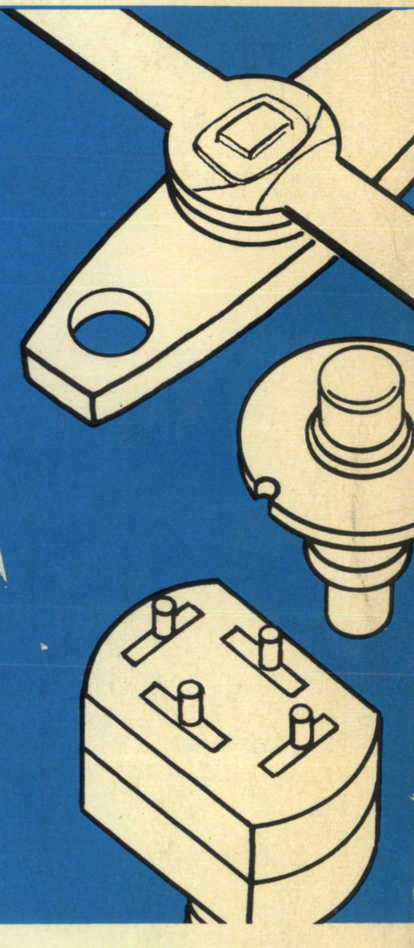
SSD-205

RCA Solid State

DATABOOK Series

RF Power Devices



Selection Guide
Data
Application Notes

$2.00 Optional Price

'72

RCA Solid State

DATABOOK Series

RF Power Devices

This DATABOOK contains complete data and related application notes on rf power devices presently available from RCA Solid State Division as standard products. For ease of reference, the data sheets are grouped in the following categories: (a) small-signal, low-noise types; (b) single-sideband types; (c) mobile-radio types; (d) aircraft-radio types; (e) vhf broadband types; (f) μhf broadband types; (g) CATV types; (h) microwave types. Application notes are included in numerical order following the data sheets.

A feature of this DATABOOK is a Selection Guide to the complete line of RCA solid-state devices (including linear integrated circuits, MOS field-effect devices, COS/MOS integrated circuits, power transistors, power hybrid circuits, thyristors, rectifiers, and other diodes, as well as rf power devices). The complete Index to Devices at the back of the book indentifies the volume of the DATABOOK series in which each type appears. The Key to RF Power Devices following the Selection Guide gives page numbers in this DATABOOK for individual types.

New solid-state devices and related publications announced during the year are described in a monthly newsletter entitled "What's New in Solid State". Copies of data sheets on new devices and other publications can be obtained by request to RCA Solid State Division, Box 3200, Somerville, N.J. 08876; RCA Limited, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex, England; or RCA S/A Parc-Industriel des Hauts-Sarts, Herstal, Liege, Belgium. If you wish to receive the monthly announcement newsletter, please fill out the form bound into the back of the book and return it to RCA.

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SOLID-STATE SELECTION GUIDE

This Selection Guide classifies RCA solid-state devices by category, by function, by material, and by performance level. This guide is particularly useful for an initial selection of suitable devices for a specific application. Complete data on these devices are given in the technical data sheets included in the respective DATABOOKS (see Index to RCA Solid-State Devices at back of book).

Transistors

AUDIO-FREQUENCY APPLICATIONS

Small Signal—Class A
Silicon n-p-n

Dissipations up to 5 W

2N697
2N699
2N718A
2N720A
2N1613
2N1711
2N1893
2N2102
2N2270
2N2405
2N2895
2N2896
2N2897
2N3053
40084

Power—Class A, AB, B
Silicon n-p-n

Dissipations up to 5 W

2N697
2N699
2N1479
2N1480
2N1481
2N1482
2N1613
2N1700
2N1711
2N1893
2N2102
2N2270
2N2405
2N2895
2N2896
2N2897
2N3053
40084
40309
40311
40314
40315
40317
40320
40321
40323
40326
40327
40360
40361
40366
40367
40385
40407
40408
40539
40611
40616
40625
40628
40635

Dissipations from 5 W to 29 W

2N1483
2N1484
2N1485
2N1486
2N1701
2N3054
2N3439
2N3440
2N3441
2N4063
2N4064
2N5320
2N5321
2N5784
2N5785
2N5786
40250
40250V1
40310
40312
40316
40324
40346
40346V1
40346V2
40347
40347V1
40347V2
40348
40348V1
40348V2
40349
40349V1
40349V2
40368
40372
40373
40374
40375
40389
40390
40392
40409
40412
40544
40594

Dissipations from 29 W to 100 W

2N1487
2N1488
2N1489
2N1490
2N1702
2N3263
2N3264
2N3583
2N3584
2N3585
2N3878
2N3879
2N4240
2N4347
2N5034
2N5035
2N5036
2N5037
2N5239
2N5240
2N5293
2N5294
2N5295
2N5296
2N5297
2N5298
2N5490
2N5491
2N5492
2N5493
2N5494
2N5495
2N5496
2N5497
2N6098
2N6099
2N6100
2N6101
2N6102
2N6103
2N6260
2N6261
2N6263
2N6264
201
202
203
204
205
520
521
40313
40318
40322
40328
40364
40369
40513
40514
40542
40543
40613
40618
40621
40622
40624
40627
40629
40630
40631
40632
40633
45190
45191
45192

Dissipations from 100 W to 300 W

2N2015
2N2016
2N2338
2N3055
2N3265
2N3266
2N3442
2N3771
2N3772
2N3773
2N4348
2N5575
2N5576
2N5577
2N5578
2N5579
2N5580
2N6253
2N6254
2N6257
2N6258
2N6259
2N6262
40251
40325
40363
40411
40636

Silicon p-n-p

Dissipations up to 10 W

2N4036
2N4037
2N4314
2N5322
2N5323
2N5415
2N5416
40319
40362
40391
40394
40406
40410
40537
40538
40595
40634

Dissipations from 10 W to 65 W

2N5781
2N5782
2N5783
2N5954
2N5955
2N5956
2N6106
2N6107
2N6108
2N6109
2N6110
2N6111
2N6211
2N6212
2N6213
101
102
103
104
105
370
371
45193
45194
45195

Germanium p-n-p

Dissipations up to 30 W

2N1183
2N1183A
2N1183B
2N1184
2N1184A
2N1184B
2N1905
2N1906
2N2147
2N2148
2N2869/2N301
2N2870/2N301A
40022
40050
40051
40254
40421
40462
40612
40623
40626

High-Voltage

Germanium p-n-p

2N3730
2N3731
2N3732
2N4346
40439
40440

Silicon n-p-n

2N2016
2N2102
2N2405
2N3263
2N3264
2N3265
2N3266
2N3439
2N3440
2N3441
2N3442
2N3583
2N3584
2N3585
2N3773
2N3878
2N3879
2N4063
2N4064
2N4240
2N4347
2N4348
2N5239
2N5240
40346
40349
40349V1
40349V2
40366
40373
40374
40375
40385
40390

RADIO-FREQUENCY APPLICATIONS

Small Signal
MOS/FET Silicon N-Channel
Single-Gate

3N128
3N138
3N139
3N142
3N143
3N152
3N153
3N154
40467A
40468A
40559A

MOS/FET Silicon N-Channel
Dual-Gate

3N140
3N141
3N159
3N187
3N200
40600
40601
40602
40603
40604
40673
40819
40820
40821
40822
40823
40841

Silicon n-p-n
f_T to 700 MHz (Typ.)

2N2102
2N2270
2N2405
2N2895
2N2896
2N2897
2N3053
40084

f_T to 1200 MHz (Min.)

2N918
2N2857
2N3478
2N3600
2N3839
2N5109
2N5179
40294
40894
40895
40896
40897

Power

Silicon n-p-n

2N1491
2N1492
2N1493
2N2631
2N2876
2N3118
2N3229
2N3375
2N3553
2N3632
2N3733
2N3866
2N4012
2N4427
2N4440
2N4932
2N4933
2N5016
2N5070
2N5071
2N5090
2N5102
2N5108
2N5470
2N5913
2N5914
2N5915
2N5916
2N5917
2N5918
2N5919
2N5919A
2N5920
2N5921
2N5992
2N5993
2N5994
2N5995
2N5996
2N6093
2N6105
2N6265
2N6266
2N6267
2N6268
2N6269
40080
40081
40082
40279
40280
40281
40282
40290
40291
40292
40294
40305
40306
40307
40340
40341
40446
40577
40578
40581
40582
40605
40608
40665
40666
40836
40837
40893
40898
40899
40909
40934
40935
40936
40939
40940
40941

COMPUTER SWITCHING APPLICATIONS

Low Level, Medium-Speed Logic Switching

Silicon n-p-n

f_T to 175 MHz (Min.)

2N697
2N699
2N718A
2N720A
2N1613
2N1711
2N1893
2N2102
2N2270
2N2405
2N2895
2N2896
2N2897
2N3053
2N3262
2N3263
2N3264
2N3265
2N3266
2N3878
2N3879
2N5202
2N5320
2N5321
40084
40375
40389
40392

Silicon p-n-p

f_T to 60 MHz (Min.)

2N4036
2N4037
2N4314
2N5322
2N5323
40391
40394

High-Speed Logic Switching

Silicon n-p-n

f_T to 600 MHz (Min.)

2N3119

High-Voltage Switching

Silicon p-n-p

f_T to 600 MHz (Min.)

2N5189
2N5262

Chopper and Multiplex Service

MOS/FET Silicon N-Channel Single-Gate

3N138
3N153

POWER SWITCHING

Low Speed Switching

Silicon n-p-n

Dissipations up to 8.75 W

2N697
2N699
2N718A
2N720A
2N1479
2N1480
2N1481
2N1482
2N1613
2N1700
2N1711
2N1893
2N2102
2N2270
2N2405
2N2895
2N2896
2N2897
2N3053
2N3262
40250V1
40309
40311
40314
40315
40317
40320
40321
40323
40326
40327
40346V1
40347
40347V1
40348
40348V1
40349
40349V1
40360
40361
40366
40367
40372
40374
40375
40385
40389
40390
40392
40407
40408
40409
40412V1

Dissipations from 8.75 W to 50 W

2N1483
2N1484
2N1485
2N1486
2N1701
2N3054
2N3439
2N3440
2N3441
2N3583
2N3584
2N3585
2N3878
2N3879
2N4063
2N4064
2N4240
2N5293
2N5294
2N5295
2N5296
2N5297
2N5298
2N5490
2N5491
2N5492
2N5493
2N5494
2N5495
2N5496
2N5497
2N6098
2N6099
2N6100
2N6101
2N6102
2N6103
2N6288
2N6289
2N6290
2N6291
2N6292
2N6293
40250
40310
40312
40313
40316
40318
40322
40324
40328
40346
40346V2
40347V2
40348V2
40349V2
40364
40368
40412
40412V2

Dissipations from 50 W to 150 W

2N1487
2N1488
2N1489
2N1490
2N1702
2N2015
2N2016
2N2338
2N3055
2N3263
2N3264
2N3265
2N3266
2N3442
2N3771
2N3772
2N3773
2N4347
2N4348
2N5034
2N5035
2N5036
2N5037
2N5038
2N5039
2N5240
2N5575
2N5576
2N5577
2N5578
2N5579
2N5580
2N5671
2N5672
2N6032
2N6033
2N6246
2N6247
2N6248
40251
40325
40363
40369
40411

Silicon p-n-p

Dissipations up to 40 W

40319
40362
40391
40394
40406
40410

Germanium p-n-p

Dissipations up to 30 W

2N1183
2N1183A
2N1183B
2N1184
2N1184A
2N1184B
2N1905
2N1906

High-Voltage Switching

Silicon n-p-n

Collector-to-Emitter Voltage to 350 V (max.)

2N3439
2N3440
2N3441
2N3442
2N3583
2N3584
2N3585
2N3773
2N4063
2N4064
2N4240
2N4347
2N4348
2N5239
2N5240
2N5804
2N5805
2N5838
2N5839
2N5840
2N6077
2N6078
2N6079
2N6175
2N6176
2N6177
2N6249
2N6250
2N6251
410
411
413
423
431
40346
40346V1
40346V2
40349
40349V1
40349V2
40354
40373
40374
40385
40390
40412
40412V1
40412V2
40850
40851
40852
40853
40854
40885
40886
40887

Silicon p-n-p

Collector-to-Emitter Sustaining Voltage to −300 V (max.)

2N5415
2N5416

POWER HYBRID CIRCUITS

Linear Amplifier

HC1000

Operational Amplifier

HC2000

Thyristors

TRIACS

Low-Voltage Operation, 50 & 60 Hz

2N5754
40525
40528
40531
40534
40684
40693
40696
40766
40767
40900

120-V Line Operation, 50 & 60 Hz

2N5441
2N5444
2N5567
2N5569
2N5571
2N5573
2N5755
40429
40431
40485
40502
40509
40511
40526
40529
40532
40535
40575
40638
40660
40662
40668
40685
40688
40691
40694
40697
40699
40702
40705
40707
40711
40713
40715
40717
40719
40721
40725
40727
40729
40731
40733
40761
40799
40802
40805
40901
40916
40919
40922

240-V Line Operation, 50 & 60 Hz

2N5442
2N5445
2N5568
2N5570
2N5572
2N5574
2N5756
40430
40432
40486
40503
40510
40512
40527
40530
40533
40536
40576
40639
40661
40663
40664
40667
40669
40686
40689
40692
40695
40698
40700
40703
40706
40708
40712
40714
40716
40718
40720
40722
40723
40724
40726
40728
40730
40732
40734
40762
40800
40803
40806
40842
40902
40917
40920
40923

High-Voltage Operation, 50 & 60 Hz

2N5443
2N5446
2N5757
40671
40672
40687
40690
40701
40704
40709
40710
40795
40796
40797
40798
40801
40804
40807
40918
40921
40924
40925
40926
40927

400-Hz Service, V_{DROM} = 200 V

40769
40771
40773
40775
40777
40779
40781
40783
40785
40787
40789
40791
40793

400-Hz Service, V_{DROM} = 400 V

40770
40772
40774
40776
40778
40780
40782
40784
40786
40788
40790
40792
40794

Silicon Controlled Rectifiers

Low-Voltage Operation, 50 & 60 Hz

2N681
2N682
2N683
2N684
2N1842A
2N1843A
2N1844A
2N1845A
2N3650
2N3668
2N3870
2N3897
106A
106F
106Q
106Y
107A
107F
107Q
107Y
40680
40737
40741
40745
40749
40753
40757
40810
40867

120-V Line Operation 50 & 60 Hz

2N685
2N1846A
2N3228
2N3528
2N3651
2N3669
2N3871
2N3897
106B
107B
40378
40504
40507
40553
40654
40656
40658
40681
40738
40742
40746
40750
40754
40758
40811
40868

240-V Line Operation, 50 & 60 Hz

2N688
2N1849A
2N3525
2N3529
2N3653
2N3670
2N3872
2N3898
106C
107C
40379
40505
40508
40554
40655
40657
40659
40682
40739
40743
40747
40751
40755
40759
40812
40869

High-Voltage Operation 50 & 60 Hz

2N686
2N687
2N689
2N690
2N1847A
2N1848A
2N1850A
2N3652
2N3873
2N4101
2N4102
2N4103
106D
106E
106M
107D
107E
107M
40216
40506
40555
40640
40641
40683
40735
40740
40744
40748
40752
40756
40760
40768
40813
40833
40834
40835
40937
40938

TV Deflection Circuits

40888
40889

Rectifiers

Silicon Rectifiers—Low Power

$I_{F(AV)}$ to 2A

1N440B
1N441B
1N442B
1N443B
1N444B
1N445B
1N536
1N537
1N538
1N539
1N540
1N547

$I_{F(AV)}$ to 2A (cont'd)

1N1095
1N1763A
1N1764A
1N2858A
1N2859A
1N2860A
1N2861A
1N2862A
1N2863A
1N2864A
1N3193
1N3194
1N3195
1N3196
1N3253
1N3254
1N3255
1N3256
1N3563
1N3754
1N3755
1N3756
1N5211
1N5212
1N5213
1N5214
1N5215
1N5216
1N5217
1N5218
1N5391
1N5392
1N5393
1N5394
1N5395
1N5396
1N5397
1N5398
1N5399
40266
40267
40642
40643
40644
44001
44002
44003
44004
44005
44006
44007

Silicon Rectifiers—High Power

$I_{F(AV)}$ 12 A to 40 A

1N248C
1N249C
1N250C
1N1183A
1N1184A
1N1186A
1N1187A
1N1188A
1N1189A
1N1190A
1N1195A
1N1196A
1N1197A
1N1198A
1N1199A
1N1200A
1N1202A
1N1203A
1N1204A
1N1205A
1N1206A
1N1341B
1N1342B
1N1344B
1N1345B
1N1346B
1N1347B
1N1348B
1N1612
1N1613
1N1614
1N1615
1N1616
40108
40109
40110
40111
40112
40113
40114
40115
40208
40209
40210
40211
40212
40213
40214

High-Voltage Rectifier Assemblies

CR101
CR102
CR103
CR104
CR105
CR106
CR107
CR108
CR109
CR110
CR201
CR203
CR204
CR206
CR208
CR210
CR212
CR280
CR301
CR302
CR303
CR304
CR305
CR306
CR307
CR311
CR312
CR313
CR314
CR315
CR316
CR317
CR321
CR322
CR323
CR324
CR325
CR331
CR332
CR333
CR334
CR335
CR341
CR342
CR343
CR344
CR351
CR352
CR353
CR354

High-Voltage Replacement Types

CR273/ 8008
CR274/ 872A
CR275/ 866A/ 3B28

Controlled-Avalanche Types

40808 40809

TV Types

40890 40891 40892

DIACS

For Triggering Triacs

1N5411 40583

Diodes

Compensating

40428

RCA Military-Specification Types

TYPE	MIL-S-19500/	TYPE	MIL-S-19500/
Transistors			
JAN-2N384	27	JAN-2N1488	208
JAN-2N388	65	JAN-2N1489	208
JAN-2N398	174	JAN-2N1490	208
JAN-2N398A	174	JAN-2N1493	247
JAN-2N404	20	JAN-2N2015	248
JAN-2N404A	20	JAN-2N2016	248
JAN-2N918	301	JAN-2N2857	343
JAN-2N1183	143	JAN-TX2N2857	343
JAN-2N1183A	143	JAN-2N3055	407
JAN-2N1183B	143	JAN-TX2N3055	407
JAN-2N1184	143	JAN-2N3375	341
JAN-2N1184A	143	JAN-TX2N3375	341
JAN-2N1184B	143	JAN-2N3439	368
JAN-2N1224	189	JAN-TX2N3439	368
JAN-2N1225	189	JAN-2N3440	368
JAN-2N1302	126	JAN-TX2N3440	368
JAN-2N1303	126	JAN-2N3441	369
JAN-2N1304	126	JAN-2N3442	370
JAN-2N2305	126	JAN-2N3553	341
JAN-2N1306	126	JAN-TX2N3553	341
JAN-2N1307	126	JAN-2N3584	384
JAN-2N1308	126	JAN-TX2N3584	384
JAN-2N1309	126	JAN-2N3585	384
JAN-2N1479	207	JAN-TX2N3585	384
JAN-2N1480	207	JAN-2N3771	413
JAN-2N1481	207	JAN-TX2N3771	413
JAN-2N1482	207	JAN-2N3772	413
JAN-2N1483	180	JAN-TX2N3772	413
JAN-TX2N1483	180	JAN-2N3866	398
JAN-2N1484	180	JAN-TX2N3866	398
JAN-TX2N1484	180	JAN-2N4440	341
JAN-2N1485	180	JAN-TX2N4440	341
JAN-TX2N1485	180	JAN-2N5038	439
JAN-2N1486	180	JAN-TX2N5038	439
JAN-TX2N1486	180	JAN-2N5039	439
JAN-2N1487	208	JAN-TX2N5039	439

Copies of specification sheets may be obtained by directing requests to Department of the Navy, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 19120

COS/MOS Digital Integrated Circuits

GATES

NOR (Positive-Logic)

Dual 3-Input Plus Inverter

CD4000AD CD4000AE CD4000AK

Quad 2-Input

CD4001AD CD4001AE CD4001AK

Dual 4-Input

CD4002AD CD4002AE CD4002AK

Triple 3-Input

CD4025AD CD4025AE CD4025AK

NAND (Positive Logic)

Quad 2-Input

CD4011AD CD4011AE CD4011AK

Dual 4-Input

CD4012AD CD4012AE CD4012AK

Triple 3-Input

CD4023AD CD4023AE CD4023AK

GATE ARRAYS

AND-OR Select Quad

CD4019AD CD4019AE CD4019AK

Exclusive-OR Quad

CD4030AD CD4030AE CD4030AK

GENERAL PURPOSE

Complementary Pair Dual Plus Inverter

CD4007AD CD4007AE CD4007AK

HEX BUFFERS LOGIC-LEVEL CONVERTERS

Inverting

CD4009AD CD4009AE CD4009AK

Non-Inverting

CD4010AD CD4010AE CD4010AK

DECODERS

BDC-to Decimal

CD4028AD CD4028AE CD4028AK

MULTIPLEXERS

Quad Bilateral Switch

CD4016AD CD4016AE CD4016AK

ARITHMETIC DEVICES

Four-Bit Full Adder

CD4008AD CD4008AE CD4008AK

Triple Serial Adder
Positive Logic

CD4032AD CD4032AE CD4032AK

Negative Logic

CD4038AD CD4038AE CD4038AK

FLIP FLOPS

Dual 'D' Type with Set-Reset

CD4013AD CD4013AE CD4013AK

Dual J–K Master-Slave

CD4027AD CD4027AE CD4027AK

COUNTER/DIVIDERS

7-Stage Binary Ripple Carry

CD4004AD CD4004AT CD4024AK
CD4004AE CD4024AD CD4024AT
CD4004AK CD4024AE

14-Stage Binary Ripple Carry

CD4020AD CD4020AE CD4020AK

Decade-10 Decoded Decimal Outputs

CD4017AD CD4017AE CD4017AK

Decade-7-Segment Display Outputs

CD4026AD CD4026AK CD4033AE
CD4026AE CD4033AD CD4033AK

Octal-8-Decoded Outputs

CD4022AD CD4022AE CD4022AK

Divide-by-'N' Fixed or Programmable

CD4018AD CD4018AE CD4018AK

Pre-Settable Up/Down

CD4029AD CD4029AE CD4029AK

STATIC SHIFT REGISTERS

18 Stage

CD4006AD CD4006AE CD4006AK

8-Stage Synchronous

CD4014AD CD4014AE CD4014AK

8-Stage Asynchronous

CD4021AD CD4021AE CD4021AK

Dual 4-Stage

CD4015AD CD4015AE CD4015AK

Linear Integrated Circuits

FM, AM, AND AUDIO CIRCUITS

Stereo Preamplifier

CA3048 CA3052

Stereo Multiplex Decoder

CA3090Q

IF Amplifier

AM

CA3088E CA3089E

FM

CA3011 CA3043 CA3076
CA3012 CA3075

Wide-Band Amplifier

CA3013 CA3041 CA3042
CA3014

Limiter

CA3013 CA3042 CA3075
CA3014 CA3043 CA3076
CA3041

Detector

AM

CA3088E CA3089E

FM

CA3013 CA3041 CA3043
CA3014 CA3042 CA3075

AF Pre Amplifier

CA3043 CA3088E CA3089E
CA3075

Driver

CA3041 CA3042 CA3043

TELEVISION CIRCUITS

Video IF System

CA3068

Automatic Fine Tuning

CA3044 CA3044V1 CA3064

Remote Control

CA3035 CA3035V1

Chroma Demodulator

CA3067 CA3072

Chroma Signal Processors

CA3066 CA3070

Chroma Amplifier

CA3066 CA3071

Detector

CA3044 CA3044V1 CA3064

Zener Diode Voltage Regulator

CA3064

DC Amplifier

CA3064

Output Amplifier

CA3044 CA3044V1

IF Amplifier/Limiter, FM Detector, Electronic Attenuator, and Audio Driver

CA3065

OPERATIONAL AMPLIFIERS

Micropower

Single OTA

CA3080 CA3080A

Triple OTA Array

CA3060AD CA3060D CA3060E
CA3060BD

Single Op Amp.

CA3078AT CA3078T

High Current

CA3033 CA3047 CA3047A
CA3033A

General Purpose

CA3458T CA3747CE CA3747T
CA3558T CA3747CT CA3748CT
CA3741CT CA3747E CA3748T
CA3741T

Wide-Band

CA3008 CA3016 CA3030A
CA3008A CA3016A CA3037
CA3010 CA3029 CA3037A
CA3010A CA3029A CA3038
CA3015 CA3030 CA3038A
CA3015A

Premium Low Noise

CA6741T

HIGH-GAIN WIDE-BAND AMPLIFIERS

Video (DC to 200 MHz)

CA3040

Low Power Video (DC to 40 MHz)

CA3021 CA3022 CA3023

Multi Purpose Power (DC to 8 MHz)

CA3020 CA3020A

DIFFERENTIAL AMPLIFIERS

DC (to 30 MHz)

CA3000 CA3000/2 CA3000/4
CA3000/1 CA3000/3

AF (to 3 kHz)

CA30007 CA3008

IF (to 15 MHz)

CA3002

RF (to 100 MHz)

CA3004 CA3005 CA3006

Video & Wide-Band (to 55 MHz)

CA3001 CA3001/2 CA3001/4
CA3001/1 CA3001/3

Dual Darlington Connected (to 20 MHz)

CA3050 CA3051

Dual Independ. (to 500 MHz)

CA3026 CA3049 CA3054

Cascade (to 500 MHz)

CA3028A CA3028B/2 CA3053
CA3028B CA3028B/3
CA3028B/1 CA3028B/4

POWER CONTROL CIRCUITS

Thyristor Control

CA3058 CA3059 CA3079

Voltage Regulator

CA3055 CA3085A CA3085B
CA3085

Optoelectronic

CA3062

ARRAYS

2 Zener Diodes, 1 Diode, 3 Transistors

CA3093E

Matched Diode Types

Individual

CA3019

Quad plus Two

CA3039

Transistor Types

General Purpose N-P-N

CA3081 CA3083 CA3183AE
CA3082 CA3086 CA3183E

General Purpose P-N-P

CA3084

Dual Darlington Connected

CA3036 CA3050 CA3051

Darlington Connected Pair plus Two Individual

CA3018 CA3118AT CA3118T
CA3018A

Differentially Connected Pair plus Three Individual

CA3045 CA3146AE CA3146E
CA3046

Amplifier Types

Dual Independent (Differential)

CA3026 CA3049 CA3054

Three-Ampl.

CA3035 CA3035V1

Four-Ampl.

CA3048

SPECIAL PURPOSE

Sense Amplifier

CA3541D

Four-Quadrant Multiplier

CA3091D

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2N5090	234
2N5102	138
2N5108	302
2N5109	290
2N5179	30
2N5470	306
2N5913	74
2N5914	80
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2N5916	238
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2N5918	244
2N5919	250
2N5919A	257
2N5920	312
2N5921	318
2N5992	88
2N5993	94
2N5994	143
2N5995	100
2N5996	106
2N6093	52
2N6104	263
2N6105	263
2N6265	326
2N6266	332
2N6267	338
2N6268	344
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40080	182
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40279	269
40280	112
40281	112
40282	112
40290	149
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40292	149
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RF Power Transistors

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Symbols for Power Transistors and Power Hybrid Circuits

General

db	– duty factor
η	– efficiency
NF	– noise figure
T	– temperature
$T_A [T_{FA}]$	– ambient temperature
T_C	– case temperature
T_J	– junction temperature
T_{MF}	– mounting-flange temperature
T_{STG}	– storage temperature
Θ	– thermal resistance
$\Theta_{J\text{-}A}$	– thermal resistance, junction-to-ambient
$\Theta_{J\text{-}C}$	– thermal resistance, junction-to-case
$\Theta_{J\text{-}MF}$	– thermal resistance, junction-to-mounting-range
t	– time
t_d	– delay time
t_f	– fall time
$t_{on}(t_d+t_r)$	– turn-on time
$t_{off}(t_s+t_f)$	– turn-off time
t_p	– pulse time
t_r	– rise time
t_s	– storage time
τ	– time constant
τ_s	– saturation stored-change time constant

Transistors

$C_{b'c}$	– collector-to-base feedback capacitance
C_c	– collector-to-case capacitance
C_{cb}	– collector-to-base capacitance
C_{ibo}	– input capacitance, open-circuit (common base)
C_{ieo}	– input capacitance, open-circuit (common emitter)
C_{obo}	– output capacitance, open-circuit (common base)
C_{oeo}	– output capacitance, open-circuit (common emitter)
$E_{s/b}$	– second-breakdown energy
f_c	– cutoff frequency
f_{hfb}	– small-signal forward-current transfer-ratio cutoff frequency, short-circuit (common base)
f_{hfe}	– small-signal forward-current transfer-ratio cutoff frequency, short circuit (common emitter)
f_T	– gain-bandwidth product (frequency at which small-signal forward-current transfer-ratio, common emitter, extrapolates to unity)
g_{me}	– small-signal transconductance (common emitter)
G_{PB}	– large-signal average power gain (common base)
G_{pb}	– small-signal average power gain (common base)
G_{PE}	– large-signal average power gain (common emitter)
G_{pe}	– small-signal average power gain (common emitter)
h_{FB}	– static forward-current transfer ratio (common base)
h_{fb}	– small-signal forward-current transfer ratio, short-circuit (common base)
h_{FE}	– static forward-current transfer ratio (common emitter)
h_{fe}	– small-signal forward-current transfer ratio, short-circuit (common emitter)
h_{ib}	– small-signal input impedance, short-circuit (common base)
h_{IE}	– static input resistance (common emitter)
h_{ie}	– small-signal input impedance, short-circuit (common emitter)
h_{ob}	– small-signal output impedance, open-circuit (common base)
h_{oe}	– small-signal output impedance, open-circuit (common emitter)
h_{rb}	– small-signal reverse-voltage transfer ratio, open-circuit (common base)
h_{re}	– small-signal reverse-voltage transfer ratio, open-circuit (common emitter)
I_B	– base current
I_{B1}	– turn-on current
I_{B2}	– turn-off current
I_C	– collector current
I_c	– collector current, instantaneous value
I_{CB}	– collector-cutoff current
I_{CBO}	– collector-cutoff current, emitter open
I_{CEO}	– collector-cutoff current, base open
I_{CER}	– collector-cutoff current, specified resistance between base and emitter
I_{CES}	– collector-cutoff current, base short-circuited to emitter
I_{CEV}	– collector-cutoff current, specified voltage between base and emitter
I_{CEX}	– collector-cutoff current, specified circuit between base and emitter
I_{CS}	– switching current (at minimum h_{FE} per specification)

Symbols for Power Transistors and Power Hybrid Circuits

Transistors

I_E	– emitter current
I_{EBO}	– emitter-cutoff current, collector open
$I_{s/b}$	– second-breakdown collector current
MAG	– maximum available amplifier gain
MAG_c	– maximum available conversion gain
MUG	– maximum usable amplifier gain
P_{BE}	– total dc or average power input to base (common emitter)
P_{BE}	– total instantaneous power input to base (common emitter)
P_{CB}	– total dc or average power input to collector (common base)
P_{CB}	– total instantaneous power input to collector (common base)
P_{CE}	– total dc or average power input to collector (common emitter)
P_{CE}	– total instantaneous power input to collector (common emitter)
P_{EB}	– total instantaneous power input to emitter (common base)
P_{IB}	– large-signal input power (common base)
P_{ib}	– small-signal input power (common base)
P_{IE}	– large-signal input power (common emitter)
P_{ie}	– small-signal input power (common emitter)
P_{OB}	– large-signal output power (common base)
P_{ob}	– small-signal output power (common base)
P_{OE}	– large-signal output power (common emitter)
P_{oe}	– small-signal output power (common emitter)
P_T	– total non-reactive power input, dc, to all terminals (transistor dissipation)
Q_s	– stored base charged
$r_{bb'}$	– intrinsic base spreading resistance
$r_{CE(sat)}$	– collector-to-emitter saturation resistance
$R_e[h_{ie}]$	– real part of small-signal input impedance, short-circuit (common emitter)
R_G	– generator resistance
R_{ie}	– input resistance (common emitter)
R_L	– load resistance
R_{oe}	– output resistance (common emitter)
R_S	– source resistance
V_{BB}	– base-supply voltage
V_{BC}	– base-to-collector voltage
V_{BE}	– base-to-emitter voltage
$V_{BE(sat)}$	– base-to-emitter saturation voltage
$V_{(BR)CBO}$	– collector-to-base breakdown voltage, emitter open
$V_{(BR)CEO}$	– collector-to-emitter breakdown voltage, base open

$V_{(BR)CER}$	– collector-to-emitter breakdown voltage, specified resistance between base and emitter
$V_{(BR)CES}$	– collector-to-emitter breakdown voltage, base short-circuited to emitter
$v_{(BR)CEV}$	– collector-to-emitter breakdown voltage, specified voltage between base and emitter
$V_{(BR)EBO}$	– emitter-to-base breakdown voltage, collector open
V_{CB}	– collector-to-base voltage
$V_{CB}^{(fl)}$	– dc open-circuit voltage between collector and base (floating potential), emitter biased with respect to base
V_{CBO}	– collector-to-base voltage (emitter open)
V_{CBV}	– collector-to-base voltage, specified voltage between emitter and base
V_{CC}	– collector-supply voltage
V_{CE}	– collector-to-emitter voltage
$V_{CE}^{(fl)}$	– dc open-circuit voltage between collector and emitter (floating potential), base biased with respect to emitter
$V_{CE(sat)}$	– collector-to-emitter saturation voltage
V_{CEO}	– collector-to-emitter voltage, base open
$V_{CEO(sus)}$	– collector-to-emitter sustaining voltage, base open
V_{CER}	– collector-to-emitter voltage, specified resistance between base and emitter
$V_{CER(sus)}$	– collector-to-emitter sustaining voltage, specified resistor between base and emitter
V_{CES}	– collector-to-emitter voltage, base short-circuited to emitter
V_{CEV}	– collector-to-emitter voltage, specified voltage between base and emitter
$V_{CEV(sus)}$	– collector-to-emitter sustaining voltage, specified voltage between base and emitter
V_{CEX}	– collector-to-emitter voltage, specified circuit between base and emitter
$V_{CEX(sus)}$	– collector-to-emitter sustaining voltage, specified circuit between base and emitter
V_{EB}	– emitter-to-base voltage
$V_{EB}^{(fl)}$	– dc open-circuit voltage between emitter and base (floating potential), collector biased with respect to base
V_{EBO}	– emitter-to-base voltage, collector open
V_{EE}	– emitter-supply voltage
V_{RT}	– reach-through voltage
Y_{fe}	– forward transconductance
Y_{ie}	– input admittance
Y_{oe}	– output admittance
Y_{re}	– reverse transconductance

Small-Signal, Low-Noise Types

Solid State Division

RF Power Transistors

2N918
2N3600

RCA-2N918 and RCA-2N3600 are double-diffused epitaxial planar transistors of the silicon n-p-n type. They are extremely useful in low-noise-amplifier, oscillator, and converter applications at VHF frequencies.

These devices utilize a hermetically sealed four-lead JEDEC TO-72 package. All active elements of the transistor are insulated from the case, which may be grounded by means of the fourth lead in applications requiring minimum feedback capacitance, shielding of the device, or both.

MAXIMUM RATINGS, Absolute-Maximum Values:

	2N918	2N3600		
COLLECTOR-TO-BASE VOLTAGE, V_{CBO}	30	30	max.	V
COLLECTOR-TO-EMITTER VOLTAGE, V_{CEO}	15	15	max.	V
EMITTER-TO-BASE VOLTAGE, V_{EBO}	3	3	max.	V
COLLECTOR CURRENT, I_C	50	*	max.	mA
TRANSISTOR DISSIPATION, P_T:				
For operation with heat sink:				
At case temperatures** up to 25°C	300	300	max.	mW
At case temperatures** above 25°C	Derate at 1.71 mW/°C			
For operation at ambient temperatures:				
At ambient temperatures up to 25°C	200	200	max.	mW
At ambient temperatures above 25°C	Derate at 1.14 mW/°C			
TEMPERATURE RANGE:				
Storage and Operating (Junction)	-65 to +200			°C
LEAD TEMPERATURE (During Soldering):				
At distances ≥ 1/16 inch from seating surface for 60 seconds max.	300	300	max.	°C

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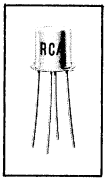
* Limited by transistor dissipation.

** Measured at center of seating surface.

SILICON N-P-N EPITAXIAL PLANAR TRANSISTORS



JEDEC TO-72

For VHF Applications In Military, Communications, and Industrial Equipment

FEATURES

- high gain-bandwidth product
- hermetically sealed four-lead package
- low leakage current
- high 200-MHz power gain

2N3600

- low noise figure
  NF = 4.5 dB max. at 200 MHz
- low collector-to-base time constant
  $r_b'C_c$ = 15 ps max.
- high power gain as neutralized amplifier
  G_{pe} = 17 dB min. at 200 MHz

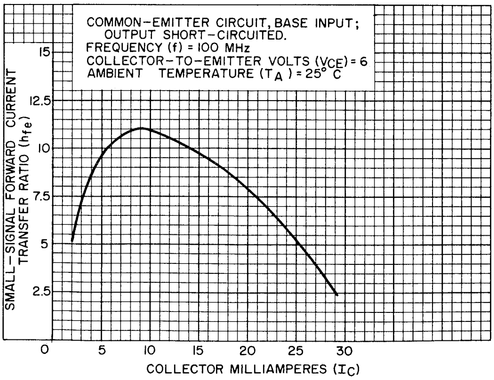


Fig.1 - Small-signal beta characteristic for types 2N918 and 2N3600.

ELECTRICAL CHARACTERISTICS

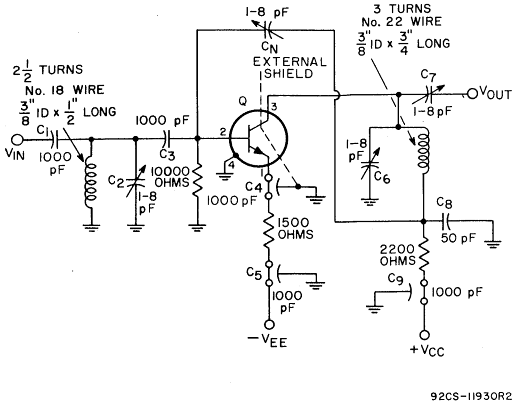
Characteristics	Symbols	TEST CONDITIONS								LIMITS						Units
		Ambient Temperature T_A	Frequency f	DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Emitter-to-Base Voltage V_{EB}	DC Emitter Current I_E	DC Collector Current I_C	DC Base Current I_B	Type 2N918			Type 2N3600			
		°C	MHz	V	V	V	mA	mA	mA	Min.	Typ.	Max.	Min.	Typ.	Max.	
Collector-Cutoff Current	I_{CBO}	25		15			0			-	-	0.01	-	-	0.01	µA
		150		15			0			-	-	1	-	-	1	µA
Collector-to-Base Breakdown Voltage	BV_{CBO}	25					0	0.001		30	-	-	30	-	-	V
Collector-to-Emitter Sustaining Voltage	BV_{CEO}(sus)	25						3	0	15	-	-	15	-	-	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}	25					0.01	0		3	-	-	3	-	-	V
Collector-to-Emitter Saturation Voltage	V_{CE}(sat)	25						10	1	-	-	0.4	-	-	0.4	V
Base-to-Emitter Saturation Voltage	V_{BE}(sat)	25						10	1	-	-	1	-	-	1	V
Static Forward Current-Transfer Ratio	h_{FE}	25			1			3		20	-	-	20	-	150	
Small-Signal Forward Current-Transfer Ratio[a]	h_{fe}	25	100		10			4		6	-	-	-	-	-	
			100		6			5		-	-	-	8.5	-	15	
			1 kHz		6			2		-	-	-	40	-	200	
Common-Base Output Capacitance[b]	C_{ob}	25	0.1 to 1	10			0			-	-	1.7	-	-	-	pF
				0			0			-	-	3	-	-	-	pF
Collector-to-Base Feedback Capacitance[b]	C_{cb}	25	0.1 to 1	10			0			-	-	-	-	-	1	pF
Common-Base Input Capacitance[c]	C_{ib}	25	0.1 to 1			0.5		0		-	-	2	-	1.4	-	pF
Collector-to-Base Time Constant[a]	$r_b'C_c$	25	40	6				2		-	15	-	-	-	-	ps
			31.9	6				5		-	-	-	4	-	15	ps
Small-Signal Power Gain in Neutralized Common-Emitter Amplifier Circuit[a] (See Fig.2 & Fig.3)	G_{pe}	25	200		12			6		15	21	-	-	-	-	dB
					6			5		-	-	-	17	-	24	dB
Small-Signal Power Gain in Unneutralized Common-Emitter Amplifier Circuit[a] (See Fig.4)	G_{pe}	25	200		10			5		-	13	-	-	-	-	dB
Power Output in Common-Emitter Oscillator Circuit[c] (See Fig.5)	P_O	25	≥ 500	10			12			30	-	-	20	-	-	mW
Nose Figure[a] (See Fig.2)	NF	25	200		6			1.5		-	-	-	-	-	4.5	dB
Noise Figure[a,d]	NF	25	60		6			1		-	-	6	-	-	3	dB

[a] Lead No.4 (case) grounded.

[b] Three-terminal measurement of the collector-to-base capacitance with the case and emitter leads connected to the guard terminal.

[c] Lead No.4 (case) floating.

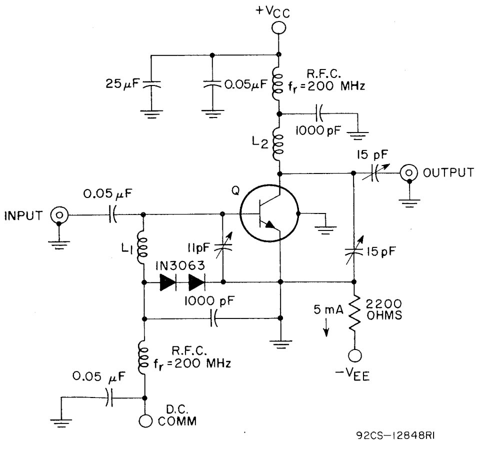
[d] Generator Resistance (R_g) = 400 ohms.



NOTE: (Neutralization Procedure): (a) Connect a 50-Ω rf voltmeter to the output of a 200-MHz signal generator (R_g = 50 Ω), and adjust the generator output to 5 mV. (b) Connect the generator to the input and the rf voltmeter to the output of the amplifier, as shown above. (c) Apply V_{EE} and V_{CC}, and adjust the generator output to provide an amplifier output of 5 mV. (d) Tune C_2, C_6, and C_7 for maximum amplifier output, readjusting the generator output, as required, to maintain an output of 5 mV from the amplifier. (e) Interchange the connections to the signal generator and the rf voltmeter. (f) With sufficient signal applied to the output terminals of the amplifier, adjust CN for a minimum indication at the amplifier input. (g) Repeat steps (a), (b), (c), and (d) to determine if retuning is necessary.

Q = Type 2N3600

Fig.2 - Neutralized amplifier circuit used to measure power gain and noise figure at 200 MHz for type 2N3600.

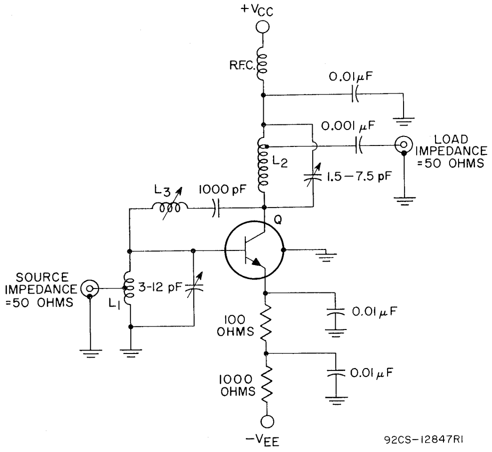


L_1 - 1 loop #12 AWG wire; I_D = 13/16"

L_2 - 1/2 loop #12 AWG wire; I_D = 1-3/16"

Q = 2N918

Fig.4 - Circuit used to measure 200-MHz unneutralized power gain for type 2N918.



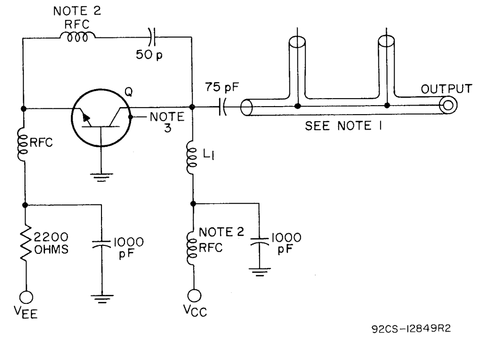
L_1 - 3.5 turns No.16 tinned copper wire; 5/16" dia.; 7/16" long; turns ratio ≃ 4:2

L_2 - 8 turns No.16 tinned copper wire; 1/8" dia.; 7/8" long; turns ratio ≃ 8:1

L_3 - MILLER #4303 (0.4 - 0.65 μH) or equivalent

Q = Type 2N918

Fig.3 - Neutralized amplifier circuit used to measure power gain at 200 MHz for type 2N918.



Note 1 - Coaxial-Line output network consisting of:
- 2 General Radio Type 874 TEE or equivalent
- 1 General Radio Type 874-D20 Adjustable Stub or equivalent
- 1 General Radio Type 874-LA Adjustable Line or equivalent
- 1 General Radio Type 874-WN3 Short-circuit termination or equivalent

Note 2 - RFC = 0.2 μH Ohmite #2-460 or equivalent

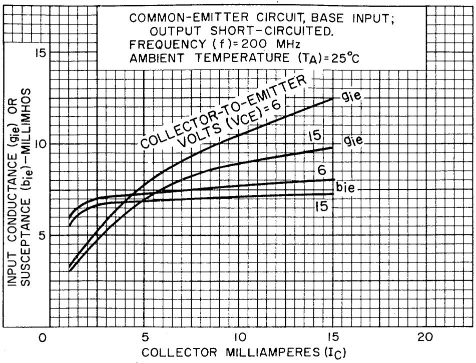
Note 3 - Lead Number 4 (case) floating

L_1 - 2 turns #16AWG wire, 3/8 inch OD, 1-1/4 inch long

Q = 2N918 or 2N3600

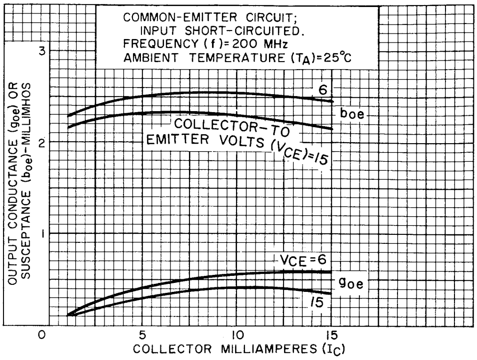
Fig.5 - Circuit used to measure 500-MHz oscillator power output for types 2N918 and 2N3600.

TWO-PORT ADMITTANCE (y) PARAMETERS AS FUNCTIONS OF COLLECTOR CURRENT (I_C) FOR RCA TYPES 2N918 AND 2N3600



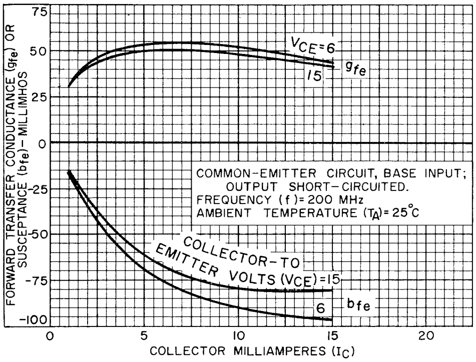
92CS-12757R2

Fig.6 - Input admittance (y_{ie}).



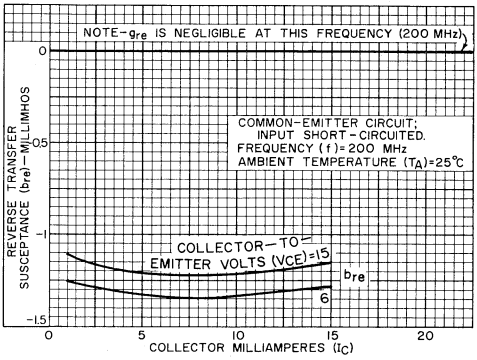
92CS-12758R2

Fig.7 - Output admittance (y_{oe}).



92CS-12759R2

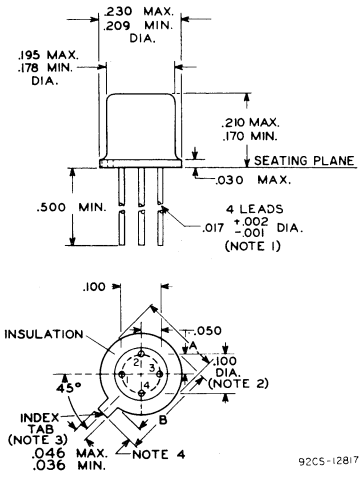
Fig.8 - Forward transadmittance (y_{fe}).



92CS-12760R2

Fig.9 - Reverse transadmittance (y_{re}).

DIMENSIONAL OUTLINE TO-72



92CS-12817

Dimensions in Inches

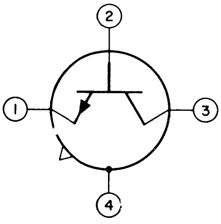
NOTE 1: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050" AND 0.250" FROM THE SEATING PLANE. FROM 0.250" TO THE END OF THE LEAD A MAXIMUM DIAMETER OF 0.021" IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 2: MAXIMUM DIAMETER LEADS AT A GAUGING PLANE 0.054" + 0.001" - 0.000" BELOW SEATING PLANE TO BE WITHIN 0.007" OF THEIR TRUE LOCATION RELATIVE TO MAX. WIDTH TAB AND TO THE MAXIMUM 0.230" DIAMETER MEASURED WITH A SUITABLE GAUGE. WHEN GAUGE IS NOT USED, MEASUREMENT WILL BE MADE AT SEATING PLANE.

NOTE 3: FOR VISUAL ORIENTATION ONLY.

NOTE 4: TAB LENGTH TO BE 0.028"MINIMUM - 0.048"MAXIMUM, AND WILL BE DETERMINED BY SUBTRACTING DIAMETER A FROM DIMENSION B.

TERMINAL DIAGRAM (Bottom View)



LEAD 1 - EMITTER

LEAD 2 - BASE

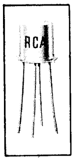
LEAD 3 - COLLECTOR

LEAD 4 - CONNECTED TO CASE

2N2857

SILICON N-P-N EPITAXIAL PLANAR TRANSISTOR

For UHF Applications in Industrial and Military Equipment



JEDEC
TO-72

RCA-2N2857 is a double-diffused epitaxial planar transistor of the silicon n-p-n type. It is extremely useful in low-noise-amplifier, oscillator, and converter applications at frequencies up to 500 MHz in the common-emitter configuration, and up to 1200 MHz in the common-base configuration.

The 2N2857 utilizes a hermetically sealed four-lead JEDEC TO-72 package. All active elements of the transistor are insulated from the case, which may be grounded by means of the fourth lead in applications requiring shielding of the device.

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE, V_{CBO} . .	30 max.	V
COLLECTOR-TO-EMITTER VOLTAGE, V_{CEO}	15 max.	V
EMITTER-TO-BASE VOLTAGE, V_{EBO} . . .	2.5 max.	V
COLLECTOR CURRENT, I_C	40 max.	mA
TRANSISTOR DISSIPATION, P_T:		
At case temperatures* up to 25° C.	300 max.	mW
At case temperatures* above 25° C. .	Derate at 1.72	mW/°C
At ambient temperatures up to 25°C	200 max.	mW
At ambient temperatures above 25° C. .	Derate at 1.14	mW/°C
TEMPERATURE RANGE:		
Storage and Operating (Junction)	-65 to +200	°C
LEAD TEMPERATURE (During soldering):		
At distances ≥ 1/32 inch from seating surface for 10 seconds max	265 max.	°C

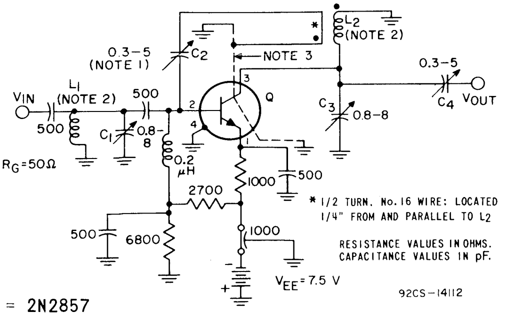
* Measured at center of seating surface.

FEATURES

- high gain-bandwidth product— f_T = 1000 MHz min.
- high converter (450-to-30 MHz) gain— G_c = 15 dB typ. for circuit bandwidth of approximately 2 MHz
- high power gain as neutralized amplifier— G_{pe} = 12.5 dB min. at 450 MHz for circuit bandwidth of 20 MHz
- high power output as uhf oscillator—

  P_o = 30 mW min., 40 mW typ. at 500 MHz
  P_o = 20 mW typ., at 1 GHz
- low device noise figure—

  NF = 4.5 dB max. as 450 MHz amplifier
  NF = 7.5 dB typ. as 450-to-30 MHz converter
- low collector-to-base time constant — $r_b'C_c$ = 7 ps typ.
- low collector-to-base feedback capacitance— C_{cb} = 0.6 pF typ.



* 1/2 TURN. No.16 WIRE: LOCATED 1/4" FROM AND PARALLEL TO L2

RESISTANCE VALUES IN OHMS.
CAPACITANCE VALUES IN pF.

Q = 2N2857

NOTE 1: (NEUTRALIZATION PROCEDURE): (A) CONNECT A 450-MHz SIGNAL GENERATOR (WITH R_G = 50 Ω) TO THE INPUT TERMINALS OF THE AMPLIFIER. (B) CONNECT A 50-Ω RF VOLTMETER ACROSS THE OUTPUT TERMINALS OF THE AMPLIFIER. (C) APPLY V_{EE}, AND WITH THE SIGNAL GENERATOR ADJUSTED FOR 5 mV OUTPUT FROM THE AMPLIFIER, TUNE C_1, C_3, AND C_4 FOR MAXIMUM OUTPUT. (D) INTERCHANGE THE CONNECTIONS TO THE SIGNAL GENERATOR AND THE RF-VOLTMETER. (E) WITH SUFFICIENT SIGNAL APPLIED TO THE OUTPUT TERMINALS OF THE AMPLIFIER, ADJUST C_2 FOR A MINIMUM INDICATION AT THE INPUT. (F) REPEAT STEPS (A), (B), AND (C) TO DETERMINE IF RETUNING IS NECESSARY.

