700	0.43	153	3.16	70	0.183	69	0.07	−163
		1000	0.42	140	2.28	60	0.252	65	0.08	165
		1500	0.47	116	1.66	47	0.357	57	0.12	155
10	10	100	0.53	−83	15.96	124	0.039	58	0.65	−36
		300	0.38	−154	6.44	94	0.070	59	0.35	−41
		500	0.41	−179	3.98	81	0.102	64	0.30	−39
		700	0.42	166	2.94	70	0.138	65	0.27	−39
		1000	0.42	151	2.12	60	0.191	66	0.24	−47
		1500	0.49	125	1.50	44	0.278	63	0.22	−72
	25	100	0.38	−104	20.85	115	0.032	60	0.48	−48
		300	0.32	−169	7.54	91	0.070	68	0.23	−48
		500	0.35	170	4.61	80	0.109	71	0.19	−43
		700	0.37	160	3.37	70	0.152	69	0.16	−39
		1000	0.37	146	2.43	61	0.210	67	0.13	−44
		1500	0.43	121	1.73	47	0.304	61	0.10	−74
	50	100	0.33	−119	22.59	109	0.029	63	0.39	−51
		300	0.30	−176	7.74	88	0.069	72	0.19	−47
		500	0.34	166	4.70	79	0.113	73	0.16	−40
		700	0.36	158	3.45	70	0.156	70	0.14	−35
		1000	0.36	144	2.46	61	0.217	66	0.11	−39
		1500	0.42	119	1.75	47	0.310	60	0.08	−72

Table 1. Common–Emitter S–Parameters

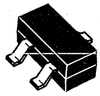
The RF Line
NPN Silicon High-Frequency Transistor

BFS17LT1

Designed primarily for use in high–gain, low–noise amplifier, oscillator and mixer applications. Packaged for thick or thin film circuits using surface mount components.

- T1 suffix indicates tape and reel packaging of 3,000 units per reel.

RF TRANSISTOR
NPN SILICON



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
(TO–236AA/AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	25	Vdc
Maximum Junction Temperature	T_{Jmax}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation, T_A = 25°C Derate above 25°C (1)	P_D	350 2.8	mW mW/°C
Storage Temperature	T_{stg}	−55 to +150	°C
Thermal Resistance Junction to Ambient (1)	$R_{\theta JA}$	357	°C/W

DEVICE MARKING

BFS17LT1 = E1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 µA)	$V_{(BR)CBO}$	25	—	—	Vdc
Collector Cutoff Current (V_{CE} = 10 V)	I_{CEO}	—	—	25	nA
Collector Cutoff Current (V_{CB} = 10 V)	I_{CBO}	—	—	25	nA
Emitter Cutoff Current (V_{EB} = 4 V)	I_{EBO}	—	—	100	µA
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 mA, V_{CE} = 1 V) (I_C = 25 mA, V_{CE} = 1 V)	h_{FE}	 20 20	 — —	 150 —	—
Collector–Emitter Saturation Voltage (I_C = 10 mA, I_B = 1 mA)	$V_{CE(sat)}$	—	—	0.4	V
Base–Emitter Saturation Voltage (I_C = 10 mA, I_B = 1 mA)	$V_{BE(sat)}$	—	—	1	V
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 2 mA, V_{CE} = 5 V, f = 500 MHz) (I_C = 25 mA, V_{CE} = 5 V, f = 500 MHz)	f_T	 — —	 1 1.3	 — —	GHz
Output Capacitance (V_{CB} = 10 V, f = 1 MHz)	CCB	—	1	—	pF
Noise Figure (I_C = 2 mA, V_{CE} = 5 V, R_S = 50 Ω, f = 30 MHz)	NF	—	5	—	dB

NOTE:
1. Package mounted on 99.5% alumina 10 x 8 x 0.6 mm.

REV 7

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

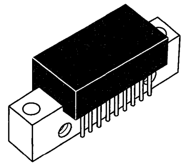
The RF Line
VHF/UHF CATV Amplifiers

CA901
CA901A

. . . designed for broadband applications requiring low–distortion amplification. Specifically intended for CATV/MATV market requirements. These amplifiers feature ion–implanted arsenic emitter transistors and an all gold metal system.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C:
  Frequency Range — 40 to 860 MHz
  Power Gain — 17 dB Typ @ f = 40 MHz
  Noise Figure — 6.5 dB Typ @ f = 500 MHz
  120 dBμV DIN45004B @ 860 MHz
- All Gold Metallization for Improved Reliability
- Superior Gain, Return Loss and DC Current Stability with Temperature

17 dB
40–860 MHz
VHF/UHF
CATV/MATV
AMPLIFIERS



CASE 714P–03, STYLE 2
(CA)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+14	dBm
Supply Voltage	V_{CC}	26	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V, 75 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	860	MHz
Power Gain (f = 40 MHz)	P_G	16.5	17	17.5	dB
Slope (40–860 MHz)	S	0.2	0.8	1.5	dB
Gain Flatness	—	—	—	0.6	dB
Input/Output Return Loss f = 40–100 MHz f = 100–800 MHz f = 800–860 MHz	IRL/ORL	20 15 10/15	— 17 12/18	— — —	dB
Second Order Intermodulation Distortion CA901 (V_{out} = +50 dBmV per ch.) CA901A	IMD_2	— —	— —	–60 –64	dB
DIN45004B (See Figure 1) f = 40–400 MHz f = 400–860 MHz	DIN	121 120	— —	— —	dBμV
Noise Figure f = 500 MHz f = 860 MHz	NF	— —	6.5 7.0	7.5 8.0	dB
Supply Current	I_{DC}	—	235	255	mA

REV 6

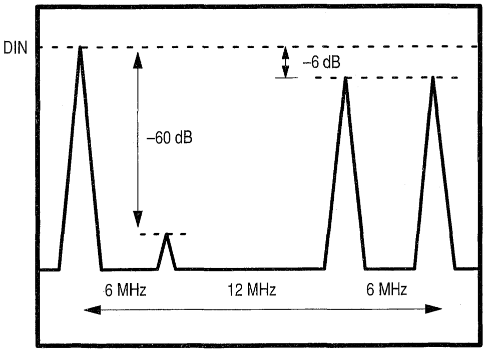


Figure 1. DIN45004B Test

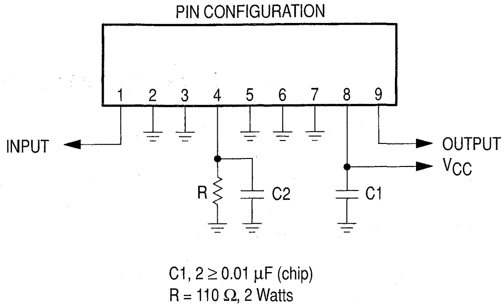


Figure 2. External Connections

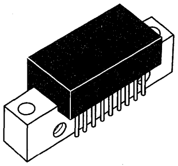
The RF Line
VHF/UHF CATV Amplifiers

CA902
CA902A

. . . designed for broadband applications requiring low–distortion and high output capability. Specifically intended for CATV/MATV market requirements. These amplifiers feature ion–implanted arsenic emitter transistors and an all gold metal system.

- Specified Characteristics at T_C = 25°C; V_{CC} = 28 V
  Frequency Range — 40 to 860 MHz
  Power Gain — 17 dB Typ @ f = 40 MHz
  Noise Figure — 7.0 dB Typ @ f = 500 MHz
  123 dBµV DIN45004B @ 860 MHz
- All Gold Metallization for Improved Reliability
- Superior Gain, Return Loss and DC Current Stability with Temperature

17 dB
40–860 MHz
VHF/UHF
CATV/MATV
AMPLIFIERS



CASE 714P–03, STYLES 2, 3
(CA)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	30	V
RF Input Power Per Tone	P_{in}	+17	dBm
Storage Temperature	T_{stg}	– 40 to +125	°C
Operating Case Temperature Range	T_C	– 20 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 28 V, 75 Ohm System)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current	I_{DC}	—	400	450	mA
Power Gain (f = 40 MHz)	PG	16.5	17	17.5	dB
Bandwidth	BW	40	—	860	MHz
Slope (40–860 MHz)	S	0.2	0.8	1.4	dB
Gain Flatness	FL	—	—	± 0.5	dB
Input/Output Return Loss f = 40 – 100 MHz	IRL/ORL	20	—	—	dB
f = 100 – 800 MHz		15	17	—	
f = 800 – 860 MHz		10	12	—	
Second Order Intermodulation Distortion (V_o = + 50 dBmV/ch.) CA902	IMD_2	—	—	–63	dB
CA902A		—	—	–67	
DIN45004B (See Figure 1) f = 40 – 400 MHz	DIN	124	—	—	dBµV
f = 400 – 860 MHz		123	—	—	
Noise Figure f = 500 MHz	NF	—	7.0	8.5	dB
f = 860 MHz		—	8.0	9.5	

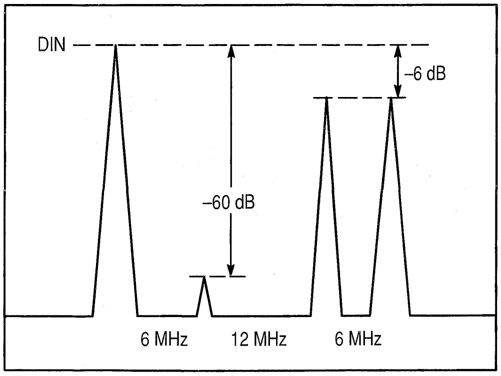


Figure 1. DIN45004B Test

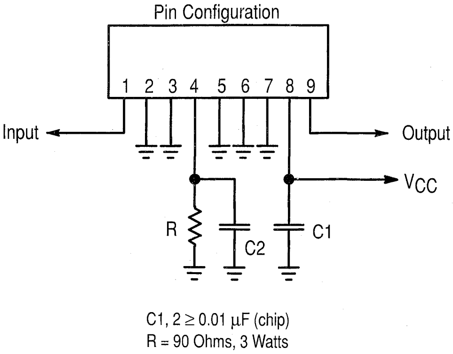


Figure 2. External Connections
Case 714P–03, Style 2

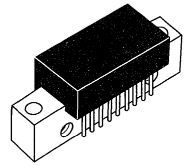
The RF Line
VHF/UHF CATV Amplifier

. . . designed for broadband applications requiring low–distortion and high output capability. Specifically intended for CATV/MATV market requirements. These amplifiers feature ion–implanted arsenic emitter transistors and an all gold metal system.

- Specified Characteristics at $T_C = 25°C$; $V_{CC} = 15$ V
  - Frequency Range — 40 to 860 MHz
  - Power Gain — 17 dB Typ @ f = 40 MHz
  - Noise Figure — 7.0 dB Typ @ f = 500 MHz
  - 123 dBμV DIN45004B @ 860 MHz
- All Gold Metallization for Improved Reliability
- Superior Gain, Return Loss and DC Current Stability with Temperature

CA912
CA912A

17 dB
40–860 MHz
VHF/UHF
CATV/MATV
AMPLIFIER



CASE 714P–03, STYLES 2, 3

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	18	V
RF Input Power Per Tone	P_{in}	+17	dBm
Storage Temperature	T_{stg}	– 40 to +100	°C
Operating Case Temperature Range	T_C	– 20 to +100	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$, $V_{CC} = 15$ V, 75 Ohm System)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current	I_{DC}	640	700	760	mA
Power Gain (f = 40 MHz)	PG	16.5	17	17.5	dB
Bandwidth	BW	40	—	860	MHz
Slope (40–860 MHz)	S	0.2	0.8	1.5	dB
Gain Flatness	FL	—	—	1.0	dB
Input/Output Return Loss f = 40 – 100 MHz f = 100 – 800 MHz f = 800 – 860 MHz	IRL/ORL	20 15 10	— 17 12	— — —	dB
Second Order Intermodulation Distortion CA912 (V_O = + 50 dBmV/ch.) CA912A	IMD_2	— —	— —	–63 –67	dB
DIN45004B (See Figure 1) f = 40 – 400 MHz f = 400 – 860 MHz	DIN	124 123	— —	— —	dBμV
Noise Figure f = 500 MHz f = 860 MHz	NF	— —	7.0 8.0	8.5 9.5	dB

REV 6

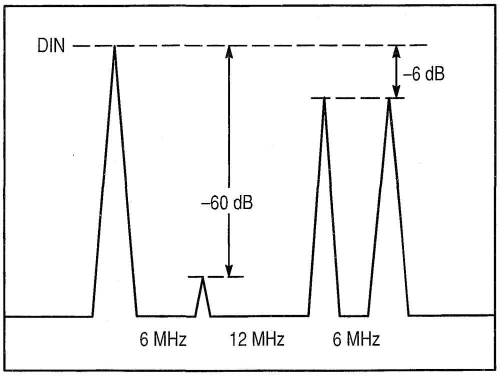


Figure 1. DIN45004B Test

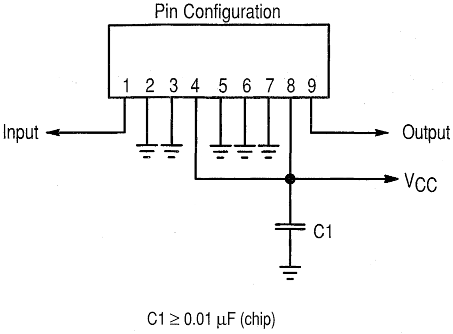


Figure 2. External Connections
Case 714P–03, Style 3

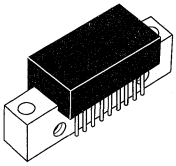
The RF Line
VHF/UHF CATV Amplifiers

CA922
CA922A

Designed for broadband applications requiring low–distortion and high output capability. Specifically intended for CATV/MATV market requirements. These amplifiers feature ion–implanted arsenic emitter transistors and an all gold metal system.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C
  Frequency Range — 40 to 860 MHz
  Power Gain — 17 dB Typ @ f = 40 MHz
  Noise Figure — 7.0 dB Typ @ f = 500 Mhz
  123 dBµV DIN45004B @ 860 MHz
- All Gold Metalization for Improved Reliability
- Superior Gain, Return Loss and DC Current Stability with Temperature
- Improved 2nd Order IMD Available (CA922A)

17 dB
40–860 MHz
VHF/UHF
CATV/MATV
AMPLIFIERS



CASE 714P–03, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	26	V
RF Input Power Per Tone	P_{in}	+16	dBm
Storage Temperature	T_{stg}	– 40 to +100	°C
Operating Case Temperature Range	T_C	– 20 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V, 75 Ohm System)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current	Idc	—	400	440	mA
Power Gain (f = 40 MHz)	PG	16.5	17	17.5	dB
Bandwidth	BW	40	—	860	MHz
Slope (40 – 860 MHz)	S	0.2	0.8	1.5	dB
Gain Flatness	FL	—	—	1.0	dB
Input/Output Return Loss f = 40–100 MHz f = 100–800 MHz f = 800–860 MHz	IRL/ORL	20 15 10/13	— 17 12/15	— — —	dB
Second Order Intermodulation Distortion (V_O = +50 dBmV/ch.) CA922 CA922A	IMD_2	— —	— —	– 63 – 67	dB dB
DIN45004B (See Figure 1) f = 40–400 MHz f = 400–860 MHz	DIN	124 123	— —	— —	dBµV
Noise Figure f = 500 MHz f = 860 MHz	NF	— —	7.0 8.0	8.5 9.5	dB

REV 6

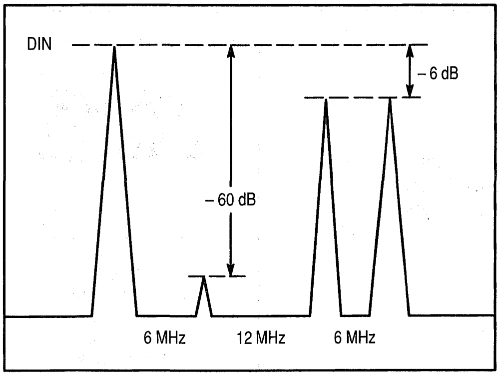


Figure 1. DIN45004B Test

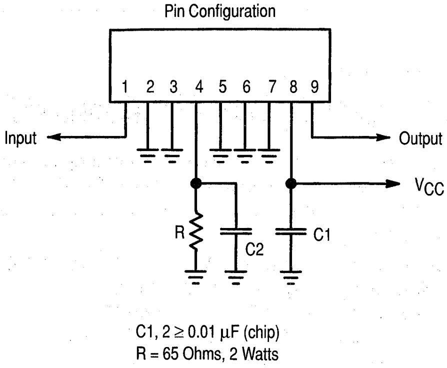


Figure 2. External Connections

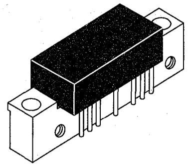
The RF Line
Wideband Linear Amplifier

CA2810C

. . . designed for amplifier applications in 50 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C:
- Frequency Range — 10 to 450 MHz
  Output Power — 1 W Typ @ 1 dB Compression, f = 200 MHz
  Power Gain — 34 dB Typ @ f = 50 MHz
  PEP — 400 mW Typ @ –32 dB IMD
  Noise Figure — 5 dB Max @ f = 300 MHz
- All Gold Metallization for Improved Reliability

**34 dB
10–450 MHz
800 mWATT
WIDEBAND
LINEAR AMPLIFIER**



**CASE 714F–03, STYLE 1
[CA (POS. SUPPLY)]**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	28	Vdc
RF Power Input	P_{in}	+5	dBm
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	450	MHz
Gain Flatness (f = 10−450 MHz)	F_L	—	—	±1.5	dB
Power Gain (f = 50 MHz)	P_G	33	34	35	dB
Noise Figure, Boradband (f = 300 MHz)	NF	—	—	5	dB
Power Output — 1 dB Compression (f = 200 MHz)	$P_{o1\ dB}$	800	1000	—	mW
Third Order Intercept (See Figure 10, f_1 = 300 MHz)	ITO	—	43	—	dBm
Input/Output VSWR (f = 10−450 MHz)	VSWR	—	—	2:1	—
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 10−300 MHz)	d_{so}	—	−55	−45	dB
Reverse Isolation (f = 10−450 MHz)	—	—	40	—	dB
Peak Envelope Power (Two Tone Distortion Test — See Figure 10) (f = 10−450 MHz @ –32 dB IMD)	PEP	—	400	—	mW
Supply Current	I_{CC}	270	310	330	mA

TYPICAL CHARACTERISTICS

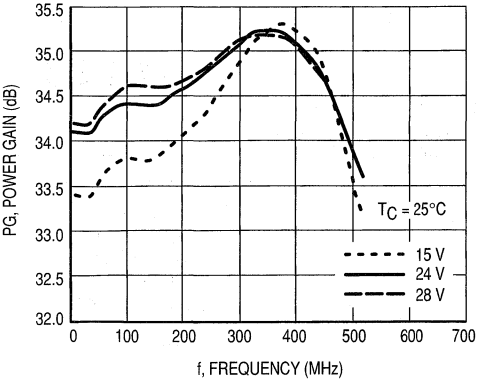


Figure 1. Power Gain versus Voltage

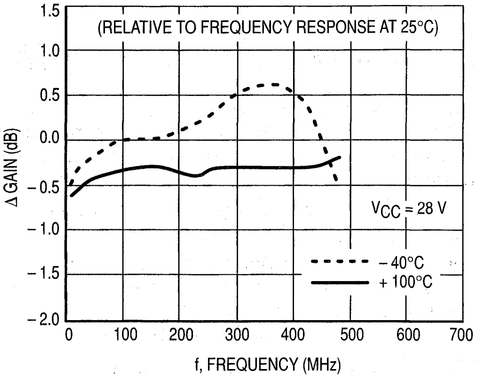


Figure 2. Relative Power Gain versus Temperature

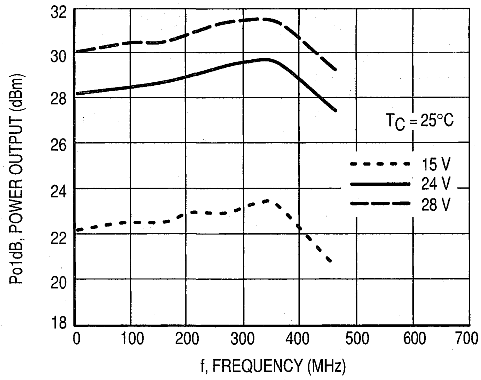


Figure 3. 1 dB Compression versus Voltage

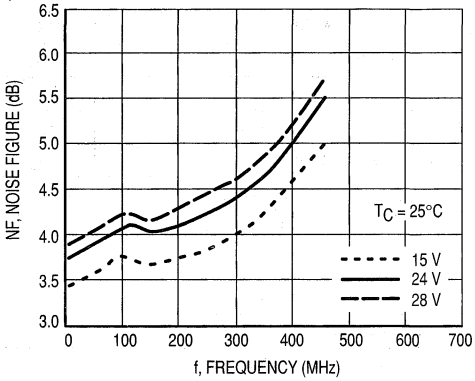


Figure 4. Noise Figure versus Voltage

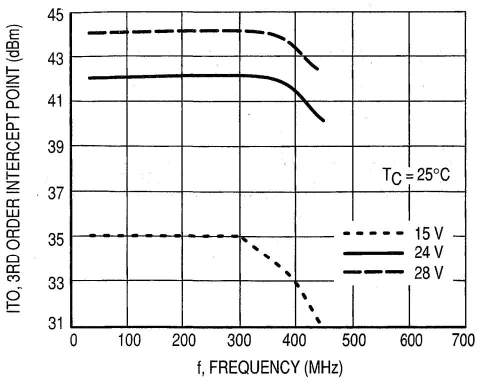


Figure 5. Third Order Intercept versus Voltage

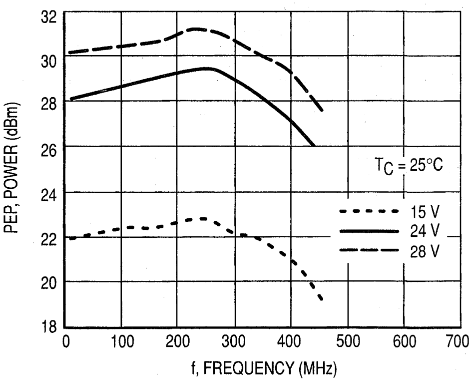


Figure 6. Peak Envelope Power versus Voltage

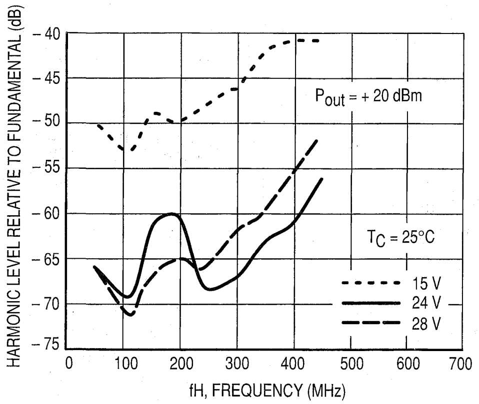


Figure 7. Second Harmonic Distortion versus Voltage

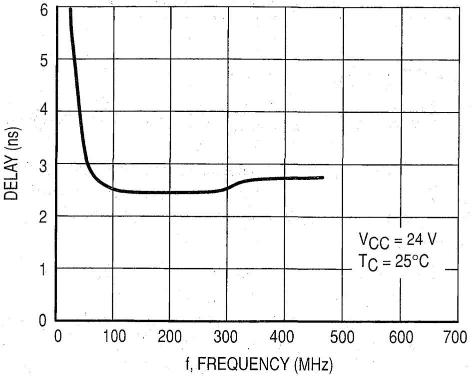


Figure 8. Group Delay versus Frequency

Biased at 24 Volts **T = 25°C Zo = 50Ω**

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
10	–13.8	3.5	34.2	–145	–46	–131	–13.5	8.2
50	–16.0	–3.0	34.2	150	–47	–172	–18.5	4.6
100	–14.4	–14	34.4	88	–48	102	–14.5	–9.2
200	–13.2	–50	34.6	2	–42	35	–13.2	–80
300	–13.9	–79	35.0	–80	–46	65	–16.7	–49
400	–14.1	–115	35.0	–80	–48	–44	–14.2	11
450	–16.2	–122	34.6	120	–53	–82	–13.8	–46

Magnitude in dB, Phase Angle in degrees.

Table 1. S–Parameters

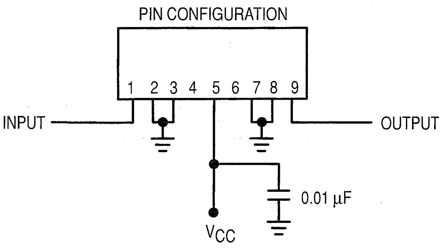
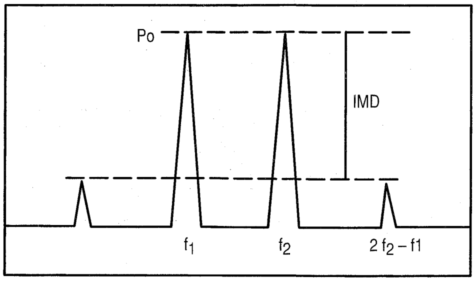


Figure 9. External Connections



ITO = Po + IMD / 2 @ IMD > 60 dB
PEP = 4 x Po @ IMD = – 32 dB

Figure 10. Intermodulation Test

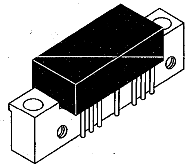
The RF Line
Wideband Linear Amplifier

CA2818C

Designed for amplifier applications in 50 to 100 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C:
  Frequency Range — 0.35 to 400 MHz
  Output Power — 1000 mW Typ @ 1 dB Compression, f = 200 MHz
  Power Gain — 18.5 dB Typ @ f = 50 MHz
  PEP — 1000 mW Typ @ −32 dB IMD, f = 200 MHz
  Noise Figure — 5 dB Typ @ f = 200 MHz
  ITO — 47 dBm Typ @ f = 150 MHz
- All Gold Metallization for Improved Reliability
- Unconditional Stability Under All Load Conditions

18.5 dB
0.35–400 MHz
1000 mWATT
WIDEBAND
LINEAR AMPLIFIER



CASE 714F–03, STYLE 1
[CA (POS. SUPPLY)]

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	28	Vdc
RF Power Input	P_{in}	+14	dBm
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	0.35	—	400	MHz
Gain Flatness (f = 0.35–400 MHz)	F_L	—	±0.5	±1	dB
Power Gain (f = 50 MHz)	P_G	17.75	18.5	19.25	dB
Noise Figure, Broadband (f = 200 MHz)	NF	—	5	6	dB
Power Output — 1 dB Compression (f = 200 MHz)	$P_{o\ 1dB}$	800	1000	—	mW
Third Order Intercept (See Figure 10, f_1 = 200 MHz)	ITO	43	45	—	dBm
Input/Output VSWR (f = 0.35–400 MHz)	VSWR	—	1.7:1	2:1	—
Second Harmonic Distortion (P_o = 100 mW) f_{2H} = 0.35–200 MHz f_{2H} = 200–400 MHz	d_{so}	— —	−65 —	−60 −50	dB
Peak Envelope Power (Two Tone Distortion Test — See Figure 10) f = 0.35–200 MHz @ −32 dB IMD f = 200–400 MHz @ −32 dB IMD	PEP	600	800	—	mW
Supply Current	I_{CC}	190	205	220	mA

REV 1

TYPICAL CHARACTERISTICS

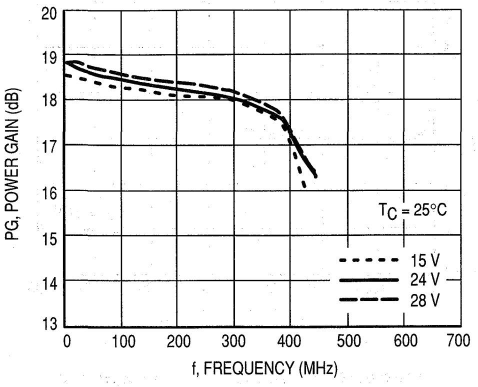


Figure 1. Power Gain versus Voltage

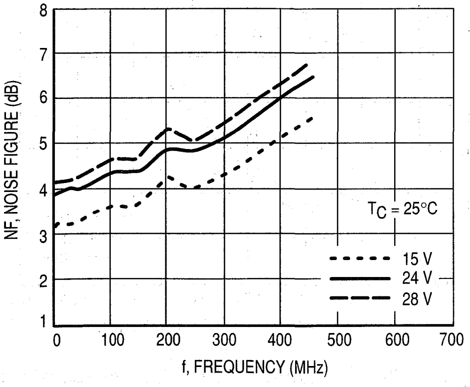


Figure 4. Noise Figure versus Voltage

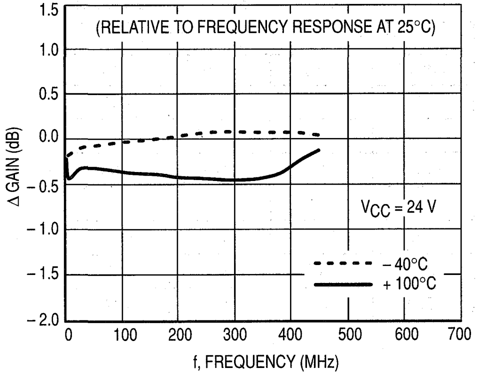


Figure 2. Relative Power Gain versus Temperature

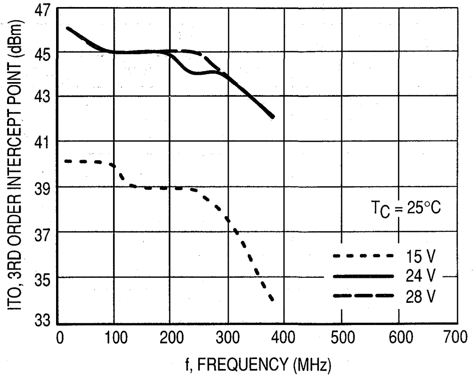


Figure 5. Third Order Intercept versus Voltage

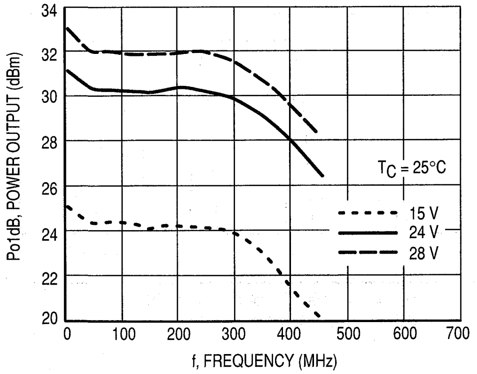


Figure 3. 1 dB Compression versus Voltage

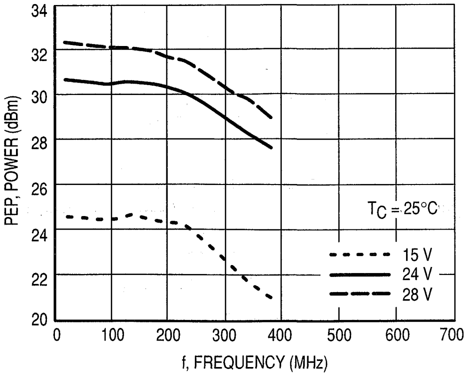


Figure 6. Peak Envelope Power versus Voltage

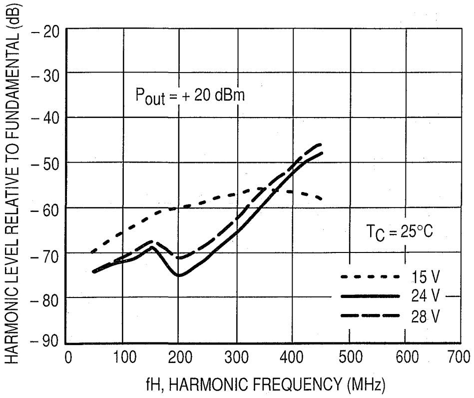


Figure 7. Second Harmonic Distortion versus Voltage

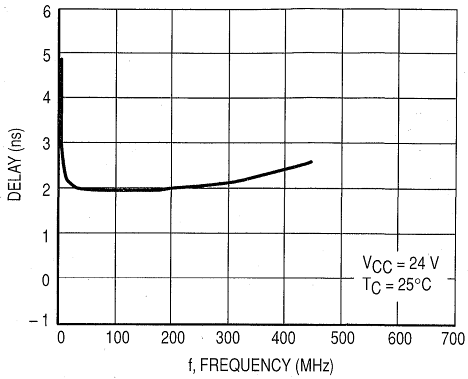


Figure 8. Group Delay versus Frequency

Biased at 24 Volts **T = 25°C Zo = 50Ω**

Frequency (MHz)	S11		S21		S12		S22	
	Mag	**Ang**	**Mag**	**Ang**	**Mag**	**Ang**	**Mag**	**Ang**
0.35	–17.0	18.7	18.4	7.4	–24.1	–169	–16.4	11.1
1	–17.3	10.7	18.6	3.4	–24.0	–175	–16.7	6.5
50	–16.3	–7.6	18.7	–38.8	–23.9	145	–17.0	–38.8
100	–15.6	–15.1	18.5	–70.1	–24.1	117	–18.4	–65.9
200	–14.0	–47.3	18.3	–149	–24.8	47.9	–20.6	–101
300	–14.1	–85	18.1	135	–25.3	–15	–16.6	–142
400	–18.0	–137	17.4	58	–25.9	–84.3	–14.2	134

Magnitude in dB, Phase Angle in degrees.

Table 1. S–Parameters

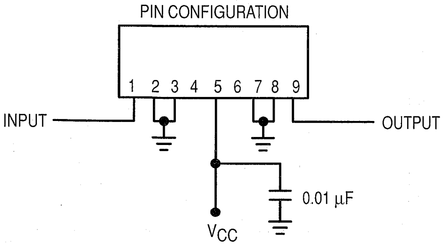
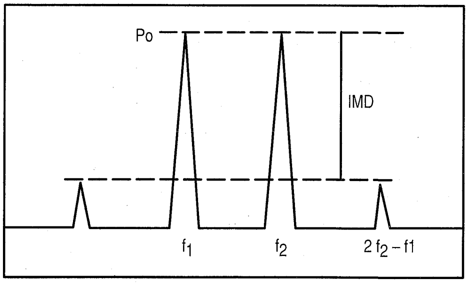


Figure 9. Functional Schematic



ITO = Po + IMD / 2 @ IMD > 60 dB
PEP = 4 x Po @ IMD = – 32 dB

Figure 10. Intermodulation Test

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

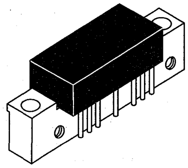
The RF Line
Wideband Linear Amplifiers

CA2830C
CA2833C

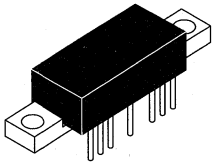
. . . designed for amplifier applications in 50 to 100 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C:
  Frequency Range — 5 to 200 MHz
  Output Power — 800 mW Typ @ 1 dB Compression, f = 200 MHz
  Power Gain — 34.5 dB Typ @ f = 100 MHz
  PEP — 800 mW Typ @ −32 dB IMD
  Noise Figure — 4.7 dB Typ @ f = 200 MHz
  ITO — 46 dBm @ f = 200 MHz
- All Gold Metallization for Improved Reliability
- Unconditional Stability Under All Load Conditions

34.5 dB
5–200 MHz
800 mWATT
WIDEBAND
LINEAR AMPLIFIERS



CASE 714F–03, STYLE 1
(CA)
CA2830C



CASE 714G–03, STYLE 1
[CA, LOW PROFILE]
CA2833C

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	28	Vdc
RF Power Input	P_{in}	+5	dBm
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	5	—	200	MHz
Gain Flatness (f = 5–200 MHz)	—	—	±0.5	±1	dB
Power Gain (f = 100 MHz)	P_G	33.5	34.5	35.5	dB
Noise Figure, Broadband (f = 200 MHz)	NF	—	4.7	5.5	dB
Power Output — 1 dB Compression (f = 5–200 MHz)	$P_{o\ 1dB}$	630	800	—	mW
Power Output — 1 dB Compression (f = 5–200 MHz, V_{CC} = 28 V)	$P_{o\ 1dB}$	1000	1260	—	mW
Third Order Intercept (See Figure 10, f_1 = 200 MHz)	ITO	44	46	—	dBm
Input/Output VSWR (f = 5–200 MHz)	VSWR	—	1.5:1	2:1	—
Second Harmonic Distortion (Tone at 100 mW, f_{2H} = 150 MHz)	d_{so}	—	−60	−50	dB
Peak Envelope Power (Two Tone Distortion Test — See Figure 10) (f = 5–200 MHz @ −32 dB IMD)	PEP	600	800	—	mW
Supply Current	I_{CC}	270	300	330	mA

TYPICAL CHARACTERISTICS

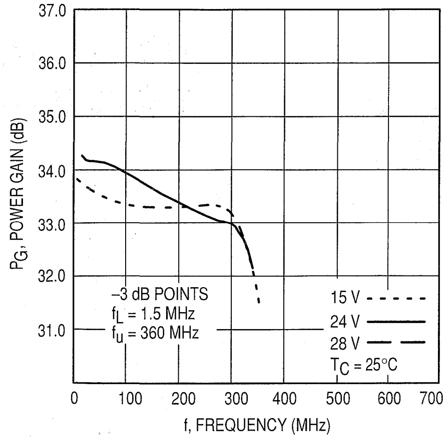


Figure 1. Power Gain versus Frequency

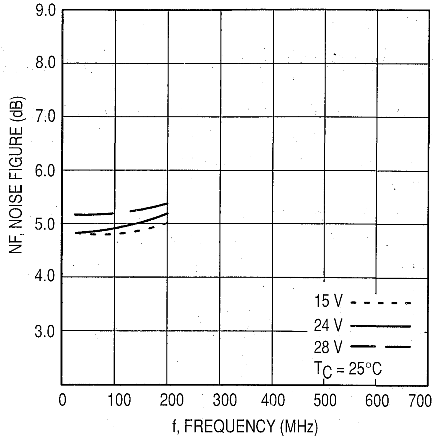


Figure 4. Noise Figure versus Voltage

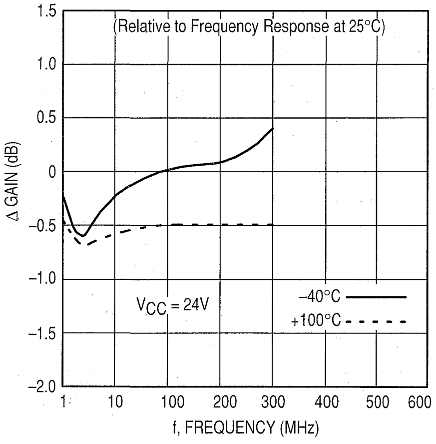


Figure 2. Relative Power Gain versus Temperature

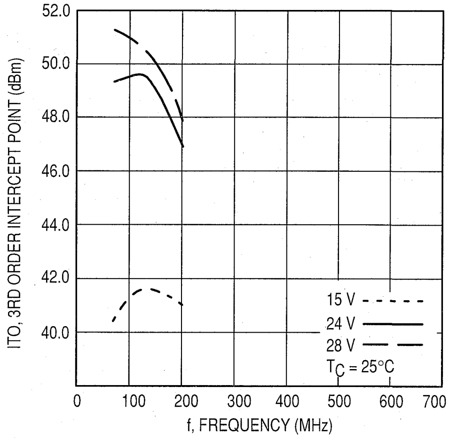


Figure 5. Third Order Intercept versus Voltage

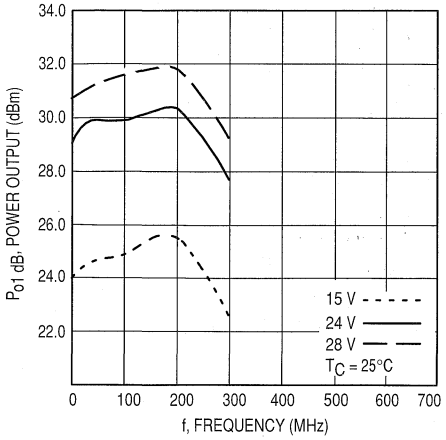


Figure 3. 1 dB Gain Compression versus Voltage

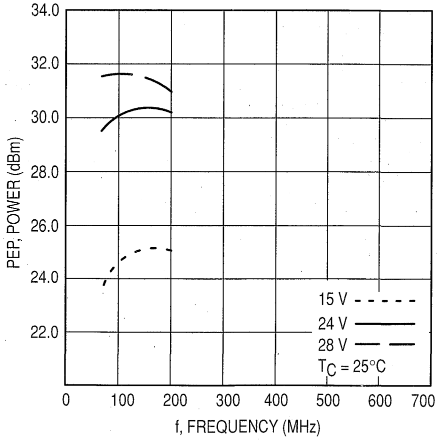


Figure 6. Peak Envelope Power versus Voltage

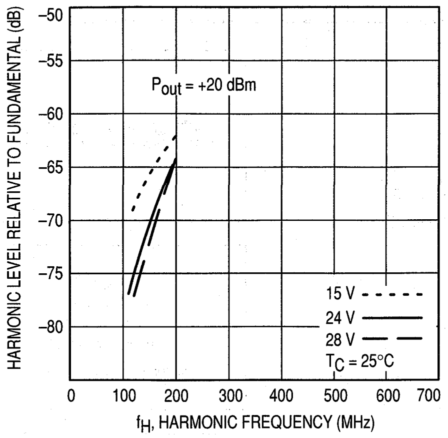


Figure 7. Second Harmonic Distortion versus Voltage

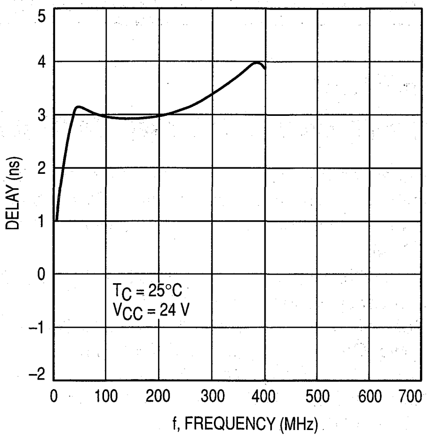


Figure 8. Group Delay versus Frequency

Biased at 24 Volts **T = 25°C Zo = 50Ω**

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
5	–18.3	66.2	34.6	15.2	–47.0	17.7	–9.8	87.4
10	–19.3	45.5	34.6	–0.6	–47.0	2.3	–14.5	76.8
50	–15.6	35.0	34.2	–56.7	–47.5	–30.3	–12.6	45.0
100	–13.2	34.4	33.9	–114	–47.9	–62.9	–10.8	10.7
200	–11.1	30.1	33.5	134	–48.3	–128	–14.9	–42.6

Magnitude in dB, Phase Angle in degrees.

Table 1. S–Parameters

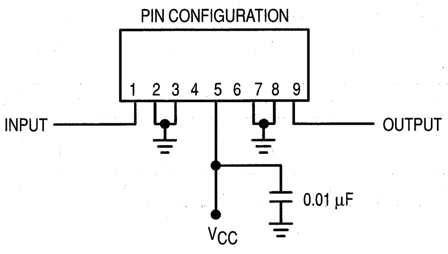
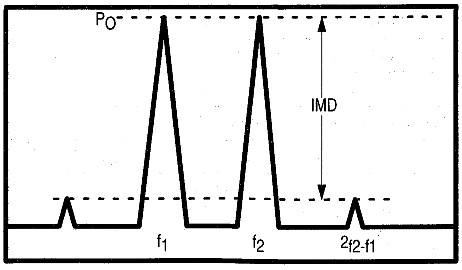


Figure 9. External Connections



$$ITO = P_O + \frac{IMD}{2} \text{ @ } IMD > 60dB$$

PEP = 4X P_O @ IMD = –32dB

Figure 10. Intermodulation Test

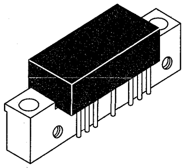
The RF Line
Wideband Linear Amplifier

CA2832C

35.5 dB
1–200 MHz
1.6 WATT
WIDEBAND
LINEAR AMPLIFIER

. . . designed for amplifier applications in 50 to 100 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 28 V, T_C = 25°C:
  Frequency Range — 1 to 200 MHz
  Output Power — 1580 mW Typ @ 1 dB Compression, f = 200 MHz
  Power Gain — 35.5 dB Typ @ f = 100 MHz
  PEP — 900 mW Typ @ –32 dB IMD
  Noise Figure — 5 dB Typ @ f = 200 MHz
  ITO — 47 dBm @ f = 200 MHz
- All Gold Metallization for Improved Reliability
- Unconditional Stability Under All Load Conditions



CASE 714F–03, STYLE 1
[CA (POS. SUPPLY)]

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	30	Vdc
RF Power Input	P_{in}	+5	dBm
Operating Case Temperature Range	T_C	–20 to +90	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 28 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	1	—	200	MHz
Gain Flatness (f = 1–200 MHz)	—	—	±0.5	±1	dB
Power Gain (f = 100 MHz)	P_G	34	35.5	37	dB
Noise Figure, Broadband (f = 200 MHz)	NF	—	5	6	dB
Power Output — 1 dB Compression (f = 1–200 MHz)	$P_{o\ 1dB}$	1260	1580	—	mW
Power Output — 1 dB Compression (f = 150 MHz)	$P_{o\ 1dB}$	—	2000	—	mW
Third Order Intercept (See Figure 10, f_1 = 200 MHz)	ITO	45	47	—	dBm
Input/Output VSWR (f = 1–200 MHz)	VSWR	—	1.5:1	2:1	—
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 150 MHz)	d_{so}	—	–70	–60	dB
Peak Envelope Power (Two Tone Distortion Test — See Figure 10) (f = 1–200 MHz @ –32 dB IMD)	PEP	—	900	—	mW
Supply Current	I_{CC}	400	435	470	mA

TYPICAL CHARACTERISTICS

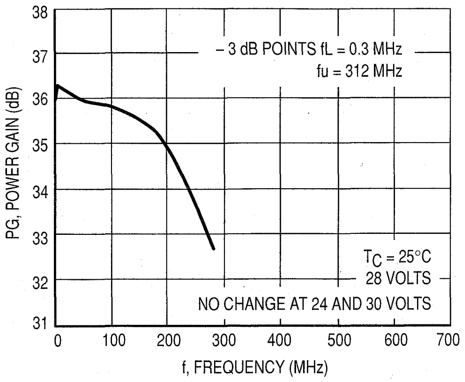


Figure 1. Power Gain versus Voltage

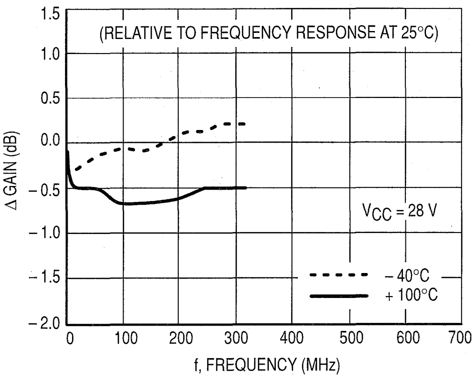


Figure 2. Relative Power Gain versus Temperature

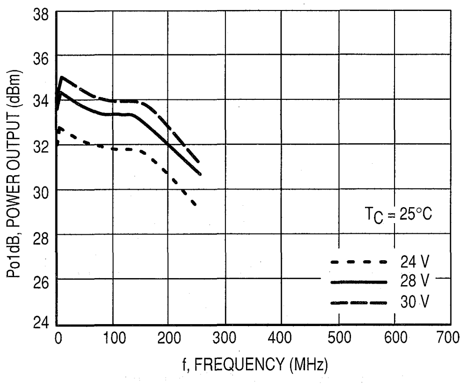


Figure 3. 1 dB Compression versus Voltage

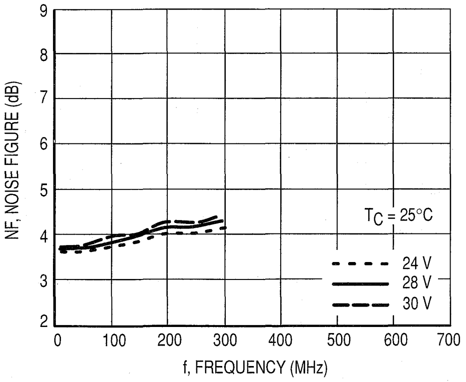


Figure 4. Noise Figure versus Voltage

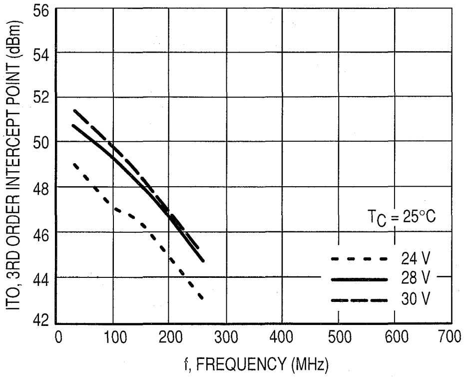


Figure 5. Third Order Intercept versus Voltage

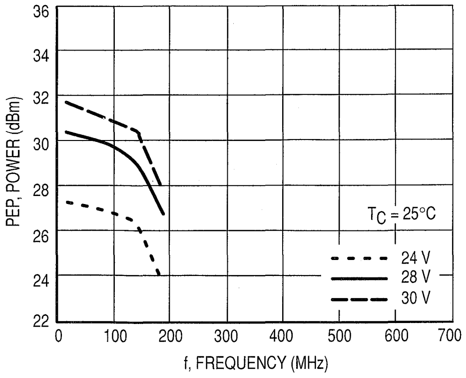


Figure 6. Peak Envelope Power versus Voltage

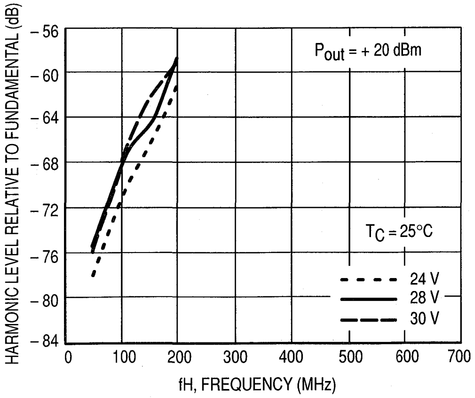


Figure 7. Second Harmonic Distortion versus Voltage

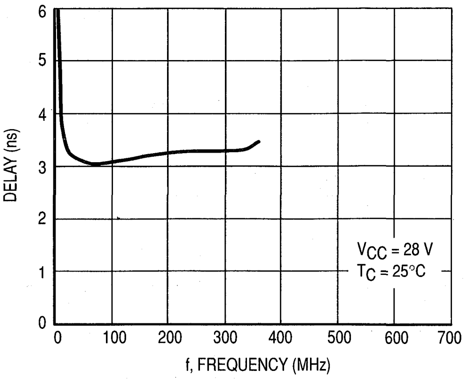


Figure 8. Group Delay versus Frequency

Biased at 28 Volts **T_C = 25°C Zo = 50Ω**

Frequency (MHz)	S11		S21		S12		S22	
	Mag	**Ang**	**Mag**	**Ang**	**Mag**	**Ang**	**Mag**	**Ang**
1	−16.7	64	36.0	23.3	−42	−5.2	−12.9	73
10	−21.5	21	36.2	−8.4	−47	−1.4	−21.9	28
50	−18.5	6.8	35.9	−56	−44	2.8	−17.9	−10
100	−16.9	−1.8	35.7	−103	−46	−68	−15.7	−48
200	−12.9	−18	34.7	145	−49	−98	−14.9	115

Magnitude in dB, Phase Angle in degrees.

Table 1. S–Parameters

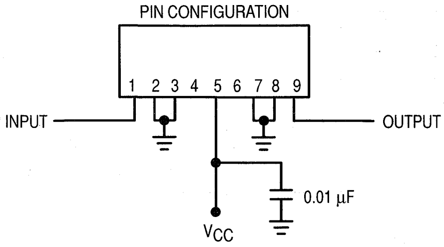
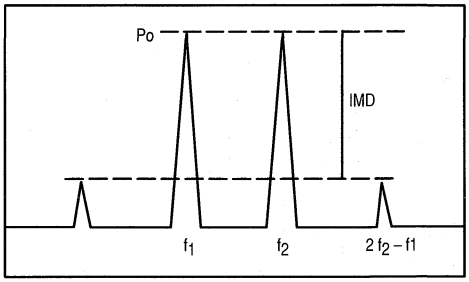


Figure 9. External Connections



ITO = Po + IMD / 2 @ IMD > 60 dB
PEP = 4 x Po @ IMD = – 32 dB

Figure 10. Intermodulation Test

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

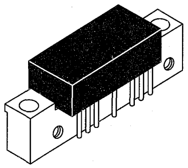
The RF Line
Wideband Linear Amplifier

CA2842C

. . . designed for amplifier applications in 50 to 100 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C:
  Frequency Range — 10–400 MHz
  Output Power — 1580 mW Typ @ 1 dB Compression, f = 200 MHz, V_{CC} = 28 V
  Power Gain — 22 dB Typ @ f = 100 MHz
  PEP — 650 mW Min @ –32 dB IMD
  Noise Figure — 4 dB Typ @ f = 100 MHz
  ITO — 46 dBm @ f = 300 MHz
- All Gold Metallization for Improved Reliability
- Unconditional Stability Under All Load Conditions

22 dB
10–400 MHz
1.2 WATTS
WIDEBAND
LINEAR AMPLIFIER



CASE 714F–03, STYLE 1
[CA (POS. SUPPLY)]

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	28	Vdc
RF Power Input	P_{in}	+14	dBm
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	10	—	400	MHz
Gain Flatness (f = 10–400 MHz)	—	—	±0.5	±1	dB
Power Gain (f = 100 MHz)	P_G	21	22	23	dB
Noise Figure, Broadband (f = 100 MHz)	NF	—	4	5	dB
Power Output — 1 dB Compression (f = 10–200 MHz, V_{CC} = 28 V)	$P_{o1\ dB}$	1260	1580	—	mW
Power Output — 1 dB Compression (f = 200–400 MHz, V_{CC} = 28 V)	$P_{o1\ dB}$	630	—	—	mW
Third Order Intercept (See Figure 10, f_1 = 10–400 MHz, See Fig. 10)	ITO	42	44	—	dBm
Input/Output VSWR (f = 10–400 MHz)	VSWR	—	1.3:1	1.5:1	—
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 300 MHz)	d_{so}	—	—	–50	dB
Peak Envelope Power (Two Tone Distortion Test — See Figure 10) (f = 200 MHz @ –32 dB IMD)	PEP	650	1000	—	mW
Supply Current	I_{CC}	200	230	250	mA

TYPICAL CHARACTERISTICS

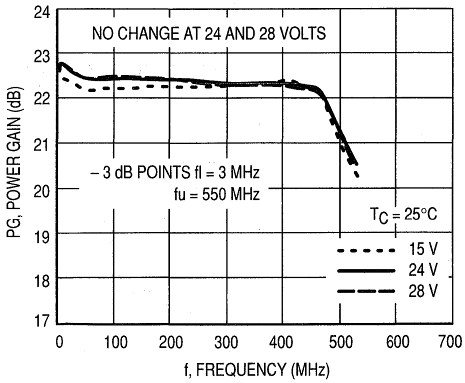


Figure 1. Power Gain versus Voltage

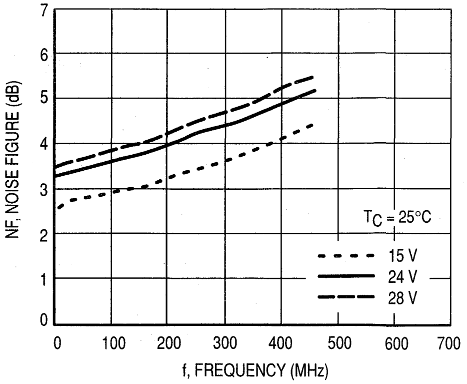


Figure 4. Noise Figure versus Voltage

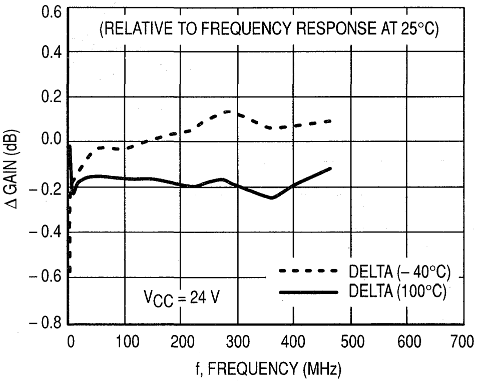


Figure 2. Relative Power Gain versus Temperature

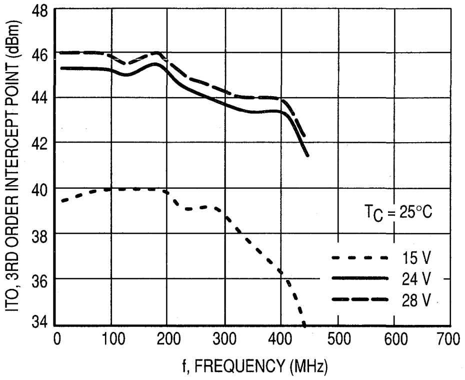


Figure 5. Third Order Intercept versus Voltage

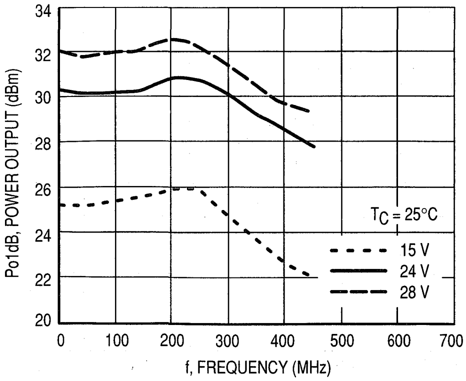


Figure 3. 1 dB Compression versus Voltage

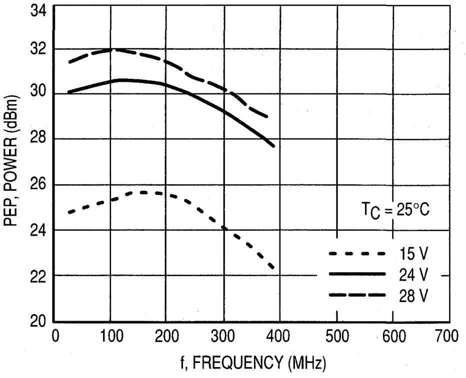


Figure 6. Peak Envelope Power versus Voltage

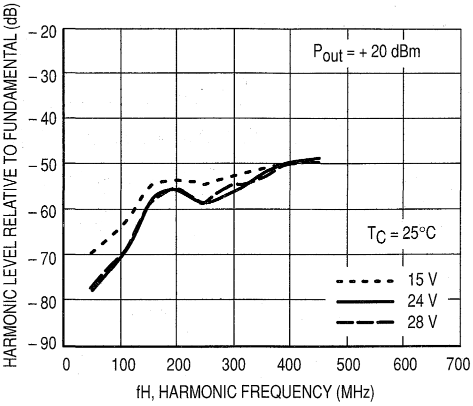


Figure 7. Second Harmonic Distortion versus Voltage

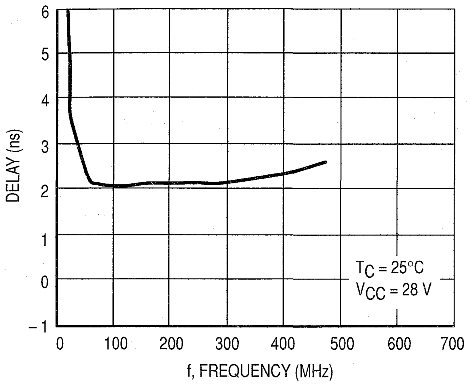


Figure 8. Group Delay versus Frequency

Biased at 24 Volts **T_C = 25°C Zo = 50Ω**

Frequency (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
10	–15.8	62	22.8	–168	–27	15	–20.2	29
50	–26.5	20	22.5	146	–27	–25	–24	15
100	–25.5	25	22.5	111	–27.5	–56	–22.5	–16
200	–20.5	–7	22.5	26	–27.9	–117	–18.1	–73
300	–17.2	–48	22.5	–51	–28.5	–170	–16.5	–125
400	–18.8	–129	22.4	–126	–28.3	114	–22.5	156

Magnitude in dB, Phase Angle in degrees.

Table 1. S–Parameters

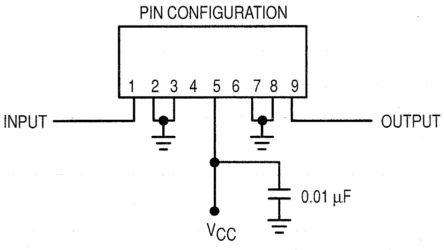
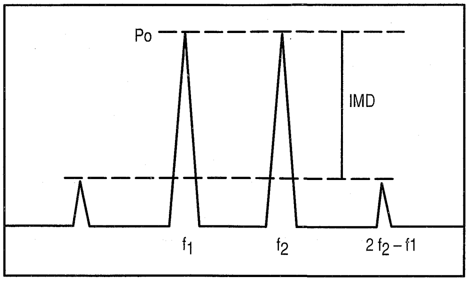


Figure 9. External Connections



ITO = Po + IMD / 2 @ IMD > 60 dB
PEP = 4 x Po @ IMD = – 32 dB

Figure 10. Intermodulation Test

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

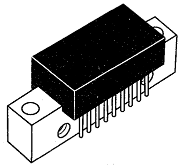
The RF Line
Wideband Linear Amplifiers

CA4800C,CS
CA4812C,CS
CA4815C,CS

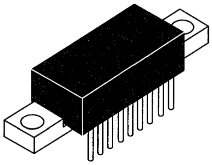
. . . designed for amplifier applications in 50 ohm systems requiring wide bandwidth, low noise and low–distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 24 V for CA4800C; 12 V for CA4812C; 15 V for CA4815C, T_C = 25°C:
  Frequency Range — 10 to 1000 MHz
  Output Power — 400 mW Typ @ 1 dB Compression, f = 900 MHz
  Power Gain — 17.5 dB Typ @ 1000 MHz
  Noise Figure — 6.5 dB Typ @ f = 500 MHz
  ITO — 38 dBm Typ @ 1000 MHz
- All Gold Metallization for Improved Reliability
- CA4812C is Optimized for 12 V Operation
- CA4815C is Optimized for 15 V Operation

17 dB
10–1000 MHz
400 mW
WIDEBAND
LINEAR AMPLIFIERS



CASE 714P–03, STYLES 2, 3
CA4800C, CA4812C, CA4815C



CASE 714T–03, STYLES 1, 2
CA4800CS, CA4812CS, CA4815CS

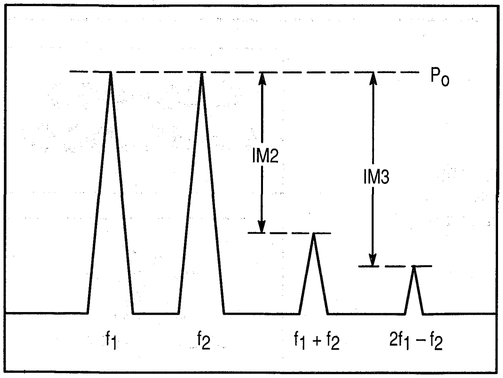
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
Supply Voltage	CA4800C,CS CA4815C,CS CA4812C,CS	V_{CC}	28 18 14	V
RF Input Power		P_{in}	+14	dBm
Storage Temperature		T_{stg}	–40 to +100	°C
Operating Case Temperature Range		T_C	–20 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 24 V for CA4800C; 12 V for CA4812C; 15 V for CA4815C, 50 Ohm System)

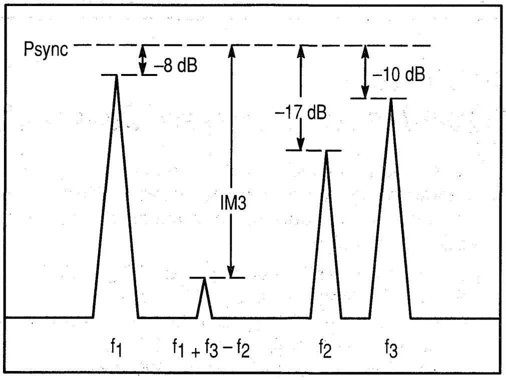
Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current CA4800C,CS CA4812C,CS; CA4815C,CS	I_{DC}	— —	220 380	240 400	mA
Power Gain (f = 1000 MHz)	PG	16.5	17.5	18.5	dB
Bandwidth (3 dB Down at 10 MHz)	BW	10	—	1000	MHz
Gain Flatness (f = 40–1000 MHz)	FL	—	1	2	dB
Power Output — 1 dB Compression (f = 900 MHz)	$P_{o\ 1dB}$	300	400	—	mW
Input/Output VSWR f = 40–900 MHz f = 900–1000 MHz	VSWR	— —	— —	2:1 2.6:1	—
Noise Figure, Broadband f = 500 MHz f = 1000 MHz	NF	— —	6.5 7.5	8 9	dB
Third Order Intercept (f_1 = 10–1000 MHz, See Figure 1)	ITO	37	38	—	dBm
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 1000 MHz)	dso	—	–50	–40	dB
Second Order Intermodulation Distortion (P_o = 2.75 dBm, f_1 = 373 MHz, f_2 = 450 MHz, See Figure 1)	IM2	—	—	–60	dB
Intermodulation Distortion, 3 Tone (f = 860 MHz, P_{sync} = 200 mW, See Figure 2)	IM3	—	–60	—	dB

REV 1



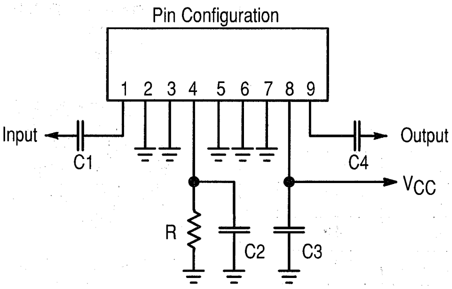
ITO = P_0 + IM3 / 2 @ IM3 > 60 dB

Figure 1. 2–Tone Intermodulation Test A



f_1 = Video
f_2 = Sideband
f_3 = Sound

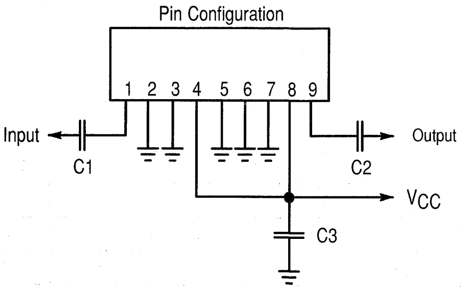
Figure 2. 3–Tone TV Intermodulation Test



C1,2,3,4 ≥ 0.01 µF (chip)
R = 200 Ohms, 1 Watt

CA4800C (Case 714P–03, Style 2)
CA4800CS (Case 714T–03, Style 1)

Figure 3. External Connections



C1,2,3 ≥ 0.01 µF (chip)

CA4812C, CA4815C (Case 714P–03, Style 3)
CA4812CS, CA4815CS (Case 714T–03, Style 2)

Figure 4. External Connections

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

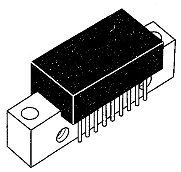
The RF Line
Wideband Linear Amplifiers

. . . designed for amplifier applications in 50 to 100 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

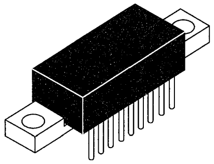
- Specified Characteristics at V_{CC} = 28 V, T_C = 25°C:
  Frequency Range — 10 to 1000 MHz
  Output Power — 1 W Typ @ 1 dB Compression, f = 900 MHz
  Power Gain — 15.5 Typ @ f = 1000 MHz
  Noise Figure — 7.5 dB Typ @ f = 500 MHz
  ITO — 40.5 dBm @ f = 1000 MHz
- All Gold Metallization for Improved Reliability
- Optimized for 28 V Operation

CA5800C
CA5800CS

15 dB
10–1000 MHz
1 WATT
WIDEBAND
LINEAR AMPLIFIERS



CASE 714P–03, STYLE 2
(CA)
CA5800C



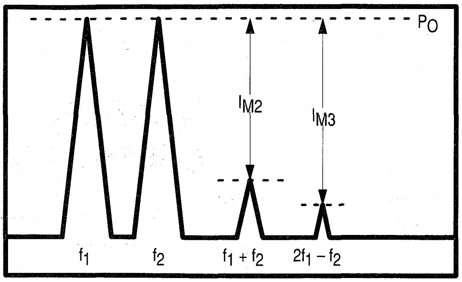
CASE 714T–03, STYLE 1
CA5800CS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	32	Vdc
RF Power Input	P_{in}	+18	dBm
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

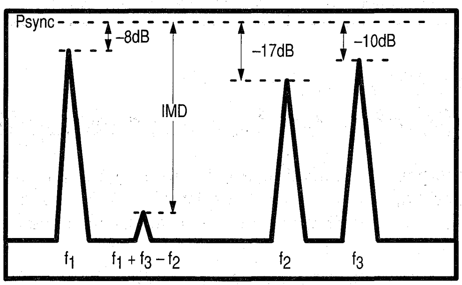
ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 28 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range (3 dB Down at 10 MHz)	BW	10	—	1000	MHz
Gain Flatness (f = 40–1000 MHz)	—	—	1	2	dB
Power Gain (f = 1000 MHz)	P_G	14.5	15.5	—	dB
Noise Figure, Broadband f = 500 MHz f = 1000 MHz	NF	— —	7.5 8.5	8.5 9.5	dB
Power Output — 1 dB Compression (f = 900 MHz)	$P_{o\ 1dB}$	800	1000	—	mW
Third Order Intercept (See Figure 1, f_1 = 10–1000 MHz)	ITO	—	40.5	—	dBm
Input/Output VSWR f = 40–900 MHz f = 900–1000 MHz	VSWR	— —	— —	2:1 2.6:1	—
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 1000 MHz)	d_{so}	—	−55	−45	dB
Supply Current	I_{CC}	360	400	440	mA
Intermodulation Distortion, 3 Tone (Vision Carrier = −8 dB, Sound Carrier = −10 dB, Sideband Signal = −17 dB. See Figure 2. f = 860 MHz, P_{sync} = 200 mW)	IMD	—	−58	—	dB
Second Order IMD (P_t = 2.75 dBm, f_1 = 373 MHz, f_2 = 450 MHz, See Figure 1)	IM2		−65	−60	dB



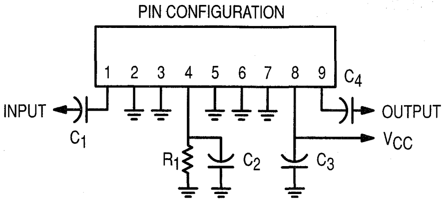
$\mathrm{ITO} = P_O + \frac{\mathrm{IM3}}{2}$ @ $\mathrm{IM3} > 60$ dB

Figure 1. 2–Tone Intermodulation, Test B



f1: video
f2: sideband
f3: sound

Figure 2. 3–Tone TV Intermodulation Test



$C_{1, 2, 3, 4} \geq 0.01\ \mu$F (Chip)
R1 = 90 OHMS, 3 WATTS

CA5800C (Case 714P–03, Style 2)
CA5800CS (Case 714T–03, Style 1)

Figure 3. External Connections

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

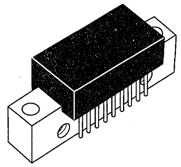
The RF Line
Wideband Linear Amplifiers

CA5801
CA5801S

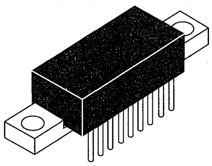
Designed for amplifier applications in 50 ohm systems requiring wide bandwidth, low noise and low–distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 28 V, T_C = 25°C
  Frequency Range — 50 to 1000 MHz
  Output Power — 1 W Typ @ 1 dB Compression, f = 900 MHz
  Power Gain — 17.5 dB Typ @ f = 1000 MHz
  Noise Figure — 7.5 dB Typ @ f = 500 MHz
  ITO — 41.5 dBm Typ @ 1000 MHz
- All Gold Metalization for Improved Reliability
- Optimized for 28 V Operation

1 W, 17 dB
50–1000 MHz
WIDEBAND
LINEAR AMPLIFIERS



CASE 714P–03, STYLE 2
CA5801



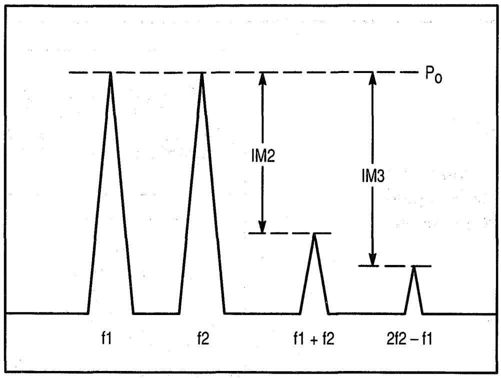
CASE 714T–03, STYLE 1
CA5801S

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	32	V
RF Input Power	P_{in}	+20	dBm
Storage Temperature	T_{stg}	– 40 to +100	°C
Operating Case Temperature Range	T_C	– 20 to +100	°C

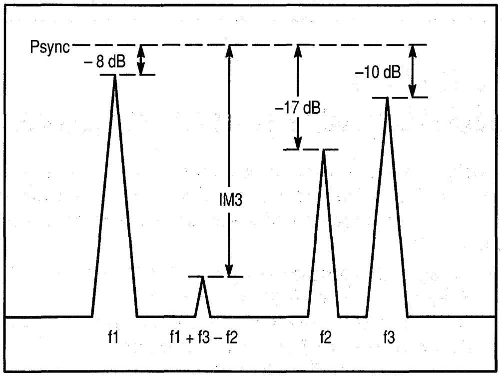
ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 28 V, 50 Ohm System)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current	Idc	—	400	440	mA
Power Gain f = 1000 MHz	PG	16.5	17.5	—	dB
Bandwidth	BW	50	—	1000	MHz
Gain Flatness (f = 50–1000 MHz)	FL	—	1	2	dB
Power Output – 1 dB Compression (f = 900 MHz)	P_o 1 dB	800	1000	—	mW
Input/Output VSWR (f = 50–900 MHz) (f = 900–1000 MHz)	VSWR	— —	— —	2:1 2.6:1	—
Noise Figure, Broadband f = 500 MHz f = 1000 MHz	NF	— —	7.5 8.5	8.5 9.5	dB
Third Order Intercept (f1 = 10–1000 MHz, See Figure 1)	ITO	—	41.5	—	dBm
Second Harmonic Distortion (P_o = 100 mW, f2H = 1000 MHz)	dso	—	– 55	– 45	dB
Second Order Intermodulation Distortion (P_o = 2.75 dBm, f1 = 373 MHz, f2 = 450 MHz, See Figure 1)	IM2	—	– 65	– 60	dB
Intermodulation Distortion, 3 Tone (f = 860 MHz, Psync = 200 mW, See Figure 2)	IM3	—	– 60	—	dB



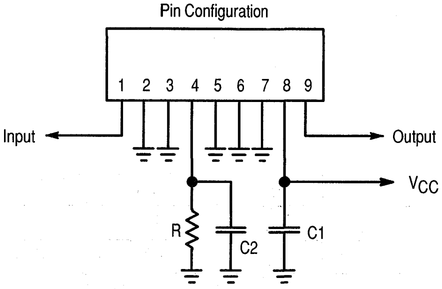
ITO = P_0 + IM3/2 @ IM3 > 60 DB

Figure 1. 2–Tone Intermodulation Test



f1 = Video
f2 = Sideband
f3 = Sound

Figure 2. 3–Tone TV Intermodulation Test



C1, C2 ≥ 0.01 µF (chip)
R = 90 Ohms, 3 Watts

Figure 3. External Connections

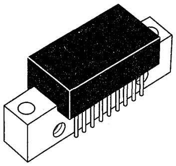
The RF Line
Wideband Linear Amplifiers

CA5815C
CA5815CS

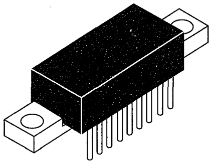
15 dB
10–1000 MHz
1 WATT
WIDEBAND
LINEAR AMPLIFIERS

. . . designed for amplifier applications in 50 to 100 ohm systems requiring wide bandwidth, low noise and low distortion. This hybrid provides excellent gain stability with temperature and linear amplification as a result of the push–pull circuit design.

- Specified Characteristics at V_{CC} = 15 V, T_C = 25°C:
  Frequency Range — 10 to 1000 MHz
  Output Power — 1 W Typ @ 1 dB Compression, f = 900 MHz
  Power Gain — 15.5 Typ @ f = 1000 MHz
  PEP — 1 W Typ @ – 32 dB IMD
  Noise Figure — 7.5 dB Typ @ f = 500 MHz
  ITO — 40.5 dBm @ f = 1000 MHz
- All Gold Metallization for Improved Reliability
- Optimized for 15 Volt Operation



CASE 714P–03, STYLE 3
(CA)
CA5815C



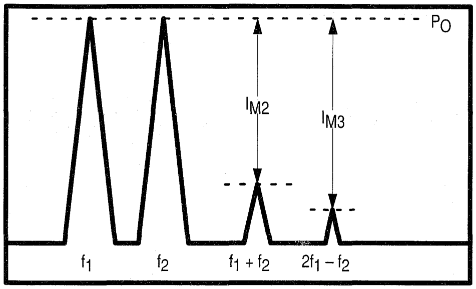
CASE 714T–03, STYLE 2
(SIP)
CA5815CS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	18	Vdc
RF Power Input	P_{in}	+18	dBm
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

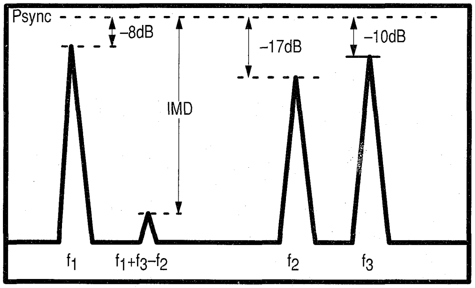
ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 15 V, 50 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range (3 dB Down at 10 MHz)	BW	10	—	1000	MHz
Gain Flatness (f = 40–1000 MHz)	—	—	1	2	dB
Power Gain (f = 1000 MHz)	P_G	14.5	15.5	—	dB
Noise Figure, Broadband f = 500 MHz f = 1000 MHz	NF	— —	7.5 8.5	8.5 9.5	dB
Power Output — 1 dB Compression (f = 900 MHz)	$P_{o\ 1dB}$	800	1000	—	mW
Third Order Intercept (See Figure 1, f = 10–1000 MHz)	ITO	—	40.5	—	dBm
Input/Output VSWR f = 40–900 MHz f = 900–1000 MHz	VSWR	— —	— —	2:1 2.6:1	—
Second Harmonic Distrotion (P_o = 100 mW, f_{2H} = 1000 MHz)	d_{so}	—	–55	–45	dB
Supply Current	I_{CC}	—	700	760	mA
Intermodulation Distortion, 3 Tone (Vision Carrier = –8 dB, Sound Carrier = –10 dB, Sideband Signal = –17 dB. See Figure 2. f = 860 MHz, P_{sync} = 200 mW)	IMD	—	–58	—	dB
Second Order IMD (P_o = 2.75 dBm, f_1 = 373 MHz, f_2 = 450 MHz, See Figure 1.)	IM2	—	–65	–60	dB



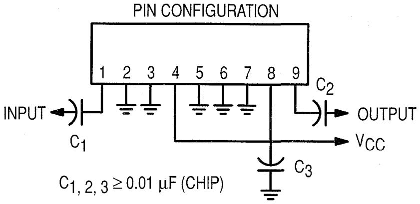
$ITO = P_O + \frac{IM_3}{2}$ @ $IM_3 < 60$ dB

Figure 1. 2–Tone Intermodulation, Test B



f1: video
f2: sideband
f3: sound

Figure 2. 3–Tone TV Intermodulation Test



CA5815C (Case 714P–03, Style 3)
CA5815CS (Case 714T–03, Style 2)

Figure 3. External Connections

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line

36-Channel (450 MHz) CATV Hi-Slope Input/Output Trunk Amplifier

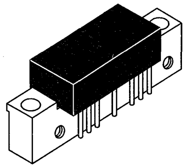
CA97901

15–20 dB
40–450 MHz
36–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER

. . . allows increased trunk length. Effectively reduces trunk distortion. 5.0 dB less output noise at low end.

Designed for broadband applications requiring low–distortion amplification. Specifically intended for CATV market requirements. These amplifiers feature ion–implanted arsenic emitter transistors and an all gold metallization system. The input amplifier is tuned for minimum noise figure while the output amplifier is tuned for minimum distortion.

- Specified Characteristics at V_{CC} = 24 V, T_C = 25°C:
  Frequency Range — 40 to 450 MHz
  Power Gain — 15.6 dB Typ @ f = 50 MHz
  — 20.7 dB Typ @ f = 450 MHz
  Noise Figure — 5.7 dB Typ @ f = 450 MHz
  CTB — –66 dB @ V_{out} = 46 dBmV
- All Gold Metallization System for Improved Reliability



CASE 714F–03, STYLE 1
[CA (POS. SUPPLY)]

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	69	dBmV
DC Supply Voltage	V_{CC}	28	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–55 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 V, T_C = 25°C, 75 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	450	MHz
Power Gain — 50 MHz — 450 MHz	G_P	14.8 20.2	15.6 20.7	16.4 21.2	dB
Gain Slope	S	4.7	5.1	5.5	dB
Gain Flatness (Note 1)	—	—	—	±0.2	dB
Return Loss — Input/Output (f = 40 MHz) (f = 50–80 MHz) (f = 80–160 MHz) (f = 160–450 MHz)	IRL/ORL	22 20 19 18	26 24 22 20	— — — —	dB
Composite Second Order Distortion (V_{out} = +46 dBmV per ch., Ch. H20, 36–CH Flat) (Note 2)	CSO	—	–68	–65	dB
Cross Modulation Distortion (V_{out} = +46 dBmV per ch., Ch. 2, 36–CH Flat) (Note 2)	XMD	—	–66	–65	dB
Composite Triple Beat (V_{out} = +46 dBmV per ch., Ch. H20, 36–CH Flat) (Note 2)	CTB	—	–66	–65	dB
Noise Figure (f = 50 MHz) (f = 450 MHz)	NF	— —	4.6 5.5	6.0 6.8	dB
DC Current	I_{DC}	—	220	240	mA

NOTE 1 and NOTE 2 — See Next Page.

NOTES:

2. Flatness calculated is based upon the following gain curve:

$G_f = G_{50} + \Delta G\,[\propto\ (f–50) + \beta\ (f–50)^2 + \gamma\ (f–50)^3]$

where: G_{50} = Gain at 50 MHz
G_f = Gain at frequency f MHz
ΔG = Gain slope between 50 MHz and 450 MHz
$\alpha = 3.132^* \ 10^{-3}$
$\beta = 1.993^* \ 10^{-6}$
$\gamma = -8.934^* \ 10^{-9}$

3. The following Channels are turned on for the CTB, XMOD and CSO measurement:

Channel #	Frequency (MHz)	Channel #	Frequency (MHz)	Channel #	Frequency (MHz)
1	55.25	13	235.25	25	325.25
2	61.25	14	247.25	26	337.25
3	133.25	15	253.25	27	349.25
4	139.25	16	259.25	28	361.25
5	145.25	17	265.25	29	367.25
6	151.25	18	271.25	30	373.25
7	163.25	19	283.25	31	385.25
8	175.25	20	289.25	32	391.25
9	187.25	21	295.25	33	409.25
10	205.25	22	301.25	34	415.25
11	217.25	23	313.25	35	421.25
12	229.25	24	319.25	36	433.25

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

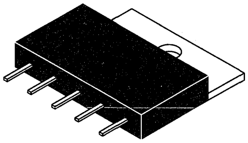
The RF Line
Video Driver Hybrid Amplifier

CR2428

The CR2428 is designed specifically for use as the video channel final stage in high resolution monitors.

- Typical 10–90% Transitions Times are 2.5 ns
- 130 MHz Minimum Bandwidth at 40 Vp–p Output
- 290 MHz Minimum Video Clock Frequency
- Up to 50 Vp–p Output Swing with 60 V Supply Voltage
- Low Power Consumption
- Excellent Grey–Scale Linearity
- Unconditional Stability
- Gold Metallization System for the Ultimate in Reliability

2.5 ns
130 MHz
VIDEO DRIVER
HYBRID
AMPLIFIER



CASE 431A–02, STYLE 1
(CR LP)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	70	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$, $V_{CC} = 60$ V, $C_{LOAD} = 8.5$ pF, 40 V peak–to–peak output swing with 30 Vdc offset; $R_1 = 215\ \Omega$, $C_1 = 90$ pF typ)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current (With Input Open Circuited)	I_{CC}	39.5	43.5	47.5	mA
Input DC Voltage (With Input Open Circuited)	V_{inDC}	1.15	1.4	1.65	V
Output DC Voltage (With Input Open Circuited)	V_{outDC}	26	30	34	V
Voltage Gain (1) (2)	A_V	11.2	12.4	13.2	V/V
Transient Response (2)					
— Rise Time (10% to 90%)	t_r	—	2.5	2.9	ns
— Overshoot	$V_{os,r}$	—	8.0	15	%
— Fall Time (90% to 10%)	t_f	—	2.5	2.9	ns
— Overshoot	$V_{os,f}$	—	6.0	10	%
Operating Supply Current (V_{out} = 40 V Peak–to–Peak, 50 MHz Square Wave with 30 V offset) (3)	I_{CC}	—	100	—	mA
Linearity Error (V_{out} = +5.0 V to +55 V)	—	—	—	5.0	%

NOTES:
1. $A_V = V_{out}/V_S$
2. Input Signal is nominally a 62.5 kHz square wave of 3.25 V peak–to–peak with 1.4 Vdc offset. Input t_r, t_f < 1.0 ns.
3. Output is not short circuit protected.

REV 1

TYPICAL CHARACTERISTICS

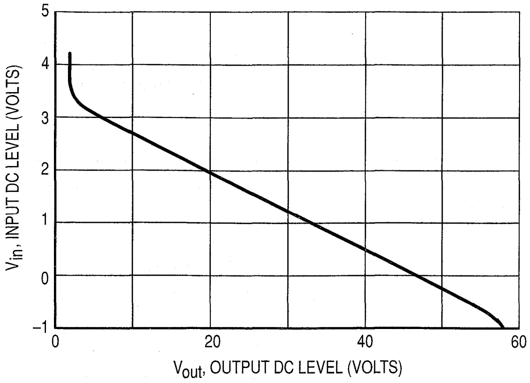


Figure 1. Voltage Ratio at RF Input Port

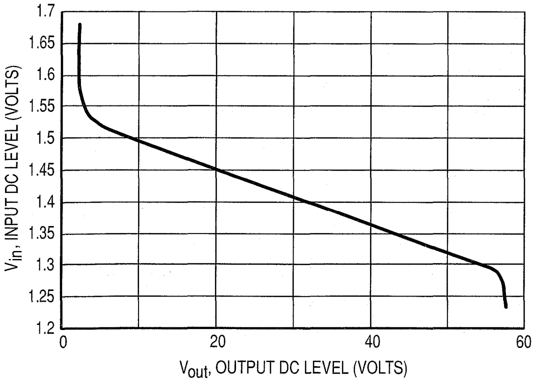


Figure 2. Voltage Ratio at Port 1

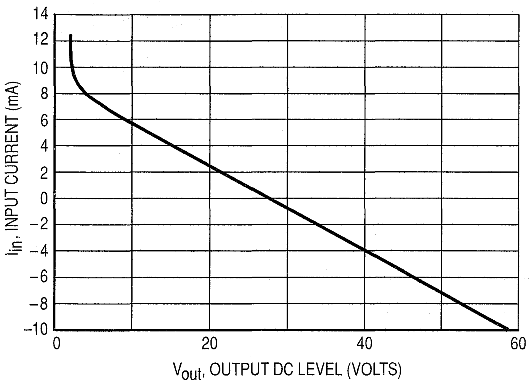


Figure 3. Output Voltage versus Input Current

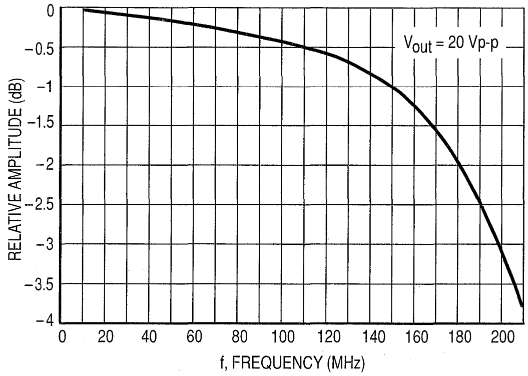


Figure 4. Frequency Response

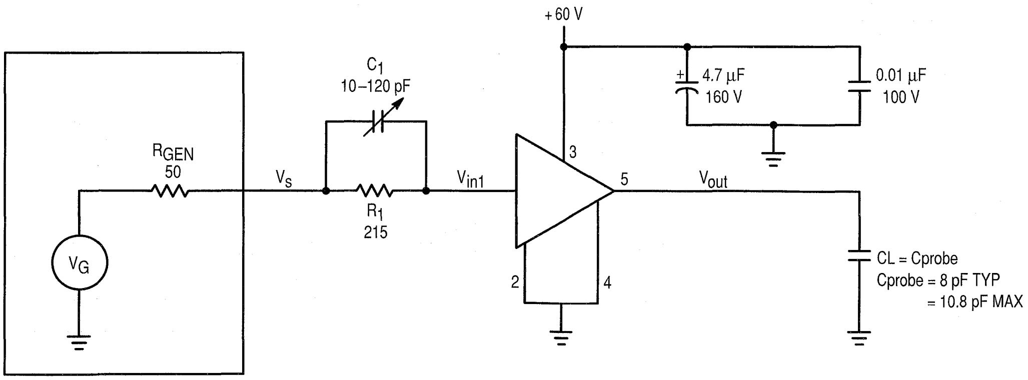


Figure 5. CRT Driver Test Circuit

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

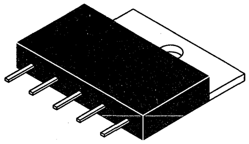
The RF Line
Video Driver Hybrid Amplifier

CR3428

2.7 ns
115 MHz
VIDEO DRIVER
HYBRID
AMPLIFIER

The CR3428 is designed specifically for use as the video channel final stage in high resolution monitors.

- 80 V Supply Operation Provide Large DC Offset Range for Color Applications
- Typical 10–90% Transitions Times are 2.7 ns
- 115 MHz Minimum Bandwidth at 40 Vp–p Output
- 260 MHz Minimum Video Clock Frequency
- Up to 70 Vp–p Output Swing with 80 V Supply Voltage
- Low Power Consumption
- Excellent Grey–Scale Linearity
- Unconditional Stability
- Gold Metallization System for the Ultimate in Reliability



CASE 431A–02, STYLE 1
(CR LP)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	90	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 80 V, C_{LOAD} = 10 pF, 40 V peak–to–peak output swing with 40 Vdc offset; R_1 = 287 Ω, C_1 = 60 pF typ)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current (With Input Open Circuited)	I_{CC}	41	45	49	mA
Input DC Voltage (With Input Open Circuited)	V_{inDC}	1.3	1.55	1.8	V
Output DC Voltage (With Input Open Circuited)	V_{outDC}	36	40	44	V
Voltage Gain (1) (2)	A_V	11.5	12.7	13.5	V/V
Transient Response (2)					
— Rise Time (10% to 90%)	t_r	—	2.7	3.1	ns
— Overshoot	$V_{os,r}$	—	—	10	%
— Fall Time (90% to 10%)	t_f	—	2.7	3.1	ns
— Overshoot	$V_{os,f}$	—	—	10	%
Operating Supply Current (V_{out} = 40 V Peak–to–Peak, 50 MHz Square Wave with 30 V offset) (3)	I_{CC}	—	100	—	mA
Linearity Error (V_{out} = +5.0 V to +55 V)	—	—	—	5.0	%

NOTES:
1. $A_V = V_{out}/V_s$
2. Input Signal is nominally a 62.5 kHz square wave of 3.25 V peak–to–peak with 1.4 Vdc offset. Input t_r, t_f < 1.0 ns.
3. Output is not short circuit protected.

REV 1

TYPICAL CHARACTERISTICS

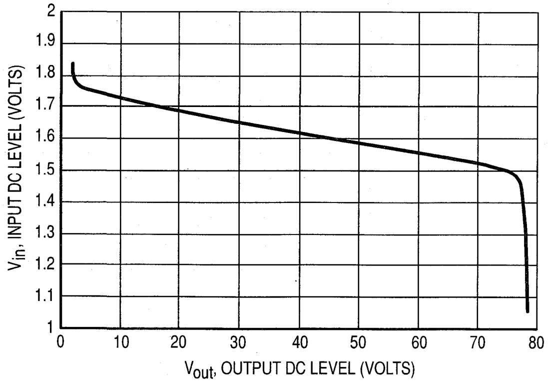


Figure 1. V_{in} versus V_{out}

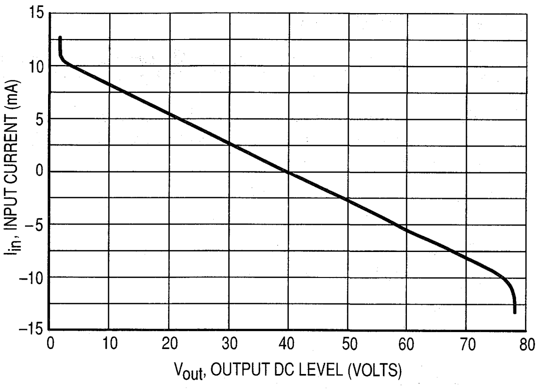


Figure 2. I_{in} versus V_{out}

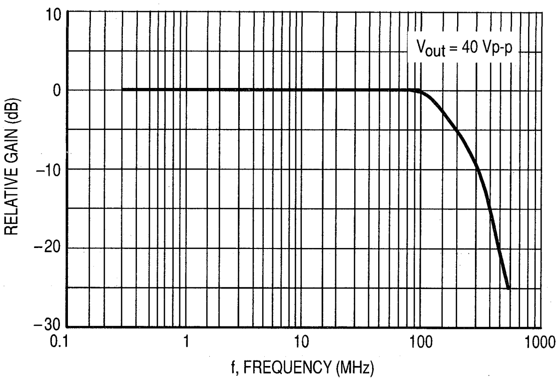


Figure 3. Frequency Response

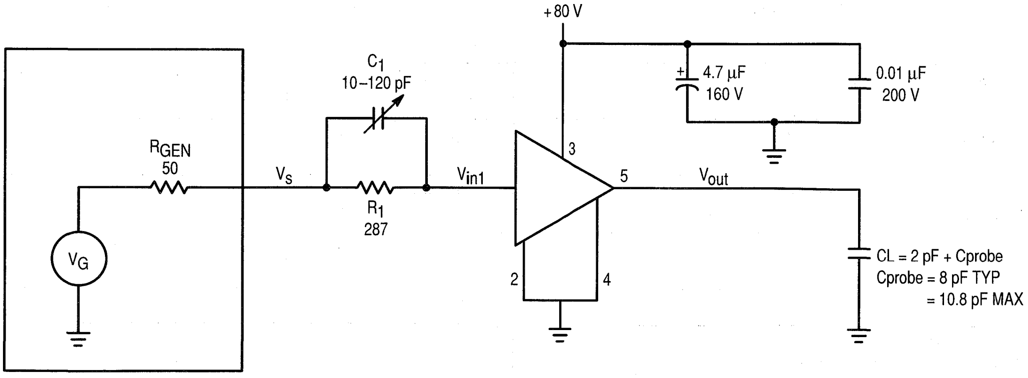


Figure 4. Hybrid Amplifier Test Circuit

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

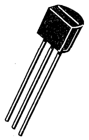
The RF Line
NPN Silicon High-Frequency Transistors

LP1001
LP1001A

The LP1001 is designed for CATV and other Broadband linear applications. This Motorola series of small–signal plastic transistors offers superior quality and performance at low cost.

- High Current Gain–Bandwidth Product
  f_T = 5 GHz (Typ) @ I_C = 10 mAdc
- High Power Gain
  G_{pe} = 12.5 dB (Typ) @ 1 GHz
- Low Noise Figure
  NF = 3 dB (Typ) @ 1 GHz
- Low Feedback Capacitance
  C_{ob} = 0.5 pF (Typ) @ V_{CB} = 10 Volts

LOW NOISE
HIGH–FREQUENCY
TRANSISTORS



CASE 29–04, STYLE 2
TO–226AA
(TO–92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	2	Vdc
Total Device Dissipation @ T_A = 25°C	P_D	625	mW

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance — Junction to Ambient — Junction to Case	$R_{\theta JA}$ $R_{\theta JC}$	200 83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1 mA, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	$V_{(BR)EBO}$	2	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nA
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) LP1001	h_{FE}	25	80	—	—
LP1001A		50	—	—	

(continued)

REV 1

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	—	0.7	pF
Current Gain–Bandwidth Product (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 500 MHz)	f_τ	—	5	—	GHz
FUNCTIONAL TESTS					
Gain @ Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc) f = 500 MHz f = 1 GHz	G_{NF}	— —	14 12.5	— —	dB
Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc) f = 500 MHz f = 1 GHz	NF	— —	2.7 3.2	— —	dB

V_{CE}	I_C	f	S_{11}		S_{21}		S_{12}		S_{22}	
(Volts)	(mA)	(MHz)	$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
10	3	100	0.75	−25	8.56	152	0.03	70	0.94	−12
		200	0.61	−47	7.06	132	0.05	62	0.84	−21
		300	0.47	−61	5.79	116	0.07	60	0.75	−25
		400	0.37	−74	4.81	105	0.08	58	0.70	−28
		500	0.30	−84	4.11	96	0.09	58	0.66	−30
		600	0.22	−94	3.51	86	0.10	58	0.63	−31
		700	0.16	−155	3.15	78	0.11	57	0.59	−34
		800	0.16	−128	2.85	72	0.13	55	0.57	−38
		900	0.12	−144	2.60	67	0.14	53	0.56	−41
		1000	0.12	−169	2.41	61	0.15	52	0.53	−44
		1100	0.12	179	2.26	56	0.17	51	0.52	−51
		1200	0.12	155	2.10	54	0.18	51	0.52	−51
10	10	100	0.48	−36	16.23	137	0.02	69	0.82	−18
		200	0.33	−55	10.98	115	0.04	68	0.68	−23
		300	0.22	−62	8.05	102	0.06	68	0.60	−25
		400	0.16	−70	6.33	93	0.07	67	0.57	−26
		500	0.12	−73	5.21	87	0.09	68	0.55	−27
		600	0.07	−72	4.39	81	0.10	67	0.53	−27
		700	0.04	−117	3.89	74	0.12	64	0.50	−29
		800	0.04	−142	3.45	67	0.13	61	0.48	−34
		900	0.02	−169	3.14	63	0.14	60	0.47	−37
		1000	0.05	127	2.87	58	0.16	58	0.45	−41
		1100	0.06	130	2.68	53	0.18	56	0.44	−47
		1200	0.08	112	2.49	52	0.19	54	0.44	−47

Table 1. Common Emitter S–Parameters

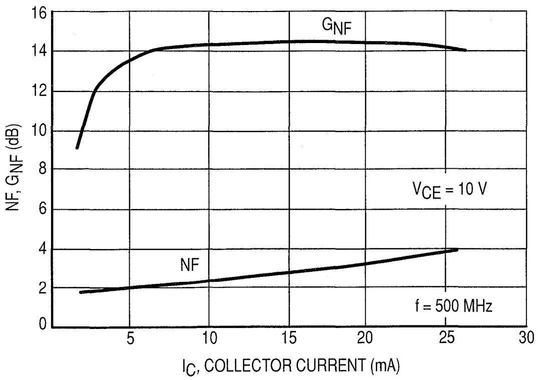


Figure 1. Gain at Noise Figure and Noise Figure versus Collector Current

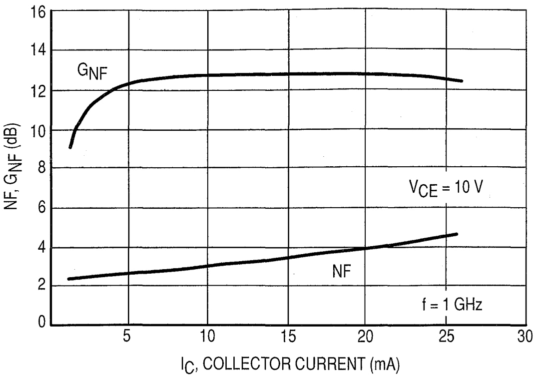


Figure 2. Gain at Noise Figure and Noise Figure versus Collector Current

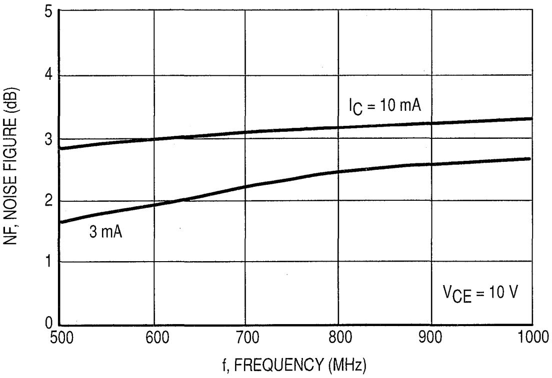


Figure 3. Noise Figure versus Frequency

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line

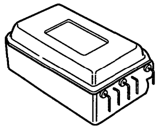
450 MHz CATV Feedforward Amplifier

MFF124B

24 dB
40–450 MHz
60–CHANNEL
CATV
FEEDFORWARD
AMPLIFIER

Designed for broadband applications requiring low–distortion amplification. Specifically intended for CATV market requirements. Two hybrid amplifiers along with couplers and delay lines are packaged together to provide extremely low distortion products at conventional CATV amplifier output levels.

- Specifically Designed to Provide Improved Performance in 450 MHz CATV Applications
- Distortion Components Reduced more than 20 dB from Conventional CATV Hybrid Amplifiers
- Specified for 60–Channel Performance
- Fully Shielded Metal Package



CASE 825A–03, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 V, T_C = 50°C, 75 Ω system unless otherwise noted)

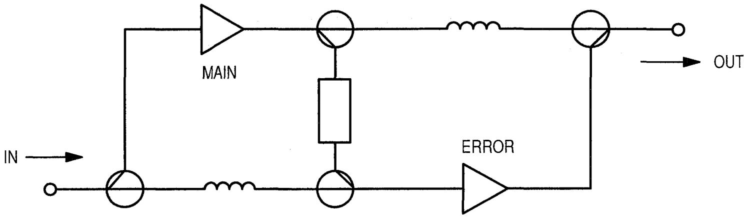
Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	550	MHz
Power Gain — 50 MHz	G_P	23.4	24	24.6	dB
Slope	S	+0.2	—	+1.4	dB
Gain Flatness	—	—	—	±0.2	dB
Return Loss — Input (f = 40−450 MHz)	IRL	18	—	—	dB
Return Loss — Output (f = 40−450 MHz)	ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +50 dBmV per ch., ch. A, H2, H22)	IMD	—	—	−80	dB
Cross Modulation Distortion	XMD_{60}				dB
(V_{out} = 46 dBmV per ch., ch. 2, 60–channels)		—	−80	—	
(V_{out} = 46 dBmV per ch., ch. 2, ——, H22)		—	—	−75	
Composite Triple Beat	CTB				dB
(V_{out} = 46 dBmV per ch., ch. 2, 60–channels)		—	−85	—	
(V_{out} = 46 dBmV per ch., ch. 2, ——, H22)		—	—	−79	
Noise Figure (f = 50 MHz)	NF	—	—	9	dB
(f = 450 MHz)		—	—	10	
DC Current	I_{DC}	—	660	725	mA

REV 1

PERFORMANCE DERATE versus TEMPERATURE (TYP)

Symbol	Characteristics	Test Conditions	–20 +80°C	–20 +100°C
G	Gain	50 MHz	±0.5 dB	±0.6 dB

CIRCUITRY BLOCK DIAGRAM



PERFORMANCE MEASUREMENT
Motorola test fixture: P/N MFF124BTF is necessary for accurate measurement.

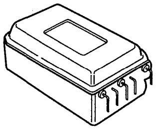
The RF Line
550 MHz CATV Feedforward Amplifier

MFF224B

**24 dB
40–550 MHz
77–CHANNEL
CATV
FEEDFORWARD
AMPLIFIER**

Designed for broadband applications requiring low–distortion amplification. Specifically intended for CATV market requirements. Two hybrid amplifiers along with couplers and delay lines are packaged together to provide extremely low distortion products at conventional CATV amplifier output levels.

- Specifically Designed to Provide Improved Performance in 550 MHz CATV Applications
- Distortion Components Reduced more than 20 dB from Conventional CATV Hybrid Amplifiers
- Specified for 77–Channel Performance
- Fully Shielded Metal Package



CASE 825A–03, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 V, T_C = 50°C, 75 Ω system unless otherwise noted)

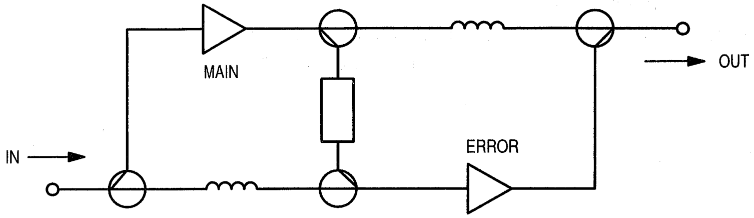
Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	550	MHz
Power Gain — 50 MHz	G_P	23.4	24	24.6	dB
Slope	S	+0.2	—	+1.8	dB
Gain Flatness	—	—	—	±0.25	dB
Return Loss — Input (f = 40−550 MHz)	IRL	18	—	—	dB
Return Loss — Output (f = 40−550 MHz)	ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +50 dBmV per ch., ch. A, H2, H22)	IMD	—	—	−80	dB
Cross Modulation Distortion (V_{out} = 44 dBmV per ch., ch. 2, 77–channels) (V_{out} = 44 dBmV per ch., ch. 2, ——, H39)	XMD_{77}	 — —	 −80 —	 — −70	dB
Composite Triple Beat (V_{out} = 44 dBmV per ch., ch. 2, 77–channels) (V_{out} = 44 dBmV per ch., ch. 2, ——, H39)	CTB	 — —	 −85 —	 — −75	dB
Noise Figure (f = 50 MHz) (f = 550 MHz)	NF	— —	— —	9 11	dB
DC Current	I_{DC}	—	660	725	mA

REV 1

PERFORMANCE DERATE versus TEMPERATURE (TYP)

Symbol	Characteristics	Test Conditions	–20 +80°C	–20 +100°C
G	Gain	50 MHz	±0.5 dB	±0.6 dB

CIRCUITRY BLOCK DIAGRAM



PERFORMANCE MEASUREMENT
Motorola test fixture: P/N MFF124BTF is necessary for accurate measurement.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

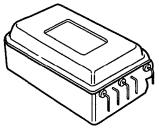
The RF Line
600 MHz CATV Feedforward Amplifier

MFF324B

24 dB
40–600 MHz
85–CHANNEL
CATV
FEEDFORWARD
AMPLIFIER

Designed for broadband applications requiring low–distortion amplification. Specifically intended for CATV market requirements. Two hybrid amplifiers along with couplers and delay lines are packaged together to provide extremely low distortion products at conventional CATV amplifier output levels.

- Specifically Designed to Provide Improved Performance in 600 MHz CATV Applications
- Distortion Components Reduced more than 20 dB from Conventional CATV Hybrid Amplifiers
- Specified for 85–Channel Performance
- Fully Shielded Metal Package



CASE 825A–03, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	28	V
RF Input Power	P_{in}	+55	dBmV
Storage Temperature Range	T_{stg}	−40 to +100	°C
Operating Case Temperature Range	T_C	−20 to +100	°C

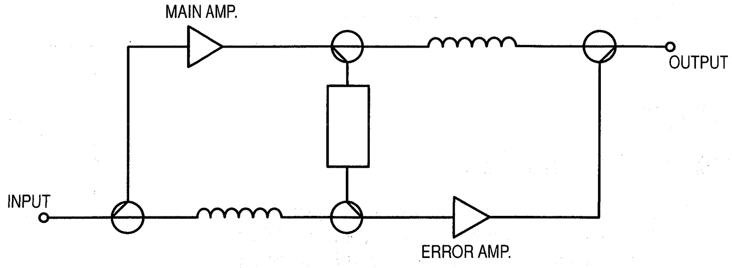
ELECTRICAL CHARACTERISTICS (T_C = 50°C, V_{CC} = 24 V, 75 Ω System)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	600	MHz
Power Gain — 50 MHz	G_p	23.4	24	24.6	dB
Slope	S	+0.4	—	+2.0	dB
Gain Flatness	—	—	—	±0.25	dB
Return Loss — Input	IRL	18	—	—	dB
Return Loss — Output	ORL	18	—	—	dB
Cross Modulation Distortion (V_{out} = +44 dBmV per ch., ch. 2, ——, H47)	XMD_{85}	—	—	−68	dB
Composite Triple Beat (V_{out} = +44 dBmV per ch., ch. 2, ——, H47)	CTB_{85}	—	—	−73	dB
Noise Figure (f = 50 MHz) (f = 600 MHz)	NF	— —	— —	9.0 12.5	dB
DC Current	I_{DC}	—	660	725	mA

PERFORMANCE DERATE versus TEMPERATURE (TYP)

Symbol	Characteristics	Test Conditions	−20 + 80°C	−20 + 100°C
ΔG_p	Change in Gain w/Temp.	50 MHz	±0.5 dB	±0.6 dB

REV 1



PERFORMANCE MEASUREMENT

Motorola test fixture: P/N MFF124BTF is necessary for accurate measurement.

Figure 1. Block Diagram of Circuit

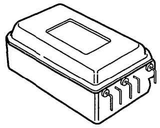
The RF Line
750 MHz CATV Feedforward Amplifier

MFF424B

24 dB
40–750 MHz
110 CHANNEL
CATV
FEEDFORWARD
AMPLIFIER

Designed for broadband applications requiring low–distortion amplification. Specifically intended for CATV market requirements. Two hybrid amplifiers along with couplers and delay lines are packaged together to provide extremely low distortion products at conventional CATV amplifier output levels.

- Specifically Designed to Provide Improved Performance in 750 MHz CATV Applications
- Distortion Components Reduced more than 20 dB from Conventional CATV Hybrid Amplifiers
- Specified for 110 Channel Performance
- Fully Shielded Metal Package



CASE 825A–03, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	28	V
RF Input Power	P_{in}	+55	dBmV
Storage Temperature Range	T_{stg}	−40 to +100	°C
Operating Case Temperature Range	T_C	−20 to +100	°C

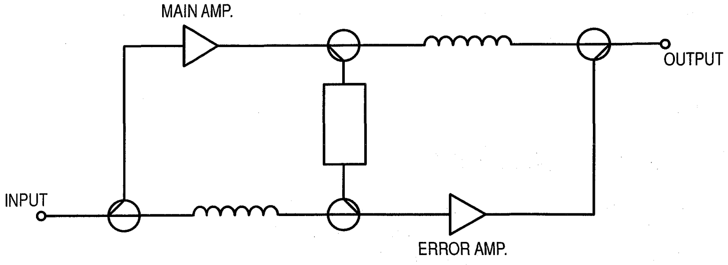
ELECTRICAL CHARACTERISTICS (T_C = 50°C, V_{CC} = 24 V, 75 Ω System)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	750	MHz
Power Gain — 50 MHz	G_p	23.4	24	24.6	dB
Slope	S	+0.4	+0.9	+1.4	dB
Gain Flatness	—	—	—	±0.3	dB
Return Loss — Input	IRL	18	—	—	dB
Return Loss — Output	ORL	18	—	—	dB
Composite Triple Beat (V_{out} = +44 dBmV at ch. 2 to ch. M73) (9 dB Up slope, V_{out} = +46 dBmV at ch. M73)	 CTB_{110} flat CTB_{110} slope	 — —	 — −68	 −65 —	dB
Composite Second Order Beat (V_{out} = +44 dBmV at ch. 2 to ch. M73) (9 dB Up slope, V_{out} = +46 dBmV at ch. M73)	 CSO_{110} flat CSO_{110} slope	 — —	 — −70	 −70 —	dB
Noise Figure (f = 50 MHz) (f = 750 MHz)	NF	—	—	9.0 13.0	dB
DC Current	I_{DC}	—	660	725	mA

PERFORMANCE DERATE versus TEMPERATURE (TYP)

Symbol	Characteristic	Test Conditions	−20 + 80°C	−20 + 100°C
ΔG_p	Change in Gain w/Temp.	50 MHz	±0.5 dB	±0.6 dB

REV 1



PERFORMANCE MEASUREMENT

Motorola test fixture: P/N MFF124BTF is necessary for accurate measurement.

Figure 1. Block Diagram of Circuit

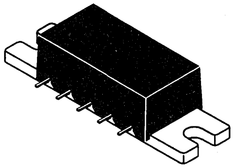
MHL8015
MHL8018

The RF Line
UHF Linear Amplifier

Designed for linear amplifier applications in 50 ohm systems requiring wide bandwidth, low noise, and low distortion. Internal DC blocking on RF ports reduces external component count and related circuit area. This hybrid utilizes push–pull circuit design.

- Supply Voltage: 15 Vdc (MHL8015)
  28 Vdc (MHL8018)
- Third Order Intercept: 38 dBm Typ
- Power Gain: 18.5 dB Typ (@ f = 900 MHz)
- Excellent Phase Linearity and Group Delay Characteristics
- 50 Ohm Input/Output Impedances

400 mW, 18.5 dB
40–1000 MHz
LINEAR AMPLIFIERS



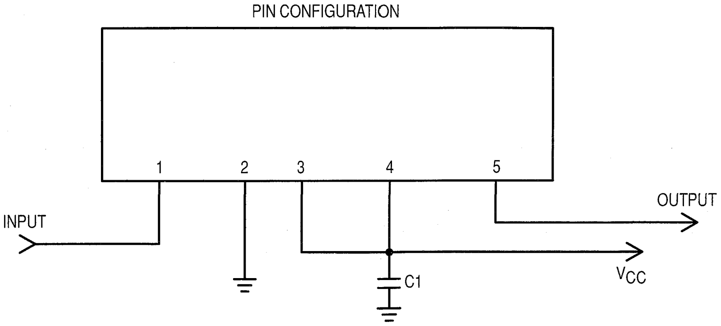
CASE 448–01
MHL8015, STYLE 2
MHL8018, STYLE 1

ABSOLUTE MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
DC Supply Voltage	MHL8015 MHL8018	V_{CC}	18 32	Vdc
RF Input Power		P_{in}	+14	dBm
Storage Temperature Range		T_{stg}	−40 to +100	°C
Operating Case Temperature Range		T_C	−20 to +100	°C

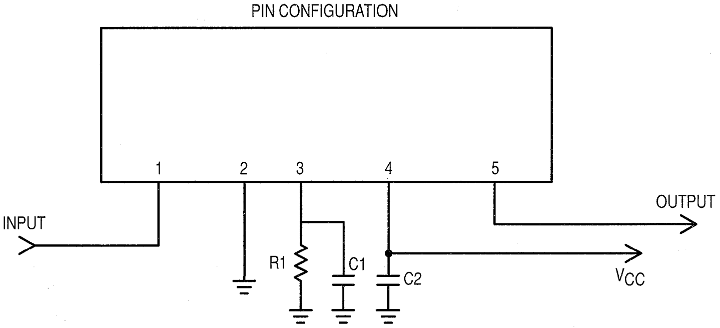
ELECTRICAL CHARACTERISTICS (T_C = +25°C; V_{CC} = 15 Vdc (MHL8015), 28 Vdc (MHL8018); 50 Ω System)

Characteristic		Symbol	Min	Typ	Max	Unit
Supply Current	MHL8015 MHL8018	I_{DC}	— —	380 210	410 240	mA
Power Gain	(f = 900 MHz)	P_G	17.5	18.5	19.5	dB
Gain Flatness	(f = 40–1000 MHz)	FL	—	1.0	2.0	dB
Power Output @ 1 dB Comp.	(f = 900 MHz)	P_{out} 1 dB	25	26	—	dBm
Third Order Intercept (f1 = 879 MHz, f2 = 884 MHz)		ITO	37	38	—	dBm
Input/Output VSWR	(f = 40–900 MHz) (f = 900–1000 MHz)	VSWR	— —	— —	2.0:1 2.6:1	
Noise Figure, Broadband	(f = 500 MHz) (f = 1000 MHz)	NF	— —	6.5 7.5	8.0 9.0	dB
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 1000 MHz)		dso	—	−50	−40	dB
Second Order Intermodulation Distortion (P_o = 2.75 dBm, f_1 = 373 MHz, f_2 = 450 MHz)		IM2	—	—	−60	dB
Intermodulation Distortion, 3 Tone (f = 860 MHz, P_{sync} = 200 mW)		IM3	—	−60	—	dB



C1 ≥ 0.01 µF (CHIP)

Figure 1. MHL8015 External Connections (Case 448–01, Style 2)



C1, C2 ≥ 0.01 µF (CHIP)
R1 = 200 Ω, 1 WATT

Figure 2. MHL8018 External Connections (Case 448–01, Style 1)

This page intentionally left blank.

This page intentionally left blank.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

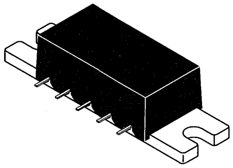
The RF Line
UHF Linear Amplifier

MHL8115
MHL8118

1 W, 17.5 dB
50–1000 MHz
LINEAR AMPLIFIERS

Designed for linear amplifier applications in 50 Ohm systems requiring wide bandwidth, low noise, and low distortion. Internal DC blocking on RF ports reduces external component count and related circuit area. This hybrid utilizes push–pull circuit design.

- Supply Voltage: 15 Vdc (MHL8115)
  28 Vdc (MHL8118)
- Third Order Intercept: 41.5 dBm Typ
- Power Gain: 17.5 dB Typ (@ 900 MHz)
- Excellent Phase Linearity and Group Delay Characteristics
- 50 Ohm Input/Output Impedances



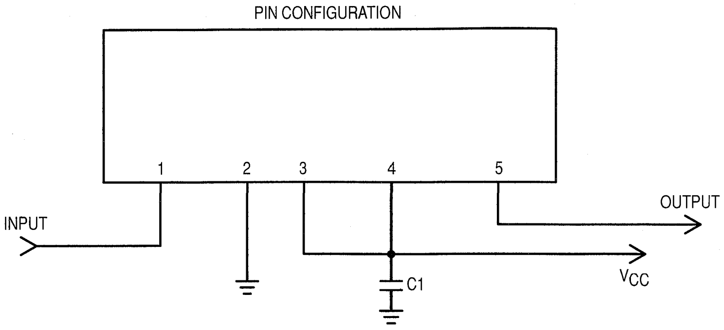
CASE 448–01
MHL8115, STYLE 2
MHL8118, STYLE 1

ABSOLUTE MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
DC Supply Voltage	MHL8115 MHL8118	V_{CC}	18 32	Vdc
RF Input Power		P_{in}	+20	dBm
Storage Temperature Range		T_{stg}	−40 to +100	°C
Operating Case Temperature Range		T_C	−20 to +100	°C

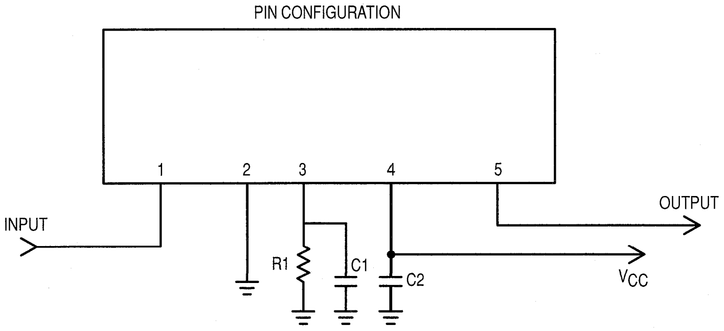
ELECTRICAL CHARACTERISTICS (T_C = +25°C; V_{CC} = 15 Vdc (MHL8115), 28 Vdc (MHL8118); 50 Ω System)

Characteristic		Symbol	Min	Typ	Max	Unit
Supply Current	MHL8115 MHL8118	I_{DC}	— —	700 400	760 440	mA
Power Gain	(f = 900 MHz)	P_G	16.5	17.5	—	dB
Gain Flatness	(f = 50–1000 MHz)	FL	—	1.0	2.0	dB
Power Output @ 1 dB Comp.	(f = 900 MHz)	P_{out} 1 dB	29	30	—	dBm
Third Order Intercept (f1 = 879 MHz, f2 = 884 MHz)		ITO	40.5	41.5	—	dBm
Input/Output VSWR	(f = 50–900 MHz) (f = 900–1000 MHz)	VSWR	— —	— —	2.0:1 2.6:1	
Noise Figure, Broadband	(f = 500 MHz) (f = 1000 MHz)	NF	— —	7.5 8.5	8.5 9.5	dB
Second Harmonic Distortion (P_o = 100 mW, f_{2H} = 1000 MHz)		dso	—	−55	−45	dB
Second Order Intermodulation Distortion (P_o = 2.75 dBm, f_1 = 373 MHz, f_2 = 450 MHz)		IM2	—	−65	−60	dB
Intermodulation Distortion, 3 Tone (f = 860 MHz, P_{sync} = 200 mW)		IM3	—	−60	—	dB



C1 ≥ 0.01 μF (CHIP)

Figure 1. MHL8115 External Connections (Case 448–01, Style 2)



C1, C2 ≥ 0.01 μF (CHIP)
R1 = 90 Ω, 3 WATTS

Figure 2. MHL8118 External Connections (Case 448–01, Style 1)

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

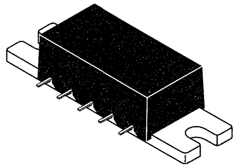
The RF Line
UHF Linear Amplifier

MHL9125
MHL9128

Designed specifically for linear amplifier applications in the cellular frequency band. Internal DC blocking on RF ports reduces external component count and related circuit area. These devices can be easily combined for higher power applications.

- Supply Voltage: 15 Vdc (MHL9125)
  28 Vdc (MHL9128)
- Third Order Intercept: 43 dBm Typ
- Power Gain: 20 dB Typ (@ f = 900 MHz)
- Excellent Phase Linearity and Group Delay Characteristics
- 50 Ohm Input/Output Impedances

1.3 W, 20 dB
800–960 MHz
LINEAR AMPLIFIERS



CASE 448–01
MHL9125, Style 2
MHL9128, Style 1

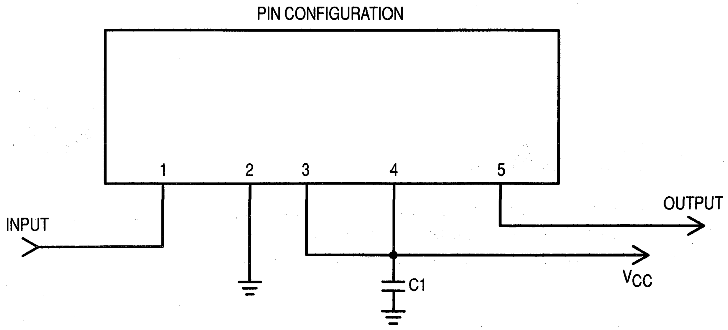
ABSOLUTE MAXIMUM RATINGS (T_C = 25°C unless otherwise stated)

Rating		Symbol	Value	Unit
DC Supply Voltage	MHL9125 MHL9128	V_{CC}	18 32	Vdc
RF Input Power		P_{in}	+20	dBm
Operating Case Temperature Range		T_C	−20 to +100	°C
Storage Temperature Range		T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 15 Vdc (MHL9125), 28 Vdc (MHL9128); T_C = 25°C; 50 Ω System, unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Supply Current	MHL9128 MHL9125	I_{DC}	400 700	— —	440 760	mA
Power Gain (1)	(f = 900 MHz)	P_G	19	20	21	dB
Absolute Phase Variation (1)	(f = 900 MHz)	$\Delta\phi$		±8	±18	Deg.
Gain Flatness	(f = 800–960 MHz)	G_F	—	0.5	0.75	dB
Power Output @ 1 dB Comp.	(f = 900 MHz)	P_{out} 1 dB	30	31	—	dBm
Input VSWR	(f = 800–920 MHz) (f = 920–960 MHz)	$VSWR_{in}$	— —	1.25:1 1.50:1	1.5:1 1.9:1	
Output VSWR	(f = 800–960 MHz)	$VSWR_{out}$	—	1.2:1	1.5:1	
Third Order Intercept (f1 = 879 MHz, f2 = 884 MHz)		ITO	42	43	—	dBm
Noise Figure	(f = 960 MHz)	NF	—	7.5	9.5	dB

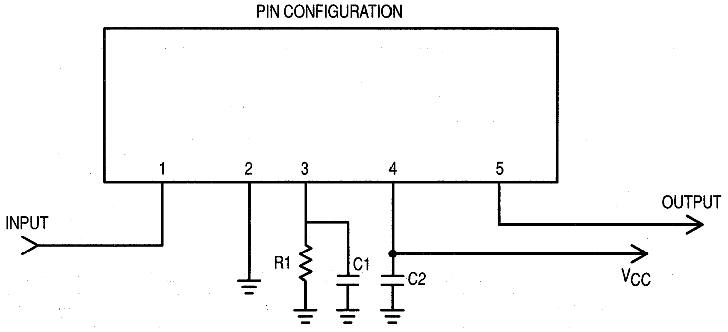
(1) Consult factory for tighter gain and/or phase windows.



PIN CONFIGURATION

C1 ≥ 0.01 µF (CHIP)

Figure 1. MHL9125 External Connections (Case 448–01, Style 2)



PIN CONFIGURATION

C1, C2 ≥ 0.01 µF (CHIP)
R1 = 90 Ω, 3 WATTS

Figure 2. MHL9128 External Connections (Case 448–01, Style 1)

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

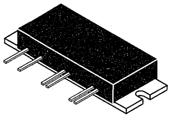
The RF Line
VHF Power Amplifier

MHW105

The MHW105 is designed specifically for portable radio applications. The MHW105 is capable of 5.0 watts power output, operates from a 7.5 volt supply and requires only 1.0 mW of RF input power.

- Specified 7.5 Volt Characteristics:
  RF Input Power — 1.0 mW (0 dBm)
  RF Output Power — 5.0 W
  Minimum Gain — 37 dB
  Harmonics — −40 dBc Max @ 2 f_0
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability

5.0 W
68 to 88 MHz
VHF POWER
AMPLIFIER



CASE 301K–02, STYLE 3

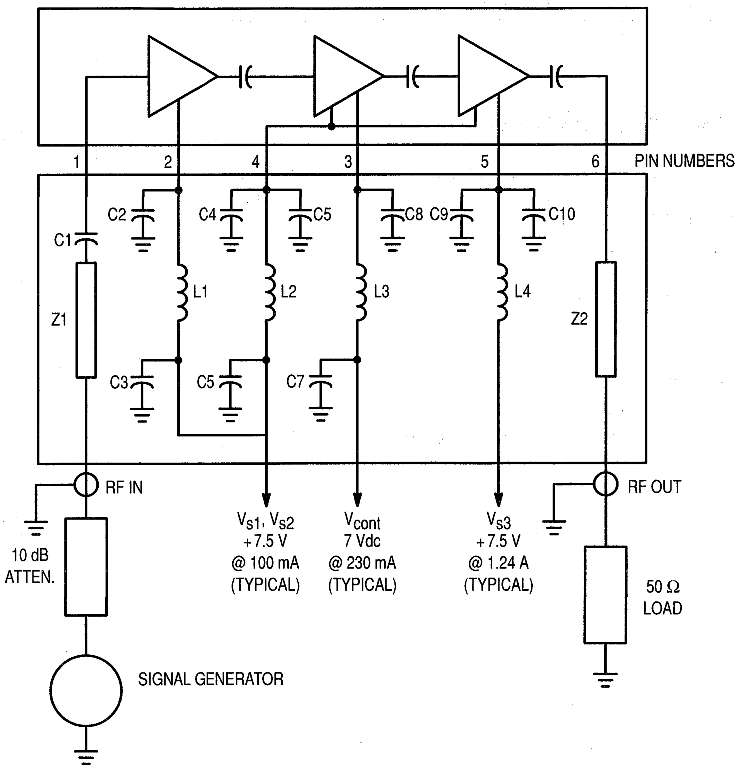
MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{S3}	9.0	Vdc
DC Control & Bias Voltage	$V_{S1,2}$	9.0	Vdc
DC Control Voltage	V_{cont}	9.0	Vdc
RF Input Power	P_{in}	5.0	mW
RF Output Power (V_{cont} = 9.0 Vdc)	P_{out}	7.0	W
Operating Case Temperature Range	T_C	−30 to +100	°C
Storage Temperature Range	T_{stg}	−30 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{S1} = V_{S2} = V_{S3}$ = 7.5 Vdc; $V_{cont} \leq$ 7.0 Vdc; T_C = +25°C, 50 Ω system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Frequency Range	BW	68	88	MHz
Power Gain (P_{out} = 5.0 W) (1)	G_P	37	—	dB
Control Voltage (P_{in} = 1.0 mW; P_{out} = 5.0 W) (1)	V_{cont}	—	7.0	Vdc
Efficiency (P_{out} = 5.0 W) (1)	η	40	—	%
Harmonics (P_{out} = 5.0 W) (1) 2 f_0, 3 f_0	—	—	−40	dBc
Input VSWR (P_{out} = 5.0 W) (1)	$VSWR_{in}$	—	2.0:1	—
Load Mismatch ($V_{S1} = V_{S2} = V_{S3}$ = 9.0 Vdc; Load VSWR = 20:1; P_{out} = 5.0 W) (1)	ψ	No Degradation in Power Output Before and After Test		
Stability (P_{in} = 1.0 to 3.0 mW; $V_{S1} = V_{S2} = V_{S3}$ = 6.0 to 9.0 Vdc; P_{out} = 1.0 W to 5.0 W; Load VSWR = 8:1, All Phase Angles) (1)	—	All Spurious Outputs More Than 60 dB Below Desired Signal		
Quiescent Current ($V_{S1} = V_{S2} = V_{S3}$ = 7.5 Vdc; V_{cont} = 7.0 Vdc; P_{in} = 0)	I_Q	—	200	mA

NOTE:
1. Adjust V_{cont} for specified P_{out}



C1, C2, C3, C4, C6, C7, C8, C9 — 18,000 pF CHIP
C5, C10 — 3.3 µF TANTALUM CHIP
L1, L2, L3, L4 — 0.2 µH
Z1, Z2 — 50 Ω MICROSTRIP LINE

Figure 1. VHF Power Module Test Circuit Diagram

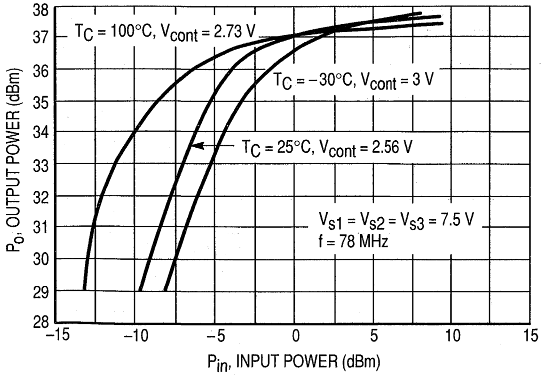


Figure 2. Output Power versus Input Power

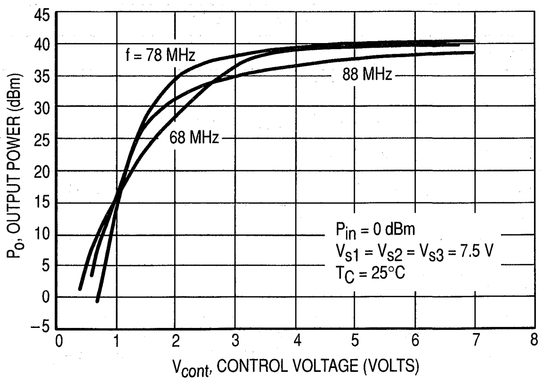


Figure 3. Output Power versus Control Voltage

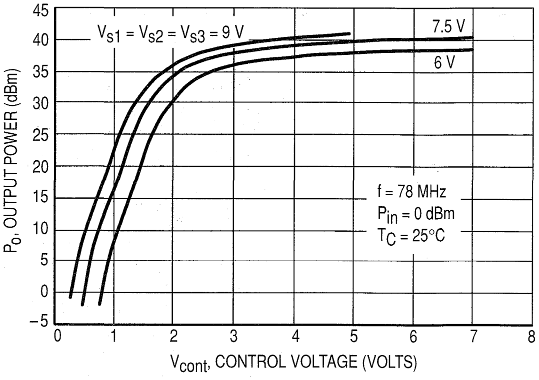


Figure 4. Output Power versus Control Voltage

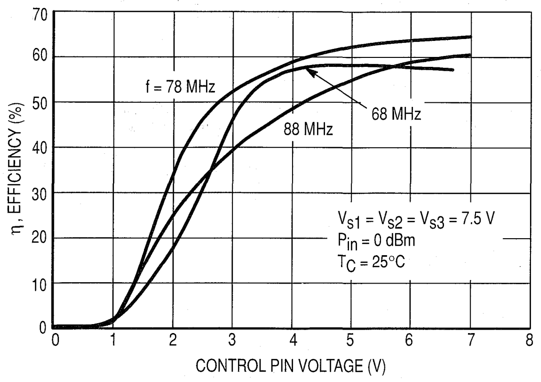


Figure 5. Efficiency versus Control Voltage

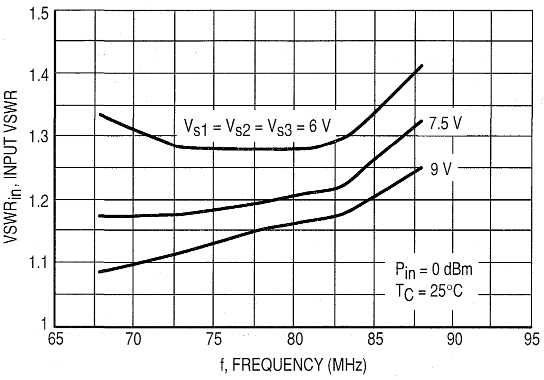


Figure 6. Input VSWR versus Frequency

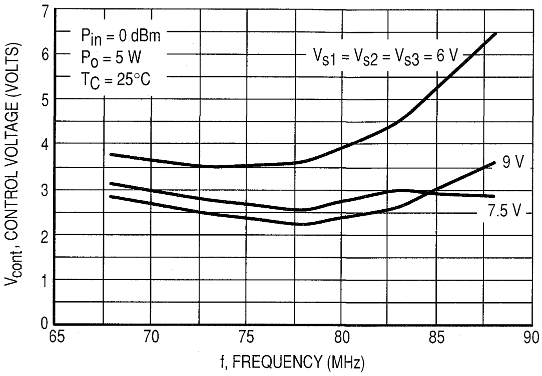


Figure 7. Control Voltage versus Frequency

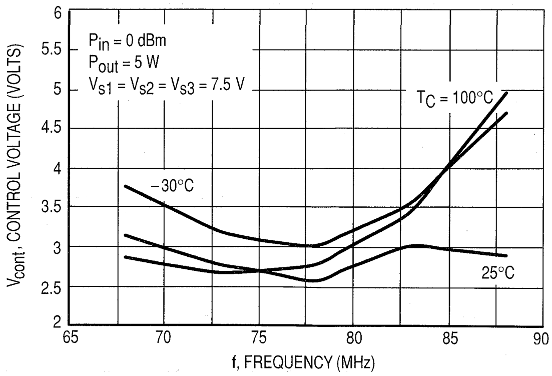


Figure 8. Control Voltage versus Frequency

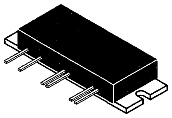
The RF Line
VHF Power Amplifiers

MHW607-1
MHW607-2
MHW607-3
MHW607-4

7.0 W — 136 to 210 MHz
6.5 W — 174 to 210 MHz
VHF POWER
AMPLIFIERS

. . . designed for 7.5 volt VHF power amplifier applications in industrial and commercial equipment primarily hand portable radios.

- MHW607–1: 136–150 MHz
- MHW607–2: 146–174 MHz
- MHW607–3: 174–195 MHz
- MHW607–4: 184–210 MHz
- Specified 7.5 Volt Characteristics:
  - RF Input Power = 1.0 mW (0 dBm)
  - RF Output Power = 7.0 Watts (MHW607–1,–2); 6.5 W (MHW607–3,–4)
  - Minimum Gain ($V_{Control}$ = 7.0 V) = 38.5 dB
  - Harmonics = –40 dBc Max @ 2.0 f_o
- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 301K–02, STYLE 3

MAXIMUM RATINGS (Flange Temperature = 25°C)

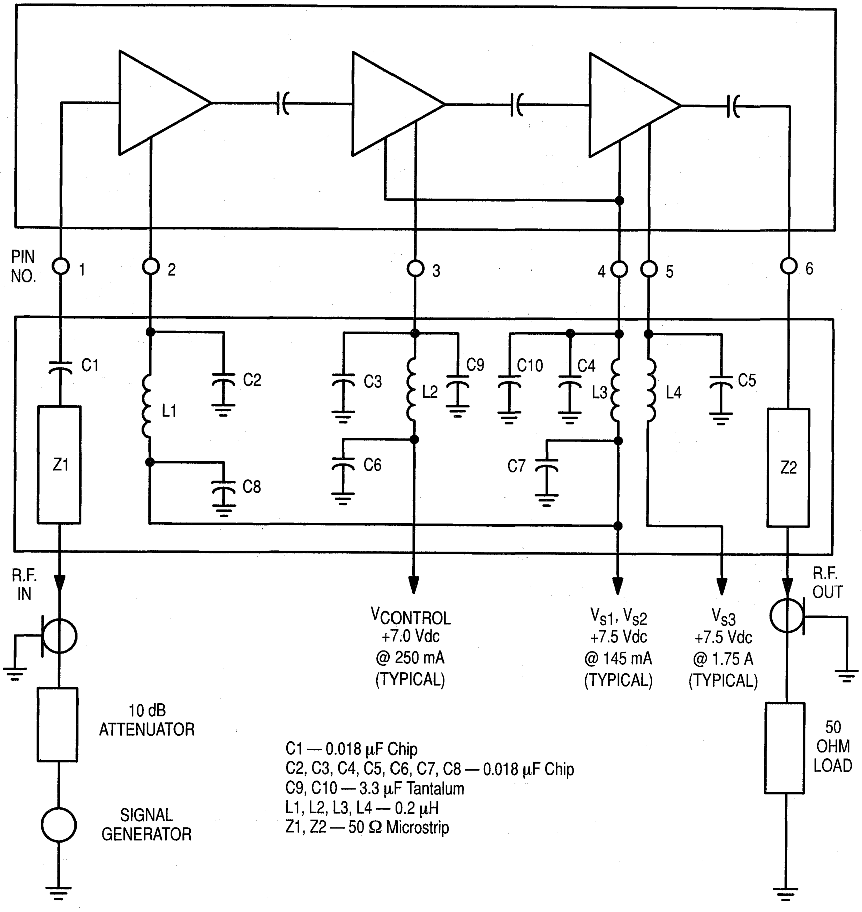
Rating	Symbol	Value	Unit
DC Supply Voltage (Pins 2, 4, 5)	$V_{s1,2,3}$	9.0	Vdc
DC Control Voltage (Pin 3)	V_{Cont}	9.0	Vdc
RF Input Power	P_{in}	5.0	mW
RF Output Power ($V_{s1} = V_{s2} = V_{s3}$ = 9.0 V)	P_{out}	10	W
Operating Case Temperature Range	T_C	–30 to +100	°C
Storage Temperature Range	T_{stg}	–30 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{s1} = V_{s2} = V_{s3}$ = 7.5 Vdc, (Pins 2, 4, 5), T_C = 25°C, 50 Ω System)

Characteristic	Symbol	Min	Max	Unit
Frequency Range MHW607–1 MHW607–2 MHW607–3 MHW607–4	—	136 146 174 184	150 174 195 210	MHz
Control Voltage (P_{out} = 7.0 W, P_{in} = 1.0 MW)(1)	V_{Cont}	0	7.0	Vdc
Quiescent Current ($V_{s1} = V_{s2} = V_{s3}$ = 7.5 Vdc, V_{Cont} = 7.0 Vdc)	$I_{s1(q)} + I_{s2(q)}$	—	160	mA
Power Gain (P_{out} = 7.0 W, V_{Cont} = 7.0 Vdc)	G_p	38.5	—	dB
Efficiency (P_{out} = 7.0 W, P_{in} = 1.0 mW)(1)	η	40	—	%
Harmonics (P_{out} = 7.0 W)(1) 2 f_o (P_{in} = 1.0 mW) 3 f_o	—	—	–40 –45	dBc
Input VSWR (P_{out} = 7.0 W, P_{in} = 1.0 mW), 50 Ω Ref. (1)	—	—	2.0:1	—
Load Mismatch ($V_{s1} = V_{s2} = V_{s3}$ = 9.0 Vdc) VSWR = 20:1, P_{out} = 8 W, P_{in} = 5.0 mW)(1)		No Degradation in Power Output		
Stability (P_{in} = 1.0–30 mW, $V_{s1} = V_{s2} = V_{s3}$ = 6.0–9.0 Vdc) P_{out} between 1.0 W and 10 W (1) Load VSWR = 8:1		All spurious outputs more than 60 dB below desired signal		
Control Current ($V_{s1} = V_{s2} = V_{s3}$ = 7.5 V, P_{in} = 0 dBm, V_{Cont} Set for P_o = 7.0 W)		—	325	mA

(1) Adjust V_{Cont} for specified P_{out}.

REV 6



C1 — 0.018 µF Chip
C2, C3, C4, C5, C6, C7, C8 — 0.018 µF Chip
C9, C10 — 3.3 µF Tantalum
L1, L2, L3, L4 — 0.2 µH
Z1, Z2 — 50 Ω Microstrip

Figure 1. Power Module Test System Block Diagram

TYPICAL CHARACTERISTICS

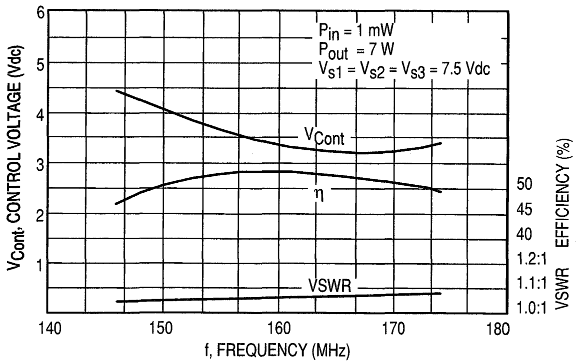


Figure 2. Control Voltage, Efficiency and VSWR versus Frequency

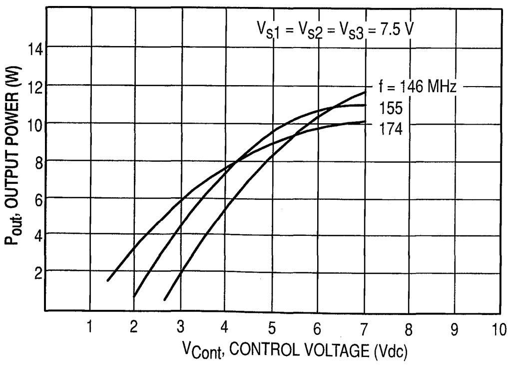


Figure 3. Output Power versus Control Voltage

TYPICAL CHARACTERISTICS

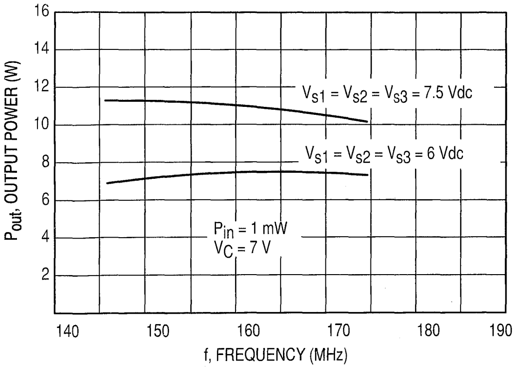


Figure 4. Output Power versus Frequency

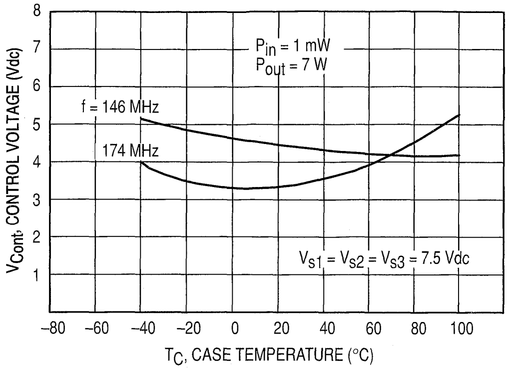


Figure 5. Control Voltage versus Case Temperature

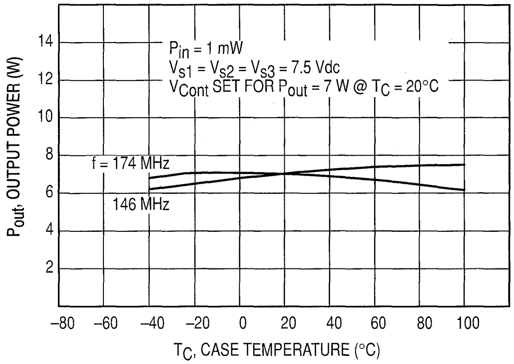


Figure 6. Output Power versus Case Temperature

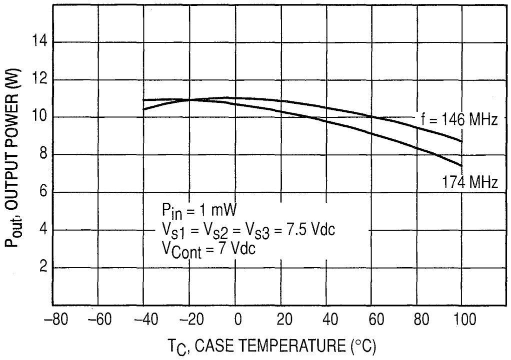


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

APPLICATIONS INFORMATION

NOMINAL OPERATION

All electrical specifications are based on the nominal conditions of $V_{S1} = V_{S2} = V_{S3} = 7.5$ Vdc (Pins 2, 4, 5) and P_{out} equal to 7.0 watts. With these conditions, maximum current density on any device is 1.5×10^5 A/cm^2 and maximum die temperature with 100°C case operating temperature is 165°C. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the limits of published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output should be limited to 7.0 watts. The preferred method of power output control is to fix $V_{S1} = V_{S2} = V_{S3} = 7.5$ Vdc (Pins 2, 4, 5), P_{in} (Pin 1) at 1.0 mW, and vary V_{Cont} (Pin 3) voltage.

DECOUPLING

Due to the high gain of the three stages and the module size limitation, external decoupling networks require careful consideration. Pins 2, 3, 4 and 5 are internally bypassed with a 0.018 µF chip capacitor which is effective for frequencies from 5.0 MHz through 174 MHz. For bypassing frequencies below 5.0 MHz, networks equivalent to that shown in Figure 1 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

LOAD MISMATCH

During final test, each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{S1} = V_{S2} = V_{S3}$ equal to 9.0 Vdc, VSWR equal to 20:1, and output power equal to 8.0 watts.

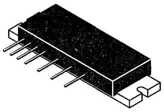
The RF Line
UHF Power Amplifier

MHW704-1
MHW704-2

3.0 W
440 to 470 MHz
UHF POWER
AMPLIFIER

Designed for 6.0 V UHF power amplifier applications in industrial and commercial equipment, primarily hand portable radios.

- Specified 6.0 Volt Characteristics:
  Bandwidth:
  MHW704–1: 400–440 MHz
  MHW704–2: 440–470 MHz
  RF Input Power — 1.0 mW (0 dBm)
  RF Output Power — 3.0 W
  Minimum Gain ($V_{Control}$ = 6.0 V) = 34.8 dB
  Harmonics — –40 dBc Max @ 2 f_o
- 50 Ω Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability



CASE 301J–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage (Pins 2, 4, 5, 6)	$V_{S1,2,3,4}$	7.5	Vdc
DC Control Voltage (Pin 3)	V_{cont}	6.0	Vdc
RF Input Power	P_{in}	3.0	mW
RF Output Power ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 7.5 Vdc)	P_{out}	4.5	W
Operating Case Temperature Range	T_C	–25 to +100	°C
Storage Temperature Range	T_{stg}	–25 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 6.0 Vdc (Pins 2, 4, 5, 6); T_C = +25°C, 50 ohm system)

Characteristic		Symbol	Min	Max	Unit
Frequency Range	MHW704–1 MHW704–2	BW	400 440	440 470	MHz
Power Gain (P_{out} = 3.0 W; V_{cont} = 6.0 V)		G_p	34.8	—	dB
Control Voltage (P_{in} = 1.0 mW; P_{out} = 3.0 W) (1)		V_{cont}	—	6.0	Vdc
Efficiency (P_{in} = 1.0 mW; P_{out} = 3.0 W) (1)	MHW704–1 MHW704–2	η	37 38	— —	%
Harmonics (P_{out} = 3.0 W; P_{in} = 1.0 mW) (1)	2 f_o	—	—	–40	dBc
Input VSWR (P_{out} = 3.0 W; P_{in} = 1.0 mW) (1)		$VSWR_{in}$	—	2.0:1	—
Load Mismatch ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 7.5 Vdc; Load VSWR = 10:1, All Phase Angles At Frequency of Test; P_{out} = 4.0 W; P_{in} = 3.0 mW) (1)		ψ	No Degradation in Power Output		
Stability (P_{in} = 1.0 to 3.0 mW; $V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 5.0 to 7.5 Vdc; P_{out} = 100 mW to 4.0 W; Load VSWR = 6:1 (MHW704–1); Load VSWR = 8:1, (MHW704–2) All Phase Angles At Frequency of Test) (1)		—	All Spurious Outputs More Than 60 dB Below Desired Signal		
Control Current (P_{out} = 3.0 W; P_{in} = 1.0 mW) (1)		I_{cont}	—	80	mA
Quiescent Current (P_{in} = 0 mW; V_{cont} = 0 Vdc)		I_Q	—	150	mA
Leakage Current ($V_{S1} = V_{S2} = V_{cont}$ = 0 Vdc; $V_{S3} = V_{S4}$ = 7.5 Vdc; P_{in} = 0 mW)		I_L	—	0.2	mA

(1) Adjust V_{Cont} for specified P_{out}.

REV 7

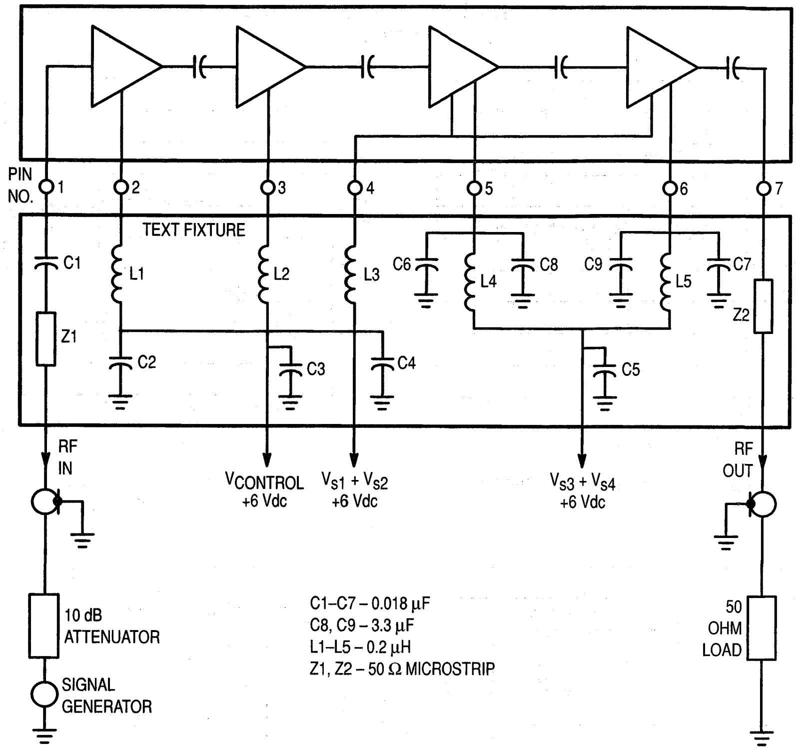


Figure 1. UHF Power Amplifier Test System Diagram

TYPICAL CHARACTERISTICS
MHW704–2

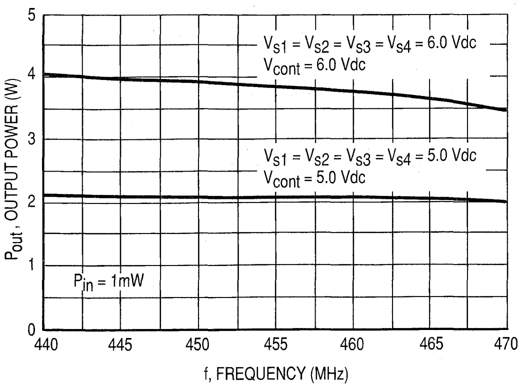


Figure 2. Output Power versus Frequency

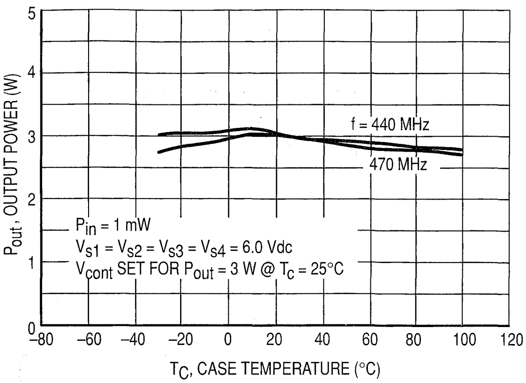


Figure 3. Output Power versus Case Temperature

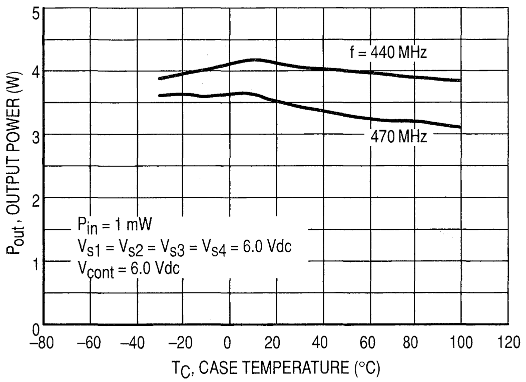


Figure 4. Output Power versus Case Temperature at Maximum Control Voltage

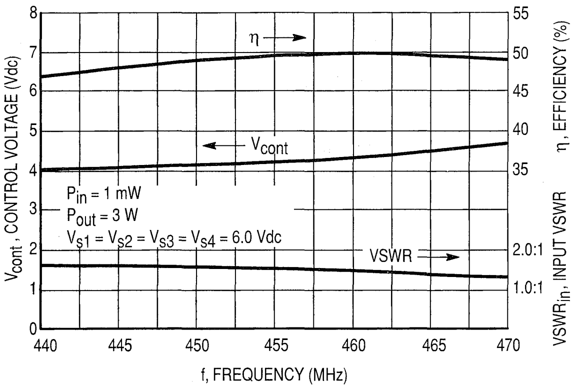


Figure 5. Control Voltage, Efficiency and VSWR versus Frequency

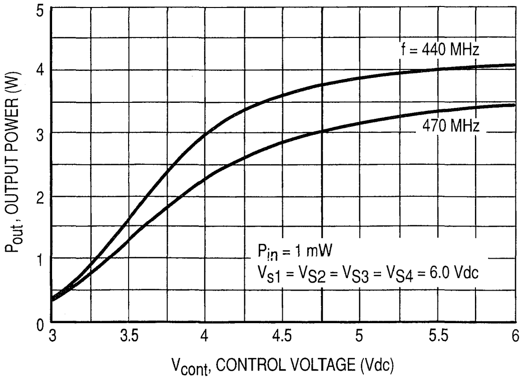


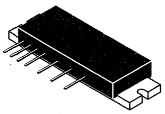
Figure 6. Output Power versus Control Voltage

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
UHF Power Amplifiers

MHW707-1
MHW707-2
MHW707-3
MHW707-4

7.0 W, 403 to 500 MHz
6.5 W, 490 to 512 MHz
UHF POWER
AMPLIFIERS



CASE 301J–04, STYLE 1

Designed for 7.5 Volt UHF power amplifier applications in industrial and commercial equipment primarily hand portable radios.

- MHW707–1, f = 403–440 MHz
- MHW707–2, f = 440–470 MHz
- MHW707–3, f = 470–500 MHz
- MHW707–4, f = 490–512 MHz
- Specified 7.5 Volt Characteristics:
  RF Input Power = 1.0 mW (0 dBm)
  RF Output Power = 7.0 Watts (2)
  Minimum Gain ($V_{Control}$ = 7.0 V) = 38.5 dB (2)
  Harmonics = −40 dBc Max @ 2 f_o
- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability
- Test fixture circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage (Pins 2,4,5,6)	$V_{S1,2,3,4}$	9.0	Vdc
DC Control Voltage (Pin 3)	V_{Cont}	7.0	Vdc
RF Input Power	P_{in}	3.0	mW
RF Output Power ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 9.0 Vdc)	P_{out}	9.0	W
Operating Case Temperature Range	T_C	−30 to +80	°C
Storage Temperature Range	T_{stg}	−30 to +80	°C

ELECTRICAL CHARACTERISTICS $V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 7.5 Vdc, (Pins 2,4,5,6), T_C = 25°C, 50 Ω System

Characteristic		Symbol	Min	Max	Unit
Frequency Range	MHW707–1 MHW707–2 MHW707–3 MHW707–4	—	403 440 470 490	440 470 500 512	MHz
Control Voltage (P_{out} = 7.0 W, P_{in} = 1.0 MW)(1)		V_{Cont}	0	7.0	Vdc
Quiescent Current ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 7.5 Vdc, P_{in} = 0 mW, V_{Cont} = 0 Vdc)			—	150	mA
Power Gain (P_{out} = 7.0 W, V_{Cont} = 7.0 Vdc) (2)		G_p	38.5	—	dB
Efficiency (P_{out} = 7.0 W, P_{in} = 1.0 mW) (1) (2)		η	40	—	%
Harmonics (P_{out} = 7.0 W) (1) (2) 2 f_o (P_{in} = 1.0 mW)		—	—	−40	dBc
Input VSWR (P_{out} = 7.0 W, P_{in} = 1.0 mW), 50 Ω Ref. (1) (2)		—	—	2.0:1	—
Control Current ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 7.5 Vdc, P_{in} = 1.0 mW) (1)		—	—	95	mA
Load Mismatch ($V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 9.0 Vdc) VSWR = 10:1, P_{out} = 9.0 W, P_{in} = 3.0 mW(1)			No Degradation in Power Output		
Stability (P_{in} = 1.0–3.0 mW, $V_{S1} = V_{S2} = V_{S3} = V_{S4}$ = 6.0–9.0 Vdc) P_{out} between 1.0 W and 9.0 W (1) Load VSWR = 8:1, All Phase Angles			All spurious outputs more than 60 dB below desired signal		

NOTES:
1. Adjust V_{Cont} for specified P_{out}.
2. MHW707–4 Specifications: P_{out} = 7.0 W @ 490 MHz
   P_{out} = 6.5 W @ 512 MHz

REV 7

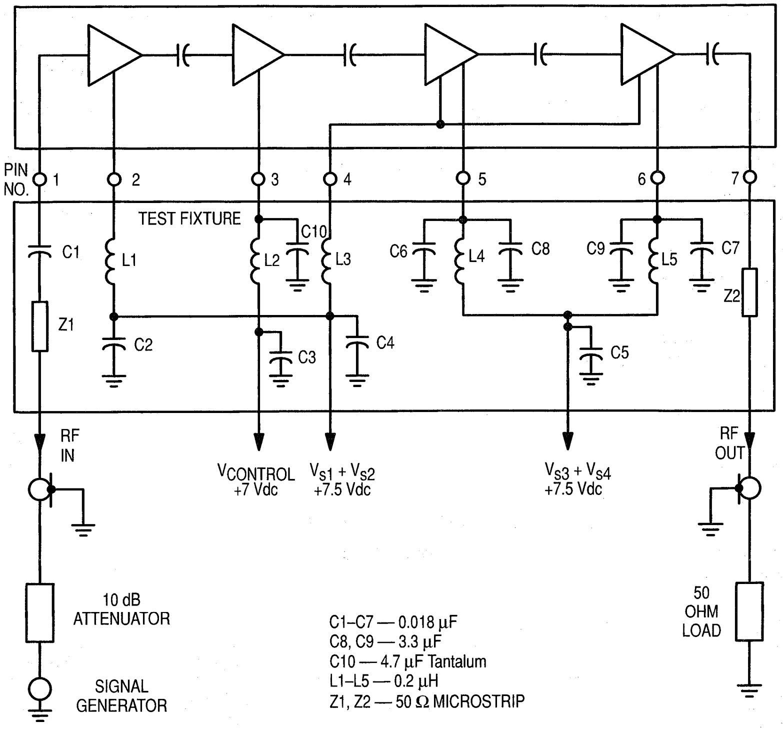


Figure 1. Power Module Test System Block Diagram

TYPICAL CHARACTERISTICS
(MHW707–1)

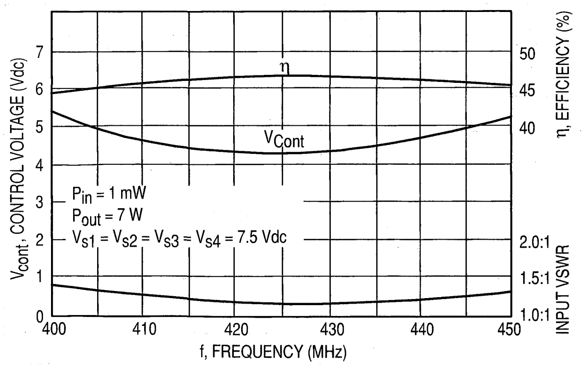


Figure 2. Control Voltage, Efficiency and VSWR versus Frequency

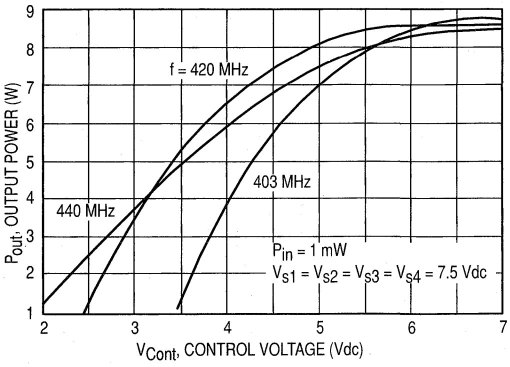


Figure 3. Output Power versus Control Voltage

TYPICAL CHARACTERISTICS
(MHW707–1)

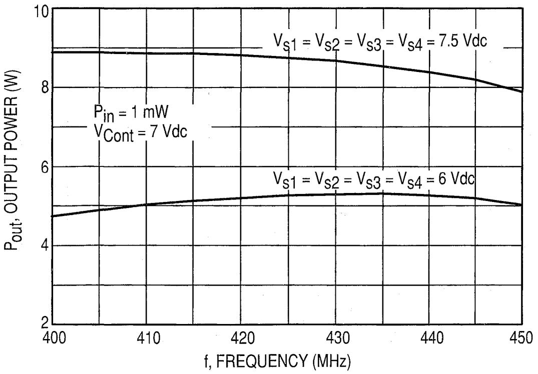


Figure 4. Output Power versus Frequency

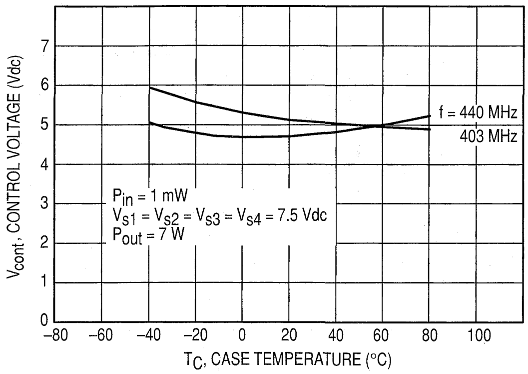


Figure 5. Control Voltage versus Case Temperature

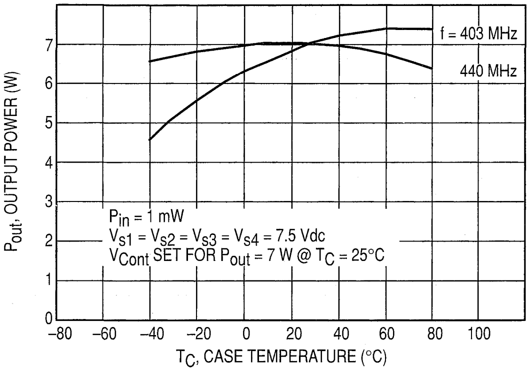


Figure 6. Output Power versus Case Temperature

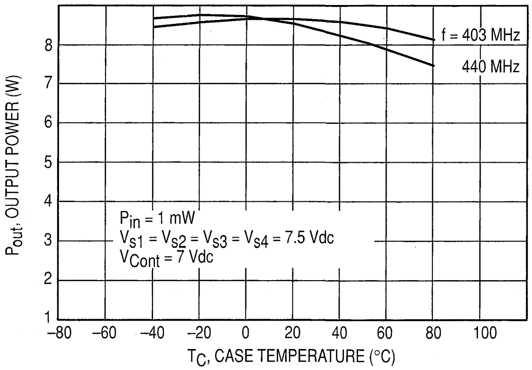


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

TYPICAL CHARACTERISTICS
(MHW707–2)

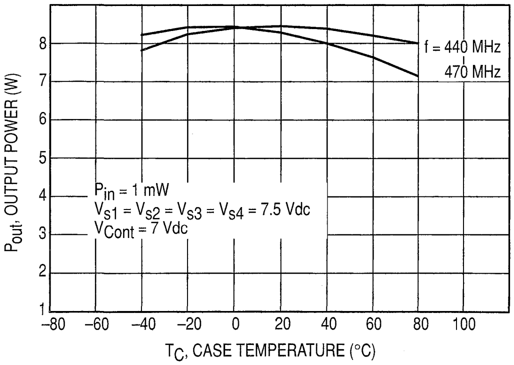


Figure 8. Output Power versus Case Temperature at Maximum Control Voltage

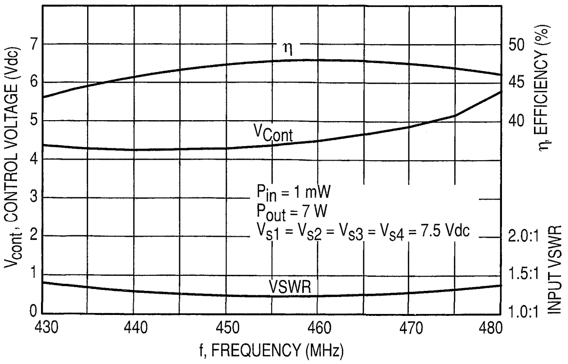


Figure 9. Control Voltage Efficiency and VSWR versus Frequency

TYPICAL CHARACTERISTICS
(MHW707–2)

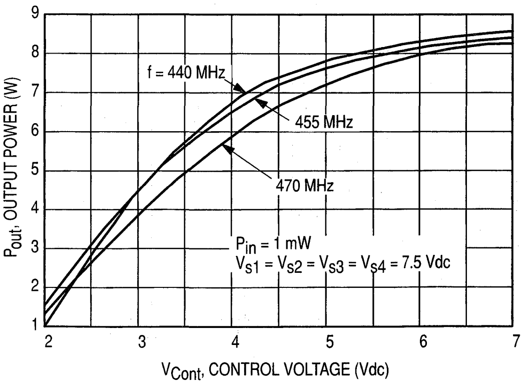


Figure 10. Output Power versus Control Voltage

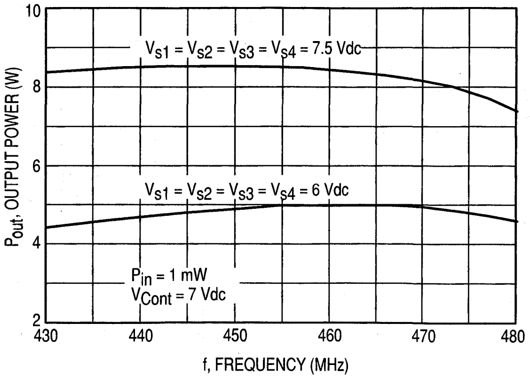


Figure 11. Output Power versus Frequency

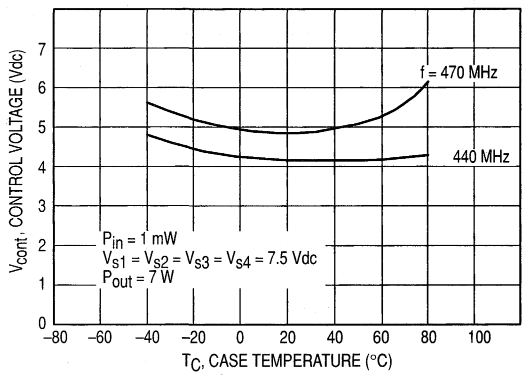


Figure 12. Control Voltage versus Case Temperature

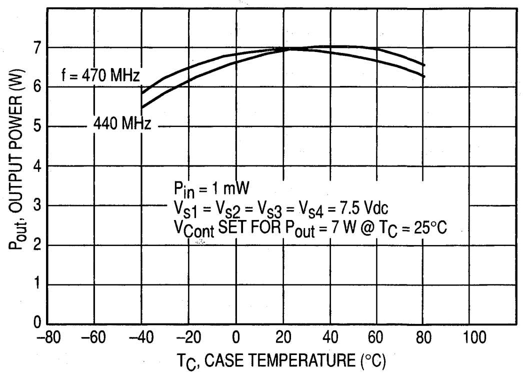


Figure 13. Output Power versus Case Temperature

TYPICAL CHARACTERISTICS
(MHW707–3)

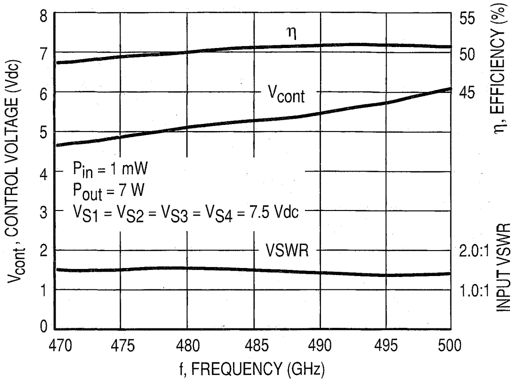


Figure 14. Control Voltage, Efficiency and VSWR versus Frequency

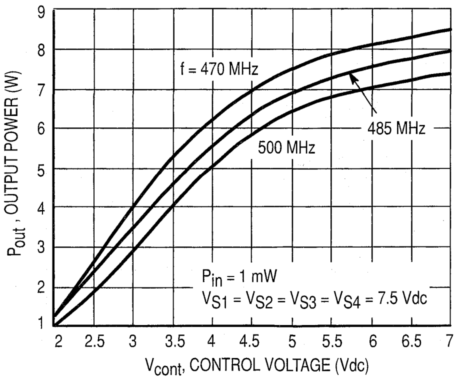


Figure 15. Output Power versus Control Voltage

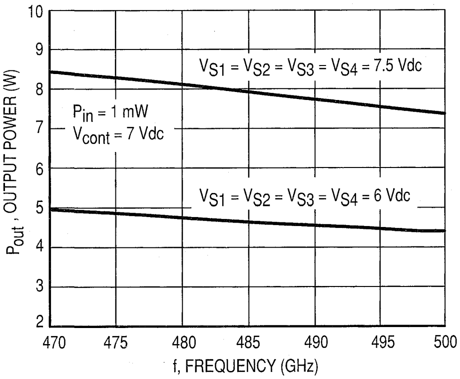


Figure 16. Output Power versus Frequency

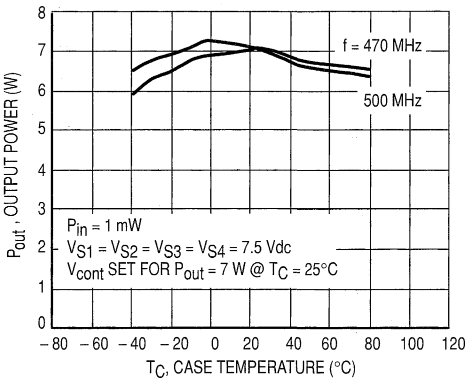


Figure 17. Output Power versus Case Temperature

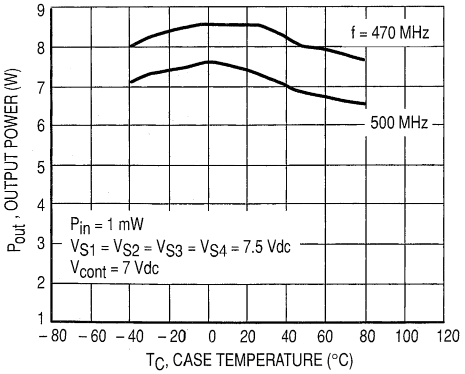


Figure 18. Output Power versus Case Temperature at Maximum Control Voltage

TYPICAL CHARACTERISTICS
(MHW707–4)

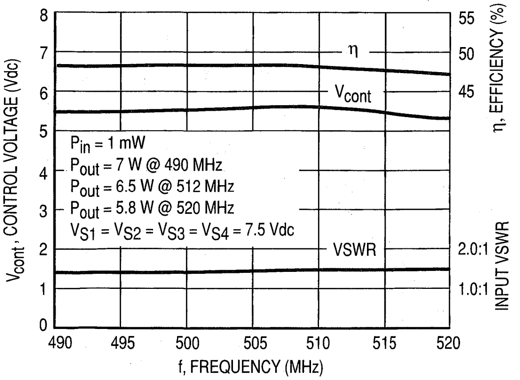


Figure 19. Control Voltage, Efficiency and VSWR versus Frequency

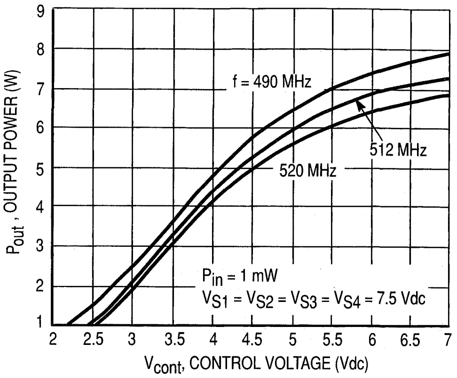


Figure 20. Output Power versus Control Voltage

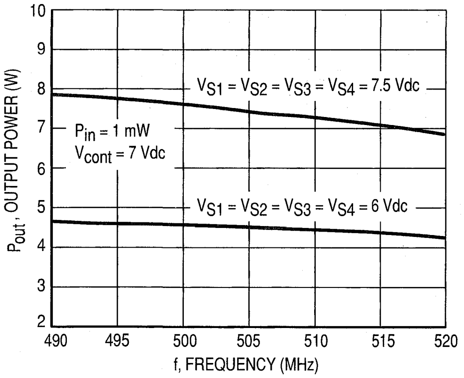


Figure 21. Output Power versus Frequency

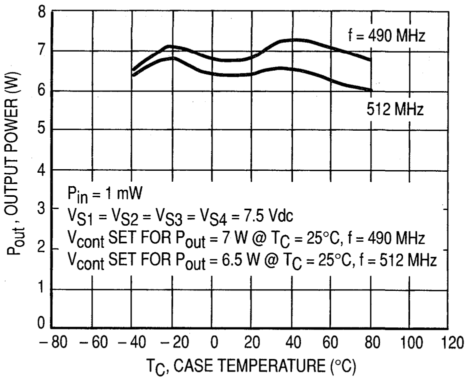


Figure 22. Output Power versus Case Temperature

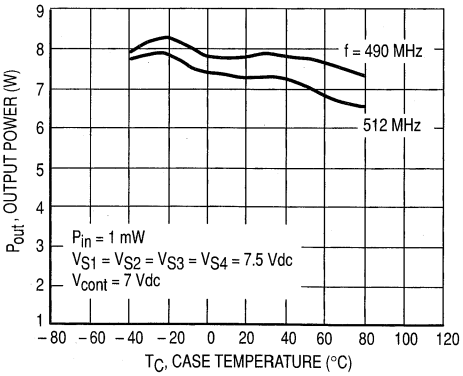


Figure 23. Output Power versus Case Temperature at Maximum Control Voltage

APPLICATIONS INFORMATION

NOMINAL OPERATION

All electrical specifications are based on the nominal conditions of $V_{S1} = V_{S2} = V_{S3} = V_{S4} = 7.5$ Vdc (Pins 2, 4, 5, 6) and P_{out} equal to 7.0 watts (6.5 W for MHW707–4). With these conditions, maximum current density on any device is 1.5×10^5 A/cm^2. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the limits of published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output should be limited to 7.0 watts. The preferred method of power output control is to fix $V_{S1} = V_{S2} = V_{S3} = V_{S4} = 7.5$ Vdc (Pins 2, 4, 5, 6), P_{in} (Pin 1) at 1.0 mW, and vary V_{cont} (Pin 3) voltage.

DECOUPLING

Due to the high gain of the four stages and the module size limitation, external decoupling networks require careful consideration. Pins 2, 3, 5 and 6 are internally bypassed with a 0.018 µF chip capacitor which is effective for frequencies from 5.0 MHz through 940 MHz. For bypassing frequencies below 5.0 MHz, networks equivalent to that shown in Figure 1 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

LOAD MISMATCH

During final test, each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{S1} = V_{S2} = V_{S3} = V_{S4}$ equal to 9.0 Vdc, VSWR equal top 10:1, and output power equal to 9.0 watts.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

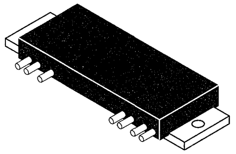
The RF Line
UHF Power Amplifiers

MHW720A1
MHW720A2

Capable of wide power range control as encountered in UHF cellular telephone applications.

- MHW720A1 400–440 MHz
- MHW720A2 440–470 MHz
- Specified 12.5 Volt, UHF Characteristics —
  Output Power = 20 Watts
  Minimum Gain = 21 dB
  Harmonics = –40 dB (Max)
- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

20 W, 400 to 470 MHz
RF POWER
AMPLIFIERS



CASE 700–04, STYLE 2

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating		Symbol	Value	Unit
DC Supply Voltages		V_{S1}, V_{S2}	15.5	Vdc
RF Input Power		P_{in}	250	mW
RF Output Power (@ $V_{S1} = V_{S2} = 12.5$ V)		P_{out}	25	W
Operating Case Temperature Range		T_C	–30 to +100	°C
Storage Temperature Range	MHW720A1, MHW720A2	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{S1} and V_{S2} set at 12.5 Vdc, T_C = 25°C, 50 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Frequency Range	MHW720A1 MHW720A2	—	400 440	440 470	MHz
Input Power (P_{out} = 20 W)		P_{in}	—	150	mW
Power Gain (P_{out} = 20 W)		G_p	21	—	dB
Efficiency (P_{out} = 20 W)	MHW720A1, MHW720A2	η	35	—	%
Harmonics (P_{out} = 20 W, Reference)		—	—	–40	dB
Input Impedance (P_{out} = 20 W, 50 Ω Reference)		Z_{in}	—	2:1	VSWR
Gain Degradation (1) (P_{out} = 20 W, Reference Gain @ T_C = + 25°C)	T_C = –30°C T_C = +80°C	—	— —	–0.7 –0.7	dB
Load Mismatch (VSWR = 30:1, $V_{S1} = V_{S2}$ = 15.5 Vdc, P_{out} = 30 W)		—	No degradation in P_{out}		
Stability (P_{in} = 0 to 250 mW, $V_{S1} = V_{S2}$ = 10 to 15.5 Vdc) 1. Load VSWR = 4:1, 50 Ω Reference 2. Source VSWR = 2:1, 50 Ω Refernece	MHW720A1, MHW720A2	—	All spurious outputs more than 60 dB below desired signal		
Quiescent Current (I_{S1} No RF Drive Applied)	MHW720A1, MHW720A2	I_{S1} (q)	—	200	mA

NOTE:
1. *See Figure 5, Input Power versus Case Temperature*

REV 7

APPLICATIONS INFORMATION

Nominal Operation

All electrical specifications are based on the nominal conditions of V_{S1} (Pin 5) and V_{S2} (Pin 3) equal to 12.5 Vdc and with output power equaling 20 watts. With these conditions, maximum current density on any device is 1.5 x 10^5 A/cm^2 and maximum die temperature with 100° base plate temperature is 165°. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the limits of published specifications is not recommended unless prior communications regarding intended use has been made with the factory representative.

Gain Control

This module is designed for wide range P_{out} level control. The recommended method of power output control, as shown in Figure 3, is to fix V_{S1} and V_{S2} at 12.5 Vdc and vary the input RF drive level at Pin 7.

In all applications, the module output power should be limited to 20 watts.

Decoupling

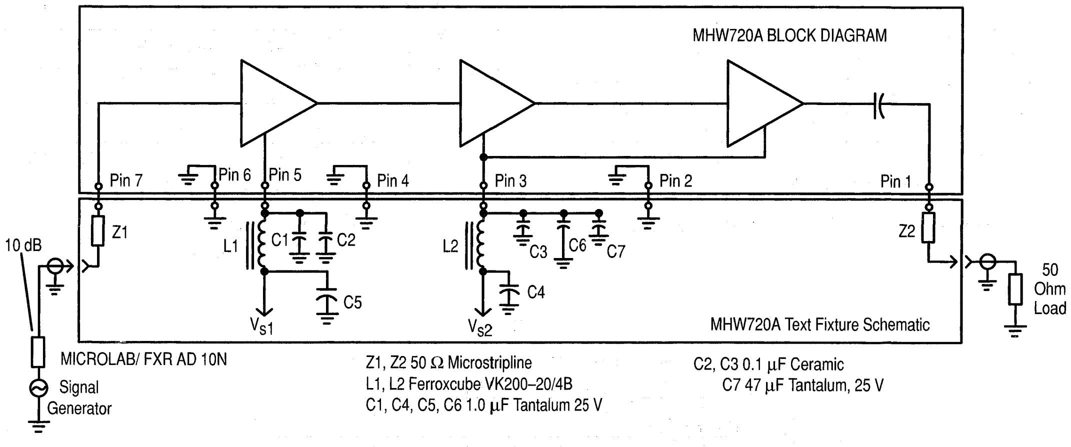
Due to the high gain of the three stages and the module size limitation, the external decoupling network requires careful consideration. Both Pins 3 and 5 are internally bypassed with a 0.018 µF chip capacitor effective for frequencies from 5 through 470 MHz. For bypassing frequencies below 5 MHz, networks equivalent to that shown in the test fixture schematic are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR less than 4:1.

Load Mismatch

During final test, each module is load mismatch tested in a fixture having the identical decoupling network described in Figure 1. Electrical conditions are V_{S1} and V_{S2} equal 15.5 V, load VSWR infinite, and output power equal to 30 watts.

Mounting Considerations

To insure optimum heat transfer from the flange to heatsink, use standard 6–32 mounting screws and an adequate quantity of silicon thermal compound (e.g., Dow Corning 340). With both mounting screws finger tight, alternately torque down the screws to 4–6 inch pounds. The heatsink mounting surface directly beneath the module flange should be flat to within 0.005 inch to prevent fracturing of ceramic substrate material. For more information on module mounting, see EB–107.



NOTE: No Internal D.C. blocking on input pin.

Figure 1. UHF Power Amplifier Test Setup

TYPICAL CHARACTERISTICS
MHW720A1, MHW720A2

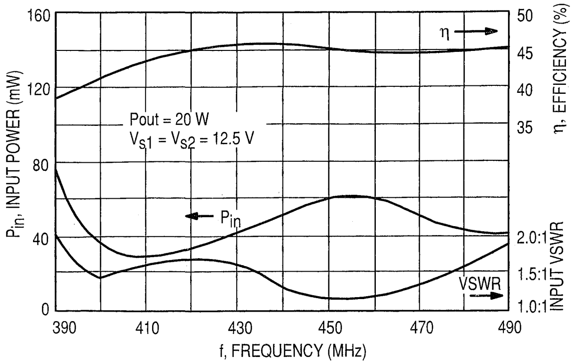


Figure 2. Input Power, Efficiency, and VSWR versus Frequency

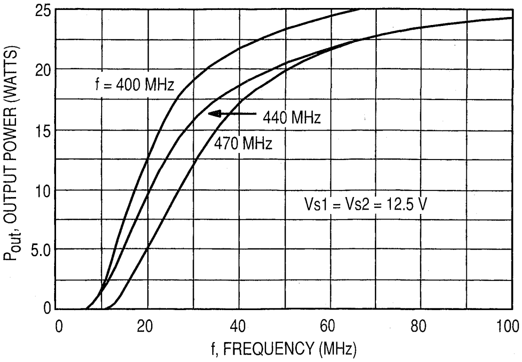


Figure 3. Output Power versus Input Power

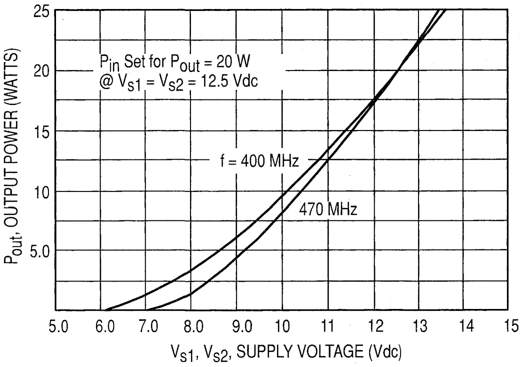


Figure 4. Output Power versus Voltage

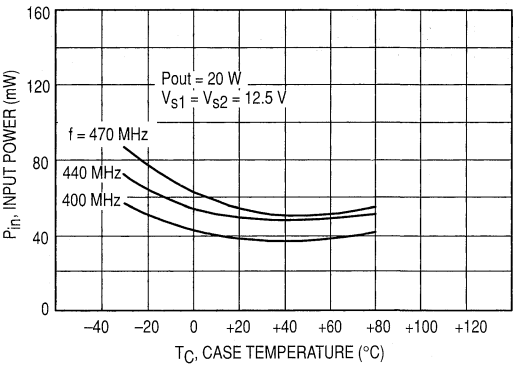


Figure 5. Input Power versus Case Temperature

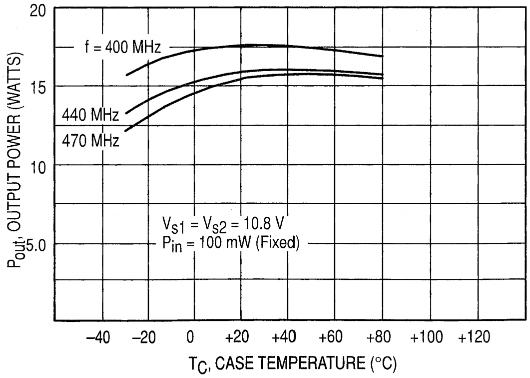


Figure 6. Output Power versus Case Temperature @ 10.8 V Supply

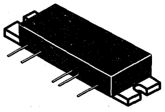
The RF Line
UHF Power Amplifiers

MHW803-1
MHW803-2
MHW803-3

. . . capable of wide power range control as encountered in portable cellular radio applications (30 dB typical).

- MHW803–1 820–850 MHz
- MHW803–2 806–870 MHz
- MHW803–3 870–905 MHz
- Specified 7.5 Volt Characteristics
  RF Input Power = 1 mW (0 dBm)
  RF Output Power = 2 Watts
  Minimum Gain ($V_{Control}$ = 4 V) = 33 dB
  Harmonics = −45 dBc Max @ 2 f_o
- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

2 W, 806 to 905 MHz
UHF POWER
AMPLIFIERS



CASE 301E–04, STYLE 1

MAXIMUM RATINGS (Flange Temperature = 25°C)

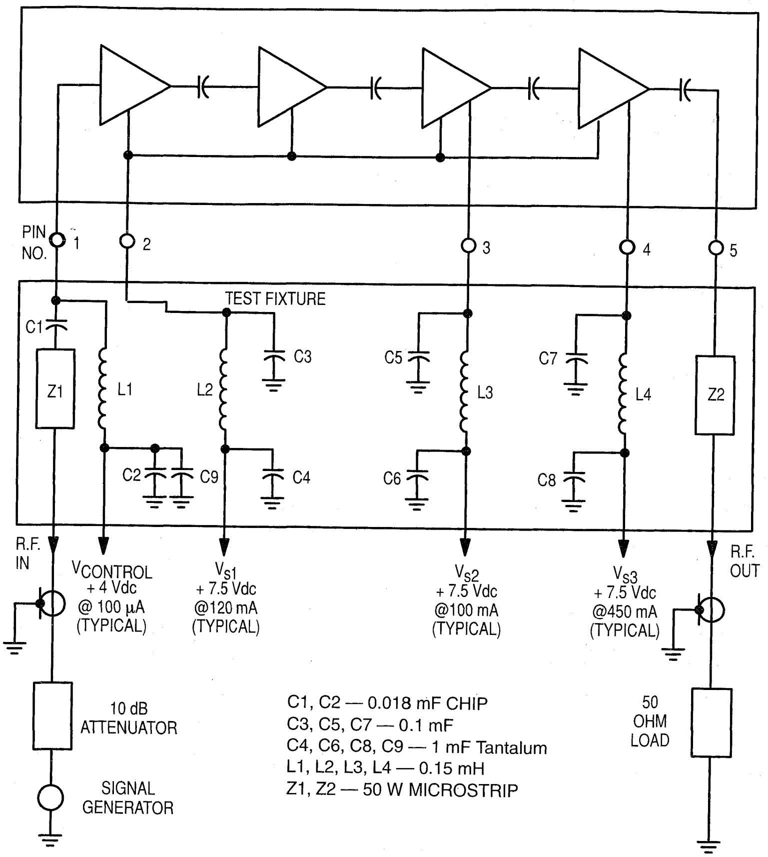
Rating	Symbol	Value	Unit
DC Supply Voltage (Pins 2,3,4)	$V_{S1,2,3}$	10	Vdc
DC Control Voltage (Pin 1)	V_{Cont}	4	Vdc
RF Input Power	P_{in}	3	mW
RF Output Power (V_{S1} = V_{S2} = V_{S3} = 10 V)	P_{out}	3	W
Operating Case Temperature Range	T_C	−30 to +100	°C
Storage Temperature Range	T_{stg}	−30 to +100	°C

ELECTRICAL CHARACTERISTICS V_{S1} = V_{S2} = V_{S3} = 7.5 Vdc, (Pins 2,3,4), T_C = 25°C, 50 Ω System

Characteristic	Symbol	Min	Max	Unit
Frequency Range MHW803–1 MHW803–2 MHW803–3	—	820 806 870	850 870 905	MHz
Control Voltage (P_{out} = 2 W, P_{in} = 1 mW) (1)	V_{Cont}	0	4	Vdc
Quiescent Current (V_{S1}, Pin 2 = 7.5 Vdc) (2)	$I_{S1(q)}$	—	65	mA
Power Gain (P_{out} = 2 W, V_{Cont} = 4 Vdc)	G_p	33	—	dB
Efficiency (P_{out} = 2 W, P_{in} = 1 mW) (1)	η	37	—	%
Harmonics (P_{out} = 2 W) (1) 2 f_o (P_{in} = 1 mW) 3 f_o	—	—	−45 −55	dBc
Input VSWR (P_{out} = 2 W, P_{in} = 1 mW), 50 Ω Ref. (1)	—	—	2.0:1	—
Noise power 30 kHz Bandwidth, 45 MHz above fo (P_{out} = 2 W (1) T_C = +25°C (P_{in} = 1 mW) T_C = +100°C	 — —	 — —	 −85 −82	 dBm dBm
Load Mismatch (V_{S1} = V_{S2} = V_{S3} = 10 Vdc) VSWR = 10:1, P_{out} = 3 W, P_{in} = 3 mW (1)		No Degradation in Power Output		
Stability (P_{in} = 0.5–2 mW, V_{S1} = V_{S2} = V_{S3} = 6–9 Vdc) P_{out} between 0 mW and 2 W (1) Load VSWR = 6:1, Source VSWR = 3:1)		All spurious outputs more than 60 dB below desired signal		

NOTES:
1. Adjust V_{cont} for specified P_{out}.
2. V_{Cont} = 0 Vdc.

REV 6



C1, C2 — 0.018 mF CHIP
C3, C5, C7 — 0.1 mF
C4, C6, C8, C9 — 1 mF Tantalum
L1, L2, L3, L4 — 0.15 mH
Z1, Z2 — 50 W MICROSTRIP

Figure 1. Power Module Test System Block Diagram

TYPICAL CHARACTERISTICS
(MHW803–1,–2)

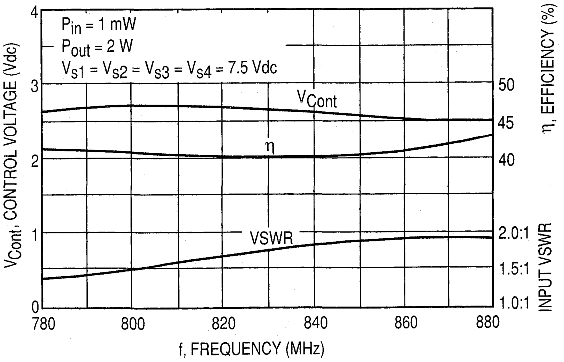


Figure 2. Control Voltage, Efficiency and VSWR versus Frequency

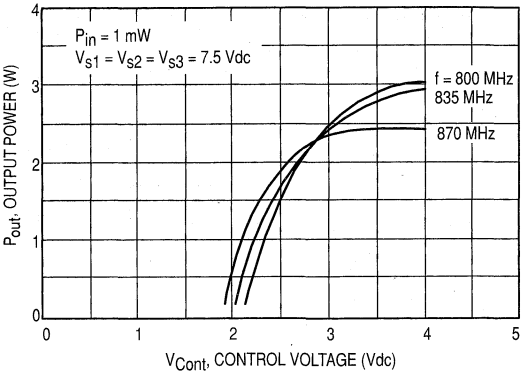


Figure 3. Output Power versus Control Voltage

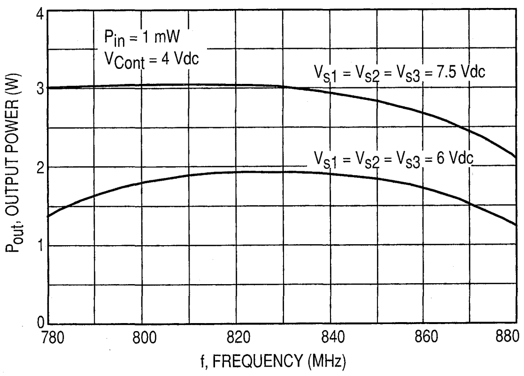


Figure 4. Output Power versus Frequency

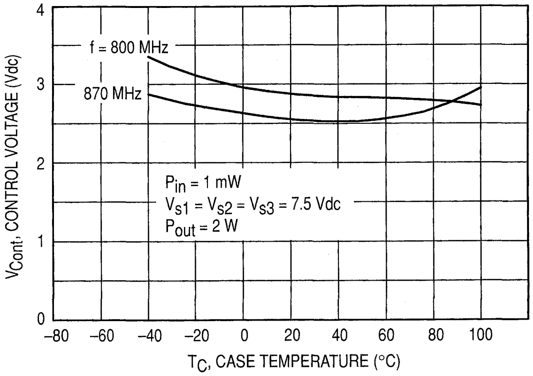


Figure 5. Control Voltage versus Case Temperature

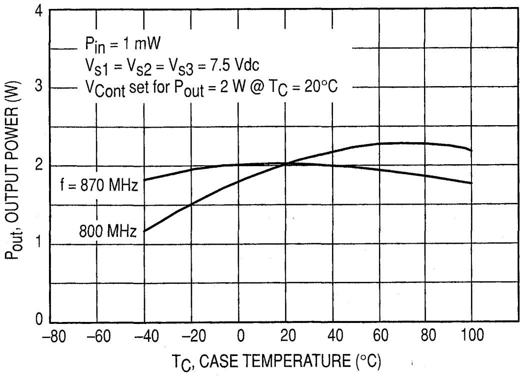


Figure 6. Output Power versus Case Temperature

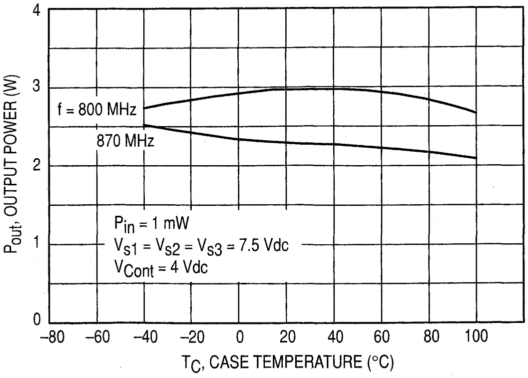


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

TYPICAL CHARACTERISTICS
(MHW803–3)

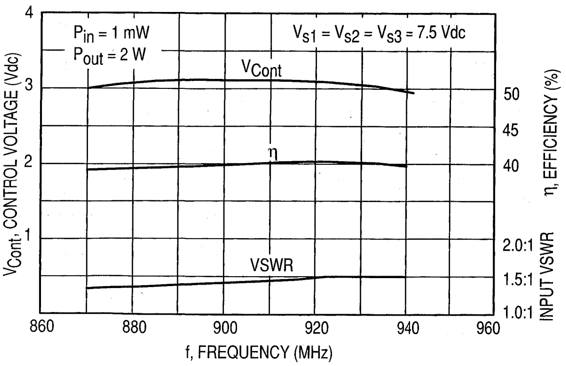


Figure 8. Control Voltage, Efficiency and VSWR versus Frequency

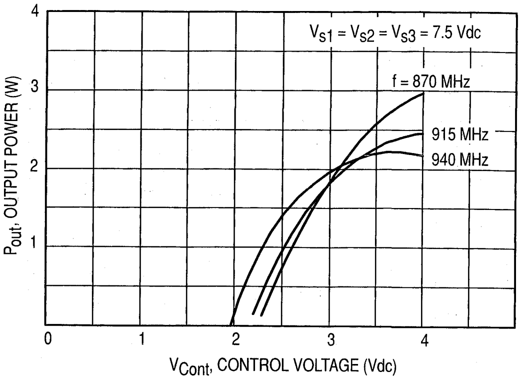


Figure 9. Output Power versus Control Voltage

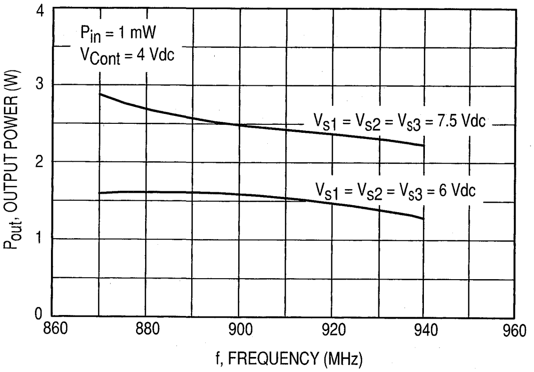


Figure 10. Output Power versus Frequency

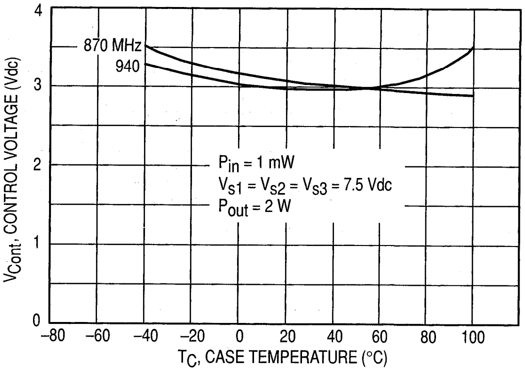


Figure 11. Control Voltage versus Case Temperature

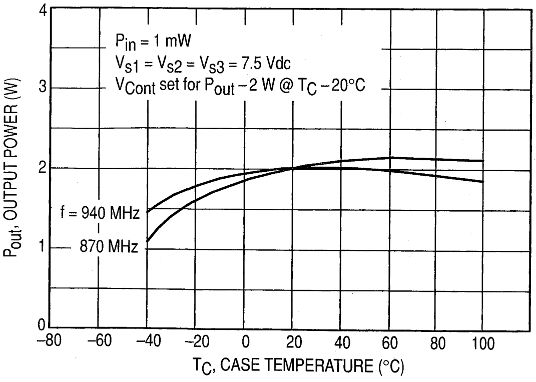


Figure 12. Output Power versus Case Temperature

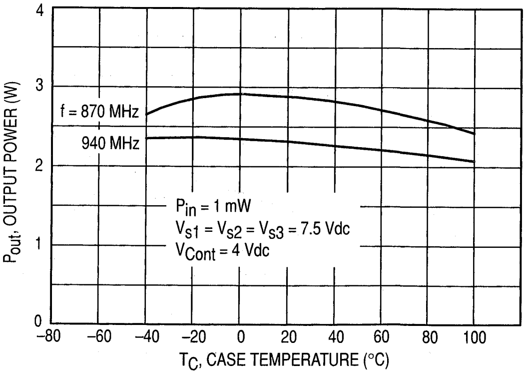


Figure 13. Output Power versus Case Temperature at Maximum Control Voltage

APPLICATIONS INFORMATION

NOMINAL OPERATION

All electrical specifications are based on the nominal conditions of $V_{S1} = V_{S2} = V_{S3} = 7.5$ Vdc (Pins 2, 3, 4) and P_{out} equal to 2 watts. With these conditions, maximum current density on any device is 1.5 x 10^5 A/cm^2 and maximum die temperature with 100°C case operating temperature is 165°C. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the limits of published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output should be limited to 2 watts. The preferred method of power output control is to fix $V_{S1} = V_{S2} = V_{S3} = 7.5$ Vdc (Pins 2, 3, 4), P_{in} (Pin 1) at 1 mW, and vary V_{Cont} (Pin 1) voltage.

DECOUPLING

Due to the high gain of the three stages and the module size limitation, external decoupling networks require careful consideration. Pins 2, 3 and 4 are internally bypassed with a 0.018 μF chip capacitor which is effective for frequencies from 5 MHz through 905 MHz. For bypassing frequencies below 5 MHz, networks equivalent to that shown in Figure 1 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

LOAD MISMATCH

During final test, each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{S1} = V_{S2} = V_{S3}$ equal to 10 Vdc, VSWR equal to 10:1, and output power equal to 3 watts.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

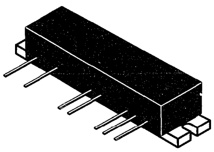
The RF Line
UHF Power Amplifiers

MHW804-1

4.0 WATTS
800 to 870 MHz
RF POWER
AMPLIFIERS

Designed specifically for portable radio applications. The MHW804 is capable of wide power range control, operates from a 7.5 volt supply and requires only 1.0 mW of RF input power.

- Specified 7.5 Volt Characteristics:
  RF Input Power — 1.0 mW (0 dBm)
  RF Output Power — 4.0 W
  Minimum Gain — 36 dB
  Harmonics — –45 dBc Max @ 2.0 f_o
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



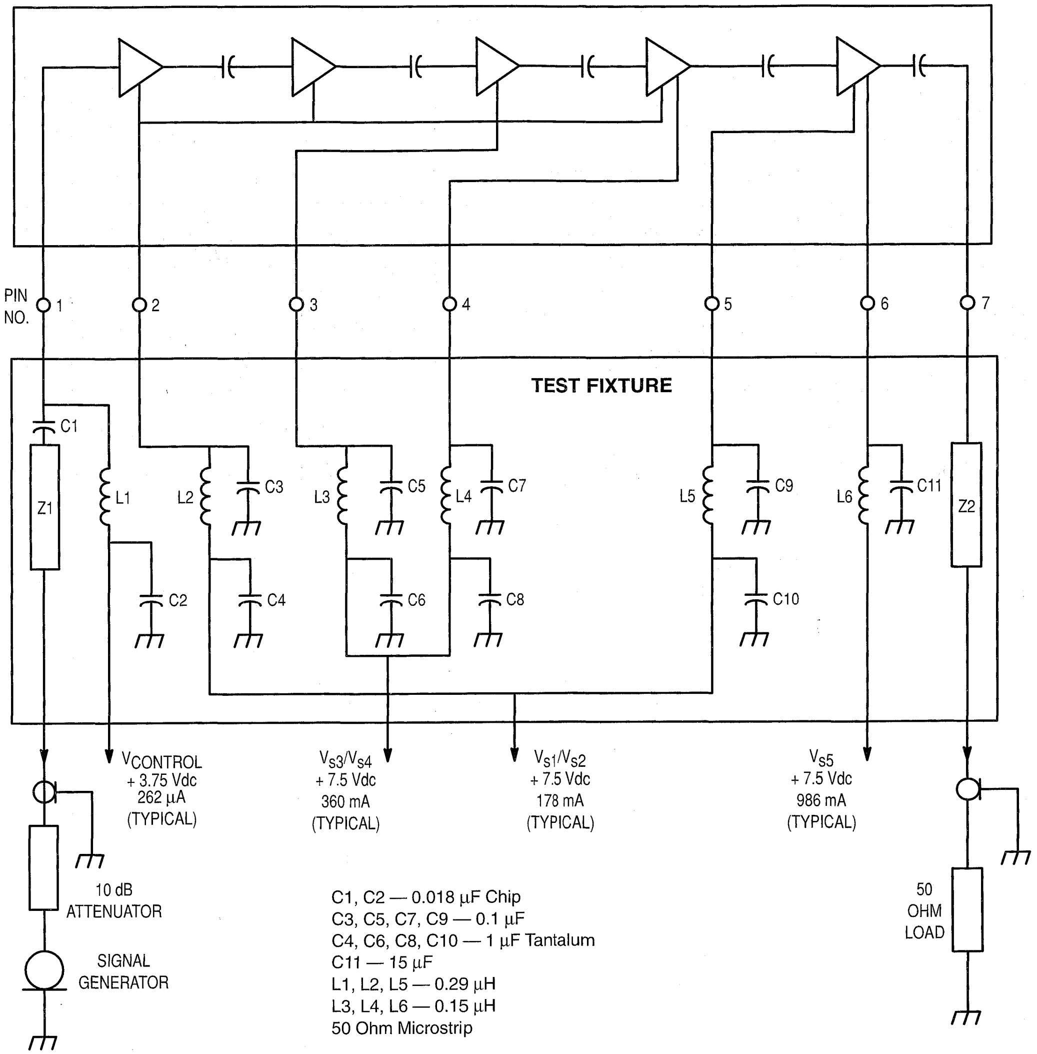
CASE 301F–03, STYLE 1

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage	V_s	10	Vdc
DC Control Voltage	V_{cont}	4.0	Vdc
RF Input Power	P_{in}	5.0	mW
RF Output Power	P_{out}	6.0	W
Operating Case Temperature Range	T_C	– 30 to +100	°C
Storage Temperature Range	T_{stg}	– 30 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = + 25°C, 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Frequency Range	BW	800	870	MHz
Power Gain ($V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5}$ = 7.5 V; V_{cont} = 3.75 V)	G_p	36	—	dB
Control Voltage (P_{in} = 0 dBm, P_{out} = 4.0 W, $V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5}$ = 7.5 V, Adjust V_{cont} for specified P_{out})	V_{cont}	—	3.75	Vdc
Efficiency (Same condition as for V_{cont})	η	32	—	%
Current Drain (Same conditions as for V_{cont}) IS1 + IS4 (Pins 2, 5) IS2 + IS3 + IS5 (Pins 3, 4, 6) $I_{control}$ (Pin 1)	I_D	— — —	210 1430 0.2	mA
Input VSWR (Same conditions as for V_{cont})	$VSWR_{in}$	—	2.0:1	—
Harmonic Content (Same conditions as for V_{cont}) 2.0 f_o 3.0 f_o	—	— —	– 45 – 50	dBc
Leakage Current — $I_{S2} + I_{S3} + I_{S5}$ ($V_{S2} = V_{S3} = V_{S5}$ = 7.5 V; $V_{S1} = V_{S4}$ = 0 V V_{cont} = 0 V; P_{in} = 0 mW)	I_L	—	0.3	mA
Standby Current — $I_{S1} + I_{S4}$ ($V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5}$ = 7.5 V V_{cont} = 4.0 V; P_{in} = 0 mW)	I_S	—	220	mA
Load Mismatch Stress ($V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5}$ = 9.0 V; P_{in} = 2.0 mW; P_{out} = 6.0 W; Load VSWR = 20:1, All Phase Angles. Adjust V_{cont} for Specified P_{out})	ψ	No Degradation in Output Power		
Stability ($V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5}$ = 6.0 to 9.0 V; P_{IN} = – 1.0 dBm to + 3.0 dBm; P_{out} = 1.0 W to 4.0 W; Load VSWR = 6:1, All Phase Angles; Adjust V_{cont} for Specified P_{out})	—	All Spurious Outputs More Than 60 dB Below Desired Signal		



C1, C2 — 0.018 µF Chip
C3, C5, C7, C9 — 0.1 µF
C4, C6, C8, C10 — 1 µF Tantalum
C11 — 15 µF
L1, L2, L5 — 0.29 µH
L3, L4, L6 — 0.15 µH
50 Ohm Microstrip

Figure 1. Power Module Test System Block Diagram

TYPICAL CHARACTERISTICS

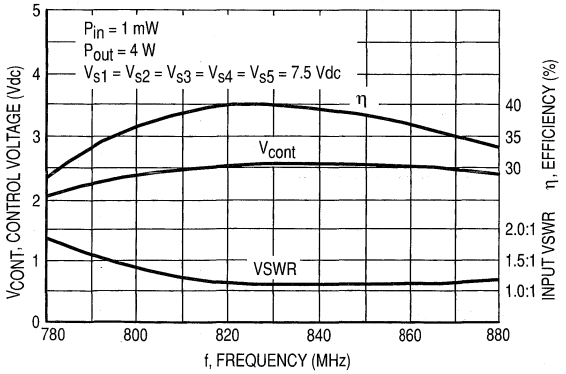


Figure 2. Control Voltage, Efficiency and VSWR versus Frequency

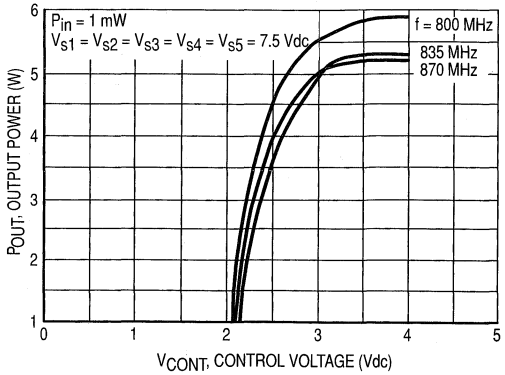


Figure 3. Output Power versus Control Voltage

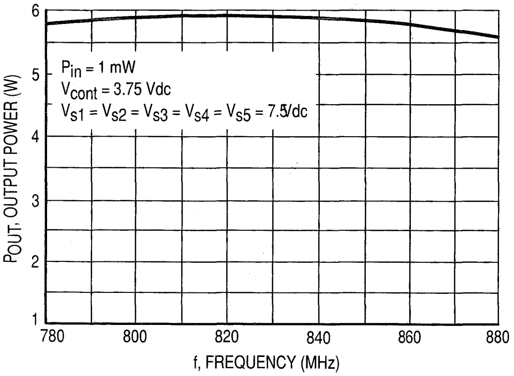


Figure 4. Output Power versus Frequency

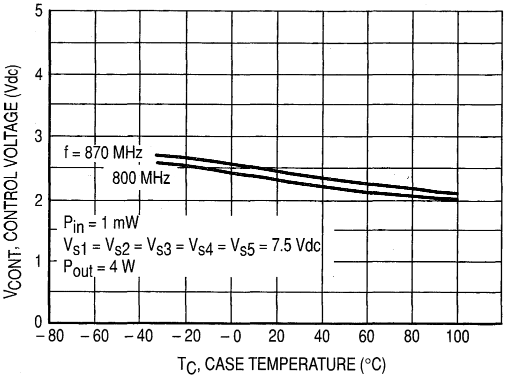


Figure 5. Control Voltage Case Temperature

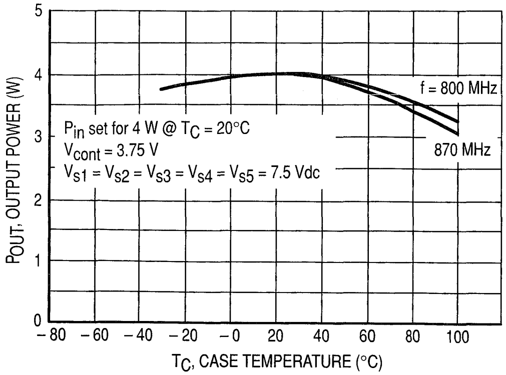


Figure 6. Output Power versus Case Temperature

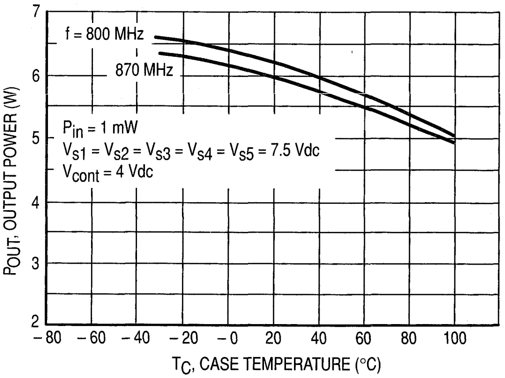


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

APPLICATIONS INFORMATION

NOMINAL OPERATION

All electrical specifications are based on the nominal conditions of $V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5} = 7.5$ Vdc (Pins 2, 3, 4, 5, 6) and P_{out} equal to 4.0 watts. With these conditions, maximum current density on any device is 1.5×10^5 A/cm^2 and maximum die temperature with 100°C case operating temperature is 165°C. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the limits of published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output should be limited to 4.0 watts. The preferred method of power output control is to fix $V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5} = 7.5$ Vdc (Pins 2, 3, 4, 5, 6), P_{in} (Pin 1) at 1.0 mW, and vary V_{cont} (Pin 1) voltage.

DECOUPLING

Due to the high gain of the four stages and the module size limitation, external decoupling networks require careful consideration. Pins 2, 3, 4, and 6 are internally bypassed with a 0.018 μF chip capacitor which is effective for frequencies from 5.0 MHz through 925 MHz. For bypassing frequencies below 5.0 MHz, networks equivalent to that shown in Figure 1 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

LOAD MISMATCH

During final test, each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{S1} = V_{S2} = V_{S3} = V_{S4} = V_{S5}$ equal to 9.0 V, VSWR equal to 20:1, and output power equal to 6.0 watts.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

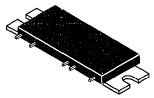
The RF Line
UHF Power Amplifiers

MHW851-1
MHW851-2
MHW851-3
MHW851-4

. . . capable of wide power range control as encountered in portable cellular radio applications (30 dB typical).

- High Efficiency
- MHW851–1: f = 820–850 MHz
- MHW851–2: f = 870–905 MHz
- MHW851–3: f = 890–915 MHz
- MHW851–4: f = 915–925 MHz
- Specified 6.0 Volt Characteristics
  RF Input Power = 1.0 mW (0 dBm)
  RF Output Power
  = 1.6 Watts (MHW851–1,–2,–4)
  = 2.0 Watts (MHW851–3)
  Minimum Gain
  ($V_{Control}$ = 3.5 V) = 32 dB (MHW851–1,–2,–4)
  ($V_{Control}$ = 3.5 V) = 33 dB (MHW851–3)
  Harmonics = –45 dBc Max @ 2.0 f_o
- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Epoxy Glass PCB Construction Gives Consistent Performance and Reliability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

1.6 W, 820–925 MHz
RF POWER
AMPLIFIERS



CASE 301N–02, STYLE 1

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage (Pins 2, 3, 4)	$V_{S1,2,3}$	7.5	Vdc
DC Control Voltage (Pin 1)	V_{Cont}	4.0	Vdc
RF Input Power	P_{in}	3.0	mW
RF Output Power ($V_{S1} = V_{S2} = V_{S3}$ = 7.5 V)	P_{out}	3.0	W
Operating Case Temperature Range	T_C	–30 to +100	°C
Storage Temperature Range	T_{stg}	–30 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{S1} = V_{S2} = V_{S3}$ = 6.0 Vdc, (Pins 2, 3, 4), T_C = 25°C, 50 Ω System)

Characteristic		Symbol	Min	Max	Unit
Frequency Range	MHW851–1	BW	820	850	MHz
	MHW851–2		870	905	
	MHW851–3		890	915	
	MHW851–4		915	925	
Control Voltage (P_{out} = 1.6 W, P_{in} = 1.0 mW) (1)(3)		V_{Cont}	0	3.5	Vdc
Quiescent Current (V_{S1}, Pin 2 = 6.0 Vdc) (2)		$I_{S1(q)}$	—	65	mA
Power Gain (P_{out} = 1.6 W, V_{Cont} = 3.5 Vdc) (3)	MHW851–1,–2,–4	G_p	32	—	dB
(P_{out} = 2.0 W, V_{Cont} = 3.5 Vdc)	MHW851–3		33		
Efficiency (P_{out} = 1.6 W, P_{in} = 1.0 mW) (1) (3)		η	45	—	%

NOTES:
1. Adjust V_{cont} for specified P_{out}.
2. V_{Cont} = 0 Vdc.
3. P_{out} = 2.0 watts for MHW851–3 only.

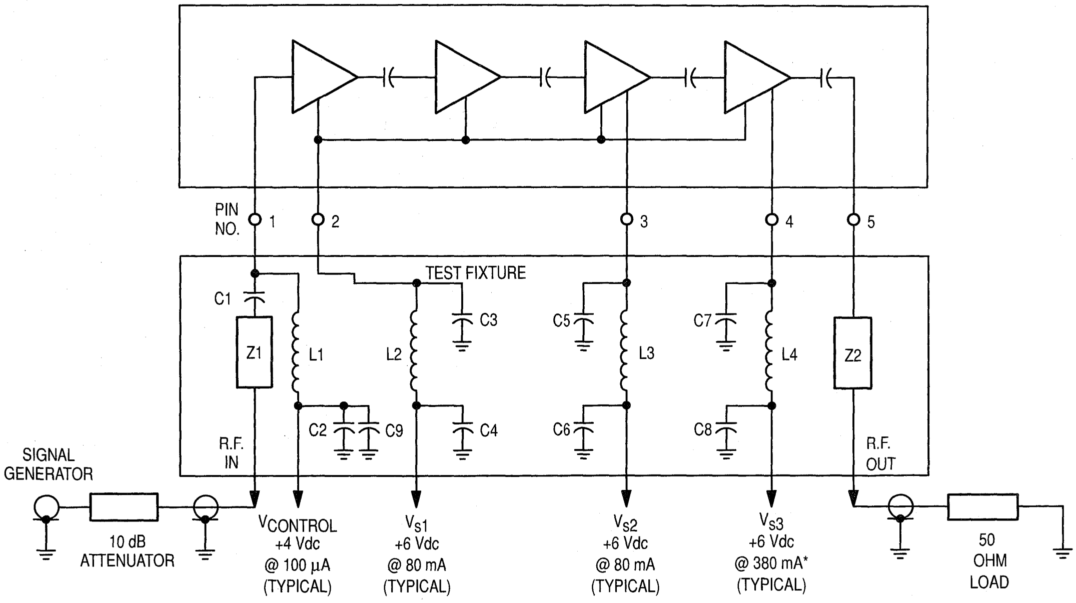
REV 6

ELECTRICAL CHARACTERISTICS — continued ($V_{S1} = V_{S2} = V_{S3}$ = 6.0 Vdc, (Pins 2, 3, 4), T_C = 25°C, 50 Ω System)

Characteristic	Symbol	Min	Max	Unit
Harmonics (P_{out} = 1.6 W) (1)(3) 2.0 f_o (P_{out} = 1.0 mW) 3.0 f_o	—	—	−45 −55	dBc
Input VSWR (P_{out} = 1.6 W, V_{Cont} = 3.5 V) (3)(4)	$VSWR_{in}$	—	2.0:1	—
Noise Power 30 kHz Bandwidth, 45 MHz, above f_o (P_{out} = 1.6 W) (1)(3) T_C = +25°C (P_{in} = 1.0 mW) T_C = +100°C	—	 — —	 −85 −82	dBm
Load Mismatch ($V_{S1} = V_{S2} = V_{S3}$ = 7.5 Vdc) VSWR = 10:1, P_{out} = 3.0 W, P_{in} = 3.0 mW) (1)	ψ	No Degradation in Power Output		
Stability (P_{in} = 0.5–2.0 mW, $V_{S1} = V_{S2} = V_{S3}$ = 4.8–7.5 Vdc P_{out} between 0 mW and 1.6 W (1)(3) Load VSWR = 6:1, Source VSWR = 3:1)		All spurious outputs more than 60 dB below desired signal		

NOTES:

1. Adjust V_{Cont} for specified P_{out}.
2. V_{Cont} = 0 Vdc.
3. P_{out} = 2.0 watts for MHW851–3 only.
4. Adjust P_{in} for specified P_{out}.



C1, C2 — 0.018 mF CHIP
C3, C5, C7 — 0.1 mF
C4, C6, C8, C9 — 1 mF TANTALUM
L1, L2, L3, L4 — 0.15 mH
Z1, Z2 — 50 W MICROSTRIP

*480 mA for MHW851–3

Figure 1. Power Module Test System Block Diagram

TYPICAL CHARACTERISTICS

MHW851–1 and MHW851–2

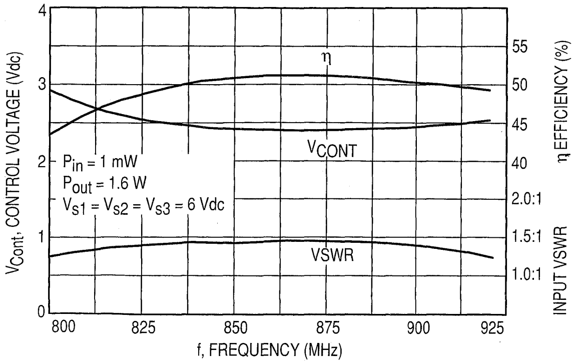


Figure 2. Control Voltage, Efficiency and Input VSWR versus Frequency

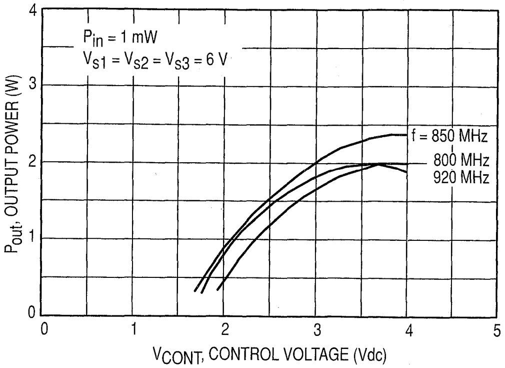


Figure 3. Output Power versus Control Voltage

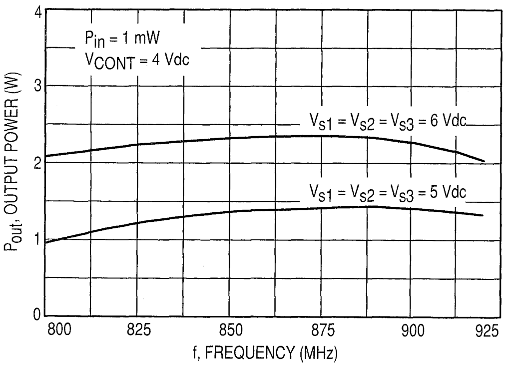


Figure 4. Output Power versus Frequency

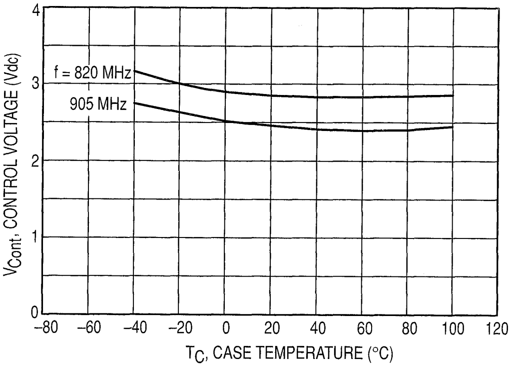


Figure 5. Control Voltage versus Case Temperature

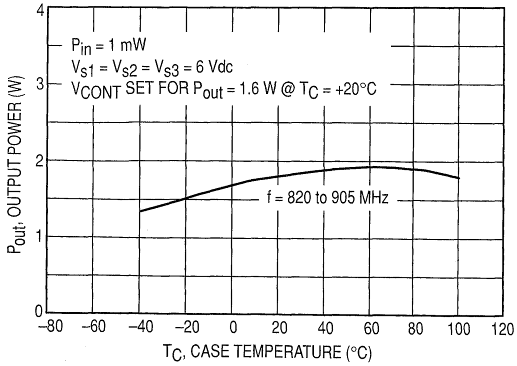


Figure 6. Output Power versus Case Temperature

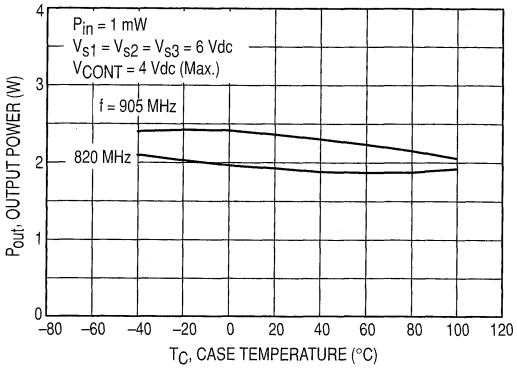


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

TYPICAL CHARACTERISTICS (continued)

MHW851–3 and MHW851–4

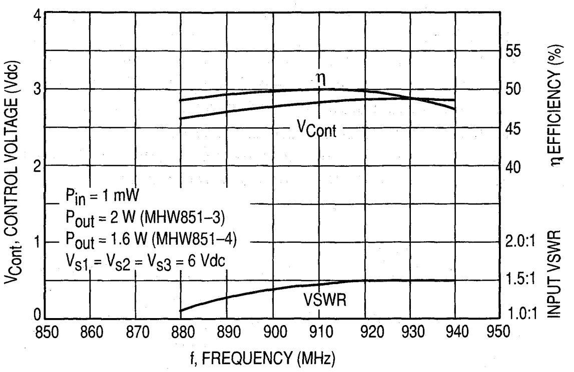


Figure 8. Control Voltage, Efficiency and VSWR versus Frequency

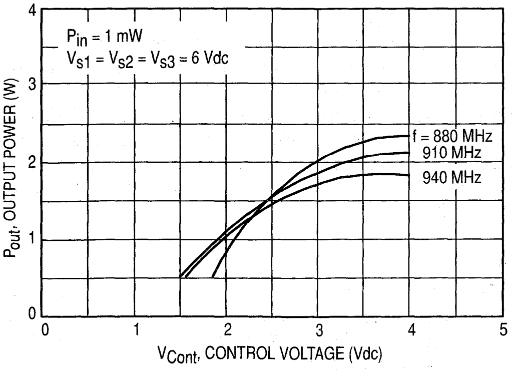


Figure 9. Output Power versus Control Voltage

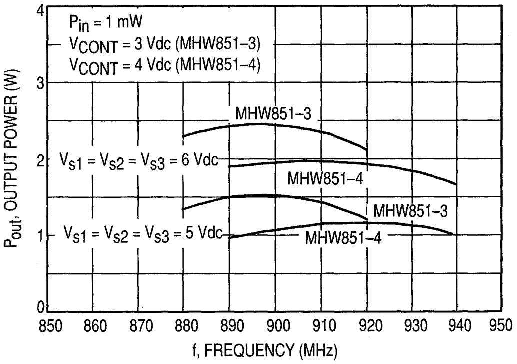


Figure 10. Output Power versus Frequency

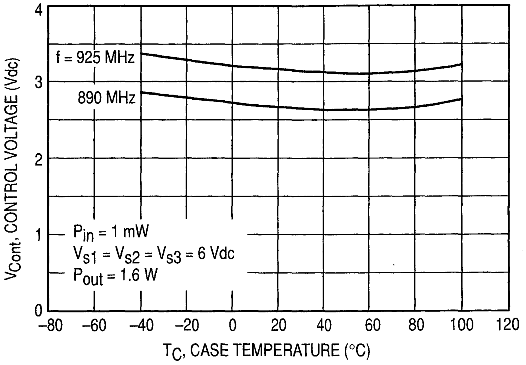


Figure 11. Control Voltage versus Case Temperature

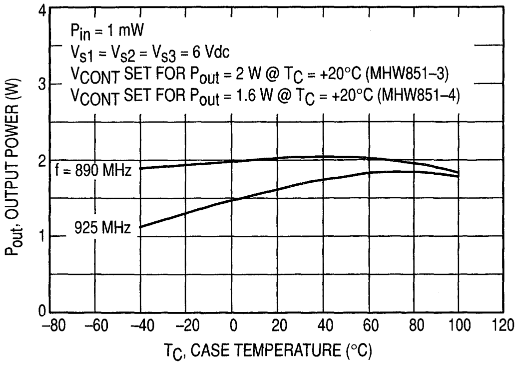


Figure 12. Output Power versus Case Temperature

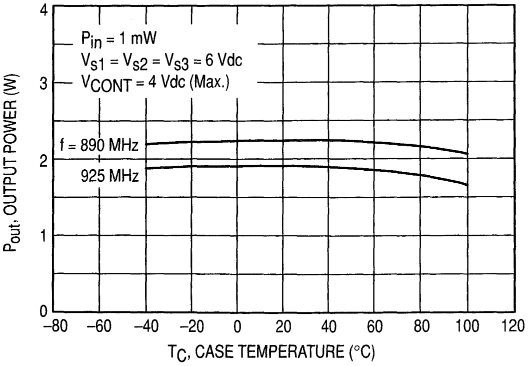


Figure 13. Output Power versus Case Temperature at Maximum Control Voltage

APPLICATIONS INFORMATION

NOMINAL OPERATION

All electrical specifications are based on the nominal conditions of $V_{S1} = V_{S2} = V_{S3} = 6.0$ Vdc (Pins 2, 3, 4). With these conditions, maximum current density on any device is 1.5×10^5 A/cm^2 and maximum die temperature with 100°C case operating temperature is 165°C. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the limits of published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output should be limited to specified value. The preferred method of power output control is to fix $V_{S1} = V_{S2} = V_{S3} = 6.0$ Vdc (Pins 2, 3, 4), P_{in} (Pin 1) at 1 mW, and vary V_{Cont} (Pin 1) voltage.

DECOUPLING

Due to the high gain of the three stages and the module size limitation, external decoupling networks require careful consideration. Pins 2, 3 and 4 are internally bypassed with a 0.018 μF chip capacitor which is effective for frequencies from 5 MHz through 940 MHz. For bypassing frequencies below 5 MHz, networks equivalent to that shown in Figure 1 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

Remember that the modules are NOT hermetic. Do not immerse a module in a flux cleaning solution or other liquids under any circumstances.

LOAD MISMATCH

During final test, each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{S1} = V_{S2} = V_{S3}$ equal to 7.5 Vdc, VSWR equal to 10:1, and output power equal to 3 watts.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

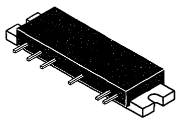
Advance Information

The RF Line

UHF Power Amplifier

MHW909

9.0 W
890 to 915 MHz
RF POWER
AMPLIFIER



CASE 301T–02, STYLE 1

. . . designed specifically for the Pan European digital 5.0 watt, GSM handheld radio. The MHW909 is capable of wide power range control, operates from a 7.2 volt supply and requires 100 mW of RF input power.

- Specified 7.2 Volt Characteristics:
  RF Input Power — 100 mW (20 dBm)
  RF Output Power — 9.0 W
  Minimum Gain — 19.5 dB
  Harmonics — –35 dBc Max @ 2.0 f_o
- New Biasing and Control Techniques Providing Dynamic Range and Control Circuit Bandwidth Ideal for GSM
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Test fixture circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage	V_S	9.0	Vdc
DC Bias Voltage	V_B	4.75	Vdc
RF Input Power	P_{in}	400	mW
RF Output Power (V_S = 9.0 Vdc)	P_{out}	10	W
Operating Case Temperature Range	T_C	–30 to +100	°C
Storage Temperature Range	T_{stg}	–30 to +100	°C

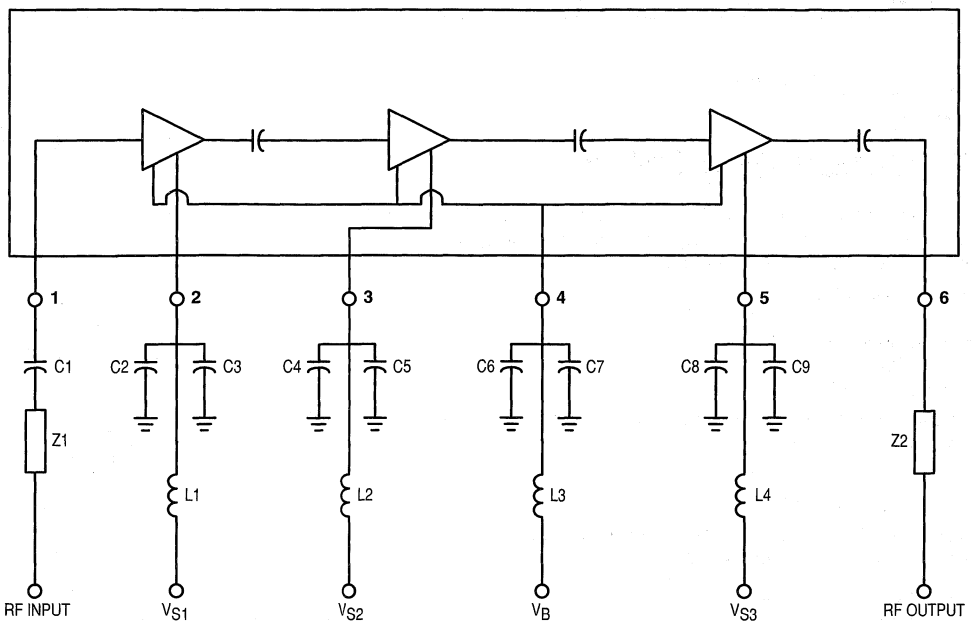
ELECTRICAL CHARACTERISTICS ($V_{S1} = V_{S2} = V_{S3}$ = 7.2 Vdc; V_B = 4.5 Vdc, T_C = +25°C, 50 ohm system, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Frequency Range		BW	890	915	MHz
Power Gain (P_{out} = 9.0 W) (1)		G_p	19.5	—	dB
Leakage Current (P_{in} = 0 mW, V_B = 0 Vdc, $V_{S1} = V_{S2} = V_{S3}$ = 9.0 Vdc)		I_L	—	5.0	mA
Efficiency (P_{out} = 9.0 W) (1)		η	30	—	%
Input VSWR (P_{out} = 9.0 W) (1)		$VSWR_{in}$	—	2.0:1	—
Harmonics (P_{out} = 9.0 W) (1)	2.0 f_o 3.0 f_o to 5.0 f_o		—	–35 –40	dBc
Noise Power (In 30 kHz Bandwidth, 935 to 960 MHz frequency range; (P_{out} = 0.03 to 9.0 W; $V_{S1} = V_{S2} = V_{S3}$ = 6.25 to 9.0 Vdc) (1)			—	–75	dBm
Linearity — % AM in Output (P_{out} = 0.2 to 9.0 W; 135 kHz 1% AM in Input) (1)		—	—	6.0	%
Output Power, Low Voltage (P_{in} = 100 mW; $V_{S1} = V_{S2} = V_{S3}$ = 6.25 Vdc)		P_{out2}	6.8	—	W
Load Mismatch Stress ($V_{S1} = V_{S2} = V_{S3}$ = 9.0 Vdc; V_B = 4.75 Vdc; P_{out} = 10 W; Load VSWR = 10:1, All Phase Angles at Frequency of Test) (1)		ψ	No Degradation In Output Power Before/After Test		
Stability ($V_{S1} = V_{S2} = V_{S3}$ = 6.0 to 9.0 Vdc; P_{out} = 0.03 to 9.0 W; Load VSWR = 6:1, Source VSWR = 3:1, All Phase Angles at Frequency of Test) (1)		—	All Spurious Outputs More Than 60 dB Below Desired Signal		

NOTE:
1. Adjust P_{in} for Specified P_{out}; Duty Cycle = 12.5%, Period = 4.6 msec

This document contains information on a new product. Specifications and information herein are subject to change without notice.

REV 6



Pin Designations:

Pin 1 — RF Input Power @ 20 dBm Max Adjust
for Output Power
Pin 2 — First Stage Collector Voltage @ 7.2 Vdc
Pin 3 — Second Stage Collector Voltage @ 7.2 Vdc
Pin 4 — Trickle Bias Voltage @ 4.5 Vdc
Pin 5 — Third Stage Collector Supply @ 7.2 Vdc
Pin 7 — RF Output Power @ 9.0 W Nominal

Element Values:

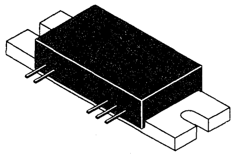
C1 = C2 = C4 = C6 = C8 = 0.018 µF
C3 = C5 = C7 = C9 = 2.2 µF
L1 – L3 = 0.29 µH
L4 = 0.2 µH
Z1, Z2 = 50 Ohm Microstrip

Figure 1. Test Circuit Diagram

UHF Silicon FET Power Amplifier

MHW913

14 WATT
880–915 MHz
RF POWER AMPLIFIER



CASE 301AB–02, STYLE 1

Designed specifically for the Pan European digital 8.0 watt, GSM mobile radio. The MHW913 is capable of wide power range control, operates from a 12.5 volt supply and requires less than 100 mW of RF input power.

- Specified 12.5 V Characteristics
  RF Input Power ≤ 100 mW (20 dBm)
  RF Output Power = 14 W
  Minimum Gain = 21.5 dB
  Minimum Efficiency = 35%
- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Epoxy Glass Substrate Eliminates Possibility of Substrate Fracture
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{bias}, V_{S2}, V_{S3}	5.0 15.6	Volt
RF Input Power	P_{in}	200	mW
RF Output Power	P_{out}	15	Watt
Storage Temperature	T_C	– 30 to +100	°C
Operating Case Temperature	T_{stg}	– 30 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{S2} = V_{S3} = 12.5 Vdc, V_{bias} = 4.8 Vdc, T_C = 25°C, 50 Ω system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Frequency Range	BW	880	915	MHz
Efficiency (P_{out} = 14 W) (1)	η	35	—	%
Power Gain (P_{out} = 14 W) (1)	G_p	21.5	—	dB
Harmonic Output (P_{out} = 14 W Reference) (1)	$2f_o$ $3f_o$	— —	– 30 – 35	dBc
Input VSWR (P_{out} = 14 W) (1)	$VSWR_{in}$	—	3:1	
Linearity — % AM in Output P_{out} = 0.02 to 14 W; 135 kHz, 1.0% AM on Input (1)	—		6.0	%
Output Power at Decreased Voltage (P_{in} = 100 mW, V_{S2} = V_{S3} = 10.8 Vdc) (1)	P_{out}	10	—	Watt

(1) Adjust P_{in} for specified P_{out}.

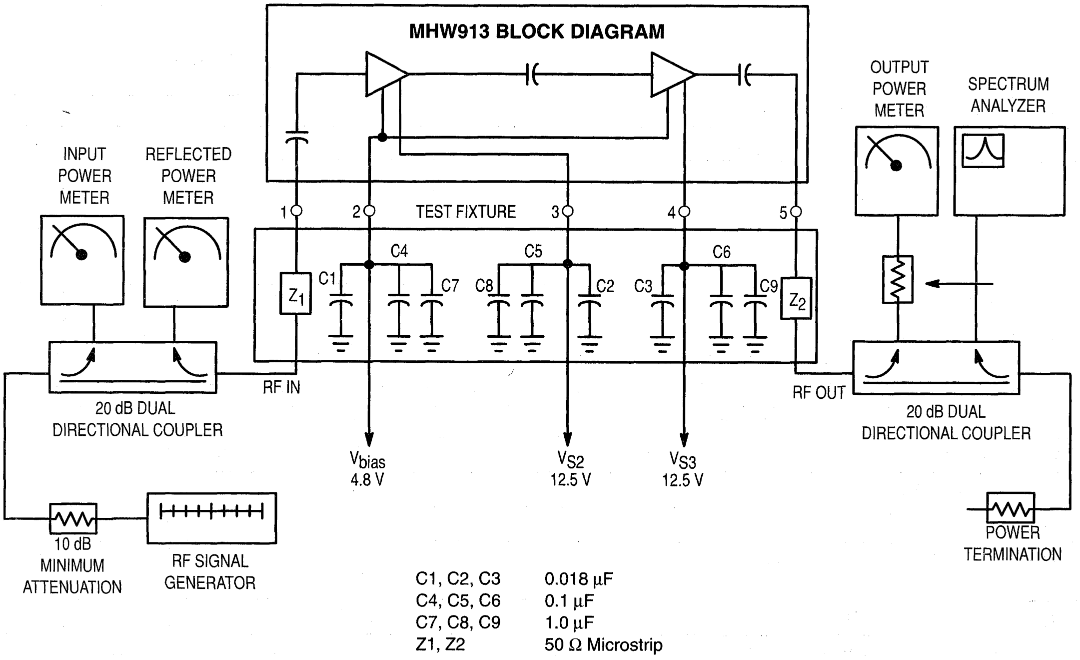
(continued)

REV 2

ELECTRICAL CHARACTERISTICS (continued) ($V_{S2} = V_{S3}$ = 12.5 V, V_{bias} = 4.8 V, T_C = 25°C, 50 Ω system, unless otherwise noted)

Load Mismatch Stress (V_{supply} = 15.6 Vdc, P_{out} = 15 W; Load VSWR = 10:1, All Phase Angles) (1)	—	No degradation in output power		
Stability (V_{supply} = 10.8 to 16 Vdc; P_{out} = 0.03 to 14 W; Load VSWR = 6:1, All Phase Angles) (1)	—	All spurious outputs more than 60 dB below desired signal		
Quiescent Current (With No RF Applied) ($V_{S2} = V_{S3}$ = 12.5 Vdc, V_{bias} = 4.8 Vdc)	I_{sq}	—	500	mA
Leakage Current (P_{in} = 0 mW, $V_{S2} = V_{S3}$ = 12.5 Vdc, V_b = 0 Vdc)	I_L	—	0.6	mA
Bias P_{in} Current (P_{out} = 14 W) (1)	I_{bias}	—	0.8	mA
Noise Power (In 30 kHz Bandwidth, 20 MHz above f_o) (P_{out} = 0.03 to 14 W, $V_{S2} = V_{S3}$ = 10.8 to 15.6 Vdc; V_{bias}= 4.8 Vdc) (1)	—	—	–70	dBm

(1) Adjust P_{in} for specified P_{out}.



C1, C2, C3	0.018 µF
C4, C5, C6	0.1 µF
C7, C8, C9	1.0 µF
Z1, Z2	50 Ω Microstrip

Figure 1. MHW913 Test Circuit Diagram

Typical Characteristics

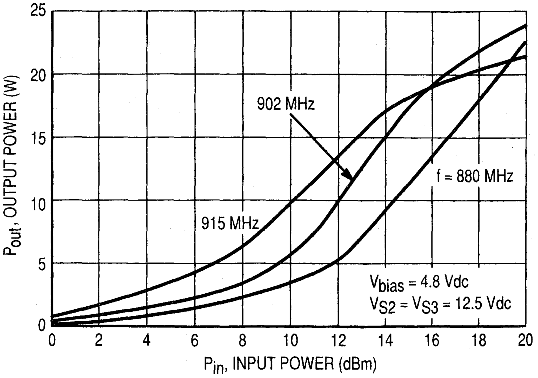


Figure 2. Output Power versus Input Power

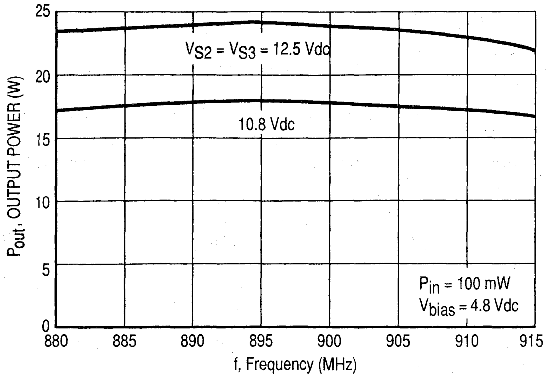


Figure 3. Output Power versus Frequency

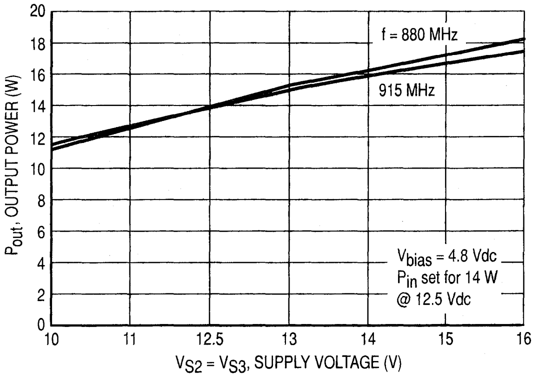


Figure 4. Output Power versus Supply Voltage

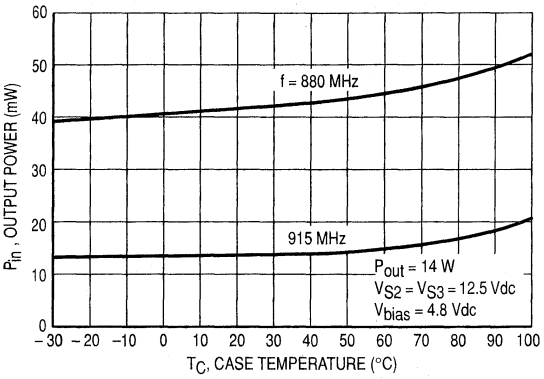


Figure 5. Input Power versus Case Temperature for P_{out} = 14 W

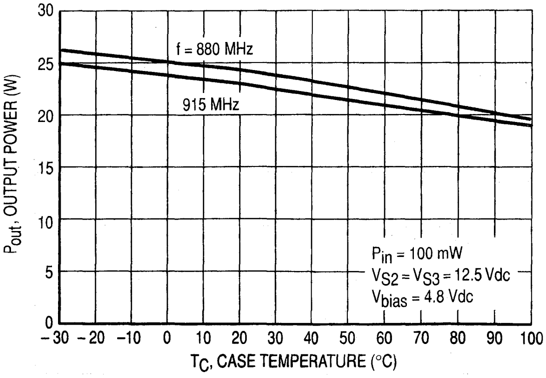


Figure 6. Output Power versus Case Temperature for Maximum Input Power

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

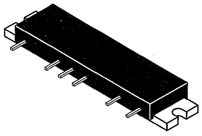
The RF Line
UHF Power Amplifiers

MHW914
MHW915

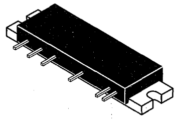
. . . designed specifically for the Pan European digital 8.0 watt, GSM mobile radio. The MHW914 and MHW915 are capable of wide power range control, operate from a 12.5 volt supply and require only 1 mW (MHW914) or 100 mW (MHW915) of RF input power.

- Specified 12.5 Volt Characteristics:
  RF Input Power — 1.0 mW (0 dBm) MHW914 or 100 mW (20 dBm) MHW915
  RF Output Power — 14 W
  Minimum Gain — 41.5 dB (MHW914) or 21.5 dB (MHW915)
  Harmonics — −30 dBc Max @ 2.0 f_o
- New Biasing and Control Techniques Providing Dynamic Range and Control Circuit Bandwidth Ideal for GSM
- Low Control Current
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

14 W
890 to 915 MHz
RF POWER
AMPLIFIERS



CASE 301R–01, STYLE 1
(MHW914)



CASE 301T–02, STYLE 1
(MHW915)

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	MHW914	MHW915	Unit
DC Supply Voltage	V_{s1}	8.5	15.6	Vdc
DC Supply Voltage	V_b	8.5	5.25	Vdc
DC Supply Voltage	$V_{s2,3}$	15.6	15.6	Vdc
DC Control Voltage	V_{cont}	4.0	—	Vdc
RF Input Power	P_{in}	3.0	400	mW
RF Output Power	P_{out}	15		W
Operating Case Temperature Range Storage Temperature Range	T_C T_{stg}	−30 to +100		°C

ELECTRICAL CHARACTERISTICS MHW914 — $V_{s2} = V_{s3} = 12.5$ Vdc; $V_{s1} = V_b = 8.0$ Vdc;
MHW915 — $V_{s1} = V_{s2} = V_{s3} = 12.5$ Vdc; $V_b = 5.0$ Vdc ($T_C = 25°C$, 50 ohm system, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Frequency Range		BW	890	915	MHz
Power Gain (P_{out} = 14 W)	MHW914 (1) MHW915 (2)	G_P	41.5 21.5	— —	dB
Control Current (P_{out} = 14 W; P_{in} = 1.0 mW)	MHW914 only (1)	I_{cont}	—	1.0	mA
Supply Current (P_{out} = 14 W; P_{in} = 1.0 mW)	MHW914 only (1)	$I_{s1} + I_b$	—	220	mA
Leakage Current (P_{in} = 0 mW; $V_{cont.} = V_{s1} = V_b = 0$ Vdc; $V_{s2} = V_{s3} = 15.6$ V for MHW914 • $V_{s1} = V_{s2} = V_{s3} = 15.6$ V; $V_b = 0$ Vdc; P_{in} = 0 mW for MHW915		I_L	—	1.0	mA
Efficiency (P_{out} = 14 W, P_{in} = 1.0 mW) MHW914 (1) (P_{out} = 14 W) MHW915 (2)		η	35 35	— —	%
Input VSWR (P_{out} = 14 W, P_{in} = 1.0 mW) MHW914 (1) (P_{out} = 14 W) MHW915 (2)		$VSWR_{in}$	— —	2.0:1 2.0:1	—
Harmonics (P_{out} = 14 W, P_{in} = 1.0 mW) MHW914 (1)	2.0 f_o 3.0 f_o to 5.0 f_o	—	— —	−30 −40	dBc
(P_{out} = 14 W) MHW915 (2)	2.0 f_o 3.0 f_o to 5.0 f_o		— —	−30 −35	

NOTES:
1. Adjust V_{cont} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms
2. Adjust P_{in} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms

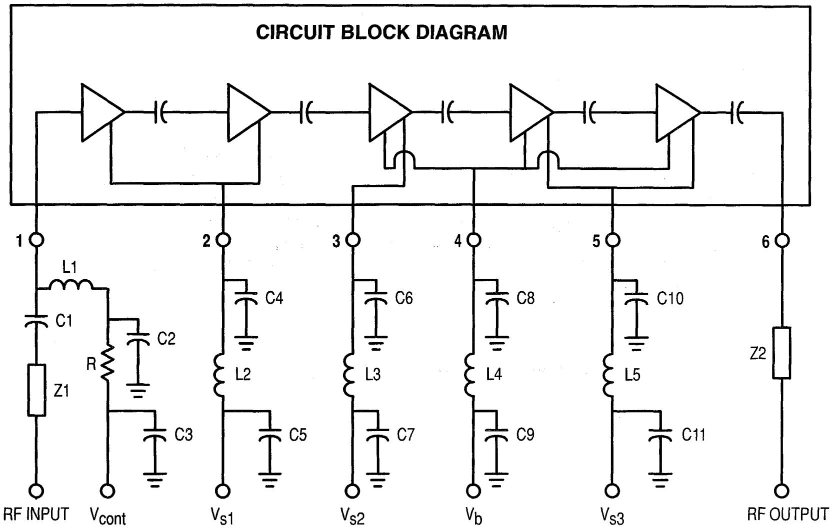
REV 6

ELECTRICAL CHARACTERISTICS — continued MHW914 — $V_{S2} = V_{S3}$ = 12.5 Vdc; $V_{S1} = V_b$ = 8.0 Vdc; MHW915 — $V_{S1} = V_{S2} = V_{S3}$ = 12.5 Vdc; V_b = 5.0 Vdc (T_C = 25°C, 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Noise Power (In 30 kHz Bandwidth, 20 MHz above f_o) (P_{out} = 0.03 to 14 W, $V_{S2} = V_{S3}$ = 10.8 to 15.6 Vdc, P_{in} = 1.0 mW) MHW914 (1) (P_{out} = 0.03 to 14 W, $V_{S1} = V_{S2} = V_{S3}$ = 10.8 to 15.6 Vdc) MHW915 (2)	—	 — —	 −70 −70	dBm
3.0 dB V_{cont} Bandwidth (P_{in} = 1.0 mW, P_{out} = 0.03 to 14 W) MHW914 only	—	1.0	—	MHz
Output Power Reduced Voltage (P_{in} = 1.0 mW; $V_{S2} = V_{S3}$ = 10.8 Vdc) MHW914 (P_{in} = 100 mW; $V_{S1} = V_{S2} = V_{S3}$ = 10.8 Vdc) MHW915	P_{OUT2}	10	—	W
Linearity — % AM in Output (P_{out} = 0.02 to 14 W; 135 kHz, 1% AM on Input) MHW915 only (2)	—	—	6.0	%
Load Mismatch Stress ($V_{S2} = V_{S3}$ = 15.6 Vdc, P_{in} = 3.0 mW, P_{out} = 15 W) MHW914 (1) ($V_{S1} = V_{S2} = V_{S3}$ = 15.6 Vdc, P_{out} = 15 W) MHW915 (2) (Load VSWR = 10:1, All Phase Angles at Frequency of Test)	ψ	No degradation in output power before and after test		
Stability ($V_{S2} = V_{S3}$ = 10.8 to 15.6 Vdc; P_{in} = 0.5 to 3.0 mW; P_{out} = 0 mW to 14 W) MHW914 (1) ($V_{S1} = V_{S2} = V_{S3}$ = 10.8 to 15.6 Vdc, P_{out} = 0.03 to 14 W) MHW915 (2) (Load VSWR = 6:1, Source VSWR = 3:1, All Phase Angles at Frequency of Test)	—	All spurious outputs more than 60 dB below desired signal		

NOTES:

1. Adjust V_{cont} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms
2. Adjust P_{in} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms



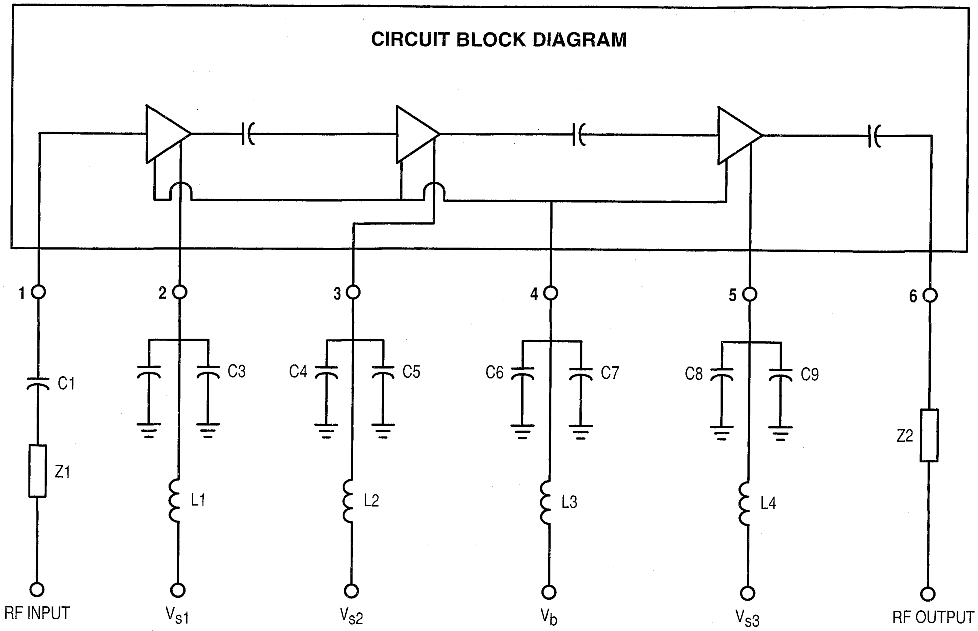
PIN DESIGNATIONS:

Pin 1 — RF Input Power @ 0 dBm and Control Voltage @ 0–3.0 Vdc
Pin 2 — First and Second Stage Collector Supply Voltage @ 8.0 Vdc
Pin 3 — Third Stage Collector Voltage @ 12.5 Vdc
Pin 4 — Trickle Bias Voltage @ 8.0 Vdc
Pin 5 — Fourth and Fifth Stage Collector Supply Voltage @ 12.5 Vdc
Pin 6 — RF Output Power @ 14 W

ELEMENT VALUES:

C1=C4=C6=C8=C10 = 0.018 µF
C2=0.1 µF
C3=C5=C7=C9=C11 = 1.0 µF
L1–L4 = 0.29 µH
L5 = 0.2 µH
R = 20 Ohms
Z1, Z2 = 50 Ohm Microstrip

Figure 1. Test Circuit Diagram — MHW914



PIN DESIGNATIONS:

Pin 1 — RF Input Power @ 20 dBm Max Adjust for Output Power
Pin 2 — First Stage Collector Voltage @ 12.5 Vdc
Pin 3 — Second Stage Collector Voltage @ 12.5 Vdc
Pin 4 — Trickle Bias Voltage @ 5.0 Vdc
Pin 5 — Third Stage Collector Supply @ 12.5 Vdc
Pin 6 — RF Output Power @ 14 W Nominal

ELEMENT VALUES:

C1=C2=C4=C6=C8 = 0.018 µF
C3=C5=C7=C9 = 2.2 µF
L1 – L3 = 0.29 µH
L4 = 0.2 µH
Z1, Z2 = 50 Ohm Microstrip

Figure 2. Test Circuit Diagram — MHW915

TYPICAL CHARACTERISTICS
(MHW914)

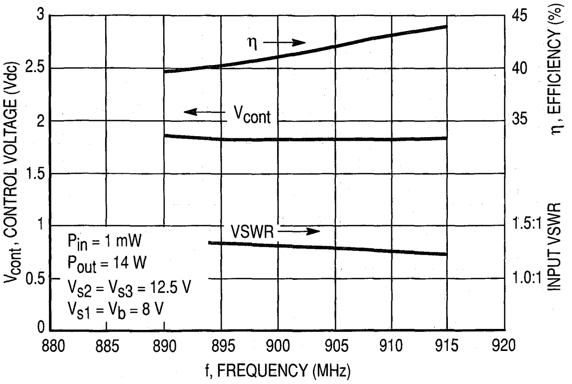


Figure 3. Control Voltage, Efficiency and Input VSWR versus Frequency

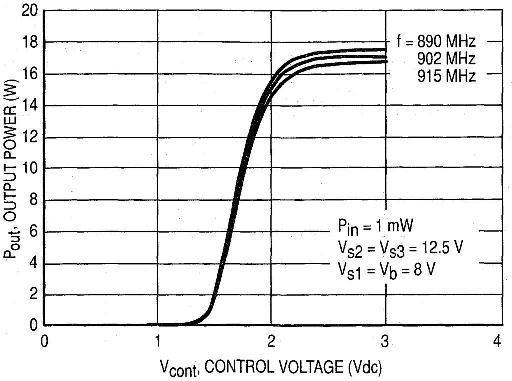


Figure 4. Output Power versus Control Voltage

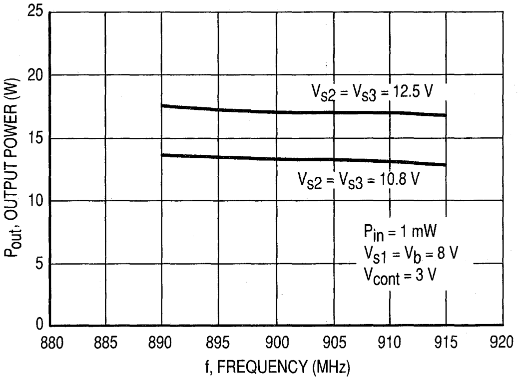


Figure 5. Output Power versus Frequency

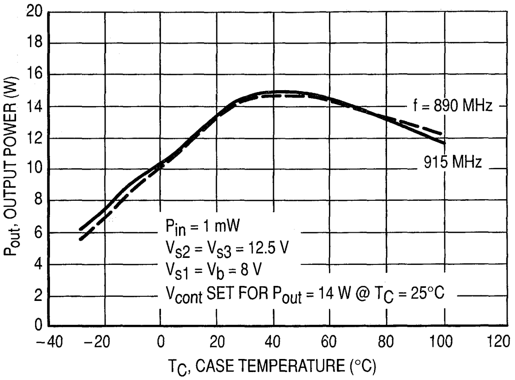


Figure 6. Output Power versus Case Temperature

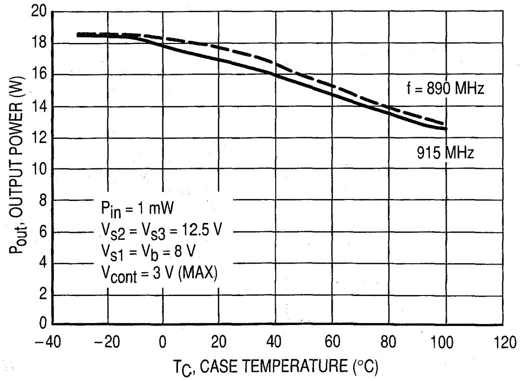


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

TYPICAL CHARACTERISTICS
(MHW915)

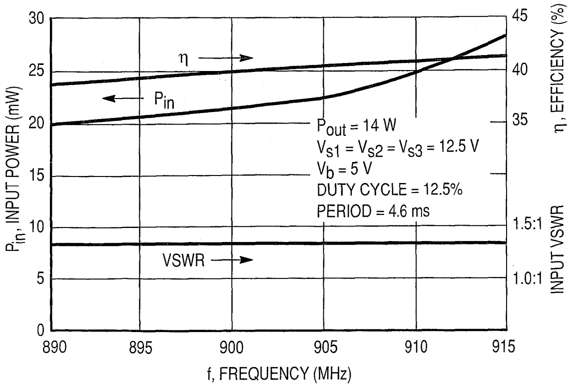


Figure 8. Input Power, Efficiency and Input VSWR versus Frequency

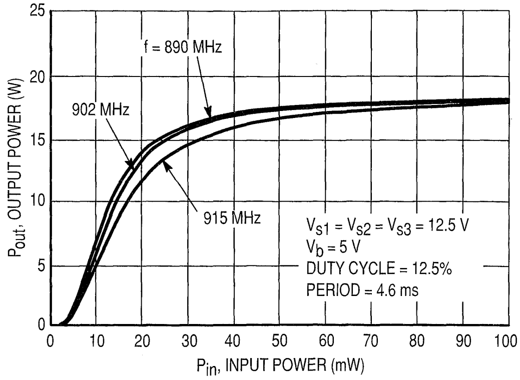


Figure 9. Output Power versus Input Power

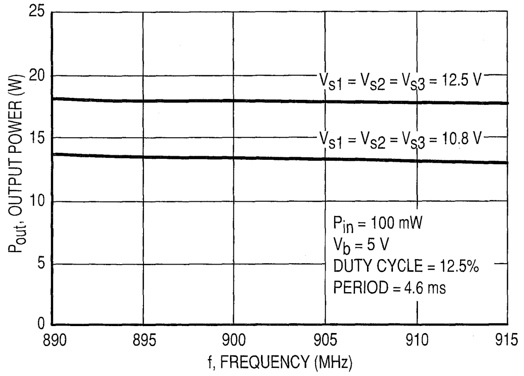


Figure 10. Output Power versus Frequency

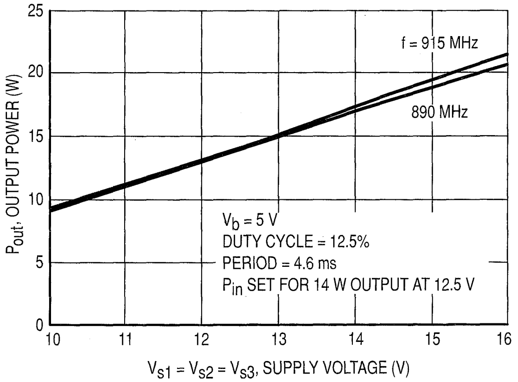


Figure 11. Output Power versus Supply Voltage

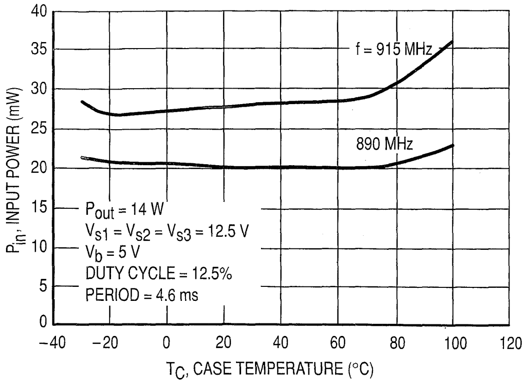


Figure 12. Input Power versus Case Temperature for P_{out} = 14 W

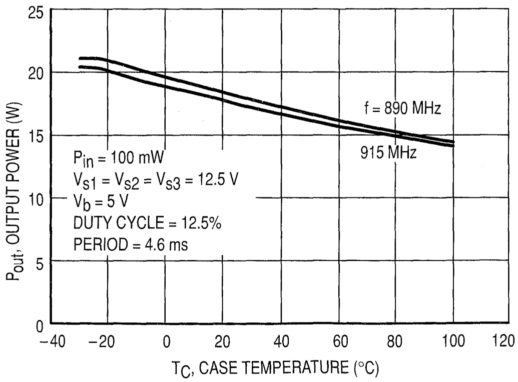


Figure 13. Output Power versus Case Temperature for Maximum Input Power

APPLICATIONS INFORMATION

NOMINAL OPERATION

For the MHW914, all electrical specifications are based on the nominal conditions of $V_b = V_{S1} = 8.0$ Vdc (Pins 2, 4), and $V_{S2} = V_{S3} = 12.5$ Vdc (Pins 3, 5). For the MHW915 the nominal conditions are $V_{S1} = V_{S2} = V_{S3} = 12.5$ Vdc (Pins 2, 3, 5) and $V_b = 5.0$ Vdc (Pin 4). With these conditions, maximum current density on any device is 1.5 x 10^5 A/cm^2 and maximum die temperature is 165°C. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output power should be limited to specified value. The preferred method of power control for the MHW914 is to fix $V_b = V_{S1} = 8.0$ Vdc, $V_{S2} = V_{S3} = 12.5$ Vdc, P_{in} (Pin 1) at 1.0 mW, and vary V_{cont} (Pin 1) voltage. The preferred method for the MHW915 is to fix all voltages at nominal and vary P_{out} (Pin 6) by changing P_{in} (Pin 1) from 0 to 100 mW.

DECOUPLING

Due to the high gain of the five stages and the module size limitation, external decoupling networks require careful consideration, Pins 2, 3, 4 and 5 are internally bypassed with a 0.018 μF chip capacitor which is effective for frequencies from 5.0 MHz through 940 MHz. For bypassing frequencies below 5.0 MHz, networks equivalent to that shown in Figure 1 and Figure 2 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

LOAD MISMATCH

During final test each module is load mismatch tested in a fixture having the identical decoupling networks described in Figures 1 and 2 for the MHW914 and MHW915 respectively. Electrical conditions are $V_b = V_{S1} = 8.0$ V (Pins 2, 4) and $V_{S2} = V_{S3} = 15.6$ Vdc (Pins 3, 5) for the MHW914 and $V_{S1} = V_{S2} = V_{S3} = 15.6$ Vdc (Pins 2, 3, 5) and $V_b = 5.0$ Vdc (Pin 4) for the MHW915. $P_{out} = 15$ W, $P_{in} = 3.0$ mW, load VSWR equals 10:1 at all phase angles for both modules.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

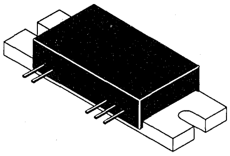
The RF Line
UHF Silicon FET Power Amplifier

Designed specifically for the European Digital Extended Group Special Mobile (GSM) Base Station applications in the 925–960 MHz frequency range. MHW916 operates from a 26 Volt supply and requires 15.5 dBm of RF input power.

- Specified 26 Volt Characteristics
  RF Input Power: 15.5 dBm Max
  RF Output Power: 16 Watts at 1.0 dB Compression Point
  Minimum Gain: 26.5 dB
  Harmonics: –35 dBc Max at 2Fo
- 50 Ω Input/Output System
- Meet GSM Linearity Specification for Base Station up to 12.5 Watts

MHW916

16 WATT
925–960 MHz
RF POWER
AMPLIFIER



CASE 301AB–02, STYLE 1

MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
DC Supply Voltage	V_S	28	Vdc
DC Bias Voltage	V_B	16	Vdc
RF Input Power	P_{in}	19	dBm
RF Output Voltage	P_{out}	25	W
Operating Case Temperature Range	T_C	– 5.0 to +85	°C
Storage Temperature Range	T_{stg}	– 30 to +100	°C
Standby Current (Pin Removed, $I_{stdby} = I_{S1} + I_{S2}$)	I_{stdby}	400	mA

ELECTRICAL CHARACTERISTICS (T_C = 25°C, $V_{S1} = V_{S2}$ = 26 Vdc, V_{bias} = 15 Vdc, 50 ohm system)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	925	—	960	MHz
Quiescent Current (P_{in} = 0 mW)	Idq1 + Idq2	—	400	—	mA
Power Gain (P_{out} = 16 W) (1)	Gp	26.5	30	32.5	dB
Output Power at 1.0 dB Compression	P1dB	16	—	—	W
Efficiency (1.0 dB Compression Power)	η_1	37	44	—	%
Efficiency (P_{out} = 16 W) (1)	η_2	33	39	—	%
Input VSWR (P_{out} = 16 W) (1)	$VSWR_{in}$	—	—	2:1	—
Harmonic 2 f_o (P_{out} = 16 W) (1)	H_2	—	–40	–35	dBc
Harmonic 3 f_o (P_{out} = 16 W) (1)	H_3	—	–60	–45	dBc
Ripple (P_{out} = 16 W) (1)	Rp	—	1.0	—	dB
Load Mismatch Stress (P_{out} = 16 W) Load VSWR = 5:1, All Phase Angles	Ψ	No Degradation in Output Power			
Stability (P_{out} = 10 mW to 16 W) Load VSWR = 3:1, All Phase Angles (Except Harmonics)	—	All Spurious Outputs More Than 60 dB Below Desired Signal			
Stability (P_{out} = –5.0 dBm to 42 dBm, f = 925 to 960 MHz) Load VSWR = 2:1, All Phase Angles	—	All Spurious Outputs Lower Than –46 dBm or –85 dBc (Whichever the Higher)			

NOTE: Adjust P_{in} for Specified P_{out}

REV 1

TYPICAL CHARACTERISTICS

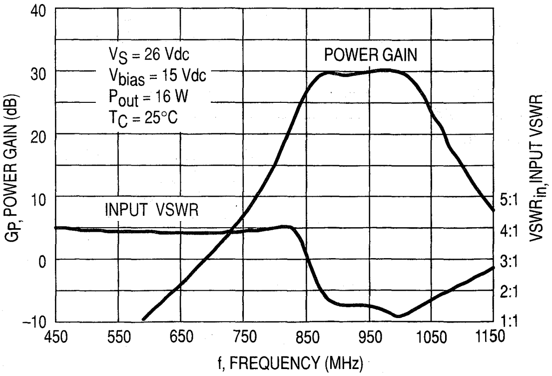


Figure 1. Power Gain and Input VSWR versus Frequency

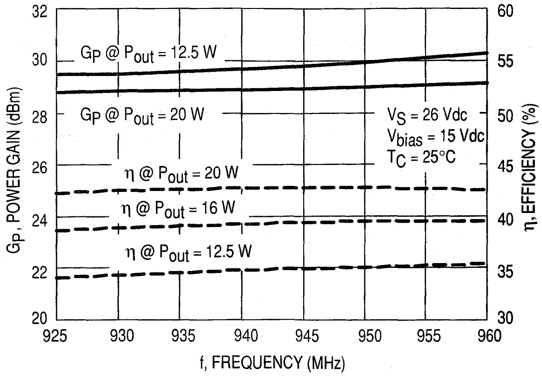


Figure 2. Power Gain and Efficiency versus Frequency

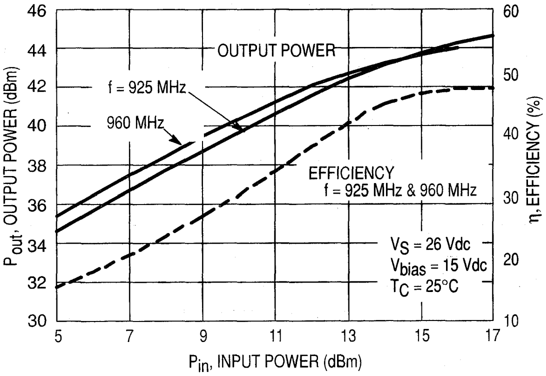


Figure 3. Output Power and Efficiency versus Input Power

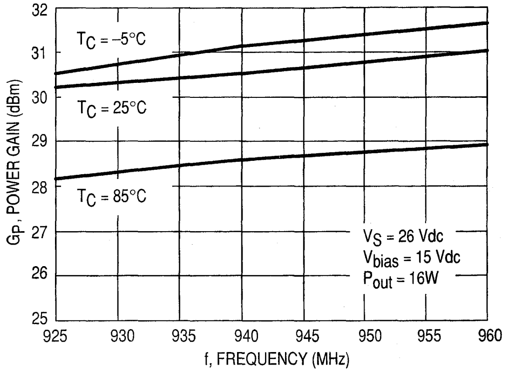


Figure 4. Power Gain versus Frequency

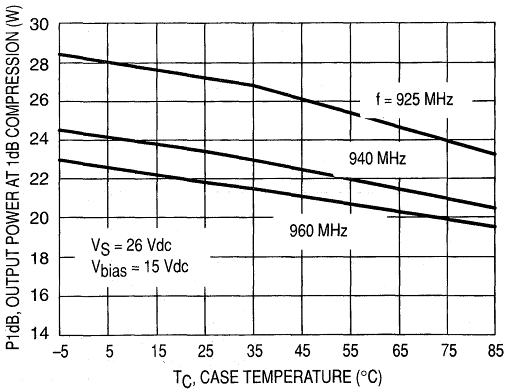


Figure 5. Output Power at 1 dB Compression versus Temperature

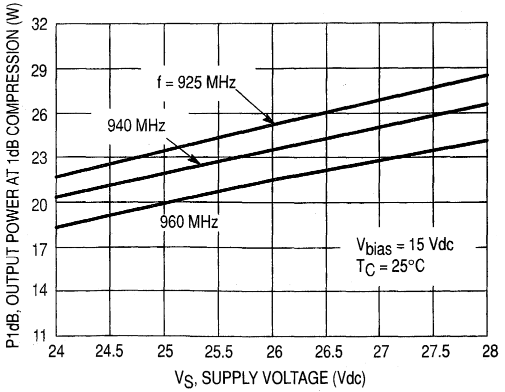


Figure 6. Output Power at 1dB Compression versus Supply Voltage

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

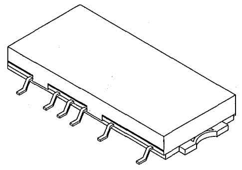
The RF Line
UHF Linear Power Amplifier

MHW920

0 dBm, 0.8 W Avg.
824–849 MHz
RF LINEAR
POWER AMPLIFIER

Designed for the North American Digital Cellular (NADC), specifically for a digital, 1 watt, handheld radio. The MHW920 power amplifier is capable of wide power range control, operates from a 6 volt supply and requires only 1 mW of RF input power.

- Specified 6 Volt Characteristics:
  RF Input Power: 1 mW (0 dBm)
  RF Output Power: 0.8 W Avg.
  Minimum Gain: 29 dB
  Harmonics: −30 dBc Max @ 2 f_o
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness



CASE 420U–02, Style 1

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage (No RF Applied)	V_{S1}, V_{S2}, V_{S3}	9	Vdc
DC Bias Voltage	V_B	5.25	Vdc
RF Input Power	P_{in}	2	mW
RF Output Power (V_s = 9 Vdc)	P_{out}	4.5	W
Operating Case Temperature Range	T_C	−30 to +80	°C
Storage Temperature Range	T_{stg}	−30 to +100	°C

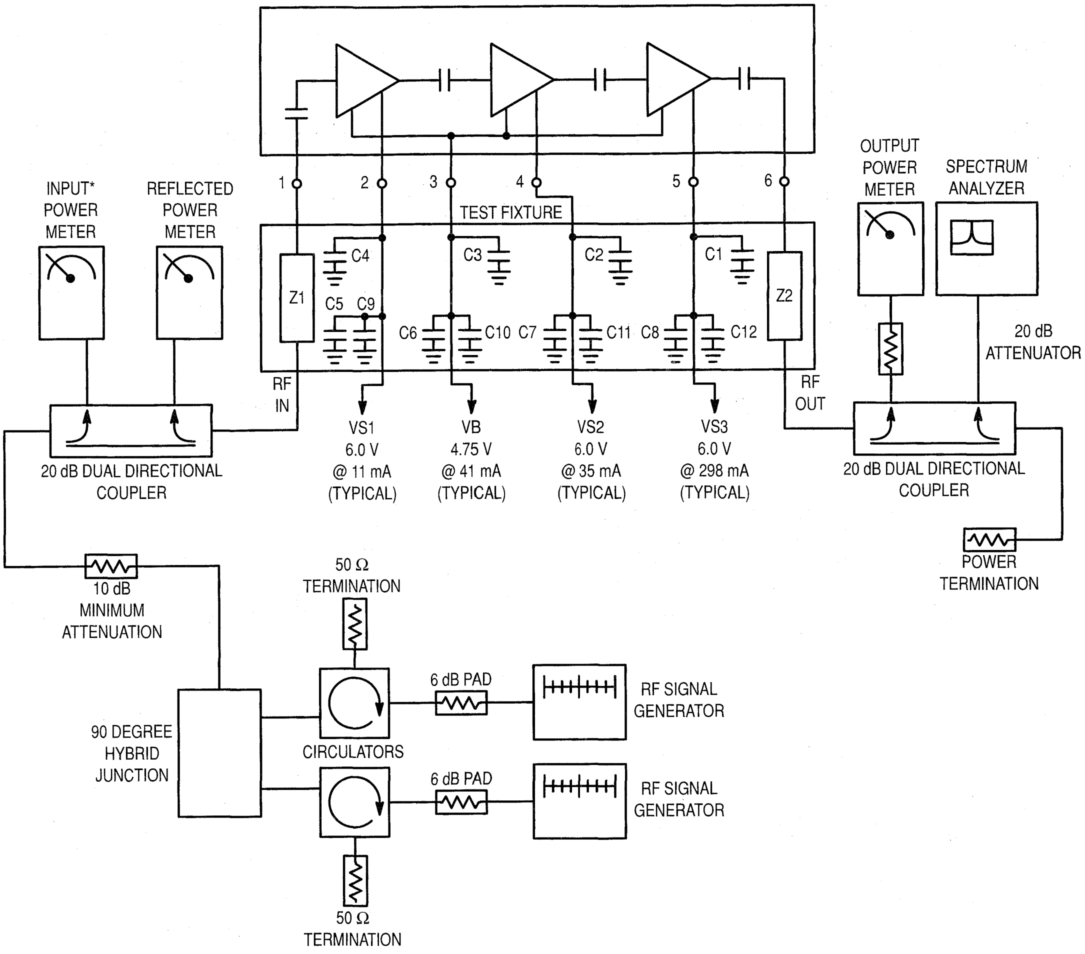
ELECTRICAL CHARACTERISTICS (V_{S1} = V_{S2} = V_{S3} = 6 Vdc; V_{BIAS} = 4.75 Vdc; T_C = +25°C; 50 ohm system, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Frequency Range		BW	824	849	MHz
Power Gain (P_{out} = 0.8 W Avg.) (1) (2)		G_P	29	—	dB
EFficiency (P_{out} = 0.8 W Avg.) (1) (2)		η	35	—	%
Input VSWR (P_{out} = 0.8 W) (1)		$VSWR_{IN}$	—	2:1	
Harmonics (P_{out} = 0.8 W) (1)	2 f_o	—	—	−30	dBc
	3 f_o		—	−45	
Noise Power (In 30 kHz Bandwidth, 45 MHz above f_o, P_{out} = 0.8 W) (1)		P_N	—	−90	dBm
Linearity (P_{out} = 0.8 W Avg.) (1) (2)	3rd Order IMD	—	—	−26	dBc
	5th Order IMD		—	−31	
	7th Order IMD		—	−35	
Linearity Low Voltage (1) (2)	3rd Order IMD	—	—	−26	dBc
(P_{out} = 0.42 W Avg.; T_C = −30°C to +80°C;	5th Order IMD		—	−31	
V_{S1} = V_{S2} = V_{S3} = 5 V; V_{BIAS} = 4.75 V)	7th Order IMD		—	−35	
Load Mismatch Stress (V_{S1} = V_{S2} = V_{S3} = 9 Vdc; P_{out} = 0.8 W; Load VSWR = 20:1; All Phase Angles at Frequency of Test) (1)		ψ	No Degradation in Output Power Before and After Test		
Stability (V_{S1} = V_{S2} = V_{S3} = 5.4–7 Vdc; P_{in} = 0.05 – 1 mW: Load VSWR = 8:1, All Phase Angles at Frequency of Test)			All Spurious Outputs More than 60 dB Below Desired Signal		

(1) Adjust P_{in} for specified P_{out}. $P_{in} \leq 1$ mW.
(2) Measured under two tone test with tones 10 kHz apart.

REV 1

INTERNAL DIAGRAM



C1, C2, C3, C4	0.018 μF
C5, C6, C7, C8	0.1 μF
C9, C10, C11, C12	1.0 μF (tant.)
Z1, Z2	50 Ω Microstrip

* Module input power is forward power as sampled by the directional coupler and read on the input power meter.

Figure 7. Power Module Test Circuit Diagram

TYPICAL CHARACTERISTICS

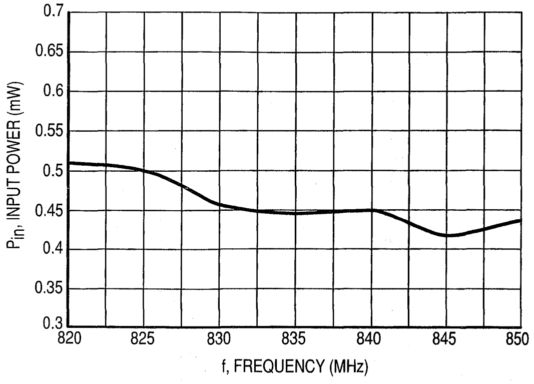


Figure 8. Input Power versus Frequency

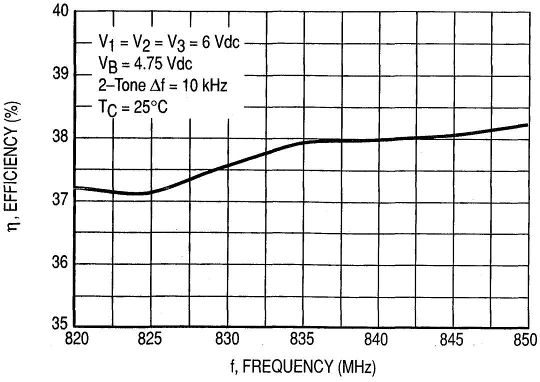


Figure 9. Efficiency versus Frequency

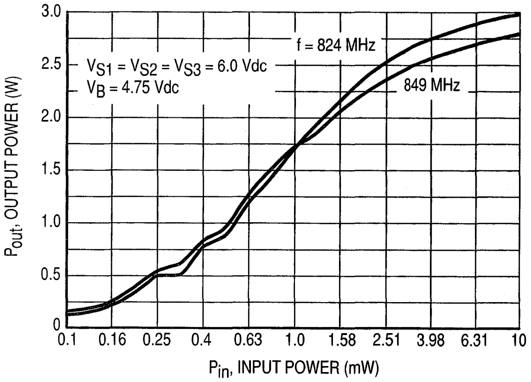


Figure 10. Input Power versus Output Power @ T = 25°C

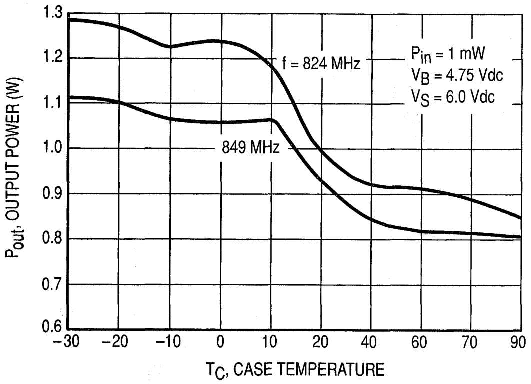


Figure 11. Output Power versus Case Temperature

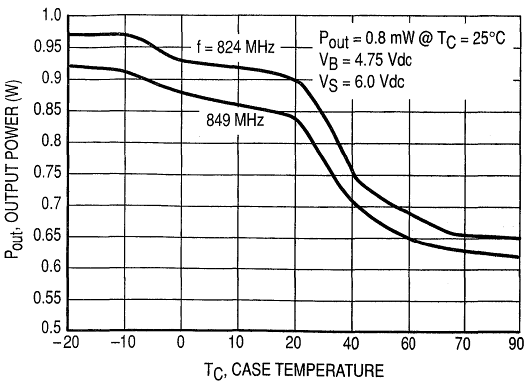


Figure 12. Output Power versus Case Temperature

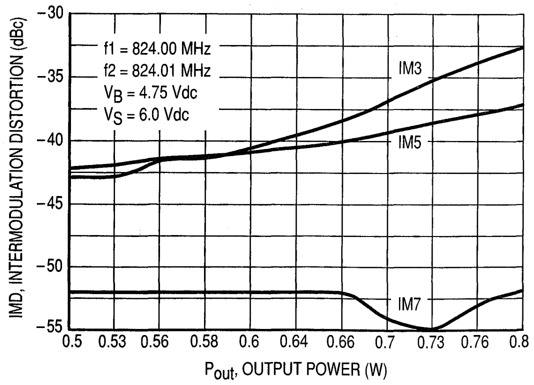


Figure 13. Intermodulation versus Output Power

TYPICAL CHARACTERISTICS

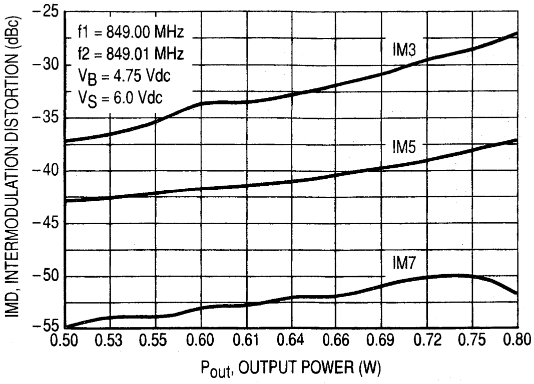
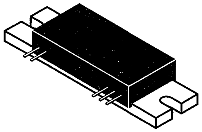


Figure 14. Intermodulation versus Output Power

The RF Line
UHF Linear Power Amplifier

MHW927B

6.0 W
824 to 849 MHz
RF LINEAR
POWER AMPLIFIER



CASE 301AA–01, STYLE 1

Designed specifically for the United States digital 3.0 W, mobile radio. MHW927B is capable of wide power range control, operates from a 12.5 Volt supply and requires 1.0 mW of RF input power.

- Operates from a 8.0 Volt Bias Supply (V_B)
- Specified 12.5 Volt Characteristics
  RF Input Power — 1.0 mW (0 dBm) Max
  RF Output Power — 6.0 W
  Power Gain — 40 dB Typ
  Harmonics — –30 dBc Max @ 2 f_0
- Linearity (IMD) — –29 dBc Max for 3rd Order; –34 dBc Max for 5th Order
- New Biasing and Control Techniques Providing Dynamic Range and Control Circuit Bandwidth Ideal for USDC
- 50 Ω Input/Output Impedances
- Guaranteed Stability and Ruggedness

MAXIMUM RATINGS (Recommended Values for Safe Operation — Not Guaranteed Performance)

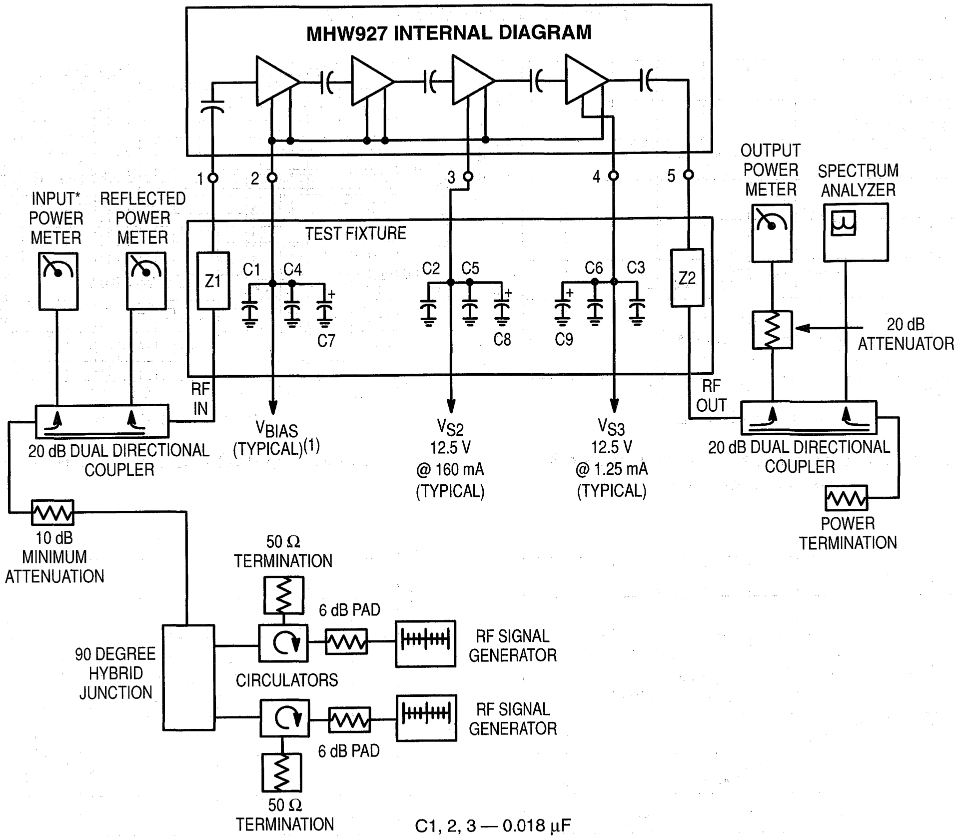
Rating	Symbol	Value	Unit
DC Supply Voltage	V_{S2}, V_{S3}	16.5	Vdc
DC Bias Voltage	V_B	10	Vdc
RF Input Power	P_{in}	3.0	mW
RF Output Power	P_{out}	13	W
Operating Case Temperature Range	T_C	–30 to +100	°C
Storage Temperature Range	T_{stg}	–30 to +100	°C

ELECTRICAL CHARACTERISTICS (V_B = 8.0 Vdc; $P_{in} \leq 1.0$ mW; T_C = +25°C, 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	824	—	849	MHz
Input Power (P_{out} = 6.0 W) (1)	P_{in}	—	—	1.0	mW
Efficiency (P_{out} = 6.0 W) (1)	η_1	28	30	—	%
Efficiency, Two Tone (P_{out} (Avg.) = 6.0 W; f_1 & f_2 10 kHz apart) (1)	η_2	28	30	—	%
Input VSWR (P_{out} = 6.0 W) (1)	$VSWR_{in}$	—	—	2.5:1	—
Harmonics (P_{out} = 6.0 W) (1) 2 f_0 3 f_0	—	— —	— —	–30 –45	dBc
Noise Power (In 30 kHz Bandwidth, 45 MHz Above f_0; T_C = +25°C to T_C = +100°C; P_{out} = 6.0 W) (1)	—	—	—	–82	dBm
Linearity (P_{out} (Avg.) = 6.0 W; f_1 & f_2 are 10 kHz apart) (1) 3rd Order IMD 5th Order IMD	—	— —	–31 –36	–29 –34	dBc
Load Mismatch Stress (V_{S2} = V_{S3} = 16 Vdc; P_{out} = 12.5 W; Pulsed at 50% Duty Cycle; Load VSWR = 20:1, All Phase Angles At Frequency of Test) (1)	ψ	No Degradation In Output Power Between Before and After Test			
Stability (V_{S2} = V_{S3} = 10 to 16 Vdc; P_{out} = 0.012 to 12 W; Load VSWR = 4:1, All Phase Angles At Frequency of Test) (1)	—	All Spurious Outputs More Than 70 dB Below Desired Signal			

NOTE:
1. Adjust P_{in} for Specified P_{out}.

REV 7



C1, 2, 3 — 0.018 µF
C4, 5, 6 — 0.1 µF
C7, 8, 9 — 1.0 µF (tant.)
Z1, Z2 — 50 Ω MICROSTRIP

(1) V_{BIAS} = 8.0 V @ 140 mA

*Module input power is forward power as sampled by the directional coupler and read on the input power meter.

Figure 1. MHW927B Test Circuit Diagram

TYPICAL CHARACTERISTICS

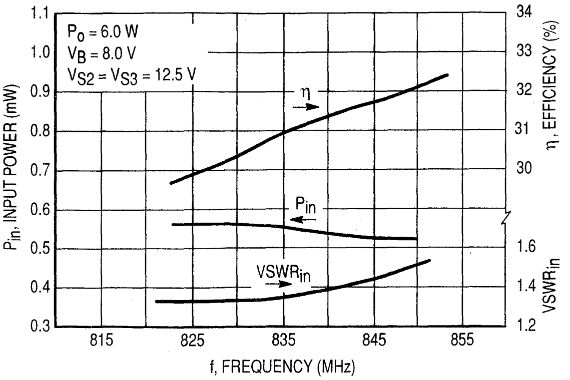


Figure 2. Input Power, Efficiency and VSWR versus Frequency

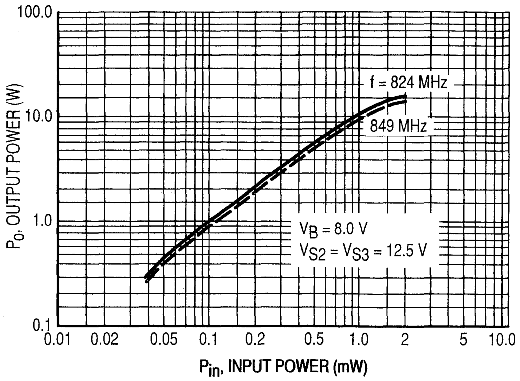


Figure 3. Output Power versus Input Power

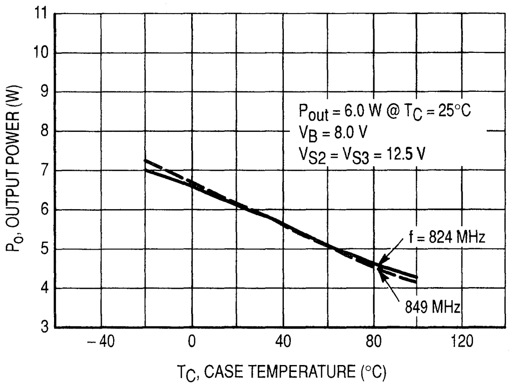


Figure 4. Output Power versus Case Temperature

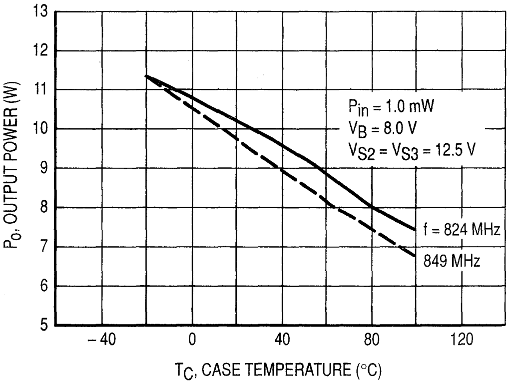


Figure 5. Output Power versus Case Temperature at Maximum Input Power

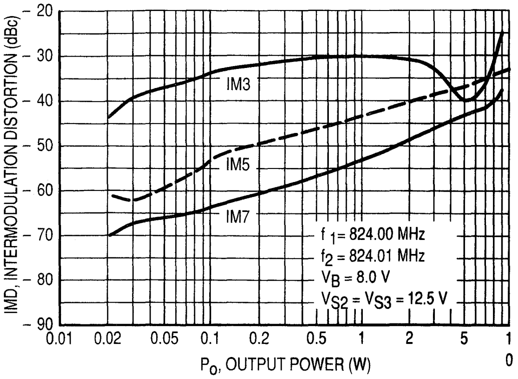


Figure 6. Intermodulation versus Output Power

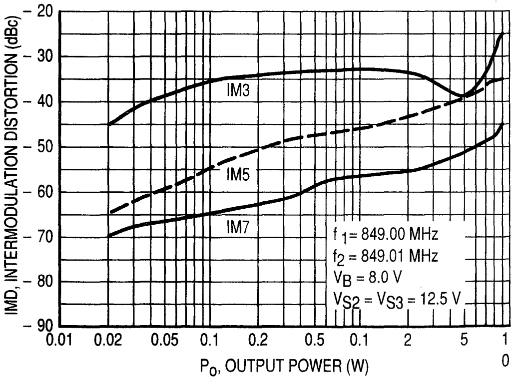


Figure 7. Intermodulation versus Output Power

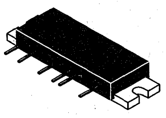
The RF Line
UHF Power Amplifiers

MHW953
MHW954

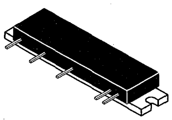
3.5 W
890 to 915 MHz
RF POWER
AMPLIFIERS

Designed specifically for the Pan European digital 2.0 watt, GSM hand–held radio. The MHW953 and MHW954 are capable of wide power range control, operate from a 7.2 volt supply and require 1.0 mW (MHW953) or 100 mW (MHW954) of RF input power.

- Specified 7.2 Volt Characteristics:
  RF Input Power — 1.0 mW (0 dBm) MHW953; 100 mW (20 dBm) MHW954
  RF Output Power — 3.5 W
  Minimum Gain — 35.4 dB (MHW953) or 15.4 dB (MHW954)
  Harmonics — –35 dBc Max @ 2.0 f_o (MHW953) or
  –30 dBc Max @ 2.0 f_o (MHW954)
- New Biasing and Control Techniques Providing Dynamic Range and Control Circuit Bandwidth Ideal for GSM
- Low Control Current
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Test fixture circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 301V–02, STYLE 1
(MHW953)



CASE 301Y–02, STYLE 1
(MHW954)

MAXIMUM RATINGS (Flange Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{s1}, V_{s2}, V_{s3}	9.0	Vdc
DC Bias Voltage (MHW953) (MHW954)	V_b	5.25 4.75	Vdc
DC Control Voltage (MHW953 only)	V_{cont}	3.0	Vdc
RF Input Power (MHW953) (MHW954)	P_{in}	2.0 400	mW
RF Output Power (V_s = 9.0 Vdc)	P_{out}	4.5	W
Operating Case Temperature Range Storage Temperature Range	T_C T_{stg}	–30 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{s1} = V_{s2} = V_{s3}$ = 7.2 Vdc; V_b = 5.0 Vdc for MHW953)
($V_{s1} = V_{s2}$ = 7.2 Vdc; V_b = 4.5 Vdc for MHW954)
(T_C = 25°C; 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Frequency Range	BW	890	915	MHz
Power Gain (P_{out} = 3.5 mW) MHW953 (1) MHW954 (2)	G_P	35.4 15.4	— —	dB
Control Current (P_{out} = 3.5 W; P_{in} = 1.0 mW) MHW953 only (1)	I_{cont}	—	1.0	mA
Supply Current (P_{out} = 3.5 W; P_{in} = 1.0 mW) MHW953 only (1)	I_b	—	85	mA
Leakage Current (P_{in} = 0 mW; $V_{cont} = V_b$ = 0 Vdc; $V_{s1} = V_{s2} = V_{s3}$ = 9.0 Vdc for MHW953. P_{in} = 0 mW; V_b = 0 Vdc; $V_{s1} = V_{s2}$ = 9.0 Vdc for MHW954)	I_L	 — —	 1.0 200	 mA μA
Input VSWR (P_{out} = 3.5 W; P_{in} = 1.0 mW) MHW953 (1) (P_{out} = 3.5 W) MHW954 (2)	$VSWR_{in}$	—	2.0:1	—

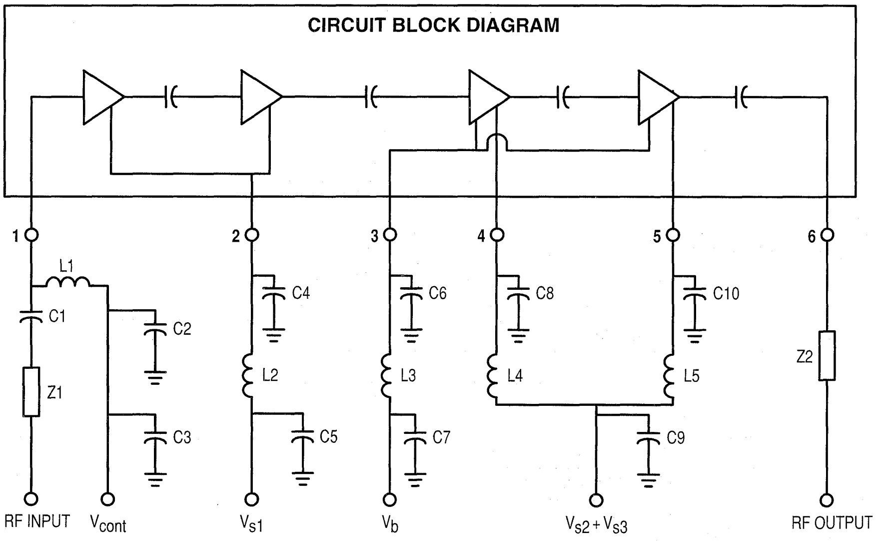
NOTES:
1. Adjust V_{cont} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms
2. Adjust P_{in} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms

REV 7

ELECTRICAL CHARACTERISTICS — continued ($V_{S1} = V_{S2} = V_{S3}$ = 7.2 Vdc; V_b = 5.0 Vdc for MHW953)
($V_{S1} = V_{S2}$ = 7.2 Vdc; V_b = 4.5 Vdc for MHW954)
(T_C = 25°C; 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Efficiency (P_{out} = 3.5 W; P_{in} = 1.0 mW) MHW953 (1) (P_{out} = 3.5 W) MHW954 (2)	η	40	—	%
Harmonics (P_{out} = 3.5 W; P_{in} = 1.0 mW) MHW953 (1) 2.0 f_o	—	—	−35	dBc
3.0 f_o		—	−45	
(P_{out} = 3.5 W) MHW954 (2) 2.0 f_o		—	−30	
3.0 f_o		—	−40	
Noise Power (In 30 kHz Bandwidth, 20 MHz above f_o) (T_C = 25°C−100°C)	—			dBm
(P_{out} = 0.3−3.5 W; $V_{S1} = V_{S2} = V_{S3}$ = 6.25−9.0 Vdc, P_{in} = 1.0 mW) MHW953 (1)		—	−65	
(P_{out} = 0.3−3.5 W; $V_{S1} = V_{S2}$ = 6.25−9.0 Vdc) MHW954 (2)		—	−75	
Output Power, Low Voltage (P_{in} = 1.0 mW; $V_{S1} = V_{S2} = V_{S3}$ = 6.25 Vdc; V_{cont} = 3.0 Vdc) MHW953	P_{o1}	2.0	—	W
(P_{in} = 100 mW; $V_{S1} = V_{S2}$ = 6.25 Vdc) MHW954		2.3	—	
Isolation (P_{in} = 1.0 mW; V_{cont} = 0 Vdc; $V_{S1} = V_b$ = 0−5 Vdc) MHW953 only (1)	—	—	−36	dBm
3.0 dB V_{cont} Bandwidth (P_{in} = 1.0 mW; P_{out} = 0.03−3.5 W) MHW953 only (1)	—	1.0	—	MHz
% AM In Output (P_{out} = 0.035−3.5 W; 135 kHz, 1% AM on Input) MHW954 only (2)	—	—	6	%
Load Mismatch Stress (P_{in} = 2.0 mW; P_{out} = 3.5 W; $V_{S1} = V_{S2} = V_{S3}$ = 9.0 Vdc) MHW953 (1) (P_{out} = 3.5 W; V_b = 4.75 Vdc; $V_{S1} = V_{S2}$ = 9.0 Vdc) MHW954 (2) (Load VSWR = 10:1, All Phase Angles at Frequency of Test)	ψ	No degradation in output power before and after test		
Stability (P_{in} = 0.5 to 2.0 mW; P_{out} = 0.03−3.5 W; $V_{S1} = V_{S2} = V_{S3}$ = 6.0 to 9.0 Vdc) MHW953 (1) (P_{out} = 0.03−3.5 W; $V_{S1} = V_{S2}$ = 6.0 to 9.0 Vdc) MHW954 (2) (Load VSWR = 6:1, Source VSWR = 3:1, All Phase Angles at Frequency of Test)	—	All spurious outputs more than 60 dB below desired signal		

NOTES:
1. Adjust V_{cont} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms
2. Adjust P_{in} for specified P_{out}; duty cycle = 12.5%, period = 4.6 ms



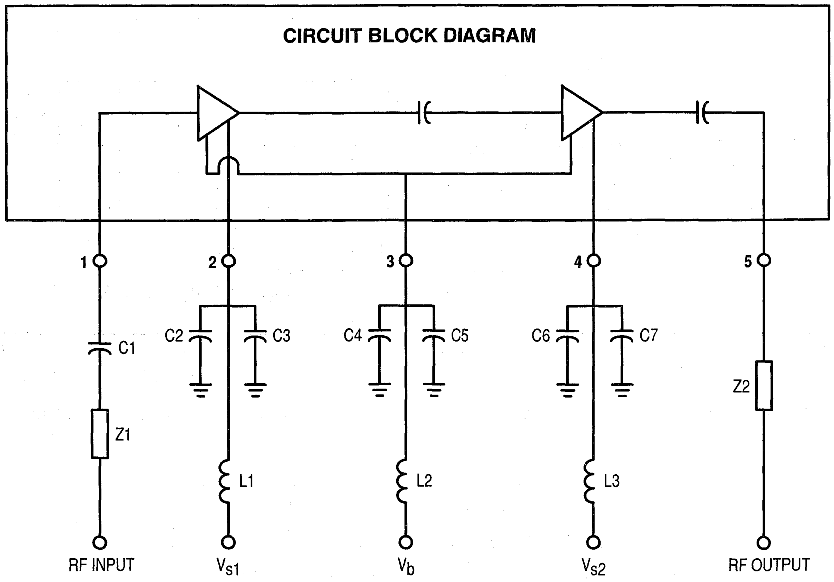
PIN DESIGNATIONS:

Pin 1 — RF Input Power @ 0 dBm and Control Voltage @ 0−3.0 Vdc
Pin 2 — First and Second Stage Collector Supply Voltage @ 7.2 Vdc
Pin 3 — Trickle Base Bias Voltage @ 5.0 Vdc
Pin 4 — Third Stage Collector Supply Voltage @ 7.2 Vdc
Pin 5 — Fourth Stage Collector Supply Voltage @ 7.2 Vdc
Pin 6 — RF Output Power @ 3.5 W

ELEMENT VALUES:

C1=C2= 0.018 μF
C4=C6=C8=C10= 0.1 μF
C3=C5=C7=C9 = 1.0 μF Tant.
L1−L3 = 0.29 μH Choke
L4, L5 = 0.15 μH Choke
Z1, Z2 = 50 Ohm Microstrip

Figure 1. Test Circuit Diagram — MHW953



PIN DESIGNATIONS:

Pin 1 — RF Input Power @ 20 dBm Max Adjust for Output Power
Pin 2 — First Stage Collector Voltage @ 7.2 Vdc
Pin 3 — Trickle Bias Voltage @ 4.5 Vdc
Pin 4 — Third Stage Collector Supply @ 7.2 Vdc
Pin 5 — RF Output Power @ 3.5 W Nominal

ELEMENT VALUES:

C1=C2=C4=C6= 0.018 µF
C3=C5=C7= 2.2 µF
L1, L2 = 0.29 µH
L3 = 0.2 µH
Z1, Z2 = 50 Ohm Microstrip

Figure 2. Test Circuit Diagram — MHW954

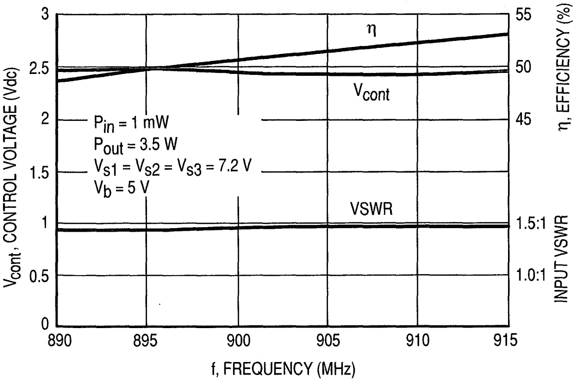


Figure 3. Control Voltage, Efficiency and Input VSWR versus Frequency

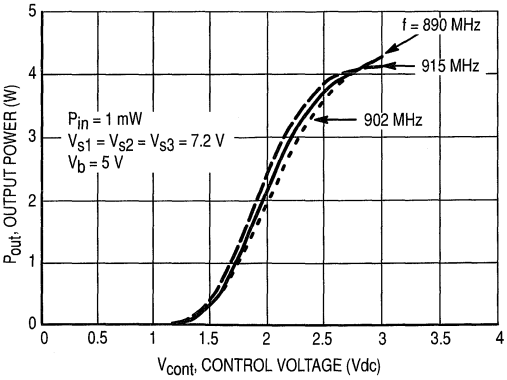


Figure 4. Output Power versus Control Voltage

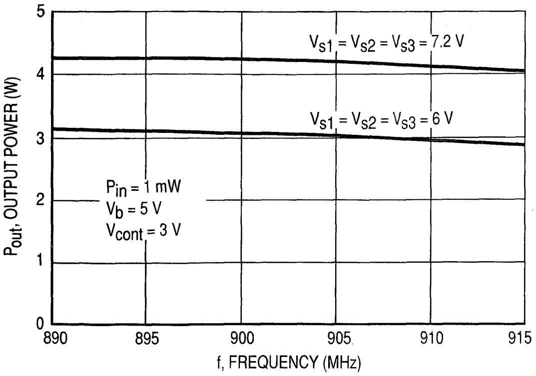


Figure 5. Output Power versus Frequency

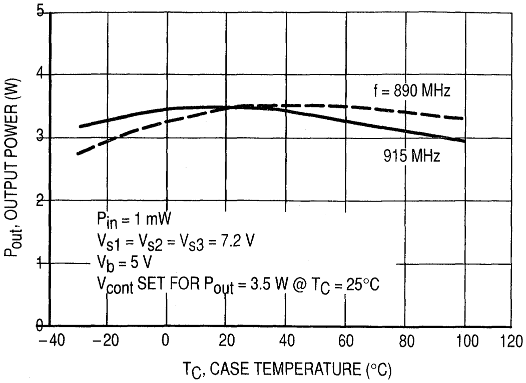


Figure 6. Output Power versus Case Temperature

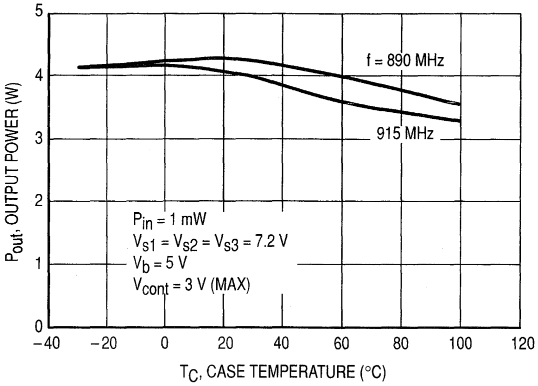


Figure 7. Output Power versus Case Temperature at Maximum Control Voltage

APPLICATIONS INFORMATION

NOMINAL OPERATION

All electrical specifications are based on the nominal conditions of $V_{S1} = V_{S2} = V_{S3} = 7.2$ Vdc (Pins 2, 4, 5) and $V_b = 5.0$ Vdc (Pin 3) for MHW953. Nominal conditions are $V_{S1} = V_{S2} = 7.2$ Vdc (Pins 2 and 4) and $V_b = 4.5$ Vdc (Pin 3) for MHW954. With these conditions, maximum current density on any device is 1.5×10^5 A/cm^2 and maximum die temperature is 165°C. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the published specifications is not recommended unless prior communications regarding intended use have been made with the factory representative.

GAIN CONTROL

The module output power should be limited to specified value. The preferred method of power control for the MHW953 is to fix $V_{S1} = V_{S2} = V_{S3} = 7.2$ Vdc, $V_b = 5.0$ Vdc, P_{in} (Pin 1) at 1.0 mW, and vary V_{cont} (Pin 1) voltage. For the MHW954, fix $V_{S1} = V_{S2} = 7.2$ Vdc and $V_b = 4.5$ Vdc; then vary P_{in} (Pin 1) to control P_{out} (Pin 5).

DECOUPLING

Due to the high gain of the four stages and the module size limitation, external decoupling networks require careful consideration, Pins 2, 3, 4 and 5 are internally bypassed with a 0.018 μF chip capacitor which is effective for frequencies from 5.0 MHz through 940 MHz. For bypassing frequencies below 5.0 MHz, networks equivalent to that shown in Figure 1 are recommended. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

MOUNTING CONSIDERATIONS

For the MHW903 Series module, mounting is generally accomplished by soldering the flange to a suitable heat sink. This can be done with a low temperature solder such as 52% In, 48% Sn and type “R” Flux which liquifies below 150°C. Under no circumstances should the MHW953 Series modules be heated to a temperature greater than ≈165°C. Internal construction of the module has been achieved using 36% Tin, 62% lead, 2% silver solder which liquifies at 179–180°C.

The modules are NOT hermetic. Do not immerse a module in a flux cleaning solution or other liquids under any circumstances.

LOAD MISMATCH

During final test each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{S1} = V_{S2} = V_{S3} = 9.0$ Vdc (Pins 2, 4, 5), and $V_b = 5.0$ Vdc (Pin 3), $P_{in} = 2.0$ mW (12.5% duty cycle, 4.6 ms period), VSWR equal to 10:1, and output power equal to 4.5 watts.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

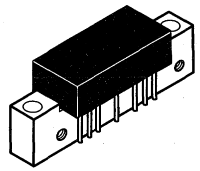
The RF Line
Low Distortion Wideband Amplifiers

MHW1134
MHW1184
MHW1224
MHW1244

13.0 dB
18.0 dB
22.0 dB
24.0 dB
5.0–200 MHz
CATV HIGH–SPLIT
REVERSE AMPLIFIERS

. . . designed specifically for broadband applications requiring low distortion characteristics. Specified for use as return amplifiers for mid–split and high–split 2–way cable TV systems. Features all gold metallization system.

- Guaranteed Broadband Power Gain @ f = 5.0–200 MHz
- Guaranteed Broadband Noise Figure @ f = 5.0–175 MHz
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- All Ion–Implanted Arsenic Emitter Transistor Chips with 6.0 GHz f_T's
- Circuit Design Optimized for Good RF Stability Under High VSWR Load Conditions
- Transformers Designed to Insure Good Low Frequency Gain Stability versus Temperature



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+65	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system)

Characteristic	Symbol	MHW1134	MHW1184	MHW1224	MHW1244	Units
Power Gain @ 10 MHz	G_P	13.0 ± 0.5	18.5 ± 0.5	22.0 ± 0.5	24.0 ± 0.5	dB
Frequency Range (Response/Return Loss) Note 1	BW	5.0–200				MHz
Cable Slope Equivalent (5.0–200 MHz)	S	−0.2 Min/+0.8 Max				dB
Gain Flatness (5.0–200 MHz)	F	±0.2 Max				dB
Input/Output Return Loss (5.0–200 MHz) Note 1	IRL/ORL	18.0 Min				dB
Cross Modulation Distortion @ +50 dBmV per ch.						
12–Channel FLAT (5.0–120 MHz)	XM_{12}	−70 Typ	−68 Typ	−67 Typ	−66 Typ	dB
22–Channel FLAT (5.0–175 MHz) (2) (3)	XM_{22}	−65 Max	−64 Max	−62 Max	−61 Max	dB
26–Channel FLAT (5.0–200 MHz)	XM_{26}	−65 Typ	−64 Typ	−62 Typ	−61 Typ	dB

NOTES:
1. Response and return loss characteristics are tested and guaranteed for the full 5.0–200 MHz frequency range.
2. Motorola 100% distortion and noise figure testing is performed over the 5.0–175 MHz frequency range. Cross modulation and composite triple beat testing are with 22–channel loading; Video carriers used are:

T7–T13	7.0–43.0 MHz	7–Channels
2–6	55.25–83.25 MHz	5–Channels
A–7	121.25–175.25 MHz	10–Channels

3. Video carriers used for 12–Channel typical performances are T7–6; For 26–Channel typical performance, Channels 8, 9, 10 and 11 are added to the 22–Channel carriers listed above.

REV 6

ELECTRICAL CHARACTERISTICS — continued (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system)

Characteristic	Symbol	MHW1134	MHW1184	MHW1224	MHW1244	Units
Composite Triple Beat Distortion @ +50 dBmV per ch.						
22–Channel FLAT (5.0–175 MHz) Notes 2 and 3	CTB_{22}	−73 Max	−72 Max	−69 Max	−68 Max	dB
26–Channel FLAT (5.0–200 MHz)	CTB_{26}	−71 Typ	−70 Typ	−68.5 Typ	−67.5 Typ	dB
Individual Triple Beat Distortion @ +50 dBmV per ch.						
Mid–Split (5.0–120 MHz) T11, T12 and CH2 @ 123.25 MHz	TB_3	−90 Typ	−88 Typ	−88 Typ	−87 Typ	dB
High–Split (5.0–175 MHz) T13, CH2 and CH5 @ 175.5 MHz	TB_3	−87 Typ	−85 Typ	−85 Typ	−84 Typ	dB
Second Order Distortion @ +50 dBmV per ch. High–Split (5.0–175 MHz) CH2, CHA @ 176.5 MHz	IMD	−72 Max	−72 Max	−72 Max	−72 Max	dB
Noise Figure High–Split (5.0–175 MHz) Note 2	NF	7.0 Max	5.5 Max	5.5 Max	5.0 Max	dB
DC Current	I_{DC}	210 Typ/240 Max				mAdc

NOTES:

1. Response and return loss characteristics are tested and guaranteed for the full 5.0–200 MHz frequency range.
2. Motorola 100% distortion and noise figure testing is performed over the 5.0–175 MHz frequency range. Cross modulation and composite triple beat testing are with 22–channel loading; Video carriers used are:

T7–T13	7.0–43.0 MHz	7–Channels
2–6	55.25–83.25 MHz	5–Channels
A–7	121.25–175.25 MHz	10–Channels

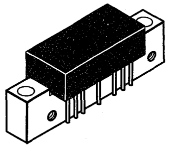
3. Video carriers used for 12–Channel typical performances are T7–6; For 26–Channel typical performance, Channels 8, 9, 10 and 11 are added to the 22–Channel carriers listed above.

The RF Line

Low Distortion Wideband Reverse Amplifier Modules

MHW1184L
MHW1224L
MHW1254L
MHW1304L

24 Vdc
50 MHz
18/22/25/30 dB
CATV LOW CURRENT AMPLIFIER



CASE 714–06, STYLE 1

Designed specifically for broadband applications requiring low distortion characteristics. Specified for use as return amplifiers for low–split 2–way cable TV systems. Features all gold metallization system.

- Guaranteed Broadband Power Gain
- Guaranteed Broadband Noise Figure
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- Circuit Design Optimized for Good RF Stability Under High VSWR Load Conditions
- Transformers Designed to Insure Good Low Frequency Gain Stability versus Temperature

MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{IN}	+70	dBmV
Operating Case Temperature Range	T_C	– 20 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = 30°C, 75 ohm system, unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
Bandwidth	All		BW	5.0	50	MHz
Power Gain	(f = 5.0 MHz)	MHW1184L MHW1224L MHW1254L MHW1304L	Gp	18.0 21.4 24.3 29.2	19.0 22.7 25.8 30.8	dB
Return Loss	(@ f = 5.0–50 MHz)	MHW1184L, MHW1224L, MHW1254L MHW1304L	RL	20 18	—	dB
Second Order Distortion	(V_{out} = +50 dBmV/ch)	All	IMD	—	–70	dBc
Cross Modulation	(V_{out} = +50 dBmV/ch)	MHW1184L MHW1224L MHW1254L MHW1304L	XMD_4	— — —	–64 –63 –62 –57	dBc
Triple Beat Distortion	(V_{out} = +50 dBmV/ch)	MHW1184L MHW1224L MHW1254L MHW1304L	TB_3	— — — —	–73 –72 –70 –66	dBc
Noise Figure	(f = 50 MHz)	MHW1184L, MHW1224L MHW1254L, MHW1304L	NF	— —	5.0 4.5	dB
DC Current	All		IDC	100	135	mA

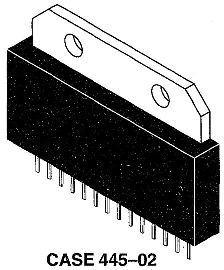
MHW2528

The RF Line
Triple Video Driver Hybrid Amplifier

2.8 ns
100 MHz
TRIPLE VIDEO DRIVER
HYBRID
AMPLIFIER

. . . designed specifically for use as the video channel final stage in high resolution color monitors.

- Typical 10–90% Transitions Times are 2.8 ns
- 100 MHz Minimum Bandwidth at 40 Vp–p Output
- Up to 50 Vp–p Output Swing with 60 V Supply Voltage
- Low Power Consumption
- Excellent Grey–Scale Linearity
- Unconditional Stability
- Gold Metallization System for the Ultimate in Reliability



CASE 445–02
Style 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	70	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$, $V_{CC} = 60$ V, $C_{LOAD} = 8.5$ pF, 40 V peak–to–peak output swing with 30 Vdc offset; $R_1 = 330$ ohms, $C_1 = 68$ pF Typ)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current (With Input Open Circuited) Per Channel	I_{CC}	27	33	39	mA
Input DC Voltage (With Input Open Circuited)	V_{inDC}	1.35	1.6	1.85	V
Output DC Voltage (With Input Open Circuited)	V_{outDC}	30	34	38	V
Voltage Gain (1) (2)	A_V	—	12.4	—	V/V
Transient Response (2)					
— Rise Time (10% to 90%)	t_r	—	2.8	3.5	ns
— Overshoot	$V_{OS,r}$	—	8.0	10	%
— Fall Time (90% to 10%)	t_f	—	2.8	3.5	ns
— Overshoot	$V_{OS,f}$	—	6.0	10	%
Operating Supply Current per Channel (V_{out} = 40 V Peak–to–Peak, 50 MHz Square Wave with 30 V offset) (3)	I_{CC}	—	70	—	mA
Linearity Error (V_{out} = +5.0 V to +55 V)	—	—	—	5.0	%

NOTES:
1. $A_V = V_{out}/V_S$
2. Input Signal is normally a 62.5 KHz square wave of 3.2 V peak–to–peak with 1.6 Vdc offset. Input t_r, t_f < 1.0 ns.
3. Output is not short circuit protected.

TYPICAL CHARACTERISTICS

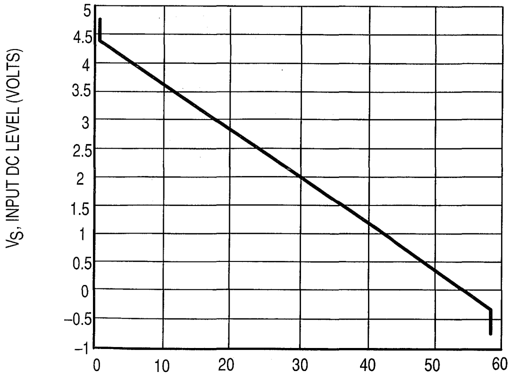


Figure 1. V_S versus V_{out}

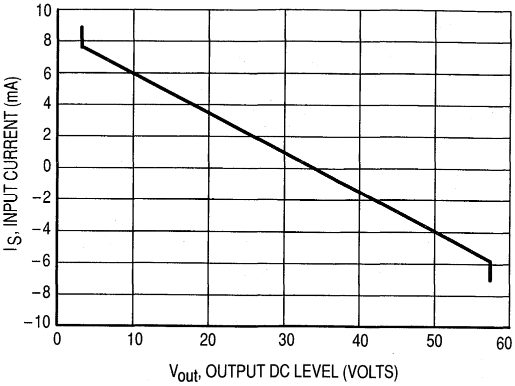


Figure 2. I_S versus V_{out}

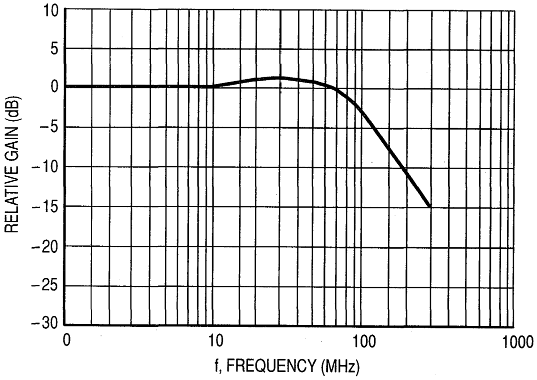


Figure 3. Frequency Response

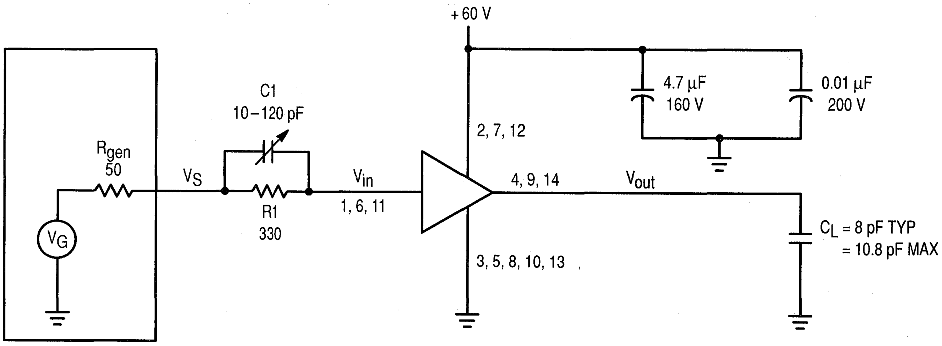


Figure 4. Hybrid Amplifier Test Circuit

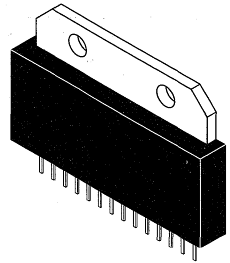
MHW3528

2.7 ns
120 MHz
TRIPLE VIDEO DRIVER
HYBRID
AMPLIFIER

The RF Line
Triple Video Driver Hybrid Amplifier

The driver is designed specifically for use as the video channel final stage in high resolution color monitors.

- 80 V Supply Operation Provide Large DC Offset Range for Color Applications
- Typical 10–90% Transitions Times are 2.7 ns
- 120 MHz Minimum Bandwidth at 40 Vp–p Output
- Up to 70 Vp–p Output Swing with 80 V Supply Voltage
- Low Power Consumption
- Excellent Grey–Scale Linearity
- Unconditional Stability
- Gold Metallization System for the Ultimate in Reliability



CASE 445–02
Style 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	90	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 80 V, C_{LOAD} = 10 pF, 40 V peak–to–peak output swing with 40 Vdc offset; R_1 = 287 ohms, C_1 = 60 pF Typ)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Current (With Input Open Circuited) Per Channel	I_{CC}	41	45	49	mA
Input DC Voltage (With Input Open Circuited)	V_{inDC}	1.3	1.55	1.8	V
Output DC Voltage (With Input Open Circuited)	V_{outDC}	36	40	44	V
Voltage Gain (1) (2)	A_V	—	12.7	—	V/V
Transient Response (2)					
— Rise Time (10% to 90%)	t_r	—	2.7	3.1	ns
— Overshoot	$V_{OS,r}$	—	8.0	10	%
— Fall Time (90% to 10%)	t_f	—	2.7	3.1	ns
— Overshoot	$V_{OS,f}$	—	6.0	10	%
Operating Supply Current per Channel (V_{out} = 40 V Peak–to–Peak, 50 MHz Square Wave with 30 V offset) (3)	I_{CC}	—	100	—	mA
Linearity Error (V_{out} = +5.0 V to +55 V)	—	—	—	5.0	%

NOTES:
1. $A_V = V_{out}/V_S$
2. Input Signal is normally a 62.5 KHz square wave of 3.2 V peak–to–peak with 1.5 Vdc offset. Input t_r, t_f < 1.0 ns.
3. Output is not short circuit protected.

TYPICAL CHARACTERISTICS

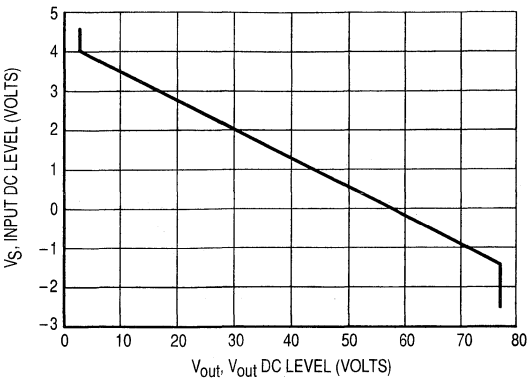


Figure 1. V_S versus V_{out}

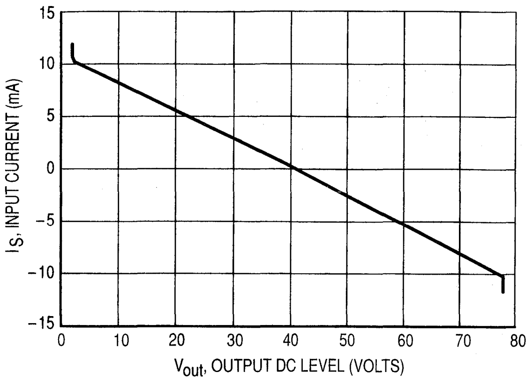


Figure 2. I_S versus V_{out}

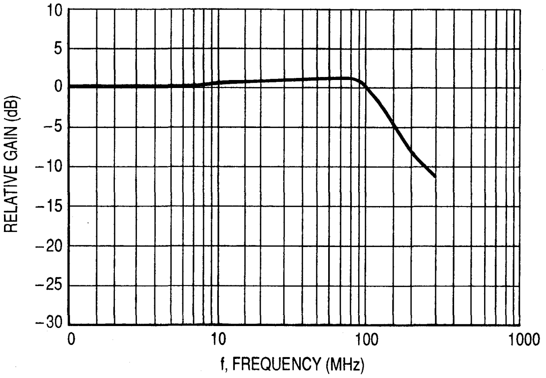


Figure 3. Frequency Response

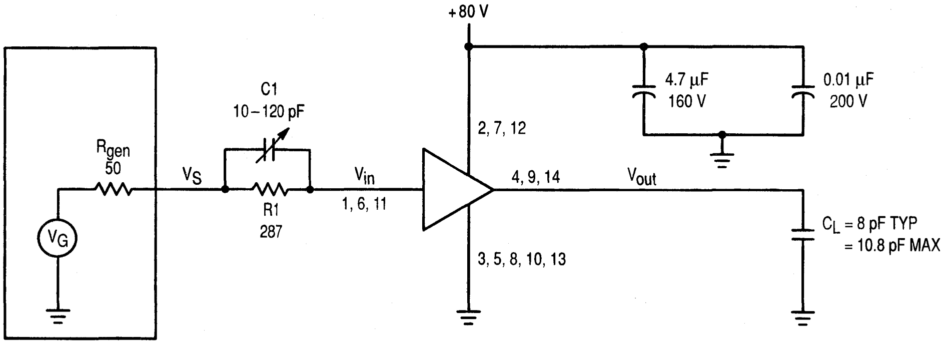


Figure 4. Hybrid Amplifier Test Circuit

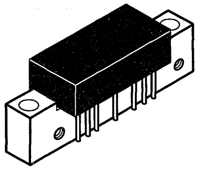
The RF Line
450 MHz CATV Amplifier

MHW5142A

14 dB GAIN
450 MHz
60–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 14 dB (Typ) @ 50 MHz
  14.5 dB (Min) @ 450 MHz
- Broadband Noise Figure @ 450 MHz
  NF = 7.0 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain — 50 MHz		G_p	13.5	14	14.5	dB
Power Gain — 450 MHz		G_p	14.0	—	—	dB
Slope		S	0.2	—	1.5	dB
Gain Flatness (Peak To Valley)		—	—	0.2	0.4	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M6, M15)			—	−78	—	
(V_{out} = +46 dBmV per ch., Ch2, M13, M22)			—	—	−74	
Cross Modulation Distortion						dB
(V_{out} = +46 dBmV per ch.)	53–Channel FLAT	XMD_{53}	—	−63	—	
	60–Channel FLAT	XMD_{60}	—	−63	−62	
Composite Triple Beat						dB
(V_{out} = +46 dBmV per ch.)	53–Channel FLAT	CTB_{53}	—	−63	—	
	60–Channel FLAT	CTB_{60}	—	−62	−61	
DIN (European Applications Only)*						dBμV**
300 MHz — (CH V + Q − P @ W)		DIN1	—	127	—	
400 MHz — (CH M8 + M15 − M9 @ M14)		DIN2	—	126	—	
450 MHz — (CH M20 + M23 − M22 @ M21)		DIN3	—	125	—	
Noise Figure (f = 450 MHz)		NF	—	6.0	7.0	dB
DC Current		I_{DC}	—	210	240	mA

REV 6

*DIN (European Applications Only)

NCTA Channel Designation	Frequency (MHz)	DIN Ouput Level (dBmV)**(Typ)		DIN Beat Level dB Relative to Ref. Ch.
		MHW5181A	**MHW5182A**	
P	253.25	+59	+61	≼−60
Q	259.25	+59	+61	
V	289.25	+65	+67	
W (Ref.)	295.25	+65	+67	
M8	361.25	+58	+60	≼−60
M9	367.25	+58	+60	
M14 (Ref.)	397.25	+64	+66	
M15	403.25	+64	+66	
M20	433.25	+63	+65	≼−60
M21 (Ref.)	439.25	+63	+65	
M22	445.25	+57	+59	
M23	451.25	+57	+59	

** DIN (dBμV) = Reference Channel Level (dBmV) + 60 dB

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

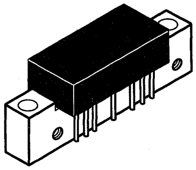
The RF Line
450 MHz CATV Amplifier

MHW5172A

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 53– and 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 17.4 dB (Typ)
- Broadband Noise Figure
  NF = 7.0 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

17 dB GAIN
450 MHz
60–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	450	MHz
Power Gain — 50 MHz	G_p	16.8	17.4	17.8	dB
Power Gain — 450 MHz	G_p	17.4	18.4	19.0	dB
Slope	S	0.3	0.5	1.5	dB
Gain Flatness (Peak To Valley)	—	—	0.2	0.4	dB
Return Loss — Input/Output 40–450 MHz (Z_o = 75 Ohms)	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +50 dBmV per ch., Ch 2, M6, M15) (V_{out} = +46 dBmV per ch., Ch 2, M13, M22)	IMD	 — —	 –78 —	 — –74	dB
Cross Modulation Distortion 53–Channel FLAT (V_{out} = +46 dBmV per ch.) 60–Channel FLAT	XMD_{53} XMD_{60}	— —	–65 –64	— –62	dB
Composite Triple Beat 53–Channel FLAT (V_{out} = +46 dBmV per ch.) 60–Channel FLAT	CTB_{53} CTB_{60}	— —	–63 –61	— –60	dB
DIN (European Applications Only)* 300 MHz — (CH V + Q – P @ W) 400 MHz — (CH M8 + M15 – M9 @ M14) 450 MHz — (CH M20 + M23 – M22 @ M21)	 DIN1 DIN2 DIN3	 — — —	 127 126 125	 — — —	dBμV**
Noise Figure (f = 450 MHz)	NF	—	6.0	7.0	dB
DC Current	I_{DC}	—	210	240	mA

***DIN (European Applications Only)**

NCTA Channel Designation	Frequency (MHz)	DIN Output Level (dBmV)**(Typ)	DIN Beat Level dB Relative to Ref. Ch.
P	253.25	+61	⩽−60
Q	259.25	+61	
V	289.25	+67	
W (Ref.)	295.25	+67	
M8	361.25	+60	⩽−60
M9	367.25	+60	
M14 (Ref.)	397.25	+66	
M15	403.25	+66	
M20	433.25	+65	⩽−60
M21 (Ref.)	439.25	+65	
M22	445.25	+59	
M23	451.25	+59	

** DIN (dBμV) = Reference Channel Level (dBmV) +60 dB

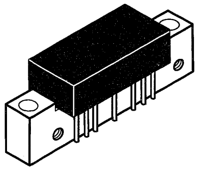
The RF Line
450 MHz CATV Amplifier

MHW5182A

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 53– and 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 18.2 dB (Typ) @ 50 MHz
  19.0 dB (Typ) @ 450 MHz
- Broadband Noise Figure
  NF = 6.5 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

18 dB GAIN
450 MHz
60–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain — 50 MHz		G_p	17.8	18.2	18.8	dB
Power Gain — 450 MHz		G_p	18.5	19	20	dB
Slope		S	0.3	—	1.5	dB
Gain Flatness (Peak To Valley)		—	—	0.2	0.4	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M6, M15)			—	−85	—	
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	−80	−72	
Cross Modulation Distortion (V_{out} = +46 dBmV per ch.)	53–Channel FLAT	XMD_{53}	—	−62	—	dB
	60–Channel FLAT	XMD_{60}	—	−61	−59	
Composite Triple Beat (V_{out} = +46 dBmV per ch.)	53–Channel FLAT	CTB_{53}	—	−64	—	dB
	60–Channel FLAT	CTB_{60}	—	−62	−61	
DIN (European Applications Only)*						dBμV**
300 MHz — (CH V + Q – P @ W)		DIN1	—	126	—	
400 MHz— (CH M8 + M15 – M9 @ M14)		DIN2	—	126	—	
450 MHz — (CH M20 + M23 – M22 @ M21)		DIN3	—	125	—	
Noise Figure (f = 450 MHz)		NF	—	5.5	6.5	dB
DC Current		I_{DC}	—	210	240	mA

***DIN (European Applications Only)**

NCTA Channel Designation	Frequency (MHz)	DIN Output Level (dBmV)**(Typ)	DIN Beat Level dB Relative to Ref. Ch.
P	253.25	+60	≤−60
Q	259.25	+60	
V	289.25	+66	
W (Ref.)	295.25	+66	
M8	361.25	+60	≤−60
M9	367.25	+60	
M14 (Ref.)	397.25	+66	
M15	403.25	+66	
M20	433.25	+65	≤−60
M21 (Ref.)	439.25	+65	
M22	445.25	+59	
M23	451.25	+59	

** DIN (dBμV) = Reference Channel Level (dBmV) +60 dB

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

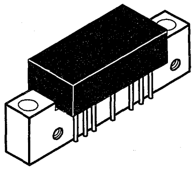
The RF Line
60-Channel (450 MHz) & 77-Channel (550 MHz) CATV Low Noise Amplifiers

MHW5183
MHW6183

18 dB GAIN
450/550 MHz
60/77 CHANNEL
LOW NOISE
CATV AMPLIFIERS

. . .designed specifically for up to 550 MHz CATV systems as input amplifiers in trunk and line extender applications. Both amplifiers feature ion–implanted, arsenic emitter transistors with 8.0 GHz f_T and an all gold metallization system.

- Specified for 60/77–Channel Performance
- Broadband Power Gain — @ f = 40 – 550 MHz
  G_P = 18.5 dB Typ @ 50 MHz
  19.1 dB Typ @ 450 MHz
  19.5 dB Typ @ 550 MHz
- Broadband Noise Figure
  NF = 4.5 dB Typ — MHW5183
  5.0 dB Typ — MHW6183
- Superior Gain, Return Loss and DC Current Stability with Temperature



CASE 714–06, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{IN}	+70	dBmV
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 ohm system, unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range	MHW5183	BW	40	—	450	MHz
	MHW6183		40	—	550	
Power Gain	50 MHz	G_P	18	18.5	19	dB
	450 MHz		18.7	19.1	20.2	
	550 MHz		19	19.5	20.5	
Slope	MHW5183	S	0.3	0.7	1.8	dB
	MHW6183		0.5	1.0	2.0	
Gain Flatness (Peak To Valley)	MHW5183	—	—	0.3	0.4	dB
	MHW6183		—	0.4	0.5	
Input/Output Return Loss	MHW5183 MHW6183	IRL/ORL	18	—	—	dB
Composite Second Order	MHW5183; V_{OUT} = +46 dBmV/ch	CSO_{60}	—	−65	−62	dB
	MHW6183; V_{OUT} = +44 dBmV/ch	CSO_{77}	—	−60	−58	
Cross Modulation Distortion						dBc
(V_{out} = +46 dBmV/ch, 60–Channel FLAT)	MHW5183	XMD_{60}	—	−59	−57	
(V_{out} = +44 dBmV/ch, 77–Channel FLAT)	MHW6183	XMD_{77}	—	−60	−58	
Composite Triple Beat						dBc
(V_{out} = +46 dBmV/ch, 60–Channel FLAT)	MHW5183	CTB_{60}	—	−62	−58	
(V_{out} = +44 dBmV/ch, 77–Channel FLAT)	MHW6183	CTB_{77}	—	−60	−58	
Noise Figure	f = 50 MHz	NF	—	3.6	4.0	dB
	MHW5183 f = 450 MHz		—	4.5	5.0	
	MHW6183 f = 550 MHz		—	5.0	5.5	
DC Current		I_{DC}	—	245	265	mA

REV 6

The RF Line

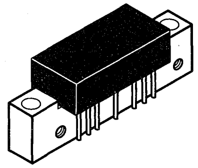
High Output Doubler 450/550/600 MHz CATV Amplifier Modules

MHW5185B
MHW6185B
MHW6185-6

The MHW5185B, MHW6185B, and MHW6185–6 are designed specifically for 450/550/600 MHz CATV applications. Features ion–implanted arsenic emitter transistors and an all gold metallization system.

- 5th Generation Die Technology
- Specified for 60/77/87–Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 18.5 dB Typ @ 50 MHz
  19.2 dB Typ @ 450 MHz
  19.5 dB Typ @ 550 MHz
  19.8 dB Typ @ 600 MHz
- Broadband Noise Figure
  NF = 4.5 dB Typ @ 50 MHz
  = 6.5 dB Typ @ 600 MHz
- Improvement in Distortion Over Conventional Hybrids
- Allows Higher Output Level Operation

18 dB GAIN
450/550/600 MHz
60/77/87–CHANNEL
CATV AMPLIFIERS



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic			Symbol	Min	Typ	Max	Unit
Frequency Range		MHW5185B MHW6185B MHW6185–6	BW	40 40 40	— — —	450 550 600	MHz
Power Gain	50 MHz 450 MHz 550 MHz 600 MHz	All MHW5185B MHW6185B MHW6185–6	G_p	18 18.5 18.8 19	18.5 19.2 19.5 19.8	19 20 20.5 21	dB
Slope	40–450 MHz 40–550 MHz 40–600 MHz	MHW5185B MHW6185B MHW6185–6	S	0.3 0.3 0.5	— — —	1.8 2.0 2.5	dB
Gain Flatness (Peak To Valley)		MHW5185B MHW6185B MHW6185–6	—	— — —	— — —	0.4 0.5 0.6	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz 40–550 MHz 40–600 MHz	MHW5185B MHW6185B MHW6185–6	IRL/ORL	18 18 18	— — —	— — —	dB
Composite Second Order 60 ch, (V_{out} = +46 dBmV) 77 ch, (V_{out} = +44 dBmV) 87 ch, (V_{out} = +44 dBmV)		 MHW5185B MHW6185B MHW6185–6	$CSO_{60/77/87}$	 — — —	 −70 −68 −60	 −67 −65 −60	dB

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic			Symbol	Min	Typ	Max	Unit
Cross Modulation Distortion			$XMD_{60/77/87}$				dB
(60 ch, V_{out} = +46 dBmV @ Fm = 55 MHz)		MHW5185B		—	−70	−67	
(77 ch, V_{out} = +44 dBmV @ Fm = 55 MHz)		MHW6185B		—	−78	−68	
(87 ch, V_{out} = +44 dBmV @ Fm = 55 MHz)		MHW6185–6		—	−70	−66	
Signal–to–Triple Beat Noise			$CTB_{60/77/87}$				dB
(60 ch, V_{out} = +46 dBmV)		MHW5185B		—	−68	−67	
(77 ch, V_{out} = +44 dBmV)		MHW6185B		—	−66	−65	
(87 ch, V_{out} = +44 dBmV)		MHW6185–6		—	−62	−62	
Noise Figure	450 MHz	MHW5185B	NF	—	5.5	7.0	dB
	550 MHz	MHW6185B		—	6.0	7.5	
	600 MHz	MHW6185–6		—	6.5	8.0	
DC Current (V_{DC} = 24 Vdc, T_C = 30°C)			I_{DC}	380	415	440	mA

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

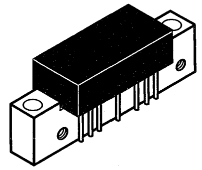
The RF Line
High Output Doubler 450 MHz CATV Amplifier

MHW5205

20 dB GAIN
450 MHz
60–CHANNEL
CATV AMPLIFIER

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 6.0 to 8.0 GHz f_T and an all gold metallization system.

- 24 V Supply Voltage
- 4th Generation Die Technology
- Specified for 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 20 dB (Typ) @ 50 MHz
  22 dB (Typ) @ 450 MHz
- Broadband Noise Figure
  NF = 6.5 dB (Typ)
- Improvement in Distortion Over Conventional Hybrids
- Allows Higher Output Level Operation



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_A = +25°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain	50 MHz 450 MHz	G_p	20 21	20.5 21.7	21 23	dB
Slope		S	0.5	—	2.5	dB
Gain Flatness (Peak to Valley)		—	—	—	0.5	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Composite Second Order — Intermodulation Distortion (V_{out} = +46 dBmV per ch.)	60–Channel FLAT	CSO_{60}	—	−63	−58	dB
Cross Modulation Distortion (V_{out} = +46 dBmV per ch.)	60–Channel FLAT	XMD_{60}	—	−67	−64	dB
Composite Triple Beat (V_{out} = +46 dBmV per ch.)	60–Channel FLAT	CTB_{60}	—	−65	−64	dB
Noise Figure	50 MHz 450 MHz	NF	— —	4.5 5.5	5.0 6.5	dB
DC Current (V_{DC} = 24 ±0.5 Vdc, T_C = 30°C)		I_{DC}	—	415	440	mA

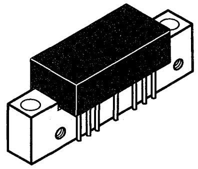
The RF Line
450 MHz CATV Amplifier

. . . designed for broadband applications requiring low distortion characteristics. Specifically intended for CATV market requirements. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 22 dB (Typ)
- Broadband Noise Figure — @ f = 40–450 MHz
  NF = 4.5 dB (Typ)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

MHW5222A

22 dB GAIN
450 MHz
60–CHANNEL
CATV TRUNK AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	450	MHz
Power Gain — 50 MHz	G_p	21.4	22	22.6	dB
Power Gain — 450 MHz	G_p	22.0	22.9	23.5	dB
Slope	S	0.2	0.5	1.5	dB
Gain Flatness (Peak To Valley)	—	—	0.2	0.4	dB
Return Loss — Input/Output 40–450 MHz (Z_o = 75 Ohms)	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion	IMD				dB
(V_{out} = +46 dBmV, Ch 2, M6, M15)		—	−80	—	
(V_{out} = +44 dBmV, Ch 2, M13, M22)		—	−78	−72	
Cross Modulation Distortion (V_{out} = +46 dBmV) 53–Channel FLAT	XMD_{53}	—	−60	—	dB
60–Channel FLAT	XMD_{60}		−60	−59	
Composite Triple Beat (V_{out} = +46 dBmV) 53–Channel FLAT	CTB_{53}	—	−63	—	dB
60–Channel FLAT	CTB_{60}	—	−61	−60	
DIN (European Applications Only)					dBμV
300 MHz — (CH V + Q – P @ W)	DIN1	—	125.5	—	
400 MHz — (CH M8 + M15 – M9 @ M14)	DIN2	—	125	—	
450 MHz — (CH M20 + M23 – M22 @ M21)	DIN3	—	124	—	
Noise Figure (f = 450 MHz)	NF	—	4.5	5.0	dB
DC Current	I_{DC}	—	210	240	mA

***DIN (European Applications Only)**

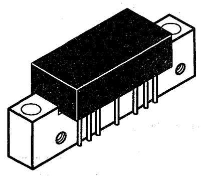
NCTA Channel Designation	Frequency (MHz)	DIN Output Level (dBmV)**(Typ)	DIN Beat Level dB Relative to Ref. Ch.
P	253.25	+59.5	⩽–60
Q	259.25	+59.5	
V	289.25	+65.5	
W (Ref.)	295.25	+65.5	
M8	361.25	+59	⩽–60
M9	367.25	+59	
M14 (Ref.)	397.25	+65	
M15	403.25	+65	
M20	433.25	+64	⩽–60
M21 (Ref.)	439.25	+64	
M22	445.25	+58	
M23	451.25	+58	

**DIN (dBμV) = Reference Channel Level (dBmV) +60 dB

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

MHW5225

22 dB GAIN
450 MHz
60-CHANNEL
CATV AMPLIFIER



CASE 714-06, STYLE 1

The RF Line
High Output Doubler 450 MHz CATV Amplifier

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 6.0 to 8.0 GHz f_T and an all gold metallization system.

- 24 V Supply Voltage
- 4th Generation Die Technology
- Specified for 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 22 dB (Typ) @ 50 MHz
  23 dB (Typ) @ 450 MHz
- Broadband Noise Figure
  NF = 4.5 dB (Typ)
- Improvement in Distortion Over Conventional Hybrids
- Allows Higher Output Level Operation

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_A = + 25°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain	50 MHz 450 MHz	G_p	21.4 22.3	22.0 23.0	22.6 23.7	dB
Slope		S	0.3	1.0	1.8	dB
Gain Flatness (Peak To Valley)		—	—	0.25	0.5	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +46 dBmV per ch., Ch 2, M13, M22)		IMD	—	−74	−69	dB
Cross Modulation Distortion (V_{out} = +46 dBmV per ch.)	60–Channel FLAT	XMD_{60}	—	−67	−62	dB
Composite Triple Beat (V_{out} = +46 dBmV per ch.)	60–Channel FLAT	CTB_{60}	—	−65	−62	dB
Noise Figure	450 MHz	NF	—	4.5	6.0	dB
DC Current		I_{DC}	—	415	440	mA

REV 6

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

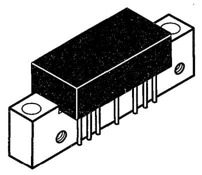
The RF Line
450 MHz CATV Amplifier

MHW5272A

27 dB GAIN
450 MHz
60–CHANNEL
CATV LINE EXTENDER
AMPLIFIER

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 53– and 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 27 dB (Typ)
- Broadband Noise Figure
  NF = 5.0 dB (Typ)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain — 50 MHz		G_p	26.2	27	27.8	dB
Power Gain — 450 MHz		G_p	27.0	28.0	29.0	dB
Slope		S	0	+1.0	+2.5	dB
Gain Flatness (Peak To Valley)		—	—	0.4	0.6	dB
Return Loss — Input/Output (Z_O = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +46 dBmV per ch., Ch 2, M 6, M15) (V_{out} = +46 dBmV per ch., Ch 2, M13, M22)		IMD	 — —	 –78 –76	 — –68	dB
Cross Modulation Distortion (V_{out} = +46 dBmV)	53–Channel FLAT 60–Channel FLAT	XMD_{53} XMD_{60}	—	–63 –63	— –60	dB
Composite Triple Beat (V_{out} = +46 dBmV)	53–Channel FLAT 60–Channel FLAT	CTB_{53} CTB_{60}	— —	–63 –61	— –59	dB
DIN (European Applications Only) 300 MHz — (CH V + Q – P @ W) 400 MHz — (CH M8 + M15 – M9 @ M14) 450 MHz — (CH M20 + M23 – M22 @ M21)		 DIN1 DIN2 DIN3	 — — —	 126 125 124	 — — —	dBμV
Noise Figure (f = 450 MHz)		NF	—	5.0	6.0	dB
DC Current		I_{DC}	—	310	340	mA

***DIN (European Applications Only)**

NCTA Channel Designation	Frequency (MHz)	DIN Output Level (dBmV)**(Typ)	DIN Beat Level dB Relative to Ref. Ch.
P Q V W (Ref.)	253.25 259.25 289.25 295.25	+60 +60 +66 +66	≤−60
M8 M9 M14 (Ref.) M15	361.25 367.25 397.25 403.25	+59 +59 +65 +65	≤−60
M20 M21 (Ref.) M22 M23	433.25 439.25 445.25 451.25	+64 +64 +58 +58	≤−60

**DIN (dBμV) = Reference Channel Level (dBmV) +60 dB

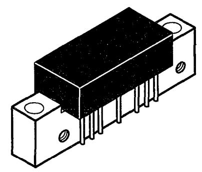
The RF Line
450 MHz CATV Amplifier

MHW5342A

34 dB GAIN
450 MHz
60–CHANNEL
CATV LINE EXTENDER
AMPLIFIER

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 53– and 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 34.5 dB Typ @ 50 MHz
  35.5 dB Typ @ 450 MHz
- Broadband Noise Figure
  NF = 5.0 dB (Typ)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain — 50 MHz		G_p	33.5	34.5	35.5	dB
Power Gain — 450 MHz		G_p	34.5	35.5	37	dB
Slope		S	0	+1.0	+2.5	dB
Gain Flatness (Peak To Valley)		—	—	0.3	0.6	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M6, M15)			—	−78	—	
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	−74	−68	
Cross Modulation Distortion	53–Channel FLAT	XMD_{53}	—	−63	—	dB
(V_{out} = +46 dBmV)	60–Channel FLAT	XMD_{60}		−63	−59	
Composite Triple Beat	53–Channel FLAT	CTB_{53}	—	−63	—	dB
(V_{out} = +46 dBmV)	60–Channel FLAT	CTB_{60}	—	−62	−59	
DIN (European Applications Only)						dBμV
300 MHz — (CH V + Q – P @ W)		DIN1	—	126	—	
400 MHz — (CH M8 + M15 – M9 @ M14)		DIN2	—	125	—	
450 MHz — (CH M20 + M23 – M22 @ M21)		DIN3	—	124	—	
Noise Figure (f = 450 MHz)		NF	—	5.0	6.0	dB
DC Current		I_{DC}	—	310	340	mA

REV 6

*DIN (European Applications Only)

NCTA Channel Designation	Frequency (MHz)	DIN Output Level (dBmV)**(Typ)	DIN Beat Level dB Relative to Ref. Ch.
P	253.25	+60	⩽−60
Q	259.25	+60	
V	289.25	+66	
W (Ref.)	295.25	+66	
M8	361.25	+59	⩽−60
M9	367.25	+59	
M14 (Ref.)	397.25	+65	
M15	403.25	+65	
M20	433.25	+64	⩽−60
M21 (Ref.)	439.25	+64	
M22	445.25	+58	
M23	451.25	+58	

**DIN (dBμV) = Reference Channel Level (dBmV) +60 dB

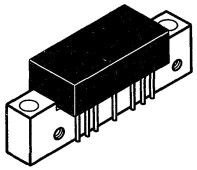
The RF Line
450 MHz CATV AMPLIFIER

MHW5382A

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 53– and 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 38 dB (Typ)
- Broadband Noise Figure
  NF = 4.0 dB (Typ)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

38 dB GAIN
450 MHz
60–CHANNEL
CATV LINE EXTENDER
AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain — 50 MHz		G_p	37	38	39.5	dB
Power Gain — 450 MHz		G_p	38	39	40	dB
Slope		S	0	+1.0	+2.5	dB
Gain Flatness (Peak To Valley)		—	—	0.3	0.6	dB
Return Loss — Input/Output (Z_O = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M6, M15)			—	−78	—	
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	−72	−64	
Cross Modulation Distortion (V_{out} = +46 dBmV)	53–Channel FLAT	XMD_{53}	—	−63	—	dB
	60–Channel FLAT	XMD_{60}		−61	−59	
Composite Triple Beat (V_{out} = +46 dBmV)	53–Channel FLAT	CTB_{53}	—	−63	—	dB
	60–Channel FLAT	CTB_{60}	—	−60	−59	
DIN (European Applications Only)						dBμV
300 MHz — (CH V + Q – P @ W)		DIN1	—	125	—	
400 MHz— (CH M8 + M15 – M9 @ M14)		DIN2	—	124	—	
450 MHz — (CH M20 + M23 – M22 @ M21)		DIN3	—	123	—	
Noise Figure (f = 450 MHz)		NF	—	4.0	5.0	dB
DC Current		I_{DC}	—	310	340	mA

*DIN (European Applications Only)

NCTA Channel Designation	Frequency (MHz)	DIN Output Level (dBmV)**(Typ)	DIN Beat Level dB Relative to Ref. Ch.
P	253.25	+59	≤−60
Q	259.25	+59	
V	289.25	+65	
W (Ref.)	295.25	+65	
M8	361.25	+58	≤−60
M9	367.25	+58	
M14 (Ref.)	397.25	+64	
M15	403.25	+64	
M20	433.25	+57	≤−60
M21 (Ref.)	439.25	+57	
M22	445.25	+63	
M23	451.25	+63	

**DIN (dBμV) = Reference Channel Level (dBmV) +60 dB

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

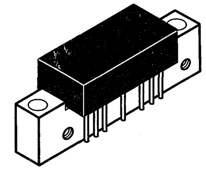
The RF Line
550 MHz CATV Amplifier

MHW6122

. . . designed specifically for 550 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 77–Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 12.5 dB (Typ) @ 50 MHz
  13 dB (Min) @ 550 MHz
- Broadband Noise Figure @ 550 MHz
  NF = 8.5 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

12 dB GAIN
550 MHz
77–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	550	MHz
Power Gain — 50 MHz	G_p	12	12.5	13	dB
Power Gain — 550 MHz	G_p	12.5	—	—	dB
Slope	S	0.2	—	1.5	dB
Gain Flatness (Peak To Valley)	—	—	0.2	0.4	dB
Return Loss — Input/Output 40–550 MHz (Z_o = 75 Ohms)	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +46 dBmV, Ch 2, M13, M22) (V_{out} = +44 dBmV, Ch 2, M30, M39)	IMD	 — —	 — —	 −72 −72	dB
Cross Modulation Distortion (V_{out} = +46 dBmV) 60–Channel FLAT (V_{out} = +44 dBmV) 77–Channel FLAT	 XMD_{60} XMD_{77}	 — —	 −63 −65	 — −62	dB
Composite Triple Beat (V_{out} = +46 dBmV) 60–Channel FLAT (V_{out} = +44 dBmV) 77–Channel FLAT	 CTB_{60} CTB_{77}	 — —	 −62 −58	 — −56	dB
Noise Figure (f = 550 MHz)	NF	—	7.0	8.5	dB
DC Current	I_{DC}	—	210	240	mA

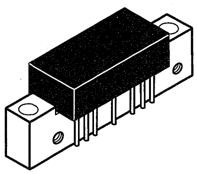
The RF Line
550 MHz CATV Amplifier

MHW6142

14 dB GAIN
550 MHz
77–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER

. . . designed specifically for 550 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 77 Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 14 dB (Typ) @ 50 MHz
  14.5 dB (Min) @ 550 MHz
- Broadband Noise Figure
  NF = 7.5 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	550	MHz
Power Gain — 50 MHz		G_p	13.5	14	14.5	dB
Power Gain — 550 MHz		G_p	14.5	—	—	dB
Slope		S	0.2	—	1.5	dB
Gain Flatness (Peak To Valley)		—	—	0.2	0.5	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–550 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	−78	—	
(V_{out} = +44 dBmV per ch., Ch 2, M30, M39)			—	−75	−72	
Cross Modulation Distortion						dB
(V_{out} = +46 dBmV per ch.)	60–Channel FLAT	XMD_{60}	—	−64	—	
(V_{out} = +44 dBmV per ch.)	77–Channel FLAT	XMD_{77}	—	−65	−62	
Composite Triple Beat						dB
(V_{out} = +46 dBmV per ch.)	60–Channel FLAT	CTB_{60}	—	−62	—	
(V_{out} = +44 dBmV per ch.)	77–Channel FLAT	CTB_{77}	—	−65	−59	
Noise Figure (f = 550 MHz)		NF	—	6.5	7.5	dB
DC Current		I_{DC}	—	210	240	mA

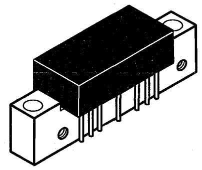
The RF Line
77-Channel (550 MHz) CATV Input/Output Trunk Amplifier

MHW6172

17 dB GAIN
550 MHz
77–CHANNEL
CATV AMPLIFIER

. . . designed specifically for 550 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7 GHz f_T and an all gold metallization system.

- Specified for 77–Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 17.2 dB (Typ)
- Broadband Noise Figure — @ f = 550 MHz
  NF = 6 dB (Typ)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz Ion–Implanted Transistors



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	550	MHz
Power Gain	50 MHz	G_p	16.8	17.2	17.8	dB
Slope		S	0	+0.5	2.0	dB
Gain Flatness (Peak To Valley)		—	—	0.2	0.4	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–550 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	−80	—	
(V_{out} = +44 dBmV per ch., Ch 2, M30, M39)			—	−78	−70	
Cross Modulation Distortion						dB
(V_{out} = +46 dBmV per ch.)	60–Channel FLAT	XMD_{60}	—	−63	—	
(V_{out} = +44 dBmV per ch.)	77–Channel FLAT	XMD_{77}	—	−65	−62	
Composite Triple Beat Noise						dB
(V_{out} = +46 dBmV per ch.)	60–Channel FLAT	CTB_{60}	—	−62	—	
(V_{out} = +44 dBmV per ch.)	77–Channel FLAT	CTB_{77}	—	−60	−59	
Noise Figure	450 MHz	NF	—	5.5	—	dB
	550 MHz		—	6	7	
DC Current		I_{DC}	—	210	240	mA

REV 6

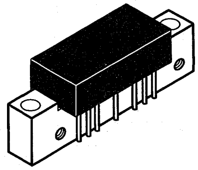
The RF Line
550 MHz CATV Amplifier

. . . designed specifically for 550 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 77 Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 18.2 dB (Typ) @ 50 MHz
  18.8 dB (Min) @ 550 MHz
- Broadband Noise Figure @ 550 MHz
  NF = 7.0 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

MHW6182

18 dB GAIN
550 MHz
77–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	550	MHz
Power Gain — 50 MHz		G_p	17.7	18.2	18.7	dB
Power Gain — 550 MHz		G_p	18.8	19.2	20	dB
Slope		S	0.5	—	2.5	dB
Gain Flatness (Peak To Valley)		—	—	0.2	0.5	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–550 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	−85	—	
(V_{out} = +44 dBmV per ch., Ch 2, M30, M39)			—	−80	−72	
Cross Modulation Distortion						dB
(V_{out} = +46 dBmV per ch.)	60–Channel FLAT	XMD_{60}	—	−61	—	
(V_{out} = +44 dBmV per ch.)	77–Channel FLAT	XMD_{77}	—	−64	−62	
Composite Triple Beat						dB
(V_{out} = +46 dBmV per ch.)	60–Channel FLAT	CTB_{60}	—	−62	—	
(V_{out} = +44 dBmV per ch.)	77–Channel FLAT	CTB_{77}	—	−60	−58	
Noise Figure (f = 550 MHz)		NF	—	—	7.0	dB
DC Current		I_{DC}	—	210	240	mA

REV 6

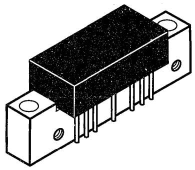
The RF Line
600 MHz CATV Amplifier Module

MHW6182-6

This module is designed specifically for 600 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7 GHz f_T and an all gold metallization system.

- Specified for 87–Channel Performance
- Broadband Power Gain — @ f = 40–600 MHz
  G_p = 17.6 dB (Min) @ 50 MHz
  18.2 dB (Min) @ 600 MHz
- Broadband Noise Figure @ 600 MHz
  NF = 6 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz Ion–Implanted Transistors

**5TH GENERATION
18 dB GAIN
600 MHz
87–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIERS**



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input	V_{in}	+60	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	600	MHz
Power Gain	f = 50 MHz	G_p	17.6	18.2	18.8	dB
Power Gain	f = 600 MHz	G_p	18.2	19.2	20	dB
Slope	f = 40–600 MHz	S	0	—	1.8	dB
Gain Flatness (Peak to Valley)	f = 40–600 MHz	—	—	0.2	0.6	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	f = 40–600 MHz	IRL/ORL	18	—	—	dB
Composite Second Order (V_{out} = +44 dBmV/Ch)	87–Channel FLAT	CSO_{87}	—	—	−56	dB
Cross Modulation Distortion (V_{out} = +44 dBmV/Ch, Fm = 55 MHz)	87–Channel FLAT	XMD_{87}	—	—	−55	dB
Composite Triple Beat (V_{out} = +44 dBmV/Ch)	87–Channel FLAT	CTB_{87}	—	—	−57	dB
Noise Figure	f = 50 MHz f = 600 MHz	NF	— —	— —	5 6	dB
DC Current (V_{DC} = 24 Vdc, T_C = 30°C)		I_{DC}	180	210	240	mA

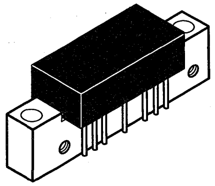
REV 1

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
High Output Power Doubler 550 MHz CATV Amplifiers

MHW6205
MHW6225

550 MHz, 24 V
77 CHANNEL
CATV AMPLIFIERS


CASE 714–06, STYLE 1

Designed specifically for 550 MHz CATV applications. Features ion–implanted, arsenic emitter transistors with an all gold metallization system.

- Supply Voltage = 24 V
- 5th Generation Die Technology
- Specified for 77 Channel Performance
- Broadband Power Gain @ f = 50 MHz
  G_p = 20 dB Typ (MHW6205)
  G_p = 22 dB Typ (MHW6225)
- Broadband Noise Figure @ f = 50 MHz
  NF = 5 dB Max
- Improvement in Distortion Over Conventional Hybrids
- Allows Higher Output Level Operation

ABSOLUTE MAXIMUM RATINGS

Parameters	Symbol	Max	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{IN}	+70	dBmV
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 V, T_C = 30°C, 75 Ω system, unless otherwise noted)

Parameters		Symbol	Min	Max	Unit
Bandwidth		BW	40	550	MHz
Power Gain f = 50 MHz f = 550 MHz	MHW6205 MHW6205	G_p	19.5 20.3	20.5 22.5	dB
Power Gain f = 50 MHz f = 550 MHz	MHW6225 MHW6225	G_p	21.4 22	22.6 24	dB
Slope (f = 40−550 MHz)		S	0.3	2	dB
Gain Flatness (f = 40−550 MHz, Peak to Valley)	MHW6205 MHW6225	G_f	— —	0.5 0.6	dB
Input/Output Return Loss (f = 40−550 MHz, Z_o = 75 Ω)		IRL/ORL	18	—	dB
Composite Second Order (V_{out} = +44 dBmV/ch, 77 Channels, FM = 541 MHz)	MHW6205 MHW6225	CSO_{77}	— —	−60 −55	dBc
Cross Modulation (V_{out} = +44 dBmV/ch, 77 Channels, FM = 55 MHz)	MHW6205 MHW6225	XMD_{77}	— —	−67 −63	dBc
Composite Triple Beat (V_{out} = +44 dBmV/ch, 77 Channels, FM = 547 MHz)	MHW6205 MHW6225	CTB_{77}	— —	−64 −62	dBc
Noise Figure f = 50 MHz f = 550 MHz f = 550 MHz	All MHW6205 MHW6225	NF	— — —	5 7.5 7	dB
DC Current		I_{DC}	390	440	mA

REV 1

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

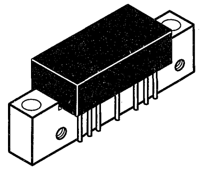
The RF Line
550 MHz CATV Amplifier

MHW6222

. . . designed specifically for 550 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 77–Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 22 dB (Typ) @ 50 MHz
  22 dB (Min) @ 550 MHz
- Broadband Noise Figure @ 550 MHz
  NF = 6.0 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

22 dB GAIN
550 MHz
77–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+60	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	550	MHz
Power Gain — 50 MHz	G_p	21.4	22	22.6	dB
Power Gain — 550 MHz	G_p	22	—	—	dB
Slope	S	0.2	—	1.5	dB
Gain Flatness (Peak To Valley)	—	—	0.2	0.4	dB
Return Loss — Input/Output (Z_o = 75 Ohms) 40–550 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion (V_{out} = +46 dBmV per ch., Ch 2, M13, M22) (V_{out} = +44 dBmV per ch., Ch 2, M30, M39)	IMD	 — —	 −80 −72	 — −66	dB
Cross Modulation Distortion (V_{out} = +46 dBmV per ch.) 60–Channel FLAT (V_{out} = +44 dBmV per ch.) 77–Channel FLAT	 XMD_{60} XMD_{77}	 — —	 −60 −60	 — −57	dB
Composite Triple Beat (V_{out} = +46 dBmV per ch.) 60–Channel FLAT (V_{out} = +44 dBmV per ch.) 77–Channel FLAT	 CTB_{60} CTB_{77}	 — —	 −61 −59	 — −57	dB
Noise Figure (f = 550 MHz)	NF	—	5.0	6.0	dB
DC Current	I_{DC}	—	210	240	mA

REV 6

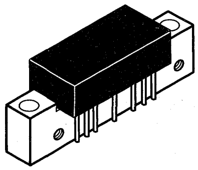
The RF Line
600 MHz CATV Amplifier Module

MHW6222-6

This module is designed specifically for 600 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7 GHz f_T and an all gold metallization system.

- Specified for 87–Channel Performance
- Broadband Power Gain — @ f = 40–600 MHz
  G_p = 21 dB (Min) @ 50 MHz
  21.7 dB (Min) @ 600 MHz
- Broadband Noise Figure @ 600 MHz
  NF = 6 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz Ion–Implanted Transistors

5TH GENERATION
22 dB GAIN
600 MHz
87–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIERS



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input	V_{in}	+60	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	600	MHz
Power Gain	f = 50 MHz	G_p	21	21.5	22	dB
Power Gain	f = 600 MHz	G_p	21.7	—	23	dB
Slope	f = 40–600 MHz	S	0	—	1.8	dB
Gain Flatness (Peak to Valley)	f = 40–600 MHz	—	—	0.2	0.6	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	f = 40–600 MHz	IRL/ORL	18	—	—	dB
Composite Second Order (V_{out} = +44 dBmV/Ch)	87–Channel FLAT	CSO_{87}	—	—	–56	dB
Cross Modulation Distortion (V_{out} = +44 dBmV/Ch, Fm = 55 MHz)	87–Channel FLAT	XMD_{87}	—	—	–56	dB
Composite Triple Beat (V_{out} = +44 dBmV/Ch)	87–Channel FLAT	CTB_{87}	—	—	–56	dB
Noise Figure	f = 50 MHz f = 600 MHz	NF	— —	— —	5 6	dB
DC Current (V_{DC} = 24 Vdc, T_C = 30°C)		I_{DC}	180	—	240	mA

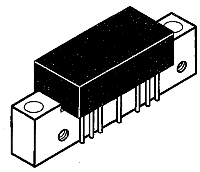
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
77-Channel (550 MHz) CATV Line Extender Amplifier

MHW6272

27 dB GAIN
550 MHz
77–CHANNEL
CATV AMPLIFIER

- Specified for 60– and 77–Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 27 dB (Typ)
- Broadband Noise Figure
  NF = 6 dB (Typ) @ 550 MHz
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz f_T Ion–Implanted Transistors



CASE 714–06, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	550	MHz
Power Gain	50 MHz	G_p	26.2	27	27.8	dB
	550 MHz		27	—	29.2	
Slope		S	0	1	2	dB
Gain Flatness (Peak To Valley)		—	—	0.4	0.8	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
	450–550 MHz		16	—	—	
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +48 dBmV per ch., Ch 2, 13, R)			—	–80	—	
(V_{out} = +46 dBmV per ch., Ch 2, M6, M15)			—	–78	—	
(V_{out} = +46 dBmV per ch., Ch 2, M13, M22)			—	–76	—	
(V_{out} = +44 dBmV per ch., Ch 2, M30, M39)			—	–69	–64	
Cross Modulation Distortion @ Ch 2						dB
(V_{out} = +46 dBmV per ch.)	53–Channel FLAT	XMD_{53}	—	–63	—	
	60–Channel FLAT	XMD_{60}	—	–62	—	
(V_{out} = +44 dBmV per ch.)	70–Channel FLAT	XMD_{70}	—	–61	—	
	77–Channel FLAT	XMD_{77}	—	–59	–57	
Composite Triple Beat						dB
(V_{out} = +46 dBmV per ch.)	53–Channel FLAT	TB_{53}	—	–63	—	
	60–Channel FLAT	TB_{60}	—	–62	—	
(V_{out} = +44 dBmV per ch.)	70–Channel FLAT	TB_{70}	—	–61	—	
	77–Channel FLAT	TB_{77}	—	–59	–57	
Noise Figure	550 MHz	NF	—	6.0	6.5	dB
DC Current		I_{DC}	—	310	340	mA

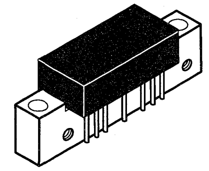
The RF Line
77-Channel (550 MHz) CATV Amplifier

MHW6342

**34 dB GAIN
550 MHz
77–CHANNEL
CATV AMPLIFIER**

. . . designed specifically for 550 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7 GHz f_T and an all gold metallization system.

- Specified for 77–Channel Performance
- Broadband Power Gain — @ f = 40–550 MHz
  G_p = 34.5 dB (Typ) @ 50 MHz
  35 dB (Min) @ 550 MHz
- Broadband Noise Figure @ 550 MHz
  NF = 5.5 dB (Typ)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz Ion–Implanted Transistors



CASE 714–06, STYLE 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	550	MHz
Power Gain	50 MHz	G_p	33.5	34.5	35.5	dB
Power Gain	550 MHz	G_p	34.5	—	—	dB
Slope		S	0	1	2	dB
Gain Flatness (Peak To Valley)		—	—	0.4	0.8	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–550 MHz 450–550 MHz	IRL/ORL	18 16	— —	— —	dB
Second Order Intermodulation Distortion (V_{out} = +46 dBmV per ch., Ch 2, M13, M22) (V_{out} = +44 dBmV per ch., Ch 2, M30, M39)		IMD	— —	−75 −70	— −64	dB
Cross Modulation Distortion (V_{out} = +46 dBmV per ch.) (V_{out} = +44 dBmV per ch.)	60–Channel FLAT 77–Channel FLAT	XMD_{60} XMD_{77}	— —	−61 −59	— −57	dB
Composite Triple Beat (V_{out} = +46 dBmV per ch.) (V_{out} = +44 dBmV per ch.)	60–Channel FLAT 77–Channel FLAT	CTB_{60} CTB_{77}	— —	−60 −58	— −57	dB
Noise Figure	550 MHz	NF	—	5.5	6.5	dB
DC Current		I_{DC}	—	310	340	mA

REV 6

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

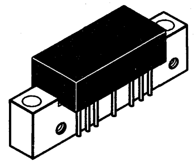
The RF Line
750/860/1000 MHz CATV Conventional Hybrid Amplifiers

MHW7142
MHW8142
MHW9142

24 Vdc
750/860/1000 MHz
110/128/152 – CHANNEL
CATV AMPLIFIERS

Designed specifically for 750/860/1000 MHz CATV applications. Features ion–implanted arsenic emitter transistors with an all gold metallization system.

- Supply Voltage = 24 Vdc
- 5th Generation Die Technology
- Specified for 110/128/152 Channel Performance
- Power Gain = 14.5 dB max @ f = 50 MHz
- Superior Gain, Return Loss and DC Current Stability
- All Gold Metallization



CASE 714–06, Style 1

MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{IN}	+70	dBmV
Operating Case Temperature Range	T_C	– 20 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24Vdc, T_C = 25°C, 75 ohm system, unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
Frequency		MHW7142	BW	40	750	MHz
		MHW8142		40	860	
		MHW9142		40	1000	
Power Gain	(f = 50 MHz)	All	Gp1	13.5	14.5	dB
Power Gain	(f = 750 MHz)	MHW7142	Gp2	14.2	15.2	dB
	(f = 860 MHz)	MHW8142		14.2	15.5	
	(f = 1000 MHz)	MHW9142		14.2	15.7	
Slope	(f = 40 – 750 MHz)	MHW7142	S	0.3	1.5	dB
	(f = 40 – 860 MHz)	MHW8142		0.3	1.8	
	(f = 40 – 1000 MHz)	MHW9142		0.3	2.0	
Gain Flatness	(f = 40 – 750 MHz, Peak to Valley)	MHW7142	G_f	—	0.6	dB
	(f = 40 – 860 MHz, Peak to Valley)	MHW8142		—	0.6	
	(f = 40 – 1000 MHz, Peak to Valley)	MHW9142		—	0.8	
Return Loss	(@ f = 40 MHz)	All	RL	20	—	dB
Return Loss Derate	(@ f > 40 MHz)	MHW7142	RLD	—	.006	dB/MHz
		MHW8142		—	.007	
		MHW9142		—	.008	
Composite Second Order	(V_{out} = +40 dBmV/ch)	MHW7142	CSO_{110}	—	–60	dBc
	(V_{out} = +38 dBmV/ch)	MHW8142	CSO_{128}	—	–60	
	(V_{out} = +38 dBmV/ch)	MHW9142	CSO_{152}	—	–59	

(continued)

ELECTRICAL CHARACTERISTICS — continued (V_{CC} = 24Vdc, T_C = 25°C, 75 ohm system, unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
Cross Modulation	(V_{out} = +40 dBmV/ch, FM = 55.25 MHz)	MHW7142	XMD_{110}	—	–66	dBc
	(V_{out} = +38 dBmV/ch, FM = 55.25 MHz)	MHW8142	XMD_{128}	—	–66	
	(V_{out} = +38 dBmV/ch, FM = 55.25 MHz)	MHW9142	XMD_{152}	—	–63	
Composite Triple Beat	(V_{out} = +40 dBmV/ch)	MHW7142	CTB_{110}	—	–62	dBc
	(V_{out} = +38 dBmV/ch)	MHW8142	CTB_{128}	—	–61	
	(V_{out} = +38 dBmV/ch)	MHW9142	CTB_{152}	—	–59	
Noise Figure	(f = 50 MHz)	All	NF_1	—	6.0	dB
Noise Figure	(f = 750 MHz)	MHW7142	NF_2	—	7.5	dB
	(f = 860 MHz)	MHW8142			8.0	
	(f = 1000 MHz)	MHW9142			8.5	
DC Current		All	IDC	180	240	mA

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line

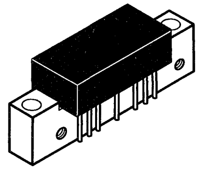
110-Channel (750 MHz), 128-Channel (860 MHz) & 152-Channel (1000 MHz) CATV Amplifiers

MHW7182
MHW8182
MHW9182

18 dB GAIN
750/860/1000 MHz
110/128/152 CHANNEL
CATV AMPLIFIERS

The MHW7182, MHW8182, and MHW9182 are designed specifically for up to 1000 MHz CATV systems as output amplifiers in trunk and line extender applications. These amplifiers feature ion–implanted, arsenic emitter transistors and an all gold metallization system.

- Specified for 110/128/152–Channel Performance
- Broadband Power Gain — @ f = 40–1000 MHz
  G_p = 18.2 dB Min @ 750, 860 & 1000 MHz
- Broadband Noise Figure
  NF = 5.5 dB Typ — MHW7182
  6.0 dB Typ — MHW8182
  6.5 dB Typ — MHW9182
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization



CASE 714–06, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{in}	+70	dBmV
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc; T_C = +30°C, 75 ohm system, unless otherwise noted)

Characteristic			Symbol	Min	Typ	Max	Unit
Frequency Range		MHW7182	BW	40	—	750	MHz
		MHW8182		40	—	860	
		MHW9182		40	—	1000	
Power Gain	50 MHz	All	G_p	17.6	18.2	18.8	dB
	750 MHz	MHW7182		18.2	18.9	20.5	
	860 MHz	MHW8182		18.2	19.0	20.5	
	1000 MHz	MHW9182		18.2	19.2	20.7	
Slope		MHW7182, MHW8182, MHW9182	S	0	1.0	2.5	—
Gain Flatness (Peak To Valley)			G_f	—	0.4	0.6	—
		MHW7182, MHW8182		—	0.4	0.8	
		MHW9182					
Input/Output Return Loss @ f = 40 MHz		MHW7182, MHW8182, MHW9182	IRL/ORL	20	24	—	dB
Derate Return Loss @ f > 40 MHz		MHW7182	RLD	—	—	0.007	dB/MHz
		MHW8182		—	—	0.008	
(Ref = 20 dB @ 40 MHz)		MHW9182		—	—	0.009	
Composite Second Order							dB
(V_{out} = +40 dBmV/ch; 110 Channels)		MHW7182	CSO_{110}	—	−67	−62	
(V_{out} = +38 dBmV/ch; 128 Channels)		MHW8182	CSO_{128}	—	−67	−60	
(V_{out} = +38 dBmV/ch; 152 Channels)		MHW9182	CSO_{152}	—	−67	−59	

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (V_{CC} = 24 Vdc; T_C = +30°C, 75 ohm system, unless otherwise noted)

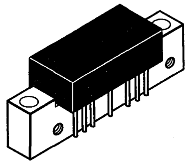
Characteristic		Symbol	Min	Typ	Max	Unit
Cross Modulation Distortion						dBc
(V_{out} = +40 dBmV/ch, 110–Channel @ Fm = 55.25 MHz)	MHW7182	XMD_{110}	—	−68	−64	
(V_{out} = +38 dBmV/ch, 128–Channel @ Fm = 55.25 MHz)	MHW8182	XMD_{128}	—	−68	−60	
(V_{out} = +38 dBmV/ch, 152–Channel @ Fm = 55.25 MHz)	MHW9182	XMD_{152}	—	−68	−59	
Composite Triple Beat						dBc
(V_{out} = +40 dBmV/ch, 110–Channels, Worst Case)	MHW7182	CTB_{110}	—	−64	−62	
(V_{out} = +38 dBmV/ch, 128–Channels, Worst Case)	MHW8182	CTB_{128}	—	−62	−60	
(V_{out} = +38 dBmV/ch, 152–Channels, Worst Case)	MHW9182	CTB_{152}	—	−61	−59	
Noise Figure f = 50 MHz		NF	—	3.6	5.0	dB
f = 750 MHz	MHW7182		—	5.5	6.5	
f = 860 MHz	MHW8182		—	6.0	7.0	
f = 1000 MHz	MHW9182		—	6.5	8.0	
DC Current		I_{DC}	180	210	240	mA

The RF Line
High Output Power Doubler 750 MHz CATV Amplifier

MHW7185

Motorola Preferred Device

24 Vdc
750 MHz
77/110 – CHANNEL
CATV AMPLIFIER



CASE 714–06, Style 1

Designed specifically for 750 MHz CATV applications. Features ion–implanted arsenic emitter transistors with an all gold metallization system.

- Supply Voltage = 24 Vdc
- 5th Generation Die Technology
- Specified for 77/110 – Channel Performance
- Broadband Power Gain @ f = 50 MHz
  Gp = 18 dB typ
- Broadband Noise Figure @ f = 50 MHz
  NF = 6 dB Max
- Improvement in Distortion Over Conventional Hybrids
- Allows Higher Output Level Operation
- All Gold Metallization

MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{IN}	+70	dBmV
Operating Case Temperature Range	T_C	– 20 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = 30°C, 75 ohm system, unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Bandwidth		BW	40	750	MHz
Power Gain	(f = 50 MHz)	Gp1	18.0	19.0	dB
Power Gain	(f = 750 MHz)	Gp2	18.5	20.5	dB
Slope	(f = 40 – 750 MHz)	S	0	2	dB
Flatness	(f = 40 – 750 MHz, Peak to Valley)	G_f	—	1	dB
Return Loss	(f = 40 MHz)	RL	18	—	dB
Return Loss Derate	(f > 40 MHz)	RLD	—	0.011	dB/MHz
Composite Triple Beat	(V_{out} = +44 dBmV/ch, 77 Channels, Worst Case)	CTB_{77}	—	–65	dBc
Composite Triple Beat	(V_{out} = +44 dBmV/ch, 110 Channels, Worst Case)	CTB_{110}	—	–56	dBc
Cross Modulation	(V_{out} = +44 dBmV/ch, 77 Channels, FM = 55 MHz)	XMD_{77}	—	–68	dBc
Cross Modulation	(V_{out} = +44 dBmV/ch, 110 Channels, FM = 55 MHz)	XMD_{110}	—	–65	dBc
Composite Second Order	(V_{out} = +44 dBmV/ch, 77 Channels, Worst Case)	CSO_{77}	—	–62	dBc
Composite Second Order	(V_{out} = +44 dBmV/ch, 110 Channels, Worst Case)	CSO_{110}	—	–56	dBc
Noise Figure	(f = 50 MHz)	NF_1	—	6	dB
Noise Figure	(f = 750 MHz)	NF_2	—	8.5	dB
DC Current		IDC	380	460	mA

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

The RF Line

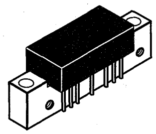
High Output Power Doubler 750 MHz CATV Amplifiers

MHW7185A
MHW7205A

Designed specifically for 750 MHz CATV applications. Features ion-implanted, arsenic emitter transistors with an all gold metallization system.

- Supply Voltage = 24 Vdc
- 6th Generation Die Technology
- Specified for 110 Channel Performance
- Broadband Power Gain @ f = 50 MHz
  Gp = 18 dB Min (MHW7185A)
  Gp = 19.5 dB Min (MHW7205A)
- Broadband Noise Figure @ f = 50 MHz
  NF = 6 dB Max
- Improvement in Distortion Over Conventional Hybrids
- Allows Higher Output Level Operation

750 MHz, 24 Vdc
110 CHANNEL
CATV AMPLIFIERS



CASE 714–06, Style 1

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{IN}	+70	dBmV
Operating Case Temperature Range	T_C	– 20 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +125	°C

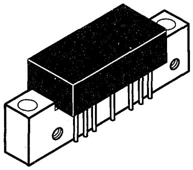
ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = 30°C, 75 Ω system, unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
Bandwidth			BW	40	750	MHz
Power Gain	(f = 50 MHz)	MHW7185A MHW7205A	Gp1	18.0 19.5	19.0 20.5	dB
Power Gain	(f = 750 MHz)	MHW7185A MHW7205A	Gp2	18.5 20.0	20.5 21.5	dB
Slope	(f = 40 – 750 MHz)		S	0	2	dB
Gain Flatness	(f = 40 – 750 MHz, Peak to Valley)		G_f	—	1	dB
Return Loss	(f = 40 MHz)		RL	18	—	dB
Return Loss Derate	(f > 40 MHz)		RLD	—	0.007	dB/MHz
Composite Triple Beat	(V_{out} = +44 dBmV/ch, 110 Channels, Worst Case)	MHW7185A MHW7205A	CTB_{110}	— —	–58 –57	dBc
Cross Modulation	(V_{out} = +44 dBmV/ch, 110 Channels, FM = 55 MHz)	MHW7185A MHW7205A	XMD_{110}	—	–65 –64	dBc
Composite Second Order	(V_{out} = +44 dBmV/ch, 110 Channels, Worst Case)	MHW7185A MHW7205A	CSO_{110}	— —	–58 –56	dBc
Noise Figure	(f = 50 MHz)		NF_1	—	6	dB
Noise Figure	(f = 750 MHz)		NF_2	—	8.5	dB
DC Current			IDC	380	460	mA

The RF Line
110-Channel (750 MHz) and 128-Channel (860 MHz) CATV Amplifiers

MHW7222
MHW8222

22 dB GAIN
750/860 MHz
110/128 CHANNEL
CATV AMPLIFIERS



CASE 714–06, STYLE 1

The MHW7222 and MHW8222 are designed specifically for up to 860 MHz CATV systems as amplifiers in trunk and line extender applications. These amplifiers feature ion–implanted, arsenic emitter transistors and an all gold metallization system.

- Specified for 110/128–Channel Performance
- Broadband Power Gain — @ f = 40–860 MHz
  G_p = 22 dB Typ @ 750 and 860 MHz
- Broadband Noise Figure
  NF = 5.5 dB Typ — MHW7222
  6.4 dB Typ — MHW8222
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{CC}	+28	Vdc
RF Input Voltage (Single Tone)	V_{in}	+70	dBmV
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic			Symbol	Min	Typ	Max	Unit
Frequency Range		MHW7222 MHW8222	BW	40 40	— —	750 860	MHz
Power Gain	f = 50 MHz f = 750 MHz f = 860 MHz	All MHW7222 MHW8222	G_p	20.8 22 21.8	21.5 22.3 22.3	22.2 24 24	dB
Slope (f = 40–750 MHz)		MHW7222, MHW8222	S	0	1	2	—
Gain Flatness (Peak To Valley) (f = 40–750 MHz)		MHW7222 MHW8222	G_f	— —	0.4 0.4	0.6 0.8	—
Input/Output Return Loss @ f = 40 MHz		MHW7222, MHW8222	IRL/ORL	20	24	—	dB
Derate Return Loss @ f > 40 MHz		MHW7222 MHW8222	RLD	— —	— —	0.008 0.009	dB/MHz
Composite Second Order (V_{out} = +40 dBmV/ch; 110 Channels) (V_{out} = +38 dBmV/ch; 128 Channels)		 MHW7222 MHW8222	 CSO_{110} CSO_{128}	 — —	 −63 −63	 −55 −56	dB

(continued)

REV 1

ELECTRICAL CHARACTERISTICS — continued

Characteristic		Symbol	Min	Typ	Max	Unit
Cross Modulation Distortion						dBc
(V_{out} = +40 dBmV/ch, 110–Channel @ Fm = 55.25 MHz)	MHW7222	XMD_{110}	—	−64	−60	
(V_{out} = +38 dBmV/ch, 128–Channel @ Fm = 55.25 MHz)	MHW8222	XMD_{128}	—	−68	−60	
Composite Triple Beat						dBc
(V_{out} = +40 dBmV/ch, 110–Channels, Worst Case)	MHW7222	CTB_{110}	—	−62	−60	
(V_{out} = +38 dBmV/ch, 128–Channels, Worst Case)	MHW8222	CTB_{128}	—	−62	−60	
Noise Figure f = 50 MHz	All	NF	—	3.6	5	dB
f = 750 MHz	MHW7222		—	5.5	7	
f = 860 MHz	MHW8222		—	6.4	7.5	
DC Current		I_{DC}	180	220	240	mA

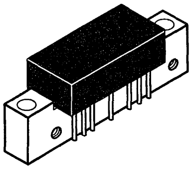
The RF Line

128-Channel (860 MHz) CATV Line Extender Amplifier

MHW8272

- Specified for 128–Channel Performance
- Broadband Power Gain — @ f = 40–860 MHz
  G_p = 27 dB (Typ)
- Broadband Noise Figure
  NF = 6 dB (Typ) @ 860 MHz
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz f_T Ion–Implanted Transistors

27 dB GAIN
860 MHz
128–CHANNEL
CATV AMPLIFIER



CASE 714–06, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	–20 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	860	MHz
Power Gain	50 MHz 860 MHz	G_p	26.2 27	27 —	27.8 29.5	dB
Slope	40–860 MHz	S	0	1.0	2.5	dB
Gain Flatness (40–860 MHz, Peak to Valley)		—	—	0.4	0.8	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	@ 40 MHz @ f > 40 MHz (Derate)	IRL/ORL	20 —	— —	— 0.007	dB dB/MHz
Composite Second Order (V_{out} = +38 dBmV/ch., Worst Case)	128–Channel FLAT	CSO_{128}	—	—	–58	dBc
Cross Modulation Distortion @ Ch 2 (V_{out} = +38 dBmV/ch., FM = 55 MHz)	128–Channel FLAT	XMD_{128}	—	—	–60	dBc
Composite Triple Beat (V_{out} = +38 dBmV/ch., Worst Case)	128–Channel FLAT	CTB_{128}	—	—	–60	dBc
Noise Figure	50 MHz 860 MHz	NF	— —	— 6.0	5.5 7.0	dB
DC Current (V_{DC} = 24 V, T_C = 30°C)		I_{DC}	280	310	350	mA

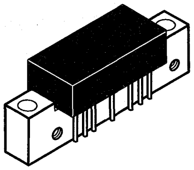
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
128-Channel (860 MHz) CATV Line Extender Amplifier

MHW8292

29 dB GAIN
860 MHz
128–CHANNEL
CATV AMPLIFIER

- Specified for 128–Channel Performance
- Broadband Power Gain — @ f = 40−860 MHz
  G_p = 29 dB (Typ)
- Broadband Noise Figure
  NF = 6 dB (Typ) @ 860 MHz
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7 GHz f_T Ion–Implanted Transistors



CASE 714–06, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+55	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	860	MHz
Power Gain	50 MHz 860 MHz	G_p	28.2 29	29 —	29.8 31.5	dB
Slope	40−860 MHz	S	0	1.0	2.5	dB
Gain Flatness (40−860 MHz, Peak to Valley)		—	—	0.4	0.8	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	@ 40 MHz @ f > 40 MHz (Derate)	IRL/ORL	20 —	— —	— 0.007	dB dB/MHz
Composite Second Order (V_{out} = +38 dBmV/ch., Worst Case)	128–Channel FLAT	CSO_{128}	—	—	−56	dBc
Cross Modulation Distortion @ Ch 2 (V_{out} = +38 dBmV/ch., FM = 55 MHz)	128–Channel FLAT	XMD_{128}	—	—	−60	dBc
Composite Triple Beat (V_{out} = +38 dBmV/ch., Worst Case)	128–Channel FLAT	CTB_{128}	—	—	−60	dBc
Noise Figure	50 MHz 860 MHz	NF	— —	— 6.0	5.5 7.0	dB
DC Current (V_{DC} = 24 V, T_C = 30°C)		I_{DC}	280	310	350	mA

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
UHF GaAs FET Power Amplifiers

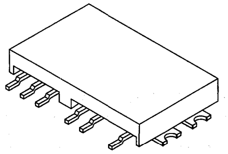
MHW9002-1
MHW9002-2

Motorola Preferred Devices

31.5 dBm
824 to 905 MHz
HIGH EFFICIENCY
RF POWER
AMPLIFIERS

Designed for use in a wide variety of telecommunications equipment, including portable cellular applications, satellite cellular applications, gateways and satellite stations. MHW9002 Series modules are capable of wide power range control (30 dB typical), operate from a 5.8 Volt supply and require only 5 mW of RF input power.

- High Efficiency
- Specified 5.8 Volt Characteristics:
  RF Input Power — 5.0 mW (7 dBm)
  RF Output Power — 1.41 W (31.5 dBm)
  Minimum Gain — 24.5 dB
  Minimum Efficiency – 55%
  Harmonics — –30 dBc Max @ 2 f_o
- 50 Ohm Input/Output Impedances
- Guaranteed Stability and Ruggedness
- Epoxy Glass Substrate Eliminates Possibility of Substrate Fracture



CASE 420A–02, STYLE 1

MAXIMUM RATINGS (Range Temperature = 25°C)

Rating	Symbol	Value	Unit
DC Supply Voltage	V_{DD2}	10	Vdc
DC Bias Voltage	$V_{GG1,\,2}$	–6	Vdc
DC Control Voltage	V_{DD1}	10	Vdc
RF Input Power	P_{in}	15	dBm
RF Output Power (V_S = 9 Vdc)	P_{out}	33	dBm
Operating Case Temperature Range	T_C	–30 to +100	°C
Storage Temperature Range	T_{stg}	–30 to +100	°C

ELECTRICAL CHARACTERISTICS ($V_{DD1} \leq 5.8$ Vdc, $V_{DD2} = 5.8$ Vdc, $V_{GG1} = V_{GG2} = -4.0$ Vdc, $P_{out} = 31.5$ dBm, $P_{in} = 7$ dBm, $T_C = +25$°C, 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range MHW9002–1 MHW9002–2	BW	824 870		849 905	MHz
Output Power, Low Voltage (T_C = –30 to +80°C, $V_{DD1} = V_{DD2} = 5.0$ Vdc)	P_{out1}	29.3	30	—	dBm
Output Power, Zero Control Voltage (V_{DD1} = 0 Vdc; P_{in} = 7 dBm)	P_{out2}	—	—	6	dBm
Gate Current (1)	I_{GG}	—	—	5	mA
Efficiency (1)	η	55	60		%
Input VSWR (1)	$VSWR_{in}$		—	3.0:1	—
Harmonics (1) 2f_o to 4f_o				–30	dBc

NOTE:
1. Adjust V_{DD1} for Specified P_{out}, V_{DD1} = 5.8 Vdc Max

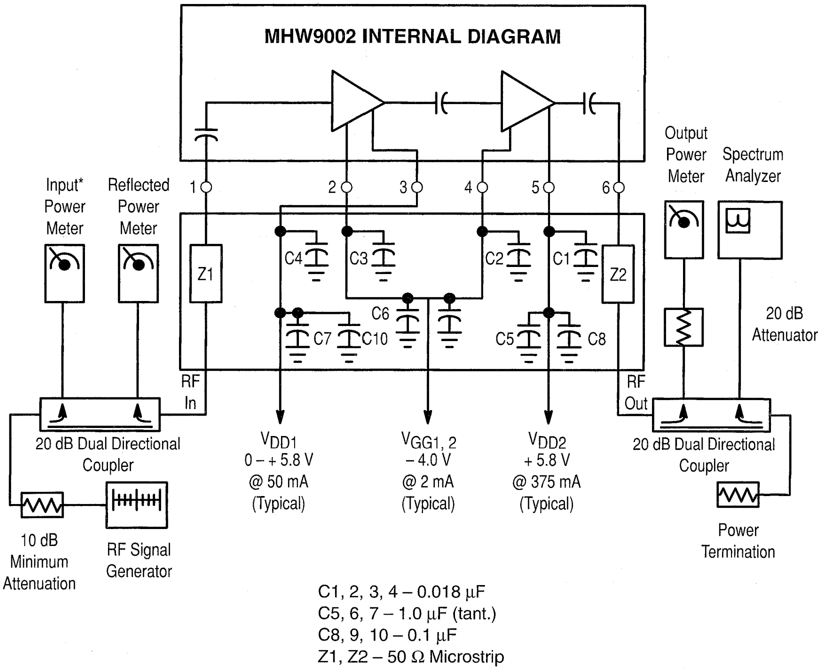
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 7

ELECTRICAL CHARACTERISTICS — continued ($V_{DD1} \le 5.8$ Vdc, $V_{DD2} = 5.8$ Vdc, $V_{GG1} = V_{GG2} = -4.0$ Vdc, $P_{out} = 31.5$ dBm, $P_{in} = 7$ dBm, $T_C = +25°C$, 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Noise Power (In 20 kHz Bandwidth, 45 MHz Above f_o, $V_{DD2} = 5$ to 7 Vdc, $V_{DD1} = 0$ to 5.8 Vdc)	P_{N1}	—	—	−95	dBm
Noise Power (In 20 kHz Bandwidth, 45 MHz Above f_o, $V_{DD2} = 5$ to 7 Vdc, $V_{DD1} = 0$ to 5.8 Vdc, $T_C = -30°C$ to $T_C = +80°C$)	P_{N2}	—	—	−92	dBm
Stability ($V_{DD1} = 0$ to 7 Vdc, $P_{in} = 4$ to 10 dBm, $V_{DD2} = 4.5$ to 8 Vdc, Load VSWR = 3:1, All Phase Angles at Frequency of Test)	—	All Spurious Outputs more than 60 dB Below Desired Signal			
Load Mismatch Stress ($V_{DD2} = 8$ Vdc, $P_{out} = 31.5$ dB Load VSWR = 20:1, All Phase Angles at Frequency of Test) (2)	ψ	No Degradation in Output Power Before and After Test			

NOTE:
2. Adjust V_{DD1} for Specified P_{out}, $V_{DD1} = 8.0$ Vdc Max



*Module input power is forward power as sampled by the directional coupler and read on the input power meter.

Figure 1. UHF Power Module Test Circuit Diagram

TYPICAL CHARACTERISTICS

MHW9002–1

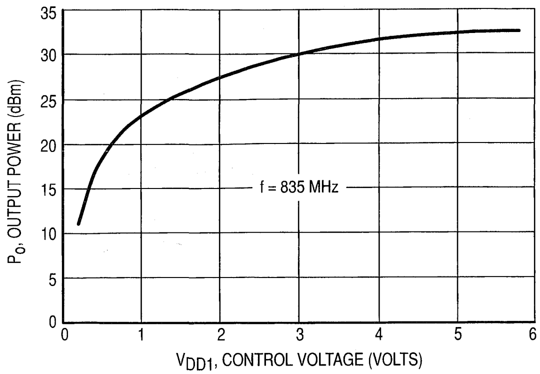


Figure 2. Output Power versus Control Voltage

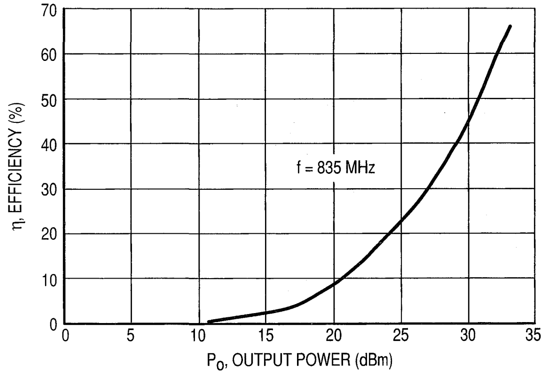


Figure 3. Efficiency versus Output Power

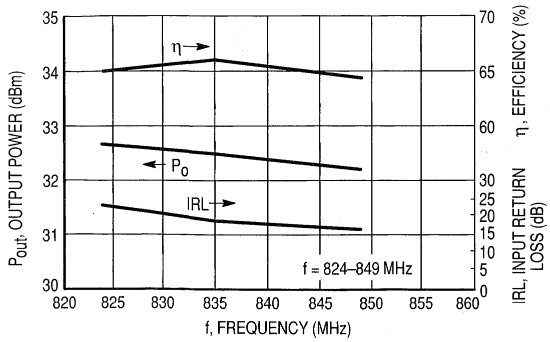


Figure 4. Output Power, Efficiency, Input Return Loss versus Frequency

MHW9002–2

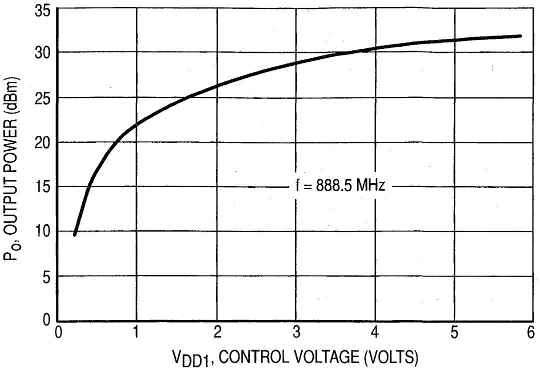


Figure 5. Output Power versus Control Voltage

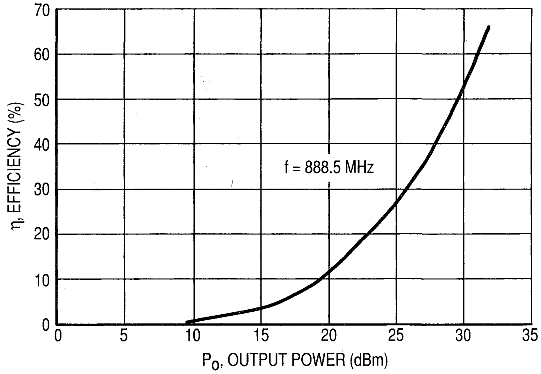


Figure 6. Efficiency versus Output Power

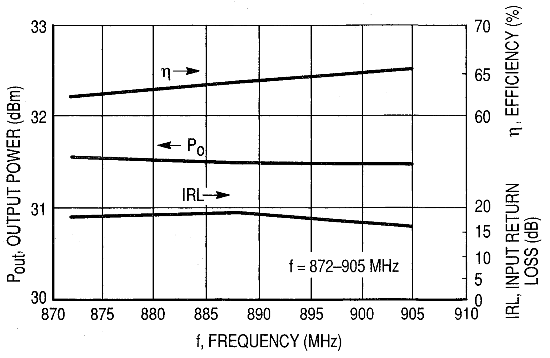


Figure 7. Output Power, Efficiency, Input Return Loss versus Frequency

APPLICATIONS INFORMATION

Mounting Considerations

For the MHW9002 Series module, mounting is done by soldering the four "feet" to a suitable heatsink. This can be done with a low temperature solder such as 52% In, 48% Sn and type "R" flux which liquifies below 150°C. Under no circumstances should the MHW9002 Series modules be heated to a temperature greater than 165°C (temperature of the flange proper). Internal construction of the module has been achieved using 36% tin, 62% lead, and 2% silver solder which liquifies at about 180°C. Also, remember that the modules are NOT hermetic.

Nominal Operation

All electrical specifications are based on the nominal conditions of $V_{DD1} \leq 5.8$ Vdc, $V_{DD2} = 5.8$ Vdc, $V_{GG1,2} = -4$ Vdc, and P_{out} equal to 31.5 dBm. While the modules are designed to have excess gain margin with ruggedness, operation of these units outside the published specifications is not recommended unless prior communications regarding intended use have been made with a factory representative.

Gain Control

The module output power should be limited to specified value. The preferred method of power control is to fix $V_{DD2} = 5.8$ Vdc (Pin 5) and $V_{GG1,2} = -4$ Vdc (Pins 2, 4), P_{in} (Pin 1) at 5 mW, and vary V_{DD1} (Pin 3) voltage.

Decoupling

External decoupling networks are recommended to ensure stable operation of the device. Pins 2, 3, 4, and 5 are internally bypassed with a 1000 pF chip capacitor. Additional external decoupling is recommended as shown in Figure 1. Inadequate decoupling will result in spurious outputs at certain operating frequencies and certain phase angles of input and output VSWR.

Handling Considerations

GaAs FETs are more sensitive to electrostatic discharge (ESD) than Si bipolar transistors. Therefore, steps should be taken in handling GaAs products to prevent damage. The use of ground straps, grounded breakers and test equipment is strongly recommended.

Soldering Leads

Be sure the soldering iron is grounded. Temperature of the iron should not exceed 350°C. Apply heat to a lead to be soldered for not more than 5 seconds.

Load Mismatch

During final test each module is load mismatch tested in a fixture having the identical decoupling networks described in Figure 1. Electrical conditions are $V_{DD2} = 8.0$ Vdc and $V_{GG1,2} = -4$ Vdc, P_{in} at 5 mW, and V_{DD1} set for 31.5 dBm output power, and VSWR equal to 20:1.

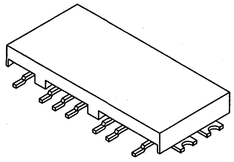
Biasing and Use Considerations

In all cases, RF input power should not be applied until the bias voltages have been applied, and RF input power should be turned off prior to removing the bias voltages. Bias application should be timed such that gate voltage ($V_{GG1,2}$) is always applied before the drain voltages (V_{DD}), and, when returning to the standby mode, gate voltage should only be removed once the drain voltages have been removed.

The RF Line
Microwave GaAs FET Power Amplifier

MHW9014

33.2 dBm
1710–1785 MHz
RF POWER AMPLIFIER



CASE 420–01, STYLE 1

Designed for applications in the Personal Communication Network System (PCN). The MHW9014 was designed specifically for a digital, 1 Watt, hand–held radio. This power amplifier is capable of wide power range control, operates from a 6 Volt supply and requires only 1.0 mW of RF input power.

- Specified 6 Volt Characteristics:
  RF Input Power: 1.0 mW (0 dBm)
  RF Output Power: 33.2 dBm
  Minimum Gain: 33.2 dB
  Harmonics: −33 dBc Max @ 2 f_0
- New Biasing and Control Techniques Providing Dynamic Range and Control Circuit Bandwidth Ideal for PCN
- Low Control Current
- 50 Ω Input/Output Impedances
- Guaranteed Stability and Ruggedness

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Supply Voltage (No RF Applied)	V_{S3}	10	Vdc
DC Bias Voltage	V_B	−4.7	Vdc
DC Control Voltage (No RF Applied)	V_{cont}	10	Vdc
RF Input Power	P_{in}	2	mW
RF Output Power	P_{out}	3	W
Operating Case Temperature Range	T_C	−30 to +100	°C
Storage Temperature Range	T_{stg}	−30 to +100	°C

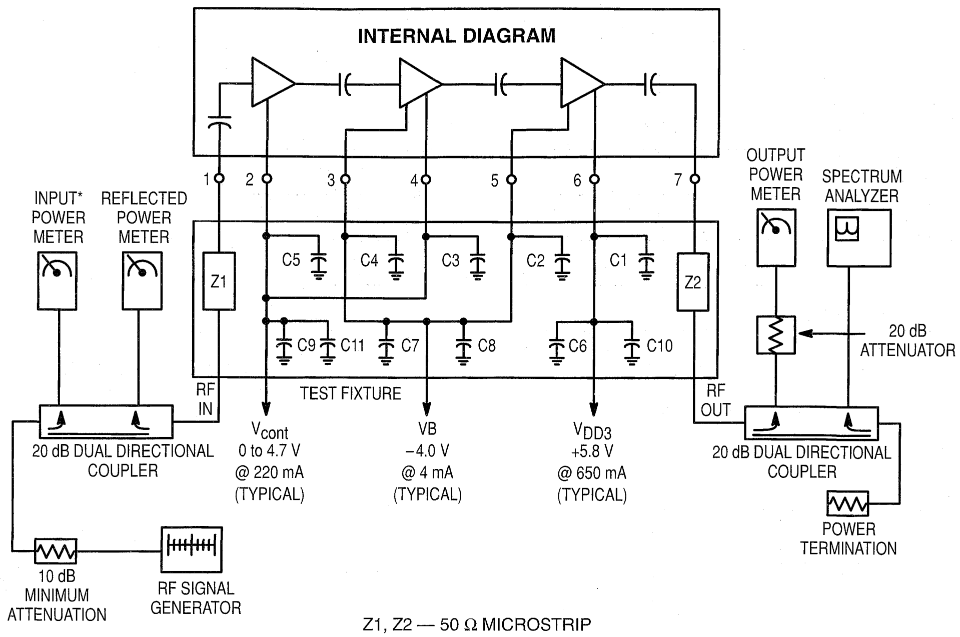
ELECTRICAL CHARACTERISTICS

(V_{cont} = 5 V; V_{S3} = 5.8 Vdc; V_B = −4 Vdc; P_{in} = 0 dBm; T_C = +25°C, 50 ohm system, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Frequency Range	BW	1710	1785	MHz
Output Power (V_{cont} = 5.0 V)	P_{out}	33.2	—	dBm
Gate Current (P_{out} = 33.2 dBm) (1)	I_G	—	5	mA
Supply Current (1)	I_S	—	300	mA
Efficiency (P_{out} = 33.2 dBm) (1)	η	40	—	%
Input Return Loss (P_{out} = 33.2 dBm) (1)	IRL	10	—	dB
Harmonics (P_{out} = 33.2 dBm) (1) 2 f_0 3 f_0, 4 f_0, 5 f_0	— —	— —	−33 −43	dBc
Noise Power (In 30 KHz Bandwidth, 95 MHz above f_0, P_{out} = 33.2 dBm) (1)	—	—	−80	dBm
Load Mismatch Stress (V_{S3} = 7 V, P_{out} = 33.2 dBm; for 1700 MHz < f < 1800 MHz, Load Return Loss = 10 dB, All Phase Angles at Frequency of Test) (2)	—	No Degradation in Output Power Before and After Test		
Stability (V_{S3} = 5 to 7 V; P_{out} = 7 to 33.2 dBm; for 1700 MHz < f < 1800 MHz, Load VSWR = 6:1, All Phase Angles at Frequency of Test. For frequencies < 1700 MHz or > 1800 MHz, Load VSWR = 10:1, All Phase Angles at Frequency of Test) (1)	—	All Spurious Outputs More than 60 dB Below Desired Signal		
Output Power, Over Temperature (V_{cont} = V_{S3} = 5 V; P_{in} = 0 dBm, T_C = −30°C to +90°C)	—	32	—	dBm
V_{cont} Low Output Power (P_{out} = 0 dBm)	V_{cont}	—	0.75	V

(1) Adjust V_{cont} for Specified P_{out}; V_{cont} is 5 V Max. Duty Cycle = 10%, Period = 600 μs.

(2) Adjust V_{cont} for Specified P_{out}; V_{cont} is 7 V Max. Duty Cycle = 10%, Period = 600 μs.



Z1, Z2 — 50 Ω MICROSTRIP
C1, 2, 3, 4, 5 — 470 pF CHIP CAP
C8, 10, 11 — 0.1 µF
C6, 7, 9 — 1.0 µF (tant.)

NOTE:
The above circuit layout is used for performance verification. A layout intended for use in a particular application should be thoroughly evaluated. When the device is surface mounted on a microstrip substrate, the ground plane pattern must be electrically and thermally grounded to the actual microstrip backplane. The drain bias pins should be individually bypassed using separate ground return paths.

*Module input power is forward power as sampled by the directional coupler and read on the input power meter.

Figure 1. MHW9014 Test Circuit Diagram

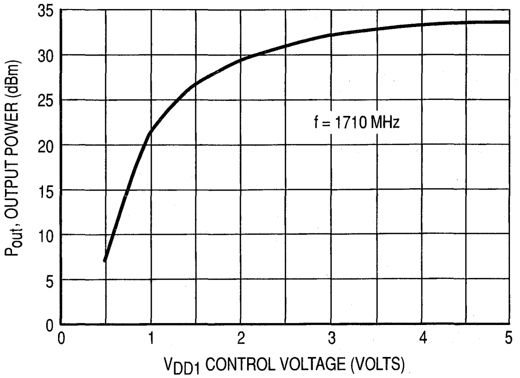


Figure 2. Output Power versus Control Voltage

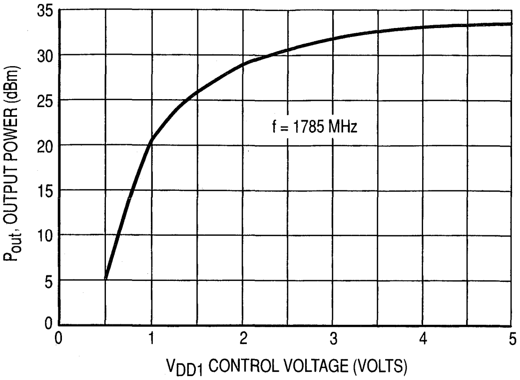


Figure 3. Output Power versus Control Voltage

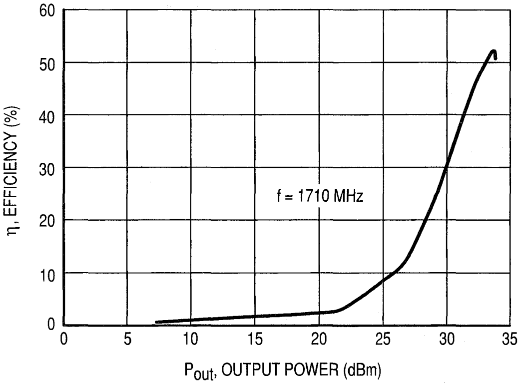


Figure 4. Efficiency versus Output Power

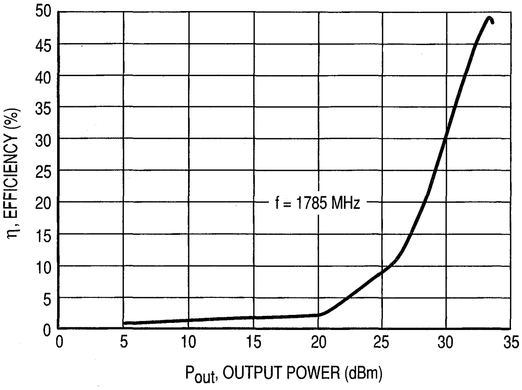


Figure 5. Efficiency versus Output Power

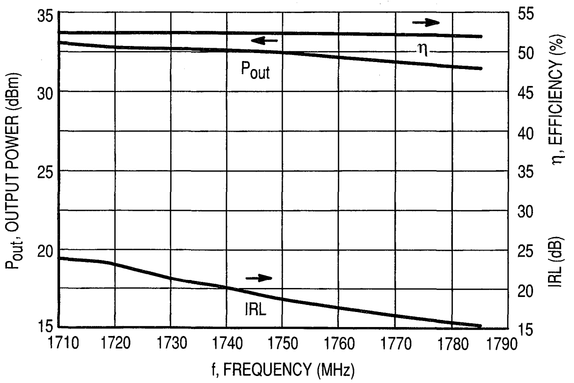


Figure 6. Output Power, Efficiency, Input Return Loss versus Frequency

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

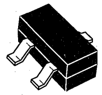
The RF Line
PNP Silicon High-Frequency Transistor

MMBR521LT1
MRF5211LT1

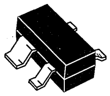
Designed primarily for use in the high–gain, low–noise small–signal amplifiers for operation up to 3.5 GHz. Also usable in applications requiring fast switching times.

- High Current Gain–Bandwidth Product —
  f_T = 3.4 GHz (Typ) @ I_C = –35 mAdc (MMBR521LT1)
  f_T = 4.2 GHz (Typ) @ I_C = –50 mAdc (MRF5211LT1)
- Low Noise Figure @ f = 1.0 GHz —
  $NF_{(matched)}$ = 2.5 dB (Typ) (MMBR521LT1)
  $NF_{(matched)}$ = 2.8 dB (Typ) (MRF5211LT1)
- High Power Gain — $G_{pe\ (matched)}$ = 11 dB (Typ)
- Guaranteed RF Parameters
- Surface Mounted SOT–23 (MMBR521LT1) & SOT–143 (MRF5211LT1) Offer Improved RF Performance
  Lower Package Parasitics
  Higher Gain
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel

I_C = –70 mA
HIGH–FREQUENCY
TRANSISTOR
PNP SILICON



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
(TO–236AA/AB)
MMBR521LT1



CASE 318A–05, STYLE 1
SOT–143
LOW PROFILE
MRF5211LT1

MAXIMUM RATINGS

Ratings	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	–10	Vdc
Collector–Base Voltage	V_{CBO}	–20	Vdc
Emitter–Base Voltage	V_{EBO}	–2.5	Vdc
Power Dissipation (1) T_C = 75°C, Derate linearly above T_C = 75°C @ All	$P_{D(max)}$	0.333 4.44	W mW/°C
Collector Current — Continuous	I_C	–70	mA
Maximum Junction Temperature	T_{Jmax}	150	°C
Storage Temperature All	T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Ratings	Symbol	Value	Unit
Thermal Resistance, Junction to Case (MMBR521LT1, MRF5211LT1)	$R_{\theta JC}$	225	°C/W

DEVICE MARKING

MMBR521LT1 = 7M	MRF5211LT1 = 04

NOTE:
1. Case Temperature is measured on the collector lead closest to the package. For case temperatures above +75°C: $P_{DISP(max)} = (T_{Jmax} - T_C) / R_{\theta JC}$

REV 7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = –1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	–10	–12	—	Vdc
Collector–Base Breakdown Voltage (I_C = –0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	–20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = –50 μAdc, I_C = 0)	$V_{(BR)EBO}$	–2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = –8.0 Vdc, I_E = 0)	I_{CBO}	—	—	–10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = –30 mAdc, V_{CE} = –5.0 Vdc)	h_{FE}	25	—	125	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = –6.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.0	1.5	pF
Current Gain — Bandwidth Product (V_{CE} = –8.0 V, I_C = –35 mA, f = 1.0 GHz) MMBR521LT1 (V_{CE} = –8.0 V, I_C = –50 mA, f = 1.0 GHz) MRF5211LT1	f_T	 — —	 3.4 4.2	 — —	GHz
FUNCTIONAL TESTS					
Power Gain at Minimum Noise Figure (V_{CE} = –6.0 V, I_C = –5.0 mA, f = 500 MHz) MMBR521LT1 (V_{CE} = –6.0 V, I_C = –5.0 mA, f = 1.0 GHz) MMBR521LT1 (V_{CE} = –6.0 V, I_C = –5.0 mA, f = 1.0 GHz) MRF5211LT1	G_{NFmin}	 13 8.0 10	 15 10 11	 — — —	dB
Noise Figure — Minimum (V_{CE} = –6.0 V, I_C = –5.0 mA, f = 500 MHz) MMBR521LT1 (V_{CE} = –6.0 V, I_C = –5.0 mA, f = 1.0 GHz) MMBR521LT1 (V_{CE} = –6.0 V, I_C = –5.0 mA, f = 1.0 GHz) MRF5211LT1	NF_{min}	 — — —	 1.5 2.5 2.8	 2.5 3.5 3.5	dB

TYPICAL CHARACTERISTICS

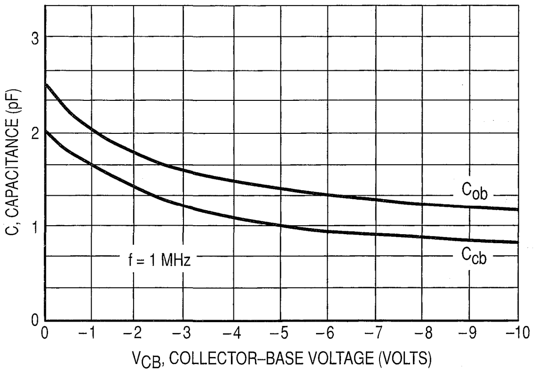


Figure 1. Junction Capacitance versus Voltage

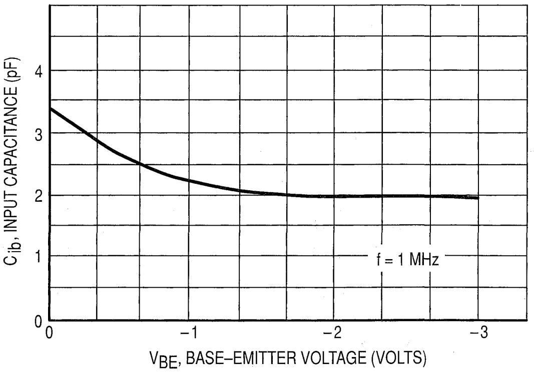
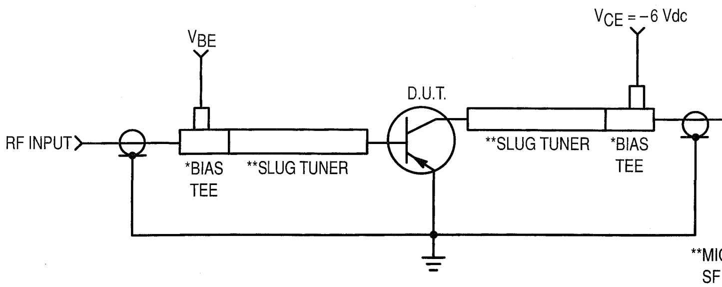


Figure 2. Input Capacitance versus Voltage



*MICROLAB
HW–XXN
AS APPLICABLE

**MICROLAB/FXR
SF — 11N < 1 GHz
SF — 311N ≥ 1 GHz

Figure 3. Functional Circuit Schematic

TYPICAL CHARACTERISTICS
MMBR521LT1

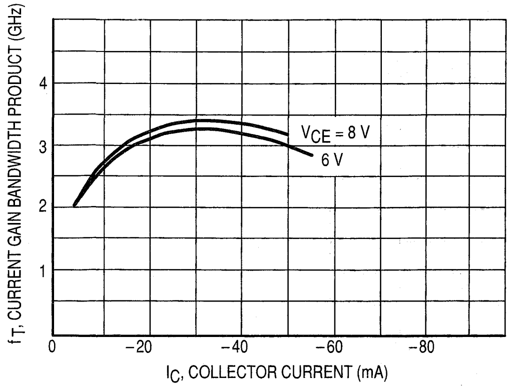


Figure 4. Current Gain Bandwidth Product versus Collector Current

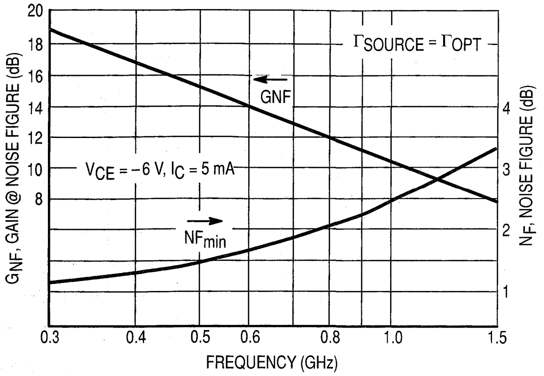


Figure 5. Minimum Noise Figure & Gain @ Noise Figure versus Frequency

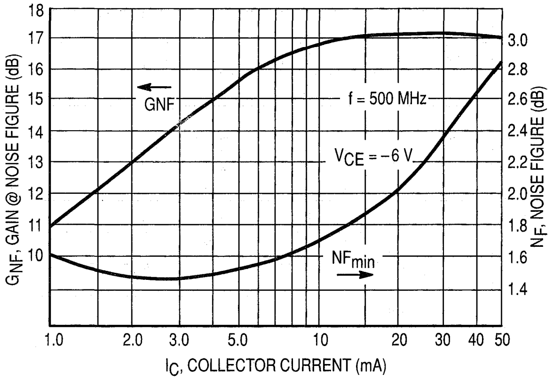


Figure 6. Minimum Noise Figure & Gain @ Noise Figure versus Collector Current

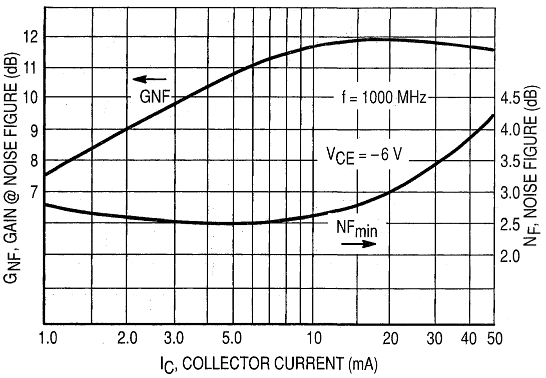


Figure 7. Minimum Noise Figure & Gain @ Noise Figure versus Collector Current

TYPICAL CHARACTERISTICS
MRF5211LT1

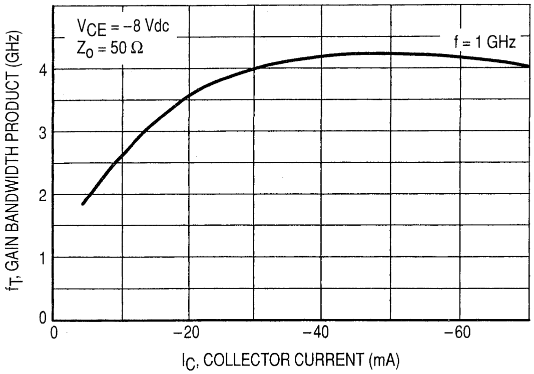


Figure 8. Gain–Bandwidth Product versus Current

GAIN AND NOISE FIGURE versus FREQUENCY

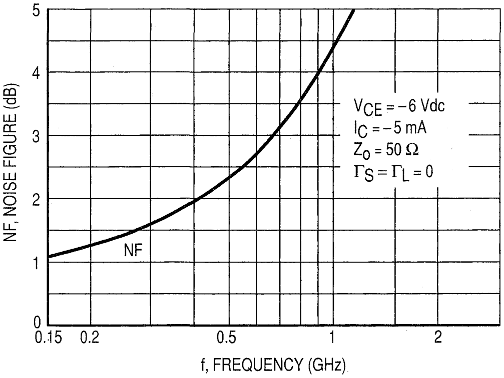


Figure 9. 50 Ohm Noise Figure

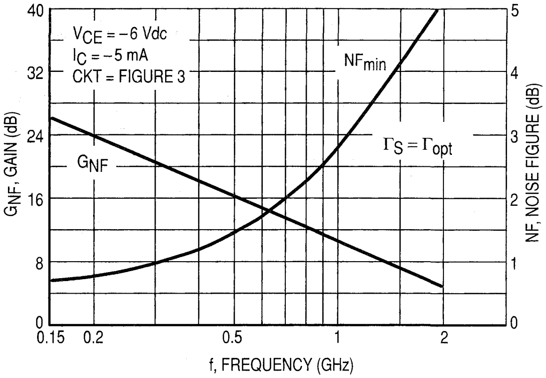


Figure 10. Tuned Circuit

GAIN AND NOISE FIGURE versus CURRENT

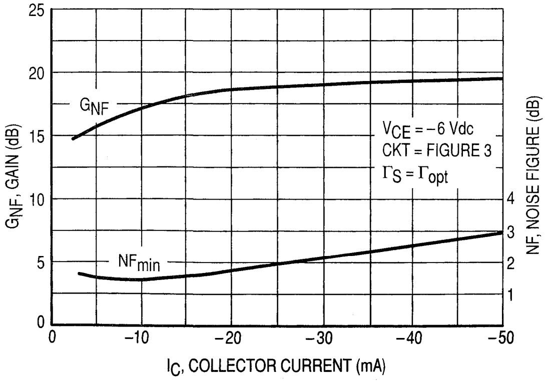


Figure 11. Tuned Circuit — Frequency 500 MHz

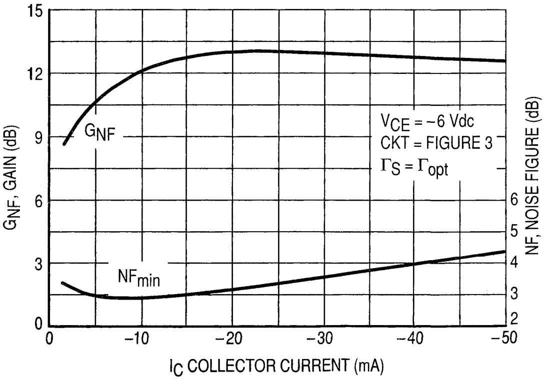


Figure 12. Tuned Circuit — Frequency 1.0 GHz

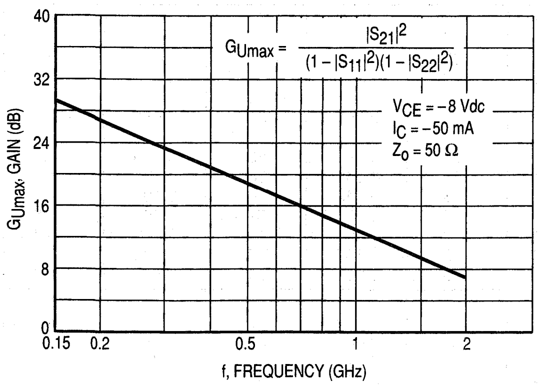


Figure 13. G_{Umax} versus Current

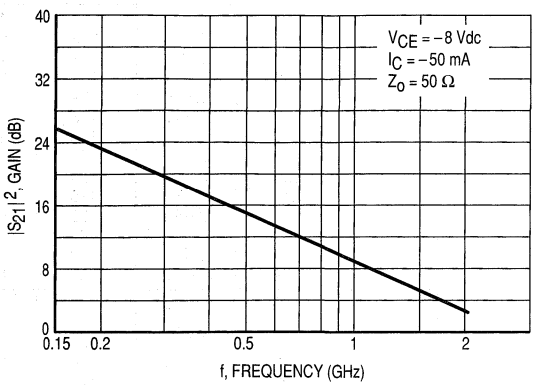


Figure 14. Insertion Gain versus Frequency

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11} \rvert$	∠φ	$\lvert S_{21} \rvert$	∠φ	$\lvert S_{12} \rvert$	∠φ	$\lvert S_{22} \rvert$	∠φ
6	5	100	0.754	–67	11.453	141	0.040	59	0.818	–24
		300	0.683	–132	6.106	105	0.065	39	0.549	–37
		500	0.667	–157	3.954	89	0.071	39	0.472	–40
		700	0.660	–171	2.890	78	0.078	44	0.452	–44
		900	0.656	179	2.294	69	0.085	50	0.449	–49
		1000	0.654	175	2.086	65	0.091	53	0.451	–52
		1500	0.641	158	1.442	48	0.130	64	0.480	–66
		2000	0.672	140	1.108	36	0.188	69	0.466	–79
		2500	0.681	124	0.917	26	0.261	66	0.483	–94
		3000	0.681	110	0.793	18	0.343	60	0.493	–110
		3500	0.686	96	0.716	13	0.426	52	0.500	–126
		4000	0.683	84	0.674	9	0.503	43	0.502	–143
		4500	0.678	73	0.653	6	0.568	34	0.503	–160
		5000	0.669	64	0.653	3	0.620	24	0.507	–176
	10	100	0.632	–92	16.621	131	0.032	55	0.694	–33
		300	0.618	–149	7.460	98	0.050	47	0.417	–41
		500	0.618	–168	4.671	85	0.061	53	0.358	–44
		700	0.616	–178	3.392	76	0.076	58	0.346	–47
		900	0.615	173	2.672	68	0.092	62	0.347	–52
		1000	0.613	170	2.429	64	0.100	63	0.352	–55
		1500	0.601	155	1.677	48	0.150	66	0.382	–68
		2000	0.633	138	1.294	36	0.208	66	0.371	–80
		2500	0.642	124	1.078	25	0.273	62	0.391	–94
		3000	0.646	110	0.929	16	0.346	56	0.408	–109
		3500	0.656	98	0.827	10	0.422	49	0.421	–124
		4000	0.662	86	0.756	4	0.494	41	0.431	–141
		4500	0.664	75	0.709	1	0.554	32	0.442	–158
		5000	0.664	66	0.683	–3	0.609	24	0.455	–174
	50	100	0.547	–149	21.107	115	0.017	63	0.441	–43
		300	0.606	–174	7.891	90	0.037	68	0.260	–42
		500	0.616	177	4.811	80	0.058	73	0.239	–44
		700	0.616	171	3.480	72	0.080	73	0.242	–48
		900	0.616	165	2.746	65	0.102	73	0.248	–54
		1000	0.615	163	2.479	61	0.113	72	0.255	–57
		1500	0.606	150	1.717	46	0.169	69	0.293	–71
		2000	0.643	135	1.327	33	0.229	65	0.289	–82
		2500	0.654	122	1.097	22	0.292	60	0.315	–96
		3000	0.662	108	0.940	13	0.359	54	0.337	–110
		3500	0.672	96	0.825	6	0.427	47	0.356	–126
		4000	0.680	84	0.743	1	0.493	39	0.373	–142
		4500	0.682	74	0.688	–2	0.551	31	0.391	–159
		5000	0.679	64	0.658	–5	0.601	22	0.409	–175
10	5	100	0.792	–59	11.498	144	0.036	62	0.848	–21
		300	0.681	–123	6.513	108	0.061	41	0.598	–32
		500	0.652	–150	4.278	91	0.068	40	0.518	–36
		700	0.639	–166	3.142	80	0.073	44	0.496	–39
		900	0.631	–177	2.491	71	0.081	49	0.489	–44
		1000	0.628	179	2.264	67	0.086	53	0.492	–46
		1500	0.616	161	1.560	50	0.120	64	0.514	–58
		2000	0.644	142	1.199	37	0.171	69	0.500	–70
		2500	0.654	126	0.985	26	0.238	68	0.516	–83
		3000	0.661	111	0.843	18	0.314	63	0.523	–98
		3500	0.670	98	0.749	12	0.399	56	0.529	–113
		4000	0.672	85	0.690	8	0.479	47	0.528	–129
		4500	0.671	73	0.656	5	0.549	38	0.524	–146
		5000	0.665	63	0.649	3	0.609	28	0.523	–162
10	10	100	0.666	–80	17.255	135	0.030	58	0.738	–28
		300	0.596	–141	8.143	101	0.047	48	0.465	–37
		500	0.587	–162	5.139	87	0.059	53	0.404	–38
		700	0.581	–174	3.741	78	0.072	58	0.388	–41
		900	0.578	177	2.947	70	0.086	61	0.387	–45
		1000	0.577	174	2.670	66	0.095	63	0.389	–48
		1500	0.565	158	1.856	50	0.139	66	0.413	–60
		2000	0.596	140	1.431	38	0.191	66	0.402	–70
		2500	0.608	126	1.177	26	0.253	64	0.420	–82
		3000	0.619	112	1.008	17	0.319	59	0.434	–96
		3500	0.632	99	0.886	9	0.393	52	0.444	–110
		4000	0.644	87	0.797	3	0.465	44	0.453	–126
		4500	0.652	75	0.732	–1	0.532	36	0.457	–143
		5000	0.654	65	0.694	–4	0.589	28	0.465	–159

Table 1. MMBR521LT1 Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11} \rvert$	$\angle \phi$	$\lvert S_{21} \rvert$	$\angle \phi$	$\lvert S_{12} \rvert$	$\angle \phi$	$\lvert S_{22} \rvert$	$\angle \phi$
−6.0	−5.0	200	0.82	−114	7.9	118	0.07	35	0.59	−46
		500	0.81	−158	4.0	88	0.08	21	0.40	−54
		1000	0.79	175	2.0	67	0.08	21	0.37	−68
		1500	0.76	158	1.3	50	0.07	30	0.43	−82
		2000	0.74	143	1.0	38	0.08	47	0.47	−95
	−10	200	0.78	−137	10.6	109	0.05	32	0.43	−63
		500	0.79	−168	4.9	84	0.06	28	0.26	−75
		1000	0.77	169	2.5	66	0.06	39	0.24	−87
		1500	0.74	155	1.6	50	0.08	49	0.29	−97
		2000	0.71	140	1.2	39	0.10	55	0.32	−106
	−50	200	0.77	−167	13.1	99	0.02	45	0.26	−108
		500	0.77	176	5.7	80	0.04	57	0.18	−132
		1000	0.76	161	2.8	65	0.06	65	0.17	−142
		1500	0.73	149	1.9	51	0.08	67	0.19	−137
		2000	0.70	136	1.4	40	0.12	65	0.20	−137
−8.0	−5.0	200	0.82	−109	8.1	119	0.07	36	0.62	−43
		500	0.80	−154	4.2	90	0.08	22	0.42	−52
		1000	0.78	175	2.2	67	0.08	22	0.38	−65
		1500	0.75	159	1.4	50	0.07	31	0.43	−78
		2000	0.72	143	1.0	37	0.09	43	0.46	−89
	−10	200	0.77	−132	11.2	110	0.05	33	0.45	−61
		500	0.77	−167	5.2	86	0.06	29	0.27	−70
		1000	0.76	169	2.6	67	0.06	39	0.25	−81
		1500	0.73	155	1.7	51	0.07	49	0.29	−90
		2000	0.70	140	1.3	39	0.10	54	0.31	−98
	−50	200	0.75	−164	14.2	100	0.02	43	0.26	−101
		500	0.76	178	6.1	82	0.04	55	0.17	−121
		1000	0.75	163	3.1	67	0.06	64	0.15	−131
		1500	0.72	151	2.0	53	0.08	67	0.18	−126
		2000	0.70	139	1.5	42	0.11	68	0.19	−127

Table 2. MRF5211LT1 Common Emitter S–Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

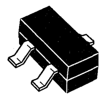
The RF Line
NPN Silicon High-Frequency Transistors

MMBR571LT1
MPS571 MRF571
MRF5711LT1

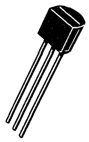
Designed for low noise, wide dynamic range front–end amplifiers and low–noise VCO's. Available in a surface–mountable plastic package, as well as the popular TO–226AA (TO–92) package. This Motorola series of small–signal plastic transistors offers superior quality and performance at low cost.

- High Gain–Bandwidth Product
  f_T = 8.0 GHz (Typ) @ 50 mA
- Low Noise Figure
  NF_{min} = 1.6 dB (Typ) @ f = 1.0 GHz (MRF5711LT1, MRF571)
- High Gain
  G_{NF} = 17 dB (Typ) @ 30 mA/500 MHz (MMBR571LT1)
- High Power Gain
  G_{pe} (matched) = 13.5 dB (Typ) (MRF5711LT1)
- State–of–the–Art Technology
  Fine Line Geometry
  Ion–Implanted Arsenic Emitters
  Gold Top Metallization and Wires
  Silicon Nitride Passivation
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel

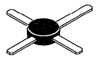
I_C = 80 mA
LOW NOISE
HIGH–FREQUENCY
TRANSISTORS



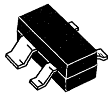
CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
MMBR571LT1



CASE 29–04, STYLE 2
TO–226AA
(TO–92)
MPS571



CASE 317–01, STYLE 2
MACRO–X
MRF571



CASE 318A–05, STYLE 1
SOT–143
LOW PROFILE
MRF5711LT1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	10	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	80	mA
Total Device Dissipation @ T_{case} = 75°C MMBR571LT1, MRF5711LT1 Derate linearly above T_{case} = 75°C @	$P_{D(max)}$	 0.33 4.44	 W mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C MPS571	P_D	0.63 5.0	Watts mW/°C
Total Device Dissipation (1) @ T_C = 75°C Derate above 75°C MRF571	P_D	0.58 7.73	Watts mW/°C
Operating and Storage Temperature	T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient MPS571	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case MRF5711LT1, MMBR571LT1	$R_{\theta JC}$	225	°C/W
Thermal Resistance, Junction to Case MRF571	$R_{\theta JC}$	130	°C/W
Maximum Junction Temperature	T_{Jmax}	150	°C

DEVICE MARKING

MMBR571LT1 = 7X	MRF5711LT1 = 02

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	$V_{(BR)CEO}$	10	12	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 50 μAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 8.0 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	—	300	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance	C_{cb}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) MPS571, MMBR571LT1		—	0.7	1.0	
(V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz) MRF5711LT1, MRF571		—	0.75	1.0	
Current Gain–Bandwidth Product MPS571	f_T	—	6.0	—	GHz
(V_{CE} = 5.0 Vdc, I_C = 50 mAdc, f = 1.0 GHz) MMBR571LT1		—	8.0	—	
(V_{CE} = 8.0 Vdc, I_C = 50 mAdc, f = 1.0 GHz) MRF5711LT1, MRF571		—	8.0	—	
FUNCTIONAL TESTS					
Gain @ Noise Figure MRF571 f = 0.5 GHz	G_{NF}	—	16.5	—	dB
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc) MRF571 f = 1.0 GHz		10	12	—	
Noise Figure MRF571 f = 0.5 GHz	NF	—	1.0	—	dB
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc) MRF571 f = 1.0 GHz		—	1.5	2.0	
f = 2.0 GHz		—	2.8	—	
Gain @ Noise Figure	G_{NF}				dB
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) MPS571 f = 0.5 GHz		—	14	—	
f = 1.0 GHz		—	9.0	—	
MMBR571LT1 f = 0.5 GHz		—	16.5	—	
f = 1.0 GHz		—	10.5	—	
(I_C = 10 mA, V_{CE} = 6.0 Vdc) MRF5711LT1 f = 1.0 GHz		—	13.5	—	
Noise Figure	NF				dB
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) MPS571 f = 0.5 GHz		—	2.0	—	
f = 1.0 GHz		—	2.6	—	
MMBR571LT1 f = 0.5 GHz		—	2.0	—	
f = 1.0 GHz		—	2.6	—	
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc) MRF5711LT1 f = 1.0 GHz		—	2.2	—	
Noise Figure (V_{CE} = 6.0 V, I_C = 10 mA, f = 1.0 GHz) MRF5711LT1	NF_{min}	—	1.6	—	dB
Power Gain in 50 Ω System (V_{CE} = 6.0 V, I_C = 10 mA, f = 1.0 GHz) MRF5711LT1	$\|S_{21}\|^2$	9.0	10	—	dB

TYPICAL CHARACTERISTICS
MPS571, MMBR571LT1

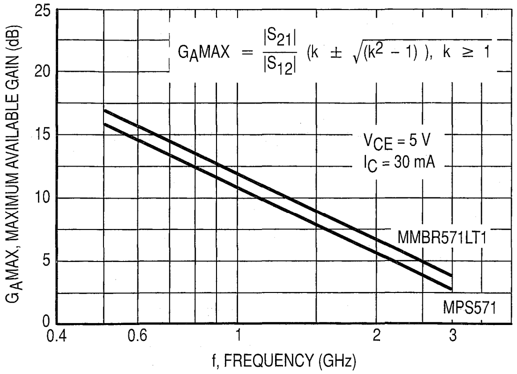


Figure 1. Maximum Available Gain versus Frequency

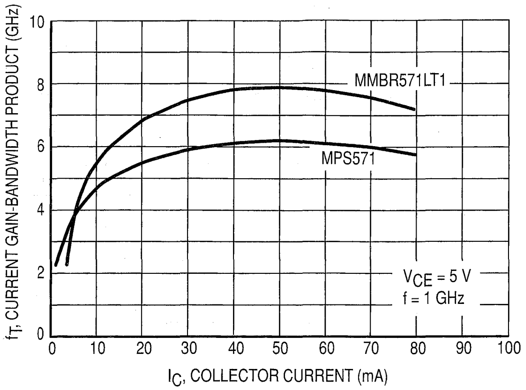


Figure 2. Current Gain–Bandwidth versus Collector Current @ 1.0 GHz

TYPICAL CHARACTERISTICS
MPS571, MMBR571LT1

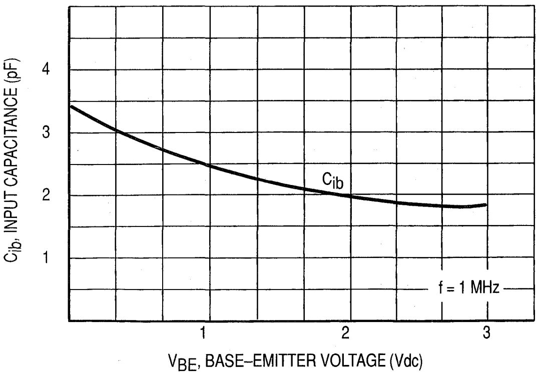

TO–92 MPS571

Figure 3. Input Capacitance versus Emitter Base Voltage

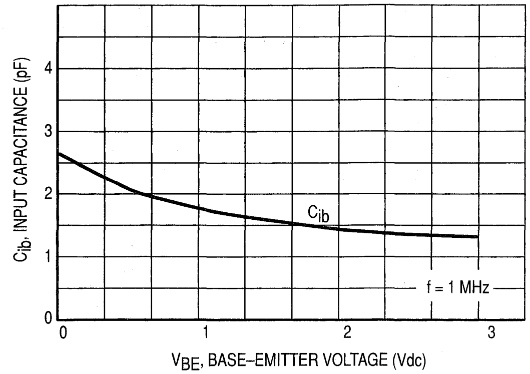

SOT–23 MMBR571LT1

Figure 4. Input Capacitance versus Emitter Base Voltage

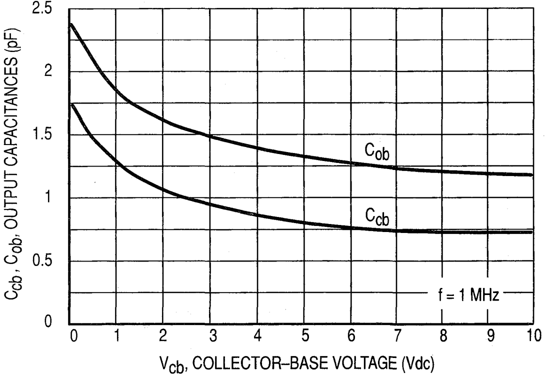

TO–92 MPS571

Figure 5. Output Capacitances versus Collector–Base Voltage

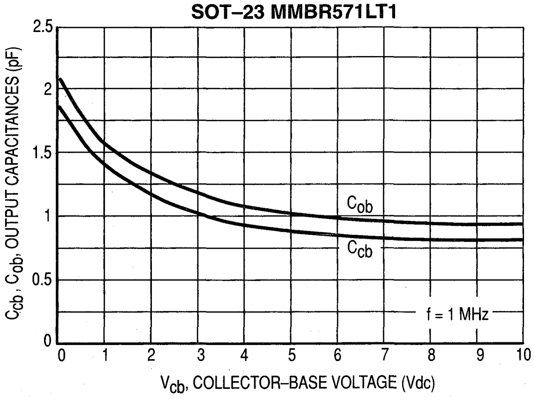

SOT–23 MMBR571LT1

Figure 6. Output Capacitances versus Collector–Base Voltage

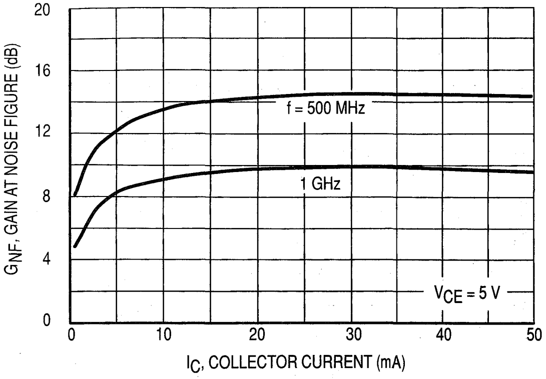

TO–92 MPS571

Figure 7. Gain at Noise Figure versus Collector Current

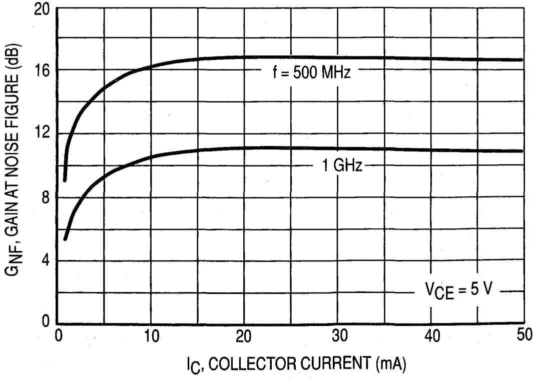

SOT–23 MMBR571LT1

Figure 8. Gain at Noise Figure versus Collector Current

TYPICAL CHARACTERISTICS
MPS571, MMBR571LT1

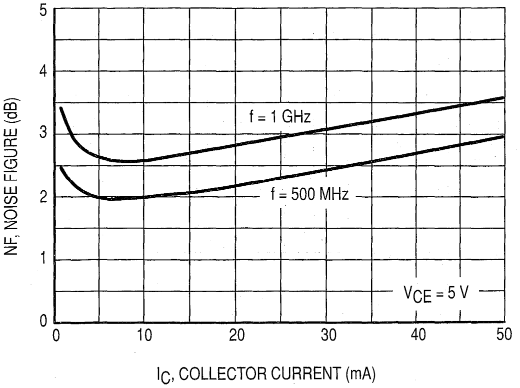

TO–92 MPS571

Figure 9. Noise Figure versus Collector Current

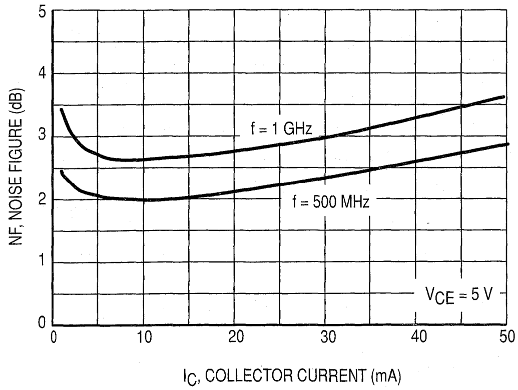

SOT–23 MMBR571LT1

Figure 10. Noise Figure versus Collector Current

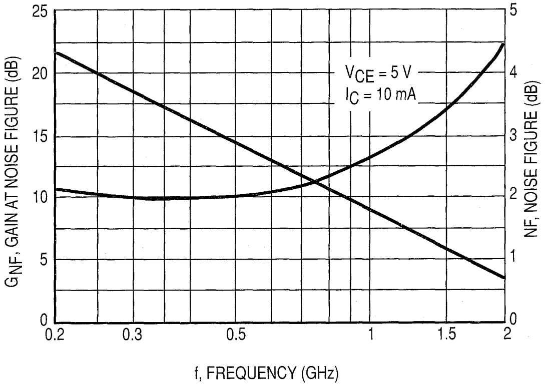

TO–92 MPS571

Figure 11. Gain at Noise Figure and Noise Figure versus Frequency

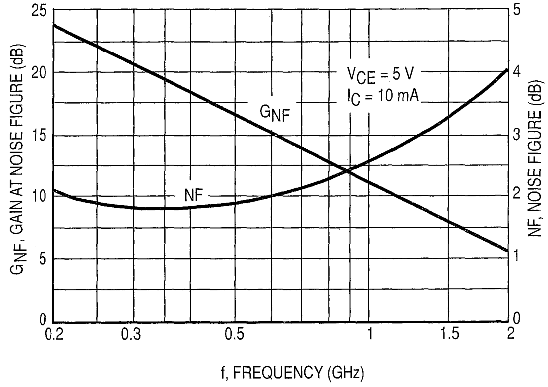

SOT–23 MMBR571LT1

Figure 12. Gain at Noise Figure and Noise Figure versus Frequency

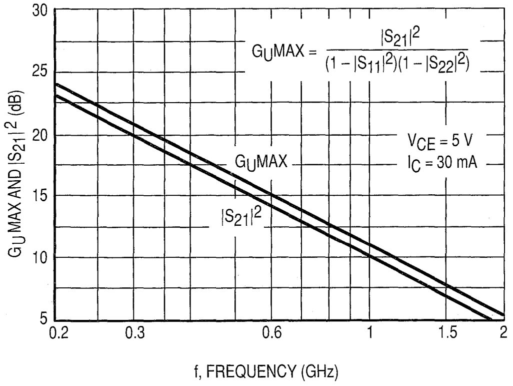

TO–92 MPS571

Figure 13. Maximum Unilateral Gain and Insertion Gain versus Frequency

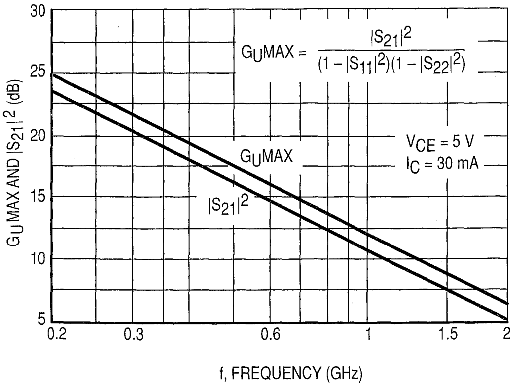

SOT–23 MMBR571LT1

Figure 14. Maximum Unilateral Gain and Insertion Gain versus Frequency

TYPICAL CHARACTERISTICS
MRF5711LT1

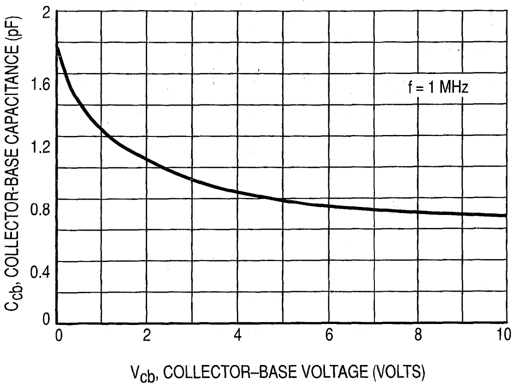


Figure 15. Collector–Base Capacitance versus Collector–Base Voltage

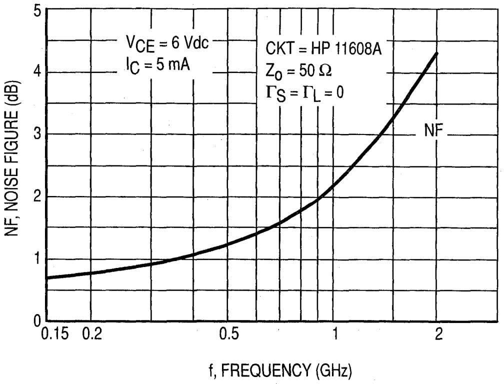


Figure 16. 50 Ω Noise Figure versus Frequency

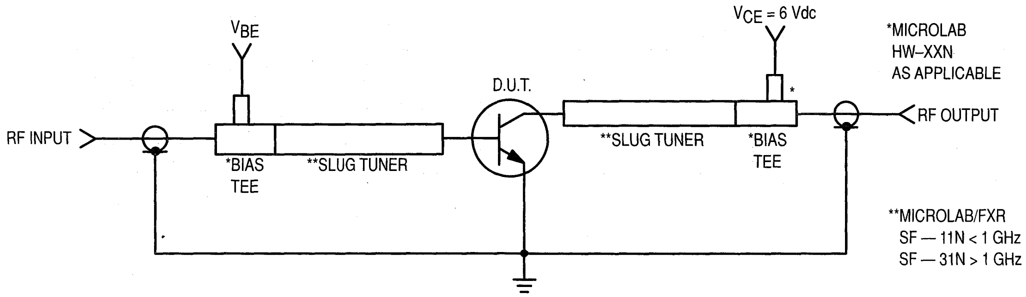


Figure 17. Functional Circuit Schematic

TYPICAL CHARACTERISTICS
MRF5711LT1

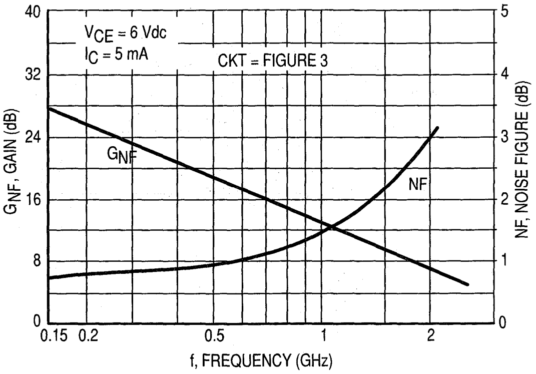


Figure 18. Gain and Noise Figure versus Frequency

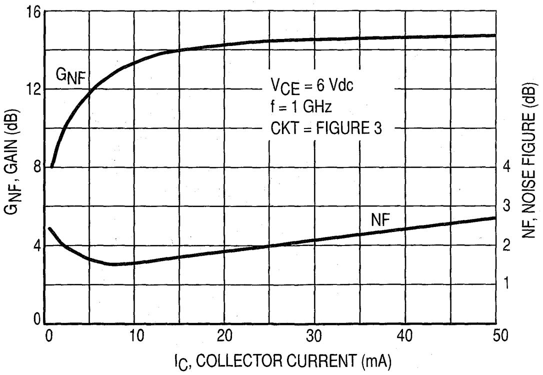


Figure 19. Gain and Noise Figure versus Collector Current

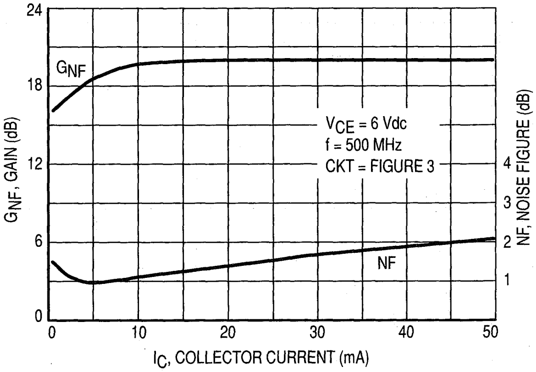


Figure 20. Gain and Noise Figure versus Collector Current

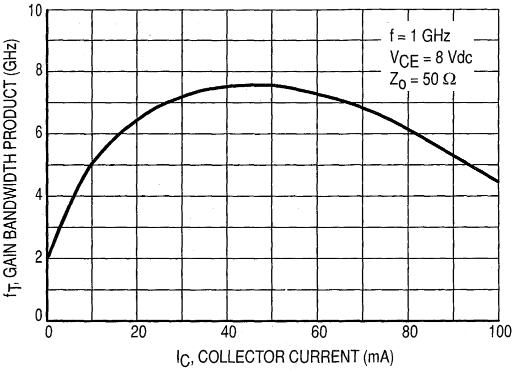


Figure 21. Gain Bandwidth Product versus Collector Current

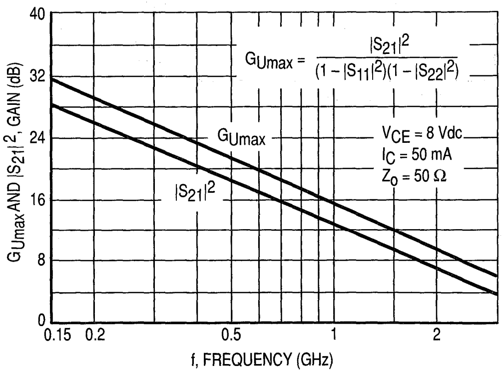


Figure 22. G_{Umax} and $|S_{21}|^2$ versus Frequency

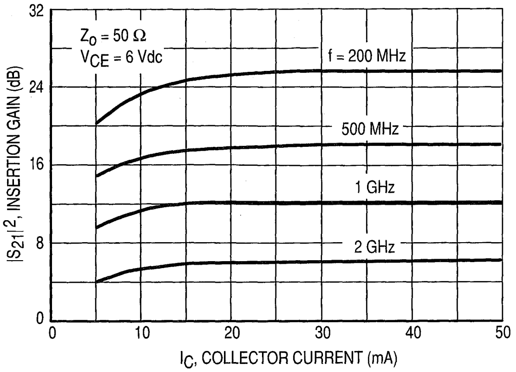


Figure 23. Insertion Gain versus Collector Current

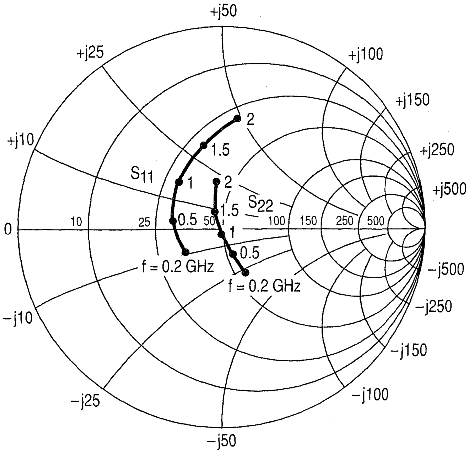


Figure 24. Input/Output Reflection Coefficients versus Frequency
V_{CE} = 5.0 V, I_C = 30 mA

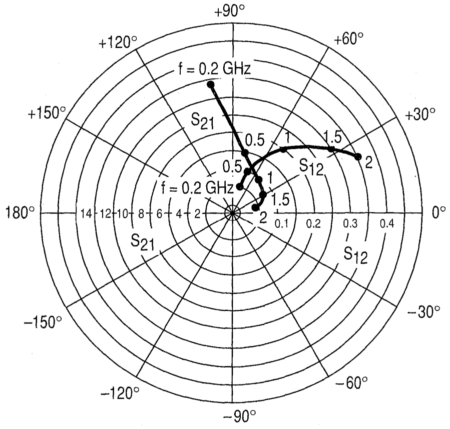


Figure 25. Forward/Reverse Transmission Coefficients versus Frequency
V_{CE} = 5.0 V, I_C = 30 mA

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
5.0	5.0	200	0.62	−80	8.22	122	0.07	56	0.63	−44
		500	0.40	−148	4.52	87	0.11	50	0.36	−58
		1000	0.39	155	2.51	54	0.16	48	0.23	−78
		1500	0.46	122	1.86	32	0.23	42	0.15	−114
		2000	0.59	100	1.50	14	0.31	33	0.14	173
	15	200	0.33	−121	12.88	105	0.05	67	0.37	−59
		500	0.28	−175	5.62	79	0.10	65	0.18	−67
		1000	0.32	143	2.99	53	0.19	55	0.08	−94
		1500	0.40	117	2.14	32	0.27	42	0.07	171
		2000	0.55	95	1.74	17	0.35	30	0.198	117
	30	200	0.23	−143	13.65	99	0.05	75	0.26	−62
		500	0.23	169	5.75	76	0.11	70	0.13	−68
		1000	0.30	130	3.05	50	0.21	55	0.04	−136
		1500	0.41	106	2.11	28	0.29	38	0.12	130
		2000	0.56	85	1.70	11	0.36	23	0.26	102
	50	200	0.21	−158	13.96	96	0.05	79	0.21	−61
		500	0.23	162	5.82	75	0.11	72	0.11	−66
		1000	0.30	128	3.09	49	0.21	56	0.03	−149
		1500	0.41	105	2.11	28	0.29	39	0.12	127
		2000	0.56	84	1.70	11	0.36	23	0.27	100

Table 1. MPS571 Common Emitter S–Parameters

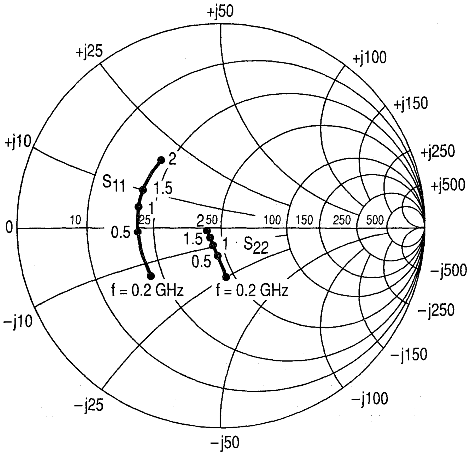


Figure 26. Input/Output Reflection Coefficients versus Frequency
V_{CE} = 5.0 V, I_C = 30 mA

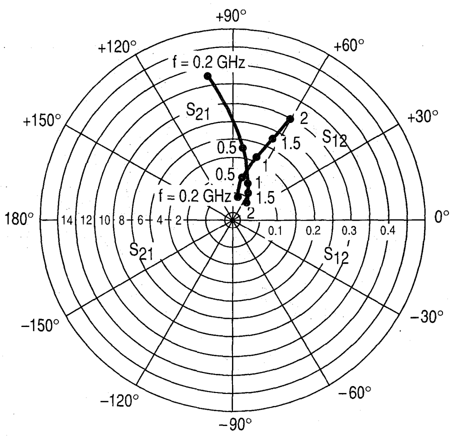
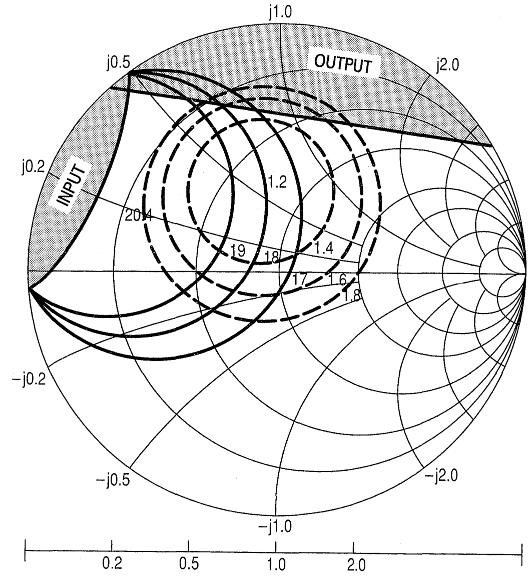


Figure 27. Forward/Reverse Transmission Coefficients versus Frequency
V_{CE} = 5.0 V, I_C = 30 mA

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
5.0	5.0	200	0.68	−82	8.41	126	0.07	53	0.61	−45
		500	0.52	−142	4.62	93	0.10	46	0.35	−60
		1000	0.50	179	2.57	72	0.14	53	0.26	−71
		1500	0.51	161	1.82	57	0.19	58	0.24	−77
		2000	0.52	143	1.48	45	0.24	59	0.22	−86
	15	200	0.46	−125	13.65	108	0.05	60	0.35	−73
		500	0.43	−169	6.03	86	0.09	66	0.17	−94
		1000	0.44	168	3.20	72	0.16	67	0.14	−111
		1500	0.45	152	2.21	58	0.22	64	0.11	−118
		2000	0.46	137	1.80	48	0.29	59	0.10	−131
	30	200	0.42	−148	14.79	102	0.04	68	0.26	−87
		500	0.41	−177	6.31	84	0.09	72	0.14	−115
		1000	0.42	165	3.35	71	0.16	70	0.12	−135
		1500	0.44	151	2.29	59	0.23	65	0.11	−144
		2000	0.44	135	1.84	48	0.30	60	0.10	−157
	50	200	0.41	−159	15.14	98	0.04	73	0.21	−96
		500	0.42	179	6.38	83	0.09	75	0.13	−124
		1000	0.43	163	3.35	70	0.16	71	0.12	−143
		1500	0.44	148	2.32	58	0.23	66	0.10	−151
		2000	0.45	134	1.84	48	0.30	60	0.09	−163

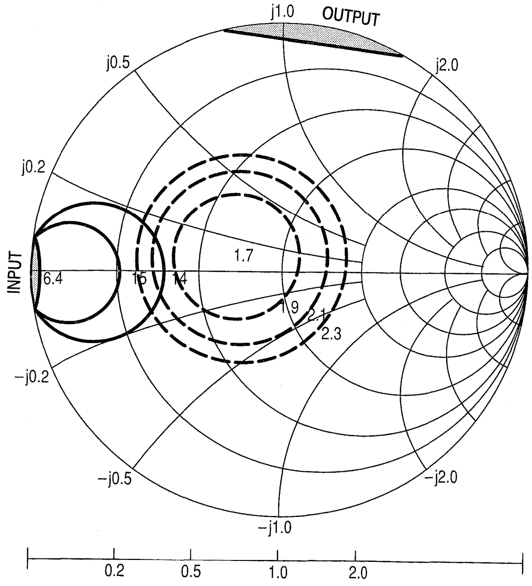
Table 2. MMBR571LT1 Common Emitter S–Parameters



V_{CE} = 5 V
I_C = 10 mA
▨ = Area of Instability

f (GHz)	NF OPT	ΓMS NF OPT	Rn	K
0.5	1.20 dB	0.36 ∠ 104°	7	0.63

Figure 28. MRF5711LT1 Constant Gain and Noise Figure Contours (f = 0.5 GHz)



V_{CE} = 5 V
I_C = 10 mA
▨ = Area of Instability

f (GHz)	NF OPT	ΓMS NF OPT	Rn	K
1.0	1.70 dB	0.20 ∠ 162°	8	0.94

Figure 29. MRF5711LT1 Constant Gain and noise Figure Contours (f = 1.0 GHz)

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
6.0	5.0	200	0.79	−90	10.9	128	0.06	46	0.70	−45
		500	0.72	−144	5.7	96	0.08	28	0.42	−66
		1000	0.69	−177	3.0	75	0.09	28	0.31	−77
		1500	0.66	164	2.0	59	0.10	32	0.34	−89
		2000	0.65	147	1.6	47	0.12	38	0.32	−94
	10	200	0.72	−115	15.2	118	0.05	41	0.55	−66
		500	0.69	−160	6.9	92	0.06	34	0.30	−92
		1000	0.67	174	3.6	74	0.08	42	0.21	−108
		1500	0.64	159	2.4	60	0.10	46	0.23	−114
		2000	0.64	143	1.8	49	0.12	50	0.20	−116
	50	200	0.67	−159	20	102	0.02	48	0.33	−111
		500	0.67	179	8.2	85	0.04	58	0.33	−142
		1000	0.66	174	3.8	72	0.07	65	0.21	−158
		1500	0.63	151	2.7	61	0.10	64	0.22	−158
		2000	0.58	138	2.1	51	0.14	62	0.17	−165
8.0	5.0	200	0.80	−87	11.1	130	0.06	47	0.71	−42
		500	0.72	−141	5.9	97	0.08	30	0.44	−60
		1000	0.70	−177	3.1	75	0.09	28	0.33	−68
		1500	0.66	166	2.1	60	0.10	32	0.35	−80
		2000	0.61	149	1.6	47	0.12	39	0.35	−85
	10	200	0.72	−113	15.6	119	0.05	42	0.56	−61
		500	0.68	−159	7.2	92	0.06	34	0.31	−82
		1000	0.66	175	3.7	74	0.08	41	0.21	−92
		1500	0.64	160	2.5	61	0.09	47	0.23	−101
		2000	0.60	144	2.0	49	0.13	50	0.21	−103
	50	200	0.66	−156	20.9	103	0.02	48	0.31	−101
		500	0.65	−179	8.6	85	0.04	58	0.19	−128
		1000	0.64	164	4.3	72	0.07	65	0.16	−144
		1500	0.61	153	2.9	61	0.10	65	0.17	−142
		2000	0.58	137	2.3	51	0.13	64	0.14	−145

Table 3. MRF5711LT1 Common Emitter S–Parameters

TYPICAL CHARACTERISTICS
MRF571

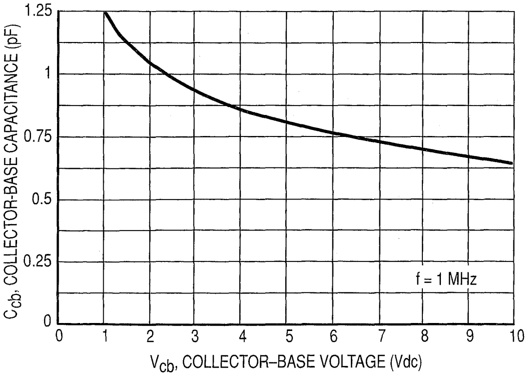


Figure 30. C_{cb}, Collector–Base Capacitance versus Voltage

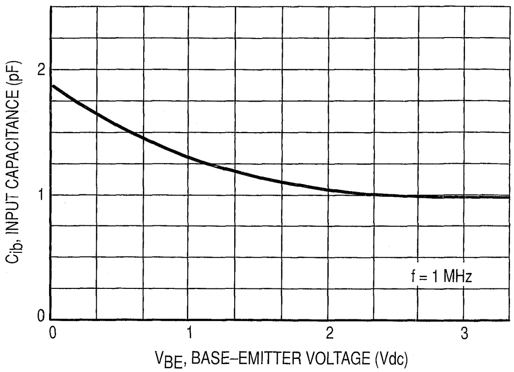


Figure 31. C_{ib}, Input Capacitance versus Emitter Base Voltage

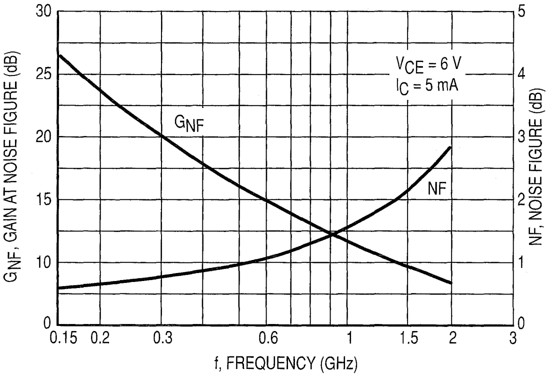


Figure 32. Gain at Noise Figure and Noise Figure versus Frequency

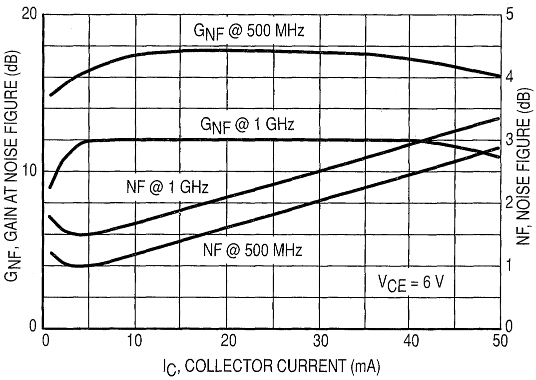


Figure 33. Gain at Noise Figure and Noise Figure versus Collector Current

TYPICAL CHARACTERISTICS
MRF571

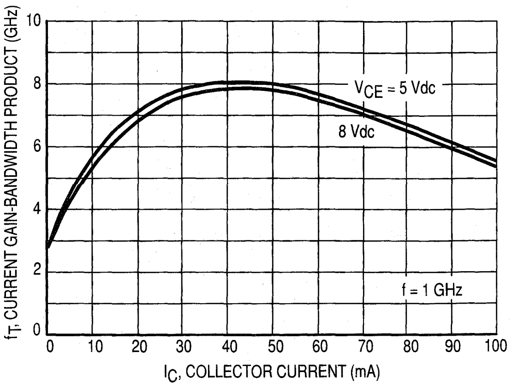


Figure 34. f_T, Current Gain–Bandwidth Product versus Collector Current

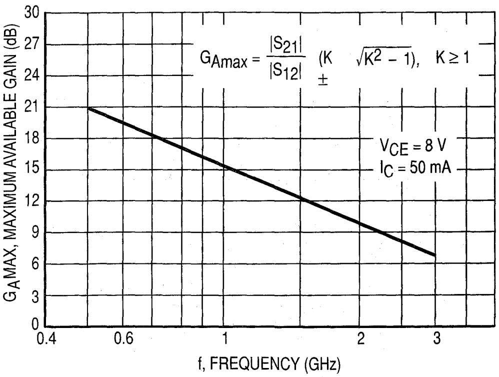


Figure 35. G_{Amax}, Maximum Available Gain versus Frequency

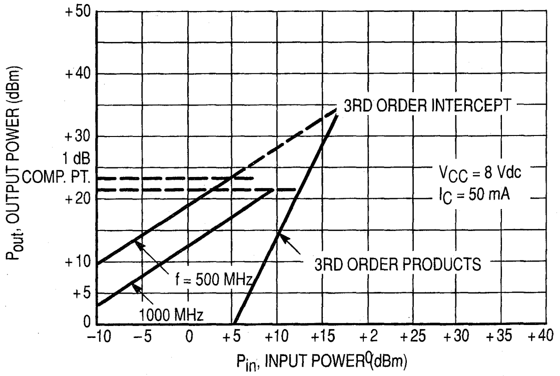


Figure 36. 1.0 dB Compression Point and Third Order Intercept

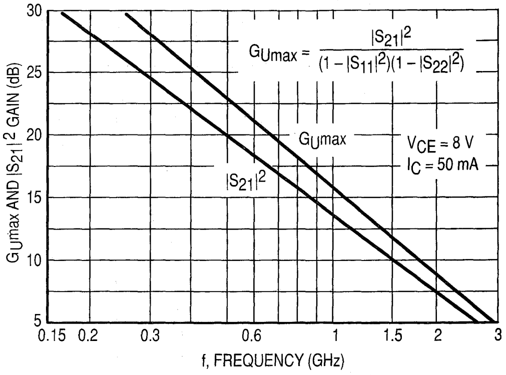


Figure 37. G_{Umax} and $|S_{21}|^2$ versus Frequency

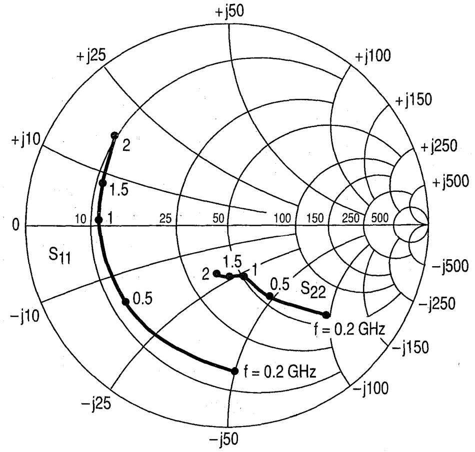


Figure 38. Input/Output Reflection Coefficients versus Frequency (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA

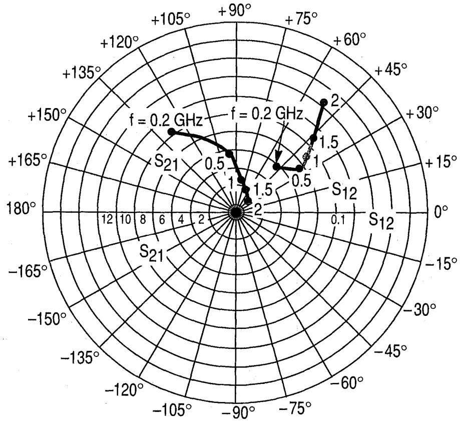
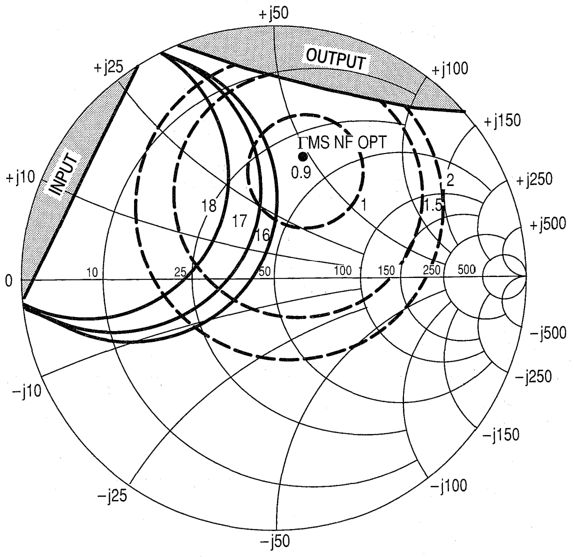


Figure 39. Forward/Reverse Transmission Coefficients versus Frequency (GHz)
V_{CE} = 6.0 V, I_C = 5.0 mA

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
6.0	5	200	0.74	−86	10.5	129	0.06	48	0.69	−42
		500	0.62	−143	5.5	97	0.08	33	0.41	−59
		1000	0.61	178	3.0	78	0.09	37	0.28	−69
		1500	0.65	158	2.0	62	0.11	44	0.26	−88
		2000	0.70	140	1.6	51	0.14	51	0.27	−99
	10	200	0.64	−111	15	118	0.04	44	0.53	−59
		500	0.58	−160	6.9	93	0.06	42	0.27	−77
		1000	0.59	168	3.7	77	0.09	52	0.16	−91
		1500	0.63	151	2.5	64	0.12	56	0.16	−113
		2000	0.67	134	2.0	53	0.16	57	0.16	−118
	50	200	0.56	−160	20.4	102	0.02	57	0.27	−98
		500	0.57	176	8.4	86	0.05	67	0.14	−130
		1000	0.60	156	4.4	75	0.09	70	0.11	−164
		1500	0.62	152	2.9	64	0.13	68	0.13	−175
		2000	0.66	127	2.4	53	0.18	62	0.11	−178
8.0	5	200	0.75	−83	10.7	129	0.06	49	0.71	−39
		500	0.62	−140	5.1	98	0.08	34	0.43	−54
		1000	0.60	−179	3.7	78	0.09	38	0.31	−62
		1500	0.64	159	2.1	62	0.10	45	0.29	−80
		2000	0.69	141	1.7	52	0.13	52	0.29	−91
	10	200	0.64	−99	15.1	120	0.05	46	0.54	−60
		500	0.52	−152	7.1	94	0.07	45	0.32	−75
		1000	0.52	170	3.7	76	0.10	54	0.15	−82
		1500	0.52	150	2.5	62	0.13	56	0.16	−108
		2000	0.57	133	2.0	51	0.18	55	0.16	−107
	50	200	0.52	−153	19.6	102	0.03	56	0.28	−92
		500	0.52	178	8.1	86	0.05	67	0.16	−98
		1000	0.56	157	4.1	73	0.10	70	0.06	−130
		1500	0.54	139	2.8	62	0.13	68	0.11	−146
		2000	0.59	126	2.2	52	0.19	63	0.10	−137

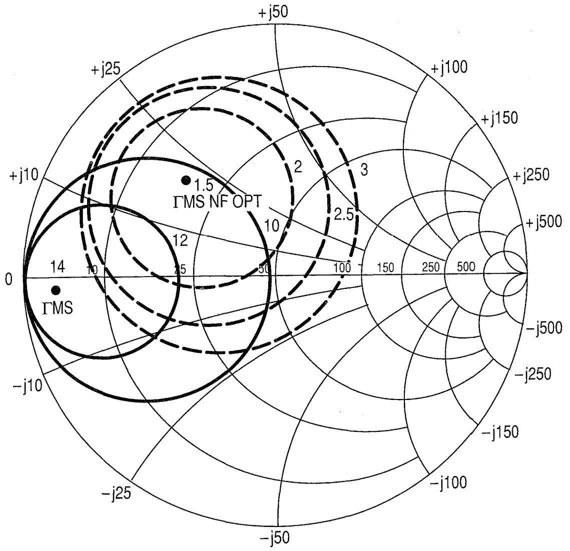
Table 4. MRF571 Common Emitter S–Parameters



$V_{CE} = 6.0$ V, $I_C = 5.0$ mA
f = 500 MHz
▨ — REGION OF INSTABILITY

f (GHz)	NF OPT (dB)	Rn (Ω)	NF50 Ω (dB)
0.5	0.9	9.3	1.3

ΓMS NF OPT	K
0.49 ∠ 74°	0.58

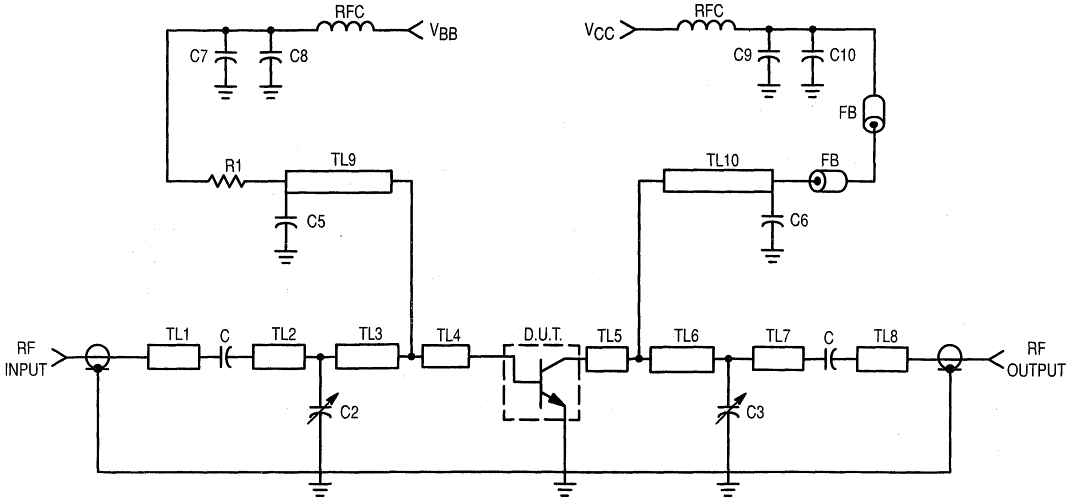


$V_{CE} = 6.0$ V, $I_C = 5.0$ mA
f = 1.0 GHz

f (GHz)	NF OPT (dB)	Rn (Ω)	NF50 Ω (dB)	ΓMS NF OPT
1.0	1.5	7.5	2.2	0.48 ∠ 134°

ΓMS	ΓML
0.89 ∠ −179°	0.81 ∠ 66°

Figure 40. MRF571 Constant Gain and Noise Figure Contours



C1, C4, C5, C6, C8, C9 — 100 pF Chip Capacitor
C2, C3 — 0.8–8.0 pF Johanson Capacitor
C7, C10 — 10 μF Tantalum Capacitor
R1 — 1.0 kOhms Res.
RFC — VK-200, Ferroxcube
FB — Ferrite Bead, Ferroxcube 56–590–65/3B
Board Material — 0.0625″ Glass Teflon, $\varepsilon_r = 2.55$

TL1, TL7, TL8 — Microstrip 0.162″ x 0.600″
TL2 — Microstrip 0.162″ x 1.060″
TL3 — Microstrip 0.162″ x 0.700″
TL4, TL5 — Microstrip 0.162″ x 0.440″
TL6 — Microstrip 0.162″ x 1.140″
TL8, TL9 — Microstrip 0.020″ x 2.130″

Figure 41. MRF571 Test Circuit Schematic

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

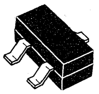
The RF Line
NPN Silicon High-Frequency Transistor

MMBR901LT1, T3
MPS901 MRF901
MRF9011LT1

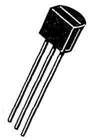
I_C = 30 mA
SURFACE MOUNTED
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON

Designed primarily for use in high–gain, low–noise small–signal amplifiers for operation up to 2.5 GHz. Also usable in applications requiring fast switching times.

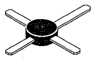
- High Current–Gain — Bandwidth Product
- Low Noise Figure @ f = 1.0 GHz —
  $NF_{(matched)}$ = 1.8 dB (Typ) (MRF9011LT1)
  = 1.9 dB (Typ) (MMBR901LT1, T3)
- High Power Gain —
  $G_{pe(matched)}$ = 13.5 dB (Typ) @ f = 1.0 GHz (MRF9011LT1)
  = 12.0 dB (Typ) @ f = 1.0 GHz (MMBR901LT1, T3)
- Guaranteed RF Parameters (MRF9011LT1)
- Surface Mounted SOT–23 & SOT–143 Offer Improved RF Performance
  Lower Package Parasitics
  High Gain
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel
  T3 suffix = 10,000 units per reel



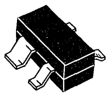
CASE 318–08, STYLE 6
SOT–23
LOW PROFILE, MMBR901LT1, T3



CASE 29–04, STYLE 2
TO–226AA (TO–92)
MPS901



CASE 317–01, STYLE 2
MRF901



CASE 318A–05, STYLE 1
SOT–143
LOW PROFILE, MRF9011LT1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	25	Vdc
Emitter–Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Power Dissipation @ T_C = 75°C (1) MMBR901LT1, T3; MRF9011LT1 Derate above 25°C	$P_{D(max)}$	0.300 4.00	Watt mW/°C
Total Device Dissipation @ T_C = 75°C (1) Derate above 75°C MPS901	P_D	300 4.0	mW mW/°C
Total Device Dissipation @ T_C = 75°C (1) Derate above 75°C MRF901	P_D	0.375 5.0	Watt mW/°C
Storage Temperature Range All	T_{stg}	–55 to +150	°C
Maximum Junction Temperature	$T_{J(max)}$	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	150	°C
Thermal Resistance, Junction to Case MRF901 MRF9011LT1, MMBR901LT1, T3	$R_{\theta JC}$	 200 250	°C/W

DEVICE MARKING

MRF9011LT1 = 01	MMBR901LT1, T3 = 7A

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	25	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	MMBR901LT1, T3 MRF9011LT1, MPS901, MRF901	h_{FE}	50 30	— 80	200 200	—
DYNAMIC CHARACTERISTICS						
Current–Gain — Bandwidth Product (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	MRF9011LT1 MPS901, MRF901	f_T	— —	3.8 4.5	— —	GHz
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MRF9011LT1 MPS901 MRF901	C_{cb}	— — —	0.55 0.50 0.40	1.0 1.0 1.0	pF
FUNCTIONAL TESTS						
Power Gain at Minimum Noise Figure (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	MRF9011LT1	G_{NFmin}	—	13.5	—	dB
Minimum Noise Figure (Figure 3) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	MRF9011LT1	NF_{min}	—	1.8	—	dB
Insertion Gain in 50 Ω System (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	MRF9011LT1	$\|S_{21}\|^2$	9.0	10.2	—	dB
Minimum Noise Figure (Figure 3) (V_{CE} = 6.0 Vdc, I_C = 5.0 mA, f = 1.0 GHz) (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	MMBR901LT1, T3	NF_{min}	—	1.9	—	dB
Minimum Noise Figure (Figure 3) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 900 MHz)	MPS901	NF_{min}	—	2.4	—	dB
Minimum Noise Figure (Figure 3) (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 GHz)	MRF901	NF_{min}	—	2.0	2.5	dB
SMALL–SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	MMBR901LT1	C_{obo}	—	—	1.0	pF
Common–Emitter Amplifier Gain (V_{CC} = 6.0 Vdc, I_C = 5.0 mAdc, f = 1.0 GHz)	MMBR901LT1	G_{pe}	—	12	—	dB

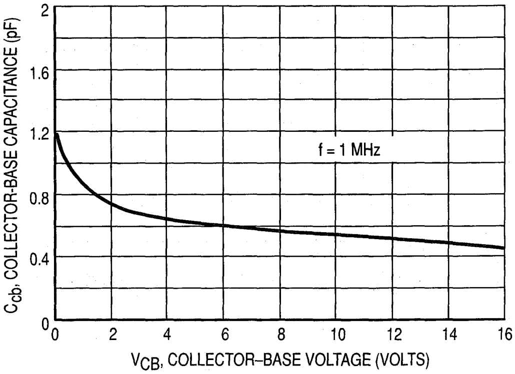


Figure 1. Collector–Base Capacitance versus Collector–Base Voltage

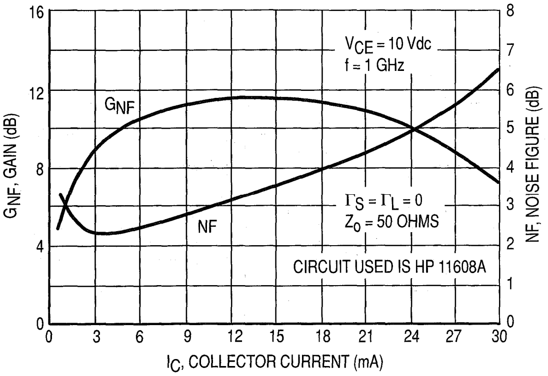


Figure 2. Gain and Noise Figure versus Collector Current

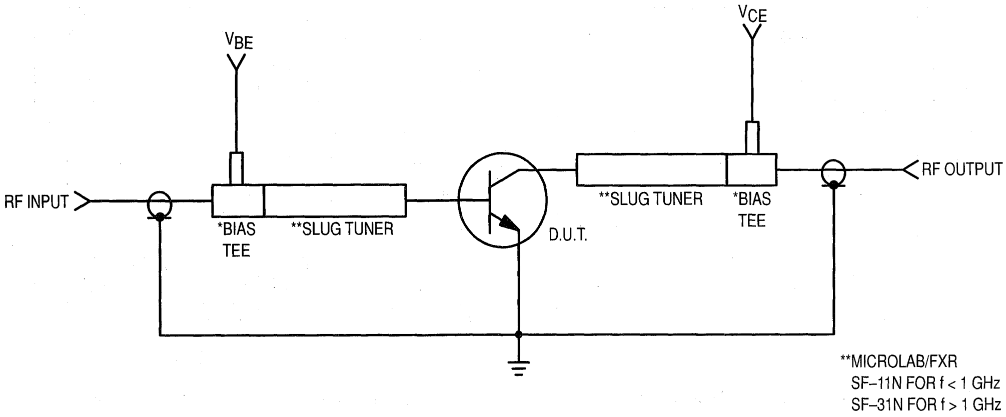


Figure 3. MRF9011LT1 Functional Circuit Schematic

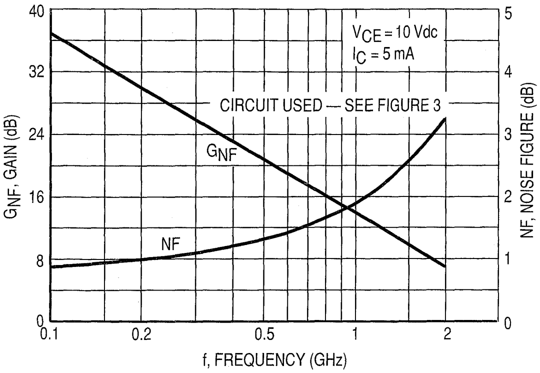


Figure 4. Gain and Noise Figure versus Frequency

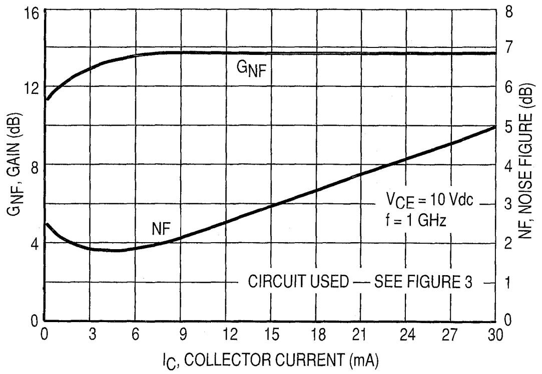


Figure 5. Gain and Noise Figure versus Collector Current

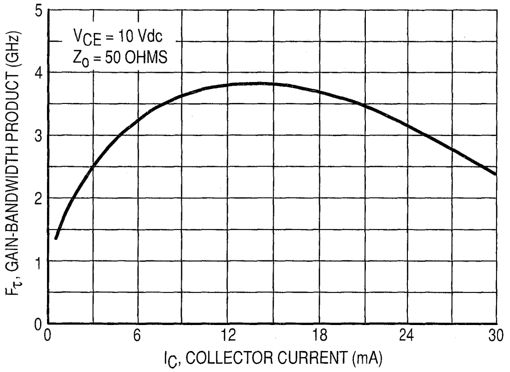


Figure 6. Gain–Bandwidth Product versus Collector Current

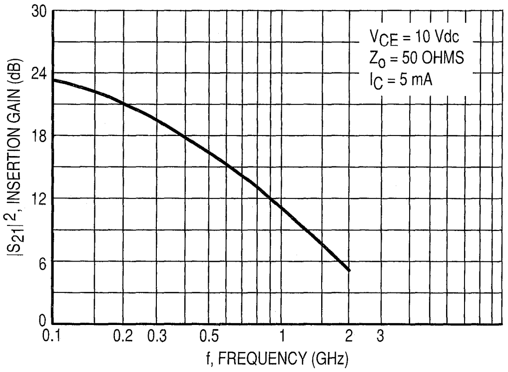


Figure 7. Insertion Gain versus Frequency

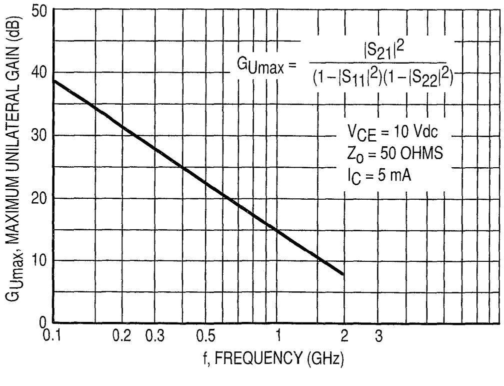


Figure 8. Maximum Unilateral Gain versus Frequency

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
5.0	5.0	100	0.85	−41	13.64	153	0.03	65	0.93	−17
		200	0.78	−76	10.77	134	0.05	54	0.80	−29
		500	0.71	−131	6.10	102	0.08	35	0.55	−42
		1000	0.66	−169	3.22	77	0.08	33	0.45	−48
		2000	0.60	152	1.65	47	0.11	46	0.47	−63
	10	100	0.72	−59	20.01	145	0.03	62	0.87	−23
		200	0.70	−100	14.31	123	0.04	49	0.67	−36
		500	0.66	−150	7.03	94	0.06	38	0.44	−43
		1000	0.63	179	3.57	73	0.07	45	0.37	−46
		2000	0.58	147	1.79	46	0.11	57	0.41	−60
	15	100	0.65	−75	23.44	138	0.02	57	0.81	−27
		200	0.66	−118	15.56	116	0.04	46	0.59	−38
		500	0.65	−159	7.10	90	0.05	42	0.40	−40
		1000	0.63	174	3.57	71	0.06	52	0.35	−43
		2000	0.59	144	1.77	45	0.11	62	0.40	−58
	20	100	0.61	−89	24.32	133	0.02	51	0.77	−28
		200	0.66	−130	15.11	111	0.03	43	0.55	−35
		500	0.66	−166	6.68	88	0.04	46	0.41	−34
		1000	0.65	171	3.32	69	0.06	56	0.39	−39
		2000	0.61	143	1.65	43	0.10	65	0.44	−56
	30	100	0.63	−132	13.18	118	0.02	47	0.72	−15
		200	0.68	−157	7.07	104	0.02	44	0.66	−16
		500	0.69	−177	3.23	90	0.03	55	0.62	−24
		1000	0.70	165	1.78	71	0.05	65	0.59	−38
		2000	0.66	138	0.93	42	0.09	79	0.62	−62
10	5.0	100	0.85	−38	13.67	155	0.03	70	0.93	−14
		200	0.80	−71	10.97	136	0.05	56	0.83	−24
		500	0.70	−126	6.35	104	0.07	37	0.60	−35
		1000	0.65	−166	3.39	78	0.07	36	0.51	−40
		2000	0.58	154	1.74	48	0.10	50	0.54	−55
	10	100	0.75	−55	20.12	147	0.02	66	0.88	−19
		200	0.71	−94	14.60	125	0.04	50	0.72	−30
		500	0.65	−145	7.33	96	0.05	39	0.50	−35
		1000	0.62	−177	3.74	74	0.06	46	0.45	−38
		2000	0.57	149	1.88	47	0.10	60	0.49	−53
	15	100	0.68	−68	23.53	140	0.02	61	0.85	−22
		200	0.67	−110	15.90	119	0.03	49	0.65	−31
		500	0.64	−155	7.45	92	0.04	42	0.47	−32
		1000	0.62	177	3.74	71	0.06	53	0.44	−35
		2000	0.58	146	1.90	45	0.09	65	0.50	−51
	20	100	0.64	−79	24.77	135	0.02	56	0.81	−23
		200	0.64	−122	15.81	114	0.03	46	0.62	−29
		500	0.64	−161	7.10	89	0.04	46	0.48	−28
		1000	0.62	174	3.53	79	0.05	56	0.46	−33
		2000	0.59	145	1.75	44	0.09	68	0.53	−50
	30	100	0.61	−114	16.25	123	0.01	48	0.79	−15
		200	0.63	−147	9.10	107	0.02	49	0.71	−15
		500	0.65	−172	4.22	90	0.03	53	0.66	−22
		1000	0.66	168	2.27	71	0.05	63	0.63	−33
		2000	0.63	140	1.15	41	0.08	79	0.67	−53

Table 1. MRF9011LT1 Common Emitter S–Parameters

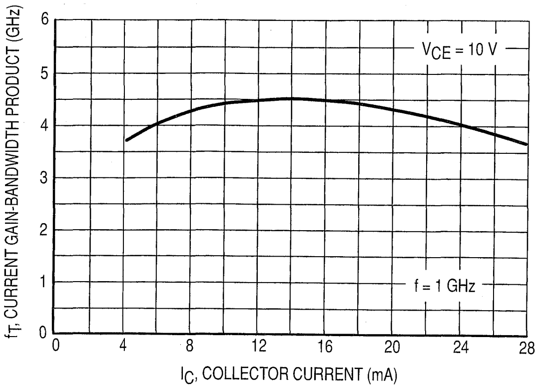


Figure 9. Current Gain–Bandwidth Product versus Collector Current

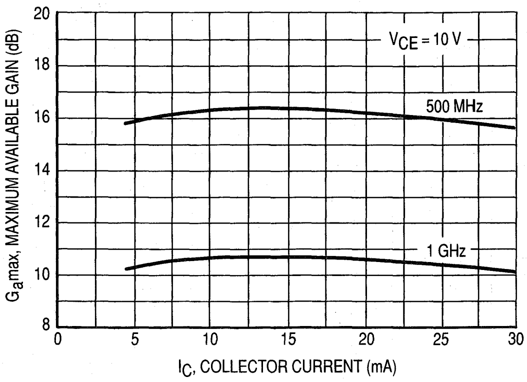


Figure 10. Maximum Available Gain versus Collector Current

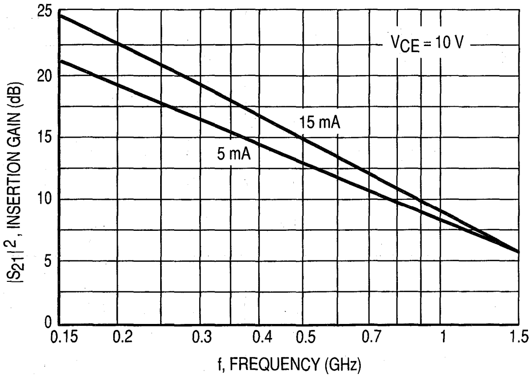


Figure 11. $|S_{21}|^2$ versus Frequency

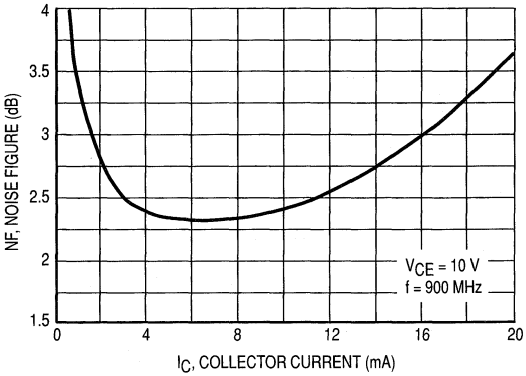


Figure 12. Noise Figure versus Collector Current

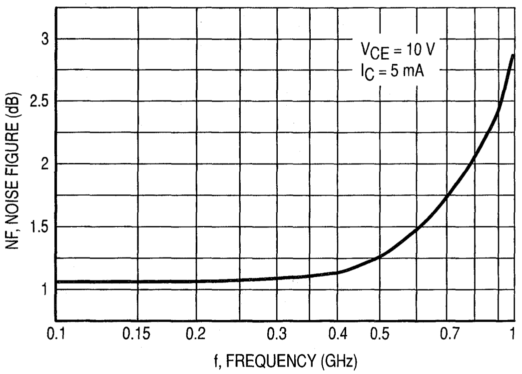


Figure 13. Noise Figure versus Frequency

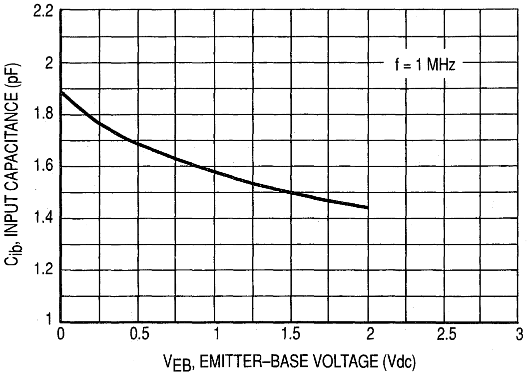


Figure 14. Input Capacitance versus Emitter–Base Voltage

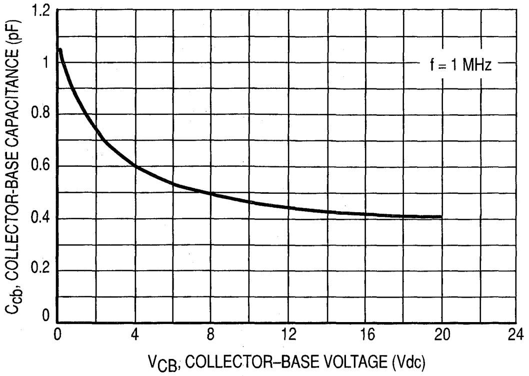


Figure 15. Collector–Base Capacitance versus Collector–Base Voltage

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
5.0	5.0	100	0.76	−35	9.42	142	0.03	67	0.85	−18
		200	0.60	−63	7.98	122	0.05	58	0.70	−26
		500	0.28	−127	4.79	84	0.09	55	0.53	−35
		1000	0.27	148	2.71	50	0.15	51	0.42	−51
		1500	0.43	113	2.02	23	0.21	42	0.28	−79
	10	100	0.57	−51	14.80	131	0.03	65	0.75	−22
		200	0.36	−87	10.80	108	0.04	62	0.60	−26
		500	0.18	−151	5.23	77	0.08	62	0.48	−31
		1000	0.25	136	2.86	47	0.15	55	0.39	−48
		1500	0.42	109	2.12	22	0.22	42	0.25	−75
	15	100	0.42	−67	17.80	123	0.02	66	0.69	−22
		200	0.26	−105	11.50	101	0.04	66	0.56	−23
		500	0.17	−169	5.27	74	0.08	66	0.47	−28
		1000	0.26	131	2.86	46	0.15	57	0.39	−47
		1500	0.43	108	2.12	21	0.22	44	0.25	−73
	20	100	0.33	−82	18.66	117	0.02	67	0.66	−21
		200	0.22	−120	11.54	98	0.03	68	0.55	−21
		500	0.17	−171	5.16	72	0.08	67	0.48	−27
		1000	0.28	129	2.80	45	0.15	58	0.40	−45
		1500	0.45	107	2.07	19	0.22	45	0.27	−71
	25	100	0.28	−103	18.11	113	0.02	68	0.64	−20
		200	0.22	−138	11.03	95	0.03	70	0.55	−19
		500	0.20	169	4.94	71	0.08	68	0.50	−25
		1000	0.32	128	2.68	43	0.15	60	0.42	−44
		1500	0.49	106	1.98	17	0.22	47	0.30	−71
	30	100	0.31	−127	16.10	109	0.02	67	0.64	−16
		200	0.28	−156	9.69	93	0.03	70	0.57	−16
		500	0.28	160	4.32	69	0.07	70	0.53	−25
		1000	0.39	125	2.37	41	0.14	63	0.46	−44
		1500	0.55	104	1.73	15	0.21	51	0.34	−72

Table 2. MPS901 Common Emitter S–Parameters, V_{CE} = 5.0 V

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
10	5.0	100	0.79	−33	9.36	144	0.03	68	0.88	−15
		200	0.63	−58	7.97	124	0.04	58	0.74	−22
		500	0.28	−117	4.87	86	0.07	57	0.60	−31
		1000	0.23	153	2.80	53	0.13	56	0.50	−46
		1500	0.38	116	2.09	26	0.19	48	0.38	−69
	10	100	0.60	−48	14.87	132	0.02	66	0.79	−18
		200	0.39	−79	11.06	110	0.03	63	0.65	−21
		500	0.16	−135	5.38	79	0.07	64	0.56	−28
		1000	0.20	138	2.97	50	0.13	59	0.47	−44
		1500	0.37	111	2.21	25	0.20	49	0.36	−66
	15	100	0.46	−61	18.20	124	0.02	66	0.74	−18
		200	0.28	−94	11.94	102	0.03	66	0.62	−19
		500	0.14	−154	5.45	76	0.07	67	0.55	−26
		1000	0.22	131	2.97	48	0.13	61	0.48	−42
		1500	0.38	109	2.21	24	0.20	50	0.36	−64
	20	100	0.37	−72	19.38	119	0.02	67	0.71	−17
		200	0.23	−105	11.97	99	0.03	68	0.61	−18
		500	0.14	−172	5.36	74	0.07	69	0.56	−24
		1000	0.23	128	2.91	47	0.13	62	0.48	−41
		1500	0.40	108	2.16	22	0.20	51	0.37	−64
	25	100	0.32	−86	19.40	115	0.02	68	0.70	−16
		200	0.22	−119	11.67	97	0.03	69	0.61	−16
		500	0.19	−176	5.28	74	0.06	70	0.57	−23
		1000	0.26	127	2.82	46	0.13	63	0.50	−41
		1500	0.43	107	2.09	21	0.19	53	0.40	−63
	30	100	0.29	−103	18.29	112	0.02	68	0.70	−14
		200	0.22	−135	10.86	95	0.03	70	0.62	−15
		500	0.20	165	4.82	72	0.06	72	0.59	−22
		1000	0.31	125	2.63	44	0.12	66	0.53	−41
		1500	0.47	106	1.95	19	0.19	55	0.43	−64

Table 3. MPS901 Common Emitter S–Parameters, V_{CE} = 10 V

MRF901

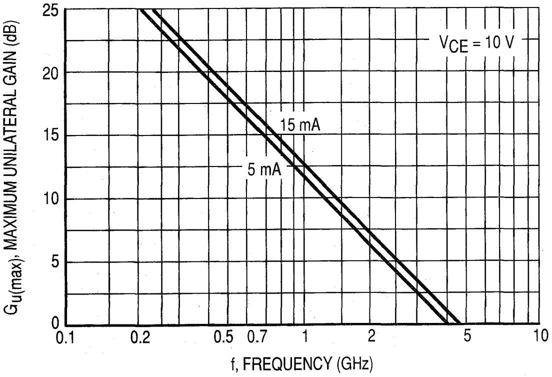


Figure 16. Maximum Unilateral Gain versus Frequency

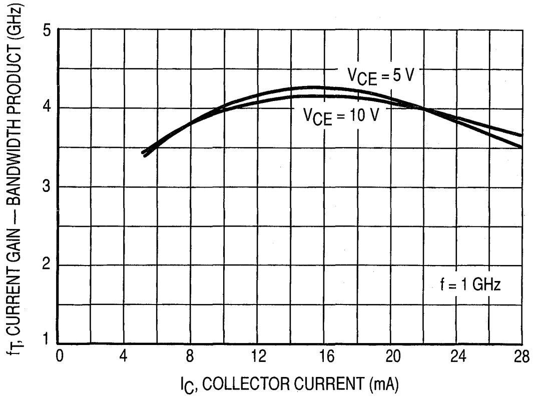


Figure 17. Current Gain — Bandwidth Product versus Collector Current

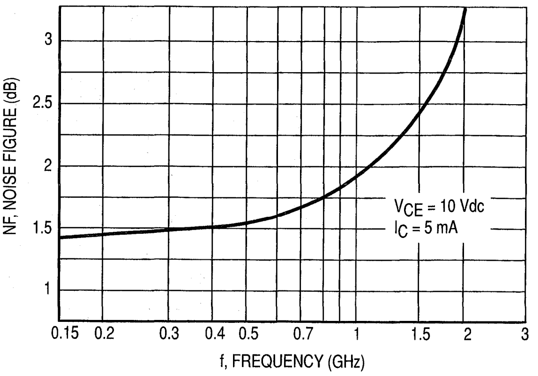


Figure 18. Noise Figure versus Frequency

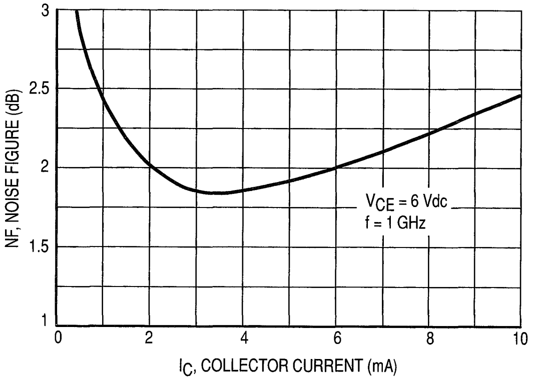


Figure 19. Noise Figure versus Collector Current

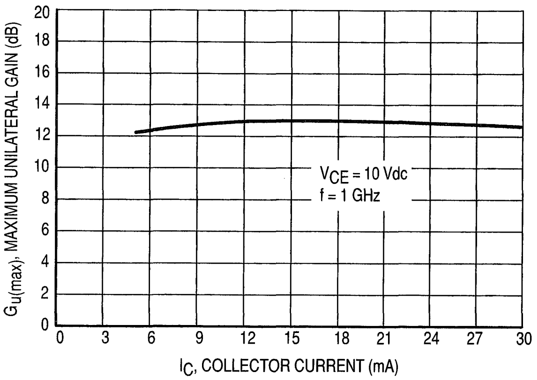


Figure 20. Maximum Unilateral Gain versus Collector Current

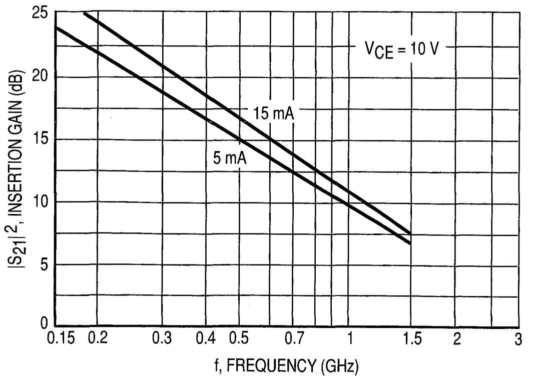


Figure 21. $|S_{21}|^2$ versus Frequency

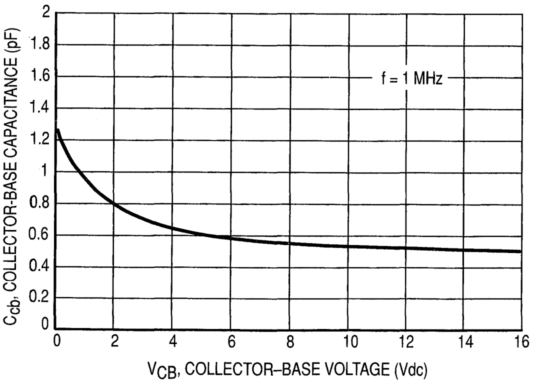


Figure 22. Collector–Base Capacitance versus Collector–Base Voltage

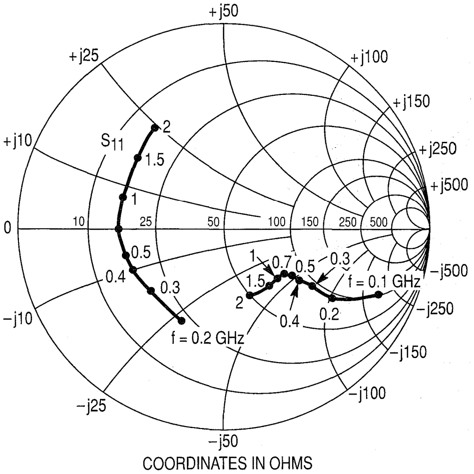


Figure 23. Input and Output Reflection Coefficients versus Frequency (V_{CE} = 10 V, I_C = 15 mA)

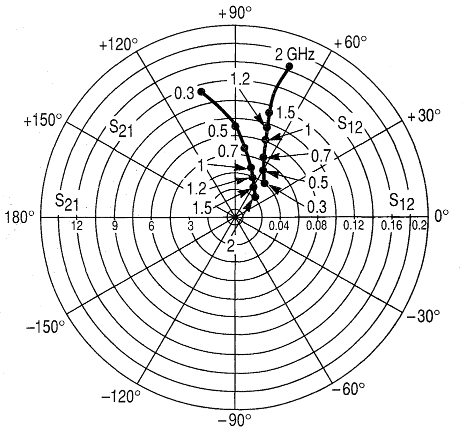


Figure 24. Forward/Reverse Transmission Coefficients versus Frequency (V_{CE} = 10 V, I_C = 15 mA)

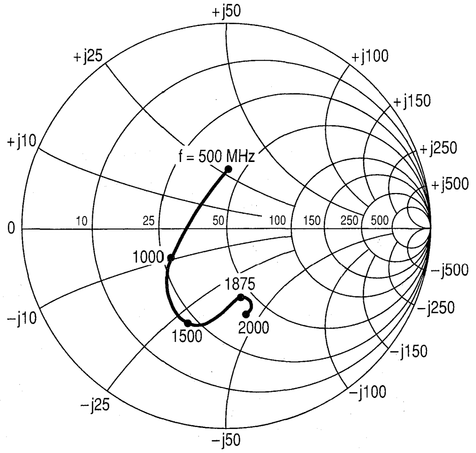
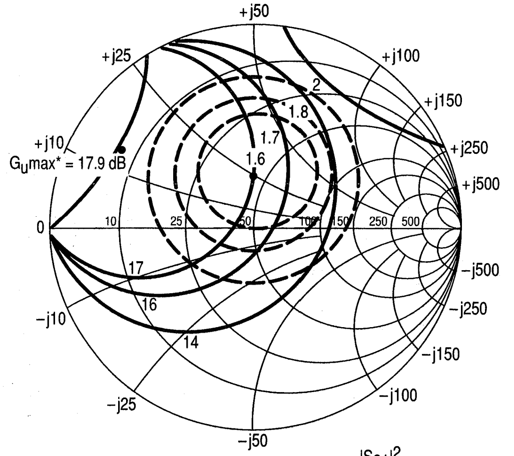
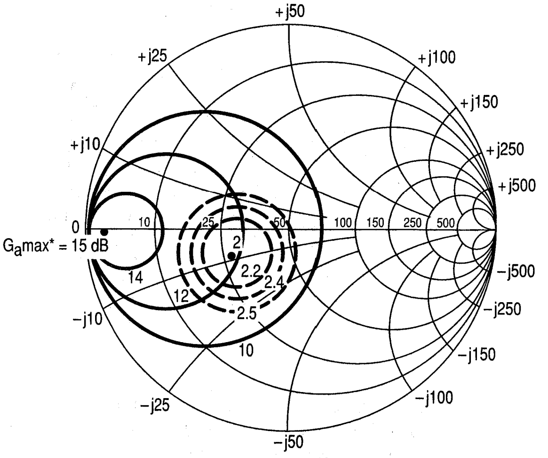


Figure 25. Source Impedance (Γms) for Optimum Noise Figure versus Frequency (V_{CE} = 10 V, I_C = 5.0 mA)



*MAXIMUM UNILATERAL GAIN, $G_u\text{max} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$ (K < 1)

Figure 26. Constant Gain and Noise Figure Contours
(V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 500 MHz)



*MAXIMUM AVAILABLE GAIN, $G_a\text{max} = \frac{|S_{21}|}{|S_{12}|}(K \pm \sqrt{K^2 - 1})$ (K > 1)

Figure 27. Constant Gain and Noise Figure Contours
(V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
5.0	5.0	100	0.71	−38	11.30	153	0.03	68	0.92	−17
		200	0.62	−75	9.48	133	0.05	55	0.76	−29
		500	0.54	−141	5.40	100	0.07	43	0.48	−44
		1000	0.53	178	2.93	76	0.09	48	0.40	−56
		2000	0.59	130	1.51	48	0.16	62	0.35	−85
	10	100	0.57	−58	16.95	145	0.03	63	0.85	−23
		200	0.51	−103	12.61	123	0.04	53	0.64	−35
		500	0.52	−161	6.24	93	0.06	50	0.38	−45
		1000	0.52	166	3.24	73	0.09	61	0.33	−54
		2000	0.59	125	1.66	47	0.17	67	0.29	−84
	15	100	0.48	−75	20.08	139	0.02	61	0.80	−27
		200	0.47	−121	13.89	117	0.04	53	0.57	−38
		500	0.53	−170	6.44	91	0.05	56	0.34	−44
		1000	0.53	162	3.33	72	0.09	66	0.31	−52
		2000	0.60	123	1.70	46	0.18	68	0.28	−82
	20	100	0.44	−88	21.62	136	0.02	60	0.76	−28
		200	0.47	−132	14.33	114	0.03	54	0.53	−38
		500	0.53	−175	6.45	89	0.05	60	0.32	−41
		1000	0.53	159	3.31	70	0.09	68	0.31	−50
		2000	0.61	122	1.69	45	0.18	70	0.28	−80
	30	100	0.43	−112	21.45	130	0.02	58	0.72	−28
		200	0.50	−148	13.38	109	0.03	57	0.51	−33
		500	0.57	178	5.82	86	0.05	65	0.35	−34
		1000	0.57	156	2.99	68	0.08	73	0.35	−46
		2000	0.65	121	1.50	42	0.18	74	0.33	−78

Table 4. MRF901 Common Emitter S–Parameters, V_{CE} = 5.0 V

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
10	5.0	100	0.73	−35	11.32	154	0.03	69	0.93	−14
		200	0.63	−69	9.69	135	0.05	57	0.79	−25
		500	0.53	−135	5.65	101	0.07	43	0.54	−38
		1000	0.51	−177	3.11	77	0.08	50	0.47	−48
		2000	0.57	132	1.58	48	0.14	66	0.41	−75
	10	100	0.59	−52	17.06	147	0.02	64	0.87	−19
		200	0.52	−95	13.06	125	0.04	54	0.69	−30
		500	0.49	−156	6.58	95	0.05	51	0.45	−37
		1000	0.50	170	3.44	74	0.08	62	0.41	−45
		2000	0.57	126	1.75	47	0.16	70	0.36	−72
	15	100	0.51	−66	20.36	141	0.02	63	0.83	−22
		200	0.47	−112	14.48	119	0.03	54	0.63	−31
		500	0.50	−166	6.81	92	0.05	57	0.41	−35
		1000	0.50	164	3.54	72	0.08	67	0.39	−43
		2000	0.58	124	1.78	46	0.16	72	0.35	−70
	20	100	0.47	−78	22.08	138	0.02	61	0.80	−23
		200	0.46	−123	15.07	116	0.03	55	0.60	−30
		500	0.50	−171	6.84	90	0.05	60	0.40	−32
		1000	0.51	162	3.51	71	0.08	69	0.39	−41
		2000	0.59	123	1.77	45	0.17	73	0.35	−68
	30	100	0.44	−98	22.70	133	0.02	59	0.76	−23
		200	0.47	−139	14.47	111	0.03	55	0.57	−27
		500	0.53	−177	6.33	87	0.04	65	0.43	−28
		1000	0.54	158	3.26	69	0.07	74	0.43	−39
		2000	0.62	122	1.61	42	0.16	77	0.39	−68

Table 5. MRF901 Common Emitter S–Parameters, V_{CE} = 10 V

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

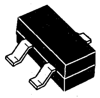
The RF Line
NPN Silicon High-Frequency Transistors

MMBR911LT1
MPS911

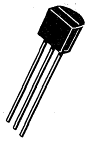
I_C = 60 mA
LOW NOISE
HIGH–FREQUENCY
TRANSISTORS
NPN SILICON

Designed for low noise, wide dynamic range front–end amplifiers and low–noise VCO's. Available in a surface–mountable plastic package, as well as the popular TO–226AA (TO–92) package. This Motorola series of small–signal plastic transistors offers superior quality and performance at low cost.

- High Gain–Bandwidth Product
  f_T = 7.0 GHz (Typ) @ 30 mA
- Low Noise Figure
  NF = 1.7 dB (Typ) @ 500 MHz
- High Gain
  G_{NF} = 17 dB (Typ) @ 10 mA/500 MHz
- State–of–the–Art Technology
  Fine Line Geometry
  Ion–Implanted Arsenic Emitters
  Gold Top Metallization and Wires
  Silicon Nitride Passivation
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
MMBR911LT1



CASE 29–04, STYLE 2
TO–226AA
(TO–92)
MPS911

MAXIMUM RATINGS

Rating	Symbol	MPS911	MMBR911LT1	Unit
Collector–Emitter Voltage	V_{CEO}	12		Vdc
Collector–Base Voltage	V_{CBO}	20		Vdc
Emitter–Base Voltage	V_{EBO}	2.0		Vdc
Collector Current — Continuous	I_C	60		mA
Power Dissipation @ T_{case} = 75°C (1) MMBR911LT1, @ T_A = 25°C MPS911	$P_{D(max)}$	625	333	mW
Derate linearly above T_{case} = 75°C MMBR911LT1, above T_A = 25°C MPS911		5	4.44	mW/°C
Storage Temperature	T_{stg}	–55 to +150		°C
Maximum Junction Temperature	T_{Jmax}	150		°C

THERMAL CHARACTERISTICS

Rating		Symbol	Value	Unit
Thermal Resistance, Junction to Case	MMBR911LT1	$R_{\theta JC}$	225	°C/W
Thermal Resistance, Junction to Ambient	MPS911	$R_{\theta JC}$	200	°C/W

DEVICE MARKING

MMBR911LT1 = 7P

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mA, I_C = 0)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	—	200	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Current Gain–Bandwidth Product MPS911 (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 1.0 GHz) MMBR911LT1	f_T	— —	7.0 6.0	— —	GHz
FUNCTIONAL TESTS					
Gain @ Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS911 f = 0.5 GHz f = 1.0 GHz MMBR911LT1 f = 0.5 GHz f = 1.0 GHz	G_{NF}	 — — — —	 16.5 11 17 11	 — — — —	dB
Noise Figure (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS911 f = 0.5 GHz f = 1.0 GHz MMBR911LT1 f = 0.5 GHz f = 1.0 GHz	NF	 — — — —	 1.7 2.7 2.0 2.9	 — — — —	dB

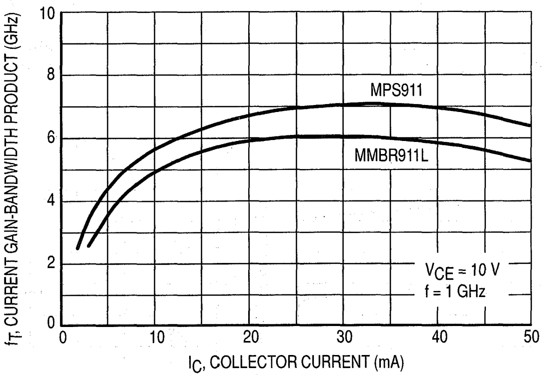


Figure 1. Current Gain–Bandwidth versus Collector Current @ 1.0 GHz

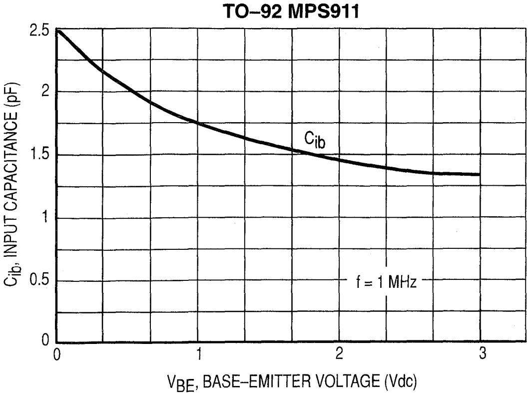


Figure 2. Input Capacitance versus Base–Emitter Voltage

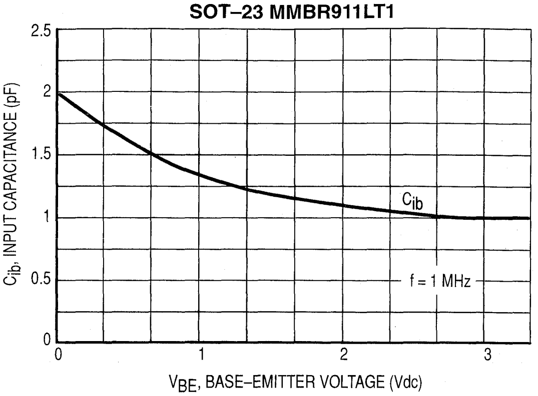


Figure 3. Input Capacitance versus Base–Emitter Voltage

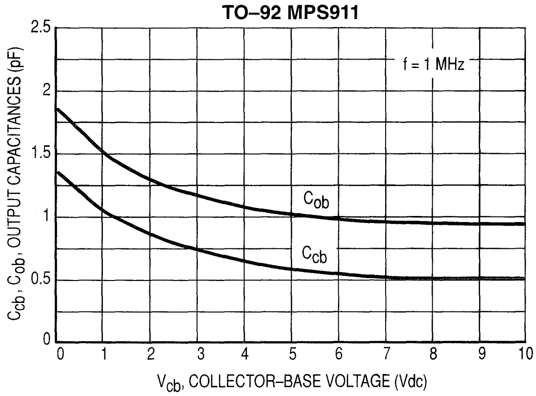


Figure 4. Output Capacitances versus Collector–Base Voltage

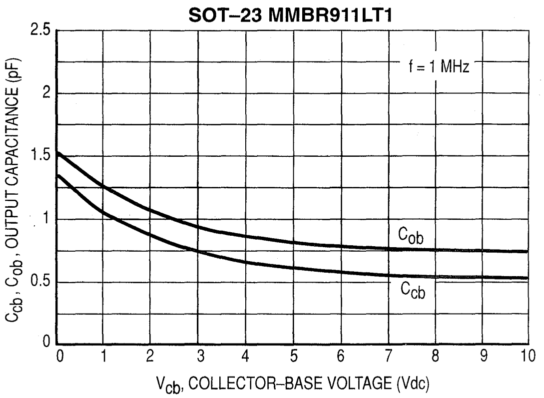


Figure 5. Output Capacitances versus Collector–Base Voltage

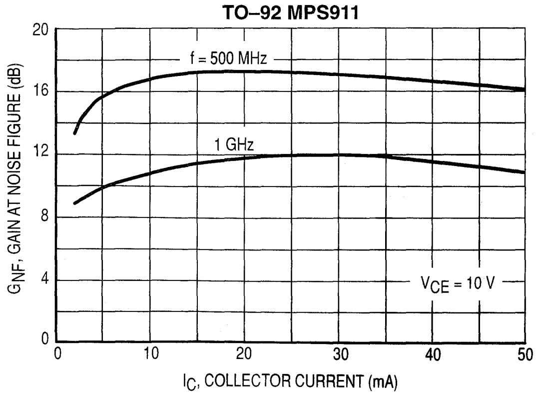


Figure 6. Gain at Noise Figure versus Collector Current

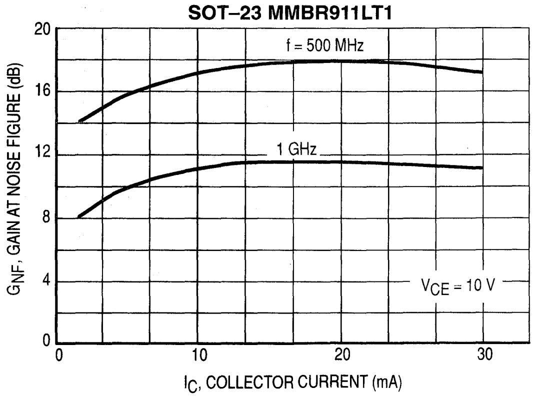


Figure 7. Gain at Noise Figure versus Collector Current

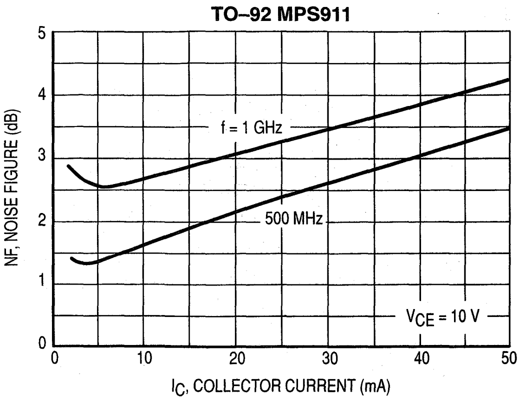

TO–92 MPS911

Figure 8. Noise Figure versus Collector Current

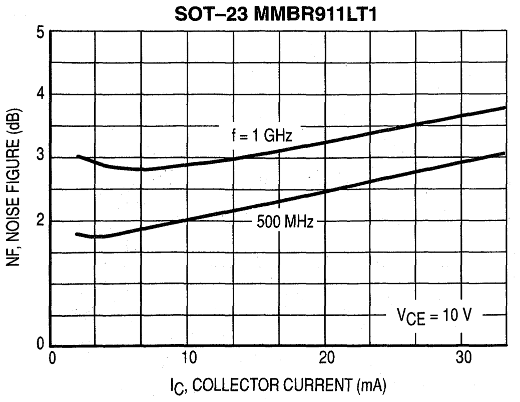

SOT–23 MMBR911LT1

Figure 9. Noise Figure versus Collector Current

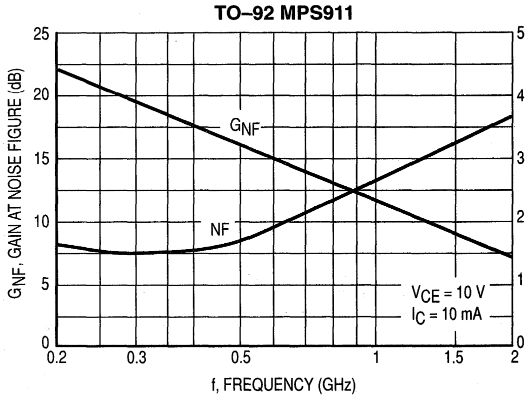

TO–92 MPS911

Figure 10. Gain at Noise Figure and Noise Figure versus Frequency

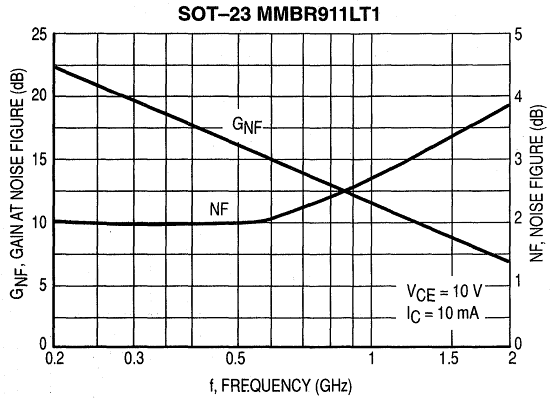

SOT–23 MMBR911LT1

Figure 11. Gain at Noise Figure and Noise Figure versus Frequency

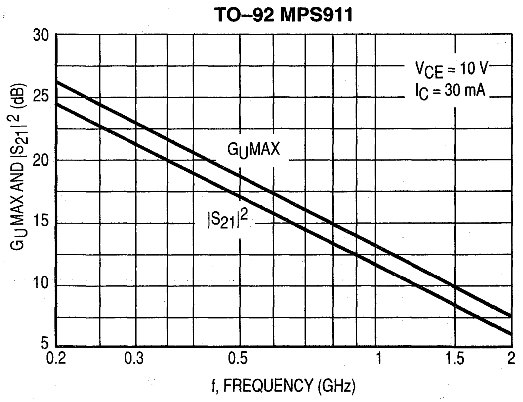

TO–92 MPS911

Figure 12. Maximum Unilateral Gain and Insertion Gain versus Frequency

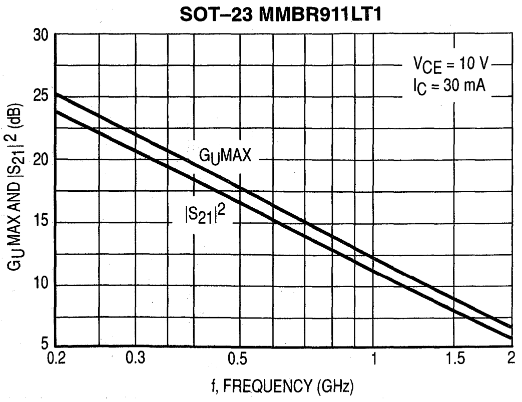

SOT–23 MMBR911LT1

Figure 13. Maximum Unilateral Gain and Insertion Gain versus Frequency

TO–92 MPS911

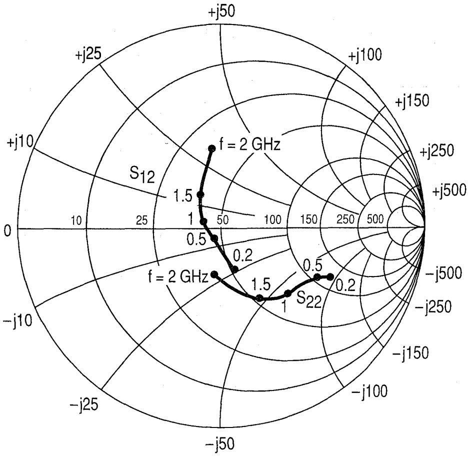


Figure 14. Input and Output Reflection Coefficients versus Frequency V_{CE} = 10 V, I_C = 30 mA

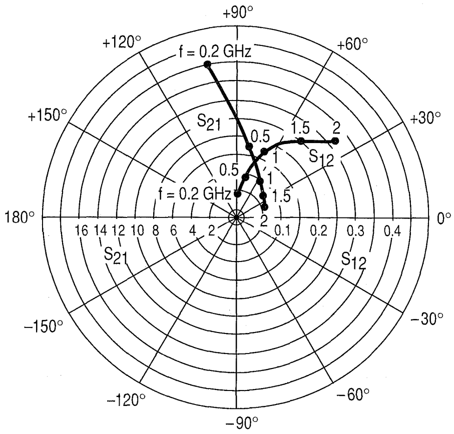


Figure 15. Forward and Reverse Transmission Coefficients versus Frequency V_{CE} = 10 V, I_C = 30 mA

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
10	2.0	200	0.78	−46	4.42	134	0.06	69	0.95	−18
		500	0.46	−107	3.35	98	0.10	56	0.78	−30
		1000	0.30	172	2.23	61	0.14	54	0.66	−48
		1500	0.41	118	1.66	34	0.20	51	0.57	−70
		2000	0.60	89	1.43	11	0.29	45	0.46	−107
	5.0	200	0.72	−55	8.75	126	0.05	68	0.87	−23
		500	0.31	−107	5.23	92	0.09	63	0.68	−31
		1000	0.18	178	3.05	61	0.15	60	0.57	−46
		1500	0.27	122	2.22	38	0.22	52	0.50	−66
		2000	0.45	94	1.90	17	0.30	43	0.38	−97
	10	200	0.48	−64	12.79	114	0.04	73	0.74	−24
		500	0.16	−100	6.19	85	0.09	71	0.60	−29
		1000	0.09	165	3.45	59	0.17	63	0.50	−44
		1500	0.22	112	2.50	36	0.25	50	0.41	−65
		2000	0.41	90	2.14	16	0.32	38	0.26	−98
	20	200	0.29	−67	15.30	106	0.04	78	0.65	−23
		500	0.08	−92	6.76	82	0.09	75	0.55	−27
		1000	0.06	144	3.71	58	0.17	64	0.46	−43
		1500	0.20	108	2.65	30	0.25	51	0.37	−63
		2000	0.38	89	2.25	18	0.32	38	0.23	−94
	30	200	0.20	−70	16.04	103	0.04	80	0.61	−22
		500	0.05	−97	6.90	81	0.09	77	0.53	−25
		1000	0.07	138	3.76	58	0.17	66	0.46	−41
		1500	0.20	109	2.68	38	0.25	52	0.37	−61
		2000	0.38	90	2.28	20	0.32	40	0.24	−91
	50	200	0.13	−78	15.26	99	0.04	82	0.62	−18
		500	0.03	−145	6.48	79	0.09	78	0.56	−23
		1000	0.11	126	3.55	56	0.17	67	0.49	−40
		1500	0.24	105	2.56	36	0.25	53	0.39	−62
		2000	0.43	87	2.17	17	0.32	40	0.25	−95

Table 1. Common Emitter S–Parameters

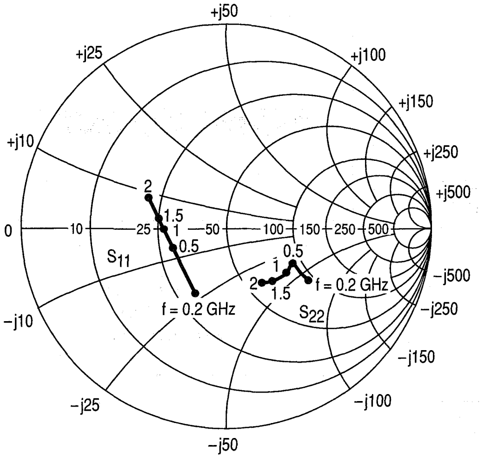


Figure 16. Input and Output Reflection Coefficients versus Frequency V_{CE} = 10 V, I_C = 30 mA

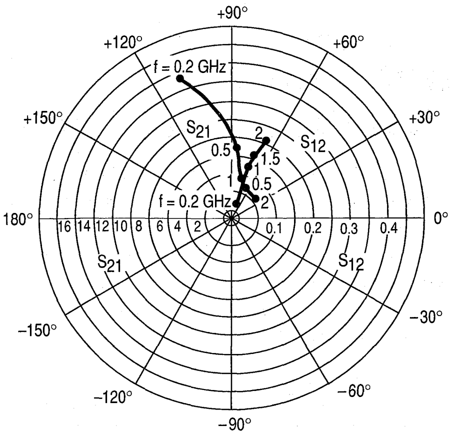


Figure 17. Forward and Reverse Transmission Coefficients versus Frequency V_{CE} = 10 V, I_C = 30 mA

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$|S_{11}|$	∠ φ	$|S_{21}|$	∠ φ	$|S_{12}|$	∠ φ	$|S_{22}|$	∠ φ
10	2.0	200	0.82	−45	4.14	145	0.06	66	0.88	−16
		500	0.60	−96	3.23	112	0.09	49	0.71	−27
		1000	0.47	−149	2.16	85	0.11	49	0.62	−34
		1500	0.46	−179	1.59	71	0.13	55	0.58	−43
		2000	0.47	162	1.35	57	0.16	62	0.56	−51
	5.0	200	0.66	−63	8.63	134	0.05	64	0.75	−25
		500	0.43	−117	5.29	100	0.07	58	0.55	−31
		1000	0.37	−163	3.05	82	0.11	63	0.48	−36
		1500	0.38	176	2.17	70	0.15	65	0.45	−44
		2000	0.40	160	1.81	57	0.19	65	0.43	−51
	10	200	0.49	−83	12.70	124	0.04	65	0.62	−30
		500	0.33	−134	6.42	94	0.07	66	0.44	−32
		1000	0.32	−171	3.53	80	0.12	70	0.41	−36
		1500	0.35	173	2.46	69	0.16	69	0.38	−45
		2000	0.37	159	2.04	58	0.20	66	0.35	−52
	20	200	0.36	−103	15.25	114	0.03	69	0.52	−32
		500	0.28	−149	6.95	90	0.06	72	0.39	−30
		1000	0.29	−176	3.73	78	0.12	73	0.37	−35
		1500	0.33	172	2.60	68	0.17	71	0.34	−43
		2000	0.36	158	2.14	58	0.21	67	0.32	−52
	30	200	0.32	−114	15.64	109	0.03	71	0.48	−29
		500	0.27	−156	6.92	88	0.06	73	0.38	−27
		1000	0.29	−178	3.71	78	0.12	74	0.37	−33
		1500	0.34	170	2.58	68	0.16	72	0.34	−44
		2000	0.37	156	2.13	57	0.21	68	0.32	−51

Table 2. Common Emitter S–Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

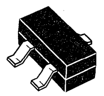
The RF Line
NPN Silicon High-Frequency Transistor

MMBR920LT1

RF AMPLIFIER
TRANSISTOR
NPN SILICON

Designed for thick and thin–film circuits using surface mount components and requiring low–noise, high–gain signal amplification at frequencies to 1.0 GHz.

- High Gain — G_{pe} = 15 dB Typ @ f = 500 MHz
- Low Noise — NF = 2.4 dB Typ @ f = 500 MHz
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	35	mAdc
Maximum Junction Temperature	T_{Jmax}	150	°C
Power Dissipation, T_C = 75°C (1) Derate linearly above 75°C @	$P_{D(max)}$	0.268 3.57	W mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	–55 to +150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	280	°C/W

DEVICE MARKING

MMBR920LT1 = 7B

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 14 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	250	—
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 14 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	f_T	—	4.5	—	GHz
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	1.0	pF
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	NF	 — —	 2.4 3.0	 — —	dB
Common–Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	G_{pe}	 — —	 15 10	 — —	dB

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

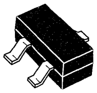
The RF Line
NPN Silicon High-Frequency Transistor

MMBR931LT1

Designed primarily for use in low–power amplifiers to 1.0 GHz. Ideal for pagers and other battery operated systems where power consumption is critical.

- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel

RF AMPLIFIER
TRANSISTOR
NPN SILICON



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
(TO–236AA/AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	5.0	Vdc
Collector–Base Voltage	V_{CBO}	10	Vdc
Emitter–Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	5.0	mAdc
Maximum Junction Temperature	T_{Jmax}	150	°C
Power Dissipation, T_{case} = 75°C (1) Derate linearly above 75°C @	$P_{D(max)}$	0.150 2.00	W mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	−55 to +150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	500	°C/W

DEVICE MARKING

MMBR931LT1 = 7D

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 0.1 mAdc, I_B = 0)	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.25 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	50	—	150	—
SMALL–SIGNAL CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	—	0.5	pF
Noise Figure (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	NF	—	4.3	—	dB
Power Gain at Optimum Noise Figure (I_E = 0.25 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	G_{NF}	—	10	—	—

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

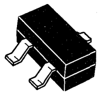
The RF Line
NPN Silicon Low Noise, High-Frequency Transistors

Designed for use in high gain, low noise small–signal amplifiers. This series features excellent broadband linearity and is offered in a variety of packages.

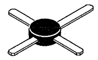
- Fully Implanted Base and Emitter Structure
- 9 Finger, 1.25 Micron Geometry with Gold Top Metal
- Gold Sintered Back Metal
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel
  T3 suffix = 10,000 units per reel
- MRF947R, T3 is Emitter–Base Pin out reversed.
  All electricals same as MRF947

MMBR941
MRF941
MRF947
MRF9411
SERIES

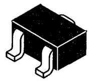
I_C = 50 mA
LOW NOISE
HIGH–FREQUENCY
TRANSISTORS



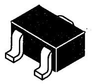
CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
MMBR941LT1, T3, MMBR941BLT1, T3



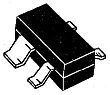
CASE 317–01, STYLE 2
MACRO–X
MRF941



CASE 419–02, STYLE 3
MRF947AT1, MRF947BT1, T3,
MRF947T1, T3



CASE 419–02, STYLE 6
MRF947RT3



CASE 318A–05, STYLE 1
SOT–143
LOW PROFILE
MRF9411LT1, MRF9411BLT1, T3

REV 7

MAXIMUM RATINGS

Rating	Symbol	MRF941	MMBR941LT1, T3	MRF9411LT1	MRF947 Series	Unit
Collector–Emitter Voltage	V_{CEO}	10	10	10	10	Vdc
Collector–Base Voltage	V_{CBO}	20	20	20	20	Vdc
Emitter–Base Voltage	V_{EBO}	1.5	1.5	1.5	1.5	Vdc
Power Dissipation (1) T_C = 75°C Derate linearly above T_{case} = 75°C @	P_{Dmax}	0.4 4.0	0.25 3.33	0.25 3.33	0.188 2.5	Watts mW/°C
Collector Current — Continuous (2)	I_C	50	50	50	50	mA
Maximum Junction Temperature	T_{Jmax}	150	150	150	150	°C
Storage Temperature	T_{stg}	−55 to +150	−55 to +150	−55 to +150	−55 to +150	°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	300	300	400	°C/W
Maximum Junction Temperature	T_{Jmax}	150	150	150	150	°C

DEVICE MARKING

MMBR941LT1, T3 = 7Y	MMBR941BLT1, T3 = 7N	MRF947T1, T3 = A	MRF947BT1, T3 = H
MRF9411LT1 = 10	MRF9411BLT1, T3 = 18	MRF947AT1 = G	MRF947RT3 = I

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (3)					
Collector–Emitter Breakdown Voltage (I_C = 0.1 mA, I_B = 0) All	$V_{(BR)CEO}$	10	12	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0) All	$V_{(BR)CBO}$	20	23	—	Vdc
Emitter Cutoff Current (V_{EB} = 1.0 V, I_C = 0) All	I_{EBO}	—	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 10 V, I_E = 0) All	I_{CBO}	—	—	0.1	μAdc
ON CHARACTERISTICS (3)					
DC Current Gain (V_{CE} = 6.0 V, I_C = 5.0 mA) (MRF941, MMBR941LT1, T3, MRF9411LT1) (MMBR941BLT1, T3, MRF9411BLT1, T3)	h_{FE}	 50 100	 — —	 200 200	—
DC Current Gain (V_{CE} = 1.0 V, I_C = 500 μA) MRF947T1, MRF947BT1	h_{FE1}	50	—	—	—
DC Current Gain (V_{CE} = 6.0 V, I_C = 5.0 mA) MRF947T1, T3; MRF947RT3 MRF947AT1 MRF947BT1, T3	 h_{FE2} h_{FE3} h_{FE4}	 50 75 100	 — — —	 — 150 200	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = 10 V, I_E = 0, f = 1.0 MHz) All	C_{cb}	—	0.35	—	pF
Current Gain — Bandwidth Product (V_{CE} = 6.0 V, I_C = 15 mA, f = 1.0 GHz) All	f_T	—	8.0	—	GHz

NOTE:

1. To calculate the junction temperature use $T_J = P_D \times R_{\theta JA} + T_{CASE}$. Case temperature measured on collector lead immediately adjacent to body of package.
2. I_C — Continuous (MTBF ≈ 10 years).
3. Pulse width ≤ 300 μs, duty cycle ≤ 2% pulsed.

PERFORMANCE CHARACTERISTICS

Conditions	Symbol	MRF941			MRF9411LT1			MMBR941LT1, T3			MRF947 Series			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Insertion Gain	$\lvert S_{21}\rvert^2$													dB
(V_{CE} = 6.0 V, I_C = 15 mA, f = 1.0 GHz)		—	16	—	—	16	—	—	14	—	—	14	—	
(V_{CE} = 6.0 V, I_C = 15 mA, f = 2.0 GHz)		—	10	—	—	10	—	—	8.0	—	—	10.8	—	
Maximum Unilateral Gain (1)	$G_{U\ max}$													dB
(V_{CE} = 6.0 V, I_C = 15 mA, f = 1.0 GHz)		—	18	—	—	18	—	—	16	—	—	14.8	—	
(V_{CE} = 6.0 V, I_C = 15 mA, f = 2.0 GHz)		—	12	—	—	12	—	—	10	—	—	11.6	—	
Noise Figure — Minimum (Figure 9)	NF_{MIN}													dB
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.0 GHz)		—	1.3	—	—	1.3	—	—	1.3	—	—	1.8	—	
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 2.0 GHz)		—	2.1	—	—	2.1	—	—	2.1	—	—	2.1	—	
Associated Gain at Minimum NF (Figure 9)	G_{NF}													dB
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.0 GHz)		—	15	—	—	15	—	—	14	—	—	14	—	
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 2.0 GHz)		—	9.5	—	—	9.5	—	—	8.5	—	—	10.5	—	
Noise Figure — 50 ohm Source (V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.0 GHz)	$NF_{50\ \Omega}$	—	1.9	2.8	—	1.9	2.8	—	1.9	2.8	—	1.9	2.8	dB

NOTE:

1. Maximum Unilateral Gain is $GU_{max} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

TYPICAL CHARACTERISTICS
MRF941; MMBR941LT1, T3; MMBR941BLT1, T3; MRF9411LT1; MRF9411BLT1, T3

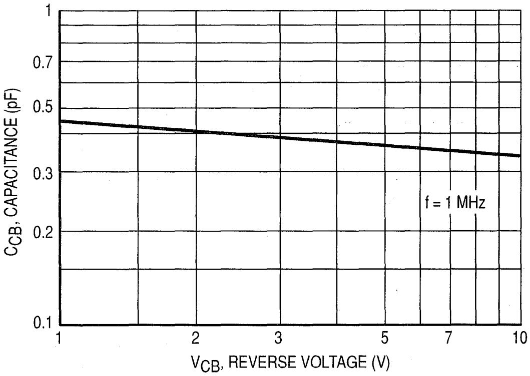


Figure 1. Collector–Base Capacitance versus Voltage

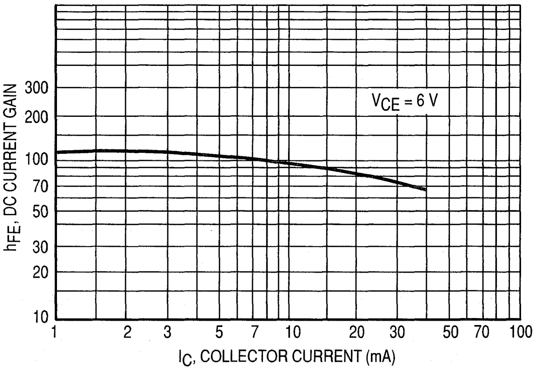


Figure 2. DC Current Gain versus Collector Current

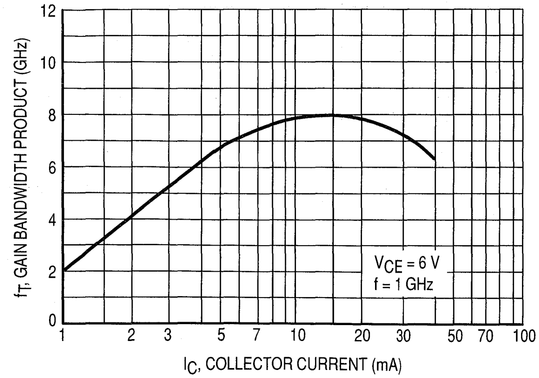


Figure 3. Gain Bandwidth Product versus Collector Current

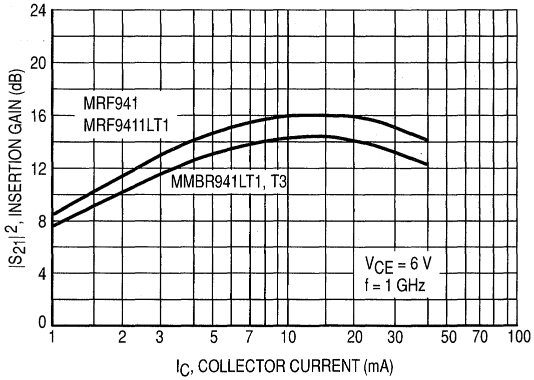


Figure 4. Insertion Gain versus Collector Current

FORWARD INSERTION GAIN AND MAXIMUM UNILATERAL GAIN versus FREQUENCY

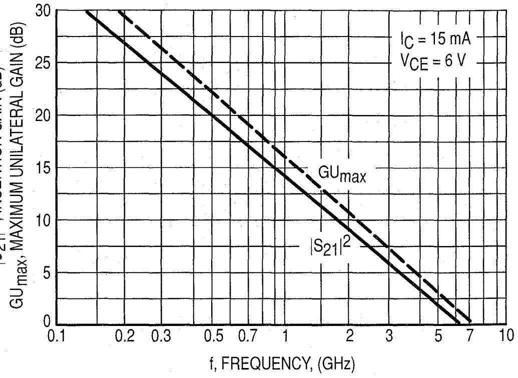


Figure 5. MMBR941LT1, T3

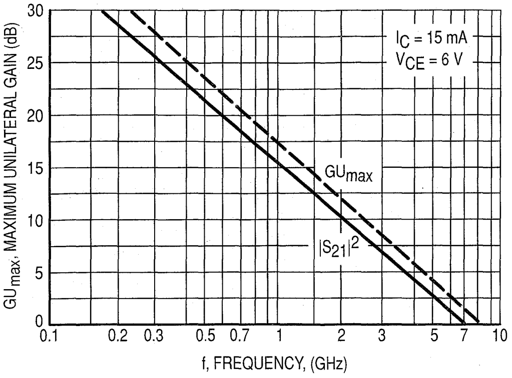


Figure 6. MRF941, MRF9411LT1

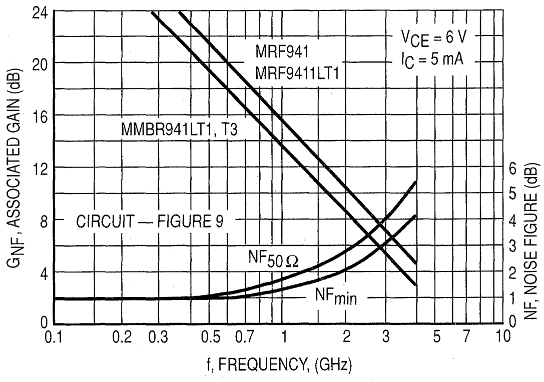


Figure 7. Noise Figure and Associated Gain versus Frequency

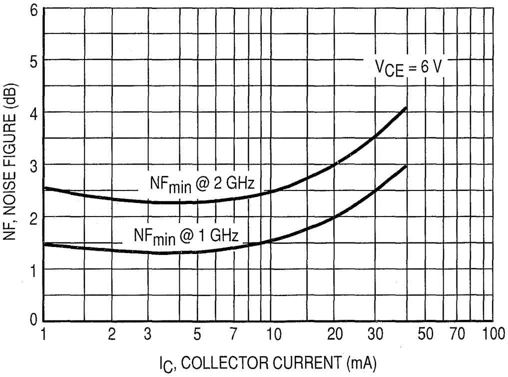
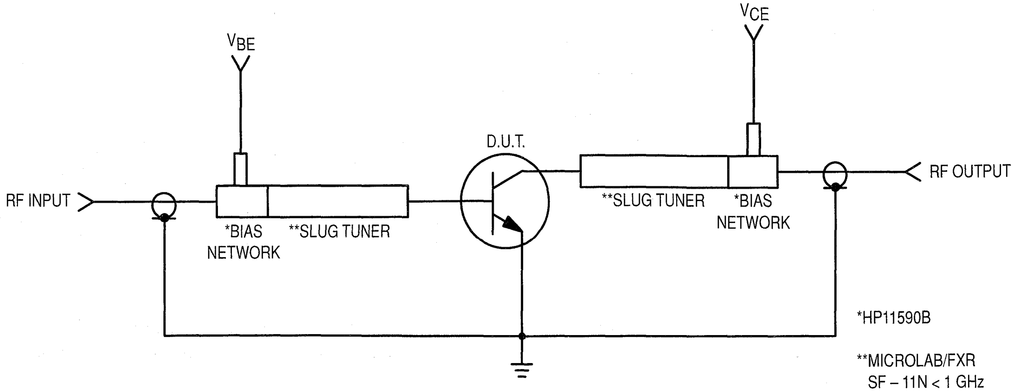


Figure 8. Minimum Noise Figure versus Collector Current



*HP11590B

**MICROLAB/FXR
SF – 11N < 1 GHz
SF – 31IN ≥ 1 GHz

Figure 9. Functional Circuit Schematic (all devices)

TYPICAL CHARACTERISTICS
MRF947 SERIES

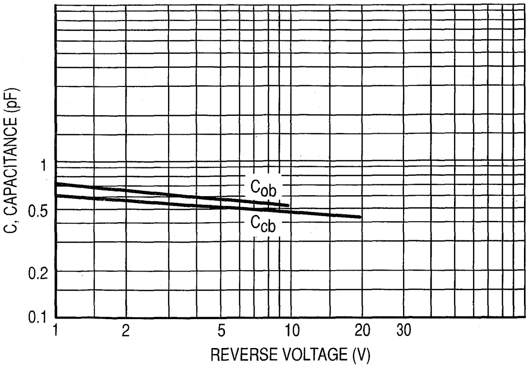


Figure 10. Capacitance versus Voltage

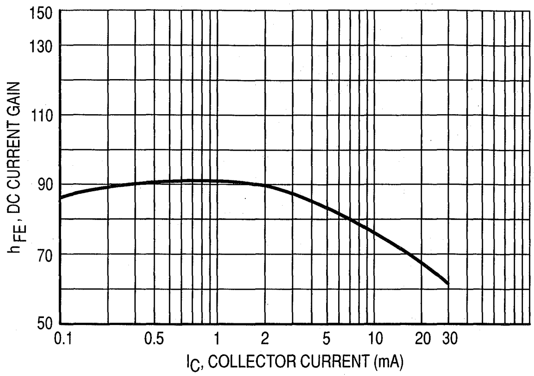


Figure 11. DC Current Gain versus Collector Current

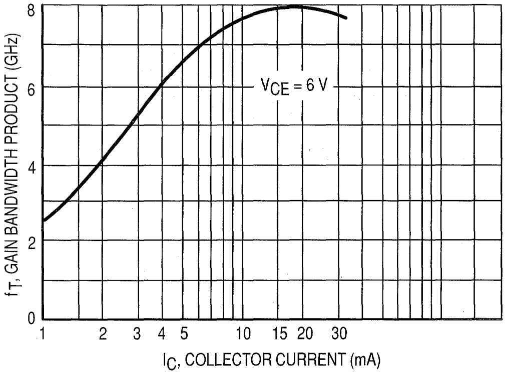


Figure 12. Gain–Bandwidth Product versus Collector Current

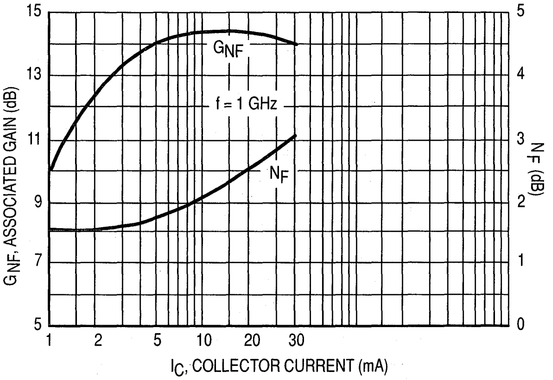


Figure 13. Associated Gain and Noise Figure versus Collector Current

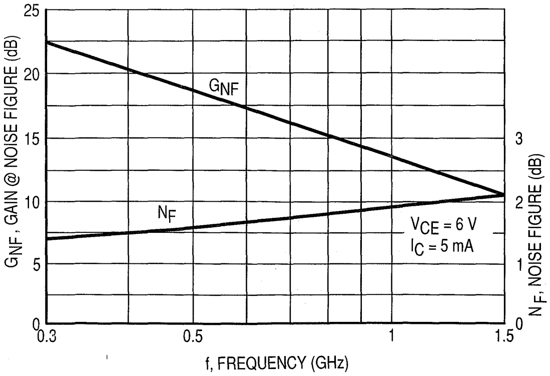


Figure 14. Noise Figure and Associated Gain versus Frequency

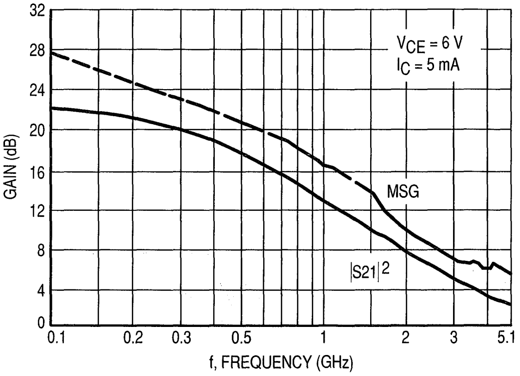


Figure 15. Forward Insertion Gain and Maximum Stable Power Gain versus Frequency

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
6.0	5.0	100	0.82	−24	14.5	162	0.02	81	0.96	−11
		200	0.77	−47	13.2	147	0.03	68	0.89	−21
		400	0.62	−84	10.3	124	0.04	53	0.73	−33
		600	0.54	−110	8.1	108	0.06	49	0.63	−39
		800	0.46	−131	6.4	98	0.06	49	0.58	−44
		1000	0.42	−148	5.3	90	0.07	52	0.55	−46
		1500	0.36	177	3.6	74	0.09	56	0.51	−53
		2000	0.34	145	2.7	61	0.11	59	0.50	−61
		2500	0.36	118	2.2	51	0.14	60	0.49	−69
		3000	0.42	90	1.9	44	0.16	56	0.46	−75
		3500	0.51	77	1.7	35	0.22	53	0.41	−90
		4000	0.58	58	1.6	28	0.23	47	0.37	−100
		5000	0.72	44	1.5	9.0	0.26	33	0.39	−151
		6000	0.86	35	1.4	−14	0.30	24	0.55	167
	10	100	0.67	−37	24.4	154	0.02	88	0.91	−17
		200	0.48	−67	20	135	0.02	55	0.79	−29
		400	0.45	−111	13.4	112	0.03	56	0.59	−37
		600	0.40	−136	9.8	99	0.04	57	0.50	−41
		800	0.44	−155	7.5	90	0.06	61	0.47	−43
		1000	0.35	−170	6.1	84	0.06	62	0.45	−44
		1500	0.31	159	4.1	70	0.08	66	0.45	−50
		2000	0.32	130	3.1	59	0.11	66	0.44	−58
		2500	0.34	107	2.4	50	0.15	65	0.44	−66
		3000	0.41	82	2.1	43	0.17	59	0.41	−71
		3500	0.49	72	1.9	35	0.21	54	0.36	−85
		4000	0.55	54	1.7	27	0.23	46	0.33	−93
		5000	0.68	42	1.6	10	0.27	32	0.32	−144
		6000	0.82	34	1.5	−12	0.30	23	0.48	−169
	15	100	0.57	−47	30.1	149	0.02	63	0.87	−20
		200	0.48	−83	23.2	128	0.02	64	0.72	−31
		400	0.40	−126	14.4	107	0.03	65	0.52	−37
		600	0.36	−150	10.2	95	0.04	65	0.46	−39
		800	0.34	−167	7.8	87	0.05	66	0.43	−42
		1000	0.33	180	6.3	81	0.06	67	0.42	−42
		1500	0.27	151	4.2	69	0.08	72	0.43	−49
		2000	0.32	124	3.1	59	0.12	69	0.42	−56
		2500	0.34	103	2.5	49	0.15	67	0.42	−64
		3000	0.41	80	2.1	42	0.17	59	0.40	−69
		3500	0.49	70	1.9	34	0.20	54	0.35	−84
		4000	0.55	52	1.7	27	0.28	47	0.32	−90
		5000	0.68	41	1.7	9.0	0.26	33	0.31	−143
		6000	0.82	33	1.5	−13	0.29	23	0.46	169
	30	100	0.41	−74	37.8	139	0.01	69	0.79	−24
		200	0.37	−116	25.8	118	0.01	65	0.62	−32
		400	0.37	−152	14.7	100	0.02	72	0.47	−32
		600	0.36	−170	10.1	90	0.03	70	0.43	−33
		800	0.35	176	7.7	83	0.04	71	0.42	−36
		1000	0.35	167	6.1	78	0.06	75	0.42	−38
		1500	0.34	142	4.1	65	0.08	72	0.44	−44
		2000	0.36	118	3.1	55	0.11	71	0.43	−53
		2500	0.38	100	2.4	46	0.14	68	0.44	−62
		3000	0.45	77	2.1	40	0.17	61	0.42	−68
		3500	0.53	68	1.8	32	0.21	58	0.37	−82
		4000	0.59	51	1.6	25	0.24	48	0.34	−92
		5000	0.72	40	1.5	7.0	0.26	34	0.33	−143
		6000	0.85	31	1.4	−15	0.30	24	0.48	171

Table 1. MRF941 Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
1.0	0.5	100	0.97	−11	1.78	170	0.03	83	0.99	−4.7
		200	0.96	−22	1.74	161	0.06	76	0.99	−9.1
		500	0.90	−53	1.60	133	0.13	56	0.93	−21
		900	0.75	−89	1.37	105	0.18	37	0.83	−33
		1000	0.72	−98	1.32	100	0.18	33	0.82	−36
		1500	0.63	−132	1.07	74	0.19	20	0.75	−47
		2000	0.57	−163	0.89	55	0.16	15	0.72	−57
		3000	0.55	144	0.67	30	0.15	40	0.71	−76
	1.0	100	0.95	−13	3.37	169	0.03	81	0.99	−6.2
		200	0.93	−27	3.27	158	0.06	73	0.98	−12
		500	0.81	−62	2.85	128	0.12	52	0.86	−26
		900	0.63	−101	2.21	101	0.15	37	0.73	−38
		1000	0.60	−110	2.08	96	0.15	34	0.71	−40
		1500	0.51	−144	1.59	73	0.16	27	0.64	−49
		2000	0.46	−173	1.28	56	0.16	29	0.61	−58
		3000	0.46	138	0.95	30	0.19	44	0.60	−75
6.0	5.0	100	0.82	−25	14.6	159	0.02	77	0.94	−13
		200	0.75	−47	12.6	142	0.04	68	0.85	−22
		400	0.55	−79	9.2	120	0.05	61	0.69	−31
		600	0.42	−98	6.9	106	0.07	60	0.60	−32
		800	0.33	−114	5.3	97	0.08	61	0.56	−33
		1000	0.28	−129	4.5	90	0.09	62	0.52	−33
		1500	0.25	−155	3.1	77	0.13	67	0.51	−37
		2000	0.16	176	2.4	66	0.16	68	0.51	−36
		2500	0.21	151	2.0	57	0.20	69	0.48	−40
		3000	0.18	122	1.7	50	0.23	68	0.48	−44
		3500	0.30	108	1.5	42	0.27	66	0.45	−46
		4000	0.29	91	1.4	37	0.32	64	0.42	−53
	10	100	0.67	−37	23.5	149	0.02	74	0.88	−18
		200	0.54	−64	18.1	129	0.03	68	0.73	−28
		400	0.37	−96	11.3	108	0.05	67	0.56	−31
		600	0.26	−114	8.0	98	0.06	67	0.50	−30
		800	0.21	−130	6.0	91	0.08	70	0.47	−30
		1000	0.18	−147	5.1	85	0.09	70	0.45	−30
		1500	0.18	−167	3.4	74	0.13	72	0.46	−34
		2000	0.11	159	2.6	64	0.17	71	0.46	−34
		2500	0.17	140	2.2	56	0.21	69	0.44	−38
		3000	0.15	107	1.8	59	0.25	67	0.45	−41
		3500	0.27	100	1.7	42	0.28	65	0.42	−42
		4000	0.26	85	1.5	37	0.33	61	0.39	−49
	15	100	0.56	−46	28.6	143	0.02	73	0.83	−22
		200	0.43	−75	20.2	122	0.03	67	0.65	−30
		400	0.29	−107	11.8	104	0.04	70	0.50	−30
		600	0.22	−125	8.2	95	0.06	74	0.46	−28
		800	0.18	−141	6.2	88	0.08	74	0.45	−27
		1000	0.16	−158	5.1	83	0.09	74	0.43	−28
		1500	0.17	−174	3.4	72	0.13	73	0.44	−32
		2000	0.11	150	2.6	63	0.17	72	0.45	−33
		2500	0.17	138	2.2	55	0.21	70	0.43	−37
		3000	0.15	102	1.9	49	0.25	67	0.44	−39
		3500	0.28	98	1.7	42	0.29	65	0.40	−41
		4000	0.25	82	1.5	37	0.32	61	0.38	−47

(continued)

Table 2. MMBR941LT1, T3 Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
6.0	20	100	0.49	−52	31.5	139	0.01	70	0.79	−23
		200	0.36	−84	21.1	118	0.02	69	0.60	−29
		400	0.25	−115	12.1	101	0.04	73	0.48	−29
		600	0.20	−134	8.3	93	0.06	74	0.45	−26
		800	0.16	−150	6.2	87	0.07	75	0.44	−26
		1000	0.15	−166	5.1	82	0.09	75	0.42	−26
		1500	0.16	−176	3.5	75	0.14	74	0.44	−31
		2000	0.12	144	2.6	63	0.17	73	0.45	−32
		2500	0.17	133	2.2	55	0.22	70	0.43	−36
		3000	0.16	101	1.9	49	0.25	68	0.44	−39
		3500	0.28	98	1.6	41	0.29	65	0.41	−40
		4000	0.26	82	1.5	36	0.33	61	0.39	−47
	30	100	0.41	−65	34.3	134	0.01	70	0.74	−25
		200	0.30	−99	21.6	113	0.02	70	0.56	−28
		400	0.23	−131	11.9	98	0.04	76	0.47	−25
		600	0.20	−147	8.1	91	0.06	76	0.45	−24
		800	0.18	−163	6.1	84	0.07	78	0.44	−23
		1000	0.17	−177	5.0	80	0.09	78	0.43	−24
		1500	0.18	174	3.4	70	0.13	76	0.45	−30
		2000	0.14	141	2.5	61	0.17	74	0.47	−31
		2500	0.20	131	2.1	54	0.21	71	0.45	−36
		3000	0.18	104	1.8	47	0.25	69	0.46	−39
		3500	0.31	100	1.6	40	0.29	65	0.42	−42
		4000	0.29	84	1.5	35	0.33	62	0.40	−48

Table 2. MMBR941LT1, T3 Common Emitter S–Parameters (continued)

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
1.0	0.5	100	0.97	−10	1.78	171	0.03	83	100	−4.7
		200	0.97	−20	1.75	163	0.05	77	100	−9.2
		500	0.93	−49	1.62	137	0.12	57	0.94	−21
		900	0.81	−84	1.43	110	0.18	36	0.86	−35
		1000	0.79	−92	1.38	104	0.19	32	0.84	−38
		1500	0.72	−125	1.12	78	0.20	14	0.77	−50
		2000	0.68	−152	0.92	57	0.20	1	0.74	−61
		3000	0.66	169	0.68	27	0.16	−11	0.73	−82
	1.0	100	0.95	−13	3.37	170	0.03	82	0.99	−6.2
		200	0.94	−25	3.30	161	0.05	74	0.98	−12
		500	0.88	−59	2.96	133	0.16	53	0.89	−27
		1000	0.70	−107	2.26	101	0.16	29	0.74	−44
		1500	0.64	−139	1.72	78	0.17	15	0.66	−55
		2000	0.61	−165	1.36	59	0.17	6.7	0.62	−65
		3000	0.61	160	0.97	32	0.14	3.0	0.61	−84

(continued)

Table 3. MRF9411LT1 Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
6.0	5.0	100	0.73	−24	14	164	0.02	92	0.96	−11
		200	0.74	−47	12.9	150	0.03	65	0.90	−20
		400	0.66	−83	10.4	129	0.05	56	0.75	−32
		600	0.62	−108	8.4	115	0.06	45	0.65	−40
		800	0.56	−127	6.7	105	0.07	46	0.60	−43
		1000	0.54	−141	5.6	96	0.07	51	0.57	−46
		1500	0.46	−166	3.9	82	0.08	55	0.52	−50
		2000	0.43	172	2.9	70	0.09	56	0.50	−54
		2500	0.41	151	2.3	62	0.11	61	0.48	−60
		3000	0.44	128	1.9	55	0.14	62	0.49	−65
		3500	0.49	117	1.6	47	0.15	61	0.46	−74
		4000	0.57	101	1.4	42	0.16	62	0.47	−81
		5000	0.60	92	1.2	32	0.21	60	0.46	−105
		6000	0.58	88	1.0	20	0.25	61	0.51	−137
	10	100	0.64	−39	23.6	157	0.01	59	0.91	−16
		200	0.60	−71	20	139	0.02	70	0.80	−27
		400	0.54	−112	13.9	117	0.03	57	0.61	−39
		600	0.52	−135	10.3	104	0.04	50	0.51	−43
		800	0.49	−151	8.0	96	0.05	54	0.46	−44
		1000	0.47	−161	6.5	89	0.06	60	0.46	−46
		1500	0.41	177	4.4	77	0.08	62	0.44	−47
		2000	0.40	158	3.2	67	0.09	65	0.43	−52
		2500	0.39	139	2.6	60	0.11	68	0.41	−56
		3000	0.44	118	2.1	53	0.13	69	0.43	−62
		3500	0.49	110	1.8	47	0.15	67	0.39	−72
		4000	0.54	96	1.6	42	0.18	65	0.41	−78
		5000	0.63	88	1.3	32	0.23	61	0.40	−101
		6000	0.58	86	1.1	20	0.26	62	0.44	−136
	15	100	0.56	−51	29.5	152	0.01	78	0.87	−20
		200	0.53	−88	23.5	131	0.02	63	0.73	−31
		400	0.51	−128	15.1	111	0.03	63	0.54	−40
		600	0.49	−148	11.8	99	0.04	56	0.46	−42
		800	0.48	−161	8.3	92	0.04	59	0.42	−41
		1000	0.46	−170	6.7	86	0.05	59	0.41	−44
		1500	0.41	−171	4.4	75	0.07	70	0.42	−45
		2000	0.40	152	3.3	66	0.09	71	0.41	−50
		2500	0.39	135	2.6	59	0.11	71	0.41	−55
		3000	0.45	116	2.2	53	0.14	73	0.42	−61
		3500	0.50	108	1.9	46	0.17	70	0.39	−70
		4000	0.55	94	1.6	41	0.19	67	0.41	−76
		5000	0.61	87	1.3	32	0.22	62	0.34	−114
		6000	0.58	85	1.1	21	0.27	63	0.43	−135
	30	100	0.45	−82	36.3	142	0.01	62	0.79	−23
		200	0.48	−121	25.5	121	0.01	48	0.62	−31
		400	0.49	−152	14.6	103	0.02	58	0.47	−33
		600	0.50	−166	10.2	93	0.03	60	0.44	−34
		800	0.49	−175	7.7	87	0.04	65	0.42	−34
		1000	0.48	177	6.1	81	0.05	76	0.43	−37
		1500	0.45	162	4.1	71	0.07	75	0.45	−39
		2000	0.45	145	3.0	62	0.09	78	0.44	−46
		2500	0.44	130	2.4	56	0.11	79	0.44	−53
		3000	0.50	113	1.9	50	0.13	79	0.45	−58
		3500	0.55	105	1.6	43	0.15	75	0.44	−70
		4000	0.61	92	1.5	39	0.19	73	0.45	−76
		5000	0.65	84	1.2	30	0.24	68	0.43	−100
		6000	0.61	82	1.0	19	0.28	64	0.48	−135

Table 3. MRF9411LT1 Common Emitter S–Parameters (continued)

V_{CE} (Vdc)	I_C (mA)	f (MHz)	NF_{min} (dB)	Γ_o (MAG, ANGLE)	r_N
6	5	1000	1.8	0.33 ∠ 77	0.28
		1500	2.1	0.26 ∠ 141	0.3

Table 4. MRF947 Series Typical Noise Parameters

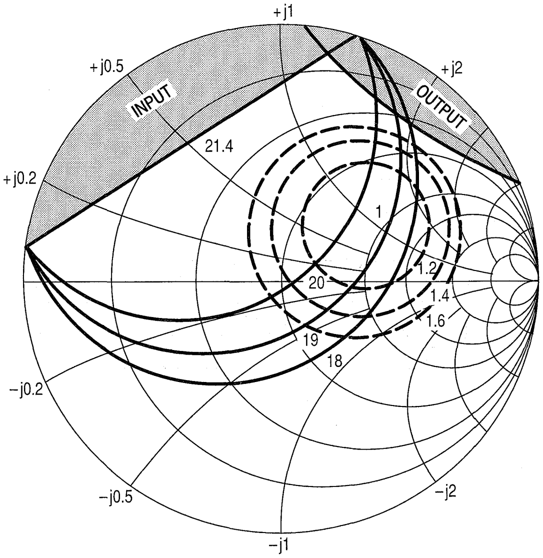
V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ϕ	Mag	∠ϕ	Mag	∠ϕ	Mag	∠ϕ
1.0	0.5	100	0.966	−11.46	1.776	170.10	0.031	82.57	0.998	−4.70
		200	0.956	−23.02	1.735	160.72	0.061	75.42	0.991	−9.25
		500	0.892	−54.71	1.587	132.34	0.135	54.85	0.923	−21.14
		900	0.749	−91.29	1.355	104.19	0.185	35.43	0.827	−33.53
		1000	0.720	−100.07	1.300	98.21	0.190	31.61	0.808	−35.99
		1500	0.637	−134.17	1.057	72.77	0.196	18.05	0.743	−47.18
		2000	0.587	−163.82	0.883	53.17	0.176	12.30	0.708	−58.12
		3000	0.572	149.42	0.672	27.46	0.149	33.04	0.680	−81.83
	1.0	100	0.941	−14.07	3.391	168.35	0.031	81	0.991	−6.46
		200	0.921	−28.11	3.285	157.61	0.060	73	0.974	−12.40
		500	0.806	−64.76	2.844	127.72	0.123	51.40	0.852	−26.69
		900	0.638	−103.89	2.196	100.55	0.158	35.25	0.717	−38.67
		1500	0.533	−145.86	1.580	72.45	0.168	25.20	0.619	−50.31
		2000	0.495	−173.94	1.281	54.58	0.164	25.37	0.581	−59.87
		3000	0.494	143.54	0.956	28.72	0.187	39.10	0.554	−81.37
2.0	0.5	100	0.979	−9.26	1.827	172.62	0.030	84.74	0.996	−4.04
		200	0.960	−18.37	1.909	164.83	0.060	79.81	0.991	−8.55
		500	0.920	−42.91	1.652	143.57	0.132	64.52	0.940	−18.86
		1000	0.749	−77.43	1.451	116.35	0.196	46.87	0.842	−32.38
		1500	0.674	−104.70	1.190	93.78	0.214	35.67	0.774	−39.43
		2000	0.548	−128.41	1.077	79.19	0.189	33.18	0.692	−43.43
		3000	0.480	−177.94	0.808	60.10	0.153	55.32	0.625	−52.49
	2.0	100	0.907	−16.39	6.640	167.45	0.029	80.99	0.977	−8.61
		200	0.846	−31.62	6.419	155.54	0.054	72.92	0.944	−16.93
		500	0.711	−67.85	4.874	128.23	0.104	57.29	0.770	−31.67
		1000	0.495	−106.45	3.178	102.77	0.138	49.89	0.603	−41.27
		1500	0.405	−131.24	2.358	86.49	0.157	52.19	0.542	−44.76
		2000	0.314	−154.66	1.910	75.22	0.173	58.26	0.490	−43.65
		3000	0.296	157.52	1.394	59.09	0.228	67.66	0.454	−47.05
	5.0	100	0.780	−27.85	14.100	158.94	0.027	77.86	0.932	−15.42
		200	0.676	−51.21	12.219	141.68	0.046	66.87	0.831	−27.35
		500	0.470	−94.63	7.373	112.66	0.078	58.67	0.568	−39.84
		1000	0.327	−131.66	4.148	92.48	0.114	62.28	0.436	−42.57
		1500	0.271	−152.62	2.921	80.85	0.151	66.45	0.413	−44.18
		2000	0.218	−177.42	2.295	71.76	0.188	69.38	0.394	−40.58
		3000	0.237	138.31	1.661	58.25	0.265	70.37	0.372	−42.71

(continued)

Table 5. MRF947 Series Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠φ	Mag	∠φ	Mag	∠φ	Mag	∠φ
2.0	10	100	0.608	−43.09	21.812	149.09	0.022	71.64	0.859	−22.70
		200	0.488	−73.47	16.618	128.80	0.038	64.60	0.689	−35.49
		500	0.330	−118.69	8.427	103.30	0.065	66.23	0.438	−41.16
		1000	0.262	−152.10	4.484	87.25	0.109	70.70	0.354	−40.02
		1500	0.227	−168.95	3.114	77.14	0.155	72.85	0.358	−41.98
		2000	0.197	166.15	2.423	69.47	0.198	73.10	0.355	−37.94
		3000	0.233	128.04	1.755	57.14	0.281	71.04	0.338	−40.40
	30	100	0.353	−99.56	25.543	130.99	0.018	69.51	0.653	−28.97
		200	0.353	−134.75	15.823	111.86	0.026	68.27	0.484	−33.62
		500	0.346	−163.46	6.979	93.31	0.054	75.98	0.367	−28.62
		1000	0.337	177.40	3.637	80.00	0.103	78.84	0.351	−30.05
		1500	0.324	165.83	2.518	71.06	0.150	79.14	0.372	−35.60
		2000	0.319	148.22	1.975	62.92	0.197	78.29	0.378	−34.91
		3000	0.374	122.07	1.441	50.52	0.290	74.82	0.363	−41.67
6.0	0.5	100	0.978	−8.66	1.791	173.27	0.024	85.89	0.995	−3.57
		200	0.964	−16.94	1.889	166.10	0.049	79.87	0.994	−7.32
		500	0.932	−40.03	1.643	146.36	0.110	66.84	0.953	−16.19
		1000	0.765	−72.66	1.473	120.56	0.165	50.45	0.869	−28.01
		1500	0.688	−99.80	1.206	98.40	0.184	39.36	0.812	−34.63
		2000	0.554	−123.40	1.099	83.59	0.162	38.05	0.735	−38.23
		3000	0.463	−174.05	0.823	63.88	0.136	63.33	0.671	−46.47
	2.0	100	0.918	−14.76	6.614	168.34	0.023	83.55	0.983	−7.19
		200	0.862	−28.56	6.456	157.28	0.045	75.14	0.956	−14.02
		500	0.729	−62.16	5.010	131.12	0.089	60.10	0.809	−26.64
		1000	0.504	−98.85	3.344	105.76	0.121	53.16	0.654	−35.06
		1500	0.397	−123.02	2.485	89.51	0.137	55.48	0.599	−38.01
		2000	0.295	−145.96	2.013	78.14	0.152	61.91	0.553	−37.03
		3000	0.257	161.75	1.452	61.78	0.202	72.72	0.523	−40.30
	5.0	100	0.806	−24.38	14.025	160.52	0.022	78.28	0.947	−12.67
		200	0.704	−45.03	12.425	144.30	0.040	70.14	0.861	−22.52
		500	0.487	−85.18	7.751	115.51	0.068	61.61	0.627	−32.81
		1000	0.316	−120.17	4.399	95.11	0.101	64.59	0.505	−34.64
		1500	0.245	−140.68	3.112	83.14	0.134	69.35	0.488	−36.12
		2000	0.177	−166.20	2.447	74.39	0.167	72.13	0.473	−33.43
		3000	0.185	139.55	1.743	60.74	0.237	74.04	0.457	−35.82
	10	100	0.657	−36.69	22.098	151.43	0.019	74.63	0.888	−18.25
		200	0.526	−63.52	17.304	131.70	0.033	67.90	0.741	−28.80
		500	0.328	−104.79	9.028	105.89	0.056	66.80	0.509	−32.64
		1000	0.228	−138.09	4.844	89.49	0.096	72.77	0.438	−31.28
		1500	0.184	−156.11	3.359	79.89	0.138	75.02	0.440	−33.55
		2000	0.140	175.01	2.591	72.03	0.175	76.11	0.441	−30.73
		3000	0.172	126.26	1.852	59.99	0.249	74.64	0.430	−33.31
	20	100	0.492	−53.13	28.934	141.62	0.017	72.00	0.808	−22.96
		200	0.372	−85.00	19.971	121.25	0.028	69.78	0.630	−30.71
		500	0.249	−126.97	9.335	99.50	0.053	73.73	0.454	−28.28
		1000	0.201	−156.11	4.878	86.00	0.094	77.63	0.418	−26.90
		1500	0.174	−171.44	3.358	77.41	0.138	78.54	0.432	−30.20
		2000	0.149	160.61	2.580	70.07	0.177	78.20	0.444	−28.32
		3000	0.193	120.90	1.852	58.27	0.253	75.92	0.435	−31.73

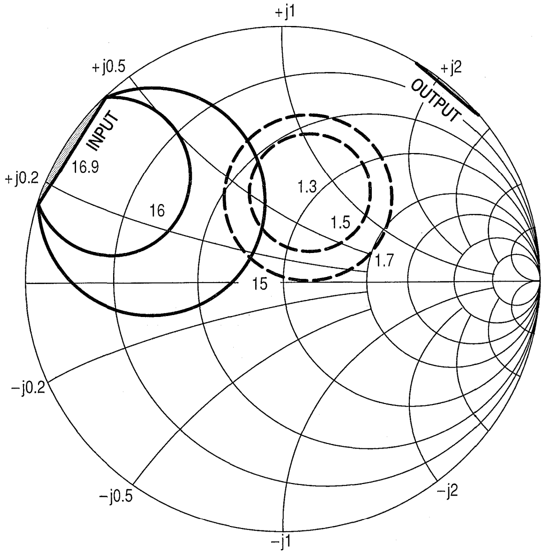
Table 5. MRF947 Series Common Emitter S–Parameters (continued)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.0	0.42 ∠ 32°	18	0.71

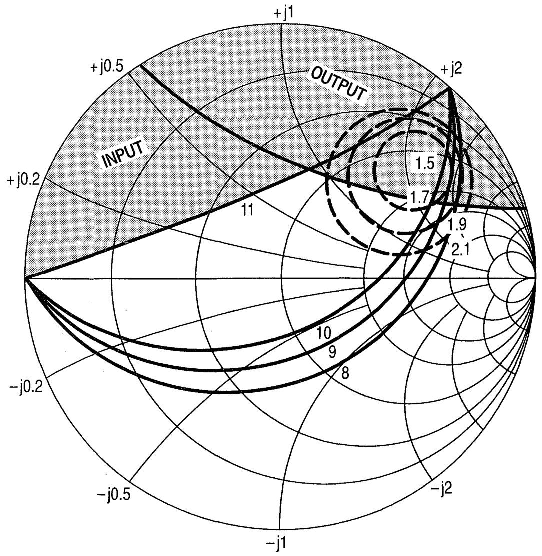
Figure 16. MRF941 Constant Gain and Noise Figure Contours (f = 0.5 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.30	0.38 ∠ 72°	16	0.98

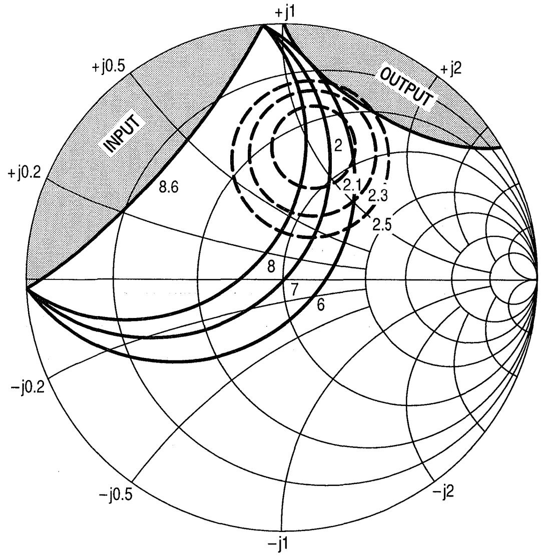
Figure 17. MRF941 Constant Gain and Noise Figure Contours (f = 1.0 GHz)



V_{CE} = 1.0 V
I_C = 0.5 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.54	0.71 ∠ 39°	38	0.28

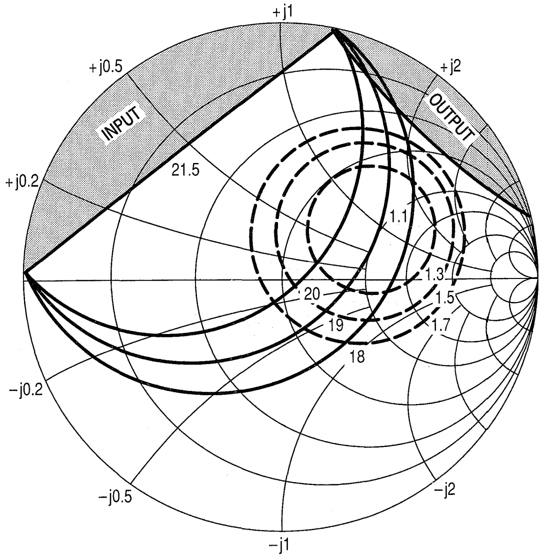
Figure 18. MMBR941LT1, T3 Constant Gain and Noise Figure Contours
(f = 1.0 GHz)



V_{CE} = 1.0 V
I_C = 0.5 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.95	0.55 ∠ 76°	28	0.51

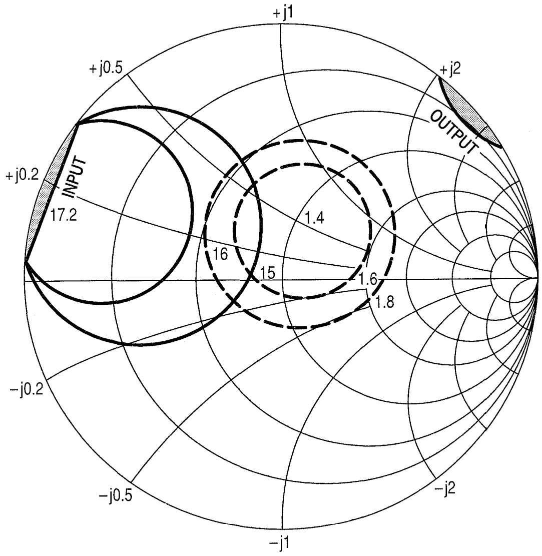
Figure 19. MMBR941LT1, T3 Constant Gain and Noise Figure Contours
(f = 0.5 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.10	0.43 ∠ 30°	18	0.67

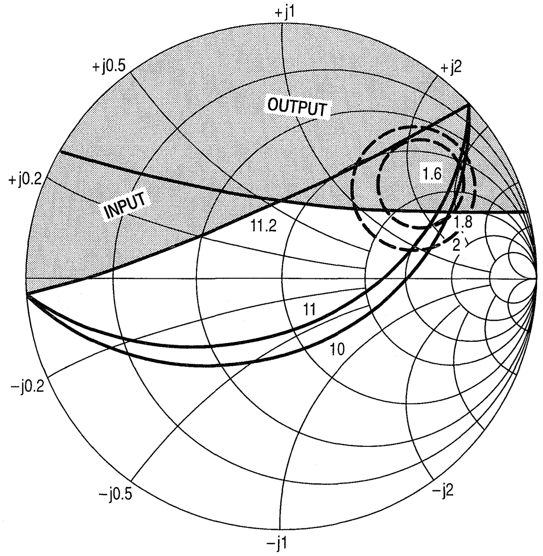
Figure 20. MMBR941LT1, T3 Constant Gain and Noise Figure Contours
(f = 0.5 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.40	0.22 ∠ 64°	13	0.96

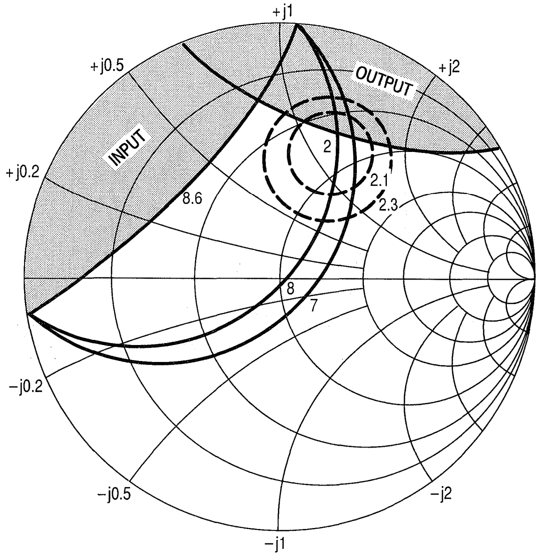
Figure 21. MMBR941LT1, T3 Constant Gain and Noise Figure Contours
(f = 1.0 GHz)



V_{CE} = 1.0 V
I_C = 0.5 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.60	0.70 ∠ 35°	40	0.22

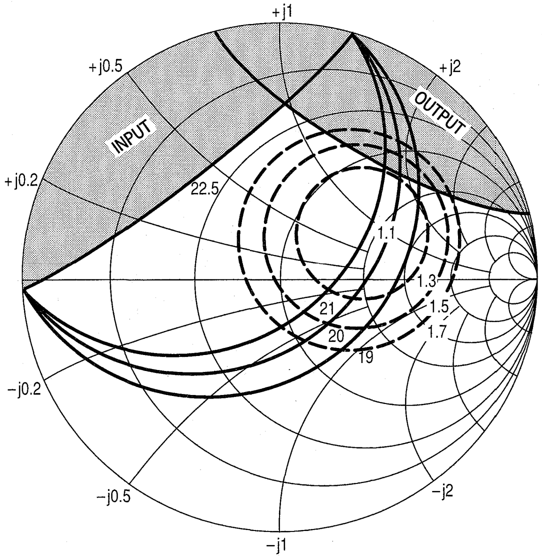
Figure 22. MRF9411LT1 Constant Gain and Noise Figure Contours
(f = 0.5 GHz)



V_{CE} = 1.0 V
I_C = 0.5 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.95	0.55 ∠ 69°	30	0.39

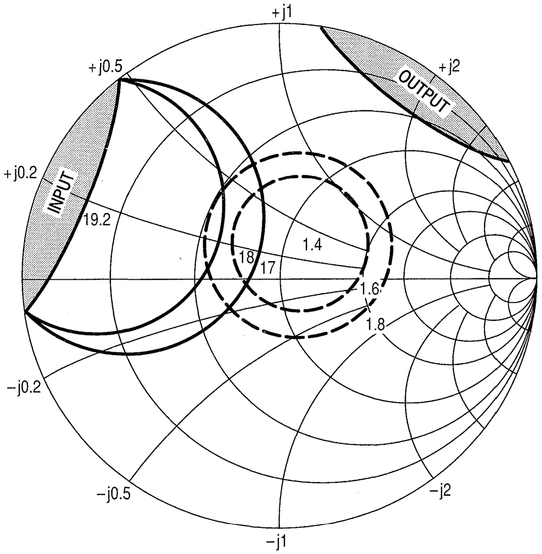
Figure 23. MRF9411LT1 Constant Gain and Noise Figure Contours
(f = 1.0 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.10	0.40 ∠ 28°	17	0.43

Figure 24. MRF9411LT1 Constant Gain and Noise Figure Contours (f = 0.5 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.40	0.17 ∠ 60°	13	0.74

Figure 25. MRF9411LT1 Constant Gain and Noise Figure Contours (f = 1.0 GHz)

V_{CE} = 6 V
I_C = 5 mA

f (GHz)	NF OPT	Γ_o	R_N	K
1.0	1.8 dB	0.33 ∠ 77°	14	0.89

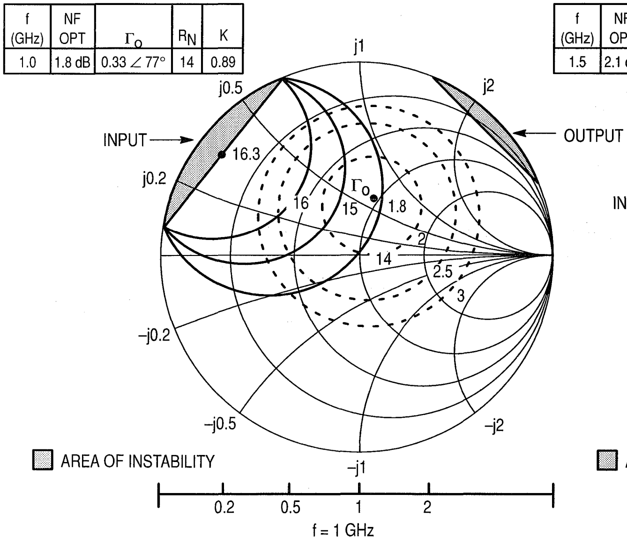


Figure 26. MRF947 Series Constant Gain and Noise Figure Contours

V_{CE} = 6 V
I_C = 5 mA

f (GHz)	NF OPT	Γ_o	R_N	K
1.5	2.1 dB	0.26 ∠ 141°	15	0.96

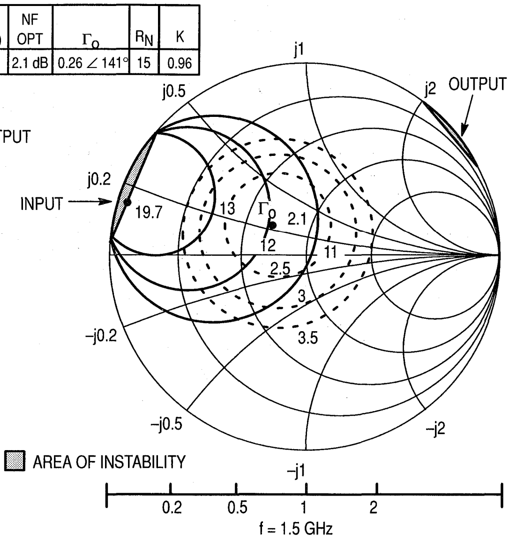


Figure 27. MRF947 Series Constant Gain and Noise Figure Contours

V_{CE} = 1 V
I_C = 0.5 mA

f (GHz)	NF OPT	ΓMS NF OPT	Rn	K
1.0	1.95 dB	0.59 ∠ 72°	30	0.50

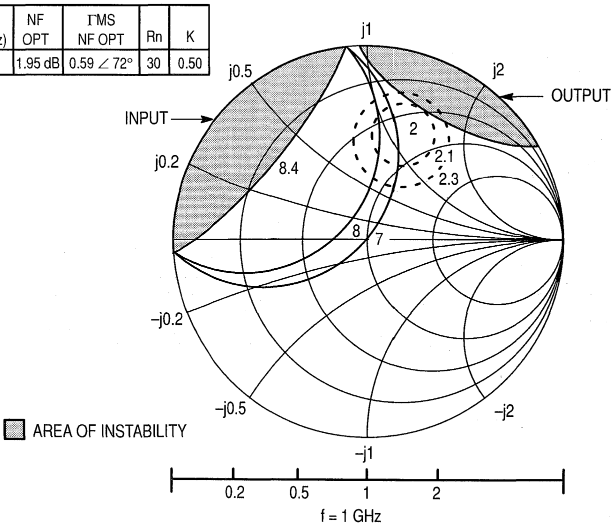


Figure 28. MRF947 Series Constant Gain and Noise Figure Contours

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

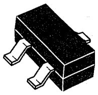
The RF Line
NPN Silicon Low Noise, High-Frequency Transistors

MMBR951
MRF951
MRF957
MRF9511
SERIES

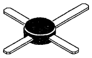
Designed for use in high gain, low noise small–signal amplifiers. This series features excellent broadband linearity and is offered in a variety of packages.

- Fully Implanted Base and Emitter Structure
- 18 Finger, 1.25 Micron Geometry with Gold Top Metal
- Gold Sintered Back Metal
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel

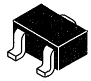
I_C = 100 mA
LOW NOISE
HIGH–FREQUENCY
TRANSISTORS



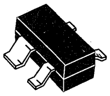
CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
MMBR951LT1, MMBR951ALT1



CASE 317–01, STYLE 2
MACRO–X
MRF951



CASE 419–02, STYLE 3
MRF957T1



CASE 318A–05, STYLE 1
SOT–143
LOW PROFILE
MRF9511LT1, MRF9511ALT1

REV 7

MAXIMUM RATINGS

Rating	Symbol	MRF951	MMBR951LT1	MRF9511LT1	MRF957T1	Unit
Collector–Emitter Voltage	V_{CEO}	10	10	10	10	Vdc
Collector–Base Voltage	V_{CBO}	20	20	20	20	Vdc
Emitter–Base Voltage	V_{EBO}	1.5	1.5	1.5	15	Vdc
Power Dissipation (1) $T_C = 75°C$ Derate linearly above $T_{case} = 75°C$ @	$P_{D(max)}$	0.475 4.76	0.322 4.29	0.322 4.29	0.227 3.03	Watts mW/°C
Collector Current — Continuous (2)	I_C	100	100	100	100	mA
Maximum Junction Temperature	T_{Jmax}	150	150	150	150	°C
Storage Temperature	T_{stg}	−55 to +150	−55 to +150	−55 to +150	−55 to +150	°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	210	233	233	330	°C/W

DEVICE MARKING

MRF9511LT1, MRF9511ALT1 = 11	MMBR951ALT1 = AAG	MMBR951LT1 = 7Z	MRF957T1 = B

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (3)					
Collector–Emitter Breakdown Voltage ($I_C = 0.1$ mA, $I_B = 0$)	$V_{(BR)CEO}$	10	13	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 0.1$ mA, $I_E = 0$)	$V_{(BR)CBO}$	20	25	—	Vdc
Emitter Cutoff Current ($V_{EB} = 1.0$ V, $I_C = 0$)	I_{EBO}	—	—	0.1	µAdc
Collector Cutoff Current ($V_{CB} = 10$ V, $I_E = 0$)	I_{CBO}	—	—	0.1	µAdc
ON CHARACTERISTICS (3)					
DC Current Gain ($V_{CE} = 6.0$ V, $I_C = 5.0$ mA) All ($V_{CE} = 6.0$ V, $I_C = 5.0$ mA) MMBR951ALT1, MRF9511ALT1	h_{FE}	 50 75	 — —	 200 150	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance ($V_{CB} = 10$ V, $I_E = 0$, f = 1.0 MHz)	C_{cb}	—	0.45	1.0	pF
Current Gain — Bandwidth Product ($V_{CE} = 6.0$ V, $I_C = 30$ mA, f = 1.0 GHz)	f_T	—	8.0	—	GHz

NOTES:

1. To calculate the junction temperature use $T_J = (P_D \times R_{\theta JA}) + T_{CASE}$. Case temperature measured on collector lead immediately adjacent to body of package.
2. I_C — Continuous (MTBF ≈ 10 years).
3. Pulse width ≤ 300 µs, duty cycle ≤ 2% pulsed.

PERFORMANCE CHARACTERISTICS

Conditions	Symbol	MRF951			MRF9511LT1, MRF9511ALT1			MMBR951LT1			MRF957T1			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Insertion Gain	$\lvert S_{21}\rvert^2$													dB
(V_{CE} = 6.0 V, I_C = 30 mA, f = 1.0 GHz)		12	14.5	—	—	14.5	—	—	12.5	—	—	13.3	—	
(V_{CE} = 6.0 V, I_C = 30 mA, f = 2.0 GHz)		—	9.5	—	—	9.0	—	—	7.0	—	—	—	—	
(V_{CE} = 5.0 V, I_C = 30 mA, f = 1.5 GHz)		—	—	—	—	—	—	—	—	—	—	10.1	—	
Maximum Unilateral Gain (1)	$G_{U\ max}$													dB
(V_{CE} = 8.0 V, I_C = 30 mA, f = 1.0 GHz)		—	17	—	—	17	—	—	14	—	—	14	—	
(V_{CE} = 8.0 V, I_C = 30 mA, f = 2.0 GHz)		—	11	—	—	10.5	—	—	8.0	—	—	—	—	
(V_{CE} = 5.0 V, I_C = 30 mA, f = 1.5 GHz)		—	—	—	—	—	—	—	—	—	—	10.8	—	
Noise Figure — Minimum (Figure 9)	NF_{MIN}													dB
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.0 GHz)		—	1.3	—	—	1.3	—	—	1.3	—	—	1.5	—	
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 2.0 GHz)		—	2.1	—	—	2.1	—	—	2.1	—	—	—	—	
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.5 GHz)		—	—	—	—	—	—	—	—	—	—	2.0	—	
Associated Gain at Minimum NF (Figure 9)	G_{NF}													dB
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.0 GHz)		—	14	—	—	14	—	—	13	—	—	11.8	—	
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 2.0 GHz)		—	9.0	—	—	9.0	—	—	7.5	—	—	—	—	
(V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.5 GHz)		—	—	—	—	—	—	—	—	—	—	9.0	—	
Noise Figure — 50 ohm Source (V_{CE} = 6.0 V, I_C = 5.0 mA, f = 1.0 GHz)	$NF_{50\ \Omega}$	—	1.9	2.8	—	1.9	2.8	—	1.9	2.8	—	1.9	2.8	dB

NOTE:

1. Maximum Unilateral Gain is $GU_{max} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

TYPICAL CHARACTERISTICS
MRF951, MMBR951LT1, MMBR951ALT1, MRF9511LT1, MRF9511ALT1

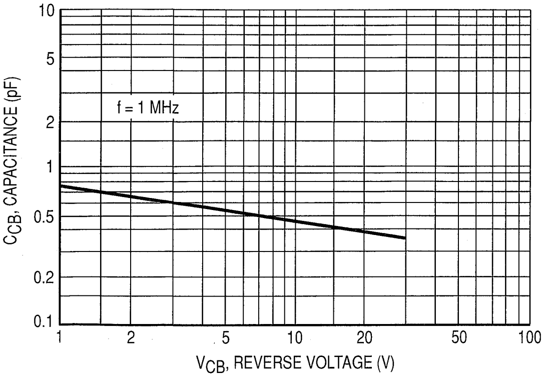


Figure 1. Collector–Base Capacitance versus Voltage

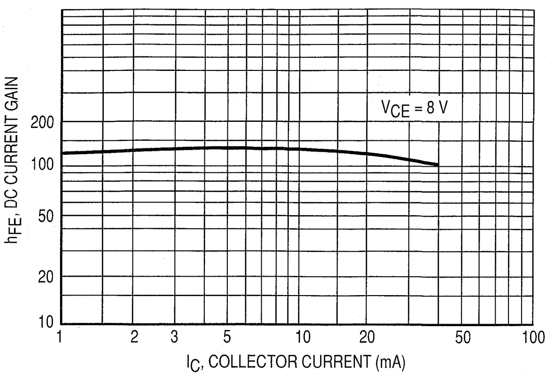


Figure 2. DC Current Gain versus Collector Current

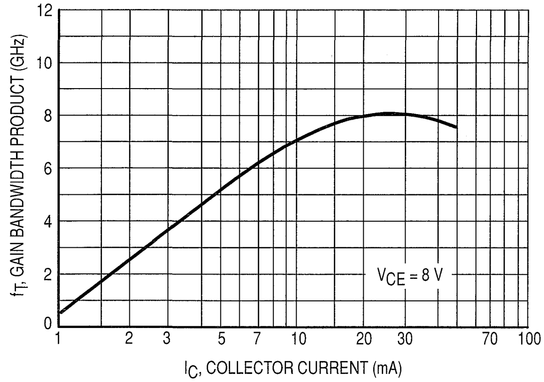


Figure 3. Gain Bandwidth Product versus Collector Current

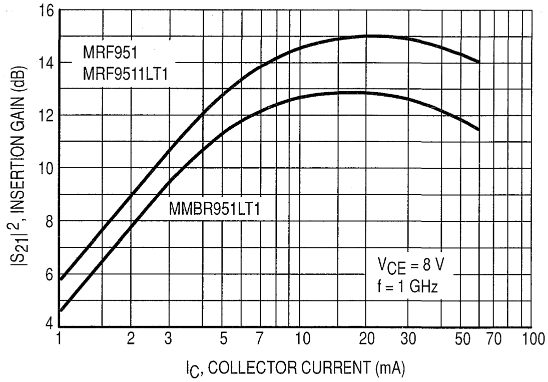


Figure 4. Insertion Gain versus Collector Current

TYPICAL FORWARD INSERTION GAIN AND MAXIMUM UNILATERAL GAIN versus FREQUENCY

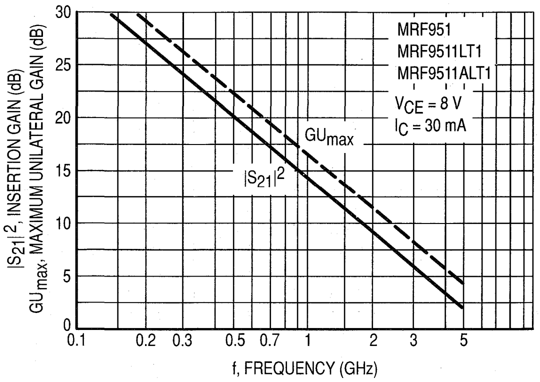


Figure 5. MRF951, MRF9511LT1, MRF9511ALT1

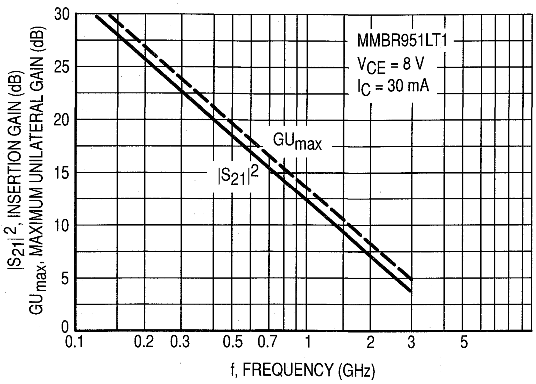


Figure 6. MMBR951LT1

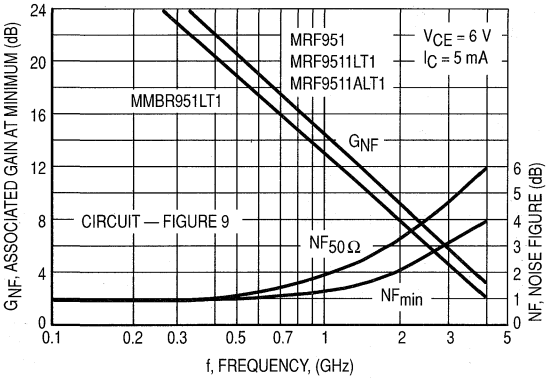


Figure 7. Typical Noise Figure and Associated Gain versus Frequency

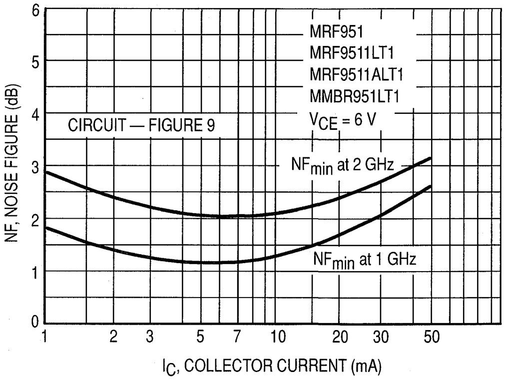
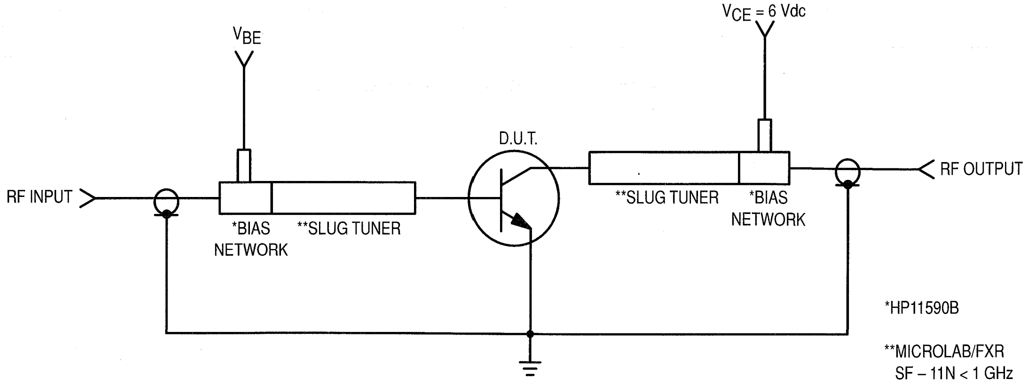


Figure 8. Typical Noise Figure versus Collector Current



*HP11590B

**MICROLAB/FXR
SF – 11N < 1 GHz
SF – 31IN ≥ 1 GHz

Figure 9. Functional Circuit Schematic (All Devices)

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
6.0	5.0	100	0.81	−36	13.89	156	0.03	72	0.94	−17
		500	0.58	−122	7.23	105	0.07	42	0.55	−46
		1000	0.53	−165	4.06	78	0.08	41	0.42	−57
		1500	0.54	172	2.78	61	0.10	44	0.40	−67
		2000	0.55	155	2.13	46	0.12	47	0.40	−79
		2500	0.56	140	1.74	32	0.15	48	0.41	−92
		3000	0.59	127	1.46	21	0.18	47	0.43	−105
		3500	0.61	115	1.28	9.0	0.22	44	0.45	−119
		4000	0.62	104	1.13	−1.0	0.26	40	0.48	−132
	10	100	0.67	−41	22.99	147	0.02	67	0.86	−26
		500	0.50	−85	8.94	97	0.05	49	0.41	−53
		1000	0.48	−34	4.75	75	0.08	54	0.31	−61
		1500	0.49	163	3.26	60	0.11	55	0.29	−71
		2000	0.51	148	2.47	46	0.14	53	0.30	−83
		2500	0.52	135	2.03	34	0.17	50	0.31	−97
		3000	0.55	123	1.72	22	0.20	46	0.34	−109
		3500	0.56	112	1.50	11	0.24	41	0.36	−122
		4000	0.59	101	1.33	1.0	0.28	37	0.39	−135
	20	100	0.52	−77	32.50	137	0.02	62	0.75	−34
		500	0.46	−96	10.00	92	0.05	60	0.30	−56
		1000	0.47	172	5.20	73	0.08	63	0.24	−63
		1500	0.48	156	3.50	59	0.11	61	0.24	−74
		2000	0.49	143	2.70	46	0.15	57	0.24	−86
		2500	0.51	131	2.20	34	0.18	52	0.26	−100
		3000	0.53	121	1.90	23	0.22	47	0.29	−112
		3500	0.55	110	1.60	13	0.25	41	0.31	−125
		4000	0.57	100	1.40	3.0	0.28	35	0.34	−137
	30	100	0.45	−95	36.80	132	0.02	64	0.68	−38
		500	0.46	−170	10.20	89	0.04	65	0.27	−55
		1000	0.47	169	5.30	72	0.08	66	0.22	−62
		1500	0.48	154	3.60	58	0.11	63	0.22	−73
		2000	0.50	142	2.80	45	0.15	58	0.23	−86
		2500	0.51	132	2.30	36	0.18	54	0.25	−97
		3000	0.53	119	1.90	23	0.22	47	0.28	−113
		3500	0.55	109	1.60	12	0.25	41	0.30	−125
		4000	0.57	99	1.50	2.0	0.29	35	0.33	−137
	60	100	0.41	−129	38.90	123	0.01	63	0.58	−40
		500	0.49	−35	9.70	86	0.04	71	0.26	−44
		1000	0.50	164	4.90	70	0.07	71	0.24	−53
		1500	0.52	151	3.30	56	0.11	67	0.24	−66
		2000	0.53	140	2.50	43	0.15	61	0.26	−79
		2500	0.55	128	2.10	31	0.18	56	0.28	−94
		3000	0.57	118	1.70	21	0.21	50	0.31	−108
		3500	0.59	108	1.50	10	0.25	44	0.33	−121
		4000	0.61	98	1.30	0	0.29	38	0.36	−134

(continued)

Table 1. MRF951 Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
8.0	5.0	100	0.82	−34	13.71	157	0.03	74	0.94	−16
		500	0.59	−119	7.35	106	0.07	42	0.57	−44
		1000	0.52	−162	4.14	78	0.08	41	0.44	−54
		1500	0.52	174	2.86	61	0.10	46	0.41	−65
		2000	0.54	156	2.19	46	0.12	48	0.41	−76
		2500	0.55	141	1.78	32	0.15	50	0.42	−90
		3000	0.58	128	1.49	21	0.18	48	0.45	−103
		3500	0.59	116	1.31	9.0	0.22	45	0.47	−116
		4000	0.62	104	1.15	−1.0	0.26	41	0.50	−129
	10	100	0.68	−50	23.16	148	0.02	67	0.86	−24
		500	0.49	−142	9.19	98	0.05	50	0.43	−49
		1000	0.47	−177	4.87	75	0.07	54	0.33	−56
		1500	0.48	164	3.33	60	0.10	56	0.32	−66
		2000	0.50	149	2.56	46	0.13	54	0.32	−77
		2500	0.51	136	2.08	34	0.16	52	0.34	−91
		3000	0.54	124	1.76	23	0.20	48	0.36	−103
		3500	0.55	113	1.54	11	0.23	43	0.38	−117
		4000	0.58	103	1.36	1.0	0.27	39	0.41	−129
	20	100	0.53	−73	32.78	138	0.02	65	0.76	−32
		500	0.45	−160	10.25	92	0.04	60	0.33	−50
		1000	0.45	174	5.33	73	0.07	62	0.27	−57
		1500	0.46	161	3.96	62	0.10	61	0.26	−65
		2000	0.48	144	2.74	46	0.14	57	0.27	−79
		2500	0.50	132	2.24	34	0.17	54	0.29	−93
		3000	0.52	121	1.90	23	0.21	48	0.31	−106
		3500	0.54	111	1.66	12	0.24	42	0.33	−118
		4000	0.56	101	1.48	3.0	0.28	37	0.36	−131
	30	100	0.45	−90	37.27	132	0.01	62	0.70	−36
		500	0.45	−102	10.50	90	0.04	65	0.30	−48
		1000	0.45	170	5.41	72	0.07	66	0.25	−55
		1500	0.47	155	3.66	58	0.11	64	0.25	−66
		2000	0.48	142	2.81	46	0.14	59	0.26	−78
		2500	0.50	131	2.27	34	0.18	55	0.27	−92
		3000	0.52	120	1.93	23	0.21	49	0.30	−105
		3500	0.54	110	1.69	12	0.25	43	0.32	−118
		4000	0.56	100	1.50	2.0	0.28	38	0.35	−131
	60	100	0.42	−124	38.02	124	0.01	63	0.60	−35
		500	0.49	−106	9.54	87	0.04	70	0.31	−38
		1000	0.50	165	4.92	70	0.07	71	0.29	−47
		1500	0.51	152	3.36	57	0.10	68	0.29	−60
		2000	0.52	140	2.55	44	0.14	62	0.30	−74
		2500	0.54	129	2.08	32	0.17	58	0.32	−88
		3000	0.56	118	1.76	21	0.21	52	0.34	−102
		3500	0.58	108	1.53	10	0.24	46	0.37	−116
		4000	0.61	98	1.35	0	0.28	40	0.39	−129

Table 1. MRF951 Common Emitter S–Parameters (continued)

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
6.0	5.0	100	0.82	−36.6	14.0	153	0.04	44.7	0.88	−18.2
		500	0.50	−119	6.6	104	0.07	48.2	0.52	−40
		1000	0.39	−162	3.5	81	0.11	55	0.43	−43
		2000	0.32	150	1.9	57	0.21	66	0.42	−50
		3000	0.36	110	1.4	40	0.31	66	0.40	−67
	10	100	0.66	−54	22.6	142	0.03	60	0.78	−29
		500	0.38	−138	7.8	96	0.07	55	0.40	−42
		1000	0.32	−176	4.0	78	0.13	71	0.34	−47
		2000	0.26	142	2.2	57	0.22	70	0.36	−46
		3000	0.31	105	1.6	41	0.32	64	0.33	−62
	20	100	0.49	−76	30	131	0.01	85	0.67	−37
		500	0.32	−153	8.3	92	0.08	76	0.34	−39
		1000	0.29	175	4.3	77	0.11	67	0.29	−44
		2000	0.24	137	2.3	57	0.24	71	0.32	−48
		3000	0.28	102	1.6	42	0.34	63	0.29	−60
	30	100	0.40	−94	33	125	0.03	87	0.58	−42
		500	0.30	−162	8.4	90	0.07	84	0.31	−35
		1000	0.29	170	4.3	76	0.12	80	0.27	−39
		2000	0.24	134	2.3	56	0.23	71	0.33	−48
		3000	0.30	101	1.6	41	0.35	66	0.30	−60
	60	100	0.38	−126	31	116	0.03	74	0.49	−37
		500	0.37	−176	7.3	77.6	0.05	84	0.34	−26
		1000	0.36	163	3.7	73.4	0.12	84	0.34	−37
		2000	0.33	130	2.0	52	0.22	78	0.37	−48
		3000	0.38	98	1.4	37	0.34	69	0.34	−62
8.0	5.0	100	0.83	−35	13.9	154	0.04	92	0.90	−19
		500	0.51	−117	6.7	104	0.08	51	0.55	−38
		1000	0.38	−160	3.6	82	0.10	72	0.44	−42
		2000	0.31	151	1.9	58	0.20	73	0.46	−47
		3000	0.35	110	1.4	41	0.32	71	0.43	−63
	10	100	0.67	−52	23	143	0.02	96	0.81	−28
		500	0.37	−135	7.9	97	0.07	64	0.43	−38
		1000	0.30	−173	4.1	80	0.11	78	0.37	−41
		2000	0.25	143	2.2	57	0.21	74	0.38	−47
		3000	0.30	105	1.6	42	0.31	67	0.34	−60
	20	100	0.51	−72	30	131	0.02	68	0.68	−35
		500	0.31	−150	8.5	92	0.07	75	0.36	−36
		1000	0.28	177	4.3	77	0.13	76	0.32	−39
		2000	0.23	138	2.3	57	0.22	72	0.35	−45
		3000	0.27	103	1.6	42	0.31	64	0.31	−58
	30	100	0.42	−87	33	125	0.02	71	0.61	−38
		500	0.31	−159	8.6	90	0.07	71	0.33	−33
		1000	0.27	172	4.4	76	0.11	74	0.32	−39
		2000	0.23	135	2.3	57	0.22	73	0.34	−42
		3000	0.28	102	1.6	41	0.31	65	0.33	−55
	60	100	0.39	−119	32	117	0.02	31	0.52	−31
		500	0.36	−174	7.4	87	0.06	84	0.37	−25
		1000	0.35	164	3.8	74	0.11	78	0.35	−33
		2000	0.32	131	2.0	53	0.22	81	0.42	−41
		3000	0.37	100	1.4	38	0.33	70	0.40	−62

Table 2. MMBR951LT1 Common Emitter S–Parameters

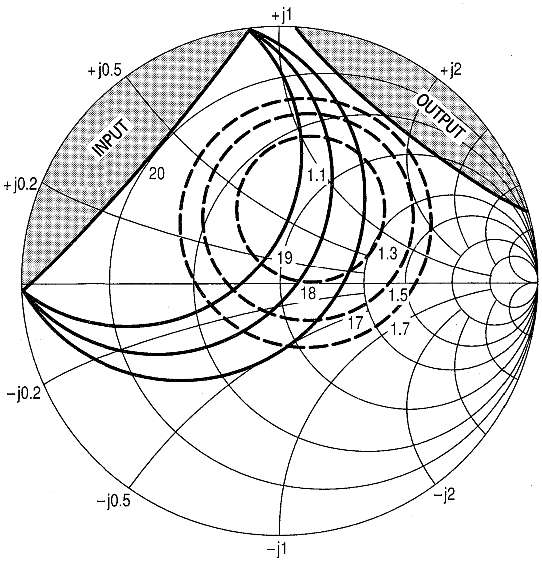
V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
6.0	5.0	100	0.81	−48	13.69	152	0.04	66	0.88	−22
		500	0.67	−122	7.58	92	0.07	41	0.57	−50
		1000	0.61	−157	4.65	76	0.09	40	0.45	−62
		1500	0.57	86	2.87	70	0.10	44	0.42	−71
		2000	0.54	156	2.14	60	0.12	52	0.42	−75
		2500	0.55	121	1.72	51	0.14	57	0.40	−86
		3000	0.57	121	1.48	44	0.17	59	0.39	−97
		3500	0.65	110	1.28	38	0.21	60	0.37	−112
		4000	0.67	100	1.14	33	0.24	54	0.38	−130
	10	100	0.71	−56	24.07	149	0.03	66	0.86	−28
		500	0.60	−143	9.47	101	0.05	46	0.41	−62
		1000	0.56	−176	4.97	81	0.07	51	0.30	−73
		1500	0.53	167	3.35	69	0.10	57	0.31	−78
		2000	0.50	148	2.54	60	0.13	63	0.30	−78
		2500	0.52	132	2.02	52	0.16	63	0.29	−89
		3000	0.54	116	1.75	45	0.19	61	0.29	−78
		3500	0.60	106	1.53	39	0.22	60	0.26	−115
		4000	0.64	97	1.35	34	0.26	57	0.28	−133
	20	100	0.59	−80	33.51	138	0.02	61	0.75	−38
		500	0.56	−159	10.39	95	0.04	54	0.31	−69
		1000	0.54	175	5.36	79	0.07	62	0.23	−79
		1500	0.51	161	3.58	68	0.10	66	0.25	−82
		2000	0.49	142	2.75	60	0.13	68	0.25	−80
		2500	0.52	128	2.18	52	0.16	66	0.23	−91
		3000	0.53	112	1.88	45	0.20	63	0.23	−99
		3500	0.60	103	1.65	39	0.24	62	0.21	−117
		4000	0.63	95	1.46	34	0.27	57	0.22	−137
	30	100	0.54	−97	37.48	133	0.02	57	0.67	−43
		500	0.56	−166	10.60	93	0.04	59	0.27	−70
		1000	0.54	171	5.45	78	0.07	68	0.21	−80
		1500	0.51	158	3.62	67	0.10	69	0.24	−81
		2000	0.50	140	2.73	60	0.13	70	0.23	−79
		2500	0.52	126	2.19	51	0.17	68	0.23	−90
		3000	0.53	111	1.89	45	0.20	64	0.23	−97
		3500	0.60	102	1.65	38	0.24	62	0.20	−115
		4000	0.63	94	1.47	33	0.27	58	0.22	−136
	60	100	0.54	−128	36.66	123	0.01	57	0.56	−43
		500	0.60	−177	8.97	89	0.03	67	0.27	−50
		1000	0.59	166	4.62	75	0.06	73	0.25	−59
		1500	0.56	153	3.05	64	0.09	75	0.29	−68
		2000	0.55	136	2.29	56	0.13	76	0.30	−71
		2500	0.57	125	1.85	48	0.16	74	0.29	−83
		3000	0.59	110	1.59	42	0.20	69	0.30	−92
		3500	0.65	102	1.41	36	0.23	67	0.27	−108
		4000	0.69	93	1.22	31	0.27	62	0.29	−130

(continued)

Table 3. MRF9511LT1, MRF9511ALT1 Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
8.0	5.0	100	0.84	−36	14.65	158	0.03	72	0.94	−18
		500	0.68	−120	7.79	110	0.07	42	0.58	−48
		1000	0.60	−161	4.32	86	0.08	41	0.44	−60
		1500	0.56	88	2.95	71	0.10	45	0.44	−68
		2000	0.53	157	2.19	60	0.11	53	0.44	−71
		2500	0.55	140	1.76	51	0.14	58	0.42	−82
		3000	0.56	122	1.50	44	0.17	60	0.42	−92
		3500	0.63	112	1.33	39	0.18	62	0.38	−107
		4000	0.68	105	1.18	33	0.21	63	0.36	−125
	10	100	0.73	−53	24.04	150	0.02	68	0.87	−26
		500	0.60	−140	9.68	101	0.05	46	0.43	−58
		1000	0.55	−174	5.10	82	0.07	52	0.32	−66
		1500	0.52	169	3.42	69	0.09	58	0.33	−72
		2000	0.49	149	2.59	61	0.12	63	0.33	−73
		2500	0.51	133	2.06	52	0.15	63	0.32	−83
		3000	0.53	116	1.78	45	0.19	63	0.32	−91
		3500	0.64	109	1.60	38	0.20	62	0.28	−108
		4000	0.67	101	1.39	34	0.23	60	0.29	−131
	20	100	0.61	−76	33.76	139	0.02	60	0.76	−36
		500	0.56	−157	10.72	96	0.04	54	0.32	−63
		1000	0.53	176	5.53	79	0.07	62	0.29	−70
		1500	0.50	162	3.69	68	0.10	66	0.27	−75
		2000	0.48	143	2.79	60	0.13	68	0.27	−74
		2500	0.51	129	2.22	52	0.16	68	0.26	−84
		3000	0.52	112	1.92	46	0.19	65	0.26	−91
		3500	0.59	104	1.75	40	0.21	64	0.24	−109
		4000	0.63	98	1.54	35	0.24	59	0.25	−131
	30	100	0.57	−89	37.35	134	0.02	58	0.71	−40
		500	0.55	−163	10.82	94	0.04	57	0.29	−63
		1000	0.53	128	5.54	78	0.07	65	0.24	−69
		1500	0.50	159	3.69	67	0.10	69	0.26	−73
		2000	0.49	141	2.77	59	0.13	70	0.27	−71
		2500	0.51	127	2.23	51	0.16	69	0.26	−82
		3000	0.52	112	1.93	45	0.19	66	0.26	−89
		3500	0.61	106	1.68	40	0.21	64	0.21	−110
		4000	0.66	97	1.51	34	0.24	60	0.23	−130
	60	100	0.55	−122	34.92	126	0.01	52	0.59	−37
		500	0.59	−175	8.71	91	0.03	65	0.33	−42
		1000	0.58	167	4.52	76	0.06	73	0.30	−53
		1500	0.55	154	3.04	65	0.09	75	0.34	−62
		2000	0.54	138	2.28	56	0.12	77	0.35	−66
		2500	0.57	125	1.82	48	0.16	76	0.34	−78
		3000	0.59	110	1.56	42	0.19	72	0.35	−88
		3500	0.66	104	1.28	36	0.22	70	0.32	−105
		4000	0.70	95	1.14	32	0.26	66	0.32	−132

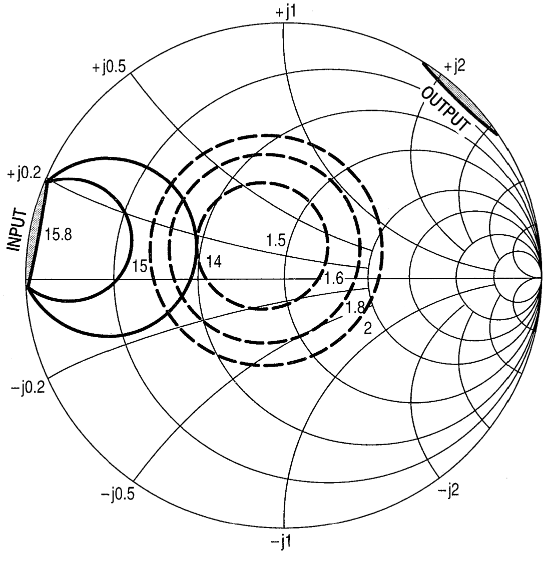
Table 3. MRF9511LT1, MRF9511ALT1 Common Emitter S–Parameters (continued)



VCE = 6.0 V
IC = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.13	0.35 ∠ 68°	9	0.68

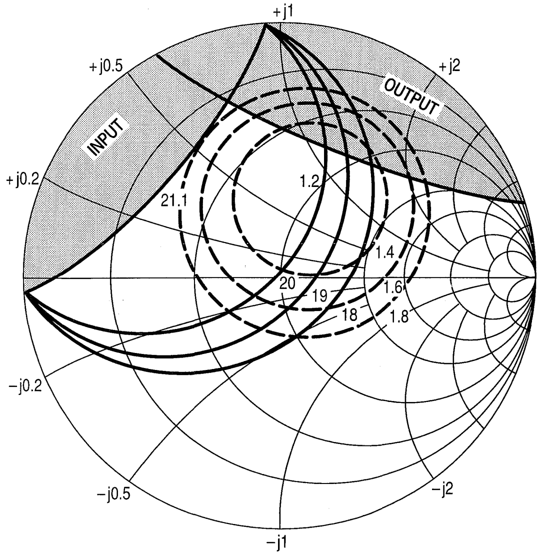
Figure 10. MMBR951LT1 Constant Gain and Noise Figure Contours (f = 0.5 GHz)



VCE = 6.0 V
IC = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.45	0.16 ∠ 124°	8	0.97

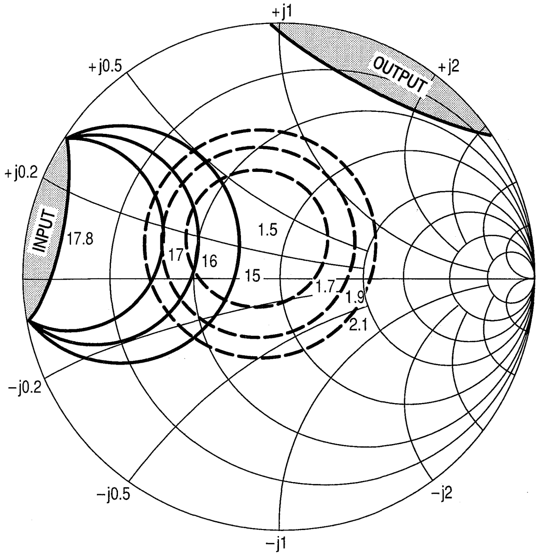
Figure 11. MMBR951LT1 Constant Gain and Noise Figure Contours (f = 1.0 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
0.5	1.20	0.37 ∠ 69°	10	0.42

Figure 12. MRF9511LT1, MRF9511ALT1 Constant Gain and Noise Figure Contours
(f = 0.5 GHz)



V_{CE} = 6.0 V
I_C = 5.0 mA
▨ — AREA OF INSTABILITY

f (GHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1.0	1.50	0.19 ∠ 120°	9	0.74

Figure 13. MRF9511LT1, MRF9511ALT1 Constant Gain and Noise Figure Contours
(f = 1.0 GHz)

V_{CE} (Vdc)	I_C (mA)	f (MHz)	NF_{min} (dB)	Γ_o (MAG, ANG)	r_N (ohms)
6.0	5.0	1000	1.7	0.27 ∠ 97	0.2
		1500	2.0	0.21 ∠ 54	0.28

Table 4. MRF957T1 Typical Noise Parameters

TYPICAL CHARACTERISTICS
MRF957T1

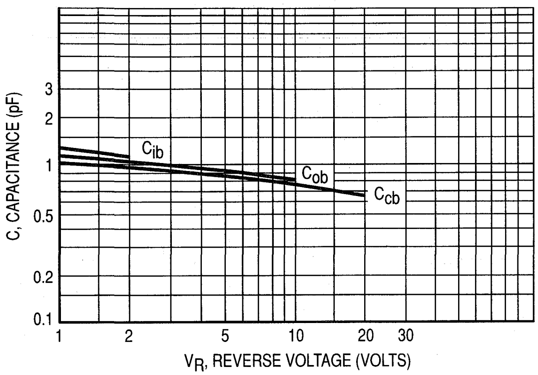


Figure 14. Capacitance versus Voltage

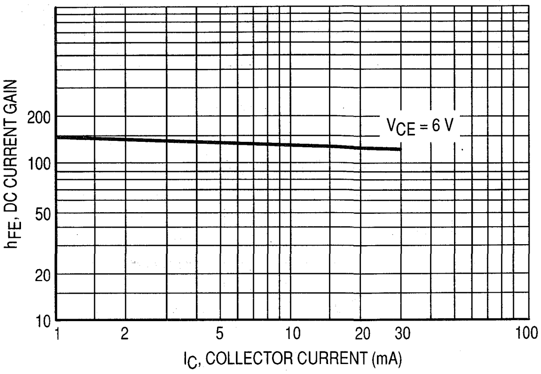


Figure 15. DC Current Gain versus Collector Current

TYPICAL CHARACTERISTICS
MRF957T1

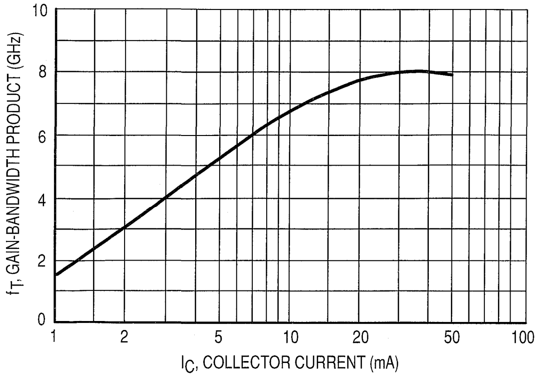


Figure 16. Gain–Bandwidth Product versus Collector Current

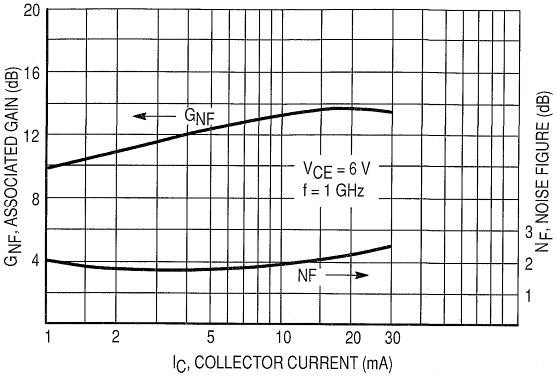


Figure 17. Associated Gain versus Collector Current

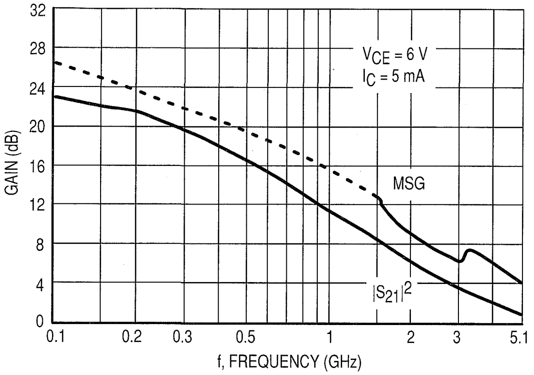


Figure 18. Insertion Gain and Maximum Stable Power Gain versus Frequency

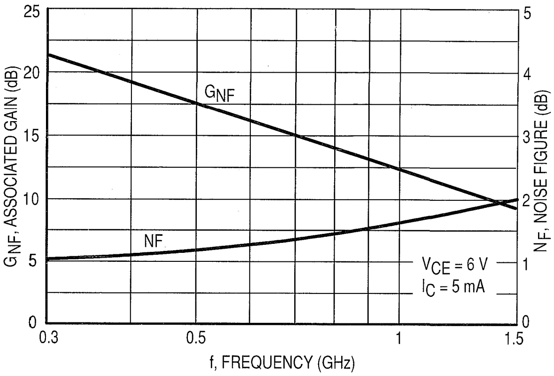


Figure 19. Noise Figure and Associated Gain versus Frequency

V_{CE} = 6.0 V I_C = 5.0 mA

f (GHz)	NF OPT	Γ_o	R_N	K
1.0	1.5 dB	0.27 ∠ 97°	10	0.91

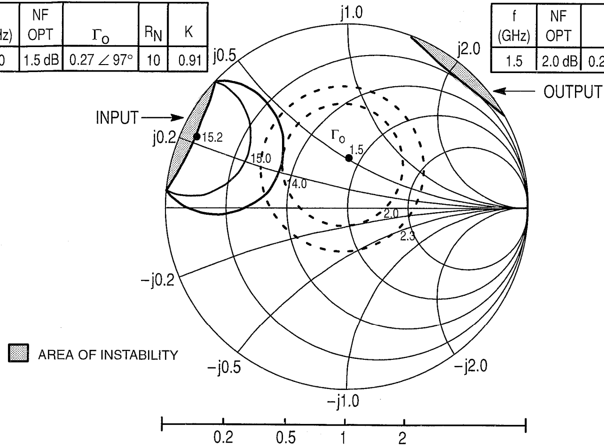


Figure 20. Constant Gain and Noise Figure Contours f = 1.0 GHz

V_{CE} = 6.0 V I_C = 5.0 mA

f (GHz)	NF OPT	Γ_o	R_N	K
1.5	2.0 dB	0.21 ∠ 54°	14	1.02

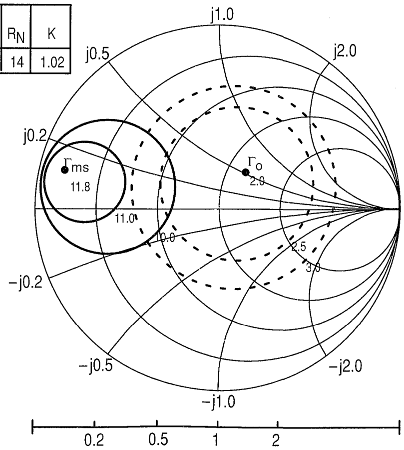


Figure 21. Constant Gain and Noise Figure Contours f = 1.5 GHz

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠φ	$\|S_{21}\|$	∠φ	$\|S_{12}\|$	∠φ	$\|S_{22}\|$	∠φ
2.0	1.0	100	0.959	−19.22	3.518	166.25	0.044	78.43	0.986	−8.12
		200	0.922	−38.32	3.482	153.75	0.079	69.06	0.948	−15.98
		500	0.825	−81.94	2.614	122.98	0.146	44.99	0.803	−30.02
		1000	0.690	−125.83	1.737	93.40	0.167	30.15	0.662	−41.41
		2000	0.600	−174.02	1.079	63.65	0.131	44.93	0.576	−51.42
		3000	0.640	147.15	0.791	50.62	0.196	80.39	0.517	−64.42
	2.0	100	0.922	−24.97	6.598	162.54	0.042	75.55	0.967	−12.35
		200	0.862	−48.55	6.177	147.47	0.075	64.60	0.893	−23.28
		500	0.713	−96.45	4.140	116.09	0.123	43.92	0.671	−38.55
		1000	0.586	−137.24	2.483	90.37	0.140	38.71	0.524	−46.93
		2000	0.506	179.54	1.462	64.47	0.158	57.00	0.456	−51.97
		3000	0.546	144.80	1.079	49.98	0.232	74.13	0.416	−61.22
	5.0	100	0.815	−39.45	14.163	153.09	0.038	70.19	0.895	−22.63
		200	0.708	−71.89	11.635	133.50	0.061	58.57	0.739	−38.46
		500	0.541	−121.43	6.284	104.78	0.090	49.12	0.454	−52.31
		1000	0.461	−155.05	3.428	85.44	0.123	54.90	0.337	−56.38
		2000	0.406	169.75	1.921	65.04	0.198	65.80	0.304	−54.16
		3000	0.438	139.42	1.424	51.41	0.282	69.61	0.276	−57.77
	10	100	0.667	−57.75	22.121	142.36	0.032	64.38	0.788	−34.26
		200	0.559	−95.89	15.709	121.54	0.048	57.27	0.574	−52.06
		500	0.447	−140.52	7.417	98.06	0.075	58.00	0.317	−63.32
		1000	0.405	−166.70	3.921	82.59	0.123	66.07	0.235	−65.49
		2000	0.360	162.90	2.155	65.25	0.222	69.45	0.220	−57.93
		3000	0.390	134.95	1.597	52.60	0.311	68.14	0.196	−57.79
	30	100	0.435	−99.80	31.662	125.82	0.023	62.49	0.570	−51.69
		200	0.421	−135.04	18.696	108.07	0.034	64.74	0.360	−68.74
		500	0.398	−162.97	8.025	91.81	0.069	71.43	0.192	−75.85
		1000	0.382	−179.33	4.163	79.67	0.127	74.17	0.151	−77.73
		2000	0.347	155.68	2.269	64.55	0.240	72.04	0.155	−63.30
		3000	0.379	130.21	1.686	52.60	0.336	67.80	0.132	−60.40
	60	100	0.442	−131.87	26.755	118.52	0.021	62.60	0.422	−56.23
		200	0.483	−155.78	15.086	103.17	0.032	66.87	0.261	−70.51
		500	0.484	−173.89	6.390	88.79	0.067	74.30	0.154	−73.64
		1000	0.472	172.69	3.317	76.81	0.127	76.73	0.140	−74.96
		2000	0.452	149.80	1.834	60.68	0.243	72.97	0.155	−66.57
		3000	0.496	126.23	1.393	48.59	0.345	68.81	0.131	−71.10

(continued)

Table 5. MRF957T1 Typical Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ϕ	$\lvert S_{21}\rvert$	∠ϕ	$\lvert S_{12}\rvert$	∠ϕ	$\lvert S_{22}\rvert$	∠ϕ
5.0	1.0	100	0.965	−17.73	3.508	167.36	0.035	78.18	0.990	−6.80
		200	0.931	−35.39	3.495	155.78	0.065	71.66	0.958	−13.35
		500	0.835	−77.08	2.680	126.50	0.122	48.12	0.839	−25.23
		1000	0.694	−120.78	1.820	97.22	0.143	33.67	0.713	−35.51
		2000	0.583	−170.80	1.133	67.35	0.115	50.88	0.629	−44.48
		3000	0.615	148.45	0.813	53.19	0.182	85.71	0.565	−55.47
	2.0	100	0.932	−22.38	6.532	164.05	0.034	77.81	0.975	−9.92
		200	0.875	−44.00	6.217	150.00	0.061	67.15	0.914	−18.98
		500	0.726	−89.77	4.314	119.58	0.106	47.42	0.724	−31.79
		1000	0.582	−131.10	2.638	93.76	0.122	41.23	0.586	−39.20
		2000	0.483	−176.30	1.544	67.35	0.140	60.85	0.521	−43.55
		3000	0.515	146.92	1.117	52.27	0.208	78.88	0.479	−51.26
	5.0	100	0.836	−34.35	14.112	155.49	0.031	71.72	0.920	−18.06
		200	0.731	−63.59	11.971	137.05	0.052	61.40	0.785	−31.06
		500	0.539	−112.00	6.737	107.93	0.080	51.32	0.522	−41.63
		1000	0.438	−147.18	3.710	88.06	0.110	57.59	0.408	−43.94
		2000	0.364	175.10	2.050	67.58	0.175	68.31	0.383	−42.49
		3000	0.392	142.26	1.501	53.59	0.251	73.36	0.357	−45.46
	10	100	0.704	−49.02	22.526	145.79	0.027	67.46	0.831	−27.03
		200	0.577	−83.93	16.647	125.23	0.042	59.78	0.634	−41.45
		500	0.421	−129.59	8.120	100.71	0.069	60.52	0.385	−47.31
		1000	0.361	−158.62	4.290	84.82	0.109	67.54	0.305	−46.57
		2000	0.307	168.57	2.330	67.52	0.196	71.46	0.305	−42.00
		3000	0.332	137.50	1.706	54.85	0.277	71.05	0.288	−42.21
	20	100	0.559	−66.34	30.018	136.00	0.023	64.88	0.720	−35.45
		200	0.453	−103.91	19.598	116.12	0.036	61.80	0.501	−48.64
		500	0.358	−143.87	8.835	96.19	0.064	68.23	0.298	−49.15
		1000	0.324	−167.05	4.595	83.08	0.112	72.95	0.247	−47.12
		2000	0.278	163.88	2.462	67.27	0.208	72.96	0.263	−41.09
		3000	0.306	133.94	1.809	55.45	0.291	70.31	0.249	−39.38
	30	100	0.492	−73.65	32.055	131.68	0.022	64.17	0.669	−37.70
		200	0.412	−110.53	20.121	113.25	0.033	64.60	0.459	−49.28
		500	0.345	−147.89	8.900	94.88	0.062	69.52	0.278	−48.58
		1000	0.319	−169.39	4.646	82.13	0.113	74.20	0.234	−46.64
		2000	0.277	162.38	2.492	67.55	0.210	73.10	0.255	−40.63
		3000	0.305	133.57	1.821	55.24	0.295	70.42	0.239	−38.73

Table 5. MRF957T1 Typical Common Emitter S–Parameters (continued)

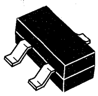
The RF Line
NPN Silicon High-Frequency Transistor

MMBR5031LT1

RF AMPLIFIER
TRANSISTOR
NPN SILICON

Designed for thick and thin–film circuits using surface mount components and requiring low–noise, high–gain signal amplification at frequencies to 1.0 GHz.

- High Gain — G_{pe} = 17 dB Typ @ f = 450 MHz
- Low Noise — NF = 2.5 dB Typ @ f = 450 MHz
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
(TO–236AA/AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	10	Vdc
Collector–Base Voltage	V_{CBO}	15	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	mAdc
Maximum Junction Temperature	T_{Jmax}	150	°C
Power Dissipation, T_{case} = 75°C (1) Derate linearly above T_{case} = 75°C @	$P_{D(max)}$	0.300 4.00	W mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	–55 to +150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	250	°C/W

DEVICE MARKING

MMBR5031LT1 = 7G

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	10	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	—	300	—
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	—	1,000	—	MHz
Collector–Base Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)	C_{cb}	—	—	1.5	pF
Minimum Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	NF_{min}	—	2.5	—	dB
Common–Emitter Amplifier Power Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	G_{pe}	—	17	25	dB

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

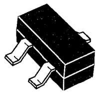
The RF Line
NPN Silicon High-Frequency Transistor

MMBR5179LT1

RF AMPLIFIER
TRANSISTOR
NPN SILICON

Designed for small–signal amplification at frequencies to 500 MHz. Specifically packaged for use in thick and thin–film circuits using surface mount components.

- High Gain — G_{pe} = 15 dB Typ @ f = 200 MHz
- Low Noise — NF = 4.5 dB Typ @ f = 200 MHz
- Available in tape and reel packaging options:
  T1 suffix = 3,000 units per reel



CASE 318–08, STYLE 6
SOT–23
LOW PROFILE
(TO–236AA/AB)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	12	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Maximum Junction Temperature	T_{Jmax}	150	°C
Power Dissipation, T_{case} = 75°C (1) Derate linearly above T_{case} = 75°C @	$P_{D(max)}$	0.375 5.00	W mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Storage Temperature	T_{stg}	–55 to +150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	200	°C/W

DEVICE MARKING

MMBR5179LT1 = 7H

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.02	µAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	—	—	—
Collector–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	—	0.4	Vdc
Base–Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	—	—	1.0	Vdc
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	—	1,400	—	MHz
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	—	—	1.0	pF
50 ohm Noise Figure (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 Ω, f = 200 MHz)	NF	—	4.5	—	dB
Common–Emitter Amplifier Power Gain (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	—	15	—	dB

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

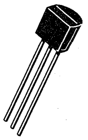
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
NPN Silicon High-Frequency Transistor

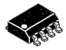
- Tape and reel packaging options available for MRF3866R2:
  R2 suffix = 2,500 units per reel

MPS3866
MRF3866R2

I_C = 400 mA
HIGH–FREQUENCY
TRANSISTORS
NPN SILICON



CASE 29–04, STYLE 1
TO–226AA
MPS3866 (TO–92)



CASE 751–05, STYLE 1
MRF3866R2 (SO–8)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C
Maximum Junction Temperature	T_{Jmax}	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient MPS3866 MRF3866R2	$R_{\theta JA}$	200 125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)	$V_{(BR)CER}$	55	—	Vdc
Collector–Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	0.02	mAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = –1.5 Vdc (Rev.), T_C = 150°C) (V_{CE} = 55 Vdc, V_{BE} = –1.5 Vdc (Rev.))	I_{CEX}	 — —	 5.0 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	—	0.1	mAdc

(continued)

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain (I_C = 360 mAdc, V_{CE} = 5.0 Vdc) (1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 5.0 10	 — 200	—
Collector–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
SMALL–SIGNAL CHARACTERISTICS				
Current–Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{obo}	—	3.0	pF
FUNCTIONAL TEST				
Amplifier Power Gain MPS3866 (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	G_{pe}	10	—	dB
Collector Efficiency MPS3866 (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	η	45	—	%

NOTE:
1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			S_{11}	∠ φ	S_{21}	∠ φ	S_{12}	∠ φ	S_{22}	∠ φ
15	50	100	0.67	−166	13.75	92	0.016	44	0.32	−27
		200	0.69	−176	6.93	81	0.024	53	0.30	−24
		300	0.70	177	4.57	73	0.032	57	0.32	−31
		400	0.71	172	3.38	67	0.042	59	0.34	−37
		500	0.72	168	2.66	61	0.049	59	0.37	−45
		600	0.72	164	2.17	54	0.056	61	0.40	−53
		700	0.72	160	1.85	49	0.061	63	0.43	−60
		800	0.72	155	1.61	44	0.068	65	0.47	−66
		900	0.71	151	1.40	39	0.075	64	0.50	−73
		1000	0.70	146	1.25	34	0.084	68	0.53	−79

Table 1. MRF3866R2 Common Emitter S–Parameters

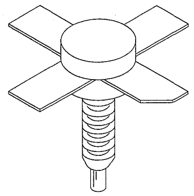
The RF Line
UHF Power Transistor

MRA1000-7L

9.0 dB, TO 1000 MHz
7.0 WATTS BROADBAND
UHF POWER TRANSISTOR

. . . designed primarily for wideband, large–signal output and driver amplifier stages to 1000 MHz.

- Designed for Class A Linear Power Amplifiers
- Specified 19 Volt, 1000 MHz Characteristics:
  Output Power — 7.0 Watts
  Power Gain — 9.0 dB Min, Small–Signal
- Built–In Matching Network for Broadband Operation
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 145D–02, STYLE 1
(.380 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	42 0.25	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case ($T_C = 70°C$)	$R_{\theta JC}$	4.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 20$ mA, $I_B = 0$)	$V_{(BR)CEO}$	28	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 20$ mA, $V_{BE} = 0$)	$V_{(BR)CES}$	50	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 20$ mA, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 5.0$ mA, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 19$ V, $I_E = 0$)	I_{CBO}	—	—	15	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ A, $V_{CE} = 5.0$ V)	h_{FE}	20	—	90	—
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 24$ V, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	—	22	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Small–Signal Gain ($V_{CE} = 19$ V, f = 1.0 GHz, $I_C = 1.2$ A)	G_{SS}	9.0	10	—	dB
Load Mismatch ($V_{CE} = 19$ V, $I_C = 1.2$ A, $P_{out} = 7.0$ W, f = 1.0 GHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			
Overdrive ($V_{CE} = 19$ V, $I_C = 1.2$ A, f = 1.0 GHz) (No degradation)	$P_{in_{over}}$	—	—	3.5	W
Output Power, 1.0 dB Compression Point ($V_{CE} = 19$ V, f = 1.0 GHz, $I_C = 1.2$ A)	$P_{o1\ dB}$	7.0	—	—	W

REV 6

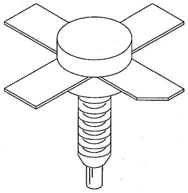
The RF Line
UHF Power Transistor

. . . designed primarily for wideband, large–signal output and driver amplifier stages to 1000 MHz.

- Designed for Class A Linear Power Amplifiers
- Specified 19 Volt, 1000 MHz Characteristics:
  Output Power — 14 Watts
  Power Gain — 8.0 dB, Small–Signal
- Built–In Matching Network for Broadband Operation
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MRA1000-14L

8.0 dB, TO 1000 MHz
14 WATTS BROADBAND
UHF POWER TRANSISTOR



CASE 145D–02, STYLE 1
(.380 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	83 0.48	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	2.1	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mA, I_B = 0)	$V_{(BR)CEO}$	28	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mA, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 25 mA, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 19 V, I_E = 0)	I_{CBO}	—	—	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 A, V_{CE} = 5.0 V)	h_{FE}	20	—	90	—

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	40	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Small–Signal Gain (V_{CE} = 19 V, P_{in} = 1.0 mW, f = 1.0 GHz, I_C = 2.4 A)	G_{SS}	8.0	—	—	dB
Load Mismatch (V_{CE} = 19 V, I_C = 2.4 A, P_{out} = 14 W, f = 1.0 GHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			
Overdrive (V_{CE} = 19 V, I_C = 2.4 A, f = 1.0 GHz) (No degradation)	$P_{in_{over}}$	—	—	7.0	W
Output Power, 1.0 dB Compression Point (V_{CE} = 19 V, f = 1.0 GHz, I_C = 2.4 A)	$P_{o1\ dB}$	14	—	—	W

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

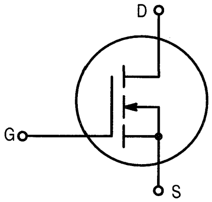
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

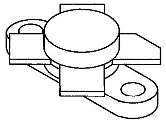
MRF134

. . . designed for wideband large–signal amplifier and oscillator applications up to 400 MHz range.

- Guaranteed 28 Volt, 150 MHz Performance
  Output Power = 5.0 Watts
  Minimum Gain = 11 dB
  Efficiency — 55% (Typical)
- Small–Signal and Large–Signal Characterization
- Typical Performance at 400 MHz, 28 Vdc, 5.0 W
  Output = 10.6 dB Gain
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR
- Low Noise Figure — 2.0 dB (Typ) at 200 mA, 150 MHz
- Excellent Thermal Stability, Ideally Suited For Class A Operation

5.0 W, to 400 MHz
N–CHANNEL MOS
BROADBAND RF POWER
FET





CASE 211–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	0.9	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	17.5 0.1	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

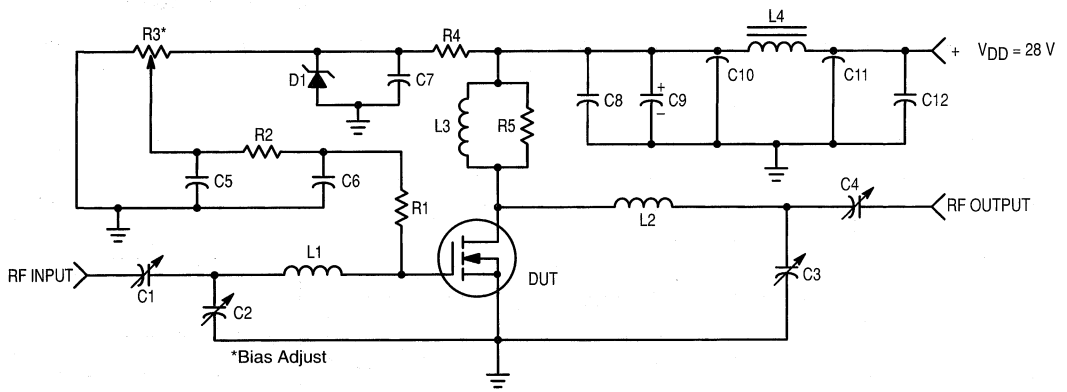
Rating	Symbol	Value	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	10	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	1.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (I_D = 10 mA, V_{DS} = 10 V)	$V_{GS(th)}$	1.0	3.5	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 100 mA)	g_{fs}	80	110	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	7.0	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	9.7	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.3	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 28 Vdc, I_D = 200 mA, f = 150 MHz)	NF	—	2.0	—	dB
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 5.0 W, I_{DQ} = 50 mA) f = 150 MHz (Fig. 1) f = 400 MHz (Fig. 14)	G_{ps}	11 —	14 10.6	— —	dB
Drain Efficiency (Fig. 1) (V_{DD} = 28 Vdc, P_{out} = 5.0 W, f = 150 MHz, I_{DQ} = 50 mA)	η	50	55	—	%
Electrical Ruggedness (Fig. 1) (V_{DD} = 28 Vdc, P_{out} = 5.0 W, f = 150 MHz, I_{DQ} = 50 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			



*Bias Adjust

C1, C4 — Arco 406, 15–115 pF
C2 — Arco 403, 3.0–35 pF
C3 — Arco 402, 1.5–20 pF
C5, C6, C7, C8, C12 — 0.1 µF Erie Redcap
C9 — 10 µF, 50 V
C10, C11 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener
L1 — 3 Turns, 0.310″ ID, #18 AWG Enamel, 0.2″ Long
L2 — 3–1/2 Turns, 0.310″ ID, #18 AWG Enamel, 0.25″ Long
L3 — 20 Turns, #20 AWG Enamel Wound on R5
L4 — Ferroxcube VK–200 — 19/4B
R1 — 68 Ω, 1.0 W Thin Film
R2 — 10 kΩ, 1/4 W
R3 — 10 Turns, 10 kΩ Beckman Instruments 8108
R4 — 1.8 kΩ, 1/2 W
R5 — 1.0 MΩ, 2.0 W Carbon
Board — G10, 62 mils

Figure 1. 150 MHz Test Circuit

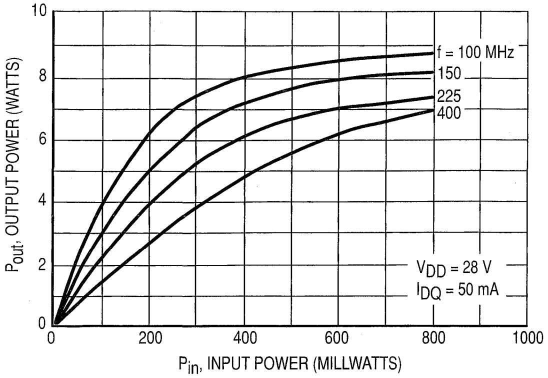


Figure 2. Output Power versus Input Power

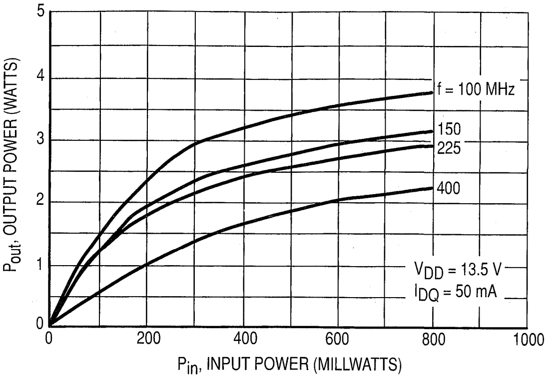


Figure 3. Output Power versus Input Power

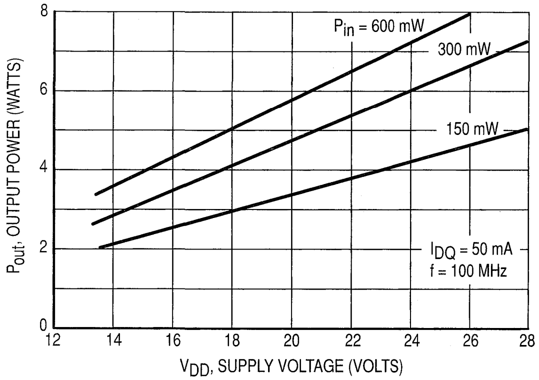


Figure 4. Output Power versus Supply Voltage

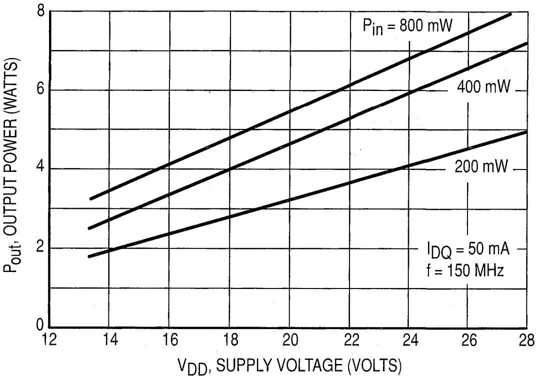


Figure 5. Output Power versus Supply Voltage

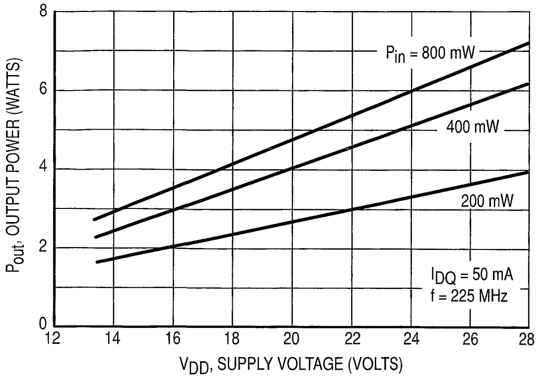


Figure 6. Output Power versus Supply Voltage

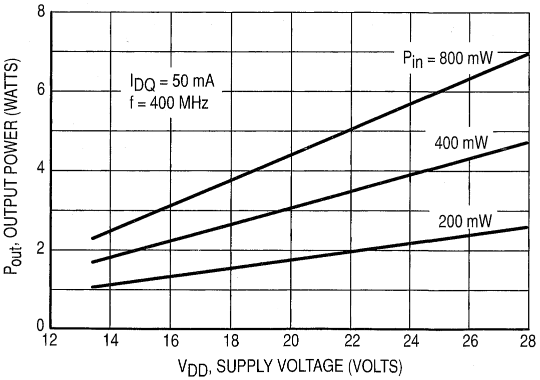


Figure 7. Output Power versus Supply Voltage

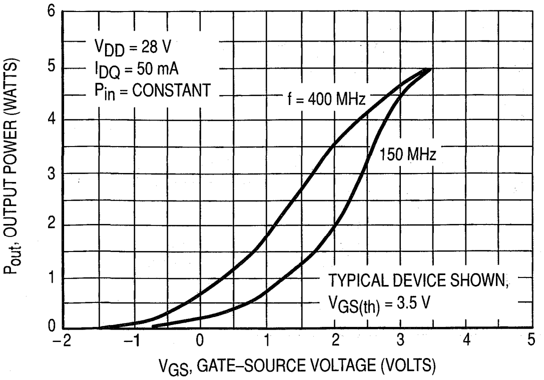


Figure 8. Output Power versus Gate Voltage

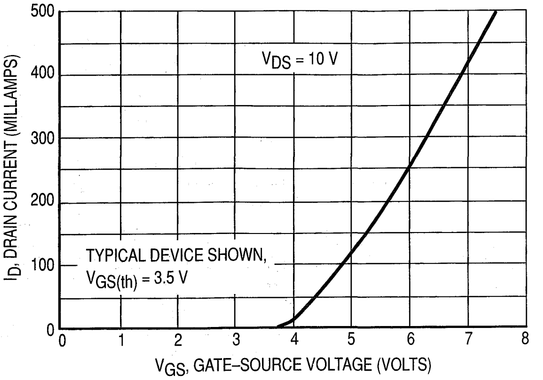


Figure 9. Drain Current versus Gate Voltage (Transfer Characteristics)

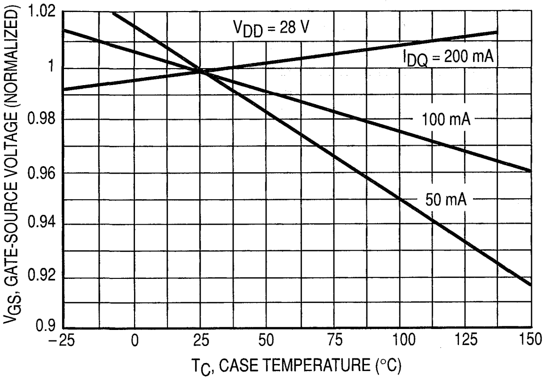


Figure 10. Gate–Source Voltage versus Case Temperature

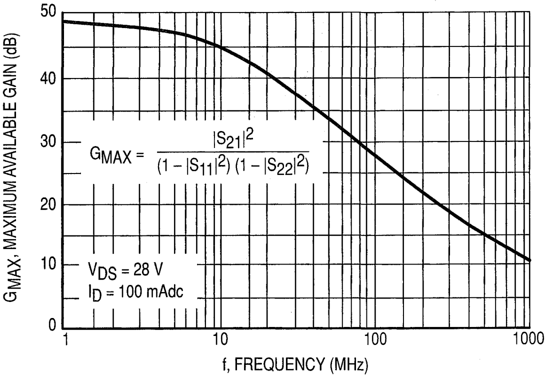


Figure 11. Maximum Available Gain versus Frequency

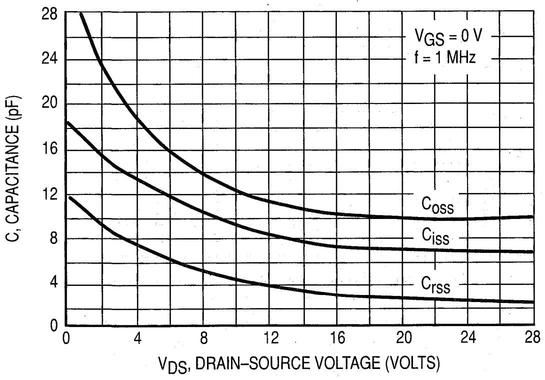


Figure 12. Capacitance versus Voltage

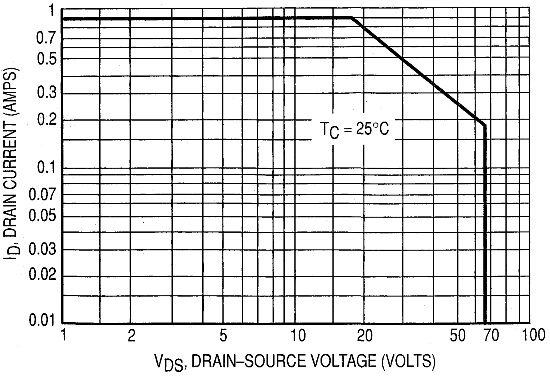
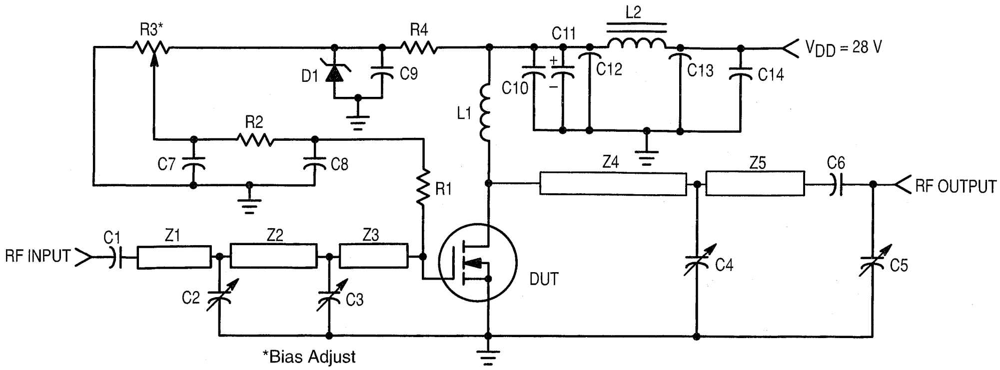


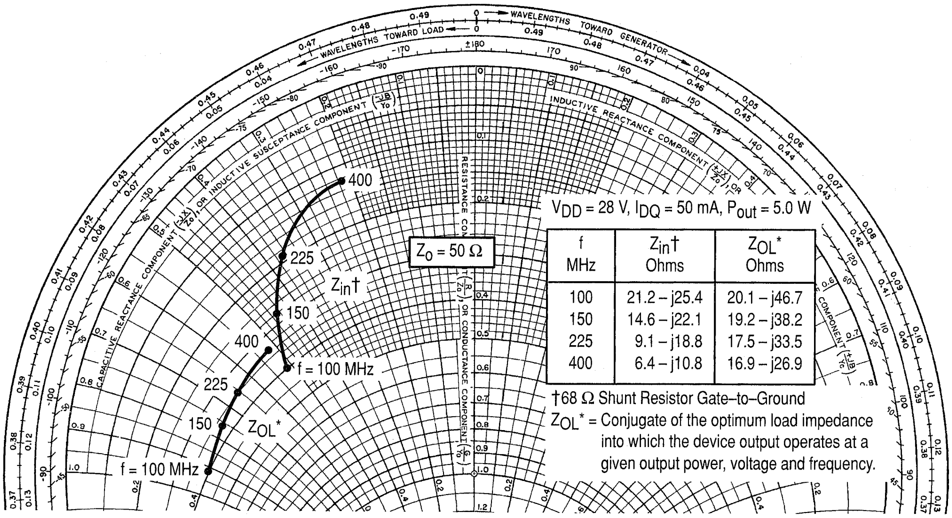
Figure 13. Maximum Rated Forward Biased Safe Operating Area



*Bias Adjust

C1, C6 — 270 pF, ATC 100 mils
C2, C3, C4, C5 — 0–20 pF Johanson
C7, C9, C10, C14 — 0.1 µF Erie Redcap, 50 V
C8 — 0.001 µF
C11 — 10 µF, 50 V
C12, C13 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener
L1 — 6 Turns, 1/4″ ID, #20 AWG Enamel
L2 — Ferroxcube VK–200 — 19/4B
R1 — 68 Ω, 1.0 W Thin Film
R2 — 10 kΩ, 1/4 W
R3 — 10 Turns, 10 kΩ Beckman Instruments 8108
R4 — 1.8 kΩ, 1/2 W
Z1 — 1.4″ x 0.166″ Microstrip
Z2 — 1.1″ x 0.166″ Microstrip
Z3 — 0.95″ x 0.166″ Microstrip
Z4 — 2.2″ x 0.166″ Microstrip
Z5 — 0.85″ x 0.166″ Microstrip
Board — Glass Teflon, 62 mils

Figure 14. 400 MHz Test Circuit



V_{DD} = 28 V, I_{DQ} = 50 mA, P_{out} = 5.0 W

f MHz	Z_{in}† Ohms	Z_{OL}* Ohms
100	21.2 – j25.4	20.1 – j46.7
150	14.6 – j22.1	19.2 – j38.2
225	9.1 – j18.8	17.5 – j33.5
400	6.4 – j10.8	16.9 – j26.9

†68 Ω Shunt Resistor Gate–to–Ground

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 15. Large–Signal Series Equivalent Input/Output Impedances, Z_{in}†, Z_{OL}*

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
1.0	0.989	−1.0	11.27	179	0.0014	89	0.954	−1.0
2.0	0.989	−2.0	11.27	179	0.0028	89	0.954	−2.0
5.0	0.988	−5.0	11.26	176	0.0069	86	0.954	−4.0
10	0.985	−10	11.20	173	0.014	83	0.951	−9.0
20	0.977	−20	10.99	166	0.027	76	0.938	−18
30	0.965	−30	10.66	159	0.039	69	0.918	−26
40	0.950	−39	10.25	153	0.051	63	0.895	−34
50	0.931	−47	9.777	147	0.060	57	0.867	−42
60	0.912	−53	9.359	142	0.069	53	0.846	−49
70	0.892	−58	8.960	138	0.077	49	0.828	−56
80	0.874	−62	8.583	135	0.085	46	0.815	−62
90	0.855	−66	8.190	131	0.091	43	0.801	−68
100	0.833	−70	7.808	128	0.096	40	0.785	−74
110	0.827	−73	7.661	125	0.101	38	0.784	−77
120	0.821	−76	7.515	122	0.107	36	0.784	−82
130	0.814	−79	7.368	119	0.113	34	0.784	−85
140	0.808	−82	7.222	116	0.119	32	0.783	−88
150	0.802	−86	7.075	114	0.125	31	0.783	−90
160	0.788	−89	6.810	112	0.127	30	0.780	−92
170	0.774	−92	6.540	110	0.128	28	0.774	−94
180	0.763	−94	6.220	108	0.130	26	0.762	−98
190	0.751	−97	5.903	106	0.132	24	0.760	−100
200	0.740	−100	5.784	104	0.134	23	0.758	−103
225	0.719	−104	5.334	100	0.136	20	0.757	−107
250	0.704	−108	4.904	97	0.139	19	0.758	−110
275	0.687	−113	4.551	92	0.141	16	0.757	−114
300	0.673	−117	4.219	89	0.141	14	0.750	−117
325	0.668	−120	3.978	86	0.142	12	0.757	−120
350	0.669	−123	3.737	83	0.142	10	0.766	−121
375	0.662	−125	3.519	80	0.143	9.0	0.768	−123
400	0.654	−127	3.325	77	0.142	8.0	0.772	−124
425	0.650	−129	3.170	75	0.140	7.0	0.772	−125
450	0.638	−131	3.048	72	0.141	6.0	0.783	−125
475	0.614	−132	2.898	71	0.136	6.0	0.786	−126
500	0.641	−133	2.833	68	0.136	5.0	0.795	−127
525	0.638	−135	2.709	66	0.135	5.0	0.801	−127
550	0.633	−137	2.574	64	0.133	4.0	0.802	−128
575	0.628	−138	2.481	62	0.131	5.0	0.805	−128
600	0.625	−140	2.408	60	0.129	5.0	0.814	−128

The Power RF characterization data were measured with a 68 ohm resistor shunting the MRF134 input port. (continued)
The scattering parameters were measured on the MRF134 device alone with no external components.

Table 1. Common Source Scattering Parameters
V_{DS} = 28 V, I_D = 100 mA

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	$\angle \phi$	$\lvert S_{21}\rvert$	$\angle \phi$	$\lvert S_{12}\rvert$	$\angle \phi$	$\lvert S_{22}\rvert$	$\angle \phi$
625	0.619	−142	2.334	58	0.128	5.0	0.818	−129
650	0.617	−144	2.259	56	0.125	6.0	0.824	−130
675	0.618	−146	2.192	55	0.123	7.0	0.834	−130
700	0.619	−147	2.124	53	0.122	8.0	0.851	−131
725	0.618	−150	2.061	51	0.120	9.0	0.859	−132
750	0.614	−152	1.983	49	0.118	11	0.857	−133
775	0.609	−154	1.908	48	0.119	13	0.865	−133
800	0.562	−155	1.877	49	0.118	15	0.872	−133
825	0.587	−156	1.869	46	0.119	16	0.869	−134
850	0.593	−158	1.794	44	0.118	18	0.875	−135
875	0.597	−160	1.749	43	0.119	18	0.881	−135
900	0.598	−162	1.700	41	0.118	18	0.889	−136
925	0.592	−164	1.641	40	0.115	18	0.888	−138
950	0.588	−166	1.590	39	0.112	20	0.877	−138
975	0.586	−168	1.572	39	0.108	23	0.864	−137
1000	0.590	−171	1.551	37	0.107	28	0.863	−137

The Power RF characterization data were measured with a 68 ohm resistor shunting the MRF134 input port. The scattering parameters were measurd on the MRF134 device alone with no external components.

Table 1. Common Source Scattering Parameters (continued)
V_{DS} = 28 V, I_D = 100 mA

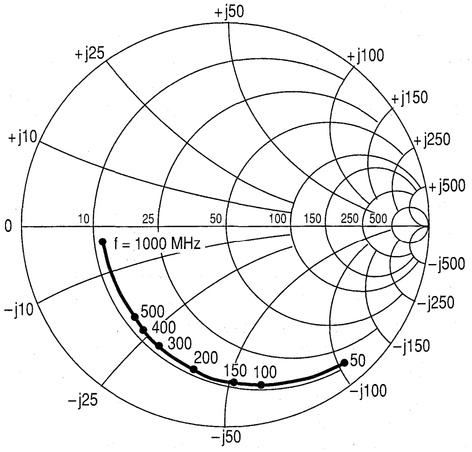


Figure 16. S_{11}, Input Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 100 mA

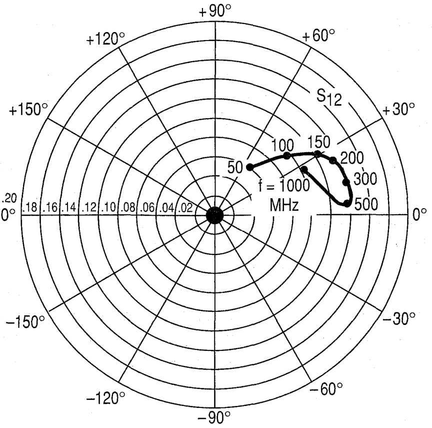


Figure 17. S_{12}, Reverse Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 100 mA

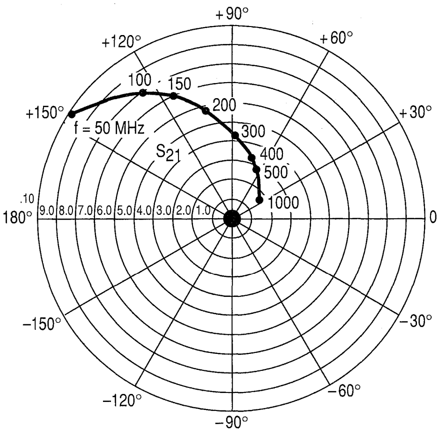


Figure 18. S_{21}, Forward Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 100 mA

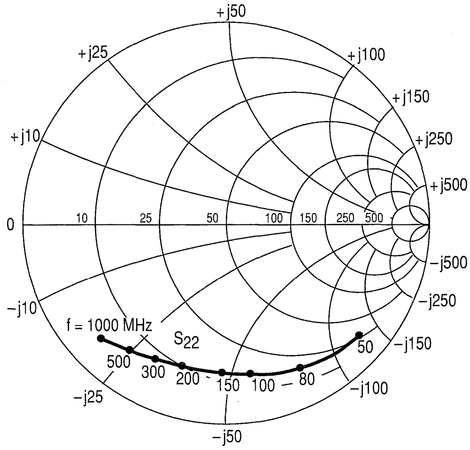


Figure 19. S_{22}, Output Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 100 mA

DESIGN CONSIDERATIONS

The MRF134 is a RF power N–Channel enhancement mode field–effect transistor (FET) designed especially for VHF power amplifier and oscillator applications. Motorola RF MOS FETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V–groove vertical power FETs.

Motorola Application Note AN–211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF134 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. See Figure 9 for a typical plot of drain current versus gate voltage. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF134 was characterized at I_{DQ} = 50 mA, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF134 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems. (See Figure 8.)

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar VHF transistors are suitable for MRF134. See Motorola Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. The higher input impedance of RF MOS FETs helps ease the task of broadband network design. Both small signal scattering parameters and large signal impedances are provided. While the s–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF MOS power FETs.

RF power FETs are triode devices and, therefore, not unilateral. This, coupled with the very high gain of the MRF134, yields a device capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. The MRF134 was characterized with a 68–ohm input shunt loading resistor. Two port parameter stability analysis with the MRF134 s–parameters provides a useful–tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A for a discussion of two port network theory and stability.

Input resistive loading is not feasible in low noise applications. The MRF134 noise figure data was generated in a circuit with drain loading and a low loss input network.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF MOSFET Line
RF Power Field-Effect Transistors
N-Channel Enhancement-Mode MOSFETs

MRF136
MRF136Y

15 W, 30 W, to 400 MHz
N–CHANNEL
MOS BROADBAND
RF POWER FETs

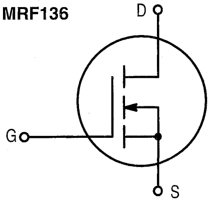
. . . designed for wideband large–signal amplifier and oscillator applications up to 400 MHz range, in either single ended or push–pull configuration.

- Guaranteed 28 Volt, 150 MHz Performance

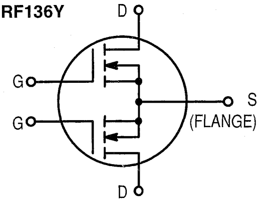
MRF136	**MRF136Y**
Output Power = 15 Watts	Output Power = 30 Watts
Narrowband Gain = 16 dB (Typ)	Broadband Gain = 14 dB (Typ)
Efficiency = 60% (Typical)	Efficiency = 54% (Typical)

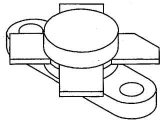
- Small–Signal and Large–Signal Characterization
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR
- Space Saving Package For Push–Pull Circuit Applications — MRF136Y
- Excellent Thermal Stability, Ideally Suited For Class A Operation
- Facilitates Manual Gain Control, ALC and Modulation Techniques

MRF136

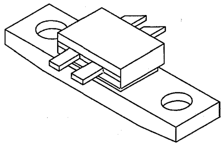


MRF136Y





CASE 211–07, STYLE 2
MRF136



CASE 319B–02, STYLE 1
MRF136Y

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MRF136	MRF136Y	
Drain–Source Voltage	V_{DSS}	65	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	65	Vdc
Gate–Source Voltage	V_{GS}	±40		Vdc
Drain Current — Continuous	I_D	2.5	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	55 0.314	100 0.571	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150		°C
Operating Junction Temperature	T_J	200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
		MRF136	MRF136Y	
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.2	1.75	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

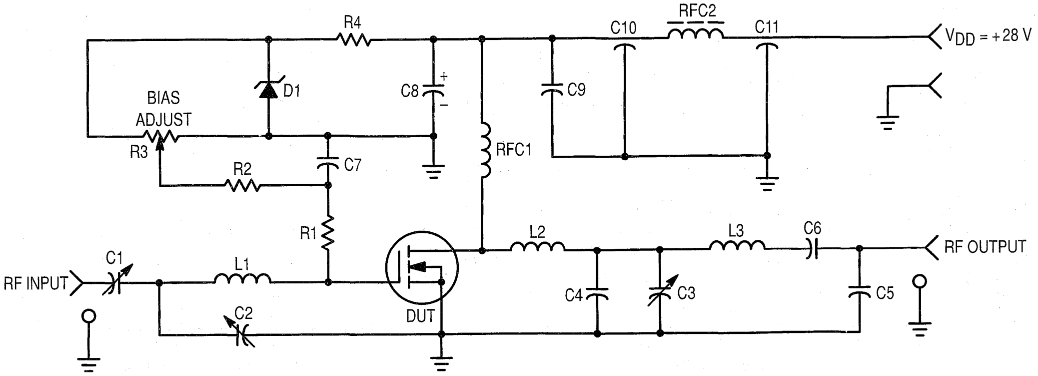
REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero–Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	2.0	mAdc
Gate–Source Leakage Current (V_{GS} = 40 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 25 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 250 mA)	g_{fs}	250	400	—	mmhos
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	24	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	27	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	5.5	—	pF
FUNCTIONAL CHARACTERISTICS (2)					
Noise Figure MRF136 (V_{DS} = 28 Vdc, I_D = 500 mA, f = 150 MHz)	NF	—	1.0	—	dB
Common Source Power Gain (Figure 1) MRF136 (V_{DD} = 28 Vdc, P_{out} = 15 W, f = 150 MHz, I_{DQ} = 25 mA)	G_{ps}	13	16	—	dB
Common Source Power Gain (Figure 2) MRF136Y (V_{DD} = 28 Vdc, P_{out} = 30 W, f = 150 MHz, I_{DQ} = 100 mA)	G_{ps}	12	14	—	dB
Drain Efficiency (Figure 1) MRF136 (V_{DD} = 28 Vdc, P_{out} = 15 W, f = 150 MHz, I_{DQ} = 25 mA)	η	50	60	—	%
Drain Efficiency (Figure 2) MRF136Y (V_{DD} = 28 Vdc, P_{out} = 30 W, f = 150 MHz, I_{DQ} = 100 mA)	η	50	54	—	%
Electrical Ruggedness (Figure 1) MRF136 (V_{DD} = 28 Vdc, P_{out} = 15 W, f = 150 MHz, I_{DQ} = 25 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
Electrical Ruggedness (Figure 2) MRF136Y (V_{DD} = 28 Vdc, P_{out} = 30 W, f = 150 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTES:

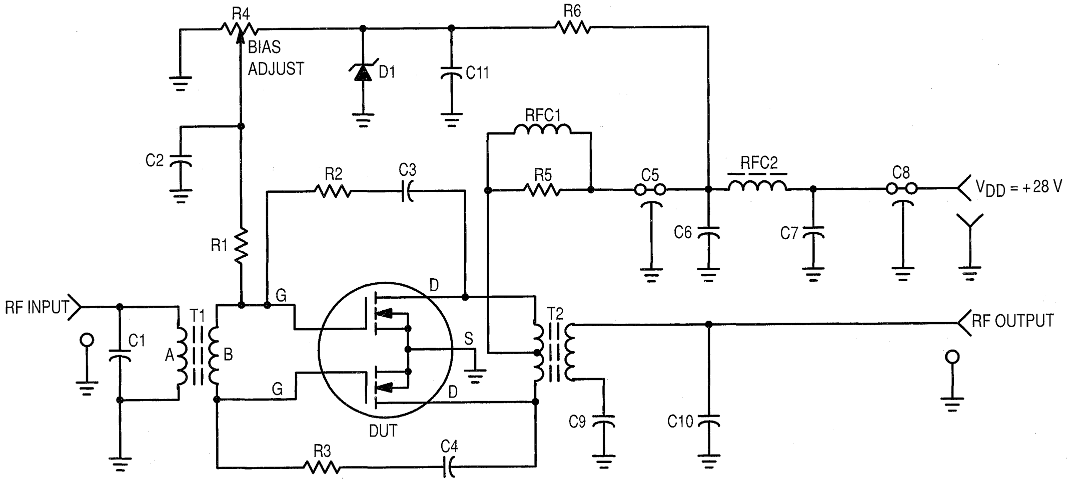
1. For MRF136Y, each side measured separately.
2. For MRF136Y measured in push–pull configuration.



C1, C2 — Arco 406, 15–115 pF or Equivalent
C3 — Arco 404, 8–60 pF or Equivalent
C4 — 43 pF Mini–Unelco or Equivalent
C5 — 24 pF Mini–Unelco or Equivalent
C6 — 680 pF, 100 Mils Chip
C7 — 0.01 µF Ceramic
C8 — 100 µF, 40 V
C9 — 0.1 µF Ceramic
C10, C11 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener

L1 — 2 Turns, 0.29″ ID, #18 AWG, 0.10″ Long
L2 — 2 Turns, 0.23″ ID, #18 AWG, 0.10″ Long
L3 — 2–1/4 Turns, 0.29″ ID, #18 AWG, 0.125″ Long
RFC1 — 20 Turns, 0.30″ ID, #20 AWG Enamel Closewound
RFC2 — Ferroxcube VK–200 — 19/4B
R1 — 27 Ω, 1 W Thin Film
R2 — 10 kΩ, 1/4 W
R3 — 10 Turns, 10 kΩ
R4 — 1.8 kΩ, 1/2 W
Board Material — 0.062″ G10, 1 oz. Cu Clad, Double Sided

Figure 1. 150 MHz Test Circuit (MRF136)



C1 — 5.0 pF
C2, C3, C4, C6, C7, C9, C11 — 0.1 µF Ceramic
C5, C8 — 680 pF Feedthru
C10 — 15 pF
D1 — 1N4740 Motorola Zener
RFC1 — 17 Turns, #24 AWG Wound on R5
RFC2 — Ferroxcube VK–200–19/4B or Equivalent
R1 — 10 kΩ, 1/4 W
R2, R3 — 560 Ω, 1/2 W
R4 — 10 Turns, 10 kΩ

R5 — 56 kΩ, 1 W
R6 — 1.6 kΩ, 1/4 W
T1 — Primary Winding — 3 Turns #28 Enameled Wire.
— Secondary Winding — 2 Turns #28 Enameled Wire. Both windings wound through a Fair/Rite Balun 65 core. Part #2865002402.
T2 — 1:1 Transformer Wound Bifilar — 2 Turns Twisted Pair #24 Enameled Wire through a Indiana General Balun Q1 core. Part #18006–1–Q1. Primary winding center tapped.
Board Material — 0.062″ G10, 1 oz. Cu Clad, Double Sided

Figure 2. 30–150 MHz Test Circuit (MRF136Y)

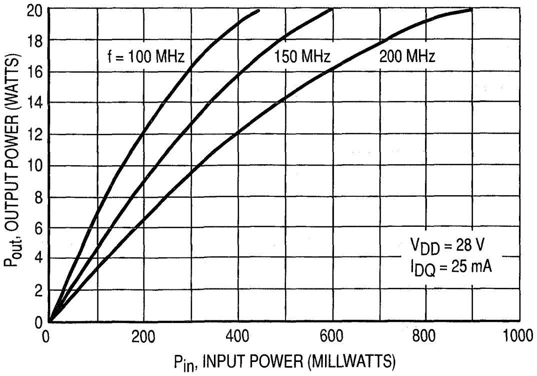


Figure 3. Output Power versus Input Power

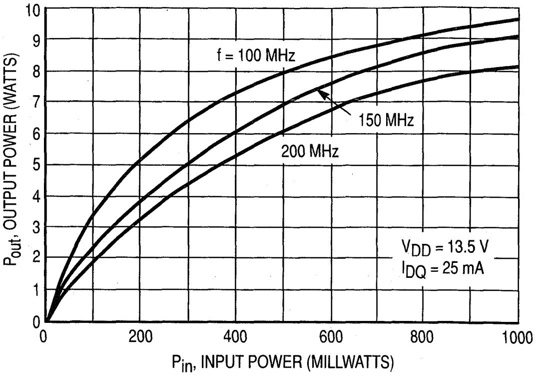


Figure 4. Output Power versus Input Power

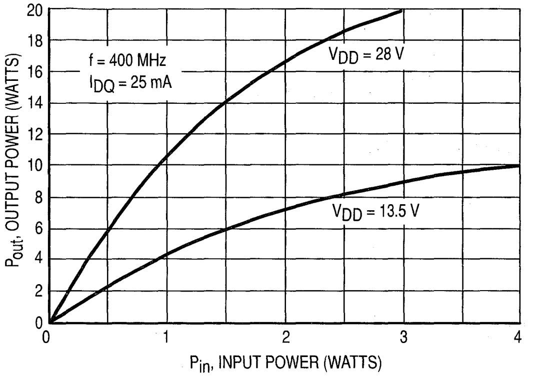


Figure 5. Output Power versus Input Power

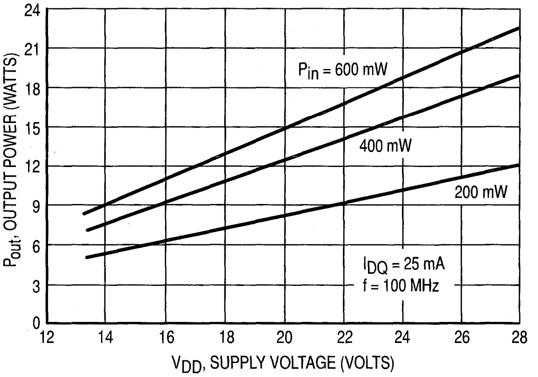


Figure 6. Output Power versus Supply Voltage

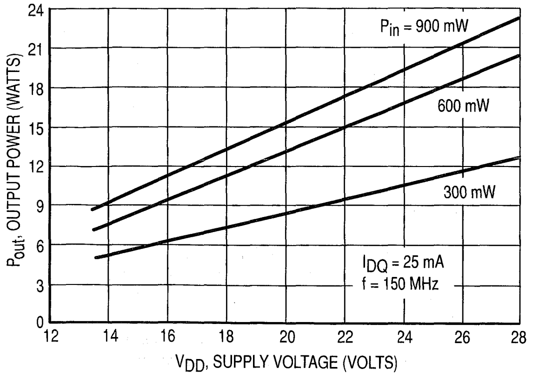


Figure 7. Output Power versus Supply Voltage

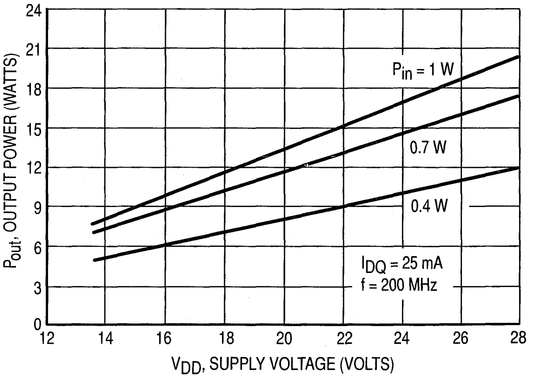


Figure 8. Output Power versus Supply Voltage

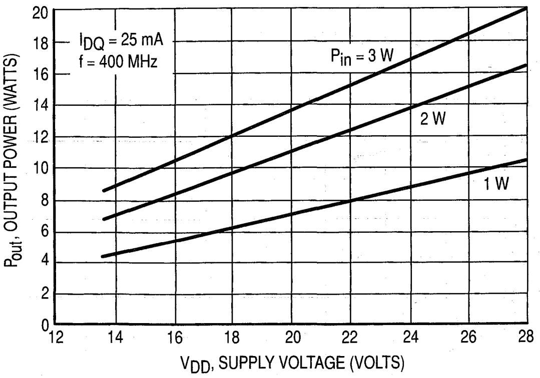


Figure 9. Output Power versus Supply Voltage
MRF136

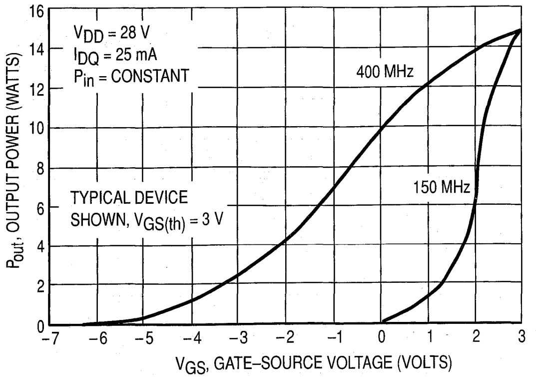


Figure 10. Output Power versus Gate Voltage
MRF136

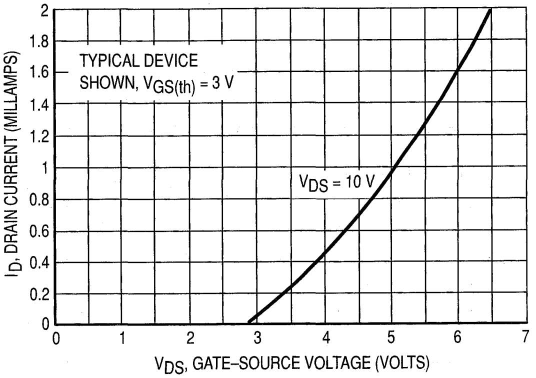


Figure 11. Drain Current versus Gate Voltage
(Transfer Characteristics)*
MRF136/MRF136Y

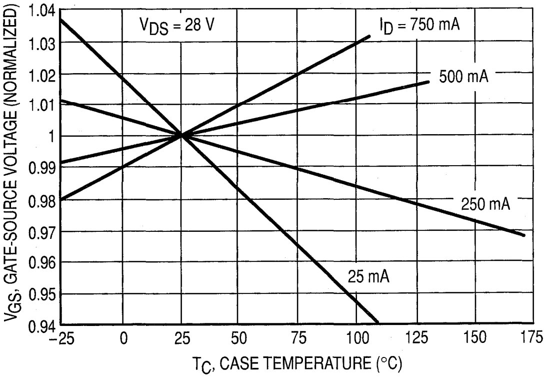


Figure 12. Gate–Source Voltage versus
Case Temperature*
MRF136/MRF136Y

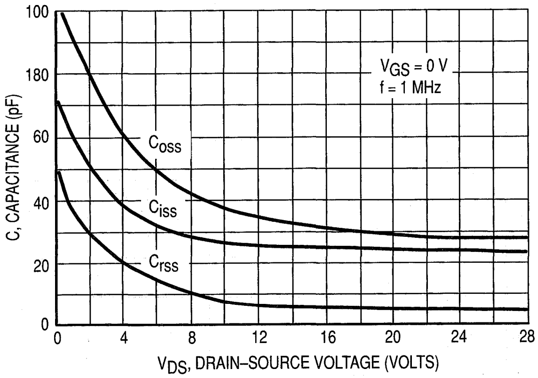


Figure 13. Capacitance versus Drain–Source Voltage*
MRF136/MRF136Y

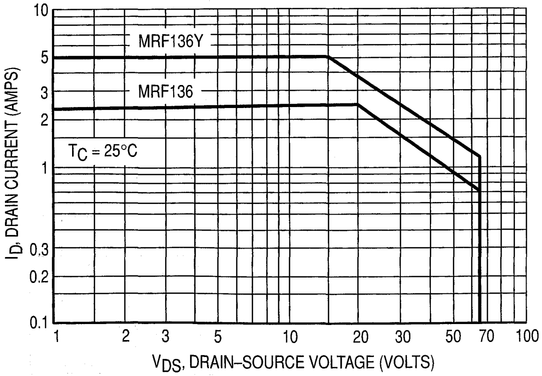


Figure 14. DC Safe Operating Area
MRF136/MRF136Y

*Data shown applies to MRF136 and each half of MRF136Y.

MRF136Y
TYPICAL PERFORMANCE IN BROADBAND TEST CIRCUIT
(Refer to Figure 2)

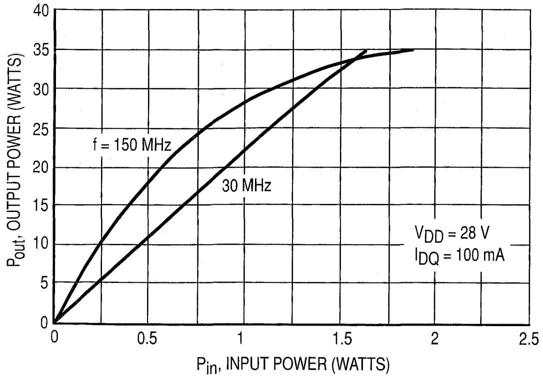


Figure 15. Output Power versus Input Power

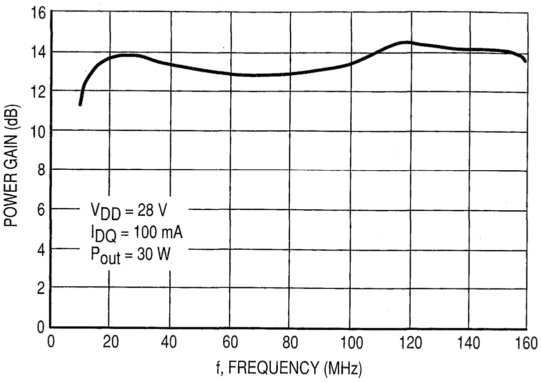


Figure 16. Power Gain versus Frequency

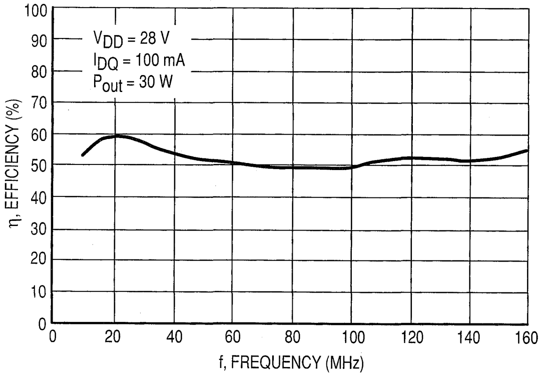


Figure 17. Drain Efficiency versus Frequency

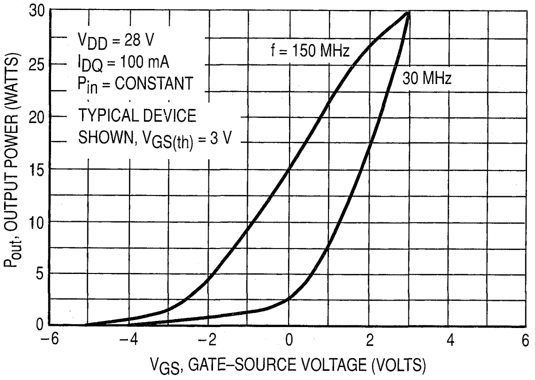


Figure 18. Output Power versus Gate Voltage

TYPICAL 400 MHz PERFORMANCE

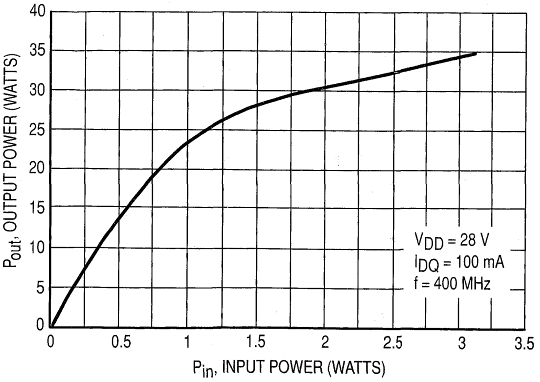


Figure 19. Output Power versus Input Power

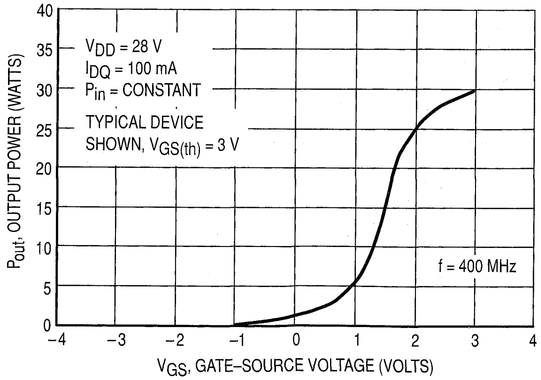
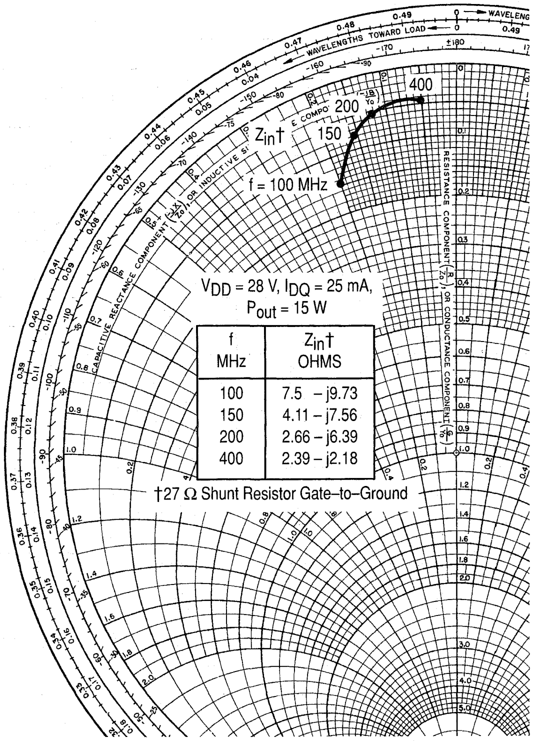


Figure 20. Output Power versus Gate Voltage

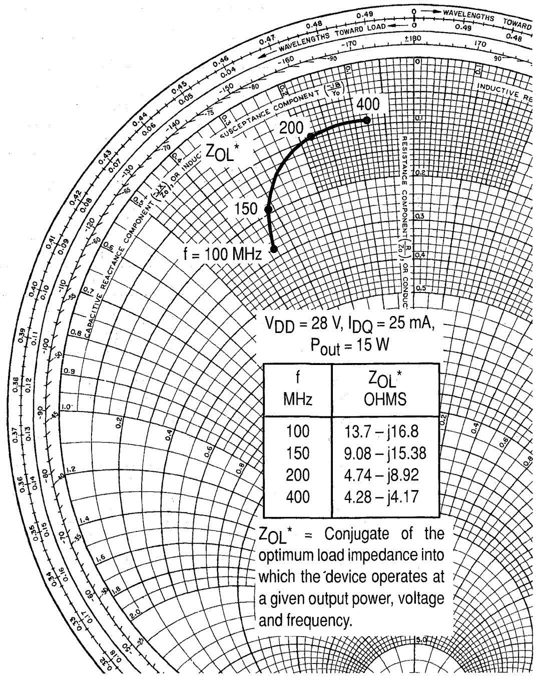


V_{DD} = 28 V, I_{DQ} = 25 mA,
P_{out} = 15 W

f MHz	Z_{in}† OHMS
100	7.5 – j9.73
150	4.11 – j7.56
200	2.66 – j6.39
400	2.39 – j2.18

†27 Ω Shunt Resistor Gate–to–Ground

Figure 21. Large–Signal Series Equivalent Input Impedance, Z_{in}† MRF136



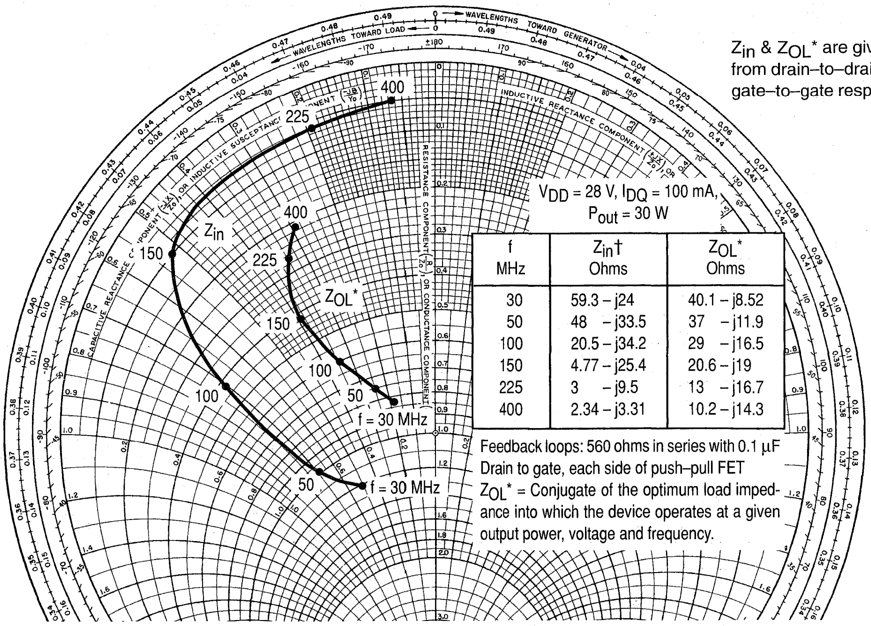
V_{DD} = 28 V, I_{DQ} = 25 mA,
P_{out} = 15 W

f MHz	Z_{OL}* OHMS
100	13.7 – j16.8
150	9.08 – j15.38
200	4.74 – j8.92
400	4.28 – j4.17

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 22. Large–Signal Series Equivalent Output Impedance, Z_{OL}* MRF136

Z_{in} & Z_{OL}* are given from drain–to–drain and gate–to–gate respectively.



V_{DD} = 28 V, I_{DQ} = 100 mA,
P_{out} = 30 W

f MHz	Z_{in}† Ohms	Z_{OL}* Ohms
30	59.3 – j24	40.1 – j8.52
50	48 – j33.5	37 – j11.9
100	20.5 – j34.2	29 – j16.5
150	4.77 – j25.4	20.6 – j19
225	3 – j9.5	13 – j16.7
400	2.34 – j3.31	10.2 – j14.3

Feedback loops: 560 ohms in series with 0.1 µF Drain to gate, each side of push–pull FET

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 23. Input and Outut Impedance MRF136Y

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
2.0	0.988	−11	41.19	173	0.006	67	0.729	−12
5.0	0.970	−27	40.07	164	0.014	62	0.720	−31
10	0.923	−52	35.94	149	0.026	54	0.714	−58
20	0.837	−88	27.23	129	0.040	36	0.690	−96
30	0.784	−111	20.75	117	0.046	27	0.684	−118
40	0.751	−125	16.49	108	0.048	22	0.680	−131
50	0.733	−135	13.41	103	0.050	19	0.679	−139
60	0.720	−142	11.43	99	0.050	16	0.678	−145
70	0.709	−147	9.871	96	0.050	14	0.679	−149
80	0.707	−152	8.663	93	0.051	13	0.683	−153
90	0.706	−155	7.784	91	0.051	13	0.682	−155
100	0.708	−157	7.008	88	0.051	13	0.680	−157
110	0.711	−159	6.435	86	0.051	14	0.681	−158
120	0.714	−161	5.899	85	0.051	15	0.682	−159
130	0.717	−163	5.439	82	0.052	16	0.684	−160
140	0.720	−164	5.068	80	0.052	17	0.684	−161
150	0.723	−165	4.709	80	0.052	18	0.686	−161
160	0.727	−166	4.455	78	0.052	18	0.690	−161
170	0.732	−167	4.200	77	0.052	18	0.694	−162
180	0.735	−168	3.967	75	0.052	19	0.699	−162
190	0.738	−169	3.756	74	0.052	19	0.703	−163
200	0.740	−170	3.545	73	0.052	20	0.706	−163
225	0.746	−171	3.140	69	0.053	22	0.717	−163
250	0.742	−172	2.783	67	0.053	25	0.724	−163
275	0.744	−173	2.540	64	0.054	27	0.724	−163
300	0.751	−174	2.323	60	0.055	29	0.736	−163
325	0.757	−175	2.140	58	0.058	32	0.749	−163
350	0.760	−176	1.963	54	0.059	35	0.758	−163
375	0.762	−177	1.838	52	0.062	38	0.768	−163
400	0.774	−179	1.696	50	0.065	41	0.783	−163
425	0.775	−179	1.590	48	0.068	43	0.793	−163
450	0.781	+179	1.493	46	0.071	46	0.805	−163
475	0.787	+177	1.415	43	0.074	47	0.813	−164
500	0.792	+176	1.332	40	0.079	48	0.825	−164
525	0.797	+175	1.259	38	0.083	50	0.831	−164
550	0.801	+175	1.185	37	0.088	51	0.843	−164
575	0.810	+174	1.145	36	0.094	52	0.855	−164
600	0.816	+173	1.091	34	0.101	52	0.869	−165
625	0.818	+171	1.041	32	0.106	53	0.871	−165
650	0.825	+170	0.994	30	0.112	53	0.884	−165
675	0.834	+169	0.962	29	0.119	53	0.890	−165
700	0.837	+168	0.922	27	0.127	53	0.906	−166
725	0.836	+167	0.879	25	0.133	52	0.909	−167
750	0.841	+166	0.838	25	0.140	53	0.917	−167
775	0.844	+165	0.824	24	0.148	52	0.933	−167
800	0.846	+163	0.785	21	0.154	50	0.941	−168

Table 1. Common Source Scattering Parameters
V_{DS} = 28 V, I_D = 0.5 A

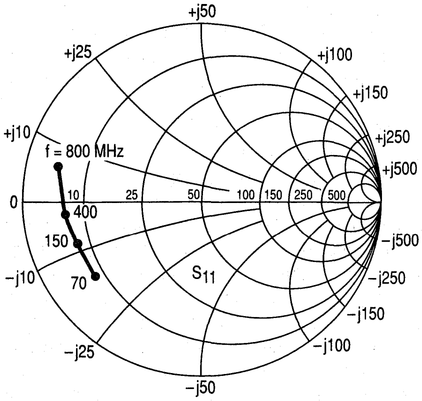


Figure 24. S_{11}, Input Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

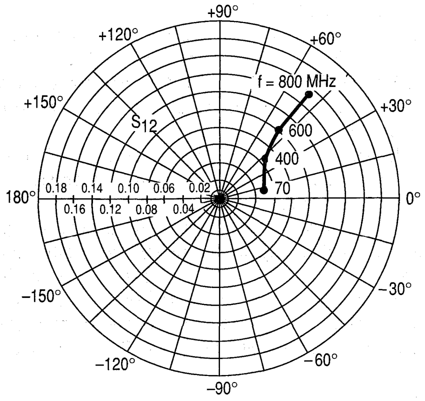


Figure 25. S_{12}, Reverse Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

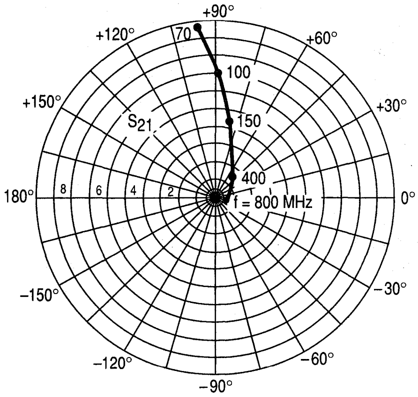


Figure 26. S_{21}, Forward Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

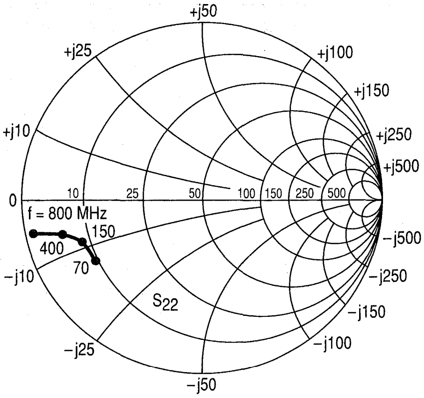


Figure 27. S_{22}, Output Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.5 A

DESIGN CONSIDERATIONS

The MRF136 and MRF136Y are RF power N–Channel enhancement mode field–effect transistors (FETs) designed especially for HF and VHF power amplifier applications. Motorola RF MOS FETs feature planar design for optimum manufacturability.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF136 and MRF136Y are enhancement mode FETs and, therefore, do not conduct when drain voltage is applied without gate bias. A positive gate voltage causes drain current to flow (see Figure 11). RF power FETs require forward bias for optimum gain and power output. A Class AB condition with quiescent drain current (I_{DQ}) in the 25–100 mA range is sufficient for many applications. For special requirements such as linear amplification, I_{DQ} may have to be adjusted to optimize the critical parameters.

The MOS gate is a dc open circuit. Since the gate bias circuit does not have to deliver any current to the FET, a simple resistive divider arrangement may sometimes suffice for this function. Special applications may require more elaborate gate bias systems.

GAIN CONTROL

Power output of the MRF136 and MRF136Y may be controlled from rated values down to the milliwatt region (>20 dB reduction in power output with constant input power) by varying the dc gate voltage. This feature, not available in bipolar RF power devices, facilitates the incorporation of manual gain control, AGC/ALC and modulation schemes into system designs. A full range of power output control may require dc gate voltage excursions into the negative region.

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar transistors are suitable for MRF136 and MRF136Y. See Motorola Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. Both small signal scattering parameters (MRF136 only) and large signal impedance parameters are provided. Large signal impedances should be used for network designs wherever possible. While the s parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is particularly useful at frequencies outside those presented in the large signal impedance plots.

RF power FETs are triode devices and are therefore not unilateral. This, coupled with the very high gain, yields a device capable of self oscillation. Stability may be achieved using techniques such as drain loading, input shunt resistive loading, or feedback. S parameter stability analysis can provide useful information in the selection of loading and/or feedback to insure stable operation. The MRF136 was characterized with a 27 ohm input shunt loading resistor, while the MRF136Y was characterized with a resistive feedback loop around each of its two active devices.

For further discussion of RF amplifier stability and the use of two port parameters in RF amplifier design, see Motorola Application Note AN215A on page 6–204 in the RF Device Data (DL110 Rev 1).

LOW NOISE OPERATION

Input resistive loading will degrade noise performance, and noise figure may vary significantly with gate driving impedance. A low loss input matching network with its gate impedance optimized for lowest noise is recommended.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

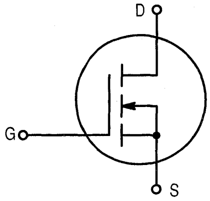
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

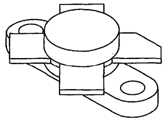
MRF137

**30 W, to 400 MHz
N–CHANNEL MOS
BROADBAND RF POWER
FET**

. . . designed for wideband large–signal output and driver stages up to 400 MHz range.

- Guaranteed 28 Volt, 150 MHz Performance
  Output Power = 30 Watts
  Minimum Gain = 13 dB
  Efficiency — 60% (Typical)
- Small–Signal and Large–Signal Characterization
- Typical Performance at 400 MHz, 28 Vdc, 30 W
  Output = 7.7 dB Gain
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR
- Low Noise Figure — 1.5 dB (Typ) at 1.0 A, 150 MHz
- Excellent Thermal Stability, Ideally Suited For Class A Operation
- Facilitates Manual Gain Control, ALC and Modulation Techniques





CASE 211–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	100 0.571	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

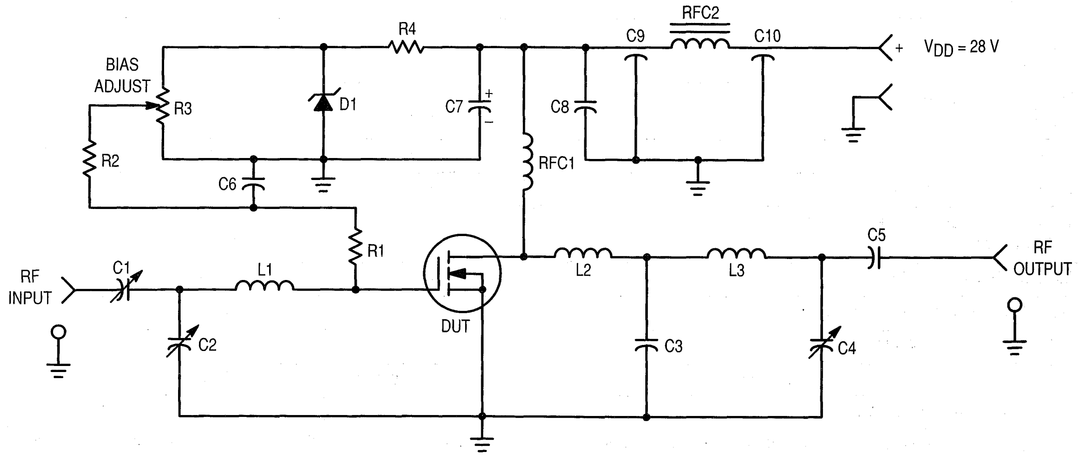
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 10 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	4.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 25 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 500 mA)	g_{fs}	500	750	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	48	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	54	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	11	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 28 Vdc, I_D = 1.0 A, f = 150 MHz)	NF	—	1.5	—	dB
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 30 W, I_{DQ} = 25 mA) f = 150 MHz (Figure 1) f = 400 MHz (Figure 14)	G_{ps}	13 —	16 7.7	— —	dB
Drain Efficiency (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 30 W, f = 150 MHz, I_{DQ} = 25 mA)	η	50	60	—	%
Electrical Ruggedness (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 30 W, f = 150 MHz, I_{DQ} = 25 mA, VSWR 30:1 at All Phase Angles)	ψ	No Degradation in Output Power			



C1 — Arco 403, 3.0–35 pF, or equivalent
C2 — Arco 406, 15–115 pF, or equivalent
C3 — 56 pF Mini–Unelco, or equivalent
C4 — Arco 404, 8.0–60 pF, or equivalent
C5 — 680 pF, 100 Mils Chip
C6 — 0.01 µF, 100 V, Disc Ceramic
C7 — 100 µF, 40 V
C8 — 0.1 µF, 50 V, Disc Ceramic
C9, C10 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener

L1 — 2 Turns, 0.29″ ID, #18 AWG Enamel, Closewound
L2 — 1–1/4 Turns, 0.2″ ID, #18 AWG Enamel, Closewound
L3 — 2 Turns, 0.2″ ID, #18 AWG Enamel, Closewound
RFC1 — 20 Turns, 0.30″ ID, #20 AWG Enamel, Closewound
RFC2 — Ferroxcube VK–200 — 19/4B
R1 — 10 kΩ, 1/2 W Thin Film
R2 — 10 kΩ, 1/4 W
R3 — 10 Turns, 10 kΩ
R4 — 1.8 kΩ, 1/2 W
Board — G10, 62 Mils

Figure 1. 150 MHz Test Circuit

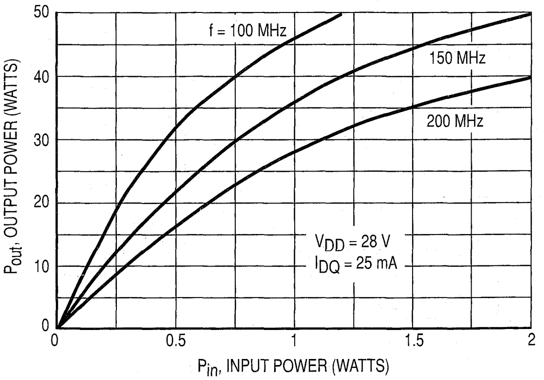


Figure 2. Output Power versus Input Power

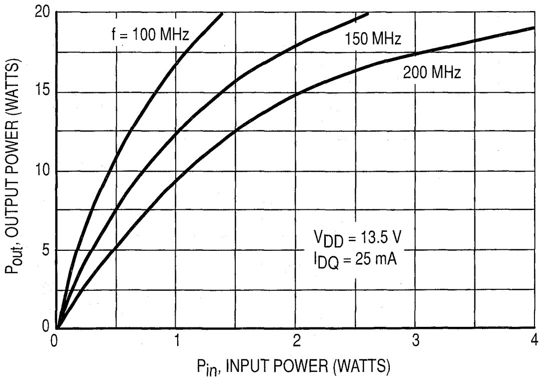


Figure 3. Output Power versus Input Power

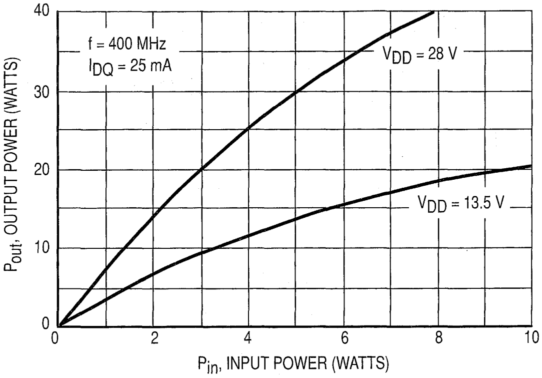


Figure 4. Output Power versus Input Power

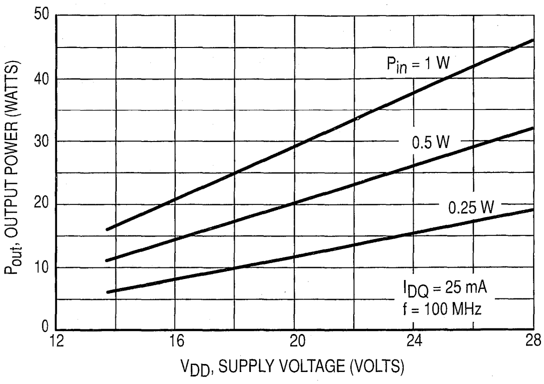


Figure 5. Output Power versus Supply Voltage

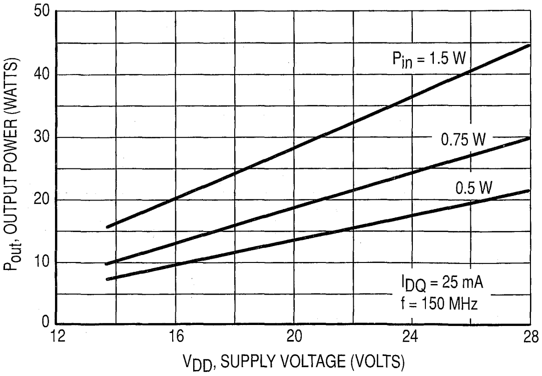


Figure 6. Output Power versus Supply Voltage

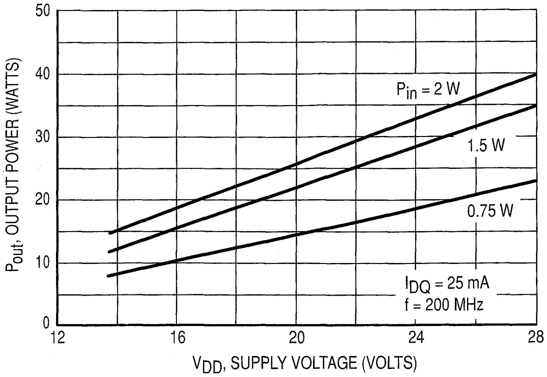


Figure 7. Output Power versus Supply Voltage

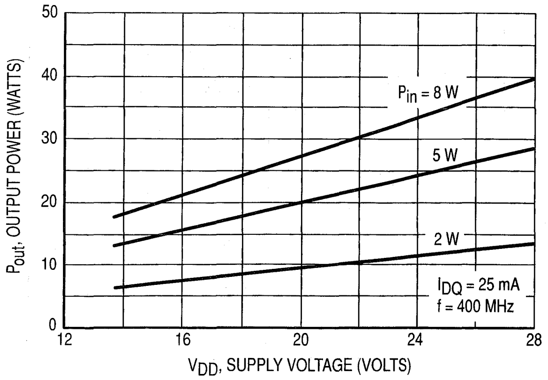


Figure 8. Output Power versus Supply Voltage

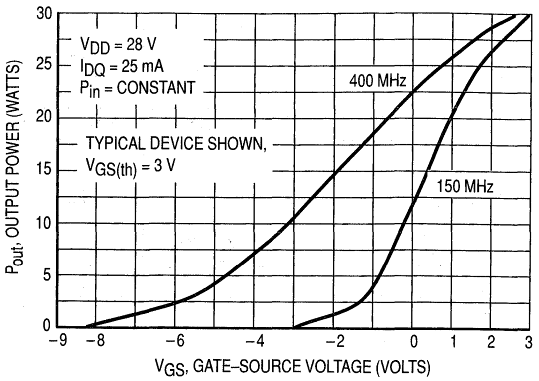


Figure 9. Output Power versus Gate Voltage

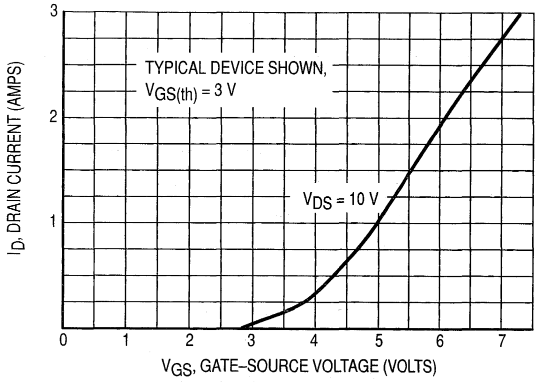


Figure 10. Drain Current versus Gate Voltage (Transfer Characteristics)

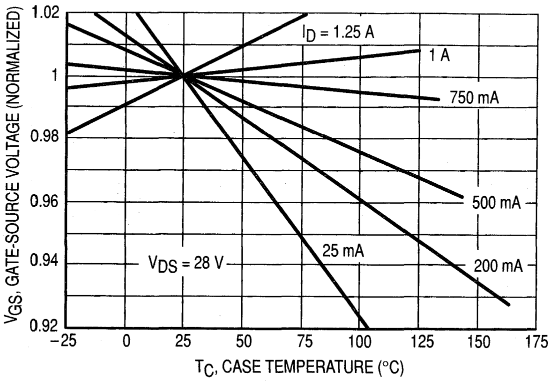


Figure 11. Gate Source Voltage versus Case Temperature

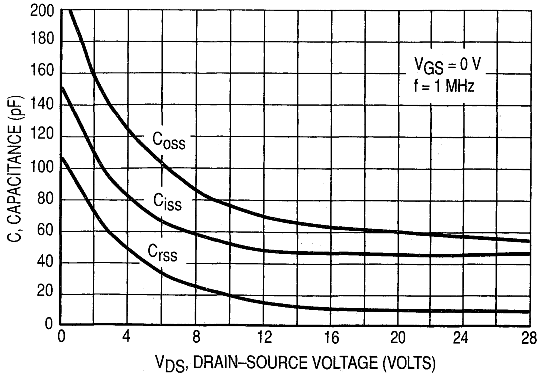


Figure 12. Capacitance versus Drain–Source Voltage

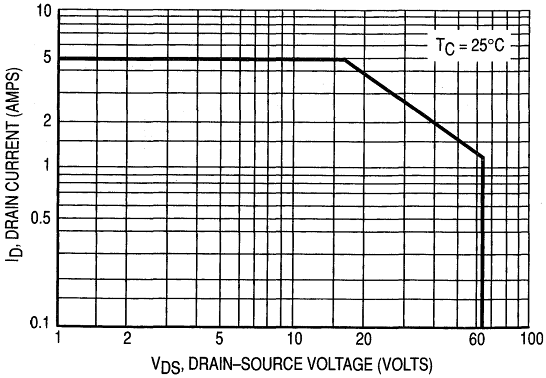
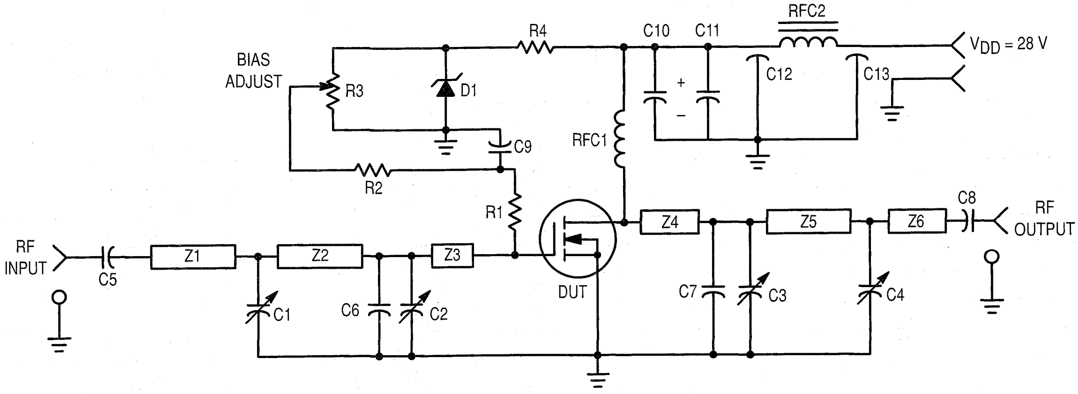


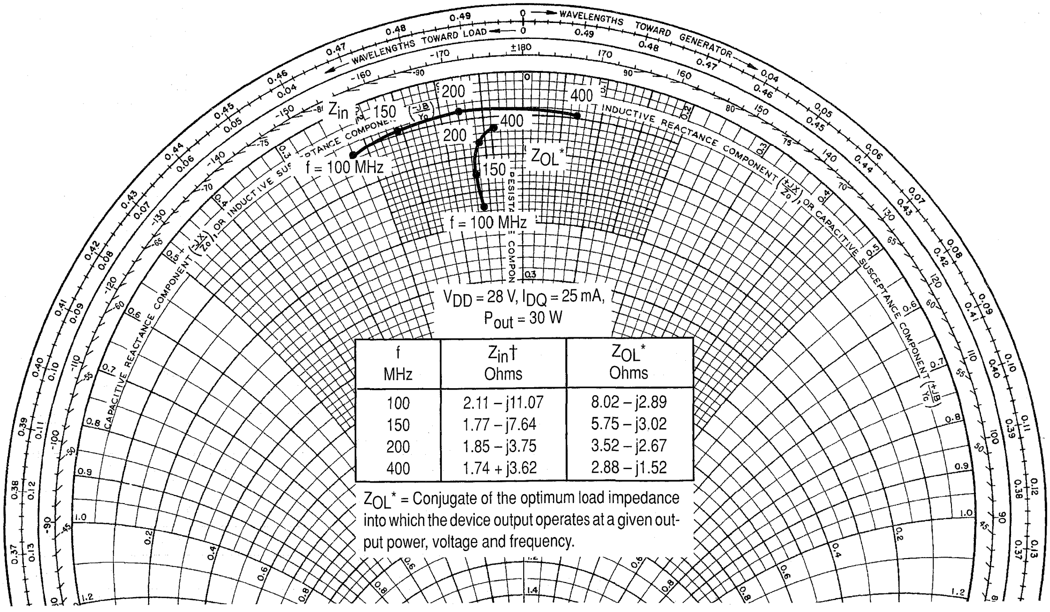
Figure 13. DC Safe Operating Area



C1, C2, C3, C4 — 0–20 pF Johanson, or equivalent
C5, C8 — 270 pF, 100 Mil Chip
C6, C7 — 24 pF Mini–Unelco, or equivalent
C9 — 0.01 μF, 100 V, Disc Ceramic
C10 — 100 μF, 40 V
C11 — 0.1 μF, 50 V, Disc Ceramic
C12, C13 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener
R1, R2 — 10 kΩ, 1/4 W
R3 — 10 Turns, 10 kΩ

R4 — 1.8 kΩ, 1/2 W
Z1 — 2.9″ x 0.166″ Microstrip
Z2, Z4 — 0.35″ x 0.166″ Microstrip
Z3 — 0.40″ x 0.166″ Microstrip
Z5 — 1.05″ x 0.166″ Microstrip
Z6 — 1.9″ x 0.166″ Microstrip
RFC1 — 6 Turns, 0.300″ ID, #20 AWG Enamel, Closewound
RFC2 — Ferroxcube VK–200 — 19/4B
Board — Glass Teflon, 62 Mils

Figure 14. 400 MHz Test Circuit



V_{DD} = 28 V, I_{DQ} = 25 mA,
P_{out} = 30 W

f MHz	Z_{in}† Ohms	Z_{OL}* Ohms
100	2.11 – j11.07	8.02 – j2.89
150	1.77 – j7.64	5.75 – j3.02
200	1.85 – j3.75	3.52 – j2.67
400	1.74 + j3.62	2.88 – j1.52

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 15. Large–Signal Series Equivalent Input and Output Impedance, Z_{in}, Z_{OL}*

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
2.0	0.977	−32	59.48	163	0.011	67	0.661	−36
5.0	0.919	−70	48.67	142	0.024	44	0.692	−78
10	0.852	−109	33.50	122	0.032	29	0.747	−117
20	0.817	−140	19.05	106	0.037	16	0.768	−146
30	0.814	−153	13.11	99	0.038	14	0.774	−157
40	0.811	−159	9.88	95	0.038	13	0.782	−162
50	0.812	−164	7.98	92	0.038	12	0.787	−165
60	0.813	−166	6.66	89	0.038	12	0.787	−168
70	0.815	−168	5.708	86	0.038	11	0.787	−169
80	0.816	−170	5.003	84	0.038	11	0.787	−170
90	0.817	−171	4.560	83	0.038	12	0.787	−171
100	0.817	−172	4.170	81	0.039	13	0.787	−172
110	0.818	−173	3.670	80	0.039	13	0.788	−172
120	0.820	−173	3.420	79	0.039	13	0.788	−173
130	0.821	−173	3.170	79	0.039	13	0.788	−173
140	0.822	−174	2.980	78	0.039	13	0.788	−173
150	0.823	−175	2.826	77	0.039	14	0.788	−173
160	0.824	−175	2.650	76	0.039	14	0.790	−174
170	0.825	−176	2.438	75	0.039	14	0.792	−174
180	0.827	−176	2.325	73	0.039	15	0.793	−174
190	0.829	−177	2.175	72	0.039	16	0.796	−174
200	0.831	−177	2.084	71	0.039	16	0.799	−174
225	0.836	−178	1.824	69	0.039	18	0.805	−174
250	0.846	−178	1.621	66	0.039	21	0.816	−174
275	0.853	−179	1.462	64	0.039	23	0.822	−174
300	0.853	−179	1.319	61	0.040	25	0.833	−174
325	0.856	−179	1.194	59	0.040	27	0.828	−174
350	0.857	+179	1.089	56	0.040	30	0.842	−174
375	0.861	+179	1.014	54	0.042	32	0.849	−174
400	0.865	+178	0.927	51	0.043	35	0.856	−174
425	0.875	+178	0.876	49	0.045	37	0.866	−174
450	0.881	+178	0.810	46	0.046	40	0.870	−174
475	0.886	+177	0.755	44	0.046	43	0.875	−174
500	0.887	+177	0.694	41	0.051	43	0.888	−174
525	0.888	+176	0.677	39	0.052	43	0.890	−174
550	0.896	+176	0.625	36	0.055	45	0.898	−174
575	0.907	+175	0.603	34	0.058	45	0.913	−174
600	0.910	+175	0.585	32	0.061	45	0.918	−174
625	0.910	+174	0.563	30	0.065	45	0.945	−174
650	0.920	+174	0.543	28	0.069	46	0.952	−174
675	0.938	+173	0.533	26	0.074	47	0.974	−174
700	0.943	+171	0.515	24	0.078	47	0.958	−176
725	0.934	+170	0.491	22	0.079	46	0.953	−177
750	0.940	+170	0.475	22	0.084	48	0.943	−177
775	0.953	+169	0.477	21	0.090	48	0.957	−177
800	0.959	+168	0.467	17	0.093	48	0.957	−179

Table 1. Common Source Scattering Parameters
50 Ω System
V_{DS} = 28 V, I_D = 0.75 A

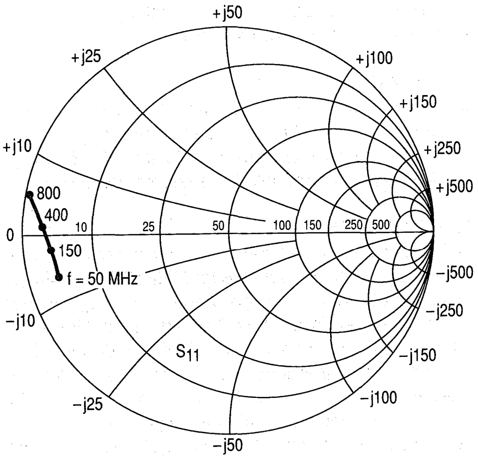


Figure 16. S_{11}, Input Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.75 A

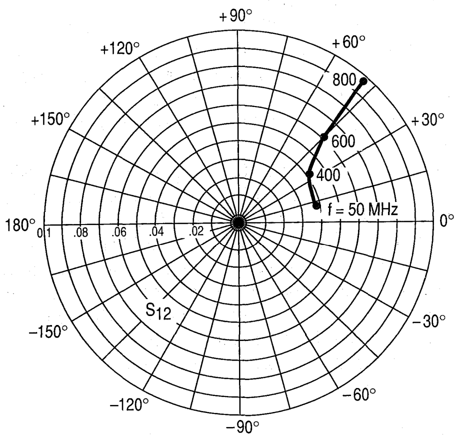


Figure 17. S_{12}, Reverse Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.75 A

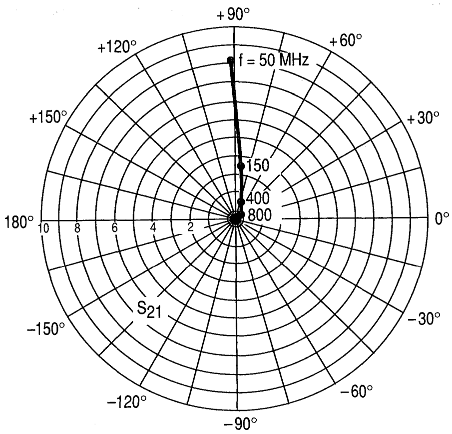


Figure 18. S_{21}, Forward Transmission Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.75 A

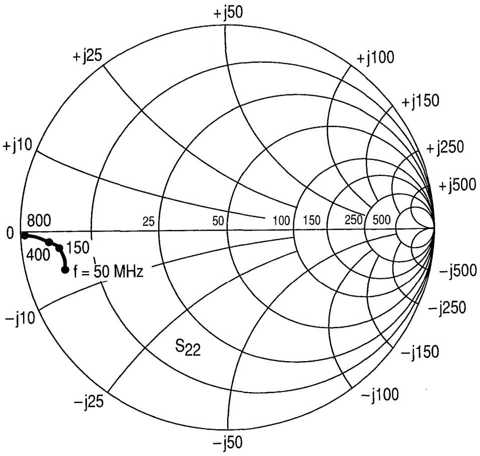


Figure 19. S_{22}, Output Reflection Coefficient versus Frequency
V_{DS} = 28 V I_D = 0.75 A

DESIGN CONSIDERATIONS

The MRF137 is a RF power N–Channel enhancement mode field–effect transistor (FET) designed especially for VHF power amplifier applications. Motorola RF MOS FETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V–groove vertical power FETs.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF137 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. See Figure 10 for a typical plot of drain current versus gate voltage. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF137 was characterized at I_{DQ} = 25 mA, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF137 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems. (See Figure 9.)