NOTE 2: L_1 & L_2 — SILVER-PLATED BRASS ROD, 1-1/2" LONG x 1/4" DIA. INSTALL AT LEAST 1/2" FROM NEAREST VERTICAL CHASSIS SURFACE.

NOTE 3: EXTERNAL INTERLEAD SHIELD TO ISOLATE THE COLLECTOR LEAD FROM THE EMITTER AND BASE LEADS.

Fig. 1 - Neutralized amplifier circuit used to measure 450 MHz power gain and noise figure for type 2N2857.

ELECTRICAL CHARACTERISTICS, *At an Ambient Temperature, $T_A = 25^o$ C, Unless Otherwise Specified*

Characteristic	Symbol	Frequency f	TEST CONDITIONS DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Emitter-to-Base Voltage V_{EB}	DC Emitter Current I_E	DC Base Current I_B	DC Collector Current I_C	LIMITS Type 2N2857 Min.	Typ.	Max.	Units
		MHz	V	V	V	mA	mA	mA				
Collector-Cutoff Current	I_{CBO}	$T_A = 25^oC$ $T_A = 150^oC$	15 15			0 0			-	-	10 1.0	nA µA
Collector-to-Base Breakdown Voltage	BV_{CBO}					0		0.001	30	-	-	V
Collector-to-Emitter Breakdown Voltage	BV_{CEO}						0	3	15	-	-	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}					-0.01		0	2.5	-	-	V
Static Forward-Current Transfer Ratio	h_{FE}			1				3	30	-	150	
Small-Signal Forward-Current Transfer Ratio	h_{fe}	0.001^c 100^c		6 6				2 5	50 10	- -	220 19	
Collector-to-Base Feedback Capacitance	C_{cb}	0.1 to 1^b	10			0			-	0.6	1.0	pF
Input Capacitance	C_{ib}	0.1 to 1^a			0.5			0	-	1.4	-	pF
Collector-to-Base Time Constant	$r_b'C_c$	31.9^c	6			-2			4	7	15	ps
Small-Signal, Common-Emitter Power Gain in Neutralized Amplifier Circuit (See Fig.1)	G_{pe}	450^c		6				1.5	12.5	-	19	dB
Power Output as Oscillator (See Fig.2)	P_O	$\geq 500^a$	10			-12			30	-	-	mW
UHF Device Noise Figure	NF	$450^{c,d,f}$		6				1.5	-	3.8	4.5	dB
UHF Measured Noise Figure	NF	$450^{c,d}$		6				1.5	-	-	5.0	dB
VHF Device Noise Figure	NF	$60^{b,d}$		6				1	-	2.2	-	dB

[a] Fourth lead (case) not connected

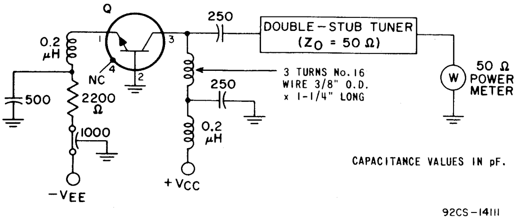
[b] Three-terminal measurement: Lead No.1 (Emitter) and lead No.4 (Case) connected to guard terminal.

[c] Fourth lead (case) grounded.

[d] Generator resistance, R_g = 50 ohms.

[e] Generator resistance, R_g = 400 ohms.

[f] Device noise figure is approximately 0.5 dB lower than the measured noise figure. The difference is due to the insertion loss at the input of the test circuit (0.25 dB) and the contribution of the following stages in the test set-up (0.25 dB).



Q = 2N2857

Fig.2 - Oscillator circuit used to measure 500-MHz power output for type 2N2857.

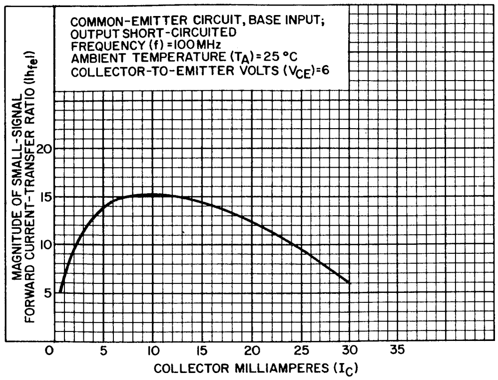


Fig.3 - Small-signal beta characteristic for type 2N2857.

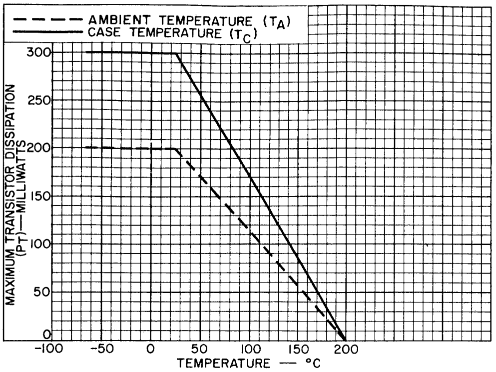


Fig.4 - Rating chart for type 2N2857.

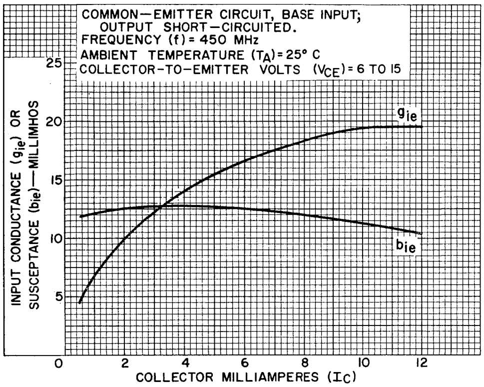


Fig.5 - Input admittance (y_{ie}).

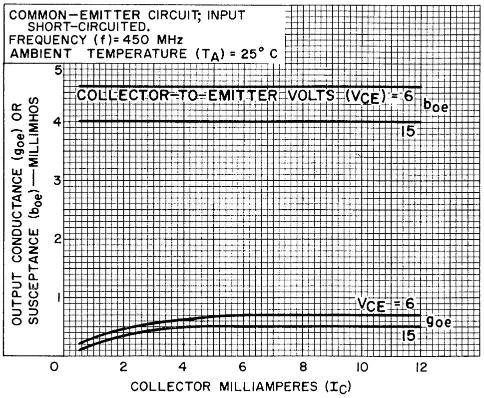


Fig.6 - Output admittance (y_{oe}).

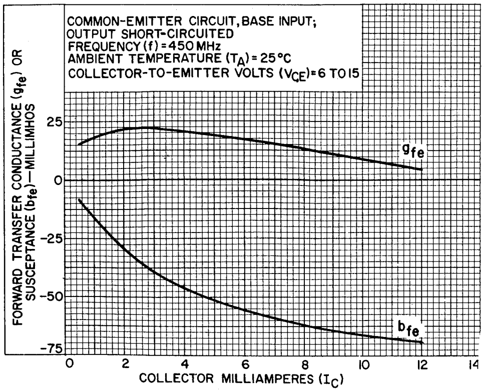


Fig.7 - Forward transadmittance (y_{fe}).

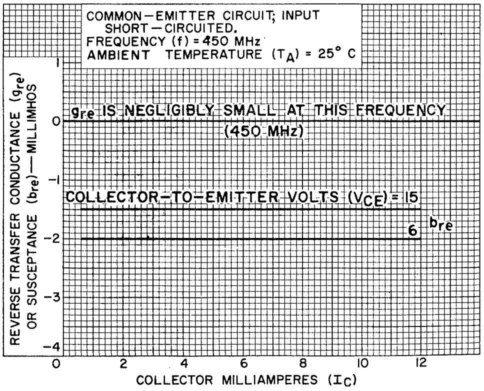
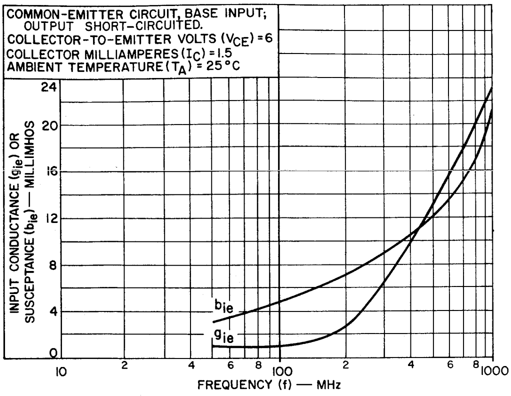
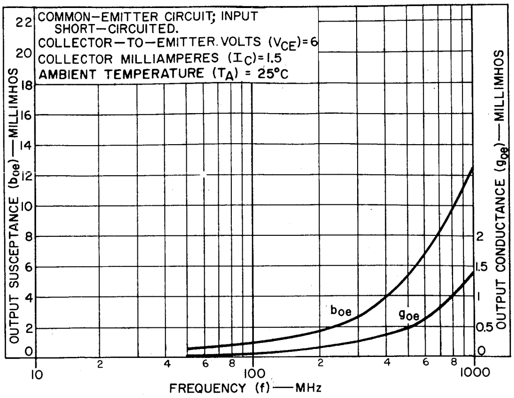


Fig.8 - Reverse transadmittance (y_{re}).



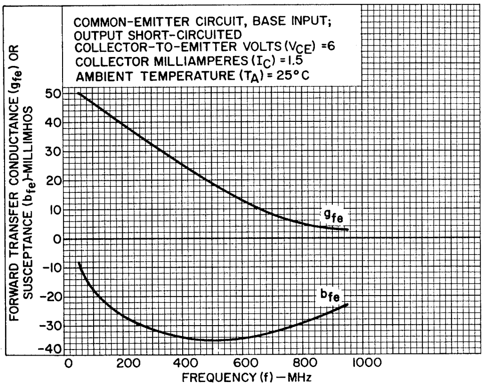
92CS-12157R1

Fig. 9 - Input admittance (y_{ie}).



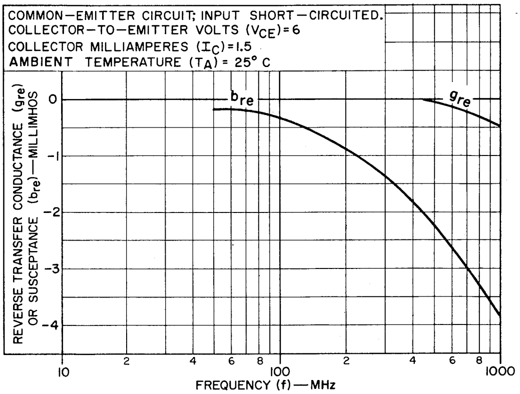
92CS-12156R2

Fig. 10 - Output admittance (y_{oe}).



92CS-12152R1

Fig. 11 - Forward transadmittance (y_{fe}).

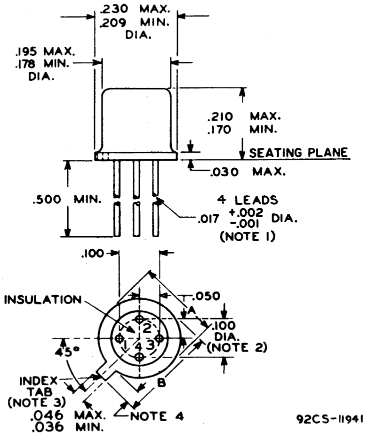


92CS-12151R3

Fig. 12 - Reverse transadmittance (y_{re}).

DIMENSIONAL OUTLINE

JEDEC TO-72



92CS-11941

NOTE 1: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050" AND 0.250" FROM THE SEATING PLANE. FROM 0.250" TO THE END OF THE LEAD A MAXIMUM DIAMETER OF 0.021" IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 2: MAXIMUM DIAMETER LEADS AT A GAUGING PLANE 0.054" + 0.001" - 0.000" BELOW SEATING PLANE TO BE WITHIN 0.007" OF THEIR TRUE LOCATION RELATIVE TO MAX. WIDTH TAB AND TO THE MAXIMUM 0.230" DIAMETER MEASURED WITH A SUITABLE GAUGE. WHEN GAUGE IS NOT USED, MEASUREMENT WILL BE MADE AT SEATING PLANE.

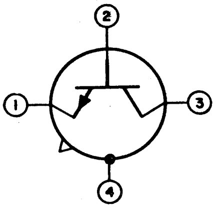
NOTE 3: FOR VISUAL ORIENTATION ONLY.

NOTE 4: TAB LENGTH TO BE 0.028" MINIMUM - 0.048" MAXIMUM, AND WILL BE DETERMINED BY SUBTRACTING DIAMETER A FROM DIMENSION B.

TERMINAL DIAGRAM

Bottom View

LEAD 1 - EMITTER
LEAD 2 - BASE
LEAD 3 - COLLECTOR
LEAD 4 - CONNECTED TO CASE



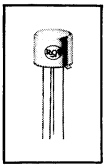
RCA
Solid State Division

2N3478

RCA-2N3478 is an epitaxial planar transistor of the silicon n-p-n type with characteristics which make it extremely useful as a general purpose RF amplifier at frequencies up to 470 MHz. These characteristics include an exceptionally low noise figure at high frequencies, low leakage current, and a high gain-bandwidth product.

The 2N3478 utilizes a hermetically sealed four-lead package in which active elements of the transistor are insulated from the case. The case may be grounded by means of a fourth lead in applications requiring minimum feedback capacitance, shielding of the device, or both.

SILICON N-P-N EPITAXIAL PLANAR TRANSISTOR



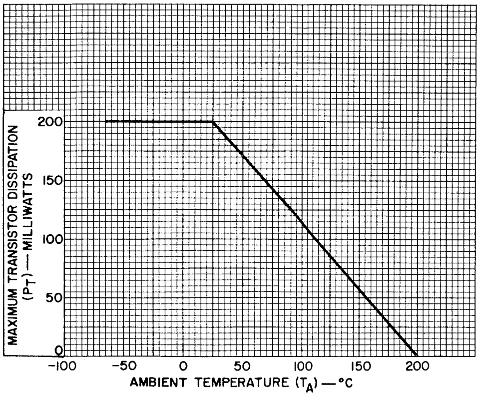
For VHF/UHF Applications in Industrial and Commercial Equipment

Maximum Ratings, *Absolute-Maximum Values:*

Collector-to-Base Voltage, V_{CBO}	30 max.	V
Collector-to-Emitter Voltage, V_{CEO} . .	15 max.	V
Emitter-to-Base Voltage, V_{EBO}	2 max.	V
Collector Current, I_C	limited by dissipation	
Transistor Dissipation, PT:		
at ambient temperatures } up to 25° C	200 max.	mW
at ambient temperatures } above 25° C.	See *Fig. 1*	
Temperature Range:		
Storage and Operating (Junction)	-65 to 200	°C
Lead Temperature (During Soldering):		
At distances not closer than 1/32" to seating surface for 10 seconds max.	265 max.	°C

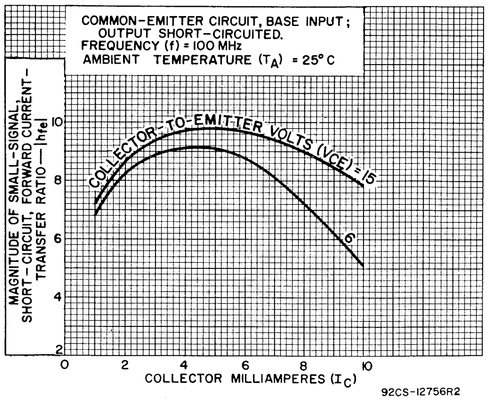
FEATURES

- high gain-bandwidth product – f_T = 900 MHz typ.
- low noise figure
  NF = 5 dB typ. at 470 MHz
  4.5 dB max. at 200 MHz
  2.5 dB typ. at 60 MHz
- high unneutralized power gain
  G_{pe} = 11.5 dB min. at 200 MHz
- hermetically sealed four-lead package
- all active elements insulated from case
- low collector-to-base feedback capacitance, C_{cb} 0.7 pF max.



92CS-12754R1

Fig. 1 - Rating chart for type 2N3478



92CS-12756R2

Fig. 2 - Typical small-signal beta characteristics for type 2N3478

ELECTRICAL CHARACTERISTICS, *At an Ambient Temperature, (T_A) of 25° C*

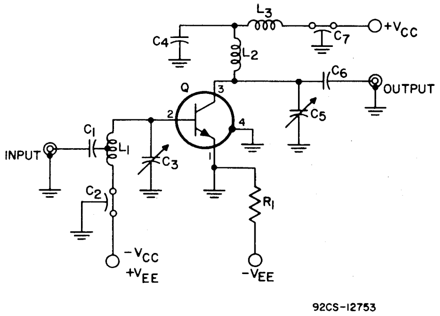
Characteristics	Symbols	TEST CONDITIONS: Frequency f MHz	TEST CONDITIONS: DC Collector-to-Base Voltage V_{CB} V	TEST CONDITIONS: DC Collector-to-Emitter Voltage V_{CE} V	TEST CONDITIONS: DC Emitter Current I_E mA	TEST CONDITIONS: DC Collector Current I_C mA	LIMITS Type 2N3478 Min.	LIMITS Type 2N3478 Typ.	LIMITS Type 2N3478 Max.	Units
Collector-Cutoff Current	I_{CBO}		1		0		–	–	0.02	μA
Collector-to-Base Breakdown Voltage	BV_{CBO}				0	0.001	30	–	–	V
Collector-to-Emitter Breakdown Voltage	BV_{CEO}					0.001	15	–	–	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}				-0.001	0	2	–	–	V
Static Forward-Current Transfer Ratio	h_{FE}			8		2	25	–	150	
Magnitude of Small-Signal Forward-Current Transfer Ratio	h_{fe}[a]	100		8		2	7.5	9	16	
Collector-to-Base Feedback Capacitance	C_{cb}[b]	0.1 to 1	8		0		–	–	0.7	pF
Small-Signal, Common-Emitter Power Gain in Unneutralized Amplifier Circuit (See *Fig. 3*)	G_{pe}[a]	200		8		2	11.5	–	17	dB
Small-Signal, Common-Emitter Power Gain in Neutralized Amplifier Circuit	G_{pe}[a, c]	470		6		1.5	–	12	–	dB
UHF Noise Figure	NF[a, c]	470		6		1.5	–	5	–	dB
VHF Noise Figure (See *Fig. 3*)	NF[a] NF[a, d]	200 60		8 8		2 1	– –	 2.5	4.5 –	dB dB

[a] Fourth lead (case) grounded.

[b] C_{cb} is a three terminal measurement of the collector-to-base capacitance with the emitter and case connected to the guard terminal.

[c] Source Resistance, R_s = 50 ohms.

[d] Source Resistance, R_s = 400 ohms.



C_1, C_4 = 510 pF
C_2, C_7 = 2300 pF
C_3, C_5 = 2-25 pF
C_6 = 10 pF
R_1 = 2000 ohms
Q = 2N3478
L_1 = ½ Turn #14 Formvar● center tapped
Length$_1$, ℓ_1 = 2 inches
L_2 = ½ Turn #14 Formvar●
Length$_2$, ℓ_2 = 1½ inches
L_3 = 1 μH RF choke
Source (Generator) Resistance R_g = 50 ohms
Load Resistance R_L = 50 ohms
● Trademark, Shawindian Products Corporation.

Fig. 3 - 200 MHz power gain and noise figure test circuit for type 2N3478

Typical Two-Port Admittance (y) Parameters as Functions of Collector Current for Type 2N3478

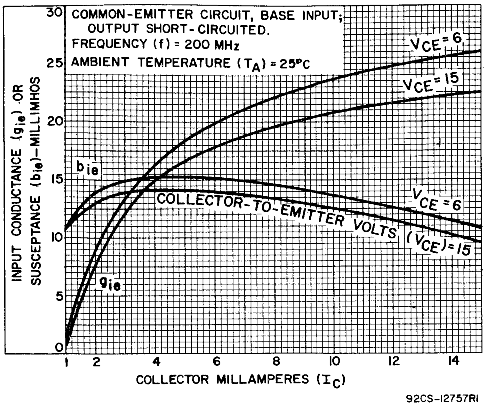


Fig. 4 - Input admittance (y_{ie})

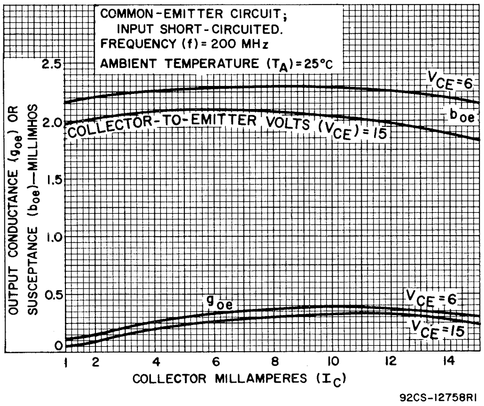


Fig. 5 - Output admittance (y_{oe})

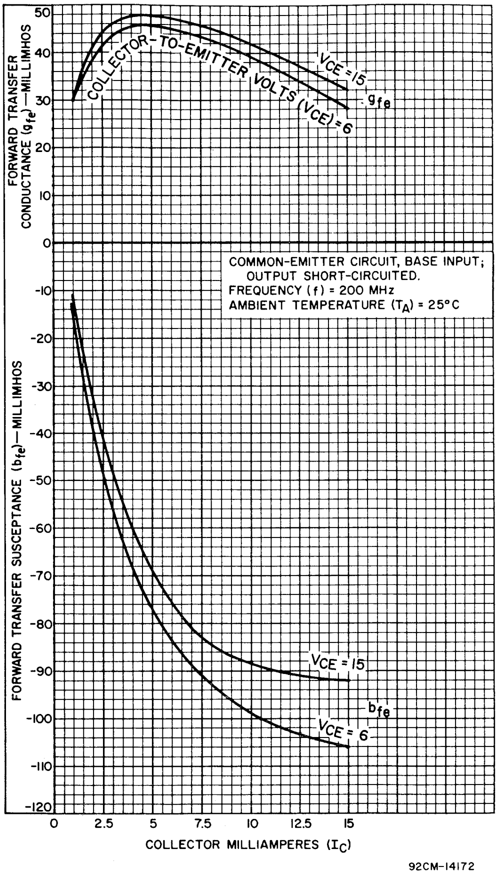


Fig. 6 - Forward transadmittance (y_{fe})

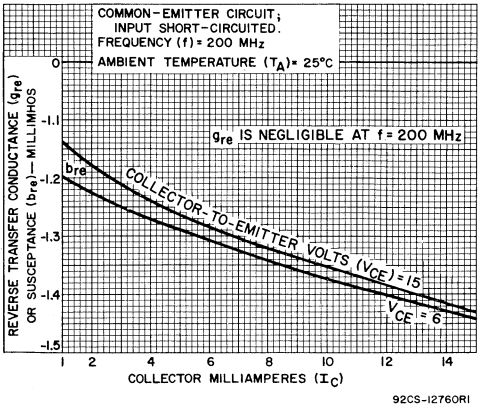
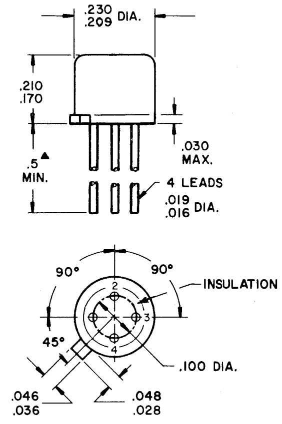


Fig. 7 - Reverse transadmittance (y_{re})

DIMENSIONAL OUTLINE



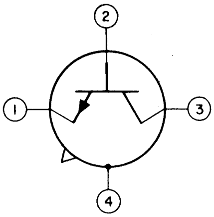
▲LEAD NO. 4 = .375 MIN.

92CS-14170

Dimensions in Inches

TERMINAL DIAGRAM

Bottom View



Lead 1 - Emitter
Lead 2 - Base

Lead 3 - Collector
Lead 4 - Connected to Case

RCA

Solid State
Division

RF Power Transistors

2N3839

RCA-2N3839* is a double-diffused epitaxial planar transistor of the silicon n-p-n type. It is extremely useful in low-noise-amplifier, oscillator, and converter applications at frequencies up to 500 MHz in the common-emitter configuration, and up to 1200 MHz, in the common-base configuration.

The 2N3839 is mechanically and electrically like the 2N2857, but has a substantially lower noise figure.

The 2N3839 utilizes a hermetically sealed four-lead JEDEC TO-72 package. All active elements of the transistor are insulated from the case, which may be grounded by means of the fourth lead in applications requiring shielding of the device.

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE, V_{CBO}	30 max.	V
COLLECTOR-TO-EMITTER VOLTAGE, V_{CEO}	15 max.	V
EMITTER-TO-BASE VOLTAGE, V_{EBO}	2.5 max.	V
COLLECTOR CURRENT, I_C	40 max.	mA
TRANSISTOR DISSIPATION, P_T:		
For operation with heat sink:		
At case temperatures** up to 25°C	300 max.	mW
At case temperatures** above 25°C	Derate at 1.72	mW/°C
For operation at ambient temperatures:		
At ambient temperatures up to 25°C	200 max.	mW
At ambient temperatures above 25°C	Derate at 1.14	mW/°C
TEMPERATURE RANGE:		
Storage and Operating (Junction)	-65 to +200	°C
LEAD TEMPERATURE (During Soldering):		
At distances ≥ 1/32 inch from seating surface for 10 seconds max.	265 max.	°C

* **Formerly Dev. No. TA-2363**

** Measured at center of seating surface.

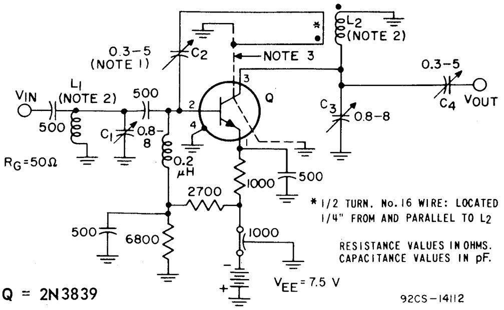
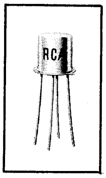


Fig.1 - Neutralized amplifier circuit used to measure 450-MHz power gain and noise figure for type 2N3839.

SILICON N-P-N EPITAXIAL PLANAR TRANSISTOR



JEDEC
TO-72

For Low-Noise UHF Applications in Industrial and Military Equipment

FEATURES

- very low device noise figure —
  NF = 3.4 dB max. as 450-MHz amplifier
- high gain-bandwidth product —
  f_T = 1000 MHz min.
- high converter (450-to-30 MHz) gain —
  G_c = 15 dB typ. for circuit bandwidth of approximately 2 MHz
- high power gain as neutralized amplifier —
  G_{pe} = 12.5 dB min. at 450 MHz for circuit bandwidth of 20 MHz
- high power output as UHF oscillator —
  P_o = 30 mW min., 40 mW typ. at 500 MHz
  = 20 mW typ. at 1 GHz
- low collector-to-base time constant —
  $r_b{}'C_c$ = 7 ps typ.
- low collector-to-base feedback capacitance —
  C_{cb} = 0.6 pF typ.

NOTE 1: (NEUTRALIZATION PROCEDURE): (A) CONNECT A 450-MHz SIGNAL GENERATOR (WITH R_g = 50 OHMS) TO THE INPUT TERMINALS OF THE AMPLIFIER. (B) CONNECT A 50-OHM RF VOLTMETER ACROSS THE OUTPUT TERMINALS OF THE AMPLIFIER. (C) APPLY V_{EE}, AND WITH THE SIGNAL GENERATOR ADJUSTED FOR 5 mV OUTPUT FROM THE AMPLIFIER, TUNE C1, C3, AND C4 FOR MAXIMUM OUTPUT. (D) INTERCHANGE THE CONNECTIONS TO THE SIGNAL GENERATOR AND THE RF VOLTMETER. (E) WITH SUFFICIENT SIGNAL APPLIED TO THE OUTPUT TERMINALS OF THE AMPLIFIER, ADJUST C2 FOR A MINIMUM INDICATION AT THE INPUT. (F) REPEAT STEPS (A), (B), AND (C) TO DETERMINE IF RETUNING IS NECESSARY.

NOTE 2: L_1 & L_2—SILVER-PLATED BRASS ROD, 1-1/2" LONG x 1/4" DIA. INSTALL AT LEAST 1/2" FROM NEAREST VERTICAL CHASSIS SURFACE.

NOTE 3: EXTERNAL INTERLEAD SHIELD TO ISOLATE THE COLLECTOR LEAD FROM THE EMITTER AND BASE LEADS.

ELECTRICAL CHARACTERISTICS, *At an Ambient Temperature, T_A, of 25°C, Unless Otherwise Specified*

CHARACTERISTICS	SYMBOL	TEST CONDITIONS							LIMITS			UNITS
		FREOUENCY f	DC COLLECTOR-TO-BASE VOLTAGE V_{CB}	DC COLLECTOR-TO-EMITTER VOLTAGE V_{CE}	DC EMITTER-TO-BASE VOLTAGE V_{EB}	DC EMITTER CURRENT I_E	DC BASE CURRENT I_B	DC COLLECTOR CURRENT I_C	TYPE 2N3839			
		MHz	V	V	V	mA	mA	mA	Min.	Typ.	Max.	
Collector-Cutoff Current T_A = 25°C T_A = 150°C	I_{CBO}		 15 15			 0 0			 - -	 - -	 10 1.0	 nA μA
Collector-to-Base Breakdown Voltage	BV_{CBO}					0		0.001	30	-	-	V
Collector-to-Emitter Breakdown Voltage	BV_{CEO}						0	3	15	-	-	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}					0.01		0	2.5	-	-	V
Static Forward Current-Transfer Ratio	h_{FE}			1				3	30	-	150	
Small-Signal Forward Current-Transfer Ratio	h_{fe}	0.001[c] 100[c]		6 6				2 5	50 10	- -	220 20	
Collector-to-Base Feedback Capacitance	C_{cb}	0.1 to 1.0[b]	10			0			-	0.6	1.0	pF
Input Capacitance	C_{ib}	0.1 to 1.0			0.5			0	-	1.4	-	pF
Collector-to-Base Time Constant	$r_b'C_c$	31.9[c]	6			-2			1	7	15	ps
Small-Signal, Common-Emitter Power Gain in Neutralized Amplifier Circuit (See *Fig.1*)	G_{pe}	450[c]		6				1.5	12.5	-	19	dB
Power Output as Oscillator (See *Fig 2*)	P_o	≥500[a]	10			-12			30	-	-	mW
UHF Measured Noise Figure (See *Fig.1*)	NF	450[c,d]		6				1.5	-	-	3.9	dB
UHF Device Noise Figure	NF	450[c,d,f]		6				1.5	-	-	3.4	dB
VHF Measured Noise Figure	NF	60[c,e]		6				1	-	2	-	dB

[a] Lead No.4 (case) not connected.

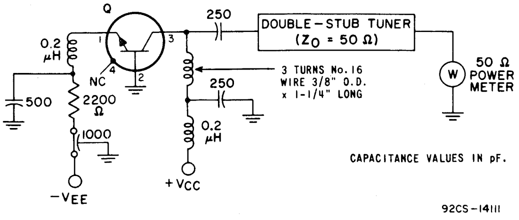
[b] 3-terminal measurement with emitter and case connected to guard terminal.

[c] Lead No.4 (case) grounded.

[d] Generator resistance, R_g = 50 ohms.

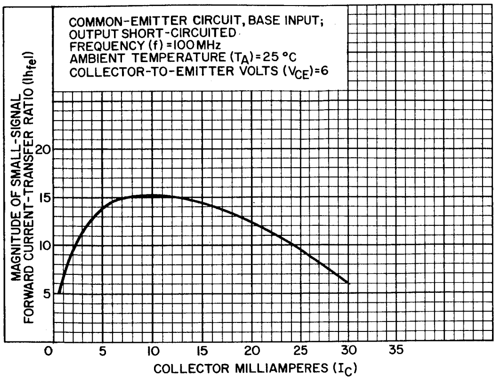
[e] Generator resistance, R_g = 400 ohms.

[f] Device noise figure is approximately 0.5 dB lower than the measured noise figure. The difference is due to the insertion loss at the input of the test circuit (0.25 dB) and the contribution of the following stages in the test setup (0.25 dB).



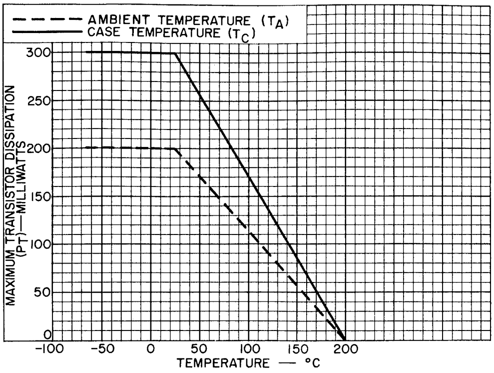
Q = 2N3839

Fig.2 - Oscillator circuit used to measure 500-MHz power output for type 2N3839.



92CS-14169

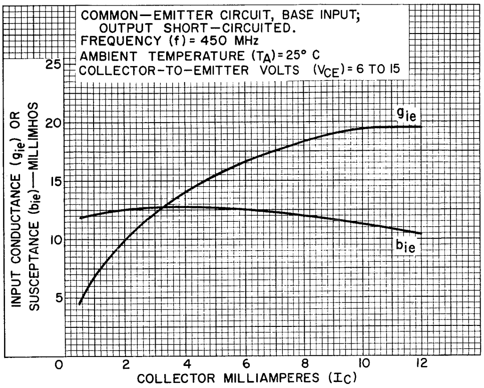
Fig.3 - *Small-Signal Beta Characteristic for Type 2N3839.*



92CS-12483R1

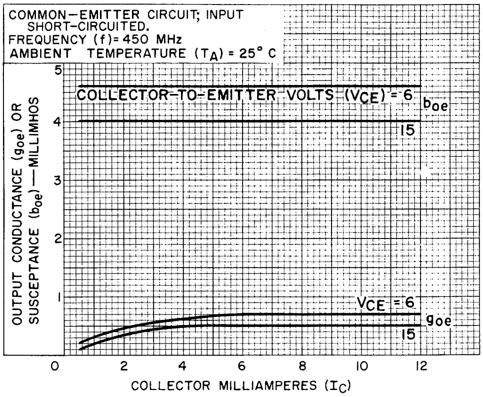
Fig.4 - *Rating Chart for Type 2N3839.*

TWO-PORT ADMITTANCE (y) PARAMETERS AS FUNCTIONS OF COLLECTOR CURRENT (I_C)



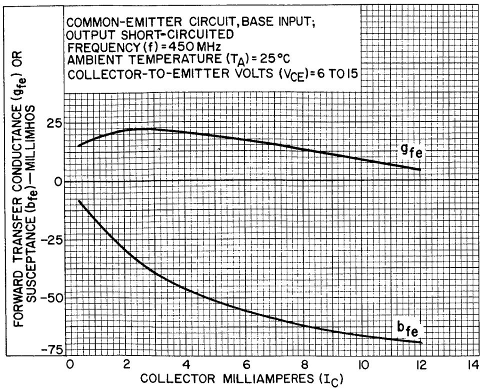
92CS-12150R1

Fig.5 - *Input Admittance (y_{ie}).*



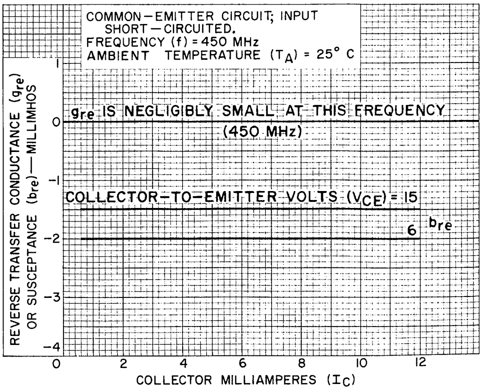
92CS-12148R1

Fig.6 - *Output Admittance (y_{oe}).*



92CS-12149R1

Fig.7 - *Forward Transadmittance (y_{fe}).*



92CS-12154R2

Fig.8 - *Reverse Transadmittance (y_{re}).*

TWO-PORT ADMITTANCE (y) PARAMETERS AS FUNCTIONS OF FREQUENCY (f)

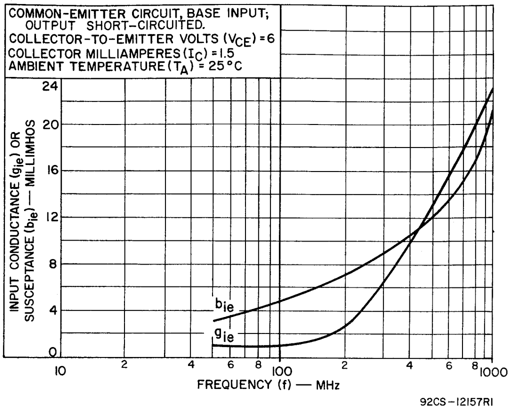


Fig.9 - Input Admittance (y_{ie}).

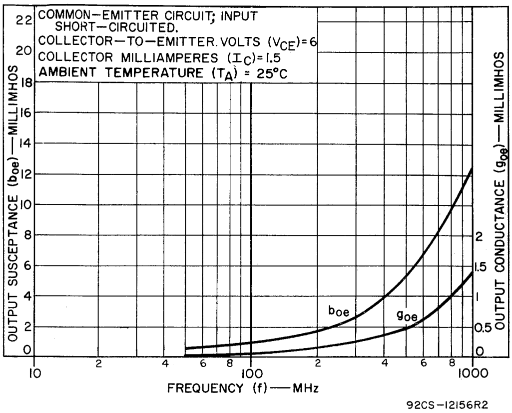


Fig.10 - Output Admittance

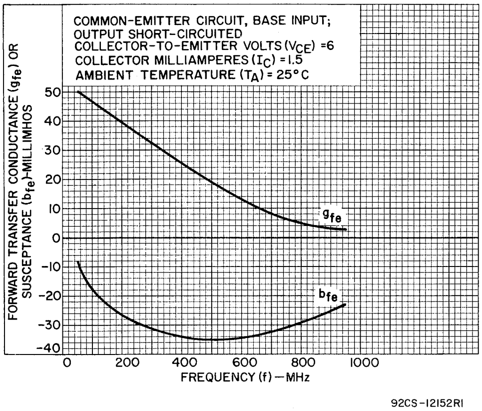


Fig.11 - Forward Transadmittance (y_{fe}).

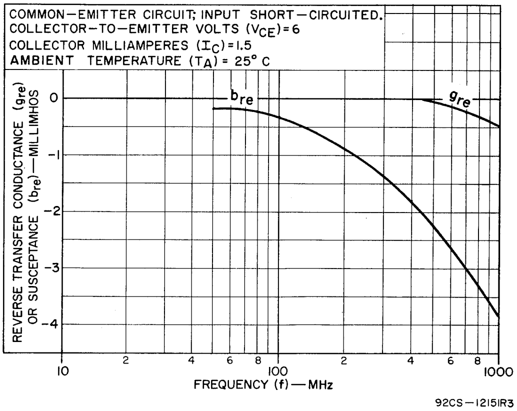
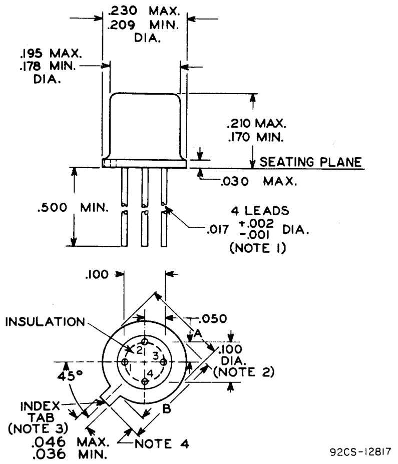
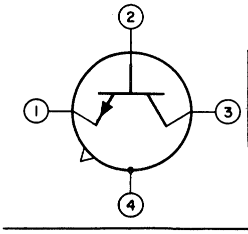


Fig.12 - Reverse Transadmittance (y_{re}).

DIMENSIONAL OUTLINE
JEDEC TO-72



TERMINAL DIAGRAM Bottom View



LEAD 1 - EMITTER
LEAD 2 - BASE
LEAD 3 - COLLECTOR
LEAD 4 - CONNECTED TO CASE

Note 1: The specified lead diameter applies in the zone between 0.050" and 0.250" from the seating plane. From 0.250" to the end of the lead a maximum diameter of 0.021" is held. Outside of these zones, the lead diameter is not controlled.

Note 2: Maximum diameter leads at a gauging plane 0.054" + 0.001" - 0.000" below seating plane to be within 0.007" of their true location relative to max. width tab and to the maximum 0.230" diameter measured with a suitable gauge. When gauge is not used, measurement will be made at seating plane.

Note 3: For visual orientation only.

Note 4: Tab length to be 0.028" minimum - 0.048" maximum, and will be determined by subtracting diameter A from dimension B.

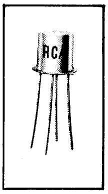
RCA

Solid State Division

RF Power Transistors

2N5179

SILICON N-P-N EPITAXIAL PLANAR TRANSISTOR



JEDEC TO-72

For UHF Applications in Military, Communications, and Industrial Equipment

RCA-2N5179* is a double-diffused epitaxial planar transistor of the silicon n-p-n type. It is extremely useful in low-noise tuned-amplifier and converter applications at UHF frequencies, and as an oscillator up to 500 MHz.

The 2N5179 utilizes a hermetically sealed four-lead JEDEC TO-72 package. All active elements of the transistor are insulated from the case, which may be grounded by means of the fourth lead in applications requiring minimum feedback capacitance, shielding of the device, or both.

Maximum Ratings, Absolute-Maximum Values:

COLLECTOR-TO-BASE VOLTAGE, V_{CBO}	20 max.	V
COLLECTOR-TO-EMITTER VOLTAGE, V_{CEO}	12 max.	V
EMITTER-TO-BASE VOLTAGE, V_{EBO}	2.5 max.	V
COLLECTOR CURRENT, I_C	50 max.	mA
TRANSISTOR DISSIPATION, P_T:		
For operation with heat sink:		
At case temperatures** up to 25°C	300 max.	mW
At case temperatures** above 25°C	Derate at 1.71mW/°C	
For operation at ambient temperatures:		
At ambient temperatures up to 25°C	200 max.	mW
At ambient temperatures above 25°C	Derate at 1.14mW/°C	
TEMPERATURE RANGE:		
Storage and Operating (Junction)	−65 to +200	°C
LEAD TEMPERATURE (During Soldering):		
At distances ≥ 1/32″ from seating surface for 10 seconds max.	265 max.	°C

- **high gain-bandwidth product — 1000MHz min.**
- **hermetically sealed TO-72 four-lead metal package**
- **low leakage current**
- **high power gain as neutralized amplifier — G_{pe} = 15dB min. at 200MHz**
- **high power output as UHF oscillator — 20mW typ. at 500MHz**
- **low noise figure — NF = 4.5dB max. at 200MHz**
- **low collector-to-base time constant — $r_b'C_c$ = 14ps max.**
- **high reliability — production lots of RCA-2N5179 are subjected to and meet the minimum mechanical, environmental, and life-test requirements of the basic MILITARY specification MIL-S-19500. See page 5 for a description of the Group A and Group B Tests.**

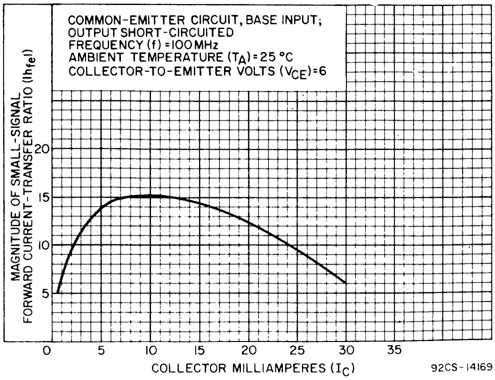


Fig. 1 – Small-Signal Beta Characteristic for Type 2N5179

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* Formerly Dev. No. TA7319.

** Measured at center of seating surface.

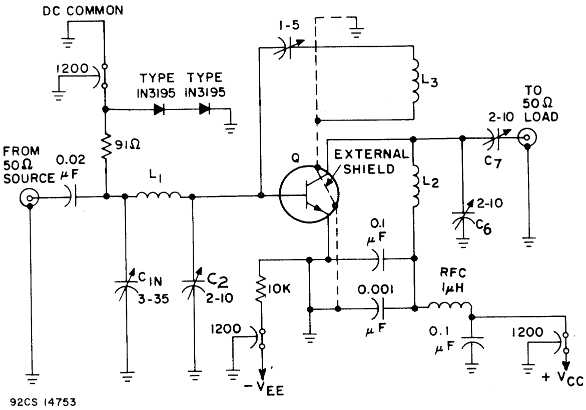
ELECTRICAL CHARACTERISTICS

Characteristics	Symbols	TEST CONDITIONS								LIMITS			Units
		Ambient Temp. T_A	Frequency f	DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Emitter-to-Base Voltage V_{EB}	DC Emitter Current I_E	DC Collector Current I_C	DC Base Current I_B	Type 2N5179			
		°C	MHz	V	V	V	mA	mA	mA	Min.	Typ.	Max.	
Collector-Cutoff Current	I_{CBO}	25 150		15 15			0 0			- -	- -	0.02 1	μA μA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$	25					0	0.001		20	-	-	V
Collector-to-Emitter Sustaining Voltage	$V_{CEO}(sus)$	25						3	0	12	-	-	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$	25					−0.01	0		2.5	-	-	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$	25						10	1	-	-	0.4	V
Base-to-Emitter Saturation Voltage	$V_{BE}(sat)$	25						10	1	-	-	1	V
Static Forward Current-Transfer Ratio	h_{FE}	25			1			3		25	70	250	
Magnitude of Small-Signal Forward Current-Transfer Ratio[a]	$\lvert h_{fe} \rvert$	25	100 1 kHz		6 6			5 2		9 25	14 90	20 300	
Collector-to-Base Feedback Capacitance[b]	C_{cb}	25	0.1 to 1	10			0			-	0.7	1	pF
Common-Base Input Capacitance[c]	C_{ib}	25	0.1 to 1			0.5		0		-	-	2	pF
Collector-to-Base Time Constant[a]	$r_b'C_c$	25	31.9	6				2		3	7	14	ps
Small-Signal Power Gain in Neutralized Common-Emitter Amplifier Circuit[a] (See Fig. 2)	G_{pe}	25	200		12			5		15	21	-	dB
Power Output in Common-Emitter Oscilator Circuit[c] (See Fig. 3)	P_o	25	>500	10			−12			20	-	-	mW
Noise Figure[a]	NF	25	200		6			1.5		-	3	4.5	dB

[a] Lead No.4(case) grounded; Rg = 125Ω

[b] Three-terminal measurement of the collector-to-base capacitance with the case and emitter leads connected to the guard terminal.

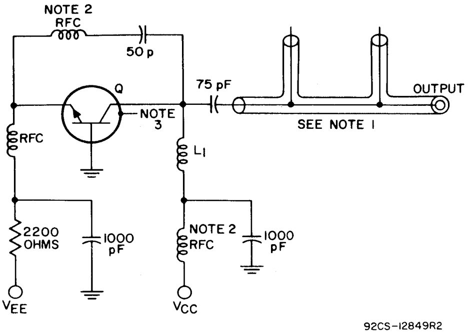
[c] Lead No. 4 (case) floating.



NOTE: (Neutralization Procedure): (a) Connect a 50-Ω rf voltmeter to the output of a 200-MHz signal generator (R_g = 50Ω), and adjust the generator output to 5mV. (b) Connect the generator to the input and the rf voltmeter to the output of the amplifier, as shown above. (c) Apply V_{EE} and V_{CC}, and adjust the generator output to provide an amplifier output of 5mV. (d) Tune C_2, C_6, and C_7 for maximum amplifier output, readjusting the generator output, as required, to maintain an output of 5mV from the amplifier. (e) Interchange the connections to the signal generator and the rf voltmeter. (f) With sufficient signal applied to the output terminals of the amplifier, adjust C_N for a minimum indication at the amplifier input. (g) Repeat steps (a), (b), (c), and (d) to determine if retuning is necessary.

Q = Type 2N5179

Fig. 2 – Neutralized Amplifier Circuit Used to Measure Power Gain and Noise Figure at 200MHz for Type 2N5179



Note 1 — Coaxial-Line output network consisting of:

2 General Radio Type 874 TEE or equivalent
1 General Radio Type 874-D20 Adjustable Stub or equivalent
1 General Radio Type 874-LA Adjustable Line or equivalent
1 General Radio Type 874-WN3 Short-circuit termination or equivalent

Note 2 — RFC = 0.2μH Ohmite #2-460 or equivalent

Note 3 — Lead Number 4 (case) floating

L_1 — 2 turns #16AWG wire, 3/8 inch OD, 1¼ inch long

Q = 2N5179

Fig. 3 – Circuit Used to Measure 500MHz Oscillator Power Output for Type 2N5179

TWO-PORT ADMITTANCE (y) PARAMETERS AS FUNCTIONS OF COLLECTOR CURRENT (I_C) FOR RCA TYPE 2N5179

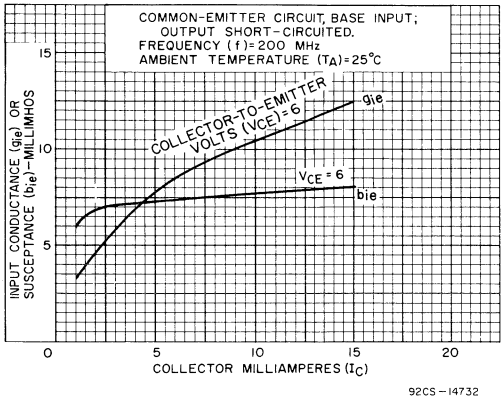


Fig. 4 – Input Admittance (y_{ie})

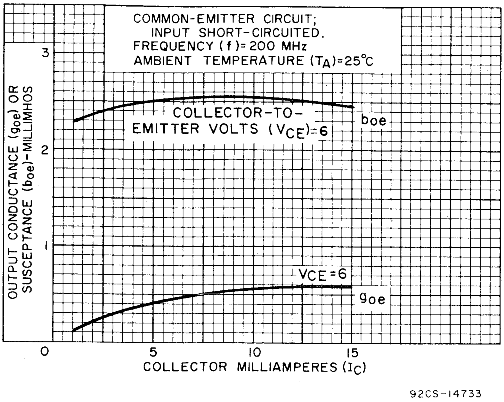


Fig. 5 – Output Admittance (y_{oe})

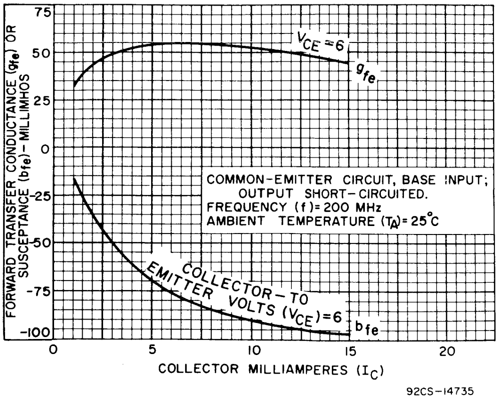


Fig. 6 – Forward Transadmittance (y_{fe})

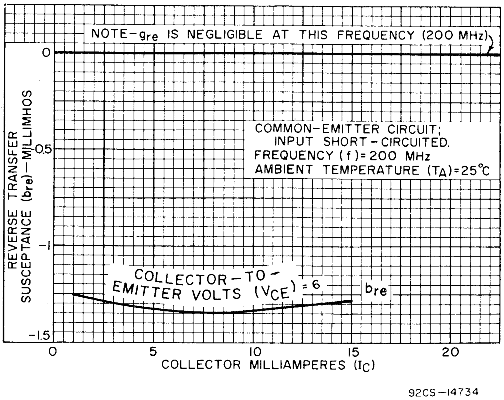


Fig. 7 – Reverse Transadmittance (y_{re})

TWO-PORT ADMITTANCE (y) PARAMETERS AS FUNCTIONS OF FREQUENCY (f) FOR RCA TYPE 2N5179

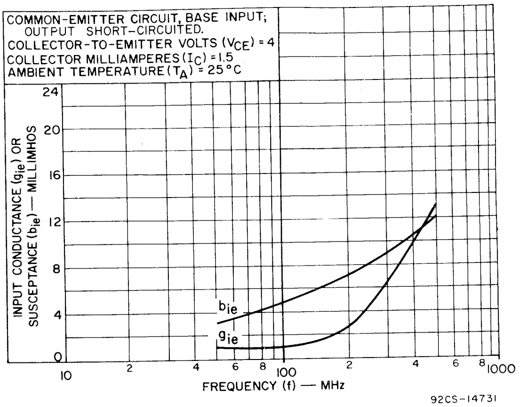


Fig. 8 – Input Admittance (y_{ie})

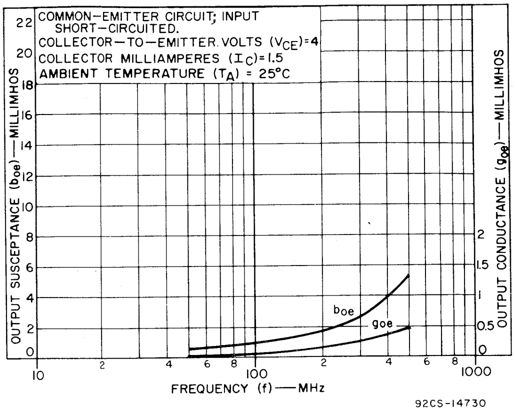


Fig. 9 – Output Admittance (y_{oe})

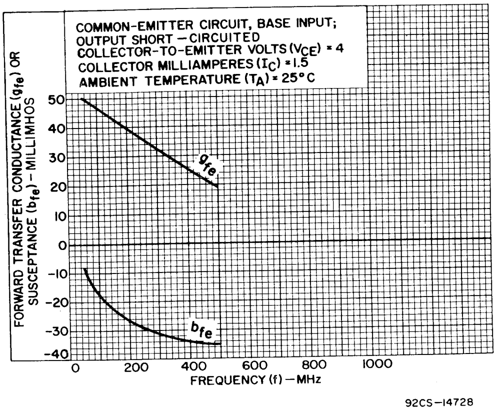


Fig. 10 – Forward Transadmittance (y_{fe})

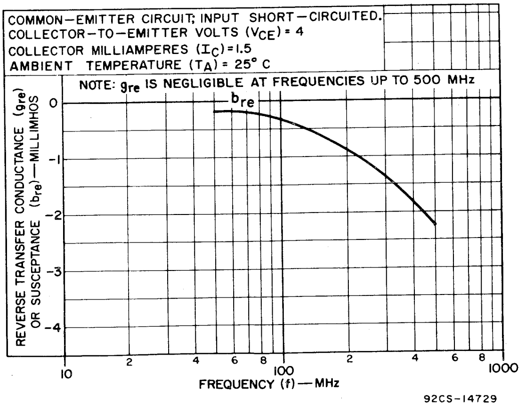
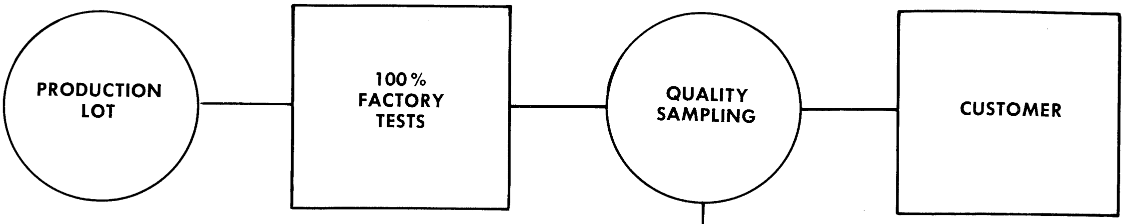


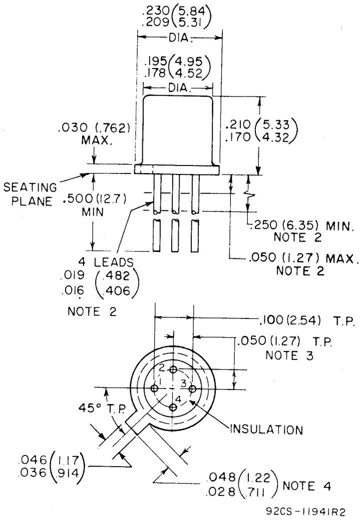
Fig. 11 – Reverse Transadmittance (y_{re})

GROUP A AND GROUP B QUALITY SAMPLING TESTS



ITEM	TEST DESCRIPTION	LTPD
GROUP A TESTS		
Subgroup 1.	Visual and Mechanical Examination	5%
Subgroup 2.	Electrical	10%
GROUP B TESTS		
Subgroup 1.	Physical Dimensions	20%
Subgroup 2.	Solderability, Temperature Cycling, Thermal Shock, Moisture Resistance	20%
Subgroup 3.	Shock, Vibration Fatigue, Vibration Variable Frequency, Constant Acceleration	20%
Subgroup 4.	Terminal Strength	20%
Subgroup 5.	Salt Atmosphere	20%
Subgroup 6.	High-Temperature Life, Non-Operating ($T_A = 200°C$)	$\lambda = 10\%$
Subgroup 7.	Steady-State-Operation Life ($P_D = 300mW$, $T_A = 25°C$)	$\lambda = 10\%$

DIMENSIONAL OUTLINE
JEDEC TO-72



Dimensions in inches and millimeters

Note 1: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

Note 2: The specified lead diameter applies in the zone between 0.050" (1.27 mm) and 0.250" (6.35 mm) from the seating plane. From 0.250" (6.35 mm) to the end of the lead a maximum diameter of 0.021" (0.533 mm) is held. Outside of these zones, the lead diameter is not controlled.

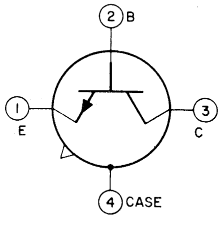
Note 3: Leads having a maximum diameter of 0.019" (0.482 mm) at a gauging plane of 0.054" (1.372 mm) + 0.001" (0.025 mm) - 0.000" (0.000 mm) below seating plane shall be within 0.007" (0.177 mm) of their true position (location) relative to a maximum width of tab.

Note 4: Measured from actual maximum diameter.

TERMINAL DIAGRAM

Bottom View

LEAD 1 – EMITTER
LEAD 2 – BASE

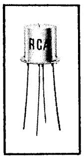


LEAD 3 – COLLECTOR
LEAD 4 – CONNECTED TO CASE

Solid State
Division

40294

ULTRA-HIGH-RELIABILITY SILICON N-P-N EPITAXIAL PLANAR TRANSISTOR



JEDEC
TO-72

For UHF Applications in Critical Aerospace and Military Equipment

RCA-40294 is an ultra-high-reliability double-diffused, epitaxial planar transistor of the silicon NPN type for low-noise amplifier, mixer, and oscillator applications at frequencies up to 500 MHz (common-emitter configuration), and up to 1200 MHz (common-base configuration).

This transistor is electrically and mechanically like RCA-2N2857, but is specially processed, preconditioned, and tested for critical aerospace and military applications.

The 40294 utilizes a hermetically sealed JEDEC TO-72 package. All active transistor elements are insulated from the case, which may be grounded by a fourth lead in applications requiring shielding of the device.

The curves of Typical Characteristics shown in the technical bulletin for RCA-2N2857 also apply for RCA-40294.

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE, V_{CBO}	30 max.	V
COLLECTOR-TO-EMITTER VOLTAGE, V_{CEO}	15 max.	V
EMITTER-TO-BASE VOLTAGE, V_{EBO}	2.5 max.	V
COLLECTOR CURRENT, I_C	40 max.	mA
TRANSISTOR DISSIPATION, P_T:		
For operation with heat sink:		
At case temperatures* up to 25°C	300 max.	mW
At case temperatures* above 25°C	Derate at 1.72	mW/°C
For operation in free air:		
At ambient temperatures up to 25°C	200 max.	mW
At ambient temperatures above 25°C	Derate at 1.14	mW/°C
TEMPERATURE RANGE:		
Storage and Operating (Junction)	-65 to +200	°C
LEAD TEMPERATURE (During soldering):		
At distances $\geq$ 1/32 inch from seating surface for 10 seconds maximum	265 max.	°C

---

* Measured at center of seating surface.

Features

- Meets performance requirements of TX2N2857 MIL-S-19500/343 USAF, 7 March 1966
- Extra-rigorous control and inspection of all parts, materials, and internal assemblies before sealing
- 100% thermal and mechanical preconditioning after sealing
- complete electrical and mechanical **QUALITY CONFORMANCE** test program
- 100% **RELIABILITY ASSURANCE** testing
- 100% **PERFORMANCE-REQUIREMENTS** testing
- 100% Noise Figure and Power Gain Tests at 450 MHz
- high gain-bandwidth product — f_T = 1000 MHz min.
- very low Device Noise Figure — NF = 4.5 dB max. at 450 MHz
- high power gain as neutralized amplifier — G_{pe} = 12.5 dB min. at 450 MHz for circuit bandwidth of 20 MHz
- high power output as uhf oscillator — P_o = 30 mW min. at 500 MHz
- low collector-to-base time constant — $r_b'C_c$ = 15 ps max.

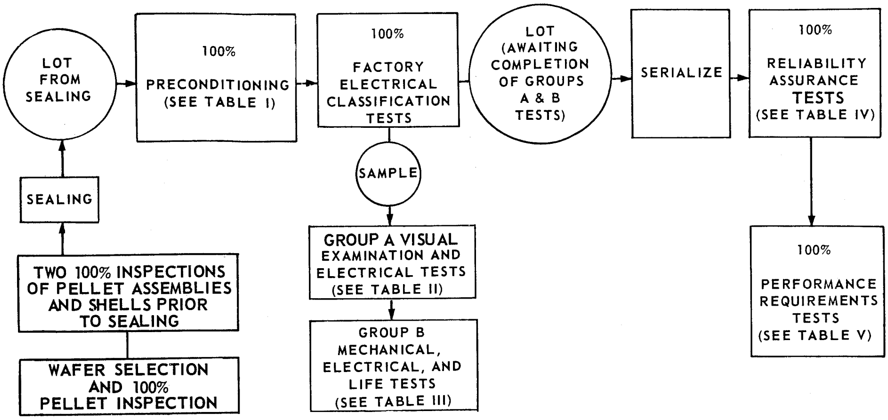


Fig. 1 - High-Reliability Testing Process Flow Diagram

TABLE I 100% PRECONDITIONING
BEFORE FACTORY, QUALITY, RELIABILITY-ASSURANCE AND PERFORMANCE REQUIREMENTS TESTS

STABILIZATION BAKE	48 hours minimum at 200° C
TEMPERATURE CYCLING (PER MIL-STD-750 METHOD 1051, COND. C)	5 complete cycles from -65° C to +200° C, each including 15 minutes at -65° C, 15 minutes at +200° C, and 5 minutes at 25° C
HELIUM-LEAK TEST (PER MIL-STD-202, METHOD 112 COND. C, PROC.IIIA)	Leakage may not exceed 10^{-8} atm cc/s
BUBBLE TEST (PER MIL-STD-202, METHOD 112 COND. A)	150° C minimum, 1 minute, ethylene glycol
CONSTANT-ACCELERATION (CENTRIFUGE) TEST (PER MIL-STD-750, METHOD 2006)	20,000 G's; Y_1 plane, 1 minute

TABLE II

GROUP A TESTS

Sub-group	Lot Tolerance Per Cent Defective	Characteristic Test	Symbol	MIL-STD 750 Reference Test Method	TEST CONDITIONS Ambient Temperature T_A	Frequency f	DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Collector Current I_C	DC Emitter Current I_E	DC Base Current I_B	LIMITS RCA 40294 Min.	 Max.	Units
					° C	MHz	V	V	mA	mA	mA	Min.	Max.	
1	5	Visual and Mechanical Examination	--	2071	--	--	--	--	--	--	--	--	--	
2	3	Collector-Cutoff Current	I_{CBO}	3036 Bias Condition D	25±3	--	15			0		--	10	nA
		Collector-Cutoff Current	I_{CES}	3041 Bias Condition C	25±3	--		16				--	100	nA
		Collector-to-Base Breakdown Voltage	BV_{CBO}	3001 Test Condition D	25±3	--			0.001	0		30	--	V
		Collector-to-Emitter Breakdown Voltage	BV_{CEO} (sus)	3011 Test Condition D	25±3	--			3*		0	15	--	V
		Emitter-to-Base Breakdown Voltage	BV_{EBO}	3026 Test Condition D	25±3	--			0	-0.001		2.5	--	V
		Base-to-Emitter Voltage	V_{BE}	3066 Test Condition A	25±3	--			10		1	--	1	V
		Collector-to-Emitter Voltage	V_{CE}	3071	25±3	--			10		1	--	0.4	V
		Static Forward Current-Transfer Ratio	h_{FE}	3076	25±3	--		1	3			30	150	
3	10	Small-Signal Power Gain▲ (See Fig. 2 for Test Circuit)	G_{pe}		25±3	450		6	1.5			12.5	19	dB
		Device Noise Figure◈: Generator Resistance (R_G) = 50 Ω (See Fig. 3 for Test Circuit)	NF		25±3	450		6	1.5			--	4.5	dB
		Measured Noise Figure Generator Resistance R_G = 50Ω (See Fig. 3 for test circuit)▲	NF		25±3	450		6	1.5			--	5.0	dB
		Collector-to-Base Time Constant▲ (See Fig. 4 for Test Circuit)	$r_b'C_c$		25±3	31.9		6		-2		4	15	ps
		Oscillator Power Output (See Fig. 5 for Test Circuit)	P_o		25±3	≥500	10			-12		30	--	mW
		Collector-to-Base Feedback Capacitance ●	C_{cb}		25±3	≥0.1 ≤1	10			0		--	1	pF
4	10	Static Forward Current Transfer Ratio (Low Temperature)	h_{FE}	3076	-55±3	--		1	3			10	--	
		Collector-Cutoff Current (High Temperature)	I_{CBO}	3036 Bias Condition D	150^{+0}_{-5}	--	15			0		--	1	μA
		Small-Signal, Short Circuit Forward Current-Transfer Ratio▲	h_{fe}	3206	25±3	0.001		6	2			50	220	
		Magnitude of Small-Signal, Short-Circuit Forward Current Transfer Ratio▲	$\|h_{fe}\|$	3206	25±3	100		6	5			10	19	

* Pulse Test

▲ Lead No. 4 (Case) Grounded

◈ Device noise figure is approximately 0.5 dB lower than the measured noise figure. The difference is due to the insertion loss at the input of the test amplifier and the contribution of the following stages in the test setup.

● Three-terminal measurement with emitter and case leads guarded.

TABLE III
GROUP B TESTS

Subgroup	Test	MIL-STD 750 Reference	Lot Tolerance Per Cent Defective %	INITIAL AND ENDPOINT CHARACTERISTICS TESTS: Charac-teristic Test	MIL-STD 750 Reference	Test Conditions	RCA-40294 Initial Values Min.	Initial Values Max.	End Point Values Min.	End Point Values Max.	Units
1	PHYSICAL DIMENSIONS (See Dimensional Outline Drawing on page 7)	2066	20	--	--	--	--	--	--	--	
2	SOLDERABILITY Solder Temp. = 260±5°C	2026	10	I_{CBO}	3036D	T_A =25±3 °C V_{CB}=15 V	--	10	--	10	nA
	TEMPERATURE-CYCLING TEST (Condition C)	1051									
	THERMAL-SHOCK TEST: $T_{min} = 0^{+5}_{-0}$ °C $T_{max} = 100^{+0}_{-5}$ °C	1056 Test Condition A		h_{FE}	3076	T_A =25±3 °C V_{CE}=1 V I_C=3 mA	30	150	30	150	
	MOISTURE-RESISTANCE TEST	1021									
3	SHOCK TEST: NON-OPERATING 1500 G's, 0.5 ms 5 blows each in X_1, Y_1, Y_2, and Z_1 planes	2016	10	I_{CBO}	3036D	T_A =25±3 °C V_{CB}=15 V	--	10	--	10	nA
	VIBRATION FATIGUE TEST: NON-OPERATING 60 ±20 Hz, 20 G's	2046		h_{FE}	3076	T_A =25±3°C V_{CE}=1 V I_C=3 mA	30	150	30	150	
	VIBRATION VARIABLE-FREQUENCY TEST	2056									
	CONSTANT-ACCELERATION TEST: 20,000 G's	2006									
4	TERMINAL STRENGTH TEST	2036 Test Condition E	20	Helium Leak Test	MIL-STD 202 Method112 Condition C Procedure III A		--	--	--	10^{-8}	atm cm³/s
				Bubble Test	MIL-STD 202 Condition A	T_A=150°C (min.) 1 minute					
5	SALT-ATMOSPHERE TEST	1041	20	I_{CBO}	3036D	T_A =25±3 °C V_{CB}=15 V	--	10	--	10	nA
				h_{FE}	3076	T_A =25±3°C V_{CE}=1 V I_C=3 mA	30	150	30	150	
6	HIGH-TEMPERATURE LIFE TEST (NON-OPERATING): T_A =200±10° C Duration=1000 hrs.	1031	λ= 7%	I_{CBO}	3036D	T_A =25±3° C V_{CB}=15 V	--	10	--	20	nA
				h_{FE}	3076	T_A =25±3 °C V_{CE}=1 V I_C=3 mA	30	150	24	180	
7	STEADY-STATE OPERATION LIFE TEST: Common-Base Circuit T_A =25±3° C V_{CB}=12.5±0.5 V P_T=200 mW Duration=1000 hrs.	1026	λ= 7%	I_{CBO}	3036D	T_A =25±3 °C V_{CB}=15 V	--	10	--	20	nA
				h_{FE}	3076	T_A =25±3 °C V_{CE}=1 V I_C=3 mA	30	150	24	180	

TABLE IV

100% RELIABILITY ASSURANCE TEST

THE CUMULATIVE REJECTS OF TABLES IV AND V SHALL NOT EXCEED 10% OF THE LOT

Test	MIL-STD 750 Reference	INITIAL AND ENDPOINT CHARACTERISTICS TESTS				
		Characteristic Test	RCA-40294 Initial Value	RCA-40294 Endpoint Value	MIL-STD 750 Reference	Test Conditions
POWER BURN-IN: Common-Base Circuit T_A =25±3°C V_{CB}=12.5±0.5 V P_T=200 mW Duration=340 hours	1026	ΔI_{CBO}	10 max. nA	Δ= ±5 nA	3036 Bias Condition D	T_A =25±3 °C V_{CB}=15 V
		Δh_{FE}	30 min. 150 max.	Δ=±15%	3076	T_A =25±3°C V_{CE}=1 V I_C=3 mA

TABLE V

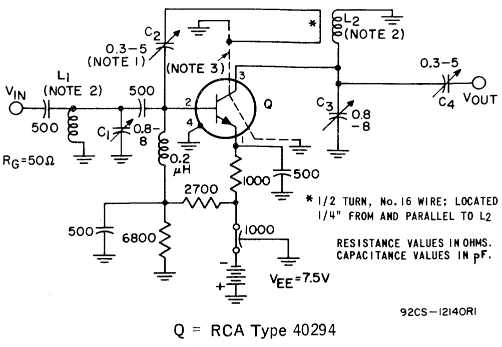
100% PERFORMANCE REQUIREMENTS TESTS

THE CUMULATIVE REJECTS OF TABLES IV AND V SHALL NOT EXCEED 10% OF THE LOT

Test	Symbol	MIL-STD 750 Reference	TEST CONDITIONS							LIMITS		Units
			Ambient Temperature T_A	Frequency f	DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Collector Current I_C	DC Emitter Current I_E	DC Base Current I_B	RCA 40294		
			°C	MHz	V	V	mA	mA	mA	Min.	Max.	
Collector-Cutoff Current	I_{CBO}	3036 Bias Condition D	25±3	--	15			0		--	10	nA
Collector-Cutoff Current	I_{CES}	3041 Bias Condition C	25±3	--		16				--	100	nA
Collector-to-Base Breakdown Voltage	BV_{CBO}	3001 Test Condition D	25±3	--			0.001	0		30	--	V
Collector-to-Emitter Breakdown Voltage	BV_{CEO} (sus)	3011 Test Condition D	25±3	--			3*		0	15	--	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}	3026 Test Condition D	25±3	--			0	−0.001		2.5	--	V
Base-to-Emitter Voltage	V_{BE}	3066 Test Condition A	25±3	--			10		1	--	1	V
Collector-to-Emitter Voltage	V_{CE}	3071	25±3	--			10		1	--	0.4	V
Static Forward Current-Transfer Ratio	h_{FE}	3076	25±3	--		1	3			30	150	
Device Noise Figure▲: Generator Resistance (R_G)=50 Ohms (See Fig. 3 for Test Circuit)	NF	--	25±3	450		6	1.5			--	4.5	dB
Measured Noise Figure Generator Resistance R_G = 50Ω (See Fig.3 for test circuit)▲	NF		25±3	450		6	1.5			--	5.0	dB
Visual Examination (External) Under 20-Power Magnification		Examine leads, header, and shell for visual defects.										

* Pulse Test

▲ Lead No. 4 (Case) Grounded



NOTE 1: (NEUTRALIZATION PROCEDURE): (A) CONNECT A 450-MHz SIGNAL GENERATOR (WITH R_g = 50 OHMS) TO THE INPUT TERMINALS OF THE AMPLIFIER. (B) CONNECT A 50-OHM RF VOLTMETER ACROSS THE OUTPUT TERMINALS OF THE AMPLIFIER. (C) APPLY V_{EE}, AND WITH THE SIGNAL GENERATOR ADJUSTED FOR 5 mV OUTPUT FROM THE AMPLIFIER, TUNE C_1, C_3, AND C_4 FOR MAXIMUM OUTPUT. (D) INTERCHANGE THE CONNECTIONS TO THE SIGNAL GENERATOR AND THE RF VOLTMETER. (E) WITH SUFFICIENT SIGNAL APPLIED TO THE OUTPUT TERMINALS OF THE AMPLIFIER, ADJUST C_2 FOR A MINIMUM INDICATION AT THE INPUT. (F) REPEAT STEPS (A), (B), AND (C) TO DETERMINE IF RETUNING IS NECESSARY.

NOTE 2: L_1 & L_2—SILVER-PLATED BRASS ROD, 1-1/2" LONG x 1/4" DIA. INSTALL AT LEAST 1/2" FROM NEAREST VERTICAL CHASSIS SURFACE.

NOTE 3: EXTERNAL INTERLEAD SHIELD TO ISOLATE THE COLLECTOR LEAD FROM THE EMITTER AND BASE LEADS.

Fig. 2 – Neutralized Amplifier Circuit Used to Measure 450-MHz Power Gain and Noise Figure for RCA-40294

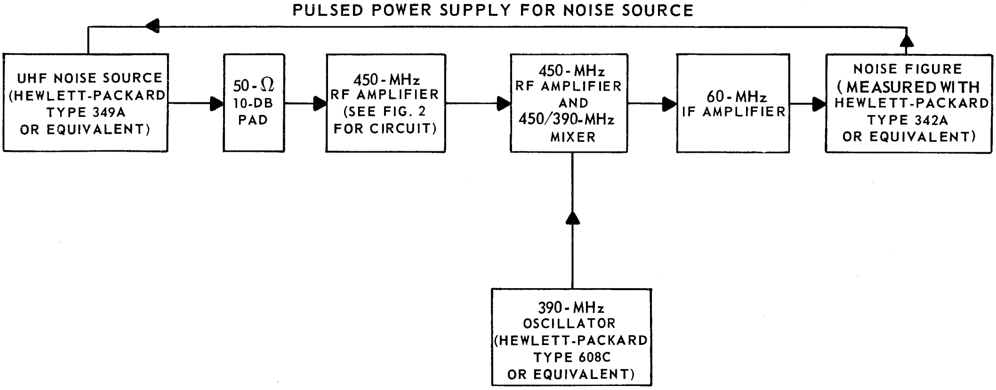
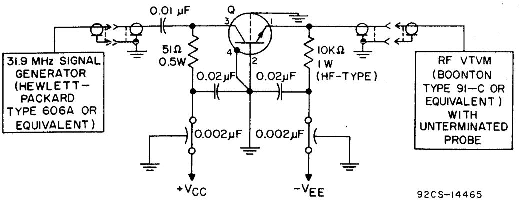


Fig. 3 - Block Diagram of 450-MHz Noise-Figure Test Circuit for RCA-40294



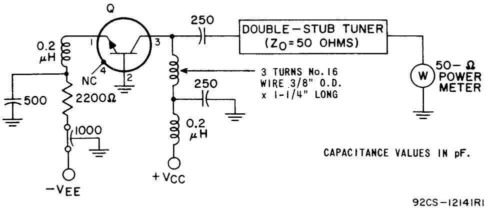
Q = RCA Type 40294

NOTE: Careful shielding must be used between input and output to keep signal feed-through to an absolute minimum.

PROCEDURE:

1. Before inserting the transistor in the test fixture, connect a short circuit between the collector and emitter terminals of the fixture and adjust the 31.9-MHz input for 0.5 V RMS at the emitter terminal.
2. Remove the short circuit between the collector and emitter terminals of the fixture, insert the transistor to be tested, and adjust V_{CC} and V_{EE} for V_{CB} = 6 V, I_C = 2 mA.
3. Read $r_b' C_c$ on rf-voltmeter scale ($r_b' C_c$ in picoseconds = 10 times meter indication in millivolts) (1 millivolt = 10 picoseconds).

Fig.4 - Collector-to-Base Time Constant Measurement Circuit

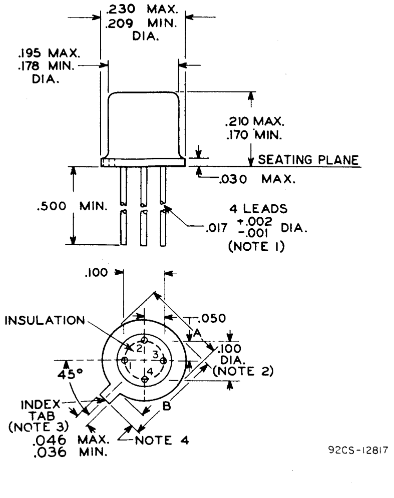


Q = RCA Type 40294

Fig.5 - Oscillator Circuit Used to Measure 500-MHz Power Output for RCA-40294

DIMENSIONAL OUTLINE

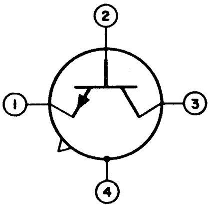
JEDEC TO-72



TERMINAL DIAGRAM

Bottom View

LEAD 1 – EMITTER
LEAD 2 – BASE
LEAD 3 – COLLECTOR
LEAD 4 – CONNECTED TO CASE



NOTE 1: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050" AND 0.250" FROM THE SEATING PLANE. FROM 0.250" TO THE END OF THE LEAD A MAXIMUM DIAMETER OF 0.021" IS HELD. OUTSIDE OF THESE ZONES, THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 2: MAXIMUM DIAMETER LEADS AT A GAUGING PLANE 0.054" + 0.001" – 0.000" BELOW SEATING PLANE TO BE WITHIN 0.007" OF THEIR TRUE LOCATION RELATIVE TO MAX. WIDTH TAB AND TO THE MAXIMUM 0.230" DIAMETER MEASURED WITH A SUITABLE GAUGE. WHEN GAUGE IS NOT USED, MEASUREMENT WILL BE MADE AT SEATING PLANE.

NOTE 3: FOR VISUAL ORIENTATION ONLY.

NOTE 4: TAB LENGTH TO BE 0.028" MINIMUM – 0.048" MAXIMUM, AND WILL BE DETERMINED BY SUBTRACTING DIAMETER A FROM DIMENSION B.

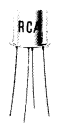
RCA
Solid State
Division

RF Power Transistors

40894 40896
40895 40897

High - Frequency Silicon N-P-N Transistors

For TV-Tuner, FM and AM/FM "Front-End", and IF Amplifier, Oscillator, and Converter Service



JEDEC TO-72 H-1299

Features:

- **High gain-bandwidth products:**
  f_T = 1200 MHz typ. for tuner types
  = 800 MHz typ. for if-amplifier types
- **Very low collector-to-base feedback capacitance:**
  C_{cb} = 0.7 pF typ. for 40894, 40895
- **Low noise figure:**
  3 dB typ. at 200 MHz for rf amplifier type
- **High power gain as neutralized amplifier:**
  G_{PE} = 15 dB min. at 200 MHz (40894)
- **High power output as uhf oscillator:**
  P_{OE} = 20 mW typ. at 500 MHz (40896)
- **Low noise figure:**
  NF = 4.5 dB max. at 200 MHz (40894)
- **Low collector-to-base time constant:**
  $r_b'C_c$ = 14 ps max.

RCA-40894, 40895, 40896, and 40897 are high-frequency n-p-n silicon devices characterized especially for rf, mixer, oscillator, and if stages of vhf, SSB, and FM receivers.

These devices utilize a hermetically sealed four-lead JEDEC TO-72 package. All active elements of the transistor are insulated from the case, which may be grounded by means of the fourth lead in applications requiring minimum feedback capacitance, shielding of the device, or both.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE	V_{CEO}	12	V
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	20	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	2.5	V
CONTINUOUS COLLECTOR CURRENT	I_C	50	mA
TRANSISTOR DISSIPATION	P_T		
With heat sink, at case temperatures up to 25°C		300	mW
With heat sink, at case temperatures above 25°C		Derate linearly 1.71	mW/°C
At ambient temperatures up to 25°C		200	mW
At ambient temperatures above 25°C		Derate linearly 1.14	mW/°C
TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
CASE TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. (0.8 mm) from seating surface for 10 seconds max.		265	°C

ELECTRICAL CHARACTERISTICS at Ambient Temperature (T_A) = 25°C unless otherwise specified

CHARACTERISTICS	SYMBOLS	TEST CONDITIONS							LIMITS												UNITS
		FREQUENCY MHz	DC COLLECTOR OR EMITTER VOLTAGE V			DC CURRENT mA			TYPE 40894 RF AMPLIFIER			TYPE 40895 MIXER			TYPE 40896 OSCILLATOR			TYPE 40897 IF AMPLIFIER			
			V_{CB}	V_{CE}	V_{EB}	I_E	I_C	I_B	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Collector-Cutoff Current	I_{CBO}		15			0			-	-	0.02	-	-	0.02	-	-	0.02	-	-	0.02	μA
T_A = 150°C			15			0			-	-	1	-	-	1	-	-	1	-	-	1	
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$					0	0.001		20	-	-	20	-	-	20	-	-	20	-	-	V
Collector-to-Emitter Sustaining Voltage	$V_{CEO}(sus)$						3	0	15	-	-	15	-	-	15	-	-	15	-	-	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$					0.01	0		2.5	-	-	2.5	-	-	2.5	-	-	2.5	-	-	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$						10	1	-	-	0.4	-	-	0.4	-	-	0.4	-	-	0.4	V
Base-to-Emitter Saturation Voltage	$V_{BE}(sat)$						10	1	-	-	1	-	-	1	-	-	1	-	-	1	V
Static Forward Current-Transfer Ratio	h_{FE}			6			1		50	80	250	40	70	250	27	50	250	70	120	250	
Magnitude of Common-Emitter, Small-Signal Short-Circuit, Forward Current Transfer Ratio[a]	$\|h_{fe}\|$	100 1 kHz		6 6			5 2		9 25	14 90	20 300	9 25	14 90	20 300	9 25	14 90	20 300	9 25	14 90	20 300	
Collector-to-Base Feedback Capacitance[b]	C_{cb}	0.1 to 1	10			0			-	0.7	1	-	0.7	1	-	0.7	1	-	0.7	1	pF
Common-Base Input Capacitance[c]	C_{ib}	0.1 to 1			0.5		0		-	-	2	-	-	2	-	-	2	-	-	2	pF
Collector-to-Base Time Constant[a]	$r_{b'}C_c$	31.9	6				2		3	7	14	3	7	14	3	7	14	3	7	14	ps
Small-Signal Power Gain in Neutralized Common-Emitter Amplifier Circuit[a] (see Fig. 6)	G_{PE}	10.7 200		12 12			5 5		– 15	– 21	– –	– 15	– 21	– –	– 15	– 21	– –	18 –	25 –	– –	dB
Noise Figure[a]	NF	200		6			1.5		-	3	4.5	-	-	-	-	-	-	-	-	-	dB

[a] Lead No. 4 (case) grounded; Rg = 125Ω

[b] Three-terminal measurement of the collector-to-base capacitance with the case and emitter leads connected to the guard terminal.

[c] Lead No. 4 (case) floating.

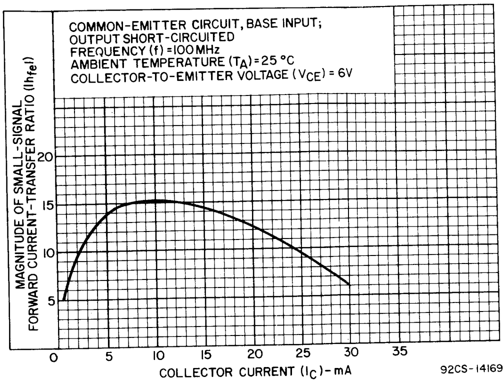


Fig. 1—Small-signal beta characteristic for all types

TWO-PORT ADMITTANCE (y) PARAMETERS AS FUNCTIONS OF FREQUENCY (f) FOR ALL TYPES

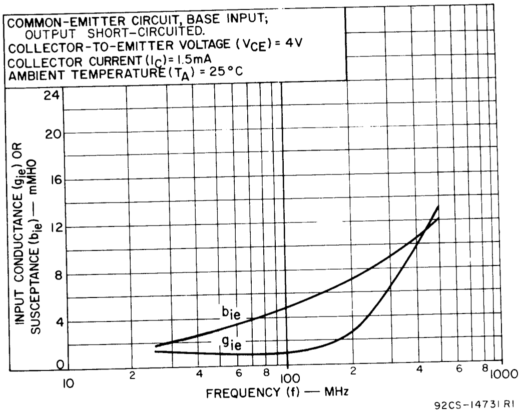


Fig. 2—Input admittance (y_{ie})

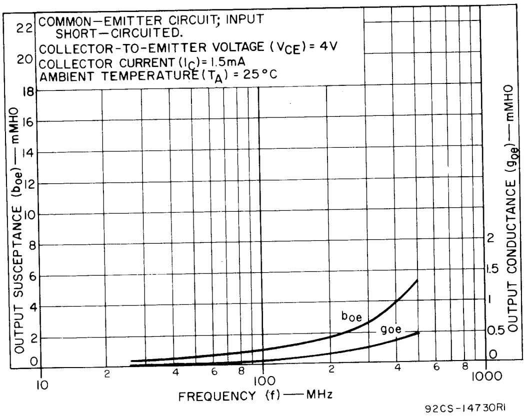


Fig. 3—Output admittance (y_{oe})

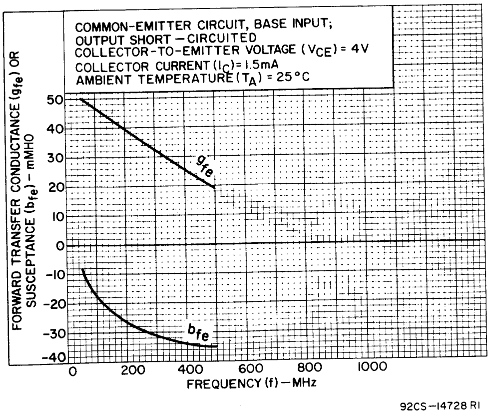


Fig. 4—Forward transadmittance (y_{fe})

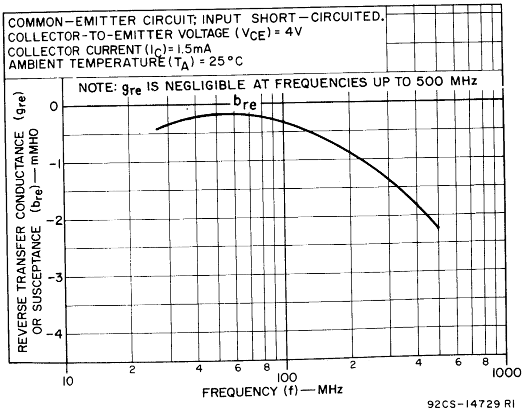
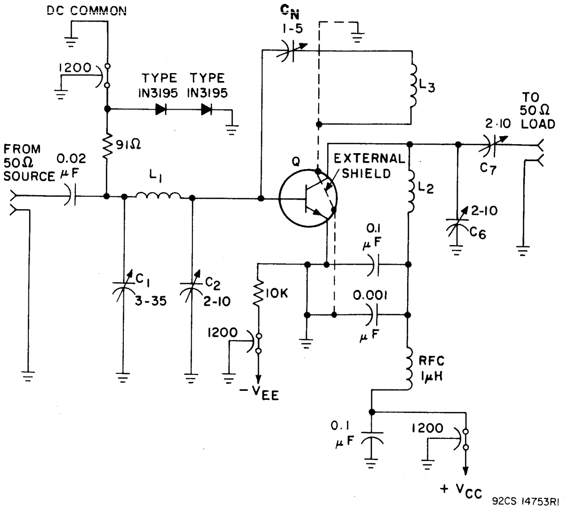


Fig. 5—Reverse transadmittance (y_{re})



NOTE: (Neutralization Procedure): (a) Connect a 50-Ω rf voltmeter to the output of a 200-MHz signal generator (R_g = 50Ω), and adjust the generator output to 5 mV. (b) Connect the generator to the input and the rf voltmeter to the output of the amplifier, as shown above. (c) Apply V_{EE} and V_{CC}, and adjust the generator output to provide an amplifier output of 5 mV. (d) Tune C2, C6, and C7 for maximum amplifier output, readjusting the generator output as required to maintain an output of 5 mV from the amplifier. (e) Interchange the connections to the signal generator and the rf voltmeter. (f) With sufficient signal applied to the output terminals of the amplifier, adjust C_N for a minimum indication at the amplifier input. (g) Repeat steps (a), (b), (c), and (d) to determine if retuning is necessary.

Q = Type 40894, 40895, 40896, or 40897

L_1: 1-3/4 turns No. 18 wire 0.5 in. (12.7 mm) long, 0.5 in. (12.7 mm) ID

L_2: 2 turns No. 16 wire, 0.5 in. (12.7 mm) long, 0.5 in. (12.7 mm) ID

L_3: 2 turns No. 18 wire, 0.25 in. (6.35 mm) long, 0.5 in. (12.7 mm) ID. Position approximately 1/4 in. (6.35 mm) from L_2.

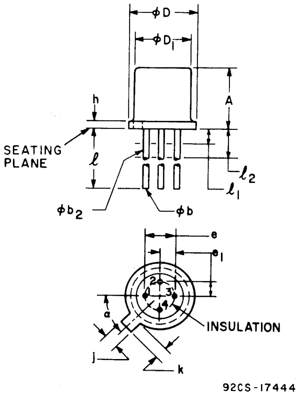
All capacitances in pF unless otherwise specified.

Fig. 6—Neutralized amplifier circuit used to measure power gain and noise figure at 200 MHz for all types

DIMENSIONAL OUTLINE

JEDEC TO–72

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.170	0.210	4.32	5.33	
ϕb	0.016	0.021	0.406	0.533	2
ϕb_2	0.016	0.019	0.406	0.483	2
ϕD	0.209	0.230	5.31	5.84	
ϕD_1	0.178	0.195	4.52	4.95	
e	0.100 T.P.		2.54 T.P.		4
e1	0.050 T.P.		1.27 T.P.		4
h		0.030		0.762	
j	0.036	0.046	0.914	1.17	
k	0.028	0.048	0.711	1.22	3
l	0.500		12.70		2
l_1		0.050		1.27	2
l_2	0.250		6.35		2
α	45° T.P.		45° T.P.		4, 6



Note 1: (Four leads). Maximum number leads omitted in this outline, "none" (0). The number and position of leads actually present are indicated in the product registration. Outline designation determined by the location and minimum angular or linear spacing of any two adjacent leads.

Note 2: (All leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and 0.50 in. (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond 0.50 in. (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the product.

Note 4: Leads having maximum diameter 0.019 in. (0.484 mm) measured in gaging plane 0.054 in. (1.37 mm) +0.001 in. (0.025 mm) – 0.000 (0.000 mm) below the seating plane of the product shall be within 0.007 in. (0.178 mm) of their true position relative to a maximum width tab.

Note 5: The product may be measured by direct methods or by gage.

Note 6: Tab centerline.

TERMINAL CONNECTIONS

Lead 1 – Emitter
Lead 2 – Base
Lead 3 – Collector
Lead 4 – Connected to case

Single-Sideband Types

RCA
Solid State Division

RF Power Transistors

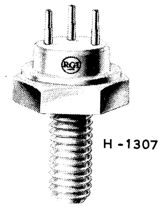
2N5070

RCA-2N5070* is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter electrode construction. It is especially designed for linear applications to provide high power in Class A or Class B service. This device is intended for 2-to-30 MHz single-sideband power amplifier operating from a 28-volt power supply.

The inherent high frequency capability of the "overlay" structure together with individually ballasted emitter sites makes it possible to forward bias the device into the active region without incurring thermal instability.

The emitter pin is common to case to minimize lead inductance.

Formerly RCA-Dev. No.TA2793



JEDEC TO-60

- **For Class-A or Class-B Amplifiers**
- **For HF Single Sideband Communications**
- **25 Watts PEP Output (min.) at 30 MHz**
  with Gain: 13 dB (min.)
  η: 40% (min.)
  IMD: 30 dB (max.)
- **Low Thermal Resistance**

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With V_{BE} = −1.5 V	V_{CEV}	65	V
With external base-to-emitter resistance R_{BE} = 5 Ω	V_{CER}	40	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT:			
Peak		10	A
Continuous	I_C	3.3	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 25° C		70	W
At case temperatures above 25° C		See *Fig.3*	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. from insulating wafer for 10 s max		230	°C

TYPICAL INTERMODULATION DISTORTION vs. RF POWER OUTPUT

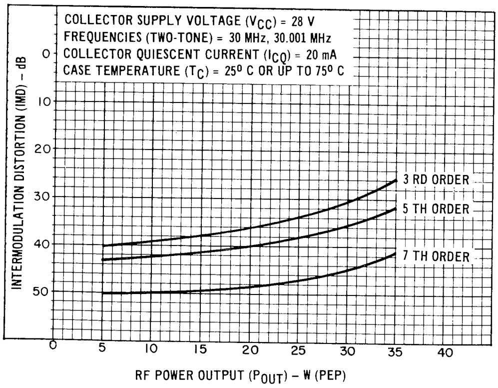


Fig. 1

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C

Characteristics	Symbol	TEST CONDITIONS					Limits		Units
		DC Collector Volts		DC Base Volts	DC Current mA				
		V_{CB}	V_{CE}	V_{BE}	I_E	I_C	Min.	Max.	
Collector-to-emitter Sustaining Voltage	$V_{CEV}(sus)$			−1.5		200[a]	65	–	V
	$V_{CER}(sus)$ $R_{BE} = 5\ \Omega$					200[a]	40	–	V
Emitter-to-base Breakdown Voltage	BV_{EBO}				10		4	–	V
Collector-to-emitter Cutoff Current	I_{CEO}		30				–	5.0	mA
Collector-to-base Cutoff Current	I_{CBO}	60					–	10	mA
Collector-to-base Capacitance f = 1 MHz	C_{ob}	30					–	85	pF
Junction-to-case Thermal Resistance	$\theta_{J\text{-}C}$						–	2.5	°C/W

[a] Pulsed through an inductor (25 mH); duty factor = 50%.

LINEAR RF POWER AMPLIFIER

Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2.

Test Operation

In test circuit shown in Fig.2, with "Two-Tone" Modulation, at T_C = 30° C, and at 30 MHz.

Collector Supply Voltage	28 V
Collector Bias Current	20 mA
RF Power Output:	
Average	12.5 min. W
Peak Envelope	25 min. W
Intermodulation Distortion[a]	30 max. dB
Collector Efficiency	40 min. %

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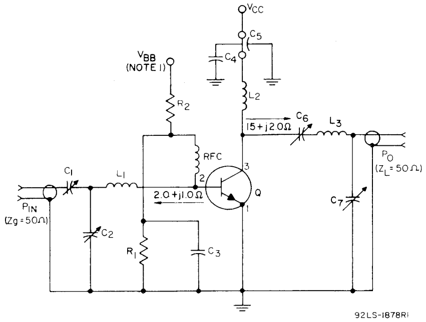
[a] Referenced to either of the two tones and without the use of feedback to enhance linearity.

LINEAR RF AMPLIFIER CIRCUIT FOR POWER OUTPUT TEST (30 MHz Operation)



L_1: 3T No.12 Wire, 1/4" I.D., 1/2" long
L_2: 6T No.14 Wire, 3/8" I.D., 3/4" long
L_3: 5T No.10 Wire, 3/4" I.D., 3/4" long
C_1: 140-680 pF, Arco 468 or equivalent
C_2: 170-780 pF, Arco 469 or equivalent
C_3: 0.05 µF, Ceramic capacitor
C_4: 0.1 µF, Ceramic capacitor
C_5: 1000 pF feedthrough capacitor
C_6: 24-200 pF Arco 425, or equivalent
C_7: 32-250 pF Arco 426, or equivalent
Q: 2N5070
R_1: 1 Ω, 5 W
R_2: 50 Ω, 25 W
RFC: 350 Ferrite choke, Ferroxcube* #VK200 01-03B, or equivalent

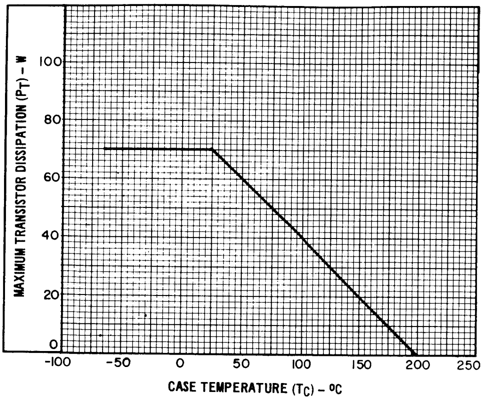
*Ferroxcube Corp. of America, Saugerties, N.Y.

Fig. 2

Note 1: Adjust V_{BB} for a collector quiescent current of 20 mA with no RF input signal.

Note 2: Impedance measurements are made at transistor socket pins.

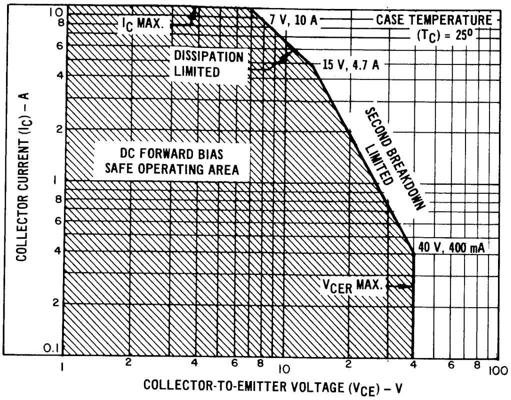
DISSIPATION DERATING CURVE



92LS-1882R2

Fig. 3

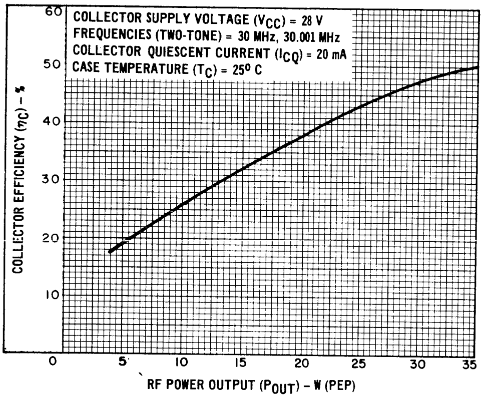
SAFE OPERATION WITH DC FORWARD BIAS



92LS-1879R1

Fig. 4

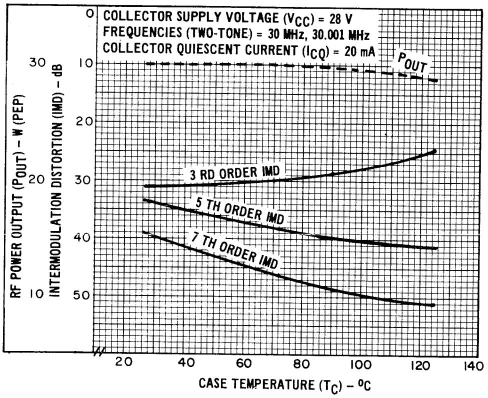
TYPICAL COLLECTOR EFFICIENCY vs. RF POWER OUTPUT



92LS-1880R1

Fig. 5

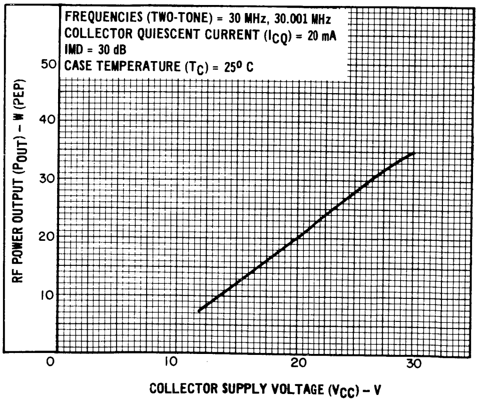
TYPICAL RF POWER OUTPUT AND INTERMODULATION DISTORTION vs. CASE TEMPERATURE



92LS-1881R1

Fig. 6

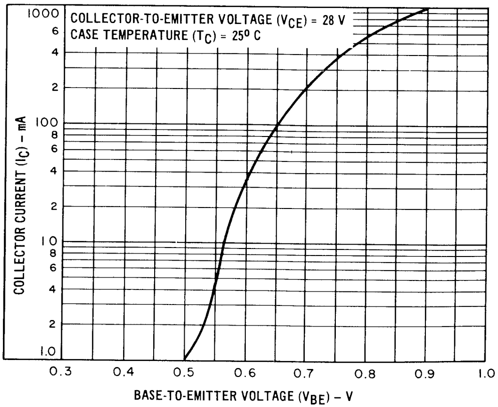
TYPICAL RF POWER OUTPUT vs. COLLECTOR SUPPLY VOLTAGE



92LS-1883R2

Fig. 7

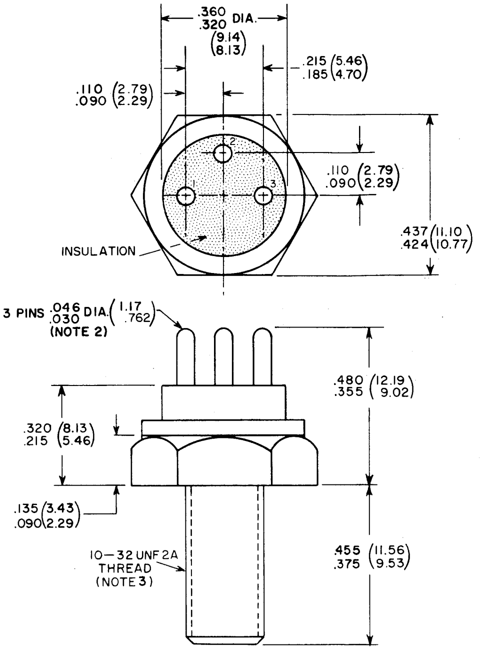
TYPICAL TRANSFER CHARACTERISTICS



92LS-2153

Fig. 8

DIMENSIONAL OUTLINE
JEDEC TO-60



92CS-12045R6

DIMENSIONS IN INCHES AND MILLIMETERS

Note 1: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

Note 2: The pin spacing permits insertion in any socket having a pin-circle diameter of 0.200" (5.08) and contacts which will accommodate pins having a diameter of 0.035" (0.889) min., 0.045" (1.143) max.

Note 3: The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

Note 4: This device may be operated in any position.

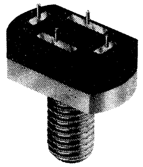
TERMINAL CONNECTIONS

Case, Mounting Stud, Pin No.1 - Emitter
Pin No.2 - Base
Pin No.3 - Collector

RCA
Solid State
Division

RF Power Transistors

2N6093



L-377

75-W (PEP) Emitter-Ballasted Overlay Transistor with Temperature-Sensing Diode

Silicon N-P-N Device for High-Gain Linear Amplifiers in HF Single-Sideband Equipment

Features:

- **For 2- to- 30-MHz Single-Sideband Communications**
- **75 Watts PEP Output (min.) at 30 MHz**
  with Gain: 13 dB (min.)
  η: 40% (min.)
  IMD: 30 dB (max.)
- **3:1 VSWR tested at rated power**
- **Low Thermal Resistance**
- **Isolated Pin-Pad Electrodes**

RCA-2N6093* is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter-electrode construction. This device utilizes many separate emitter elements and has individual ballast resistance in each of these emitter sites for stabilization. Linearity and greater protection from second breakdown are achieved by equalizing the current sharing between the emitter sites.

The 2N6093 is especially designed for linear applications to provide high power in class A or class B rf amplifier service.

The device is intended for 2- to- 30-MHz single-sideband power amplifiers operating from a 28-volt power supply.

Forward-bias control with temperature change is obtained by use of the built-in temperature-sensing diode.

Type 2N6093 features a molded silicone-plastic case with low-inductance, isolated electrodes. The case provides circuit flexibility for wiring to lumped-constant, strip-line, and printed-board circuits.

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* Formerly RCA Type No.40675.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
Base connected to emitter	V_{CES}	70	V
* With base open	V_{CEO}	35	V
*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	70	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*COLLECTOR CURRENT:	I_C		
CONTINUOUS		10	A
PEAK		30	A
DIODE CURRENT (DC, Max.)	I_F	100	mA
*TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		83.3	W
At case temperatures above 75°C		*See Fig. 9*	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

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*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, *Case Temperature = 25° C*
STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Collector Voltage-V	DC Base Voltage-V	DC Current mA					
		V_{CE}	V_{BE}	I_E	I_C	I_D	Min.	Max.	
* Collector-to-Emitter Breakdown Voltage: With base connected to emitter	$V_{(BR)CES}$		0		200[a]		70	–	V
With base open	$V_{(BR)CEO}$		0		200[a]		35	–	V
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			20	0		3.5	–	V
* Collector-to-Emitter Cutoff Current: Base-emitter junction shorted, T_C = 55°C (Diode Voltage = 0)	I_{CES}	60	0				–	30	mA
* Compensating Diode Forward Voltage Drop	V_F				0	10	–	0.8	V
* DC Forward-Current Transfer Ratio	h_{FE}	6			5A		20	–	
Thermal Resistance Junction-to-case	$\theta_{J\text{-}C}$						–	1.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

DYNAMIC (Operating in a 30 MHz single-sideband amplifier)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Collector Voltage-V		Power Output W(PEP)	Frequency MHz	DC Collector Bias Current-mA			
		V_{CB}	V_{CC}	P_{OE}	f	I_C	Min.	Max.	
RF Power Input* (See Fig. 12): Average	P_{IE}		28	37.5	30	20	–	1.88	W
Peak envelope (PEP)	P_{IE}		28	75	30	20	–	3.75	W
* Power Gain	G_{PE}		28	75	30	20	13		dB
* Collector Efficiency	η_C		28	75	30	20	40	–	%
* Magnitude of Common-Emitter, Small-Signal, Short-Circuit, Forward-Current Transfer Ratio	$\lvert h_{fe} \rvert$		28 (V_{CE})		50	1A	2	–	
Intermodulation Distortion	IMD		28	75	30	20	–	–30	dB
* Collector-to-Base Capacitance	C_{obo}	30			1		–	250	pF

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

PERFORMANCE DATA

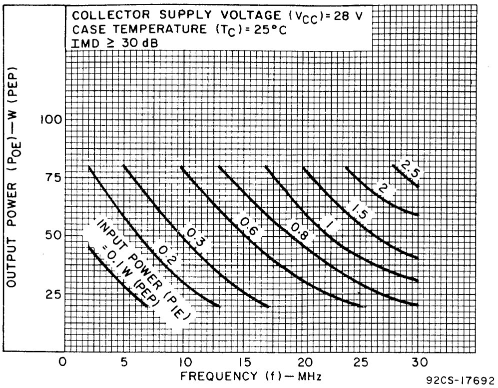


Fig. 1—Typical output power vs. frequency.