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar VHF transistors are suitable for MRF137. See Motorola Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. The higher input impedance of RF MOS FETs helps ease the task of broadband network design. Both small signal scattering parameters and large signal impedances are provided. While the s–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF MOS power FETs.

RF power FETs are triode devices and, therefore, not unilateral. This, coupled with the very high gain of the MRF137, yields a device capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. Two port parameter stability analysis with the MRF137 s–parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A for a discussion of two port network theory and stability.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

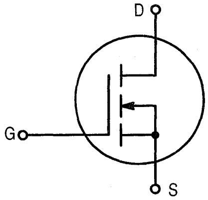
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

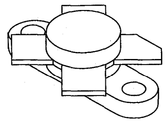
MRF138

. . . designed for power amplifier applications in industrial, commercial and amateur radio equipment to 175 MHz.

- Superior High Order IMD
- Specified 28 Volts, 30 MHz Characteristics
  Output Power = 30 Watts
  Power Gain = 17 dB (Typ)
  Efficiency = 40% (Typ)
- $IMD_{(d3)}$ (30 W PEP) — –30 dB (Typ)
- $IMD_{(d11)}$ (30 W PEP) — –60 dB (Typ)
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR

30 W, 175 MHz
N–CHANNEL MOS
LINEAR RF POWER





CASE 211–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	6.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.66	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.52	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 10 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 10 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 2.5 A)	$V_{DS(on)}$	—	—	2.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 2.5 A)	g_{fs}	0.8	1.2	—	mhos

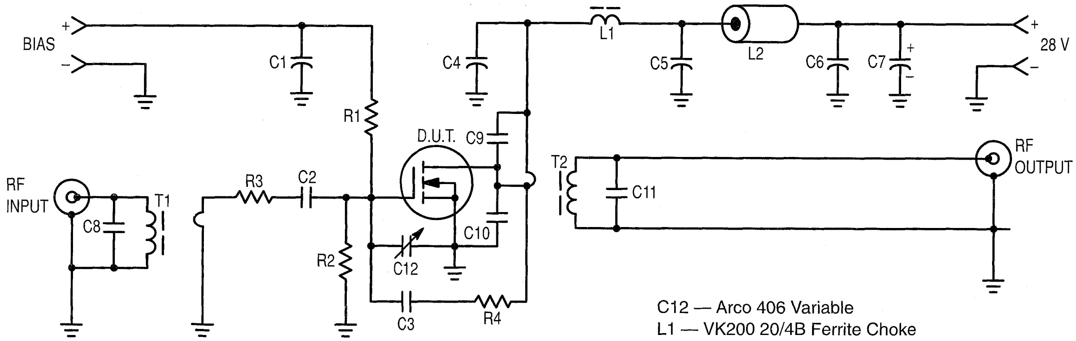
Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	55	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	70	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	14	—	pF
FUNCTIONAL TESTS (SSB)					
Common Source Amplifier Power Gain (V_{DD} = 28 V, P_{out} = 30 W (PEP), (30 MHz) (Figure 1) I_{DQ} = 100 mA) (150 MHz) (Figure 6)	G_{ps}	 — —	 17 14	 — —	dB
Drain Efficiency (Figure 1) (30 W PEP) (V_{DD} = 28 V, f = 30 MHz, I_{DQ} = 100 mA) (30 W CW)	η	— —	40 50	— —	%
Intermodulation Distortion (Figure 1) (V_{DD} = 28 V, P_{out} = 30 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 100 mA)	 $IMD_{(d3)}$ $IMD_{(d11)}$	 — —	 −30 −60	 — —	dB
Load Mismatch (Figure 1) (V_{DD} = 28 V, P_{out} = 30 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
CLASS A PERFORMANCE					
Intermodulation Distortion (1) and Power Gain (V_{DD} = 28 V, P_{out} = 10 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 1.0 A)	G_{PS} $IMD_{(d3)}$ $IMD_{(d9-13)}$	— — —	20 −50 −70	— — —	dB

NOTE:
1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C1, C2, C3, C4, C5, C6 — 0.1 µF Ceramic Chip or Equivalent
C7 — 10 µF, 100 V Electrolytic
C8 — 10 pF Dipped Mica
C9 — 68 pF Dipped Mica
C10, C11 — 47 pF Dipped Mica

C12 — Arco 406 Variable
L1 — VK200 20/4B Ferrite Choke
or Equivalent (3.0 µH)
L2 — Ferrite Bead(s), 2.0 µH
R1, R2 — 200 Ω, 1/2 W Carbon
R3 — 2.2 Ω, 1/2 W Carbon
R4 — 330 Ω, 1.0 W Carbon
T1 — 4:1 Impedance Transformer
T2 — 1:4 Impedance Transformer

Figure 1. 2.0 to 50 MHz Broadband Test Circuit

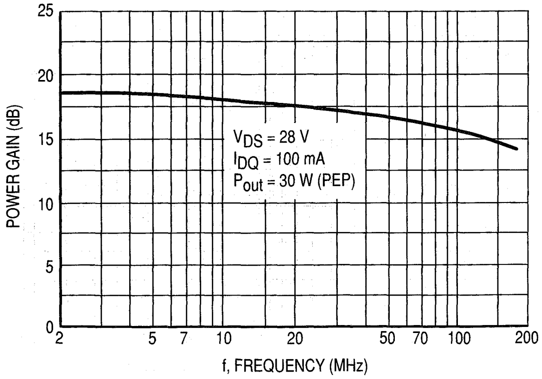


Figure 2. Power Gain versus Frequency

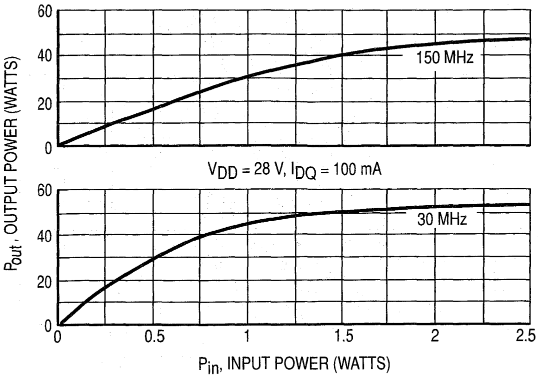


Figure 3. Output Power versus Input Power

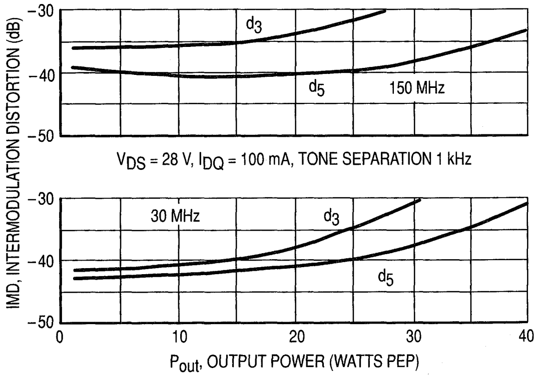


Figure 4. IMD versus P_{out}

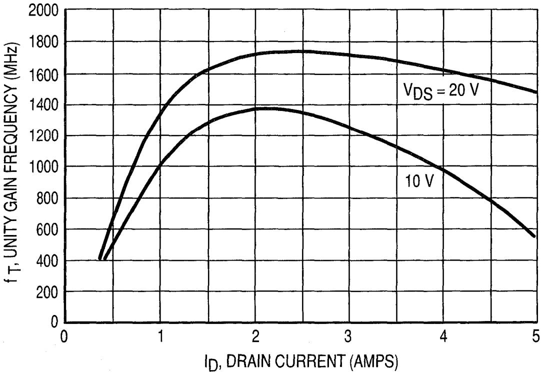
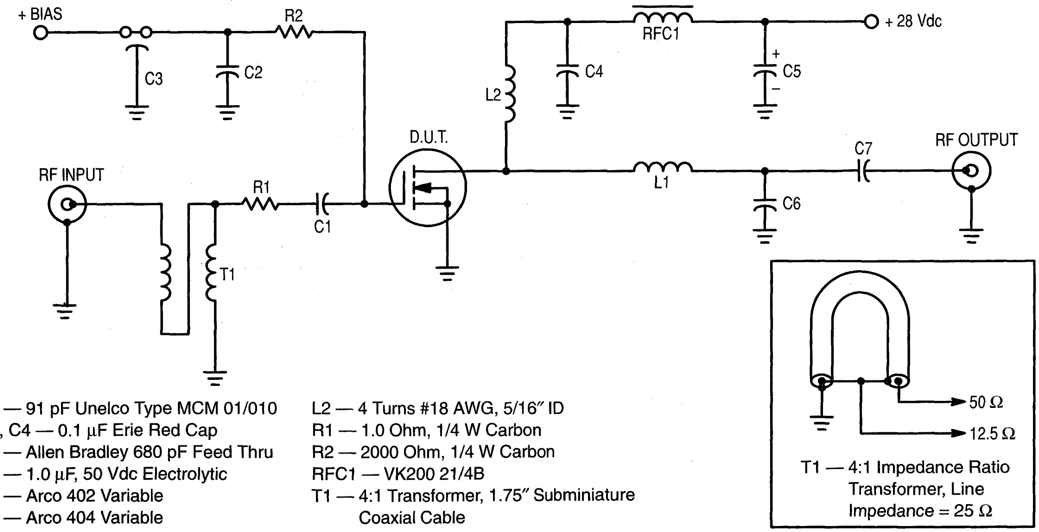


Figure 5. Common Source Unity Current Gain Frequency versus Drain Current



C1 — 91 pF Unelco Type MCM 01/010
C2, C4 — 0.1 µF Erie Red Cap
C3 — Allen Bradley 680 pF Feed Thru
C5 — 1.0 µF, 50 Vdc Electrolytic
C6 — Arco 402 Variable
C7 — Arco 404 Variable
L1 — 2 Turns #18 AWG, 5/16″ ID
L2 — 4 Turns #18 AWG, 5/16″ ID
R1 — 1.0 Ohm, 1/4 W Carbon
R2 — 2000 Ohm, 1/4 W Carbon
RFC1 — VK200 21/4B
T1 — 4:1 Transformer, 1.75″ Subminiature Coaxial Cable

Figure 6. 150 MHz Test Circuit

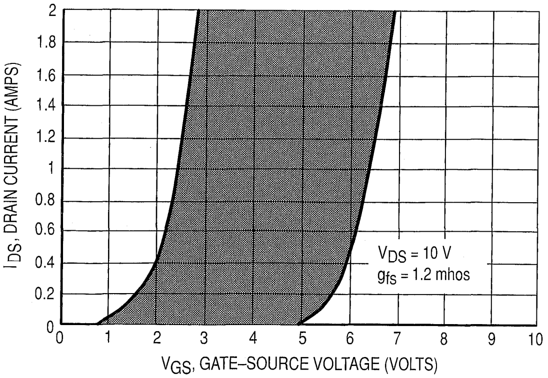


Figure 7. Gate Voltage versus Drain Current

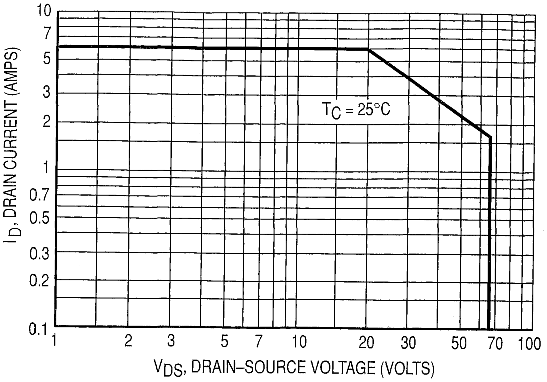
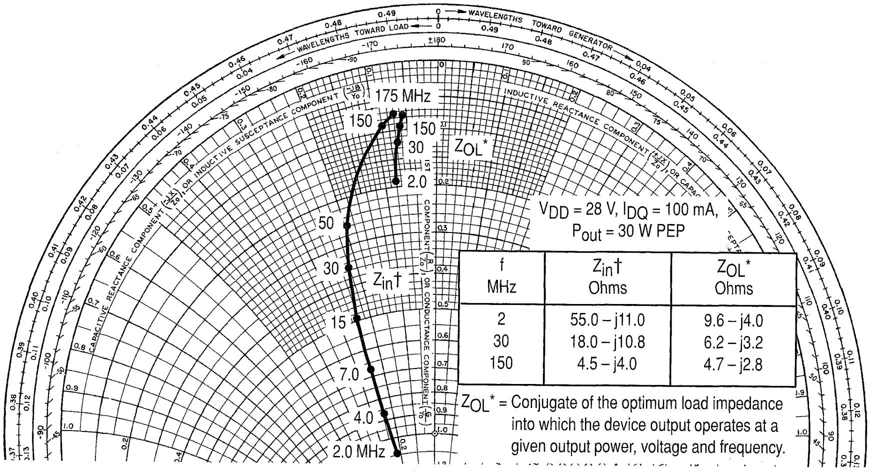


Figure 8. DC Safe Operating Area



V_{DD} = 28 V, I_{DQ} = 100 mA,
P_{out} = 30 W PEP

f MHz	Z_{in}† Ohms	Z_{OL}* Ohms
2	55.0 – j11.0	9.6 – j4.0
30	18.0 – j10.8	6.2 – j3.2
150	4.5 – j4.0	4.7 – j2.8

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

†Gate Shunted by 100 Ω.

Figure 9. Large–Signal Series Equivalent Input/Output Impedance, Z_{in}†, Z_{OL}*

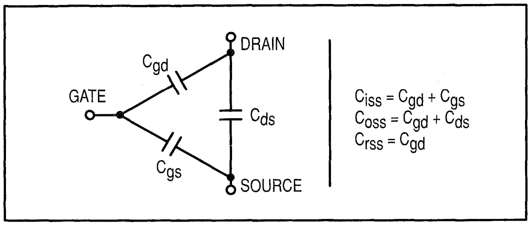
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$r_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

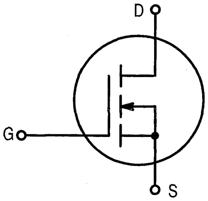
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

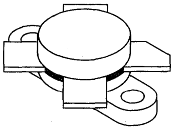
MRF140

150 W, to 150 MHz
N–CHANNEL MOS
LINEAR RF POWER
FET

Designed primarily for linear large–signal output stages up to 150 MHz frequency range.

- Specified 28 Volts, 30 MHz Characteristics
  Output Power = 150 Watts
  Power Gain = 15 dB (Typ)
  Efficiency = 40% (Typ)
- Superior High Order IMD
- $IMD_{(d3)}$ (150 W PEP) — –30 dB (Typ)
- $IMD_{(d11)}$ (150 W PEP) — –60 dB (Typ)
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage	V_{DGO}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.7	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

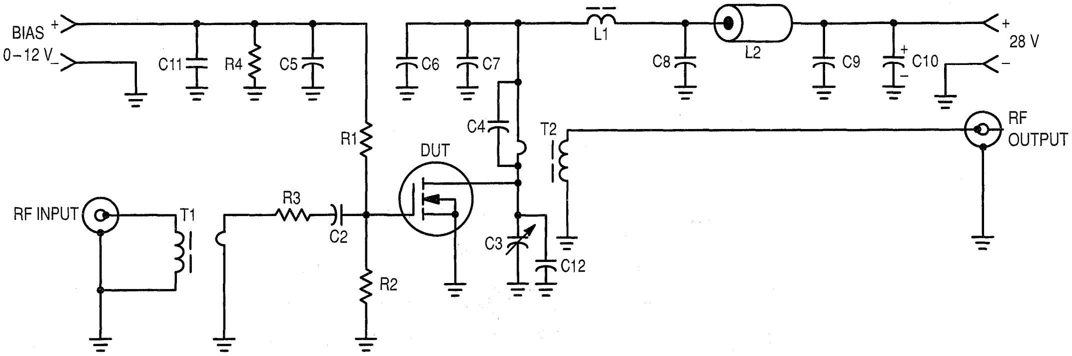
Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 Vdc, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 Adc)	$V_{DS(on)}$	0.1	0.9	1.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	4.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	450	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	450	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	100	—	pF
FUNCTIONAL TESTS (SSB)					
Common Source Amplifier Power Gain (30 MHz) (V_{DD} = 28 V, P_{out} = 150 W (PEP), I_{DQ} = 250 mA) (150 MHz)	G_{ps}	— —	15 6.0	— —	dB
Drain Efficiency (V_{DD} = 28 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_D (Max) = 6.5 A)	η	—	40	—	%
Intermodulation Distortion (1) (V_{DD} = 28 V, P_{out} = 150 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 250 mA)	$IMD_{(d3)}$ $IMD_{(d11)}$	— —	−30 −60	— —	dB
Load Mismatch (V_{DD} = 28 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 250 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:
1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C2, C5, C6, C7, C8, C9 — 0.1 μF Ceramic Chip or Monolythic with Short Leads
C3 — Arco 469
C4 — 820 pF Unencapsulated Mica or Dipped Mica with Short Leads
C10 — 10 μF/100 V Electrolytic
C11 — 1 μF, 50 V, Tantalum
C12 — 330 pF, Dipped Mica (Short leads)

L1 — VK200/4B Ferrite Choke or Equivalent, 3.0 μH
L2 — Ferrite Bead(s), 2.0 μH
R1, R2 — 51 Ω/1.0 W Carbon
R3 — 1.0 Ω/1.0 W Carbon or Parallel Two 2 Ω, 1/2 W Resistors
R4 — 1 kΩ/1/2 W Carbon
T1 — 16:1 Broadband Transformer
T2 — 1:25 Broadband Transformer

Figure 1. 30 MHz Test Circuit (Class AB)

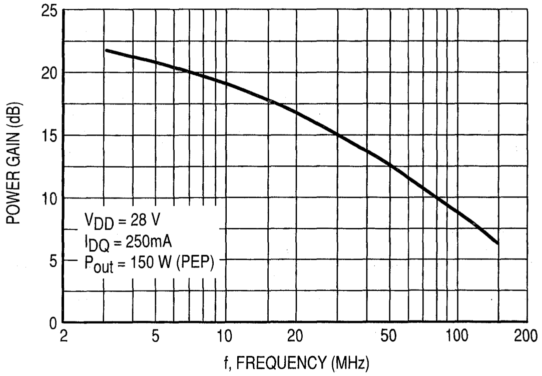


Figure 2. Power Gain versus Frequency

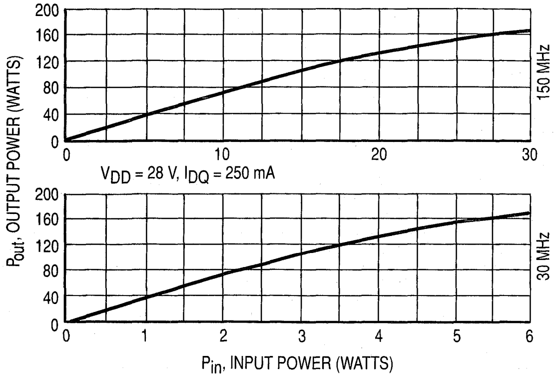


Figure 3. Output Power versus Input Power

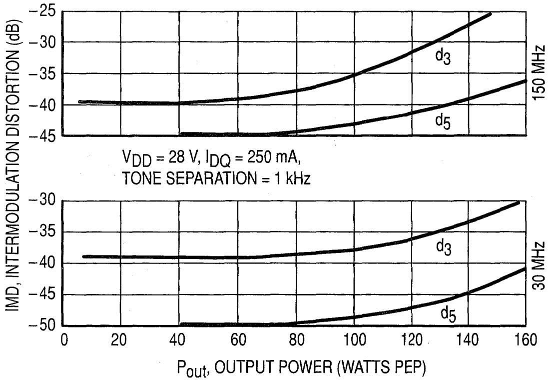


Figure 4. IMD versus P_{out}

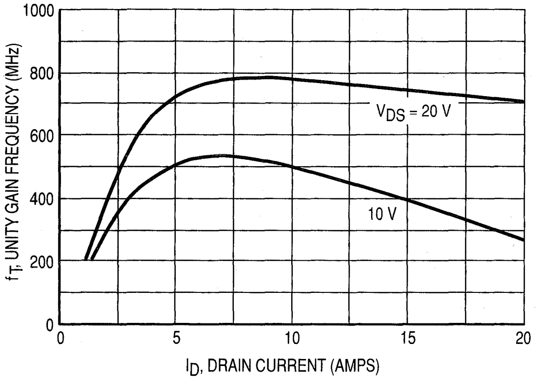


Figure 5. Common Source Unity Gain Frequency versus Drain Current

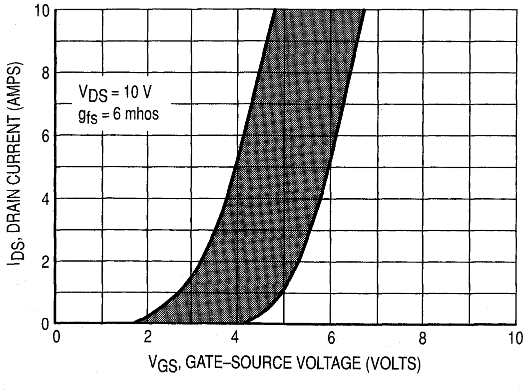
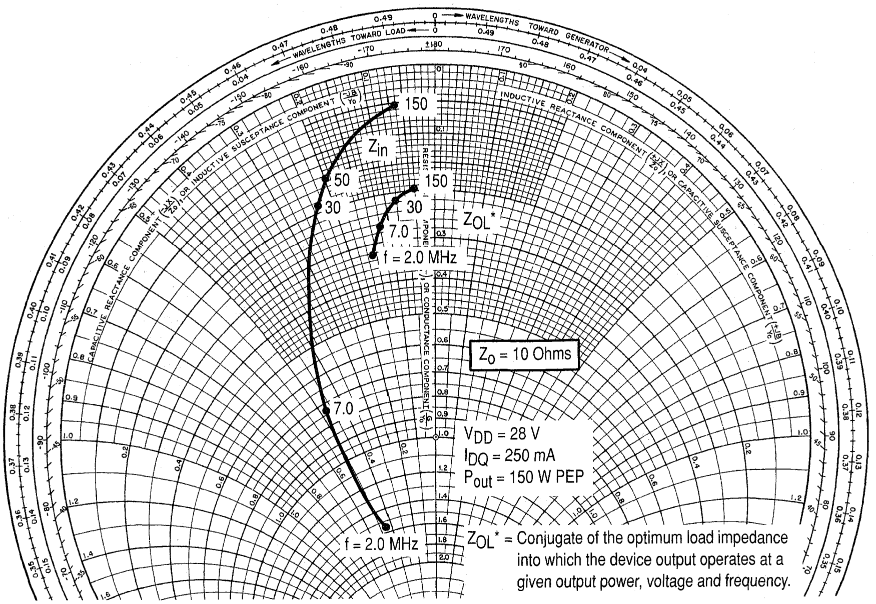
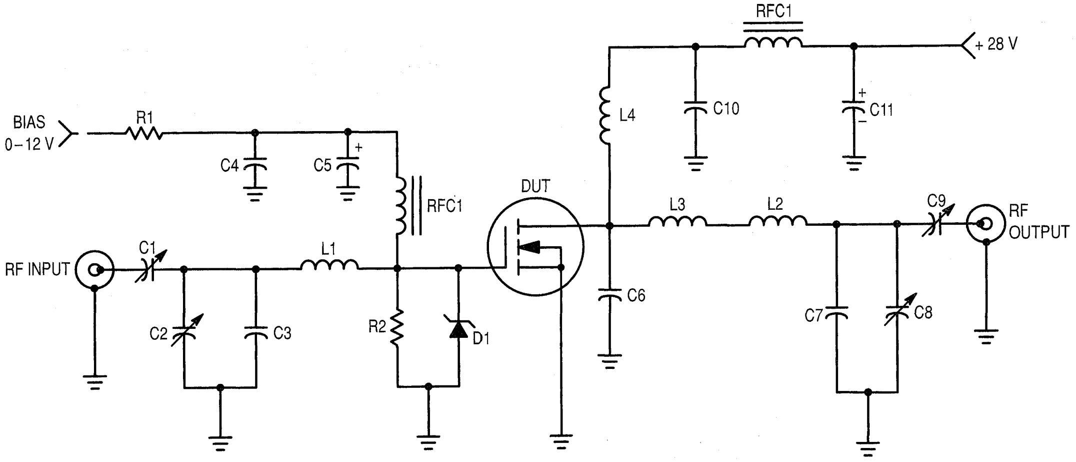


Figure 6. Gate Voltage versus Drain Current



NOTE: Gate Shunted by 25 Ohms.

Figure 7. Series Equivalent Impedance



C1, C2, C8 — Arco 463 or equivalent
C3 — 25 pF, Unelco
C4 — 0.1 µF, Ceramic
C5 — 1.0 µF, 15 WV Tantalum
C6 — 15 pF, Unelco J101
C7 — 25 pF, Unelco J101
C9 — Arco 262 or equivalent
C10 — 0.05 µF, Ceramic
C11 — 15 µF, 35 WV Electrolytic

L1 — 3/4″, #18 AWG into Hairpin
L2 — Printed Line, 0.200″ x 0.500″
L3 — 7/8″, #16 AWG into Hairpin
L4 — 2 Turns, #16 AWG, 5/16 ID
RFC1 — 5.6 µH, Molded Choke
RFC2 — VK200-4B
R1, R2 — 150 Ω, 1.0 W Carbon

Figure 8. 150 MHz Test Circuit (Class AB)

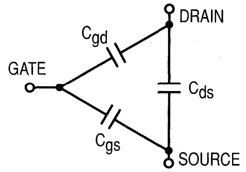
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$$C_{iss} = C_{gd} + C_{gs}$$
$$C_{oss} = C_{gd} + C_{ds}$$
$$C_{rss} = C_{gd}$$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$r_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

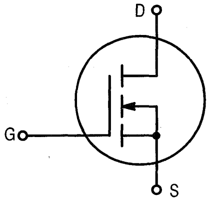
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode MOSFET

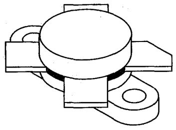
MRF141

Designed for broadband commercial and military applications at frequencies to 175 MHz. The high power, high gain and broadband performance of this device makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance at 30 MHz, 28 V:
  - Output Power — 150 W
  - Gain — 18 dB (22 dB Typ)
  - Efficiency — 40%
- Typical Performance at 175 MHz, 50 V:
  - Output Power — 150 W
  - Gain — 13 dB
- Low Thermal Resistance
- Ruggedness Tested at Rated Output Power
- Nitride Passivated Die for Enhanced Reliability

150 W, 28 V, 175 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFET





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage	V_{DGO}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	300 1.71	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

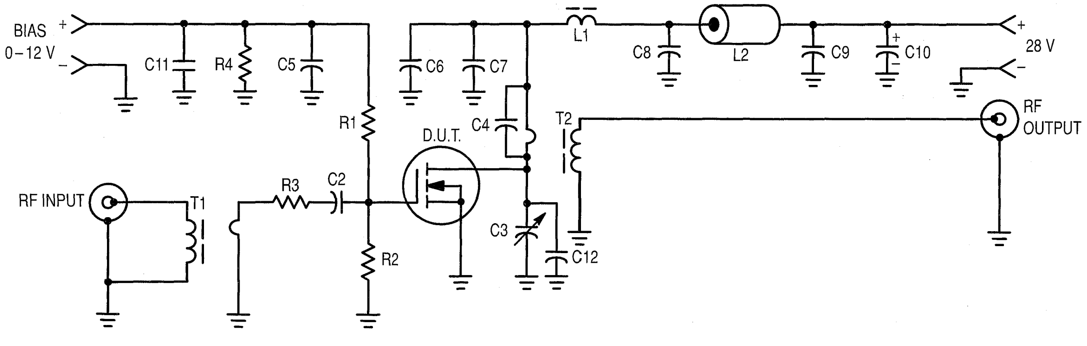
REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 A)	$V_{DS(on)}$	0.1	0.9	1.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	5.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	350	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	420	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	40	—	pF
FUNCTIONAL TESTS					
Common Source Amplifier Power Gain, f = 30; 30.001 MHz (V_{DD} = 28 V, P_{out} = 150 W (PEP), I_{DQ} = 250 mA) f = 175 MHz	G_{ps}	16 —	20 10	— —	dB
Drain Efficiency (V_{DD} = 28 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 250 mA, I_D (Max) = 5.95 A)	η	40	45	—	%
Intermodulation Distortion (1) (V_{DD} = 28 V, P_{out} = 150 W (PEP), f = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 250 mA)	$IMD_{(d3)}$ $IMD_{(d11)}$	— —	−30 −60	−28 —	dB
Load Mismatch (V_{DD} = 28 V, P_{out} = 150 W (PEP), f1 = 30; 30.001 MHz, I_{DQ} = 250 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
CLASS A PERFORMANCE					
Intermodulation Distortion (1) and Power Gain (V_{DD} = 28 V, P_{out} = 50 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 4.0 A)	G_{PS} $IMD_{(d3)}$ $IMD_{(d9-13)}$	— — —	23 −50 −75	— — —	dB

NOTE:

1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C2, C5, C6, C7, C8, C9 — 0.1 μF Ceramic Chip or Monolythic with Short Leads
C3 — Arco 469
C4 — 820 pF Unencapsulated Mica or Dipped Mica with Short Leads
C10 — 10 μF/100 V Electrolytic
C11 — 1 μF, 50 V, Tantalum
C12 — 330 pF, Dipped Mica (Short leads)

L1 — VK200/4B Ferrite Choke or Equivalent, 3.0 μH
L2 — Ferrite Bead(s), 2.0 μH
R1, R2 — 51 Ω/1.0 W Carbon
R3 — 1.0 Ω/1.0 W Carbon or Parallel Two 2 Ω, 1/2 W Resistors
R4 — 1 kΩ/1/2 W Carbon
T1 — 16:1 Broadband Transformer
T2 — 1:25 Broadband Transformer
Board Material — 0.062″ Fiberglass (G10), 1 oz. Copper Clad, 2 Sides, ε_r = 5

Figure 1. 30 MHz Test Circuit (Class AB)

TYPICAL CHARACTERISTICS

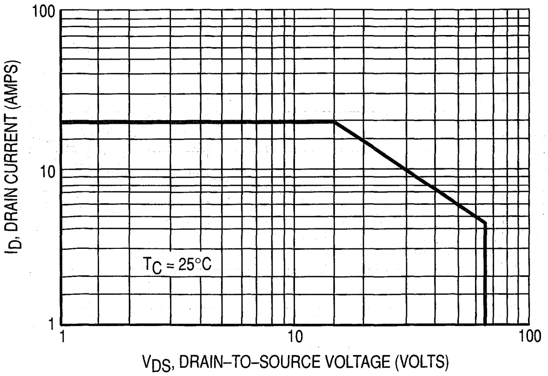


Figure 2. DC Safe Operating Area

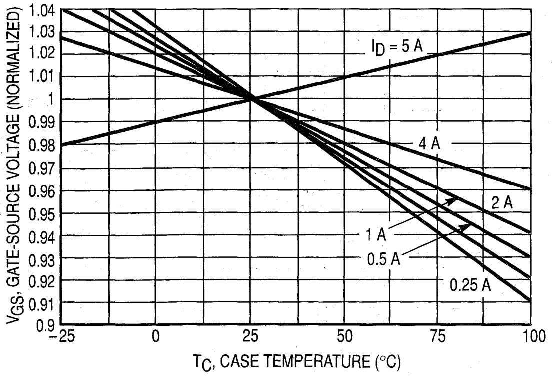


Figure 3. Gate–Source Voltage versus Case Temperature

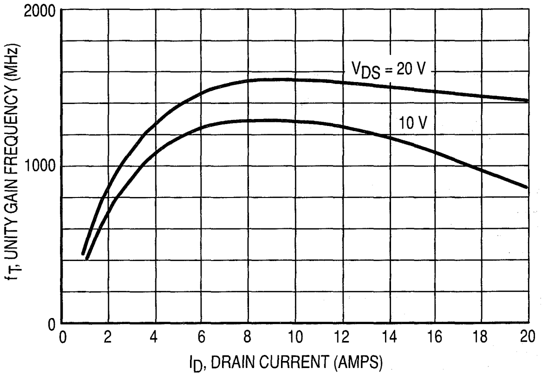


Figure 4. Common Source Unity Gain Frequency versus Drain Current

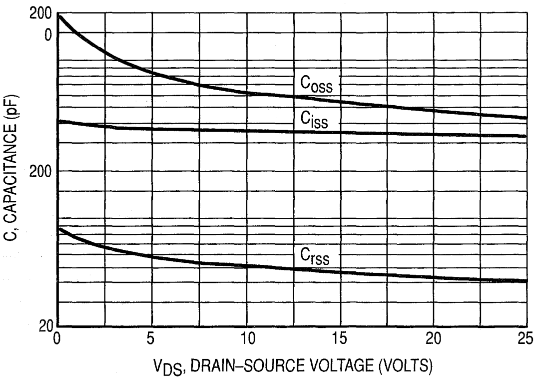


Figure 5. Capacitance versus Drain–Source Voltage

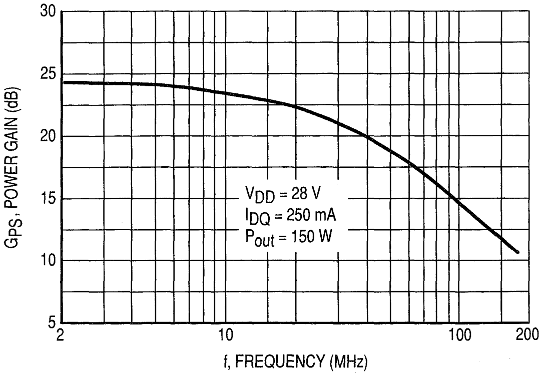


Figure 6. Power Gain versus Frequency

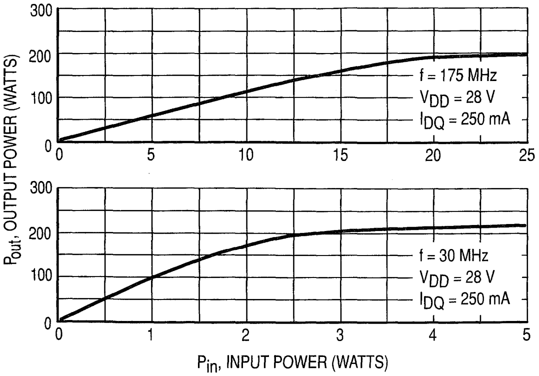


Figure 7. Output Power versus Input Power

TYPICAL CHARACTERISTICS

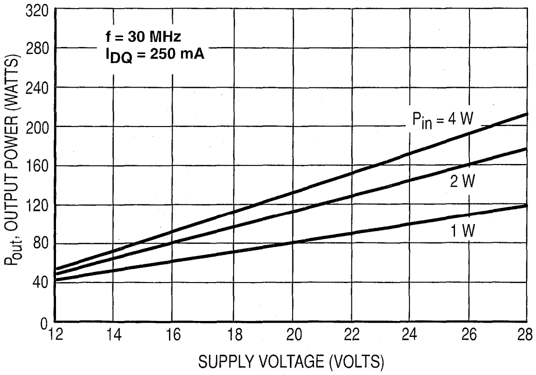


Figure 8. Output Power versus Supply Voltage

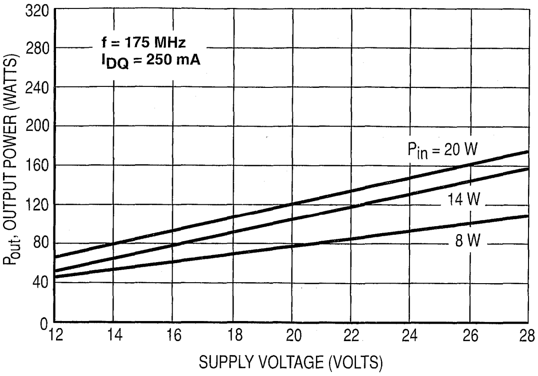


Figure 9. Output Power versus Supply Voltage

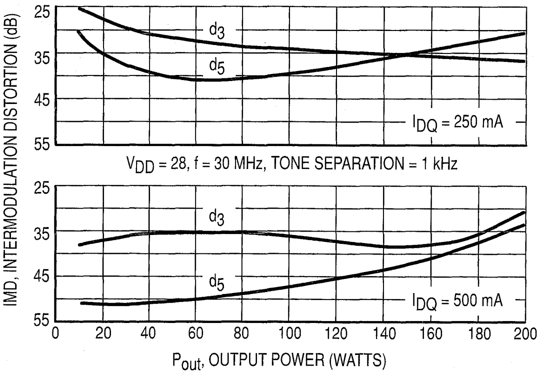
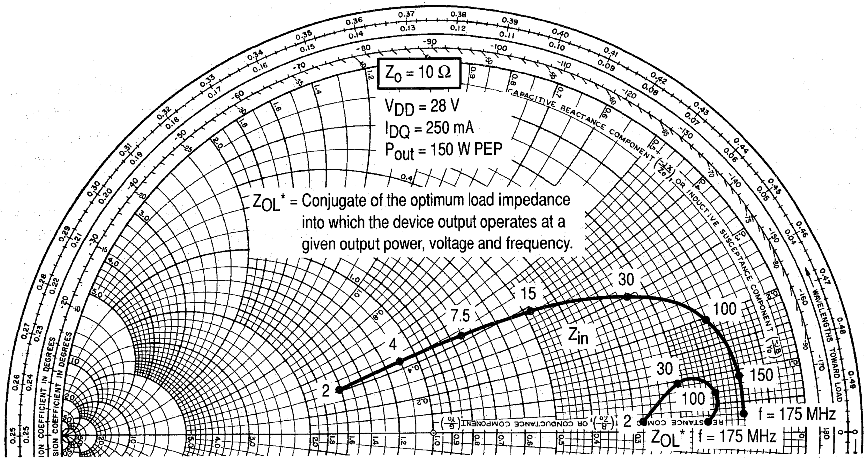
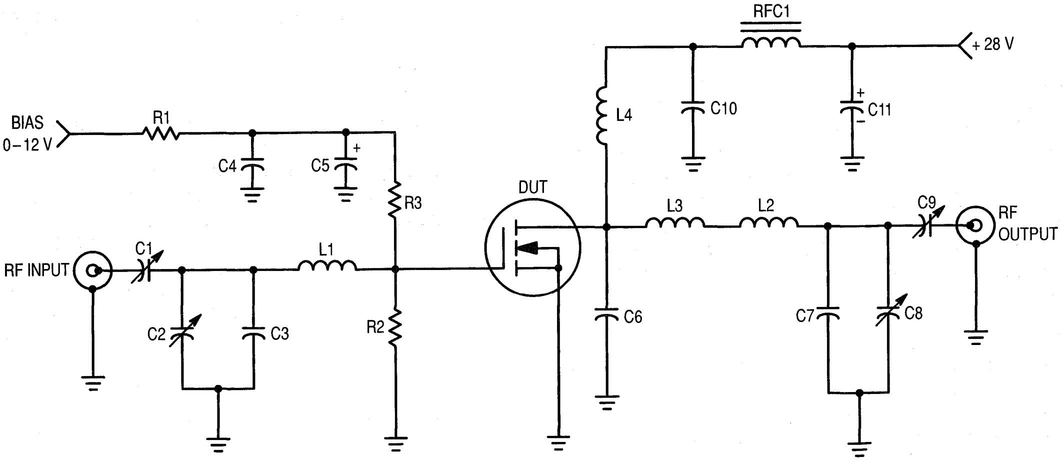


Figure 10. IMD versus P_{out} (PEP)



ZOL* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 11. Input and Output Impedances



C1, C2, C8 — Arco 463 or equivalent
C3 — 25 pF, Unelco
C4 — 0.1 µF, Ceramic
C5 — 1.0 µF, 15 WV Tantalum
C6 — 25 pF, Unelco J101
C7 — 25 pF, Unelco J101
C9 — Arco 262 or equivalent
C10 — 0.05 µF, Ceramic
C11 — 15 µF, 35 WV Electrolytic

L1 — 3/4″, #18 AWG into Hairpin
L2 — Printed Line, 0.200″ x 0.500″
L3 — 7/8″, #16 AWG into Hairpin
L4 — 2 Turns, #16 AWG, 5/16 ID
RFC1 — 5.6 µH, Molded Choke
RFC2 — VK200–4B
R1 — 150 Ω, 1.0 W Carbon
R2 — 10 kΩ, 1/2 W Carbon
R3 — 120 Ω, 1/2 W Carbon

Figure 12. 175 MHz Test Circuit (Class AB)

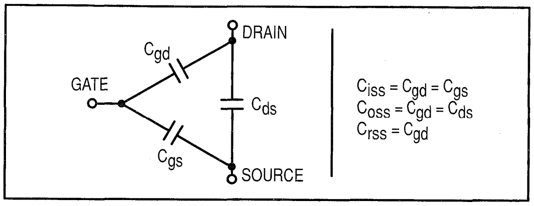
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal anode gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} = C_{gs}$
$C_{oss} = C_{gd} = C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 4 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gate of this device is essentially capacitor. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the device due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — This device does not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

HANDLING CONSIDERATIONS

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with a grounded iron.

DESIGN CONSIDERATIONS

The MRF141 is an RF Power, MOS, N–channel enhancement mode field–effect transistor (FET) designed for HF and VHF power amplifier applications.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power MOSFETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal.

DC BIAS

The MRF141 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF141 was characterized at I_{DQ} = 250 mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF141 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

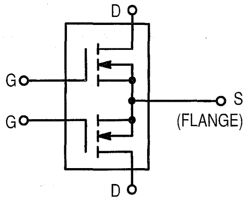
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode MOSFET

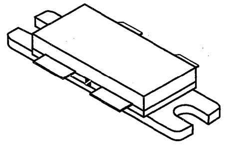
MRF141G

300 W, 28 V, 175 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFET

Designed for broadband commercial and military applications at frequencies to 175 MHz. The high power, high gain and broadband performance of this device makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance at 175 MHz, 28 V:
  Output Power — 300 W
  Gain — 12 dB (14 dB Typ)
  Efficiency — 50%
- Low Thermal Resistance — 0.35°C/W
- Ruggedness Tested at Rated Output Power
- Nitride Passivated Die for Enhanced Reliability





CASE 375–04, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage	V_{DGO}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	32	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	500 2.85	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.35	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

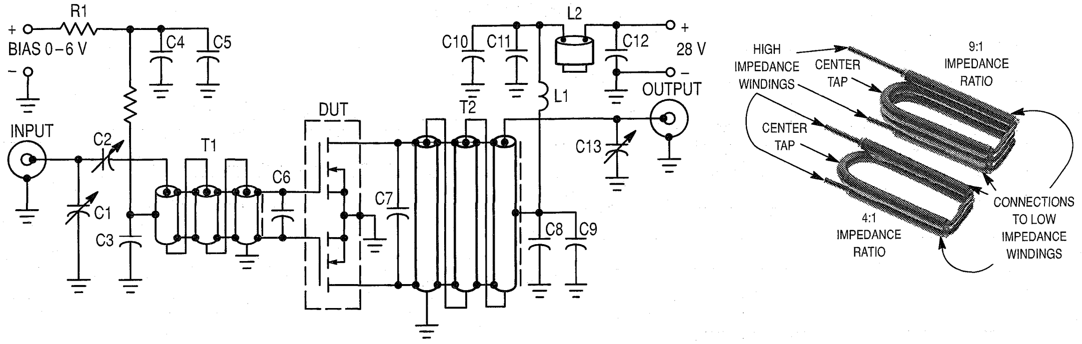
REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 A)	$V_{DS(on)}$	0.1	0.9	1.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	5.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	350	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	420	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	40	—	pF
FUNCTIONAL TESTS (2)					
Common Source Amplifier Power Gain (V_{DD} = 28 V, P_{out} = 300 W, I_{DQ} = 500 mA, f = 175 MHz)	G_{ps}	12	14	—	dB
Drain Efficiency (V_{DD} = 28 V, P_{out} = 300 W, f = 175 MHz, I_D (Max) = 21.4 A)	η	45	55	—	%
Load Mismatch (V_{DD} = 28 V, P_{out} = 300 W, I_{DQ} = 500 mA, f = 175 MHz, VSWR 5:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTES:

1. Each side measured separately.
2. Measured in push–pull configuration.



C1 — Arco 402, 1.5–20 pF
C2 — Arco 406, 15–115 pF
C3, C4, C8, C9, C10 — 1000 pF Chip
C5, C11 — 0.1 µF Chip
C6 — 330 pF Chip
C7 — 200 pF and 180 pF Chips in Parallel
C12 — 0.47 µF Ceramic Chip, Kemet 1215 or Equivalent
C13 — Arco 403, 3.0–35 pF
L1 — 10 Turns AWG #16 Enameled Wire, Close Wound, 1/4″ I.D.
L2 — Ferrite Beads of Suitable Material for 1.5–2.0 µH Total Inductance
R1 — 100 Ohms, 1/2 W
R2 — 1.0 kOhm, 1/2 W

Unless Otherwise Noted, All Chip Capacitors are ATC Type 100 or Equivalent.

T1 — 9:1 RF Transformer. Can be made of 15–18 Ohms Semirigid Co–Ax, 62–90 Mils O.D.
T2 — 1:9 RF Transformer. Can be made of 15–18 Ohms Semirigid Co–Ax, 70–90 Mils O.D.

Board Material — 0.062″ Fiberglass (G10), 1 oz. Copper Clad, 2 Sides, $\varepsilon_r = 5$

NOTE: For stability, the input transformer T1 must be loaded with ferrite toroids or beads to increase the common mode inductance. For operation below 100 MHz. The same is required for the output transformer.

See pictures for construction details.

Figure 1. 175 MHz Test Circuit

TYPICAL CHARACTERISTICS

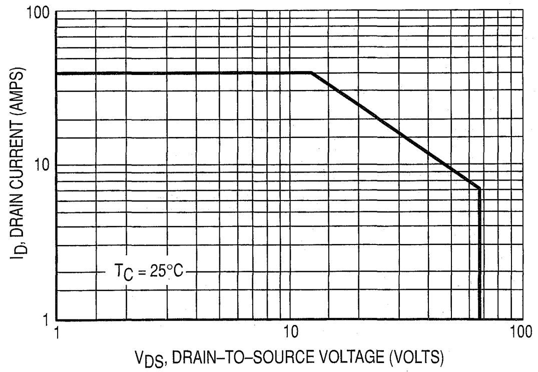


Figure 2. DC Safe Operating Area

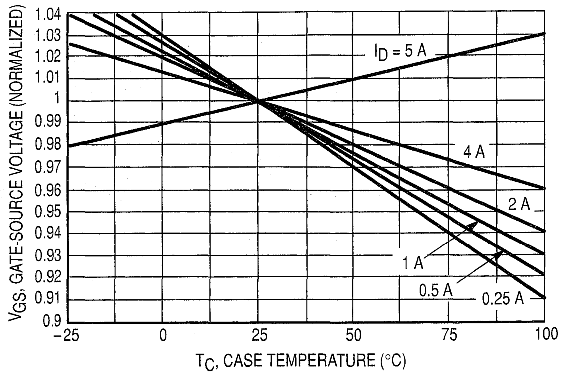
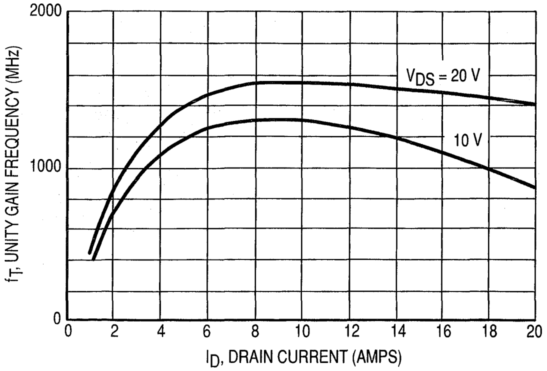


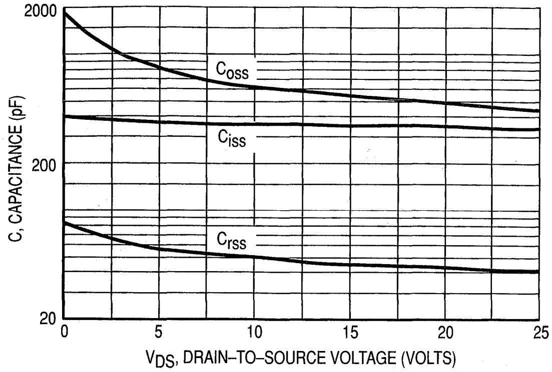
Figure 3. Gate–Source Voltage versus Case Temperature

TYPICAL CHARACTERISTICS



NOTE: Data shown applies to each half of MRF141G.

Figure 4. Common Source Unity Gain Frequency versus Drain Current



NOTE: Data shown applies to each half of MRF141G.

Figure 5. Capacitance versus Drain–Source Voltage

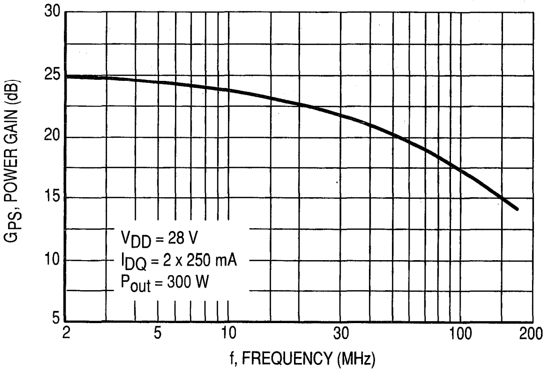


Figure 6. Power Gain versus Frequency

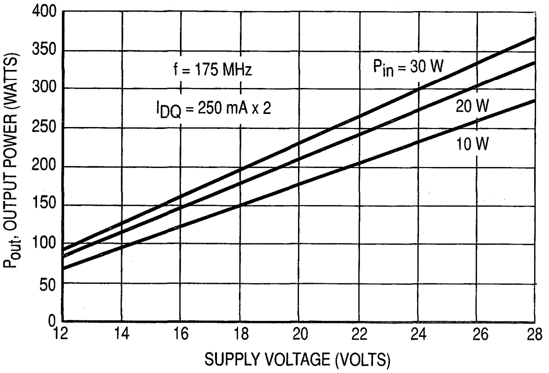
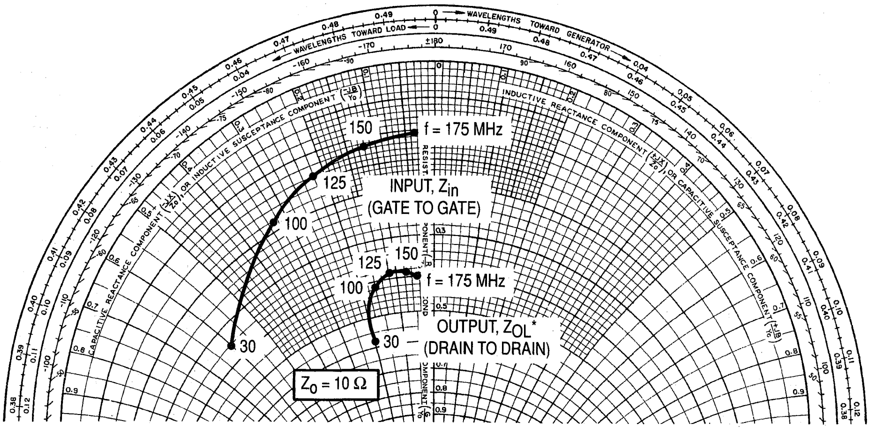


Figure 7. Output Power versus Supply Voltage



Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 8. Input and Output Impedances

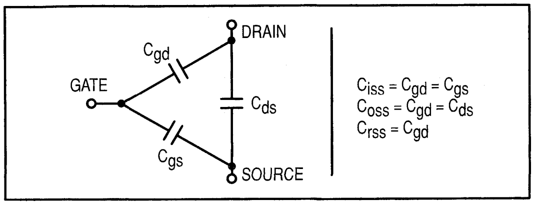
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal anode gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} = C_{gs}$
$C_{oss} = C_{gd} = C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 4 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gate of this device is essentially capacitor. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the device due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — This device does not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

HANDLING CONSIDERATIONS

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with a grounded iron.

DESIGN CONSIDERATIONS

The MRF141G is an RF Power, MOS, N–channel enhancement mode field–effect transistor (FET) designed for HF and VHF power amplifier applications.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power MOSFETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal.

DC BIAS

The MRF141G is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF141G was characterized at $I_{DQ} = 250$ mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF141G may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

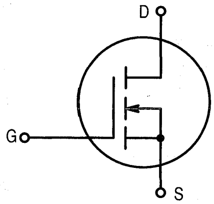
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

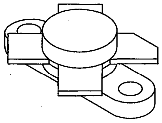
MRF148

30 W, to 175 MHz
N–CHANNEL MOS
LINEAR RF POWER
FET

Designed for power amplifier applications in industrial, commercial and amateur radio equipment to 175 MHz.

- Superior High Order IMD
- Specified 50 Volts, 30 MHz Characteristics
  Output Power = 30 Watts
  Power Gain = 18 dB (Typ)
  Efficiency = 40% (Typ)
- $IMD_{(d3)}$ (30 W PEP) — –35 dB (Typ)
- $IMD_{(d11)}$ (30 W PEP) — –60 dB (Typ)
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR





CASE 211–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	120	Vdc
Drain–Gate Voltage	V_{DGO}	120	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	6.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.66	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.52	°C/W

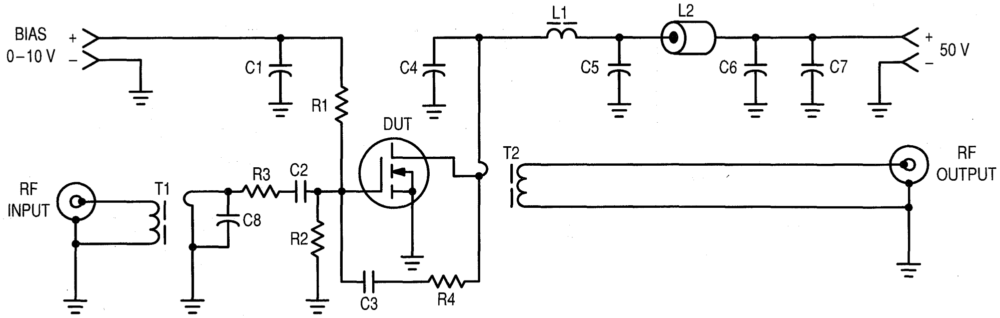
Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 10 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	1.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	100	nAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 10 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 2.5 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 2.5 A)	g_{fs}	0.8	1.2	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	50	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	35	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	8.0	—	pF
FUNCTIONAL TESTS (SSB)					
Common Source Amplifier Power Gain (30 MHz) (V_{DD} = 50 V, P_{out} = 30 W (PEP), I_{DQ} = 100 mA) (175 MHz)	G_{ps}	— —	18 15	— —	dB
Drain Efficiency (30 W PEP) (V_{DD} = 50 V, f = 30 MHz, I_{DQ} = 100 mA) (30 W CW)	η	— —	40 50	— —	%
Intermodulation Distortion (V_{DD} = 50 V, P_{out} = 30 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 100 mA)	$IMD_{(d3)}$ $IMD_{(d11)}$	— —	−35 −60	— —	dB
Load Mismatch (V_{DD} = 50 V, P_{out} = 30 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
CLASS A PERFORMANCE					
Intermodulation Distortion (1) and Power Gain (V_{DD} = 50 V, P_{out} = 10 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 1.0 A)	G_{PS} $IMD_{(d3)}$ $IMD_{(d9-13)}$	— — —	20 −50 −70	— — —	dB

NOTE:
1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C1, C2, C3, C4, C5, C6 — 0.1 µF Ceramic Chip or Equivalent
C7 — 10 µF, 100 V Electrolytic
C8 — 100 pF Dipped Mica
L1 — VK200 20/4B Ferrite Choke or Equivalent (3.0 µH)
L2 — Ferrite Bead(s), 2.0 µH

R1, R2 — 200 Ω, 1/2 W Carbon
R3 — 4.7 Ω, 1/2 W Carbon
R4 — 470 Ω, 1.0 W Carbon
T1 — 4:1 Impedance Transformer
T2 — 1:2 Impedance Transformer

Figure 1. 2.0 to 50 MHz Broadband Test Circuit

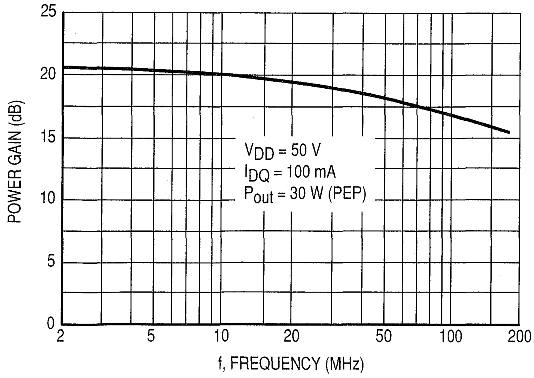


Figure 2. Power Gain versus Frequency

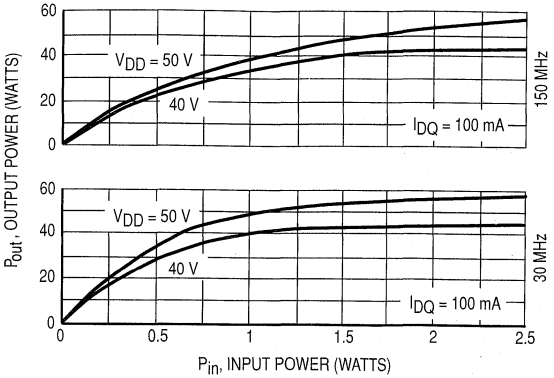


Figure 3. Output Power versus Input Power

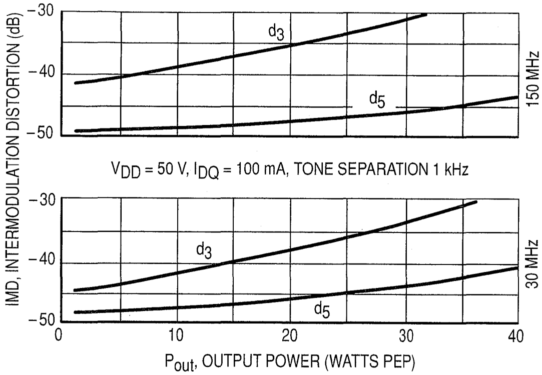


Figure 4. IMD versus P_{out}

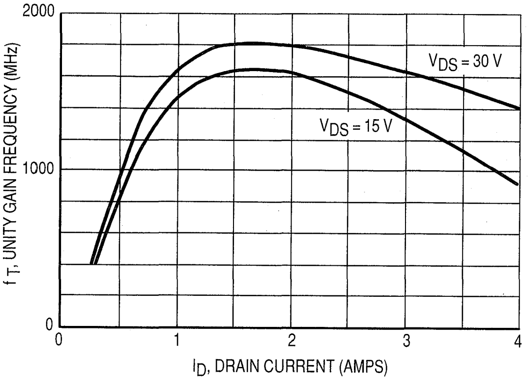
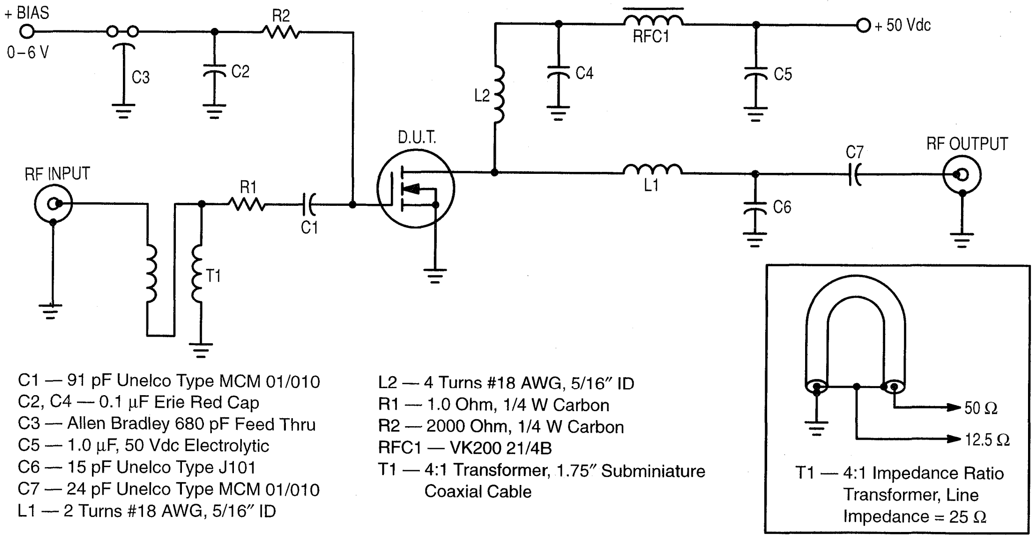


Figure 5. Common Source Unity Gain Frequency versus Drain Current



C1 — 91 pF Unelco Type MCM 01/010
C2, C4 — 0.1 µF Erie Red Cap
C3 — Allen Bradley 680 pF Feed Thru
C5 — 1.0 µF, 50 Vdc Electrolytic
C6 — 15 pF Unelco Type J101
C7 — 24 pF Unelco Type MCM 01/010
L1 — 2 Turns #18 AWG, 5/16″ ID
L2 — 4 Turns #18 AWG, 5/16″ ID
R1 — 1.0 Ohm, 1/4 W Carbon
R2 — 2000 Ohm, 1/4 W Carbon
RFC1 — VK200 21/4B
T1 — 4:1 Transformer, 1.75″ Subminiature Coaxial Cable

T1 — 4:1 Impedance Ratio Transformer, Line Impedance = 25 Ω

Figure 6. 150 MHz Test Circuit

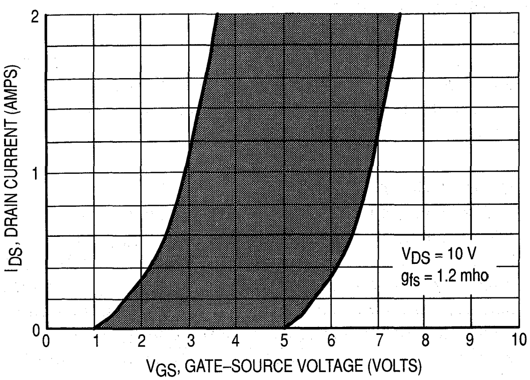


Figure 7. Gate Voltage versus Drain Current

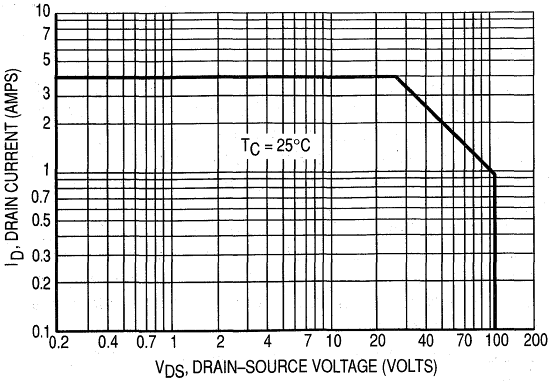
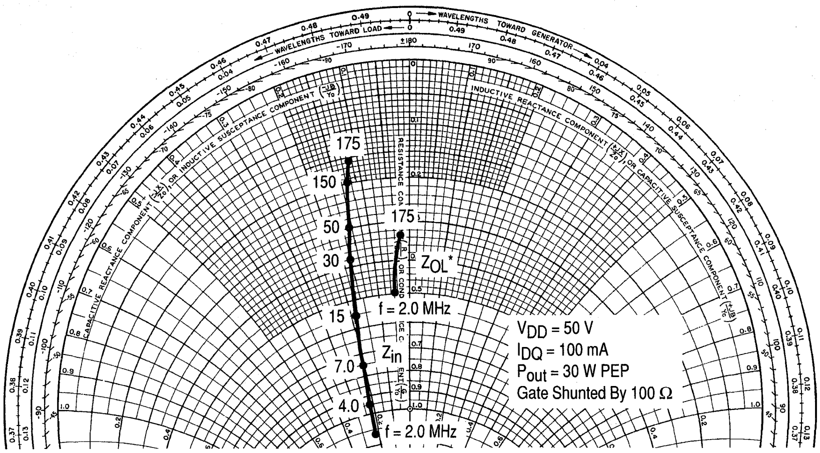


Figure 8. DC Safe Operating Area (SOA)



Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 9. Impedance Coordinates — 50 Ohm Characteristic Impedance

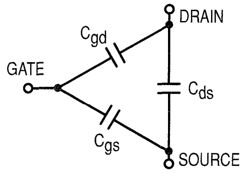
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$r_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

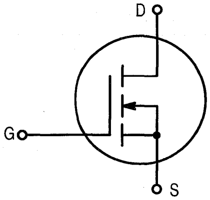
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

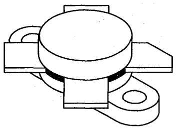
MRF150

Designed primarily for linear large–signal output stages up to 150 MHz frequency range.

- Specified 50 Volts, 30 MHz Characteristics
  Output Power = 150 Watts
  Power Gain = 17 dB (Typ)
  Efficiency = 45% (Typ)
- Superior High Order IMD
- $\mathrm{IMD}_{(d3)}$ (150 W PEP) — –32 dB (Typ)
- $\mathrm{IMD}_{(d11)}$ (150 W PEP) — –60 dB (Typ)
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR

150 W, to 150 MHz
N–CHANNEL MOS
LINEAR RF POWER
FET





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	125	Vdc
Drain–Gate Voltage	V_{DGO}	125	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

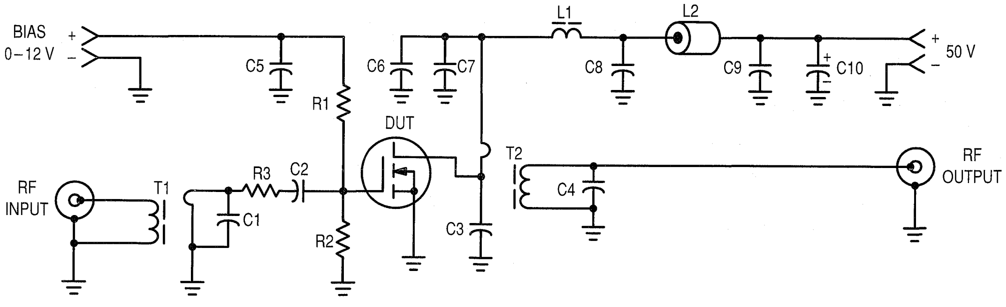
REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	4.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	450	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	250	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	40	—	pF
FUNCTIONAL TESTS (SSB)					
Common Source Amplifier Power Gain f = 30 MHz (V_{DD} = 50 V, P_{out} = 150 W (PEP), I_{DQ} = 250 mA) f = 150 MHz	G_{ps}	— —	17 8.0	— —	dB
Drain Efficiency (V_{DD} = 50 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_D (Max) = 3.75 A)	η	—	45	—	%
Intermodulation Distortion (1) (V_{DD} = 50 V, P_{out} = 150 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 250 mA)	$IMD_{(d3)}$ $IMD_{(d11)}$	— —	−32 −60	— —	dB
Load Mismatch (V_{DD} = 50 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 250 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
CLASS A PERFORMANCE					
Intermodulation Distortion (1) and Power Gain (V_{DD} = 50 V, P_{out} = 50 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 3.0 A)	G_{PS} $IMD_{(d3)}$ $IMD_{(d9-13)}$	— — —	20 −50 −75	— — —	dB

NOTE:

1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C1 — 470 pF Dipped Mica
C2, C5, C6, C7, C8, C9 — 0.1 μF Ceramic Chip or Monolythic with Short Leads
C3 — 200 pF Unencapsulated Mica or Dipped Mica with Short Leads
C4 — 15 pF Unencapsulated Mica or Dipped Mica with Short Leads
C10 — 10 μF/100 V Electrolytic
L1 — VK200/4B Ferrite Choke or Equivalent, 3.0 μH
L2 — Ferrite Bead(s), 2.0 μH
R1, R2 — 51 Ω/1.0 W Carbon
R3 — 3.3 Ω/1.0 W Carbon (or 2.0 x 6.8 Ω/1/2 W in Parallel
T1 — 9:1 Broadband Transformer
T2 — 1:9 Broadband Transformer

Figure 1. 30 MHz Test Circuit (Class AB)

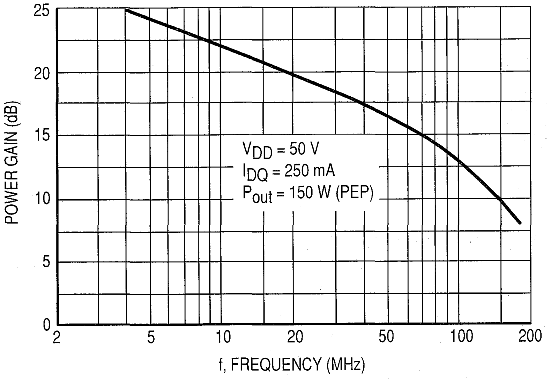


Figure 2. Power Gain versus Frequency

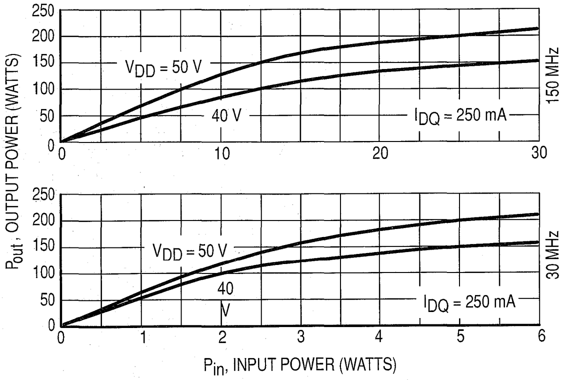


Figure 3. Output Power versus Input Power

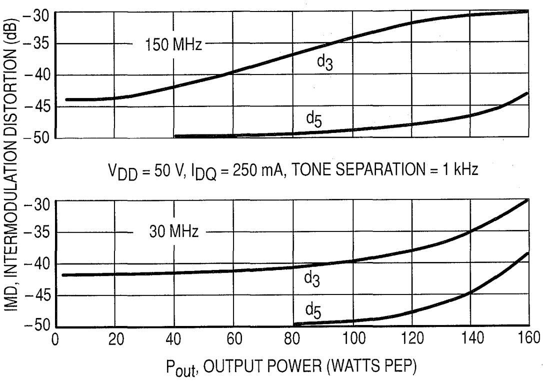


Figure 4. IMD versus P_{out}

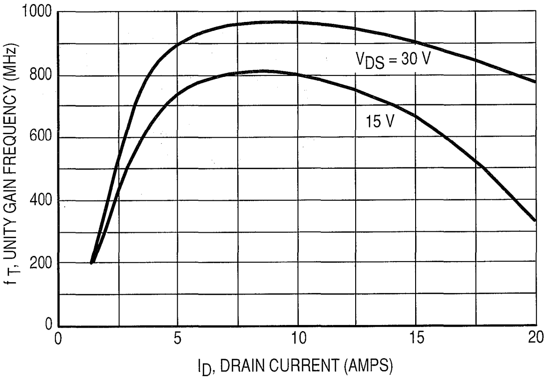


Figure 5. Common Source Unity Gain Frequency versus Drain Current

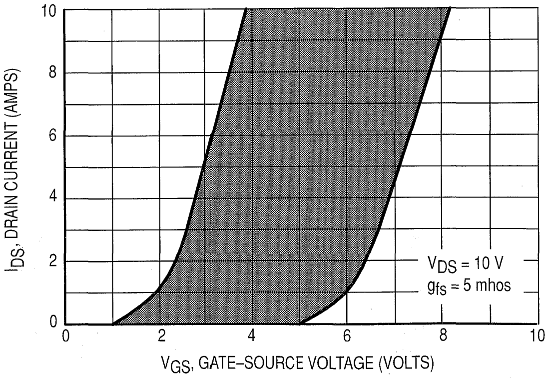
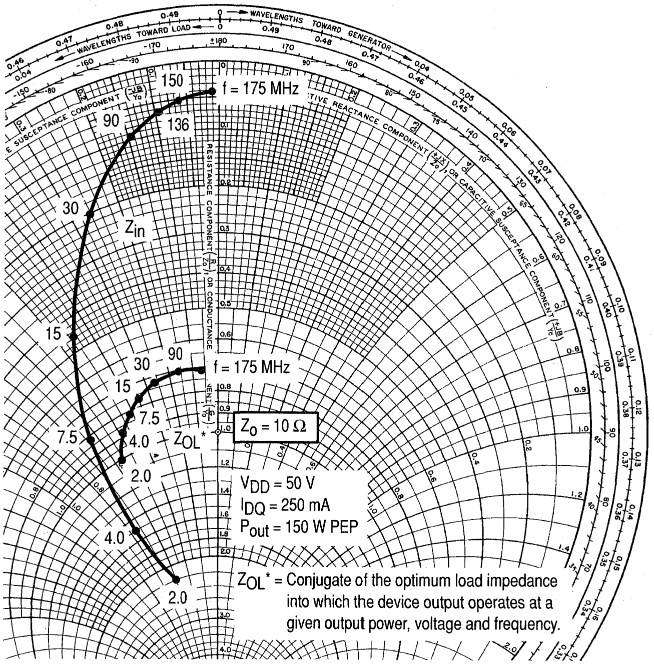


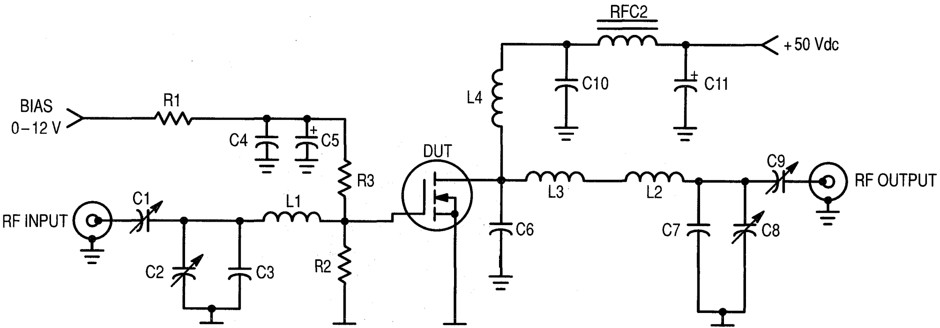
Figure 6. Gate Voltage versus Drain Current



Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

NOTE: Gate Shunted by 25 Ohms.

Figure 7. Series Equivalent Impedance



C1, C2, C8 — Arco 463 or equivalent
C3 — 25 pF, Unelco
C4 — 0.1 µF, Ceramic
C5 — 1.0 µF, 15 WV Tantalum
C6 — 25 pF, Unelco J101
C7 — 25 pF, Unelco J101
C9 — Arco 262 or equivalent
C10 — 0.05 µF, Ceramic
C11 — 15 µF, 60 WV Electrolytic

L1 — 3/4″, 18 AWG into Hairpin
L2 — Printed Line, 0.200″ x 0.500″
L3 — 1″, #16 AWG into Hairpin
L4 — 2 Turns #16 AWG, 5/16 ID
RFC1 — 5.6 µH, Choke
RFC2 — VK200–4B
R1 — 150 Ω, 1.0 W Carbon
R2 — 10 kΩ, 1/2 W Carbon
R3 — 120 Ω, 1/2 W Carbon

Figure 8. 150 MHz Test Circuit (Class AB)

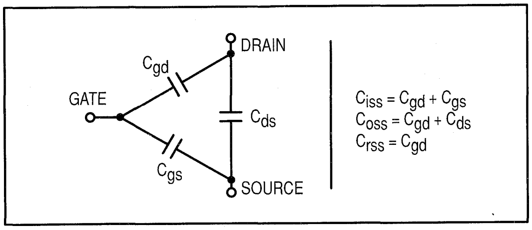
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$$C_{iss} = C_{gd} + C_{gs}$$
$$C_{oss} = C_{gd} + C_{ds}$$
$$C_{rss} = C_{gd}$$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$r_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

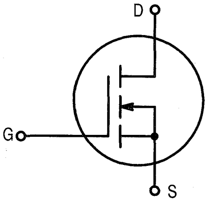
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode MOSFET

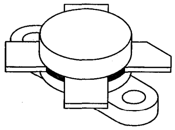
MRF151

150 W, 50 V, 175 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFET

Designed for broadband commercial and military applications at frequencies to 175 MHz. The high power, high gain and broadband performance of this device makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance at 30 MHz, 50 V:
  Output Power — 150 W
  Gain — 18 dB (22 dB Typ)
  Efficiency — 40%
- Typical Performance at 175 MHz, 50 V:
  Output Power — 150 W
  Gain — 13 dB
- Low Thermal Resistance
- Ruggedness Tested at Rated Output Power
- Nitride Passivated Die for Enhanced Reliability





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	125	Vdc
Drain–Gate Voltage	V_{DGO}	125	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

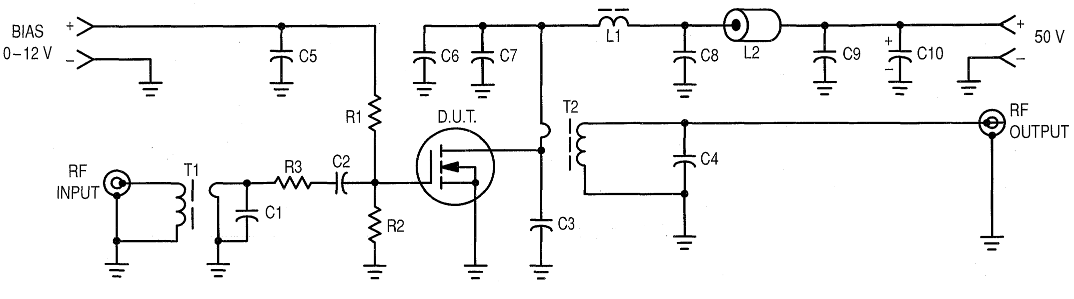
NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	5.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	350	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	225	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	20	—	pF
FUNCTIONAL TESTS					
Common Source Amplifier Power Gain, f = 30; 30.001 MHz (V_{DD} = 50 V, P_{out} = 150 W (PEP), I_{DQ} = 250 mA) f = 175 MHz	G_{ps}	18 —	22 13	— —	dB
Drain Efficiency (V_{DD} = 50 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_D (Max) = 3.75 A)	η	40	45	—	%
Intermodulation Distortion (1) (V_{DD} = 50 V, P_{out} = 150 W (PEP), f = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 250 mA)	$IMD_{(d3)}$ $IMD_{(d11)}$	— —	−32 −60	−30 —	dB
Load Mismatch (V_{DD} = 50 V, P_{out} = 150 W (PEP), f1 = 30; 30.001 MHz, I_{DQ} = 250 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
CLASS A PERFORMANCE					
Intermodulation Distortion (1) and Power Gain (V_{DD} = 50 V, P_{out} = 50 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 3.0 A)	G_{PS} $IMD_{(d3)}$ $IMD_{(d9-13)}$	— — —	23 −50 −75	— — —	dB

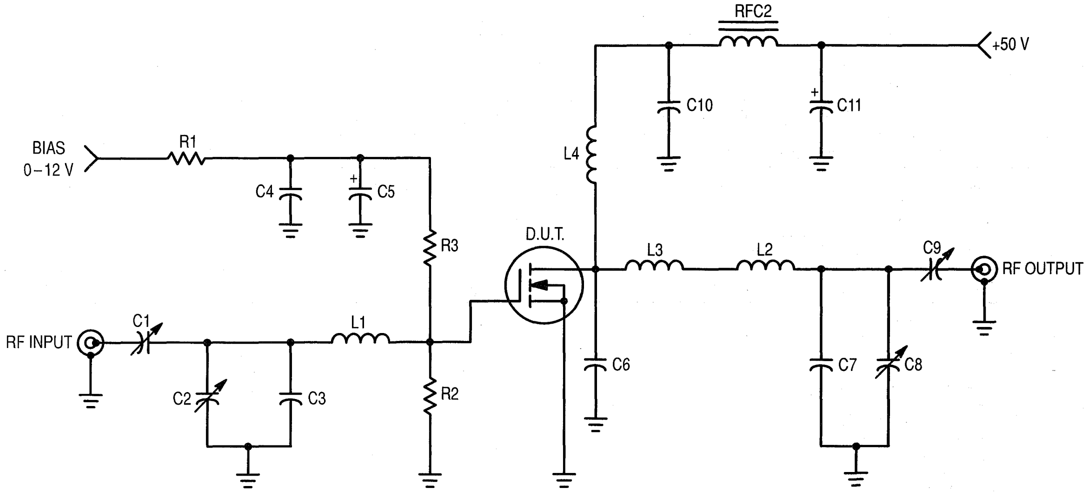
NOTE:
1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C1 — 470 pF Dipped Mica
C2, C5, C6, C7, C8, C9 — 0.1 μF Ceramic Chip or Monolythic with Short Leads
C3 — 200 pF Unencapsulated Mica or Dipped Mica with Short Leads
C4 — 15 pF Unencapsulated Mica or Dipped Mica with Short Leads
C10 — 10 μF/100 V Electrolytic

L1 — VK200/4B Ferrite Choke or Equivalent, 3.0 μH
L2 — Ferrite Bead(s), 2.0 μH
R1, R2 — 51 Ω/1.0 W Carbon
R3 — 3.3 Ω/1.0 W Carbon (or 2.0 x 6.8 Ω/1/2 W in Parallel)
T1 — 9:1 Broadband Transformer
T2 — 1:9 Broadband Transformer
Board Material — 0.062″ Fiberglass (G10), 1 oz. Copper Clad, 2 Sides, ε_r = 5

Figure 1. 30 MHz Test Circuit



C1, C2, C8 — Arco 463 or equivalent
C3 — 25 pF, Unelco
C4 — 0.1 µF, Ceramic
C5 — 1.0 µF, 15 WV Tantalum
C6 — 15 pF, Unelco J101
C7 — 25 pF, Unelco J101
C9 — Arco 262 or equivalent
C10 — 0.05 µF, Ceramic
C11 — 15 µF, 60 WV Electrolytic
D1 — 1N5347 Zener Diode

L1 — 3/4″, #18 AWG into Hairpin
L2 — Printed Line, 0.200″ x 0.500″
L3 — 1″, #16 AWG into Hairpin
L4 — 2 Turns, #16 AWG, 5/16 ID
RFC1 — 5.6 µH, Choke
RFC2 — VK200–4B
R1 — 150 Ω, 1.0 W Carbon
R2 — 10 kΩ, 1/2 W Carbon
R3 — 120 Ω, 1/2 W Carbon
Board Material — 0.062″ Fiberglass (G10),
1 oz. Copper Clad, 2 Sides, $\varepsilon_r = 5.0$

Figure 2. 175 MHz Test Circuit

TYPICAL CHARACTERISTICS

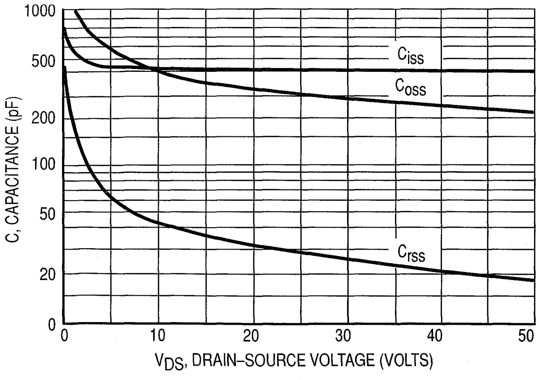


Figure 3. Capacitance versus Drain–Source Voltage

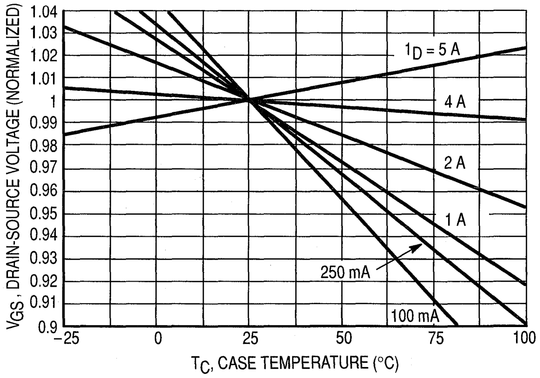


Figure 4. Gate–Source Voltage versus Case Temperature

TYPICAL CHARACTERISTICS

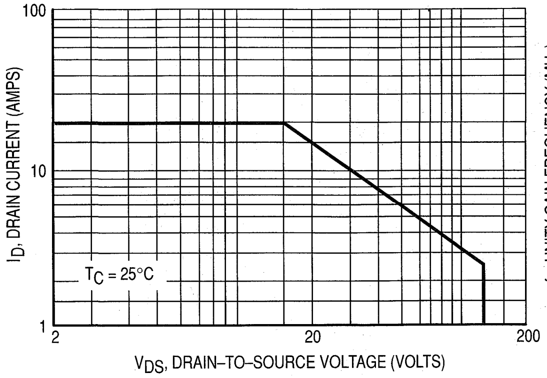


Figure 5. DC Safe Operating Area

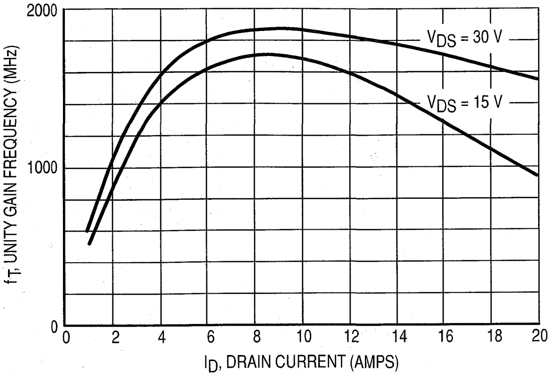


Figure 6. Common Source Unity Gain Frequency versus Drain Current

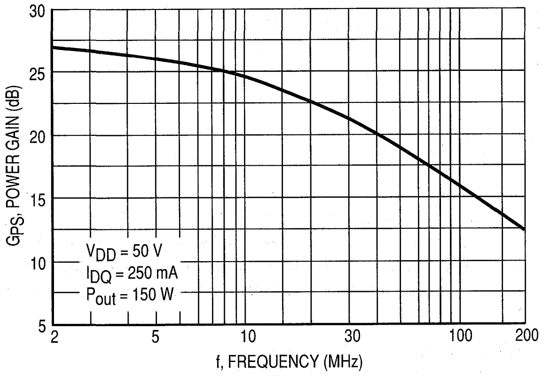


Figure 7. Power Gain versus Frequency

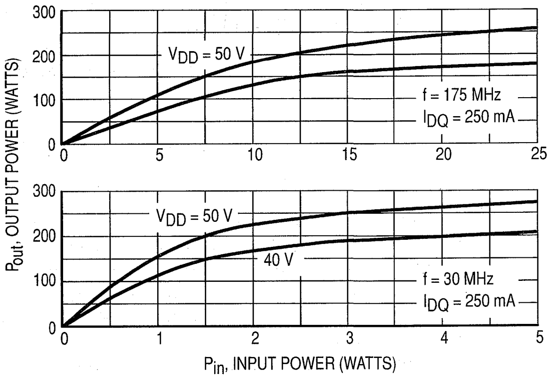


Figure 8. Output Power versus Input Power

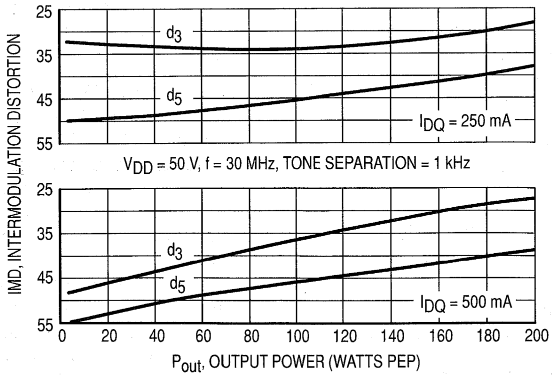


Figure 9. IMD versus P_{out}

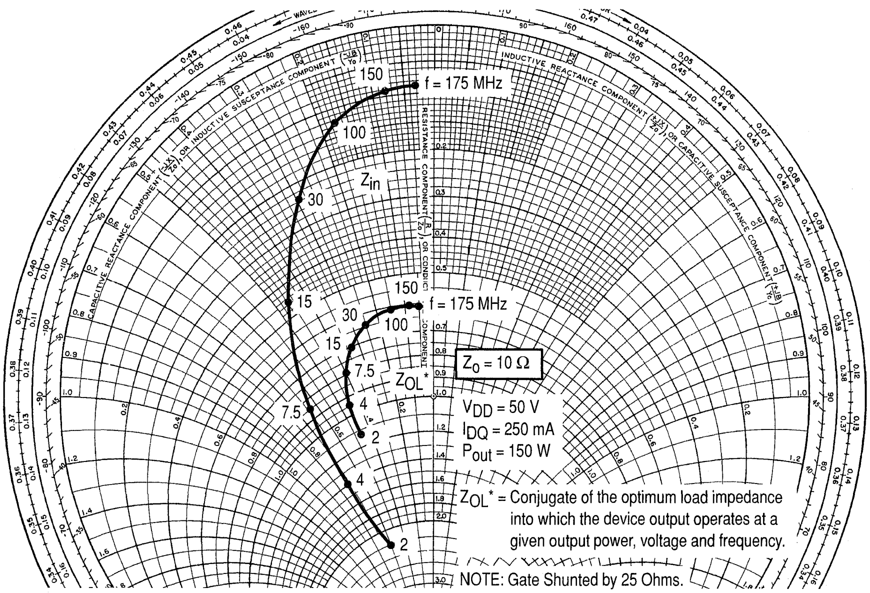


Figure 10. Series Equivalent Impedance

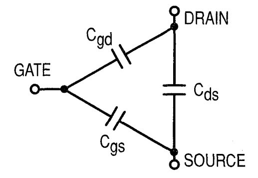
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal anode gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} = C_{gs}$
$C_{oss} = C_{gd} = C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 6 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gate of this device is essentially capacitor. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the device due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — This device does not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

HANDLING CONSIDERATIONS

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with a grounded iron.

DESIGN CONSIDERATIONS

The MRF151 is an RF Power, MOS, N–channel enhancement mode field–effect transistor (FET) designed for HF and VHF power amplifier applications.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power MOSFETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal.

DC BIAS

The MRF151 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF151 was characterized at I_{DQ} = 250 mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF151 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

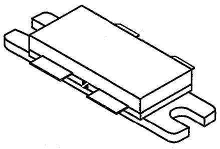
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode MOSFET

MRF151G

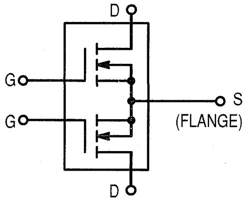
Designed for broadband commercial and military applications at frequencies to 175 MHz. The high power, high gain and broadband performance of this device makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance at 175 MHz, 50 V:
  Output Power — 300 W
  Gain — 14 dB (16 dB Typ)
  Efficiency — 50%
- Low Thermal Resistance — 0.35°C/W
- Ruggedness Tested at Rated Output Power
- Nitride Passivated Die for Enhanced Reliability

300 W, 50 V, 175 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFET



CASE 375–04, STYLE 2



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	125	Vdc
Drain–Gate Voltage	V_{DGO}	125	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	40	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 2.85	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

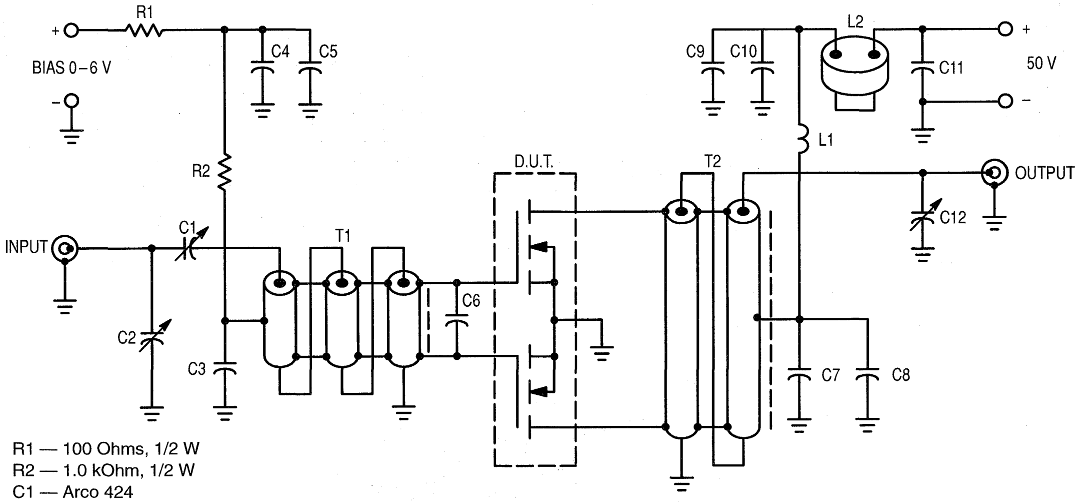
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.35	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (Each Side)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS (Each Side)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	5.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS (Each Side)					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	350	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	225	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	20	—	pF
FUNCTIONAL TESTS					
Common Source Amplifier Power Gain (V_{DD} = 50 V, P_{out} = 300 W, I_{DQ} = 500 mA, f = 175 MHz)	G_{ps}	14	16	—	dB
Drain Efficiency (V_{DD} = 50 V, P_{out} = 300 W, f = 175 MHz, I_D (Max) = 11 A)	η	50	55	—	%
Load Mismatch (V_{DD} = 50 V, P_{out} = 300 W, I_{DQ} = 500 mA, VSWR 5:1 at all Phase Angles)	ψ	No Degradation in Output Power			



R1 — 100 Ohms, 1/2 W
R2 — 1.0 kOhm, 1/2 W
C1 — Arco 424
C2 — Arco 404
C3, C4, C7, C8, C9 — 1000 pF Chip
C5, C10 — 0.1 μF Chip
C6 — 330 pF Chip
C11 — 0.47 μF Ceramic Chip, Kemet 1215 or Equivalent (100 V)
C12 — Arco 422
L1 — 10 Turns AWG #18 Enameled Wire, Close Wound, 1/4″ I.D.
L2 — Ferrite Beads of Suitable Material for 1.5−2.0 μH Total Inductance

Unless Otherwise Noted, All Chip Capacitors are ATC Type 100 or Equivalent.

T1 — 9:1 RF Transformer. Can be made of 15−18 Ohms Semirigid Co–Ax, 62−90 Mils O.D.
T2 — 1:4 RF Transformer. Can be made of 16−18 Ohms Semirigid Co–Ax, 70−90 Mils O.D.
Board Material — 0.062″ Fiberglass (G10), 1 oz. Copper Clad, 2 Sides, ε_r = 5.0

NOTE: For stability, the input transformer T1 must be loaded with ferrite toroids or beads to increase the common mode inductance. For operation below 100 MHz. The same is required for the output transformer.

See Figure 6 for construction details of T1 and T2.

Figure 1. 175 MHz Test Circuit

TYPICAL CHARACTERISTICS

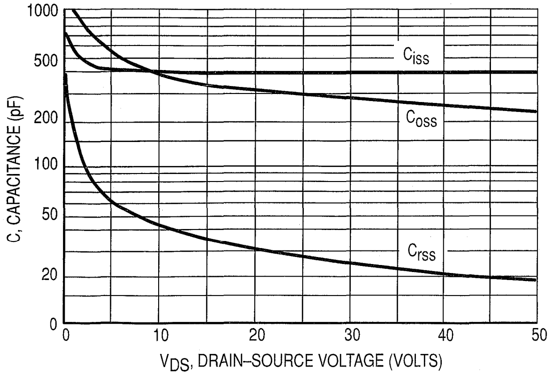


Figure 2. Capacitance versus Drain–Source Voltage*

*Data shown applies to each half of MRF151G.

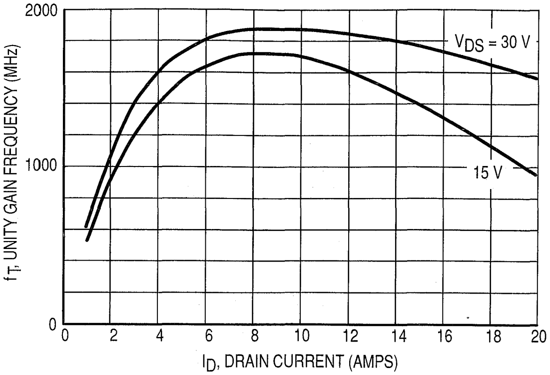


Figure 3. Common Source Unity Gain Frequency versus Drain Current*

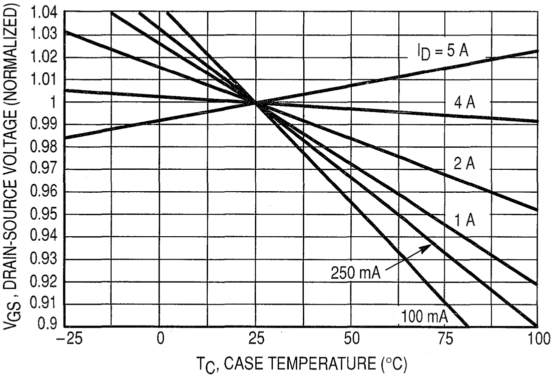


Figure 4. Gate–Source Voltage versus Case Temperature*

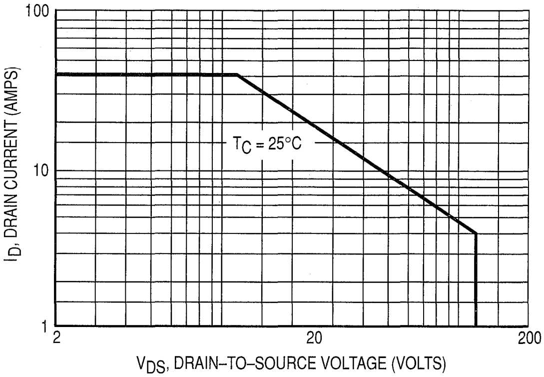


Figure 5. DC Safe Operating Area

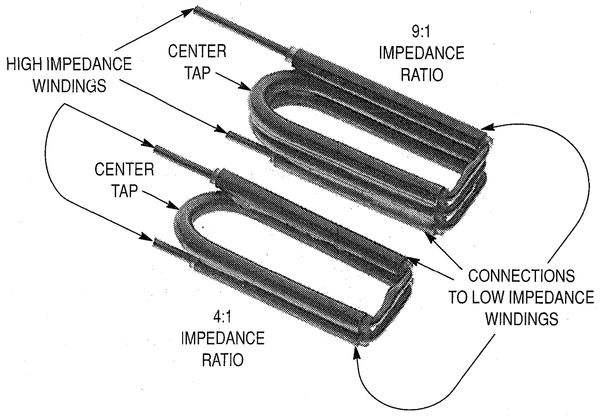


Figure 6. RF Transformer

TYPICAL CHARACTERISTICS

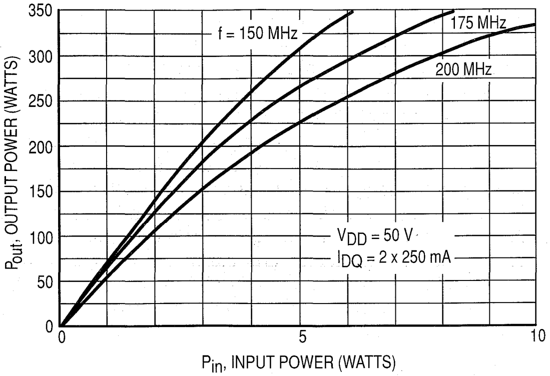


Figure 7. Output Power versus Input Power

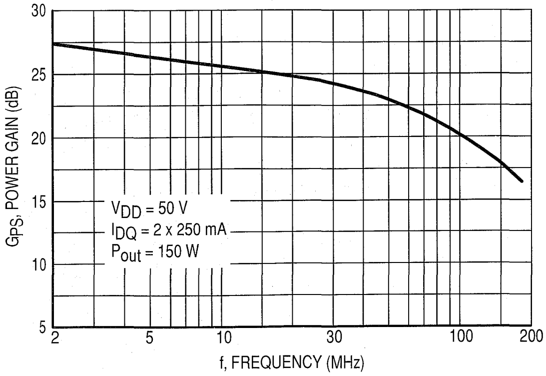
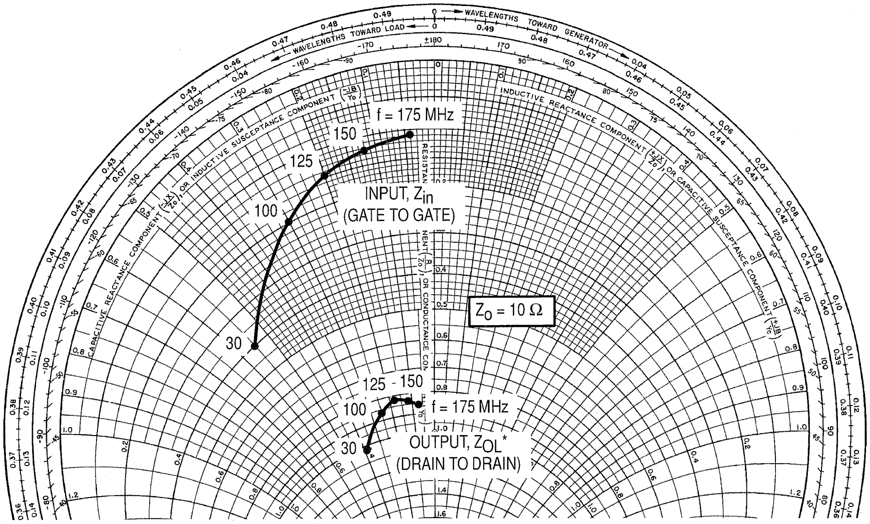


Figure 8. Power Gain versus Frequency



Z_{OL}^* = Conjugate of the optimum load impedance
into which the device output operates at a
given output power, voltage and frequency.

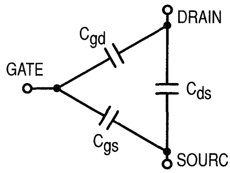
Figure 9. Input and Output Impedance

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal anode gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} = C_{gs}$
$C_{oss} = C_{gd} = C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 3 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

HANDLING CONSIDERATIONS

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with a grounded iron.

DESIGN CONSIDERATIONS

The MRF151G is an RF Power, MOS, N–channel enhancement mode field–effect transistor (FET) designed for HF and VHF power amplifier applications.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power MOSFETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal.

DC BIAS

The MRF151G is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF151G was characterized at I_{DQ} = 250 mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF151G may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

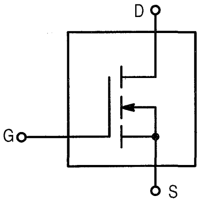
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode MOSFET

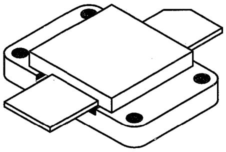
MRF154

Designed primarily for linear large–signal output stages in the 2.0–100 MHz frequency range.

- Specified 50 Volts, 30 MHz Characteristics
  Output Power = 600 Watts
  Power Gain = 17 dB (Typ)
  Efficiency = 45% (Typ)

600 W, 50 V, 80 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFET





CASE 368–03, STYLE 2
(HOG PAC)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	125	Vdc
Drain–Gate Voltage	V_{DGO}	125	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	60	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1350 7.7	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

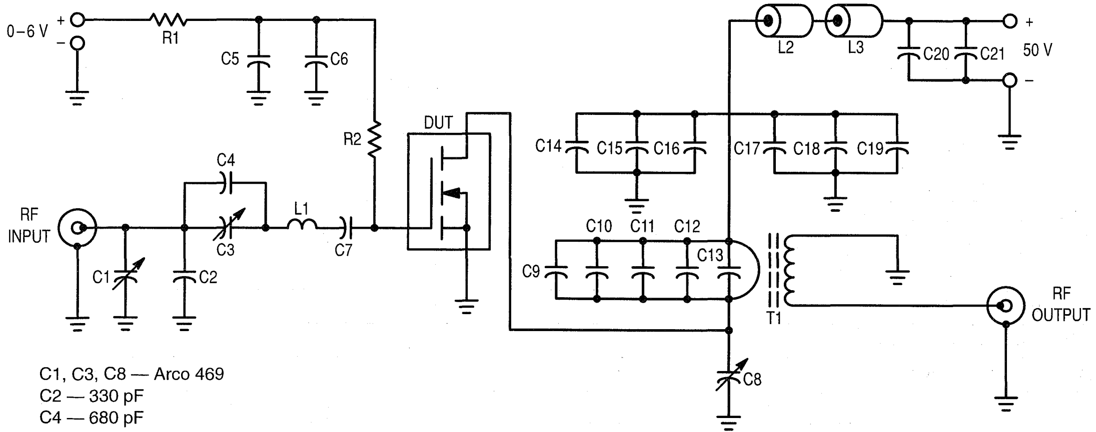
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.13	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	20	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	5.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 40 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 20 A)	g_{fs}	16	20	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	1600	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	1000	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	200	—	pF
FUNCTIONAL TESTS					
Common Source Amplifier Power Gain (V_{DD} = 50 V, P_{out} = 600 W, I_{DQ} = 800 mA, f = 30 MHz)	G_{ps}	—	17	—	dB
Drain Efficiency (V_{DD} = 50 V, P_{out} = 600 W, I_{DQ} = 800 mA, f = 30 MHz)	η	—	45	—	%
Intermodulation Distortion (V_{DD} = 50 V, P_{out} = 600 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 800 mA)	$IMD_{(d3)}$	—	−25	—	dB



C1, C3, C8 — Arco 469
C2 — 330 pF
C4 — 680 pF
C5, C19, C20 — 0.47 μF, RMC Type 2225C
C6, C7, C14, C15, C16 — 0.1 μF
C9, C10, C11 — 470 pF
C12 — 1000 pF
C13 — Two Unencapsulated 1000 pF Mica, in Series
C17, C18 — 0.039 μF
C21 — 10 μF/100 V Electrolytic
L1 — 2 Turns #16 AWG, 1/2″ ID, 3/8″ Long
L2, L3 — Ferrite Beads, Fair–Rite Products Corp. #2673000801

R1, R2 — 10 Ohms/2.0 W Carbon
T1 — RF Transformer, 1:25 Impedance Ratio. See Motorola Application Note AN749, Figure 4 for details. Ferrite Material: 2 Each, Fair–Rite Products Corp. #2667540001

All capacitors ATC type 100/200 chips or equivalent unless otherwise noted.

Figure 1. 30 MHz Test Circuit

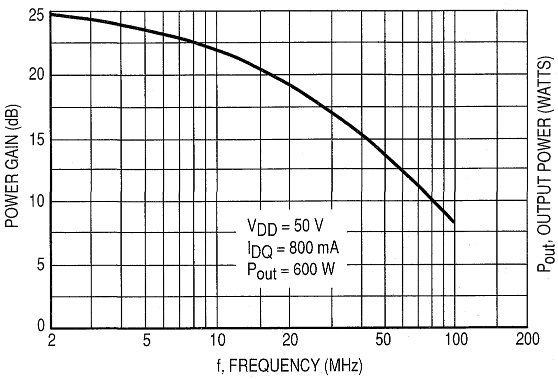


Figure 2. Power Gain versus Frequency

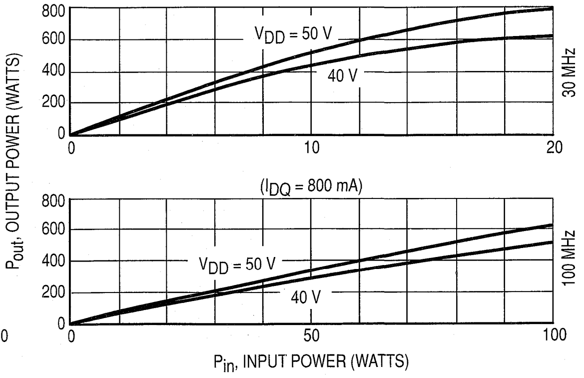


Figure 3. Output Power versus Input Power

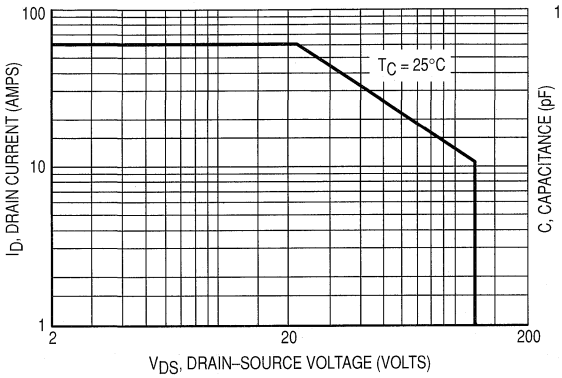


Figure 4. DC Safe Operating Area

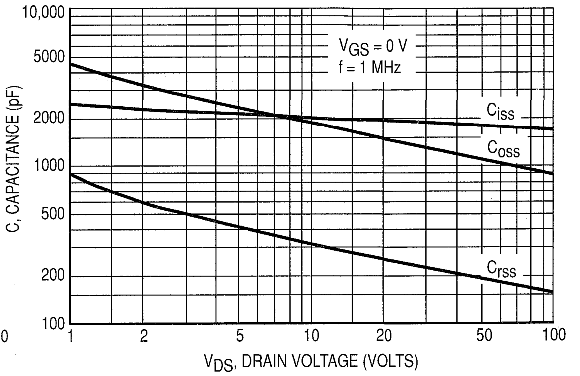


Figure 5. Capacitance versus Drain Voltage

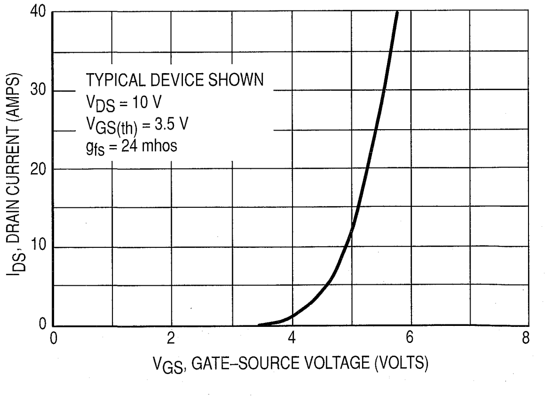


Figure 6. Gate Voltage versus Drain Current

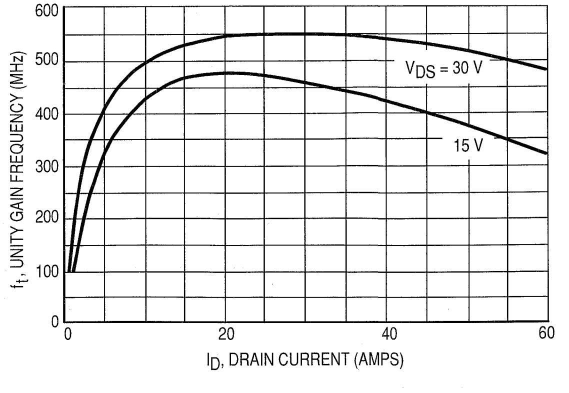


Figure 7. Common Source Unity Gain Frequency versus Drain Current

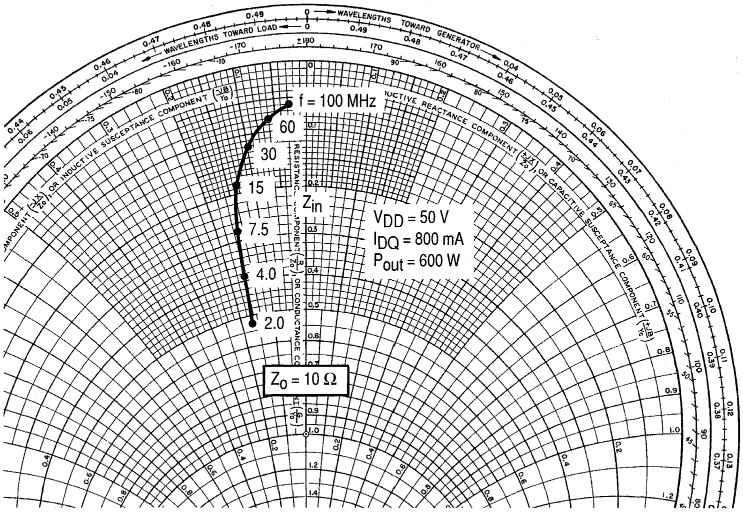
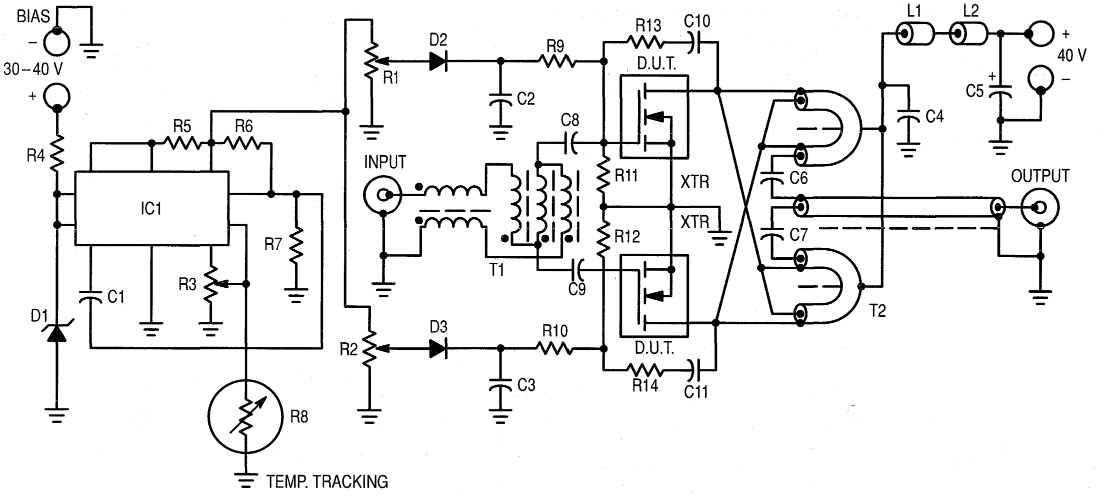


Figure 8. Series Equivalent Impedance



C1 — 1000 pF Ceramic
C2, C3, C4, C8, C9, C10, C11 — 0.1 µF Ceramic
C5 — 10 µF/100 V Electrolytic
C6, C7 — 0.1 µF Ceramic, (ATC 200/823 or Equivalent)
D1 — 28 V Zener, 1N5362 or Equivalent
D3 — 1N4148
IC1 — MC1723
L1, L2 — Fair–Rite Products Corp. Ferrite Beads #2673000801
R1, R2, R3 — 10 k Trimpot
R4 — 1.0 k/1.0 W
R5 — 10 Ohms
R6 — 2.0 k
R7 — 10 k
R8 — Thermistor, 10 k (25°C), 2.5 k (75°C)
R9, R10 — 100 Ohms
R11, R12 — 1.0 k
R13, R14 — 50–100 Ohms, 4.0 x 2.0 W Carbon in Parallel
T1 — 9:1 Transformer, Trifilar and Balun Wound on Separate Fair–Rite Products Corp. Balun Cores #286100012, 5 Turns Each.
T2 — 1:9 Transformer, Balun 50 Ohm CO–AX Cable RG–188, Low Impedance Lines W.L. Gore 16 Ohms CO–AX Type CXN 1837. Each Winding Threaded Through Two Fair–Rite Products Corp. #2661540001 Ferrite Sleeves (6 Each).
XTR — MRF154

Figure 9. 20–80 MHz 1.0 kW Broadband Amplifier

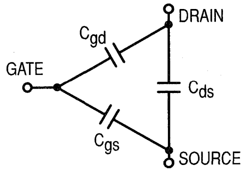
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

MOUNTING OF HIGH POWER RF POWER TRANSISTORS

The package of this device is designed for conduction cooling. It is extremely important to minimize the thermal resistance between the device flange and the heat dissipator.

Since the device mounting flange is made of soft copper, it may be deformed during various stages of handling or during transportation. It is recommended that the user makes a final inspection on this before the device installation. ±0.0005″ is considered sufficient for the flange bottom.

The same applies to the heat dissipator in the device mounting area. If copper heatsink is not used, a copper head spreader is strongly recommended between the device mounting surfaces and the main heatsink. It should be at least 1/4″ thick and extend at least one inch from the flange edges. A thin layer of thermal compound in all interfaces is, of course, essential. The recommended torque on the 4–40 mounting screws should be in the area of 4–5 lbs.–inch, and spring type lock washers along with flat washers are recommended.

For die temperature calculations, the Δ temperature from a corner mounting screw area to the bottom center of the flange is approximately 5°C and 10°C under normal operating conditions (dissipation 150 W and 300 W respectively).

The main heat dissipator must be sufficiently large and have low R_θ for moderate air velocity, unless liquid cooling is employed.

CIRCUIT CONSIDERATIONS

At high power levels (500 W and up), the circuit layout becomes critical due to the low impedance levels and high RF currents associated with the output matching. Some of the components, such as capacitors and inductors must also withstand these currents. The component losses are directly proportional to the operating frequency. The manufacturers specifications on capacitor ratings should be consulted on these aspects prior to design.

Push–pull circuits are less critical in general, since the ground referenced RF loops are practically eliminated, and the impedance levels are higher for a given power output. High power broadband transformers are also easier to design than comparable LC matching networks.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$r_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

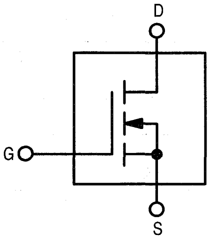
The RF Power MOS Line
Power Field Effect Transistor
N–Channel Enhancement Mode

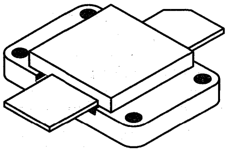
MRF157

600 W, to 80 MHz
MOS LINEAR
RF POWER FET

Designed primarily for linear large–signal output stages to 80 MHz.

- Specified 50 Volts, 30 MHz Characteristics
  Output Power = 600 Watts
  Power Gain = 21 dB (Typ)
  Efficiency = 45% (Typ)





CASE 368–03, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	125	Vdc
Drain–Gate Voltage	V_{DGO}	125	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	60	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1350 7.7	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

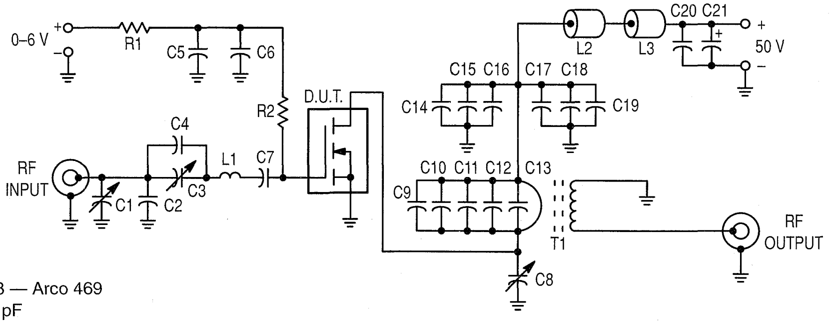
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.13	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	20	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	5.0	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 40 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 20 A)	g_{fs}	16	24	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	1800	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	750	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	75	—	pF
FUNCTIONAL TESTS					
Common Source Amplifier Power Gain (V_{DD} = 50 V, P_{out} = 600 W, I_{DQ} = 800 mA, f = 30 MHz)	G_{ps}	15	21	—	dB
Drain Efficiency (V_{DD} = 50 V, P_{out} = 600 W, f = 30 MHz, I_{DQ} = 800 mA)	h	40	45	—	%
Intermodulation Distortion (V_{DD} = 50 V, P_{out} = 600 W(PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 800 mA)	$IMD_{(d3)}$	—	−25	—	dB



C1, C3, C8 — Arco 469
C2 — 330 pF
C4 — 680 pF
C5, C19, C20 — 0.47 µF, RMC Type 2225C
C6, C7, C14, C15, C16 — 0.1 µF
C9, C10, C11 — 470 pF
C12 — 1000 pF
C13 — Two Unencapsulated 1000 pF Mica, in Series
C17, C18 — 0.039 µF
C21 — 10 µF/100 V Electrolytic
L1 — 2 Turns #16 AWG, 1/2″ ID, 3/8″ Long
L2, L3 — Ferrite Beads, Fair–Rite Products Corp. #2673000801

R1, R2 — 10 Ohms/2W Carbon
T1 — RF Transformer, 1:25 Impedance Ratio. See Motorola Application Note AN749, Figure 4 for details. Ferrite Material: 2 Each, Fair–Rite Products Corp. #2667540001

All capacitors ATC type 100/200 chips or equivalent unless otherwise noted.

Figure 1. 30 MHz Test Circuit

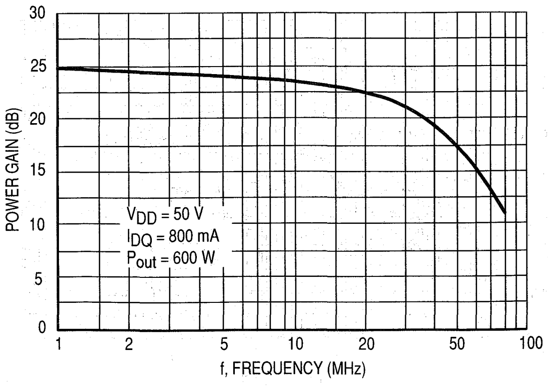


Figure 2. Power Gain versus Frequency

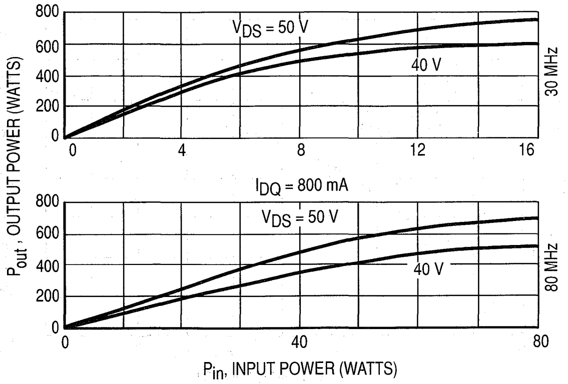


Figure 3. Output Power versus Input Power

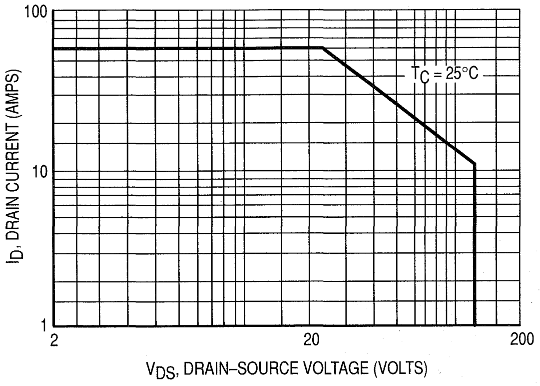


Figure 4. DC Safe Operating Area

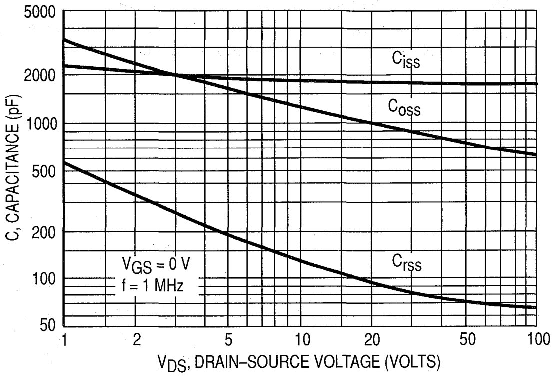


Figure 5. Capacitance versus Drain Voltage

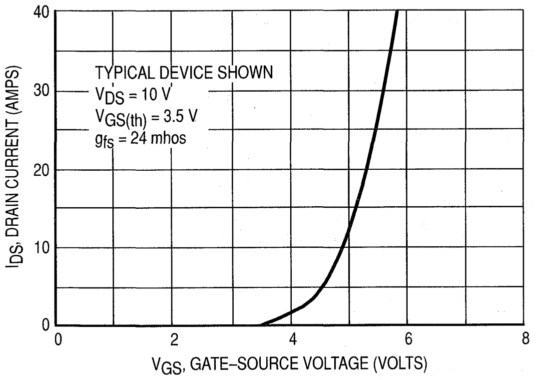


Figure 6. Gate Voltage versus Drain Current

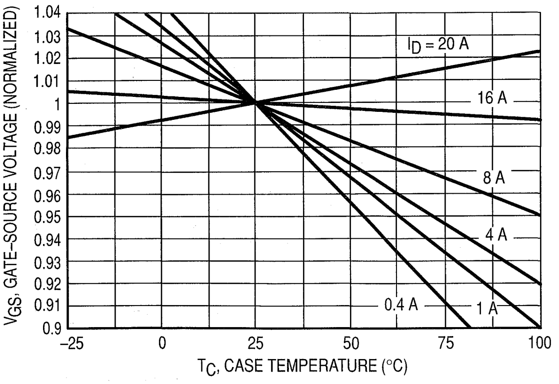


Figure 7. Gate–Source Voltage versus Case Temperature

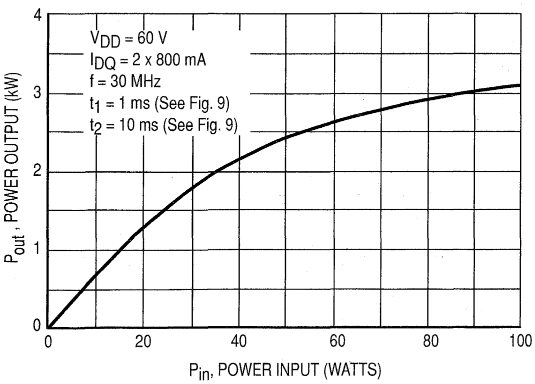


Figure 8. Output Power versus Input Power Under Pulse Conditions (2 x MRF157)

Note: Pulse data for this graph was taken in a push–pull circuit similar to the one shown. However, the output matching network was modified for the higher level of peak power.

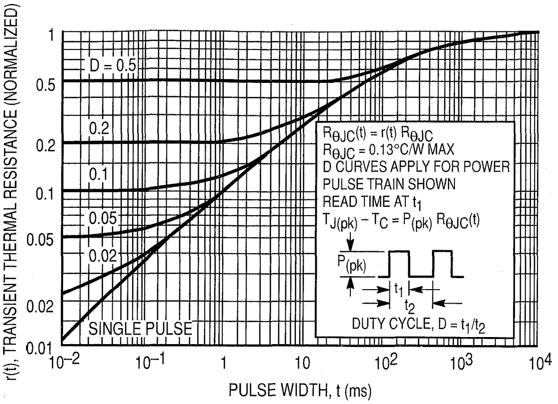
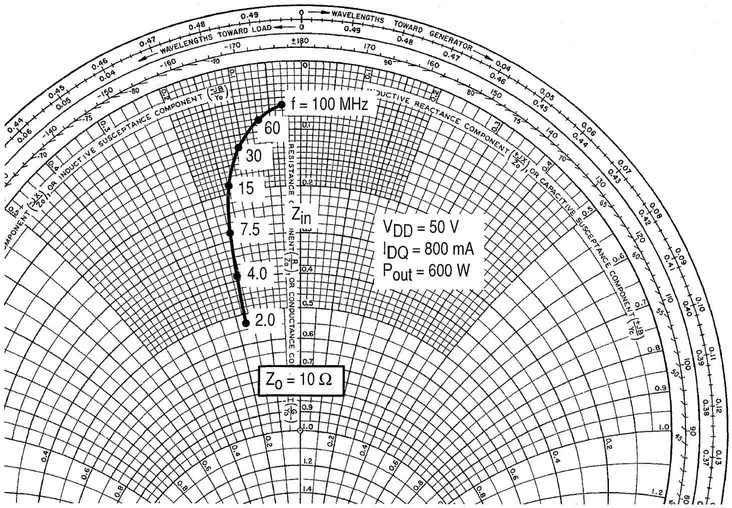
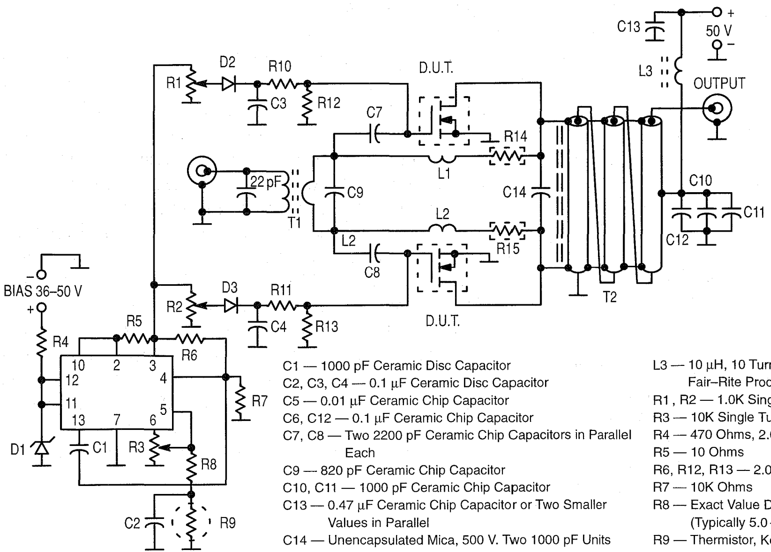


Figure 9. Thermal Response versus Pulse Width



Note: To determine Z_{OL}*, use formula $\frac{(V_{CC} - V_{sat})^2}{2\ P_o} = Z_{OL}$*

Figure 10. Series Equivalent Impedance



C1 — 1000 pF Ceramic Disc Capacitor
C2, C3, C4 — 0.1 µF Ceramic Disc Capacitor
C5 — 0.01 µF Ceramic Chip Capacitor
C6, C12 — 0.1 µF Ceramic Chip Capacitor
C7, C8 — Two 2200 pF Ceramic Chip Capacitors in Parallel Each
C9 — 820 pF Ceramic Chip Capacitor
C10, C11 — 1000 pF Ceramic Chip Capacitor
C13 — 0.47 µF Ceramic Chip Capacitor or Two Smaller Values in Parallel
C14 — Unencapsulated Mica, 500 V. Two 1000 pF Units in Series, Mounted Under T2
D1 — 1N5357A or Equivalent
D2, D3 — 1N4148 or Equivalent.
IC1 — MC1723 (723) Voltage Regulator
L1, L2 — 15 ηH, Connecting Wires to R14 and R15, 2.5 cm Each #20 AWG
L3 — 10 µH, 10 Turns #12 AWG Enameled Wire on Fair–Rite Products Corp. Ferrite Toroid #5961000401 or Equivalent
R1 , R2 — 1.0K Single Turn Trimpots
R3 — 10K Single Turn Trimpot
R4 — 470 Ohms, 2.0 Watts
R5 — 10 Ohms
R6, R12, R13 — 2.0K Ohms
R7 — 10K Ohms
R8 — Exact Value Depends on Thermistor R9 used (Typically 5.0 – 10K)
R9 — Thermistor, Keystone RL1009–5820–97–D1 or Equivalent
R10, R11 — 100 Ohms, 1.0W Carbon
R14, R15 — EMC Technology Model 5308 or KDI Pyrofilm PPR 870–150–3 Power Resistors, 25 Ohms
T1, T2 — 9:1 and 1:9 Impedance Ratio RF Transformers

Unless otherwise noted, all resistors are 1/2 watt metal film type. All chip capacitors except C13 are ATC type 100/200B or Dielectric Laboratories type C17.

Figure 11. 2.0 to 50 MHz, 1.0 kW Wideband Amplifier

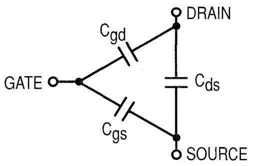
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the TMOS® FET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the interterminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the TMOS FET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. The addition of an internal zener diode may result in detrimental effects on the reliability of a power MOSFET. If gate protection is required, an external zener diode is recommended.

IMPEDANCE CHARACTERISTICS

Device input and output impedances are normally obtained by measuring their conjugates in an optimized narrow band test circuit. These test circuits are designed and constructed for a number of frequency points depending on the frequency coverage of characterization. For low frequencies the circuits consist of standard LC matching networks including variable capacitors for peak tuning. At increasing power levels the output impedance decreases, resulting in higher RF currents in the matching network. This makes the practicality of output impedance measurements in the manner described questionable at power levels higher than 200–300 W for devices operated at 50 V and 150–200 W for devices operated at 28 V. The physical sizes and values required for the components to withstand the RF currents increase to a point where physical construction of the output matching network gets difficult if not impossible. For this reason the output impedances are not given for high power devices such as the MRF154 and MRF157. However, formulas like $\frac{(V_{DS} - V_{sat})^2}{2P_{out}}$ for a single ended design or $\frac{2((V_{DS} - V_{sat})^2)}{P_{out}}$ for a push–pull design can be used to obtain reasonably close approximations to actual values.

MOUNTING OF HIGH POWER RF POWER TRANSISTORS

The package of this device is designed for conduction cooling. It is extremely important to minimize the thermal resistance between the device flange and the heat dissipator.

If a copper heatsink is not used, a copper head spreader is strongly recommended between the device mounting surfaces and the main heatsink. It should be at least 1/4″ thick and extend at least one inch from the flange edges. A thin layer of thermal compound in all interfaces is, of course, essential. The recommended torque on the 4–40 mounting screws should be in the area of 4–5 lbs.–inch, and spring type lock washers along with flat washers are recommended.

For die temperature calculations, the Δ temperature from a corner mounting screw area to the bottom center of the flange is approximately 5°C and 10°C under normal operating conditions (dissipation 150 W and 300 W respectively).

The main heat dissipator must be sufficiently large and have low R_θ for moderate air velocity, unless liquid cooling is employed.

CIRCUIT CONSIDERATIONS

At high power levels (500 W and up), the circuit layout becomes critical due to the low impedance levels and high RF currents associated with the output matching. Some of the components, such as capacitors and inductors must also withstand these currents. The component losses are directly proportional to the operating frequency. The manufacturers specifications on capacitor ratings should be consulted on these aspects prior to design.

Push–pull circuits are less critical in general, since the ground referenced RF loops are practically eliminated, and the impedance levels are higher for a given power output. High power broadband transformers are also easier to design than comparable LC matching networks.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$R_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF TMOS® Line

Power Field Effect Transistor

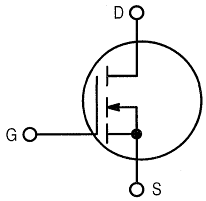
N–Channel Enhancement Mode

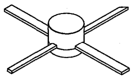
MRF158

2.0 W, to 500 MHz
TMOS
BROADBAND
RF POWER FET

Designed for wideband large–signal amplifier and oscillator applications to 500 MHz.

- Guaranteed 28 Volt, 400 MHz Performance
  Output Power = 2.0 Watts
  Minimum Gain = 16 dB
  Efficiency = 55% (Typical)
- Grounded Source Package for High Gain and Excellent Heat Dissipation (MRF158R)
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 100% Tested for Load Mismatch at All Phase Angles with 30:1 VSWR
- Excellent Thermal Stability, Ideally Suited for Class A Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.





CASE 305A–01, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	0.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 45	Watts mW/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

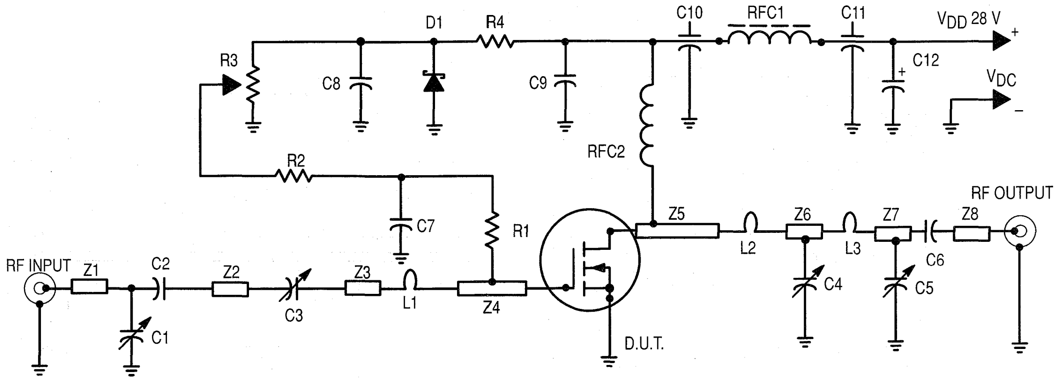
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	13.2	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

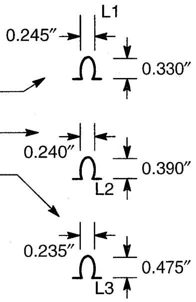
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	0.5	mAdc
Gate–Source Leakage Current (V_{GS} = 40 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (I_D = 10 mA, V_{DS} = 10 V)	$V_{GS(th)}$	1.0	4.0	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 100 mA)	g_{fs}	50	85	—	mmhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	3.0	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	4.2	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	0.45	—	pF
FUNCTIONAL CHARACTERISTICS (Figure 1)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 2.0 W, f = 400 MHz, I_{DQ} = 100 mA)	G_{ps}	16	20	—	dB
Drain Efficiency (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 2.0 W, f = 400 MHz, I_{DQ} = 100 mA)	η	45	55	—	%
Electrical Ruggedness (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 2.0 W, f = 400 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
Series Equivalent Input Impedance (V_{DD} = 28 V, P_{out} = 2.0 W, f = 400 MHz, I_{DQ} = 100 mA)	Z_{in}	—	8.8 – j27.37	—	Ohms
Series Equivalent Output Impedance (V_{DD} = 28 V, P_{out} = 2.0 W, f = 400 MHz, I_{DQ} = 100 mA)	Z_{out}	—	16.96 – j62	—	Ohms



C1, C4, C5 — Johanson Trimmer Capacitor, 2–20 pF
C2, C6 — 270 pF Chip Capacitor
C3 — Arco 404
C7, C8, C9 — 0.1 µF
C10, C11 — 680 pF Feed Through
C12 — 50 µF, 50 V
D1 — 1N5925A Motorola Zener
L1 — #18 AWG, Hairpin 0.825″ long, bend into hairpin
L2 — #18 AWG, Hairpin 0.875″ long, bend into hairpin
L3 — #18 AWG, Hairpin 0.965″ long, bend into hairpin

Board Material — 0.062″, Teflon Fiberglass, 2 oz., Copper clad both sides, $\epsilon_r = 2.55$



R1 — 91 Ω 1/2 Watt
R2 — 10 kΩ 1/2 Watt
R3 — 10 kΩ, 10 Turns Bourns
R4 — 1.8 k 1.4 Watt
RFC1 — Ferroxcube VK200–19/4B
RFC2 — 10 Turns #20 AWG Enameled, 0.250″ ID
Z1 — Microstrip Line 0.150″ wide, 0.420″ long
Z2 — Microstrip Line 0.150″ wide, 0.420″ long
Z3 — Microstrip Line 0.150″ wide, 0.475″ long
Z4 — Microstrip Line 0.150″ wide, 0.825″ long
Z5 — Microstrip Line 0.150″ wide, 0.750″ long
Z6 — Microstrip Line 0.150″ wide, 0.500″ long
Z7 — Microstrip Line 0.150″ wide, 0.500″ long
Z8 — Microstrip Line 0.150″ wide, 0.450″ long

Figure 1. 400 MHz Test Circuit

TYPICAL CHARACTERISTICS

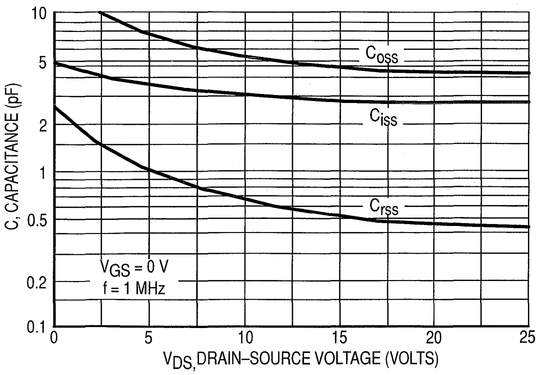


Figure 2. Capacitance versus Drain–Source Voltage

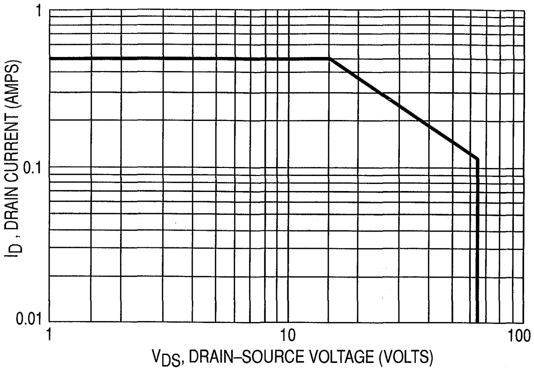


Figure 3. DC Safe Operating Area

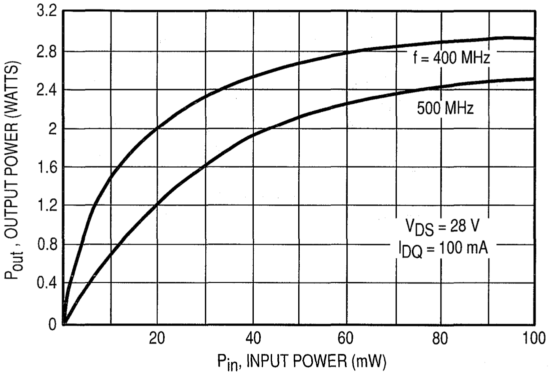


Figure 4. Output Power versus Input Power

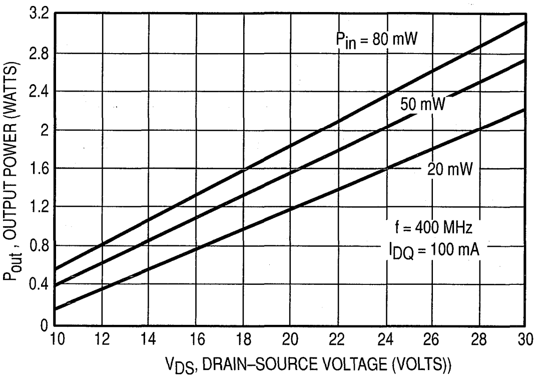


Figure 5. Output Power versus Voltage

Table 1. Typical Common Emitter S–Parameters

V_{DS} (Volts)	I_D (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ϕ	$\lvert S_{21}\rvert$	∠ϕ	$\lvert S_{12}\rvert$	∠ϕ	$\lvert S_{22}\rvert$	∠ϕ
28	100	5	1.00	–2.0	3.84	–179	0.003	73	0.97	–2.0
		10	1.00	–2.0	3.81	179	0.004	83	0.97	–2.0
		30	1.00	–7.0	3.74	174	0.011	81	0.97	–6.0
		50	1.00	–11	3.72	170	0.018	78	0.96	–9.0
		100	0.98	–21	3.62	159	0.034	70	0.95	–19
		200	0.93	–41	3.28	137	0.061	52	0.90	–35
		300	0.88	–58	2.88	120	0.077	39	0.86	–50
		400	0.83	–75	2.57	104	0.088	27	0.81	–63
		500	0.79	–87	2.24	91	0.090	17	0.78	–74
		600	0.75	–99	1.94	78	0.084	8.0	0.75	–84
		700	0.73	–110	1.72	68	0.077	2.0	0.75	–93
		800	0.72	–120	1.52	58	0.067	–3.0	0.75	–99
		900	0.71	–130	1.35	48	0.055	–6.0	0.74	–108
		1000	0.71	–139	1.18	40	0.043	–4.0	0.73	–114

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

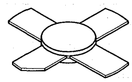
The RF MOSFET Line
Power Field Effect Transistor
N–Channel Enhancement–Mode MOSFET

MRF160

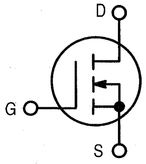
Designed primarily for wideband large–signal output and driver from 30–500 MHz.

- Typical Performance at 400 MHz, 28 Vdc
  Output Power = 4.0 Watts
  Gain = 17 dB
  Efficiency = 50%
- Excellent Thermal Stability, Ideally Suited for Class A Operation
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 100% Tested for Load Mismatch at All Phase Angles with 30:1 VSWR
- Low C_{rss} – 0.8 pF Typical at V_{DS} = 28 Volts

4.0 W, to 400 MHz
MOSFET BROADBAND
RF POWER FET



CASE 249–06, STYLE 3



MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain–Gate Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	± 40	Vdc
Drain Current–Continuous	I_D	1.0	ADC
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	24 0.14	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

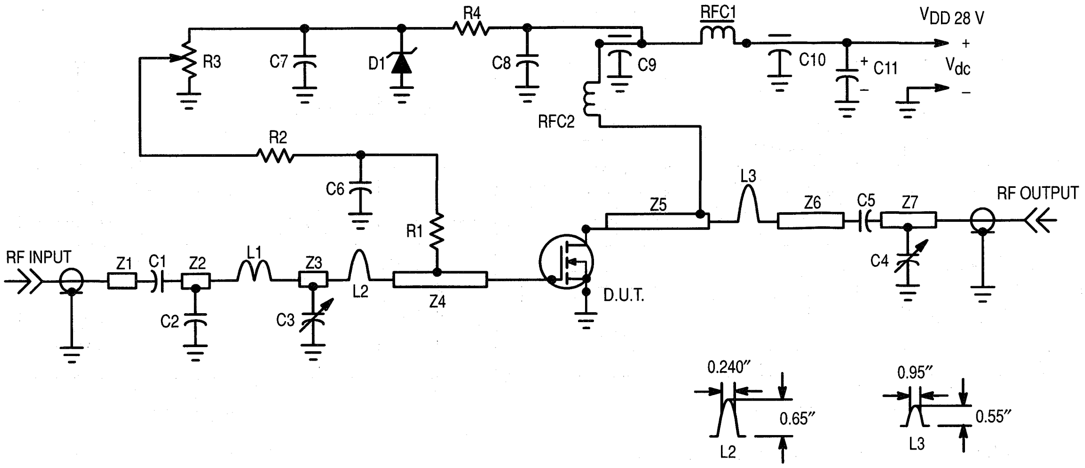
Thermal Resistance — Junction to Case	$R_{\theta JC}$	7.2	°C/W

NOTE: Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 2

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{DS} = 0 Vdc, V_{GS} = 0 Vdc, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 Vdc, V_{GS} = 0 V)	I_{DSS}	—	—	0.8	mA
Gate–Source Leakage Current (V_{GS} = 40 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1.0	μA
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Drain Source On–Voltage ($V_{DS\ (on)}$, V_{GS} = 10 Vdc, I_D = 500 mA)	$V_{DS(on)}$	—	3.8	—	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 250 mA)	g_{fs}	110	160	—	mS
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	6.0	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0 Vdc, f = 1.0 MHz)	C_{oss}	—	8.0	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)	C_{rss}	—	0.8	—	pF
FUNCTIONAL CHARACTERISTICS					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 4.0 W, f = 400 MHz, I_{DQ} = 50 mA)	G_{ps}	15	17	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 4.0 W, f = 400 MHz, I_{DQ} = 50 mA)	η	45	50	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 4.0 W, f = 400 MHz, I_{DQ} = 50 mA) Load VSWR = 30:1 at All Phase Angles at Frequency of Test	ψ	No Degradation in Output Power			
Series Equivalent Input Impedance (V_{DD} = 28 Vdc, P_{out} = 4.0 W, f = 400 MHz, I_{DQ} = 50 mA)	Z_{in}	—	5.23–j 27.2	—	Ohms
Series Equivalent Output Impedance (V_{DD} = 28 Vdc, P_{out} = 4.0 W, f = 400 MHz, I_{DQ} = 50 mA)	Z_{out}	—	14.7–j 31.2	—	Ohms



C1, C5	220 pF, Chip Capacitor	R3	10 kΩ, 10 Turns Bourns
C2	18 pF, ATC Chip Capacitor	R4	1.8 kΩ, 1/4 Watt
C3	2.0–20 pF, Johanson Trimmer Capacitor	RFC1	Ferroxcube VK200–19/4B
C4	2.0–10 pF, Johanson Trimmer Capacitor	RFC2	10 Turns, #20 AWG, Enameled Close Wound, 0.250″ ID
C6, C7, C8	0.1 µF		
C9, C10	680 pF, Feed Through	Z1	Microstrip Line 0.167″ wide, 0.820″ long
C11	50 µF, 50 V	Z2	Microstrip Line 0.240″ wide, 0.240″ long
L1	#20 AWG, 1 Turn 0.255″ ID	Z3	Microstrip Line 0.240″ wide, 0.240″ long
L2	#20 AWG, Hairpin 1.3″ long, bend into hairpin	Z4	Microstrip Line 0.230″ wide, 0.590″ long
L3	#20 AWG, Hairpin 1.1″ long, bend into hairpin	Z5	Microstrip Line 0.230″ wide, 0.580″ long
R1	160 Ω, 1/2 Watt	Z6	Microstrip Line 0.167″ wide, 0.620″ long
R2	10 kΩ, 1/2 Watt	Z7	Microstrip Line 0.167″ wide, 0.800″ long

Board Material 0.060″ Glass Teflon® 2 oz. Copper clad both sides $\varepsilon_r = 2.55$

Figure 1. 400 MHz Test Circuit

Typical Characteristics

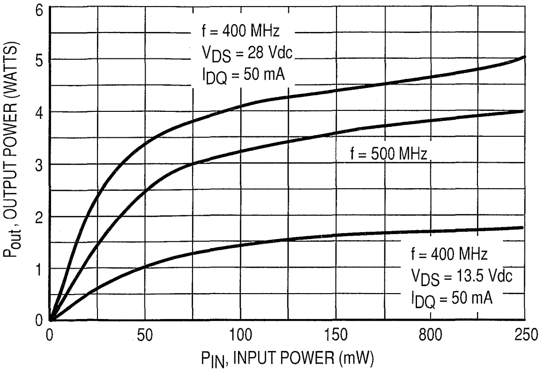


Figure 2. Output Power versus Input Power

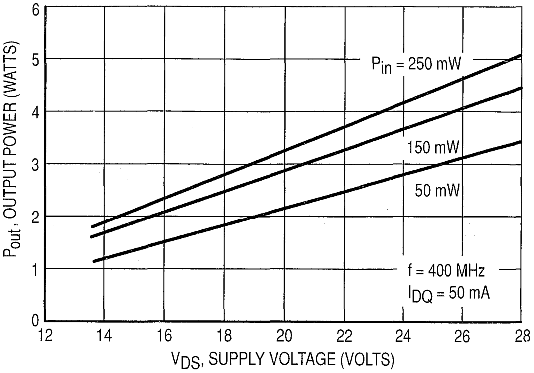


Figure 3. Output Power versus Voltage

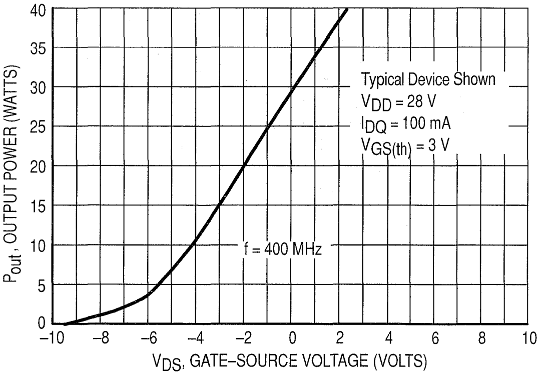


Figure 4. Output Power versus Gate Voltage

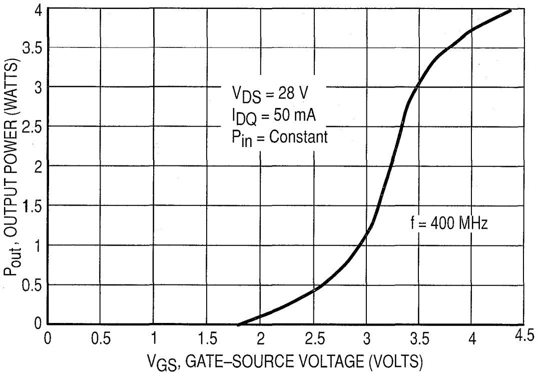


Figure 5. Output Power versus Gate Voltage

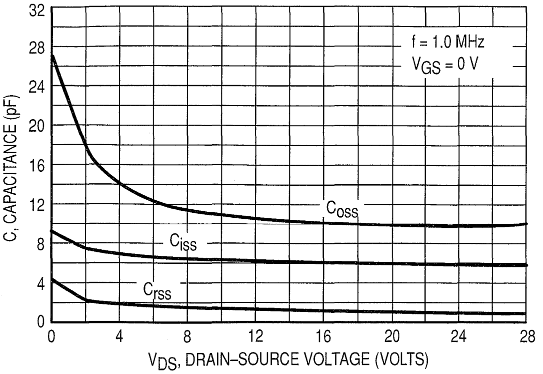


Figure 6. Capacitance versus Drain–Source Voltage

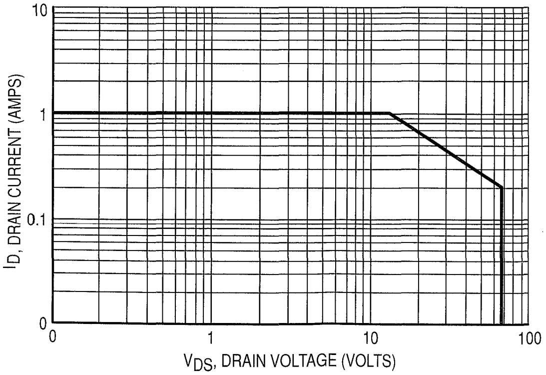


Figure 7. DC Safe Operating Area

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\|S_{11}\|$	∠φ	$\|S_{21}\|$	∠φ	$\|S_{12}\|$	∠φ	$\|S_{22}\|$	∠φ
10	0.96	–2.0	14.47	177	0.01	96	1.11	–5.0
30	0.99	–16	13.34	169	0.02	79	0.92	–11
50	0.97	–28	12.96	159	0.03	70	0.90	–22
75	0.94	–40	12.24	148	0.04	60	0.87	–35
100	0.90	–52	11.40	139	0.05	51	0.84	–45
120	0.87	–61	10.70	132	0.05	45	0.81	–53
150	0.83	–72	9.66	123	0.06	37	0.77	–63
170	0.81	–79	9.05	118	0.06	33	0.75	–69
200	0.78	–88	8.21	110	0.06	26	0.72	–77
220	0.77	–93	7.67	106	0.07	23	0.71	–81
250	0.75	–100	7.00	100	0.07	18	0.69	–87
300	0.72	–110	6.00	92	0.07	12	0.67	–96
350	0.71	–118	5.24	84	0.07	6.0	0.66	–103
390	0.71	–124	4.73	79	0.07	1.0	0.66	–108
400	0.70	–125	4.63	77	0.07	0	0.67	–109
410	0.70	–127	4.52	76	0.07	–1.0	0.66	–110
450	0.70	–131	4.10	71	0.07	–5.0	0.66	–114
470	0.70	–133	3.93	69	0.06	–6.0	0.67	–116
500	0.70	–137	3.68	65	0.06	–8.0	0.67	–118
600	0.71	–145	3.01	55	0.06	–14	0.69	–126
700	0.72	–153	2.51	46	0.05	–18	0.71	–132
800	0.73	–160	2.13	37	0.04	–21	0.73	–137
900	0.75	–166	1.83	30	0.03	–19	0.75	–142
1000	0.76	–171	1.60	23	0.03	–10	0.77	–146
1100	0.77	–177	1.40	16	0.02	3.0	0.79	–151
1200	0.78	177	1.25	10	0.02	18	0.80	–155
1300	0.79	172	1.11	4.0	0.03	29	0.82	–159
1400	0.81	166	1.00	–1.0	0.03	35	0.83	–163
1500	0.81	161	0.90	–6.0	0.03	48	0.85	–166

Table 1. Common Source Scattering Parameters (V_{DS} = 28 Vdc, I_D = 200 mA, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\lvert S_{11}\rvert$	∠ϕ	$\lvert S_{21}\rvert$	∠ϕ	$\lvert S_{12}\rvert$	∠ϕ	$\lvert S_{22}\rvert$	∠ϕ
10	0.96	– 4.0	16.09	176	0.01	85	1.08	– 8.0
20	1.00	–15	14.82	171	0.02	82	0.88	–10
30	0.98	– 23	14.64	164	0.03	73	0.89	– 20
50	0.94	– 39	13.76	152	0.04	63	0.86	– 38
85	0.86	– 61	11.81	134	0.06	47	0.79	– 61
150	0.73	– 91	8.63	112	0.08	27	0.70	– 91
170	0.71	– 97	7.90	107	0.09	23	0.68	– 98
200	0.68	–106	6.97	101	0.09	17	0.67	–106
210	0.68	–109	6.68	99	0.09	15	0.66	–108
250	0.66	–117	5.75	92	0.09	10	0.65	–116
300	0.64	–126	4.85	84	0.09	4.0	0.64	–124
350	0.64	–133	4.18	78	0.09	–1.0	0.64	–129
390	0.64	–137	3.75	73	0.09	– 5.0	0.65	–133
400	0.64	–138	3.66	71	0.09	– 6.0	0.65	–134
410	0.64	–140	3.57	70	0.09	–7.0	0.65	–135
450	0.64	–143	3.23	66	0.08	–10	0.66	–138
470	0.65	–145	3.08	64	0.08	–11	0.66	–139
500	0.65	–147	2.88	61	0.08	–13	0.67	–141
550	0.66	–151	2.59	56	0.08	–16	0.67	–144
600	0.67	–154	2.35	52	0.07	–18	0.68	–146
700	0.69	–160	1.96	43	0.07	– 22	0.71	–150
800	0.70	–166	1.67	35	0.06	– 25	0.73	–154
900	0.72	–171	1.43	28	0.05	– 24	0.75	–158
1000	0.74	–177	1.26	22	0.04	– 21	0.77	–161
1100	0.74	178	1.11	16	0.04	–14	0.78	–164
1200	0.76	173	0.99	10	0.04	– 6.0	0.80	–168
1300	0.78	168	0.88	5.0	0.04	2.0	0.81	–171
1400	0.79	163	0.80	0	0.03	8.0	0.83	–174
1500	0.80	158	0.72	– 5.0	0.03	19	0.84	–177

Table 2. Common Source Scattering Parameters (V_{DS} = 12.5 Vdc, I_D = 200 mA, 50 Ω System)

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

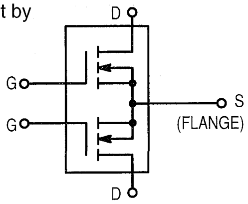
The RF TMOS Line
Power Field Effect Transistor
N–Channel Enhancement Mode

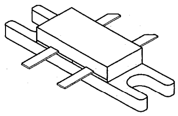
MRF164W

20 W, to 500 MHz
TMOS
BROADBAND
RF POWER FET

Designed primarily for wideband large–signal output and driver stages to 500 MHz.

- Guaranteed Performance at 400 MHz, 28 Vdc
- Output Power = 20 W
- Minimum Gain = 15 dB
- Push–Pull Configuration Reduces Even Numbered Harmonics
- Excellent Thermal Stability, Ideally Suited for Class A Operation
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 100% Tested for Load Mismatch at All Phase Angles with 30:1 VSWR
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.





CASE 412–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	116 0.67	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

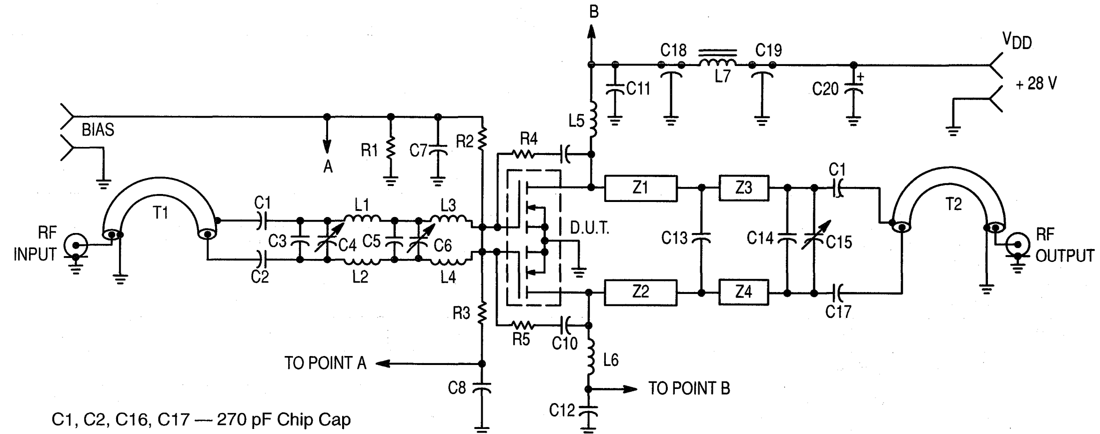
REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

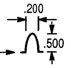
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	1.0	mAdc
Gate–Source Leakage Current (V_{GS} = 40 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 10 mA)	$V_{GS(th)}$	1.0	4.0	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 0.75 A)	g_{fs}	400	500	—	mmhos
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	18	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	20	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	2.5	—	pF
FUNCTIONAL CHARACTERISTICS (Figure 1) (2)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 20 W, f = 400 MHz, I_{DQ} = 50 mA)	G_{ps}	15	17	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 20 W, f = 400 MHz, I_{DQ} = 50 mA)	η	45	50	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 20 W, f = 400 MHz, I_{DQ} = 50 mA, Load VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power Before and After Test			

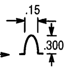
NOTES:

1. Each side of device measured separately.
2. Measured push–pull configuration.



C1, C2, C16, C17 — 270 pF Chip Cap
C3 — 6.8 pF Chip Cap
C4, C6, C15 — 1.0–20 pF Variable Cap
C5 — 18 pF Chip Cap
C7, C8, C11, C12 — 0.1 μF Ceramic Cap
C9, C10 — 0.01 μF Ceramic Cap
C13 — 6.8 pF Chip Cap
C14 — 4.7 pF Chip Cap
C18, C19 — 620 pF feedthru Cap
C20 — 10 μF 50 V Tantalum Cap
L1, L2 — Hairpin Inductor #18 Wire
L3, L4 — Hairpin Inductor #18 Wire
L5, L6 — 10 Turns #18 W .300 ID
L7 — VK–200/19–4B





R1 — 1.0K 1/4 W Resistor
R2, R3 — 10K 1/4 W Resistor
R4, R5 — 470 Ω 1/4 W Resistor
T1, T2 — Balun 2″ 50 Ω Semi Ridgid Coax
Z1, Z2 — Microstrip Element .850 long x .125 W
Z3, Z4 — Microstrip Element .525 long x .125 W
Board Material — Teflon Fiberglass, ε_r = 2.55 Copper Clad, 2 oz. Copper .060″ Dielectric Thickness

Figure 1. 400 MHz Test Circuit

TYPICAL CHARACTERISTICS

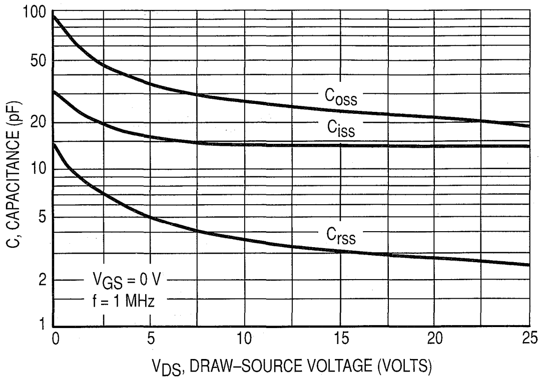


Figure 2. Capacitance versus Voltage

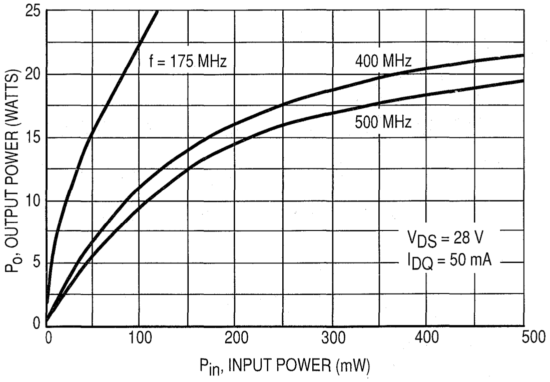


Figure 3. Output Power versus Input Power

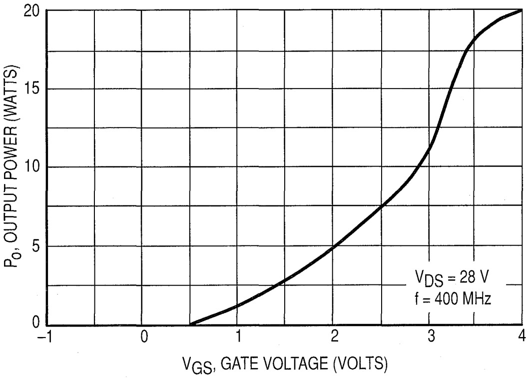


Figure 4. Output Power versus Gate Voltage

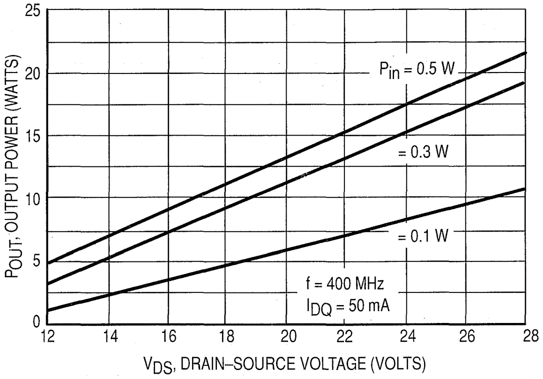
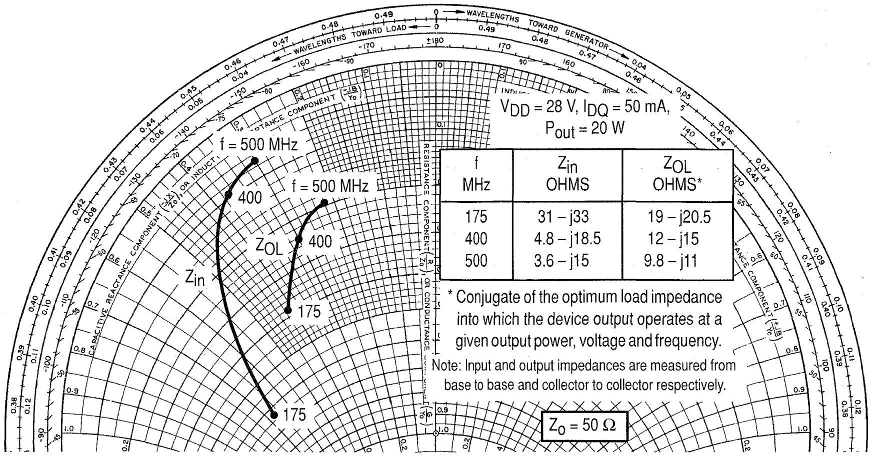


Figure 5. Output Power versus Voltage



V_{DD} = 28 V, I_{DQ} = 50 mA,
P_{out} = 20 W

f MHz	Z_{in} OHMS	Z_{OL} OHMS*
175	31 – j33	19 – j20.5
400	4.8 – j18.5	12 – j15
500	3.6 – j15	9.8 – j11

* Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Note: Input and output impedances are measured from base to base and collector to collector respectively.

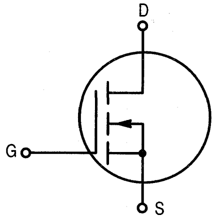
Figure 6. Series Equivalent Input/Output Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement Mode MOSFETs

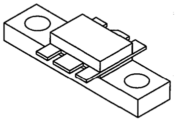
Designed primarily for wideband large–signal output and driver from 30–500 MHz.

- Low C_{rss} — 4.5 pF @ V_{DS} = 28 V
- MRF166C — Typical Performance at 400 MHz, 28 Vdc
  Output Power = 20 W
  Gain = 17 dB
  Efficiency = 55%
- Replacement for Industry Standards such as MRF136, DV2820, BLF244, SD1902, and ST1001
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- Excellent Thermal Stability, Ideally Suited for Class A Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



MRF166C

20 W, 500 MHz
MOSFET
BROADBAND
RF POWER FETs



CASE 319–07, STYLE 3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Gate Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Adc
Drain Current — Continuous	I_D	4.0	Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	70 0.4	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to 150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

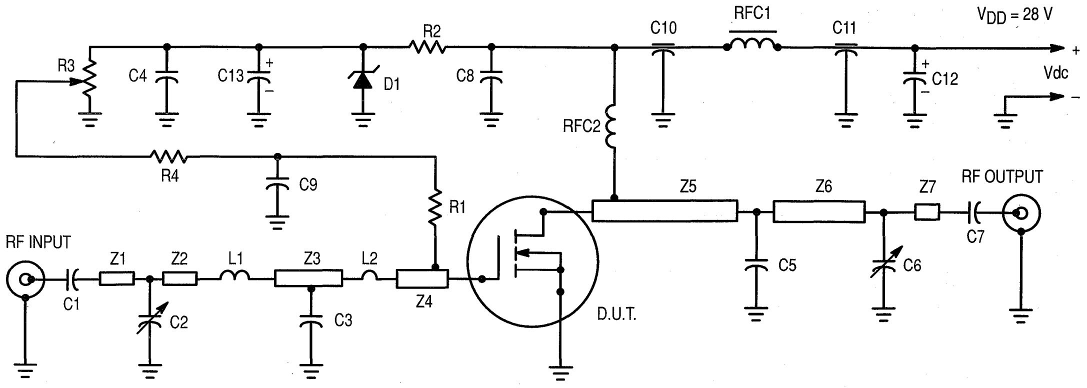
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	°C/W

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0 V, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	V
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0 V)	I_{DSS}	—	—	1.0	mA
Gate–Source Leakage Current (V_{GS} = 40 V, V_{DS} = 0 V)	I_{GSS}	—	—	1.0	μA
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 25 mA)	$V_{GS(th)}$	1.0	3.0	6.0	V
Forward Transconductance (V_{DS} = 10 V, I_D = 1.5 A)	g_{fs}	600	800	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	30	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{oss}	—	35	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{rss}	—	4.5	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 28 V, f = 30 MHz, I_{DQ} = 50 mA)	NF	—	2.5	—	dB
Common Source Power Gain (V_{DD} = 28 V, P_{out} = 20 W, f = 400 MHz, I_{DQ} = 100 mA)	G_{ps}	14	17	—	dB
Drain Efficiency (V_{DD} = 28 V, P_{out} = 20 W, f = 400 MHz, I_{DQ} = 100 mA)	η	50	55	—	%
Electrical Ruggedness (V_{DD} = 28 V, P_{out} = 20 W, f = 400 MHz, I_{DQ} = 100 mA, Load VSWR 30:1 at All Phase Angles)	ψ	No Degradation in Output Power			



C1, C7 — 270 pF Chip Capacitor
C2, C6 — Johanson Trimmer Capacitor, 2–20 pF
C3 — 21 pF Mini Unelco
C4, C8, C9 — 0.01 μF
C5 — 18 pF Mini Unelco
C10, C11 — 680 pF Feed Through
C12, C13 — 50 μF, 50 V
D1 — 1N5925A Motorola Zener

Board Material — Teflon fiberglass
2 oz. Copper clad both sides, $\varepsilon_r = 2.55$
0.060″ Dielectric Thickness

L1 — #18 AWG, 2 Turns, 0.25″ ID 0.15″ Wide
L2 — #18 AWG Hairpin 0.7″ long, bend into hairpin
RFC1 — Ferroxcube VK200–19/4B
RFC2 — 18 Turns #18 AWG Enameled, 0.3″ ID
R1 — 220 Ω 1/2 Watt
R2 — 1.8 kΩ 1/4 Watt
R3 — 10 kΩ, 10 Turns Bourns
R4 — 10 k 1/4 Watt
Z1 — Microstrip Line 0.150″ wide, 0.420″ long
Z2 — Microstrip Line 0.150″ wide, 0.350″ long
Z3 — Microstrip Line 0.150″ wide, 0.350″ long
Z4 — Microstrip Line 0.150″ wide, 0.450″ long
Z5 — Microstrip Line 0.150″ wide, 1.1″ long
Z6 — Microstrip Line 0.150″ wide, 0.650″ long
Z7 — Microstrip Line 0.150″ wide, 0.200″ long

Figure 1. MRF166C 400 MHz Test Circuit

TYPICAL CHARACTERISTICS

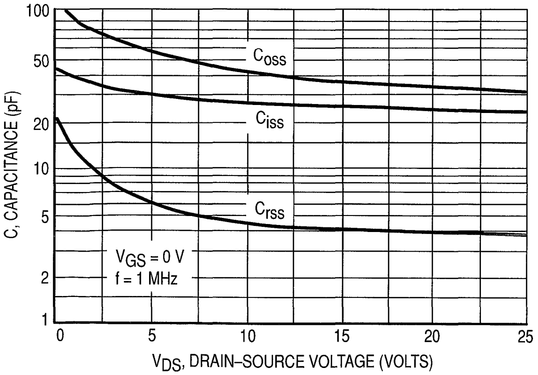


Figure 2. Capacitance versus Drain–Source Voltage

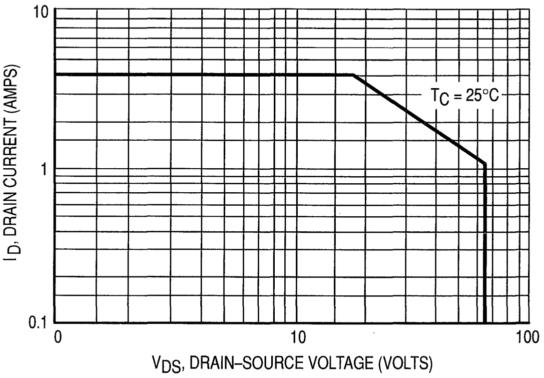


Figure 3. DC Safe Operating Area

TYPICAL CHARACTERISTICS

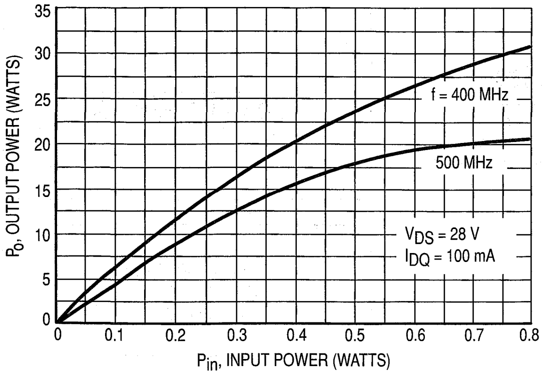


Figure 4. Output Power versus Input Power

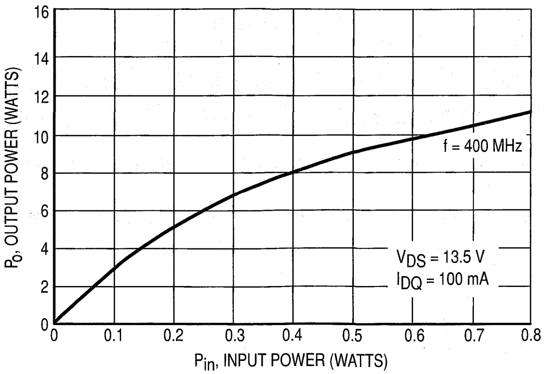


Figure 5. Output Power versus Input Power

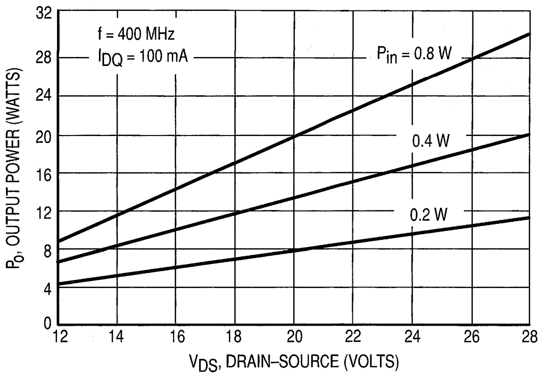
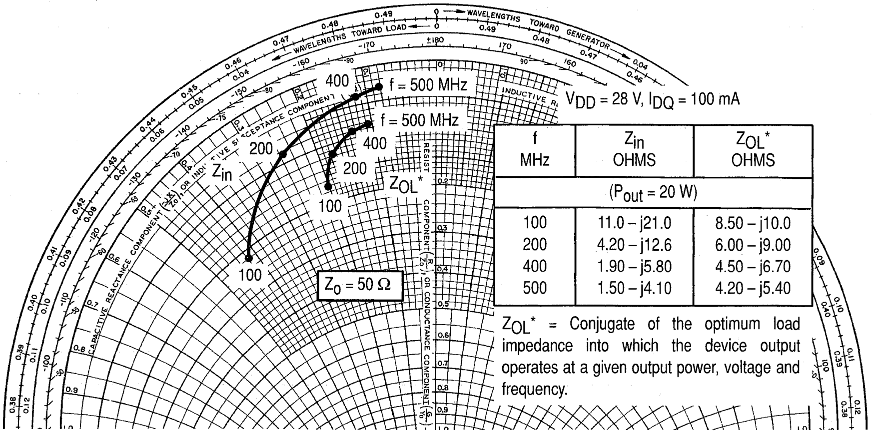


Figure 6. Output Power versus Voltage



f MHz	Z_{in} OHMS	Z_{OL}* OHMS
(P_{out} = 20 W)		
100	11.0 – j21.0	8.50 – j10.0
200	4.20 – j12.6	6.00 – j9.00
400	1.90 – j5.80	4.50 – j6.70
500	1.50 – j4.10	4.20 – j5.40

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 7. Series Equivalent Input and Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

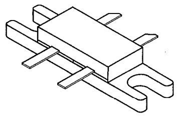
The RF MOSFET Line
Power Field Effect Transistor
N–Channel Enhancement–Mode MOSFET

MRF166W

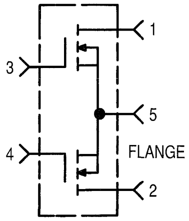
40 W, 500 MHz
TMOS BROADBAND
RF POWER FET

Designed primarily for wideband large–signal output and driver stages to 500 MHz.

- Push–Pull Configuration Reduces Even Numbered Harmonics
- Typical Performance at 400 MHz, 28 Vdc
  Output Power = 40 Watts
  Gain = 13 dB
  Efficiency = 50%
- Typical Performance at 175 MHz, 28 Vdc
  Output Power = 40 Watts
  Gain = 17 dB
  Efficiency = 60%
- Excellent Thermal Stability, Ideally Suited for Class A Operation
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 100% Tested for Load Mismatch at All Phase Angles with 30:1 VSWR
- Low C_{rss} — 4.5 pF @ V_{DS} = 28 Volts
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 412–01, Style 1



MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain–Gate Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	± 40	Adc
Drain Current — Continuous	I_D	8.0	ADC
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0	Watts °C/W
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Thermal Resistance — Junction to Case	$R_{\theta JC}$	1.0	°C/W

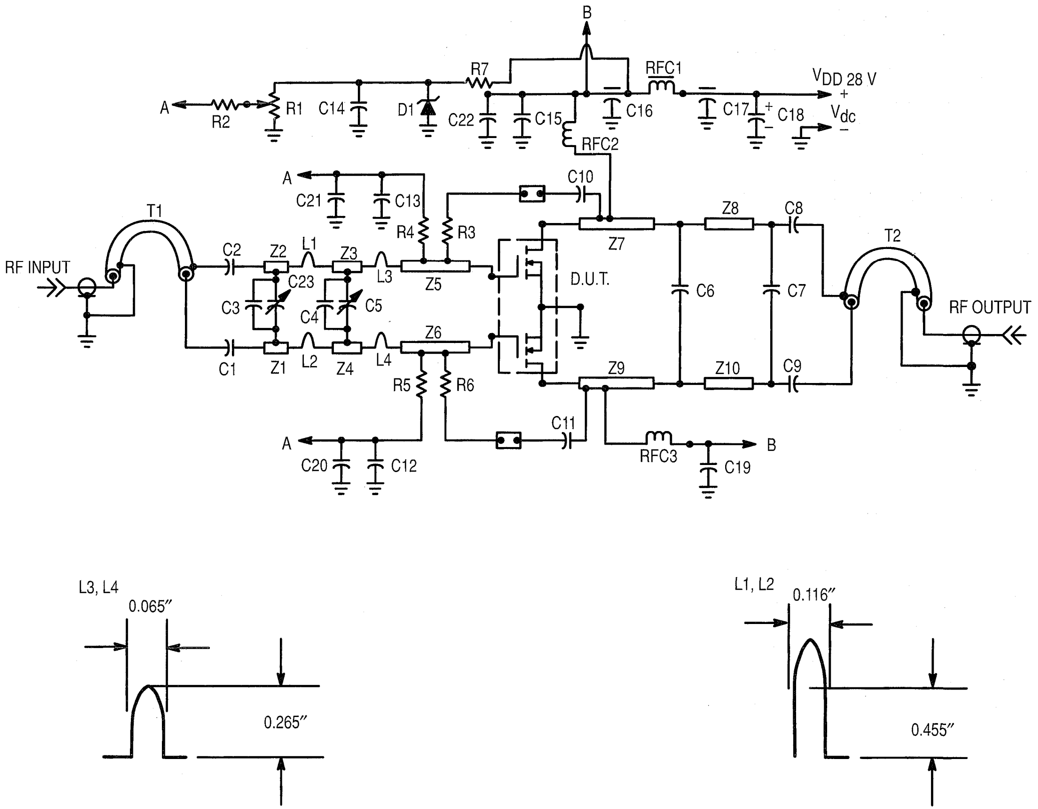
NOTE: Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0 Vdc, I_D = 5.0 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1.0	mA
Gate–Source Leakage Current (V_{GS} = 40 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1.0	μA
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS}= 10 Vdc, I_D = 25 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Forward Transconductance (V_{DS}= 10 Vdc, I_D = 1.5 A)	g_{fs}	600	800	—	mS
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)	C_{iss}	—	30	—	pF
Output Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)	C_{oss}	—	35	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)	C_{rss}	—	4.5	—	pF
FUNCTIONAL CHARACTERISTICS (2)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 40 W, f = 400 MHz, I_{DG} = 100 mA)	G_{ps}	11	13	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 40 W, f = 400 MHz, I_{DG} = 100 mA)	η	45	50	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 40 W, f = 400 MHz, I_{DG} = 100 mA) Load VSWR = 30:1, All phase angles at frequency of test	Ψ	No Degradation in Output Power			

(1) Each transistor chip measured separately.
(2) Both transistor chips operating in a push–pull amplifier.



C1, C2, C8, C9, C12, C13, C15	270 pF, Chip Cap
C3	5.6 pF, Chip Cap
C4	20 pF, Chip Cap
C5	0 – 20 pF, Johanson*
C6	8.2 pF, Chip Cap
C7	15 pF, Chip Cap
C10, C11, C14, C19, C20, C21, C22	0.01 µF
C16, C17	680 pF, Feedthru
C18	10 µF, 50 V
C23	0 – 10 pF, Johanson*
D1	IN5343 – Motorola Zener
L1, L2	Hair Pin Inductor #18 AWG, 0.065 W x 0.265 H
L3, L4	Hair Pin Inductor #18 AWG, 0.116 W x 0.445 H

RFC1	Ferroxcube VK–200–19/4B
RFC2, RFC3	10T, ID = 1/4″, 18 AWG
R1	10 kΩ, 10T
R2	9.2 kΩ, 1/2 W
R3, R6	330 Ω, 1.0 W
R4 R5	520 Ω, 1/4 W
R7	1.5 kΩ, 1/2 W
T1, T2	Balun 2.0″, 50 Ω Semi–Rigid Coax
Z1, Z2	0.120 x 0.467″
Z3, Z4	0.120 x 0.55″ *
Z5, Z6	0.120 x 0.49″
Z7, Z9	0.120 x 0.85″
Z8, Z10	0.120 x 0.6″ for C6

* C4, C5 Center of Z3 and Z4

Board Material – Teflon® Fiberglass

Dielectric Thickness = 0.030″, ε_r = 2.55 Copper Clad, 2.0 oz. Copper

Figure 1. MRF166 400 MHz Test Circuit Schematic

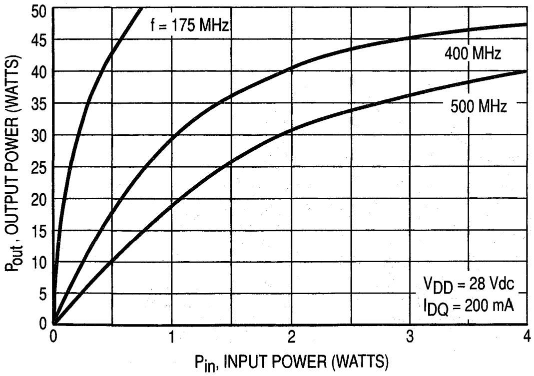


Figure 2. Output Power versus Input Power

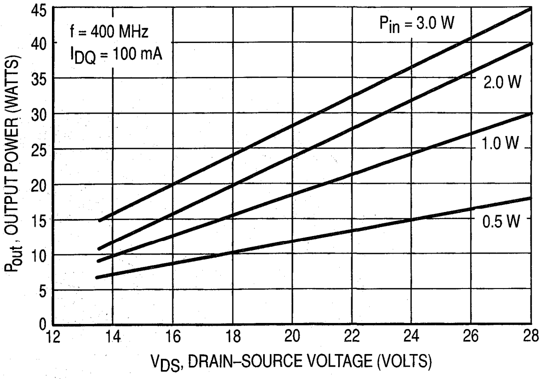


Figure 3. Output Power versus Voltage

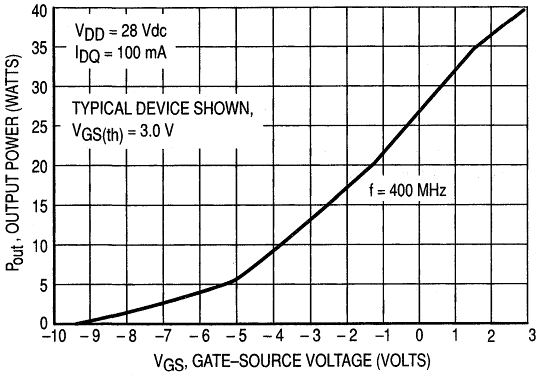


Figure 4. Output Power versus Gate Voltage

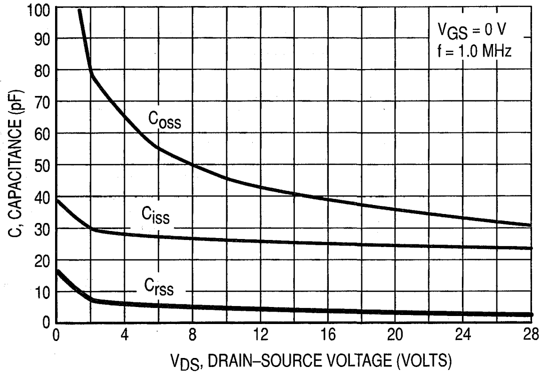
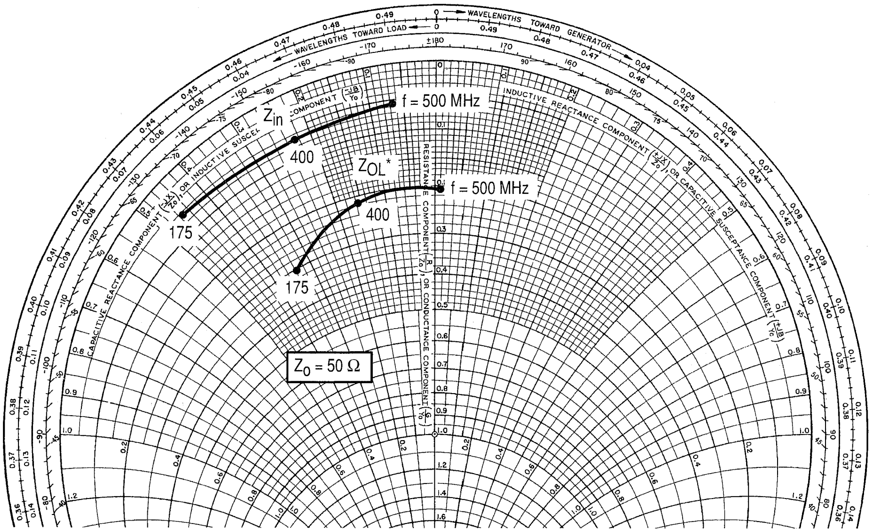


Figure 5. Capacitance versus Voltage



V_{DD} = 28 Vdc, I_{DQ} = 100 mA, P_{out} = 40 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
175	3.7 – j 22.4	15.2 – j 16.6
400	3.6 – j 10.99	10.3 – j 7.99
500	2.6 – j 3.2	10.2 + j 0.5

Table 1. Input and Output Impedances

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

NOTE: Input and output impedance values given are measured from gate to gate and drain to drain respectively.

Figure 6. Series Equivalent Input/Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

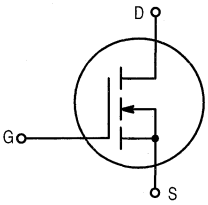
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode

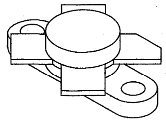
MRF171

45 W, to 200 MHz
N–CHANNEL MOS
BROADBAND RF POWER
FET

. . . designed primarily for wideband large–signal output and driver stages up to 200 MHz frequency range.

- Guaranteed Performance at 150 MHz, 28 Vdc
  Output Power = 45 Watts
  Minimum Gain = 12 dB
  Efficiency = 50% (Min)
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR
- Excellent Thermal Stability, Ideally Suited For Class A Operation
- Low Noise Figure — 1.5 dB Typ at 1.0 A, 150 MHz





CASE 211–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	4.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.66	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

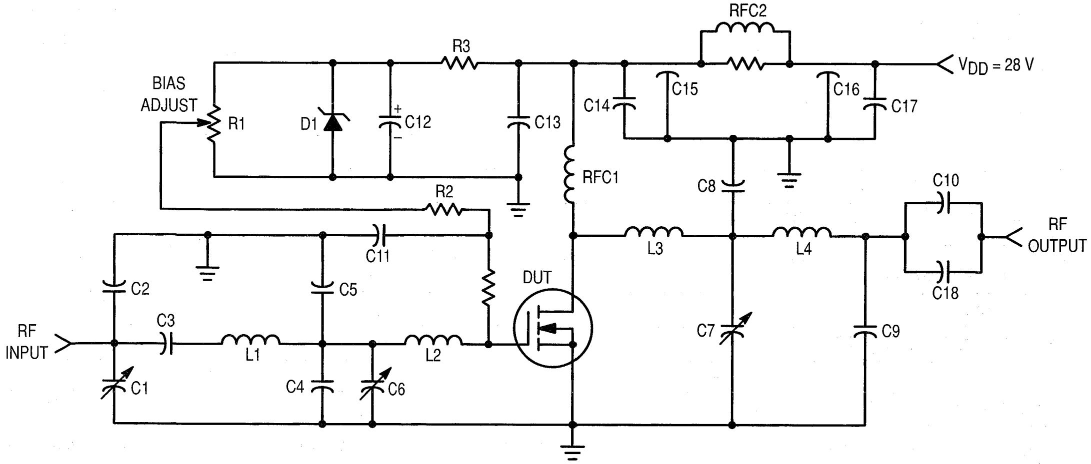
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.52	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 10 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 25 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 1.0 A)	g_{fs}	0.7	1.1	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	55	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	70	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	14	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DS} = 28 Vdc, I_D = 1.0 A, f = 150 MHz)	NF	—	1.5	—	dB
Common Source Power Gain (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 45 W, f = 150 MHz, I_{DQ} = 25 mA)	G_{ps}	12	15	—	dB
Drain Efficiency (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 45 W, f = 150 MHz, I_{DQ} = 25 mA)	η	50	60	—	%
Electrical Ruggedness (Figure 1) (V_{DD} = 28 Vdc, P_{out} = 45 W, f = 150 MHz, I_{DQ} = 25 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			



C1, C6, C7 — 1.0–20 pF Johanson
C2, C4, C5, C8 — 63 pF ATC Chip (100 mils)
C3, C10, C18 — 680 pF ATC Chip (100 mils)
C9 — 12 pF ATC Chip (100 mils)
C11, C13, C14, C17 — 0.1 μF Erie Redcap, 50 V
C12 — 25 μF, 50 V
C15, C16 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener
L1 — 2 Turns, #18 AWG, 0.3″ ID, 0.3″ Long
L2 — 1–1/4 Turns, #18 AWG, 0.21″ ID
L3 — 1–1/4 Turns, #18 AWG, 0.21″ ID
L4 — 2 Turns, #18 AWG, 0.23″ ID, 0.15″ Long
RFC1 — 20 Turns, #20 AWG Enameled, 0.3″ ID, Close Wound
RFC2 — 15 Turns, #20 AWG Enameled on 2.0 W, 10 Ω Resistor
R1 — 10 kΩ, 10 Turns Helipot 7216–R10K–L.25
R2 — 10 kΩ, 1/4 W
R3 — 1.8 kΩ, 1/2 W
R4 — 47 Ω, 1/2 W

Figure 1. 150 MHz Test Circuit

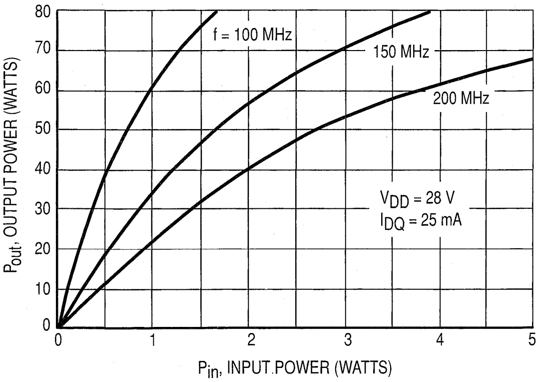


Figure 2. Output Power versus Input Power

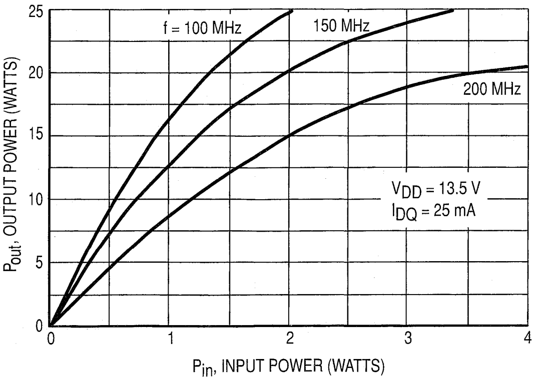


Figure 3. Output Power versus Input Power

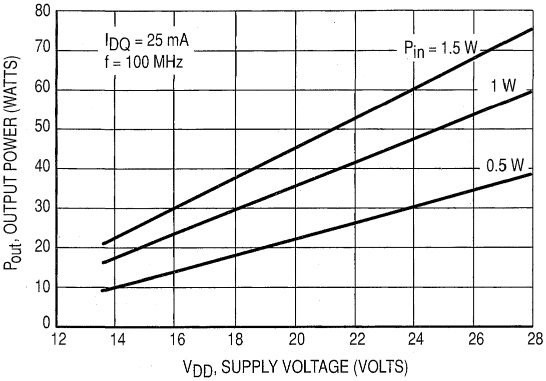


Figure 4. Output Power versus Supply Voltage

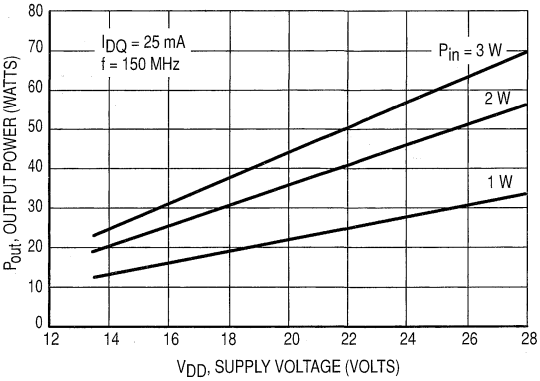


Figure 5. Output Power versus Supply Voltage

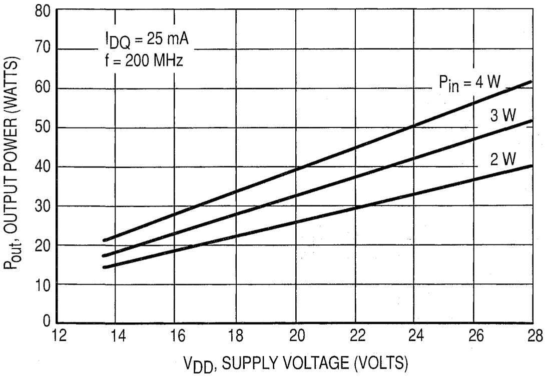


Figure 6. Output Power versus Supply Voltage

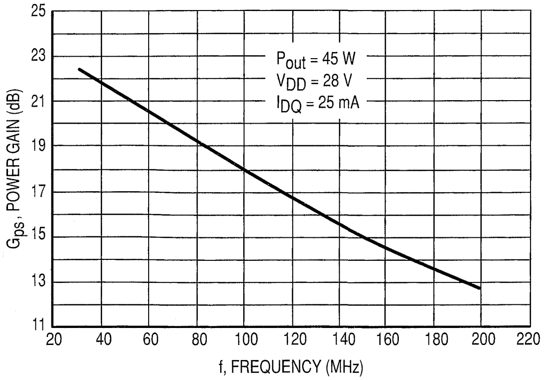


Figure 7. Power Gain versus Frequency

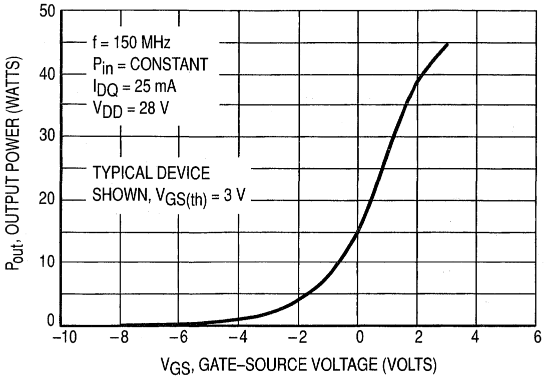


Figure 8. Output Power versus Gate Voltage

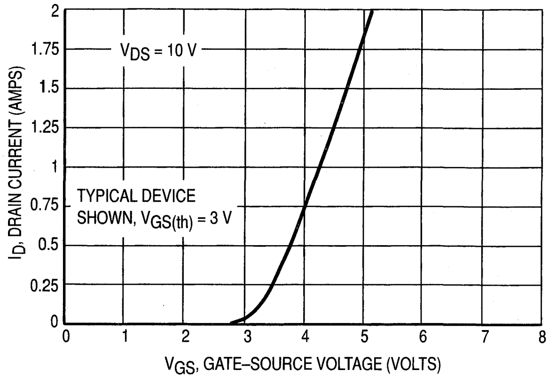


Figure 9. Drain Current versus Gate Voltage (Transfer Characteristics)

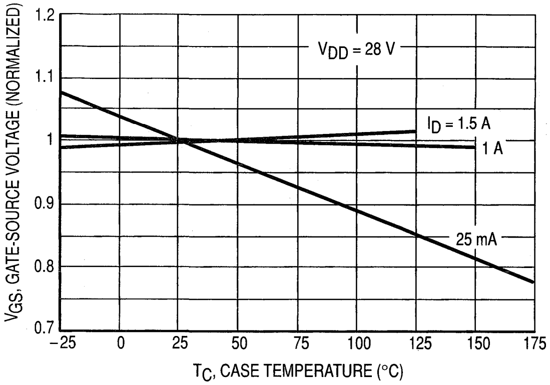


Figure 10. Gate–Source Voltage versus Case Temperature

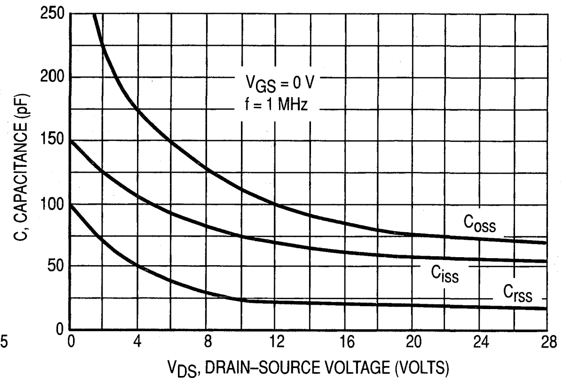


Figure 11. Capacitance versus Drain Voltage

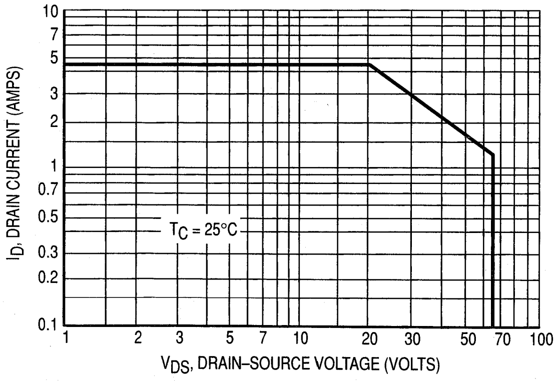


Figure 12. DC Safe Operating Area

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
2.0	0.966	−50	72.4	153	0.014	63	0.674	−59
5.0	0.891	−97	50.8	128	0.025	39	0.757	−109
10	0.841	−132	30.1	110	0.030	23	0.801	−141
20	0.821	−155	15.9	99	0.032	14	0.818	−160
30	0.817	−162	10.7	93	0.032	11	0.822	−166
40	0.816	−167	8.06	90	0.032	10	0.823	−169
50	0.816	−169	6.45	88	0.032	11	0.825	−171
60	0.816	−171	5.37	85	0.032	11	0.826	−172
70	0.816	−172	4.60	84	0.032	12	0.828	−173
80	0.816	−172	4.01	82	0.032	13	0.829	−174
90	0.816	−173	3.56	80	0.033	14	0.830	−174
100	0.816	−173	3.15	77	0.034	15	0.832	−174
110	0.816	−173	2.85	76	0.035	16	0.832	−175
120	0.816	−173	2.59	75	0.036	18	0.832	−175
130	0.817	−174	2.40	74	0.036	19	0.832	−175
140	0.817	−174	2.23	72	0.037	20	0.834	−175
150	0.820	−174	2.09	71	0.037	21	0.835	−175
160	0.823	−174	1.97	70	0.037	22	0.836	−175
170	0.825	−175	1.85	69	0.037	23	0.839	−175
180	0.826	−175	1.75	68	0.037	25	0.840	−175
190	0.829	−175	1.66	67	0.037	26	0.843	−175
200	0.832	−175	1.59	66	0.038	27	0.845	−175
250	0.844	−176	1.24	61	0.039	37	0.856	−175
300	0.855	−176	1.02	55	0.042	45	0.867	−174
350	0.862	−177	0.88	51	0.047	53	0.878	−174
400	0.868	−178	0.76	48	0.052	59	0.885	−174
450	0.873	−179	0.67	45	0.059	64	0.897	−174
500	0.907	179	0.63	42	0.067	67	0.892	−175

Table 1. Common Source Scattering Parameters
V_{DS} = 28 V, I_D = 0.5 A

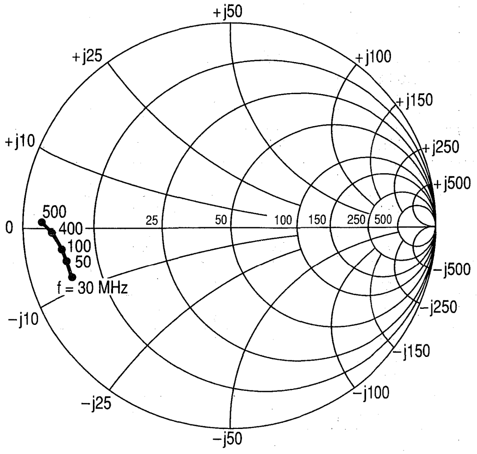


Figure 13. S_{11}, Input Reflection Coefficient versus Frequency
V_{DS} = 28 V, I_D = 0.5 A

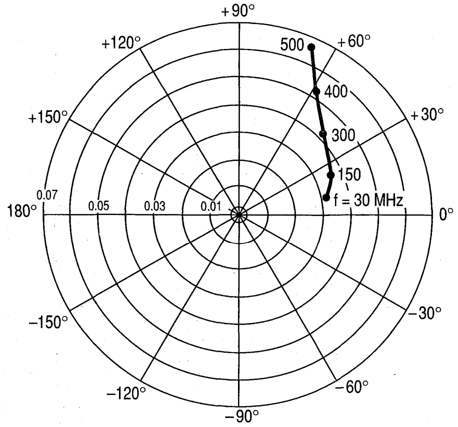


Figure 14. S_{12}, Reverse Transmission Coefficient versus Frequency
V_{DS} = 28 V, I_D = 0.5 A

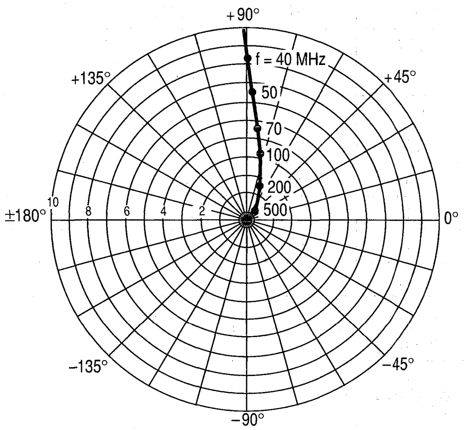


Figure 15. S_{21}, Forward Transmission Coefficient versus Frequency
V_{DS} = 28 V, I_D = 0.5 A

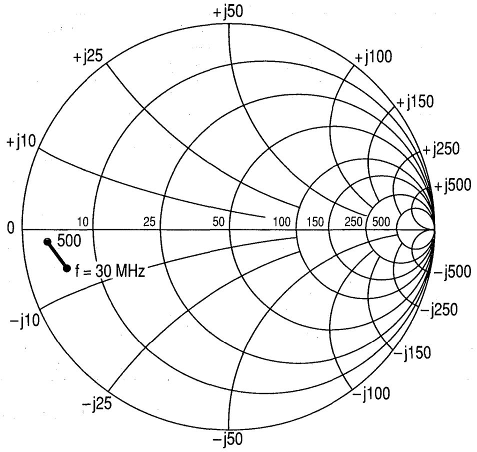
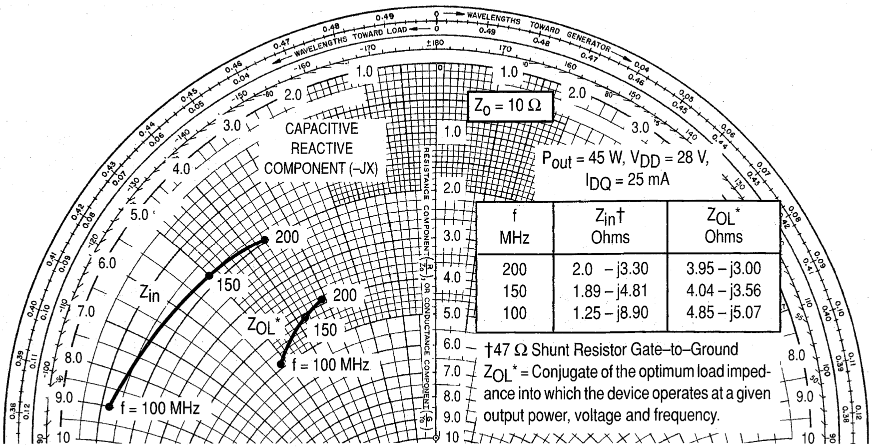


Figure 16. S_{22}, Output Reflection Coefficient versus Frequency
V_{DS} = 28 V, I_D = 0.5 A



P_{out} = 45 W, V_{DD} = 28 V,
I_{DQ} = 25 mA

f MHz	Z_{in}† Ohms	Z_{OL}* Ohms
200	2.0 – j3.30	3.95 – j3.00
150	1.89 – j4.81	4.04 – j3.56
100	1.25 – j8.90	4.85 – j5.07

†47 Ω Shunt Resistor Gate–to–Ground

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 17. Large–Signal Series Equivalent Input/Output Impedance

DESIGN CONSIDERATIONS

The MRF171 is a RF power N–Channel enhancement mode field–effect transistor (FET) designed especially for UHF power amplifier and oscillator applications. Motorola RF MOSFETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V–groove vertical power FETs.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF171 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. See Figure 9 for a typical plot of drain current versus gate voltage. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF171 was characterized at $I_{DQ} = 25$ mA, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF171 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems. (See Figure 8.)

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar UHF transistors are suitable for MRF171. See Motorola Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. The higher input impedance of RF MOSFETs helps ease the task of broadband network design. Both small signal scattering parameters and large signal impedances are provided. While the s–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF MOS power FETs.

RF power FETs are triode devices and, therefore, not unilateral. This, coupled with the very high gain of the MRF171, yields a device capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. Two port parameter stability analysis with the MRF171 s–parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A for a discussion of two port network theory and stability.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

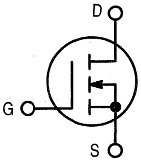
The RF MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement Mode MOSFETs

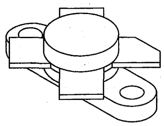
MRF173

80 W, 28 V, 175 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFETs

Designed for broadband commercial and military applications up to 200 MHz frequency range. The high–power, high–gain and broadband performance of these devices make possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance at 150 MHz, 28 V:
  Output Power = 80 W
  Gain = 11 dB (13 dB Typ)
  Efficiency = 55% Min. (60% Typ)
- Low Thermal Resistance
- Ruggedness Tested at Rated Output Power
- Nitride Passivated Die for Enhanced Reliability
- Low Noise Figure — 1.5 dB Typ at 2.0 A, 150 MHz
- Excellent Thermal Stability; Suited for Class A Operation





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage	V_{DGO}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	9.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	220 1.26	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Temperature Range	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{DS} = 0 V, V_{GS} = 0 V) I_D = 50 mA	$V_{(BR)DSS}$	65	—	—	V
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0 V)	I_{DSS}	—	—	2.0	mA
Gate–Source Leakage Current (V_{GS} = 40 V, V_{DS} = 0 V)	I_{GSS}	—	—	1.0	µA
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 50 mA)	$V_{GS(th)}$	1.0	3.0	6.0	V
Drain–Source On–Voltage ($V_{DS(on)}$, V_{GS} = 10 V, I_D = 3.0 A)	$V_{DS(on)}$	—	—	1.4	V
Forward Transconductance (V_{DS} = 10 V, I_D = 2.0 A)	g_{fs}	1.8	2.2	—	mhos

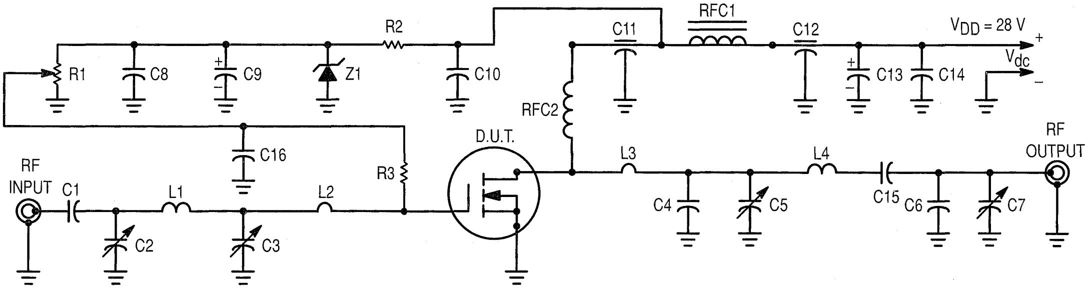
(continued)

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{iss}	—	110	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{oss}	—	105	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0 V, f = 1.0 MHz)	C_{rss}	—	10	—	pF
FUNCTIONAL CHARACTERISTICS					
Noise Figure (V_{DD} = 28 V, f = 150 MHz, I_{DQ} = 50 mA)	NF	—	1.5	—	dB
Common Source Power Gain (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA)	G_{ps}	11	13	—	dB
Drain Efficiency (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA)	η	55	60	—	%
Electrical Ruggedness (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA) Load VSWR 30:1 at all phase angles	ψ	No Degradation in Output Power			
Series Equivalent Input Impedance MRF173 (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA)	Z_{in}	—	2.99–j4.5	—	Ohms
Series Equivalent Output Impedance MRF173 (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA)	Z_{out}	—	2.68–j1.3	—	Ohms
Series Equivalent Input Impedance MRF173CQ (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA)	Z_{in}	—	1.35–j5.15	—	Ohms
Series Equivalent Output Impedance MRF173CQ (V_{DD} = 28 V, P_{out} = 80 W, f = 150 MHz, I_{DQ} = 50 mA)	Z_{out}	—	2.72–j149	—	Ohms



C1, C15 — 470 pF Unelco
C2, C3, C5 — 9–180 pF, Arco 463
C4, C6 — 15 pF, Unelco
C7 — 5–80 pF, Arco 462
C8, C10, C14, C16 — 0.1 µF
C9, C13 — 50 µF, 50 Vdc
C11, C12 — 680 pF, Feed Through
L1 — #16 AWG, 1–1/4 Turns, 0.3″ ID
L2 — #16 AWG Hairpin 1″ long →

L3 — #14 AWG Hairpin 0.8″ long →
L4 — #14 AWG Hairpin 1.1″ long →

RFC1 — Ferroxcube VK200–19/4B
RFC2 — 18 Turns #18 AWG Enameled, 0.3″ ID
R1 — 10 kΩ, 10 Turns Bourns
R2 — 1.8 kΩ, 1/4 W
R3 — 10 kΩ, 1/2 W
Z1 — 1N5925A Motorola Zener

Figure 1. 150 MHz Test Circuit

TYPICAL CHARACTERISTICS

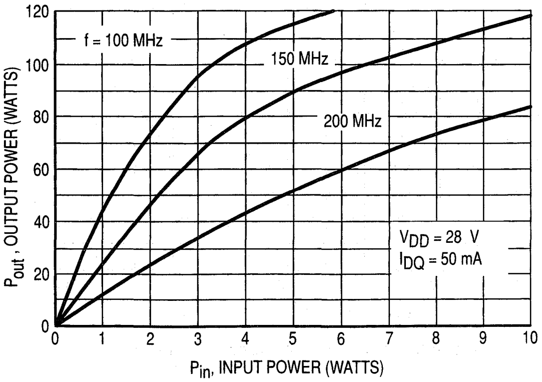


Figure 2. Output Power versus Input Power

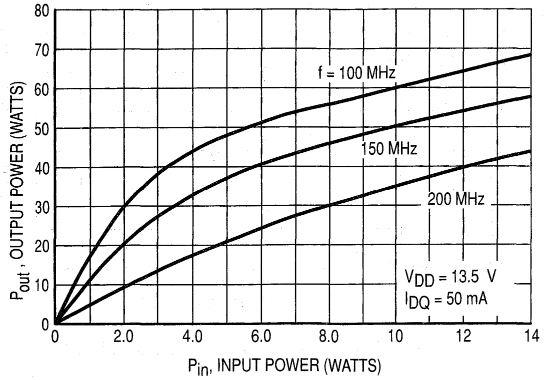


Figure 3. Output Power versus Input Power

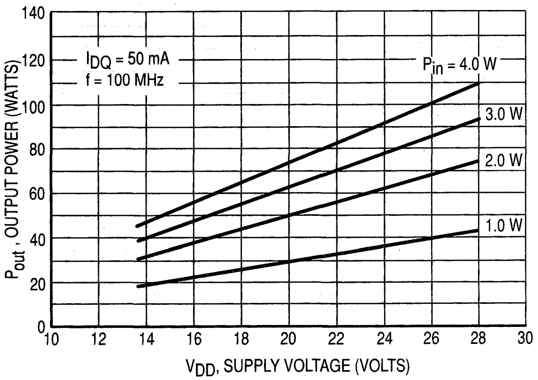


Figure 4. Output Power versus Supply Voltage

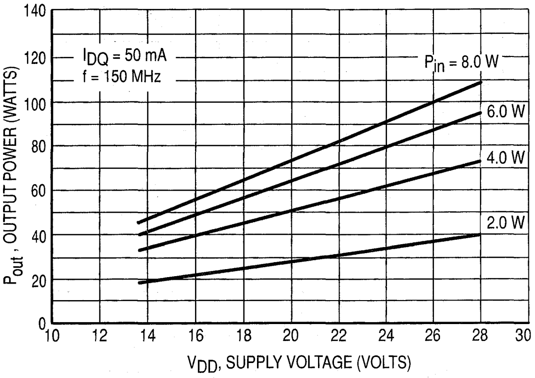


Figure 5. Output Power versus Supply Voltage

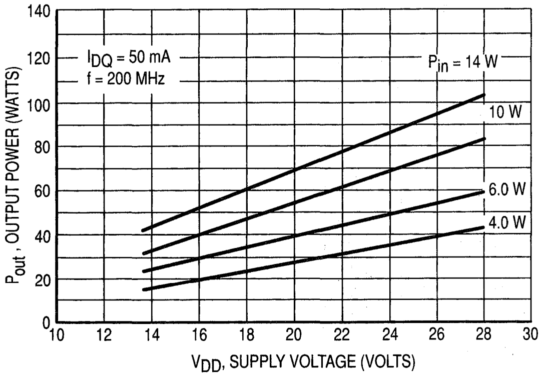


Figure 6. Output Power versus Supply Voltage

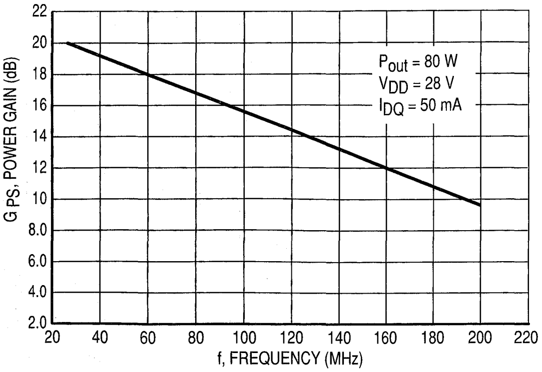


Figure 7. Power Gain versus Frequency

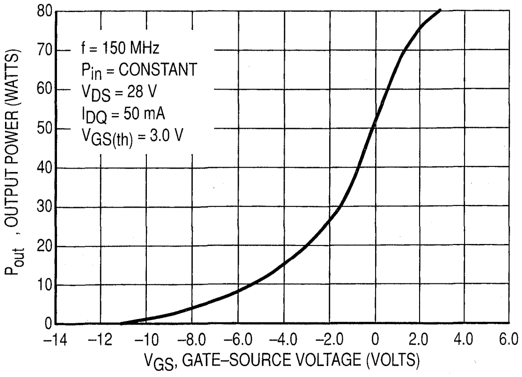


Figure 8. Output Power versus Gate Voltage

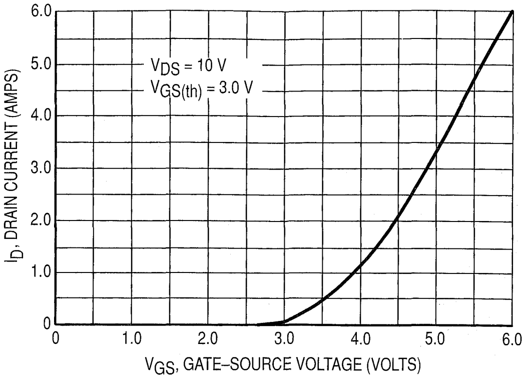


Figure 9. Drain Current versus Gate Voltage

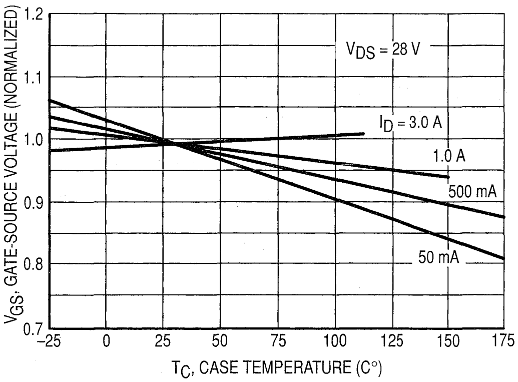


Figure 10. Gate–Source Voltage versus Case Temperature

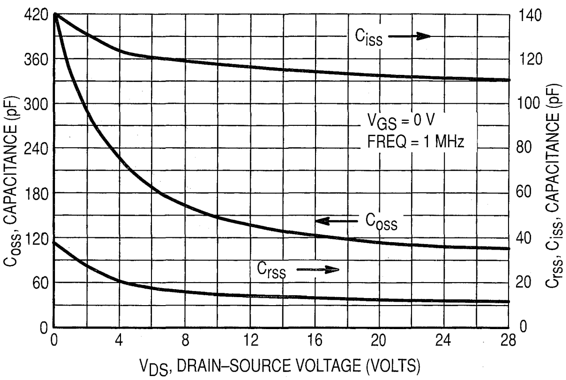


Figure 11. Capacitance versus Drain Voltage

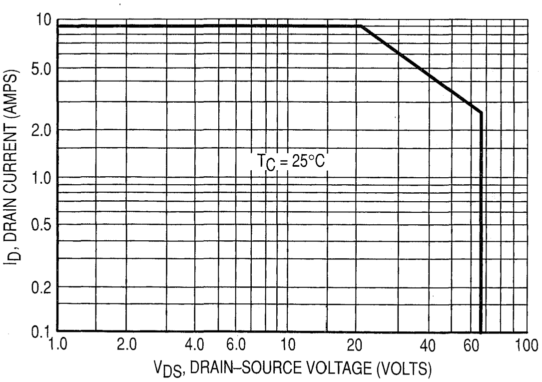


Figure 12. DC Safe Operating Area

DESIGN CONSIDERATIONS

The MRF173 is a RF MOSFET power N–channel enhancement mode field–effect transistor (FET) designed for VHF power amplifier applications. Motorola's RF MOSFETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V–groove power FETs.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF173 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. See Figure 9 for a typical plot of drain current versus gate voltage. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF173 was characterized at I_{DQ} = 50 mA, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF173 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems. (see Figure 8.)

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar VHF transistors are suitable for MRF173. See Motorola Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. The higher input impedance of RF MOSFETs helps ease the task of broadband network design. Both small–signal scattering parameters and large–signal impedances are provided. While the s–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF MOS power FETs.

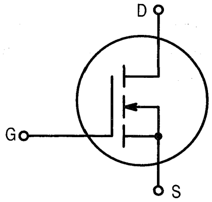
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode

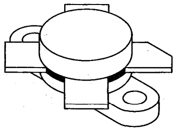
MRF174

**125 W, to 200 MHz
N–CHANNEL MOS
BROADBAND RF POWER
FET**

. . . designed primarily for wideband large–signal output and driver stages up to 200 MHz frequency range.

- Guaranteed Performance at 150 MHz, 28 Vdc
  Output Power = 125 Watts
  Minimum Gain = 9.0 dB
  Efficiency = 50% (Min)
- Excellent Thermal Stability, Ideally Suited For Class A Operation
- Facilitates Manual Gain Control, ALC and Modulation Techniques
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR
- Low Noise Figure — 3.0 dB Typ at 2.0 A, 150 MHz





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	13	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

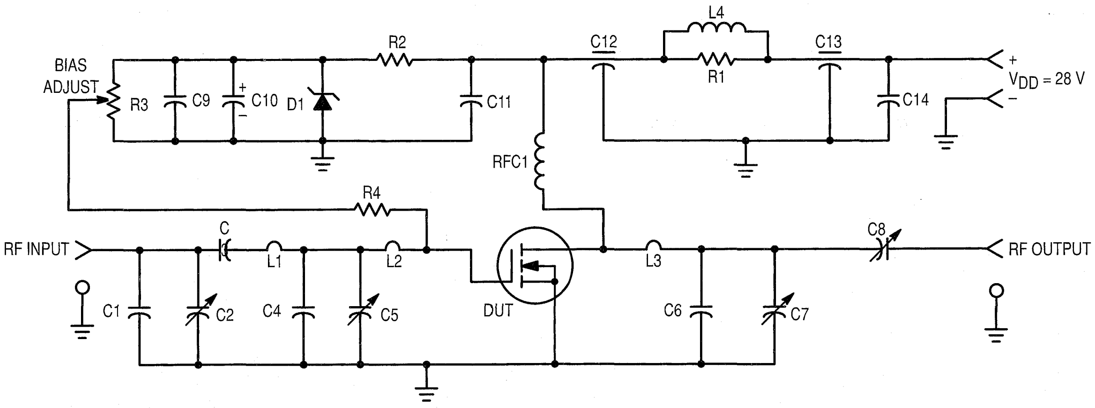
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 50 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	10	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 3.0 A)	g_{fs}	1.75	2.5	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	175	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	230	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	40	—	pF
FUNCTIONAL CHARACTERISTICS (Figure 1)					
Noise Figure (V_{DD} = 28 Vdc, I_D = 2.0 A, f = 150 MHz)	NF	—	3.0	—	dB
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 125 W, f = 150 MHz, I_{DQ} = 100 mA)	G_{ps}	9.0	11.8	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 125 W, f = 150 MHz, I_{DQ} = 100 mA)	η	50	60	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 125 W, f = 150 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			



C1 — 15 pF Unelco
C2 — Arco 462, 5.0–80 pF
C3 — 100 pF Unelco
C4 — 25 pF Unelco
C6 — 40 pF Unelco
C7 — Arco 461, 2.7–30 pF
C5, C8 — Arco 463, 9.0–180 pF
C9, C11, C14 — 0.1 µF Erie Redcap
C10 — 50 µF, 50 V
C12, C13 — 680 pF Feedthru
D1 — 1N5925A Motorola Zener

L1 — #16 AWG, 1–1/4 Turns, 0.213″ ID
L2 — #16 AWG, Hairpin 0.25″ 0.062″
L3 — #14 AWG, Hairpin 0.47″ 0.2″
L4 — 10 Turns #16 AWG Enameled Wire on R1
RFC1 — 18 Turns #16 AWG Enameled Wire, 0.3″ ID
R1 — 10 Ω, 2.0 W
R2 — 1.8 kΩ, 1/2 W
R3 — 10 kΩ, 10 Turn Bourns
R4 — 10 kΩ, 1/4 W

Figure 1. 150 MHz Test Circuit

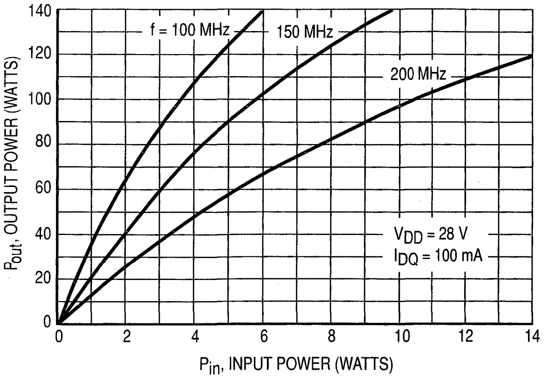


Figure 2. Output Power versus Input Power

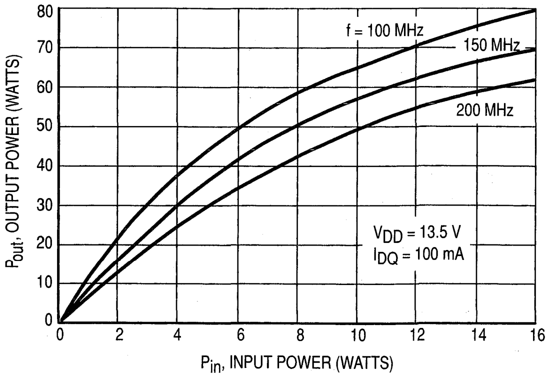


Figure 3. Output Power versus Input Power

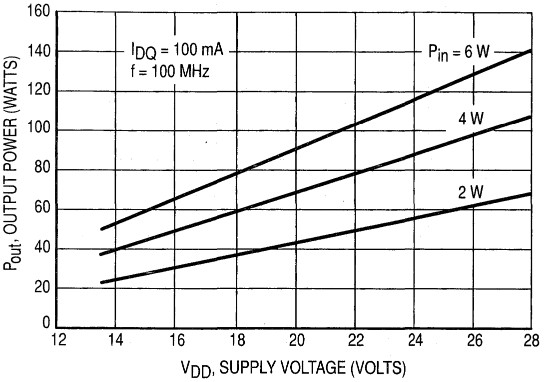


Figure 4. Output Power versus Supply Voltage

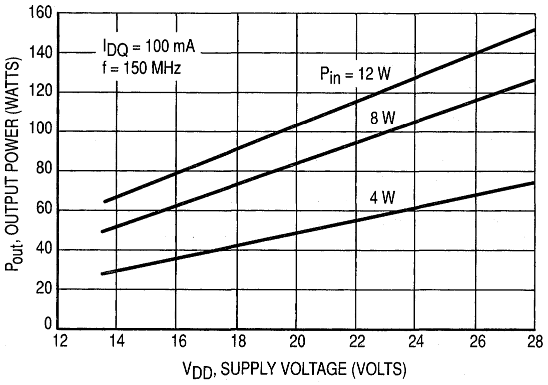


Figure 5. Output Power versus Supply Voltage

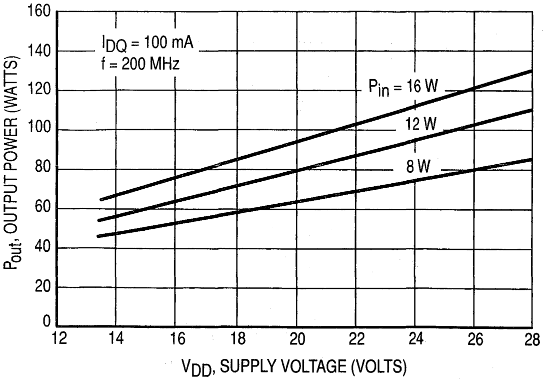


Figure 6. Output Power versus Supply Voltage

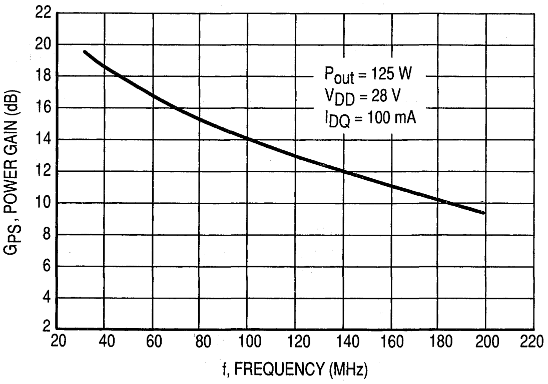


Figure 7. Power Gain versus Frequency

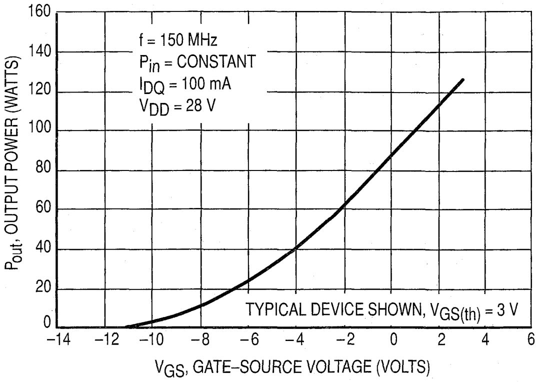


Figure 8. Output Power versus Gate Voltage

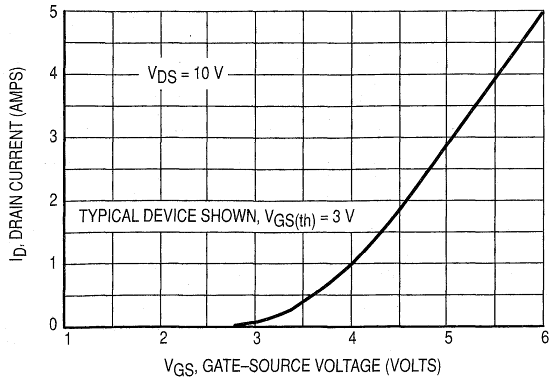


Figure 9. Drain Current versus Gate Voltage (Transfer Characteristics)

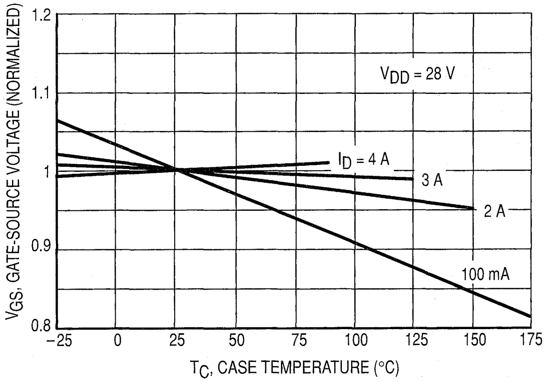


Figure 10. Gate–Source Voltage versus Case Temperature

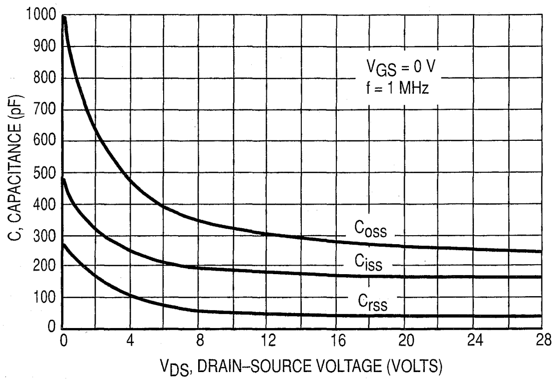


Figure 11. Capacitance versus Drain Voltage

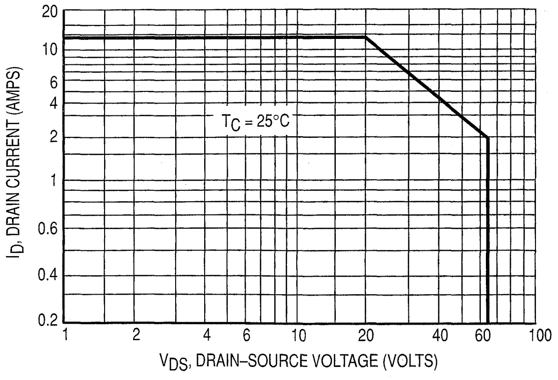


Figure 12. DC Safe Operating Area

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	$\angle \phi$	$\lvert S_{21}\rvert$	$\angle \phi$	$\lvert S_{12}\rvert$	$\angle \phi$	$\lvert S_{22}\rvert$	$\angle \phi$
2.0	0.932	−133	74.0	112	0.011	23	0.835	−151
5.0	0.923	−160	31.6	98	0.011	12	0.886	−168
10	0.921	−170	16.0	93	0.011	10	0.896	−174
20	0.921	−175	8.00	88	0.011	12	0.899	−177
30	0.921	−177	5.32	86	0.011	16	0.900	−178
40	0.921	−177	3.98	83	0.012	21	0.901	−178
50	0.922	−178	3.17	81	0.012	26	0.902	−178
60	0.923	−178	2.63	79	0.012	30	0.903	−178
70	0.924	−178	2.24	77	0.013	34	0.904	−178
80	0.925	−178	1.95	75	0.013	39	0.906	−178
90	0.927	−178	1.72	73	0.014	43	0.907	−178
100	0.930	−178	1.50	71	0.016	45	0.910	−178
110	0.930	−178	1.31	70	0.018	46	0.912	−178
120	0.931	−178	1.19	68	0.019	47	0.914	−178
130	0.942	−178	1.10	67	0.019	49	0.919	−178
140	0.936	−178	1.01	66	0.021	50	0.921	−178
150	0.938	−178	0.936	65	0.021	53	0.922	−178
160	0.938	−178	0.879	64	0.022	53	0.923	−178
170	0.940	−178	0.830	63	0.023	54	0.923	−177
180	0.942	−178	0.780	61	0.024	56	0.924	−177
190	0.942	−178	0.737	60	0.026	59	0.928	−177
200	0.952	−178	0.705	59	0.027	58	0.929	−177
210	0.950	−178	0.668	57	0.029	61	0.934	−177
220	0.942	−178	0.626	56	0.030	61	0.933	−177
230	0.943	−178	0.592	56	0.032	62	0.939	−177
240	0.946	−177	0.566	55	0.033	64	0.941	−177
250	0.952	−177	0.545	54	0.035	64	0.943	−177
260	0.958	−177	0.523	53	0.036	65	0.946	−177
270	0.956	−177	0.500	52	0.038	67	0.943	−177
280	0.960	−177	0.481	52	0.039	68	0.946	−177
290	0.956	−178	0.460	51	0.042	68	0.944	−177
300	0.955	−178	0.443	50	0.043	68	0.947	−177

Table 1. Common Source Scattering Parameters
V_{DS} = 28 V, I_D = 3.0 A

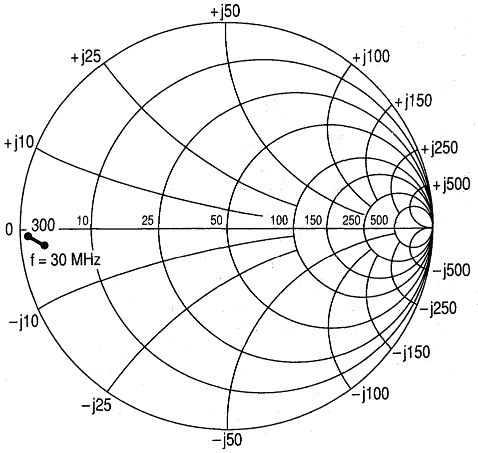


Figure 13. S_{11}, Input Reflection Coefficient versus Frequency V_{DS} = 28 V, I_D = 3.0 A

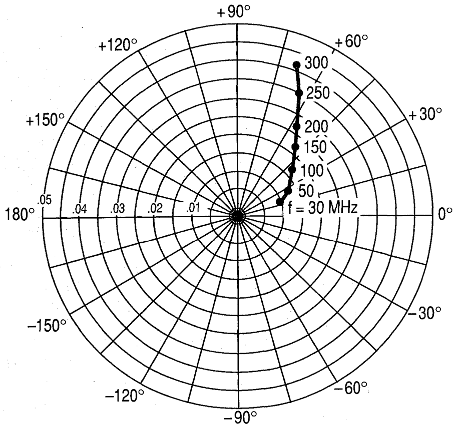


Figure 14. S_{12}, Reverse Transmission Coefficient versus Frequency V_{DS} = 28 V, I_D = 3.0 A

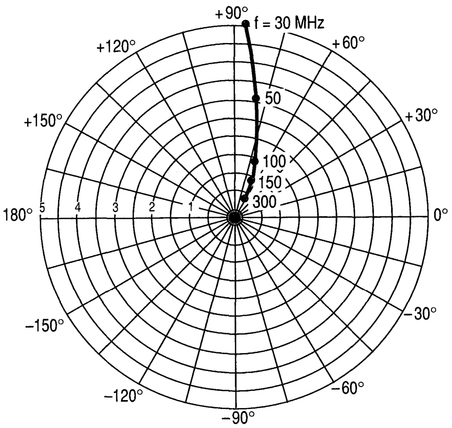


Figure 15. S_{21}, Forward Transmission Coefficient versus Frequency V_{DS} = 28 V, I_D = 3.0 A

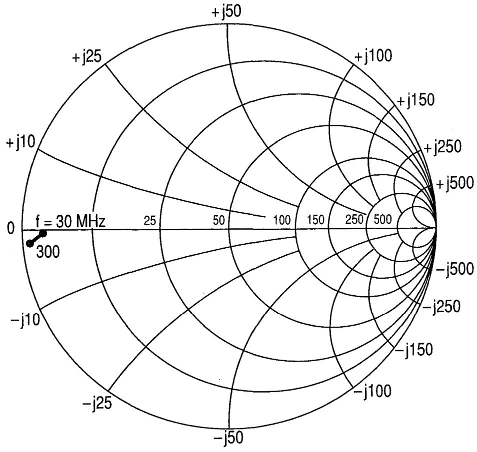
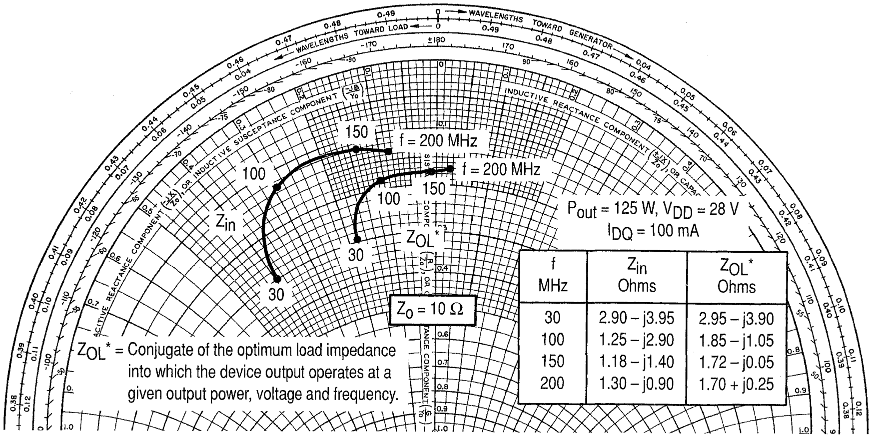


Figure 16. S_{22}, Output Reflection Coefficient versus Frequency V_{DS} = 28 V, I_D = 3.0 A



P_{out} = 125 W, V_{DD} = 28 V
I_{DQ} = 100 mA

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
30	2.90 – j3.95	2.95 – j3.90
100	1.25 – j2.90	1.85 – j1.05
150	1.18 – j1.40	1.72 – j0.05
200	1.30 – j0.90	1.70 + j0.25

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 17. Series Equivalent Input/Output Impedance, Z_{in}, Z_{OL}*

DESIGN CONSIDERATIONS

The MRF174 is a RF power N–Channel enhancement mode field–effect transistor (FET) designed especially for UHF power amplifier and oscillator applications. Motorola RF MOSFETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V–groove vertical power FETs.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF174 is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. See Figure 9 for a typical plot of drain current versus gate voltage. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF174 was characterized at I_{DQ} = 100 mA, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF174 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems. (See Figure 8.)

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar UHF transistors are suitable for MRF174. See Motorola Application Note AN721, Impedance Matching Networks Applied to RF Power Transistors. The higher input impedance of RF MOSFETs helps ease the task of broadband network design. Both small signal scattering parameters and large signal impedances are provided. While the s–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF MOS power FETs.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

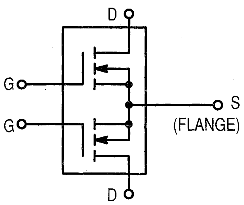
The RF MOSFET Line
RF Power Field-Effect Transistors
N–Channel Enhancement–Mode

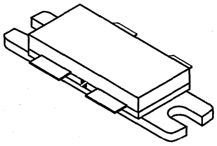
MRF175GU
MRF175GV

200/150 WATTS, 28 V, 500 MHz
N–CHANNEL MOS
BROADBAND
RF POWER FETs

Designed for broadband commercial and military applications using push pull circuits at frequencies to 500 MHz. The high power, high gain and broadband performance of these devices makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance
  MRF175GV @ 28 V, 225 MHz (“V” Suffix)
    Output Power — 200 Watts
    Power Gain — 14 dB Typ
    Efficiency — 65% Typ
  MRF175GU @ 28 V, 400 MHz (“U” Suffix)
    Output Power — 150 Watts
    Power Gain — 12 dB Typ
    Efficiency — 55% Typ
- 100% Ruggedness Tested At Rated Output Power
- Low Thermal Resistance
- Low C_{rss} — 20 pF Typ @ V_{DS} = 28 V





CASE 375–04, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	26	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	400 2.27	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.44	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 50 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	2.5	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc

(continued)

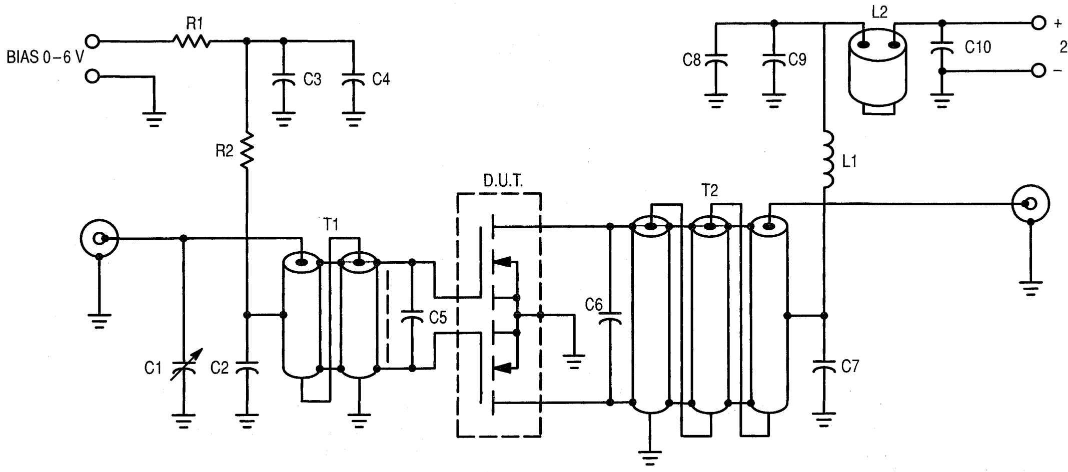
Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 5.0 A)	$V_{DS(on)}$	0.1	0.9	1.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 2.5 A)	g_{fs}	2.0	3.0	—	mhos
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	180	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	200	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	20	—	pF
FUNCTIONAL CHARACTERISTICS — MRF175GV (2) (Figure 1)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 200 W, f = 225 MHz, I_{DQ} = 2.0 x 100 mA)	G_{ps}	12	14	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 200 W, f = 225 MHz, I_{DQ} = 2.0 x 100 mA)	η	55	65	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 200 W, f = 225 MHz, I_{DQ} = 2.0 x 100 mA, VSWR 10:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTES:
1. Each side of device measured separately.
2. Measured in push–pull configuration.



C1 — Arco 404, 8.0–60 pF
C2, C3, C7, C8 — 1000 pF Chip
C4, C9 — 0.1 µF Chip
C5 — 180 pF Chip
C6 — 100 pF and 130 pF Chips in Parallel
C10 — 0.47 µF Chip, Kemet 1215 or Equivalent
L1 — 10 Turns AWG #16 Enamel Wire, Close Wound, 1/4″ I.D.
L2 — Ferrite Beads of Suitable Material for 1.5–2.0 µH Total Inductance

Board material — .062″ fiberglass (G10), Two sided, 1 oz. copper, $\varepsilon_r \cong 5$

Unless otherwise noted, all chip capacitors are ATC Type 100 or Equivalent.

R1 — 100 Ohms, 1/2 W
R2 — 1.0 k Ohm, 1/2 W
T1 — 4:1 Impedance Ratio RF Transformer. Can Be Made of 25 Ohm Semirigid Coax, 47–52 Mils O.D.
T2 — 1:9 Impedance Ratio RF Transformer. Can Be Made of 15–18 Ohms Semirigid Coax, 62–90 Mils O.D.

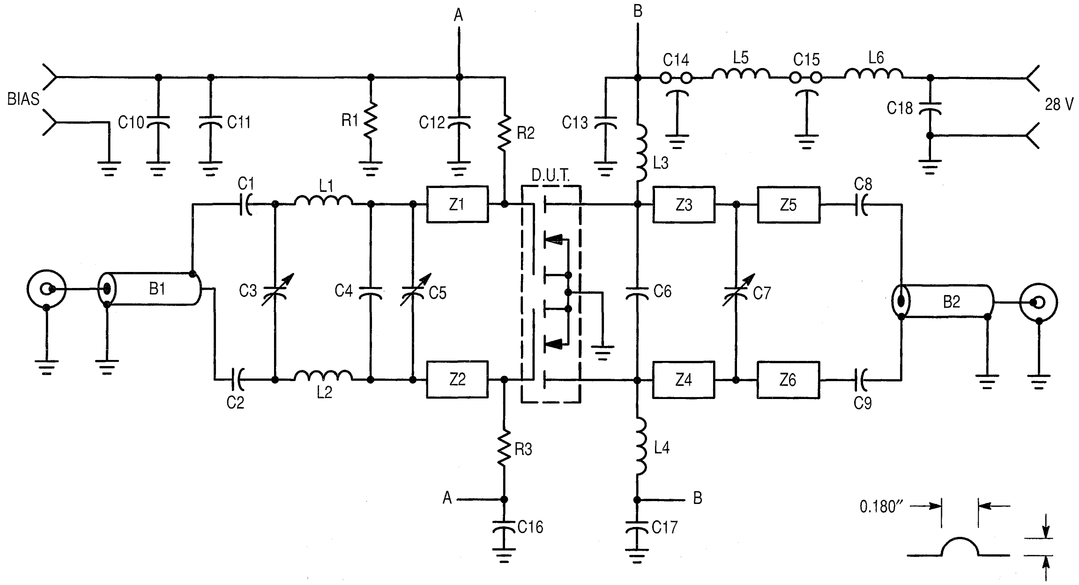
NOTE: For stability, the input transformer T1 should be loaded with ferrite toroids or beads to increase the common mode inductance. For operation below 100 MHz. The same is required for the output transformer.

Figure 1. 225 MHz Test Circuit

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS — MRF175GU (1) (Figure 2)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 150 W, f = 400 MHz, I_{DQ} = 2.0 x 100 mA)	G_{ps}	10	12	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 150 W, f = 400 MHz, I_{DQ} = 2.0 x 100 mA)	η	50	55	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 150 W, f = 400 MHz, I_{DQ} = 2.0 x 100 mA, VSWR 10:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:
1. Measured in push–pull configuration.



B1 — Balun 50 Ω Semi Rigid Coax 0.086″ O.D. 2″ Long
B2 — Balun 50 Ω Semi Rigid Coax 0.141″ O.D. 2″ Long
C1, C2, C8, C9 — 270 pF ATC Chip Cap
C3, C5, C7 — 1.0–20 pF Trimmer Cap
C4 — 15 pF ATC Chip Cap
C6 — 33 pF ATC Chip Cap
C10, C12, C13, C16, C17 — 0.01 µF Ceramic Cap
C11 — 1.0 µF 50 V Tantalum
C14, C15 — 680 pF Feedthru Cap
C18 — 20 µF 50 V Tantalum

L1, L2 — Hairpin Inductor #18 Wire
L3, L4 — 12 Turns #18 Enameled Wire 0.340″ I.D.
L5 — Ferroxcube VK200 20/4B
L6 — 3 Turns #16 Enameled Wire 0.340″ I.D.
R1 — 1.0 kΩ 1/4 W Resistor
R2, R3 — 10 kΩ 1/4 W Resistor
Z1, Z2 — Microstrip Line 0.400″ x 0.250″
Z3, Z4 — Microstrip Line 0.870″ x 0.250″
Z5, Z6 — Microstrip Line 0.500″ x 0.250″

Board material — 0.060″ Teflon–fiberglass, ε_r = 2.55, copper clad both sides, 2 oz. copper.

Figure 2. 400 MHz Test Circuit

TYPICAL CHARACTERISTICS

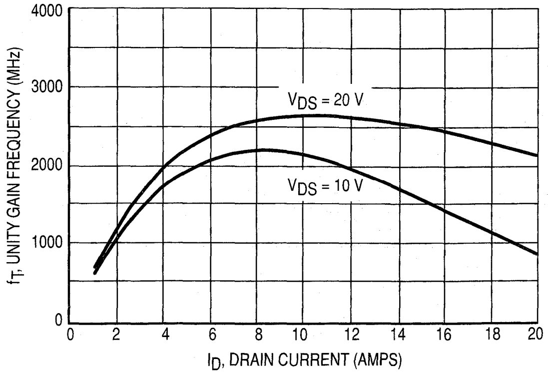


Figure 3. Common Source Unity Current Gain Frequency versus Drain Current

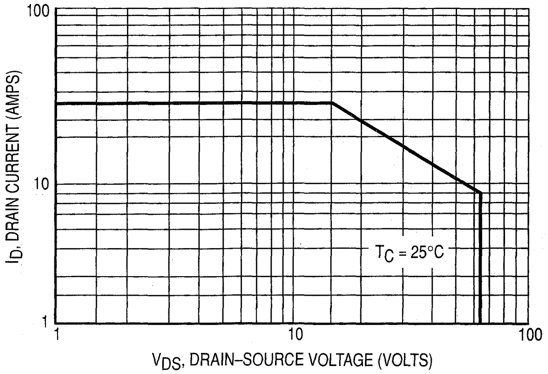


Figure 4. DC Safe Operating Area

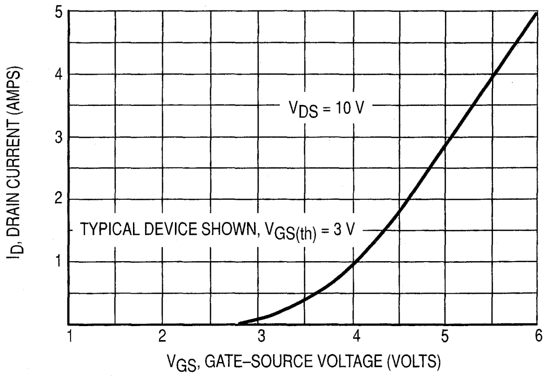


Figure 5. Drain Current versus Gate Voltage (Transfer Characteristics)

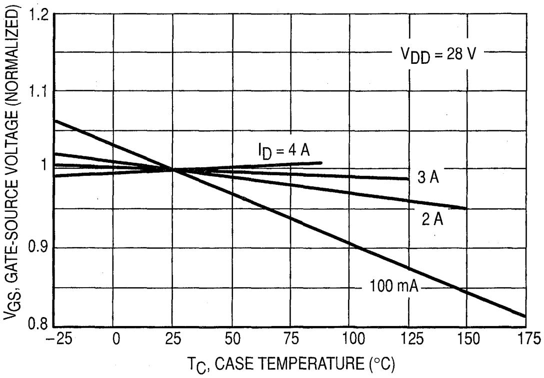


Figure 6. Gate–Source Voltage versus Case Temperature

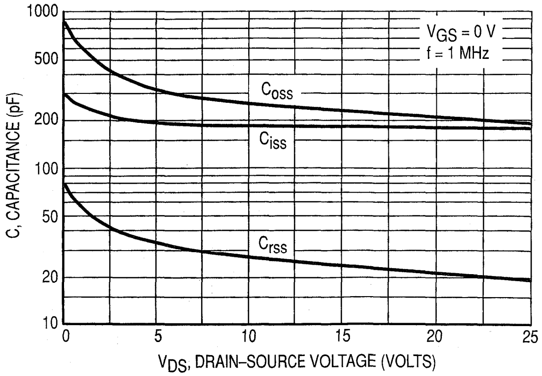


Figure 7. Capacitance versus Drain–Source Voltage*

* Data shown applies to each half of MRF175GU/GV.

TYPICAL CHARACTERISTICS

MRF175GV

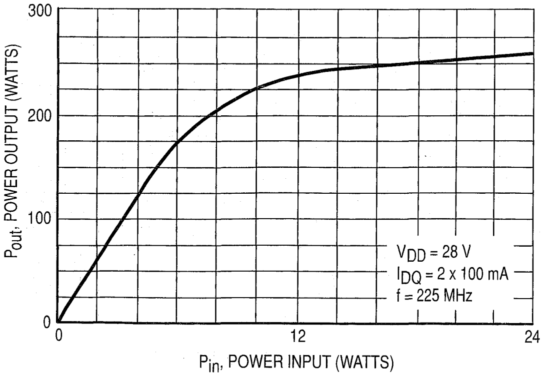


Figure 8. Power Input versus Power Output

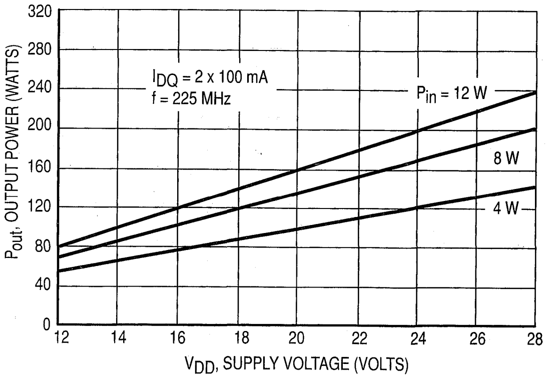


Figure 9. Output Power versus Supply Voltage

MRF175GU

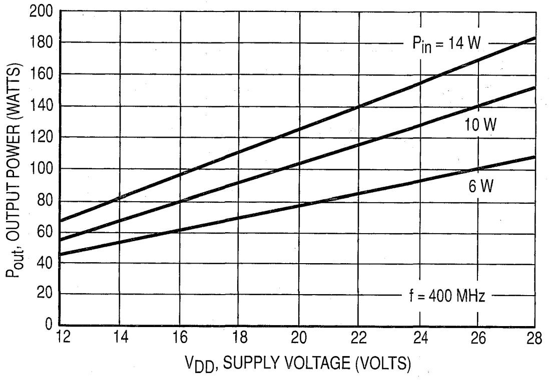


Figure 10. Output Power versus Supply Voltage

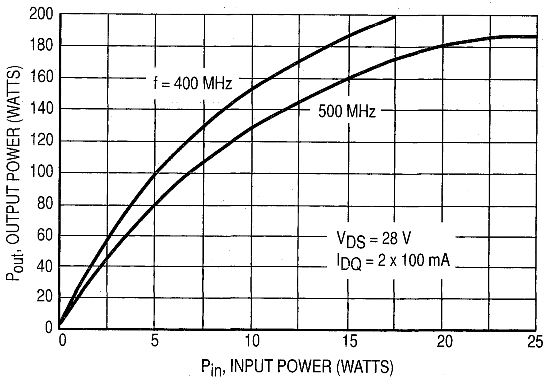


Figure 11. Output Power versus Input Power

MRF175GV

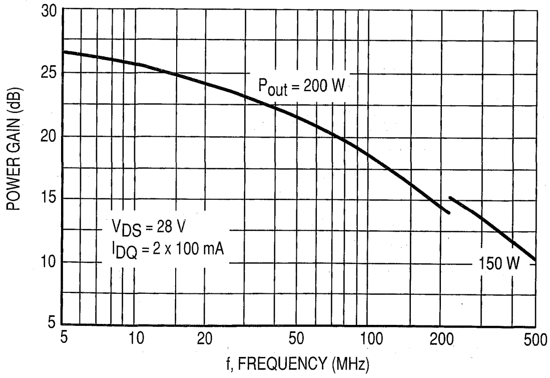
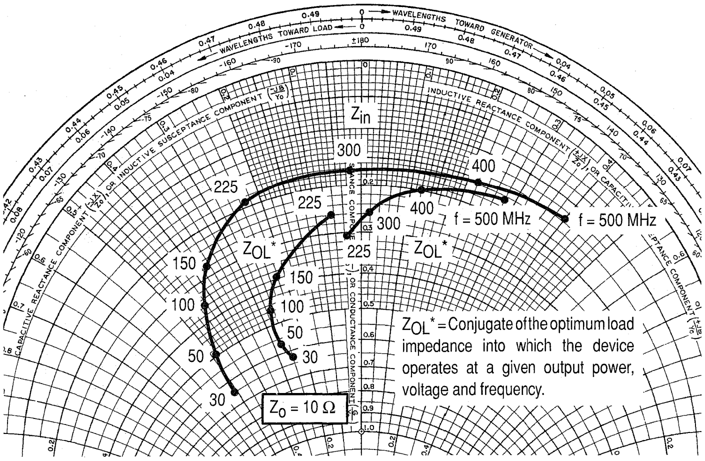


Figure 12. Power Gain versus Frequency

INPUT AND OUTPUT IMPEDANCE



$Z_{OL}{}^*$ = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

V_{DD} = 28 V, I_{DQ} = 2 x 100 mA

f MHz	Z_{in} OHMS	$Z_{OL}{}^*$ OHMS
(P_{out} = 150 W)		
225	1.95 – j2.30	3.10 – j0.25
300	1.75 – j0.20	2.60 + j0.20
400	1.60 + j2.20	2.00 + j1.20
500	1.35 + j4.00	1.70 + j2.70
(P_{out} = 200 W)		
30	6.50 – j5.10	6.30 – j2.50
50	5.00 – j4.80	5.75 – j2.75
100	3.60 – j4.20	4.60 – j2.65
150	2.80 – j3.60	2.60 – j2.20
225	1.95 – j2.30	2.60 – j0.60

NOTE: Input and output impedance values given are measured from gate to gate and drain to drain respectively.

Figure 13. Series Equivalent Input/Output Impedance

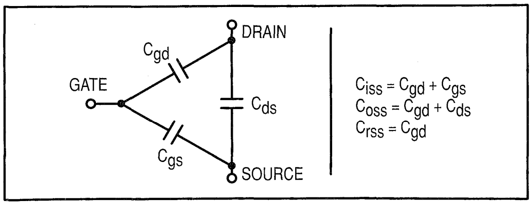
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

The C_{iss} given in the electrical characteristics table was measured using method 2 above. It should be noted that C_{iss}, C_{oss}, C_{rss} are measured at zero drain current and are provided for general information about the device. They are not RF design parameters and no attempt should be made to use them as such.

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain, data presented in Figure 3 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating (or any of the maximum ratings on the front page). Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of this device are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

HANDLING CONSIDERATIONS

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with grounded equipment.

DESIGN CONSIDERATIONS

The MRF175G is a RF power N–channel enhancement mode field–effect transistor (FETs) designed for HF, VHF and UHF power amplifier applications. Motorola RF MOSFETs feature a vertical structure with a planar design.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal.

DC BIAS

The MRF175G is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF175G was characterized at I_{DQ} = 100 mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF176 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

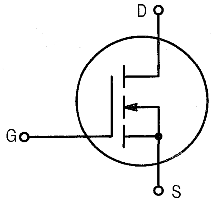
The RF MOSFET Line
RF Power Field-Effect Transistors
N–Channel Enhancement–Mode

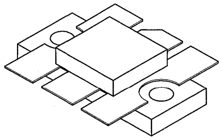
MRF175LU
MRF175LV

100 W, 28 V, 400 MHz
N–CHANNEL
BROADBAND
RF POWER FETs

Designed for broadband commercial and military applications using single ended circuits at frequencies to 400 MHz. The high power, high gain and broadband performance of each device makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Guaranteed Performance
  MRF175LU @ 28 V, 400 MHz ("U" Suffix)
    Output Power — 100 Watts
    Power Gain — 10 dB Typ
    Efficiency — 55% Typ
  MRF175LV @ 28 V, 225 MHz ("V" Suffix)
    Output Power — 100 Watts
    Power Gain — 14 dB Typ
    Efficiency — 65% Typ
- 100% Ruggedness Tested At Rated Output Power
- Low Thermal Resistance
- Low C_{rss} — 20 pF Typ @ V_{DS} = 28 V





CASE 333–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	13	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 50 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	2.5	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	µAdc

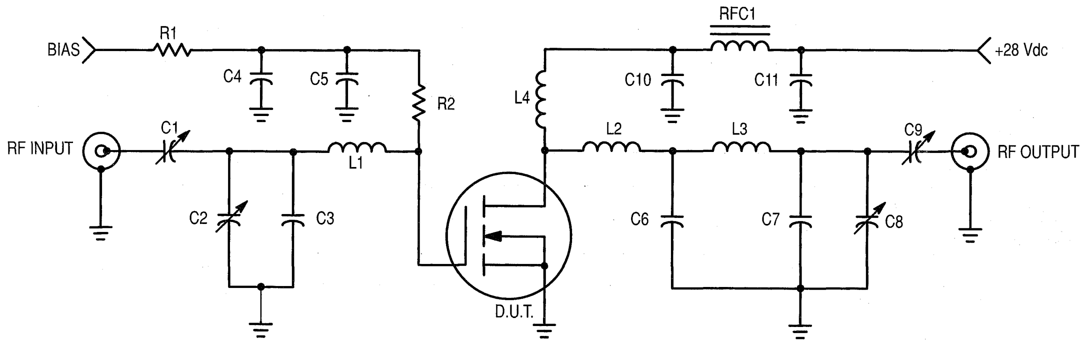
(continued)

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

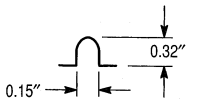
ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 5.0 A)	$V_{DS(on)}$	0.1	0.9	1.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 2.5 A)	g_{fs}	2.0	3.0	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	180	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	200	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	20	—	pF
FUNCTIONAL CHARACTERISTICS — MRF175LV (Figure 1)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 225 MHz, I_{DQ} = 100 mA)	G_{ps}	12	14	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 225 MHz, I_{DQ} = 100 mA)	η	55	65	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 225 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			
FUNCTIONAL CHARACTERISTICS — MRF175LU (Figure 2)					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, I_{DQ} = 100 mA)	G_{ps}	8.0	10	—	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, I_{DQ} = 100 mA)	η	50	55	—	%
Electrical Ruggedness (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, I_{DQ} = 100 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			



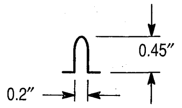
C1, C2, C8 — Arco 463 or Equivalent
C3, C7 — 25 pF Unelco Cap
C4 — 1000 pF Chip Cap
C5 — 0.01 µF Chip Cap
C6 — 250 pF Unelco Cap
C9 — Arco 462 or Equivalent
C10 — 1000 pF ATC Chip Cap
C11 — 10 µF 100 V Electrolytic

L1 — Hairpin Inductor #18 Wire



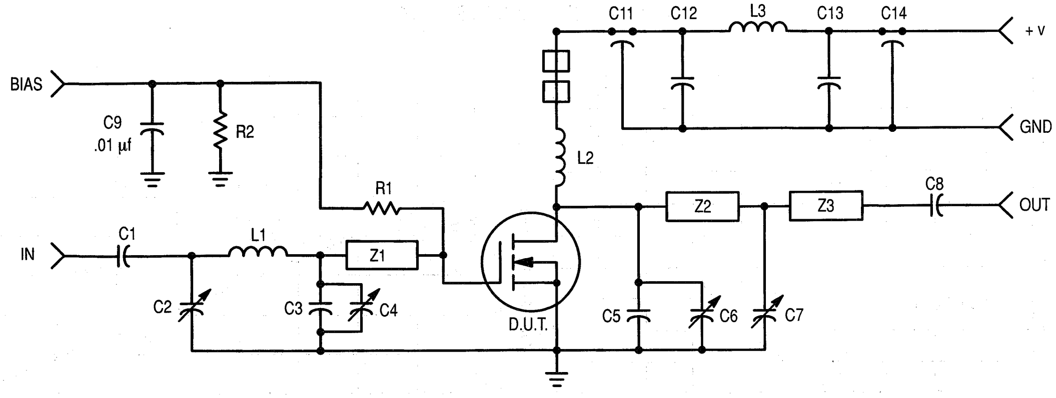
L2 — Stripline Inductor 0.200″ x 0.500″

L3 — Hairpin Inductor #16 Wire



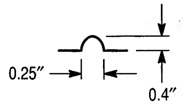
L4 — 2 Turns #16 Wire 5/16″ ID
RFC1 — VK200–4B
R1 — 1.0 k 1/4 W Resistor
R2 — 100 Ω Resistor

Figure 1. 225 MHz Test Circuit



C1, C8 — 270 pF ATC Chip Cap
C2, C4, C6, C7 — 1.0–20 pF Trimmer Cap
C3 — 15 pF Mini Unelco Cap
C5 — 33 pF Mini Unelco Cap
C9, C12 — 0.1 µF Ceramic Cap
C11, C14 — 680 pF Feed Thru Cap
C13 — 50 µF Tantalum Cap

L1 — Hairpin Inductor #18 Wire



L2 — 12 Turns #18 Wire 0.450″ ID
L3 — Ferroxcube VK200 20/4B

R1 — 10 k 1/4 W Resistor
R2 — 1 k 1/4 W Resistor
R3 — 1.5 k 1/4 W Resistor
Z1 — Microstrip Line 0.950″ x 0.250″
Z2 — Microstrip Line 1″ x 0.250″
Z3 — Microstrip Line 0.550″ x 0.250″

Board Material — 0.062″ Teflon — fiberglass, $\varepsilon_r = 2.56$, 1 oz. copper clad both sides

Figure 2. 400 MHz Test Circuit

TYPICAL CHARACTERISTICS

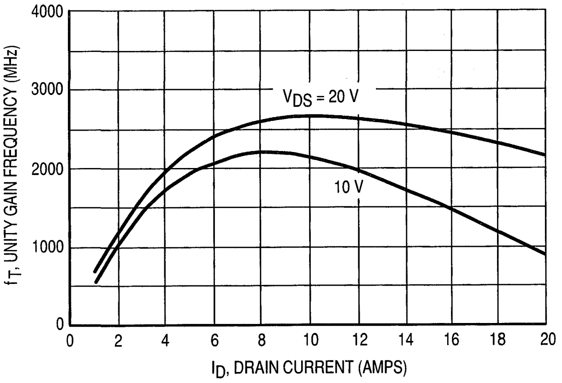


Figure 3. Common Source Unity Current Gain Frequency versus Drain Current

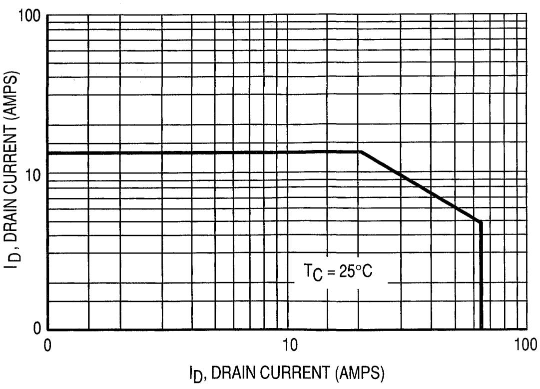


Figure 4. DC Safe Operating Area

TYPICAL CHARACTERISTICS

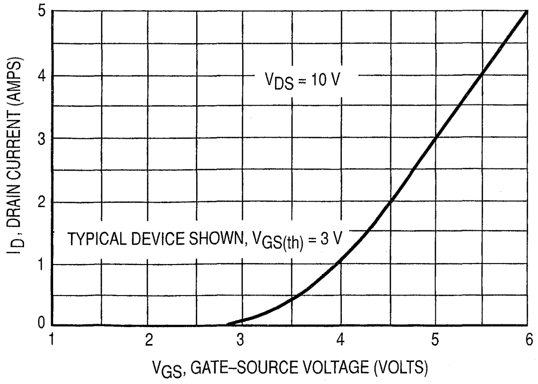


Figure 5. Drain Current versus Gate Voltage (Transfer Characteristics)

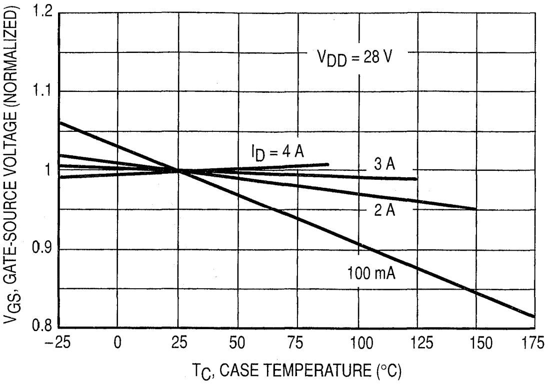


Figure 6. Gate–Source Voltage versus Case Temperature

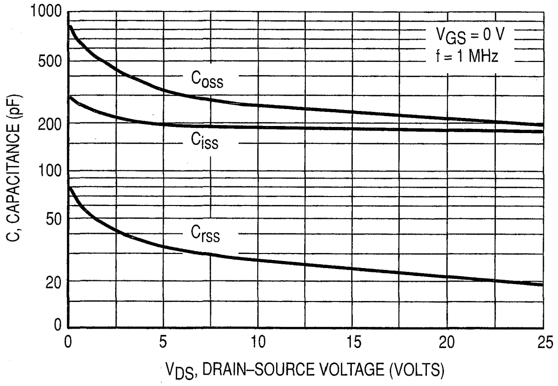


Figure 7. Capacitance versus Drain–Source Voltage

TYPICAL CHARACTERISTICS

MRF175LV

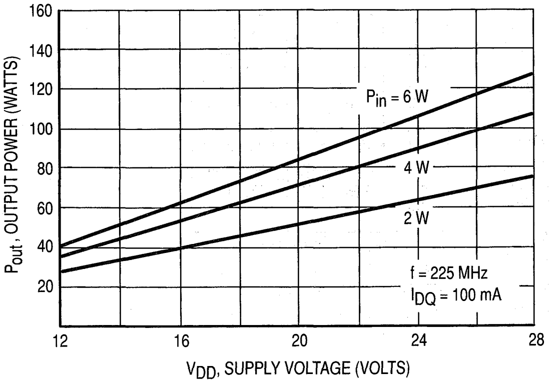


Figure 8. Output Power versus Supply Voltage

MRF175LU

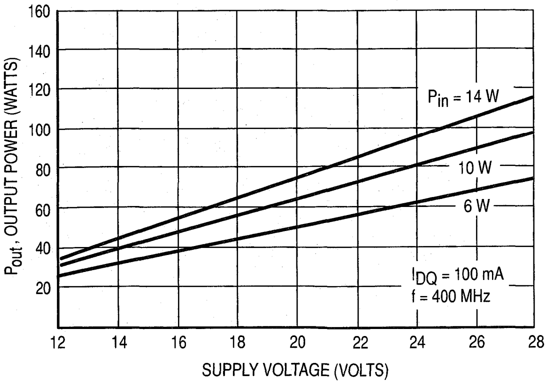


Figure 9. Output Power versus Supply Voltage

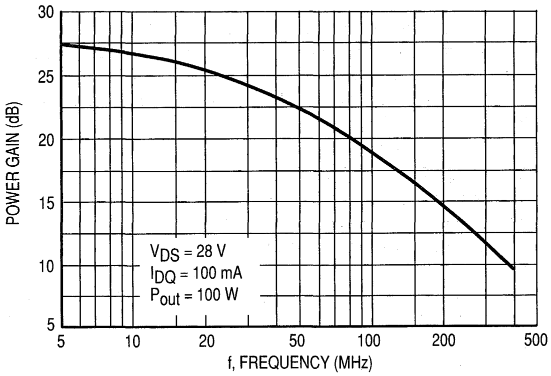


Figure 10. Power Gain versus Frequency

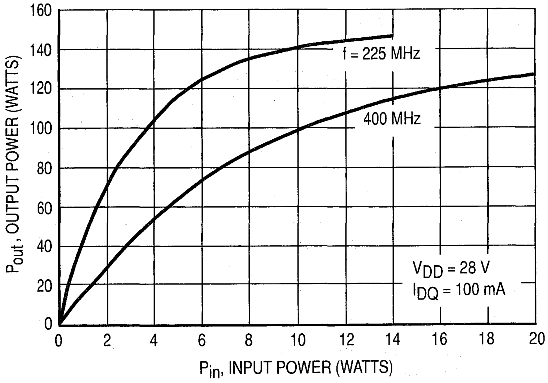
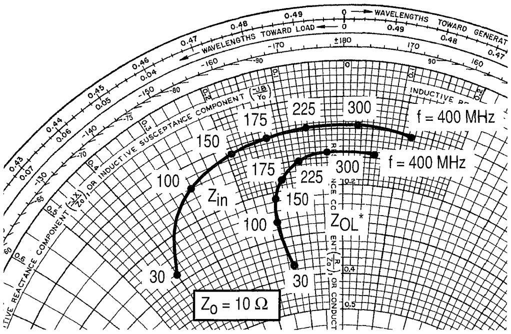


Figure 11. Output Power versus Input Power

INPUT AND OUTPUT IMPEDANCE



V_{DD} = 28 V, I_{DQ} = 100 mA,
(P_{out} = 100 W)

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
30	2.80 – j4.00	3.65 – j1.30
100	1.40 – j2.80	2.60 – j1.50
150	1.10 – j1.90	2.10 – j1.40
175	1.00 – j1.25	1.80 – j1.20
225	0.95 – j0.65	1.50 – j0.80
300	0.95 + j0.20	1.35 – j0.30
400	1.05 + j1.15	1.45 + j0.55

Z_{OL}* = CONJUGATE OF THE OPTIMUM LOAD IMPEDANCE INTO WHICH THE DEVICE OUTPUT OPERATES AT A GIVEN OUTPUT POWER, VOLTAGE AND FREQUENCY.

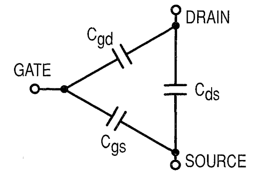
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the FET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 3 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the FET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

HANDLING CONSIDERATIONS

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with a grounded iron.

DESIGN CONSIDERATIONS

The MRF175L is a RF power N–channel enhancement mode field–effect transistor (FETs) designed for HF, VHF and UHF power amplifier applications. Motorola FETs feature a vertical structure with a planar design.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal.

DC BIAS

The MRF175L is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF175L was characterized at $I_{DQ} = 100$ mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF175L may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

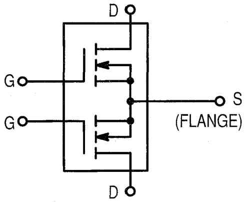
The RF MOSFET Line
RF Power Field-Effect Transistors
N–Channel Enhancement–Mode

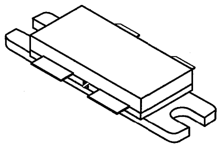
MRF176GU
MRF176GV

200/150 W, 50 V, 500 MHz
N–CHANNEL MOS
BROADBAND
RF POWER FETs

Designed for broadband commercial and military applications using push pull circuits at frequencies to 500 MHz. The high power, high gain and broadband performance of these devices makes possible solid state transmitters for FM broadcast or TV channel frequency bands.

- Electrical Performance
  MRF176GU @ 50 V, 400 MHz (“U” Suffix)
    Output Power — 150 Watts
    Power Gain — 14 dB Typ
    Efficiency — 50% Typ
  MRF176GV @ 50 V, 225 MHz (“V” Suffix)
    Output Power — 200 Watts
    Power Gain — 17 dB Typ
    Efficiency — 55% Typ
- 100% Ruggedness Tested At Rated Output Power
- Low Thermal Resistance
- Low C_{rss} — 7.0 pF Typ @ V_{DS} = 50 V





CASE 375–04, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	125	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	400 2.27	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.44	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	125	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 50 V, V_{GS} = 0)	I_{DSS}	—	—	2.5	mAdc
Gate–Body Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc

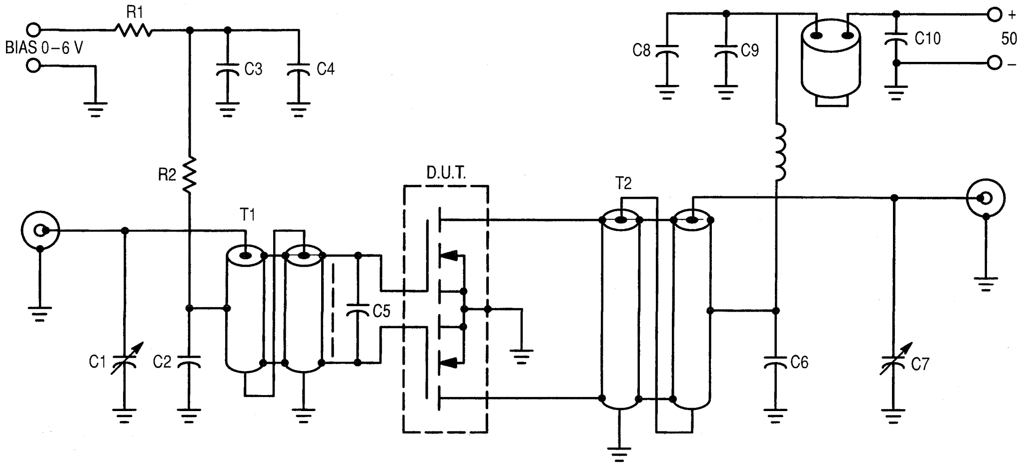
NOTE:
1. Each side of device measured separately.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (1)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 5.0 A)	$V_{DS(on)}$	1.0	3.0	5.0	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 2.5 A)	g_{fs}	2.0	3.0	—	mhos
DYNAMIC CHARACTERISTICS (1)					
Input Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	180	—	pF
Output Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	110	—	pF
Reverse Transfer Capacitance (V_{DS} = 50 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	7.0	—	pF
FUNCTIONAL CHARACTERISTICS — MRF176GV (2) (Figure 1)					
Common Source Power Gain (V_{DD} = 50 Vdc, P_{out} = 200 W, f = 225 MHz, I_{DQ} = 2.0 x 100 mA)	G_{ps}	15	17	—	dB
Drain Efficiency (V_{DD} = 50 Vdc, P_{out} = 200 W, f = 225 MHz, I_{DQ} = 2.0 x 100 mA)	η	50	55	—	%
Electrical Ruggedness (V_{DD} = 50 Vdc, P_{out} = 200 W, f = 225 MHz, I_{DQ} = 2.0 x 100 mA, VSWR 10:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTES:
1. Each side of device measured separately.
2. Measured in push–pull configuration.



C1 — Arco 404, 8.0–60 pF
C2, C3, C6, C8 — 1000 pF Chip
C4, C9 — 0.1 µF Chip
C5 — 180 pF Chip
C7 — Arco 403, 3.0–35 pF
C10 — 0.47 µF Chip, Kemet 1215 or Equivalent
L1 — 10 Turns AWG #16 Enameled Wire, Close Wound, 1/4″ I.D.

Board material — .062″ fiberglass (G10), Two sided, 1 oz. copper, $\varepsilon_r \cong 5$

Unless otherwise noted, all chip capacitors are ATC Type 100 or Equivalent

L2 — Ferrite Beads of Suitable Material for 1.5–2.0 µH, Total Inductance
R1 — 100 Ohms, 1/2 W
R2 — 1.0 kOhms, 1/2 W
T1 — 4:1 Impedance Ratio RF Transformer. Can Be Made of 25 Ohm Semirigid Co–Ax, 47–62 Mils O.D.
T2 — 1:4 Impedance Ratio RF Transformer. Can Be Made of 25 Ohm Semirigid Co–Ax, 62–90 Mils O.D.

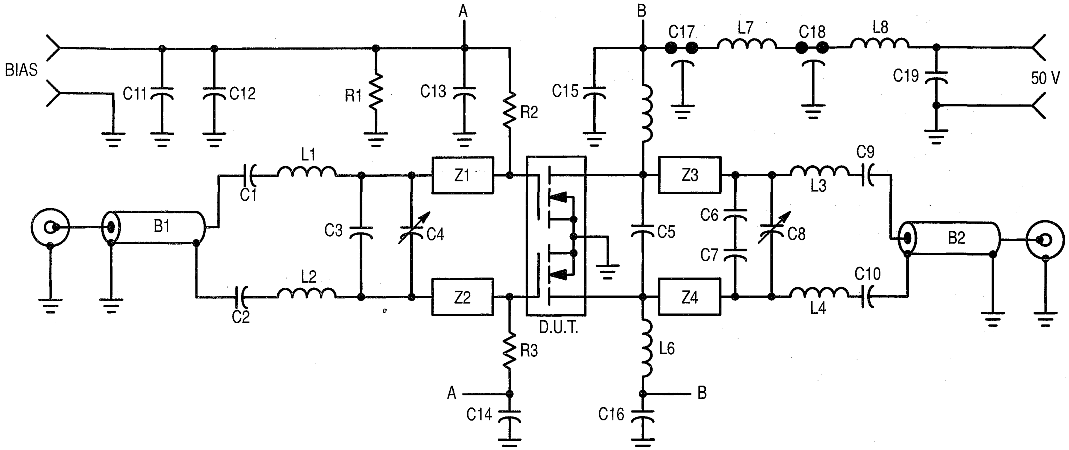
NOTE: For stability, the input transformer T1 should be loaded with ferrite toroids or beads to increase the common mode inductance. For operation below 100 MHz. The same is required for the output transformer.

Figure 1. 225 MHz Test Circuit

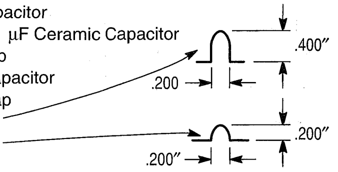
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS — MRF176GU (1) (Figure 2)					
Common Source Power Gain (V_{DD} = 50 Vdc, P_{out} = 150 W, f = 400 MHz, I_{DQ} = 2.0 x 100 mA)	G_{ps}	12	14	—	dB
Drain Efficiency (V_{DD} = 50 Vdc, P_{out} = 150 W, f = 400 MHz, I_{DQ} = 2.0 x 100 mA)	η	45	50	—	%
Electrical Ruggedness (V_{DD} = 50 Vdc, P_{out} = 150 W, f = 400 MHz, I_{DQ} = 2.0 x 100 mA, VSWR 10:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:
1. Measured in push–pull configuration.



B1 — Balun, 50 Ω Semirigid Coax .086 OD 2″ Long
B2 — Balun, 50 Ω Semirigid Coax .141 OD 2″ Long
C1, C2, C9, C10 — 270 pF ATC Chip Capacitor
C3 — 15 pF ATC Chip Cap
C4, C8 — 1.0–20 pF Piston Trimmer Cap
C5 — 27 pF ATC Chip Cap
C6, C7 — 22 pF Mini Unelco Capacitor
C11, C13, C14, C15, C16 — 0.01 µF Ceramic Capacitor
C12 — 1.0 µF 50 V Tantalum Cap
C17, C18 — 680 pF Feedthru Capacitor
C19 — 10 µF 100 V Tantalum Cap
L1, L2 — Hairpin Inductor #18 W
L3, L4 — Hairpin Inductor #18 W



L5, L6 — 13T #18 W .250 ID
L7 — Ferroxcube VK–200 20/4B
L8 — 3T #18 W .340 ID
R1 — 1.0 kΩ 1/4 W Resistor
R2, R3 — 10 kΩ 1/4 W Resistor
Z1, Z2 — Microstrip Line .400L x .250W
Z3, Z4 — Microstrip Line .450L x .250W

Ckt Board Material — .060″ teflon–fiberglass, copper clad both sides, 2 oz. copper, ε_r = 2.55

Figure 2. 400 MHz Test Circuit

TYPICAL CHARACTERISTICS

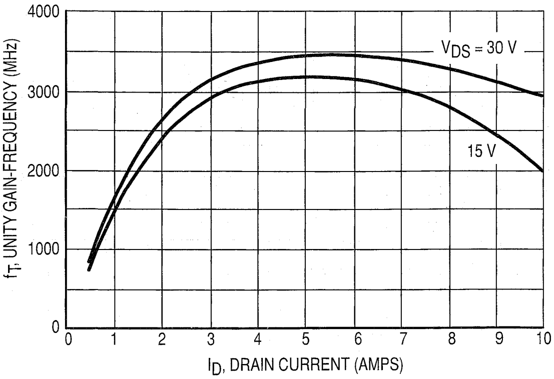


Figure 3. Common Source Unity Current Gain* Gain–Frequency versus Drain Current

* Data shown applies to each half of MRF176GU/GV

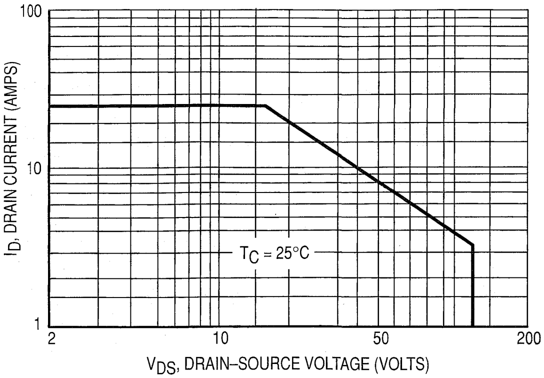
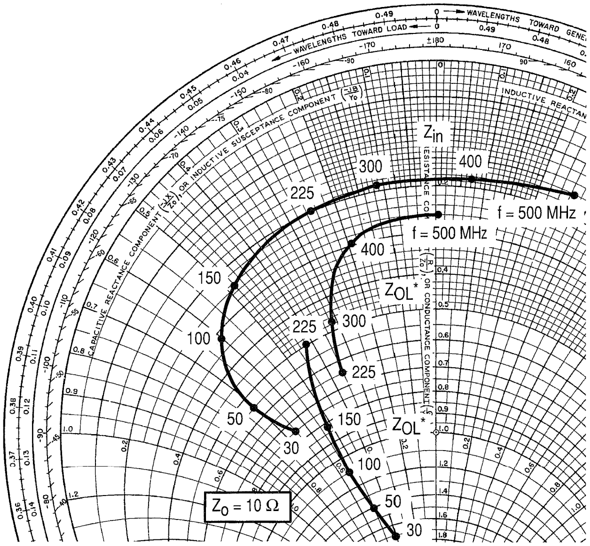


Figure 4. DC Safe Operating Area



INPUT AND OUTPUT IMPEDANCE
MRF176GU/GV
V_{DD} = 50 V, I_{DQ} = 2 x 100 mA

f MHz	Z_{in} OHMS	Z_{OL}* OHMS
(P_{out} = 150 W)		
225	2.05 – j2.50	6.50 – j3.50
300	2.00 – j1.10	4.80 – j3.10
400	1.85 + j0.75	3.00 – j1.90
500	1.60 + j2.70	2.60 + j0.10
(P_{out} = 200 W)		
30	7.50 – j6.50	17.00 – j4.00
50	5.50 – j7.00	14.00 – j5.00
100	3.20 – j6.00	11.00 – j5.20
150	2.50 – j4.80	8.20 – j5.00
225	2.05 – j2.50	5.00 – j4.20

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

NOTE: Input and output impedance values given are measured from gate to gate and drain to drain respectively.

Figure 5. Series Equivalent Input/Output Impedance

TYPICAL CHARACTERISTICS

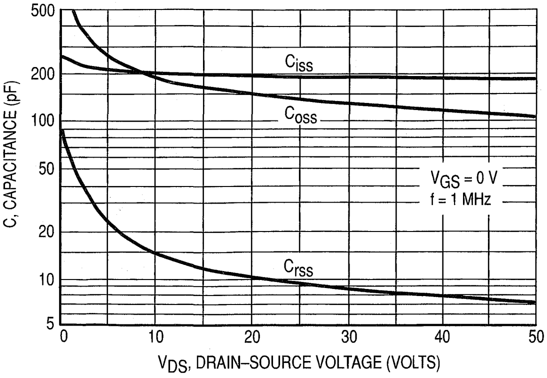


Figure 6. Capacitance versus Drain–Source Voltage*

* Data shown applies to each half of MRF176GU/GV

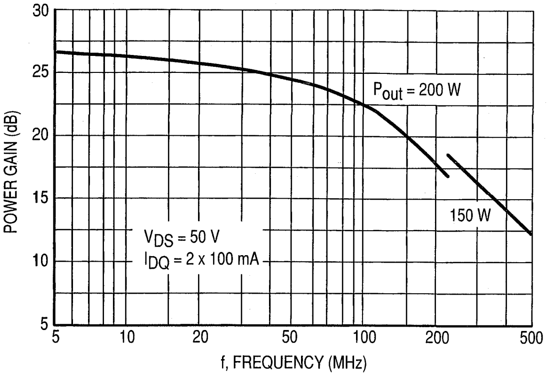


Figure 7. Power Gain versus Frequency

MRF176GV

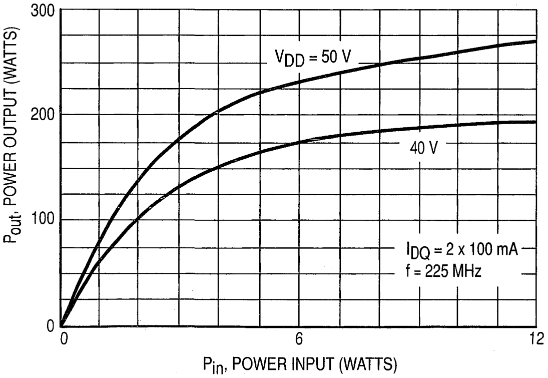


Figure 8. Power Input versus Power Output

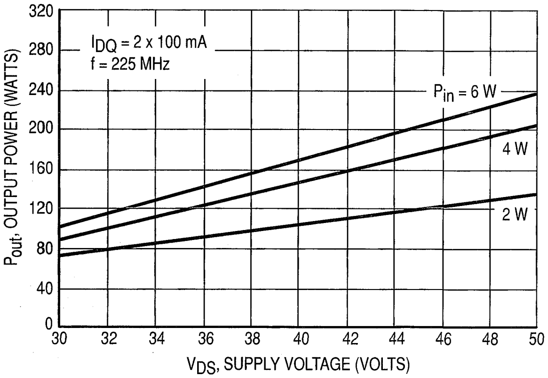


Figure 9. Output Power versus Supply Voltage

TYPICAL CHARACTERISTICS
MRF176GU

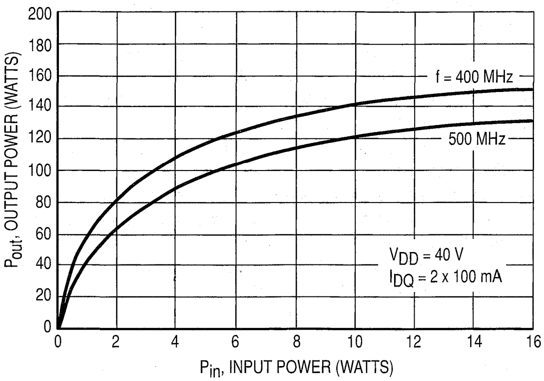


Figure 10. Output Power versus Input Power

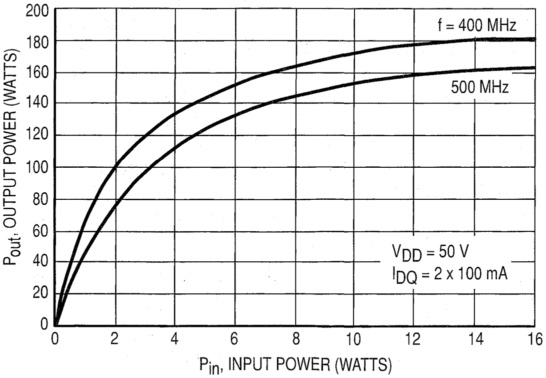


Figure 11. Output Power versus Input Power

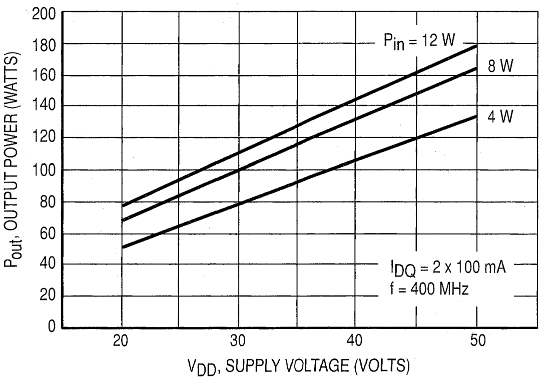


Figure 12. Output Power versus Supply Voltage

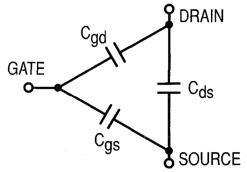
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

The C_{iss} given in the electrical characteristics table was measured using method 2 above. It should be noted that C_{iss}, C_{oss}, C_{rss} are measured at zero drain current and are provided for general information about the device. They are not RF design parameters and no attempt should be made to use them as such.

LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain, data presented in Figure 3 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating (or any of the maximum ratings on the front page). Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of this device are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — This device does not have an internal monolithic zener diode from gate–to–source. The addition of an internal zener diode may result in detrimental effects on the reliability of a power MOSFET. If gate protection is required, an external zener diode is recommended.

HANDLING CONSIDERATIONS

The gate of the MOSFET, which is electrically isolated from the rest of the die by a very thin layer of SiO_2, may be damaged if the power MOSFET is handled or installed improperly. Exceeding the 40 V maximum gate–to–source voltage rating, $V_{GS(max)}$, can rupture the gate insulation and destroy the FET. RF Power MOSFETs are not nearly as susceptible as CMOS devices to damage due to static discharge because the input capacitances of power MOSFETs are much larger and absorb more energy before being charged to the gate breakdown voltage. However, once breakdown begins, there is enough energy stored in the gate–source capacitance to ensure the complete perforation of the gate oxide. To avoid the possibility of device failure caused by static discharge, precautions similar to those taken with small–signal MOSFET and CMOS devices apply to power MOSFETs.

When shipping, the devices should be transported only in antistatic bags or conductive foam. Upon removal from the packaging, careful handling procedures should be adhered to. Those handling the devices should wear grounding straps and devices not in the antistatic packaging should be kept in metal tote bins. MOSFETs should be handled by the case and not by the leads, and when testing the device, all leads should make good electrical contact before voltage is applied. As a final note, when placing the FET into the system it is designed for, soldering should be done with grounded equipment.

The gate of the power MOSFET could still be in danger after the device is placed in the intended circuit. If the gate may see voltage transients which exceed $V_{GS(max)}$, the circuit designer should place a 40 V zener across the gate and source terminals to clamp any potentially destructive spikes. Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

DESIGN CONSIDERATIONS

The MRF176G is a RF power N–channel enhancement mode field–effect transistor (FETs) designed for VHF and

UHF power amplifier applications. Motorola RF MOSFETs feature a vertical structure with a planar design, thus avoiding the processing difficulties associated with V–groove MOS power FETs.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

The major advantages of RF power FETs include high gain, low noise, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage. Power output can be varied over a wide range with a low power dc control signal, thus facilitating manual gain control, ALC and modulation.

DC BIAS

The MRF176G is an enhancement mode FET and, therefore, does not conduct when drain voltage is applied. Drain current flows when a positive voltage is applied to the gate. RF power FETs require forward bias for optimum performance. The value of quiescent drain current (I_{DQ}) is not critical for many applications. The MRF176G was characterized at $I_{DQ} = 100$ mA, each side, which is the suggested minimum value of I_{DQ}. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

Power output of the MRF176 may be controlled from its rated value down to zero (negative gain) by varying the dc gate voltage. This feature facilitates the design of manual gain control, AGC/ALC and modulation systems.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement Mode MOSFETs

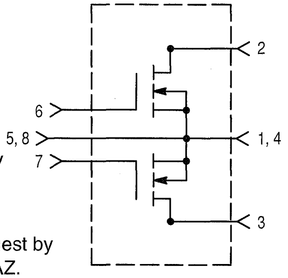
MRF177
MRF177M

100 W, 28 V, 400 MHz
N–CHANNEL
BROADBAND
RF POWER MOSFETs

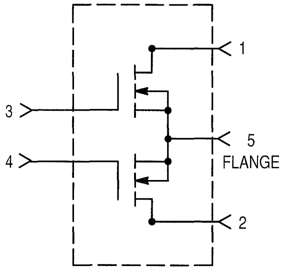
Designed for broadband commercial and military applications up to 400 MHz frequency range. Primarily used as drivers or output amplifiers in push–pull configurations. Can be used in manual gain control, ALC and modulation circuits.

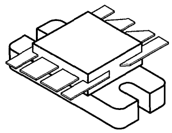
- Typical Performance at 400 MHz, 28 V:
  Output Power — 100 W
  Gain — 12 dB
  Efficiency — 60%
- Low Thermal Resistance
- Low C_{rss} — 10 pF Typ @ V_{DS} = 28 Volts
- Ruggedness Tested at Rated Output Power
- Nitride Passivated Die for Enhanced Reliability
- Excellent Thermal Stability; Suited for Class A Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

CASE 744A–01

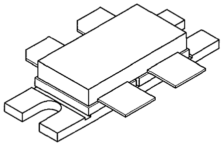


CASE 390B–01





CASE 744A–01, STYLE 2
MRF177



CASE 390B–01, STYLE 1
MRF177M

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Temperature Range	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction–to–Case	$R_{\theta JC}$	0.65	°C/W

NOTE:
1. Total device dissipation rating applies only when the device is operated as an RF push–pull amplifier.

NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic (2)	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 50 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	—	—	2.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS (2)					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 50 mA)	$V_{GS(th)}$	1.0	3.0	6.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 3.0 A)	$V_{DS(on)}$	—	—	1.4	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 2.0 A)	g_{fs}	1.8	2.2	—	mhos
DYNAMIC CHARACTERISTICS (2)					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	110	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	105	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	10	—	pF
FUNCTIONAL CHARACTERISTICS (Figures 7 & 8) (4)					
Common Source Power Gain (3) (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, I_{DQ} = 200 mA)	G_{PS}	10	12	—	dB
Drain Efficiency (3) (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, I_{DQ} = 200 mA)	η	55	60	—	%
Electrical Ruggedness (3) (V_{DD} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, I_{DQ} = 200 mA, Load VSWR = 30:1, All Phase Angles At Frequency of Test)	ψ	No Degradation in Output Power Before & After Test			
TYPICAL INPUT/OUTPUT DEVICE IMPEDANCES					
MRF177					
Series Equivalent Input Impedance (V_{DD} = 28 V, I_{DQ} = 200 mA, P_{out} = 100 W, f = 400 MHz)	Z_{in}	—	2.35 + j0.4	—	Ohms
Series Equivalent Output Impedance (V_{DD} = 28 V, I_{DQ} = 200 mA, P_{out} = 100 W, f = 400 MHz)	Z_{out}	—	3.2 – j1.38	—	Ohms
MRF177M					
Series Equivalent Input Impedance (V_{DD} = 28 V, I_{DQ} = 200 mA, P_{out} = 100 W, f = 400 MHz)	Z_{in}	—	2.64 + j1.64	—	Ohms
Series Equivalent Output Impedance (V_{DD} = 28 V, I_{DQ} = 200 mA, P_{out} = 100 W, f = 400 MHz)	Z_{out}	—	3.15 + j0.05	—	Ohms

NOTES:
1. Note each transistor chip measured separately
2. Both transistor chips operating in push–pull amplifier
3. RF functional specification is the same for MRF177 & MRF177M

TYPICAL CHARACTERISTICS

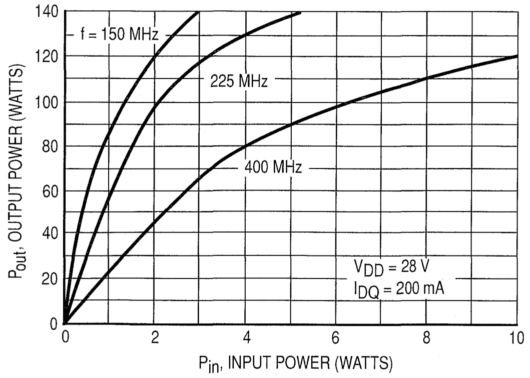


Figure 1. Output Power versus Input Power

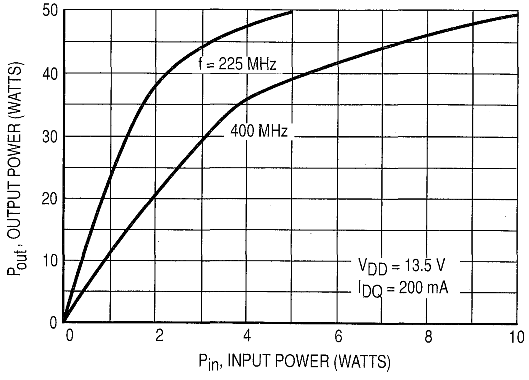


Figure 2. Output Power versus Input Power

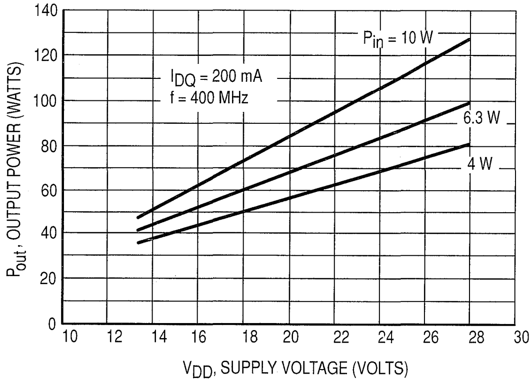


Figure 3. Output Power versus Supply Voltage

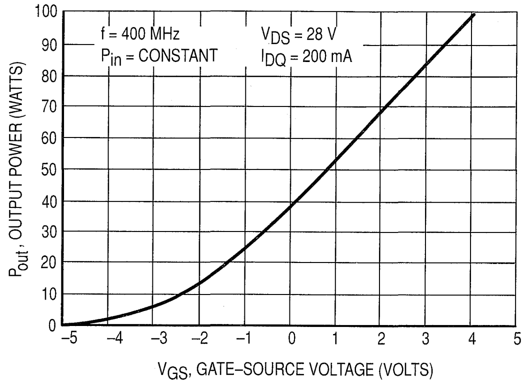


Figure 4. Output Power versus Gate Voltage

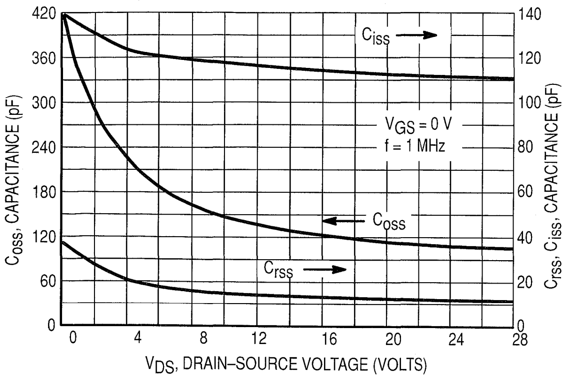


Figure 5. Capacitance versus Drain Voltage

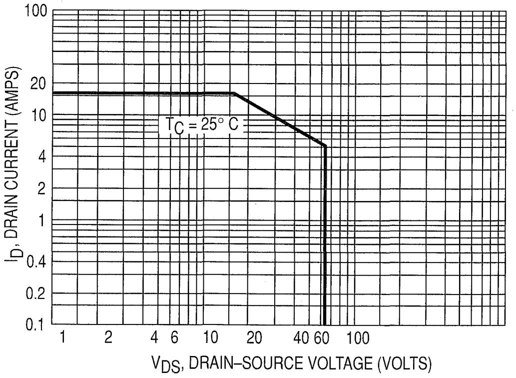
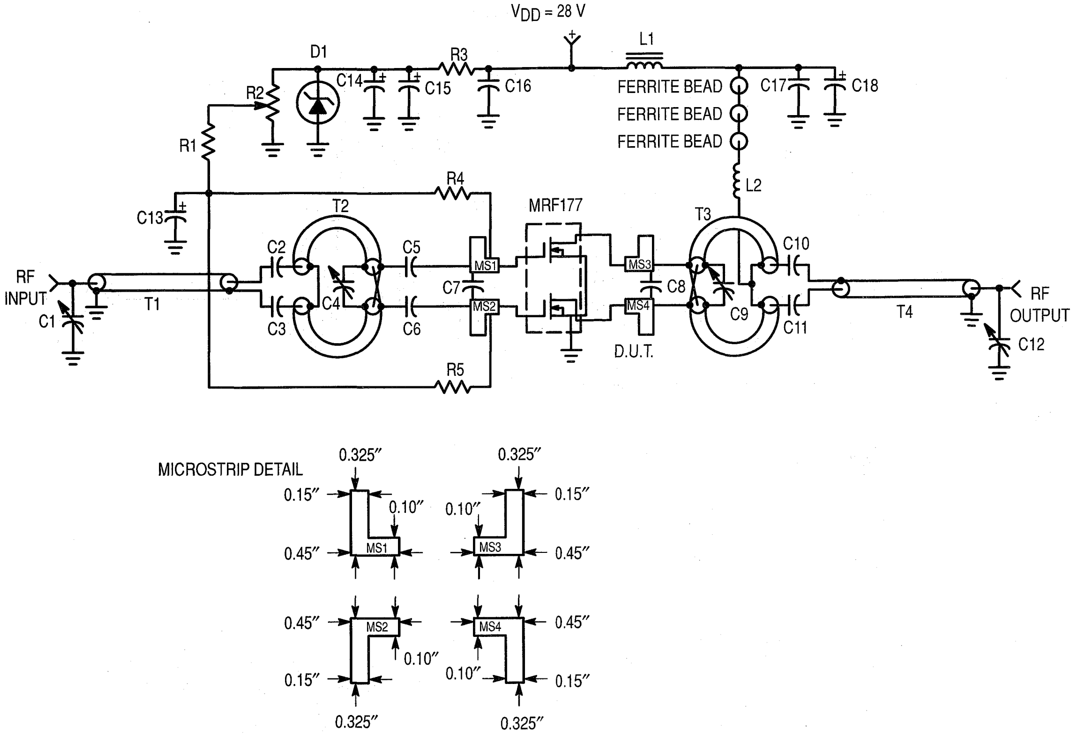
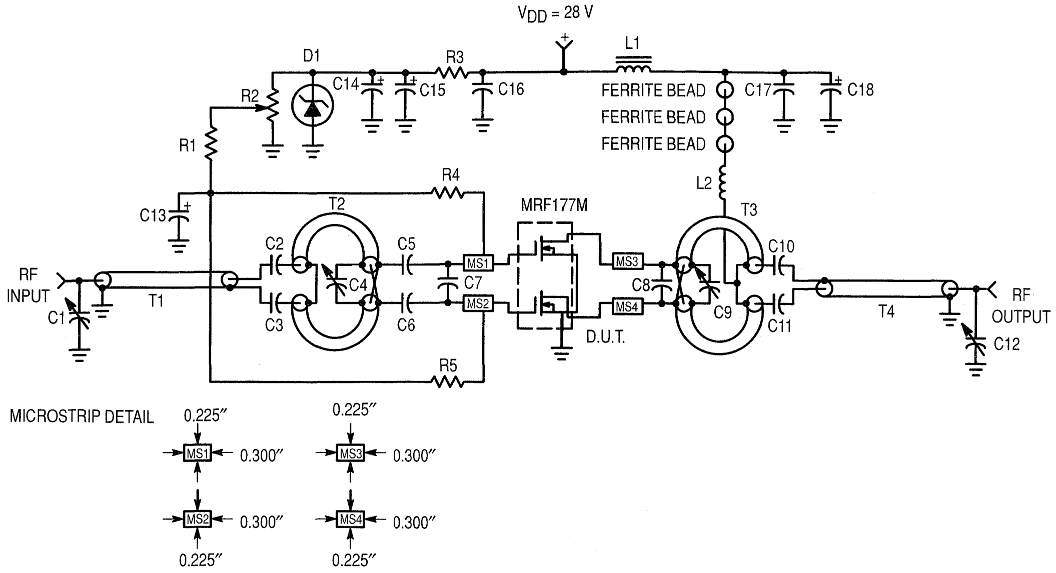


Figure 6. DC Safe Operating Area



C1, C12	1–10 pF JOHANSON OR EQUIVALENT	D1	1N5347B, 20 Vdc
C2, C3, C5, C6, C10, C11	270 pF ATC 100 MIL CHIP CAP	L1	1–TURN NO. 18, 0.25″, 2–HOLE FERRITE BEAD
C4, C9	1–20 pF	L2	8–1/2 TURNS NO. 18, CLOSE WOUND .375″ DIA.
C7	36 pF CHIP CAP	R1, R4, R5	10 kΩ @ 1/2 W RESISTOR
C8	10 pF CHIP CAP	R2	10 kΩ, 10 TURN RESISTOR
C13, C14	0.1 μFD @ 50 Vdc	R3	2.0 kΩ @ 1/2 W RESISTOR
C15, C18	10 μFD @ 50 Vdc	T1	1–1/2 T, 50 Ω COAX, .034″ DIA. ON DUAL 0.5″ FERRITE CORE
C16	500 pF BUTTON	T2	2.0″ 25 Ω COAX, .075″ DIA.
C17	1000 pF UNCASED MICA	T3	2.1″ 10 Ω COAX, .075″ DIA.
		T4	4.0″ 50 Ω COAX, .0865″ DIA.
		BOARD	.0625″, Cu–Clad, Teflon Fiberglass, ε_r = 2.55

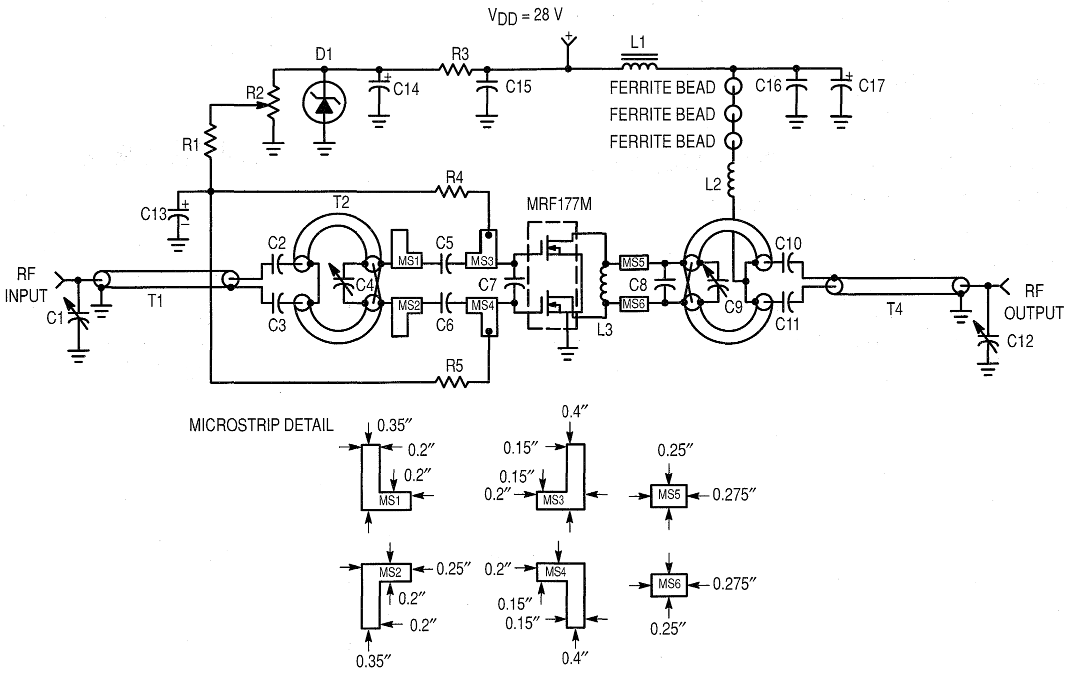
Figure 7. Test Circuit Electrical Schematic — MRF177



C1, C12	1–10 pF JOHANSON OR EQUIVALENT
C2, C3, C5, C6, C10, C11	270 pF ATC 100 MIL CHIP CAP
C4, C9	1–20 pF
C7	36 pF CHIP CAP
C8	10 pF CHIP CAP
C13, C14	0.1 μFD @ 50 Vdc
C15, C18	10 μFD @ 50 Vdc
C16	500 pF BUTTON
C17	1000 pF UNCASED MICA

D1	1N5347B, 20 Vdc MOTOROLA ZENER
L1	1–TURN NO. 18, 0.25″, 2–HOLE FERRITE BEAD
L2	8–1/2 TURNS NO. 18, CLOSE WOUND .375″ DIA.
R1, R4, R5	10 kΩ @ 1/2 W RESISTOR
R2	10 kΩ, 10 TURN RESISTOR
R3	2.0 kΩ @ 1/2 W RESISTOR
T1	1–1/2 T, 50 Ω COAX, .034″ DIA. ON DUAL 0.5″ FERRITE CORE
T2	2.0″ 25 Ω COAX, .075″ DIA.
T3	2.1″ 10 Ω COAX, .075″ DIA.
T4	4.0″ 50 Ω COAX, .0865″ DIA.
BOARD	.0625″, Cu–Clad, Teflon Fiberglass, $\varepsilon_r = 2.55$

Figure 8. Test Fixture Electrical Schematic — MRF177M



C1, C12	1–10 pF JOHANSON OR EQUIVALENT	D1	1N5347B, 20 Vdc MOTOROLA ZENER
C2, C3, C5, C6, C10, C11	270 pF ATC 100 MIL CHIP CAP	L1	1–TURN NO. 18, 0.25″, 2–HOLE FERRITE BEAD
C4, C9	1–20 pF	L2	8–1/2 TURNS NO. 18, CLOSE WOUND .375″ DIA.
C7	43 pF CHIP CAP	L3	4–TURNS NO. 22, 1/8″ DIA., 0.25″ LONG
C8	10 pF CHIP CAP	R1, R4, R5	10 kΩ @ 1/2 W RESISTOR
C13, C14	0.1 µFD @ 50 Vdc	R2	10 kΩ, 10 TURN RESISTOR
C15	500 pF BUTTON	R3	2.0 kΩ @ 1/2 W RESISTOR
C16	1000 pF UNCASED MICA	T1	1–1/2 T, 50 Ω COAX, .034″ DIA. ON DUAL 0.5″ FERRITE CORE
C17	10 µFD @ 50 Vdc	T2	2.0″ 25 Ω COAX, .075″ DIA.
		T3	2.1″ 10 Ω COAX, .075″ DIA.
		T4	4.0″ 50 Ω COAX, .0865″ DIA.
		BOARD	.0625″, Cu–Clad, Teflon Fiberglass, $\varepsilon_r = 2.55$

Figure 9. Broadband Amplifier Schematic — MRF177M

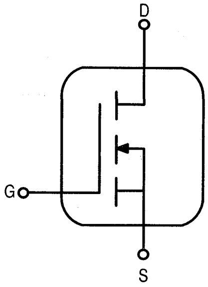
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

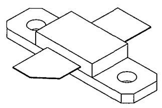
The RF MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement–Mode Lateral MOSFETs

MRF182

- High gain, rugged device
- Broadband performance from HF to 1 GHz.
- Bottom side source eliminates DC isolators, reducing common mode inductances.

30 WATTS, 1.0 GHz,
28 VOLTS
LATERAL N–CHANNEL
BROADBAND RF
POWER MOSFET





CASE 360B–01
STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Gate–Source Voltage	V_{GS}	±20	Vdc
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	117 0.67	W W/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

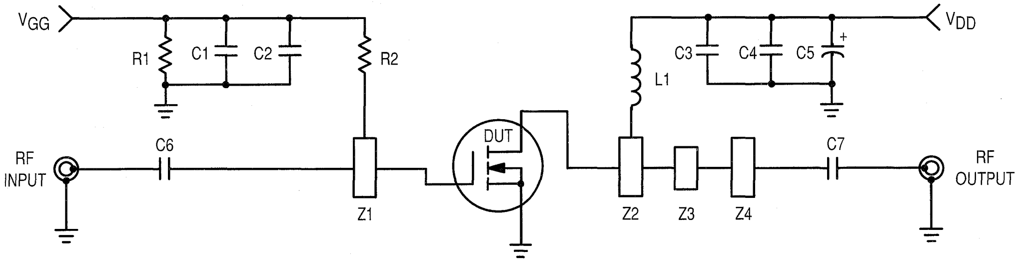
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 50\ \mu A$)	$V_{(BR)DSS}$	65	–	–	Vdc
Zero Gate Voltage Drain Current ($V_{DS} = 28$ V, $V_{GS} = 0$)	I_{DSS}	–	–	1	mAdc
Gate–Source Leakage Current ($V_{GS} = 20$ V, $V_{DS} = 0$)	I_{GSS}	–	–	1	μAdc

NOTE – **CAUTION** – MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 2

ELECTRICAL CHARACTERISTICS – continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 50 mA)	$V_{GS(th)}$	1	3	4	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 1 A)	$V_{DS(on)}$	–	0.34	–	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 3 A)	g_{fs}	1.6	1.8	–	S
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	–	56	–	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1 MHz)	C_{oss}	–	28	–	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1 MHz)	C_{rss}	–	2.5	–	pF
FUNCTIONAL CHARACTERISTICS					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 30 W, I_{DQ} = 50 mA, f = 960 MHz)	G_{ps}	11	15	–	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 30 W, I_{DQ} = 50 mA, f = 960 MHz)	η	45	55	–	%
Series Equivalent Input Impedance (V_{DD} = 28 Vdc, P_{out} = 30 W, I_{DQ} = 50 mA, f = 960 MHz)	Z_{in}	–	0.81 + j1.6	–	ohms
Series Equivalent Output Impedance (V_{DD} = 28 Vdc, P_{out} = 30 W, I_{DQ} = 50 mA, f = 960 MHz)	Z_{out}	–	2.15 – j1.7	–	ohms



C1, C3 — 0.1 µF Ceramic Capacitor
C2, C4 — 240 pF 0.1″ Chip Capacitor
C5 — 150 µF, 50 V Electrolytic Capacitor
C6, C7 — 220 pF 0.1″ Chip Capacitor
L1–3T, #18 AWG 1/8″ ID 0.285″ Long
R1 — 1 KΩ, 1/4 W
R2 — 10 KΩ, 1/4 W
Z1–Z4 — Microstrip

Figure 1. Test Circuit Schematic

TYPICAL CHARACTERISTICS

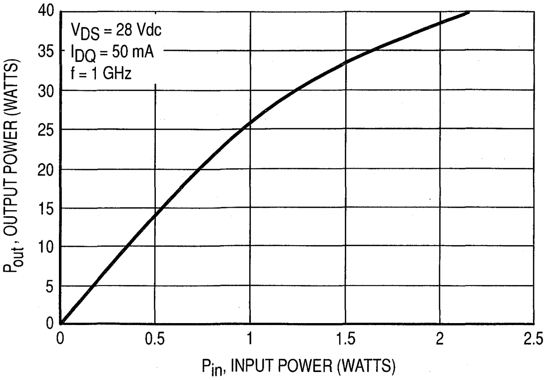


Figure 2. Output Power versus Input Power at 1 GHz

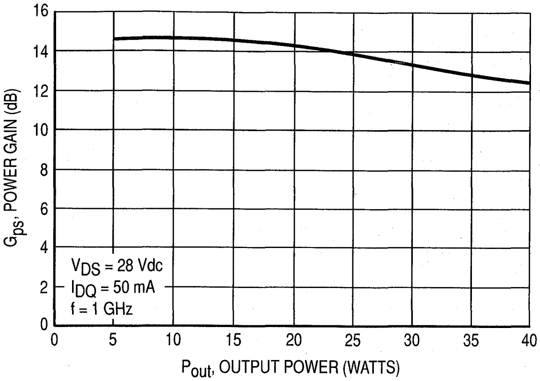


Figure 3. Power Gain versus Output Power at 1 GHz

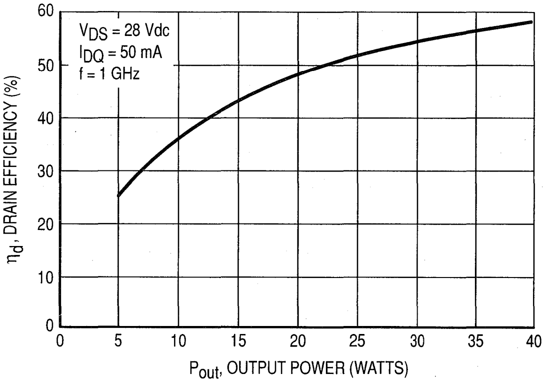


Figure 4. Drain Efficiency versus Output Power at 1 GHz

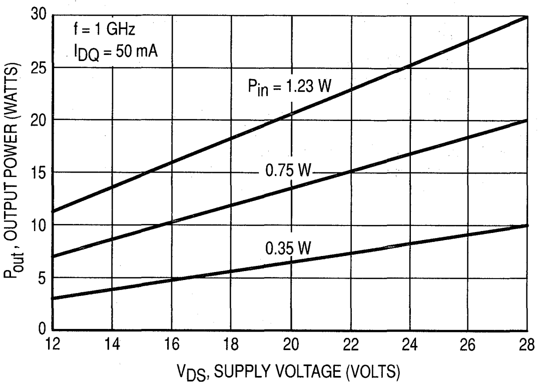


Figure 5. Output Power versus Supply Voltage

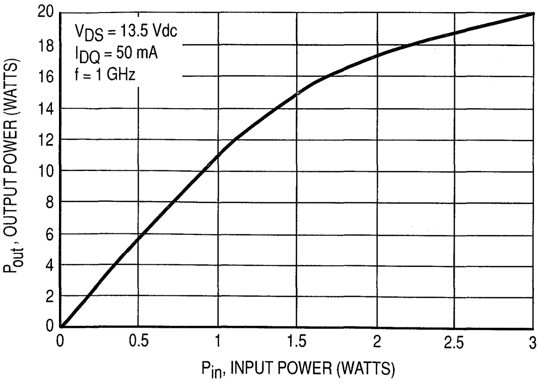


Figure 6. Output Power versus Input Power

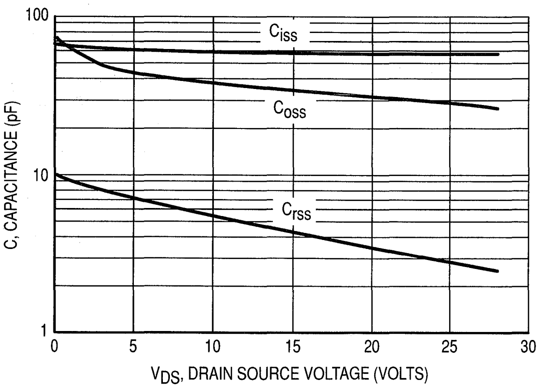


Figure 7. Capacitance versus Drain Source Voltage

Table 1. Typical Common Source S–Parameters (V_{DS} = 13.5 V)

I_D = 1.0 A

f MHz	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
20	0.933	–131.2	40.806	111.9	0.0207	22.6	0.664	–138.4
30	0.922	–147.7	29.305	104.0	0.0222	15.0	0.700	–150.5
40	0.892	–155.8	22.187	98.5	0.0224	9.5	0.718	–157.6
50	0.876	–160.5	17.909	94.9	0.0226	6.6	0.725	–161.7
60	0.869	–163.9	14.673	92.3	0.0225	4.4	0.732	–164.4
70	0.863	–166.0	12.569	90.4	0.0224	2.3	0.735	–166.3
80	0.860	–167.7	11.000	88.8	0.0223	1.1	0.738	–167.7
90	0.859	–168.8	9.788	87.2	0.0224	–0.1	0.740	–168.6
100	0.858	–169.9	8.793	85.8	0.0223	–1.3	0.741	–169.4
150	0.858	–173.0	5.780	79.5	0.0222	–6.5	0.750	–171.5
200	0.862	–174.9	4.290	74.0	0.0216	–10.7	0.759	–172.2
250	0.867	–175.8	3.381	69.2	0.0210	–13.5	0.770	–172.6
300	0.875	–176.7	2.768	64.8	0.0204	–16.8	0.780	–172.7
350	0.876	–177.4	2.316	60.6	0.0197	–19.0	0.793	–172.8
400	0.882	–178.2	1.981	56.0	0.0190	–21.7	0.808	–173.0
450	0.892	–178.7	1.724	52.4	0.0180	–23.6	0.816	–173.4
500	0.898	–179.5	1.508	48.7	0.0173	–25.5	0.828	–173.8
550	0.897	179.6	1.327	45.4	0.0165	–27.0	0.838	–174.2
600	0.907	178.9	1.192	41.6	0.0155	–28.4	0.849	–174.7
650	0.914	178.5	1.069	38.2	0.0145	–28.1	0.859	–175.2
700	0.915	177.4	0.950	34.9	0.0141	–25.4	0.867	–175.7
750	0.919	176.6	0.883	33.5	0.0146	–26.3	0.874	–176.2
800	0.924	176.0	0.804	30.0	0.0145	–27.1	0.884	–176.9
850	0.928	175.2	0.743	27.0	0.0150	–33.3	0.891	–177.6
900	0.928	174.0	0.683	24.9	0.0125	–38.2	0.897	–178.1
950	0.933	173.4	0.631	22.3	0.0111	–39.1	0.905	–178.7
1000	0.934	172.7	0.583	19.7	0.0097	–36.6	0.912	–179.5
1050	0.930	171.5	0.544	16.8	0.0089	–33.3	0.918	179.7
1100	0.937	170.7	0.515	14.9	0.0088	–29.4	0.924	179.1
1150	0.933	170.1	0.477	13.1	0.0082	–27.5	0.929	178.2
1200	0.929	169.2	0.453	10.1	0.0077	–25.3	0.930	177.3
1250	0.938	168.1	0.419	8.4	0.0074	–22.6	0.935	176.7
1300	0.935	167.7	0.396	6.4	0.0068	–20.8	0.934	175.8
1350	0.933	166.7	0.375	4.3	0.0063	–19.1	0.936	175.0
1400	0.936	165.5	0.348	2.3	0.0054	–14.1	0.939	174.1
1450	0.936	164.9	0.331	0.2	0.0051	–5.4	0.934	173.5
1500	0.926	163.8	0.315	–2.0	0.0042	–0.2	0.930	172.7

Table 2. Typical Common Emitter S–Parameters (V_{DS} = 28 V)

I_D = 1.0 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
20	0.964	–98.8	54.394	128.5	0.0143	39.3	0.429	–108.1
30	0.949	–120.9	43.459	117.7	0.0171	28.2	0.478	–124.6
40	0.909	–134.2	34.345	108.7	0.0179	19.7	0.520	–136.7
50	0.884	–142.4	28.265	102.7	0.0183	14.5	0.540	–144.0
60	0.875	–148.2	23.376	98.3	0.0186	10.7	0.553	–148.8
70	0.862	–152.4	20.099	95.1	0.0186	7.6	0.562	–152.0
80	0.861	–155.6	17.641	92.3	0.0186	5.3	0.569	–154.3
90	0.858	–157.9	15.722	89.9	0.0186	2.8	0.575	–155.9
100	0.858	–160.0	14.110	87.6	0.0186	1.1	0.580	–157.1
150	0.856	–165.9	9.261	78.5	0.0181	–6.6	0.606	–160.0
200	0.862	–169.4	6.802	71.0	0.0176	–11.6	0.633	–160.9
250	0.871	–171.0	5.291	64.9	0.0168	–16.1	0.661	–161.3
300	0.882	–172.7	4.272	59.3	0.0160	–20.7	0.690	–161.8
350	0.883	–173.9	3.520	54.1	0.0150	–23.3	0.718	–162.3
400	0.895	–175.2	2.969	48.8	0.0140	–25.9	0.747	–163.0
450	0.904	–176.0	2.539	44.6	0.0130	–27.9	0.767	–164.0
500	0.911	–177.0	2.197	40.5	0.0120	–29.8	0.789	–164.9
550	0.911	–178.2	1.904	36.8	0.0113	–29.6	0.807	–165.9
600	0.923	–179.2	1.688	32.8	0.0101	–30.2	0.825	–166.9
650	0.929	–179.9	1.496	29.5	0.0091	–28.9	0.841	–167.9
700	0.929	178.9	1.318	25.9	0.0088	–21.7	0.855	–168.9
750	0.933	177.9	1.206	24.4	0.0097	–21.6	0.865	–169.9
800	0.938	177.2	1.091	20.8	0.0093	–20.4	0.877	–170.9
850	0.942	176.3	1.000	18.0	0.0101	–31.4	0.886	–171.9
900	0.942	174.9	0.915	15.7	0.0077	–36.9	0.894	–172.8
950	0.947	174.2	0.839	13.2	0.0062	–37.6	0.904	–173.7
1000	0.946	173.4	0.772	11.1	0.0051	–27.6	0.912	–174.7
1050	0.943	172.2	0.718	8.0	0.0047	–17.6	0.919	–175.7
1100	0.948	171.4	0.672	6.2	0.0044	–9.0	0.926	–176.5
1150	0.945	170.7	0.620	4.0	0.0045	–0.8	0.932	–177.5
1200	0.939	169.8	0.587	1.1	0.0042	3.2	0.934	–178.7
1250	0.949	168.7	0.539	–0.7	0.0045	12.3	0.940	–179.5
1300	0.947	168.2	0.506	–3.0	0.0045	18.4	0.939	179.5
1350	0.944	167.1	0.478	–4.4	0.0046	22.3	0.941	178.5
1400	0.945	165.7	0.442	–6.9	0.0040	34.2	0.943	177.6
1450	0.944	165.3	0.421	–8.5	0.0047	44.9	0.940	176.8
1500	0.933	164.1	0.400	–10.4	0.0048	55.2	0.936	175.9

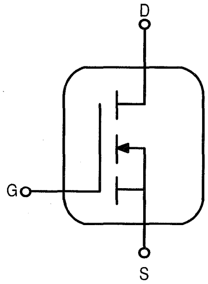
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

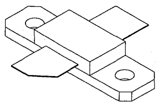
The RF MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement–Mode Lateral MOSFETs

MRF183

45 WATTS, 1.0 GHz,
28 VOLTS
LATERAL N–CHANNEL
BROADBAND RF
POWER MOSFET

- High gain, rugged device
- Broadband performance from HF to 1 GHz.
- Bottom side source eliminates DC isolators, reducing common mode inductances.





CASE 360B–01
STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Gate–Source Voltage	V_{GS}	±20	Vdc
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	140 0.80	W W/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.25	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

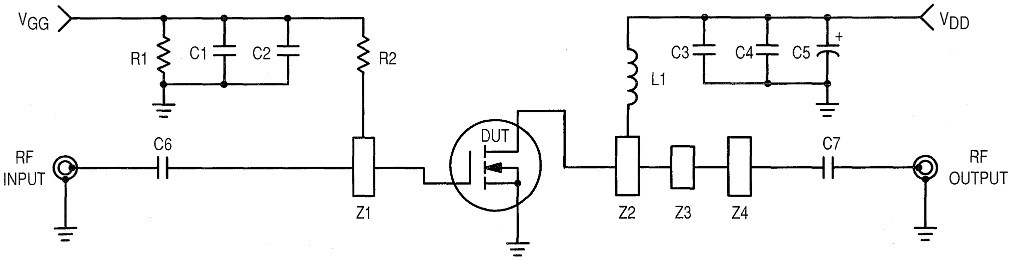
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 250 μA)	$V_{(BR)DSS}$	65	–	–	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 V, V_{GS} = 0)	I_{DSS}	–	–	1	mAdc
Gate–Source Leakage Current (V_{GS} = 20 V, V_{DS} = 0)	I_{GSS}	–	–	1	μAdc

NOTE – **CAUTION** – MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 2

ELECTRICAL CHARACTERISTICS – continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 75 mA)	$V_{GS(th)}$	1	3	5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 1 A)	$V_{DS(on)}$	–	0.23	–	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 3 A)	g_{fs}	–	2.6	–	S
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1 MHz)	C_{iss}	–	82	–	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1 MHz)	C_{oss}	–	38	–	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1 MHz)	C_{rss}	–	3.8	–	pF
FUNCTIONAL CHARACTERISTICS					
Common Source Power Gain (V_{DD} = 28 Vdc, P_{out} = 45 W, I_{DQ} = 75 mA, f = 1 GHz)	G_{ps}	–	12	–	dB
Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 45 W, I_{DQ} = 75 mA, f = 1 GHz)	η	–	55	–	%
Series Equivalent Input Impedance (V_{DD} = 28 Vdc, P_{out} = 45 W, I_{DQ} = 75 mA, f = 1 GHz)	Z_{in}	–	0.52 + j1.29	–	Ω
Series Equivalent Output Impedance (V_{DD} = 28 Vdc, P_{out} = 45 W, I_{DQ} = 75 mA, f = 1 GHz)	Z_{out}	–	1.49 – j1.65	–	Ω



C1, C3 — 0.1 µF Ceramic Capacitor
C2, C4 — 240 pF 0.1″ Chip Capacitor
C5 — 150 µF, 50 V Electrolytic Capacitor
C6, C7 — 220 pF 0.1″ Chip Capacitor
L1–3T, #18 AWG 1/8″ ID 0.285″ Long
R1 — 1 KΩ, 1/4 W
R2 — 10 KΩ, 1/4 W
Z1–Z4 — Microstrip

Figure 1. Test Circuit Schematic

TYPICAL CHARACTERISTICS

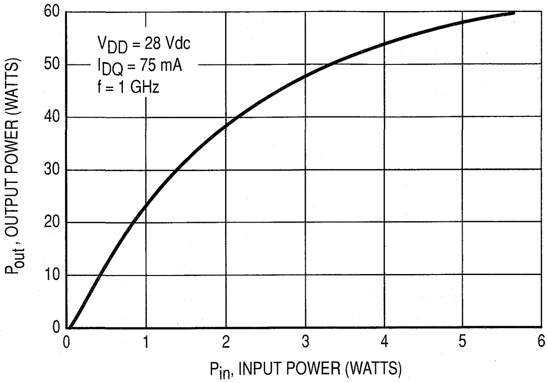


Figure 2. Output Power versus Input Power at 1 GHz

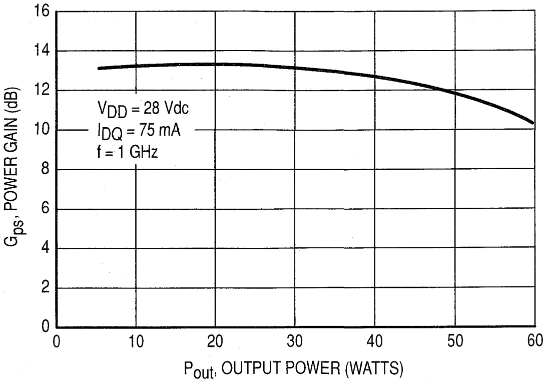


Figure 3. Power Gain versus Output Power at 1 GHz

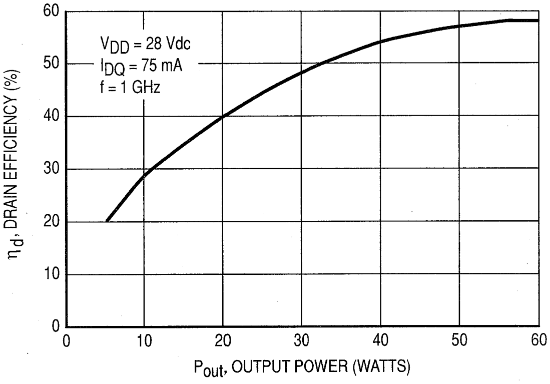


Figure 4. Drain Efficiency versus Output Power at 1 GHz

Table 1. Typical Common Source S–Parameters (V_{DS} = 13.5 V)

I_D = 1.5 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠φ	$\|S_{21}\|$	∠φ	$\|S_{12}\|$	∠φ	$\|S_{22}\|$	∠φ
20	0.954	–156.5	29.575	100.0	0.0167	11.3	0.778	–161.2
30	0.941	–163.6	19.733	96.4	0.0169	8.3	0.796	–167.6
40	0.922	–168.2	14.838	92.9	0.0168	4.1	0.804	–170.4
50	0.907	–170.6	11.936	90.5	0.0168	2.8	0.808	–172.0
60	0.903	–172.3	9.754	88.7	0.0168	1.8	0.812	–173.2
70	0.899	–173.3	8.340	87.5	0.0167	0.2	0.814	–173.9
80	0.898	–174.1	7.293	86.4	0.0167	–0.9	0.816	–174.5
90	0.896	–174.6	6.485	85.1	0.0167	–1.8	0.816	–174.8
100	0.897	–175.3	5.830	84.0	0.0167	–2.4	0.817	–175.2
150	0.895	–176.6	3.823	78.8	0.0166	–5.7	0.822	–176.0
200	0.898	–177.6	2.838	73.9	0.0161	–8.6	0.828	–176.1
250	0.902	–178.0	2.240	69.6	0.0157	–11.3	0.835	–176.1
300	0.908	–178.6	1.840	65.5	0.0153	–13.9	0.842	–176.1
350	0.905	–179.2	1.545	61.7	0.0148	–16.1	0.850	–176.0
400	0.913	–179.7	1.323	57.6	0.0143	–17.8	0.861	–176.1
450	0.920	179.9	1.148	54.2	0.0135	–18.2	0.865	–176.4
500	0.924	179.3	1.006	50.6	0.0131	–20.1	0.874	–176.6
550	0.922	178.8	0.888	47.3	0.0126	–20.7	0.881	–176.7
600	0.931	178.2	0.798	43.7	0.0118	–21.4	0.889	–177.0
650	0.935	178.0	0.720	40.7	0.0112	–19.9	0.895	–177.3
700	0.935	177.0	0.639	37.7	0.0114	–16.5	0.901	–177.7
750	0.937	176.5	0.593	36.6	0.0120	–18.0	0.905	–178.0
800	0.940	176.2	0.538	33.1	0.0119	–19.6	0.913	–178.4
850	0.943	175.6	0.498	30.1	0.0124	–28.5	0.919	–178.9
900	0.945	174.7	0.461	27.7	0.0100	–32.5	0.924	–179.2
950	0.947	174.2	0.428	25.6	0.0087	–34.3	0.930	–179.6
1000	0.947	173.6	0.398	23.8	0.0076	–28.6	0.935	179.7
1050	0.947	172.8	0.371	21.0	0.0072	–23.5	0.939	179.1
1100	0.952	172.1	0.347	19.3	0.0071	–19.2	0.944	178.7
1150	0.949	171.6	0.319	17.3	0.0067	–17.3	0.948	178.0
1200	0.946	171.0	0.304	14.3	0.0064	–15.7	0.948	177.3
1250	0.954	170.1	0.282	12.0	0.0060	–12.8	0.953	176.9
1300	0.952	169.8	0.270	9.4	0.0058	–11.7	0.950	176.1
1350	0.949	169.1	0.255	8.6	0.0056	–10.3	0.951	175.5
1400	0.948	168.0	0.233	7.9	0.0048	–6.7	0.953	174.8
1450	0.948	167.5	0.218	5.9	0.0042	3.7	0.948	174.4
1500	0.940	166.7	0.205	3.8	0.0039	19.4	0.944	173.7

Table 2. Typical Common Source S–Parameters (V_{DS} = 28 V)

I_D = 1.5 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\vert S_{11}\vert$	∠ϕ	$\vert S_{21}\vert$	∠ϕ	$\vert S_{12}\vert$	∠ϕ	$\vert S_{22}\vert$	∠ϕ
20	0.968	–131.6	45.785	112.7	0.0143	24.0	0.579	–145.3
30	0.953	–145.3	31.747	105.5	0.0149	16.6	0.623	–156.7
40	0.921	–154.4	24.333	99.1	0.0152	11.5	0.648	–161.4
50	0.904	–159.4	19.676	94.9	0.0151	7.2	0.661	–164.2
60	0.898	–162.8	16.109	91.8	0.0152	4.5	0.670	–166.1
70	0.890	–165.1	13.788	89.5	0.0151	2.4	0.677	–167.3
80	0.886	–166.7	12.060	87.4	0.0152	0.5	0.681	–168.2
90	0.886	–168.0	10.714	85.5	0.0150	–0.9	0.684	–168.6
100	0.887	–169.3	9.606	83.7	0.0151	–2.9	0.688	–168.9
150	0.886	–172.3	6.260	76.0	0.0147	–8.5	0.706	–169.8
200	0.890	–174.3	4.594	69.4	0.0141	–12.6	0.724	–169.5
250	0.898	–174.9	3.570	63.6	0.0135	–16.5	0.744	–169.3
300	0.906	–175.9	2.876	58.5	0.0128	–18.9	0.764	–169.3
350	0.908	–176.8	2.367	53.5	0.0120	–22.5	0.785	–169.3
400	0.915	–177.6	1.996	48.5	0.0111	–24.1	0.807	–169.5
450	0.924	–178.1	1.708	44.5	0.0105	–24.6	0.821	–170.0
500	0.930	–178.8	1.475	40.6	0.0098	–26.1	0.838	–170.5
550	0.928	–179.7	1.277	37.3	0.0091	–25.9	0.851	–171.0
600	0.937	179.6	1.128	33.4	0.0083	–25.4	0.865	–171.6
650	0.944	179.2	0.999	30.1	0.0074	–22.2	0.878	–172.2
700	0.943	178.3	0.878	26.6	0.0077	–14.4	0.888	–172.9
750	0.946	177.6	0.806	25.3	0.0083	–15.3	0.895	–173.4
800	0.949	177.0	0.730	22.1	0.0086	–17.1	0.906	–174.1
850	0.954	176.5	0.670	19.6	0.0090	–28.3	0.912	–174.8
900	0.953	175.4	0.608	17.6	0.0068	–33.7	0.919	–175.4
950	0.957	174.9	0.557	15.1	0.0051	–31.6	0.927	–176.0
1000	0.957	174.4	0.512	12.8	0.0042	–22.0	0.934	–176.8
1050	0.957	173.5	0.475	9.7	0.0040	–10.7	0.939	–177.6
1100	0.962	172.6	0.447	8.0	0.0040	–2.3	0.945	–178.2
1150	0.959	172.2	0.413	6.7	0.0041	3.4	0.950	–178.9
1200	0.955	171.3	0.391	4.2	0.0040	9.1	0.950	–179.8
1250	0.962	170.4	0.355	2.3	0.0042	12.5	0.955	179.6
1300	0.959	170.1	0.332	0.0	0.0039	17.2	0.953	178.8
1350	0.956	169.3	0.310	–1.4	0.0041	25.2	0.954	178.0
1400	0.954	168.3	0.291	–4.4	0.0035	32.0	0.957	177.2
1450	0.955	168.0	0.277	–5.9	0.0037	45.5	0.952	176.7
1500	0.948	167.1	0.261	–6.8	0.0042	56.1	0.948	176.0

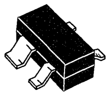
The RF Line
NPN Silicon High-Frequency Transistor

MRF0211LT1

. . . designed primarily for use in the high–gain, low–noise small–signal amplifiers for operation up to 3.5 GHz. Also usable in applications requiring fast switching times.

- High Current–Gain–Bandwidth Product —
  f_T = 5.5 GHz (Typ) @ I_C = 40 mAdc
- Low Noise Figure @ f = 1.0 GHz —
  $NF_{(matched)}$ = 1.8 dB (Typ)
- High Power Gain —
  G_{pe} (matched) = 13 dB (Typ)
- Surface Mount SOT–143 Offers Improved RF Performance
  Lower Package Parasitics
  Higher Gain
- Higher Voltage Version of MRF5711LT1
- Electrically Similar to NEC NE 02133
- Available in tape and reel packaging:
  T1 suffix = 3,000 units per reel

**SURFACE MOUNT
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON**



CASE 318A–05, STYLE 1
LOW PROFILE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	15	Vdc
Collector–Base Voltage	V_{CBO}	30	Vdc
Emitter–Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	70	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.58 4.64	Watts mW/°C
Total Device Dissipation @ T_C = 75°C (1) Derate above 75°C	P_D	0.58 7.73	Watts mW/°C
Maximum Junction Temperature	T_{Jmax}	150	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	130	°C/W

DEVICE MARKING

MRF0211LT1 = 15

NOTE:
1. Case Temperature is measured on the collector lead where it first contacts the printed circuit board closest to the package.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		$V_{(BR)CBO}$	30	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 50 μAdc, I_C = 0)		$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 30 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	50	—	300	—
DYNAMIC CHARACTERISTICS						
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	Figure 1	C_{cb}	—	0.7	1.0	pF
Current Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 40 mA, f = 1.0 GHz)	Figure 7	f_T	—	5.5	—	GHz
FUNCTIONAL TESTS						
Gain at Noise Figure (Tuned) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc)	Figure 4 f = 0.5 GHz f = 1.0 GHz	G_{NFmin}	 — —	 19 13	 — —	dB
Noise Figure (Tuned) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc)	Figure 4 f = 0.5 GHz f = 1.0 GHz f = 2.0 GHz	NF_{min}	 — — —	 0.9 1.8 3.0	 — —	dB
Power Gain in 50 Ω System (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	Figure 2	G_{NF}	—	9.5	—	dB
Noise Figure in 50 Ω System (V_{CE} = 10 Vdc, I_C = 5.0 mA, f = 1.0 GHz)	Figure 2	NF	—	2.7	3.0	dB
Insertion Gain (V_{CE} = 10 Vdc, I_C = 25 mA, f = 1.0 GHz)		S_{21}^2	11	13.5	—	dB
Maximum Unilateral Gain (V_{CE} = 10 Vdc, I_C = 25 mA, f = 1.0 GHz)		G_{Umax}	—	15.5	—	dB

TYPICAL CHARACTERISTICS

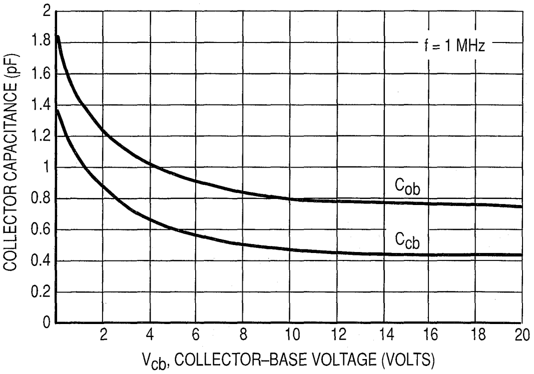


Figure 1. Device Capacitances versus Voltage

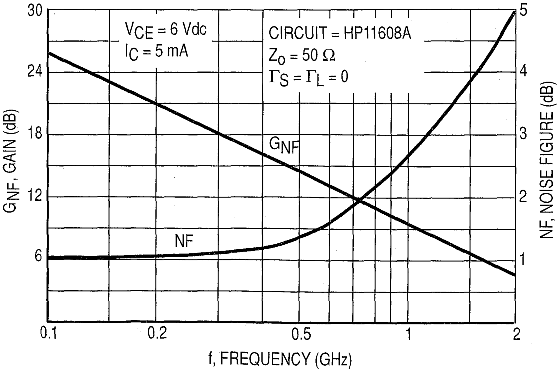


Figure 2. Gain and Noise Figure versus Frequency

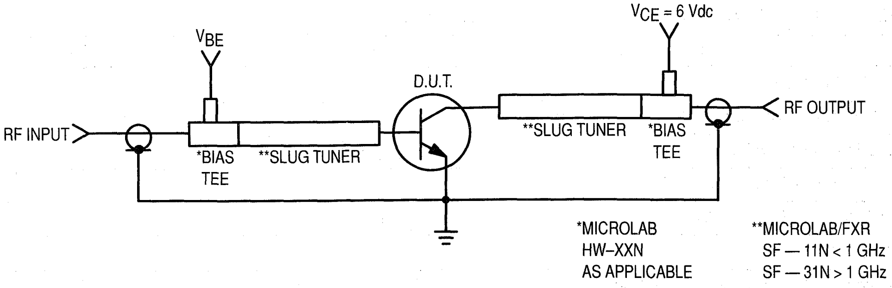


Figure 3. Functional Circuit Schematic

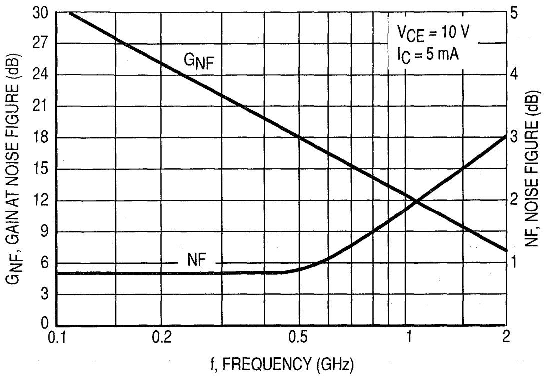


Figure 4. Gain at Noise Figure and Noise Figure versus Frequency

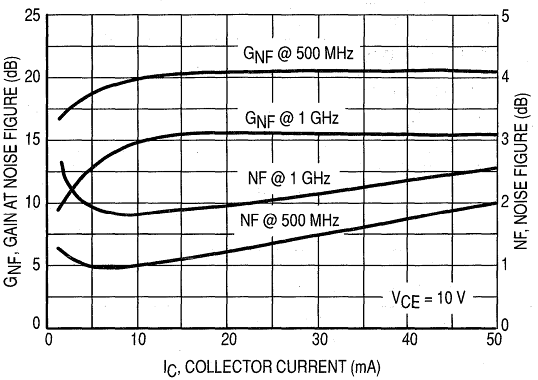


Figure 5. Gain at Noise Figure and Noise Figure versus Collector Current

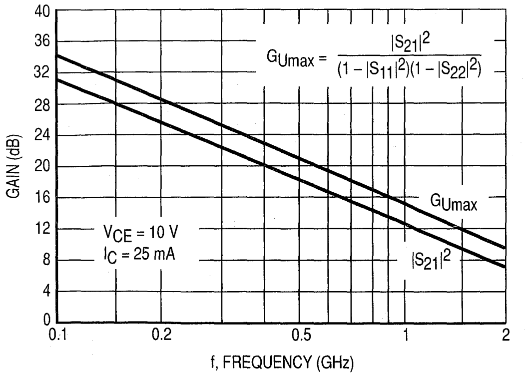


Figure 6. Unilateral–Gain and Insertion Gain versus Frequency

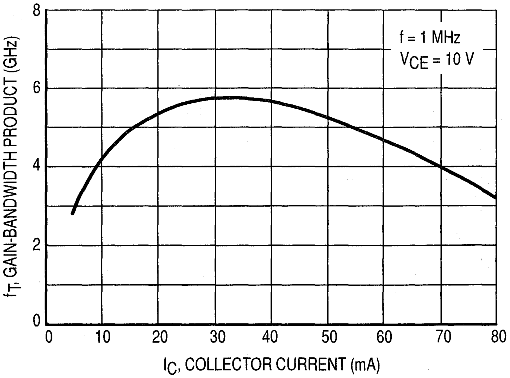


Figure 7. Gain–Bandwidth Product versus Collector Current

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
5.0	5.0	100	0.84	−50	13.2	151	0.04	64	0.90	−22
		200	0.81	−87	10.4	130	0.06	49	0.74	−35
		500	0.74	−139	5.6	100	0.07	32	0.50	−48
		1000	0.68	−175	2.9	77	0.09	32	0.42	−58
		1500	0.66	167	2.0	61	0.09	40	0.44	−67
		2000	0.65	149	1.5	51	0.11	51	0.44	−73
	10	100	0.76	−66	20.6	144	0.03	60	0.83	−32
		200	0.73	−106	14.8	122	0.05	44	0.62	−49
		500	0.69	−153	7.1	96	0.06	37	0.36	−63
		1000	0.65	178	3.7	76	0.08	44	0.28	−71
		1500	0.62	162	2.5	63	0.09	51	0.30	−77
		2000	0.61	145	1.9	54	0.12	59	0.20	−78
	25	100	0.65	−89	28.8	134	0.03	55	0.71	−44
		200	0.67	−126	18.2	114	0.04	45	0.48	−64
		500	0.65	−163	8.3	92	0.05	45	0.27	−80
		1000	0.63	172	4.2	76	0.07	55	0.20	−90
		1500	0.60	158	2.8	64	0.10	60	0.22	−92
		2000	0.59	142	2.2	55	0.13	63	0.20	−90
	50	100	0.62	−110	30.4	126	0.02	51	0.62	−49
		200	0.66	−142	18.0	109	0.03	45	0.41	−65
		500	0.66	−171	7.9	90	0.04	52	0.25	−79
		1000	0.64	168	4.1	75	0.06	62	0.20	−91
		1500	0.62	155	2.7	62	0.10	65	0.20	−93
		2000	0.60	140	2.1	55	0.13	67	0.14	−90
10	5.0	100	0.86	−46	13.2	153	0.03	69	0.92	−18
		200	0.82	−81	10.6	132	0.05	51	0.80	−28
		500	0.72	−134	5.9	102	0.07	36	0.57	−38
		1000	0.65	−171	3.2	78	0.08	38	0.49	−46
		1500	0.63	169	2.1	62	0.08	47	0.52	−55
		2000	0.61	149	1.6	51	0.10	60	0.53	−61
	10	100	0.77	−60	20.7	145	0.03	62	0.85	−26
		200	0.72	−98	15.2	124	0.04	48	0.66	−38
		500	0.65	−147	7.5	97	0.06	42	0.44	−46
		1000	0.59	−177	3.9	77	0.07	48	0.37	−51
		1500	0.58	165	2.6	64	0.09	56	0.39	−59
		2000	0.56	145	2.0	54	0.13	65	0.40	−62
	25	100	0.67	−80	29.4	136	0.02	57	0.75	−35
		200	0.66	−118	19.3	116	0.03	47	0.53	−48
		500	0.63	−158	8.9	94	0.05	47	0.33	−55
		1000	0.61	175	4.6	77	0.07	57	0.26	−60
		1500	0.58	161	3.1	64	0.09	61	0.29	−65
		2000	0.57	144	2.3	55	0.12	66	0.30	−65
	50	100	0.65	−99	32.2	129	0.02	54	0.67	−38
		200	0.65	−135	19.5	110	0.03	44	0.45	−48
		500	0.64	−167	8.5	91	0.04	53	0.31	−51
		1000	0.61	170	4.2	75	0.06	62	0.26	−55
		1500	0.59	157	2.9	63	0.09	58	0.30	−61
		2000	0.58	141	2.3	54	0.11	71	0.31	−63

Table 1. Common Emitter S–Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

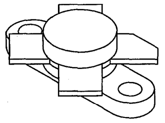
The RF Line
NPN Silicon RF Power Transistor

MRF224

40 W, 175 MHz
RF POWER
TRANSISTOR
NPN SILICON

. . . designed for 12.5 Volt VHF large–signal power amplifier applications required in commercial and industrial equipment operating to VHF frequencies.

- Specified 12.5 Volt, 175 MHz Characteristics —
  Output Power = 40 W
  Power Gain = 4.5 dB Min
  Efficiency = 70% Min



CASE 211–07, STYLE 1

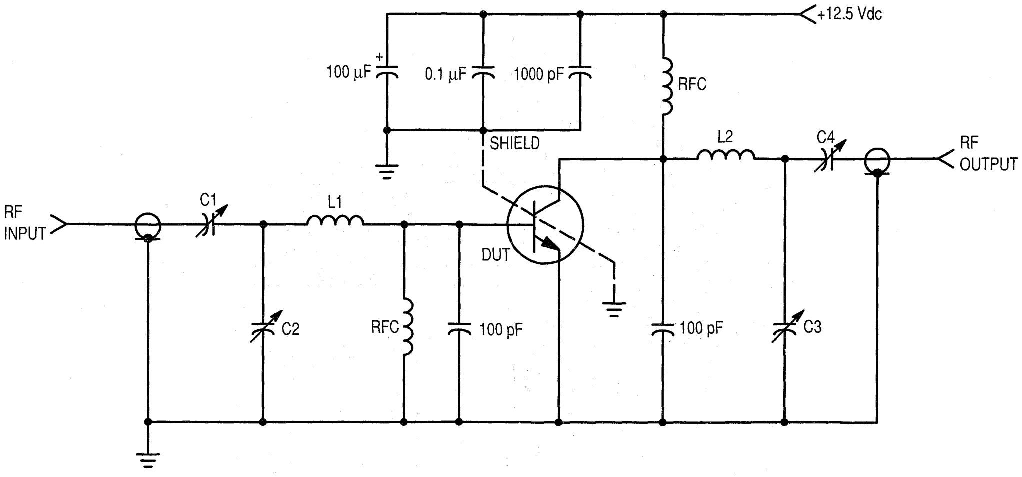
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	18	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	7.0	Adc
Total Device Dissipation @ T_C = 25°C (2) Derate above 25°C	P_D	80 0.46	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C
Stud Torque (1)	—	6.5	in. lb.

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = +55°C)	I_{CES}	—	—	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	2.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	—	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	—	170	200	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	4.5	—	—	dB
Collector Efficiency (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	70	—	—	%

NOTES:
1. For repeated assembly use 5 in. lb.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



C1, C2, C3, C4 — 5.0– 80 pF ARCO 462
L1 — Straight Wire, #14 AWG, 1–3/8″ Long
L2 — 1 Turn, #14 AWG, 3/8″ ID, Length Plus Leads = 1″
RFC — VK200–20/4B, FERROXCUBE

Figure 1. 175 MHz Test Circuit

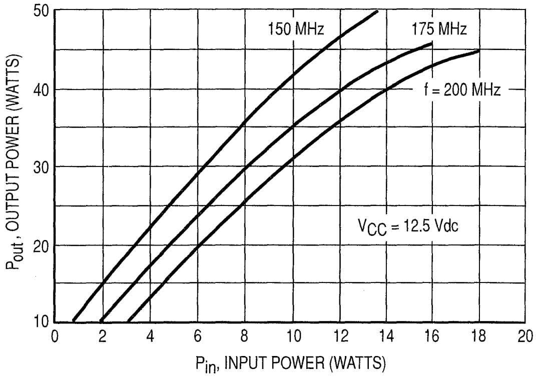


Figure 2. Output Power versus Input Power

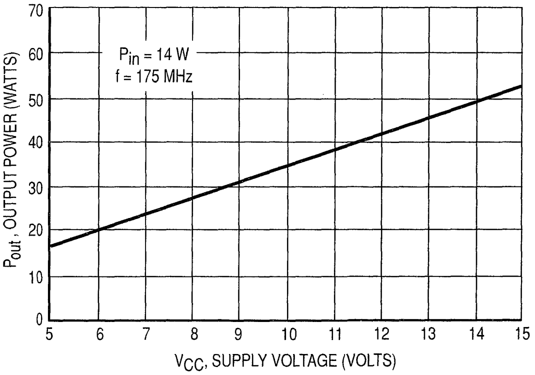
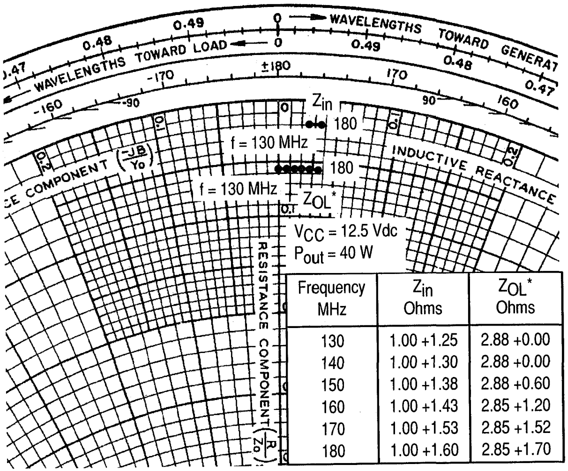


Figure 3. Output Power versus Supply Voltage



Frequency MHz	Z_{in} Ohms	Z_{OL}^* Ohms
130	1.00 +1.25	2.88 +0.00
140	1.00 +1.30	2.88 +0.00
150	1.00 +1.38	2.88 +0.60
160	1.00 +1.43	2.85 +1.20
170	1.00 +1.53	2.85 +1.52
180	1.00 +1.60	2.85 +1.70

Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 4. Series Equivalent Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

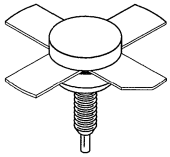
The RF Line
NPN Silicon RF Power Transistors

MRF240

40 W, 145–175 MHz
RF POWER
TRANSISTORS
NPN SILICON

. . . designed for 13.6 volt VHF large–signal class C and class AB linear power amplifier applications in commercial and industrial equipment.