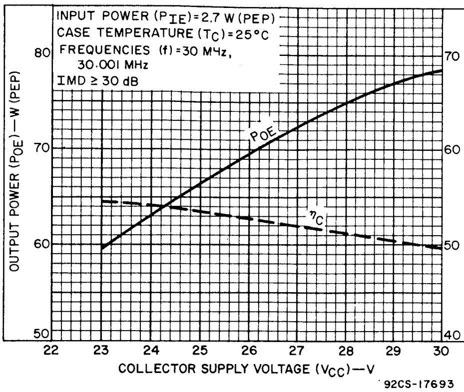


Fig. 2—Typical output power or collector efficiency vs. collector supply voltage.

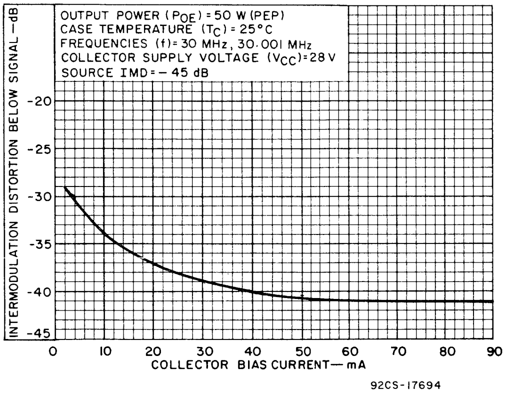


Fig. 3—Typical IMD vs. collector bias current.

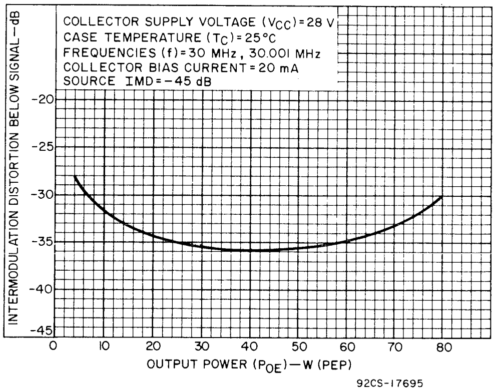


Fig. 4—Typical IMD vs. output power (PEP).

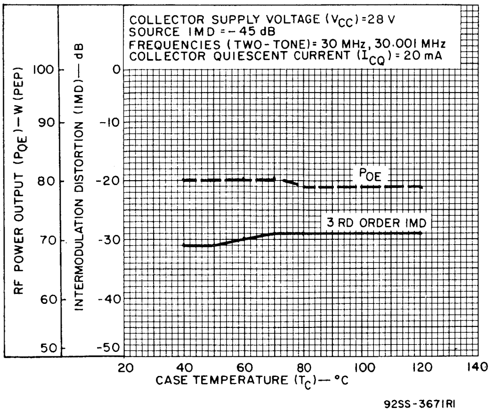


Fig. 5—Typical RF power output and intermodulation distortion vs. case temperature.

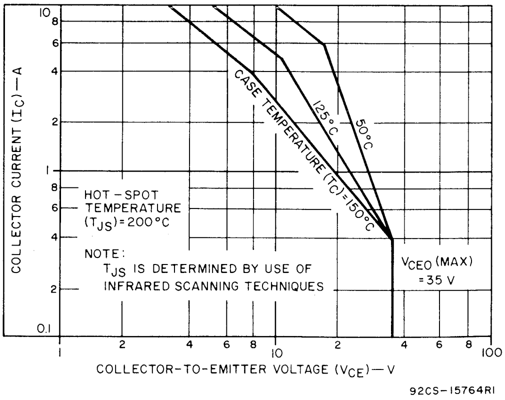


Fig. 6—Safe area for dc operation.

DESIGN DATA

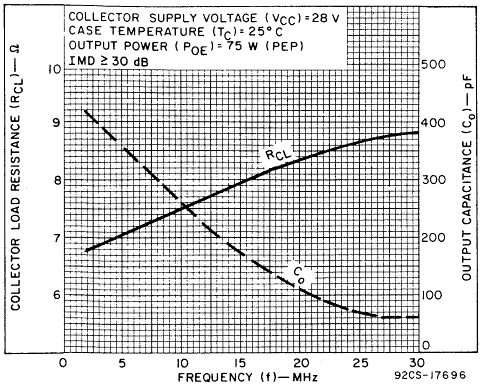


Fig. 7 — Typical large-signal parallel collector load resistance and parallel output capacitance vs. frequency.

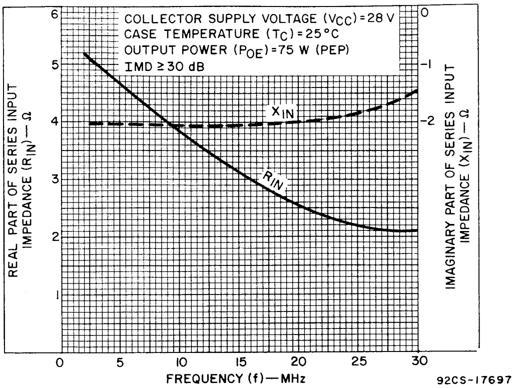


Fig. 8 — Typical large-signal series input impedance (R_{in} † $j X_{in}$) vs. frequency.

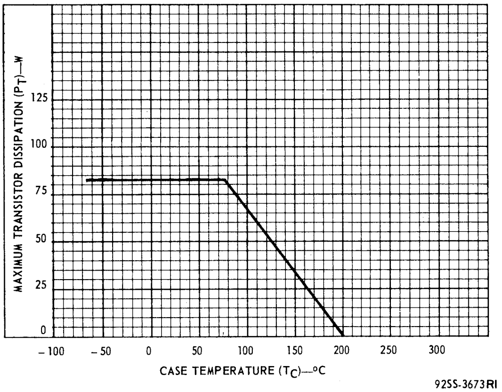


Fig. 9 — RF dissipation derating.

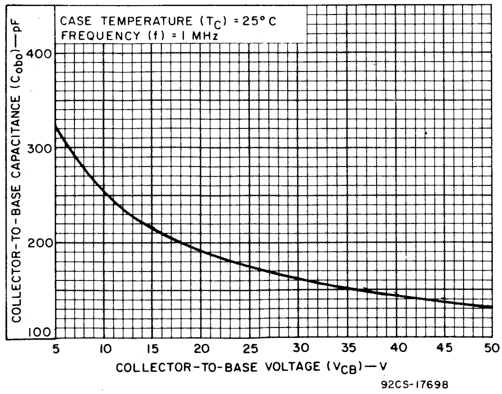


Fig. 10 — Typical variation of collector-to-base capacitance vs. collector-to-base voltage.

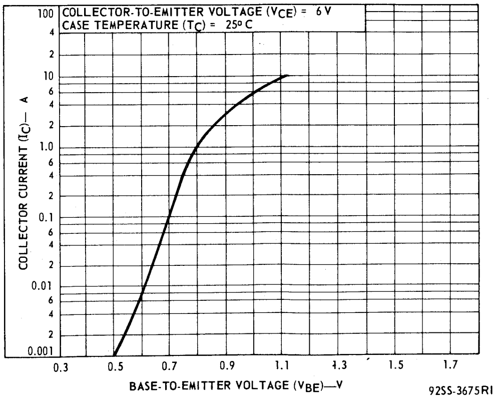
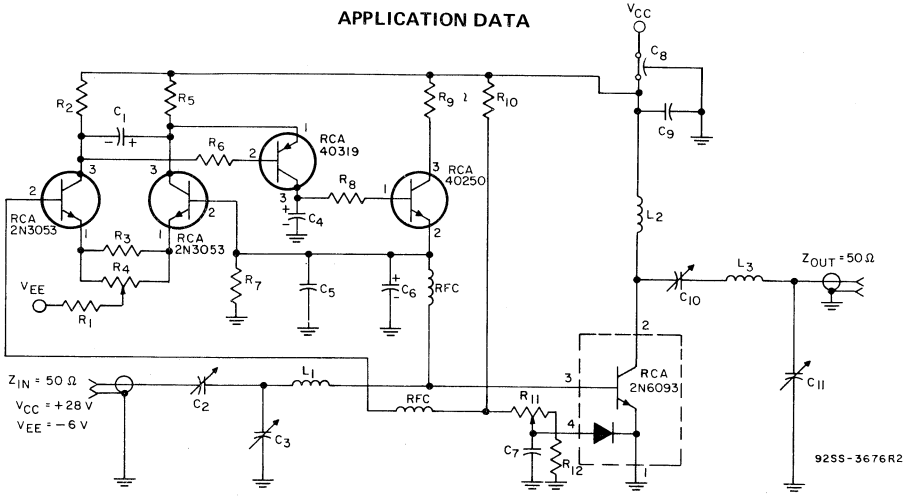


Fig. 11 — Typical transfer characteristic.

APPLICATION DATA

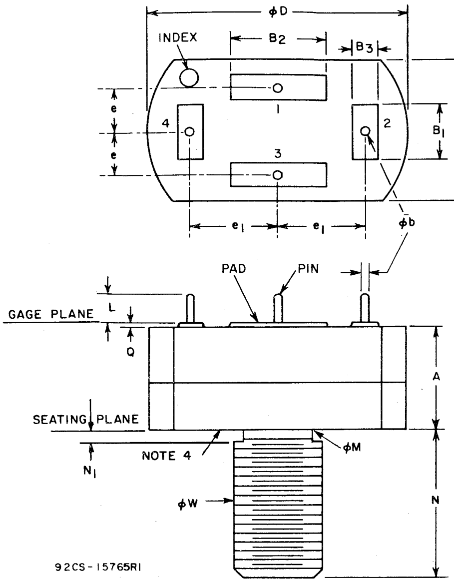


C_1, C_4: 1 μF, 3 V, electrolytic
C_2: 32-250 pF
C_3: 55-300 pF
C_5, C_7: 0.0027 μF
C_6: 100 μF, 3 V, electrolytic
C_8: 1000 pF feedthrough
C_9: 0.3 μF, 50 V
C_{10}: 170-780 pF
C_{11}: 80-480 pF
L_1: 3 turns No.14 wire, ¼ in. I.D. ½ in. long
L_2: 3 turns No.10 wire, ½ in. I.D. 3/8 in. long
L_3: 3½ turns No.10 wire, 5/8 in. I.D. ½ in. long

R_1, R_8: 510 Ω
R_2, R_5: 2 k Ω
R_3: 33 Ω
R_4: 100 Ω
R_6: 200 Ω
R_7: 39 Ω
R_9: 50 Ω
R_{10}: 24 k Ω
R_{11}: 100 Ω
R_{12}: 1.5 k Ω
RFC: Ferroxcube No.VK200-01-3B, or equivalent
All resistors ½ watt

Fig. 12—30-MHz linear rf amplifier with temperature compensation.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.295	0.325	7.50	8.25	–
B_1	0.135	0.150	3.43	3.81	–
B_2	0.235	0.250	5.97	6.35	–
B_3	0.055	0.065	1.40	1.65	5
ϕb	0.020	0.025	0.508	0.635	4 Pins
ϕD	0.650	0.680	16.51	17.27	–
E	0.360	0.380	9.15	9.65	–
e	0.111	0.131	2.82	3.32	1
e_1	0.213	0.233	5.42	5.91	1
L	0.114	0.133	2.90	3.37	–
ϕM	0.220	0.249	5.59	6.23	–
N	0.420	0.460	10.67	11.68	–
N_1	–	0.090	–	2.28	–
Q	–	0.015	–	0.038	–
ϕW	–	–	–	–	2

NOTES:

1. The pin center-to-center dimensions are measured at the gage plane.
2. ¼ in. 28 UNF 2A (Mod). Applied torque not to exceed 12 inch-pounds.
3. This device may be operated in any position.
4. Seating plate to be flat within 0.003 inches.
5. Typical 4 places.

TERMINAL CONNECTIONS

Pin. No.1—Emitter & Diode Cathode
Pin. No.2—Collector
Pin. No.3—Base
Pin. No.4—Diode Anode

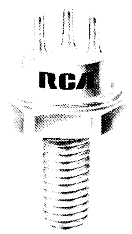
WARNING: The body of this device contains beryllium oxide. Do not crush, grind, or abrade that portion because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

RCA

**Solid State
Division**

RF Power Transistors

40936



JEDEC TO-60

H-1307

20-W(PEP) Emitter-Ballasted Overlay Transistor

For 2- to-30-MHz Single-Sideband Linear Amplifier Applications

Features:

- **For class A or class B amplifier service**
- **Integral emitter-ballasting resistors**
- **20 W(PEP) output (min.) at 30 MHz with:
gain = 13 dB (min.); collector efficiency = 40% (min.);
intermodulation distortion = -30 dB (max.)**
- **Low-Thermal-Resistance Package**

RCA – 40936* is an epitaxial silicon n-p-n planar transistor with overlay emitter-electrode construction. It is designed especially for use in linear amplifiers to provide high power in class A or class B service. This device is intended for 2-to-30-MHz single-sideband power amplifiers operating from 28-volt power supplies.

The inherent high-frequency capability of the overlay structure, together with individually ballasted emitter sites, makes it possible to forward-bias the device into the active region without incurring thermal instability.

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*Formerly RCA Dev. No. TA8236.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With V_{BE} = -1.5 V	V_{CEV}	65	V
With external base-to-emitter resistance R_{BE} = 5 Ω	V_{CER}	40	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT:			
Peak		10	A
Continuous	I_C	3.3	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 75°C		50	W
At case temperatures above 75°C		Derate linearly at 0.4 W/°C.	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. (0.787 mm) from insulating wafer for 10 s max		230	°C

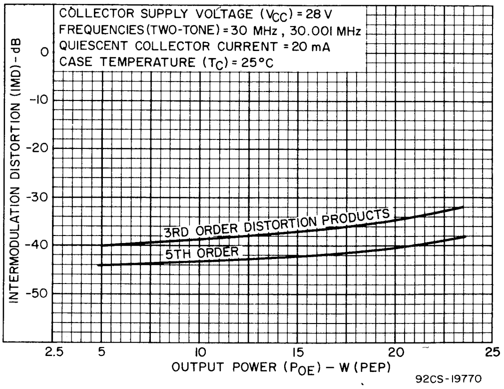


Fig. 1—Typical intermodulation distortion vs. output power.

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25°C

STATIC

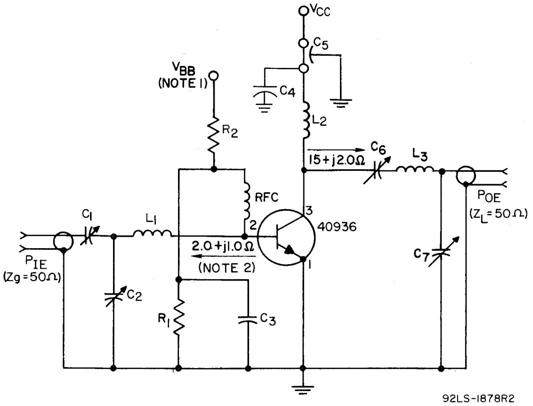
CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC COLLECTOR VOLTAGE (V)		DC BASE VOLTAGE (V)	DC CURRENT (mA)				
		V_{CB}	V_{CE}	V_{BE}	I_E	I_C	MIN.	MAX.	
Collector-to-Emitter Sustaining Voltage: With base-emitter junction reverse biased	V_{CEV}(sus)			−1.5		200[a]	65	–	V
With external base-to-emitter resistance (R_{BE})=5Ω	V_{CER}(sus)					200[a]	40	–	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$				20		4	–	V
Collector-to-Emitter Cutoff Current	I_{CEO}		30				–	5.0	mA
Collector-to-Base Cutoff Current	I_{CBO}	60					—	10	mA
Collector-to-Base Capacitance (f = 1 MHz)	C_{obo}	30					–	85	pF
Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$						–	2.5	°C/W

[a] Pulsed through an inductor (25 mH); duty factor = 50%.

DYNAMIC (30-MHz Single-Sideband Amplifier)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC COLLECTOR SUPPLY VOLTAGE (V)	OUTPUT POWER W(PEP)	FREQUENCY (MHz)	DC CURRENT (mA)			
		V_{CC}	P_{OE}	f	I_C	MIN.	MAX.	
RF Input Power: Average	P_{IE}	28	10	30	20	–	0.5	W
Peak envelope (PEP)	P_{IE}	28	20	30	20	–	1.0	W
Power Gain	G_{PE}	28	20	30	20	13	–	dB
Collector Efficiency	η_C	28	20	30	20	40	–	%
Intermodulation Distortion*	IMD	28	20	30	20	–	-30	dB

*Referenced to either of the two tones, and without the use of feedback to enhance linearity.



L_1: 3 turns No. 12 wire, 1/4 in. (6.35 mm) I.D., 1/2 in. (12.7 mm) long

L_2: 6 turns No. 14 wire, 3/8 in. (9.53 mm) I.D., 3/4 in. (19.05 mm) long

L_3: 5 turns No. 10 wire, 3/4 in. (19.05 mm) I.D., 3/4 in. (19.05 mm) long

C_1: 140–680 pF, Arco 468, or equivalent

C_2: 170–780 pF, Arco 469, or equivalent

C_3: 0.05 pF, ceramic

C_4: 0.1 μF, ceramic

C_5: 1000 pF, feedthrough

C_6: 24–200 pF, Arco 425, or equivalent

C_7: 32–250 pF, Arco 426, or equivalent

R_1: 20Ω, 1 W

R_2: 300Ω, 5 W

RFC: 350Ω, Ferrite choke, Ferroxcube* No. 01-03B, or equivalent

*Ferroxcube Corp. of America, Saugerties, N.Y.

NOTES:

1. V_{BB} adjusted for a quiescent collector current of 20 mA.
2. Impedances measured at socket terminals.

Fig. 2—30-MHz linear amplifier test circuit used for measurement of dynamic characteristics.

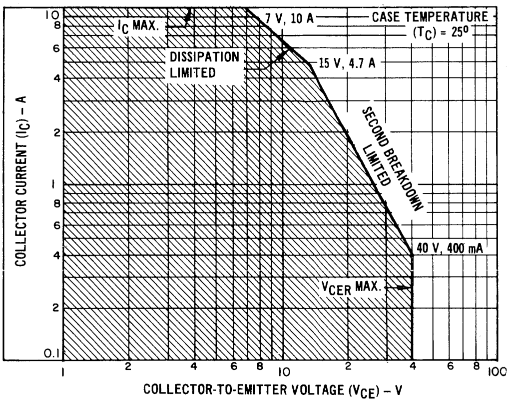


Fig. 3—Maximum operating area for forward-bias operation.

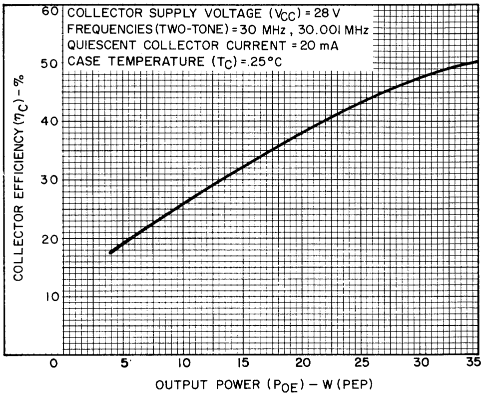


Fig. 4—Typical collector efficiency vs. output power.

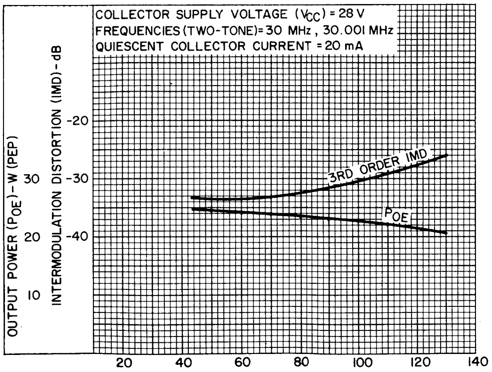


Fig. 5—Typical output power and intermodulation distortion vs. case temperature.

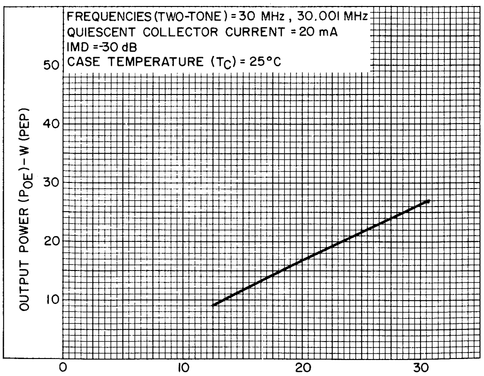


Fig. 6—Typical output power vs. collector supply voltage.

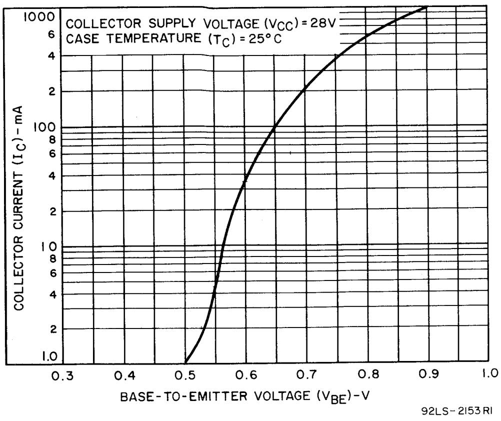


Fig. 7—Typical transfer characteristic.

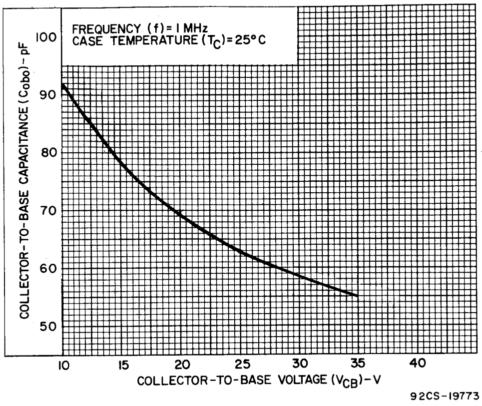
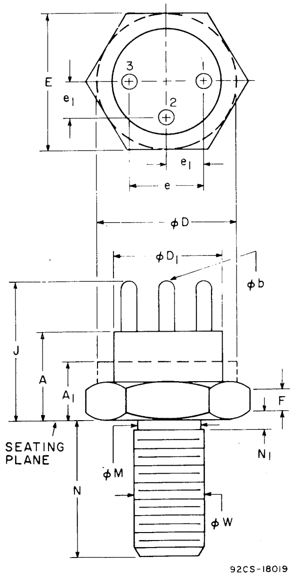


Fig. 8—Variation of output capacitance with collector-to-base voltage.

DIMENSIONAL OUTLINE
JEDEC TO-60



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A_1	–	0.165	–	4.19	2
φb	0.030	0.046	0.762	1.17	4
φD	0.360	0.437	9.14	11.10	2
$φD_1$	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e_1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
φM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N_1	–	0.078	–	1.98	
φW	0.1658	0.1697	4.212	4.310	3, 5

NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing perimts insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17 mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

TERMINAL CONNECTIONS

Case, Mounting Stud, Pin No. 1 – Emitter
Pin No. 2 – Base
Pin No. 3 – Collector

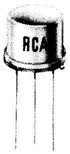
DIMENSIONS IN INCHES AND MILLIMETERS

Mobile-Radio Types

Solid State Division

RF Power Transistors

2N4427



JEDEC TO-39

H-1381

Silicon N-P-N Overlay Transistor

High-Gain Driver for VHF-UHF

Features:

- **1 W output with 10 dB gain (min.) at 175 MHz** $V_{CC} = 12$ V
- **0.4 W output with 5 dB gain (typ.) at 470 MHz** $V_{CC} = 12$ V

RCA-2N4427 is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter electrode construction. It is intended for class A, B, or C amplifier, frequency-multiplier, or oscillator circuits; it may be used in output, driver, or pre-driver stages in vhf and uhf equipment.

In the overlay structure, a number of individual emitter sites are connected in parallel and used in conjunction with a single base and collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, and frequency capability.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	40	V
* COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	20	V
* EMITTER-TO-BASE VOLTAGE	V_{EBO}	2	V
* CONTINUOUS COLLECTOR CURRENT	I_C	0.4	A
* CONTINUOUS BASE CURRENT	I_B	0.4	A
* TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 100°C		2	W
At case temperatures above 100°C		*See Fig. 14*	
* TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to 200	°C
* LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. (0.8 mm) from insulating wafer for 10 s max.		230	°C

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* In accordance with JEDEC registration data format JS-6 RDF-3.

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C.

Characteristic	Symbol	TEST CONDITIONS DC Voltage (V) V_{BE}	 V_{EB}	 V_{CB}	 V_{CE}	 DC Current (mA) I_E	 I_B	 I_C	Limits Min.	 Max.	Units
* Collector-Cutoff Current: With base open	I_{CEO}				12		0		–	0.02	mA
With base-emitter junction reverse-biased	I_{CEV}	−1.5			40				–	0.1	
T_C = 150°C		−1.5			12				–	5	
* Emitter-Cutoff Current	I_{EBO}		2						–	0.1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$					0		0.1	40	–	V
* Collector-to-Emitter Sustaining Voltage: With base open	$V_{CEO}(sus)$						0	5	20	–	V
With external base-to-emitter resistance (R_{BE}) = 10Ω	$V_{CER}(sus)$							5	40	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$					0.1		0	2	–	V
* Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$						20	100	–	0.5	V
* DC Forward Current Transfer Ratio	h_{FE}				5 5			360 100	5 10	– 200	
* Magnitude of Common-Emitter Small-Signal, Short-Circuit Forward Current Transfer Ratio (f = 200 MHz)	$\|h_{fe}\|$				15			50	2.5	–	
* Collector-to-Base Capacitance (f = 1 MHz)	C_{ob}			12		0			–	4	pF
RF Power Output Class C Amplifier, Unneutralized (f = 175 MHz, P_{IE} = 0.1 W, $\eta_C \geq$ 50%) See Fig. 2	P_{OE}			12 (V_{CC})					1	–	W
* Available Amplifier Signal Input Power (f = 175 MHz, P_{OE} = 1 W, Z_{IN} = 50 Ω) See Fig. 2	P_i			12 (V_{CC})					–	0.1	W
* Collector Efficiency (f = 175 MHz, P_{OE} = 1 W, Z_{IN} = 50 Ω) See Fig. 2	η_C			12 (V_{CC})					50	–	%
Thermal Resistance Junction-to-Case	$R_{\theta JC}$								–	50	°C/W

* In accordance with JEDEC registration data format JS–6 RDF–3.

175 MHz OPERATION

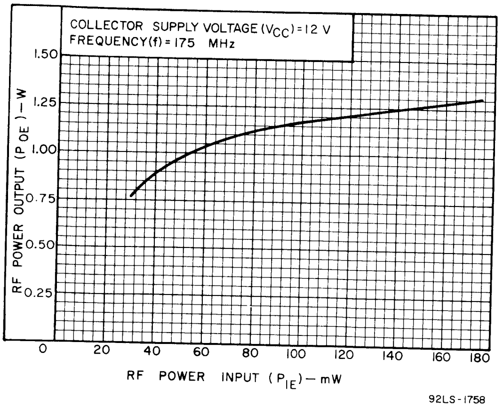
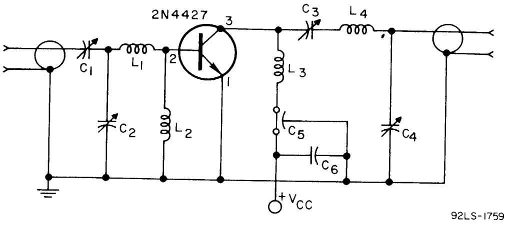


Fig. 1— Power output vs. power input.



C_1, C_2, C_3, & C_4: 3-15 pF trimmer, ARCO 403 or equivalent
C_5: 1,000 pF feedthrough
C_6: 0.01 μF disc.
L_1: 2 turns No.16 wire, 3/16 in. (4.76 mm) ID, 1/4 in. (6.35 mm) long
L_2: Ferrite choke, Z = 450 Ω
L_3: 2 turns No.16 wire, 1/4 in. (6.35 mm) ID, 1/4 in. (6.35 mm) long
L_4: 4 turns No.16 wire, 3/8-in. (9.52 mm) ID, 3/8 in. (9.52 mm) long

Fig.2—175-MHz rf amplifier circuit for power-output test.

470 MHz OPERATION

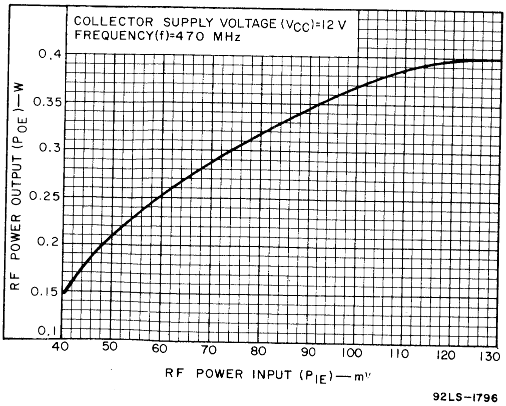
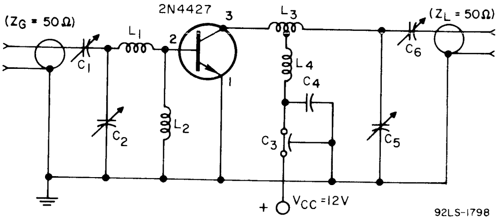


Fig.3— Power output vs. power input.



C_1, C_2, C_5, & C_6: 0.9—7 pF trimmer, ARCO 400, or equivalent
C_3: 1000 pF feedthrough
C_4: 0.02 μF disc.
L_1: 1 turn No.20 wire, 3/16 in. (4.76 mm) ID, Space wire diameter
L_2: 0.47 μH Nytronics Corp., or equivalent
L_3: 2 turns No.18 wire, 1/4 in. (6.35 mm) ID, Space wire diameter C.T.
L_4: 2 turns No.20 wire, 3/16 in. (4.76 mm) ID, Space wire diameter

Fig.4—470-MHz rf amplifier circuit.

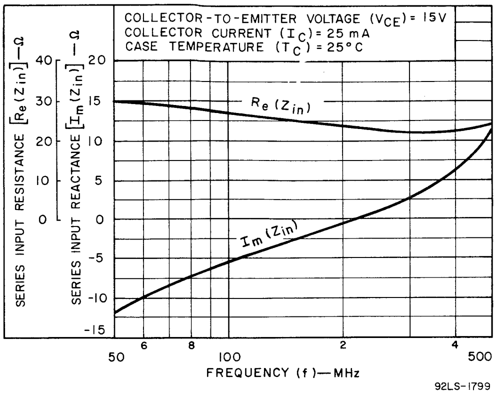


Fig.5—Series input impedance vs. frequency.

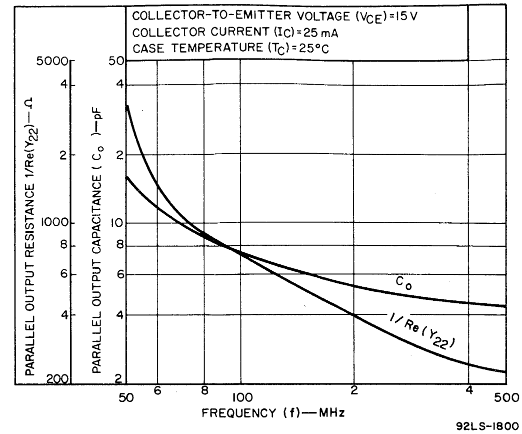


Fig.6—Parallel output resistance & capacitance vs. frequency.

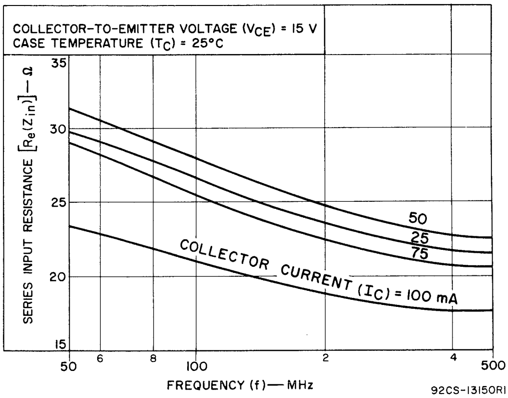


Fig.7—Series input resistance vs. frequency.

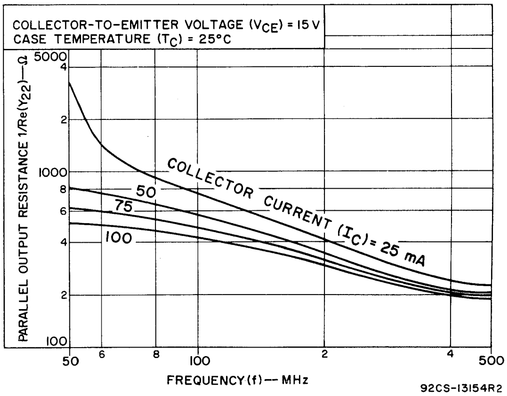


Fig.8—Parallel output resistance vs. frequency.

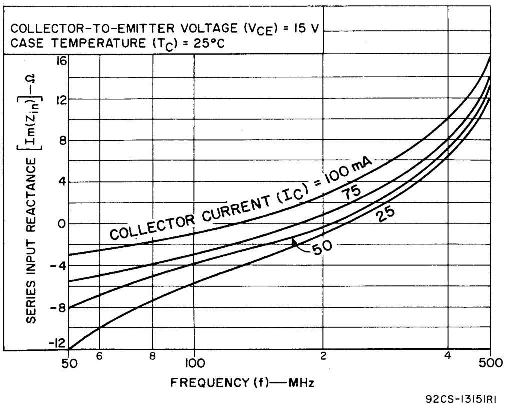


Fig.9—Series input reactance vs. frequency.

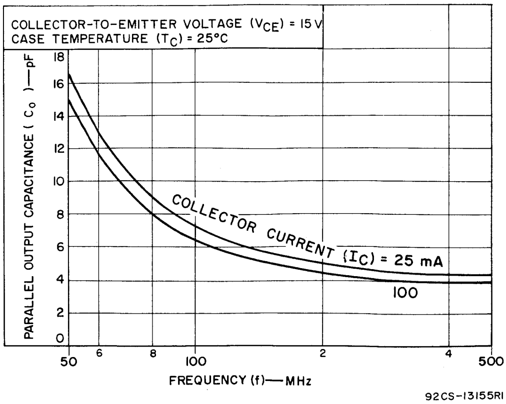


Fig.10—Parallel output capacitance vs. frequency.

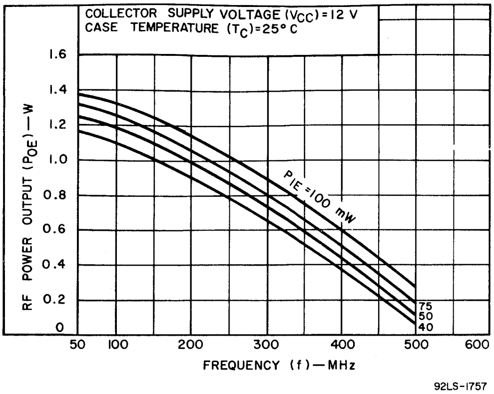


Fig. 11—Power output vs. frequency.

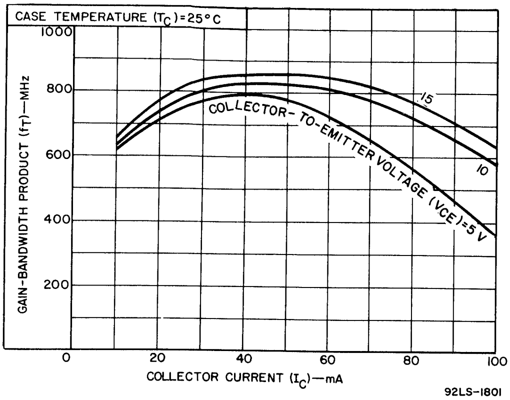


Fig. 12—Gain-bandwidth product vs. collector current.

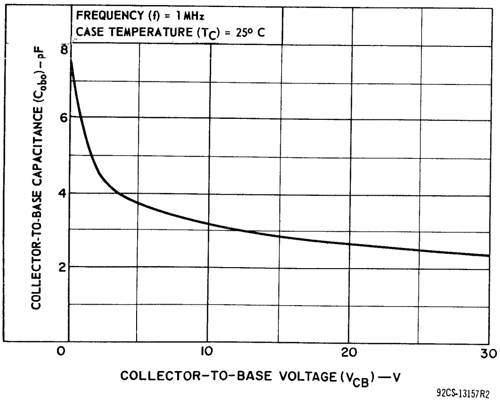


Fig. 13—Variation of collector-to-base capacitance.

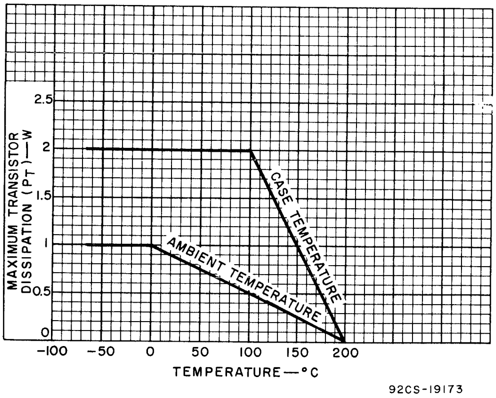
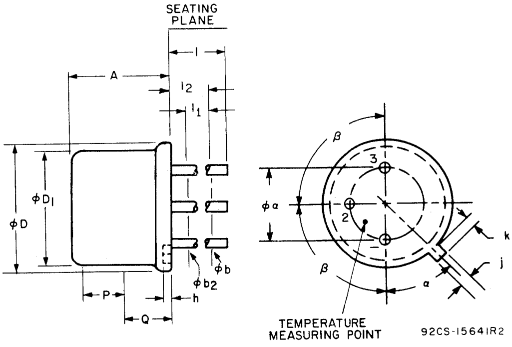


Fig. 14—Dissipation derating curve.

DIMENSIONAL OUTLINE
JEDEC No. TO-39



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
φa	0.190	0.210	4.83	5.33	
A	0.240	0.260	6.10	6.60	
φb	0.016	0.021	0.406	0.533	2
ϕb_2	0.016	0.019	0.406	0.483	2
φD	0.350	0.370	8.89	9.40	
ϕD_1	0.315	0.335	8.00	8.51	
h	0.009	0.041	0.229	1.04	
j	0.028	0.034	0.711	0.864	
k	0.029	0.040	0.737	1.02	3
l	0.500		12.70		2
l_1		0.050		1.27	2
l_2	0.250		6.35		2
P	0.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010 in (0.254 mm).

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. φb applies between l_2 and 0.5 in (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond 0.5 in (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the actual device.

Note 4: Details of outline in this zone optional.

TERMINAL CONNECTIONS

LEAD 1 – EMITTER
LEAD 2 – BASE
LEAD 3 – COLLECTOR, CASE

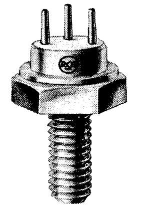
RCA
Solid State Division

RF Power Transistors
2N4932
2N4933

RCA-2N4932* and RCA-2N4933▲ are epitaxial silicon n-p-n planar transistors of the "overlay" emitter electrode construction. They are especially intended to provide high power as class C rf amplifiers for International VHF Mobile and Portable Communications service (66 to 88 MHz). The 2N4932 is designed to operate from a 13.5-volt power supply; the 2N4933, from a 24-volt power supply.

The transistors feature protection against load mismatch.

In the overlay structure, there are a number of individual emitter sites which are all connected in parallel and used in conjunction with a common collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, frequency capability, and linearity.


JEDEC TO-60

For International VHF Mobile and Portable Communication, 66 to 88 MHz

Operation From a Power Supply of –
13.5 volts (2N4932)
24 volts (2N4933)

Power Output (Min.) at 88 MHz
12 watts (2N4932)
20 watts (2N4933)

Load Protection
High Voltage Ratings

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* Formerly RCA-Dev. No.TA2828
▲ Formerly RCA-Dev. No.TA2792

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

		2N4932	2N4933	
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	50	70	V
COLLECTOR-TO-EMITTER VOLTAGE:				
With base open	V_{CEO}	25	35	V
With $V_{BE} = -1.5V$	V_{CEV}	50	70	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4.0		V
COLLECTOR CURRENT:				
Peak		10		A
Continuous	I_C	3.3		A
RF INPUT POWER	P_{in}			
At 88 MHz		3.5		W
Below 88 MHz		See *Fig.7*		
TRANSISTOR DISSIPATION	P_T			
At case temperatures up to 25° C		70		W
At case temperatures above 25° C		See *Fig.1*		
TEMPERATURE RANGE:				
Storage & Operating (Junction)		−65 to 200		°C
LEAD TEMPERATURE (During soldering):				
At distances ≥ 1/32 in. from insulating wafer for 10 s max.		230		°C

DISSIPATION DERATING CURVE

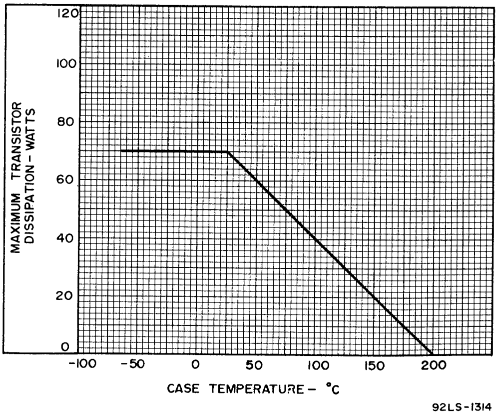


Fig.1

ELECTRICAL CHARACTERISTICS FOR 2N4932

Case Temperature = 25° C

Characteristic	Symbol	TEST CONDITIONS						Limits		Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		15			0			1.0	mA
	I_{CBO}	40			0				10	mA
Collector-to-Emitter Breakdown Voltage	$V_{CEV}(sus)$			−1.5			200[a]	50		V
	$V_{CEO}(sus)$					0	200[a]	25		V
Emitter-to-Base Breakdown Voltage	BV_{EBO}				10		0	4		V
Collector-to-Base Capacitance	C_{ob}	15			0				120	pF
RF Power Output (See *Fig.2*)	P_{out}							12[c]		W

ELECTRICAL CHARACTERISTICS FOR 2N4933

Case Temperature = 25° C

Characteristic	Symbol	TEST CONDITIONS						Limits		Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		30			0			1.0	mA
	I_{CBO}	50			0				10	mA
Collector-to-Emitter Breakdown Voltage	$V_{CEV}(sus)$			−1.5			200[a]	70		V
	$V_{CEO}(sus)$					0	200[a]	35		V
Emitter-to-Base Breakdown Voltage	BV_{EBO}				10		0	4		V
Collector-to-Base Capacitance	C_{ob}	30			0				85	pF
RF Power Output (See *Fig.3*)	P_{out}							20[b]		W

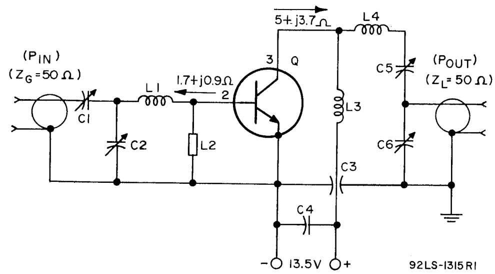
[a] Pulsed through an inductor (25mH), duty factor = 50%

[b] For P_{in} = 3.5 W, at 88 MHz; V_{cc} = 24V, minimum efficiency = 70%

[c] For P_{in} = 3.5 W, at 88 MHz; V_{cc} = 13.5V, minimum efficiency = 70%

RF AMPLIFIER CIRCUIT FOR POWER OUTPUT TEST
(66 to 88 MHz Operation)

2N4932



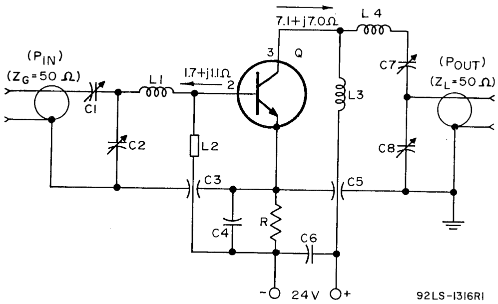
C_1 = 7-100 pF
C_2 = 14-150 pF
C_3 = 1000 pF
C_4 = .05 µF
C_5 = 70-350 pF
C_6 = 32-250 pF

L_1 = 1 turn, No.16 wire, 1/4" ID, 1/8" long
L_2 = Ferrite Choke, Z = 450 Ω, Ferroxcube #VK200 01-3B*
L_3 = 2 turns, No.16 wire, 1/4" ID, 3/8" long
L_4 = 2 turns, No.10 wire, 1/2" ID, 1/2" long
Q = 2N4932

*Ferroxcube Corp. of America
Saugerties, N.Y.

Fig. 2

2N4933



C_1 = 7-100 pF
C_2 = 14-150 pF
C_3, C_5 = 1000 pF
C_4, C_6 = .05 µF
C_7 = 70-350 pF
C_8 = 32-250 pF
R = 0.33 Ω

L_1 = 1 turn, No.16 wire, 1/4" ID, 1/8" long
L_2 = Ferrite Choke, Z = 450 Ω, Ferroxcube #VK200 01-3B*
L_3 = 3.5 turns, No.16 wire, 1/4" ID, 1/2" long
L_4 = 3 turns, No.10 wire, 1/2" ID, 3/4" long
Q = 2N4933

*Ferroxcube Corp. of America
Saugerties, N.Y.

Fig. 3

TYPICAL POWER OUTPUT vs POWER INPUT

2N4932

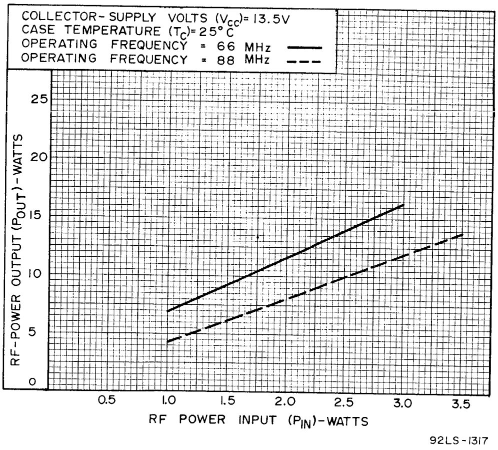


Fig. 4

2N4933

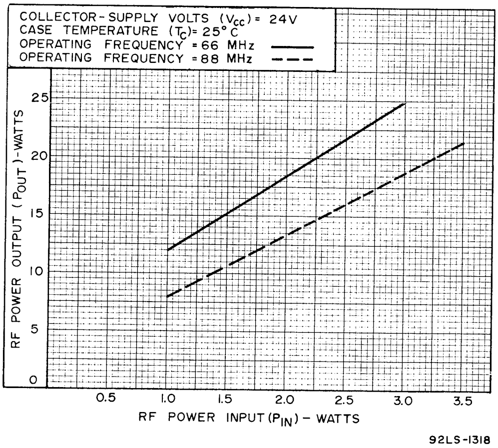


Fig. 5

SPECIAL PERFORMANCE DATA

The transistor can withstand any mismatch in load, which can be demonstrated in the following test:

1. The test is performed using the arrangement in *Fig.6*.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions: V_{cc} = 13.5V (2N4932), 24V (2N4933); RF input power = 3W @ 66 MHz.
4. Transistor Dissipation Rating must not be exceeded. During the above test, the transistor will not be damaged or degraded.

BLOCK DIAGRAM FOR MISMATCH TEST

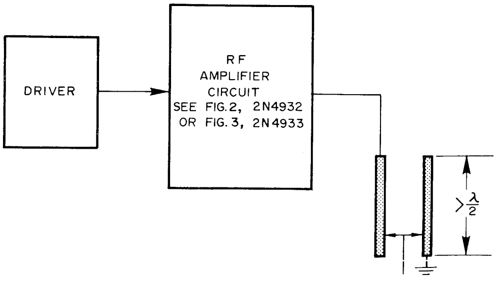


Fig. 6

INPUT DERATING CURVE

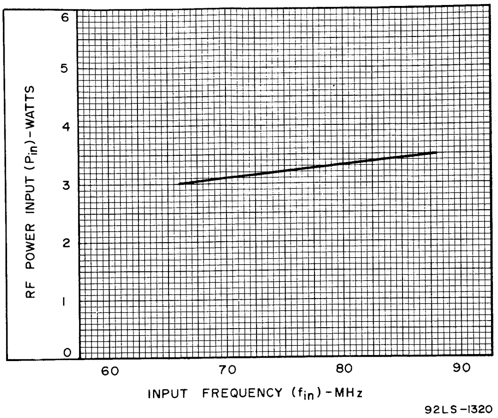
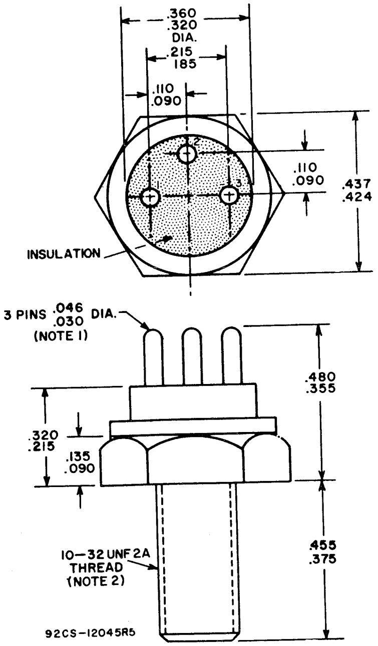


Fig. 7

DIMENSIONAL OUTLINE
JEDEC TO-60



DIMENSIONS IN INCHES

TERMINAL CONNECTIONS

Case, Mounting Stud, Pin No.1 - Emitter
Pin No.2 - Base
Pin No.3 - Collector

NOTE 1: The pin spacing permits insertion in any socket having a pin-circle diameter of 0.200" and contacts which will accommodate pins having a diameter of 0.035" min., 0.046" max.

NOTE 2: The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

NOTE 3: This device may be operated in any position.

REFERENCES

1. *The Overlay Transistor,* Electronics, August 23, 1965.

   Part I - *New Geometry Boosts Power,* D. R. Carley, P. L. McGeough, and J. F. O'Brien.
   Part II - *Putting the Overlay to Work at Hi-Frequency,* Dr. D. J. Donahue and B. A. Jacoby.

2. *Design Trade-Offs for RF Transistor Power Amplifiers,* R. Minton, RCA Publication No.ST-3250.

3. *Semiconductor High-Frequency Power Amplifier Design,* R. Minton, RCA Publication No.ST-3230.

4. *RF Power Transistors in Vehicular Radio Communications Equipment,* S. Matyckas, RCA Publication No.ST-3219.

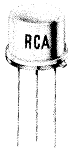
RCA
Solid State Division

RF Power Transistors

2N5913

Silicon N-P-N Overlay Transistor

12.5-Volt, High-Gain Type for Class-C Amplifiers in VHF/UHF Communications Equipment



JEDEC TO-39

H-1381

Features:

- **High Power Gain, High Power Output . . .**
  At 12.5 V:
    2-W (typ.) output at 470 MHz (7-dB gain)
    2-W (typ.) output at 250 MHz (9-dB gain)
    2-W (typ.) output at 175 MHz (13-dB gain)
  At 8 V:
    1.5-W (typ.) output at 470 MHz (4.8-dB gain)
    1.5-W (typ.) output at 250 MHz (7.0-dB gain)
    1.5-W (typ.) output at 175 MHz (10-dB gain)

MAXIMUM RATINGS, ***Absolute-Maximum Values:***

* COLLECTOR-TO-BASE VOLTAGE.	V_{CBO}	36	V
COLLECTOR-TO-EMITTER BREAKDOWN VOLTAGE:			
With base shorted to emitter	$V_{(BR)CES}$	36	V
* With base open	$V_{(BR)CEO}$	14	V
* EMITTER-TO-BASE VOLTAGE . . .	V_{EBO}	3.5	V
* CONTINUOUS COLLECTOR CURRENT	I_C	0.33	A
* TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C. .		3.5	W
At case temperatures above 75°C .		Derate at 0.0028 W/°C	
* TEMPERATURE RANGE:			
Storage & Operating (Junction) . .		-65 to +200	°C
* LEAD TEMPERATURE:			
At distances ≥ 1/32 in. (0.8 mm) from seating plane for 10 s max.		230	°C

RCA Type 2N5913[▲] is an epitaxial silicon n-p-n planar transistor featuring "overlay" emitter electrode construction. It is intended for VHF/UHF mobile, portable, and VHF marine transmitters, as well as UHF CB, sonobuoy, beacon, and other applications where intermediate power output is required at low supply voltage.

[▲] Formerly RCA Developmental Type TA7477.

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* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS DC Voltage (V) V_{CE}	TEST CONDITIONS DC Voltage (V) V_{EB}	TEST CONDITIONS DC Current (mA) I_E	TEST CONDITIONS DC Current (mA) I_B	TEST CONDITIONS DC Current (mA) I_C	LIMITS Min.	LIMITS Max.	UNITS
* Collector-Cutoff Current Base Connected to Emitter	I_{CES}	12.5			0			1.0^b	mA
Base Open	I_{CEO}	10			0			0.3	mA
* Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.5	36	–	V
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$				0	25^a	14	–	V
With base connected to emitter	$V_{(BR)CES}$		0			25^a	36	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.5		0	3.5	–	V
Thermal Resistance: (Junction-to-Case)	$\theta_{J\text{-}C}$						–	35.7	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

[b] $T_C = 100°C$.

DYNAMIC

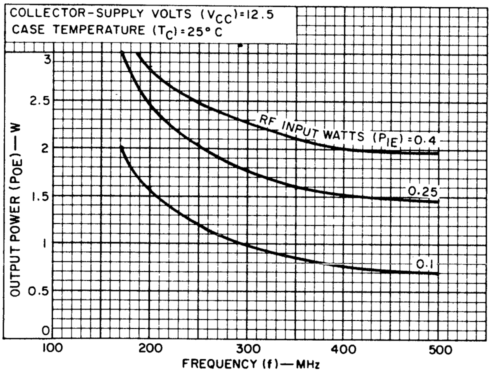
TEST & CONDITIONS	SYMBOL	FREQUENCY MHz	LIMITS MINIMUM	LIMITS TYPICAL	UNITS
Power Output (V_{CC} = 12.5 V): P_{IE} = 0.1 W	P_{OE}	175	1.75		W
* Large-Signal Common-Emitter Power Gain (V_{CC} = 12.5 V): P_{IE} 0.1 W	G_{PE}	175	12.4		dB
* Collector Efficiency (V_{CC} = 12.5 V): P_{IE} = 0.1 W	η_C	175	50		%
* Common-Base Output Capicatance V_{CB} = 12 V	C_{obo}	1	15 (max.)		pF
Gain-Bandwidth Product V_{CE} = 12 V, I_C = 200 mA	f_T	–	–	900	MHz

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

PERFORMANCE DATA

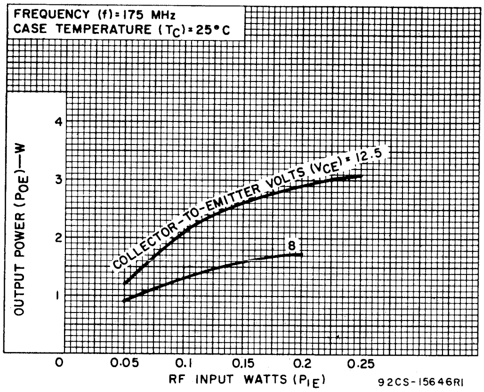
TYPICAL AMPLIFIER PERFORMANCE (V_{CE} = 12.5 V)

FREQUENCY (f)−MHz	INPUT POWER (P_{IB}) - W	OUTPUT POWER (P_{OB}) - W	COLLECTOR EFFICIENCY η_C	CIRCUIT
175	0.1	2	60	Fig.6
250	0.25	2	65	Fig.6
470	0.4	2	65	Fig.7
156 (Marine Transmitter)	.005	2	–	Fig.8



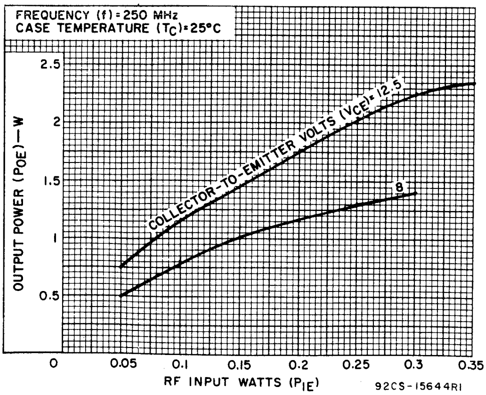
92CS-15645RI

Fig.1 - Typical power output vs. frequency.



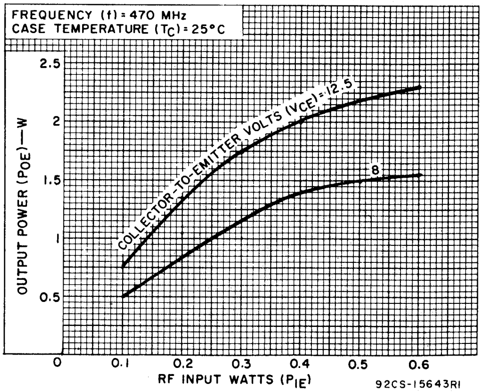
92CS-15646RI

Fig. 2 - Typical power output vs. power input at 175 MHz for circuit shown in Fig.5.



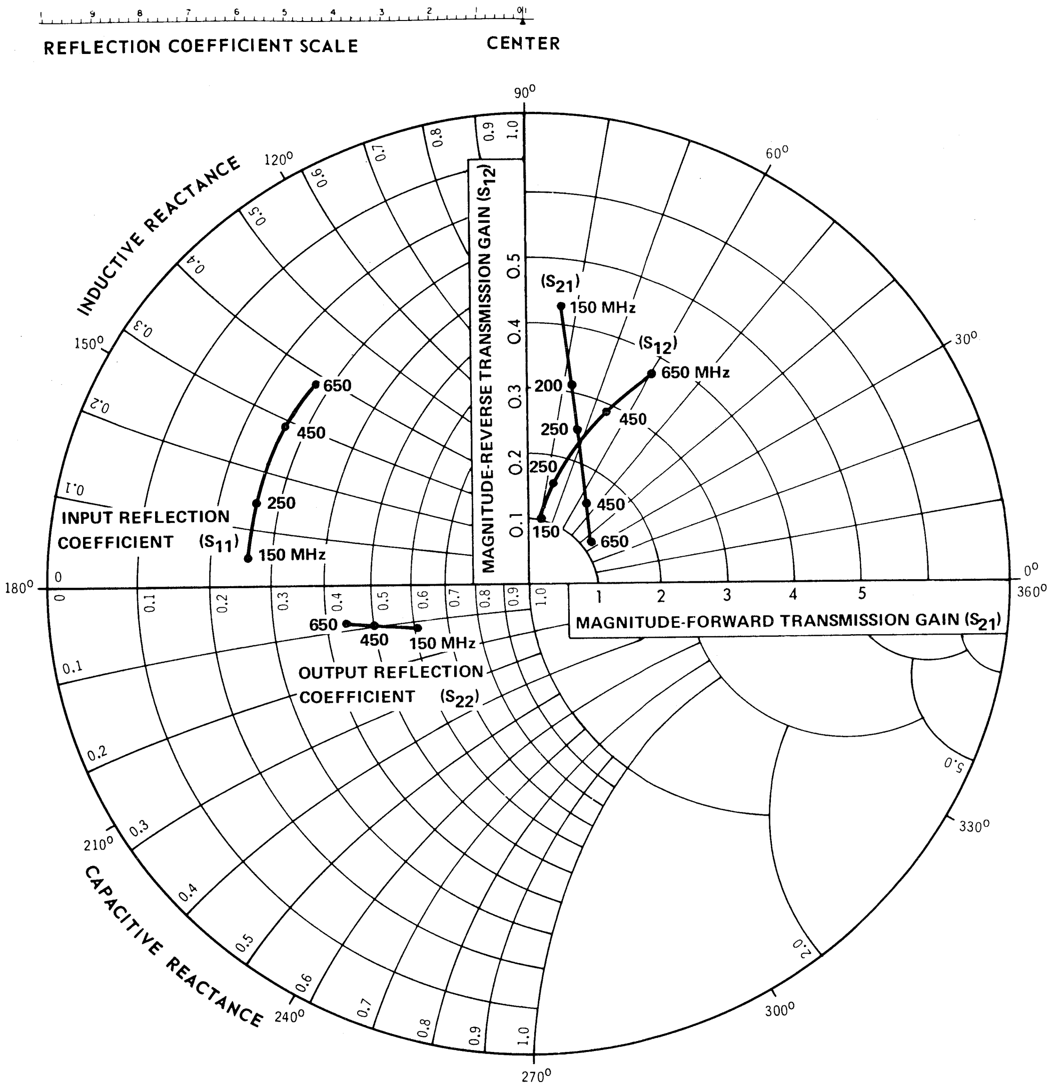
92CS-15644RI

Fig. 3 - Typical power output vs. power input at 250 MHz for circuit shown in Fig.5.



92CS-15643RI

Fig. 4 - Typical power output vs. power input at 470 MHz for circuit shown in Fig.7.

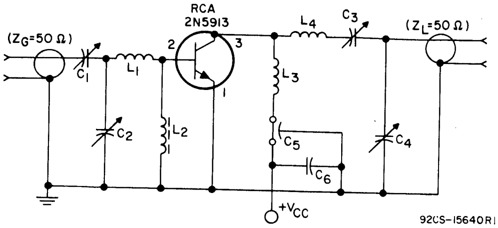


Collector-to-Emitter Voltage (V_{CE}) = 12.5 V
Collector-Current (I_C) = 100 mA
Case Temperature (T_C) = 25°C

92CM-16066

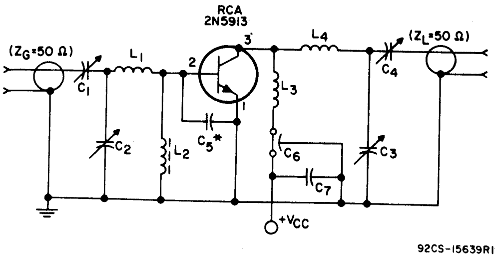
Fig. 5 - Typical S parameters vs. frequency.

APPLICATION DATA



C_1, C_2, C_3, & C_4: 7-35 pF, ARCO 403, or equivalent
C_5: 1,000 pF, feed-through
C_6: 0.005 μF, disc ceramic
L_1: 2 turns No.16 wire, 3/16 in. ID, 1/4 in. long
L_2: Z = 450 ohms; Ferroxcube VK200-09/3B, or equivalent
L_3: 2 turns No.14 wire, 1/4 in. ID, 5/16 in. long
L_4: 3 turns No.14 wire, 3/8 in. ID, 3/8 in. long

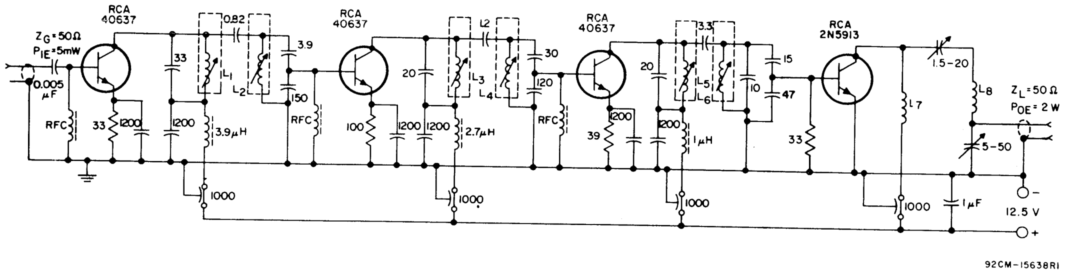
Fig. 6 - 175/250-MHz amplifier test circuit for measurement of power output.



C_1, C_2, C_3: 0.9-7 pF, ARCO 400, or equivalent
C_4: 7-35 pF, ARCO 903, or equivalent
C_5: 22 pF, ± 5% silver mica
C_6: 470 pF, feed-through
C_7: 0.1 μF, disc ceramic
L_1, L_3, L_4: 1 turn No.18 wire 1/4 in. ID, 1/8 in. long
L_2: 0.39 μH, Nytronics Deci-Ductor, or equivalent

* Mount C_5 as close as possible to base and emitter pins.

Fig. 7 - 470-MHz amplifier test circuit for measurement of power output.



L_1 - L_2: 10-1/2 turns, close-wound, #22 enameled wire
L_3 - L_4: 4-1/2 turns, close-wound, #22 enameled wire
L_5 - L_6: 1-1/2 turns, 1/4 in. length, #20 bare wire

All coils on slug-tuned forms 15/64-in. O.D. Corbonyl* S.F. 10-32 threaded slug or equivalent, with 1/2-in. x 1/2-in. x 1-in. shield cans.

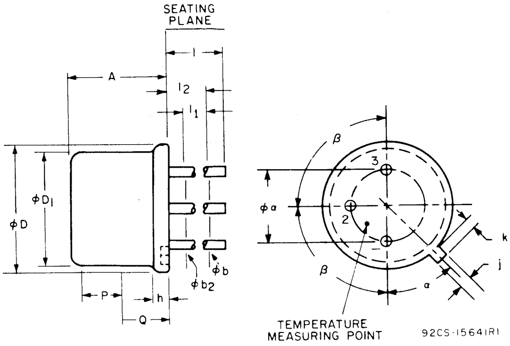
L_7: 2 turns, 3/16-in. length, 3/16-in. dia., #20 bare wire
L_8: 2-1/2 turns, 1/4-in. length, #20 bare wire
RFC: 4 turns, #30 enameled wire on Ferroxcube† ferrite bead #56-590-65/48, or equivalent

All capacitor values are in picofarads unless otherwise specified.
All resistances are in ohms and are 1/4-watt types.

* Arnold Magnetics Corp., Los Angeles, Cal.
† Ferroxcube Corp. of America, Saugerties, N.Y.

Fig. 8 - Typical circuit for a frequency-multiplier chain (f_{IN} = 13 MHz, f_{OUT} = 156 MHz) for 156-MHz marine-radio transmitter.

DIMENSIONAL OUTLINE
JEDEC No.TO-39



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕa	.190	.210	4.83	5.33	
A	.240	.260	6.10	6.60	
ϕb	.016	.021	.406	.533	2
ϕb_2	.016	.019	.406	.483	2
ϕD	.350	.370	8.89	9.40	
ϕD_1	.315	.335	8.00	8.51	
h	.009	.125	.229	3.18	
j	.028	.034	.711	.864	
k	.029	.040	.737	1.02	3
l	.500		12.70		2
l_1		.050		1.27	2
l_2	.250		6.35		2
P	.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed .010 in (.254 mm).

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and .5 in (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond .5 in (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the actual device.

Note 4: Details of outline in this zone optional.

TERMINAL CONNECTIONS

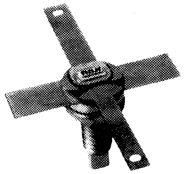
LEAD 1 – EMITTER
LEAD 2 – BASE
LEAD 3 – COLLECTOR, CASE

RCA

Solid State Division

RF Power Transistors

2N5914 2N5915



High-Power Silicon N-P-N Overlay Transistors

12.5-Volt, High-Power Types For Class-C Amplifiers in VHF/UHF Communications Equipment

Features:

- Low inductance radial leads – particularly useful for strip-line circuits
- Hermetically sealed ceramic-metal package
- Electrically isolated mounting stud
- 6 watts minimum output from 2N5915 amplifier at 470 MHz
- 7-dB gain from 2N5914 driver at 470 MHz

MAXIMUM RATINGS, ***Absolute-Maximum Values:***

		2N5914	2N5915	
• COLLECTOR-TO-BASE BREAKDOWN VOLTAGE	$V_{(BR)CBO}$	36	36	V
• COLLECTOR-TO-EMITTER BREAKDOWN VOLTAGE:				
With base connected to emitter	$V_{(BR)CES}$	36	36	V
With base open	$V_{(BR)CEO}$	14	14	V
• EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	3.5	V
• COLLECTOR CURRENT:				
Continuous.	I_C	0.5	1.5	A
• TRANSISTOR DISSIPATION: . . .	P_T			
At case temperatures up to 75°C		5.7	10.7	W
At case temperatures above 75°C		See Fig. 7		
• TEMPERATURE RANGE:				
Storage & Operating (Junction) . .		-65 to +200°C		
• CASE TEMPERATURE (During soldering):				
For 10 s max.		230		°C

• In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA 2N5914[a] and 2N5915[b] are epitaxial silicon n-p-n planar transistors featuring overlay emitter electrode construction.

2N5914 and 2N5915 feature an hermetic, ceramic-metal package having leads isolated from the mounting stud. These rugged, low-inductance, radial-lead types are designed for strip-line, as well as lumped-constant circuits.

[a] Formerly RCA Dev. Type TA7408.

[b] Formerly RCA Dev. Type TA7409.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

Static

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS				UNITS
			DC COLLECTOR VOLTS	DC BASE VOLTS	DC CURRENT mA			2N5914		2N5915		
			V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	MIN.	MAX.	
●	Collector-Cutoff Current	I_{CEO}	10			0		–	0.3	–	1.0	mA
●	Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.5	36	–	–	–	V
							1.0	–	–	36	–	
●	Collector-to-Emitter Breakdown voltage: With base open	$V_{(BR)CEO}$			0		25[a]	14	–	–	–	V
							75[a]	–	–	14	–	
	With base connected to emitter	$V_{(BR)CES}$		0			25[a]	36	–	–	–	
							75[a]	–	–	36	–	
●	Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.5		0	3.5	–	–	–	V
					1.0		0	–	–	3.5	–	

[a] Pulsed through a 25-mH inductor; duty factor = 50%

Dynamic

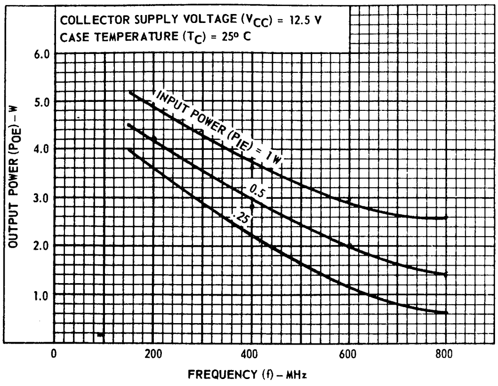
	CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS				UNITS
			DC Collector Supply (V_{CC}) – Volts		Input Power (P_{IE}) – Watts	Frequency (f) – MHz	2N5914		2N5915		
							MIN.	TYP.	MIN.	TYP.	
●	Power Output	P_{OE}	12.5		0.4	470	2.0		–		W
					2.0		–		6		
●	Power Gain	G_{PE}	12.5		0.4	470	7		–		dB
					2.0		–		4.8		
●	Collector Efficiency	η_C	12.5		0.4	470	65		–		%
					2.0		–		65		
	Load Mismatch (Fig. 14)	LM	12.5		2N5914 0.4 2N5915 2	470	GO/NO GO				
●	Collector-to-Base Capacitance	C_{obo}	12 $I_C = 0$			1	–	15 (max.)	–	30 (max.)	pF
	Gain-Bandwidth Product	f_T	12	I_C = 200 mA				900	–		MHz
				I_C = 300 mA			–			800	

● In accordance with JEDEC registration data fromat JS-6 RDF-3/JS-9 RDF-7

Typical Application Information

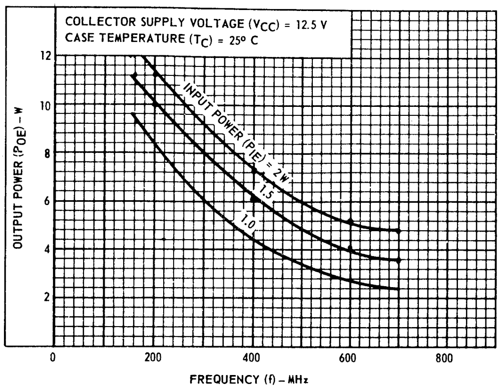
Application	Output Power (P_{OE}) W	Input Power (P_{IE}) W	Collector Efficiency (η_C) %	Circuit (Fig.)
470 MHz Amplifier				
2N5915	6.5	2	70	13
2N5914	2.3	0.4	70	13
175 MHz Amplifier				
2N5915	9	1	70	15
2N5914	4	0.25	70	15
470 MHz Amplifier	6	0.4	–	16

PERFORMANCE DATA



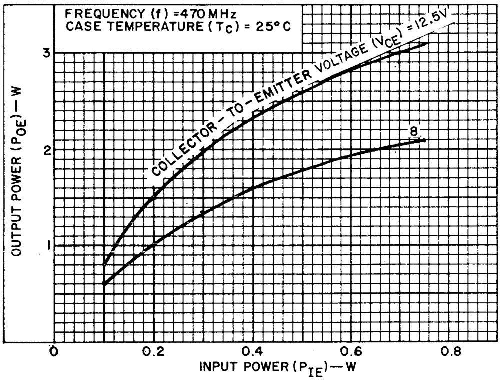
92LS-3034R1

Fig. 1 - Typical output power vs. frequency for 2N5914



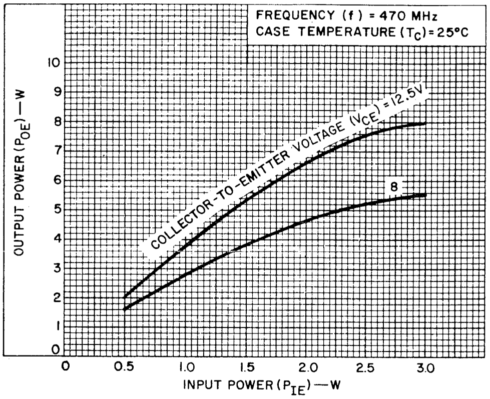
92LS-3042R1

Fig. 2 - Typical output power vs. frequency for 2N5915



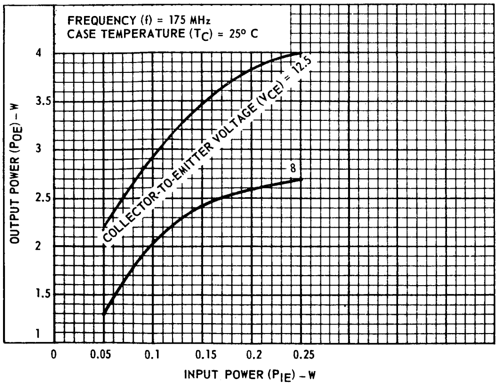
92LS-3038RI

Fig. 3 - Typical output power vs. input power at 470 MHz for 2N5914 in circuit shown in Fig. 8



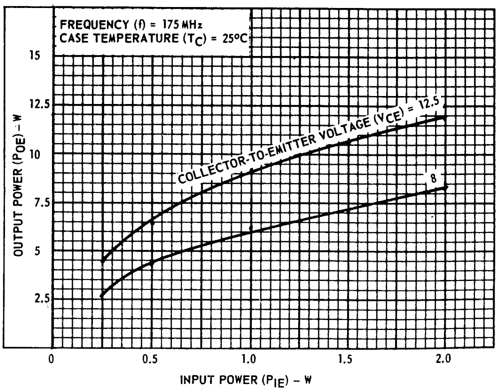
92LS-3037RI

Fig. 4 - Typical output power vs. input power at 470 MHz for 2N5915 in circuit shown in Fig. 8



92SS-4492

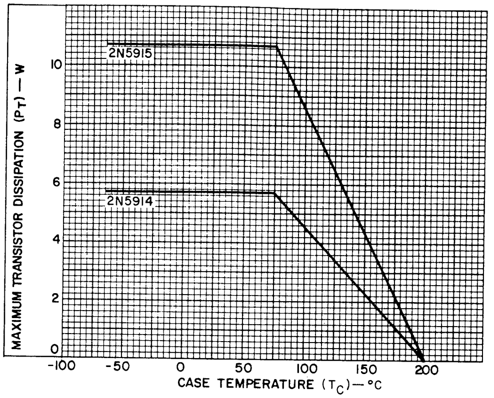
Fig. 5 - Typical output power vs. input power at 175 MHz for 2N5914 (Fig. 15)



92SS-4493

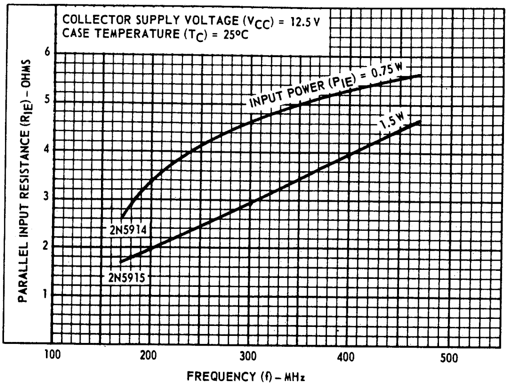
Fig. 6 - Typical output power vs. input power at 175 MHz for 2N5915 (Fig. 15)

DESIGN DATA



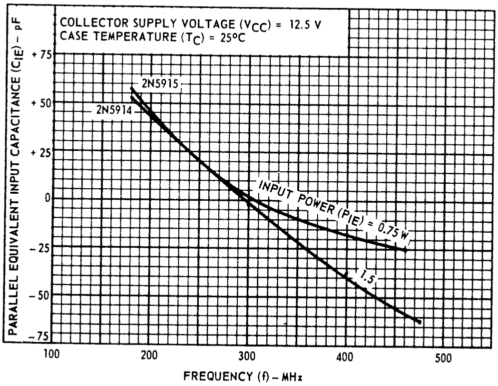
92LS-3036RI

Fig. 7 - Dissipation derating for 2N5914 and 2N5915



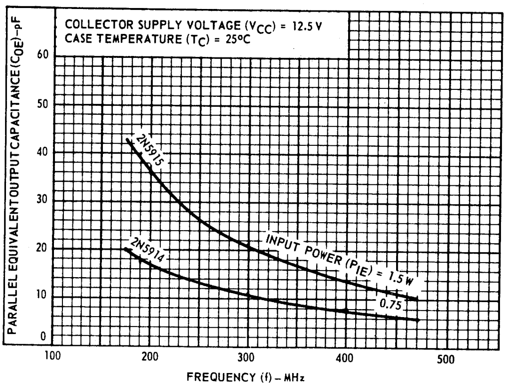
92SS-4494

Fig. 8 - Large signal equivalent parallel input resistance vs. frequency for 2N5914 and 2N5915



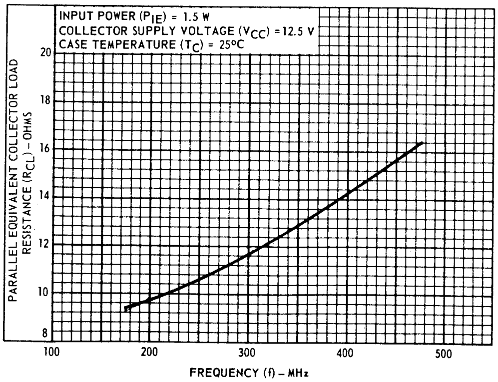
92SS-4495

Fig. 9 - Large signal parallel equivalent input capacitance vs. frequency for 2N5914 and 2N5915



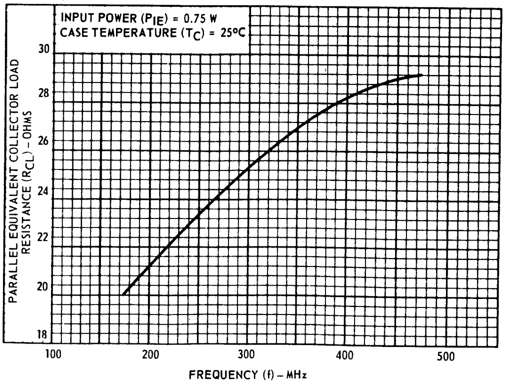
92SS-4496

Fig. 10 - Large signal equivalent parallel output capacitance vs. frequency for 2N5914 and 2N5915



92SS-4497

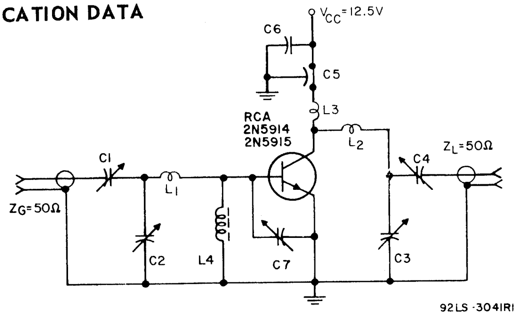
Fig. 11 - Large signal parallel load resistance vs. frequency for 2N5915



92SS-4498

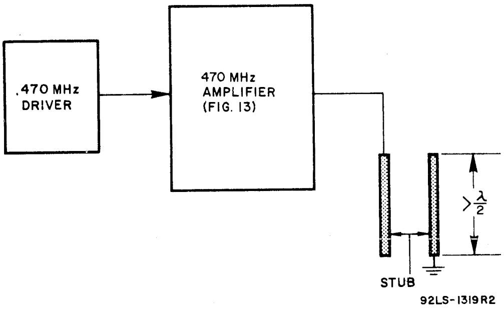
Fig. 12 - Large signal parallel load resistance vs. frequency for 2N5914

APPLICATION DATA



C_1, C_2, C_3 - 0.9-7.0 pF,. ARCO # 400, or equivalent
C_4 - 1.5-20. pF, ARCO # 402, or equivalent
C_5 - 1000 pF (feed-through)
C_6 - 0.1 μF (ceramic)
C_7 - 2-18 pF, Amperex HT10MA/218, or equivalent connect between the base and emitter with the shortest possible leads.
L_1, L_2 - 1 turn # 16 wire, 3/16 in. I.D., 1/8 in. long
L_3 - 1 turn # 20 wire, 3/16 in. I.D., 1/8 in. long
L_4 - Ferrite choke, 450Ω impedance, Ferroxcube VK-200-09-3B, or equivalent

Fig. 13. 470 MHz amplifier used for measuring power output and power gain in 2N5914 and 2N5915

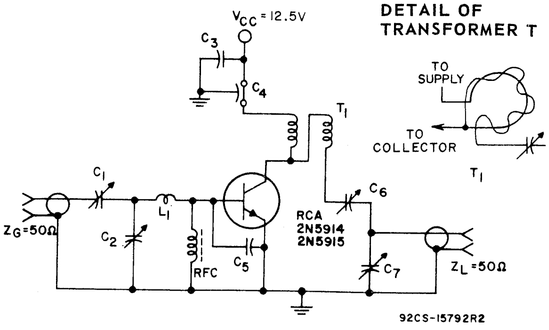


SPECIAL PERFORMANCE DATA

The transistor can withstand any mismatch in load, which can be demonstrated in the following test:

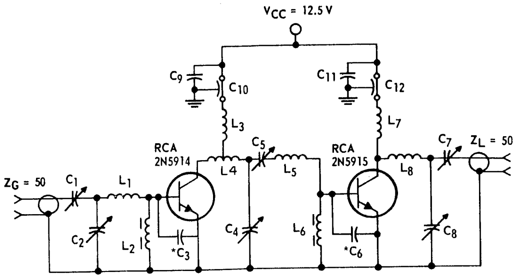
1. The test is performed using the arrangement shown.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions; V_{CC} = 12.5
   RF input power = 0.4 W for 2N5914, 2.0 W for 2N5915
4. Transistor Dissipation Rating must not be exceeded. During the above test, the transistor will not be damaged or degraded.

Fig. 14 - Test set-up for testing load mismatch capability of 2N5914 and 2N5915



L_1 - 1/2 turn # 14 wire, 1/4-in. I.D.
RFC - Z = 450Ω, Ferroxcube VK-200-09/3B, or equivalent
C_1 - 7-100 pF, Arco 423, or equivalent
C_2 - 4-40 pF, Arco 422, or equivalent
C_3 - 0.1 μF ceramic
C_4 - 0.001 μF feedthrough
C_5 - 62 pF silver mica
C_6 - 14-150 pF, Arco 424, or equivalent
C_7 - 24-200 pF, Arco 425, or equivalent
T_1 - Twisted pair of # 20 enameled wire; 14 turns/in. Formed in a loop 3/8 in. diameter, cross connected (End of one winding connected to beginning of other)

Fig. 15 - 175-MHz amplifier for measuring power output and power gain in 2N5914 and 2N5915



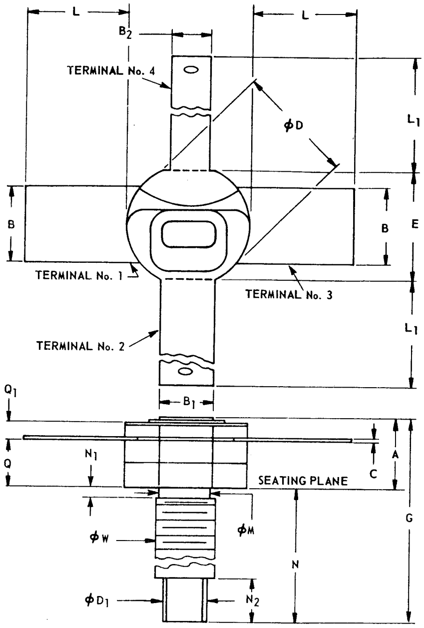
C_1, C_2, C_4, C_5, C_7, C_8	0.9 – 7.0 pF		
C_3, C_6	18 pF	L_4	1 TURN NO. 18 WIRE 1/4 IN. I.D., 1/8 IN. LONG TAP AT 1/4 TURN FROM COLLECTOR
C_9, C_{11}	0.1 μF	L_5	1 TURN NO. 20 WIRE 1/8 IN. I.D., 1/8 IN LONG
C_{10}, C_{12}	.001 μF	L_8	1 TURN NO. 18 WIRE 1/4 IN. I.D. 1/8 IN. LONG
L_1	1 TURN NO. 16 WIRE 3/16 IN. I.D. 1/8 IN LONG		
L_2, L_6	FERRITE CHOKE Z = 450 Ω FERROX CUBE VK-200-09-3B OR EQUIV.		
L_3, L_7	1 TURN NO. 20 WIRE 3/16 IN. I.D. 1/8 LONG		

*CONNECT C_3 AND C_6 BETWEEN THE BASE AND EMITTER

92SM-4499

Fig. 16 - Typical 470 MHz amplifier with 0.4 W input and 6.0 W output

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.150	.230	3.81	5.84	–
B	.195	.205	4.96	5.20	–
B_1	.135	.145	3.43	3.68	–
B_2	.095	.105	2.42	2.66	–
C	.004	.010	.11	.25	3
ϕD	.305	.320	7.48	8.12	–
ϕD_1	.110	.130	2.80	3.30	1
E	.275	.300	6.99	7.62	–
G	.590	.705	14.99	17.90	–
L	.265	.290	6.74	7.36	–
L_1	.455	.510	11.56	12.95	–
ϕM	.120	.163	3.05	4.14	–
N	.425	.470	10.80	11.93	–
N_1	–	.078	–	1.98	4
N_2	.110	.150	2.80	3.81	–
Q	.120	.170	3.05	4.31	–
Q_1	.025	.045	.64	1.14	–
ϕW	.1399	.1437	3.531	3.632	2

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

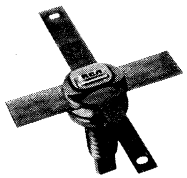
NOTES:
1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

TERMINAL CONNECTIONS

Terminal No. 1, 3 – Emitter
Terminal No. 2 – Base
Terminal Nol 4 – Collector

2N5992



7-W AM, 66-to-88-MHz Emitter-Ballasted Silicon N-P-N Overlay Transistor

For 12.5-V Amplifiers in VHF Communications Equipment

Features

- **7-W min. (carrier) output, 10-dB min. gain at 88 MHz**
- **90% min. modulation**
- **Emitter ballasted**
- **Infinite VSWR tested at rated output power under full modulation at 66 MHz**
- **Hermetically sealed stripline ceramic-metal package**
- **Electrically isolated mounting stud**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
* COLLECTOR-TO-EMITTER BREAKDOWN VOLTAGE:			
With base shorted to emitter	$V_{(BR)CES}$	65	V
With base open	$V_{(BR)CEO}$	30	V
* EMITTER-TO-BASE VOLTAGE. ..	V_{EBO}	3.5	V
* CONTINUOUS COLLECTOR CURRENT	I_C	5	A
* TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		35.7	W
At case temperatures above 75°C ·		See Fig.5	
* TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
* LEAD TEMPERATURE:			
At distances $\geq$ 1/32 in. (0.8 mm) from seating plane for 10 s max.		230	°C

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* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA type 2N5992[a] is an epitaxial silicon n-p-n planar transistor featuring overlay emitter eletrode construction. This device utilizes many separate emitter elements and has individual ballast resistance in each of the emitter sites for stabilization.

The transistor is completely tested for load-mismatch capability at 66 MHz with an infinity-to-one VSWR through all phases under rated power with full modulation.

This device features a hermetic, ceramic-metal package having leads isolated from the mounting stud. These rugged, low-inductance, radial leads are designed for stripline as well as lumped-constant circuits.

---

[a] Formerly RCA Dev. Type TA7920

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Collector Voltage (V)	DC Base Voltage (V)	DC Current (mA)					
		V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
* Collector-to-Emitter Cutoff Current: Base-to-emitter shorted	I_{CES}	60	0				–	10^b	mA
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$				0	200[a]	30	–	V
With base connected to emitter	$V_{(BR)CES}$		0			200[a]	65	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			10		0	3.5	–	V
Thermal Resistance: (Junction-to-Case)	θ_{J-C}						–	3.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

[b] T_C = 25 to 100°C

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS			UNITS
		DC Collector Supply (V_{CC}) V	Output Power (Carrier) P_{OE} W	Frequency (f) - MHz	Min.	Typ.	Max.	
Power Input	P_{IE}	12.5	7	66 88	– –	0.35 0.5	0.5 0.7	W
* Power Gain	G_{PE}	12.5	7	66 88	11.5 10	13 11.5	– –	dB
* Collector Efficiency	η_C	12.5	7	66 88	55 60	60 70	– –	%
Modulation[c]	m	12.5	7	66 88	90 90	97 95	– –	%
Load Mismatch[c] (Fig.10)	LM	12.5	7	66	GO/NO GO			
* Collector-to-Base Capacitance	C_{obo}	12.5 (V_{CB})		1	—	60	70	pF

[c] Input power and collector supply voltage are modulated

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7

PERFORMANCE DATA

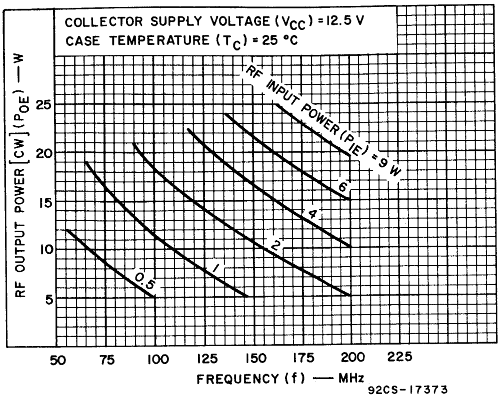


Fig. 1 - RF output power (cw) vs. frequency.

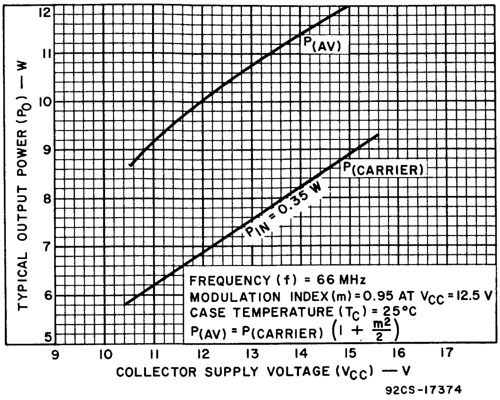


Fig. 2 - Typical output power vs. collector supply voltage.

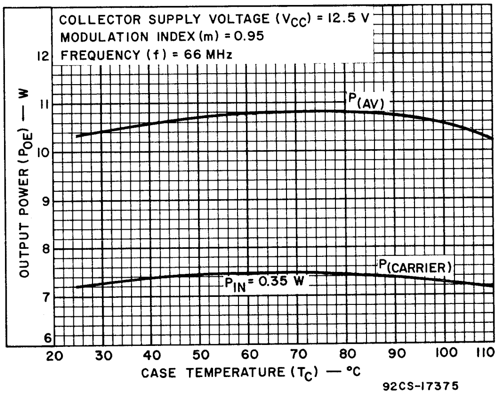


Fig. 3 - Typical output power vs. case temperature.

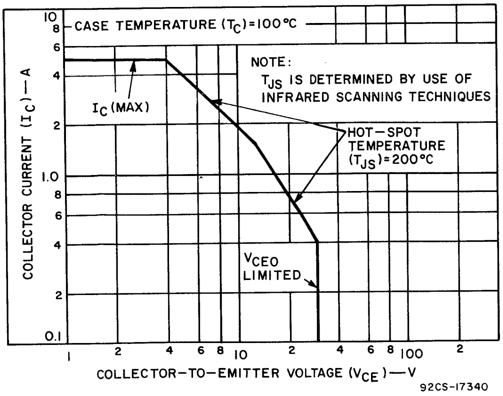


Fig. 4 - Safe area for dc operation.

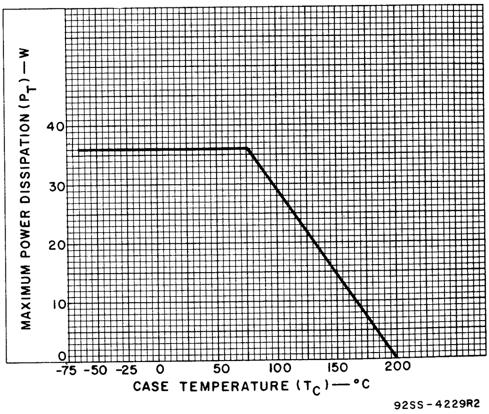


Fig. 5 - RF dissipation derating.

DESIGN DATA

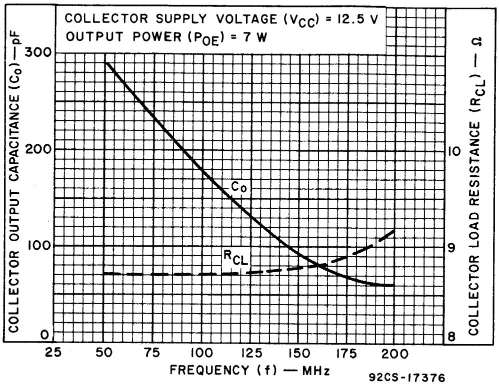


Fig. 6 - Typical large-signal parallel collector load and parallel output capacitance vs. frequency.

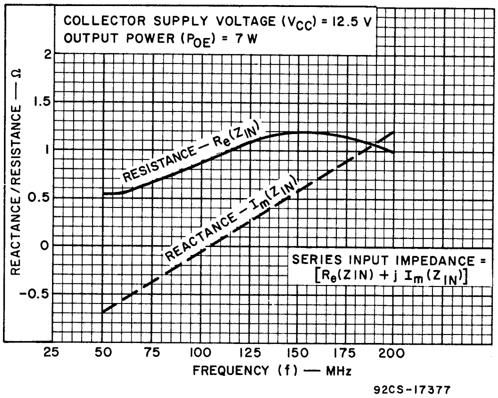


Fig. 7 - Typical large-signal series input impedance vs. frequency.

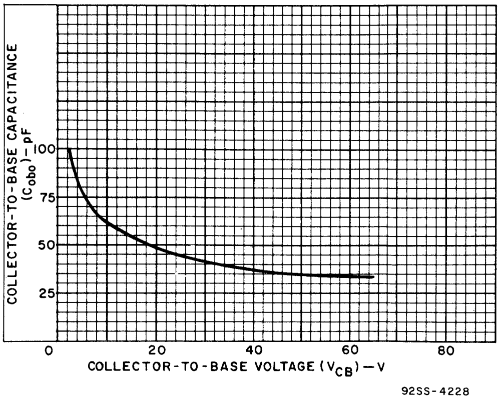
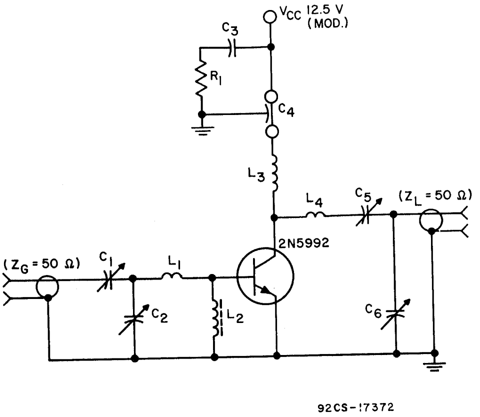


Fig. 8 - Typical collector-to-base capacitance vs. collector-to-base voltage.

APPLICATION DATA



C_1, C_2: 9-180 pF, ARCO 463 or equivalent
C_3: 0.02 μF ceramic
C_4: 0.01 μF feedthrough
C_5, C_6: 5-380 pF, ARCO 465 or equivalent
L_1: 1 turn No. 14 B.T., 1/4-in. I.D., 3/16-in. long
L_2: RFC, Z = 450 Ω, Ferroxcube or equivalent
L_3: 4 turns No. 16 B.T., 1/4-in. I.D., 5/16-in. long
L_4: 2 turns No. 14 B.T., 9/16-in. I.D., 3/8-in. long
R_1: 12Ω, 1/4 watt

Fig. 9 - 66–88-MHz amplifier for measuring output power, power gain, and modulation index.

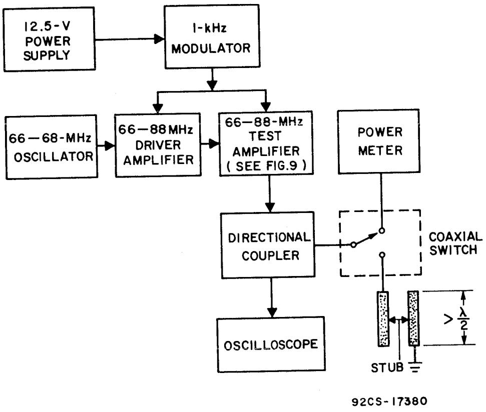


Fig. 10 - Test setup for testing output power, power gain, modulation index, and load-mismatch capability.

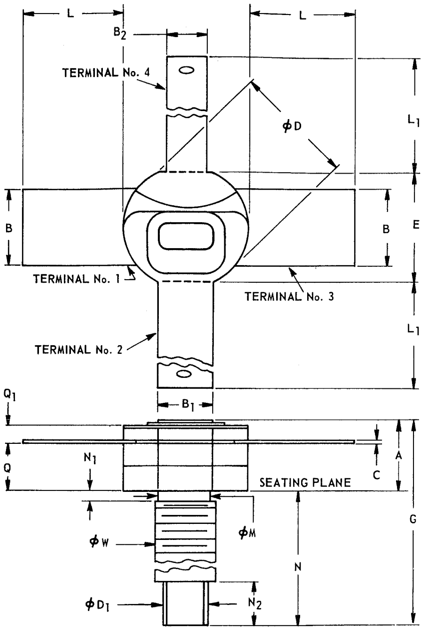
SPECIAL PERFORMANCE DATA

The Infinite load-mismatch capability of the transistor can be demonstrated in the following test:

1. The test setup is shown in Fig. 10.
2. The tuning network is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions are as follows: V_{CC} = 12.5 V, rf output power = 7 W under full modulation at 66 MHz.

Care should be taken not to exceed the maximum junction temperature by providing sufficient heatsinking during the above test to prevent device damage or degradation.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
ϕD	0.305	0.320	7.48	8.12	–
$ϕD_1$	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	–
G	0.590	0.705	14.99	17.90	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0,510	11.56	12.95	–
ϕM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
ϕW	0.1399	0.1437	3.531	3.632	2

Millimeter dimensions are derived from original inch dimensions

NOTES:

1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

TERMINAL CONNECTIONS

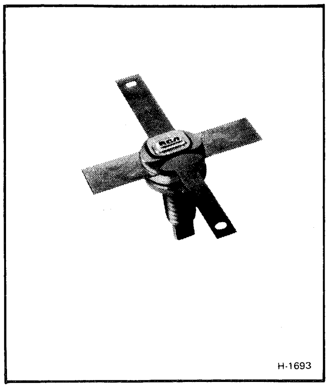
Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

WARNING: RCA Type **2N5992** should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor because the dust resulting from such action may be hazardous if inhaled.

RCA

Solid State
Division

2N5993



18-W, (CW) 88-MHz Emitter-Ballasted Overlay Transistor

Silicon N-P-N Type for 12.5-Volt Applications
in VHF Communications Equipment

Features:

- **Emitter-ballasting resistors**
- **Low-inductance radial leads**
- **Hermetically sealed ceramic-metal package**
- **Electrically isolated mounting stud**
- **18 W min. output, 10 dB min. gain at 88 MHz**
- **Infinite load mismatch tested at 66 MHz**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	36	V
*COLLECTOR-TO-EMITTER VOLTAGE:			
With base connected to emitter	$V_{(BR)CES}$	36	V
With base open	V_{CEO}	18	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*COLLECTOR CURRENT:			
Continuous	I_C	5.0	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		35.7	W
At case temperatures above 75°C		See Fig. 9	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

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*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA type 2N5993[a] is an epitaxial silicon n-p-n planar transistor featuring overlay emitter electrode construction. This device utilizes many separate emitter elements and has individual ballast resistance in each of the emitter sites for stabilization.

The transistor is completely tested for load mismatch capability at 66 MHz with a VSWR of infinity-to-one through all phases under rated power.

This device features a hermetic, ceramic-metal package having leads isolated from the mounting stud. These rugged, low-inductance, radial leads are designed for stripline as well as lumped-constant circuits.

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[a] Formerly RCA Dev. Type TA7921.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
			DC Collector Voltage-V	DC Base Voltage-V	DC Current mA					
			V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
*	Collector-Cutoff Current	I_{CEO}	10			0		–	5.0	mA
*	Collector-to-Base Breakdown Voltage	$V_{(BR)\ CBO}$			0		15	36	–	V
*	Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)\ CEO}$			0		200[a]	18	–	V
	With base connected to emitter	$V_{(BR)\ CES}$		0			200[a]	36	–	
*	Emitter-to-Base Breakdown Voltage	$V_{(BR)\ EBO}$			10			3.5	–	V
	Thermal Resistance Junction-to-Case	$\theta_{J\text{-}C}$						–	3.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

DYNAMIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS			UNITS
			DC Collector Supply (V_{CC}) -Volts	Input Power (P_{IE}) -Watts	Frequency (f) -MHz	MIN.	TYP.	MAX.	
*	Power Output	P_{OE}	12.5	1.0	66	18	20	–	W
				1.75	88	18	20	–	
*	Power Gain	G_{PE}	12.5	1.0	66	12.5	13	–	dB
				1.75	88	10.1	10.6	–	
*	Collector Efficiency	η_C	12.5	1.0	66	65	80	–	%
				1.75	88	65	80	–	
	Load Mismatch (Fig. 11)	LM	12.5	1.0	66	GO/NO GO			
*	Collector-to-Base Capacitance	C_{obo}	12 I_C = 0	–	1	–	–	100	pF

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7

PERFORMANCE DATA

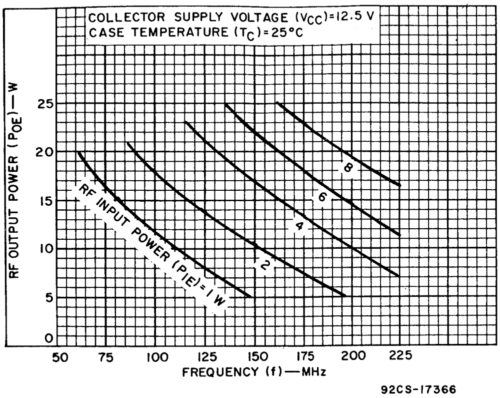


Fig. 1 – RF output power vs. frequency

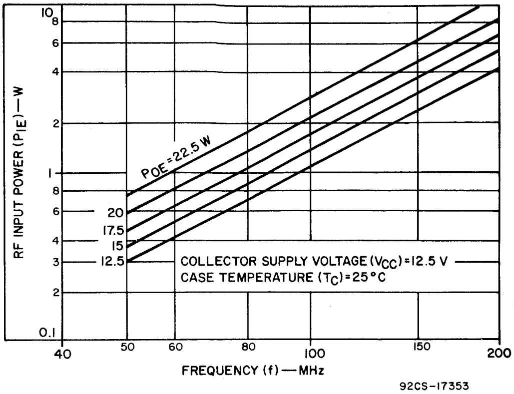


Fig. 2 – RF input power vs. frequency

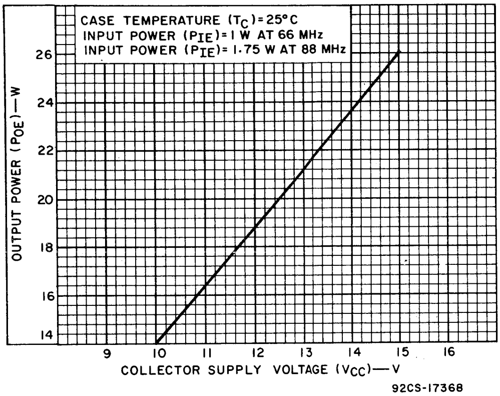


Fig. 3 – Typical output power vs. collector supply voltage (amplifier tuned at V_{CC} = 12.5 V)

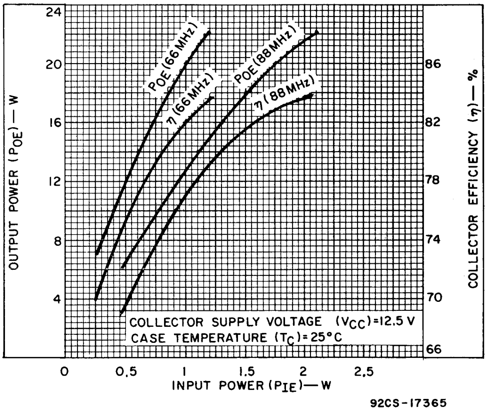


Fig. 4 – Typical output power and collector efficiency vs. input power at 66 and 88 MHz

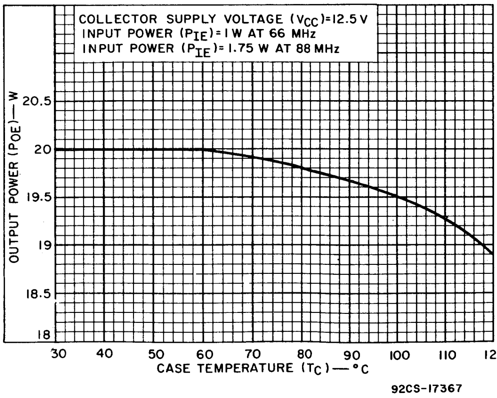


Fig. 5 – Typical output power vs. case temperature

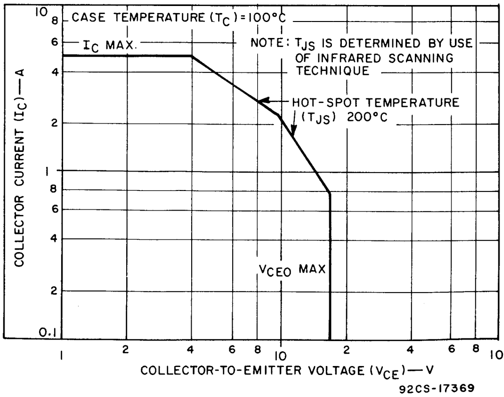


Fig. 6 – Safe area for dc operation

DESIGN DATA

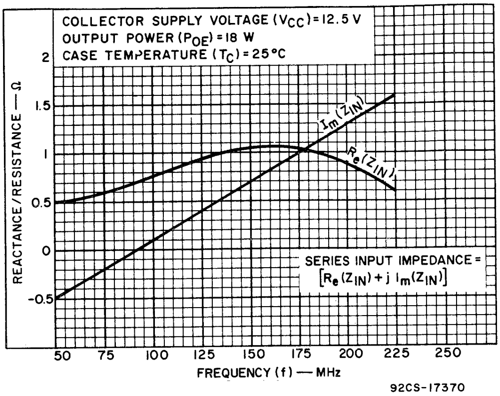


Fig. 7 — Typical large-signal series input impedance vs. frequency

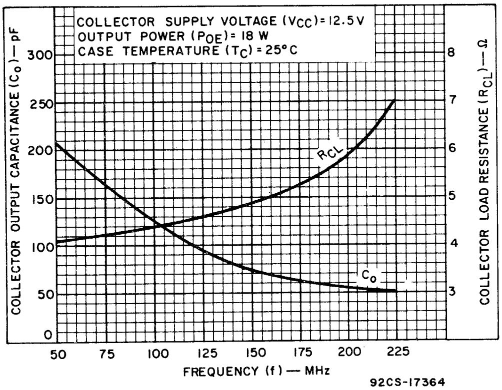


Fig. 8 — Typical large-signal parallel collector load and parallel output capacitance vs. frequency

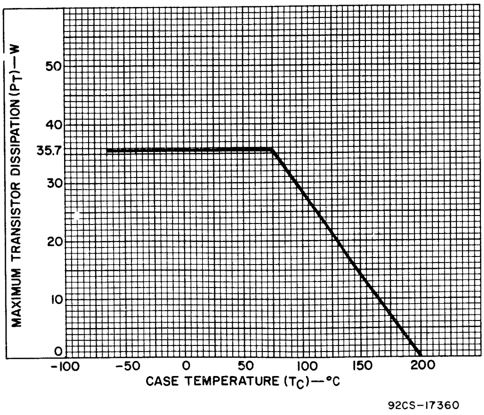
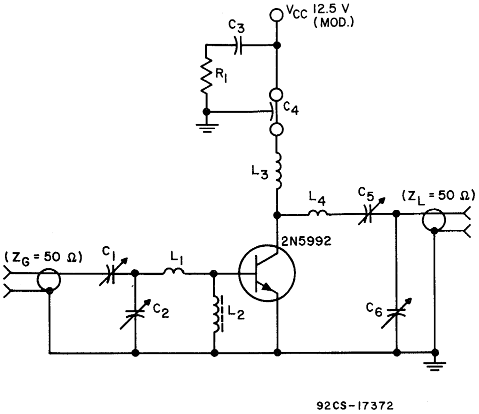


Fig. 9 — RF dissipation derating.