- High Common Emitter Power Gain
- Specified 13.6 V, 160 MHz Performance:
  Output Power = 40 Watts
  Power Gain = 9.0 dB Min
  Efficiency = 55% Min
- Load Mismatch Capability at Rated Voltage and RF Drive
- Silicon Nitride Passivated
- Low Intermodulation Distortion, $d_3 = -30$ dB Typ



CASE 145A–09, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	100 0.57	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	1.75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	70	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	90	125	pF

NOTES:

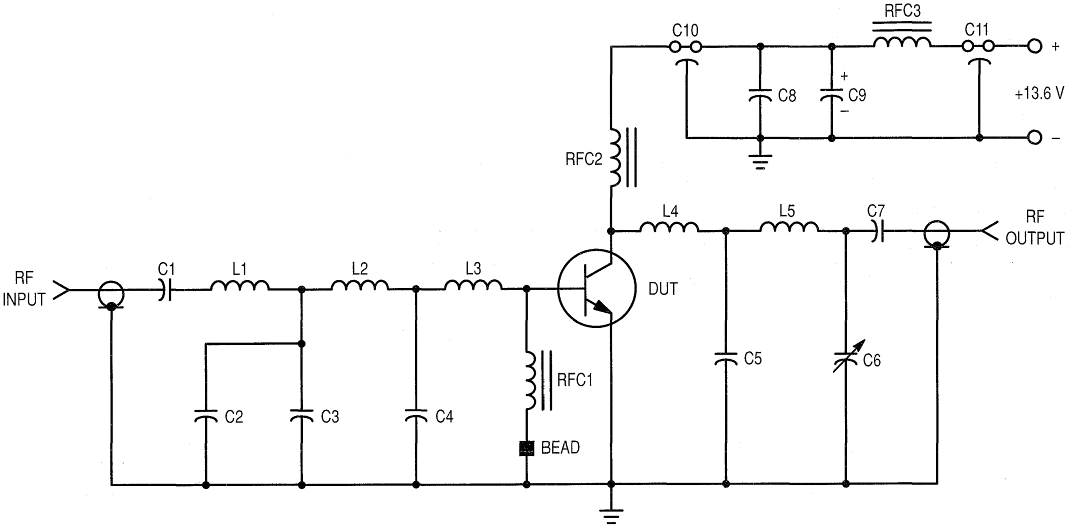
(continued)

1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 13.6 Vdc, P_{out} = 40 W, f = 160 MHz)	G_{PE}	9.0	10	—	dB
Collector Efficiency (V_{CC} = 13.6 Vdc, P_{out} = 40 W, f = 160 MHz)	η	55	—	—	%
TYPICAL SSB PERFORMANCE					
Intermodulation Distortion (3) (V_{CC} = 13.6 Vdc, P_{out} = 35 W (PEP), f1 = 146 MHz, f2 = 146.002 MHz, I_{CQ} = 50 mAdc)	IMD (d_3)	—	−30	—	dB

NOTE:
3. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C1 — 200 pF, 350 Vdc, UNELCO
C2 — 100 pF, 350 Vdc, UNELCO
C3 — 40 pF, 350 Vdc, UNELCO
C4, C5 — 80 pF, 350 Vdc, UNELCO
C6 — 1.0–20 pF, ARCO Trimmer
C7 — 100 pF 350 Vdc, UNELCO
C8 — 0.1 μF ERIE Disc Ceramic
C9 — 1.0 μF TANTALUM

C10, C11 — 680 pF ALLEN BRADLEY Feedthru
RFC1 — 0.15 μH Molded Choke
RFC2 — 10 Turns, #18 AWG on 470 Ohm, 1.0 Watt Resistor
Bead — FERROXCUBE Bead
RFC3 — FERROXCUBE Choke, VK200–4B
L1 — 3.3 x 0.2 cm AIRLINE Inductor
L2 — 1.0 x 0.2 cm AIRLINE Inductor

L3 — 1.2 x 0.6 cm Brass Pad
L4 — 1.2 x 0.6 cm Brass Pad and 2.0 x 0.2 cm AIRLINE Inductor

Board — G10, ε_r = 5, t = 62 mils 2 sided, 2 oz. Clad

Connectors: Type N

Figure 1. 160 MHz Test Circuit Schematic

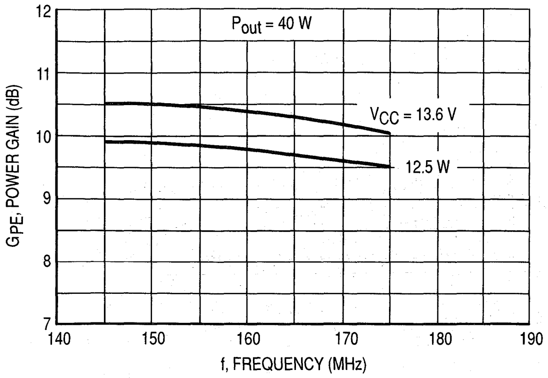


Figure 2. Power Gain versus Frequency

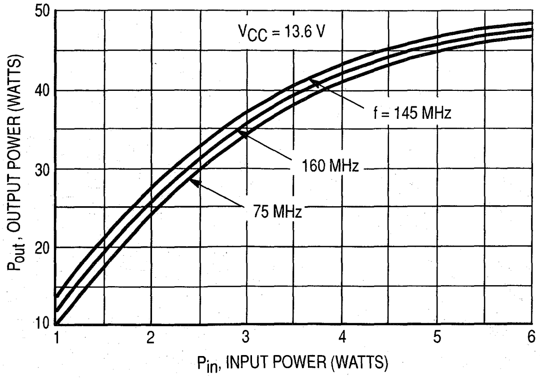


Figure 3. Output Power versus Input Power

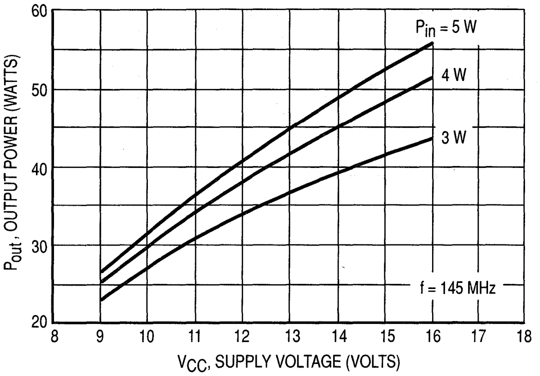


Figure 4. Output Power versus Supply Voltage

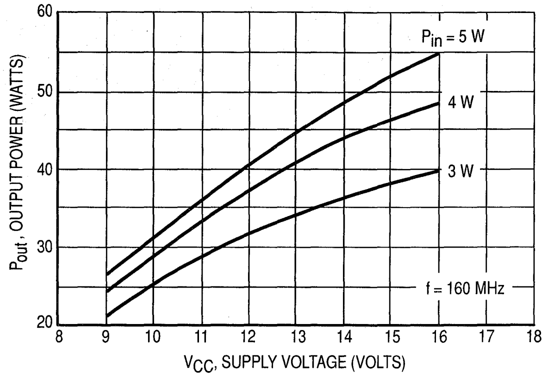


Figure 5. Output Power versus Supply Voltage

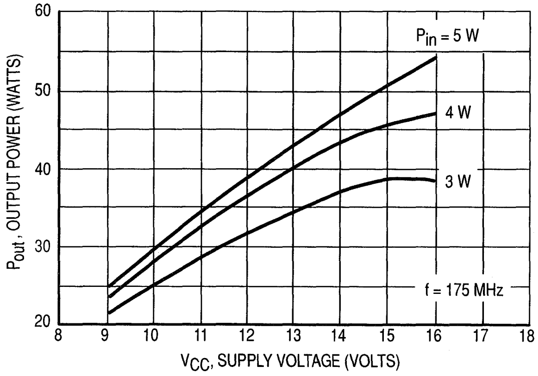
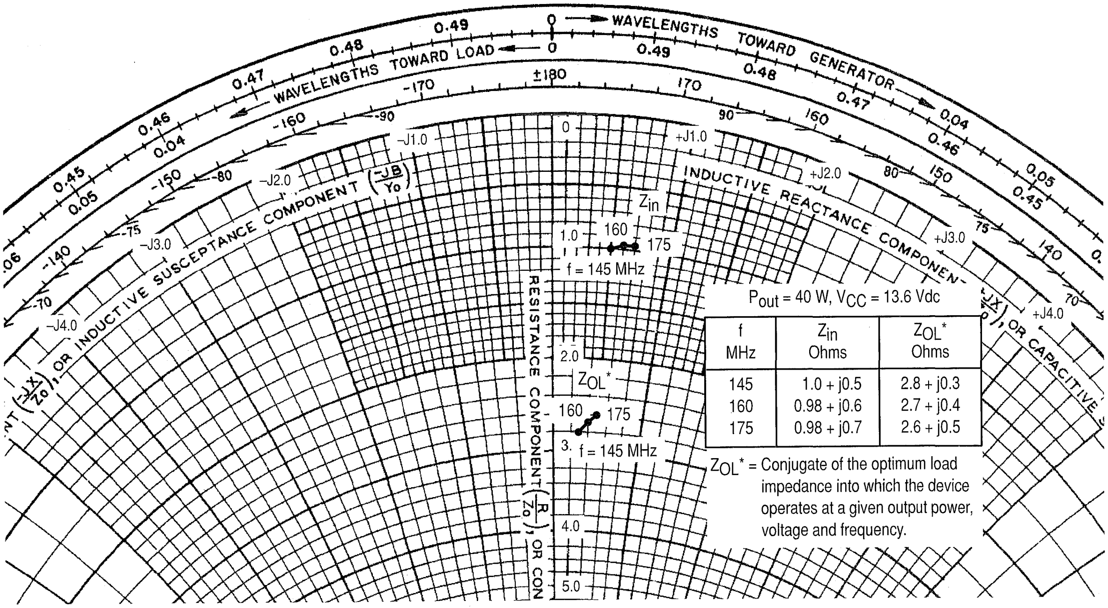


Figure 6. Output Power versus Supply Voltage



P_{out} = 40 W, V_{CC} = 13.6 Vdc

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
145	1.0 + j0.5	2.8 + j0.3
160	0.98 + j0.6	2.7 + j0.4
175	0.98 + j0.7	2.6 + j0.5

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 7. Series Equivalent Input/Output Impedances

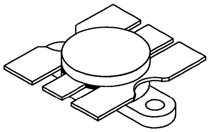
The RF Line
NPN Silicon RF Power Transistor

MRF247

. . . designed for 12.5 Volt VHF large–signal amplifier applications in industrial and commercial FM equipment operating to 175 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics —
  Output Power = 75 Watts
  Power Gain = 7.0 dB Min
  Efficiency = 55% Min
- Characterized With Series Equivalent Large–Signal Impedance Parameters
- Internal Matching Network Optimized for Minimum Gain Frequency Slope Response Over the Range 136 to 175 MHz
- Load Mismatch Capability at Rated P_{out} and Supply Voltage

75 W, 175 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	18	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Peak	I_C	20	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	0.7	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc

NOTES:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	75	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	235	300	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 75 Watts, f = 175 MHz)	G_{PE}	7.0	8.5	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 75 Watts, f = 175 MHz)	η	55	60	—	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 75 Watts, f = 175 MHz, VSWR = 30:1 All Phase Angles)	ψ	No Degradation in Output Power			

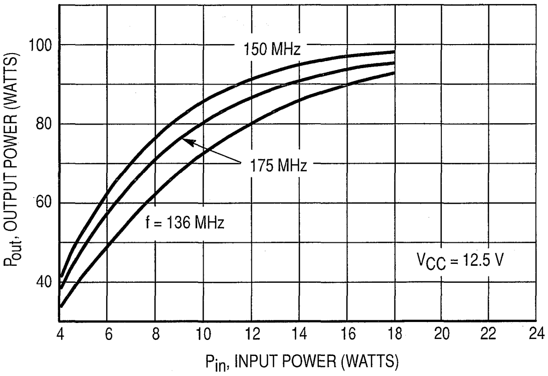


Figure 1. Output Power versus Input Power

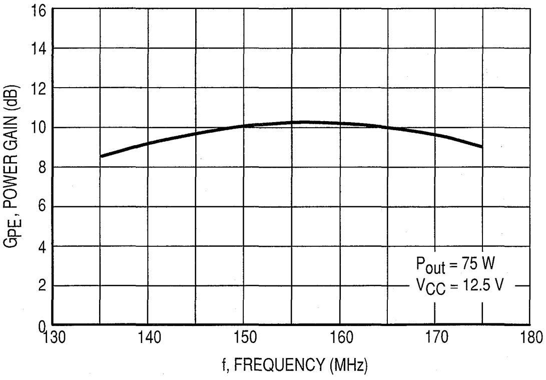


Figure 2. Power Gain versus Frequency

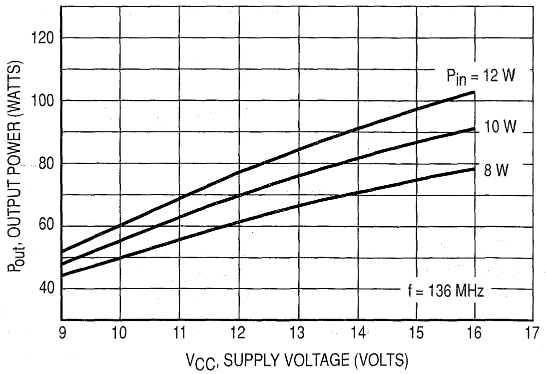


Figure 3. Output Power versus Supply Voltage

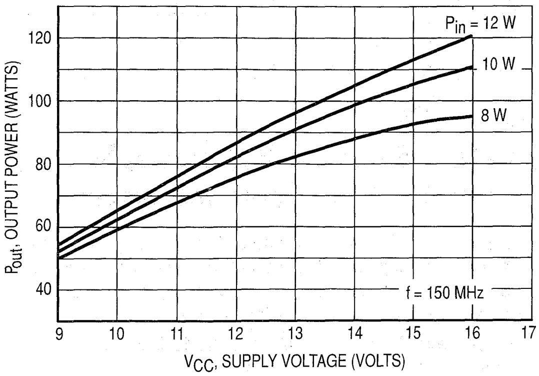


Figure 4. Output Power versus Supply Voltage

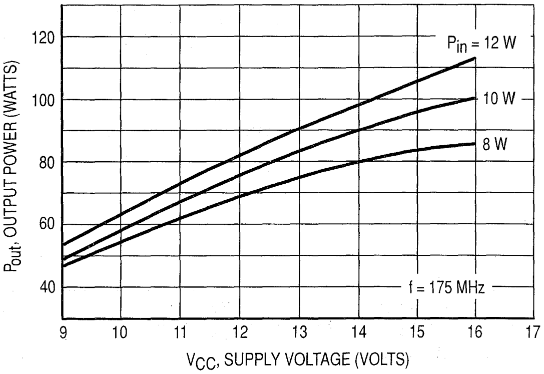
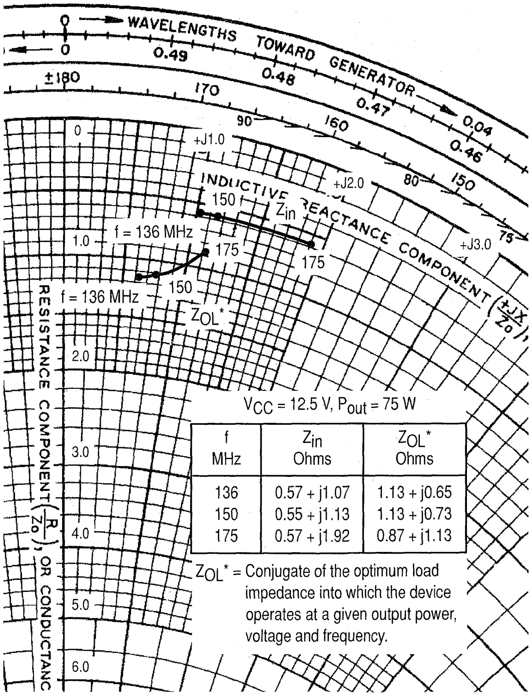


Figure 5. Output Power versus Supply Voltage



V_{CC} = 12.5 V, P_{out} = 75 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
136	0.57 + j1.07	1.13 + j0.65
150	0.55 + j1.13	1.13 + j0.73
175	0.57 + j1.92	0.87 + j1.13

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

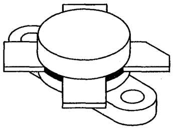
The RF MOSFET Line
RF Power Field-Effect Transistor
N–Channel Enhancement–Mode

MRF255

55 W, 12.5 Vdc, 54 MHz
N–CHANNEL
BROADBAND
RF POWER FET

Designed for broadband commercial and industrial applications at frequencies to 54 MHz. The high gain, broadband performance and linear characterization of this device makes it ideal for large–signal, common source amplifier applications in 12.5 Volt mobile and base station equipment.

- Guaranteed Performance at 54 MHz, 12.5 Volts
  Output Power — 55 Watts PEP
  Power Gain — 13 dB Min
  Two–Tone IMD — –25 dBc Max
  Efficiency — 40% Min, Two–Tone Test
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- Excellent Thermal Stability
- All Gold Metal for Ultra Reliability
- Aluminum Nitride Package Electrical Insulator
- Circuit Board Photomaster Available by Ordering Document MRF255PHT/D from Motorola Literature Distribution.



CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	36	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 MΩ)	V_{DGR}	36	Vdc
Gate–Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous	I_D	22	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

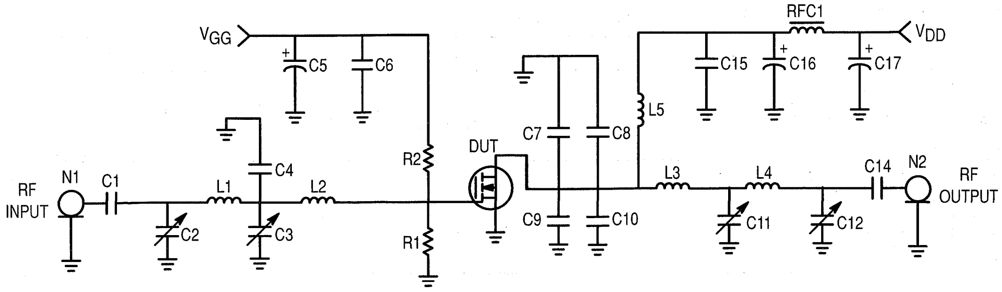
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

Handling and Packaging — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 20 mAdc)	$V_{(BR)DSS}$	36	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	5.0	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 25 mAdc)	$V_{GS(th)}$	1.25	2.3	3.5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 4.0 Adc)	$V_{DS(on)}$	—	—	0.4	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3.0 Adc)	g_{fs}	4.2	—	—	S
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	140	—	pF
Output Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	285	—	pF
Reverse Transfer Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	38	44	pF
FUNCTIONAL TESTS (In Motorola Test Fixture.)					
Common Source Amplifier Power Gain, f_1 = 54, f_2 = 54.001 MHz (V_{DD} = 12.5 Vdc, P_{out} = 55 W (PEP), I_{DQ} = 400 mA)	G_{ps}	13	16	—	dB
Intermodulation Distortion (1), f_1 = 54.000 MHz, f_2 = 54.001 MHz (V_{DD} = 12.5 Vdc, P_{out} = 55 W (PEP), I_{DQ} = 400 mA)	$IMD_{(d3,d5)}$	—	–30	–25	dBc
Drain Efficiency, f_1 = 54; f_2 = 54.001 MHz (V_{DD} = 12.5 Vdc, P_{out} = 55 W (PEP), I_{DQ} = 400 mA)	η	40	45	—	%
Drain Efficiency, f = 54 MHz (V_{DD} = 12.5 Vdc, P_{out} = 55 W CW, I_{DQ} = 400 mA)	η	—	60	—	%
Output Mismatch Stress, f_1 = 54; f_2 = 54.001 MHz (V_{DD} = 12.5 Vdc, P_{out} = 55 W (PEP), I_{DQ} = 400 mA, VSWR = 20:1, at all phase angles)	ψ	No Degradation in Output Power Before and After Test			

(1) To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C1 — 470 pF, Chip Capacitor
C2, C3, C11, C12 — 20–200 pF, Trimmer, ARCO #464
C4 — 100 pF, Chip Capacitor
C5, C17 — 100 µF, 15 V, Electrolytic
C6 — 0.001 µF, Disc Ceramic
C7, C8, C9, C10 — 330 pF, Chip Capacitor
C14 — 1200 pF, ATC Chip Capacitor
C15 — 910 pF, 500 V, Dipped Mica
C16 — 47 µF, 16 V, Electrolytic

L1 — 8 Turns, #20 AWG, 0.126″ ID
L2 — 5 Turns, #18 AWG, 0.142″ ID
L3 — 3 Turns, #20 AWG, 0.102″ ID
L4 — 7 Turns, #24 AWG, 0.070″ ID
L5 — 6.5 Turns, #18 AWG, 0.230″ ID, 0.5″ Long
N1, N2 — Type N Flange Mount
RFC1 — Ferroxcube VK–200–19/4B
R1 — 39 kΩ, 1/4 W Carbon
R2 — 150 Ω, 1/4 W Carbon
Board — G–10 .060″

Figure 1. 54 MHz Linear RF Test Circuit Electrical Schematic

TYPICAL CHARACTERISTICS

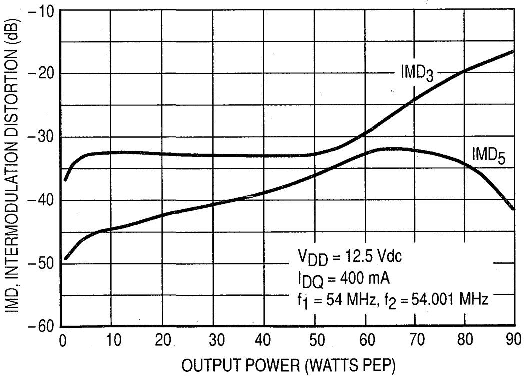


Figure 2. IMD versus Output Power

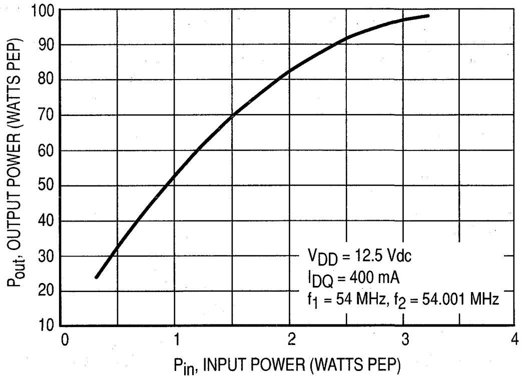


Figure 3. Output Power versus Input Power

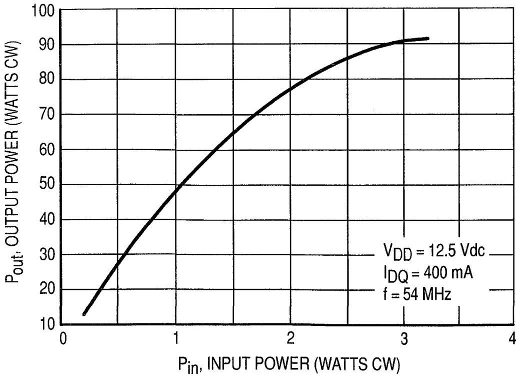


Figure 4. Output Power versus Input Power

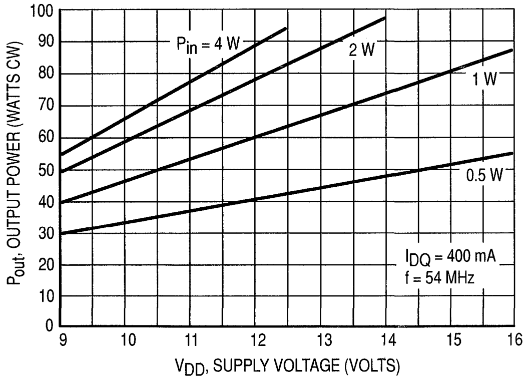


Figure 5. Output Power versus Supply Voltage

TYPICAL CHARACTERISTICS

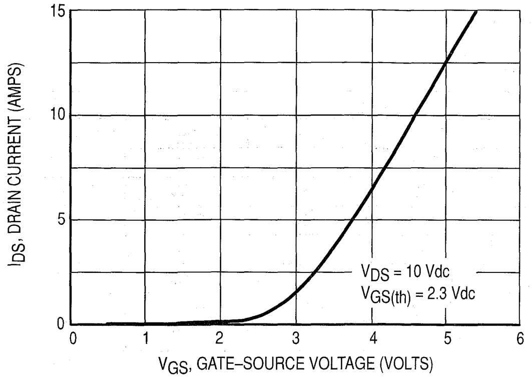


Figure 6. Drain Current versus Gate Voltage

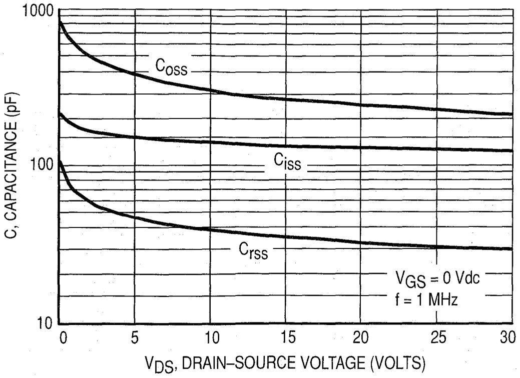


Figure 7. Capacitance versus Voltage

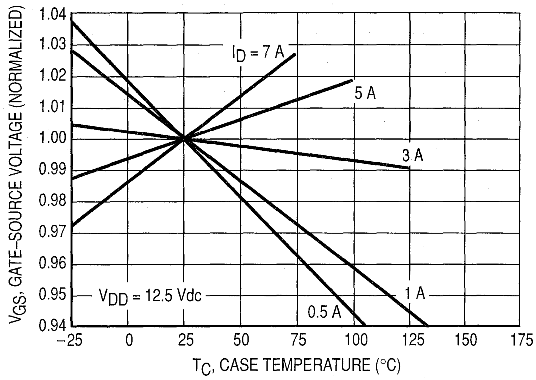


Figure 8. Gate–Source Voltage versus Case Temperature

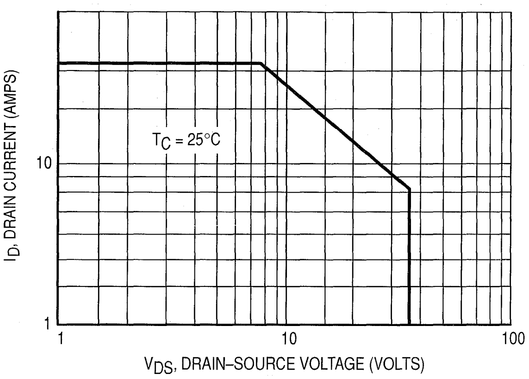


Figure 9. DC Safe Operating Area

Table 2. Series Equivalent Input and Output Impedance

V_{DD} = 12.5 Vdc, I_{DQ} = 400 mA, P_{out} = 55 W PEP
Optimized for Efficiency and IM Performance

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
54	6.50 + j7.96	1.27 + j1.54

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given power, voltage and frequency.

Table 3. Common Source Scattering Parameters
(V_{DS} = 12.5 Vdc)

I_D = 100 mA

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
1	0.98	−32	39.6	161	0.013	71	0.32	−80
2	0.92	−60	34.6	145	0.023	56	0.50	−108
5	0.81	−110	21.3	118	0.035	29	0.75	−143
10	0.76	−140	11.9	102	0.039	14	0.83	−160
20	0.74	−158	6.08	90	0.040	4	0.86	−169
30	0.75	−163	4.03	82	0.039	−2	0.87	−173
40	0.75	−166	2.98	77	0.038	−5	0.87	−174
50	0.76	−167	2.35	72	0.037	−8	0.88	−175
60	0.78	−168	1.91	67	0.036	−10	0.89	−176
70	0.79	−168	1.60	63	0.034	−12	0.89	−176
80	0.80	−169	1.36	59	0.032	−13	0.90	−177
90	0.81	−169	1.18	56	0.031	−14	0.90	−177
100	0.82	−169	1.03	52	0.029	−15	0.91	−177
120	0.85	−170	0.81	46	0.025	−14	0.92	−178
140	0.87	−171	0.65	41	0.022	−11	0.93	−179
160	0.88	−172	0.54	37	0.019	−6	0.94	180
180	0.90	−173	0.45	33	0.017	2	0.95	179
200	0.91	−174	0.38	30	0.016	12	0.95	178
220	0.92	−175	0.33	27	0.016	23	0.96	177
240	0.93	−176	0.29	25	0.016	34	0.96	176
260	0.94	−177	0.25	23	0.018	44	0.97	175

I_D = 400 mA

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
1	0.98	−46	56.6	155	0.008	66	0.45	−148
2	0.95	−80	46.1	137	0.013	48	0.64	−151
5	0.90	−129	25.1	113	0.017	25	0.84	−164
10	0.88	−153	13.4	100	0.019	14	0.89	−172
20	0.88	−167	6.82	91	0.019	10	0.91	−176
30	0.88	−171	4.55	87	0.019	9	0.91	−178
40	0.88	−173	3.41	83	0.019	10	0.91	−178
50	0.88	−175	2.72	80	0.019	11	0.91	−179
60	0.88	−176	2.25	78	0.019	12	0.91	−179
70	0.88	−176	1.92	75	0.019	14	0.92	−180
80	0.88	−177	1.67	72	0.019	16	0.92	180
90	0.89	−177	1.47	70	0.019	18	0.92	179
100	0.89	−178	1.31	68	0.019	20	0.92	179
120	0.89	−178	1.08	63	0.019	24	0.92	179
140	0.89	−179	0.90	59	0.019	29	0.93	178
160	0.90	−179	0.77	55	0.020	34	0.93	177
180	0.90	−180	0.67	52	0.021	38	0.93	177
200	0.91	180	0.59	48	0.022	43	0.94	176
220	0.91	179	0.53	45	0.023	47	0.94	175
240	0.91	179	0.47	42	0.025	50	0.95	175
260	0.92	178	0.43	40	0.026	53	0.95	174

Table 2. Common Source Scattering Parameters (continued)
(V_{DS} = 12.5 Vdc)

I_D = 1 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$|S_{11}|$	∠ ϕ	$|S_{21}|$	∠ ϕ	$|S_{12}|$	∠ϕ	$|S_{22}|$	∠ ϕ
1	0.98	−54	65.5	152	0.006	63	0.60	−162
2	0.96	−91	50.9	133	0.009	44	0.75	−163
5	0.93	−137	26.2	110	0.011	23	0.88	−170
10	0.93	−158	13.7	99	0.012	15	0.91	−175
20	0.92	−169	6.96	92	0.012	15	0.92	−178
30	0.92	−173	4.65	89	0.012	18	0.93	−179
40	0.92	−175	3.49	86	0.013	21	0.93	−180
50	0.92	−176	2.79	84	0.013	25	0.93	180
60	0.92	−177	2.32	82	0.013	28	0.93	179
70	0.92	−178	1.99	80	0.014	31	0.93	179
80	0.92	−179	1.74	78	0.014	34	0.93	179
90	0.92	−179	1.54	76	0.015	37	0.93	178
100	0.92	−180	1.39	74	0.016	40	0.93	178
120	0.92	180	1.15	71	0.017	44	0.93	177
140	0.92	179	0.98	68	0.019	48	0.93	177
160	0.92	178	0.86	65	0.020	51	0.93	176
180	0.92	178	0.76	62	0.022	54	0.93	176
200	0.92	177	0.68	59	0.024	56	0.94	175
220	0.92	177	0.61	56	0.026	58	0.94	175
240	0.92	176	0.56	53	0.028	59	0.94	174
260	0.92	176	0.51	51	0.030	61	0.94	173

DESIGN CONSIDERATIONS

The MRF255 is a common–surce, RF power, N–channel enhancement mode Metal–Oxide Semiconductor Field–Effect Transistor (MOSFET). Motorola RF MOSFETs feature a vertical structure with a planar design.

Motorola Application Note AN211A, FETs in Theory and Practice, is suggested reading for those not familiar with the construction and characteristics of FETs.

This device was designed primarily for HF 12.5 V mobile linear power amplifier applications. The major advantages of RF power MOSFETs include high gain, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage.

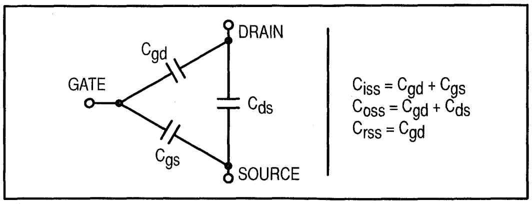
MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between all three terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate.

In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



DRAIN CHARACTERISTICS

One critical figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $R_{DS(on)}$, occurs in the linear region of the output characteristic and is specified at a specific gate–source voltage and drain current. The drain–source voltage under these conditions is termed $V_{DS(on)}$. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient at high temperatures because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage to the gate greater than the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

Using a resistor to keep the gate–to–source impedance low also helps damp transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

DC BIAS

Since the MRF255 is an enhancement mode FET, drain current flows only when the gate is at a higher potential than the source. See Figure 8 for a typial plot of drain current versus gate voltage. RF power FETs operate optimally with a quiescent drain current (I_{DQ}), whose value is application dependent. The MRF255 was characterized for linear and CW operation at I_{DQ} = 400 mA, which is the suggested value of bias current for typical applications.

The gate is a dc open circuit and draws essentially no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some applications may require a more elaborate bias sytem.

GAIN CONTROL

For CW applications, power output of the MRF255 may be controlled to some degree with a low power dc control signal applied to the gate, thus facilitating applications such as manual gain control, AGC/ALC and modulation systems. The characteristic is very dependent on frequency and load line.

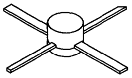
The RF Line
NPN Silicon High-Frequency Transistor

MRF313

. . . designed for wideband amplifier, driver or oscillator applications in military, mobile, and aircraft radio.

- Specified 28 Volt, 400 MHz Characteristics —
  Output Power = 1.0 Watt
  Power Gain = 15 dB Min
  Efficiency = 45% Typ
- Emitter Ballast and Low Current Density for Improved MTBF
- Common Emitter for Improved Stability

1.0 W, 400 MHz
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON



CASE 305A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	40	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.1 35	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	28.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

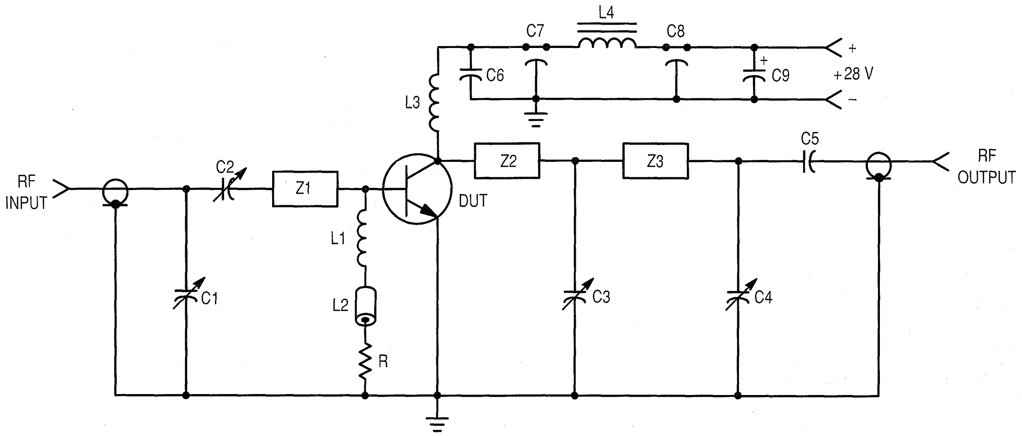
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	35	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	$V_{(BR)CBO}$	35	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	—	—	1.0	mAdc

(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	60	150	—
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	—	2.5	—	GHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.5	5.0	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (1) (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	G_{pe}	15	16	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	η	—	45	—	%
Series Equivalent Input Impedance (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	Z_{in}	—	6.4 – j4.8	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 28 Vdc, P_{out} = 1.0 W, f = 400 MHz)	Z_{out}	—	75 – j45	—	Ohms

NOTE:
1. Class C



C1, C2, C4 — 1.0–20 pF JOHANSON 9063
C3 — 1.0–10 pF JOHANSON
C5 — 150 pF Chip
C6 — 0.1 µF
C7, C8 — 680 pF Feedthru
C9 — 1.0 µF TANTALUM

L1, L3 — 5 Turns, AWG #20, 1/4″ I.D.
L2 — Ferrite Bead, FERROXCUBE No. 56–590–65/4B
L4 — FERROXCUBE VK200–20/4B
Input/Output Connectors — Type N
Board — Glass Teflon, ε = 2.56, t = 0.062″

R — 4.7 Ohms, 1/4 W
Z1 — 2.0″ x 0.1″ MICROSTRIP LINE
Z2, Z3 — 2.6″ x 0.1″ MICROSTRIP LINE

Figure 1. 400 MHz Power Gain Test Circuit

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

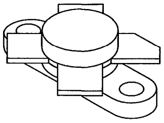
The RF Line
NPN Silicon RF Power Transistors

MRF314

. . . designed primarily for wideband large–signal driver and output amplifier stages in the 30–200 MHz frequency range.

- Guaranteed Performance at 150 MHz, 28 Vdc
  Output Power = 30 Watts
  Minimum Gain = 10 dB
- 100% Tested for Load Mismatch at All Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability Applications

30 W, 30–200 MHz
RF POWER
TRANSISTORS
NPN SILICON



CASE 211–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	35	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	3.4	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	82 0.47	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.13	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

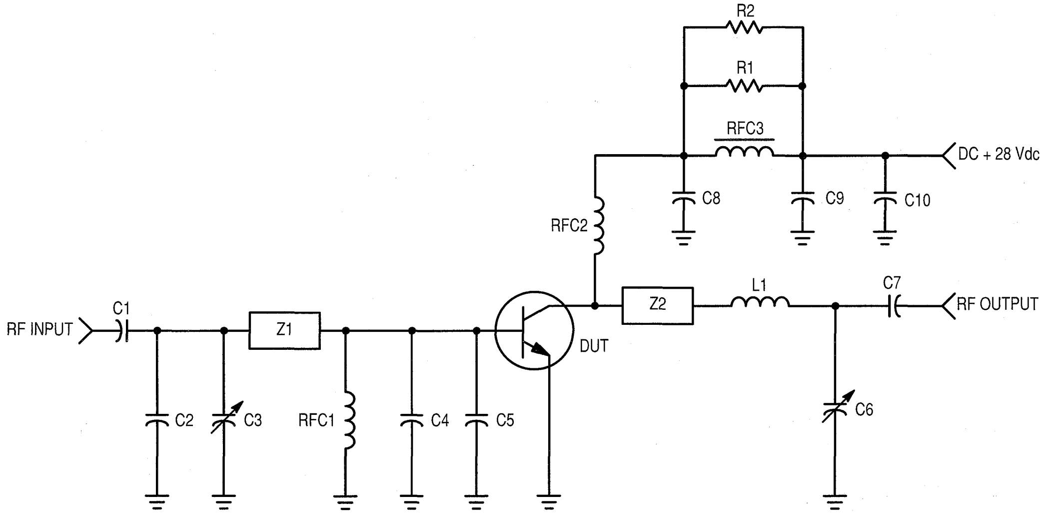
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 30 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 30 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 3.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	3.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	80	—

(continued)

NOTE:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	30	40	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 150 MHz)	G_{PE}	10	13.5	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 150 MHz)	η	50	—	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 150 MHz, VSWR = 30:1 all phase angles)	ψ	No Degradation in Power Output			



C1, C7 — 18 pF, 100 mil ATC
C2 — 68 pF, 100 mil ATC
C3, C6 — Johanson #JMC 5501
C4 — 270 pF, 100 mil ATC
C5 — 240 pF, 100 mil ATC
C8, C9 — 100 pF Underwood
C10 — 1.0 μF Tantalum
L1 — 2 Turns, 2.5″ #20 Wire, ID = 0.275″

R1, R2 — 10 Ω, 1.0 W
RFC1 — 15 μH Molded Coil
RFC2 — 2 Turns, 2.5″ #20 Wire, ID = 0.2″
RFC3 — Ferroxcube VK200–19/4B
Z1 — Microstrip, 0.168″ W x 1.6″ L
Z2 — Microstrip, 0.168″ W x 1.2″ L
Board — Glass Teflon ε_r = 2.55

Figure 1. 150 MHz Test Circuit

TYPICAL PERFORMANCE CURVES

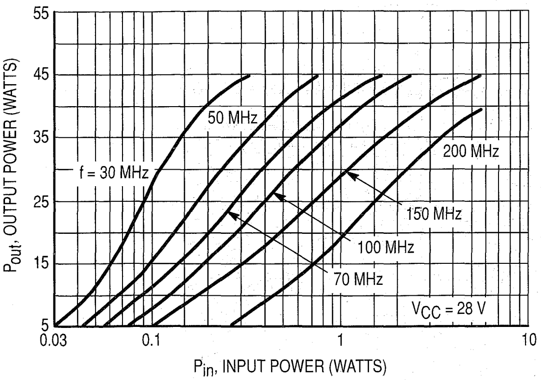


Figure 2. Output Power versus Input Power

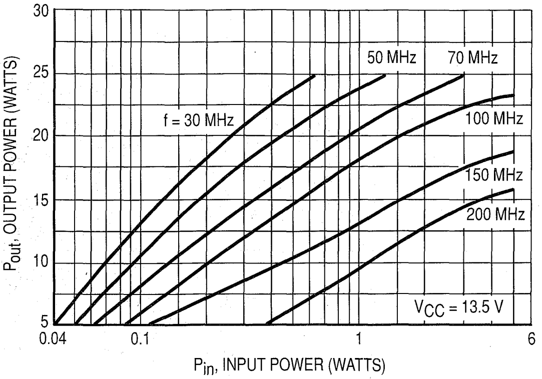


Figure 3. Output Power versus Input Power

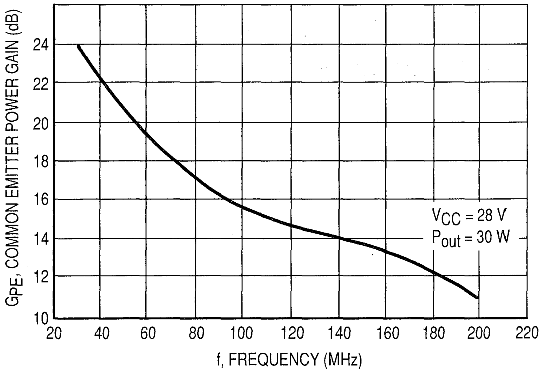


Figure 4. Power Gain versus Frequency

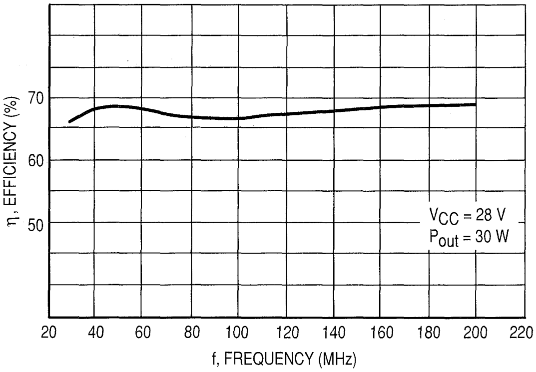
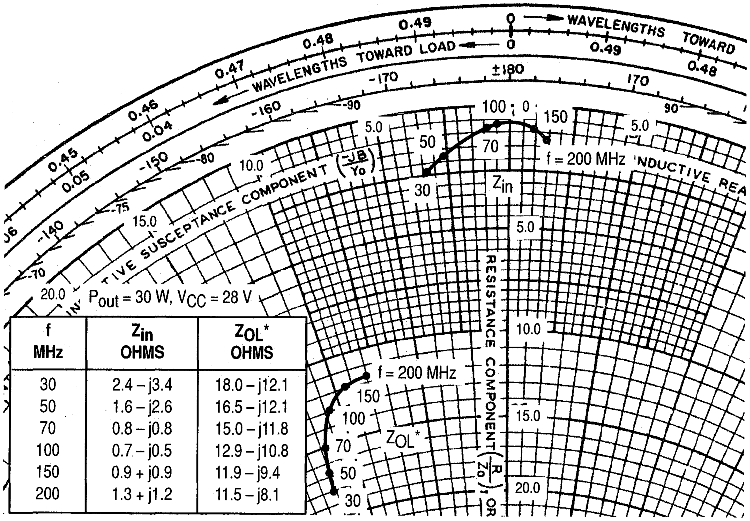


Figure 5. Efficiency versus Frequency



P_{out} = 30 W, V_{CC} = 28 V

f MHz	Z_{in} OHMS	Z_{OL}* OHMS
30	2.4 – j3.4	18.0 – j12.1
50	1.6 – j2.6	16.5 – j12.1
70	0.8 – j0.8	15.0 – j11.8
100	0.7 – j0.5	12.9 – j10.8
150	0.9 + j0.9	11.9 – j9.4
200	1.3 + j1.2	11.5 – j8.1

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input/Output Impedance

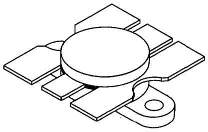
The RF Line
NPN Silicon RF Power Transistor

MRF316

. . . designed primarily for wideband large–signal output amplifier stages in the 30–200 MHz frequency range.

- Guaranteed Performance at 150 MHz, 28 Vdc
  Output Power = 80 Watts
  Minimum Gain = 10 dB
- Built–In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability Applications

80 W, 3.0–200 MHz
CONTROLLED “Q”
BROADBAND RF POWER
TRANSISTOR
NPN SILICON



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	35	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous Peak	I_C	9.0 13.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	220 1.26	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	130	200	pF

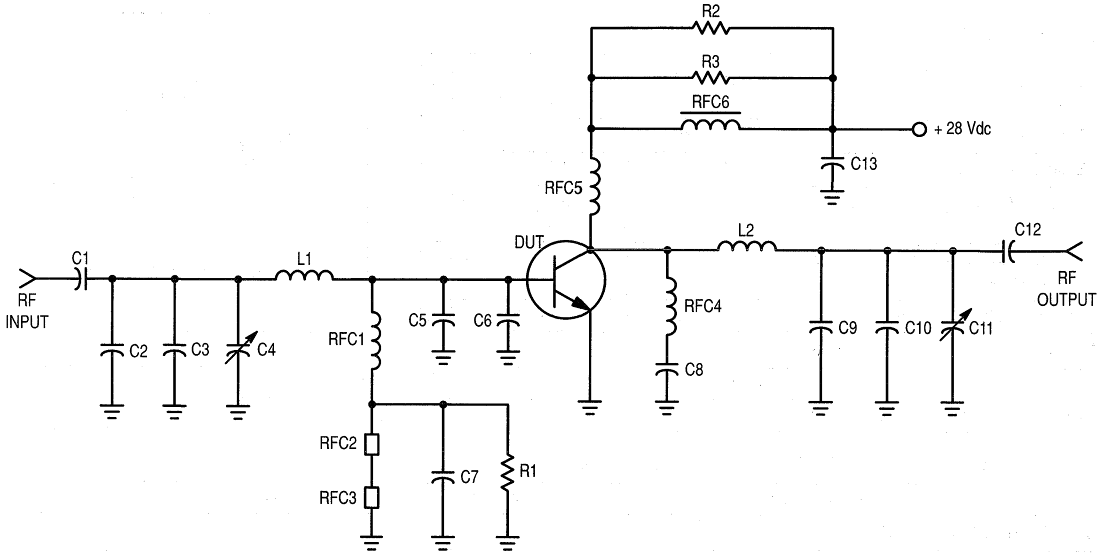
(continued)

NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
NARROW BAND FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 80 W, f = 150 MHz)	G_{PE}	10	13	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 80 W, f = 150 MHz)	η	55	—	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 80 W CW, f = 150 MHz, VSWR = 30:1 all phase angles)	ψ	No Degradation in Output Power			



C1 — 22 pF 100 mil ATC
C2, C3 — 24 pF 100 mil ATC
C4, C11 — 0.8–20 pF JMC #5501 Johanson
C5 — 200 pF 100 mil ATC
C6 — 240 pF 100 mil ATC
C7 — Dipped Mica 1000 pF
C8 — 0.1 µF Erie Red Cap
C9, C10, C12 — 30 pF 100 mil ATC
C13 — 1.0 µF Tantalum

L1 — 0.8″, #20 Wire
L2 — 1.0″, #20 Wire

RFC1, RFC4 — 0.15 µH Molded Coil
RFC2, RFC3 — Ferroxcube Bead 56–590–65–3B
RFC5 — 2.5″, #20 Wire, 1.5 Turns
RFC6 — Ferroxcube VK200–19/4B

R1 — 10 Ω, 1/2 W
R2, R3 — 10 Ω, 1.0 W

Figure 1. 150 MHz Test Amplifier

TYPICAL PERFORMANCE CURVES

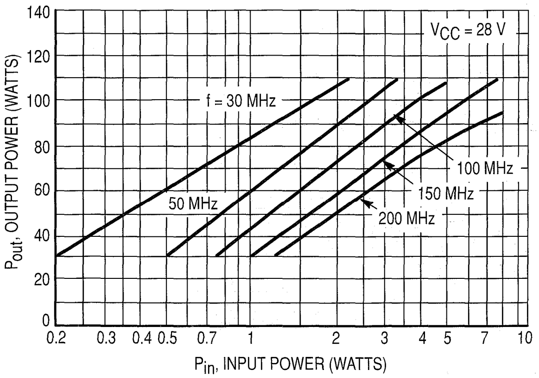


Figure 2. Output Power versus Input Power

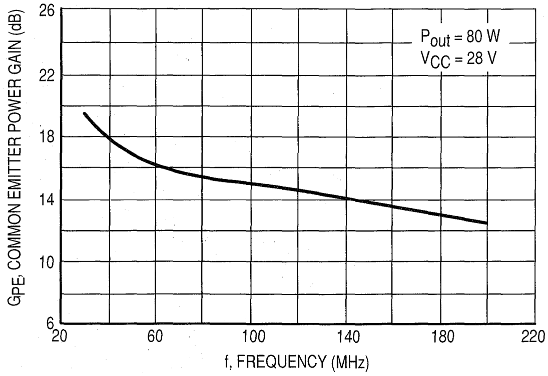


Figure 3. Power Gain versus Frequency

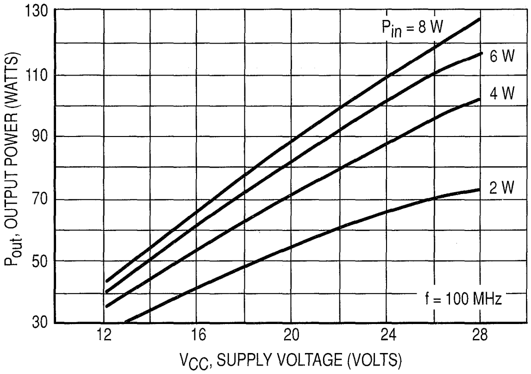


Figure 4. Output Power versus Supply Voltage

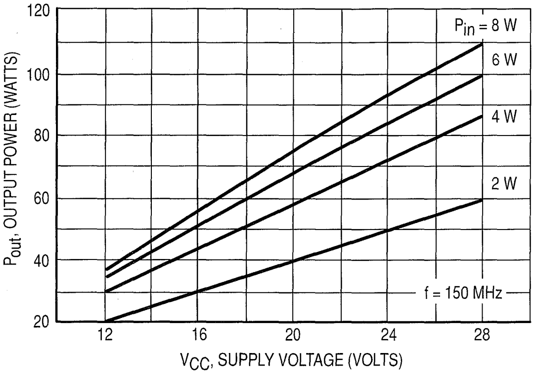


Figure 5. Output Power versus Supply Voltage

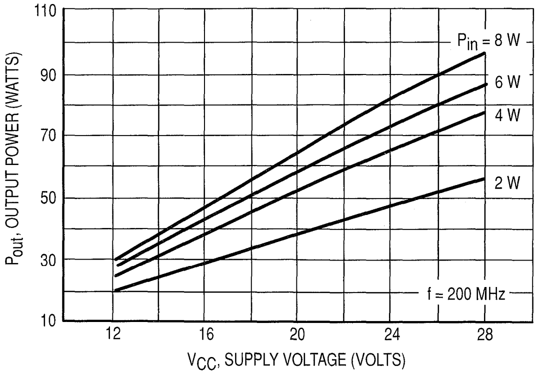
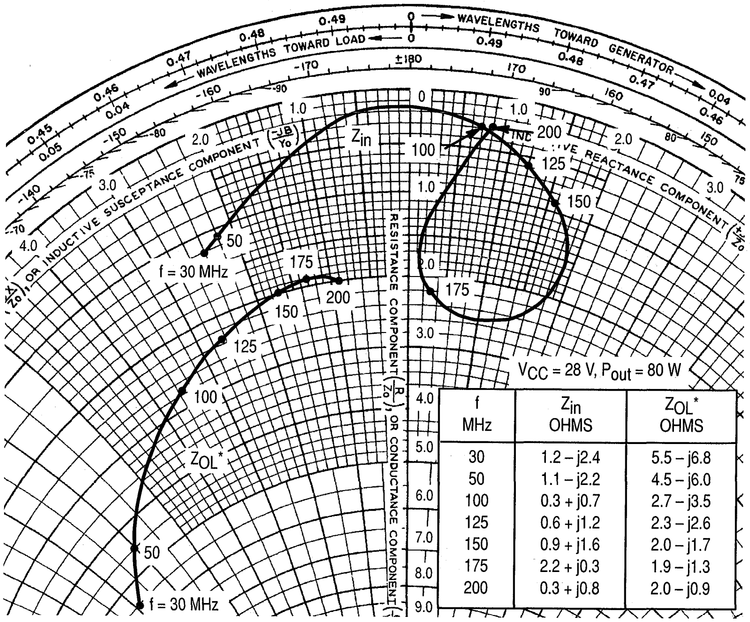


Figure 6. Output Power versus Supply Voltage



V_{CC} = 28 V, P_{out} = 80 W

f MHz	Z_{in} OHMS	Z_{OL}* OHMS
30	1.2 – j2.4	5.5 – j6.8
50	1.1 – j2.2	4.5 – j6.0
100	0.3 + j0.7	2.7 – j3.5
125	0.6 + j1.2	2.3 – j2.6
150	0.9 + j1.6	2.0 – j1.7
175	2.2 + j0.3	1.9 – j1.3
200	0.3 + j0.8	2.0 – j0.9

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 7. Series Equivalent Input–Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

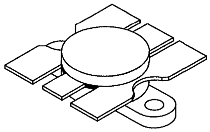
The RF Line
NPN Silicon RF Power Transistor

MRF317

100 W, 30–200 MHz
CONTROLLED Q
BROADBAND RF POWER
TRANSISTOR
NPN SILICON

. . . designed primarily for wideband large–signal output amplifier stages in 30–200 MHz frequency range.

- Guaranteed Performance at 150 MHz, 28 Vdc
  Output Power = 100 W
  Minimum Gain = 9.0 dB
- Built–In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability
- High Output Saturation Power — Ideally Suited for 30 W Carrier/120 W Peak AM Amplifier Service
- Guaranteed Performance in Broadband Test Fixture



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	35	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak (10 seconds)	I_C	12 18	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	25	80	—

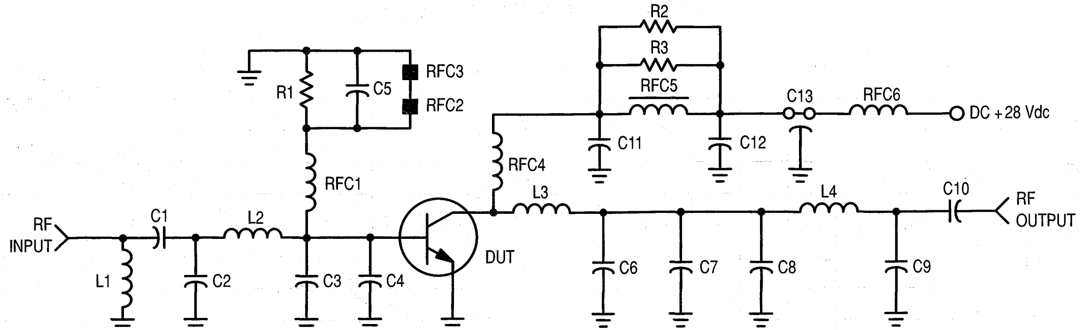
NOTE:
(continued)

1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	200	250	pF
FUNCTIONAL TESTS (Figure 2)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 150 MHz, I_C (Max) = 6.5 Adc)	G_{PE}	9.0	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 150 MHz, I_C (Max) = 6.5 Adc)	η	55	60	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 100 W CW, f = 150 MHz, VSWR = 30:1 all phase angles)	ψ	No Degradation in Output Power			



C1, C9 — 39 pF, 100 mil ATC
C2 — 120 pF, 100 mil ATC
C3, C4 — 360 pF, 100 mil ATC
C5 — 1000 pF Dipped Mica
C6, C7 — 100 pF, 100 mil ATC*
C8 — 18 pF, 100 mil ATC*
C10 — 43 pF, 100 mil ATC

C11 — 60 pF, Underwood
C12 — 0.1 μF Erie Redcap
C13 — 1000 pF, Underwood J102
L1 — 50 nH
L2 — 6.0 nH
L3 — 8.0 nH
L4 — 32 nH

RFC1 — 0.15 μH Molded Coil
RFC2, RFC3 — Ferroxcube Bead 56–590–65/3B
RFC4 — 1 Turn, #18 Wire, 2.0″ L
RFC5 — Ferroxcube VK200 19/4B
RFC6 — 7 Turns, #18 Wire, 0.3″ ID
R1 — 10 Ω 1/2 W
R2, R3 — 10 Ω 1.0 W
*Combination of C6, C7, C8 equals 220 pF.

Figure 1. 110–160 MHz Broadband Amplifier — Test Fixture Schematic

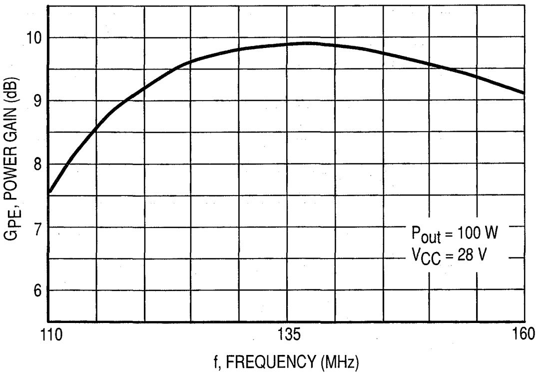


Figure 2. Power Gain versus Frequency Broadband Test Fixture

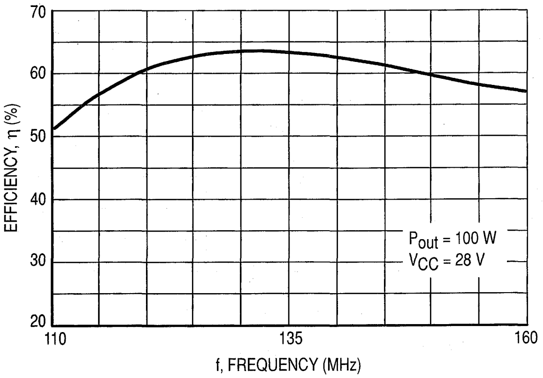


Figure 3. Efficiency versus Frequency Broadband Test Fixture

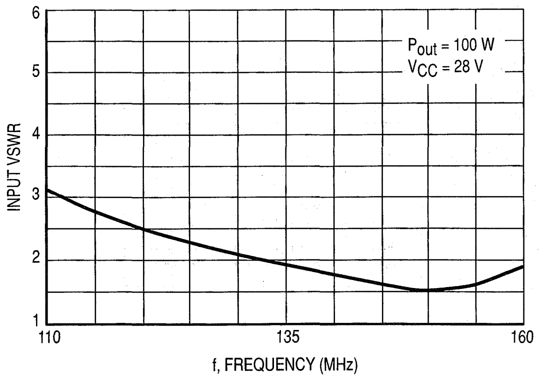


Figure 4. Input VSWR versus Frequency Broadband Test Fixture

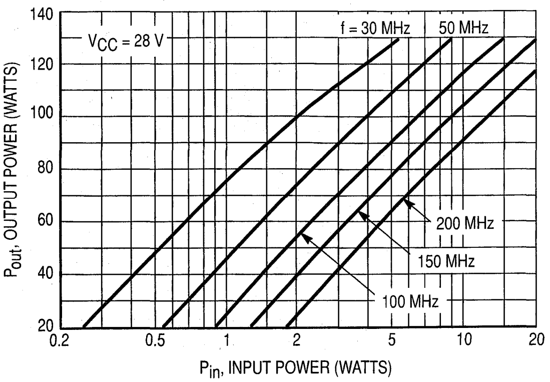


Figure 5. Output Power versus Input Power

TYPICAL PERFORMANCE CURVES

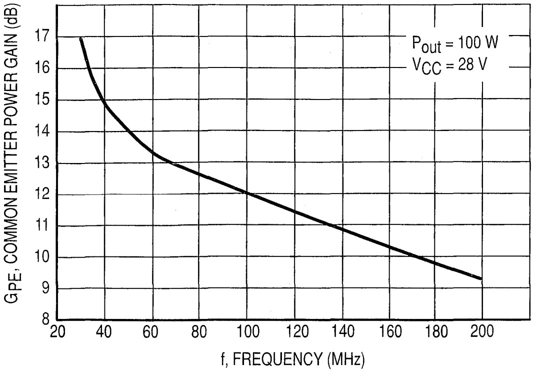


Figure 6. Power Gain versus Frequency

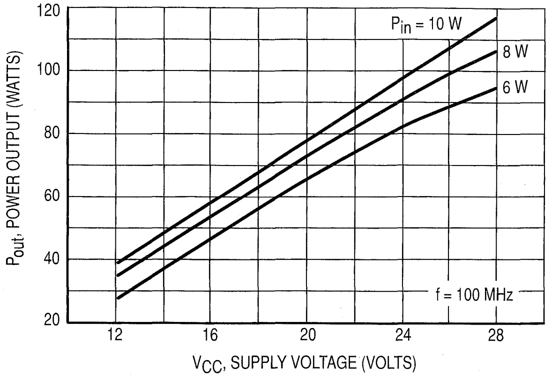


Figure 7. Power Output versus Supply Voltage

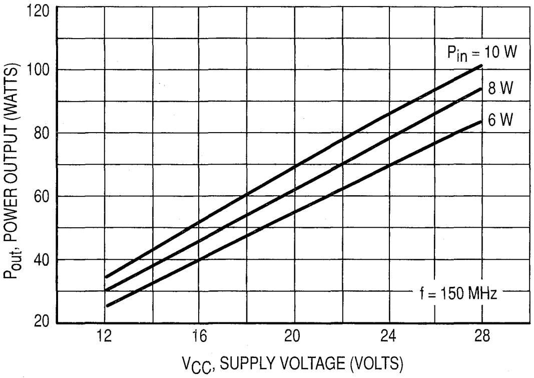


Figure 8. Power Output versus Supply Voltage

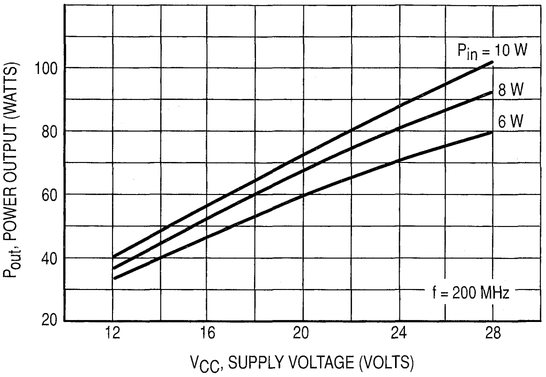
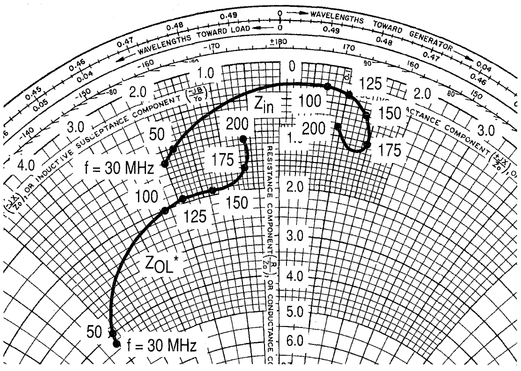


Figure 9. Power Output versus Supply Voltage



V_{CC} = 28 V, P_{out} = 100 W

f MHz	Z_{in} OHMS	Z_{OL}* OHMS
30	1.2 – j2.0	4.3 – j5.0
50	1.0 – j1.8	4.0 – j4.9
100	0.3 + j0.7	2.0 – j2.3
125	0.3 + j1.0	1.9 – j1.9
150	0.6 + j1.3	1.9 – j1.3
175	1.0 + j1.5	1.6 – j0.6
200	0.9 + j1.0	1.1 – j0.6

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 10. Series Equivalent Input–Output Impedance

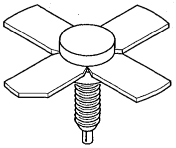
The RF Line
NPN Silicon
RF Power Transistor

MRF321

10 W, 400 MHz
RF POWER
TRANSISTOR
NPN SILICON

. . . designed primarily for wideband large–signal driver and predriver amplifier stages in 200–500 MHz frequency range.

- Guaranteed Performance at 400 MHz, 28 Vdc
  Output Power = 10 Watts
  Power Gain = 12 dB Min
  Efficiency = 50% Min
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability
- Computer–Controlled Wirebonding Gives Consistent Input Impedance



CASE 244–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	33	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	1.1 1.5	Adc
Total Device Dissipation @ $T_A = 25°C$ (1) Derate above 25°C	P_D	27 160	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	6.4	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

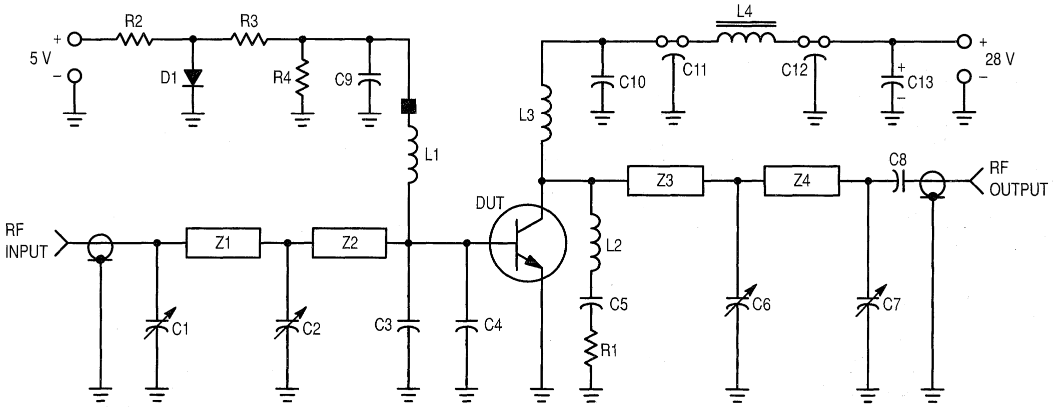
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 20$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	33	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 20$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	60	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 20$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 2.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 500$ mA, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	—	80	—

NOTE:
(continued)

1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	10	12	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz)	G_{PE}	12	13	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz)	η	50	60	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz, VSWR = 30:1 all phase angles)	ψ	No Degradation in Output Power			



C1, C2, C3 — 1.0–20 pF Johanson Trimmer (JMC 5501)
C3, C4 — 47 pF ATC Chip Capacitor
C5, C10 — 0.1 µF Erie Redcap
C7 — 0.5–10 pF Johanson Trimmer (JMC 5201)
C8 — 0.018 µF Vitramon Chip Capacitor
C9 — 200 pF UNELCO Capacitor
C11, C12 — 680 pF Feedthru
C13 — 1.0 µF, 50 Volt Tantalum Capacitor
D1 — 1N4001
L1 — 0.33 µH Molded Choke with Ferroxcube Bead (Ferroxcube 56–590–65/4B) on Ground End of Coil
L2 — 4 Turns #20 Enamel, 1/8″ ID

L3 — 6 Turns #20 Enamel, 1/4″ ID
L4 — Ferroxcube VK200–19/4B
R1 — 5.1 Ω, 1/4 Watt
R2 — 120 Ω, 1.0 Watt
R3 — 20 Ω, 1/2 Watt
R4 — 47 Ω, 1/2 Watt
Z1 — Microstrip 0.1″ W x 1.35″ L
Z2 — Microstrip 0.1″ W x 0.55″ L
Z3 — Microstrip 0.1″ W x 0.8″ L
Z4 — Microstrip 0.1″ W x 1.75″ L
Board — Glass Teflon, ε_R = 2.56, t = 0.062″
Input/Output Connectors — Type N

Figure 1. 400 MHz Test Circuit Schematic

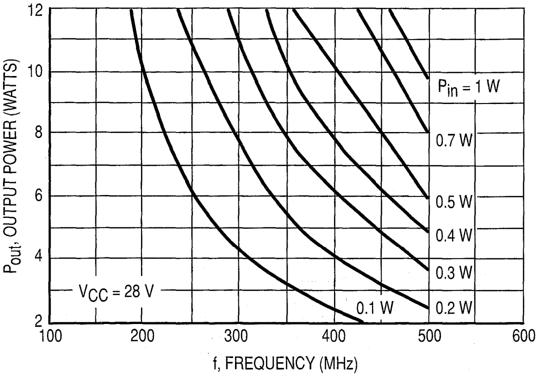


Figure 2. Output Power versus Frequency

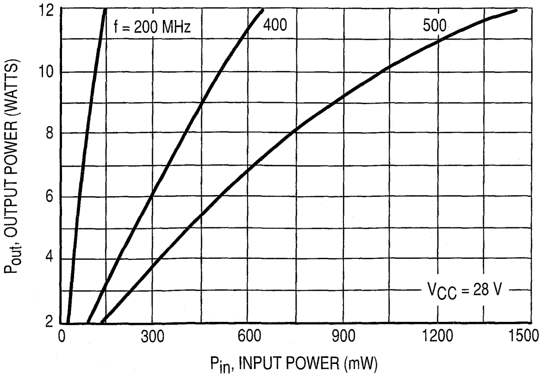


Figure 3. Output Power versus Input Power

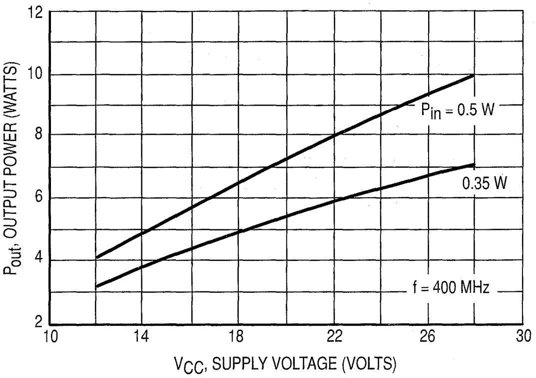


Figure 4. Output Power versus Supply Voltage

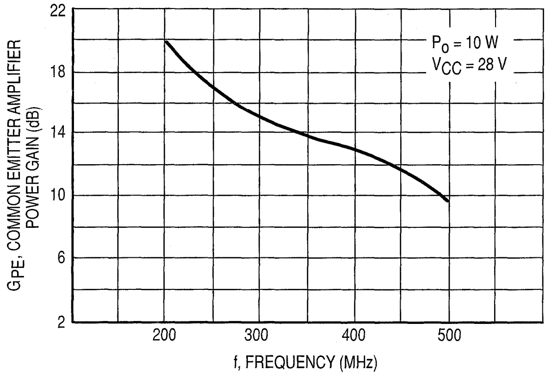
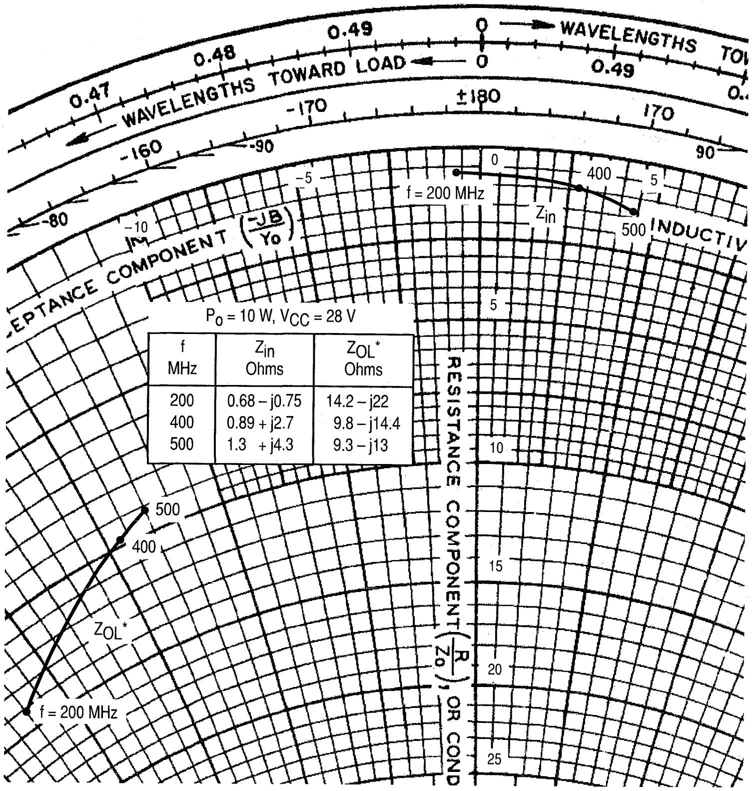


Figure 5. Power Gain versus Frequency



P_o = 10 W, V_{CC} = 28 V

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
200	0.68 – j0.75	14.2 – j22
400	0.89 + j2.7	9.8 – j14.4
500	1.3 + j4.3	9.3 – j13

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Impedance

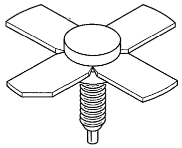
The RF Line
NPN Silicon RF Power Transistor

MRF323

. . . designed primarily for wideband large–signal driver and predriver amplifier stages in the 200–500 MHz frequency range.

- Guaranteed Performance at 400 MHz, 28 V
  Output Power = 20 Watts
  Power Gain = 10 dB Min
  Efficiency = 50% Min
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability
- Computer–Controlled Wirebonding Gives Consistent Input Impedance

**20 W, 400 MHz
RF POWER
TRANSISTOR
NPN SILICON**



CASE 244–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	33	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	2.2 3.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	55 310	Watts mW/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.2	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

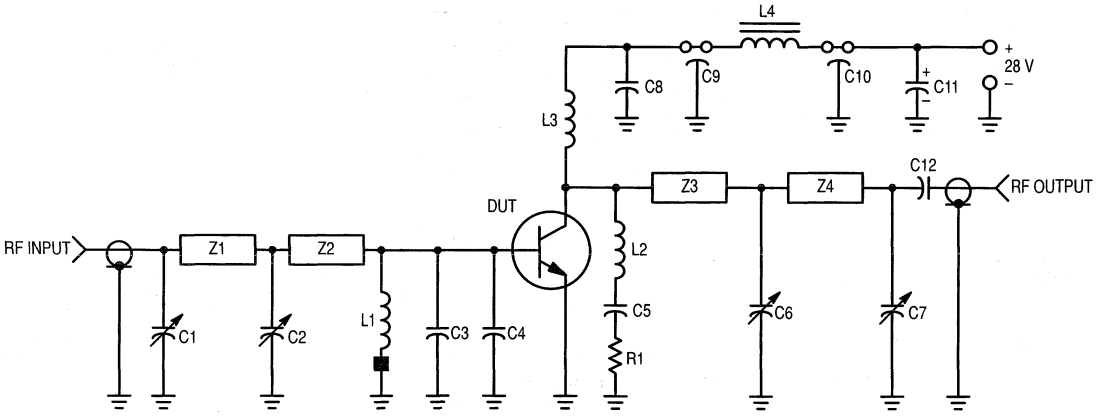
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	33	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 20 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	80	—

(continued)

NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	20	24	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 20 W, f = 400 MHz)	G_{PE}	10	11	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 20 W, f = 400 MHz)	η	50	60	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 20 W, f = 400 MHz, VSWR = 30:1 all phase angles)	ψ	No Degradation in Output Power			



C1, C2, C6 — 1.0–20 pF Johanson Trimmer (JMC 5501)
C3, C4 — 47 pF ATC Chip Capacitor
C5, C8 — 0.1 µF Erie Redcap
C7 — 0.5–10 pF Johanson Trimmer (JMC 5201)
C9, C10 — 680 pF Feedthru
C11 — 1.0 µF 50 Volt Tantalum
C12 — 0.018 µF Vitramon Chip Capacitor
L1 — 0.33 µH Molded Choke with Ferroxcube Bead
(Ferroxcube 56–590–65/4B) on Ground End

L2 — 6 Turns #20 Enamel, 1/4″ ID, Closewound
L3 — 4 Turns #20 Enamel, 1/8″ ID, Closewound
L4 — Ferroxcube VK200–19/4B
R1 — 5.1 Ω 1/4 Watt
Z1 — Microstrip 0.1″ W x 1.35″ L
Z2 — Microstrip 0.1″ W x 0.55″ L
Z3 — Microstrip 0.1″ W x 0.8″ L
Z4 — Microstrip 0.1″ W x 1.75″ L
Board — Glass Teflon ε_r = 2.56, t = 0.062″
Input/Output Connectors — Type N

Figure 1. 400 MHz Test Circuit Schematic

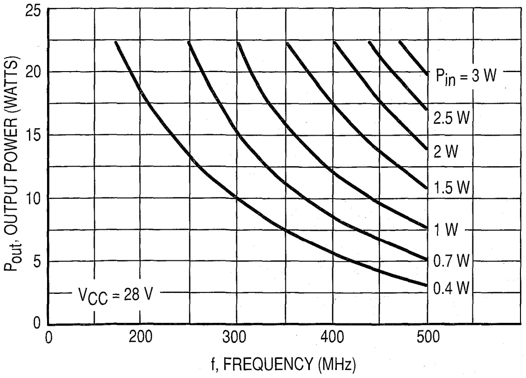


Figure 2. Output Power versus Frequency

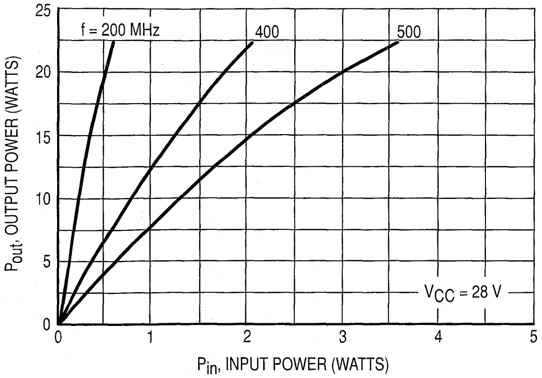


Figure 3. Output Power versus Input Power

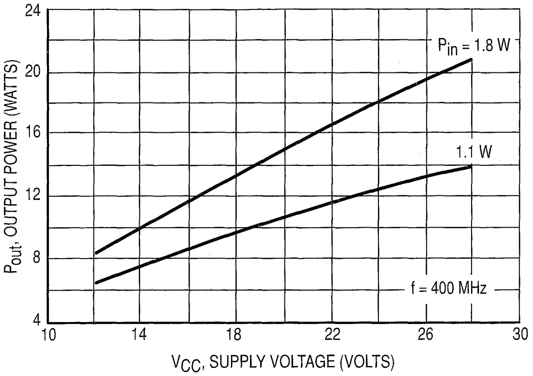


Figure 4. Output Power versus Supply Voltage

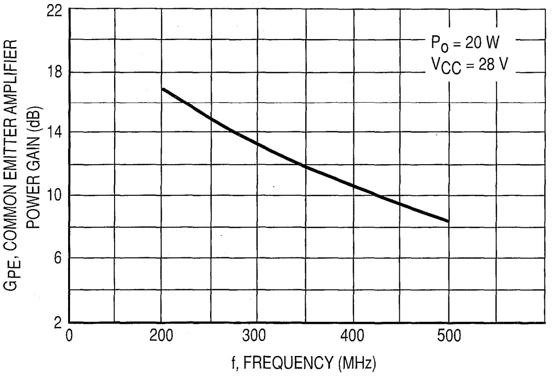
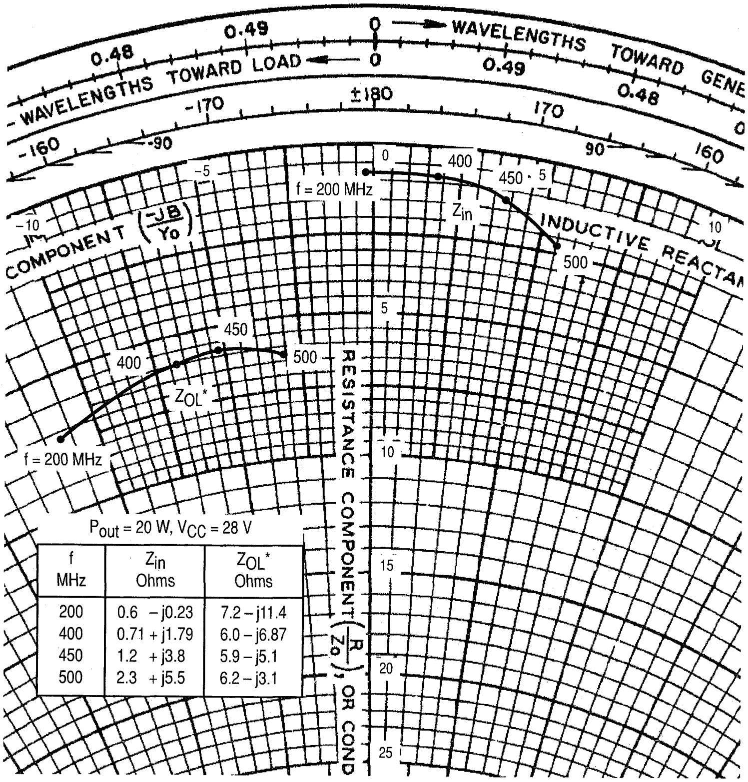


Figure 5. Power Gain versus Frequency



P_{out} = 20 W, V_{CC} = 28 V

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
200	0.6 – j0.23	7.2 – j11.4
400	0.71 + j1.79	6.0 – j6.87
450	1.2 + j3.8	5.9 – j5.1
500	2.3 + j5.5	6.2 – j3.1

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Impedance

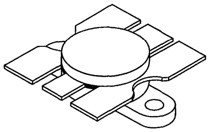
The RF Line
NPN Silicon RF Power Transistor

MRF325

**30 W, 225 to 400 MHz
CONTROLLED "Q"
BROADBAND RF POWER
TRANSISTOR
NPN SILICON**

. . . designed primarily for wideband large–signal output and driver amplifier stages in 100 to 500 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics —
  Output Power = 30 Watts
  Minimum Gain = 8.5 dB
  Efficiency = 54% (Min)
- Built–In Matching Network for Broadband Operation Using Internal Matching Techniques
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization for High Reliability Applications



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	33	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	3.4 4.5	Adc
Total Device Dissipation @ $T_C = 25°C$ (1) Derate above 25°C	P_D	82 0.47	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.13	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

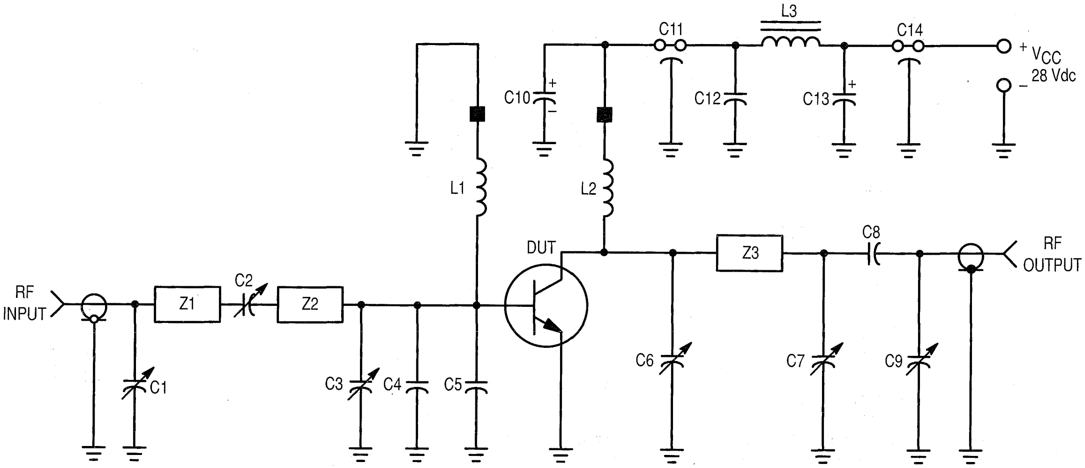
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 30$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	33	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 30$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 3.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 30$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	3.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.5$ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	—	80	—

NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	30	40	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz)	G_{PE}	8.5	9.5	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz)	η	50	60	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz, VSWR = 30:1 all angles)	ψ	No Degradation in Output Power			



C1, C9 — 1.0–10 pF Johanson Capacitor (JMC 5201)
C2, C3, C6, C7 — 1.0–20 pF Johanson Capacitor (JMC 5501)
C4, C5 — 36 pF ATC 100–mil Chip Capacitor
C8 — 100 pF UNELCO
C10, C13 — 1.0 µF 50 V Tantalum
C11, C14 — 680 pF Feedthru
C12 — 0.1 µF Erie Redcap
L1 — 8 Turns #26 AWG Enameled, 1/16″ ID Closewound with Ferroxcube Bead (#56–590–65/4B) on Ground End
L2 — 14 Turns, #22 AWG Enameled, Closewound on a 470 Ω, 2.0 Watt Resistor with Ferroxcube Bead (#56–590–65/4B) on Cold End of L2
L3 — Ferroxcube VK200–19/4B Ferrite Choke
Z1 — Microstrip 0.19″ W x 0.88″ L
Z2 — Microstrip 0.28″ W x 1.0″ L
Z3 — Microstrip 0.31″ W x 1.25″ L
Board — Glass Teflon ε_r = 2.56, t = 0.062″
Input/Output Connectors — Type N
DUT Socket Lead Frame Etched from 80–mil–Thick Copper

Figure 1. 400 MHz Test Circuit

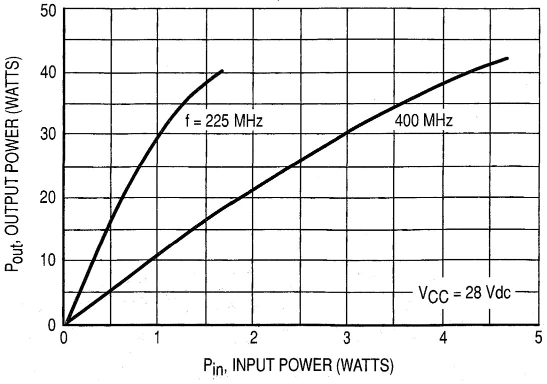


Figure 2. Output Power versus Input Power

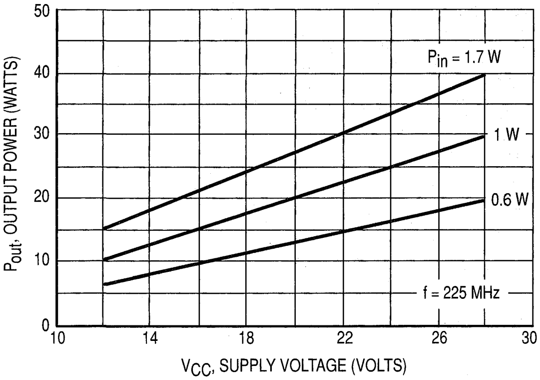


Figure 3. Output Power versus Supply Voltage

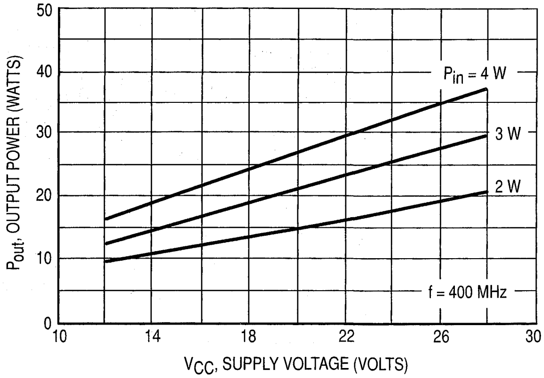
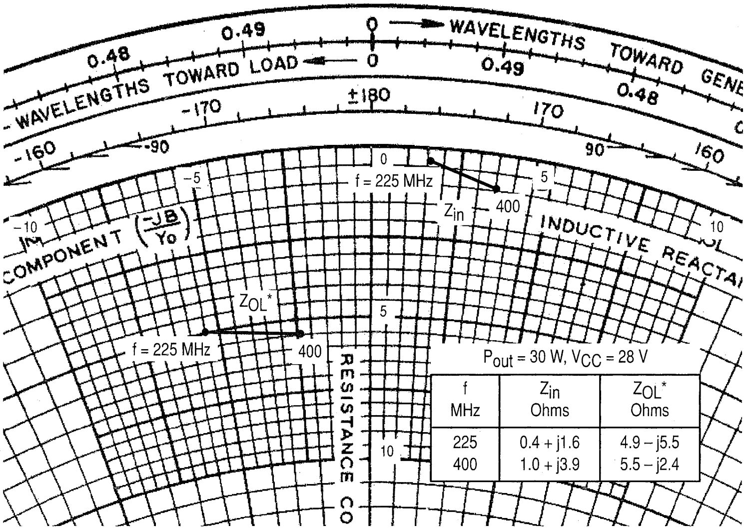


Figure 4. Output Power versus Supply Voltage



P_{out} = 30 W, V_{CC} = 28 V

f MHz	Z_{in} Ohms	$Z_{OL}{}^*$ Ohms
225	0.4 + j1.6	4.9 – j5.5
400	1.0 + j3.9	5.5 – j2.4

$Z_{OL}{}^*$ = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Impedance

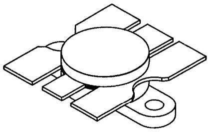
The RF Line
NPN Silicon RF Power Transistor

MRF326

. . . designed primarily for wideband large–signal output amplifier stages in the 100 to 500 MHz frequency range.

- Guaranteed Performance @ 400 MHz, 28 Vdc
  Output Power = 40 Watts
  Minimum Gain = 9.0 dB
- Built–In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability Applications

40 W, 225 to 400 MHz
CONTROLLED “Q”
BROADBAND RF POWER
TRANSISTOR
NPN SILICON



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	33	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	4.5 6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	110 0.63	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.6	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

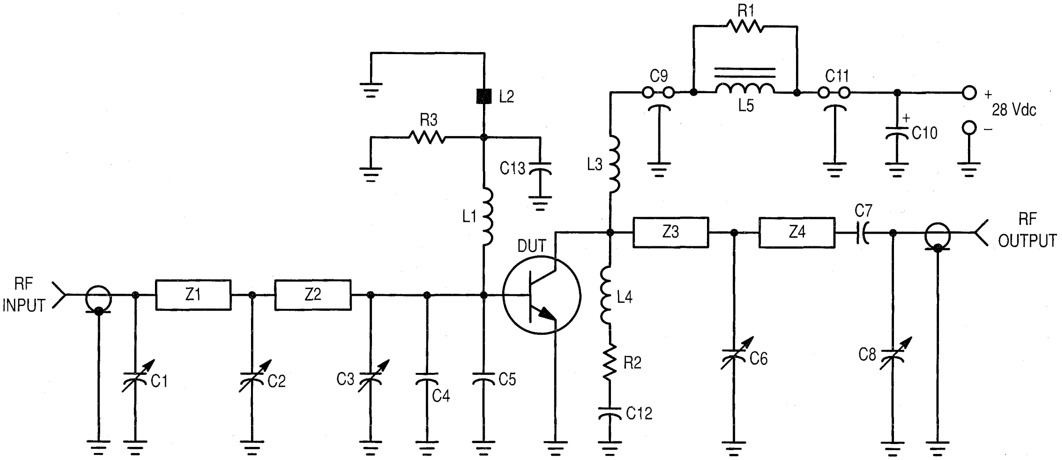
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 40 mAdc, I_B = 0)	$V_{(BR)CEO}$	33	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 40 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 4.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 40 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	4.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	50	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	45	60	pF

(continued)

NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 40 W, f = 400 MHz, I_C Max = 2.85 Adc)	G_{PE}	9.0	11	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 40 W, f = 400 MHz, I_C Max = 2.85 Adc)	η	50	—	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 40 W CW, f = 400 MHz, VSWR = 30:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 1.0–10 pF Johanson, Capacitor (JMC 5201)
C2, C3, C6, C8 — 1.0–20 pF Johanson Capacitor
C4, C5 — 36 pF ATC “B” Style Chip Capacitor
C7, C9, C13 — 100 pF UNELCO Capacitor
C11 — 680 pF Feedthru
C10 — 1.0 µF 50 V Tantalum
C12 — 0.1 µF Erie Redcap
L1 — 8 Turns #26 AWG Enameled, 1/16″ ID Closewound
L2, L5 — Ferroxcube VK200–19/4B Ferrite Choke

L3 — 8 Turns #20 AWG Enameled, 1/4″ ID Closewound
L4 — 4 Turns #26 AWG 0.1″ ID
R1 — 10 Ohm 2.0 W Carbon
R2, R3 — 10 Ohm 1.0 W Carbon
Z1 — Microstrip 0.19″ W x 1.28″ L
Z2 — Microstrip 0.28″ W x 1.0″ L
Z3 — Microstrip 0.31″ W x 1.0″ L
Z4 — Microstrip 0.31″ W x 0.9″ L
Board — Glass Teflon ε_r = 2.56 t = 0.062″
Input/Output Connectors — Type N UG58 A/U

Figure 1. 400 MHz Test Amplifier

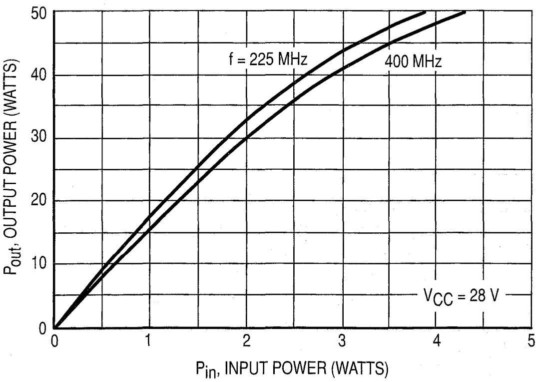


Figure 2. Output Power versus Input Power

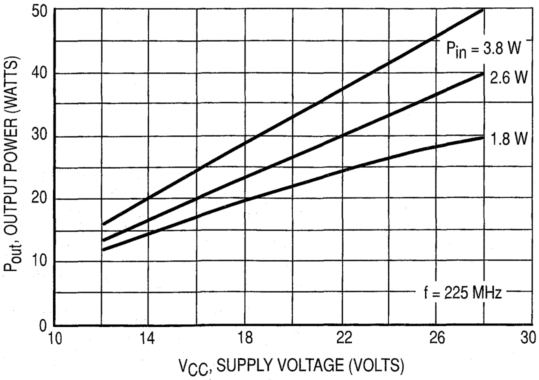


Figure 3. Output Power versus Supply Voltage

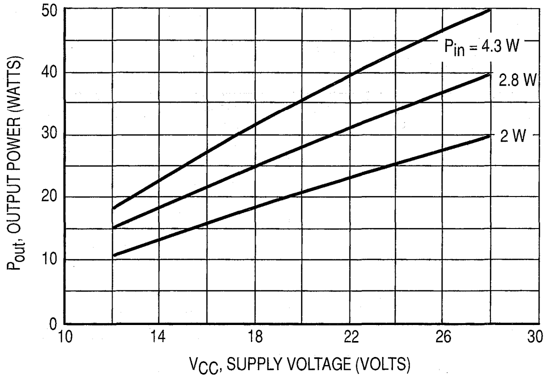
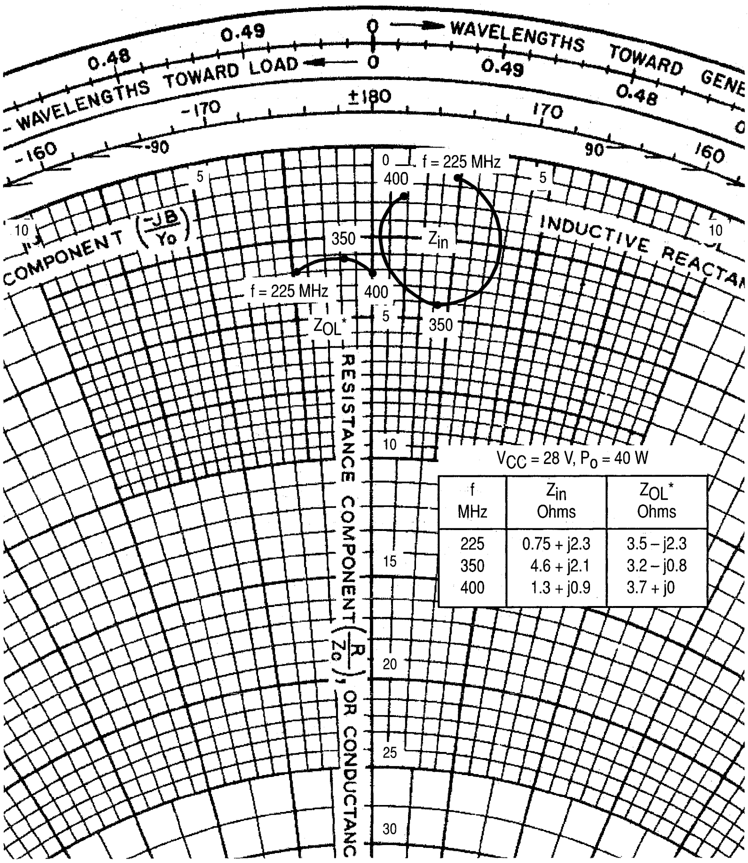


Figure 4. Output Power versus Supply Voltage
f = 400 MHz



V_{CC} = 28 V, P_o = 40 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
225	0.75 + j2.3	3.5 – j2.3
350	4.6 + j2.1	3.2 – j0.8
400	1.3 + j0.9	3.7 + j0

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Input–Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

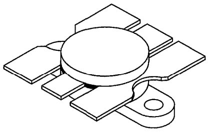
The RF Line
NPN Silicon RF Power Transistor

MRF327

80 W, 100 to 500 MHz
CONTROLLED "Q"
BROADBAND RF POWER
TRANSISTOR
NPN SILICON

. . . designed primarily for wideband large–signal output amplifier stages in the 100 to 500 MHz frequency range.

- Guaranteed Performance @ 400 MHz, 28 Vdc
  Output Power = 80 Watts over 225 to 400 MHz Band
  Minimum Gain = 7.3 dB @ 400 MHz
- Built–In Matching Network for Broadband Operation Using Double Match Technique
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Gold Metallization System for High Reliability Applications
- Characterized for 100 to 500 MHz



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	33	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	9.0 12	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.7	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

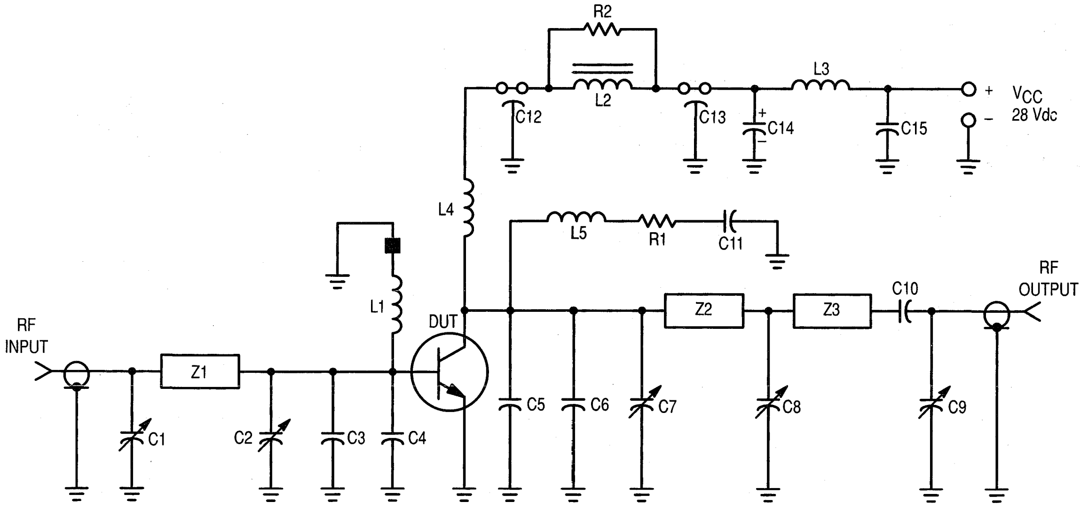
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 80 mAdc, I_B = 0)	$V_{(BR)CEO}$	33	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 80 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 8.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 80 mAdc, I_C = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	100	145	pF

(continued)

NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 80 W, f = 400 MHz)	G_{PE}	7.3	9.0	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 80 W, f = 400 MHz)	η	50	60	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 80 W, f = 400 MHz, VSWR = 30:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1, C2, C7, C8, C9 — 1.0–20 pF Piston Trimmer (Johanson JMC 5501)
C3, C4 — 36 pF ATC 100 mil Chip Capacitor
C5, C6 — 43 pF ATC 100 mil Chip Capacitor
C10 — 100 pF UNELCO
C11, C15 — 0.1 µF Erie Redcap
C12, C13 — 680 pF Feedthru
C14 — 1.0 µF 50 V Tantalum
L1 — 4 Turns #22 AWG Enameled, 3/16″ ID Closewound with Ferroxcube Bead (#56–590–65/4B) on Ground End of Coil
L2 — Ferroxcube VK200–19/4B Ferrite Choke
L3 — 7 Turns #18 AWG, 11/16″ Long, Wound on a 100 kΩ 2.0 Watt Resistor
L4 — 6 Turns #20 AWG Enameled, 3/16″ ID Closewound
L5 — 4 Turns #22 AWG Enameled, 1/8″ ID Closewound
Z1 — Microstrip 0.2″ W x 1.5″ L
Z2 — Microstrip 0.17″ W x 1.16″ L
Z3 — Microstrip 0.17″ W x 0.63″ L
R1, R2 — 10 Ω 2.0 Watt
Board — Glass Teflon ε_r = 2.56, t = 0.062″
Input/Output Connectors Type N
DUT Socket Lead Frame Etched from 80–mil–Thick Copper

Figure 1. 400 MHz Test Circuit

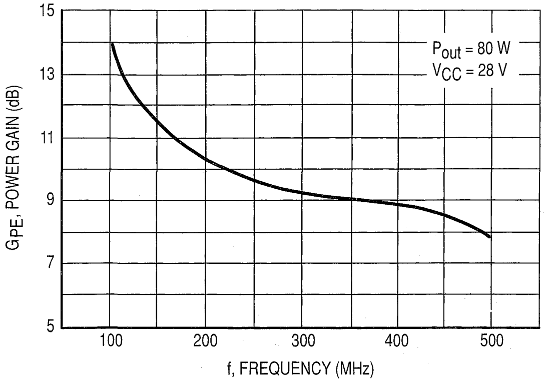


Figure 2. Power Gain versus Frequency

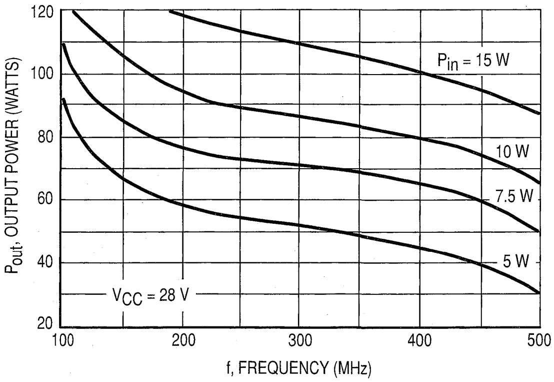


Figure 3. Output Power versus Frequency

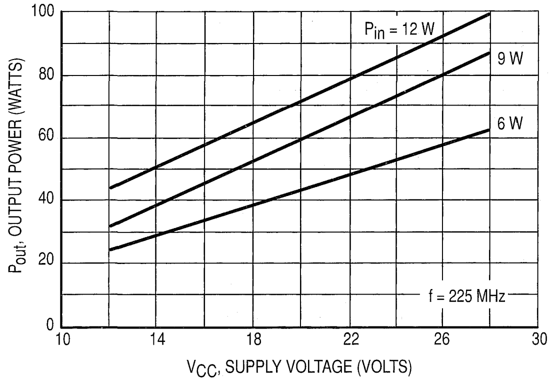


Figure 4. Output Power versus Supply Voltage

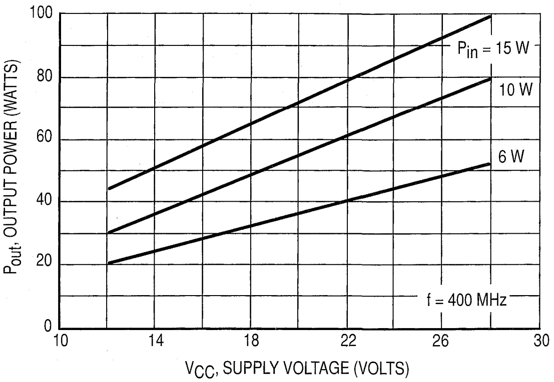


Figure 5. Output Power versus Supply Voltage

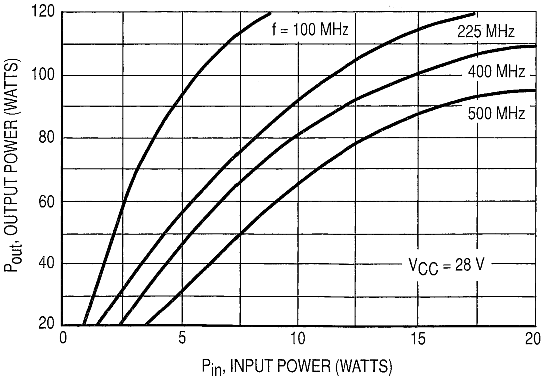
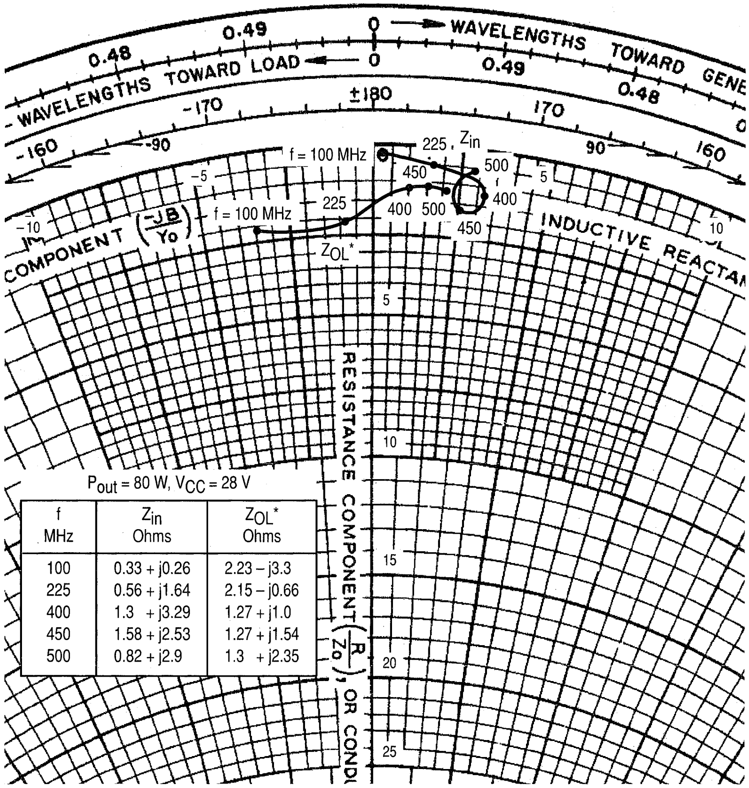


Figure 6. Output Power versus Input Power



P_{out} = 80 W, V_{CC} = 28 V

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
100	0.33 + j0.26	2.23 – j3.3
225	0.56 + j1.64	2.15 – j0.66
400	1.3 + j3.29	1.27 + j1.0
450	1.58 + j2.53	1.27 + j1.54
500	0.82 + j2.9	1.3 + j2.35

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 7. Series Equivalent Input–Output Impedance

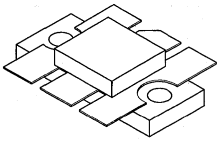
The RF Line
NPN Silicon RF Power Transistor

MRF329

100 W, 100 to 500 MHz
CONTROLLED "Q"
BROADBAND RF POWER
TRANSISTOR
NPN SILICON

. . . designed primarily for wideband large–signal output and driver amplifier stages in the 100 to 500 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics —
  Output Power = 100 Watts
  Minimum Gain = 7.0 dB
  Efficiency = 50% (Min)
- Built–In Matching Network for Broadband Operation Using Double Match Technique
- 100% Tested for Load Mismatch at all Phase Angles with 3:1 VSWR
- Gold Metallization System for High Reliability



CASE 333–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	9.0 12	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	0.65	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 80 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 80 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 8.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc

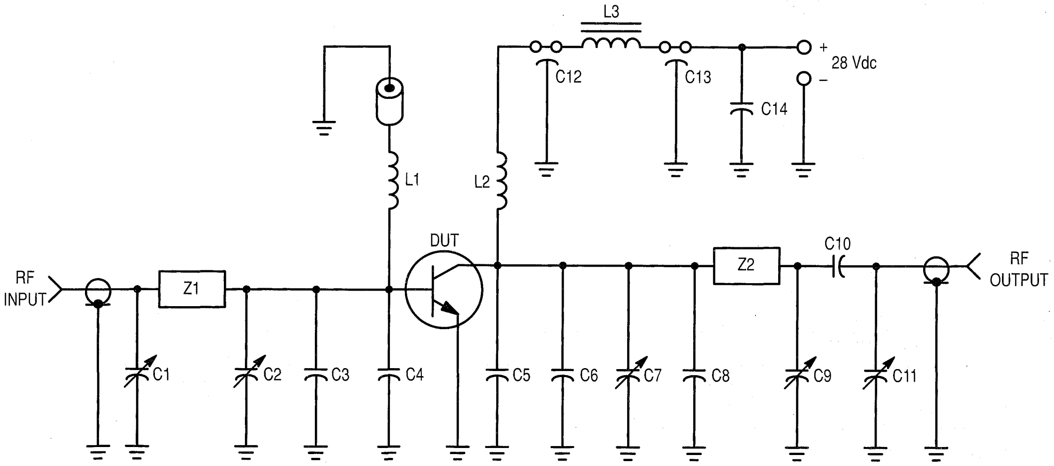
(continued)

NOTES:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (continued)					
Collector–Base Breakdown Voltage (I_C = 80 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	95	125	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 400 MHz)	G_{PE}	7.0	9.7	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 400 MHz)	η	50	60	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 400 MHz, VSWR = 3:1 all angles)	ψ	No Degradation in Output Power			



C1, C2, C7, C9 — 1.0–20 pF Johanson (JMC 5501)
C3, C4 — 36 pF 100 mil Chip Cap (ATC)
C5, C6 — 50 pF 100 mil Chip Cap (ATC)
C8 — 30 pF 100 mil Chip Cap (ATC)
C10 — 2.0–150 pF 100 mil Chip Caps in Parallel (ATC)
C11 — 1.0–10 pF Johanson (JMC 5201)
C12, C13 — 1000 pF UNELCO Feedthru
C14 — 0.1 µF Erie Redcap

L1 — 0.15 µH Molded Choke with Ferrite Bead (Ferroxcube #56–590–65/4B) on Ground End
L2 — 4 Turns #18 AWG, 1/4″ ID
L3 — Ferroxcube VK200–19/4B
Z1 — Microstrip Line 2300 mils L x 210 mils W
Z2 — Microstrip Line 2300 mils L x 280 mils W
Board — Glass Teflon, t = 0.062″, ε_r = 2.56

Figure 1. 400 MHz Test Circuit

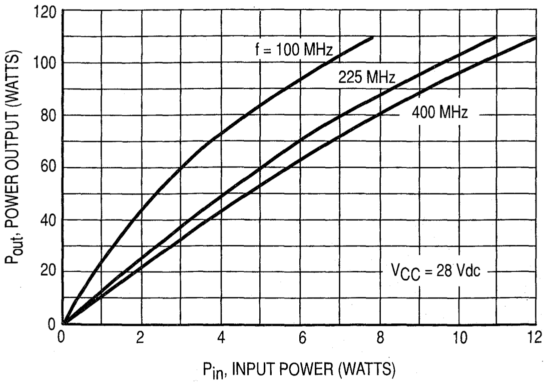


Figure 2. Output Power versus Input Power

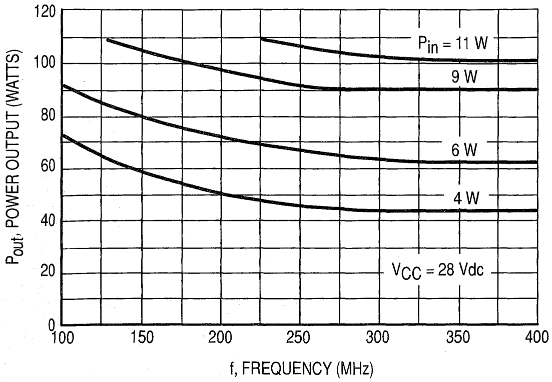


Figure 3. Output Power versus Frequency

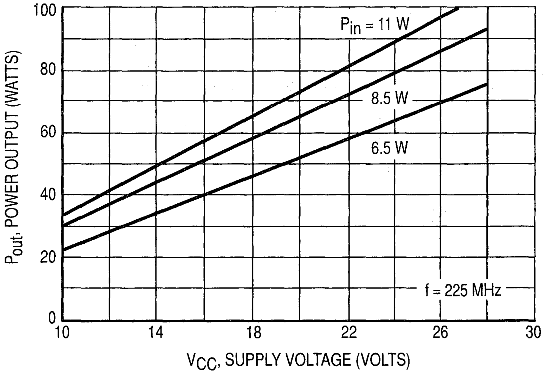


Figure 4. Output Power versus Supply Voltage

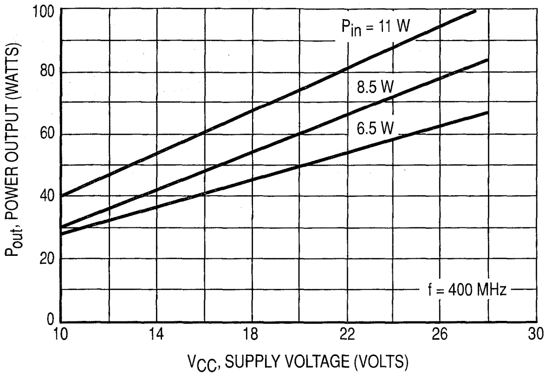


Figure 5. Output Power versus Supply Voltage

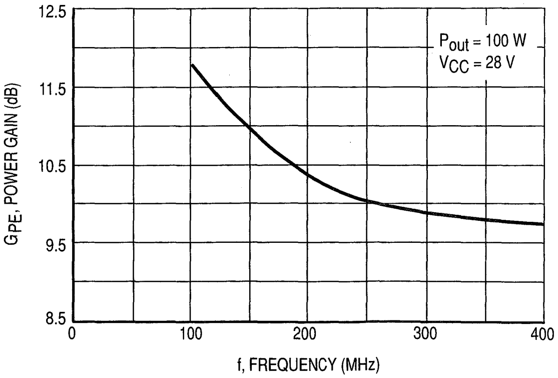
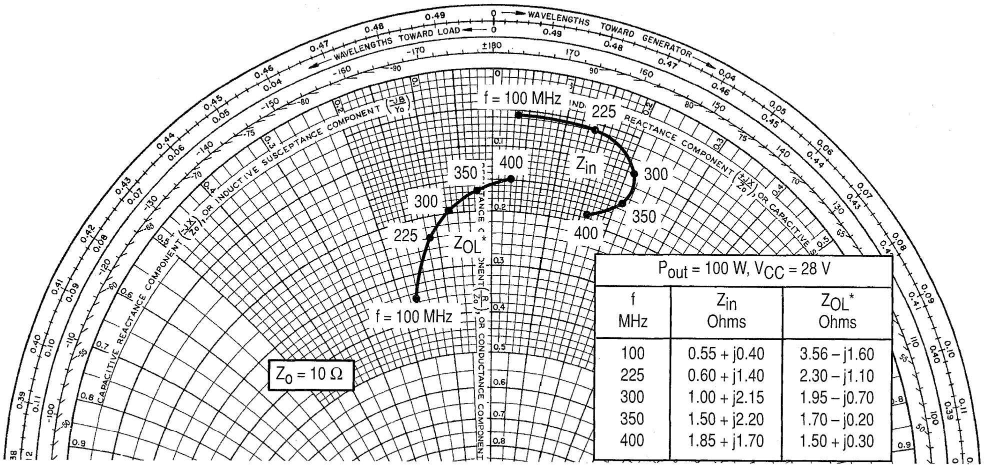


Figure 6. Power Gain versus Frequency



$P_{out} = 100$ W, $V_{CC} = 28$ V

f MHz	Z_{in} Ohms	Z_{OL}^* Ohms
100	0.55 + j0.40	3.56 – j1.60
225	0.60 + j1.40	2.30 – j1.10
300	1.00 + j2.15	1.95 – j0.70
350	1.50 + j2.20	1.70 – j0.20
400	1.85 + j1.70	1.50 + j0.30

Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 7. Series Equivalent Input/Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

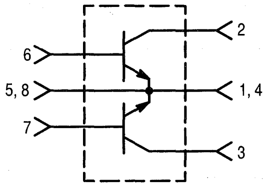
The RF Line
NPN Silicon Push-Pull RF Power Transistor

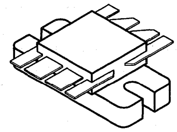
MRF392

125 W, 30 to 500 MHz
CONTROLLED "Q"
BROADBAND PUSH–PULL
RF POWER TRANSISTOR
NPN SILICON

Designed primarily for wideband large–signal output and driver amplifier stages in the 30 to 500 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics —
  Output Power = 125 W
  Typical Gain = 10 dB
  Efficiency = 55% (Typ)
- Built–In Input Impedance Matching Networks for Broadband Operation
- Push–Pull Configuration Reduces Even Numbered Harmonics
- Gold Metallization System for High Reliability
- 100% Tested for Load Mismatch
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.





CASE 744A–01, STYLE 1

The MRF392 is two transistors in a single package with separate base and collector leads and emitters common. This arrangement provides the designer with a space saving device capable of operation in a push–pull configuration.

PUSH–PULL TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

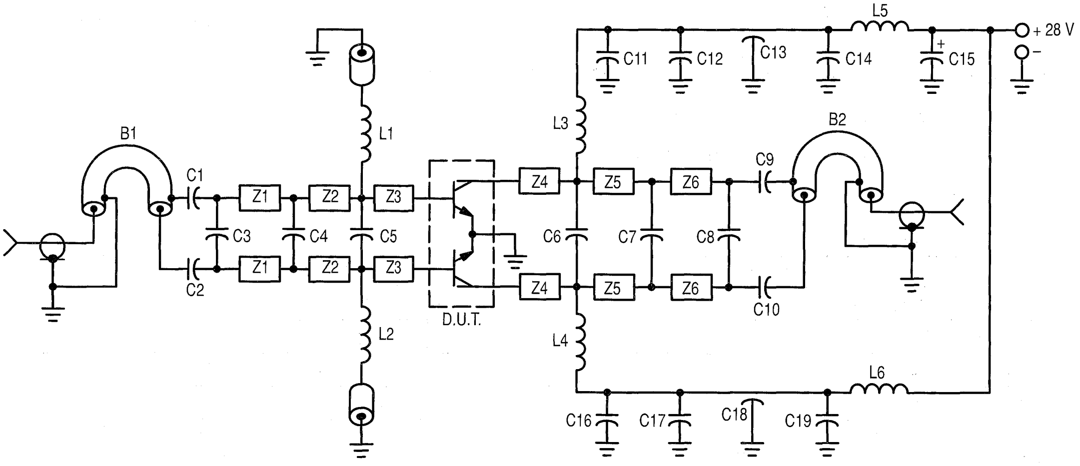
NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF push–pull amplifier.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	100	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	75	115	pF
FUNCTIONAL TESTS (2) **— See Figure 1**					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 125 W, f = 400 MHz)	G_{pe}	8.0	10	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 125 W, f = 400 MHz)	η	50	55	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 125 W, f = 400 MHz, VSWR = 30:1, all phase angles)	ψ	No Degradation in Output Power			

NOTES:
1. Each transistor chip measured separately.
2. Both transistor chips operating in push–pull amplifier.



C1, C2 — 240 pF, 100 Mil Chip Cap (ATC) or Equivalent
C3 — 3.6 pF, 100 Mil Chip Cap (ATC) or Equivalent
C4, C8 — 8.2 pF, 100 Mil Chip Cap (ATC) or Equivalent
C5, C6 — 20 pF, 100 Mil Chip Cap (ATC) or Equivalent
C7 — 18 pF, Mini Unelco or Equivalent
C9, C10 — 270 pF, 100 Mil Chip Cap (ATC) or Equivalent
C11, C12, C16, C17 — 470 pF 100 Mil Chip Cap (ATC) or Equivalent
C13, C18 — 680 pF Feedthru
C14, C19 — 0.1 µF Erie Redcap or Equivalent
C15 — 20 µF, 50 V

L1, L2 — 0.15 µH Molded Choke With Ferrite Bead
L3, L4 — 2–1/2 Turns #20 AWG, 0.200 ID
L5, L6 — 3–1/2 Turns #18 AWG, 0.200 ID

B1 — Balun, 50 Ω Semi–Rigid Coaxial Cable 86 Mil OD, 2″ L
B2 — Balun, 50 Ω Semi–Rigid Coaxial Cable 86 Mil OD, 2″ L

Z1 — Microstrip Line 270 Mil L x 125 Mil W
Z2 — Microstrip Line 375 Mil L x 125 Mil W
Z3 — Microstrip Line 280 Mil L x 125 Mil W
Z4 — Microstrip Line 300 Mil L x 125 Mil W
Z5 — Microstrip Line 350 Mil L x 125 Mil W
Z6 — Microstrip Line 365 Mil L x 125 Mil W

Board Material — 0.0625″ Teflon Fiberglass ε_r = 2.5 ± 0.05 1 oz. Cu. CLAD, Double Sided

Figure 1. 400 MHz Test Fixture

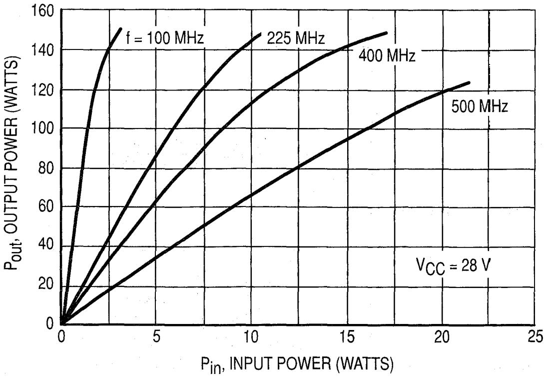


Figure 2. Output Power versus Input Power

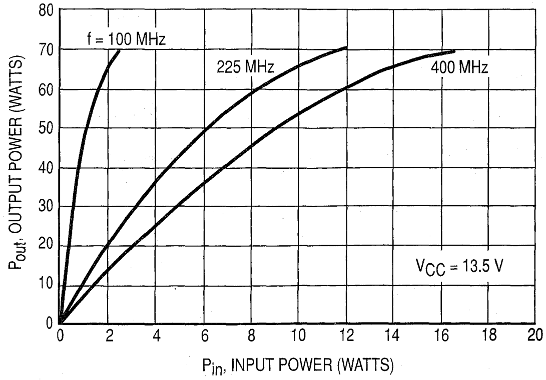


Figure 3. Output Power versus Input Power

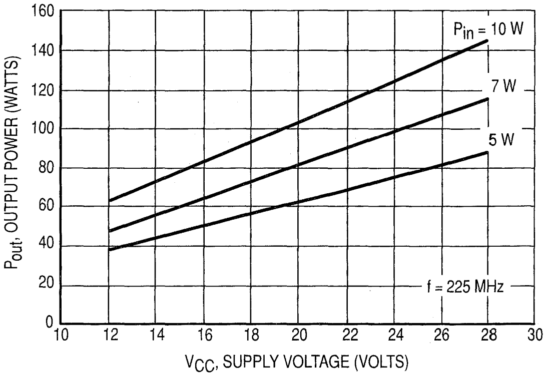


Figure 4. Output Power versus Supply Voltage

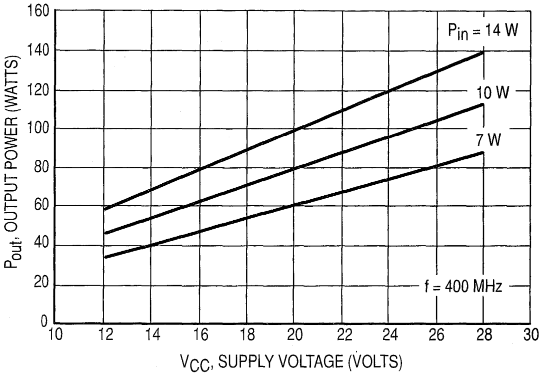
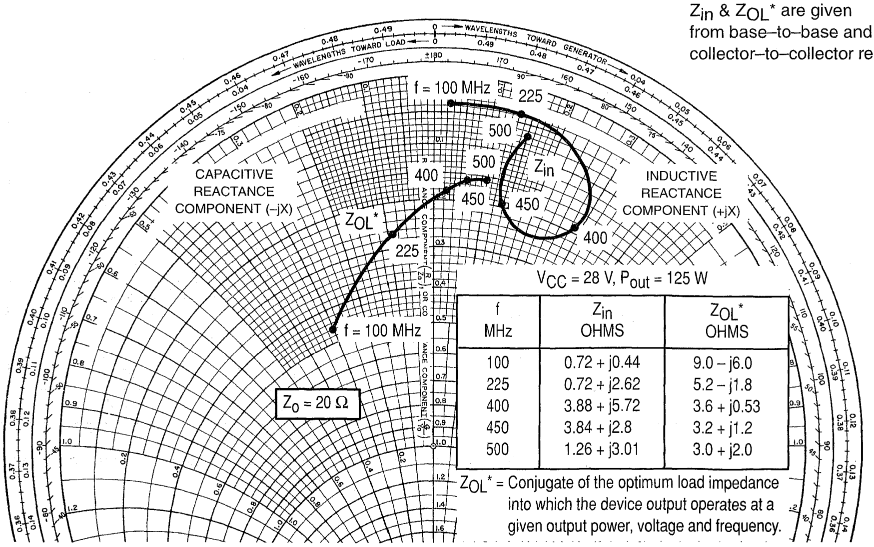


Figure 5. Output Power versus Supply Voltage

Z_{in} & Z_{OL}* are given from base–to–base and collector–to–collector respectively.



V_{CC} = 28 V, P_{out} = 125 W

f MHz	Z_{in} OHMS	Z_{OL}* OHMS
100	0.72 + j0.44	9.0 – j6.0
225	0.72 + j2.62	5.2 – j1.8
400	3.88 + j5.72	3.6 + j0.53
450	3.84 + j2.8	3.2 + j1.2
500	1.26 + j3.01	3.0 + j2.0

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input/Output Impedance

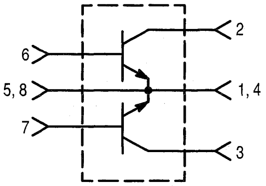
The RF Line
NPN Silicon Push-Pull RF Power Transistor

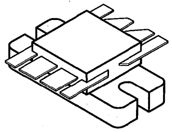
MRF393

100 W, 30 to 500 MHz
CONTROLLED "Q"
BROADBAND PUSH–PULL
RF POWER TRANSISTOR
NPN SILICON

. . . designed primarily for wideband large–signal output and driver amplifier stages in the 30 to 500 MHz frequency range.

- Specified 28 Volt, 500 MHz Characteristics —
  Output Power = 100 W
  Typical Gain = 9.5 dB (Class AB); 8.5 dB (Class C)
  Efficiency = 55% (Typ)
- Built–In Input Impedance Matching Networks for Broadband Operation
- Push–Pull Configuration Reduces Even Numbered Harmonics
- Gold Metallization System for High Reliability
- 100% Tested for Load Mismatch
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.





CASE 744A–01, STYLE 1

The MRF393 is two transistors in a single package with separate base and collector leads and emitters common. This arrangement provides the designer with a space saving device capable of operation in a push–pull configuration.

PUSH–PULL TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	270 1.54	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.65	°C/W

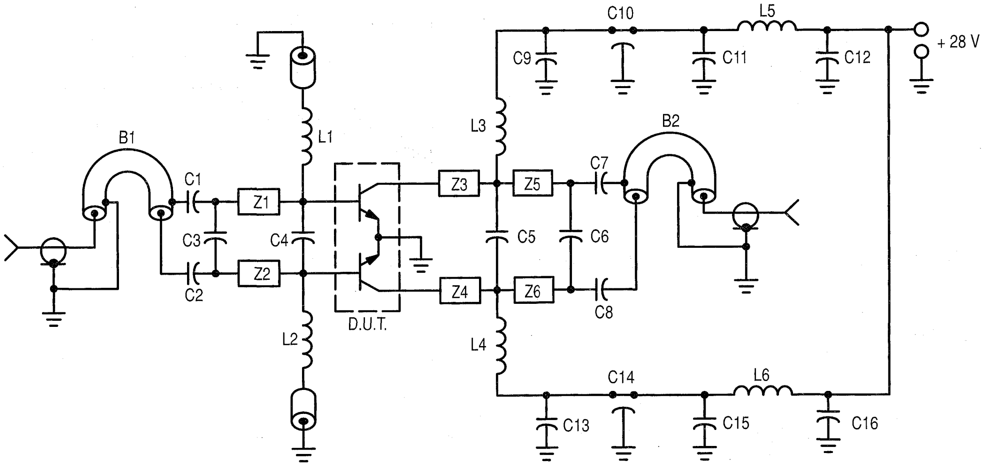
NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF push–pull amplifier.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	100	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	75	115	pF
FUNCTIONAL TESTS (2) **— See Figure 1**					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 500 MHz)	G_{pe}	7.5	8.5	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 500 MHz)	η	50	55	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 100 W, f = 500 MHz, VSWR = 30:1, all phase angles)	ψ	No Degradation in Output Power			

NOTES:
1. Each transistor chip measured separately.
2. Both transistor chips operating in push–pull amplifier.



C1, C2, C7, C8 — 240 pF 100 mil Chip Cap
C3 — 15 pF 100 mil Chip Cap
C4 — 24 pF 100 mil Chip Cap
C5 — 33 pF 100 mil Chip Cap
C6 — 12 pF 100 mil Chip Cap
C9, C13 — 1000 pF 100 mil Chip Cap
C10, C14 — 680 pF Feedthru Cap
C11, C15 — 0.1 µF Ceramic Disc Cap
C12, C16 — 50 µF 50 V

L1, L2 — 0.15 µH Molded Choke with Ferrite Bead
L3, L4 — 2–1/2 Turns #20 AWG 0.200″ ID
L5, L6 — 3–1/2 Turns #18 AWG 0.200″ ID
B1, B2 — Balun 50 Ω Semi Rigid Coax, 86 mil OD, 4″ Long
Z1, Z2 — 850 mil Long x 125 mil W. Microstrip
Z3, Z4 — 200 mil Long x 125 mil W. Microstrip
Z5, Z6 — 800 mil Long x 125 mil W. Microstrip
Board Material — 0.0325″ Teflon–Fiberglass, ε_r = 2.56,
1 oz. Copper Clad both sides.

Figure 1. 500 MHz Test Fixture

CLASS C

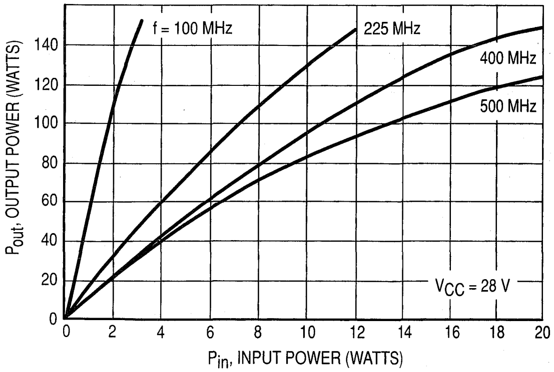


Figure 2. Output Power versus Input Power

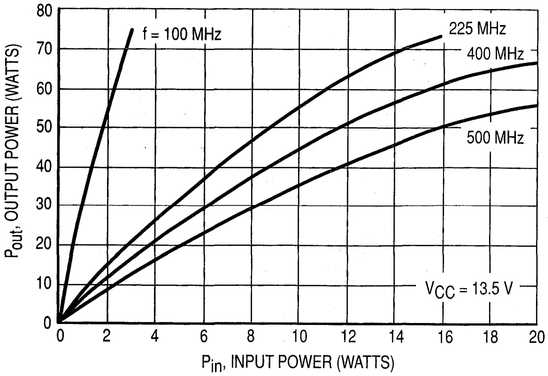


Figure 3. Output Power versus Input Power

CLASS C

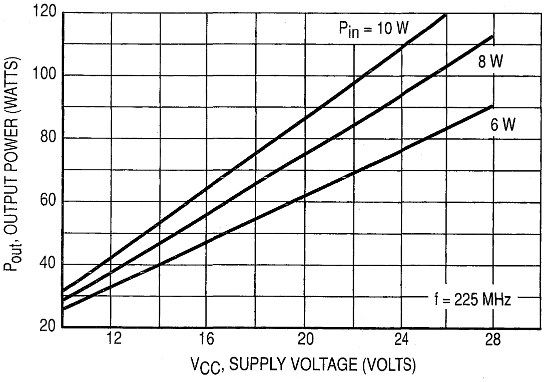


Figure 4. Output Power versus Supply Voltage

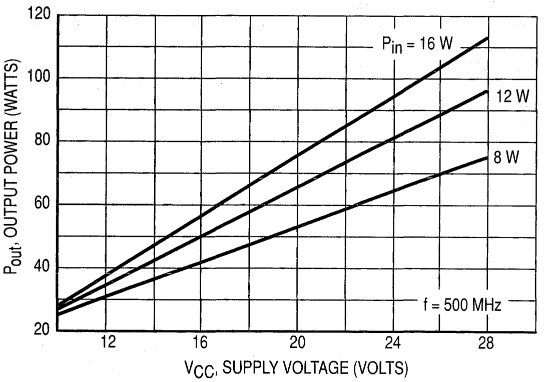
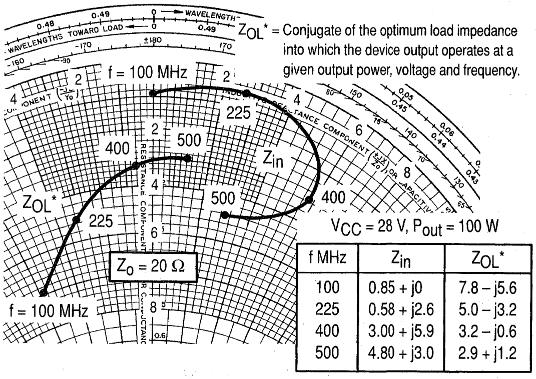


Figure 5. Output Power versus Supply Voltage



Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

f MHz	Z_{in}	Z_{OL}*
100	0.85 + j0	7.8 – j5.6
225	0.58 + j2.6	5.0 – j3.2
400	3.00 + j5.9	3.2 – j0.6
500	4.80 + j3.0	2.9 + j1.2

NOTE: Z_{in} & Z_{OL}* are given from base–to–base and collector–to–collector respectively.

Figure 6. Series Equivalent Input/Output Impedance

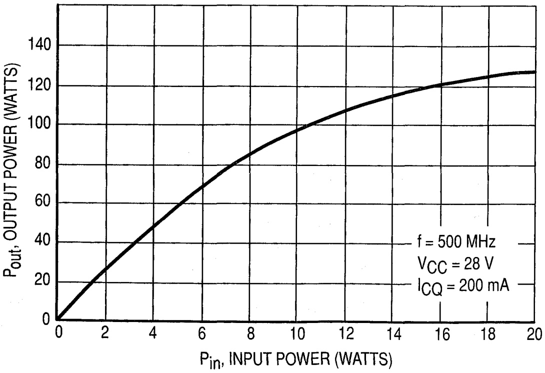


Figure 7. Class AB Output Power versus Input Power

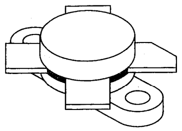
The RF Line
NPN Silicon RF Power Transistor

MRF421

Designed primarily for application as a high–power linear amplifier from 2.0 to 30 MHz.

- Specified 12.5 Volt, 30 MHz Characteristics —
  Output Power = 100 W (PEP)
  Minimum Gain = 10 dB
  Efficiency = 40%
- Intermodulation Distortion @ 100 W (PEP) —
  IMD = −30 dB (Min)
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR

100 W (PEP), 30 MHz
RF POWER
TRANSISTORS
NPN SILICON



CASE 211–11, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	20	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	Adc
Withstand Current — 10 s	—	30	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	290 1.66	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	45	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 200 mAdc, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 16 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	10	mAdc

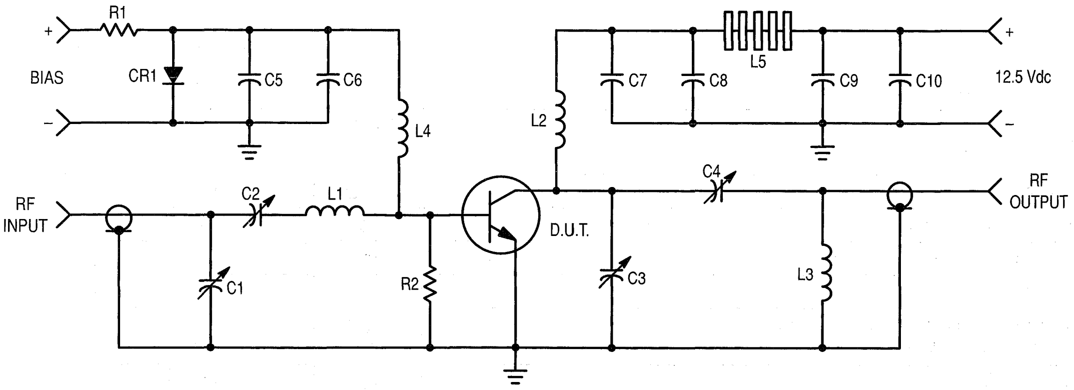
(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	30	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	550	800	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 100 W, $I_{C(max)}$ = 10 Adc, I_{CQ} = 150 mAdc, f = 30, 30.001 MHz)	G_{PE}	10	12	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 100 W, $I_{C(max)}$ = 10 Adc, I_{CQ} = 150 mA, f = 30, 30.001 MHz)	η	40	—	—	%
Intermodulation Distortion (1) (V_{CE} = 12.5 Vdc, P_{out} = 100 W, I_C = 10 Adc, I_{CQ} = 150 mA, f = 30, 30.001 MHz)	IMD	—	−33	−30	dB

NOTE:

1. To proposed EIA method of measurement. Reference peak envelope power.



C1, C2, C4 — 170–780 pF, ARCO 469
C3 — 80–480 pF, ARCO 466
C5, C7, C10 — ERIE 0.1 µF, 100 V
C6 — MALLORY 500 µF @ 15 V Electrolytic
C9 — 100 µF, 15 V Electrolytic
C8 — 1000 pF, 350 V UNDERWOOD
R1 — 10 Ω, 25 Watt Wirewound

R2 — 10 Ω, 1.0 Watt Carbon
CR1 — 1N4997
L1 — 3 Turns, #16 Wire, 5/16″ I.D., 5/16″ Long
L2 — 12 Turns, #16 Enameled Wire Closewound, 1/4″ I.D.
L3 — 1–3/4 Turns, 1/8″ Tubing, 3/8″ I.D., 3/8″ Long
L4 — 10 µH Molded Choke
L5 — 10 Ferrite Beads — FERROXCUBE #56–590–65/3B

Figure 1. 30 MHz Test Circuit Schematic

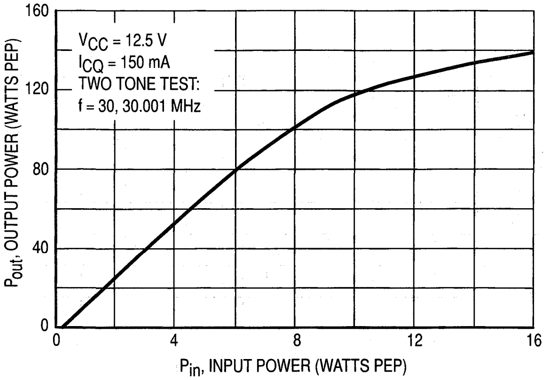


Figure 2. Output Power versus Input Power

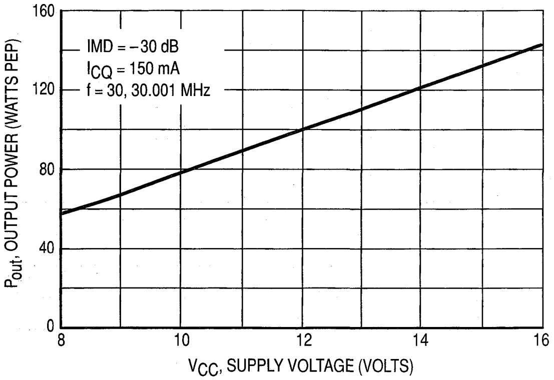


Figure 3. Output Power versus Supply Voltage

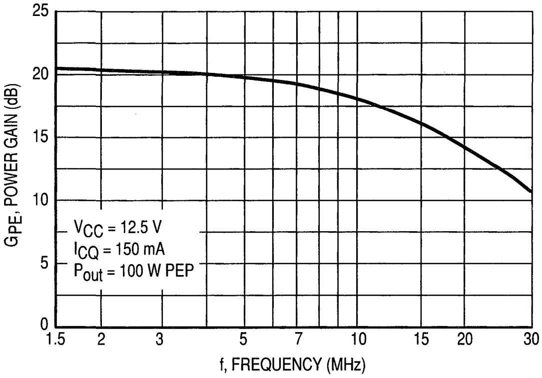


Figure 4. Power Gain versus Frequency

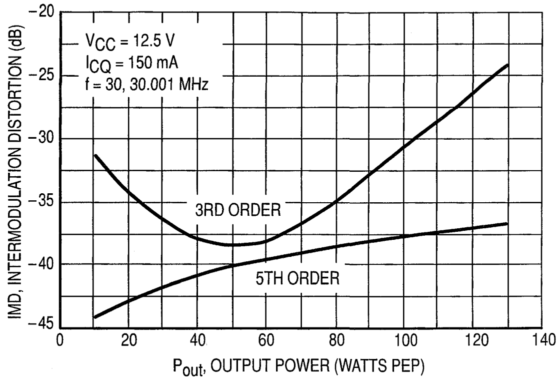


Figure 5. Intermodulation Distortion versus Output Power

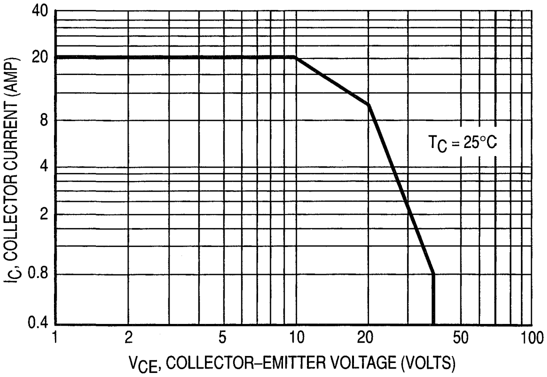
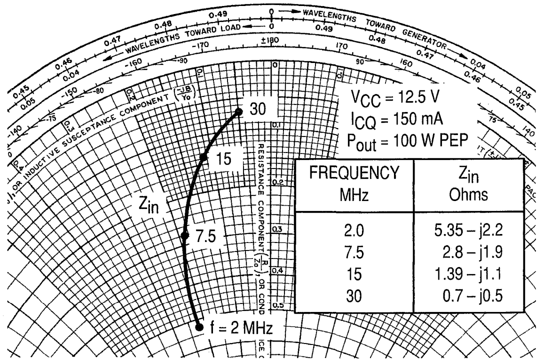


Figure 6. DC Safe Operating Area



FREQUENCY MHz	Zin Ohms
2.0	5.35 – j2.2
7.5	2.8 – j1.9
15	1.39 – j1.1
30	0.7 – j0.5

Figure 7. Series Equivalent Impedance

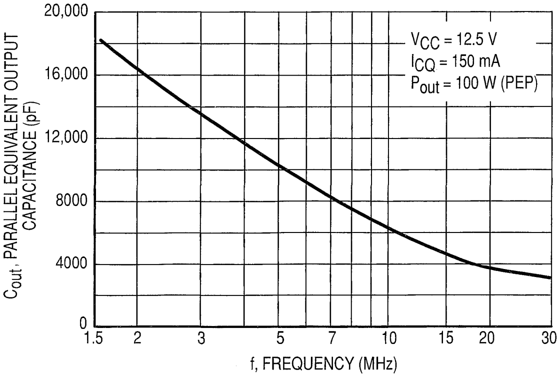


Figure 8. Output Capacitance versus Frequency

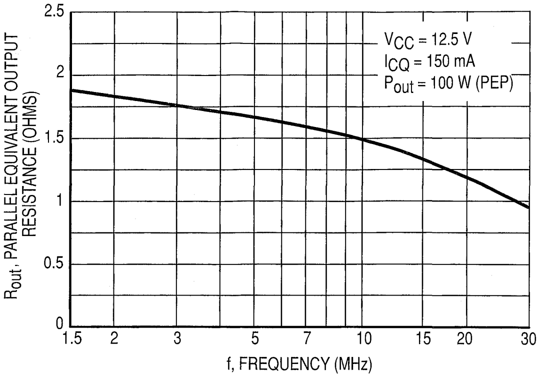


Figure 9. Output Resistance versus Frequency

The RF Line

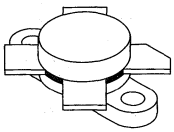
NPN Silicon RF Power Transistor

MRF422

Designed primarily for applications as a high–power linear amplifier from 2.0 to 30 MHz.

- Specified 28 Volt, 30 MHz Characteristics —
  Output Power = 150 W (PEP)
  Minimum Gain = 10 dB
  Efficiency = 40%
- Intermodulation Distortion @ 150 W (PEP) —
  IMD = −30 dB (Min)
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR

**150 W (PEP), 30 MHz
RF POWER
TRANSISTORS
NPN SILICON**



CASE 211–11, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	40	Vdc
Collector–Base Voltage	V_{CBO}	85	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	20	Adc
Withstanding Current — 10 s	—	30	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	290 1.66	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 200$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 100$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	85	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 100$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	85	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 10$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $V_{BE} = 0$, $T_C = 25°C$)	I_{CES}	—	—	20	mAdc

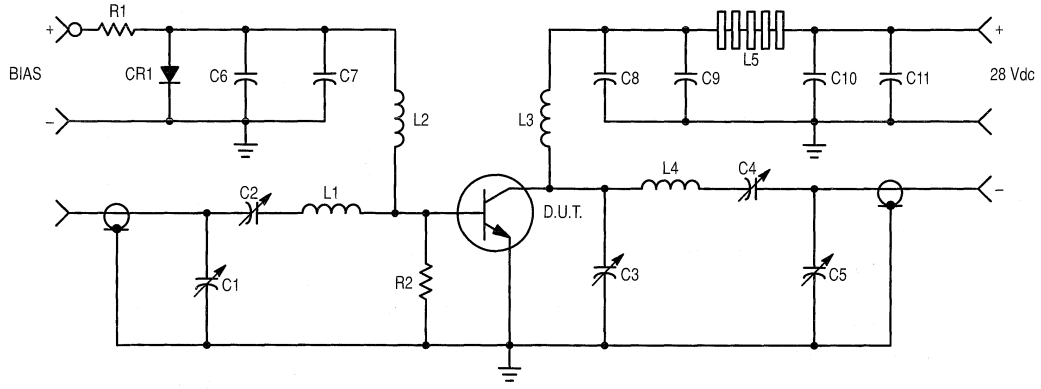
(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	30	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	420	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 150 W (PEP), $I_{C(max)}$ = 6.7 Adc, I_{CQ} = 150 mAdc, f = 30, 30.001 MHz)	G_{PE}	10	13	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 150 W (PEP), $I_{C(max)}$ = 6.7 Adc, I_{CQ} = 150 mAdc, f = 30, 30.001 MHz)	η	—	45	—	%
Intermodulation Distortion (1) (V_{CE} = 28 Vdc, P_{out} = 150 W (PEP), I_C = 6.7 Adc, I_{CQ} = 150 mAdc, f = 30, 30.001 MHz)	IMD	—	−33	−30	dB
Output Power (V_{CE} = 28 Vdc, f = 30 MHz)	P_{out}	150	—	—	Watts (PEP)

NOTE:
1. To Mil–Std–1311 Version A, Test Method 2204, Two Tone, Reference each Tone.



C1, C2, C3, C5 — 170−680 pF, ARCO 469
C4 — 80−480 pF, ARCO 466
C6, C8, C11 — ERIE 0.1 µF, 100 V
C7 — MALLORY 500 µF, 15 V Electrolytic
C9 — UNDERWOOD 1000 pF, 350 V
C10 — 10 µF, 50 V Electrolytic
R1 — 10 Ω, 25 Watt Wire Wound
R2 — 10 Ω, 1.0 Watt Carbon
CR1 — 1N4997

L1 — 3 Turns, #16 Wire, 5/16″ I.D., 5/16″ Long
L2 — 10 µH Molded Choke
L3 — 12 Turns, #16 Enameled Wire, Close Wound, 1/4″ Dia.
L4 — 5 Turns, 1/8″ Copper Tubing
L5 — 10 Ferrite Beads — FERROXCUBE #56–590–65/3B

Figure 1. 30 MHz Test Circuit Schematic

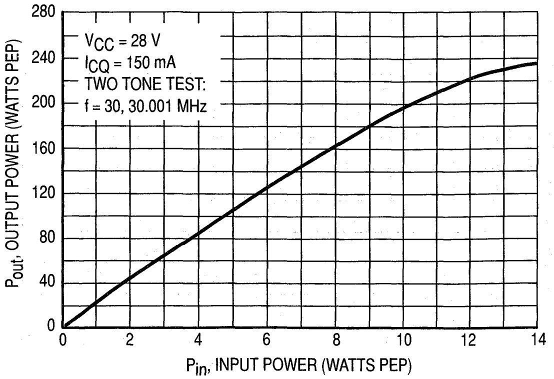


Figure 2. Output Power versus Input Power

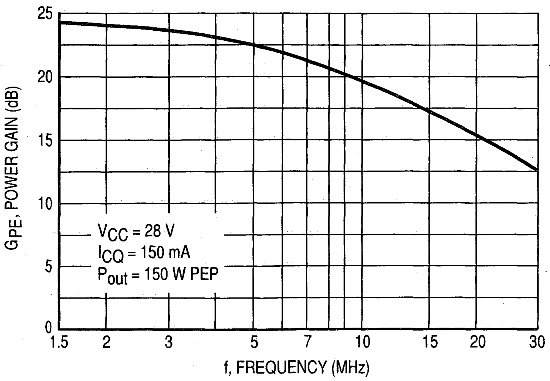


Figure 3. Power Gain versus Frequency

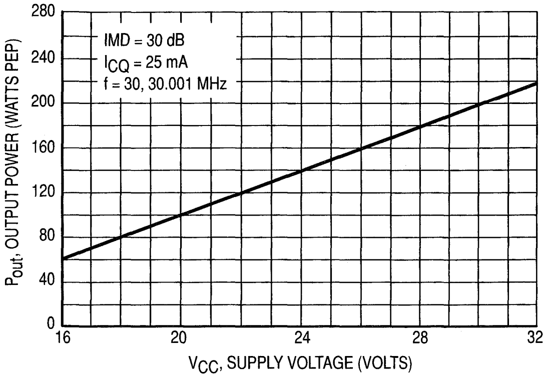


Figure 4. Linear Output Power versus Supply Voltage

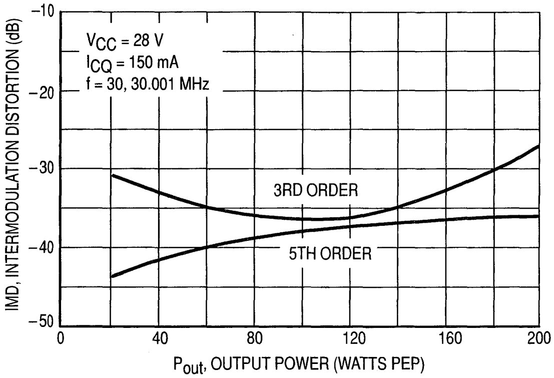


Figure 5. Intermodulation Distortion versus Output Power

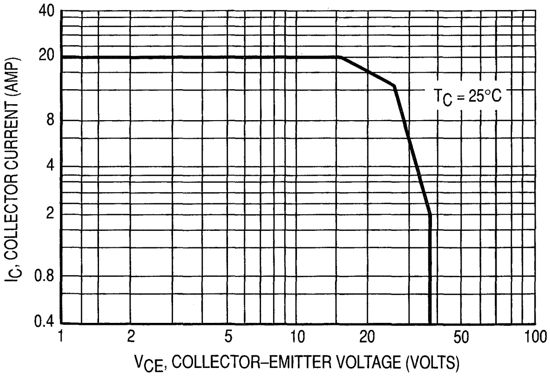
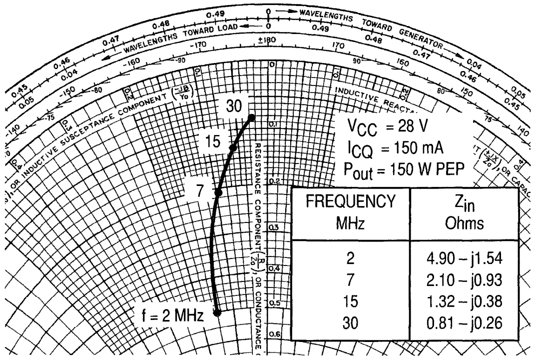


Figure 6. DC Safe Operating Area



FREQUENCY MHz	Z_{in} Ohms
2	4.90 − j1.54
7	2.10 − j0.93
15	1.32 − j0.38
30	0.81 − j0.26

Figure 7. Series Input Impedance

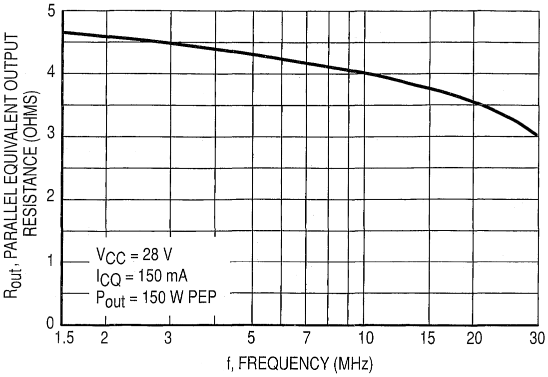


Figure 8. Output Resistance versus Frequency

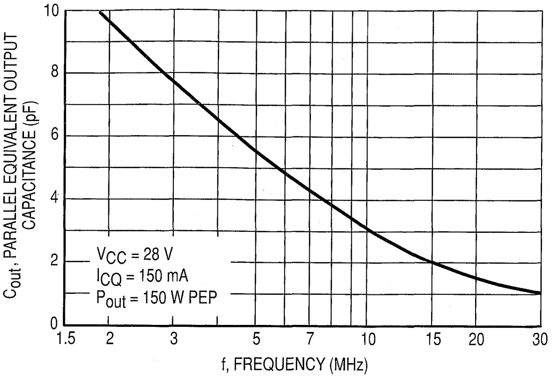


Figure 9. Output Capacitance versus Frequency

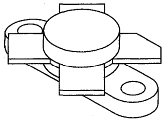
The RF Line
NPN Silicon RF Power Transistor

MRF426

. . . designed for high gain driver and output linear amplifier stages in 1.5 to 30 MHz HF/SSB equipment.

- Specified 28 Volt, 30 MHz Characteristics —
  Output Power = 25 W (PEP)
  Minimum Gain = 22 dB
  Efficiency = 35%
- Intermodulation Distortion @ 25 W (PEP) —
  IMD = −30 dB (Max)
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Class A and AB Characterization
- BLX 13 Equivalent

25 W (PEP), 30 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 211–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	35	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	3.0	Adc
Withstand Current — 5 s	—	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	70 0.4	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	35	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	mAdc

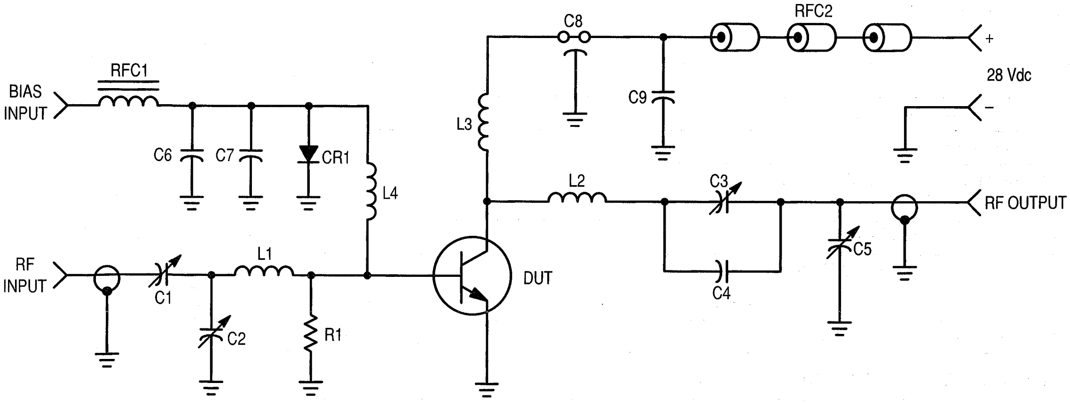
(continued)

NOTE:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	35	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	60	80	pF
FUNCTIONAL TESTS (SSB)					
Common–Emitter Amplifier Gain (V_{CC} = 28 Vdc, P_{out} = 25 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{CQ} = 25 mA)	G_{PE}	22	25	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 25 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{CQ} = 25 mA)	η	35	—	—	%
Intermodulation Distortion (2) (V_{CC} = 28 Vdc, P_{out} = 25 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{CQ} = 25 mA)	$IMD_{(d3)}$	—	−35	−30	dB
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 25 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{CQ} = 25 mA, VSWR 30:1 at All Phase Angles)	ψ	No Degradation in Output Power			
CLASS A PERFORMANCE					
Intermodulation Distortion (2) and Power Gain (V_{CC} = 28 Vdc, P_{out} = 8.0 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{CQ} = 1.2 Adc)	G_{PE} $IMD_{(d3)}$ $IMD_{(d5)}$	— — —	23.5 −40 −55	— — —	dB

NOTE:
2. To Mil–Std–1311 Version A, Test Method 2204B, Two Tone, Reference each Tone.



C1, C2 — ARCO 469, 190–780 pF
C3, C4 — ARCO 464, 25–280 pF
C5 — 120 pF Dipped Mica
C6, C7 — 100 µF, 15 Vdc
C8 — 680 pF F.T. Allen Bradley
C9 — 1.0 µF 35 V Tantalum
CR1 — 1N4997

L1 — 3 Turns #16 0.25″ ID
L2 — 6 Turns #16 0.5″ ID
L3 — 7 Turns #20 0.38″ ID
L4 — 10 µH Molded Choke Delevan
RFC1 — Ferroxcube VK200/20–4B
RFC2 — 3–Ferroxcube 5653065–3B
RF — Input/Output Connectors UG53 A/µ
R1 — 10 Ω 1/2 Watt 10%

Adjust Bias (Base) for I_{CQ} = 20 mA with No RF Applied

Figure 1. 30 MHz Linear Test Circuit

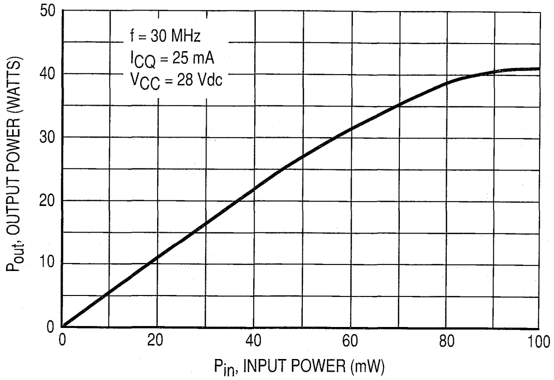


Figure 2. Output Power versus Input Power

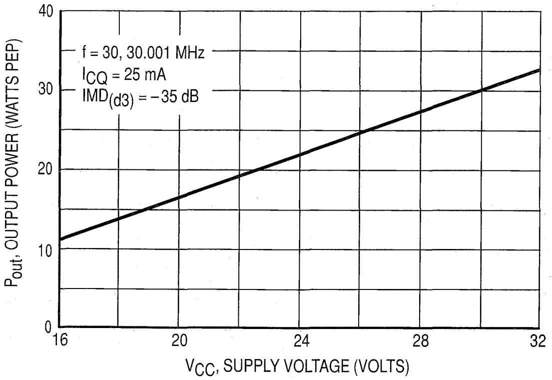


Figure 3. Output Power versus Supply Voltage

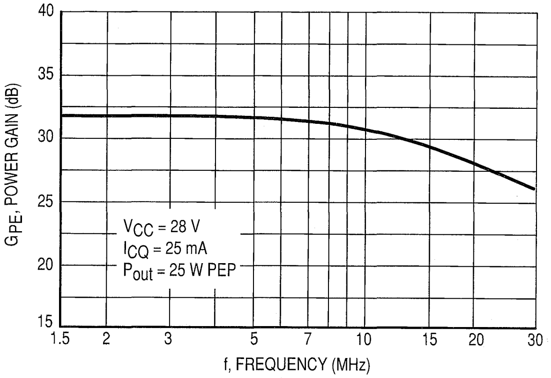


Figure 4. Power Gain versus Frequency

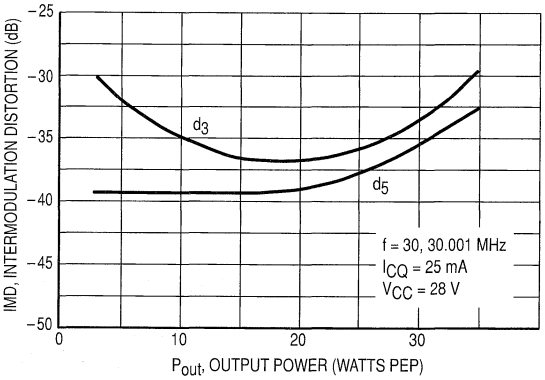


Figure 5. Intermodulation Distortion versus Output Power

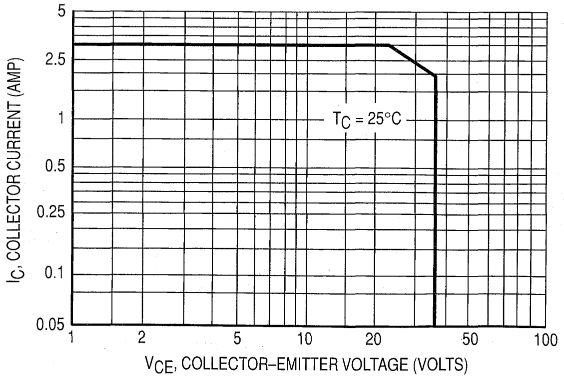


Figure 6. DC Safe Operating Area

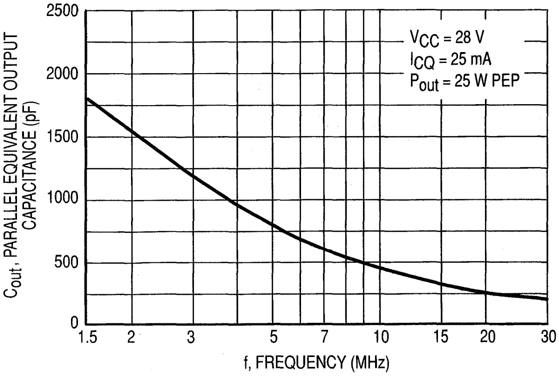


Figure 7. Output Capacitance versus Frequency

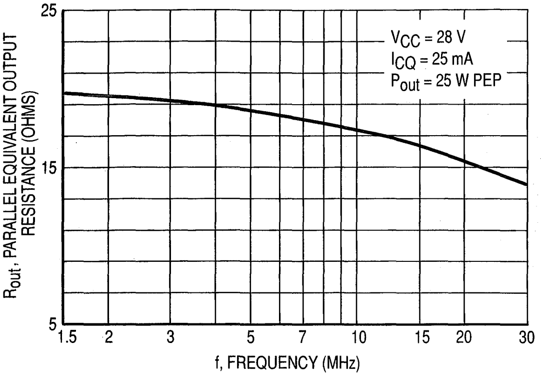
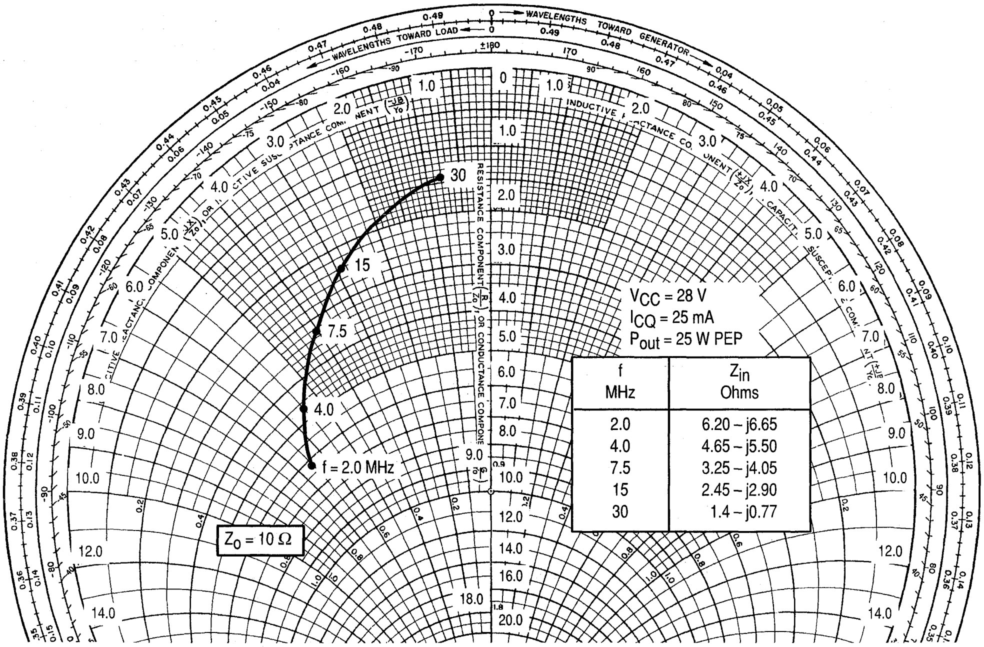


Figure 8. Output Resistance versus Frequency



f MHz	Zin Ohms
2.0	6.20 – j6.65
4.0	4.65 – j5.50
7.5	3.25 – j4.05
15	2.45 – j2.90
30	1.4 – j0.77

Figure 9. Series Equivalent Input Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

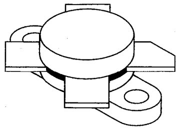
The RF Line
NPN Silicon RF Power Transistor

MRF429

Designed primarily for high–voltage applications as a high–power linear amplifier from 2.0 to 30 MHz. Ideal for marine and base station equipment.

- Specified 50 Volt, 30 MHz Characteristics —
  Output Power = 150 W (PEP)
  Minimum Gain = 13 dB
  Efficiency = 45%
- Intermodulation Distortion @ 150 W (PEP) —
  IMD = –32 dB (Max)
- Diffused Emitter Resistors for Superior Ruggedness
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR @ 150 W CW

**150 W (LINEAR), 30 MHz
RF POWER
TRANSISTOR
NPN SILICON**



CASE 211–11, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	50	Vdc
Collector–Base Voltage	V_{CBO}	100	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Withstand Current — 10 s	—	20	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	233 1.33	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.75	°C/W

ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	100	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 mAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc

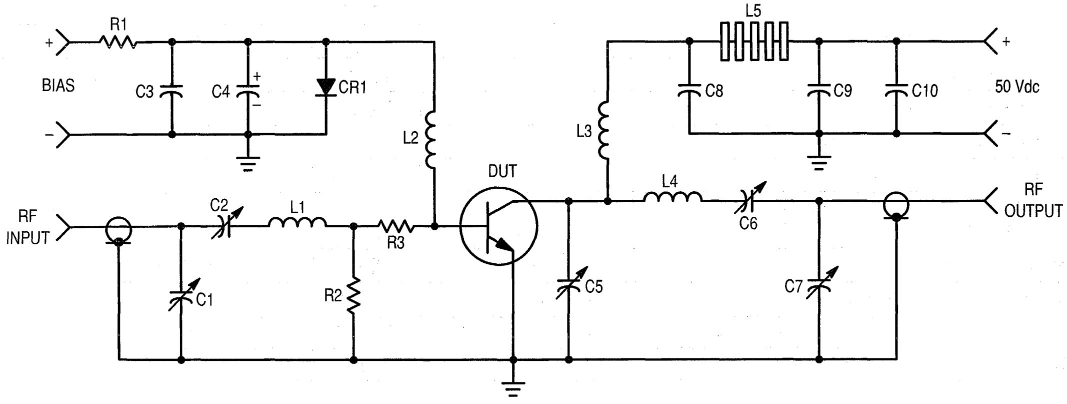
(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	30	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 50 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	220	300	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Gain (V_{CC} = 50 Vdc, P_{out} = 150 W (PEP), I_C(max) = 3.32 Adc, f = 30; 30.001 MHz)	G_{PE}	13	15	—	dB
Output Power (V_{CE} = 50 Vdc, f = 30; 30.001 MHz)	P_{out}	150	—	—	W (PEP)
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 150 W (PEP), I_C(max) = 3.32 Adc, f = 30, 30.001 MHz)	η	45	—	—	%
Intermodulation Distortion (1) (V_{CE} = 50 Vdc, P_{out} = 150 W (PEP), I_C = 3.32 Adc)	IMD	—	−35	−32	dB
Electrical Ruggedness (V_{CC} = 50 Vdc, P_{out} = 150 W CW, f = 30 MHz, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:

1. To Mil–Std–1311 Version A, Test Method 2204, Two Tone, Reference each Tone.



C1, C2, C7 — 170–780 pF, Arco 469
C3, C8, C9 — 0.1 µF, 100 V Erie
C4 — 500 µF @ 6.0 V
C5 — 9.0–180 pF, Arco 463
C6 — 80–480 pF, Arco 466
C10 — 30 µF, 100 V
R1 — 10 Ω, 10 Watt
R2 — 10 Ω, 1.0 Watt
R3 — 5.0 – 3.3 Ω 1/2 Watt Carbon Resistors in Parallel
CR1 — 1N4997
L1 — 3 Turns, #16 Wire, 5/16″ I.D., 5/16″ Long
L2 — 10 µH Molded Choke
L3 — 12 Turns, #16 Enameled Wire Closewound, 1/4″ I.D.
L4 — 5 Turns, 1/8″ Copper Tubing, 9/16″ I.D., 3/4″ Long
L5 — 10 Ferrite Beads — Ferroxcube #56–590–65/3B

Figure 1. 30 MHz Test Circuit Schematic

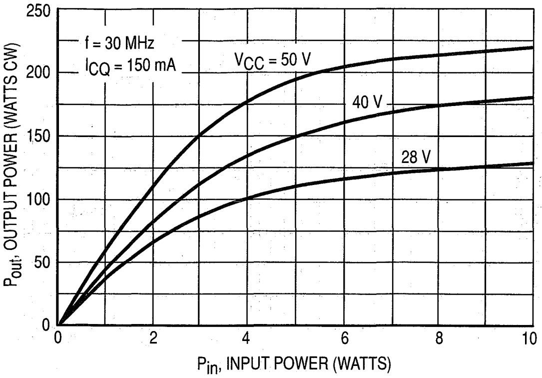


Figure 2. Output Power versus Input Power

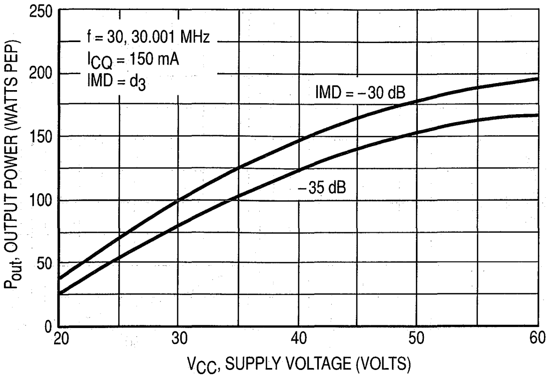


Figure 3. Output Power versus Supply Voltage

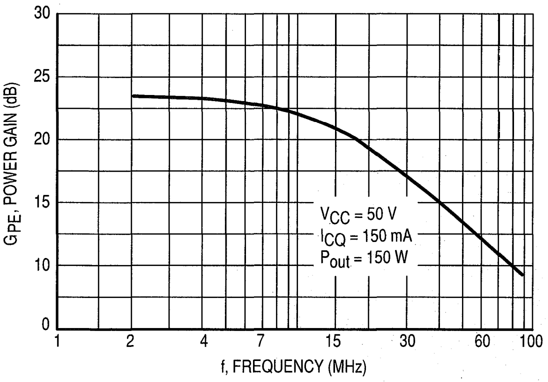


Figure 4. Power Gain versus Frequency

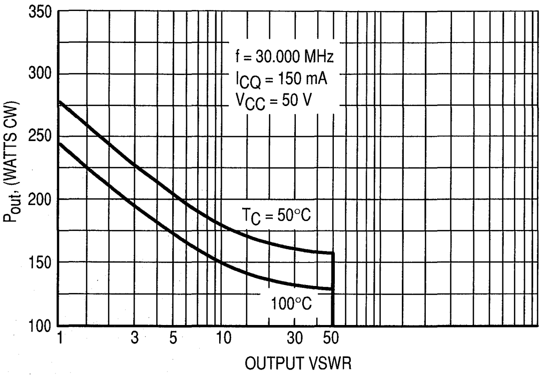


Figure 5. RF Safe Operating Area (SOAR)

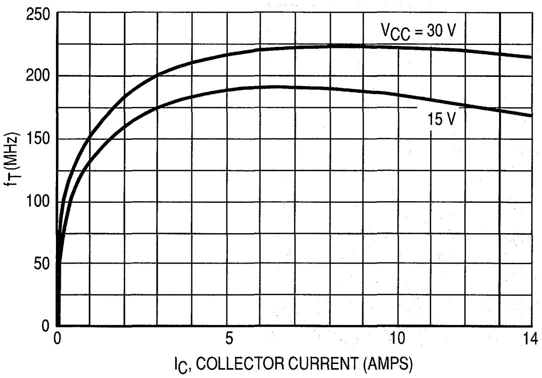


Figure 6. f_T versus Collector Current

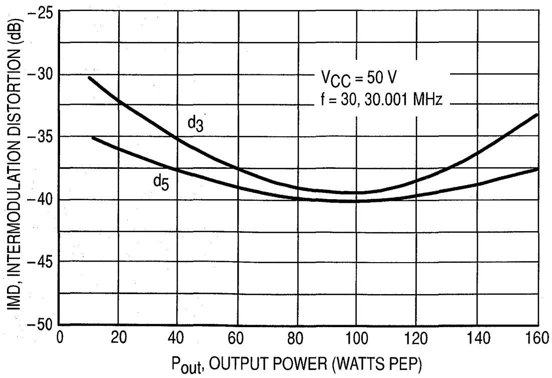


Figure 7. IMD versus P_{out}

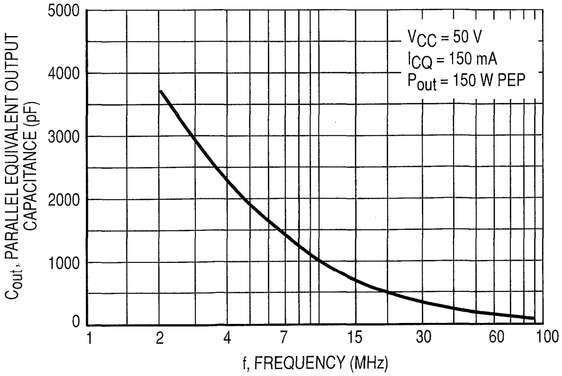


Figure 8. Output Capacitance versus Frequency

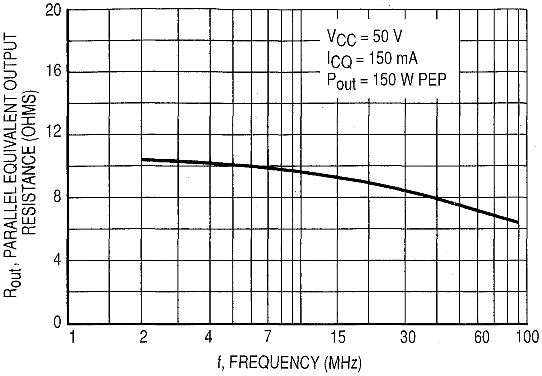
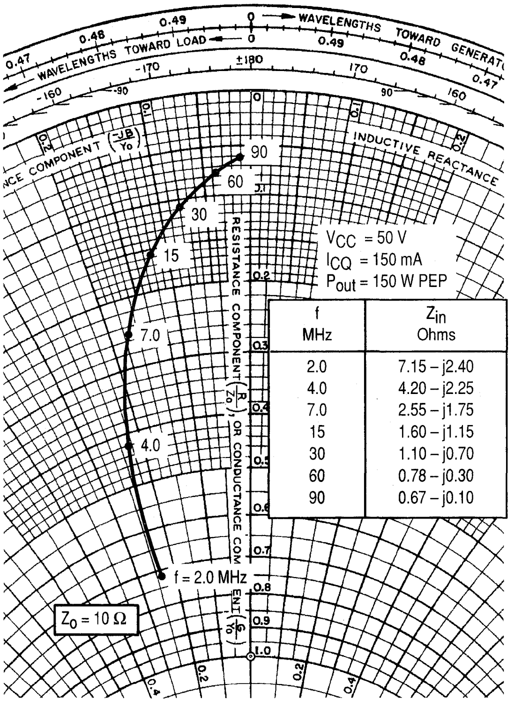


Figure 9. Output Resistance versus Frequency



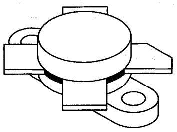
f MHz	Z_{in} Ohms
2.0	7.15 – j2.40
4.0	4.20 – j2.25
7.0	2.55 – j1.75
15	1.60 – j1.15
30	1.10 – j0.70
60	0.78 – j0.30
90	0.67 – j0.10

Figure 10. Series Equivalent Impedance

The RF Line
NPN Silicon RF Power Transistor

MRF448

250 W, 30 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 211–11, STYLE 1

Designed primarily for high–voltage applications as a high–power linear amplifier from 2.0 to 30 MHz. Ideal for marine and base station equipment.

- Specified 50 Volt, 30 MHz Characteristics
  Output Power = 250 W
  Minimum Gain = 12 dB
  Efficiency = 45%
- Intermodulation Distortion @ 250 W (PEP) —
  IMD = −30 dB (Max)
- 100% Tested for Load Mismatch at all Phase Angles with 3:1 VSWR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	50	Vdc
Collector–Base Voltage	V_{CBO}	100	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Withstand Current — 10 s	—	20	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	290 1.67	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	100	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 mAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc

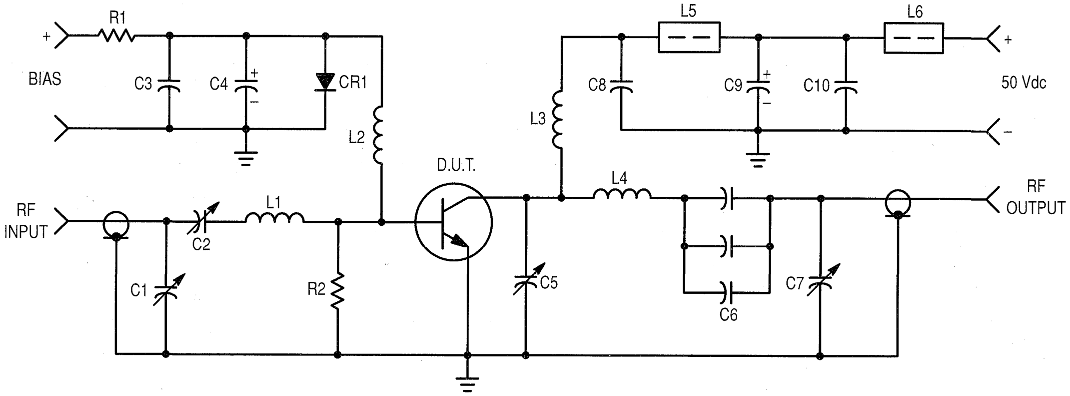
(continued)

NOTE:
1. P_D is a measurement reflecting short term maximum condition. See SOAR curve for operating conditions.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	10	30	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 50 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	350	450	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 250 W CW, f = 30 MHz, I_{CQ} = 250 mA)	G_{PE}	12	14	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 250 W, f = 30 MHz, I_{CQ} = 250 mA)	η	— —	45 65	— —	% (PEP) % (CW)
Intermodulation Distortion (2) (V_{CE} = 50 Vdc, P_{out} = 250 W (PEP), I_{CQ} = 250 mA, f = 30 MHz)	IMD	—	−33	−30	dB
Electrical Ruggedness (V_{CC} = 50 Vdc, P_{out} = 250 W CW, f = 30 MHz, VSWR 3:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:
2. To Mil–Std–1311 Version A, Test Method 2204, Two Tone, Reference each Tone.



C1, C2, C5, C7 — 170–780 pF, Arco 469
C3, C8, C9 — 0.1 µF, 100 V Erie
C4 — 500 µF @ 6.0 V
C6 — 360 pF, 3 x 120 pF 3.0 kV in parallel
C10 — 10 µF, 100 V
R1 — 10 Ω, 10 Watt
R2 — 10 Ω, 1.0 Watt

CR1 — 1N4997 or equivalent
L1 — 3 Turns, #16 Wire, 0.4″ I.D., 0.3″ Long
L2 — 0.8 µH, Ohmite Z–235 or equivalent
L3 — 12 Turns, #16 Enameled Wire Closewound 0.25″ I.D.
L4 — 4 Turns, 1/8″ Copper Tubing, 0.6″ I.D., 1.0″ Long
L5, L6 — 2.0 µH, Fair–Rite 2643021801 Ferrite bead each or equivalent

Figure 1. 30 MHz Test Circuit Schematic

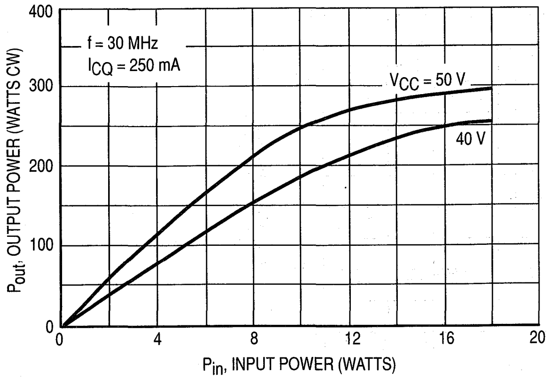


Figure 2. Output Power versus Input Power

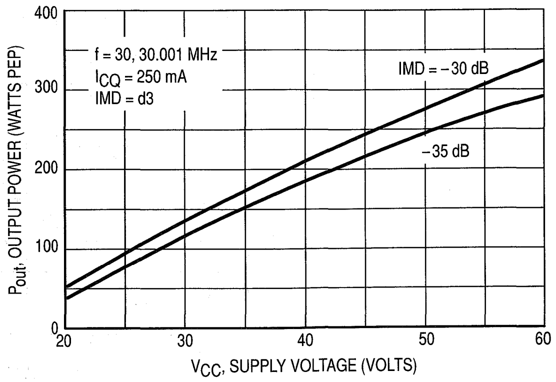


Figure 3. Output Power versus Supply Voltage

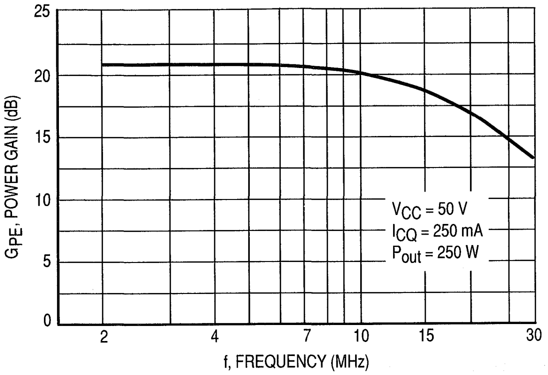


Figure 4. Power Gain versus Frequency

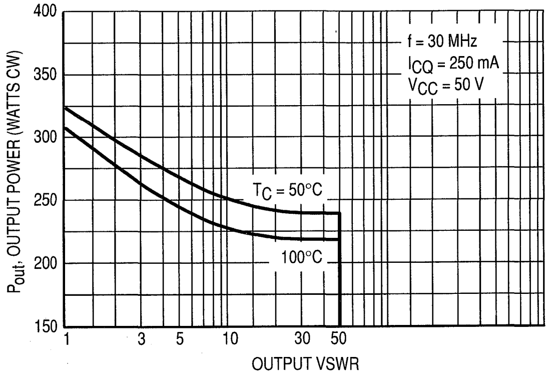


Figure 5. RF SOAR (Class AB)
P_{out} versus Output VSWR

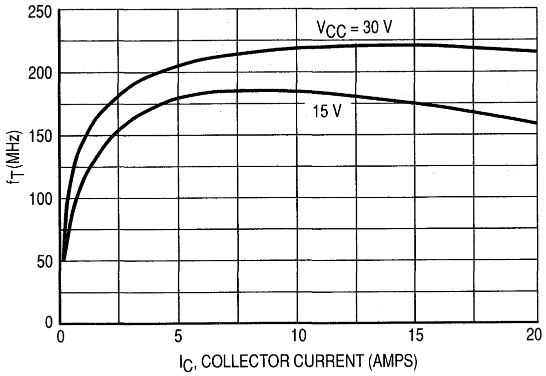


Figure 6. f_T versus Collector Current

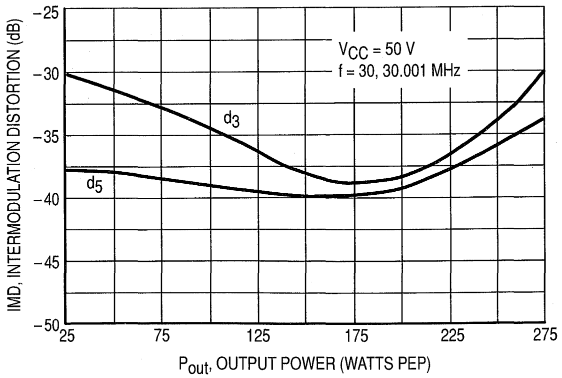


Figure 7. IMD versus P_{out}

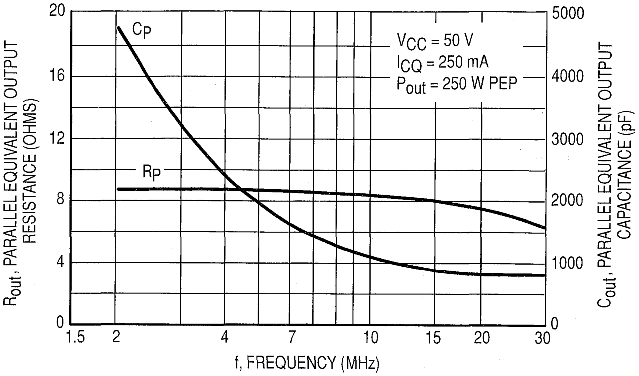
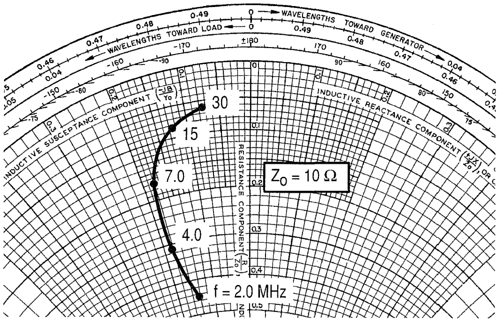


Figure 8. Output Resistance and Capacitance versus Frequency



V_{CC} = 50 V
I_{CQ} = 150 mA
P_{out} = 250 W PEP

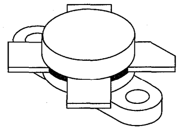
f MHz	Z_{in} Ohms
2.0	4.50 – j1.40
4.0	3.10 – j1.80
7.0	1.70 – j1.75
15	0.80 – j1.25
30	0.60 – j0.75

Figure 9. Series Equivalent Impedance

The RF Line
NPN Silicon RF Power Transistor

MRF454

**80 W, 30 MHz
RF POWER
TRANSISTOR
NPN SILICON**



CASE 211–11, STYLE 1

Designed for power amplifier applications in industrial, commercial and amateur radio equipment to 30 MHz.

- Specified 12.5 Volt, 30 MHz Characteristics —
  Output Power = 80 Watts
  Minimum Gain = 12 dB
  Efficiency = 50%

MAXIMUM RATINGS

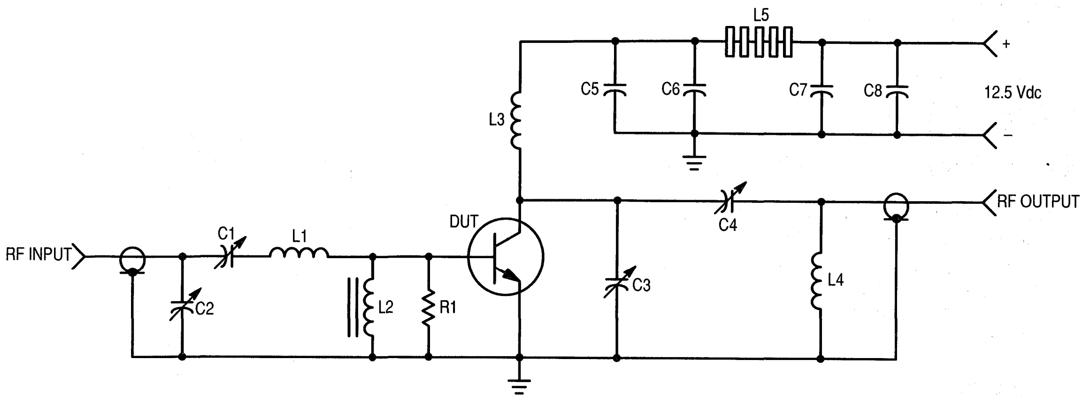
Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	25	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	20	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.7	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	250	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 80 W, f = 30 MHz)	G_{pe}	12	—	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 80 W, f = 30 MHz)	η	50	—	—	%
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 80 W, f = 30 MHz)	Z_{in}	—	.938–j.341	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 80 W, f = 30 MHz)	Z_{out}	—	1.16–j.201	—	Ohms
Parallel Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 80 W, f = 30 MHz)	—	—	1.06 Ω 1817 pF	—	—
Parallel Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 80 W, f = 30 MHz)	—	—	1.19 Ω 777 pF	—	—



C1, C2, C4 — ARCO 469
C3 — ARCO 466
C5 — 1000 pF, UNELCO
C6, C7 — 0.1 µF Disc Ceramic
C8 — 1000 µF/15 V Electrolytic
R1 — 10 Ohm/1.0 Watt, Carbon

L1 — 3 Turns, #18 AWG, 5/16″ I.D., 5/16″ Long
L2 — VK200–20/4B, FERROXCUBE
L3 — 12 Turns, #18 AWG Enameled Wire, 1/4″ I.D., Close Wound
L4 — 3 Turns 1/8″ O.D. Copper Tubing, 3/8″ I.D., 3/4″ Long
L5 — 7 FERRITE Beads, FERROXCUBE #56–590–65/3B

Figure 1. 30 MHz Test Circuit Schematic

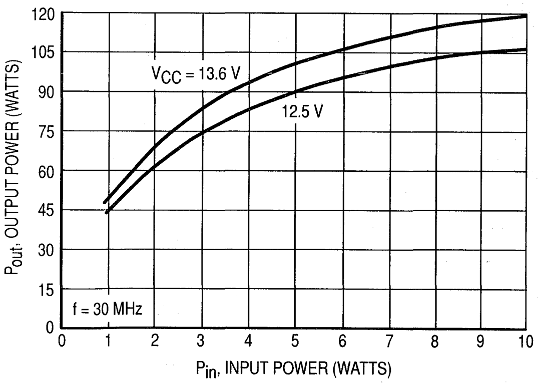


Figure 2. Output Power versus Input Power

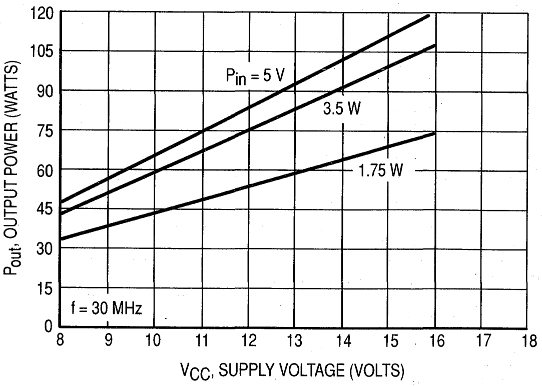


Figure 3. Output Power versus Supply Voltage

The RF Line
NPN Silicon RF Power Transistor

MRF455

. . . designed for power amplifier applications in industrial, commercial and amateur radio equipment to 30 MHz.

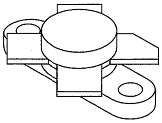
- Specified 12.5 Volt, 30 MHz Characteristics —
  Output Power = 60 Watts
  Minimum Gain = 13 dB
  Efficiency = 55%

60 W, 30 MHz
RF POWER
TRANSISTOR
NPN SILICON

MATCHING PROCEDURE

In the push–pull circuit configuration it is preferred that the transistors are used as matched pairs to obtain optimum performance.

The matching procedure used by Motorola consists of measuring h_{FE} at the data sheet conditions and color coding the device to predetermined h_{FE} ranges within the normal h_{FE} limits. A color dot is added to the marking on top of the cap. Any two devices with the same color dot can be paired together to form a matched set of units.



CASE 211–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	18	Vdc
Collector–Emitter Voltage	V_{CES}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	15	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

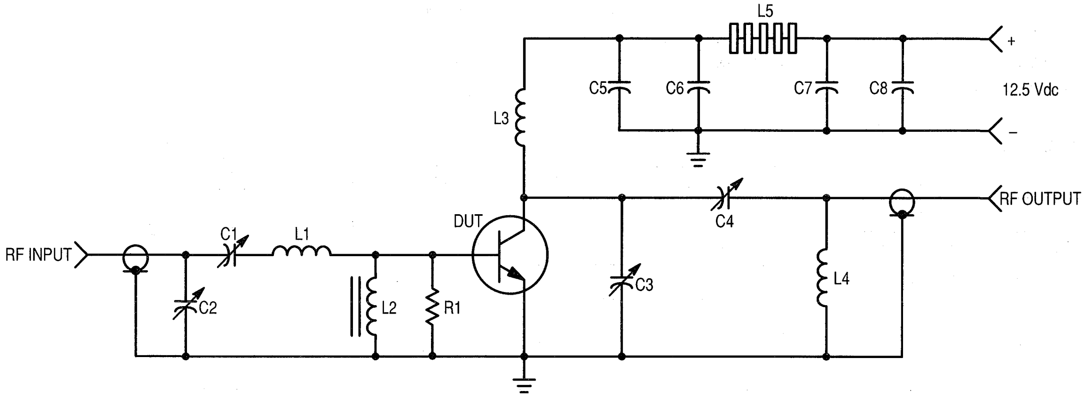
ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	250	pF

(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 30 MHz)	G_{pe}	13	—	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 30 MHz)	η	55	—	—	%
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 30 MHz)	Z_{in}	—	1.66–j.844	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 30 MHz)	Z_{out}	—	1.73–j.188	—	Ohms
Parallel Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 30 MHz)	Z_{in}	—	2.09/1030	—	Ω/pF
Parallel Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 60 W, f = 30 MHz)	Z_{out}	—	1.75/330	—	Ω/pF



C1, C2, C4 — ARCO 469
C3 — ARCO 466
C5 — 1000 pF, UNELCO
C6, C7 — 0.1 µF Disc Ceramic
C8 — 1000 µF/15 V Electrolytic
R1 — 10 Ohm/1.0 Watt, Carbon

L1 — 3 Turns, #18 AWG, 5/16″ I.D., 5/16″ Long
L2 — VK200–20/4B, FERROXCUBE
L3 — 12 Turns, #18 AWG Enameled Wire, 1/4″ I.D., Close Wound
L4 — 3 Turns 1/8″ O.D. Copper Tubing, 3/8″ I.D., 3/4″ Long
L5 — 7 FERRITE Beads, FERROXCUBE #56–590–65/3B

Figure 1. 30 MHz Test Circuit Schematic

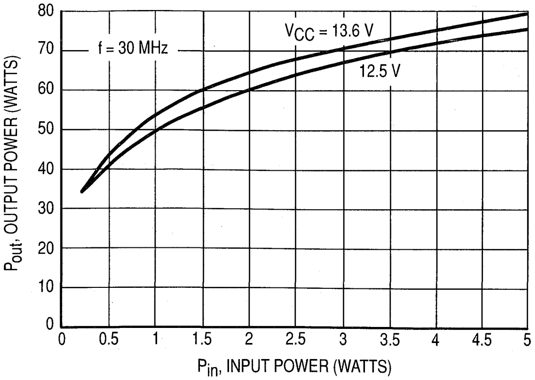


Figure 2. Output Power versus Input Power

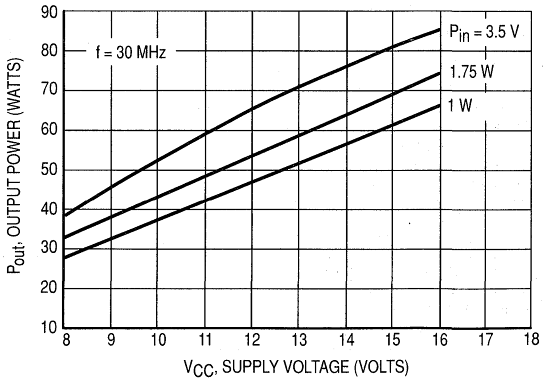


Figure 3. Output Power versus Supply Voltage

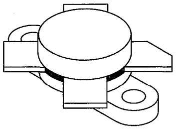
The RF Line
NPN Silicon RF Power Transistor

MRF492

Designed for 12.5 volt low band VHF large–signal power amplifier applications in commercial and industrial FM equipment.

- Specified 12.5 V, 50 MHz Characteristics —
  Output Power = 70 W
  Minimum Gain = 11 dB
  Efficiency = 50%
- Load Mismatch Capability at High Line and RF Overdrive

70 W, 50 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 211–11, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	18	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	20	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

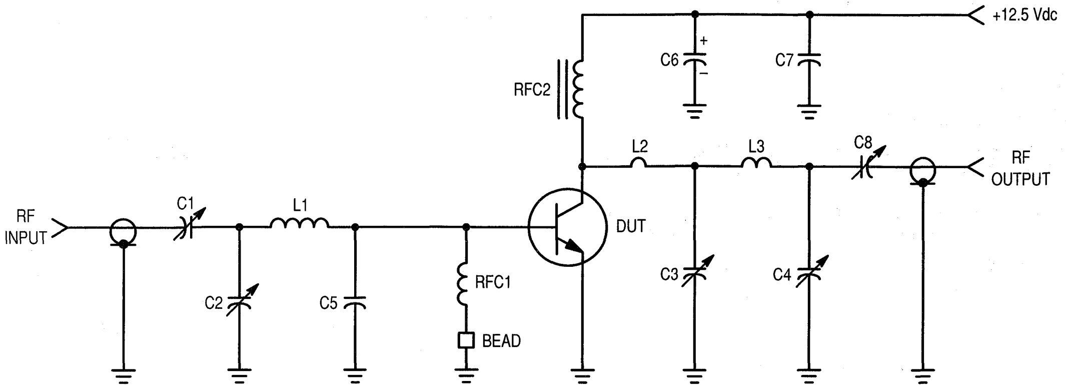
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	0.7	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 13.6 Vdc, V_{BE} = 0)	I_{CES}	—	—	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	275	450	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 70 W, f = 50 MHz)	G_{PE}	11	13	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 70 W, f = 50 MHz)	η	50	—	—	%

NOTES:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.



C1, C8 — 9.0–180 pF, Arco 463	RFC2 — 12 Turns, #16 AWG, Enameled Wire Closewound on a 2.0 W Carbon Resistor
C2, C3, C4 — 80–480 pF, Arco 466	L1 — 2 Turns, #18 AWG Enameled Wire, 0.4″ ID, 0.15″ Long
C5 — 1000 pF, 350 V, Unelco	L2 — Loop, #12 AWG Wire, 0.6″ High, 0.4″ Wide
C6 — 10 µF, 25 Vdc	L3 — 2 Turns, #12 AWG Wire, ID 0.4″, 0.25″ Long
C7 — 0.01 µF, Ceramic	Bead — Ferrite Bead Ferroxcube #56–590–65/3B
RFC1 — 10 µH Molded Choke	

Figure 1. 50 MHz Test Circuit

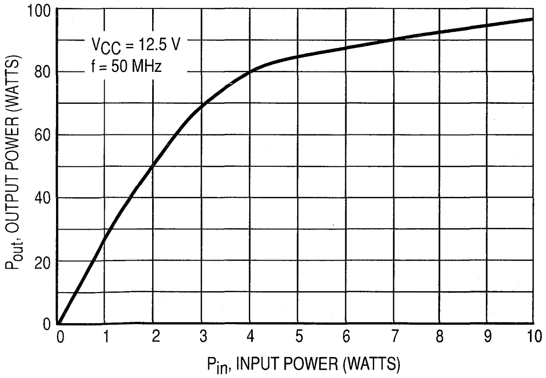


Figure 2. Output Power versus Input Power

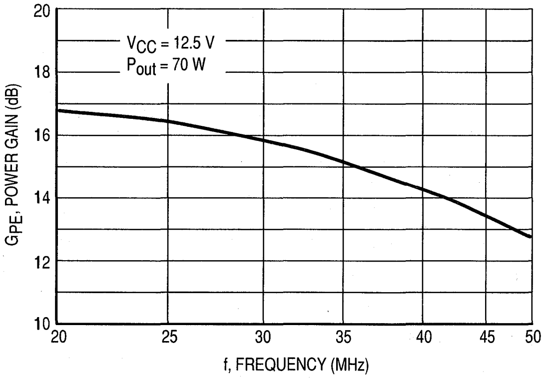


Figure 3. Power Gain versus Frequency

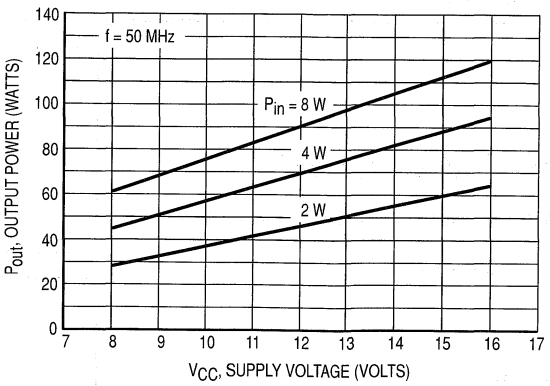
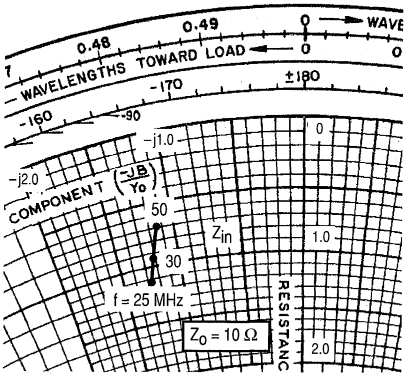


Figure 4. Output Power versus Supply Voltage



V_{CC} = 12.5 V, P_{out} = 70 W

f MHz	Z_{in} Ohms	Z_{OL}^* Ohms
25	1.12 – j1.28	0.85 – j1.46
30	0.93 – j1.24	0.76 – j1.3
50	0.7 – j1.17	0.58 – j1.0

Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

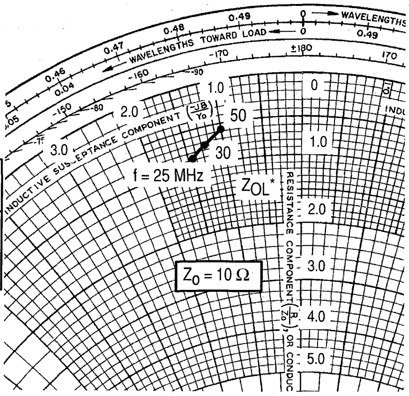


Figure 5. Series Equivalent Input/Output Impedances

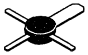
The RF Line
NPN Silicon RF Low Power Transistor

Designed primarily for wideband large signal predriver stages in the VHF frequency range.

- Specified @ 12.5 V, 175 MHz Characteristics
  Output Power = 1.5 W
  Minimum Gain = 11.5 dB
  Efficiency 60% (Typ)
- Cost Effective PowerMacro Package
- Electroless Tin Plated Leads for Improved Solderability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MRF553

1.5 W, 175 MHz
RF LOW POWER
TRANSISTOR
NPN SILICON



CASE 317D–02, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_C = 75°C (1, 2) Derate above 75°C	P_D	3.0 40	Watts mW/°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	—	200	—

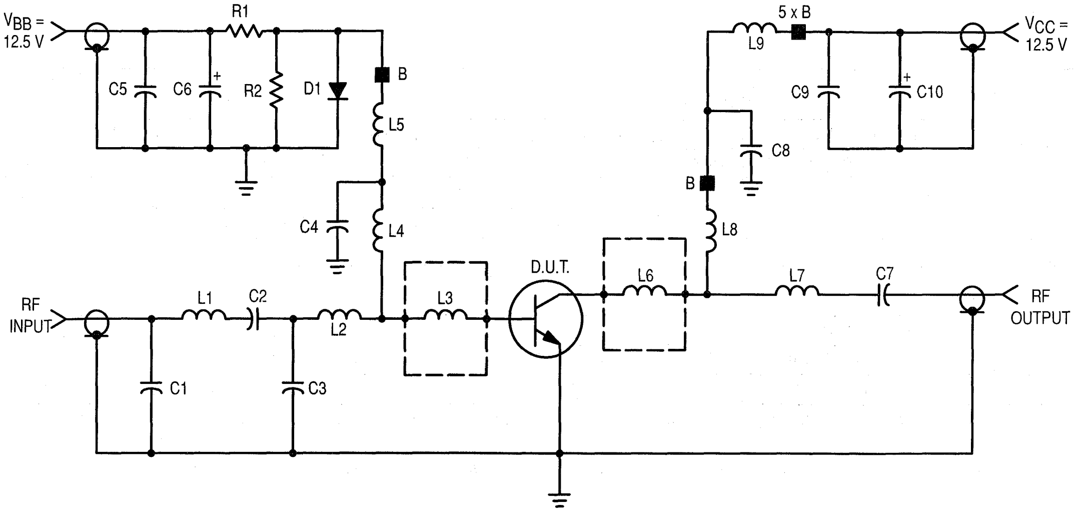
(continued)

NOTES:
1. T_C, Case temperature measured on collector lead immediately adjacent to body of package.
2. The MRF553 PowerMacro must be properly mounted for reliable operation. AN938, “Mounting Techniques in PowerMacro Transistor,” discusses methods of mounting and heatsinking.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	12	20	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain Figures 1, 2 (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 175 MHz)	G_{pe}	11.5	13	—	dB
Collector Efficiency Figures 1, 2 (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 175 MHz)	η	50	60	—	%
Load Mismatch Stress (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 175 MHz, VSWR ≥ 10:1 All Phase Angles)	ψ	No Degradation in Output Power			—



C1 — 36 pF Mini Underwood
C2 — 47 pF Mini Underwood
C3 — 91 pF Mini Underwood
C4 — 68 pF Mini Underwood
C5, C9 — 1.0 µF Erie Red Cap Capacitor
C6, C10 — 0.1 µF, 35 V Tantulum
C7 — 470 pF Chip Capacitor
C8 — 2200 pF Chip Capacitor
R1 — 4.7 kΩ, 1/4 W
R2 — 100 Ω, 1/4 W
D1 — 1N4148 Diode

L1 — 3 Turns, #18 AWG, 0.210″ ID, 3/16″ Length
L2, L4, L7 — 0.62″, #18 AWG Wire Bent into “V”
L3, L6 — 60 x 125 x 250 Mils Copper Pad on 27 Mils Thick Alumina Substrate
L5 — 12 µH Molded Choke
L8 — 7 Turns, #18 AWG, 0.170″ ID, 7/16″ Length
L9 — 1.0″, #18 AWG Wire with 5 Ferrite Beads
B — Ferrite Bead
Board Material — Glass Teflon, ε_r = 2.56, t = 0.0625″

Figure 1. 140–175 MHz Broadband Circuit Schematic

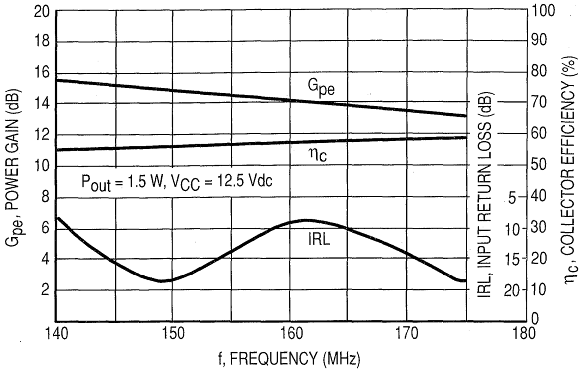


Figure 2. Typical Performance in Broadband Circuit

f Frequency MHz	Z_{in} Ohms						Z_{OL}* Ohms					
	V_{CC} = 7.5 V; P_{in}			V_{CC} = 12.5 V; P_{in}			V_{CC} = 7.5 V; P_{out}			V_{CC} = 12.5 V; P_{out}		
	100 mW	**200 mW**	**300 mW**	**50 mW**	**100 mW**	**150 mW**	**1.0 W**	**1.6 W**	**2.2 W**	**1.1 W**	**2.0 W**	**2.6 W**
140	1.65–j3.6	2.0–j2.6	2.3–j1.2	1.7–j4.1	1.8–j3.1	1.9–j2.7	9.9–j11.1	10.6–j5.1	10–j4.9	28.3–j21.5	16–j20.5	16.3–j16.5
175	2.5–j5.6	2.3–j5.9	2.8–j4.0	2.3–j4.6	2.4–j1.2	2.4–j5.7	12.1–j14.9	7.2–j9.8	8.1–j5.4	30.8–j23.3	11.4–j20.9	11.1–j14.3

f Frequency MHz	Z_{in} Ohms						Z_{OL}* Ohms					
	V_{CC} = 7.5 V; P_{in}			V_{CC} = 12.5 V; P_{in}			V_{CC} = 7.5 V; P_{out}			V_{CC} = 12.5 V; P_{out}		
	50 mW	**100 mW**	**200 mW**	**25 mW**	**50 mW**	**100 mW**	**1.25 W**	**1.5 W**	**2.0 W**	**1.5 W**	**2.25 W**	**3.0 W**
90	2.5–j9.3	2.5–j6.4	2.5–j4.4	1.6–j10.7	2.5–j7.1	2.2–j1.3	31.8–j9.2	32–j8.9	30.2–j10.7	45.8–j7.2	45.2–j3.9	40–j4.5

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 1. Z_{in} and Z_{OL} versus Collector Voltage, Input Power, and Output Power

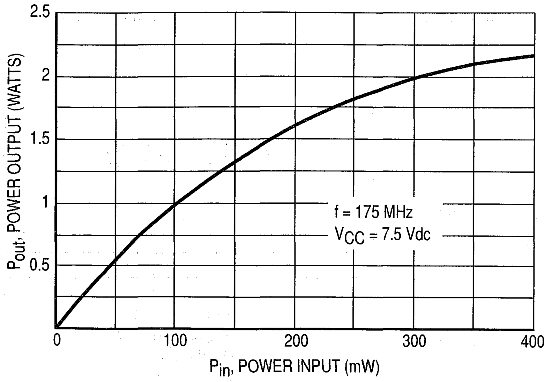


Figure 3. Power Output versus Power Input

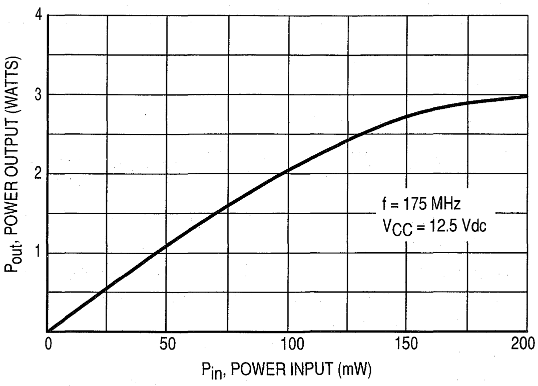


Figure 4. Power Output versus Power Input

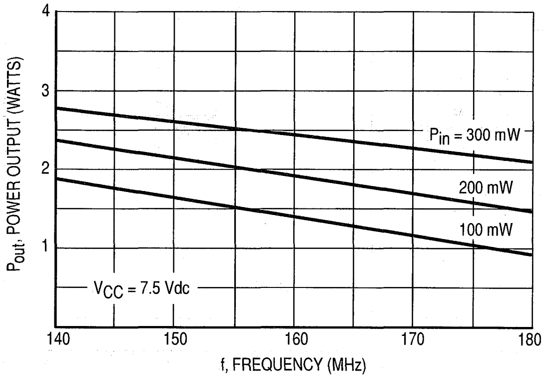


Figure 5. Power Output versus Frequency

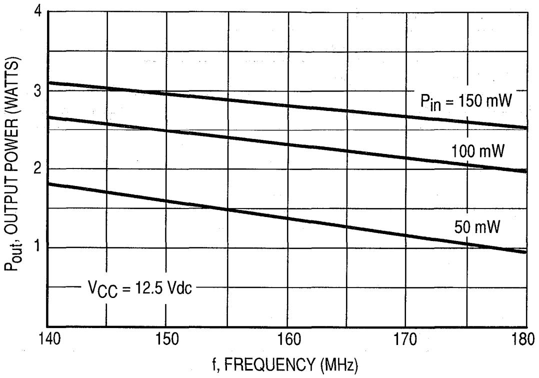


Figure 6. Power Output versus Frequency

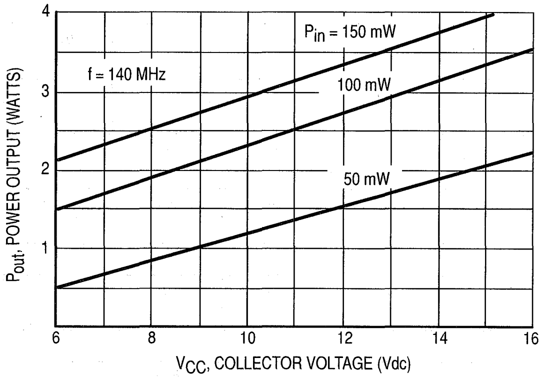


Figure 7. Power Output versus Collector Voltage

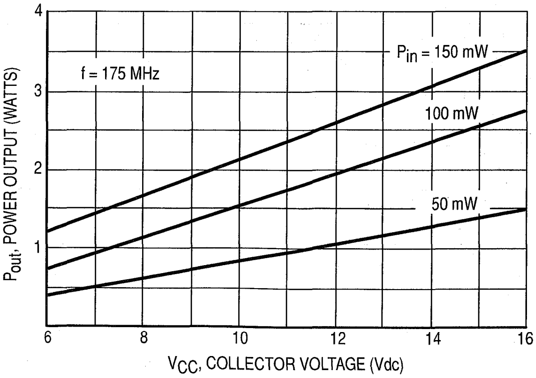


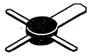
Figure 8. Power Output versus Collector Voltage

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
NPN Silicon RF Low Power Transistor

MRF555

1.5 W, 470 MHz
RF LOW POWER
TRANSISTOR
NPN SILICON



CASE 317D–02, STYLE 2

Designed primarily for wideband large signal predriver stages in the UHF frequency range.

- Specified @ 12.5 V, 470 MHz Characteristics @ P_{out} = 1.5 W
  Common Emitter Power Gain = 12.5 dB (Typ)
  Efficiency 60% (Typ)
- Cost Effective PowerMacro Package
- Electroless Tin Plated Leads for Improved Solderability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Operating Junction Temperature	T_J	150	°C
Total Device Dissipation @ T_C = 75°C (1, 2) Derate above 75°C	P_D	3.0 40	Watts mW/°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	90	200	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.5	5.0	pF

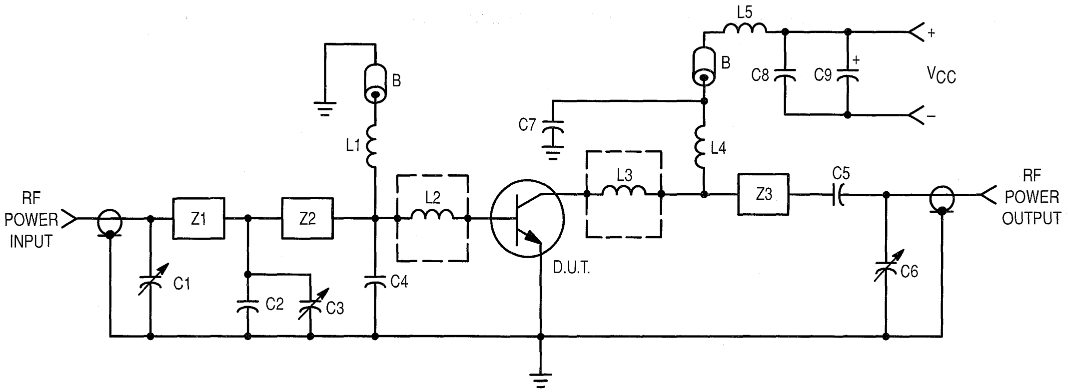
(continued)

NOTES:
1. T_C, Case temperature measured on collector lead immediately adjacent to body of package.
2. The MRF555 PowerMacro must be properly mounted for reliable operation. AN938, "Mounting Techniques in PowerMacro Transistor," discusses methods of mounting and heatsinking.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (f = 470 MHz)					
Common–Emitter Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W)	G_{pe}	11	12.5	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W)	η_c	50	60	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, P_{in} = 125 mW, VSWR ≥ 10:1 all phase angles)	ψ	No Degradation in Output Power			



*C1, C3, C6 — 0.8−11 pF Johanson
C2 — 15 pF Clamped Mica, Mini–Underwood
C4 — 36 pF Clamped Mica, Mini–Underwood
C5 — 470 pF Ceramic Chip Capacitor
C7 — 91 pF Clamped Mica, Mini–Underwood
C8 — 68 pF Clamped Mica, Mini–Underwood
C9 — 1.0 µF, 25 V Tantalum
B — Bead, Ferroxcube 56–590–65/3B

*Fixed tuned for broadband response

L1 — 5 Turns #21 AWG, 5/32″ I.D.
L2, L3 — 60 x 125 x 250 Mils Copper Pad on 27 Mil Thick Alumina Substrate
L4, L5 — 7 Turns #21 AWG 5/32″ I.D.
Z1 — 1.29″ x 0.16″ Microstrip
Z2 — 0.70″ x 0.16″ Microstrip
Z3 — 2.18″ x 0.16″ Microstrip

PCB — 1/16″ Glass Teflon, 1 oz. cu. clad, double sided, ε_r = 2.5

Figure 1. 400−512 MHz Broadband Circuit

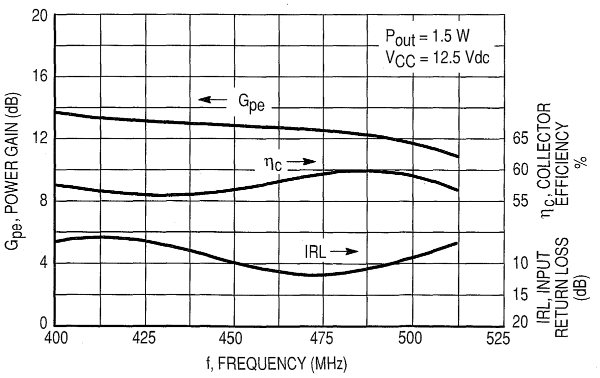


Figure 2. Performance in Broadband Circuit

f Frequency MHz	Z_{in} Ohms		Z_{OL}* Ohms	
	V_{CC} = 7.5 V	V_{CC} = 12.5 V	V_{CC} = 7.5 V	V_{CC} = 12.5 V
	P_{in} = 100 mW	P_{in} = 50 mW	P_{out} 400 MHz = 1.5 W P_{out} 450 MHz = 1.35 W P_{out} 512 MHz = 1.05 W	P_{out} 400 MHz = 1.9 W P_{out} 450 MHz = 1.45 W P_{out} 512 MHz = 0.9 W
400	2.9 – j2.7	1.9 – j3.1	18.0 – j13.4	12.2 – j19.7
450	2.2 – j0.8	2.6 – j4.0	21.6 = j9.9	20.2 – j18.6
512	3.5 – j1.2	2.6 – j2.6	20.1 – j1.0	23.4 – j23.0

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 1. Z_{in} and Z_{OL} versus Collector Voltage, Input Power and Output Power

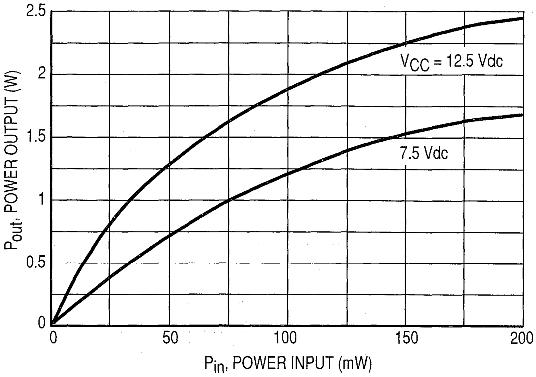


Figure 3. Power Output versus Power Input

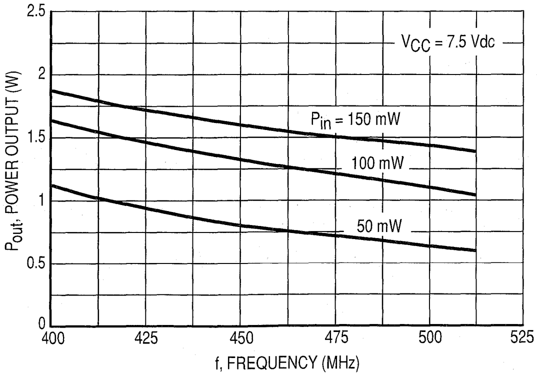


Figure 4. Power Output versus Frequency

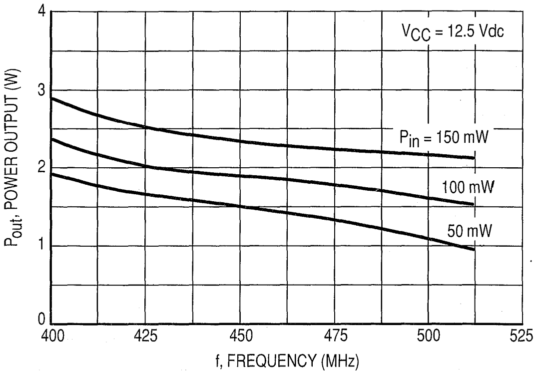


Figure 5. Power Output versus Frequency

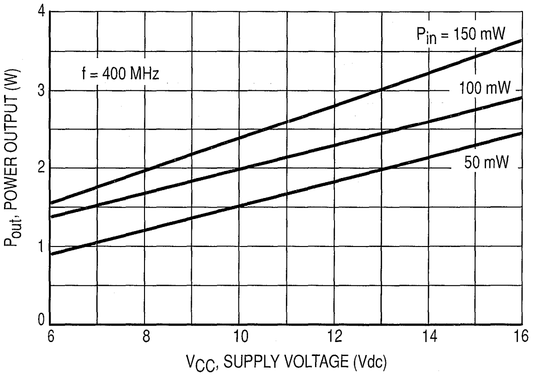


Figure 6. Power Output versus Supply Voltage

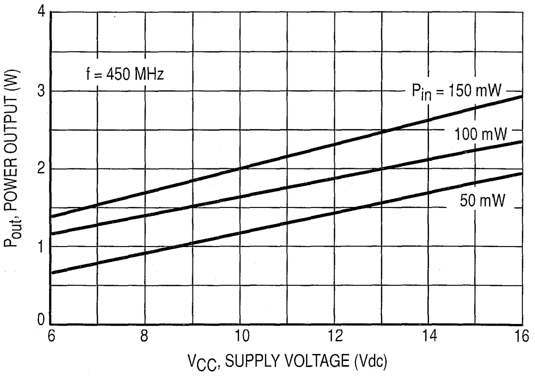


Figure 7. Power Output versus Supply Voltage

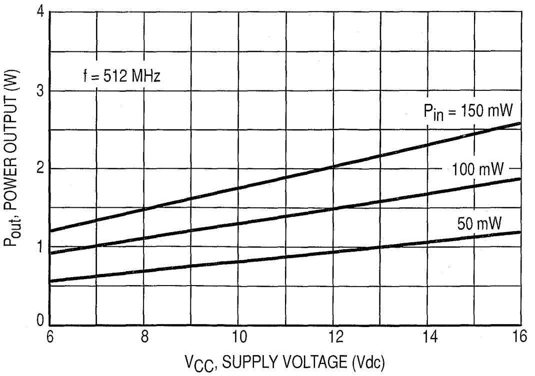


Figure 8. Power Output versus Supply Voltage

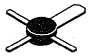
The RF Line
NPN Silicon
RF Low Power Transistor

MRF557

**1.5 W, 870 MHz
RF LOW POWER
TRANSISTOR
NPN SILICON**

Designed primarily for wideband large signal predriver stages in the 800 MHz frequency range.

- Specified @ 12.5 V, 870 MHz Characteristics
  Output Power = 1.5 W
  Minimum Gain = 8.0 dB
  Efficiency 60% (Typ)
- Cost Effective PowerMacro Package
- Electroless Tin Plated Leads for Improved Solderability
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 317D–02, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 75°C$ (1, 2) Derate above 75°C	P_D	3.0 40	Watts mW/°C
Storage Temperature Range	T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_C = 25°C$)	I_{CES}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	50	90	200	—
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	3.5	5.0	pF

NOTES:

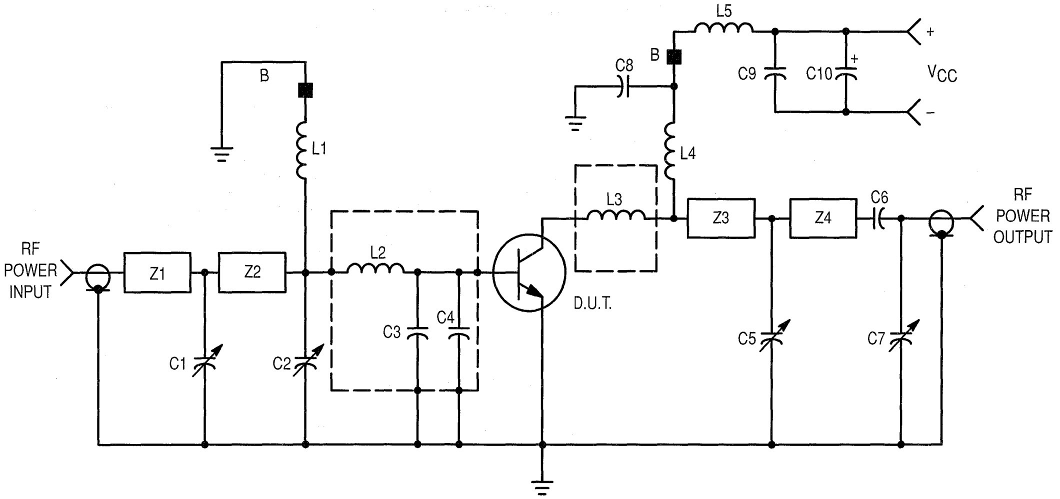
(continued)

1. T_C, Case temperature measured on collector lead immediately adjacent to body of package.
2. The MRF557 PowerMacro must be properly mounted for reliable operation. AN938, “Mounting Techniques in PowerMacro Transistor,” discusses methods of mounting and heatsinking.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain Figures 1, 2 (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 870 MHz)	G_{pe}	8.0	9.0	—	dB
Collector Efficiency Figures 1, 2 (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 870 MHz)	η_c	55	60	—	%
Load Mismatch Stress Figures 1, 2 (V_{CC} = 15.5 Vdc, P_{in} = 225 mW, f = 870 MHz, VSWR ≥ 10:1 all phase angles)	ψ	No Degradation in Output Power			



C1, C2, C5, C7 — 0.8–8.0 pF Johanson Gigatrim*
C3, C4 — 15 pF Clamped Mica, Mini–Underwood
C6 — 27 pF Clamped Mica, Mini–Underwood
C8 — 91 pF Clamped Mica, Mini–Underwood
C9 — 68 pF Clamped Mica, Mini–Underwood
C10 — 1.0 µF, 25 V Tantalum
B — Bead, Ferroxcube 56–590–65/3B
PCB — 1/16″ Glass Teflon, ε_r = 2.56

L1, L4 — 5 Turns #21 AWG, 5/32″ ID
L2, L3 — 60 x 125 x 250 Mils Copper Tab on 27 Mil Thick Alumina Substrate
L5 — 7 Turns #21 AWG, 5/32″ ID
Z1 — 1.65 x 0.163″ Microstrip, Z_o = 50 Ω
Z2 — 0.85 x 0.163″ Microstrip, Z_o = 50 Ω
Z3 — 0.625 x 0.163″ Microstrip, Z_o = 50 Ω
Z4 — 1.35 x 0.163″ Microstrip, Z_o = 50 Ω

*Fixed tuned for broadband response.

Figure 1. 800–880 MHz Broadband Circuit

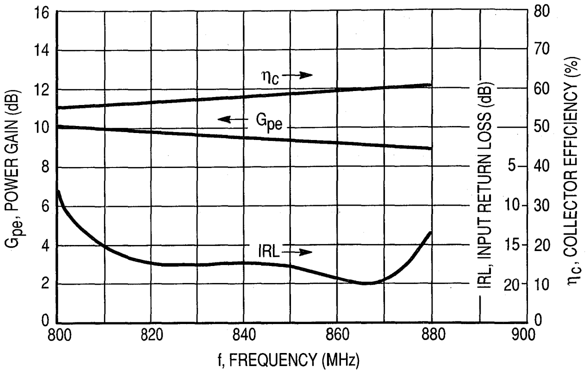


Figure 2. Performance in Broadband Circuit

f Frequency MHz	Z_{in} Ohms		Z_{OL}* Ohms	
	V_{CC} = 7.5 V	V_{CC} = 12.5 V	V_{CC} = 7.5 V	V_{CC} = 12.5 V
	P_{in} = 300 mW	P_{in} = 200 mW	P_{out} 806 MHz = 1.7 W P_{out} 870 MHz = 1.4 W P_{out} 960 MHz = 1.0 W	P_{out} 806 MHz = 2.1 W P_{out} 870 MHz = 1.8 W P_{out} 960 MHz = 1.1 W
806	2.4 + j3.9	2.4 + j3.1	14.7 – j4.4	13.6 – j12.8
870	2.5 + j4.6	2.7 + j3.7	17.2 – j8.6	16 – j13.2
960	6.1 + j7.4	6.8 + j8.3	40 – j8.3	38 – j10.5

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 1. Z_{in} and Z_{OL} versus Collector Voltage, Input Power and Output Power

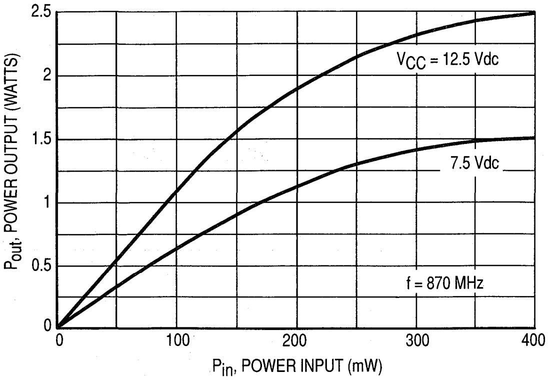


Figure 3. Power Output versus Power Input

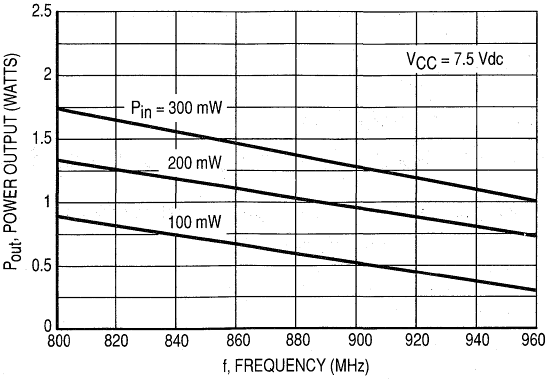


Figure 4. Power Output versus Frequency

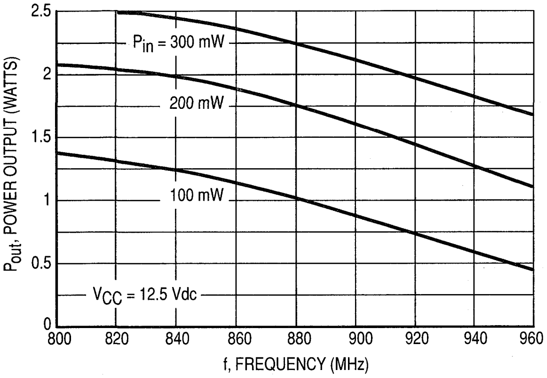


Figure 5. Power Output versus Frequency

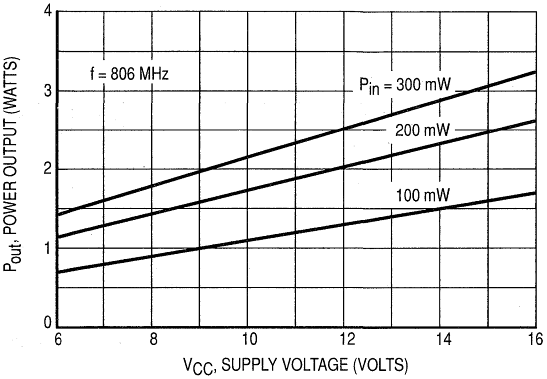


Figure 6. Power Output versus Supply Voltage

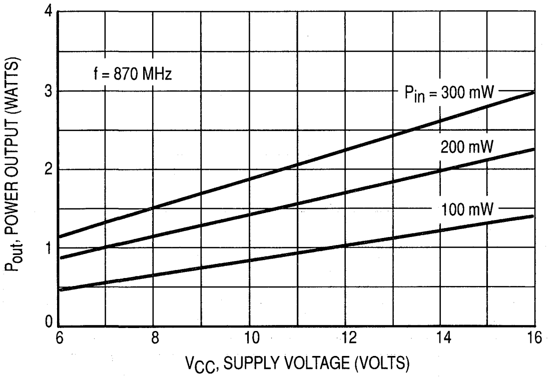


Figure 7. Power Output versus Supply Voltage

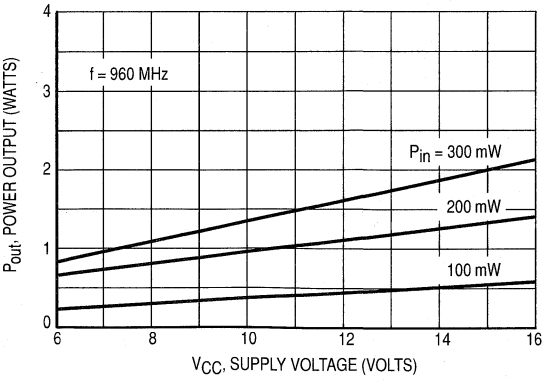


Figure 8. Power Output versus Supply Voltage

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

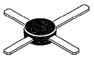
The RF Line
NPN Silicon High-Frequency Transistor

MRF559

. . . designed for UHF linear and large–signal amplifier applications.

- Specified 12.5 Volt, 870 MHz Characteristics —
  Output Power = 0.5 Watts
  Minimum Gain = 8.0 dB
  Efficiency 50%
- S Parameter Data From 250 MHz to 1.5 GHz
- 1.0 dB Compression > +20 dBm Typ
- Ideally Suited for Broadband, Class A, Low–Noise Applications
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

**0.5 W, 870 MHz
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON**



CASE 317–01, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	2.0 20	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	$V_{(BR)EBO}$	3.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	90	200	—
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	f_T	—	3000	—	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.0	2.5	pF

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS						
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	G_{PE}	8.0 —	9.5 13	— —	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	η	50 —	65 60	— —	%
TYPICAL PERFORMANCE @ V_{CC} = 7.5 V						
Common–Emitter Amplifier Power Gain (V_{CC} = 7.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	G_{PE}	— —	6.5 10	— —	dB
Collector Efficiency (V_{CC} = 7.5 Vdc, P_{out} = 0.5 W)	f = 870 MHz f = 512 MHz	η	— —	70 65	— —	%

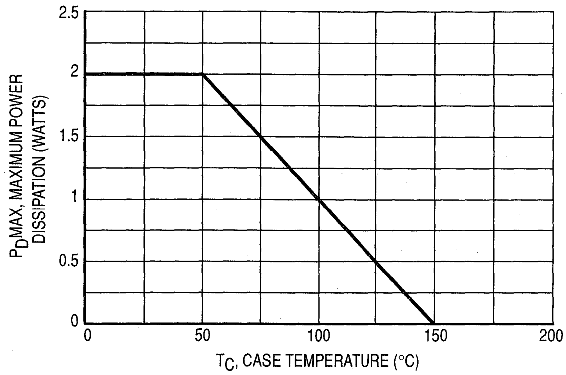
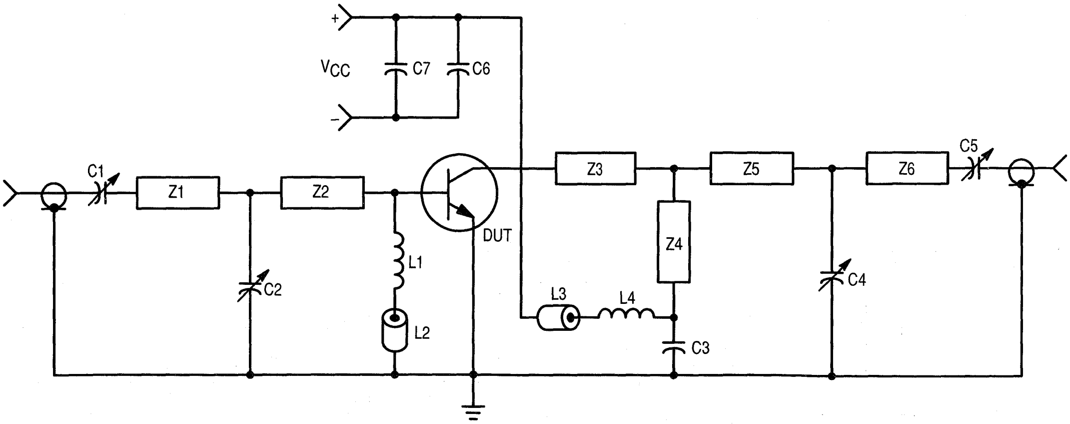


Figure 1. Power Dissipation



C1, C2, C4, C5 — 1.0–10 pF Johanson
C3, C6 — 0.001 µF Chip Capacitor
C7 — 1.0 µF Tantalum
L1, L4 — 4 Turns #26 AWG, 0.3 cm ID, 0.4 cm Long
L2, L3 — Ferrite Bead
Microstrip Elements — ε_r = 2.55

Z1 — 50 Ω 1.5 cm
Z2 — 30 Ω 2.5 cm
Z3 — 50 Ω 2.0 cm
Z4 — 50 Ω 1.2 cm
Z5, Z6 — 50 Ω 1.25 cm

Figure 2. 870 MHz Test Fixture

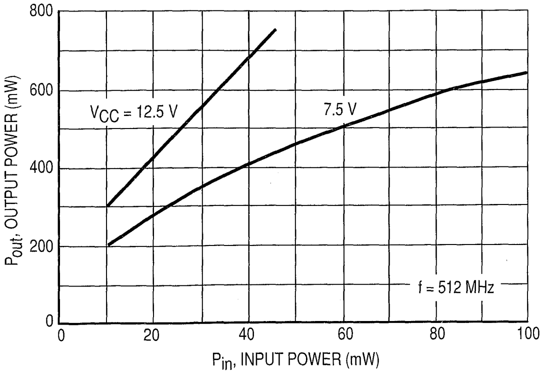


Figure 3. Output Power versus Input Power

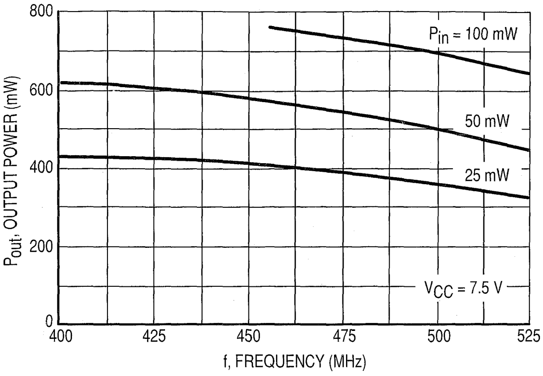


Figure 4. Output Power versus Frequency

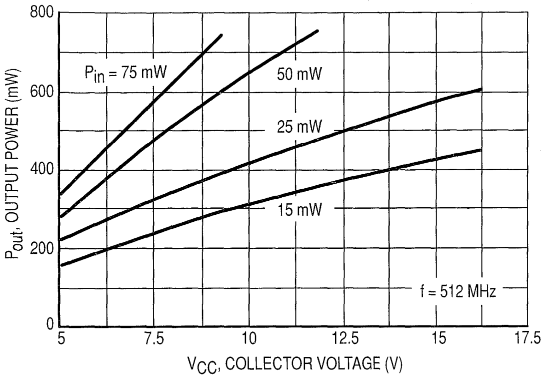


Figure 5. Output Power versus Collector Voltage

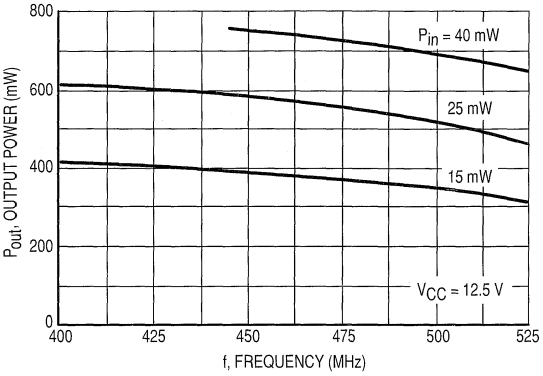


Figure 6. Output Power versus Frequency

f Frequency MHz	Z_{in} Ohms			Z_{OL}* Ohms					
	V_{CC} = 7.5–12.5 V			V_{CC} = 7.5 V			V_{CC} = 12.5 V		
	15 mW	**25 mW**	**50 mW**	**0.25 W**	**0.5 W**	**0.75 W**	**0.25 W**	**0.5 W**	**0.75 W**
400	4.3 – j13.3	4.9 – j11.0	5.7 – j8.7	31 – j49	44 – j34	42 – j4.9	20 – j68	42 – j60	52 – j54
440	3.9 – j8.8	4.5 – j8.7	5.4 – j6.9	27 – j42	39 – j30	40 – j6.9	19 – j62	37 – j54	49 – j50
480	3.5 – j4.4	4.1 – j6.5	5.0 – j4.3	24 – j36	36 – j25	39 – j9.0	18 – j56	33 – j48	47 – j46
520	3.2 – j2.2	3.8 – j4.3	4.7 – j1.7	22 – j30	34 – j20	37 – j12	17 – j52	31 – j44	47 – j42

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 1. Z_{in} and Z_{OL} versus Collector Voltage, Input Power, and Output Power

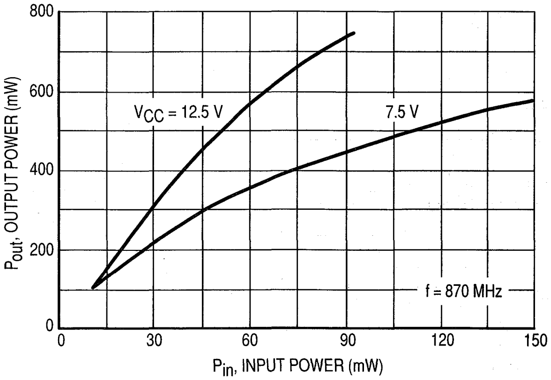


Figure 7. Output Power versus Input Power

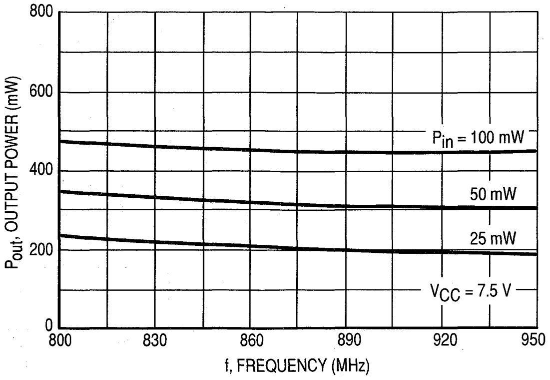


Figure 8. Output Power versus Frequency

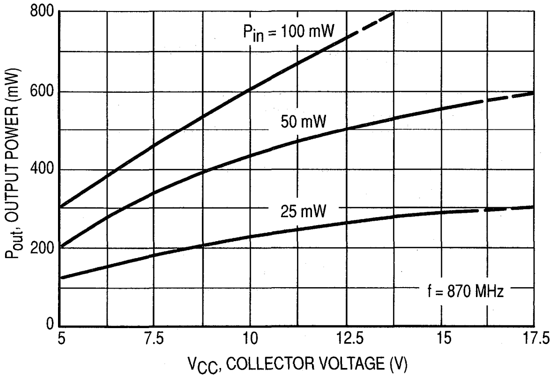


Figure 9. Output Power versus Collector Voltage

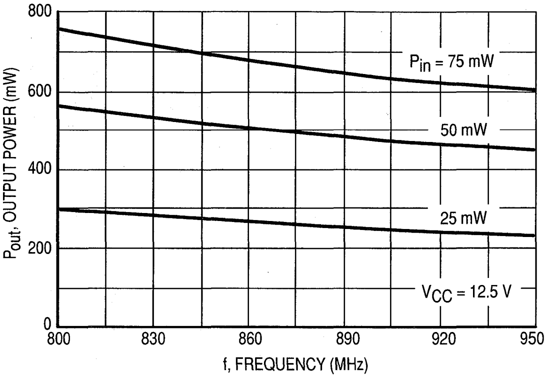
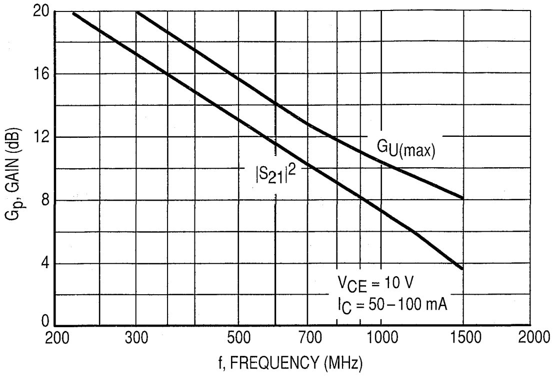


Figure 10. Output Power versus Frequency

f Frequency MHz	Z_{in} Ohms			Z_{OL}* Ohms					
	V_{CC} = 7.5–12.5 V			V_{CC} = 7.5 V			V_{CC} = 12.5 V		
	25 mW	**50 mW**	**100 mW**	**0.25 W**	**0.5 W**	**0.75 W**	**0.25 W**	**0.5 W**	**0.75 W**
800	2.9 + j2.2	3.8 + j4.4	4.7 + j6.5	15.0 – j36.8	22.7 – j30.6	27.1 – j22.6	14.6 – j43.6	17.2 – j39.7	23.4 – j37.7
850	3.2 + j3.5	3.8 + j5.2	4.8 + j7.4	15.7 – j35.3	23.9 – j28.7	27.3 – j21.5	16.3 – j40.8	17.8 – j39.5	23.7 – j36.8
900	3.8 + j5.7	4.4 + j7.0	5.4 + j8.7	16.4 – j33.7	25.1 – j27.0	27.5 – j20.5	17.3 – j38.2	18.3 – j39.3	23.9 – j36.0
950	4.1 + j7.4	4.5 + j8.8	5.5 + j10.1	17.0 – j32.2	26.3 – j25.2	27.6 – j19.4	17.2 – j36.1	20.1 – j38.5	24.5 – j35.6

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 2. Z_{in} and Z_{OL} versus Collector Voltage, Input Power, and Output Power



$$G_{U(max)} = \frac{|S_{21}|^2}{(1 - |S_{11}|^2)(1 - |S_{22}|^2)}$$

Figure 11. Gain versus Frequency

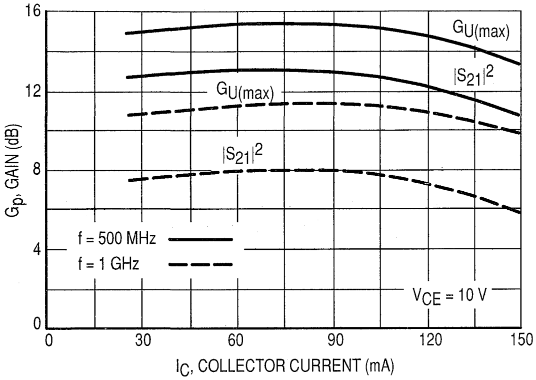


Figure 12. Gain versus Collector Current

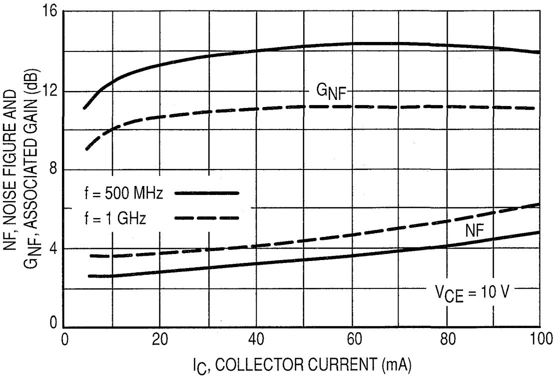


Figure 13. Noise Figure and Associated Gain versus Collector Current

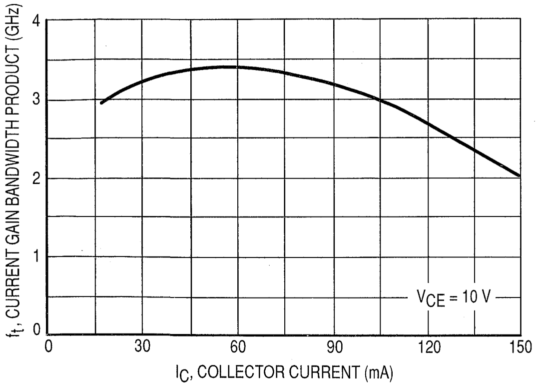


Figure 14. Current Gain Bandwidth Product versus Collector Current

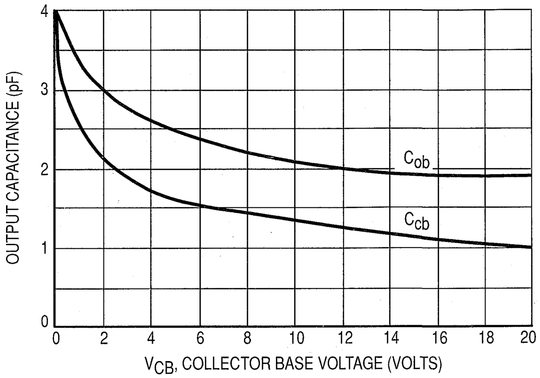


Figure 15. Output Capacitance versus Collector Base Voltage

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
5.0	10	250	0.72	−161	6.20	93	0.057	30	0.30	−91
		500	0.73	179	3.16	76	0.069	43	0.27	−94
		1000	0.76	158	1.62	55	0.105	63	0.27	−119
		1500	0.82	142	1.08	41	0.155	70	0.41	−137
	25	250	0.70	−173	7.17	89	0.045	47	0.26	−123
		500	0.70	172	3.63	75	0.073	60	0.20	−128
		1000	0.74	152	1.90	54	0.134	67	0.21	−157
		1500	0.79	136	1.32	39	0.196	66	0.32	−167
	50	250	0.72	−178	7.63	89	0.038	56	0.27	−139
		500	0.72	170	3.85	77	0.068	67	0.23	−141
		1000	0.75	153	2.01	59	0.129	72	0.23	−162
		1500	0.81	137	1.40	46	0.188	70	0.32	−164
	100	250	0.73	179	7.34	88	0.036	61	0.26	−143
		500	0.74	169	3.70	77	0.067	71	0.22	−144
		1000	0.76	153	1.94	59	0.130	74	0.24	−166
		1500	0.81	138	1.36	46	0.191	71	0.32	−167
	150	250	0.78	176	5.19	92	0.033	64	0.22	−131
		500	0.78	167	2.76	78	0.065	74	0.21	−131
		1000	0.80	151	1.49	58	0.129	77	0.24	−155
		1500	0.85	135	1.05	45	0.191	73	0.35	−161
10	10	250	0.69	−157	7.03	94	0.050	33	0.34	−67
		500	0.70	−178	3.59	77	0.060	46	0.32	−69
		1000	0.74	160	1.84	55	0.094	67	0.29	−94
		1500	0.81	142	1.20	41	0.148	76	0.42	−121
	25	250	0.67	−168	8.30	91	0.039	46	0.24	−93
		500	0.68	176	4.25	77	0.060	60	0.21	−89
		1000	0.72	158	2.19	57	0.109	71	0.19	−114
		1500	0.78	142	1.47	44	0.165	74	0.31	−134
	50	250	0.68	−174	8.88	90	0.035	55	0.21	−110
		500	0.68	172	4.49	77	0.060	67	0.18	−104
		1000	0.72	155	2.31	59	0.113	74	0.17	−128
		1500	0.77	139	1.58	46	0.169	74	0.28	−140
	100	250	0.68	−178	8.49	89	0.030	61	0.19	−104
		500	0.69	170	4.32	76	0.060	71	0.17	−97
		1000	0.72	153	2.25	58	0.120	76	0.17	−123
		1500	0.78	137	1.53	44	0.180	75	0.28	−137
	150	250	0.72	178	6.53	91	0.029	64	0.22	−71
		500	0.73	169	3.37	77	0.056	75	0.24	−75
		1000	0.76	152	1.79	57	0.112	80	0.22	−105
		1500	0.83	137	1.22	43	0.175	79	0.34	−129

Table 3. Common Emitter Scattering Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

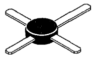
The RF Line
NPN Silicon High-Frequency Transistors

MRF581
MRF581A
MRF5812, R1, R2

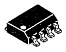
Designed for high current low power amplifiers up to 1.0 GHz.

- Low Noise (2.0 dB @ 500 MHz)
- Low Intermodulation Distortion
- High Gain
- State–of–the–Art Technology
  - Fine Line Geometry
  - Arsenic Emitters
  - Gold Top Metallization
  - Nichrome Thin–Film Ballasting Resistors
- Excellent Dynamic Range
- Fully Characterized
- High Current–Gain Bandwidth Product
- MRF5812 available in tape and reel packaging by adding suffix:
  - R1 suffix = 500 units per reel
  - R2 suffix = 2,500 units per reel

I_C = 200 mA
LOW NOISE
HIGH–FREQUENCY
TRANSISTORS
NPN SILICON



CASE 317–01, STYLE 2
MRF581,A



CASE 751–05, STYLE 1
SORF (SO–8)
MRF5812

MAXIMUM RATINGS

Rating		Symbol	MRF581	MRF581A	MRF5812	Unit
Collector–Emitter Voltage		V_{CEO}	18	15	15	Vdc
Collector–Base Voltage		V_{CBO}	36	30	30	Vdc
Emitter–Base Voltage		V_{EBO}	2.5			Vdc
Collector Current — Continuous		I_C	200			mAdc
Thermal Resistance θJC (1)	MRF581, A	$R_{\theta JC}$	40			°C/W
Thermal Resistance θJC (1)	MRF5812	$R_{\theta JC}$	45			°C/W
Total Device Dissipation @ T_C = 75°C (1) Derate above T_C = 75°C	MRF581, A	P_D	1.88 25			Watts mW/°C
Total Device Dissipation @ T_C = 75°C (1) Derate above T_C = 75°C	MRF5812	P_D	1.67 22.2			Watts mW/°C
Storage Junction Temperature Range		T_{stg}	– 55 to +150			°C
Maximum Junction Temperature		T_{Jmax}	150			°C

DEVICE MARKING

MRF5812 = 5812

NOTES:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MRF581,A	$V_{(BR)CEO}$	18 15	— —	— —	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	MRF5812	$V_{(BR)CEO}$	15	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	MRF5812	$V_{(BR)CES}$	30	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	MRF581,A	$V_{(BR)CBO}$	36 30	— —	— —	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	MRF581,A MRF5812	$V_{(BR)EBO}$	2.5	—	—	Vdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, V_{BE} = 0)	MRF581,A	I_{EBO}	—	—	100	µAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	MRF581,A	I_{CBO}	—	—	100	µAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	MRF5812	I_{CBO}	—	—	0.1	mAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	MRF581 MRF581A	h_{FE}	50 90	— —	200 250	—
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	MRF5812	h_{FE}	30	90	200	—
DYNAMIC CHARACTERISTICS						
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MRF581,A	C_{ob}	—	1.4	2.0	pF
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MRF5812	C_{cb}	—	1.2	2.0	pF
Current–Gain Bandwidth Product (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	MRF581,A	f_T	—	5.0	—	GHz
Current–Gain — Bandwidth Product (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	MRF5812	f_T	—	5.5	—	GHz
FUNCTIONAL TESTS						
Noise Figure (Minimum) (Figure 11) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MRF581 MRF581A	NF_{min}	— —	2.0 1.8	3.0 2.5	dB
Noise Figure (Minimum) (Figure 11) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MRF5812	NF_{min}	—	2.0	—	dB
Noise Figure (50 Ohm Insertion) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MRF5812	$NF_{50\,\Omega}$	—	2.5	3.0	dB
Power Gain at Optimum Noise Figure (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MRF581,A	G_{NF}	13	15.5	—	dB
Insertion Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)	MRF5812	$\|S_{21}\|^2$	13	15.5	—	dB
Maximum Unilateral Gain (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 0.5 GHz)		G_{Umax}(2)	—	17	—	dB
Intermodulation Distortion (3) (V_{CE} = 10 V, I_C = 75 mA, V_{out} = +50 dBmV)		IMD(d3)	—	−65	—	dB

NOTES:

1. 300 µs pulse on Tektronix 576 or equivalent.
2. $G_{Umax} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$
3. 2 Tones, f1 = 497 MHz, f2 = 503 MHz, 3rd Order Single Tone reference.

TYPICAL CHARACTERISTICS
MRF581, MRF581A

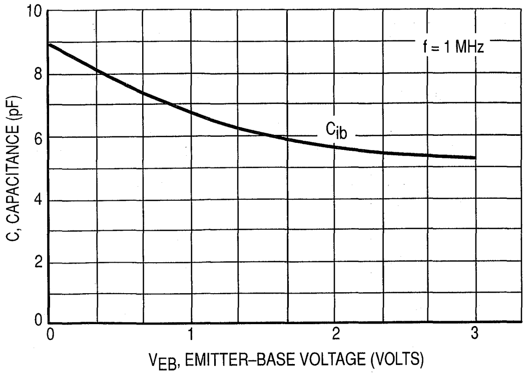


Figure 1. C_{ib} Input Capacitance versus Voltage

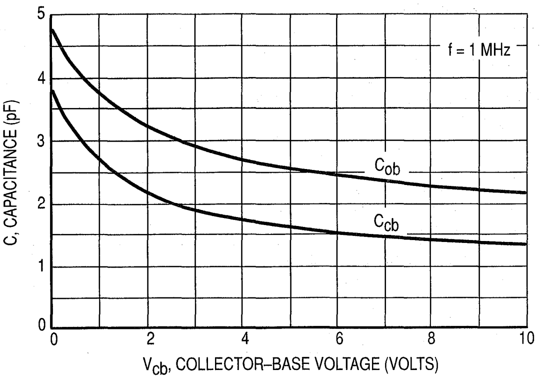


Figure 2. C_{cb}, C_{ob} Collector–Base Capacitance versus Voltage

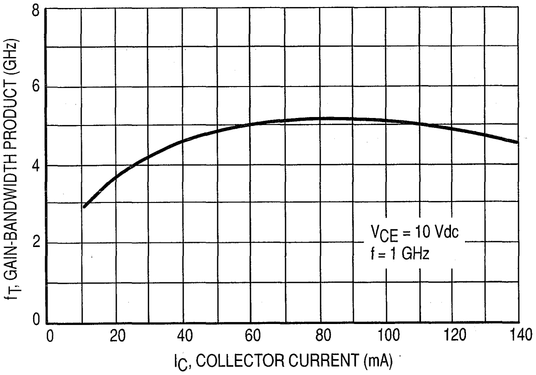


Figure 3. Gain–Bandwidth Product versus Collector Current

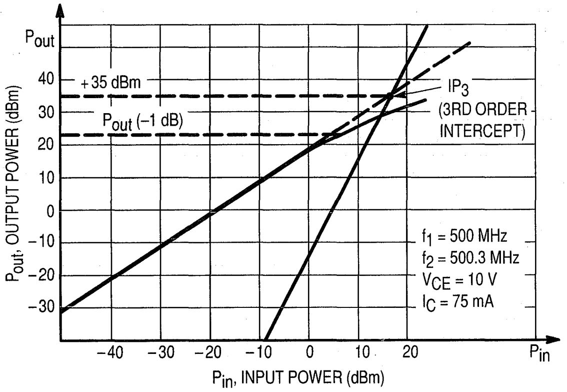


Figure 4. 3rd Order Intercept Point

TYPICAL CHARACTERISTICS
MRF581, MRF581A

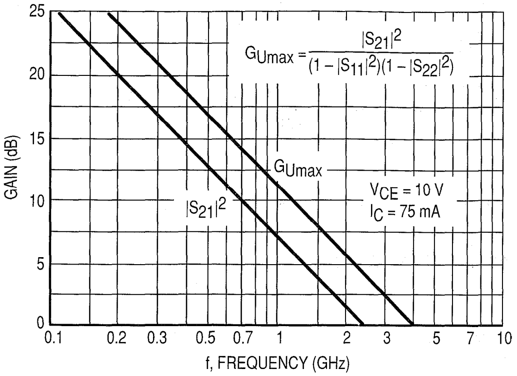


Figure 5. G_{Umax} — Maximum Unilateral Gain, $|S_{21}|^2$ versus Frequency

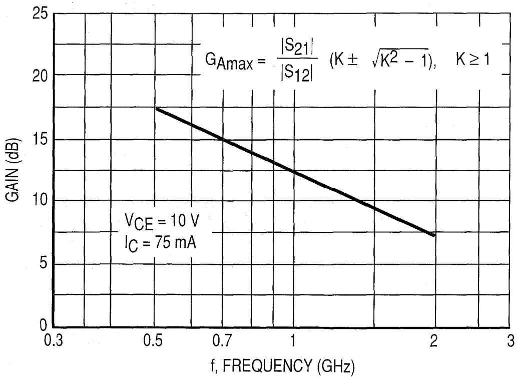


Figure 6. G_{Amax}, Maximum Available Gain versus Frequency

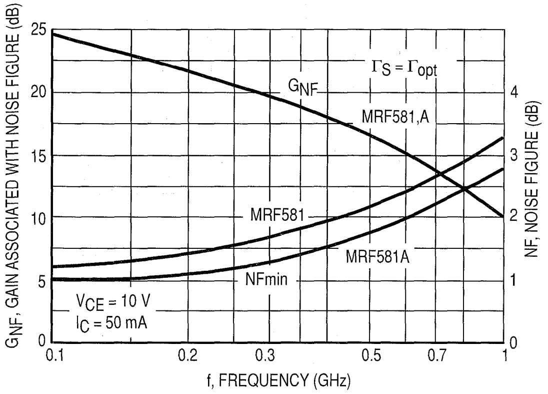


Figure 7. Minimum Noise Figure and Gain Associated with Minimum Noise Figure versus Frequency

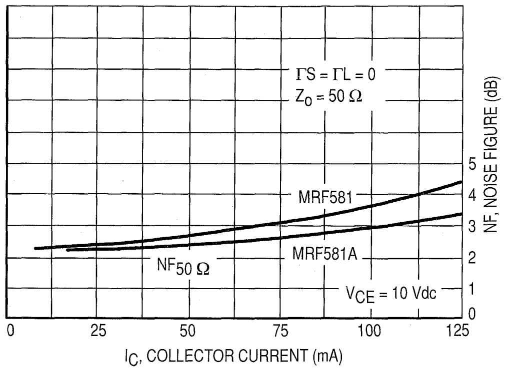


Figure 8. Noise Figure versus Collector Current f = 500 MHz

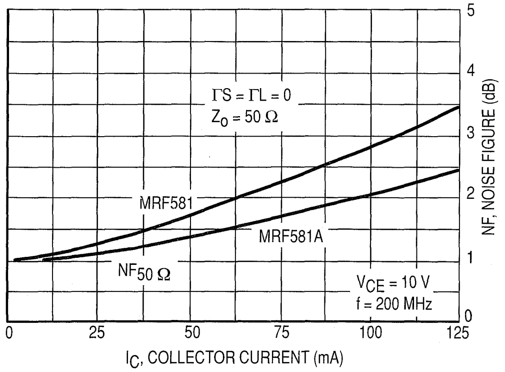


Figure 9. Noise Figure versus Collector Current

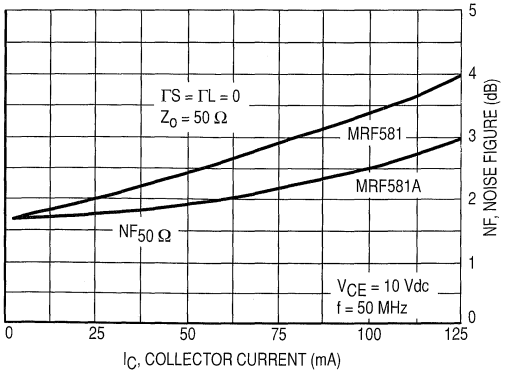


Figure 10. Noise Figure and Gain Associated with Noise Figure versus Collector Current

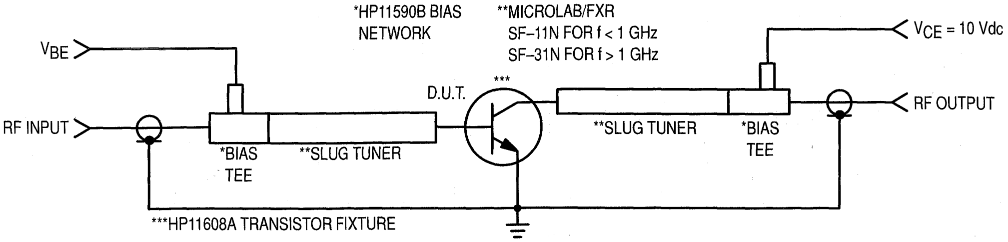


Figure 11. MRF581, A, MRF5812 Functional Circuit Schematic

TYPICAL CHARACTERISTICS
MRF5812

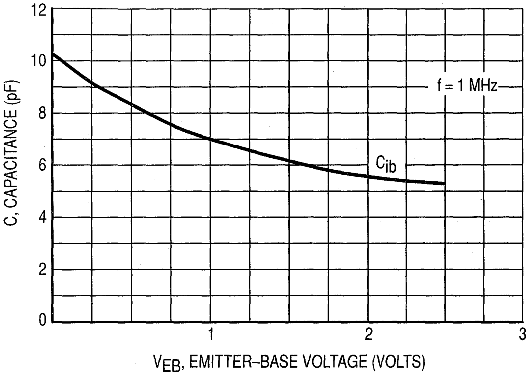


Figure 12. C_{ib} Input Capacitance versus Voltage

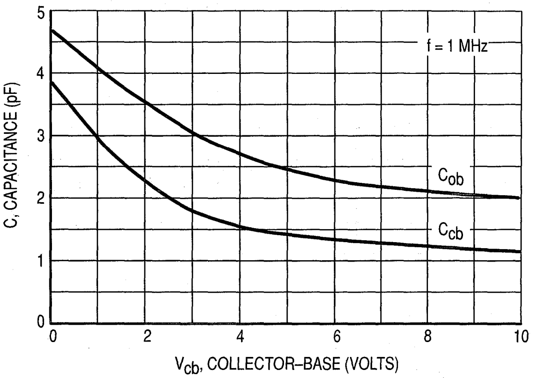


Figure 13. C_{cb}, C_{ob} Collector–Base Capacitance versus Voltage

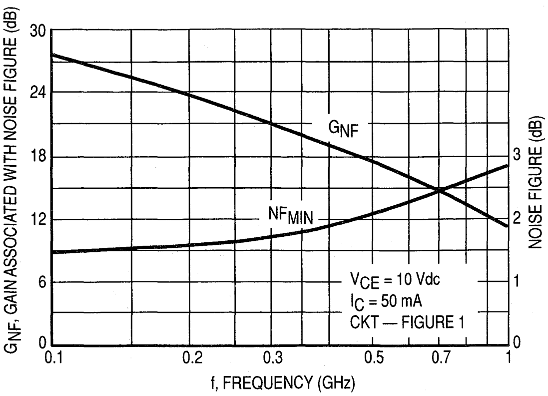


Figure 14. Minimum Noise Figure and Gain Associated with Noise Figure versus Frequency

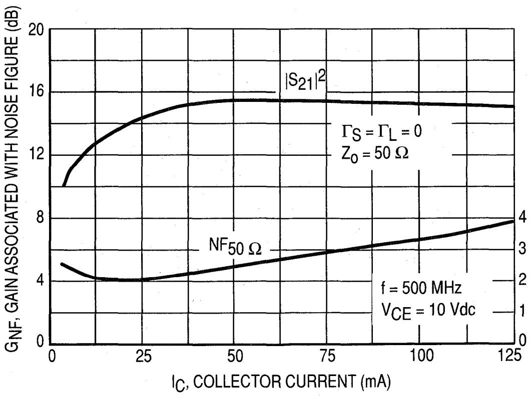


Figure 15. Noise Figure and Insertion Gain versus Collector Current

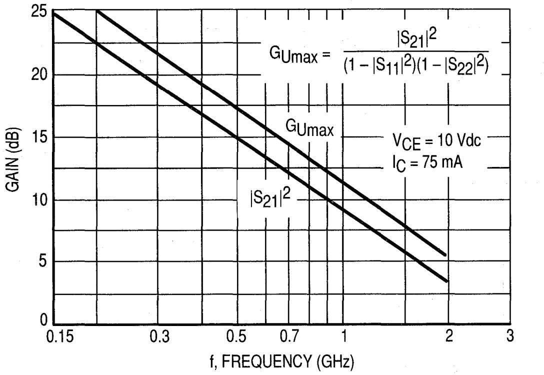


Figure 16. G_{Umax} — Maximum Unilateral Gain, $|S_{21}|^2$ versus Frequency

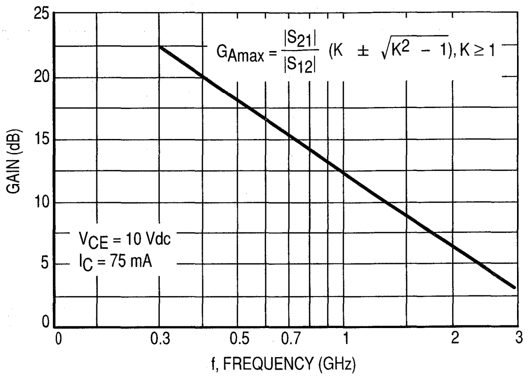


Figure 17. G_{Amax}, Maximum Available Gain versus Frequency

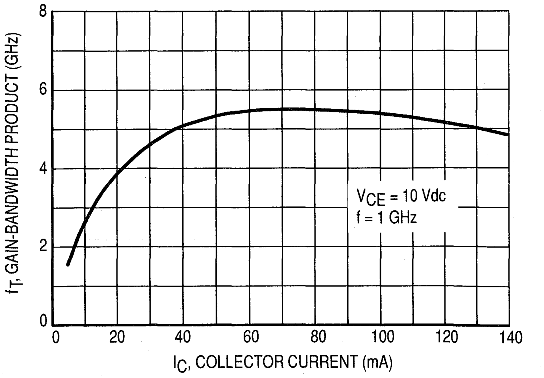


Figure 18. Gain–Bandwidth Product versus Collector Current

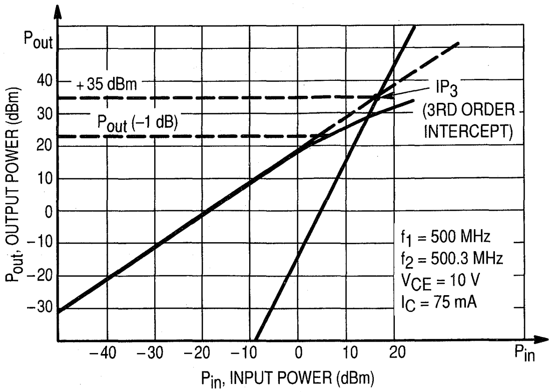


Figure 19. 3rd Order Intercept Point and 1.0 dB Compression Point

V_{CE} = 10 V I_C = 50 mA

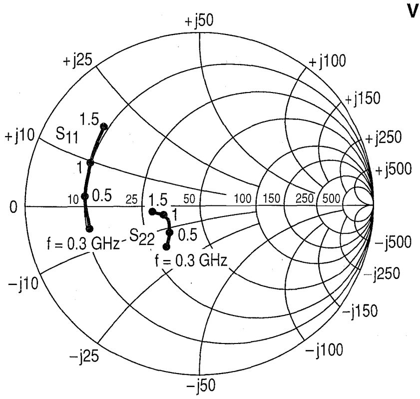


Figure 20. MRF581,A Input/Output Reflection Coefficient versus Frequency

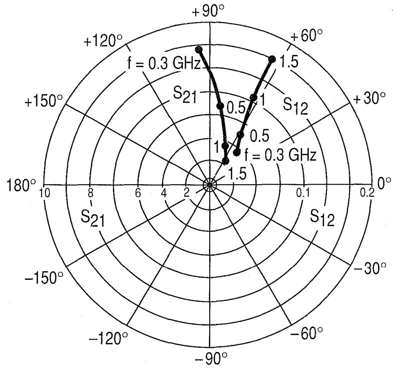


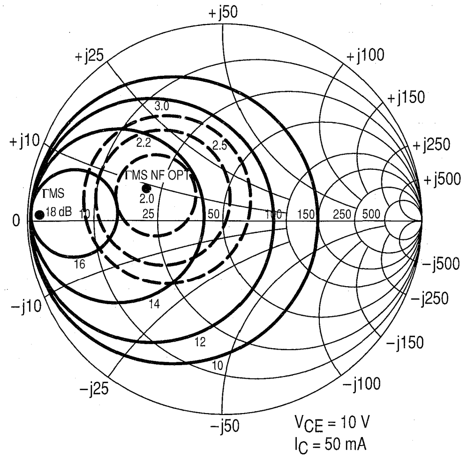
Figure 21. MRF581,A Forward/Reverse Transmission Coefficients versus Frequency

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
5.0	25	300	0.69	−169	6.57	93	0.06	39	0.34	−129
		500	0.72	176	3.95	82	0.07	47	0.29	−142
		1000	0.73	157	2.10	62	0.12	60	0.27	−165
		1500	0.76	139	1.47	50	0.17	61	0.33	−172
	50	300	0.70	−173	7.14	93	0.05	45	0.38	−144
		500	0.72	173	4.27	82	0.07	53	0.34	−157
		1000	0.72	157	2.24	65	0.13	62	0.33	179
		1500	0.76	138	1.61	53	0.18	61	0.37	173
	75	300	0.70	−175	7.26	92	0.05	48	0.40	−148
		500	0.72	172	4.33	82	0.07	55	0.37	−161
		1000	0.72	155	2.28	65	0.13	63	0.30	176
		1500	0.76	138	1.64	53	0.19	61	0.39	170
	100	300	0.70	−176	7.30	92	0.05	48	0.40	−151
		500	0.72	172	4.34	82	0.07	56	0.37	−163
		1000	0.72	155	2.28	65	0.13	63	0.36	175
		1500	0.75	137	1.64	53	0.19	61	0.39	168
10	25	300	0.66	−165	7.58	95	0.05	40	0.29	−106
		500	0.69	178	4.56	82	0.07	48	0.23	−116
		1000	0.70	159	2.39	64	0.11	61	0.19	−141
		1500	0.74	141	1.65	50	0.16	64	0.26	−153
	50	300	0.65	−169	8.25	94	0.05	46	0.30	−126
		500	0.68	175	4.96	82	0.07	54	0.24	−138
		1000	0.69	157	2.60	65	0.12	63	0.22	−164
		1500	0.72	139	1.82	52	0.17	63	0.27	−171
	75	300	0.66	−171	8.49	93	0.05	48	0.30	−132
		500	0.68	175	5.06	82	0.07	55	0.25	−145
		1000	0.69	157	2.64	65	0.12	64	0.23	−170
		1500	0.72	139	1.86	53	0.17	63	0.27	−176
	100	300	0.66	−172	8.46	93	0.05	49	0.30	−134
		500	0.68	174	5.06	82	0.07	56	0.25	−147
		1000	0.68	157	2.64	65	0.12	64	0.23	−172
		1500	0.72	139	1.86	52	0.17	63	0.27	−177
15	25	300	0.65	−163	7.96	95	0.05	40	0.28	−92
		500	0.67	179	4.82	82	0.06	48	0.21	−98
		1000	0.68	160	2.51	63	0.11	62	0.17	−119
		1500	0.72	141	1.73	49	0.16	65	0.24	−137
	50	300	0.64	−167	8.76	94	0.0	46	0.26	−112
		500	0.66	177	5.37	82	0.06	54	0.20	−122
		1000	0.67	159	2.75	65	0.11	64	0.16	−148
		1500	0.71	141	1.91	51	0.16	64	0.22	−157
	75	300	0.64	−168	8.93	93	0.05	47	0.25	−117
		500	0.66	176	5.34	82	0.06	55	0.20	−128
		1000	0.69	158	2.78	65	0.11	65	0.16	−154
		1500	0.70	140	1.93	51	0.16	64	0.22	−162
	100	300	0.64	−169	8.91	93	0.05	48	0.25	−117
		500	0.66	176	5.33	82	0.06	56	0.19	−129
		1000	0.67	158	2.78	64	0.11	65	0.16	−154
		1500	0.70	140	1.93	51	0.16	64	0.21	−160

Table 1. MRF581,A Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
5.0	25	100	0.66	−123	18.3	118	0.04	43	0.53	−79
		300	0.66	−167	7.0	92	0.06	44	0.31	−120
		500	0.65	178	4.3	81	0.08	52	0.28	−133
		1000	0.62	154	2.2	63	0.13	61	0.28	−141
		2000	0.57	109	1.3	39	0.28	57	0.31	−148
		3000	0.55	68	1.0	23	0.41	41	0.34	−164
	50	100	0.64	−133	20.2	114	0.04	44	0.51	−93
		300	0.65	−171	7.6	91	0.06	50	0.34	−137
		500	0.65	175	4.6	81	0.08	56	0.31	−148
		1000	0.61	152	2.3	63	0.13	63	0.28	−149
		2000	0.56	109	1.3	39	0.28	57	0.30	−150
		3000	0.52	70	1.0	23	0.41	39	0.29	−169
	75	100	0.64	−137	20.8	113	0.04	44	0.50	−99
		300	0.66	−173	7.7	91	0.06	52	0.35	−142
		500	0.64	174	4.7	82	0.08	59	0.32	−154
		1000	0.61	151	2.4	65	0.14	64	0.30	−164
		2000	0.54	107	1.4	42	0.30	55	0.27	−167
		3000	0.52	69	1.1	24	0.42	37	0.25	−172
	100	100	0.64	−140	20.8	112	0.03	44	0.50	−103
		300	0.65	−174	7.6	90	0.06	53	0.36	−145
		500	0.64	173	4.7	81	0.08	60	0.33	−156
		1000	0.61	151	2.4	65	0.15	64	0.31	−166
		2000	0.54	107	1.4	42	0.30	54	0.27	−169
		3000	0.52	65	1.1	24	0.42	37	0.25	−174
10	25	100	0.65	−112	20.2	121	0.04	46	0.56	−62
		300	0.63	−162	8.0	93	0.05	46	0.29	−93
		500	0.62	−178	5.0	82	0.07	52	0.25	−102
		1000	0.60	157	2.5	63	0.11	63	0.26	−112
		2000	0.55	112	1.4	39	0.25	61	0.35	−125
		3000	0.55	69	1.0	23	0.39	47	0.40	−145
	50	100	0.63	−122	22.9	117	0.03	46	0.50	−74
		300	0.62	−167	8.8	92	0.05	51	0.28	−112
		500	0.60	178	5.3	82	0.07	58	0.24	−122
		1000	0.58	154	2.7	64	0.12	65	0.23	−129
		2000	0.51	111	1.5	40	0.26	59	0.28	−132
		3000	0.50	70	1.2	24	0.39	44	0.34	−144
	75	100	0.63	−126	23.8	116	0.03	45	0.49	−80
		300	0.63	−168	9.0	92	0.05	51	0.28	−120
		500	0.62	177	5.5	82	0.07	58	0.24	−130
		1000	0.58	154	2.8	65	0.12	65	0.23	−137
		2000	0.52	111	1.5	41	0.26	58	0.27	−135
		3000	0.50	70	1.2	24	0.39	42	0.32	−145
	100	100	0.62	−128	23.8	114	0.03	46	0.46	−82
		300	0.62	−169	8.9	91	0.05	54	0.26	−120
		500	0.60	176	5.4	81	0.07	61	0.23	−130
		1000	0.57	152	2.8	64	0.12	66	0.21	−136
		2000	0.51	109	1.5	40	0.27	59	0.26	−134
		3000	0.50	68	1.2	24	0.39	43	0.32	−145
15	25	100	0.66	−106	21	123	0.03	47	0.57	−54
		300	0.63	−159	8.5	94	0.05	46	0.30	−77
		500	0.61	−177	5.2	82	0.06	52	0.26	−84
		1000	0.58	156	2.6	62	0.11	64	0.28	−96
		2000	0.54	110	1.4	36	0.23	63	0.39	−115
		3000	0.56	68	1.0	22	0.37	49	0.46	−137
	50	100	0.62	−114	24	119	0.03	46	0.51	−64
		300	0.60	−163	9.2	93	0.05	51	0.26	−92
		500	0.58	−179	5.7	81	0.07	58	0.22	−100
		1000	0.56	154	2.9	63	0.12	66	0.23	−109
		2000	0.52	109	1.5	39	0.25	60	0.32	−118
		3000	0.52	67	1.1	22	0.37	46	0.39	−137
	75	100	0.62	−118	24.6	117	0.03	46	0.48	−67
		300	0.59	−165	9.4	92	0.05	53	0.24	−96
		500	0.58	179	5.7	81	0.07	60	0.21	−104
		1000	0.56	154	2.9	63	0.12	66	0.22	−111
		2000	0.50	109	1.5	38	0.25	60	0.31	−118
		3000	0.52	67	1.1	22	0.37	46	0.38	−136
	100	100	0.62	−121	24.8	116	0.03	46	0.46	−68
		300	0.60	−165	9.3	91	0.05	53	0.23	−96
		500	0.58	179	5.7	81	0.07	61	0.20	−102
		1000	0.56	155	2.9	63	0.12	65	0.22	−109
		2000	0.50	111	1.5	39	0.25	62	0.32	−117
		3000	0.50	68	1.1	23	0.37	47	0.39	−136

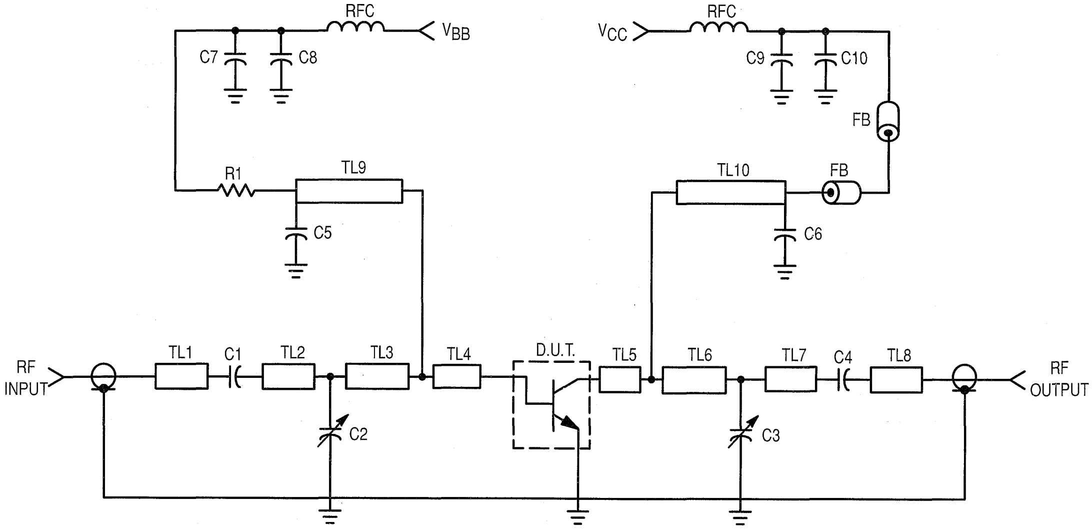
Table 2. MRF5812 Common Emitter S–Parameters



f (MHz)	ΓMS	ΓML	ΓMS NF OPT	G_AMAX (dB)	Rn (Ω)	NF OPT	NF (50 Ω)
500	0.91 ∠ 176°	0.78 ∠ 77°	0.39 ∠ 159°	18	10.5	2.0	2.5

Circuit Per Figure 14

Figure 22. MRF581 Constant Gain Contours Noise Figure Contours



C1, C4, C5, C6, C8, C9 — 1000 pF, Chip Capacitor
C2, C3 — 1.0−10 pF, Johanson Capacitor
C7, C10 — 10 μF, Tantalum Capacitor
R1 — 1.0 kΩ Res.
RFC — VK–200, Ferroxcube
FB — Ferrite Bead, Ferroxcube, 56–590–65/3B
Board Material — 0.0625″ Thick Glass Teflon ε_r = 2.55

TL1, TL7, TL8 — Microstrip 0.162″ x 0.600″
TL2 — Microstrip 0.162″ x 1.000″
TL3 — Microstrip 0.162″ x 0.800″
TL4 — Microstrip 0.162″ x 0.440″
TL5 — Microstrip 0.120″ x 0.440″
TL6 — Microstrip 0.120″ x 1.160″
TL9, TL10 — Microstrip 0.025″ x 4.250″

Figure 23. MRF581 Test Fixture Schematic

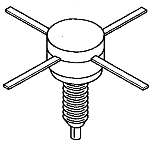
The RF Line
NPN Silicon High-Frequency Transistor

MRF587

NF = 3.0 dB @ 0.5 GHz
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON

. . . designed for use in high–gain, low–noise, ultra–linear, tuned and wideband amplifiers. Ideal for use in CATV, MATV, and instrumentation applications.

- Low Noise Figure —
  NF = 3.0 dB (Typ) @ f = 500 MHz, I_C = 90 mA
- High Power Gain —
  $G_{U(max)}$ = 16.5 dB (Typ) @ f = 500 MHz
- Ion Implanted
- All Gold Metal System
- High f_T — 5.5 GHz
- Low Intermodulation Distortion:
  TB_3 = –70 dB
  DIN = 125 dB μV
- Nichrome Emitter Ballast Resistors



CASE 244A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	17	Vdc
Collector–Base Voltage	V_{CBO}	34	Vdc
Emitter–Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_C = 50°C Derate above T_C = 50°C	P_D	5.0 33	Watts mW/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Junction Temperature	T_J	200	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	17	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	34	—	—	Vdc
Emitter–Base Breakdown Voltage (I_C = 0, I_E = 0.1 mAdc)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	50	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	—	200	—

NOTE:
1. 300 μs pulse on Tektronix 576 or equivalent.

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (2) (I_C = 90 mAdc, V_{CE} = 15 Vdc, f = 0.5 GHz)	f_T	—	5.5	—	GHz
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.7	2.2	pF
FUNCTIONAL TESTS					
Narrowband — Figure 15 (I_C = 90 mA, V_{CC} = 15 V, f = 0.5 GHz)					dB
Noise Figure	NF	—	3.0	4.0	
Power Gain at Optimum Noise Figure	G_{NF}	11	13	—	
Broadband — Figure 16 (I_C = 90 mA, V_{CC} = 15 V, f = 0.3 GHz)					dB
Noise Figure	NF	—	6.3	—	
Power Gain at Optimum Noise Figure	G_{NF}	—	11	—	
Triple Beat Distortion (I_C = 50 mA, V_{CC} = 15 V, P_{Ref} = 50 dBmV) (I_C = 90 mA, V_{CC} = 15 V, P_{Ref} = 50 dBmV)	TB_3	—	–70	—	dB
DIN 45004 (I_C = 90 mA, V_{CC} = 15 V) (I_C = 90 mA, V_{CC} = 15 V)	DIN	—	125	—	dBµV
Maximum Available Power Gain (3) (I_C = 90 mA, V_{CE} = 15 Vdc, f = 0.5 GHz)	G_{Umax}	—	16.5	—	dB

NOTES:

2. Characterized on HP8542 Automatic Network Analyzer
3. $G_{Umax} = \frac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

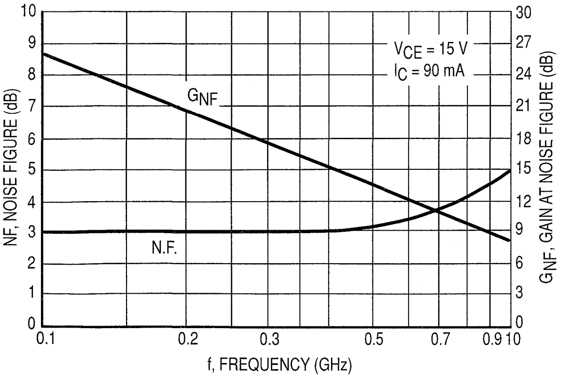


Figure 1. Typical Noise Figure and Associated Gain versus Frequency

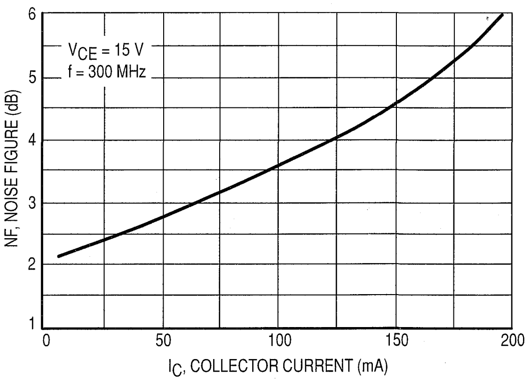


Figure 2. Noise Figure versus Collector Current

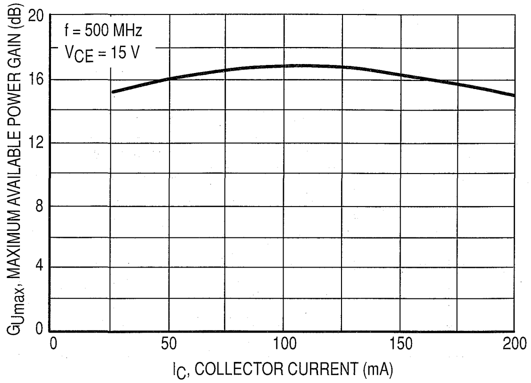


Figure 3. G_{Umax} versus Collector Current

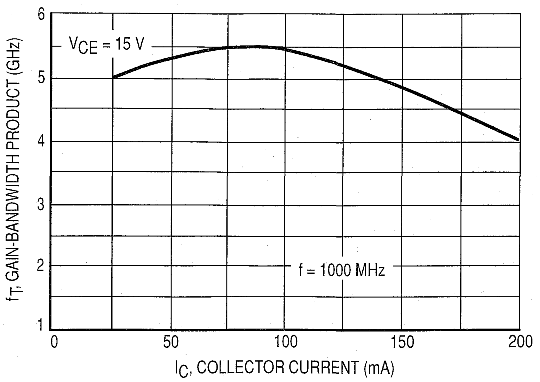


Figure 4. Gain–Bandwidth Product versus Collector Current

TYPICAL PERFORMANCE

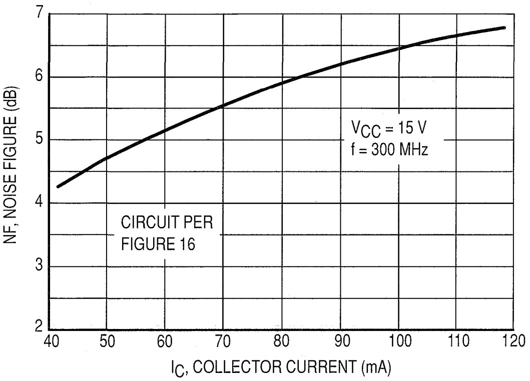


Figure 5. Broadband Noise Figure

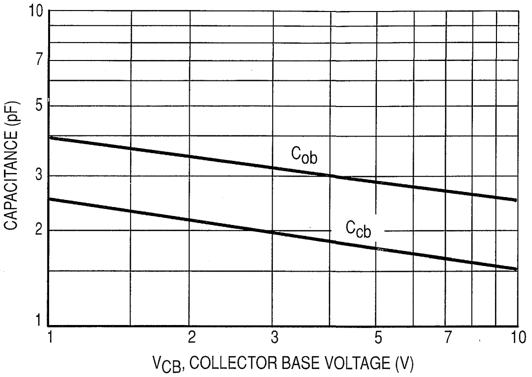


Figure 6. Junction Capacitance versus Voltage

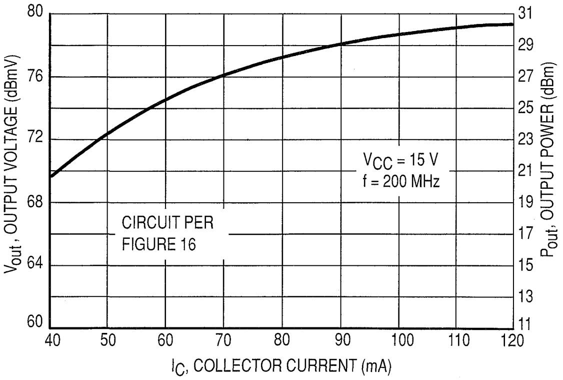


Figure 7. 1.0 dB Compression Point versus Collector Current

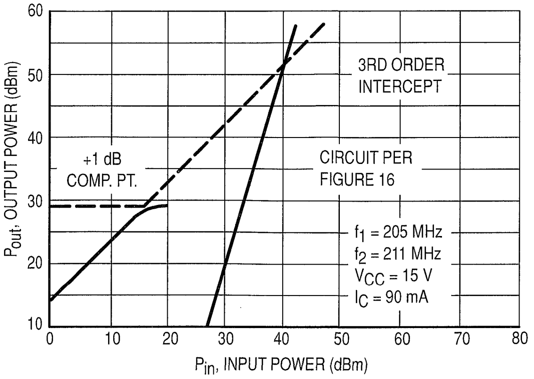


Figure 8. Third Order Intercept Point

TYPICAL PERFORMANCE (continued)

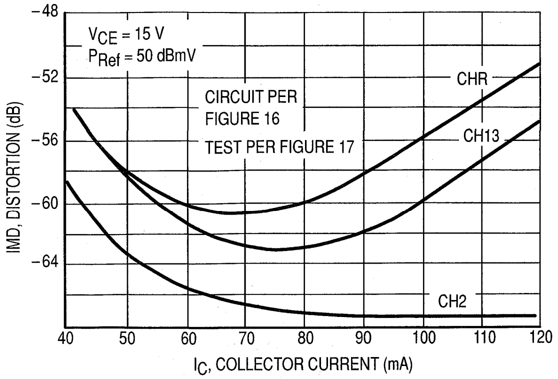


Figure 9. Second Order Distortion versus Collector Current

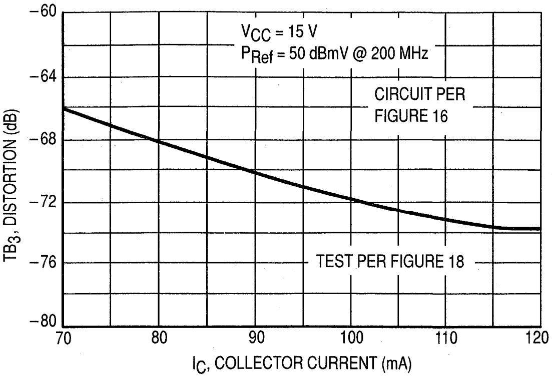


Figure 10. Triple Beat Distortion versus Collector Current

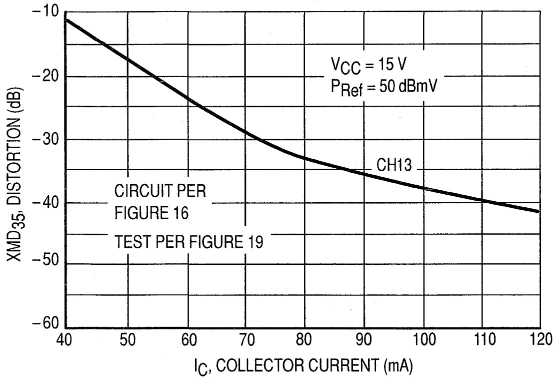


Figure 11. 35–Channel X–Modulation Distortion versus Collector Current

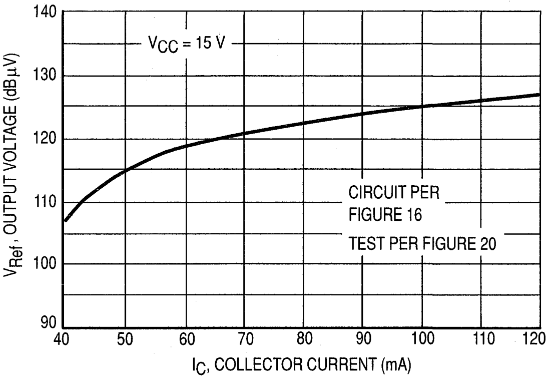


Figure 12. DIN 45004B versus Collector Current

V_{CE} = 15 V I_C = 90 mA

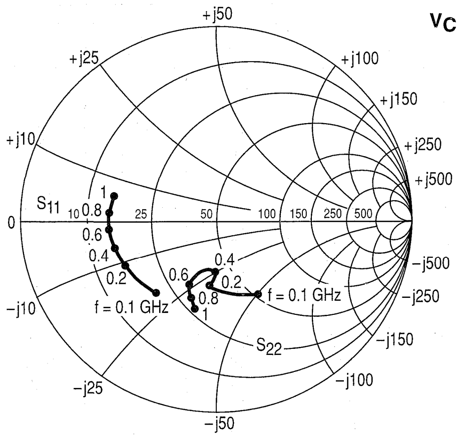


Figure 13. Input/Output Reflection Coefficient versus Frequency (GHz)

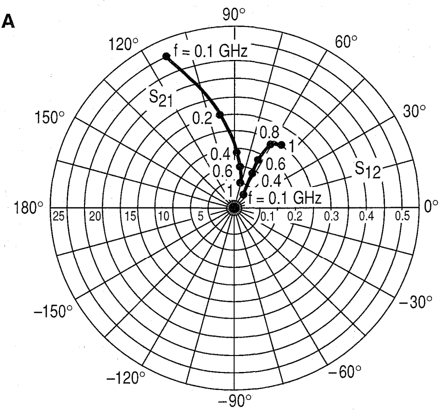


Figure 14. Forward/Reverse Transmission Coefficients versus Frequency (GHz)

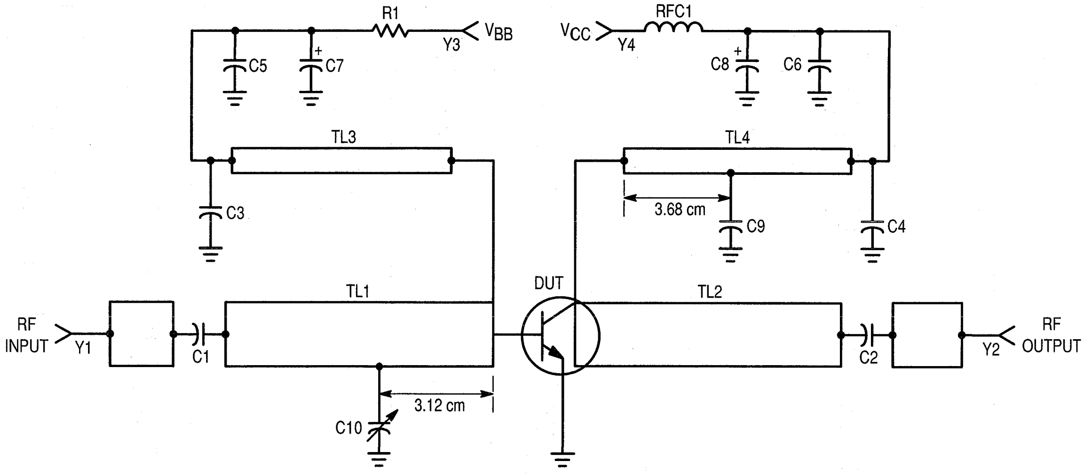
V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
5.0	30	100	0.56	−131	16.45	113	0.04	45	0.49	−91
		200	0.58	−159	9.42	98	0.06	49	0.38	−116
		400	0.60	−178	5.00	86	0.08	55	0.35	−132
		600	0.64	170	3.61	76	0.11	56	0.38	−138
		800	0.67	162	2.92	67	0.14	55	0.41	−144
		1000	0.70	155	2.55	58	0.17	54	0.44	−152
	60	100	0.53	−141	17.89	110	0.04	50	0.47	−102
		200	0.56	−164	10.05	97	0.05	55	0.39	−126
		400	0.59	178	5.31	85	0.09	60	0.38	−141
		600	0.63	169	3.82	76	0.12	59	0.40	−146
		800	0.66	161	3.09	67	0.15	57	0.44	−153
		1000	0.69	155	2.67	58	0.18	55	0.47	−160
	90	100	0.52	−145	18.26	109	0.04	52	0.47	−106
		200	0.56	−166	10.20	96	0.05	57	0.39	−130
		400	0.59	177	5.38	85	0.09	62	0.39	−144
		600	0.63	168	3.86	76	0.12	60	0.41	−149
		800	0.66	161	3.12	67	0.15	58	0.45	−155
		1000	0.69	155	2.70	58	0.19	55	0.48	−162
10	30	100	0.53	−122	18.36	115	0.04	48	0.50	−75
		200	0.53	−153	10.63	100	0.05	51	0.36	−96
		400	0.55	175	5.71	87	0.08	57	0.33	−112
		600	0.59	173	4.16	78	0.10	58	0.35	−119
		800	0.62	165	3.37	68	0.13	57	0.39	−127
		1000	0.65	158	2.95	59	0.15	55	0.42	−136
	60	100	0.49	−132	20.19	112	0.03	51	0.46	−85
		200	0.51	−158	11.54	99	0.05	57	0.35	−107
		400	0.53	−178	6.12	87	0.08	61	0.33	−123
		600	0.58	171	4.43	78	0.11	60	0.36	−129
		800	0.60	164	3.58	68	0.14	59	0.40	−136
		1000	0.63	157	3.12	60	0.16	57	0.44	−144
	90	100	0.48	−135	20.82	111	0.03	53	0.45	−88
		200	0.50	−160	11.77	98	0.05	59	0.34	−111
		400	0.53	−179	6.22	86	0.08	63	0.33	−126
		600	0.57	171	4.50	78	0.11	62	0.36	−131
		800	0.60	164	3.64	68	0.14	59	0.41	−139
		1000	0.63	157	3.18	60	0.17	57	0.44	−147

(continued)

Table 1. Common–Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
15	30	100	0.49	−112	20.34	118	0.04	54	0.51	−52
		200	0.52	−145	11.51	101	0.05	56	0.36	−77
		400	0.48	−164	6.12	87	0.09	63	0.32	−74
		600	0.52	−174	4.19	75	0.12	62	0.32	−90
		800	0.53	177	3.29	68	0.16	61	0.38	−90
		1000	0.53	168	2.76	61	0.20	56	0.47	−90
	60	100	0.45	−122	22.14	115	0.03	56	0.45	−60
		200	0.49	−150	12.24	99	0.05	60	0.33	−86
		400	0.45	−166	6.45	86	0.09	65	0.30	−83
		600	0.50	−175	4.42	75	0.13	63	0.32	−99
		800	0.51	177	3.47	68	0.16	61	0.38	−98
		1000	0.51	168	2.91	62	0.20	55	0.46	−96
	90	100	0.44	−127	22.76	114	0.03	58	0.43	−62
		200	0.48	−152	12.44	98	0.05	62	0.32	−89
		400	0.44	−167	6.55	85	0.09	66	0.29	−85
		600	0.50	−176	4.47	75	0.13	64	0.32	−102
		800	0.51	176	3.51	69	0.17	61	0.38	−100
		1000	0.51	168	2.95	62	0.20	55	0.46	−98

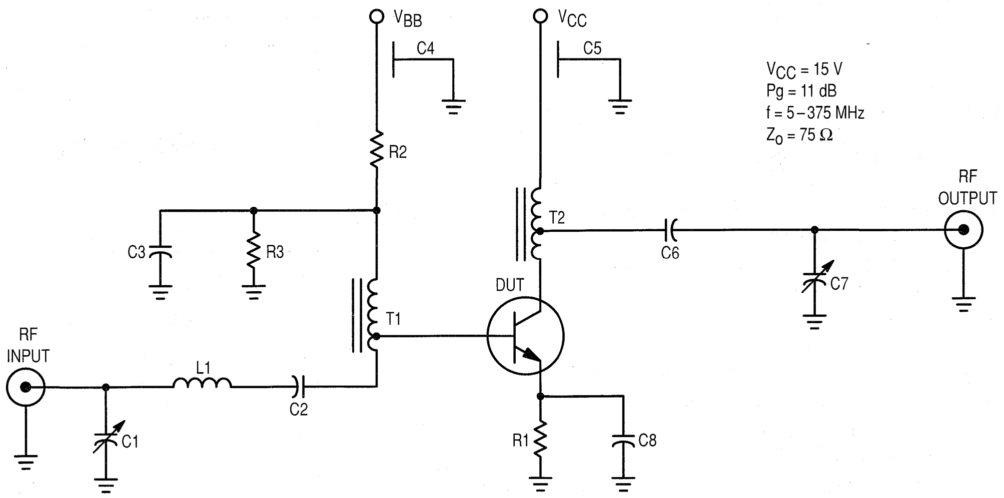
Table 1. Common–Emitter S–Parameters (continued)



C1, C2 — 470 pF Chip (Ceramic)
C3, C4 — 0.018 μF Chip Capacitor
C5, C6 — 0.1 μF Mylar
C7, C8 — 1.0 μF, 25 Vdc Electrolytic
C9 — 91 pF Mini–Unelco (C9 Taped 3.68 cm from Collector Connection on TL4 as shown)
C10 — 35–45 pF Johanson Ceramic Capacitor, JMC 5801 or Equivalent (C10 Taped 3.12 cm from Base Connection on TL1)

R1 — 2.7 kΩ, 1–1/2 W
RFC1 — 0.15 μH Molded Choke
TL1, TL2 — Z_o = 26 Ω, 0.0625 TFG as shown in Photomaster
TL3, TL4 — $\lambda/4$ Microstrip, Z_o = 100 Ω
Y1, Y2 — N–Type Connection (Female)
Y3, Y4 — BNC–Type Connector (Female)
Board Material — 0.0625″ Thick Glass Teflon $\varepsilon_r = 2.5$

**Figure 15. Narrowband Test Fixture Schematic
500 MHz**



C1, C7 — 0.5–10 pF
C2, C6 — 0.001 µF
C3 — 0.01 µF
C4, C5 — 0.01 µF Feedthru
C8 — 12 pF

R1 — 12 Ω 1.0 W (2.0–24 Ω on each emitter port)
R2 — 1.8 k 1/8 W
R3 — 2.2 k 1/8 W
L1 — 1 Turn 0.012 dia #22 AWG
T1(1) — 5 Turns Tapped at 2 Turns, #30 AWG
T2(1) — 8 Turns Tapped at 3 Turns, #30 AWG

(1) Ferroxcube 135 CT050 3D3 Material

Figure 16. Broadband Test Circuit Schematic

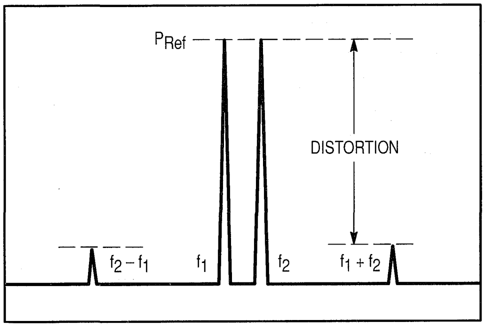


Figure 17. Second Order Distortion Test

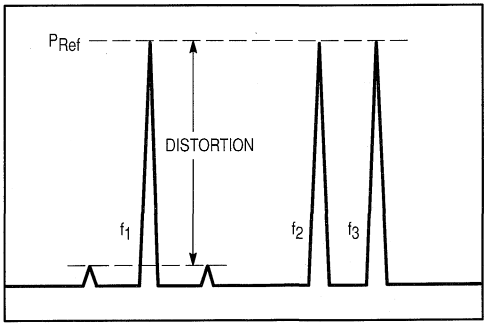


Figure 18. Triple Beat Distortion Test

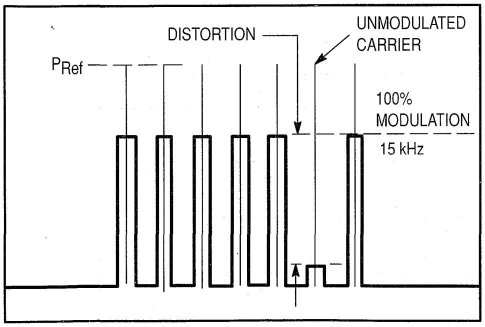


Figure 19. Cross Modulation Distortion Test

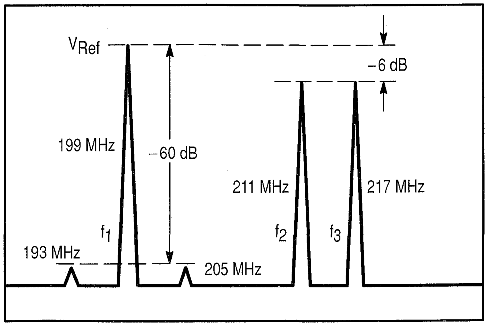


Figure 20. DIN 45004B Intermodulation Test

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

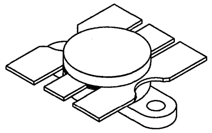
The RF Line
NPN Silicon
RF Power Transistor

. . . designed for 12.5 Volt UHF large–signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics —
  Output Power = 15 Watts
  Minimum Gain = 7.8 dB
  Efficiency = 55%
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- Built–In Matching Network for Broadband Operation
- Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 16–Volt High Line and Overdrive
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MRF641

15 W, 470 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	3.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	43.7 0.25	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	4.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

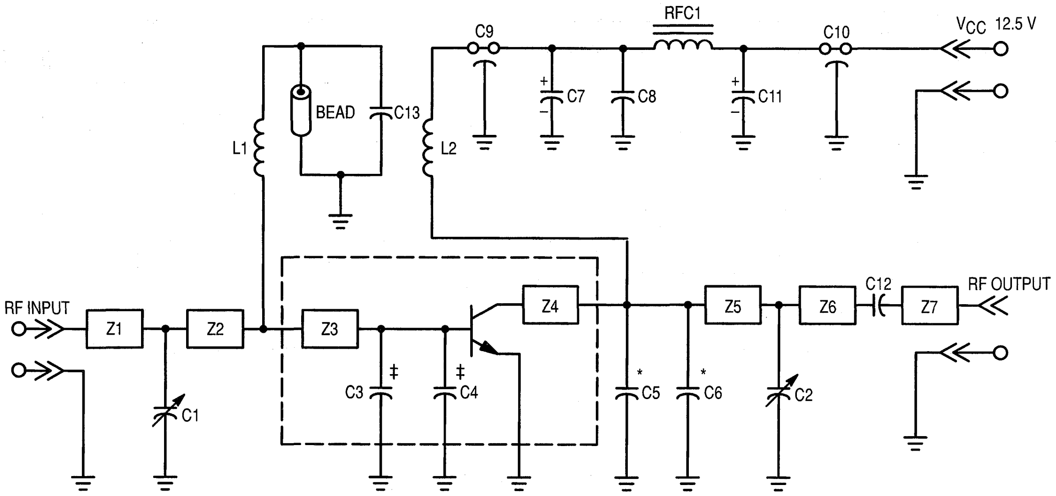
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	5.0	mAdc

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	70	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	40	60	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 470 MHz)	G_{pe}	7.8	8.5	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 470 MHz)	η	55	60	—	%
Output Mismatch Stress (V_{CC} = 16 Vdc, P_{in} = 3.0 W, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ	No Degradation in Output Power			



PARTS

Z1 — 1.225″ x 0.187″ Microstrip
Z2 — 0.884″ x 0.187″ Microstrip
Z3 — Capacitor Block (Base)
Z4 — Collector Block
Z5 — 1.1″ x 0.187″ Microstrip
Z6 — 0.433″ x 0.187″ Microstrip
Z7 — 0.4″ x 0.187″ Microstrip

Dotted Area — Capacitor Assembly

C1, C2 — 0.8–10 pF Johanson
C3, C4 — 24 pF Chip Caps 100 mils ATC
C5, C6 — 22 pF Chip Caps 100 mils ATC
C12 — 220 pF Chip Cap 100 mils ATC
C7, C11 — 1.0 µF Tantalum 35 Vdc
C9, C10 — 680 pF Feedthrough Allen–Bradley
C13 — 200 pF UNELCO
C8 — 0.1 µF, 50 V Erie Red Cap
RFC1 — VK 200 — 104B Ferrite Choke
L1 — 4 Turns 0.2″ Dia. #16 AWG
L2 — 9 Turns 0.15″ Dia. #16 AWG

Bead — Ferroxcube 56–590–65–35EB

NOTES

*C5, C6, are mounted as close to the capacitor assembly as possible.
‡‡C3, C4 are mounted in the capacitor assembly.
Board — 62.5 mil Glass Teflon, ε_r = 2.55.

Figure 1. Test Circuit Schematic

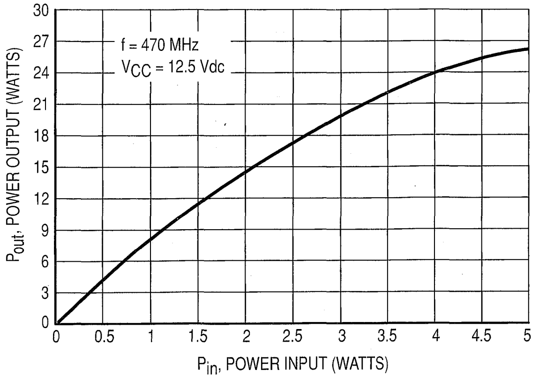


Figure 2. Power Output versus Power Input

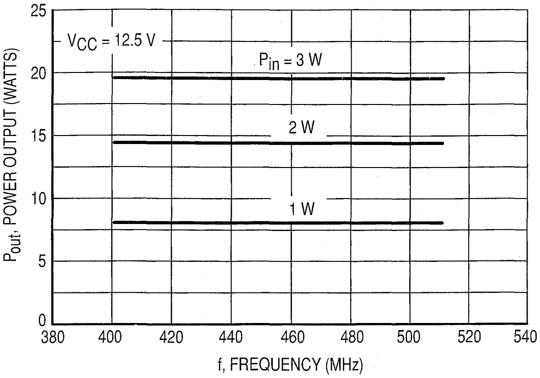


Figure 3. Power Output versus Frequency

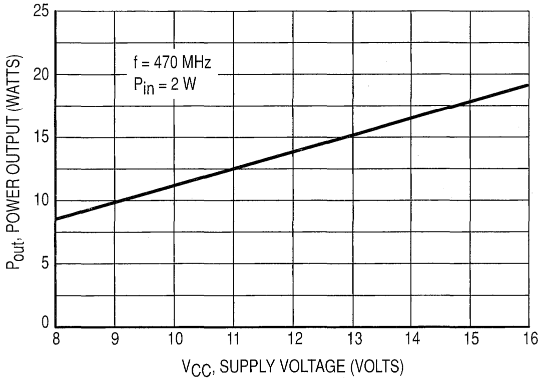


Figure 4. Power Output versus Supply Voltage

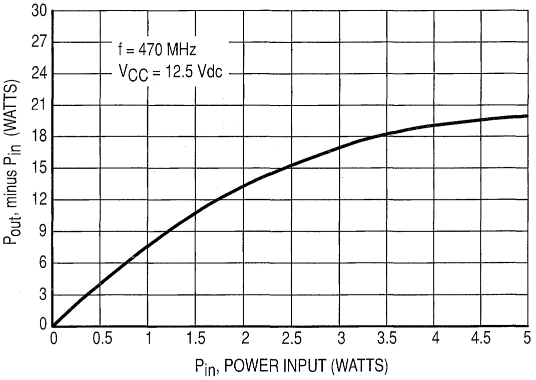
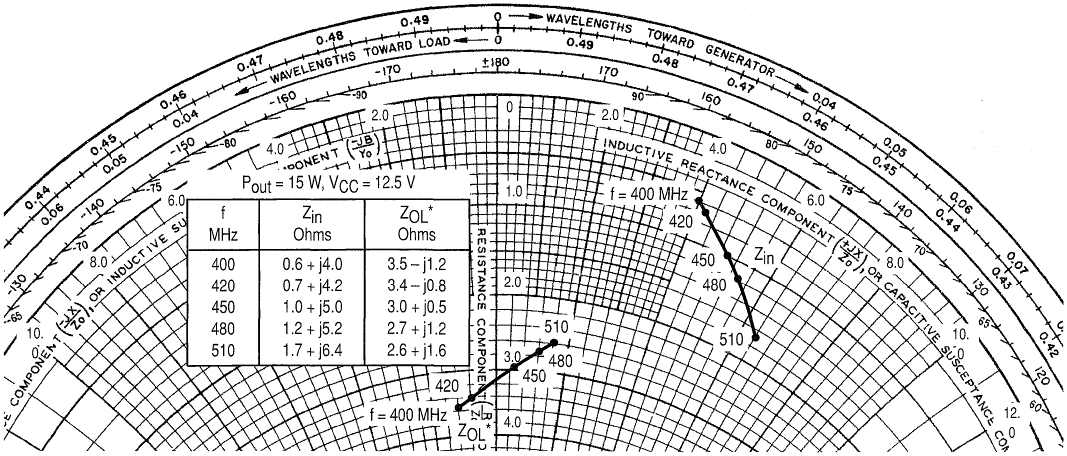


Figure 5. Power Saturation Profile


P_{out} = 15 W, V_{CC} = 12.5 V

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
400	0.6 + j4.0	3.5 – j1.2
420	0.7 + j4.2	3.4 – j0.8
450	1.0 + j5.0	3.0 + j0.5
480	1.2 + j5.2	2.7 + j1.2
510	1.7 + j6.4	2.6 + j1.6

Z_{OL}* = Conjugate of the load impedance into which the device output operates at a given power, η, and frequency.

Figure 6. Series Equivalent Input–Output Impedance

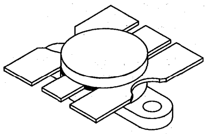
The RF Line
NPN Silicon RF Power Transistor

MRF644

. . . designed for 12.5 Volt UHF large–signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics —
  Output Power = 25 Watts
  Minimum Gain = 6.2 dB
  Efficiency = 60%
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- Built–In Matching Network for Broadband Operation
- Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 16–Volt High Line and 50% Overdrive
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

**25 W, 470 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON**



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	103 0.59	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.7	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	5.0	mAdc

(continued)

REV 6

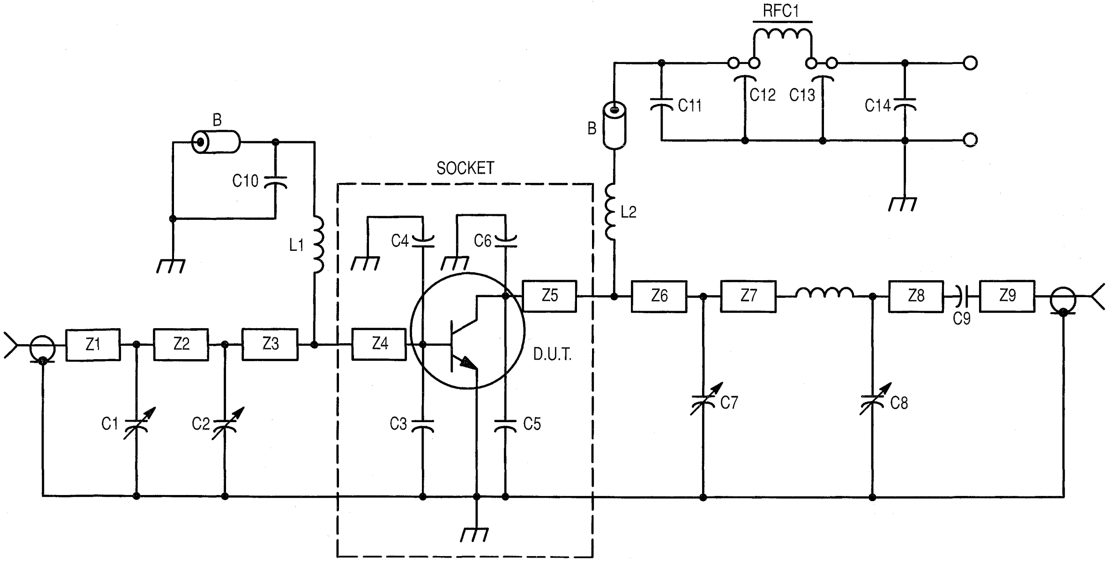
ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	40	70	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	60	85	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 25 W, I_C (MAX) = 3.6 Adc, f = 470 MHz)	G_{pe}	6.2	7.0	—	dB
Input Power (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz)	P_{in}	—	5.0	6.0	Watts
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 25 W, I_C (MAX) = 3.6 Adc, f = 470 MHz)	η	55	60	—	%
Output Mismatch Stress (V_{CC} = 16 Vdc, P_{in} = Note 1, f = 470 MHz, VSWR = 20:1, All Phase Angles)	ψ *	No Degradation in Output Power			
Series Equivalent Input Impedance (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz)	Z_{in}	—	1.2 + j3.3	—	Ohms
Series Equivalent Output Impedance (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz)	Z_{OL}	—	1.9 + j2.1	—	Ohms

NOTE:

1. P_{in} = 150% of Drive Requirement for 25 W Output at 12.5 Vdc.

* ψ = Mismatch stress factor — the electrical criterion established to verify the device resistance to load mismatch failure. The mismatch stress test is accomplished in the standard test fixture (Figure 1) terminated in a 20:1 minimum load mismatch at all phase angles.



C1, C2, C7, C8 — 1.0–20 pF Johanson Variable
C3 — 27 pF 100 mil ATC
C4 — 30 pF 100 mil ATC
C5, C6 — 33 pF 100 mil ATC
C9 — 250 pF 100 mil ATC
C10 — 100 pF UNELCO
C11, C14 — 1.0 µF 35 V TANTALUM
C12, C13 — 680 pF Feedthrough
L1 — 5″ #22 AWG 0.100″ ID
L2 — 5″ #20 AWG 0.187″ ID
RFC1 — Ferroxcube VK200–20–4B
B — Ferroxcube Bead 56–590–65–3B
Z1 — 0.25″ x 0.20″ Microstrip
Z2 — 1.63″ x 0.20″ Microstrip
Z3 — 0.20″ x 0.20″ Microstrip
Z4, Z5 — 1/2″ #18 AWG bent in a "V" shape 1/8″ Wide
Z6 — 0.20″ x 0.20″ Microstrip
Z7 — 0.70″ x 0.20″ Microstrip
Z8 — 0.33″ x 0.20″ Microstrip
Z9 — 0.50″ x 0.20″ Microstrip
Board — 62.5 mil Glass Teflon, ε_r = 2.55

Figure 1. Test Circuit Schematic

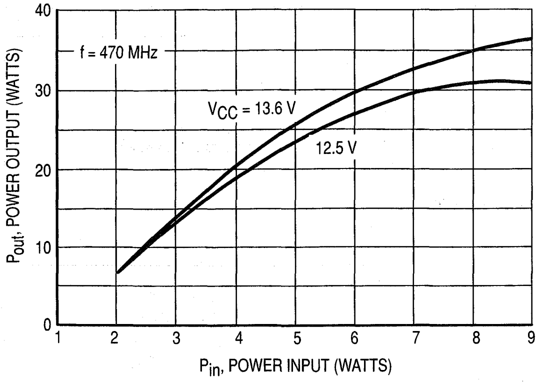


Figure 2. Power Output versus Power Input

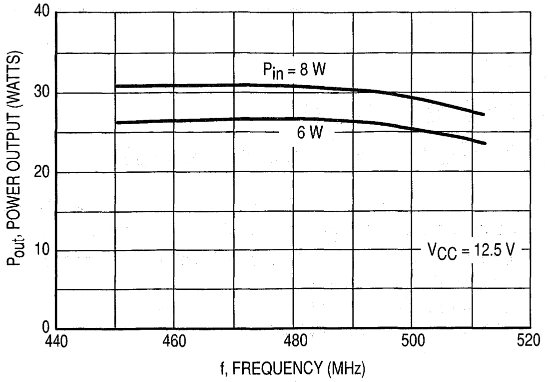


Figure 3. Power Output versus Frequency

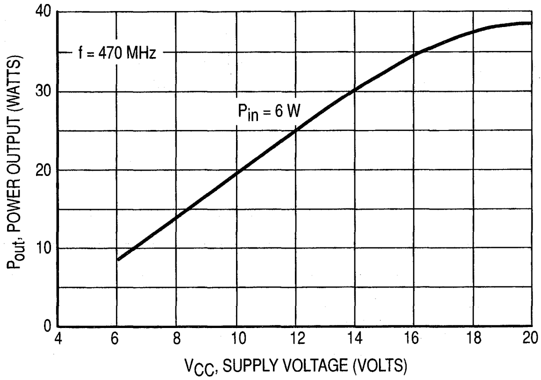


Figure 4. Power Output versus Supply Voltage

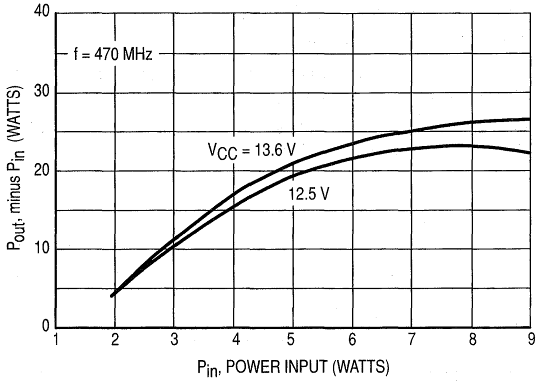
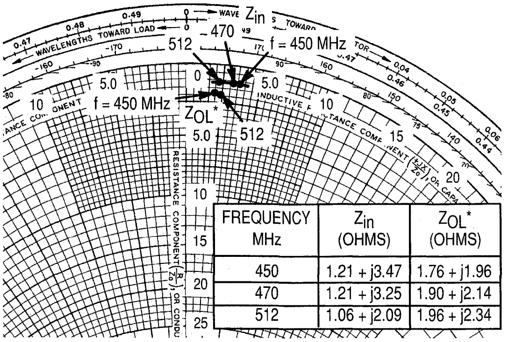


Figure 5. Power Saturation Profile



FREQUENCY MHz	Z_{in} (OHMS)	Z_{OL}* (OHMS)
450	1.21 + j3.47	1.76 + j1.96
470	1.21 + j3.25	1.90 + j2.14
512	1.06 + j2.09	1.96 + j2.34

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input–Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

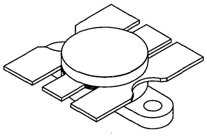
The RF Line
NPN Silicon RF Power Transistor

MRF650

50 W, 512 MHz
RF POWER
TRANSISTOR
NPN SILICON

Designed for 12.5 Volt UHF large–signal amplifier applications in industrial and commercial FM equipment operating to 520 MHz.

- Guaranteed 440, 470, 512 MHz 12.5 Volt Characteristics
  Output Power = 50 Watts
  Minimum Gain = 5.2 dB @ 440, 470 MHz
  Efficiency = 55% @ 440, 470 MHz
  IRL = 10 dB
- Characterized with Series Equivalent Large–Signal Impedance Parameters from 400 to 520 MHz
- Built–In Matching Network for Broadband Operation
- Triple Ion Implanted for More Consistent Characteristics
- Implanted Emitter Ballast Resistors
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 15.5 Vdc, 2.0 dB Overdrive
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16.5	Vdc
Collector–Emitter Voltage	V_{CES}	38	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	12	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	135 0.77	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.3	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16.5	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	38	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	70	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	135	170	pF

(continued)

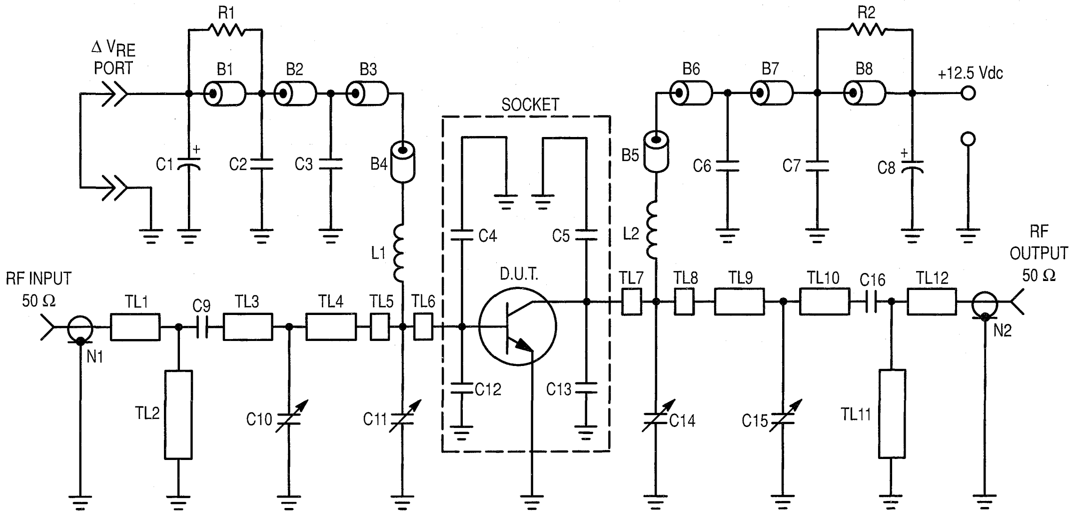
REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (In Motorola Test Fixture. See Figure 1.)					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 50 W, f = 440, 470 MHz)	G_{pe}	5.2	6.1	—	dB
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 50 W, f = 512 MHz)	G_{pe}	5.0	5.9	—	dB
Input Return Loss (V_{CC} = 12.5 Vdc, P_{out} = 50 W, f = 440, 470, 512 MHz)	IRL	10	15	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 50 W, f = 440, 470 MHz)	η	55	65	—	%
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 50 W, f = 512 MHz)	—	50	60	—	%
Output Mismatch Stress (V_{CC} = 15.5 V, 2.0 dB Overdrive, f = 470 MHz, VSWR = 20:1, All Phase Angles) (1)	ψ (2)	No Degradation in Output Power			

NOTES:

1. P_{in} = 2.0 dB above drive requirement for 50 W output at 12.5 Vdc.
2. ψ = Mismatch stress factor — the electrical criterion established to verify the device resistance to load mismatch failure. The mismatch stress test is accomplished in the standard test fixture (Figure 1) terminated in a 20:1 minimum load mismatch at all phase angles.



B1, B8 — Ferrite Bead Ferroxcube VK200 20–4B
B2, B3, B4, B5, B6, B7 — Ferrite Bead Ferroxcube #56–590–3B
C1, C8 — 10 µF, 25 V, 25%, Electrolytic, ECS TE–1204
C2, C7 — 1000 pF, Chip Cap, 5%, ATC 100B102JC50
C3, C6 — 91 pF, 5%, Mica, SAHA 3HS0006–91
C4, C5, C12, C13 — 36 pF, 5%, SAHA 3HS0006–36
C9, C16 — 220 pF, Chip Cap, 5%, ATC 100B221JC200
C10, C11, C15 — 0.8–10 pF, Variable, Johanson JMC501 PG26J200
C14 — 1.0–20 pF, Variable, Johanson JMC5501 PG26J200
L1, L2 — 3 Turns, 18 AWG, 0.19″ ID — Total Length 3.5″
N1, N2 — N Coaxial Conn., Omni–Spectra 3052–1648–10
R1, R2 — 10 Ohm, 10%, 1.0 W, Carbon, RCA 831010

TL1, TL12 — Z_o = 50 Ohm
TL2 — See Photomaster
TL3 — See Photomaster
TL4 — See Photomaster
TL5 — See Photomaster
TL6 — See Photomaster
TL7 — See Photomaster
TL8 — See Photomaster
TL9 — See Photomaster
TL10 — See Photomaster
TL11 — See Photomaster

Transmission Line Boards: 1/16″ Glass–Teflon
Keene GX–0600–55–22
2 oz. Cu Clad Both Sides
ε_r = 2.55

Bias Boards: 1/16″ G10 or Equivalent
2 oz. Cu Clad Double Sided

Figure 1. 440 to 512 MHz Broadband Test Circuit Schematic

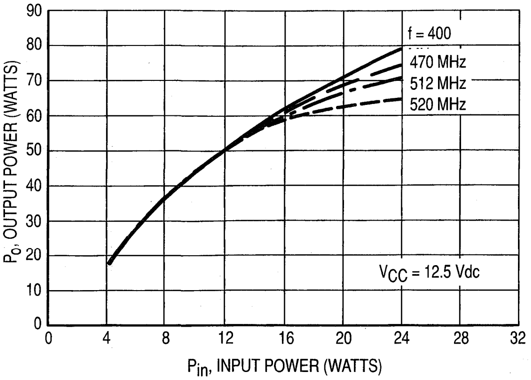


Figure 2. Output Power versus Input Power

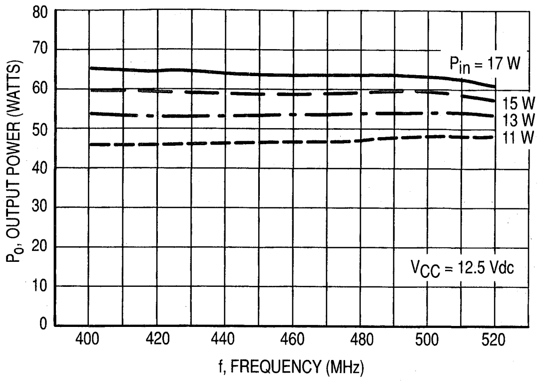


Figure 3. Output Power versus Frequency

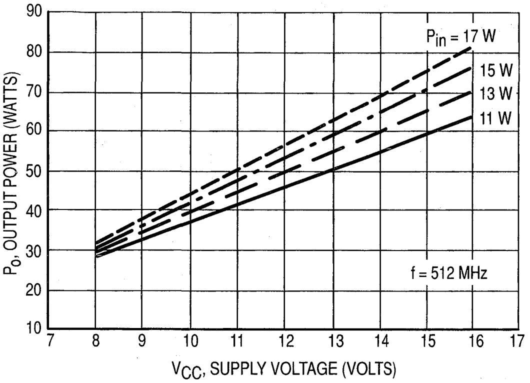


Figure 4. Output Power versus Supply Voltage

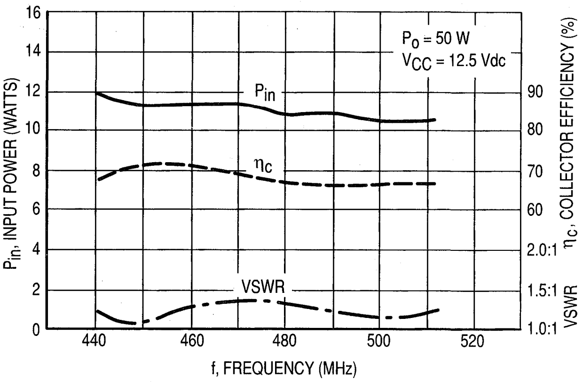
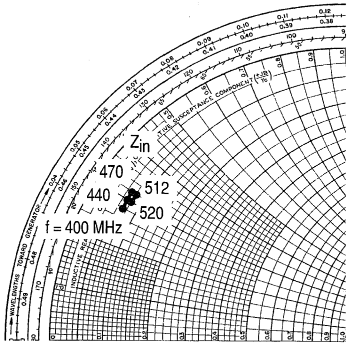


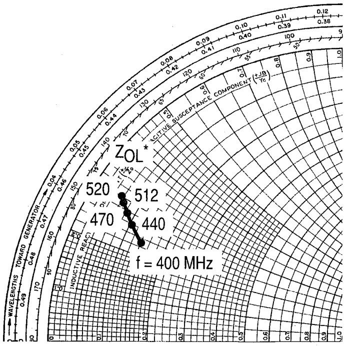
Figure 5. Broadband Performance for P_o = 50 W



P_{out} = 50 W, V_{CC} = 12.5 Vdc

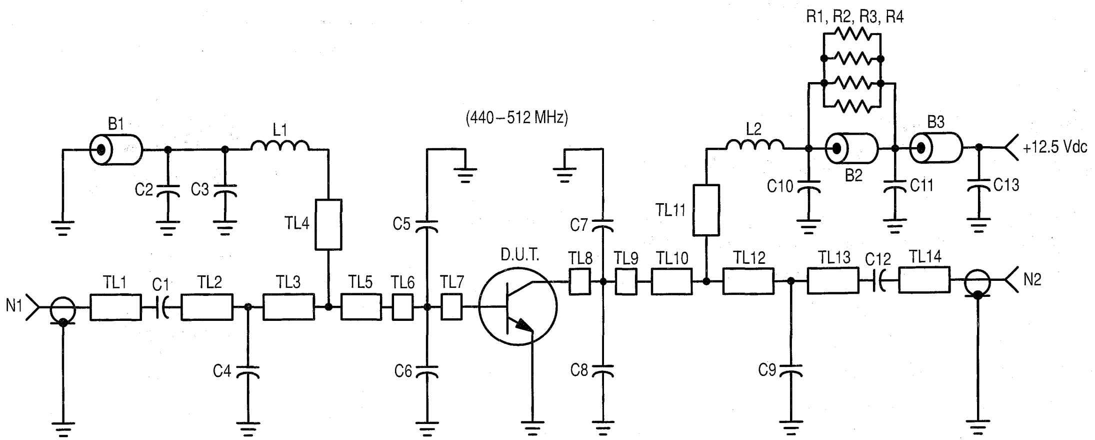
TUNED FOR MAXIMUM GAIN AT P_o = 50 W

f (MHz)	Z_{in} Ω	Z_{OL}* Ω
400	0.7 + j2.8	1.4 + j2.3
440	0.7 + j3.2	1.1 + j2.6
470	0.8 + j3.3	0.8 + j2.7
512	0.8 + j3.2	0.7 + j2.9
520	0.7 + j3.0	0.6 + j3.0



Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 6. Input and Output Impedance Normalized to 10 Ohms
Circuit Tuned for Maximum Gain @ P_o = 50 W



B1, B2 — Ferrite Bead Fair Rite Products Corp.
B3 — Ferrite Bead Fair Rite Products Corp.

C2, C11 — 820 pF, 5%
C3, C10 — 91 pF, 5%, Mica, SAHA 3HS0006–91
C1, C12 — 220 pF, 5%, Murata Erie
C4 — 9.1 pF, 5%, Murata Erie
C5, C6, C7, C8 — 43 pF, 5%, Mica SAHA 3HS0006–43
C9 — 10 pF, 5%, Murata Erie
C13 — 10 µF, Electrolytic, 50 V, Panasonic

L1 — 7 Turns, 24 AWG, ID Dia. 0.116″
L2 — 5 Turns, 18 AWG, ID Dia. 0.165″

N1, N2 — SMA Flange Mount, Omni–Spectra 2052–1618–02

R1, R2, R3, R4 — 39 Ohm 1/8 W 5% Rohm
TL1 — Z_o = 50 Ohm
TL2 — Z_o = 50 Ohm
TL3 — Z_o = 50 Ohm
TL4 — See Photomaster
TL5 — Z_o = 50 Ohm
TL6 — See Photomaster
TL7 — See Photomaster
TL8 — See Photomaster
TL9 — See Photomaster
TL10 — Z_o = 50 Ohm
TL11 — See Photomaster
TL12 — Z_o = 50 Ohm
TL13 — Z_o = 50 Ohm
TL14 — Z_o = 50 Ohm
Board Material: 1/16″ G10, ε_r = 4.5
2 oz. Cu Clad Both Sides

Figure 7. Schematic of Broadband Demonstration Amplifier (3)

PERFORMANCE CHARACTERISTICS OF BROADBAND DEMONSTRATION AMPLIFIER

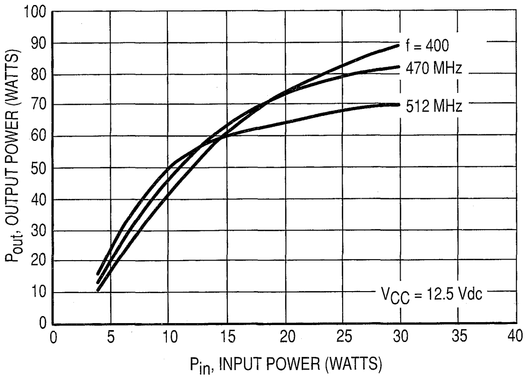


Figure 8. Output Power versus Input Power

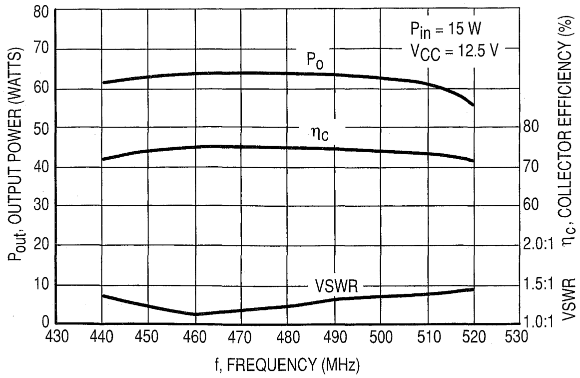


Figure 9. P_o, η_c and VSWR versus Frequency

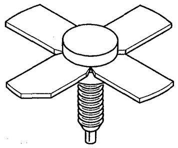
(3) Detailed design and performance information available from Motorola upon request.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

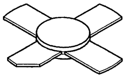
The RF Line
NPN Silicon RF Power Transistors

MRF652
MRF652S

5.0 W, 512 MHz
RF POWER
TRANSISTORS
NPN SILICON



CASE 244–04, STYLE 1
MRF652



CASE 249–06, STYLE 1
MRF652S

Designed for 12.5 Vdc UHF large–signal, amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Guaranteed 12.5 Volt, 512 MHz Characteristics
  Output Power = 5.0 Watts
  Minimum Gain = 10 dB
  Efficiency = 65% (Typ)
- Typical Performance at 512 MHz, 12.5 V, 5.0 W Output = 6.0 dB
- Series Equivalent Large–Signal Characterization
- Gold Metallized, Emitter Ballasted for Long Life and Reliability
- Capable of 30:1 VSWR Load Mismatch at 15.5 V Supply Voltage
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 143	Watts mW/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	7.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

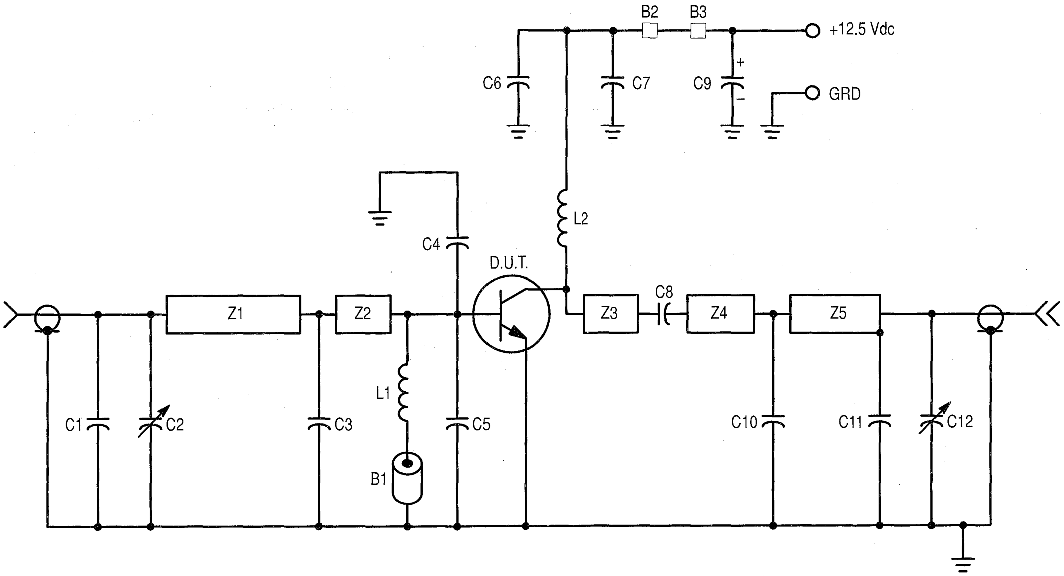
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 25 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	150	—

(continued)

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	9.5	15	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 5.0 W) f = 512 MHz f = 870 MHz	G_{pe}	10 —	11 6.0	— —	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 5.0 W, f = 512 MHz)	η	60	65	—	%
Load Mismatch (V_{CC} = 15.5 Vdc, P_{in} = 500 mW, f = 512 MHz, VSWR = 30:1, At All Phase Angles)	ψ	No Degradation in Output Power			



B1, B2, B3 — Ferrite Bead
C1 — 7.0 pF Unelco Mica
C2 — 1.0–6.0 pF Johanson Variable 5201
C3 — 15 pF Unelco Mica
C4 — 43 pF Mini–Underwood Mica
C5 — 56 pF Mini–Underwood Mica
C6 — 1000 pF Unelco Mica
C7 — 0.1 µF Ceramic
C8 — 68 pF Mini–Underwood Mica
C9 — 1.0 µF Electrolytic 25 V
C10, C11 — 5.0 pF Unelco Mica
C12 — 1.0–10 pF Johanson Variable 5501
L1, L2 — 6 Turns, 20 AWG Wire 0.125″ ID
Z1, Z2 — 25 Ohm µStripline
Z3, Z4, Z5 — 50 Ohm µStripline
Board — 0.032″ Glass–Teflon

Figure 1. 440–512 MHz Broadband Test Circuit

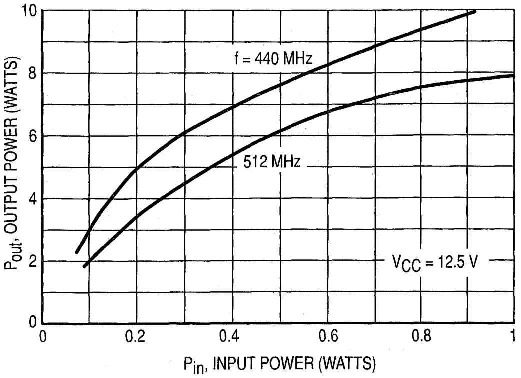


Figure 2. Output Power versus Input Power

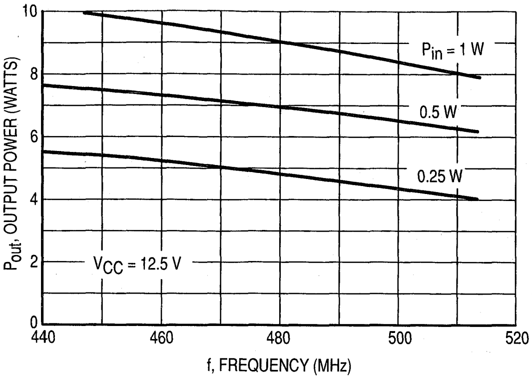


Figure 3. Output Power versus Frequency

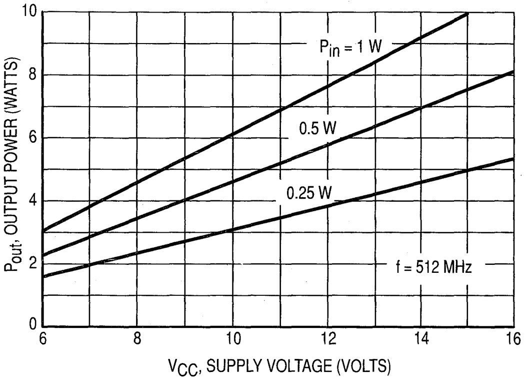


Figure 4. Output Power versus Supply Voltage

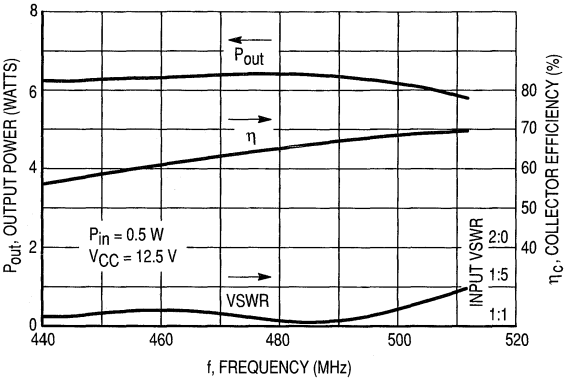
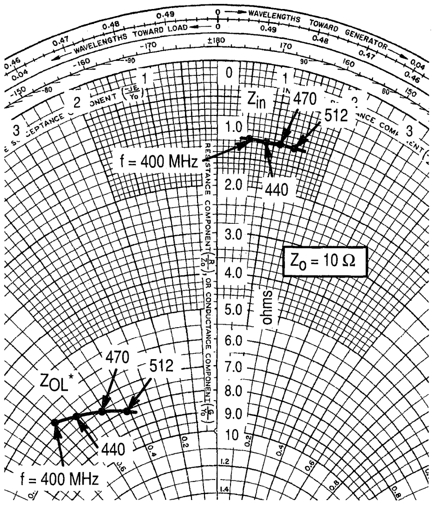


Figure 5. Typical Broadband Circuit Performance



V_{CC} = 12.5 Vdc
P_{out} = 5.0 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
400	1.18 + j0.54	6.7 – j6.9
440	1.19 + j0.88	7.05 – j6.1
470	1.19 + j1.11	7.6 – j5.1
512	1.19 + j1.35	8.1 – j4.1

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input/Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

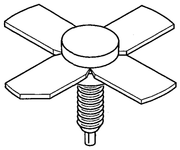
The RF Line
NPN Silicon RF Power Transistors

MRF653
MRF653S

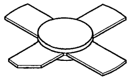
Designed for 12.5 Volt UHF large–signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 512 MHz Characteristics
  Output Power = 10 W
  Gain = 8.0 dB (Typ)
  Efficiency = 65% (Typ)
- Gold Metallized, Emitter Ballasted for Long Life and Reliability
- Capable of 20:1 VSWR Load Mismatch at 16 V Supply Voltage
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

10 W, 512 MHz
RF POWER
TRANSISTORS
NPN SILICON



CASE 244–04, STYLE 1
MRF653



CASE 249–06, STYLE 1
MRF653S

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16.5	Vdc
Collector–Base Voltage	V_{CBO}	38	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.75	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	44 0.25	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

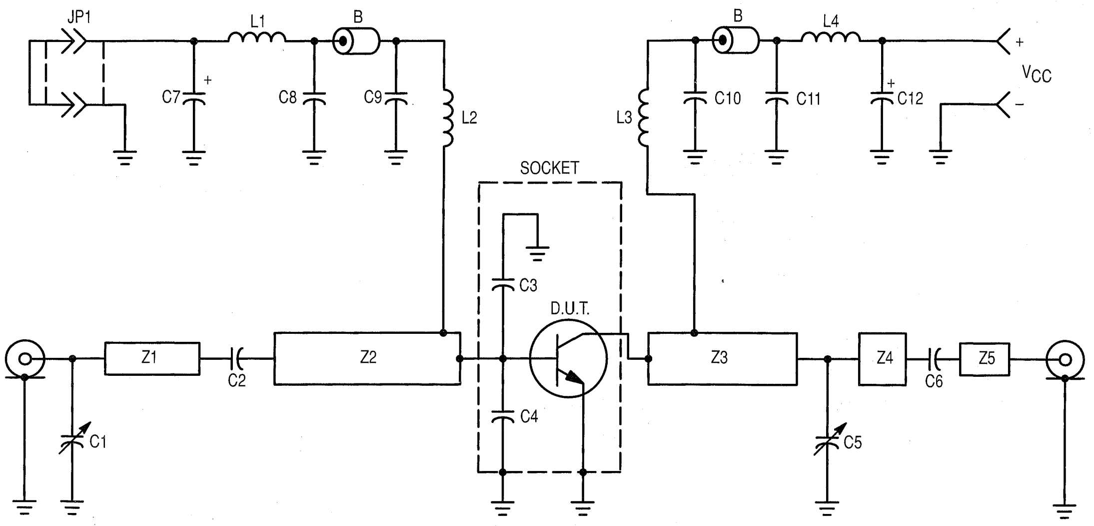
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	4.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	16.5	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	38	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	22	28	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 10 W, f = 512 MHz)	G_{pe}	7.0	8.0	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 10 W, f = 512 MHz)	η_c	55	65	—	%
Load Mismatch Stress (V_{CC} = 16 Vdc, f = 512 MHz, P_{in} (1) = 2.6 W, VSWR = 20:1, All Phase Angles)	ψ	No Degradation in Output Power			

NOTE:
1. P_{in} = 2.0 dB over the typical input power required for 10 W output power @ 12.5 Vdc.

REV 7



C1, C5 — 1.0−20 pF, Johanson
C2, C6 — 330 pF, 100 Mil ATC
C3, C4 — 36 pF, Mini–Unelco
C7, C12 — 10 µF, 35 V, Tantalum
C8, C11 — 0.1 µF, Ceramic
C9, C10 — 91 pF, Mini–Unelco

L1, L4 — 4–1/2 Turns, #18 AWG, 0.16″ ID
L2, L3 — 2 Turns, #18 AWG, 0.16″ ID
B — Ferrite Bead, Ferroxcube 56–590–65–3B
Z1 — 51 x 630 mils
Z2 — 162 x 1300 mils
Z3 — 210 x 1350 mils
Z4 — 210 x 280 mils
Z5 — 51 x 300 mils
Board Material — 0.032″ epoxy glass G10, 1 oz., copper clad, double sided, $\varepsilon_r = 5$
JP1 — Jumper, #14 AWG w/Banana Plugs

Figure 1. Broadband Test Circuit Schematic

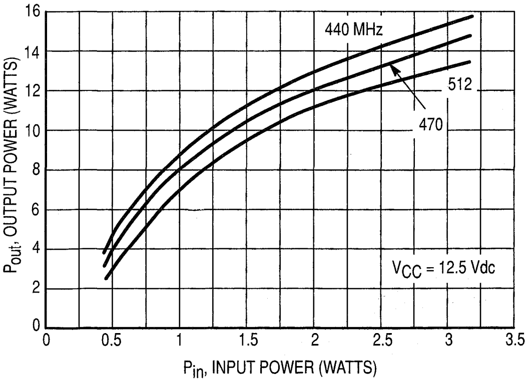


Figure 2. Output Power versus Input Power

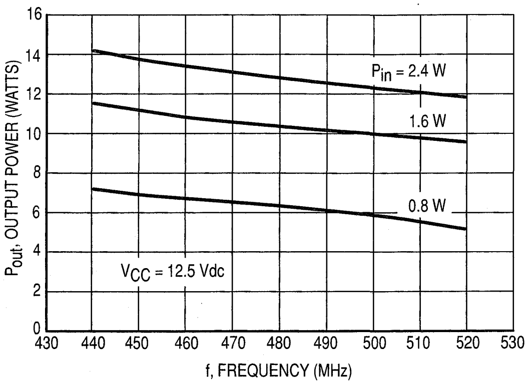


Figure 3. Output Power versus Frequency

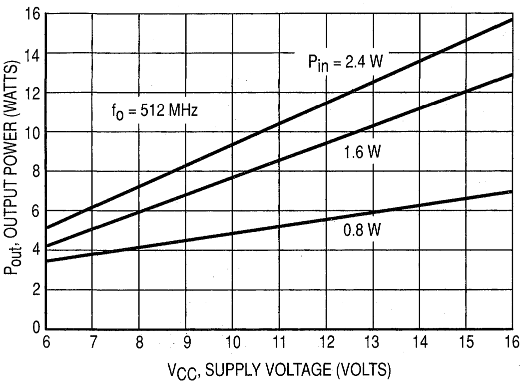


Figure 4. Output Power versus Supply Voltage

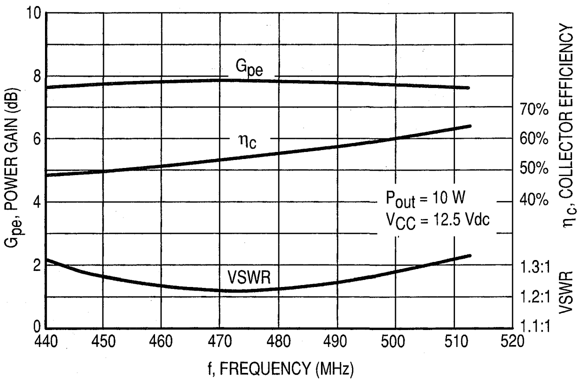
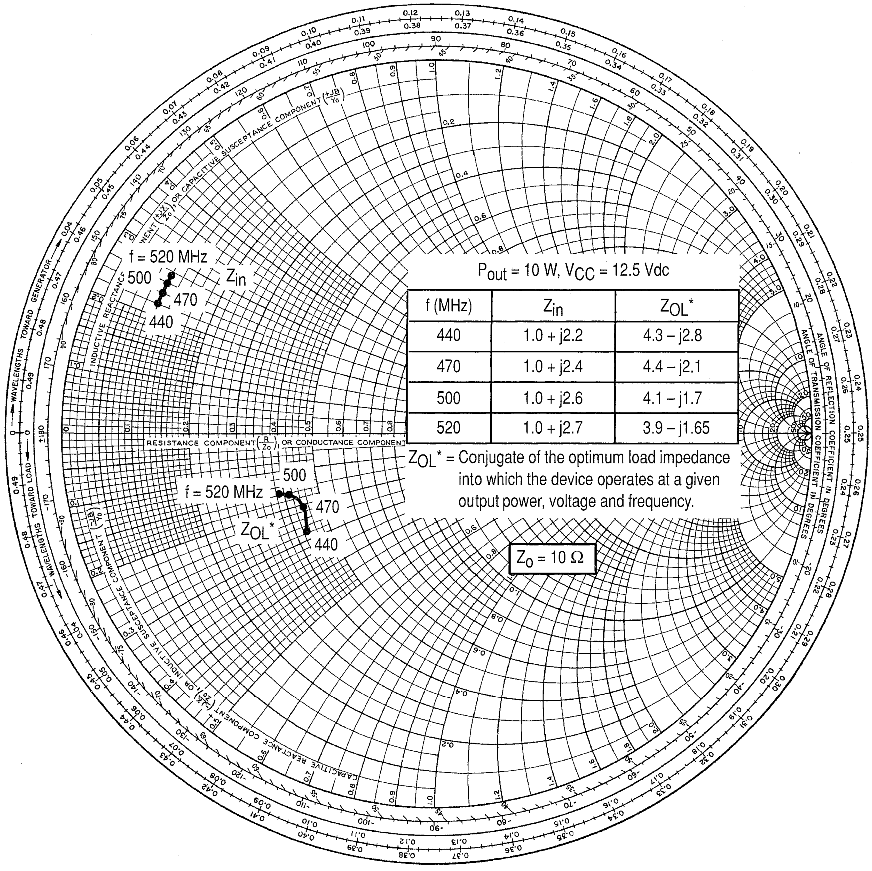


Figure 5. Typical Broadband Circuit Performance



P_{out} = 10 W, V_{CC} = 12.5 Vdc

f (MHz)	Z_{in}	Z_{OL}*
440	1.0 + j2.2	4.3 – j2.8
470	1.0 + j2.4	4.4 – j2.1
500	1.0 + j2.6	4.1 – j1.7
520	1.0 + j2.7	3.9 – j1.65

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input and Output Impedance

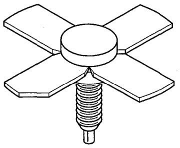
The RF Line
NPN Silicon RF Power Transistor

MRF654

15 W, 470 MHz
RF POWER
TRANSISTOR
NPN SILICON

. . . designed for 12.5 Volt UHF large–signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 512 MHz Characteristics
  Output Power = 15 W
  Minimum Gain = 7.8 dB
  Efficiency = 55%
- Built–In Matching Network for Broadband Operation
- Gold Metallized, Emitter Ballasted for Long Life and Reliability
- Capable of 20:1 VSWR Load Mismatch at 15.5 V Supply Voltage
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 244–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	44 0.25	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	4.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

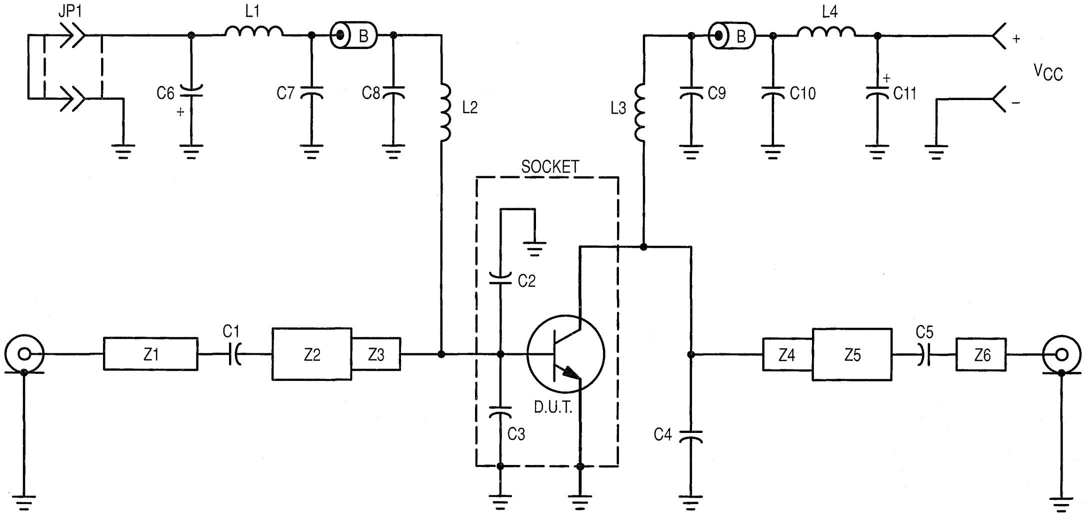
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	—	—	2.0	mAdc

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	31	45	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 512 MHz)	G_{pe}	7.8	8.8	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 512 MHz)	η	55	63	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, f = 512 MHz, P_{in} = 3.0 W, VSWR = 20:1, All Phase Angles)	ψ	No Degradation in Output Power			



C1, C5 — 68 pF Mini–Unelco
C2, C3 — 33 pF, Mini–Unelco
C4 — 47 pF, Mini–Unelco
C6, C11 — 10 µF, 25 V Tantalum
C7, C10 — 0.1 µF, Ceramic
C8, C9 — 91 pF, Mini–Unelco
L1, L4 — 4–1/2 Turns, #18 AWG, Enamel Covered, 0.16″ ID
L2, L3 — 2 Turns, #18 AWG Enamel Covered, 0.16″ ID
B — Ferrite Bead, Ferroxcube 56–590–65–3B
Z1–Z6 — See PCB Artwork
PCB — 1/32″ G–10, ε_r = 4.5 @ UHF
Socket — See Socket Drawings
JP1 — Jumper, #14 AWG w/Banana Plugs

Figure 1. 440–512 MHz Broadband Test Circuit

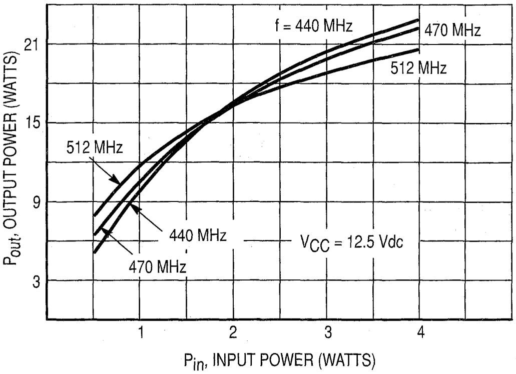


Figure 2. Output Power versus Input Power

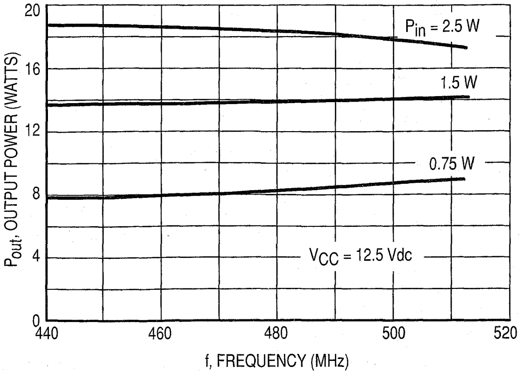


Figure 3. Output Power versus Frequency

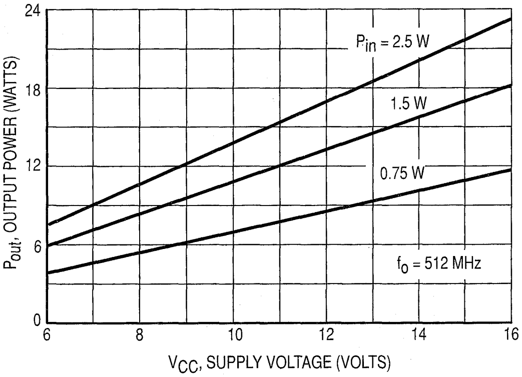


Figure 4. Power Output versus Supply Voltage

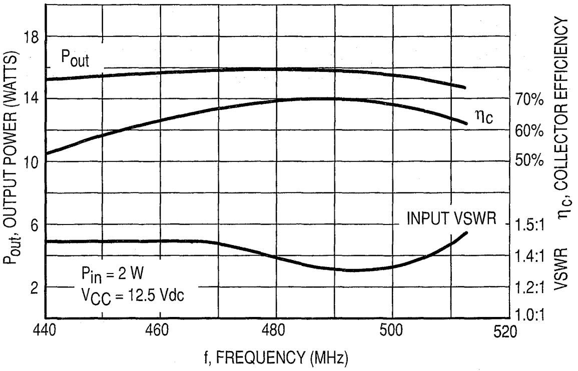
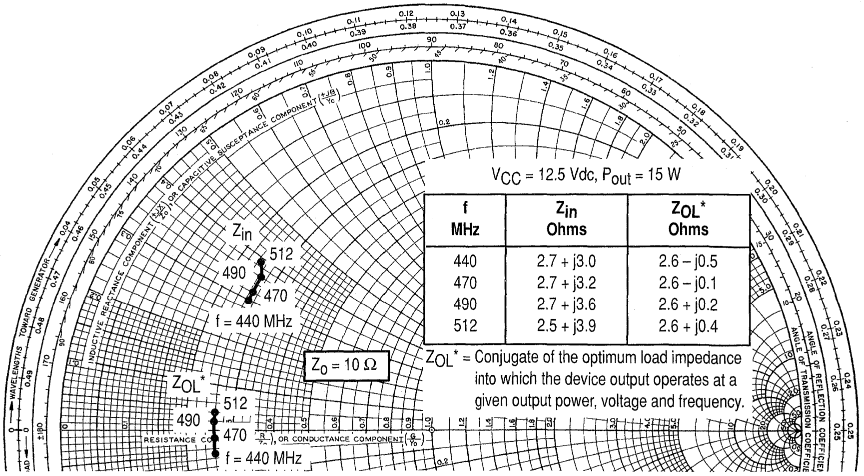


Figure 5. Typical Broadband Circuit Performance



VCC = 12.5 Vdc, Pout = 15 W

f MHz	Zin Ohms	ZOL* Ohms
440	2.7 + j3.0	2.6 – j0.5
470	2.7 + j3.2	2.6 – j0.1
490	2.7 + j3.6	2.6 + j0.2
512	2.5 + j3.9	2.6 + j0.4

ZOL* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input and Output Impedance

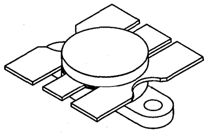
The RF Line
NPN Silicon RF Power Transistor

MRF658

65 W, 512 MHz
RF POWER TRANSISTOR
NPN SILICON

Designed for 12.5 Volt UHF large–signal, common emitter, class–C amplifier applications in industrial and commercial FM equipment operating to 520 MHz.

- Specified 12.5 Volt, 512 MHz Characteristics
  Output Power = 65 Watts
  Minimum Gain = 4.15 dB
  Minimum Efficiency = 50%
- Characterized with Series Equivalent Large–Signal Impedance Parameters from 400 to 520 MHz
- Built–In Matching Network for Broadband Operation
- Triple Ion Implanted for More Consistent Characteristics
- Implanted Emitter Ballast Resistors for Improved Ruggedness
- Silicon Nitride Passivated
- Capable of Surviving Load Mismatch Stress at all Phase Angles with 20:1 VSWR @ 15.5 Vdc and 2.0 dB Overdrive



CASE 316–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16.5	Vdc
Collector–Emitter Voltage	V_{CES}	38	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	15	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	175 1.0	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

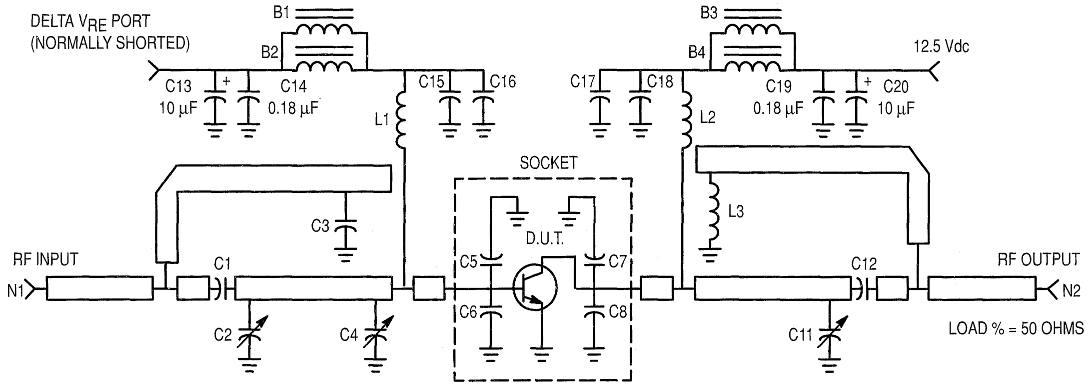
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 50$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16.5	29	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 50$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	38	45	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 10$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	4.6	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$, $T_C = 25°C$)	I_{CES}	—	0.1	10	mAdc

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	40	85	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	170	220	pF
FUNCTIONAL TESTS (In Motorola Test Fixture. See Figure 1.)					
Output Power (V_{CC} = 12.5 Vdc, P_{in} = 25 W, f = 470 & 512 MHz)	P_{out}	65	—	—	W
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 65 W, f = 470 & 512 MHz)	η	50	60	—	%
Output Mismatch Stress (V_{CC} = 15.5 Vdc, P_{in} = 32 W, f = 512 MHz, VSWR 20:1, All Phase Angles)	ψ	No Degradation in Output Power			
Input Return Loss (P_o = 65 W, f = 470 & 512 MHz, V_{CC} = 12.5 V)	IRL	10	15	—	dB



B1–B4 — Long Bead, Fair Rite (2743019446)
C1 — 56 pF, Chip Capacitor, Murata Erie
C2 — 1–20 pF Trimmer, Johanson–JMC 5501 PG26J200
C3 — 39 pF, Chip Capacitor, Murata Erie
C4 — 1–20 pF Trimmer, Johanson–JMC 5501
C5 — 33 pF, Miniature Clamped Mica, SAHA
C6 — 33 pF, Miniature Clamped Mica, SAHA
C7 — 33 pF, Miniature Clamped Mica, SAHA
C8 — 27 pF, Miniature Clamped Mica, SAHA
C11 — 1–20 pF Trimmer, Johanson–JMC 5501 PG26J200
C12 — 110 pF, Chip Capacitor, Murata Erie
C13 — 10 µF, 50 V Electrolytic, Panasonic–ECEV1HV100R
C14 — 0.18 µF Chip Capacitor
C15 — 130 pF, Chip Capacitor, Murata Erie
C16 — 130 pF, Chip Capacitor, Murata Erie
C17 — 130 pF, Chip Capacitor, Murata Erie
C18 — 130 pF, Chip Capacitor, Murata Erie
C19 — 0.18 µF Chip Capacitor
C20 — 10 µF, 50 V Electrolytic, Panasonic–ECEV1HV100R
Board — 1/16″ Glass Teflon, ε_r = 2.55, Keene (GX–0600–55–22)
L1, L2 — 5 Turns, 20 AWG, ID 0.126″
L3 — 2 Turns, 26 AWG, ID 0.073″
N1, N2 — Type N Flange, Omni Spectra (3052–1648–10)

Murata Erie Chip Capacitors —
GRH710COGxxxx100VBE
SAHA Mini Clamped Mica Capacitors — 3HS0006–xx

Figure 1. 512 MHz Test Circuit

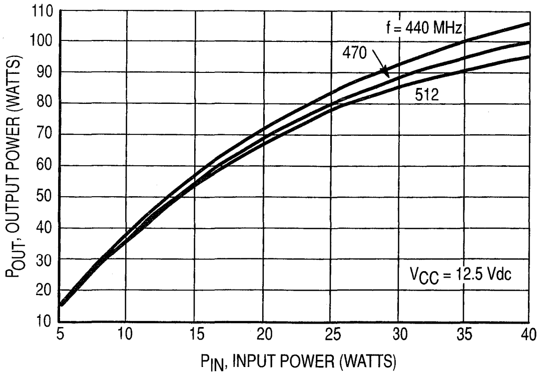


Figure 2. Output Power versus Input Power

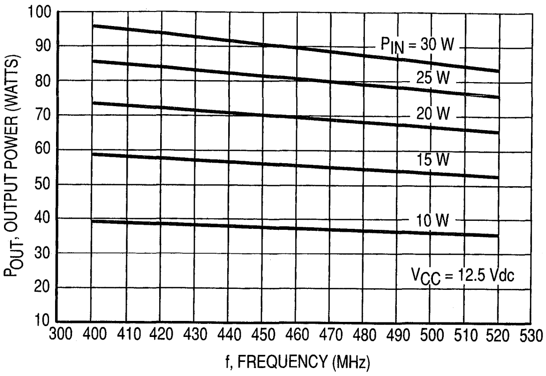


Figure 3. Output Power versus Frequency

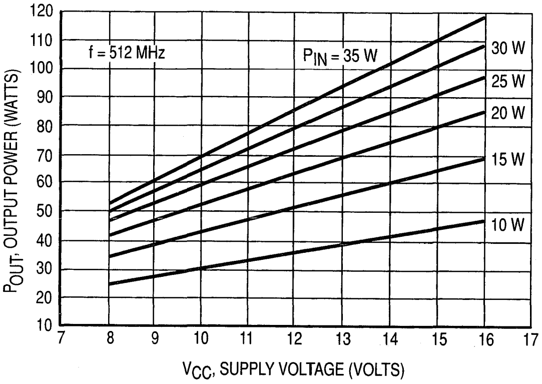
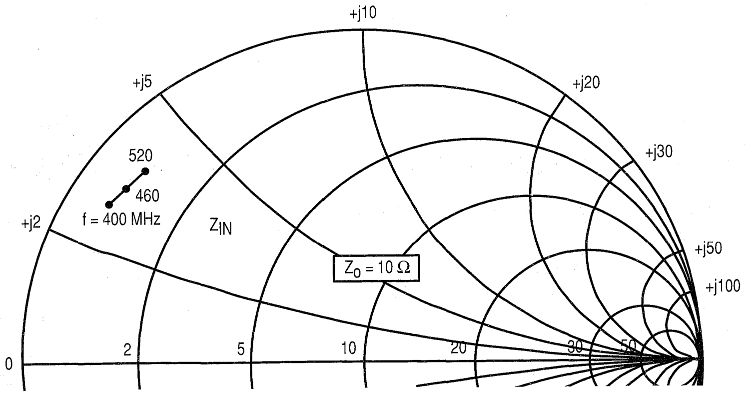
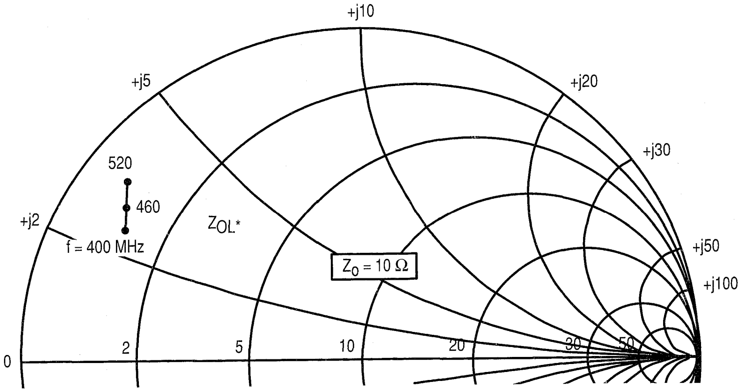


Figure 4. Output Power versus Supply Voltage



V_{CC} = 12.5 V P_o = 70 W

f MHz	ZIN OHMS	ZOL* OHMS
400	0.62 + j2.8	1.20 + j2.5
440	0.72 + j3.1	1.10 + j2.8
480	0.81 + j3.3	0.94 + j3.1
520	0.90 + j3.6	0.80 + j3.4



Z_{OL}* = Conjugate of optimum load impedance into
which the device operates at a given output
power, voltage and frequency.