APPLICATION DATA



C_1, C_2: 9–180 pF, ARCO 463 or equivalent
C_3: 0.02 μF ceramic
C_4: 0.01 μF feedthrough
C_5, C_6: 5–380 pF, ARCO 465 or equivalent
L_1: 1 turn No. 14 B.T., 1/4-in. I.D., 3/16-in. long
L_2: RFC, Z = 450 Ω, Ferroxcube or equivalent
L_3: 4 turns No. 16 B.T., 1/4-in. I.D., 5/16-in. long
L_4: 2 turns No. 14 B.T., 9/16-in. I.D., 3/8-in. long
R_1: 12 Ω, 1/4 watt

Fig. 10 – 66-88-MHz amplifier for measuring output power, power gain, and modulation index

SPECIAL PERFORMANCE DATA

The infinite load-mismatch capability of the transistor can be demonstrated in the following test:

1. The test setup is shown in Fig. 11.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions are as follows: V_{CC} = 12.5 V RF input power = 1 W at 66 MHz

Care should be taken not to exceed the maximum junction temperature by providing sufficient heatsinking during the above test to prevent device damage or degradation.

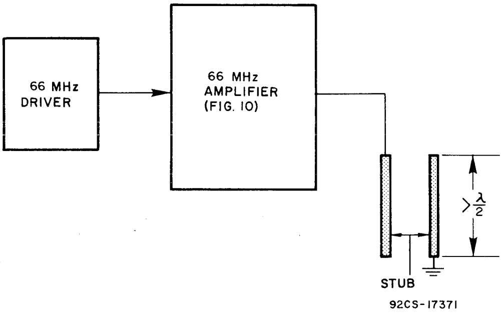
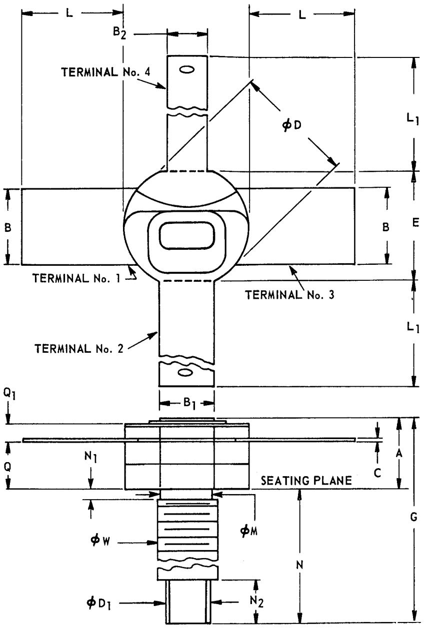


Fig. 11 – Test setup for testing load-mismatch capability

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
φD	0.305	0.320	7.48	8.12	–
$φD_1$	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	–
G	0.590	0.705	14.99	17.90	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0.510	11.56	12.95	–
φM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
φW	0.1399	0.1437	3.531	3.632	2

Millimeter dimensions are derived from original inch dimensions

NOTES:

1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF φ W

92SS-3763R3

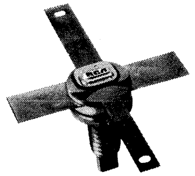
TERMINAL CONNECTIONS

Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

WARNING: RCA Type **2N5993** should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor because the dust resulting from such action may be hazardous if inhaled.

Solid State
Division

2N5995



7-W, (CW) 175-MHz Silicon N-P-N Overlay Transistor

For 12.5-Volt Applications in VHF Communications Equipment

Features:

- **Low-inductance radial leads**
- **Hermetically sealed ceramic-metal package**
- **Electrically isolated mounting stud**
- **7 watt (min.) output at 175 MHz**
- **9.7 dB (min.) gain at 175 MHz**
- **Infinite load mismatch tested at 175 MHz**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	36	V
*COLLECTOR-TO-EMITTER BREAKDOWN VOLTAGE:			
With base connected to emitter	$V_{(BR)CES}$	36	V
With base open	$V_{(BR)CEO}$	14	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*COLLECTOR CURRENT:			
Continuous	I_C	1.5	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		10.7	W
At case temperatures above 75°C		See Fig. 9	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

RCA type 2N5995[a] is an epitaxial silicon n-p-n planar transistor featuring overlay emitter-electrode construction. This type features a hermetic ceramic-metal package having leads isolated from the mounting stud. This rugged, low-inductance, radial-lead type is designed for stripline as well as lumped-constant circuits.

This transistor is completely tested for load-mismatch capability at 175 MHz with an infinity-to-one VSWR through all phases under rated power.

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*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

[a] Formerly RCA Dev. Type TA7922

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Collector Voltage-V	DC Base Voltage-V	DC Current mA					
		V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
* Collector-Cutoff Current With base open	I_{CEO}	10			0		–	2.5	mA
With base connected to emitter	I_{CES}	12.5	0				–	5[b]	
* Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		5	36	–	V
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$			0		75[a]	14	–	V
With base connected to emitter	$V_{(BR)CES}$		0			75[a]	36	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			2		0	3.5	–	V
Thermal Resistance (Junction-to-Case)	$\theta_{J\text{-}C}$						–	11.7	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%

[b] T_C = 100°C

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS		UNITS
		DC Collector Supply (V_{CC}) -Volts	Input Power (P_{IE}) -Watts	Frequency (f) -MHz	MIN.	MAX.	
* Power Output	P_{OE}	12.5	0.75	175	7	–	W
* Power Gain	G_{PE}	12.5	0.75	175	9.7	–	dB
* Collector Efficiency	η_C	12.5	0.75	175	65	–	%
Load Mismatch (Fig. 11)	LM	12.5	0.75	175	GO/NO GO		
* Collector-to-Base Capacitance	C_{ob}	12	–	1	–	80	pF

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7

PERFORMANCE DATA

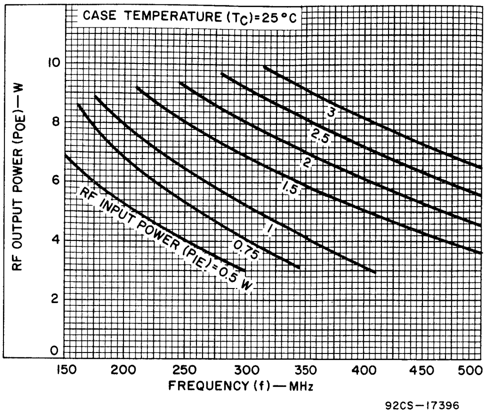


Fig. 1 – Typical rf output power vs. frequency.

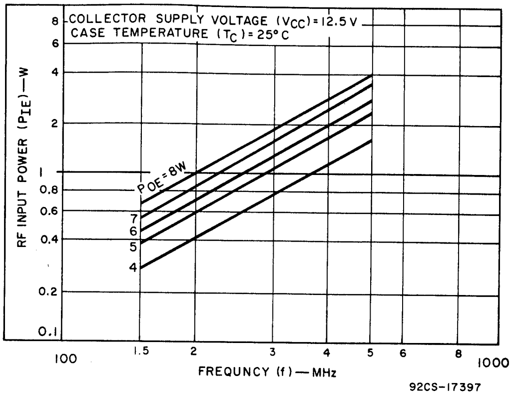


Fig. 2 – Typical rf input power vs. frequency.

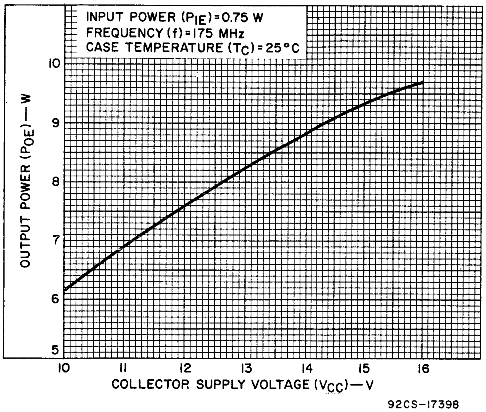


Fig. 3 – Typical output power vs. supply voltage (amplifier tuned at V_{CC} = 12.5 V).

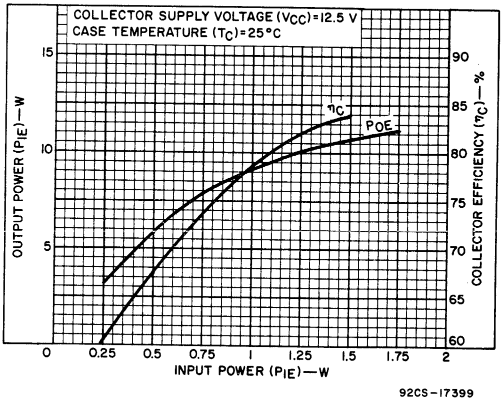


Fig. 4 – Typical output power and collector efficiency vs. input power at 175 MHz.

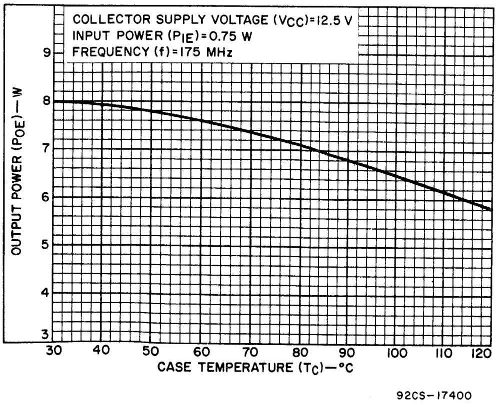


Fig. 5 – Typical output power vs. case temperature.

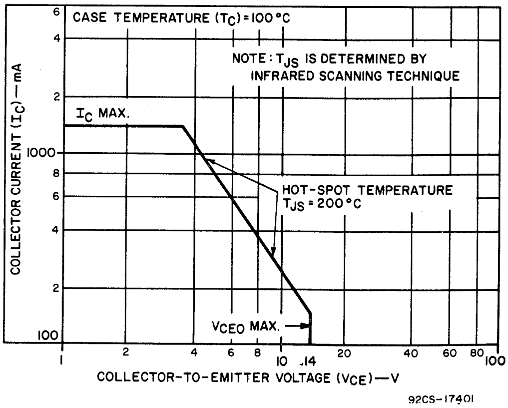


Fig. 6 – Safe area for dc operation.

DESIGN DATA

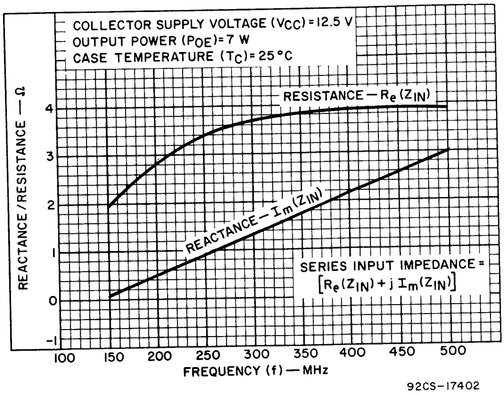


Fig. 7 – Typical large-signal series input impedance vs. frequency.

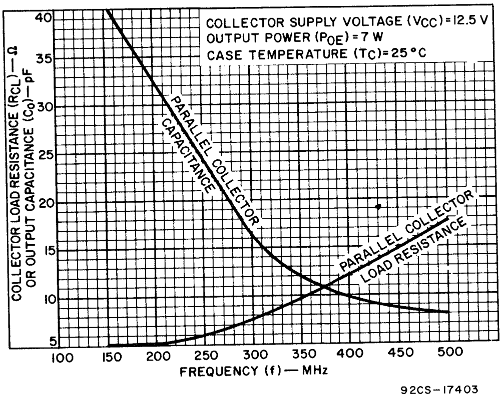


Fig. 8 – Typical large-signal parallel collector load resistance and parallel output capacitance vs. frequency.

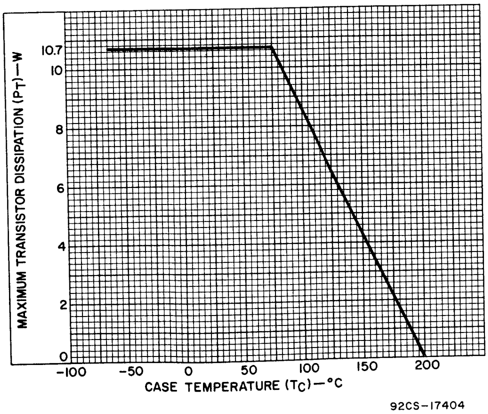
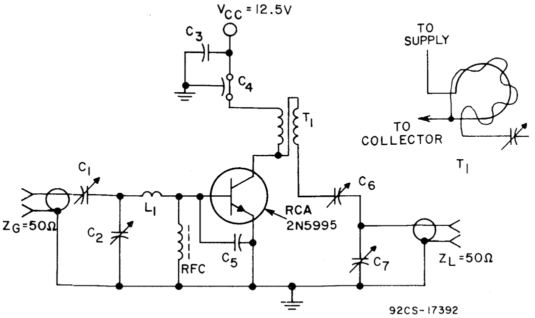


Fig. 9 – RF dissipation derating.

APPLICATION DATA



L_1 - 1/2 turn No. 14 wire, 1/4-in. I.D.
RFC - Z = 450 Ω, Ferroxcube VK-200-09/3B or equivalent
C_1 - 7-100pF, Arco 423 or equivalent
C_2 - 4-40 pF, Arco 422 or equivalent
C_3 - 0.1 μF ceramic
C_4 - 0.001 μF feedthrough
C_5 - 62 pF silver mica
C_6 - 14-150pF, Arco 424 or equivalent
C_7 -24-200 pF, Arco 425 or equivalent
T_1 - Twisted pair of No. 20 enameled wire; 14 turns/in.
Formed in a loop 3/8 in. diameter, cross connected
(End of one winding connected to beginning of other)

Fig. 10 – 175-MHz amplifier for measuring power output and power gain.

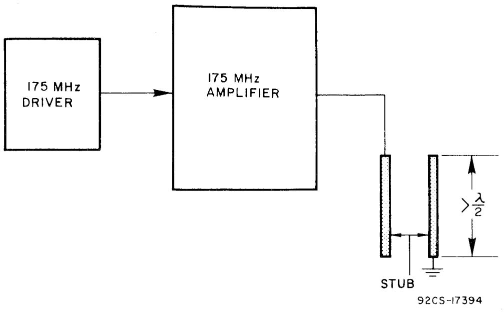


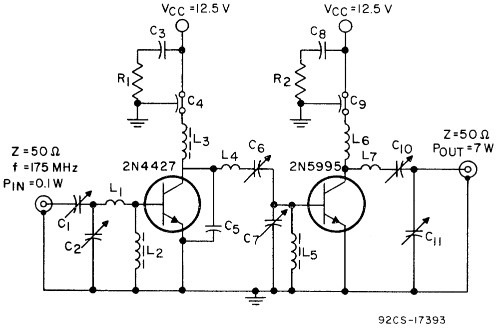
Fig. 11 – Test setup for testing load mismatch capability.

SPECIAL PERFORMANCE DATA

The infinite VSWR load-mismatch capability of the transistor can be demonstrated in the following test:

1. The test setup is shown in Fig. 11.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions are as follows: V_{CC} = 12.5 V, RF input power = 0.75 W.

Care should be taken not to exceed the maximum junction temperature by providing sufficient heatsinking during the above test to prevent device damage or degradation.

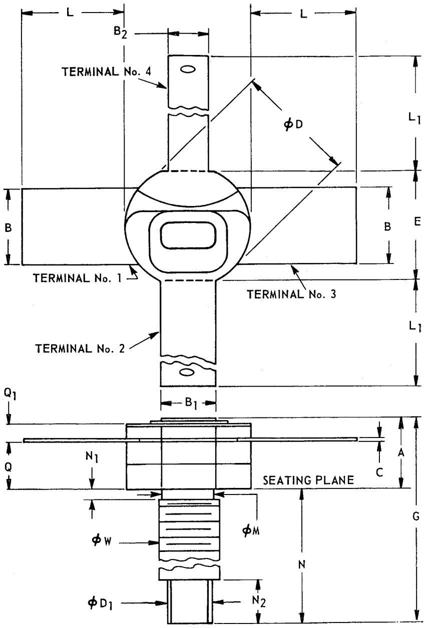


C_1, C_2, C_6: 8-60 pF, ARCO 404 or equivalent
C_3, C_8: 0.02 μF disc ceramic
C_4, C_9: 0.001 μF feedthrough
C_5: 15 pF silver mica
C_7: 14-150 pF, ARCO 424 or equivalent
C_{10}, C_{11}: 24-200 pF, ARCO 425 or equivalent

L_1: 2 Turns No. 18 wire, 1/4-in. I.D., 1/16-in. long
L_2, L_5: RFC, Z = 450 Ω, Ferroxcube No. VK-200-09/3B or equivalent
L_3: 1 μH, Nytronics Deci-Ductor or equivalent
L_4: 2 Turns No. 18 wire, 1/4-in. I.D., 3/16-in. long
L_6: 3 Turns No. 16 wire, 1/4-in. I.D., 3/8-in. long
L_7: 1 Turn No. 16 wire, 1/4-in. I.D., 3/16-in. long
R_1, R_2: 12 Ω, 1/2 W

Fig. 12 – 175-MHz two-stage amplifier using 2N5995

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
ΦD	0.305	0.320	7.48	8.12	–
ϕD_1	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	–
G	0.590	0.705	14.99	17.90	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0.510	11.56	12.95	–
ΦM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
ΦW	0.1399	0.1437	3.531	3.632	2

Millimeter dimensions are derived from original inch dimensions

NOTES:

1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF Φ W

92SS-3763R3

TERMINAL CONNECTIONS

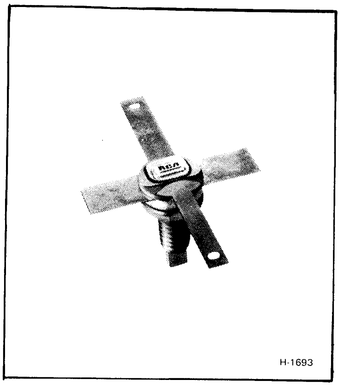
Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

WARNING: RCA Type **2N5995** should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor **because the dust** resulting from such action may be hazardous if inhaled.

RCA
Solid State
Division

RF Power Transistors

2N5996



15-W, (CW) 175-MHz Emitter-Ballasted Overlay Transistor

Silicon N-P-N Device for 12.5-Volt Applications in VHF Communications Equipment

Features:

- **Emitter-ballasting resistors**
- **Low-inductance radial leads**
- **Hermetically sealed ceramic-metal package**
- **Electrically isolated mounting stud**
- **15-watt min. output at 175 MHz**
- **Infinite load mismatch tested at 175 MHz**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	36	V
*COLLECTOR-TO-EMITTER BREAKDOWN VOLTAGE:			
With base connected to emitter	$V_{(BR)CES}$	36	V
With base open	$V_{(BR)CEO}$	18	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*COLLECTOR CURRENT:			
Continuous	I_C	5.0	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		35.7	W
At case temperatures above 75°C		See Fig. 9	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

---

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA type 2N5996[a] is an epitaxial silicon n-p-n planar transistor featuring overlay emitter electrode construction. This device utilizes many separate emitter elements and has individual ballast resistance in each of the emitter sites for stabilization.

The transistor is completely tested for load mismatch capability at 175 MHz with an infinity-to-one VSWR through all phases under rated power.

This device features a hermetic, ceramic-metal package with leads isolated from the mounting stud. These rugged, low-inductance, radial leads are designed for stripline as well as lumped-constant circuits.

---

[a] Formerly RCA Dev. Type TA7923

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

		TEST CONDITIONS							
CHARACTERISTIC	SYMBOL	DC Collector Voltage-V	DC Base Voltage-V	DC Current mA			LIMITS		UNITS
		V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
* Collector-Cutoff Current Base-to-Emitter Shorted (T_C = 100°C)	I_{CES}	12.5	0				–	10	mA
With base open	I_{CEO}	10			0		–	5	
* Collector-to-Base Breakdown Voltage	$V_{(BR)\ CBO}$			0		15	36	–	V
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)\ CEO}$			0		200[a]	18	–	V
With base connected to emitter	$V_{(BR)\ CES}$		0			200[a]	36	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)\ EBO}$			10		0	3.5	–	V
Thermal Resistance Junction-to-Case	$\theta_{J\text{-}C}$						–	3.5	°C/W

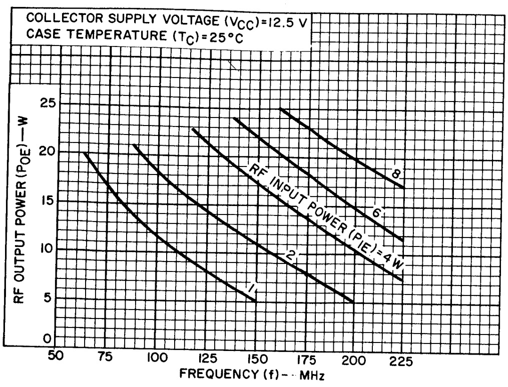
[a] Pulsed through a 25-mH inductor; duty factor = 50%

DYNAMIC

		TEST CONDITIONS			LIMITS		
CHARACTERISTIC	SYMBOL	DC Collector Supply (V_{CC}) -Volts	Input Power (P_{IE}) -Watts	Frequency (f) -MHz	MIN.	MAX.	UNITS
* Power Output	P_{OE}	12.5	5.3	175	15	–	W
* Power Gain	G_{PE}	12.5	5.3	175	4.5	–	dB
* Collector Efficiency	η_C	12.5	5.3	175	75	–	%
Load Mismatch (Fig. 11)	LM	12.5	5.3	175	GO/NO GO		
* Collector-to-Base Capacitance	C_{obo}	12		1	–	100	pF

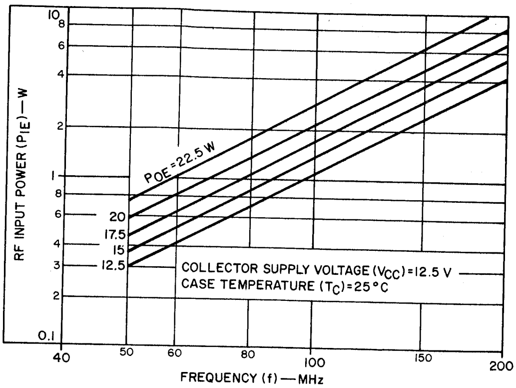
*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7

PERFORMANCE DATA



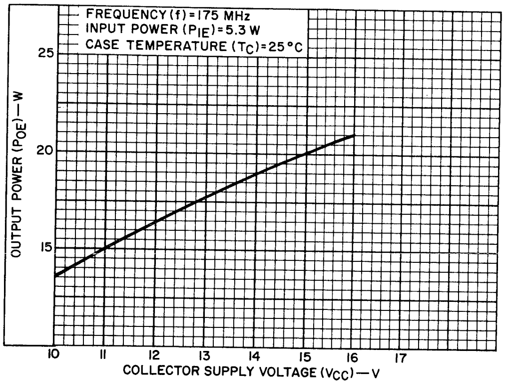
92CS-17352

Fig. 1 — Typical rf output power vs. frequency.



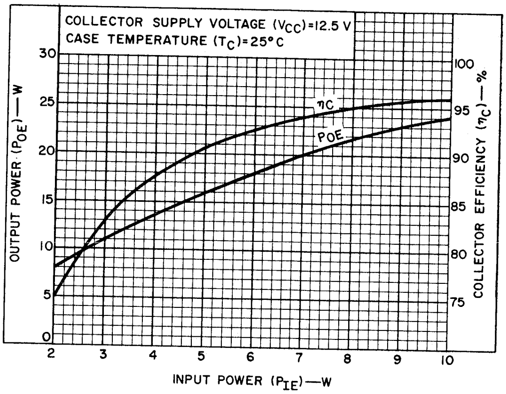
92CS-17353

Fig. 2 — Typical rf input power vs. frequency.



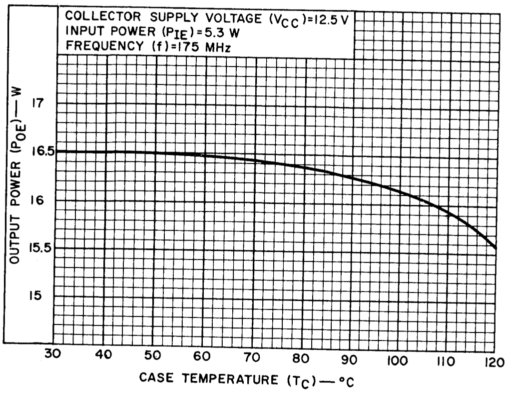
92CS-17354

Fig. 3 — Typical output power vs. supply voltage collector (amplifier tuned at V_{CC} = 12.5 V).



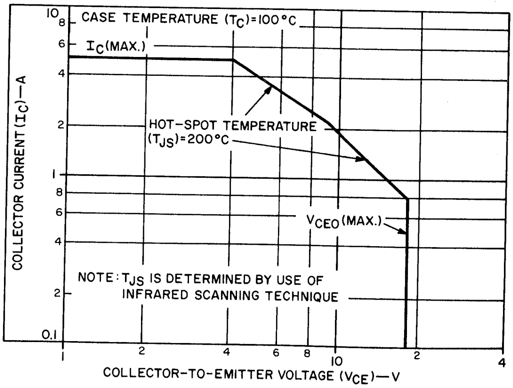
92CS-17355

Fig. 4 — Typical output power and collector efficiency vs. input power at 175 MHz.



92CS-17356

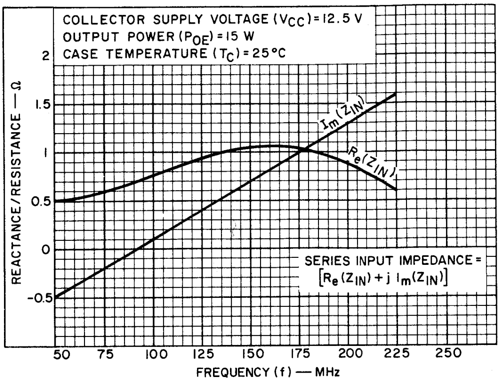
Fig. 5 — Typical output power vs. case temperature.



92CS-17357

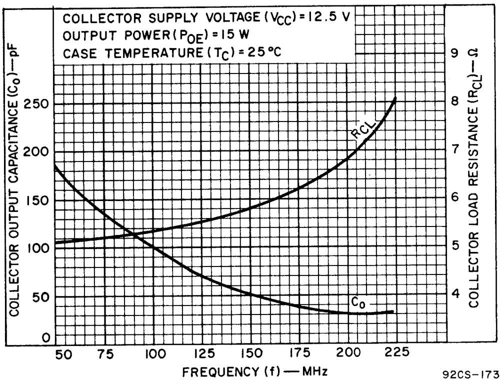
Fig. 6 — Safe area for dc operation.

DESIGN DATA



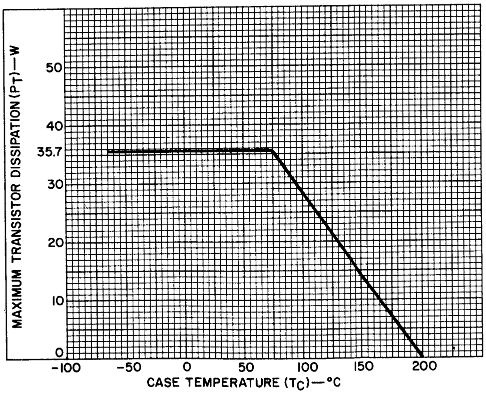
92CS-17358

Fig. 7 — Typical large-signal series input impedance vs. frequency.



92CS-17359

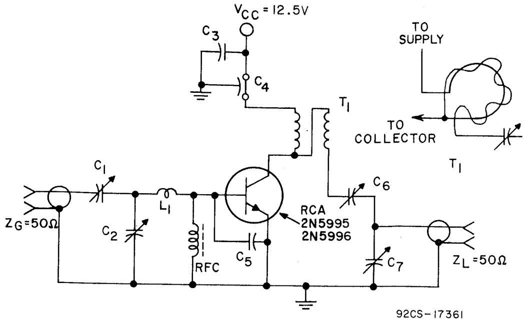
Fig. 8 — Typical large-signal parallel collector load and parallel output capacitance vs. frequency.



92CS-17360

Fig. 9 — RF dissipation derating.

APPLICATION DATA



L_1 - ½ turn No. 14 wire, ¼-in. I.D.
RFC - Z = 450 Ω, Ferroxcube VK-200-09/3B or equivalent
C_1 - 7-100pF, Arco 423 or equivalent
C_2 - 4-40 pF, Arco 422 or equivalent
C_3 - 0.1 μF ceramic
C_4 - 0.001 μF feedthrough
C_5 - 62 pF silver mica
C_6 - 14-150pF, Arco 424 or equivalent
C_7 - 24-200pF, Arco 425 or equivalent
T_1 - Twisted pair of No. 20 enameled wire; 14 turns/in.
Formed in a loop 3/8 in. diameter, cross connected
(End of one winding connected to beginning of other)

Fig. 10 – 175-MHz amplifier for measuring power output and power gain.

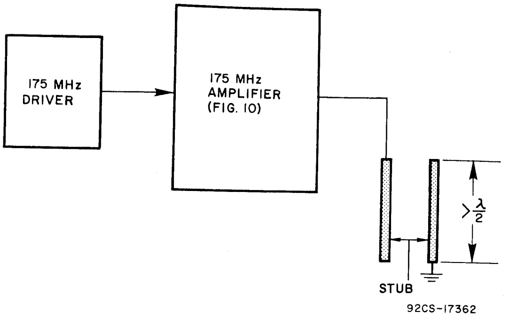


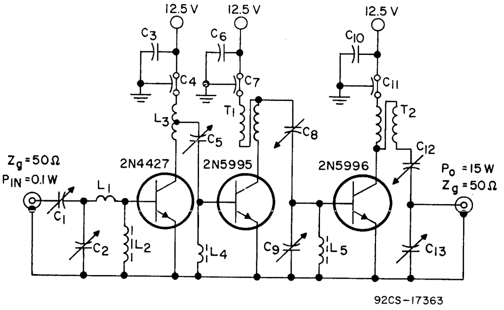
Fig. 11 – Test setup for testing load mismatch capability.

SPECIAL PERFORMANCE DATA

The infinite VSWR load-mismatch capability of the transistor can be demonstrated in the following test:

1. The test setup is shown in Fig. 11.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions are as follows: V_{CC} = 12.5 V, RF input power = 5.3 W.

Care should be taken not to exceed the maximum junction temperature by providing sufficient heatsinking during the above test to prevent device damage or degradation.



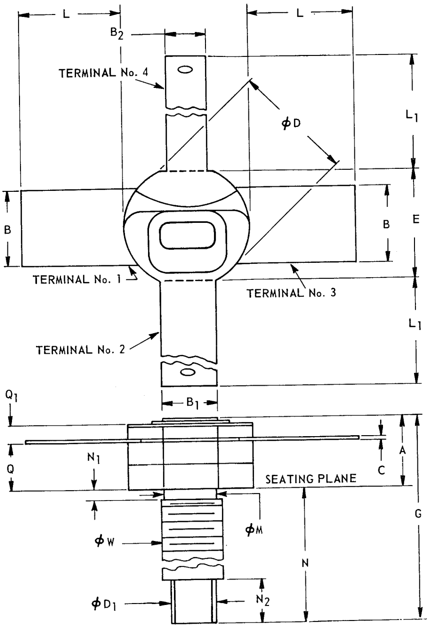
C_1, C_2, C_5: 8-60 pF, ARCO 404 or equivalent
C_3, C_6, C_{10}: 0.05 μF ceramic
C_4, C_7, C_{11}: 0.001 μF feedthrough
C_8, C_9: 7-100 pF, ARCO 423 or equivalent
C_{12}, C_{13}: 14-150 pF, ARCO 424 or equivalent

L_1: 3 turns No. 20 enam. wire, 1/8-in. I.D., 1/4-in. long
L_2: 1 turn No. 20 enam. wire on Ferroxcube bead No. 56-590-65-4A or equivalent
L_3: 5 turns No. 20 B.T., 1/4-in. I.D., 3/8-in. long, tapped 4-1/2 turns from collector
L_4: 3/8-in. loop No. 20 Ferroxcube bead No. 56-590-65-4A or equivalent
L_5: Ferroxcube No. VK-200-09-3B, Z = 450 Ω or equivalent

T_1, T_2: No. 20 enam. wire twisted pair, 14 turns/in., formed into 3/8-in. dia. loop, cross connected

Fig. 12 – Typical 175-MHz amplifier using 2N5996.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
ϕD	0.305	0.320	7.48	8.12	–
ϕD_1	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	–
G	0.590	0.705	14.99	17.90	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0,510	11.56	12.95	–
ϕM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
ϕW	0.1399	0.1437	3.531	3.632	2

Millimeter dimensions are derived from original inch dimensions

NOTES:

1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

TERMINAL CONNECTIONS

Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

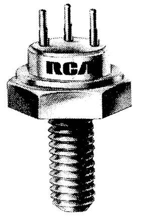
WARNING: RCA Type **2N5996** should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor **because the dust** resulting from such action may be hazardous if inhaled.

RCA

Solid State
Division

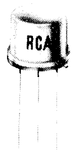
RF Power Transistors

40280
40281
40282



40281, 40282
JEDEC TO-60

H-1307



40280
JEDEC TO-39

H-1381

1,4,&12-W, 175-MHz Overlay Transistors

Silicon N-P-N Devices for High-Power VHF Amplifier Service

Features

- **Suitable for low-voltage supplies (13.5 V)**
- **High output power at 175 MHz, unneutralized class C amplifier**
- **High efficiency at 175 MHz**
- **Low input impedance**

RCA-40280, 40281, and 40282 are epitaxial silicon n-p-n planar transistors of the "overlay" emitter electrode construction. They are intended especially for high-power output, vhf class-C-amplifier service in low-voltage-supply applications.

In the overlay structure, a number of individual emitter sites are connected in parallel and used in conjuction with a single base and collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, and frequency capability.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

		40280	40281	40282	
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	36	36	36	V
COLLECTOR-TO-EMITTER VOLTAGE:					
With base open	V_{CEO}	18	18	18	V
With V_{BE} = −1.5V	V_{CEV}	36	36	36	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	4	4	V
COLLECTOR CURRENT	I_C	0.5	1	2	A
TRANSISTOR DISSIPATION	P_T				
At case temperatures up to 25°C		7.0	11.6	23.2	W
At case temperatures above 25°C		Derate linearly to 0 watts at 200°C			
TEMPERATURE RANGE:					
Storage & Operating (Junction)		−65 to 200			°C
LEAD TEMPERATURE (During soldering):					
At distances ≥1/32 in. (0.8 mm) from insulating wafer (TO-60) package or from seating plane (TO-39 package) for 10 s max.		230			°C

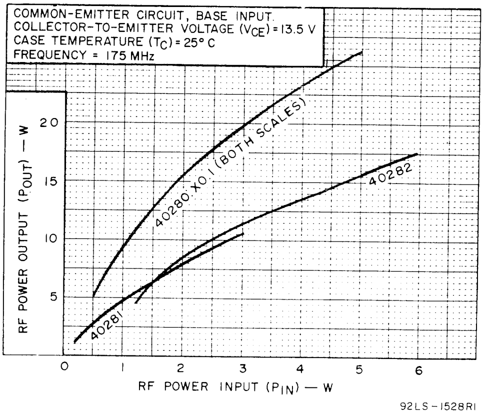


Fig. 1—Typical rf power output vs. rf power input at 175 MHz.

ELECTRICAL CHARACTERISTICS, *At Case Temperature (T_C) = 25°C*

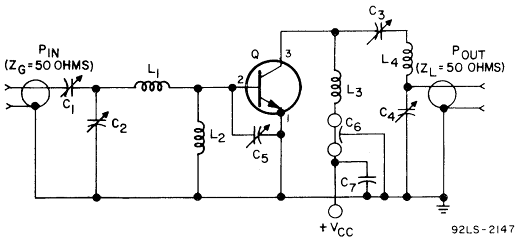
CHARACTERISTICS	SYMBOL	TEST CONDITIONS DC Collector Volts V_{CB}	TEST CONDITIONS DC Collector Volts V_{CE}	DC Base Volts V_{BE}	DC Current (Milliamperes) I_E	DC Current (Milliamperes) I_B	DC Current (Milliamperes) I_C	LIMITS Type 40280 Min.	Type 40280 Max.	Type 40281 Min.	Type 40281 Max.	Type 40282 Min.	Type 40282 Max.	UNITS
Collector Cutoff Current	I_{CEO}		15			0		–	100	–	100	–	250	µA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$				0 0		0.25 0.50	36 –	– –	36 –	– –	– 36	– –	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$				0.10 0.25		0 0	4 –	– –	4 –	– –	– 4	– –	V
Collector-to-Emitter Breakdown Voltage	$V_{(BR)CEV}$			-1.5			200[a]	36	–	36	–	36	–	V
Collector-to-Emitter Sustaining Voltage	$V_{CEO}(sus)$					0	200[a]	18	–	18	–	18	–	V
Real Part of Common-Emitter High-Frequency Input Impedance (f = 175 MHz)	h_{ie}(real)		13.5 13.5 13.5				100 400 800	10 (typ.) – –	 – –	– 7 (typ.) –	– –	– – 5 (typ.)	– – 	Ω
RF Power Output: As class C amplifier unneutralized (f = 175 MHz) See *Figs. 2 & 3*	P_{OUT}		13.5					1[b]	–	4[c]	–	12[d]	–	W
Gain-Bandwidth Product	f_T		13.5 13.5 13.5				100 400 800	550 (typ.) – –	 – –	– 400(typ.) –	– –	– – 350 (typ.)	– – 	MHz
Collector-to-Base Capacitance (f = 1 MHz)	C_{ob}	13.5			0			–	15	–	22	–	45	pF
Collector-to-Case Capacitance	C_s							–	–	–	5	–	5	pF
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$							–	25	–	15	–	7.5	°C/W

[a] Pulsed through an inductor (25 mH); duty factor = 50%.

[b] For P_{IN} = 0.125 w; minimum efficiency = 60%.

[c] For P_{IN} = 1.0W; minimum efficiency = 70%.

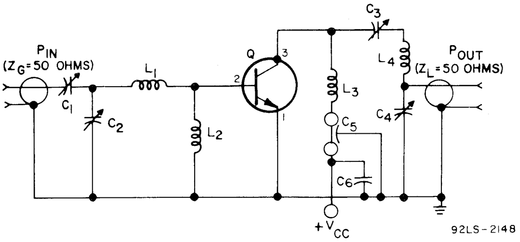
[d] For P_{IN} = 4.0W; minimum efficiency = 80%.



C_1, C_2,
C_3, & C_4: 7-100 pF
C_5: 8-60 pF
C_6: 1,000 pF
C_7: 0.01 µF
L_1: 3 turns No.16 wire,
3/16 in. (4.76 mm) ID,
5/16 in. (7.93 mm) long
L_2: Ferrite Choke,
Z = 450 ohms

L_3: 1 turn No.16 wire
1/4 in. (6.35 mm) ID,
3/8 in. (9.52 mm) long
L_4: 2 turns No.16 wire,
1/4 in. (6.35 mm) ID,
1/4 in. (6.35 mm) long
Q: 40281, 40282

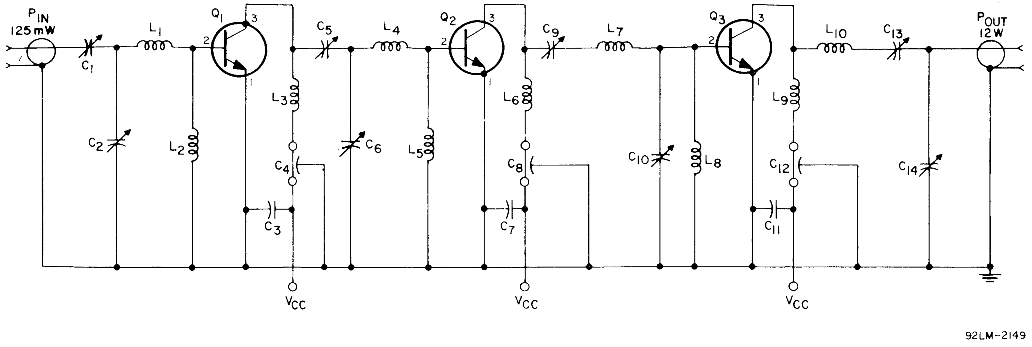
Fig.2—RF amplifier circuit for power-output test at 175 MHz for types 40281 and 40282.



C_1, C_2,
C_3, & C_4: 3-30 pF
C_5: 1,000 pF
C_6: 0.01 µF
L_1: 2 turns No.16 wire,
3/16 in. (4.76 mm) ID,
1/4 in. (6.35 mm) long
L_2: Ferrite choke,
Z = 450 ohms

L_3: 2 turns No.16 wire,
1/4 in. (6.35 mm) ID,
1/4 in. (6.35 mm) long
L_4: 4 turns No.16 wire,
3/8 in. (9.52 mm) ID,
3/8 in. (9.52 mm) long
Q: 40280

Fig.3—RF amplifier circuit for power-output test at 175 MHz for type 40280.



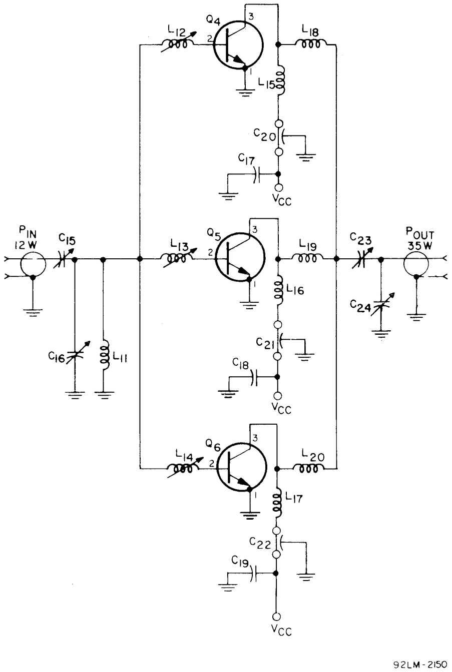
Capacitors

C$_1$: 3-35 pF
C$_2$, C$_6$, C$_{10}$, C$_{24}$: 8-60 pF
C$_3$, C$_7$, C$_{11}$: 0.01 µF
C$_4$, C$_8$, C$_{12}$: 1500 pF
C$_9$, C$_{10}$, C$_{13}$, C$_{14}$, C$_{23}$: 7-100 pF
C$_{15}$: 1.5-20 pF
C$_{17}$, C$_{18}$, C$_{19}$: 0.2 pF
C$_{20}$, C$_{21}$, C$_{22}$: 1500 pF

Transistors

Q$_1$: 40280
Q$_2$: 40281
Q$_3$–Q$_6$: 40282

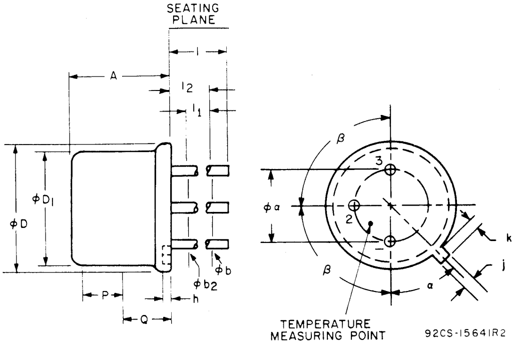
Inductors	Turns	Wire Size	ID (in.)	(mm)	Length (in.)	(mm)
L$_1$	2	16	3/16	4.76	1/4	6.35
L$_2$, L$_5$, L$_8$: ferrite choke, Z = 450 Ω						
L$_3$, L$_6$, L$_{11}$: 1 µH choke						
L$_4$, L$_7$	3	16	3/16	4.76	1/4	6.35
L$_9$	1-1/2	16	1/4	6.35	3/8	9.52
L$_{10}$	2	16	1/4	6.35	5/16	7.93
L$_{12}$, L$_{13}$, L$_{14}$ (adjustable core)	3-1/2	16	1/4	6.35	3/8	9.52
L$_{15}$, L$_{16}$, L$_{17}$	2	18	1/8	3.17	1/8	3.17
L$_{18}$, L$_{19}$, L$_{20}$	2	18	1/4	6.35	1/4	6.35



Note: Driver and final supply voltages, V$_{CC}$ = 13.5 V.

Fig.4—Typical 175-MHz amplifier.

DIMENSIONAL OUTLINE FOR TYPE 40280 JEDEC TO-39



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
φa	0.190	0.210	4.83	5.33	
A	0.240	0.260	6.10	6.60	
φb	0.016	0.021	0.406	0.533	2
φb2	0.016	0.019	0.406	0.483	2
φD	0.350	0.370	8.89	9.40	
φD1	0.315	0.335	8.00	8.51	
h	0.009	0.125	0.229	3.18	
j	0.028	0.034	0.711	0.864	
k	0.029	0.040	0.737	1.02	3
l	0.500		12.70	-	2
l1		0.050		1.27	2
l2	0.250		6.35		2
P	0.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010 in (0.254 mm)

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and 0.5 in (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond in (12.70 mm) from seating plane.

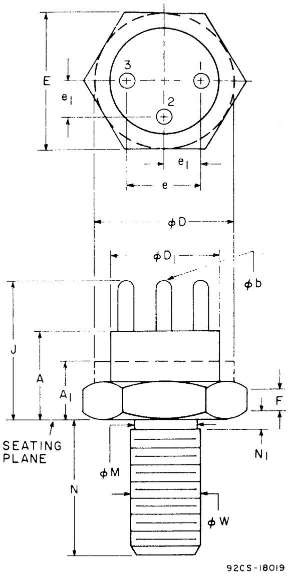
Note 3: Measured from maximum diameter of the actual device.

Note 4: Details of outline in this zone optional.

TERMINAL CONNECTIONS FOR ALL TYPES

Pin or Lead No. 1 – Emitter (40280)
Emitter, Case (40281, 40282)
Pin or Lead No. 2 – Base
Pin or Lead No. 3 – Collector (40281, 40282)
Collector, Case (40280)

DIMENSIONAL OUTLINE FOR TYPES 40281, 40282 JEDEC TO-60



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A1	–	0.165	–	4.19	2
φb	0.030	0.046	0.762	1.17	4
φD	0.360	0.437	9.14	11.10	2
φD1	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
φM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N1	–	0.078	–	1.98	
φW	0.1658	0.1697	4.212	4.310	3, 5

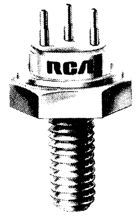
NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing perimts insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

RCA

Solid State
Division

RF Power Transistors
40340
40341



JEDEC TO-60

H-1307

High-Power 50-MHz Emitter-Ballasted Silicon N-P-N Overlay Transistors

For 13.5-V and 24-V Applications in Mobile Communications Equipment

Features

- **Emitter ballasting resistors**
- **13.5 V–25 W min. power output, 7 dB min. gain (40340)**
- **24 V–30 W min. power output, 10 dB min. gain (40341)**
- **Emitter connected to case**
- **Infinite load mismatch tested at 50 MHz**

RCA-40340 and 40341 are epitaxial silicon n-p-n planar transistors of the "overlay" emitter electrode construction. They are intended especially for high-power-output, class-C amplifier service at frequencies up to 100 MHz.

In the overlay structure, a number of individual emitter sites are connected in parallel and used in conjunction with a single base and collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, and frequency capability.

MAXIMUM RATINGS, *Absolute-Maximum Values:*		40340	40341	
COLLECTOR-TO-EMITTER VOLTAGE:				
With base open	V_{CEO}	25	35	V
With base-emitter junction reverse-biased (V_{BE}) = −1.5 volts	V_{CEV}	60	70	V
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	60	70	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4.0	4.0	V
PEAK COLLECTOR CURRENT		10	10	A
CONTINUOUS COLLECTOR CURRENT	I_C	3.3	3.3	A
TRANSISTOR DISSIPATION	P_T			
At case temperatures up to 25°C		70	70	W
TEMPERATURE (Operating junction)	T_J	200	200	°C

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS				UNITS
		DC Collector Voltage (V)		DC Base Voltage (V)	DC Current (mA)		40340		40341		
		V_{CB}	V_{CE}	V_{BE}	I_E	I_C	Min.	Max.	Min.	Max.	
Collector-Cutoff Current: With base open	I_{CEO}		30				–	–	–	1.0	mA
			15				–	1.0	–	–	
With emitter open	I_{CBO}	50					–	–	–	10	
		40					–	10	–	–	
Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$					200[a]	25	–	35	–	V
With base-emitter junction reverse biased, and external base-to-emitter resistance (R_{BE}) = 20 Ω	$V_{(BR)CEV}$			−1.5		200[a]	60	–	70	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$				10		4	–	4	–	V
Thermal Resistance: (Junction-to-Case)	$R_{\theta JC}$						2.5		2.5		°C/W

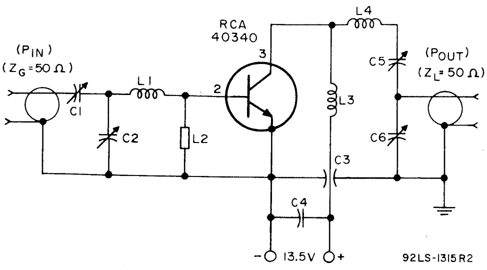
[a] Pulsed through a 25-mH inductor; duty factor = 50%.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS				UNITS
		DC Collector Supply (V_{CC})–V	Input Power (P_{IE})–W	Frequency (f) - MHz	40340		40341		
					Min.	Max.	Min.	Max.	
Power Output	P_{OE}	▲ 13.5	5	50	25	–	–	–	W
		‡ 24	3	50	–	–	30	–	
Power Gain	G_{PE}	▲ 13.5	5	50	7	–	–	–	dB
		‡ 24	3	50	–	–	10	–	
Collector Efficiency	η_C	▲ 13.5	5	50	60	–	–	–	%
		‡ 24	3	50	–	–	60	–	
Load Mismatch	LM	▲ 13.5	5	50	GO/NO GO				
		‡ 24	3	50					
Collector-to-Base Capacitance	C_{obo}	V_{CB} = 30		1	–	–	–	85	pF
		V_{CB} = 15		1	–	120	–	–	

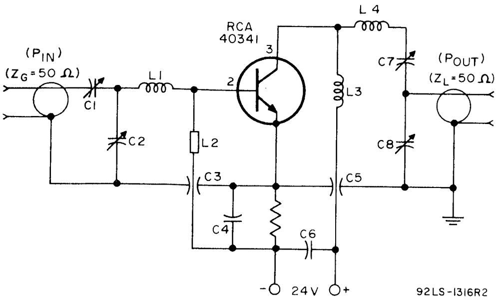
▲ In circuit shown in Fig.1.

‡ In circuit shown in Fig.2.



C_1: 14-150 pF
C_2: 90-400 pF
C_3: 1000 pF
C_4: 0.02 μF
C_5: 32-250 pF
C_6: 32-250 pF
L_1: 1 turn, No.16 wire, 5/16 in. (7.93 mm) ID,, 1/8 in. (3.17 mm) long
L_2: Ferrite Choke, Z = 450 Ω
L_3: 10 turns, No.20 enamel wire, close wound, 1/4 in. (6.35 mm) ID
L_4: 3 turns, No.10 wire, 3/4 in. (19.05 mm) ID, 3/4 in. (19.05 mm) long

Fig.1—RF amplifier circuit for 40340 power-output test (50-MHz operation).



C_1: 14-150 pF
C_2: 110-580 pF
C_3, C_5: 1000 pF
C_4: 0.0018 μF
C_6: 0.2 μF
C_7: 140-680 pF
C_8: 32-250 pF
L_1: 2 turns, No.16 wire, 1/4 in. (6.35 mm) ID, 1/4 in. (6.35 mm) long
L_2: Ferrite Choke, Z = 450 Ω
L_3: 10 turns, No.20 enamel wire, close wound, 1/4 in. (6.35 mm) ID
L_4: 3 turns, No.10 wire, 3/4 in. (19.05 mm) ID, 3/4 in. (19.05 mm) long
R_1: 0.33 ohms

Fig.2—RF amplifier circuit for 40341 power-output test (50-MHz operation).

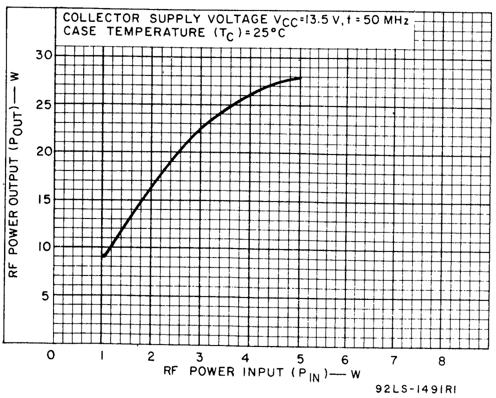


Fig.3—Typical performance of type 40340 in the common-emitter amplifier shown in Fig.1.

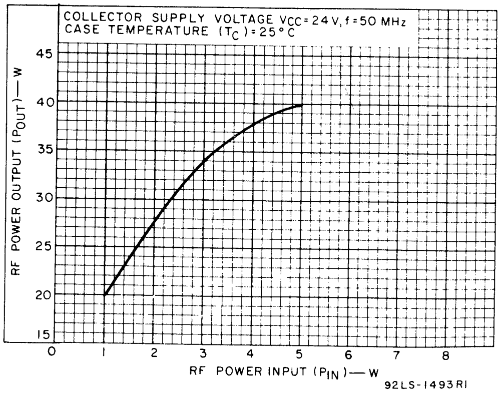


Fig.4—Typical performance of type 40341 in the common-emitter amplifier shown in Fig.2.

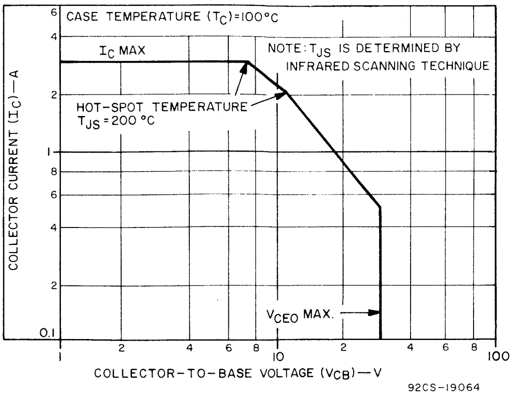


Fig.5—Safe area for dc operation.

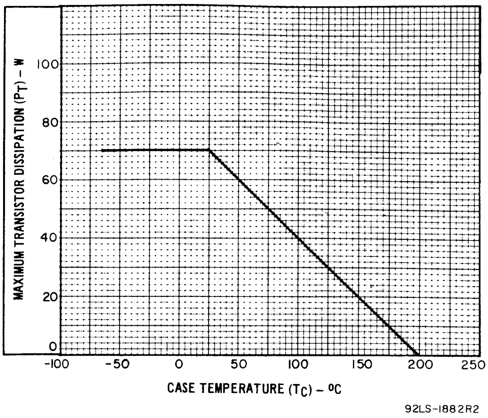
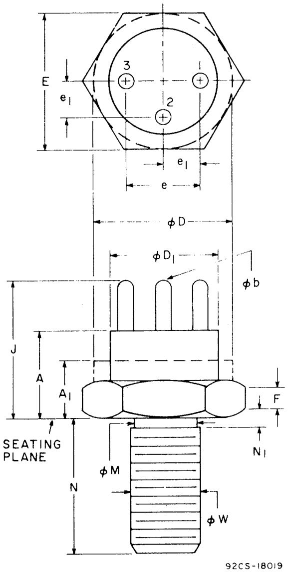


Fig.6—Dissipation derating curve.

DIMENSIONAL OUTLINE
JEDEC TO-60



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A_1	–	0.165	–	4.19	2
ϕb	0.030	0.046	0.762	1.17	4
ϕD	0.360	0.437	9.14	11.10	2
ϕD_1	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e_1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
ϕM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N_1	–	0.078	–	1.98	
ϕW	0.1658	0.1697	4.212	4.310	3.5

NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing perimts insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

TERMINAL CONNECTIONS

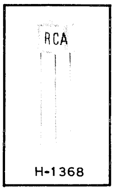
Pin No.1 – Emitter
Pin No.2 – Base
Pin No.3 – Collector
Case, Mounting Stud – Emitter

Solid State Division

RF Power Transistors

40637

SILICON N-P-N EPITAXIAL PLANAR TRANSISTOR



H-1368

JEDEC TO-52

For Frequency-Multiplier Service in Mobile, Marine, and Sonobouy VHF Transmitters

RCA-40637 is an epitaxial planar transistor of the silicon n-p-n type, intended for frequency multiplier service to 175 MHz. The RCA-40637 is particularly suitable for low-level frequency-multiplier stages in VHF transmitters, such as Mobile and Marine.

A multiplier chain of 3 RCA-40637's will deliver 100 mW at 156 MHz from a 5 mW, 13-MHz input with a 12 volt supply.

The RCA-40637 is hermetically sealed in the compact JEDEC TO-52 package.

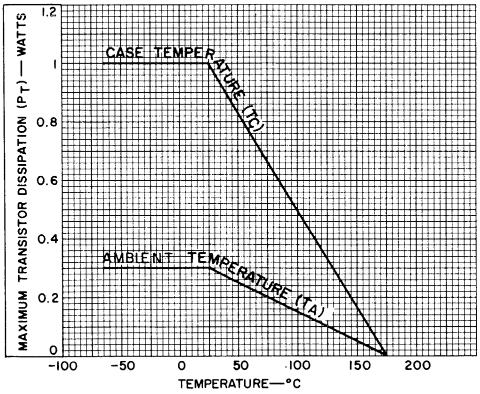
Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE, V_{CES}	30 max.	V
EMITTER-TO-BASE VOLTAGE, V_{EBO}	5 max.	V
COLLECTOR CURRENT, I_C	100 max.	mA
TRANSISTOR DISSIPATION, P_T:		
For case temperatures up to 25°C	1 max.	W
For case temperatures above 25°C	See Fig.1	
For ambient temperatures up to 25°C	0.3 max.	W
For ambient temperatures above 25°C	See Fig.1	
TEMPERATURE RANGE:		
Storage	-65 to +200	°C
Operating	-65 to +175	°C
LEAD TEMPERATURE (During soldering):		
At distances greater than 1/16 inch from seating surface for 10 seconds max.	265 max.	°C

FEATURES:

- **Hermetically sealed JEDEC TO-52 package**
- **High gain-bandwidth product–** f_T = 300 MHz typ. at I_C = 50 mA, V_{CE} = 1 V
- **Low output capacitance–** C_{ob} = 3 pF typ.
- **High power dissipation rating–** P_T = 1 W at T_C = 25°C

RATING CHART FOR RCA-40637



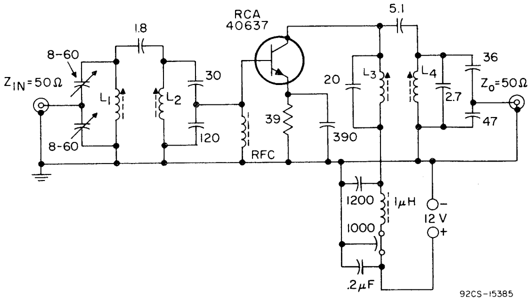
92CS-12114R1

Fig.1

ELECTRICAL CHARACTERISTICS, at T_A = 25°C

Characteristics	Symbols	TEST CONDITIONS Frequency f	DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Base-to-Emitter Voltage V_{BE}	DC Base Current I_B	DC Emitter Current I_E	DC Collector Current I_C	LIMITS RCA-40637 Min.	Max.	Units
		MHz	V	V	V	mA	mA	mA			
Collector-to-Emitter Breakdown Voltage	BV_{CES}				0			0.01	30	–	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}						-0.01	0	5	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					1		10	–	0.6	V
Magnitude of Small-Signal Forward Current-Transfer Ratio	$\vert h_{fe} \vert$	100		1				50	3 (typ.)		
Collector-to-Base Capacitance	C_{ob}	0.1 to 1	12				0		3 (typ.)		pF
Power Output as a Frequency Doubler	P_{OUT}	f_{IN}=78 f_{OUT}=156			See Fig.2 RF Power Input = 37 mW				100	–	mW
Efficiency as a Frequency Doubler	η	f_{IN}=78 f_{OUT}=156			See Fig.2				18	–	%
Thermal Resistance (junction-to-case)	$\theta_{J\text{-}C}$								–	0.15	°C/mW

TYPICAL 78 MHz-156 MHz MULTIPLIER
12-VOLT SUPPLY



L_1 - L_2: 4-1/2 turns, close-wound, #22 enameled wire

L_3 - L_4: 1-1/2 turns, 1/4-inch length, #20 bare wire

All coils on slug-tuned forms 15/64-inch O.D., Corbonyl* S.F. 10-32 threaded slug or equivalent, with 1/2-inch x 1/2-inch x 1-inch shield cans.

RFC: 4 turns, #30 enameled wire on Ferroxcube† ferrite bead #56-590-65/48.

* Arnold Magnetics Corp., Los Angeles, California.

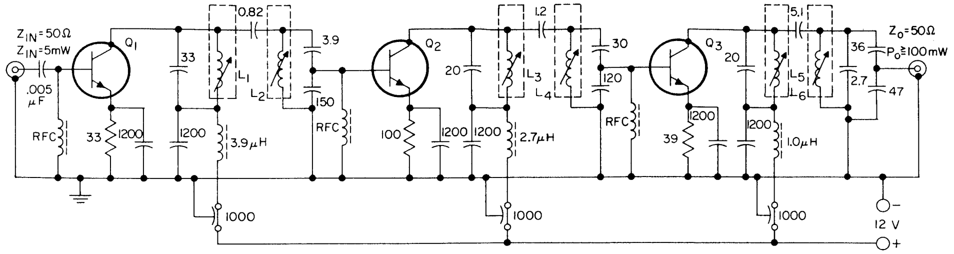
† Ferroxcube Corp. of America, Saugerties, New York.

All capacitor values are in pico-farads unless otherwise specified.
All resistors in ohms and 1/4-watt unless otherwise specified.

Fig.2

TYPICAL FREQUENCY MULTIPLIER CHAIN

f_{IN} = 13.0 MHz/f_{OUT} = 156 MHz



92CM-15386

L_1 - L_2: 10-1/2 turns, close-wound, #22 enameled wire
L_3 - L_4: 4-1/2 turns, close-wound, #22 enameled wire
L_5 - L_6: 1-1/2 turns, 1/4-inch length, #20 bare wire

All coils on slug-tuned forms 15/64-inch O.D. Corbonyl* S.F. 10-32 threaded slug or equivalent, with 1/2-inch x 1/2-inch x 1-inch shield cans.

RFC: 4 turns, #30 enameled wire on Ferroxcube† ferrite bead #56-590-65/48.

Q_1, Q_2, Q_3 – RCA-40637.

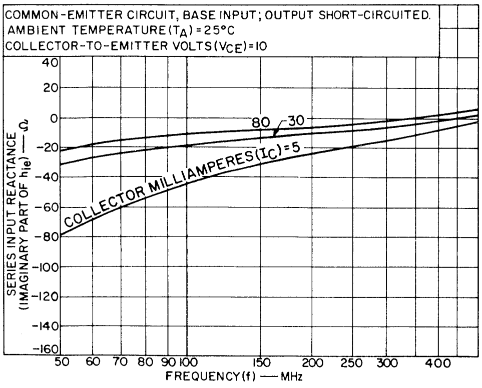
* Arnold Magnetics Corp., Los Angeles, California.
† Ferroxcube Corp. of America, Saugerties, New York.

All capacitor values are in pico-farads unless otherwise specified.
All resistors in ohms and 1/4-watt unless otherwise specified.

Fig.3

TYPICAL CHARACTERISTICS

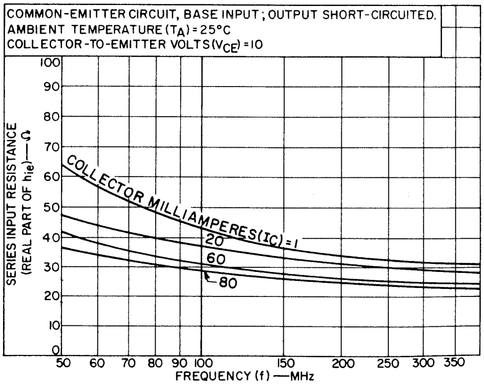
SERIES INPUT REACTANCE vs FREQUENCY FOR RCA-40637



92CS-13735

Fig.4

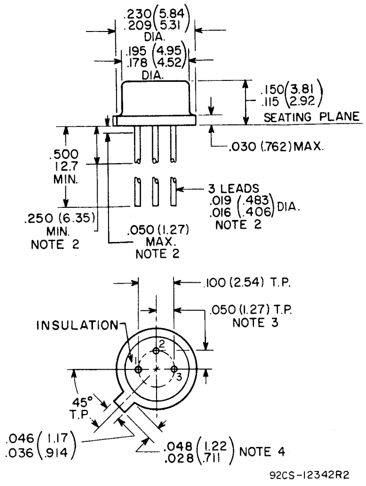
SERIES INPUT RESISTANCE VS FREQUENCY FOR RCA-40637



92CS-13736

Fig.5

DIMENSIONAL OUTLINE
JEDEC No.TO-52



Dimensions in Inches and Millimeters

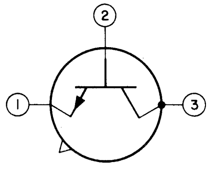
Note 1: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

Note 2: The specified lead diameter applies in the zone between 0.050″ (1.27 mm) and 0.250″ (6.35 mm) from the seating plane. From 0.250″ (6.35 mm) to the end of the lead a maximum diameter of 0.021″ (0.533 mm) is held. Outside of these zones, the lead diameter is not controlled.

Note 3: Leads having a maximum diameter of 0.019″ (0.482 mm) at a gauging plane of 0.054″ (1.372 mm) + 0.001″ (0.025 mm) − 0.000″ (0.000 mm) below seating plane shall be within 0.007″ (0.177 mm) of their true position (location) relative to a maximum width of tab.

Note 4: Measured from actual maximum diameter.

TERMINAL DIAGRAM
Bottom View

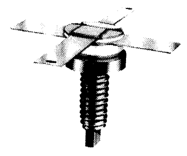


LEAD 1 – EMITTER
LEAD 2 – BASE
LEAD 3 – COLLECTOR, CASE

RCA
Solid State Division

RF Power Transistors

40893



RCA HF-36
Package

15-W, 470-MHz Emitter-Ballasted Overlay Transistor

Silicon N-P-N Type for Class C Amplifiers in 12.5-V Mobile Communications Equipment

Features:

- 5.2-dB gain (min.) at 470 MHz, P_{OE} = 15 W (min.)
- VSWR tested – ∞ :1, P_{IE} = 4.5 W
- For operation in the 406–512-MHz band
- Integral emitter-ballasting resistors
- Hermetically-sealed, ceramic-metal, stud package
- Low-inductance radial leads for stripline circuits
- All leads isolated from mounting stud

RCA-40893* is an epitaxial silicon n-p-n planar transistor with "overlay" emitter-electrode construction.

Integral emitter-ballast resistance is employed for improved ruggedness and increased overdrive capability.

The 40893 features a hermetic, ceramic-metal package with rugged, low-inductance radial leads for stripline or lumped-constant circuits.

This transistor is intended for use in high-power, broadband, mobile uhf amplifiers operating from a 12.5-volt supply.

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* Formerly RCA Dev. No. TA7686

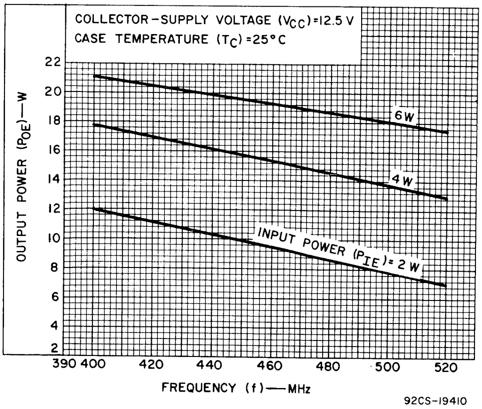


Fig. 1–Typical output power vs. frequency.

MAXIMUM RATINGS, Absolute-Maximum Values:

COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	14	V
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	36	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4.0	V
CONTINUOUS COLLECTOR CURRENT	I_C	3.0	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 120°C		20	W
At case temperatures above 120°C		Derate at 0.25	W/°C
TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

ELECTRICAL CHARACTERISTICS, *At Case Temperature (T_C) = 25ºC*

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Voltage—V	DC Base Voltage—V	DC Current—mA				
		V_{CE}	V_{EB}	I_E	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CES}	12.5	0			–	10	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0	20	36	–	V
Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$		0		200	14	–	V
With base connected to emitter	$V_{(BR)CES}$				200	36	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			5		4.0	–	V
Thermal Resistance: (Junction-to-Case)	$R_{\theta JC}$						4.0	ºC/W

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS		UNITS
		Supply Voltage (V_{CC})–V	Input Power (P_{IE}) - W	Frequency (f) - MHz	Min.	Typ.	
Power Output	P_{OE}	12.5	4.5	470	15	–	W
Power Gain	G_{PE}	12.5	4.5	470	5.2	–	dB
Collector Efficiency	η_C	12.5	4.5	470	60	–	%
Load Mismatch (See Fig. 10)	LM	12.5	4.5	470	Go/No Go		
Collector-to-Base Capacitance	C_{obo}	12(V_{CB})		1	60 (max.)		pF

TYPICAL APPLICATION INFORMATION

CIRCUIT	OUTPUT POWER (P_{OE})—W	INPUT POWER (P_{IE})—W	Collector Efficiency (η_C)—%	Figure No.
406-MHz Amplifier	18.0	4.5	68	4*
512-MHz Amplifier	14.5	4.5	65	4*
450–470-MHz Amplifier	15.0	4.5	60–72	4 ●

* Amplifier tuned to indicated frequency.

● Amplifier tuned at 470 MHz for maximum gain and minimum input reflection.

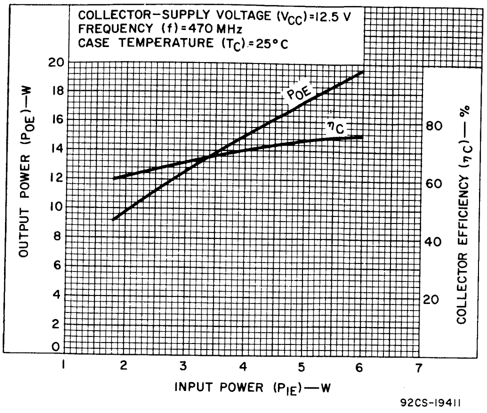


Fig. 2–Typical output power and collector efficiency vs. input power.

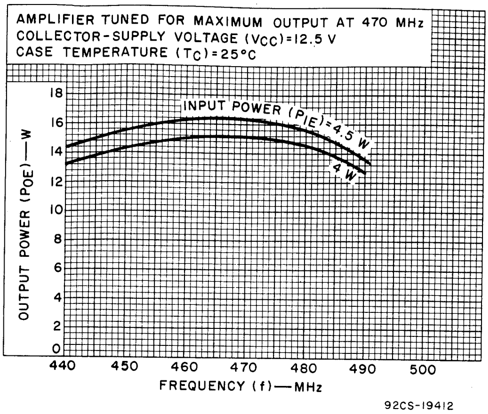
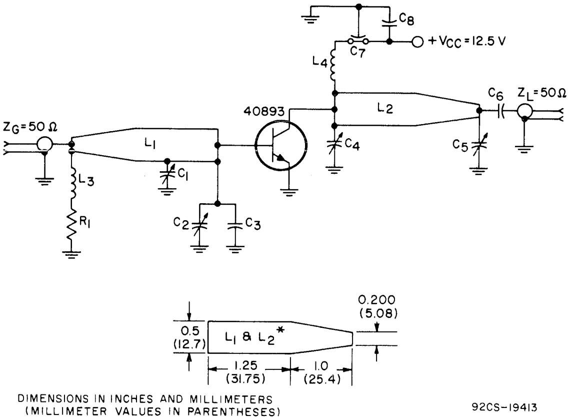


Fig. 3–Typical performance of the 450–470-MHz amplifier shown shown in Fig. 4



C_1, C_2, C_4, C_5 – 2–18 pF, Amperex HT10MA/218 ■
C_3 – 30 pF, American Technical Ceramics ATC-100 ■
C_6 – 0.01 μF, disc ceramic
C_7 – 1000 pF, feedthrough Allen-Bradley FA5C ■
C_8 – 1000 pF, ATC-100 ■
R_1 – 0.47 Ω, 1 W
L_3 – 0.22 μH, rf choke
L_4 – 10 turns No. 22 wire, 0.12" ID

■ Or equivalent

Allen-Bradley Co., Milwaukee, Wisc.
American Technical Ceramics
Huntington Station, N.Y.

* Produced by etching upper layer of double-clad teflon board: 1/16 in. thick, ε = 2.6

Fig. 4–Amplifier test circuit for measurement of output power, gain, efficiency, and load mismatch.

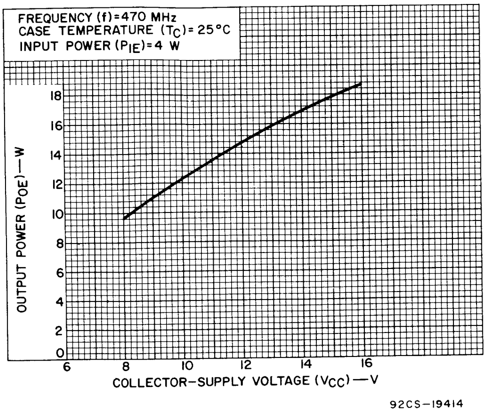


Fig. 5–Typical output power vs. collector-supply voltage.

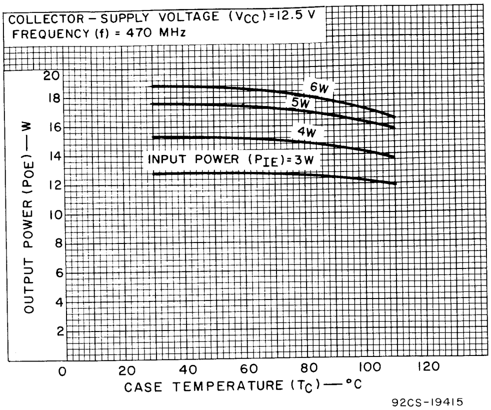


Fig. 6–Typical output power vs. case temperature.

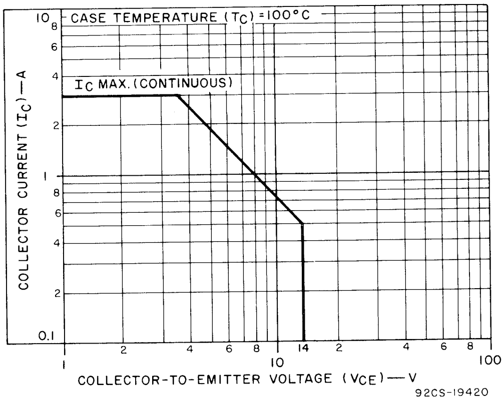


Fig. 7–Maximum dc operating area for type 40893.

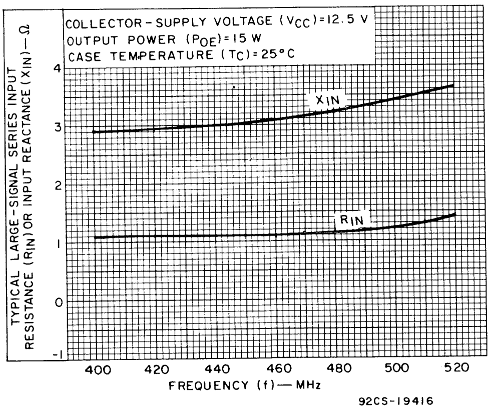


Fig. 8–Typical large-signal series input impedance vs. frequency.

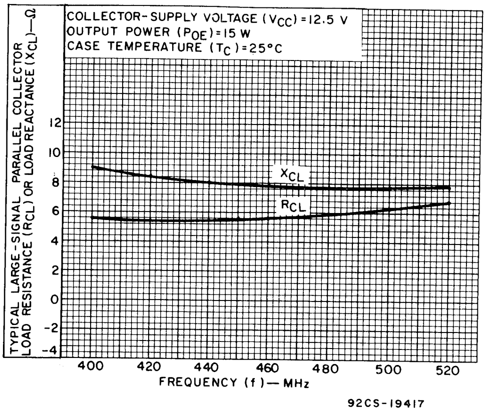


Fig. 9—Typical large-signal parallel collector load impedance vs. frequency.

SPECIAL PERFORMANCE DATA

The transistor must withstand any load mismatch provided by the following test conditions:

1. The test is performed using the arrangement shown.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions: V_{CC} = 12.5 V, rf input power = 4.5 W.
4. Transistor dissipation rating must not be exceeded during the above test so that the transistor will not be damaged or degraded.

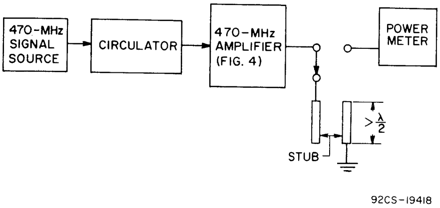
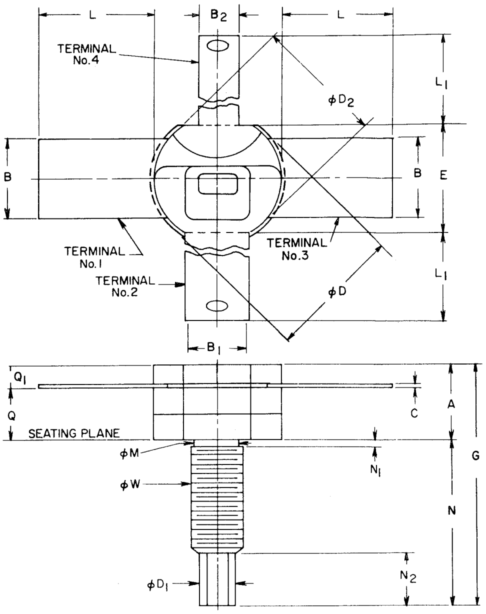


Fig. 10—Test set-up for testing load-mismatch capability.



92CS-19419

TERMINAL CONNECTIONS

Terminal No. 1, 3	— Emitter
Terminal No. 2	— Base
Terminal No. 4	— Collector

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.185	0.240	4.70	6.11	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
ϕ D	0.319	0.335	8.12	8.52	–
ϕ D_1	0.033	0.065	0.84	1.65	1
ϕ D_2	0.305	0.320	7.48	8.12	–
E	0.275	0.300	6.99	7.62	–
G	0.635	0.730	16.11	18.51	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0.510	11.56	12.95	–
ϕ M	0.120	0.163	3.05	4.14	–
N	0.450	0.490	11.41	12.45	–
N_1	–	0.078	–	1.98	4
N_2	0.095	0.135	2.42	3.43	–
Q	0.145	0.170	3.68	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
ϕ W	0.1399	0.1437	3.531	3.632	2

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

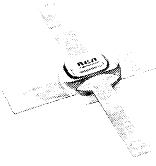
NOTES:
1. 0.053–0.064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS.
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W
5. RECOMMENDED TORQUE: 5 INCH-POUNDS

RCA

Solid State
Division

RF Power Transistors

40934 40935



RCA HF-31 Package
("Studless TO-216 AA")

H-1676

High-Power Silicon N-P-N VHF/UHF Transistors

12.5-Volt Types For Class C Amplifier Applications

Features:

- **Low-inductance radial leads — particularly useful for stripline circuits**
- **Hermetically sealed ceramic-metal package**
- **Electrically isolated mounting surface**
- **6 watts minimum output from 40935 amplifier at 470 MHz**
- **7-dB gain from 40934 driver at 470 MHz**

RCA 40934[a] and 40935[b] are epitaxial silicon n-p-n planar transistors featuring overlay emitter-electrode construction.

The 40934 and 40935 feature a hermetic ceramic-metal package with leads isolated from the mounting surface. These rugged, low-inductance, radial-lead types are designed for stripline, as well as lumped-constant circuits.

Types 40934 and 40935 are electrically identical to the RCA-2N5914 and 2N5915, respectively, but employ a "studless TO-216AA" package.

---

[a] Formerly RCA Dev. No. TA7941.

[b] Formerly RCA Dev. No. TA8151.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

		40934	40935	
COLLECTOR-TO-BASE BREAKDOWN VOLTAGE	$V_{(BR)CBO}$	36	36	V
COLLECTOR-TO-EMITTER BREAKDOWN VOLTAGE				
With base connected to emitter	$V_{(BR)CES}$	36	36	V
With base open	$V_{(BR)CEO}$	14	14	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	3.5	V
COLLECTOR CURRENT:	I_C			
Continuous		0.5	1.5	A
TRANSISTOR DISSIPATION:	P_T			
At case temperatures up to 75°C		5.7	10.7	W
At case temperatures above 75°C, derate linearly at		0.0456	0.856	W/°C
TEMPERATURE RANGE:				
Storage & Operating (Junction)		-65 to +200°C		
CASE TEMPERATURE (During soldering):				
For 10 s max.		230		°C

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS: DC COLLECTOR VOLTAGE (V) V_{CE}	DC BASE VOLTAGE (V) V_{BE}	DC CURRENT (mA) I_E	I_B	I_C	LIMITS 40934 MIN.	40934 MAX.	40935 MIN.	40935 MAX.	UNITS
Collector-Cutoff Current	I_{CEO}	10			0		–	0.3	–	1.0	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.5 1.0	36 –	– –	– 36	– –	V
Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$			0		25[a] 75[a]	14 –	– –	– 14	– –	V
With base connected to emitter	$V_{(BR)CES}$		0			25[a] 75[a]	36 –	– –	– 36	– –	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.5 1.0		0 0	3.5 –	– –	– 3.5	– –	V

[a] Pulsed through a 25-mH inductor; duty factor = 50%

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS: DC Collector Supply (V_{CC})–V	Input Power (P_{IE})–W	Frequency (f)–MHz	LIMITS 40934 Min.	40934 Typ.	40935 Min.	40935 Typ.	UNITS
Power Output	P_{OE}	12.5	0.4 2.0	470	2.0 –		– 6		W
Power Gain	G_{PE}	12.5	0.4 2.0	470	7 –		– 4.8		dB
Collector Efficiency	η_C	12.5	0.4 2.0	470	65 –		– 65		%
Load Mismatch (Fig. 11)	LM	12.5	0.4(40934) 2.0(40935)	470	Open circuit through short circuit				–
Collector-to-Base Capacitance	C_{obo}	12 $I_C = 0$		1	–	15 (max.)	–	30 (max.)	pF
Gain-Bandwidth Product	f_T	12 I_C = 200 mA				900	–		MHz
		I_C = 300 mA			–		–	800	

PERFORMANCE DATA

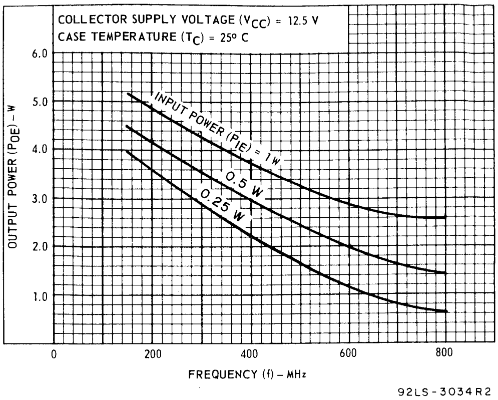


Fig. 1—Typical output power vs. frequency for type 40934.

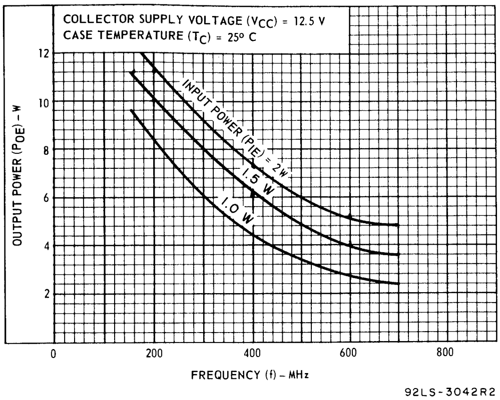


Fig. 2—Typical output power vs. frequency for type 40935.

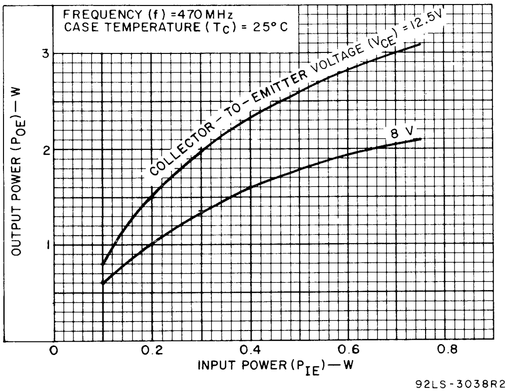


Fig. 3—Typical output power vs. input power at 470 MHz for 40934 in circuit shown in Fig. 10.

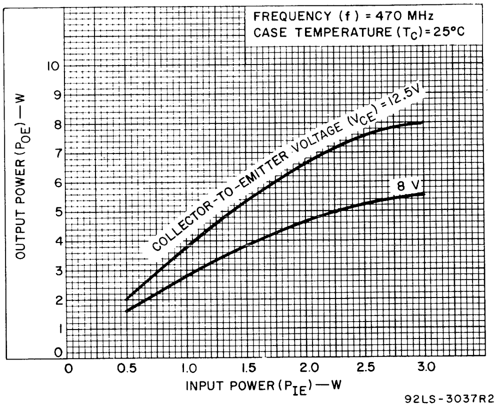
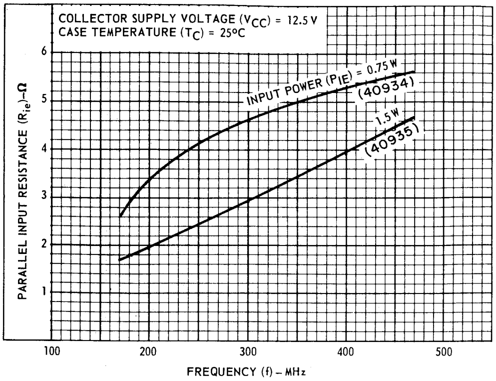


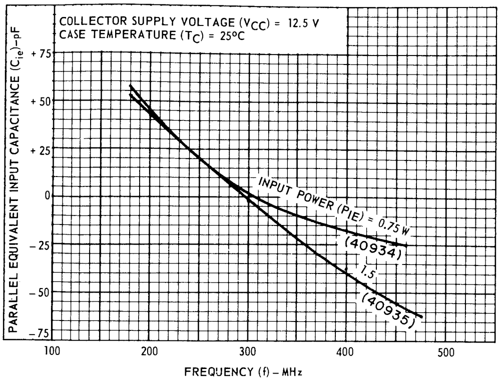
Fig. 4—Typical output power vs. input power at 470 MHz for 40935 in circuit shown in Fig. 10.

DESIGN DATA



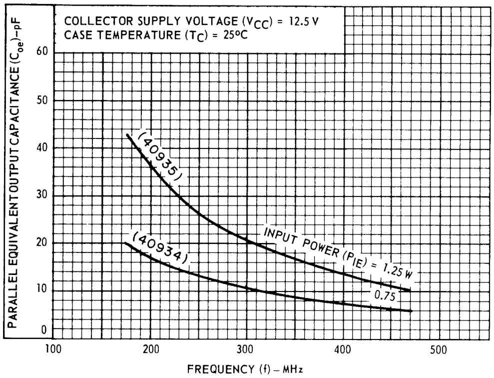
92SS-4494RI

Fig. 5—Large-signal equivalent parallel input resistance vs. frequency for 40934 and 40935.



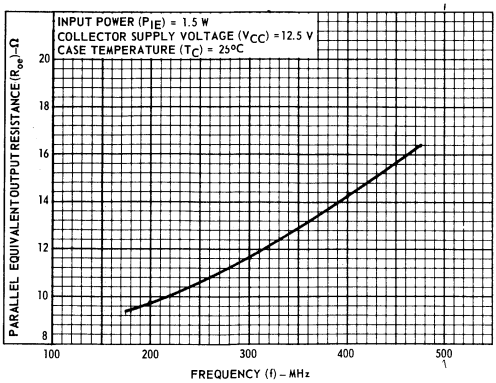
92SS-4495RI

Fig. 6—Large-signal parallel equivalent input capacitance vs. frequency for 40934 and 40935.



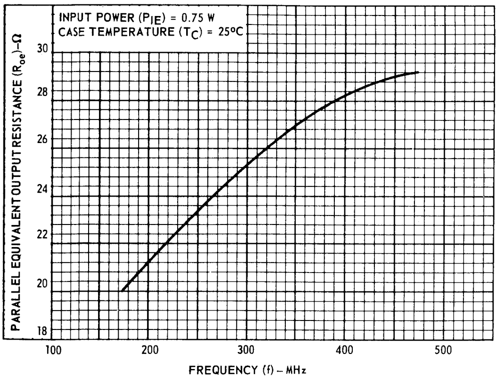
92SS-4496RI

Fig. 7—Large-signal equivalent parallel output capacitance vs. frequency for 40934 and 40935.



92SS-4497

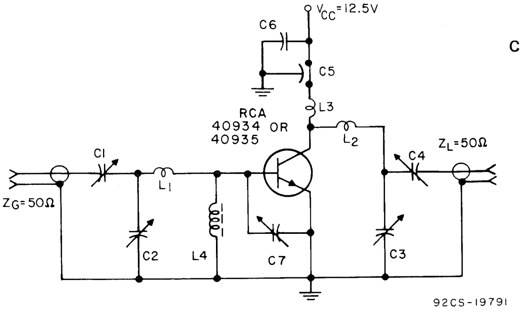
Fig. 8—Large-signal parallel load resistance vs. frequency for 40935.



92SS-4498

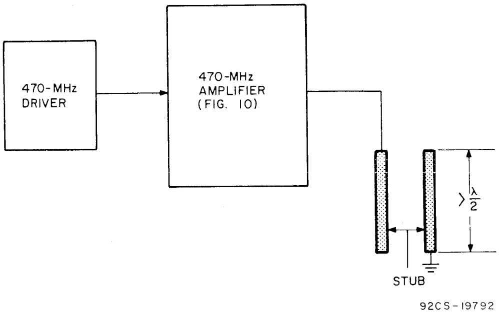
Fig. 9—Large-signal parallel load resistance vs. frequency for 40934.

APPLICATION DATA



C_1,C_2,C_3: 0.9–7.0 pF, ARCO 400, or equivalent
C_4: 1.5–2.0. pF, ARCO 402, or equivalent
C_5: 1000 pF, feedthrough
C_6: 0.1 , μF, ceramic
C_7: 2–18 pF, Amperex HT10MA/218, or equivalent, connected between the base and emitter with the shortest possible leads.
L_1,L_2: 1 turn No.16 wire, 3/16 in. (4.78 mm) I.D., 1/8 in. (3.18 mm) long
L_3: 1 turn No.20 wire, 3/16 in. (4.78 mm) I.D., 1/8 in. (3.18 mm) long
L_4: Ferrite choke, 450Ω impedance, Ferroxcube VK-200-09--3B, or equivalent

Fig. 10—470-MHz amplifier test circuit for measurement of output power, gain, and load-mismatch capability.

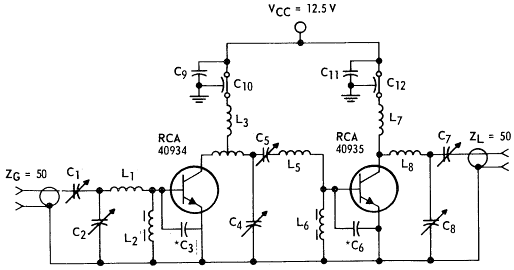


SPECIAL PERFORMANCE DATA

The transistor must withstand any mismatch in load which can be demonstrated by means of the following test:

1. The test is performed using the arrangement shown above.
2. The tuning stub is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions: V_{CC} = 12.5 V, rf input power = 0.4 W for 40934, 2.0 W for 40935.
4. Transistor dissipation rating must not be exceeded during the above test so that the transistor will not be damaged or degraded.

Fig. 11—Test set-up for checking load-mismatch capability of 40934 and 40935.



$C_1, C_2, C_4, C_5, C_7, C_8$: 0.9–7.0 pF
C_3, C_6 : 18 pF
C_9, C_{11} : 0.1 μF
C_{10}, C_{12} : 0.001 μF
L_1 : 1 turn No. 16 wire, 3/16 in. (4.78 mm) I.D., 1/8 in. (3.18 mm) long
L_2, L_6 : Ferrite choke, Z = 450 Ω, Ferroxcube VK-200-09-3B, or equivalent
L_3, L_7 : 1 turn No. 20 wire, 3/16 in. (4.78 mm) I.D., 1/8 in. (3.18 mm) long

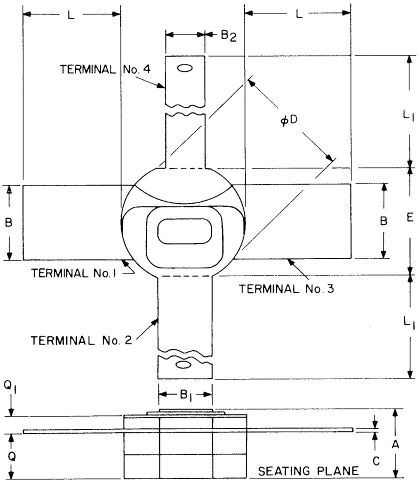
L_4 1 turn No. 18 wire, 1/4 in. (6.35 mm) I.D., 1/8 in. (3.18 mm) long (Tap at 1/4 turn from collector end)
L_5 1 turn No. 20 wire, 1/8 in. (3.18 mm) I.D., 1/8 in. (3.18 mm) long
L_8 1 turn No. 18 wire, 1/4 in. (6.35 mm) I.D., 1/8 in. (3.18 mm) long

*Connected between the base and emitter terminals with the shortest possible leads.

92SM-4499 RI

Fig. 12—Typical 470-MHz amplifier circuit employing types 40934 and 40935.

DIMENSIONAL OUTLINE
RCA HF-31 ("Studless TO-216AA")



92CS-19793

WARNING: The ceramic heat-sink portion of these devices contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.150	0.230	3.81	5.84
B	0.195	0.205	4.96	5.20
B_1	0.135	0.145	3.43	3.68
B_2	0.095	0.105	2.42	2.66
C*	0.004	0.010	0.11	0.25
φD	0.305	0.320	7.48	8.12
E	0.275	0.300	6.99	7.62
L	0.265	0.290	6.74	7.36
L_1	0.455	0.510	11.56	12.95
Q	0.120	0.170	3.05	4.31
Q_1	0.025	0.045	0.64	1.14

*Typical for all leads

TERMINAL CONNECTIONS

Terminal No. 1, 3 — Emitter
Terminal No. 2 — Base
Terminal No. 4 — Collector

Aircraft-Radio Types

RCA

Solid State
Division

RF Power Transistors

2N5102

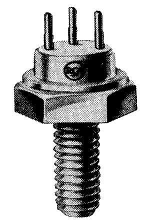
RCA-2N5102* is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter electrode construction. It is especially designed with integral ballast resistors in each emitter site to provide high power as a class-C rf amplifier for VHF Aircraft Communications service (108 to 150 MHz) with amplitude modulation and 24-volt power supply.

The transistor features complete protection against any load mismatch. Each unit is tested at 118 MHz with full modulation and no current limiting for all load mismatch conditions from short-circuit to open-circuit.

In the overlay structure, there are a number of individual emitter sites which are all connected in parallel and used in conjunction with a common collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain efficiency, frequency capability, and linearity.

Formerly RCA-Dev. No. TA2791.

High-Power Device for Class-C, AM Operation in VHF Circuits



JEDEC TO-60

H-1307

- 15 Watts Output Min. at 136 MHz
- For 24-Volt Aircraft Communication
- Complete Load Mismatch Protection
- High Voltage Ratings
- Case Connected to Emitter

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With $V_{BE} = -1.5$ volts	V_{CEV}	100	V
With external base-to-emitter resistance $R_{BE} = 5\,\Omega$	V_{CER}	50	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT:			
Peak		10	A
Continuous	I_C	3.3	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 25° C		70	W
At case temperatures above 25° C		See Fig. 8.	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distances $\geq$ 1/32 in. from insulating wafer for 10 s max		230	°C

TYPICAL POWER OUTPUT vs. FREQUENCY

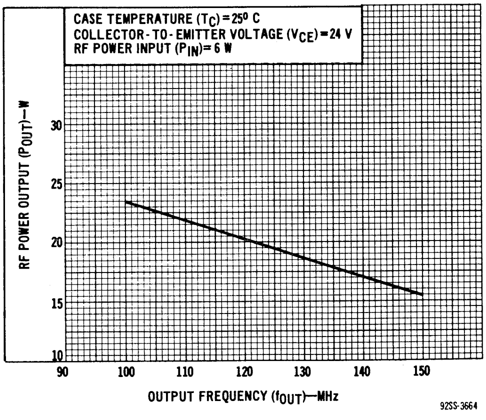


Fig. 1

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C

Characteristic	Symbol	TEST CONDITIONS							LIMITS		Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)		RF Power Watts	Frequency MHz			
		V_{CB}	V_{CE}	V_{BE}	I_E	I_C	P_{IN}	f	Min.	Max.	
Collector-Cutoff Current With external base-to-emitter resistance (R_{BE}) = 5 Ω	I_{CER}		50							10	mA
Collector-to-Emitter Sustaining Voltage With base-to-emitter junction reverse biased	V_{CEV}(sus)			- 1.5		600[a]			100		V
With external base-to-emitter resistance (R_{BE}) = 5 Ω	V_{CER}(sus)					200[a]			50		V
Emitter-to-Base Breakdown Voltage	BV_{EBO}				10	0			4		V
Collector-to-Base Capacitance	C_{ob}	30				0				85	pF
RF Power Output *(See Fig. 2.)*	P_{OUT}		24 (V_{CC})				6	136	15[b]		W
Modulation[c]	M		24					118	80		%
Load Mismatch[d]	LP		24					118	Will not be[d] damaged		–
Dynamic Input Impedance *(See Fig. 2.)*	Z_{IN}		24			1,100	6	150	1.7 + j 2.6 (typ.)		Ω

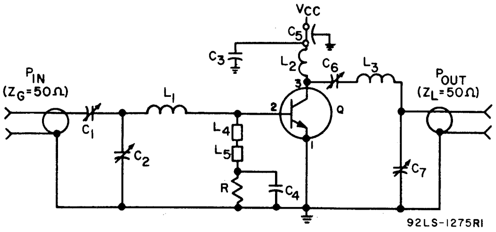
[a] Pulsed through an inductor (9 MH); duty factor = 50%.

[b] Unmodulated carrier.

[c] See Fig. 2 & 3. Carrier Power, P_{CAR}, = 15 W; V_{CC} modulation = 100%; $M = \sqrt{\frac{2(P_{AM} - P_{CAR})}{P_{CAR}}} \times 100\%$.

[d] Under conditions of *footnote* c, the transistor is subjected to all conditions of load mismatch from short-circuit to open-circuit.

RF AMPLIFIER CIRCUIT FOR POWER OUTPUT TEST



C_1, C_6: 3-35 pF

C_2, C_7: 7-100 pF

C_3: 0.1 μF

C_4: 0.05 μF

C_5: 1,000 pF

R: 1 Ω wire wound

L_1: 3 1/4 turns, 1/8" diameter, No. 14 wire

L_2: 2 turn, 3/8" diameter, No. 14 wire

L_3: 4 turns, 3/8" diameter, No. 14 wire

L_4, L_5: 350 Ω Ferrite choke, Ferroxcube # VK200 01-3B*

Q: 2N5102

*Ferroxcube Corp. of America
Saugerties, N.Y.

Fig. 2

BLOCK DIAGRAM FOR MODULATION TEST

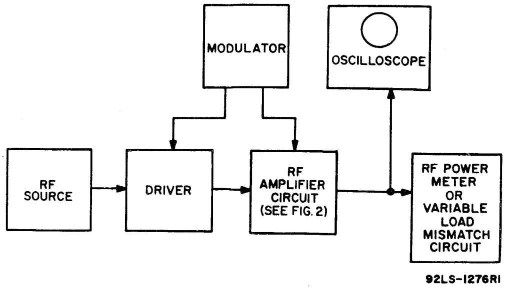
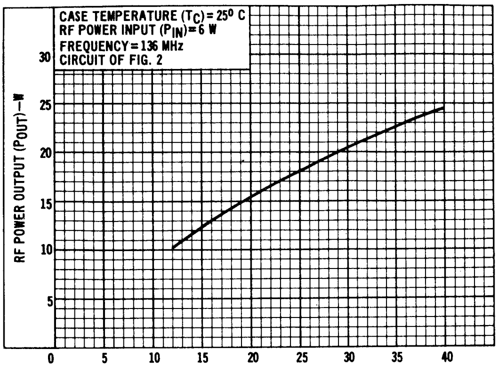


Fig. 3

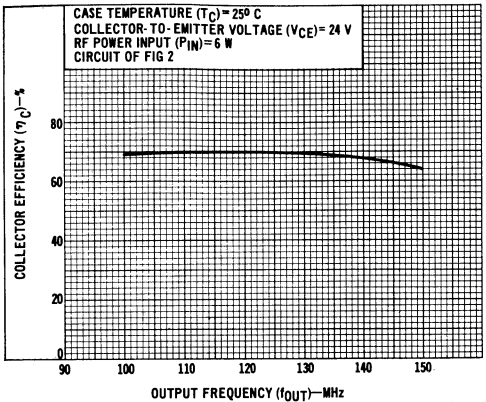
TYPICAL RF POWER OUTPUT vs. COLLECTOR-TO-EMITTER VOLTAGE



92SS-3665

Fig. 4

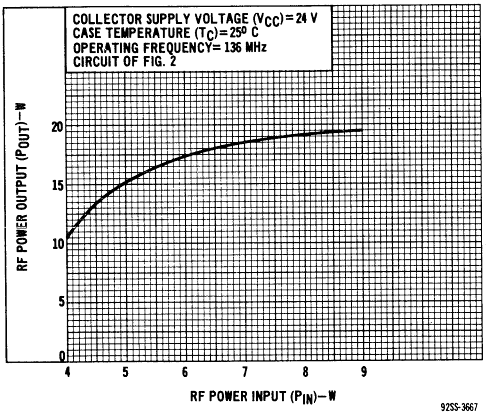
TYPICAL COLLECTOR EFFICIENCY vs. FREQUENCY



92SS-3666

Fig. 5

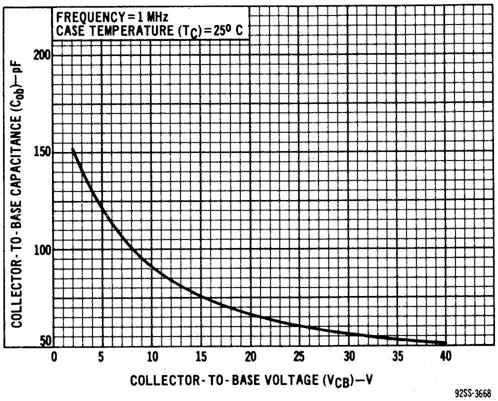
TYPICAL POWER OUTPUT vs. POWER INPUT



92SS-3667

Fig. 6

TYPICAL VARIATION OF COLLECTOR-TO-BASE CAPACITANCE



92SS-3668

Fig. 7

DISSIPATION DERATING CURVE

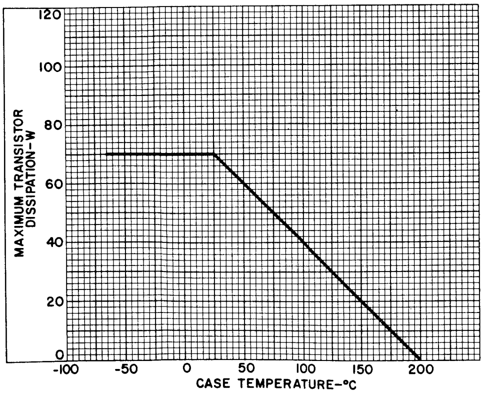


Fig. 8

92LS-1279RI

SAFE OPERATION WITH DC FORWARD BIAS

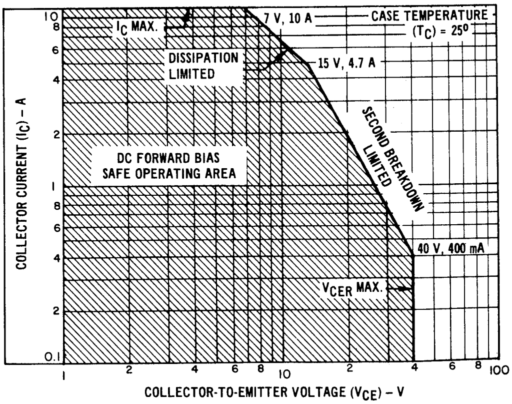
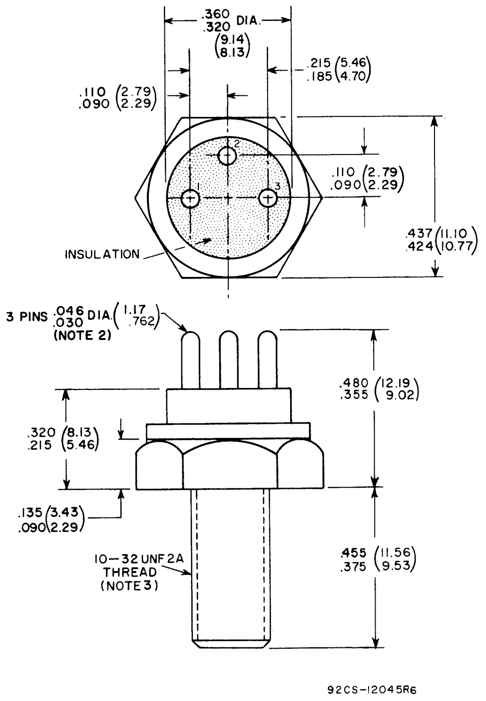


Fig. 9

92LS-1879RI

DIMENSIONAL OUTLINE

JEDEC TO-60



DIMENSIONS IN INCHES AND MILLIMETERS

Note 1: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

Note 2: The pin spacing permits insertion in any socket having a pin-circle diameter of 0.200" (5.08) and contacts which will accommodate pins having a diameter of 0.030" (.762) min., .046" (1.17) max.

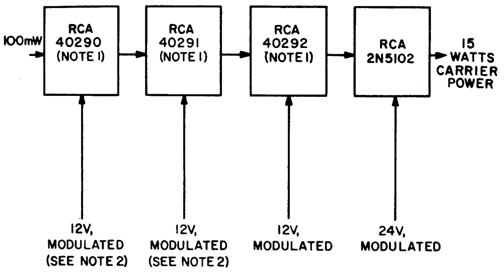
Note 3: The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

Note 4: This device may be operated in any position.