Figure 5. Series Equivalent Input and Output Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

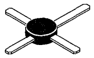
The RF Line
NPN Silicon RF Low Power Transistor

MRF837
MRF8372, R1, R2

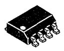
Designed primarily for wideband large signal predriver stages in 800 MHz and UHF frequency ranges.

- Specified @ 12.5 V, 870 MHz Characteristics
  Output Power = 750 mW
  Minimum Gain = 8.0 dB
  Efficiency 60% (Typ)
- Low Cost Macro–X Plastic Package or SORF Plastic Surface Mounted Package
- State–of–the–Art Technology
  Fine Line Geometry
  Gold Top Metal and Wires
  Silicon Nitride Passivated
  Ion Implanted Arsenic Emitters
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.
- MRF8372 available in tape and reel packaging options by adding suffix:
  R1 suffix = 500 units per reel
  R2 suffix = 2,500 units per reel

750 mW, 870 MHz
RF LOW POWER
TRANSISTOR
NPN SILICON



CASE 317–01, STYLE 2
MACRO–X
MRF837



CASE 751–05, STYLE 1
SORF (SO–8)
MRF8372

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector–Emitter Voltage		V_{CEO}	16	Vdc
Collector–Base Voltage		V_{CBO}	36	Vdc
Emitter–Base Voltage		V_{EBO}	4.0	Vdc
Collector Current — Continuous		I_C	200	mAdc
Total Device Dissipation @ T_C = 75°C (1) Derate above 75°C	MRF837	P_D	1.88 25	Watts mW/°C
Total Device Dissipation @ T_C = 75°C (1) Derate above 75°C	MRF8372	P_D	1.67 22.2	Watts mW/°C
Storage Temperature Range		T_J, T_{stg}	–55 to +150	°C
Maximum Junction Temperature		T_{Jmax}	150	°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Case	MRF837	$R_{\theta JC}$	40	°C/W
Thermal Resistance, Junction to Case	MRF8372	$R_{\theta JC}$	45	°C/W

DEVICE MARKING

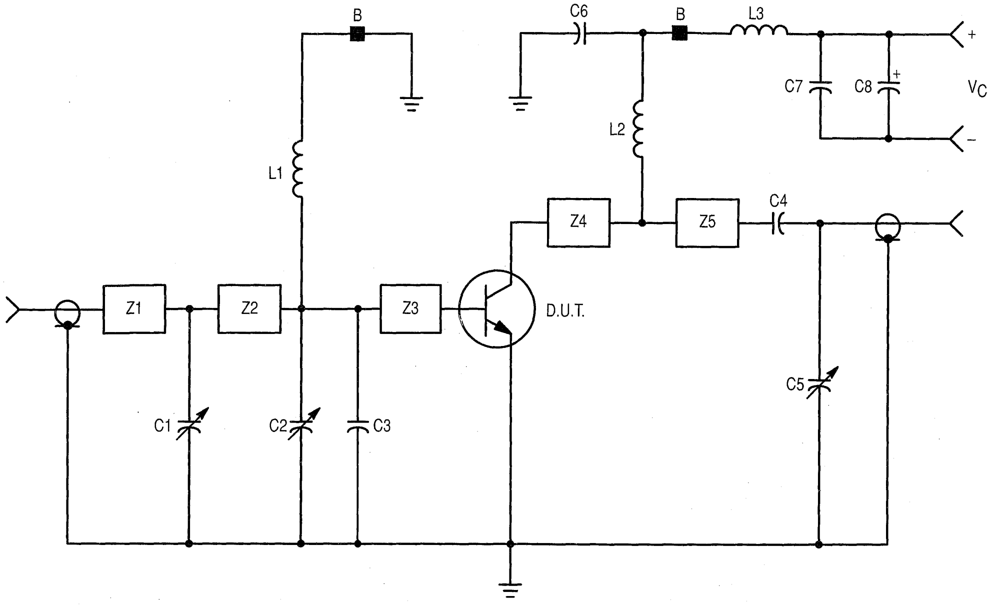
MRF8372 = 8372

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

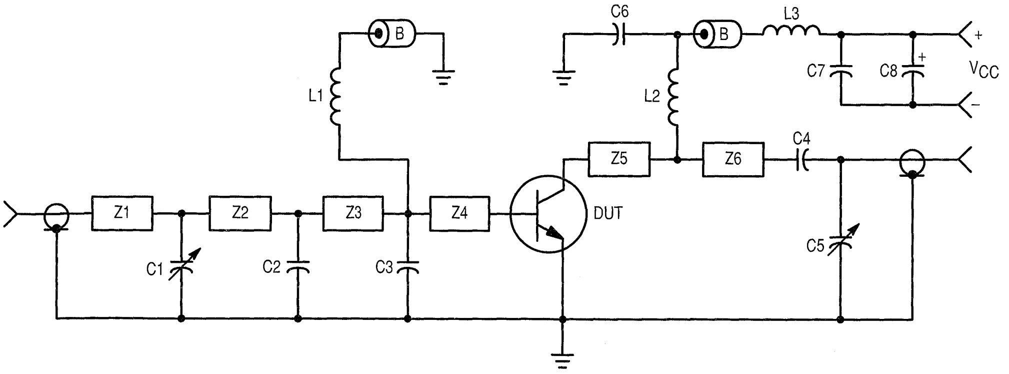
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	90	200	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	1.8	2.5	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 870 MHz)	G_{pe}	8.0	10	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 870 MHz)	η	55	60	—	%



C1, C2, C5 — 0.8–8.0 pF Johanson Gigatrim
C3 — 5.0 pF Clamped Mica, Mini–Underwood
C6 — 91 pF Clamped Mica, Mini–Underwood
C4 — 470 pF Ceramic Chip Capacitor
C7 — 68 pF Clamped Mica, Mini–Underwood
C8 — 1.0 μF 25 V Tantalum
B — Bead, Ferroxcube 56–590–65/3B

L1, L2 — 4 Turns, #21 AWG, 5/32″ ID
L3 — 7 Turns, #21 AWG, 5/32″ ID
Z1 — 0.80″ x 0.163″ Microstrip, Z_O = 50 Ω
Z2 — 1.375″ x 0.163″ Microstrip, Z_O = 50 Ω
Z3, Z4 — 0.375″ x 0.163″ Microstrip, Z_O = 50 Ω
Z5 — 1.35″ x 0.163″ Microstrip, Z_O = 50 Ω
PCB — 1/16″ Glass Teflon, ε_r = 2.56

Figure 1. MRF837 800–880 MHz Broadband Circuit



C1, C5 — 0.8–8.0 pF Johanson Gigatrim
C2, C3 — 10 pF Ceramic Chip Capacitor
C6 — 91 pF Clamped Mica, Mini–Underwood
C4 — 47 pF Ceramic Chip Capacitor
C7 — 91 pF Clamped Mica, Mini–Underwood
C8 — 1.0 μF 25 V Tantalum
B — Bead, Ferroxcube 56–590–65/3B

L1, L2 — 4 Turns, #21 AWG, 5/32″ ID
L3 — 7 Turns, #21 AWG, 5/32″ ID
Z1, Z2 — 1″ x 0.078″ Microstrip, Z_O = 50 Ohms
Z3 — 0.25″ x 0.078″ Microstrip, Z_O = 50 Ohms
Z4 — 0.15″ x 0.078″ Microstrip, Z_O = 50 Ohms
Z5 — 0.30″ x 0.078″ Microstrip, Z_O = 50 Ohms
Z6 — 1.63″ x 0.078″ Microstrip, Z_O = 50 Ohms
PCB — 1/32″ Glass Teflon, ε_r = 2.56

Figure 2. MRF8372 800–900 MHz Broadband Circuit

800/900 MHz BAND DATA

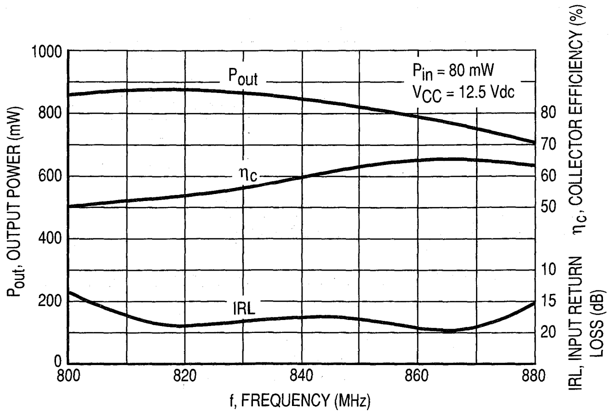


Figure 3. MRF837 Typical Broadband Performance

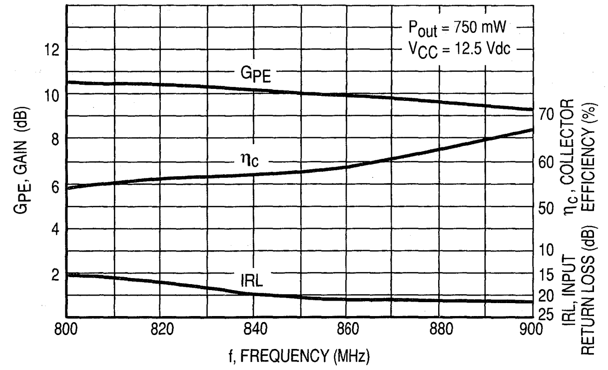


Figure 4. MRF8372 Typical Broadband Performance

	Z_{in} Ohms		Z_{OL}* Ohms	
	V_{CC} = 7.5 V	V_{CC} = 12.5 V	V_{CC} = 7.5 V	V_{CC} = 12.5 V
f Frequency MHz	P_{in} = 150 mW	P_{in} = 100 mW	P_{out} 806 MHz = 870 mW P_{out} 870 MHz = 820 mW P_{out} 960 MHz = 700 mW	P_{out} 806 MHz = 1.05 W P_{out} 870 MHz = 950 mW P_{out} 960 MHz = 725 mW
806	6.1 + j3.6	4.3 + j0.6	38.3 – j16.4	23.2 – j31.6
870	5.6 + j5.2	6.5 + j3.6	40.8 – j18.9	41.3 – j18.4
960	6.1 + j6.8	6.4 + j4.5	43.8 – j14.7	41.4 – j19.0

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage, and frequency.

Table 1. MRF837 Z_{in} and Z_{OL} versus Collector Voltage, Input Power and Output Power

f Frequency MHz	Z_{in} Ohms		Z_{OL}* Ohms	
	V_{CC} = 7.5 V	V_{CC} = 12.5 V	V_{CC} = 7.5 V	V_{CC} = 12.5 V
	P_{in} = 150 mW	P_{in} = 100 mW	P_{out} = 806 MHz = 820 mW P_{out} = 870 MHz = 635 mW P_{out} = 960 MHz = 530 mW	P_{out} = 806 MHz = 1.05 mW P_{out} = 870 MHz = 855 mW P_{out} = 960 MHz = 580 mW
806	8.0 + j1.9	4.0 + j1.2	24.7 – j19.2	20.9 – j31.0
870	5.2 + j3.5	6.0 + j1.9	36.9 – j20.5	32.1 – j26.6
960	6.8 + j4.0	6.1 + j2.5	39.3 – j18.5	36.3 – j25.7

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage, and frequency.

Table 2. MRF8372 Series Equivalent Input/Output Impedance

MRF837
800/900 MHz BAND DATA (continued)

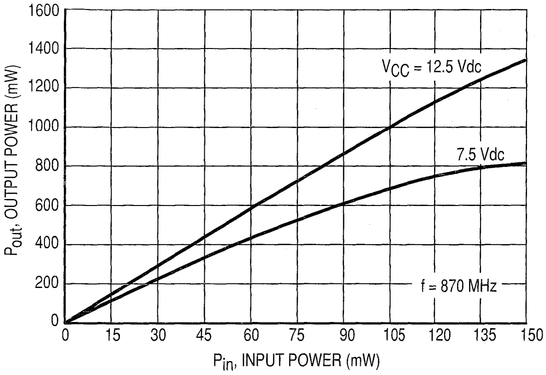


Figure 5. Output Power versus Input Power

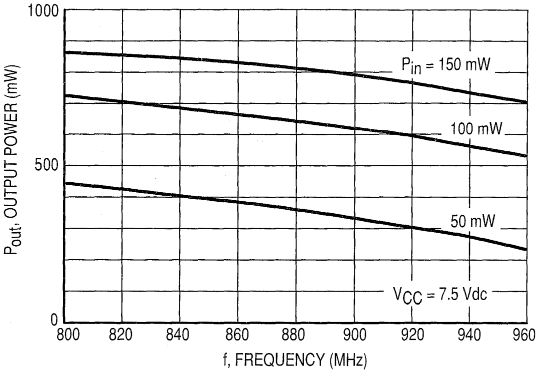


Figure 6. Output Power versus Frequency

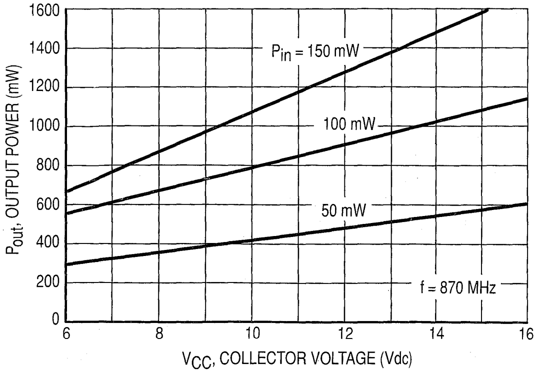


Figure 7. Output Power versus Collector Voltage

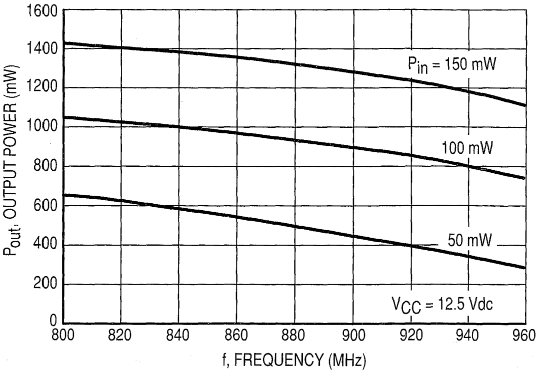


Figure 8. Output Power versus Frequency

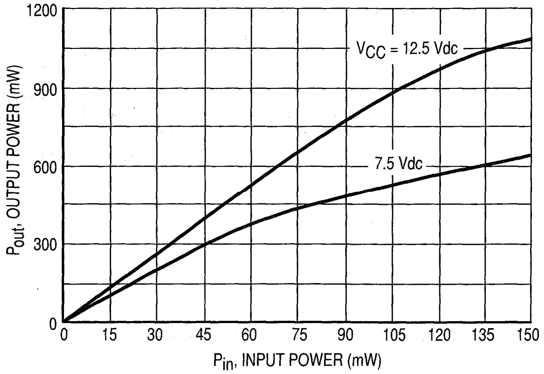


Figure 9. Output Power versus Input Power
f = 870 MHz

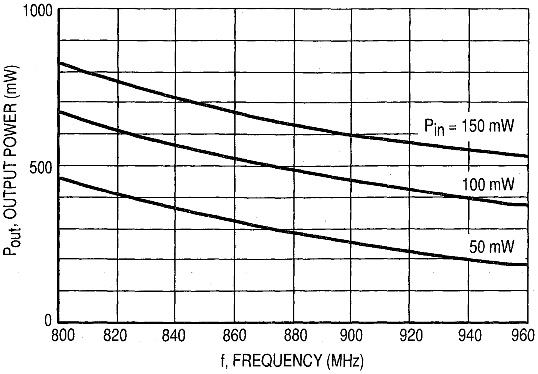


Figure 10. Output Power versus Frequency
V_{CC} = 7.5 Vdc

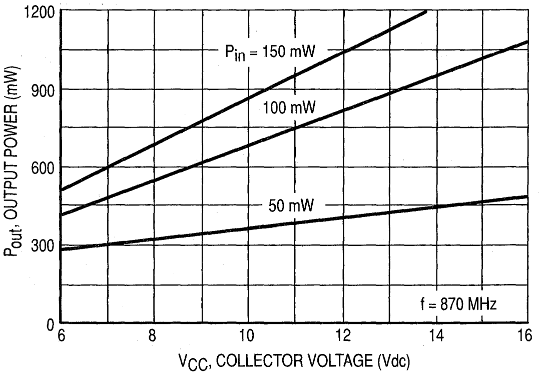


Figure 11. Output Power versus Collector Voltage

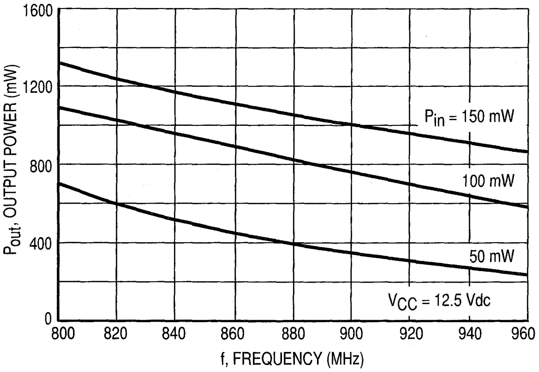


Figure 12. Output Power versus Frequency

MRF837 UHF BAND DATA

	Z_{in} Ohms		Z_{OL}* Ohms	
	V_{CC} = 7.5 V	V_{CC} = 12.5 V	V_{CC} = 7.5 V	V_{CC} = 12.5 V
f Frequency MHz	**P_{in} = 75 mW**	**P_{in} = 50 mW**	**P_{out} 400 MHz = 875 mW P_{out} 450 MHz = 790 mW P_{out} 512 MHz = 675 mW**	**P_{out} 400 MHz = 1.25 W P_{out} 450 MHz = 1.1 W P_{out} 512 MHz = 775 mW**
400	9.6 – j7.5	8.2 – j11.5	37.8 + j12.3	51.8 – j7.2
450	11.3 – j7.5	9.7 – j11	35.8 + j8.6	52.2 – j16.7
512	11.5 – j6.8	12 – j9.2	42.4 + j0.24	43.7 – j5.7

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 2. MRF837 Z_{in} and Z_{OL} versus Collector Voltage, Input Power, and Output Power

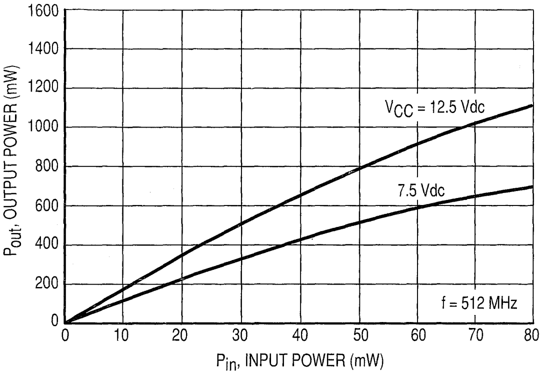


Figure 13. Output Power versus Input Power

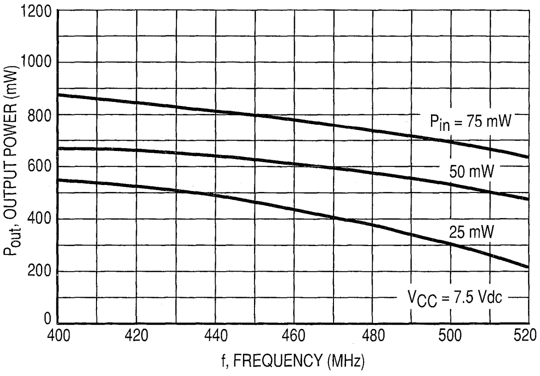


Figure 14. Output Power versus Frequency

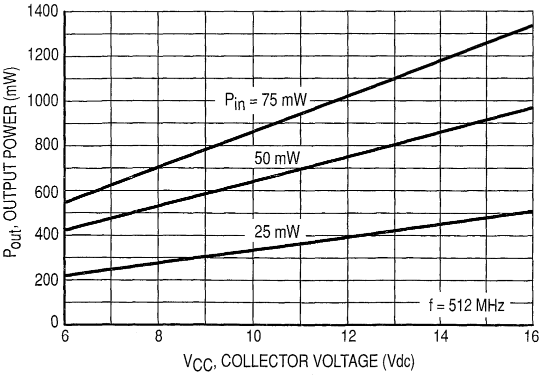


Figure 15. Output Power versus Collector Voltage

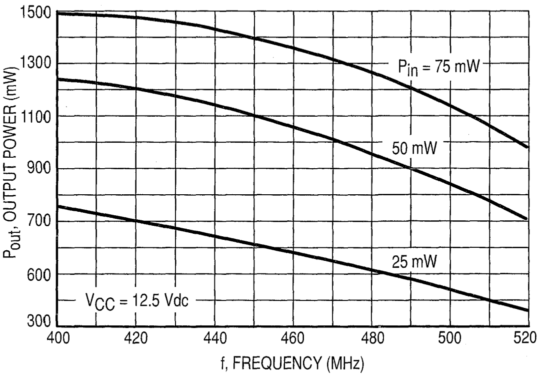
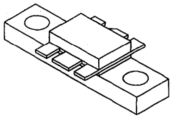


Figure 16. Output Power versus Frequency

The RF Line
NPN Silicon RF Power Transistors

MRF839F

**3.0 W, 806–960 MHz
RF POWER
TRANSISTORS
COMMON–EMITTER
NPN SILICON**



**CASE 319–07, STYLE 2
MRF839F**

. . . designed for 12.5 Volt UHF large–signal, common–emitter amplifier applications in industrial and commercial FM equipment operating in the range of 806–960 MHz.

- Specified 12.5 V, 870 MHz Characteristics
  Output Power = 3.0 Watts
  Power Gain = 8.0 dB Min
  Efficiency = 55% Min
- 100% Tested for Load Mismatch at Rated Input Power and 15.5 V
- Series Equivalent Large–Signal Characterization
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.6	Adc
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ T_C = 110°C Derate above 110°C	P_D	10 111	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	9.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	90	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	6.5	10	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	G_{PE}	8.0	10	—	dB
Collector Efficiency (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	η_C	55	63	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, P_{in} = 0.5 W, f = 870 MHz, VSWR = 20:1, all phase angles)	ψ	No Degradation in Output Power			

REV 6

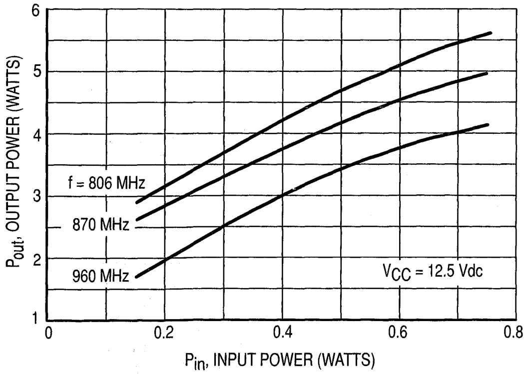


Figure 1. Output Power versus Input Power

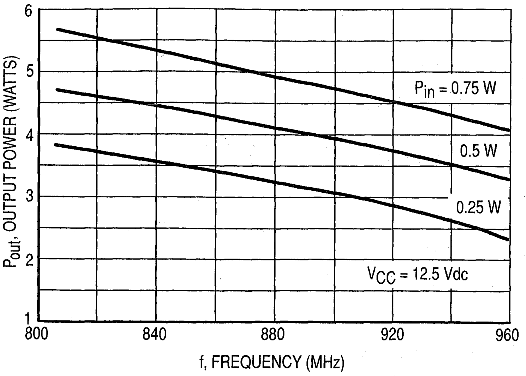


Figure 2. Output Power versus Frequency

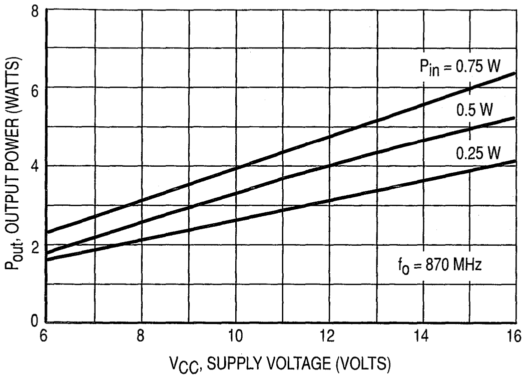


Figure 3. Output Power versus Supply Voltage

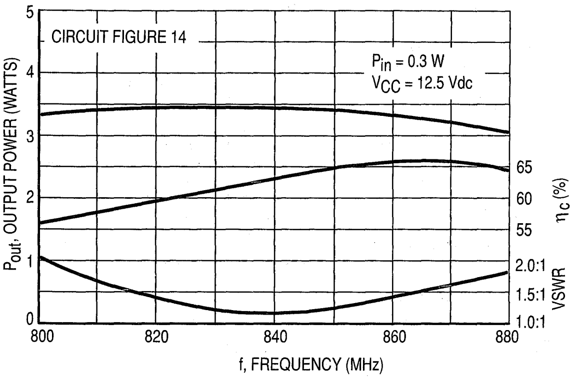
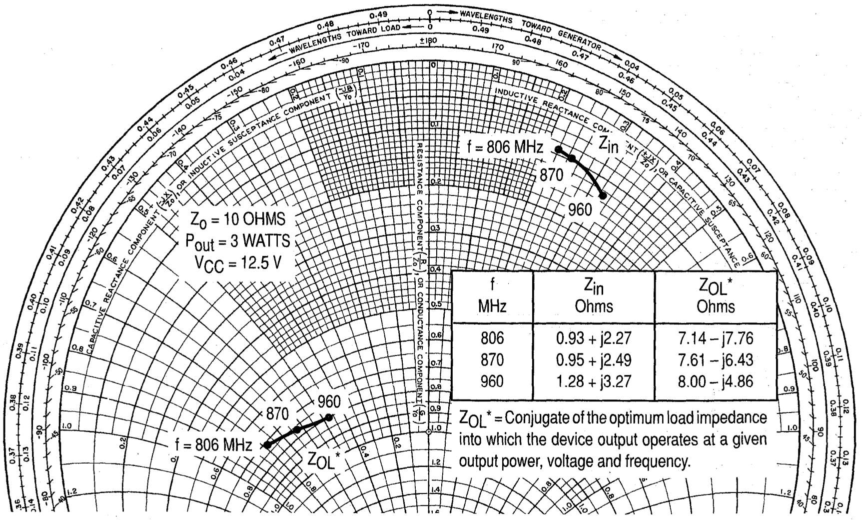


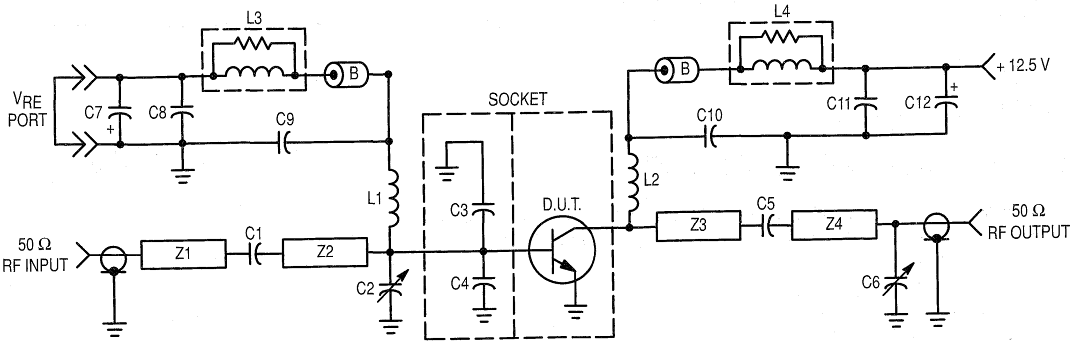
Figure 4. Broadband Performance



f MHz	Zin Ohms	ZOL* Ohms
806	0.93 + j2.27	7.14 – j7.76
870	0.95 + j2.49	7.61 – j6.43
960	1.28 + j3.27	8.00 – j4.86

ZOL* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Input/Output Impedances



B — Bead, Ferroxcube #56–590–65/3B
C1 — 47 pF Chip Cap (Murata Erie MA20470B)
C3, C4 — 13 pF Mini–Underwood
C5 — 51 pF Chip Cap (ATC 100B510JC500)
C2, C6 — 0.8–8.0 pF Johanson #7291
C7, C12 — 10 μF, 35 V Electrolytic Capacitor
C8, C11 — 1000 pF Unelco, J101
C9, C10 — 91 pF Mini–Underwood

L1, L2 — 4 Turns, #18 Enameled, 5/32″ ID
L3, L4 — 12 Turns, #22 Enameled over 10 Ohm, 1/2 W Carbon Resistor
Z1, Z4 — 50 Ohm Stripline
Z2 — 32 Ohm Stripline (1/4 λ @ 838 MHz)
Z3 — 16 Ohm Stripline (1/4 λ @ 838 MHz)
Board Material — 0.032″ Glass Teflon, 2 oz. Copper Clad, $\varepsilon_r = 2.55$

Figure 6. 800–880 MHz Broadband Test Circuit

The RF Line

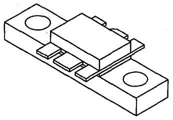
NPN Silicon
RF Power Transistor

MRF840

. . . designed for 12.5 volt UHF large–signal, common–base amplifier applications in industrial and commercial FM equipment operating in the range of 806–960 MHz.

- Specified 12.5 Volt, 870 MHz Characteristics
  Output Power = 10 Watts
  Power Gain = 6.0 dB Min
  Efficiency = 50% Min
- Series Equivalent Large–Signal Characterization
- Internally Matched Input for Broadband Operation
- Tested for Load Mismatch Stress at All Phase Angles with 20:1 VSWR @ 15.5 Volt Supply and 50% RF Overdrive
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated

10 W, 870 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 319–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	3.8	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	40 0.32	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	3.1	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	2.0	mAdc

(continued)

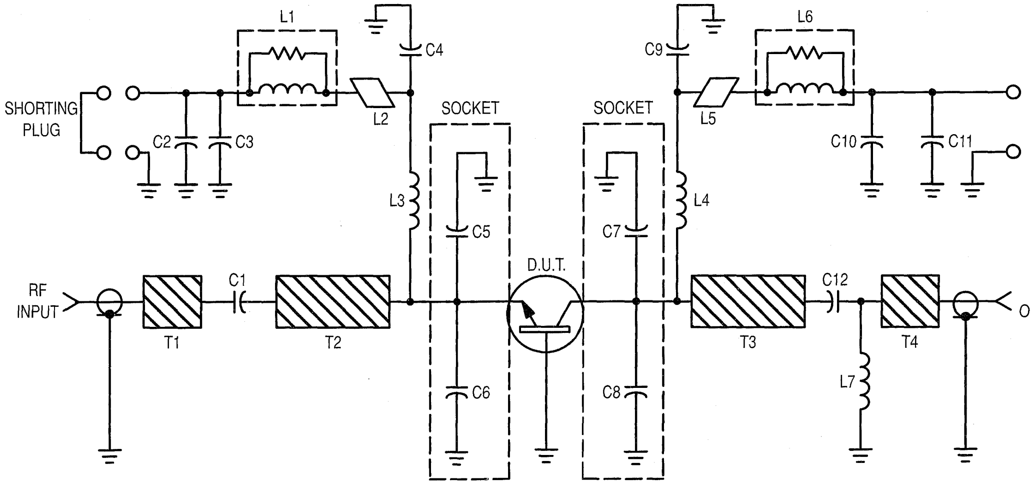
NOTES:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	24	35	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (P_{out} = 10 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	G_{PE}	6.0	7.0	—	dB
Collector Efficiency (P_{out} = 10 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	η	50	55	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, P_{in} = 3.0 W, (3) f = 870 MHz, VSWR = 20:1, all phase angles)	—	No Degradation in Output Power			

NOTE:
3. P_{in} = 150% of the typical input power requirement for 10 W output power @ 12.5 Vdc.



C1, C12 — 50 pF, 100 Mil Chip Capacitor
C2, C11 — 15 µF, 20 V Tantalum
C3, C10 — 1000 pF, 350 V UNELCO
C4, C9 — 91 pF Mini–Underwood
C5 — 15 pF
C6 — 15 pF
C7 — 15 pF
C8 — 15 pF

L1, L6 — 11 Turns 20 AWG Around 10 Ω 1/2 W Resistor
L2, L5 — Ferrite Bead
L3, L4 — 4 Turn 20 AWG 0.2″ I.D.
T1, T4 — Z_O = 50 Ω
T2 — Z_O = 30 Ω $\ell = \lambda/4$ @ 838 MHz
T3 — Z_O = 13.5 Ω $\ell = \lambda/4$ @ 838 MHz

L7 — 18 AWG Wire Loop

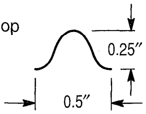


Figure 1. 870 MHz Test Circuit

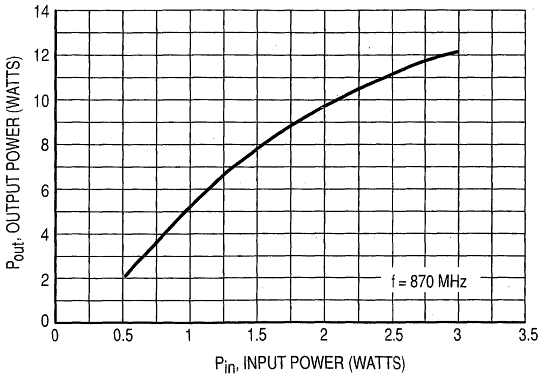


Figure 2. Output Power versus Input Power

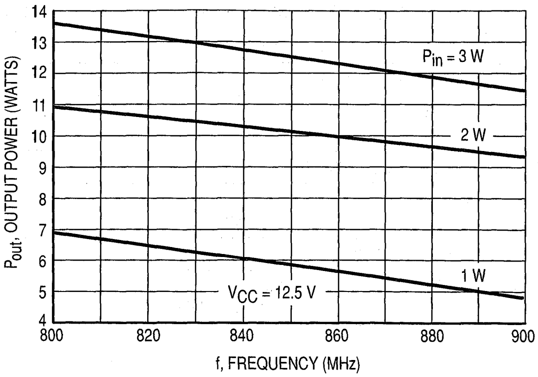


Figure 3. Output Power versus Frequency

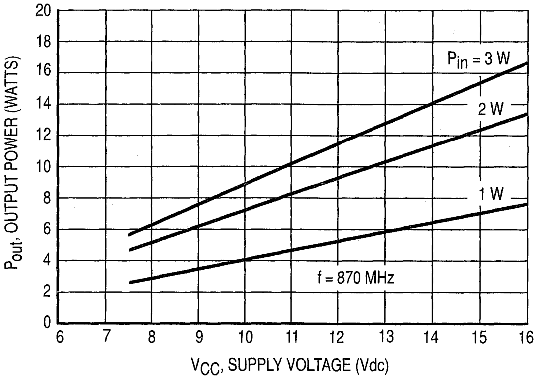
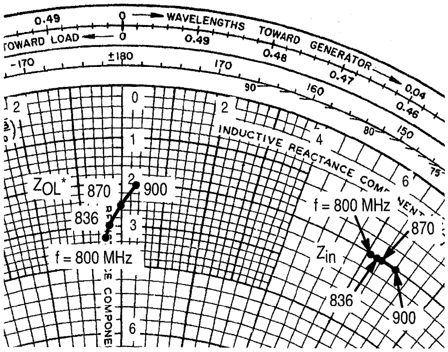


Figure 4. Output Power versus Supply Voltage



P_{out} = 10 W, V_{CC} = 12.5 Vdc

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
800	2.0 + j6.1	3.3 – j0.4
836	2.0 + j6.2	3.0 – j0.3
870	2.0 + j6.4	2.5 + j0.0
900	2.0 + j6.8	2.0 + j0.3

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Input/Output Impedance

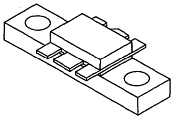
The RF Line
NPN Silicon RF Power Transistor

MRF842

. . . designed for 12.5 volt UHF large–signal, common–base amplifier applications in industrial and commercial FM equipment operating in the range of 806–960 MHz.

- Specified 12.5 Volt, 870 MHz Characteristics
  Output Power = 20 Watts
  Power Gain = 6.0 dB Min
  Efficiency = 50% Min
- Series Equivalent Large–Signal Characterization
- Internally Matched Input for Broadband Operation
- 100% Tested for Load Mismatch Stress at All Phase Angles with 20:1 VSWR @ 15.5 Volt Supply and 50% RF Overdrive
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated

20 W, 870 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 319–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	7.6	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	80 0.64	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	1.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc

NOTES: (continued)

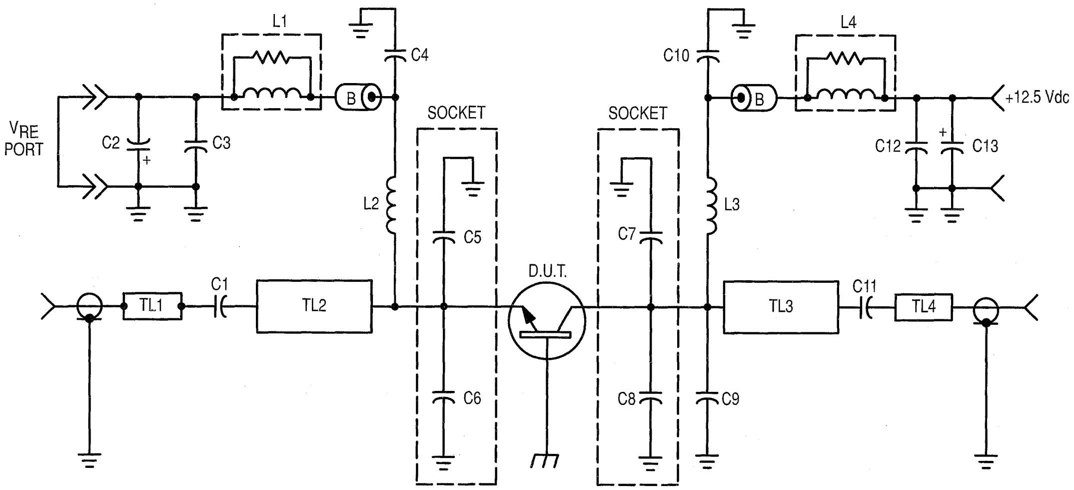
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	45	65	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	G_{PB}	6.0	7.0	—	dB
Collector Efficiency (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	η	50	55	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, P_{in} (3) = 6.0 W, f = 870 MHz, VSWR = 20:1, all phase angles)	—	No Degradation in Output Power			

NOTE:
3. P_{in} = 150% of the typical input power requirement for 20 W output power @ 12.5 Vdc.



B — Ferrite Bead, Ferroxcube 56–590–65–3B
C1, C11 — 51 pF, 100 Mil Chip Capacitor
C2, C13 — 15 µF, 20 WV Tantalum
C3, C12 — 1000 pF Unelco J101
C4, C10 — 91 pF Mini–Underwood
C5 — 15 pF Mini–Underwood
C6 — 12 pF Mini–Underwood
C7, C8 — 21 pF Mini–Underwood
C9 — 11 pF Mini–Underwood

L1, L4 — 11 Turns #20 AWG Over 10 ohm 1/2 W Carbon
L2, L3 — 4 Turns #20 AWG, 200 Mil ID
TL1, TL4 — Micro Strip, Z_o = 50 Ω
TL2 — Micro Strip, Z_o = 38 Ω, λ/4 @ 838 MHz
TL3 — Micro Strip, Z_o = 24 Ω, λ/4 @ 838 MHz
Board — 0.032″ Glass Teflon
2 oz. Cu CLAD, ε_r = 2.55

Figure 1. 870 MHz Test Circuit Schematic

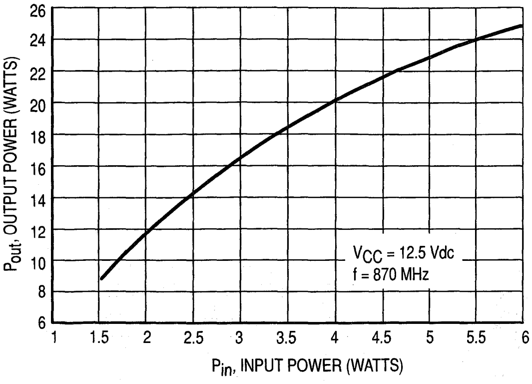


Figure 2. Output Power versus Input Power

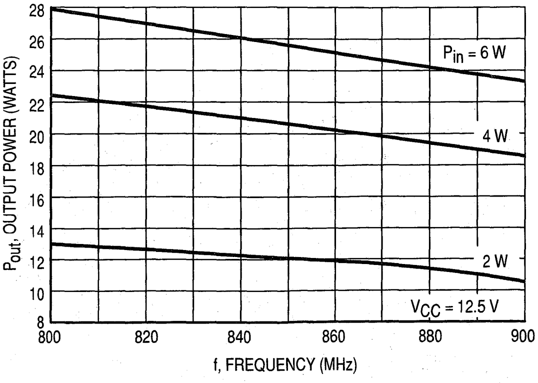


Figure 3. Output Power versus Frequency

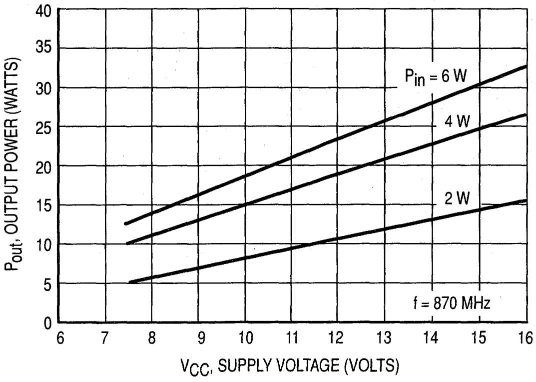
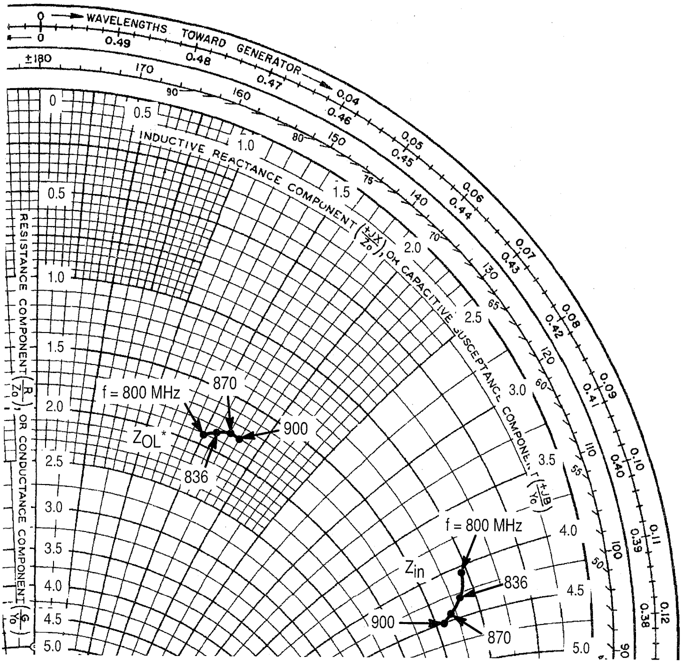


Figure 4. Output Power versus Supply Voltage



P_{out} = 20 W, V_{CC} = 12.5 Vdc

f MHz	Z_{in} Ohms	Z_{OL}^* Ohms
800	1.1 + j4.1	1.9 + j1.5
836	1.2 + j4.3	1.85 + j1.6
870	1.4 + j4.4	1.8 + j1.7
900	1.6 + j4.5	1.8 + j1.8

Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Input/Output Impedance

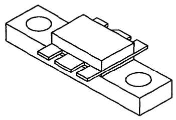
The RF Line
NPN Silicon RF Power Transistor

MRF844

. . . designed for 12.5 volt UHF large–signal, common–base amplifier applications in industrial and commercial FM equipment operating in the range of 806–960 MHz.

- Specified 12.5 Volt, 870 MHz Characteristics
  Output Power = 30 Watts
  Power Gain = 5.2 dB Min
  Efficiency = 50% Min
- Series Equivalent Large–Signal Characterization
- Internally Matched Input for Broadband Operation
- Tested for Load Mismatch Stress at All Phase Angles with 20:1 VSWR @ High Line and RF Overdrive
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated

**30 W, 870 MHz
RF POWER
TRANSISTOR
NPN SILICON**



CASE 319–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	10.9	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	115 0.66	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	1.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	10	mAdc

(continued)

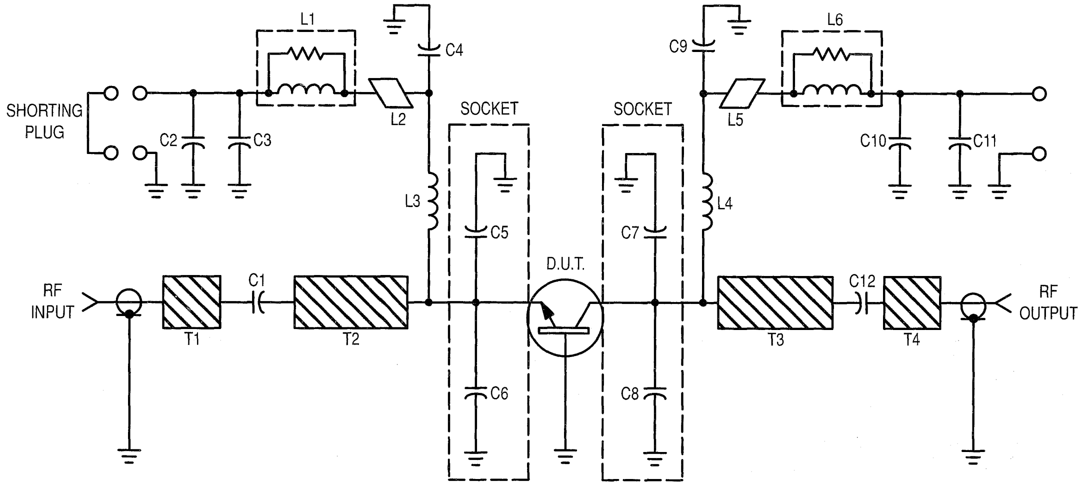
NOTES:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	40	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	60	90	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (P_{out} = 30 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	G_{PB}	5.2	6.0	—	dB
Collector Efficiency (P_{out} = 30 W, V_{CC} = 12.5 Vdc, f = 870 MHz)	η	50	55	—	%
Load Mismatch Stress (V_{CC} = 15.5 Vdc, P_{in} = 12 W (3), f = 870 MHz, VSWR = 20:1, all phase angles)	—	No Degradation in Output Power			

NOTE:
3. P_{in} = 150% of the typical input power requirement for 30 W output power @ 12.5 Vdc.



C1, C12 — 50 pF, 100 Mil Chip Capacitor
C2, C11 — 15 µF, 20 V Tantalum
C3, C10 — 1000 pF, 350 V UNELCO
C4, C9 — 91 pF Mini–Underwood
C5 — 15 pF Mini–Underwood
C6 — 15 pF Mini–Underwood
C7 — 18 pF Mini–Underwood
C8 — 24 pF Mini–Underwood

L1, L6 — 11 Turns 20 AWG Around 10 Ω 1/2 W Resistor
L2, L5 — Ferrite Bead
L3, L4 — 4 Turn 20 AWG 0.2″ I.D.
T1, T4 — Z_O = 50 Ω
T2 — Z_O = 38 Ω $\ell = \lambda/4$ @ 838 MHz
T3 — Z_O = 26 Ω $\ell = \lambda/4$ @ 838 MHz

Figure 1. 870 MHz Test Circuit

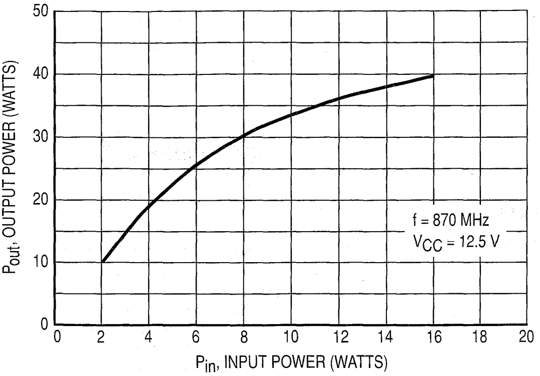


Figure 2. Output Power versus Input Power

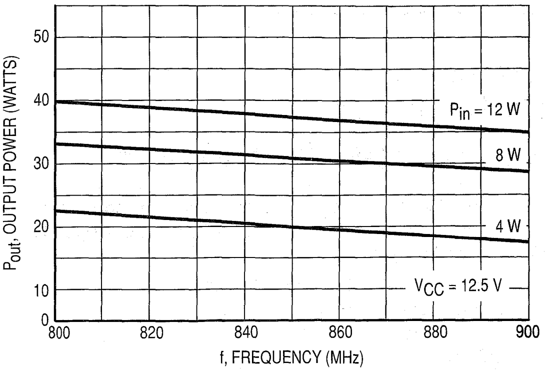


Figure 3. Output Power versus Frequency

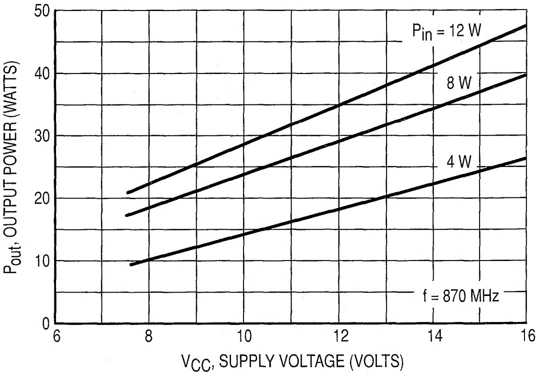
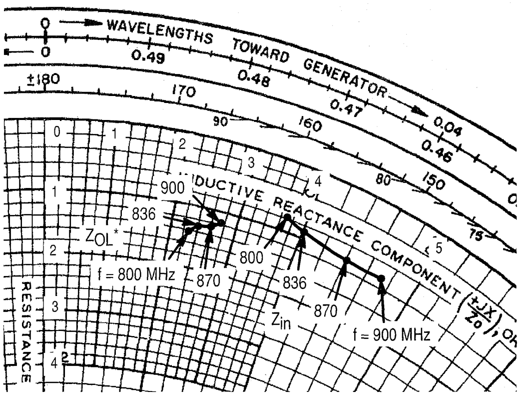


Figure 4. Output Power versus Supply Voltage



P_{in} = 7.5 W, P_{out} = 30 W, V_{CC} = 12.5 Vdc

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
800	0.8 + j3.7	1.4 + j2.3
836	0.9 + j4.0	1.3 + j2.4
870	1.0 + j4.4	1.25 + j2.6
900	1.0 + j4.7	1.2 + j2.7

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Input/Output Impedance

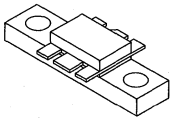
The RF Line
NPN Silicon RF Power Transistor

MRF847

. . . designed for 12.5 volt UHF large–signal, **common–base** amplifier applications in industrial and commercial FM equipment operating in the range of 806–960 MHz.

- Specified 12.5 Volt, 870 MHz Characteristics
  Output Power = 45 Watts
  Power Gain = 4.5 dB Min
  Efficiency = 60% Min
- Series Equivalent Large–Signal Characterization
- Internally Matched Input for Broadband Operation
- Tested for Load Mismatch Stress at All Phase Angles with 10:1 VSWR @ High Line and Rated Drive
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated

45 W, 870 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 319–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16.5	Vdc
Collector–Base Voltage	V_{CBO}	38	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	12	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	150 0.85	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.17	°C/W

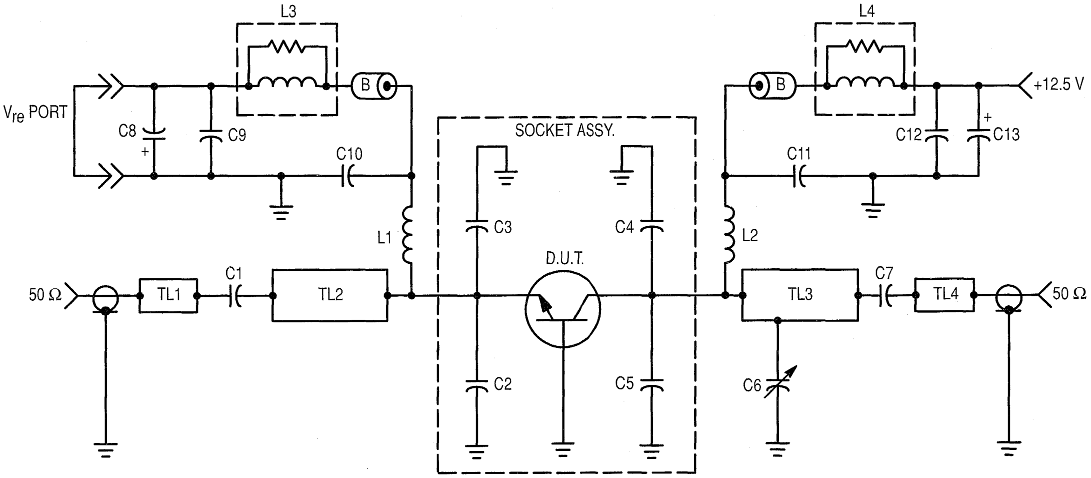
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Emitter–Base Breakdown Voltage ($I_E = 5.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 50$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	16.5	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 50$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	38	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	10	mAdc

(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	40	65	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	75	90	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 45 W, f = 870 MHz)	G_{PB}	4.5	5.5	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 45 W, f = 870 MHz)	η_c	60	68	—	%
Load Mismatch (V_{CC} = 15.5 Vdc, P_{in} = 16 W, f = 870 MHz, VSWR = 10:1, All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 51 pF, 100 mil Chip Capacitor
C2 — 12 pF, Mini–Underwood
C3 — 11 pF, Mini–Underwood
C4, C5 — 21 pF, Mini–Underwood
C6 — 0.08–8.0 pF Johansen Gigatrim
C7 — 47 pF, 100 mil Chip Capacitor
C8, C13 — 10 µF, 25 WV Electrolytic Capacitor
C9, C12 — 1000 pF Unelco J101
C10, C11 — 91 pF Mini–Underwood
L1, L2 — 4 Turns #18 Enameled, 200 mil ID
L3, L4 — 12 Turns #22 Enameled, Wound Over 10 Ω Resistor
TL1, TL4 — 50 Ω Microstrip Line
TL2 — Microstrip (Z_o = 38 ohms, λ/4 @ 838 MHz)
TL3 — Microstrip (Z_o = 28 ohms, λ/4 @ 838 MHz)
Board Material — 0.032″ Glass–Teflon, 2 oz. cu. clad, ε_r = 2.56
B — Ferrite Bead, Ferroxcube 56–590–65–3B

Figure 1. 806–870 MHz Broadband Test Circuit

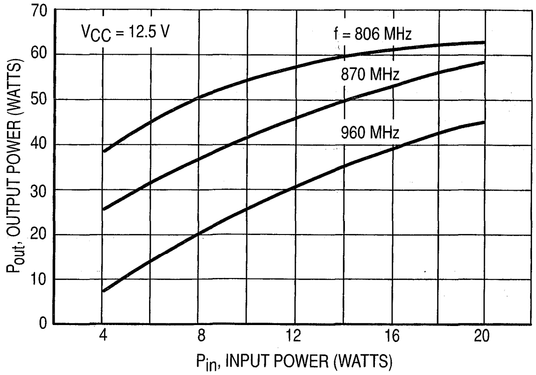


Figure 2. Output Power versus Input Power

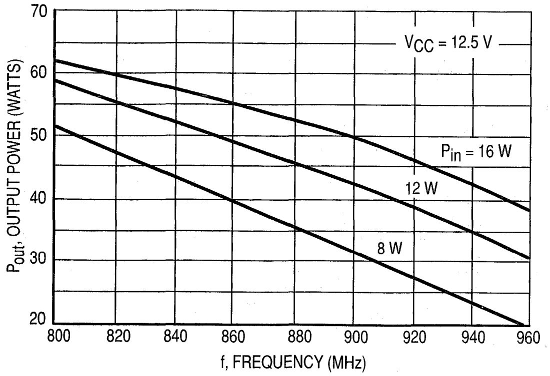


Figure 3. Output Power versus Frequency

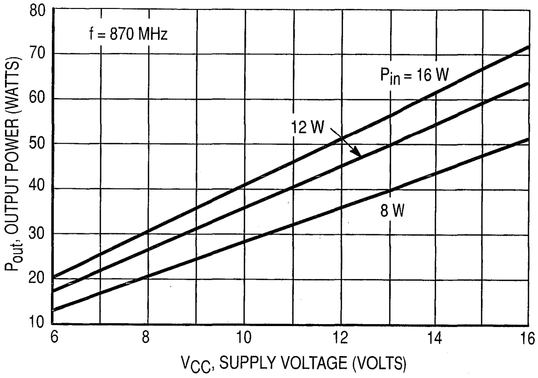


Figure 4. Output Power versus Supply Voltage

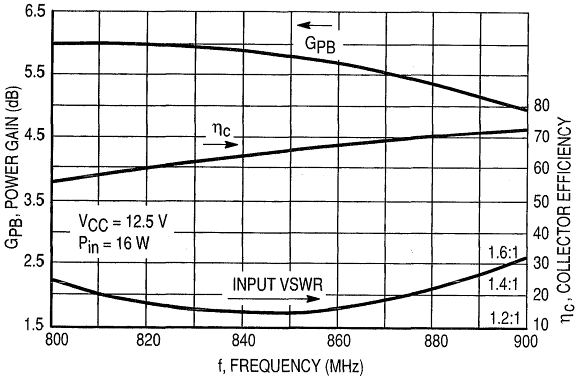
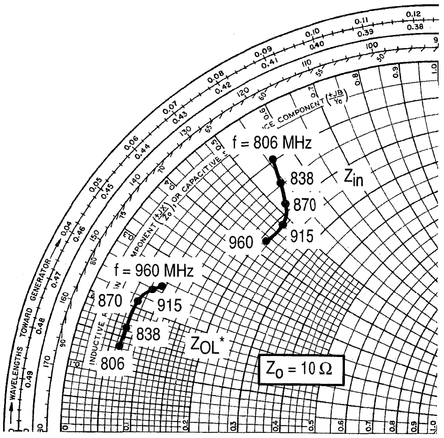


Figure 5. Typical Broadband Circuit Performance



V_{CC} = 12.5 Vdc, P_{in} = 16 W, P_{out} = 45 W

f MHz	Zin (Ohms)		f MHz	ZOL* (Ohms)	
806	0.99	+j5.52	806	0.67	+j1.33
838	1.48	+j5.47	838	0.68	+j1.66
870	1.79	+j5.25	870	0.72	+j2.16
915	2.12	+j4.80	915	0.83	+j2.40
960	2.11	+j4.28	960	0.99	+j2.50

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Input/Output Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

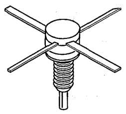
The RF Line
NPN Silicon
RF Power Transistor

MRF857
MRF857S

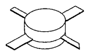
CLASS A
800–960 MHz
2.1 W (CW), 24 V
NPN SILICON
RF POWER TRANSISTOR

Designed for 24 Volt UHF large–signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800–960 MHz.

- Specified for V_{CE} = 24 Vdc, I_C = 0.3 Adc Characteristics
  Output Power = 2.1 Watts CW
  Minimum Power Gain = 12.5 dB
  Minimum ITO = +43 dBm
  Typical Noise Figure = 5.25 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800–960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, I_C = 0.3 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 0.4 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 305–01, STYLE 1
MRF857



CASE 305D–01, STYLE 1
MRF857S

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	17 0.114	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (T_J = 150°C, T_C = 50°C)	$R_{\theta JC}$	8.4	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mA, I_B = 0)	$V_{(BR)CEO}$	28	35	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mA, V_{BE} = 0)	$V_{(BR)CES}$	55	85	—	Vdc
Collector–Base Breakdown Voltage (I_C = 20 mA, I_E = 0)	$V_{(BR)CBO}$	55	85	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1 mA, I_C = 0)	$V_{(BR)EBO}$	4	5	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CES}	—	—	1	mA

(continued)

REV 2

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 A, V_{CE} = 5 V)	h_{FE}	30	60	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 V, f = 1 MHz)	C_{ob}	2.4	3.3	4.4	pF
FUNCTIONAL CHARACTERISTICS					
Common–Emitter Power Gain (V_{CE} = 24 V, I_C = 0.3 A, f = 840–900 MHz, Power Output = 2.1 W)	P_g	12.5	13.5	—	dB
Load Mismatch (P_o = 2.1 W) (V_{CE} = 24 V, I_C = 0.3 A, f = 840 MHz, Load VSWR = 30:1, All Phase Angles)	ψ	No Degradation in Output Power			
RF Input Overdrive (V_{CE} = 24 V, I_C = 0.3 A, f = 840 MHz) No degradation	$P_{in(over)}$	—	—	0.4	W
Third Order Intercept Point (V_{CE} = 24 V, I_C = 0.3 A) (f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = –40 dBc)	ITO	+43	+44.5	—	dBm
Noise Figure (V_{CE} = 24 V, I_C = 0.3 A, f = 900 MHz)	NF	—	5.25	—	dB
Input Return Loss (V_{CE} = 24 V, I_C = 0.3 A, f = 840–900 MHz, Power Output = 2.1 W)	IRL	—	–15	–10	dB

Table 1. MRF857/S Common Emitter S–Parameters

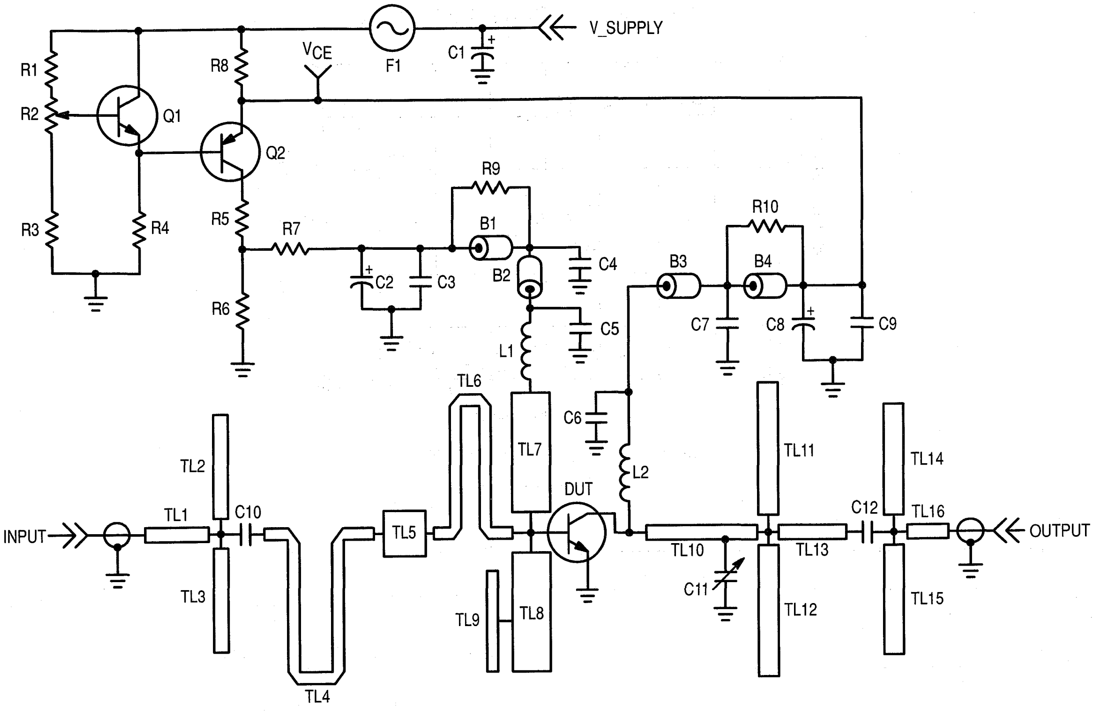
V_{CE} (V)	I_C (A)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
24	0.3	800	0.915	165	2.098	54	0.037	58	0.343	–157
		820	0.915	165	2.049	53	0.038	58	0.345	–157
		840	0.915	165	1.991	52	0.038	58	0.349	–157
		860	0.913	164	1.951	51	0.039	59	0.352	–158
		880	0.914	164	1.912	50	0.040	59	0.355	–158
		900	0.914	163	1.865	49	0.041	59	0.359	–158
		920	0.913	163	1.832	48	0.042	59	0.362	–158
		940	0.915	162	1.783	47	0.043	59	0.366	–159
		960	0.916	162	1.748	46	0.043	59	0.369	–159

Table 2. Z_{in} and Z_{OL}* versus Frequency

f (MHz)	Z_{in} (Ohms)		Z_{OL}* (Ohms)	
840	1.5	4.4	18.4	–26.3
870	1.7	4.7	18.0	–26.1
900	1.5	4.8	14.9	–26.2

V_{CE} = 24 V, I_C = 0.3 A, P_o = 2.1 W

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.



B1, B4	Long Ferrite Bead, Fair Rite (2743021447)
B2, B3	Short Ferrite Bead, Fair Rite (2743019447)
C1	250 µF, 50 Vdc Electrolytic Capacitor
C2, C8	10 µF, 50 Vdc Electrolytic Capacitor
C3, C9	0.1 µF, Chip Capacitor
C4, C7	1000 pF, Chip Capacitor
C5, C6	100 pF, Chip Capacitor
C10, C12	43 pF, 100 Mil Chip Capacitor
C11	0.8–8 pF, Johansen Gigatrim
F1	1 A Micro–Fuse
L1, L2	5 Turns, 20 AWG, 0.126″ ID, 46.2 nH
Q1	MMBT2222ALT1, NPN Transistor
Q2	BD136, PNP Transistor

R1	330 Ω, 1/4 W
R2	500 Ω Potentiometer, 1/4 W
R3	4.7K Ω, 1/4 W
R4	2 x 4.7K Ω, 1/4 W
R5	47 Ω, 2 W
R6	75 Ω, 1/4 W
R7	4.7 Ω, 1/4 W
R8	10 Ω, 3 W
R9, R10	4 x 39 Ω, 1/8 W Chip Resistors in Parallel
TL1–TL16	Microstrip Transmission Line
V_Supply	+27 Vdc ±0.5 V Due to Resistor Tolerance
V_{CE}	+24 Vdc @ 0.3 A
Board	0.030″ Glass–Teflon® 2 oz. Cu, ε_r = 2.55

Figure 1. MRF857/S Class A RF Test Fixture Schematic

TYPICAL CHARACTERISTICS

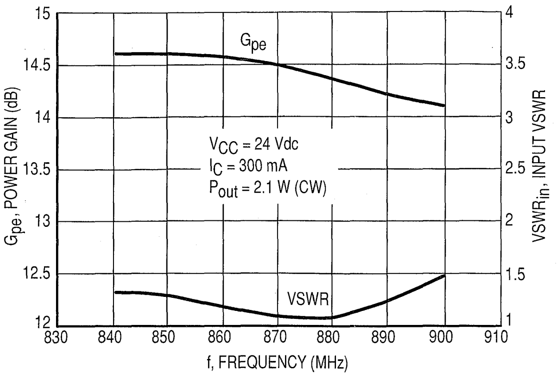


Figure 2. Performance of MRF857 in Broadband Circuit

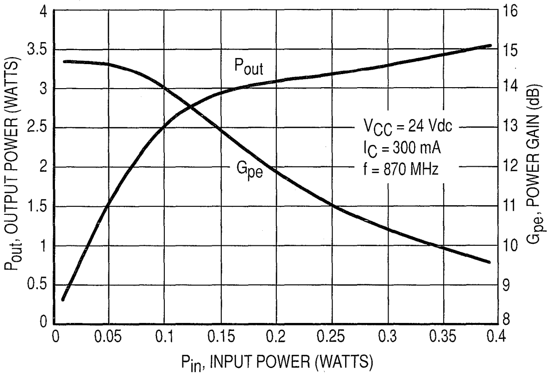


Figure 3. MRF857 Output Power & Power Gain versus Input Power

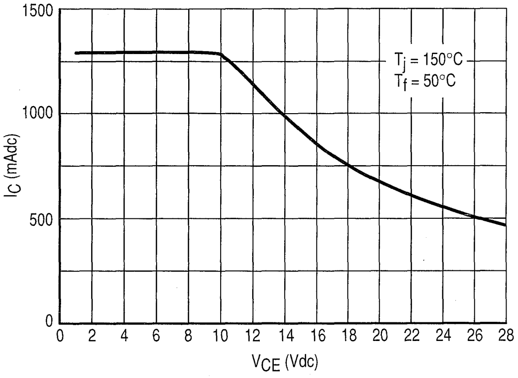


Figure 4. MRF857 DC SOA

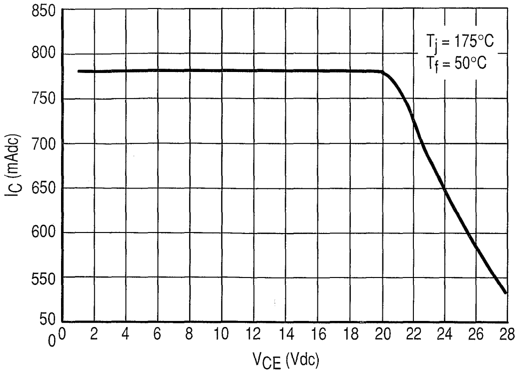


Figure 5. MRF857 DC SOA (This device is MTBF limited for $V_{CE} < 20$ Vdc.)

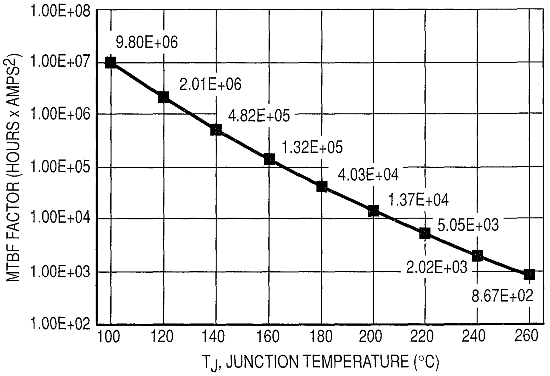


Figure 6. MRF857 MTBF Factor versus Junction Temperature

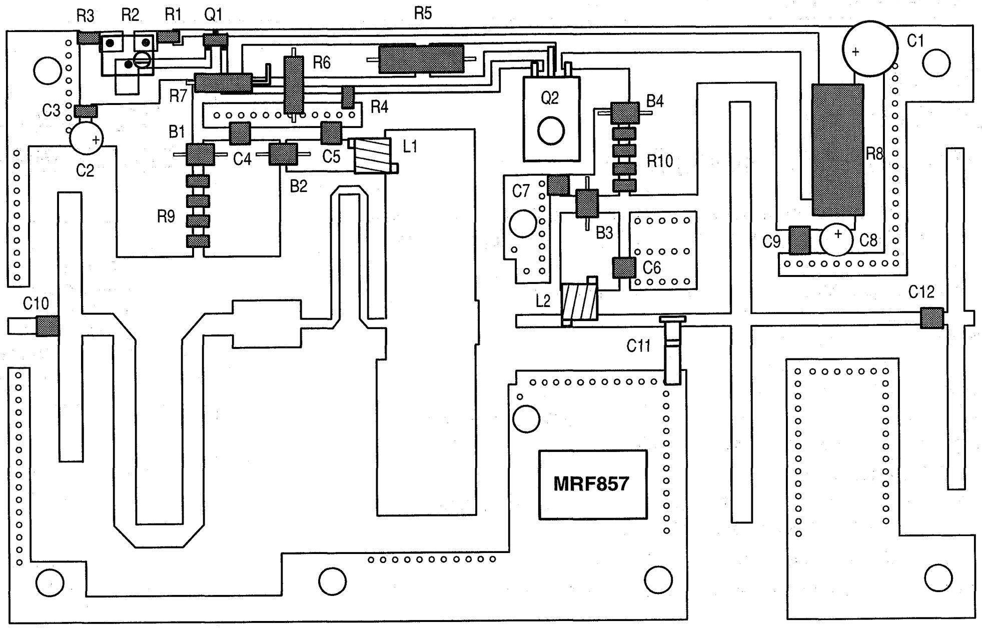


Figure 7. MRF857 Test Fixture Component Layout

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

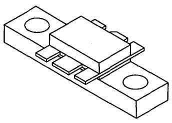
The RF Line
NPN Silicon RF Power Transistor

MRF858
MRF858S

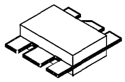
Designed for 24 Volt UHF large–signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800–960 MHz.

- Specified for V_{CE} = 24 Vdc, I_C = 0.5 Adc Characteristics
  Output Power = 3.6 Watts CW
  Minimum Power Gain = 11 dB
  Minimum ITO = +44.5 dBm
  Typical Noise Figure = 6 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800–960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, I_C = 0.5 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 0.85 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

CLASS A
800–960 MHz
3.6 W (CW), 24 V
NPN SILICON
RF POWER TRANSISTOR



CASE 319–07, STYLE 2
MRF858



CASE 319A–02, STYLE 2
MRF858S

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	20 0.138	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (T_J = 150°C, T_C = 50°C)	$R_{\theta JC}$	6.9	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mA, I_B = 0)	$V_{(BR)CEO}$	28	35	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mA, V_{BE} = 0)	$V_{(BR)CES}$	55	85	—	Vdc
Collector–Base Breakdown Voltage (I_C = 20 mA, I_E = 0)	$V_{(BR)CBO}$	55	85	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1 mA, I_C = 0)	$V_{(BR)EBO}$	4	5	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CES}	—	—	1	mA

(continued)

REV 2

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 A, V_{CE} = 5 V)	h_{FE}	30	60	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 V, f = 1 MHz)	C_{ob}	—	6.5	8	pF
FUNCTIONAL CHARACTERISTICS					
Common–Emitter Power Gain (V_{CE} = 24 V, I_C = 0.5 A, f = 840–900 MHz, Power Output = 3.6 W)	P_g	11	12	—	dB
Load Mismatch (P_o = 3.6 W) (V_{CE} = 24 V, I_C = 0.5 A, f = 840 MHz, Load VSWR = 30:1, All Phase Angles)	ψ	No Degradation in Output Power			
RF Input Overdrive (V_{CE} = 24 V, I_C = 0.5 A, f = 840 MHz) No degradation	$P_{in(over)}$	—	—	0.85	W
Third Order Intercept Point (V_{CE} = 24 V, I_C = 0.5 A) (f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = −40 dBc)	ITO	+44.5	+45.5	—	dBm
Noise Figure (V_{CE} = 24 V, I_C = 0.5 A, f = 900 MHz)	NF	—	6	—	dB
Input Return Loss (V_{CE} = 24 V, I_C = 0.5 A, f = 840–900 MHz, Power Output = 3.6 W)	IRL	—	−12	−9	dB

Table 1. MRF858 Common Emitter S–Parameters

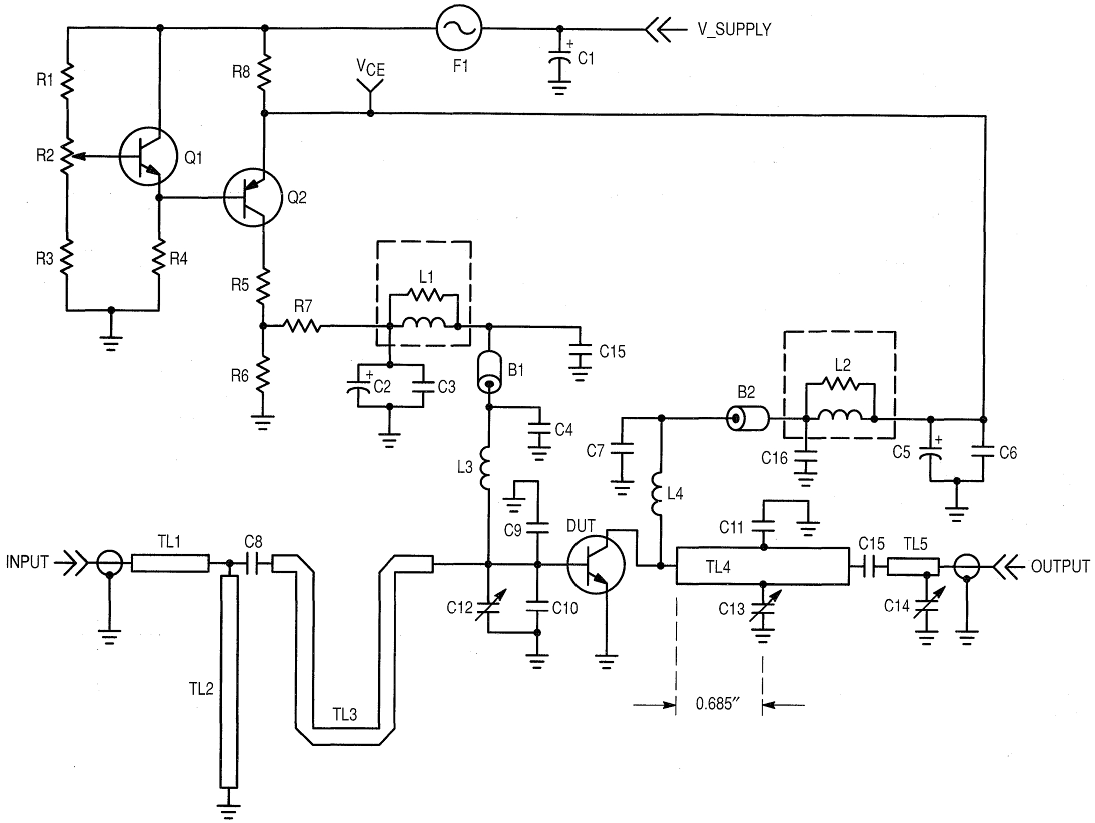
V_{CE} (V)	I_C (A)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
24	0.5	800	0.942	167	1.493	50	0.027	58	0.538	−165
		820	0.942	166	1.453	50	0.027	58	0.541	−164
		840	0.941	166	1.415	49	0.028	59	0.545	−165
		860	0.940	166	1.379	48	0.028	59	0.550	−165
		880	0.941	165	1.351	47	0.029	59	0.553	−165
		900	0.940	165	1.320	46	0.030	59	0.557	−165
		920	0.940	165	1.289	45	0.030	59	0.562	−165
		940	0.940	164	1.252	44	0.031	59	0.566	−165
		960	0.940	164	1.222	43	0.031	59	0.570	−165

Table 2. Z_{in} and Z_{OL}* versus Frequency

f (MHz)	Z_{in} (Ohms)		Z_{OL}* (Ohms)	
840	1.1	2.9	9.9	−14.4
870	1.1	3.5	9.5	−14.6
900	1.2	3.5	9	−14.5

V_{CE} = 24 V, I_C = 0.5 A, P_o = 3.6 W

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.



B1, B2	Short Ferrite Bead, Fair Rite (2743021447)
C1	250 µF, 50 Vdc Electrolytic Capacitor
C2, C5	10 µF, 50 Vdc Electrolytic Capacitor
C3, C6	0.1 µF, Chip Capacitor
C4, C7	100 pF, Chip Capacitor
C8, C15	43 pF, 100 Mil Chip Capacitor
C9, C10	10 pF, Mini–Unelco
C11	5 pF, Mini–Unelco
C12, C13, C14	0.8–8.0 pF, Johanson Gigatrim
C15, C16	1000 pF, Chip Capacitor
F1	1 A Micro–Fuse
L1, L2	10 Turns, 20 AWG, 0.150″ ID (10 Ω 1/2 W Resistor)
L3	4 Turns, 16 AWG, 0.101″ ID
L4	0.5″ 18 AWG Wire
Q1	MMBT2222ALT1, NPN Transistor
Q2	BD136, PNP Transistor
R1	390 Ω, 1/4 W
R2	500 Ω Potentiometer, 1/4 W
R3	7.5K Ω, 1/4 W
R4	2 x 4.7K Ω, 1/4 W
R5	56 Ω, 2 W
R6	75 Ω, 1/4 W
R7	4.7 Ω, 1/4 W
R8	4 Ω, 10 W
TL1, TL5	50 Ω, Microstrip Transmission Line
TL2	Microstrip Transmission Line
TL3	Microstrip Transmission Line
TL4	Microstrip Transmission Line
V_Supply	+26 Vdc ±0.5 Vdc Due to Resistor Tolerance
V_{CE}	+24 Vdc @ 0.5 A
Board	0.030″ Glass–Teflon® 2 oz. Cu, $\varepsilon_r = 2.55$

Figure 1. MRF858 Class A RF Test Fixture Schematic

TYPICAL CHARACTERISTICS

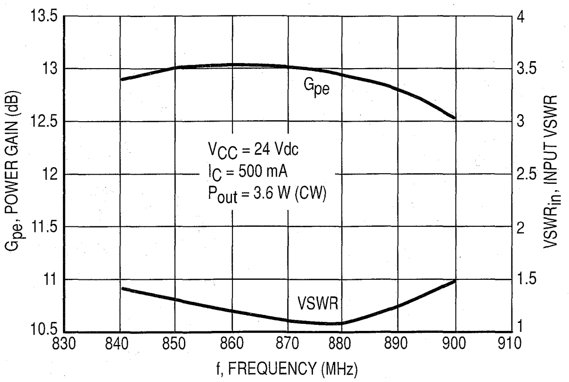


Figure 2. Performance in Broadbandband Circuit

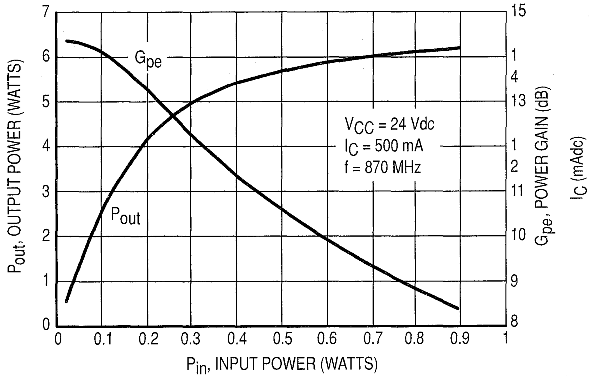


Figure 3. Output Power & Power Gain versus Input Power

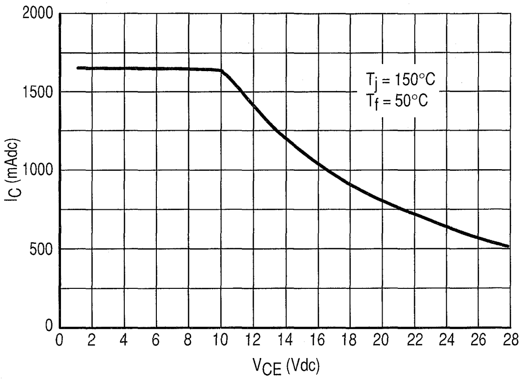


Figure 4. DC SOA

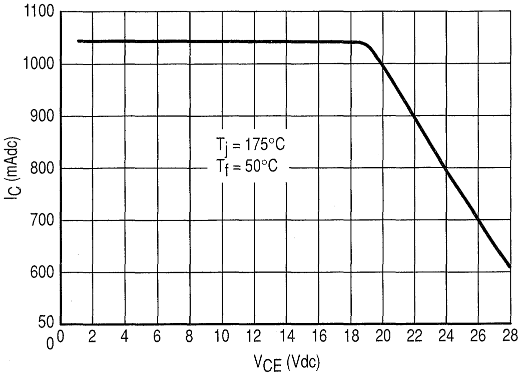


Figure 5. DC SOA
(This device is MTBF limited for $V_{CE} < 20$ Vdc.)

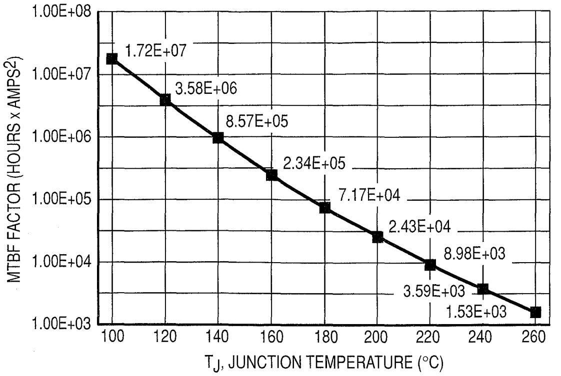


Figure 6. MTBF Factor versus Junction Temperature

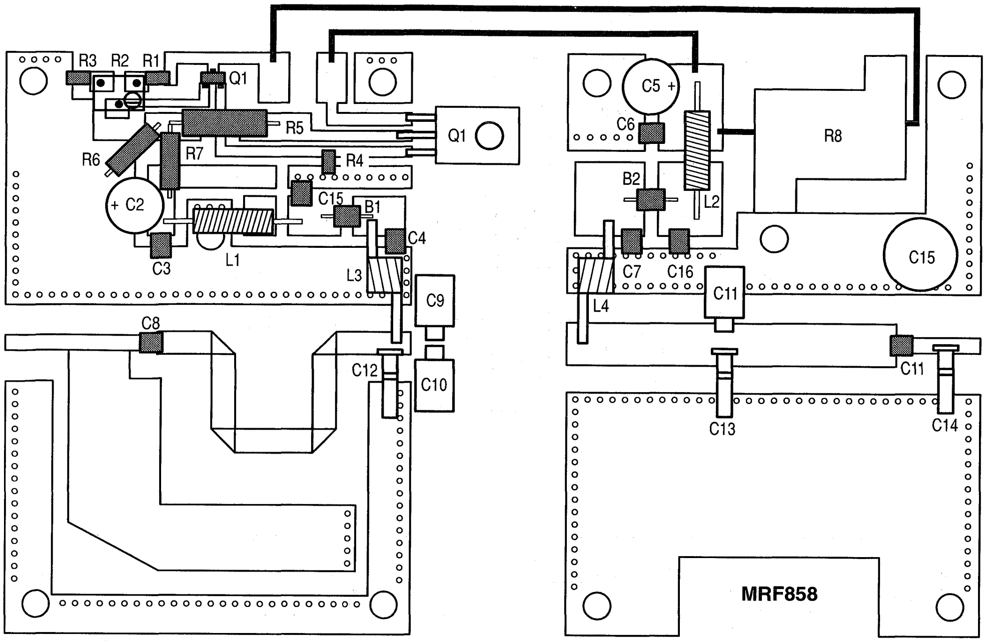


Figure 7. MRF858 Test Fixture Component Layout

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

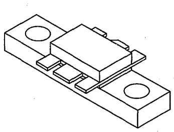
The RF Line
NPN Silicon RF Power Transistor

MRF859
MRF859S

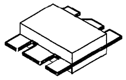
CLASS A
800–960 MHz
6.5 W (CW), 24 V
NPN SILICON
RF POWER TRANSISTOR

Designed for 24 Volt UHF large–signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800 to 960 MHz.

- Specified for V_{CE} = 24 Vdc, I_C = 0.9 Adc Characteristics
  Output Power = 6.5 Watts CW
  Minimum Power Gain = 11.5 dB
  Minimum ITO = +47 dBm
  Typical Noise Figure = 6 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, I_C = 0.9 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 2 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit Board Photomaster Available by Ordering Document MRF859PHT/D from Motorola Literature Distribution.



CASE 319–07, STYLE 2
MRF859



CASE 319A–02, STYLE 2
MRF859S

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ T_C = 60°C Derate above 60°C	P_D	34 0.24	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (T_J = 150°C, T_C = 60°C)	$R_{\theta JC}$	3.9	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mA, I_B = 0)	$V_{(BR)CEO}$	28	32	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mA, V_{BE} = 0)	$V_{(BR)CES}$	55	75	—	Vdc
Collector–Base Breakdown Voltage (I_C = 25 mA, I_E = 0)	$V_{(BR)CBO}$	55	75	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5 mA, I_C = 0)	$V_{(BR)EBO}$	4	5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 V, I_E = 0)	I_{CES}	—	—	2	mA

(continued)

REV 2

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 A, V_{CE} = 5 V)	h_{FE}	20	60	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 V, f = 1 MHz)	C_{ob}	13	—	26	pF
FUNCTIONAL CHARACTERISTICS					
Common–Emitter Power Gain (V_{CE} = 24 V, I_C = 0.9 A, f = 840–900 MHz, P_{out} = 6.5 W)	P_g	11.5	13	—	dB
Load Mismatch (V_{CE} = 24 V, I_C = 0.9 A, f = 840 MHz, P_{out} = 6.5 W, Load VSWR = 30:1, All Phase Angles)	ψ	No Degradation in Output Power			
RF Input Overdrive (V_{CE} = 24 V, I_C = 0.9 A, f = 840 MHz) No degradation	$P_{in(over)}$	—	—	2	W
Third Order Intercept Point (V_{CE} = 24 V, I_C = 0.9 A, f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = −40 dBc)	ITO	+47	+48	—	dBm
Noise Figure (V_{CE} = 24 V, I_C = 0.9 A, f = 900 MHz)	NF	—	6	—	dB
Input Return Loss (V_{CE} = 24 V, I_C = 0.9 A, f = 840–900 MHz, P_{out} = 6.5 W)	IRL	—	—	−9	dB

Table 1. Common Emitter S–Parameters

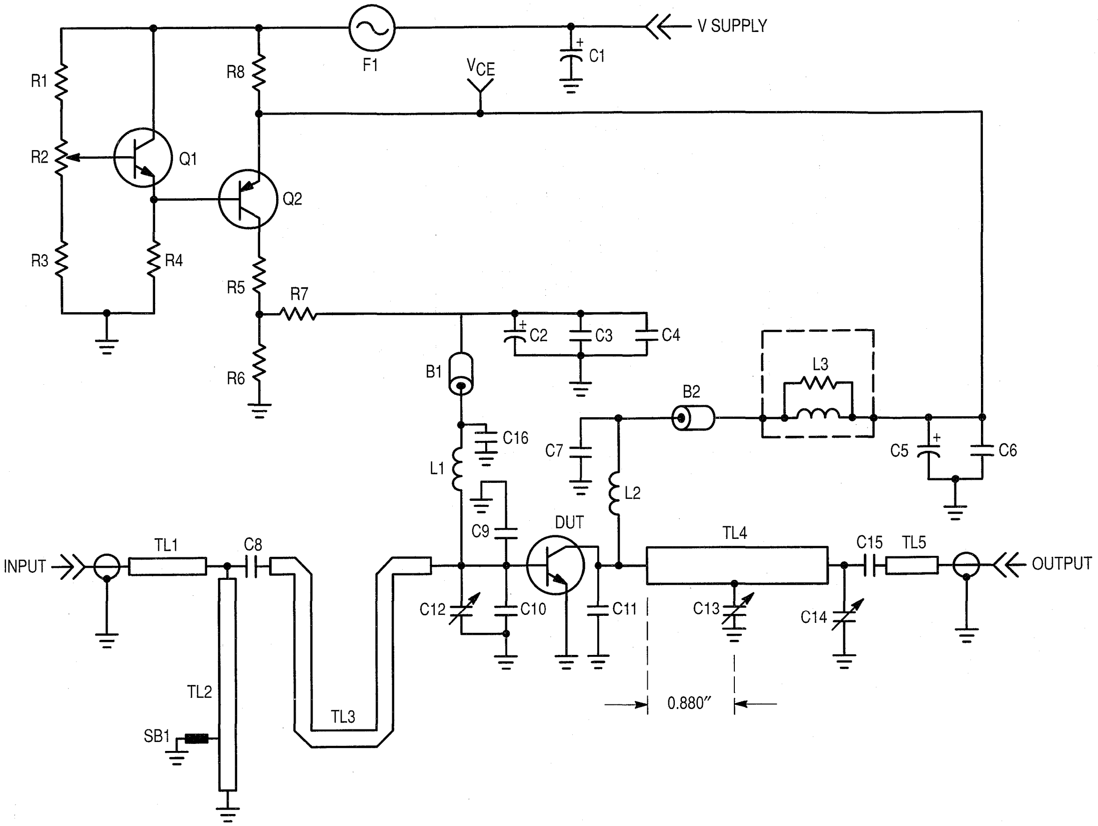
V_{CE} (V)	I_C (A)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
24	0.9	800	0.906	170	1.022	12	0.016	11	0.804	−168
		820	0.902	170	1.022	7	0.015	8	0.823	−167
		840	0.897	171	1.018	3	0.013	6	0.845	−167
		860	0.894	171	1.012	−3	0.011	4	0.870	−167
		880	0.893	171	1.005	−8	0.009	3	0.895	−168
		900	0.893	171	0.988	−14	0.007	5	0.920	−168
		920	0.894	172	0.962	−20	0.005	14	0.946	−169
		940	0.897	172	0.924	−26	0.008	47	0.969	−170
		960	0.903	172	0.884	−32	0.004	102	0.987	−172

Table 2. Z_{in} and Z_{OL}* versus Frequency

f (MHz)	Z_{in} (Ohms)		Z_{OL}* (Ohms)	
840	1.6	3.3	2	−4.1
870	1.5	3.6	1.6	−3.3
900	2.2	3.5	1.7	−2.7

V_{CE} = 24 V, I_C = 0.9 A, P_o = 6.5 W

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.



B1, B2	Ferrite Bead, Ferroxcube (56–390–65/3B)
C1	250 µF, 50 Vdc, Electrolytic Capacitor
C2, C5	10 µF, 50 Vdc, Electrolytic Capacitor
C3, C6	0.1 µF, Chip Capacitor
C4	1000 pF, Chip Capacitor
C7, C16	100 pF, Chip Capacitor
C8, C15	43 pF, 100 Mil Chip Capacitor
C9, C10	6.8 pF, Mini–Unelco
C11	18 pF, Mini–Unelco
C12, C13, C14	0.8–8.0 pF, Johanson Gigatrim
F1	3 Amp Micro–Fuse
L1, L2	3 Turns, 18 AWG, 0.170″ ID
L3	12 Turns, 22 AWG, 0.150″ ID (10 Ω 1/2 W Resistor)
Q1	MMBT2222ALT1, NPN Transistor
Q2	BD136, PNP Transistor

R1	470 Ω, 1/4 W
R2	500 Ω Potentiometer, 1/4 W
R3	4.7K Ω, 1/4 W
R4	2 x 4.7K Ω, 1/4 W
R5	50 Ω, 2 W
R6	75 Ω, 1/4 W
R7	4.7 Ω, 1/4 W
R8	4 Ω, 10 W
SB1	Copper Block 0.550″ x 0.180″ x 0.050″
TL1, TL5	50 Ω, Microstrip Transmission Line
TL2	Microstrip Transmission Line
TL3	Microstrip Transmission Line
TL4	Microstrip Transmission Line
Board	0.030″ Glass–Teflon® 2 oz. Cu, ε_r = 2.55
V Supply	+27.6 Vdc ±0.5 Vdc Due to Resistor Tolerance
V_{CE}	+24 Vdc @ 0.9 A

Figure 1. MRF859 Class A RF Test Fixture Schematic

TYPICAL CHARACTERISTICS

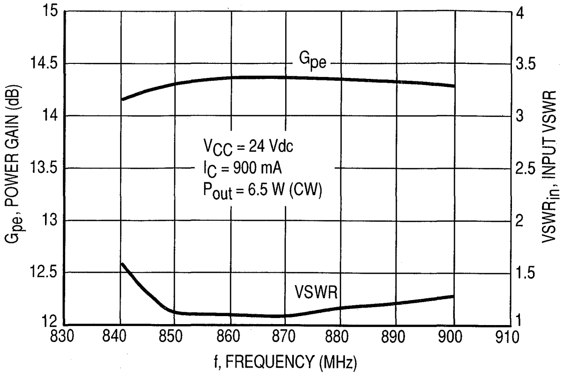


Figure 2. Performance in Broadband Circuit

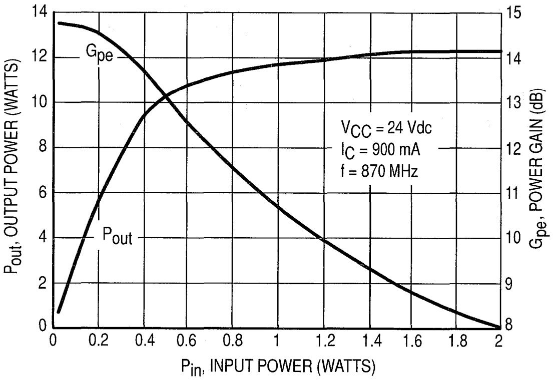


Figure 3. Output Power & Power Gain versus Input Power

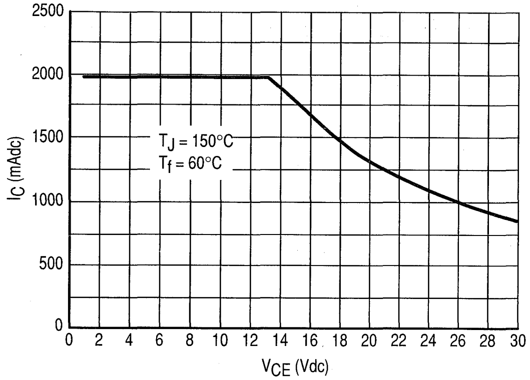


Figure 4. DC SOA

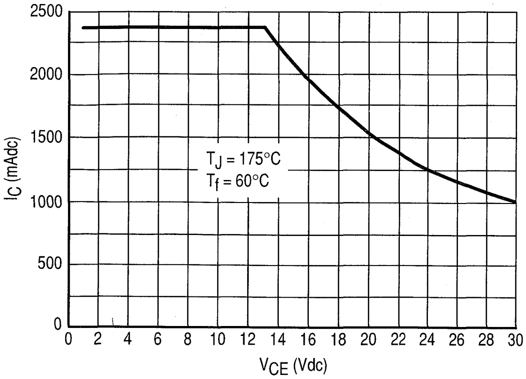


Figure 5. DC SOA

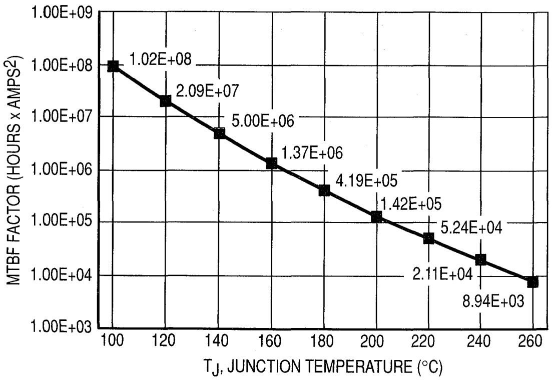


Figure 6. MTBF Factor versus Junction Temperature

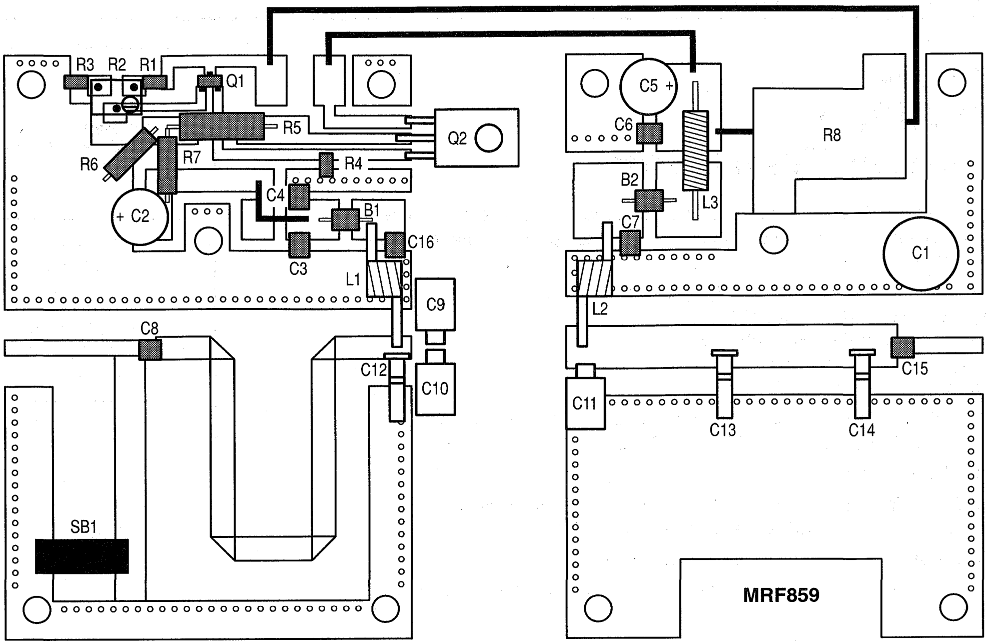


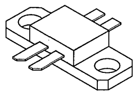
Figure 7. MRF859 Test Fixture Component Layout

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
NPN Silicon
RF Power Transistor

MRF860

CLASS A
800–960 MHz
13.7 W (CW), 24 V
NPN SILICON
RF POWER TRANSISTOR



CASE 395B–01, STYLE 1

Designed for 24 Volt UHF large–signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800–960 MHz.

- Specified for V_{CE} = 24 Vdc, I_C = 1.9 Adc Characteristics
  Output Power = 13.7 Watts CW
  Minimum Power Gain = 11 dB
  Minimum ITO = +51.5 dBm
  Typical Noise Figure = 6.5 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800–960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, I_C = 1.9 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 3.25 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ T_C = 60°C Derate above 60°C	P_D	71 0.51	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (T_J = 150°C, T_C = 60°C)	$R_{\theta JC}$	1.9	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector–Emitter Breakdown Voltage (I_C = 50 mA, I_B = 0)	$V_{(BR)CEO}$	28	33	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mA, V_{BE} = 0)	$V_{(BR)CES}$	60	80	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mA, I_E = 0)	$V_{(BR)CBO}$	60	80	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5 mA, I_C = 0)	$V_{(BR)EBO}$	4	4.7	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CES}	—	—	10	mA

(1) All DC tests are per side.

(continued)

REV 2

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1 A, V_{CE} = 5 V)	h_{FE}	30	80	120	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 24 V, f = 1 MHz)	C_{ob}	14	21	28	pF
FUNCTIONAL CHARACTERISTICS (2)					
Common–Emitter Power Gain (V_{CE} = 24 V, I_C = 1.9 A, f = 900 MHz, Power Output = 13.7 W)	P_g	11	12.5	—	dB
Load Mismatch (V_{CE} = 24 V, I_C = 1.9 A, f = 900 MHz, Power Output = 13.7 W, Load VSWR = 30:1, All Phase Angles)	ψ	No Degradation in Output Power			
RF Input Overdrive (V_{CE} = 24 V, I_C = 1.9 A, f = 900 MHz) No degradation	$P_{in(over)}$	—	—	3.25	W
Third Order Intercept Point (V_{CE} = 24 V, I_C = 1.9 A, f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = −40 dBc)	ITO	+51.5	+52.5	—	dBm
Noise Figure (V_{CE} = 24 V, I_C = 1.9 A, f = 900 MHz)	NF	—	6.5	—	dB
Input Return Loss (V_{CE} = 24 V, I_C = 1.9 A, f = 900 MHz, Power Output = 13.7 W)	IRL	—	—	−10	dB

(1) All DC tests are per side.
(2) Operating bias point I_C is the total for both halves.

Table 1. MRF860 Common Emitter S–Parameters (Per Side)

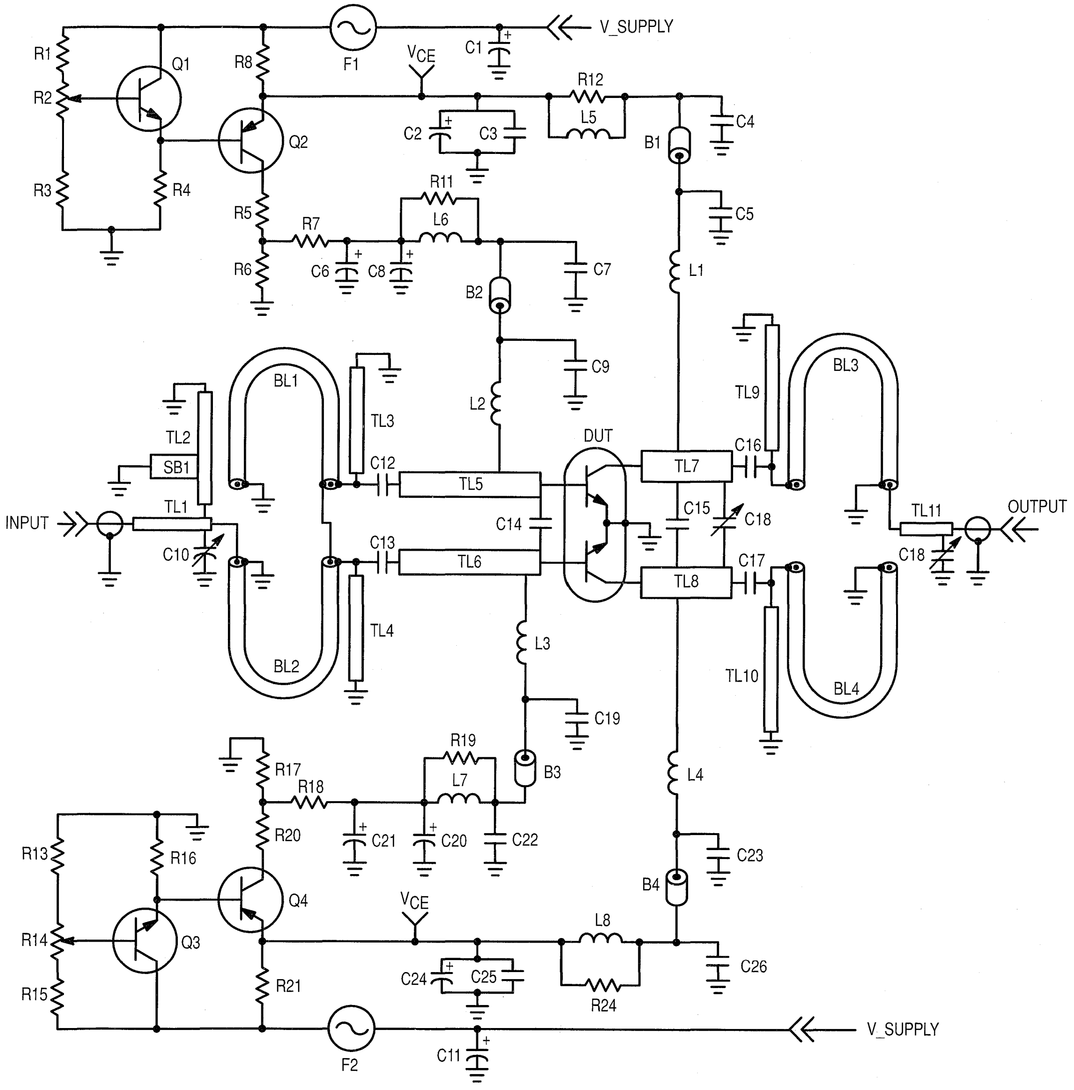
V_{CE} (V)	I_C (A)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
24	0.95	800	0.964	171	0.829	45	0.012	15	0.781	174
		820	0.963	170	0.831	43	0.012	15	0.779	174
		840	0.963	170	0.839	42	0.013	13	0.779	173
		860	0.959	169	0.844	40	0.013	13	0.778	173
		880	0.957	169	0.856	38	0.014	12	0.779	173
		900	0.952	169	0.870	36	0.014	11	0.778	173
		920	0.951	168	0.884	34	0.015	9	0.778	173
		940	0.944	168	0.897	32	0.015	8	0.774	173
		960	0.941	168	0.917	30	0.016	7	0.774	173

Table 2. Z_{in} and Z_{OL}* versus Frequency

f (MHz)	Z_{in} (Ohms)		Z_{OL}* (Ohms)	
840	1.6	9	3.6	−2.1
870	1.4	9.7	4.4	−2.3
900	1.7	9.9	4.9	−2.3

V_{CE} = 24 V, I_C = 1.9 A, P_o = 13.7 W

Notes: Z_{in} is a balanced base–to–base measurement.
Z_{OL}* = Conjugate of optimum load impedance, collector to collector, into which the device operates at a given output power, bias current, voltage and frequency.



B1, B2, B3, B4	Short Ferrite Bead, Fair Rite (2743019447)	R1, R15	470 Ω, 1/4 W
BL1–BL4	2.20″ 50 Ω 0.085″ OD Semi–Rigid Coax	R2, R14	500 Ω Potentiometer, 1/4 W
C1, C11	470 µF, 50 Vdc Electrolytic Capacitor	R3, R13	4.7K Ω, 1/4 W
C6, C21	220 µF, 50 Vdc Electrolytic Capacitor	R4, R16	2 x 4.7K Ω, 1/4 W
C2, C8, C20, C24	10 µF, 50 Vdc Electrolytic Capacitor	R5, R20	47 Ω, 2 W
C3, C7, C22, C25	0.1 µF, Chip Capacitor	R6, R17	75 Ω, 1/4 W
C4, C26	1000 pF, Chip Capacitor	R7, R18	4.7 Ω, 1/4 W
C5, C9, C19, C23	100 pF, Chip Capacitor	R8, R21	4 Ω, 10 W
C10, C18	0.8–8.0 pF, Johanson Gigatrim	R11, R12, R19, R24	4 x 39 Ω, 1/8 W Chip Resistors in Parallel
C12, C13, C16, C17	43 pF, 100 Mil Chip Capacitor	SB1	Copper 0.500″ x 0.200″ x 0.050″
C14	13 pF, 50 Mil Chip Capacitor	TL1, TL11	50 Ω, Microstrip Transmission Line
C15	7.5 pF, 100 Mil Chip Capacitor	TL2–TL10	Microstrip Transmission Line
F1, F2	3 A Micro–Fuse	V_Supply	+27.8 Vdc ±0.5 Vdc Due to Resistor Tolerance
L1–L8	5 Turns 18 AWG 0.142″ ID (47.5 nH)	V_{CE}	+24 Vdc @ 0.95 A
Q1, Q3	MMBT2222ALT1, NPN Transistor	Board	0.030″ Glass–Teflon® 2 oz. Cu, ε_r = 2.55
Q2, Q4	BD136, PNP Transistor		

Figure 1. MRF860 Class A RF Test Fixture Schematic

TYPICAL CHARACTERISTICS

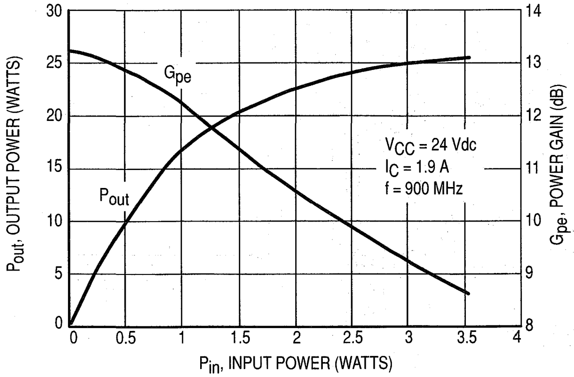


Figure 2. Output Power & Power Gain versus Input Power

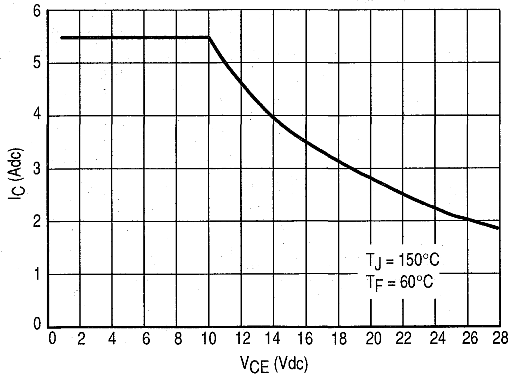


Figure 3. DC SOA (Total I_C for both halves operating.)

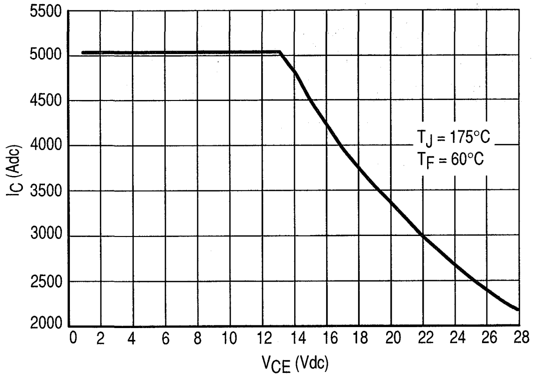


Figure 4. DC SOA (This device is MTBF limited for $V_{CE} < 14$ Vdc; total I_C for both halves operating.)

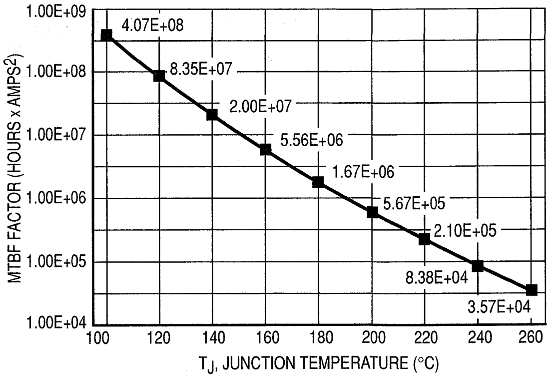


Figure 5. MTBF Factor versus Junction Temperature

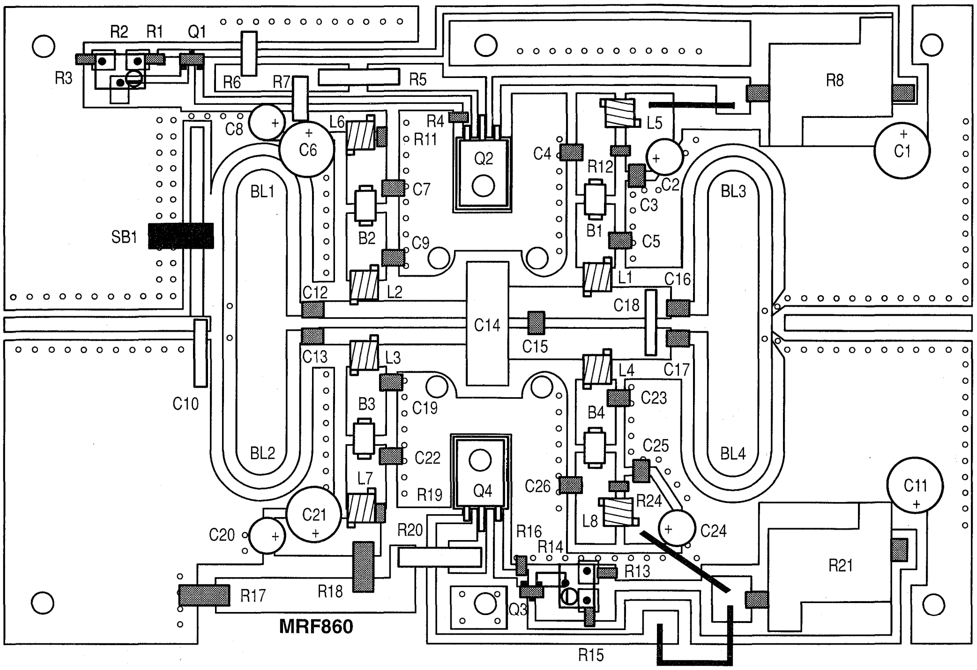


Figure 6. MRF860 Test Fixture Component Layout

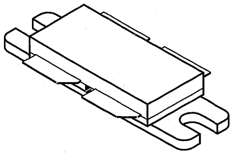
The RF Line
NPN Silicon RF Power Transistor

MRF861

CLASS A
800–960 MHz
27 W (CW), 24 V
NPN SILICON
RF POWER TRANSISTOR

Designed for 24 Volt UHF large–signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800–960 MHz.

- Specified for V_{CE} = 24 Vdc, I_C = 3.75 Adc Characteristics
  Output Power = 27 Watts CW
  Minimum Power Gain = 9.5 dB
  Minimum ITO = +53.5 dBm
  Typical Noise Figure = 6.5 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800–960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, I_C = 3.75 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 8 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 375A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	130 1	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (T_J = 150°C, T_C = 70°C)	$R_{\theta JC}$	0.92	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector–Emitter Breakdown Voltage (I_C = 50 mA, I_B = 0)	$V_{(BR)CEO}$	28	33	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mA, V_{BE} = 0)	$V_{(BR)CES}$	60	75	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mA, I_E = 0)	$V_{(BR)CBO}$	60	75	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5 mA, I_C = 0)	$V_{(BR)EBO}$	4	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CES}	—	—	10	mA

(1) All DC tests are per side.

(continued)

REV 2

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1 A, V_{CE} = 5 V)	h_{FE}	30	60	120	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 24 V, f = 1 MHz) (3)	C_{ob}	—	45	—	pF
FUNCTIONAL CHARACTERISTICS (2)					
Common–Emitter Power Gain (V_{CE} = 24 V, I_C = 3.75 A, f = 840–900 MHz, Power Output = 27 W)	P_g	9.5	11	—	dB
Load Mismatch (V_{CE} = 24 V, I_C = 3.75 A, f = 840 MHz, Power Output = 27 W, Load VSWR = 30:1, All Phase Angles)	ψ	No Degradation in Output Power			
RF Input Overdrive (V_{CE} = 24 V, I_C = 3.75 A, f = 840 MHz) No degradation	$P_{in(over)}$	—	—	8	W
Third Order Intercept Point (V_{CE} = 24 V, I_C = 3.75 A, f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = –40 dBc)	ITO	+53.5	+54.5	—	dBm
Noise Figure (V_{CE} = 24 V, I_C = 3.75 A, f = 900 MHz)	NF	—	6.5	—	dB
Input Return Loss (V_{CE} = 24 V, I_C = 3.75 A, f = 840–900 MHz, Power Output = 27 W)	IRL	—	—	–8	dB

(1) All DC tests are per side.
(2) Operating bias point I_C is the total for both halves.
(3) C_{ob} measurement is for reference only. This device is collector matched.

Table 1. MRF861 Common Emitter S–Parameters (Per Side)

V_{CE} (V)	I_C (A)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
24	1.875	800	0.980	163	0.532	81	0.023	62	0.904	164
		820	0.976	162	0.577	77	0.023	58	0.896	164
		840	0.968	161	0.632	73	0.024	55	0.884	164
		860	0.958	160	0.708	67	0.025	51	0.871	164
		880	0.940	159	0.792	60	0.027	45	0.856	164
		900	0.919	158	0.884	52	0.027	38	0.838	164
		920	0.887	158	0.991	41	0.027	28	0.822	166
		940	0.848	158	1.087	29	0.025	16	0.814	168
		960	0.812	159	1.148	14	0.023	3	0.824	170

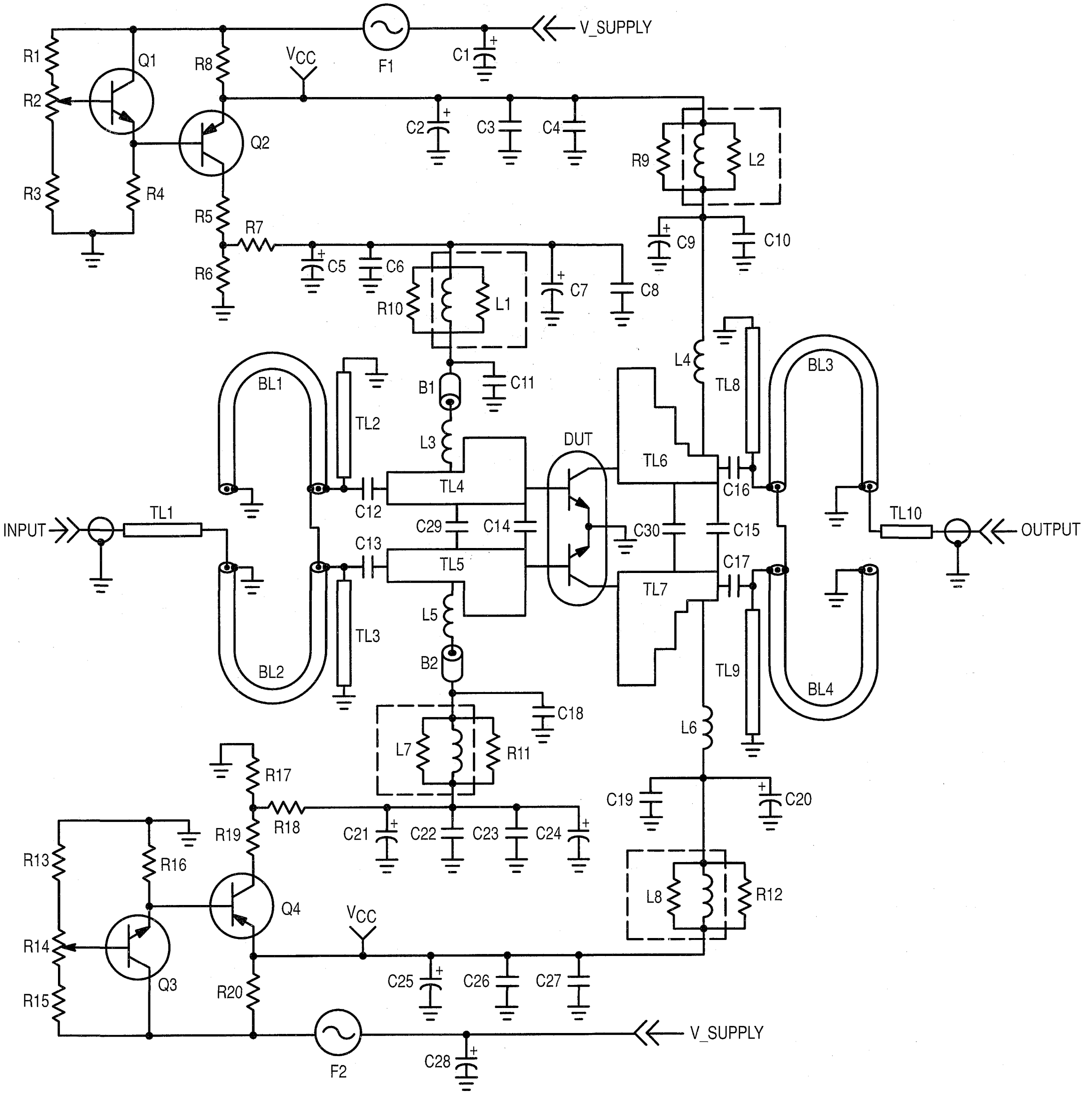
Table 2. Z_{in} and Z_{OL}* versus Frequency

f (MHz)	Z_{in} (Ohms)		Z_{OL}* (Ohms)	
840	2.6	11.4	12	1.8
870	3.2	12.3	12	0.5
900	3.9	12.4	9.4	–0.8

V_{CE} = 24 V, I_C = 3.75 A, P_o = 27 W

Z_{in} is a balanced base–to–base measurement.

Z_{OL}* = Conjugate of optimum load impedance, collector to collector, into which the device operates at a given output power, bias current, voltage and frequency.



B1, B2	Short Ferrite Bead	Q1, Q3	MMBT2222ALT1, NPN Transistor
BL1 – BL4	2.20″ 50 Ω 0.085″ OD Semi–Rigid Coax	Q2, Q4	BD136, PNP Transistor
C1, C5, C21, C28	470 µF, 50 Vdc Electrolytic Capacitor	R1, R15	470 Ω, 1/4 W
C2, C7, C9, C20, C24, C25	10 µF, 50 Vdc Electrolytic Capacitor	R2, R14	500 Ω Potentiometer, 1/4 W
C3, C8, C23, C26	0.1 µF, Chip Capacitor	R3, R13	4.7K Ω, 1/4 W
C4, C6, C22, C27	1000 pF, Chip Capacitor	R4, R16	2 x 4.7K Ω, 1/4 W
C10, C11, C18, C19	100 pF, 100 Mil Chip Capacitor	R5, R19	47 Ω, 2 W
C12, C13, C16, C17	43 pF, 100 Mil Chip Capacitor	R6, R17	82 Ω, 1 W
C14	7.5 pF, 50 Mil Chip Capacitor	R7, R18	4.7 Ω, 1/4 W
C15	1.7 pF, 100 Mil Chip Capacitor	R8, R20	2 Ω, 10 W
C29	2.7 pF, 100 Mil Chip Capacitor	R9, R10, R11, R12	4 x 39 Ω 1/8 W Chip Resistors in Parallel
C30	0.3 pF, 100 Mil Chip Capacitor	TL1, TL10	50 Ω, Microstrip Transmission Line
F1, F2	3 A Micro–Fuse	TL2 –TL9	Microstrip Transmission Line
L1, L2, L7, L8	12 Turns, 22 AWG, 0.150″ ID	V_Supply	+27.75 Vdc ±0.5 Vdc Due to Resistor Tolerance
	(Wrapped around 10 Ω, 1/2 W Resistor)	V_{CC}	+24 Vdc @ 1.875 A
L3, L4, L5, L6	4 Turns, 20 AWG, 0.163″ ID	Board	0.030″ Glass–Teflon® 2 oz. Cu, ε_r = 2.55

Figure 1. Class A RF Test Fixture Schematic

TYPICAL CHARACTERISTICS

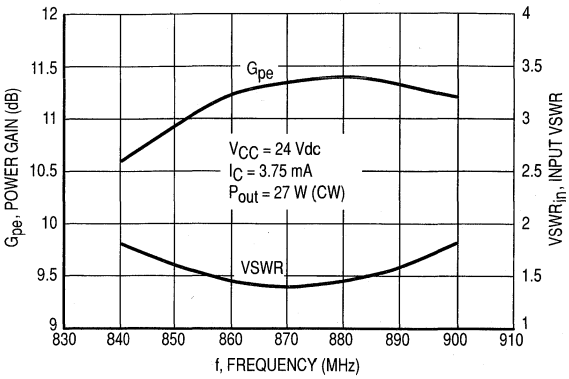


Figure 2. Performance in Broadband Circuit

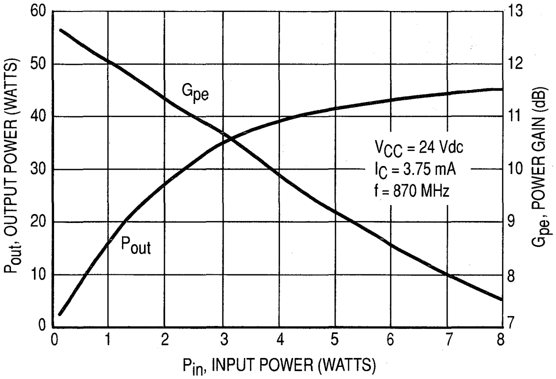


Figure 3. Output Power & Power Gain versus Input Power

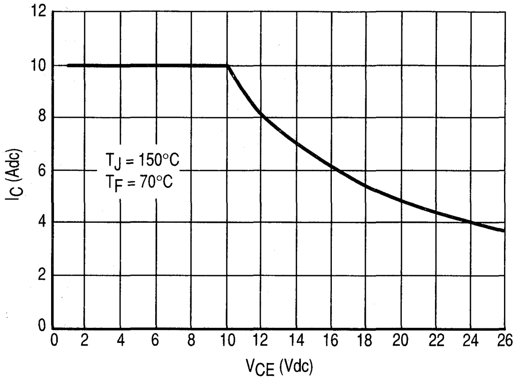


Figure 4. DC SOA
(Total I_C for both halves operating.)

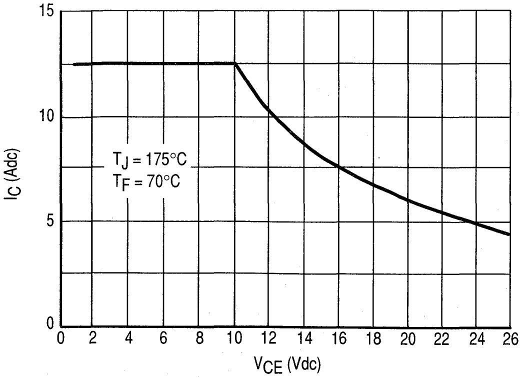


Figure 5. DC SOA
(Total I_C for both halves operating.)

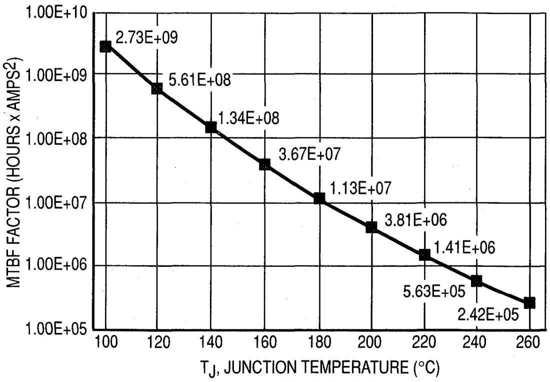


Figure 6. MTBF Factor versus Junction Temperature

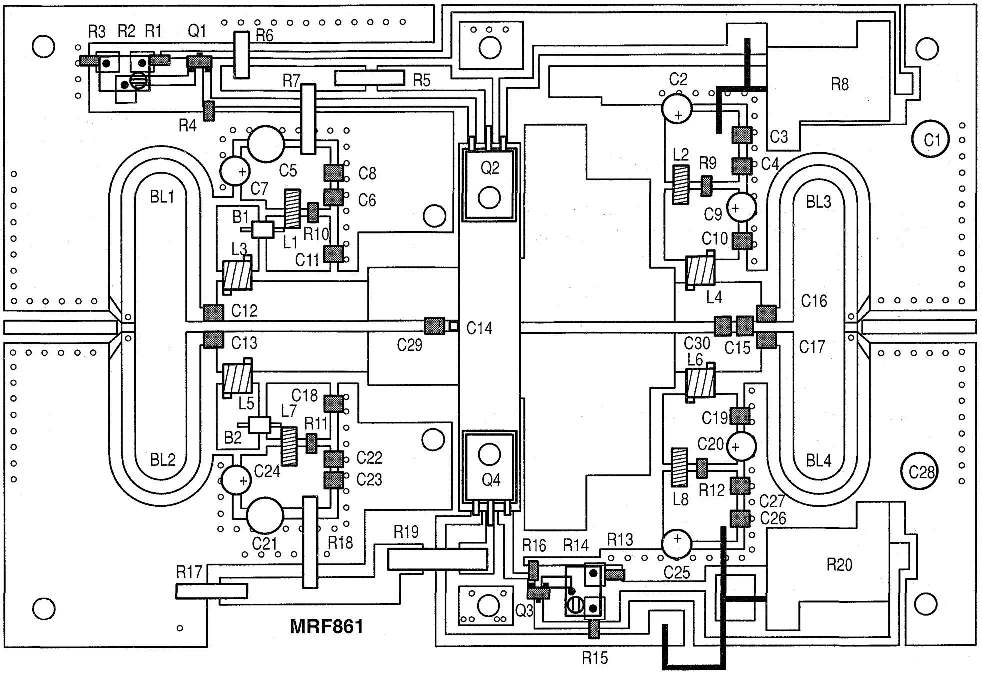


Figure 7. MRF861 Test Fixture Component Layout

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

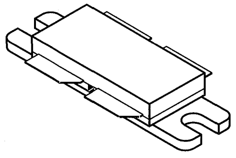
The RF Line
NPN Silicon RF Power Transistor

MRF862

CLASS A
800–960 MHz
36 W (CW), 24 V
NPN SILICON
RF POWER TRANSISTOR

Designed for 24 Volt UHF large–signal, common emitter, class A linear amplifier applications in industrial and commercial equipment operating in the range of 800–960 MHz.

- Specified for V_{CE} = 24 Vdc, I_C = 5 Adc Characteristics
  Output Power = 36 Watts CW
  Minimum Power Gain = 9 dB
  Minimum ITO = +55 dBm
  Typical Noise Figure = 6.5 dB
- Characterized with Small–Signal S–Parameters and Series Equivalent Large–Signal Parameters from 800–960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 30:1 VSWR @ 24 Vdc, I_C = 5 Adc and Rated Output Power
- Will Withstand RF Input Overdrive of 13.6 W CW
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 375A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	164 1.27	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (T_J = 150°C, T_C = 70°C)	$R_{\theta JC}$	0.75	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector–Emitter Breakdown Voltage (I_C = 100 mA, I_B = 0)	$V_{(BR)CEO}$	28	37	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mA, V_{BE} = 0)	$V_{(BR)CES}$	60	75	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mA, I_E = 0)	$V_{(BR)CBO}$	60	75	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mA, I_C = 0)	$V_{(BR)EBO}$	4	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CES}	—	—	10	mA

(1) All DC tests are per side.

(continued)

REV 2

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1 A, V_{CE} = 5 V)	h_{FE}	30	75	120	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 24 V, f = 1 MHz) (3)	C_{ob}	—	75	—	pF
FUNCTIONAL CHARACTERISTICS (2)					
Common–Emitter Power Gain (V_{CE} = 24 V, I_C = 5 A, f = 840–900 MHz, P_{out} = 36 W)	P_g	9	10	—	dB
Load Mismatch (V_{CE} = 24 V, I_C = 5 A, f = 840 MHz, P_{out} = 36 W, Load VSWR = 30:1, All Phase Angles)	ψ	No Degradation in Output Power			
RF Input Overdrive (V_{CE} = 24 V, I_C = 5 A, f = 840 MHz) No degradation	$P_{in(over)}$	—	—	13.6	W
Third Order Intercept Point (V_{CE} = 24 V, I_C = 5 A, f1 = 900 MHz, f2 = 900.1 MHz, Meas. @ IMD 3rd Order = –40 dBc)	ITO	+55	+56	—	dBm
Noise Figure (V_{CE} = 24 V, I_C = 5 A, f = 900 MHz)	NF	—	6.5	—	dB
Input Return Loss (V_{CE} = 24 V, I_C = 5 A, f = 840–900 MHz, P_{out} = 36 W)	IRL	—	—	-8	dB

(1) All DC tests are per side.
(2) Operating bias point I_C is the total for both halves.
(3) C_{ob} measurement is for reference only. This device is collector matched.

Table 1. MRF862 Common Emitter S–Parameters (Per Side)

V_{CE} (V)	I_C (A)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	$\angle\phi$	$\lvert S_{21}\rvert$	$\angle\phi$	$\lvert S_{12}\rvert$	$\angle\phi$	$\lvert S_{22}\rvert$	$\angle\phi$
24	2.5	800	0.934	161	0.679	55	0.021	44	0.883	169
		820	0.911	160	0.766	46	0.021	36	0.873	169
		840	0.877	160	0.852	34	0.020	26	0.867	170
		860	0.843	161	0.936	21	0.018	14	0.871	171
		880	0.813	163	0.971	4	0.015	–1	0.891	172
		900	0.807	166	0.942	–12	0.010	–15	0.920	173
		920	0.823	168	0.868	–28	0.005	–24	0.947	173
		940	0.847	169	0.769	–40	0.002	50	0.967	172
		960	0.873	169	0.671	–50	0.004	124	0.978	171

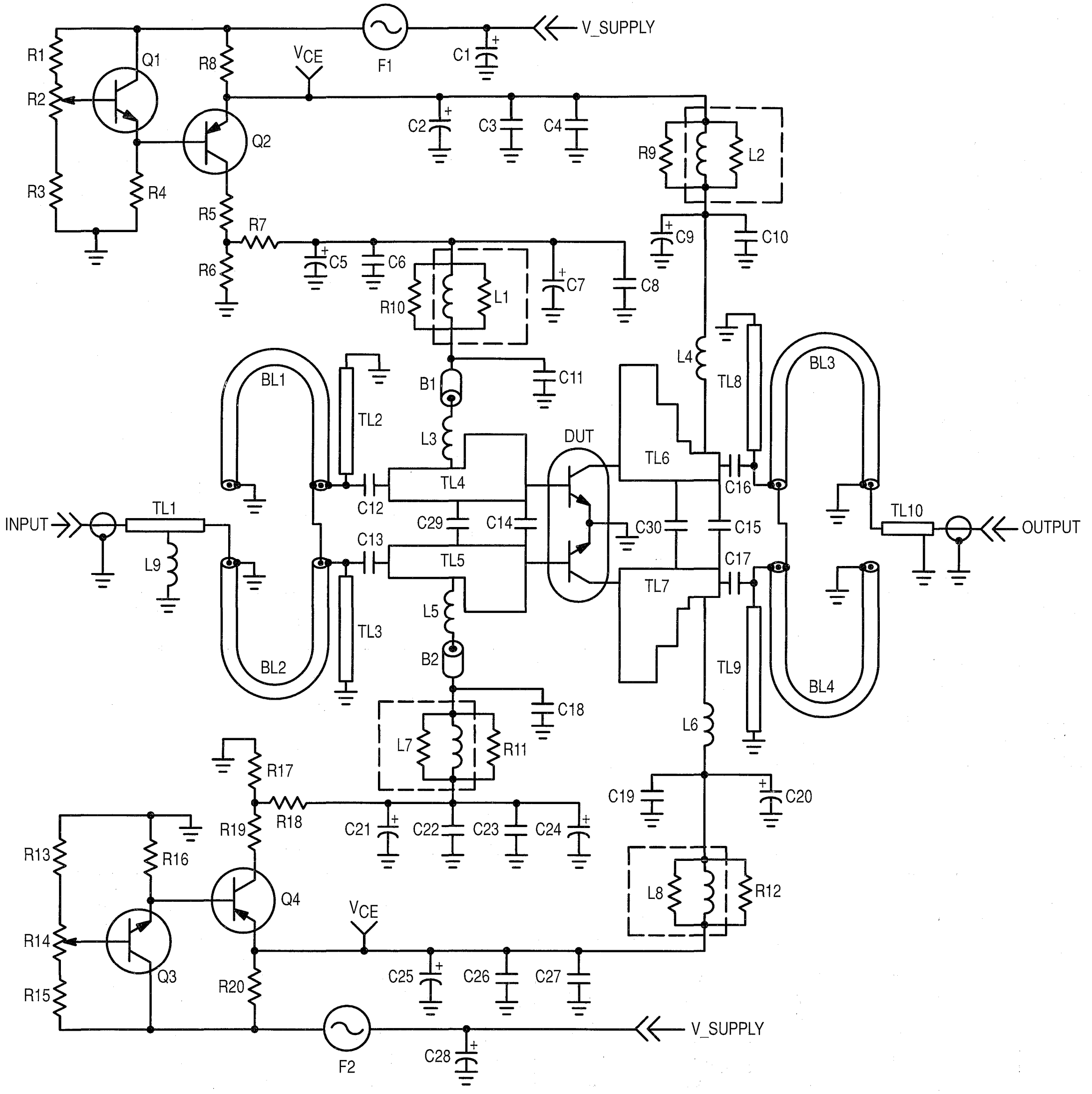
Table 2. Z_{in} and Z_{OL}* versus Frequency

f (MHz)	Z_{in} (Ohms)		Z_{OL}* (Ohms)	
840	4.3	11.8	6.4	–1.3
870	5.7	12.4	5.1	–1.3
900	7.6	11.7	4.5	–1.1

V_{CE} = 24 V, I_C = 5 A, P_o = 36 W

Z_{in} is a balanced base–to–base measurement.

Z_{OL}* = Conjugate of optimum load impedance, collector to collector, into which the device operates at a given output power, bias current, voltage and frequency.



B1, B2	Short Ferrite Bead, Fair Rite (2743019447)	Q1, Q3	MMBT2222ALT1, NPN Transistor
BL1–BL4	2.20″, 50 Ω, 0.085″ OD, Semi–Rigid Coax	Q2, Q4	BD136, PNP Transistor
C1, C5, C21, C28	470 µF, 50 Vdc Electrolytic Capacitor	R1, R15	330 Ω, 1/4 W
C2, C7, C9, C20, C24, C25	10 µF, 50 Vdc Electrolytic Capacitor	R2, R14	500 Ω Potentiometer, 1/4 W
C3, C8, C23, C26	0.1 µF, Chip Capacitor	R3, R13	5.6K Ω, 1/4 W
C4, C6, C22, C27	1000 pF Chip Capacitor	R4, R16	2 x 4.7K Ω, 1/4 W
C10, C11, C18, C19	100 pF, 100 Mil, Chip Capacitor	R5, R19	56 Ω, 2 W
C12, C13, C16, C17	43 pF, 100 Mil, Chip Capacitor	R6, R17	75 Ω, 1/4 W
C14	5.6 pF, 50 Mil, Chip Capacitor	R7, R18	3.3 Ω, 1/4 W
C15	0.8 pF, 100 Mil, Chip Capacitor	R8, R20	1 Ω, 10 W
C29	3.0 pF, 100 Mil, Chip Capacitor	R9, R10, R11, R12	4 x 39 Ω 1/8 W Chip Resistors in Parallel
C30	3.9 pF, 100 Mil, Chip Capacitor	TL1, TL10	50 Ω, Microstrip Transmission Line
F1, F2	5 A Micro–Fuse	TL2–TL9	Microstrip Transmission Line
L1, L2, L7, L8	12 Turns, 22 AWG, 0.150″ ID	V_Supply	+26.5 Vdc ±0.5 Vdc Due to Resistor Tolerance
	(Wrapped around 10 Ω, 1/2 W Resistor)	V_{CE}	+24 Vdc @ 2.5 A
L3, L4, L5, L6	4 Turns, 20 AWG, 0.163″ ID	Board	0.030″ Glass–Teflon® 2 oz. Cu, ε_r = 2.55
L9	3 Turns, 20 AWG, 0.102″ ID		

Figure 1. Class A RF Test Fixture Schematic

TYPICAL CHARACTERISTICS

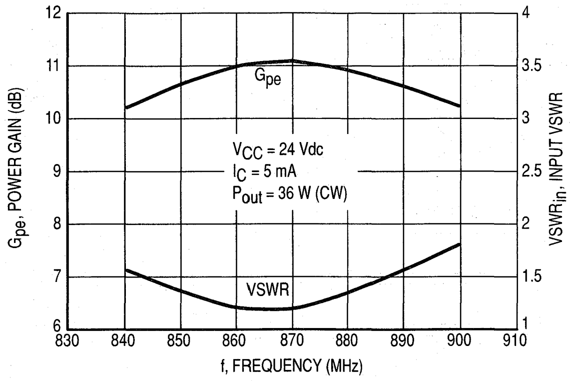


Figure 2. Performance in Broadband Circuit

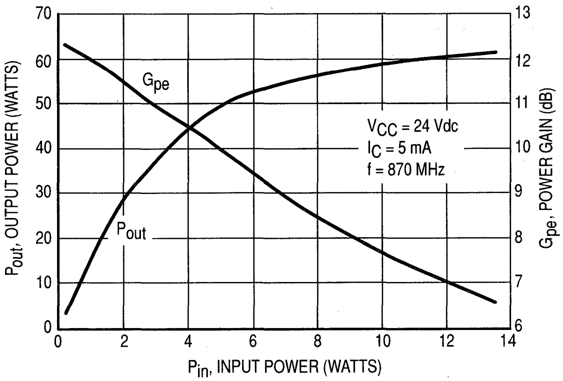


Figure 3. Output Power & Power Gain versus Input Power

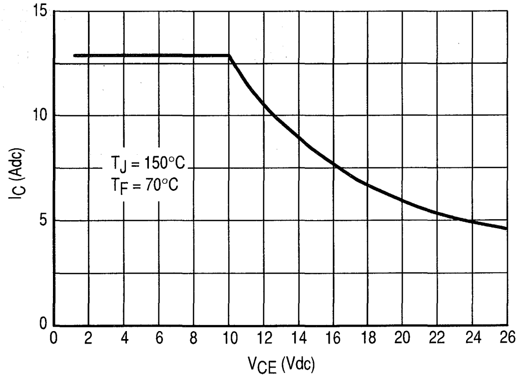


Figure 4. DC SOA (Total I_C for both halves operating.)

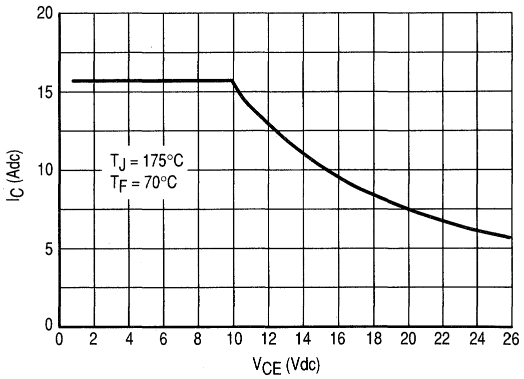


Figure 5. DC SOA (Total I_C for both halves operating.)

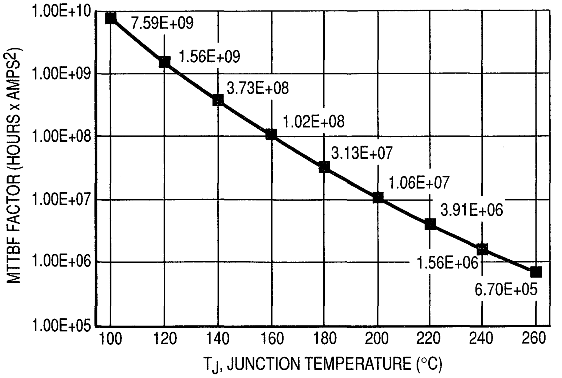


Figure 6. MTBF Factor versus Junction Temperature

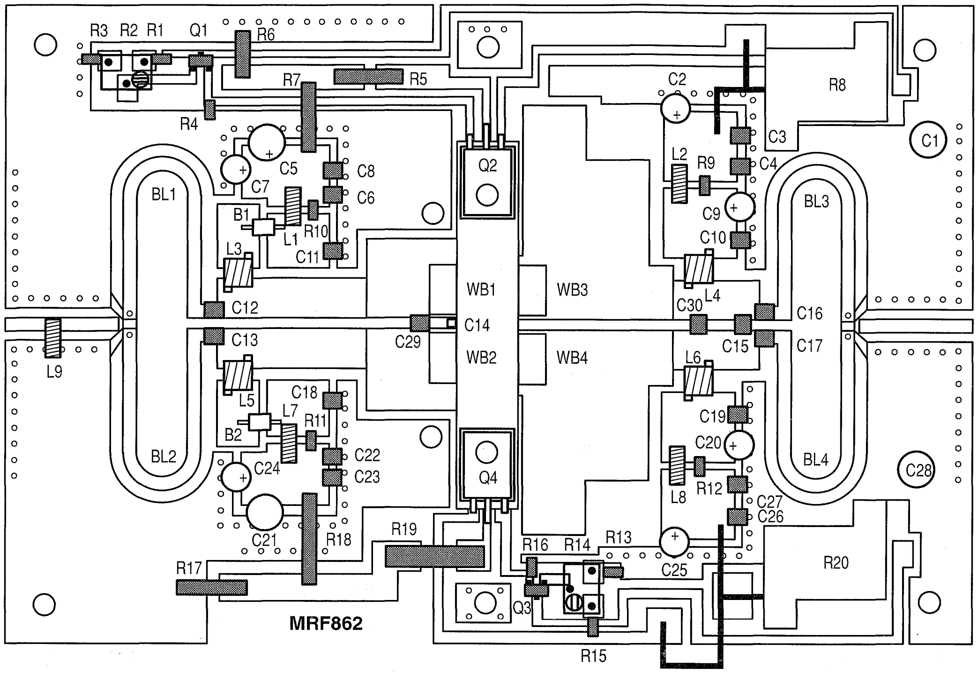
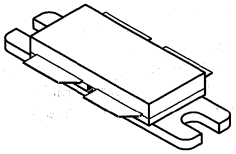


Figure 7. MRF862 Test Fixture Component Layout

The RF Line
NPN Silicon RF Power Transistor

MRF880

90 W, 900 MHz
RF POWER TRANSISTOR
NPN SILICON



CASE 375A–01, STYLE 1

Designed for 26 V UHF large–signal, common emitter, class–AB linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 800–960 MHz.

- Specified 26 V, 900 MHz Characteristics
  Output Power = 90 Watts
  Gain = 8.5 dB Min. @ 900 MHz, class AB
  Efficiency = 35% Min. @ 900 MHz, 90 Watts (PEP)
  Intermodulation Distortion −29 dBc Max. @ 90 Watts (PEP)
- Characterized with Series Equivalent Large–Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 5:1 VSWR @ 26 Vdc, and rated output power
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	15	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	140 0.80	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.25	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

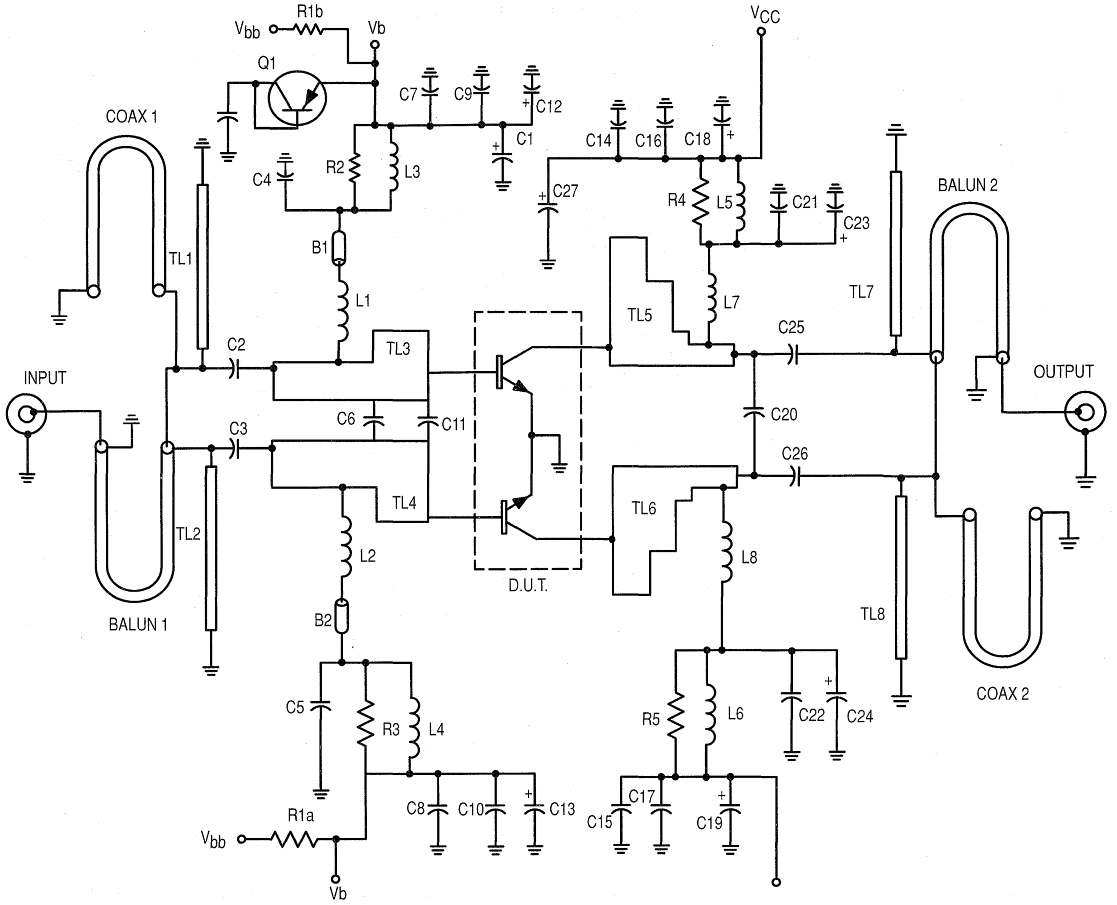
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	28	33	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	75	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	4.5	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	—	10.0	mAdc

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	60	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 Vdc, I_E = 0, f = 1.0 MHz) — for information only. This part is collector matched.	C_{ob}	—	45	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 90 Watts (PEP), I_{CQ} = 250 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	G_{pe}	8.5	9.5	—	dB
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 90 Watts (PEP), I_{CQ} = 250 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	η_C	35	42	—	%
Intermodulation Distortion (V_{CC} = 26 Vdc, P_{out} = 90 Watts (PEP), I_{CQ} = 250 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	IMD	—	−32	−29	dBc
Output Mismatch Stress (V_{CC} = 26 Vdc, P_{out} = 90 Watts (PEP), I_{CQ} = 250 mA, f_1 = 900 MHz, f_2 = 900.1 MHz Load VSWR = 5:1, All phase angles at frequency of test)	ψ	No Degradation in Output Power Before and After Test			



B1, B2 — Ferrite Bead
C1 — 200 µF Cap, 50 Vdc Min
C2, C3, C25, C26 — 43 pF Chip Cap, 100 Mil
C4, C5, C21, C22 — 100 pF Chip Cap, 100 Mil
C6 — 3.3 pF Chip Cap, 100 Mil
C7, C8, C14, C15 — 1000 pF Chip Cap, 100 Mil
C9, C10, C16, C17 — 1800 pF Chip Cap, 100 Mil
C11 — 7.5 pF Chip Cap, 50 Mil
C12, C13, C18, C19, C23, C24 — 10 µF Cap, 50 Vdc
C20 — 1.8 pF Chip Cap
C27 — 500 µF Cap, 50 Vdc Min
L1, L2, L7, L8 — 4T No. 20 AWG, 0.163″ ID CW
L3, L4, L5, L6 — 12T No. 22 AWG, 0.140″ ID CW
Q1 — BD166
R1a, R1b — 56 Ohm, 1 W Resistor
R2, R3, R4, R5 — 4 x 39 Ohm, 1/8 W Chip Resistor
TL1–8 — On PCB Mask
Balun 1,2 Coax 1,2 — 2.20″ 50 Ohm Semi–Rigid Coax, 0.088″ OD
PCB — 0.030″, Teflon®–Fiberglass, ϵ_r = 2.55
Wear Blocks — 0.330″ x 0.170″ x 0.50″ Beryllium Copper

Figure 1. Broadband Test Circuit

TYPICAL CHARACTERISTICS

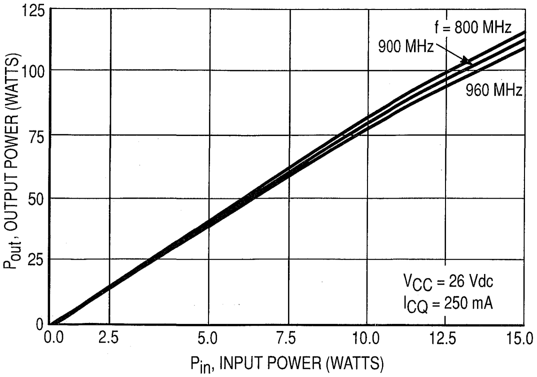


Figure 2. Output Power versus Input Power

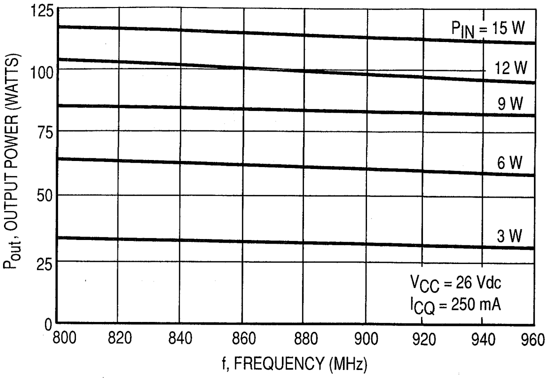


Figure 3. Output Power versus Frequency

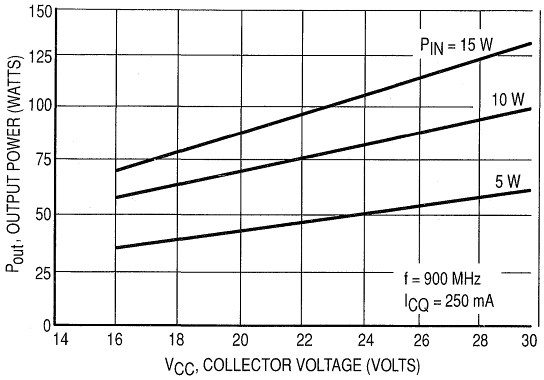


Figure 5. Output Power versus Supply Voltage

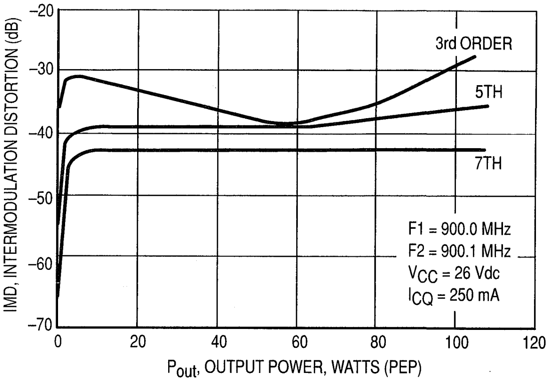
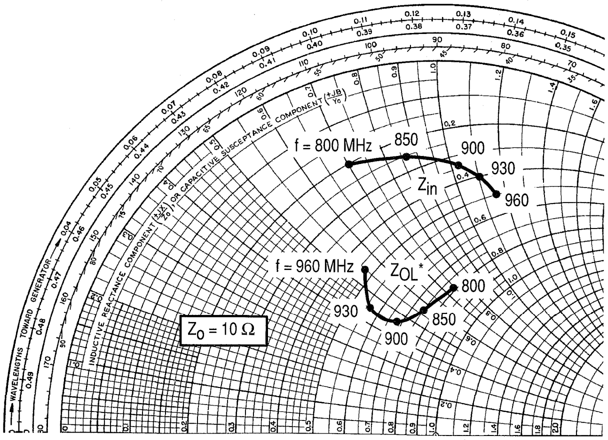


Figure 4. Intermodulation Distortion versus Output Power



P_o = 90 W, V_{CC} = 26 V

f (MHz)	Z_{in} ohms	Z_{OL}* ohms
800	2.00 + j6.90	7.68 + j7.33
850	2.45 + j8.60	7.38 + j5.86
900	3.30 + j10.1	6.93 + j4.53
930	3.90 + j10.9	5.89 + j4.42
960	5.00 + j11.5	4.58 + j5.57

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.

NOTE: Z_{in} & Z_{OL}* are given from base–to–base and collector–to–collector respectively.

Figure 6. Series Equivalent Input/Output Impedances

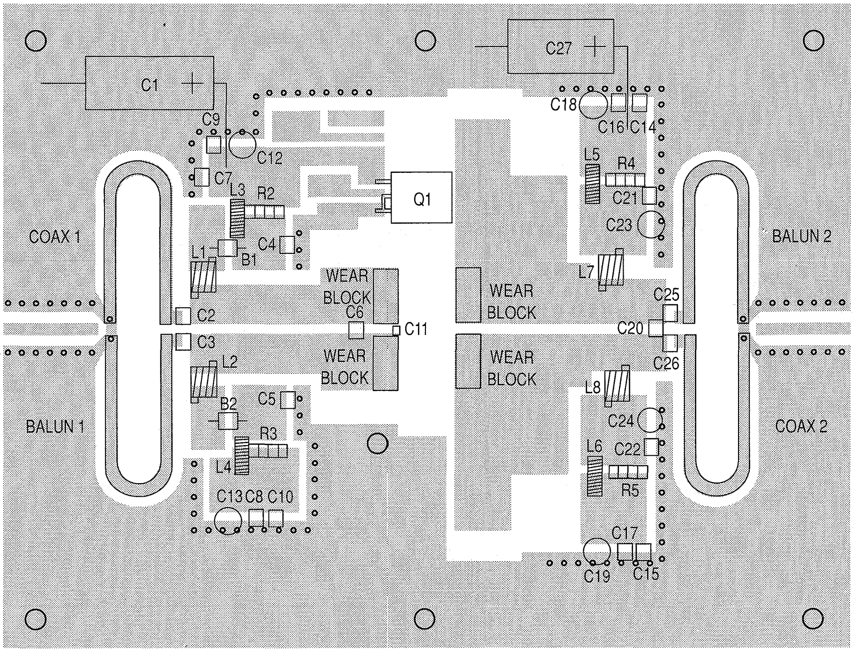


Figure 7. Fixture Component Layout

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

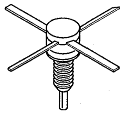
The RF Line
NPN Silicon
RF Power Transistors

MRF890

2.0 W, 900 MHz
RF POWER
TRANSISTORS
NPN SILICON

Designed for 24 volt UHF large–signal, common–emitter amplifier applications in industrial and commercial FM equipment operating in the range of 804–960 MHz.

- Specified 24 Volt, 900 MHz Characteristics
  Output Power = 2.0 Watts
  Power Gain = 9.0 dB Min
  Efficiency = 55% Min
- Series Equivalent Large–Signal Characterization
- Capable of 30:1 VSWR Load Mismatch at Rated Output Power and Supply Voltage
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 305–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	7.0 40	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Emitter–Base Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	100	—

NOTES:

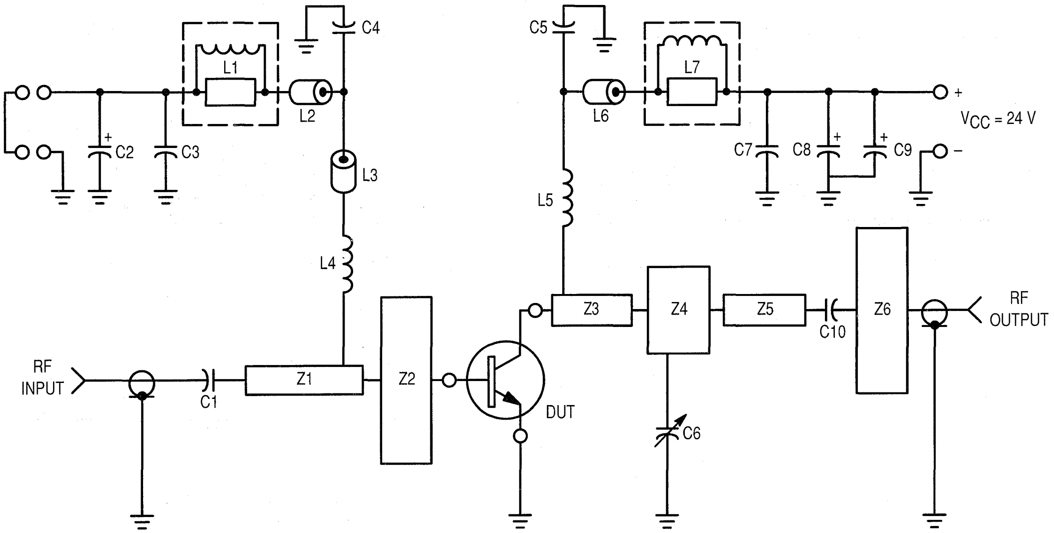
(continued)

1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.0	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (P_{out} = 2.0 W, V_{CC} = 24 Vdc, f = 900 MHz)	G_{PE}	8.5	9.0	—	dB
Collector Efficiency (P_{out} = 2.0 W, V_{CC} = 24 Vdc, f = 900 MHz)	η	55	60	—	%



C1, C4, C5 — 91 pF Mini Underwood Mica
C2, C8 — 1.0 µF Electrolytic
C3, C7 — 250 pF Unelco
C6 — Johanson 0.5–4.0 pF Giga–Trim
C9 — 10 µF, 50 V, Electrolytic
C10 — 39 pF Mini Underwood
L1, L7 — 10 Turns Around 10 Ω 1/2 W Resistor
L2, L3, L6 — Ferrite Bead
L4, L5 — 5 Turns 20 AWG 0.1″ ID
Z1, Z2, Z3, Z4, Z5, Z6 — Distributed Microstrip Elements (see photomask)
Board Material — Glass Teflon ε_r = 2.55 t = 0.031″

Figure 1. 850–900 MHz Test Circuit

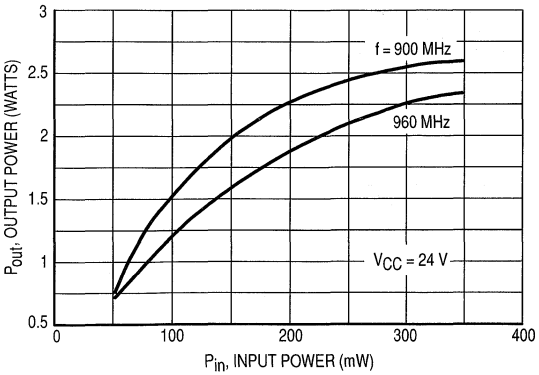


Figure 2. Output Power versus Input Power

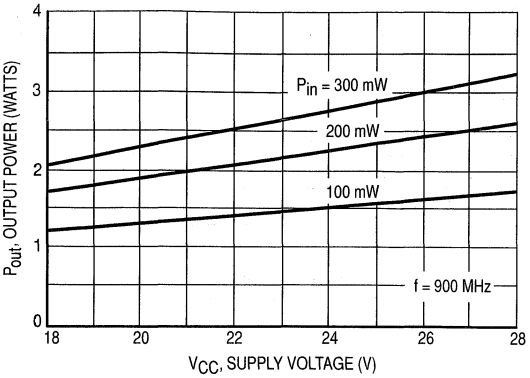


Figure 3. Output Power versus Supply Voltage

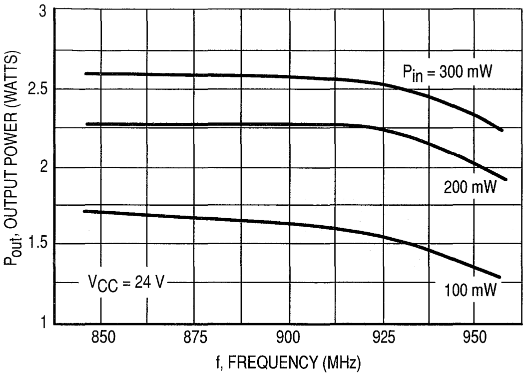


Figure 4. Output Power versus Frequency

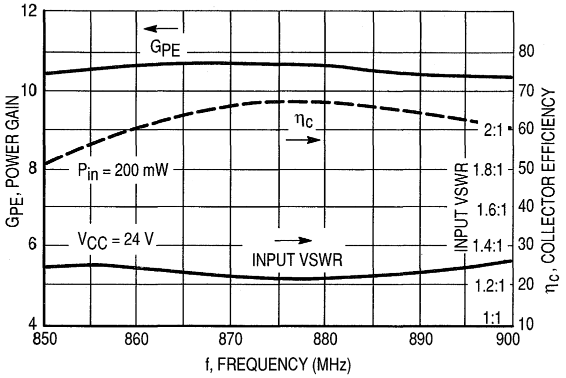
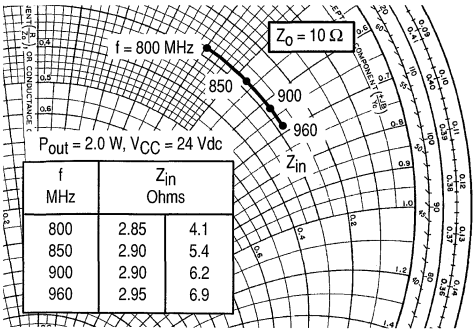
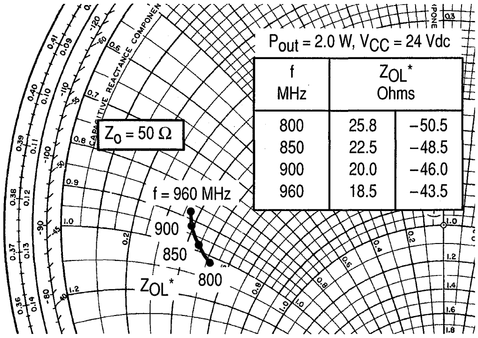


Figure 5. Typical Performance in Broadband Circuit



f MHz	Zin Ohms	
800	2.85	4.1
850	2.90	5.4
900	2.90	6.2
960	2.95	6.9

Figure 6. Series Equivalent Input Impedance



f MHz	ZOL* Ohms	
800	25.8	-50.5
850	22.5	-48.5
900	20.0	-46.0
960	18.5	-43.5

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 7. Series Equivalent Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

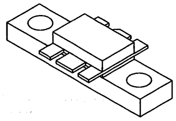
The RF Line
NPN Silicon RF Power Transistors

MRF891
MRF891S

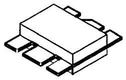
. . . designed for 24 volt UHF large–signal, common–emitter amplifier applications in industrial and commercial FM equipment operating in the range of 800–960 MHz.

- Specified 24 Volt, 900 MHz Characteristics
  Output Power = 5.0 Watts
  Power Gain = 9.0 dB Min
  Efficiency = 50% Min
- Series Equivalent Large–Signal Characterization
- Capable of Withstanding 20:1 VSWR Load Mismatch at Rated Output Power and Supply Voltage
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

5.0 W, 900 MHz
RF POWER
TRANSISTORS
NPN SILICON



CASE 319–07, STYLE 2
MRF891



CASE 319A–02, STYLE 2
MRF891S

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Emitter Voltage	V_{CES}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.6	Adc
Total Device Dissipation @ T_A = 50°C (1) Derate above 50°C	P_D	18 0.143	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	7.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

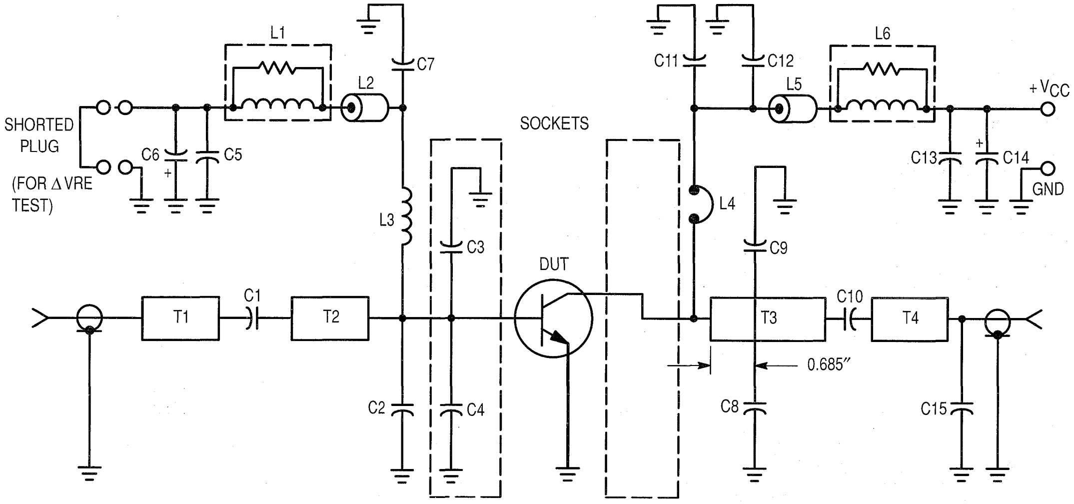
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	—	150	—

NOTES:
(continued)
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	6.5	8.0	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (Broadband) (V_{CC} = 24 Vdc, P_{out} = 5.0 W, f = 900 MHz)	G_{pe}	9.0	10	—	dB
Collector Efficiency (V_{CC} = 24 Vdc, P_{out} = 5.0 W, f = 900 MHz)	η	50	57	—	%
Load Mismatch Stress (V_{CC} = 24 Vdc, P_{in} = 0.63 W, f = 900 MHz, VSWR = 20:1, all phase angles)	ψ	No Degradation in Output Power			



C1 — 39 pF, 100 Mil Chip Capacitor
C2, C8, C15 — 0.8–8.0 pF Johansen Gigatrim
C3, C4 — 12 pF, Mini–Unelco
C5, C13 — 1000 pF, 350 V Unelco
C6, C14 — 10 µF, 25 V Tantalum
C7, C11, C12 — 91 pF, Mini–Unelco
C9 — 5.0 pF, MIni–Unelco
C10 — 47 pF, 100 Mil Chip Capacitor

L1, L6 — 10 Turns #20 AWG Around 10 Ohm 1/2 Watt Resistor
L2, L5 — Ferrite Bead
L3 — 4 Turns #16 AWG Choke
L4 — 0.5″, #18 AWG Wire
T1, T4 — 50 Ohm Microstrip Line
T2 — W = 165 Mils, ℓ = 1946 Mils
T3 — W = 166 Mils, ℓ = 1563 Mils
PC Board — 0.031″ Glass Teflon (ε_r = 2.56)

Figure 1. Broadband Test Fixture

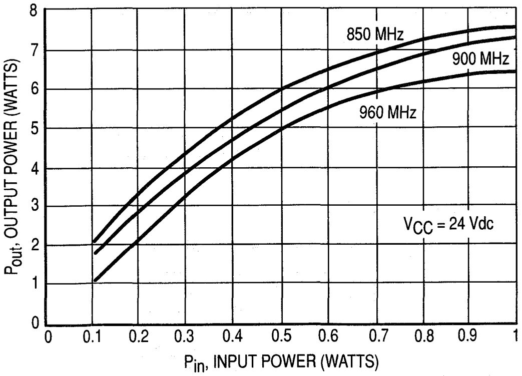


Figure 2. Output Power versus Input Power

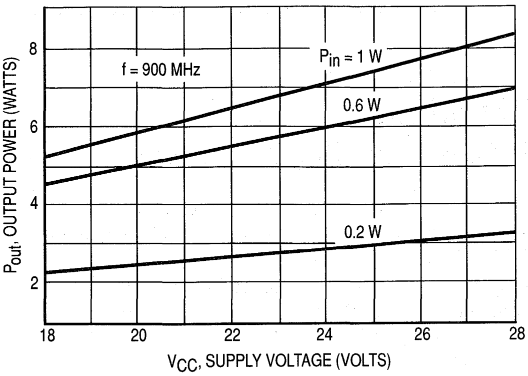


Figure 3. Output Power versus Supply Voltage

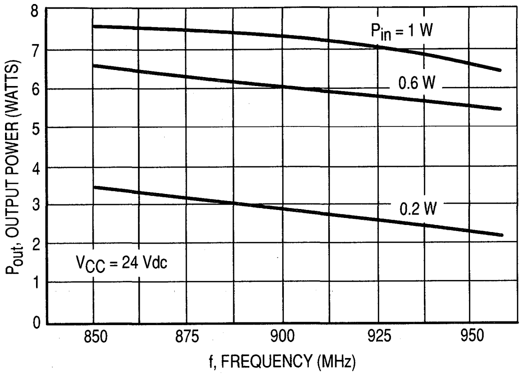


Figure 4. Output Power versus Frequency

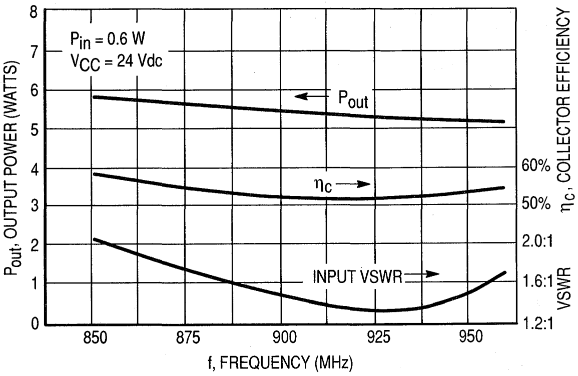


Figure 5. Typical Broadband Circuit Performance

V_{CC} = 24 Vdc, P_{out} = 5.0 W, Eff > 50%

f MHz	Z_{in} Ohms
850	1.1 + j3.0
900	1.0 + j3.25
960	1.18 + j3.5

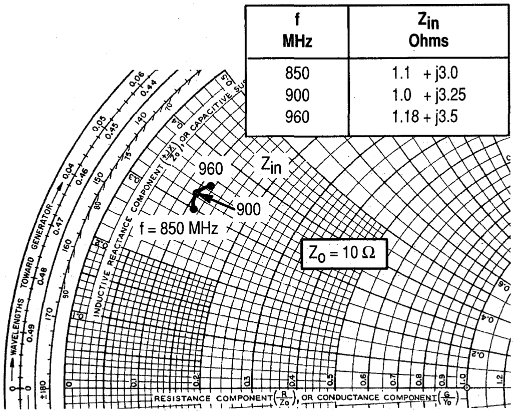


Figure 6. Series Equivalent Input Impedance

V_{CC} = 24 Vdc, P_{out} = 5.0 W, Eff > 50%

f MHz	Z_{OL}* Ohms
850	8.34 – j13.2
900	9.1 – j13.8
960	10.4 – j14.6

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

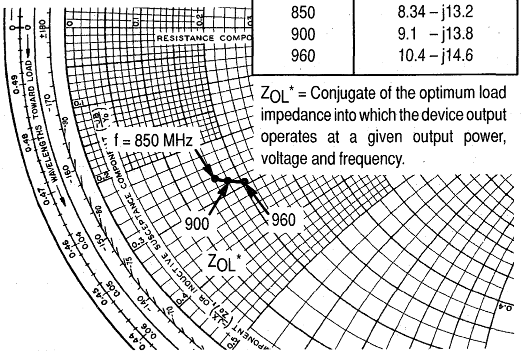


Figure 7. Series Equivalent Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

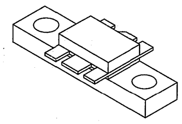
The RF Line
NPN Silicon RF Power Transistor

MRF892

. . . designed for 24 volt UHF large–signal, common–base amplifier applications in industrial and commercial FM equipment operating in the range of 804–960 MHz.

- Specified 24 Volt, 900 MHz Characteristics
  Output Power = 14 Watts
  Power Minimum = 8.5 dB Min
  Efficiency = 55% Min
- Series Equivalent Large–Signal Characterization
- Capable of 30:1 VSWR Load Mismatch at Rated Output Power and Supply Voltage
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated

14 W, 900 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 319–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	50 0.29	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	3.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	2.0	mAdc

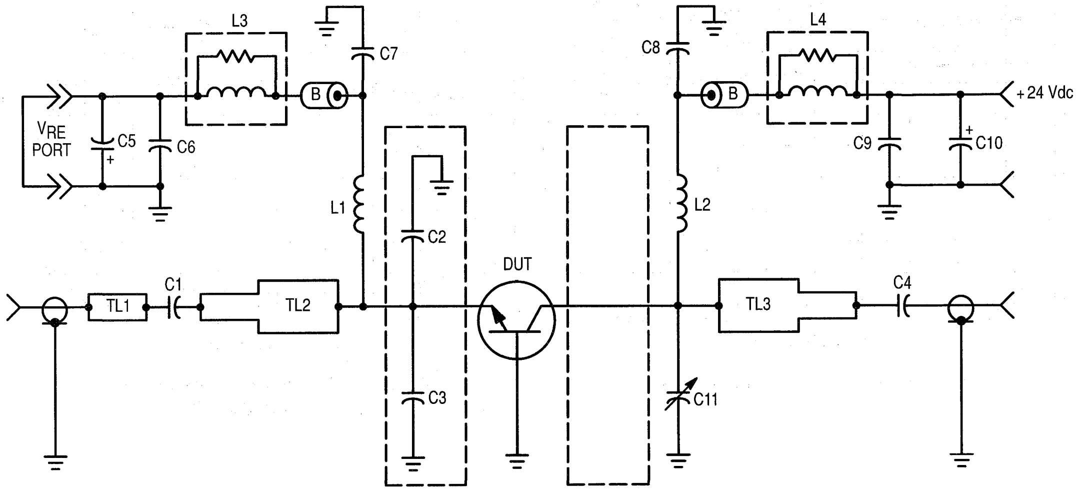
(continued)

NOTES:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	12.5	—	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (P_{out} = 14 W, V_{CC} = 24 Vdc, f = 900 MHz)	G_{PE}	8.5	9.5	—	dB
Collector Efficiency (P_{out} = 14 W, V_{CC} = 24 Vdc, f = 900 MHz)	η	50	60	—	%



B — Ferrite Bead, Ferroxcube 56–590–65–3B
C1 — 51 pF, 100 Mil Chip Capacitor
C2, C3 — 13 pF Mini–Unelco
C4 — 43 pF, 100 Mil Chip Capacitor
C5, C10 — 10 μF, 35 WV
C6, C9 — 500 pF Unelco J101
C7, C8 — 91 pF Mini–Unelco
C11 — 0.8–8.0 pF Johanson Gigatrim

L1, L2 — 4 Turns #18 Enameled, 5/32″ ID
L3, L4 — 14 Turns #22 Enameled Over 10 Ω Carbon Resistor
TL1 — Micro Strip, 50 Ω
TL2 — Micro Strip, Z_o = 26 Ω, λ/4 @ 875 MHz
TL3 — Micro Strip, Z_o = 14 Ω, λ/4 @ 875 MHz
Board — 0.032″ Glass Teflon
2 oz. Cu CLAD, ε_r = 2.55

Figure 1. 850–900 MHz Broadband Circuit Schematic

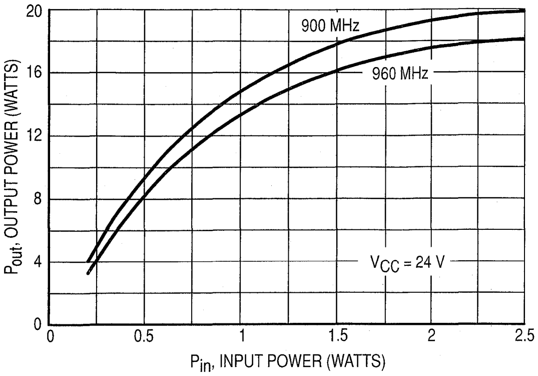


Figure 2. Output Power versus Input Power

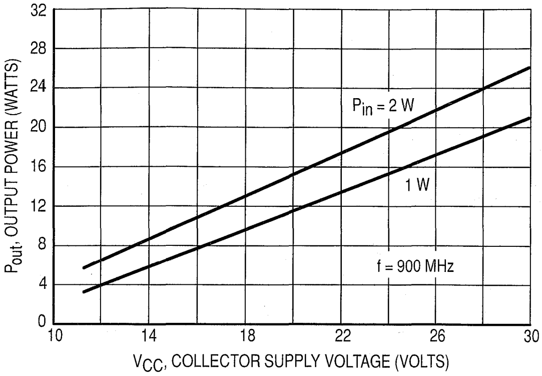


Figure 3. Output Power versus Supply Voltage

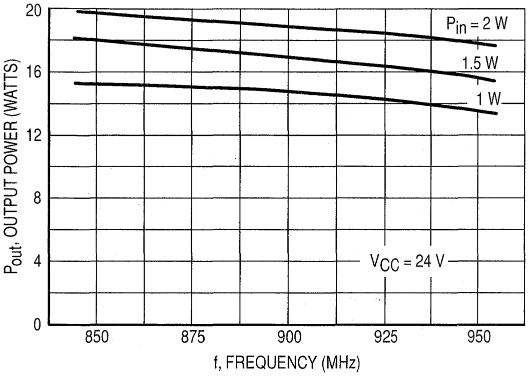


Figure 4. Output Power versus Frequency

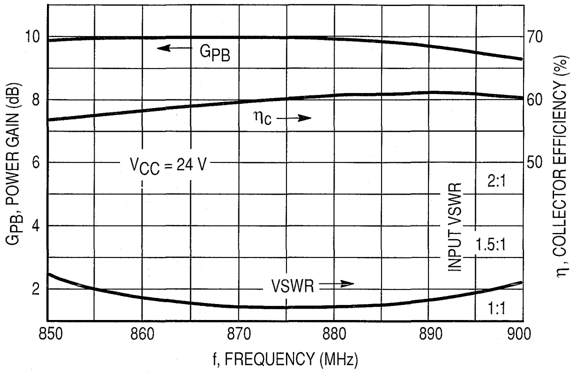
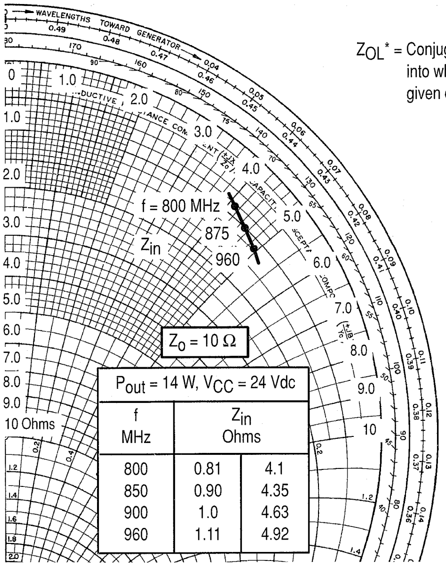


Figure 5. Typical Performance in Broadband Circuit

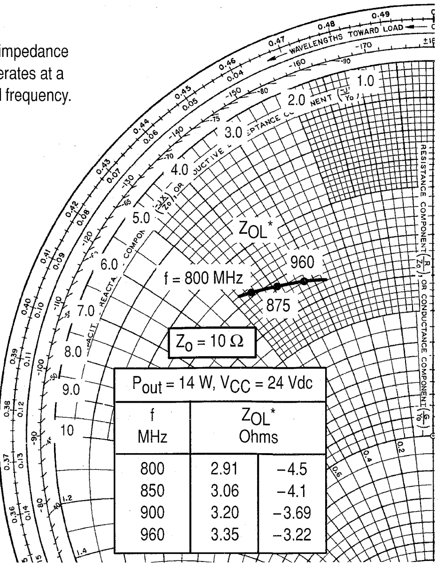


$P_{out} = 14$ W, $V_{CC} = 24$ Vdc

f MHz	Z_{in} Ohms	
800	0.81	4.1
850	0.90	4.35
900	1.0	4.63
960	1.11	4.92

Figure 6. Series Equivalent Input Impedance

$Z_{OL}{}^*$ = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.



$P_{out} = 14$ W, $V_{CC} = 24$ Vdc

f MHz	$Z_{OL}{}^*$ Ohms	
800	2.91	−4.5
850	3.06	−4.1
900	3.20	−3.69
960	3.35	−3.22

Figure 7. Series Equivalent Output Impedance

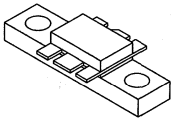
The RF Line
NPN Silicon RF Power Transistor

MRF894

30 W, 900 MHz
RF POWER
TRANSISTOR
NPN SILICON

. . . designed for 24 volt UHF large–signal, common–base amplifier applications in industrial and commercial FM equipment operating in the range of 804–960 MHz.

- Specified 24 Volt, 900 MHz Characteristics
  Output Power = 30 Watts
  Power Gain = 7.0 dB Min
  Efficiency = 55% Min
- Series Equivalent Large–Signal Characterization
- Capable of 30:1 VSWR Load Mismatch at Rated Output Power and Supply Voltage
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated



CASE 319–07, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	7.0	Adc
Total Device Dissipation @ $T_C = 25°C$ (1) Derate above 25°C	P_D	115 0.66	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	1.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 25$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 25$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 5.0$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	—	—	10	mAdc

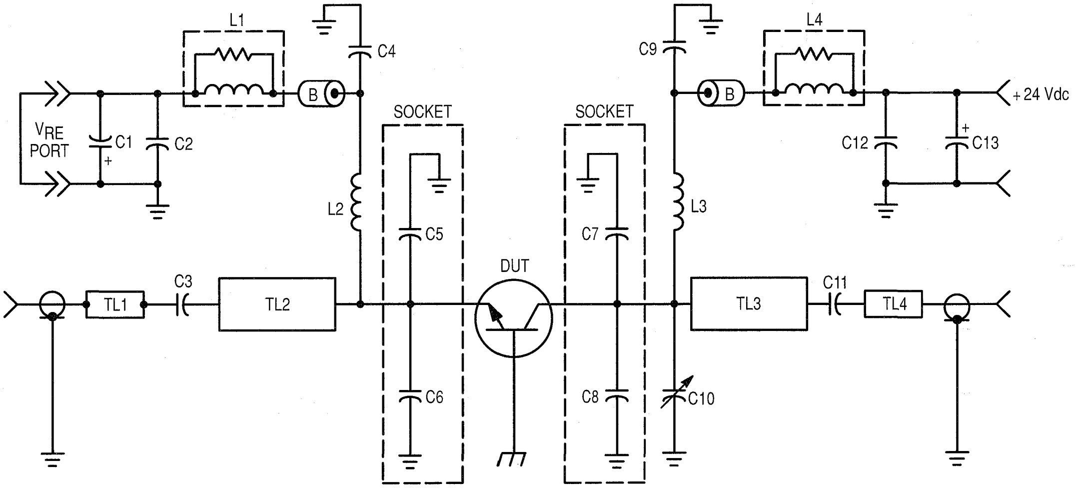
(continued)

NOTES:
1. This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	45	—	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (P_{out} = 30 W, V_{CC} = 24 Vdc, f = 900 MHz)	G_{PE}	7.0	8.5	—	dB
Collector Efficiency (P_{out} = 30 W, V_{CC} = 24 Vdc, f = 900 MHz)	η	55	60	—	%



B — Ferrite Bead, Ferroxcube 56–590–65–3B
C1, C13 — 5.0 µF, 50 Vdc
C2, C12 — 1000 pF Unelco
C3, C11 — 47 pF, 100 Mil Chip Capacitor
C4, C9 — 91 pF, Mini–Underwood
C5, C6 — 12 pF, Mini–Underwood
C7 — 18 pF, Mini–Underwood
C8 — 24 pF, Mini–Underwood
C10 — 0.8–8.0 pF Johanson Gigatrim

L1, L4 — 11 Turns #20 Enameled Over 10 Ω Carbon Resistor
L2, L3 — 4 Turns #20 Enameled, .15″ ID
TL1, TL4 — Micro Strip Line, 50 Ω
TL2 — Micro Strip, Z_o = 30 Ω, λ/4 @ 875 MHz
TL3 — Micro Strip, Z_o = 22 Ω, λ/4 @ 875 MHz
Board — 0.032″ Glass Teflon
2 oz. Cu CLAD, ε_r = 2.55

Figure 1. 850–900 MHz Broadband Circuit Schematic

TYPICAL CHARACTERISTICS

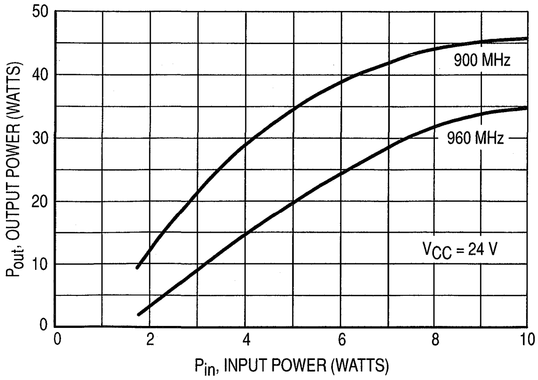


Figure 2. Output Power versus Input Power

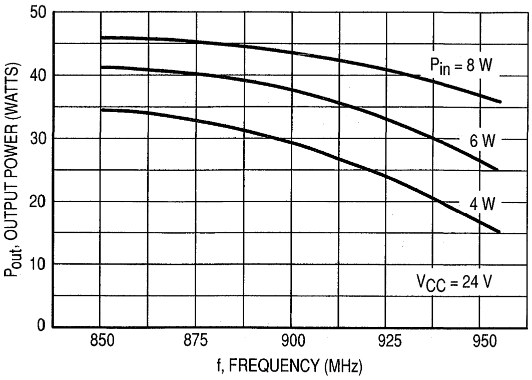


Figure 3. Output Power versus Frequency

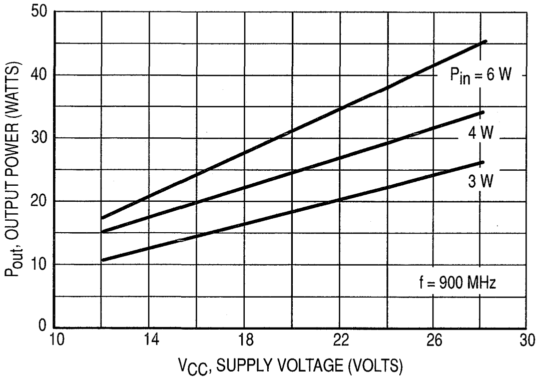


Figure 4. Output Power versus Supply Voltage

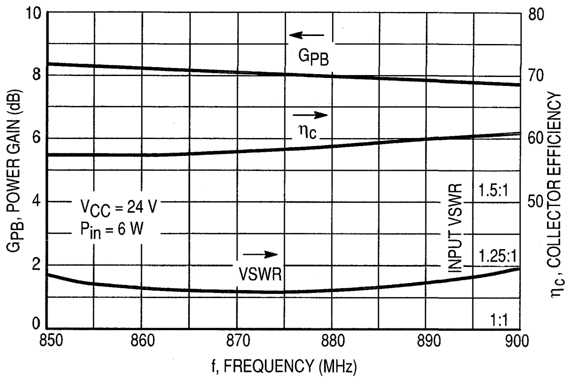
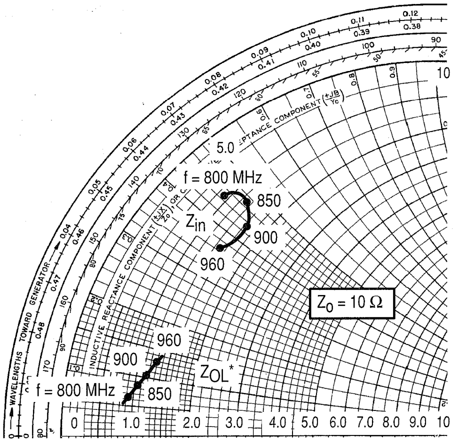


Figure 5. Typical Broadband Circuit Performance



V_{CC} = 24 Vdc, P_{out} = 30 W

f Frequency MHz	Z_{in} Ohms	Z_{OL}^* Ohms
800	0.9 + j4.5	1.0 + j0.7
850	1.3 + j4.7	1.1 + j0.9
900	1.6 + j4.4	1.2 + j1.1
960	1.5 + j3.7	1.2 + j1.3

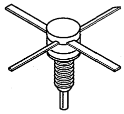
Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 6. Series Equivalent Impedance

The RF Line
NPN Silicon RF Power Transistors

MRF896

3.0 W, 900 MHz
RF POWER
TRANSISTORS
NPN SILICON



CASE 305–01, STYLE 1
MRF896

Designed for 24 Volt UHF large–signal, common emitter, Class AB and Class A linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 800–960 MHz.

- Specified 24 Volt, I_{cq} = 8.0 mA (Class AB), 900 MHz Characteristics
  Output Power = 3.0 Watts
  Minimum Gain = 10 dB @ 900 MHz
  Minimum Efficiency = 30% @ 900 MHz, 3.0 Watts
  Maximum Intermodulation Distortion –30 dBc @ 3.0 Watts (PEP)
- Characterized with Series Equivalent Large–Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 5:1 VSWR @ 26 Vdc, at rated output power
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Emitter Voltage	V_{CES}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current — Continuous	I_C	0.45	Adc
Total Device Dissipation @ T_C = 50°C Derate Above 50°C	P_D	17 0.143	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	7.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise stated)

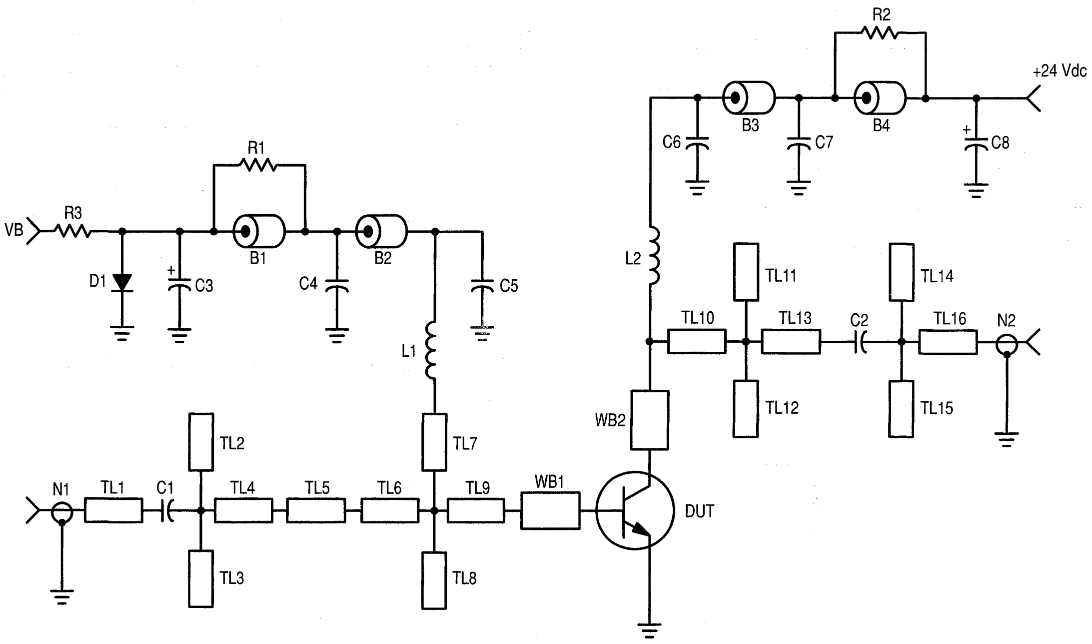
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	37	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	92	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	1.0 nA	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_E = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	60	120	—

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise stated)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	2.4	3.3	4.4	pF
FUNCTIONAL TESTS (In Motorola Test Fixture. See Figure 1.)					
Common–Emitter Amplifier Power Gain (V_{CC} = 24 Vdc, P_{out} = 3.0 Watts, I_{cq} = 8.0 mA, f = 900 MHz)	G_{pe}	10	12	—	dB
Collector Efficiency (V_{CC} = 24 Vdc, P_{out} = 3.0 Watts, I_{cq} = 8.0 mA, f = 900 MHz)	η_c	30	45	—	%
3rd Order Intermodulation Distortion (V_{CC} = 24 Vdc, P_{out} = 3.0 Watts (PEP), I_{cq} = 8.0 mA, f_1 = 900 MHz, F_2 = 900.1 MHz)	IMD	—	−37	−30	dBc
Output Mismatch Stress (V_{CC} = 26 Vdc, P_{out} = 3.0 Watts, I_{cq} = 8.0 mA, f = 900 MHz, Load VSWR = 5:1, all phase angles)	ψ	No Degradation in Output Power Before and After Test			



B1, B4 — Long Bead, Fair Rite (2743019446)
B2, B3 — Short Bead, Fair Rite (2743021446)
C1, C2 — 43 pF, 100 Mil Chip Capacitor, ATC (100B430JCA500X)
C3, C8 — 10 µF, 50 V Electrolytic, Panasonic (ECEV1HV100R)
C4, C7 — 820 pF, Surface Mount, Kemit (C1206N821J1GSC)
C5, C6 — 100 pF Chip Cap, Murata Erie (GRH710COG101J100VBE)
D1 — Diode 1N4001, Motorola
L1, L2 — 7 Turns, 24 AWG, IDIA 0.116″

N1, N2 — Type N Flange, Omni Spectra (3052–1648–10)
R1, R2 — 4 x 39 Ohm, 1/8 W chips in parallel, Rohm (390–J)
R3 — 82 Ohm, 1.0 W
TL1 — Z_o = 50 Ohm
TL2–TL15 — See Photomaster
TL16 — Z_o = 50 Ohm
WB1 — Wear Block .200″ x .005″ BeCu
WB2 — Wear Block .200″ x .060″ x .005″ BeCu
Board — 30 mil Glass Teflon, ε_r = 2.55, Keene (GX–0300–55–22)

Figure 1. 840–960 MHz Broadband Test Circuit

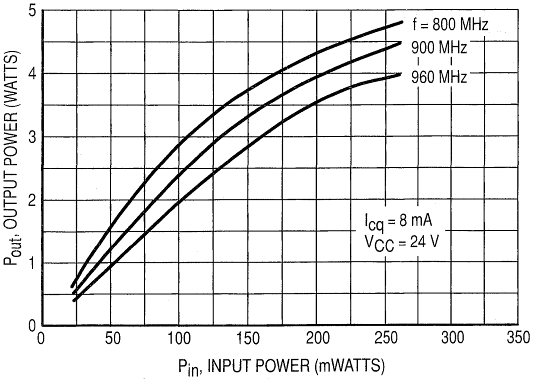


Figure 2. Output Power versus Input Power

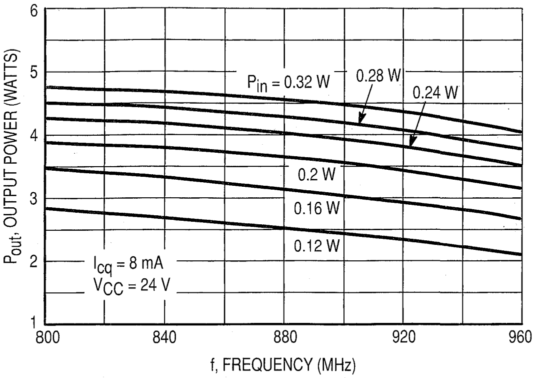


Figure 3. Output Power versus Frequency

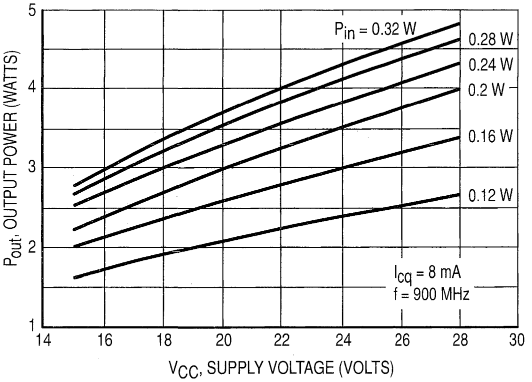


Figure 4. Output Power versus Supply Voltage

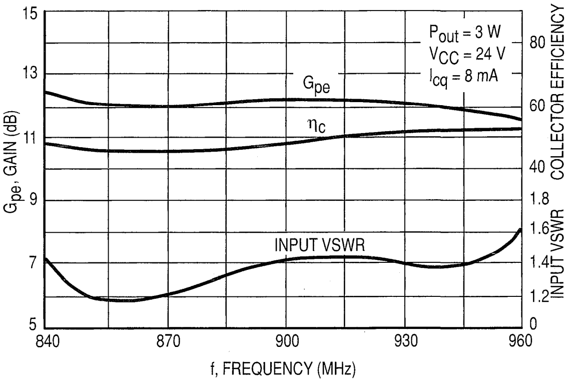


Figure 5. Performance in Broadband Test Fixture

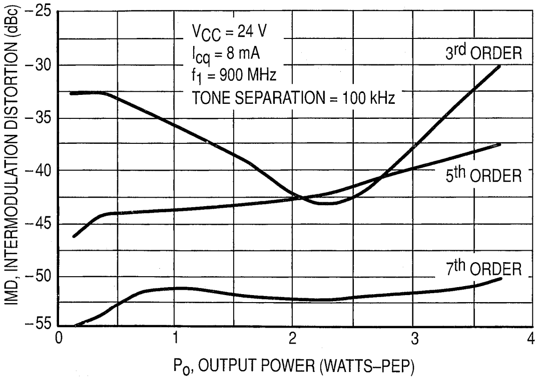
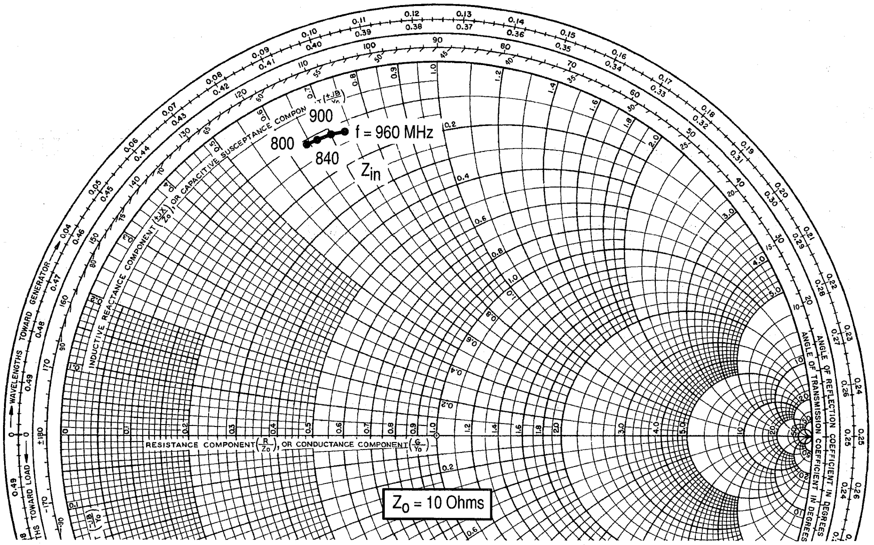
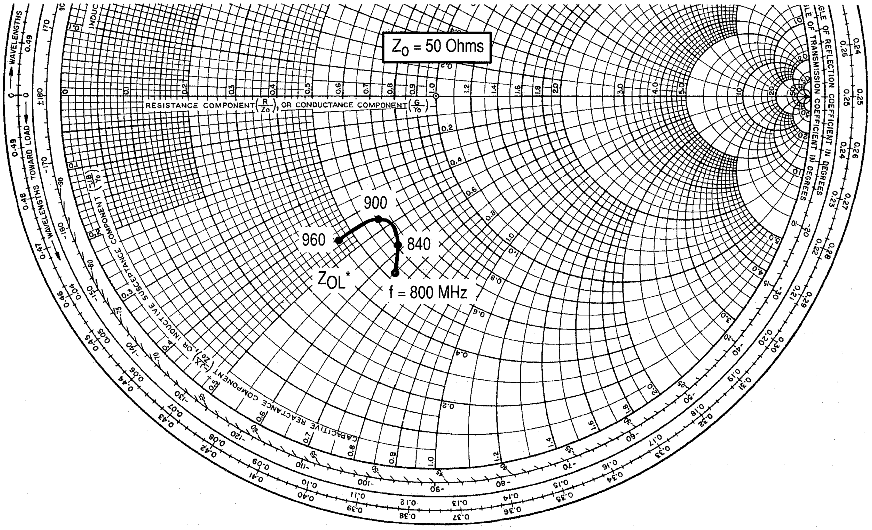


Figure 6. Intermodulation versus Output Power



f (MHz)	Z_in Ohms	Z_OL* Ohms
800	1.1 + j6.4	26.4 – j32.7
840	1.2 + j6.6	30.3 – j28.9
900	1.2 + j7.0	30.1 – j23.4
960	1.3 + j7.3	22.1 – j22.5



$Z_{OL}{}^*$ = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

P_o = 3 W, V_{CC} = 24 V, I_{CQ} = 8 mA

Figure 7. Series Equivalent Input/Output Impedances

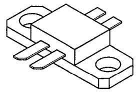
The RF Line
NPN Silicon RF Power Transistor

MRF897

Designed for 24 Volt UHF large–signal, common emitter, class–AB linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 800–970 MHz.

- Specified 24 Volt, 900 MHz Characteristics
  Output Power = 30 Watts
  Minimum Gain = 10 dB @ 900 MHz, class–AB
  Minimum Efficiency = 30% @ 900 MHz, 30 Watts (PEP)
  Maximum Intermodulation Distortion –30 dBc @ 30 Watts (PEP)
- Characterized with Series Equivalent Large–Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 5:1 VSWR @ 26 Vdc, and Rated Output Power
- Gold Metalized, Emitter Ballasted for Long Life and Resistance to Metal–Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

**30 W, 900 MHz
RF POWER
TRANSISTOR
NPN SILICON**



CASE 395B–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	105 0.60	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.67	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

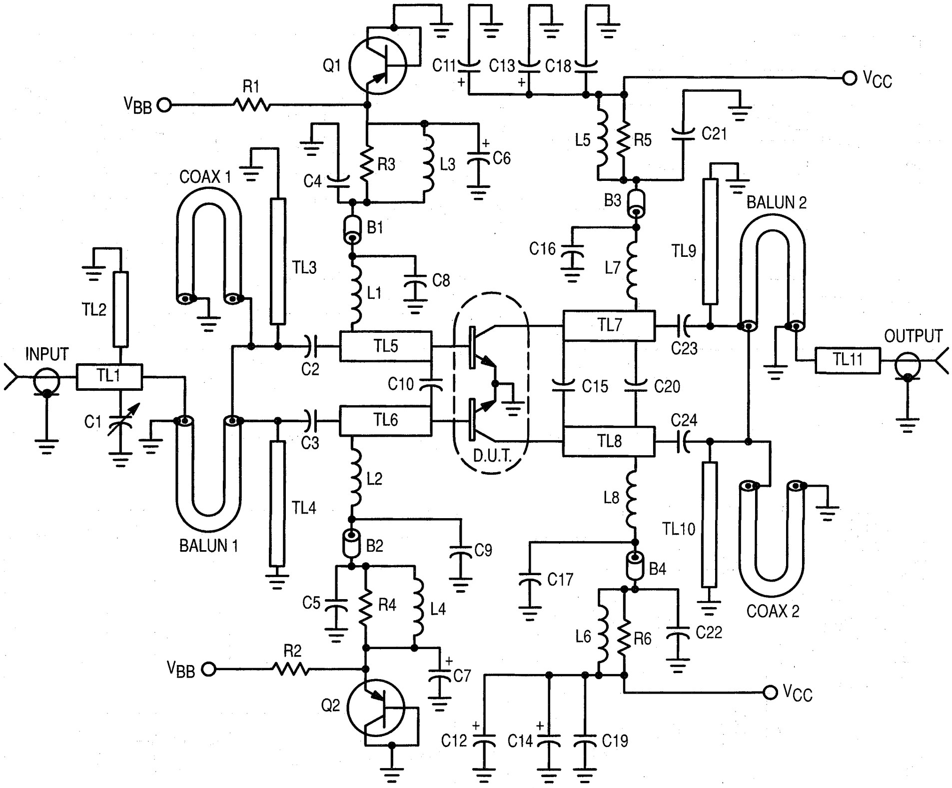
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 50$ mAdc, $I_B = 0$)	$V_{(BR)CEO}$	30	33	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 50$ mAdc, $V_{BE} = 0$)	$V_{(BR)CES}$	60	80	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 5$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	4.0	4.7	—	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0$)	I_{CES}	—	—	10.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_{CE} = 1.0$ Adc, $V_{CE} = 5$ Vdc)	h_{FE}	30	80	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 24$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	14	21	28	pF

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Common–Emitter Amplifier Power Gain (V_{CC} = 24 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	G_{pe}	10.0	12.0	—	dB
Collector Efficiency (V_{CC} = 24 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	η	35	38	—	%
Intermodulation Distortion (V_{CC} = 24 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	IMD	—	–37	–30	dBc
Output Mismatch Stress (V_{CC} = 26 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz, Load VSWR = 5:1 (all phase angles))	ψ	No Degradation in Output Power Before and After Test			



B1, B2, B3, B4 — Ferrite Bead, Fair Rite #2743019447
C1 — 0.8–8.0 pF Trimmer Capacitor, Johanson
C2, C3, C23, C24 — 43 pF, 100 mil, ATC Chip Capacitor
C4, C5, C18, C19, C21, C22 — 820 pF, 100 mil, Chip Capacitor, Kemet
C6, C7, C11, C12 — 10 µF, Lytic Capacitor, Panasonic
C8, C9, C16, C17 — 100 pF, 100 mil, Chip Capacitor, Murata Erie
C10 — 13 pF, 50 mil, ATC Chip Capacitor
C13, C14 — 250 µF Lytic Capacitor, Mallory
C15 — 1.1 pF, 50 mil, ATC Chip Capacitor
C20 — 6.8 pF, 100 mil, ATC Chip Capacitor
L1, L2, L3, L4, L5, L6 — 5 Turns 20 AWG, IDIA 0.126″ choke

N1, N2 — Type N Flange Mount, Omni Spectra 3052–1648–10
Q1 — Bias Transistor BD136 PNP
R1, R12 — 39 Ohm, 2.0 W
R3, R4, R5, R6 — 4.0 x 39 Ohm, 1/8 W, Chips in Parallel, Rohm 390–J
TL1–TL11 — See Photomaster
Balun1, Balun2, Coax 1, Coax 2 — 2.20″ 50 Ohm, 0.088″ o.d. semi–rigid coax, Micro Coax UT–85–M17
Board — 1/32″ Glass Teflon, Arlon GX–0300–55–22, ε_r = 2.55

Figure 1. MRF897 Broadband Test Circuit

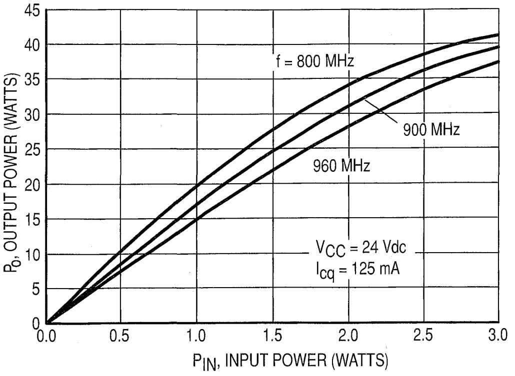


Figure 2. Output Power versus Input Power

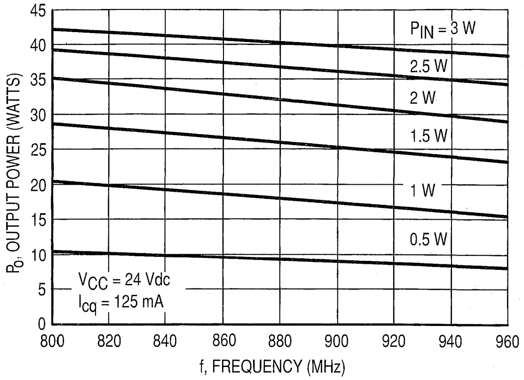


Figure 3. Output Power versus Frequency

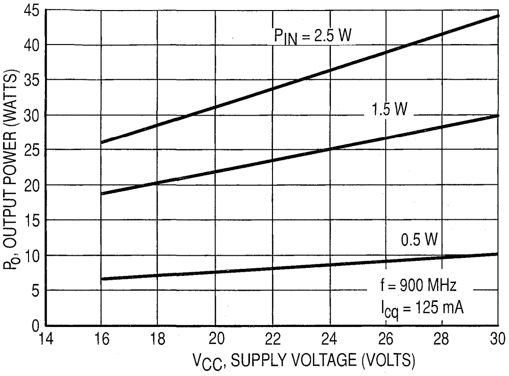


Figure 4. Output Power versus Supply Voltage

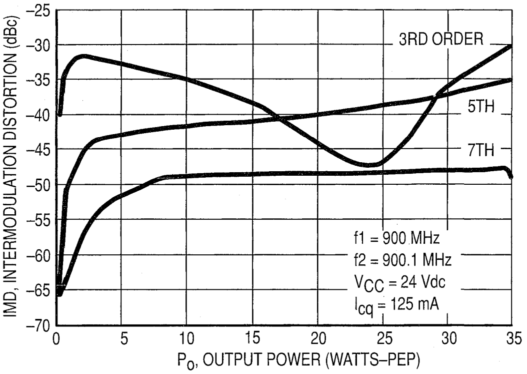


Figure 5. Intermodulation versus Output Power

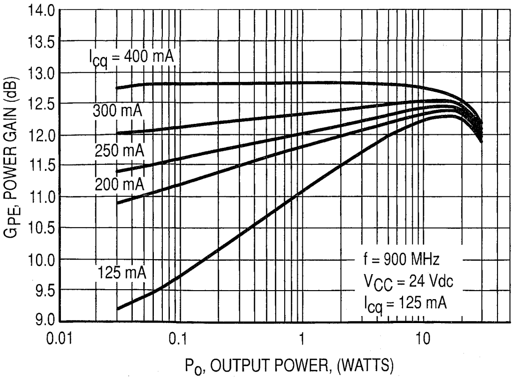


Figure 6. Power Gain versus Output Power

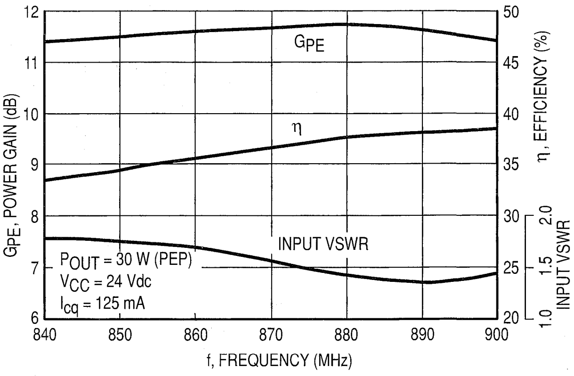
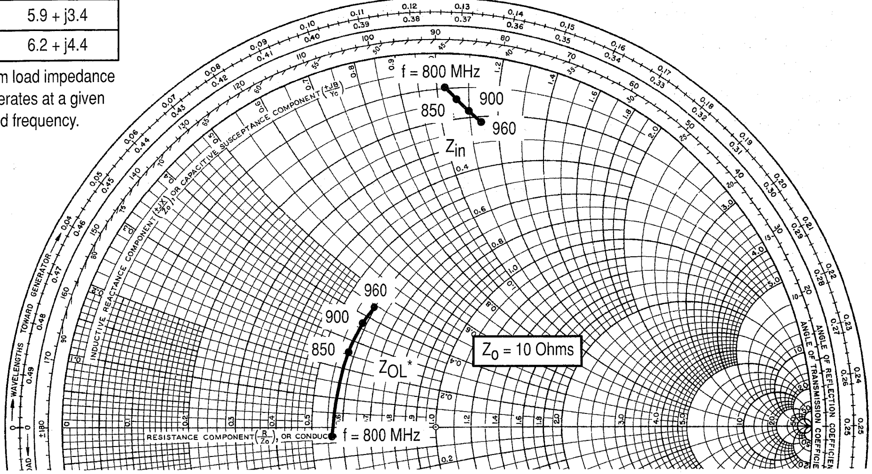


Figure 7. Broadband Test Fixture Performance

f MHz	Z_{in} Ohms	$Z_{OL}{}^*$ Ohms
800	1.0 + j10.3	5.9 – j0.4
850	1.5 + j10.5	5.7 + j2.6
900	1.8 + j11.0	5.9 + j3.4
960	2.2 + j11.4	6.2 + j4.4

$Z_{OL}{}^*$ = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.



NOTE: Z_{in} & $Z_{OL}{}^*$ are given from base–to–base and collector–to–collector respectively.

P_o = 300 W (PEP), V_{CC} = 24 V

Figure 8. Series Equivalent Input/Output Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

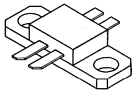
The RF Line
NPN Silicon RF Power Transistor

MRF897R

30 W, 900 MHz
RF POWER
TRANSISTOR
NPN SILICON

Designed for 24 Volt UHF large–signal, common emitter, class–AB linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 800–970 MHz.

- Specified 24 Volt, 900 MHz Characteristics
  - Output Power = 30 Watts
  - Minimum Gain = 10.5 dB @ 900 MHz, class–AB
  - Minimum Efficiency = 30% @ 900 MHz, 30 Watts (PEP)
  - Maximum Intermodulation Distortion –30 dBc @ 30 Watts (PEP)
- Characterized with Series Equivalent Large–Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 5:1 VSWR @ 26 Vdc, and Rated Output Power
- Gold Metalized, Emitter Ballasted for Long Life and Resistance to Metal–Migration
- Circuit Board Photomaster Available by Ordering Document MRF897RPHT/D from Motorola Literature Distribution.



CASE 395B–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	105 0.60	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.67	°C/W

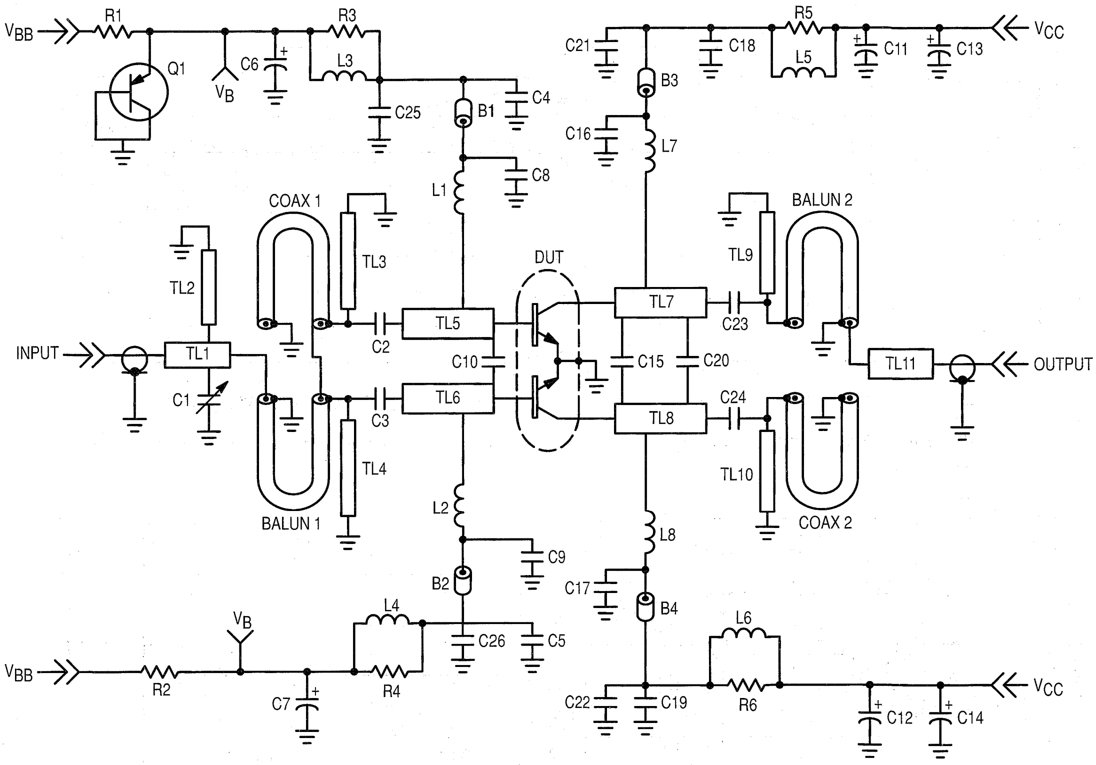
ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	33	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	80	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	4.7	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	10.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1.0 Adc, V_{CE} = 5 Vdc)	h_{FE}	30	80	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	14	21	28	pF

(continued)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Common–Emitter Amplifier Power Gain (V_{CC} = 24 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	G_{pe}	10.5	12.0	—	dB
Collector Efficiency (V_{CC} = 24 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	η	30	38	—	%
Intermodulation Distortion (V_{CC} = 24 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz)	IMD	—	–37	–30	dBc
Output Mismatch Stress (V_{CC} = 26 Vdc, P_{out} = 30 Watts (PEP), I_{cq} = 125 mA, f_1 = 900 MHz, f_2 = 900.1 MHz, Load VSWR = 5:1 (all phase angles))	ψ	No Degradation in Output Power			



B1, B2, B3, B4 — Short Ferrite Bead, Fair Rite #2743019447
C1 — 0.8–8.0 pF Var Capacitor, Johansen Gigatrim
C2, C3, C23, C24 — 43 pF, 100 mil, ATC Chip Capacitor
C4, C5, C21, C22 — 1000 pF, 100 mil, ATC Chip Capacitor
C6, C7, C11, C12 — 10 µF, Electrolytic Capacitor, Panasonic
C8, C9, C16, C17 — 100 pF, 100 mil, ATC Chip Capacitor
C10 — 9.1 pF, 50 mil, ATC Chip Capacitor
C13 — 250 µF Electrolytic Capacitor, Mallory
C14, C18, C19, C25 — 0.1 µF, Chip Capacitor, Kemet
C15 — 1.1 pF, 50 mil, ATC Chip Capacitor
C20 — 6.8 pF, 100 mil, ATC Chip Capacitor
L1, L2, L3, L4, L5, L6, L7, L8 — 5 Turns 20 AWG, IDIA 0.126″ Choke, Taylor Spring 46 nH

N1, N2 — Type N Flange Mount, Omni Spectra 3052–1648–10
Q1 — Bias Transistor BD136 PNP
R1, R12 — 27 Ohm, 2.0 W
R3, R4, R5, R6 — 4.0 x 39 Ohm, 1/8 W, Chips Resistors in Parallel, Rohm 390–J
SB1 — 0.15″ x 0.3″ x 0.03″ Cu
TL1–TL11 — Microstrip Line, See Photomaster
Balun1, Balun2, Coax 1, Coax 2 — 2.20″ 50 Ohm, 0.086″ o.d. semi–rigid coax, Micro Coax UT–85–M17
Circuit Board — 1/32″ Glass Teflon, Arlon GX–0300–55–22, ε_r = 2.55

Figure 1. 840–900 MHz Test Circuit Schematic

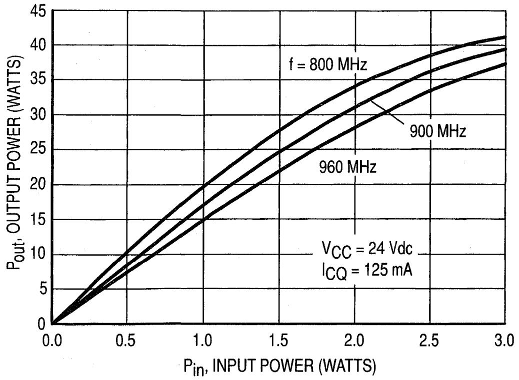


Figure 2. Output Power versus Input Power

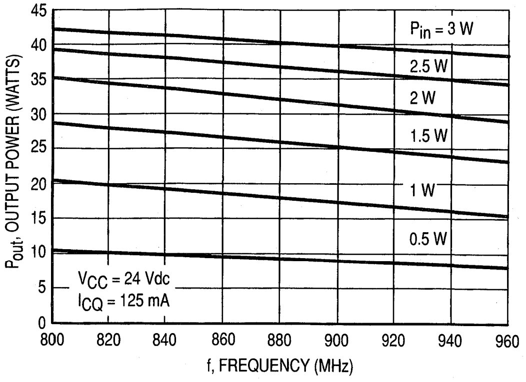


Figure 3. Output Power versus Frequency

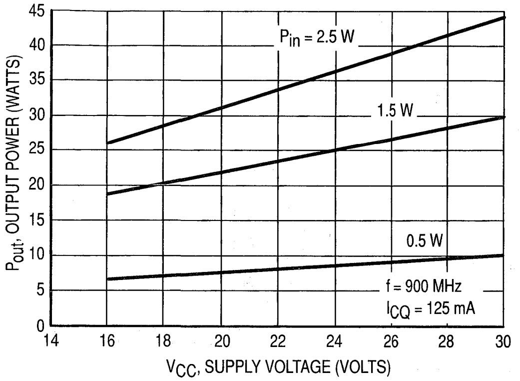


Figure 4. Output Power versus Supply Voltage

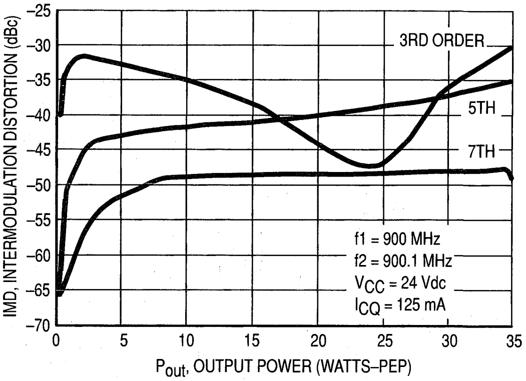


Figure 5. Intermodulation versus Output Power

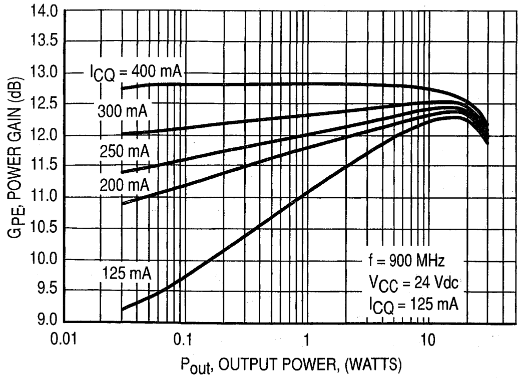


Figure 6. Power Gain versus Output Power

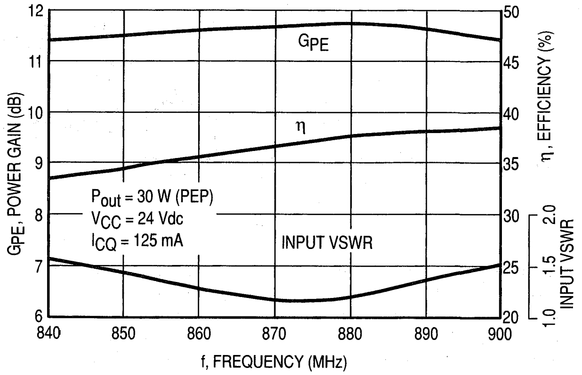
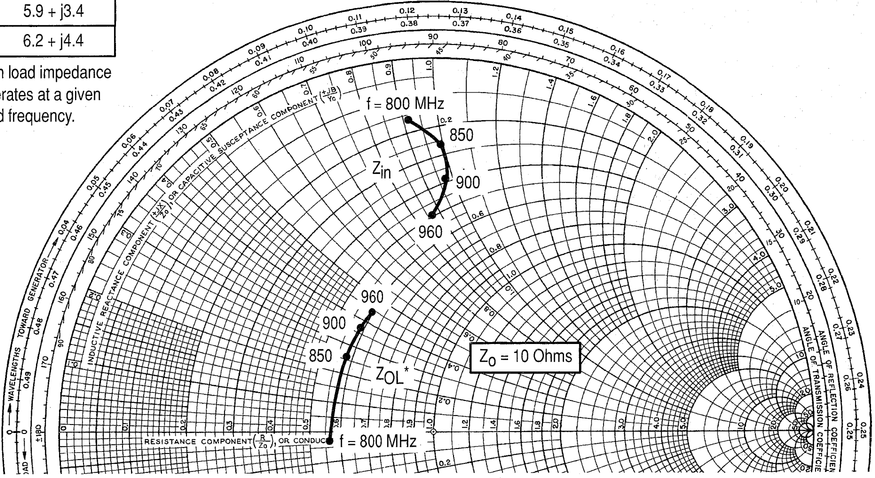


Figure 7. Broadband Test Fixture Performance

P_{out} = 30 W (PEP), V_{CC} = 24 V

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
800	1.7 + j9.2	5.9 − j0.4
850	2.6 + j10	5.7 + j2.6
900	4 + j9.9	5.9 + j3.4
950	5 + j8.8	6.2 + j4.4

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.



NOTE: Z_{in} & Z_{OL}* are given from base–to–base and collector–to–collector respectively.

Figure 8. Series Equivalent Input/Output Impedances

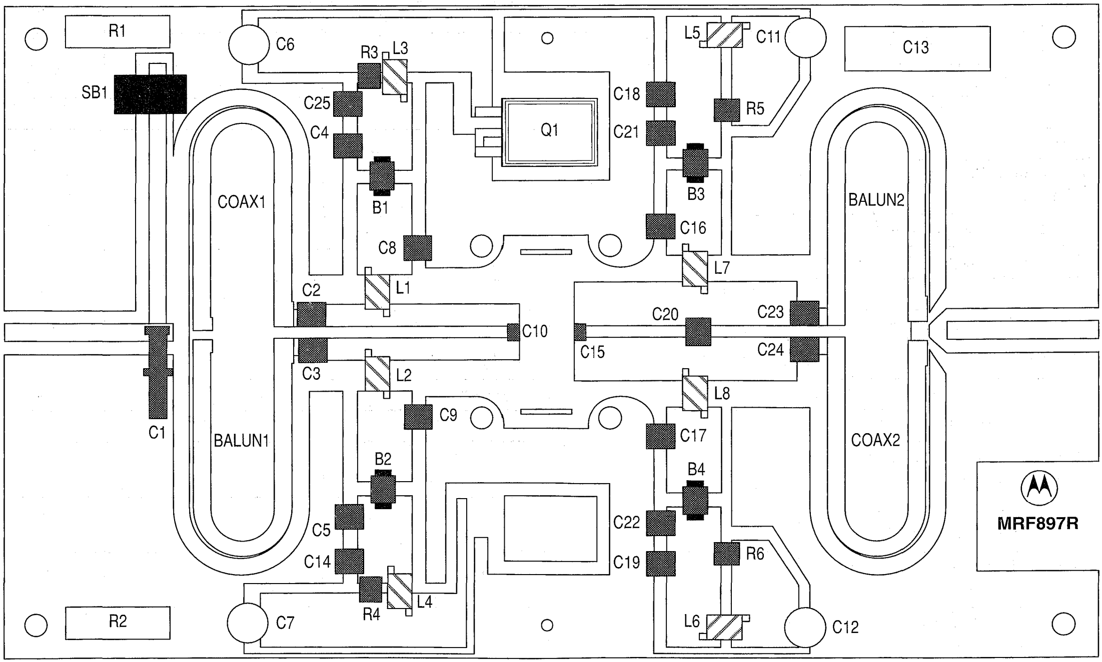


Figure 9. 840−900 MHz Test Circuit Component Layout

The RF Line

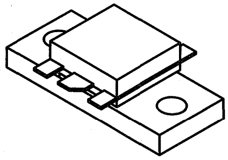
NPN Silicon RF Power Transistor

MRF898

. . . designed for 24 Volt UHF large–signal, common base amplifier applications in industrial and commercial FM equipment operating in the range of 850–960 MHz.

- Motorola Advanced Amplifier Concept Package
- Specified 24 Volt, 900 MHz Characteristics
  Output Power = 60 Watts
  Power Gain = 7.0 dB Min
  Efficiency = 60% Min
- Double Input/Output Matched for Wideband Performance and Simplified External Matching
- Series Equivalent Large–Signal Characterization
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Silicon Nitride Passivated
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

60 W, 850–960 MHz
RF POWER
TRANSISTOR
NPN SILICON



CASE 333A–02, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	10	mAdc

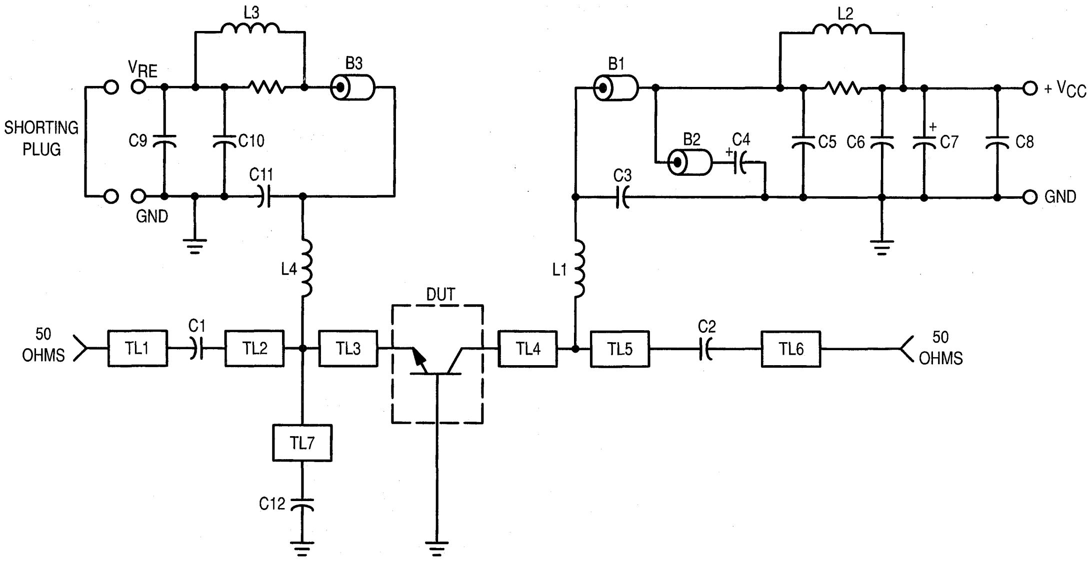
(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	50	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (1) (V_{CB} = 24 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	60	—	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 24 Vdc, P_{out} = 60 W, f = 900 MHz)	G_{pb}	7.0	7.9	—	dB
Collector Efficiency (V_{CC} = 24 Vdc, P_{out} = 60 W, f = 900 MHz)	η	60	65	—	%
Output Mismatch Stress (V_{CC} = 24 Vdc, P_{out} = 60 W, f = 900 MHz, VSWR = 5:1, all phase angles)	ψ	No Degradation in Output Power			

NOTE:
1. Value of "C_{ob}" is that of die only. It is not measurable in MRF898 because of internal matching network.



B1, B2, B3 — Bead, Ferroxcube 56–390–65/3B
C1, C2, C12 — 39 pF, 100 Mil Chip Capacitor
C3, C11 — 91 pF, Mini Underwood or Equivalent
C4, C7, C9 — 10 µF, 35 V Electrolytic
C5 — 4000 pF, 1.0 kV Ceramic
C6, C10 — 1000 pF, 350 V Unelco or Equivalent
C8 — 47 pF, 100 Mil Chip Capacitor
L1, L4 — 4 Turns #18 AWG Choke
L2 — 11 Turns #20 AWG Choke on 10 Ohm, 1.0 Watt Resistor
L3 — 3 Turns #18 AWG Choke on 10 Ohm, 1.0 Watt Resistor

TL1, TL6 — 50 Ohm Microstrip
TL2 — 400 x 950 Mils
TL3, TL4 — 140 x 200 Mils
TL5 — 320 x 690 Mils
TL7 — 260 x 230 Mils

Board — 3M Epsilam–10, 50 Mil
Bias Boards — 1/32″ G10 or Equivalent

Figure 1. 850–960 MHz Broadband Test Circuit

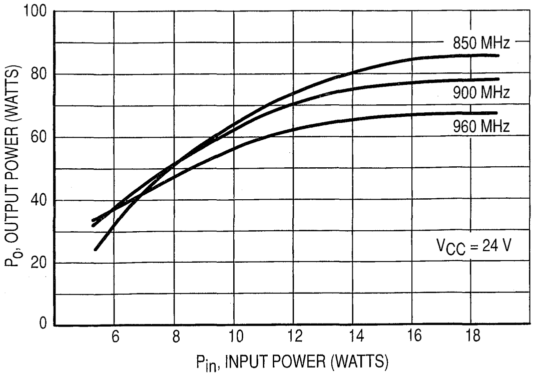


Figure 2. Output Power versus Input Power

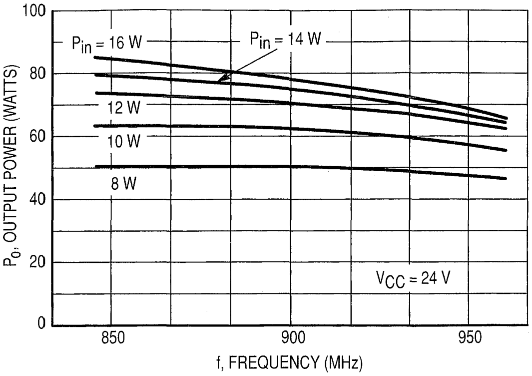


Figure 3. Output Power versus Frequency

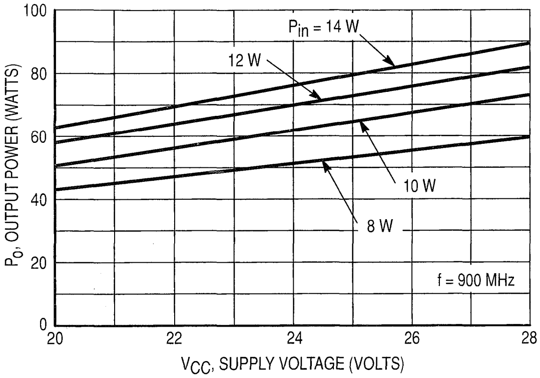


Figure 4. Output Power versus Supply Voltage

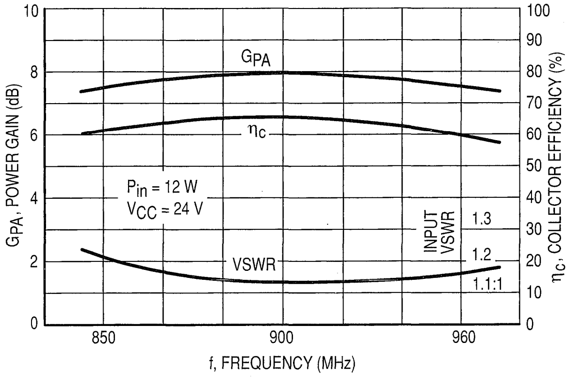
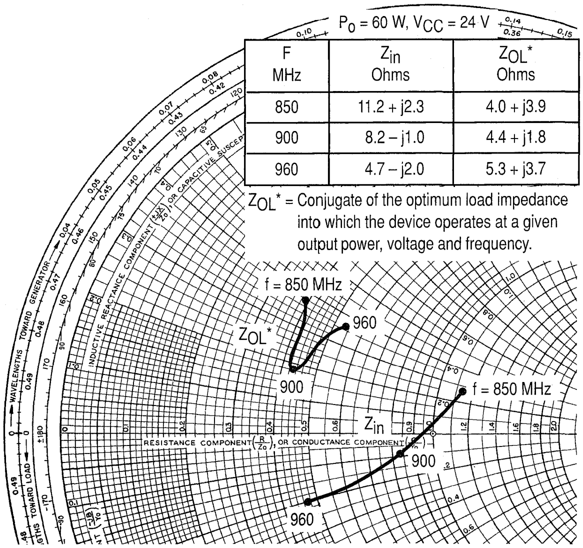


Figure 5. Typical Broadband Circuit Performance



P_o = 60 W, V_{CC} = 24 V

F MHz	Z_{in} Ohms	Z_{OL}^* Ohms
850	11.2 + j2.3	4.0 + j3.9
900	8.2 – j1.0	4.4 + j1.8
960	4.7 – j2.0	5.3 + j3.7

Z_{OL}^* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 6. Input/Output Impedance versus Frequency

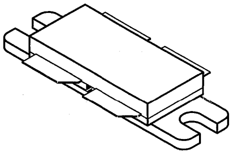
The RF Line
NPN Silicon RF Power Transistor

MRF899

150 W, 900 MHz
RF POWER
TRANSISTOR
NPN SILICON

Designed for 26 Volt UHF large–signal, common emitter, Class AB linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 800–960 MHz.

- Specified 26 Volt, 900 MHz Characteristics
  Output Power = 150 Watts (PEP)
  Minimum Gain = 8.0 dB @ 900 MHz, Class AB
  Minimum Efficiency = 35% @ 900 MHz, 150 Watts (PEP)
  Maximum Intermodulation Distortion –28 dBc @ 150 Watts (PEP)
- Characterized with Series Equivalent Large–Signal Parameters from 800 to 960 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 5:1 VSWR @ 26 Vdc, and Rated Output Power
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 375A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current — Continuous	I_C	25	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	230 1.33	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	$V_{(BR)CEO}$	28	37	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	85	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	4.9	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	75	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 Vdc, I_E = 0, f = 1.0 MHz) (1)	C_{ob}	—	75	—	pF

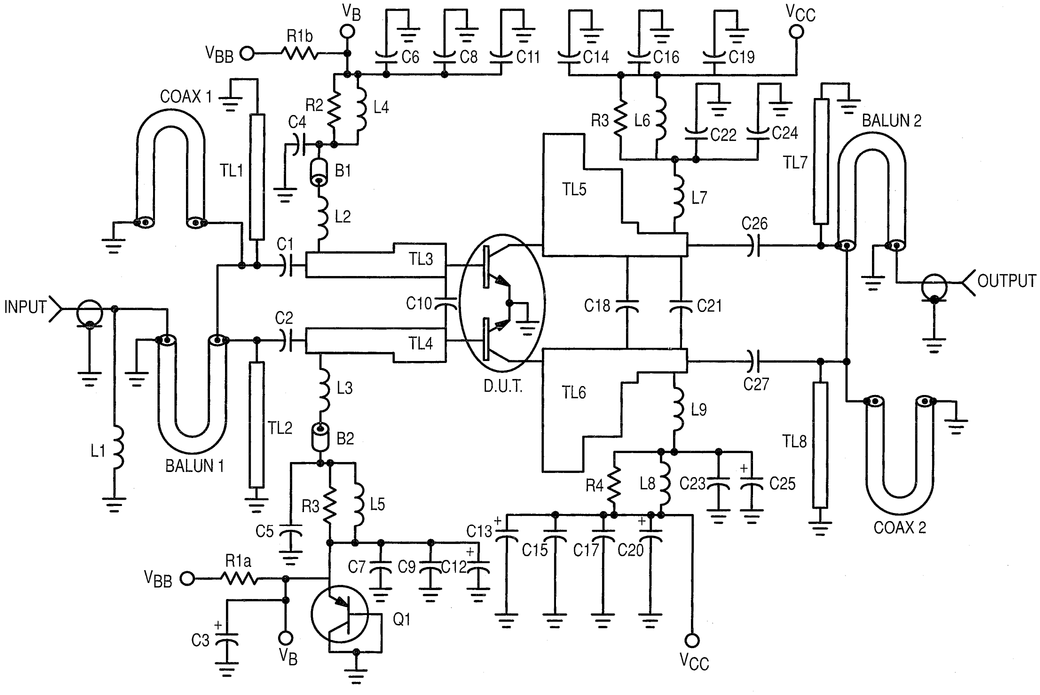
(continued)

NOTE:
1. For information only. This part is collector matched.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL CHARACTERISTICS					
Common–Emitter Amplifier Power Gain V_{CC} = 26 Vdc, P_{out} = 150 Watts (PEP), I_{cq} = 300 mA, f_1 = 900 MHz, f_2 = 900.1 MHz	G_{pe}	8.0	9.0	—	dB
Collector Efficiency V_{CC} = 26 Vdc, P_{out} = 150 Watts (PEP), I_{cq} = 300 mA, f_1 = 900 MHz, f_2 = 900.1 MHz	η	30	40	—	%
3rd Order Intermodulation Distortion V_{CC} = 26 Vdc, P_{out} = 150 Watts (PEP), I_{cq} = 300 mA, f_1 = 900 MHz, f_2 = 900.1 MHz	IMD	—	−32	−28	dBc
Output Mismatch Stress V_{CC} = 26 Vdc, P_{out} = 150 Watts (PEP), I_{cq} = 300 mA, f_1 = 900 MHz, f_2 = 900.1 MHz, VSWR = 5:1 (all phase angles)	ψ	No Degradation in Output Power Before and After Test			



B1, B2 — Ferrite Bead, Ferroxcube #56–590–65–3B
C1, C2, C26, C27 — 43 pF, B Case, ATC Chip Capacitor
C3 — 200 µF Lytic Capacitor
C4, C5, C22, C23 — 100 pF, B Case, ATC Chip Capacitor
C6, C7, C14, C15 — 1000 pF, B Case, ATC Chip Capacitor
C10 — 9.1 pF, A Case, ATC Chip Capacitor
C13 — 500 µF Electrolytic Capacitor
C18 — 3.9 pF, B Case, ATC Chip Capacitor
C21 — 0.8 pF, B Case, ATC Chip Capacitor
C8, C9, C16, C17 — CDR32BP182AJWS, 1800 pF, AVX Chip Capacitor
C11, C12, C19, C20, C24, C25 — 10 µF, Electrolytic Capacitor Panasonic
L1 — 5 Turns 24 AWG IDIA 0.059″ Choke, 19.8 nH
L2, L3, L7, L9 — 4 Turns 20 AWG IDIA 0.163″ Choke
L4, L5, L6, L8 — 12 Turns 22 AWG IDIA 0.140″ Choke, on 10−20 Ω Resistor
N1, N2 — Type N Flange Mount, Omni Spectra
Q1 — Bias Transistor BD136 PNP
R2, R3, R4, R5 — 4.0 x 39 Ohm 1/8 W Chips in Parallel
R1a, R1b — 56 Ohm 1.0 W
TL1−TL8 — See Photomaster
Balun1, Balun2, Coax 1, Coax 2 — 2.20″ 50 Ohm 0.088″ o.d. semi–rigid coax
Board — 1/32″ Glass Teflon, ε_r = 2.55″ Arlon (GX–0300–55–22)

Figure 1. 900 MHz Power Gain Test Circuit

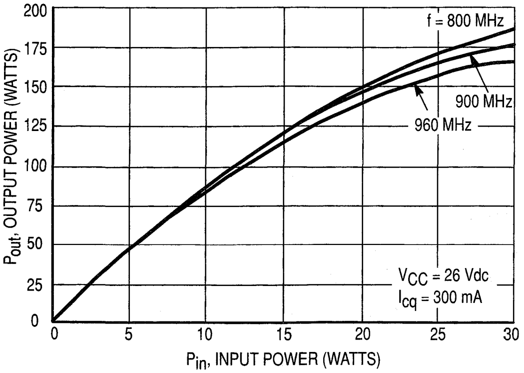


Figure 2. Output Power versus Input Power

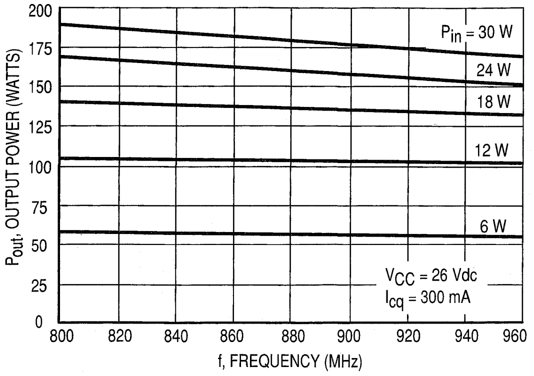


Figure 3. Output Power versus Frequency

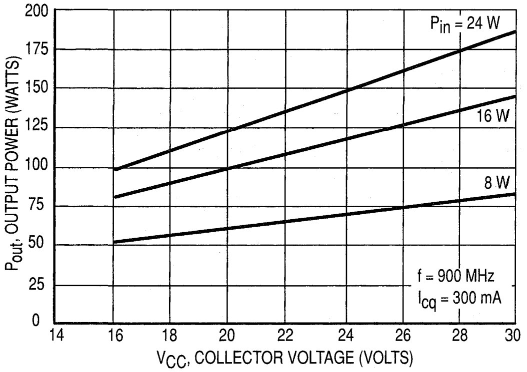


Figure 4. Output Power versus Supply Voltage

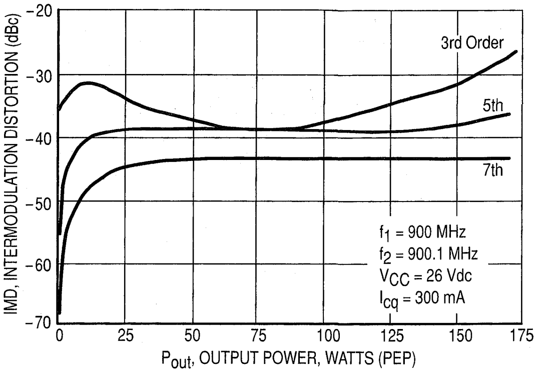


Figure 5. Intermodulation versus Output Power

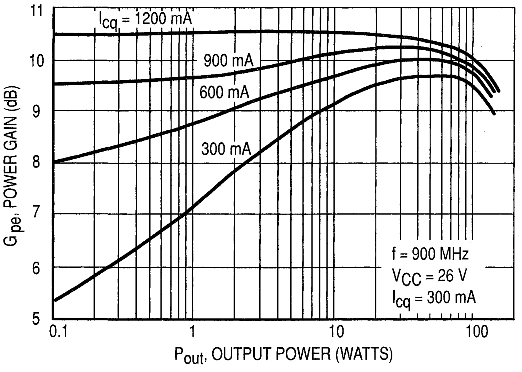


Figure 6. Power Gain versus Output Power

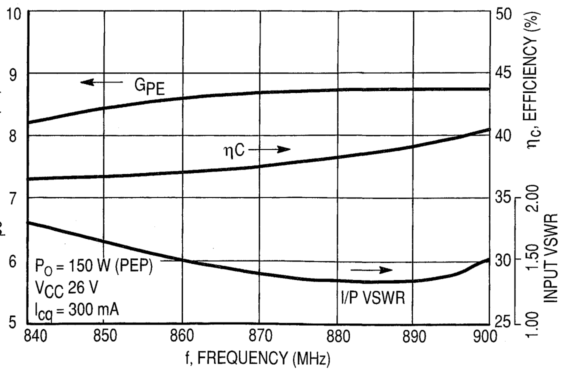
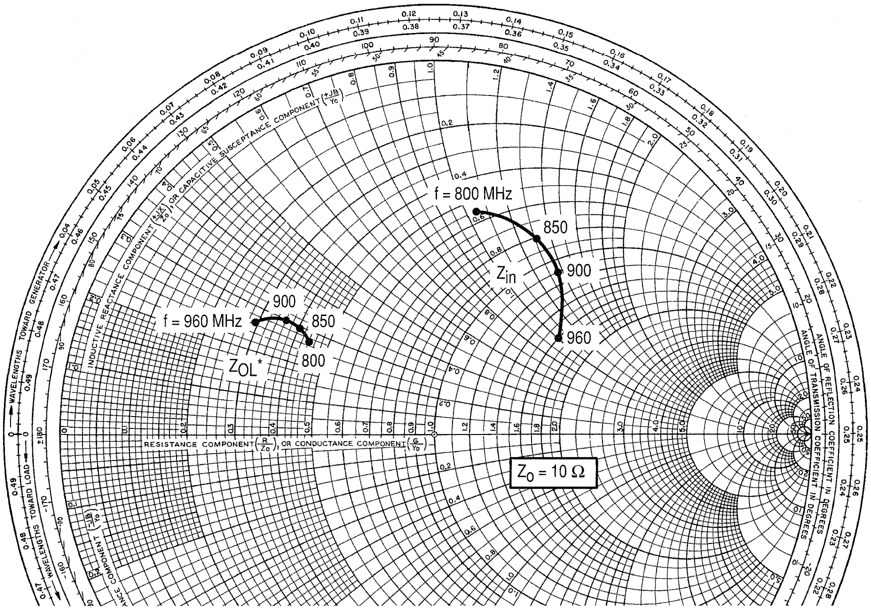


Figure 7. Broadband Test Fixture Performance



f MHz	Z_{in} Ohms	$Z_{OL}{}^*$ Ohms
800	5.51 + j10.6	4.52 + j2.64
850	8.17 + j13.2	4.21 + j2.98
900	11.2 + j13.8	3.68 + j2.97
960	16.8 + j10.1	2.98 + j2.71

$Z_{OL}{}^*$ = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.

NOTE: Z_{in} & $Z_{OL}{}^*$ are given from base–to–base and collector–to–collector respectively

Figure 8. Input and Output Impedances with Circuit Tuned for Maximum Gain @ P_O = 150 W (PEP), V_{CC} = 26 V

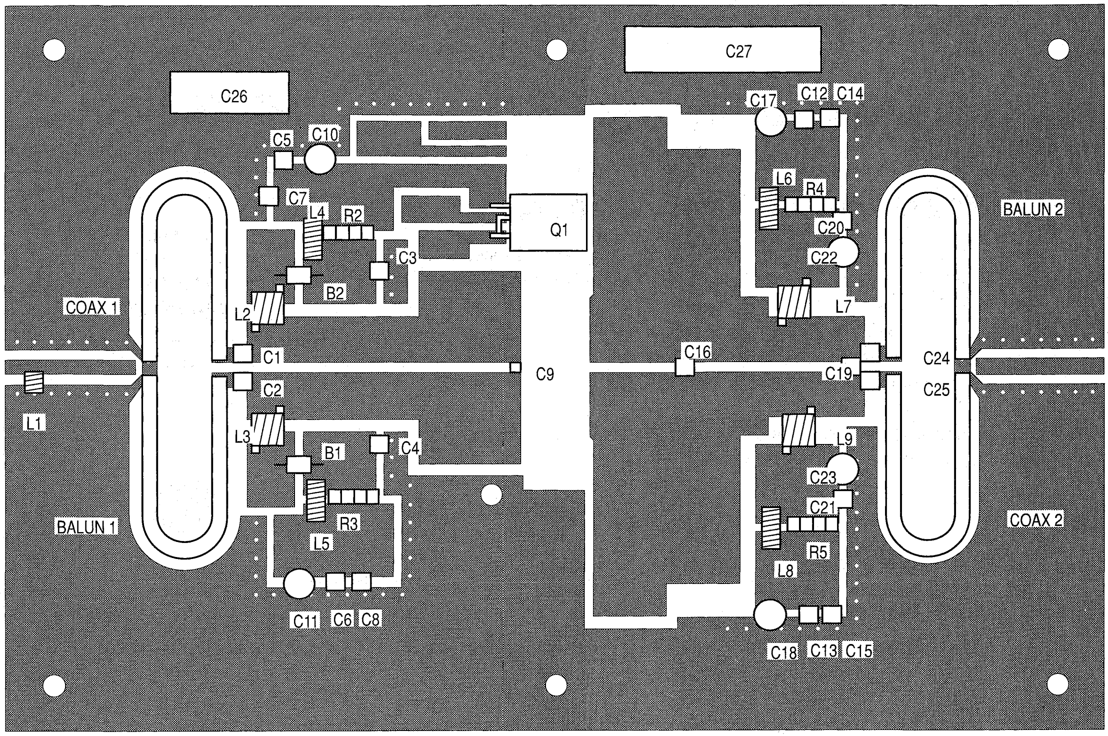


Figure 9. MRF899 Test Fixture Component Layout

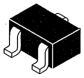
MRF927T1

The RF Small Signal Line
NPN Silicon Low Voltage, Low Current, Low Noise, High-Frequency Transistors

Designed for use in low voltage, low current applications at frequencies to 2.0 GHz. Specifically aimed at portable communication devices such as pagers and hand–held phones.

- High Gain (G_{Umax} 15 dB Typ @ 1.0 GHz) @ 1.0 mA
- Small, Surface–Mount Package (SC–70)
- High Current Gain–Bandwidth Product at Low Current, Low Voltage (f_τ = 8.0 GHz Typ @ 3.0 V, 5.0 mA)
- Available in Tape and Reel by Adding T1 Suffix to Part Number. T1 Suffix = 3,000 Units per 8 mm, 7 inch Reel.

I_C = 10 mA
LOW NOISE
HIGH FREQUENCY
TRANSISTOR



CASE 419–02, STYLE 3
(SC–70/SOT–323)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	10	Vdc
Collector–Base Voltage	V_{CBO}	20	Vdc
Emitter–Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	10	mAdc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	100 1.0	mW mW/°C
Storage Temperature Range	T_{stg}	– 55 to +150	°C
Operating Temperature Range	T_J	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction–to–Case	$R_{\theta JC}$	1000	°C/W

DEVICE MARKING

MRF927T1 = F

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 0.1 mA, I_B = 0 mA)	$V_{(BR)CEO}$	10	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.1 mA, I_E = 0)	$V_{(BR)CBO}$	20	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mA, I_C = 0)	$V_{(BR)EBO}$	1.5	—	—	Vdc
Emitter Cutoff Current (V_{EB} = 1.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	μA
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 1.0 Vdc, I_C = 0.5 mA)	h_{FE}	50	—	200	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	0.33	—	pF
Current–Gain Bandwidth Product (V_{CE} = 3.0 Vdc, I_E = 5.0 mA, f = 1.0 GHz)	f_τ	—	8.0	—	GHz
PERFORMANCE CHARACTERISTICS					
Noise Figure — Minimum (V_{CE} = 1.0 Vdc, I_C = 1.0 mA, f = 1000 MHz) Figure 3	NF_{min}	—	1.7	—	dB
Associated Gain at Minimum Noise Figure (V_{CE} = 1.0 Vdc, I_C = 1.0 mA, f = 1000 MHz) Figure 3	G_{NF}	—	9.8	—	dB
Maximum Unilateral Gain (V_{CE} = 1.0 Vdc, I_C = 1.0 mA, f = 1000 MHz)	G_{Umax}	—	15	—	dB
Insertion Gain (V_{CE} = 1.0 Vdc, I_C = 1.0 mA, f = 1000 MHz)	$\|S_{21}\|^2$	—	8.0	—	dB
Noise Resistance (V_{CE} = 1.0 Vdc, I_C = 1.0 mA, f = 1000 MHz)	R_N	—	62	—	Ohms

TYPICAL CHARACTERISTICS

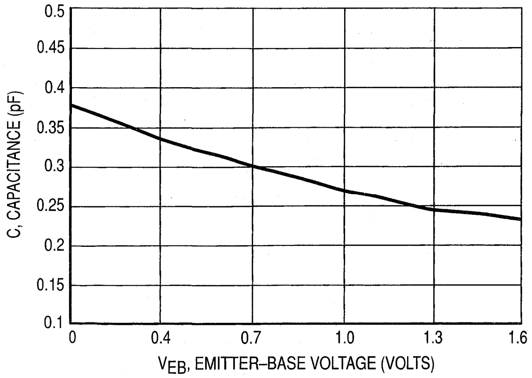


Figure 10. C_{ib} Input Capacitance versus Voltage

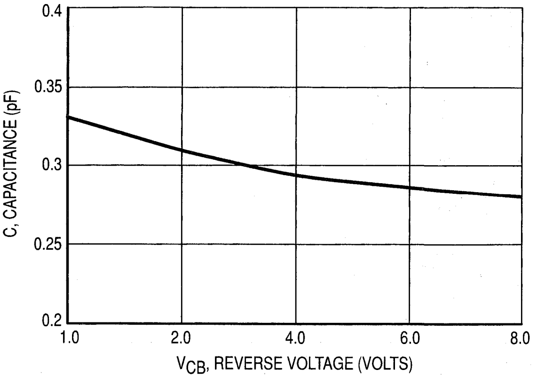


Figure 11. C_{cb}, Collector–Base Capacitance versus Voltage

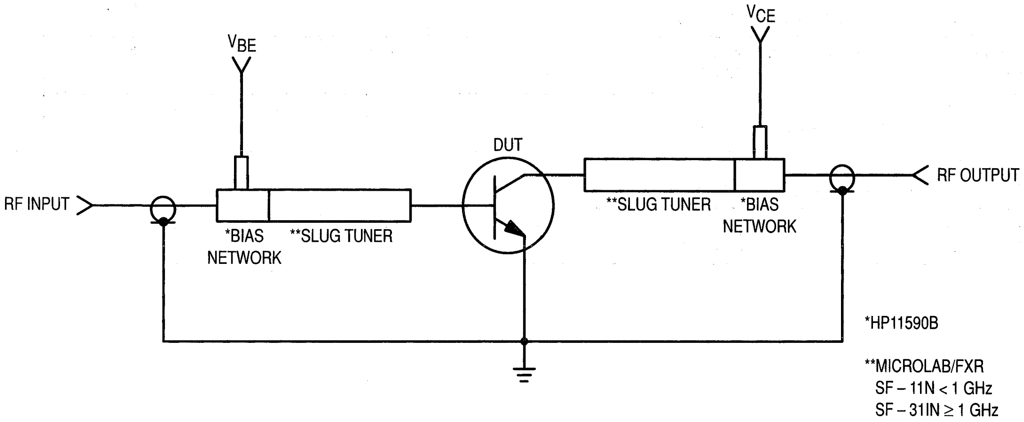


Figure 12. Functional Circuit Schematic

TYPICAL CHARACTERISTICS

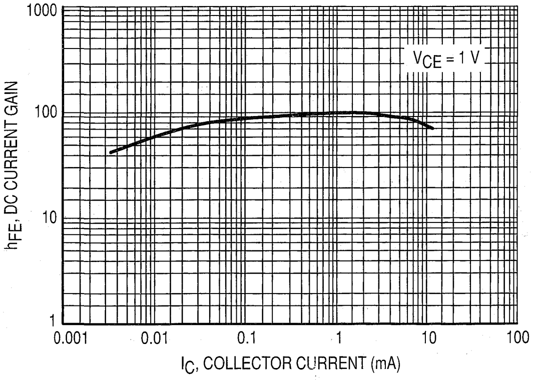


Figure 13. DC Current Gain versus Collector Current

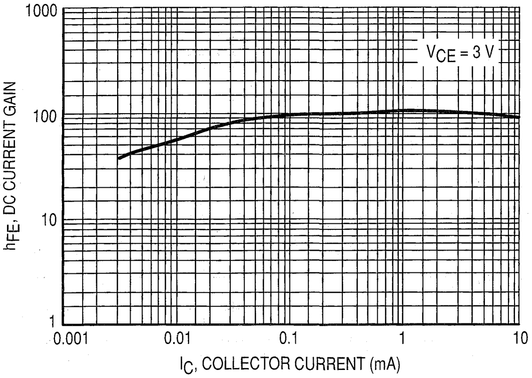


Figure 14. DC Current Gain versus Collector Current

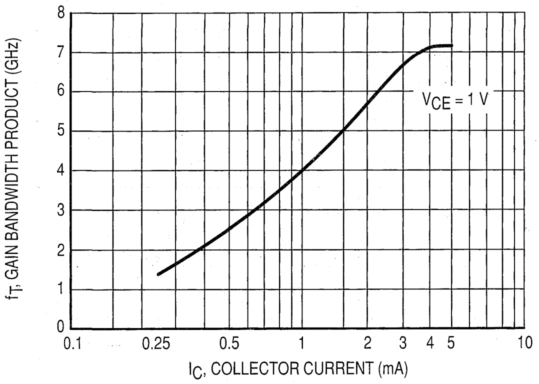


Figure 15. Gain Bandwidth Product versus Collector Current

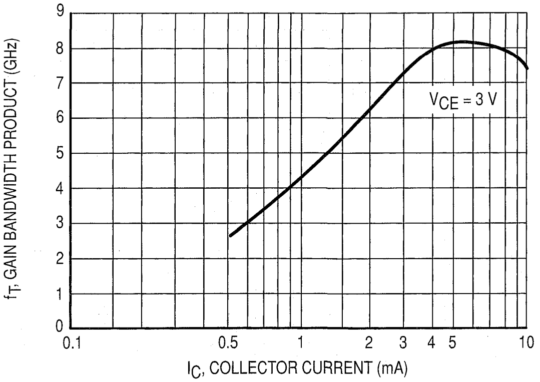


Figure 16. Gain Bandwidth Product versus Collector Current

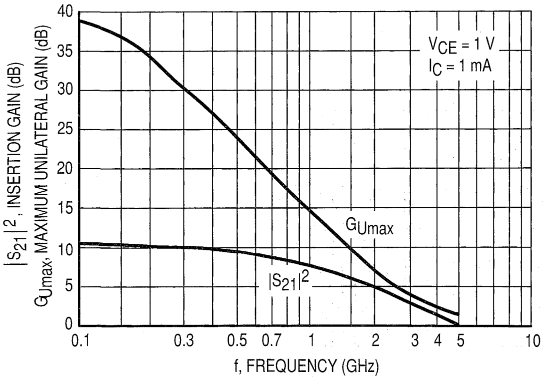


Figure 17. Forward Insertion Gain and Maximum Unilateral Gain versus Frequency

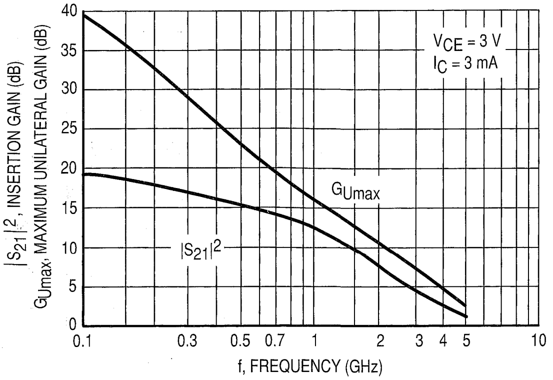


Figure 18. Forward Insertion Gain and Maximum Unilateral Gain versus Frequency

TYPICAL CHARACTERISTICS

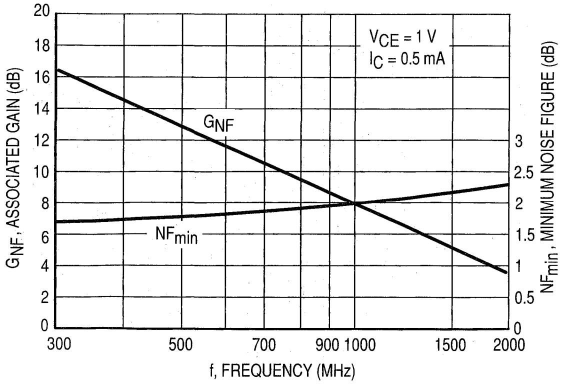


Figure 19. Minimum Noise Figure and Associated Gain versus Frequency

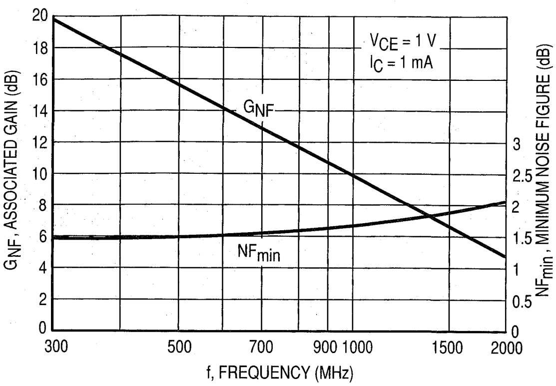


Figure 20. Minimum Noise Figure and Associated Gain versus Frequency

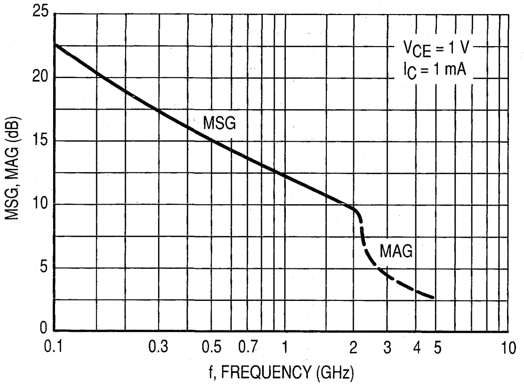


Figure 21. MSG, Maximum Stable Gain; MAG, Maximum Available Gain versus Frequency

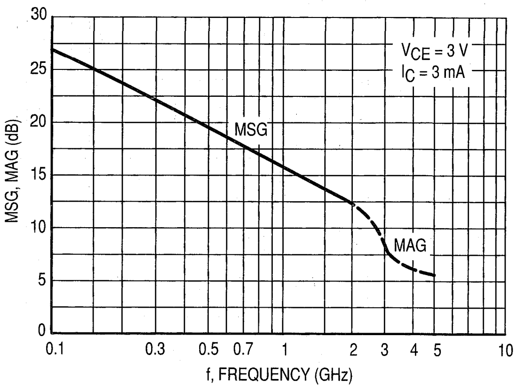


Figure 22. MSG, Maximum Stable Gain; MAG, Maximum Available Gain versus Frequency

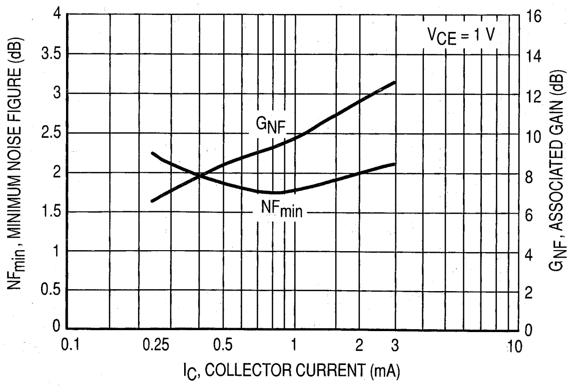


Figure 23. Noise Figure and Gain @ Minimum Noise Figure versus Collector Current

V_{CE} (Vdc)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
1.0	0.25	0.10	0.992	–4	0.911	174	0.020	86	0.997	–3
		0.20	0.990	–9	0.903	169	0.039	83	0.993	–6
		0.30	0.983	–13	0.909	163	0.059	80	0.992	–8
		0.40	0.978	–17	0.904	157	0.077	77	0.988	–11
		0.50	0.973	–21	0.834	149	0.095	72	0.975	–13
		0.60	0.943	–25	0.892	144	0.111	69	0.966	–16
		0.70	0.929	–29	0.873	139	0.127	66	0.958	–19
		0.80	0.889	–33	0.901	135	0.142	63	0.949	–22
		0.90	0.895	–37	0.888	129	0.158	60	0.939	–24
		1.00	0.876	–41	0.890	124	0.171	57	0.929	–26
		1.50	0.772	–60	0.871	100	0.227	44	0.873	–38
		2.00	0.670	–78	0.835	80	0.261	34	0.823	–48
		2.50	0.564	–96	0.812	62	0.276	25	0.776	–58
		3.00	0.477	–114	0.785	48	0.276	18	0.741	–68
		3.50	0.412	–132	0.741	36	0.270	15	0.722	–77
		4.00	0.364	–151	0.701	25	0.261	14	0.711	–87
		4.50	0.308	–172	0.702	17	0.261	18	0.682	–97
		5.00	0.297	166	0.639	11	0.270	22	0.686	–107
	0.5	0.10	0.983	–5	1.788	174	0.020	86	0.994	–3
		0.20	0.977	–10	1.763	168	0.040	82	0.992	–7
		0.30	0.965	–16	1.764	162	0.059	79	0.984	–10
		0.40	0.953	–21	1.735	156	0.077	76	0.976	–13
		0.50	0.947	–26	1.637	147	0.094	70	0.954	–16
		0.60	0.901	–30	1.673	142	0.109	67	0.941	–19
		0.70	0.878	–34	1.619	137	0.124	64	0.927	–21
		0.80	0.827	–38	1.601	132	0.136	62	0.912	–24
		0.90	0.825	–43	1.594	127	0.151	58	0.893	–27
		1.00	0.796	–48	1.571	122	0.162	56	0.877	–29
		1.50	0.659	–67	1.420	99	0.207	45	0.797	–40
		2.00	0.535	–85	1.275	80	0.232	37	0.733	–49
		2.50	0.417	–102	1.177	63	0.247	32	0.678	–58
		3.00	0.332	–122	1.097	50	0.256	29	0.639	–67
		3.50	0.271	–143	1.014	38	0.265	28	0.617	–75
		4.00	0.238	–164	0.949	28	0.279	29	0.604	–84
		4.50	0.212	170	0.928	19	0.305	31	0.573	–94
		5.00	0.218	147	0.856	12	0.333	31	0.574	–105
	1.0	0.10	0.965	–7	3.383	172	0.020	85	0.990	–4
		0.20	0.952	–14	3.315	165	0.040	81	0.982	–9
		0.30	0.928	–20	3.277	157	0.057	77	0.965	–13
		0.40	0.905	–26	3.172	151	0.074	73	0.947	–16
		0.50	0.88	–33	3.027	141	0.090	67	0.910	–19
		0.60	0.819	–37	2.936	136	0.102	64	0.887	–23
		0.70	0.783	–42	2.804	130	0.115	61	0.861	–26
		0.80	0.725	–47	2.666	125	0.125	59	0.839	–28
		0.90	0.702	–52	2.623	119	0.136	56	0.810	–31
		1.00	0.664	–57	2.525	114	0.145	54	0.787	–33
		1.50	0.504	–75	2.085	93	0.181	47	0.690	–42
		2.00	0.382	–92	1.759	75	0.207	42	0.626	–50
		2.50	0.278	–108	1.548	61	0.229	40	0.577	–58
		3.00	0.21	–129	1.397	48	0.252	38	0.543	–66
		3.50	0.168	–154	1.271	38	0.276	36	0.523	–73
		4.00	0.15	–177	1.177	28	0.303	35	0.513	–82
		4.50	0.148	155	1.123	19	0.336	34	0.490	–91
		5.00	0.165	132	1.049	12	0.369	32	0.487	–101

Table 1. Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
1.0	2.0	0.10	0.928	–10	6.181	169	0.020	83	0.980	–6
		0.20	0.901	–19	5.967	160	0.037	78	0.959	–12
		0.30	0.856	–28	5.744	150	0.054	73	0.923	–17
		0.40	0.811	–36	5.410	142	0.068	69	0.886	–22
		0.50	0.753	–43	5.051	132	0.080	63	0.828	–25
		0.60	0.681	–48	4.679	126	0.091	61	0.790	–28
		0.70	0.632	–54	4.367	119	0.100	59	0.753	–31
		0.80	0.574	–59	4.021	114	0.108	57	0.726	–33
		0.90	0.538	–64	3.831	109	0.116	55	0.692	–35
		1.00	0.497	–68	3.595	104	0.123	54	0.667	–37
		1.50	0.349	–86	2.732	85	0.156	50	0.576	–44
		2.00	0.255	–102	2.200	70	0.186	47	0.527	–50
		2.50	0.182	–120	1.871	57	0.216	45	0.491	–58
		3.00	0.137	–143	1.647	46	0.246	42	0.469	–66
		3.50	0.115	–167	1.478	36	0.276	39	0.460	–73
		4.00	0.109	167	1.356	27	0.306	36	0.453	–81
		4.50	0.115	138	1.268	19	0.337	33	0.443	–89
		5.00	0.136	119	1.190	11	0.368	30	0.441	–98

Table 1. Common Emitter S–Parameters (continued)

V_{CE} (Vdc)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
3.0	0.5	0.10	0.985	–5	1.796	174	0.018	86	0.995	–3
		0.20	0.980	–10	1.776	169	0.034	83	0.993	–6
		0.30	0.969	–15	1.778	163	0.051	79	0.986	–9
		0.40	0.959	–19	1.753	157	0.066	76	0.980	–12
		0.50	0.952	–24	1.651	149	0.081	71	0.961	–14
		0.60	0.910	–28	1.693	144	0.095	68	0.949	–17
		0.70	0.888	–32	1.639	139	0.108	65	0.937	–20
		0.80	0.841	–36	1.628	134	0.119	63	0.924	–23
		0.90	0.839	–41	1.618	129	0.131	60	0.908	–25
		1.00	0.812	–45	1.596	124	0.142	57	0.894	–27
		1.50	0.681	–64	1.445	102	0.184	47	0.824	–38
		2.00	0.565	–80	1.294	83	0.210	39	0.768	–47
		2.50	0.455	–96	1.190	66	0.226	33	0.720	–56
		3.00	0.369	–112	1.106	53	0.237	30	0.687	–64
		3.50	0.308	–128	1.019	41	0.246	28	0.670	–72
		4.00	0.264	–146	0.950	30	0.256	28	0.661	–81
		4.50	0.212	–166	0.933	21	0.274	29	0.638	–89
		5.00	0.201	171	0.858	13	0.294	30	0.642	–99
	1.0	0.10	0.969	–6	3.341	173	0.017	85	0.992	–4
		0.20	0.958	–13	3.284	166	0.034	81	0.985	–8
		0.30	0.938	–19	3.255	159	0.050	78	0.972	–11
		0.40	0.917	–24	3.163	152	0.064	74	0.957	–15
		0.50	0.896	–30	3.019	143	0.078	68	0.925	–18
		0.60	0.838	–35	2.951	138	0.089	66	0.905	–21
		0.70	0.805	–40	2.823	132	0.101	63	0.883	–23
		0.80	0.750	–44	2.700	127	0.110	61	0.864	–26
		0.90	0.732	–49	2.661	122	0.121	58	0.838	–28
		1.00	0.696	–53	2.570	117	0.129	56	0.818	–31
		1.50	0.541	–71	2.139	95	0.163	48	0.731	–40
		2.00	0.424	–86	1.807	78	0.188	43	0.674	–47
		2.50	0.325	–100	1.588	63	0.210	40	0.629	–55
		3.00	0.252	–116	1.430	51	0.230	37	0.600	–63
		3.50	0.204	–132	1.294	40	0.250	36	0.589	–70
		4.00	0.170	–150	1.195	30	0.272	34	0.581	–78
		4.50	0.136	–173	1.141	21	0.297	33	0.565	–86
		5.00	0.134	162	1.063	13	0.323	32	0.566	–95

Table 2. Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
3.0	3.0	0.10	0.902	–11	8.541	168	0.017	83	0.976	–7
		0.20	0.863	–21	8.133	156	0.031	77	0.946	–13
		0.30	0.805	–31	7.647	146	0.045	73	0.901	–18
		0.40	0.746	–39	7.050	137	0.056	69	0.856	–22
		0.50	0.673	–45	6.436	127	0.066	65	0.794	–24
		0.60	0.604	–50	5.853	121	0.074	63	0.757	–27
		0.70	0.552	–55	5.378	115	0.082	61	0.721	–29
		0.80	0.499	–59	4.897	110	0.089	60	0.697	–30
		0.90	0.461	–63	4.586	105	0.096	59	0.667	–32
		1.00	0.424	–66	4.260	100	0.103	59	0.647	–33
		1.50	0.295	–80	3.141	83	0.136	56	0.578	–38
		2.00	0.215	–91	2.494	70	0.169	54	0.542	–44
		2.50	0.152	–105	2.101	58	0.201	51	0.514	–51
		3.00	0.108	–124	1.837	47	0.232	47	0.497	–59
		3.50	0.083	–146	1.641	38	0.263	44	0.490	–66
		4.00	0.071	–173	1.501	30	0.294	41	0.485	–73
		4.50	0.069	148	1.395	21	0.325	38	0.480	–81
		5.00	0.090	121	1.310	14	0.357	35	0.478	–90
	5.0	0.10	0.839	–15	12.345	164	0.016	81	0.961	–9
		0.20	0.774	–28	11.339	149	0.030	75	0.906	–16
		0.30	0.690	–38	10.154	137	0.041	71	0.840	–21
		0.40	0.614	–47	8.971	127	0.050	68	0.780	–24
		0.50	0.528	–52	7.877	119	0.058	65	0.715	–26
		0.60	0.464	–57	6.974	112	0.066	64	0.677	–27
		0.70	0.414	–61	6.267	107	0.073	63	0.646	–28
		0.80	0.370	–65	5.628	102	0.080	63	0.625	–29
		0.90	0.338	–68	5.165	98	0.087	63	0.602	–30
		1.00	0.307	–71	4.742	94	0.094	62	0.587	–31
		1.50	0.207	–83	3.389	79	0.130	61	0.536	–36
		2.00	0.148	–96	2.658	66	0.165	58	0.512	–41
		2.50	0.100	–113	2.221	56	0.200	54	0.490	–49
		3.00	0.072	–138	1.930	46	0.233	51	0.475	–56
		3.50	0.059	–168	1.720	37	0.266	47	0.470	–64
		4.00	0.062	152	1.569	29	0.299	43	0.466	–72
		4.50	0.080	118	1.451	21	0.331	40	0.462	–80
		5.00	0.107	103	1.362	14	0.365	36	0.460	–88

Table 2. Common Emitter S–Parameters (continued)

V_{CE} (Vdc)	I_C (mA)	f (MHz)	NF_{min} (dB)	Γ_o (MAG, ANG)	R_N (ohms)
1.0	0.5	300	1.65	0.81 ∠8	89
		500	1.70	0.80 ∠13	86
		900	1.85	0.77 ∠23	78
		1000	1.90	0.77 ∠25	76
		1500	2.05	0.74 ∠40	64
		2000	2.20	0.70 ∠56	50
	1.0	300	1.45	0.76 ∠7	71
		500	1.47	0.76 ∠12	69
		900	1.65	0.75 ∠21	63
		1000	1.70	0.74 ∠24	62
		1500	1.90	0.71 ∠38	53
		2000	2.05	0.67 ∠55	44

Table 3. Common–Emitter Noise Parameters

V_{CE} (Vdc)	I_C (mA)	f (MHz)	NF_{min} (dB)	Γ_o (MAG, ANG)	R_N (ohms)
3.0	1.0	300	1.60	0.72 ∠7	61
		500	1.62	0.72 ∠12	60
		900	1.64	0.70 ∠21	57
		1000	1.64	0.70 ∠24	56
		1500	1.70	0.67 ∠39	49
		2000	1.80	0.63 ∠55	41
	3.0	300	1.80	0.63 ∠7	48
		500	1.82	0.62 ∠11	47
		900	1.84	0.60 ∠19	45
		1000	1.85	0.59 ∠22	44
		1500	1.94	0.56 ∠37	40
		2000	2.12	0.51 ∠56	34

Table 3. Common–Emitter Noise Parameters (continued)

Name	Value	Name	Value	Name	Value
IS	187.1E–18	IRB	80.0E–6	TF	13.0E–12
BF	133	RBM	31	XTF	500
NF	0.9958	RE	3.3	VTF	1.1
VAF	40	RC	6	ITF	0.35
IKF	0.07	XTB	0(1)	PTF	50
ISE	5.393E–12	EG	1.11(1)	TR	2.38E–9
NE	4.933	XTI	3(1)	FC	0.9
BR	17	CJE	280.0E–15	CJS	0(1)
NR	0.9929	VJE	0.884	VJS	1(1)
VAR	2.6	MJE	0.318	MJS	0(1)
IKR	0.018	CJC	290.0E–15	AF	1(1)
ISC	28.92E–18	VJC	0.424	KF	0(1)
NC	1.049	MJC	0.108		
RB	31	XCJC	0.2		

Note
1. These parameters have not been extracted. Default values are shown.

Table 4. Spice Parameters (MRF927 Die Gummel–Poon Parameters)

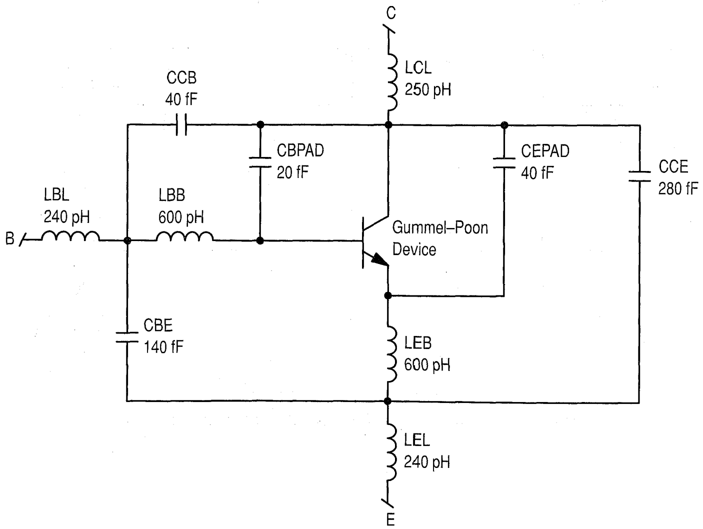
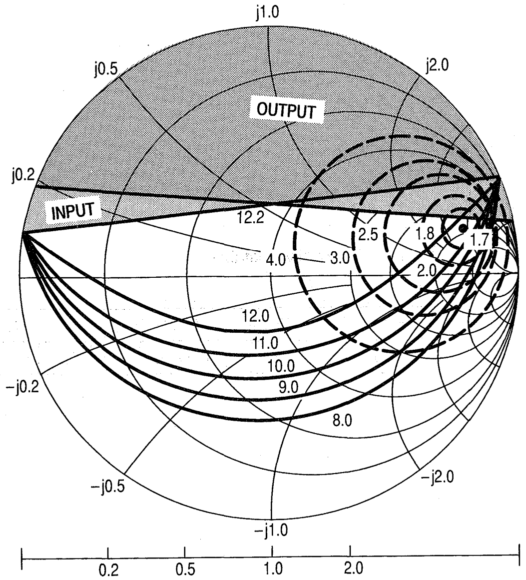


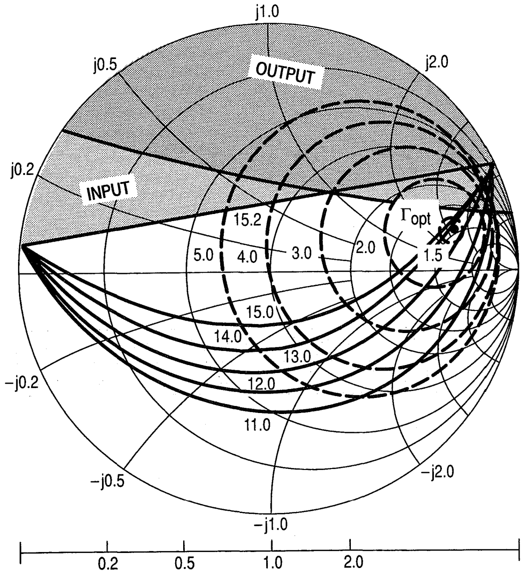
Figure 24. MRF927 SC–70 Package Equivalent Circuit



V_{CE} = 1.0 V
I_C = 0.5 mA
▨ — Potentially Unstable

f (MHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
500	1.7	0.80 ∠ 13°	86	0.25

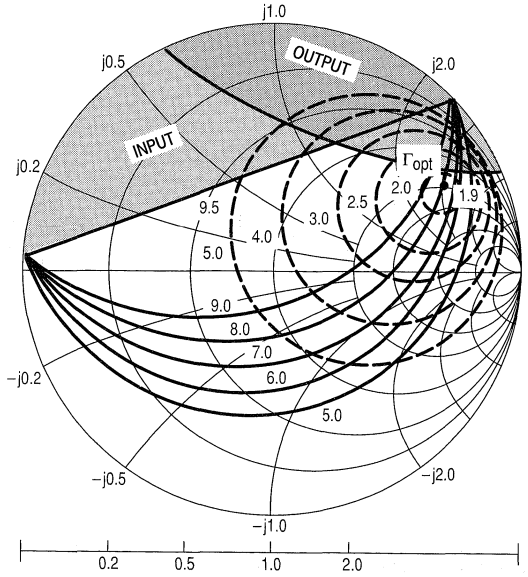
Figure 25. Constant Gain and Noise Figure Contours



V_{CE} = 1.0 V
I_C = 1.0 mA
▨ — Potentially Unstable

f (MHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
500	1.47	0.76 ∠ 12°	69	0.29

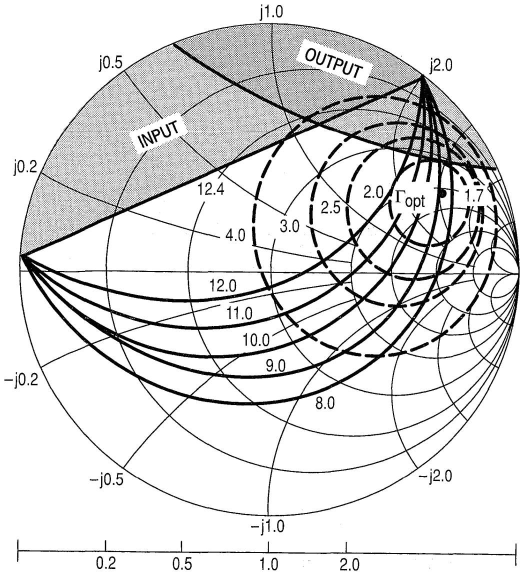
Figure 26. Constant Gain and Noise Figure Contours



V_{CE} = 1.0 V
I_C = 0.5 mA
▨ — Potentially Unstable

f (MHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1000	1.9	0.77 ∠ 25°	76	0.43

Figure 27. Constant Gain and Noise Figure Contours



V_{CE} = 1.0 V
I_C = 1.0 mA
▨ — Potentially Unstable

f (MHz)	NF OPT (dB)	ΓMS NF OPT	Rn	K
1000	1.7	0.74 ∠ 24°	62	0.51

Figure 28. Constant Gain and Noise Figure Contours

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

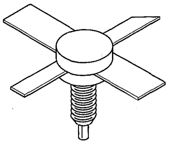
The RF Line
Microwave Pulse Power Transistors

MRF1000MA
MRF1000MB

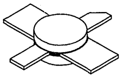
. . . designed for Class A and AB common emitter amplifier applications in the low–power stages of IFF, DME, TACAN, radar transmitters, and CW systems.

- Guaranteed Performance @ 1090 MHz, 18 Vdc — Class A
  Output Power = 0.2 Watt
  Minimum Gain = 10 dB
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Industry Standard Package
- Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input Matching for Broadband Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

0.7 W, 960–1215 MHz
CLASS A/AB
MICROWAVE POWER
TRANSISTORS
NPN SILICON



CASE 332–04, STYLE 2
MRF1000MA



CASE 332A–03, STYLE 2
MRF1000MB

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	20	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	7.0 40	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	100	—

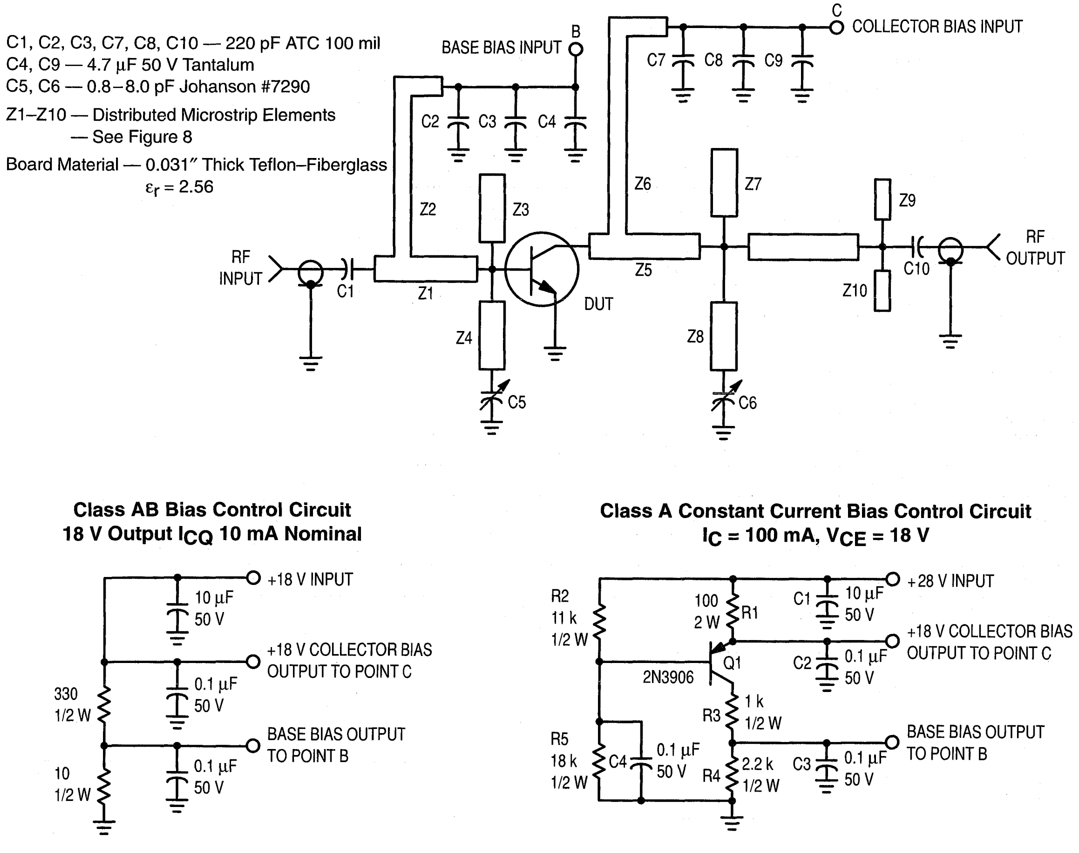
(continued)

NOTES:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the device is operated as RF amplifiers.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.0	5.0	pF
FUNCTIONAL TESTS					
Common–Emitter Power Gain — Class A (V_{CE} = 18 Vdc, I_C = 100 mAdc, f = 1090 MHz, P_{out} = 200 mW)	G_{PE}	10	12	—	dB
Common–Emitter Power Gain — Class AB (V_{CE} = 18 Vdc, I_{CQ} = 10 mAdc, f = 1090 MHz, P_{out} = 0.7 W)	G_{PE}	—	10.7	—	dB
Load Mismatch — Class A (V_{CE} = 18 Vdc, I_C = 100 mAdc, f = 1090 MHz, P_{out} = 200 mW, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Power Output			



C1, C2, C3, C7, C8, C10 — 220 pF ATC 100 mil
C4, C9 — 4.7 μF 50 V Tantalum
C5, C6 — 0.8–8.0 pF Johanson #7290
Z1–Z10 — Distributed Microstrip Elements
— See Figure 8
Board Material — 0.031″ Thick Teflon–Fiberglass
ε_r = 2.56

Figure 1. 1090 MHz Test Circuit

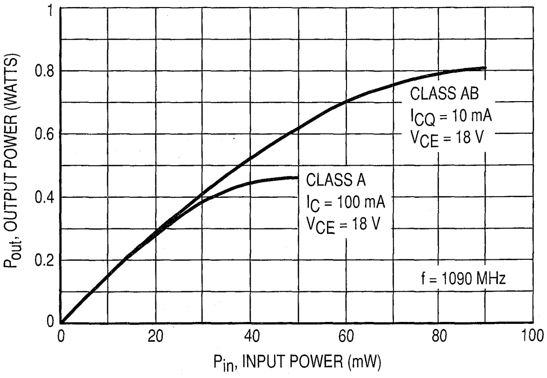


Figure 2. Output Power versus Input Power

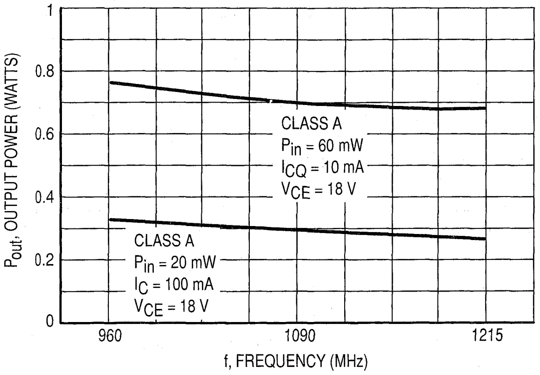


Figure 3. Output Power versus Frequency

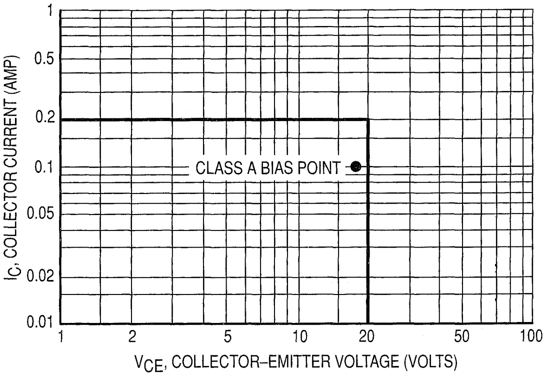


Figure 4. DC Safe Operating Area

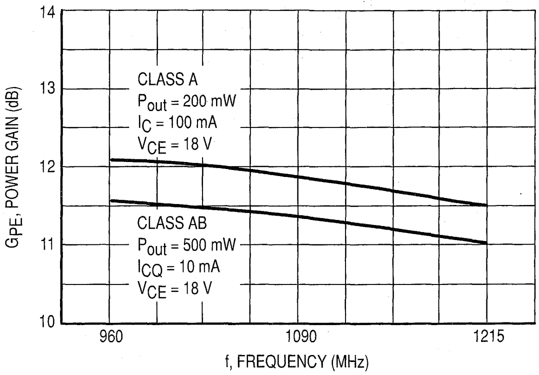
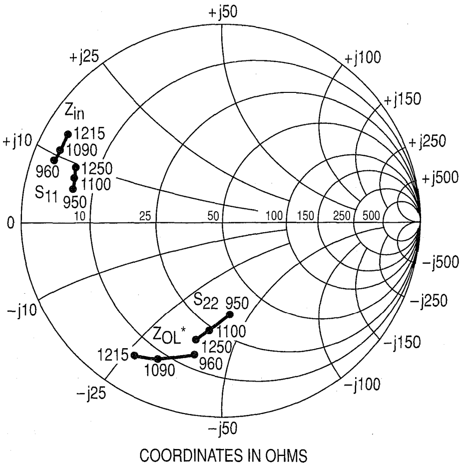


Figure 5. Power Gain versus Frequency



SERIES EQUIVALENT IMPEDANCES
P_{out} = 0.5 W, V_{CE} = 18 Vdc,
I_{CQ} = 10 mAdc, Class AB

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
960	3.0 + j9.0	16 – j40
1090	3.2 + j10	8.5 – j31
1215	2.8 + j12	7.0 – j26

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage, and frequency.

S-PARAMETERS — V_{CE} = 18 Vdc, I_C = 100 mAdc, Class A

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
950	0.77	166	2.42	40	0.016	42	0.48	-87
1000	0.78	165	2.36	38	0.016	48	0.50	-90
1050	0.77	163	2.31	33	0.016	46	0.51	-94
1100	0.77	162	2.31	28	0.016	46	0.54	-97
1150	0.78	161	2.20	23	0.015	46	0.57	-100
1200	0.78	159	2.20	19	0.016	47	0.59	-103
1250	0.78	158	2.12	12	0.016	42	0.61	-106

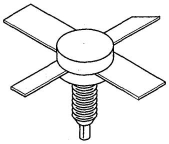
Figure 6. Common–Emitter S–Parameters and Series Equivalent Input/Output Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
Microwave Pulse Power Transistors

MRF1004MA

4.0 W, 960–1215 MHz
MICROWAVE POWER
TRANSISTORS
NPN SILICON



CASE 332–04, STYLE 1

Designed for Class B and C common base amplifier applications in short and long pulse TACAN, IFF, DME, and radar transmitters.

- Guaranteed Performance @ 1090 MHz, 35 Vdc
  Output Power = 4.0 Watts Peak
  Minimum Gain = 10 dB
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Industry Standard Package
- Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input Matching for Broadband Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	20	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	7.0 40	Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 75 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	100	—

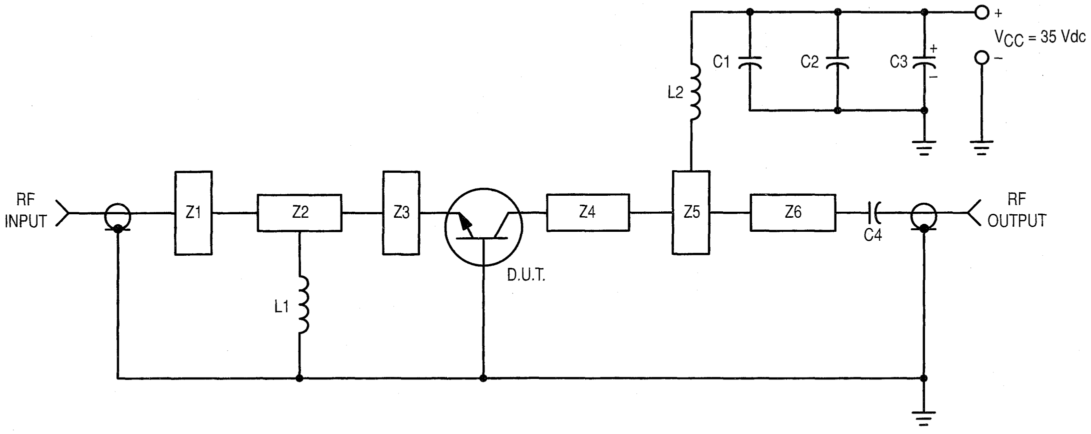
(continued)

NOTES:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the device is operated as RF amplifiers.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 35 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	3.3	5.0	pF
FUNCTIONAL TESTS (Pulse Width = 10 µs, Duty Cycle = 1.0%)					
Common–Base Amplifier Power Gain (V_{CC} = 35 Vdc, P_{out} = 4.0 W pk, f = 1090 MHz)	G_{PB}	10	11	—	dB
Collector Efficiency (V_{CC} = 35 Vdc, P_{out} = 4.0 W pk, f = 1090 MHz)	η	40	45	—	dB
Load Mismatch (V_{CC} = 35 Vdc, P_{out} = 4.0 W pk, f = 1090 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Power Output			



C1 — 0.1 µF
C2, C4 — 220 pF Chip Capacitor
C3 — 20 µF, 50 V Electrolytic
L1, L2 — 3 Turns #18 AWG, 1/8″ ID
Z1–Z6 Distributed Microstrip Elements, See Photomaster
Board Material — 0.031″ Thick Glass Teflon

Figure 1. 1090 MHz Test Circuit

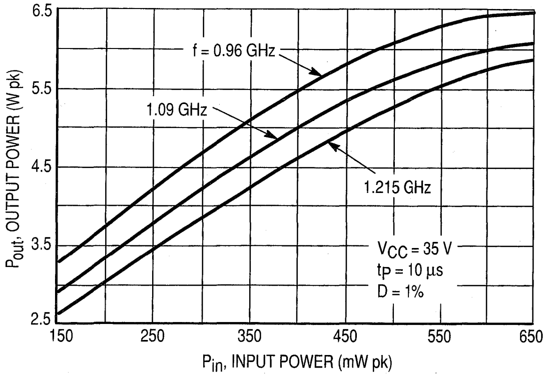


Figure 2. Output Power versus Input Power

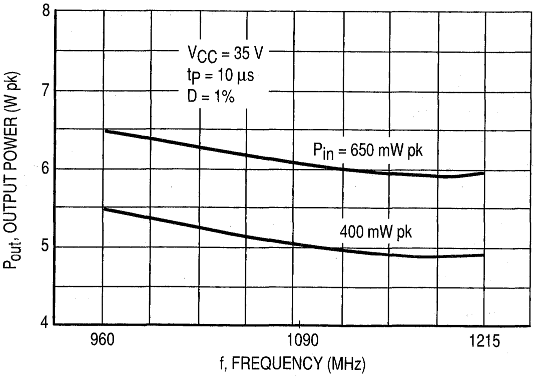


Figure 3. Output Power versus Frequency

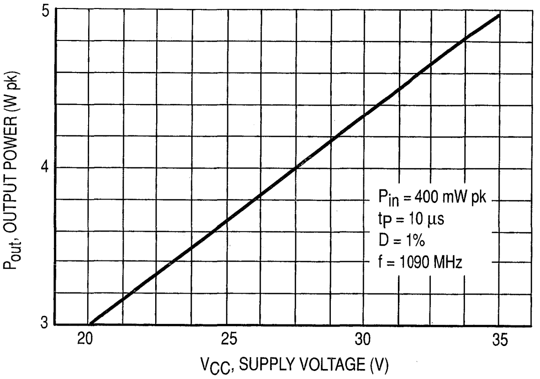


Figure 4. Output Power versus Supply Voltage

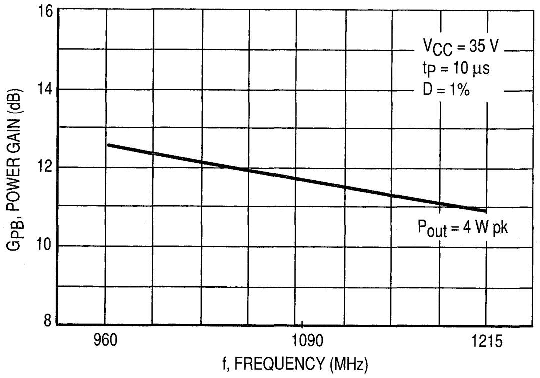
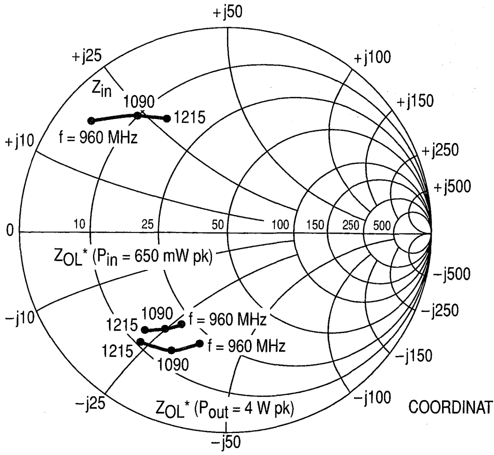


Figure 5. Power Gain versus Frequency

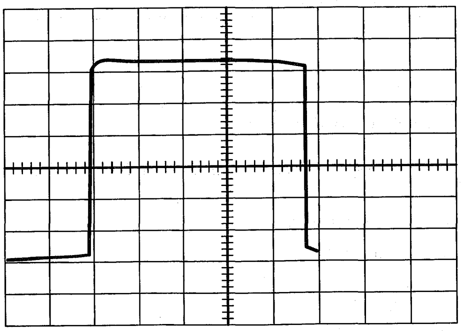


COORDINATES IN OHMS

f MHz	Z_{in} Ohms	Z_{OL}* (P_{in} = 400 mW pk) Ohms	Z_{OL}* (P_{out} = 4.0 W pk) Ohms
960	5.0 + j17.5	23.5 − j26	22.5 − j36
1090	10 + j23	18.5 − j25	15 − j32.5
1215	16 + j29.5	15.5 − j23.5	11 − j23

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage, and frequency.

Figure 6. Series Equivalent Input/Output Impedance



P_{out} = 4 W pk
V_{CC} = 35 V
t_P = 1 ms
D = 10%
f = 1090 MHz

Figure 7. Typical Long Pulse Performance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

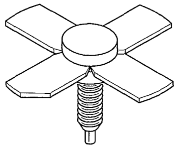
The RF Line
UHF Power Transistor

MRF1029

. . . designed primarily for wideband, large–signal output and driver amplifier stages to 1.0 GHz.

- Designed for Class A Linear Power Amplifiers
- Specified 25 Volt, 900 MHz Characteristics:
  Output Power — 1.5 Watts
  Power Gain — 8.0 dB Min, Class AB
- Gold Metallization for Improved Reliability

1.5 W, TO 1.0 GHz
LINEAR
UHF POWER TRANSISTOR
NPN SILICON



CASE 244–04, STYLE 1
(.280 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	14.5 0.084	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	12	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mA, V_{BE} = 0)	$V_{(BR)CES}$	60	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 mA, I_E = 0)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 V, I_E = 0)	I_{CBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mA, V_{CE} = 5.0 V)	h_{FE}	20	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	4.75	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 25 V, P_{out} = 1.5 W, f = 900 MHz, I_C = 0.2 A)	G_{PE}	8.0	9.3	—	dB
Load Mismatch (V_{CE} = 25 V, I_C = 0.2 A, P_{out} = 1.5 W, f = 900 MHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			

REV 6

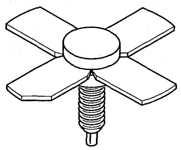
The RF Line
UHF Power Transistor

MRF1032

6.0 W, TO 1.0 GHz
LINEAR
UHF POWER TRANSISTOR
NPN SILICON

. . . designed primarily for large–signal output and driver amplifier stages to 1.0 GHz.

- Designed for Class A Linear Power Amplifiers
- Specified 25 Volt, 900 MHz Characteristics:
  Output Power — 6.0 Watts
  Power Gain — 6.5 dB Min, Class AB
- Gold Metallization for Improved Reliability



CASE 244–04, STYLE 1
(.280 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	50 0.286	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case ($T_C = 70°C$)	$R_{\theta JC}$	3.5	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 20$ mA, $I_B = 0$)	$V_{(BR)CEO}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 20$ mA, $V_{BE} = 0$)	$V_{(BR)CES}$	60	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 20$ mA, $I_E = 0$)	$V_{(BR)CBO}$	60	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 5.0$ mA, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 25$ V, $I_E = 0$)	I_{CBO}	—	—	3.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0$ mA, $V_{CE} = 5.0$ V)	h_{FE}	20	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 28$ V, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	—	19.5	pF
FUNCTIONAL TESTS					
Common Emitter Amplifier Power Gain ($V_{CE} = 25$ V, $P_{out} = 6.0$ W, f = 900 MHz, $I_C = 0.85$ A)	G_{PE}	6.5	7.5	—	dB
Load Mismatch ($V_{CE} = 25$ V, $P_{out} = 6.0$ W, f = 900 MHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			

REV 6

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

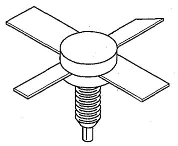
The RF Line
Microwave Pulse Power Transistors

MRF1090MA

90 W PEAK, 960–1215 MHz
MICROWAVE POWER
TRANSISTORS
NPN SILICON

Designed for Class B and C common base amplifier applications in short pulse TACAN, IFF, and DME transmitters.

- Guaranteed Performance @ 1090 MHz, 50 Vdc
  Output Power = 90 Watts Peak
  Minimum Gain = 8.4 dB
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Industry Standard Package
- Nitride Passivated
- Gold Metallized for Long Life and Resistance to Metal Migration
- Internal Input Matching for Broadband Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 332–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CBO}	70	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current — Peak (1)	I_C	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) (2) Derate above 25°C	P_D	290 1.66	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.6	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	70	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 25 mAdc, I_E = 0)	$V_{(BR)CBO}$	70	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (4) (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	30	—	—

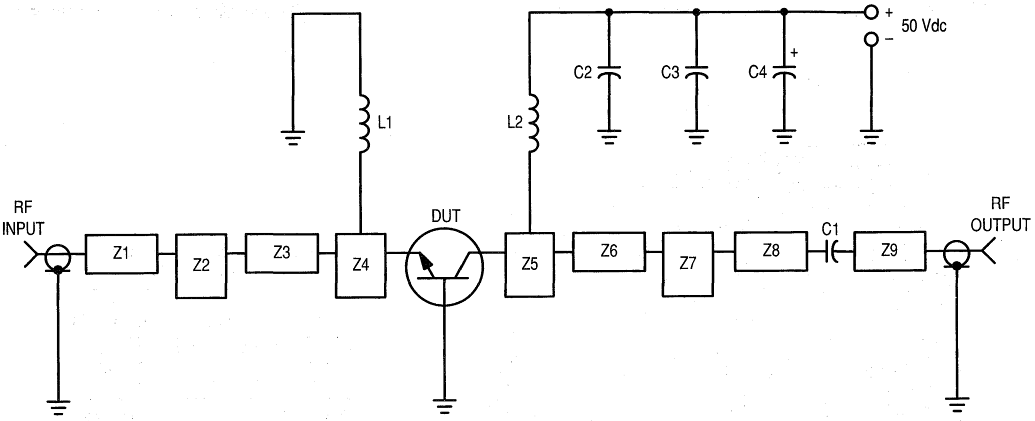
(continued)

NOTES:
1. Pulse Width = 10 µs, Duty Cycle = 1%.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the device is operated as RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.
4. 80 µs Pulse on Tektronix 576 or equivalent.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 50 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	12	16	pF
FUNCTIONAL TESTS (Pulse Width = 10 µs, Duty Cycle = 1.0%)					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 90 W pk, f = 1090 MHz)	G_{PB}	8.4	10.8	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 90 W pk, f = 1090 MHz)	η	35	40	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 90 W pk, f = 1090 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Power Output			



C1, C2 — 220 pF Chip Capacitor, 100–mil ATC
C3 — 0.1 µF
C4 — 47 µF/75 V
L1, L2 — 3 Turns #18 AWG, 1/8″ ID
Z1–Z9 — Distributed Microstrip Elements,
See Photomaster
Board Material — 0.031″ Thick Glass Teflon, ε_r = 2.5

Figure 1. 1090 MHz Test Circuit

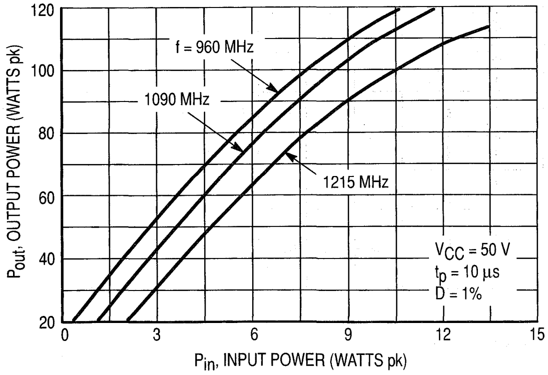


Figure 2. Output Power versus Input Power

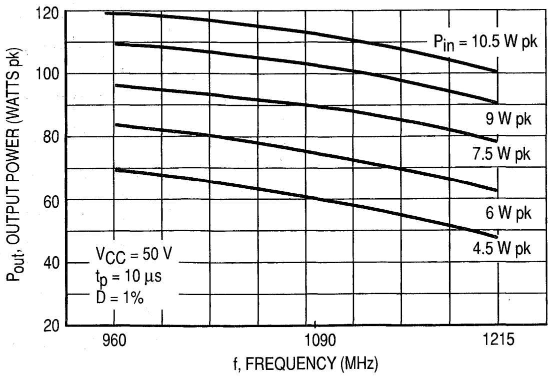


Figure 3. Output Power versus Frequency

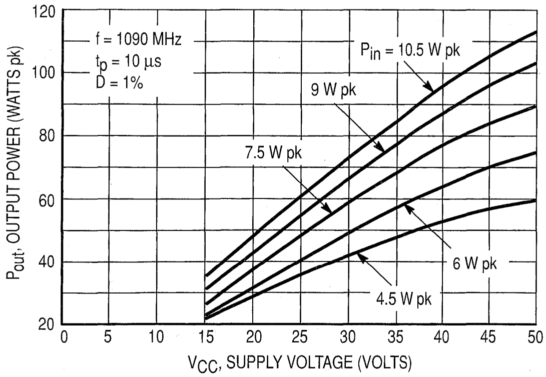


Figure 4. Output Power versus Supply Voltage

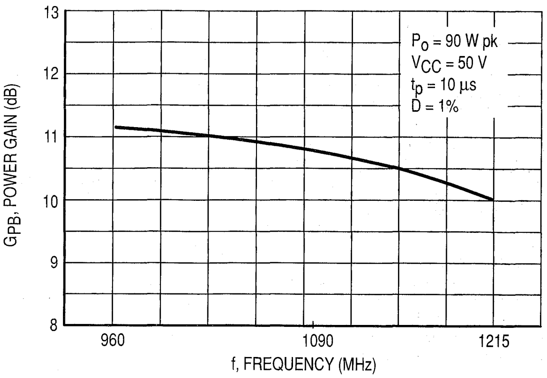
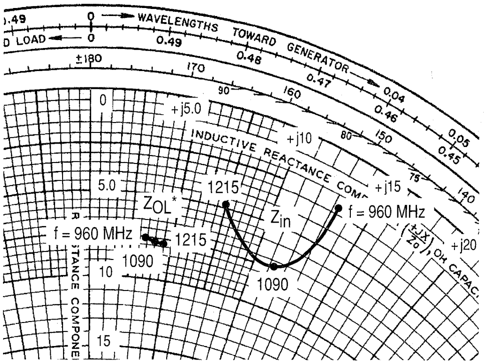


Figure 5. Power Gain versus Frequency



Coordinates in Ohms

P_{out} = 90 W pk V_{CC} = 50 V
t_p = 10 µs D = 1%

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
960	2.8 + j13.2	7.6 + j3.5
1090	7.4 + j11.4	7.6 + j4.0
1215	4.7 + j7.5	7.7 + j4.5

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage, and frequency.

Figure 6. Series Equivalent Input/Output Impedance

P_o = 90 W pk
V_{CC} = 50 V
t_p = 10 µs
D = 1%
f = 1090 MHz

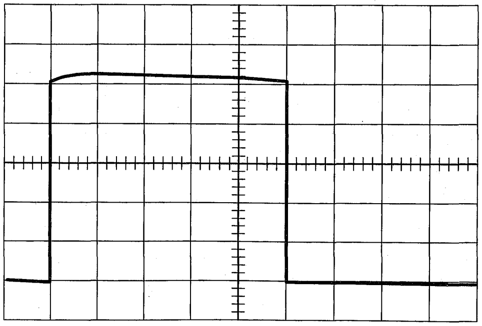


Figure 7. Typical Pulse Performance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

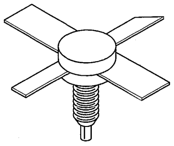
The RF Line
Microwave Pulse Power Transistors

MRF1150MA

Designed for Class B and C common base amplifier applications in short pulse TACAN, IFF, and DME transmitters.

- Guaranteed Performance @ 1090 MHz, 50 Vdc
  Output Power = 150 Watts Peak
  Minimum Gain = 7.8 dB
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Industry Standard Package
- Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input Matching for Broadband Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

150 W PEAK, 960–1215 MHz
MICROWAVE POWER
TRANSISTORS
NPN SILICON



CASE 332–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CBO}	70	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Peak (1)	I_C	12	Adc
Total Device Dissipation @ T_C = 25°C (1) (2) Derate above 25°C	P_D	583 3.33	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.3	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	70	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc, I_E = 0)	$V_{(BR)CBO}$	70	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (4) (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	30	—	—

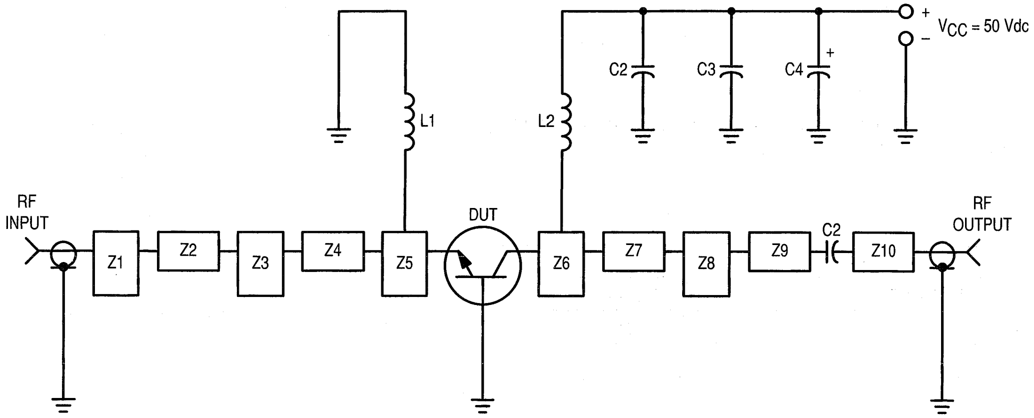
(continued)

NOTES:
1. Pulse Width = 10 µs, Duty Cycle = 1%.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the device is operated as RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.
4. 80 µs Pulse on Tektronix 576 or equivalent.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 50 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	25	32	pF
FUNCTIONAL TESTS (Pulse Width = 10 µs, Duty Cycle = 1.0%)					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 150 W pk, f = 1090 MHz)	G_{PB}	7.8	9.8	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 150 W pk, f = 1090 MHz)	η	35	40	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 150 W pk, f = 1090 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Power Output			



C1, C2 — 220 pF Chip Capacitor, 100–mil ATC
C3 — 0.1 µF/100 V
C4 — 47 µF/75 V Electrolytic
L1, L2 — 3 Turns #18 AWG, 1/8″ ID
Z1 – Z10 — Distributed Microstrip Elements — See Photomaster
Board Material — 0.031″ Thick Teflon–Fiberglass, ε_r = 2.5

Figure 1. 1090 MHz Test Circuit

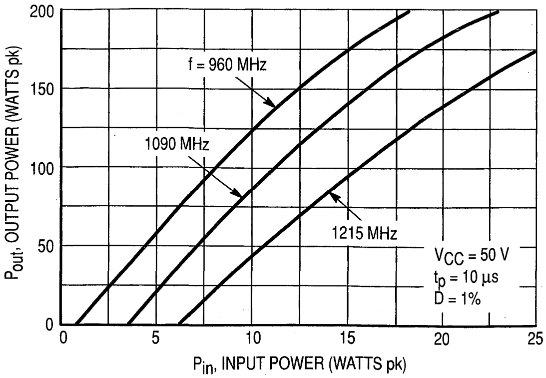


Figure 2. Output Power versus Input Power

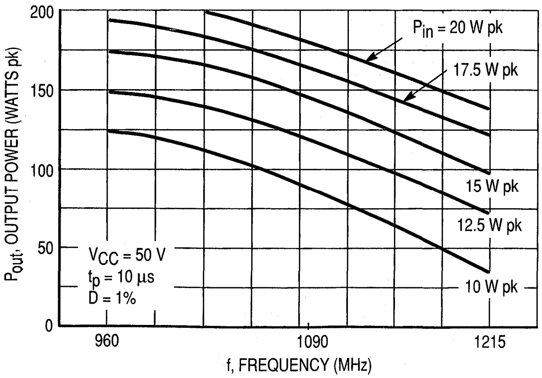


Figure 3. Output Power versus Frequency

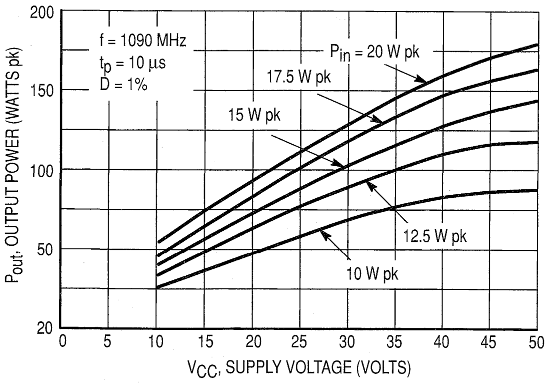


Figure 4. Output Power versus Supply Voltage

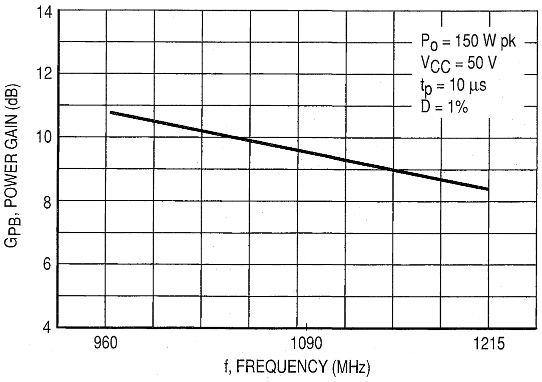
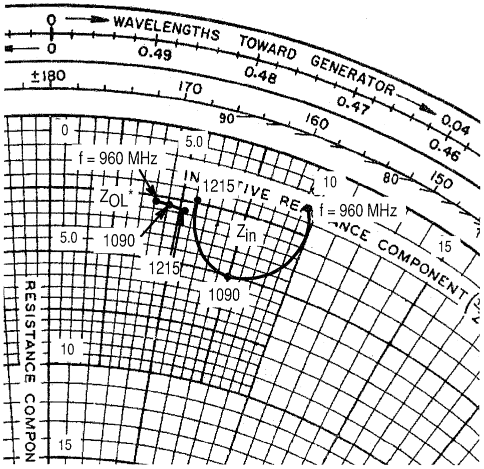


Figure 5. Power Gain versus Frequency



P_{out} = 150 W pk V_{CC} = 50 V
t_p = 10 µs D = 1%

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
960	1.5 + j9.6	2.6 + j4.1
1090	5.0 + j7.5	2.7 + j4.6
1215	2.4 + j5.6	2.8 + j5.3

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage, and frequency.

Figure 6. Series Equivalent Input/Output Impedance

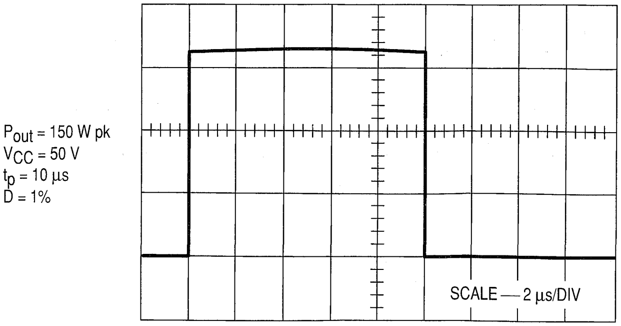


Figure 7. Typical Pulse Performance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

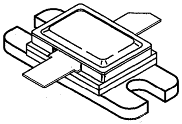
The RF Line
Microwave Pulse Power Transistor

MRF1375

375 W (PEAK), 1025–1150 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON

Designed for 1025–1150 MHz pulse common base amplifier applications such as TACAN and DME.

- Guaranteed Performance @ 1090 MHz
  Output Power = 375 Watts Peak
  Gain = 6.7 dB Min 7.5 dB (Typ)
- 100% Tested for Load Mismatch at All Phase Angles with 3:1 VSWR
- Hermetically Sealed Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input Matching
- Characterized using 10 μs, 1% Duty Pulse Format



CASE 355G–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	70	Vdc
Collector–Base Voltage	V_{CBO}	70	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Peak (1)	I_C	29	Adc
Total Device Dissipation @ T_C = 25°C (1) (2) Derate above 25°C	P_D	1458 8.33	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +200	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

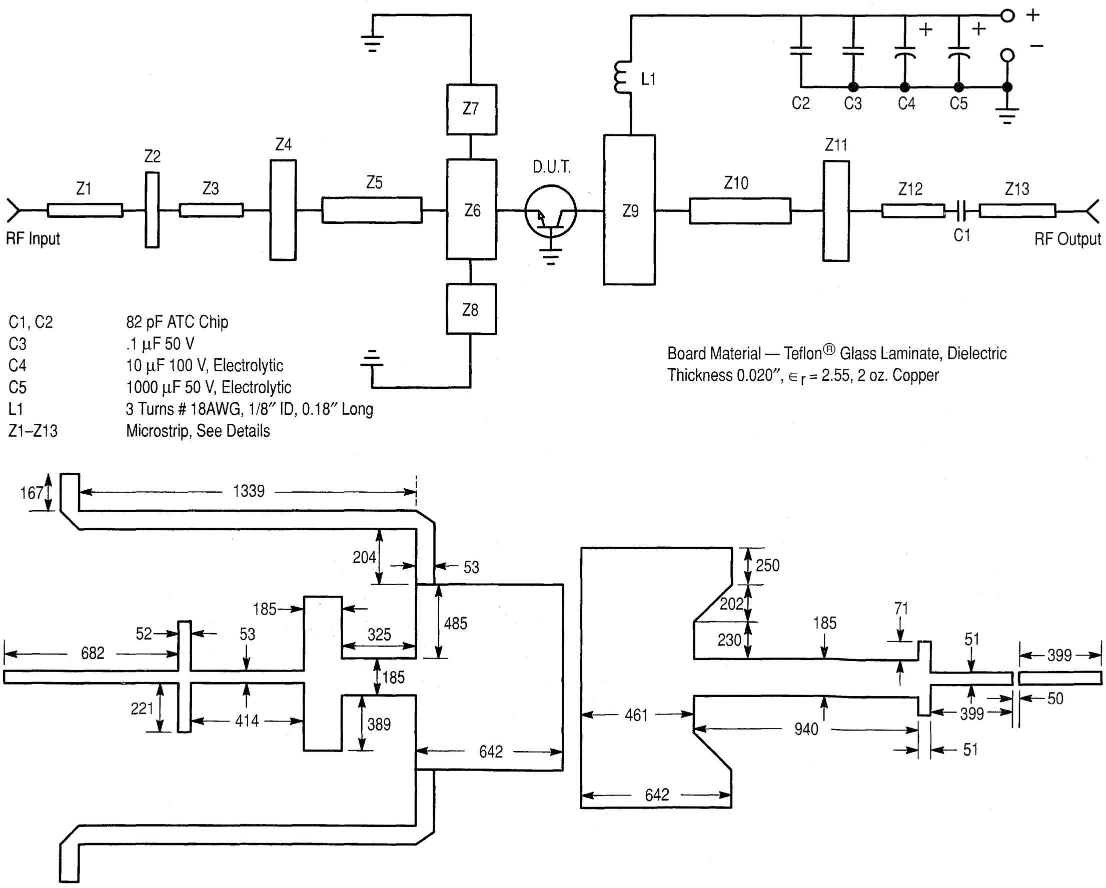
Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3) (4)	$R_{\theta JC}$	0.12	°C/W

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as pulsed RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.
4. Pulse Width = 10 μs, Duty Cycle = 1%.

REV 7

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	70	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 60 mAdc, I_E = 0)	$V_{(BR)CBO}$	70	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	3.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—	—
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 375 W Peak, f = 1090 MHz)	G_{PB}	6.7	7.5	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 375 W Peak, f = 1090 MHz)	η_c	40	—	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 375 W Peak, f = 1090 MHz, Load VSWR = 3:1 All Phase Angles)	Ψ	No Degradation in Output Power			



C1, C2	82 pF ATC Chip
C3	.1 µF 50 V
C4	10 µF 100 V, Electrolytic
C5	1000 µF 50 V, Electrolytic
L1	3 Turns # 18AWG, 1/8″ ID, 0.18″ Long
Z1–Z13	Microstrip, See Details

Board Material — Teflon® Glass Laminate, Dielectric Thickness 0.020″, ϵ_r = 2.55, 2 oz. Copper

Figure 1. Test Circuit

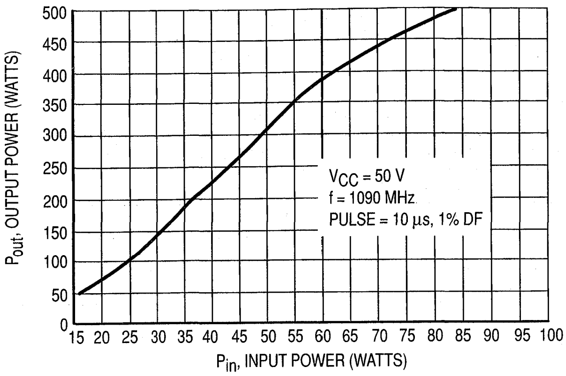


Figure 2. Output Power versus Input Power

P_{out} = 375 W, V_{CC} = 50 V
T_p = 10 μs, DF = 1%

Freq MHz	Z_{in} Ohms	Z_{OL}* Ohms (1)
1025	2.4 + j1.7	1.1 + j1.3
1050	2.1 + j1.2	1.1 + j1.4
1090	1.8 + j1.1	1.1 + j1.3
1125	1.6 + j1.1	1.3 + j1.3
1150	1.4 + j1.0	1.2 + j1.6

(1) Z_{OL}* is the conjugate of the optimum load impedance into which the device operates at a given output power voltage and frequency.

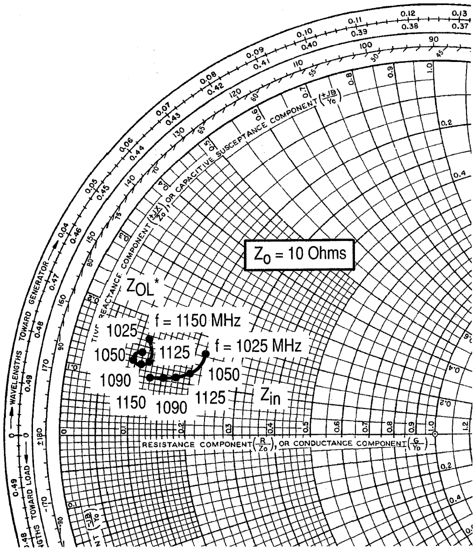


Figure 3. Series Equivalent Input/Output Impedances

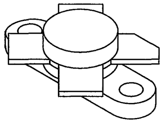
The RF Line
NPN Silicon Power Transistors

MRF1946
MRF1946A

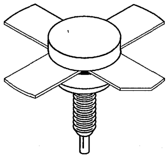
30 W, 136–220 MHz
RF POWER
TRANSISTORS
NPN SILICON

. . . designed for 12.5 volt large–signal power amplifiers in commercial and industrial equipment.

- High Common Emitter Power Gain
- Specified 12.5 V, 175 MHz Performance
  Output Power = 30 Watts
  Power Gain = 10 dB
  Efficiency = 60%
- Diffused Emitter Resistor Ballasting
- Characterized to 220 MHz
- Load Mismatch at High Line and Overdrive Conditions



CASE 211–07, STYLE 1
MRF1946



CASE 145A–09, STYLE 1
MRF1946A

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	16	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 0.57	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

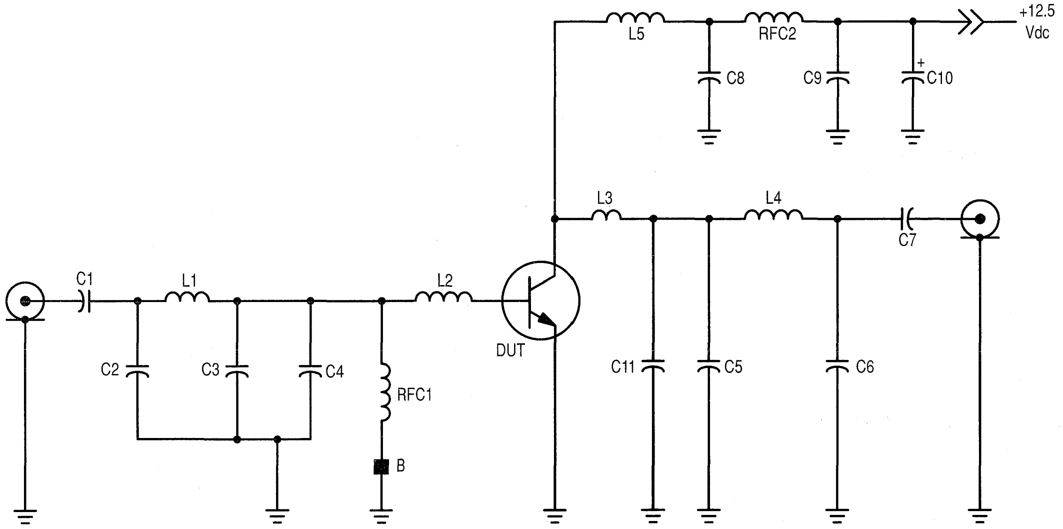
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	16	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	—	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	40	75	150	—

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	75	100	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 30 W, f = 175 MHz)	G_{pe}	10	11	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 30 W, f = 175 MHz)	η	60	70	—	%
Load Mismatch (V_{CC} = 15.5 Vdc, P_{in} = 2.0 dB Overdrive, Load VSWR = 30:1)	ψ	No Degradation in Power Output			



C1 — 56 pF Mini–Unelco, 3HS0006–56
C2 — 47 pF Mini–Unelco, 3HS0006–47
C3, C4 — 180 pF Chip Cap, ATC 100B181JC500
C5 — 150 pF Unelco, J101–150
C6 — 39 pF Mini–Unelco, 3HS0006–39
C7, C8 — 1000 pF Chip Cap, ATC 100B102JC50
C9 — 0.1 µF Ceramic Capacitor
C10 — 10 µF, 25 V Electrolytic Capacitor
C11 — 56 pF Mini–Unelco, 3HS0006–56

L1 — 2 Turns #18 AWG, 0.125″ ID
L2, L3 — Circuit Board and Mounting Pad Inductance
L4 — 3 Turns #18 AWG, 0.125″ ID
L5 — 6 Turns #16 Enameled, 0.250″ ID
RFC1 — 0.15 µH Molded Choke w/Ferrite Bead
RFC2 — Ferrite Choke, Fair Rite VK200–4B
Board Material — 1/32, Glass Teflon, 1 oz. Cu Plating
Bead — Ferroxcube

Figure 1. Broadband Test Circuit Schematic

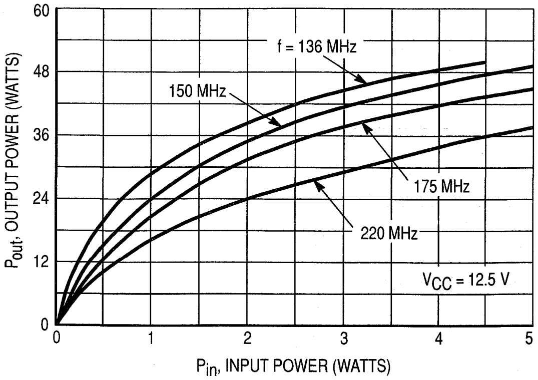


Figure 2. Output Power versus Input Power

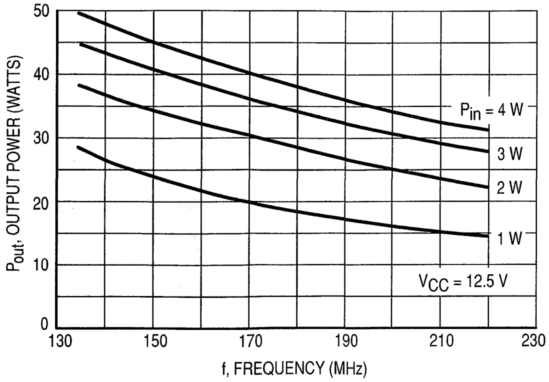


Figure 3. Output Power versus Frequency

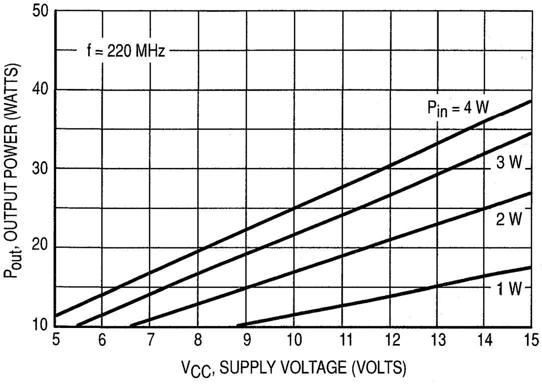


Figure 4. Output Power versus Supply Voltage

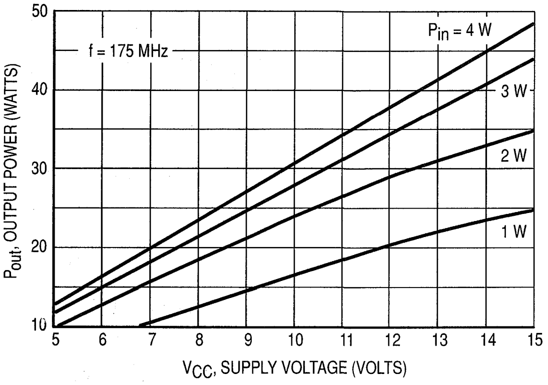


Figure 5. Output Power versus Supply Voltage

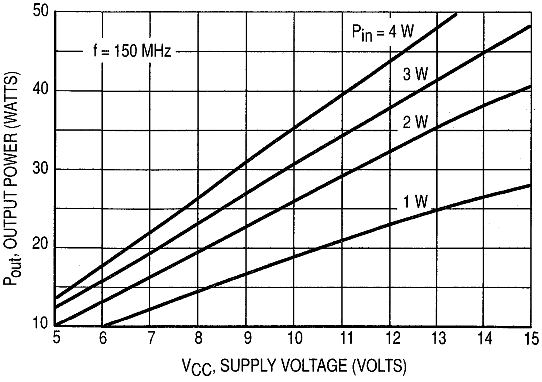


Figure 6. Output Power versus Supply Voltage

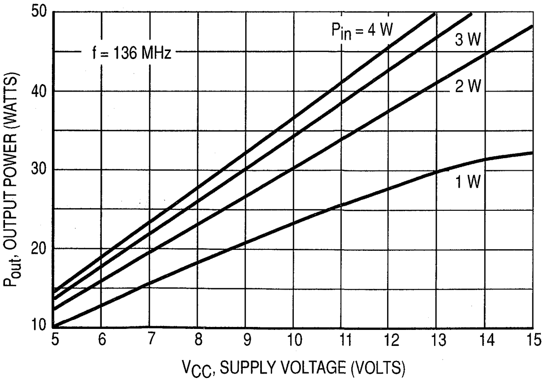


Figure 7. Output Power versus Supply Voltage

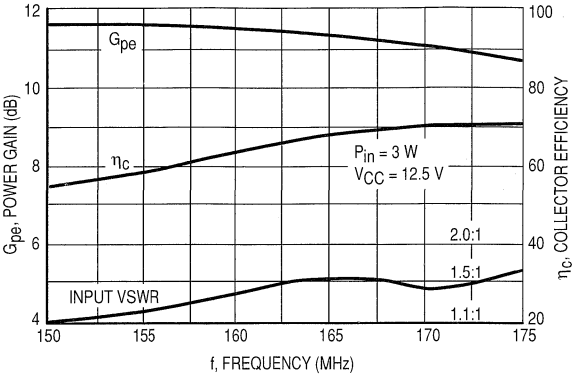
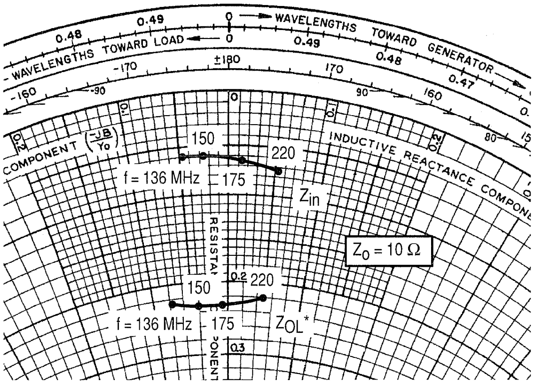


Figure 8. Typical Performance in a Broadband Circuit



V_{CC} = 12.5 Vdc, P_{out} = 30 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
136	0.60 – j0.48	2.22 – j0.74
150	0.63 – j0.26	2.30 – j0.40
175	0.62 + j0.13	2.35 – j0.04
220	0.73 + j0.57	2.20 + j0.43

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 9. Series Equivalent Input and Output Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line

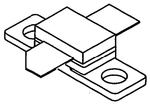
Microwave Linear Power Transistor

MRF2000-5L

Designed primarily for wideband, large signal output and driver amplifier stages in the 1.0 to 2.0 GHz frequency range.

- Designed for Class A or AB, Common Emitter Power Amplifiers
- Specified 20 Volt, 2.0 GHz Characteristic Power Gain — 7.0 dB Min @ 5.0 W P_{out}
- Built In Matching Network for Broadband Operation
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

7.0–8.0 dB GAIN
USABLE 1.0–2.0 GHz
5.0 WATTS
MICROWAVE
LINEAR POWER TRANSISTOR



CASE 360A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	22	Vdc
Collector–Base Voltage	V_{CES}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case, DC	$R_{\theta JC}$ (DC)	12	°C/W
Thermal Resistance, Junction to Case, RF	$R_{\theta JC}$ (RF)	10	°C/W

ELECTRICAL CHARACTERISTICS

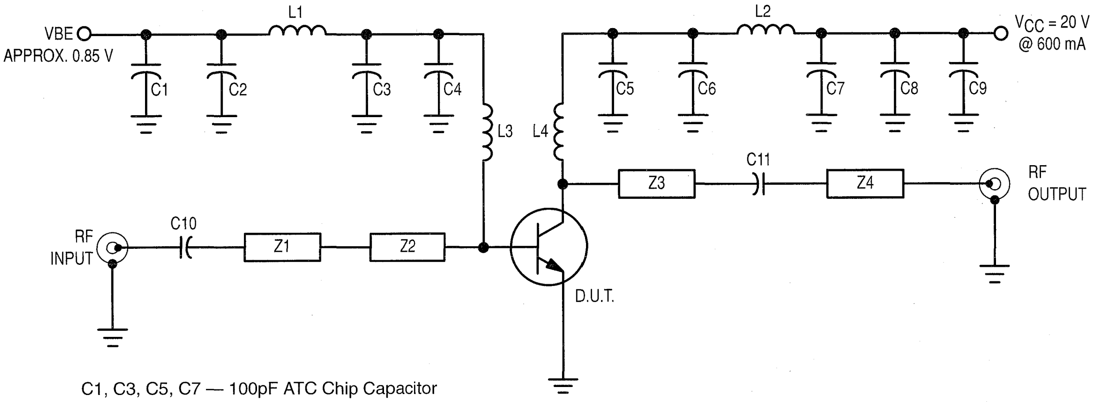
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mA, I_C = 0)	$V_{(BR)CEO}$	22	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mA, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 1.25 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mA, R_{BE} = 10 Ohms)	$V_{(BR)CER}$	35	—	—	Vdc
Collector Cutoff Current (V_{CE} = 20 V, I_E = 0)	I_{CBO}	—	—	1.25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.5 A, V_{CE} = 5.0 V)	h_{FE}	20	35	100	—

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 5.0 W, f = 2.0 GHz, I_C = 600 mA)	G_{PE1}	7.0	—	—	dB
Collector Efficiency (V_{CE} = 20 V, P_{out} = 5.0 W, f = 2.0 GHz, I_C = 600 mA)	η_C	39	—	—	%
Typical Class AB Performance					
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 6.0 W, f = 2.0 GHz, I_{CQ} = 100 mA)	G_{PE2}	—	5.0	—	dB
Collector Efficiency (V_{CE} = 20 V, P_o = 6.0 W, f = 2.0 GHz, I_{CQ} = 100 mA)	η_C	—	48	—	%
Common–Emitter Amplifier Power Gain (V_{CE} = 24 V, P_{out} = 8.0 W, f = 2.0 GHz, I_{CQ} = 100 mA)	G_{PE3}	—	6.5	—	dB
Collector Efficiency (V_{CE} = 24 V, P_o = 8.0 W, f = 2 .0 GHz, I_{CQ} = 100 mA)	η_C	—	50	—	%



C1, C3, C5, C7 — 100pF ATC Chip Capacitor
C2, C4, C6, C8 — 0.1 µF Chip Capacitor
C9 — 50 µF Electrolytic Capacitor
C10, C11 — 28 pF ATC Chip Capacitor
L1, L2, L3 — 3 Turns, 0.125″ Dia., 18 AWG
L4 — Loop, 18 AWG
Z1, Z4 — 50r Line
Z2 — 0.55″ wide x 0.4″ Long Microstrip
Z3 — 0.4″ wide x 1.125″ Long Microstrip
PC Board — 0.018″ Teflon® Fiberglass, Cu Clad ϵ_r = 2.55

Figure 1. 2.0 GHz Test Circuit

TYPICAL CHARACTERISTICS

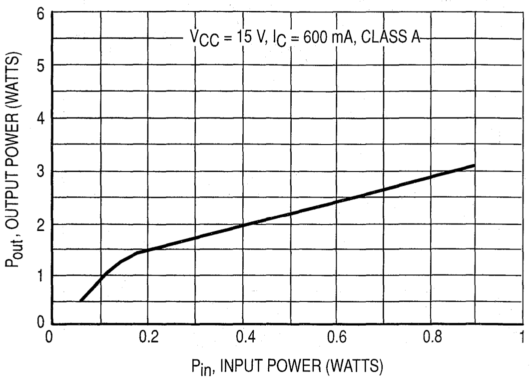


Figure 2. Output Power versus Input Power

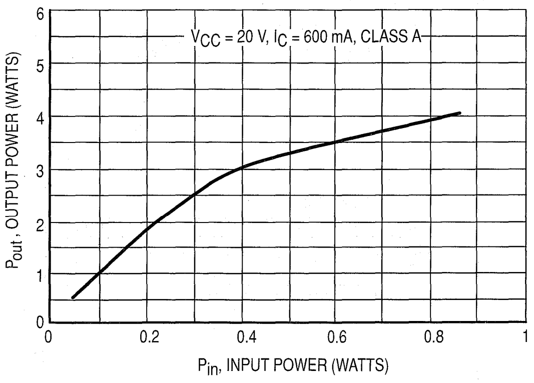


Figure 3. Output Power versus Input Power

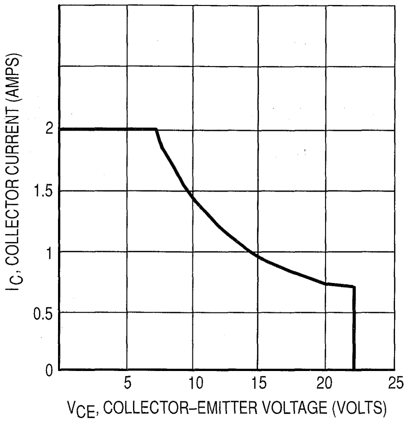
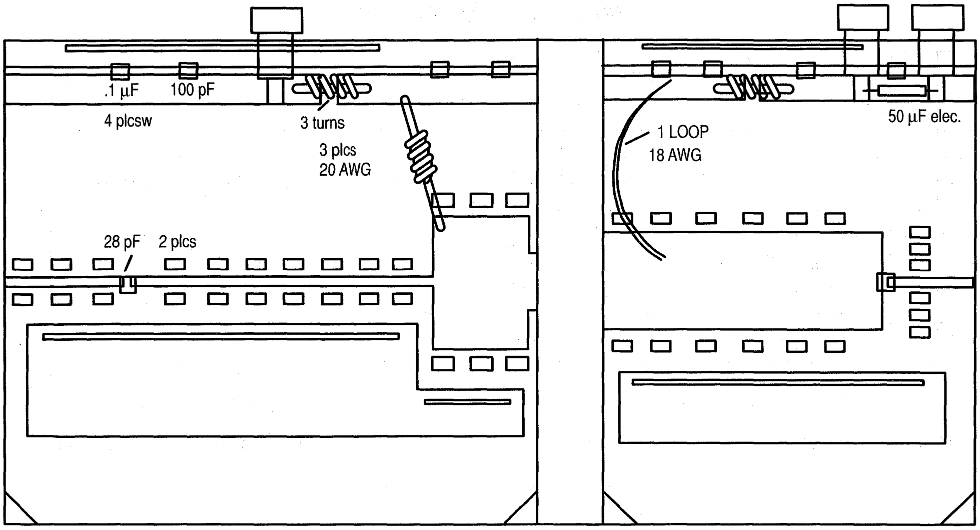


Figure 4. DC Safe Operating Area

V_{CE} (Vdc)	I_C (mA)	f MHz	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
20	500	500	0.94	174	1.95	– 17	0.02	– 63	0.57	– 170
		600	0.94	172	1.65	– 40	0.02	– 78	0.59	– 170
		700	0.94	171	1.44	– 62	0.02	– 93	0.61	– 170
		800	0.93	170	1.28	– 84	0.02	– 107	0.63	– 170
		900	0.92	169	1.16	– 107	0.02	– 121	0.65	– 169
		1000	0.92	169	1.06	– 129	0.02	– 138	0.67	– 169
		1100	0.91	169	0.99	– 152	0.02	– 155	0.70	– 169
		1200	0.90	169	0.93	– 175	0.02	– 172	0.73	– 169
		1300	0.89	169	0.88	161	0.02	171	0.75	– 169
		1400	0.88	169	0.84	137	0.02	154	0.76	– 170
		1500	0.88	170	0.81	113	0.02	141	0.80	– 170
		1600	0.87	171	0.77	88	0.01	130	0.81	– 171
		1700	0.87	172	0.73	62	0.01	120	0.83	– 173
		1800	0.81	172	0.69	34	0.01	123	0.83	– 174
		1900	0.89	173	0.64	8	0.01	125	0.83	– 176
		2000	0.90	173	0.58	– 18	0.01	127	0.83	– 177
		2100	0.92	173	0.52	– 46	0.01	122	0.82	– 178
		2200	0.93	172	0.48	– 73	0.02	110	0.81	– 179
		2300	0.94	170	0.42	– 99	0.02	95	0.80	– 179
		2400	0.95	167	0.37	– 126	0.02	82	0.80	– 180
		2500	0.95	165	0.32	– 153	0.03	67	0.81	– 180

Table 1. Common Emitter S–Parameters



NOTE: MATERIAL IS TEFLON FIBERGLASS, 20 MIL THICK, Cu CLAD 2 SIDES

Figure 5. Test Circuit Board — Component Placement

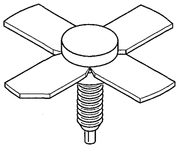
The RF Line
NPN Silicon RF Power Transistor

MRF2628

15 W 136–220 MHz
RF POWER
TRANSISTOR
NPN SILICON

. . . designed for 12.5 volt VHF large–signal power amplifiers in commercial and industrial FM equipment.

- Compact .280 Stud Package
- Specified 12.5 V, 175 MHz Performance
  - Output Power = 15 Watts
  - Power Gain = 12 dB Min
  - Efficiency = 60% Min
- Characterized to 220 MHz
- Load Mismatch Capability at High Line and Overdrive



CASE 244–04, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	18	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	40 0.23	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	4.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

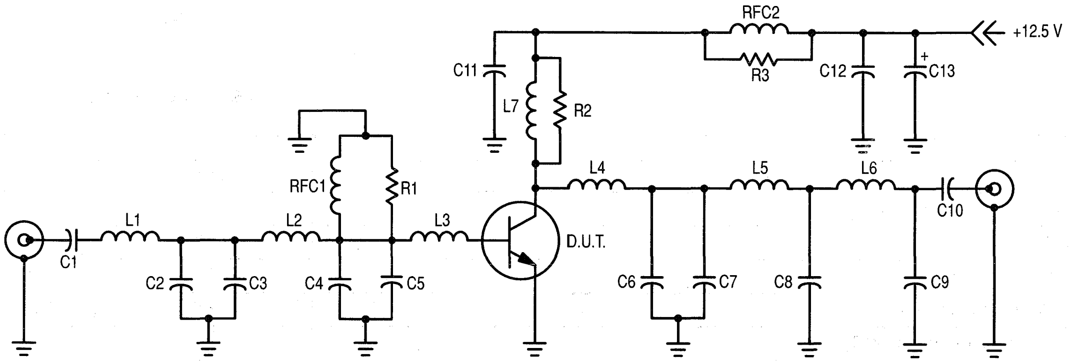
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	mAdc

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	70	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	33	60	pF
FUNCTIONAL TESTS (Figure 1)					
Common–Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 175 MHz)	G_{pe}	12	13	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 175 MHz)	η	60	68	—	%
Load Mismatch (V_{CC} = 15.5 Vdc, P_{in} = 2.0 dB Overdrive, Load VSWR = 30:1)	ψ	No Degradation in Output Power			



C1, C10, C11 — 1000 pF Ceramic Chip Capacitor
C2 — 27 pF Mini Unelco Capacitor
C3 — 33 pF Mini Unelco Capacitor
C4, C5 — 270 pF Unelco J101 Capacitor
C6, C9 — 18 pF Mini Unelco Capacitor
C7 — 91 pF Mini Unelco Capacitor
C8 — 68 pF Mini Unelco Capacitor
C12 — 0.1 µF Monolythic Capacitor
C13 — 100 µF, 15 V Electrolytic
L1 — 3 Turns #18 AWG, 3/16″ ID
L2 — 1–1/8″ #18 AWG into 1/2″ High Loop
L3 — Copper Pad, 0.200 x 0.400 x 0.060
L4 — 1/4″ #18 AWG into 1/8″ High Loop
L5 — 3 Turns #24 AWG Enameled, 3/32″ ID
L6 — 6 Turns #24 AWG Enameled, 3/32″ ID
L7 — 1–3/4″ #16 AWG into 3/4″ High Loop
R1 — 12 Ω, 1/2 W Carbon
R2 — 100 Ω, 1.0 W Carbon
R3 — 10 Ω, 1.0 W Carbon
RFC1 — 0.15 µH Molded Choke
RFC2 — Ferroxcube Choke, VK200–4B

Figure 1. Broadband Circuit

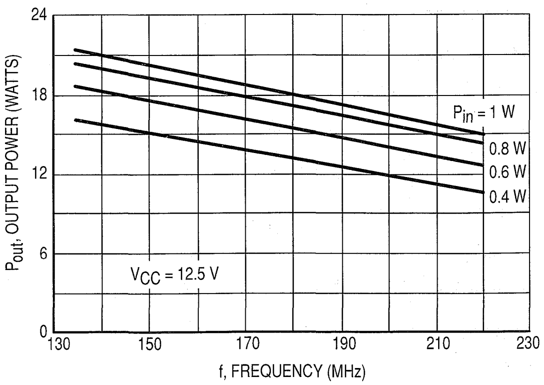


Figure 2. Output Power versus Frequency

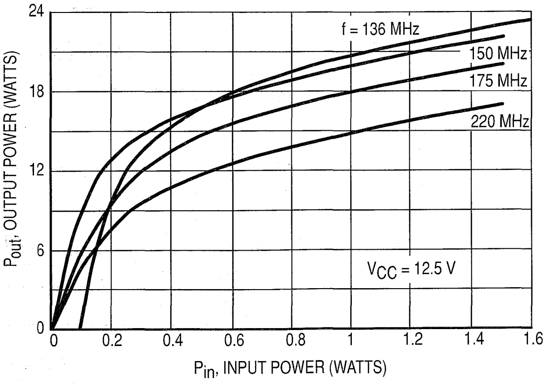


Figure 3. Output Power versus Input Power

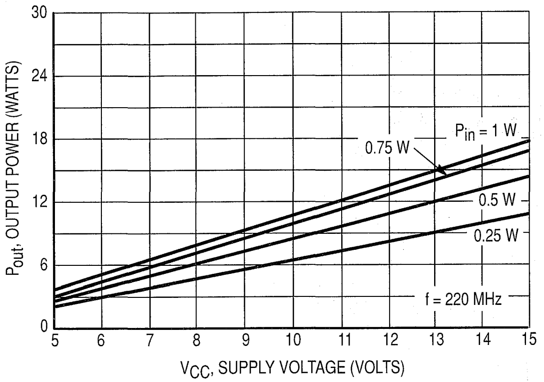


Figure 4. Output Power versus Supply Voltage

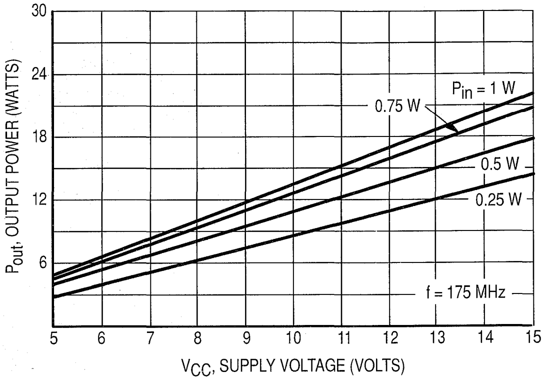


Figure 5. Output Power versus Supply Voltage

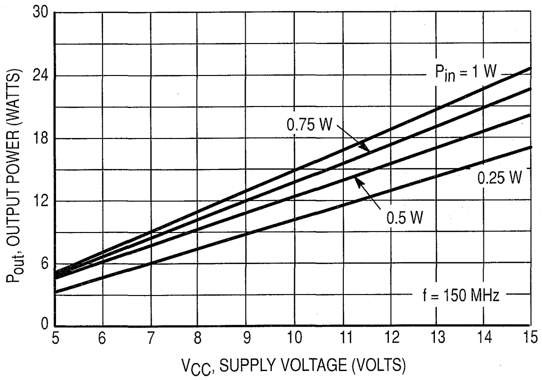


Figure 6. Output Power versus Supply Voltage

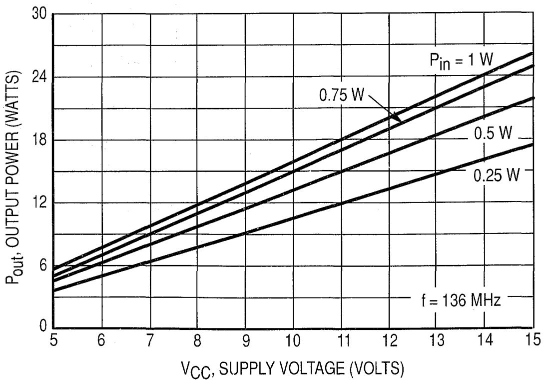


Figure 7. Output Power versus Supply Voltage

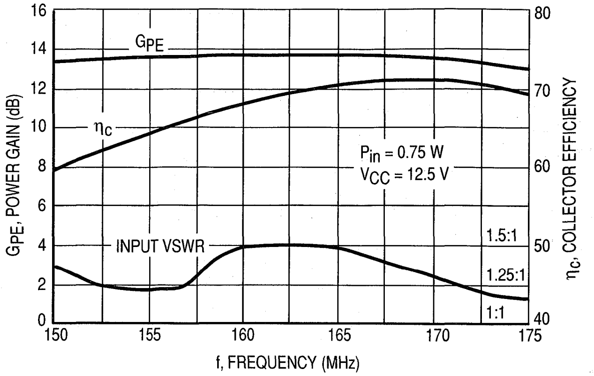
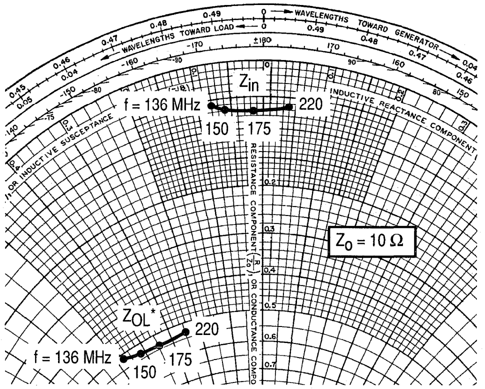


Figure 8. Typical Performance in a Broadband Circuit



V_{CC} = 12.5 V, P_{out} = 15 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
136	0.59 – j0.80	5.07 – j4.76
150	0.68 – j0.61	5.23 – j4.14
175	0.69 – j0.17	5.26 – j3.46
220	0.62 + j0.39	5.25 – j2.46

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 9. Series Equivalent Impedance

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

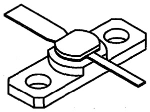
The RF Line
Microwave Linear Power Transistors

MRF3094
MRF3095
MRF3096

9.0–12 dB
1.55–1.65 GHz
0.5–1.6 WATTS
MICROWAVE LINEAR
POWER TRANSISTORS

Designed for Class A, common emitter linear power amplifiers.

- Specified 20 Volt, 1.6 GHz Characteristics
  Output Power — 0.5, 0.8, 1.6 Watts
  Gain — 9.0–12 dB
- Low Parasitic Microwave Stripline Package
- Gold Metallization Diffused Emitter Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 328A–03, STYLE 2

MAXIMUM RATINGS

Rating		Symbol	Limit	Unit
Collector Base Voltage		V_{CES}	50	Vdc
Emitter Base Voltage		V_{EBO}	3.5	Vdc
Collector Emitter Voltage		V_{CEO}	22	Vdc
Collector Current	MRF3094, 3095 MRF3096	I_C	0.4 0.8	Adc
Operating Junction Temperature		T_J	200	°C
Storage Temperature		T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max			Unit
		MRF3094	MRF3095	MRF3096	
Thermal Resistance, Junction to Case	$R_{\theta JC}$	40	35	22	°C/W

REV 7

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA) MRF3094, MRF3095 (I_C = 20 mA) MRF3096	$V_{(BR)CES}$	50	—	—	Vdc
Emitter Base Breakdown Voltage (I_E = 0.25 mA) MRF3094, MRF3095 (I_E = 0.5 mA) MRF3096	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Base Breakdown Voltage (I_C = 1.0 mA) MRF3094, MRF3095 (I_C = 2.0 mA) MRF3096	$V_{(BR)CBO}$	45	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mA) MRF3094, MRF3095 (I_C = 20 mA) MRF3096	$V_{(BR)CEO}$	22	—	—	Vdc
Collector Cutoff Current (V_{CB} = 28 V) MRF3094, MRF3095 MRF3096	I_{CBO}	— —	— —	0.25 0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 5.0 V, I_C = 100 mA) MRF3094, MRF3095 (V_{CE} = 5.0 V, I_C = 200 mA) MRF3096	h_{fe}	20	35	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, f = 1.0 MHz) MRF3094, MRF3095 MRF3096	C_{ob}	— —	— —	3.5 5.5	pF
Functional Tests (V_{CE} = 20 V, I_C = 120 mA, P_o = 0.5 W, f = 1.6 GHz) MRF3094 (V_{CE} = 20 V, I_C = 120 mA, P_o = 0.8 W, f = 1.6 GHz) MRF3095 (V_{CE} = 20 V, I_C = 240 mA, P_o = 1.6 W, f = 1.6 GHz) MRF3096	G_{PE}	10.5 9.0 9.0	11.5 10 9.5	— — —	dB
Output Load Mismatch (V_{CE} = 20 V, I_C = 120 mA, P_o = 0.5 W, f = 1.6 GHz, Load VSWR = ∞:1) MRF3094 (V_{CE} = 20 V, I_C = 120 mA, P_o = 0.8 W, f = 1.6 GHz, Load VSWR = ∞:1) MRF3095 (V_{CE} = 20 V, I_C = 240 mA, P_o = 1.6 W, f = 1.6 GHz, Load VSWR = ∞:1) MRF3096	ψ	No degradation in output power			
Gain Linearity (V_{CE} = 20 V, I_C = 120 mA, f = 1.6 GHz, P_{o1} = 0.5 W, P_{o2} = 0.5 mW) MRF3094 (V_{CE} = 20 V, I_C = 120 mA, f = 1.6 GHz, P_{o1} = 0.8 W, P_{o2} = 0.8 mW) MRF3095 (V_{CE} = 20 V, I_C = 120 mA, f = 1.6 GHz, P_{o1} = 1.6 W, P_{o2} = 1.6 mW) MRF3096	L_G	— — —	— — —	−0.2 to +1.0 −0.2 to +1.0 −0.2 to +1.0	dB

TYPICAL CHARACTERISTICS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ ϕ	Mag	∠ ϕ	Mag	∠ ϕ	Mag	∠ ϕ
20	100	500	0.77	−177.9	6.16	83.7	0.36	31.9	0.32	−57.1
		600	0.78	176.7	5.20	77.2	0.38	32.2	0.30	−60.3
		700	0.78	171.8	4.48	71.1	0.40	33.4	0.29	−62.6
		800	0.78	167.4	3.90	66.3	0.41	35.0	0.29	−67.3
		900	0.79	163.3	3.46	61.2	0.42	36.6	0.28	−70.8
		1000	0.79	159.3	3.11	56.4	0.46	38.1	0.29	−74.5
		1100	0.80	155.7	2.81	52.0	0.48	39.2	0.29	−79.3
		1200	0.80	152.4	2.60	47.5	0.50	40.1	0.29	−83.3
		1300	0.80	149.3	2.40	43.5	0.53	40.7	0.30	−88.3
		1400	0.80	147.1	2.18	40.6	0.57	42.2	0.30	−93.3
		1500	0.81	143.6	2.06	34.3	0.59	41.0	0.30	−97.7
		1600	0.81	140.8	1.92	30.8	0.62	41.9	0.30	−103.4
		1700	0.82	137.9	1.81	27.9	0.66	42.5	0.31	−107.6
		1800	0.82	135.2	1.67	22.7	0.68	41.9	0.32	−112.7
		1900	0.83	132.7	1.61	19.4	0.71	41.9	0.33	−117.8
		2000	0.83	130.2	1.52	16.3	0.75	41.8	0.34	−121.3

Table 1. MRF3094 Common Emitter S–Parameters

MRF3094

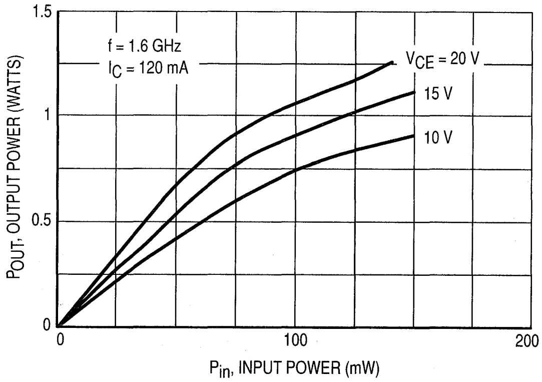


Figure 1. Output Power versus Input Power

f GHz	Z_{in} Ohms		Z_{OL}* Ohms	
	R	jx	R	jx
1.55	5.9	11.9	10.2	0.23
1.60	5.8	11.3	11.3	−2.4
1.65	5.6	10.6	12.4	−6.0

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and power.

Figure 2. Series Equivalent Input and Output Impedance

TYPICAL CHARACTERISTICS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
20	120	500	0.83	−177.4	4.90	71.1	0.29	21.7	0.36	−81.6
		600	0.83	179.6	4.08	64.4	0.30	22.1	0.37	−87.2
		700	0.83	176.9	3.48	59.3	0.31	23.6	0.39	−92.3
		800	0.83	175.0	3.20	52.8	0.34	23.2	0.42	−96.4
		900	0.82	171.6	2.70	48.6	0.33	25.0	0.43	−103.2
		1000	0.82	169.5	2.49	42.3	0.36	24.9	0.46	−107.6
		1100	0.83	167.4	2.26	37.0	0.38	25.2	0.48	−112.5
		1200	0.80	164.3	2.10	29.4	0.39	22.1	0.51	−117.7
		1300	0.81	162.2	1.87	27.9	0.41	25.9	0.54	−121.6
		1400	0.81	160.1	1.77	21.7	0.44	24.4	0.57	−125.3
		1500	0.80	157.8	1.63	15.2	0.45	22.4	0.58	−129.3
		1600	0.80	155.2	1.46	11.1	0.46	22.6	0.61	−131.7
		1700	0.80	152.3	1.42	9.6	0.48	23.9	0.66	−133.9
		1800	0.78	148.5	1.36	2.5	0.53	21.6	0.66	−136.6
		1900	0.77	144.5	1.25	−3.1	0.54	19.7	0.66	−139.3
		2000	0.78	141.0	1.17	−5.6	0.58	20.3	0.67	−141.9

Table 2. MRF3095 Common Emitter S–Parameters

MRF3095

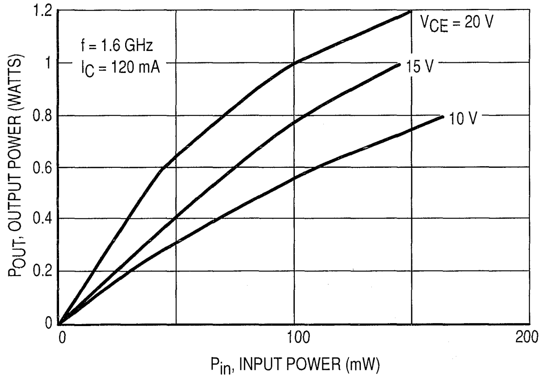


Figure 3. Output Power versus Input Power

f GHz	Z_{in} Ohms		Z_{OL}* Ohms	
	R	jx	R	jx
1.55	5.2	10.6	8.6	−22.4
1.60	4.9	9.9	9.6	−25.4
1.65	4.8	9.3	10.3	−27.8

*Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and power.

Figure 4. Series Equivalent Input and Output Impedance

TYPICAL CHARACTERISTICS

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
20	230	500	0.87	174.6	3.66	65.2	0.31	17.2	0.34	−133.0
		600	0.88	171.1	3.01	57.8	0.32	18.9	0.36	−137.4
		700	0.88	167.9	2.56	50.9	0.33	20.5	0.39	−140.0
		800	0.88	165.2	2.21	44.9	0.36	21.9	0.41	−143.0
		900	0.88	161.8	1.92	37.8	0.37	23.6	0.44	−145.8
		1000	0.88	158.9	1.72	32.7	0.39	24.7	0.48	−149.2
		1100	0.88	156.0	1.54	26.3	0.40	25.8	0.50	−152.4
		1200	0.88	153.2	1.39	20.5	0.42	25.7	0.53	−156.2
		1300	0.88	150.6	1.28	15.2	0.44	26.5	0.56	−158.6
		1400	0.88	147.9	1.15	10.3	0.50	27.2	0.58	−162.9
		1500	0.88	146.2	1.06	4.8	0.50	26.6	0.60	−166.1
		1600	0.88	143.2	0.98	−1.0	0.52	26.4	0.64	−170.4
		1700	0.89	140.9	0.90	−4.2	0.54	27.3	0.65	−173.3
		1800	0.88	138.5	0.84	−10.5	0.58	25.4	0.67	−175.9
		1900	0.88	136.0	0.79	−15.2	0.59	24.2	0.67	179.1
		2000	0.88	133.6	0.73	−16.6	0.64	26.2	0.69	178.6

Table 3. MRF3096 Common Emitter S–Parameters

MRF3096

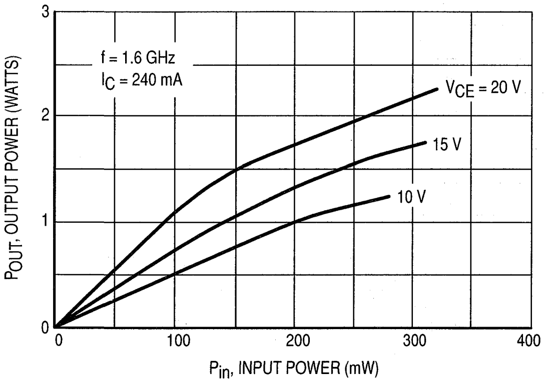


Figure 5. Output Power versus Input Power

f GHz	Z_{in} Ohms		Z_{OL}* Ohms	
	R	jx	R	jx
1.55	2.9	6.1	8.2	−12.0
1.60	3.0	5.2	8.5	−12.8
1.65	2.7	4.6	8.9	−14.3

Z_{OL} = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and power.

Figure 6. Series Equivalent Input and Output Impedance

MRF3104
MRF3105
MRF3106

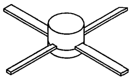
The RF Line
Microwave Linear Power Transistors

- Designed for Class A, Common Emitter Linear Power Amplifiers.
- Specified 20 Volt, 1.6 GHz Characteristics:

	MRF3104	MRF3105	MRF3106
Output Power	0.5 W	0.8 W	1.6 W
Power Gain	10.5 dB	9 dB	8 dB

- Low Parasitic Microwave Stripline Package
- Gold Metalization for Improved Reliability
- Diffused Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

8.0–12 dB GAIN
1.55–1.65 GHz
MICROWAVE LINEAR
POWER TRANSISTORS



CASE 305A–01, STYLE 1
(.204″ PILL)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	22	Vdc
Collector–Emitter Voltage	V_{CES}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current MRF3104, MRF3105 MRF3106	I_C	0.4 0.8	Adc
Operating Junction Temperature	T_j	200	°C
Storage Temperature	T_{stg}	−65 to +125	°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Case, DC	MRF3104 MRF3105 MRF3106	$R_{\theta JC}$ (DC)	40 35 22	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	BV_{CEO}	22	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mA, V_{BE} = 0)	BV_{CES}	50	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1 mA, I_E = 0)	BV_{CBO}	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.25 mA, I_C = 0)	BV_{EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 28 V, I_E = 0) MRF3104, MRF3105 MRF3106	I_{CBO}	— —	— —	0.25 0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 5.0 V, I_C = 100 mA)	h_{FE}	20	35	120	—

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued

Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	MRF3104	C_{OB}	—	—	1.5	pF
	MRF3105		—	—	3.5	
	MRF3106		—	—	5.5	
FUNCTIONAL TESTS						
Common Emitter Amplifier Gain		Gpe				dB
(V_{CE} = 20 V, I_C = 120 mA, P_{out} = 0.5 W, f = 1.6 GHz)	MRF3104		10.5	11.5	—	
(V_{CE} = 20 V, I_C = 120 mA, P_{out} = 0.8 W, f = 1.6 GHz)	MRF3105		9.0	10.0	—	
(V_{CE} = 20 V, I_C = 240 mA, P_{out} = 1.6 W, f = 1.6 GHz)	MRF3106		8.0	9.0	—	
Output Load Mismatch						
(V_{CE} = 20 V, I_C = 120 mA, P_{out} = 0.5 W, f = 1.6 GHz)	MRF3104	No Degradation in Output Power				—
(V_{CE} = 20 V, I_C = 120 mA, P_{out} = 0.8 W, f = 1.6 GHz)	MRF3105					—
(V_{CE} = 20 V, I_C = 240 mA, P_{out} = 1.6 W, f = 1.6 GHz)	MRF3106					—
Gain Linearity		L_G				dB
(V_{CE} = 20 V, I_C = 120 mA, f = 1.6 GHz, P_{o1} = 0.5 W, P_{o2} = 0.5 mW)	MRF3104		—	—	–0.2 to 1.0	
(V_{CE} = 20 V, I_C = 120 mA, f = 1.6 GHz, P_{o1} = 0.8 W, P_{o2} = 0.5 mW)	MRF3105		—	—	–0.2 to 1.0	
(V_{CE} = 20 V, I_C = 240 mA, f = 1.6 GHz, P_{o1} = 1.6 W, P_{o2} = 0.5 mW)	MRF3106		—	—	–0.2 to 1.0	

TYPICAL CHARACTERISTICS

MRF3104

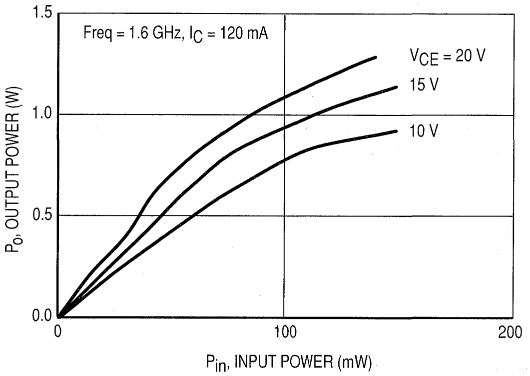


Figure 1. Output Power versus Input Power

V_{CE} (V)	I_C (mA)	f (MHz)	S11		S21		S12		S22	
			Mag	Deg	Mag	Deg	Mag	Deg	Mag	Deg
20	120	1550	0.75	123	1.97	21	0.08	44	0.31	–113
		1575	0.76	123	1.93	20	0.09	44	0.32	–115
		1600	0.76	122	1.91	19	0.09	43	0.32	–116
		1625	0.76	122	1.80	18	0.09	42	0.32	–117
		1650	0.76	121	1.85	17	0.09	42	0.33	–119

Table 1. Common Emitter S–Parameters

TYPICAL CHARACTERISTICS — continued

MRF3105

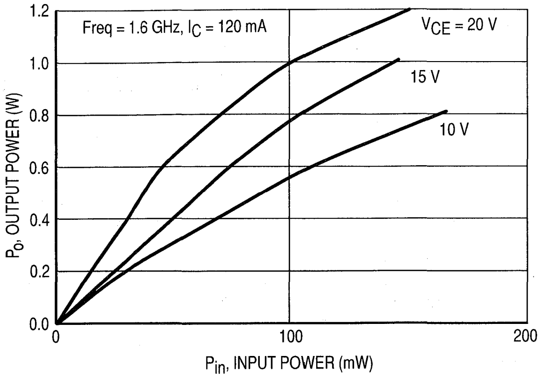


Figure 2. Output Power versus Input Power

V_{CE} (V)	I_C (mA)	f (MHz)	S11		S21		S12		S22	
			Mag	Deg	Mag	Deg	Mag	Deg	Mag	Deg
20	120	1550	0.75	139	1.49	19	0.09	44	0.42	–124
		1575	0.75	138	1.46	18	0.10	43	0.42	–126
		1600	0.75	137	1.44	17	0.10	43	0.43	–127
		1625	0.75	137	1.42	15	0.10	43	0.43	–129
		1650	0.75	136	1.39	14	0.10	42	0.44	–130

Table 2. Common Emitter S–Parameters

MRF3106

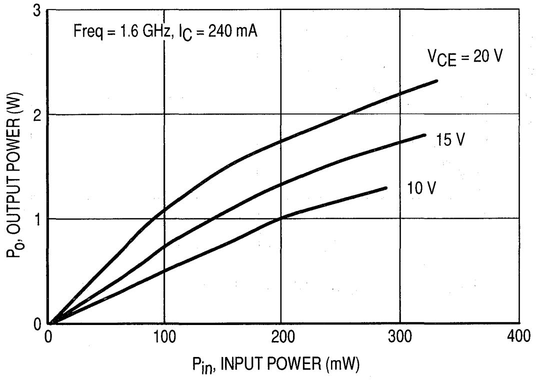


Figure 3. Output Power versus Input Power

V_{CE} (V)	I_C (mA)	f (MHz)	S11		S21		S12		S22	
			Mag	Deg	Mag	Deg	Mag	Deg	Mag	Deg
20	240	1550	0.97	145	0.78	11	0.20	–130	0.56	169
		1575	0.97	143	0.78	10	0.17	–104	0.56	168
		1600	0.96	142	0.77	9	0.16	–104	0.56	166
		1625	0.96	140	0.76	8	0.14	–104	0.56	165
		1650	0.95	139	0.75	7	0.12	–104	0.56	164

Table 3. Common Emitter S–Parameters

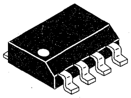
The RF Line
NPN Silicon RF Low Power Transistor

MRF4427, R2

Designed for amplifier, frequency multiplier, or oscillator applications in industrial equipment constructed with surface mount components. Suitable for use as output driver or pre–driver stages in VHF and UHF equipment.

- Low Cost SORF Plastic Surface Mount Package
- Guaranteed RF Specification — $|S_{21}|^2$
- S–Parameter Characterization
- Low Voltage Version of MRF3866
- Tape and Reel Packaging Options Available by adding R2 suffix.
  R2 suffix = 2,500 units per reel

**1.0 W, 175 MHz
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON**



**CASE 751–05, STYLE 1
SORF
(SO–8)**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	20	Vdc
Collector–Base Voltage	V_{CBO}	40	Vdc
Emitter–Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	1.67 22.2	Watts mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W

DEVICE MARKING

MRF4427 = 4427

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	20	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{(BR)CER}$	40	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 100 μAdc)	$V_{(BR)EBO}$	2.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	—	—	20	μAdc

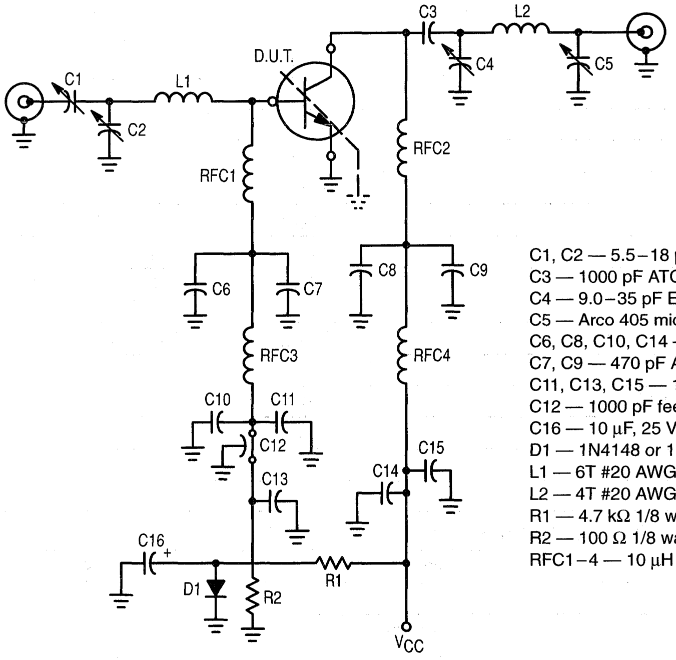
(continued)

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10 5.0	50 —	200 —	—
Collector–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	—	60	—	mVdc
DYNAMIC CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 12 Vdc, f = 200 MHz)	f_T	—	1600	—	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	3.0	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (P_{in} = 15 mW, V_{CC} = 12 Vdc, f = 175 MHz)	G_{pe}	—	18	—	dB
Collector Efficiency (Figure 1) (P_{out} = 1.0 W, V_{CC} = 12 Vdc, f = 175 MHz)	η	—	60	—	%
Insertion Gain (V_{CE} = 12 Vdc, I_C = 50 mA, f = 200 MHz)	$\lvert S_{21}\rvert^2$	14	16.4	—	dB



C1, C2 — 5.5–18 pF Erie ceramic trimmer
C3 — 1000 pF ATC 100 mil chip cap.
C4 — 9.0–35 pF Erie ceramic trimmer
C5 — Arco 405 mica trimmer
C6, C8, C10, C14 — 0.1 µF Erie blue cap.
C7, C9 — 470 pF ATC 100 mil chip cap.
C11, C13, C15 — 1.0 µF Erie blue cap, non–polar
C12 — 1000 pF feedthru
C16 — 10 µF, 25 V tantalum
D1 — 1N4148 or 1N914
L1 — 6T #20 AWG on #2 drill bit
L2 — 4T #20 AWG on #4 drill bit
R1 — 4.7 kΩ 1/8 watt carbon
R2 — 100 Ω 1/8 watt carbon
RFC1–4 — 10 µH molded choke

Figure 1. 175 MHz RF Amplifier Circuit for Functional Tests

TYPICAL CHARACTERISTICS

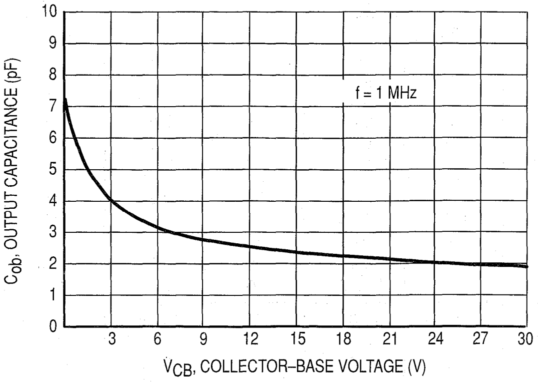


Figure 2. Collector–Base Capacitance versus Voltage

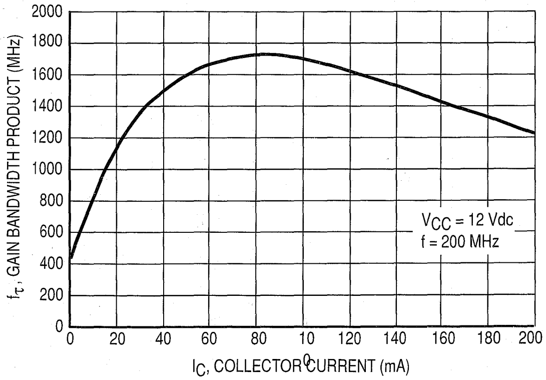


Figure 3. Gain Bandwidth Product versus Collector Current

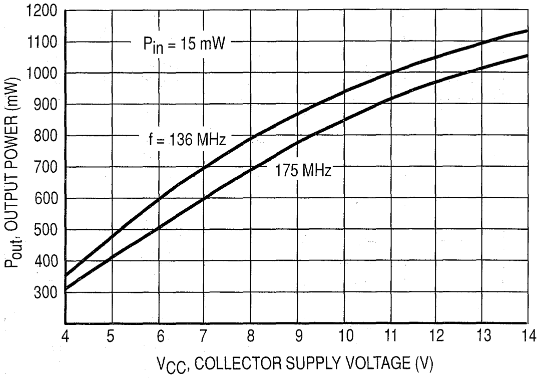


Figure 4. Output Power versus Voltage

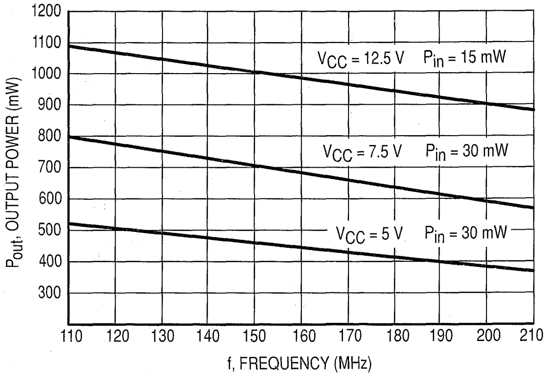


Figure 5. Output Power versus Frequency

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
5.0	5.0	50	0.82	−104	10.3	125	0.05	38	0.68	−34
		100	0.83	−141	6.1	103	0.06	26	0.51	−40
		200	0.81	−165	3.2	85	0.07	21	0.44	−46
		500	0.80	169	1.3	57	0.07	32	0.49	−73
		750	0.79	156	0.8	42	0.08	49	0.58	−94
		1000	0.76	144	0.6	30	0.11	61	0.65	−114
	25	50	0.77	−151	19	107	0.02	36	0.35	−75
		100	0.79	−168	9.9	94	0.03	37	0.21	−87
		200	0.79	−180	5.0	82	0.04	49	0.16	−97
		500	0.78	163	2.0	61	0.07	62	0.22	−106
		750	0.77	152	1.3	48	0.10	66	0.31	−115
		1000	0.74	141	0.9	36	0.13	66	0.37	−127
	50	50	0.77	−163	21.1	103	0.02	37	0.29	−98
		100	0.79	−174	10.7	92	0.02	50	0.19	−119
		200	0.79	177	5.4	82	0.03	62	0.16	−134
		500	0.78	162	2.2	62	0.07	67	0.20	−131
		750	0.77	151	1.4	50	0.10	69	0.26	−130
		1000	0.74	140	1.1	38	0.13	67	0.32	−139
12	5.0	50	0.83	−97	11	129	0.04	46	0.75	−26
		100	0.82	−135	6.8	107	0.05	29	0.61	−29
		200	0.81	−162	3.6	88	0.05	24	0.54	−34
		500	0.79	171	1.4	60	0.06	37	0.47	−57
		750	0.78	157	0.9	44	0.07	55	0.64	−76
		1000	0.75	145	0.7	32	0.09	68	0.70	−95
	25	50	0.73	−143	22.1	111	0.02	38	0.43	−52
		100	0.76	−164	11.7	96	0.02	39	0.29	−52
		200	0.77	−177	6.0	84	0.03	48	0.22	−53
		500	0.76	165	2.4	63	0.06	64	0.27	−69
		750	0.75	154	1.6	49	0.08	67	0.35	−84
		1000	0.72	143	1.1	38	0.11	69	0.42	−98
	50	50	0.73	−156	25.5	106	0.02	41	0.32	−67
		100	0.75	−171	13.1	94	0.02	49	0.20	−69
		200	0.76	59	6.6	83	0.03	60	0.15	−71
		500	0.75	164	2.6	64	0.06	69	0.20	−81
		750	0.74	153	1.7	51	0.09	70	0.27	−92
		1000	0.71	142	1.2	38	0.12	70	0.34	−104

Table 1. Common Emitter S–Parameters

Freq. (MHz)	P_{in} (mW)	P_{out} (mW)	V_{CC} (Volts)	Z_{in} (Ohms)	Z_{OL}* (Ohms)
136	15	—	12.5	6.2 – j11.6	—
175	15	—	12.5	4.6 – j10.4	—
136	—	1000	12.5	—	47.7 + j41.7
175	—	1000	12.5	—	47.4 – j34.4
136	30	—	7.5	5.65 – j12.6	—
175	30	—	7.5	6.25 – j12.2	—
136	—	650	7.5	—	27.6 – j32.4
175	—	650	7.5	—	27.9 – j27.6
136	30	—	5.0	6.1 – j13.3	—
175	30	—	5.0	5.9 – j12.22	—
136	—	450	5.0	—	24.8 – j22.8
175	—	450	5.0	—	28.3 – j29.3

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Table 2. Series Input/Output Impedances

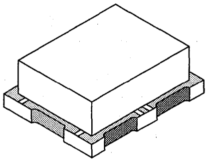
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode

MRF5003

The MRF5003 is designed for broadband commercial and industrial applications at frequencies to 520 MHz. The high gain and broadband performance of this device makes it ideal for large–signal, common source amplifier applications in 7.5 Volt and 12.5 Volt mobile, portable, and base station FM equipment.

- Guaranteed Performance at 512 MHz, 7.5 Volts
  Output Power = 3.0 Watts
  Power Gain = 9.5 dB
  Efficiency = 45%
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- S–Parameter Characterization at High Bias Levels
- Excellent Thermal Stability
- All Gold Metal for Ultra Reliability
- Capable of Handling 20:1 VSWR, @ 15.5 Vdc, 512 MHz, 2.0 dB Overdrive
- Suitable for 12.5 Volt Applications
- True Surface Mount Package
- Available in Tape and Reel by Adding R1 Suffix to Part Number.
  R1 Suffix = 500 Units per 16 mm, 7 inch Reel.
- Circuit board photomaster available upon request by contacting
  RF Tactical Marketing in Phoenix, AZ.

3.0 W, 7.5 V, 512 MHz
N–CHANNEL
BROADBAND
RF POWER FET



CASE 430–01, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	36	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 Meg Ohm)	V_{DGR}	36	Vdc
Gate–Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous	I_D	1.7	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	12.5 0.07	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

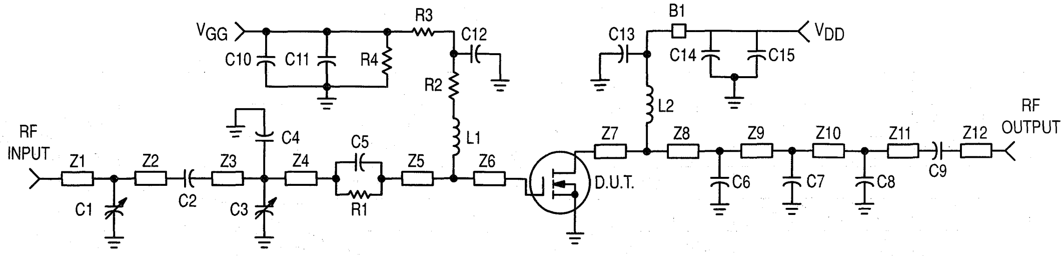
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	14	°C/W

NOTE – **CAUTION** – MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 2.5 mAdc)	$V_{(BR)DSS}$	36	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	—	—	1.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	1.0	µAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 5.0 mAdc)	$V_{GS(th)}$	1.25	2.25	3.5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 0.5 Adc)	$V_{DS(on)}$	—	—	0.375	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 0.5 Adc)	g_{fs}	0.6	—	—	mho
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	16.5	—	pF
Output Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	37	—	pF
Reverse Transfer Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	3.5	4.4	5.4	pF
FUNCTIONAL TESTS (In Motorola Test Fixture)					
Common–Source Amplifier Power Gain	G_{ps}				dB
(V_{DD} = 7.5 Vdc, P_{out} = 3.0 W, I_{DQ} = 50 mA) f = 512 MHz		9.5	10.5	—	
f = 175 MHz		—	15	—	
Drain Efficiency	h				%
(V_{DD} = 7.5 Vdc, P_{out} = 3.0 W, I_{DQ} = 50 mA) f = 512 MHz		45	50	—	
f = 175 MHz		—	55	—	



C1, C3, C7, C8	0 to 20 pF Johanson
C2, C9	56 pF, 100 mil Chip
C4	10 pF, 100 mil Chip
C5	47 pF, Miniature Clamped Mica Capacitor
C6	22 pF, 100 mil Chip
C10, C15	10 µF, 50 V, Electrolytic
C11, C14	0.1 µF, Capacitor
C12	1000 pF, 100 mil Chip
C13	160 pF, 100 mil Chip
R1	35 Ω, 1/4 W Carbon
R2	30 Ω, 0.1 W Chip
R3	1.0 kΩ, 0.1 W Chip
R4	1.0 MΩ, 1/4 W Carbon
B1	Fair Rite Products Short Ferrite Bead (2743021446)

Board — Glass Teflon®, 31 mils

Note: Plated ceramic part locators (0.1″ x 0.15″) soldered onto Z6 and Z7.

Z1	0.350″ x 0.08″ Microstrip
Z2	0.190″ x 0.08″ Microstrip
Z3	0.800″ x 0.08″ Microstrip
Z4	0.380″ x 0.08″ Microstrip
Z5	0.150″ x 0.08″ Microstrip
Z6	0.285″ x 0.08″ Microstrip
Z7	0.340″ x 0.08″ Microstrip
Z8	0.070″ x 0.08″ Microstrip
Z9	0.280″ x 0.08″ Microstrip
Z10	0.840″ x 0.08″ Microstrip
Z11	0.180″ x 0.08″ Microstrip
Z12	0.600″ x 0.08″ Microstrip
L1	7 Turns, 0.076″ ID, #24 AWG Enamel
L2	5 Turns, 0.126″ ID, #20 AWG Enamel

Input/Output Connectors — Type N

Figure 1. 512 MHz Narrowband Test Circuit

TYPICAL CHARACTERISTICS

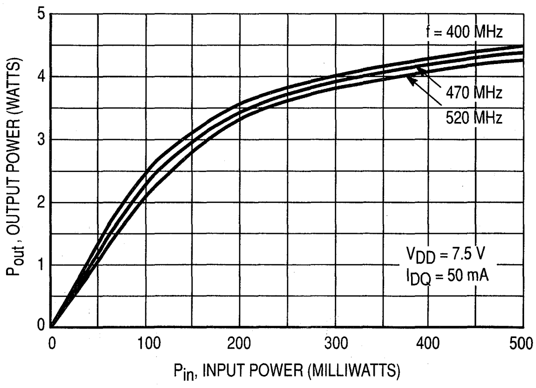


Figure 2. Output Power versus Input Power

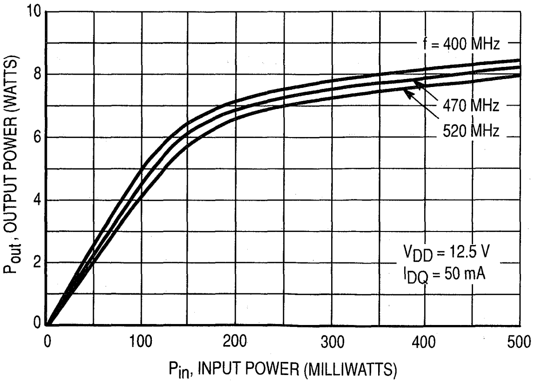


Figure 3. Output Power versus Input Power

TYPICAL CHARACTERISTICS

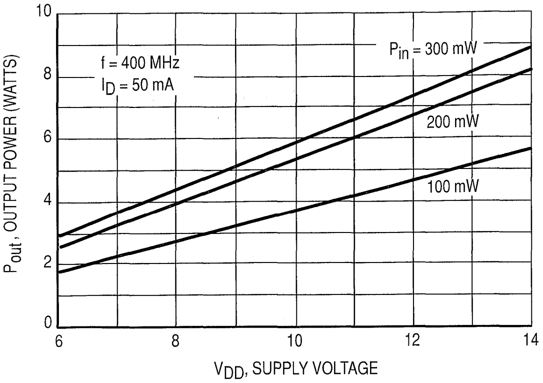


Figure 4. Output Power versus Supply Voltage

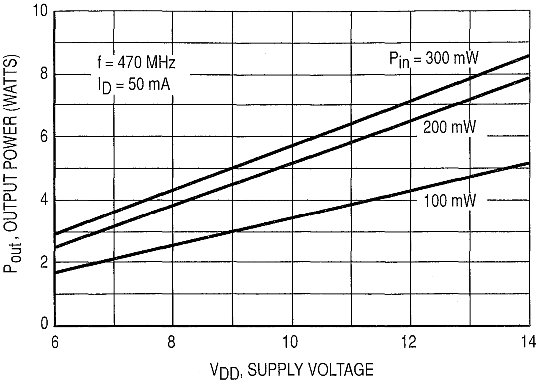


Figure 5. Output Power versus Supply Voltage

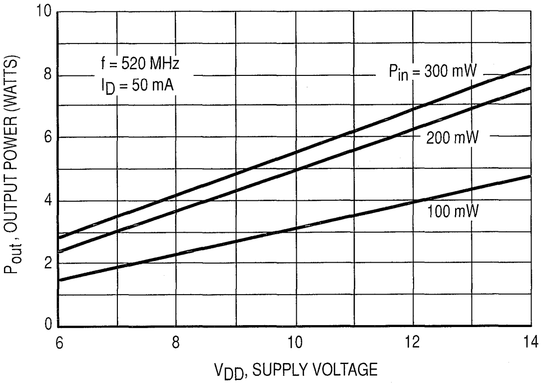


Figure 6. Output Power versus Supply Voltage

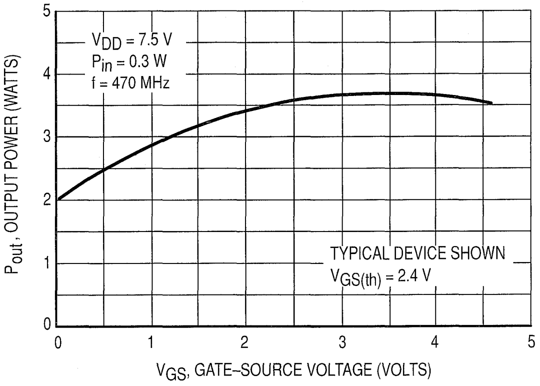


Figure 7. Output Power versus Gate Voltage

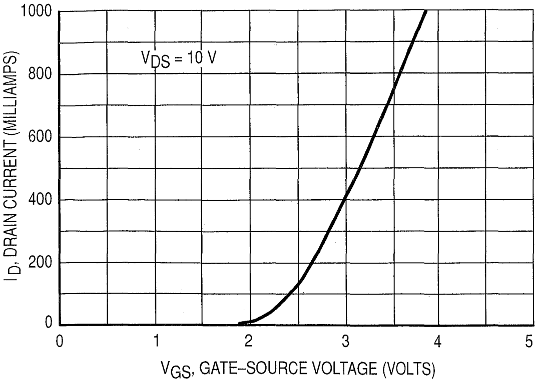


Figure 8. Drain Current versus Gate Voltage (Typical Device Shown)

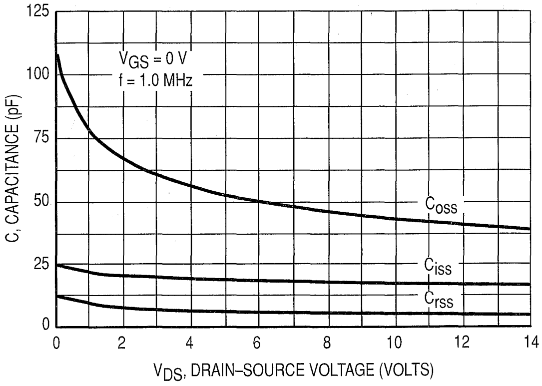


Figure 9. Capacitance versus Voltage

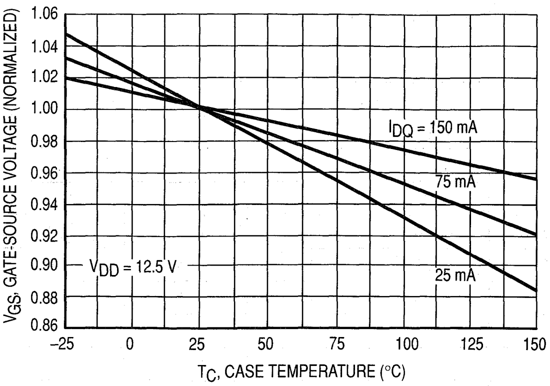


Figure 10. Gate–Source Voltage versus Case Temperature

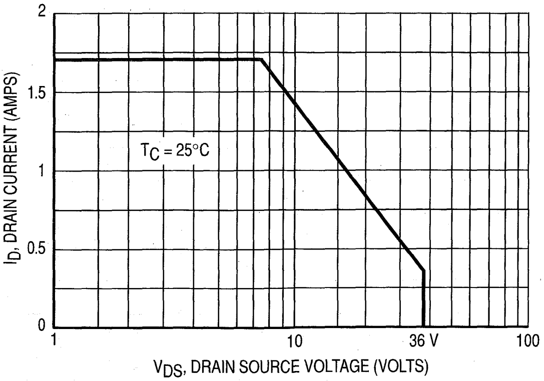
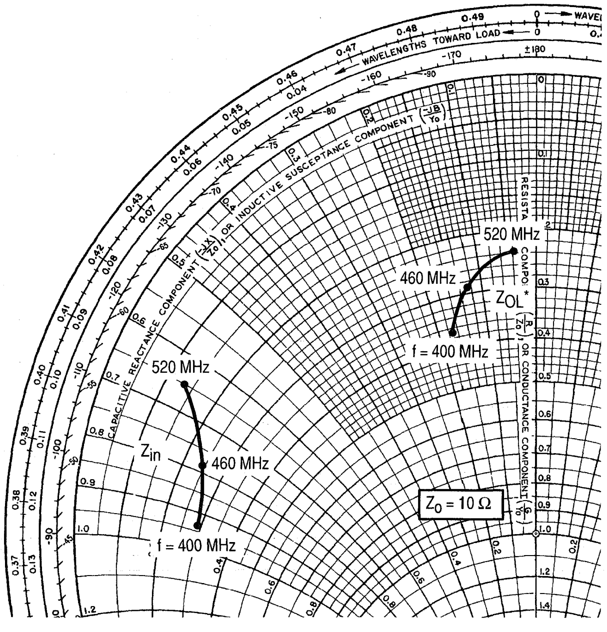


Figure 11. Maximum Rated Forward Biased Safe Operating Area



V_{DD} = 7.5 V, I_{DQ} = 50 mA, P_{out} = 3.0 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
400	2.8 – j9.2	3.6 – j1.7
430	2.7 – j8.5	3.3 – j1.5
460	2.5 – j7.8	2.7 – j1.1
490	2.0 – j7.2	2.5 – j0.8
520	1.3 – j6.5	2.4 – j0.5

Z_{in} = Conjugate of source impedance with parallel 35 Ω resistor and 47 pF capacitor in series with gate.

Z_{OL}* = Conjugate of the load impedance at given output power, voltage, frequency, and η_D > 50%.

Note: Z_{ol}* was chosen based on tradeoffs between gain, drain efficiency, and device stability.

Figure 12. Series Equivalent Input and Output Impedance

Table 1. Common Source Scattering Parameters (V_{DS} = 10 V)

I_D = 50 mA

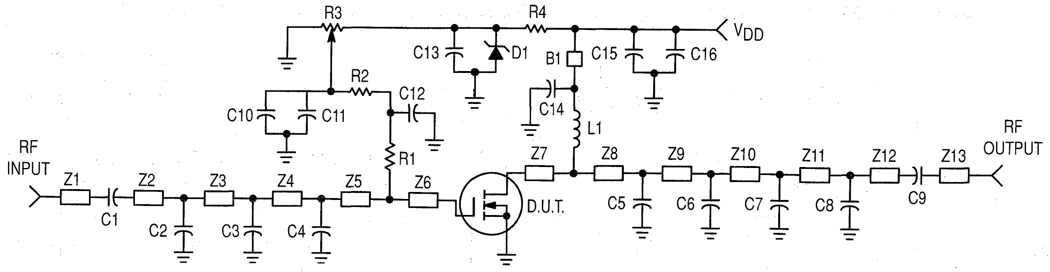
f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$|S_{11}|$	$\angle\phi$	$|S_{21}|$	$\angle\phi$	$|S_{12}|$	$\angle\phi$	$|S_{22}|$	$\angle\phi$
50	0.69	−90	10.8	117	0.07	29	0.74	−119
100	0.58	−120	6.0	96	0.08	10	0.78	−146
200	0.58	−139	3.0	75	0.08	−7	0.81	−161
300	0.64	−147	1.9	61	0.07	−16	0.84	−166
400	0.70	−152	1.3	50	0.06	−21	0.86	−169
500	0.75	−157	0.99	41	0.05	−24	0.88	−172
700	0.82	−165	0.61	28	0.03	−15	0.92	−176
850	0.86	−171	0.45	21	0.02	13	0.94	−179
1000	0.89	−176	0.34	16	0.02	47	0.95	178

I_D = 500 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$|S_{11}|$	$\angle\phi$	$|S_{21}|$	$\angle\phi$	$|S_{12}|$	$\angle\phi$	$|S_{22}|$	$\angle\phi$
50	0.76	−124	15.0	109	0.04	23	0.76	−151
100	0.72	−150	7.9	94	0.04	12	0.81	−165
200	0.72	−163	4.0	80	0.04	6	0.83	−172
300	0.73	−168	2.6	71	0.04	5	0.84	−175
400	0.75	−171	1.9	62	0.04	7	0.85	−176
500	0.77	−173	1.5	55	0.03	12	0.86	−178
700	0.81	−177	0.97	42	0.03	29	0.89	−180
850	0.84	−180	0.75	35	0.03	44	0.90	178
1000	0.86	177	0.60	29	0.04	55	0.92	176

I_D = 1.0 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$|S_{11}|$	$\angle\phi$	$|S_{21}|$	$\angle\phi$	$|S_{12}|$	$\angle\phi$	$|S_{22}|$	$\angle\phi$
50	0.80	−125	14.6	110	0.04	23	0.75	−155
100	0.76	−150	7.8	95	0.04	10	0.81	−167
200	0.76	−164	3.9	81	0.04	1	0.83	−173
300	0.77	−169	2.6	71	0.04	−3	0.84	−175
400	0.79	−172	1.9	63	0.03	−5	0.85	−176
500	0.80	−174	1.4	56	0.03	−5	0.86	−177
700	0.83	−178	0.95	43	0.03	−1	0.88	−179
850	0.85	179	0.73	35	0.02	9	0.90	179
1000	0.87	177	0.58	28	0.02	22	0.91	178



C1, C9	100 pF 100 mil Chip
C2	16 pF, 100 mil Chip
C3	24 pF, 100 mil Chip
C4	68 pF, 100 mil Chip
C5	51 pF, 100 mil Chip
C6	39 pF, 100 mil Chip
C7	6.2 pF, 100 mil Chip
C8	9.1 pF, 100 mil Chip
C10, C15	39000 pF, 100 mil Chip
C11, C16	10 μF, 50 V Electrolytic
C12	10000 pF, 100 mil Chip
B1	Fair Rite Products Short Ferrite Bead (2743021446)

C13	0.1 μF, 100 mil Chip
C14	160 pF, 100 mil Chip
R1	43 Ω, 0.1 W Chip Resistor
R2	1000 Ω, 0.1 W Chip Resistor
R3	10 kΩ Potentiometer
R4	3000 Ω, 0.1 W Chip Resistor
L1	5 Turns, 0.126″ ID, #20 AWG Enamel
Z1 to Z13	See Photomaster
D1	1N4734 Motorola Zener

Board — G10, 1/32″
Input/Output Connectors — SMA

Figure 13. Schematic of Broadband Demonstration Amplifier

PERFORMANCE CHARACTERISTICS OF BROADBAND DEMONSTRATION AMPLIFIER

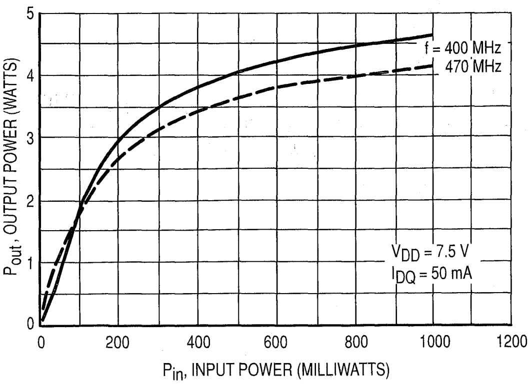


Figure 14. Output Power versus Input Power

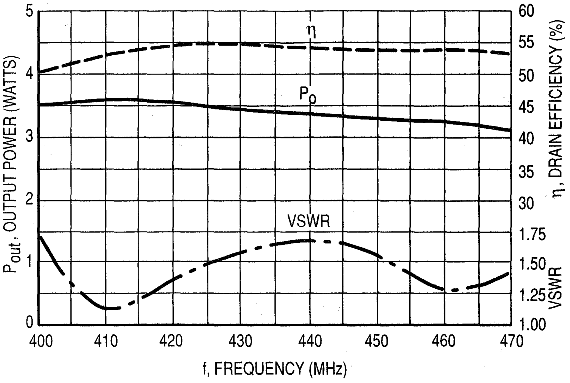


Figure 15. Output Power, Drain Efficiency and VSWR versus Frequency

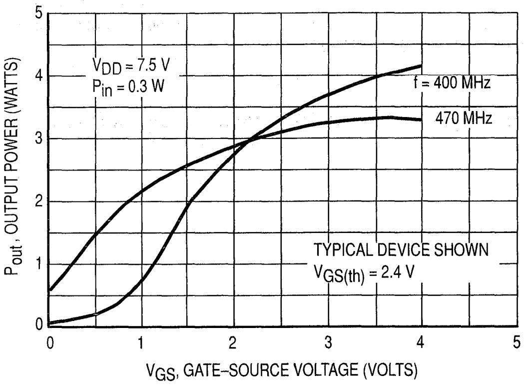


Figure 16. Output Power versus Gate Voltage

DESIGN CONSIDERATIONS

The MRF5003 is a common–source, RF power, N–Channel enhancement mode, Metal–Oxide Semiconductor Field–Effect Transistor (MOSFET). Motorola RF MOSFETs feature a vertical structure with a planar design. Motorola Application Note AN211A, “FETs in Theory and Practice”, is suggested reading for those not familiar with the construction and characteristics of FETs.

This surface mount packaged device was designed primarily for VHF and UHF power amplifier applications. Manufacturability is improved by utilizing the tape and reel capability for fully automated pick and placement of parts.

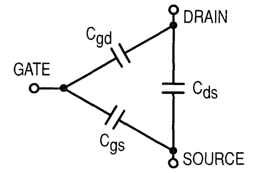
The major advantages of RF power MOSFETs include high gain, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage.

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between all three terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}). These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate.

In the latter case, the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$C_{iss} = C_{gd} + C_{gs}$
$C_{oss} = C_{gd} + C_{ds}$
$C_{rss} = C_{gd}$

DRAIN CHARACTERISTICS

One critical figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $R_{DS(on)}$, occurs in the linear region of the output characteristic and is specified at a specific gate–source voltage and drain current. The drain–source voltage under these conditions is termed $V_{DS(on)}$. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient at high temperatures because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of $10^9\ \Omega$ — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage to the gate greater than the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended with appropriate RF decoupling.

Using a resistor to keep the gate–to–source impedance low also helps dampen transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

DC BIAS

Since the MRF5003 is an enhancement mode FET, drain current flows only when the gate is at a higher potential than the source. See Figure 8 for a typical plot of drain current versus gate voltage. RF power FETs operate optimally with a quiescent drain current (I_{DQ}), whose value is application dependent. The MRF5003 was characterized at I_{DQ} = 50 mA, which is the suggested value of bias current for typical applications. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF5003 may be controlled from its rated value down to zero (negative gain) with a low power dc control signal, thus facilitating applications such as manual gain control, ALC/AGC and modulation systems. Figure 16 is an example of output power variation with gate–source bias voltage. This characteristic is very dependent on frequency and load line.

MOUNTING

The specified maximum thermal resistance of 14°C/W assumes a majority of the 0.100″ x 0.200″ source contact on the back side of the package is in good contact with an appropriate heat sink. In the test fixture shown in Figure 1, the device is clamped directly to a copper pedestal. In the demonstration amplifier, the device was mounted on top of the G10 circuit board and heat removal was accomplished through several solder filled plated through holes. As with all RF power devices, the goal of the thermal design should be to minimize the temperature at the back side of the package.

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar transistors are suitable for the MRF5003. For examples see Motorola Application Note AN721, “Impedance Matching Networks Applied to RF Power Transistors”. Both small–signal S–parameters and large–signal impedances are provided. While the S–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF power MOSFETs.

Since RF power MOSFETs are triode devices, they are not unilateral. This coupled with the very high gain of the MRF5003 yield a device capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. Different stabilizing techniques were applied to the test fixture and demonstration amplifiers. The RF test fixture implements a parallel resistor and capacitor in series with the gate while the demonstration amplifier utilizes a 43 Ω shunt resistor from gate to ground. Both circuits have a load line selected for a higher efficiency, lower gain, and more stable operating region.

Two port stability analysis with the MRF5003 S–parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A, “RF Small–Signal Design Using Two–Port Parameters”, for a discussion of two port network theory and stability.

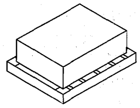
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode

MRF5007

7.0 W, 7.5 Vdc
512 MHz
N–CHANNEL
BROADBAND
RF POWER FET

The MRF5007 is designed for broadband commercial and industrial applications at frequencies to 520 MHz. The high gain and broadband performance of this device makes it ideal for large–signal, common source amplifier applications in 7.5 Volt portable FM equipment.

- Guaranteed Performance at 512 MHz, 7.5 Volts
  Output Power = 7.0 Watts
  Power Gain = 10 dB Min
  Efficiency = 50% Min
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- S–Parameter Characterization at High Bias Levels
- Excellent Thermal Stability
- All Gold Metal for Ultra Reliability
- Capable of Handling 20:1 VSWR, @ 10 Vdc, 512 MHz, 2.0 dB Overdrive
- True Surface Mount Package
- Available in Tape and Reel by Adding R1 Suffix to Part Number.
  R1 Suffix = 500 Units per 16 mm, 7 inch Reel.



CASE 430B–01, Style 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	25	Vdc
Drain–Gate Voltage (R_{GS} = 1.0 Meg Ohm)	V_{DGR}	25	Vdc
Gate–Source Voltage	V_{GS}	±20	Vdc
Drain Current — Continuous	I_D	4.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.14	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

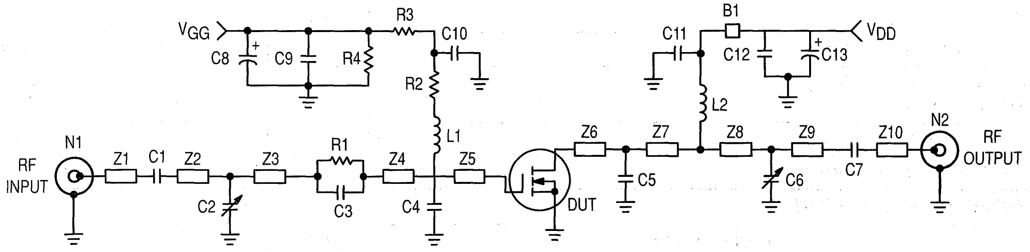
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.8	°C/W

NOTE – **CAUTION** – MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 2.5 mAdc)	$V_{(BR)DSS}$	25	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	—	—	1.0	mAdc
Gate–Source Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc)	$V_{GS(th)}$	1.25	2.2	3.5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 1.0 Adc)	$V_{DS(on)}$	—	—	0.3	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 1.0 Adc)	g_{fs}	0.9	—	—	S
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 7.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	32	—	pF
Output Capacitance (V_{DS} = 7.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	63	—	pF
Reverse Transfer Capacitance (V_{DS} = 7.5 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	10	13	16	pF
FUNCTIONAL TESTS (In Motorola Test Fixture)					
Common–Source Amplifier Power Gain f = 512 MHz (V_{DD} = 7.5 Vdc, P_{out} = 7.0 W, I_{DQ} = 75 mA)	G_{ps}	10	11.5	—	dB
Drain Efficiency f = 512 MHz (V_{DD} = 7.5 Vdc, P_{out} = 7.0 W, I_{DQ} = 75 mA)	η	50	55	—	%



B1	Fair Rite Products Short Ferrite Bead (2743021446)
C1, C7	100 pF, 100 mil Chip
C2, C6	0–20 pF, Johanson
C3	47 pF, Miniature Clamped Mica Capacitor
C4	16 pF, Miniature Clamped Mica Capacitor
C5	21 pF, Miniature Clamped Mica Capacitor
C8, C13	10 μF, 50 V, Electrolytic
C9, C12	0.1 μF, Chip Capacitor
C10	1000 pF, 100 mil Chip
C11	140 pF, 100 mil Chip
L1	7 Turns, 0.076″ ID, #24 AWG Enamel
L2	5 Turns, 0.126″ ID, #20 AWG Enamel
N1, N2	Type N Flange Mount
R1	39 Ω, 1/4 W Carbon
R2	30 Ω, 0.1 W Chip

R3	1.0 kΩ, 0.1 W Chip
R4	1.1 MΩ, 1/4 W Carbon
Z1, Z10	0.594″ x 0.08″ Microstrip
Z2	0.811″ x 0.08″ Microstrip
Z3	0.270″ x 0.08″ Microstrip
Z4	0.122″ x 0.08″ Microstrip
Z5	0.303″ x 0.08″ Microstrip
Z6	0.211″ x 0.08″ Microstrip
Z7	0.084″ x 0.08″ Microstrip
Z8	0.060″ x 0.08″ Microstrip
Z9	1.343″ x 0.08″ Microstrip

Board — Glass Teflon®, 31 mils
Note: BeCu part locators (0.147″ x 0.093″)
soldered onto Z5 and Z6

Figure 1. 512 MHz Narrowband Test Circuit

TYPICAL CHARACTERISTICS

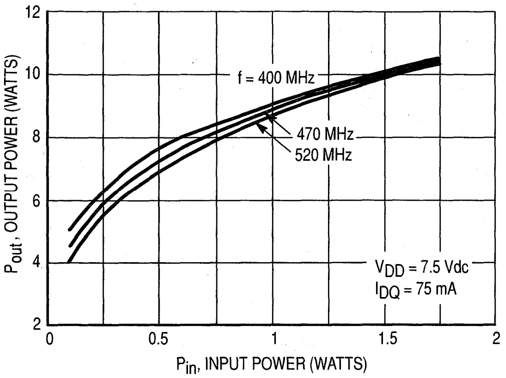


Figure 2. Output Power versus Input Power

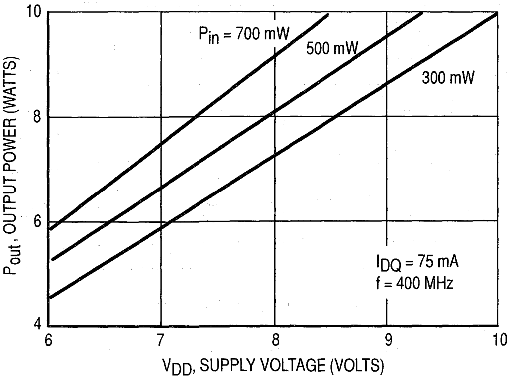


Figure 3. Output Power versus Supply Voltage

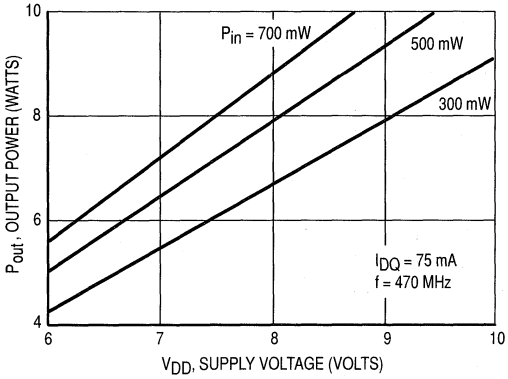


Figure 4. Output Power versus Supply Voltage

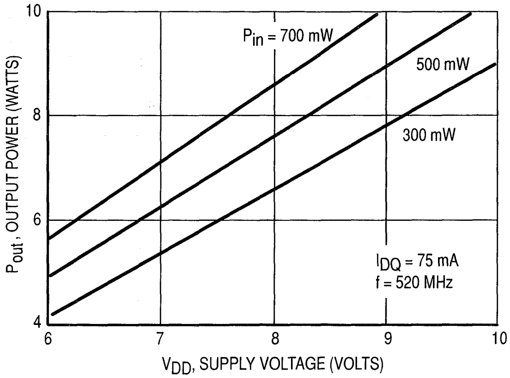


Figure 5. Output Power versus Supply Voltage

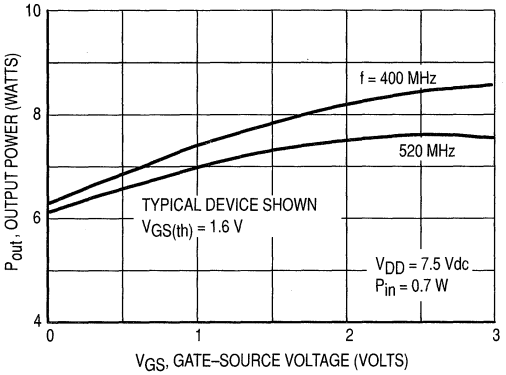


Figure 6. Output Power versus Gate Voltage

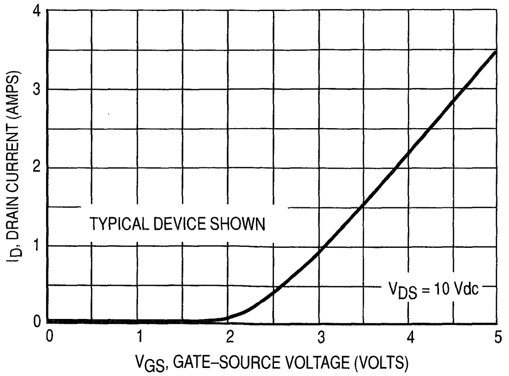


Figure 7. Drain Current versus Gate Voltage

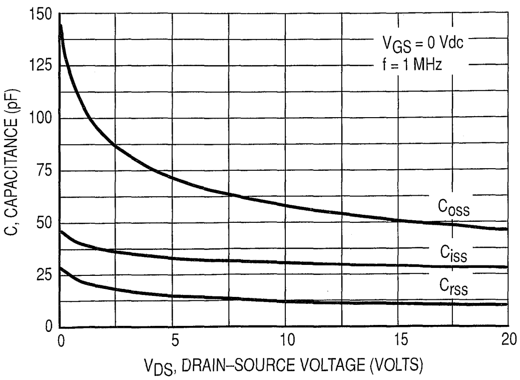


Figure 8. Capacitance versus Voltage

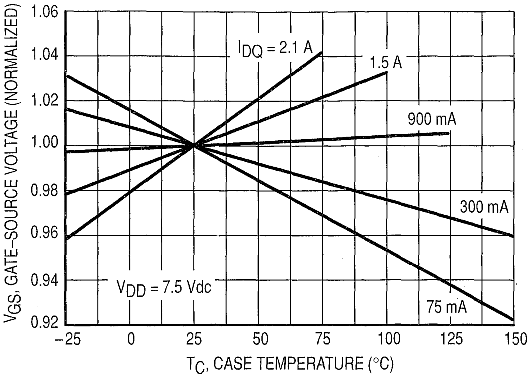


Figure 9. Gate–Source Voltage versus Case Temperature

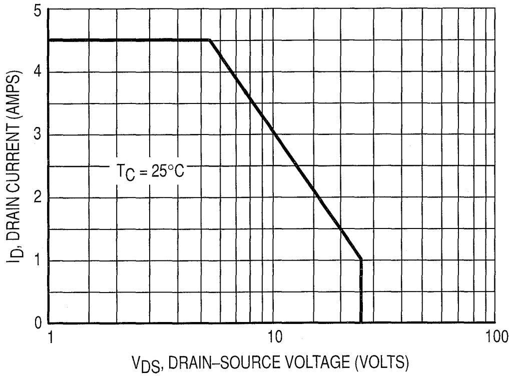
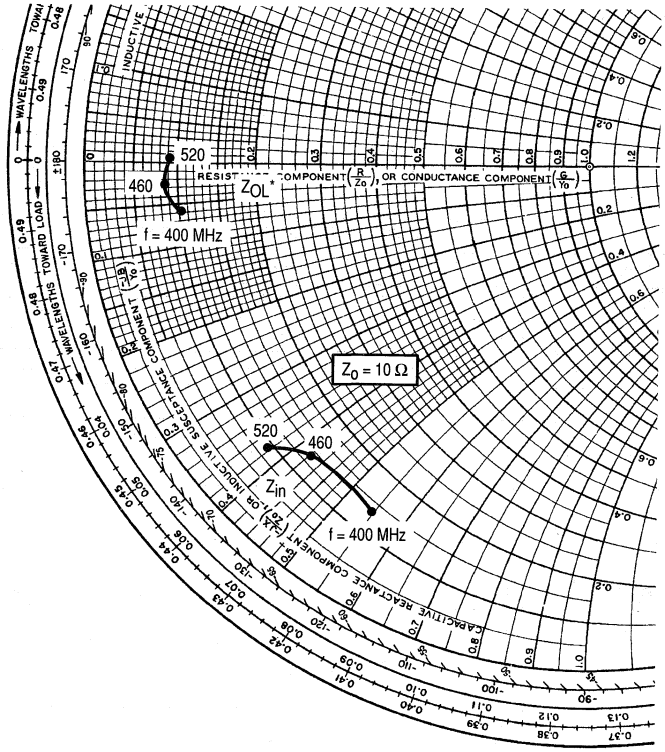


Figure 10. Maximum Rated Forward Biased Safe Operating Area



V_{DD} = 7.5 Vdc, I_{DQ} = 75 mA, P_{out} = 7.0 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
400	1.4 – j5.4	1.0 – j0.6
430	1.4 – j4.5	0.9 – j0.5
460	1.3 – j4.2	0.9 – j0.3
490	1.2 – j4.0	0.9 – j0.1
520	1.0 – j3.7	0.9 + j0.1

Z_{in} = Conjugate of source impedance with parallel 39 Ω resistor and 47 pF capacitor in series with gate.

Z_{OL}* = Conjugate of the load impedance at given output power, voltage, frequency, and η_D > 50%.

Note: Z_{OL}* was chosen based on tradeoffs between gain, drain efficiency, and device stability.

Figure 11. Series Equivalent Input and Output Impedance

Table 1. Common Source Scattering Parameters (V_{DS} = 7.5 Vdc)

I_D = 75 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
50	0.75	−132	6.05	103	0.08	15	0.76	−156
100	0.73	−152	3.13	88	0.08	1	0.80	−166
200	0.75	−162	1.52	71	0.08	−13	0.83	−171
300	0.78	−164	0.95	59	0.07	−22	0.85	−172
400	0.81	−166	0.66	49	0.06	−29	0.88	−173
500	0.83	−167	0.49	40	0.06	−35	0.90	−174
700	0.87	−170	0.30	27	0.05	−43	0.93	−175
850	0.89	−171	0.22	19	0.04	−46	0.94	−177
1000	0.91	−173	0.17	13	0.03	−48	0.96	−178
1200	0.92	−174	0.13	7	0.03	−48	0.97	−180

I_D = 500 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
50	0.88	−152	6.89	100	0.03	12	0.87	−172
100	0.87	−166	3.50	91	0.03	4	0.88	−176
200	0.87	−172	1.74	81	0.03	−2	0.89	−178
300	0.87	−175	1.15	74	0.03	−6	0.89	−178
400	0.88	−176	0.84	68	0.03	−8	0.90	−179
500	0.88	−176	0.66	63	0.03	−11	0.90	−179
700	0.89	−177	0.45	53	0.03	−14	0.92	−179
850	0.90	−178	0.35	46	0.03	−15	0.92	−180
1000	0.90	−178	0.28	40	0.02	−15	0.93	179
1200	0.91	−179	0.22	34	0.02	−14	0.94	179

I_D = 1.5 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
50	0.91	−155	6.67	99	0.03	11	0.91	−174
100	0.91	−167	3.38	91	0.03	5	0.92	−177
200	0.91	−174	1.69	83	0.03	1	0.92	−179
300	0.91	−176	1.12	77	0.03	−1	0.92	−179
400	0.91	−177	0.83	72	0.02	−2	0.93	−180
500	0.91	−177	0.65	67	0.02	−3	0.93	180
700	0.92	−178	0.45	57	0.02	−4	0.93	179
850	0.92	−178	0.36	51	0.02	−4	0.94	179
1000	0.93	−179	0.29	46	0.02	−3	0.94	178
1200	0.93	−179	0.23	39	0.02	0	0.95	177

DESIGN CONSIDERATIONS

The MRF5007 is a common–source, RF power, N–Channel enhancement mode, Metal–Oxide Semiconductor Field–Effect Transistor (MOSFET). Motorola RF MOSFETs feature a vertical structure with a planar design. Motorola Application Note AN211A, "FETs in Theory and Practice," is suggested reading for those not familiar with the construction and characteristics of FETs.

This surface mount packaged device was designed primarily for VHF and UHF portable power amplifier applications. Manufacturability is improved by utilizing the tape and reel capability for fully automated pick and placement of parts. However, care should be taken in the design process to insure proper heat sinking of the device.

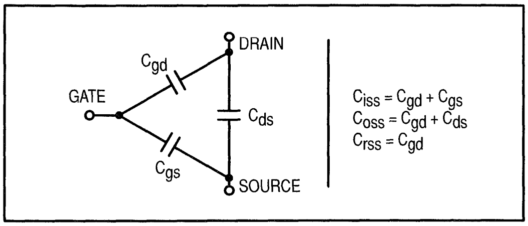
The major advantages of RF power MOSFETs include high gain, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage.

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between all three terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}). These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate.

In the latter case, the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



$$C_{iss} = C_{gd} + C_{gs}$$
$$C_{oss} = C_{gd} + C_{ds}$$
$$C_{rss} = C_{gd}$$

DRAIN CHARACTERISTICS

One critical figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $R_{DS(on)}$, occurs in the linear region of the output characteristic and is specified at a specific gate–source voltage and drain current. The drain–source voltage under these conditions is termed $V_{DS(on)}$. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient at high temperatures because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The DC input resistance is very high — on the order of $10^9\ \Omega$ — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage to the gate greater than the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended with appropriate RF decoupling.

Using a resistor to keep the gate–to–source impedance low also helps dampen transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

DC BIAS

Since the MRF5007 is an enhancement mode FET, drain current flows only when the gate is at a higher potential than the source. See Figure 7 for a typical plot of drain current versus gate voltage. RF power FETs operate optimally with a quiescent drain current (I_{DQ}), whose value is application dependent. The MRF5007 was characterized at I_{DQ} = 75 mA, which is the suggested value of bias current for typical applications. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF5007 may be controlled to some degree with a low power dc control signal applied to the gate, thus facilitating applications such as manual gain control, ALC/AGC and modulation systems. Figure 6 is an example of output power variation with gate–source bias voltage. This characteristic is very dependent on frequency and load line.

MOUNTING

The specified maximum thermal resistance of 7.0°C/W assumes a majority of the 0.137″ x 0.185″ source contact on the back side of the package is in good contact with an appropriate heat sink. In the test fixture shown in Figure 1, the device is clamped directly to a copper pedestal. As with all RF power devices, the goal of the thermal design should be to minimize the temperature at the back side of the package. It is recomended that this temperature not exceed 100°C for any operating condition. Contact customer service for additional information on thermal considerations for mounting.

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar transistors are suitable for the MRF5007. For examples see Motorola Application Note AN721, "Impedance Matching Networks Applied to RF Power Transistors." Both small–signal S–parameters and large–signal impedances are provided. While the S–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF power MOSFETs.

Since RF power MOSFETs are triode devices, they are not unilateral. This coupled with the very high gain of the MRF5007 yields a device capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. The RF test fixture implements a parallel resistor and capacitor in series with the gate and has a load line selected for a higher efficiency, lower gain, and more stable operating region.

Two port stability analysis with the MRF5007 S–parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A, "RF Small–Signal Design Using Two–Port Parameters," for a discussion of two port network theory and stability.

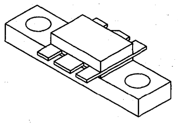
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode

MRF5015

15 W, 512 MHz, 12.5 VOLTS
N–CHANNEL BROADBAND
RF POWER FET

Designed for broadband commercial and industrial applications at frequencies to 520 MHz. The high gain and broadband performance of this device makes it ideal for large–signal, common source amplifier applications in 12.5 volt mobile, and base station FM equipment.

- Guaranteed Performance at 512 MHz, 12.5 Volts
  Output Power — 15 Watts
  Power Gain — 10 dB Min
  Efficiency — 50% Min
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- S–Parameter Characterization at High Bias Levels
- Excellent Thermal Stability
- All Gold Metal for Ultra Reliability
- Capable of Handling 20:1 VSWR, @ 15.5 Vdc, 512 MHz, 2 dB Overdrive
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 319–07, STYLE 3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	36	Vdc
Drain–Gate Voltage (RGS = 1 MΩ)	V_{DGR}	36	Vdc
Gate–Source Voltage	V_{GS}	± 20	Vdc
Drain Current — Continuous	I_D	6	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	50 0.29	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 5 mAdc)	$V_{(BR)DSS}$	36	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	—	—	5	mAdc
Gate–Source Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	2	μAdc

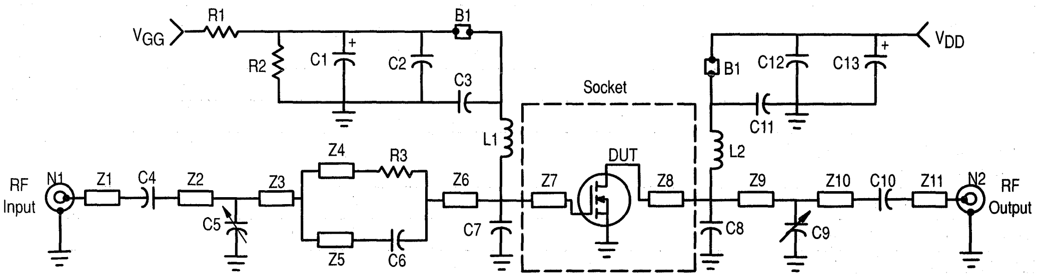
(continued)

NOTE – **CAUTION** – MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 mAdc)		$V_{GS(th)}$	1.25	2.3	3.5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 1 Adc)		$V_{DS(on)}$	—	—	0.375	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 1 Adc)		g_{fs}	1.2	—	—	S
DYNAMIC CHARACTERISTICS						
Input Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	—	33	—	pF
Output Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1 MHz)		C_{oss}	—	74	—	pF
Reverse Transfer Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1 MHz)		C_{rss}	7	8.8	10.8	pF
FUNCTIONAL TESTS (In Motorola Test Fixture)						
Common–Source Amplifier Power Gain (V_{DD} = 12.5 Vdc, P_{out} = 15 W, I_{DQ} = 100 mA)	f = 512 MHz f = 175 MHz	G_{ps}	10 —	11.5 15	— —	dB
Drain Efficiency (V_{DD} = 12.5 Vdc, P_{out} = 15 W, I_{DQ} = 100 mA)	f = 512 MHz f = 175 MHz	η	50 —	55 55	— —	%
Load Mismatch (V_{DD} = 15.5 Vdc, 2 dB Overdrive, f = 512 MHz, Load VSWR = 20:1, All Phase Angles at Frequency of Test)		ψ	No Degradation in Output Power			



B1, B2	Ferrite Bead, Fair Rite Products	R3	160 Ω, 0.1 W Chip
C1, C13	10 µF, 50 V, Electrolytic	Z1, Z11	Transmission Line*
C2, C12	0.1 µF, Chip Capacitor	Z2	Transmission Line*
C3, C4, C10, C11	120 pF, Chip Capacitor	Z3	Transmission Line*
C5, C9	0 to 20 pF, Trimmer Capacitor	Z4	Transmission Line*
C6	36 pF, Chip Capacitor	Z5	Transmission Line*
C7	43 pF, Chip Capacitor	Z6	Transmission Line*
C8	30 pF, Chip Capacitor	Z7, Z8	Transmission Line+
L1, L2	7 Turns, 24 AWG 0.116″ ID	Z9	Transmission Line*
N1, N2	Type N Flange Mount	Z10	Transmission Line*
R1	1 kΩ, 1/4 W, Carbon	Board	Glass Teflon® 0.060″
R2	470 kΩ, 1/4 W, Carbon		+ Part of Capacitor Mount Socket
			*See Photomaster

Figure 1. 512 MHz Narrowband Test Circuit Electrical Schematic

TYPICAL CHARACTERISTICS

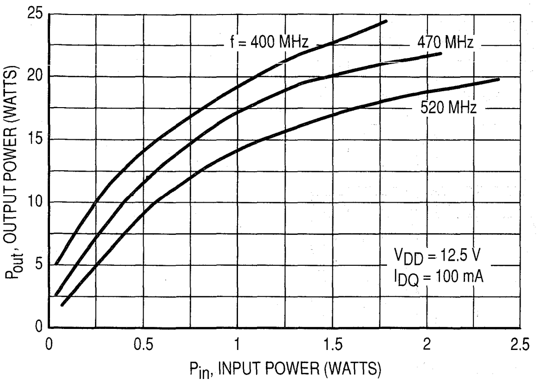


Figure 2. Output Power versus Input Power

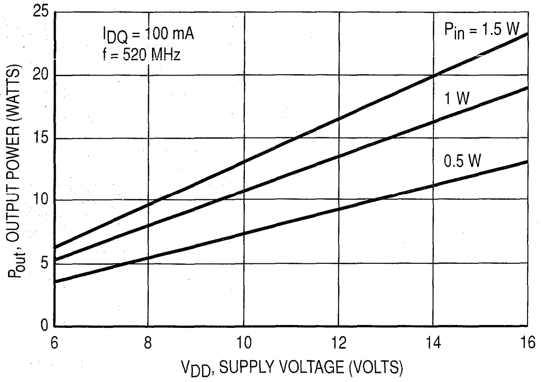


Figure 3. Output Power versus Supply Voltage

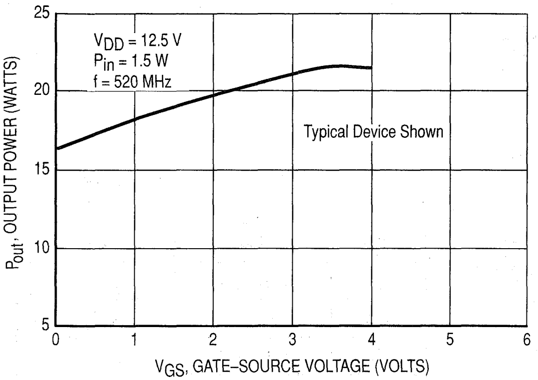


Figure 4. Output Power versus Gate Voltage

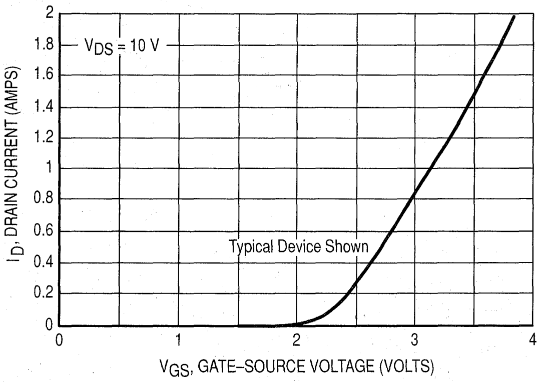


Figure 5. Drain Current versus Gate Voltage

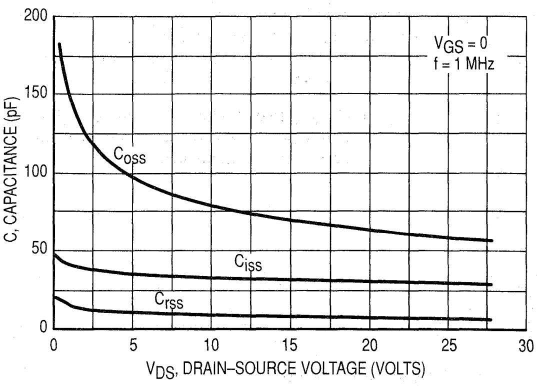


Figure 6. Capacitance versus Voltage

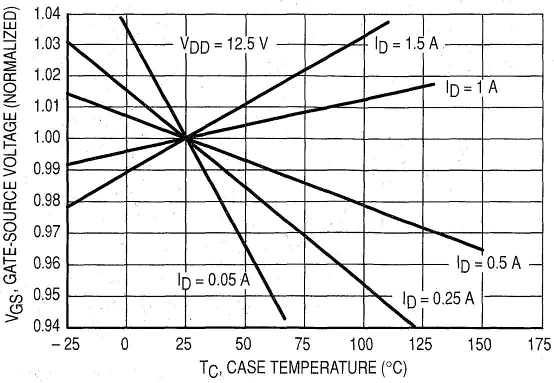


Figure 7. Gate–Source Voltage versus Case Temperature

TYPICAL CHARACTERISTICS

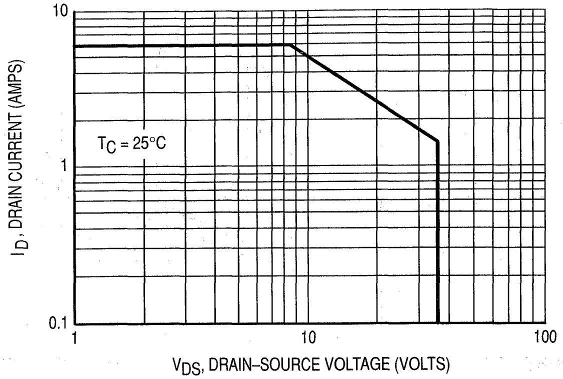
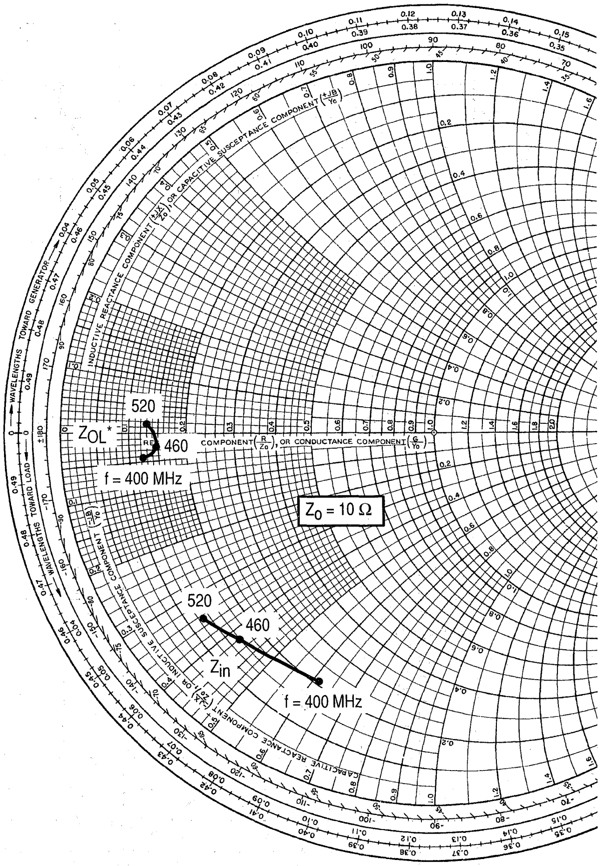


Figure 8. DC Safe Operating Area



V$_{DD}$ = 12.5 V, I$_{DQ}$ = 100 mA, P$_{out}$ = 15 W

f (MHz)	Z$_{in}$ (Ω)	Z$_{OL}$* (Ω)
400	2.0 – j6.1	1.3 – j0.4
420	1.8 – j5.3	1.4 – j0.4
440	1.6 – j4.7	1.5 – j0.4
460	1.5 – j4.2	1.5 – j0.3
480	1.4 – j3.8	1.5 – j0.2
500	1.3 – j3.6	1.4 – j0.1
520	1.2 – j3.5	1.3 + j0.1

Z$_{in}$ = Conjugate of source impedance with parallel 160 Ω resistor and 36 pF capacitor in series with gate.

Z$_{OL}$* = Conjugate of the load impedance at given output power, voltage and frequency that produces maximum gain.

Figure 9. Series Equivalent Input and Output Impedance

Table 1. Common Source Scattering Parameters (V_{DS} = 12.5 V)

I_D = 50 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11} \rvert$	∠ ϕ	$\lvert S_{21} \rvert$	∠ ϕ	$\lvert S_{12} \rvert$	∠ ϕ	$\lvert S_{22} \rvert$	∠ ϕ
50	0.63	–123	8	100	0.063	11	0.79	–149
100	0.62	–142	4	82	0.063	– 6	0.82	–162
200	0.70	–152	1.8	61	0.056	– 23	0.86	–169
300	0.78	–157	1.1	47	0.046	– 35	0.90	–171
400	0.84	–162	0.70	36	0.037	– 42	0.93	–174
500	0.88	–165	0.49	28	0.029	– 46	0.94	–175
700	0.93	–171	0.28	17	0.016	– 45	0.97	–179
850	0.95	–175	0.20	13	0.010	– 31	0.97	179
1000	0.96	–178	0.15	10	0.007	11	0.98	178

I_D = 100 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11} \rvert$	∠ ϕ	$\lvert S_{21} \rvert$	∠ ϕ	$\lvert S_{12} \rvert$	∠ ϕ	$\lvert S_{22} \rvert$	∠ ϕ
50	0.67	–136	9.1	99	0.047	10	0.82	–158
100	0.66	–153	4.6	84	0.048	–3	0.85	–168
200	0.71	–160	2.2	66	0.043	–17	0.87	–172
300	0.77	–163	1.3	54	0.037	– 26	0.90	–174
400	0.82	–165	0.89	44	0.031	– 32	0.92	–175
500	0.86	–168	0.64	36	0.025	– 35	0.94	–177
700	0.91	–173	0.37	25	0.015	– 30	0.96	–179
850	0.93	–176	0.27	20	0.010	–11	0.97	179
1000	0.95	–179	0.20	16	0.009	25	0.98	177

I_D = 500 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11} \rvert$	∠ ϕ	$\lvert S_{21} \rvert$	∠ ϕ	$\lvert S_{12} \rvert$	∠ ϕ	$\lvert S_{22} \rvert$	∠ ϕ
50	0.81	–150	11.1	98	0.027	11	0.85	–168
100	0.81	–164	5.6	86	0.027	2	0.87	–174
200	0.82	–170	2.7	73	0.025	– 5	0.88	–176
300	0.84	–173	1.7	63	0.023	– 9	0.89	–177
400	0.86	–174	1.2	55	0.020	– 9	0.91	–178
500	0.88	–175	0.92	47	0.018	– 7	0.92	–179
700	0.91	–178	0.57	35	0.013	7	0.94	180
850	0.93	180	0.43	29	0.013	26	0.95	178
1000	0.94	178	0.33	23	0.014	44	0.96	177

I_D = 2.5 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11} \rvert$	∠ ϕ	$\lvert S_{21} \rvert$	∠ ϕ	$\lvert S_{12} \rvert$	∠ ϕ	$\lvert S_{22} \rvert$	∠ ϕ
50	0.86	–144	10.1	101	0.022	15	0.85	–171
100	0.85	–161	5.2	88	0.022	5	0.87	–175
200	0.86	–170	2.5	74	0.021	–1	0.89	–177
300	0.87	–173	1.6	64	0.019	– 4	0.90	–178
400	0.89	–175	1.1	55	0.017	– 2	0.91	–178
500	0.91	–176	0.84	48	0.015	2	0.93	–179
700	0.93	–179	0.52	37	0.013	22	0.95	179
850	0.94	179	0.39	30	0.014	39	0.96	178
1000	0.95	177	0.30	26	0.016	52	0.96	176

DESIGN CONSIDERATIONS

The MRF5015 is a common–source, RF power, N–Channel enhancement mode, Metal–Oxide Semiconductor Field–Effect Transistor (MOSFET). Motorola RF MOSFETs feature a vertical structure with a planar design. Motorola Application Note AN211A, "FETs in Theory and Practice," is suggested reading for those not familiar with the construction and characteristics of FETs.

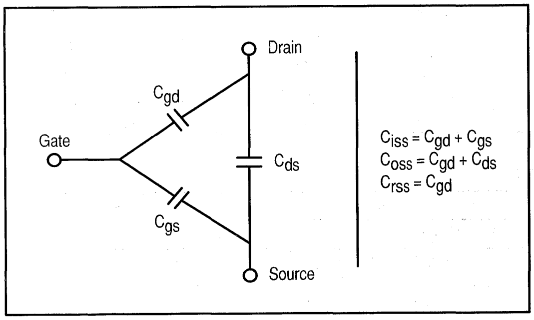
This device was designed primarily for 12.5 volt VHF and UHF power amplifier applications. The major advantages of RF power MOSFETs include high gain, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage.

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between all three terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}). These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate.

In the latter case, the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



DRAIN CHARACTERISTICS

One critical figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $R_{ds(on)}$, occurs in the linear region of the output characteristic and is specified at a specific gate–source voltage and drain current. The drain–source voltage under these conditions is termed $V_{ds(on)}$. For MOSFETs, $V_{ds(on)}$ has a positive temperature coefficient at high temperatures because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high, on the order of 10^9 Ω, resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage to the gate greater than the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating – Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination – The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating must be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection – These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended with appropriate RF decoupling networks.

Using a resistor to keep the gate–to–source impedance low also helps dampen transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

DC BIAS

Since the MRF5015 is an enhancement mode FET, drain current flows only when the gate is at a higher potential than the source. See Figure 5 for a typical plot of drain current versus gate voltage. RF power FETs operate optimally with a quiescent drain current (I_{DQ}), whose value is application dependent. The MRF5015 was characterized at I_{DQ} = 100 mA, which is the suggested value of bias current for typical applications. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws essentially no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF5015 may be controlled to some degree with a low power dc control signal applied to the gate, thus facilitating applications such as manual gain control, ALC/AGC and modulation systems. Figure 4 is an example of output power variation with gate–source bias voltage with P_{in} held constant. This characteristic is very dependent on frequency and load line.

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar transistors are suitable for the MRF5015. For examples see Motorola Application Note AN721, "Impedance Matching Networks Applied to RF Power Transistors." Both small–signal S–parameters and large–signal impedances are provided. While the S–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF power MOSFETs.

Since RF power MOSFETs are triode devices, they are not unilateral. This coupled with the very high gain of MRF5015 yield a device quite capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. Different stabilizing techniques may be required depending on the desired gain and bandwidth of the application. The RF test fixture implements a parallel resistor and capacitor in series with the gate to improve stability and input impedance Q.

Two port stability analysis with the MRF5015 S–parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A, "RF Small–Signal Design Using Two–Port Parameters," for a discussion of two port network theory and stability.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

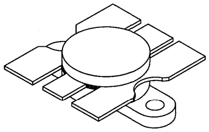
The RF MOSFET Line
RF Power Field Effect Transistor
N–Channel Enhancement–Mode

MRF5035

35 W, 12.5 VOLTS, 512 MHz
N–CHANNEL BROADBAND
RF POWER FET

Designed for broadband commercial and industrial applications at frequencies to 520 MHz. The high gain and broadband performance of this device makes it ideal for large–signal, common source amplifier applications in 12.5 volt mobile, and base station FM equipment.

- Guaranteed Performance at 512 MHz, 12.5 Volt
  Output Power — 35 Watts
  Power Gain — 6.5 dB Min
  Efficiency — 50% Min
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- S–Parameter Characterization at High Bias Levels
- Excellent Thermal Stability
- All Gold Metal for Ultra Reliability
- Capable of Handling 20:1 Load VSWR, @ 15.5 Volt, 512 MHz, 2 dB Overdrive
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 316–01, STYLE 3

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	36	Vdc
Drain–Gate Voltage (RGS = 1 MΩ)	V_{DGR}	36	Vdc
Gate–Source Voltage	V_{GS}	± 20	Vdc
Drain Current — Continuous	I_D	15	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	97 0.56	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.8	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 20$ mAdc)	$V_{(BR)DSS}$	36	—	—	Vdc
Zero Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	—	—	5	mAdc
Gate–Source Leakage Current ($V_{GS} = 20$ Vdc, $V_{DS} = 0$)	I_{GSS}	—	—	5	µAdc

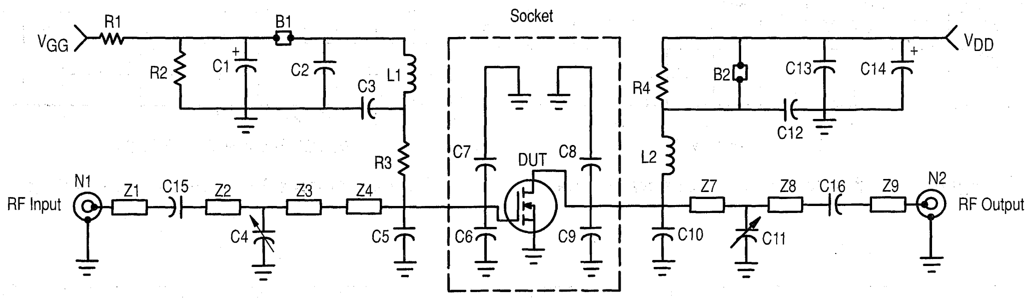
(continued)

NOTE – **CAUTION** – MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 25 mAdc)	$V_{GS(th)}$	1.25	2.3	3.5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 3 Adc)	$V_{DS(on)}$	—	—	0.422	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3 Adc)	g_{fs}	3.2	—	—	S
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	88	—	pF
Output Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1 MHz)	C_{oss}	—	197	—	pF
Reverse Transfer Capacitance (V_{DS} = 12.5 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	18	24	29	pF
FUNCTIONAL TESTS (In Motorola Test Fixture)					
Common–Source Amplifier Power Gain (V_{DD} = 12.5 Vdc, P_{out} = 35 W, f = 512 MHz I_{DQ} = 400 mA) f = 175 MHz	G_{ps}	 6.5 —	 7.5 12	 — —	dB
Drain Efficiency (V_{DD} = 12.5 Vdc, P_{out} = 35 W, f = 512 MHz I_{DQ} = 400 mA) f = 175 MHz	η	 50 —	 55 55	 — —	%
Load Mismatch (V_{DD} = 15.5 Vdc, 2 dB Overdrive, f = 512 MHz, Load VSWR = 20:1, All Phase Angles at Frequency of Test)	ψ	No Degradation in Output Power			



Components List

B1, B2	Short Ferrite Bead, Fair Rite Products	N1, N2	Type N Flange Mount
C1, C14	10 μF, 50 V, Electrolytic	R1	1 kΩ, 1/4 W, Carbon
C2	1500 pF, Chip Capacitor	R2	1 MΩ, 1/4 W, Carbon
C3	140 pF, Chip Capacitor	R3	100 Ω, 1/4 W, Carbon
C4, C11	0–10pF, Trimmer Capacitor	R4	110 Ω, 1/4 W, Carbon
C5	30 pF, Chip Capacitor	Z1, Z9	Transmission Line*
C6, C7	43 pF, Chip Capacitor	Z2	Transmission Line*
C8, C9	36 pF, Chip Capacitor	Z3	Transmission Line*
C10	3.6 pF, Chip Capacitor	Z4	Transmission Line*
C12, C15, C16	120 pF, Chip Capacitor	Z7	Transmission Line*
C13	0.1 μF, Chip Capacitor	Z8	Transmission Line*
L1	5 Turns, 18 AWG, 0.116″ ID	Board	Glass Teflon® 0.060″
L2	8 Turns, 20 AWG, 0.125″ ID		*See Photomaster for Dimensions

Figure 1. 512 MHz Narrowband Test Circuit Electrical Schematic

TYPICAL CHARACTERISTICS

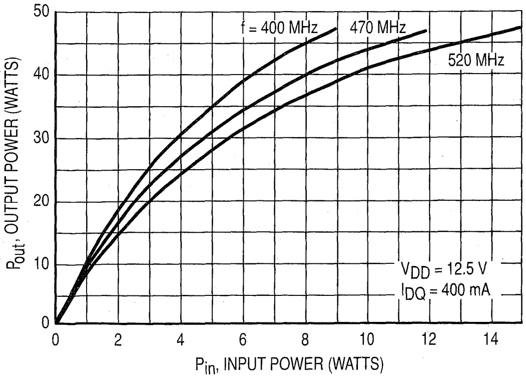


Figure 2. Output Power versus Input Power

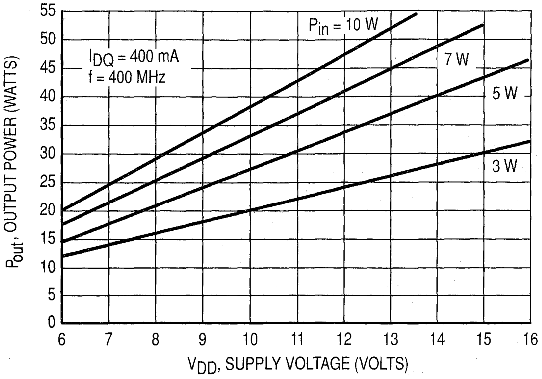


Figure 3. Output Power versus Supply Voltage

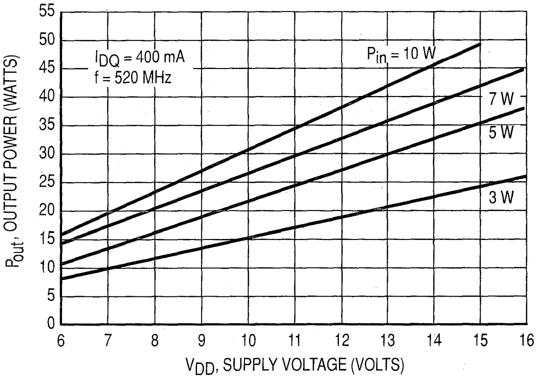


Figure 4. Output Power versus Supply Voltage

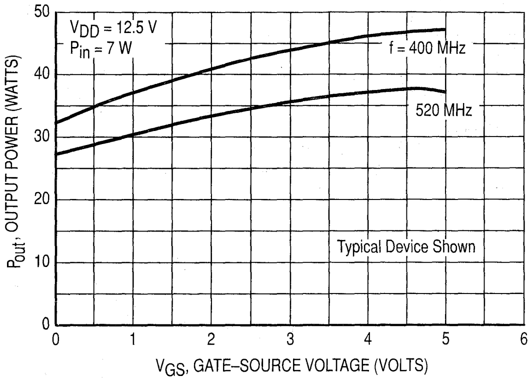


Figure 5. Output Power versus Gate Voltage

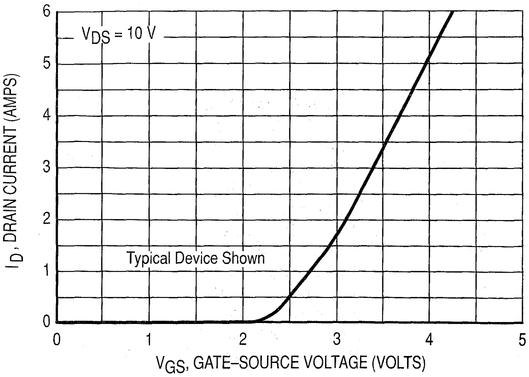


Figure 6. Drain Current versus Gate Voltage

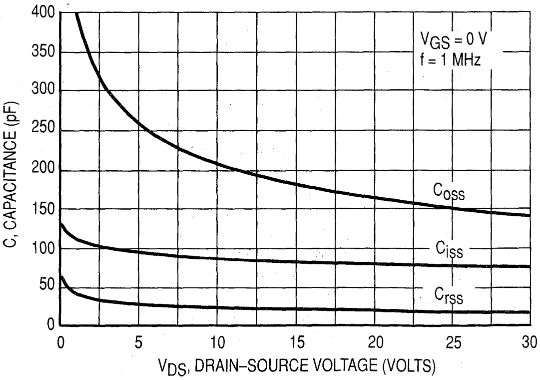


Figure 7. Capacitance versus Voltage

TYPICAL CHARACTERISTICS

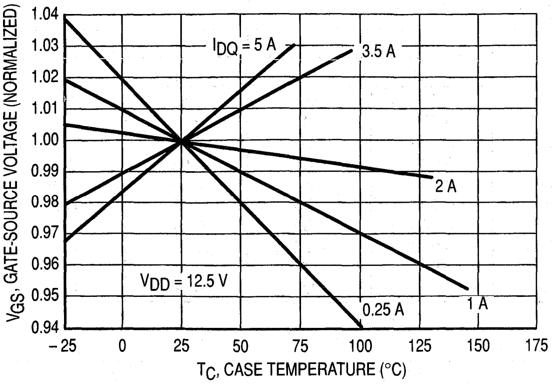


Figure 8. Gate–Source Voltage versus Case Temperature

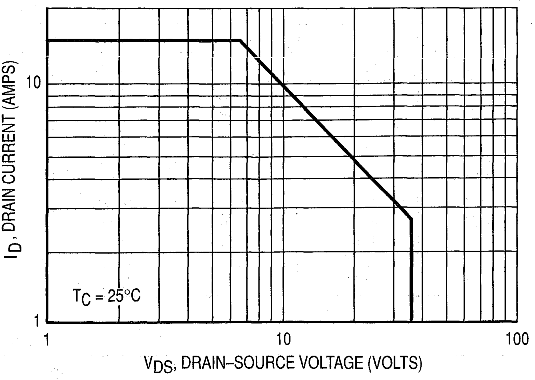
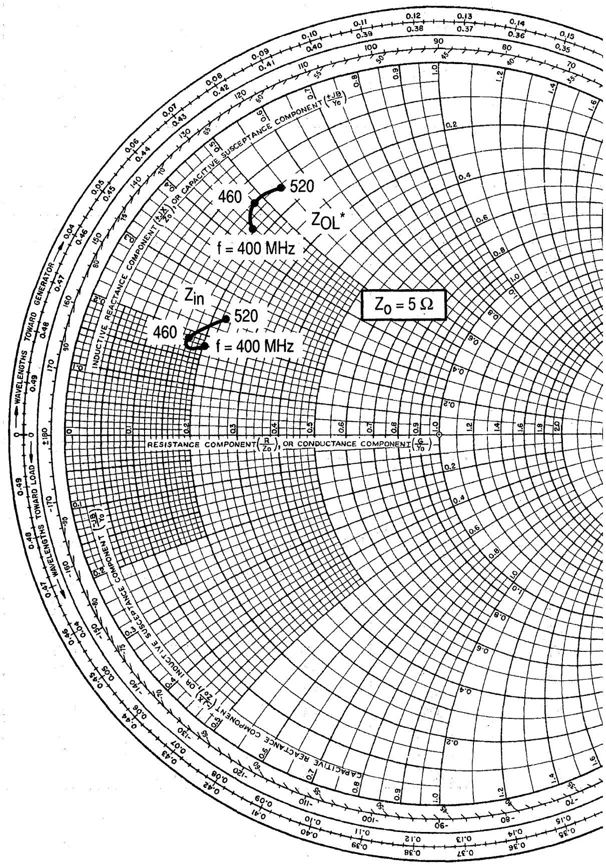


Figure 9. DC Safe Operating Area



V_{DD} = 12.5 V, I_{DQ} = 400 mA, P_{in} = 7.8 W, Tune for Maximum Output Power

f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
400	1.0 + j0.89	0.87 + j2.1
420	0.90 + j0.83	0.79 + j2.2
440	0.83 + j0.81	0.73 + j2.3
460	0.82 + j0.83	0.71 + j2.4
480	0.87 + j0.90	0.71 + j2.5
500	0.97 + j1.0	0.74 + j2.6
520	1.1 + j1.2	0.80 + j2.7

Z_{in} = Conjugate of source impedance.

Z_{OL}* = Conjugate of the load impedance at given input power, voltage and frequency that produces maximum output power.

Figure 10. Series Equivalent Input and Output Impedance

Table 1. Common Source Scattering Parameters (V_{DS} = 12.5 V)

I_D = 100 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
25	0.74	–153	6.9	94	0.039	6	0.87	–169
50	0.74	–164	3.4	82	0.039	–5	0.89	–174
100	0.77	–168	1.6	67	0.036	–16	0.90	–176
150	0.81	–170	1	56	0.032	–25	0.92	–178
200	0.85	–171	0.69	46	0.028	–31	0.93	–179
300	0.90	–174	0.38	32	0.019	–36	0.96	179
400	0.93	–178	0.24	22	0.013	–30	0.97	177
450	0.94	–179	0.20	19	0.010	–22	0.97	175
500	0.95	179	0.17	16	0.008	–8	0.98	174
600	0.96	176	0.12	13	0.008	27	0.98	172

I_D = 400 mA

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
25	0.88	–163	7.8	94	0.018	7	0.93	–175
50	0.88	–172	3.9	87	0.018	3	0.93	–178
100	0.88	–176	1.9	77	0.018	–1	0.94	–180
150	0.89	–178	1.3	70	0.017	–2	0.94	179
200	0.89	–179	0.91	63	0.016	–1	0.94	178
300	0.91	180	0.57	51	0.014	3	0.95	177
400	0.92	178	0.39	41	0.012	14	0.96	175
450	0.93	177	0.33	37	0.012	22	0.96	174
500	0.94	176	0.29	33	0.012	29	0.97	173
600	0.95	174	0.22	27	0.014	42	0.97	171

I_D = 1 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
25	0.92	–165	7.8	95	0.013	9	0.94	–177
50	0.91	–173	3.9	88	0.013	6	0.95	–179
100	0.92	–177	1.9	81	0.013	7	0.95	179
150	0.92	–179	1.3	75	0.013	9	0.95	179
200	0.92	180	0.95	69	0.012	12	0.95	178
300	0.93	178	0.61	59	0.012	21	0.96	176
400	0.94	176	0.43	50	0.013	32	0.96	174
450	0.94	175	0.38	46	0.013	37	0.97	174
500	0.94	174	0.33	43	0.014	42	0.97	173
600	0.95	173	0.26	36	0.016	49	0.97	171

I_D = 5 A

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠ ϕ	$\|S_{21}\|$	∠ ϕ	$\|S_{12}\|$	∠ ϕ	$\|S_{22}\|$	∠ ϕ
25	0.94	–164	7.2	95	0.010	10	0.95	–178
50	0.94	–172	3.6	89	0.010	9	0.95	–180
100	0.94	–177	1.8	81	0.010	11	0.96	179
150	0.94	–179	1.2	76	0.011	16	0.96	178
200	0.94	179	0.89	70	0.011	21	0.96	177
300	0.95	177	0.57	61	0.011	31	0.96	176
400	0.95	176	0.42	52	0.013	41	0.97	174
450	0.95	175	0.36	48	0.013	45	0.97	173
500	0.96	174	0.32	45	0.014	48	0.97	172
600	0.96	172	0.26	39	0.017	54	0.97	171

DESIGN CONSIDERATIONS

The MRF5035 is a common–source, RF power, N–Channel enhancement mode, Metal–Oxide Semiconductor Field–Effect Transistor (MOSFET). Motorola RF MOSFETs feature a vertical structure with a planar design. Motorola Application Note AN211A, “FETs in Theory and Practice,” is suggested reading for those not familiar with the construction and characteristics of FETs.

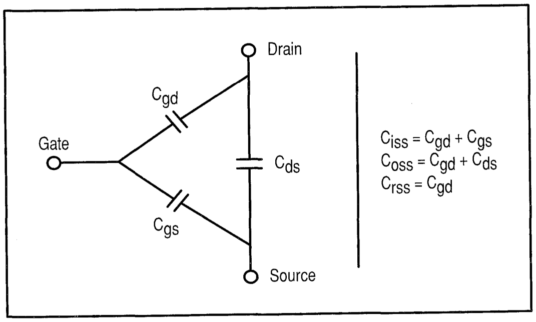
This device was designed primarily for 12.5 volt VHF and UHF Land Mobile FM power amplifier applications. The major advantages of RF power MOSFETs include high gain, simple bias systems, relative immunity from thermal runaway, and the ability to withstand severely mismatched loads without suffering damage.

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between all three terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}). These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate.

In the latter case, the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



DRAIN CHARACTERISTICS

One critical figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $R_{ds(on)}$, occurs in the linear region of the output characteristic and is specified at a specific gate–source voltage and drain current. The drain–source voltage under these conditions is termed $V_{ds(on)}$. For MOSFETs, $V_{ds(on)}$ has a positive temperature coefficient at high temperatures because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high, on the order of 10^9 Ω, resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage to the gate greater than the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating – Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

Gate Termination – The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating must be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection – These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended with appropriate RF decoupling networks.

Using a resistor to keep the gate–to–source impedance low also helps dampen transients and serves another important function. Voltage transients on the drain can be coupled to the gate through the parasitic gate–drain capacitance. If the gate–to–source impedance and the rate of voltage change on the drain are both high, then the signal coupled to the gate may be large enough to exceed the gate–threshold voltage and turn the device on.

DC BIAS

Since the MRF5035 is an enhancement mode FET, drain current flows only when the gate is at a higher potential than the source. See Figure 6 for a typical plot of drain current versus gate voltage. RF power FETs operate optimally with a quiescent drain current (I_{DQ}), whose value is application dependent. The MRF5035 was characterized at I_{DQ} = 400 mA, which is the suggested value of bias current for typical applications. For special applications such as linear amplification, I_{DQ} may have to be selected to optimize the critical parameters.

The gate is a dc open circuit and draws essentially no current. Therefore, the gate bias circuit may generally be just a simple resistive divider network. Some special applications may require a more elaborate bias system.

GAIN CONTROL

Power output of the MRF5035 may be controlled to some degree with a low power dc control signal applied to the gate, thus facilitating applications such as manual gain control, ALC/AGC and modulation systems. Figure 5 is an example of output power variation with gate–source bias voltage with P_{in} held constant. This characteristic is very dependent on frequency and load line.

AMPLIFIER DESIGN

Impedance matching networks similar to those used with bipolar transistors are suitable for the MRF5035. For examples see Motorola Application Note AN721, "Impedance Matching Networks Applied to RF Power Transistors." Both small–signal S–parameters and large–signal impedances are provided. While the S–parameters will not produce an exact design solution for high power operation, they do yield a good first approximation. This is an additional advantage of RF power MOSFETs.

Since RF power MOSFETs are triode devices, they are not unilateral. This coupled with the high gain of the MRF5035 yield a device quite capable of self oscillation. Stability may be achieved by techniques such as drain loading, input shunt resistive loading, or output to input feedback. Different stabilizing techniques may be required depending on the desired gain and bandwidth of the application. The RF test fixture implements a resistor in shunt with the gate to improve stability. Two port stability analysis with the MRF5035 S–parameters provides a useful tool for selection of loading or feedback circuitry to assure stable operation. See Motorola Application Note AN215A, "RF Small–Signal Design Using Two–Port Parameters," for a discussion of two port network theory and stability.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

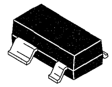
The RF Line
NPN Silicon High-Frequency Transistor

MRF5811LT1

I_C = 200 mA
LOW NOISE
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON

Designed for high current low power amplifiers up to 1.0 GHz.

- Low Noise (2.0 dB @ 500 MHz)
- Low Intermodulation Distortion
- High Gain
- State–of–the–Art Technology
  Fine Line Geometry
  Arsenic Emitters
  Gold Top Metallization
  Nichrome Thin–Film Ballasting Resistors
- Excellent Dynamic Range
- Fully Characterized
- High Current–Gain Bandwidth Product
- Available in Tape and Reel by Adding T1 Suffix to Part Number.
  T1 Suffix = 3,000 Units per 8 mm, 7 inch Reel.



CASE 318A–05, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	18	Vdc
Collector–Base Voltage	V_{CBO}	36	Vdc
Emitter–Base Voltage	V_{EBO}	2.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Thermal Resistance θJC (1)	$R_{\theta JC}$	106	°C/W
Total Device Dissipation @ T_C = 75°C Derate above T_C = 75°C	P_D	0.71 9.4	Watts mW/°C
Storage Junction Temperature Range	T_{stg}	– 55 to +150	°C
Maximum Junction Temperature	T_{Jmax}	150	°C

DEVICE MARKING

MRF5811L = 20

NOTES:
1. Case temperature measured on collector lead immediately adjacent to body of package.

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	18	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	$V_{(BR)CBO}$	36	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	$V_{(BR)EBO}$	2.5	—	—	Vdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, V_{BE} = 0)	I_{EBO}	—	—	100	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	—	200	—
DYNAMIC CHARACTERISTICS					
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.0	—	pF
Collector–Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	—	1.2	2.0	pF
Current–Gain Bandwidth Product (2) (I_C = 75 mAdc, V_{CE} = 10 Vdc, f = 1.0 GHz)	f_T	—	5.0	—	GHz
FUNCTIONAL TESTS					
Noise Figure (Minimum), Figure 3 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 500 MHz)	NF_{min}	—	2.0	3.0	dB
Noise Figure (50 Ohm Insertion) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 500 MHz)	$NF_{50\ \Omega}$	—	2.5	—	dB
Power Gain at Optimum Noise Figure, Figure 3 (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 500 MHz)	G_{NF}	—	18.4	—	dB
Insertion Gain (I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 500 MHz)	$\|S_{21}\|^2$	—	14.2	—	dB
Maximum Unilateral Gain (2) (I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 500 MHz)	$G_{U\ max}$	—	18	—	dB

NOTES:

1. 300 μs pulse on Tektronix 576 or equivalent.
2. $G_{Umax} = \dfrac{|S_{21}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$

TYPICAL CHARACTERISTICS

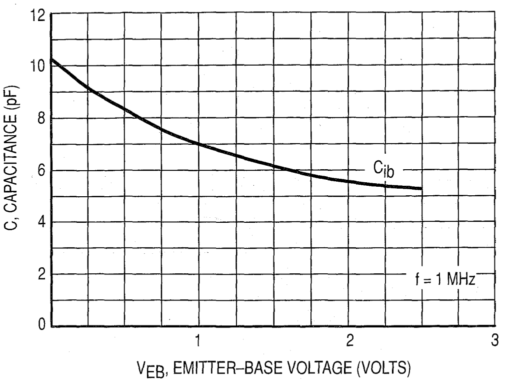


Figure 1. C_{ib} Input Capacitance versus Voltage

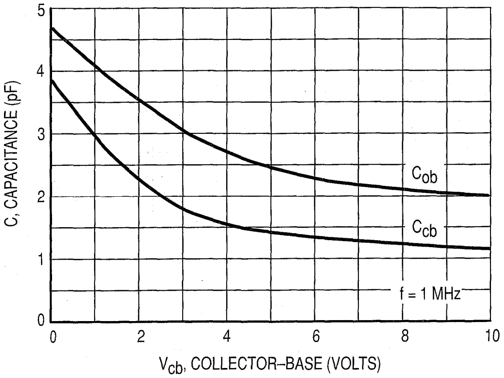


Figure 2. C_{cb}, C_{ob} Collector–Base Capacitance versus Voltage

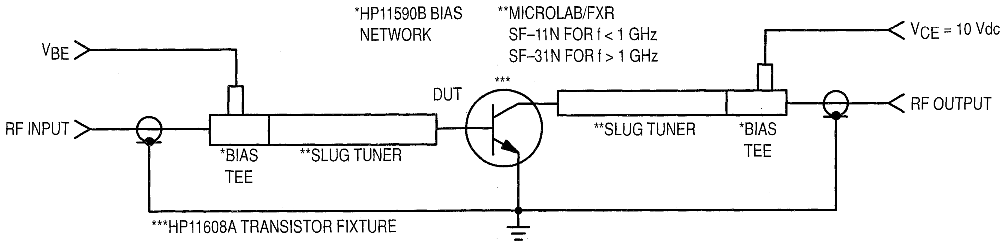


Figure 3. MRF5811L Functional Circuit Schematic

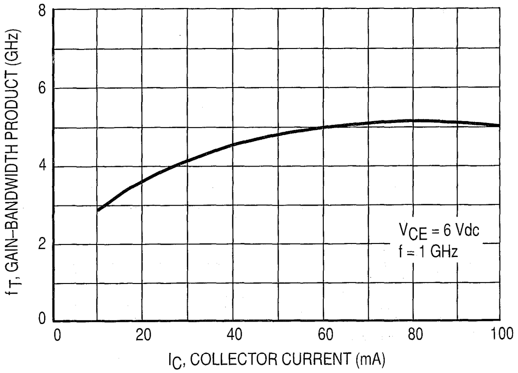


Figure 4. Gain–Bandwidth Product versus Collector Current

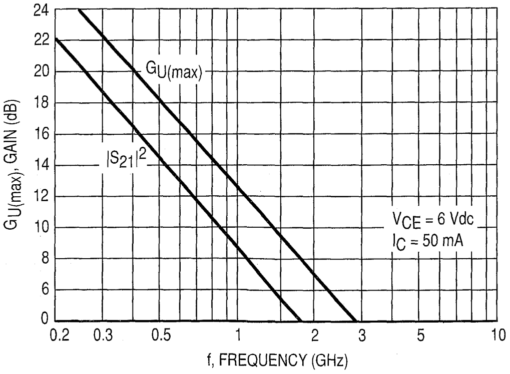


Figure 5. $G_{U(max)}$ Maximum Unilateral Gain, $|S_{21}|^2$ versus Frequency

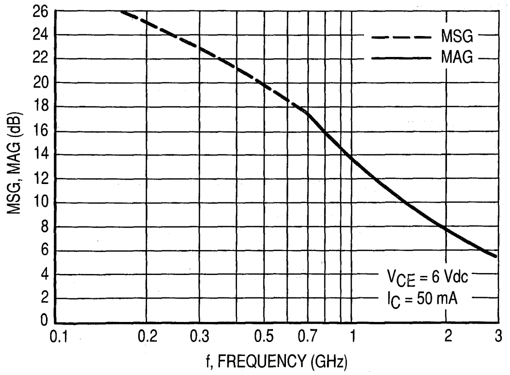


Figure 6. MSG — Maximum Stable Gain, MAG — Maximum Available Gain versus Frequency

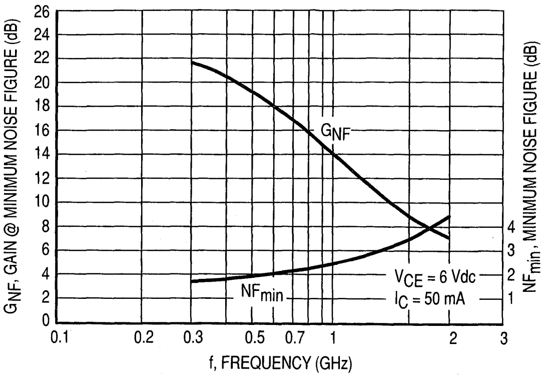


Figure 7. Minimum Noise Figure and Gain @ Minimum Noise Figure versus Frequency

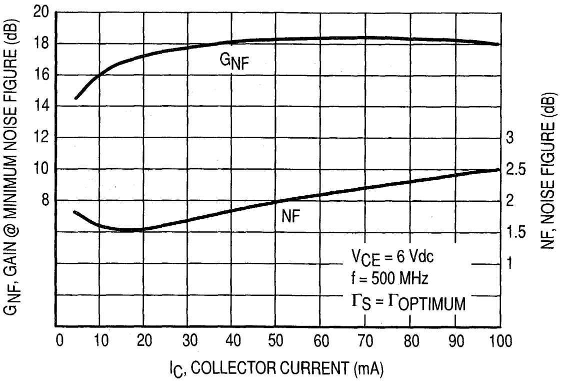


Figure 8. Noise Figure and Gain @ Minimum Noise Figure versus Collector Current

V_{CE} (Vdc)	I_C (mA)	f (MHz)	NF_{min} (dB)	lGam Optl	< Gam Opt	Rn
6.0	10	500	1.64	0.49	164	3.5
		1000	2.81	0.68	–173	3.5
	50	500	2.0	0.51	177	3.9
		1000	2.85	0.61	–168	4.7

Table 1. Common Emitter Noise Parameters

V_{CE} (Volts)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11} \rvert$	∠ϕ	$\lvert S_{21} \rvert$	∠ϕ	$\lvert S_{12} \rvert$	∠ϕ	$\lvert S_{22} \rvert$	∠ϕ
3.0	25	0.10	0.734	−132	17.54	115	0.045	37	0.544	−89
		0.20	0.765	−157	9.66	99	0.051	30	0.395	−120
		0.30	0.771	−168	6.59	90	0.056	32	0.354	−135
		0.40	0.773	−174	4.98	84	0.060	34	0.340	−143
		0.50	0.768	−180	4.01	81	0.065	38	0.319	−150
		0.60	0.768	176	3.36	76	0.070	41	0.319	−153
		0.70	0.769	173	2.89	73	0.076	43	0.321	−155
		0.80	0.771	170	2.55	69	0.081	44	0.325	−157
		0.90	0.770	167	2.27	65	0.088	46	0.329	−158
		1.00	0.771	165	2.06	62	0.094	47	0.335	−159
		1.50	0.773	152	1.41	47	0.127	49	0.367	−163
		2.00	0.777	140	1.08	33	0.162	48	0.408	−167
		2.50	0.786	129	0.87	22	0.194	45	0.461	−171
		3.00	0.793	118	0.75	12	0.229	40	0.498	−177
		3.50	0.803	108	0.65	4	0.262	35	0.530	177
		4.00	0.812	100	0.58	−2	0.294	30	0.563	169
		4.50	0.811	91	0.53	−7	0.328	24	0.587	162
		5.00	0.816	83	0.50	−11	0.355	18	0.616	154
	50	0.10	0.732	−141	19.19	112	0.039	36	0.542	−105
		0.20	0.764	−163	10.33	97	0.045	34	0.44	−136
		0.30	0.771	−172	7.01	90	0.050	37	0.416	−149
		0.40	0.772	−177	5.29	84	0.056	40	0.408	−156
		0.50	0.768	178	4.26	81	0.062	44	0.392	−162
		0.60	0.768	174	3.57	77	0.069	47	0.392	−165
		0.70	0.769	171	3.08	74	0.076	49	0.393	−167
		0.80	0.770	168	2.71	70	0.083	50	0.395	−169
		0.90	0.769	166	2.42	67	0.090	51	0.396	−170
		1.00	0.769	163	2.19	64	0.098	51	0.399	−172
		1.50	0.769	151	1.51	50	0.135	51	0.414	−176
		2.00	0.771	139	1.17	37	0.171	48	0.434	−180
		2.50	0.778	128	0.96	26	0.204	44	0.467	178
		3.00	0.783	118	0.83	16	0.237	39	0.487	173
		3.50	0.792	108	0.73	7	0.268	33	0.506	168
		4.00	0.802	100	0.66	0	0.297	28	0.53	162
		4.50	0.800	91	0.60	−6	0.328	22	0.546	156
		5.00	0.808	83	0.56	−12	0.353	16	0.572	149
	75	0.10	0.738	−145	19.35	110	0.036	35	0.54	−112
		0.20	0.769	−165	10.31	96	0.042	35	0.458	−142
		0.30	0.774	−173	6.98	89	0.048	39	0.44	−153
		0.40	0.776	−178	5.26	84	0.054	43	0.434	−160
		0.50	0.772	177	4.24	81	0.061	47	0.42	−166
		0.60	0.772	173	3.55	77	0.068	49	0.42	−169
		0.70	0.773	170	3.06	74	0.076	51	0.421	−171
		0.80	0.773	168	2.69	71	0.084	52	0.422	−172
		0.90	0.772	165	2.41	67	0.091	53	0.423	−174
		1.00	0.772	162	2.18	65	0.099	53	0.426	−175
		1.50	0.771	150	1.50	50	0.138	52	0.436	−180
		2.00	0.772	139	1.17	38	0.175	48	0.451	176
		2.50	0.778	128	0.96	27	0.208	44	0.478	174
		3.00	0.783	117	0.83	17	0.241	38	0.493	169
		3.50	0.790	108	0.74	8	0.271	33	0.507	165
		4.00	0.800	99	0.67	1	0.299	27	0.526	158
		4.50	0.798	91	0.62	−5	0.329	21	0.538	153
		5.00	0.806	83	0.57	−11	0.353	15	0.561	147

Table 2. Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
3.0	100	0.10	0.747	–149	18.83	109	0.035	35	0.531	–117
		0.20	0.775	–167	9.95	95	0.041	35	0.463	–145
		0.30	0.781	–175	6.72	88	0.047	40	0.448	–156
		0.40	0.782	–179	5.07	83	0.053	44	0.444	–162
		0.50	0.779	176	4.08	81	0.061	48	0.431	–168
		0.60	0.778	173	3.42	77	0.068	50	0.431	–170
		0.70	0.779	170	2.95	74	0.076	52	0.432	–172
		0.80	0.779	167	2.60	70	0.084	53	0.434	–174
		0.90	0.778	164	2.32	67	0.092	53	0.434	–175
		1.00	0.778	162	2.10	64	0.100	54	0.436	–177
		1.50	0.776	150	1.45	50	0.139	52	0.445	179
		2.00	0.777	138	1.13	38	0.177	48	0.46	175
		2.50	0.782	127	0.93	27	0.209	44	0.485	173
		3.00	0.786	117	0.81	17	0.243	38	0.498	168
		3.50	0.794	107	0.72	9	0.273	32	0.51	163
		4.00	0.802	99	0.65	1	0.301	27	0.528	157
		4.50	0.800	91	0.60	–5	0.330	21	0.539	152
		5.00	0.807	83	0.56	–11	0.354	15	0.56	145
6.0	25	0.10	0.715	–122	19.96	119	0.039	40	0.562	–72
		0.20	0.742	–151	11.31	101	0.046	33	0.364	–98
		0.30	0.748	–164	7.76	92	0.050	33	0.298	–112
		0.40	0.750	–171	5.89	86	0.054	36	0.271	–120
		0.50	0.743	–177	4.73	82	0.058	39	0.24	–127
		0.60	0.744	179	3.97	78	0.063	42	0.237	–131
		0.70	0.746	175	3.42	74	0.068	44	0.239	–134
		0.80	0.748	172	3.00	70	0.074	46	0.243	–135
		0.90	0.747	169	2.68	66	0.079	47	0.248	–137
		1.00	0.748	166	2.42	63	0.085	49	0.255	–139
		1.50	0.753	153	1.64	47	0.115	52	0.3	–144
		2.00	0.760	141	1.25	33	0.148	51	0.352	–150
		2.50	0.772	130	1.00	21	0.180	49	0.417	–155
		3.00	0.783	119	0.84	11	0.215	44	0.464	–163
		3.50	0.795	109	0.72	2	0.249	40	0.505	–170
		4.00	0.807	101	0.63	–5	0.283	34	0.545	–179
		4.50	0.808	92	0.56	–10	0.319	28	0.576	173
		5.00	0.815	84	0.51	–14	0.349	22	0.609	164
	50	0.10	0.706	–131	22.47	116	0.034	40	0.527	–86
		0.20	0.734	–157	12.38	99	0.041	36	0.37	–117
		0.30	0.740	–168	8.44	91	0.046	38	0.325	–132
		0.40	0.742	–174	6.38	86	0.051	42	0.308	–140
		0.50	0.736	–179	5.13	82	0.057	46	0.283	–147
		0.60	0.737	177	4.30	78	0.063	48	0.281	–151
		0.70	0.738	173	3.70	74	0.069	50	0.282	–154
		0.80	0.740	170	3.26	71	0.075	51	0.285	–155
		0.90	0.739	168	2.90	68	0.082	52	0.287	–157
		1.00	0.740	165	2.63	65	0.089	53	0.291	–158
		1.50	0.742	152	1.79	50	0.123	53	0.315	–162
		2.00	0.748	141	1.37	36	0.158	50	0.348	–165
		2.50	0.758	129	1.11	25	0.189	47	0.395	–168
		3.00	0.768	119	0.94	14	0.222	42	0.427	–173
		3.50	0.780	109	0.81	5	0.253	37	0.458	–178
		4.00	0.793	101	0.72	–3	0.283	32	0.491	175
		4.50	0.795	92	0.65	–9	0.316	26	0.518	169
		5.00	0.805	84	0.58	–15	0.343	20	0.552	161

Table 2. Common Emitter S–Parameters (continued)

V_{CE} (Volts)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
6.0	75	0.10	0.710	–135	22.99	114	0.033	39	0.505	–93
		0.20	0.735	–159	12.49	98	0.039	37	0.367	–123
		0.30	0.741	–169	8.49	90	0.044	40	0.33	–137
		0.40	0.742	–175	6.42	85	0.050	44	0.317	–145
		0.50	0.737	180	5.16	82	0.056	48	0.295	–153
		0.60	0.737	176	4.32	78	0.062	50	0.294	–156
		0.70	0.739	173	3.72	74	0.069	52	0.295	–158
		0.80	0.740	170	3.27	71	0.076	53	0.297	–160
		0.90	0.739	167	2.92	68	0.083	54	0.298	–161
		1.00	0.740	164	2.64	65	0.090	54	0.302	–162
		1.50	0.742	152	1.80	50	0.125	53	0.322	–166
		2.00	0.747	140	1.38	37	0.160	50	0.349	–169
		2.50	0.757	129	1.12	25	0.191	47	0.392	–171
		3.00	0.766	119	0.95	15	0.224	42	0.42	–176
		3.50	0.778	109	0.82	5	0.254	36	0.448	180
		4.00	0.791	100	0.73	–3	0.284	31	0.479	173
		4.50	0.793	92	0.66	–9	0.315	26	0.504	167
		5.00	0.803	84	0.60	–15	0.342	20	0.536	160
	100	0.10	0.718	–138	22.70	112	0.032	38	0.481	–96
		0.20	0.740	–161	12.22	97	0.038	37	0.354	–126
		0.30	0.745	–170	8.28	90	0.043	41	0.321	–140
		0.40	0.746	–176	6.25	84	0.049	45	0.309	–147
		0.50	0.741	179	5.03	81	0.055	49	0.29	–154
		0.60	0.741	175	4.21	77	0.062	51	0.289	–157
		0.70	0.743	172	3.62	74	0.069	53	0.29	–159
		0.80	0.744	169	3.19	70	0.076	54	0.293	–161
		0.90	0.743	166	2.84	67	0.083	54	0.294	–162
		1.00	0.744	164	2.57	64	0.090	55	0.298	–163
		1.50	0.745	151	1.75	49	0.126	54	0.318	–166
		2.00	0.750	140	1.35	36	0.160	51	0.347	–169
		2.50	0.760	129	1.09	25	0.192	47	0.39	–171
		3.00	0.769	118	0.93	14	0.224	42	0.418	–175
		3.50	0.781	109	0.80	5	0.255	37	0.447	180
		4.00	0.793	100	0.71	–3	0.284	31	0.478	173
		4.50	0.794	91	0.64	–9	0.316	26	0.502	167
		5.00	0.804	84	0.58	–15	0.342	20	0.534	160

Table 2. Common Emitter S–Parameters (continued)

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

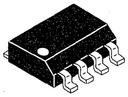
The RF Line
NPN Silicon High-Frequency Transistor

MRF5943, R1, R2

. . . designed for amplifier, oscillator or frequency multiplier applications in industrial equipment. Suitable for use as a Class A, B or C output driver or pre–driver stages in VHF and UHF.

- Low Cost SORF Plastic Surface Mount Package
- Guaranteed RF Specification — $|S_{21}|^2$
- S–Parameter Characterization
- Tape and Reel Packaging Options Available by adding suffix:
  R1 suffix = 500 units per reel
  R2 suffix = 2,500 units per reel

I_C = 400 mA
SURFACE MOUNT
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON



CASE 751–05, STYLE 1
(SO–8)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	40	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

DEVICE MARKING

MRF5943 = 5943

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Storage Temperature	T_{stg}	150	°C
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 5.0 mA)	$V_{(BR)CEO}$	30	—	—	V
Collector–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	40	—	—	V
Emitter–Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	3.5	—	—	V
Collector Cutoff Current (V_{CE} = 20 V)	I_{CEO}	—	—	50	μA
Collector Cutoff Current (V_{CB} = 15 V)	I_{CBO}	—	—	10	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mA, V_{CE} = 15 V)	h_{FE}	25	—	300	—
Collector–Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	—	—	0.2	V
Base–Emitter Saturation Voltage (I_C = 100 mA, I_B = 10 mA)	$V_{BE(sat)}$	—	—	1.0	V
SMALL–SIGNAL CHARACTERISTICS					
Current–Gain — Bandwidth Product (I_C = 35 mA, V_{CE} = 15 V, f = 100 MHz)	f_T	—	1550	—	MHz
Insertion Gain (V_{CE} = 15 V, I_C = 35 mA, f = 250 MHz)	$|S_{21}|^2$	12	15	—	dB

REV 6

V_{CE} (Volts)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
15	35	10	0.37	−63	53.7	157	0.01	59	0.91	−18
		30	0.52	−120	36.5	128	0.01	48	0.64	−38
		50	0.58	−142	25.4	113	0.02	45	0.47	−44
		70	0.59	−154	19	105	0.02	46	0.38	−44
		100	0.60	−162	13.6	97	0.02	49	0.32	−43
		300	0.64	178	4.6	77	0.05	59	0.28	−49
		500	0.65	168	2.8	64	0.07	60	0.32	−62
		700	0.65	159	2.0	53	0.09	63	0.38	−76
		1000	0.64	144	1.4	38	0.13	63	0.46	−93

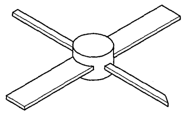
Table 1. Common Emitter S–Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
NPN Silicon RF Power Transistor

MRF6401

0.5 W, 1.0 to 2.0 GHz
RF LINEAR
POWER TRANSISTOR



CASE 305C–02, STYLE 1
SOE200–PILL

The MRF6401 is designed for Class A common emitter, linear power amplifiers in the 1.0–2.0 GHz frequency range. It has been specifically designed for use in Personal Communications Network (PCN) base station and INMARSAT Standard M applications.

- Specified 20 Volts, 1.66 GHz Characteristics:
  Output Power — 0.5 Watts
  Gain — 10 dB Min
  Class A Operation
- Specified 20 Volts, 1.88 GHz Characteristics:
  Output Power — 0.5 Watts
  Gain — 9.0 dB Min
  Class A Operation
- Circuit Board Photomaster Available by Ordering Document MRF6401PHT/D from Motorola Literature Distribution.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	22	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.8 0.033	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	30	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

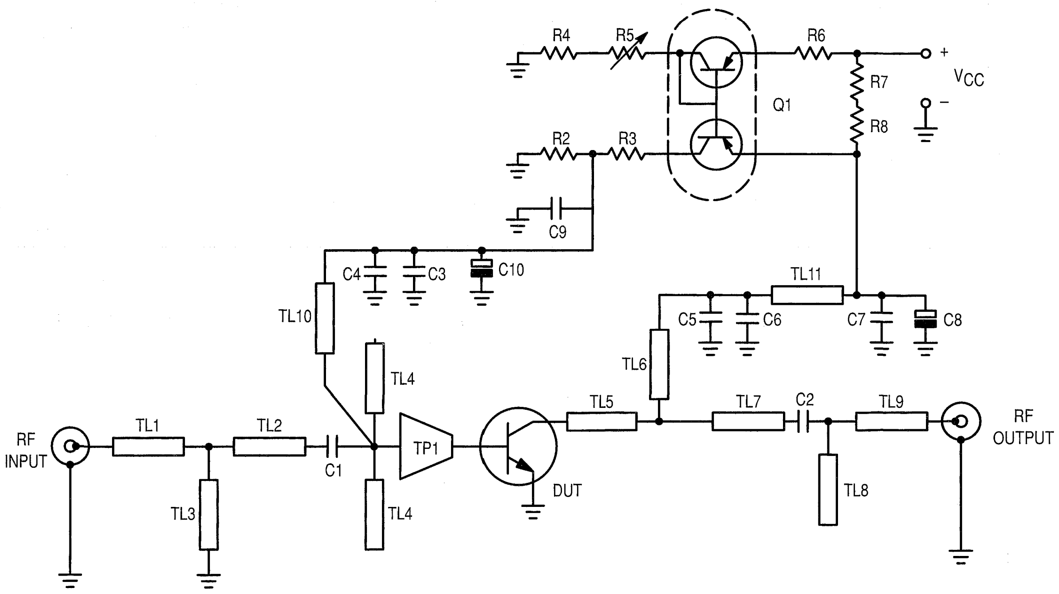
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 10$ mAdc, $R_B = 75\ \Omega$)	$V_{(BR)CER}$	28	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 0.25$ mAdc)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 1$ mAdc)	$V_{(BR)CBO}$	45	—	—	Vdc

(1) Thermal resistance is determined under specified RF operating condition.

REV 1

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 Adc, V_{CE} = 5 Vdc)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 V, I_E = 0, f = 1 MHz)	C_{ob}	—	1.4	—	pF
FUNCTIONAL TESTS (V_{CC} = 20 V, I_{CQ} = 80 mA)					
Common–Emitter Amplifier Power Gain (f = 1660 MHz, P_{out} = 0.5 W) (f = 1880 MHz, P_{out} = 0.5 W)	G_p	 10 9	 11 10	 — —	dB
Load Mismatch (f = 1660 MHz, f = 1880 MHz, P_{out} = 0.5 W, Load VSWR = 20:1, all phase angles at frequency of test)	ψ	No Degradation in Output Power			
Intermodulation Distortion (P_{out} = 0.5 W PEP, f1 = 1659.2 MHz, f2 = 1660 MHz) (P_{out} = 0.5 W PEP, f1 = 1879.2 MHz, f2 = 1880 MHz)	IMD	 –30 –30	 –35 –35	 — —	dBc



C1	1.5 pF, ATC Chip Capacitor 100A
C2	3.9 pF, ATC Chip Capacitor 100A
C3	56 pF, ATC Chip Capacitor 100A
C4, C6, C7, C9	15 nF, Chip Capacitor 0805
C5	47 pF, ATC Chip Capacitor 100A
C8	4.7 µF, 35 V, Capacitor
C10	10 µF, 16 V, Capacitor
C11	100 pF, ATC Chip Capacitor 100A
Q1	Transistor, BCV62
R2	470 Ω, Chip Resistor 0805
R3	4.7 kΩ, Chip Resistor 0805
R4	8.2 kΩ, Chip Resistor 0805
R5	5 kΩ, SMD Potentiometer
R6	680 Ω, Chip Resistor 0805
R7, R8	7.5 Ω, Chip Resistor 0805
TL1 to TL11	µStrip Lines; See Photomaster Document, MRF6401PHT/D
TP1	µStrip Taper; See Photomaster Document, MRF6401PHT/D

Figure 1. 1600–2000 MHz Broadband Application Amplifier Schematic

TYPICAL CHARACTERISTICS

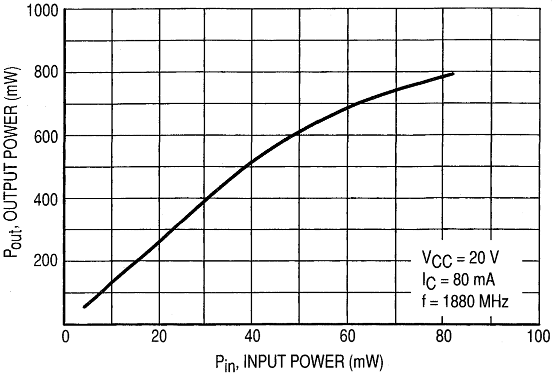


Figure 2. Output Power versus Input Power

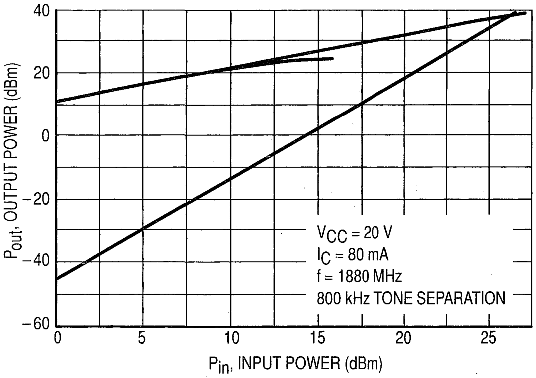


Figure 3. Third Order Intercept

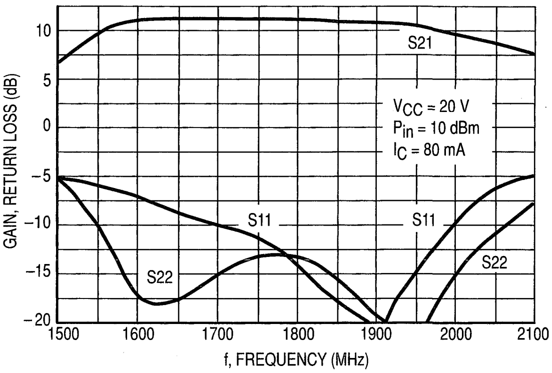


Figure 4. Performance in Broadband Test Fixture

Table 1. Common Emitter S–Parameters

V_{CC} = 20 V, I_C = 80 mA

POLAR S–PARAMETERS IN 50 Ω SYSTEM								
f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
100	0.626	–118	28.4	127	0.0186	45	0.649	–40
200	0.718	–149	17.1	106	0.0230	35	0.434	–49
400	0.754	–171	9.10	88	0.0271	35	0.303	–53
600	0.761	179	6.15	77	0.0312	38	0.272	–56
800	0.762	171	4.65	68	0.0359	42	0.266	–62
1000	0.763	165	3.73	60	0.0409	44	0.271	–68
1200	0.758	159	3.13	52	0.0469	44	0.286	–75
1400	0.753	155	2.60	44	0.0490	46	0.291	–87
1600	0.765	150	2.30	39	0.0574	50	0.288	–93
1800	0.769	144	2.06	32	0.0665	49	0.303	–97
1900	0.768	142	1.98	29	0.0714	48	0.312	–100
2000	0.767	139	1.88	25	0.0756	48	0.322	–103

V_{CC} = 20 V, I_C = 50 mA

POLAR S–PARAMETERS IN 50 Ω SYSTEM								
f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
100	0.618	–113	26.2	130	0.0195	45	0.678	–36
200	0.713	–145	16.2	108	0.0251	34	0.465	–47
400	0.758	–168	8.78	89.2	0.0288	32	0.331	–51
600	0.763	180	5.94	78	0.0323	35	0.297	–55
800	0.761	169	4.49	68	0.0363	39	0.290	–61
1000	0.764	166	3.61	60	0.0415	41	0.294	–68
1200	0.758	160	3.02	52	0.0467	42	0.310	–75
1400	0.757	155	2.52	44.5	0.0486	45	0.313	–87
1600	0.768	150	2.22	39	0.0566	48	0.311	–92
1800	0.772	145	2	32	0.0655	48	0.328	–97
1900	0.770	142	1.91	28	0.0705	47	0.335	–101
2000	0.772	140	1.81	25	0.0745	47	0.345	–104

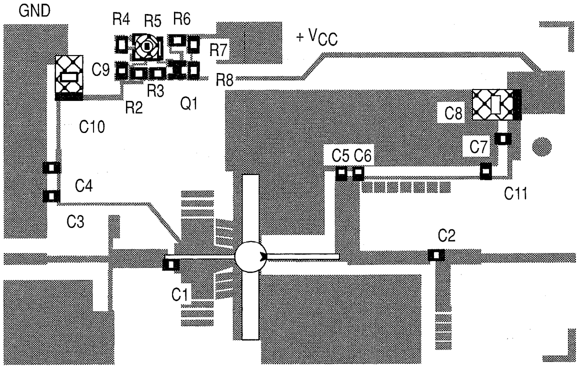


Figure 5. Test Circuit Components Layout

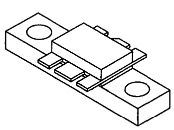
The RF Line
NPN Silicon RF Power Transistor

MRF6402

The MRF6402 is designed for 1.8 GHz Personal Communications Network (PCN) base stations applications. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness. For ease of design, this transistor has an internally matched input.

- To be used in Class AB for PCN and Cellular Radio Applications
- Specified 26 V, 1.88 GHz Characteristics
  Output Power — 4.5 Watts
  Gain — 10 dB Typ
  Efficiency — 45% Typ
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

4.5 W, 1.88 GHz
RF POWER TRANSISTOR
NPN SILICON



CASE 319–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CER}	40	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector–Current — Continuous	I_C	0.7	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	15 0.2	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	5	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 10$ mA, $R_{BE} = 75\ \Omega$)	$V_{(BR)CER}$	40	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 5$ mAdc)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 10$ mAdc)	$V_{(BR)CBO}$	40	—	—	Vdc
Collector–Emitter Leakage ($V_{CE} = 26$ V, $R_{BE} = 75\ \Omega$)	I_{CER}	—	—	5	mA

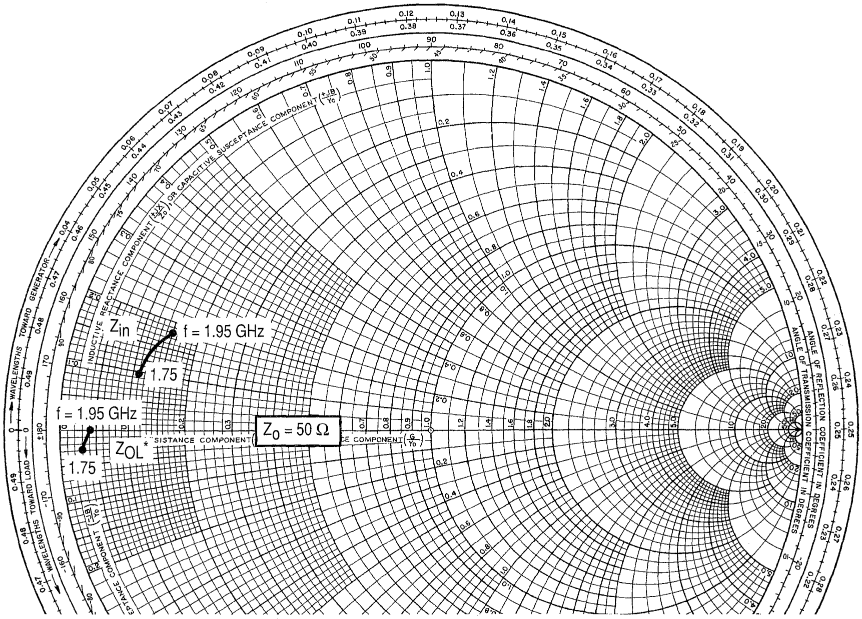
(continued)

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 Adc, V_{CE} = 20 Vdc)	h_{FE}	50	—	200	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 V, I_E = 0, f = 1 MHz)	C_{ob}	—	6	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 V, P_{out} = 4 W, I_{CQ} = 40 mA, f = 1.88 GHz)	G_p	9	10	—	dB
Collector Efficiency (V_{CC} = 26 V, P_{out} = 4 W, f = 1.88 GHz)	η	40	43	—	%
Load Mismatch (V_{CC} = 26 V, P_{out} = 4.5 W, I_{CQ} = 40 mA, f = 1.88 GHz, Load VSWR = 3:1, All Phase Angles at Frequency of Test)	Ψ	No Degradation in Output Power			



f (GHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
1.75	5.9 + j9.2	2.8 + j2.7
1.80	6.2 + j9.6	2.9 + j2.3
1.84	6.5 + j10	2.9 + j1.8
1.90	6.8 + j9.1	2.9 + j1.4
1.95	7.3 + j8.1	3.1 + j0.9

Z_{OL}*: Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 1. Input and Output Impedances with Circuit Tuned for Maximum Gain @ V_{CE} = 26 V, I_{CQ} = 40 mA, P_{out} = 4.5 W

TYPICAL CHARACTERISTICS

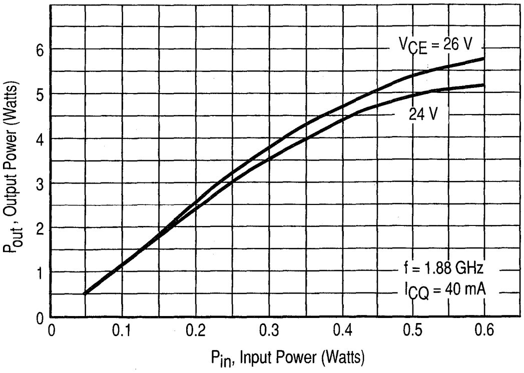


Figure 2. Typical Output Power versus Input Power

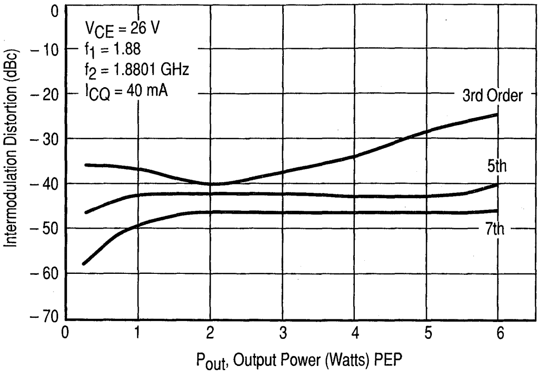
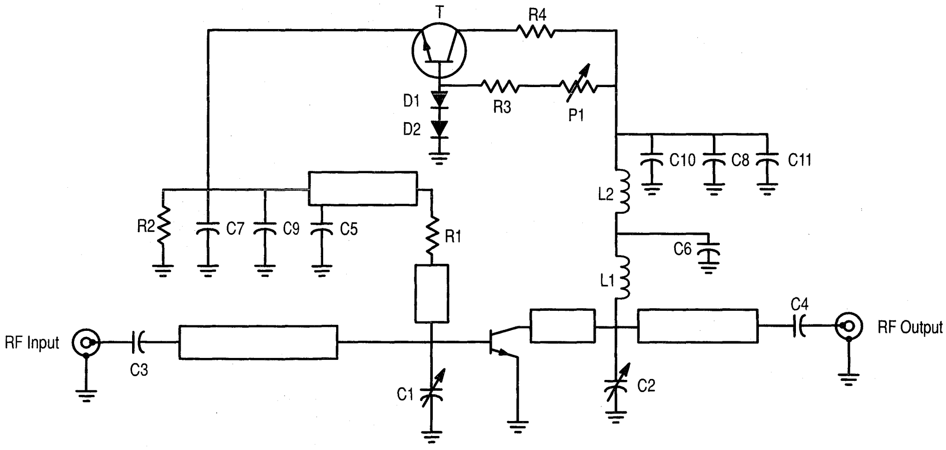


Figure 3. IMD versus Output Power



C1, C2	1 to 5 pF, Trimmer Capacitor, Johanson
C3, C4	100A, 68 pF, Chip Capacitor, ATC
C5, C6	100A, 82 pF, Chip Capacitor, ATC
C7, C8	15 nF, Chip Capacitor, 0805
C9, C10	330 pF, Chip Capacitor, 0805
C11	4.7 µF, 35 V, Capacitor
D1, D2	Diode, 1N4148

L1	2 Turns, Wire 0.5 mm, ID 2 mm
L2	Ferrite Bead, SMD Fair–Rite
P1	10 kΩ, Trimmer
R1	2.2 Ω, Chip Resistor, 0805
R2	56 Ω, Chip Resistor, 1206
R3	1.2 kΩ, 1/4 W, 5%, Resistor
R4	100 Ω, 3 W, Power Resistor
T	Transistor, BD135

Figure 4. 1.80–1.88 GHz Test Circuit Electrical Schematic

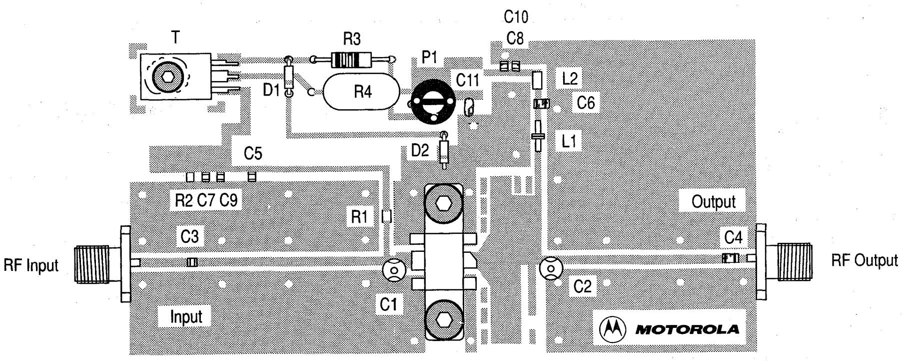


Figure 5. Test Circuit Components View and Parts List

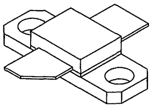
The RF Line
NPN Silicon RF Power Transistor

MRF6404

30 W, 1.88 GHz
RF POWER TRANSISTOR
NPN SILICON

The MRF6404 is designed for 26 volts microwave large signal, common emitter, class AB linear amplifier applications operating in the range 1.8 to 2.0 GHz.

- Specified 26 Volts, 1.88 GHz Characteristics
  Output Power — 30 Watts
  Gain — 7.5 dB Min @ 30 Watts
  Efficiency — 38% Min @ 30 Watts
- Characterized with Series Equivalent Large–Signal Parameters from 1.8 to 2.0 GHz
- To be used in Class AB for DCS1800 and PCS1900/Cellular Radio
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration



CASE 395C–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	24	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 0.71	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	1.4	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

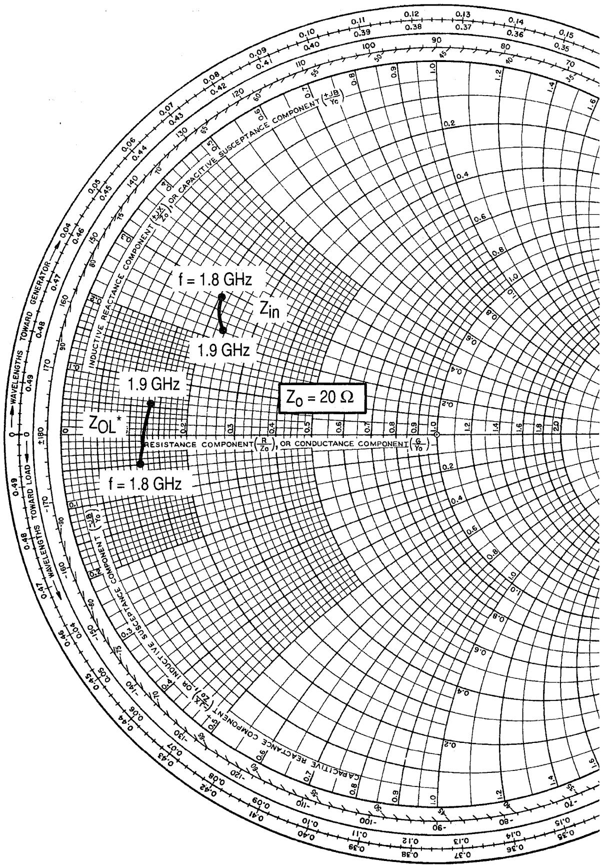
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mA, I_B = 0)	$V_{(BR)CEO}$	24	29	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc)	$V_{(BR)EBO}$	4	5	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc)	$V_{(BR)CES}$	60	68	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 75 Ω)	$V_{(BR)CER}$	40	56	—	Vdc
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0)	I_{CES}	—	—	10	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 Adc, V_{CE} = 5 Vdc)	h_{FE}	20	50	120	—

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

REV 1

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 V, I_E = 0, f = 1 MHz) For information only. This part is collector matched.	C_{ob}	30	38	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 V, P_{out} = 30 W, I_{CQ} = 150 mA, f = 1.88 GHz)	G_{pe}	7.5	8.5	—	dB
Common–Emitter Amplifier Power Gain (V_{CC} = 26 V, P_{out} = 28 W, I_{CQ} = 150 mA) (f = 1.99 GHz)	G_{pe}	7	8	—	dB
Collector Efficiency (V_{CC} = 26 V, P_{out} = 30 W, f = 1.88 GHz) (V_{CC} = 26 V, P_{out} = 28 W, f = 1.99 GHz)	η	 38 35	 43 40	 — —	%
Output Power at 1 dBc (V_{CC} = 26 V, f = 1.88 GHz) (V_{CC} = 26 V, f = 1.99 GHz)	P_{1dBc}	 30 28	 35 33	 — —	Watts
Output Mismatch Stress: VSWR = 3:1 (all phase angles) (V_{CC} = 26 Vdc, P_{out} = 25 W, I_{CQ} = 150 mA, f = 1.88 GHz)	Ψ	No Degradation in Output Power			



DCS EVALUATION

f (GHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
1.8	4.3 + j6.1	2.7 – j1.0
1.85	4.6 + j5.3	2.9 + j0.3
1.9	4.8 + j5.0	3.0 + j1.2

Z_{OL}*: Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 1. Input and Output Impedances with Circuit Tuned for Maximum Gain @ V_{CC} = 26 V, I_{CQ} = 150 mA, P_{out} = 30 W

TYPICAL CHARACTERISTICS

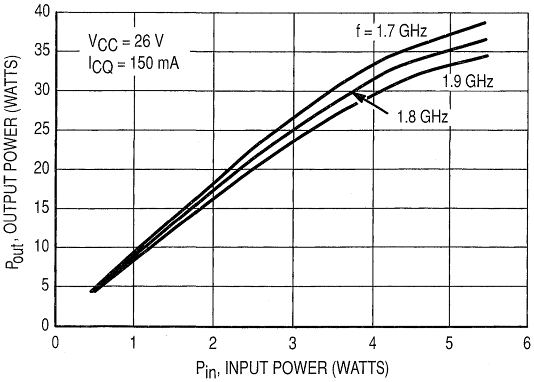


Figure 2. Output Power versus Input Power

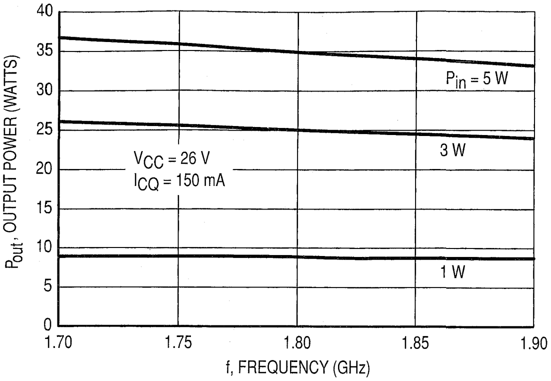


Figure 3. Output Power versus Frequency

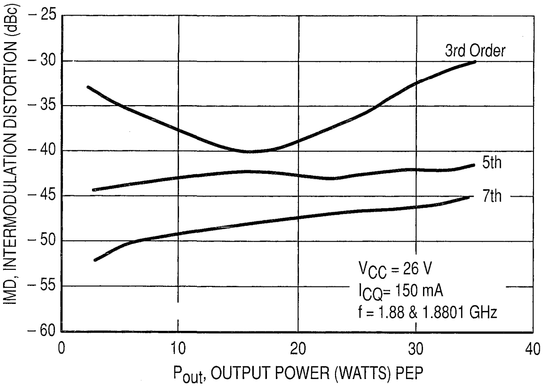


Figure 4. Intermodulation versus Output Power

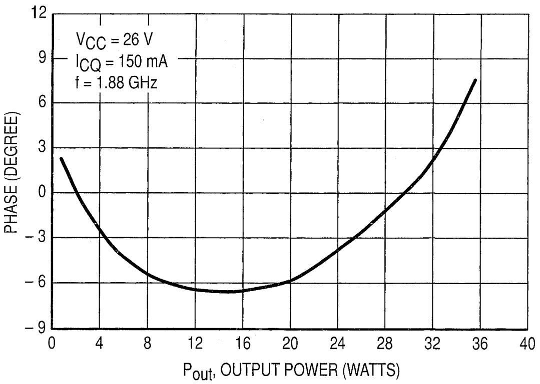
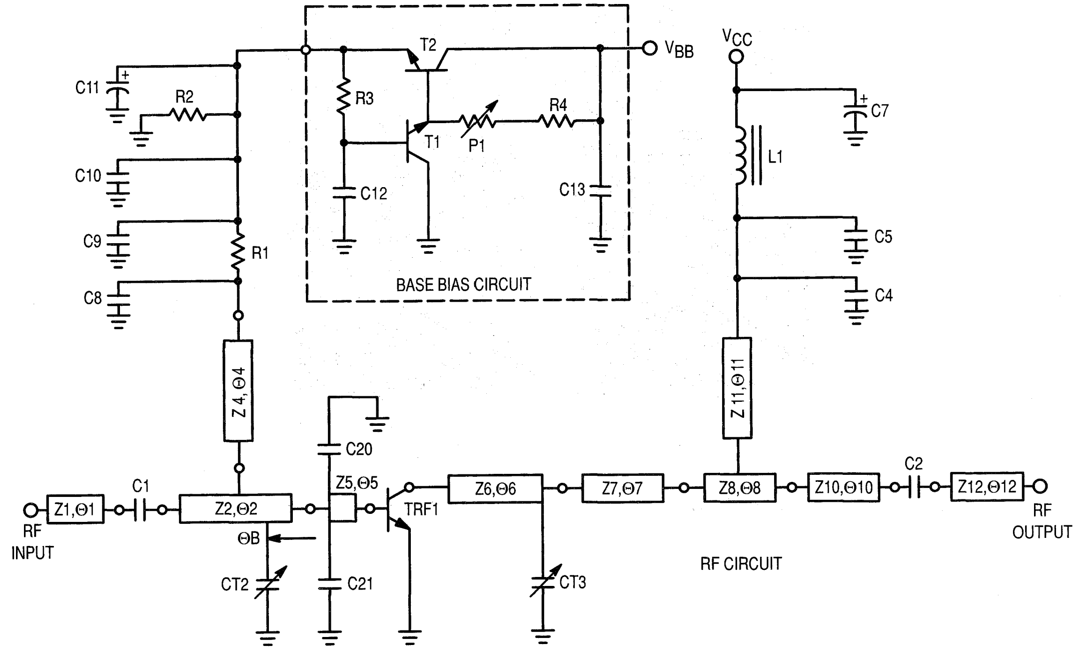


Figure 5. AM/PM Conversion



Base Bias Circuit

C12, C13	15 nF, Chip Capacitor, Vitramon (0805 A153 JXB)
P1	1 KΩ, Trimmer
R3	47 Ω, Chip Resistor, 0805
R4	330 Ω, Chip Resistor, 0805
T1,T2	Motorola MJD 31C

Decoupling Base Bias Circuit

C4	68 pF, Chip Capacitor, ATC 100A
C5, C9	330 pF, Chip Capacitor, Vitramon (0805 A331 JXB)
C7, C11	4.7 μF, 63 V, Electrolytic Capacitor
C8	68 pF, Chip Capacitor, ATC 100A
C10	15 nF, Chip Capacitor, Vitramon (0805 A153 JXB)
R1	1.5 Ω, Chip Resistor, 0805
R2	56 Ω, Chip Resistor, 1206

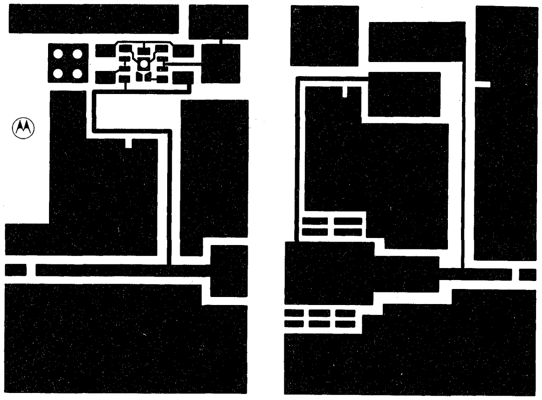
RF Circuit

C1, C2	68 pF, Chip Capacitor, ATC 100A
C20, C21	1.3 pF, Chip Capacitor, ATC 100A
CT2	Trimmer Capacitor, Gigatrim, Ref 37281
CT3	Trimmer Capacitor, Gigatrim, Ref 37291
TRF1	MRF6404

PC Board Material:
$\varepsilon_r = 2.55$, H = 0.508 mm, T = 0.035 mm

All Electrical Lengths Are Referenced from λg @ f = 1.9 GHz
Z1 : 50 Ω Θ1 : 10°
Z2 : 50 Ω Θ2 : 74.5° ΘB : 16.5°
Z4 : 74 Ω Θ4 : 68°
Z5 : 12.8 Ω Θ5 : 21°
Z6 : 10.4 Ω Θ6 : 49.5°
Z7 : 18 Ω Θ7 : 36.5°
Z8 : 45 Ω Θ8 : 20°
Z10 : 50 Ω Θ10 : 10°
Z11 : 74 Ω Θ11 : 74.5°
Z12 : 50 Ω Θ12 : 10°

Figure 6. 1.80–1.88 GHz Test Circuit Electrical Schematic and Components List



Teflon® Glass 0.5 mm – Double Side 35 µm Cu.

Figure 7. 1.80–1.88 GHz PCN Test Circuit Photomaster

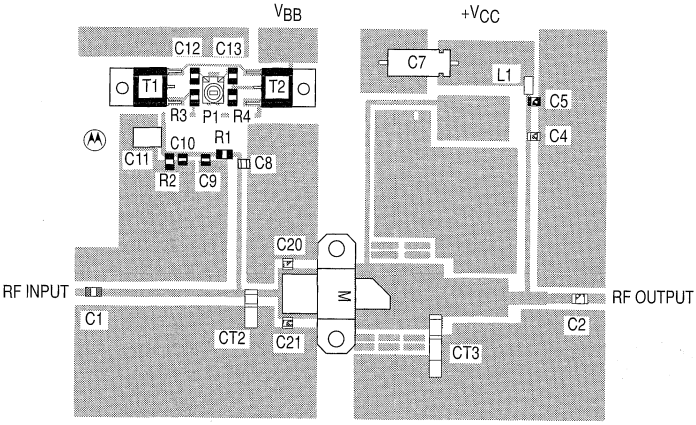
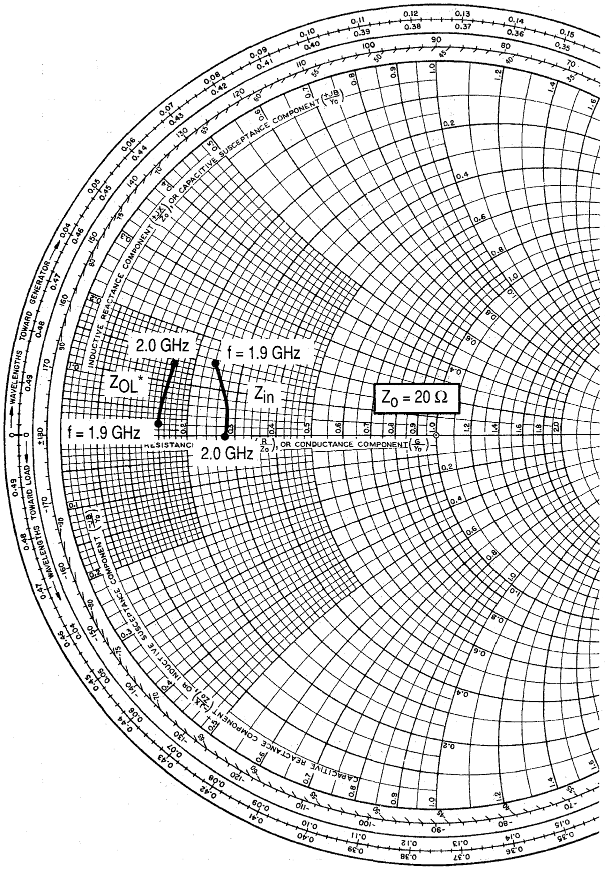


Figure 8. 1.80–1.88 GHz PCN Test Circuit Components Layout



PCS EVALUATION

f (GHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
1.90	4.9 + j3.0	3.2 + j0.5
1.93	5.4 + j2.5	3.3 + j1.2
1.97	5.6 + j1.4	3.4 + j1.5
2.00	5.4 – j0.2	3.6 + j2.5

Z_{OL}*: Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 9. Input and Output Impedances with Circuit Tuned for Maximum Gain @ V_{CC} = 26 V, I_{CQ} = 150 mA, P_{out} = 28 W

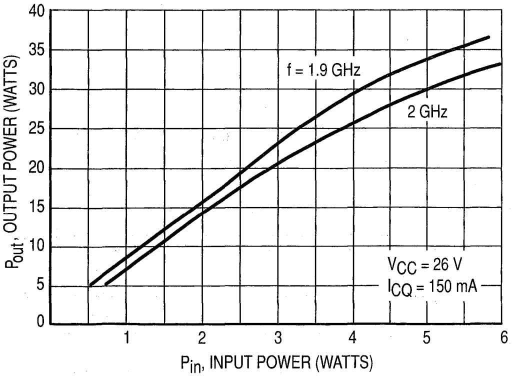


Figure 10. Output Power versus Input Power

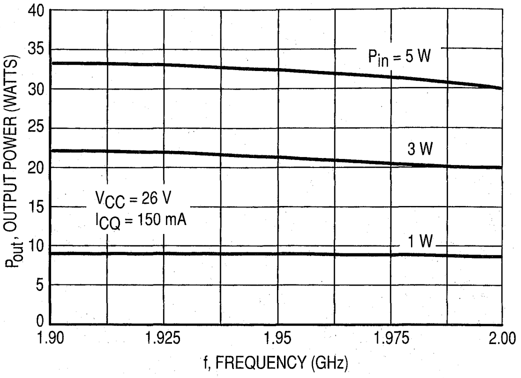


Figure 11. Output Power versus Frequency

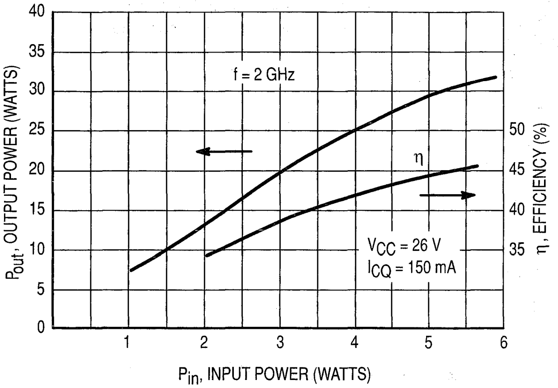


Figure 12. Output Power and Efficiency versus Input Power

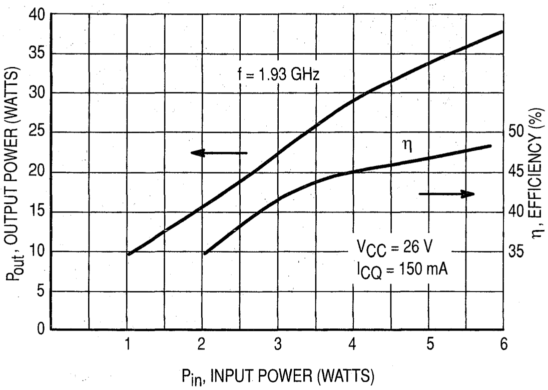


Figure 13. Output Power and Efficiency versus Input Power

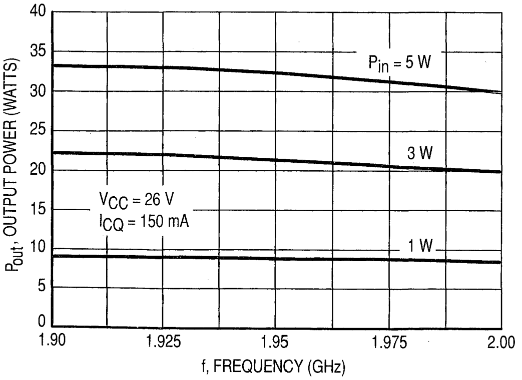
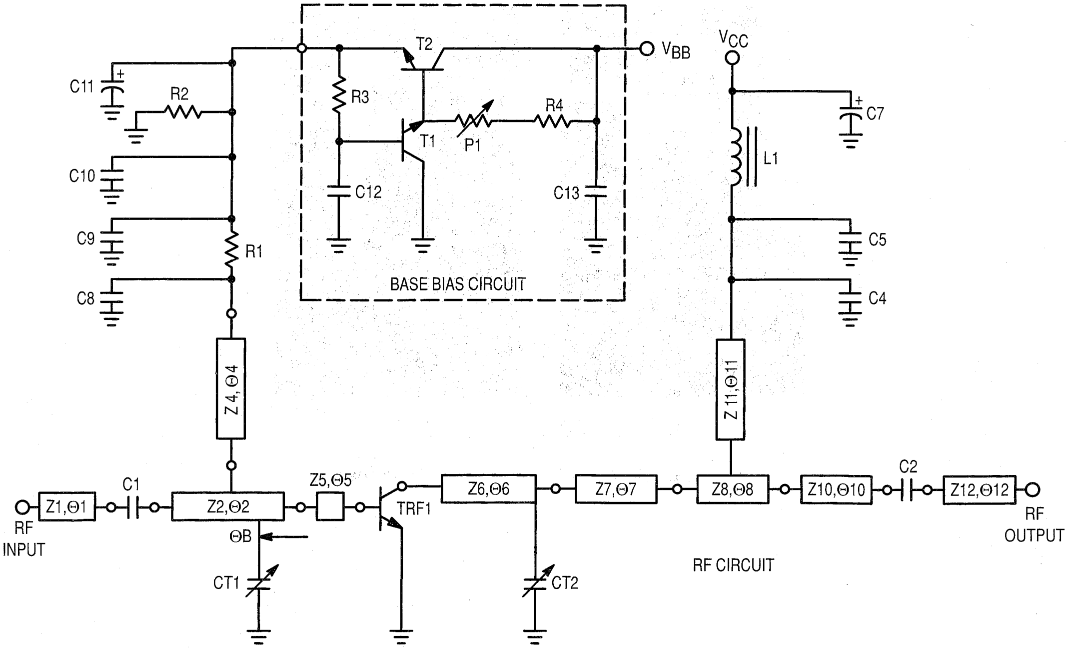


Figure 14. Output Power versus Frequency



Base Bias Circuit

C12, C13	15 nF, Chip Capacitor, Vitramon (0805 A153 JXB)
P1	1 KΩ, Trimmer
R3	47 Ω, Chip Resistor, 0805
R4	330 Ω, Chip Resistor, 0805
T1,T2	Motorola MJD 31C

RF Circuit

C1, C2	68 pF, Chip Capacitor, ATC 100A
C20, C21	1.3 pF, Chip Capacitor, ATC 100A
CT1, CT2	Trimmer Capacitor, Gigatrim, Ref 37271
TRF1	MRF6404

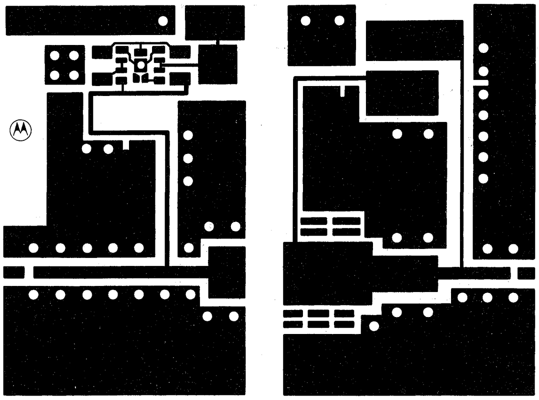
PC Board Material:
ε_r = 2.55, H = 0.508 mm, T = 0.035 mm

Decoupling Base Bias Circuit

C4	68 pF, Chip Capacitor, ATC 100A
C5, C9	330 pF, Chip Capacitor, Vitramon (0805 A331 JXB)
C7, C11	4.7 μF, 63 V, Electrolytic Capacitor
C8	68 pF, Chip Capacitor, ATC 100A
C10	15 nF, Chip Capacitor, Vitramon (0805 A153 JXB)
R1	1.2 Ω, Chip Resistor, 0805
R2	56 Ω, Chip Resistor, 1206

All Electrical Lengths Are Referenced from λg @ f = 1.9 GHz
Z1 : 50 Ω Θ1 : 10°
Z2 : 50 Ω Θ2 : 74.5° ΘB : 16.5°
Z4 : 74 Ω Θ4 : 68°
Z5 : 12.8 Ω Θ5 : 21°
Z6 : 10.4 Ω Θ6 : 49.5°
Z7 : 18 Ω Θ7 : 36.5°
Z8 : 45 Ω Θ8 : 20°
Z10 : 50 Ω Θ10 : 10°
Z11 : 74 Ω Θ11 : 60°
Z12 : 50 Ω Θ12 : 10°

Figure 15. 1.9–2.0 GHz Test Circuit Electrical Schematic and Components List


(Not to Scale)

Teflon® Glass 0.5 mm – Double Side 35 μm Cu.

Figure 16. 1.9–2.0 GHz Test Circuit Photomaster

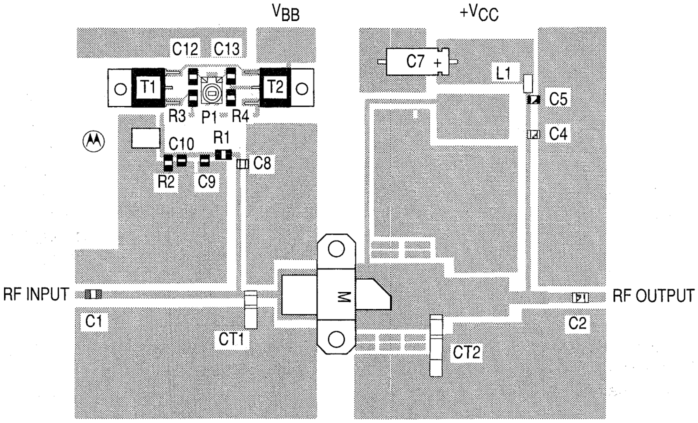


Figure 17. 1.9–2.0 GHz Test Circuit Components Layout

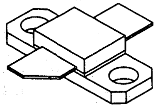
The RF Line
NPN Silicon RF Power Transistor

MRF6408

12 W, 2.0 GHz
RF POWER TRANSISTOR
NPN SILICON

Designed for PCN and PCS base station applications, the MRF6408 incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

- To be used in class AB for PCN–PCS / Cellular Radio
- Specified 26 Volts, 1.88 GHz Characteristics
  Output Power = 12 Watts CW
  Typical Gain = 8.8 dB
  Typical Efficiency = 42%
- Specified 26 Volts, 1.99 GHz Characteristics
  Output Power = 12 Watts CW
  Typical Gain = 8.3 dB
  Typical Efficiency = 39%
- Circuit Board Photomaster Available by Ordering Document MRF6408PHT/D from Motorola Literature Distribution.



CASE 395C–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	24	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 0.35	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	2.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

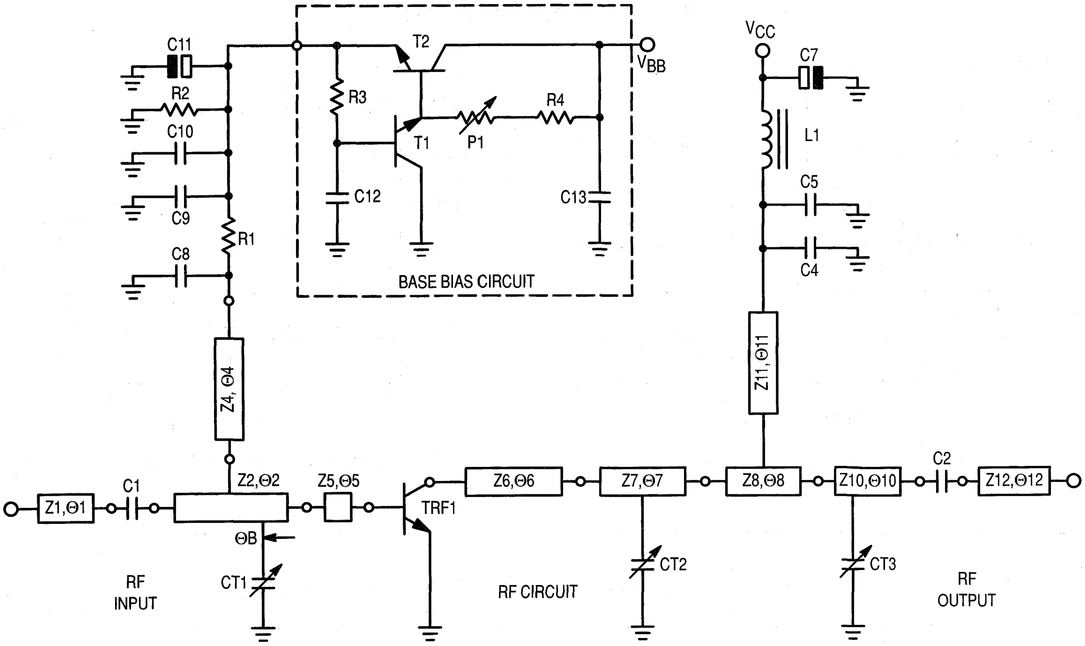
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	24	30	—	Vdc
Emitter–Base Breakdown Voltage (I_B = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	4	5	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	64	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	—	6	mA

(1) Thermal resistance is determined under specified RF operating condition.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1 Adc, V_{CE} = 5 Vdc)	h_{FE}	20	35	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (2) (V_{CB} = 26 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	18	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 12 W (CW), I_{CQ} = 100 mA, f = 1.88 GHz)	G_{pe}	7.8	8.8	—	dB
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 12 W (CW), I_{CQ} = 100 mA, f = 1.99 GHz)	G_{pe}	7.5	8.3	—	dB
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 12 W (CW), I_{CQ} = 100 mA, f = 1.88 GHz)	η	37	42	—	%
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 12 W (CW), I_{CQ} = 100 mA, f = 1.99 GHz)	η	34	39	—	%
Output Power at 1 dB Compression Point (V_{CC} = 26 Vdc, I_{CQ} = 100 mA, f = 1.88 GHz)	P @ 1 dB	15	—	—	W
Output Power at 1 dB Compression Point (V_{CC} = 26 Vdc, I_{CQ} = 100 mA, f = 1.99 GHz)	P @ 1 dB	14	—	—	W
Intermodulation Distortion (V_{CC} = 26 Vdc, P_{out} = 12 W (PEP), I_{CQ} = 100 mA, f1 = 1880 MHz, f2 = 1880.1 MHz)	IMD	—	−35	−30	dBc
Intermodulation Distortion (V_{CC} = 26 Vdc, P_{out} = 12 W (PEP), I_{CQ} = 100 mA, f1 = 1990 MHz, f2 = 1990.1 MHz)	IMD	—	−35	−30	dBc
Load Mismatch (V_{CC} = 26 Vdc, P_{out} = 12 W (CW), I_{CQ} = 100 mA, f = 1.99 GHz, Load VSWR = 3:1, All Phase Angles at Frequency of Test)	ψ	No Degradation in Output Power			

(2) For information only. This part is collector matched.



C4	47 pF, Chip Capacitor, ATC100A
C5, C9	330 pF, 0805 Chip Capacitor, Vitramon JXB
C7	4.7 μF 63 V, Electrolytic Capacitor
C10, C12, C13	15 nF, 0805 Chip Capacitor, Vitramon JXB
C11	100 μF 16 V, Electrolytic Capacitor
L1	SMD Ferrite Bead, Fair–Rite 2743021447
P1	1 kΩ, Trimmer Resistor
R1	1 Ω, 1206 Chip Resistor
R2	56 Ω, 1206 Chip Resistor
R3	47 Ω, 0805 Chip Resistor
R4	330 Ω, 0805 Chip Resistor
T1, T2	MJD31C, NPN Transistor, Motorola

Test Circuits Bias and Decoupling Components List

C1, C2	33 pF, Chip Capacitor, ATC100A
CT1	Trimmer Capacitor, Gigatrim 37281
CT2	Trimmer Capacitor, Gigatrim 37281
CT3	Trimmer Capacitor, Gigatrim 37281
Z1	50 Ω Θ1 = 10°
Z2	50 Ω Θ2 = 74.5° ΘB = 16.5°
Z4	74 Ω Θ4 = 68°
Z5	12.8 Ω Θ5 = 21°
Z6	10.4 Ω Θ6 = 49.5°
Z7	18 Ω Θ7 = 36.5°
Z8	45 Ω Θ8 = 20°
Z10	50 Ω Θ10 = 10°
Z11	74 Ω Θ11 = 74.5°
Z12	50 Ω Θ12 = 10°

1.88 GHz Test Circuit RF Components List

C1, C2	33 pF, Chip Capacitor, ATC100A
CT1	Trimmer Capacitor, Gigatrim 37281
CT2	Trimmer Capacitor, Gigatrim 37281
CT3	Not Used
Z1	50 Ω Θ1 = 10°
Z2	50 Ω Θ2 = 74.5° ΘB = 16.5°
Z4	74 Ω Θ4 = 68°
Z5	12.8 Ω Θ5 = 21°
Z6	10.4 Ω Θ6 = 49.5°
Z7	18 Ω Θ7 = 36.5°
Z8	45 Ω Θ8 = 20°
Z10	50 Ω Θ10 = 10°
Z11	74 Ω Θ11 = 60°
Z12	50 Ω Θ12 = 10°

1.99 GHz Test Circuit RF Components List

Electrical Lengths are referenced from I_G @ f = 1.9 GHz

Figure 1. Test Circuits Schematic

TYPICAL CHARACTERISTICS

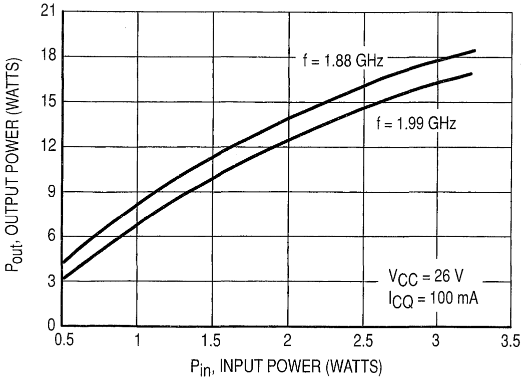


Figure 2. Output Power versus Input Power (CW)

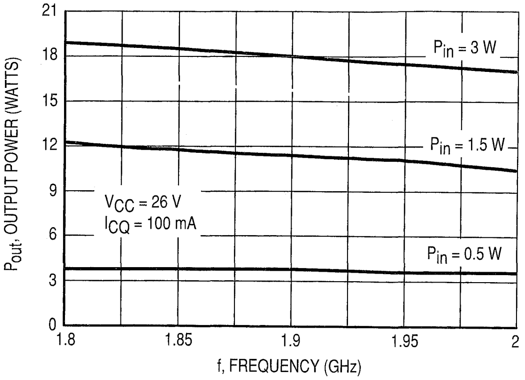


Figure 3. Output Power (CW) versus Frequency

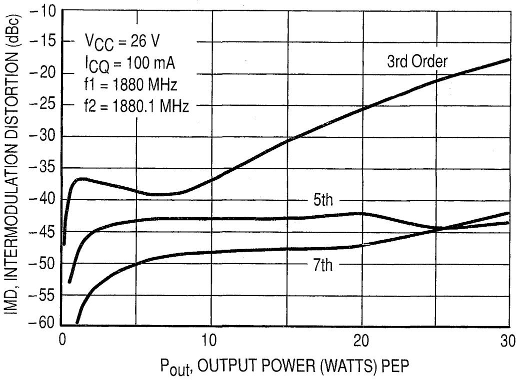


Figure 4. Intermodulation Distortion versus Output Power

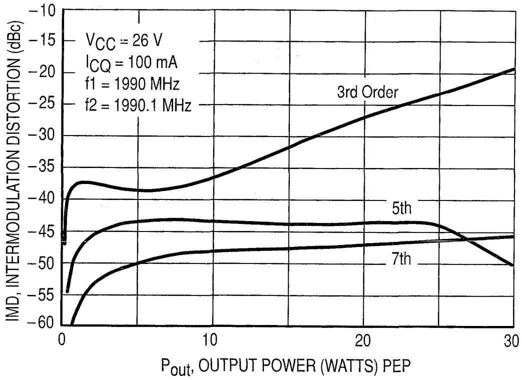


Figure 5. Intermodulation Distortion versus Output Power

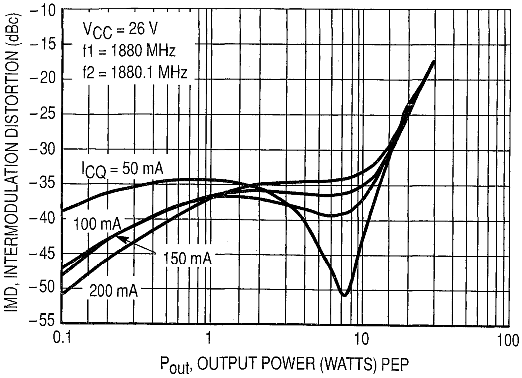


Figure 6. Intermodulation Distortion versus Output Power

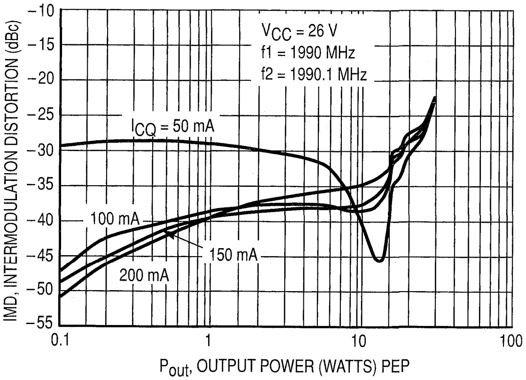
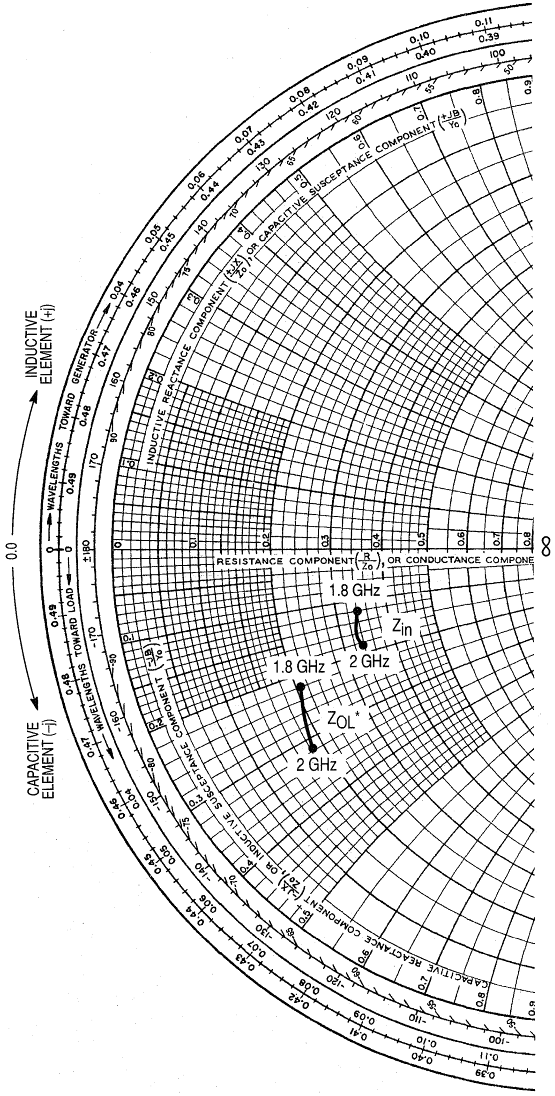


Figure 7. Intermodulation Distortion versus Output Power



Normalized to 20 Ω

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
1800	7.5 – j2.5	5.1 – j4.5
1900	6.5 – j4	4.6 – j5.1
2000	4 – j5.9	4.1 – j6.4

Z_{OL}*: Conjugate of optimum load impedance into which the device operates at a given output power, voltage current and frequency.

Figure 8. Input and Output Impedances with Circuit Tuned for Maximum Gain @ V_{CC} = 26 V, I_{CQ} = 100 mA, P_{out} = 12 W (CW)

V_{CE} (Vdc)	I_C (Adc)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
26	1.0	1000	0.987	176	0.502	−179	0.012	136	0.898	172
		1050	0.986	176	0.478	−177	0.012	136	0.886	172
		1100	0.984	175	0.570	179	0.014	138	0.874	172
		1150	0.982	175	0.553	−177	0.014	137	0.859	171
		1200	0.979	174	0.623	176	0.017	140	0.844	171
		1250	0.974	173	0.660	177	0.017	140	0.826	171
		1300	0.970	172	0.757	176	0.021	138	0.807	171
		1350	0.962	171	0.790	170	0.021	138	0.785	171
		1400	0.950	170	0.932	169	0.025	132	0.760	171
		1450	0.932	169	0.996	161	0.028	131	0.727	172
		1500	0.899	167	1.272	154	0.031	123	0.690	173
		1550	0.845	165	1.407	145	0.035	113	0.649	177
		1600	0.761	165	1.587	132	0.041	100	0.628	−176
		1650	0.670	170	1.763	109	0.041	076	0.672	−168
		1700	0.667	−179	1.671	092	0.039	055	0.776	−166
		1750	0.746	−173	1.390	069	0.030	035	0.861	−168
		1800	0.823	−173	1.184	061	0.024	013	0.897	−172
		1850	0.875	−174	0.901	046	0.018	001	0.911	−175
		1900	0.907	−176	0.755	044	0.015	−012	0.909	−177
		1950	0.928	−177	0.614	038	0.013	−022	0.921	−179
		2000	0.941	−178	0.484	036	0.010	−037	0.901	−179

Table 2. Small Signal S–Parameters

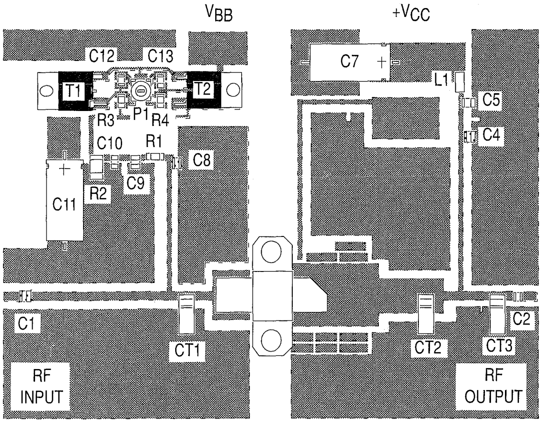


Figure 9. 1.88 GHz Test Circuit Components Layout

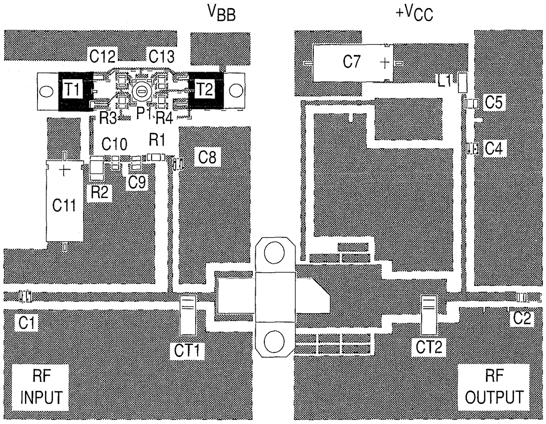


Figure 10. 1.99 GHz Test Circuit Components Layout

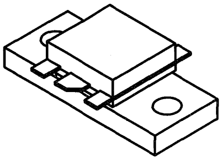
The RF Line
NPN Silicon RF Power Transistor

MRF6414

50 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON

The MRF6414 is designed for 26 volt UHF large signal, common emitter, class AB linear amplifier applications.

- Specified 26 Volt, 960 MHz Characteristics
  Output Power = 50 Watts
  Minimum Gain = 8.5 dB @ 960 MHz, Class AB
  Minimum Efficiency = 50% @ 960 MHz, 50 Watts
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit Board Photomaster Available by Ordering Document MRF6414PHT/D from Motorola Literature Distribution.



CASE 333A–02, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	6	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	134 0.77	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.3	°C/W

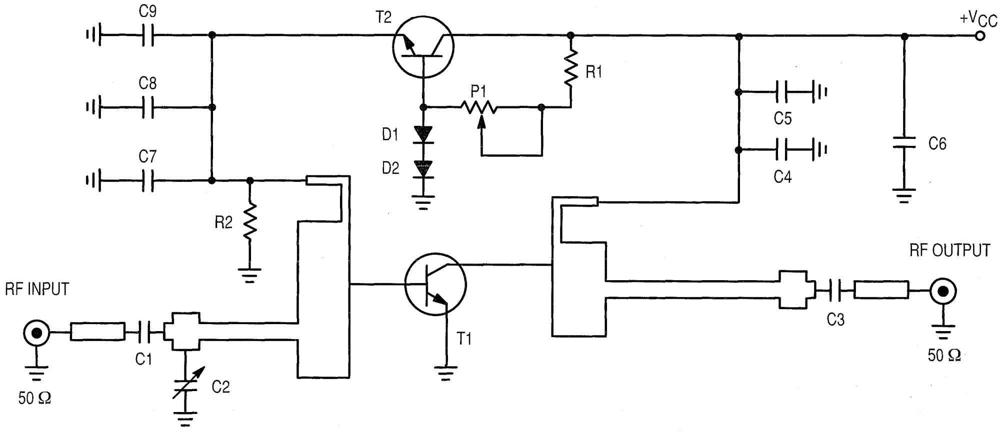
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	$V_{(BR)CEO}$	28	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 20 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector–Emitter Leakage Current (V_{CE} = 30 Vdc, R_{BE} = 75 Ω)	I_{CER}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1 Adc, V_{CE} = 5 Vdc)	h_{FE}	30	—	120	—

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 Vdc, I_E = 0, f = 1 MHz) (1)	C_{ob}	—	45	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 50 W, I_{CQ} = 200 mA, f = 960 MHz)	G_{pe}	8.5	—	—	dB
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 50 W, I_{CQ} = 200 mA, f = 960 MHz)	η	50	55	—	%
Output Mismatch Stress (V_{CC} = 26 Vdc, P_{out} = 50 W, I_{CQ} = 200 mA, f = 960 MHz) VSWR = 3:1; all phase angles at frequency of test	Ψ	No Degradation in Output Power			

(1) For information only. It is not measurable in MRF6414 because of internal matching network.



C1, C3	100 pF, Chip Capacitor, Hight Q	P1	1 kΩ, Trimmer
C2, C7	330 pF, Chip Capacitor, 0805	R1	1 kΩ, Resistor
C5, C8	10 nF, Chip Capacitor, 0805	R2	58 Ω, Resistor, 0805
C6	15 µF, Capacitor, 63 V	T1	MRF6414
C9	100 µF, Capacitor, 16 V	T2	Transistor NPN Type BD135
D1, D2	Diode 1N4007		

Figure 11. 960 MHz Test Circuit Schematic

TYPICAL CHARACTERISTICS

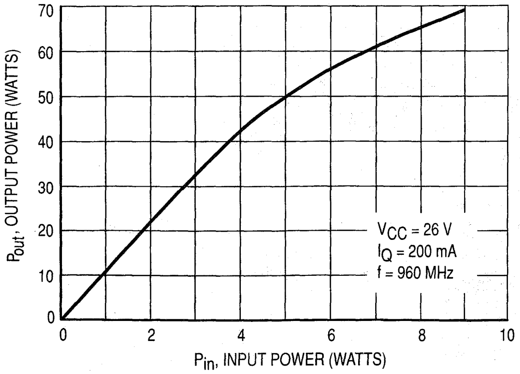


Figure 12. Output Power versus Input Power (Typical)

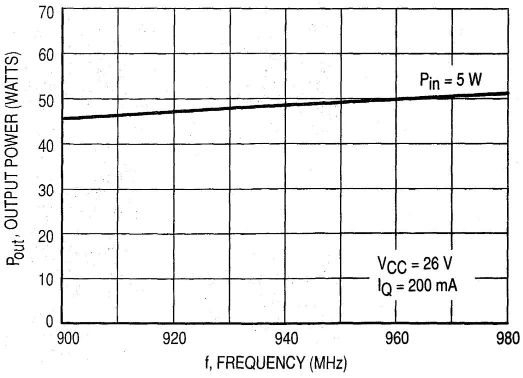


Figure 13. Output Power versus Frequency

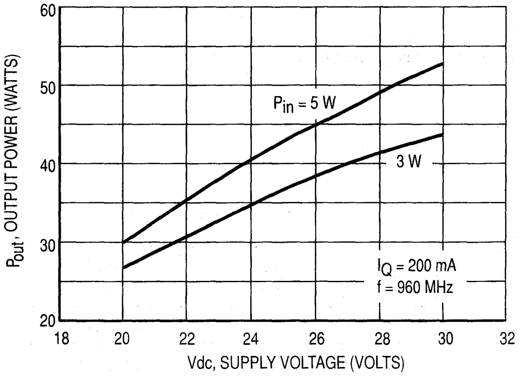


Figure 14. Output Power versus Supply Voltage

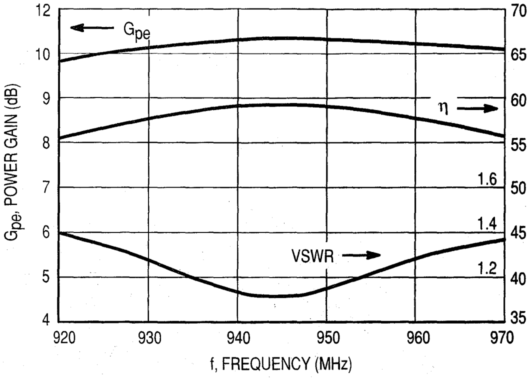


Figure 15. Typical Broadband Amplifier

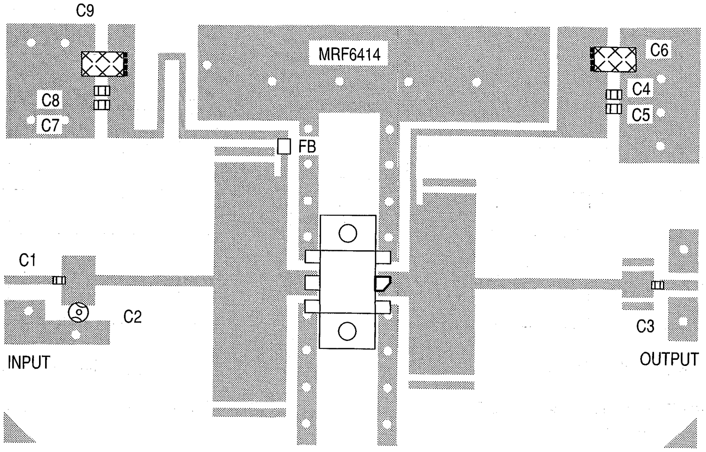
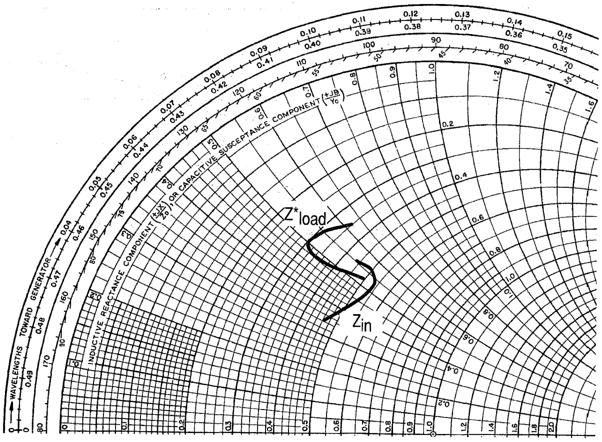


Figure 16. 960 MHz Test Circuit Components Layout



Normalized to 10 Ω

f MHz	Z_{in} Ohms	$Z_{OL}{}^*$ Ohms
900	4.4 + j4.6	4.7 + j4.7
935	5.1 + j4.8	4.0 + j3.9
960	5.4 + j3.6	3.7 + j4.5
980	4.7 + j2.5	3.4 + j4.7

$Z_{OL}{}^*$: Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 17. Input and Output Impedances with Circuit Tuned for Maximum Gain @ V_{CC} = 26 V, I_Q = 200 mA, P_{out} = 50 W

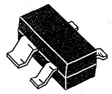
The RF Line
NPN Silicon High-Frequency Transistor

MRF9331LT1

Designed primarily for use in low power amplifiers to 1.0 GHz. Ideal for pagers and other battery operated systems where low power consumption is critical.

- Low Power Consumption Characterized for I_E = 0.1 to 1.0 mA
- High Current–Gain — Bandwidth Product —
  f_T = 5.0 GHz (Typ) @ I_C = 1.0 mAdc
- Low Noise Figure and High Power Gain @ f = 1.0 GHz —
  NF(matched) = 2.5 dB (Typ)
  GNF(matched) = 12.5 dB (Typ)
- Guaranteed RF Parameters
- Surface Mounted SOT–143 Offers Improved RF Performance
  Lower Package Parasitics
  High Gain
- Available in tape and reel packaging:
  T1 suffix = 3,000 units per reel

I_C = 1.0 mA
SURFACE MOUNTED
HIGH–FREQUENCY
TRANSISTOR
NPN SILICON



CASE 318A–05, STYLE 1
SOT–143
LOW PROFILE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	8.0	Vdc
Collector–Base Voltage	V_{CBO}	15	Vdc
Emitter–Base Voltage	V_{EBO}	2.0	Vdc
Collector Current — Continuous	I_C	2.0	mAdc
Total Device Dissipation @ T_C = 100°C (1) Derate above 100°C	P_D	50 1.0	mW mW/°C
Storage Temperature Range	T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1000	°C/W

DEVICE MARKING

MRF9331LT1 = 05

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{(BR)CEO}$	8.0	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	$V_{(BR)CBO}$	15	—	—	Vdc
Emitter–Base Leakage Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	—	—	0.1	mAdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc

NOTE:
1. Case temperature measured on collector lead immediately adjacent to body of package.

(continued)

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	30	80	200	—
DYNAMIC CHARACTERISTICS						
Current–Gain — Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 GHz)	Figure 2	f_T	3.5	5.0	—	GHz
Collector–Base Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 1.0 MHz)	Figure 1	C_{cb}	—	0.21	0.3	pF
FUNCTIONAL TESTS						
Power Gain at Minimum Noise Figure (V_{CE} = 1.0 Vdc, I_C = 0.5 mA, f = 1.0 GHz)	Figures 3, 5	G_{NFmin}	—	12.5	—	dB
Noise Figure (V_{CE} = 1.0 Vdc, I_C = 0.5 mA, f = 1.0 GHz)	Figures 3, 5	NF_{min}	—	2.5	—	dB

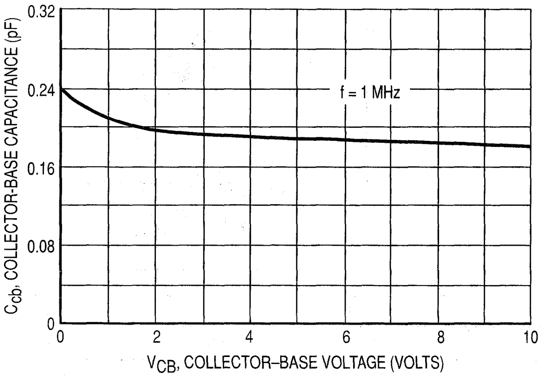


Figure 1. Collector–Base Capacitance versus Collector–Base Voltage

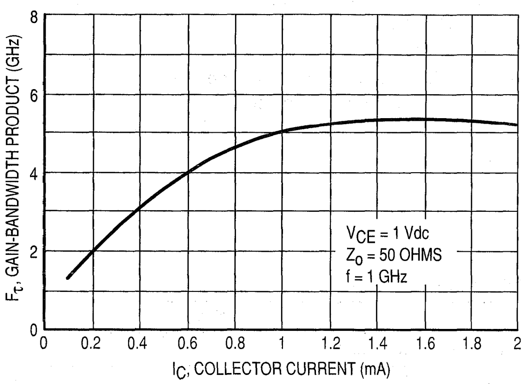
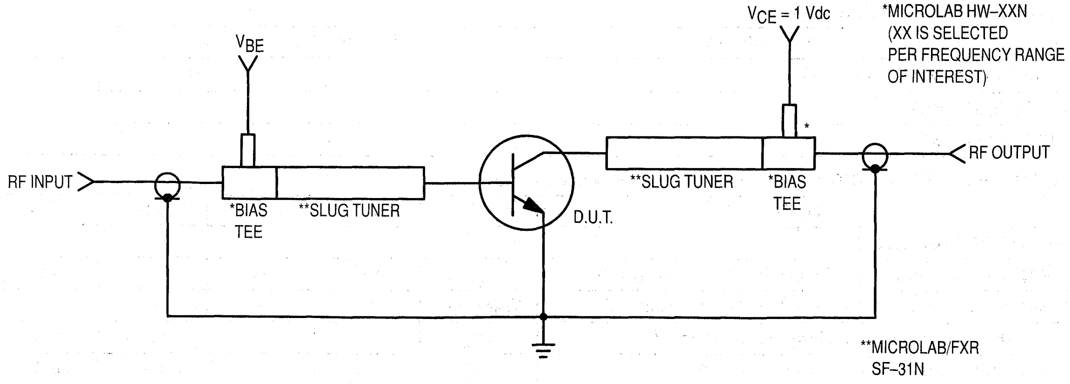


Figure 2. Current Gain–Bandwidth Product versus Collector Current



*MICROLAB HW–XXN
(XX IS SELECTED
PER FREQUENCY RANGE
OF INTEREST)

**MICROLAB/FXR
SF–31N

Figure 3. Functional Circuit Schematic

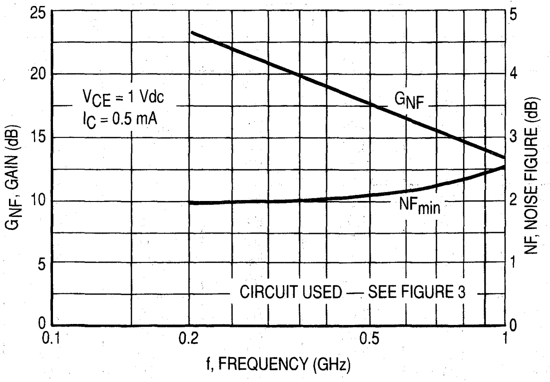


Figure 4. Gain and Minimum Noise Figure versus Frequency

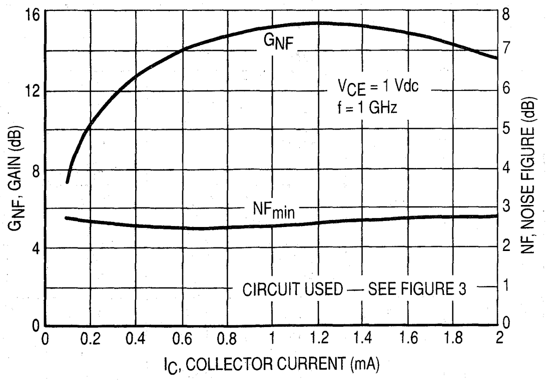


Figure 5. Gain and Minimum Noise Figure versus Collector Current

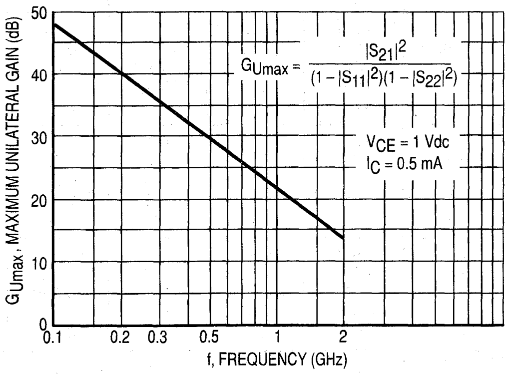


Figure 6. Maximum Unilateral Gain versus Frequency

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			$\lvert S_{11}\rvert$	∠ ϕ	$\lvert S_{21}\rvert$	∠ ϕ	$\lvert S_{12}\rvert$	∠ ϕ	$\lvert S_{22}\rvert$	∠ ϕ
1.0	0.1	100	0.99	−1.0	0.35	174	0.01	87	0.99	−1.0
		200	0.99	−3.0	0.35	171	0.03	86	0.99	−4.0
		500	0.97	−9.0	0.34	156	0.07	81	0.99	−9.0
		1000	0.98	−19	0.38	134	0.13	72	0.99	−21
		2000	0.98	−36	0.45	103	0.22	59	0.99	−38
	0.25	100	0.99	−1.0	0.77	175	0.01	86	0.99	−1.0
		200	0.99	−4.0	0.77	173	0.03	86	0.99	−4.0
		500	0.96	−11	0.73	160	0.06	79	0.99	−11
		1000	0.96	−23	0.75	140	0.13	70	0.98	−23
		2000	0.94	−42	0.77	110	0.21	56	0.93	−42
	0.5	100	0.99	−2.0	1.43	174	0.01	86	0.99	−1.0
		200	0.99	−5.0	1.42	172	0.03	84	0.99	−5.0
		500	0.95	−13	1.33	158	0.06	77	0.99	−12
		1000	0.92	−28	1.30	137	0.13	67	0.95	−25
		2000	0.83	−51	1.20	107	0.19	54	0.91	−43

(continued)

Table 1. Common Emitter S–Parameters

V_{CE} (Vdc)	I_C (mA)	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			|S_{11}|	∠ φ	|S_{21}|	∠ φ	|S_{12}|	∠ φ	|S_{22}|	∠ φ
1.0	1.0	100	0.97	−3.0	2.68	173	0.01	85	0.99	−2.0
		200	0.97	−8.0	2.68	169	0.03	83	0.98	−6.0
		500	0.91	−19	2.42	152	0.06	74	0.96	−15
		1000	0.82	−37	2.22	128	0.11	62	0.89	−29
		2000	0.63	−59	1.74	97	0.17	53	0.80	−46
	2.0	100	0.93	−6.0	4.55	169	0.01	84	0.99	−4.0
		200	0.92	−13	4.3	163	0.03	81	0.98	−9.0
		500	0.81	−29	3.8	142	0.06	69	0.91	−19
		1000	0.62	−52	3.1	115	0.10	59	0.81	−31
		2000	0.40	−66	2.0	85	0.14	55	0.75	−44
3.0	0.1	100	0.99	−1.0	0.34	175	0.01	88	0.99	−1.0
		200	0.99	−3.0	0.34	172	0.03	86	0.99	−3.0
		500	0.99	−8.0	0.32	157	0.06	81	0.99	−9.0
		1000	0.99	−18	0.36	137	0.11	73	0.99	−20
		2000	0.99	−34	0.43	107	0.20	61	0.99	−37
	0.25	100	0.99	−1.0	0.76	175	0.01	86	0.99	−1.0
		200	0.99	−4.0	0.76	173	0.03	86	0.99	−4.0
		500	0.98	−10	0.72	161	0.06	80	0.99	−10
		1000	0.98	−21	0.75	143	0.11	72	0.99	−22
		2000	0.97	−40	0.75	113	0.19	59	0.98	−39
	0.5	100	0.99	−2.0	1.4	175	0.01	86	0.99	−1.0
		200	0.99	−5.0	1.42	172	0.03	84	0.99	−4.0
		500	0.96	−12	1.3	159	0.06	78	0.99	−11
		1000	0.93	−25	1.3	141	0.11	68	0.96	−23
		2000	0.87	−47	1.2	111	0.18	57	0.93	−41
	1.0	100	0.97	−3.0	2.67	174	0.01	85	0.99	−2.0
		200	0.98	−7.0	2.67	170	0.02	84	0.98	−6.0
		500	0.93	−17	2.42	154	0.06	76	0.97	−14
		1000	0.84	−34	2.29	133	0.10	65	0.91	−26
		2000	0.67	−55	1.82	101	0.16	56	0.85	−43
	2.0	100	0.95	−5.0	4.64	172	0.01	85	0.99	−3.0
		200	0.94	−10	4.62	166	0.02	81	0.99	−8.0
		500	0.85	−25	4.0	147	0.05	72	0.94	−17
		1000	0.69	−44	3.4	122	0.09	63	0.84	−29
		2000	0.48	−61	2.3	91	0.13	57	0.78	−42
5.0	0.1	100	0.99	0	0.36	175	0.01	85	0.99	−1.0
		200	0.99	−3.0	0.34	172	0.02	87	0.99	−3.0
		500	0.99	−8.0	0.32	158	0.06	82	0.99	−9.0
		1000	0.99	−17	0.36	138	0.11	74	0.99	−19
		2000	0.94	−35	0.42	108	0.20	63	0.99	−36
	0.25	100	0.99	−1.0	0.76	176	0.01	86	0.99	−1.0
		200	0.99	−3.0	0.76	174	0.02	86	0.99	−4.0
		500	0.97	−9.0	0.71	161	0.06	80	0.99	−10
		1000	0.97	−20	0.74	143	0.11	73	0.99	−21
		2000	0.97	−38	0.75	115	0.18	61	0.99	−38
	0.5	100	0.99	−1.0	1.4	175	0.01	86	0.99	−1.0
		200	0.99	−5.0	1.41	173	0.02	85	0.99	−4.0
		500	0.98	−12	1.3	159	0.06	79	0.99	−11
		1000	0.93	−25	1.3	141	0.10	70	0.97	−23
		2000	0.87	−45	1.2	111	0.17	58	0.94	−40
	1.0	100	0.98	−3.0	2.7	174	0.01	86	0.99	−2.0
		200	0.98	−7.0	2.7	170	0.02	84	0.99	−5.0
		500	0.93	−17	2.42	155	0.05	76	0.97	−13
		1000	0.85	−33	2.3	134	0.09	66	0.92	−26
		2000	0.67	−55	2.0	103	0.15	57	0.85	−42
	2.0	100	0.95	−4.0	4.6	172	0.01	86	0.99	−3.0
		200	0.94	−10	4.6	166	0.02	83	0.98	−7.0
		500	0.86	−24	3.9	148	0.05	73	0.94	−16
		1000	0.70	−43	3.4	123	0.09	64	0.86	−28
		2000	0.50	−60	2.3	92	0.13	59	0.80	−40

Table 1. Common Emitter S–Parameters (continued)

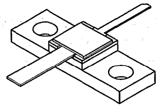
The RF Line
Microwave Power Transistor

. . . designed for CW and long pulsed common base amplifier applications, such as JTIDS and Mode S, in the 0.96 to 1.215 GHz frequency range at high overall duty cycles.

- Guaranteed Performance @ 1.215 GHz, 28 Vdc
  Output Power = 5.0 Watts CW
  Minimum Gain = 8.5 dB, 10.3 dB (Typ)
- RF Performance Curves given for 28 Vdc and 36 Vdc Operation
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Hermetically Sealed Industry Standard Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input Matching for Broadband Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MRF10005

5.0 W, 960–1215 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON



CASE 336E–02, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	55	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous (1)	I_C	1.25	mAdc
Total Device Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	25 143	Watt mW/°C
Storage Temperature Range	T_{stg}	–65 to +200	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

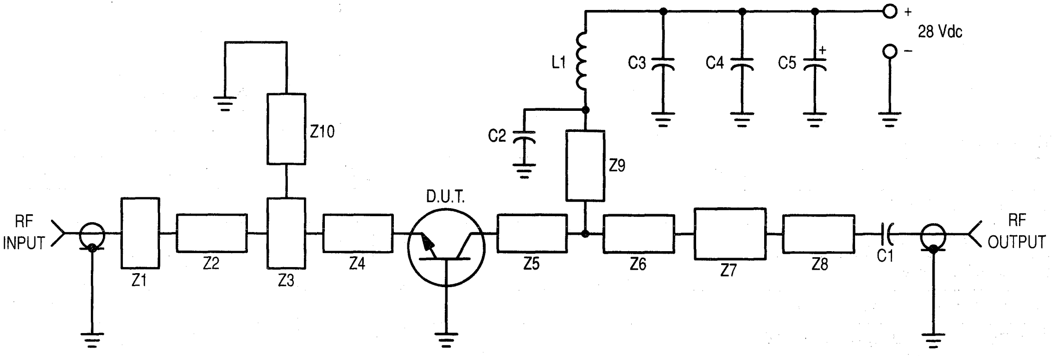
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	7.0	°C/W

NOTES:
1. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.
2. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 25 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 28 Vdc, I_E = 0)	I_{CBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	7.0	10	pF
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 5.0 W, f = 1215 MHz)	G_{PB}	8.5	10.3	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 5.0 W, f = 1215 MHz)	η	45	55	—	%
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 5.0 W, f = 1215 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1, C2, C3 — 220 pF 100 mil Chip Capacitor
C4 — 0.1 μF
C5 — 47 μF/50 V Electrolytic
L1 — 3 turn #18 AWG, 1/8″ ID, 0.18″ Long

Z1–Z10 — Microstrip, see details below
Board Material — 0.030″ Glass Teflon,
2.0 oz. Copper, ε_r = 2.55

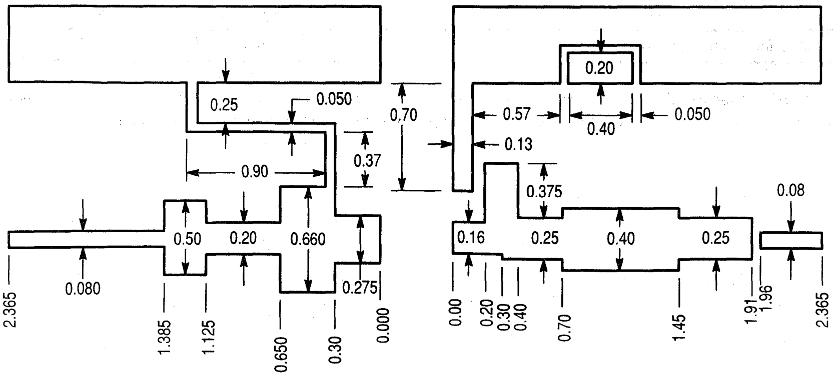


Figure 1. Test Circuit

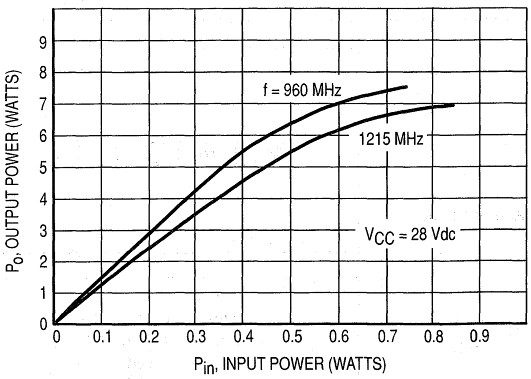


Figure 2. Output Power versus Input Power

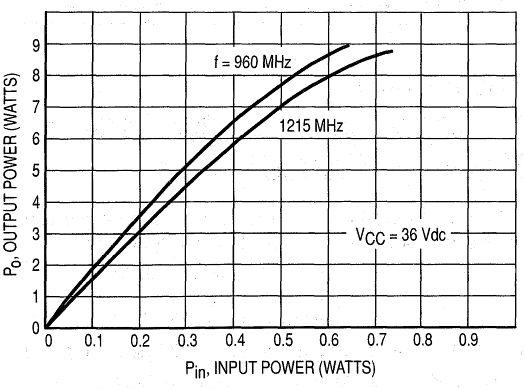
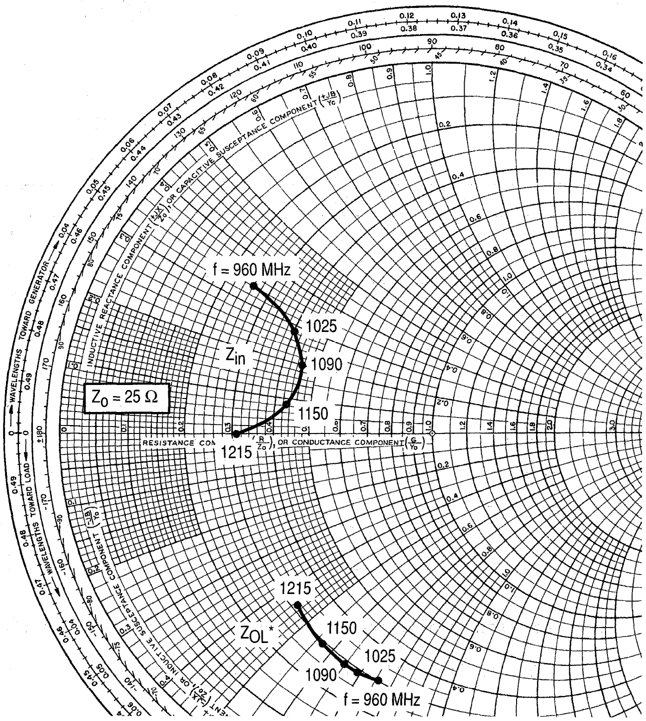


Figure 3. Output Power versus Input Power



P_{out} = 5 W, V_{CC} = 28 V

f MHz	Z_{in} OHMS	$Z_{OL}{}^*$ OHMS
960	6.5 + j8.5	7.4 – j18.9
1025	10.0 + j7.0	7.2 – j17.4
1090	11.2 + j4.9	7.1 – j16.3
1150	10.8 + j2.0	7.15 – j14.3
1215	7.8 + j0.0	7.8 – j11.2

$Z_{OL}{}^*$ = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 4. Series Equivalent Input/Output Impedances

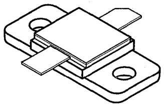
The RF Line
Microwave Long Pulse Power Transistor

MRF10031

Designed for 960–1215 MHz long or short pulse common base amplifier applications such as JTIDS and Mode–S transmitters.

- Guaranteed Performance @ 960 MHz, 36 Vdc
  Output Power = 30 Watts Peak
  Minimum Gain = 9.0 dB Min (9.5 dB Typ)
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Hermetically Sealed Industry Standard Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input Matching for Broadband Operation

**30 W (PEAK)
960–1215 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON**



CASE 376B–02, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	55	Vdc
Collector–Base Voltage (1)	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous (1)	I_C	3.0	Adc
Total Device Dissipation @ $T_C = 25°C$ (1), (2) Derate above 25°C	P_D	110 0.625	Watts mW/°C
Storage Temperature Range	T_{stg}	– 65 to + 200	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

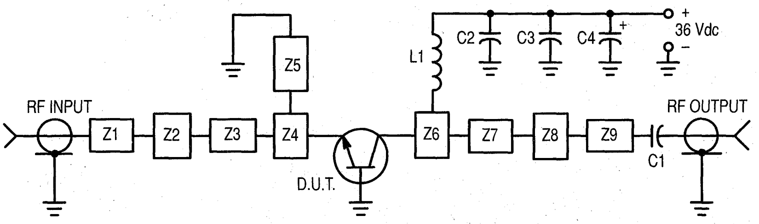
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	1.6	°C/W

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as pulsed RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques. (Worst case θ_{JC} value measured @ 23% duty cycle)

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 25 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 36 Vdc, I_E = 0)	I_{CBO}	—	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
FUNCTIONAL TESTS (10 μs Pulses @ 50% duty cycle for 3.5 ms; overall duty cycle – 25%)					
Common–Base Amplifier Power Gain (V_{CC} = 36 Vdc, P_{out} = 30 W Peak, f = 960 MHz)	G_{PB}	9.0	9.5	—	dB
Collector Efficiency (V_{CC} = 36 Vdc, P_{out} = 30 W Peak, f = 960 MHz)	η	40	45	—	%
Load Mismatch (V_{CC} = 36 Vdc, P_{out} = 30 W Peak, f = 960 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 75 pF 100 Mil Chip Capacitor
C2 — 39 pF 100 Mil Chip Capacitor
C3 — 0.1 μF
C4 — 1000 μF, 50 Vdc, Electrolytic
L1 — 3 Turns #18 AWG, 1/8″ ID, 0.18 Long

Z1–Z9 — Microstrip, See Details
Board Material — Teflon, Glass Laminate
Dielectric Thickness = 0.030″
ε_r = 2.55, 2 Oz. Copper

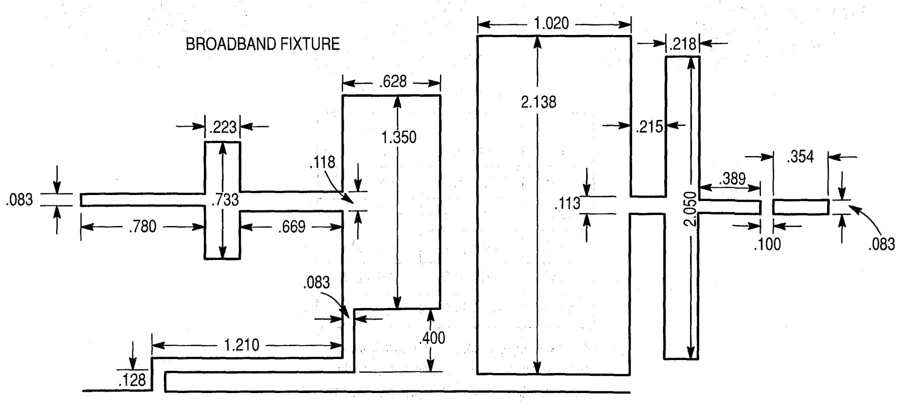


Figure 1. Test Circuit

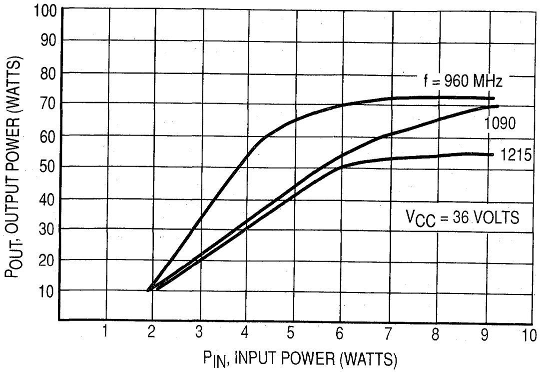
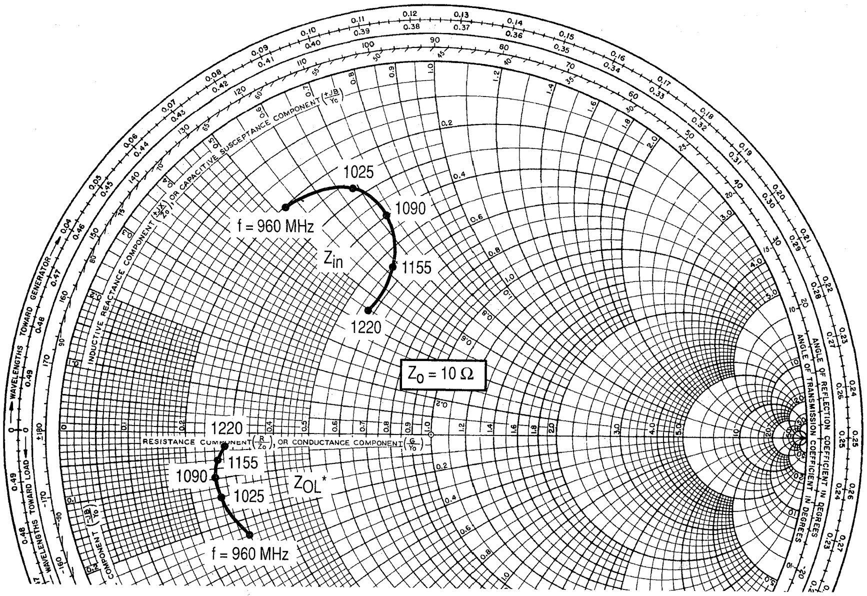


Figure 2. Output Power versus Input Power



P_{out} = 30 W Pk V_{CC} = 36 V

f MHz	Zin Ohms	Z_{OL}* Ohms
960	2.05 + j5.2	2.9 – j2.35
1025	2.67 + j6.34	2.55 – j1.3
1090	4.0 + j7.1	2.52 – j0.9
1155	5.5 + j6.2	2.6 – j0.6
1220	5.7 + j4.3	2.8 – j0.3

Z_{OL}* = Conjugate of the optimum load impedance into which the device operates at a given output power, voltage, and frequency.

Figure 3. Series Equivalent Input/Output Impedances

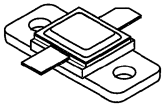
The RF Line
Microwave Pulse Power Transistor

MRF10070

Designed for 1025–1150 MHz pulse common base amplifier applications such as TCAS, TACAN and Mode–S transmitters.

- Guaranteed Performance @ 1090 MHz
  Output Power = 70 Watts Peak
  Gain = 9.0 dB Min
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Characterized with 10 μs, 10% Duty Cycle Pulses
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input and Output Matching
- Hermetically Sealed Package
- Recommended Driver for MRF10500 Transistor or a Pair of MRF10350 Transistors

70 W (PEAK)
1025 –1150 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON



CASE 376C–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	65	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Peak (1)	I_C	8.8	Adc
Total Device Dissipation @ T_C = 25°C (1), (2) Derate above 25°C	P_D	438 2.5	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to + 200	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

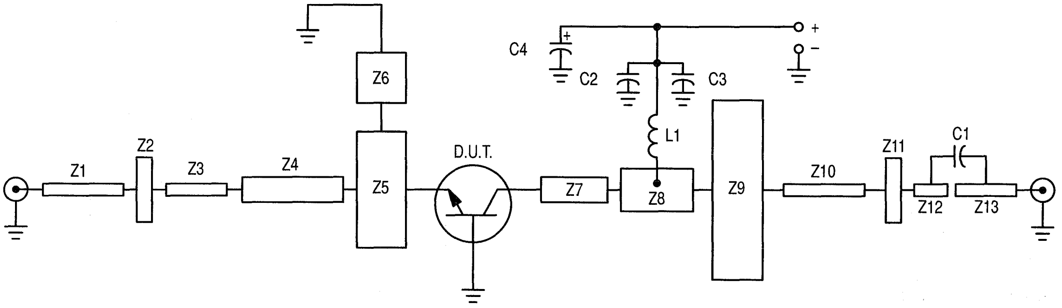
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.4	°C/W

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as pulsed RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques. (Worst case θ_{JC} value measured @ 10 μs, 10%.)

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 60 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 70 W Peak, f = 1090 MHz)	G_{PB}	9.0	10	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 70 W Peak, f = 1090 MHz)	η	40	—	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 70 W Peak, f = 1090 MHz, Load VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Output Power Before or After Test			



C1 — 82 pF 100 mil Chip Capacitor
C2 — 82 pF 100 mil Chip Capacitor
C3 — 0.1 µF
C4 — 100 µF/100 Vdc Electrolytic
L1 — 3 turns #18 AWG, 1/8″ ID, 0.18″ Long

Z1 – Z13 — Microstrip, see details below
Board Material — 0.030″ Glass Teflon®; 2 oz. Cu clad; both sides; ϵ_r = 2.55

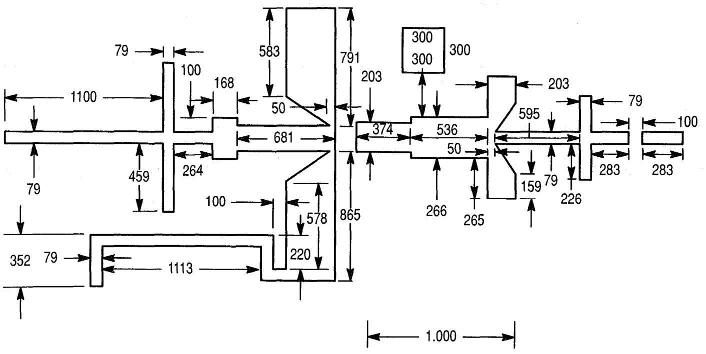


Figure 1. Test Circuit

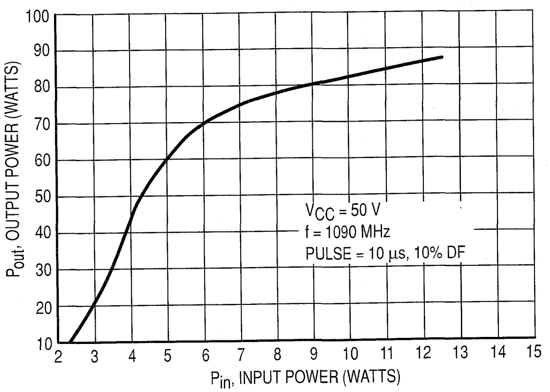
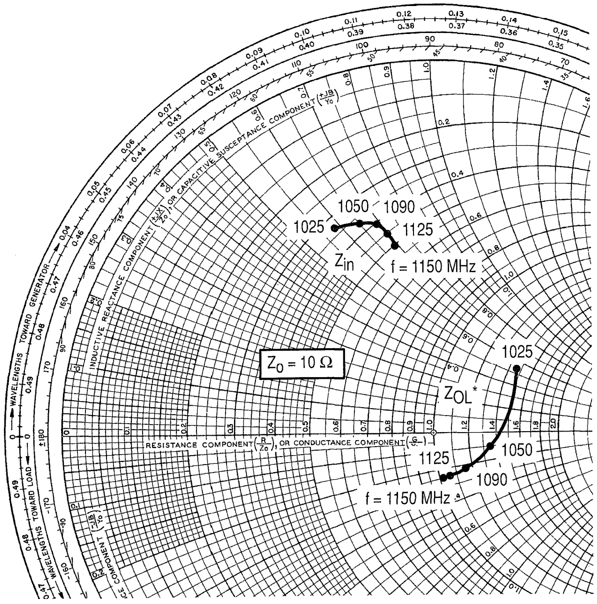


Figure 2. Output Power versus Input Power



P_{out} = 70 W Pk V_{CC} = 50 V

f MHz	ZIN OHMS	Z_{OL}* (Z_{OUT}) OHMS
1025	3.3 + j5.8	14.3 + j5.6
1050	3.6 + j6.5	13.3 – j1.0
1090	4.0 + j6.9	11.3 – j2.1
1125	4.5 + j6.9	10.4 – j2.5
1150	5.0 + j6.9	10.2 – j2.6

Z_{OL}* is the conjugate of the optimum load impedance into which the device operates at a given output power voltage and frequency.

Figure 3. Series Equivalent Input/Output Impedances

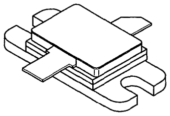
The RF Line
Microwave Long Pulse Power Transistor

MRF10120

**120 W (PEAK), 960–1215 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON**

Designed for 960–1215 MHz long pulse common base amplifier applications such as JTIDS and Mode S transmitters.

- Guaranteed Performance @ 1.215 GHz, 36 Vdc
  Output Power = 120 Watts Peak
  Gain = 8.0 dB Min., 9.2 dB (Typ)
- 100% Tested for Load Mismatch at All Phase Angles with 3:1 VSWR
- Hermetically Sealed Industry Standard Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input and Output Matching for Broadband Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 355C–02, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	55	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Peak (1)	I_C	15	Adc
Total Device Dissipation @ T_C = 25°C (1), (2) Derate above 25°C	P_D	380 2.17	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C
Junction Temperature	T_J	200	

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.46	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 60 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 36 Vdc, I_E = 0)	I_{CBO}	—	—	25	mAdc

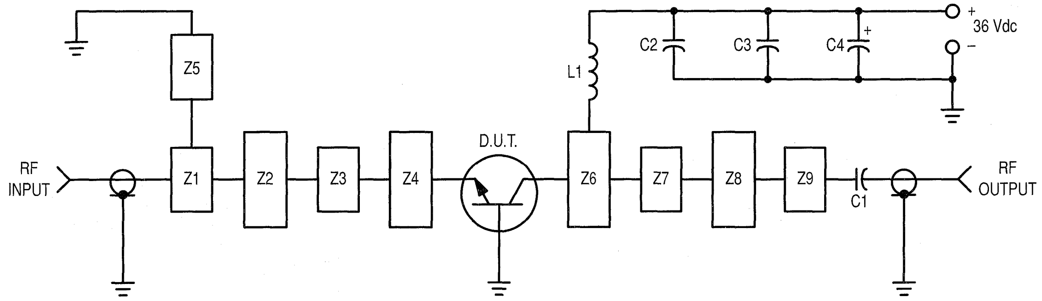
(continued)

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the device is operated as RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
FUNCTIONAL TESTS (7.0 µs Pulses @ 54% duty cycle for 3.4 ms; then off for 4.5 ms; overall duty cycle = 23%)					
Common–Base Amplifier Power Gain (V_{CC} = 36 Vdc, P_{out} = 120 W Peak, f = 1215 MHz)	G_{PB}	8.0	9.2	—	dB
Collector Efficiency (V_{CC} = 36 Vdc, P_{out} = 120 W Peak, f = 1215 MHz)	η	50	55	—	%
Load Mismatch (V_{CC} = 36 Vdc, P_{out} = 120 W Peak, f = 1215 MHz, VSWR = 3:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 270 pF 100 Mil Chip Capacitor
C2 — 220 pF 100 Mil Chip Capacitor
C3 — 0.1 µF
C4 — 47 µF 50 V Electrolytic
L1 — 3 Turns #18 AWG, 1/8″ ID, 0.18 Long

Z1–Z9 — Microstrip, See Details
Board Material — Teflon®/Glass Laminate,
Dielectric Thickness = 0.030″,
ε_r = 2.55, 2 Oz. Copper

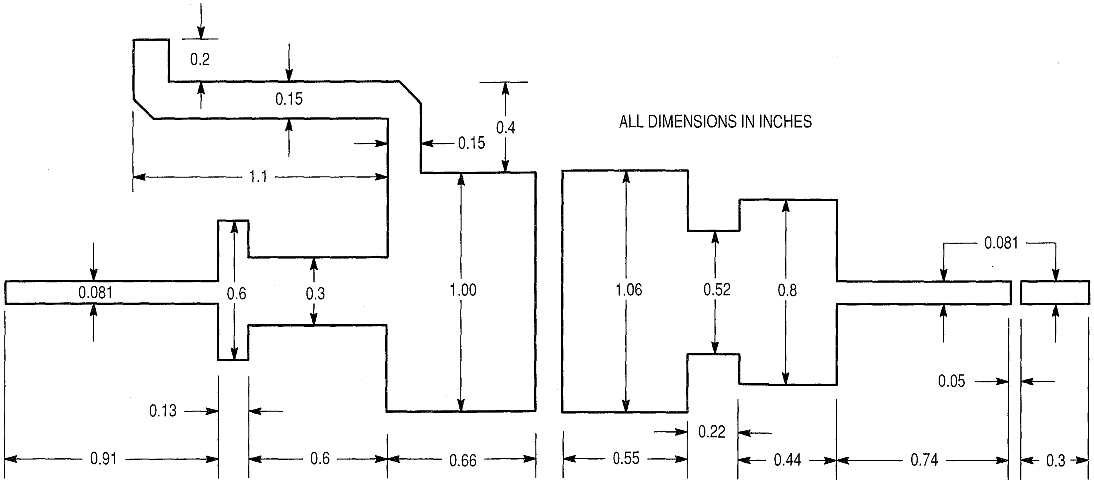


Figure 1. Test Circuit

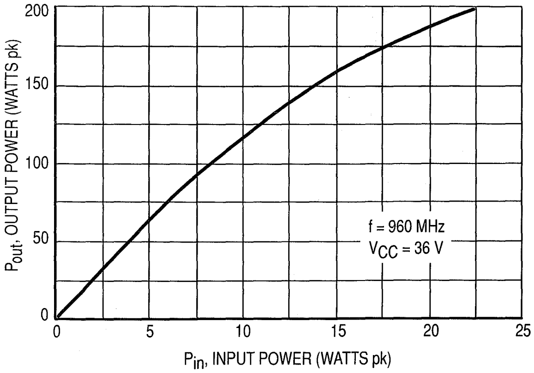


Figure 2. Output Power versus Input Power

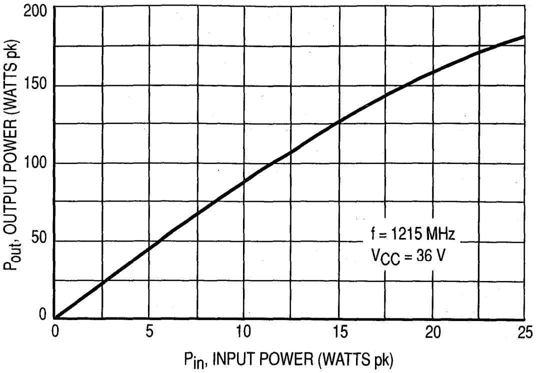
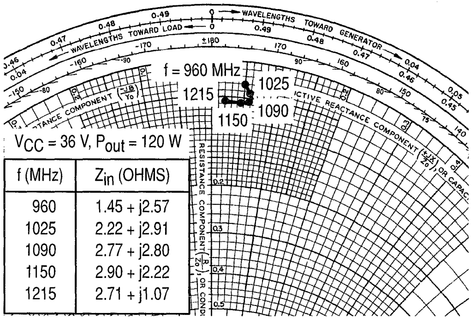


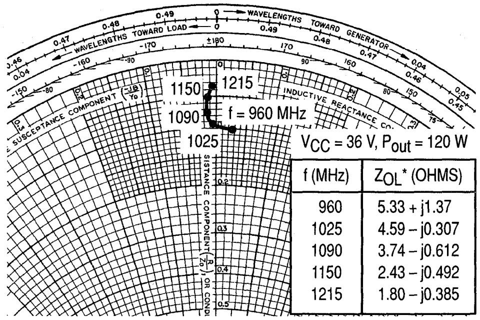
Figure 3. Output Power versus Input Power



V_{CC} = 36 V, P_{out} = 120 W

f (MHz)	Z_{in} (OHMS)
960	1.45 + j2.57
1025	2.22 + j2.91
1090	2.77 + j2.80
1150	2.90 + j2.22
1215	2.71 + j1.07

Figure 4. Series Equivalent Input Impedances



V_{CC} = 36 V, P_{out} = 120 W

f (MHz)	Z_{OL}* (OHMS)
960	5.33 + j1.37
1025	4.59 – j0.307
1090	3.74 – j0.612
1150	2.43 – j0.492
1215	1.80 – j0.385

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 5. Series Equivalent Output Impedance

The RF Line

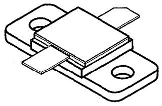
Microwave Pulse Power Transistor

MRF10150

. . . designed for 1025–1150 MHz pulse common base amplifier applications such as TCAS, TACAN and Mode–S transmitters.

- Guaranteed Performance @ 1090 MHz
  Output Power = 150 Watts Peak
  Gain = 9.5 dB Min, 10.0 dB (Typ)
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Hermetically Sealed Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input and Output Matching
- Characterized with 10 µs, 10% Duty Cycle Pulses
- Recommended Driver for a Pair of MRF10500 Transistors

150 W (PEAK)
1025–1150 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON



CASE 376B–02, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	65	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Peak (1)	I_C	14	Adc
Total Device Dissipation @ T_C = 25°C (1), (2) Derate above 25°C	P_D	700 4.0	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C
Junction Temperature	T_J	200	°C

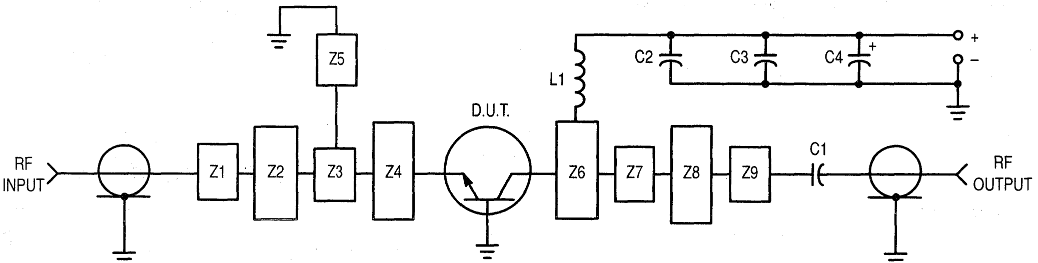
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.25	°C/W

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as pulsed RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques. (Worst case θ_{JC} value measured @ 10 µs, 10%.)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 60 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 36 Vdc, I_E = 0)	I_{CBO}	—	—	25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 150 W Peak, f = 1090 MHz)	G_{PB}	9.5	10	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 150 W Peak, f = 1090 MHz)	η	40	—	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 150 W Peak, f = 1090 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 82 pF 100 Mil Chip Capacitor
C2 — 39 pF 100 Mil Chip Capacitor
C3 — 0.1 µF
C4 — 100 µF, 100 Vdc, Electrolytic
L1 — 3 Turns #18 AWG, 1/8″ ID, 0.18 Long

Z1–Z9 — Microstrip, See Details
Board Material — Teflon Glass Laminate
Dielectric Thickness = 0.030″
ε_r = 2.55, 2 Oz. Copper

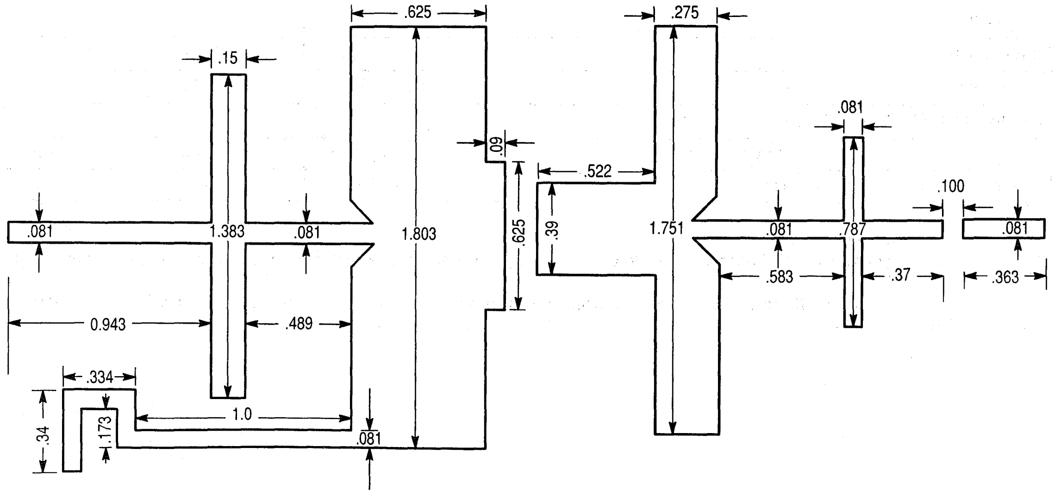


Figure 1. Test Circuit

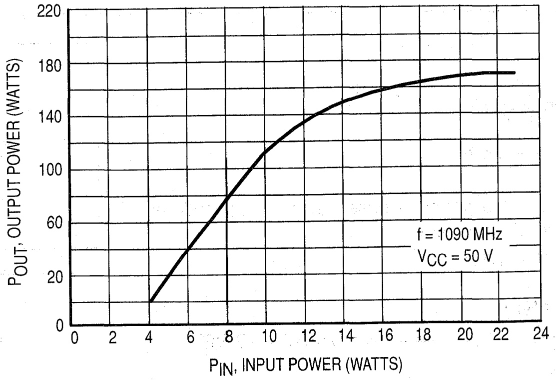
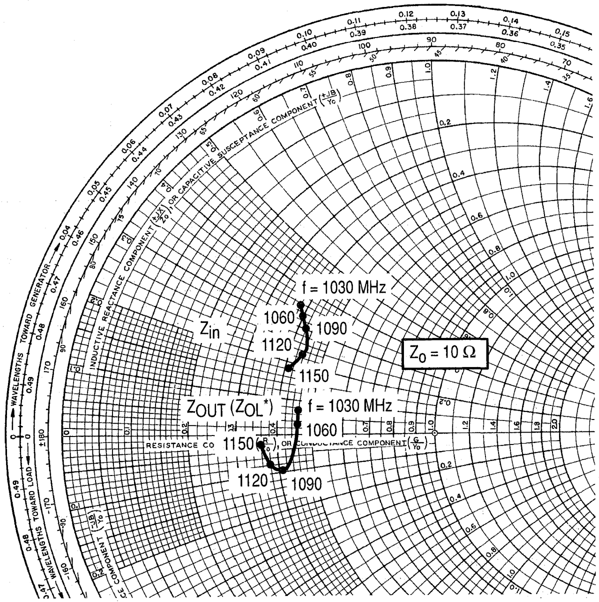


Figure 2. Output Power versus Input Power



P_{OUT} = 150 W Pk V_{CC} = 50 V

f MHz	Z_{in} OHMS	Z_{OL}* (Z_{OUT}) OHMS
1030	3.8 + j3.5	4.6 + j0.7
1060	4.0 + j3.3	4.6 + j0.3
1090	4.2 + j3.0	4.1 – j1.0
1120	4.4 + j2.3	3.8 – j0.8
1150	4.1 + j1.8	3.6 – j0.3

Z_{OL}* is the conjugate of the optimum load impedance into which the device operates at a given output power voltage and frequency.

Figure 3. Series Equivalent Input/Output Impedances

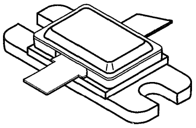
The RF Line
Microwave Pulse Power Transistor

MRF10350

Designed for 1025–1150 MHz pulse common base amplifier applications such as TCAS, TACAN and Mode–S transmitters.

- Guaranteed Performance @ 1090 MHz
  Output Power = 350 Watts Peak
  Gain = 8.5 dB Min, 9.0 dB (Typ)
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Hermetically Sealed Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input and Output Matching
- Characterized using Mode–S Pulse Format

**350 W (PEAK)
1025–1150 MHz
MICROWAVE POWER
TRANSISTOR
NPN SILICON**



CASE 355E–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	65	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Peak (1)	I_C	31	Adc
Total Device Dissipation @ $T_C = 25°C$ (1), (2) Derate above 25°C	P_D	1590 9.1	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +200	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

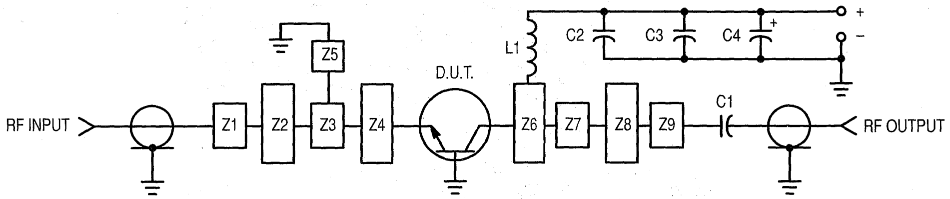
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.11	°C/W

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as pulsed RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques. (Worst Case θ_{JC} measured using Mode–S pulse train, 128 µs burst 0.5 µs on, 0.5 µs off repeating at 6.4 ms interval.)

REV 1

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 60 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 36 Vdc, I_E = 0)	I_{CBO}	—	—	25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 350 W Peak, f = 1090 MHz)	G_{PB}	8.5	9.0	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 350 W Peak, f = 1090 MHz)	η	40	—	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 350 W Peak, f = 1090 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 75 pF 100 Mil Chip Capacitor
C2 — 39 pF 100 Mil Chip Capacitor
C3 — 0.1 μF
C4 — 100 μF, 100 Vdc, Electrolytic
L1 — 3 Turns #18 AWG, 1/8″ ID, 0.18 Long

Z1–Z9 — Microstrip, See Details
Board Material — Teflon, Glass Laminate
Dielectric Thickness = 0.030″
ε_r = 2.55, 2 Oz. Copper

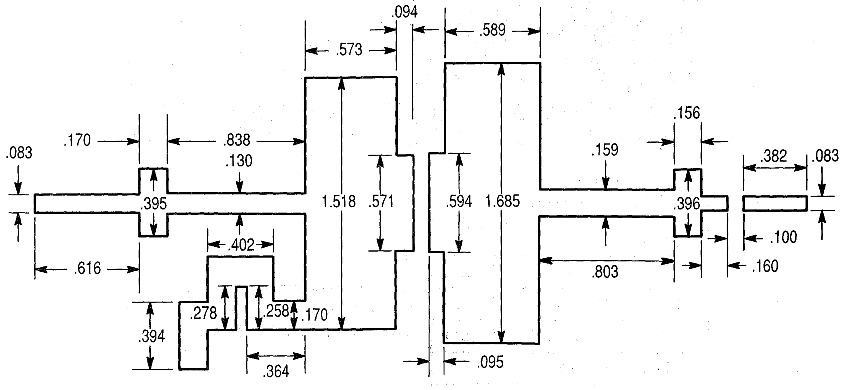
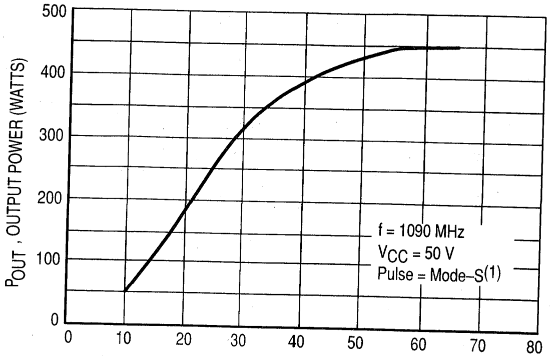
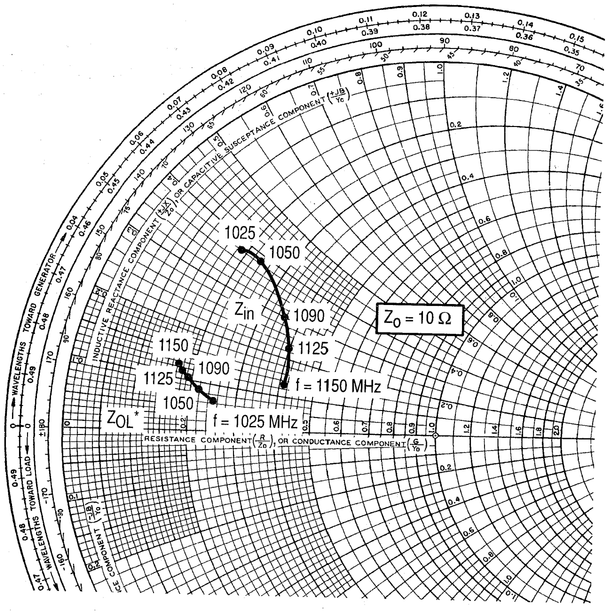


Figure 1. Test Circuit



(1) 128 µs burst 0.5 µs on, 0.5 µs off repeating at 6.4 ms interval.

Figure 2. Output Power versus Input Power



P_{OUT} = 350 W Pk V_{CC} = 50 V

f MHz	Z_{in} OHMS	Z_{OL}* (1) OHMS
1025	1.92 + j3.80	2.52 + j0.70
1050	2.44 + j3.92	2.18 + j0.85
1090	3.55 + j3.02	1.94 + j1.13
1125	4.11 + j2.27	1.80 + j1.22
1150	4.13 + j1.35	1.71 + j1.31

Z_{OL}* is the conjugate of the optimum load impedance into which the device operates at a given output power voltage and frequency.

Figure 3. Series Equivalent Input/Output Impedances

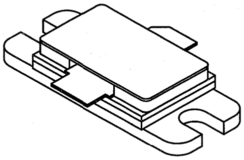
The RF Line
Microwave Pulse Power Transistors

MRF10500
MRF10501

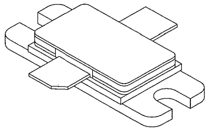
. . . designed for 1025–1150 MHz pulse common base amplifier applications such as TCAS, TACAN and Mode–S transmitters.

- Guaranteed Performance @ 1090 MHz
  Output Power = 500 Watts Peak
  Gain = 8.5 dB Min, 9.0 dB (Typ)
- 100% Tested for Load Mismatch at All Phase Angles with 10:1 VSWR
- Hermetically Sealed Industry Package
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Internal Input and Output Matching
- Characterized with 10 μs, 1% Duty Cycle Pulses

**500 W (PEAK)
1025–1150 MHz
MICROWAVE POWER
TRANSISTORS
NPN SILICON**



**CASE 355D–02, STYLE 1
MRF10500**



**CASE 355H–01, STYLE 1
MRF10501**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	65	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Peak (1)	I_C	29	Adc
Total Device Dissipation @ T_C = 25°C (1), (2) Derate above 25°C	P_D	1460 8.3	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +200	°C
Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

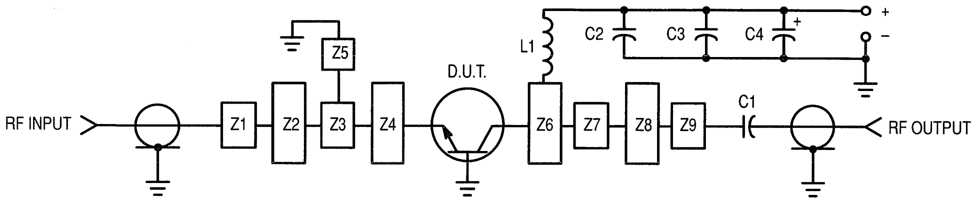
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (3)	$R_{\theta JC}$	0.12	°C/W

NOTES:
1. Under pulse RF operating conditions.
2. These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as pulsed RF amplifiers.
3. Thermal Resistance is determined under specified RF operating conditions by infrared measurement techniques. (Worst case θ_{JC} value measured @ 32 μs, 2%.)

REV 6

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	65	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 60 mAdc, I_E = 0)	$V_{(BR)CBO}$	65	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 36 Vdc, I_E = 0)	I_{CBO}	—	—	25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	—	—
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 500 W Peak, f = 1090 MHz)	G_{PB}	8.5	9.0	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 500 W Peak, f = 1090 MHz)	η	40	45	—	%
Load Mismatch (V_{CC} = 50 Vdc, P_{out} = 500 W Peak, f = 1090 MHz, VSWR = 10:1 All Phase Angles)	ψ	No Degradation in Output Power			



C1 — 82 pF 100 Mil Chip Capacitor
C2 — 39 pF 100 Mil Chip Capacitor
C3 — 0.1 µF
C4 — 100 µF, 100 Vdc, Electrolytic
L1 — 3 Turns #18 AWG, 1/8″ ID, 0.18 Long

Z1–Z9 — Microstrip, See Details
Board Material — Teflon, Glass Laminate
Dielectric Thickness = 0.030″
ε_r = 2.55, 2 Oz. Copper

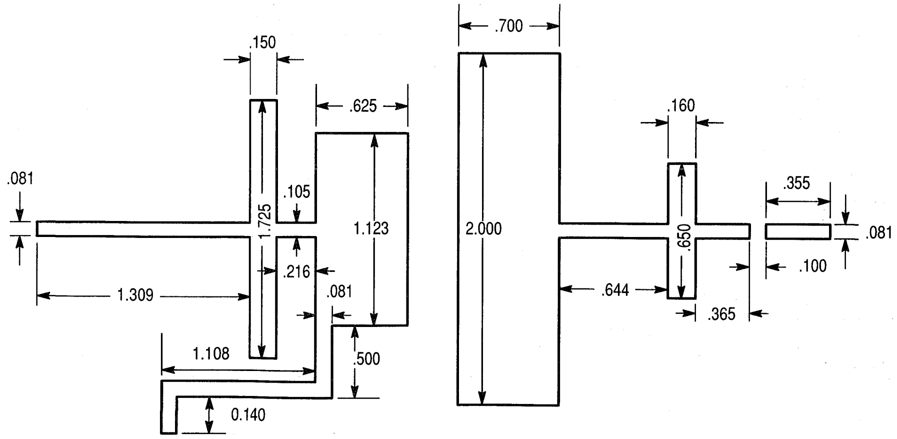


Figure 1. Test Circuit

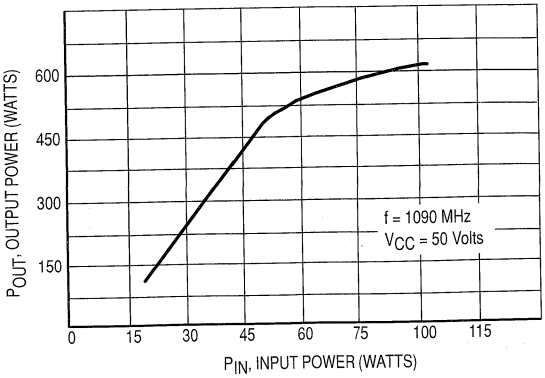
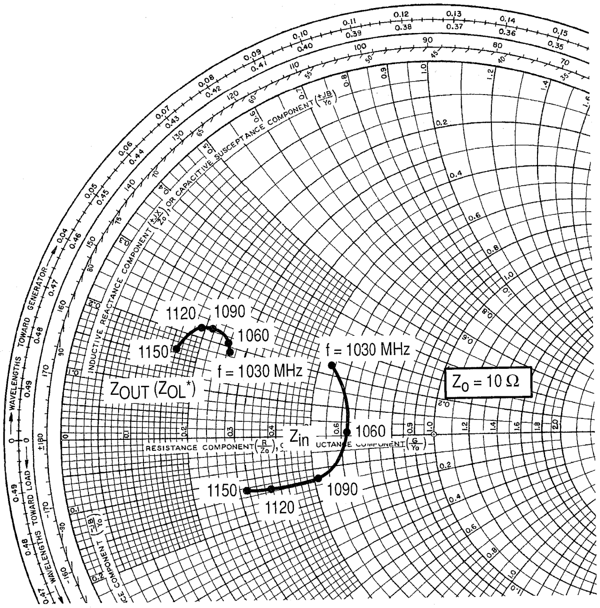


Figure 2. Output Power versus Input Power



P_{OUT} = 500 W Pk V_{CC} = 50 V

f MHz	Z_{in} OHMS	Z_{OL}* (Z_{OUT}) OHMS
1030	5.3 + j2.25	2.6 + j1.89
1060	6.2 + j0.2	2.56 + j2.0
1090	5.2 – j1.4	2.12 + j2.2
1120	3.7 – j1.35	1.9 + j2.15
1150	3.15 – j1.3	1.6 + j1.62

Z_{OL}* is the conjugate of the optimum load impedance into which the device operates at a given output power voltage and frequency.

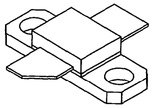
Figure 3. Series Equivalent Input/Output Impedances

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
NPN Silicon RF Power Transistor

MRF15030

30 W, 1.5 GHz
RF POWER TRANSISTOR
NPN SILICON



CASE 395C–01, STYLE 1

Designed for 26 volts microwave large–signal, common emitter, class A and class AB linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 1400–1600 MHz.

- Specified 26 Volts, 1490 MHz, Class AB Characteristics:
  Output Power — 30 Watts
  Gain — 9 dB Min @ 30 Watts (PEP)
  Efficiency — 30% Min @ 30 Watts (PEP)
  Intermodulation Distortion — –30 dBc Max @ 30 Watts (PEP)
- Third Order Intercept Point — 53.5 dBm Typ @ 1490 MHz, V_{CE} = 24 Vdc, I_C = 2.5 Adc
- Characterized with Series Equivalent Large–Signal Parameters from 1400–1600 MHz
- Characterized with Small Signal S–Parameters from 1000–2000 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at all Phase Angles with 3:1 Load VSWR @ 28 Vdc, at Rated Output Power
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	25	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 0.71	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.40	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	29	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	64	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 100 Ω)	$V_{(BR)CER}$	30	52	—	Vdc

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS — continued					
Emitter–Base Breakdown Voltage (I_E = 5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4	5	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1 Adc, V_{CE} = 5 Vdc)	h_{FE}	20	35	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	30	38	50	pF
FUNCTIONAL TESTS (Figure 12)					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 30 W (PEP), I_{CQ} = 125 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	G_{pe}	9.0	9.6	—	dB
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 30 W (PEP), I_{CQ} = 125 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	η	30	34	—	%
Intermodulation Distortion (V_{CC} = 26 Vdc, P_{out} = 30 W (PEP), I_{CQ} = 125 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	IMD	—	– 34	– 30	dBc
Input Return Loss (V_{CC} = 26 Vdc, P_{out} = 30 W (PEP), I_{CQ} = 125 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	IRL	12	15	—	dB
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 30 W (PEP), I_{CQ} = 125 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz, Load VSWR = 3:1, All Phase Angles at Frequency of Test)	ψ	No Degradation in Output Power			

TYPICAL CHARACTERISTICS

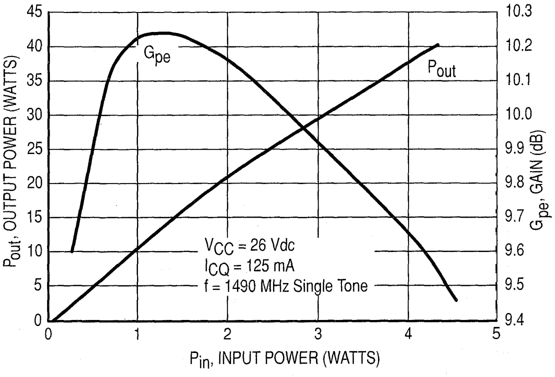


Figure 1. Output Power & Power Gain versus Input Power

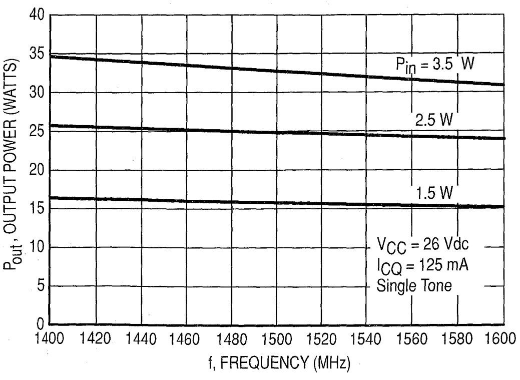


Figure 2. Output Power versus Frequency

TYPICAL CHARACTERISTICS

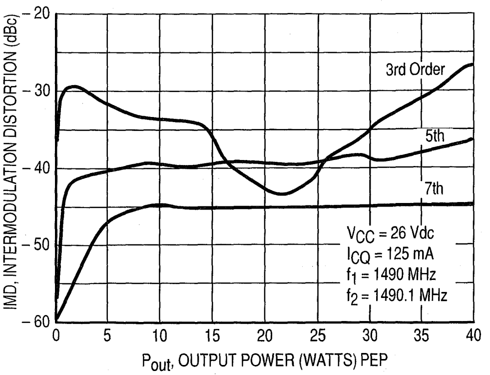


Figure 3. Intermodulation Distortion versus Output Power

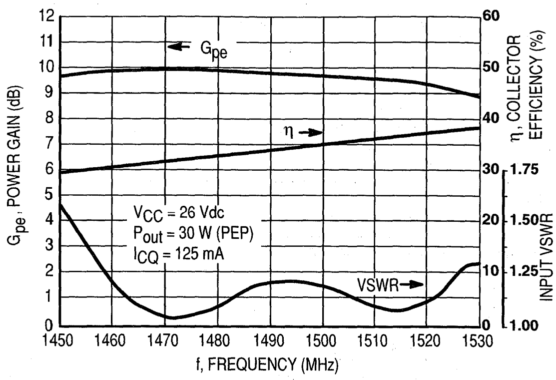


Figure 4. Performance in Broadband Circuit

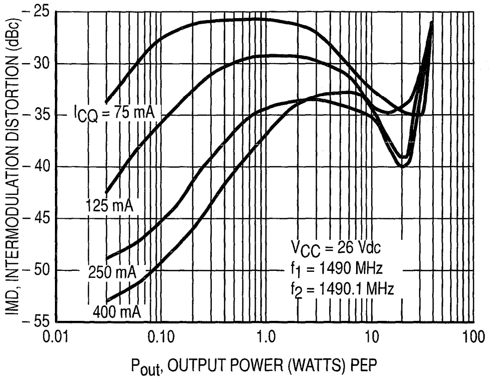


Figure 5. Intermodulation Distortion versus Output Power

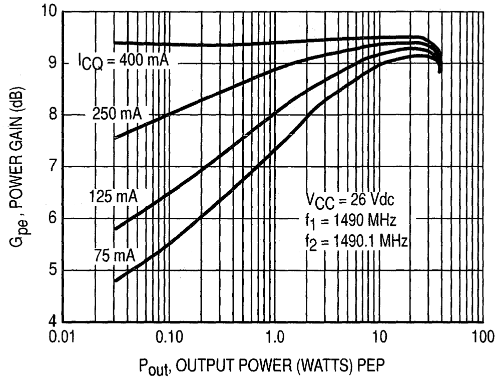


Figure 6. Power Gain versus Output Power

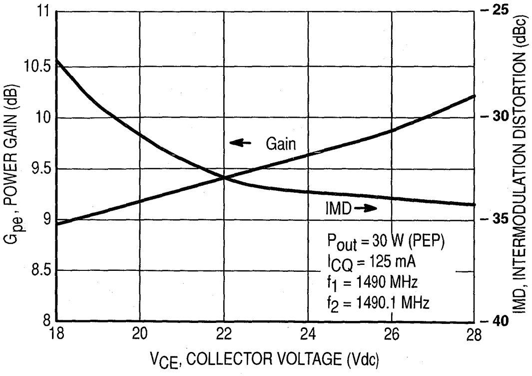


Figure 7. Power Gain and Intermodulation Distortion versus Collector Voltage

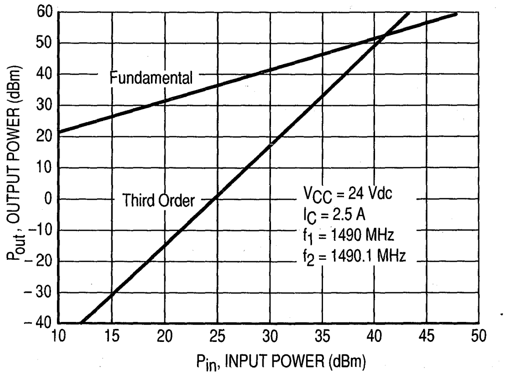


Figure 8. Class A Third Order Intercept Point

TYPICAL CHARACTERISTICS

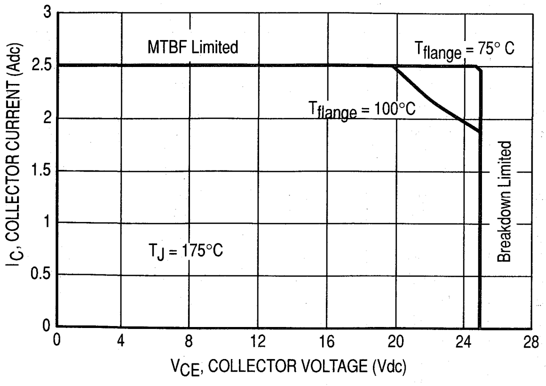


Figure 9. DC Safe Operating Area

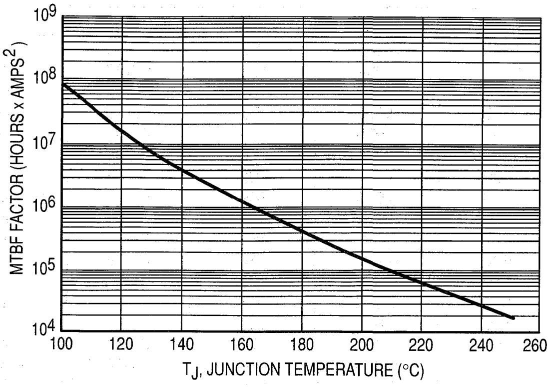
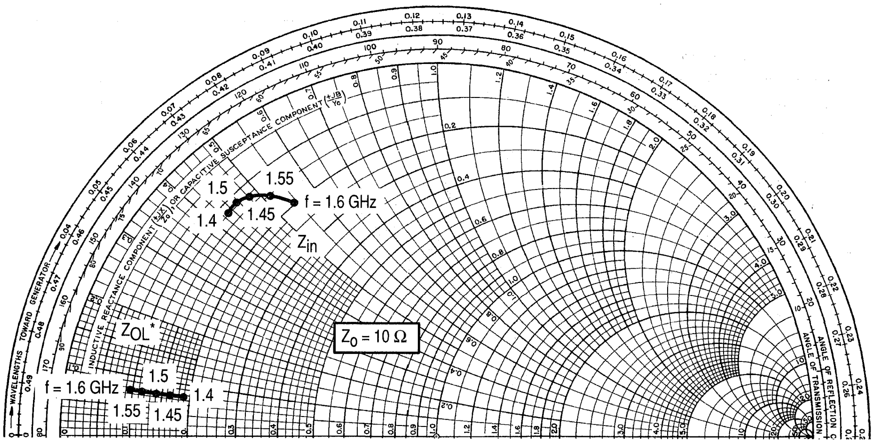


Figure 10. MTBF Factor versus Junction Temperature

The above graph displays calculated MTBF in hours x ampere^2 emitter current. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTBF Factor by I_C^2 for MTBF in a particular application.



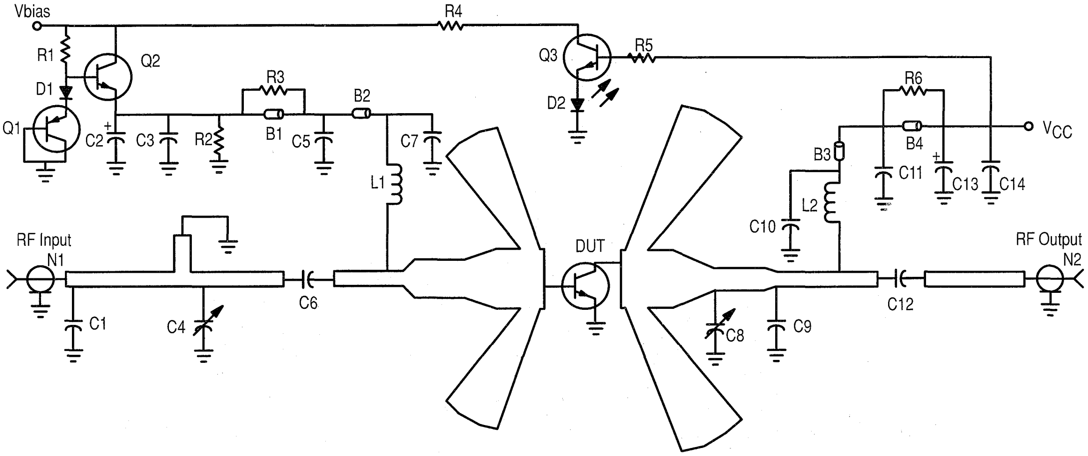
f (GHz)	Z_{in} (Ω)	Z^*_{OL} (Ω)
1.40	1.15 + j4.25	1.87 + j0.78
1.45	1.15 + j4.55	1.67 + j0.78
1.50	1.20 + j4.80	1.47 + j0.78
1.55	1.45 + j5.15	1.27 + j0.78
1.60	1.89 + j5.25	1.00 + j0.78

Z^*_{OL} = Conjugate of optimum load impedance into which the device operates at a given output power, voltage and frequency.

Figure 11. Input and Output Impedances with Circuit Tuned for Maximum Gain @ P_{out} = 30 Watts (PEP), V_{CC} = 26 Volts, I_{CQ} = 125 mA, and Driven by Two Equal Amplitude Tones with Separation of 100 KHz

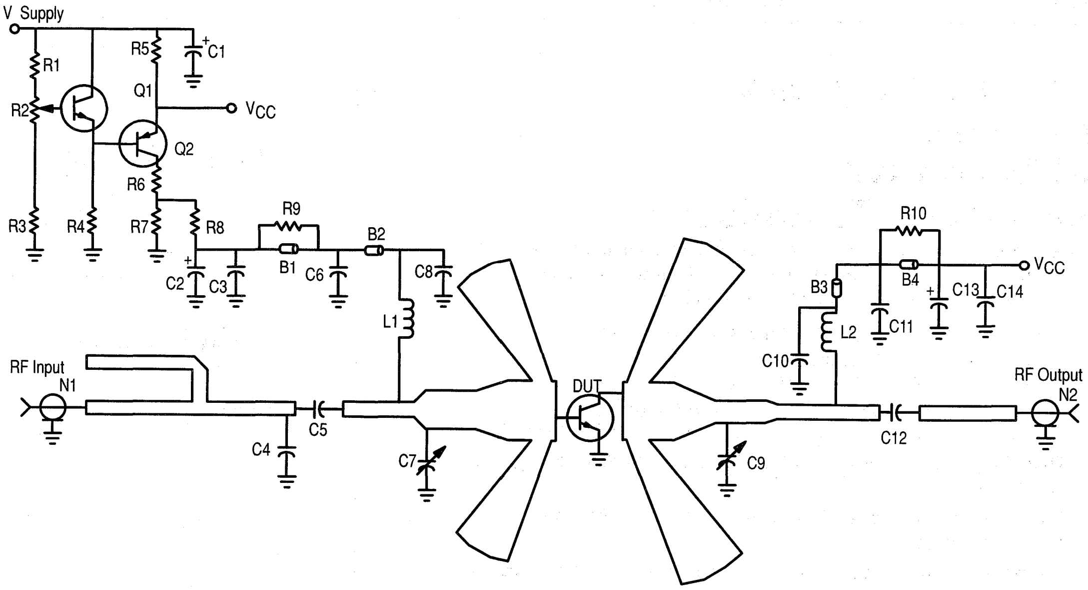
Table 1. Small Signal S Parameters at V_{CE} = 24 Vdc, I_C = 2.5 Adc

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11} \rvert$	$\angle \phi$	$\lvert S_{21} \rvert$	$\angle \phi$	$\lvert S_{12} \rvert$	$\angle \phi$	$\lvert S_{22} \rvert$	$\angle \phi$
1000	0.983	173	0.366	49	0.006	36	0.890	178
1050	0.984	172	0.367	46	0.007	33	0.893	178
1100	0.978	172	0.367	43	0.007	33	0.888	178
1150	0.975	171	0.373	40	0.007	30	0.885	178
1200	0.975	171	0.382	36	0.008	31	0.886	177
1250	0.969	170	0.391	33	0.007	27	0.881	177
1300	0.963	169	0.408	29	0.008	21	0.879	177
1350	0.955	169	0.428	25	0.009	20	0.879	177
1400	0.945	168	0.452	20	0.008	7	0.873	177
1450	0.933	167	0.487	13	0.009	1	0.875	178
1500	0.915	166	0.525	6	0.009	– 8	0.875	178
1550	0.889	166	0.572	– 3	0.009	–18	0.877	178
1600	0.856	166	0.618	–16	0.009	– 35	0.887	178
1650	0.833	168	0.654	– 30	0.010	– 54	0.901	178
1700	0.820	171	0.654	– 48	0.010	– 86	0.918	178
1750	0.839	174	0.600	– 66	0.010	–120	0.930	177
1800	0.872	175	0.517	– 81	0.010	–152	0.932	176
1850	0.909	176	0.435	– 94	0.010	–176	0.925	174
1900	0.937	175	0.357	–104	0.011	159	0.924	173
1950	0.957	174	0.296	–112	0.012	148	0.917	173
2000	0.970	173	0.247	–119	0.012	136	0.915	173



B1, B4	Long Bead, Fair Rite
B2, B3	Short Bead, Fair Rite
C1	0.3 pF, B Case Chip Capacitor, ATC
C2	220 µF, Electrolytic Capacitor, Mallory
C3, C14	0.1 µF, Chip Capacitor, Kemit
C4, C8	0.8 to 8 pF, Variable Capacitor, Johanson
C5, C11	1800 pF, Chip Capacitor, Kemit
C6, C12	18 pF, B Case Chip Capacitor, ATC
C7, C10	51 pF, Chip Capacitor, Murata Erie
C9	1.7 pF, B Case Chip Capacitor, ATC
C13	470 µF, Electrolytic Capacitor, Mallory
D1	Surface Mount Diode, Motorola
D2	Light Emitting Diode, Industrial Devices
L1, L2	3 Turn, 20 AWG, 0.126″ ID Choke
N1, N2	Type N Flange Mount RF Connector, Omni Spectra
Q1	Transistor PNP Motorola (BD136)
Q2, Q3	Surface Mount Transistor, NPN, Motorola (MJD47)
R1	2 x 330 Ω, 1/8 Watt Chip Resistors in Parallel, Rohm
R2	100 Ω, 1/8 Watt, Chip Resistor, Rohm
R3, R6	4 x 38 Ω, 1/8 Watt, Chip Resistors in Parallel, Rohm
R4	39 Ω, 1/8 Watt, Chip Resistor, Rohm
R5	22 KΩ, 1/8 Watt, Chip Resistor, Rohm
Board	Glass Teflon®, Arlon GX–0300–55–22, ε_r = 2.55

Figure 12. Class AB Broadband Test Fixture Electrical Schematic



B1, B4	Long Bead, Fair Rite	Q1	Transistor NPN Motorola (BD135)
B2, B3	Short Bead, Fair Rite	Q2	Transistor PNP Motorola (BD136)
C1, C2	100 µF, Electrolytic Capacitor, Mallory	R1	250 Ω, 1/8 Watt, Chip Resistor Rohm
C3, C14	0.1 µF, Chip Capacitor, Kemit	R2	500 Ω, 1/4 Watt Potentiometer, State of the Art
C4	1.3 pF, B Case Chip Capacitor, ATC	R3	4.7 KΩ, 1/8 Watt, Chip Resistor, Rohm
C5, C12	18 pF, B Case Chip Capacitor, ATC	R4	2 x 4.7 KΩ, 1/8 Watt, Chip Resistors in Parallel, Rohm
C6, C11	1800 pF, Chip Capacitor, Kemit	R5	1.0 Ω, 10 Watt, Resistor, Dale
C7, C9	0.8 to 8 pF, Variable Capacitor, Johanson	R6	38 Ω, 1.0 Watt, Resistor
C8, C10	51 pF, Chip Capacitor, Murata Erie	R7	75 Ω, 1/8 Watt, Chip Resistor, Rohm
C13	470 µF, Electrolytic Capacitor, Mallory	R8	2 x 10 Ω, 1/8 Watt, Chip Resistors in Parallel, Rohm
L1, L2	3 Turn, 20 AWG, 0.126″ ID Choke	R9, R10	4 x 38 Ω, 1/8 Watt, Chip Resistors in Parallel, Rohm
N1, N2	Type N Flange Mount RF Connector, Omni Spectra	Board	Glass Teflon®, Arlon GX–0300–55–22, $\varepsilon_r = 2.55$

Figure 13. Class A Test Fixture Electrical Schematic

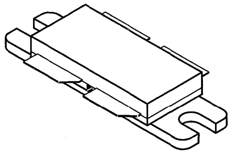
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Advance Information

The RF Line
NPN Silicon RF Power Transistor

MRF15090

90 W, 1.5 GHz
RF POWER TRANSISTOR
NPN SILICON



CASE 375A–01, STYLE 1

Designed for 26 volts microwave large–signal, common emitter, class A and class AB linear amplifier applications in industrial and commercial FM/AM equipment operating in the range 1400–1600 MHz.

- Specified 26 Volts, 1490 MHz, Class AB Characteristics
  Output Power — 90 Watts (PEP)
  Gain — 7.5 dB Min @ 90 Watts (PEP)
  Collector Efficiency — 30% Min @ 90 Watts (PEP)
  Intermodulation Distortion — –28 dBc Max @ 90 Watts (PEP)
- Third Order Intercept Point — 56.5 dBm Typ @ 1490 MHz, V_{CE} = 24 Vdc, I_C = 5 Adc
- Characterized with Series Equivalent Large–Signal Parameters from 1400–1600 MHz
- Characterized with Small–Signal S–Parameters from 1000–2000 MHz
- Silicon Nitride Passivated
- 100% Tested for Load Mismatch Stress at All Phase Angles with 3:1 Load VSWR @ 28 Vdc, and Rated Output Power
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	25	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous @ $T_{J(max)}$ = 150°C	I_C	15	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.70	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	28	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	65	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 100 Ω)	$V_{(BR)CER}$	30	—	—	Vdc

(continued)

This document contains information on a new product. Specifications and information herein are subject to change without notice.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS — continued					
Emitter–Base Breakdown Voltage (I_E = 5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4	4.8	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1 Adc, V_{CE} = 5 Vdc)	h_{FE}	20	40	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 Vdc, I_E = 0, f = 1 MHz) – For Information Only. This Part Is Collector Matched.	C_{ob}	—	52	—	pF
FUNCTIONAL TESTS (Figure 12)					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 90 W (PEP), I_{CQ} = 250 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	G_{pe}	7.5	8.3	—	dB
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 90 W (PEP), I_{CQ} = 250 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	η	30	36	—	%
Intermodulation Distortion (V_{CC} = 26 Vdc, P_{out} = 90 W (PEP), I_{CQ} = 250 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	IMD	—	– 32	– 28	dBc
Input Return Loss (V_{CC} = 26 Vdc, P_{out} = 90 W (PEP), I_{CQ} = 250 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz)	IRL	12	15	—	dB
Load Mismatch (V_{CC} = 28 Vdc, P_{out} = 90 W (PEP), I_{CQ} = 250 mA, f_1 = 1490 MHz, f_2 = 1490.1 MHz, Load VSWR = 3:1, All Phase Angles at Frequency of Test)	ψ	No Degradation in Output Power			

TYPICAL CHARACTERISTICS

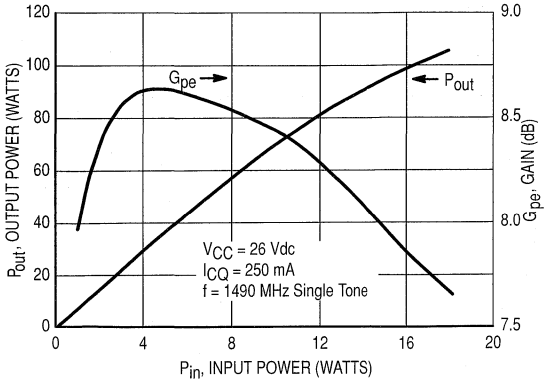


Figure 1. Output Power & Power Gain versus Input Power

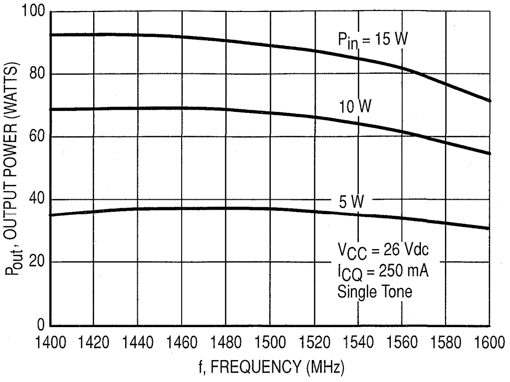


Figure 2. Output Power versus Frequency

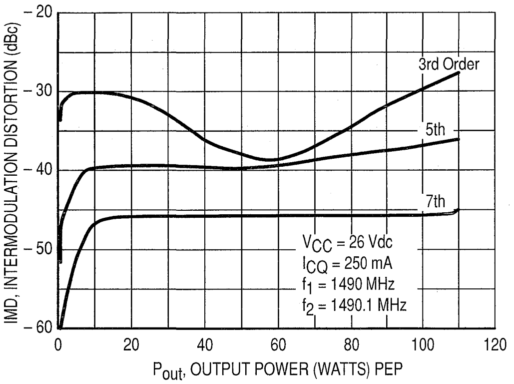


Figure 3. Intermodulation Distortion versus Output Power

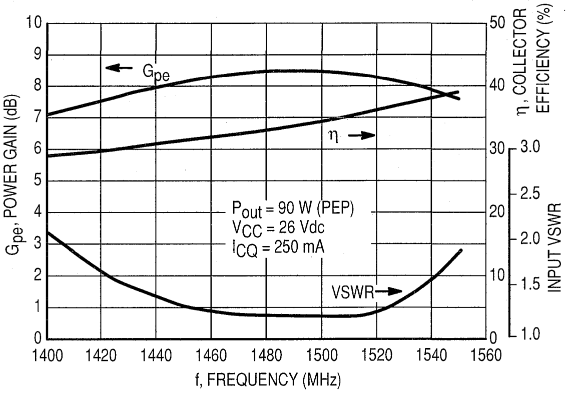


Figure 4. Performance in Broadband Circuit

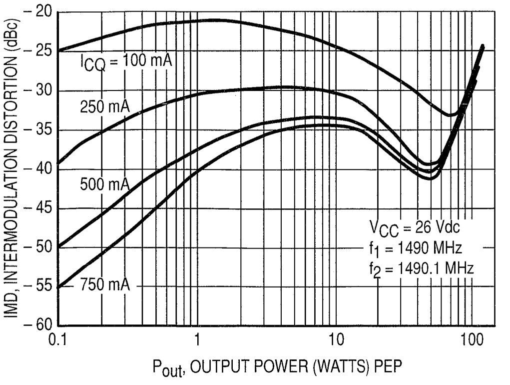


Figure 5. Intermodulation Distortion versus Output Power

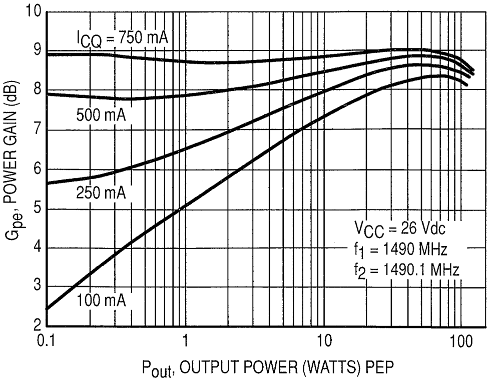


Figure 6. Power Gain versus Output Power

TYPICAL CHARACTERISTICS

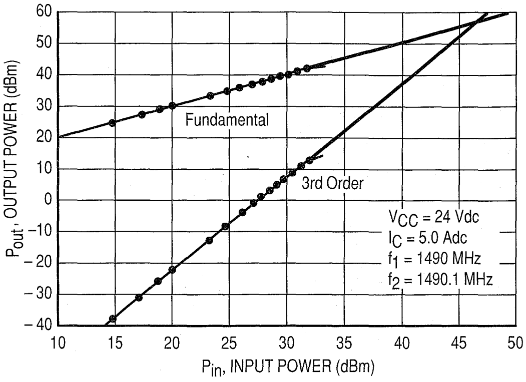


Figure 7. Class A Third Order Intercept Point

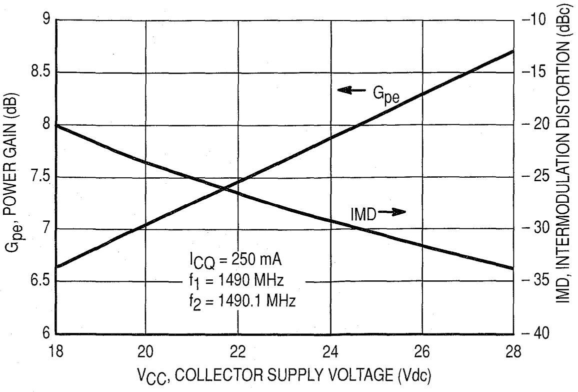


Figure 8. Power Gain and Intermodulation Distortion versus Supply Voltage

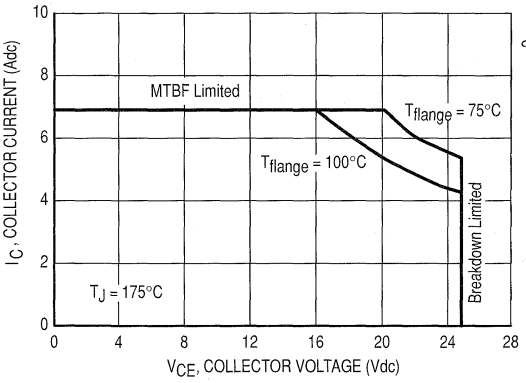


Figure 9. DC Safe Operating Area

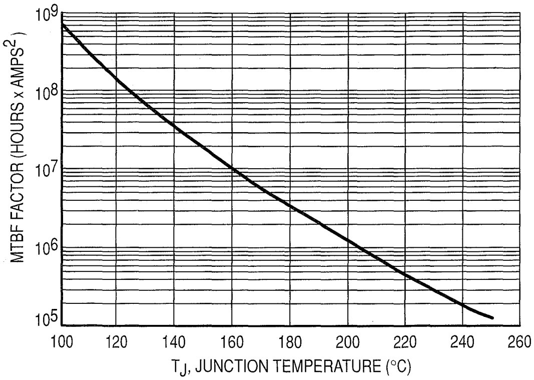
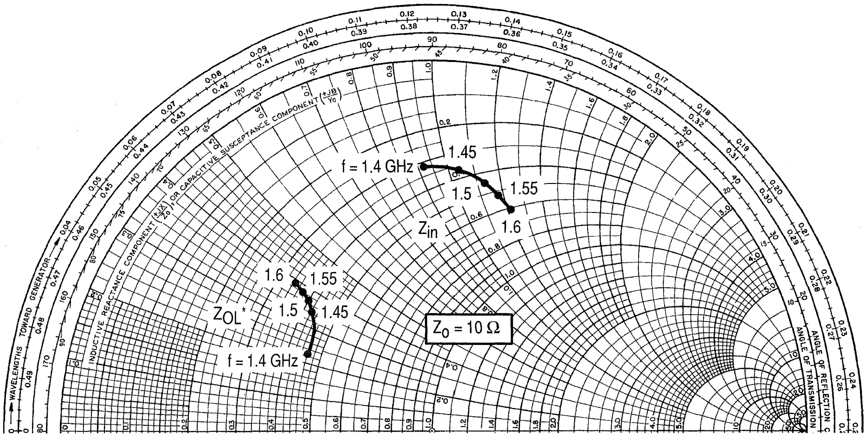


Figure 10. MTBF Factor versus Junction Temperature

The graph above displays calculated MTBF in hours x ampere^2 emitter current. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTBF Factor by I_C^2 for MTBF in a particular application.



f (MHz)	Z_{in} (Ω)	$Z_{OL}{}^*$ (Ω)
1400	3.28 + j9.07	4.62 + j2.23
1450	3.85 + j10.4	4.35 + j3.41
1500	4.55 + j11.4	4.08 + j3.60
1550	5.45 + j11.9	3.80 + j3.78
1600	6.20 + j12.2	3.55 + j3.84

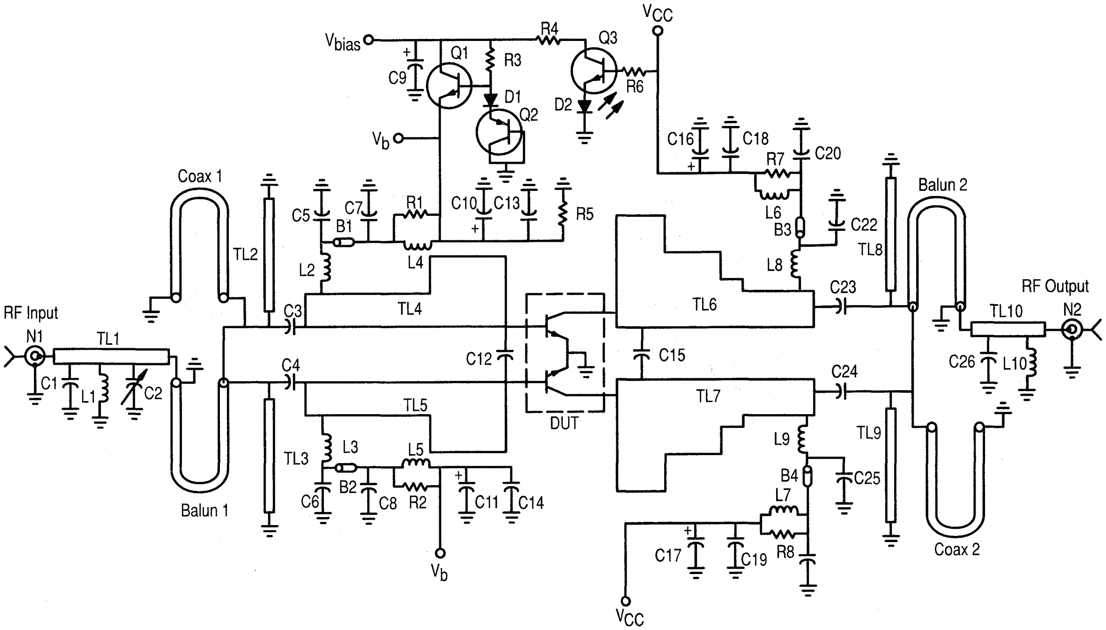
Z_{in} = Input impedance is a balanced base to base measurement.

$Z_{OL}{}^*$ = Conjugate of optimum load impedance collector to collector into which the device operates at a given output power, bias current, voltage and frequency.

Figure 11. Input and Output Impedances with Circuit Tuned for Maximum Gain @ P_{out} = 90 Watts (PEP), V_{CC} = 26 Volts, I_{CQ} = 250 mA, and Driven by Two Equal Amplitude Tones with Separation of 100 KHz

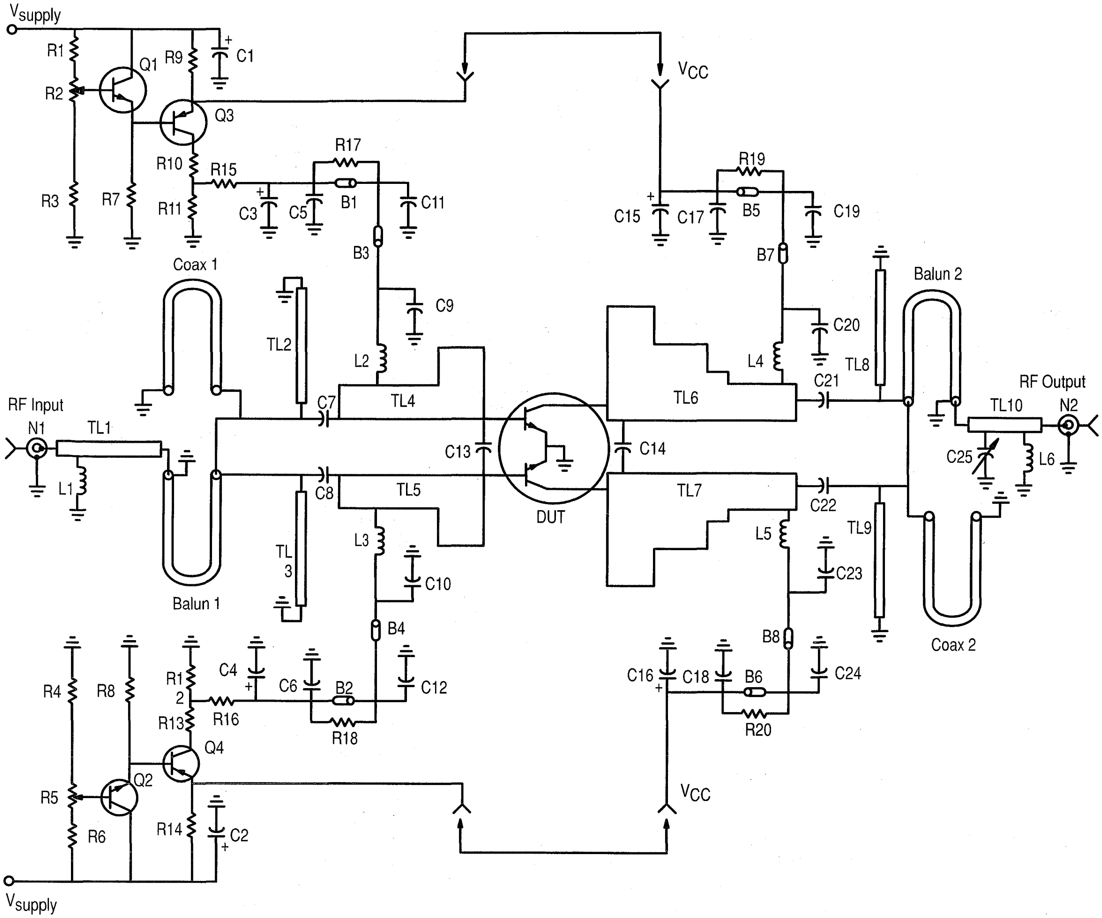
Table 1. Common Emitter S–Parameters (for One Side of Push–Pull MRF15090) at V_{CE} = 24 Vdc, I_C = 2.5 Adc

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
1000	0.999	172	0.164	108	0.006	72	0.957	173
1050	0.999	171	0.179	103	0.007	69	0.956	172
1100	0.994	170	0.196	97	0.007	66	0.948	172
1150	0.992	170	0.216	92	0.008	63	0.940	171
1200	0.994	169	0.241	86	0.008	62	0.935	171
1250	0.986	168	0.269	80	0.009	57	0.924	170
1300	0.982	167	0.306	73	0.010	51	0.915	170
1350	0.973	166	0.351	66	0.011	45	0.905	170
1400	0.957	164	0.408	56	0.012	33	0.888	170
1450	0.938	163	0.483	44	0.013	22	0.876	170
1500	0.903	162	0.571	29	0.014	7	0.859	171
1550	0.857	163	0.651	10	0.014	–13	0.855	173
1600	0.821	165	0.673	–14	0.013	– 40	0.877	174
1650	0.837	169	0.623	– 37	0.011	– 67	0.902	174
1700	0.872	170	0.529	– 56	0.009	–104	0.922	173
1750	0.901	170	0.437	–70	0.008	–138	0.931	172
1800	0.920	170	0.363	– 81	0.007	–165	0.932	171
1850	0.940	169	0.309	– 90	0.008	173	0.930	170
1900	0.954	169	0.265	– 98	0.008	150	0.932	169
1950	0.965	168	0.232	–104	0.009	139	0.930	169
2000	0.971	167	0.205	–110	0.010	132	0.929	168



B1, B2, B3, B4	Ferrite Bead, Ferroxcube	L1	1 Turn, 24 AWG, 0.042″ ID Choke
C1	2.7 pF, B Case Chip Capacitor, ATC	L2, L3, L8, L9	3 Turn, 20 AWG, 0.126″ ID Choke
C2	0.6–4.0 pF, Variable Capacitor, Johanson	L4, L5, L6, L7	12 Turns, 22 AWG, 0.140″ ID Choke
C3, C4, C23, C24	18 pF, B Case Chip Capacitor, ATC	L10	3 Turns, 24 AWG, 0.046″ ID Choke
C5, C6, C22, C25	51 pF, Chip Capacitor, Murata Erie	N1, N2	Type N Flange Mount RF Connector, Omni Spectra
C7, C8, C20, C21	1800 pF, Chip Capacitor, Kemit	Q1, Q3	Transistor, NPN, Motorola (MJD47)
C9, C10, C11	100 μF, Electrolytic Capacitor, Mallory	Q2	Transistor PNP Motorola (BD136)
C12	5.1 pF, A Case Chip Capacitor, ATC	R1, R2, R7, R8	10 Ω, 1/2 W, Resistor
C13, C14, C18, C19	0.1 μF, Chip Capacitor, Kemit	R3	150 Ω, 1/2 W, Resistor
C15	1.1 pF, B Case Chip Capacitor, ATC	R4	2 x 66 Ω, 1/8 W, Chip Resistors in Parallel, Rohm
C16, C17	470 μF, Electrolytic Capacitor, Mallory	R5	93 Ω, 1/8 W, Chip Resistor, Rohm
C26	0.3 pF, B Case Chip Capacitor, ATC	R6	22 KΩ, 1/8 W, Chip Resistor, Rohm
D1	Diode, Motorola (MUR5120T3)	TL1 to TL10	See Photomaster
D2	Light Emitting Diode, Industrial Devices	Board	Glass Teflon®, Arlon GX–0300–55–22, $\varepsilon_r = 2.55$

Figure 12. Class AB Test Fixture Electrical Schematic



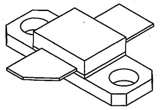
B1, B2, B5, B6	Long Bead, Fair Rite	N1, N2	Type N Flange Mount RF Connector, Omni Spectra
B3, B4, B7, B8	Short Bead, Fair Rite	Q1, Q2	Transistor NPN Motorola (BD135)
C1, C2, C3, C4	100 µF, Electrolytic Capacitor, Mallory	Q3, Q4	Transistor PNP Motorola (BD136)
C5, C6, C17, C18	0.1 µF, Chip Capacitor, Kemit	R1, R6	250 Ω, 1/8 W, Chip Resistor, Rohm
C7, C8, C21, C22	18 pF, B Case Chip Capacitor, ATC	R2, R5	500 Ω, 1/4 W, Potentiometer, State of the Art
C9, C10, C20, C23	51 pF, Chip Capacitor, Murata Erie	R3, R4	4.7 Ω, 1/8 W, Chip Resistor, Rohm
C11, C12, C19, C24	1800 pF, Chip Capacitor, Kemit	R7, R8	2 x 4.7 KΩ, 1/8 W, Chip Resistors in Parallel, Rohm
C13	4.3 pF, B Case Chip Capacitor, ATC		
C14	2.0 pF, B Case Chip Capacitor, ATC	R9, R14	1.0 Ω, 10 W, Resistor, Dale
C15, C16	470 µF, Electrolytic Capacitor, Mallory	R10, R13	38 Ω, 1 W, Resistor
C25	0.6–4 pF Variable Capacitor, Johanson	R11, R12	75 Ω, 1/8 W, Chip Resistor, Rohm
L1	3 Turns, 24 AWG, 0.046″ ID Choke	R15, R16	2 x 10 Ω, 1/8 W, Chip Resistors in Parallel, Rohm
L2, L3, L4, L5	3 Turns, 20 AWG, 0.126″ ID Choke	R17, R18, R19, R20	4 x 38 Ω, 1/8 W, Chip Resistors in Parallel, Rohm
L6	2 Turns, 24 AWG, 0.042″ ID Choke	Board	Glass Teflon®, Arlon GX–0300–55–22, $\varepsilon_r = 2.55$

Figure 13. Class A Test Fixture Electrical Schematic

The RF Line
NPN Silicon
RF Power Transistor

MRF16006

6.0 WATTS, 1.6 GHz
RF POWER TRANSISTOR
NPN SILICON



CASE 395C–01, STYLE 2

Designed for 28 Volt microwave large–signal, common base, Class–C CW amplifier applications in the range 1600 – 1640 MHz.

- Specified 28 Volt, 1.6 GHz Class–C Characteristics
  Output Power = 6 Watts
  Minimum Gain = 7.4 dB, @ 6 Watts
  Minimum Efficiency = 40% @ 6 Watts
- Characterized with Series Equivalent Large–Signal Parameters from 1500 MHz to 1700 MHz
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	26 0.15	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

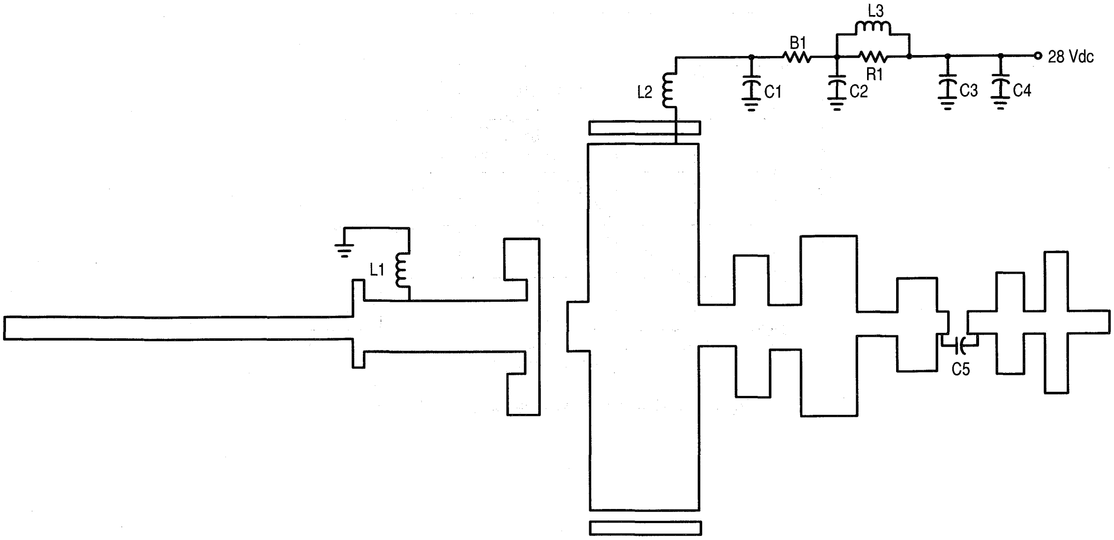
Thermal Resistance — Junction to Case (1) (2)	$R_{\theta JC}$	6.8	°C/W

(1) Thermal measurement performed using CW RF operating condition.
(2) Thermal resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 2

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

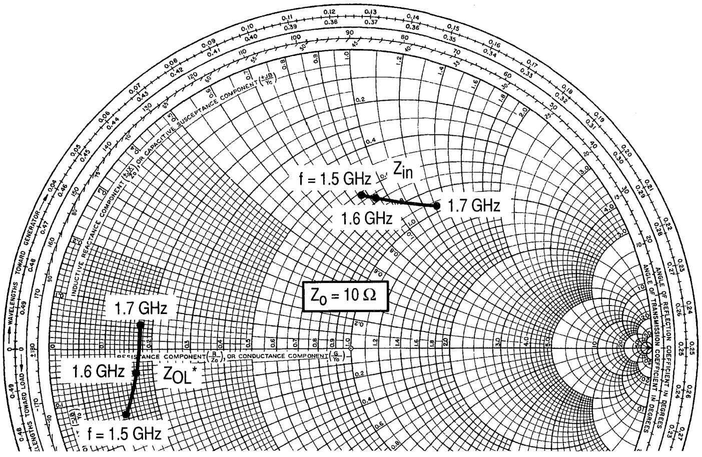
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 40 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 40 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 2.5 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (VCE = 28 Vdc, V_{BE} = 0)	I_{CES}	—	—	2.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 0.2 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB}= 28 Vdc, f = 1.0 MHz)	C_{ob}	11	—	—	pf
FUNCTIONAL TESTS					
Common–Base Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 6 Watts, f = 1600/1640 MHz)	G_{pe}	7.4	—	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 6 Watts, f = 1600/1640 MHz)	η	40	45	—	%
Return Loss (V_{CC} = 28 Vdc, P_{out} = 6 Watts, f = 1600/1640 MHz)	I_{RL}	—	8.0	—	dB
Output Mismatch Stress (V_{CC} = 28 Vdc, P_{out} = 6 Watts, f = 1600 MHz, Load VSWR = 3:1 all phase angles at frequency of test)	ψ	No Degradation in Output Power			



Board Material – Teflon® Glass Laminate Dielectric
Thickness – 0.30″, ε_r = 2.55″, 2.0 oz. Copper

B1	Fair Rite Bead on #24 Wire	C4	47 µF, 50 V, Electrolytic Cap
C1, C5	100 pF, B Case, ATC Chip Cap	L1, L2	3 Turns, #18, 0.133″ ID, 0.15″ Long
C2	0.1 µF, Dipped Mica Cap	L3	9 Turns, #24 Enamel
C3	0.1 µF, Chip Cap	R1	82 Ω, 1.0 W, Carbon Resistor

Figure 1. MRF16006 Test Fixture Schematic



V_{CC} = 28 Vdc, P_{out} = 6 W

f MHz	Z_{in} Ohms	Z_{OL}* Ohms
1500	6.28 + j 8.53	1.22 – j 1.37
1600	7.04 + j 9.00	1.58 – j 0.53
1700	9.55 + j 12.86	1.71 + j 0.39

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

Figure 2. Series Equivalent Input/Output Impedance

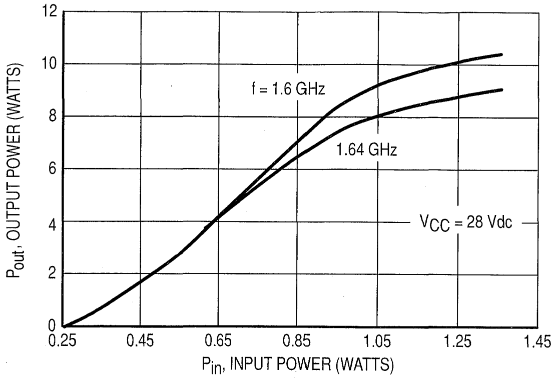


Figure 3. Output Power versus Input Power

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

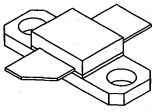
The RF Line
NPN Silicon
RF Power Transistor

MRF16030

30 WATTS, 1.6 GHz
RF POWER TRANSISTOR
NPN SILICON

Designed for 28 Volt microwave large–signal, common base, Class–C CW amplifier applications in the range 1600 – 1640 MHz.

- Specified 28 Volt, 1.6 GHz Class–C Characteristics
  Output Power = 30 Watts
  Minimum Gain = 7.5 dB, @ 30 Watts
  Minimum Efficiency = 40% @ 30 Watts
- Characterized with Series Equivalent Large–Signal Parameters from 1500 MHz to 1700 MHz
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 395C–01, STYLE 2

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CES}	60	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector–Current	I_C	4.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	103 0.58	Watts °C/W
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

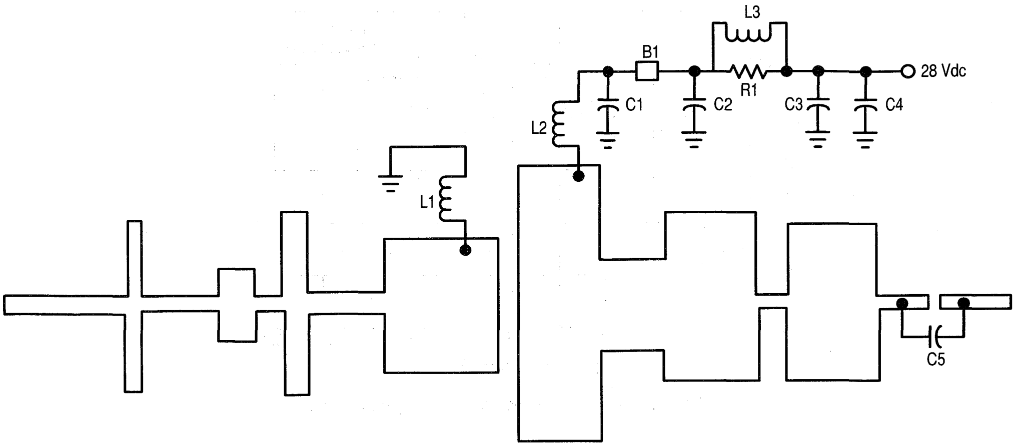
Thermal Resistance — Junction to Case (1) (2)	$R_{\theta JC}$	1.7	°C/W

(1) Thermal measurement performed using CW RF operating condition.
(2) Thermal resistance is determined under specified RF operating conditions by infrared measurement techniques.

REV 2

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

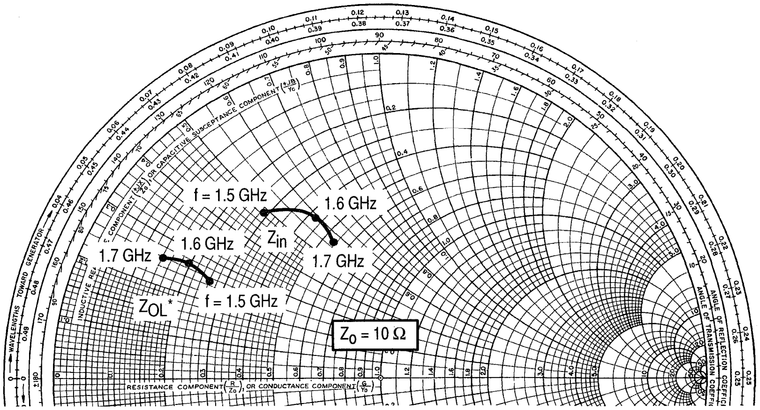
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	55	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 mAdc, I_E = 0)	$V_{(BR)CBO}$	55	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	35	80	—
FUNCTIONAL TESTS					
Collector–Base Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 1600/1640 MHz)	G_{pe}	7.5	7.7	—	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 1600/1640 MHz)	η	40	45	—	%
Input Return Loss (V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 1600/1640 MHz)	I_{RL}	8.0	—	—	dB
Output Mismatch Stress V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 1600 MHz, Load VSWR = 3:1, All phase angles at frequency of test	Ψ	No Degradation in Output Power			



Board Material – Teflon® Glass Laminate Dielectric
Thickness = 0.30″, ε_r = 2.55″, 2.0 oz. Copper

B1	Fair Rite Bead on #24 Wire	C4	47 µF, 50 V, Electrolytic
C1, C5	100 pF, B Case, ATC Chip Cap	L1, L2	3 Turns, #18, 0.133″ ID, 0.15″ Long
C2	0.1 µF, Dipped Mica Cap	L3	9 Turns, #24 Enamel
C3	0.1 µF, Chip Cap	R1	82 Ω, 1.0 W, Carbon

Figure 1. MRF16030 Test Fixture Schematic



V_{CC} = 28 Vdc, P_{out} = 30 W

f MHz	Z_{in} Ohms	Z_{OL}^* Ohms
1500	3.05 + j 4.88	2.66 + j 2.53
1600	4.32 + j 6.00	1.79 + j 2.80
1700	5.62 + j 5.79	1.51 + j 2.64

Z_{OL}^* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

NOTE: Input and output impedance values given are measured from gate to gate and drain to drain respectively.

Figure 2. Series Equivalent Input/Output Impedance

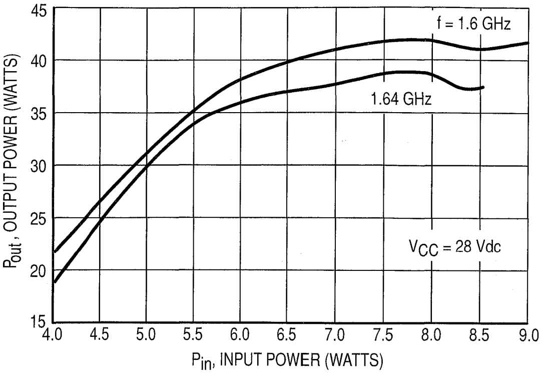
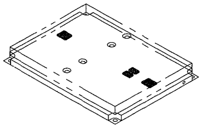


Figure 3. Output Power versus Input Power

The RF Line
Broadband RF Array for TV Transmitter

MRFA2600

25 W, 470–860 MHz
CLASS A
RF POWER AMPLIFIER



CASE 429A–02
STYLE 1

The MRFA2600 is a solid state class A amplifier and is specifically designed for TV transposers and transmitters. This amplifier incorporates microstrip technology and reliable Motorola push–pull transistors.

- Specified 26.5 Volts: 470–860 MHz Characteristics
  Output Power: 25 Watts Min @ 1 dB Comp. (CW)
  Gain: 10.5 dB Min (Small Signal)
- Suitable for 28 Volts Application
- 50 Ω Input and Output Impedance

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	29	Vdc
Current	I_{max}	4	Adc
Storage Temperature Range	T_{stg}	–40 to +100	°C
Operating Temperature (1)	T_{op}	–20 to +70	°C

NOMINAL OPERATION CONDITION

Supply	Transposer Application	V_{CC} = 26.5 V	I_{sup} = 3.8 A
	Transmitter Application	V_{CC} = 28 V	I_{sup} = 3.6 A

ELECTRICAL CHARACTERISTICS (T_C = 25°C, V_{CC} = 26.5 V, I_{sup} = 3.8 A, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Instantaneous Bandwidth	BW	470	860	MHz
Power Gain (small signal)	G_p	10.5	—	dB
Gain Ripple (small signal)	G_{rple}	—	±1	dB
Output Power @ 1 dB Compression	P_{out}	25	—	W
Mismatch Tolerance (P_{out} = 25 W)	VSWR	∞:1	—	—
Intermodulation (–8 dB/–16 dB/–10 dB, P_{ref} = 20 W)	IMD	—	–53	dB_{ref}
Intermodulation (–8 dB/–16 dB/–7 dB, P_{ref} = 20 W)	IMD	—	–50	dB_{ref}
Input Return Loss	IRL	15	—	dB

(1) Temperature is measured at temperature test point (on the flange of the transistor).

REV 2

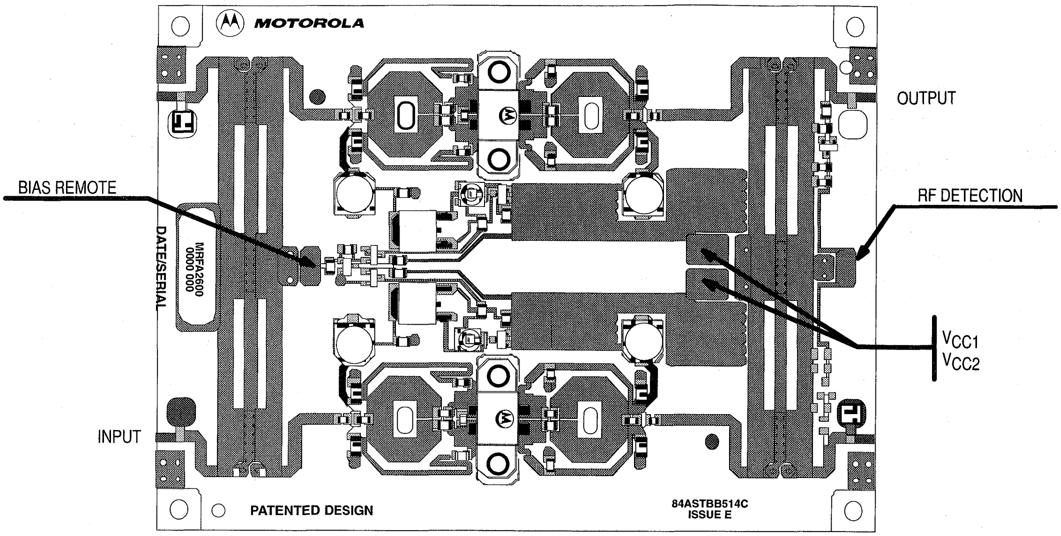
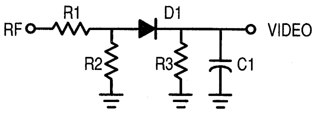


Figure 1. MRFA2600 Connections

RF DETECTION

V_D = 1 V @ 25 W
on infinite load

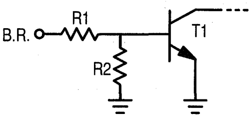
C1	22 pF
D1	MMBD701
R1	22 kΩ
R2	680 Ω
R3	2.2 kΩ



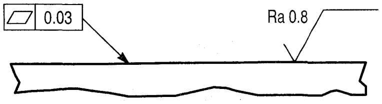
BIAS REMOTE

If B.R. = “1” (TTL signal)
bias circuit is off

R1	4.7 kΩ
R2	4.7 kΩ
T1 .	BCX20



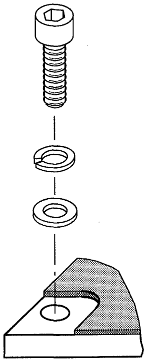
MOUNTING RECOMMENDATIONS



○ 8 Fixing holes M3
Minimum useful depth: — Copper/Aluminum: 6 mm

HEATSINK TOOLING

- Flatness better than 0.03 mm.
- Roughness: Typical value 0.8.



THERMAL COMPOUND

- Paste with silicones: SICERONT KF Ref. 1201 Recommended.
- Thickness: Optimum between 0.06 mm and 0.15 mm, on the whole back surface of the amplifier.
  (Typical volume: 700 mm 3 for 0.1 mm thickness)
  (Equivalent weight: 1.5g for 2.2 density paste).

SCREWS

- Socket head cap screws: — CHC M3 x 10 for Copper/Aluminum Heatsink.
- Material: Nickel plated steel.

WASHERS

- Split lock washers WZ ∅3 + Flat washers ZU ∅3.

CLEANING

- Some components of this amplifier are not qualified for every kind of cleaning solvent.
- Do not clean the amplifier in a solvent bath.
- Local cleaning is recommended.

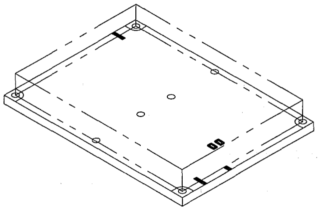
The RF Line
Broadband RF Power Amplifier for TV Transmitter

MRFA2602

60 W, 470–860 MHz
CLASS A
RF POWER AMPLIFIER

The MRFA2602 is a solid state class A amplifier and is specifically designed for TV transposers and transmitters. This amplifier incorporates microstrip technology and reliable Motorola push–pull transistors.

- Specified 25.5 Volts, 470–860 MHz Characteristics
  Output Power — 40 Watts @ –50 dB (3 Tones)
  Output Power — 60 Watts Min @ 1 dB Comp. (CW)
  Gain — 8.5 dB Min (Small Signal)



CASE 429C–03, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	26.5	Vdc
Input Power	P_{in}	15	W
Storage Temperature Range	T_{stg}	–40 to +100	°C
Operating Temperature (1)	T_{op}	–20 to +70	°C

NOMINAL OPERATION CONDITION (T_C = 60°C)

Supply	V_{CC} = 25.5 V	I_{sup} = 9.2 A

ELECTRICAL CHARACTERISTICS (T_C = 25°C, Nominal Supply, 470–860 MHz Bandwidth, unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Power Gain (small signal)	G_p	8.5	—	—	dB
Gain Ripple (small signal)	G_{rple}	—	—	±1	dB
Output Power @ 1 dB Compression	P_{out}	60	—	—	W
Mismatch Tolerance (P_{out} = 60 W)	VSWR	∞:1	—	—	—
Intermodulation (–8 dB/–7 dB/–16 dB, P_{ref} = 40 W)	IMD1	—	—	–50	dB
Intermodulation (–8 dB/–10 dB/–16 dB, P_{ref} = 40 W)	IMD2	—	—	–53	dB
Input Return Loss/Output Return Loss	IRL/ORL	—	—	–15	dB

NOTE:
1. Temperature is measured at temperature test point (on the flange of the transistor).

REV 2

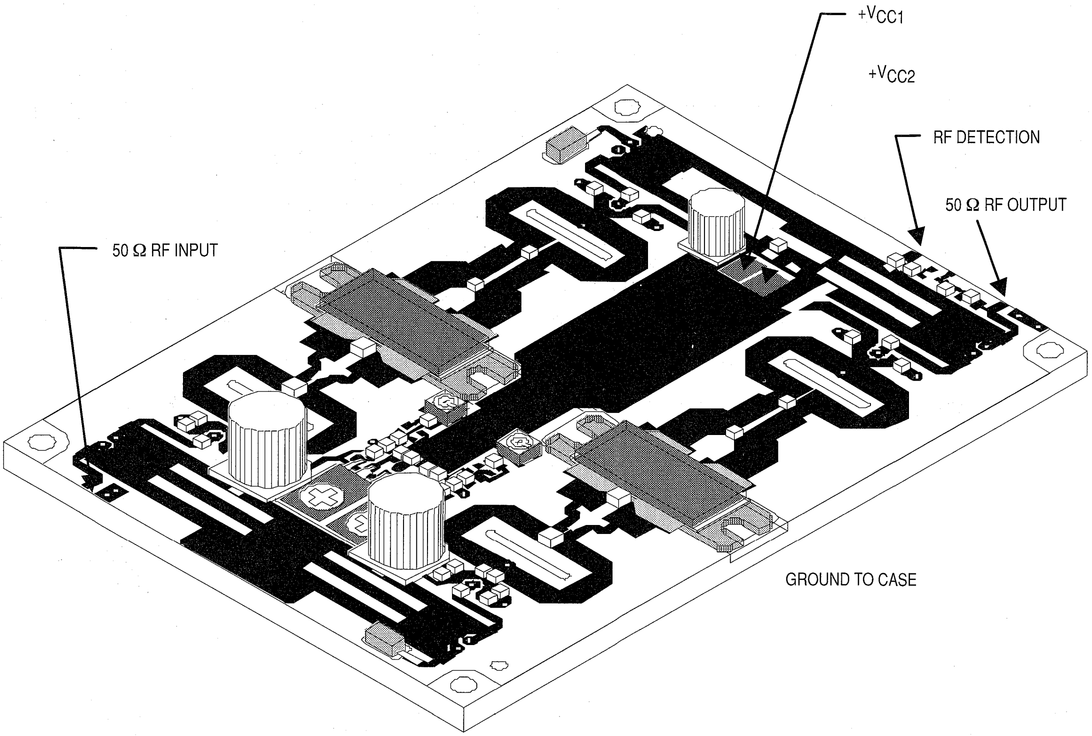


Figure 2. MRFA2602 Connections

TYPICAL CHARACTERISTICS

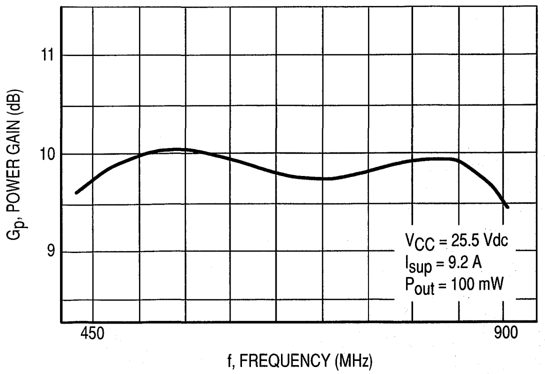


Figure 3. Power Gain versus Frequency

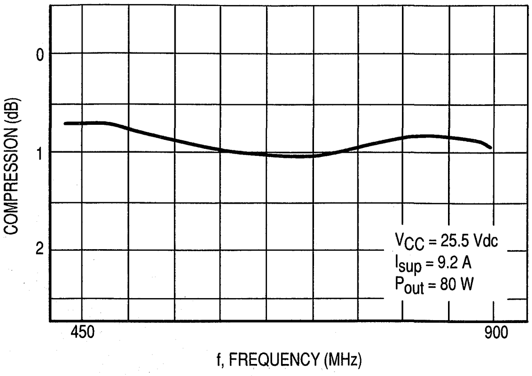


Figure 4. Gain Compression versus Frequency

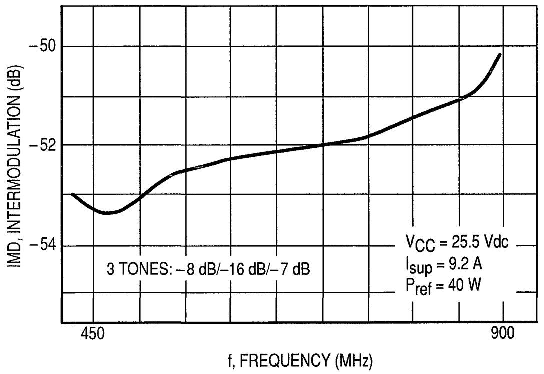


Figure 5. Intermodulation versus Frequency

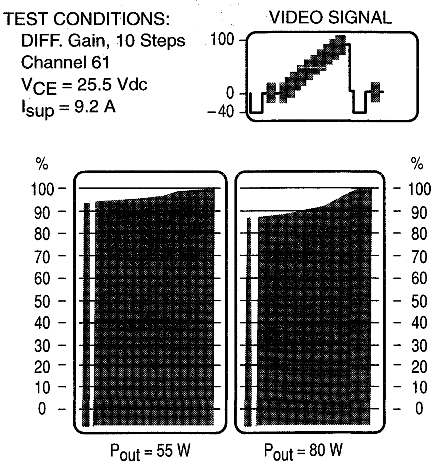

TEST CONDITIONS:
DIFF. Gain, 10 Steps
Channel 61
V_{CE} = 25.5 Vdc
I_{sup} = 9.2 A

Figure 6. Differential Gain

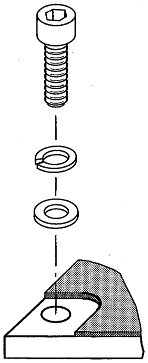
MOUNTING RECOMMENDATIONS

1. HEATSINK TOOLING

- Planarity: Better than 0.03 mm
- Roughness: Typical Value 0.8
- 8 Fixing Holes M3

2. THERMAL COMPOUND

- Paste with silicones: SICERONT KF Ref. 1201 Recommended.
- Thickness: Optimum between 0.06 mm and 0.15 mm, on the whole back surface of the amplifier.
  (Typical volume: 700 mm 3 for 0.1 mm thickness)
  (Equivalent weight: 1.5 g for 2.2 density paste)



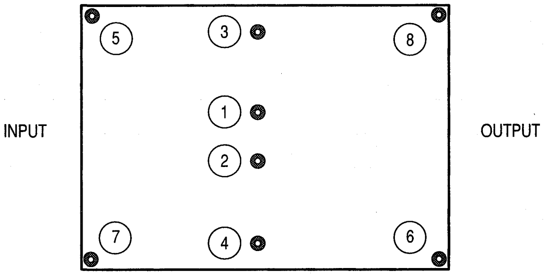
3. SCREWS

- Socket head cap screws: — CHC M3 x 10 for Copper/Aluminum Heatsink.
- Material: Nickel plated steel.

4. WASHERS

- Split lock washers WZ ∅3 + Flat washers ZU ∅3.

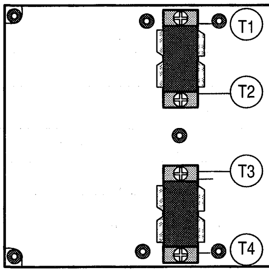
5. TIGHTENING ORDER



Recommended Torque: 12 Kg.cm (10.5 in. lbs.)

6. MOUNTING VERIFICATION

Supply the amplifier (25.5 Vdc) without RF signal, and measure temperature on points 1, 2, 3, and 4.



Characteristic	Typ	Max	Unit
T1, T2, T3, T4	—	70	°C
Δ(T1, T2), Δ(T3, T4)	3	5	°C

CLEANING RECOMMENDATIONS

Some components of this amplifier are not qualified for every kind of cleaning solvent, so DO NOT clean the amplifier in a solvent bath. Local cleaning is recommended.

The RF Line
Broadband R.F. Array for TV Transmitter

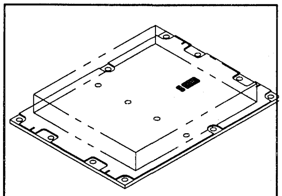
MRFA2604

230 W PEAK SYNC.
470–860 MHz
CLASS AB
RF POWER AMPLIFIER

The MRFA2604 is a solid state class AB amplifier specifically designed for TV transposers and transmitters. This amplifier incorporates microstrip technology and reliable Motorola push–pull transistors.

The MRFA2604 includes a thermal compensation (differential gain is constant versus average picture level (APL)) which can be partially disconnected.

- Specified 28 Volts, 470–860 MHz Characteristics
  Output Power = 175 Watts (CW)/230 Watts (Video)
  Minimum Gain = 8.0 dB (@ Nominal Power)
- 50 Ω Input and Output Impedance
- Class AB Operation
- Thermally Compensated



CASE 439–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	32	Vdc
Current	I_{max}	15	Adc
Storage Temperature Range	T_{stg}	−40 to +100	°C
Operating Temperature (1)	T_{op}	−20 to +70	°C

NOMINAL OPERATION CONDITION

Supply Voltage/Quiescent Current (2)	V_{CC} = 28 V	I_Q = 0.9 A

ELECTRICAL CHARACTERISTICS IN CW (T_C = 25°C, V_{CC} = 28 V, I_Q = 0.5 A, without thermal correction)

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Bandwidth	BW	470	—	860	MHz
Power Gain (P_{out} = 175 W)	G_p	8.0	9.0	—	dB
Gain Ripple (P_{out} = 175 W)	G_{rple}	—	±0.5	±1.0	dB
Output Power @ 1.0 dB Compression	P_{out}	175 (3)	190	—	W
Efficiency (P_{out} = 175 W)	η	45 (3)	50	—	%
Input Return Loss	I_{RL}	—	−20	−15	dB

ELECTRICAL CHARACTERISTICS IN VIDEO (T_C = 25°C, I_{sup} = 0.9 A, with thermal compensation)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Power @ 28 V (Peak Sync. B/G standard)	P_{out}	230	240	—	W
Power Gain @ black level (P_{sync} = 230 W, V_{CC} = 28 V)	G_p	8.0	9.0	—	dB

(1) Temperature is measured at temperature test point (on the flange of the transistor).

(2) Tuned in the factory for optimum thermal correction @ 25°C.

(3) Thermal correction cannot be disconnected, and CW performances are slightly affected (−5.0 W, −3% typical), but output power with a video signal remain the same.

TYPICAL CHARACTERISTICS

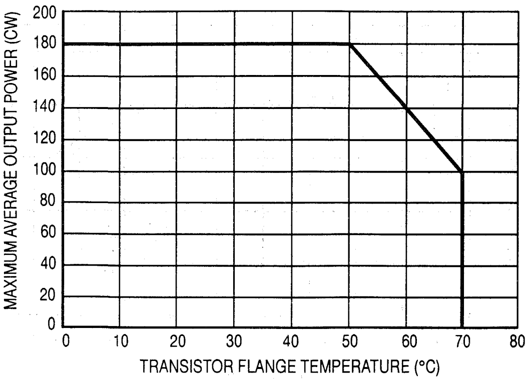


Figure 1. Maximum Average Output Power versus Temperature

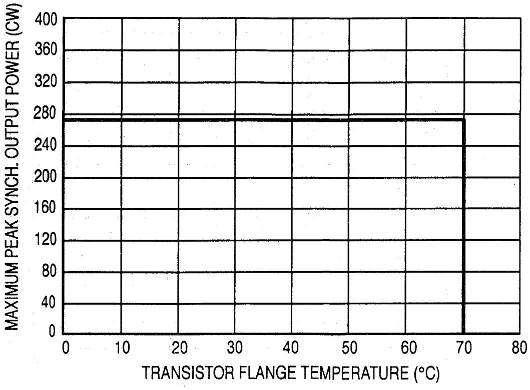
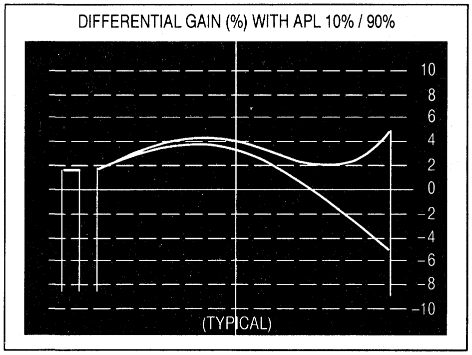


Figure 2. Maximum Peak Synch. Output Power (B/G Standard) versus Temperature



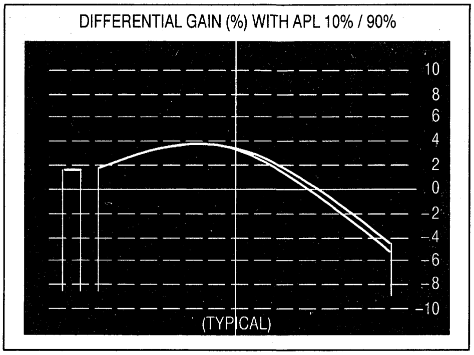
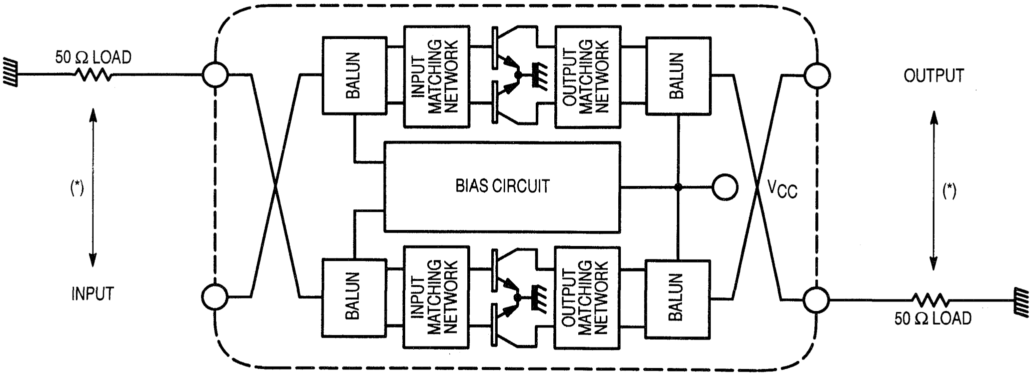


Figure 3. Without Thermal Compensation

Figure 4. With Thermal Compensation

WARNING: Please read instructions carefully for operating/set–up and mounting recommendations prior to operating this device.



* Loads positions can be inverted if required.

Figure 5. Internal Schematic and External Connections

CW MEASUREMENTS WITHOUT THERMAL COMPENSATION**
(see Figure 23)

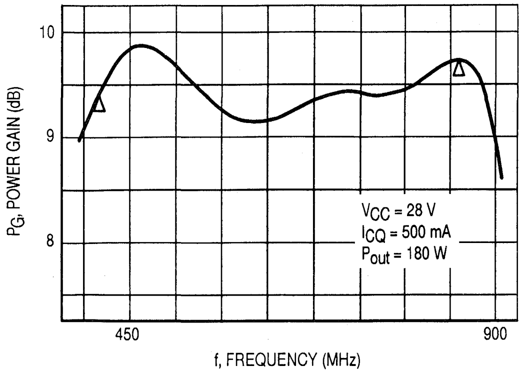


Figure 6. Power Gain versus Frequency

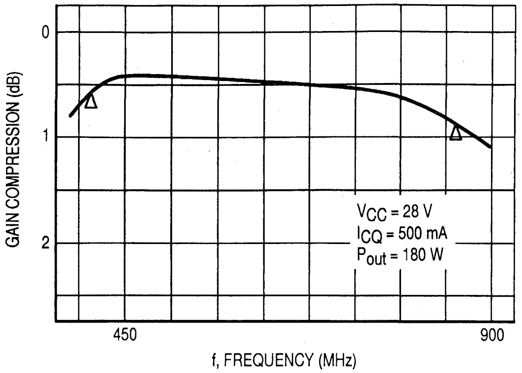


Figure 7. Gain Compression versus Frequency

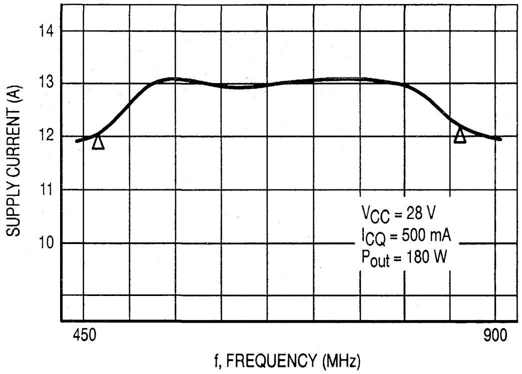


Figure 8. Supply Current versus Frequency

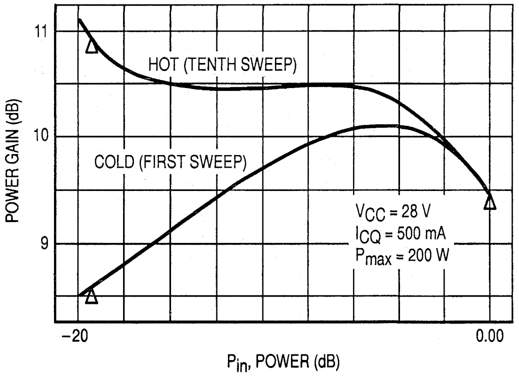


Figure 9. Power Gain versus Input Power

** Measurement results are typical values and are not guaranteed

VIDEO MEASUREMENTS WITH THERMAL COMPENSATION, B/G STANDARD
(Measurement results are typical values and are not guaranteed)

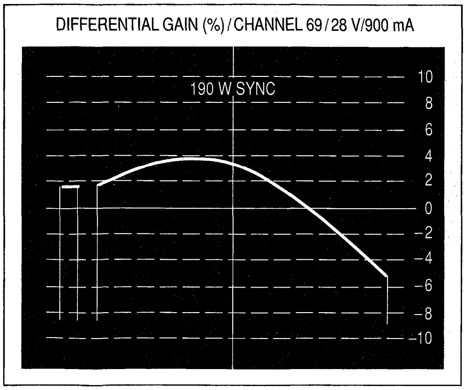


Figure 10. Differential Gain 190 W Sync

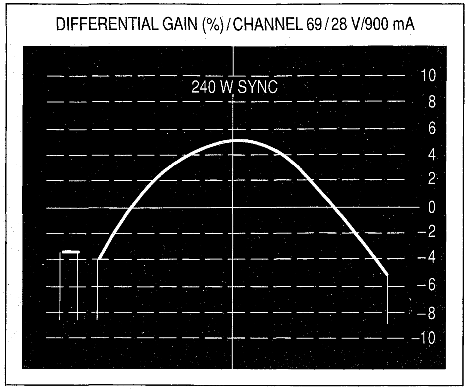


Figure 11. Differential Gain 240 W Sync

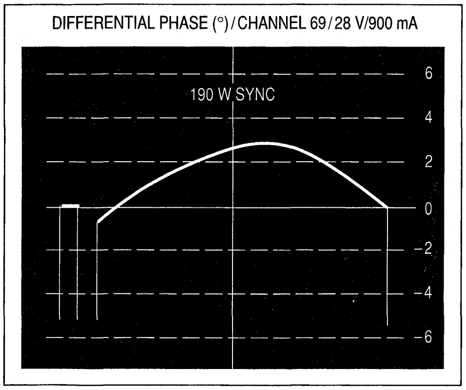


Figure 12. Differential Phase 190 W Sync

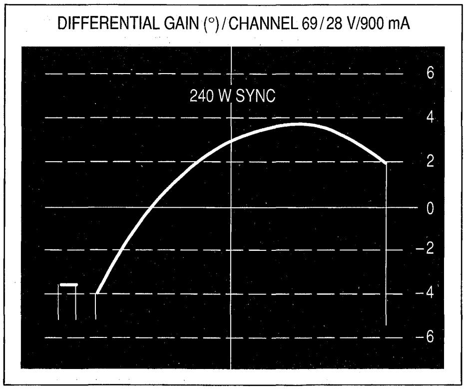
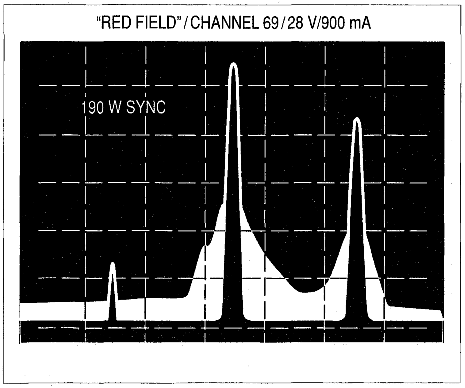
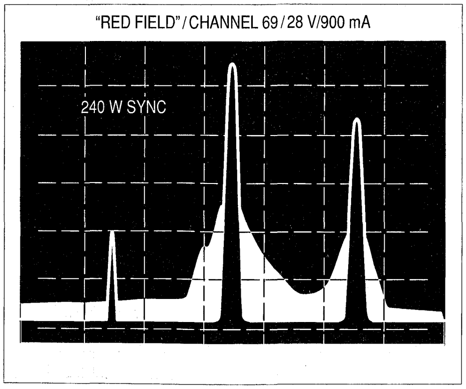


Figure 13. Differential Phase 240 W Sync



SIDE BAND REGENERATION 10 dB/div–2 MHz/div

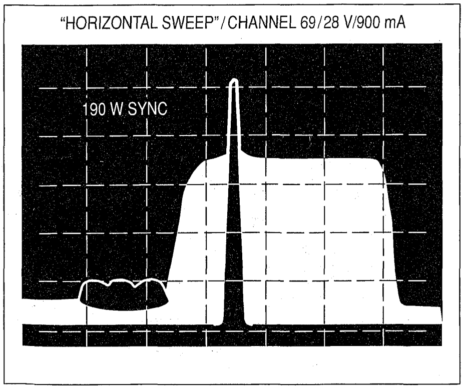
Figure 14. "Red Field" 190 W Sync



SIDE BAND REGENERATION 10 dB/div–2 MHz/div

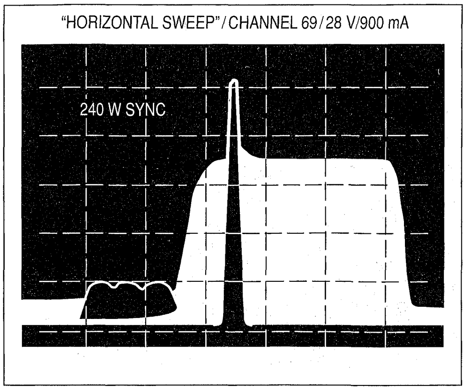
Figure 15. "Red Field" 240 W Sync

VIDEO MEASUREMENTS WITH THERMAL COMPENSATION, BG STANDARD
(Measurement results are typical values and are not guaranteed)



SIDE BAND REGENERATION 10 dB/div–2 MHz/div

Figure 16. "Horizontal Sweep" 190 W Sync



SIDE BAND REGENERATION 10 dB/div–2 MHz/div

Figure 17. "Horizontal Sweep" 240 W Sync

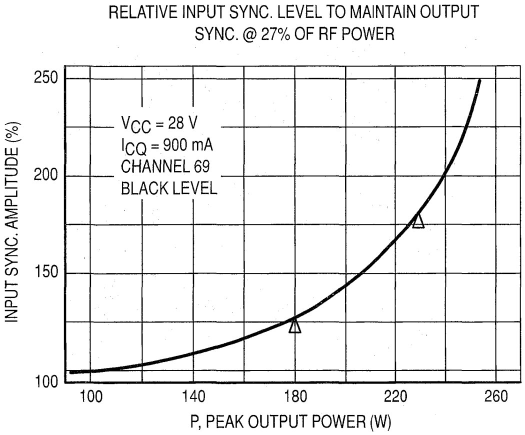


Figure 18. Input Sync. versus Output Power

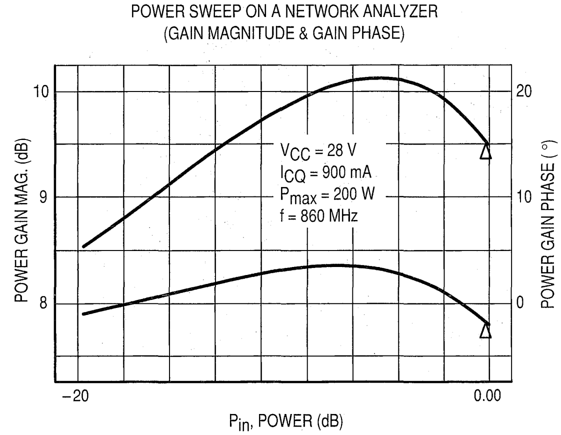


Figure 19. Power Gain versus Input Power

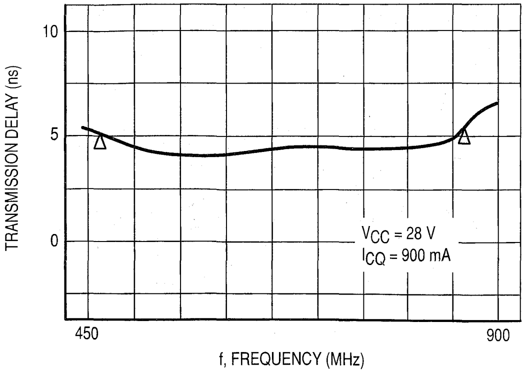


Figure 20. Delay versus Frequency

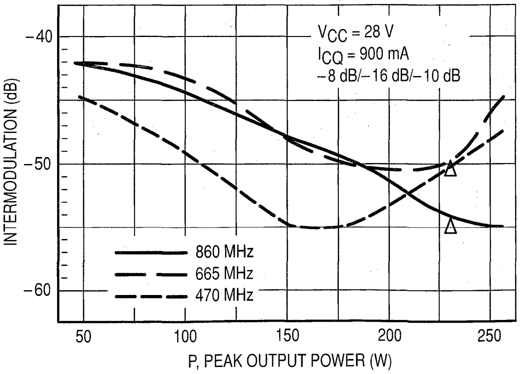


Figure 21. Intermodulation versus Output Power

OPERATING AND SET–UP RECOMMENDATIONS

1. QUIESCENT CURRENT

- **With Thermal Compensation:** The amplifier is tuned in the factory at 28 V/900 mA (total current) with the compensation "ON." Depending on the temperature of the amplifier and of the RF transistor, this value can be slightly different but it does not affect the overall performances.
- **Without Thermal Compensation:** If the amplifier has to be used without the compensation, P1 (tuning of quiescent current) has to be set–up in its initial position before applying power supply (see Figure 22). When power supply is applied P1 is tuned to obtain 500 mA.
- **Max. current:** In any case I_Q **must not exceed 1.2 A.**

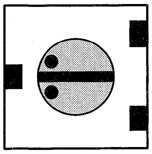


Figure 22. Initial Position of P1

2. THERMAL COMPENSATION

The amplifier is tuned in the factory for optimum compensation at 180 W peak, B/G standard, channel 69. If the amplifier is used at a different level (driver for instance), the compensation may not be optimized and can be retuned by using P2.

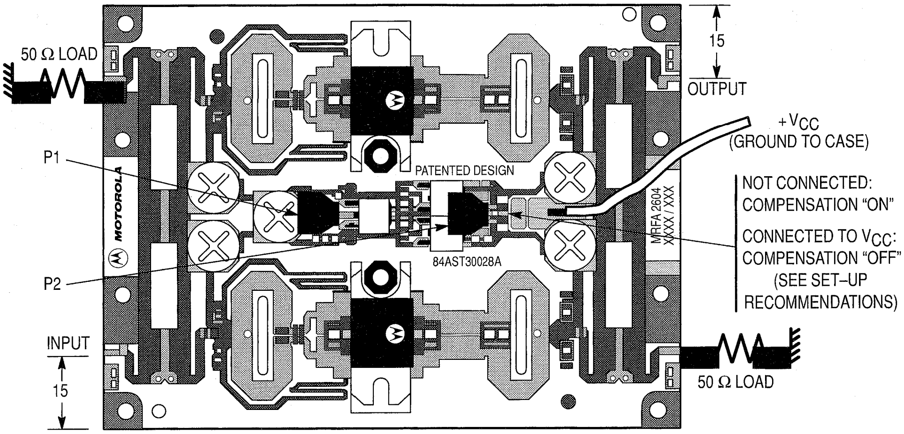
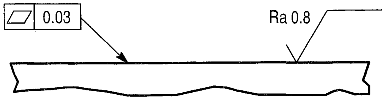


Figure 23. MRFA2604 Connections



MOUNTING RECOMMENDATIONS

1. HEATSINK TOOLING

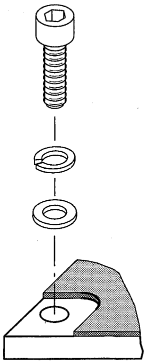
- Flatness: better than 0.03 mm
- Roughness: Typical value 0.8

2. SCREWS

- CHC M3 x 10 for Copper/Aluminum Heatsink
- Socket head cap screws
- Material: Nickel plated steel

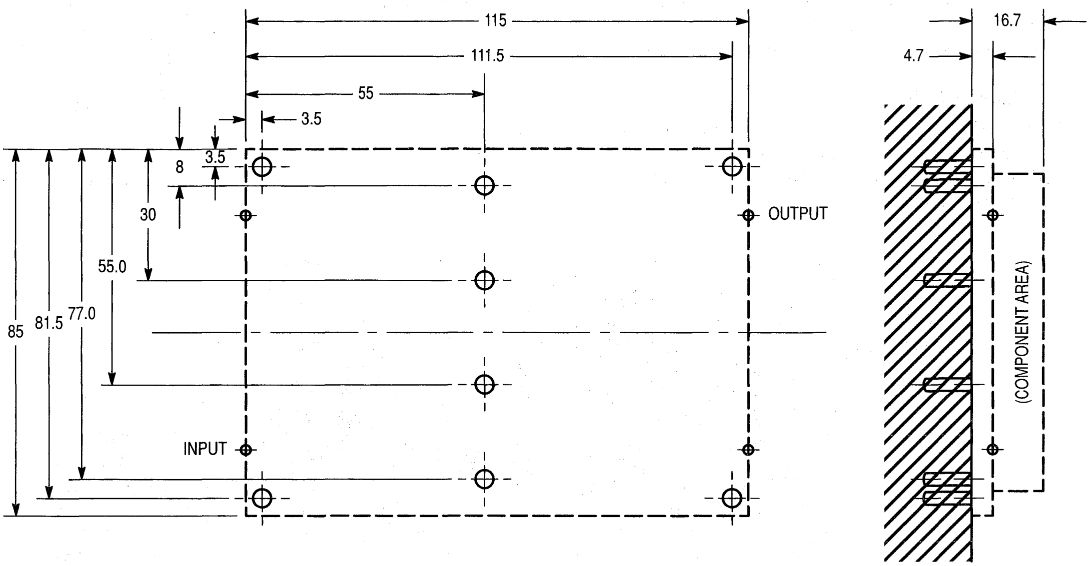
3. WASHERS

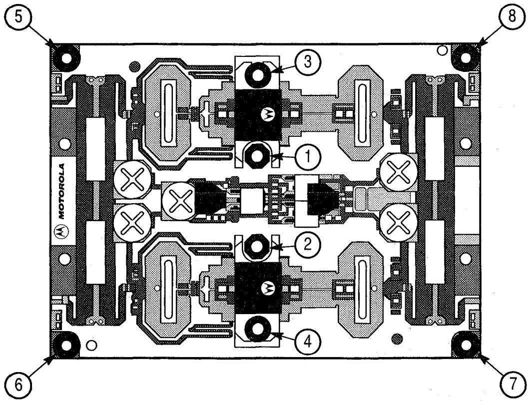
- Split lock washers WZ ∅3 + Flat washers ZU ∅3



MOUNTING RECOMMENDATIONS (cont')

5. THERMAL COMPOUND:
   - Paste with silicones: SICERONT KF Ref. 1201 Recommended.
   - Thickness: optimum between 0.06 mm and 0.15 mm, on the whole back surface of the amplifier.
     (Typical volume: 700 mm 3 for 0.1 mm thickness)
     (Equivalent weight: 1.5 g for 2.2 density paste).





6. TIGHTENING SEQUENCE:

   Engage all screws down to contact, then apply torque **according to given sequence** (see drawing on the right).

7. TORQUE:

   Recommended Torque: 12 Kg.cm (10.5 in. lbs.)

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Advance Information

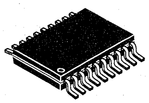
The MRFIC Line Quadrature Modulator

MRFIC0001

QUADRATURE MODULATOR INTEGRATED CIRCUIT

The MRFIC0001 is an integrated Quadrature Modulator designed for operation in the 50 to 260 MHz frequency range. The design utilizes Motorola's advanced MOSAIC 3 silicon bipolar RF process to yield superior performance in a cost effective monolithic device. Applications include DQPSK for PDC, NADC, and PHS; GMSK for GSM and DCS1800; and QPSK for CATV.

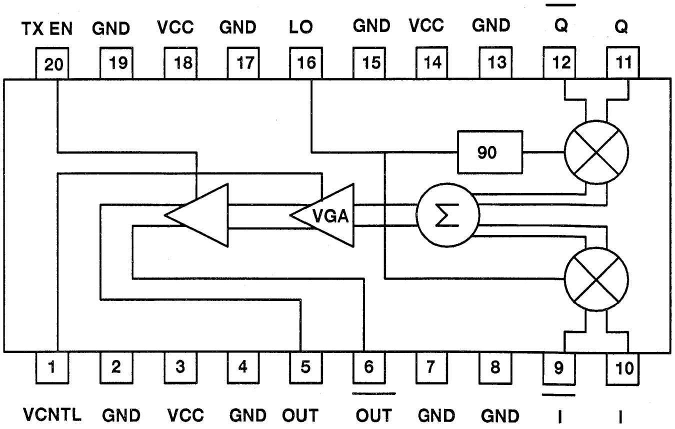
- Linear I/Q Ports
- On Chip LO Phase Shifter
- I/Q Phase Imbalance = 2 degrees (Typ)
- I/Q Amplitude Imbalance = 0.3 dB (Typ)
- Gain Control = 30 dB (Typ)
- Single Source Low Operating Supply Voltage
- Low Power Consumption
- Low–Cost, Low Profile Plastic TSSOP Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M001



CASE 948D–03
(TSSOP–20)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	6.5	Vdc
Control Voltages	TX EN, VCNTL	6.5	Vdc
LO Input Power	P_{LO}	0.0	dBm
Differential I/Q Input Voltage	V_D	2.0	V_{pp}
I, $\overline{I}$, Q, and $\overline{Q}$ DC Bias Voltage	V_B	2.0	Vdc
Ambient Operating Temperature	T_A	–30 to +85	°C
Storage Temperature	T_{stg}	–65 to +125	°C



Pin Connections and Functional Block Diagram

REV 2

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	2.7 to 5.5	Vdc
LO Input Power	P_{LO}	–10	dBm
LO Frequency	f_{LO}	50 to 260	MHz
Differential I/Q Input Voltage	V_D	0 to 1.0	Vdc
I, $\bar{I}$, Q, and $\bar{Q}$ DC Bias Voltage	V_B	1.5 to 1.7	Vdc
Variable Gain Amplifier Control Voltage	CNTL	0 to V_{CC}	Vdc
Transmit Enable Low Voltage	TX EN	0 to 0.2	Vdc
Transmit Enable High Voltage	TX EN	V_{CC} – 0.2 to V_{CC}	Vdc

ELECTRICAL CHARACTERISTICS (V_{CC} = 3.0 V, TX EN = 3.0 V, VCNTL = 0.0 V, V_D = 0.8 V_{PP}, V_B = 1.6 V, P_{LO} = –10 dBm, f_{LO} = 248 MHz, f_D = 100 kHz, T_A = 25°C unless otherwise noted)

Characteristic	Min	Typ	Max	Unit
Supply Current	–	10	12	mA
Standby Current (TX EN = 0.0V)	–	40	100	µA
Single Sideband Output Power Level	–15	–13	–	dBm
Single Sideband Output Power 1dB Compression Point	–	–10	–	dBm
LO Leakage	–	–55	–45	dBm
Undesired Sideband Level	–	–35	–30	dBc
Output Level Dynamic Range (VCNTL = 0 to 2.2V)	–	30	–	dB
Turn–on/off time	–	2	–	µs
I/Q Data				
Input 3dB Bandwidth	–	5	–	MHz
Amplitude Imbalance	–	0.3	–	dB
Phase Imbalance	–	2	–	degree

* (1) All electrical characteristics measured in test circuit schematic shown in Figure 1.
V_B is the bias voltage on the input data ports.
V_D is the sinusoidal differential voltage on the input data ports when testing the part in a single sideband mode.
Above power levels are the single–ended output power.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

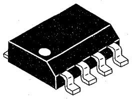
The MRFIC Line
Broadband GaAs Switch

MRFIC0903

ANTENNA SWITCH
GaAs MONOLITHIC
INTEGRATED CIRCUIT

The MRFIC0903 is an integrated GaAs SPDT switch designed for transceivers operating in the 100 MHz to 2.0 GHz frequency range. The design utilizes Motorola's advanced GaAs RF process to yield superior performance in a cost effective monolithic device. Applications for the MRFIC0903 include Class 4 and 5 GSM, Class 1 and 2 DCS1800, DCS1900, DAMPS, PDC, digital cellular systems as well as analog cellular systems.

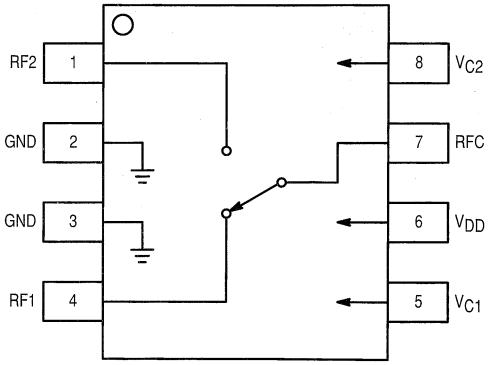
- 2.8 W Transmitting Capability through the Transmit Path with a 5.0 Volt Differential Control Signal
- 1.25 W Transmitting Capability through the Transmit Path with a 3.0 Volt Differential Control Signal
- Single Source Operating Supply Voltage
- Low Power Consumption
- Low–Cost, Low Profile Plastic SOIC Package
- Available in Tape and Reel by Adding R2 Suffix. R2 Suffix = 2,500 Units per Reel.
- Device Marking = M0903



CASE 751–05
(SO–8)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltage	V_{DD}	10	Vdc
Control Voltage	V_{C1}, V_{C2}	V_{DD} + 0.8, V_{DD} – 12	Vdc
Power Dissipation	P_D	1.0	W
Power Input (Non–selected Port)	P_{in}	0.325	W
Ambient Operating Temperature	T_A	–35 to +85	°C
Storage Temperature	T_{stg}	–65 to +150	°C



Pin Connections and Functional Block Diagram

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	0 to 5.0	Vdc
Control Voltage Range	V_{C1}, V_{C2}	V_{DD} – 5.0 to V_{DD} + 0.5	Vdc
RF Frequency Range	f_{RF}	100 to 2000	MHz

ELECTRICAL CHARACTERISTICS (V_{DD} = 5.0 V, P_{in} = 2.5 W (34 dBm), f = 900 MHz, T_A = 25°C unless otherwise noted)

Characteristic	Min	Typ	Max	Unit
Supply Current				
I_{DD}	—	100	170	µA
$I_{Control}$	—	150	300	µA
VSWR	—	1.5:1	—	
Insertion Loss (RFC/RF1, RFC/RF2)	—	0.55	0.8	dB
Isolation (RFC/RF2, RFC/RF1)	18	20	—	dB
Output Power at 0.1 dB Compression	—	34.5	—	dBm

Electrical Characteristics at 900 MHz measured in test circuit schematic shown in Figure 1 with board losses removed.

ELECTRICAL CHARACTERISTICS (V_{DD} = 5.0 V, P_{in} = 2.0 W (33 dBm), f = 1800 MHz, T_A = 25°C unless otherwise noted)

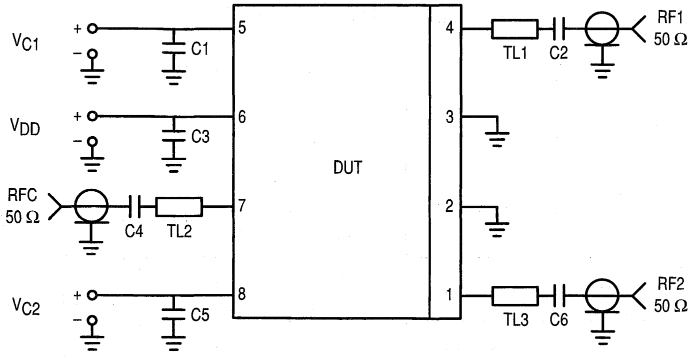
Characteristic	Min	Typ	Max	Unit
Supply Current				
I_{DD}	—	100	170	µA
$I_{Control}$	—	150	300	µA
VSWR	—	1.5:1	—	
Insertion Loss (RFC/RF1, RFC/RF2)	—	0.7	0.85	dB
Isolation (RFC/RF2, RFC/RF1)	18	20	—	dB
Output Power at 0.1 dB Compression	—	34	—	dBm

Electrical Characteristics at 1800 MHz measured in test circuit schematic shown in Figure 2 with board losses removed.

V_{C1} and V_{C2} Input Voltage	Min	Typ	Max	Unit
High	V_{DD}	—	V_{DD} + 0.5	Vdc
Low	V_{DD} – 10	—	V_{DD} – 5	Vdc

V_{C1}	V_{C2}	RFC – RF1	RFC – RF2
High	Low	Insertion Loss	Isolation
Low	High	Isolation	Insertion Loss

Table 1. Logic Levels

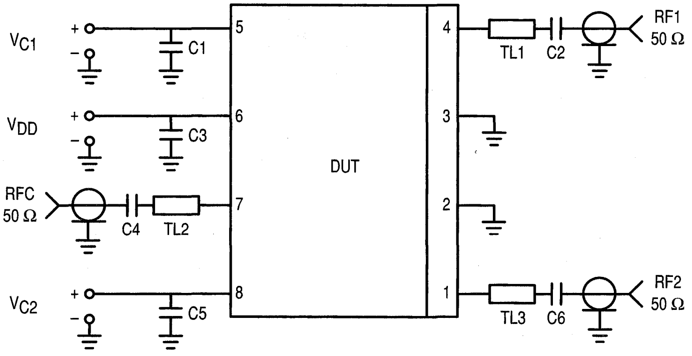


C1, C5 — 2.7 pF, Chip Capacitor
C2, C4, C6 — 100 pF, Chip Capacitor
C3 — 10 pF, Chip Capacitor

TL1, TL3 — 12 degrees of 50 Ω line at 1 GHz
TL2 — 15 degrees of 50 Ω line at 1 GHz

Note: Decoupling capacitors on pins 5, 6 and 8 must be as close as possible to the pins.

Figure 1. 300 MHz to 1600 MHz Test Circuit Configuration



C1, C5 — 1.3 pF, Chip Capacitor
C2, C3, C4, C6 — 8.2 pF, Chip Capacitor

TL1, TL3 — 12 degrees of 50 Ω line at 1 GHz
TL2 — 15 degrees of 50 Ω line at 1 GHz

Note: Decoupling capacitors on pins 5, 6 and 8 must be as close as possible to the pins.

Figure 2. 1600 MHz to 2000 MHz Test Circuit Configuration

TYPICAL CHARACTERISTICS

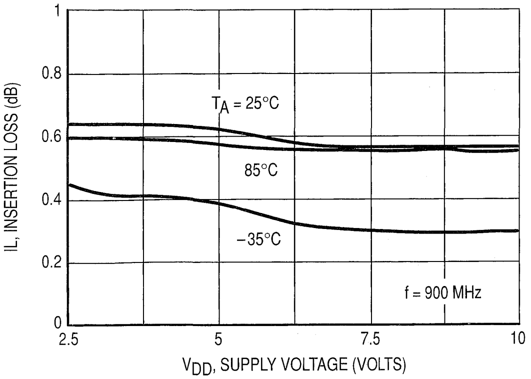


Figure 3. Insertion Loss at 0.1 dB Compression versus Supply Voltage

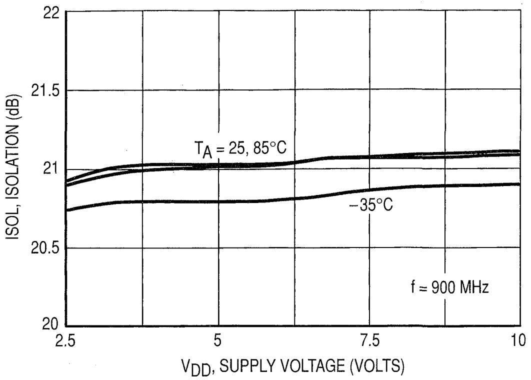


Figure 4. Isolation at 0.1 dB Compression versus Supply Voltage

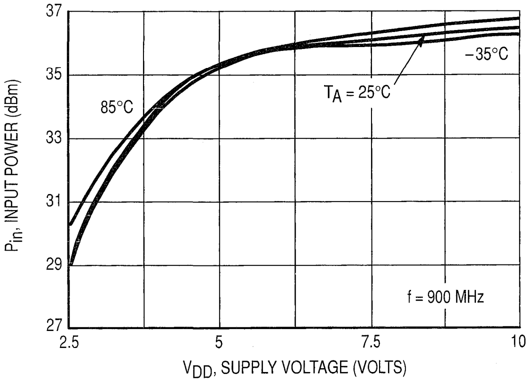


Figure 5. Input Power at 0.1 dB Compression versus Supply Voltage

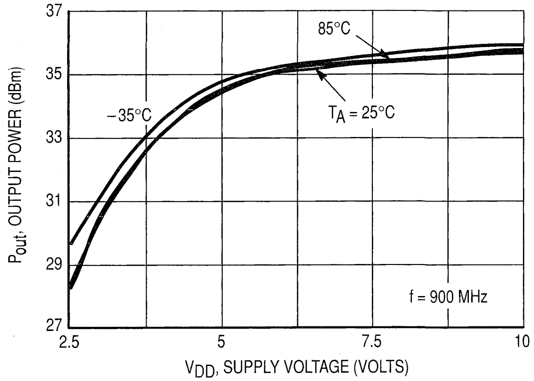


Figure 6. Output Power at 0.1 dB Compression versus Supply Voltage

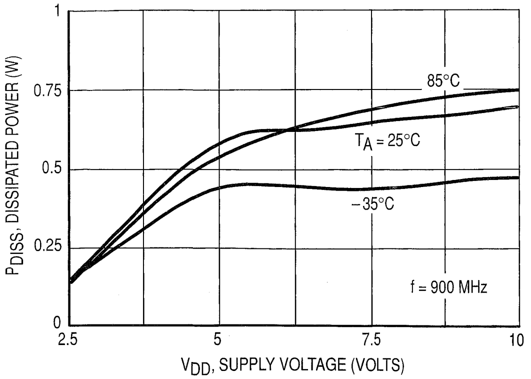


Figure 7. Dissipated Power at 0.1 dB Compression versus Supply Voltage

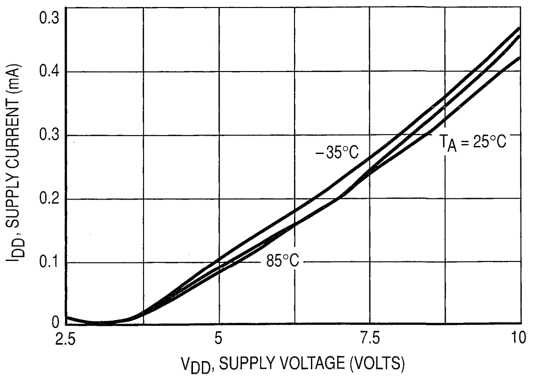


Figure 8. Supply Current at 0.1 dB Compression versus Supply Voltage

TYPICAL CHARACTERISTICS

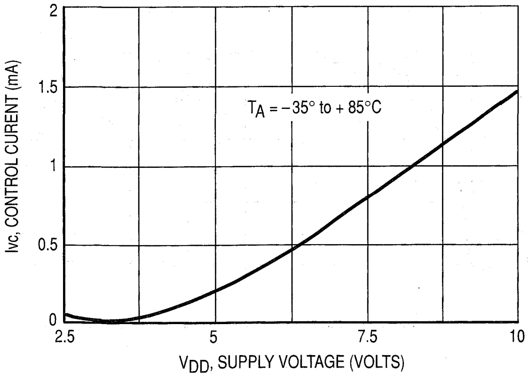


Figure 9. Control Current at Vc Pins at 0.1 dB Compression versus Supply Voltage

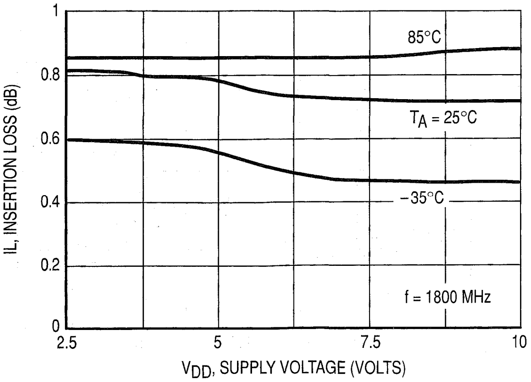


Figure 10. Insertion Loss at 0.1 dB Compression versus Supply Voltage

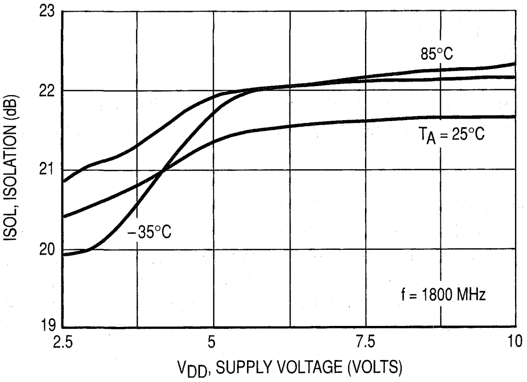


Figure 11. Isolation at 0.1 dB Compression versus Supply Voltage

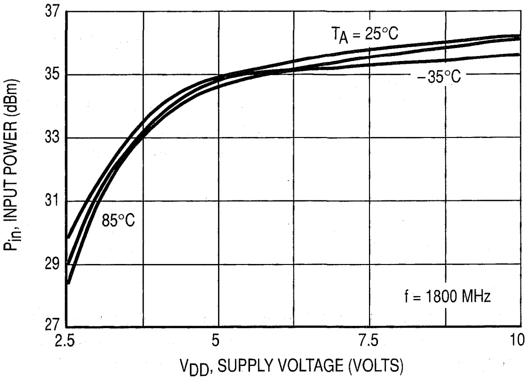


Figure 12. Input Power at 0.1 dB Compression versus Supply Voltage

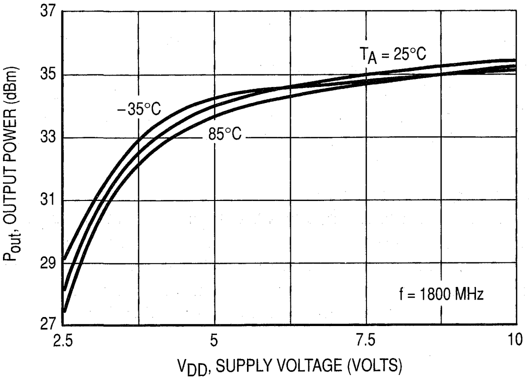


Figure 13. Output Power at 0.1 dB Compression versus Supply Voltage

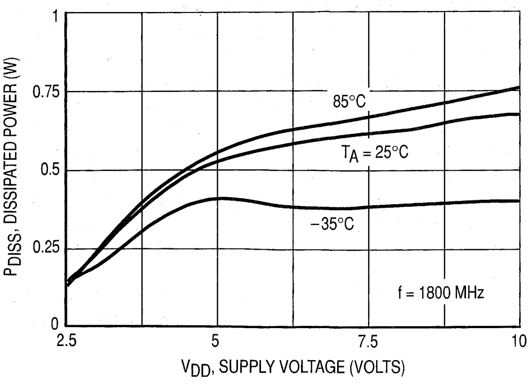


Figure 14. Dissipated Power at 0.1dB Compression versus Supply Voltage

TYPICAL CHARACTERISTICS

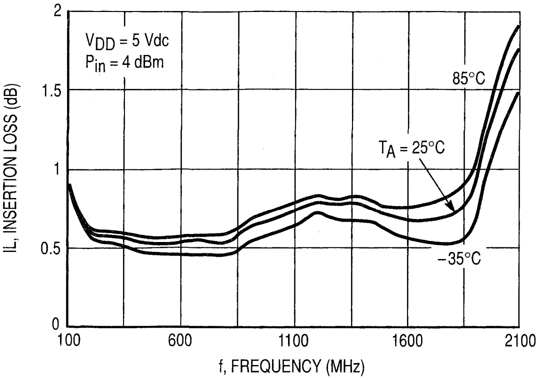


Figure 15. Insertion Loss versus Frequency

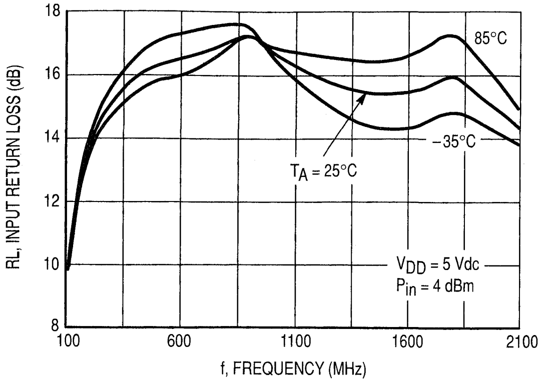


Figure 16. Input Return Loss versus Frequency

APPLICATIONS INFORMATION

DESIGN INFORMATION

The MRFIC0903 SPDT antenna switch was designed for low cost, flexibility and ease of use. This is accomplished by its internal topology that allows control of the switch through its TTL/CMOS compatible (0 to V_{DD}) control pins. Operating on a single positive supply, the switch was designed for a minimum supply voltage, minimum power consumption and low current TTL/CMOS compatible control signals.

THEORY OF OPERATION

The MRFIC0903 can be used as a transmit and receive or antenna diversity switch in the frequency range from 100 MHz to 2 GHz with incident power levels as high as 4 watts.

The frequency behavior can be optimized by resonating the DC blocking capacitor's position and value with the parasitic inductance of the package lead. Operation from 300 MHz to 1.6 GHz can be optimized with a high Q 100 pF blocking capacitor. For the higher frequency band from 1.6 GHz to 2.0 GHz, a 8.2 pF capacitor is suggested. Further improvements can be achieved by resonating the inductance of V_{DD}, V_{C1}, and V_{C2} pins with the appropriate capacitor values.

The power handling capability and linearity of the MRFIC0903 is dependent only on the supply voltage. With a 3 V supply, the device handles 1.25 W (1.6 W PEP) of incident power while maintaining good linearity and low harmonic distortion. The power transmitting capability increases to 3 W of incident power with a 5 V supply and up to 4 W with a 7.5 V supply.

Due to the device's inherently low harmonic distortion, the switch requires little harmonic filtering at its outputs. It also has a high reverse third–order intercept point for use in non–TDMA antenna diversity applications (analog cellular systems).

BIASING CONSIDERATIONS

The MRFIC0903 is based on a floating "cold FET" topology. With this topology, the differential voltage between V_{C1} and V_{C2} dictates the power handling capability. For example, the device's power handling capability is the same with the device biased with 5 V at V_{C1} and 0 V at V_{C2}, with 0 V at V_{C1} and –5 V at V_{C2}, or with 3 V at V_{C1} and –2 V at V_{C2}.

POSSIBLE APPLICATIONS

The MRFIC0903 can be used in a number of cellular and cordless phone applications. The part is applicable for analog cellular phones in systems such as AMPS, TACS, NAMPS, ETACS and NMT900; for digital cellular phones in systems such as GSM, PDC, DAMPS, DCS1800, PCS and NADC; and for cordless phones in systems such as DECT, PHS, ISM, CT1 and CT2. In general it can fit into any application where high power handling capability is required for frequencies ranging from 100 MHz to 2 GHz.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

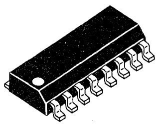
The MRFIC Line
900 MHz GaAs Two-Stage Driver Amplifier

MRFIC0904

900 MHz GaAs
TWO STAGE DRIVER AMP
INTEGRATED CIRCUIT

The MRFIC0904 is an integrated driver amplifier designed for class A/B operation in the 800 MHz to 1 GHz frequency range. The design utilizes Motorola's Advanced GaAs FET process (MAFET) to yield superior performance and efficiency in a cost effective monolithic device. Off–chip output matching provides maximum flexibility in design. Applications for the MRFIC0904 include GSM, AMPS, and ISM band transmitters.

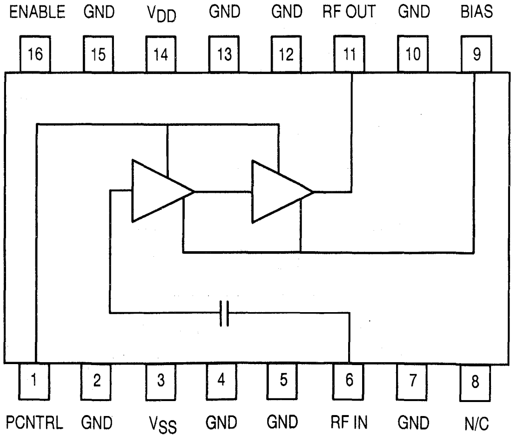
- GSM Ramping/Gain Control of 45 dB with Power Control Function (PCNTRL)
- Class 4 P_{out} (1 dB Gain Compression) = 26 dBm @ 4.8 V (Typical)
- Class 4 Supply Current (1 dB) = 120 mA @ 4.8 V (Typical)
- Class 5 P_{out} (1 dB Gain Compression) = 24 dBm 3.6 V (Typical)
- Class 5 Supply Current (1 dB) = 120 mA @ 3.6 V (Typical)
- Low Cost Surface Mount Plastic Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M0904



CASE 751B–05
(SO–16)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Limit	Unit
Supply Voltage	V_{DD} V_{SS}	6.0 –3	Vdc
Power Control Voltage	PCNTRL	V_{DD}	Vdc
Enable Voltage	ENABLE	V_{DD}	Vdc
Input Power	P_{in}	5	dBm
Operating Ambient Temperature	T_A	– 35 to +85	°C
Storage Temperature	T_{stg}	–65 to +150	°C



Pin Connections and Functional Block Diagram

REV 1

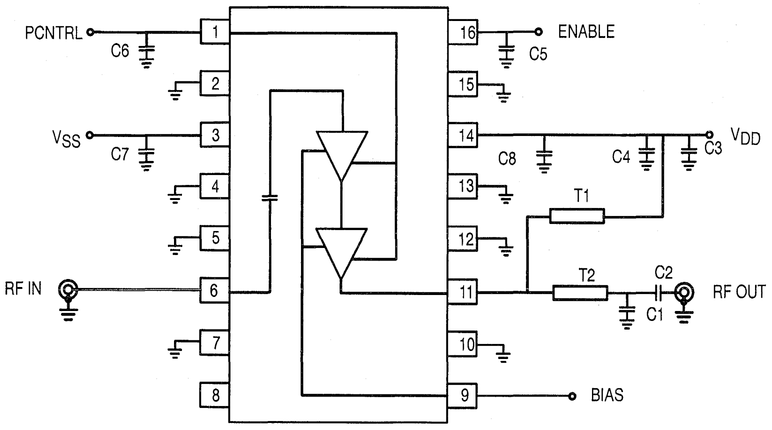
RECOMMENDED OPERATING RANGES (T_A = 25°C unless otherwise noted)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD} V_{SS}	2.7 to 5.0 –2.75 to –2.25	Vdc
Bias Voltage Range	BIAS	0 to 1.0	Vdc
Power Control Voltage Range	PCNTRL	0 to 3.0	Vdc
Enable Voltage ON State	ENABLE	2.5	Vdc
Enable Voltage OFF State	ENABLE	0.5	Vdc
RF Frequency	f	800 to 1000	MHz

ELECTRICAL CHARACTERISTICS (V_{DD} = 3.6 V, V_{SS} = –2.5 V, BIAS = 0.0 V, PCNTRL = 3.0 V, ENABLE = 3.0 V, P_{in} = –2 dBm, f = 900 MHz, Z_O = 50 Ω, T_A = 25°C unless otherwise noted)

Characteristic	Min	Typ	Max	Unit
Supply Current				mA
I_{DD}	—	120	160	
I_{SS}	—	1.0	1.75	
Standby Current: Off–mode (ENABLE = 0 V)				µA
I_{DD}	—	50	130	
I_{SS}	—	60	360	
Output Power	22.5	24	—	dBm
Output Power at 1 dB Gain Compression	—	24.5	—	dBm
Input Return Loss	—	14	—	dB
PCNTRL Current	—	200	—	µA
ENABLE Current	—	200	—	µA
Gain Control Range	—	45	—	dB
Enable/Control Input 3 dB Bandwidth	—	1	—	MHz

(1) All electrical Characteristics are measured in test circuit schematic as shown in Figure 1.



C1 – 2.7 pF
C2, C4, C8 – 100 pF
C3 – 1 µF
C5, C6 – 10 pF

C7 – 1000 pF
T1 – 90° @ 900 MHz, Z_0 = 100 Ω
T2 – 9° @ 900 MHz, Z_0 = 50 Ω
BOARD MATERIAL = FR4

Figure 1. Applications Circuit Configuration

TYPICAL CHARACTERISTICS

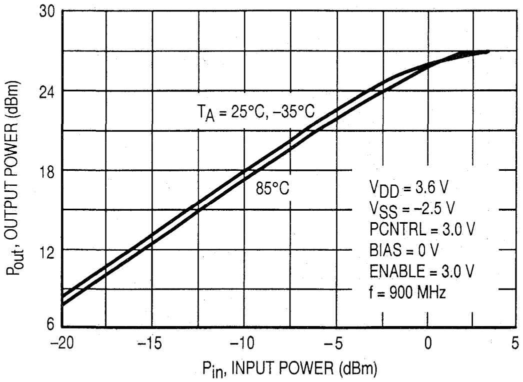


Figure 2. Output Power versus Input Power

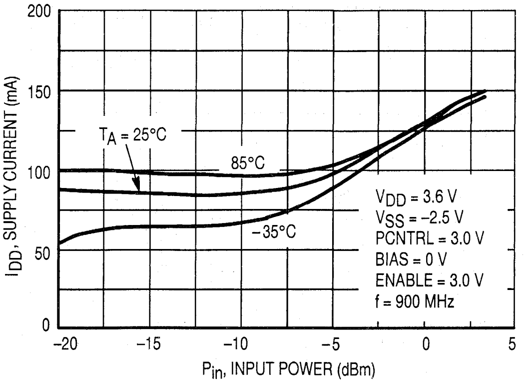


Figure 3. Supply Current versus Input Power

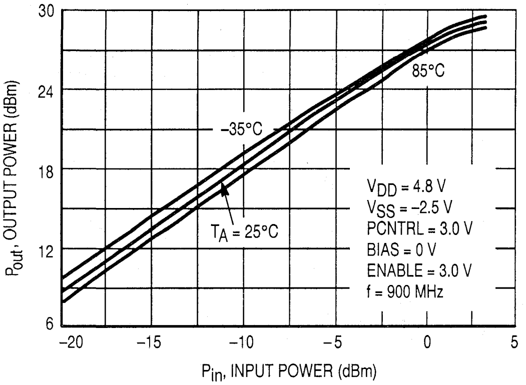


Figure 4. Output Power versus Input Power

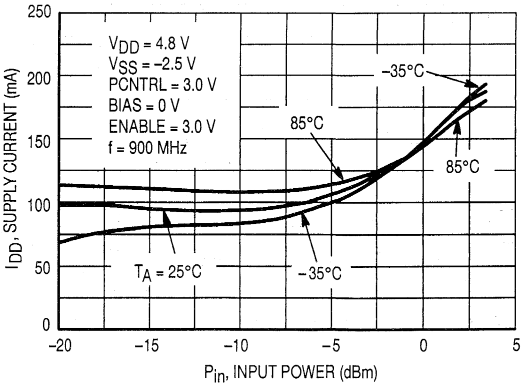


Figure 5. Supply Current versus Input Power

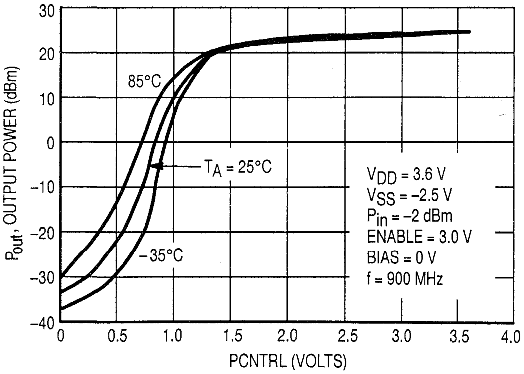


Figure 6. Output Power versus PCNTRL

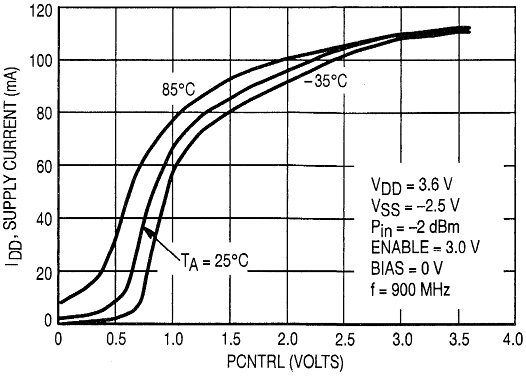


Figure 7. Supply Current versus PCNTRL

TYPICAL CHARACTERISTICS

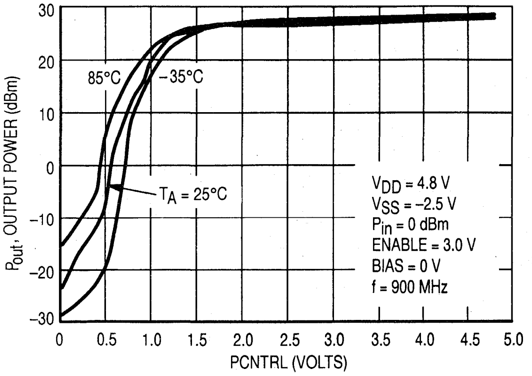


Figure 8. Output Power versus PCNTRL

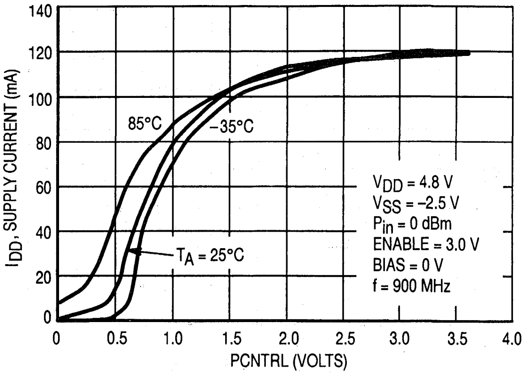


Figure 9. Supply Current versus PCNTRL

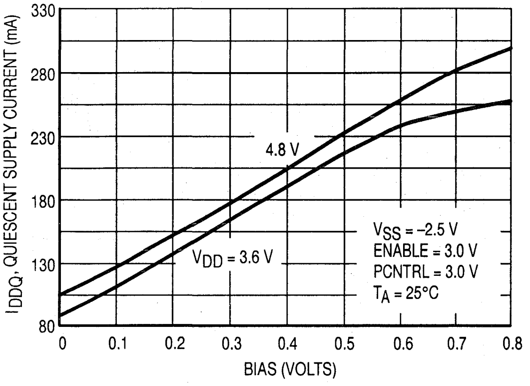


Figure 10. Quiescent Supply Current versus BIAS

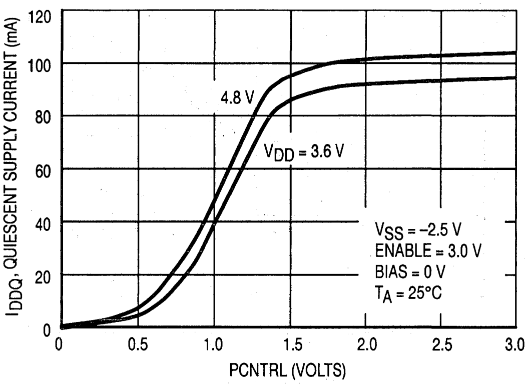


Figure 11. Quiescent Supply Current versus PCNTRL

Table 1. Scattering Parameters

(V_{DD} = 3.6 V, V_{SS} = –2.5 V, BIAS = 0.0 V, PCNTRL, ENABLE = 3 V, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
500	0.922	–40.93	12.201	–76.39	0.002	72.64	0.276	166.48
550	0.887	–52.05	16.242	–98.58	0.002	62.03	0.276	169.80
600	0.826	–65.21	21.133	–116.66	0.003	44.52	0.297	175.47
650	0.698	–81.22	28.039	–140.66	0.004	26.65	0.342	173.06
700	0.419	–99.95	33.973	174.46	0.004	6.35	0.360	169.94
750	0.206	–106.43	32.195	145.72	0.006	–9.10	0.393	163.65
800	0.073	–56.19	31.685	121.12	0.006	–31.13	0.392	154.83
850	0.146	–4.45	29.419	85.45	0.006	–47.59	0.351	146.93
900	0.170	–1.59	25.996	64.50	0.006	–61.44	0.305	145.90
950	0.183	10.82	24.115	45.18	0.007	–80.54	0.276	152.91
1000	0.232	27.47	22.091	16.72	0.007	–107.22	0.287	162.87
1050	0.302	34.19	19.995	–5.08	0.007	–116.06	0.310	167.00
1100	0.395	34.85	17.411	–26.64	0.006	–125.77	0.337	170.51
1150	0.522	29.21	14.15	–52.28	0.006	–146.60	0.380	169.57
1200	0.607	23.25	11.961	–71.38	0.005	–154.46	0.403	167.34
1250	0.675	17.30	9.76	–88.04	0.005	–177.16	0.419	163.73
1300	0.743	9.17	7.951	–108.01	0.004	160.61	0.436	159.33

Table 2. Scattering Parameters

(V_{DD} = 4.8 V, V_{SS} = –2.5 V, BIAS = 0.0 V, PCNTRL, ENABLE = 3 V, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
500	0.910	–41.17	12.58	–78.69	0.0012	65.66	0.228	168.72
550	0.873	–51.75	17.09	–99.91	0.0024	43.49	0.232	172.87
600	0.807	–64.98	22.33	–118.28	0.0032	48.13	0.252	177.75
650	0.671	–81.03	29.24	–142.97	0.0041	17.29	0.293	174.31
700	0.409	–100.12	35.95	172.30	0.0040	–10.22	0.326	172.83
750	0.200	–104.83	34.04	143.18	0.0055	–14.65	0.349	164.57
800	0.080	–53.72	33.08	118.78	0.0056	–28.05	0.345	156.12
850	0.142	–6.52	30.64	83.58	0.0057	–45.38	0.307	147.87
900	0.165	0.32	27.22	62.36	0.0065	–62.81	0.248	146.40
850	0.187	14.68	24.95	41.95	0.0066	–86.95	0.226	146.72
1000	0.252	28.28	22.30	14.13	0.0062	–100.71	0.257	167.95
1050	0.323	32.92	20.06	–7.52	0.0057	–113.16	0.279	172.05
1100	0.409	32.35	17.37	–28.14	0.0049	–121.71	0.310	173.62
1150	0.527	26.77	14.03	–53.24	0.0051	–152.49	0.349	171.86
1200	0.606	21.18	11.89	–71.66	0.0051	–159.64	0.365	169.36
1250	0.669	15.59	9.74	–87.41	0.0043	–155.55	0.381	163.46
1300	0.735	8.10	7.96	–107.51	0.0039	171.99	0.397	161.81

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC0904 is a versatile driver amplifier designed to operate in the 800 MHz to 1 GHz frequency range for cellular phone and Industrial, Scientific, and Medical (ISM) applications. The amplifier is designed using depletion mode GaAs MESFETs to perform at high efficiency at battery voltages of 3.6 and 4.8 Volts. While designed as a driver amplifier for a discrete transistor final stage, the device can act as a power amplifier for lower power systems such as ISM applications in telemetry and cordless telephones.

THEORY OF OPERATION

The MRFIC0904 has various control features making it versatile and applicable to both linear and saturated applications. The BIAS pin allows the setting of drain quiescent current. For non–linear applications such as GSM cellular, the pin can be grounded. For better gain and linearity, a positive voltage up to about 0.6 Volts can be applied. The PCNTRL pin allows the control of the output power over a wide dynamic range with low AM to AM distortion such as is required in GSM and other cellular systems. As shown in Figures 6 through 9, PCNTRL affects both the output power and the drain current thus maintaining good efficiency over a range of output power. The ENABLE pin is used to control the on–off state of the device and is useful as a reduced current standby control. A logic high signal of more than 2.5 Volts turns the device on. A logic low signal of less than 0.5 Volts reduces total supply current to typically less than 200 μA.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

The MRFIC Line

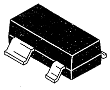
General Purpose RF Cascode Amplifier

MRFIC0916

The MRFIC0916 is a cost–effective, high isolation cascode silicon monolithic amplifier in the industry standard SOT–143 surface mount package designed for general purpose RF applications. On chip bias circuitry sets the bias point while matching is accomplished off chip affording the maximum in application flexibility.

- Usable Frequency Range = 100 to 2500 MHz
- 18.5 dB typical gain at 850 MHz, V_{CC} = 2.7 Volts
- 2.3 dBm typical Output Power at 1 dB Gain Compression at 850 MHz, V_{CC} = 2.7 Volts
- 44 dB Typical Reverse Isolation at 850 MHz
- 5.6 mA Max Bias Current at V_{CC} = 2.7 Volts
- 2.7 to 5 Volt Supply
- Available in Tape and Reel by Adding T1 Suffix to Part Number. T1 Suffix = 3,000 Units per 8 mm, 7 inch Reel.
- Device Marking = 16

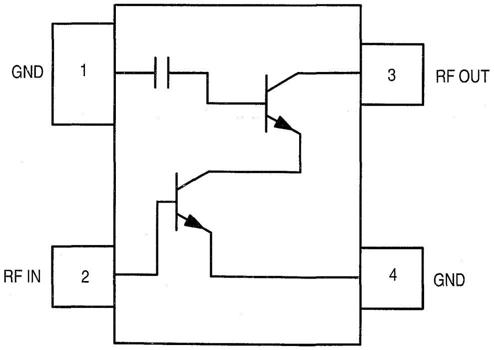
**900 MHz
SILICON GENERAL PURPOSE
RF CASCODE AMPLIFIER**



**CASE 318A–05
(SOT–143)**

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Limit	Unit
Supply Voltage	V_{CC}	6	Vdc
RF Input Power	P_{RF}	10	dBm
Power Dissipation	P_{DIS}	100	mW
Supply Current	I_{CC}	20	mA
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	°C/W
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Case Temperature	T_C	– 35 to +100	°C



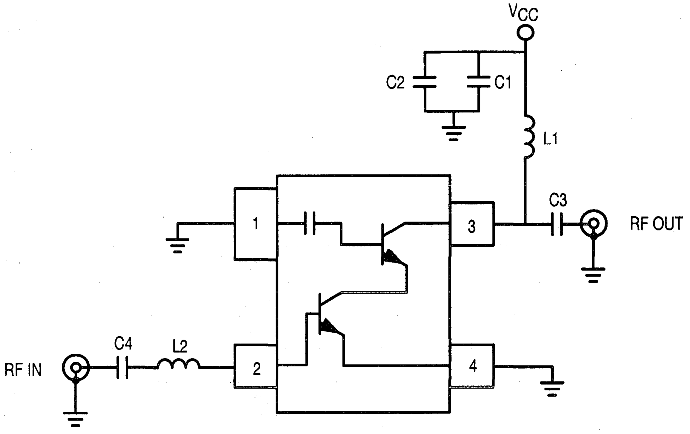
Pin Connections and Functional Block Diagram

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
RF Frequency	f_{RF}	100 to 2500	MHz
Supply Voltage	V_{CC}	2.7 to 5	Vdc

ELECTRICAL CHARACTERISTICS (V_{CC} = 2.7 V, T_A = 25°C, f_{RF} = 850 MHz, Tested in Circuit Shown in Figure 1)

Characteristic	Min	Typ	Max	Unit
Small Signal Gain	16.5	18.5	20.5	dB
Noise Figure	—	1.9	—	dB
Power Output at 1dB Gain Compression	0	2.3	—	dBm
Output 3rd Order Intercept Point	—	11	—	dBm
Reverse Isolation	—	44	—	dB
Supply Current	3.8	4.7	5.6	mA



C1 – 100 pF
C2 – 0.01 µF
C3 – 1.4 pF
C4 – 100 pF
L1 – 8.2 nH
L2 – 6.8 nH

Figure 1. 850 MHz Applications Circuit Configuration

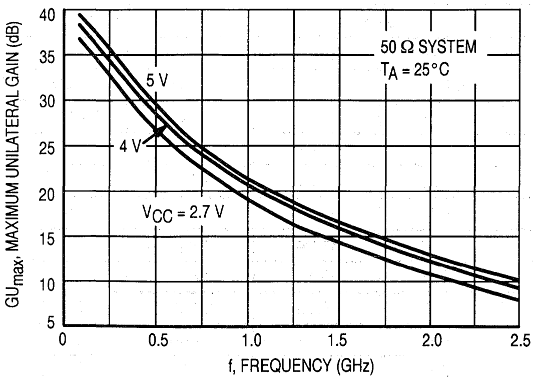


Figure 2. GU_{max} versus Frequency

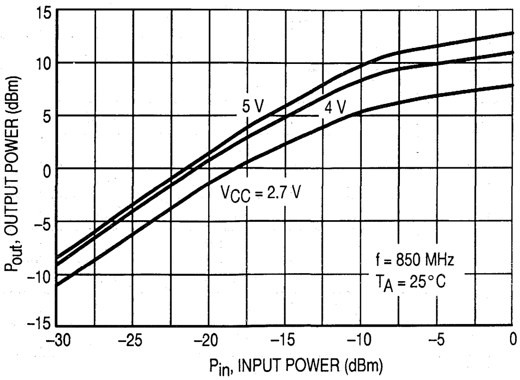


Figure 3. Output Power versus Input Power

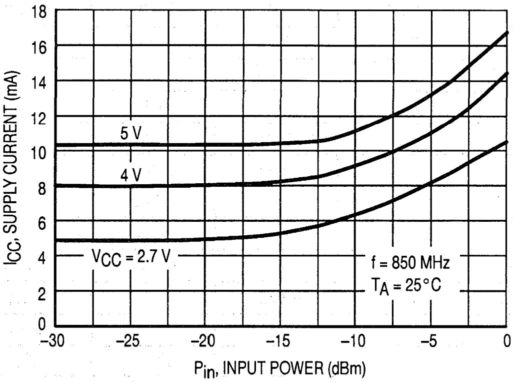


Figure 4. Supply Current versus Input Power

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	$\angle \phi$	$\lvert S_{21}\rvert$	$\angle \phi$	$\lvert S_{12}\rvert$	$\angle \phi$	$\lvert S_{22}\rvert$	$\angle \phi$
100	0.806	–17.01	12.03	162.32	0.001	–0.14	0.956	–4.69
200	0.765	–33.28	11.18	145.74	0.001	71.58	0.948	–8.69
300	0.713	–47.99	10.18	130.99	0.002	69.67	0.945	–13.23
400	0.652	–61.35	9.06	118.01	0.003	64.61	0.930	–17.35
500	0.574	–70.94	8.06	106.50	0.003	62.93	0.904	–20.85
600	0.533	–81.00	7.09	96.50	0.003	61.94	0.891	–24.71
700	0.493	–89.33	6.36	87.60	0.003	63.16	0.875	–28.18
800	0.469	–97.65	5.62	79.57	0.003	66.33	0.857	–31.89
900	0.432	–103.64	5.16	72.38	0.002	80.79	0.845	–35.21
1000	0.409	–110.68	4.70	65.39	0.002	100.33	0.831	–38.86
1100	0.396	–116.17	4.29	58.75	0.002	127.72	0.815	–42.52
1200	0.383	–122.20	3.91	52.55	0.003	152.57	0.799	–45.77
1300	0.373	–126.00	3.66	46.34	0.004	164.39	0.789	–49.49
1400	0.369	–131.29	3.38	40.61	0.006	169.63	0.776	–53.23
1500	0.366	–134.46	3.14	35.29	0.008	172.81	0.762	–56.86
1600	0.366	–140.07	2.93	29.63	0.011	172.47	0.751	–60.74
1700	0.364	–143.07	2.75	23.86	0.013	172.79	0.738	–64.66
1800	0.368	–147.48	2.58	18.42	0.016	171.54	0.727	–68.29
1900	0.377	–148.91	2.42	13.15	0.020	170.15	0.719	–72.29
2000	0.381	–153.42	2.27	7.58	0.023	167.89	0.707	–76.58
2100	0.394	–155.23	2.15	2.46	0.027	165.86	0.695	–80.50
2200	0.396	–158.91	2.03	–3.00	0.032	163.46	0.685	–84.85
2300	0.416	–160.43	1.90	–8.32	0.037	161.00	0.672	–88.93
2400	0.424	–162.98	1.81	–13.30	0.042	158.00	0.662	–93.38
2500	0.434	–166.35	1.68	–18.45	0.047	155.58	0.654	–97.89

Table 1. Scattering Parameters (V_{CC} = 2.7 V, 50 Ω System)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
100	0.744	–17.43	16.979	160.38	0.001	–2.89	0.955	–4.40
200	0.691	–33.58	15.442	142.46	0.001	83.36	0.950	–8.33
300	0.627	–47.53	13.633	127.28	0.002	76.39	0.946	–12.79
400	0.558	–59.50	11.851	114.52	0.002	70.12	0.931	–16.75
500	0.482	–67.02	10.284	103.51	0.002	67.02	0.907	–20.11
600	0.440	–75.50	8.957	94.12	0.002	66.00	0.895	–23.85
700	0.401	–81.87	7.930	85.95	0.002	68.71	0.880	–27.22
800	0.377	–88.89	7.003	78.57	0.002	73.50	0.863	–30.83
900	0.348	–93.11	6.348	71.96	0.002	90.55	0.852	–34.06
1000	0.328	–98.88	5.747	65.59	0.002	113.74	0.838	–37.62
1100	0.317	–103.27	5.223	59.57	0.002	146.45	0.822	–41.18
1200	0.306	–108.54	4.765	53.98	0.003	165.49	0.808	–44.34
1300	0.301	–111.30	4.425	48.39	0.004	175.51	0.798	–47.95
1400	0.297	–116.30	4.082	43.18	0.006	177.46	0.785	–51.59
1500	0.298	–118.89	3.790	38.32	0.008	179.45	0.771	–55.11
1600	0.298	–124.58	3.531	33.13	0.011	178.69	0.760	–58.88
1700	0.301	–127.19	3.300	28.02	0.014	178.02	0.748	–62.66
1800	0.305	–131.73	3.093	23.10	0.016	176.25	0.737	–66.16
1900	0.319	–133.16	2.901	18.34	0.020	174.44	0.729	–70.03
2000	0.324	–137.94	2.724	13.33	0.023	172.03	0.717	–74.16
2100	0.339	–140.09	2.575	8.67	0.027	169.82	0.706	–77.92
2200	0.342	–143.98	2.434	3.79	0.032	166.99	0.696	–82.07
2300	0.367	–146.00	2.278	–0.98	0.036	164.37	0.684	–86.04
2400	0.375	–148.75	2.166	–5.56	0.042	161.35	0.674	–90.25
2500	0.387	–152.75	2.020	–10.12	0.046	158.69	0.666	–94.64

Table 2. Scattering Parameters (V_{CC} = 4 V, 50 Ω System)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
100	0.707	–17.56	20.04	159.03	0.001	–7.95	0.954	–4.25
200	0.648	–33.40	17.93	140.29	0.001	86.24	0.950	–8.15
300	0.579	–46.60	15.53	124.94	0.002	78.79	0.946	–12.54
400	0.509	–57.44	13.31	112.38	0.002	72.27	0.931	–16.42
500	0.438	–63.51	11.40	101.70	0.002	69.34	0.908	–19.68
600	0.397	–70.90	9.87	92.70	0.002	69.55	0.896	–23.35
700	0.363	–76.05	8.69	84.92	0.002	71.59	0.882	–26.64
800	0.340	–82.18	7.67	77.89	0.002	79.44	0.865	–30.20
900	0.316	–85.44	6.91	71.60	0.002	95.59	0.855	–33.36
1000	0.298	–90.52	6.24	65.56	0.001	121.55	0.841	–36.86
1100	0.290	–94.44	5.67	59.82	0.002	152.13	0.826	–40.37
1200	0.280	–99.17	5.17	54.53	0.003	169.84	0.811	–43.48
1300	0.277	–101.65	4.79	49.25	0.005	177.80	0.802	–47.02
1400	0.274	–106.49	4.42	44.27	0.006	–179.84	0.790	–50.59
1500	0.278	–109.07	4.10	39.65	0.008	–179.19	0.776	–54.04
1600	0.276	–114.88	3.82	34.68	0.011	–179.68	0.765	–57.73
1700	0.281	–117.46	3.56	29.88	0.013	179.47	0.753	–61.43
1800	0.285	–122.11	3.34	25.21	0.016	177.73	0.742	–64.85
1900	0.300	–123.94	3.14	20.70	0.019	175.80	0.734	–68.66
2000	0.305	–128.93	2.95	15.91	0.023	173.47	0.723	–72.71
2100	0.322	–131.48	2.78	11.50	0.027	171.04	0.712	–76.37
2200	0.324	–135.50	2.63	6.84	0.031	168.25	0.703	–80.42
2300	0.351	–138.04	2.47	2.33	0.036	165.47	0.691	–84.31
2400	0.358	–140.88	2.34	–2.05	0.041	162.71	0.681	–88.42
2500	0.371	–145.28	2.19	–6.40	0.046	160.19	0.674	–92.74

Table 3. Scattering Parameters (V_{CC} = 5 V, 50 Ω System)

The MRFIC Line
1.8 GHz Antenna Switch

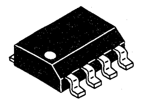
MRFIC1801

1.8 GHz
TRANSMIT/RECEIVE
ANTENNA SWITCH
GaAs MONOLITHIC
INTEGRATED CIRCUIT

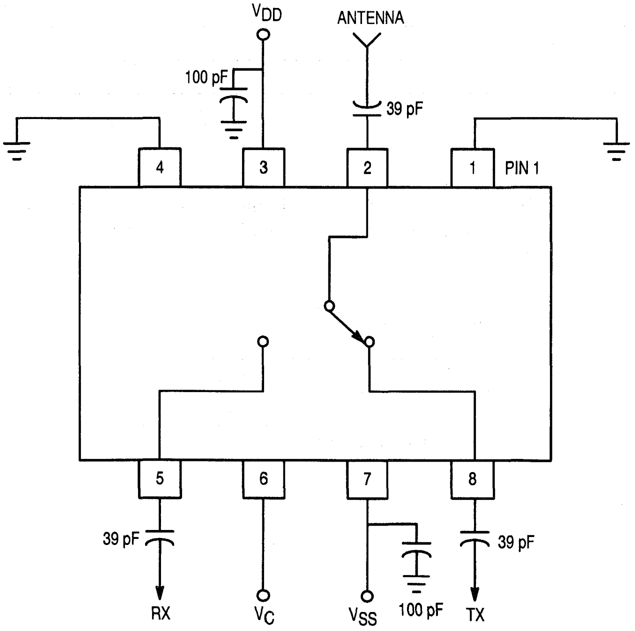
Designed primarily for use in DECT, Japan Personal Handy System (PHS), other wireless Personal Communication Systems (PCS) applications, and 2.4 GHz ISM band applications. The MRFIC1801 is a single pole, double throw reflective antenna switch featuring low insertion loss and high power handling capability in a low-cost SOIC-8 package. The integrated circuit requires no off-chip matching and provides for easy control circuit interface. The high power handling capability allows application in higher power wireless systems than traditional GaAs antenna switches.

Together with the rest of the MRFIC180X series, this GaAs IC family offers the complete transmit and receive functions, less LO and filters, needed for a typical 1.8 GHz cordless telephone.

- Usable Frequency Range 1.5 to 2.5 GHz
- High 1.0 dB Compression Point = 29 dBm (Typ)
- Low Transmit Insertion Loss = 0.75 dB (Typ)
- High Transmit to Receive Isolation = 22 dB (Typ)
- Single Control Pin for Easy Switching Signal Interface
- Low Current Drain = 300 µA (Typ) in TX, 45 µA (Typ) in RX
- Low Cost Surface Mount Plastic Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 12 mm, 13 inch Reel.
- Device Marking = M1801



CASE 751–05
(SO-8)



Functional Block Diagram and Pin Assignment

REV 1

MAXIMUM RATINGS (T_A= 25°C unless otherwise noted)

Ratings	Symbol	Value	Unit
Supply Voltage	V_{DD}	10	Vdc
Supply Voltage Difference	$V_{DD} - V_{SS}$	8	Vdc
RF Input Power	P_{in}	33	dBm
Switch Control Voltage	V_C	V_{DD} +1, V_{SS} −1	Vdc
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Ambient Temperature	T_A	– 30 to + 85	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	2.7 to 5.5	Vdc
Supply Voltage Difference	$V_{DD} - V_{SS}$	5.5	Vdc
Switch Control Voltage	V_C	V_{DD} to V_{SS}	Vdc
Operating Frequency	f	1.5 to 2.5	GHz

ELECTRICAL CHARACTERISTICS (V_{DD}= 3 V, V_{SS} = – 2.5 V, T_A = 25°C, f = 1.9 GHz)

Characteristic	Min	Typ	Max	Unit
Antenna to Receive Insertion Loss (RX Mode, P_{IN} = 0 dBm)	—	0.8	1	dB
Transmit to Antenna Insertion Loss (TX Mode, P_{IN} = +27 dBm)	—	0.6	1	dB
Transmit to Receive Isolation in TX Mode (P_{IN} = +27 dBm)	—	22	—	dB
Antenna to Transmit Isolation in RX Mode (P_{IN} = 0 dBm)	—	18	—	dB
Input Return Loss, all ports	—	15	—	dB
Transmit to Antenna Input 1.0 dB Compression	—	29	—	dBm
Leakage Current (RX Mode)	—	45	—	µA
Total Supply Current (TX Mode)	—	300	—	µA

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

Mode	V_C
RX	V_{SS}
TX	V_{DD}

Table 1. Logic Table

TYPICAL CHARACTERISTICS
(V_{DD} = 3 V; V_{SS} = – 2.5 V)

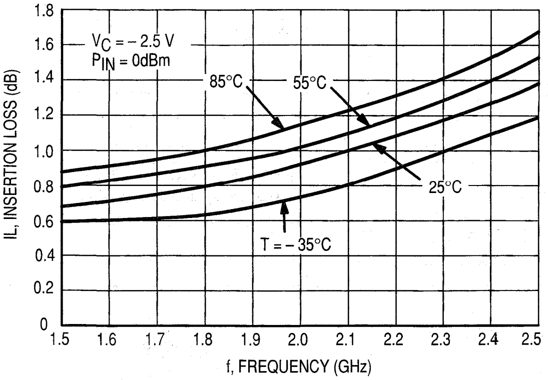


Figure 1. Antenna to Receive Insertion Loss

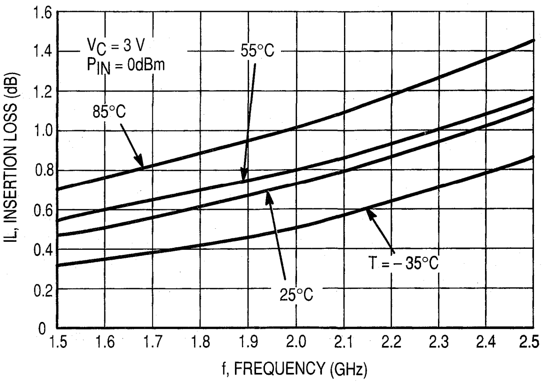


Figure 2. Transmit to Antenna Insertion Loss (Small Signal)

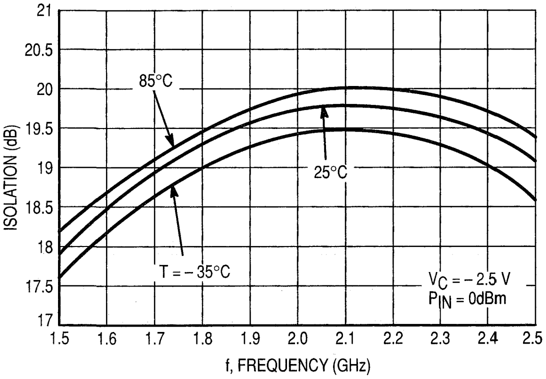


Figure 3. Antenna to Transmit Isolation in RX Mode

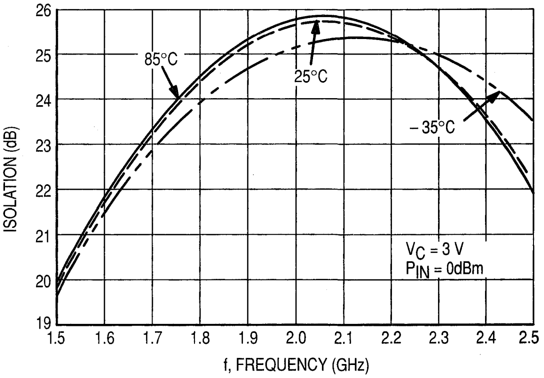


Figure 4. Transmit to Receive Isolation in TX Mode

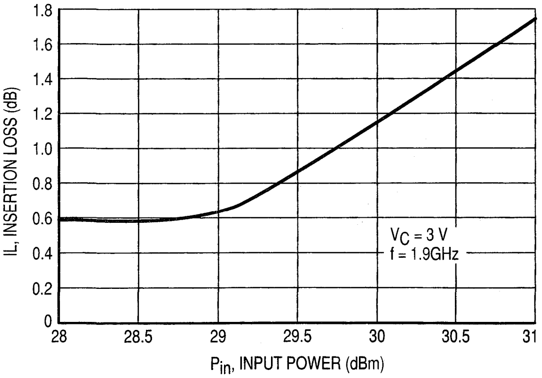


Figure 5. Antenna Switch Insertion Loss versus Input Power (Large Signal)

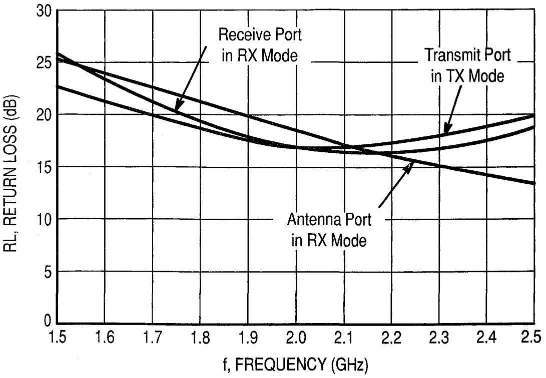


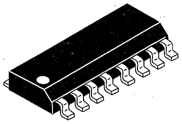
Figure 6. Return Loss

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The MRFIC Line
1.8 GHz Upconverter

MRFIC1803

1.8 GHz UPMIXER,
EXCITER AND LO AMP
GaAs MONOLITHIC
INTEGRATED CIRCUIT



CASE 751B-05
(SO–16)

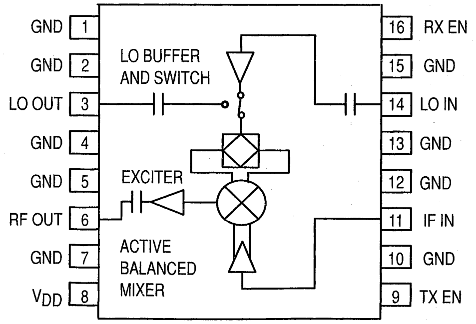
Designed primarily for use in DECT, Japan's Personal Handy System (PHS), and other wireless Personal Communication Systems (PCS) applications at 1.8 GHz, but also applicable to Industrial, Scientific and Medical (ISM) applications at 2.5 GHz. The MRFIC1803 is a complete active upmixer, exciter amplifier, and LO buffer amplifier in a low-cost SOIC-16 package. The low power consumption design includes a single balanced active mixer, CMOS compatible receive and transmit enable inputs, a buffer/exciter amplifier, and a buffered LO output capable of driving the MRFIC1804 downconverter. IF, LO and RF ports are matched to 50 Ω and no off-chip baluns are required. With both TX and RX enable pins low, the device is in standby mode and draws less than 0.3 mA.

Together with the rest of the MRFIC180X series, this GaAs IC family offers the complete transmit and receive functions, less LO and filters, needed for a typical 1.8 GHz cordless telephone.

- 10 dB IF to RF Conversion Gain
- Usable Frequency Range = 1.7 to 2.5 GHz
- Low Power Consumption = 80 mW (Typ)
- Single Bias Supply = 2.7 to 3.3 V
- No External Baluns Required
- IF, LO and RF Ports Matched to 50 Ω
- Low LO Power Requirement = –10 dBm (Typ)
- Low Cost Surface Mount Plastic Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M1803

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Ratings	Symbol	Value	Unit
Supply Voltage	V_{DD}	5	Vdc
IF Input Power	P_{IF}	3	dBm
LO Input Power	P_{LO}	3	dBm
Transmit and Receive Enable Voltage	TX EN, RX EN	5	Vdc
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Ambient Temperature	T_A	– 30 to + 85	°C



Pin Connections and Functional Block Diagram

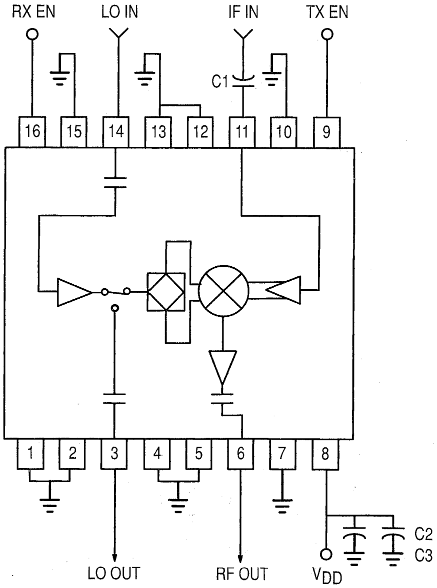
REV 2

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
LO Input Frequency	f_{LO}	1.5 to 2.2	GHz
LO Input Power	P_{LO}	–10	dBm
IF Input Frequency	f_{IF}	70 to 325	MHz
RF Output Frequency	f_{RF}	1.7 to 2.5	GHz
Transmit and Receive Enable Voltage	TX EN, RX EN	2.7 to 3.3	Vdc
Supply Voltage	V_{DD}	2.7 to 3.3	Vdc

ELECTRICAL CHARACTERISTICS (V_{DD} = 3 V, T_A = 25°C, LO = 1790 MHz @ –10 dBm, IF = 110 MHz @ –15 dBm, TX EN = 3.0 V, RX EN = 0 V, unless otherwise noted)

Characteristic	Min	Typ	Max	Unit
IF to RF Conversion Gain	8	10	—	dB
RF Output 1 dB Compression	—	– 2	—	dBm
RF Output 3rd Order Intercept	—	9	—	dBm
LO Feed Through to RF Port	—	–19	—	dBm
Auxiliary LO Output Power (TX EN = 0 V, RX EN = 3 Vdc)	—	– 4	—	dBm
Supply Current, TX Mode	—	28	50	mA
Supply Current, RX Mode (TX EN = 0 V, RX EN = 3 Vdc)	—	3	—	mA
Standby Mode Current (TX EN = 0 V, RX EN = 0 Vdc)	—	0.1	0.3	mA



C1 470 pF
C2 100 pF
C3 0.1 µF (optional)

Figure 1. Applications Circuit Configuration

Typical Characteristics

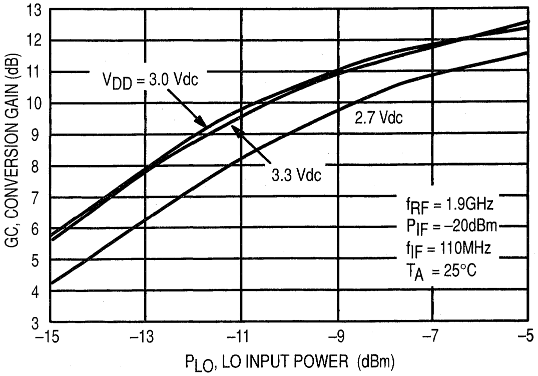


Figure 2. Conversion Gain versus LO Power

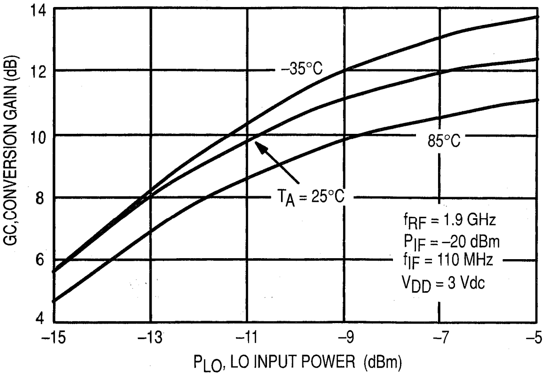


Figure 3. Conversion Gain versus LO Power

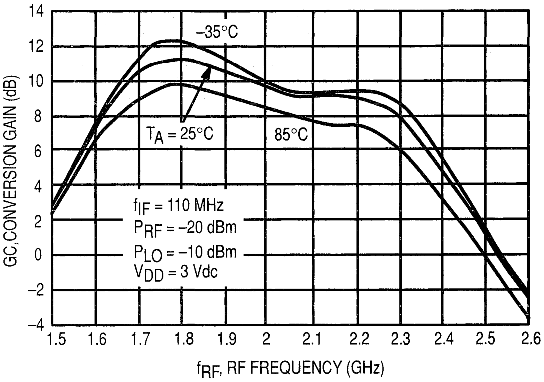


Figure 4. Conversion Gain versus RF Frequency

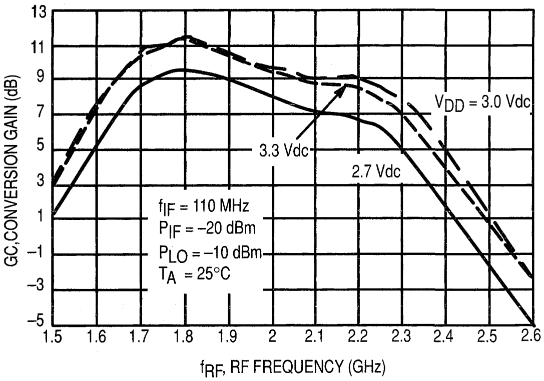


Figure 5. Conversion Gain versus RF Frequency

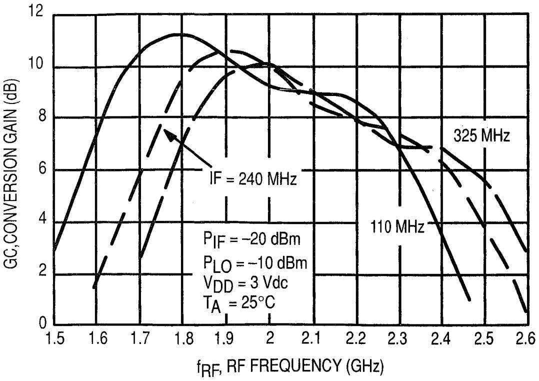


Figure 6. Conversion Gain versus RF Frequency

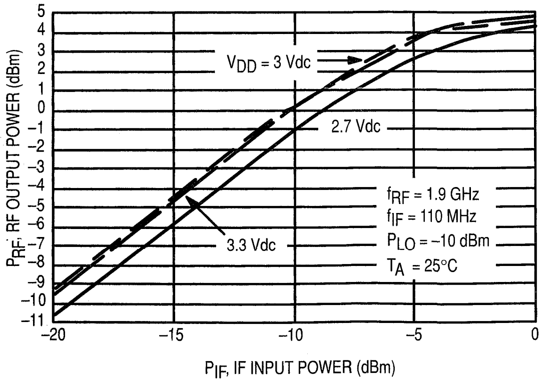


Figure 7. RF Output Power versus IF Input Power

Typical Characteristics

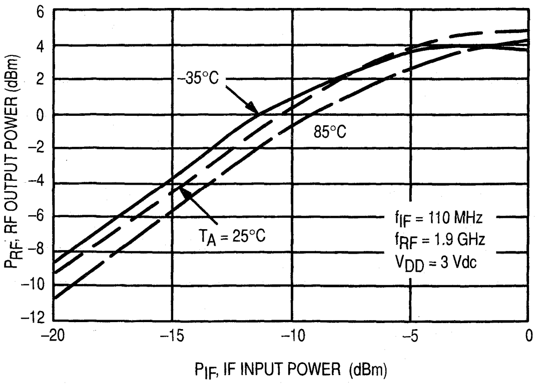


Figure 8. RF Output Power versus IF Input Power

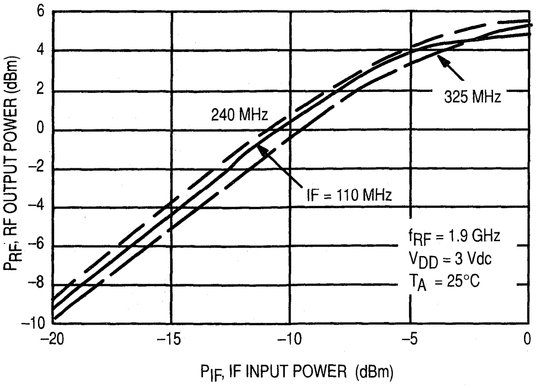


Figure 9. RF Output Pwer versus IF Input Power

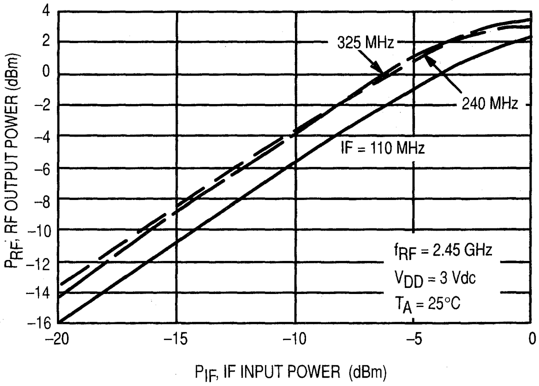


Figure 10. RF Output Power versus IF Input Power at 2.45GHz

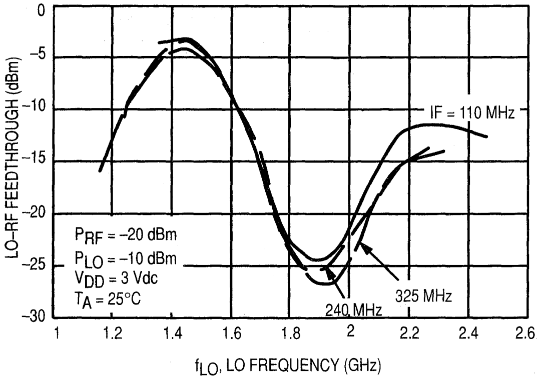


Figure 11. LO to RF Feedthrough versus LO Frequency

Frequency (MHz)	RF Output	LO Input	LO Output
1500	22.07 –j11.36	41.98 +j22.31	20.09 +j31.15
1550	21.74 –j4.69	50.60 +j9.80	26.39 +j40.79
1600	22.28 +j2.16	41.93 –j0.07	37.63 +j52.47
1650	24.01 +j8.25	32.74 +j3.32	56.16 +j63.47
1700	26.64 +J14.13	28.78 +j11.39	87.97 +j67.31
1750	30.83 +j20.11	28.98 +j21.04	131.33 +j40.34
1800	36.39 +j25.30	32.13 +j30.26	137.85 –j16.48
1850	43.92 +j29.26	37.68 +j40.38	103.88 –j50.81
1900	54.37 +j30.98	48.31 +j54.15	69.58 –j53.97
1950	65.34 +j28.57	68.80 +j70.87	50.13 –j46.24
2000	75.30 +j21.12	118.18 +j86.46	38.97 –j36.86
2050	81.19 +j8.43	220.83 +j17.19	32.08 –j27.58
2100	80.22 –j4.24	148.91 –j120.77	28.43 –j19.86
2150	74.20 –j14.00	58.50 –j105.11	26.56 –j12.82
2200	65.50 –j19.72	27.23 –j71.51	26.03 –j5.89
2250	57.40 –j21.38	17.22 –j50.26	26.73 –j0.03
2300	50.59 –j20.61	13.00 –j35.19	28.46 +j5.10
2350	44.53 –j18.16	10.95 –j22.96	30.88 +j9.86
2400	40.24 –j14.78	10.23 –j13.58	33.75 +j13.92
2450	37.73 –j10.54	10.20 –j5.32	37.50 +j17.32
2500	36.38 –j6.72	10.62 +j2.90	42.00 +j20.34

Table 1. Selected Device Impedances

DESIGN AND APPLICATIONS INFORMATION

The MRFIC1803 combines a single–balanced FET mixer with an LO pre–amp and an exciter amplifier to form a self–contained upconverter. The device is usable from RF frequencies of 1.7 to 2.5 GHz and at IF frequencies of 70 to 325 MHz. The design is optimized for low side injection in hetrodyne transmitter applications. In the upconversion process, modulation is imparted to an IF carrier which is converted to the RF transmit frequency by a mixer. By DC coupling the IF input, the device can be used for simple on–off keying (OOK) or bi–phase shift keying (BPSK) applications with no IF.

The MRFIC1803 design minimizes the need for off–chip components. An active balun is employed at the IF input and provides an excellent broadband 50Ω match over the full range of IF frequencies. The LO quadrature divider is passive and internal to the device. The LO buffer amplifier is equipped with a diversity switch which switches the amplified LO signal to the LO output pin during RECEIVE mode. The –5 dBm LO output is the appropriate level to drive the MRFIC1804 for 1.8 GHz applications or the MRFIC2401 for 2.4 GHz applications.

As shown in Figure 1, the device is easy to use with minimal off–chip components. More or less bypassing of the control and supply lines may be required depending on board layout and shielding. Careful layout of the RF frequency portions of the board is critical to successful implementation. Controlled impedance lines must be used and any off–chip components must be mounted as close to the IC as possible. The applications circuit was used to gather the information displayed in the typical characteristics curves. Since the MRFIC1803 design was optimized for the 1.7 to 1.9 GHz frequency range, improved performance can be had with some off–chip matching at frequencies outside this range. In particular, matching of the LO port will supply higher LO drive and improve conversion gain. At the RF output, either better gain or better 1dB compression can be had with external matching.

Filtering is generally required in the upconversion process to reduce image and LO radiation. To minimize pin count, this filtering is accomplished external to the device at the exciter output. For the frequency ranges of application, two and three pole ceramic surface filters are available at reasonable cost and with less than 2 dB of loss.

EVALUATION BOARDS

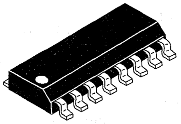
Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

The MRFIC Line

1.8 GHz LNA/Downmixer

MRFIC1804

1.8 GHz LOW NOISE AMPLIFIER AND DOWNMIXER GaAs MONOLITHIC INTEGRATED CIRCUIT

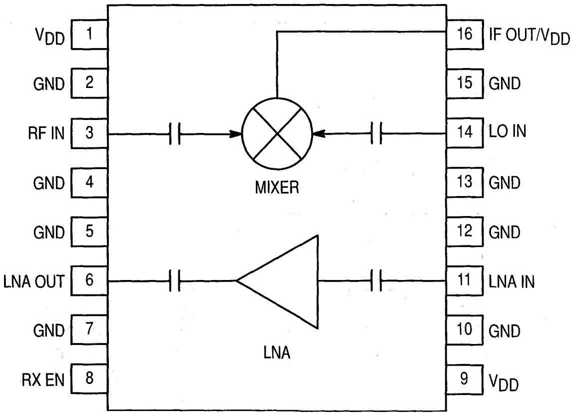


CASE 751B-05
(SO–16)

Designed primarily for use in DECT, Japan Personal Handy Phone (JPHP), and other wireless Personal Communication Systems (PCS) applications. The MRFIC1804 includes a low noise amplifier and downmixer in a low-cost SOIC-16 package. The integrated circuit requires minimal off-chip matching while allowing for the maximum in flexibility and efficiency. The mixer is optimized for low side injection and offers reasonable intercept point as well as high efficiency and 4 dB of conversion gain. Image filtering is implemented off-chip to allow maximum flexibility. With both TX and RX enable pins low, the device is in standby mode and draws less than 0.5 mA.

Together with the rest of the MRFIC180X series, this GaAs IC family offers the complete transmit and receive functions, less LO and filters, needed for a typical 1.8 GHz cordless telephone.

- Usable Frequency Range = 1.5 to 2.2 GHz
- 14 dB Gain, 2.3 dB Noise Figure LNA
- 4 dB Gain, 13 dB Noise Figure Mixer
- 0.9 dB Mixer Input Intercept Point
- Simple LO/IF Off-Chip Matching for Maximum Flexibility
- Low Power Consumption = 24 mW (Typ)
- Single Bias Supply = 2.7 to 3.3 V
- Low LO Power Requirement = – 5 dBm (Typ)
- Low Cost Surface Mount Plastic Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number. R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M1804



Pin Connections and Functional Block Diagram

REV 2

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

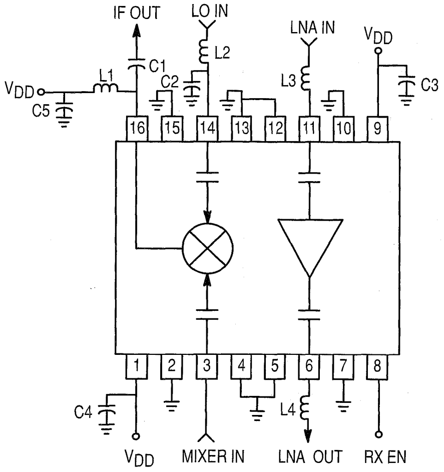
Rating	Symbol	Limit	Unit
Supply Voltage	V_{DD}	5	Vdc
LNA Input Power (Standby Mode)	LNA_{in}	10	dBm
LO Input Power	P_{LO}	0	dBm
Receive Enable Voltage	RX EN	5	Vdc
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Ambient Temperature	T_A	– 30 to +85	°C

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
RF Input Frequency	f_{RF}	1.8 to 1.925	GHz
Mixer LO Frequency	f_{LO}	1.5 to 1.9	GHz
IF Output Frequency	f_{IF}	70 to 325	MHz
Supply Voltage	V_{DD}	2.7 to 3.3	Vdc
Receive Enable Voltage	RX EN	2.7 to 3.3	Vdc

ELECTRICAL CHARACTERISTICS (V_{DD} = 3 V, T_A = 25°C, LO = 1790 MHz @ – 5 dBm, RF = 1.9 GHz , RX EN = 3 V)

Characteristic	Min	Typ	Max	Unit
LNA Gain	—	14	—	dB
LNA Noise Figure	—	2.3	—	dB
LNA Input 3rd Order Intercept	—	–11	—	dBm
Mixer Conversion Gain (into 50 Ω)	—	4	—	dB
Mixer Noise Figure	—	13	—	dB
Mixer Input 3rd Order Intercept	—	0.9	—	dBm
Downconverter Gain (Less Image Filter Loss)	16	—	—	dB
Supply Current, RX Mode (RX EN = 3 V, LO_{off})	—	7	10	mA
Standby Mode Current (RX EN = 0 V, LO off)	—	—	0.5	mA



C1	12 pF (110 MHz) or 7.5 pF (240 MHz)
C2	0.8 pF
C3, C4	100 pF
C5	1000 pF
L1	82 nH (110 MHz) or 15 nH (240 MHz)
L2	8.2 nH
L3, L4	3.0 nH (Microstrip)

Figure 1. Applications Circuit Configuration (for 110 MHz and 240 MHz IF)

	S_{11}		S_{21}		S_{12}		S_{22}	
Freq (GHz)	**Mag**	**Angle**	**Mag**	**Angle**	**Mag**	**Angle**	**Mag**	**Angle**
1.5	0.801	–64.71	5.65	–63.77	0.025	139.08	0.685	–62.55
1.6	0.741	–70.03	6.07	–80.96	0.033	128.21	0.622	–74.44
1.7	0.641	–73.54	6.63	–98.00	0.038	123.07	0.622	–83.36
1.8	0.559	–72.72	6.70	–113.87	0.047	113.17	0.560	–92.40
1.82	0.533	–71.10	6.58	–117.42	0.046	111.66	0.543	–93.20
1.84	0.512	–71.20	6.32	–120.25	0.046	109.36	0.530	–94.40
1.86	0.494	–69.93	5.92	–123.27	0.049	107.72	0.513	–95.19
1.88	0.478	–68.86	5.79	–126.51	0.052	106.52	0.498	–95.56
1.9	0.467	–67.50	5.88	–129.49	0.054	104.49	0.486	–96.35
1.92	0.452	–66.18	5.98	–132.33	0.055	103.55	0.476	–97.14
2.0	0.383	–57.10	5.57	–143.54	0.055	97.41	0.412	–96.10
2.1	0.326	–47.69	5.06	–155.69	0.058	92.26	0.344	–90.55
2.2	0.271	–35.10	4.61	–167.78	0.063	86.81	0.276	–83.89
2.3	0.205	–15.07	4.12	175.72	0.072	83.78	0.192	–63.78
2.4	0.708	–12.53	1.84	–155.83	0.073	45.03	0.406	–48.22
2.5	0.462	–34.07	3.18	–178.63	0.055	58.37	0.292	–66.60

Table 1. LNA S–Parameters

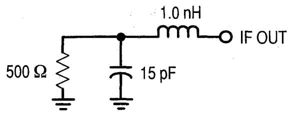


Figure 2. Equivalent IF Output Circuit

TYPICAL CHARACTERISTICS
(V_{DD} = 3 V)

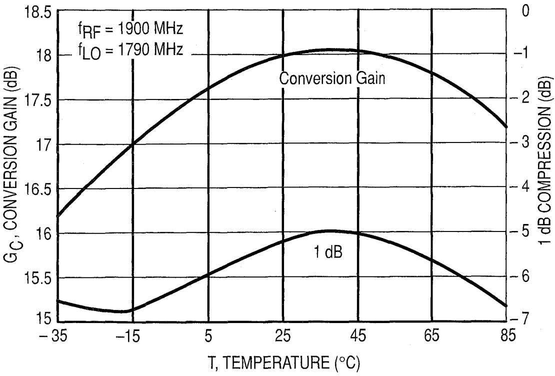


Figure 3. Downconverter Conversion Gain (less Image Filter) and 1 dB Compression versus Temperature

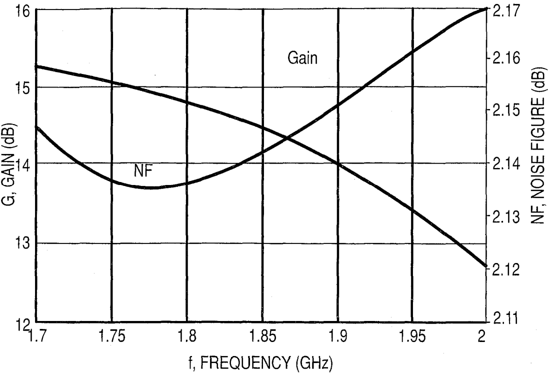


Figure 4. LNA Gain and Noise Figure versus Frequency

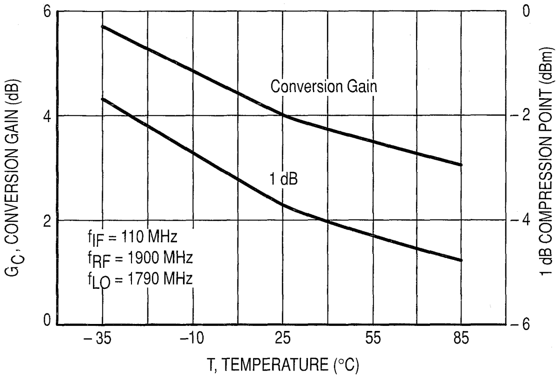


Figure 5. Mixer Conversion Gain and 1 dB Compression versus Temperature

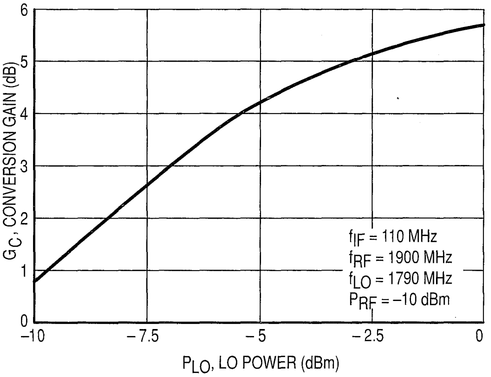


Figure 6. Mixer RF to IF Conversion Gain versus LO Power

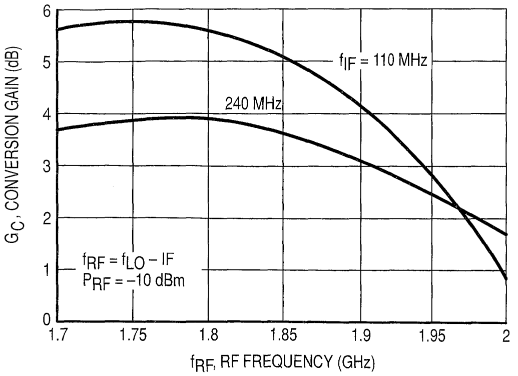


Figure 7. Mixer RF to IF Conversion Gain versus RF Frequency

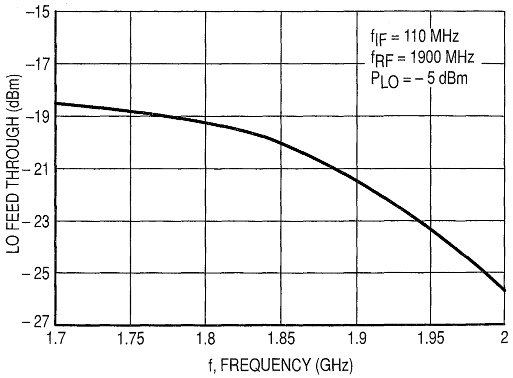


Figure 8. Mixer LO to IF Feed Through versus RF Frequency

DESIGN AND APPLICATIONS INFORMATION

The MRFIC1804 consists of a two–stage GaAs MESFET low noise amplifier and a single ended MESFET mixer. The LNA design conserves bias current through stacking of the two FETs, thus reusing the current. The mixer consists of a common gate stage driving a common source stage with the IF output being the drain of the common source stage shunted with 15 pF. The LNA output and mixer input have been separated to allow the addition of an external image filter. Such a filter, usually ceramic, is useful in improving the mixer noise figure and third order intercept performance. It also provides LO rejection to reduce the amount of LO power which may leak to the antenna. Alternatively, image trapping can be implemented at the LNA input or output with discrete or distributed components.

The design has been optimized for application in the PCS bands around 1.9 GHz but is usable from around 1.5 GHz to 2.2 GHz. For applications at 1.9 GHz and IFs of 110 MHz or 240 MHz, the circuit shown in Figure 1 can be used. This circuit was used to derive the characterization data shown in Figures 3 through 8. For other IF frequencies in the 100 MHz to 350 MHz range, use the IF equivalent circuit shown in Figure 2 for matching network design. As can be seen in the characterization curves, performance appears to degrade above about 1.85 GHz. This is partially a function of the circuit shown in Figure 1 and can be improved, first, by adjusting the LO input match, second, by matching LNA input and and the mixer input off chip.

As with all RF circuits, layout is important. Ground vias must be close to the component or lead to be grounded and vias must be plentiful. RF signal lines should be controlled impedance such as microstrip. Bypassing of power supply leads as shown in Figure 1 is essential to avoid oscillation of the circuits.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The MRFIC Line
1.8 GHz PA Driver/Ramp

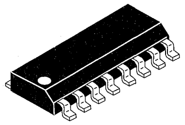
MRFIC1806

1.8 GHz DRIVER AMPLIFIER
AND RAMP CIRCUIT
GaAs MONOLITHIC
INTEGRATED CIRCUIT

Designed primarily for use in DECT, Japan Personal Handy System (PHS), and other wireless Personal Communication Systems (PCS) applications. The MRFIC1806 includes a two stage driver amplifier and transmit waveform shaping circuitry in a low–cost SOIC–16 package. The amplifier portion employs depletion mode power GaAs MESFETs to produce +21 dBm output with 0 dBm input. The ramping circuit controls the burst–mode transmit rise and fall time and is adjustable through external components. This circuitry also places the amplifier in standby during TDMA receive mode. The MRFIC1806 is sized to drive the MRFIC1807 PA/Switch.

Together with the rest of the MRFIC1800 GaAs ICs, this family offers the complete transmit and receive functions, less LO and filters, needed for a typical 1.8 GHz cordless telephone.

- Usable 1500–2500 MHz
- 23 dB Typical Gain
- +21 dBm Typical 1.0 dB Compression
- Simple Off–Chip Matching for Maximum Flexibility
- 3.0 to 5.0 Volt Supply
- Low Cost Surface Mount Plastic Package
- Tape and Reel Option Available by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M1806



CASE 751B–05
(SO–16)

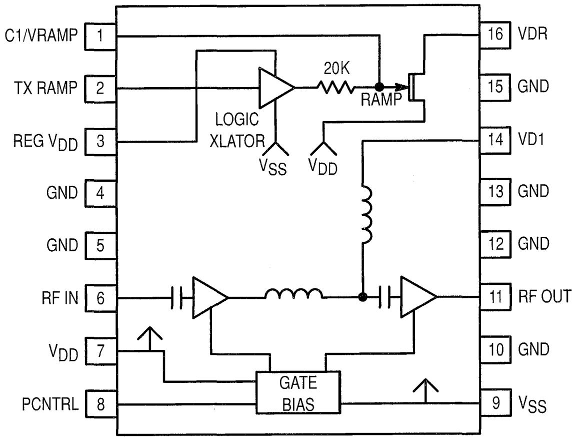


Figure 1. Pin Connections and Functional Block Diagram

REV 1

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Limit	Unit
Supply Voltage	V_{DD}	6.0	Vdc
Supply Voltage	V_{SS}	−4.0	Vdc
Supply Voltage	REG V_{DD}	4.5	Vdc
Bias Control Voltage	PCNTRL	3.0	Vdc
RF Input Power	P_{IN}	10	dBm
Ramp Circuit Input Voltage (High)	TX RAMP	6.0	Vdc
Storage Temperature Range	T_{stg}	−65 to +150	°C
Ambient Operating Temperature	T_A	−10 to +70	°C

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
RF Input Frequency	f_{RF}	1.5−2.5	GHz
Supply Voltage	V_{DD}	3.0 to 5.0	Vdc
Supply Voltage	V_{SS}	−2.75 to −2.25	Vdc
Supply Voltage	REG V_{DD}	2.9 to 3.1	Vdc
Bias Control Voltage	PCNTRL	0.5 to 1.5	Vdc
RF Input Power	P_{IN}	−20 to +5	dBm
Transmit Burst Enable Voltage (High)	TX RAMP	2.8 to 3.5	Vdc
Transmit Burst Enable Voltage (Low)	TX RAMP	−0.2 to +0.2	Vdc

ELECTRICAL CHARACTERISTICS

DECT Application with Internal Logic Translator (See Figure 2. V_{DD} = 3.5 V, REG V_{DD} = 3.0 V, T_A = 25°C, V_{SS} = −2.5 V, TX RAMP = 3.0 V, PCNTRL set for Quiescent I_{DD} = 120 mA, P_{IN} = −3.0 dBm @ 1.9 GHz unless otherwise stated.)

Characteristic	Min	Typ	Max	Unit
Small Signal Gain (P_{IN} = −7.0 dBm)	21	23	—	dB
Input Return Loss	—	12	—	dB
Reverse Isolation	—	36	—	dB
Output Power	18	19.5	—	dBm
Harmonic Output	—	−36	—	dBc
Output Third Order Intercept	—	33	—	dBm
Supply Current, I_{SS} (Pin 9)	—	0.35	0.6	mA
Supply Current, I_{DD} (Pin 7)	—	115	135	mA
Supply Current, REG I_{DD} (Pin 3)	—	0.6	0.9	mA
Ramp Circuit Dynamic Range	40	44	—	dB

STANDBY MODE (TX RAMP = 0 V)

Characteristic	Min	Typ	Max	Unit
Output Power	—	−25	—	dBm
Supply Current, I_{SS} (Pin 9)	—	0.4	0.6	mA
Supply Current, REG I_{DD} (Pin 3)	—	0.25	0.4	mA

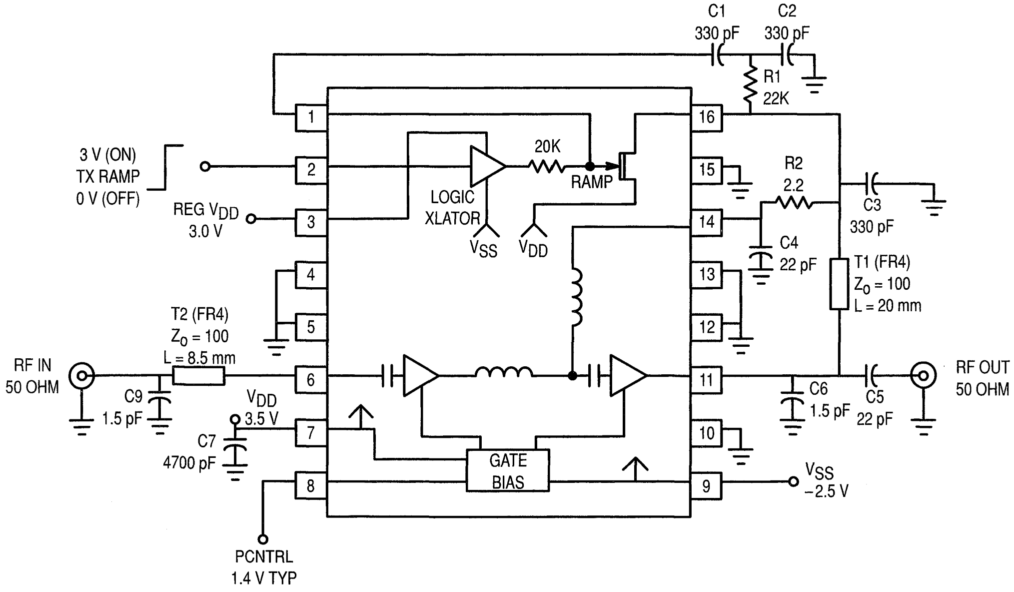


Figure 2. Applications Circuit Details for DECT using Internal Logic Translator

ELECTRICAL CHARACTERISTICS

General Application without Internal Logic Translator (See Figure 3. V_{DD} = 3.5 V, REG V_{DD} (Pin 2) open, V_{SS} = −2.5 V, TX RAMP (Pin 2) grounded, V_{RAMP} = 3.0 V, PCNTRL set for Quiescent I_{DD} = 120 mA, P_{IN} = 0 dBm @ 1.9 GHz, T_A = 25°C unless otherwise stated.)

Characteristic	Min	Typ	Max	Unit
Small Signal Gain (P_{IN} = −7.0 dBm)	21	23	—	dB
Output Power (P_{IN} = 0 dBm)	20	22	—	dBm
Output Power (P_{IN} = +4.0 dBm)	—	23	—	dBm
Supply Current, I_{SS} (Pin 9)	—	0.3	0.5	mA
Supply Current, I_{DD} (Pin 7)	—	130	145	mA

STANDBY MODE (V_{RAMP} = −2.4 V)

Characteristic	Min	Typ	Max	Unit
Output Power	—	−25	—	dBm
Supply Current, I_{SS} (Pin 9)	—	0.4	0.6	mA

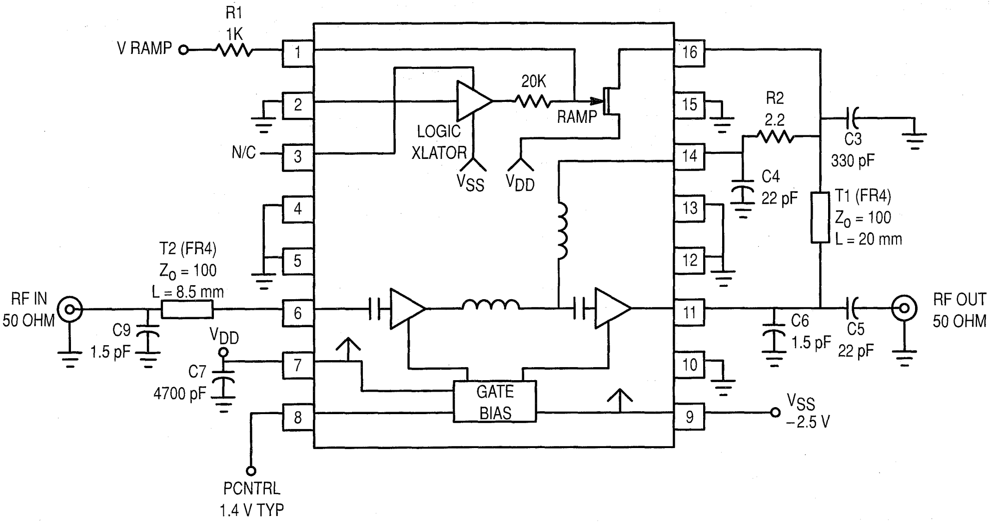


Figure 3. 1.9 GHz General Application Circuit Details (Internal Translator Disabled)

Table 1. Small Signal S−Parameters

(V_{DD} = 3.5 V, I_{DQ} = 120 mA, T_A = 25°C, no matching circuit, reference plane at pins 6 and 11.)

Freq (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	Mag	Angle	Mag	Angle	Mag	Angle	Mag	Angle
1.5	0.734	−76.8	13.11	−87.9	0.009	−176	0.278	−98.9
1.6	0.654	−82.4	13.01	−109.4	0.012	178	0.326	−116.4
1.7	0.620	−72.6	11.17	−117.4	0.011	152	0.344	−109.8
1.8	0.636	−79.8	12.25	−137.0	0.014	170	0.423	−134.1
1.9	0.607	−80.6	10.77	−151.3	0.017	169	0.421	−147.7
2.0	0.592	−79.4	10.88	−165.1	0.019	163	0.427	−161.8
2.1	0.581	−79.4	9.64	−174.9	0.024	163	0.432	−172.3
2.2	0.571	−78.9	9.30	174.1	0.026	158	0.429	178.8
2.3	0.560	−79.1	7.95	166.9	0.029	157	0.432	171.1
2.4	0.541	−79.8	7.80	155.7	0.033	153	0.442	164.6
2.5	0.521	−80.1	6.90	147.2	0.042	154	0.445	161.7

DESIGN AND APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC1806 is designed to drive the MRFIC1807 Power Amplifier and Transmit/Receive Switch IC in Personal Communications System (PCS) applications such as Europe's DECT and Japan's Personal Handy System (PHS). The design incorporates not only a two–stage GaAs MESFET driver/exciter amplifier, but also externally controllable bias and ramping circuitry. The IC is designed to drive the MRFIC1807 with about +19 dBm which will, in turn, produce +26 dBm output, suitable for DECT. To reduce chip size (and cost) and to allow for flexibility of application, the amplifier has limited on–chip matching. The ramp circuitry is used to shape the drain voltage to the FETs for Time Domain Multiple Access (TDMA) applications and is comprised of a depletion mode pass device driven by a logic translator. Attack and release times are controllable through the use of external components. The IC is configured such that all, part or none of the ramping circuitry can be used, depending on the application.

AMPLIFIER CIRCUIT APPLICATION

As can be seen in Figures 2 and 3, the off–chip matching is straight forward. At frequencies near 1.9 GHz, the input requires 4.7 nH in series and 1.5 pF in shunt. The 4.7 nH series inductance may be implemented with a high–impedance transmission line as shown. The output, being close to 25 Ω, requires only a shunt 1.5 pF capacitor. Drain voltage for stage 1 is supplied through pin 14 and for stage 2 through pin 11, the RF output. Pin 8, PCNTRL is used to set the quiescent bias point for both stages. While nominal I_{DDQ} is 120 mA, it can be set as high as 180 mA for better linearity or lower for better efficiency. 120 mA is a good compromise for DECT and PHS. DECT, which employs GMSK constant envelope modulation can use RF amplifiers close to or in saturation without experiencing spectral regrowth of the signal. PHS, on the other hand, employs π/4 DQPSK modulation which has some residual AM associated with the encoding. With AM present, RF amplifiers must be backed off from saturation so as not to regrow the filtered sidebands. The MRFIC1806 has plenty of backoff capability for PHS where the MRFIC1807 PA/switch must only produce about +21 dBm. With the 8.0 dB gain of the MRFIC1807, the MRFIC1806 need only produce +13 dBm output so the bias point can be reduced below the 120 mA suggested for DECT. As with all RF circuits, board layout and grounding are important. All RF signal paths must be controlled impedance structures. RF chip components must be high quality. Bypassing capacitors must be close to the IC and to ground vias. Pins which are designated as ground connections must be as close as possible to ground vias.

RAMPING CIRCUIT OPTIONS

The on–chip ramp circuit can be used to control the amplifier attack and release time for DECT applications through the use of a few external components as shown in Figure 2. This ramping is required to control the burst signal rise and fall time to avoid adjacent channel interference. At the same time, system specifications require the transmitter to reach full power in a minimum time. For DECT, it has been shown that a rise time of not greater than 2 microseconds will produce acceptable adjacent channel performance. The system requires full power in not greater than 10 microseconds. A good compromise, and the timing implemented in Figure 2, is 7 microseconds.

The on–chip logic translator can be bypassed as shown in Figure 3 by applying a ramp voltage to Pin 1 through a 1.0 kΩ resistor. This configuration allows flexibility in ramping the amplifier. The regulated V_{DD} voltage is not required so current consumption can be reduced. −2.3 V at Pin 1 turns the pass transistor, and the amplifier, off while a positive voltage will turn the pass transistor on. For full on state it is recommended that V_{RAMP} be close to V_{DD}. V_{RAMP} can also be used to on–off key the amplifier for simple telemetry applications or as transmit/receive control.

For more complex modulation schemes such as π/4 DQPSK used in PHS, burst ramping can be implemented with the burst mode logic. Referring to Figure 3, the V_{RAMP} voltage should be set to V_{DD} to leave the pass transistor on. The on–chip pass transistor can also be bypassed and V_{DD} applied to Pins 11 and 14.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

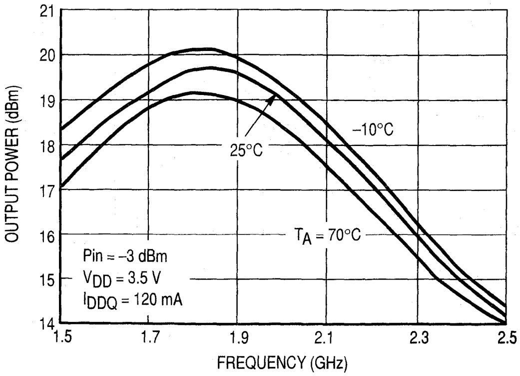


Figure 4. Output Power versus Frequency With Internal Logic Translator

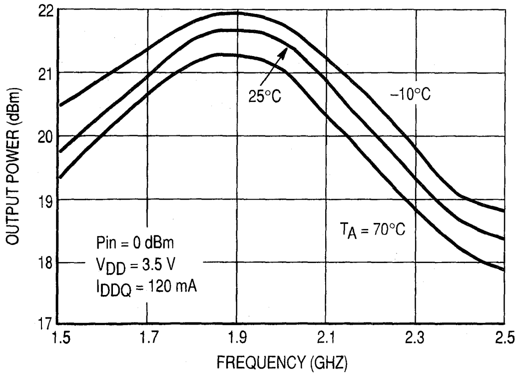


Figure 5. Output Power versus Frequency Without Internal Logic Translator

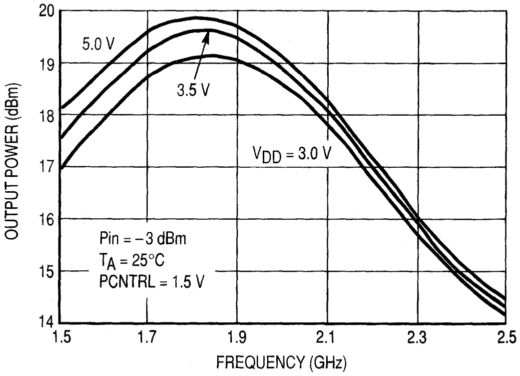


Figure 6. Output Power versus Frequency With Internal Logic Translator

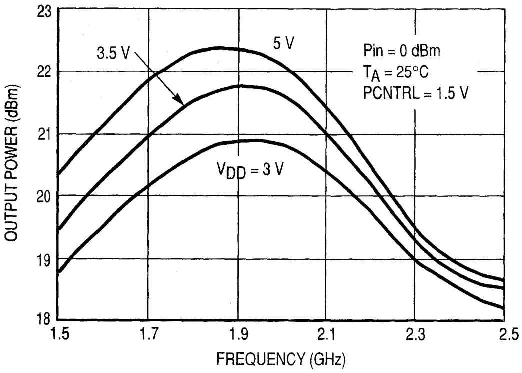


Figure 7. Output Power versus Frequency Without Internal Translator

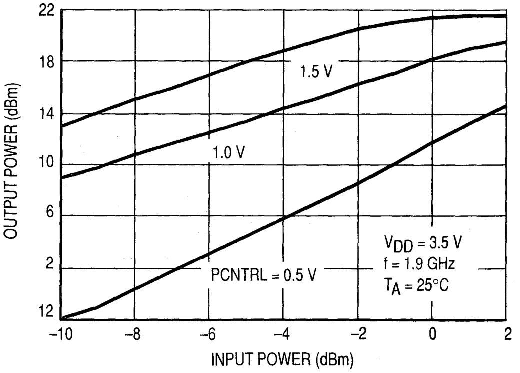


Figure 8. Output Power versus Input Power With Internal Logic Translator

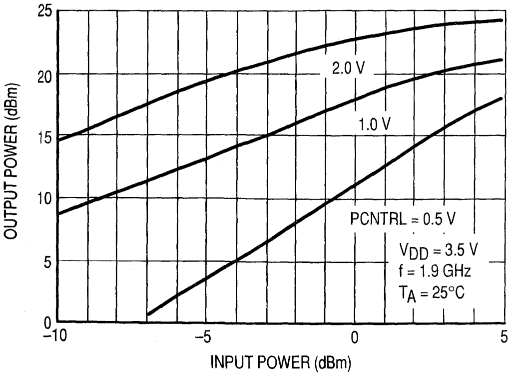


Figure 9. Output Power versus Input Power Without Internal Logic Translator

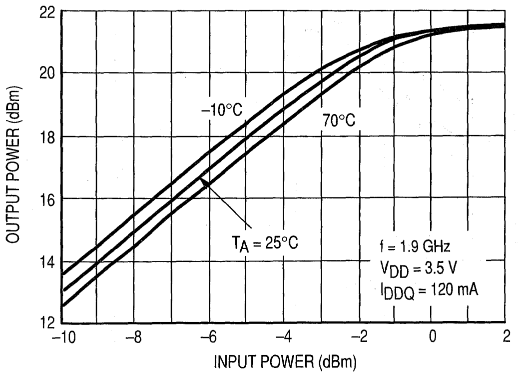


Figure 10. Output Power versus Input Power With Internal Logic Translator

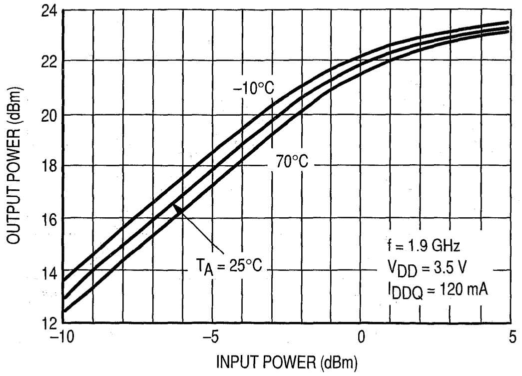


Figure 11. Output Power versus Input Power Without Internal Logic Translator

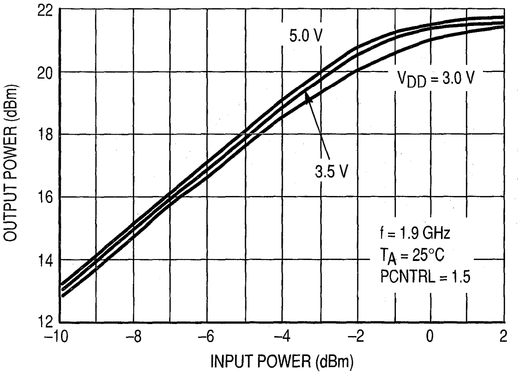


Figure 12. Output Power versus Input Power With Internal Logic Translator

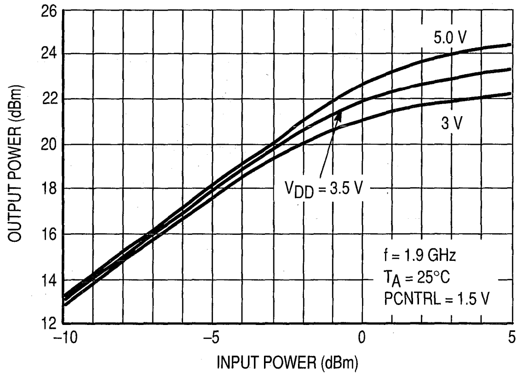


Figure 13. Output Power versus Input Power Without Internal Logic Translator

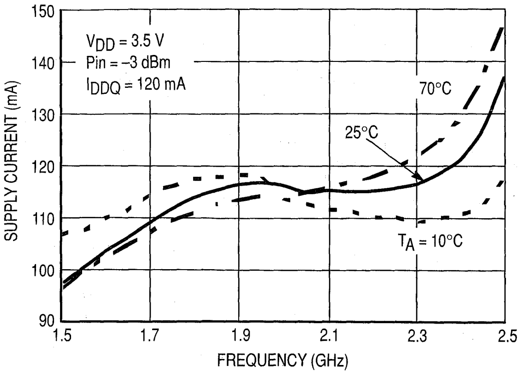


Figure 14. Supply Current versus Frequency With Internal Logic Translator

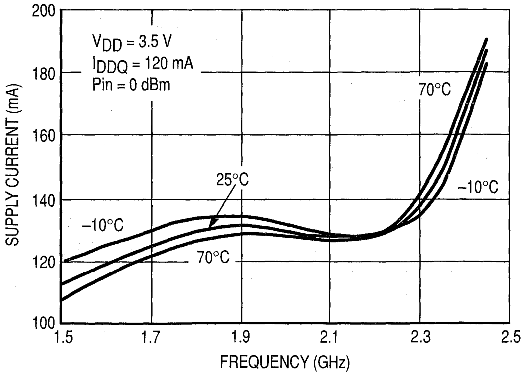


Figure 15. Supply Current versus Frequency Without Internal Logic Translator

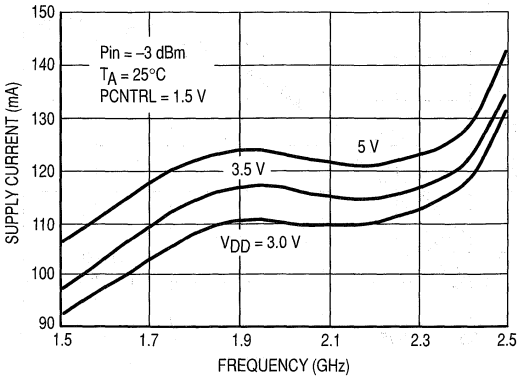


Figure 16. Supply Current versus Frequency With Internal Logic Translator

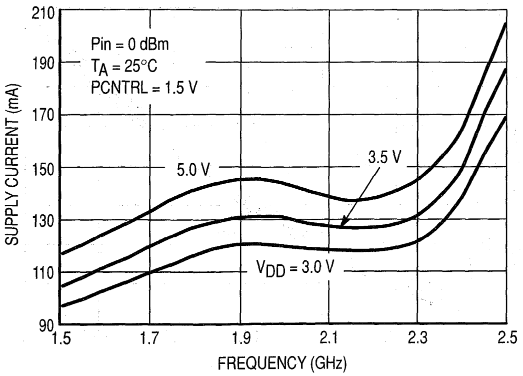


Figure 17. Supply Current versus Frequency Without Internal Logic Translator

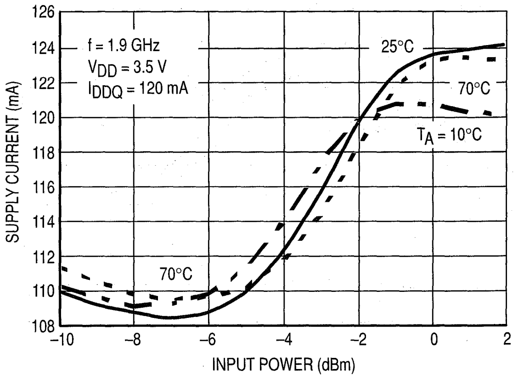


Figure 18. Supply Current versus Input Power With Internal Translator

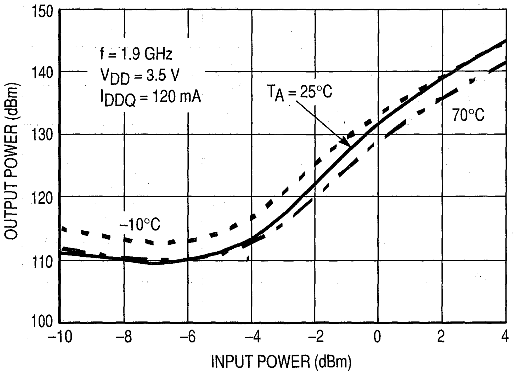


Figure 19. Supply Current versus Input Power Without Internal Translator

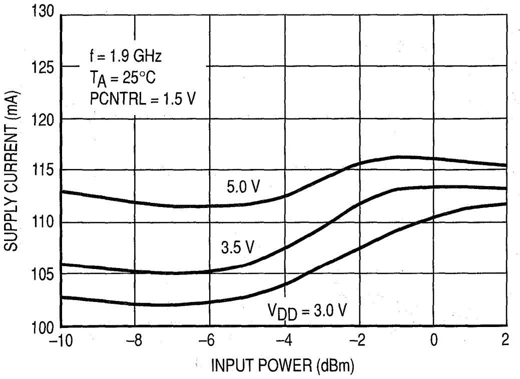


Figure 20. Supply Current versus Input Power With Internal Translator

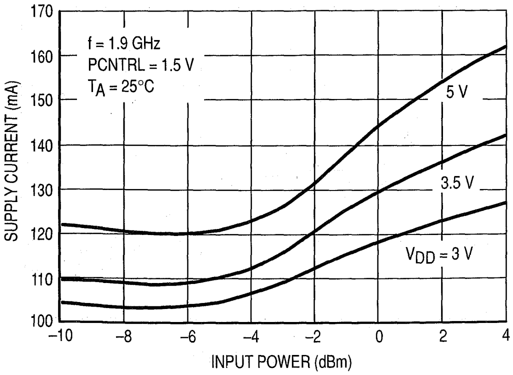


Figure 21. Supply Current versus Input Power Without Internal Logic Translator

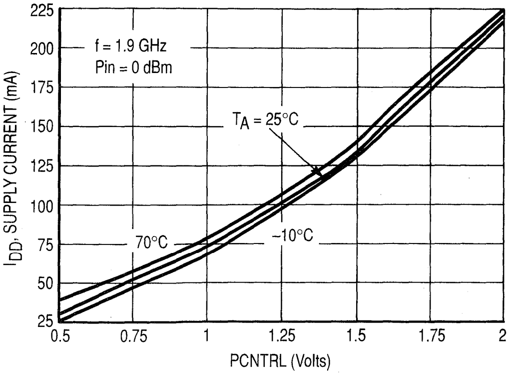


Figure 22. Supply Current versus PCNTRL Without Internal Logic Translator

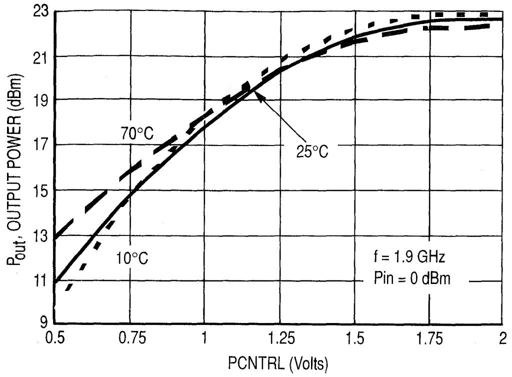


Figure 23. P_{out} versus PCNTRL Without Internal Logic Translator

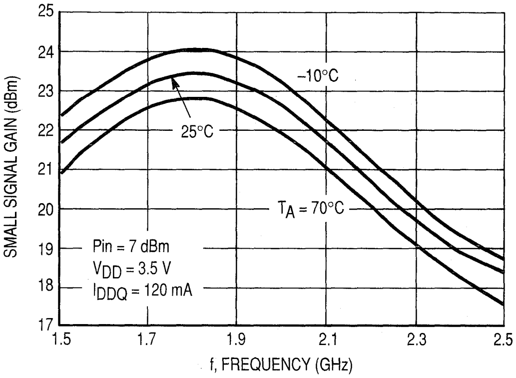


Figure 24. Small Signal Gain versus Frequency With Internal Logic Translator

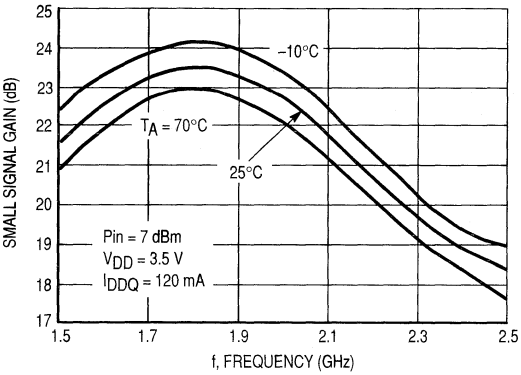


Figure 25. Small signal Gain versus Frequency Without Internal Logic Translator

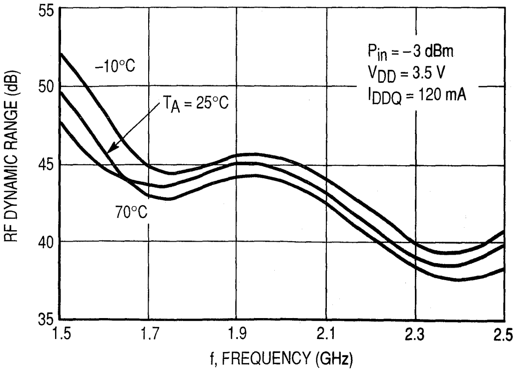


Figure 26. Dynamic Range versus Frequency With Internal Logic Translator

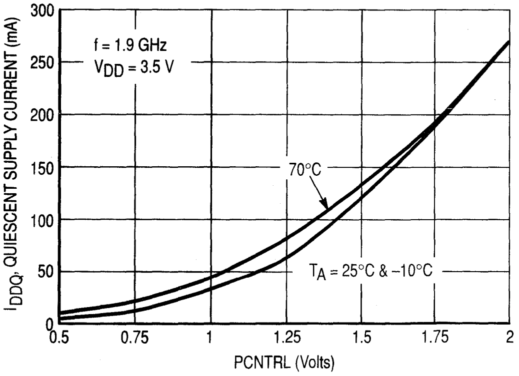


Figure 27. Quiescent Supply Current versus PCNTRL With Internal Logic Translator

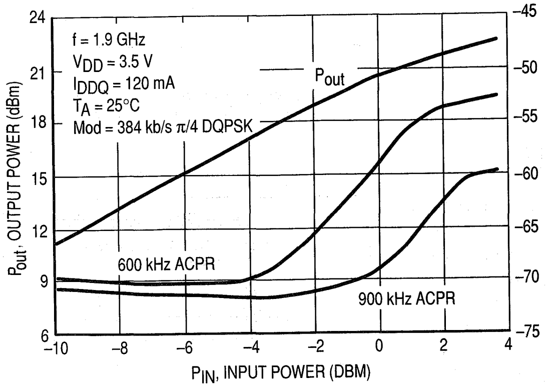


Figure 28. Output Power and Adjacent Channel Power Ratio versus Input Power Without Internal Logic Translator

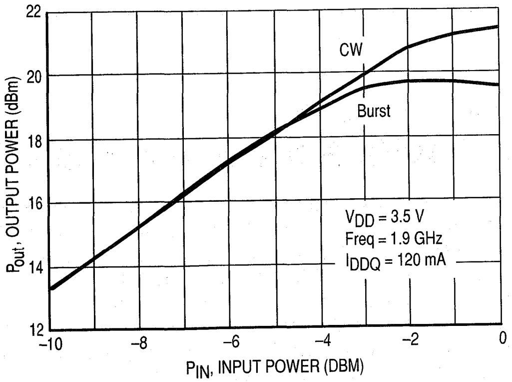


Figure 29. Continuous and Burst Mode Output Power versus Input Power With Internal Logic Translator

MRFIC1807

1.8 GHz POWER AMPLIFIER AND TRANSMIT/RECEIVE SWITCH
GaAs MONOLITHIC INTEGRATED CIRCUIT

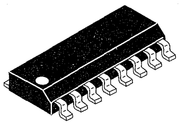
The MRFIC Line

1.8 GHz Power Amp/Switch

Designed primarily for use in DECT, Japan Personal Handy System (PHS) and other wireless Personal Communication Systems (PCS) applications. The MRFIC1807 includes a single–stage power amplifier and transmit/receive switch in a low–cost SOIC–16 package. The amplifier portion employs a depletion mode power GaAs MESFET and produces up to +27 dBm output with +19 dBm input. On–chip power control circuitry allows bias adjustment for optimum performance. The T/R switch is capable of handling up to +28 dBm through the transmit path without significant increase in insertion loss. The switch is controlled by CMOS logic level signals — no negative control voltage required. The MRFIC1807 is sized to be driven by the MRFIC1806 Driver/ Ramp IC.

Together with the rest of the MRFIC1800 GaAs ICs, this family offers the complete transmit and receive functions, less LO and filters, needed for a typical 1.8 GHz cordless telephone.

- Usable 1500–2200 MHz
- 8.0 dB Gain Including Switch
- +26 dBm Minimum Output Power at Antenna Port
- 1.0 dB Typ RX Path Insertion Loss
- Simple Off–Chip Matching for Maximum Flexibility
- 3.0 to 5.0 V Supply
- No Spurious Outputs for Load VSWR up to 8:1
- CMOS Level Switching Signal for T/R Switch
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M1807



CASE 751B–05
(SO–16)

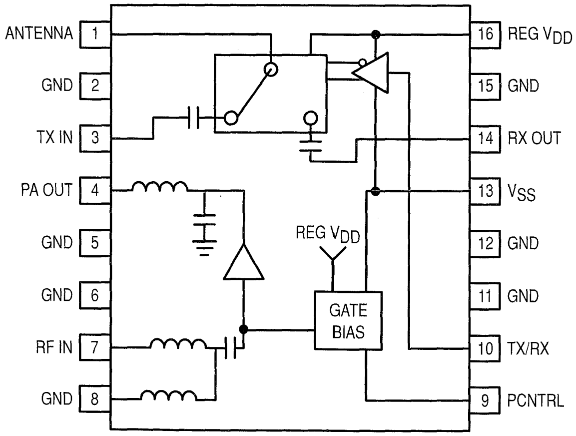


Figure 1. Pin Connection and Functional Block Diagram

REV 1

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C Unless Otherwise noted)

Rating	Symbol	Limit	Unit
PA Supply Voltage	V_{DD}	6.0	Vdc
Supply Voltage	REG V_{DD}	4.5	Vdc
Supply Voltage	V_{SS}	−4.0	Vdc
RF Input Power	P_{in}	+25	dBm
Switch Control Voltage	TX/RX	6.0	Vdc
PA Control Voltage	PCNTRL	3.0	Vdc
Ambient Operating Temperature	T_A	−10 to +70	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
RF Input Frequency	f_{RF}	1.5 to 2.2	GHz
PA Supply Voltage	V_{DD}	3.0 to 5.0	Vdc
Supply Voltage	REG V_{DD}	2.9 to 3.1	Vdc
Supply Voltage	V_{SS}	−2.75 to −2.25	Vdc
RF Input Power	P_{IN}	+5.0 to +23	dBm
Switch Control Voltage, High (TX Mode)	TX/RX	2.8 to 3.5	Vdc
Switch Control Voltage, Low (RX Mode)	TX/RX	−0.2 to 0.2	Vdc
PA Control Voltage	PCNTRL	0.0 to 2.5	Vdc

ELECTRICAL CHARACTERISTICS (1)

Transmit Mode (V_{DD} = 3.5 V, REG V_{DD} = 3.0 V, T_A = 25°C, V_{SS} = −2.5 V, PCNTRL 0 V to 2.5 V, P_{IN} = 20 dBm @ 1.9 GHz, TX/RX = 3 V, P_{OUT} Measured at ANT Port)

Characteristic	Min	Typ	Max	Unit
Small Signal Gain (P_{IN} = 0 dBm, PCNTRL set for I_{DDQ} = 180 mA)	7.0	8.0	—	dB
Output Power (PCNTRL adjusted for efficiency ≥ 35%)	26	26.8	—	dBm
Output 1.0 dB Compression (PCNTRL set for I_{DDQ} = 180 mA)	—	25	—	dBm
Harmonic Output (PCNTRL set for P_{OUT} = 26 dBm)	—	−40	—	dBc
Switch RX to TX Switching Time	—	0.1	—	μsec
TX/RX Control Input Current, Pin 10	—	0.2	—	mA
Drain Efficiency (P_{out} = 26 dBm) (2)	—	40	—	%
Supply Current, I_{SS}	—	0.8	1.2	mA
Supply Current, REG I_{DD}	—	0.8	1.2	mA
PCNTRL Control Input Current (Pin 9)	—	15	—	μA
Leakage Power at RX Port	—	−1	+ 6	dBm

Receive Mode (V_{DD} = 0 V, REG V_{DD} = 3.0 V, V_{SS} = −2.5 V, TX/RX = 0 V, T_A = 25°C, Freq = 1.9 GHz)

Characteristic	Min	Typ	Max	Unit
ANT to RX Insertion Loss	—	1.0	1.3	dB
Switch TX to RX Switching Time	—	1.0	—	μsec
Supply Current, REG I_{DD}	—	60	250	μA
Supply Current, I_{SS}	—	60	250	μA

NOTES:

1. Measured with circuit configuration shown in Figure 2.
2. Includes switch loss.

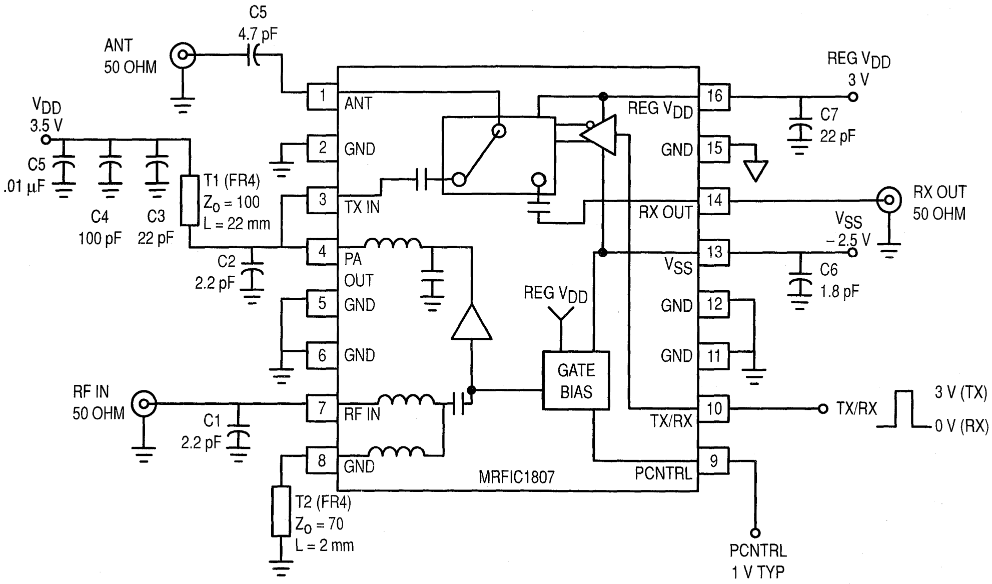


Figure 2. 1.9 GHz Applications Circuit Configuration

Table 1. Small Signal S–Parameters

(V_{DD} = 3.5 V, I_{DDQ} = 180 mA, T_A = 25°C, no input or output matching)

	S_{11}		S_{21}		S_{12}		S_{22}	
Freq (GHz)	**Mag**	**Angle**	**Mag**	**Angle**	**Mag**	**Angle**	**Mag**	**Angle**
1.5	0.614	–171.5	2.203	82.6	0.104	74.5	0.741	175.4
1.6	0.695	175.7	1.871	71.7	0.110	69.2	0.746	171.5
1.7	0.747	167.3	1.647	63.4	0.108	64.0	0.745	167.4
1.8	0.777	160.3	1.473	56.2	0.106	58.7	0.746	163.0
1.9	0.799	154.2	1.341	49.2	0.120	54.0	0.753	158.9
2.0	0.814	148.3	1.230	43.0	0.118	49.6	0.758	154.8
2.1	0.826	142.5	1.128	36.8	0.114	45.2	0.764	150.6
2.2	0.835	137.0	1.041	31.2	0.120	40.6	0.767	146.7
2.3	0.842	131.4	0.959	26.4	0.127	37.0	0.780	143.4
2.4	0.856	126.6	0.895	21.1	0.124	33.8	0.796	139.8
2.5	0.870	121.7	0.840	16.0	0.126	30.4	0.808	136.4

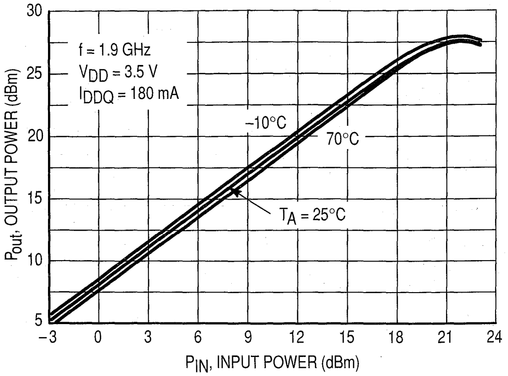


Figure 3. Output Power versus Input Power

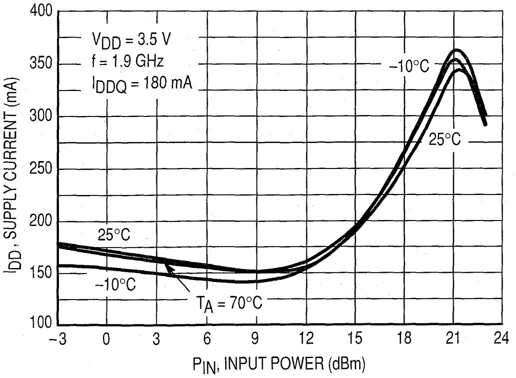


Figure 4. Supply Current versus Input Power

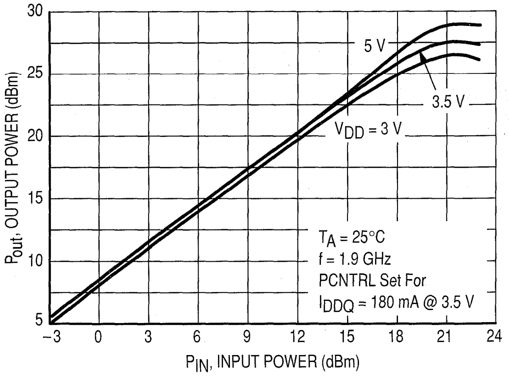


Figure 5. Output Power versus Input Power

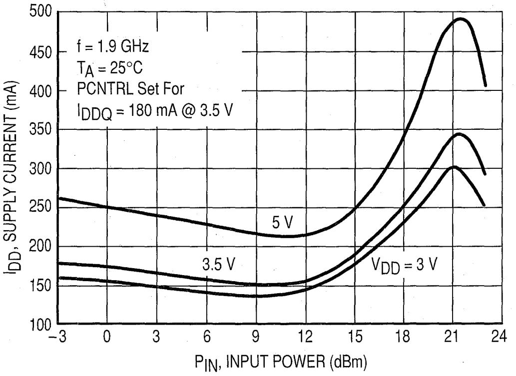


Figure 6. Supply Current versus Input Power

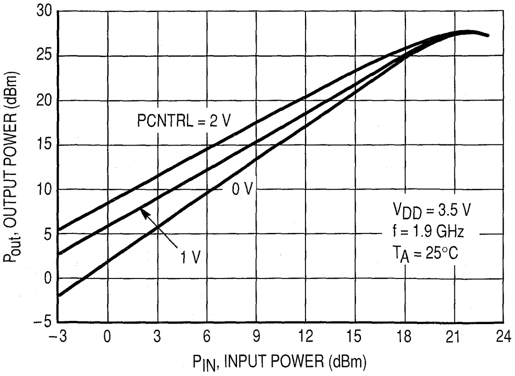


Figure 7. Output Power versus Input Power

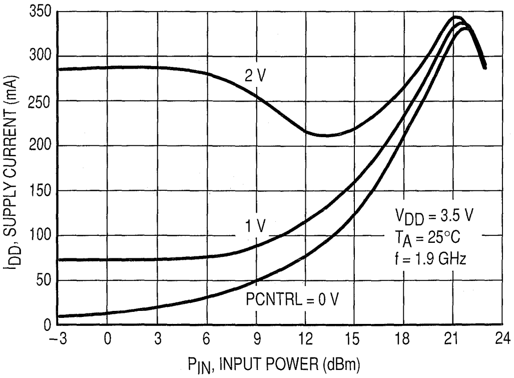


Figure 8. Supply Current versus Input Power

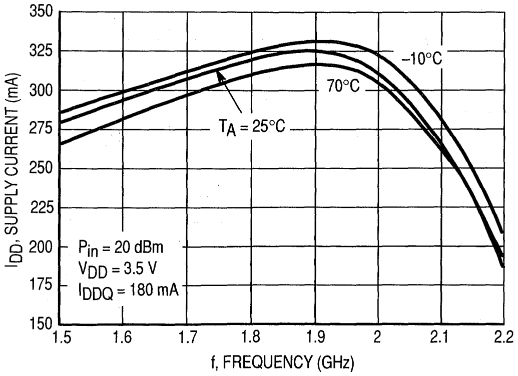


Figure 9. Supply Current versus Frequency

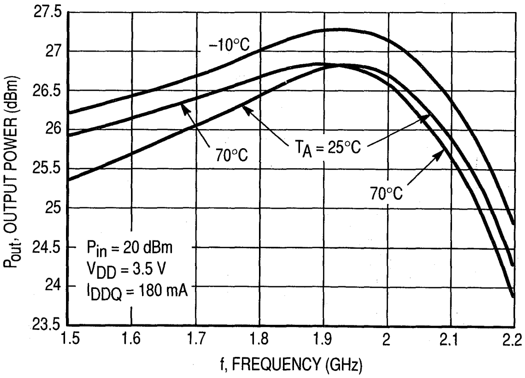


Figure 10. Output Power versus Frequency

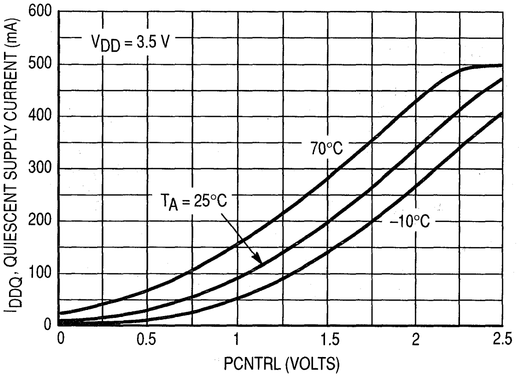


Figure 11. Quiescent Supply Current versus PCNTRL

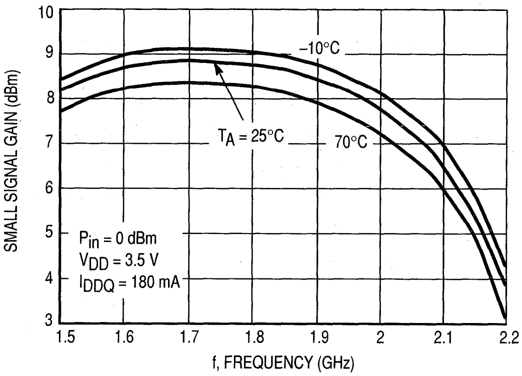


Figure 12. Small Signal Gain versus Frequency

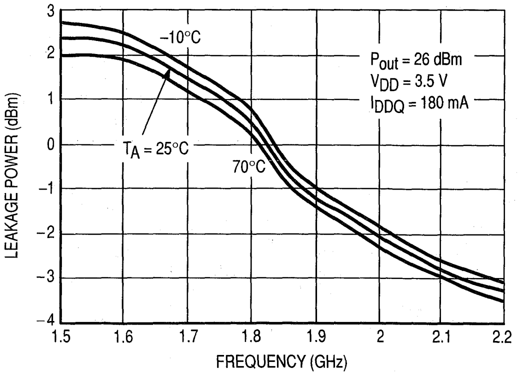


Figure 13. Leakage Power at RX Port in TX Mode versus Frequency

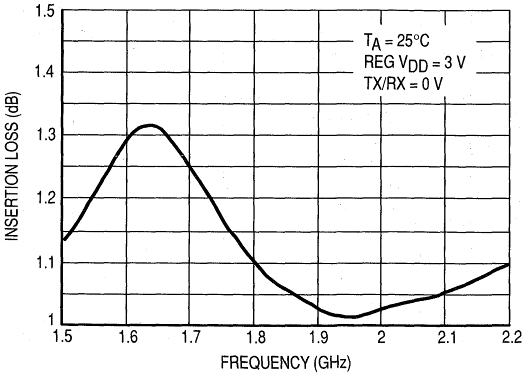


Figure 14. RX Path Insertion Loss in RX Mode versus Frequency

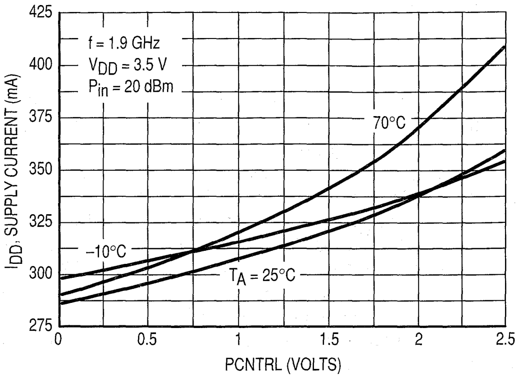


Figure 15. Supply Current versus PCNTRL

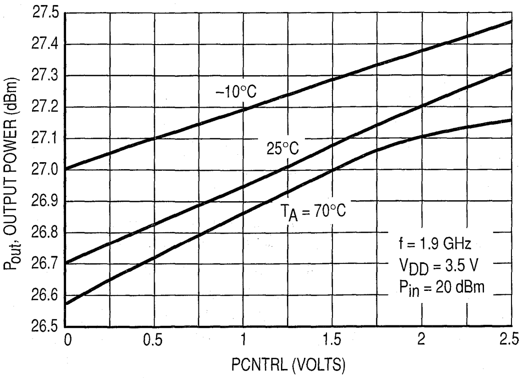


Figure 16. Output Power versus PCNTRL

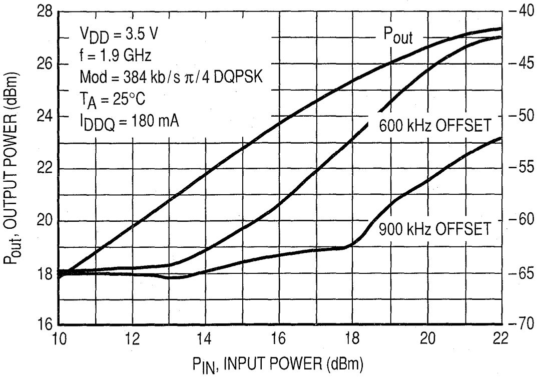


Figure 17. Output Power and Adjacent Channel Power Ratio versus Input Power

DESIGN AND APPLICATIONS INFORMATION

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC1807 is designed to operate with the MRFIC1806 Driver/Ramp IC in 1.9 GHz Personal Communication System (PCS) applications such as Europe's DECT and Japan's PHS. The design incorporates a depletion mode GaAs power MESFET with a high–power transmit/receive switch and associated bias circuitry in one low–cost SOIC–16 package.

The power MESFET is sized to produce at least 27 dBm saturated output power, including switch loss, from a 3.5 V supply, but the output power can be controlled using the PCNTRL input. This control voltage also allows setting of the quiescent current of the FET. PCNTRL can be set to give best efficiency or linearity for the particular system application. The TX/RX control pin allows fast switching of the T/R switch for TDMA applications. When switching from transmit to receive, the battery supply voltage should be removed from the PA (Pin 4), to avoid excessive current drain. This is usually accomplished using an external pass transistor controlled by the TX/RX signal. Alternatively, if PCNTRL is reduced to 0 V during RX mode, the bias current is reduced to nearly zero.

The Transmit/Receive switch is a reflective MESFET design which is optimized for low loss and power handling in transmit mode. The design can handle 28 dBm of transmit power without significant increase in insertion loss. A regulated 3.0 Volt supply is required at pin 16 for the T/R switch and the bias and control circuitry.

DECT APPLICATIONS

Figure 2 shows the component values for a DECT implementation of the MRFIC1807. For use in equipment designed for DECT, the power amplifier is operated close to saturation to improve device efficiency. Maximum power output at the antenna connector is 24 dBm during a burst. The constant envelope characteristics of the GMSK modulation allow non–linear amplification without spectral regrowth. The transmit signal must be shaped or "ramped" to meet system transmit turn on time requirements of 10 μsec minimum while not splattering into adjacent channels. A turn on time on greater than 2.0 μsec has been shown to give adequate adjacent channel power performance. Most DECT realizations have the modulation applied to the transmit VCO so the most straight forward way of implementing this ramping function is at the power amplifier. The MRFIC1806 Driver/Ramp IC has an on–chip ramping circuit specifically designed for DECT. When ramped in this manner, the MRFIC1806 will supply the appropriately ramped RF signal to the MRFIC1807 which only has to be turned on and off with TX/RX. Alternate off–chip ramping can be implemented either with external components or at baseband. Consult the MRFIC1806 datasheet for more information.

PHS APPLICATIONS

For Japan's Personal Handy System applications, the modulation is π/4 DQPSK. When amplified with a non–linear amplifier, the signal will regrow the sidebands which have been carefully filtered at baseband, resulting in adjacent channel interference. To avoid this spectral regrowth, the amplifier must be operated "backed off" from saturation. The amount of backoff required has been shown to be a function of amplifier saturated output capability and may be as high as 5.0 dB. The PHS specification calls for a maximum average power during a burst to be 19 dBm. This is consistent with 5.0 dB backoff from the DECT operating point so the same DECT operating condition could be used. Alternatively, PCNTRL can be adjusted for a lower bias point to improve efficiency or higher bias for better linearity. With π/4 DQPSK modulation, ramping can be accomplished in the encoder so no external ramp circuit is needed. See the MRFIC1806 data sheet for further details.

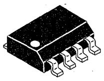
EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

The MRFIC Line
900 MHz Downconverter (LNA/Mixer)

MRFIC2001

**900 MHz
DOWNCONVERTER
LNA/MIXER
SILICON MONOLITHIC
INTEGRATED CIRCUIT**



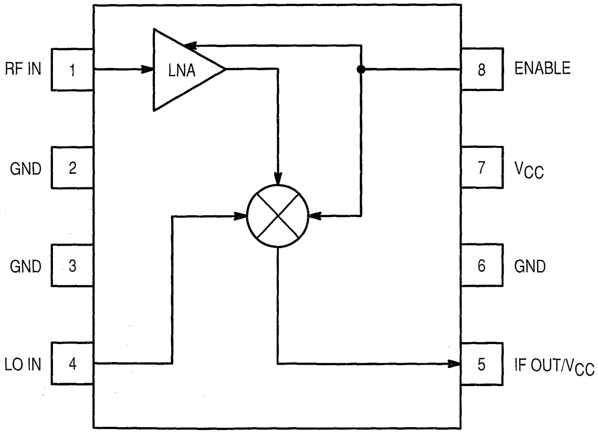
**CASE 751-05
(SO-8)**

The MRFIC2001 is an integrated downconverter designed for receivers operating in the 800 MHz to 1.0 GHz frequency range. The design utilizes Motorola's advanced MOSAIC 3 silicon bipolar RF process to yield superior performance in a cost effective monolithic device. Applications for the MRFIC2001 include CT-1 and CT-2 cordless telephones, remote controls, video and audio short range links, low cost cellular radios, and ISM band receivers. A power down control is provided to minimize current drain with minimum recovery/turn-on time.

- Conversion Gain = 23 dB (Typ)
- Supply Current = 4.7 mA (Typ)
- Power Down Supply Current = 2.0 μA (Max)
- Low LO Drive = –10 dBm (Typ)
- LO Impedance Insensitive to Power Down
- No Image Filtering Required
- No Matching Required for RF IN Port
- All Ports are Single Ended
- Available in Tape and Reel by Adding R2 Suffix to Part Number. R2 suffix = 2,500 Units per 12 mm, 13 inch Reel.
- Device Marking = M2001

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	5.5	Vdc
Control Voltage	ENABLE	5.0	Vdc
Input Power, RF and LO Ports	P_{RF}, P_{LO}	+10	dBm
Operating Ambient Temperature	T_A	– 35 to + 85	°C
Storage Temperature	T_{stg}	– 65 to +150	°C



Pin Connections and Functional Block Diagram

REV 1

RECOMMENDED OPERATING RANGES

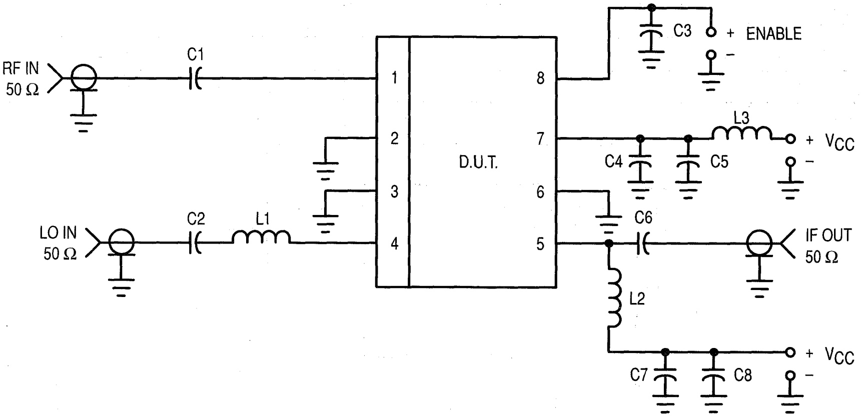
Parameter	Symbol	Value	Unit
Supply Voltage Range	V_{CC}	2.7 to 5.0	Vdc
Control Voltage Range	ENABLE	0 to 5.0	Vdc
RF Port Frequency Range	f_{RF}	500 to 1000	MHz
IF Port Frequency Range	f_{IF}	0 (dc) to 250	MHz

ELECTRICAL CHARACTERISTICS (V_{CC}, ENABLE = 3.0 V, T_A = 25°C, RF @ 900 MHz, LO @ 1.0 GHz, P_{LO} = –7.0 dBm, IF @ 100 MHz unless otherwise noted)

Characteristic (1)	Min	Typ	Max	Unit
Supply Current: On-Mode	—	4.7	5.5	mA
Supply Current: Off-Mode (ENABLE < 1.0 Volts)	—	0.1	2.0	μA
ENABLE Response Time	—	1.0	—	μs
Conversion Gain	20	23	26	dB
Input Return Loss (RF IN Port)	—	13	—	dB
Single Sideband Noise Figure	—	5.5	—	dB
Input 3rd Order Intercept Point	– 26	– 22.5	—	dBm
Output Power at 1.0 dB Gain Compression	—	–10	—	dBm
LO – RF Isolation (1.0 GHz)	—	37	—	dB
LO – IF Isolation (1.0 GHz)	—	33	—	dB
RF – IF Isolation (900 MHz)	—	4.0	—	dB
RF – LO Isolation (900 MHz)	—	19	—	dB

NOTE:

1. All Electrical Characteristics measured in test circuit schematic shown in Figure 1 below:



C1, C2, C4, C7 — 100 pF Chip Capacitor
C3, C5, C8 — 1000 pF Chip Capacitor
C6 — 6.8 pF Chip Capacitor
L1 — 8.2 nH Chip Inductor
L2 — 270 nH Chip Inductor

L3 — 150 nH Chip Inductor
RF Connectors — SMA Type
Board Material — 0.025″ Thick Duroid,
0.062″ Copper Clad, 0.5 oz. Copper, ϵ_r = 10.2

Figure 1. Test Circuit Configuration

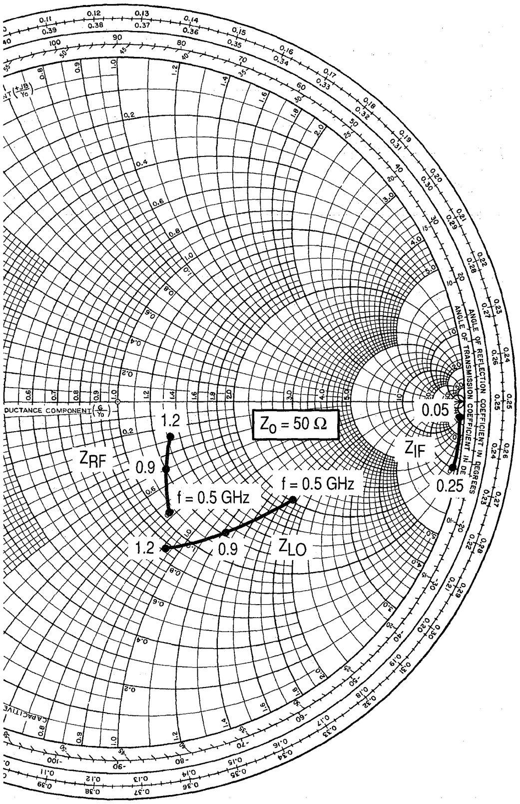


Figure 2. Port Impedances versus Frequency (GHz)

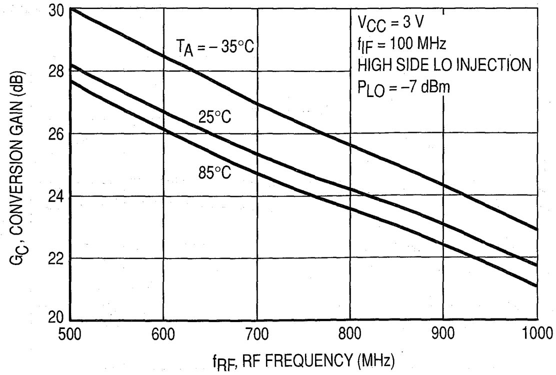


Figure 3. Conversion Gain versus RF Frequency

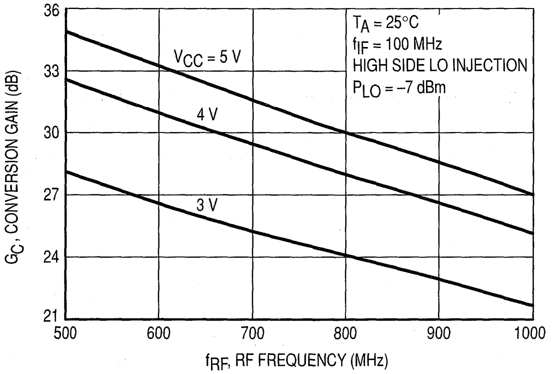


Figure 4. Conversion Gain versus RF Frequency

V_{CC} (Volts)	f (MHz)	Γ_{IF}		Γ_{RF}		Γ_{LO}	
		Mag	∠φ Degrees	Mag	∠φ Degrees	Mag	∠φ Degrees
3.0	50	0.998	– 2.5	—	—	—	—
	100	0.996	– 4.9	—	—	—	—
	150	0.993	– 7.2	—	—	—	—
	200	0.990	–10	—	—	—	—
	250	0.987	–12	—	—	—	—
	500	—	—	0.36	–70	0.58	– 31
	600	—	—	0.32	–70	0.55	– 36
	700	—	—	0.29	– 69	0.53	– 42
	800	—	—	0.26	– 68	0.51	– 48
	900	—	—	0.23	– 63	0.50	– 54
	1000	—	—	0.20	– 58	0.49	– 61
	1100	—	—	0.18	– 51	0.47	– 68
	1200	—	—	0.17	– 44	0.45	– 76

Table 1. Port Reflection Coefficients
(ENABLE = 3.0 V, Z_o = 50 Ω, T_A = 25°C)

TYPICAL CHARACTERISTICS

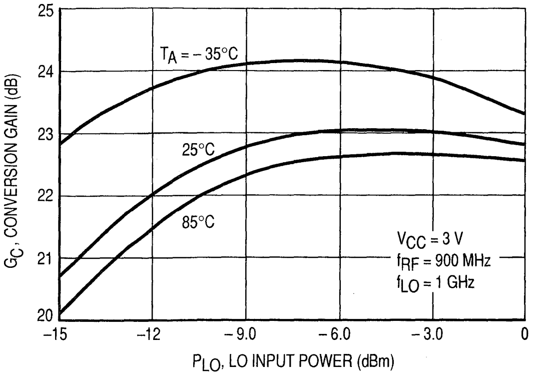


Figure 5. Conversion Gain versus LO Input Power

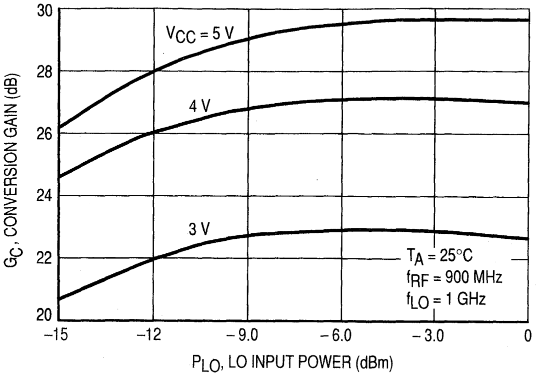


Figure 6. Conversion Gain versus LO Input Power

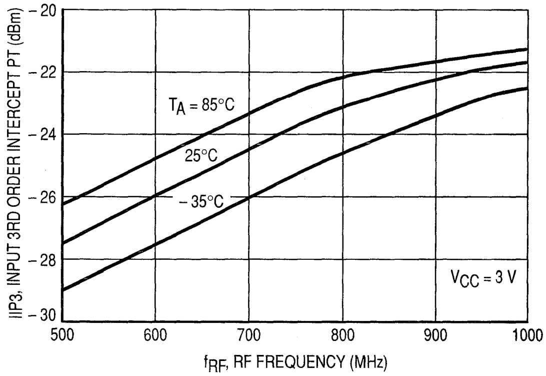


Figure 7. Input Third Order Intercept Point versus RF Frequency

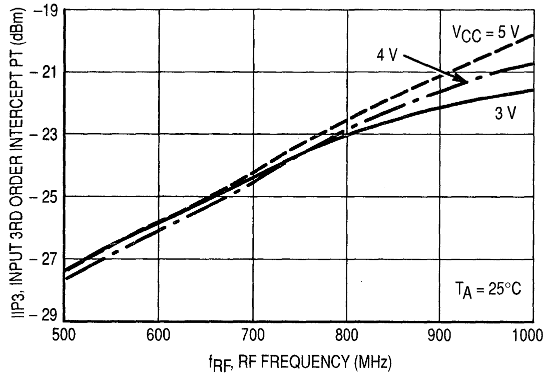


Figure 8. Input Third Order Intercept Point versus RF Frequency

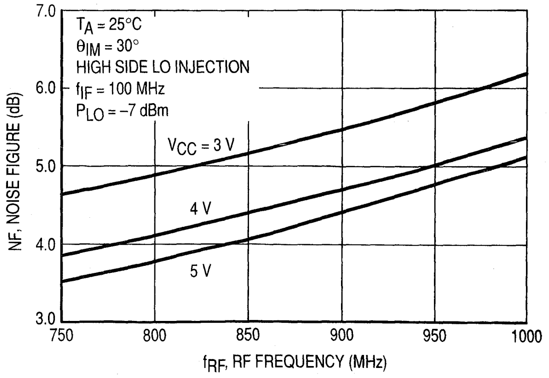


Figure 9. Noise Figure versus RF Frequency

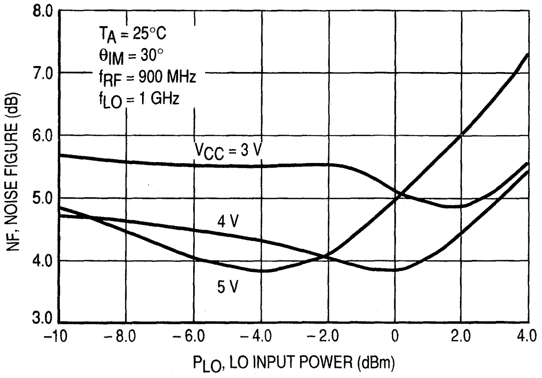


Figure 10. Noise Figure versus LO Input Power

TYPICAL CHARACTERISTICS

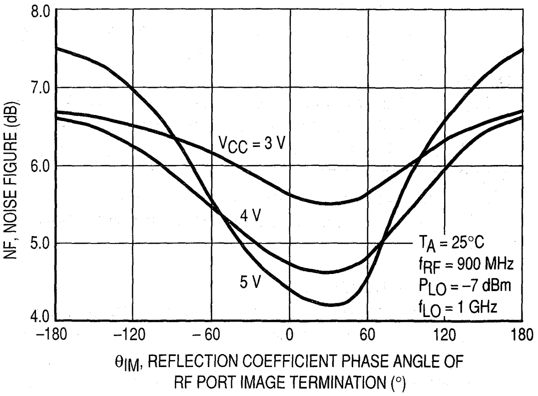


Figure 11. Noise Figure versus Reflection Coefficient Phase Angle of RF Port Image Termination

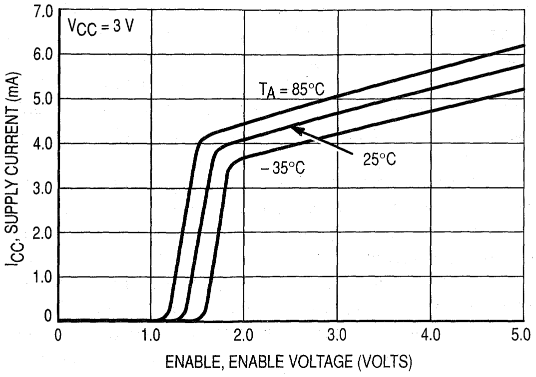


Figure 12. Supply Current versus Enable Voltage

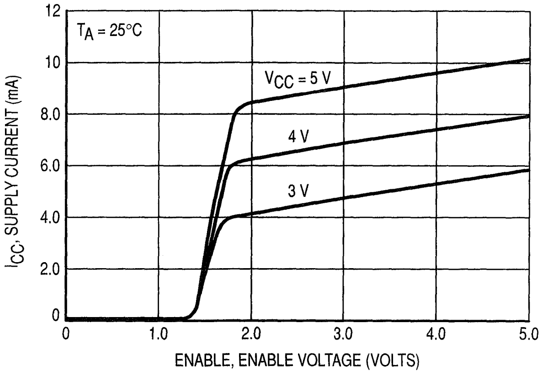


Figure 13. Supply Current versus Enable Voltage

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC2001 was designed for low cost, small size, and ease of use. This is accomplished by minimizing the number of necessary external components.

The most significant external component eliminated was an image filter between the LNA and mixer. It was found the ensuing image noise entering the mixer from the LNA could be minimized by optimizing the LNA input termination at the image frequency. Also, a double-balanced mixer was used to reject the IF noise from the LNA. This results in excellent LO and spurious rejection.

To eliminate the need for external baluns or decoupling elements, the unused LO and RF ports of the mixer are decoupled internally. Only one of the IF outputs is used, eliminating the need for an external balun on the IF port as well. Also, the LNA input is matched to 50 ohms internally. External matching is required for the LO and IF ports.

To minimize current drain in various TDD/TDMA systems, the MRFIC2001 has a TTL/CMOS compatible enable pin.

THEORY OF OPERATION

Optimizing the LNA input termination to minimize image noise is quite simple. The optimum LNA input (RF IN pin) termination is $1\angle 30^\circ$ at the image frequency (regardless of what the image frequency is). A reflection coefficient magnitude close to 1 is automatically obtained from a front-end filter, since the image frequency would be in the stop-band. The 30° phase angle can be obtained by rotating the phase angle of the front-end filter with a series 50 ohm transmission line. The dependance of single-sideband noise figure on the image phase angle is shown in Figure 11. As the plot indicates, there is a little over 1.0 dB of variation across all possible phase angles for a 3.0 V supply. Therefore, setting the phase angle is not critical. At higher supply voltages setting the phase angle is more critical (and more rewarding).

Matching the LO port to 50 ohms can be done several ways. The recommended approach is a series inductor as close to the IC as possible. The inductor value is small enough (~8–15 nH depending on LO frequency) to be printed on the board. A DC block is required and should not be placed between the inductor and IC since this will prevent the inductor from being close enough to the IC to provide a good match.

The IF port is an open collector resulting in a very high output impedance. For optimum linearity (IP3), the IF port should be loaded with a 1000 ohm load-line. Since the output requires a bias inductor and blocking capacitor, the IF filter impedance can be transformed to 1000 ohms with these two elements. If a low output VSWR is desired (to reduce IF filter ripple), a 2.0–4.0 K ohm resistor can be placed in parallel with the bias inductor. This will reduce the conversion gain by 1.0–2.0 dB.

The RF port is nearly 55 ohms resistive in series with a small amount of capacitive reactance, which results in a 12–13 dB return loss. If a higher return loss is desired, a 3.0–4.0 nH series inductor printed on the board as close to the IC as possible will improve it to over 20 dB. A DC block is also required.

Supply decoupling must be done as close to the IC as possible. A 1000 pF capacitor is recommended. An additional 100 pF capacitor and an RF choke are recommended to keep the LO signal off the supply line.

Enabling/Disabling the MRFIC2001 can be done with its TTL/CMOS compatible Enable pin. The trip point is between 1.0 and 2.0 volts.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

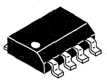
The MRFIC Line
900 MHz Transmit Mixer

MRFIC2002

The MRFIC2002 is a double-balanced, active mixer designed for transmitters operating in the 800 MHz to 1.0 GHz frequency range. The design utilizes Motorola's advanced MOSAIC 3 silicon bipolar RF process to yield superior performance in a cost effective monolithic device. Applications for the MRFIC2002 include CT1 and CT2 cordless telephones, GSM, remote controls, video and audio short range links, low cost cellular radios, and ISM band transmitters. A power down control is provided to minimize current drain with minimum recovery/turn-on time.

- Conversion Gain = 10 dB (Typ)
- Supply Current = 5.5 mA (Typ)
- Power Down Supply Current = 2.0 µA (Max)
- LO-RF Isolation = 25 dB (Typ)
- Low LO Drive Required = –10 dBm (Typ)
- LO Impedance Insensitive to Power Down
- No Matching Required for RF OUT Port
- All Ports are Single Ended
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 12 mm, 13 inch Reel.
- Device Marking = M2002

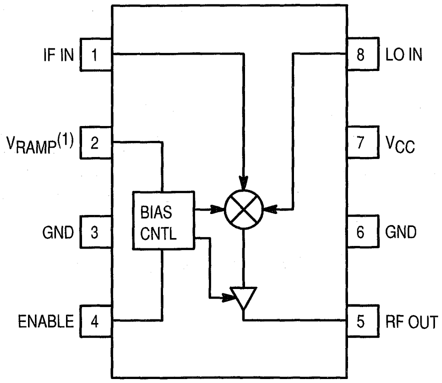
900 MHz TX-MIXER
SILICON MONOLITHIC
INTEGRATED CIRCUIT



CASE 751-05
(SO-8)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	5.5	Vdc
Control Voltages	ENABLE, V_{RAMP}	5.0	Vdc
Input Power, LO and IF Ports	P_{LO}, P_{IF}	+10	dBm
Operating Ambient Temperature	T_A	–35 to +85	°C
Storage Temperature	T_{stg}	–65 to +150	°C



(1) For CT2 applications, apply ramp voltage provided in MRFIC2004. For non-CT2, leave open circuited.

Pin Connections and Functional Block Diagram

REV 1

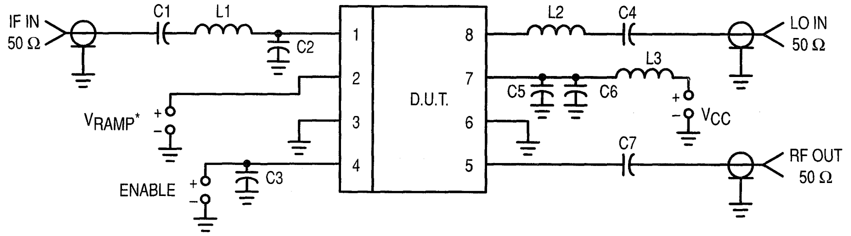
RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
Supply Voltage Range	V_{CC}	2.7 to 5.0	Vdc
Control Voltage Ranges	ENABLE, V_{RAMP}	0 to 5.0	Vdc
RF Port Frequency Range	f_{RF}	500 to 1000	MHz
IF Port Frequency Range	f_{IF}	0 (dc) to 250	MHz

ELECTRICAL CHARACTERISTICS (V_{CC}, Enable = 3.0 V and V_{Ramp}(1) Open Circuited, P_{LO} = −7.0 dBm, IF @ 100 MHz, LO @ 1.0 GHz, RF @ 900 MHz, T_A = 25°C unless otherwise noted)

Characteristic (2)	Min	Typ	Max	Unit
Supply Current: On-Mode	—	5.5	7.0	mA
Supply Current: Off-Mode (Enable < 1.0 V)	—	0.1	2.0	µA
Enable Response Time	—	1.0	—	µs
Conversion Gain	8.0	10	12	dB
Single Sideband Noise Figure	—	10	—	dB
Output Power at 1.0 dB Gain Compression	—	−18	—	dBm
Output Power at Saturation	−16	−14	—	dBm
LO-RF Isolation (1.0 GHz)	—	25	—	dB
LO-IF Isolation (1.0 GHz)	—	65	—	dB
IF-RF Isolation (100 MHz)	—	18	—	dB
IF-LO Isolation (100 MHz)	—	50	—	dB

NOTES:
1. For CT2 applications, apply ramp voltage provided in MRFIC2004. For non-CT2, leave open circuited.
2. All Electrical Characteristics are measured in test circuit schematic as shown in Figure 1.



C1, C3, C6 — 1000 pF Chip Capacitor
C2 — 6.8 pF Chip Capacitor
C4 — 3.9 pF Chip Capacitor
C5 — 100 pF Chip Capacitor
C7 — 5.6 pF Chip Capacitor
L1 — 270 nH Chip Inductor

L2 — 10 nH Chip Inductor
L3 — 390 nH Chip Inductor
RF Connectors — SMA Type
Board Material — 0.025″ Thick Duroid,
0.062″ Copper Clad, 0.5 oz. Copper, ϵ_r = 10.2

Figure 1. Test Circuit Configuration

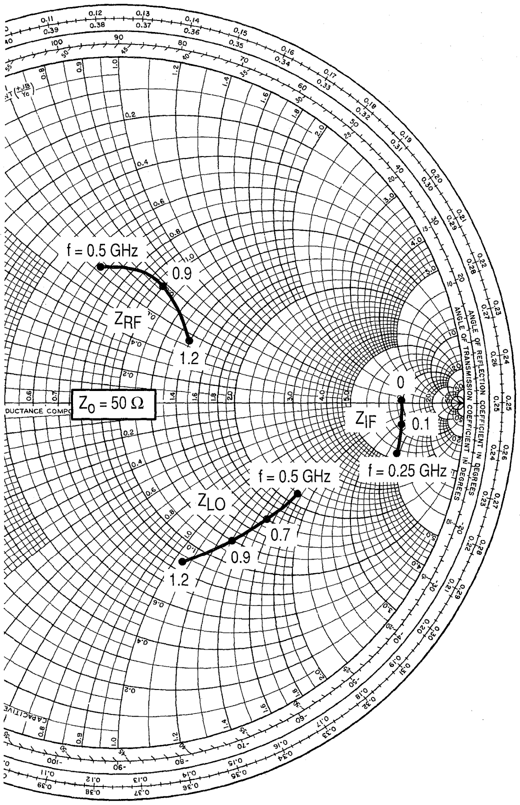


Figure 2. Port Impedances versus Frequency

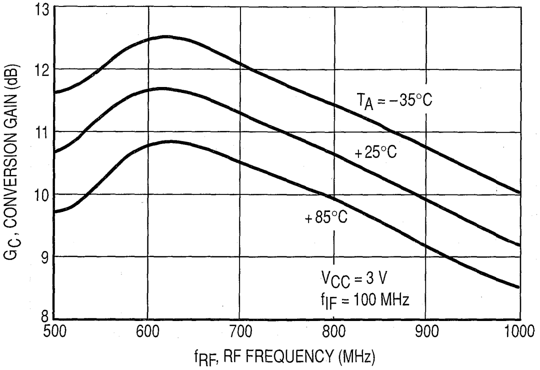


Figure 3. Gain versus RF Frequency

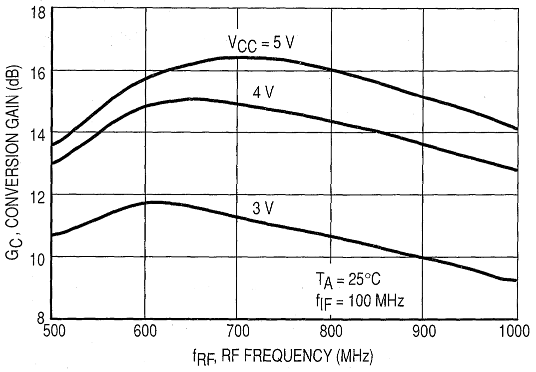


Figure 4. Gain versus RF Frequency

V_{CC} (Volts)	f (MHz)	Γ_{IF}		Γ_{RF}		Γ_{LO}	
		Mag	∠ϕ Degrees	Mag	∠ϕ Degrees	Mag	∠ϕ Degrees
3.0	50	0.83	−2.4	—	—	—	—
	100	0.82	−4.7	—	—	—	—
	150	0.82	−7.1	—	—	—	—
	200	0.81	−9.6	—	—	—	—
	250	0.81	−11.7	—	—	—	—
	500	—	—	0.42	100	0.57	−29
	600	—	—	0.41	94	0.55	−35
	700	—	—	0.40	88	0.54	−41
	800	—	—	0.39	80	0.52	−48
	900	—	—	0.36	71	0.51	−54
	1000	—	—	0.33	63	0.50	−60
	1100	—	—	0.31	55	0.49	−65
	1200	—	—	0.28	45	0.49	−70

Table 1. Deembedded Port Reflection Coefficients
(Enable = 3.0 V, Z_O = 50 Ω, T_A = 25°C)

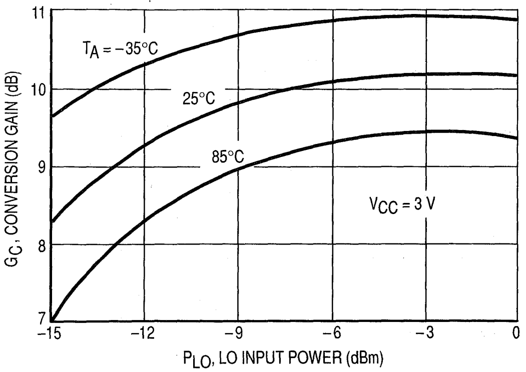


Figure 5. Gain versus LO Input Power

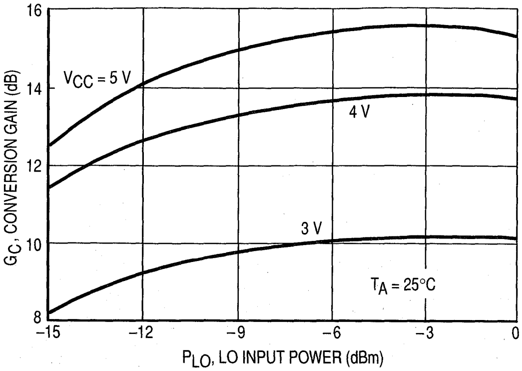


Figure 6. Gain versus LO Input Power

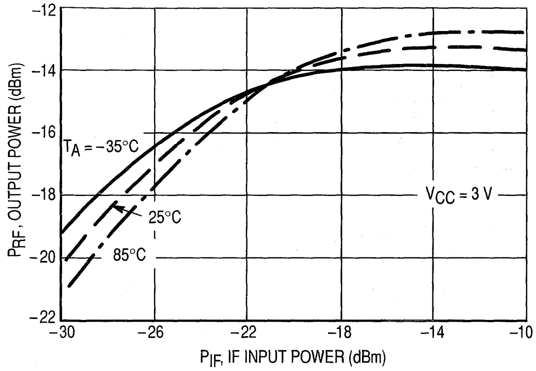


Figure 7. Output Power versus IF Input Power

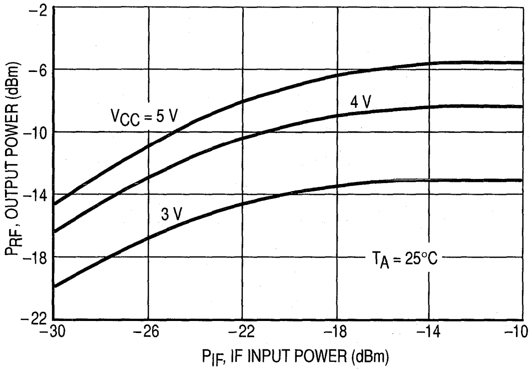


Figure 8. Output Power versus IF Input Power

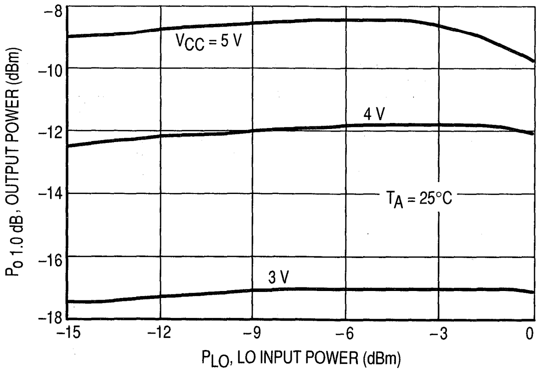


Figure 9. Output Power at 1.0 dB Gain Compression versus LO Input Power

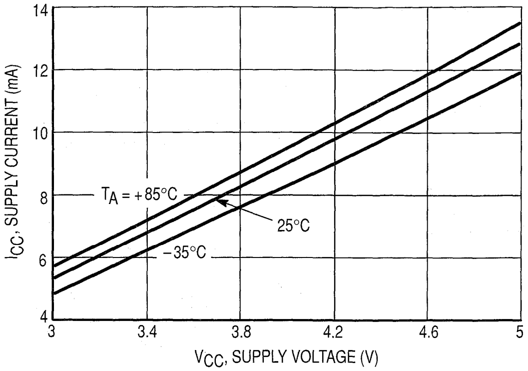


Figure 10. I_{CC} versus V_{CC}

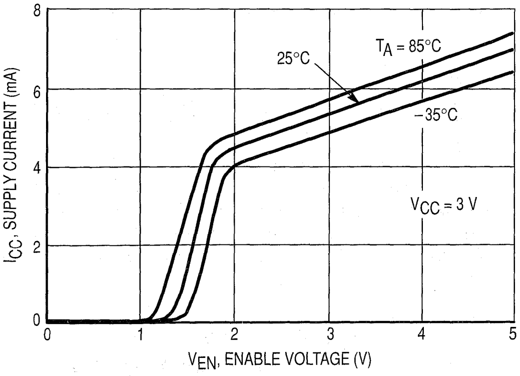


Figure 11. I_{CC} versus Enable Voltage

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC2002 was designed to have excellent LO and spurious rejection. This is accomplished by using a double-balanced configuration and using a symmetrical die layout.

To eliminate the need for external baluns or decoupling elements, the unused LO and IF ports are decoupled internally. Only one of the RF outputs is used, eliminating the need for an external balun on the RF port as well. Also, the RF port is buffered to provide a 50 ohm output impedance. External matching is required for the LO and IF ports.

To minimize current drain in various TDD/TDMA systems, two methods of enabling/disabling the MRFIC2002 are provided: one that is TTL/CMOS compatible and one that is triggered from a ramp, such as the one provided in the MRFIC2004. The former method must be used if a ramp is not available. The latter method is more desirable since the MRFIC2002 can remain off during guard times and while in idle mode.

THEORY OF OPERATION

Matching the LO port to 50 ohms can be done several ways. The recommended approach is a series inductor as close to the IC as possible. The inductor value is small enough (~8−15 nH depending on LO frequency) to be printed on the board. A DC block is required and should not be placed between the inductor and IC since this will prevent the inductor from being placed close enough to the IC to provide a good match.

The IF port is approximately 500 ohms resistive in parallel with 1.3 pF of capacitance. If 50 ohms is the desired IF port impedance, a shunt capacitor followed by a series inductor will provide the transformation. A DC block is required and can be placed on either side of the matching network.

The RF port is nearly 50 ohms resistive in series with a small amount of inductive reactance, which results in an 8−11 dB return loss. However, a series 5.6 pF capacitor placed as close to the IC as possible will typically provide greater than a 15 dB return loss. The series capacitor also serves as a DC block which is required.

Supply decoupling must be done as close to the IC as possible. A 1000 pF capacitor is recommended. An additional 100 pF capacitor and an RF choke are recommended to keep the RF and LO signals off the supply line.

For systems that use a ramp, like the one provided in the MRFIC2004, enabling/disabling can be done by applying the ramp voltage to the V_{RAMP} pin which trips the IC between 0.6 and 1.0 volts. The Enable pin must either be tied high or to the inverse of the receiver enable control line, $\overline{\text{RXEN}}$. An inverter is provided in the MRFIC2004 to invert RXEN.

For systems that do not use a ramp, the V_{RAMP} pin can be left open circuited and enabling/disabling the MRFIC2002 can be done with its TTL/CMOS compatible Enable pin. The trip point is between 1.0 and 2.0 volts.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

The MRFIC Line

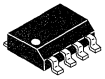
900 MHz GaAs Antenna Switch

MRFIC2003

**900 MHz GaAs
ANTENNA SWITCH
GaAs MONOLITHIC
INTEGRATED CIRCUIT**

The MRFIC2003 is an integrated GaAs SPDT Antenna Switch designed for transceivers operating in the 800 MHz to 1.0 GHz frequency range. The design utilizes Motorola's CS-1 advanced GaAs RF process to yield superior performance in a cost effective monolithic device. Applications for the MRFIC2003 include CT-2 and the ISM band cordless telephones.

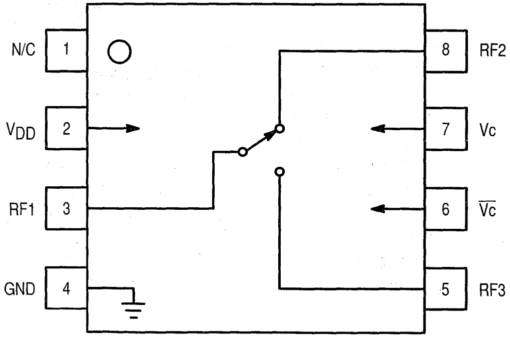
- Surface Mount SO-8 Package
- Low Power Consumption
- 50 mW Power Handling Capability
- Single Source Low Operating Supply Voltage (2.8 – 6.0 Volts)
- Low Cost
- Available in Tape and Reel by Adding R2 suffix to Part Number.
  R2 suffix = 2,500 Units per 12 mm, 13 inch Reel.
- Device Marking = M2003



**CASE 751-05
(SO-8)**

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Voltages, Supply and Control	V_{DD}, Vc, $\overline{Vc}$	6.5	Vdc
Supply Current	I_D	100	µA
Input Power, All Ports (V_{DD} = 3.0 V)	RF1, RF2, RF3	25	dBm
Operating Ambient Temperature	T_A	– 35 to + 85	°C
Storage Temperature	T_{stg}	– 65 to +150	°C



Pin Connections and Functional Block Diagram

REV 1

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
Nominal Impedance	Z_o	50	Ω
Supply Voltage Range	V_{DD}	2.8 to 6.0	Vdc
Control Voltage Range, High	Vc, $\overline{\text{Vc}}$	2.8 to 6.0	Vdc
Control Voltage Range, Low	Vc, $\overline{\text{Vc}}$	0 to 0.2	Vdc
Frequency Range	f	100–1000	MHz

ELECTRICAL CHARACTERISTICS (V_{DD} = 3.0 V, T_A = 25°C, f = 900 MHz, P_{in} = 50 mW (17 dBm) unless otherwise noted)

Characteristic (1)	Min	Typ	Max	Unit
RF1 to RF2 on:				
RF1 SWR	—	1.1:1	1.4:1	
RF2 VSWR	—	1.2:1	1.4:1	
Insertion Loss (RF1/RF2)	—	0.8	1.0	dB
Isolation	19	23	—	dB
RF1 to RF3 on:				
RF1 SWR	—	1.1:1	1.4:1	
RF3 SWR	—	1.1:1	1.4:1	
Insertion Loss (RF1/RF3)	—	0.5	0.8	dB
Isolation	17	20	—	dB
Input Power @ 1.0 dB Compression	—	21	—	dBm

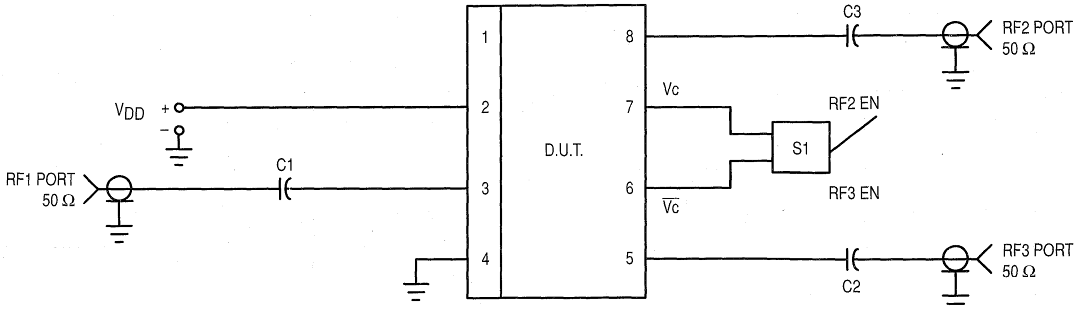
NOTE:
1. All Electrical Characteristics measured in test circuit schematic shown in Figure 1 below.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

Vc	$\overline{\text{Vc}}$	RF1 – RF2	RF1 – RF3
V_{DD}	0 Volts	Isolation	Insertion Loss
0 Volts	V_{DD}	Insertion Loss	Isolation

Table 1. Logic Table



C1, C2, C3 — 100 pF 50 mil Chip Capacitor
S1 — DPDT Switch with Aluminum Switch Bracket
RF Connectors SMA Type
Board Material — 0.025″ Thick Duriod, 0.5 oz. Copper, ϵ_r = 10.2

Figure 1. Test Circuit Configuration

TYPICAL CHARACTERISTICS

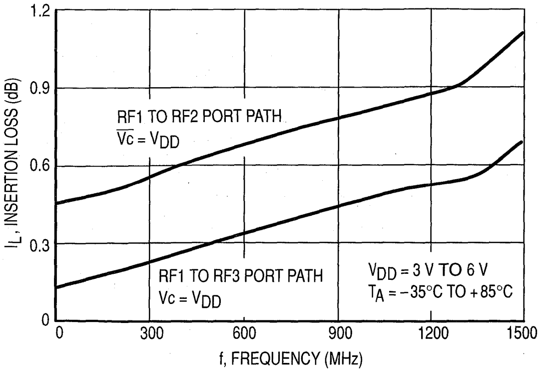


Figure 2. Insertion Loss versus Frequency

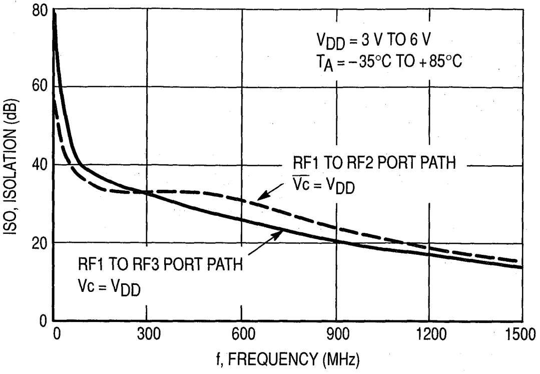


Figure 3. Isolation versus Frequency

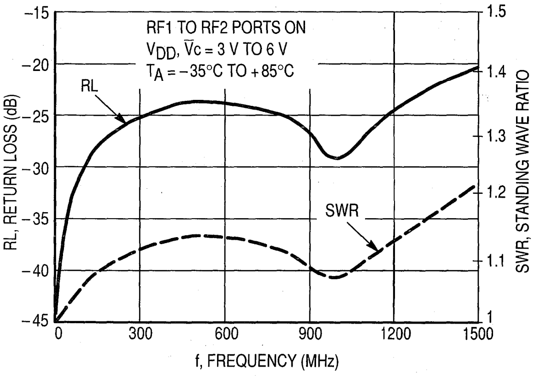


Figure 4. RF1 Port Return Loss and SWR versus Frequency

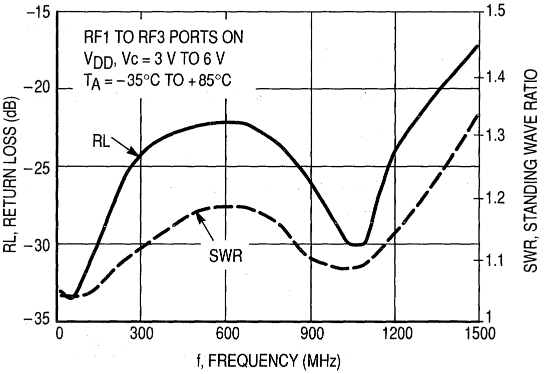


Figure 5. RF1 Port Return Loss and SWR versus Frequency

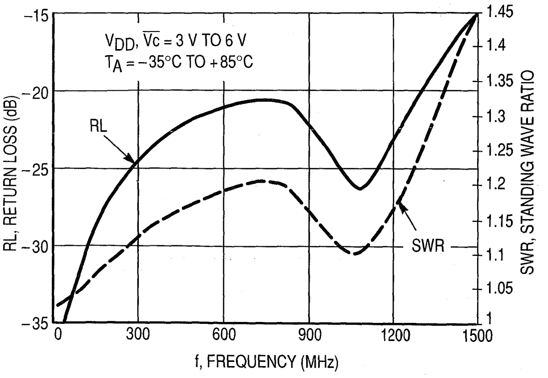


Figure 6. RF2 Port Return Loss and SWR versus Frequency

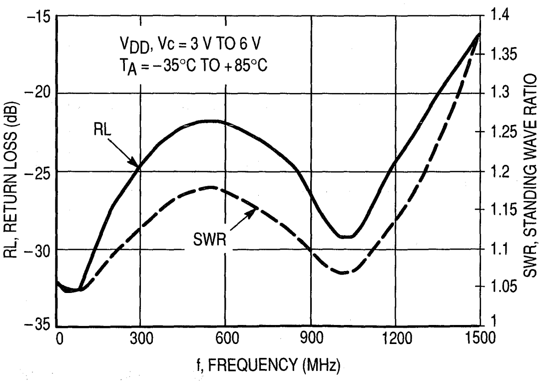


Figure 7. RF3 Port Return Loss and SWR versus Frequency

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The MRFIC Line

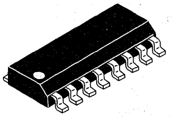
900 MHz Driver and Ramp

MRFIC2004

900 MHz DRIVER
& RAMP
SILICON MONOLITHIC
INTEGRATED CIRCUIT

The MRFIC2004 is an integrated Driver and Ramp designed for transmitters operating in the 800 MHz to 1.0 GHz frequency range. The Ramp is an integrator which can be used for burst control for TDD/TDMA systems. The Driver uses a cascode configuration for high gain and reverse isolation. A power down control is provided to minimize current drain with minimum recovery/turn-on time. Also, an on-board inverter is included to provide complementary control for an antenna switch, such as the MRFIC2003. The design utilizes Motorola's advanced MOSAIC 3 silicon bipolar RF process to yield superior performance in a cost effective monolithic device. Applications for the MRFIC2004 include CT1 and CT2 cordless telephones, GSM, remote controls, video and audio short range links, low cost cellular radios, and ISM band transmitters.

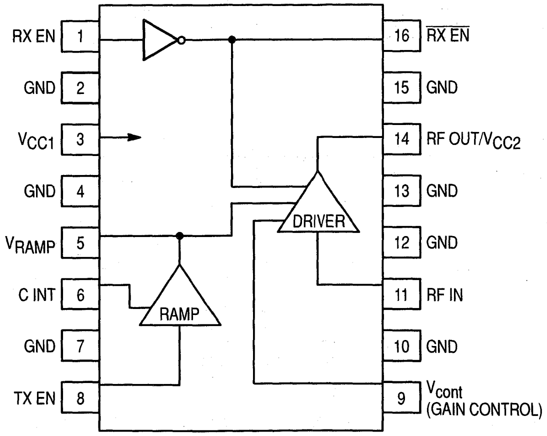
- Small Signal Gain = 21.5 dB (Typ)
- Small Signal Gain Control = 34 dB (Typ)
- $P_{O\ 1.0\ dB}$ = −1.0 dBm (Typ)
- On Board Ramp for Burst Control
- Power Down Supply Current = 0.7 mA (Typ)
- Low Operating Supply Voltage (2.7 to 4.0 Volts)
- Input/Output VSWR Insensitive to Gain Control
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M2004



CASE 751B-05
(SO-16)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltages	V_{CC1} V_{CC2}	4.5 6.0	Vdc
Control Voltages	RXEN, TXEN, V_{cont}	6.0	Vdc
Input Power, RF IN Port	P_{RF}	+10	dBm
Operating Ambient Temperature	T_A	−35 to +85	°C
Storage Temperature	T_{stg}	−65 to +150	°C



Pin Connections and Functional Block Diagram

REV 1

RECOMMENDED OPERATING RANGES

Parameter	Symbol	Value	Unit
Supply Voltage Ranges	V_{CC1}, V_{CC2}	2.7 to 4.0	Vdc
Control Voltage Ranges	TX EN, RX EN, V_{cont}	0 to V_{CC1}	Vdc
Frequency Range	f	800 to 1000	MHz

ELECTRICAL CHARACTERISTICS (V_{CC1}, V_{CC2} = 3.0 V, C_{INT} = 2.0 nF, T_A = 25°C, f = 900 MHz, V_{CONT} = 1.3 V)

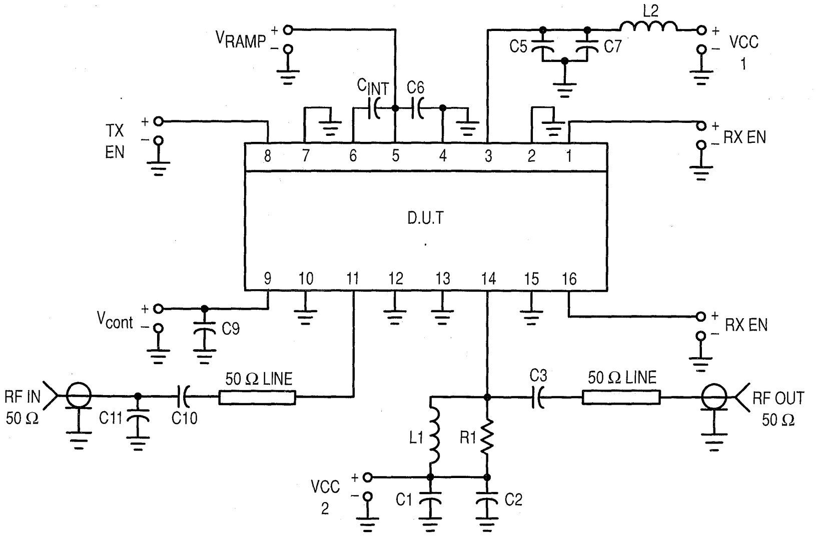
Characteristics (1)	Min	Typ	Max	Unit
Supply Current, TX EN High, RX EN Low	—	11	13	mA
Supply Current, TX EN Low, RX EN High	—	0.7	1.5	mA
Driver Characteristics (1)				
Gain (Small Signal)	19	21.5	24	dB
Gain Control (Small Signal)	—	34	—	dB
Power Out @ 1.0 dB Gain Compression	−4.0	−1.0	—	dBm
Third Order Intercept Point (out)	—	+7.5	—	dBm
Reverse Isolation	—	32	—	dB
Ramp Characteristics (1)				
Ramp Up Delay Time Rise Time Total Time	— — —	4.0 18 22	— — —	µs
Ramp Down Delay Time Fall Time Total Time	— — —	4.0 18 22	— — —	µs

LOGIC LEVELS (V_{CC1} = 2.7 to 4.0 V, T_A = 25°C)

RX EN & TX EN Input Voltage	Min	Typ	Max	Unit
High Low	V_{CC1} − 0.8 —	— —	— 0.8	V
$\overline{\text{RX EN}}$ Output Voltage				
High Low	V_{CC1} − 0.2 —	— —	— 0.2	V

NOTE:

1. All electrical characteristics measured in test circuit schematic shown in Figure 1 below.



C1, C7, C9 — 1000 pF Chip Capacitor
C2, C5, C6, C10 — 100 pF Chip Capacitor
C3 — 1.6 pF Chip Capacitor
C_{INT} — 2000 pF Chip Capacitor

C11 — 6.2 pF Chip Capacitor
L1 — 4.7 nH Chip Inductor
L2 — 150 nH Chip Inductor
R1 — 330 Ω Chip Resistor

RF Connectors — SMA Type
Board Material — 0.025″ Thick Duroid,
0.062″ Copper Clad, 0.5 oz. Copper, ϵ_r = 10.2

Figure 1. Typical Biasing Configuration

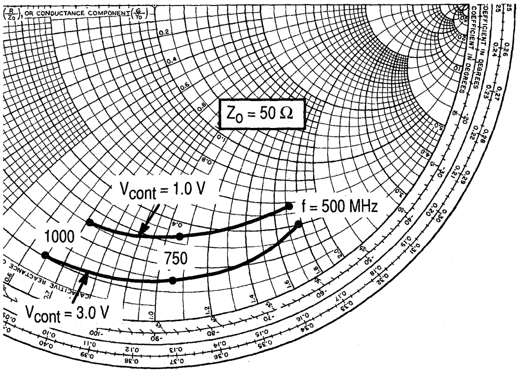


Figure 2. S_{11} versus Frequency versus V_{cont}

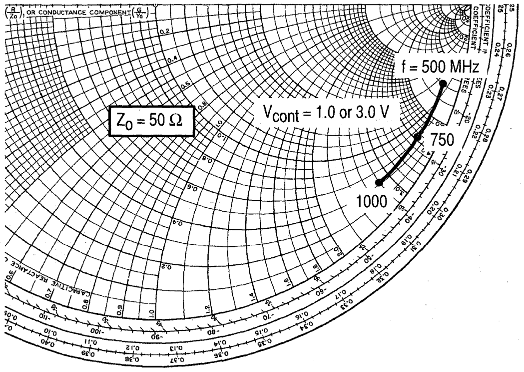


Figure 3. S_{22} versus Frequency

V_{cont}	f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
		$\lvert S_{11}\rvert$	∠ϕ	$\lvert S_{21}\rvert$	∠ϕ	$\lvert S_{12}\rvert$	∠ϕ	$\lvert S_{22}\rvert$	∠ϕ
1.0	100	0.85	−11.3	10.48	171.5	0.0002	142.7	0.99	−2.9
	300	0.83	−32.8	10.33	156.3	0.0020	129.0	0.99	−7.3
	500	0.79	−56.9	10.15	140.5	0.0030	130.6	0.98	−15.9
	550	0.79	−62.5	10.04	135.9	0.0030	132.6	0.98	−17.9
	600	0.78	−68.5	9.85	130.2	0.0040	133.3	0.98	−20.0
	650	0.77	−74	9.47	126.9	0.0040	135.9	0.98	−22.3
	700	0.76	−79	9.23	123.6	0.0050	137.2	0.98	−24.7
	750	0.76	−84.4	9.02	119.4	0.0050	138.1	0.97	−27.0
	800	0.75	−89.6	8.69	113.8	0.0060	139.7	0.97	−29.3
	850	0.74	−94.5	8.33	110.8	0.0070	140.3	0.97	−31.4
	900	0.73	−99.1	8.13	108.9	0.0080	141.2	0.96	−33.2
	950	0.73	−102	7.98	105.4	0.0090	138.3	0.96	−36.3
	1000	0.72	−106.9	7.70	101.0	0.0100	133.7	0.95	−38.4
1.9	100	0.85	−11.3	0.53	−173.5	0.0002	104.3	0.99	−2.9
	300	0.86	−33.5	0.69	−169.7	0.0009	118.7	0.98	−8.7
	500	0.87	−59.3	0.89	−179.5	0.0010	134.3	0.98	−15.5
	550	0.87	−65.7	0.96	175.1	0.0020	136.3	0.98	−17.5
	600	0.88	−73.1	1.02	169.9	0.0020	138.9	0.97	−19.6
	650	0.88	−78.7	1.04	167.3	0.0020	142.6	0.97	−21.8
	700	0.88	−84.7	1.07	165.0	0.0030	147.8	0.97	−24.1
	750	0.89	−90.7	1.14	161.5	0.0030	153.4	0.96	−26.4
	800	0.89	−98.2	1.17	155.8	0.0040	161.0	0.96	−28.8
	850	0.88	−104.6	1.22	151.2	0.0050	161.8	0.96	−30.7
	900	0.87	−110.1	1.24	144.6	0.0060	162.7	0.95	32.8
	950	0.86	−114.6	1.26	139.9	0.0070	160.3	0.95	−35.1
	1000	0.85	−118.8	1.27	134.1	0.0080	158.2	0.94	−37.2
3.0	100	0.85	−10.9	0.003	−85.9	0.0001	115.0	0.99	−2.8
	300	0.86	−31.9	0.014	−78.8	0.0006	121.0	0.99	−8.5
	500	0.87	−56.9	0.032	−61.1	0.0010	128.0	0.98	−15.1
	550	0.88	−62.4	0.038	−65.8	0.0010	136.2	0.98	−17.0
	600	0.89	−69.4	0.048	−68.3	0.0010	140.0	0.98	−19.2
	650	0.90	−75.1	0.058	−75.1	0.0020	145.1	0.98	−21.3
	700	0.90	−81.3	0.069	−82.4	0.0020	150.8	0.97	−23.6
	750	0.91	−87.3	0.081	−89.4	0.0020	156.8	0.97	−25.8
	800	0.91	−93.8	0.092	−113.4	0.0030	160.3	0.97	−28.1
	850	0.92	−100.7	0.092	−121.8	0.0040	163.3	0.96	−30.1
	900	0.91	−106.8	0.089	−128.2	0.0050	163.3	0.96	−32.3
	950	0.90	−111.4	0.083	−137.1	0.0060	155.2	0.95	−34.5
	1000	0.89	−115.2	0.077	−151.9	0.0060	150.0	0.95	−36.6

Table 1. Small Signal Deembedded S Parameters

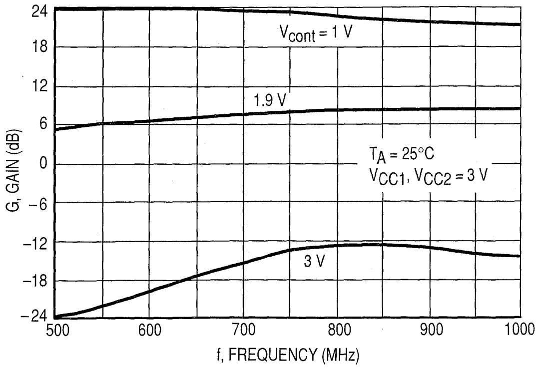


Figure 4. Small Signal Gain versus Frequency

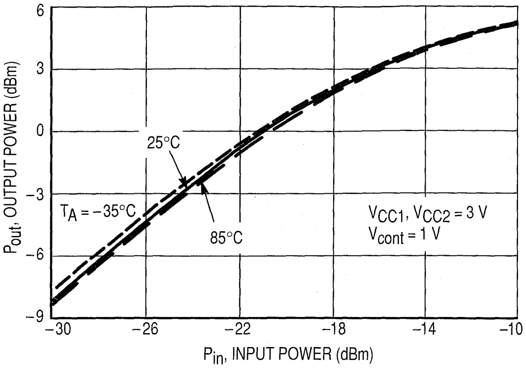


Figure 5. Output Power versus Input Power

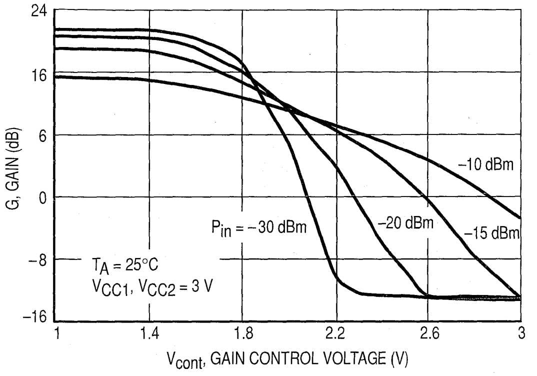


Figure 6. Driver Gain versus Gain Control Voltage

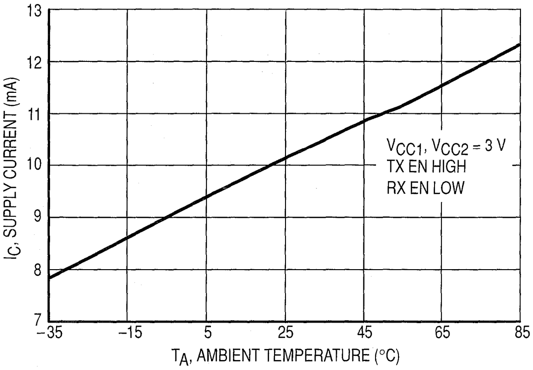


Figure 7. Supply Current versus Ambient Temperature

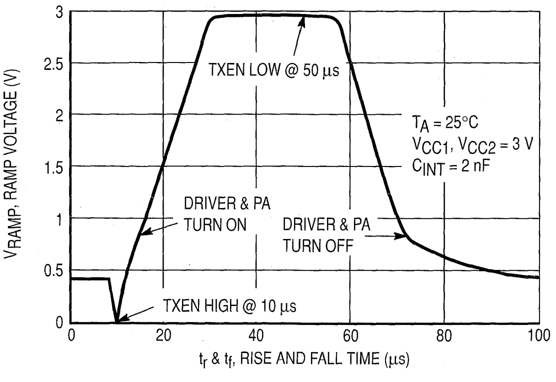


Figure 8. Ramp Voltage versus Rise & Fall Time

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC2004 was designed as a support IC for a CT2 chip-set. The other chips making up the chip-set are the MRFIC2001 downconverter, the MRFIC2002 transmit mixer, the MRFIC2003 antenna switch and the MRFIC2006 PA. A complete CT2 front-end solution requires a ramp for burst control, an inverter for complementary antenna switch control and gain control (or an attenuator) for the transmitter low power mode. In order to keep the other chips in the chip-set relatively general purpose, yet provide the system designer with an easily controlled solution, these functions were combined with a driver amplifier into one IC, the MRFIC2004.

THEORY OF OPERATION

The driver is a cascode design that exits the IC open-collector. Impedance matching must be done externally. Since the output requires a bias inductor and DC blocking capacitor, the output can be matched with these two elements. To keep the driver unconditionally stable, it is recommended that a 300–400 ohm resistor be placed in parallel with the bias inductor as close to the IC as possible. Since the output impedance of the driver by itself is very high, the resistor sets the output impedance. The input can be matched with a series inductor followed by a shunt capacitor. Alternatively, a series transmission line followed by a shunt capacitor can be used. A DC block is also required on the input.

Gain control is provided to meet the CT2 low power mode requirement. The CT2 Common Air Interface specification requires the transmitter to be capable of dropping the output power by 16 ± 4.0 dB. Although the driver has 34 dB of small signal gain control, it can be reduced by adding a resistor in series with the gain control pin. The value of the resistor depends on the logic levels being used and the amount of gain compression after the driver. Also, the amount of gain control is a function of the driver input power level. The input power should be kept less than –10 dBm to allow for sufficient gain control to achieve the low power mode. The gain control can also be used for PA output power trimming. However, this is not an efficient method.

The ramp is an integrator which is used to slow down the driver and PA turn-on and turn-off times to reduce AM splatter. By applying a pulse waveform to the input, a linear ramp waveform is created at the output which is then applied to the current mirrors of the driver and PA. An external integrating capacitor is used so that the rise/fall time can be programmed externally. A minimum value of 2.0–2.4 nF is needed to meet the CT2 Common Air Interface splatter specification. For non-TDD/TDMA systems the ramp reverts to an enable/disable function.

The inverter is CMOS/TTL compatible and was included to provide complementary control for an antenna switch such as the MRFIC2003. By applying the receiver enable control line, RXEN, to the inverter the inverse $\overline{\text{RXEN}}$ will be created. RXEN and $\overline{\text{RXEN}}$ can then be used to control the MRFIC2003 antenna switch.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The MRFIC Line

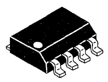
900 MHz 2 Stage PA

MRFIC2006

900 MHz 2 STAGE PA
SILICON MONOLITHIC
INTEGRATED CIRCUIT

The MRFIC2006 is an Integrated PA designed for linear operation in the 800 MHz to 1.0 GHz frequency range. The design utilizes Motorola's advanced MOSAIC 3 silicon bipolar RF process to yield superior performance in a cost effective monolithic device. Applications for the MRFIC2006 include CT-1 and CT-2 cordless telephones, remote controls, video and audio short range links, low cost cellular radios, and ISM band transmitters.

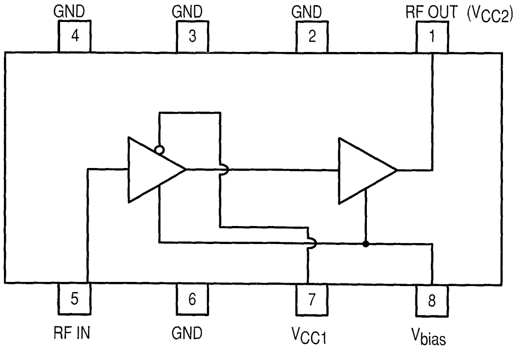
- 50 Ω Input and Output Impedance
- Typical Gain = 23 dB @ 900 MHz
- Bias Current Externally Adjustable
- Bias Pin can be used to Ramp or Disable
- Class A or AB Linear Operation
- Unconditionally Stable
- SO-8 Leaded Plastic Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 12 mm, 13 inch Reel.
- Device Marking = M2006



CASE 751-05
(SO-8)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C, Z_o = 50 Ω unless otherwise noted)

Rating	Symbol	Value	Unit
Supply Voltages	V_{CC1}, V_{CC2}	5.0	Vdc
Bias Voltage	V_{bias}	6.0	Vdc
Total Supply Current	I_{CC1}, I_{CC2}	100	mA
RF Output Power ($V_{CC2} < 4.0$ V)	P_{out}	+21	dBm
RF Output Power (4.0 V < $V_{CC2} \leq 5.0$ V)	P_{out}	53 – 8 V_{CC2}	dBm
RF Input Power	P_{in}	+10	dBm
Operating Ambient Temperature	T_A	– 35 to + 85	°C
Storage and Junction Temperature	T_{stg}	– 65 to +150	°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	63	°C/W



Pin Connections and Functional Block Diagram

REV 1

RECOMMENDED OPERATING RANGES

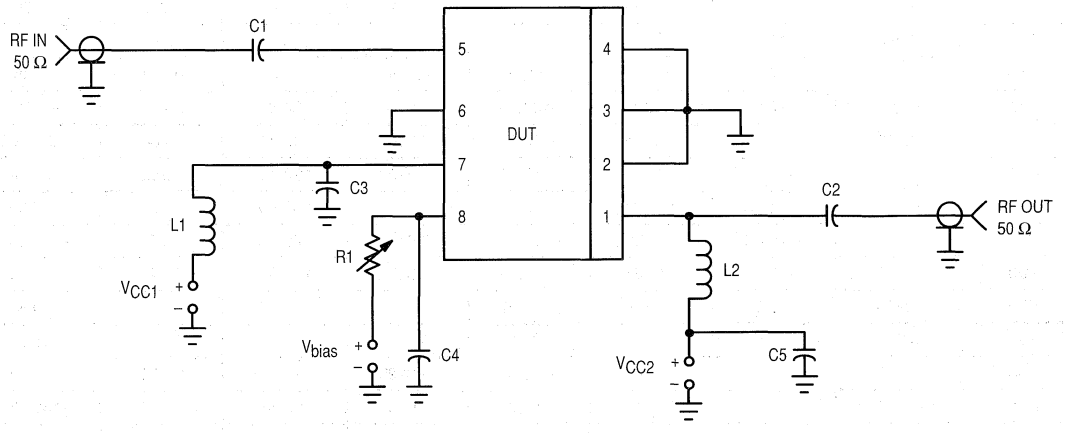
Parameter	Symbol	Value	Unit
Supply Voltage Ranges	V_{CC1}, V_{CC2}	1.8 to 4.0	Vdc
Bias Voltage Range	V_{bias}	0 to 5.0	Vdc
RF Frequency Range	f	500 to 1000	MHz

ELECTRICAL CHARACTERISTICS (V_{CC1}, V_{CC2}, V_{bias} = 3.0 V, T_A = 25°C, f = 900 MHz, Z_o = 50 Ω unless otherwise noted)

Characteristics (1)	Min	Typ	Max	Unit
Supply Current — Total	—	46	55	mA
I_{CC1}	—	14	—	mA
I_{CC2}	—	29	—	mA
I Bias	—	3.0	—	mA
Small Signal Gain	19	23	26	dB
Input Return Loss, RF IN Port	—	15	—	dB
Output Return Loss, RF OUT Port	—	15	—	dB
Reverse Isolation	—	35	—	dB
Output Power at 1.0 dB Gain Compression	+12	+15.5	—	dBm
3rd Order Intercept Point (Out)	—	+ 25	—	dBm
5th Order Intercept Point (Out)	—	+ 21	—	dBm

NOTE:

1. All electrical characteristics measured in test circuit schematic shown in Figure 1 below.



C1, C2 — 100 pF Chip Capacitor
C3, C5 — 1.0 nF Chip Capacitor
C4 — 10 nF Chip Capacitor
L1 — 150 nH Chip Inductor
L2 — 10 nH Chip Inductor

R1 — Resistor Optional
RF Connectors — SMA Type
Board Material — 0.025″ Thick Duroid, 0.062″
Copper Clad 0.5 oz. Copper, ϵ_r = 10.2

Figure 1. Typical Biasing Configuration

Table 1. Scattering Parameters for 900 MHz Two–Stage PA

(V_{CC1}, V_{CC2}, V_{BIAS} = 3 V, I = 49 mA, T_A = 25°C, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
50	0.739	–16.67	3.785	51.56	0.003	–163.12	0.461	–89.23
100	0.702	–24.53	5.772	46.52	0.001	15.96	0.354	–117.30
150	0.671	–33.09	7.901	40.16	0.001	84.34	0.263	–144.77
200	0.649	–41.55	10.065	32.12	0.001	–165.89	0.208	–167.08
250	0.630	–49.79	12.287	23.06	0.002	–159.68	0.169	170.65
300	0.610	–58.60	14.576	12.25	0.002	171.75	0.136	145.40
350	0.592	–67.09	16.834	1.32	0.003	–160.23	0.113	113.52
400	0.567	–75.32	19.009	–10.72	0.005	–167.93	0.105	73.18
450	0.537	–83.69	20.901	–23.88	0.005	167.71	0.122	33.86
500	0.495	–91.79	22.237	–37.89	0.007	159.88	0.157	2.30
525	0.470	–95.35	22.626	–45.02	0.007	168.37	0.178	–10.93
550	0.448	–98.65	22.821	–52.22	0.010	162.65	0.196	–22.73
575	0.421	–101.69	22.834	–59.20	0.009	159.52	0.216	–32.62
600	0.397	–104.40	22.647	–66.13	0.010	155.15	0.233	–42.62
625	0.371	–106.50	22.299	–73.01	0.011	151.24	0.246	–50.98
650	0.349	–108.28	21.813	–79.43	0.011	148.14	0.258	–59.21
675	0.329	–109.85	21.204	–85.70	0.012	145.35	0.269	–66.61
700	0.310	–111.02	20.538	–91.62	0.012	140.66	0.273	–73.29
725	0.293	–111.65	19.824	–97.20	0.014	136.88	0.280	–79.97
750	0.278	–112.24	19.094	–102.54	0.014	136.98	0.281	–85.86
775	0.265	–112.60	18.334	–107.76	0.014	134.67	0.285	–91.50
800	0.252	–112.81	17.594	–112.54	0.016	133.71	0.284	–96.72
825	0.242	–113.50	16.880	–117.13	0.015	129.16	0.282	–102.24
850	0.233	–114.93	16.127	–122.44	0.017	131.80	0.281	–107.68
875	0.224	–115.32	15.438	–126.92	0.017	126.66	0.279	–112.88
900	0.216	–116.04	14.796	–130.89	0.017	127.06	0.275	–117.56
925	0.210	–116.66	14.165	–134.57	0.018	121.77	0.273	–120.85
950	0.203	–117.91	13.555	–138.19	0.019	122.40	0.269	–125.53
975	0.195	–118.87	13.009	–141.73	0.019	120.80	0.265	–129.73
1000	0.191	–120.47	12.515	–145.08	0.019	122.53	0.265	–132.68
1025	0.186	–122.39	12.004	–148.23	0.020	119.56	0.259	–137.22
1050	0.179	–124.03	11.517	–151.36	0.022	115.24	0.254	–140.85
1075	0.175	–126.22	11.063	–154.40	0.022	117.88	0.251	–144.69
1100	0.168	–128.77	10.634	–157.40	0.024	112.04	0.248	–148.25
1125	0.163	–131.41	10.228	–160.15	0.023	112.42	0.246	–151.75
1150	0.161	–133.93	9.841	–163.04	0.023	115.77	0.245	–155.28
1175	0.155	–136.68	9.479	–165.88	0.025	110.34	0.241	–158.69
1200	0.152	–140.85	9.125	–168.50	0.025	109.94	0.241	–161.95

TYPICAL CHARACTERISTICS

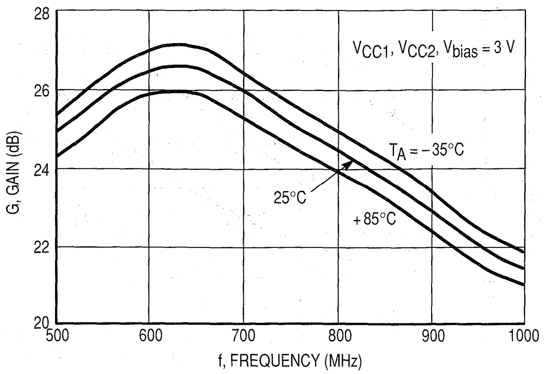


Figure 2. Gain versus Frequency

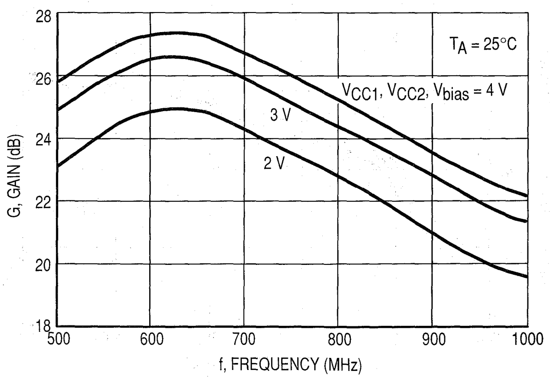


Figure 3. Gain versus Frequency

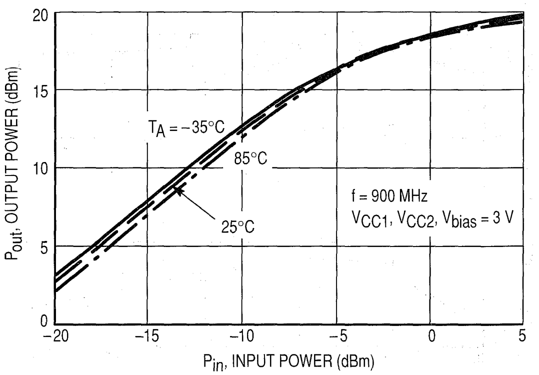


Figure 4. Output Power versus Input Power

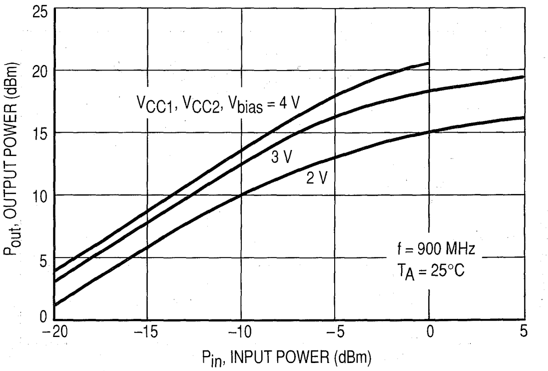


Figure 5. Output Power versus Input Power

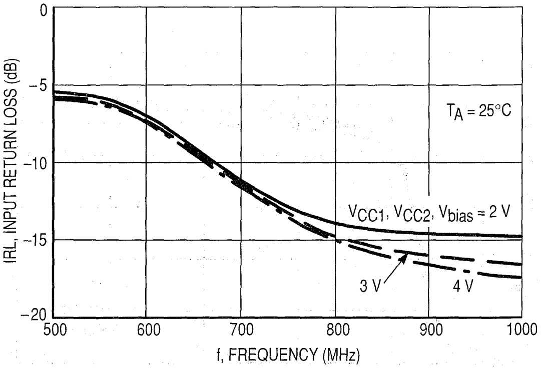


Figure 6. Input Return Loss versus Frequency

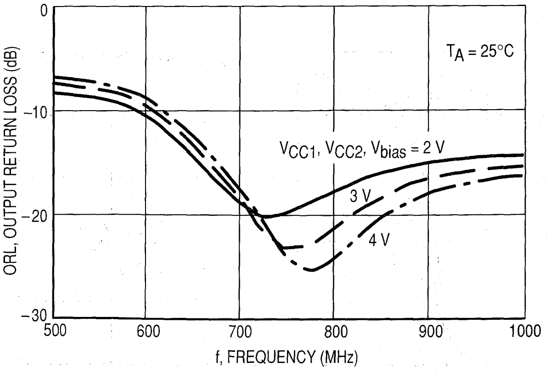


Figure 7. Output Return Loss versus Frequency

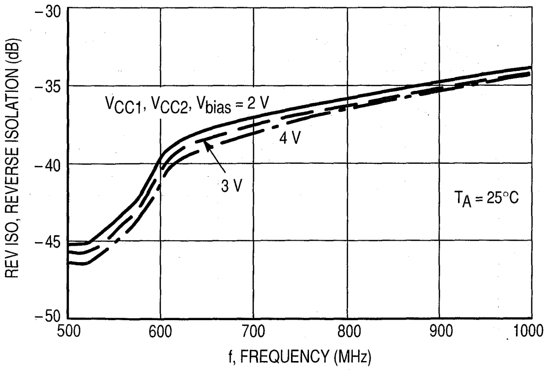


Figure 8. Reverse Isolation versus Frequency

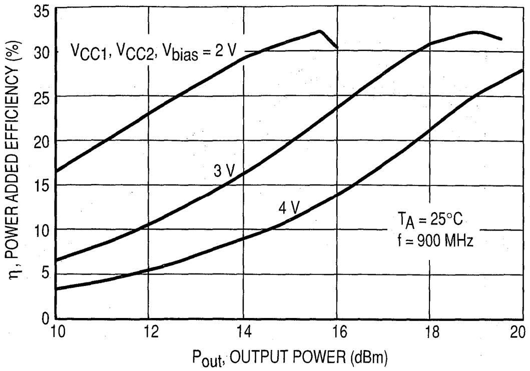


Figure 9. Power Added Efficiency versus Output Power

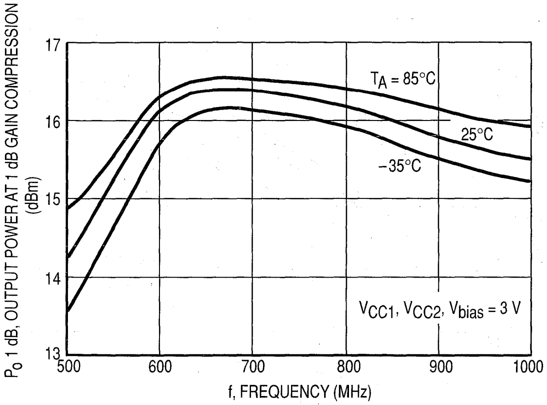


Figure 10. Output Power at 1 dB Gain Compression versus Frequency

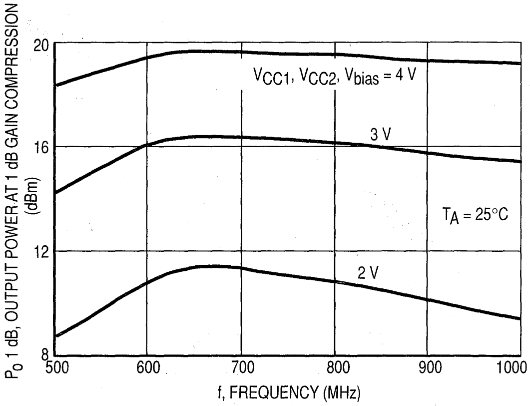


Figure 11. Output Power at 1 dB Gain Compression versus Frequency

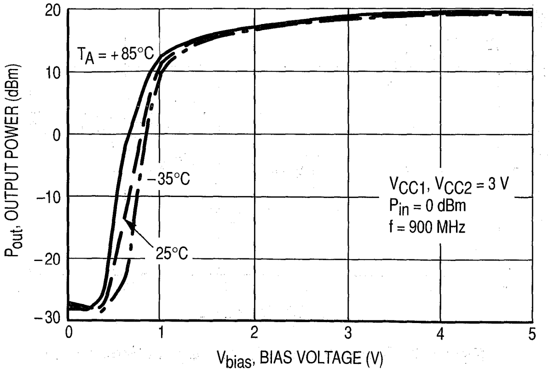


Figure 12. Output Power versus Bias Voltage

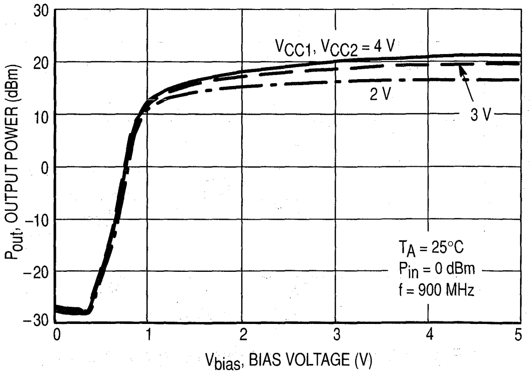


Figure 13. Output Power versus Bias Voltage

TYPICAL CHARACTERISTICS

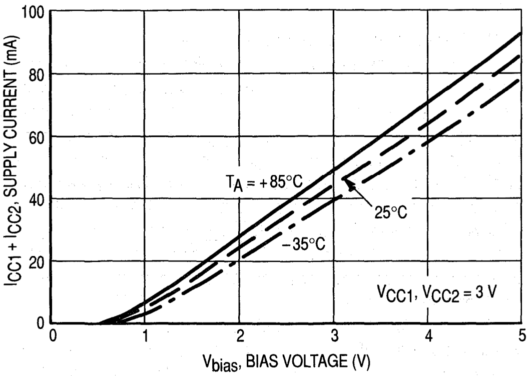


Figure 14. Supply Current versus Bias Voltage

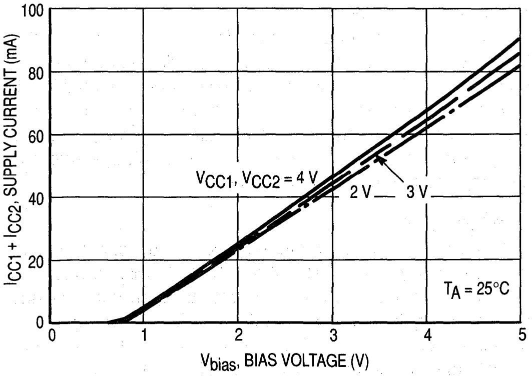


Figure 15. Supply Current versus Bias Voltage

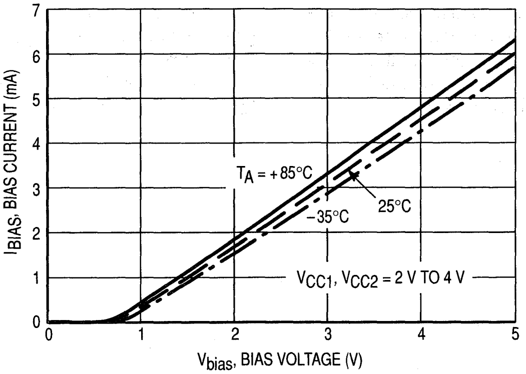


Figure 16. Bias Current versus Bias Voltage

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC2006 was designed for low cost and flexibility. Low cost was achieved by minimizing external components and using an SOIC package. Flexibility was achieved by allowing the bias current to be externally adjustable resulting in a broad range of output power capability. The bias pin can be ramped to reduce AM splatter in TDD/TDMA systems and can be used to trim the RF output power.

THEORY OF OPERATION

The input port is internally matched to 50 ohms. Return loss is typically 15–16 dB in the 800–1000 MHz range. The output port is nearly 50 ohms but is an open collector and therefore requires an external bias inductor. Using an RF choke will result in a 11–12 dB output return loss. However, a 10 nH inductor will improve it to 15–20 dB. A 10 nH inductor is small enough in value to be printed on the board. DC blocks are required on the input and output. Values of 100 pF are recommended.

Supply decoupling must be done as close to the IC as possible. A 1000 pF capacitor is recommended. A series RF choke is recommended to keep the RF signal off the supply line. A 10 nF decoupling capacitor is recommended on the V_{bias} line but does not need to be very close to the IC.

The V_{bias} pin can be used several ways. Tying it directly to V_{CC} will maximize the bias current which will maximize linearity. Adding a series resistor will reduce the bias current which will improve efficiency. Figure 9 shows the efficiency versus output power with V_{bias} tied to V_{CC}. The series resistor will cause these curves to shift to the left. The RF output power can be trimmed by using a variable resistor. The V_{bias} pin can also be used to power down the IC or, in the case of TDD/TDMA systems, to ramp the IC. By applying a linear ramp voltage, such as the one provided by the MRFIC2004, it has been demonstrated to meet the CT2 Common Air Interface splatter specifications.

The MRFIC2006 is internally temperature compensated. For input powers of −5.0 to 0 dBm the output power temperature variation is typically less than 0.2 dB from −35 to +85°C.

EVALUATION BOARDS

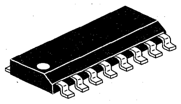
Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The MRFIC Line
900 MHz TX-Mixer/Exciter

MRFIC2101

900 MHz
TX-MIXER/EXCITER
SILICON MONOLITHIC
INTEGRATED CIRCUIT



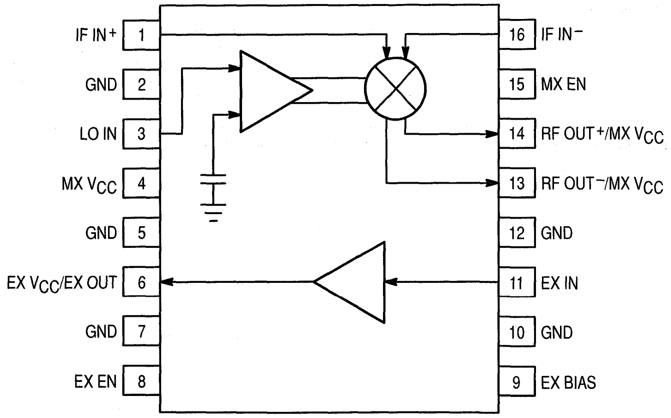
CASE 751B-05
(SO-16)

The MRFIC2101 is a transmit mixer and exciter designed primarily for United States and Japan Digital Cellular radio systems. The mixer is double-balanced for excellent LO and spurious rejection. An on-board LO buffer is provided to reduce LO power requirements and eliminate the need for an external LO balun. A power down control is provided to minimize current drain with minimum recovery/turn-on time. The design utilizes Motorola's advanced MOSAIC 3 silicon bipolar RF process to yield superior performance in a cost effective monolithic device.

- High Linearity $IP3_O$ = 23 dBm (Typ)
- Low LO Drive Required = –15 dBm (Typ)
- Externally Adjustable Exciter Bias Current
- Power Down Supply Current = 2.0 μA (Typ)
- SO-16 Narrow Body Plastic Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M2101

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Ratings	Symbol	Value	Unit
Supply Voltage	EX V_{CC}, MX V_{CC}, EX BIAS	5	Vdc
Enable Voltages	MX EN, EX EN	6	Vdc
Input Power, LO and IF Ports	P_{LO}, P_{IF}	+10	dBm
Operating Ambient Temperature	T_A	– 35 to + 85	°C
Storage Temperature	T_{stg}	– 65 to +150	°C
RF Output Power (EX V_{CC} < 4 V)	P_{out}	18	dBm
RF Output Power (4 V< EX V_{CC} ≤ 5 V)	P_{out}	38 – 5 EX V_{CC}	dBm



Pin Connections and Functional Block Diagram

REV 2

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Supply Voltages	EX V_{CC}, MX V_{CC}, EX BIAS	4.75	Vdc
Enable Voltages	MX EN, EX EN	0, 4.75	Vdc
RF Port Frequency Range	RF	800 to 1000	MHz
IF Port Frequency Range	IF	0 to 250	MHz

LOGIC LEVELS (T_A = 25°C)

Input Voltage (MX EN, EX EN)	Min	Max	Unit
High	MX V_{CC} –0.8, EX V_{CC} –0.8	—	Volts
Low	—	0.8	Volts

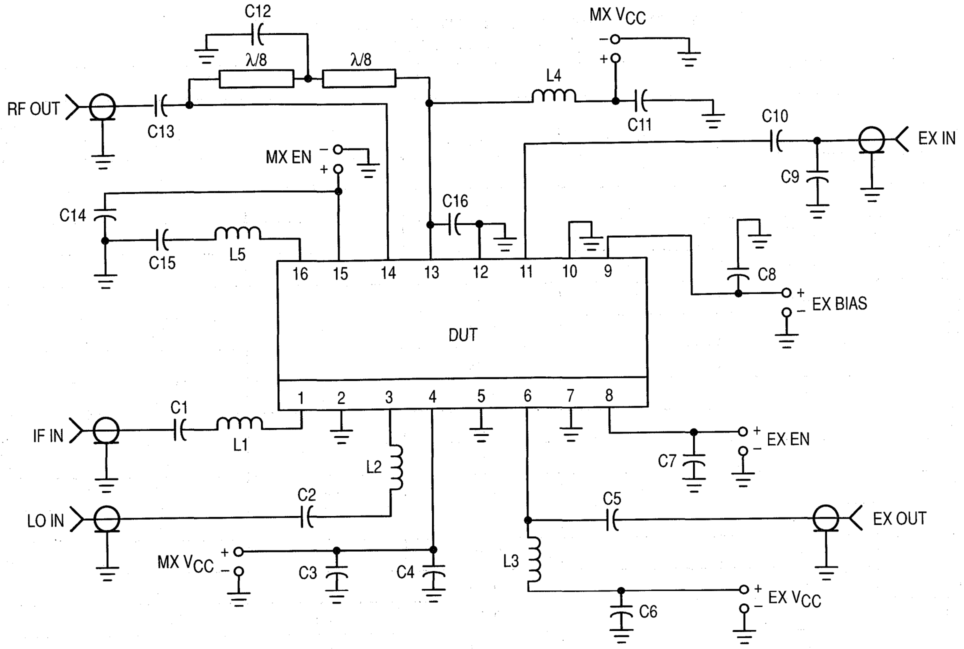
MIXER ELECTRICAL CHARACTERISTICS (MX V_{CC}, MX EN = 4.75 V, T_A = 25°C, RF @ 900 MHz, LO @ 800 MHz, IF @ 100 MHz, P_{LO} = –15 dBm unless otherwise noted)

Characteristic (1)	Min	Typ	Max	Unit
Conversion Gain (Small Signal)	24	26.5	29	dB
Output Power at 1 dB Gain Compression	2.5	4.5	—	dBm
Output Third Order Intercept Point (– 5 dBm out/tone)	—	14	—	dBm
Output Fifth Order Intercept Point (– 5 dBm out/tone)	—	11	—	dBm
LO Leakage	—	– 30	—	dBm
Supply Current (Enabled)	—	45	54	mA
Supply Current (Disabled)	—	1	—	µA
Noise Figure (Single Sideband)	—	5	—	dB

EXCITER ELECTRICAL CHARACTERISTICS (EX V_{CC}, EX EN, EX BIAS = 4.75 V, T_A = 25°C, RF @ 900 MHz unless otherwise noted)

Characteristic (1)	Min	Typ	Max	Unit
Gain (Small Signal)	14	16	18	dB
Output Power at 1 dB Gain Compression	16	18	—	dBm
Output Third Order Intercept Point (+ 3 dBm out/tone)	—	30	—	dBm
Output Fifth Order Intercept Point (+ 3 dBm out/tone)	—	22	—	dBm
LO Leakage (P_{LO} = –15 dBm into Mixer)	—	– 30	—	dBm
Supply Current (Enabled)	—	38	46	mA
Supply Current (Disabled)	—	1	—	µA
Noise Figure	—	5	—	dB

(1) All electrical characteristics are measured in test circuit schematic as shown in Figure 1.



C1, C2, C3,	1000 pF, Chip Capacitor	L1, L5	82 nH, Chip Inductor
C4	100 pF, Chip Capacitor	L2	15 nH, Chip Inductor
C5, C6, C7	1000 pF, Chip Capacitor	L3	8.2 nH, Chip Inductor
C8, C10, C11	1000 pF, Chip Capacitor	L4	12 nH, Chip Inductor
C9, C12	5.6 pF, Chip Capacitor	RF Connectors	SMA Type
C13, C16	2.7 pF, Chip Capacitor	Board Material	0.031″ Thick FR4, 0.5 oz. Copper, ε_r = 4.45, Coplanar Waveguide
C14, C15	1000 pF, Chip Capacitor		

Figure 1. Test Circuit Configuration

Table 1. Mixer Deembedded Port Reflection Coefficients
(Z_O = 50 Ω, T_A = 25°C)

f (MHz)	Γ_{IF}		Γ_{RF}		Γ_{LO}	
	Mag	∠φ Degrees	Mag	∠φ Degrees	Mag	∠φ Degrees
50	0.68	–9.4	—	—	—	—
100	0.68	–18	—	—	—	—
150	0.67	–26	—	—	—	—
200	0.66	–33	—	—	—	—
250	0.65	–40	—	—	—	—
500	—	—	0.93	–28	0.79	–30
600	—	—	0.92	–33	0.79	–32
700	—	—	0.91	–37	0.79	–33
800	—	—	0.89	–41	0.77	–34
900	—	—	0.87	–45	0.75	–34
1000	—	—	0.85	–48	0.73	–35
1100	—	—	0.82	–50	0.69	–36
1200	—	—	0.79	–53	0.65	–37
1300	—	—	0.75	–56	0.61	–41
1400	—	—	0.71	–61	0.56	–47
1500	—	—	0.66	–66	0.52	–55

Table 2. Exciter Small Signal Deembedded S Parameters
(Z_O = 50 Ω, T_A = 25°C)

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11}\rvert$	∠φ	$\lvert S_{21}\rvert$	∠φ	$\lvert S_{12}\rvert$	∠φ	$\lvert S_{22}\rvert$	∠φ
100	0.51	−121	35.51	131	0.02	50	0.65	−67
200	0.62	−149	22.61	109	0.03	42	0.49	−103
300	0.65	−162	16.05	96	0.03	41	0.43	−122
400	0.65	−170	12.16	87	0.04	41	0.40	−134
500	0.63	−177	9.75	81	0.04	42	0.38	−141
600	0.61	176	8.18	75	0.05	41	0.37	−146
700	0.59	169	7.06	70	0.05	40	0.36	−149
800	0.58	161	6.18	65	0.06	38	0.35	−153
900	0.58	154	5.44	60	0.07	33	0.35	−156
1000	0.59	145	4.91	55	0.07	30	0.35	−163
1100	0.61	139	4.39	51	0.08	27	0.35	−170
1200	0.65	134	3.94	47	0.08	22	0.35	−177
1300	0.67	131	3.56	43	0.08	20	0.37	174
1400	0.69	129	3.22	39	0.09	16	0.40	166
1500	0.71	127	2.92	36	0.09	13	0.43	160

TYPICAL CHARACTERISTICS

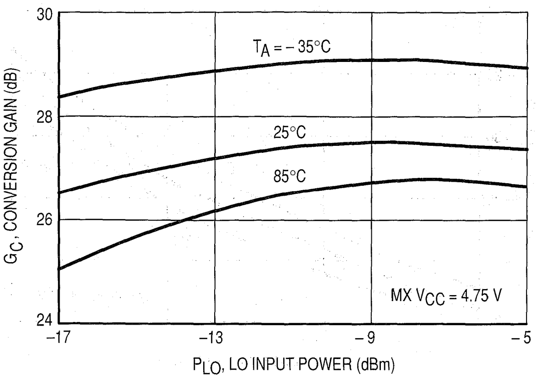


Figure 2. Mixer Gain versus LO Input Power

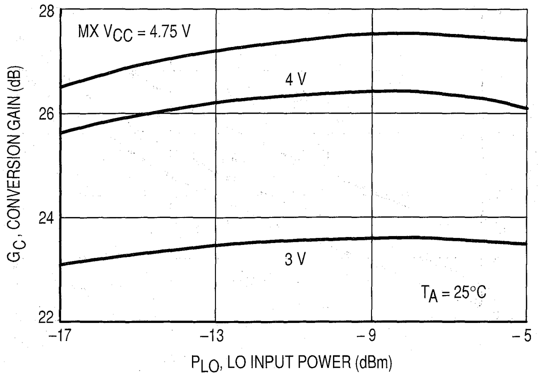


Figure 3. Mixer Gain versus LO Input Power

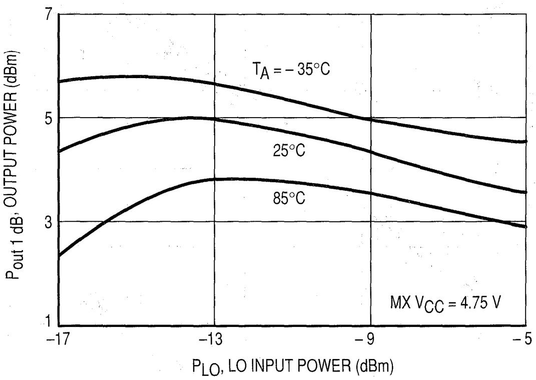


Figure 4. Mixer Output Power at 1 dB Gain Compression versus LO Input Power

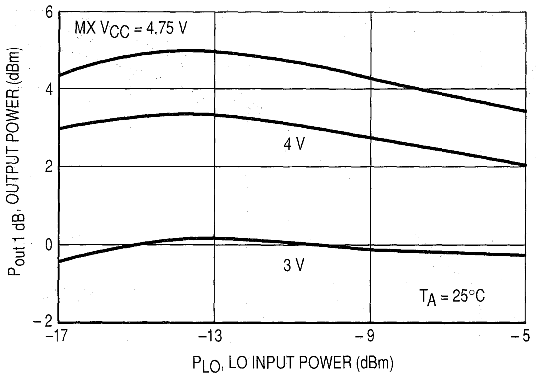


Figure 5. Mixer Output Power at 1 dB Gain Compression versus LO Input Power

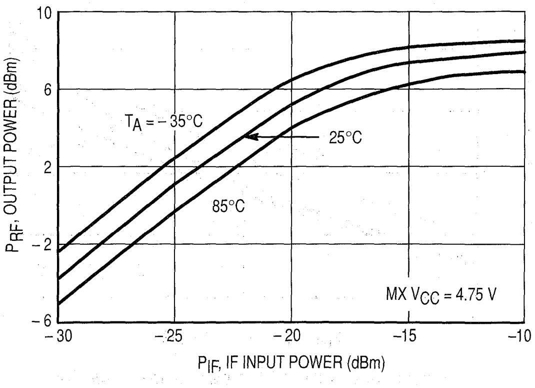


Figure 6. Mixer Output Power versus IF Input Power

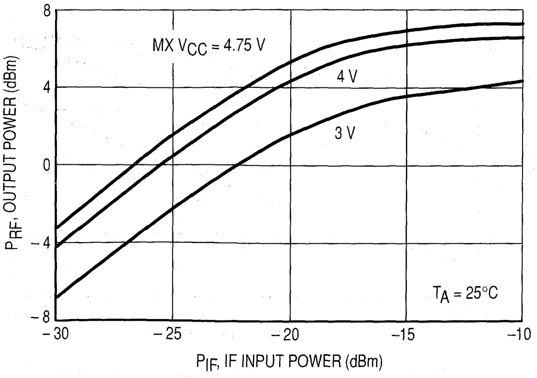


Figure 7. Mixer Output Power versus IF Input Power

TYPICAL CHARACTERISTICS

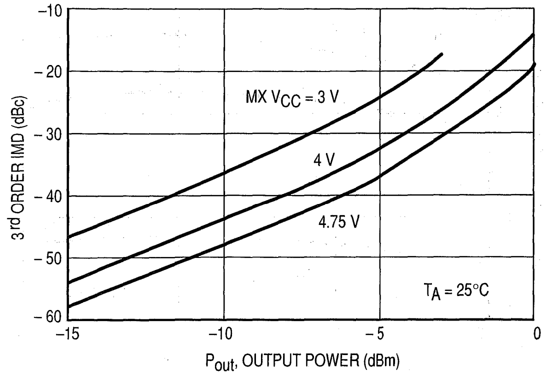


Figure 8. Mixer 3rd Order Intermodulation Distortion versus Output Power

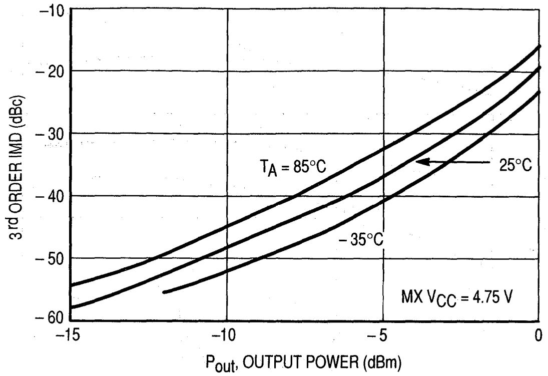


Figure 9. Mixer 3rd Order Intermodulation Distortion versus Output Power

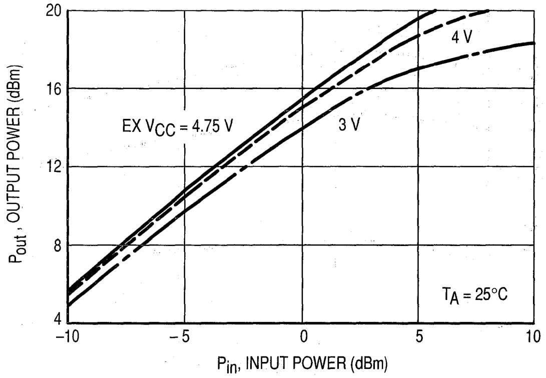


Figure 10. Exciter Output Power versus Input Power

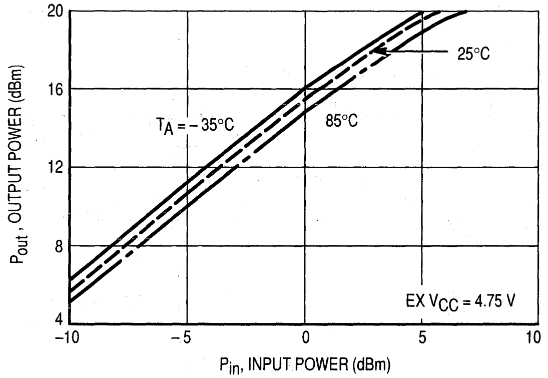


Figure 11. Exciter Output Power versus Input Power

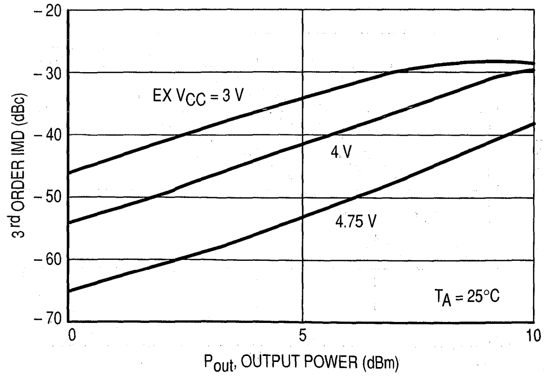


Figure 12. Exciter 3rd Order Intermodulation Distortion versus Output Power

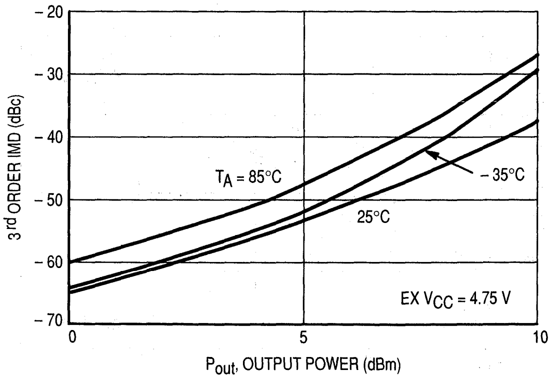


Figure 13. Exciter 3rd Order Intermodulation Distortion versus Output Power

TYPICAL CHARACTERISTICS

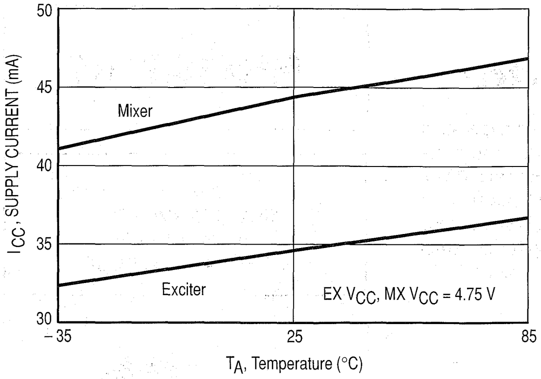


Figure 14. I_{CC} versus Temperature

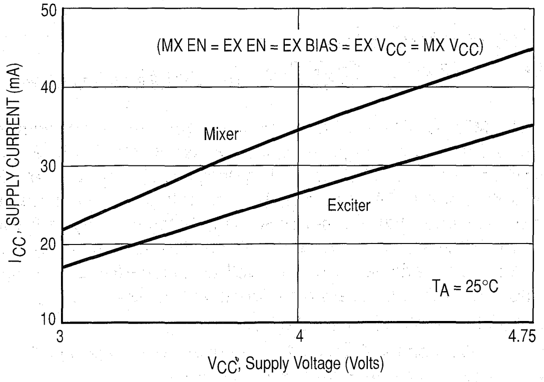


Figure 15. I_{CC} versus V_{CC}

APPLICATIONS INFORMATION

DESIGN PHILOSOPHY

The MRFIC2101 was designed as a linear upconverter for U.S. and Japan digital cellular radios. However, it is versatile enough to be used in other applications such as analog cellular, GSM, and the 900 MHz ISM band.

The mixer is double-balanced to minimize spurious and LO emission. An external balun is required on the mixer RF output to maximize linearity and maintain good balance. An inexpensive and easy to implement balun is described below in the theory of operation. The IF and LO ports do not require baluns. The LO split is achieved on-chip with a buffer amplifier which also reduces the LO power requirement. The IF port can be driven differentially or single-ended with a decoupling capacitor on the unused IF input.

To maximize efficiency in various systems, the exciter bias current is externally adjustable. The bias current can also be ramped to reduce spectral splatter.

To minimize current drain in TDD/TDMA systems, the MRFIC2101 has separate TTL/CMOS compatible enable pins for the mixer and the exciter.

THEORY OF OPERATION

Matching the LO port to 50 ohms can be done several ways. The recommended approach is a series inductor as close to the IC as possible. The inductor value is small enough (~8 – 15 nH depending on LO frequency and distance from the IC) to be printed on the board. A DC block is required and should not be placed between the inductor and IC since the added electrical length will cause a poor match.

The IF ports are approximately 250 ohms resistive in parallel with 5.0 pF of capacitance. Matching directly into this impedance is not recommended. Series 82 nH chip inductors should first be placed as close to both IF ports as possible. This presents a high impedance to the IF ports at the LO frequency which substantially reduces the LO leakage out of the RF port. The resulting impedance then may be matched to the desired characteristic impedance. DC blocking capacitors are also required.

Both RF ports are approximately 25 ohms resistive in series with 1.5 pF of capacitance (or the parallel equivalent, 380 ohms in parallel with 1.9 pF). Best linearity is achieved by loading each port with 100 ohms resistive and resonating the 1.9 pF. Ideally, a half wavelength transmission line could be used to combine the two differential RF ports into one; however, the size of such a line would be very large. Any number of balun type network can be employed so long as the network presents 100 ohms to each port, resonates 1.9 pF capacitance at each port, and exhibits 180 degree phase difference between the two ports. The network shown in Figure 1 combines very well without a lot of added board space or complexity. Essentially, a quarter wavelength of transmission line (~1.5 inches of 50 ohms stripline in FR4) is used with additional phase shift coming from capacitors C12, C13 and C16. This network will operate anywhere from 800–1000 MHz by adjusting bias inductor L4 and C16 only.

The exciter input requires external matching and a DC block. It is best matched to 50 ohms using a short 50 ohms transmission line followed by a 5–10 pF shunt capacitor. The exciter output is approximately 50 ohms resistive in parallel with 4 pF of capacitance in the 800–1000 MHz range. It is best matched to 50 ohms using a 6–10 nH bias inductor placed as close to the IC as possible. The exciter is conditionally stable. Placing a 100-300 ohm resistor in parallel with the bias inductor, when driving large VSWR loads, may be needed to keep the exciter stable.

Supply decoupling must be done as close to the IC as possible. A 1000 pF capacitor is recommended. An additional 100 pF capacitor and an RF choke are recommended to keep the LO signal off the supply line.

Enabling/Disabling the MRFIC2101 can be done with the separate TTL/CMOS compatible enable pins for the mixer and exciter. The trip point is between 1 and 2 volts.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

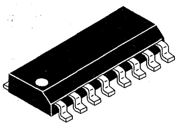
The MRFIC Line
2.4 GHz GaAs Downconverter

MRFIC2401

2.4 GHz
DOWNCONVERTER
GaAs MONOLITHIC
INTEGRATED CIRCUIT

The MRFIC2401 is a GaAs low–noise amplifier and downmixer in a low–cost 16 lead plastic package designed for use in the 2.4 to 2.5 GHz Industrial–Scientific–Medical (ISM) band. The design is optimized for efficiency at 5.0 Volt operation at 2.45 GHz but is usable from 2.0 to 3.0 GHz in applications such as telemetry and Multichannel Multipoint Distribution System (MMDS) wireless cable TV systems. Performance is suitable for frequency hopping or direct sequence spread spectrum as well as single–frequency applications. LNA output and mixer input are available to allow image filtering.

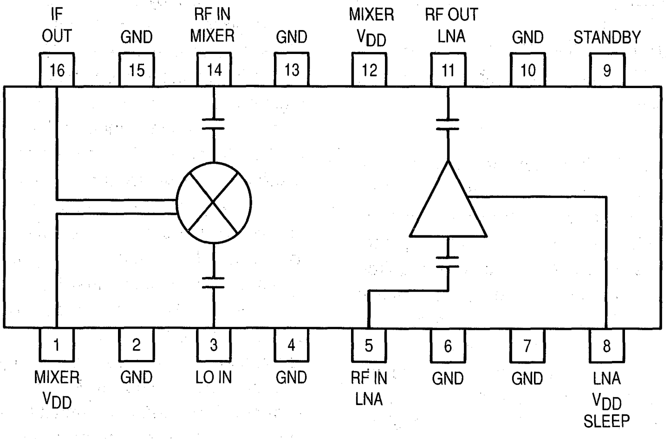
- Single Supply Voltage = 5.0 Volts
- High Conversion Gain = 21 dB Typical Less Image Filter
- Low Supply Current = 9.5 mA Typical
- Low–Cost, Low Profile Plastic SOIC Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M2401



CASE 751B-05
(SO-16)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	6.0	Vdc
Input Power, RF IN Ports	P_{RF}	+5.0	dBm
Input Power, LO IN Port	P_{LO}	+5.0	dBm
Ambient Operating Temperature	T_A	–30 to +85	°C
Storage Temperature	T_{stg}	–65 to +125	°C
Bias Control Voltage	STANDBY	6.0	Vdc



Pin Connections and Functional Block Diagram

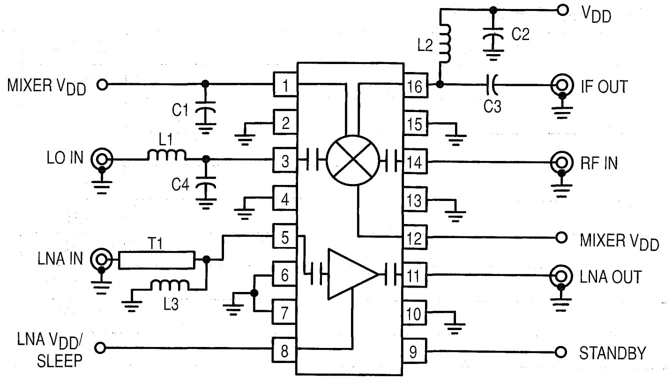
REV 3

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	4.75 to 5.25	Vdc
IF Frequency Range	f_{IF}	100 to 350	MHz
LO Drive Power Level	P_{LO}	–10 to 0	dBm
LO Frequency Range	f_{LO}	2050 to 2400	MHz
RF Frequency Range	f_{RF}	2400 to 2500	MHz
STANDBY Mode ON	STANDBY	V_{DD}	Vdc
STANDBY Mode OFF	STANDBY	0	Vdc
SLEEP Mode OFF	SLEEP	V_{DD}	Vdc
SLEEP Mode ON	SLEEP	0	Vdc

ELECTRICAL CHARACTERISTICS (V_{DD} = 5.0 Vdc, T_A = 25°C, RF = 2.45 GHz, LO = 2.125 GHz @ –5.0 dBm, STANDBY = 0 Vdc)

Characteristic	Min	Typ	Max	Unit
Conversion Gain – Downconverter (Less Image Filter Loss)	19	21	–	dB
Gain – LNA	–	17	–	dB
Conversion Gain – Mixer	–	4.0	–	dB
Noise Figure – LNA	–	1.9	–	dB
Noise Figure – Mixer	–	11	–	dB
Return Loss – Mixer Input, LO Input, LNA Output	–	10	–	dB
Input Third Order Intercept – Downconverter (Less Image Filter Loss)	–	–18	–	dBm
Input Third Order Intercept – LNA	–	–13	–	dBm
Input Third Order Intercept – Mixer	–	0	–	dBm
Reverse Isolation – Downconverter (Less Image Filter Loss)	–	30	–	dB
Isolation – LO to RF, LO to IF	–	20	–	dB
Supply Current – Downconverter	–	9.5	11	mA
SLEEP Mode Supply Current – Downconverter (No LO, STANDBY= 5 Vdc, V_{DD}/SLEEP = 5 Vdc)	–	600	–	µA
Turn On, Turn Off Time – LNA	–	1.0	–	µs



325 MHz IF:
C1, C2 – 100 pF
C3 – 5.6 pF
C4 – 0.5 pF
L1 – 4.7 nH
L2 – 8.2nH
L3 – 6.8 nH
T1 – 100 Ω Line, 92 MILS

240 MHz IF:
C1, C2 – 100 pF
C3 – 5.6 pF
C4 – 0.5 pF
L1 – 8.2 nH
L2 – 18 nH
L3 – 6.8 nH
T1 – 100 Ω Line, 92mils

Board Material – FR4

110 MHz IF:
C1 – 100 pF
C2 – 1000 pF
C3 – 8.2 pF
C4 – 0.3 pF
L1 – 8.2 nH
L2 – 82 nH
L3 – 6.8 nH
T1 – 100 Ω Line, 92 mils

Figure 1. Applications Circuit Configuration

f	LO Z_{in}	
Frequency (GHz)	**R**	**jX**
2.0	39.7	23.9
2.1	35.7	22.1
2.2	32.1	19.8
2.3	29.1	17.1
2.4	26.5	14.0
2.5	24.4	10.7

Table 1. Selected Port Impedances
(from Conjugate Match)

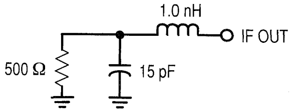


Figure 2. Equivalent IF Output Circuit

Table 2. LNA Scattering Parameters

(VDD = 5 V, T_A = 25°C, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\vert S_{11}\vert$	∠ ϕ	$\vert S_{21}\vert$	∠ ϕ	$\vert S_{12}\vert$	∠ ϕ	$\vert S_{22}\vert$	∠ ϕ
2000	0.823	–50.8	5.35	14.3	0.0373	164.2	0.609	–64.1
2050	0.783	–62.9	6.13	–0.3	0.0425	154.3	0.558	–78.7
2100	0.752	–76.8	6.56	–18.3	0.0477	138	0.497	–94.3
2150	0.713	–89.8	6.8	–34	0.05	121	0.425	–110.7
2200	0.656	–104.2	7.14	–50.2	0.0511	106.4	0.343	–129.6
2250	0.583	–119	7.44	–66.4	0.0527	91.8	0.25	–152.3
2300	0.509	–134.1	7.8	–84.2	0.0554	78.1	0.155	176.2
2350	0.425	–148.2	7.86	–102.6	0.0579	59.89	0.088	120.7
2400	0.34	–163.6	7.84	–119.4	0.0552	42.31	0.111	43.8
2450	0.261	–177.8	7.78	–138.1	0.0528	28.27	0.191	2.2
2500	0.175	173.4	7.43	–154.6	0.0514	13.37	0.269	–21.9
2550	0.103	170.4	7.15	–170.6	0.0484	–0.842	0.338	–41.8
2600	0.056	–160.5	6.72	173	0.0455	–15.4	0.393	–59.4
2650	0.067	–130.7	6.47	159.1	0.0422	–28.11	0.436	–76.2
2700	0.102	–117.8	6.25	142.3	0.039	–41.5	0.472	–92.2
2750	0.132	–119.5	5.53	127.1	0.0353	–53.47	0.496	–107.5
2800	0.166	–125.2	5.26	117.5	0.0329	–63.28	0.513	–121.3
2850	0.19	–134.8	5.15	102.4	0.0309	–75.04	0.533	–135
2900	0.219	–144.8	4.71	87.6	0.0283	–87.86	0.547	–148.8
2950	0.235	–155.9	4.43	76.1	0.025	–95.83	0.559	–162.4
3000	0.262	–165.9	4.08	62.3	0.0235	–108.4	0.57	–175.7

TYPICAL CHARACTERISTICS

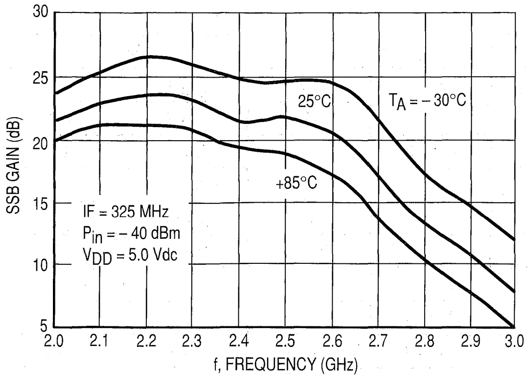


Figure 3. Downconverter Gain versus Frequency

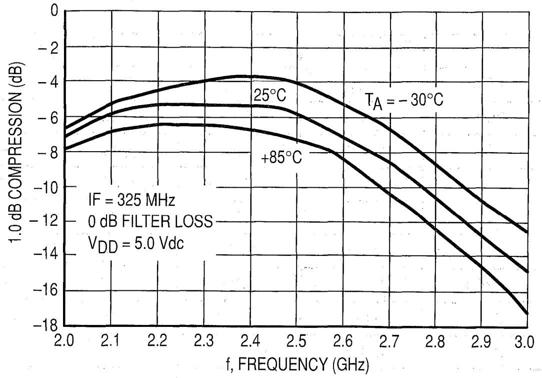


Figure 4. Downconverter 1.0 dB Compression versus Frequency

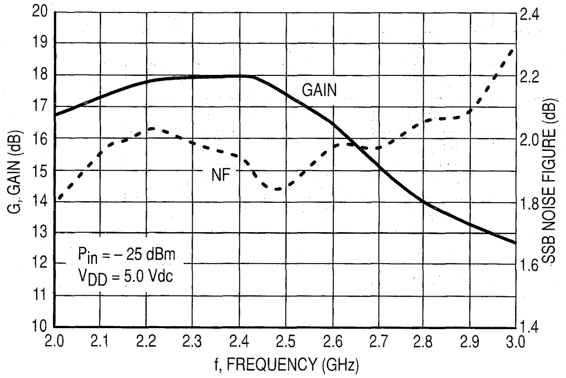


Figure 5. LNA Gain and Noise Figure versus Frequency

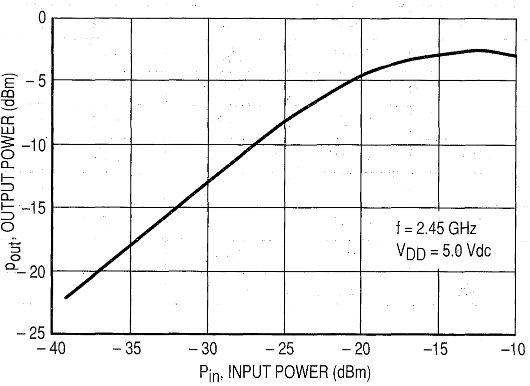


Figure 6. LNA Output Power versus Input Power

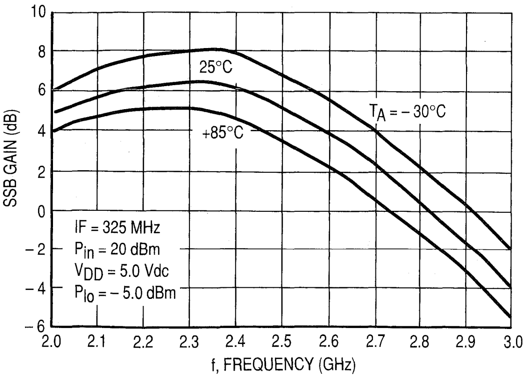


Figure 7. Mixer Conversion Gain versus Frequency

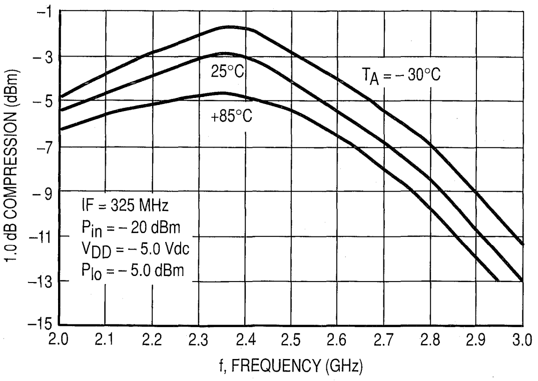


Figure 8. Mixer 1.0 dB Compression versus Frequency

TYPICAL CHARACTERISTICS

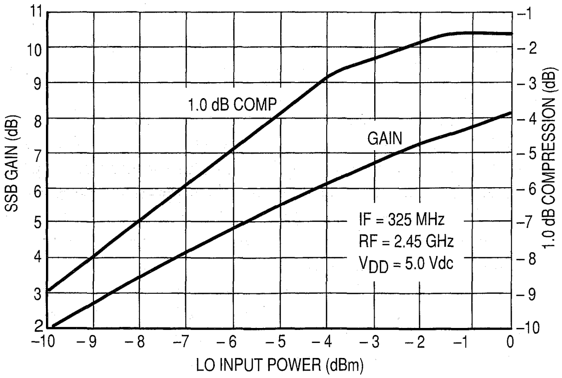


Figure 9. Mixer 1.0 dB Compression and Gain versus LO Power

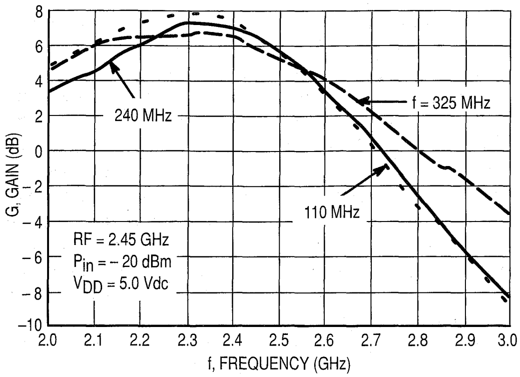


Figure 10. Mixer Gain versus Frequency

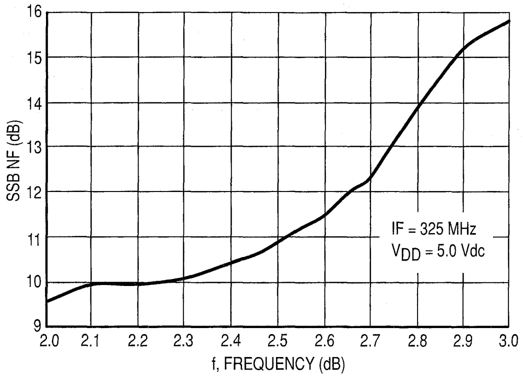


Figure 11. Mixer Noise Figure versus Frequency

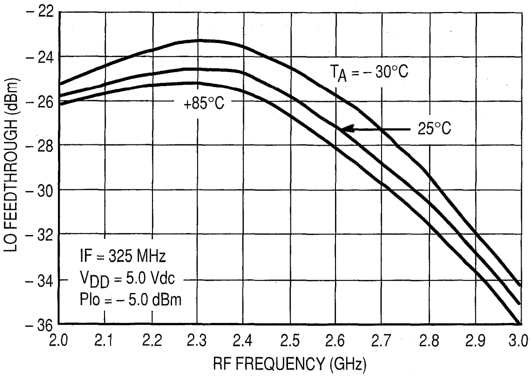


Figure 12. Mixer LO Feedthrough versus RF Frequency

DESIGN AND APPLICATIONS INFORMATION

The MRFIC2401 consists of a two–stage GaAs MESFET low noise amplifier and a single ended MESFET mixer. The LNA design conserves bias current through stacking of the two FETs, thus reusing the current. The mixer consists of a common gate stage driving a common source stage with the IF output being the drain of the common source stage shunted with 15 pF. The LNA output and mixer input have been separated to allow the addition of an external image filter. Such a filter, usually ceramic, is useful in improving the mixer noise figure and third order intercept performance. It also provides LO rejection to reduce the amount of LO power which may leak to the antenna. Alternatively, image trapping can be implemented at the LNA input or output with discrete or distributed components.

The design has been optimized for best performance from 2.4 to 2.5 GHz, but the device is usable with reduced performance from 2.0 to 3.0 GHz as shown in the performance curves. These curves were generated using the circuit shown in Figure 1 and performance above 2.5 GHz can be enhanced by rematching the LO input port. Matching circuit details are shown for IFs of 110 MHz, 240 MHz, and 325 MHz matched to 50 Ω and LO frequencies consistent with an RF frequency of 2.45 GHz. Customized IF matching can be accomplished by using the Equivalent IF Output circuit model shown in Figure 2. The best gain/noise figure tradeoff match is shown in the LNA input impedance column of Table 1. The LO input impedance is shown in the same table. These numbers are derived from conjugate match measurements of the applications circuit. The LNA output and mixer input are matched to 50 Ω.

As with all RF circuitry, layout is important. Controlled impedance lines should be used at all RF ports. RF bypassing of power supply connections as close to the part as possible, while not always shown in the applications circuit, are recommended. Additional power supply “stiffening” and digital transient bypassing should be accomplished with electrolytic or tantalum capacitors.

The device can be placed in a reduced current “standby” mode by applying 5.0 Vdc to the STANDBY pin and removing the LO drive. Further current reduction “sleep” mode, is enabled by applying 0 Vdc to V_{DD}/SLEEP. This sleep mode can also be used to disable the LNA under high signal level conditions and give higher input intercept point if V_{DD} is still applied to the mixer.

EVALUATION BOARDS

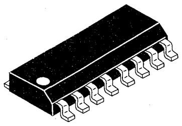
Evaluation boards are available for RF Monolithic Integrated Circuits by adding a “TF” suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The MRFIC Line
2.4 GHz GaAs Power Amplifier

MRFIC2403

2.4 GHz
POWER AMPLIFIER
GaAs MONOLITHIC
INTEGRATED CIRCUIT



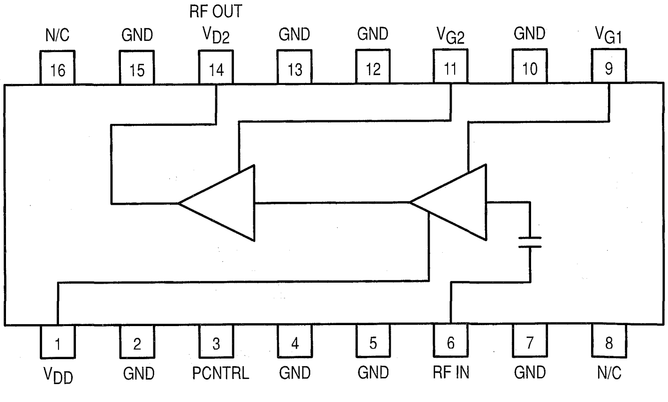
CASE 751B-05
(SO–16)

The MRFIC2403 is a two–stage class B GaAs power amplifier in a low–cost 16 lead plastic package designed for use in the 2.4 to 2.5 GHz Industrial–Scientific–Medical (ISM) band. The design is optimized for efficiency at 5.0 Volt operation at 2.5 GHz but is usable from 2.0 to 3.0 GHz in applications such as telemetry and Multichannel Multipoint Distribution System (MMDS) wireless cable TV systems. Performance is suitable for frequency hopping or direct sequence spread spectrum as well as single–frequency applications. Power control circuitry allows 20 dB dynamic range for setting the output power.

- High Output Power = +23.5 dBm Typical
- High Gain = 23 dB Typical
- Excellent Efficiency = 55% Typical
- Power Control = 20 dB Range
- Low–Cost, Low Profile Plastic SOIC Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number. R2 Suffix = 2,500 Units per 16 mm, 13 inch Reel.
- Device Marking = M2403

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	6.0	Vdc
Power Control Voltage	V_{CONTRL}	6.0	Vdc
Gate Bias Voltage	V_{G1}, V_{G2}	–4.0	Vdc
RF Input Power	RF IN	+10	dBm
Ambient Operating Temperature	T_A	–30 to +85	°C
Storage Temperature	T_{stg}	–65 to +125	°C



Pin Connections and Functional Block Diagram

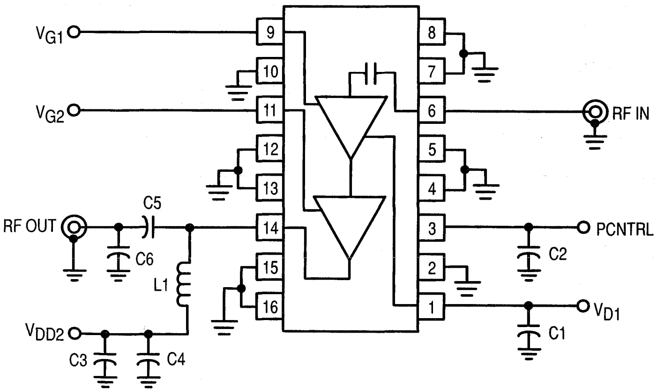
REV 1

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	4.75 to 5.25	Vdc
Gate Bias Voltage, Input Stage	V_{G1}	–1.0	Vdc
Gate Bias Voltage, Output Stage	V_{G2}	–2.0	Vdc
Quiescent Drain Current, Stage One	I_{DQ1}	12	mA
Quiescent Drain Current, Stage Two	I_{DQ2}	10	mA
Operating Frequency Range	f_{OP}	2200 to 2700	MHz

ELECTRICAL CHARACTERISTICS (V_{DD} = 5.0 Vdc, T_A = 25°C, RF = 2.45 GHz @ +4.0 dBm, V_{G1} = –1.0 Vdc, V_{G2} = –2.0 Vdc, PCNTRL = 5.0 Vdc)

Characteristic	Min	Typ	Max	Unit
Small Signal Gain (P_{in} = –6.0 dBm)	–	23	–	dB
Power Output (P_{in} = +4.0 dBm)	23	23.5	–	dBm
Power Output, Saturation	–	23.5	–	dBm
Power Output, 1.0 dB Compression	–	19	–	dBm
2nd Harmonic Output	–	–20	–	dBc
3rd Harmonic Output	–	–30	–	dBc
Third Order Intermodulation Products (P_{in} = +4.0 dBm PEP)	–	–15	–	dBc
Reverse Isolation	–	32	–	dB
Power Control Range, PCNTRL	–	20	–	dB
Reverse Isolation	–	30	–	dB
Supply Current	–	95	140	mA
SLEEP Mode Supply Current (VG1 = VG2 = –3.0 Vdc, PCNTRL = 0 Vdc)	–	150	–	µA



C1, C2, C3 – 0.01 µF
C4 – 5.1 pF
C5 – 15 pF
C6 – 1.0 pF
L1 – 6.8 nH
Board Material – 30 MIL FR4
Connectors – SMA type

Figure 1. Applications Circuit Configuration

Table 1. Class A Scattering Parameters

(VDD = 5 V, I_{DQ1} = 24 mA, I_{DQ2} = 96 mA, T_A = 25°C, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
2000	0.377	–157.00	27.625	57.40	0.004	–74.70	0.740	–102.10
2050	0.218	–171.70	28.938	36.80	0.006	–101.60	0.763	–115.30
2100	0.075	–178.80	29.088	17.20	0.007	–130.70	0.724	–126.80
2150	0.049	–96.10	27.904	–0.20	0.007	–163.20	0.663	–135.80
2200	0.104	–56.60	26.930	–14.90	0.008	–169.60	0.601	–141.80
2250	0.130	–60.60	24.246	–27.80	0.009	173.50	0.550	–146.30
2300	0.125	–65.40	24.286	–39.40	0.010	165.00	0.504	–149.10
2350	0.106	–67.60	22.287	–49.60	0.010	157.70	0.471	–151.60
2400	0.083	–56.10	21.867	–59.80	0.009	140.70	0.444	–153.80
2450	0.064	–27.00	21.837	–68.90	0.011	141.40	0.422	–155.90
2500	0.072	26.20	20.113	–78.00	0.012	139.80	0.401	–158.60
2550	0.110	44.60	19.828	–86.40	0.009	140.00	0.385	–161.20
2600	0.160	44.50	18.941	–94.30	0.007	124.50	0.364	–164.50
2650	0.194	40.60	18.001	–101.90	0.012	128.30	0.350	–167.70
2700	0.237	36.60	17.268	–109.20	0.011	102.30	0.335	–171.40
2750	0.269	31.30	16.379	–116.30	0.010	110.90	0.317	–174.50
2800	0.304	25.50	15.826	–123.40	0.009	105.80	0.311	–178.60
2850	0.325	19.80	15.125	–130.40	0.010	103.60	0.292	177.50
2900	0.345	14.50	14.611	–137.50	0.008	99.70	0.279	172.80
2950	0.356	9.40	14.048	–143.60	0.009	92.80	0.271	168.90
3000	0.370	2.40	13.663	–150.40	0.011	88.20	0.259	163.80

Table 2. Class B Scattering Parameters

(VDD = 5 V, I_{DQ1} = 12 mA, I_{DQ2} = 10 mA, T_A = 25°C, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\lvert S_{11}\rvert$	∠ φ	$\lvert S_{21}\rvert$	∠ φ	$\lvert S_{12}\rvert$	∠ φ	$\lvert S_{22}\rvert$	∠ φ
2000	0.634	–149.00	12.40	88.00	0.007	–59.00	0.893	–81.00
2050	0.554	–170.00	14.76	72.00	0.013	–81.00	0.966	–89.00
2100	0.456	163.00	17.00	53.00	0.015	–95.00	0.990	–100.00
2150	0.362	129.00	18.09	32.00	0.017	–117.00	0.955	–110.00
2200	0.310	91.00	18.81	12.00	0.020	–138.00	0.870	–119.00
2250	0.298	58.00	17.37	–5.00	0.021	–156.00	0.771	–125.00
2300	0.298	30.00	17.22	–21.00	0.021	–169.00	0.681	–128.00
2350	0.289	11.00	15.89	–34.00	0.020	179.00	0.612	–130.00
2400	0.275	0.00	14.74	–45.00	0.020	168.00	0.562	–130.00
2450	0.248	–8.00	15.35	–56.00	0.021	155.00	0.528	–131.00
2500	0.216	–10.00	13.62	–66.00	0.019	147.00	0.498	–131.00
2550	0.199	–8.00	13.46	–75.00	0.021	143.00	0.473	–132.00
2600	0.187	–2.00	12.95	–83.00	0.020	134.00	0.447	–132.00
2650	0.185	4.00	12.32	–91.00	0.020	129.00	0.426	–134.00
2700	0.202	10.00	11.78	–99.00	0.021	123.00	0.405	–135.00
2750	0.218	13.00	11.25	–107.00	0.021	115.00	0.384	–136.00
2800	0.244	14.00	10.83	–114.00	0.018	106.00	0.373	–137.00
2850	0.268	13.00	10.34	–121.00	0.019	98.00	0.353	–139.00
2900	0.285	10.00	10.05	–129.00	0.019	99.00	0.332	–140.00
2950	0.301	7.00	9.61	–135.00	0.018	102.00	0.316	–143.00
3000	0.317	3.00	9.46	–142.00	0.018	90.00	0.302	–145.00

TYPICAL CHARACTERISTICS

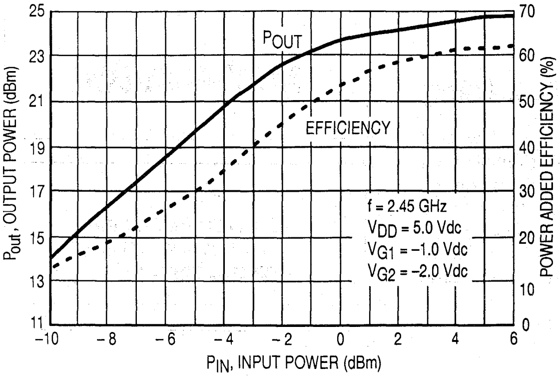


Figure 2. Output Power and Efficiency versus Input Power

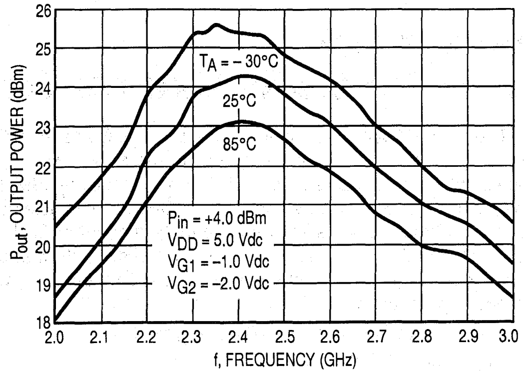


Figure 3. Output Power versus Frequency

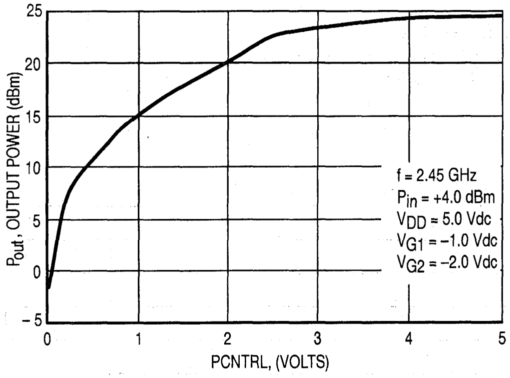


Figure 4. Output Power versus PCNTRL Voltage

DESIGN AND APPLICATIONS INFORMATION

The MRFIC2403 is a two–stage power amplifier designed using Motorola's MAFET planar, refractory gate MESFET IC process. The RF MESFETs are power, depletion mode devices and, therefore, require negative bias on the MESFET gates. For class B operation, –1.0 Vdc is applied to V_{G1} and –2.0 Vdc is applied to V_{G2}. Class A biasing will yield slightly higher gain and 1.0 dB compression point and can be accomplished by adjusting the bias on VG1 for I_{DQ1} = 24 mA and V_{G2} for I_{DQ2} = 96 mA. Where negative voltages are not already available, Motorola's MC33128 Power Management IC can produce –2.5 Vdc from a single positive supply.

The device is capable of better than +23 dBm saturated output power in the 2.4 to 2.5 GHz ISM band with the output matching circuit shown in Figure 1. The device can be operated at other frequencies in the 2.0 GHz to 3.0 GHz range with this circuit but performance can be improved with tuning for the specific frequency of use. Input matching is provided on chip. This circuit provides the best gain, saturated output power and efficiency tradeoff. Saturated operation has the advantage of best efficiency with less variation in performance over frequency and temperature. Operation in saturation is acceptable for constant envelope modulation schemes such as 2 and 4 level FM as specified for frequency hopping (FHSS) radios in the proposed IEEE 802.11 PHY layer specification. For direct sequence (DSSS) IEEE 802.11 operation, where differential binary phase shift keying (DBPSK) and differential quadrature phase shift keying (DQPSK) are specified, the amplifier will have to be "backed off" from saturation by 5.0 dB or more to avoid spectral regrowth. Care must be taken in the layout of the circuit and controlled impedance lines must be used at the RF pins. Capacitive bypassing as shown in the Applications Circuit must be implemented as close to the chip as possible to avoid amplifier instability. Additionally, the supply voltage should be supported by sufficient "stiffening" capacitance, typically electrolytic or tantalum bypass capacitors, to eliminate noise from digital circuits.

Output power control is accomplished by varying the voltage on the PCNTRL pin. 0 Vdc gives minimum output and reduces the current drawn by the amplifier to the quiescent value. The amplifier can be put into "sleep" mode by decreasing the voltage on the gate bias pins to –3.0 Vdc and the current drain is reduced to a few hundred microamps.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

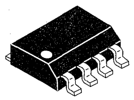
The MRFIC Line
2.4 GHz GaAs Exciter Amplifier

MRFIC2404

**2.4 GHz
EXCITER AMPLIFIER
GaAs MONOLITHIC
INTEGRATED CIRCUIT**

The MRFIC2404 is a single–stage class A GaAs amplifier in a low–cost 8 lead plastic package designed to drive the MRFIC2403 power amplifier for use in the 2.4 to 2.5 GHz Industrial–Scientific–Medical (ISM) band. The design is optimized for 5.0 Volt operation at 2.45 GHz but is usable from 2.0 to 3.0 GHz in applications such as telemetry and Multichannel Multipoint Distribution System (MMDS) wireless cable TV systems. Performance is suitable for frequency hopping or direct sequence spread spectrum as well as single–frequency applications.

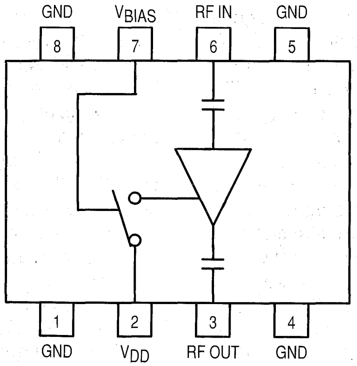
- High Output Capability = +5.0 dBm Typical
- High Gain = 17 dB Typical
- Low Current Drain = 9.0 mA Typical
- Single Supply Voltage = 5.0 Volts
- Good Noise Figure = 4.3 dB Typical
- Low–Cost, Low Profile Plastic SOIC Package
- Available in Tape and Reel by Adding R2 Suffix to Part Number.
  R2 Suffix = 2,500 Units per 12 mm, 13 inch Reel.
- Device Marking = M2404



**CASE 751-05
(SO-8)**

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	12	Vdc
RF Input Power	RF IN	+10	dBm
Bias Enable Voltage	V_{bias}	6.0	Vdc
Ambient Operating Temperature	T_A	–30 to +85	°C
Storage Temperature	T_{stg}	–65 to +125	°C



Pin Connections and Functional Block Diagram

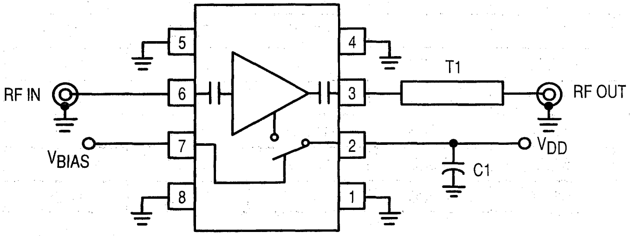
REV 1

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
Supply Voltage	V_{DD}	4.75 to 5.25	Vdc
Bias Enable Voltage – ON	V_{bias}	0	Vdc
Bias Enable Voltage – OFF	V_{bias}	5.0	Vdc
Operating Frequency Range	f_{OP}	2000 to 3000	MHz

ELECTRICAL CHARACTERISTICS (V_{DD} = 5.0 Vdc, T_A= 25°C, RF = 2.45 GHz, V_{bias} = 0 Vdc)

Characteristic	Min	Typ	Max	Unit
Small Signal Gain	16	17	–	dB
Power Output, 1.0 dB Compression	–	+5.0	–	dBm
Power Output (P_{in} = –11 dBm)	4.0	5.0	–	dBm
Third Order Intercept Point	–	+15	–	dBm
Noise Figure	–	4.3	–	dB
Reverse Isolation	–	25	–	dB
Turn On Time	–	1.0	–	µs
Supply Current	–	9.0	12	mA
SLEEP Mode Supply Current (V_{bias} = 5.0 Vdc)	–	800	–	µA



C1 – 15 pF
T1 – 100 Ω Line, 185 MILs (3.3 nH)
Board Material – 30 MIL FR4
Connectors – SMA Type

Figure 1. Applications Circuit Configuration

Table 1. Scattering Parameters

(VDD = 5 V, T_A = 25°C, 50 Ω System)

f	S_{11}		S_{21}		S_{12}		S_{22}	
(MHz)	$\|S_{11}\|$	$\angle \phi$	$\|S_{21}\|$	$\angle \phi$	$\|S_{12}\|$	$\angle \phi$	$\|S_{22}\|$	$\angle \phi$
2000	0.232	–92.34	6.290	165.97	0.024	–51.08	0.483	–123.13
2050	0.174	–90.78	7.049	147.75	0.029	–66.26	0.383	–125.77
2100	0.122	–76.88	7.563	127.95	0.032	–78.38	0.281	–124.34
2150	0.102	–48.38	7.803	109.02	0.035	–97.84	0.191	–109.23
2200	0.128	–19.45	8.046	91.04	0.037	–105.62	0.159	–80.33
2250	0.185	–6.60	8.144	72.36	0.039	–123.88	0.196	–53.35
2300	0.244	–5.52	7.977	55.31	0.038	–135.36	0.273	–42.38
2350	0.300	–8.04	7.979	39.91	0.043	–144.83	0.350	–41.15
2400	0.343	–12.42	8.147	23.40	0.044	–160.94	0.423	–43.39
2450	0.379	–17.11	8.020	5.27	0.045	–173.09	0.477	–47.05
2500	0.403	–21.90	7.550	–10.93	0.041	173.83	0.522	–50.67
2550	0.424	–26.32	7.245	–25.36	0.043	165.85	0.556	–54.67
2600	0.436	–30.95	6.911	–39.88	0.042	154.14	0.582	–58.35
2650	0.443	–34.94	6.631	–52.32	0.041	145.35	0.600	–62.23
2700	0.447	–39.48	6.566	–65.57	0.044	135.12	0.610	–65.41
2750	0.445	–43.12	6.338	–79.97	0.043	123.72	0.622	–68.57
2800	0.446	–46.68	6.009	–93.15	0.042	114.52	0.624	–72.06
2850	0.441	–50.42	5.733	–105.10	0.043	107.18	0.620	–74.86
2900	0.439	–53.14	5.565	–116.69	0.041	98.95	0.617	–77.74
2950	0.437	–57.27	5.393	–129.54	0.042	90.72	0.608	–80.01
3000	0.409	–61.28	4.938	–142.70	0.043	81.68	0.611	–81.12

Typical Characteristics

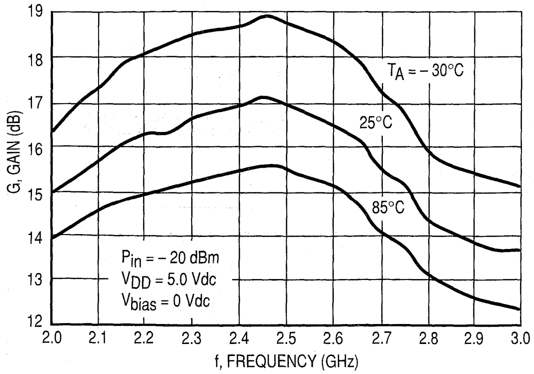


Figure 2. Gain versus Frequency

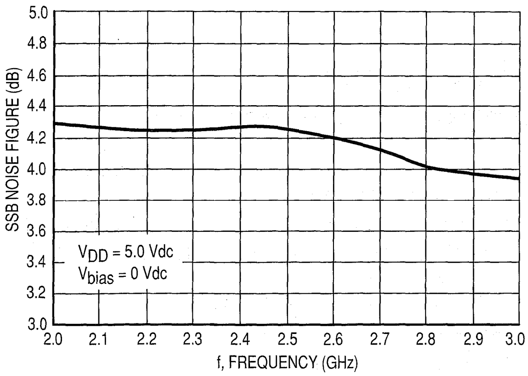


Figure 3. Noise Figure versus Frequency

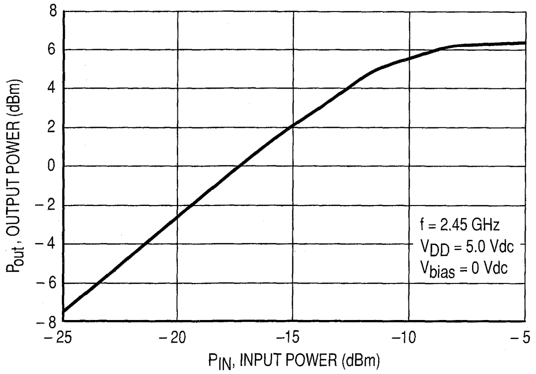


Figure 4. Output Power versus Input Power

DESIGN AND APPLICATIONS INFORMATION

The MRFIC2404 is a single–stage GaAs amplifier designed for exciter applications such as driving the MRFIC2403 power amplifier. The 4.3 dB noise figure, 17 dB gain and +5.0 dBm power output at 1.0 dB gain compression make the MRFIC2404 suitable for high–performance receiver IF application, Multichannel Multipoint Distribution System (MMDS) applications, telemetry and other applications in the 2.0 to 3.0 GHz range.

The characterization curves show typical performance in the 2.0 to 3.0 GHz range in the circuit shown in Figure 1. This circuit was also used to derive the device impedance shown in Table 1. The amplifier input is matched to 50 Ω while the output requires about 3.3 nH series inductance for best match at 2.45 GHz. The V_{DD} supply line should be bypassed as close to the chip as possible to avoid low frequency oscillations. Power supply "stiffening" and digital transient bypassing in the form of electrolytic of tantalum capacitors should be added.

The device can be put into a reduced current "sleep" mode by 5.0 Vdc to the V_{bias} pin.

EVALUATION BOARDS

Evaluation boards are available for RF Monolithic Integrated Circuits by adding a "TF" suffix to the device type. For a complete list of currently available boards and ones in development for newly introduced poduct, please contact your local Motorola Distributor or Sales Office.

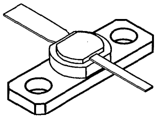
The RF Line
Microwave Power Transistors

MRW2001
MRW2005

Designed primarily for large–signal output and driver amplifier stages in the 1.0 to 2.3 GHz frequency range.

- Designed for Class B or C, Common Base Power Amplifiers
- Specified 28 Volt, 2.0 GHz Characteristics:
  Power Gain — 5.2 to 9.0 dB, Min
  Collector Efficiency — 40%, Min
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

5.2–9.0 dB
1.0–2.3 GHz
MICROWAVE
POWER TRANSISTORS



CASE 328A–03, STYLE 1
(GP–13)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CES}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous MRW2001 MRW2005	I_C	 0.25 1.0	Adc
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, RF, Junction to Case MRW2001 MRW2005	$R_{\theta JC}$	 25 8.5	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 10$ mA, $V_{BE} = 0$) MRW2001 ($I_C = 40$ mA, $V_{BE} = 0$) MRW2005	$V_{(BR)CES}$	 50 50	 — —	 — —	Vdc

(continued)

REV 7

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (continued)						
Emitter–Base Breakdown Voltage		$V_{(BR)EBO}$				Vdc
(I_E = 0.2 mA, I_C = 0)	MRW2001		3.5	—	—	
(I_E = 0.5 mA, I_C = 0)	MRW2005		3.5	—	—	
Collector Cutoff Current	MRW2001	I_{CBO}	—	—	0.5	mAdc
(V_{CB} = 28 V, I_E = 0)	MRW2005		—	—	0.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 100 mA, V_{CE} = 5.0 V)	MRW2001		10	—	120	
(I_C = 200 mA, V_{CE} = 5.0 V)	MRW2005		10	—	100	
DYNAMIC CHARACTERISTICS						
Output Capacitance	MRW2001	C_{ob}	—	—	4.0	pF
(V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	MRW2005		—	—	7.0	
FUNCTIONAL TESTS						
Common–Base Amplifier Power Gain		G_{PB}	9.0	—	—	dB
(V_{CE} = 28 V, P_{out} = 1.0 W, f = 2.0 GHz)	MRW2001					
Common–Base Amplifier Power Gain		G_{PB}	8.0	—	—	dB
(V_{CE} = 28 V, P_{out} = 5.0 W, f = 2.0 GHz)	MRW2005					
Collector Efficiency		η	40	—	—	%
(V_{CE} = 28 V, P_{out} = 1.0 W, f = 2.0 GHz)	MRW2001					
(V_{CE} = 28 V, P_{out} = 5.0 W, f = 2.0 GHz)	MRW2005					
Load Mismatch		ψ	No Degradation in Output Power			
(V_{CE} = 28 V, f = 2.0 GHz, Load VSWR = ∞:1, All Phase Angles)						
P_{out} = 1.0 W	MRW2001					
P_{out} = 5.0 W	MRW2005					
Saturated Output Power						W
(V_{CE} = 28 V, f = 2.3 GHz)	MRW2001	$P_{sat\,1}$	—	1.0	—	
(V_{CE} = 28 V, f = 1.5 GHz)		$P_{sat\,2}$	—	1.2	—	
(V_{CE} = 28 V, f = 1.0 GHz)		$P_{sat\,3}$	—	1.3	—	
(V_{CE} = 28 V, f = 2.3 GHz)	MRW2005		—	5.0	—	
(V_{CE} = 28 V, f = 1.5 GHz)			—	6.5	—	
(V_{CE} = 28 V, f = 1.0 GHz)			—	7.5	—	

TYPICAL CHARACTERISTICS

MRW2001

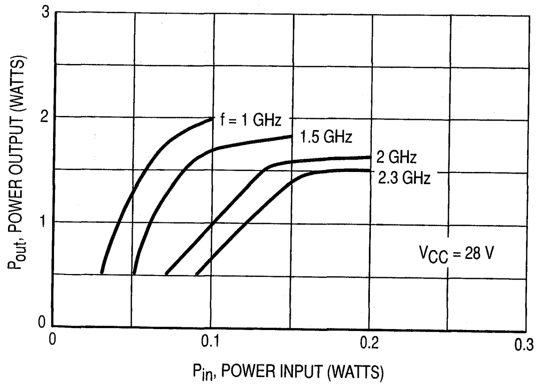


Figure 1. Output Power versus Input Power

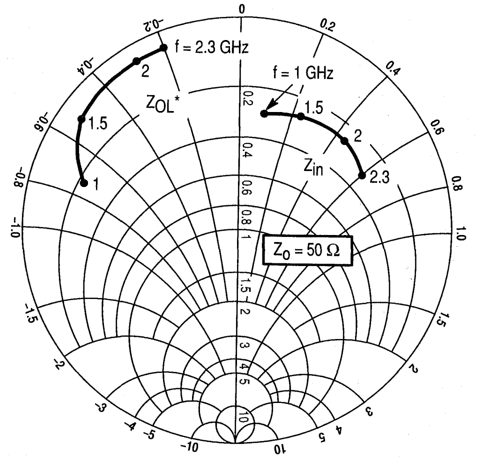


Figure 2. Series Equivalent Input/Output Impedance
V_{CC} = 28 V

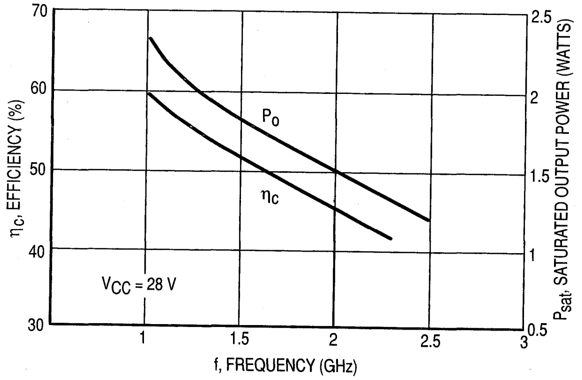


Figure 3. Power Output and Efficiency versus Frequency

TYPICAL CHARACTERISTICS

MRW2005

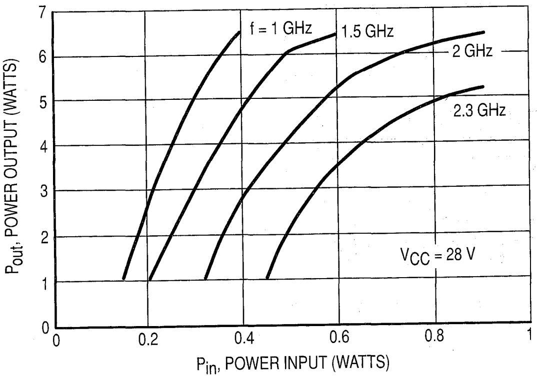


Figure 4. Output Power versus Input Power

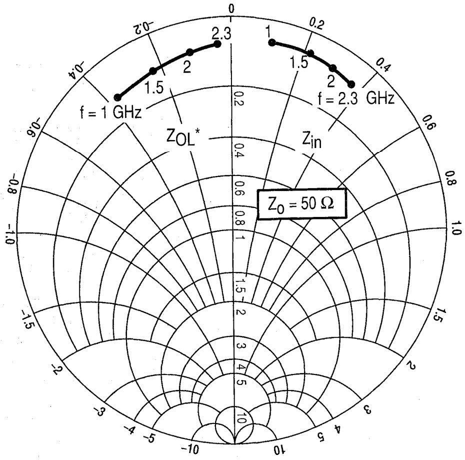


Figure 5. Series Equivalent Input/Output Impedance
V_{CC} = 28 V

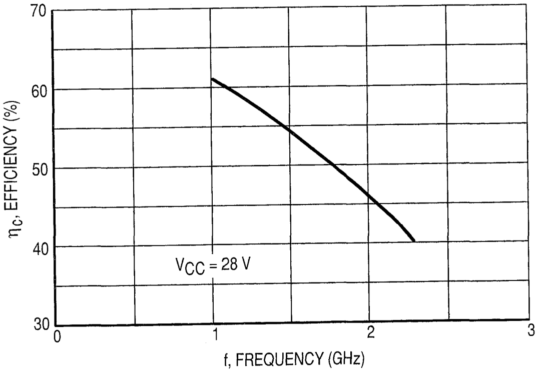


Figure 6. Power Output and Efficiency versus Frequency

The graph shown below displays MTTF in hours x ampere^2 emitter current for each of the "Super 2.0 GHz" devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Sample MTTF calculations based on operating conditions are included on the graph.

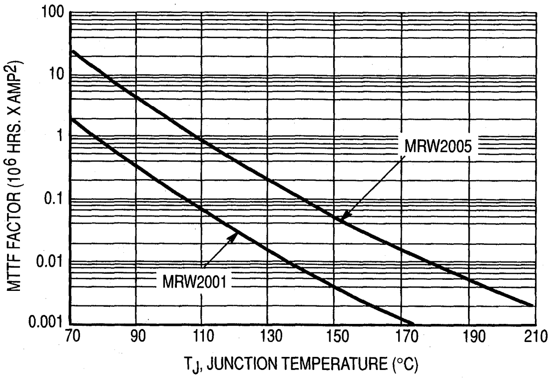


Figure 7. MTTF Factor

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

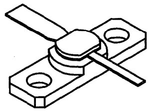
The RF Line
Microwave Power Transistors

. . . designed primarily for large–signal output and driver amplifier stages in the 1.5 to 3.0 GHz frequency range.

- Designed for Class B or C, Common Base Linear Power Amplifiers
- Specified 28 Volt, 3.0 GHz Characteristics:
  Output Power — 1.0 to 5.0 Watts
  Power Gain — 5.0 to 7.0 dB Min
  Collector Efficiency — 30% Min
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MRW3001
MRW3003
MRW3005

5.0–7.0 dB
1.5–3.0 GHz
1.0–5.0 WATTS
MICROWAVE
POWER TRANSISTORS



CASE 328A–03, STYLE 1
(GP–13)
MRW3001, 3003, 3005

MAXIMUM RATINGS

Rating	Symbol	3001	3003	3005	Unit
Collector–Base Voltage	V_{CBO}	45			Vdc
Emitter–Base Voltage	V_{EBO}	3.5			Vdc
Operating Junction Temperature	T_J	200			°C
Storage Temperature Range	T_{stg}	–65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max			Unit
Thermal Resistance, RF, Junction to Case	$R_{\theta JC}$	35	17	8.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage		$V_{(BR)CES}$				Vdc
(I_C = 10 mA, V_{BE} = 0)	MRW3001		50	—	—	
(I_C = 30 mA, V_{BE} = 0)	MRW3003		50	—	—	
(I_C = 50 mA, V_{BE} = 0)	MRW3005		50	—	—	
Collector–Base Breakdown Voltage		$V_{(BR)CBO}$				Vdc
(I_C = 1.0 mA, I_E = 0)	MRW3001		45	—	—	
(I_C = 3.0 mA, I_E = 0)	MRW3003		45	—	—	
(I_C = 5.0 mA, I_E = 0)	MRW3005		45	—	—	
Emitter–Base Breakdown Voltage (I_E = 1.0 mA, I_C = 0)		$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 28 V, I_E = 0)	MRW3001	I_{CBO}	—	—	0.5	mAdc
	MRW3003		—	—	0.75	
	MRW3005		—	—	1.25	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 100 mA, V_{CE} = 5.0 V)	MRW3001		10	—	120	
(I_C = 300 mA, V_{CE} = 5.0 V)	MRW3003		10	—	120	
(I_C = 500 mA, V_{CE} = 5.0 V)	MRW3005		10	—	120	

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS						
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	MRW3001 MRW3003 MRW3005	C_{ob}	— — —	3.5 5.7 8.4	4.0 7.0 10	pF
FUNCTIONAL TESTS						
Common–Base Amplifier Power Gain (V_{CE} = 28 V, P_{out} = 1.0 W, f = 3.0 GHz) (V_{CE} = 28 V, P_{out} = 3.0 W, f = 3.0 GHz) (V_{CE} = 28 V, P_{out} = 5.0 W, f = 3.0 GHz)	 MRW3001 MRW3003 MRW3005	G_{PB}	 7.0 6.0 5.0	 — — —	 — — —	dB
Collector Efficiency (V_{CE} = 28 V, P_{out} = 1.0 W, f = 3.0 GHz) (V_{CE} = 28 V, P_{out} = 3.0 W, f = 3.0 GHz) (V_{CE} = 28 V, P_{out} = 5.0 W, f = 3.0 GHz)	 MRW3001 MRW3003 MRW3005	η_c	 30 30 30	 — — —	 — — —	%
Load Mismatch (V_{CE} = 28 V, f = 3.0 GHz, Load VSWR = ∞:1, All Phase Angles) P_{out} = 1.0 W P_{out} = 3.0 W P_{out} = 5.0 W	 MRW3001 MRW3003 MRW3005	ψ	No Degradation in Output Power			

MRW3001
TYPICAL CHARACTERISTICS

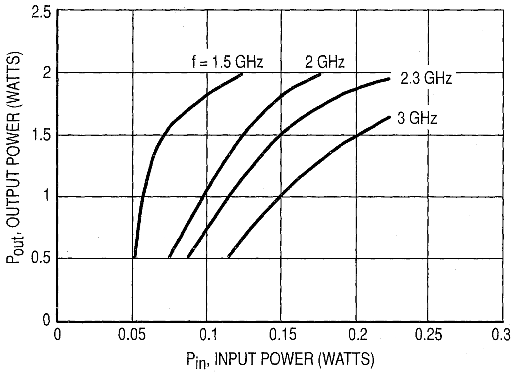


Figure 1. Output Power versus Input Power

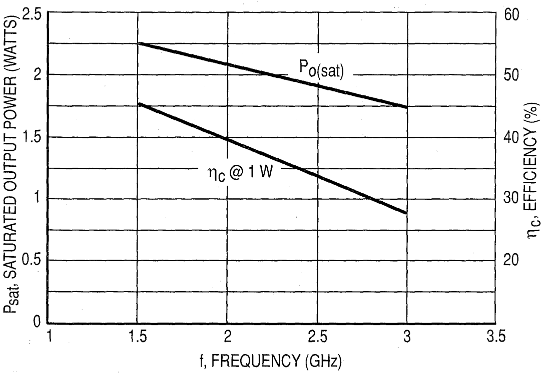


Figure 2. P_{sat} and η versus Frequency

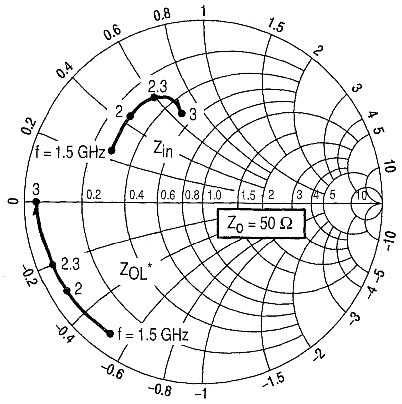


Figure 3. Series Equivalent Input/Output Impedance

TYPICAL CHARACTERISTICS

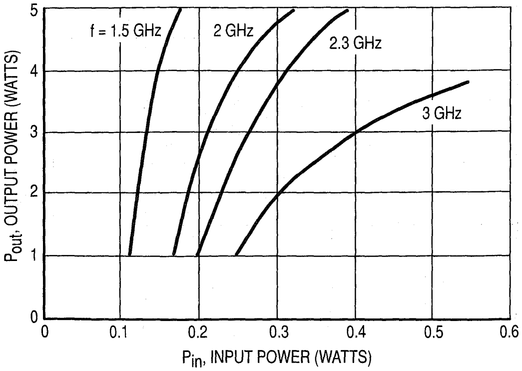


Figure 4. Output Power versus Input Power

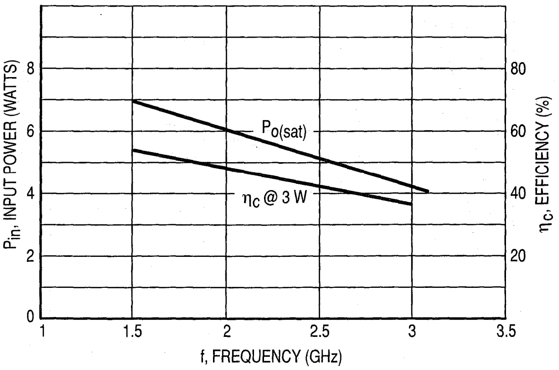


Figure 5. P_{sat} and η versus Frequency

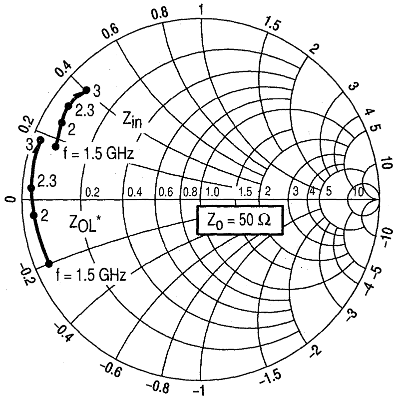


Figure 6. Series Equivalent Input/Output Impedance

MRW3005
TYPICAL CHARACTERISTICS

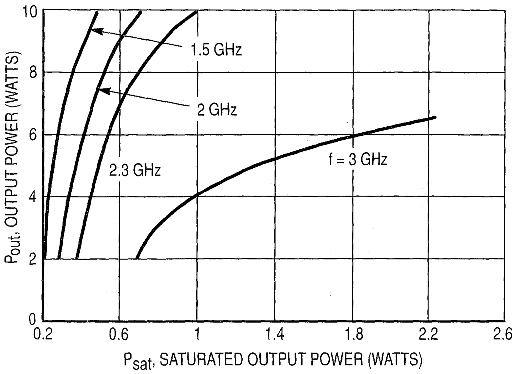


Figure 7. Output Power versus Input Power

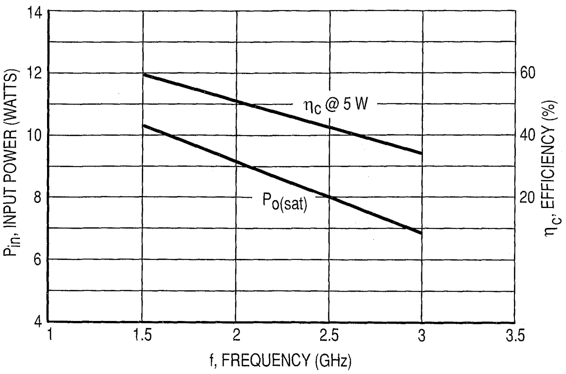


Figure 8. P_{sat} and η versus Frequency

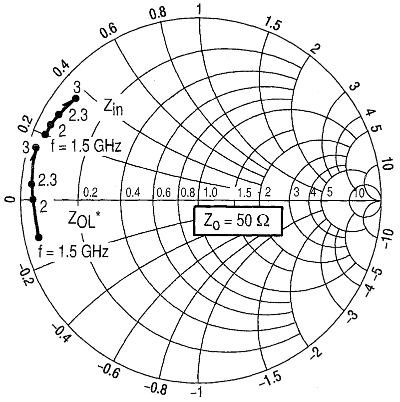


Figure 9. Series Equivalent Input/Output Impedance

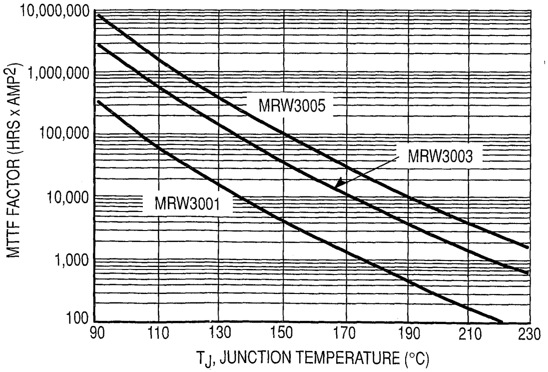


Figure 10. MTTF Factor versus Junction Temperature

MTTF Factor
(Normalized to 1.0 ampere^2 Continuous Duty)

The graph shown displays MTTF in hours x ampere^2 emitter current for each of the 3.0 GHz devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. **CAUTION** — A calculation is required to obtain actual metal life. Sample MTTF calculations based on operating conditions are shown below.

Junction Temperature — °C

To calculate metal lifetime under any set of conditions, obtain actual data or estimate from typical performance curves. Solve for T_J (°C):

$$(1)\ T_J = \theta_{JF}\left(\frac{P_{out}\ \text{x}\ 100}{\eta_c\ \%} + P_{in} - P_{out}\right) + T_{FLANGE}$$

Enter graph of MTF factor versus T_J. Obtain MTF factor. Calculate metal life by:

$$(2)\ \text{Metal Life in Hours} = \frac{\text{MTF Factor}}{I_C{}^2\ \text{(Amps)}}$$

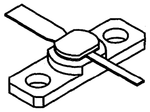
The RF Line
Microwave Linear Power Transistor

MRW53601

. . . designed primarily for wideband, large–signal output and driver amplifier stages in the 1.0 to 3.0 GHz frequency range.

- Designed for Class A or AB, Common–Emitter Linear Power Amplifiers
- Specified 20 Volt, 3.0 GHz Characteristics:
  Output Power — 0.8 Watts
  Power Gain — 7.5 to 8.5 dB, Min
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors

7.5–8.5 dB
1.0–3.0 GHz
0.8 WATT
MICROWAVE LINEAR
POWER TRANSISTOR



CASE 328A–03, STYLE 1
(GP–13)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	22	Vdc
Collector–Base Voltage	V_{CES}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	–65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, RF, Junction to Case	$R_{\theta JC}$	31	°C/W
Thermal Resistance, DC, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	22	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mA, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1.0 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.25 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 28 V, I_E = 0)	I_{CBO}	—	—	0.25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	3.5	pF

(continued)

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 0.8 W, f = 2.0 GHz)	G_{PE}	8.5	—	—	dB
Load Mismatch (V_{CE} = 20 V, I_E = 120 mA, P_{out} = 0.8 W, f = 2.0 GHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			
Cutoff Frequency (V_{CE} = 20 V, I_E = 120 mA)	f_τ	—	3.0	—	GHz
Gain Linearity (V_{CE} = 20 V, I_E = 120 mA, f = 2.0 GHz, P_{o1} = 0.8 W, P_{o2} = 0.8 mW)	L_G	— —	— —	−0.2 +1.0	dB
Intermodulation Distortion, 3rd Order (V_{CE} = 20 V, I_E = 120 mA, P_o (PEP) = 0.8 W, Tones at 2.0 GHz and 3.005 GHz)	IMD	—	−30	—	dB

TYPICAL CHARACTERISTICS

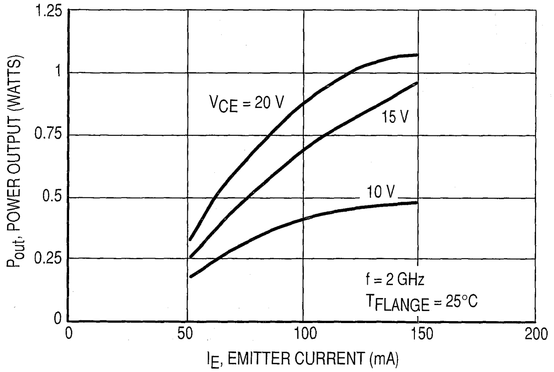


Figure 1. 1.0 dB Compression Point versus Emitter Current

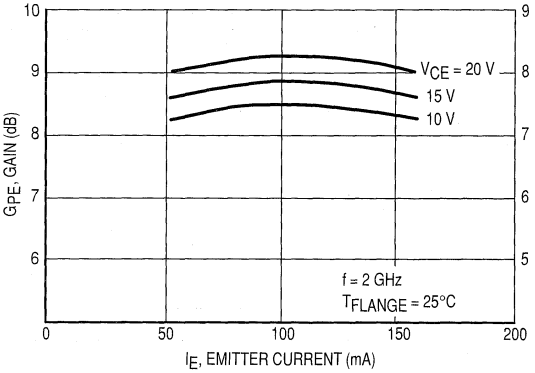


Figure 2. Gain versus Emitter Current

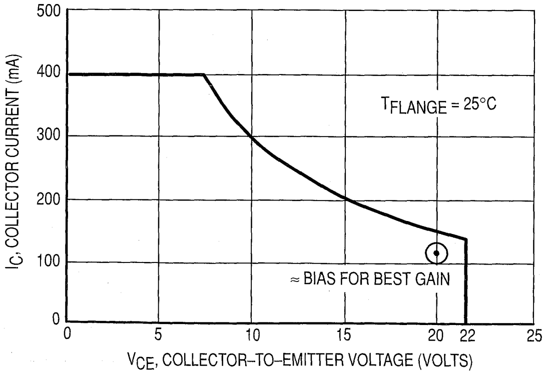


Figure 3. DC Safe Operating Area

V_{CE} (Volts)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ ϕ	Mag	∠ ϕ	Mag	∠ ϕ	Mag	∠ ϕ
20	120	0.5	0.83	−177	4.91	71	0.03	22	0.36	−82
		1.0	0.82	170	2.48	42	0.04	25	0.46	−108
		1.3	0.81	162	1.87	28	0.04	26	0.54	−122
		1.6	0.80	155	1.45	11	0.05	23	0.62	−132
		2.0	0.78	141	1.17	−6.0	0.06	20	0.67	−142
		2.3	0.83	132	1.02	−20	0.07	15	0.69	−151
		2.5	0.84	130	0.91	−29	0.07	11	0.72	−158
		2.7	0.79	125	0.85	−35	0.08	10	0.76	−160
		3.0	0.64	110	0.79	−43	0.10	6.0	0.80	−168
		3.3	0.61	82	0.77	−57	0.12	−2.0	0.79	−174

Table 1. Common Emitter S–Parameters

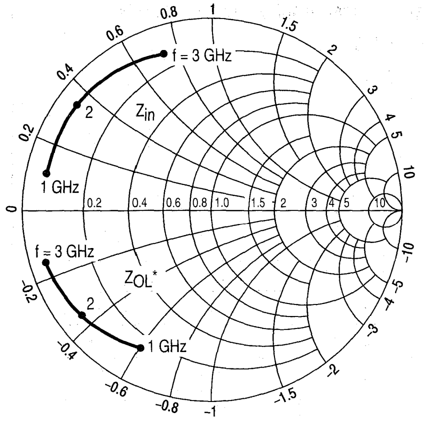


Figure 4. Series Equivalent Input/Output Impedance Conditions: V_{CE} = 20 V, I_E = 120 mA, T_{FLANGE} = 25°C

The graph shown below displays MTTF in hours x ampere^2 emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Divide MTTF by $I_C{}^2$ for MTTF in a particular application.

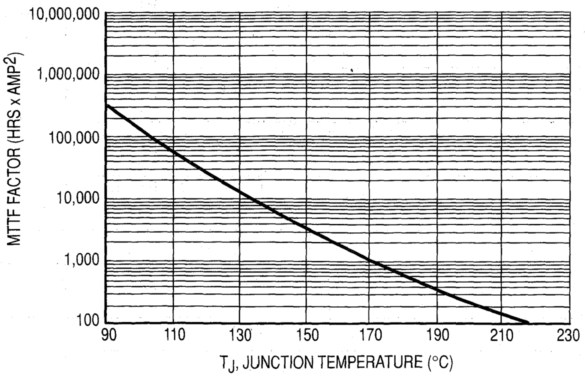


Figure 5. MTTF Factor versus Junction Temperature

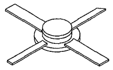
The RF Line
Microwave Linear Power Transistors

. . . designed primarily for large–signal output and driver amplifier stages in the 1.0 to 4.0 GHz frequency range.

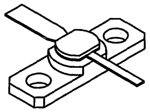
- Designed for Class A or AB, Common–Emitter Linear Power Amplifiers
- Specified 20 Volt, 2.0 GHz Characteristics:
  Output Power — 0.5 Watt
  Power Gain — 10 to 11 dB
- 100% Tested for Load Mismatch at All Phase Angles with ∞:1 VSWR
- Gold Metallization for Improved Reliability
- Diffused Ballast Resistors

MRW54001
MRW54601

10–11 dB
1.0–4.0 GHz
0.5 WATT
MICROWAVE LINEAR
POWER TRANSISTORS



CASE 400–01, STYLE 1
(TW200)
MRW54001



CASE 328A–03, STYLE 1
(GP–13)
MRW54601

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	22	Vdc
Collector–Base Voltage	V_{CES}	50	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	40	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA, I_B = 0)	$V_{(BR)CEO}$	22	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mA, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1.0 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 0.25 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 28 V, I_E = 0)	I_{CBO}	—	—	0.25	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	20	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	3.5	pF

(continued)

ELECTRICAL CHARACTERISTICS — continued

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS						
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 0.5 W, f = 2.0 GHz, I_E = 120 mA)	MRW54001	G_{PE}	10	—	—	dB
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 0.5 W, f = 2.0 GHz, I_E = 120 mA)	MRW54601	G_{PE}	11	—	—	dB
Load Mismatch (V_{CE} = 20 V, I_E = 120 mA, P_{out} = 0.5 W, f = 2.0 GHz, Load VSWR = ∞:1, All Phase Angles)		ψ	No Degradation in Output Power			
Cutoff Frequency (V_{CE} = 20 V, I_E = 120 mA)		f_τ	4.0	4.5	—	GHz
Gain Linearity (V_{CE} = 20 V, I_E = 120 mA, f = 2.0 GHz, P_{o1} = 0.5 W, P_{o2} = 0.5 mW)		L_G	— —	— —	−0.2 +1.0	dB
Intermodulation Distortion, 3rd Order (V_{CE} = 20 V, I_E = 120 mA, P_o (PEP) = 0.5 W, Tones at 2.0 GHz and 2.005 GHz)		IMD	—	−30	—	dB

TYPICAL CHARACTERISTICS

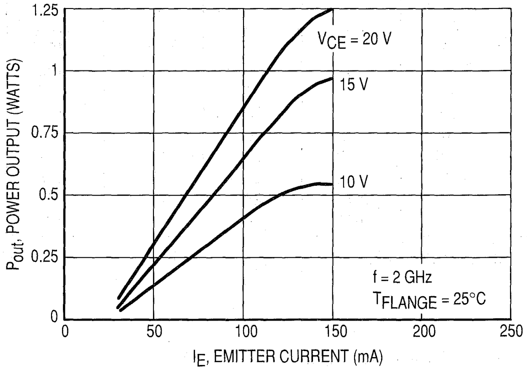


Figure 1. 1.0 dB Compression Point versus Emitter Current

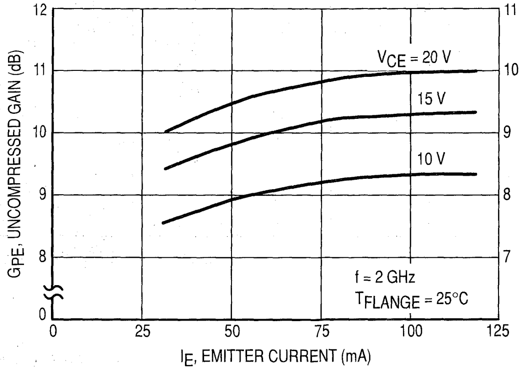


Figure 2. Gain versus Emitter Current

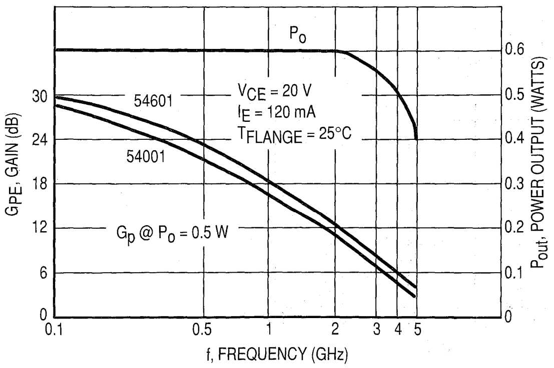


Figure 3. Gain and 1.0 dB Compressed Power versus Frequency

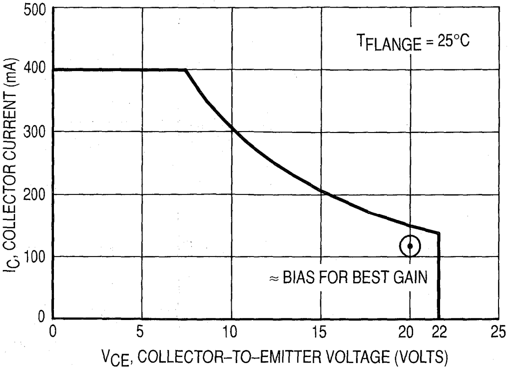


Figure 4. DC Safe Operating Area

V_{CE} (Volts)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
20	100	0.5	0.76	−177	6.65	74	0.03	20	0.43	−73
		1.0	0.76	159	3.24	39	0.03	24	0.50	−104
		1.3	0.76	148	2.46	21	0.04	25	0.56	−120
		1.5	0.75	141	2.07	9.0	0.04	24	0.60	−130
		1.7	0.76	134	1.80	−1.0	0.05	24	0.64	−140
		2.0	0.76	124	1.51	−14	0.06	22	0.68	−152
		2.3	0.74	113	1.27	−33	0.06	13	0.74	−167
		2.5	0.73	106	1.15	−43	0.07	9.0	0.76	−173
		2.7	0.72	98	1.06	−52	0.07	5.0	0.77	179
		32	0.69	85	0.95	−67	0.08	−4.0	0.82	170
		3.3	0.64	71	0.86	−81	0.09	−14	0.85	161
		3.5	0.61	60	0.81	−94	0.10	−22	0.87	155
		3.7	0.57	47	0.77	−103	0.10	−30	0.80	149
		4.0	0.51	24	0.70	−119	0.11	−44	0.92	141

Table 1. MRW54001 Common Emitter S–Parameters

V_{CE} (Volts)	I_C (mA)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ φ	Mag	∠ φ	Mag	∠ φ	Mag	∠ φ
20	100	0.5	0.77	−178	6.17	84	0.04	32	0.32	−57
		1.0	0.79	159	3.11	56	0.05	38	0.28	−75
		1.3	0.80	149	2.40	44	0.05	41	0.29	−88
		1.5	0.81	144	2.06	34	0.06	41	0.30	−98
		1.7	0.82	138	1.81	28	0.06	43	0.32	−108
		2.0	0.83	130	1.52	16	0.08	42	0.35	−121
		2.3	0.85	127	1.29	7.0	0.09	41	0.39	−135
		2.5	0.86	123	1.17	−1.0	0.10	39	0.41	−142
		2.7	0.87	119	1.06	−5.0	0.10	39	0.43	−150
		3.0	0.89	113	0.96	−16	0.12	35	0.48	−162
		3.3	0.89	105	0.83	−25	0.13	31	0.53	−172
		3.5	0.91	102	0.76	−31	0.14	27	0.57	−178
		3.7	0.93	98	0.70	−35	0.15	25	0.59	176
		4.0	0.89	90	0.62	−44	0.17	19	0.66	166

Table 2. MRW54601 Common Emitter S–Parameters

The graph shown below displays MTTF in hours x ampere^2 emitter current for each of the devices. Life tests at elevated temperatures have correlated to better than ±10% to the theoretical prediction for metal failure. Divide MTTF by I_C^2 for MTTF in a particular application.

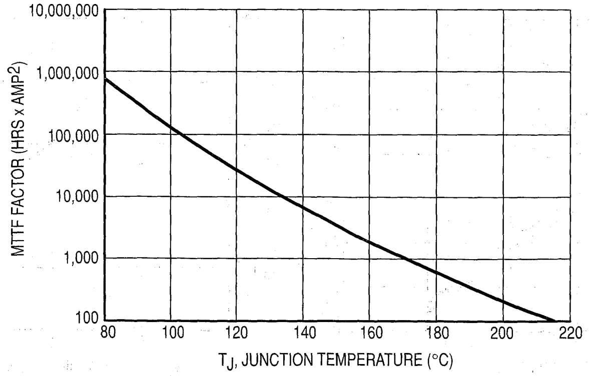


Figure 5. MTTF Factor versus Junction Temperature

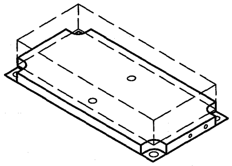
The RF Line
Broadband RF Array for TV Transmitter

RFA8090B

140 W, 470–860 MHz
CLASS AB
RF POWER AMPLIFIER

The RFA8090B is a solid state class AB amplifier and is specifically designed for TV transposers and transmitters. This amplifier incorporates microstrip technology and reliable Motorola push–pull transistors.

- Specified 28 Volts, 470–860 MHz Characteristics
  Output Power — 95 Watts (CW)
  Output Power — 140 Watts (peak)
  Gain — 8 dB min (@ 95 Watts)
- 50 Ω Input and Output Impedance



CASE 429E–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	32	Vdc
Quiescent Current	I_{CQ}	2 x 300	mAdc
Input Power	P_{in}	20	Watts
Storage Temperature Range	T_{stg}	−40 to +100	°C
Operating Temperature (1)	T_{op}	−20 to +70	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$, $V_{CC} = 28$ V, $I_{CQ} = 200$ mA, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Instantaneous Bandwidth	BW	470	860	MHz

FUNCTIONAL TESTS IN CW (SOUND) ($T_C = 25°C$, $V_{CC} = 28$ V, $I_{CQ} = 200$ mA, unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Power Gain ($P_{out} = 95$ W)	G_p	8	—	dB
Gain Ripple ($P_{out} = 95$ W)	G_{rple}	—	±0.7	dB
Output Power @ 1 dB Compression	P_{out}	95	—	Watts
Mismatch Tolerance ($P_{out} = 95$ W)	VSWR	3:1	—	—
Efficiency ($P_{out} = 95$ W)	η	50	—	%

FUNCTIONAL TESTS IN VIDEO (standard black level)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Output Power (synch.) ($V_{CC} = 28$ Vdc, $I_{CQ} = 200$ mA, f = 860 MHz)	P_{out}	120	—	—	Watts
Peak Output Power (synch.) ($V_{CC} = 32$ Vdc, $I_{CQ} = 100$ mA, f = 860 MHz)	P_{out}	140	—	—	Watts

NOTE:
1. Temperature is measured at temperature test point (on the flange of the transistor).

TYPICAL CHARACTERISTICS

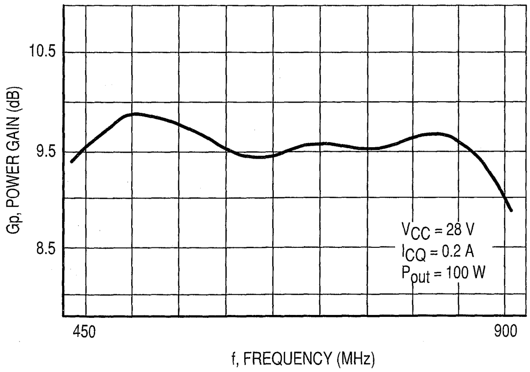


Figure 1. Power Gain versus Frequency

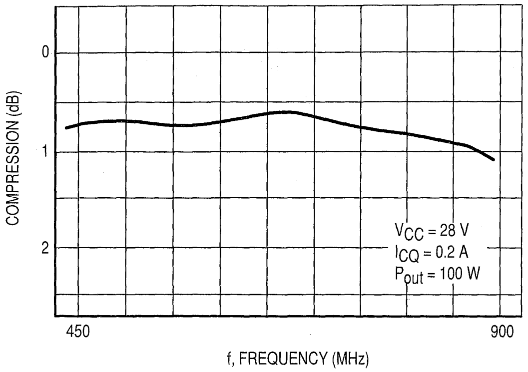


Figure 2. Gain Compression versus Frequency

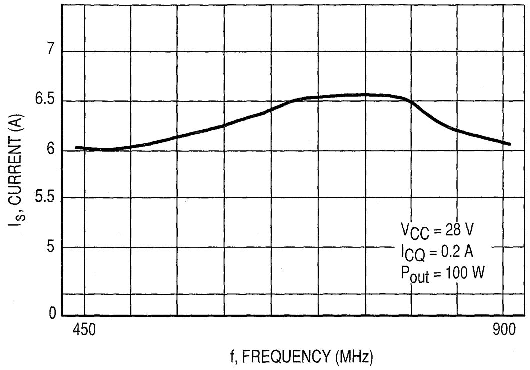


Figure 3. Supply Current versus Frequency

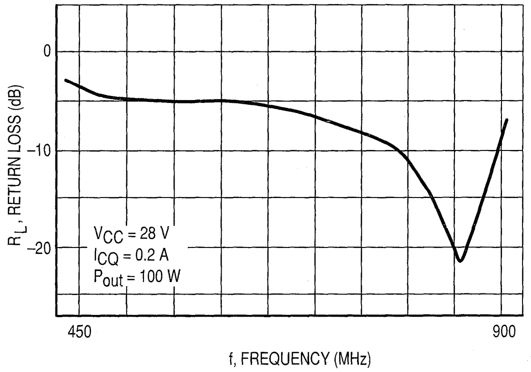


Figure 4. Input Return Loss versus Frequency

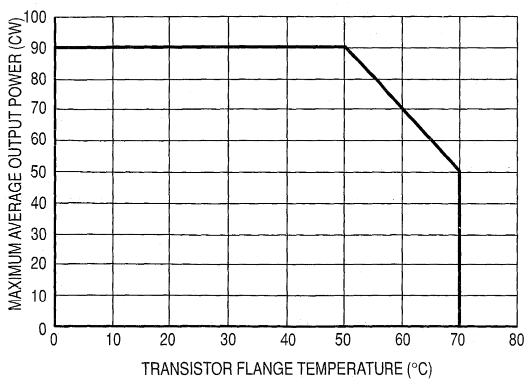


Figure 5. Maximum Average Output Power versus Temperature

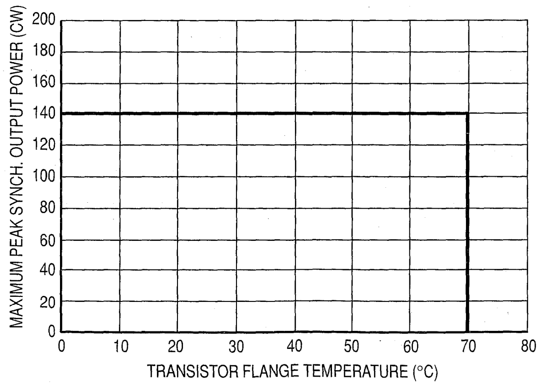


Figure 6. Maximum Peak Synch. Output Power (B/G Standard) versus Temperature

TYPICAL VIDEO CHARACTERISTICS

TEST CONDITIONS:
DIFF. Gain, 10 Steps
Channel 61, 10% rest carrier
V_{CE} = 28 V
I_Q = 0.2 A

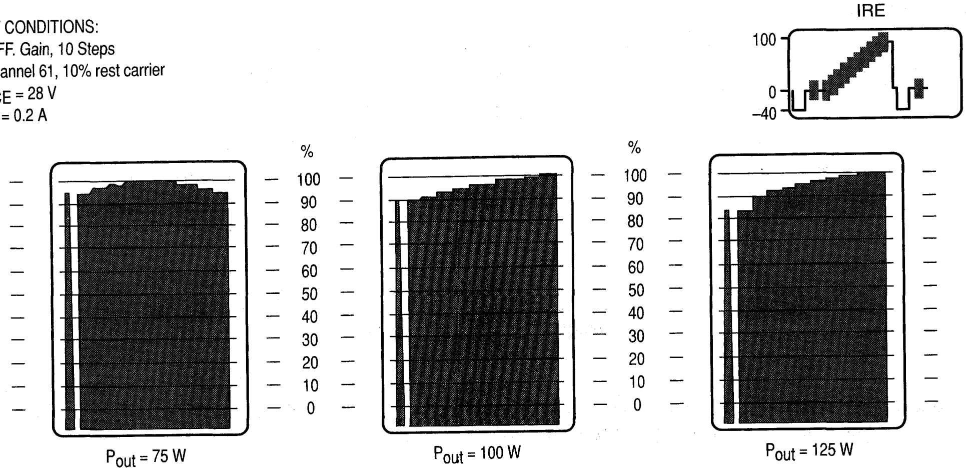


Figure 7. Differential Gain

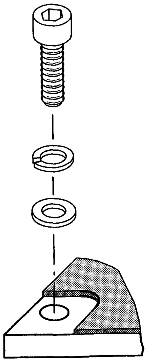
MOUNTING RECOMMENDATIONS

HEATSINK TOOLING

- Planarity: Better than 0.03 mm
- Roughness: Typical value 0.8
- 6 fixing holes M3

THERMAL COMPOUND

- Paste with silicones: SICERONT KF Ref. 1201 Recommended.
- Thickness: Optimum between 0.06 mm and 0.15 mm, on the whole back surface of the amplifier.
  (Typical volume: 215 mm 3 for 0.1 mm thickness)
  (Equivalent weight: 0.5g for 2.2 density paste).



SCREWS

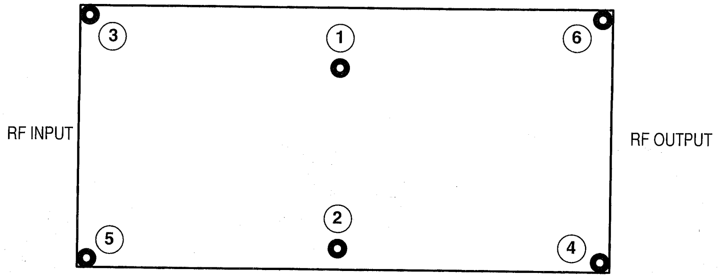
- Socket head cap screws: CHC M3 x 10 for Copper/Aluminum Heatsink.
- Material: Nickel plated steel.

WASHERS

- Split lock washers WZ ∅3 + Flat washers ZU ∅3.

MOUNTING RECOMMENDATIONS (continued)

TIGHTENING ORDER



RECOMMENDED TORQUE: 12 Kg.cm (10.5 in. lbs)

CLEANING

Some components of the RFA8090B are not qualified for every kind of cleaning solvent; do not clean the amplifier in a solvent bath. Local cleaning is recommended.

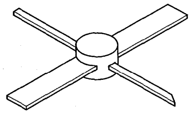
The RF Line
NPN Silicon
RF Power Transistor

The TP3007S is designed for 24 volts common emitter base station amplifiers, operating up to 1 GHz bandwidth. It has been specifically designed for use in analog and digital Global System Mobile (GSM) systems. The studless package offers a possibility for surface mounting.

- Specified 24 Volts, 960 MHz Characteristics
  Output Power — 2 Watts
  Gain — 9 dB min
  Efficiency — 50% min, 2 Watts
- Characterized with Series Equivalent Large–Signal Parameters from 920–960 MHz
- Silicon Nitride Passivated
- Gold Metallized, Emitter Ballasted for Long Life and Resistance to Metal Migration
- Class AB Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

TP3007S

2 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON



CASE 305C–02, STYLE 1
SOE200 STUDLESS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CER}	45	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	1	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	8.3 0.048	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1) (Studless)	$R_{\theta JC}$	21	°C/W

ELECTRICAL CHARACTERISTICS (T$_C$ = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 5$ mAdc, $R_{BE} = 75\ \Omega$)	$V_{(BR)CER}$	45	—	—	Vdc
Collector–Base Breakdown Voltage ($I_C = 5$ mAdc, $I_E = 0$)	$V_{(BR)CBO}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 1$ mAdc, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc

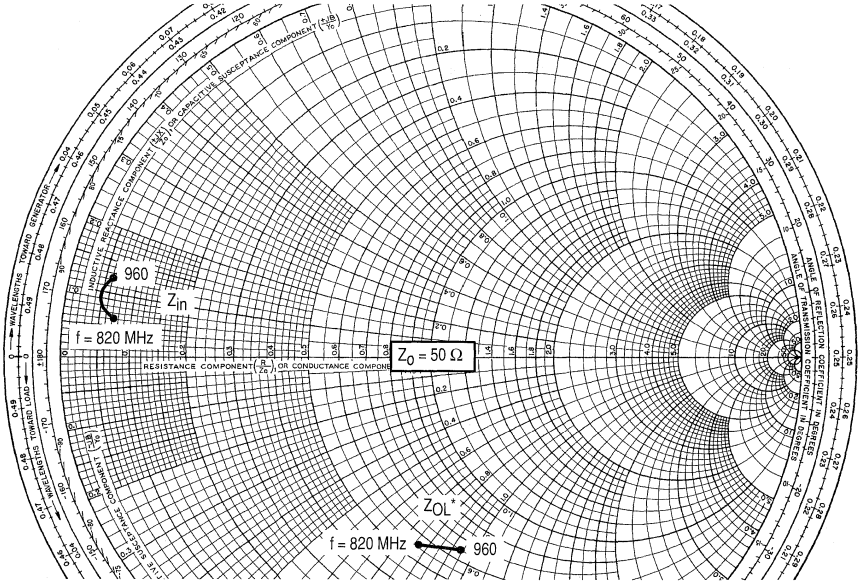
NOTE:
1. Thermal resistance is determined under specified RF operating condition.

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_{CE} = 0.1 Adc, V_{CE} = 5 Vdc)	h_{FE}	10	—	150	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	2	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 24 Vdc, P_{out} = 2 W, I_{CQ} = 30 mA, f = 960 MHz)	G_p	9	10	—	dB
Collector Efficiency (V_{CC} = 24 Vdc, P_{out} = 2 W, I_{CQ} = 30 mA, f = 960 MHz)	h	50	56	—	%
Output Mismatch Stress (V_{CC} = 24 Vdc, P_{out} = 2 W, I_{CQ} = 30 mA, f = 960 MHz, Load VSWR = 10:1, all phase angles at frequency of test)	Ψ	No Degradation in Output Power			

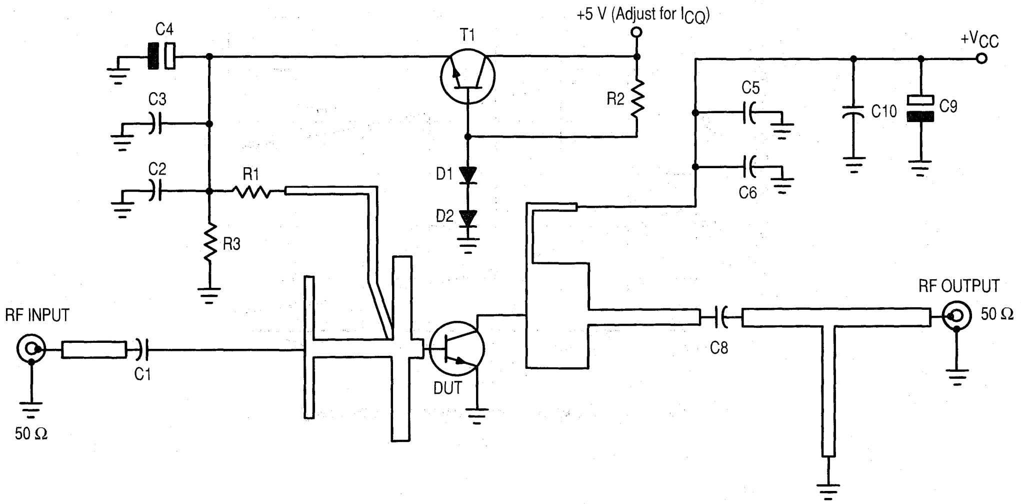


Output Impedances with circuit tuned for maximum gain
@ V_{CC} = 24 V, P_{out} = 2 W

f **(MHz)**	Z_{in} (Ω)	Z_{OL}* (Ω)
820	4 + j3.8	29 – j41
860	3.4 + j4.4	30 – j43
900	3.1 + j5.1	31 – j44
960	3.5 + j5.5	35 – j45

Z_{OL}* = Conjugate of optimum load impedance
into which the device operates at a given
output power, voltage, current and frequency.

Figure 1. Series Equivalent Input and Output Impedances



C1	3.9 pF, ATC Chip Capacitor 100A	C10	15 nF, Chip Capacitor
C2,C6	100 pF, ATC Chip Capacitor 100A	D1,D2	Diode, BAS16
C3,C5	15 nF, Chip Capacitor 0805	R1	2.2 Ω, Chip Resistor 1206
C4	10 µF, 16 V, Capacitor	R2	1.2 kΩ, Chip Resistor 1206
C7	15 nF, Chip Capacitor 0805	R3	68 Ω, Chip Resistor 1206
C8	47 pF, Chip Capacitor 100A	T1	Transistor, MJD31C
C9	4.7 µF, 50 V, Capacitor		

Figure 2. 960 MHz Electrical Schematic

TYPICAL CHARACTERISTICS

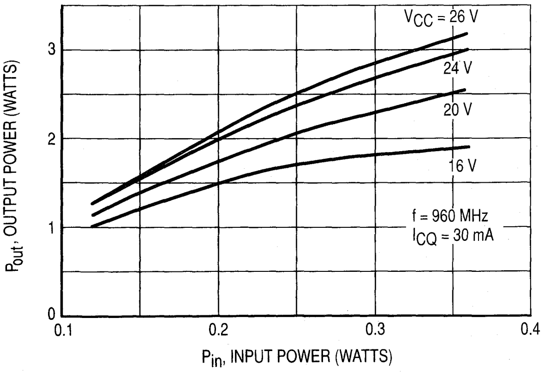


Figure 3. Output Power versus Input Power

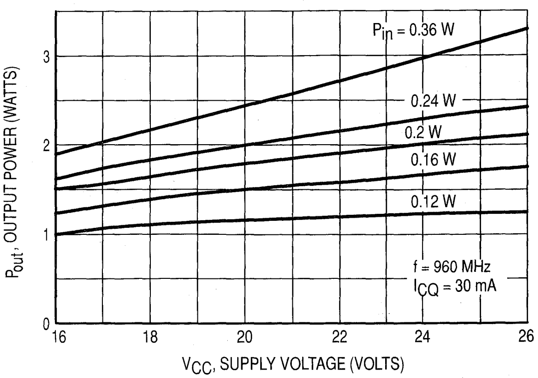


Figure 4. Output Power versus Supply Voltage

TYPICAL CHARACTERISTICS

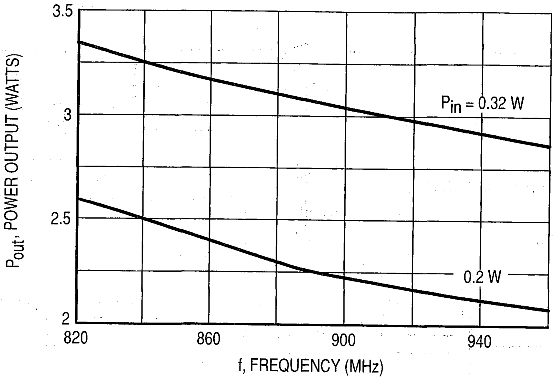


Figure 5. Output Power versus Frequency

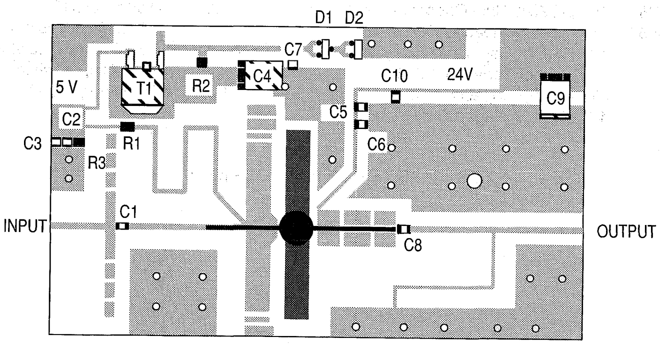
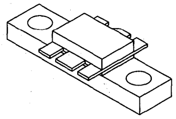


Figure 6. 960 MHz Test Circuit Components View

The RF Line
RF Power Transistor

TP3008

4 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON



CASE 319–07, STYLE 2

The TP3008 is designed for 960 MHz cellular radio base stations in both analog and digital applications. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

- Specified 24 Volts, 960 MHz Characteristics
  Output Power — 4 Watts
  Gain — 11.5 dB min
  Efficiency — 45% min
- Class AB Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CER}	40	Vdc
Collector–Base Voltage	V_{CBO}	50	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	1	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	35 0.2	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

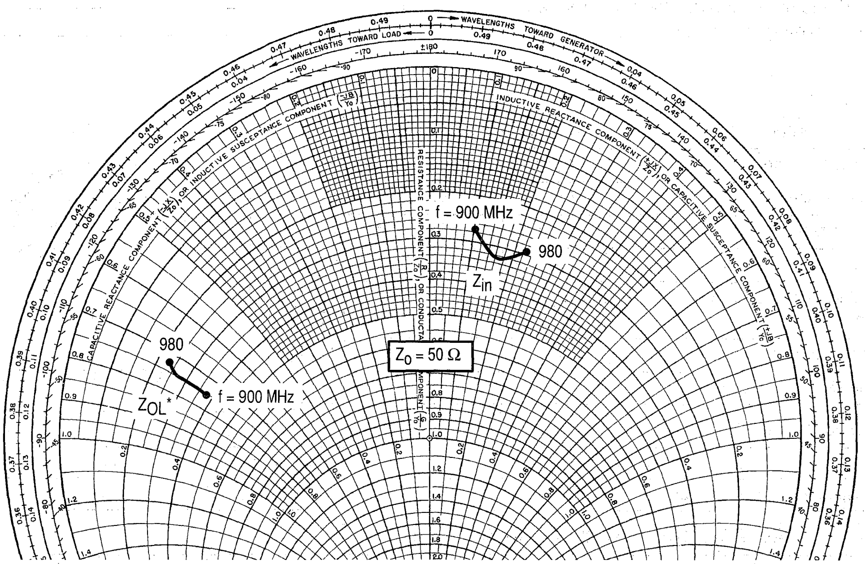
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage ($I_C = 15$ mA, $R_{BE} = 75\ \Omega$)	$V_{(BR)CER}$	40	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 3$ mAdc)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage ($I_E = 2$ mA, $I_C = 0$)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector–Emitter Leakage ($V_{CE} = 26$ V, $R_{BE} = 75\ \Omega$)	I_{CER}	—	—	2	mA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.2$ Adc, $V_{CE} = 5$ Vdc)	h_{FE}	15	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CE} = 24$ V, $I_E = 0$, f = 1 MHz)	C_{ob}	—	6	—	pF

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (V_{CC} = 24 V, f = 960 MHz)					
Common–Emitter Amplifier Gain (P_{out} = 4 W, I_{CQ} = 50 mA)	G_p	11.5	—	—	dB
Collector Efficiency (P_{out} = 4 W, I_{CQ} = 50 mA)	h	45	50	—	%
Load Mismatch (P_{out} = 4 W, I_{CQ} = 50 mA, Load VSWR = 5:1, all phase angles at frequency of test)	Ψ	No Degradation in Output Power			

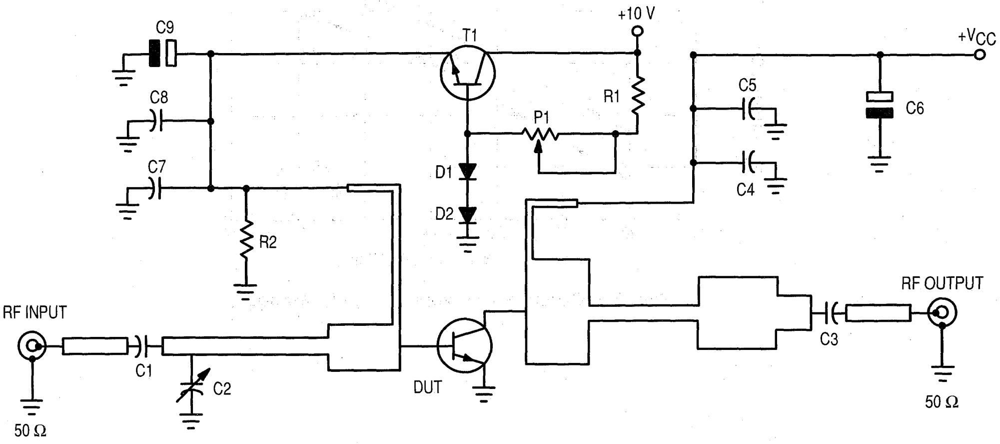


Output impedance with circuit tuned for maximum gain
@ P_{out} = 4 W, V_{CE} = 24 V

f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
900	6 + j5	7.6 – j15
935	6.2 + j4.7	5.5 – j13.5
960	6.8 + j3.6	5.5 – j13.5
980	7.2 + j2	5.3 – j13.5

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 1. Series Equivalent Input and Output Impedance



Components List

C1,C3	100 pF, ATC Chip Capacitor 100A
C2	1 to 5 pF, Trimmer Capacitor
C4,C7	330 pF, Chip Capacitor 0805
C5,C8	10 nF, Chip Capacitor 0805
C6	15 µF, 63 V, Capacitor
C9	100 µF, 16 V, Capacitor
D1,D2	Diode, BAS16
P1	1 kΩ, Trimmer
R1	1 kΩ, Resistor
R2	56 Ω, 0805 Resistor
T1	Transistor, NPN Type, MJD31C

Figure 2. 960 MHz Electrical Schematic

TYPICAL CHARACTERISTICS

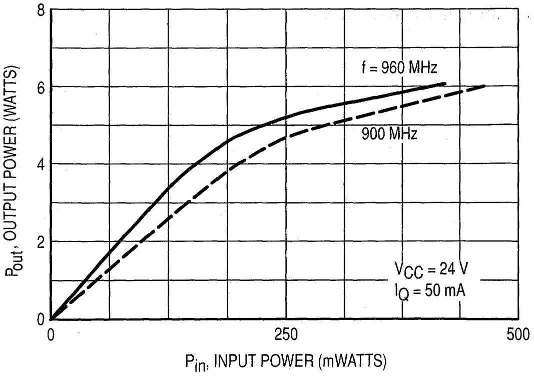


Figure 3. Output Power versus Input Power

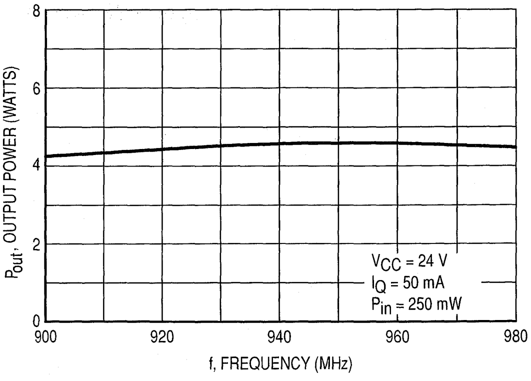


Figure 4. Output Power versus Frequency

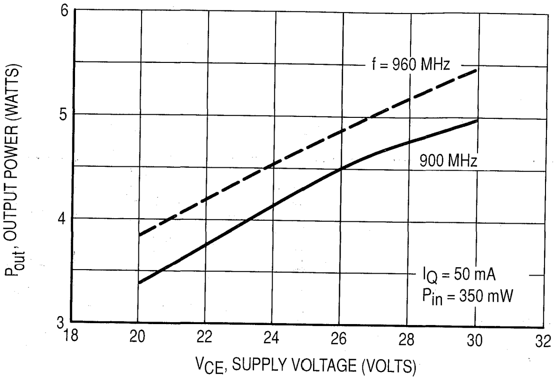


Figure 5. Output Power versus Supply Voltage

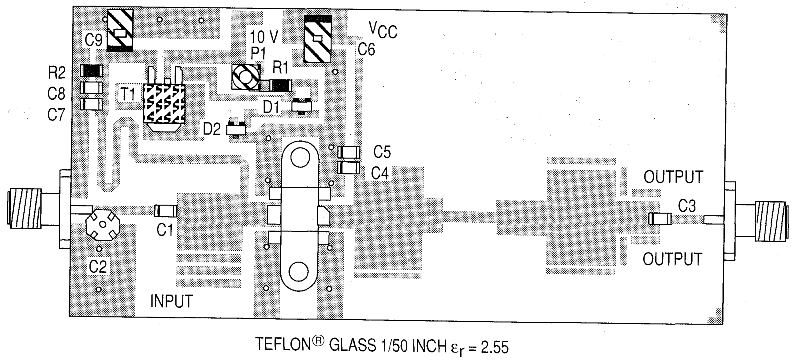


Figure 6. 960 MHz Test Circuit Components View

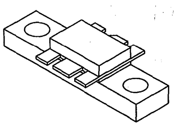
The RF Line
UHF Power Transistor

TP3021

10 W, 960 MHz
UHF POWER
TRANSISTOR
NPN SILICON

The TP3021 is designed for 24 V common emitter base station amplifiers. Operating in the 820–960 MHz bandwidth, it has been specifically designed for use in analog and digital (GSM) systems as a medium power output device.

- Specified 24 Volts, 960 MHz Characteristics
  Output Power = 10 Watts
  Minimum Gain = 10 dB
  Class AB
  I_Q = 60 mA
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 319–07, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	27	Vdc
Collector–Base Voltage	V_{CBO}	48	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	35 0.35	Watts W/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1) at 70°C Case	$R_{\theta JC}$	5.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 25 mA, R_{BE} = 75 Ω)	$V_{(BR)CER}$	40	—	—	Vdc
Emitter–Base Breakdown Voltage (I_C = 5.0 mAdc)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Base Breakdown Voltage (I_E = 50 mAdc)	$V_{(BR)CBO}$	48	—	—	Vdc
Collector–Emitter Leakage (V_{CE} = 26 V, R_{BE} = 75 Ω)	I_{CER}	—	—	5.0	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	15	—	100	—

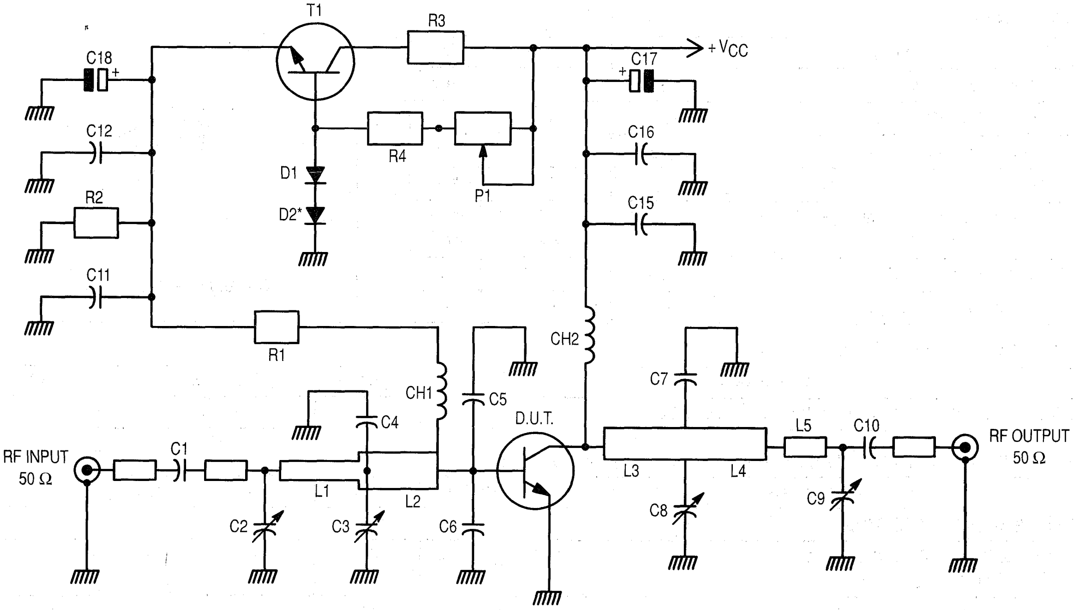
(continued)

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 V, I_E = 0, f = 1.0 MHz)	C_{ob}	15	—	25	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 24 V, P_{out} = 10 W, I_{CQ} = 60 mA, f = 960 MHz)	G_p	10	—	—	dB
Load Mismatch (V_{CC} = 26 V, P_{out} = 10 W, I_{CQ} = 60 mA, Load VSWR = 20:1, at all phase angles)	ψ	No Degradation in Output Power Before and After Test			
Collector Efficiency (V_{CC} = 24 V, P_{out} = 10 W, f = 960 MHz)	η_c	50	55	—	%



*D2 is in Physical Contact with RF Transistor

C1, C10, C11, C15 — Capacitor Chip 0805 330 pF 5%
C2, C4, C8, C9 — Trimmer Capacitor 0.5–4.0 pF
C4 — Capacitor Chip 0805 3.9 pF 5%
C5, C6 — Capacitor Chip 15 pF HQ
C7 — Chip Resistor 0805 8.2 pF
C12, C16 — Capacitor Chip 0805 15 nF 5%
C17, C18 — Capacitor Chip 0805 6.0, 8.0 µF 35 V
CH1 — Microstrip Line 80 Ω L = 40 mm
CH2 — Microstrip Line 80 Ω L = 23 mm
D1, D2 — Diode 1N4148

L1 — Microstrip Line 50 Ω L = 20 mm
L2 — Microstrip Line 25 Ω L = 13 mm
L3 — Microstrip Line 25 Ω L = 10 mm
L4 — Microstrip Line 50 Ω L = 5 mm
L5 — Microstrip Line 50 Ω L = 7 mm
P1 — Trimmer 5.0 kΩ
R1 — Chip Resistor 2.2 Ω 1206 5%
R2 — Chip Resistor 75 Ω 0805 5%
R3 — Resistor 100 Ω 2.0 W
R4 — Resistor 1.0 kΩ 5%
T1 — Transistor BD135 or Similar
Board Material — 1/50″, Teflon Glass, Cu Clad 2 Sides, 35 µm Thick

Figure 1. 960 MHz Test Circuit

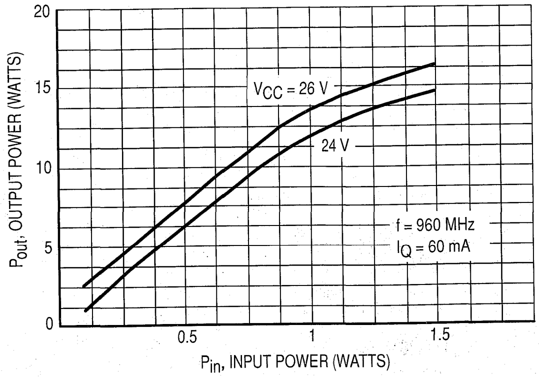
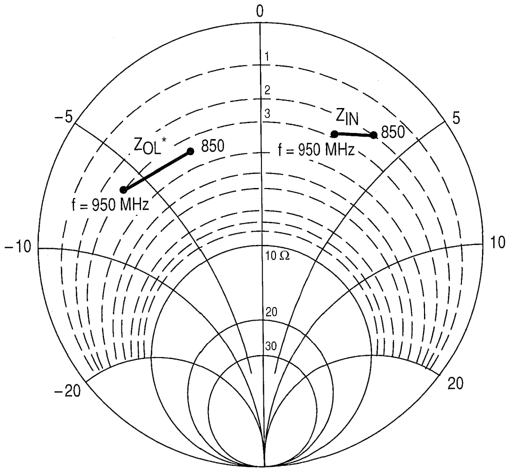


Figure 2. Output Power versus Input Power



P$_{out}$ = 10 W V$_{CE}$ = 24 V

f MHz	Z$_{IN}$ OHMS	Z$_{OL}$* OHMS
850	2.4 + j3.5	3.4 – j3.2
900	2.6 + j3.4	3.1 – j4.4
950	2.8 + j3.4	2.7 – j6.2

Z$_{OL}$* = Conjugate of the optimum load impedance. Into which the device operates at a given output power, voltage, and frequency.

Figure 3. Series Equivalent Input/Output Impedances

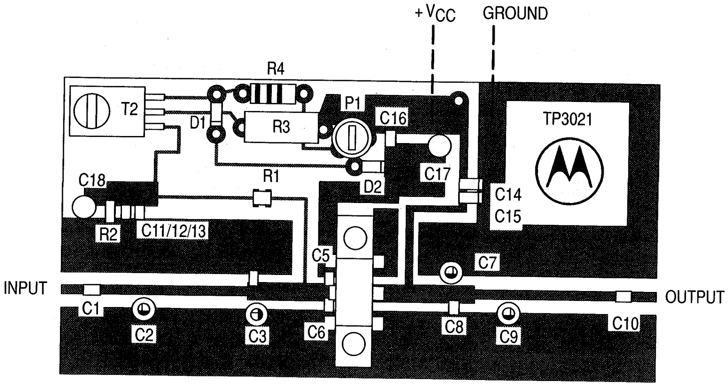
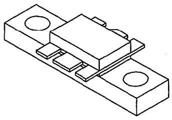


Figure 4. Test Circuit — Component Locations

The RF Line
NPN Silicon RF Power Transistor

TP3034

**35 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON**



CASE 319–07, STYLE 2

The TP3034 is designed for 960 MHz cellular radio base stations in both analog and digital applications. It incoporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

- Specified 24 Volts, 960 MHz Characteristics
  - Output power — 35 Watts
  - Gain — 7 dB Min
  - Efficiency — 50% Min
- Class AB Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CER}	40	Vdc
Collector–Base Voltage	V_{CBO}	48	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	76 0.43	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.3	°C/W

ELECTRICAL CHARACTERISTICS (TC = 25°C unless otherwise noted.)

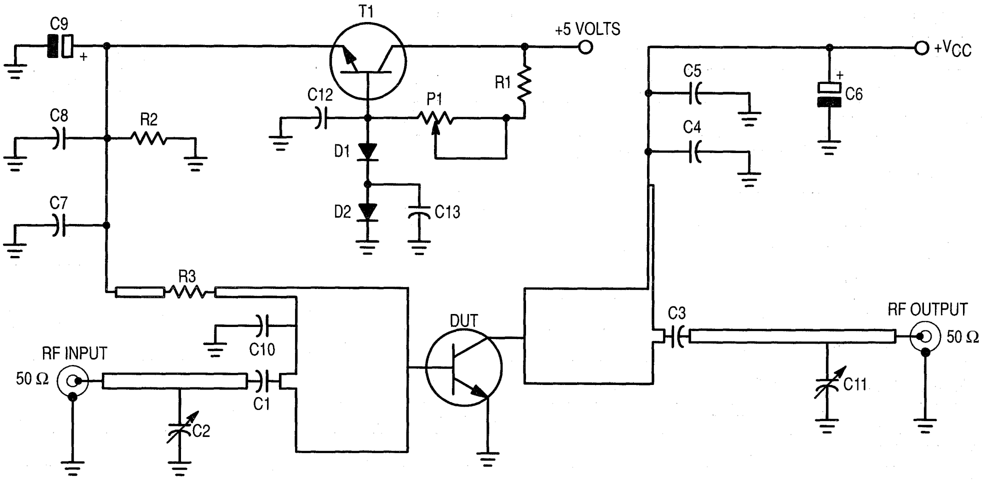
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mA, R_{BE} = 75 Ω)	$V_{(BR)CER}$	40	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc)	$V_{(BR)CBO}$	48	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 6 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Collector–Emitter Leakage (V_{CE} = 26 V, I_C = 1 A, R_{BE} = 75 Ω)	I_{CER}	—	—	10	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 Adc, V_{CE} = 10 Vdc)	h_{FE}	15	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 24 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	40	—	pF

(continued)

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Gain (P_{out} = 35 W, I_{CQ} = 60 mA, V_{CC} = 24 V, f = 960 MHz)	G_{p1}	7	8	—	dB
Collector Efficiency (P_{out} = 35 W, V_{CC} = 24 V, f = 960 MHz)	η_{C1}	50	55	—	%
Load Mismatch (P_{out} = 35 W, I_{CQ} = 60 mA, V_{CC} = 24 V, f = 960 MHz, Load VSWR = 20:1, All Phase Angles at frequency of test)	ψ	—	No Degradation in Output Power		
Input Return Loss (P_{out} = 35 W, I_{CQ} = 60 mA, V_{CC} = 24 V, f = 960 MHz)	IRL	12	—	—	dB
Common–Emitter Amplifier Gain (P_{out} = 15 W, I_{CQ} = 100 mA, V_{CC} = 25 V, f = 960 MHz)	G_{p2}	8	—	—	dB
Collector Efficiency (P_{out} = 15 W, I_{CQ} = 100 mA, V_{CC} = 25 V, f = 960 MHz)	η_{C2}	40	—	—	%



C1, C3	100 pF, ATC Chip Capacitor 100A	D1, D2	Diode, Type BAS16
C2, C11	0.5–20 pF, Trimmer Capacitor	P1	1 kΩ, Trimmer
C4, C7	330 pF, Chip Capacitor 0805	R1	1 kΩ, Resistor 0805
C5, C6, C12, C13	10 nF, Chip Capacitor 0805	R2	56 Ω, Resistor 0805
C6	4.7 µF, 50 Volts, Capacitor	R3	2.2 Ω, Resistor 0805
C9	10 µF, 16 Volts, Capacitor	T1	Transistor, NPN Type MJD31C
C10	5.6 pF, ATC Chip Capacitor 100A		

Figure 1. 960 MHz Electrical Schematic

TYPICAL CHARACTERISTICS

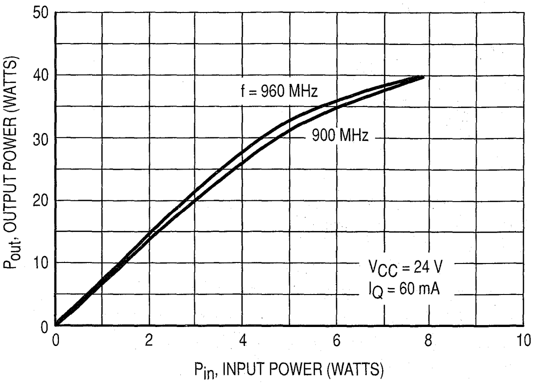


Figure 2. Output Power versus Input Power

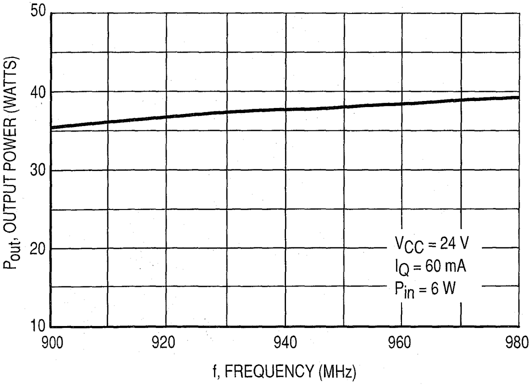


Figure 3. Output Power versus Frequency

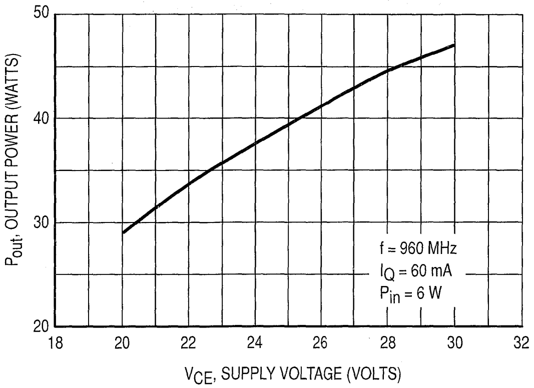
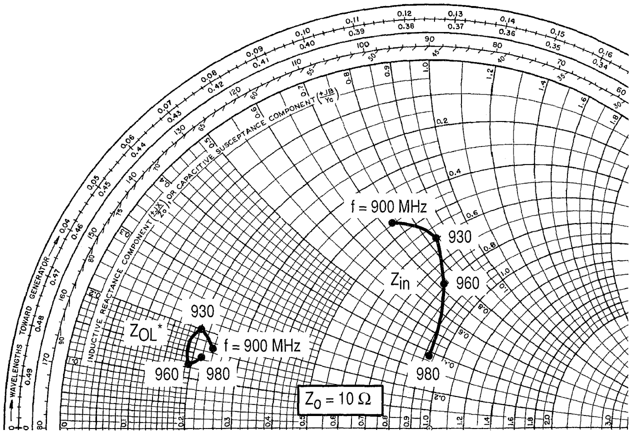


Figure 4. Output Power versus Supply Voltage



V_{CE} = 24 V P_{out} = 35 W

f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
900	4.5 + j7.4	2.4 + j1.7
930	5.8 + j8.4	2 + j2
960	7.9 + j7.2	2 + j1.3
980	9.4 + j3.8	2.2 + j1.5

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 5. Series Equivalent Input and Output Impedances

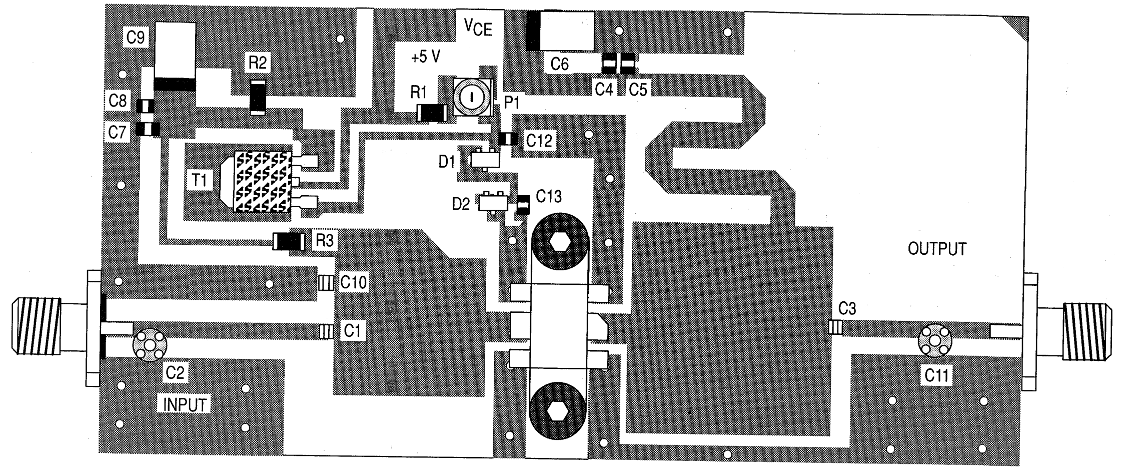


Figure 6. Test Circuit Components View

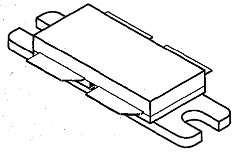
The RF Line
RF Power Transistor

TP3069

100 W, 960 MHz
RF POWER TRANSISTOR
NPN SILICON

The TP3069 is designed for cellular radio base station amplifiers up to 960 MHz. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness. The TP3069 also features input and output matching networks and high impedances. It can easily operate in a full 935–960 MHz bandwidth in a simple circuit.

- Class AB Operation
- Specified 26 Volts, 960 MHz Characteristics
  Output Power — 100 Watts
  Gain — 7.5 dB min
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.



CASE 375A–01, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	30	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector Current — Continuous	I_C	20	Adc
Storage Temperature Range	T_{stg}	– 40 to +100	°C
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	245 1.4	Watts W/°C
Quiescent Current	I_{CQ}	2 x 500	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	0.7	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mA)	$V_{(BR)CEO}$	30	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 20 mAdc)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 35 mAdc)	$V_{(BR)CBO}$	65	—	—	Vdc
Collector–Emitter Leakage (V_{CE} = 28 V, R_{BE} = 75 Ω)	I_{CER}	—	—	15	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 Adc, V_{CE} = 10 V)	h_{FE}	30	—	120	—
DYNAMIC CHARACTERISTICS (V_{CB} = 28 V, I_E = 0, f = 1 MHz)					
Output Capacitance (each side) (2)	C_{ob}	—	75	—	pF

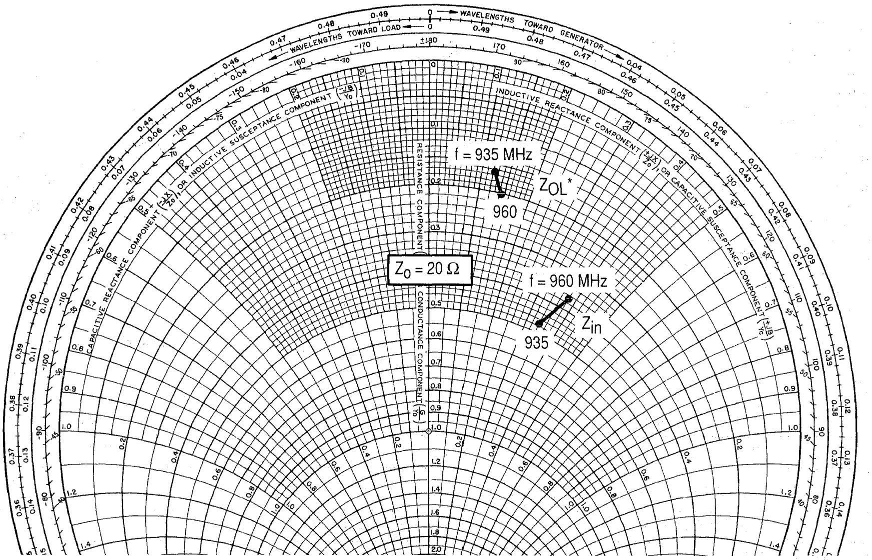
(continued)

NOTES:
1. Thermal resistance is determined under specified RF operating condition.
2. Value of “C_{ob}” is that of die only. It is not measurable in TP3069 because of internal matching network.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (V_{CC} = 26 V, f = 960 MHz)					
Common–Emitter Amplifier Gain (P_{out} = 100 W, I_{CQ} = 2 x 100 mA)	G_p	7.5	8.8	—	dB
Collector Efficiency (P_{out} = 100 W)	η	45	50	—	%
Over Drive 2 dB Input Power Overdrive	OD	No Degradation in Output Power			
3rd Order Intermodulation (P_{out} = 100 W PEP, I_{CQ} = 2 x 50 mA, Δf = 400 KHz)	IMD3	—	– 32	—	dB

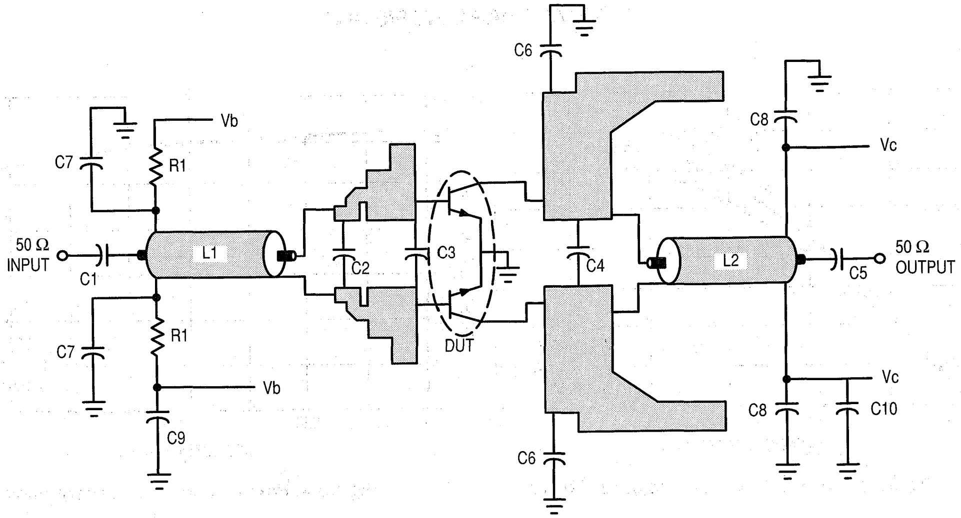


V_{CE} = 26 V P_{out} = 100 W

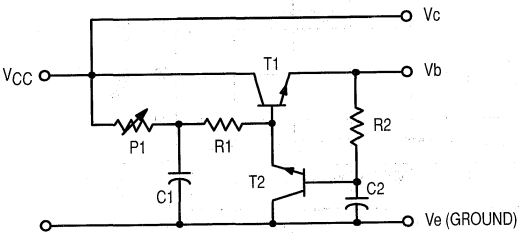
f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
935	9.5 + j7	3.4 + j2.7
960	8.8 + j7.5	3.8 + j2.8

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

Figure 1. Series Equivalent Input and Output Impedances



C1	10 pF, ATC Chip Capacitor 100A
C2	2.2 pF, ATC Chip Capacitor 100A
C3	12 pF, ATC Chip Capacitor 100A
C4	10 pF, ATC Chip Capacitor 175B
C5	47 pF, ATC Chip Capacitor 100A
C6	5.6 pF, ATC Chip Capacitor 175B
C7	1000 pF, Vitramon
C8	1 µF, Vitramon
C9	1 µF, 16 V, Tantalum
C10	4.7 µF, 35 V, Tantalum
L1	25 Ω/41 mm (Teflon)
L2	25 Ω/41 mm (Teflon)
R1	0.5 Ω, Resistor 0805 (2 x 1 Ω)



C1	15 nF
C2	15 nF
P1	2.2 kΩ
R1	3.3 kΩ
R2	51 Ω
T1	BD135
T2	BD135

Figure 2. 960 MHz Test Circuit and Bias Circuit

TYPICAL CHARACTERISTICS

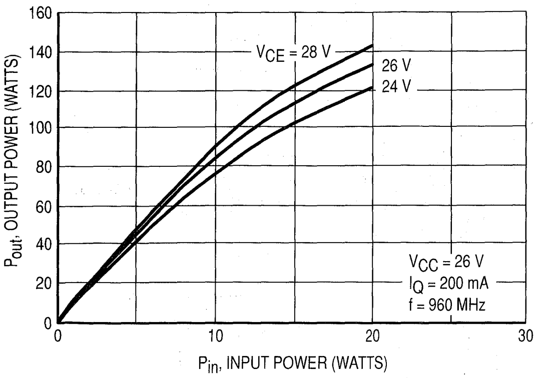


Figure 3. Output Power versus Input Power

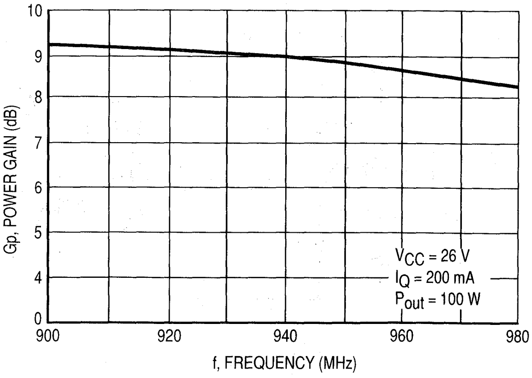


Figure 4. Power Gain versus Frequency

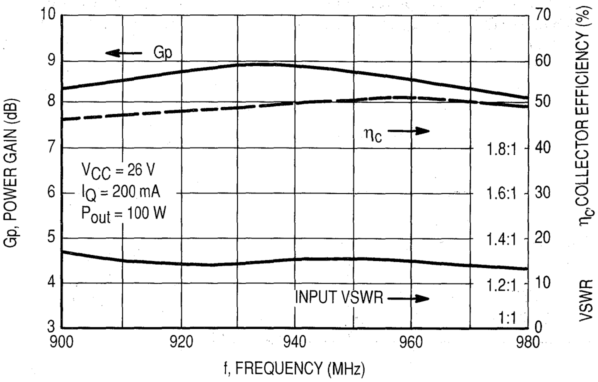


Figure 5. Broadband Amplifier

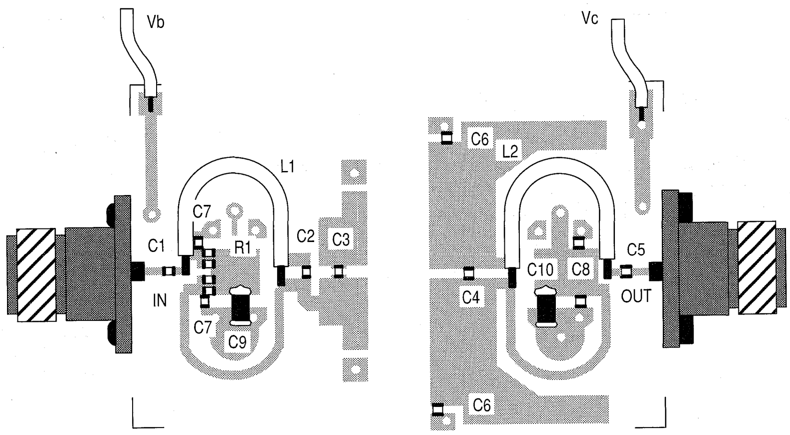
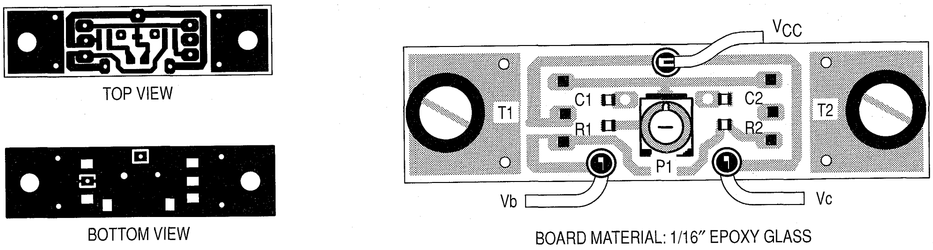


Figure 6. 960 MHz Test Circuit: Printed Circuit Board (PCB) + Components Location (Scale 0.75:1)


TOP VIEW

BOTTOM VIEW

BOARD MATERIAL: 1/16″ EPOXY GLASS

Figure 7. Bias Printed Circuit Board (PCB) (Scale 0.75:1) & Components Location (Not to Scale)

The RF Line

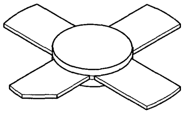
UHF Linear Power Transistor

TP5002S

The TP5002S is an NPN gold metallized transistor using diffused ballast resistors for reliability and ruggedness. The TP5002S was specifically designed as a low power driver with high gain and can be operated in Class A, B or C.

- 380–512 MHz
- 1.5 W — P_{out}
- 24 V — V_{CC}
- High Gain — 13 dB Min, Class A @ 470 MHz

1.5 W, 380 to 512 MHz
UHF LINEAR
POWER TRANSISTOR
NPN SILICON



CASE 249–06, STYLE 1
(.280 SOE S)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 0.045	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

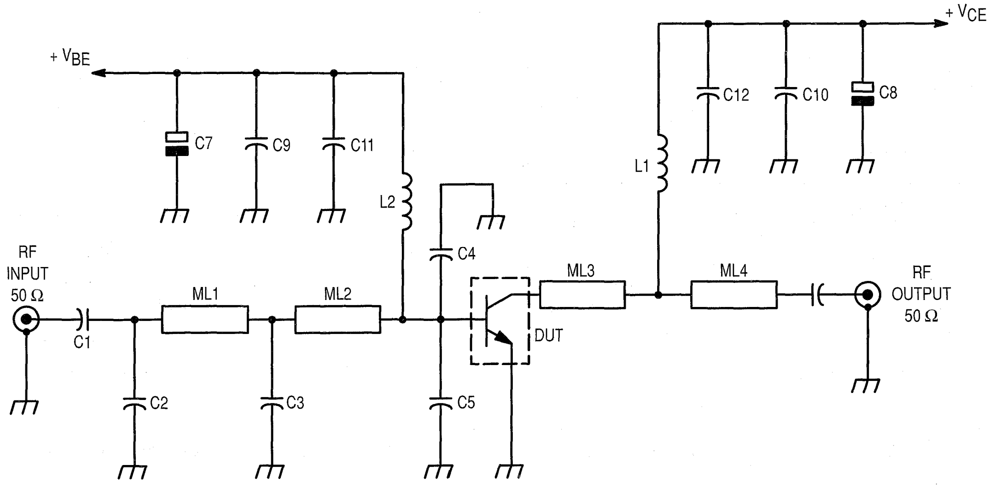
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	21	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Base Breakdown Voltage (I_C = 2.0 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 2.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 24 V, I_E = 0)	I_{CBO}	—	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	15	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	4.5	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 23 V, P_{out} = 1.5 W, f = 470 MHz, I_C = 200 mA)	G_{PE}	13	—	—	dB
Saturated Output Power (V_{CE} = 23 V, f = 470 MHz, I_C = 200 mA)	P_{sat}	—	2.2	—	W

REV 1



C1, C6 — 220 pF 0805 681C Sprague
C2 — 8.2 pF ATC100A8R2DP50
C3 — 10 pF ATC100A100DP50
C4, C5 — 27 pF ATC100A8R2DP50
C7 — 10 µF 35 V
C8 — 100 µF 63 V
C9, C10 — 1.0 nF 0805 681C Sprague
C11, C12 — 220 pF 0805 681C Sprague

L1 — Hairpin wire 1.1 mm L = 33 mm
L2 — 4 turns, ID 2.5 mm, 0.5 mm wire
ML1 — Microstrip Line W = 2.5 mm Z_O = 70 Ω, L = 6% λg at 470 MHz
ML2 — Microstrip Line W = 2.5 mm Z_O = 70 Ω, L = 3% λg at 470 MHz
ML3 — Microstrip Line W = 2.5 mm Z_O = 70 Ω, L = 5% λg at 470 MHz
ML4 — Microstrip Line W = 2.5 mm Z_O = 70 Ω, L = 3% λg at 470 MHz
Board Material: 1/16 In. Teflon Glass, ε_r = 2.55, h = 1.59 mm
Note: λg is the wavelength in the microstrip circuit

Figure 1. 400–500 MHz Broadband Amplifier

FREQUENCY (MHz)	400	410	420	430	440	450	460	470	480	490	500
RE(Zin)Ω	2.5	2.5	2.5	2.3	2.4	2.3	2.2	2.2	2.1	2.1	2.0
IM(Zin)Ω	2.0	2.2	2.7	3.2	3.5	3.8	3.9	4.0	4.2	4.9	5.0
RE(Zload)Ω	33.4	35.5	36.5	37.0	38.4	39.5	40.4	41.4	42.4	43.4	44.4
IM(Zload)Ω	48.3	48.9	49.4	49.9	50.8	50.9	51.3	51.7	52.2	52.6	53.0

Table 1. Impedance Data
V_{CC} = 23 Volts
I_C = 200 mA
P_{out} = 1.5 Watts

TYPICAL CHARACTERISTICS

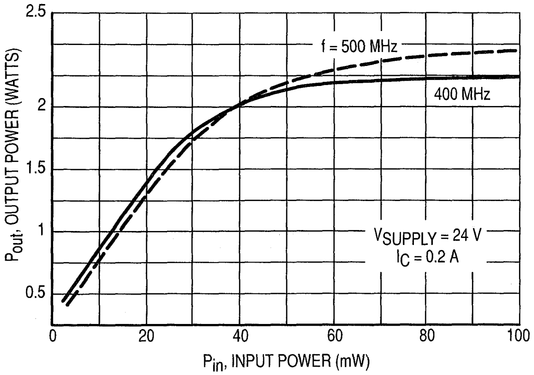


Figure 2. Output Power versus Input Power

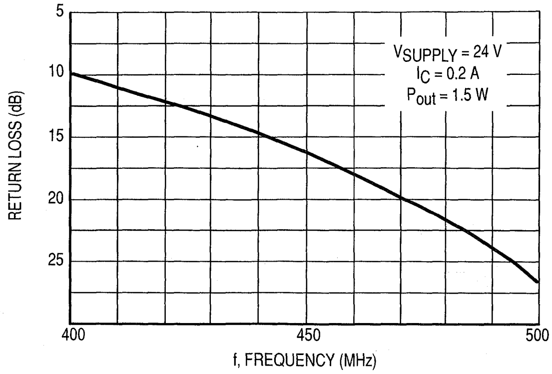


Figure 3. Return Loss versus Frequency

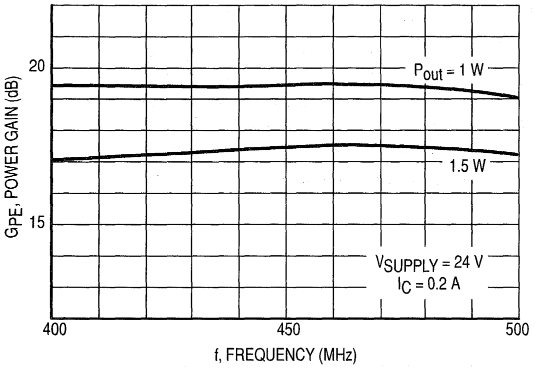


Figure 4. Power Gain versus Frequency

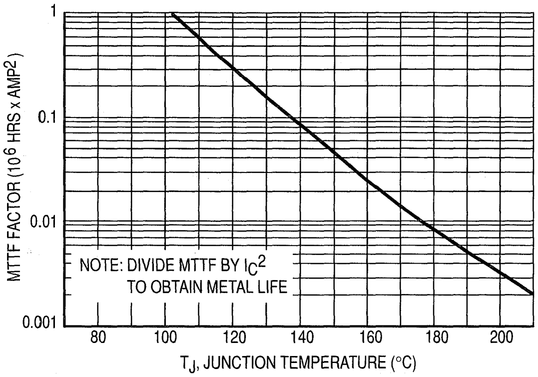
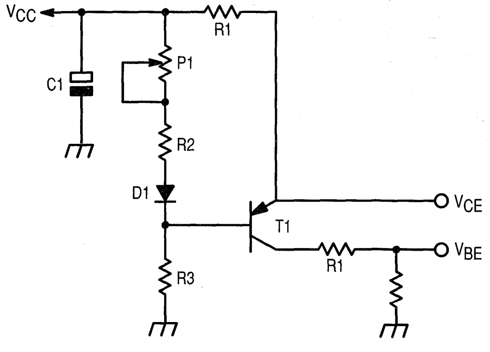


Figure 5. MTTF Factor versus Junction Temperature



C1 — 100 µF 63 V
D1 — 1N4148
P1 — 1.0 kΩ
R1 — 10 Ω 1/2 W
R2 — 180 Ω 1/4 W
R3 — 10 kΩ 1/4 W
R4 — 50 Ω 1/4 W
R5 — 100 Ω 1/4 W
T1 — BD136

Figure 6. Class A Bias Circuit

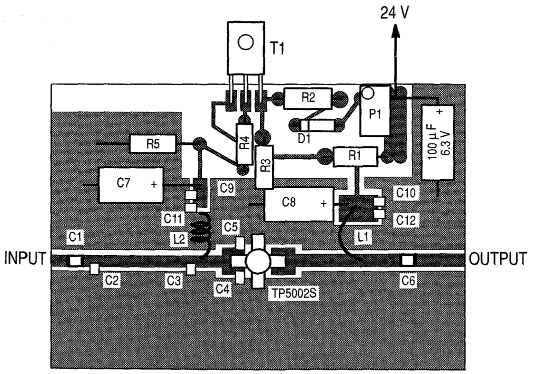


Figure 7. Component Layout

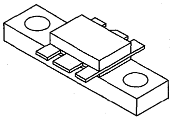
The RF Line
UHF Linear Power Transistor

TP5015

. . . designed for 24 Volt UHF large–signal common emitter amplifier applications in industrial and commercial FM equipment operating in the 380 to 512 MHz frequency range, i.e., cellular radio base stations.

- 380–512 MHz
- 15 W — P_{out}
- 24 V — V_{CC}
- High Gain — 11 dB Min, Class AB
- Gold Metallization for Reliability

**15 W, 380–512 MHz
UHF LINEAR
POWER TRANSISTOR
NPN SILICON**



**CASE 319–07, STYLE 2
(EB)**

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ $T_C = 70°C$ Derate above 70°C	P_D	18 0.143	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case ($T_C = 70°C$)	$R_{\theta JC}$	7.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Emitter–Base Breakdown Voltage ($I_E = 5.0$ mA, $I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Emitter Breakdown Voltage ($I_C = 10$ mA, $R_{BE} = 75\ \Omega$)	$V_{(BR)CER}$	40	—	—	Vdc
Collector–Emitter Leakage ($V_{CE} = 26$ V, $R_{BE} = 75\ \Omega$)	I_{CER}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ mA, $V_{CE} = 10$ V)	h_{FE}	15	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 24$ V, $I_E = 0$, f = 1.0 MHz)	C_{ob}	—	16	25	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain ($V_{CE} = 24$ V, $P_{out} = 15$ W, f = 470 MHz, $I_Q = 50$ mA)	G_{PE}	11	—	—	dB
Collector Efficiency ($V_{CE} = 24$ V, $P_{out} = 15$ W, f = 470 MHz, $I_Q = 50$ mA)	η_c	50	60	—	%

REV 6

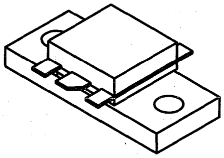
The RF Line
NPN Silicon RF Power Transistor

TP5051

The TP5051 is designed for 470 MHz cellular radio base stations in both analog and digital applications. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

- Specified 470 MHz Characteristics
  Output Power — 50 Watts @ 24 Volts, 60 Watts @ 26 Volts
  Gain — 9 dB min
  Efficiency — 60% min
  Class AB or C Operation
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

**50/60 W, 470 MHz
RF POWER TRANSISTOR
NPN SILICON**



CASE 333A–02, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CER}	40	Vdc
Collector–Base Voltage	V_{CBO}	48	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	145 0.8	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case at 70°C Case (1)	$R_{\theta JC}$	1.2	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mA, R_{BE} = 75 Ω)	$V_{(BR)CER}$	40	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 15 mAdc)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc)	$V_{(BR)CBO}$	48	—	—	Vdc
Collector–Emitter Leakage (V_{CE} = 26 V, R_{BE} = 75 Ω)	I_{CER}	—	—	15	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 Adc, V_{CE} = 10 Vdc)	h_{FE}	15	—	80	—

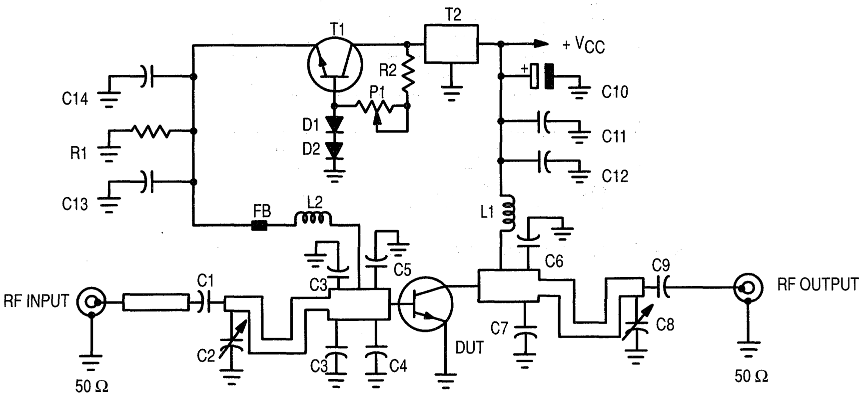
(continued)

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 V, I_E = 0, f = 1 MHz)	C_{ob}	—	60	—	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 24 V, P_{out} = 50 W, I_{CQ} = 150 mA, f = 470 MHz)	G_{p1}	9	10	—	dB
Collector Efficiency (V_{CC} = 24 V, P_{out} = 50 W, f = 470 MHz)	η1	60	65	—	%
Load Mismatch (V_{CC} = 24 V, P_{out} = 50 W, I_{CQ} = 150 mA Load VSWR = 5:1, all phase angles at frequency of test)	ψ1	No Degradation in Output Power			
Overdrive (V_{CC} = 24 V, P_{in} = 12 W, f = 470 MHz)	OD	No Degradation in Output Power			
Power Saturation (V_{CC} = 24 V, f = 470 MHz)	P_{sat}	65	—	—	W
Common–Emitter Amplifier Power Gain (V_{CC} = 26 V, P_{out} = 60 W, I_{CQ} = 150 mA, f = 470 MHz)	G_{p2}	9	10	—	dB
Collector Efficiency (V_{CC} = 26 V, P_{out} = 60 W, f = 470 MHz)	η2	60	65	—	%
Load Mismatch (V_{CC} = 26 V, P_{out} = 60 W, I_{CQ} = 150 mA Load VSWR = 5:1, all phase angles at frequency of test)	ψ2	No Degradation in Output Power			

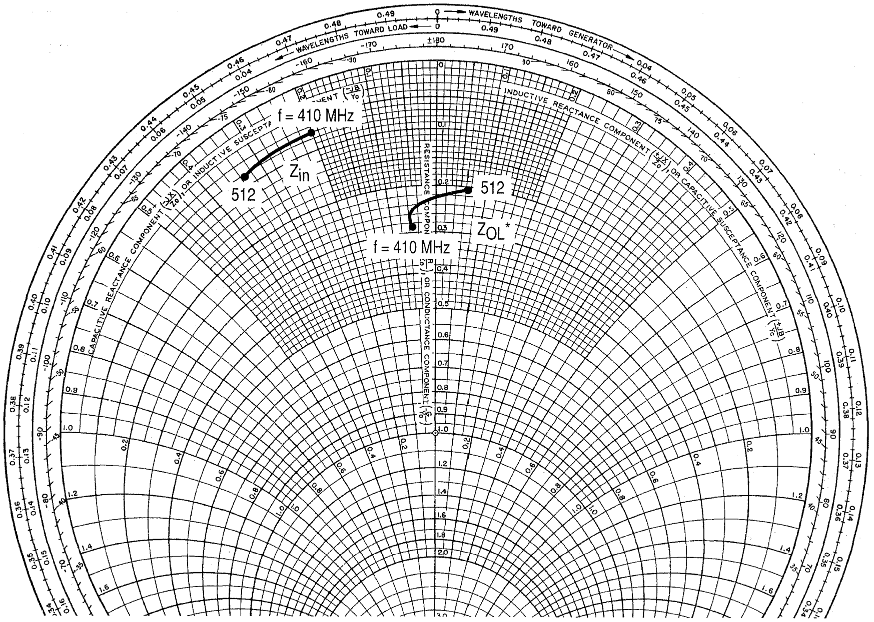


EPOXY GLASS 1/16 INCH ∈r = 4.5

Components List

C1,C9,	330 pF, 5%, Chip Capacitor 0805	D1,D2	Diode, 1N4148
C2,C8	AIRTRONIC Trimmer Capacitor 5400	FB	Ferrite Board
C3	10 pF, ATC Chip Capacitor	L1,L2	6 Turns, #18 AWG φ 4 mm Choke
C3′	12 pF, ATC Chip Capacitor	P1	1 kΩ, Trimmer
C4,C5	22 pF, ATC Chip Capacitor	R1	56 Ω, 5%, Chip Resistor 1205
C6	15 pF, ATC Chip Capacitor	R2	470 Ω, 5%, Chip Resistor 0805
C7	18 pF, ATC Chip Capacitor	T1	SMD Transistor, MJD31C or Similiar
C10	47 µF, 63 V, Electrolytic Capacitor	T2	Voltage Regulator 7805
C11,C14	15 nF, Chip Capacitor 0805		
C12,C13	330 pF, 5%, Chip Capacitor 0805		

Figure 1. 470 MHz Electrical Schematic



P_{out} = 50 W, V_{CE} = 24 V

f (MHz)	Z_{in} (Ω)	Z_{OL}* (Ω)
512	1 – j3.2	2 – j0.7
490	0.97 – j2.8	2.2 – j0.5
470	0.9 – j2.7	2.4 + j0.13
450	0.85 – j2.5	2.6 + j0.9
410	0.8 – j2.1	3 + j0.5

Figure 2. Series Equivalent Input and Output Impedances

TYPICAL CHARACTERISTICS

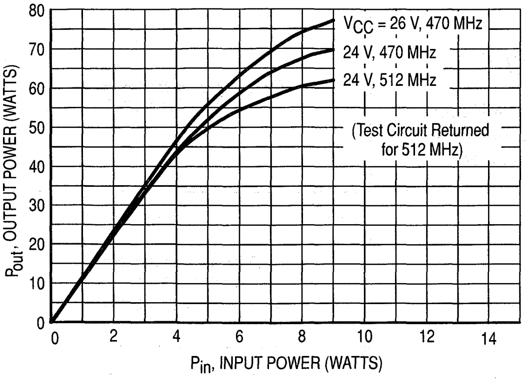


Figure 3. Output Power versus Input Power

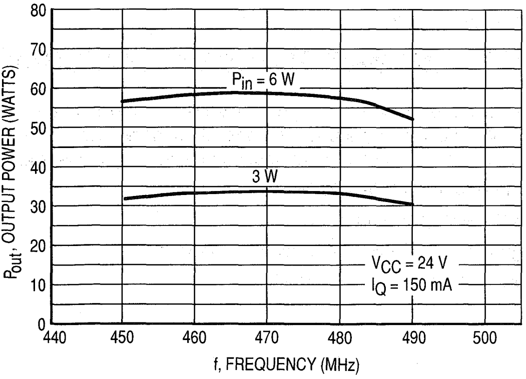


Figure 4. Output Power versus Frequency

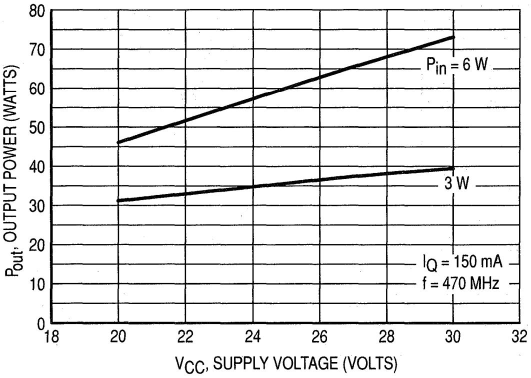


Figure 5. Output Power versus Supply Voltage

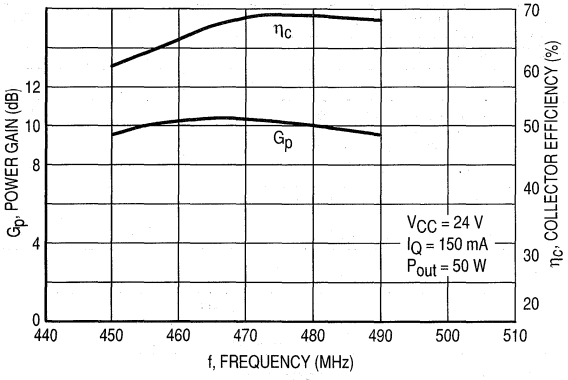
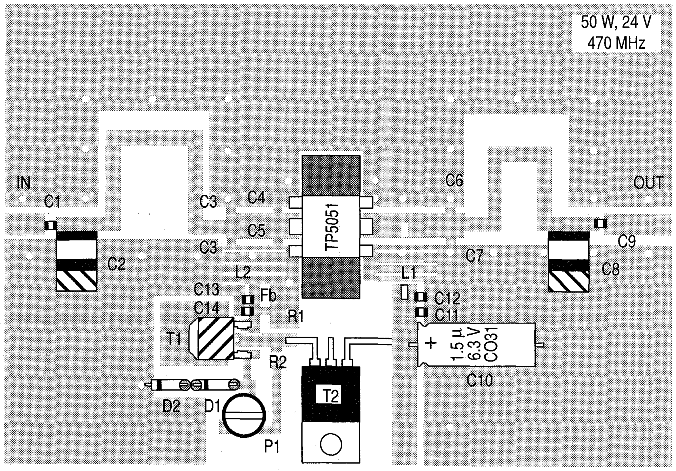


Figure 6. Power Gain, Collector Efficiency versus Frequency



EPOXY GLASS 1/16 INCH ε_r = 4.5

Figure 7. 470 MHz Test Circuit Components View

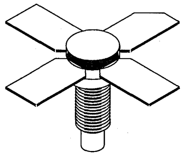
The RF Line
UHF Linear Power Transistor

. . . designed for very high output 1.5 V MATV amplifiers up to 860 MHz and 500 mW Band V TV transposer stages. Gold metallization and diffused emitter ballast resistors are used to enhanced reliability, ruggedness and linearity.

- Band IV and V (470–860 MHz)
- 0.5 W — P_{ref} @ −58 dB IMD
- High Gain — 12 dB Typ, Class A, f = 860 MHz
- Gold Metallization for Reliability

TPV596A

0.5 W, 470–860 MHz
UHF LINEAR
POWER TRANSISTOR



CASE 244–04, STYLE 1
(.280 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	24	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	0.7	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 0.05	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	20	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mA, I_B = 0)	$V_{(BR)CEO}$	24	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 1.0 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 4.0 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Emitter–Base Leakage Current (V_{EB} = 2.0 V)	I_{EBO}	—	—	0.25	mA
Collector Cutoff Current (V_{CB} = 28 V, I_E = 0)	I_{CBO}	—	—	1.0	mAdc
Collector–Emitter Breakdown Voltage (I_C = 20 mA, R_{BE} = 10 Ω)	$V_{(BR)CER}$	50	—	—	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mA, V_{CE} = 5.0 V)	h_{FE}	15	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	5.0	pF

(continued)

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 0.5 W, f = 860 MHz, I_E = 0.22 A)	G_{PE}	11.5	12	—	dB
Load Mismatch (V_{CE} = 20 V, P_{out} = 1.0 W, I_E = 0.22 A, f = 860 MHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			
Intermodulation Distortion, 3 Tone (f = 860 MHz, V_{CE} = 20 V, I_E = 0.22 A, P_{ref} = 1.0 W, Vision Carrier = −8.0 dB, Sound Carrier = −7.0 dB, Sideband Signal = −16 dB, Specification TV05001)	IMD_1	—	—	−50	dB
Intermodulation Distortion (IDEM) (f = 860 MHz, V_{CE} = 20 V, I_E = 0.22 A, P_{ref} = 0.5 W, Vision Carrier = −8.0 dB, Sound Carrier = −10 dB, Sideband Signal = −16 dB)	IMD_2	—	−60	−58	dB

TYPICAL CHARACTERISTICS

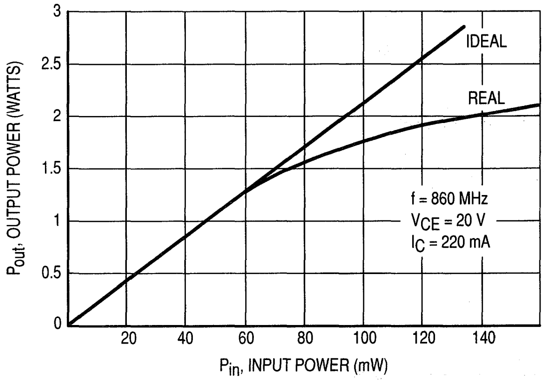


Figure 1. Power Output versus Power Input

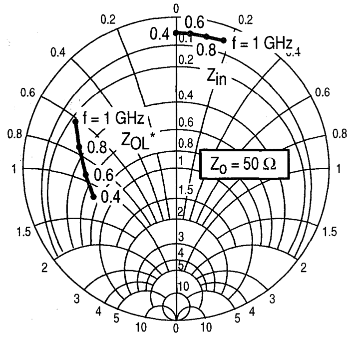


Figure 2. Large Signal Impedances
V_{CE} = 20 V — I_C = 220 mA

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

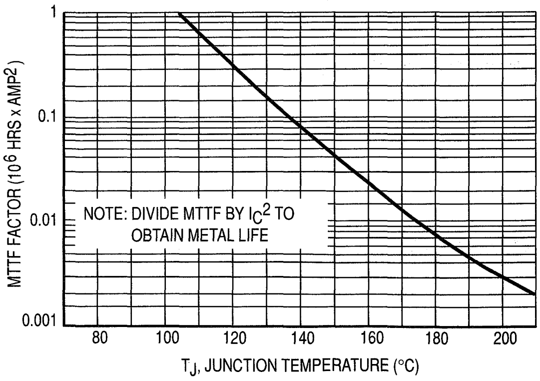


Figure 3. MTTF Factor versus Junction Temperature

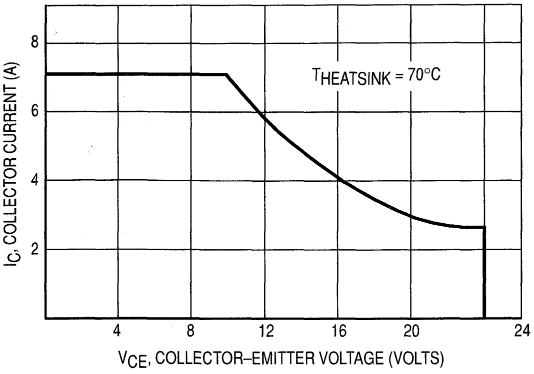
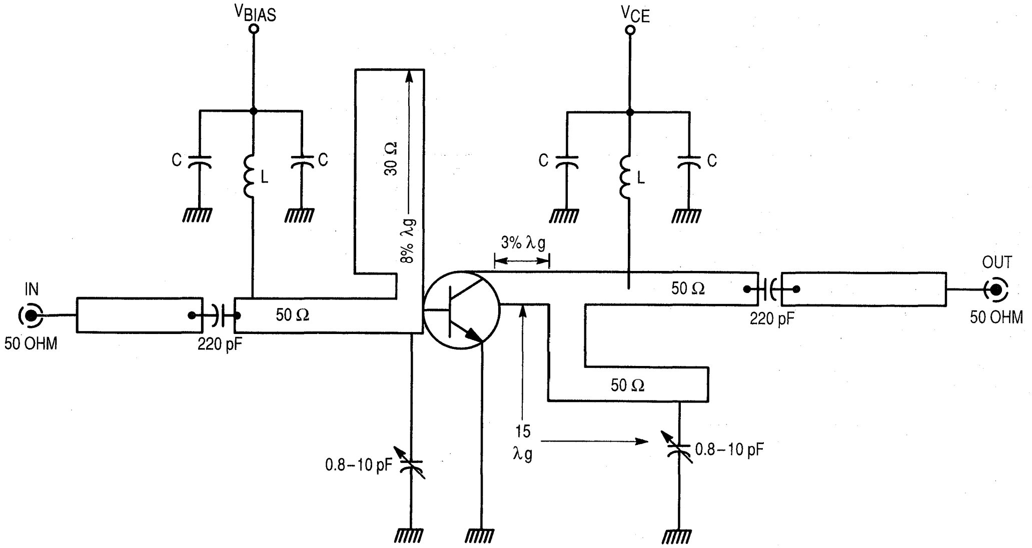
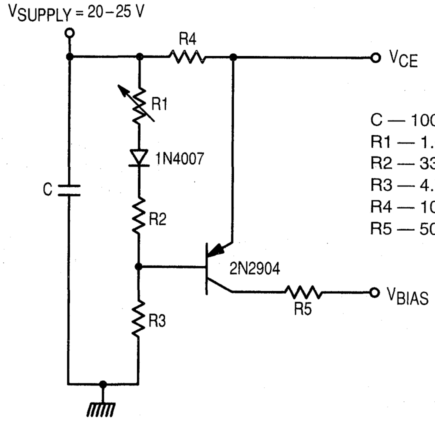


Figure 4. DC Safe Operating Area



NOTE: λg is the wave length in the microstrip circuit

Figure 5. 860 MHz Test Circuit



C — 100 F + 10 nF + 1.0 nF
R1 — 1.0 kohm
R2 — 330 ohm
R3 — 4.7 kohm
R4 — 10 ohm 1/2 W
R5 — 50 ohm

Figure 6. Class A Bias Circuit

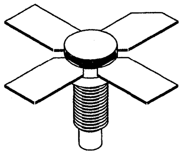
The RF Line
UHF Linear Power Transistor

. . . designed for 1.0 watt stages in Band V TV transposer amplifiers. Gold metallized dice and diffused emitter ballast resistors are used to enhance reliability, ruggedness and linearity.

- Band IV and V (470–860 MHz)
- 1.0 W — P_{ref} @ −58 dB IMD
- 20 V — V_{CC}
- High Gain — 11 dB Typ, Class A @ f = 860 MHz
- Gold Metallization for Reliability

TPV597

1.0 W, 470–860 MHz
UHF LINEAR
POWER TRANSISTOR



CASE 244–04, STYLE 1
(.280 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	24	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	3.5	Vdc
Collector Current — Continuous	I_C	1.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	19 0.11	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	9.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 40 mA, I_B = 0)	$V_{(BR)CEO}$	24	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 2.0 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 4.0 mA, I_C = 0)	$V_{(BR)EBO}$	3.5	—	—	Vdc
Emitter–Base Leakage Current (V_{EB} = 2.0 V)	I_{EBO}	—	—	0.5	mA
Collector–Emitter Breakdown Voltage (I_C = 40 mA, R_{BE} = 10 Ω)	$V_{(BR)CER}$	50	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 V, I_E = 0)	I_{CBO}	—	—	1.2	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mA, V_{CE} = 5.0 V)	h_{FE}	15	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	7.0	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 20 V, P_{out} = 1.0 W, f = 860 MHz, I_E = 0.44 A)	G_{PE}	10.5	11	—	dB
Load Mismatch (V_{CE} = 20 V, P_{out} = 2.0 W, I_E = 0.44 A, f = 860 MHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			

(continued)

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (continued)					
Intermodulation Distortion, 3 Tone (f = 860 MHz, V_{CE} = 20 V, I_E = 0.44 A, P_{ref} = 1.0 W, Vision Carrier = –8.0 dB, Sound Carrier = –7.0 dB, Sideband Signal = –16 dB, Specification TV05001)	IMD_1	—	–60	–58	dB
Cutoff Frequency (V_{CE} = 20 V, I_E = 0.44 A)	f_τ	2.2	2.5	—	GHz
Intermodulation Distortion (IDEM) (f = 860 MHz, V_{CE} = 20 V, I_E = 0.44 A, P_{ref} = 2.0 W, Vision Carrier = –8.0 dB, Sound Carrier = –10 dB, Sideband Signal = –16 dB)	IMD_2	—	—	–51	dB

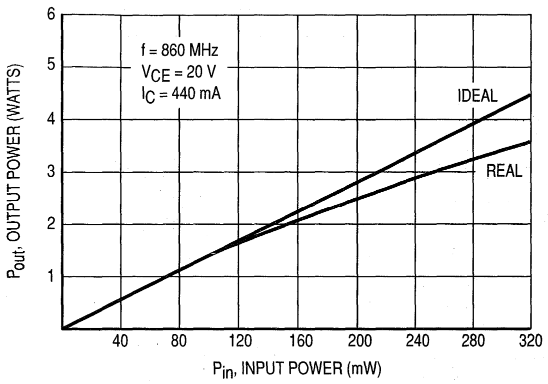


Figure 1. Power Output versus Power Input

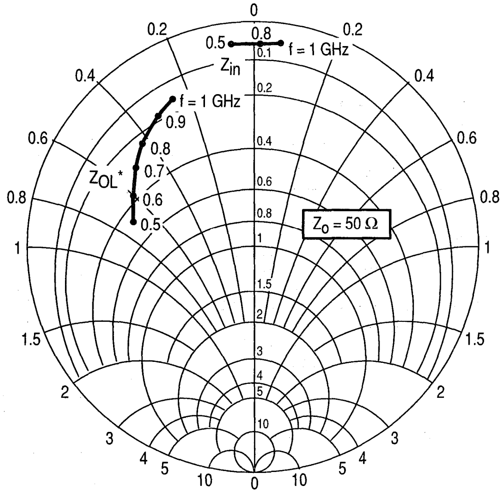


Figure 2. Large Signal Impedances
V_{CE} = 20 V — I_C = 440 mA

Z_{OL}* = Conjugate of the optimum load impedance into which the device output operates at a given output power, voltage and frequency.

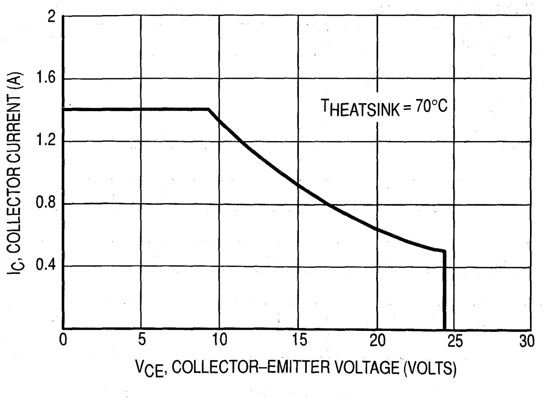


Figure 3. Safe Operating Area

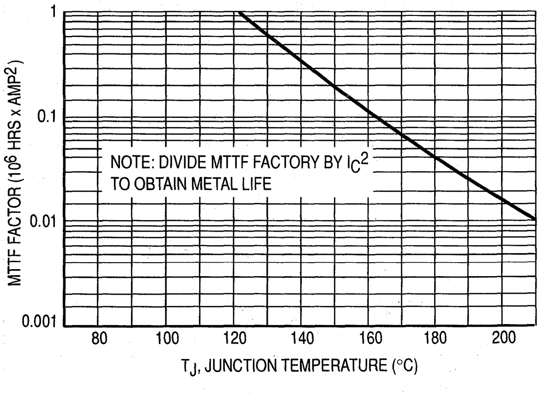
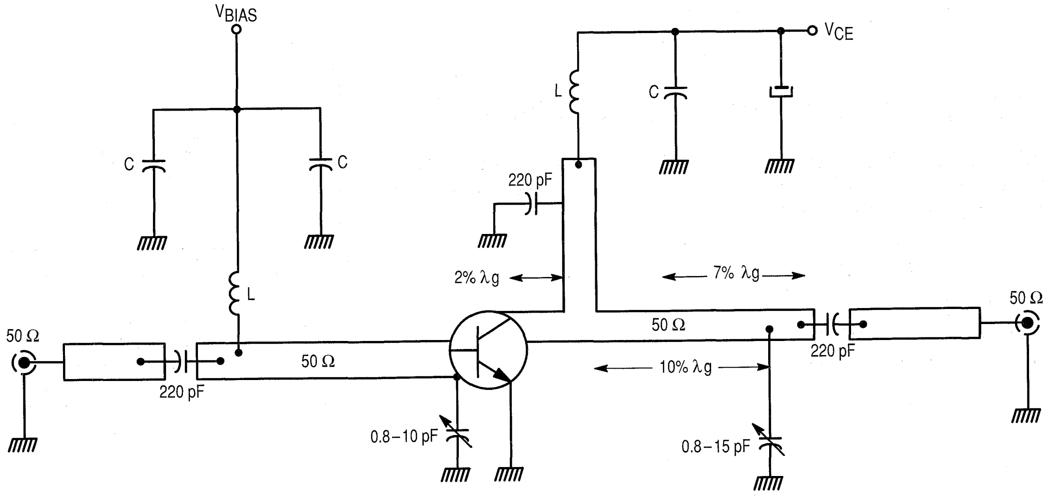


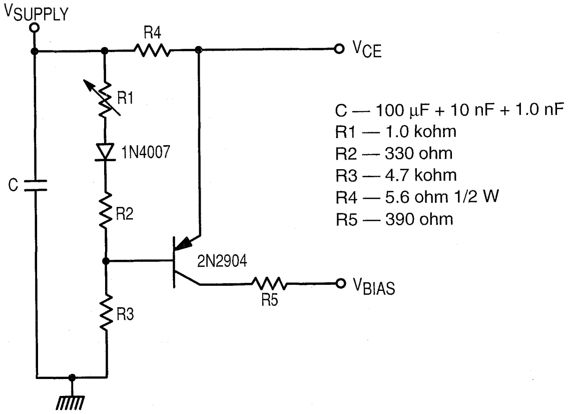
Figure 4. MTTF Factor versus Junction Temperature



L = 6 turns ID = 1 mm Wire diameter = 0.6 mm
The lengths are given for f = 860 MHz

NOTE: λg is the wave length in the microstrip circuit

Figure 5. 860 MHz Test Circuit



C — 100 µF + 10 nF + 1.0 nF
R1 — 1.0 kohm
R2 — 330 ohm
R3 — 4.7 kohm
R4 — 5.6 ohm 1/2 W
R5 — 390 ohm

Figure 6. Class A Bias Circuit

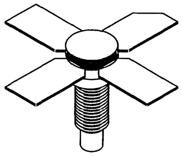
The RF Line
UHF Linear Power Transistor

Designed for 4.0 watt stages in Band V TV transposer amplifiers. Gold metallized dice and diffused emitter ballast resistors are used to enhance reliability, ruggedness and linearity.

- Band IV and V (470–860 MHz)
- 4.0 W — P_{ref} @ −60 dB IMD
- 25 V — V_{CC}
- High Gain — 7.0 dB Min, Class A @ f = 860 MHz
- Gold Metallization for Reliability

TPV598

4.0 W, 470–860 MHz
UHF LINEAR
POWER TRANSISTOR



CASE 244–04, STYLE 1
(.280 SOE)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	27	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +200	°C

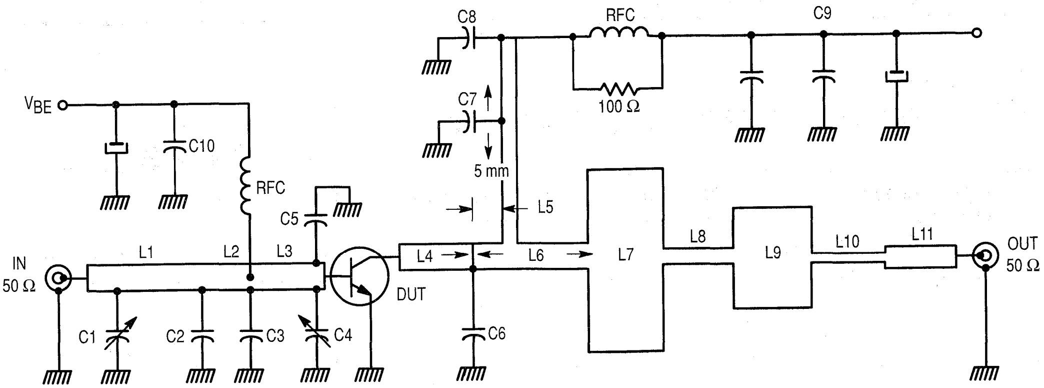
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	6.2	°C/W
Thermal Resistance, Case to Heatsink	$R_{\theta CH}$	0.4 Typ	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 60 mA, I_B = 0)	$V_{(BR)CEO}$	27	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 10 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 3.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector–Emitter Leakage Current (V_{CE} = 20 V)	I_{CEO}	—	—	5.0	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mA, V_{CE} = 20 V)	h_{FE}	10	—	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 25 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	—	20	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 25 V, P_{out} = 4.0 W, f = 860 MHz, I_C = 850 mA)	G_{PE}	7.0	—	—	dB
Intermodulation Distortion, 3 Tone (f = 860 MHz, V_{CE} = 25 V, I_E = 850 mA, P_{ref} = 4.0 W, Vision Carrier = −8.0 dB, Sound Carrier = −7.0 dB, Sideband Signal = −16 dB, Specification TV05001)	IMD_1	—	—	−58	dB
Cutoff Frequency (V_{CE} = 25 V, I_C = 850 mA)	f_{τ}	—	2.0	—	GHz

REV 1



C1 — Variable 0.5–4.7 pF Airtronic
C2, C3 — ATC 4.7 pF
C4 — ATC 10 pF + Variable 0.5–4.7 pF Airtronic
C5 — ATC 10 pF + ATC 5.6 pF
C6 — ATC 18 pF + 0.5–4.7 pF Variable Airtronic
C7 — 470 pF Chip Capacitor
C8 — 1.0 nF + 10 nF Decoupling
C9 — 1.0 nF + 10 nF + 0.1 µF + 10 µF
C10 — 10 nF + 1.0 µF + 10 µF

RFC = 8 turns, ID 2.5 mm, Wire = 0.5 mm

L1 — 50 Ω line 6.2% λg at 860 MHz
L2 — 50 Ω line 4.2% λg at 760 MHz
L3 — 50 Ω line 4.9% λg at 860 MHz
L4 — 20 Ω line 6.5% λg at 860 MHz
L5 — 50 Ω line 5% λg at 860 MHz
L6 — 20 Ω line 9.5% λg at 860 MHz
L7 — 4.0 Ω line 8% λg at 860 MHz
L8 — 55 Ω line 7.5% λg at 860 MHz
L9 — 7.5 Ω line 8% λg at 860 MHz
L10 — 100 Ω line 8% λg at 860 MHz
L11 — 20 Ω line 8% λg at 860 MHz

Note: λg is the wavelength in the microstrip circuit

Figure 1. Broadband Test Circuit

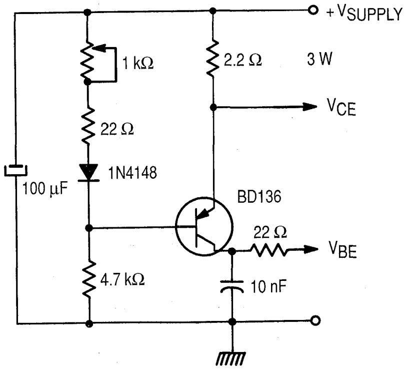


Figure 2. Class A Bias Circuit

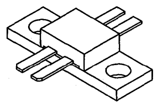
The RF Line
UHF Linear Power Transistor

TPV695A

Designed for driver and output stages in band IV and V TV transposers and transmitter amplifiers. The TPV695A uses gold metallized die with diffused emitter ballast resistors to enhance reliability, ruggedness and linearity.

- Band IV and V (470–860 MHz)
- 14 W — P_{ref} @ −47 dB IMD
- 25 V — V_{CC}
- High Gain — 10 dB Min, Class A, f = 860 MHz
- Gold Metallization for Reliability
- Push–Pull Package

14 W, 470–860 MHz
UHF LINEAR
POWER TRANSISTOR



CASE 395B–01, STYLE 1
BMA2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CES}	50	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	50 0.4	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−50 to +200	°C
Operating Case Temperature Range	T_C	−15 to +70	°C

THERMAL CHARACTERISTICS

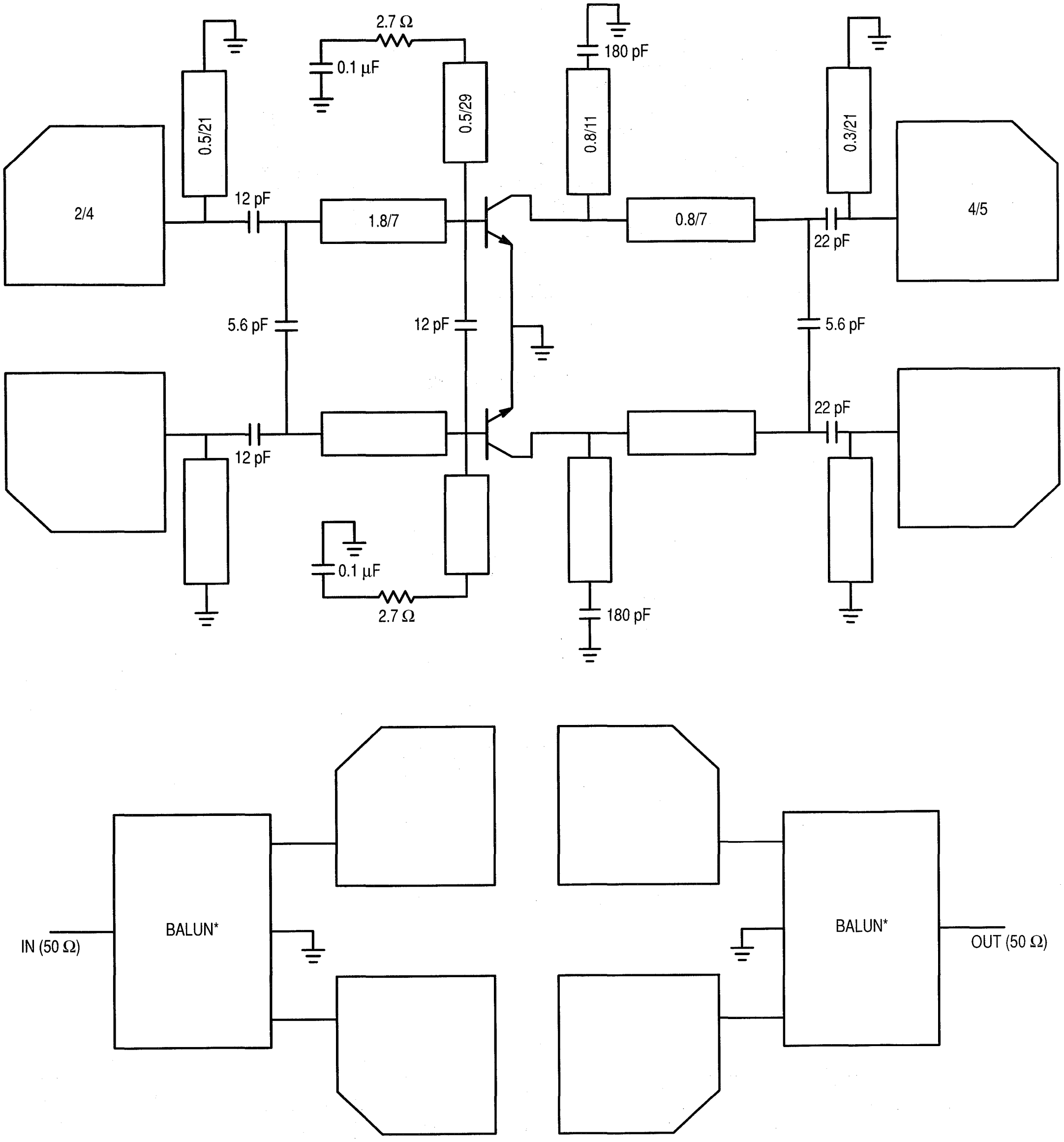
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 20 mA, I_B = 0)	$V_{(BR)CEO}$	28	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 20 mA, V_{BE} = 0)	$V_{(BR)CES}$	50	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 5.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 19 V, I_E = 0)	I_{CBO}	—	—	15	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 A, V_{CE} = 10 V)	h_{FE}	20	—	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	—	18	20	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 25 V, P_{out} = 14 W, f = 860 MHz, I_C = 2.0 x 900 mA)	G_{PE}	10	—	—	dB
Overdrive (no degradation) (f = 470 MHz, V_{CE} = 25 V, I_C = 2.0 x 900 mA)	$P_{in_{over}}$	12.5	—	—	W
Intermodulation Distortion, 3 Tone (f = 860 MHz, V_{CE} = 25 V, I_E = 2.0 x 900 mA, P_{ref} = 14 W, Vision Carrier = −7.0 dB, Sound Carrier = −8.0 dB, Sideband Signal = −16 dB, Specification TV05001)	IMD_1	—	−47	−46	dB

REV 7

Dimension: width/length mm
Board Material — 1/50″, Teflon Glass, $\varepsilon_r = 2.55$



— Balun is 50 Ω unbalanced to 2 x 25 Ω balanced

Figure 1. 470–860 MHz Test Circuit

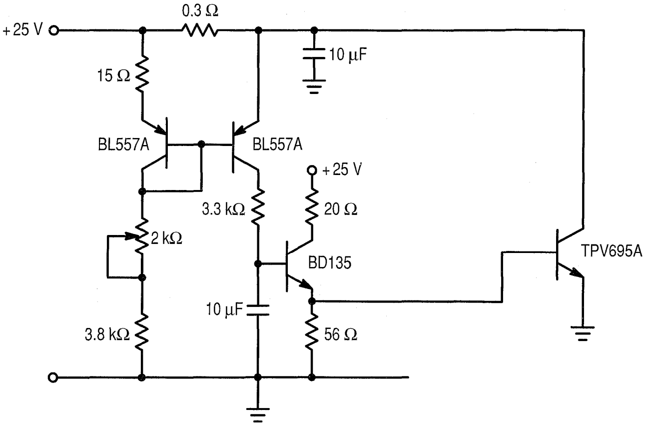


Figure 2. Bias Network

Intermodulation Distortion, 3 Tone

Test Conditions:
@ −8 dB Ref. Vision Carrier, −7 dB Ref. Sound Carrier,
−16 dB Ref. Sideband Signal
P_{ref} = 14 Watts
V_{CB} = 25 Volts & I_{CS} = 2 x 900 mA

Frequency MHz	IMD dB
860	−47
760	−47
660	−47
560	−47
470	−48

Figure 3. IMD versus Frequency

f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	$\lvert S_{11} \rvert$	∠ φ	$\lvert S_{21} \rvert$	∠ φ	$\lvert S_{12} \rvert$	∠ φ	$\lvert S_{22} \rvert$	∠ φ
400	0.918	176.6	0.605	58.3	$2.75 \cdot 10^{-4}$	−8.2	0.449	−173.1
450	0.908	175.6	1.44	53.1	$3.01 \cdot 10^{-4}$	−11.8	0.452	−172.4
500	0.877	176.1	1.28	48.3	$3.10 \cdot 10^{-4}$	−12.8	0.438	−171.7
550	0.889	174.5	1.21	42.3	$3.72 \cdot 10^{-4}$	−16.3	0.452	−170.1
600	0.891	174.0	1.16	36.3	$4.31 \cdot 10^{-4}$	−18.5	0.466	−168.9
650	0.863	173.6	1.15	29.9	$6.11 \cdot 10^{-4}$	−25	0.469	−167.2
700	0.839	173.1	1.15	21.9	$6.03 \cdot 10^{-4}$	−34.3	0.500	−165.5
750	0.805	172.8	1.15	13.8	$6.55 \cdot 10^{-4}$	−39.9	0.541	−164.2
800	0.800	172.6	1.15	4.7	$7.29 \cdot 10^{-4}$	−46.6	0.583	−163.5
850	0.771	172.3	1.20	−8.2	$8.39 \cdot 10^{-4}$	−57.4	0.673	−163.1
900	0.762	172.2	1.11	−21.1	$8.55 \cdot 10^{-4}$	−67.6	0.759	−164.3

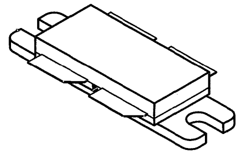
Table 1. S–Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
NPN Silicon RF Power Transistor

TPV6030

35 W, 470–860 MHz
NPN SILICON
RF POWER TRANSISTOR



CASE 375A–01, STYLE 1

The TPV6030 is designed for driver stages in band IV and V TV transmitter amplifiers. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

Including double input and output matching networks, the TPV6030 features high impedances. It can easily operate in a full 470 MHz to 860 MHz bandwidth in a single and simple circuit.

- To be used class A for TV band IV and V.
- Specified 25 Volts, 860 MHz Characteristics
  Output Power = 20 Watts @ −51 dB (3 tones)
  Output Power = 35 Watts @ 1 dB Comp. (CW)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CBO}	55	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature	T_J	200	°C
Total Device Dissipation @ T = 25°C Derate above 25°C	P_D	160 0.9	W W/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	1.1	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 35 mA, R_{be} = 75 Ω)	$V_{(BR)CER}$	40	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector–Base Breakdown Voltage (I_E = 35 mAdc)	$V_{(BR)CBO}$	55	—	—	Vdc
Collector–Emitter Leakage (V_{CE} = 30 V, R_{be} = 75 Ω)	I_{CER}	—	—	10	mA
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 Adc, V_{CE} = 10 Vdc)	h_{FE}	15	—	100	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (each side) (2) (V_{CB} = 28 V, I_E = 0, f = 1 MHz)	C_{ob}	—	45	—	pF

(continued)

NOTES:
1. Thermal resistance is determined under specified RF operating condition.
2. Value of "C_{ob}" is that of die only. It is not measurable in TPV6030 because of internal matching network.

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CE} = 25 V, I_C = 4.5 A, f = 860 MHz)	G_p	9.5	10.5	—	dB
Intermodulation (−8 dB/−7 dB/−16 dB) (3) (V_{CE} = 25 V, P_{out} = 20 W ref, I_C = 4.5 A, f = 860 MHz)	IMD	—	−52	−51	dB
Output Power @ 1 dB Compression (V_{CE} = 25 V, I_C = 4.5 A, f = 860 MHz)	P_{out}	35	40	—	W

NOTE:

3. Vision Carrier, Sound Carrier and Sideband Signal respectively.

V_{CE} = 25 V, I_C = 4.5 A

f MHz	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠∅	$\|S_{21}\|$	∠∅	$\|S_{12}\|$	∠∅	$\|S_{22}\|$	∠∅
460	.98	175	1.04	98	.012	50	.73	168
560	.97	172	1.17	83	.015	39	.66	170
660	.94	170	1.46	60	.020	23	.59	176
760	.88	168	1.77	35	.026	−4	.59	−168
860	.81	171	1.70	−7	.027	−42	.77	−163

Table 1. Common Emitter S–Parameters

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

The RF Line
UHF Linear Power Transistor

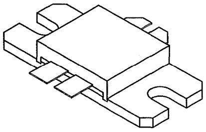
. . . designed for output stages in Band IV & V TV transmitter amplifiers. Internal matching of both input and output along with use of a push–pull package configuration aids broadband amplifier designs.

Gold metallized dice with diffused emitter ballast resistors enhances reliability, ruggedness and linearity.

- Band IV & V (470–860 MHz)
- 25 W — P_{ref} @ –45 dB IMD
- 25 V — V_{CC}
- Push–Pull Package
- Gold Metallization for Reliability

TPV7025

25 W, 470–860 MHz
UHF LINEAR
POWER TRANSISTOR



CASE 398–03, STYLE 1
(BMA–4)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	28	Vdc
Collector–Base Voltage	V_{CBO}	45	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	–50 to +200	°C
Operating Case Temperature	T_C	70	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (T_C = 70°C)	$R_{\theta JC}$	1.5	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS (1)					
Collector–Emitter Breakdown Voltage (I_C = 120 mA, I_B = 0)	$V_{(BR)CEO}$	28	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 20 mA, I_E = 0)	$V_{(BR)CBO}$	45	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 6.0 mA, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 A, V_{CE} = 20 V)	h_{FE}	10	—	60	—
DYNAMIC CHARACTERISTICS (1)					
Output Capacitance (V_{CB} = 28 V, I_E = 0, f = 1.0 MHz)	C_{ob}	64	—	80	pF

NOTE:
1. Each transistor chip measured separately.

(continued)

ELECTRICAL CHARACTERISTICS — continued

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (2)					
Common–Emitter Amplifier Power Gain (V_{CE} = 25 V, P_{out} = 25 W, f = 860 MHz, I_{CQ} = 3.2 A)	G_{PE}	9.0	—	10.5	dB
Load Mismatch (V_{CE} = 25 V, P_{out} = 24 W, f = 860 MHz, Load VSWR = ∞:1, All Phase Angles)	ψ	No Degradation in Output Power			
Overdrive (f = 470 MHz, 2 tones, V_{CE} = 25 V, I_C = 3.2 A) (No Degradation)	$P_{in_{over}}$	24	—	—	W
Intermodulation Distortion, 3 Tone (f = 860 MHz, V_{CE} = 25 V, I_E = 3.2 A, P_{ref} = 25 W, Vision Carrier = –8.0 dB, Sound Carrier = –7.0 dB, Sideband Signal = –16 dB, Specification TV05001)	IMD_1	—	—	–45	dB
Cross Modulation Distortion (P_{ref} = 25 W, f = 860 MHz, Δ% Sound = (–7.0 dB), Vision 0 – Peak)	X_{MOD}	—	—	20	%

NOTE:

2. Both transistor chips operating in push–pull amplifier.

TYPICAL CHARACTERISTICS

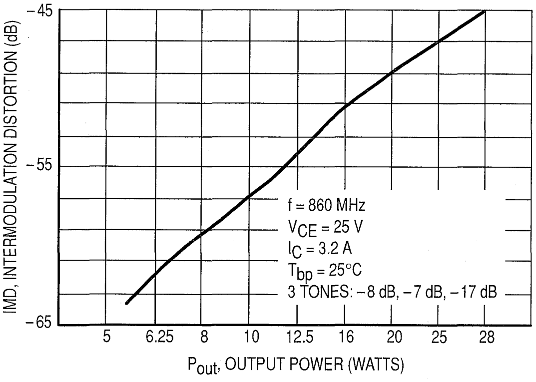


Figure 1. IMD versus Output Power

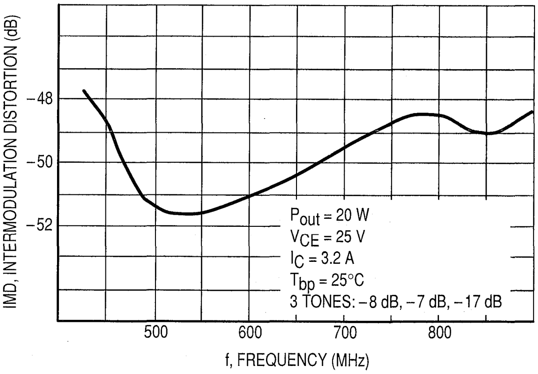
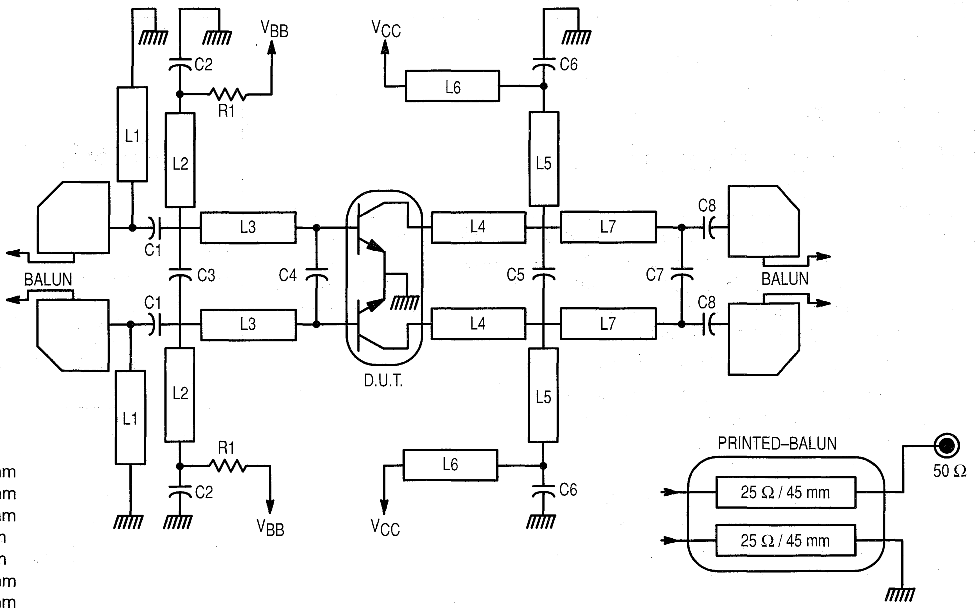


Figure 2. IMD versus Frequency



C1 — 15 pF
C2 — 180 pF
C3 — 10 pF
C4 — 15 pF
C5 — 15 pF
C6 — 180 pF
C7 — 4.7 pF
C8 — 100 pF
L1 — 90 / 16 mm
L2 — 90 / 16 mm
L3 — 35 / 10 mm
L4 — 25 / 7 mm
L5 — 70 / 6 mm
L6 — 70 / 26 mm
L7 — 60 / 16 mm
R1 — 3.3 Ω

Board Material: Teflon Glass Substrate .020 In.

Note: L1 to L7 dimension given in length/width.

Figure 3. 470–860 MHz Broadband Test Circuit

V_{CE} (Volts)	I_C (A)	f (GHz)	S_{11}		S_{21}		S_{12}		S_{22}	
			Mag	∠ ϕ	**Mag**	∠ ϕ	**Mag**	∠ ϕ	**Mag**	∠ ϕ
25	2 x 1.8	0.44	1.0	178	1.25	80	0.02	29	0.89	156
		0.46	1.0	176	1.25	84	0.02	31	0.78	151
		0.48	1.0	174	1.30	81	0.02	30	0.70	148
		0.50	0.99	173	1.39	75	0.02	29	0.65	145
		0.52	0.98	171	1.42	70	0.03	26	0.59	142
		0.54	0.97	173	1.52	65	0.03	17	0.53	140
		0.56	0.97	171	1.67	67	0.03	12	0.46	139
		0.58	0.94	169	1.77	49	0.03	8.0	0.39	138
		0.60	0.92	164	1.93	40	0.04	0	0.31	142
		0.62	0.89	163	2.05	30	0.04	−9.0	0.23	157
		0.64	0.86	163	2.19	18	0.05	−19	0.21	−173
		0.66	0.82	164	2.29	4.0	0.05	−30	0.30	−150
		0.68	0.79	166	2.29	−11	0.05	−42	0.43	−147
		0.70	0.79	169	2.16	−26	0.05	−55	0.57	−150
		0.72	0.79	171	1.99	−40	0.05	−66	0.68	−155
		0.74	0.82	172	1.80	−52	0.05	−76	0.77	−161
		0.76	0.84	172	1.59	−63	0.04	−87	0.83	−168
		0.78	0.86	172	1.38	−74	0.04	−96	0.86	−173
		0.80	0.88	171	1.23	−82	0.03	−102	0.88	−178
		0.82	0.89	170	1.10	−88	0.03	−106	0.88	178
		0.84	0.90	170	0.99	−94	0.03	−110	0.89	175
		0.86	0.90	169	0.89	−100	0.03	−115	0.88	172
		0.88	0.90	168	0.80	−107	0.03	−119	0.87	170

Table 2. Common Emitter S–Parameters

The RF Line
NPN Silicon
RF Power Transistor

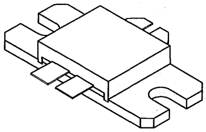
TPV8100B

The TPV8100B is designed for output stages in band IV and V TV transmitter amplifiers. It incorporates high value emitter ballast resistors, gold metallizations and offers a high degree of reliability and ruggedness.

Including double input and output matching networks, the TPV8100B features high impedances. It can easily operate in a full 470 MHz to 860 MHz bandwidth in a single and simple circuit.

- To be used class AB for TV band IV and V.
- Specified 28 Volts, 860 MHz Characteristics
  - Output Power = 125 Watts (peak sync.)
  - Output Power = 100 Watts (CW)
  - Minimum Gain = 8.5 dB
- Specified 32 Volts, 860 MHz Characteristics
  - Output Power = 150 Watts (peak sync.)
- Circuit board photomaster available upon request by contacting RF Tactical Marketing in Phoenix, AZ.

150 W, 470–860 MHz
NPN SILICON
RF POWER TRANSISTOR



CASE 398–03, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CER}	40	Vdc
Collector–Base Voltage	V_{CBO}	65	Vdc
Emitter–Base Voltage	V_{EBO}	4	Vdc
Collector–Current — Continuous	I_C	12	Adc
Total Device Dissipation @ 25°C Case Derate above 25°C	P_D	215 1.25	Watts W/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (1)	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mA, R_{be} = 75 Ω)	$V_{(BR)CER}$	30	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc)	$V_{(BR)EBO}$	4	—	—	Vdc
Collector–Base Breakdown Voltage (I_E = 20 mAdc)	$V_{(BR)CBO}$	65	—	—	Vdc
Collector–Emitter Leakage (V_{CE} = 28 V, R_{be} = 75 Ω)	I_{CER}	—	—	10	mA

(continued)

NOTE:
1. Thermal resistance is determined under specified RF operating condition.

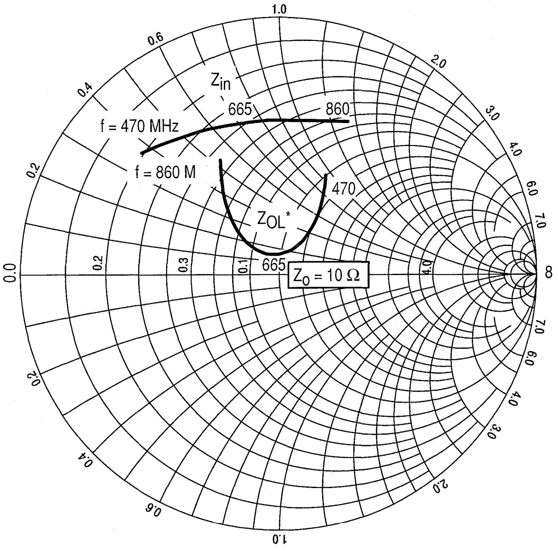
REV 6

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 Adc, V_{CE} = 10 Vdc)	h_{FE}	30	—	120	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (each side) (2) (V_{CB} = 28 V, I_E = 0, f = 1 MHz)	C_{ob}	—	44	—	pF
FUNCTIONAL TESTS IN CW (SOUND)					
Common–Emitter Amplifier Power Gain (V_{CC} = 28 V, P_{out} = 100 W, I_{CQ} = 2 x 50 mA, f = 860 MHz)	G_p	8.5	9.5	—	dB
Collector Efficiency (V_{CC} = 28 V, P_{out} = 100 W, I_Q = 2 x 50 mA, f = 860 MHz)	η	55	58	—	%
Output Power @ 1 dB Compression (P_{ref} = 25 W) (V_{CC} = 28 V, I_{CQ} = 2 x 50 mA, f = 860 MHz)	P_{out}	100	110	—	W
FUNCTIONAL TESTS IN VIDEO (STANDARD BLACK LEVEL)					
Peak Output Power (synch.) (V_{CC} = 28 V, I_{CQ} = 2 x 50 mA, f = 860 MHz)	P_{out}	125	135	—	W
Peak Output Power (synch.) (V_{CC} = 32 V, I_{CQ} = 2 x 25 mA, f = 860 MHz)	P_{out}	150	160	—	W
Recommended Quiescent Current	I_{CQ}	—	—	2 x 0.3	A

NOTE:

2. Value of "C_{ob}" is that of die only. It is not measurable in TPV8100B because of internal matching network.



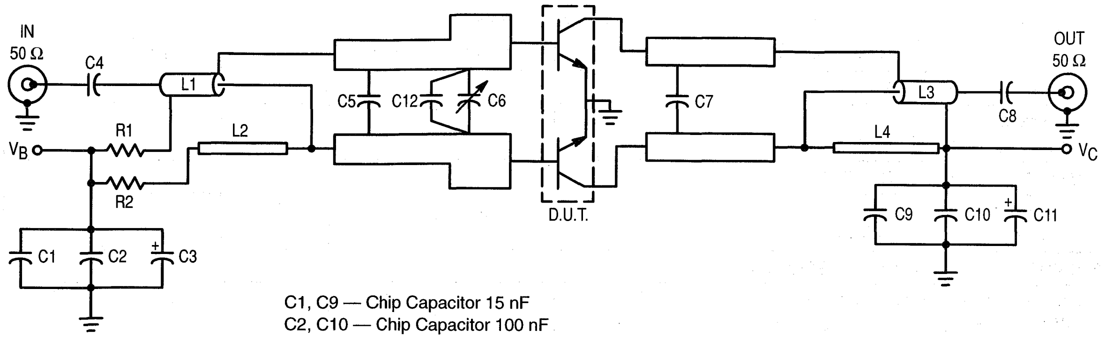
f (MHz)	Z_{in} (Ohms)	Z_{OL}* (Ohms)
470	1.95 + j3.67	10.0 + j9.50
665	3.65 + j6.82	9.23 + j1.30
860	6.66 + j13.8	4.45 + j5.22

Z_{OL}* = Conjugate of optimum load impedance into which the device operates at a given output power, voltage, current and frequency.

NOTE: Z_{in} & Z_{OL}* are given from base–to–base and collector–to–collector respectively.

Input and Output impedances with circuit tuned for maximum linearity @ V_{CC} = 28 V / I_{CQ} = 2 x 50 mA / P_{out} = 100 W

Figure 1. Series Equivalent Input/Output Impedances



C1, C9 — Chip Capacitor 15 nF
C2, C10 — Chip Capacitor 100 nF
C3, C11 — Chip Capacitor 100 µF/40 V
C4 — Chip Capacitor 15 pF ATC 100A
C5 — Chip Capacitor 5.6 pF ATC 100A
C6 — Trimmer Capacitor 1–4 pF
C7 — Chip Capacitor 12 pF ATC 100B
C8 — Chip Capacitor 15 pF ATC 100A
C12 — Chip Capacitor 12 pF ATC 100A
L1, L3 — Coaxial Wire 25 Ω/85 Mils/40 mm
L2, L4 — Printed Board Inductance
R1, R2 — Chip Resistor 1 Ω 0805 5%

Figure 2. Test Circuit

TYPICAL CHARACTERISTICS

CW — WIDEBAND

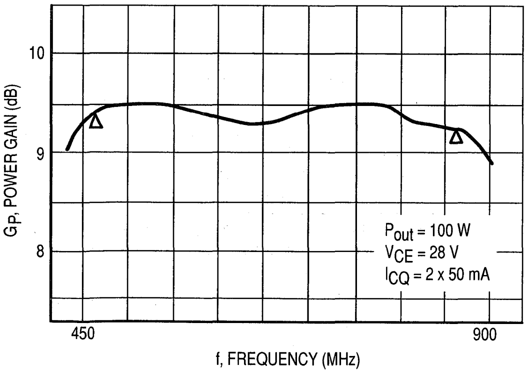


Figure 3. Power Gain versus Frequency

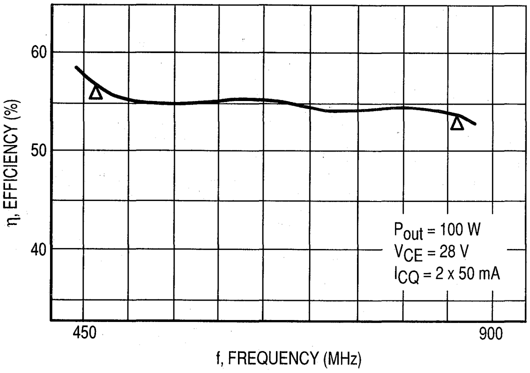
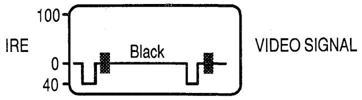


Figure 4. Collector Efficiency versus Frequency

TYPICAL VIDEO CHARACTERISTICS @ f = 800 MHz
V_{CE} = 28 V



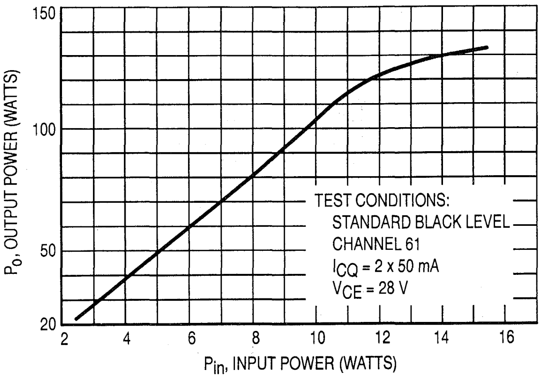


Figure 5. Peak Output Power versus Peak Input Power

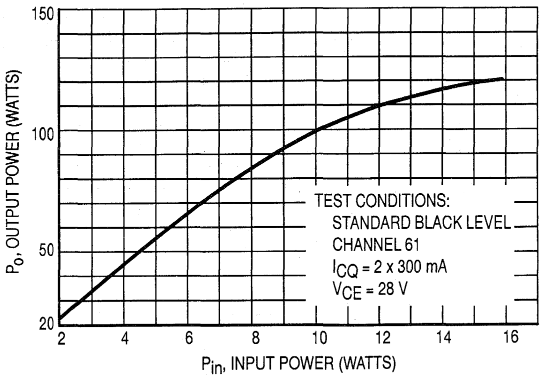
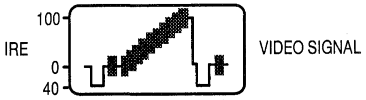


Figure 6. Peak Output Power versus Peak Input Power

TEST CONDITIONS:
DIFF. Gain, 10 Steps
Channel 61
V_{CE} = 28 V



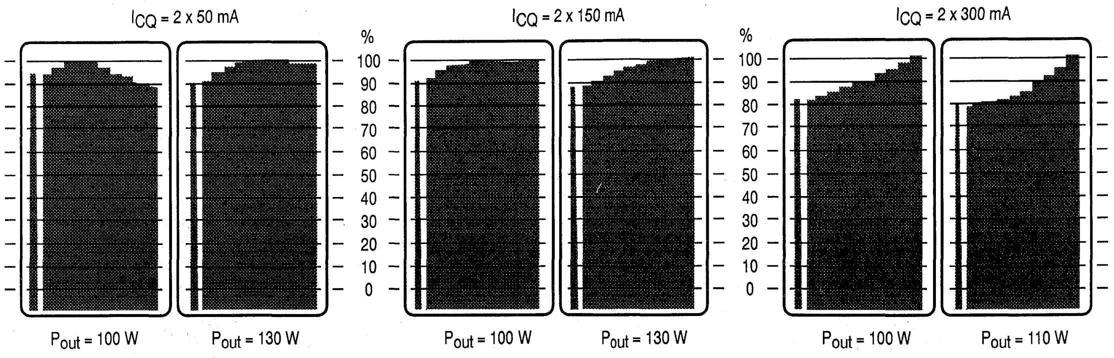
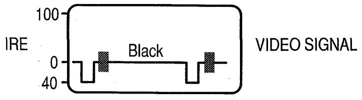


Figure 7. Gain versus Output Power

TYPICAL VIDEO CHARACTERISTICS @ f = 800 MHz
V_{CE} = 32 V



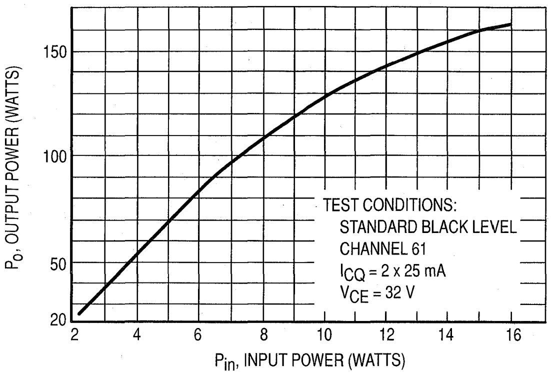


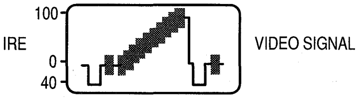
Figure 8. Peak Output Power versus Peak Input Power

V_{CE} = 32 V, I_{CQ} = 2 x 25 mA

P_{out}	Gain
25 W	10.6 dB
50 W	11.1 dB
100 W	11.3 dB
120 W	11.1 dB
130 W	11.0 dB
140 W	10.7 dB
150 W	10.5 dB
160 W	10.2 dB

(see curve on left)

TEST CONDITIONS:
DIFF. Gain, 10 Steps
Channel 61
V_{CE} = 32 V
I_{CQ} = 2 x 25 mA



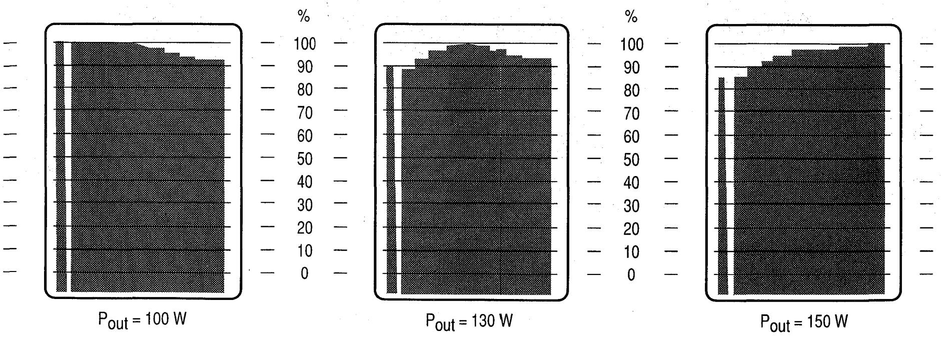


Figure 9. Differential Gain

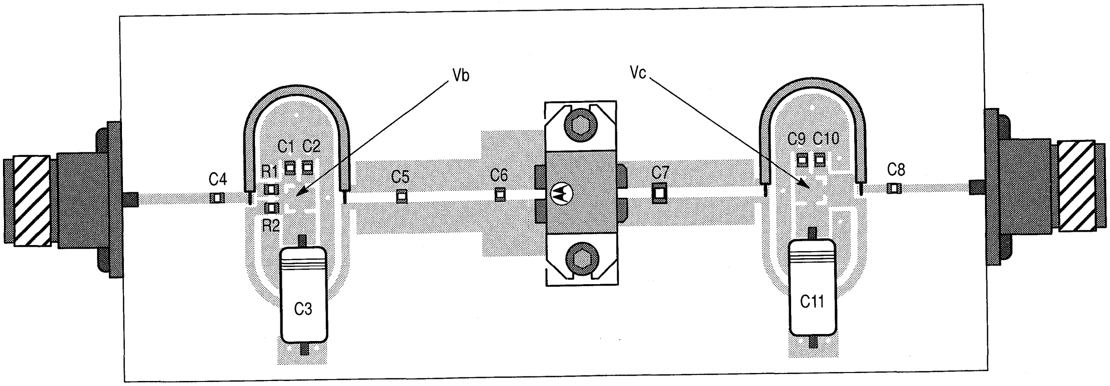


Figure 10. Components View

Section Three

Tape and Reel Specifications and Packaging Specifications

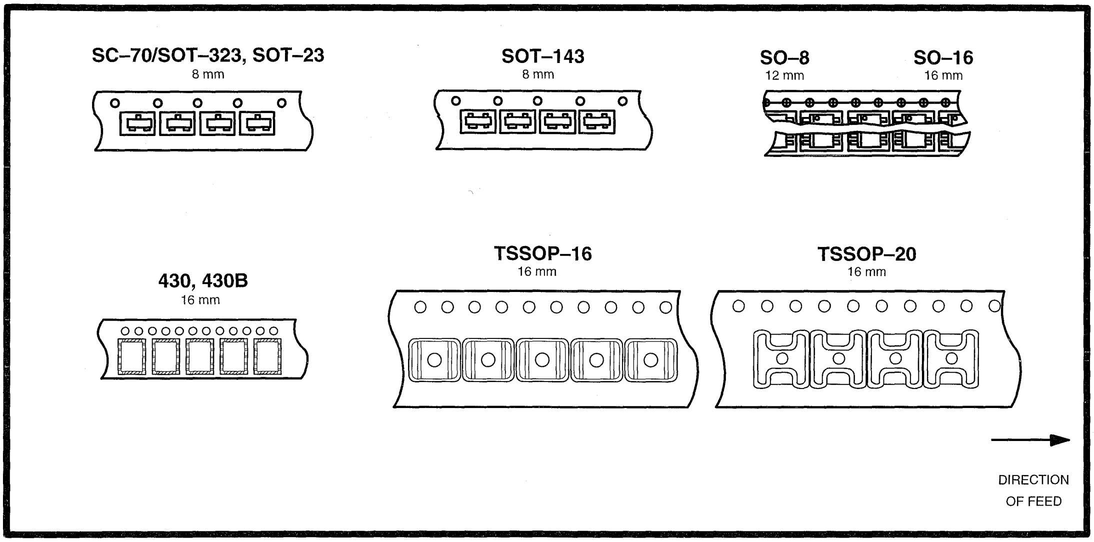
Table of Contents

Tape and Reel Specifications and Packaging Specifications

Embossed Tape and Reel is used to facilitate automatic pick and place equipment feed requirements. The tape is used as the shipping container for various products and requires a minimum of handling. The antistatic/conductive tape provides a secure cavity for the product when sealed with the “peel–back” cover tape.

- Two Reel Sizes Available (7″ and 13″)
- Used for Automatic Pick and Place Feed Systems
- Minimizes Product Handling
- EIA 481, –1, –2
- SC–70/SOT–323, SOT–23, SOT–143 in 8 mm Tape
- SO–8 in 12 mm Tape
- SO–16, TSSOP–16, TSSOP–20, PFP–16, 430 and 430B in 16 mm Tape

Use the standard device title and add the required suffix as listed in the option table on the following page. Note that the individual reels have a finite number of devices depending on the type of product contained in the tape. Also note the minimum lot size is one full reel for each line item, and orders are required to be in increments of the single reel quantity.

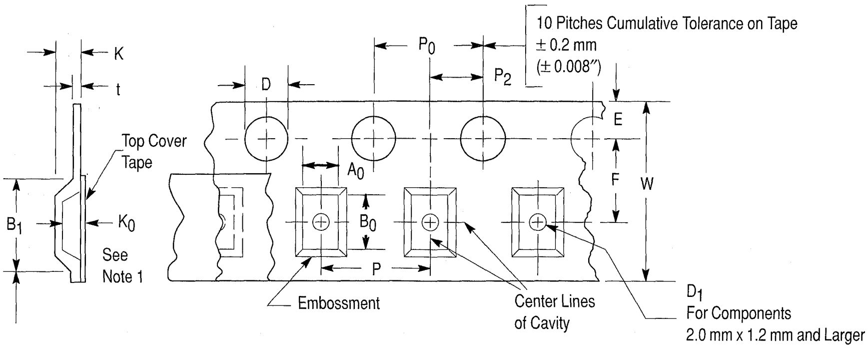


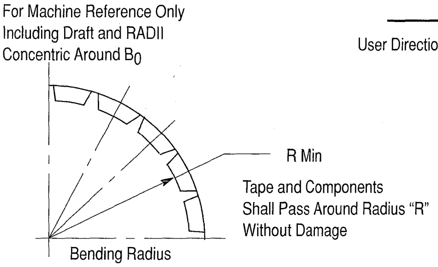
EMBOSSED TAPE AND REEL ORDERING INFORMATION

Package	Tape Width (mm)	Pitch mm (inch)	Reel Size mm (inch)	Devices Per Reel and Minimum Order Quantity	Device Suffix
SC–70/SOT–323	8	4.0 ± 0.1 (.157 ± .004)	178 (7)	3,000	T1
	8		330 (13)	10,000	T3
SO–8	12	8.0 ± 0.1 (.315 ± .004)	178 (7)	500	R1
	12		330 (13)	2,500	R2
SO–16	16	8.0 ± 0.1 (.315 ± .004)	178 (7)	500	R1
	16		330 (13)	2,500	R2
SOT–23	8	4.0 ± 0.1 (.157 ± .004)	178 (7)	3,000	T1
	8		330 (13)	10,000	T3
SOT–143	8	4.0 ± 0.1 (.157 ± .004)	178 (7)	3,000	T1
	8		330 (13)	10,000	T3
TSSOP–16	16	8.0 ± 0.1 (.315 ± .004)	330 (13)	2,500	R2
TSSOP–20	16	8.0 ± 0.1 (.315 ± .004)	330 (13)	2,000	R2
430, 430B	16	8.0 ± 0.1 (.315 ± .004)	178 (7)	500	R1
PFP–16	16	12.0 ± 0.1 (.471 ± .004)	330 (13)	To Be Determined	R2

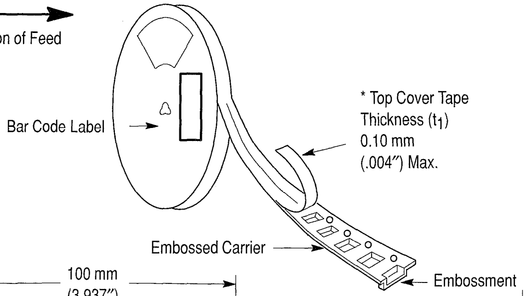
EMBOSSED TAPE AND REEL DATA FOR DISCRETES

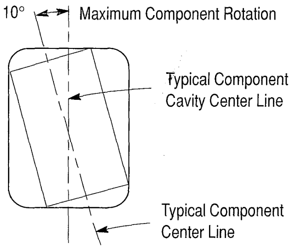
CARRIER TAPE SPECIFICATIONS

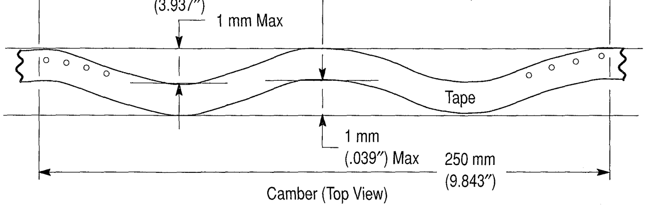




User Direction of Feed







Camber (Top View)
Allowable Camber To Be 1 mm/100 mm Nonaccumulative Over 250 mm

DIMENSIONS

Tape Size	B_1 Max	D	D_1	E	F	K	P_0	P_2	R Min	T Max	W Max
8 mm	4.55 mm (.179″)	1.5 + 0.1 mm − 0.0 (.059 + .004″ − 0.0)	1.0 Min (.039″)	1.75 ± 0.1 mm (.069 ± .004″)	3.5 ± 0.05 mm (.138 ± .002″)	2.4 mm Max (.094″)	4.0 ± 0.1 mm (.157 ± .004″)	2.0 ± 0.1 mm (.079 ± .002″)	25 mm (.98″)	0.6 mm (.024″)	8.3 mm (.327″)
12 mm	8.2 mm (.323″)		1.5 mm Min (.060″)		5.5 ± 0.05 mm (.217 ± .002″)	6.4 mm Max (.252″)			30 mm (1.18″)		12 ± .30 mm (.470 ± .012″)
16 mm	12.1 mm (.476″)				7.5 ± 0.10 mm (.295 ± .004″)	7.9 mm Max (.311″)					16.3 mm (.642″)

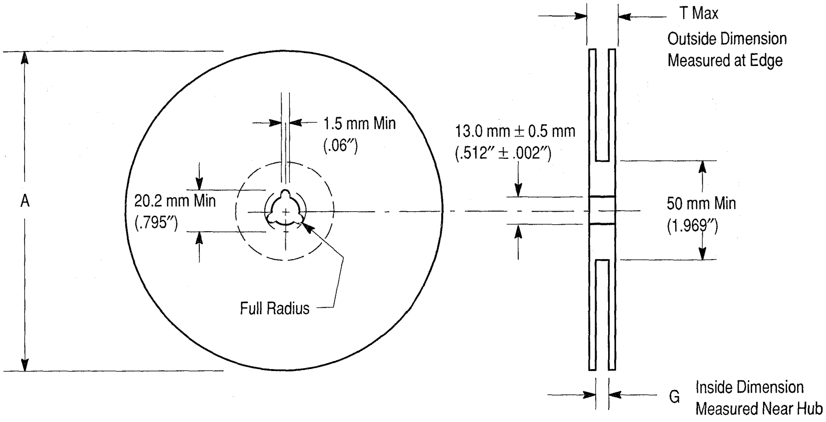
Metric dimensions govern — English are in parentheses for reference only.

NOTE 1: A_0, B_0, and K_0 are determined by component size. The clearance between the components and the cavity must be within .05 mm min. to .50 mm max., the component cannot rotate more than 10° within the determined cavity.

NOTE 2: If B_1 exceeds 4.2 mm (.165) for 8 mm embossed tape, the tape may not feed through all tape feeders.

NOTE 3: Pitch information is contained in the Embossed Tape and Reel Ordering Information on pg. 3–3.

EMBOSSED TAPE AND REEL DATA FOR DISCRETES



Size	A Max	G	T Max
8 mm	330 mm (12.992″)	8.4 mm + 1.5 mm, −0.0 (.33″ + .059″, −0.00)	14.4 mm (.56″)
12 mm	330 mm (12.992″)	12.4 mm + 2.0 mm, −0.0 (.49″ + .079″, −0.00)	18.4 mm (.72″)
16 mm	360 mm (14.173″)	16.4 mm + 2.0 mm, −0.0 (.646″ + .078″, −0.00)	22.4 mm (.882″)

Reel Dimensions

Metric Dimensions Govern — English are in parentheses for reference only

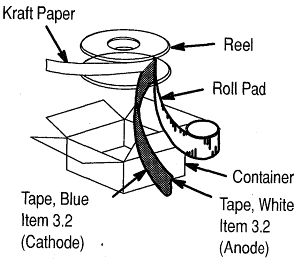


Figure 1. Reel Packing

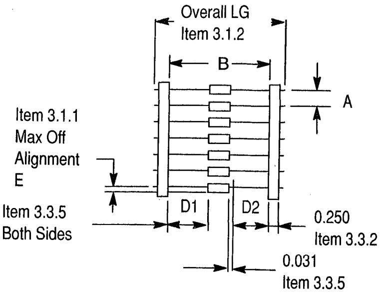


Figure 2. Component Spacing

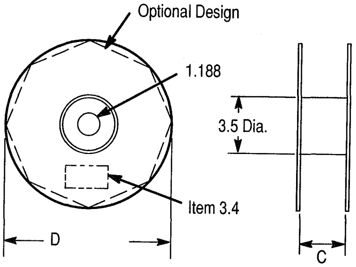


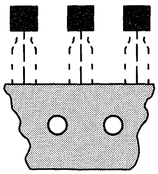
Figure 3. Reel Dimensions

TO–92 EIA, IEC, EIAJ Radial Tape in Fan Fold Box or On Reel

Radial tape in fan fold box or on reel of the reliable TO–92 package are the best methods of capturing devices for automatic insertion in printed circuit boards. These methods of taping are compatible with various equipment for active and passive component insertion.

- Available in Fan Fold Box
- Available on 365 mm Reels
- Accommodates All Standard Inserters
- Allows Flexible Circuit Board Layout
- 2.5 mm Pin Spacing for Soldering
- EIA–468, IEC 286–2, EIAJ RC1008B

TO–92 RADIAL TAPE IN FAN FOLD BOX OR ON REEL



Ordering Notes:

When ordering radial tape in fan fold box or on reel, specify the style per Figures 2 through 6. Add the suffix "RLR" and "Style" to the device title, i.e. MPS901RLRA. This will be a standard MPS901 radial taped and supplied on a reel per Figure 7.

Fan Fold Box Information — Minimum order quantity 1 Box/$200LL.
Order in increments of 2000.
Reel Information — Minimum order quantity 1 Reel/$200LL.
Order in increments of 2000.

US/European Suffix Conversions

US	EUROPE
RLRA	RL
RLRE	RL1

TO–92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

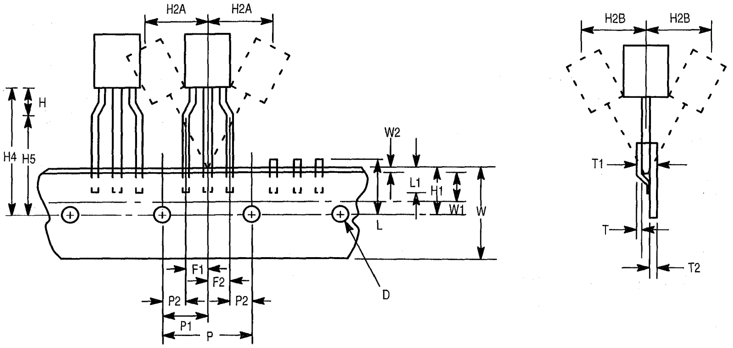


Figure 1. Device Positioning on Tape

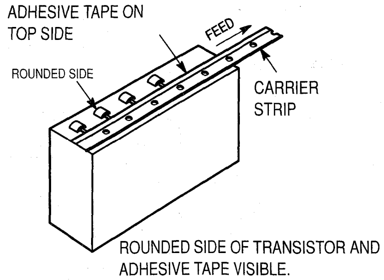
Symbol	Item	Specification			
		Inches		Millimeter	
		Min	Max	Min	Max
D	Tape Feedhole Diameter	0.1496	0.1653	3.8	4.2
D2	Component Lead Thickness Dimension	0.015	0.020	0.38	0.51
F1, F2	Component Lead Pitch	0.0945	0.110	2.4	2.8
H	Bottom of Component to Seating Plane	.059	.156	1.5	4.0
H1	Feedhole Location	0.3346	0.3741	8.5	9.5
H2A	Deflection Left or Right	0	0.039	0	1.0
H2B	Deflection Front or Rear	0	0.051	0	1.0
H4	Feedhole to Bottom of Component	0.7086	0.768	18	19.5
H5	Feedhole to Seating Plane	0.610	0.649	15.5	16.5
L	Defective Unit Clipped Dimension	0.3346	0.433	8.5	11
L1	Lead Wire Enclosure	0.09842	—	2.5	—
P	Feedhole Pitch	0.4921	0.5079	12.5	12.9
P1	Feedhole Center to Center Lead	0.2342	0.2658	5.95	6.75
P2	First Lead Spacing Dimension	0.1397	0.1556	3.55	3.95
T	Adhesive Tape Thickness	0.06	0.08	0.15	0.20
T1	Overall Taped Package Thickness	—	0.0567	—	1.44
T2	Carrier Strip Thickness	0.014	0.027	0.35	0.65
W	Carrier Strip Width	0.6889	0.7481	17.5	19
W1	Adhesive Tape Width	0.2165	0.2841	5.5	6.3
W2	Adhesive Tape Position	.0059	0.01968	.15	0.5

NOTES:

1. Maximum alignment deviation between leads not to be greater than 0.2 mm.
2. Defective components shall be clipped from the carrier tape such that the remaining protrusion (L) does not exceed a maximum of 11 mm.
3. Component lead to tape adhesion must meet the pull test requirements established in Figures 3, 4 and 5.
4. Maximum non–cumulative variation between tape feed holes shall not exceed 1 mm in 20 pitches.
5. Holddown tape not to extend beyond the edge(s) of carrier tape and there shall be no exposure of adhesive.
6. No more than one consecutive missing component is permitted.
7. A tape trailer and leader, having at least three feed holes, is required before the first and after the last component.
8. Splices will not interfere with the sprocket feed holes.

TO–92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

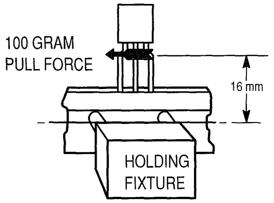
FAN FOLD BOX STYLES



Style P fan fold box is equivalent to styles A and B of reel pack dependent on feed orientation from box.

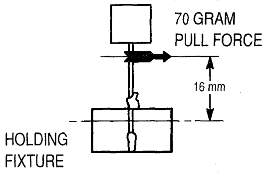
Figure 2. Style P

ADHESION PULL TESTS



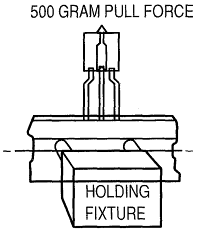
The component shall not pull free with a 300 gram load applied to the leads for 3 ± 1 second.

Figure 3. Test #1



The component shall not pull free with a 70 gram load applied to the leads for 3 ± 1 second.

Figure 4. Test #2

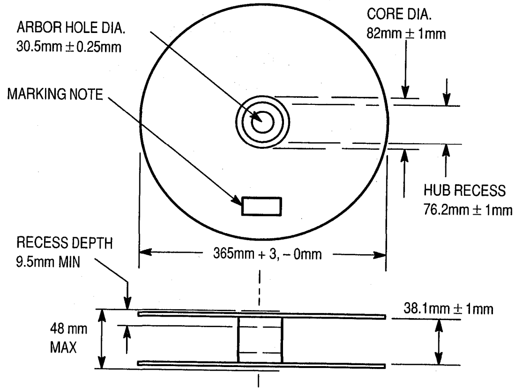


There shall be no deviation in the leads and no component leads shall be pulled free of the tape with a 500 gram load applied to the component body for 3 ± 1 second.

Figure 5. Test #3

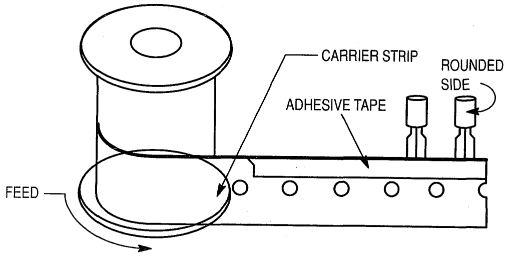
TO–92 EIA RADIAL TAPE IN FAN FOLD BOX OR ON REEL

REEL STYLES



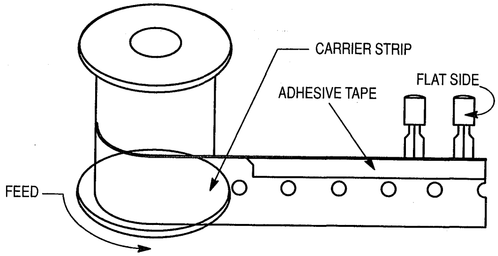
Material used must not cause deterioration of components or degrade lead solderability.

Figure 6. Reel Specifications



Rounded side of transistor and adhesive tape visible.

Figure 7. Style A



Flat side of transistor and adhesive tape visible.

Figure 8. Style E

Section Four

Surface Mount Information

In Brief . . .

Surface Mount Technology is now being utilized to offer answers to many problems that have been created in the use of insertion technology.

Limitations have been reached with insertion packages and PC board technology. Surface Mount Technology offers the opportunity to continue to advance the state–of–the–art designs that cannot be accomplished with Insertion Technology.

Surface Mount Packages allow more optimum device performance with the smaller Surface Mount configuration. Internal lead lengths, parasitic capacitance and inductance that placed limitations on chip performance have been reduced.

The lower profile of Surface Mount Packages allows more boards to be utilized in a given amount of space. They are stacked closer together and utilize less total volume than insertion populated PC boards.

Printed circuit costs are lowered with the reduction of the number of board layers required. The elimination or reduction of the number of plated through holes in the board contribute significantly to lower PC board prices.

Surface Mount assembly does not require the preparation of components that is common on insertion technology lines. Surface Mount components are sent directly to the assembly line, eliminating an intermediate step.

Automatic placement equipment is available that can place Surface Mount components at the rate of a few thousand per hour to hundreds of thousands of components per hour.

Surface Mount Technology is cost effective, allowing the manufacturer the opportunity to produce smaller units and offer increased functions with the same size product.

Table of Contents

INFORMATION FOR USING SURFACE MOUNT PACKAGES

RECOMMENDED FOOTPRINTS FOR SURFACE MOUNTED APPLICATIONS

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface between the board and the package. With the correct pad geometry, the packages will self align when subjected to a solder reflow process.

POWER DISSIPATION FOR A SURFACE MOUNT DEVICE

The power dissipation for a surface mount device is a function of the collector pad size. These can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by $T_{J(max)}$, the maximum rated junction temperature of the die, $R_{\theta JA}$, the thermal resistance from the device junction to ambient, and the operating temperature, T_A. Using the values provided on the data sheet, P_D can be calculated as follows:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

The values for the equation are found in the maximum ratings table on the data sheet. Substituting these values into the equation for an ambient temperature T_A of 25°C, one can calculate the power dissipation of the device. For example, for an SO–8 device, P_D is calculated as follows.

$$P_D = \frac{150°C - 25°C}{100°C/W} = 1.25 \text{ Watts}$$

The 100°C/W for the SO–8 package assumes the use of the recommended footprint on a glass epoxy printed circuit board to achieve a power dissipation of 1.25 Watts. There are other alternatives to achieving higher power dissipation from the surface mount packages. One is to increase the area of the collector pad. By increasing the area of the collector pad, the power dissipation can be increased. Although the power dissipation can almost be doubled with this method, area is taken up on the printed circuit board which can defeat the purpose of using surface mount technology.

Another alternative would be to use a ceramic substrate or an aluminum core board such as Thermal Clad™. Using a board material such as Thermal Clad, an aluminum core board, the power dissipation can be doubled using the same footprint.

SOLDER STENCIL GUIDELINES

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. Solder stencils are used to screen the optimum amount. These stencils are typically 0.008 inches thick and may be made of brass or stainless steel. For packages such as the SC–70/SOT–323, SOT–23, SOT–143 and the SO–8, the stencil opening should be the same as the pad size or a 1:1 registration.

SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference should be a maximum of 10°C.
- The soldering temperature and time should not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used since the use of forced cooling will increase the temperature gradient and will result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling.

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 1 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems, but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

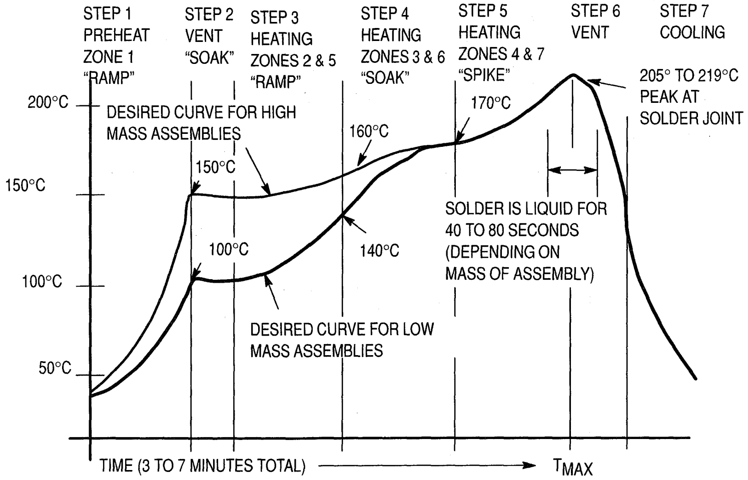
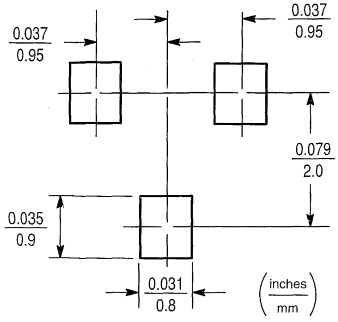
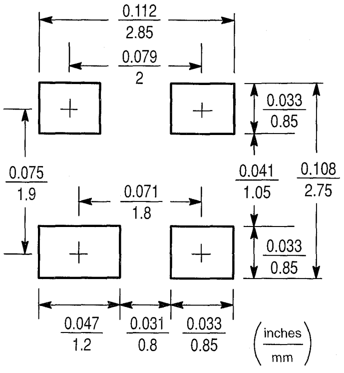


Figure 1. Typical Solder Heating Profile

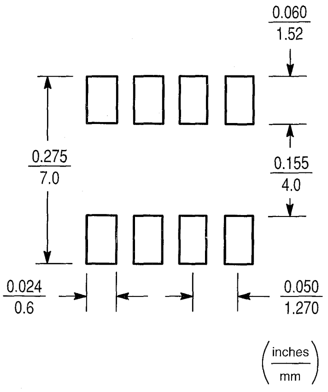
Footprints for Soldering



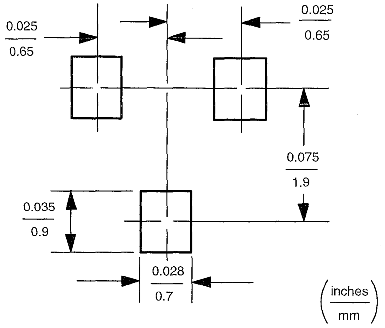
SOT–23



SOT–143



SO–8

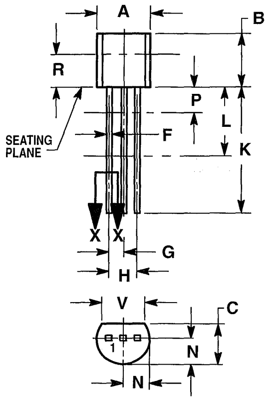


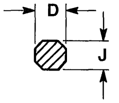
SC–70/SOT–323

Section Five

Case Dimensions

Case Dimensions





SECTION X–X

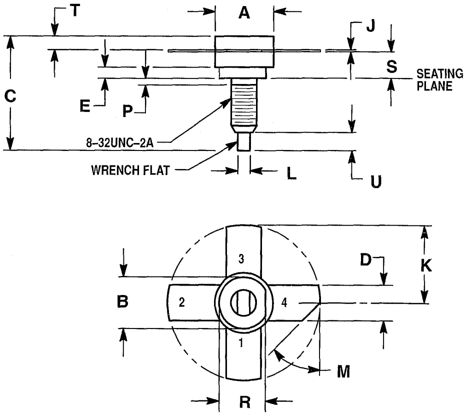
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. DIMENSION F APPLIES BETWEEN P AND L. DIMENSION D AND J APPLY BETWEEN L AND K MINIMUM. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.022	0.41	0.55
F	0.016	0.019	0.41	0.48
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	—	12.70	—
L	0.250	—	6.35	—
N	0.080	0.105	2.04	2.66
P	—	0.100	—	2.54
R	0.115	—	2.93	—
V	0.135	—	3.43	—

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 29–04
ISSUE AD
(TO–236AA)



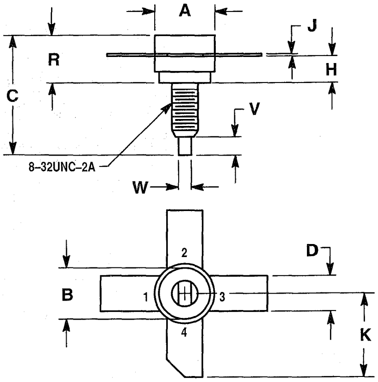
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.370	0.385	9.40	9.78
B	0.320	0.330	8.13	8.38
C	0.670	0.790	17.02	20.07
D	0.215	0.235	5.46	5.97
E	0.070	—	1.78	—
J	0.003	0.007	0.08	0.18
K	0.490	—	12.45	—
L	0.055	0.070	1.40	1.78
M	45°NOM		45°NOM	
P	—	0.050	—	1.27
R	0.299	0.307	7.59	7.80
S	0.158	0.178	4.01	4.52
T	0.083	0.100	2.11	2.54
U	0.098	0.132	2.49	3.35

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 145A–09
ISSUE M
(.380″ STUD)

CASE DIMENSIONS (continued)

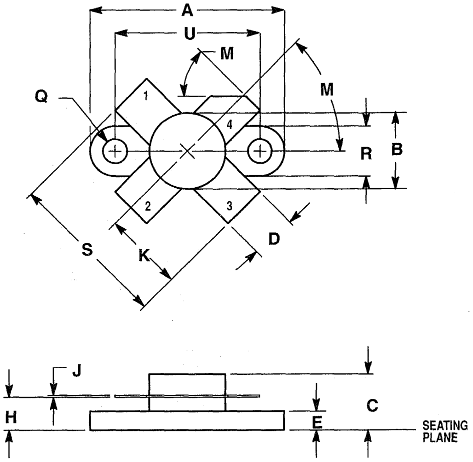


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.320	0.385	9.28	9.77
B	0.320	0.330	8.13	8.38
C	0.700	0.778	17.78	19.76
D	0.220	0.230	5.59	5.84
H	0.160	0.170	4.07	4.31
J	0.003	0.006	0.08	0.15
K	0.490	0.520	12.45	13.20
R	0.248	0.275	6.30	7.23
V	0.100	0.130	2.54	3.30
W	0.055	0.065	1.40	1.65

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 145D–02
ISSUE A
(.380″ SOE)



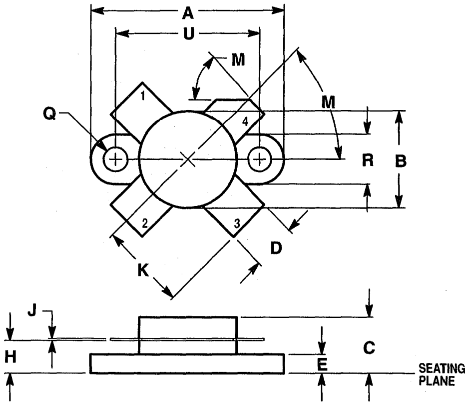
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.960	0.990	24.39	25.14
B	0.370	0.390	9.40	9.90
C	0.229	0.281	5.82	7.13
D	0.215	0.235	5.47	5.96
E	0.085	0.105	2.16	2.66
H	0.150	0.108	3.81	4.57
J	0.004	0.006	0.11	0.15
K	0.395	0.405	10.04	10.28
M	40°	50°	40°	50°
Q	0.113	0.130	2.88	3.30
R	0.245	0.255	6.23	6.47
S	0.790	0.810	20.07	20.57
U	0.720	0.730	18.29	18.54

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. SOURCE
2. GATE
3. SOURCE
4. DRAIN

CASE 211–07
ISSUE N
(.380″ FLANGE)



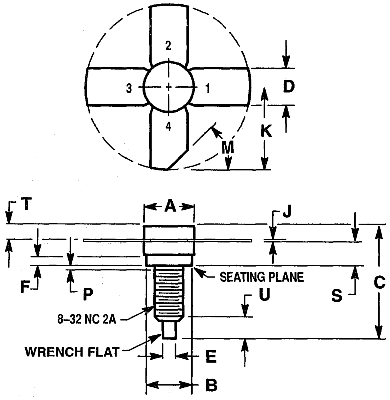
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.960	0.990	24.39	25.14
B	0.465	0.510	11.82	12.95
C	0.229	0.275	5.82	6.98
D	0.216	0.235	5.49	5.96
E	0.084	0.110	2.14	2.79
H	0.144	0.178	3.66	4.52
J	0.003	0.007	0.08	0.17
K	0.435	—	11.05	—
M	45 °NOM		45 °NOM	
Q	0.115	0.130	2.93	3.30
R	0.246	0.255	6.25	6.47
U	0.720	0.730	18.29	18.54

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. SOURCE
2. GATE
3. SOURCE
4. DRAIN

CASE 211–11
ISSUE N
(.500″ FLANGE)

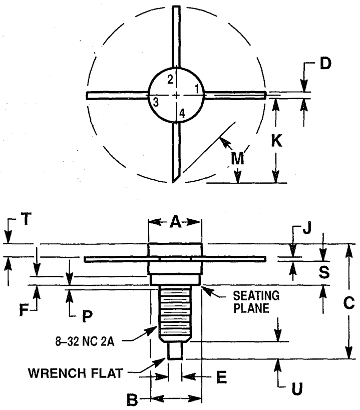


	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	14.99	16.51	0.590	0.650
D	5.46	5.96	0.215	0.235
E	1.40	1.65	0.055	0.065
G	1.52	—	0.060	—
J	0.08	0.17	0.003	0.007
K	11.05	—	0.435	—
M	45° NOM		45° NOM	
P	—	1.27	—	0.050
S	3.00	3.25	0.118	0.128
T	1.40	1.77	0.055	0.070
U	2.92	3.68	0.115	0.145

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 244–04
ISSUE J
(.280″ STUD)

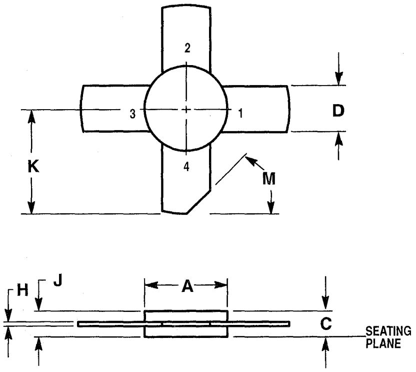
CASE DIMENSIONS (continued)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.20	6.50	0.244	0.256
C	15.24	16.51	0.600	0.650
D	0.66	0.86	0.026	0.034
E	1.40	1.65	0.055	0.065
F	1.52	—	0.060	—
J	0.10	0.15	0.004	0.006
K	11.17	—	0.440	—
M	45° NOM		45° NOM	
P	—	1.27	—	0.050
S	2.74	3.35	0.108	0.132
T	1.40	1.78	0.055	0.070
U	2.92	3.68	0.115	0.145

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 244A–01
ISSUE A



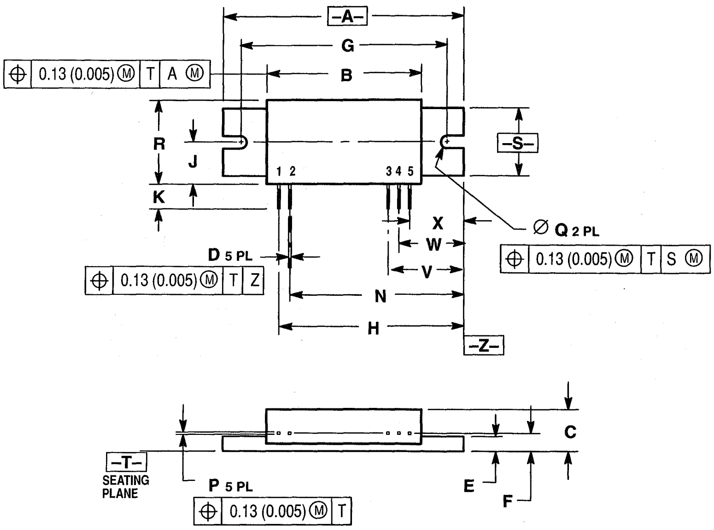
NOTES:
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
4. CONTROLLING DIMENSION: INCH.
5. SEATING PLANE = GROUND AND IS CONNECTED TO PIN 1 AND 3.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.271	0.286	6.88	7.26
C	0.112	0.136	2.84	3.45
D	0.215	0.235	5.46	5.97
H	0.055	0.065	1.40	1.65
J	0.003	0.007	0.08	0.18
K	0.435	——	11.05	——
M	45° REF		45° REF	

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

STYLE 3:
PIN 1. SOURCE
2. GATE
3. SOURCE
4. DRAIN

CASE 249–06
ISSUE H
(.280″ PILL)

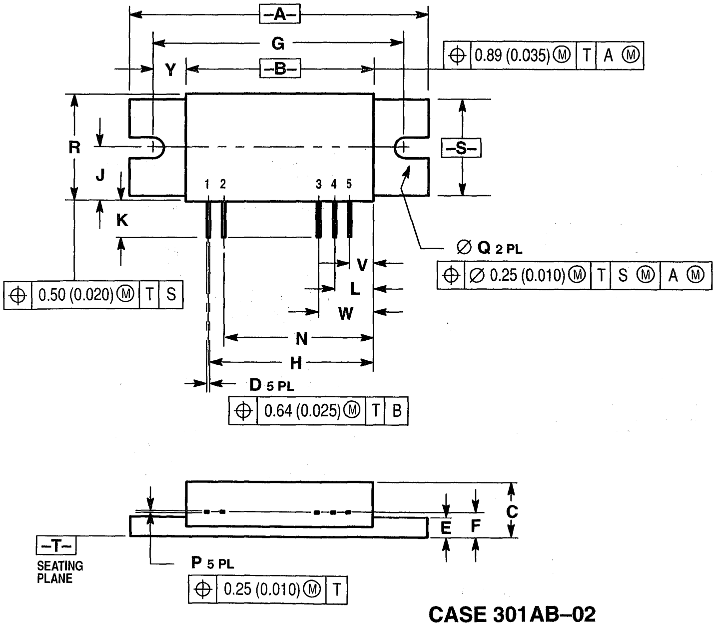


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	2.190	2.210	55.63	56.13
B	1.395	1.415	35.44	35.94
C	0.355	0.380	9.02	9.65
D	0.018	0.022	0.46	0.55
E	0.120	0.135	3.05	3.42
F	0.164 BSC		4.16 BSC	
G	1.900 BSC		48.26 BSC	
H	1.700 BSC		43.18 BSC	
J	0.345	0.385	8.77	9.77
K	0.225	—	5.72	—
N	1.600 BSC		40.64 BSC	
P	0.008	0.012	0.21	0.30
Q	0.150	0.160	3.81	4.06
R	0.690	0.770	17.53	19.55
S	0.595	0.615	15.12	15.62
V	0.700 BSC		17.78 BSC	
W	0.600 BSC		15.24 BSC	
X	0.500 BSC		12.70 BSC	

STYLE 1:
PIN 1. RF INPUT
2. V_{BIAS} (8.0 V)
3. V_{CC2} (12.5 V)
4. V_{CC3} (12.5 V)
5. RF OUTPUT

CASE 301AA–01
ISSUE O



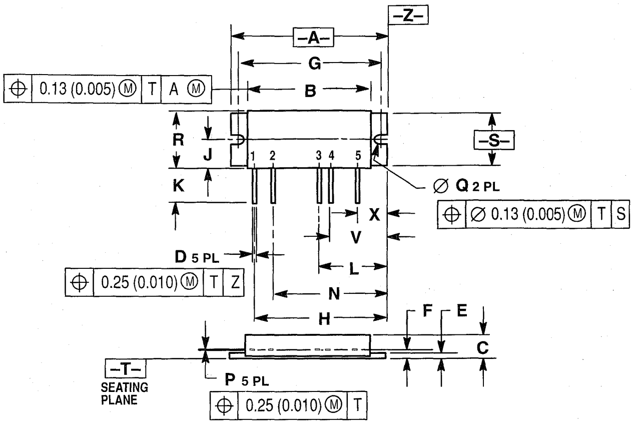
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.
4. REF INDICATES NON–CONTROLLED DIMENSION FOR REFERENCE USE ONLY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.890	1.910	48.01	48.51
B	1.170	1.190	29.72	30.23
C	0.350	0.376	8.89	9.55
D	0.018	0.022	0.46	0.56
E	0.120	0.135	3.05	3.43
F	0.165 BSC		4.19 BSC	
G	1.600 BSC		40.64 BSC	
H	1.055 BSC		26.80 BSC	
J	0.336	0.360	8.53	9.14
K	0.225	—	5.72	—
L	0.255 BSC		6.48 BSC	
N	0.955 BSC		24.26 BSC	
P	0.008	0.012	0.20	0.31
Q	0.151	0.161	3.84	4.09
R	0.685	0.705	17.40	17.91
S	0.598	0.612	15.19	15.55
V	0.155 BSC		3.94 BSC	
W	0.355 BSC		9.02 BSC	
Y	0.210 REF		5.33 REF	

STYLE 1:
PIN 1. RF INPUT
2. +DC (BIAS)
3. +DC (SUPPLY)
4. +DC (SUPPLY)
5. RF OUTPUT
CASE: GROUND

CASE 301AB–02
ISSUE F

CASE DIMENSIONS (continued)

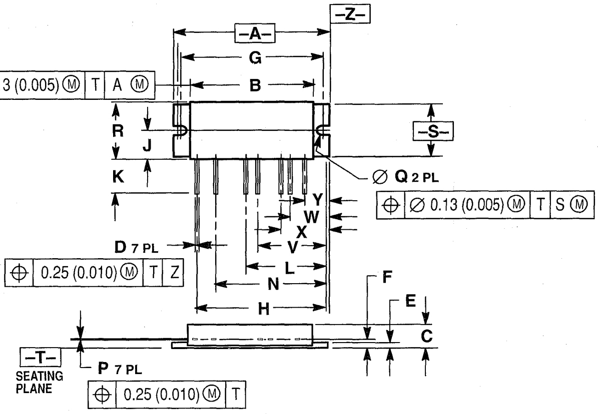


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.760	1.780	44.71	45.21
B	1.370	1.390	34.80	35.30
C	0.245	0.265	6.23	6.73
D	0.018	0.022	0.46	0.55
E	0.080	0.100	2.04	2.54
F	0.130 BSC		3.30 BSC	
G	1.650 BSC		41.91 BSC	
H	1.485 BSC		37.72 BSC	
J	0.267	0.278	6.79	7.06
K	0.230	0.300	5.85	7.62
L	0.785 BSC		19.94 BSC	
N	1.285 BSC		32.64 BSC	
P	0.008	0.012	0.21	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.09
S	0.445	0.465	11.31	11.81
V	0.685 BSC		17.40 BSC	
X	0.385 BSC		9.78 BSC	

STYLE 1:
PIN 1. RF INPUT/V CONT
2. VS1
3. VS2
4. VS3
5. RF OUTPUT
CASE: GROUND

CASE 301E–04
ISSUE F



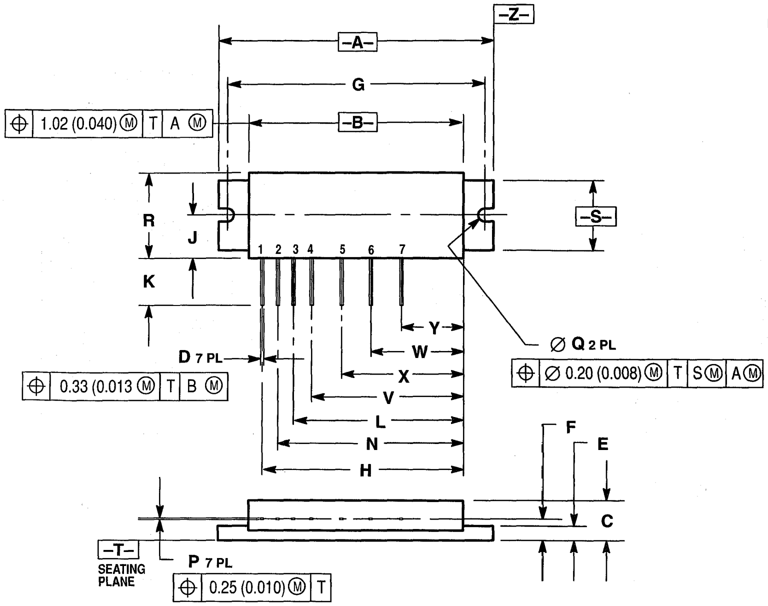
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	2.380	2.395	60.46	6.083
B	1.970	1.990	50.04	50.54
C	0.250	0.265	6.35	6.73
D	0.018	0.022	0.46	0.55
E	0.085	0.100	2.16	2.54
F	0.132 BSC		3.35 BSC	
G	2.260 BSC		57.40 BSC	
H	2.042 BSC		51.87 BSC	
J	0.267	0.278	6.78	7.06
K	0.230	0.300	5.85	7.62
L	1.242 BSC		31.55 BSC	
N	1.742 BSC		44.25 BSC	
P	0.008	0.012	0.21	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.09
S	0.445	0.465	11.31	11.81
V	1.142 BSC		29.01 BSC	
W	0.542 BSC		13.77 BSC	
X	0.642 BSC		16.31 BSC	
Y	0.342 BSC		8.69 BSC	

STYLE 1:
PIN 1. RF INPUT/V CONT
2. VS1
3. VS2
4. VS3
5. VS4
6. VS5
7. RF OUTPUT
CASE: GROUND

CASE 301F–03
ISSUE C

CASE DIMENSIONS (continued)

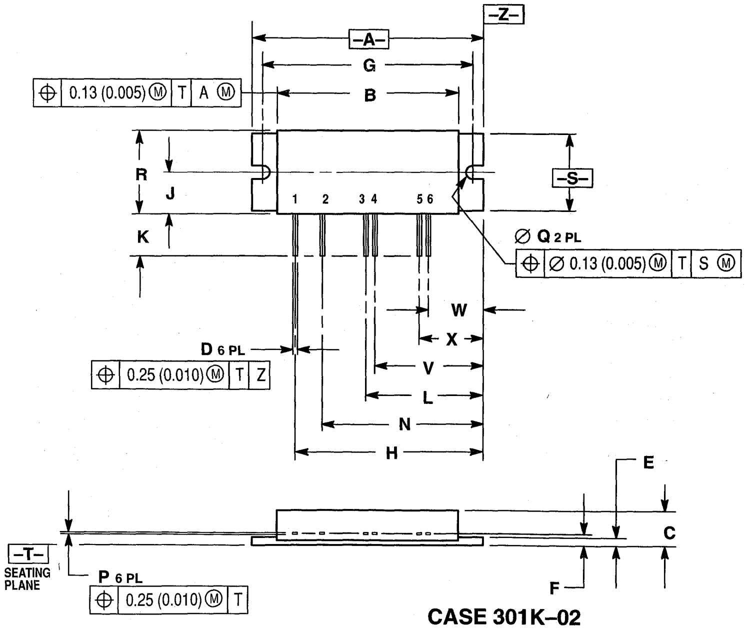


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.
4. REF INDICATES NON–CONTROLLED DIMENSION FOR REFERENCE USE ONLY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.760	1.780	44.70	45.21
B	1.370	1.390	34.80	35.31
C	0.245	0.265	6.22	6.73
D	0.017	0.023	0.43	0.58
E	0.080	0.100	2.03	2.54
F	0.132 BSC		3.35 BSC	
G	1.650 BSC		41.91 BSC	
H	1.290 BSC		32.77 BSC	
J	0.266	0.280	6.76	7.11
K	0.230	0.300	5.84	7.62
L	1.090 BSC		27.69 BSC	
N	1.190 BSC		30.23 BSC	
P	0.010 REF		0.25 REF	
Q	0.118	0.132	3.00	3.35
R	0.535	0.555	13.59	14.10
S	0.445	0.465	11.30	11.81
V	0.990 BSC		25.15 BSC	
W	0.590 BSC		14.99 BSC	
X	0.790 BSC		20.07 BSC	
Y	0.390 BSC		9.91 BSC	

STYLE 1:
PIN 1. RF INPUT
2. VS1
3. VCONT
4. VS2
5. VS3
6. VS4
7. RF OUTPUT
CASE: GROUND

CASE 301J–04
ISSUE F



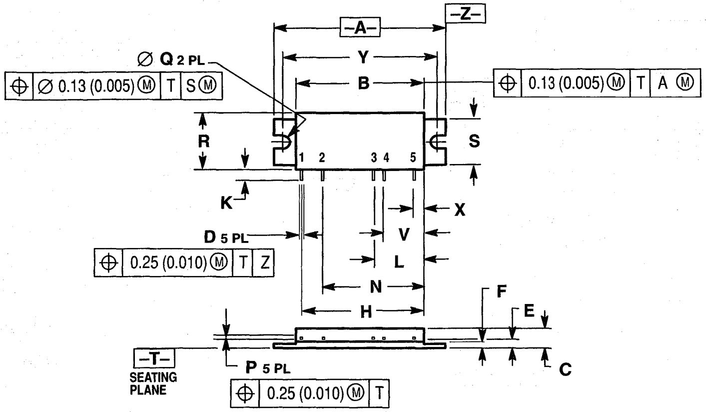
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.770	1.785	44.96	45.35
B	1.370	1.390	34.80	35.31
C	0.250	0.265	6.35	6.73
D	0.018	0.022	0.46	0.55
E	0.085	0.100	2.16	2.54
F	0.132 BSC		3.35 BSC	
G	1.655 BSC		42.04 BSC	
H	1.490 BSC		37.85 BSC	
J	0.267	0.278	6.78	7.06
K	0.230	0.300	5.85	7.62
L	0.990 BSC		25.15 BSC	
N	1.290 BSC		32.77 BSC	
P	0.008	0.012	0.21	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.09
S	0.445	0.465	11.31	11.81
V	0.890 BSC		22.61 BSC	
W	0.285 BSC		7.24 BSC	
X	0.390 BSC		9.91 BSC	

STYLE 3:
PIN 1. RF INPUT
2. VS1
3. VCONT
4. VS2
5. VS3
6. RF OUTPUT
CASE: GROUND

CASE 301K–02
ISSUE G

CASE DIMENSIONS (continued)

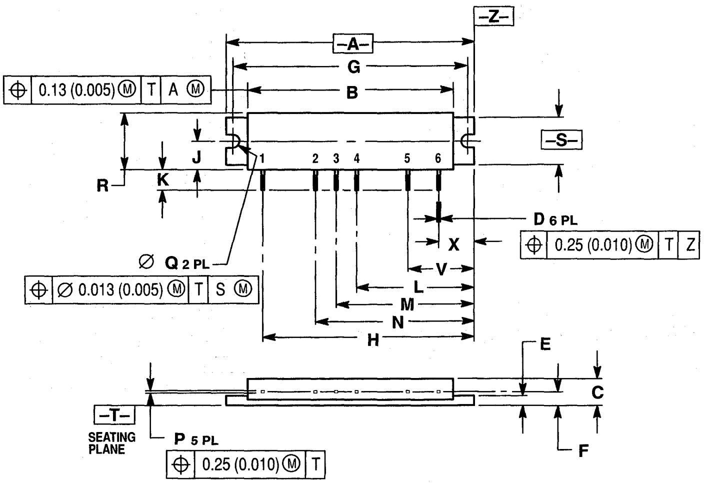


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION F TO CENTER OF LEADS.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	42.80	43.05	1.685	1.695
B	32.01	32.38	1.260	1.275
C	4.45	4.75	0.175	0.187
D	0.46	0.55	0.018	0.022
E	1.02	1.14	0.040	0.045
F	1.96	2.41	0.077	0.095
H	30.61 BSC		1.205 BSC	
K	2.54	—	0.100	—
L	12.83 BSC		0.505 BSC	
N	25.53 BSC		1.005 BSC	
P	0.21	0.30	0.008	0.012
Q	3.05	3.30	0.120	0.130
R	13.85	14.22	0.545	0.560
S	11.43	11.68	0.450	0.460
V	10.29 BSC		0.405 BSC	
X	2.67 BSC		0.105 BSC	
Y	38.99 BSC		1.535 BSC	

STYLE 1:
PIN 1. RF INPUT/V CONT
2. VS1
3. VS2
4. VS3
5. RF OUTPUT
CASE: GROUND

CASE 301N–02
ISSUE A



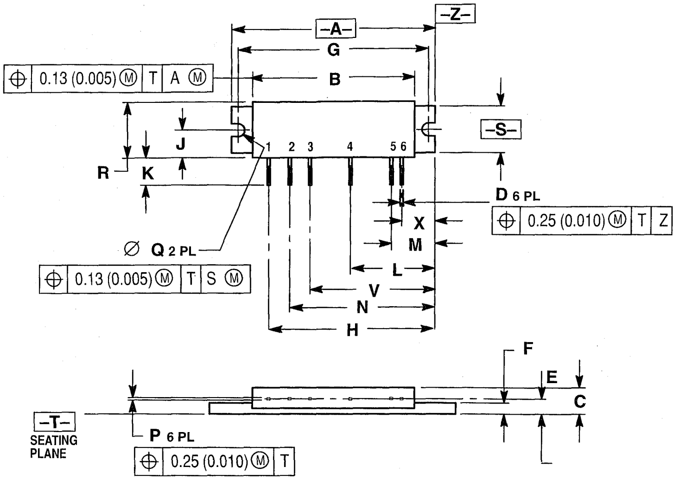
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	2.380	2.395	60.46	60.83
B	1.970	1.990	50.04	50.54
C	0.250	0.265	6.35	6.73
D	0.018	0.022	0.46	0.55
E	0.085	0.100	2.16	2.54
F	0.132 BSC		3.35 BSC	
G	2.260 BSC		57.40 BSC	
H	2.042 BSC		51.87 BSC	
J	0.267	0.278	6.78	7.06
K	0.177	0.217	4.49	5.51
L	1.142 BSC		29.01 BSC	
M	1.342 BSC		34.09 BSC	
N	1.542 BSC		39.17 BSC	
P	0.008	0.012	0.21	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.09
S	0.445	0.465	11.31	11.81
V	0.642 BSC		16.31 BSC	
X	0.342 BSC		8.69 BSC	

STYLE 1:
PIN 1. RF INPUT/VCONT
2. VS1
3. VS2
4. Vb
5. VS3
6. RF OUTPUT

CASE 301R–01
ISSUE O

CASE DIMENSIONS (continued)

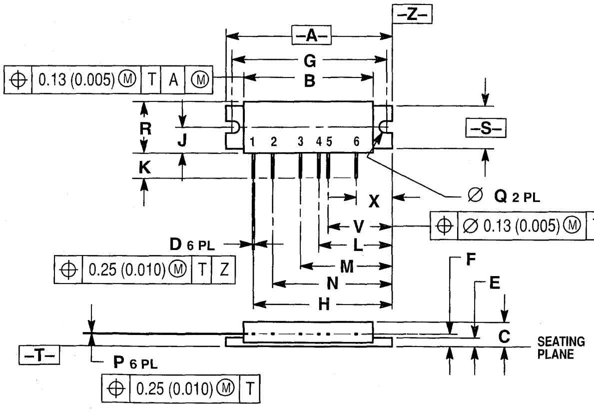


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.970	1.990	50.04	50.55
B	1.570	1.590	39.88	4.039
C	0.245	0.265	6.23	6.73
D	0.018	0.022	0.46	0.56
E	0.100	0.115	2.54	2.92
F	0.147 BSC		3.73 BSC	
G	1.860 BSC		47.24 BSC	
H	1.626 BSC		41.28 BSC	
J	0.267	0.278	6.78	7.06
K	0.177	0.217	4.50	5.51
L	0.825 BSC		20.96 BSC	
M	0.425 BSC		10.80 BSC	
N	1.425 BSC		36.20 BSC	
P	0.008	0.012	0.20	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.10
S	0.445	0.465	11.30	11.81
V	1.225 BSC		31.12 BSC	
X	0.325 BSC		8.26 BSC	

STYLE 1:
PIN 1. RF INPUT
2. DC TERMINAL, Vs1
3. DC TERMINAL, Vs2
4. DC TERMINAL, Vb
5. DC TERMINAL, Vs3
6. RF OUTPUT

CASE 301T–02
ISSUE B

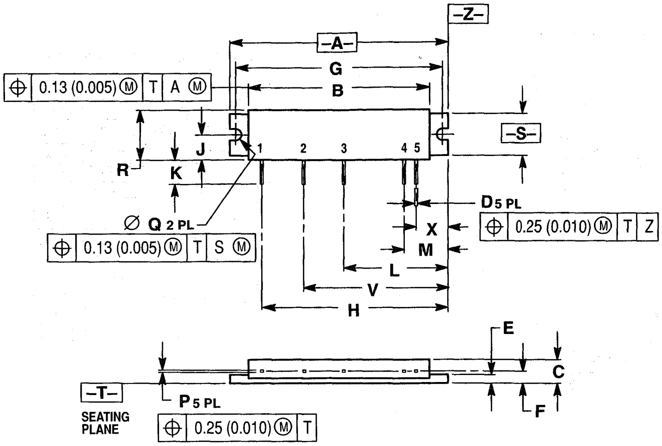


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.760	1.780	44.71	45.21
B	1.370	1.390	34.80	35.30
C	0.245	0.265	6.23	6.73
D	0.018	0.022	0.46	0.55
E	0.080	0.100	2.04	2.54
F	0.130 BSC		3.30 BSC	
G	1.650 BSC		41.91 BSC	
H	1.485 BSC		37.72 BSC	
J	0.267	0.278	6.79	7.09
K	0.177	0.217	4.50	5.51
L	0.785 BSC		19.94 BSC	
M	0.985 BSC		25.02 BSC	
N	1.285 BSC		32.64 BSC	
P	0.008	0.012	0.21	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.09
S	0.445	0.465	11.31	11.81
V	0.685 BSC		17.40 BSC	
X	0.385 BSC		9.78 BSC	

STYLE 1:
PIN 1. RF INPUT/V CONT
2. VS1
3. Vb
4. VS2
5. VS3
6. RF OUTPUT
CASE: GROUND

CASE 301V–02
ISSUE D

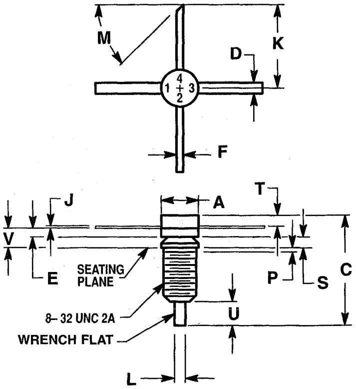


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION F TO CENTER OF LEADS.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.970	1.990	50.04	50.55
B	1.570	1.590	39.88	40.39
C	0.245	0.265	6.23	6.73
D	0.018	0.022	0.46	0.56
E	0.100	0.115	2.54	2.92
F	0.147 BSC		3.73 BSC	
G	1.860 BSC		47.24 BSC	
H	1.625 BSC		41.28 BSC	
J	0.267	0.278	6.78	7.06
K	0.177	0.217	4.50	5.51
L	0.825 BSC		20.96 BSC	
M	0.425 BSC		10.80 BSC	
P	0.008	0.012	0.20	0.30
Q	0.120	0.130	3.05	3.30
R	0.535	0.555	13.59	14.10
S	0.445	0.465	11.30	11.81
V	1.225 BSC		31.12 BSC	
X	0.325 BSC		8.26 BSC	

STYLE 1:
PIN 1. RF INPUT
2. DC TERMINAL, Vs1
3. DC TERMINAL, Vb
4. DC TERMINAL, Vs2
5. RF OUTPUT

CASE 301Y–02
ISSUE C

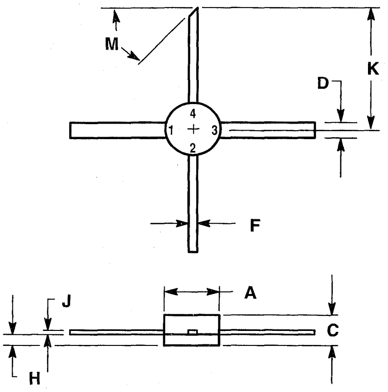


	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.200	0.220	5.08	5.59
C	0.550	0.640	13.97	16.26
D	0.055	0.065	1.40	1.65
E	0.040	0.050	1.02	1.27
F	0.025	0.035	0.64	0.89
J	0.003	0.007	0.08	0.18
K	0.435	—	11.05	—
L	0.055	0.065	1.40	1.65
M	45° NOM		45° NOM	
P	—	0.050	—	1.27
S	0.055	0.065	1.40	1.65
T	0.055	0.070	1.40	1.78
U	0.110	0.150	2.79	3.81
V	0.095	0.115	2.41	2.92

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 305–01
ISSUE O
(.204″ STUD)

CASE DIMENSIONS (continued)



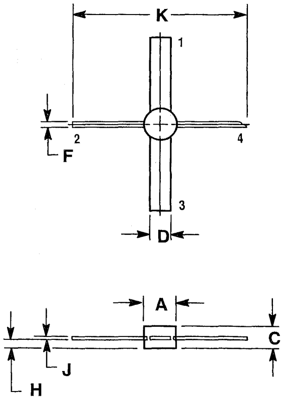
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.200	0.220	5.08	5.59
C	0.095	0.130	2.41	3.30
D	0.055	0.065	1.40	1.65
F	0.025	0.035	0.64	0.89
H	0.040	0.050	1.02	1.27
J	0.003	0.007	0.08	0.18
K	0.435	—	11.05	—
M	45 °REF		45 °REF	

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

STYLE 2:
PIN 1. SOURCE
2. GATE
3. SOURCE
4. DRAIN

CASE 305A–01
ISSUE A
(.204″ PILL)



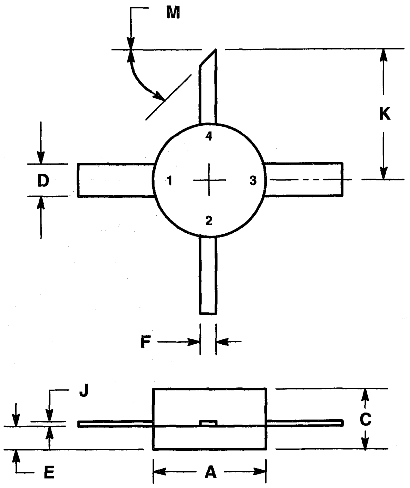
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.200	0.210	5.08	5.33
C	—	0.125	—	3.17
D	0.120	0.130	3.05	3.30
F	0.025	0.035	0.64	0.88
H	0.035	0.045	0.88	1.14
J	0.004	0.006	0.11	0.15
K	0.970	1.030	24.64	26.16

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 305C–02
ISSUE A

CASE DIMENSIONS (continued)

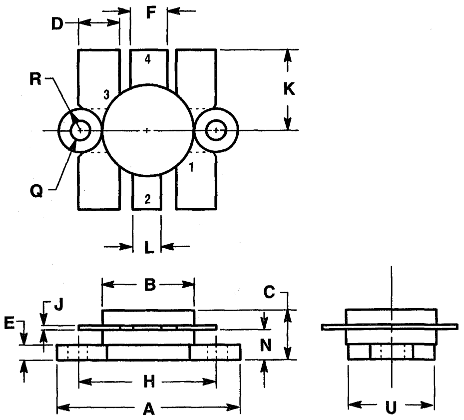


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.200	0.220	5.08	5.59
C	0.095	0.130	2.41	3.30
D	0.055	0.065	1.40	1.65
E	0.040	0.050	1.02	1.27
F	0.025	0.035	0.64	0.89
J	0.003	0.007	0.08	0.18
K	0.235	0.265	5.97	6.73
M	45° NOM		45° NOM	

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 305D–01
ISSUE O



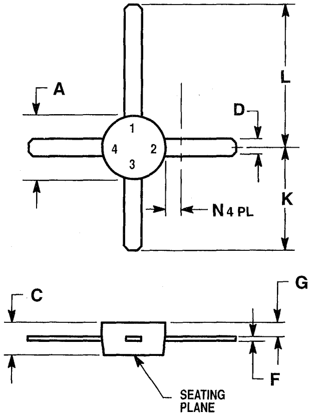
NOTES:
1. FLANGE IS ISOLATED IN ALL STYLES.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	24.38	25.14	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.58	0.210	0.220
E	2.16	3.04	0.085	0.120
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.29	11.17	0.405	0.440
L	3.81	4.06	0.150	0.160
N	3.81	4.31	0.150	0.170
Q	2.92	3.30	0.115	0.130
R	3.05	3.30	0.120	0.130
U	11.94	12.57	0.470	0.495

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE

STYLE 3:
PIN 1. SOURCE
2. DRAIN
3. SOURCE
4. GATE

CASE 316–01
ISSUE D
(.500″ CQ)



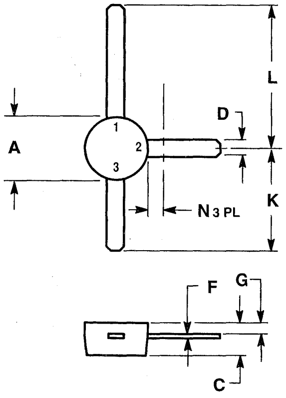
NOTES:
1. DIMENSION D NOT APPLICABLE IN ZONE N.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.84	0.99	0.033	0.039
F	0.20	0.30	0.080	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450
N	—	1.65	—	0.065

STYLE 1:
PIN 1. DRAIN
2. SOURCE
3. GATE 1
4. GATE 2

STYLE 2:
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

CASE 317–01
ISSUE E
(MACRO–X)



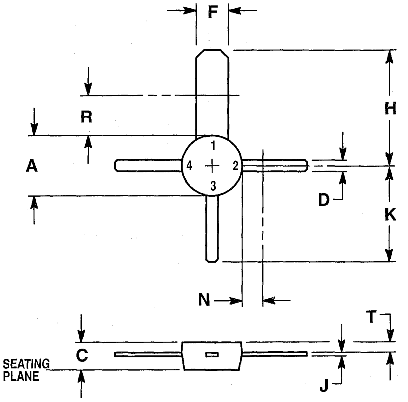
NOTES:
1. DIMENSION D NOT APPLICABLE IN ZONE N.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.44	5.21	0.175	0.205
C	1.90	2.54	0.075	0.100
D	0.84	0.99	0.033	0.039
F	0.20	0.30	0.008	0.012
G	0.76	1.14	0.030	0.045
K	7.24	8.13	0.285	0.320
L	10.54	11.43	0.415	0.450
N	—	1.65	—	0.065

STYLE 2:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 317A–01
ISSUE B
(MACRO–T)

CASE DIMENSIONS (continued)

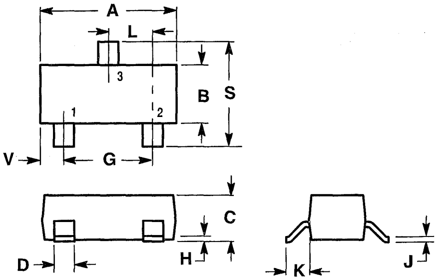


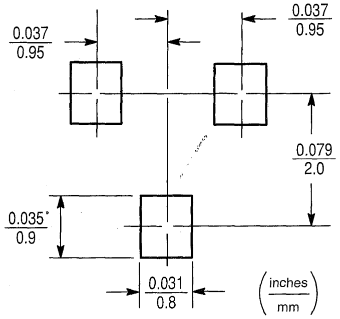
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. LEAD DIMENSIONS UNCONTROLLED WITHIN DIMENSION N AND R.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
C	0.075	0.100	1.91	2.54
D	0.033	0.039	0.84	0.99
F	0.097	0.104	2.46	2.64
H	0.348	0.383	8.84	9.72
J	0.008	0.012	0.24	0.30
K	0.285	0.320	7.24	8.12
N	—	0.065	—	1.65
R	—	0.128	—	3.25
T	0.025	0.040	0.64	1.01

STYLE 2:
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

CASE 317D–02
ISSUE C
(POWER MACRO)





SOT–23
FOOTPRINT

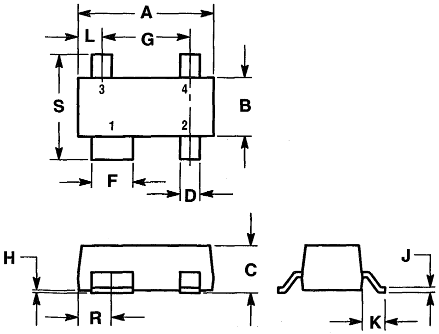
STYLE 6:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

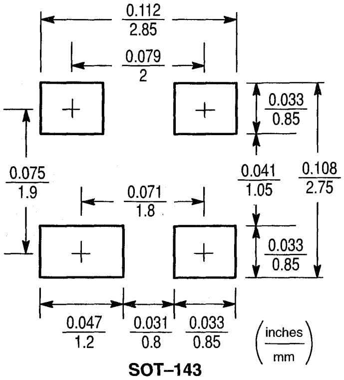
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. MAXIUMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.1102	0.1197	2.80	3.04
B	0.0472	0.0551	1.20	1.40
C	0.0350	0.0440	0.89	1.11
D	0.0150	0.0200	0.37	0.50
G	0.0701	0.0807	1.78	2.04
H	0.0005	0.0040	0.013	0.100
J	0.0034	0.0070	0.085	0.177
K	0.0140	0.0285	0.35	0.69
L	0.0350	0.0401	0.89	1.02
S	0.0830	0.1039	2.10	2.64
V	0.0177	0.0236	0.45	0.60

CASE 318–08
ISSUE AE
(TO–236AB)

CASE DIMENSIONS (continued)





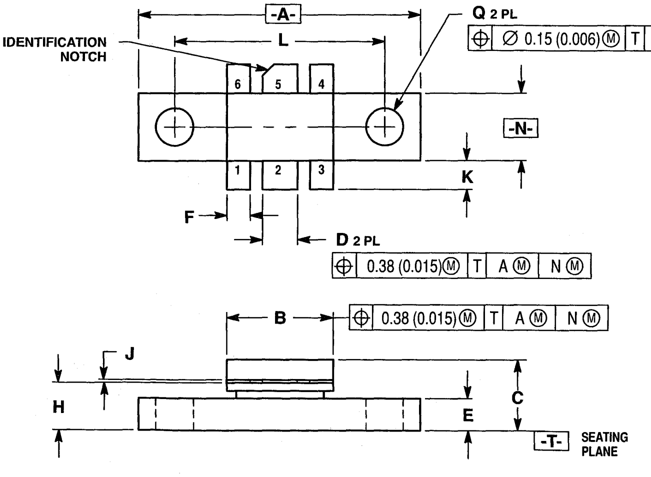
SOT–143
FOOTPRINT

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. EMITTER
4. BASE

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.110	0.120
B	1.20	1.39	0.047	0.055
C	0.84	1.14	0.033	0.045
D	0.39	0.50	0.015	0.020
F	0.79	0.93	0.031	0.037
G	1.78	2.03	0.070	0.080
H	0.013	0.10	0.0005	0.004
J	0.08	0.15	0.003	0.006
K	0.46	0.60	0.018	0.024
L	0.445	0.60	0.0175	0.024
R	0.72	0.83	0.028	0.033
S	2.11	2.48	0.083	0.098

CASE 318A–05
ISSUE J



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETER	
	MIN	MAX	MIN	MAX
A	0.965	0.985	24.52	25.01
B	0.355	0.375	9.02	9.52
C	0.230	0.260	5.85	6.60
D	0.115	0.125	2.93	3.17
E	0.102	0.114	2.59	2.90
F	0.075	0.085	1.91	2.15
H	0.160	0.170	4.07	4.31
J	0.004	0.006	0.11	0.15
K	0.090	0.110	2.29	2.79
L	0.725 BSC		18.42 BSC	
N	0.225	0.241	5.72	6.12
Q	0.125	0.135	3.18	3.42

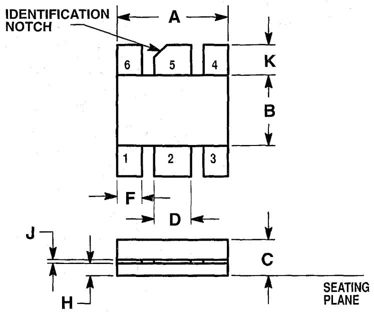
STYLE 1:
PIN 1. BASE (COMMON)
2. EMITTER (INPUT)
3. BASE (COMMON)
4. BASE (COMMON)
5. COLLECTOR (OUTPUT)
6. BASE (COMMON)

STYLE 2:
PIN 1. EMITTER (COMMON)
2. BASE (INPUT)
3. EMITTER (COMMON)
4. EMITTER (COMMON)
5. COLLECTOR (OUTPUT)
6. EMITTER (COMMON)

STYLE 3:
PIN 1. SOURCE (COMMON)
2. GATE (INPUT)
3. SOURCE (COMMON)
4. SOURCE (COMMON)
5. DRAIN (OUTPUT)
6. SOURCE (COMMON)

CASE 319–07
ISSUE M
(CS–12)

CASE DIMENSIONS (continued)

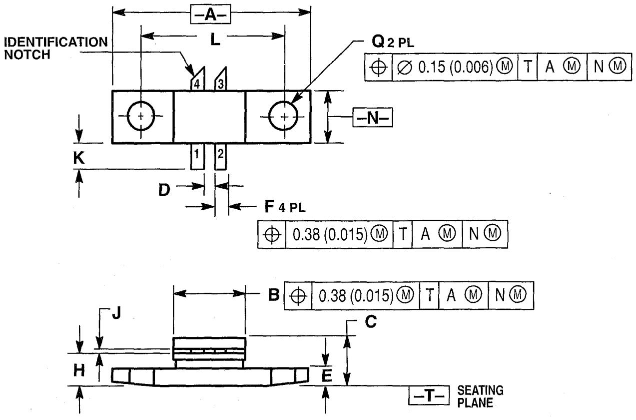


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.355	0.365	9.02	9.27
B	0.225	0.235	5.72	5.96
C	0.110	0.125	2.80	3.17
D	0.115	0.125	2.93	3.17
F	0.075	0.085	1.91	2.15
H	0.035	0.045	0.89	1.14
J	0.004	0.006	0.11	0.15
K	0.090	0.110	2.29	2.79

STYLE 2:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. EMITTER
5. COLLECTOR
6. EMITTER

CASE 319A–02
ISSUE B



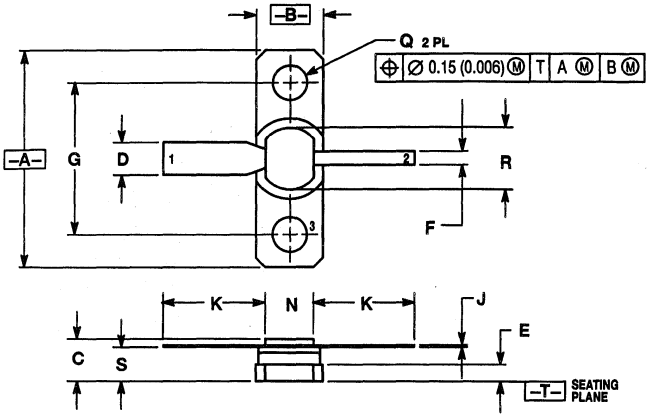
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.965	0.985	24.51	25.02
B	0.355	0.375	9.02	9.52
C	0.230	0.260	5.84	6.60
D	0.055	0.065	1.40	1.65
E	0.102	0.114	2.59	2.90
F	0.055	0.065	1.40	1.65
H	0.160	0.170	4.06	4.31
J	0.004	0.006	0.10	0.15
K	0.120	0.140	3.05	3.55
L	0.725 BSC		18.42 BSC	
N	0.225	0.241	5.72	6.12
Q	0.125	0.135	3.18	3.42

STYLE 1:
PIN 1. GATE (INPUT)
2. GATE (INPUT)
3. DRAIN (OUTPUT)
4. DRAIN (OUTPUT)
SOURCE IS FLANGE

CASE 319B–02
ISSUE C

CASE DIMENSIONS (continued)



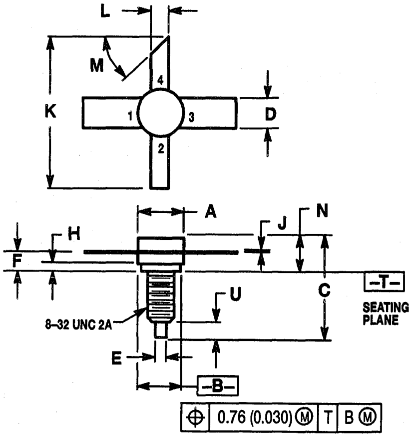
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M. 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.795	0.805	20.20	20.45
B	0.245	0.255	6.23	6.47
C	0.145	0.170	3.69	4.31
D	0.115	0.125	2.93	3.17
E	0.055	0.065	1.40	1.65
F	0.045	0.055	1.15	1.39
G	0.562 BSC		14.27 BSC	
J	0.003	0.006	0.08	0.15
K	0.260	0.375	6.60	9.52
N	0.175	0.185	4.45	4.69
Q	0.120	0.135	3.05	3.42
R	0.225	0.235	5.72	5.97
S	0.120	0.130	3.05	3.30

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

STYLE 2:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

CASE 328A–03
ISSUE D



NOTES:
1. DIMENSION K APPLIES TWO PLACES.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1973.

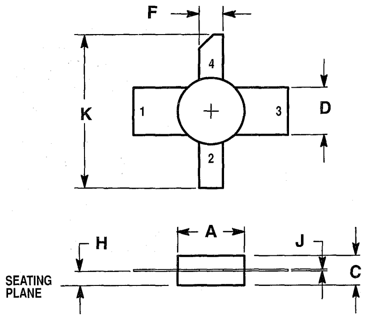
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	6.86	7.62	0.270	0.300
B	6.10	6.60	0.240	0.260
C	16.26	16.76	0.640	0.660
D	4.95	5.21	0.195	0.205
E	1.40	1.65	0.055	0.065
F	2.67	4.32	0.105	0.170
H	1.40	1.65	0.055	0.065
J	0.08	0.18	0.003	0.007
K	15.24	—	0.600	—
L	2.41	2.67	0.095	0.105
M	45 °NOM		45 °NOM	
N	4.97	6.22	0.180	0.245
U	2.92	3.68	0.115	0.145

STYLE 1:
PIN 1. BASE
2. EMITTER
3. BASE
4. COLLECTOR

STYLE 2:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 332–04
ISSUE D
(.280″ STUD)

CASE DIMENSIONS (continued)

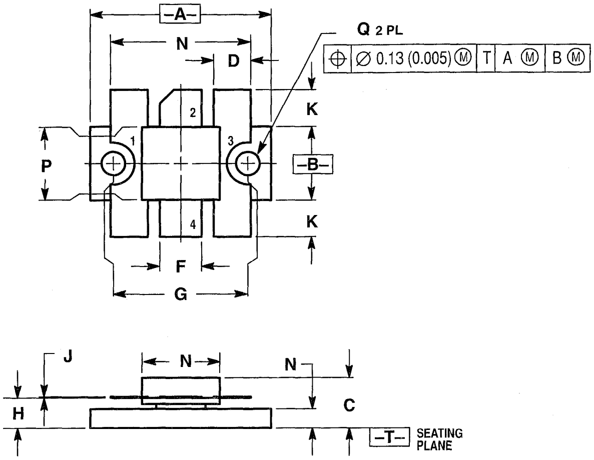


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.270	0.290	6.86	7.36
C	0.115	0.135	2.93	3.42
D	0.195	0.205	4.96	5.20
F	0.095	0.105	2.42	2.66
H	0.050	0.070	1.27	1.77
J	0.003	0.007	0.08	0.17
K	0.600	—	15.24	—

STYLE 2:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

CASE 332A–03
ISSUE D
(.280″ PILL)



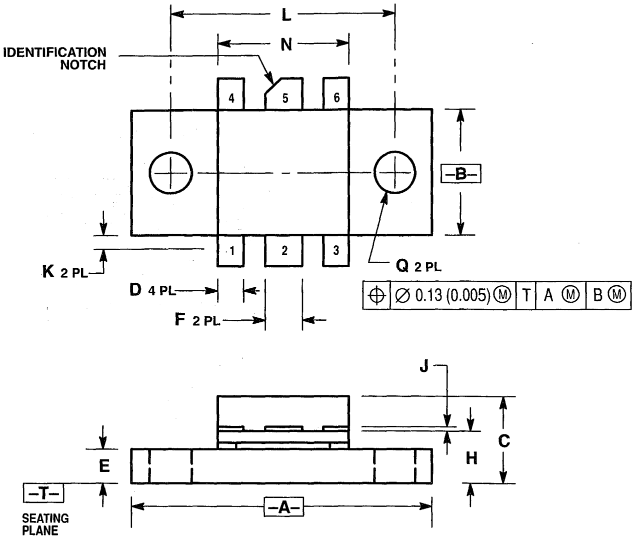
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.965	0.985	24.51	25.02
B	0.390	0.410	9.91	10.41
C	0.250	0.290	6.73	7.36
D	0.190	0.210	4.83	5.33
E	0.095	0.115	2.42	2.92
F	0.215	0.235	5.47	5.96
G	0.725 BSC		18.42 BSC	
H	0.155	0.175	3.94	4.44
J	0.004	0.006	0.10	0.15
K	0.195	0.205	4.95	5.21
L	0.740	0.770	18.80	19.55
N	0.415	0.425	10.54	10.80
P	0.390	0.400	9.91	10.16
Q	0.120	0.135	3.05	3.42

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE

CASE 333–04
ISSUE E

CASE DIMENSIONS (continued)



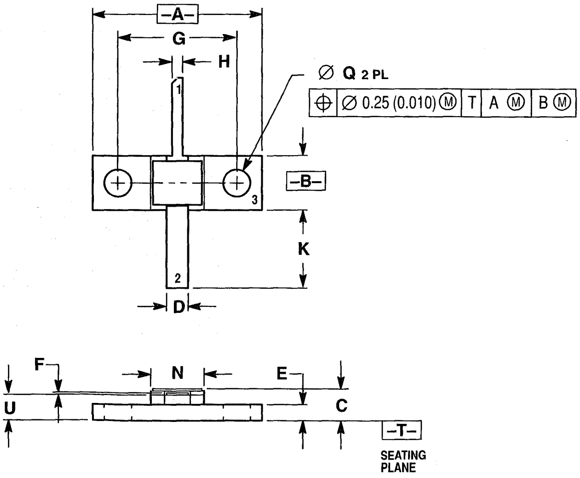
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.965	0.985	24.52	25.01
B	0.390	0.410	9.91	10.41
C	0.250	0.290	6.35	7.36
D	0.075	0.090	1.91	2.28
E	0.095	0.115	2.42	2.92
F	0.110	0.130	2.80	3.30
H	0.155	0.175	3.94	4.44
J	0.004	0.006	0.11	0.15
K	0.090	0.116	2.29	2.94
L	0.725 BSC		18.41 BSC	
N	0.415	0.435	10.55	11.04
Q	0.120	0.135	3.05	3.42

STYLE 1:
PIN 1. BASE
2. EMITTER
3. BASE
4. BASE
5. COLLECTOR
6. BASE

STYLE 2:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. EMITTER
5. COLLECTOR
6. EMITTER

CASE 333A–02
ISSUE C
(MAAC PAC)



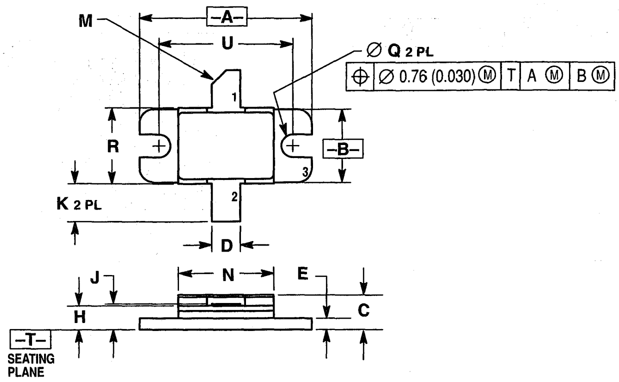
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.790	0.810	20.07	20.57
B	0.253	0.267	6.43	6.78
C	0.144	0.160	3.66	4.06
D	0.093	0.107	2.37	2.71
E	0.074	0.080	1.88	2.03
F	0.002	0.006	0.06	0.15
G	0.560 BSC		14.22 BSC	
H	0.043	0.057	1.10	1.44
K	0.346	0.394	8.79	10.10
N	0.243	0.257	6.18	6.52
Q	0.125	0.135	3.18	3.42
U	0.117	0.128	2.98	3.25

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 336E–02
ISSUE B

CASE DIMENSIONS (continued)

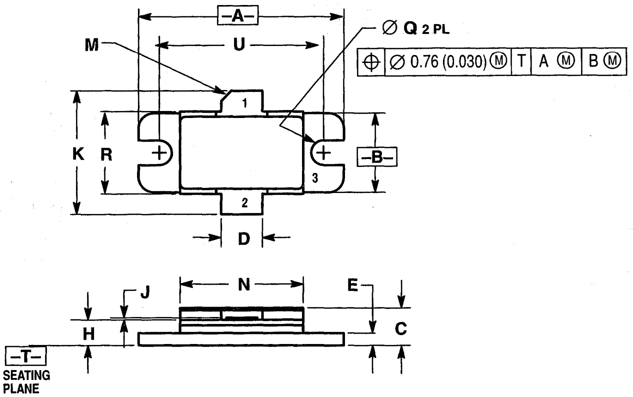


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.890	0.910	22.61	23.11
B	0.375	0.395	9.53	10.03
C	0.150	0.165	3.81	4.19
D	0.145	0.155	3.69	3.93
E	0.055	0.065	1.40	1.65
H	0.120	0.130	3.05	3.30
J	0.003	0.006	0.08	0.15
K	0.185	0.215	4.70	5.46
M	45° REF		45° REF	
N	0.490	0.510	12.45	12.95
Q	0.115	0.125	2.93	3.17
R	0.395	0.405	10.04	10.28
U	0.700 BSC		17.78 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 355C–02
ISSUE C

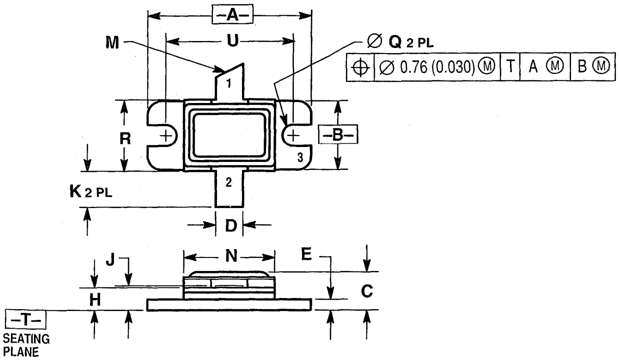


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.990	1.010	25.15	25.65
B	0.375	0.395	9.53	10.03
C	0.150	0.165	3.81	4.19
D	0.195	0.205	4.95	5.21
E	0.055	0.065	1.40	1.65
H	0.120	0.130	3.05	3.30
J	0.003	0.006	0.08	0.15
K	0.570	0.630	14.48	16.00
M	45° REF		45° REF	
N	0.590	0.610	14.99	15.49
Q	0.115	0.125	2.92	3.18
R	0.395	0.405	10.03	10.29
U	0.800 BSC		20.32 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 355D–02
ISSUE B

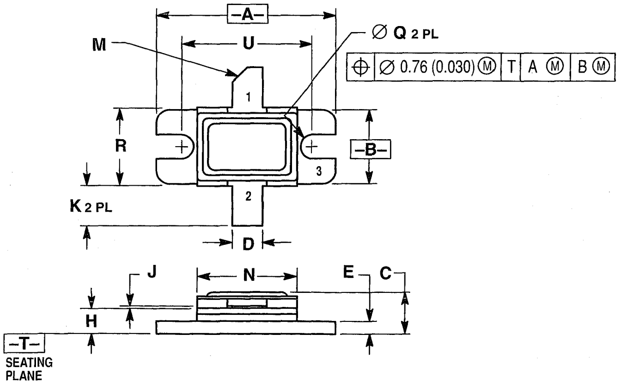


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.890	0.910	22.61	23.11
B	0.375	0.395	9.53	10.03
C	0.190	0.210	4.83	5.33
D	0.145	0.155	3.69	3.93
E	0.055	0.065	1.40	1.65
H	0.120	0.130	3.05	3.30
J	0.003	0.006	0.08	0.15
K	0.185	0.215	4.70	5.46
M	45°REF		45°REF	
N	0.490	0.510	12.45	12.95
Q	0.115	0.125	2.93	3.17
R	0.395	0.405	10.04	10.28
U	0.700 BSC		17.78 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 355E–01
ISSUE B



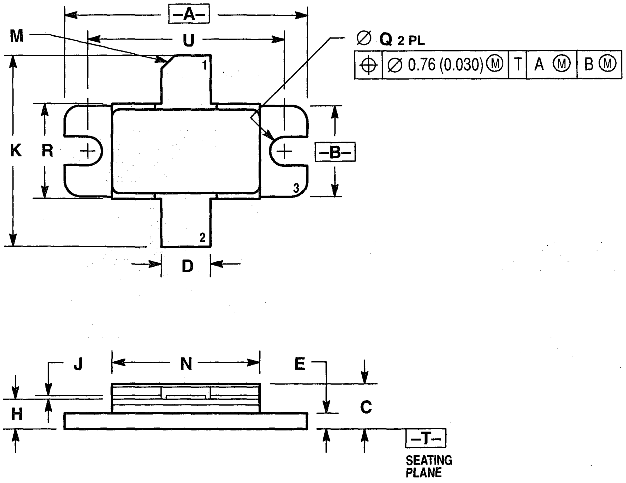
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.890	0.910	22.61	23.11
B	0.375	0.395	9.53	10.03
C	0.190	0.210	4.83	5.33
D	0.145	0.155	3.69	3.93
E	0.055	0.065	1.40	1.65
H	0.120	0.130	3.05	3.30
J	0.003	0.006	0.08	0.15
K	0.185	0.215	4.70	5.46
M	45°REF		45°REF	
N	0.490	0.510	12.45	12.95
Q	0.115	0.125	2.93	3.17
R	0.395	0.405	10.04	10.28
U	0.650 BSC		16.51 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 355G–01
ISSUE A

CASE DIMENSIONS (continued)

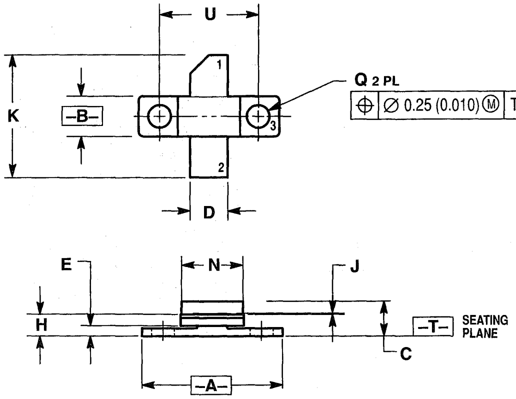


NOTES:
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
5. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.990	1.010	25.15	25.65
B	0.375	0.395	9.53	10.03
C	0.150	0.165	3.81	4.19
D	0.195	0.205	4.95	5.21
E	0.055	0.065	1.40	1.65
H	0.120	0.130	3.05	3.30
J	0.003	0.006	0.08	0.15
K	0.780	0.820	19.81	20.83
M	45° REF		45° REF	
N	0.590	0.610	14.99	15.49
Q	0.115	0.125	2.92	3.18
R	0.395	0.405	10.03	10.29
U	0.800 BSC		20.32 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 355H–01
ISSUE A



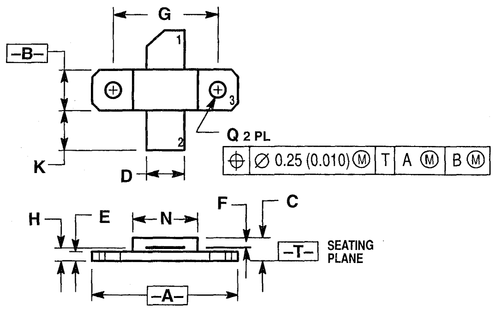
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.795	0.805	20.19	20.45
B	0.225	0.235	5.71	5.97
C	0.184	0.216	4.67	5.49
D	0.210	0.220	5.33	5.59
E	0.055	0.065	1.40	1.65
H	0.115	0.135	2.92	3.43
J	0.004	0.006	0.10	0.15
K	0.670	0.730	17.02	18.54
N	0.345	0.355	8.76	9.02
Q	0.125	0.135	3.18	3.43
U	0.560 BSC		14.22 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 360A–01
ISSUE A

CASE DIMENSIONS (continued)

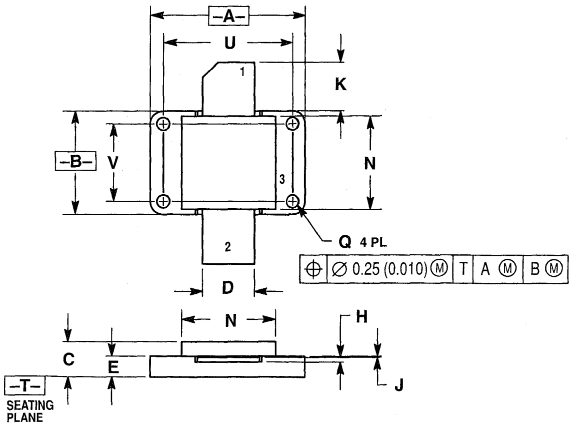


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.790	0.810	20.07	20.57
B	0.220	0.240	5.59	6.09
C	0.125	0.175	3.18	4.45
D	0.205	0.225	5.21	5.71
E	0.050	0.070	1.27	1.77
F	0.004	0.006	0.11	0.15
G	0.562 BSC		14.27 BSC	
H	0.070	0.090	1.78	2.29
K	0.215	0.255	5.47	6.47
N	0.350	0.370	8.89	9.39
Q	0.120	0.140	3.05	3.55

STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 360B–01
ISSUE O



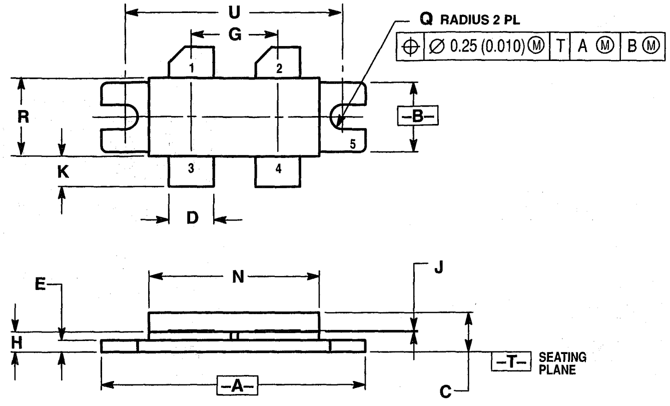
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.490	1.510	37.85	38.35
B	0.990	1.010	25.15	25.65
C	0.330	0.365	8.38	9.27
D	0.490	0.510	12.45	12.95
E	0.195	0.205	4.95	5.21
H	0.045	0.055	1.14	1.39
J	0.004	0.006	0.10	0.15
K	0.425	0.500	10.80	12.70
N	0.890	0.910	22.87	23.11
Q	0.120	0.130	3.05	3.30
U	1.250 BSC		31.75 BSC	
V	0.750 BSC		19.05 BSC	

STYLE 2:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 368–03
ISSUE C
(HOG PAC)

CASE DIMENSIONS (continued)

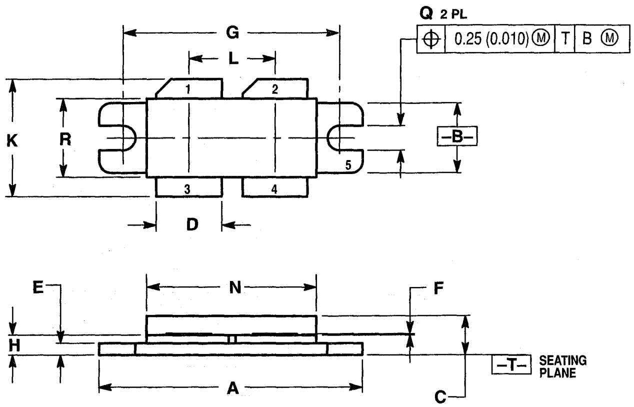


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.330	1.350	33.79	34.29
B	0.370	0.410	9.40	10.41
C	0.190	0.230	4.83	5.84
D	0.215	0.235	5.47	5.96
E	0.050	0.070	1.27	1.77
G	0.430	0.440	10.92	11.18
H	0.102	0.112	2.59	2.84
J	0.004	0.006	0.11	0.15
K	0.185	0.215	4.83	5.33
N	0.845	0.875	21.46	22.23
Q	0.060	0.070	1.52	1.78
R	0.390	0.410	9.91	10.41
U	1.100 BSC		27.94 BSC	

STYLE 2:
PIN 1. DRAIN
2. DRAIN
3. GATE
4. GATE
5. SOURCE

CASE 375–04
ISSUE D



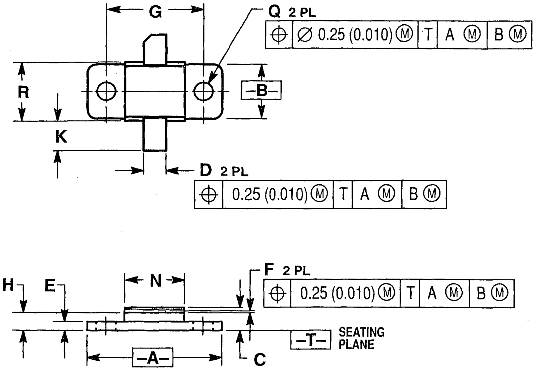
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.330	1.350	33.79	34.29
B	0.375	0.395	9.52	10.03
C	0.180	0.205	4.57	5.21
D	0.320	0.340	8.13	8.64
E	0.060	0.070	1.52	1.77
F	0.004	0.006	0.11	0.15
G	1.100 BSC		27.94 BSC	
H	0.082	0.097	2.08	2.46
K	0.580	0.620	14.73	15.75
L	0.435 BSC		11.05 BSC	
N	0.845	0.875	21.46	22.23
Q	0.118	0.130	3.00	3.30
R	0.390	0.410	9.91	10.41

STYLE 1:
PIN 1. COLLECTOR
2. COLLECTOR
3. BASE
4. BASE
5. EMITTER

CASE 375A–01
ISSUE O

CASE DIMENSIONS (continued)

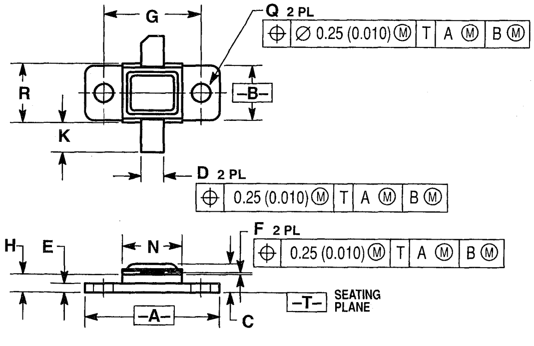


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.890	0.910	22.61	23.11
B	0.370	0.400	9.40	10.16
C	0.145	0.160	3.69	4.06
D	0.140	0.160	3.56	4.06
E	0.055	0.065	1.40	1.65
F	0.003	0.006	0.08	0.15
G	0.650 BSC		16.51 BSC	
H	0.110	0.130	2.80	3.30
K	0.180	0.220	4.57	5.59
N	0.390	0.410	9.91	10.41
Q	0.115	0.135	2.93	3.42
R	0.390	0.140	9.91	10.41

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 376B–02
ISSUE B



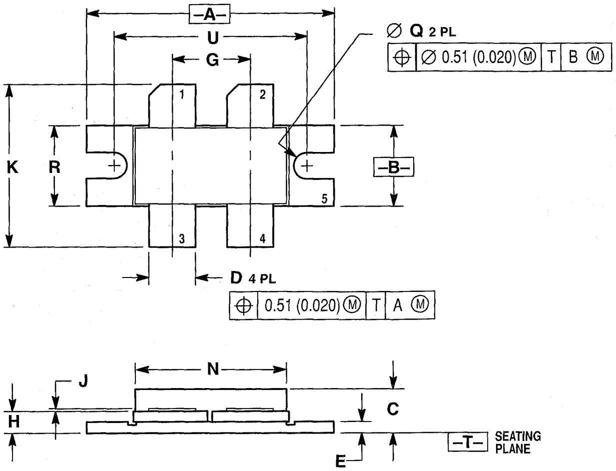
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.890	0.910	22.61	23.11
B	0.370	0.400	9.40	10.16
C	0.190	0.210	4.83	5.33
D	0.140	0.160	3.56	4.06
E	0.055	0.065	1.40	1.65
F	0.003	0.006	0.08	0.15
G	0.650 BSC		16.51 BSC	
H	0.110	0.130	2.80	3.30
K	0.180	0.220	4.57	5.59
N	0.390	0.410	9.91	10.41
Q	0.115	0.135	2.93	3.42
R	0.390	0.140	9.91	10.41

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE

CASE 376C–01
ISSUE O

CASE DIMENSIONS (continued)

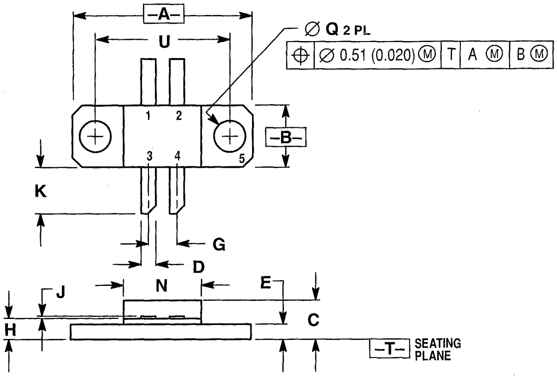


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.190	1.210	30.23	30.73
B	0.375	0.400	9.53	10.16
C	0.190	0.230	4.83	5.84
D	0.215	0.235	5.46	5.96
E	0.050	0.070	1.27	1.77
G	0.385 BSC		9.78 BSC	
H	0.090	0.115	2.29	2.92
J	0.002	0.005	0.06	0.12
K	0.770	0.780	19.56	21.08
N	0.750	0.780	19.05	19.81
Q	0.106	0.148	2.70	3.75
R	0.375	0.395	9.53	10.03
U	0.935 BSC		23.75 BSC	

STYLE 1:
PIN 1. DRAIN
2. DRAIN
3. GATE
4. GATE
5. SOURCE

CASE 390B–01
ISSUE O



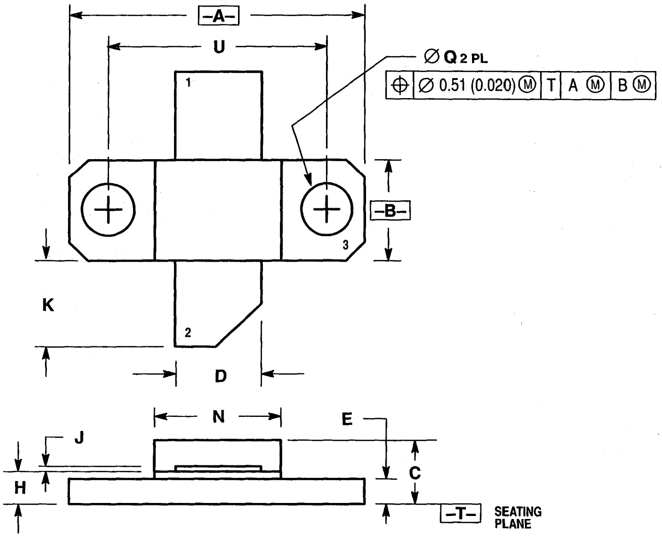
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.739	0.750	18.77	19.05
B	0.240	0.260	6.10	6.60
C	0.165	0.198	4.19	5.03
D	0.055	0.065	1.40	1.65
E	0.055	0.070	1.40	1.78
G	0.110	0.130	2.79	3.30
H	0.079	0.091	2.01	2.31
J	0.003	0.005	0.08	0.13
K	0.180	0.220	4.57	5.59
N	0.315	0.330	8.00	8.38
Q	0.125	0.135	3.18	3.42
U	0.560 BSC		14.22 BSC	

STYLE 1:
PIN 1. BASE
2. BASE
3. COLLECTOR
4. COLLECTOR
5. EMITTER

CASE 395B–01
ISSUE A

CASE DIMENSIONS (continued)



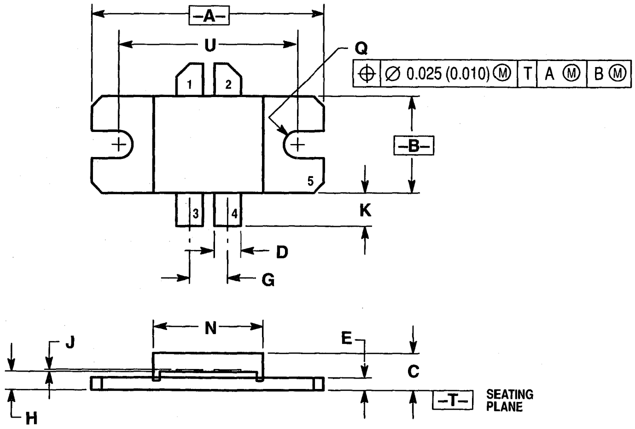
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.739	0.750	18.77	19.05
B	0.240	0.260	6.10	6.60
C	0.165	0.198	4.19	5.03
D	0.215	0.225	5.46	5.72
E	0.055	0.070	1.40	1.78
H	0.079	0.091	2.01	2.31
J	0.004	0.006	0.10	0.15
K	0.210	0.240	5.33	6.10
N	0.315	0.330	8.00	8.38
Q	0.125	0.135	3.18	3.42
U	0.560 BSC		14.23 BSC	

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

CASE 395C–01
ISSUE A



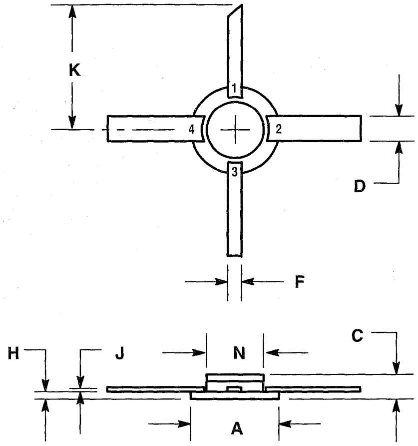
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.094	1.110	27.79	28.19
B	0.457	0.465	11.61	11.81
C	0.165	0.182	4.25	4.62
D	0.121	0.131	3.08	3.32
E	0.055	0.065	1.40	1.65
G	0.177	0.185	4.50	4.69
H	0.081	0.091	2.06	2.31
J	0.002	0.004	0.06	0.10
K	0.142	0.163	3.60	4.14
N	0.510	0.520	12.95	13.21
Q	0.125	0.135	3.18	3.42
U	0.844 BSC		21.44 BSC	

STYLE 1:
PIN 1. COLLECTOR
2. COLLECTOR
3. BASE
4. BASE
5. EMITTER

CASE 398–03
ISSUE C

CASE DIMENSIONS (continued)

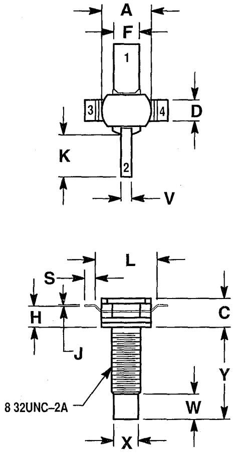


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.203	0.207	5.16	5.25
C	0.049	0.065	1.25	1.65
D	0.055	0.065	1.40	1.65
F	0.025	0.035	0.64	0.88
H	0.017	0.023	0.44	0.58
J	0.002	0.004	0.06	0.10
K	0.280	0.320	7.12	8.12
N	0.123	0.133	3.13	3.37

STYLE 1:
PIN 1. COLLECTOR
2. EMITTER
3. BASE
4. EMITTER

CASE 400–01
ISSUE B

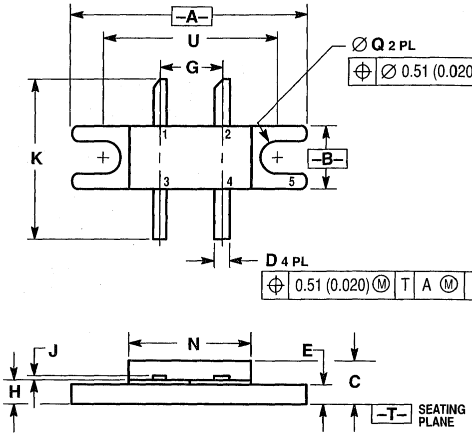


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.225	0.240	5.72	6.09
C	—	0.175	—	4.44
D	0.095	0.105	2.42	2.66
F	0.115	0.125	2.93	3.17
H	0.115	0.135	2.93	3.42
J	0.003	0.007	0.08	0.17
K	0.200	—	5.08	—
L	0.280	0.300	7.12	7.62
S	0.050	—	1.27	—
V	0.045	0.055	1.15	1.39
W	0.115	0.145	2.92	3.68
X	0.110	0.120	2.80	3.04
Y	0.420	0.460	10.67	11.68

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. EMITTER

CASE 401–02
ISSUE C

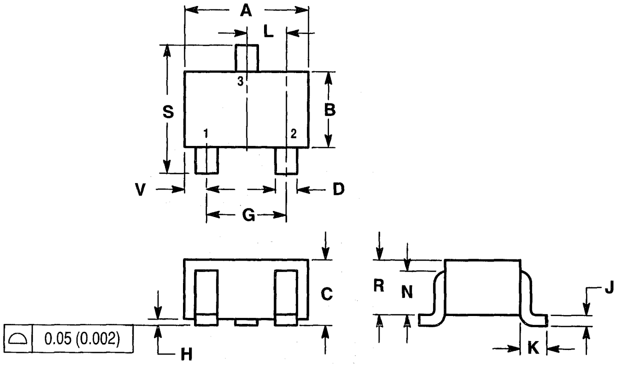


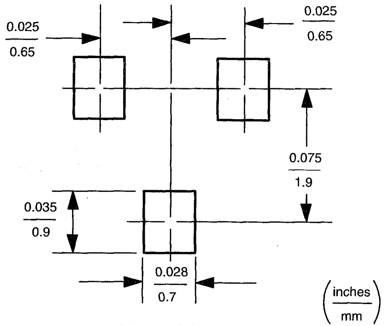
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.965	0.985	24.52	25.01
B	0.245	0.265	6.23	6.73
C	0.165	0.185	4.20	4.69
D	0.050	0.070	1.27	1.77
E	0.070	0.080	1.78	2.03
G	0.254 BSC		6.45 BSC	
H	0.095	0.105	2.42	2.66
J	0.003	0.006	0.08	0.15
K	0.625	0.675	15.88	17.14
N	0.495	0.520	12.58	13.20
Q	0.120	0.140	3.05	3.55
U	0.725 BSC		18.42 BSC	

STYLE 1:
PIN 1. DRAIN
2. DRAIN
3. GATE
4. GATE
5. SOURCE

CASE 412–01
ISSUE O





SC–70/SOT–323
FOOTPRINT

STYLE 3:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

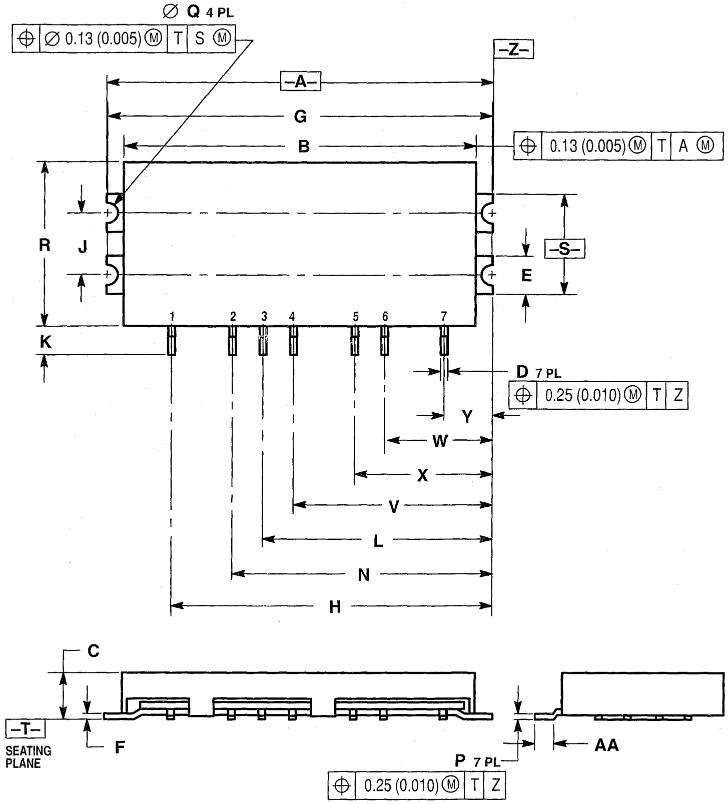
STYLE 6:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.035	0.049	0.90	1.25
D	0.012	0.016	0.30	0.40
G	0.047	0.055	1.20	1.40
H	0.000	0.004	0.00	0.10
J	0.004	0.010	0.10	0.25
K	0.017 REF		0.425 REF	
L	0.026 BSC		0.650 BSC	
N	0.028 REF		0.700 REF	
R	0.031	0.039	0.80	1.00
S	0.079	0.087	2.00	2.20
V	0.012	0.016	0.30	0.40

CASE 419–02
ISSUE G

CASE DIMENSIONS (continued)



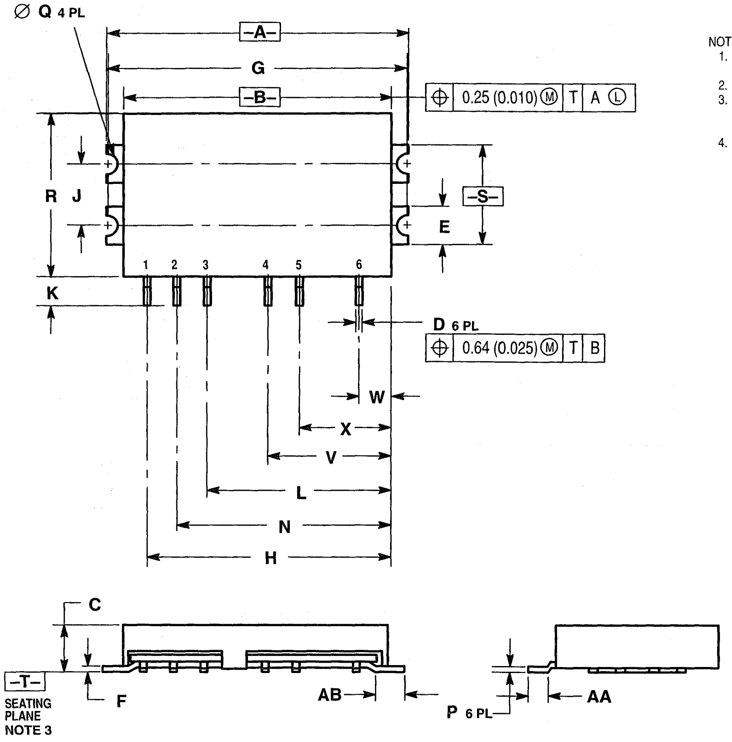
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	31.74	32.00	1.250	1.260
B	28.80	29.20	1.134	1.150
C	3.64	4.00	0.143	0.157
D	0.46	0.55	0.018	0.022
E	2.80	3.20	0.110	0.126
F	0.17	0.43	0.007	0.017
G	31.50 BSC		1.248 BSC	
H	26.50 BSC		1.043 BSC	
J	5.00 BSC		0.197 BSC	
K	2.20	2.48	0.087	0.097
L	19.08 BSC		0.748 BSC	
N	21.50 BSC		0.846 BSC	
P	0.21	0.30	0.008	0.012
Q	1.37	1.63	0.054	0.064
R	13.17	13.43	0.519	0.529
S	7.80	8.20	0.307	0.323
V	16.50 BSC		0.650 BSC	
W	9.00 BSC		0.354 BSC	
X	11.50 BSC		0.453 BSC	
Y	4.00 BSC		0.157 BSC	
AA	1.37	1.63	0.054	0.064

STYLE 1:
PIN 1. P IN
2. VDD1
3. VGG2
4. VDD2
5. VGG3
6. VDD3
7. P OUT

CASE 420–01
ISSUE B

CASE DIMENSIONS (continued)



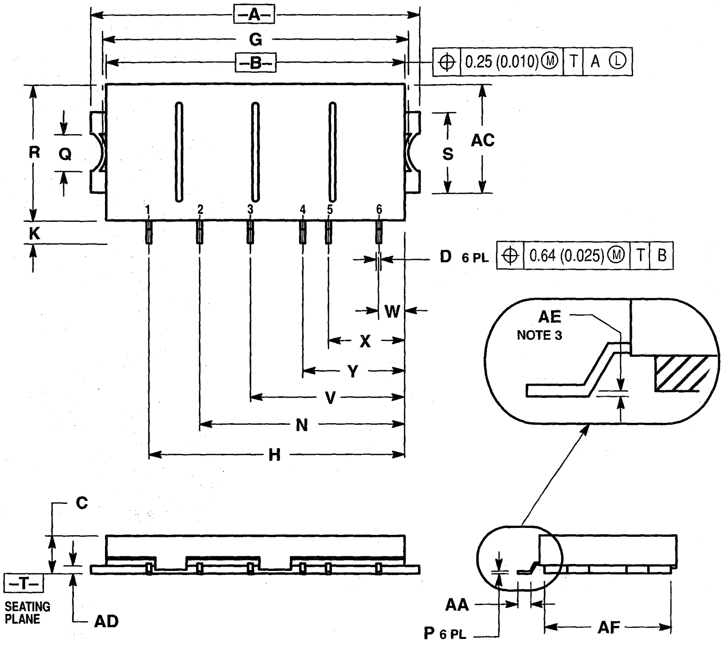
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. THE BOTTOM OF THE DEVICE LEADS MUST BE COMPLANAR WITH THE REFERENCE PLANE –T– TO +0.051/–0.076 (+0.002/–0.003).
4. REF INDICATES NON–CONTROLLED DIMENSION FOR REFERENCE USE ONLY.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	24.74	25.00	0.974	0.984
B	21.89	22.20	0.862	0.874
C	3.63	4.00	0.143	0.157
D	0.43	0.58	0.017	0.023
E	3.00 REF		0.118 REF	
F	0.30 REF		0.012 REF	
G	24.59 REF		0.968 REF	
H	20.10 BSC		0.791 BSC	
J	5.00 REF		0.197 REF	
K	2.11	2.62	0.083	0.103
L	15.10 BSC		0.594 BSC	
N	17.60 BSC		0.693 BSC	
P	0.25 REF		0.010 REF	
Q	1.52 REF		0.060 REF	
R	13.16	13.46	0.518	5.30
S	8.00 REF		0.315 REF	
V	10.10 BSC		0.398 BSC	
W	2.60 BSC		0.102 BSC	
X	7.60 BSC		0.299 BSC	
AA	1.35	1.70	0.053	0.067
AB	2.50 REF		0.100 REF	

STYLE 1:
PIN 1. P IN
2. VGG1
3. VDD1
4. VGG2
5. VDD2
6. P OUT

CASE 420A–02
ISSUE B

CASE DIMENSIONS (continued)



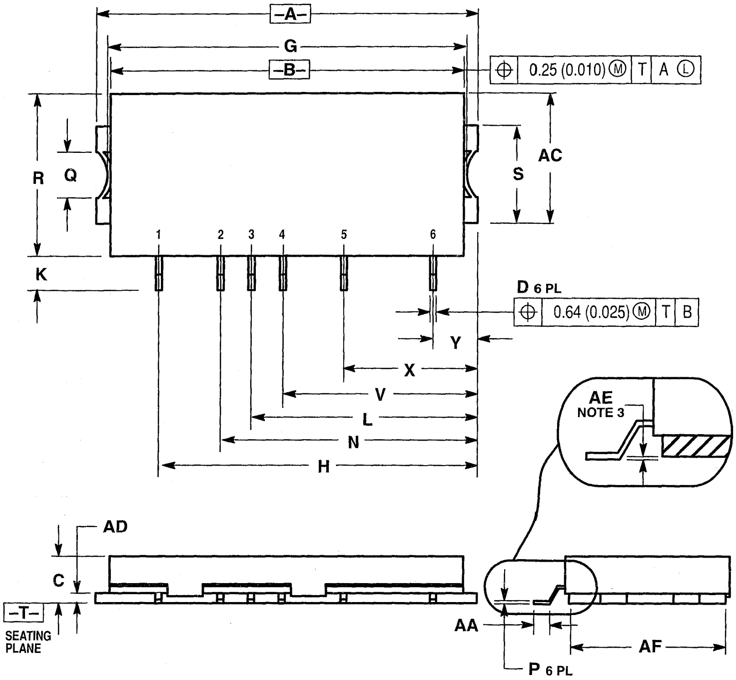
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION AE (PACKAGE COPLANARITY): THE BOTTOM OF THE DEVICE LEADS AND THE REFERENCE PLANE –T– MUST BE COPLANAR WITHIN DIMENSION AE.
4. REF INDICATES NON–CONTROLLED DIMENSION FOR REFERENCE USE ONLY.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	31.75	32.05	1.250	1.262
B	28.85	29.10	1.136	1.146
C	3.70	4.00	0.146	0.157
D	0.43	0.58	0.017	0.023
G	29.60 REF		1.165 REF	
H	25.03 BSC		0.985 BSC	
K	2.10	2.62	0.083	0.103
N	20.03 BSC		0.789 BSC	
P	0.25 REF		0.010 REF	
Q	3.78 REF		0.149 REF	
R	13.15	13.45	0.518	0.530
S	8.00 REF		0.315 REF	
V	15.03 BSC		0.595 BSC	
W	2.53 BSC		0.100 BSC	
X	7.53 BSC		0.297 BSC	
Y	10.03 BSC		0.395 BSC	
AA	1.35	1.70	0.053	0.067
AC	10.50 REF		0.413 REF	
AD	0.81 REF		0.032 REF	
AE	+0.050	–0.076	+0.002	–0.003
AF	12.80 REF		0.504 REF	

STYLE 1:
PIN 1. RF INPUT POWER /V_{CONT}
2. VDD1
3. V_{BIAS}
4. VDD2
5. VDD3
6. RF OUTPUT
CASE: GROUND

CASE 420L–03
ISSUE C

CASE DIMENSIONS (continued)



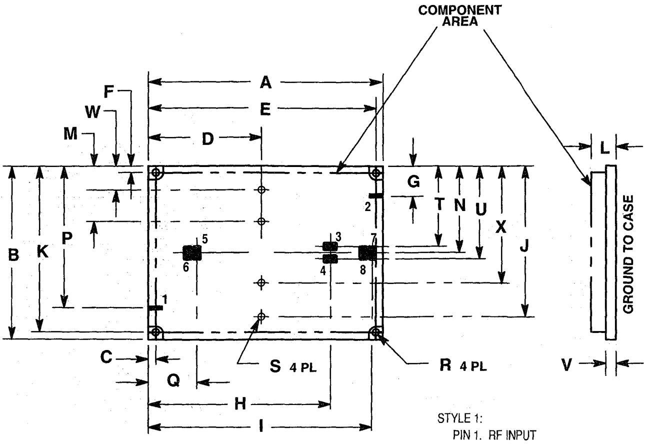
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION AE (PACKAGE COPLANARITY):THE BOTTOM OF THE DEVICE LEADS AND THE REFERENCE PLANE –T– MUST BE COPLANAR WITHIN THE DIMENSION AE.
4. REF INDICATES NON–CONTROLLED DIMENSION FOR REFERENCE USE ONLY.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	31.75	32.05	1.250	1.262
B	28.85	29.10	1.136	1.146
C	3.70	4.00	0.146	0.157
D	0.43	0.58	0.017	0.023
G	29.6 REF		1.165 REF	
H	25.03 BSC		0.985 BSC	
K	2.10	2.62	0.083	0.103
L	17.53 BSC		0.690 BSC	
N	20.03 BSC		0.789 BSC	
P	0.25 REF		0.010 REF	
Q	3.78 REF		0.149 REF	
R	13.15	13.45	0.518	0.530
S	8.00 REF		0.315 REF	
V	15.03 BSC		0.592 BSC	
X	10.03 BSC		0.395 BSC	
Y	2.53 BSC		0.100 BSC	
AA	1.35	1.70	0.053	0.067
AC	10.50 REF		0.413 REF	
AD	0.81 REF		0.032 REF	
AE	+0.050	–0.076	+0.002	–0.003
AF	12.80 REF		0.504 REF	

STYLE 1:
PIN 1. P IN
2. VCC1
3. VBIAS
4. VCC2
5. VCC3
6. P OUT

CASE 420U–02
ISSUE A

CASE DIMENSIONS (continued)

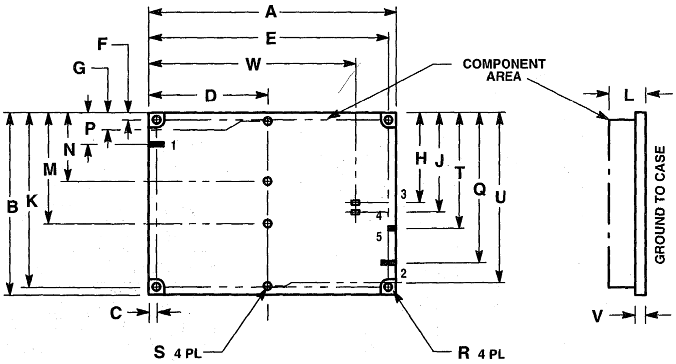


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	114.88	115.12	4.523	4.532
B	84.88	85.12	3.342	3.351
C	3.40	3.60	0.134	0.142
D	54.70	54.90	2.154	2.161
E	111.40	111.60	4.386	4.394
F	3.40	3.60	0.134	0.142
G	14.60	15.40	0.575	0.606
H	88.70	89.50	3.492	3.524
I	109.50	110.30	4.311	4.343
J	74.00	74.20	2.913	2.921
K	81.40	81.60	3.205	3.213
L	—	12.00	—	0.472
M	25.00	25.20	0.984	0.992
N	42.40	42.60	1.669	1.677
P	69.60	70.40	2.740	2.772
Q	23.00	23.80	0.906	0.937
R	3.40	3.70	0.134	0.146
S	3.18	3.42	0.125	0.135
T	39.10	39.90	1.539	1.571
U	45.10	45.90	1.776	1.807
V	4.50	4.90	0.177	0.193
W	10.80	11.00	0.425	0.433
X	59.80	60.00	2.354	2.362

STYLE 1:
PIN 1. RF INPUT
2. RF OUTPUT
3. $+V_{CC}1$ – (GROUND TO CASE)
4. $+V_{CC}2$ – (GROUND TO CASE)
5. BIAS REMOTE
6. GROUND (BIAS REMOTE ONLY)
7. RF DETECTION
8. GROUND (RF DETECTION ONLY)

CASE 429A–02
ISSUE A



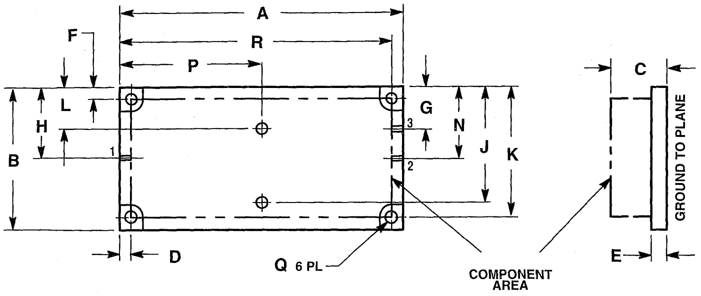
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	114.88	115.12	4.523	4.532
B	84.88	85.12	3.342	3.351
C	3.40	3.60	0.134	0.142
D	54.70	54.90	2.154	2.161
E	111.40	111.60	4.386	4.394
F	3.40	3.60	0.134	0.142
G	4.00	4.20	0.157	0.165
H	39.90	40.70	1.571	1.602
J	44.30	45.10	1.744	1.776
K	81.40	81.60	3.205	3.213
L	—	17.00	—	0.669
M	51.80	52.00	2.039	2.047
N	33.00	33.20	1.229	1.307
P	14.60	15.40	0.575	0.606
Q	69.60	70.40	2.740	2.772
R	3.40	3.70	0.134	0.146
S	3.00	3.30	0.118	0.130
T	53.50	54.30	2.106	2.138
U	80.80	81.00	3.181	3.189
V	4.50	4.90	0.177	0.193
W	95.80	96.60	3.772	3.803

STYLE 1:
PIN 1. RF INPUT
2. RF OUTPUT
3. $+V_{CC}1$
4. $+V_{CC}2$
5. RF DETECTION GROUND TO CASE

CASE 429C–03
ISSUE B

CASE DIMENSIONS (continued)

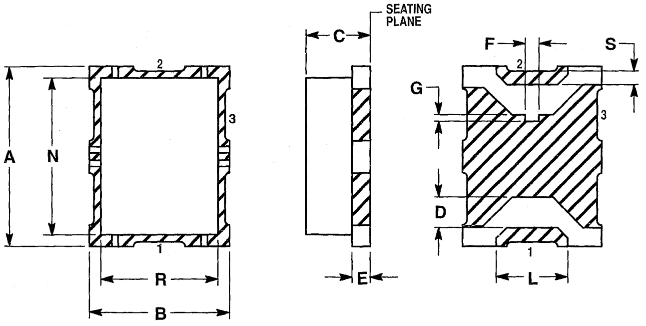


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	3.342	3.351	84.88	85.12
B	1.669	1.678	42.38	42.62
C	—	0.669	—	17.00
D	0.124	0.132	3.15	3.35
E	0.177	0.193	4.50	4.90
F	0.124	0.132	3.15	3.35
G	0.476	0.508	12.10	12.90
H	0.909	0.941	23.10	23.90
J	1.354	1.362	34.40	34.60
K	1.541	1.549	39.15	39.35
L	0.488	0.496	12.40	12.60
N	0.909	0.941	23.10	23.90
P	1.569	1.577	39.85	40.05
Q	0.122	0.134	3.10	3.40
R	3.215	3.222	81.65	81.85

STYLE 1:
PIN 1. RF INPUT
2. RF OUTPUT
3. $+V_{CC}$
GROUND TO CASE

CASE 429E–01
ISSUE O



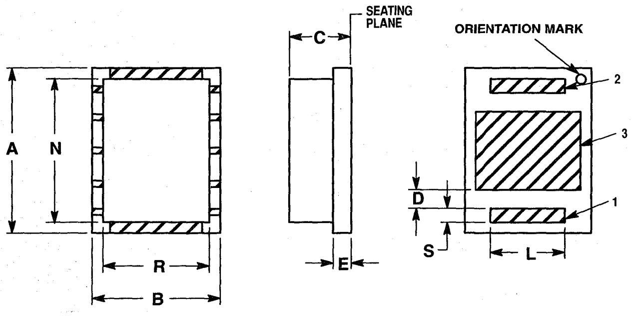
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.260	0.270	6.60	6.86
B	0.200	0.210	5.08	5.33
C	0.090	0.104	2.29	2.64
D	0.040	0.050	1.02	1.27
E	0.022	0.028	0.56	0.71
F	0.015	0.025	0.38	0.64
G	0.005	0.015	0.13	0.38
L	0.100	0.110	2.54	2.79
N	0.226	0.236	5.74	5.99
R	0.166	0.176	4.22	4.47
S	0.025	0.035	0.64	0.89

STYLE 2:
PIN 1. GATE
2. DRAIN
3. SOURCE

CASE 430–01
ISSUE O

CASE DIMENSIONS (continued)

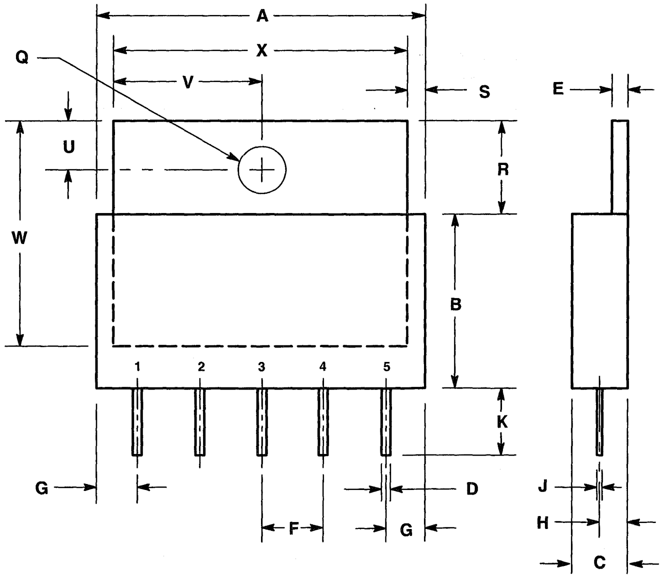


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	**MIN**	**MAX**	**MIN**	**MAX**
A	0.260	0.270	6.60	6.86
B	0.200	0.210	5.08	5.33
C	0.090	0.104	2.29	2.64
D	0.020	0.040	0.51	1.02
E	0.022	0.028	0.56	0.71
L	0.115	0.125	2.92	3.18
N	0.226	0.236	5.74	5.99
R	0.166	0.176	4.22	4.47
S	0.019	0.029	0.48	0.74

STYLE 1:
PIN 1. GATE
2. DRAIN
3. SOURCE

CASE 430B–01
ISSUE O



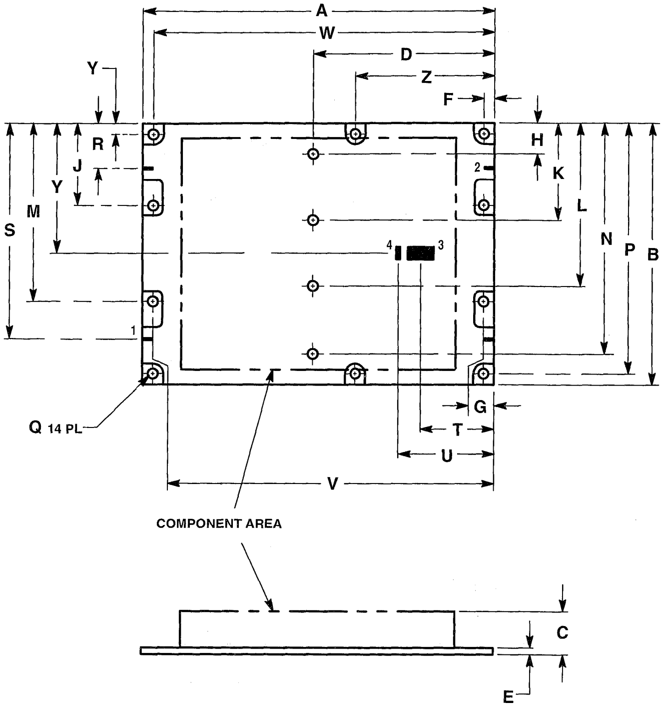
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH

	INCHES		MILLIMETERS	
DIM	**MIN**	**MAX**	**MIN**	**MAX**
A	1.055	1.065	26.80	27.05
B	0.550	0.565	13.97	14.35
C	0.175	0.185	4.45	4.70
D	0.020	—	0.51	—
E	0.045	0.055	1.14	1.40
F	0.195	0.205	4.95	5.21
G	0.125	0.135	3.18	3.43
H	0.080	0.090	2.03	2.29
J	0.010	—	0.25	—
K	0.215	0.225	5.46	5.72
Q	0.145	0.155	3.68	3.94
R	0.300	0.320	7.62	8.13
S	0.045	0.055	1.14	1.40
U	0.155	0.165	3.94	4.19
V	0.470	0.480	11.94	12.19
W	0.730	0.740	18.54	18.80
X	0.945	0.955	24.00	24.26

STYLE 1:
PIN 1. V_{in}
2. GROUND
3. $+V_{CC}$
4. GROUND
5. Vout

CASE 431A–02
ISSUE A

CASE DIMENSIONS (continued)



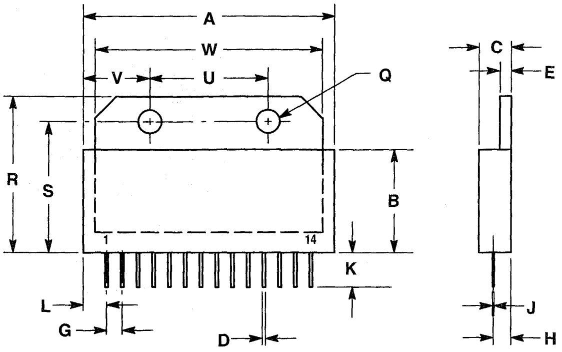
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	114.88	115.12	4.523	4.532
B	84.88	85.12	3.342	3.351
C	—	14.0	—	0.551
D	59.9	60.01	2.358	2.366
E	2.0	2.4	0.079	0.094
F	3.4	3.6	0.134	0.142
G	3.15	3.35	0.124	0.132
H	9.9	10.1	0.390	0.398
J	26.8	27.0	1.055	1.063
K	31.9	32.1	1.256	1.264
L	52.9	53.1	2.083	2.091
M	58.0	58.2	2.283	2.291
N	74.9	75.1	2.949	2.957
P	81.4	81.6	3.205	3.213
Q	3.1	3.4	0.122	0.134
R	14.6	15.4	0.575	0.606
S	69.6	70.4	2.740	2.772
T	24.0	24.8	0.945	0.976
U	31.6	32.4	1.244	1.276
V	111.65	111.85	4.396	4.404
W	111.4	111.6	4.386	4.394
X	3.4	3.6	0.134	0.142
Y	42.1	42.9	1.657	1.689
Z	45.9	46.1	1.807	1.815

STYLE 1:
PIN 1. RF INPUT
2. RF OUTPUT
3. DC VOLTAGE
4. CORRECTION
GROUND TO PLANE

CASE 439–01
ISSUE O

CASE DIMENSIONS (continued)

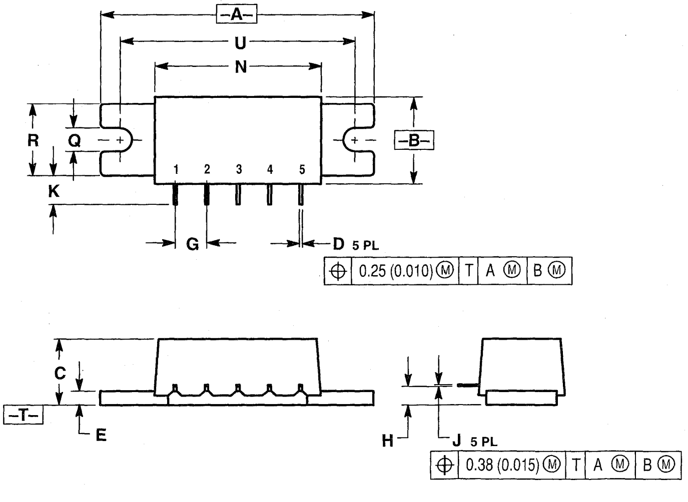


STYLE 1:
PIN 1. V_{IN}
2. $+V_{CC}$
3. GROUND
4. V_{OUT}
5. GROUND
6. V_{IN}
7. $+V_{CC}$
8. GROUND
9. V_{OUT}
10. GROUND
11. V_{IN}
12. $+V_{CC}$
13. GROUND
14. V_{OUT}

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	—	1.570	—	39.88
B	—	0.665	—	16.89
C	0.210	0.225	5.33	5.72
D	0.020	—	0.51	—
E	0.070	0.085	1.78	2.16
G	0.095	0.105	2.41	2.67
H	0.105	0.130	2.67	3.30
J	0.010	—	0.25	—
K	0.210	0.230	5.33	5.84
L	0.120	0.145	3.05	3.68
Q	0.140	0.155	3.56	3.94
R	0.995	1.015	25.27	25.78
S	0.835	0.855	21.21	21.72
U	0.745	0.755	18.92	19.18
V	0.385	0.415	9.78	10.54
W	1.440	1.455	36.58	36.96

CASE 445–02
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

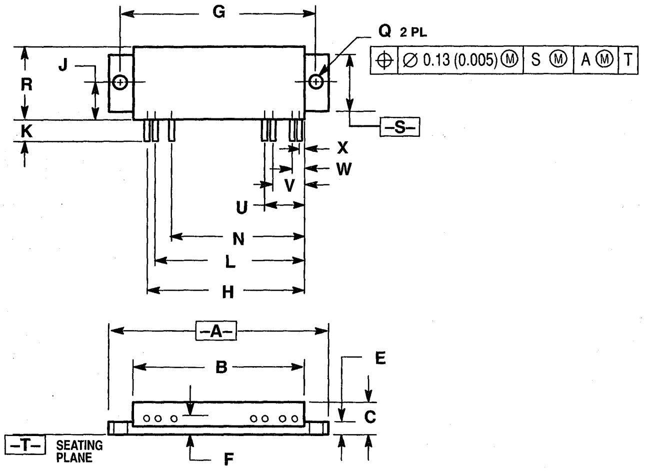
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.740	1.760	44.20	44.70
B	0.550	0.570	13.97	14.49
C	0.405	0.445	10.29	11.30
D	0.018	0.022	0.46	0.55
E	0.085	0.095	2.16	2.41
G	0.200 BSC		5.08 BSC	
H	0.120 BSC		3.05 BSC	
J	0.009	0.011	0.23	0.28
K	0.170	0.210	4.32	5.33
N	1.045	1.075	26.54	27.30
Q	0.145	0.155	3.68	3.94
R	0.455	0.465	11.56	11.81
U	1.490	1.510	37.85	38.35

STYLE 1:
PIN 1. RF INPUT
2. GROUND
3. RESISTOR–GROUND
4. VCC
5. RF OUTPUT

STYLE 2:
PIN 1. RF INPUT
2. GROUND
3. VCC1
4. VCC2
5. RF OUTPUT

CASE 448–01
ISSUE O

CASE DIMENSIONS (continued)

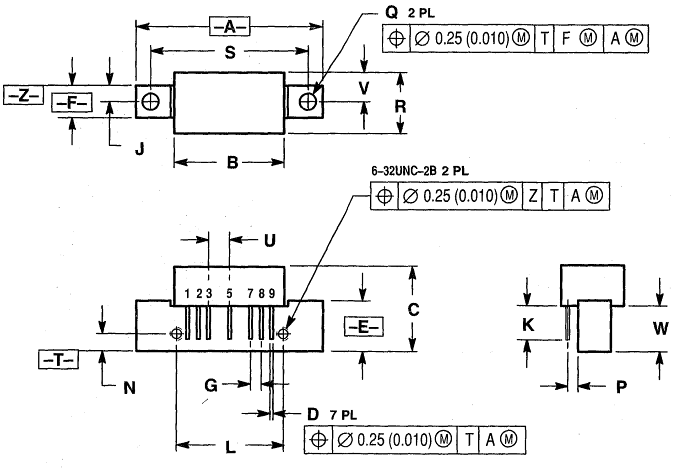


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	2.640	2.660	67.06	67.56
B	2.040	2.085	51.82	52.95
C	0.335	0.360	8.51	9.14
E	0.100	0.115	2.54	2.92
F	0.085	0.115	2.16	2.92
G	2.405 BSC		61.09 BSC	
H	1.885	1.915	47.88	48.64
J	0.400	0.440	10.16	11.18
K	0.230	0.300	5.85	7.62
L	1.785	1.815	45.34	46.10
N	1.585	1.615	40.26	41.02
Q	0.136	0.146	3.46	3.70
R	0.800	0.820	20.32	20.82
S	0.670	0.690	17.02	17.52
U	0.485	0.515	12.32	13.08
V	0.385	0.415	9.78	10.54
W	0.185	0.215	4.70	5.46
X	0.085	0.115	2.16	2.92

STYLE 2:
PIN 1. RF OUTPUT
2. GROUND
3. Vs 2
4. GROUND
5. Vs 1
6. GROUND
7. RF INPUT

CASE 700–04
ISSUE F



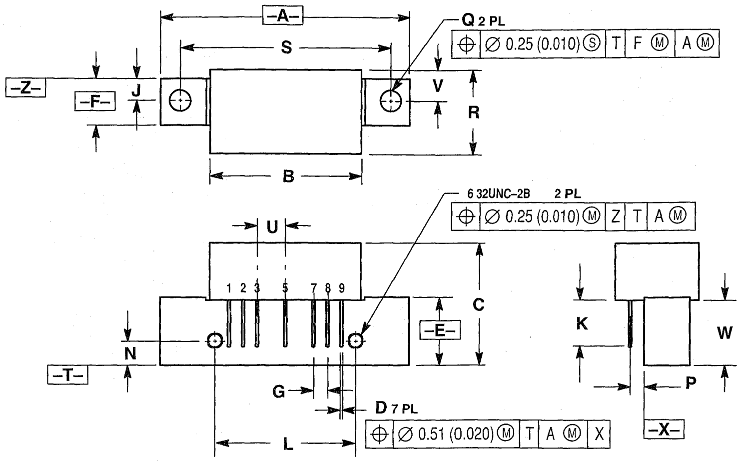
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.775	—	45.08
B	—	1.085	—	27.56
C	—	0.840	—	21.34
D	0.018	0.022	0.46	0.56
E	0.465	0.510	11.81	12.95
F	0.300	0.325	7.62	8.25
G	0.100 BSC		2.54 BSC	
J	0.156 BSC		3.96 BSC	
K	0.315	0.355	8.00	8.50
L	1.00 BSC		25.40 BSC	
N	0.165 BSC		4.10 BSC	
P	0.100 BSC		2.54 BSC	
Q	0.148	0.168	3.76	4.27
R	—	0.595	—	15.11
S	1.500 BSC		38.10 BSC	
U	0.200 BSC		5.08 BSC	
V	0.280 BSC		7.11 BSC	
W	0.435	0.450	11.05	11.43

STYLE 1:
PIN 1. RF INPUT
2. GROUND
3. GROUND
4. DELETED
5. VDC
6. DELETED
7. GROUND
8. GROUND
9. RF OUTPUT

CASE 714–06
ISSUE K

CASE DIMENSIONS (continued)

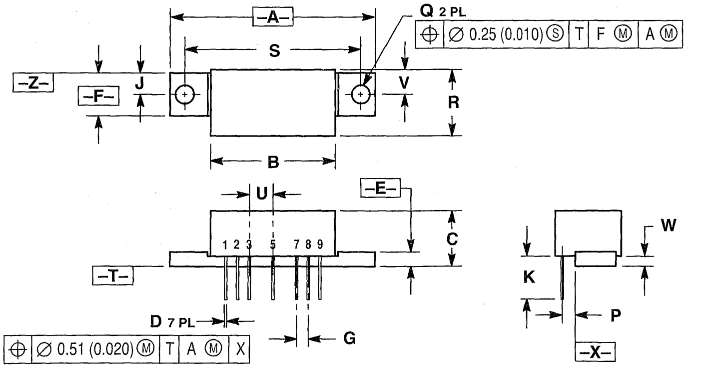


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.775	—	45.08
B	—	1.085	—	27.56
C	—	0.870	—	22.10
D	0.018	0.022	0.46	0.56
E	0.465	0.510	11.81	12.95
F	0.300	0.325	7.62	8.25
G	0.100 BSC		2.54 BSC	
J	0.156 BSC		3.96 BSC	
K	0.330	0.370	8.38	9.40
L	1.000 BSC		25.40 BSC	
N	0.165 BSC		4.19 BSC	
P	0.100 BSC		2.54 BSC	
Q	0.148	0.168	3.76	4.27
R	—	0.595	—	15.11
S	1.500 BSC		38.10 BSC	
U	0.200 BSC		5.08 BSC	
V	0.209	0.239	5.31	6.07
W	0.425	—	10.80	—

STYLE 1:
PIN 1. RF INPUT
2. GROUND
3. GROUND
5. $+V_{CC}$
7. GROUND
8. GROUND
9. RF OUTPUT

CASE 714F–03
ISSUE C



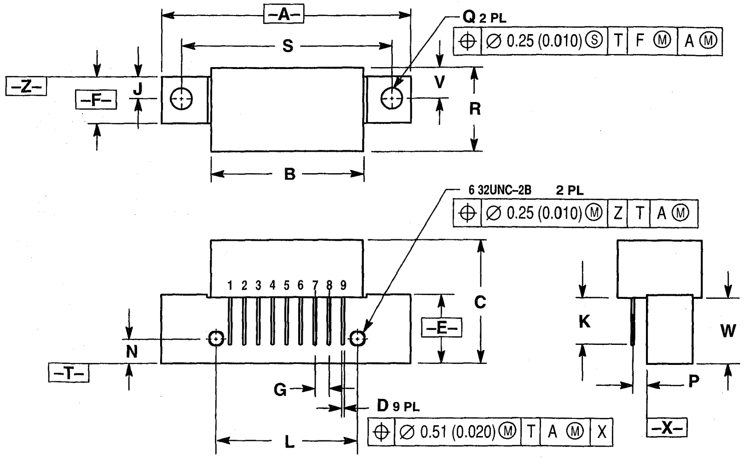
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.775	—	45.08
B	—	1.085	—	27.56
C	—	0.495	—	12.57
D	0.018	0.022	0.46	0.56
E	0.120	0.130	3.05	3.30
F	0.300	0.325	7.62	8.25
G	0.100 BSC		2.54 BSC	
J	0.156 BSC		3.96 BSC	
K	0.330	0.370	8.38	9.40
P	0.100 BSC		2.54 BSC	
Q	0.148	0.168	3.76	4.27
R	—	0.595	—	15.11
S	1.500 BSC		38.10 BSC	
U	0.200 BSC		5.08 BSC	
V	0.209	0.239	5.31	6.07
W	0.050	—	1.27	—

STYLE 1:
PIN 1. RF INPUT
2. GROUND
3. GROUND
5. +VCC
7. GROUND
8. GROUND
9. RF OUTPUT

CASE 714G–03
ISSUE D

CASE DIMENSIONS (continued)



NOTES:

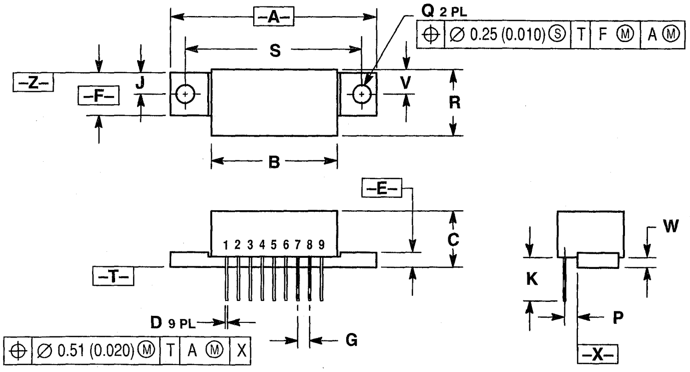
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.775	—	45.08
B	—	1.085	—	27.56
C	—	0.870	—	22.10
D	0.018	0.022	0.46	0.56
E	0.465	0.510	11.81	12.95
F	0.300	0.325	7.62	8.25
G	0.100 BSC		2.54 BSC	
J	0.156 BSC		3.96 BSC	
K	0.330	0.370	8.38	9.40
L	1.000 BSC		25.40 BSC	
N	0.165 BSC		4.19 BSC	
P	0.100 BSC		2.54 BSC	
Q	0.148	0.168	3.76	4.27
R	—	0.595	—	15.11
S	1.500 BSC		38.10 BSC	
V	0.209	0.239	5.31	6.07
W	0.425	—	10.80	—

STYLE 2:
PIN 1. RF INPUT
2. GROUND
3. GROUND
4. RESISTOR-GROUND
5. GROUND
6. GROUND
7. GROUND
8. V_{CC} 1
9. RF OUTPUT

STYLE 3:
PIN 1. RF INPUT
2. GROUND
3. GROUND
4. V_{CC} 1
5. GROUND
6. GROUND
7. GROUND
8. V_{CC} 2
9. RF OUTPUT

CASE 714P–03
ISSUE B



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

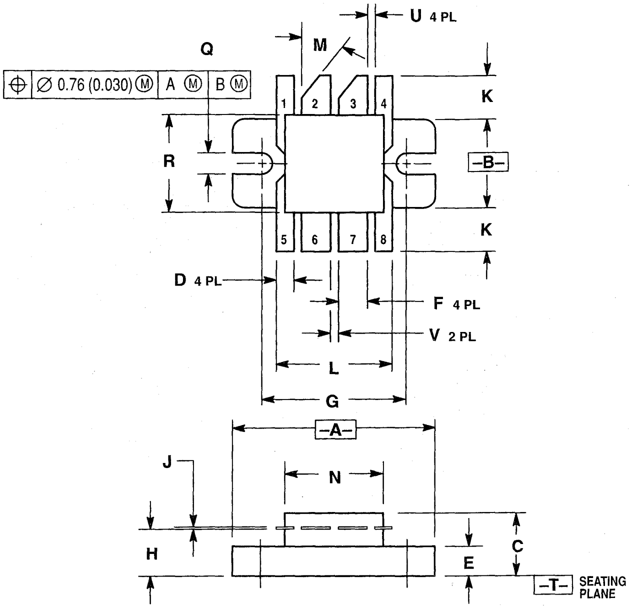
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.775	—	45.08
B	—	1.085	—	27.56
C	—	0.495	—	12.57
D	0.018	0.022	0.46	0.56
E	0.120	0.130	3.05	3.30
F	0.300	0.325	7.62	8.25
G	0.100 BSC		2.54 BSC	
J	0.156 BSC		3.96 BSC	
K	0.330	0.370	8.38	9.40
P	0.100 BSC		2.54 BSC	
Q	0.148	0.168	3.76	4.27
R	—	0.595	—	15.11
S	1.500 BSC		38.10 BSC	
V	0.209	0.239	5.31	6.07
W	0.050	—	1.27	—

STYLE 1:
PIN 1. RF INPUT
2. GROUND
3. GROUND
4. RESISTOR-GROUND
5. GROUND
6. GROUND
7. GROUND
8. V_{CC} 1
9. RF OUTPUT

STYLE 2:
PIN 1. RF INPUT
2. GROUND
3. GROUND
4. V_{CC} 1
5. GROUND
6. GROUND
7. GROUND
8. V_{CC} 2
9. RF OUTPUT

CASE 714T–03
ISSUE B

CASE DIMENSIONS (continued)



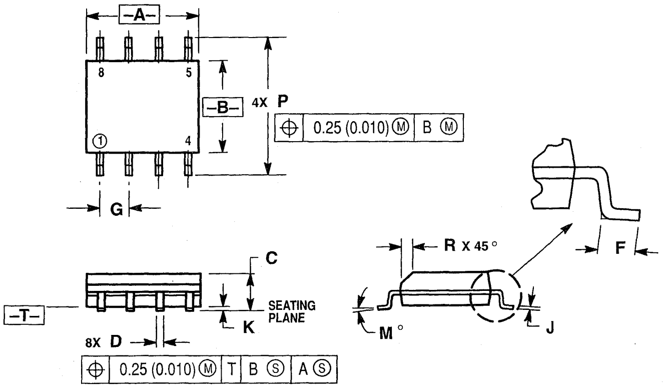
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

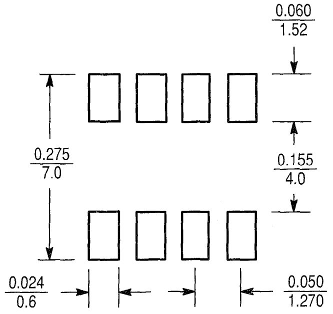
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	22.60	23.11	0.890	0.910
B	9.52	10.03	0.375	0.395
C	6.65	7.16	0.262	0.282
D	1.60	1.95	0.063	0.077
E	2.94	3.40	0.116	0.134
F	2.87	3.22	0.113	0.127
G	16.51 BSC		0.650 BSC	
H	4.01	4.36	0.158	0.172
J	0.07	0.15	0.003	0.006
K	4.34	4.90	0.171	0.193
L	12.45	12.95	0.490	0.510
M	45°NOM		45°NOM	
N	1.051	11.02	0.414	0.434
Q	3.04	3.35	0.120	0.132
R	9.90	10.41	0.390	0.410
U	1.02	1.27	0.040	0.050
V	0.64	0.89	0.025	0.035

STYLE 1:
PIN 1. EMITTER (COMMON)
2. COLLECTOR
3. COLLECTOR
4. EMITTER (COMMON)
5. EMITTER (COMMON)
6. BASE
7. BASE
8. EMITTER (COMMON)

STYLE 2:
PIN 1. SOURCE (COMMON)
2. DRAIN
3. DRAIN
4. SOURCE (COMMON)
5. SOURCE (COMMON)
6. GATE
7. GATE
8. SOURCE (COMMON)

CASE 744A–01
ISSUE C





SO–8 FOOTPRINT

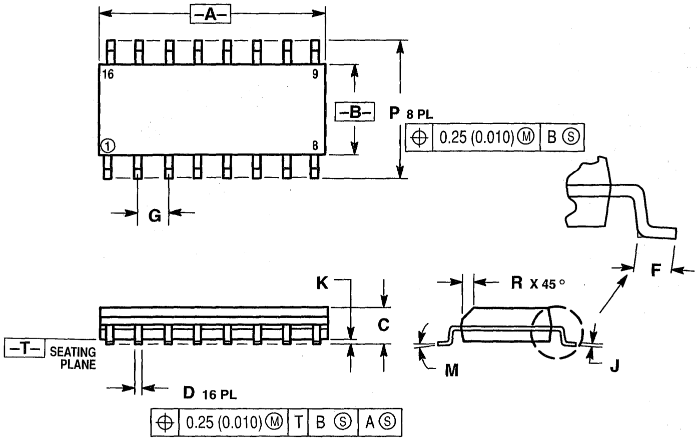
$\left(\frac{\text{inches}}{\text{mm}}\right)$

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. COLLECTOR
4. EMITTER
5. EMITTER
6. BASE
7. BASE
8. EMITTER

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.18	0.25	0.007	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

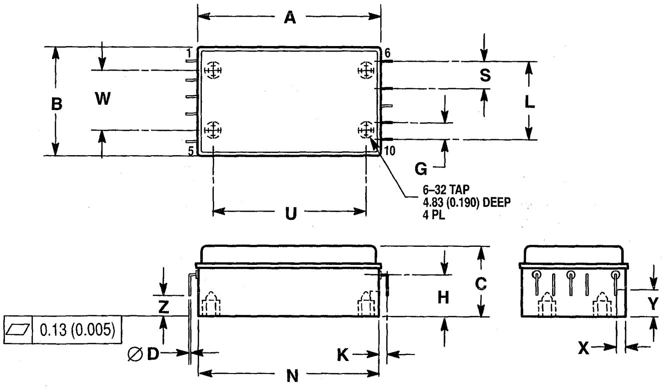
CASE 751–05
ISSUE N



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

CASE 751B–05
ISSUE J



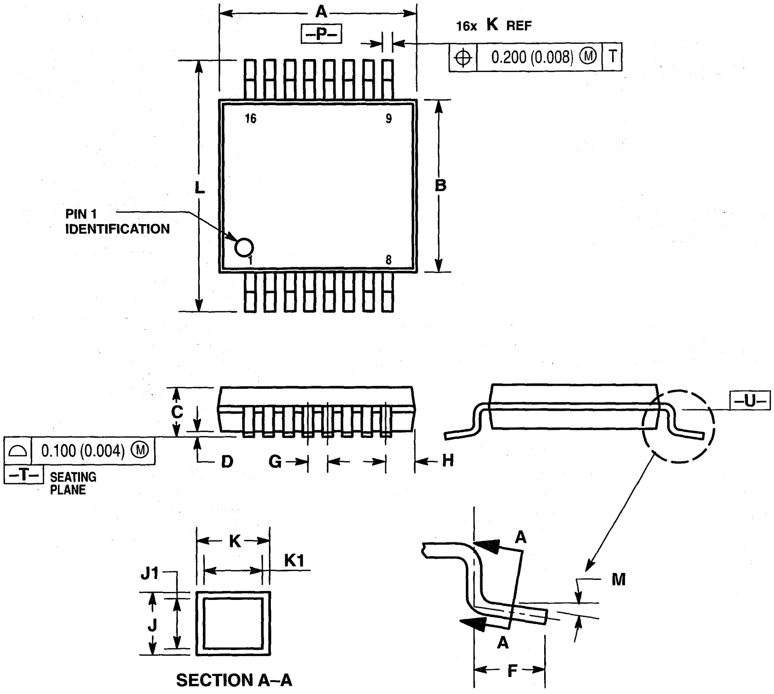
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	2.107	2.165	53.52	55.00
B	1.225	1.265	31.12	32.13
C	0.805	0.845	20.45	21.46
D	0.018	0.022	0.46	0.56
G	0.190	0.210	4.83	5.33
H	0.490	0.510	12.45	12.95
K	0.100	0.120	2.54	3.05
L	0.910	0.930	23.12	23.62
N	2.053	2.083	52.15	52.90
S	0.310	0.330	7.87	8.38
U	1.785	1.815	45.34	46.10
W	0.690	0.710	17.53	18.03
X	0.090	0.110	2.29	2.79
Y	0.290	0.310	7.37	7.87
Z	0.230	0.270	5.84	6.86

STYLE 2:
PIN 1. 24 V
2. GROUND
3. INPUT
4. GROUND
5. N/C
6. N/C
7. GROUND
8. OUTPUT
9. GROUND
10. 24 V

CASE 825A–03
ISSUE C

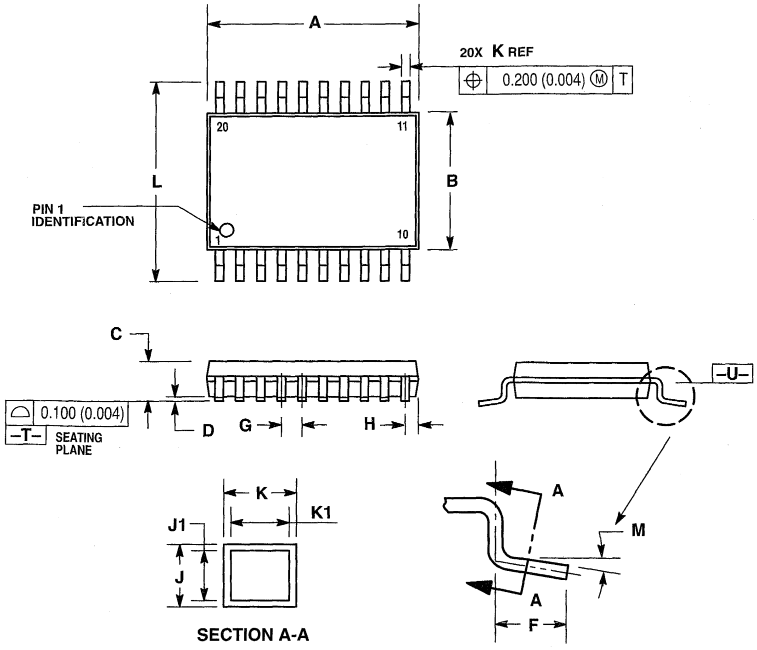
CASE DIMENSIONS (continued)



CASE 948C–03
ISSUE B
(TSSOP–16)

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSIONS A AND B ARE TO BE DETERMINED AT DATUM PLANE –U–.

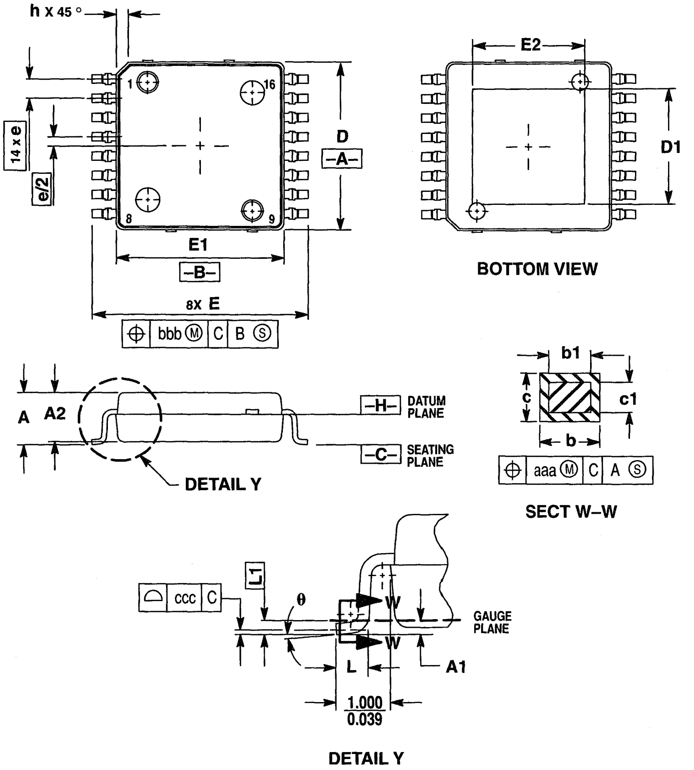
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	—	5.10	—	0.200
B	4.30	4.50	0.169	0.177
C	—	1.20	—	0047
D	0.05	0.25	0.002	0.010
F	0.45	0.55	0.018	0.022
G	0.65 BSC		0.026 BSC	
H	0.22	0.23	0.009	0.010
J	0.09	0.24	0.004	0.009
J1	0.09	0.18	0.004	0.007
K	0.16	0.32	0.006	0.013
K1	0.16	0.26	0.006	0.010
L	6.30	6.50	0.248	0.256
M	0°	10°	0°	10°



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
7. DIMENSIONS A AND B ARE TO BE DETERMINED AT DATUM PLANE –U–.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	—	6.60	—	0.260
B	4.30	4.50	0.169	0.177
C	—	1.20	—	0.047
D	0.05	0.25	0.002	0.010
F	0.45	0.55	0.018	0.022
G	0.65 BSC		0.026 BSC	
H	0.275	0.375	0.011	0.015
J	0.09	0.24	0.004	0.009
J1	0.09	0.18	0.004	0.007
K	0.16	0.32	0.006	0.013
K1	0.16	0.26	0.006	0.010
L	6.30	6.50	0.248	0.256
M	0°	10°	0°	10°

CASE 948D–03
ISSUE B
(TSSOP–20)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DATUM PLANE –H– IS LOCATED AT BOTTOM OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE BOTTOM OF THE PARTING LINE.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.250 (0.010) PER SIDE. DIMENSIONS D AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –H–.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION IS 0.127 (0.005) TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS –A– AND –B– TO BE DETERMINED AT DATUM PLANE –H–.

	MILLIMETERS		INCHES	
DIM	**MIN**	**MAX**	**MIN**	**MAX**
A	2.000	2.350	0.079	0.092
A1	0.050	0.200	0.002	0.008
A2	1.950	2.150	0.068	0.085
D	6.950	7.100	0.274	0.280
D1	4.372	5.180	0.172	0.204
E	8.850	9.150	0.348	0.360
E1	6.950	7.100	0.274	0.280
E2	4.372	5.180	0.172	0.204
L	0.466	0.720	0.018	0.028
L1	0.250 BSC		0.010 BSC	
b	0.300	0.432	0.012	0.017
b1	0.300	0.375	0.012	0.015
c	0.180	0.279	0.007	0.011
c1	0.180	0.230	0.007	0.009
e	0.800 BSC		0.032 BSC	
h	—	0.600	—	0.024
θ	0°	8°	0°	8°
aaa	0.200		0.008	
bbb	0.200		0.008	
ccc	0.100		0.004	

CASE 978–01
ISSUE O
(PFP–16)

Section Six

Cross Reference and Sales Offices

Index and Cross Reference

The Index and Cross Reference provides a listing of Motorola's closest replacement devices to industry standard devices. It is Motorola's intent to provide suitable replacement devices and to encourage the device user to investigate these alternatives.

Several guidelines are used to determine Motorola's closest replacement devices. For low power devices, guidelines are based on dc voltage ratings, cutoff frequency, current rating, junction capacitance, and noise figure. The high power guidelines are dc voltage ratings, output power, gain, frequency of operation and output capacitance.

New chip technologies and packaging requirements are constantly evolving to meet the explosive demands of the Communications market. Motorola's portfolio of RF devices reflects this growth and the changes in the Communications market.

Products listed with an asterisk are designated as "Not Recommended for New Design." These devices have become obsolete as dictated by poor market acceptance, or a technology or package that is reaching the end of its life cycle. Products "Not Recommended for New Design" have an uncertain future and do not represent a good selection for new device designs or long term usage.

Industry Part Number	Motorola Closest Replacement	Page No.
2N1491	MRF5812	2–542
2N2857	MMBR5179LT1	2–264
2N2876	MRF134	2–270
2N3296	MRF134	2–270
2N3375	MRF134	2–270
2N3478	MMBR5179LT1	2–264
2N3553	—	
2N3600	MMBR5179LT1	2–264
2N3632	MRF134	2–270
2N3733	MRF134	2–270
2N3818	MRF134	2–270
2N3839	MMBR5179LT1	2–264
2N3866*	MRF3866R2	2–265
2N3866A*	MRF3866R2	2–265
2N3880	MMBR5031LT1	2–263
2N3924	MRF5003	2–727
2N3925	MRF5003	2–727
2N3927	MRF2628	2–711
2N3948	MRF4427	2–723
2N3959	MRF9011LT1	2–209
2N3961	MRF134	2–270
2N4012	MRF134	2–270
2N4040	MRF321	2–467
2N4072	MRF5003	2–727
2N4073	MRF4427	2–723
2N4130	—	
2N4427*	MRF4427	2–723
2N4428	—	
2N4932	MRF2628	2–711
2N4957	—	
2N4958	—	
2N4959	—	
2N5016	MRF323	2–471
2N5031*	MMBR5031LT1	2–263
2N5032	MMBR5031LT1	2–263
2N5070	MRF426	2–505
2N5108	—	
2N5109*	MRF5943	2–766
2N5160	—	
2N5179*	MMBR5179LT1	2–264
2N5180	MMBR5179LT1	2–264
2N5421	MRF4427	2–723
2N5424	MRF2628	2–711
2N5583	—	
2N5589	MRF5003	2–727
2N5590	MRF2628	2–711
2N5591	MRF1946	2–703
2N5635	—	
2N5636	MRF321	2–467
2N5637	MRF323	2–471
2N5641*	MRF134	2–270
2N5642	MRF166C	2–364
2N5643	MRF137	2–289
2N5644	MRF5003	2–727
2N5645	MRF652	2–568
2N5646	MRF653	2–571
2N5688	MRF2628	2–711
2N5689	MRF2628	2–711
2N5690	MRF1946	2–703
2N5697	MRF5003	2–727
2N5698	MRF5003	2–727
2N5699	MRF652	2–568
2N5710	MRF4427	2–723
2N5711	MRF134	2–270
2N5713	MRF137	2–289
2N5774	MRF321	2–467
2N5775	MRF325	2–475
2N5829	—	
2N5835*	BFR92ALT1	2–10
2N5836	MRF581/559/837	2–542, 536, 582
2N5837	MRF555/557	2–528, 532
2N5841	MRF571	2–194
2N5842	MRF571	2–194
2N5847	MRF2628	2–711
2N5848	MRF1946	2–703
2N5862	MRF316	2–459
2N5914	MRF5003	2–727
2N5915	MRF653	2–571
2N5918	MRF321	2–467
2N5919A	MRF323	2–471

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
2N5941	MRF137	2–289
2N5942	—	
2N5943*	MRF5943	2–766
2N5944*	MRF5003	2–727
2N5945*	MRF652	2–568
2N5946*	MRF653	2–571
2N5947	MRF587	2–551
2N5992	MRF2628	2–711
2N5993	MRF1946	2–703
2N5995	MRF2628	2–711
2N5996	MRF1946	2–703
2N6080*	MRF5003	2–727
2N6081*	MRF2628	2–711
2N6082*	MRF1946	2–703
2N6083*	MRF1946	2–703
2N6084*	MRF1946	2–703
2N6093	—	
2N6104	MRF325	2–475
2N6105	MRF325	2–475
2N6136	MRF644	2–561
2N6166	MRF173	2–381
2N6197	MRF134	2–270
2N6198*	MRF134	2–270
2N6199	MRF137	2–289
2N6200	MRF137	2–289
2N6201	MRF317	2–463
2N6203	MRF321	2–467
2N6204	MRF323	2–471
2N6205	MRF325	2–475
2N6206	MRF891	2–643
2N6207	MRF892	2–646
2N6255	MRF5003	2–727
2N6256	MRF559	2–536
2N6304*	—	
2N6305	—	
2N6366	MRF5003	2–727
2N6368	MRF455	2–519
2N6439	2N6439	2–2
2N6455	MRF1946	2–703
2N6457	MRF492	2–521
2N6460	MRF492	2–521
2N6603	MRF901	2–209
2N6604	MRF571	2–194
2N6679	MRF951	2–247
2N6985*	MRF392	2–491
2N6986	MRF393	2–494
2SA1161	MMBR521LT1	2–187
2SA1223	MMBR521LT1	2–187
2SA1228	MMBR521LT1	2–187
2SA1230	MMBR521LT1	2–187
2SA1245	—	
2SA711	MRF9011LT1	2–209
2SA800	MMBR521LT1	2–187
2SC1043	MRF587	2–551
2SC1081	MRF654	2–575
2SC1090–1	MMBR911LT1	2–222
2SC1119	MRF901	2–209
2SC1251	MRF587	2–551
2SC1252	MRF5812	2–542
2SC1253	MRF5812	2–542
2SC1256	MRF5003	2–727
2SC1257	MRF2628	2–711
2SC1258	MRF2628	2–711
2SC1259	MRF1946	2–703
2SC1260	MMBR5179LT1	2–264
2SC1268	MRF571	2–194
2SC1275	MMBR5179LT1	2–264
2SC1297	MRF137	2–289
2SC1336	MRF571	2–194
2SC1365	MRF5812	2–542
2SC1366	MRF5812	2–542
2SC1424	MRF571	2–194
2SC1426	BFR96	2–14
2SC1560	MRF571	2–194
2SC1592	MRF587	2–551
2SC1593	MRF587	2–551
2SC1594	MRF587	2–551
2SC1600	MRF5812	2–542
2SC1605A	MRF2628	2–711
2SC1606	MRF5003	2–727
2SC1729	MRF2628	2–711
2SC1763	—	
2SC1764	—	
2SC1804	MRF321	2–467
2SC1805	MRF323	2–471
2SC1808	MRF652	2–568
2SC1946	MRF1946	2–703
2SC1946A	MRF1946	2–703
2SC1947	MRF5003	2–727
2SC1949	MRF951	2–247
2SC1955	MRF5003	2–727
2SC1966	MRF652	2–568
2SC1967	MRF653	2–571
2SC1968A	MRF641	2–558
2SC1970	MRF553	2–524
2SC1988	MRF571	2–194
2SC2025	BFR96	2–14
2SC2026	MPS911	2–222
2SC2040	MRF587	2–551
2SC2065	MRF587	2–551
2SC2081	MRF5003	2–727
2SC2082	MRF653	2–571
2SC2083	MRF654	2–575
2SC2100	MRF492	2–521
2SC2101	MRF2628	2–711
2SC2102	MRF2628	2–711
2SC2103A	MRF1946	2–703
2SC2104	MRF652	2–568
2SC2105	MRF653	2–571
2SC2106	MRF654	2–575
2SC2131	MRF5003	2–727
2SC2148	MMBR911LT1	2–222
2SC2149	MRF571	2–194
2SC2174	MRF571	2–194
2SC2181	MRF224	2–436
2SC2217	MRF571	2–194
2SC2218	MRF571	2–194
2SC2222	MRF653	2–571
2SC2280	MRF5003	2–727
2SC2281	MRF653	2–571

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
2SC2282	MRF2628	2–711
2SC2290	MRF454	2–517
2SC2350	MRF571	2–194
2SC2351	MMBR571LT1	2–194
2SC2367	MRF571	2–194
2SC2369	MRF0211LT1	2–432
2SC2420	MRF1946	2–703
2SC2498	MPS911	2–222
2SC2499	MPS901	2–209
2SC2508	MRF1946	2–703
2SC2510	MRF422	2–501
2SC2570	MPS571	2–194
2SC2586	MRF5003	2–727
2SC2627	MRF5003	2–727
2SC2628	MRF2628	2–711
2SC2629	MRF1946	2–703
2SC2630	MRF247	2–443
2SC2642	MRF641	2–558
2SC2643	MRF644	2–561
2SC2652	MRF448	2–513
2SC2694	MRF247	2–443
2SC2753	MPS571	2–194
2SC2759	MMBR911LT1	2–222
2SC2782	MRF247	2–443
2SC2876	MRF571	2–194
2SC2879	MRF421	2–497
2SC2886	MRF321	2–467
2SC2887	MRF321	2–467
2SC2888	MRF314	2–455
2SC2890	MRF316	2–459
2SC2891	MRF317	2–463
2SC2893	MRF321	2–467
2SC2894	MRF323	2–471
2SC2895	MRF325	2–475
2SC2896	2N6439	2–2
2SC2897	MRF327	2–483
2SC2915	MRF658	2–578
2SC2917	MRF247	2–443
2SC2931	MRF557	2–532
2SC2932	MRF840	2–592
2SC2933	MRF842	2–595
2SC2952	MRF5812	2–542
2SC2953	MRF587	2–551
2SC2954	BFR96	2–14
2SC3011	MMBR901LT1	2–209
2SC3019	MRF559	2–536
2SC3020	MRF652	2–568
2SC3021	MRF653	2–571
2SC3022	MRF644	2–561
2SC3099	MMBR901LT1	2–209
2SC3101	MRF5003	2–727
2SC3102	MRF658	2–578
2SC3105	MRF844	2–599
2SC3120	MMBR911LT1	2–222
2SC3139	MRF890	2–640
2SC3147	MRF247	2–443
2SC319	MRF4427	2–723
2SC3268	MRF5711LT1	2–194
2SC3282	MRF842	2–595
2SC3283	MRF844	2–599

Industry Part Number	Motorola Closest Replacement	Page No.
2SC3301	MRF5711LT1	2–194
2SC3302	MRF571	2–194
2SC3355	MPS571	2–194
2SC3356	MMBR571LT1	2–194
2SC3358	MRF571	2–194
2SC3429	MMBR571LT1	2–194
2SC3445	MMBR571LT1	2–194
2SC3484	MRF571	2–194
2SC3582	MPS571	2–194
2SC3583	MMBR571LT1	2–194
2SC3604	MRF571	2–194
2SC3660A	TPV8100B	2–1018
2SC4093	MRF9411LT1	2–230
2SC4226	MRF957T1	2–247
2SC4228	MRF947T1	2–230
2SC4321	MRF947T1	2–230
2SC4394	MRF957T1	2–247
2SC567	MMBR5179LT1	2–264
2SC568	MMBR5179LT1	2–264
2SC573	MRF2628	2–711
2SC585	MRF134	2–270
2SC600	MRF134	2–270
2SC635	MRF134	2–270
2SC636	MRF134	2–270
2SC638	MRF2628	2–711
2SC651	MRF3866R2	2–265
2SC652	MRF3866R2	2–265
2SC730	MRF4427	2–723
2SC821	MRF4427	2–723
2SC822	MRF4427	2–723
2SC823	MRF5943	2–766
2SC824	MRF5943	2–766
2SC831	MRF321	2–467
2SC852	MRF5943	2–766
2SC890	MRF5003	2–727
2SC891	MRF652	2–568
2SC892	MRF653	2–571
2SC988	MRF571	2–194
2SC988A	MRF571	2–194
2SC990	MRF323	2–471
2SC994	MRF4427	2–723
2SC998	MRF5003	2–727
AT0017	MRF9011LT1	2–209
AT0017A	MRF9011LT1	2–209
AT004	MRF9011LT1	2–209
AT0045	MRF9011LT1	2–209
AT1425	BFR90	2–7
AT1825	MMBR911LT1	2–222
AT1845	MRF901	2–209
AT1845A	MRF901	2–209
AT25	MRF901	2–209
AT25A	MRF901	2–209
AT25B	MRF901	2–209
AT2625	MRF901	2–209
AT2645	MRF901	2–209
AT2645A	MRF901	2–209
AT2715	MRF951	2–247
AT50	BFR90	2–7
AT51	BFR90	2–7
AT52	BFR90	2–7

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
ATV5030	—	
ATV5030P	—	
ATV5090B	MRFA2604	2–848
ATV6031	—	
ATV6060	MRFA2602	2–844
ATV7050	MRFA2602	2–844
ATV7060	MRFA2602	2–844
ATV7060P	—	
BF100–35	MRF174	2–386
BF14–35	MRF136	2–279
BF25–35	MRF137	2–289
BF430	MRF5711LT1	2–194
BF431	MRF9011LT1	2–209
BF432	MRF9331LT1	2–795
BF433	MRF5812	2–542
BF50–35	MRF173	2–381
BF679	MMBR521LT1	2–187
BF7–35	MRF134	2–270
BF751	MPS911	2–222
BFG134	MRF581	2–542
BFG195	MRF571	2–194
BFG197/X	MRF5711LT1	2–194
BFG25A/X	MRF9331LT1	2–795
BFG33	MRF9411LT1	2–230
BFG33H	MRF9411LT1	2–230
BFG34	MRF557	2–532
BFG520/X	MRF9411LT1	2–230
BFG540/X	MRF9511LT1	2–247
BFG65	MRF941	2–230
BFG67	MRF9411LT1	2–230
BFG67/X	MRF9411LT1	2–230
BFG90A	MRF901	2–209
BFG91A	MRF0211LT1	2–432
BFG92A/X	MRF9011LT1	2–209
BFG93A/X	MRF5211LT1	2–187
BFG96	MRF581	2–542
BFG97	MRF5812	2–542
BFP10	MRF571	2–194
BFP520	MRF951	2–247
BFP90A	MRF571	2–194
BFP91A	MRF0211LT1	2–432
BFP96	MRF581	2–542
BFQ163	MRF5812	2–542
BFQ18A	MRF5812	2–542
BFQ19	BFR96	2–14
BFQ22	MRF9011LT1	2–209
BFQ22S	MRF571	2–194
BFQ23	MMBR521LT1	2–187
BFQ24	MMBR521LT1	2–187
BFQ32M	MMBR521LT1	2–187
BFQ34	MRF587	2–551
BFQ34T	MRF5812	2–542
BFQ43	MRF5003	2–727
BFQ43S	MRF5003	2–727
BFQ51	MMBR521LT1	2–187
BFQ63	MRF571	2–194
BFQ66	MRF571	2–194
BFQ67	MMBR951LT1	2–247
BFQ67W	MRF947T1	2–230
BFQ85	MRF571	2–194
BFR134	MRF5812	2–542
BFR38	—	
BFR49	MRF901	2–209
BFR520	MMBR941LT1	2–230
BFR53	MMBR920LT1	2–228
BFR540	MMBR951LT1	2–247
BFR541	MRF951	2–247
BFR63	MRF587	2–551
BFR64	MRF587	2–551
BFR65	MRF587	2–551
BFR90	BFR90	2–7
BFR90A	BFR90	2–7
BFR91*	MMBR911LT1	2–222
BFR91A	MRF571	2–194
BFR92A	BFR92ALT1	2–10
BFR92AL	BFR92ALT1	2–10
BFR92ALT1	BFR92ALT1	2–10
BFR92L	BFR92ALT1	2–10
BFR92LT1	BFR92ALT1	2–10
BFR92SLT1	BFR92ALT1	2–10
BFR93	BFR93ALT1	2–12
BFR93A	BFR93ALT1	2–12
BFR93AL	BFR93ALT1	2–12
BFR93ALT1	BFR93ALT1	2–12
BFR93L	BFR93ALT1	2–12
BFR93LT1	BFR93ALT1	2–12
BFR93S	BFR93ALT1	2–12
BFR93SLT1	BFR93ALT1	2–12
BFR94	MRF587	2–551
BFR95	MMBR521LT1	2–187
BFR96	BFR96	2–14
BFR96S	MRF581A	2–542
BFR99	—	
BFS17	BFS17LT1	2–18
BFS17L	BFS17LT1	2–18
BFS17LT1	BFS17LT1	2–18
BFS17S	BFS17LT1	2–18
BFS17SLT1	BFS17LT1	2–18
BFS520	MRF947T1	2–230
BFS540	MRF957T1	2–247
BFT24	MMBR931LT1	2–229
BFT25A	MMBR931LT1	2–229
BFT50	MRF9011LT1	2–209
BFT92	MMBR521LT1	2–187
BFT95	MMBR521LT1	2–187
BFT96	MMBR521LT1	2–187
BFW92A	—	
BFW93	MRF571	2–194
BFW94	MRF559	2–536
BFX89	—	
BFY90*	—	
BGD102	MHW5185B	2–148
BGD104	MHW5205	2–150
BGD106	MHW5225	2–153
BGD502	MHW6185B	2–148
BGX885	CA901	2–19
BGY110A	MHW851–1	2–104
BGY110B	MHW851–2	2–104
BGY110D	MHW803–1	2–95
BGY110E	MHW803–3	2–95

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
BGY110F	MHW803–3	2–95
BGY112B	MHW607–1	2–78
BGY112C	MHW607–2	2–78
BGY113A	MHW707–1	2–85
BGY113B	MHW707–2	2–85
BGY114C	MHW909	2–109
BGY115A	MHW9002–1	2–180
BGY115B	MHW9002–2	2–180
BGY115C	MHW9002–3	2–180
BGY200	MHW953	2–129
BGY201	MHW914	2–114
BGY49A	MHW720A1	2–92
BGY49B	MHW720A2	2–92
BGY50	—	
BGY51	—	
BGY52	MHW5172A	2–143
BGY53	MHW5172A	2–143
BGY54	MHW5172A	2–143
BGY55	MHW5172A	2–143
BGY56	MHW5222A	2–151
BGY57	MHW5222A	2–151
BGY580	MHW6122	2–160
BGY581	MHW6122	2–160
BGY582	MHW6142	2–161
BGY583	MHW6142	2–161
BGY584	MHW6172	2–162
BGY584A	MHW6182	2–163
BGY585	MHW6172	2–162
BGY585A	MHW6182	2–163
BGY586	MHW6222	2–166
BGY587	MHW6222	2–166
BGY587B	MHW6272	2–168
BGY588	MHW6342	2–169
BGY58A	MHW5342A	2–156
BGY59	MHW5382A	2–158
BGY61	MHW1134	2–134
BGY67	MHW1224	2–134
BGY67A	MHW1244	2–134
BGY70	—	
BGY71	—	
BGY78	MHW5342A	2–156
BGY80	—	
BGY81	—	
BGY82	MHW5142A	2–141
BGY83	MHW5142A	2–141
BGY84	MHW5172A	2–143
BGY84A	MHW5182A	2–145
BGY85	MHW5172A	2–143
BGY85A	MHW5182A	2–145
BGY86	MHW5222A	2–151
BGY87	MHW5222A	2–151
BGY87B	MHW5272A	2–154
BGY88	MHW5342A	2–156
BGY89	MHW5382A	2–158
BGY92C	MHW913	2–111
BGY95A	MHW803–1	2–95
BGY95B	MHW803–3	2–95
BLF145	MRF137	2–289
BLF147	MRF141	2–307
BLF175	MRF148	2–318

Industry Part Number	Motorola Closest Replacement	Page No.
BLF177	MRF151	2–328
BLF242	MRF134	2–270
BLF244	MRF136	2–279
BLF245	MRF137	2–289
BLF245B	MRF136Y	2–279
BLF246	MRF173	2–381
BLF246B	MRF177	2–416
BLF248	MRF141G	2–313
BLF277	MRF151	2–328
BLF278	MRF151G	2–334
BLF346	MRF173	2–381
BLF348	MRF175GV	2–394
BLF368	MRF175GV	2–394
BLF378	MRF151G	2–334
BLF521	MRF158	2–351
BLF544	MRF166C	2–364
BLF544B	MRF164W	2–361
BLF548	MRF175GU	2–394
BLT90	MRF557	2–532
BLT90SL	MRF557	2–532
BLU10/12	MRF653	2–571
BLU15/12	MRF654	2–575
BLU20/12	MRF644	2–561
BLU53	MRF392	2–491
BLU60/12	MRF658	2–578
BLU97	MRF653	2–571
BLU98	MRF581	2–542
BLU99	MRF652	2–568
BLV10	MRF2628	2–711
BLV103	MRF891	2–643
BLV12	MRF1946	2–703
BLV13	MRF1946	2–703
BLV193	MRF842	2–595
BLV194	MRF842	2–595
BLV20	MRF134	2–270
BLV21	MRF314	2–455
BLV57	TPV695A	2–1010
BLV75/12	MRF247	2–443
BLV80/28	MRF316	2–459
BLV90	MRF557	2–532
BLV90/SL	MRF557	2–532
BLV91	MRF840	2–592
BLV92	MRF840	2–592
BLV93	MRF840	2–592
BLV94	MRF842	2–595
BLV945A	MRF897	2–658
BLV948	MRF899	2–669
BLV95	MRF844	2–599
BLV96	MRF847	2–602
BLV97	MRF894	2–650
BLV98	MRF892	2–646
BLV99	MRF894	2–650
BLW29	MRF2628	2–711
BLW30	MRF1946	2–703
BLW31	MRF1946	2–703
BLW32	TPV596A	2–1002
BLW33	TPV597	2–1005
BLW40	MRF240	2–439
BLW50F	—	
BLW60	MRF1946	2–703

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
BLW60C	MRF1946	2–703
BLW76	—	
BLW77	MRF422	2–501
BLW78	—	
BLW79	MRF5003	2–727
BLW80	MRF652	2–568
BLW81	MRF653	2–571
BLW82	MRF644	2–561
BLW83	MRF426	2–505
BLW84	MRF314	2–455
BLW85	MRF224	2–436
BLW87	MRF1946	2–703
BLW91	MRF321	2–467
BLW91/SL	MRF321	2–467
BLW95	MRF429	2–509
BLW96	MRF448	2–513
BLW97	MRF422	2–501
BLW98	TPV598	2–1008
BLW99	MRF421	2–497
BLX13	MRF426	2–505
BLX13C	MRF426	2–505
BLX14	—	
BLX65	MRF5003	2–727
BLX65ES	MRF5003	2–727
BLX66	MRF5003	2–727
BLX67	MRF653	2–571
BLX68	MRF653	2–571
BLX69A	MRF654	2–575
BLX91	MRF313	2–453
BLX91A	MRF313	2–453
BLX93	MRF321	2–467
BLX93A	MRF321	2–467
BLX94A	MRF325	2–475
BLX94C	MRF323	2–471
BLX95	MRF325	2–475
BLX96	TPV596A	2–1002
BLX97	TPV597	2–1005
BLX98	TPV598	2–1008
BLY53A	MRF653	2–571
BLY58	MRF2628	2–711
BLY59	MRF134	2–270
BLY60	MRF134	2–270
BLY87A	MRF2628	2–711
BLY87C	MRF2628	2–711
BLY88A	MRF2628	2–711
BLY88C	MRF2628	2–711
BLY88C/01	MRF2628	2–711
BLY89A	MRF1946	2–703
BLY89C	MRF1946	2–703
BLY91A	MRF134	2–270
BLY91C	MRF134	2–270
BLY93A	MRF314	2–455
BLY93C	MRF314	2–455
BM100–28	MRF317	2–463
BM45–12	MRF247	2–443
BM70–12	MRF247	2–443
BM80–12	MRF247	2–443
BRF521	MRF941	2–230
BTF500F	—	
CA100	MHW5172A	2–143

Industry Part Number	Motorola Closest Replacement	Page No.
CA200	MHW5172A	2–143
CA2100	MHW5172A	2–143
CA2101	MHW5172A	2–143
CA2200	MHW5172A	2–143
CA2201	MHW5172A	2–143
CA2300	MHW5222A	2–151
CA2301	MHW5222A	2–151
CA2422	MHW1224	2–134
CA2600	MHW5342A	2–156
CA2700	MHW5382A	2–158
CA2800	CA2818C	2–30
CA2808	—	
CA2810	CA2810C	2–27
CA2810B	CA2810C	2–27
CA2810C	CA2810C	2–27
CA2810CH	CA2810C	2–27
CA2810H	CA2810C	2–27
CA2813	CA2810C	2–27
CA2813B	CA2810C	2–27
CA2813C	CA2810C	2–27
CA2813CH	CA2810C	2–27
CA2818	CA2818C	2–30
CA2818B	CA2818C	2–30
CA2818C	CA2818C	2–30
CA2818H	CA2818C	2–30
CA2820	—	
CA2822C–004	—	
CA2828CH	CA2818C	2–30
CA2830	CA2830C	2–33
CA2830B	CA2830C	2–33
CA2830C	CA2830C	2–33
CA2830H	CA2830C	2–33
CA2832	CA2832C	2–36
CA2832B	CA2832C	2–36
CA2832C	CA2832C	2–36
CA2832H	CA2832C	2–36
CA2833	CA2833C	2–33
CA2833C	CA2833C	2–33
CA2836C	—	
CA2837C	—	
CA2840	CA2842C	2–39
CA2840H	CA2842C	2–39
CA2842	CA2842C	2–39
CA2842B	CA2842C	2–39
CA2842C	CA2842C	2–39
CA2842H	CA2842C	2–39
CA2843C	—	
CA2846	CA2842C	2–39
CA2850	MHW5182A	2–145
CA2850CR	—	
CA2870	CA2810C	2–27
CA2870B	MHW5342A	2–156
CA2870C	CA2810C	2–27
CA2870H	CA2810C	2–27
CA2885	MHW5185B	2–148
CA2888	CA2832C	2–36
CA2888H	CA2832C	2–36
CA2889	CA2832C	2–36
CA2889H	CA2832C	2–36
CA2890	CA2810C	2–27

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
CA2890B	CA2810C	2–27
CA2890H	CA2810C	2–27
CA3100	MHW5172A	2–143
CA3101	MHW5172A	2–143
CA3170	MHW5172A	2–143
CA3180	MHW5142A	2–141
CA3200	MHW5172A	2–143
CA3201	MHW5172A	2–143
CA3220	MHW5182A	2–145
CA3270	MHW5172A	2–143
CA3280	MHW5142A	2–141
CA3300	MHW5222A	2–151
CA3301	MHW5222A	2–151
CA3600	MHW5342A	2–156
CA3700	MHW5382A	2–158
CA4101	MHW5172A	2–143
CA4170	MHW5172A	2–143
CA4180	MHW5142A	2–141
CA4201	MHW5172A	2–143
CA4220	MHW5182A	2–145
CA4270	MHW5172A	2–143
CA4280	MHW5142A	2–141
CA4300	MHW5222A	2–151
CA4301	MHW5222A	2–151
CA4411	MHW1134	2–134
CA4412	MHW1134	2–134
CA4422	MHW1224	2–134
CA4424	MHW1244	2–134
CA4600	MHW5342A	2–156
CA4700	MHW5342A	2–156
CA4800	CA4800C	2–42
CA4800C	CA4800C	2–42
CA4800CL	—	
CA4800CS	CA4800CS	2–42
CA4800H	CA4800CS	2–42
CA4812	CA4812C	2–42
CA4812C	CA4812C	2–42
CA4812CS	CA4812CS	2–42
CA4812H	CA4812CS	2–42
CA4815	CA4815C	2–42
CA4815C	CA4815C	2–42
CA4815CS	CA4815CS	2–42
CA4815H	CA4815CS	2–42
CA4900	CA4800C	2–42
CA4900S	CA4800CS	2–42
CA4912	CA4812C	2–42
CA4912S	CA4812CS	2–42
CA4915	CA4815C	2–42
CA4915S	CA4815CS	2–42
CA5001	MHW5182A	2–145
CA5101	MHW5182A	2–145
CA5170	MHW5172A	2–143
CA5180	MHW5142A	2–141
CA5201	MHW5182A	2–145
CA5270	MHW5172A	2–143
CA5280	MHW5142A	2–141
CA5300	MHW5222A	2–151
CA5301	MHW5222A	2–151
CA5501	MHW5185B	2–148
CA5520	MHW5185B	2–148

Industry Part Number	Motorola Closest Replacement	Page No.
CA5600	MHW5342A	2–156
CA5700	MHW5382A	2–158
CA5800	CA5800C	2–44
CA5800C	CA5800C	2–44
CA5800CS	CA5800CS	2–44
CA5800H	CA5800CS	2–44
CA5801	CA5801	2–46
CA5801S	CA5801S	2–46
CA5815	CA5815C	2–48
CA5815C	CA5815C	2–48
CA5815CS	CA5815CS	2–48
CA5815H	CA5815CS	2–48
CA5900	CA5800C	2–44
CA5900S	CA5800CS	2–44
CA5915	CA5815C	2–48
CA5915S	CA5815CS	2–48
CA601B/U	MHW5342A	2–156
CA6101	MHW6182	2–163
CA6201	MHW6182	2–163
CA6220	MHW6182	2–163
CA636	MHW5342A	2–156
CA6501	MHW6185B	2–148
CA6520	MHW6185B	2–148
CA7901	CA97901	2–50
CA8004	—	
CA900	CA901	2–19
CA901	CA901	2–19
CA9011	—	
CA901A	CA901A	2–19
CA902	CA902	2–21
CA902A	CA902A	2–21
CA912	CA912	2–23
CA912A	CA912A	2–23
CA912C	—	
CA922	CA922	2–25
CA922A	CA922A	2–25
CA97901	CA97901	2–50
CAB914	CA901	2–19
CAR2424H	CR2428	2–52
CF4–28	MRF160	2–355
CG125	MRF901	2–209
CG125A	MRF901	2–209
CG125B	MRF571	2–194
CG125C	MRF571	2–194
CG125D	MMBR911LT1	2–222
CG125L	MMBR911LT1	2–222
CG127	MRF571	2–194
CG127A	MRF571	2–194
CG127B	MRF571	2–194
CR2424	CR2428	2–52
CR2424A	CR2428	2–52
CR2424H	CR2428	2–52
CR2424R	—	
CR2425	CR2428	2–52
CR2425A	CR2428	2–52
CR2428	CR2428	2–52
CR24402	CR2428	2–52
CR24403	CR2428	2–52
CR3424	CR3428	2–54
CR3424A	CR3428	2–54

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
CR3424H	CR3428	2–54
CR3424R	—	
CR3425	CR3428	2–54
CR3425A	CR3428	2–54
CR3428	CR3428	2–54
DME10	—	
DME120L	MRF1150MA	2–697
DME150	MRF10150	2–811
DME2	—	
DME25	—	
DME250	MRF10350	2–814
DME30L	—	
DME375	MRF10350	2–814
DME375A	MRF10350	2–814
DME50	MRF1090MA	2–694
DME75	—	
DMEG250	MRF10350	2–814
DMEG70	MRF1090MA	2–694
DU2812OU	MRF174	2–386
DU2820S	MRF166C	2–364
DU2840S	MRF183	2–427
FF124	MFF124B	2–59
FF124B	MFF124B	2–59
FF224	MFF224B	2–61
FF224B	MFF224B	2–61
H100–28	MRF422	2–501
H100–50	MRF429	2–509
H175–50	MRF429	2–509
H50–28	—	
HMIL–100–28	MRF422	2–501
HMIL–150–50	MRF429	2–509
HXTR2102	MMBR911LT1	2–222
HXTR6104	MRF901	2–209
HXTR6105	MRF901	2–209
IMD2001	MRW2001	2–954
IMD2005	MRW2005	2–954
IMD604HA	MRW2001	2–954
IMD604HC	MRW2005	2–954
J01006	MRF317	2–463
J02000	MRF325	2–475
J02005	MRF325	2–475
J02007A	2N6439	2–2
J02009	MRF325	2–475
J02014	MRF326	2–479
J02015A	MRF327	2–483
J02015AD	MRF327	2–483
J02015AP	MRF327	2–483
J02016	MRF327	2–483
J03012	MRF641	2–558
J03015	MRF641	2–558
J03025	MRF644	2–561
J03028	MRF644	2–561
J03037	MRF658	2–578
J03037	MRF658	2–578
J03055	MRF658	2–578
J03060	MRF658	2–578
J03401	MRF840	2–592
J03402	MRF842	2–595
J03403	MRF844	2–599
J03404	MRF844	2–599
J03405	MRF847	2–602
J03406	MRF847	2–602
J03501	MRF892	2–646
J03502	MRF894	2–650
J04020	MRF247	2–443
J04028	MRF247	2–443
J04030	MRF247	2–443
J04036	MRF1946	2–703
J04040	MRF247	2–443
J04045	MRF1946/MRF247	2–703, 443
J04070	MRF247	2–443
J04075	MRF247	2–443
J04080	MRF247	2–443
LF40100M	MRF177M	2–416
LF4030C	MRF182	2–422
LMIL1	MRF890	2–640
LP1001	LP1001	2–56
LP1001A	LP1001A	2–56
LP1006	LP1001	2–56
LP1006A	LP1001	2–56
LP1006B	LP1001	2–56
LP1983*	MPS901	2–209
LT1001A	MRF5812	2–542
LT1041	—	
LT1839	—	
LT2001	MRF581	2–542
LT2034	MRF581	2–542
LT3005	MRF581	2–542
LT3014	MRF581	2–542
LT3046	MRF5812	2–542
LT3047	MRF9011LT1	2–209
LT3072	MRF9011LT1	2–209
LT3203	MRF581	2–542
LT3204	MRF581	2–542
LT3700	MRF901	2–209
LT3703	MRF901	2–209
LT3704	MRF901	2–209
LT3746	MRF5812	2–542
LT3772	MRF9011LT1	2–209
LT4217A	—	
LT4239A	—	
LT4403	BFR96	2–14
LT4404	MRF951	2–247
LT4485	MRF951	2–247
LT4700	MRF901	2–209
LT4703	MMBR911LT1	2–222
LT4704	MRF571	2–194
LT4746	BFR96	2–14
LT4772	MRF571	2–194
LT5217	MRF5211LT1	2–187
LT5239	MRF5211LT1	2–187
M57729/L	MHW720A1	2–92
M57729H	MHW720A2	2–92
M57734	MHW720A2	2–92
M57744	MHW913	2–111
M57765	MHW804–1	2–100
M57768	MHW913	2–111
M57773	MHW803–1	2–95
M57783H	MHW607–2	2–78
M57783L	MHW607–1	2–78

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
M57785H	MHW607–2	2–78
M57785L	MHW607–1	2–78
M57785M	MHW607–2	2–78
M57786M	MHW707–2	2–85
M57789	MHW913	2–111
M57795	MHW803–2	2–95
M57799M	MHW707–2	2–85
M67729H	MHW720A2	2–92
M67729L	MHW720A1	2–92
M67743	MHW105	2–75
M67748H	MHW607–2	2–78
M67748L	MHW607–1	2–78
M67749H	MHW707–2	2–85
M67749L	MHW707–1	2–85
M67749SH	MHW707–4	2–85
M67749UH	MHW707–3	2–85
M67766	MHW927B	2–126
M67768	—	
M67769	MHW909	2–109
M67770	MHW914	2–114
M67771	MHW953	2–129
M67780L	MHW851–1	2–104
M67780M	MHW851–2	2–104
MC5381	MHW5182A	2–145
MC5382	MHW5182A	2–145
MC5383	MHW5272A	2–154
MC5384	MHW5182A	2–145
MC5385	MHW5182A	2–145
MC5386	MHW5342A	2–156
MC5387	MHW6182	2–163
MC5388	MHW6182	2–163
MC5389	MHW5342A	2–156
MC5813	MHW1134	2–134
MC5814	MHW5222A	2–151
MC5815	MHW5222A	2–151
MC5816	MHW6222	2–166
MC5817	MHW6222	2–166
MC5819	MHW6182	2–163
MC5820	MHW6182	2–163
MC5821	MHW5342A	2–156
MC5822	MHW1224	2–134
MC5824	MHW1244	2–134
MF137MP	MRF137	2–289
MF410	—	
MFF124	MFF124B	2–59
MFF124B	MFF124B	2–59
MFF224	MFF224B	2–61
MFF224B	MFF224B	2–61
MFF324	MFF324B	2–63
MFF324B	MFF324B	2–63
MFF424B	MFF424B	2–65
MHL8015	MHL8015	2–67
MHL8018	MHL8018	2–67
MHL8115	MHL8115	2–71
MHL8118	MHL8118	2–71
MHL9125	MHL9125	2–73
MHL9128	MHL9128	2–73
MHW105	MHW105	2–75
MHW1121	—	
MHW1122	—	

Industry Part Number	Motorola Closest Replacement	Page No.
MHW1134	MHW1134	2–134
MHW1172	MHW5172A	2–143
MHW1184	MHW1184	2–134
MHW1184L	MHW1184L	2–136
MHW1222	MHW5222A	2–151
MHW1224	MHW1224	2–134
MHW1224L	MHW1224L	2–136
MHW1244	MHW1244	2–134
MHW1254L	MHW1254L	2–136
MHW1304L	MHW1304L	2–136
MHW1341	MHW5342A	2–156
MHW1342	MHW5342A	2–156
MHW1343	MHW5342A	2–156
MHW2172	MHW5172A	2–143
MHW2528	MHW2528	2–137
MHW2902	MHW2902	1–28
MHW3171	MHW5172A	2–143
MHW3172	MHW5172A	2–143
MHW3181	MHW5182A	2–145
MHW3182	MHW5182A	2–145
MHW3222	MHW5222A	2–151
MHW3272A	MHW5272A	2–154
MHW3342*	MHW5342A	2–156
MHW3382A*	MHW5382A	2–158
MHW3528	MHW3528	2–139
MHW4171	MHW5172A	2–143
MHW4172	MHW5172A	2–143
MHW4342	MHW5342A	2–156
MHW4524F	MFF124B	2–59
MHW5122	—	
MHW5122A	—	
MHW5141A	MHW5142A	2–141
MHW5142	MHW5142A	2–141
MHW5142A	MHW5142A	2–141
MHW5162A	MHW5172A	2–143
MHW5171	MHW5172A	2–143
MHW5171A	MHW5172A	2–143
MHW5172	MHW5172A	2–143
MHW5172A	MHW5172A	2–143
MHW5172R	MHW5172A	2–143
MHW5181	MHW5182A	2–145
MHW5181A*	MHW5182A	2–145
MHW5182*	MHW5182A	2–145
MHW5182A	MHW5182A	2–145
MHW5182R	—	
MHW5183	MHW5183	2–147
MHW5185*	MHW5185B	2–148
MHW5185B	MHW5185B	2–148
MHW5185R	—	
MHW5205	MHW5205	2–150
MHW5205R	—	
MHW5222*	MHW5222A	2–151
MHW5222A	MHW5222A	2–151
MHW5222R*	—	
MHW5225	MHW5225	2–153
MHW5225R	—	
MHW5272A	MHW5272A	2–154
MHW5332	MHW5342A	2–156
MHW5332A	MHW5342A	2–156
MHW5341	MHW5342A	2–156

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MHW5342	MHW5342A	2–156
MHW5342A	MHW5342A	2–156
MHW5342F	MHW5342A	2–156
MHW5382	MHW5382A	2–158
MHW5382A	MHW5382A	2–158
MHW580	MHW5342A	2–156
MHW590	—	
MHW591	—	
MHW592	—	
MHW593	—	
MHW594	MHW5172A	2–143
MHW595	MHW5172A	2–143
MHW596	—	
MHW597	—	
MHW607–1	MHW607–1	2–78
MHW607–2	MHW607–2	2–78
MHW607–3	MHW607–3	2–78
MHW607–4	MHW607–4	2–78
MHW6122	MHW6122	2–160
MHW6141	MHW6142	2–161
MHW6142	MHW6142	2–161
MHW6171	MHW6172	2–162
MHW6172	MHW6172	2–162
MHW6181*	MHW6182	2–163
MHW6182	MHW6182	2–163
MHW6182–6	MHW6182–6	2–164
MHW6183	MHW6183	2–147
MHW6185*	MHW6185B	2–148
MHW6185–6	MHW6185–6	2–148
MHW6185–6A	MHW6185–6A	1–31
MHW6185B	MHW6185B	2–148
MHW6205	MHW6205	2–165
MHW6205–6A	MHW6205–6A	1–31
MHW6222	MHW6222	2–166
MHW6222–6	MHW6222–6	2–167
MHW6225	MHW6225	2–165
MHW6272	MHW6272	2–168
MHW6342	MHW6342	2–169
MHW6342F	MHW5342A	2–156
MHW703	MHW704–2	2–82
MHW704–1	MHW704–1	2–82
MHW704–2	MHW704–2	2–82
MHW707–1	MHW707–1	2–85
MHW707–2	MHW707–2	2–85
MHW707–3	MHW707–3	2–85
MHW707–4	MHW707–4	2–85
MHW709–1	MHW720A1	2–92
MHW709–2	MHW720A2	2–92
MHW709–3	—	
MHW710–1	MHW720A1	2–92
MHW710–2	MHW720A2	2–92
MHW710–3	—	
MHW7142	MHW7142	2–170
MHW7182	MHW7182	2–172
MHW7185	MHW7185	2–174
MHW7185A	MHW7185A	2–175
MHW720–1	MHW720A1	2–92
MHW720–2	MHW720A2	2–92
MHW7205	MHW7205A	2–175
MHW7205A	MHW7205A	2–175

Industry Part Number	Motorola Closest Replacement	Page No.
MHW720A1	MHW720A1	2–92
MHW720A2	MHW720A2	2–92
MHW720A3	—	
MHW721A2*	—	
MHW7222	MHW7222	2–176
MHW7272	MHW7272	1–31
MHW7292	MHW7292	1–31
MHW801–1	MHW851–1	2–104
MHW801–2*	MHW851–2	2–104
MHW801–3	MHW851–3	2–104
MHW801–4	MHW851–4	2–104
MHW802–1	MHW803–1	2–95
MHW802–2	MHW803–2	2–95
MHW803–1	MHW803–1	2–95
MHW803–2	MHW803–2	2–95
MHW803–3	MHW803–3	2–95
MHW804–1	MHW804–1	2–100
MHW804–2	—	
MHW806A1	—	
MHW806A2	—	
MHW806A3	—	
MHW806A4	—	
MHW807–1	—	
MHW807–2	—	
MHW808–1*	—	
MHW808–3	—	
MHW808A2	—	
MHW808A3	—	
MHW812–3	MHW913	2–111
MHW812A3*	MHW913	2–111
MHW8142	MHW8142	2–170
MHW8182	MHW8182	2–172
MHW820–1*	—	
MHW820–2*	—	
MHW820–3*	—	
MHW8222	MHW8222	2–176
MHW8272	MHW8272	2–178
MHW8292	MHW8292	2–179
MHW851–1	MHW851–1	2–104
MHW851–2	MHW851–2	2–104
MHW851–3	MHW851–3	2–104
MHW851–4	MHW851–4	2–104
MHW9002–1	MHW9002–1	2–180
MHW9002–2	MHW9002–2	2–180
MHW9002–3	—	
MHW9002–4	—	
MHW9014	MHW9014	2–184
MHW902	—	
MHW903	MHW953	2–129
MHW909	MHW909	2–109
MHW912	MHW914	2–114
MHW913	MHW913	2–111
MHW914	MHW914	2–114
MHW9142	MHW9142	2–170
MHW915	MHW915	2–114
MHW916	MHW916	2–120
MHW9182	MHW9182	2–172
MHW920	MHW920	2–122
MHW926	—	
MHW927A	MHW927B	2–126

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MHW927B	MHW927B	2–126
MHW932	—	
MHW953	MHW953	2–129
MHW954	MHW954	2–129
MKB12040WS	—	
MKB12100WS	MRF1090MA	2–694
MKB12140W	MRF1090MA	2–694
MM1500	MRF5812	2–542
MM1500A	MRF5812	2–542
MM1501A	MRF5812	2–542
MM1550	MRF321	2–467
MM1551	MRF323	2–471
MM1557	MRF134	2–270
MM1559	MRF137	2–289
MM1601	MRF5003	2–727
MM1602	MRF2628	2–711
MM1603	MRF1946	2–703
MM1605	MRF571	2–194
MM1606	MRF571	2–194
MM1607	MRF571	2–194
MM1608	MRF5003	2–727
MM1612	MRF5003	2–727
MM1632	MRF137	2–289
MM1633	—	
MM1660	MRF5003	2–727
MM1661	MRF652	2–568
MM1662	MRF653	2–571
MM1665	MRF644	2–561
MM1666	MRF1946	2–703
MM1667	MRF1946	2–703
MM1668	MRF1946	2–703
MM1669	MRF1946	2–703
MM1680	MRF5003	2–727
MM1681	MRF2628	2–711
MM1713	MRF559	2–536
MM1943	MRF559	2–536
MM1945	MRF559	2–536
MM4018	—	
MM4049	MMBR521LT1	2–187
MM439	—	
MM4500	—	
MM5177	MRF325	2–475
MM8000	MRF5943	2–766
MM8001*	MRF5943	2–766
MM8003	MRF587	2–551
MM8006	MMBR5031LT1	2–263
MM8007	MMBR5031LT1	2–263
MM8008	MRF5812	2–542
MM8009	—	
MM8010	MRF5812	2–542
MM8011	MRF5812	2–542
MM8012	MRF587	2–551
MM8020	MRF951	2–247
MM8021	MRF951	2–247
MM8023	MRF5943	2–766
MMBR2060	BFS17LT1	2–18
MMBR2060L	BFS17LT1	2–18
MMBR2060LT1	BFS17LT1	2–18
MMBR2857	MMBR5179LT1	2–264
MMBR2857L	MMBR5179LT1	2–264

Industry Part Number	Motorola Closest Replacement	Page No.
MMBR2857LT1	MMBR5179LT1	2–264
MMBR4957	—	
MMBR4957L	—	
MMBR4957LT1	—	
MMBR4957LT3	—	
MMBR5031	MMBR5031LT1	2–263
MMBR5031L	MMBR5031LT1	2–263
MMBR5031LT1	MMBR5031LT1	2–263
MMBR5031LT3	MMBR5031LT1	2–263
MMBR5179	MMBR5179LT1	2–264
MMBR5179L	MMBR5179LT1	2–264
MMBR5179LT1	MMBR5179LT1	2–264
MMBR5179LT3	MMBR5179LT1	2–264
MMBR521L	MMBR521LT1	2–187
MMBR521LT1	MMBR521LT1	2–187
MMBR536	MMBR521LT1	2–187
MMBR536L	MMBR521LT1	2–187
MMBR536LT1	MMBR521LT1	2–187
MMBR536LT3	MMBR521LT1	2–187
MMBR571	MMBR571LT1	2–194
MMBR571L	MMBR571LT1	2–194
MMBR571LT1	MMBR571LT1	2–194
MMBR571LT3	MMBR571LT1	2–194
MMBR901	MMBR901LT1	2–209
MMBR901L	MMBR901LT1	2–209
MMBR901LT1	MMBR901LT1	2–209
MMBR901LT3	MMBR901LT3	2–209
MMBR911	MMBR911LT1	2–222
MMBR911L	MMBR911LT1	2–222
MMBR911LT1	MMBR911LT1	2–222
MMBR911LT3	MMBR911LT1	2–222
MMBR920	MMBR920LT1	2–228
MMBR920L	MMBR920LT1	2–228
MMBR920LT1	MMBR920LT1	2–228
MMBR920LT3	MMBR920LT1	2–228
MMBR930	MMBR911LT1	2–222
MMBR930L	MMBR911LT1	2–222
MMBR930LT1	MMBR911LT1	2–222
MMBR931	MMBR931LT1	2–229
MMBR931L	MMBR931LT1	2–229
MMBR931LT1	MMBR931LT1	2–229
MMBR931LT3	MMBR931LT1	2–229
MMBR941	MMBR941LT1	2–230
MMBR941BLT1	MMBR941BLT1	2–230
MMBR941BLT3	MMBR941BLT3	2–230
MMBR941L	MMBR941LT1	2–230
MMBR941LT1	MMBR941LT1	2–230
MMBR941LT3	MMBR941LT3	2–230
MMBR951	MMBR951LT1	2–247
MMBR951AL	MMBR951ALT1	2–247
MMBR951ALT1	MMBR951ALT1	2–247
MMBR951ALT3	MMBR951ALT1	2–247
MMBR951L	MMBR951LT1	2–247
MMBR951LT1	MMBR951LT1	2–247
MO1011B150Y	MRF1150MA	2–697
MO1011B250Y	MRF10350	2–814
MPS1983	MPS901	2–209
MPS3866	MPS3866	2–265
MPS3866–005	MPS3866	2–265
MPS3866A	MPS3866	2–265

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MPS3866A18	MPS3866	2–265
MPS3866A5	MPS3866	2–265
MPS3866ARLR	MPS3866	2–265
MPS3866RLRA	MPS3866	2–265
MPS3866RLRP	MPS3866	2–265
MPS536	MMBR521LT1	2–187
MPS536RLRP	—	
MPS571	MPS571	2–194
MPS901	MPS901	2–209
MPS901RLRA	MPS901RLRP	2–209
MPS901RLRP	MPS901RLRP	2–209
MPS911	MPS911	2–222
MPS911RLRA	MPS911RLRA	2–222
MPS911RLRE	MPS911RLRA	2–222
MPS911RLRP	MPS911RLRA	2–222
MR1011B150Y	MRF1150MA	2–697
MR1011B300Y	MRF10350	2–814
MRA0204–30V	MRF325	2–475
MRA0204–60	2N6439	2–2
MRA0204–60V	2N6439	2–2
MRA0204–70	MRF327	2–483
MRA0510–50H	—	
MRA0610–003	—	
MRA0610–009	—	
MRA0610–18A	—	
MRA0610–23	—	
MRA0610–9E	—	
MRA1000–14L	MRA1000–14L	2–268
MRA1000–3.5L	—	
MRA1000–7L	MRA1000–7L	2–267
MRA1014–012	—	
MRA1214–55H	MRF10120	2–808
MRA1318–006	—	
MRA1417–002	—	
MRA1417–006	MRF16006	2–833
MRA1417–011	—	
MRA1417–25A	—	
MRA1600–002	—	
MRA1600–006	MRF16006	2–833
MRA1600–013	—	
MRA1600–030	MRF16030	2–837
MRA1618–35H	—	
MRA1720–002	—	
MRA1720–005*	—	
MRA1720–009	—	
MRA1720–020	—	
MRA2000–5L	MRF2000–5L	2–707
MRAL1417–002	—	
MRAL1417–006	—	
MRAL1417–011	—	
MRAL1720–002	—	
MRAL1720–005	—	
MRAL1720–009	—	
MRAL1720–020	—	
MRAL2023–003	—	
MRAL2023–006	—	
MRAL2023–012	—	
MRAL2023–018	—	
MRAL2023–1.5	—	
MRAL2327–003	—	

*Active, Not Recommended for New Design

Industry Part Number	Motorola Closest Replacement	Page No.
MRAL2327–006	—	
MRAL2327–012	—	
MRB12175YR	MRF1150MA	2–697
MRB12350YR	MRF10350	2–814
MRF0211	MRF0211LT1	2–432
MRF0211L	MRF0211LT1	2–432
MRF0211LT1	MRF0211LT1	2–432
MRF10005	MRF10005	2–799
MRF1000MA	MRF1000MA	2–685
MRF1000MB	MRF1000MB	2–685
MRF1000MC	MRF1000MA	2–685
MRF1001A*	MRF5812	2–542
MRF1002MA	—	
MRF1002MB	—	
MRF1002MC	—	
MRF10030	MRF10031	2–802
MRF10031	MRF10031	2–802
MRF1004MA	MRF1004MA	2–688
MRF1004MB	—	
MRF1004MC	MRF1004MA	2–688
MRF10070	MRF10070	2–805
MRF10120	MRF10120	2–808
MRF10150	MRF10150	2–811
MRF1015MA	—	
MRF1015MB	—	
MRF1015MC	—	
MRF1029	MRF1029	2–692
MRF1030	—	
MRF1031	—	
MRF1032	MRF1032	2–693
MRF10350	MRF10350	2–814
MRF1035MA	—	
MRF1035MB	—	
MRF1035MC	—	
MRF10500	MRF10500	2–817
MRF10501	MRF10501	2–817
MRF1090MA	MRF1090MA	2–694
MRF1090MB	—	
MRF1090MC	MRF1090MA	2–694
MRF1150M	MRF10150	2–811
MRF1150MA	MRF1150MA	2–697
MRF1150MB	—	
MRF1150MC	MRF1150MA	2–697
MRF1250M	MRF10350	2–814
MRF1325M	MRF10350	2–814
MRF134	MRF134	2–270
MRF136	MRF136	2–279
MRF136Y	MRF136Y	2–279
MRF137	MRF137	2–289
MRF1375	MRF1375	2–700
MRF138	MRF138	2–289
MRF140	MRF140	2–302
MRF140MP	MRF140	2–302
MRF141	MRF141	2–307
MRF141G	MRF141G	2–313
MRF148	MRF148	2–318
MRF148MP	MRF148	2–318
MRF150	MRF150	2–323
MRF1500	—	
MRF15030	MRF15030	2–820

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MRF15090	MRF15090	2–826
MRF150MP	MRF150	2–323
MRF151	MRF151	2–328
MRF151G	MRF151G	2–334
MRF153	MRF157	2–345
MRF154	MRF154	2–339
MRF154MP	MRF154	2–339
MRF157	MRF157	2–345
MRF158	MRF158	2–351
MRF158R*	–	
MRF160	MRF160	2–355
MRF16006	MRF16006	2–833
MRF16030	MRF16030	2–837
MRF161	MRF160	2–355
MRF162	MRF166C	2–364
MRF163*	MRF166C	2–364
MRF164W	MRF164W	2–361
MRF166	MRF166C	2–364
MRF166C	MRF166C	2–364
MRF166W	MRF166W	2–368
MRF171	MRF183	2–427
MRF171MP	MRF183	2–427
MRF172	MRF173	2–381
MRF173	MRF173	2–381
MRF173CQ	MRF173	2–381
MRF174	MRF174	2–386
MRF174MP	MRF174	2–386
MRF175GU	MRF175GU	2–394
MRF175GV	MRF175GV	2–394
MRF175LU	MRF175LU	2–401
MRF175LV	MRF175LV	2–401
MRF176GU	MRF176GU	2–408
MRF176GV	MRF176GV	2–408
MRF177	MRF177	2–416
MRF177M	MRF177M	2–416
MRF182	MRF182	2–422
MRF183	MRF183	2–427
MRF1946	MRF1946	2–703
MRF1946A	MRF1946A	2–703
MRF2000–5L	MRF2000–5L	2–707
MRF2001	MRW2001	2–954
MRF2005	MRW2005	2–954
MRF2005B	MRW2005	2–954
MRF201	MRF5003	2–727
MRF203	MRF247	2–443
MRF207	MRF4427	2–723
MRF208	—	
MRF212	MRF2628	2–711
MRF216	MRF247	2–443
MRF220	—	
MRF221	MRF2628	2–711
MRF222	MRF1946	2–703
MRF223	MRF1946	2–703
MRF224	MRF224	2–436
MRF226	MRF5015	2–745
MRF227*	MRF5003	2–727
MRF229	MRF5003	2–727
MRF231	MRF5003	2–727
MRF232	MRF2628	2–711
MRF233*	MRF2628	2–711

Industry Part Number	Motorola Closest Replacement	Page No.
MRF234	MRF1946	2–703
MRF2369*	MRF0211LT1	2–432
MRF237*	MRF5003	2–727
MRF238*	MRF1946	2–703
MRF239*	MRF1946	2–703
MRF240	MRF240	2–439
MRF240A*	MRF1946	2–703
MRF243	MRF247	2–443
MRF245*	MRF247	2–443
MRF247	MRF247	2–443
MRF248	MRF247	2–443
MRF255	MRF255	2–446
MRF260	—	
MRF262	—	
MRF2628	MRF2628	2–711
MRF264	—	
MRF3001	MRW3001	2–959
MRF3001F	MRW3001	2–959
MRF3003	MRW3003	2–959
MRF3003F	MRW3003	2–959
MRF3005	MRW3005	2–959
MRF3005F	MRW3005	2–959
MRF305	MRF325	2–475
MRF306	2N6439	2–2
MRF309	2N6439	2–2
MRF3094	MRF3094	2–715
MRF3095	MRF3095	2–715
MRF3096	MRF3096	2–715
MRF3104	MRF3104	2–720
MRF3105	MRF3105	2–720
MRF3106	MRF3106	2–720
MRF313	MRF313	2–453
MRF313A	MRF313	2–453
MRF314	MRF314	2–455
MRF314A	MRF314	2–455
MRF315*	—	
MRF315A	—	
MRF316	MRF316	2–459
MRF317	MRF317	2–463
MRF321	MRF321	2–467
MRF323	MRF323	2–471
MRF325	MRF325	2–475
MRF326	MRF326	2–479
MRF327	MRF327	2–483
MRF329	MRF329	2–487
MRF331	MRF321	2–467
MRF338*	MRF393	2–494
MRF340	—	
MRF342	—	
MRF344	—	
MRF3866	MRF3866R2	2–265
MRF3866R1	MRF3866R2	2–265
MRF3866R2	MRF3866R2	2–265
MRF390	MRF392	2–491
MRF392	MRF392	2–491
MRF393	MRF393	2–494
MRF401	MRF426	2–505
MRF402	MRF4427	2–723
MRF406	—	
MRF4070	MRF247	2–443

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MRF412	MRF492	2–521
MRF412A	MRF492	2–521
MRF415	MRF5003	2–727
MRF417	MRF455	2–519
MRF418	MRF455	2–519
MRF420	MRF454	2–517
MRF421	MRF421	2–497
MRF4217A*	——	
MRF422	MRF422	2–501
MRF422A	MRF422	2–501
MRF422MP	MRF422	2–501
MRF4239A	—	
MRF426	MRF426	2–505
MRF426A	MRF426	2–505
MRF427	MRF148	2–318
MRF427A	MRF148	2–318
MRF428	MRF429	2–509
MRF428A	MRF429	2–509
MRF429	MRF429	2–509
MRF429MP	MRF429	2–509
MRF430	MRF157	2–345
MRF430MP	MRF157	2–345
MRF433	MRF2628	2–711
MRF435	MRF422	2–501
MRF4427	MRF4427	2–723
MRF4427R1	MRF4427R2	2–723
MRF4427R2	MRF4427R2	2–723
MRF448	MRF448	2–513
MRF448MP	MRF448	2–513
MRF449	MRF1946	2–703
MRF449A	MRF1946	2–703
MRF450	MRF455	2–519
MRF450A	MRF455	2–519
MRF451	MRF455	2–519
MRF452	MRF455	2–519
MRF453	MRF454	2–517
MRF453A	MRF454	2–517
MRF454	MRF454	2–517
MRF454A	MRF454	2–517
MRF454MP	MRF454	2–517
MRF455	MRF455	2–519
MRF455A	MRF455	2–519
MRF458	MRF454	2–517
MRF458A	MRF454	2–517
MRF460	MRF455	2–519
MRF464	—	
MRF464A	—	
MRF466*	MRF137	2–289
MRF475	—	
MRF476	—	
MRF477	—	
MRF485	—	
MRF486	—	
MRF492	MRF492	2–521
MRF492A	MRF492	2–521
MRF497	—	
MRF5003	MRF5003	2–727
MRF5003R1	MRF5003R1	2–727
MRF5007	MRF5007	2–737
MRF5007R1	MRF5007R1	2–737
MRF501	MMBR5179LT1	2–264
MRF5015	MRF5015	2–745
MRF502	MMBR5179LT1	2–264
MRF5035	MRF5035	2–752
MRF504	MRF587	2–551
MRF511	MRF587	2–551
MRF515*	MRF559	2–536
MRF5160	—	
MRF517*	—	
MRF5174	—	
MRF5175	—	
MRF5176	MRF323	2–471
MRF5177	MRF325	2–475
MRF5177A	MRF325	2–475
MRF5178	2N6439	2–2
MRF521	MRF5211LT1	2–187
MRF5211	MRF5211LT1	2–187
MRF5211L	MRF5211LT1	2–187
MRF5211LT1	MRF5211LT1	2–187
MRF522	MRF5211LT1	2–187
MRF524	MRF5211LT1	2–187
MRF525	MRF5003	2–727
MRF526	MRF5812	2–542
MRF531	—	
MRF532	—	
MRF534	MMBR521LT1	2–187
MRF536	MMBR521LT1	2–187
MRF542	—	
MRF543	—	
MRF544	—	
MRF545	—	
MRF546	—	
MRF547	—	
MRF548	—	
MRF548	—	
MRF553	MRF553	2–524
MRF555	MRF555	2–528
MRF557	MRF557	2–532
MRF5583	—	
MRF5583R1	—	
MRF5583R2	—	
MRF559	MRF559	2–536
MRF571	MRF571	2–194
MRF5711	MRF5711LT1	2–194
MRF5711L	MRF5711LT1	2–194
MRF5711LT1	MRF5711LT1	2–194
MRF572	MRF571	2–194
MRF580	MRF581	2–542
MRF580A	MRF581A	2–542
MRF581	MRF581	2–542
MRF5811LT1	MRF5811LT1	2–759
MRF5812	MRF5812	2–542
MRF5812R1	MRF5812R1	2–542
MRF5812R2	MRF5812R2	2–542
MRF581A	MRF581A	2–542
MRF586*	MRF5812	2–542
MRF587	MRF587	2–551
MRF5943	MRF5943	2–766
MRF5943C	MRF5943	2–766
MRF5943R1	MRF5943R1	2–766

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MRF5943R2	MRF5943R2	2–766
MRF601	MRF559	2–536
MRF602	MRF644	2–561
MRF603	MRF2628	2–711
MRF604	MRF4427	2–723
MRF605	2N6439	2–2
MRF607	—	
MRF616	MRF652S	2–568
MRF618	MRF641	2–558
MRF619	MRF644	2–561
MRF620	MRF644	2–561
MRF627	—	
MRF628	MRF559	2–536
MRF629*	MRF5003	2–727
MRF630*	MRF5003	2–727
MRF6401	MRF6401	2–768
MRF6402	MRF6402	2–772
MRF6404	MRF6404	2–776
MRF6408	MRF6408	2–785
MRF641	MRF641	2–558
MRF6414	MRF6414	2–791
MRF644	MRF644	2–561
MRF646*	MRF650	2–564
MRF648*	MRF650	2–564
MRF650	MRF650	2–564
MRF652	MRF652	2–568
MRF652S	MRF652S	2–568
MRF653	MRF653	2–571
MRF653S	MRF653S	2–571
MRF654	MRF654	2–575
MRF658	MRF658	2–578
MRF660	—	
MRF750	MRF555	2–528
MRF752*	MRF5003	2–727
MRF754	—	
MRF816	MRF837	2–582
MRF837	MRF837	2–582
MRF8372	MRF8372	2–582
MRF8372R1	MRF8372R1	2–582
MRF8372R2	MRF8372R2	2–582
MRF838	MRF557	2–532
MRF838A	MRF557	2–532
MRF839*	MRF840	2–592
MRF839F	MRF839F	2–589
MRF840	MRF840	2–592
MRF841	—	
MRF841F*	—	
MRF842	MRF842	2–595
MRF843	MRF842	2–595
MRF843F	MRF842	2–595
MRF844	MRF844	2–599
MRF846*	MRF847	2–602
MRF847	MRF847	2–602
MRF857	MRF857	2–605
MRF857S	MRF857S	2–605
MRF858	MRF858	2–610
MRF858S	MRF858S	2–610
MRF859	MRF859	2–615
MRF859S	MRF859S	2–615
MRF860	MRF860	2–620

Industry Part Number	Motorola Closest Replacement	Page No.
MRF861	MRF861	2–625
MRF862	MRF862	2–630
MRF870	MRF840	2–592
MRF870A	MRF840	2–592
MRF873	—	
MRF873S	—	
MRF880	MRF880	2–635
MRF890	MRF890	2–640
MRF890S	MRF890	2–640
MRF891	MRF891	2–643
MRF891S	MRF891S	2–643
MRF892	MRF892	2–646
MRF894	MRF894	2–650
MRF896	MRF896	2–658
MRF896S	—	
MRF897	MRF897	2–658
MRF897A	—	
MRF897R	MRF897R	2–662
MRF898	MRF898	2–666
MRF899	MRF899	2–669
MRF901	MRF901	2–209
MRF9011	MRF9011LT1	2–209
MRF9011L	MRF9011LT1	2–209
MRF9011LT1	MRF9011LT1	2–209
MRF902	MRF901	2–209
MRF904*	MRF9011LT1	2–209
MRF905	MRF5812	2–542
MRF911*	MRF571	2–194
MRF912	MMBR911LT1	2–222
MRF914*	MRF571	2–194
MRF927T1	MRF927T1	2–674
MRF931	MRF9331LT1	2–795
MRF9331	MRF9331LT1	2–795
MRF9331L	MRF9331LT1	2–795
MRF9331LT1	MRF9331LT1	2–795
MRF941	MRF941	2–230
MRF9411	MRF9411LT1	2–230
MRF9411BL	MRF9411BLT1	2–230
MRF9411BLT1	MRF9411BLT1	2–230
MRF9411BLT3	MRF9411BLT3	2–230
MRF9411L	MRF9411LT1	2–230
MRF9411LT1	MRF9411LT1	2–230
MRF9411LT3	MRF9411LT1	2–230
MRF942	MRF941	2–230
MRF947	MRF947T1	2–230
MRF947AT1	MRF947AT1	2–230
MRF947AT3	MRF947AT1	2–230
MRF947B	MRF947BT1	2–230
MRF947BT1	MRF947BT1	2–230
MRF947BT3	MRF947BT3	2–230
MRF947RT1	MRF947RT3	2–230
MRF947RT3	MRF947RT3	2–230
MRF947T1	MRF947T1	2–230
MRF947T3	MRF947T3	2–230
MRF951	MRF951	2–247
MRF9511	MRF9511LT1	2–247
MRF9511ALT1	MRF9511ALT1	2–247
MRF9511ALT3	MRF9511ALT1	2–247
MRF9511L	MRF9511LT1	2–247
MRF9511LT1	MRF9511LT1	2–247

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MRF9511LT3	MRF9511LT1	2–247
MRF952	MRF951	2–247
MRF957	MRF957T1	2–247
MRF957T1	MRF957T1	2–247
MRF957T3	MRF957T1	2–247
MRF961	MRF951	2–247
MRF962	MRF951	2–247
MRF965	BFR96	2–14
MRF966	—	
MRFA2600	MRFA2600	2–841
MRFA2602	MRFA2602	2–844
MRFA2604	MRFA2604	2–848
MRFIC0001	MRFIC0001	2–855
MRFIC0001R2	MRFIC0001R2	2–855
MRFIC0903	MRFIC0903	2–857
MRFIC0903R2	MRFIC0903R2	2–857
MRFIC0904	MRFIC0904	2–863
MRFIC0904R2	MRFIC0904R2	2–863
MRFIC0913	MRFIC0913	1–23
MRFIC0913R2	MRFIC0913R2	1–23
MRFIC0914	MRFIC0914	1–23
MRFIC0914R2	MRFIC0914R2	1–23
MRFIC0916	MRFIC0916	2–869
MRFIC0916T1	MRFIC0916T1	2–869
MRFIC1801	MRFIC1801	2–875
MRFIC1801R2	MRFIC1801R2	2–875
MRFIC1803	MRFIC1803	2–878
MRFIC1803R2	MRFIC1803R2	2–878
MRFIC1804	MRFIC1804	2–883
MRFIC1804R2	MRFIC1804R2	2–883
MRFIC1806	MRFIC1806	2–888
MRFIC1806R2	MRFIC1806R2	2–888
MRFIC1807	MRFIC1807	2–898
MRFIC1807R2	MRFIC1807R2	2–898
MRFIC1808	MRFIC1808	1–21
MRFIC1808R2	MRFIC1808R2	1–21
MRFIC1814	MRFIC1814	1–21
MRFIC1814R2	MRFIC1814R2	1–21
MRFIC2001	MRFIC2001	2–905
MRFIC2001R2	MRFIC2001R2	2–905
MRFIC2002	MRFIC2002	2–911
MRFIC2002R2	MRFIC2002R2	2–911
MRFIC2003	MRFIC2003	2–916
MRFIC2003R2	MRFIC2003R2	2–916
MRFIC2004	MRFIC2004	2–919
MRFIC2004R2	MRFIC2004R2	2–919
MRFIC2006	MRFIC2006	2–924
MRFIC2006R2	MRFIC2006R2	2–924
MRFIC2101	MRFIC2101	2–931
MRFIC2101R2	MRFIC2101R2	2–931
MRFIC2401	MRFIC2401	2–938
MRFIC2401R2	MRFIC2401R2	2–938
MRFIC2403	MRFIC2403	2–945
MRFIC2403R2	MRFIC2403R2	2–945
MRFIC2404	MRFIC2404	2–950
MRFIC2404R2	MRFIC2404R2	2–950
MRFQ17*	—	
MRFQ17R1	—	
MRFQ19	—	
MRT0105–75	MRF393	2–494
MRT0105–75V	MRF393	2–494
MRT0204–110V	MRF392	2–491
MRT0204–125	MRF392	2–491
MRW2001	MRW2001	2–954
MRW2001F	MRW2001	2–954
MRW2003*	—	
MRW2005	MRW2005	2–954
MRW2005F	MRW2005	2–954
MRW2010	—	
MRW2015	—	
MRW2020	—	
MRW205E	—	
MRW2301	—	
MRW2301F	—	
MRW2304	—	
MRW2304F	—	
MRW2307*	—	
MRW2307F	—	
MRW3001	MRW3001	2–959
MRW3001F	MRW3001	2–959
MRW3003	MRW3003	2–959
MRW3003F	MRW3003	2–959
MRW3005	MRW3005	2–959
MRW3005F	MRW3005	2–959
MRW52001	—	
MRW52501	—	
MRW52504	—	
MRW52601*	—	
MRW52602	—	
MRW52604*	—	
MRW53001	—	
MRW53101	MRW53601	2–963
MRW53102	—	
MRW53201	MRW53601	2–963
MRW53401	MRW53601	2–963
MRW53501*	—	
MRW53502	—	
MRW53505	—	
MRW53601	MRW53601	2–963
MRW53602	—	
MRW53605	—	
MRW54001	MRW54001	2–966
MRW54101	—	
MRW54501	MRW54601	2–966
MRW54601	MRW54601	2–966
MSC1000M	MRF1000MA	2–685
MSC1002M	—	
MSC1004M	MRF1004MA	2–688
MSC1015M	—	
MSC1035M	—	
MSC1075M	MRF1090MA	2–694
MSC1090M	MRF1090MA	2–694
MSC1175M	MRF10150	2–811
MSC1250M	MRF10350	2–814
MSC1325M	MRF10350	2–814
MSC2001	MRW2001	2–954
MSC2005	MRW2005	2–954
MSC82001	MRW2001	2–954
MSC82005	MRW2005	2–954
MSC82201	MRW2001	2–954

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
MWA0204	—	
MWA0211L	—	
MWA0211LT1	—	
MWA0304	—	
MWA0311L	—	
MWA0311LT1	—	
MWA110	—	
MWA120	—	
MWA130	—	
MWA131*	—	
MWA210	—	
MWA220	—	
MWA230	—	
MWA310	—	
MWA320	—	
MWA330	—	
MWA5121	—	
MX20–1	MHW720A1	2–92
MX20–2	MHW720A2	2–92
MXR100	MRF5812	2–542
MXR3866	MRF3866R2	2–265
MXR5583	—	
MXR571	MRF5711LT1	2–194
MXR5943	MRF5943	2–766
MXR911	MMBR911LT1	2–222
NE020320–12	MRF5003	2–727
NE020320–28	MRF321	2–467
NE020620–07	MRF653	2–571
NE021020–12	MRF653	2–571
NE021020–28	MRF321	2–467
NE02107	MRF571	2–194
NE02132	MPS571	2–194
NE02133	MMBR571LT1	2–194
NE02137	MRF0211LT1	2–432
NE022025–12	MRF2628	2–711
NE022025–28	MRF314	2–455
NE022526–12	MRF1946	2–703
NE028029–12	MRF247	2–443
NE028029–28	MRF316	2–459
NE050214–12	MRF5003	2–727
NE050320–12	MRF5003	2–727
NE051020–28	MRF321	2–467
NE051025–12	MRF653	2–571
NE051525–12	MRF654	2–575
NE052025–28	MRF323	2–471
NE080420–12	MRF840	2–592
NE21935	MRF571	2–194
NE21937	MRF571	2–194
NE22120	MRF587	2–551
NE24615	MRF5812	2–542
NE24620	MRF587	2–551
NE32702	MMBR911LT1	2–222
NE32707	MMBR911LT1	2–222
NE41603	MRF951	2–247
NE41607	MRF951	2–247
NE41610	BFR96	2–14
NE41612	BFR96	2–14
NE41615	BFR96	2–14
NE41620	MRF587	2–551
NE41635	MRF951	2–247
NE57510	MRF5812	2–542
NE57520	MRF587	2–551
NE57803	MRF941	2–230
NE57807	MRF941	2–230
NE59312	MMBR521LT1	2–187
NE59335	MRF5812	2–542
NE59503	MRF581	2–542
NE64310	MRF5812	2–542
NE64320	MRF587	2–551
NE68132	MPS571	2–194
NE68133	MMBR571LT1	2–194
NE68137	MRF571	2–194
NE73412	MRF571	2–194
NE73432	MMBR911LT1	2–222
NE73433	MMBR911LT1	2–222
NE73435	MMBR911LT1	2–222
NE73437	MMBR911LT1	2–222
NE74014	MRF5812	2–542
NE74020	MRF587	2–551
NE74113	MRF5812	2–542
NE74114	MRF5812	2–542
NE77320	MRF587	2–551
NE85632	MPS571	2–194
NE85633	MMBR571LT1	2–194
NE85637	MRF571	2–194
NE88912	MMBR521LT1	2–187
NE88933	MMBR521LT1	2–187
NEL080120–24	MRF890	2–640
NEM020C29–28	MRF317	2–463
NEM050C29–28	MRF327	2–483
NEM054029–28	MRF325	2–475
NEM056029–12	MRF658	2–578
NEM056029–28	2N6439	2–2
NEM080481E–12	MRF839F	2–589
NEM081081B–12	MRF840	2–592
NEM081081E–12	MRF842	2–595
NEM082081B–12	MRF842	2–595
NEM084081B–12	MRF844	2–599
NEM085081B–12	MRF847	2–602
NEM090701–7	MRF840	2–592
NEM092081B–28	MRF892	2–646
NEM094081B–28	MRF894	2–650
ON4184	MPS901	2–209
PEE0015U	MRF323	2–471
PEE0020U	MRF323	2–471
PEE0035U	MRF325	2–475
PH0105–100	MRF393	2–494
PH0412H	MRF321	2–467
PH0425H	MRF325	2–475
PH0450D	2N6439	2–2
PH0450H	2N6439	2–2
PH0506H	MRF321	2–467
PH0512H	MRF321	2–467
PH0525H	MRF325	2–475
PH0550H	2N6439	2–2
PH1100C	MRF1150MA	2–697
PH1100H	MRF1150MA	2–697
PH1110C	—	
PH1150C	MRF1090MA	2–694
PH1175	MRF1150MA	2–697

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
PH8193	MRF5812	2–542
PHA3317–1	MHW5172A	2–143
PHA3317–2	MHW5172A	2–143
PHA3318–1	MHW5182A	2–145
PHA3318–2	MHW5182A	2–145
PHA3334–2	MHW5272A	2–154
PHA4517–1	MHW5172A	2–143
PHA4517–2	MHW5172A	2–143
PHA4518–1	MHW5182A	2–145
PHA4518–2	MHW5182A	2–145
PHA4534	MHW5342A	2–156
PHA5018–1	MHW6182	2–163
PHA5018–2	MHW6182	2–163
PHA5034	MHW5342A	2–156
PME04030U	MRF325	2–475
PT3501	MRF4427	2–723
PT3503	MRF5003	2–727
PT3535	MRF4427	2–723
PT3536	MRF553	2–524
PT3537	MRF5003	2–727
PT3570	MRF587	2–551
PT3571	MRF5943	2–766
PT3571A	MRF5943	2–766
PT3690	MRF134	2–270
PT4537	MRF5003	2–727
PT4555	MRF1946	2–703
PT4570	MRF587	2–551
PT4572A	MRF587	2–551
PT4574	MRF587	2–551
PT4579	MRF5812	2–542
PT4599G	MRF5812	2–542
PT4617	MRF587	2–551
PT5695	MRF2628	2–711
PT5701	MRF4427	2–723
PT5740	MRF2628	2–711
PT5741	MRF1946	2–703
PT5788	—	
PT62602	—	
PT6665A	—	
PT8549	MRF5003	2–727
PT8554A	MRF492	2–521
PT8717	MRF5003	2–727
PT8769	MRF2628	2–711
PT8809	MRF5003	2–727
PT8809S	MRF652S	2–568
PT8810	MRF652	2–568
PT8811	MRF653	2–571
PT8811A	MRF653	2–571
PT8825	MRF644	2–561
PT8837	MRF2628	2–711
PT8838	MRF1946	2–703
PT8851A	MRF2628	2–711
PT8852	MRF1946	2–703
PT8852A	MRF1946	2–703
PT8854	MRF492	2–521
PT8854A	MRF492	2–521
PT8860	MRF4427	2–723
PT8861A	MRF5003	2–727
PT8863	MRF1946	2–703
PT8863A	MRF1946	2–703
PT8864	MRF224	2–436
PT8864A	MRF1946	2–703
PT8865	MRF492	2–521
PT8865A	MRF492	2–521
PT8866	MRF5003	2–727
PT8870A	MRF2628	2–711
PT8871	MRF652S	2–568
PT8871A	MRF5003	2–727
PT8873A	MRF2628	2–711
PT8874	MRF224	2–436
PT8874A	MRF1946	2–703
PT8877	MRF5003	2–727
PT8881	MRF652S	2–568
PT8881A	MRF5003	2–727
PT8889	MRF5812	2–542
PT9073B	MRF321	2–467
PT9604	—	
PT9624	—	
PT9701B	MRF321	2–467
PT9702	MRF323	2–471
PT9702B*	MRF323	2–471
PT9703	MRF321	2–467
PT9703B	MRF321	2–467
PT9704	MRF325	2–475
PT9704A	MRF325	2–475
PT9704B	MRF166C	2–364
PT9730	MRF321	2–467
PT9730F	—	
PT9731	MRF314	2–455
PT9731F	MRF323	2–471
PT9732	MRF321	2–467
PT9733	MRF314	2–455
PT9734	MRF323	2–471
PT9734F	MRF323	2–471
PT9776	MRF492	2–521
PT9776A	MRF492	2–521
PT9780	MRF422	2–501
PT9780A	MRF422	2–501
PT9782	MRF317	2–463
PT9782A	MRF317	2–463
PT9783	—	
PT9783A	—	
PT9784	MRF454	2–517
PT9784A	MRF454	2–517
PT9785	MRF421	2–497
PT9788	MRF426	2–505
PT9788A	MRF426	2–505
PT9790	—	
PT9795	MRF1946	2–703
PT9795A	MRF2628	2–711
PT9796	MRF1946	2–703
PT9796A	MRF1946	2–703
PT9798	MRF429	2–509
PT9847	MRF421	2–497
PTE801	MRF890	2–640
RATV5030	—	
RATV5030P	—	
RATV5090B	MRFA2604	2–848
RATV6031	—	
RATV7060P	—	

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
RF1004	MRF1946	2–703
RF1023	MRF321	2–467
RF1023R	MRF321	2–467
RF1029	MRF1029	2–692
RF1030	—	
RF1031	—	
RF1032	MRF1032	2–693
RF105	MRF421	2–497
RF1052	—	
RF1053	—	
RF110	MRF421	2–497
RF14	MRF455	2–519
RF15	MRF455	2–519
RF16	MRF455	2–519
RF2081	MRF247	2–443
RF2092	MRF455	2–519
RF2123	MRF1946	2–703
RF2127	MRF247	2–443
RF2135	MRF1946	2–703
RF2143	MRF454	2–517
RF2144	MRF224	2–436
RF23	MRF224	2–436
RF25	MRF455	2–519
RF3065	—	
RF3094	MRF3094	2–715
RF3095	MRF3095	2–715
RF3096	MRF3096	2–715
RF3104	MRF3104	2–720
RF3105	MRF3105	2–720
RF3106	MRF3106	2–720
RF3114	—	
RF3118	—	
RF35	MRF455	2–519
RF45	MRF455	2–519
RF46	MRF1946	2–703
RF48	MRF1946	2–703
RF49	MRF1946	2–703
RF85	MRF454	2–517
RFA6031	MRFA2600	2–841
RFA6060	MRFA2602	2–844
RFA8090B	RFA8090B	2–969
RFA8180B*	MRFA2604	2–848
S–AU16H	MHW707–2	2–85
S–AU27L	MHW720A1	2–92
S–AU27M	MHW720A2	2–92
S–AU9	MHW913	2–111
S–AV16H	MHW607–2	2–78
S–AV16L	MHW607–1	2–78
S–AV16VH	MHW607–2	2–78
SD1005	MRF587	2–551
SD1006	MRF5943	2–766
SD1007–1	MRF587	2–551
SD1012	MRF5003	2–727
SD1013	MRF134	2–270
SD1014–2	MRF2628	2–711
SD1015	MRF314	2–455
SD1018	MRF1946	2–703
SD1018–15	MRF224	2–436
SD1018–6	MRF224	2–436
SD1019	MRF316	2–459

*Active, Not Recommended for New Design

Industry Part Number	Motorola Closest Replacement	Page No.
SD102–6	MRF313	2–453
SD102–7	MRF313	2–453
SD1021	MRF2628	2–711
SD1022	MRF1946	2–703
SD1074	MRF455	2–519
SD1076	MRF454	2–517
SD1078	—	
SD1080–4	MRF4427	2–723
SD1080–7	MRF557	2–532
SD1087	MRF641	2–558
SD1088	MRF644	2–561
SD1095	MRF840	2–592
SD1096	MRF842	2–595
SD1098	MRF844	2–599
SD1099	MRF847	2–602
SD1124	MRF247	2–443
SD1127	MRF5003	2–727
SD1131	MRF5003	2–727
SD1132–5	MRF557	2–532
SD1133	MRF2628	2–711
SD1133–1	MRF2628	2–711
SD1134	MRF5003	2–727
SD1134–1	MRF5003	2–727
SD1135	MRF652	2–568
SD1135–3	MRF652S	2–568
SD1136	MRF653	2–571
SD1143	MRF2628	2–711
SD1146	MRF2628	2–711
SD1148	MRF321	2–467
SD1149	MRF323	2–471
SD1150	MRF652	2–568
SD1150–3	MRF652S	2–568
SD1168	MRF1946	2–703
SD1174	MRF5003	2–727
SD1177	MRF5003	2–727
SD1200	MRF3866R2	2–265
SD1212–2	MRF5003	2–727
SD1214–12	MRF2628	2–711
SD1216	MRF1946	2–703
SD1218	MRF1946	2–703
SD1220	MRF134	2–270
SD1220–1	MRF134	2–270
SD1224–10	MRF137	2–289
SD1224–4	MRF137	2–289
SD1229–1	MRF1946	2–703
SD1229–7	MRF1946	2–703
SD1242–5	MRF134	2–270
SD1245	MRF321	2–467
SD1256	MRF5003	2–727
SD1272	MRF1946	2–703
SD1272–2	MRF1946	2–703
SD1273	MRF240	2–439
SD1274	MRF1946	2–703
SD1274–1	MRF1946	2–703
SD1275–1	MRF224	2–436
SD1278	MRF240	2–439
SD1288	MRF455	2–519
SD1289	MRF455	2–519
SD1295	MRF421	2–497
SD1299	MRF326	2–479

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
SD1308	MRF5812	2–542
SD1309	MMBR5179LT1	2–264
SD1315	MRF587	2–551
SD1316	MRF5812	2–542
SD1317	MRF587	2–551
SD1330	MRF571	2–194
SD1331	MRF571	2–194
SD1332	MRF901	2–209
SD1333	MRF951	2–247
SD1334	MRF581	2–542
SD1347–7	MRF4427	2–723
SD1375	—	
SD1398	—	
SD1400–2	MRF892	2–646
SD1400–3	MRF892	2–646
SD1401	MRF894	2–650
SD1402	MRF559	2–536
SD1403	MRF429	2–509
SD1405	MRF454	2–517
SD1407	MRF422	2–501
SD1407–8	MRF317	2–463
SD1409	MRF840	2–592
SD1410	MRF840	2–592
SD1410–1	MRF842	2–595
SD1410–3	MRF840	2–592
SD1411	MRF448	2–513
SD1412	MRF842	2–595
SD1412–3	MRF842	2–595
SD1414	MRF847	2–602
SD1415	MRF247	2–443
SD1416	MRF247	2–443
SD1418	MRF842	2–595
SD1420	TP3008	2–977
SD1420–1	MRF890	2–640
SD1421	MRF844	2–599
SD1422	MRF644	2–561
SD1423	—	
SD1424	—	
SD1426	MRF898	2–666
SD1427	MRF247	2–443
SD1428	MRF247	2–443
SD1429	MRF641	2–558
SD1429–3	MRF641	2–558
SD1430	MRF1946	2–703
SD1433	MRF653	2–571
SD1438	MRF316	2–459
SD1438–2	MRF317	2–463
SD1439	TPV596A	2–1002
SD1444	MRF5003	2–727
SD1446	MRF492	2–521
SD1448	TPV598	2–1008
SD1449	TPV597	2–1005
SD1450	MRF422	2–501
SD1451	MRF455	2–519
SD1451–1	MRF455	2–519
SD1452	MRF454	2–517
SD1461	MRF313	2–453
SD1462	MRF327	2–483
SD1463	MRF392	2–491
SD1464	MRF393	2–494
SD1466	MRF326	2–479
SD1467	MRF326	2–479
SD1468	MRF327	2–483
SD1469	MRF329	2–487
SD1470	MRF329	2–487
SD1475	MRF321	2–467
SD1484–10	MRF4427	2–723
SD1487	MRF421	2–497
SD1490	TPV7025	2–1015
SD1492	TPV8100B	2–1018
SD1495	MRF894	2–650
SD1495–3	MRF894	2–650
SD1496	MRF898	2–666
SD1496–3	MRF898	2–666
SD1499	MRF393	2–494
SD1499–1	MRF658	2–578
SD1512	MRF10005	2–799
SD1513	MRF10031	2–802
SD1514	MRF10150	2–811
SD1520	MRF1000MA	2–685
SD1520–3	MRF1000MB	2–685
SD1522	MRF1000MA	2–685
SD1522–3	—	
SD1522–4	—	
SD1524	MRF1004MA	2–688
SD1524–1	—	
SD1528	—	
SD1528–6	—	
SD1530	—	
SD1530–1	—	
SD1532	MRF1090MA	2–694
SD1534	MRF1090MA	2–694
SD1534–1	—	
SD1536	MRF1090MA	2–694
SD1536–3	—	
SD1538	MRF1150MA	2–697
SD1538–2	MRF10150	2–811
SD1538–8	MRF10150	2–811
SD1540	MRF10350	2–814
SD1540–8	MRF10350	2–814
SD1541	MRF10500	2–817
SD1541–1	MRF10500	2–817
SD1541–9	MRF10500	2–817
SD1542	MRF10500	2–817
SD1546–1	—	
SD1554	MRF10070	2–805
SD1555	MRF10070	2–805
SD1556	MRF10350	2–814
SD1557	MRF10350	2–814
SD1650	—	
SD1680	TP3069	2–989
SD1724–1	—	
SD1726	MRF429	2–509
SD1727	MRF429	2–509
SD1728	MRF448	2–513
SD1729	MRF422	2–501
SD1730	MRF422	2–501
SD1731	MRF448	2–513
SD1847	–	
SD1900	MRF134	2–270

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
SD1900–1	MRF160	2–355
SD1902	MRF136	2–279
SD1902–1	MRF166C	2–364
SD1904	MRF137	2–289
SD1904–1	MRF166C	2–364
SD1905	MRF183	2–427
SD1906–1	MRF173	2–381
SD1907	MRF173	2–381
SD1908–1	MRF174	2–386
SD1912	MRF141	2–307
SD1912–2	MRF141G	2–313
SD1918	MRF148	2–318
SD1920	MRF151	2–328
SD1920–2	MRF151G	2–334
SD4011	TPV598	2–1008
SD4590	MRF899	2–669
ST1001	MRF166C	2–364
ST1002	MRF183	2–427
ST1004	MRF173	2–381
ST1005	MRF173	2–381
ST1006	MRF175LV	2–401
ST1007	MRF164W	2–361
ST1010	MRF174	2–386
ST1011	MRF174	2–386
ST1014	MRF166C	2–364
ST1015	MRF177M	2–416
ST1016	MRF136Y	2–279
ST1019	MRF177	2–416
ST1020	MRF175GU	2–394
ST1027	MRF141G	2–313
ST1028	MRF141G	2–313
STM915–12	MHW914	2–114
TAN15	—	
TAN150H	MRF1150MA	2–697
TAN250A	MRF10350	2–814
TAN75	MRF1090MA	2–694
TCC0105–100	MRF393	2–494
TCC0204–125	MRF392	2–491
TCC20L08	MRF3095	2–715
TCC20L15	MRF3096	2–715
TCC2100	MRF3094	2–715
TCC3000	MRW3001	2–959
TCC3001	MRW3001	2–959
TCC3003	MRW3003	2–959
TCC3005	MRW3005	2–959
TCC598	TPV598	2–1008
TP1940	MRF151G	2–334
TP2031	MRF5003	2–727
TP2033	MRF1946	2–703
TP2034	MRF1946	2–703
TP2034F	MRF224	2–436
TP2037	MRF1946	2–703
TP212	MRF5003	2–727
TP2180	MRF247	2–443
TP2300	MRF5003	2–727
TP2304	MRF1946	2–703
TP2307	MRF5003	2–727
TP2314	MRF5003	2–727
TP2325	MRF1946	2–703
TP2330	MRF1946	2–703
TP2330F	MRF1946	2–703
TP2335	MRF1946	2–703
TP2370	MRF247	2–443
TP2502	MRF652S	2–568
TP2503	MRF652	2–568
TP2505	MRF652	2–568
TP2505S	MRF652	2–568
TP2510	MRF653	2–571
TP2511	MRF653	2–571
TP2520	MRF644	2–561
TP254	MRF652	2–568
TP3004	TP3008	2–977
TP3005	TP3008	2–977
TP3006	TP3008	2–977
TP3007	TP3007S	2–973
TP3007S	TP3007S	2–973
TP3008	TP3008	2–977
TP3009	MRF557	2–532
TP3009S	MRF557	2–532
TP301	MRF557	2–532
TP3010	MRF557	2–532
TP3010S	MRF557	2–532
TP3011	MRF840	2–592
TP3011S	MRF840	2–592
TP3012	MRF842	2–595
TP3013	MRF840	2–592
TP3015	MRF842	2–595
TP3019S	TP3007S	2–973
TP301S	MRF557	2–532
TP302	MRF840	2–592
TP3020A*	TP3008	2–977
TP3020AS	TP3008	2–977
TP3021	TP3021	2–981
TP3022A	TP3021	2–981
TP3022B	TP3021	2–981
TP3023	TP3008	2–977
TP3024A	TP3034	2–985
TP3024B	TP3034	2–985
TP3024BR	TP3034	2–985
TP302S	MRF840	2–592
TP303	MRF840	2–592
TP3031	—	
TP3032	—	
TP3034	TP3034	2–985
TP303S	MRF840	2–592
TP3040	—	
TP3060	—	
TP3061	MRF6414	2–791
TP3062	—	
TP3064	—	
TP3069	TP3069	2–989
TP3093	MRF5812	2–542
TP312	BFR96	2–14
TP3400	MRF587	2–551
TP3401	MRF587	2–551
TP3401S	MRF581	2–542
TP393	MMBR911LT1	2–222
TP394	MRF5812	2–542
TP4001	MRF6401	2–768
TP4001S	MRF6401	2–768

*Active, Not Recommended for New Design

INDEX AND CROSS REFERENCE (continued)

Industry Part Number	Motorola Closest Replacement	Page No.
TP4004	MRF6402	2–772
TP4035	MRF6404	2–776
TP491	MMBR911LT1	2–222
TP5002	TP5002S	2–994
TP5002S	TP5002S	2–994
TP5015	TP5015	2–997
TP5015R	—	
TP5025	MRF323	2–471
TP5040	TP5051	2–998
TP5050	TP5051	2–998
TP5051	TP5051	2–998
TP5060	MRF393	2–494
TP62601	—	
TP62602	—	
TP63602A	—	
TP8828	MRF2628	2–711
TP9380	MRF173	2–381
TP9380RS	MRF173	2–381
TP9383	MRF141	2–307
TP9383A	MRF151	2–328
TP9383RS	MRF141	2–307
TP9383SE	MRF141	2–307
TP9383T	MRF151	2–328
TP9386	MRF141	2–307
TP9390	MRF151G	2–334
TPA0102–130	MRF392	2–491
TPM401	—	
TPM4040	—	
TPM405	—	
TPM4100	MRF392	2–491
TPM4130	—	
TPM4131S	—	
TPM425	MRF325	2–475
TPR10	—	
TPR150	—	
TPR50	—	
TPS1010	MRF652S	2–568
TPS1011	—	
TPV1325B	MRF151G	2–334
TPV3100	—	
TPV3250B	MRF151G	2–334
TPV364	—	
TPV375	—	
TPV376	—	
TPV385	—	
TPV387	—	
TPV5051	—	
TPV5055B	—	
TPV590	—	
TPV591	—	
TPV593	—	
TPV595A*	—	
TPV596	TPV596A	2–1002
TPV596A	TPV596A	2–1002
TPV597	TPV597	2–1005
TPV598	TPV598	2–1008
TPV6030	TPV6030	2–1013
TPV6080B	TPV8100B	2–1018
TPV693	—	
TPV695A	TPV695A	2–1010
TPV698	TPV598	2–1008
TPV7025	TPV7025	2–1015
TPV7025C	—	
TPV8100B	TPV8100B	2–1018
TPV8200B	TPV8100B	2–1018
TRF559	MRF559	2–536
TRW2001	MRW2001	2–954
TRW2005	MRW2005	2–954
TRW3001	MRW3001	2–959
TRW3003	MRW3003	2–959
TRW3005	MRW3005	2–959
TRW53101	MRW53601	2–963
TRW53201	MRW53601	2–963
TRW53401	MRW53601	2–963
TRW53601	MRW53601	2–963
TRW54001	MRW54001	2–966
TRW54601	MRW54601	2–966
TRW62601	—	
TRW64602	—	
TSD1275	MRF240	2–439
UF28100V	MRF177	2–416
UF2815B	MRF166C	2–364
UF2820P	MRF136Y	2–279
UTV005	TPV596A	2–1002
UTV010	TPV597	2–1005
UTV040	TPV598	2–1008
UTV080	TPV695A	2–1010
UTV120	TPV695A	2–1010
UTV150	TPV7025	2–1015
UTV1500	TPV8100B	2–1018
UTV200	TPV7025	2–1015
VTV1250	MRF141	2–307

*Active, Not Recommended for New Design

MOTOROLA AUTHORIZED DISTRIBUTOR & WORLDWIDE SALES OFFICES

NORTH AMERICAN DISTRIBUTORS

UNITED STATES

ALABAMA

Huntsville

Arrow/Schweber Electronics . . . (205)837–6955
FAI . . . . (205)837–9209
Future Electronics . . . . (205)830–2322
Hamilton/Hallmark . . . . (205)837–8700
Newark . . . . (205)837–9091
Time Electronics 1–800–789–TIME
Wyle Electronics . . . . (205)830–1119

ARIZONA

Phoenix

FAI . . . . (602)731–4661
Future Electronics . . . . (602)968–7140
Hamilton/Hallmark . . . . (602)414–3000
Wyle Electronics . . . . (602)804–7000

Tempe

Arrow/Schweber Electronics . . . (602)431–0030
Newark . . . . (602)966–6340
PENSTOCK . . . . (602)967–1620
Time Electronics 1–800–789–TIME

CALIFORNIA

Agoura Hills

Future Electronics . . . . (818)865–0040
Time Electronics Corporate . . 1–800–789–TIME

Belmont

Richardson Electronics . . . . . . (415)592–9225

Calabassas

Arrow/Schweber Electronics . . . (818)880–9686
Wyle Electronics . . . . (818)880–9000

Chatsworth

Time Electronics 1–800–789–TIME

Costa Mesa

Hamilton/Hallmark . . . . (714)789–4100

Culver City

Hamilton/Hallmark . . . . (310)558–2000

Garden Grove

Newark . . . . (714–893–4909

Irvine

Arrow/Schweber Electronics . . (714)587–0404
FAI . . . . (714)753–4778
Future Electronics . . . . (714)453–1515
Wyle Laboratories Corporate . . . (714)753–9953
Wyle Electronics . . . . (714)863–9953

Los Angeles

FAI . . . . (818)879–1234
Wyle Electronics . . . . (818)880–9000

Manhattan Beach

PENSTOCK . . . . (310)546–8953

Mountain View

Richardson Electronics . . . . . . (415)960–6900

Newberry Park

PENSTOCK . . . . (805)375–6680

Palo Alto

Newark . . . . (415)812–6300

Riverside

Newark . . . . (909)784–1101

Rocklin

Hamilton/Hallmark . . . . (916)632–4500

Sacramento

FAI . . . . (916)782–7882
Newark . . . . (916)565–1760
Wyle Electronics . . . . (916)638–5282

San Diego

Arrow/Schweber Electronics . . (619)565–4800
FAI . . . . (619)623–2888
Future Electronics . . . . (619)625–2800
Hamilton/Hallmark . . . . (619)571–7540
Newark . . . . (619)453–8211
PENSTOCK . . . . (619)623–9100
Wyle Electronics . . . . (619)565–9171

San Jose

Arrow/Schweber Electronics . . . (408)441–9700
Arrow/Schweber Electronics . . . (408)428–6400
FAI . . . . (408)434–0369
Future Electronics . . . . (408)434–1122

Santa Clara

Wyle Electronics . . . . (408)727–2500

Sierra Madre

PENSTOCK . . . . (818)355–6775

Sunnyvale

Hamilton/Hallmark . . . . (408)435–3500
PENSTOCK . . . . (408)730–0300
Time Electronics 1–800–789–TIME

Thousand Oaks

Newark . . . . (805)449–1480

Torrance

Time Electronics 1–800–789–TIME

Tustin

Time Electronics 1–800–789–TIME

Woodland Hills

Hamilton/Hallmark . . . . (818)594–0404
Richardson Electronics . . . . . . (615)594–5600

COLORADO

Lakewood

FAI . . . . (303)237–1400
Future Electronics . . . . (303)232–2008

Denver

Newark . . . . (303)373–4540

Englewood

Arrow/Schweber Electronics . . . (303)799–0258
Hamilton/Hallmark . . . . (303)790–1662
PENSTOCK . . . . (303)799–7845
Time Electronics 1–800–789–TIME

Thornton

Wyle Electronics . . . . (303)457–9953

CONNECTICUT

Bloomfield

Newark . . . . (203)243–1731

Cheshire

FAI . . . . (203)250–1319
Future Electronics . . . . (203)250–0083
Hamilton/Hallmark . . . . (203)271–2844

Southbury

Time Electronics 1–800–789–TIME

Wallingfort

Arrow/Schweber Electronics . . . (203)265–7741

FLORIDA

Altamonte Springs

Future Electronics . . . . (407)865–7900

Clearwater

FAI . . . . (813)530–1665
Future Electronics . . . . (813)530–1222

Deerfield Beach

Arrow/Schweber Electronics . . . (305)429–8200
Wyle Electronics . . . . (305)420–0500

Ft. Lauderdale

FAI . . . . (305)428–9494
Future Electronics . . . . (305)436–4043
Hamilton/Hallmark . . . . (305)484–5482
Newark . . . . (305)486–1151
Time Electronics 1–800–789–TIME

Lake Mary

Arrow/Schweber Electronics . . . (407)333–9300

Largo/Tampa/St. Petersburg

Hamilton/Hallmark . . . . (813)547–5000
Newark . . . . (813)287–1578
Wyle Electronics . . . . (813)576–3004
Time Electronics 1–800–789–TIME

Orlando

FAI . . . . (407)865–9555

Tallahassee

FAI . . . . (904)668–7772

Tampa

PENSTOCK . . . . (813)247–7556

Winter Park

Hamilton/Hallmark . . . . (407)657–3300
PENSTOCK . . . . (407)672–1114
Richardson Electronics . . . . . . (407)644–1453

GEORGIA

Atlanta

FAI . . . . (404)447–4767
Time Electronics 1–800–789–TIME
Wyle Electronics . . . . (404)441–9045

Duluth

Arrow/Schweber Electronics . . . (404)497–1300
Hamilton/Hallmark . . . . (404)623–4400

Norcross

Future Electronics . . . . (770)441–7676
Newark . . . . (770)448–1300
PENSTOCK . . . . (770)734–9990
Wyle Electronics . . . . (770)441–9045

IDAHO

Boise

FAI . . . . (208)376–8080

ILLINOIS

Addison

Wyle Laboratories . . . . (708)620–0969

Bensenville

Hamilton/Hallmark . . . . (708)797–7322

Chicago

FAI . . . . (708)843–0034
Newark Electronics Corp. . . . . (312)784–5100

Hoffman Estates

Future Electronics . . . . (708)882–1255

Itasca

Arrow/Schweber Electronics . . (708)250–0500

LaFox

Richardson Electronics . . . . . . (708)208–2401

Palatine

PENSTOCK . . . . (708)934–3700

Schaumburg

Newark . . . . (708)310–8980
Time Electronics 1–800–789–TIME

INDIANA

Indianapolis

Arrow/Schweber Electronics . . . (317)299–2071
Hamilton/Hallmark . . . . (317)575–3500
FAI . . . . (317)469–0441
Future Electronics . . . . (317)469–0447
Newark . . . . (317)259–0085
Time Electronics 1–800–789–TIME

Ft. Wayne

Newark . . . . (219)484–0766
PENSTOCK . . . . (219)432–1277

IOWA

Cedar Rapids

Newark . . . . (319)393–3800
Time Electronics 1–800–789–TIME

KANSAS

Kansas City

FAI . . . . (913)381–6800

Lenexa

Arrow/Schweber Electronics . . . (913)541–9542
Hamilton/Hallmark . . . . (913)663–7900

Olathe

PENSTOCK . . . . (913)829–9330

Overland Park

Future Electronics . . . . (913)649–1531
Newark . . . . (913)677–0727
Time Electronics 1–800–789–TIME

MARYLAND

Baltimore

FAI . . . . (410)312–0833

Columbia

Arrow/Schweber Electronics . . . (301)596–7800
Future Electronics . . . . (410)290–0600
Hamilton/Hallmark . . . . (410)720–3400
Time Electronics 1–800–789–TIME
PENSTOCK . . . . (410)290–3746
Wyle Electronics . . . . (410)312–4844

Hanover

Newark . . . . (410)712–6922

AUTHORIZED DISTRIBUTORS – continued

UNITED STATES – continued

MASSACHUSETTS

Boston

Arrow/Schweber Electronics	(508)658–0900
FAI	(508)779–3111

Bolton

Future Corporate	(508)779–3000

Burlington

PENSTOCK	(617)229–9100
Wyle Electronics	(617)271–9953

Norwell

Richardson Electronics	(617)871–5162

Peabody

Time Electronics	1–800–789–TIME
Hamilton/Hallmark	(508)532–9893

Woburn

Newark	(617)935–8350

MICHIGAN

Detroit

FAI	(313)513–0015
Future Electronics	(616)698–6800

Grand Rapids

Newark	(616)954–6700

Livonia

Arrow/Schweber Electronics	(810)455–0850
Future Electronics	(313)261–5270
Hamilton/Hallmark	(313)416–5800
Time Electronics	1–800–789–TIME

Troy

Newark	(810)583–2899

MINNESOTA

Bloomington

Wyle Electronics	(612)853–2280

Burnsville

PENSTOCK	(612)882–7630

Eden Prairie

Arrow/Schweber Electronics	(612)941–5280
FAI	(612)947–0909
Future Electronics	(612)944–2200
Hamilton/Hallmark	(612)881–2600
Time Electronics	1–800–789–TIME

Minneapolis

Newark	(612)331–6350

Earth City

Hamilton/Hallmark	(314)291–5350

MISSOURI

St. Louis

Arrow/Schweber Electronics	(314)567–6888
Future Electronics	(314)469–6805
FAI	(314)542–9922
Newark	(314)453–9400
Time Electronics	1–800–789–TIME

NEW JERSEY

Bridgewater

PENSTOCK	(908)575–9490

Cherry Hill

Hamilton/Hallmark	(609)424–0110

East Brunswick

Newark	(908)937–6600

Fairfield

FAI	(201)331–1133

Long Island

FAI	(516)348–3700

Marlton

Arrow/Schweber Electronics	(609)596–8000
FAI	(609)988–1500
Future Electronics	(609)596–4080

Pinebrook

Arrow/Schweber Electronics	(201)227–7880
Wyle Electronics	(201)882–8358

Parsippany

Future Electronics	(201)299–0400
Hamilton/Hallmark	(201)515–1641

Wayne

Time Electronics	1–800–789–TIME

NEW MEXICO

Albuquerque

Alliance Electronics	(505)292–3360
Hamilton/Hallmark	(505)828–1058
Newark	(505)828–1878

NEW YORK

Bohemia

Newark	(516)567–4200

Hauppauge

Arrow/Schweber Electronics	(516)231–1000
Future Electronics	(516)234–4000
Hamilton/Hallmark	(516)434–7400
PENSTOCK	(516)724–9580

Konkoma

Hamilton/Hallmark	(516)737–0600

Melville

Wyle Laboratories	(516)293–8446

Pittsford

Newark	(716)381–4244

Rochester

Arrow/Schweber Electronics	(716)427–0300
Future Electronics	(716)387–9550
FAI	(716)387–9600
Hamilton/Hallmark	(716)272–2740
Richardson Electronics	(716)264–1100
Time Electronics	1–800–789–TIME

Rockville Centre

Richardson Electronics	(516)872–4400

Syracuse

FAI	(315)451–4405
Future Electronics	(315)451–2371
Newark	(315)457–4873
Time Electronics	1–800–789–TIME

NORTH CAROLINA

Charlotte

FAI	(704)548–9503
Future Electronics	(704)547–1107
Richardson Electronics	(704)548–9042

Raleigh

Arrow/Schweber Electronics	(919)876–3132
FAI	(919)876–0088
Future Electronics	(919)790–7111
Hamilton/Hallmark	(919)872–0712
Newark	(919)781–7677
Time Electronics	1–800–789–TIME

OHIO

Centerville

Arrow/Schweber Electronics	(513)435–5563

Cleveland

FAI	(216)446–0061
Newark	(216)391–9330
Time Electronics	1–800–789–TIME

Columbus

Newark	(614)326–0352
Time Electronics	1–800–789–TIME

Dayton

FAI	(513)427–6090
Future Electronics	(513)426–0090
Hamilton/Hallmark	(513)439–6735
Newark	(513)294–8980
Time Electronics	1–800–789–TIME

Mayfield Heights

Future Electronics	(216)449–6996

Solon

Arrow/Schweber Electronics	(216)248–3990
Hamilton/Hallmark	(216)498–1100

Worthington

Hamilton/Hallmark	(614)888–3313

OKLAHOMA

Tulsa

FAI	(918)492–1500
Hamilton/Hallmark	(918)459–6000
Newark	(918)252–5070

OREGON

Beaverton

Arrow/Almac Electronics Corp.	(503)629–8090
Future Electronics	(503)645–9454
Hamilton/Hallmark	(503)526–6200
Wyle Electronics	(503)643–7900

Portland

FAI	(503)297–5020
Newark	(503)297–1984
PENSTOCK	(503)646–1670
Time Electronics	1–800–789–TIME

PENNSYLVANIA

Coatesville

PENSTOCK	(610)383–9536

Ft. Washington

Newark	(215)654–1434

Mt. Laurel

Wyle Electronics	(609)439–9110

Montgomeryville

Richardson Electronics	(215)628–0805

Philadelphia

Time Electronics	1–800–789–TIME
Wyle Electronics	(609)439–9110

Pittsburgh

Arrow/Schweber Electronics	(412)963–6807
Newark	(412)788–4790
Time Electronics	1–800–789–TIME

TENNESSEE

Franklin

Richardson Electronics	(615)791–4900

Knoxville

Newark	(615)588–6493

TEXAS

Austin

Arrow/Schweber Electronics	(512)835–4180
Future Electronics	(512)502–0991
FAI	(512)346–6426
Hamilton/Hallmark	(512)219–3700
Newark	(512)338–0287
PENSTOCK	(512)346–9762
Time Electronics	1–800–789–TIME
Wyle Electronics	(512)833–9953

Benbrook

PENSTOCK	(817)249–0442

Carollton

Arrow/Schweber Electronics	(214)380–6464

Dallas

FAI	(214)231–7195
Future Electronics	(214)437–2437
Hamilton/Hallmark	(214)553–4300
Newark	(214)458–2528
Richardson Electronics	(214)239–3680
Time Electronics	1–800–789–TIME
Wyle Electronics	(214)235–9953

El Paso

FAI	(915)577–9531

Ft. Worth

Allied Electronics	(817)336–5401

Houston

Arrow/Schweber Electronics	(713)647–6868
FAI	(713)952–7088
Future Electronics	(713)785–1155
Hamilton/Hallmark	(713)781–6100
Newark	(713)894–9334
Time Electronics	1–800–789–TIME
Wyle Electronics	(713)879–9953

Richardson

PENSTOCK	(214)479–9215

San Antonio

FAI	(210)738–3330

UTAH

Salt Lake City

Arrow/Schweber Electronics	(801)973–6913
FAI	(801)467–9696
Future Electronics	(801)467–4448
Hamilton/Hallmark	(801)266–2022
Newark	(801)261–5660
Wyle Electronics	(801)974–9953

West Valley City

Time Electronics	1–800–789–TIME
Wyle Electronics	(801)974–9953

AUTHORIZED DISTRIBUTORS – continued

UNITED STATES – continued

WASHINGTON

Bellevue

Almac Electronics Corp.	(206)643–9992
Newark	(206)641–9800
PENSTOCK	(206)454–2371
Richardson Electronics	(206)646–7224

Bothell

Future Electronics	(206)489–3400

Redmond

Hamilton/Hallmark	(206)882–7000
Time Electronics	1–800–789–TIME
Wyle Electronics	(206)881–1150

Seattle

FAI	(206)485–6616
Wyle Electronics	(206)881–1150

Spokane

Arrow/Almac Electronics Corp.	(509)924–9500

WISCONSIN

Brookfield

Arrow/Schweber Electronics	(414)792–0150
Future Electronics	(414)879–0244
Wyle Electronics	(414)521–9333

Milwaukee

FAI	(414)792–9778
Time Electronics	1–800–789–TIME

New Berlin

Hamilton/Hallmark	(414)780–7200

Wauwatosa

Newark	(414)453–9100

CANADA

ALBERTA

Calgary

Electro Sonic Inc.	(403)255–9550
FAI	(403)291–5333

BRITISH COLUMBIA

Future Electronics	(403)250–5550
Hamilton/Hallmark	(800)663–5500

Edmonton

FAI	(403)438–5888
Future Electronics	(403)438–2858
Hamilton/Hallmark	(800)663–5500

Saskatchewan

Hamilton/Hallmark	(800)663–5500

Vancouver

Arrow Electronics	(604)421–2333
Electro Sonic Inc.	(604)273–2911
FAI	(604)654–1050
Future Electronics	(604)294–1166
Hamilton/Hallmark	(604)420–4101

MANITOBA

Winnipeg

Electro Sonic Inc.	(204)783–3105
FAI	(204)786–3075
Future Electronics	(204)944–1446
Hamilton/Hallmark	(800)663–5500

ONTARIO

Kanata

PENSTOCK	(613)592–6088

Mississauga

PENSTOCK	(905)403–0724

Ottawa

Arrow Electronics	(613)226–6903
Electro Sonic Inc.	(613)728–8333
FAI	(613)820–8244
Future Electronics	(613)820–8313
Hamilton/Hallmark	(613)226–1700

Toronto

Arrow Electronics	(905)670–7769
Electro Sonic Inc.	(416)494–1666
FAI	(905)612–9888
Future Electronics	(905)612–9200
Hamilton/Hallmark	(905)564–6060
Newark	(905)670–2888
Richardson Electronics	(905)795–6300

QUEBEC

Montreal

Arrow Electronics	(514)421–7411
FAI	(514)694–8157
Future Electronics	(514)694–7710
Hamilton/Hallmark	(514)335–1000
Richardson Electronics	(514)748–1770

Quebec City

Arrow Electronics	(418)687–4231
FAI	(418)682–5775
Future Electronics	(418)877–6666

INTERNATIONAL DISTRIBUTORS

AUSTRALIA

AVNET VSI Electronics (Australia)	(61)2 878–1299
Veltek Australia Pty Ltd	(61)3 9808–7511

AUSTRIA

EBV Austria	(43) 1 8941774
Elbatex GmbH	(43) 1 866420
Spoerle Austria	(43) 222 31872700

BELGIUM

Diode Spoerle	(32) 2 725 4660
EBV Belgium	(32) 2 716 0010

CHINA

Advanced Electronics Ltd.	(852)2 305–3633
AVNET WKK Components Ltd.	(852)2 357–8888
China El. App. Corp. Xiamen Co	(86)592 513–2489
Nanco Electronics Supply Ltd.	(852) 2 333–5121
Qing Cheng Enterprises Ltd.	(852) 2 493–4202

DENMARK

Arrow Exatec	(45) 44 927000
Avnet Nortec A/S	(45) 44 880800
EBV Denmark	(45) 39690511

FINLAND

Arrow Field OY	(35) 807 775 71
Avnet Nortec OY	(35) 806 13181

FRANCE

Arrow Electronique	(33) 1 49 78 49 78
Avnet Components	(33) 1 49 65 25 00
EBV France	(33) 1 64 68 86 00
Future Electronics	(33)1 69821111
Newark	(33)1–30954060
SEI/Scaib	(33) 1 69 19 89 00

GERMANY

Avnet E2000	(49) 89 4511001
EBV Elektronik GmbH	(49) 89 99114–0
Future Electronics GmbH	(49) 89–957 270
Jermyn GmbH	(49) 6431–5080
Newark	(49)2154–70011
Sasco GmbH	(49) 89–46110
Spoerle Electronic	(49) 6103–304–0

HOLLAND

EBV Holland	(31) 3465 623 53
Diode Spoerle BV	(31) 4054 5430

HONG KONG

AVNET WKK Components Ltd.	(852)2 357–8888
Nanshing Clr. & Chem. Co. Ltd	(852)2 333–5121

INDIA

Canyon Products Ltd	(91) 80 558–7758

INDONESIA

P.T. Ometraco	(62) 21 619–6166

ITALY

Avnet Adelsy SpA	(39) 2 38103100
EBV Italy	(39) 2 660961
Silverstar SpA	(39) 2 66 12 51

JAPAN

AMSC Co., Ltd.	81–422–54–6800
Fuji Electronics Co., Ltd.	81–3–3814–1411
Marubun Corporation	81–3–3639–8951
Nippon Motorola Micro Elec.	81–3–3280–7300
OMRON Corporation	81–3–3779–9053
Tokyo Electron Ltd.	81–3–5561–7254

KOREA

Jung Kwang Sa	(82)2278–5333
Lite–On Korea Ltd.	(82)2858–3853
Nasco Co. Ltd.	(82)23772–6800

NEW ZEALAND

AVNET VSI (NZ) Ltd	(64)9 636–7801

NORWAY

Arrow Tahonic A/S	(47)2237 8440
Avnet Nortec A/S Norway	(47) 66 846210

PHILIPPINES

Alexan Commercial	(63) 2241–9493

SINGAPORE

GEIC	(65) 298–7633
Strong Pte. Ltd	(65) 276–3996
Uraco Impex Asia Pte Ltd.	(65) 545–7811

SPAIN

Amitron Arrow	(34) 1 304 30 40
EBV Spain	(34) 1 804 32 56
Selco S.A.	(34) 1 637 10 11

SWEDEN

Arrow–Th:s	(48) 8 362970
Avnet Nortec AB	(48) 8 629 14 00

SWITZERLAND

EBV Switzerland	(41) 1 7456161
Elbatex AG	(41) 56 43751111
Spoerle	(41) 1 8746262

THAILAND

Shapiphat Ltd.	(66)2221–0432 or 2221–5384

TAIWAN

Mercuries & Assoc. Ltd	(886)2 503–1111
Solomon Technology Corp.	(886)2 788–8989
Strong Electronics Co. Ltd.	(886)2 917–9917

UNITED KINGDOM

Arrow Electronics (UK) Ltd	(44) 1 234 270027
Avnet/Access	(44) 1 462 488500
Future Electronics Ltd.	(44) 1 753 763000
Macro Marketing Ltd.	(44) 1 628 60600
Newark	(44) 1 420 543333

12/1/95

MOTOROLA WORLDWIDE SALES OFFICES

UNITED STATES

ALABAMA	Huntsville	(205)464–6800
ALASKA		(800)635–8291
ARIZONA	Tempe	(602)302–8056
CALIFORNIA	Calabasas	(818)878–6800
	Irvine	(714)753–7360
	Los Angeles	(818)878–6800
	San Diego	(619)541–2163
	Sunnyvale	(408)749–0510
COLORADO	Denver	(303)337–3434
CONNECTICUT	Wallingford	(203)949–4100
FLORIDA	Clearwater	(813)524–4177
	Maitland	(407)628–2636
	Pompano Beach/Ft. Lauderdale	(305)351–6040
GEORGIA	Atlanta	(404)729–7100
IDAHO	Boise	(208)323–9413
ILLINOIS	Chicago/Schaumburg	(708)413–2500
INDIANA	Indianapolis	(317)571–0400
	Kokomo	(317)455–5100
IOWA	Cedar Rapids	(319)378–0383
KANSAS	Kansas City/Mission	(913)451–8555
MARYLAND	Columbia	(410)381–1570
MASSACHUSETTS	Marlborough	(508)481–8100
	Woburn	(617)932–9700
MICHIGAN	Detroit	(810)347–6800
	Literature	(800)392–2016
MINNESOTA	Minnetonka	(612)932–1500
MISSOURI	St. Louis	(314)275–7380
NEW JERSEY	Fairfield	(201)808–2400
NEW YORK	Fairport	(716)425–4000
	Fishkill	(914)896–0511
	Hauppauge	(516)361–7000
NORTH CAROLINA	Raleigh	(919)870–4355
OHIO	Cleveland	(216)349–3100
	Columbus/Worthington	(614)431–8492
	Dayton	(513)438–6800
OKLAHOMA	Tulsa	(918)459–4565
OREGON	Portland	(503)641–3681
PENNSYLVANIA	Colmar	(215)997–1020
	Philadelphia/Horsham	(215)957–4100
TENNESSEE	Knoxville	(615)584–4841
TEXAS	Austin	(512)502–2100
	Houston	(713)251–0006
	Plano	(214)516–5100
VIRGINIA	Richmond	(804)285–2100
UTAH	CSI Inc.	(801)572–4010
WASHINGTON	Bellevue	(206)454–4160
	Seattle Access	(206)622–9960
WISCONSIN	Milwaukee/Brookfield	(414)792–0122

Field Applications Engineering Available
Through All Sales Offices

CANADA

BRITISH COLUMBIA	Vancouver	(604)293–7650
ONTARIO	Ottawa	(613)226–3491
	Toronto	(416)497–8181
QUEBEC	Montreal	(514)333–3300

INTERNATIONAL

AUSTRALIA	Melbourne	(61–3)98870711
	Sydney	(61–2)29661071
BRAZIL	Sao Paulo	55(11)815–4200
CHINA	Beijing	86–10–8437222
	Guangzhou	86–20–7537888
	Shanghai	86–21–3747668
	Tianjin	86–22–5325072
FINLAND	Helsinki	358–0–351 61191
	car phone	358(49)211501
FRANCE	Paris	33134 635900
GERMANY	Langenhagen/Hanover	49(511)786880
	Munich	49 89 92103–0
	Nuremberg	49 911 96–3190
	Sindelfingen	49 7031 79 710
	Wiesbaden	49 611 973050
HONG KONG	Kwai Fong	852–2–610–6888
	Tai Po	852–2–666–8333
INDIA	Bangalore	91–80–5598615
ISRAEL	Herzlia	972–9–590222
ITALY	Milan	39(2)82201
JAPAN	Fukuoka	81–92–725–7583
	Gotanda	81–3–5487–8311
	Nagoya	81–52–232–3500
	Osaka	81–6–305–1802
	Sendai	81–22–268–4333
	Takamatsu	81–878–37–9972
	Tokyo	81–3–3440–3311
KOREA	Pusan	82(51)4635–035
	Seoul	82(2)554–5118
MALAYSIA	Penang	60(4)228–2514
MEXICO	Mexico City	52(5)282–0230
	Guadalajara	52(36)21–8977
	Marketing	52(36)21–2023
	Customer Service	52(36)669–9160
NETHERLANDS	Best	(31)4998 612 11
PHILIPPINES	Manila	(63)2 822–0625
PUERTO RICO	San Juan	(809)282–2300
SINGAPORE		(65)4818188
SPAIN	Madrid	34(1)457–8204
	or	34(1)457–8254
SWEDEN	Solna	46(8)734–8800
SWITZERLAND	Geneva	41(22)799 11 11
	Zurich	41(1)730–4074
TAIWAN	Taipei	886(2)717–7089
THAILAND	Bangkok	66(2)254–4910
UNITED KINGDOM	Aylesbury	44 1 (296)395252

FULL LINE REPRESENTATIVES

CALIFORNIA, Loomis	Galena Technology Group	(916)652–0268
NEVADA, Reno	Galena Tech. Group	(702)746–0642
NEW MEXICO, Albuquerque	S&S Technologies, Inc.	(602)414–1100
UTAH, Salt Lake City	Utah Comp. Sales, Inc.	(801)561–5099
WASHINGTON, Spokane	Doug Kenley	(509)924–2322

HYBRID/MCM COMPONENT SUPPLIERS

Chip Supply	(407)298–7100
Elmo Semiconductor	(818)768–7400
Minco Technology Labs Inc.	(512)834–2022
Semi Dice Inc.	(310)594–4631

2PHX11136Q-18 Printed in USA 1/96 BANTA CO. MOTO #38 15,000 RF YBACAA

MOTOROLA

How to reach us:
USA/EUROPE: Motorola Literature Distribution;
P.O. Box 20912, Phoenix, Arizona 85036. 1-800-441-2447

MFAX: RMFAX@email.sps.mot.com - TOUCHTONE (602)244-6609
INTERNET: http://Design-NET.com

JAPAN: Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, Toshikatsu Otsuki.
6F Seibu-Butsuryu-Center, 3-14-2 Tatsumi Koto-Ku,Tokyo 135, Japan. 03-3521-8315

HONG KONG: Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298