TERMINAL CONNECTIONS

Mounting stud, case, Pin No. 1 - Emitter
Pin No. 2 - Base
Pin No. 3 - Collector

BLOCK DIAGRAM OF A TYPICAL NARROWBAND AIRCRAFT RADIO TRANSMITTER CHAIN



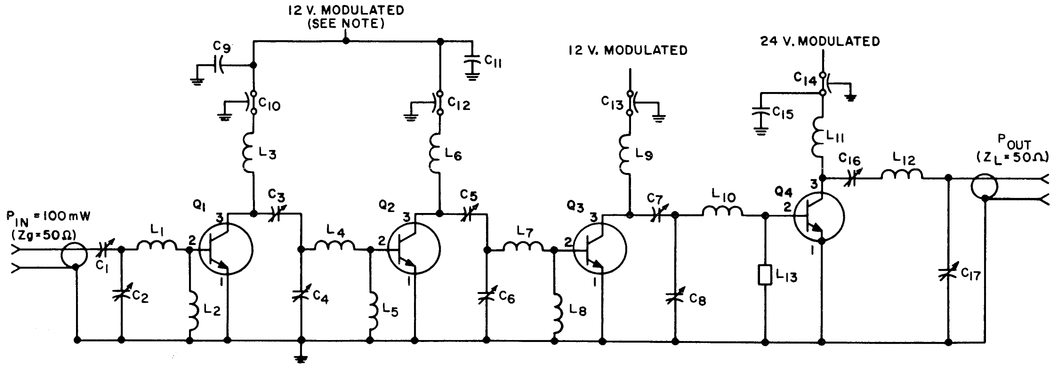
92LS-1277RI

Note 1: For technical bulletin write RCA Commercial Eng., Harrison, N.J.

Note 2: Upward Modulation only.

Fig. 10

CIRCUIT DIAGRAM OF A TYPICAL NARROWBAND AIRCRAFT RADIO TRANSMITTER CHAIN



92LM-1278RI

C_1, C_3, C_5, C_7, C_{16}: 3-35 pF

C_2, C_4, C_6, C_8, C_{17}: 8-60 pF

C_9, C_{11}, C_{13}: 0.03 μF

C_{10}, C_{12}, C_{14}: 1,000 pF

C_{15}: 0.1 μF

L_1, L_9: 3 turns, 1/4" diameter, No. 16 wire

L_2, L_5: Ferrite choke, Z = 450 ohms, Ferroxcube # VK200 01-4B*

L_3: RF choke, 1.5 μH

L_4, L_7: 4 turns, 1/4" diameter, No. 16 wire

L_6: RF choke, 1.0 μH

L_8: wire wound resistor, R = 2.4 ohms

L_{10}: 3 turns, 1/8" diameter, No. 14 wire

L_{11}: 2 turns, 1/2" diameter, No. 16 wire

L_{12}: 4 turns, 1/2" diameter, No. 16 wire

L_{13}: 350 Ω ferrite choke, Ferroxcube # VK200 01-3B*

Q_1: RCA-40290

Q_2: RCA-40290 or 40291

Q_3: RCA-40292

Q_4: 2N5102

Note: Upward modulation only.

*Ferroxcube Corp. of America
Saugerties, N.Y.

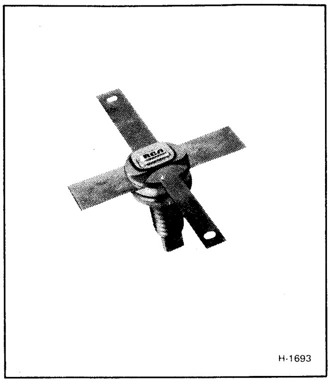
Fig. 11

RCA

Solid State
Division

RF Power Transistors

2N5994



15-W AM and 35-W CW Emitter-Ballasted Overlay Transistor

Silicon N-P-N Device for 12.5-V AM and 28-V FM Amplifiers in VHF Communications Equipment

Features:

- **In 12.5 V AM (118-136 MHz) commercial aircraft communications equipment 15 W (min.) carrier at 118 MHz: Gain = 7 dB min; η_C = 70% min; Modulation = 90% min**
- **In 28 V FM communications equipment: Output = 35 W typ. at 175 MHz; Gain = 7.5 dB; η_C = 65%**
- **Infinity-to-one VSWR tested at rated output at 118 MHz under full modulation**
- **Hermetically sealed stripline ceramic metal package**
- **Electrically isolated mounting stud**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* COLLECTOR-TO-EMITTER VOLTAGE:			
Base shorted to emitter	$V_{(BR)CES}$	65	V
With base open	V_{CEO}	30	V
* COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
* EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
* CONTINUOUS COLLECTOR CURRENT	I_C	5	A
* TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		35.7	W
At case temperatures above 75°C		See Fig. 6	
* TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
* CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

---

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA type 2N5994● is an epitaxial silicon n-p-n planar transistor featuring overlay emitter-electrode construction. This device utilizes many separate emitter elements and has individual ballast resistance in each of these emitter sites for stabilization. It is especially designed for use in 12.5-volt amplitude-modulated class C rf amplifiers operating in the aircraft frequency band (118-136 MHz). This device is also useful for FM and AM applications at 175 MHz.

This transistor is completely tested for load mismatch capability at 118 MHz with a VSWR of infinity-to-one through all phases under full modulation.

The 2N5994 features a hermetic ceramic-metal package having terminals isolated from the mounting stud. These rugged, low-inductance, radial leads are designed for stripline as well as lumped-constant circuits.

● Formerly RCA Dev. Type TA7589.

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25° C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Voltage-V	DC Base Voltage-V	DC Current mA				
		V_{CE}	V_{BE}	I_E	I_C	MIN.	MAX.	
* Collector-Cutoff Current Base-to-Emitter Shorted	I_{CES}	60	0			–	5[b]	mA
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)\,CEO}$				200[a]	30	–	V
With base connected to emitter	$V_{(BR)\,CES}$				200[a]	65	–	V
* Emitter-to-Base Breakdown Voltage	$V_{(BR)\,EBO}$			5		3.5	–	V
Thermal Resistance Junction-to-Case	$\theta_{J\text{-}C}$					–	3.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%. [b] T_C = 25 to 100°C.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS		UNITS
		DC Collector Supply (V_{CC}) -V	Carrier Output Power (P_{OE})-W	Frequency (f) -MHz	MIN.	MAX.	
Power Input	P_{IE}	12.5	15	118	—	3	W
* Power Gain	G_{PE}	12.5	15	118	7	—	dB
* Collector Efficiency	η_C	12.5	15	118	70	—	%
Modulation[c]	m	12.5	15	118	90	—	%
Load Mismatch[c] (Fig. 12)	LM	12.5	15	118	GO/NO GO		
* Collector-to-Base Capacitance f = 1 MHz	C_{obo}	12.5 (V_{CB})		1	—	70	pF

[c] Input power and collector supply voltage are modulated.

---

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

APPLICATION	CIRCUIT (FIG.)	DC COLLECTOR SUPPLY VOLTAGE (V_{CC})–V	INPUT POWER (P_{IE}) W	OUTPUT POWER (P_{OE}) W	MODULATION INDEX (m) %	COLLECTOR EFFICIENCY (η_C)%
118 MHz Amplifier (AM)	10	12.5	3	16.5	95	75
150 MHz Amplifier (AM)	11	12.5	3.5	15	95	80
175 MHz Amplifier (FM)	11	28	6	35	—	65
118-136 MHz Broadband Amplifier (AM)	13	12.5	15 mW	15	90	70

PERFORMANCE DATA

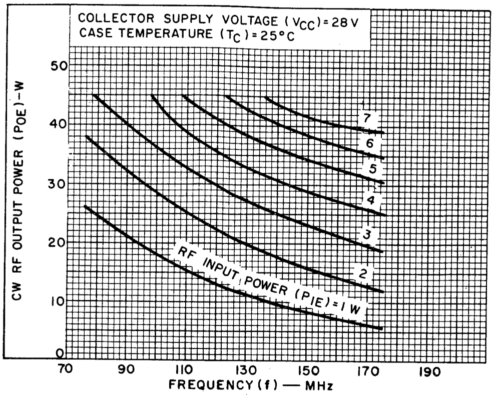


Fig. 1 - Typical output power vs. frequency.

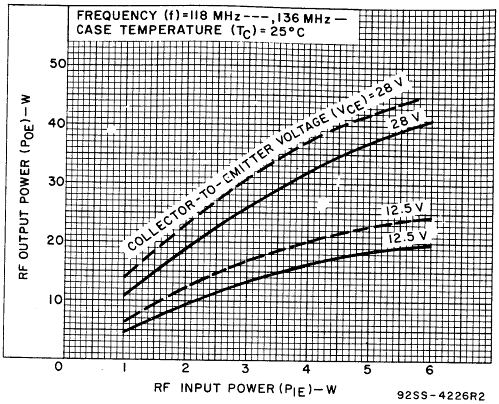


Fig. 2 - Typical output power vs. input power.

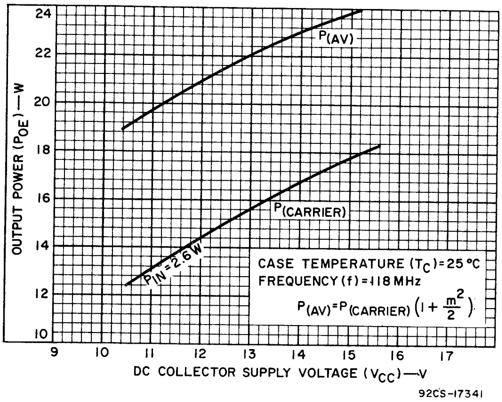


Fig. 3 - Typical output power vs. collector supply voltage.

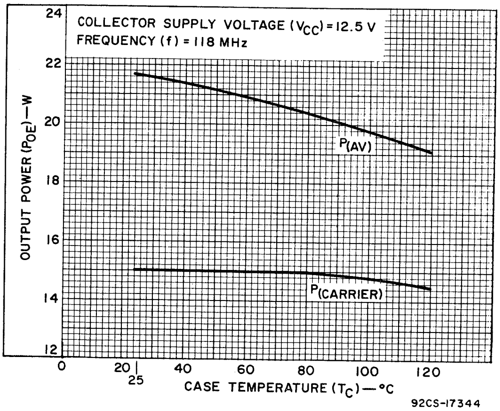


Fig. 4 - Typical output power vs. case temperature.

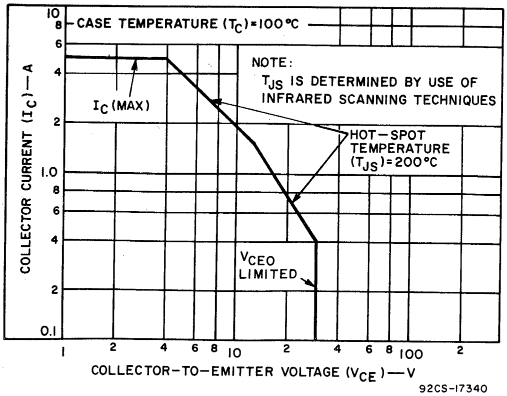


Fig. 5 - Safe area for dc operation.

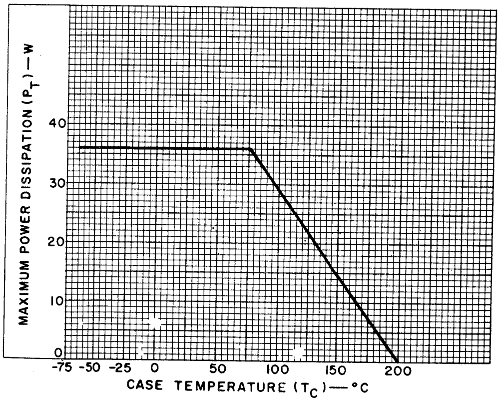
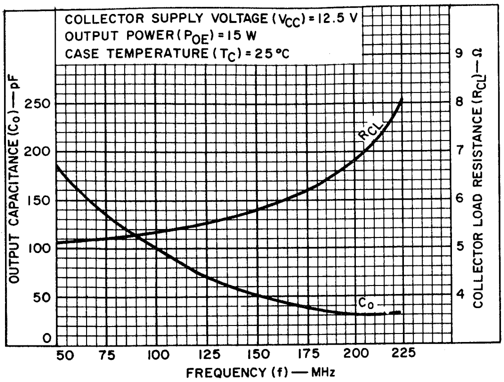


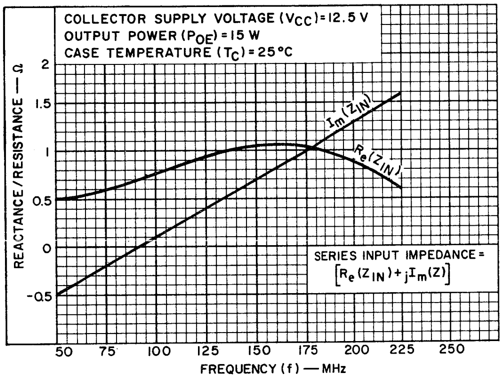
Fig. 6 - RF dissipation derating.

DESIGN DATA



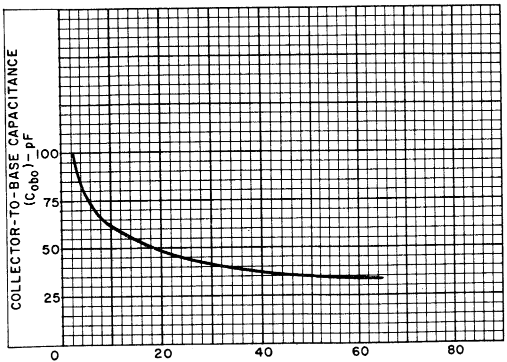
92CS-17339

Fig. 7 - Typical large-signal parallel collector load and parallel output capacitance vs. frequency.



92CS-17342

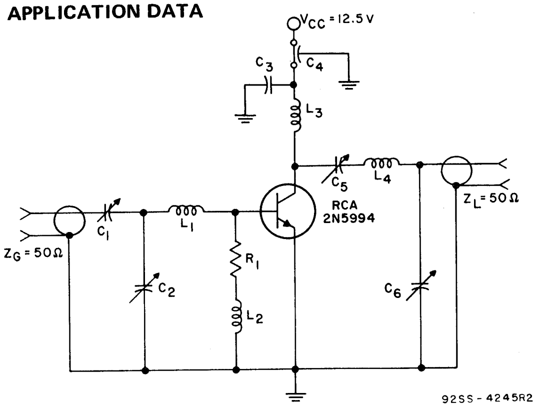
Fig. 8 - Typical large-signal series input impedance vs. frequency.



92SS-4228

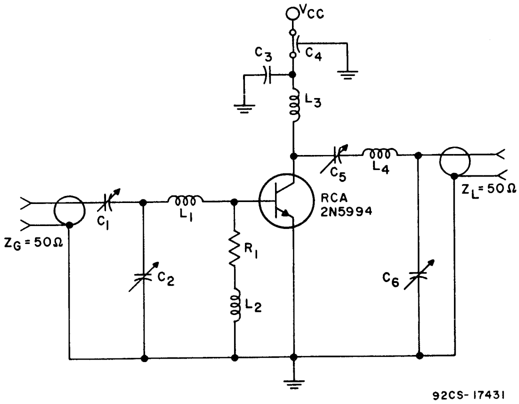
Fig. 9 - Typical collector-to-base capacitance vs. collector-to-base voltage.

APPLICATION DATA



C1, C5: 3-35 pF, Arco 403 or equiv.
C2: 8-60 pF, Arco 404 or equiv.
C3: 0.1 μF ceramic
C4: 1000 pF feedthrough
C6: 14-150 pF, Arco 424 or equiv.
R1: 1Ω, 1 W (wirewound)
L1: 2 turns No. 16 wire ¼ in. dia. 1/8 in. long
L2: RFC 1.2 μH
L3: 2 turns No. 14 wire, 3/8 in. dia., 3/16 in. long
L4: 3 turns No. 14 wire, 3/8 in. dia., ¼ in. long

Fig. 10 - 118—MHz amplifier for power output test.



C1, C2, C5: 3-35 pF, ARCO 403 or equiv.
C3: 0.1 μF ceramic
C4: 1000 pF feedthrough
C6: 7-100 pF ARCO 423 or equiv.
R1: 1Ω, 1 W (wirewound)
L1: 1 turn No. 16 wire ¼ in. dia. 1/8 in. long.
L2: RFC 1.2 μH
L3: 2 turns No. 14 wire 3/8 in. dia. 3/16 in. long
L4: 3 turns No. 14 wire 3/8 in. dia. ¼ in. long

NOTE: (1) 150 MHz, V_{CC} = 12.5 V, Modulated
(2) 175 MHz, V_{CC} = 28 V, Unmodulated

Fig. 11 - Typical 150- or 175-MHz rf power amplifier.

APPLICATION DATA

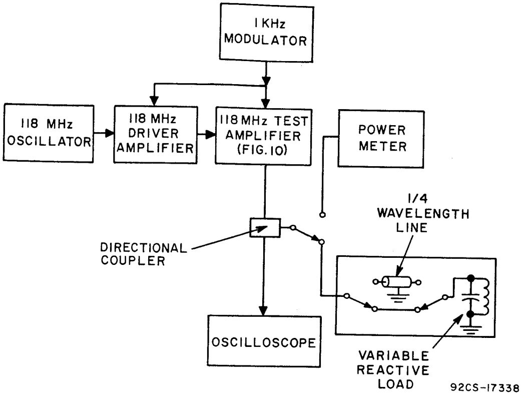


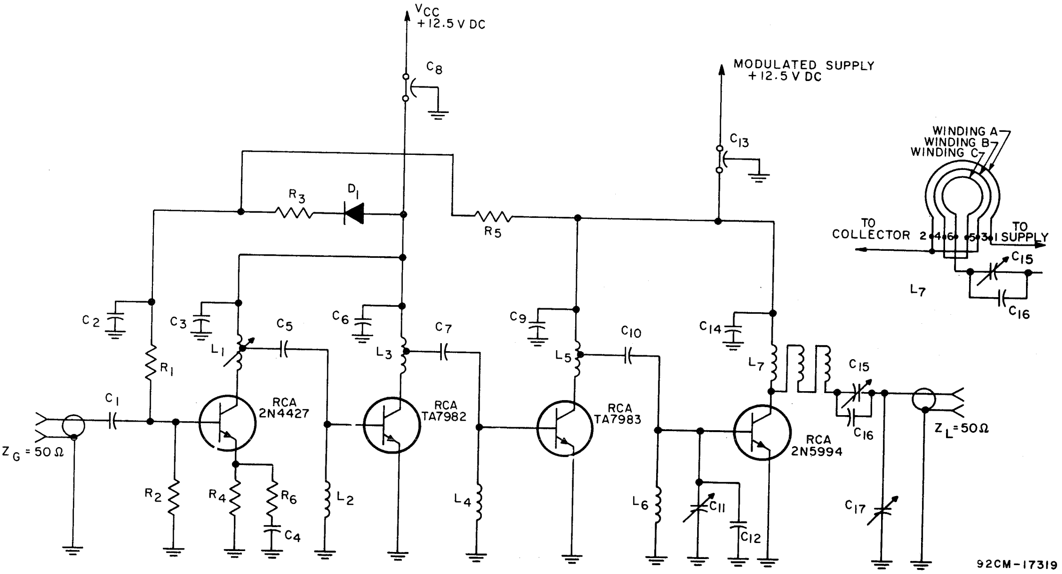
Fig. 12 - Test setup for testing output power, modulation index, and load-mismatch capability.

SPECIAL PERFORMANCE DATA

The infinite load-mismatch capability of the transistor can be demonstrated in the following test:

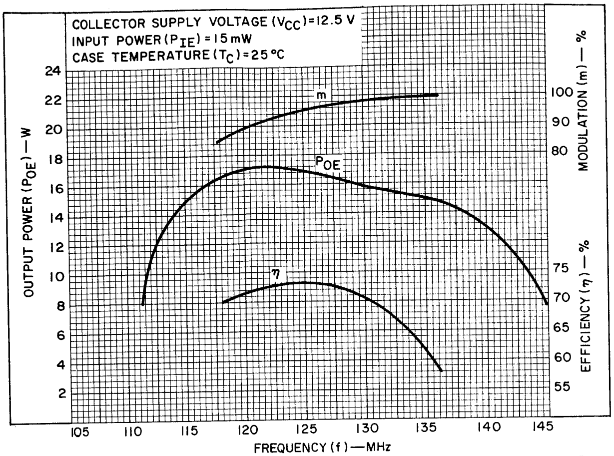
1. The test setup is shown in Fig. 12.
2. The tuning network is varied through a half wavelength, which effectively varies the load from an open circuit to a short circuit.
3. Operating conditions are as follows: V_{CC} = 12.5 V, rf output carrier power = 15 W under full modulation.

Care should be taken not to exceed the maximum junction temperature by providing sufficient heatsinking during the above test to prevent device damage or degradation.



C1: 91 pF silver mica
C2, C3, C9, C14: 0.01 μF ceramic
C4: 200 pF silver mica
C5: 50 pF silver mica
C6: 0.001 μF ceramic
C7: 56 pF silver mica
C8, C13: 1000 pF feedthrough
C10, C12: 68 pF silver mica
C11, C15: 8-60 pF, ARCO 404 or equivalent
C16: 10 pF silver mica
C17: 3-35 pF, ARCO 403 or equivalent
D1: 1N3193
R1: 2,7 kΩ, ½ W
R2: 470 Ω, ½ W
R3, R5: 5.1 Ω, ½ W
R4: 51Ω
R6: 20Ω, ¼ W
L1: 6 turns No. 18 wire, 0.225-in. dia., 0.4-in. long; tapped at 4½ turns from collector
L2, L4, L6: RFC 1 turn No. 28 wire, ferrite bead, Ferroxcube No. 56-590-65/4B or equivalent
L3: 7½ turns No. 18 wire, 0.15-in. dia., 0.55-in. long; tapped at 5½ turns from collector
L5: 5 turns No. 18 wire, 0.225-in. dia., 0.35-in. long; tapped at 2½ turns from collector
L7: 3 strands No. 20 enameled wire twisted at 6 turns/in., formed in a loop of 3/8-in. dia., then cross-connected as shown

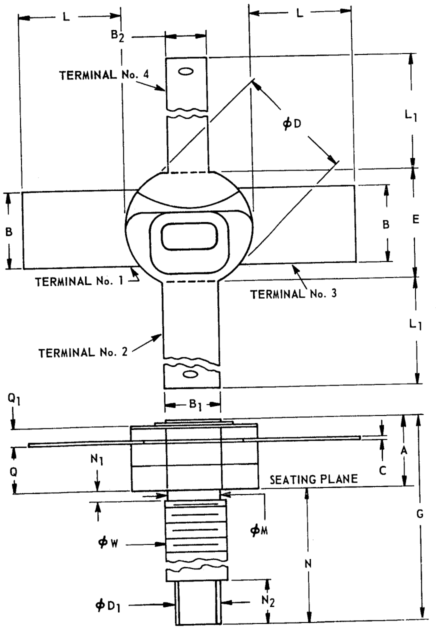
Fig. 13 - 15-Watt amplitude-modulated amplifier for 118–136 MHz operation.



92CS-17343

Fig. 14 - Typical broadband performance of the 118–136 MHz amplifier circuit shown in Fig. 13.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
ϕD	0.305	0.320	7.48	8.12	–
$ϕD_1$	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	–
G	0.590	0.705	14.99	17.90	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0.510	11.56	12.95	–
ϕM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
ϕW	0.1399	0.1437	3.531	3.632	2

Millimeter dimensions are derived from original inch dimensions

NOTES:

1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

WARNING: RCA Type **2N5994** should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor because the dust resulting from such action may be hazardous if inhaled.

TERMINAL CONNECTIONS

Terminals 1, 3 - Emitter

Terminal 2 - Base

Terminal 4 - Collector

RCA
Solid State
Division

RF Power Transistors
40290
40291
40292

RCA-40290, 40291, and 40292 are epitaxial planar transistors of the silicon n-p-n type. They employ an "overlay" emitter electrode design and are intended for low-voltage, high-power output, amplitude modulated, VHF Class-C amplifier service.

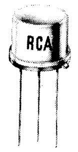
The voltage ratings for these transistors include RF voltage breakdown characteristics necessary to assure safe transistor operation with high RF voltages on the collector; a condition normally encountered in amplitude-modulated Class-C amplifiers.

For Low Supply Voltage, High Power Output, Amplitude Modulated, VHF Class-C Amplifier Service in Aircraft, Military, and Industrial Communications Equipment

RF SERVICE

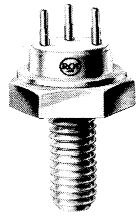
Maximum Ratings, *Absolute-Maximum Values:*

	40290	40291	40292	
COLLECTOR-TO-EMITTER VOLTAGE:				
With V_{BE} = -1.5 volts, V_{CEX}	50	50	50	volts
At f = 100 Mc, $V_{CEV}(RF)$.	90	90	90	volts
EMITTER-TO-BASE VOLTAGE, V_{EBO}	4	4	4	volts
COLLECTOR CURRENT, I_C . .	0.5	0.5	1.25	amperes
TRANSISTOR DISSIPATION, P_T:				
At case temperatures up to 25° C.	7.0	11.6	23.2	watts
At case temperatures above 25° C.	Derate linearly to 0 watts at 200° C			
TEMPERATURE RANGE:				
Storage.		-65 to 200°C		
Operating (Junction) .		-65 to 200°C		
PIN OR LEAD TEMPERATURE (During soldering): At distances ≥ 1/32 from insulating wafer (TO-60 package) or from seating plane (TO-39 package) for 10 seconds maximum .			230	°C



40290

JEDEC TO-39



40291,40292

JEDEC TO-60

FEATURES

- High carrier output power as 135 Mc Class-C amplifier with 12.5 volt collector supply voltage
  40290 — 2 watts (min.) at P_{IN} = 0.5 watt
  40291 — 2 watts (min.) at P_{IN} = 0.5 watt
  40292 — 6 watts (min.) at P_{IN} = 2.0 watts
- 100% testing of all transistors performed to assure excellent upward modulation characteristics
- High collector efficiency at 135 Mc
- All electrodes isolated from case (40291 and 40292)

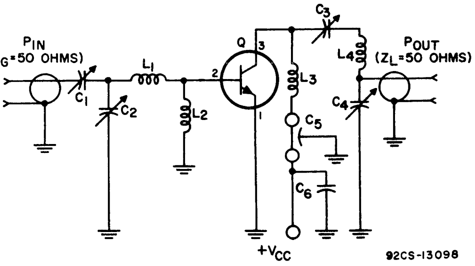
ELECTRICAL CHARACTERISTICS, *At Case Temperature (T_C) = 25° C*

Characteristic	Symbol	TEST CONDITIONS: DC Collector Volts V_{CB}	V_{CE}	DC Base Volts V_{BE}	DC Current (Milliamperes) I_E	I_B	I_C	LIMITS: Type 40290 Min.	Max.	Type 40291 Min.	Max.	Type 40292 Min.	Max.	Units
Collector Cutoff Current	I_{CEO}		15			0		-	100	-	100	-	250	μa
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4.0	-	4.0	-	-	-	volts
					0.25		0	-	-	-	-	4.0	-	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEX}			-1.5			200[a]	50	-	50	-	50	-	volts
	$V_{CEV}(RF)$			-2			50	90[b]	-	90[b]	-	-	-	volts
				-2			100	-	-	-	-	90[b]	-	volts
Real Part of Common-Emitter Input Impedance (At f = 135 Mc)	$h_{ie}(real)$		12.5				100	12 (typ.)		12 (typ.)		-	-	ohms
			12.5				400	-	-	-	-	6.5 (typ.)		ohms
RF Carrier Power Output: As Class-C Amplifier, (At f = 135 Mc)	P_{OUT}		12.5					2.0[c]	-	2.0[c]	-	6.0[d]	-	watts
Gain-Bandwidth Product	f_T		12.5				100	500 (typ.)		500 (typ.)		-	-	Mc
			12.5				400	-	-	-	-	300 (typ.)		Mc
Collector-to-Base Capacitance (At f = 1 Mc)	C_{ob}	12.5			0			-	17	-	17	-	30	pf
Collector-to-Case Capacitance	C_s							-	-	-	6.0	-	6.0	pf
Thermal Resistance (Junction-to-Case)	$\theta_{J\text{-}C}$							-	25	-	15	-	7.5	°C/w

[a] Pulsed through an inductor (25 mh); R_{BE} = 39 ohms; duty factor = 50%.
[b] At frequencies of 100 Mc or higher.
[c] For P_{IN} = 0.5 w; minimum efficiency = 70%.
[d] For P_{IN} = 2.0 w; minimum efficiency = 70%.

RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST
(135-Mc Operation)

	Q = 40290, 40291	**Q = 40292**
C_1, C_3	3-35 pf	3-35 pf
C_2, C_4	8-60 pf	8-60 pf
C_5	1000 pf	1000 pf
C_6	0.02 μf	0.02 μf
L_1	3 turns No.16 wire, 5/16" ID, 5/16" long	3 turns No.16 wire, 5/16" ID, 5/16" long
L_2	Ferrite choke, Z = 450 ohms	wire wound resistor, R = 2.4 ohms
L_3	3 turns No.18 wire, 1/4" ID, 5/16" long	1 turn No.16 wire, 5/16" ID, 1/8" long
L_4	5 turns No.16 wire, 7/16" ID, 5/8" long	4 turns No.16 wire, 7/16" ID, 3/8" long

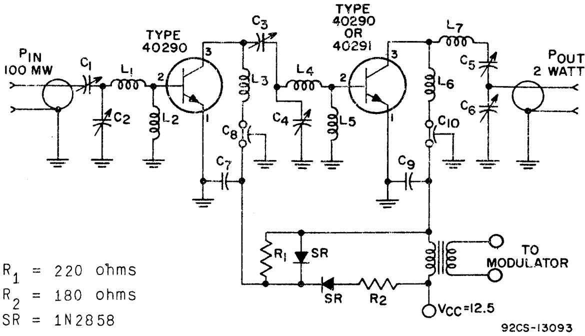


AMPLITUDE-MODULATED AMPLIFIER

135-Mc Operation, Carrier Power = 2 watts minimum, Bandwidth = 5%

C_1, C_3, C_5 = 3-35 pf
C_2, C_4, C_6 = 8-60 pf
C_7, C_9 = 0.03 μf
C_8, C_{10} = 1000 pf
L_1 = 3 turns No.16 wire, 1/4" ID, 1/4" long
L_2, L_5 = Ferrite choke, Z = 450 ohms
L_3 = RF choke, 1.5 μh
L_4 = 4 turns No.16 wire, 1/4" ID, 3/8" long
L_6 = 3 turns No.18 wire, 3/16" ID, 3/8" long
L_7 = 5 turns No.16 wire, 3/8" ID, 1/2" long

R_1 = 220 ohms
R_2 = 180 ohms
SR = 1N2858

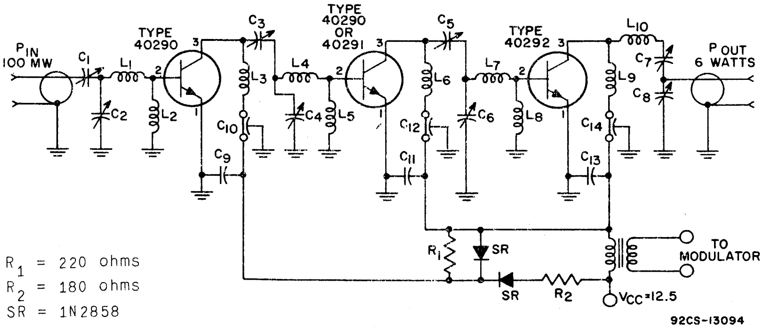


AMPLITUDE-MODULATED AMPLIFIER

135-Mc Operation, Carrier Power = 6 watts minimum, Bandwidth = 5%

C_1, C_3, C_5, C_7 = 3-35 pf
C_2, C_4, C_6, C_8 = 8-60 pf
C_9, C_{11}, C_{13} = 0.03 μf
C_{10}, C_{12}, C_{14} = 1000 pf
L_1, L_9 = 3 turns No.16 wire, 1/4" ID, 1/4" long
L_2, L_5 = Ferrite choke, Z = 450 ohms
L_3 = RF choke, 1.5 μh
L_4, L_7 = 4 turns No.16 wire, 1/4" ID, 3/8" long
L_6 = RF choke, 1.0 μh
L_8 = wire wound resistor, R = 2.4 ohms
L_{10} = 5 turns No.16 wire, 3/8" ID, 1/2" long

R_1 = 220 ohms
R_2 = 180 ohms
SR = 1N2858

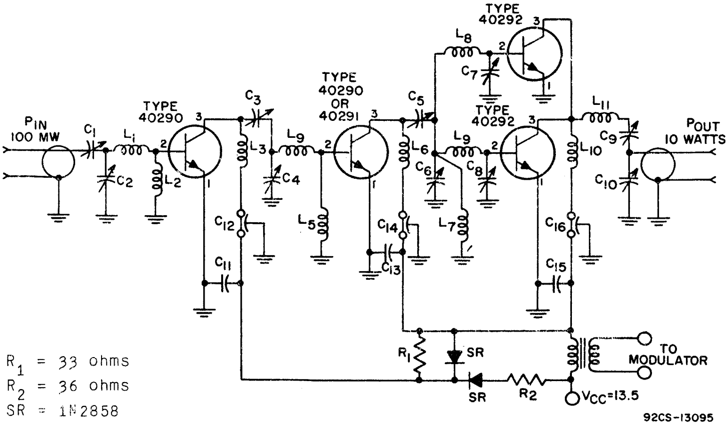


AMPLITUDE-MODULATED AMPLIFIER

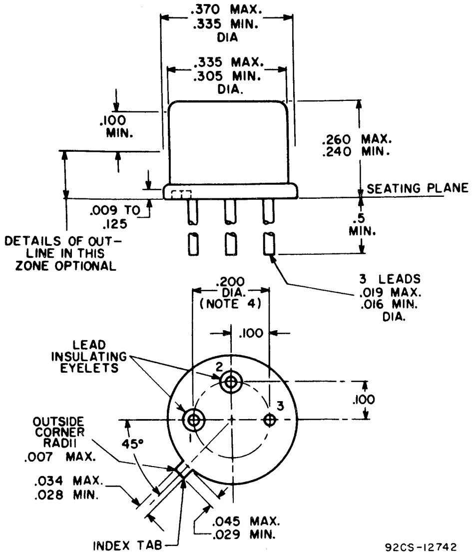
135-Mc Operation, Carrier Power = 10 watts minimum, Bandwidth = 5%

C_1, C_3, C_5, C_9 = 3-35 pf
C_2, C_4, C_6, C_{10} = 8-60 pf
C_7, C_8 = 1.5-20 pf
C_{11}, C_{13}, C_{15} = 0.03 μf
C_{12}, C_{14}, C_{16} = 1000 pf
L_1 = 3 turns No.16 wire, 1/4" ID, 1/4" long
L_2, L_5 = Ferrite choke, Z = 450 ohms
L_3 = RF choke, 1.5 μh
L_4 = 4 turns No.16 wire, 1/4" ID, 3/8" long
L_6, L_7 = RF choke, 1.0 μh
L_8, L_9 = 3 turns No.16 wire, 1/4" ID, 3/8" long
L_{10} = 1 turn No.16 wire, 5/16" ID, 1/8" long
L_{11} = 4 turns No.16 wire, 3/8" ID, 1/2" long

R_1 = 33 ohms
R_2 = 36 ohms
SR = 1N2858



DIMENSIONAL OUTLINE FOR TYPE 40290 JEDEC TO-39



Dimensions in Inches

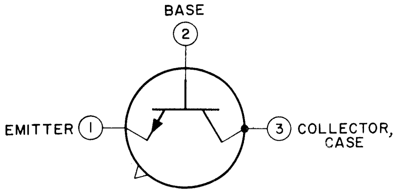
NOTE 1: THIS ZONE IS CONTROLLED FOR AUTOMATIC HANDLING. THE VARIATION IN ACTUAL DIAMETER WITHIN THE ZONE SHALL NOT EXCEED 0.010".

NOTE 2: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050" AND 0.250" FROM THE SEATING PLANE. BETWEEN 0.250" AND 1.5", A MAXIMUM OF 0.021" DIAMETER IS HELD. OUTSIDE OF THESE ZONES THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 3: MEASURED FROM MAXIMUM DIAMETER OF THE ACTUAL DEVICE.

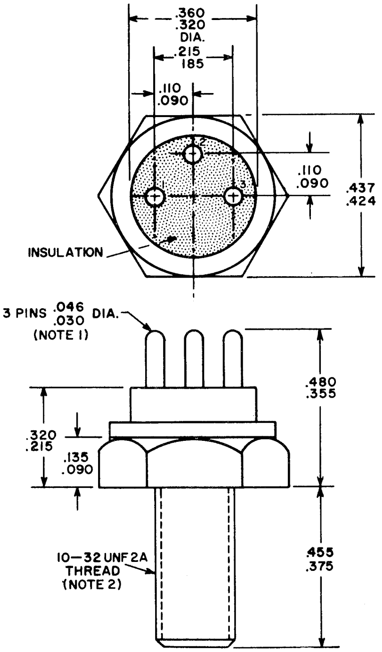
NOTE 4: LEADS HAVING MAXIMUM DIAMETER (0.019") MEASURED IN GAUGING PLANE OF 0.054" + 0.001" − 0.000" BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN 0.007" OF THEIR TRUE LOCATIONS RELATIVE TO A MAXIMUM-WIDTH TAB.

TERMINAL DIAGRAM



(Bottom View)

DIMENSIONAL OUTLINE FOR TYPES 40291 & 40292 JEDEC TO-60



Dimensions in Inches 92CS-12045R5

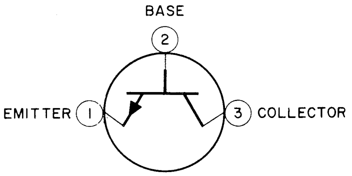
NOTE 1: THE PIN SPACING PERMITS INSERTION IN ANY SOCKET HAVING A PIN-CIRCLE DIAMETER OF 0.200" AND CONTACTS WHICH WILL ACCOMMODATE PINS HAVING A DIAMETER OF 0.035" MINIMUM, 0.045" MAXIMUM.

NOTE 2: THE TORQUE APPLIED TO A 10-32 HEX NUT ASSEMBLED ON THE THREAD DURING INSTALLATION SHOULD NOT EXCEED 12 INCH-POUNDS.

NOTE 3: THIS DEVICE MAY BE OPERATED IN ANY POSITION.

NOTE 4: ALL ELECTRODES ISOLATED FROM CASE.

TERMINAL DIAGRAM



(Bottom View)

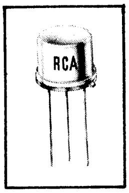
VHF Broadband Types

RCA
Solid State
Division

RF Power Transistors
2N1491
2N1492
2N1493

RCA-2N1491, 2N1492, and 2N1493 are triple-diffused transistors of the silicon n-p-n type. These transistors are intended for a wide variety of applications in industrial and military electronic equipment. They are particularly useful in large-signal power-amplifier, video-amplifier, and oscillator circuits operating in the HF and VHF regions over wide ranges of ambient temperature.

VHF Amplifier & Oscillator Service



JEDEC TO-39

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

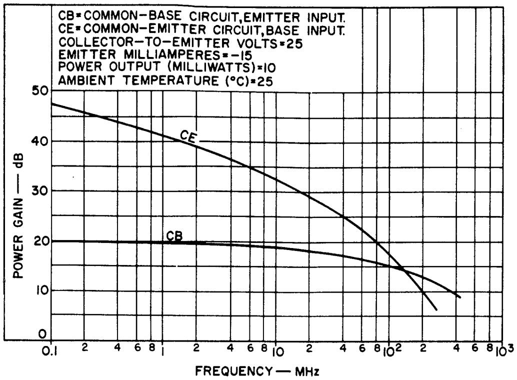
		2N1491	2N1492	2N1493		
COLLECTOR-TO-BASE VOLTAGE . . .	V_{CBO}	30	60	100	max.	V
COLLECTOR-TO-EMITTER VOLTAGE:						
With emitter-to-base reverse biased. .	V_{CEV}	30	60	100	max.	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	1	2	4.5	max.	V
COLLECTOR CURRENT	I_C	500	500	500	max.	mA
EMITTER CURRENT		500	500	500	max.	mA
TRANSISTOR DISSIPATION, See *Fig.3:*	P_T					
Operation in free air:						
Ambient temperature = 25° C . . .		0.5	0.5	0.5	max.	W
Ambient temperature = 100° C . . .		0.25	0.25	0.25	max.	W
Operation with heat sink:						
Case temperature = 25° C		3	3	3	max.	W
Case temperature = 100° C		1.5	1.5	1.5	max.	W
AMBIENT TEMPERATURE RANGE:						
Operating and storage			−65 to +175			°C

- **High V_{CB} Ratings – up to 100 V**
- **High Transistor-Dissipation Ratings – up to 3 watts**
- **High Typical f_T at I_C = 25 mA – up to 380 MHz**
- **High Typical Power Gain at 70 MHz – up to 12 db at 500-mW output**
- **JEDEC TO-39 Package**

ELECTRICAL CHARACTERISTICS, *Ambient Temperature = 25° C*

Characteristics	Symbol	TEST CONDITIONS: DC Collector Voltage (volts) V_{CB}	DC Collector Voltage (volts) V_{CE}	DC Collector Current (mA)	DC Emitter Current (mA)	LIMITS: Type 2N1491 Min.	Type 2N1491 Max.	Type 2N1492 Min.	Type 2N1492 Max.	Type 2N1493 Min.	Type 2N1493 Max.	Units
Collector Breakdown Voltage	BV_{CBO}			0.1	0	30		60		100		volts
Collector Cutoff Current	I_{CBO}	12			0		10		10		10	µA
Emitter Cutoff Current	I_{EBO}		V_{EB} 0.5	0			100		100		100	µA
Collector-to-Base and Stem Capacitance	–	30			0		5		5		5	pF
Small-Signal Current Transfer Ratio: at 1 KHz	h_{fe}		20	15		15	200	15	200	15	200	
Power Gain at 70 MHz Power Output (mW) See *Fig.11* = 10	PG	20			−15	13						dB
= 100		30			−15			13				dB
= 500		50			−25					10		dB
Thermal Resistance Junction-to-case	R_T						50		50		50	°C/W

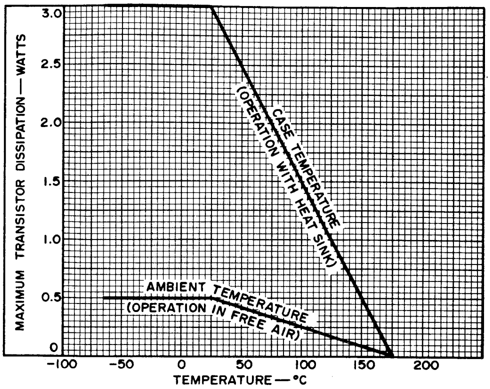
PERFORMANCE CHARACTERISTICS



92CS-10517R1

Fig. 1

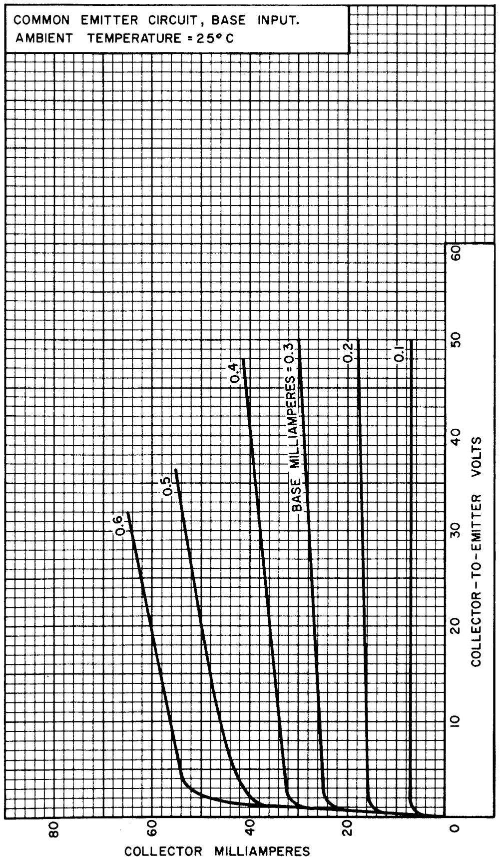
DISSIPATION DERATING GRAPH



92CS-10506R2

Fig. 3

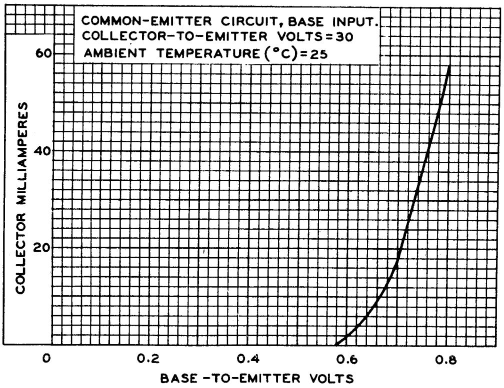
TYPICAL COLLECTOR CHARACTERISTICS



92LM-1497

Fig. 2

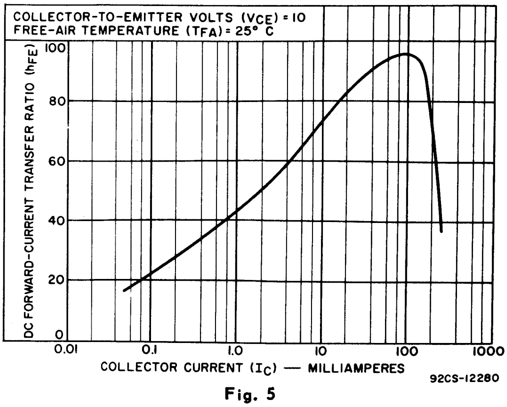
TYPICAL CHARACTERISTICS



92CS-10508

Fig. 4

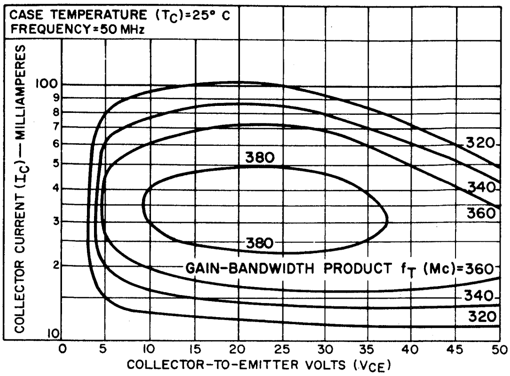
TYPICAL DC BETA CHARACTERISTICS



92CS-12280

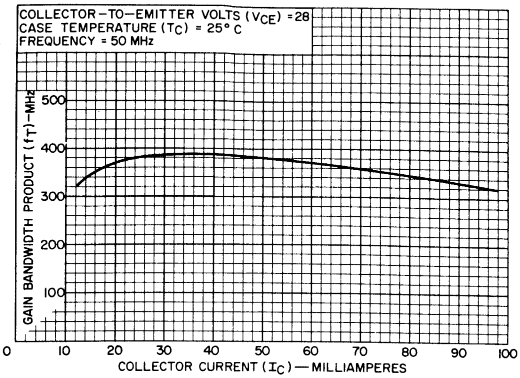
Fig. 5

TYPICAL SMALL-SIGNAL OPERATION CHARACTERISTICS



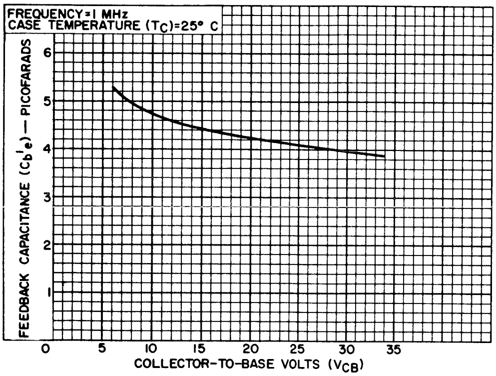
92CS-12286

Fig. 6



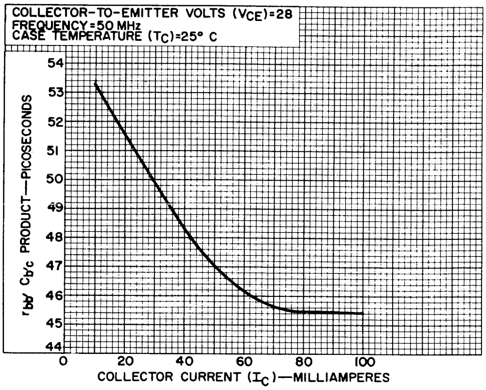
92CS—12287

Fig. 7



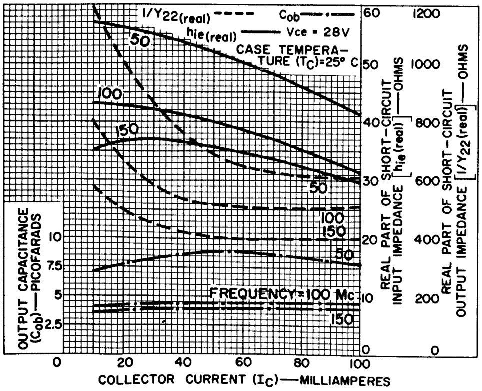
92CS-12283R1

Fig. 8



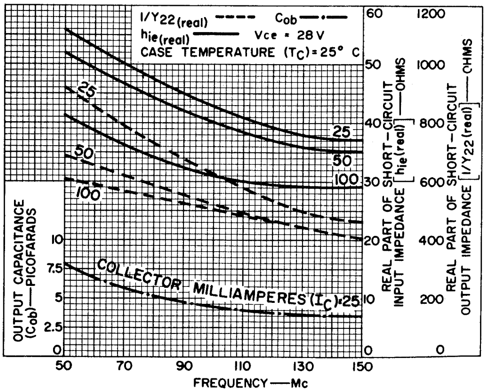
92CS-12284

Fig. 9



92CS-12289R1

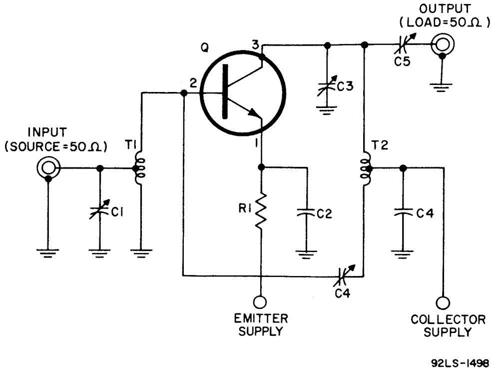
Fig. 10



92CS-12288R1

Fig. 11

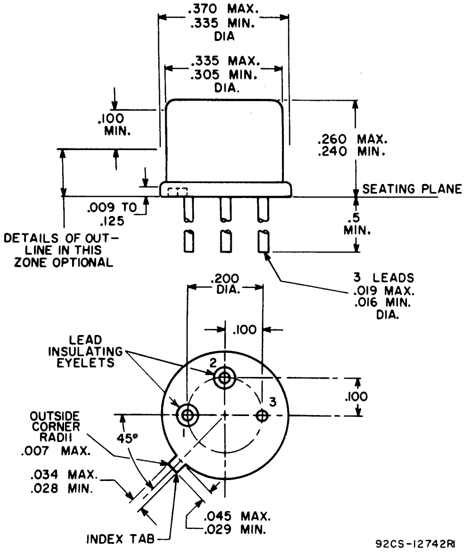
POWER GAIN TEST CIRCUIT



C_1: 3-20 pF variable
C_2, C_6: 0.01 μF
C_3: 3-20 pF variable
C_4: 7-100 pF variable
C_5: 3-20 pF variable
Q: All Types
T_1: 8 turns No.24 wire tapped at 1 turn
T_2: 8 turns No.24 wire tapped at 2.5 turns

Fig. 12

DIMENSIONAL OUTLINE
JEDEC TO-39



DIMENSIONS IN INCHES

TERMINAL CONNECTIONS

Lead No.3 – Emitter

Lead No.2 – Base

Case, Lead No.3 – Collector

RCA

Solid State
Division

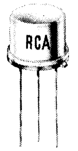
RF Power Transistors

2N2631
2N2876

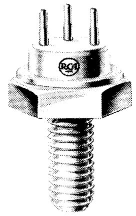
For Large-Signal, High-Power, VHF Applications in Military and Industrial Communications Equipment

RCA-2N2876 and 2N2631 are triple-diffused planar transistors of the silicon n-p-n type. These devices are intended for applications in AM, FM, and CW service at frequencies up to 150 Mc.

The 2N2876 utilizes a stud-mounted TO-60 package which is electrically isolated from all the electrodes and is designed to provide excellent performance at very high frequencies. The 2N2631 TO-39 package is identical to the JEDEC TO-5 package except for shorter leads (0.5 inch).



JEDEC TO-39



JEDEC TO-60

RF SERVICE

Maximum Ratings, *Absolute-Maximum Values:*

	2N2876	2N2631		
COLLECTOR-TO-BASE VOLTAGE, V_{CBO} . . .	80	80	max.	volts
COLLECTOR-TO-EMITTER VOLTAGE:				
With base open, V_{CEO} .	60	60	max.	volts
With V_{BE} = -1.5 volts, V_{CEV} . . .	80	80	max.	volts
EMITTER-TO-BASE VOLTAGE, V_{EBO} . . .	4	4	max.	volts
COLLECTOR CURRENT, I_C .	2.5	1.5	max.	amp
TRANSISTOR DISSIPATION, P_T:				
At case temperatures up to 25°C	17.5	8.75	max.	watts
At case temperatures above 25°C	Derate linearly 100mw/°C	Derate linearly 50 mw/°C		
TEMPERATURE RANGE:				
Storage.	-65to+200	-65to+200		°C
Operating (Junction)	-65to+200	-65to+200		°C
LEAD TEMPERATURE (During soldering):				
At distances ≥ 1/32" from ceramic wafer for 10 sec. max. .	230	-	max.	°C
At distances ≥ 1/32" from seating surface for 10 sec. max. .	-	230	max.	°C

- High Power Output, Unneutralized (P_{OUT}):
  - 10 w min. at 50 Mc, 3 w min. at 150 Mc — 2N2876
  - 7.5 w min. at 50 Mc, 3 w min. at 150 Mc — 2N2631
- High Voltage Ratings:
  - V_{CBO} = 80 volts max.
  - V_{CEO} = 60 volts max.
- 100 per cent tested to assure freedom from second breakdown in class A operation at maximum ratings

RCA-2N2876 Features:

- Low Thermal Resistance (θ_{J-C})—
  - high-thermal-conductivity ceramic insulation between collector and mounting stud
- Isolated Stud Package:
  - all three electrodes electrically isolated from case —for design flexibility
  - heavy copper mounting stud—for effective contact with heat sink
  - pin terminals arranged on a .200" pin-circle diameter —fit commercially available sockets

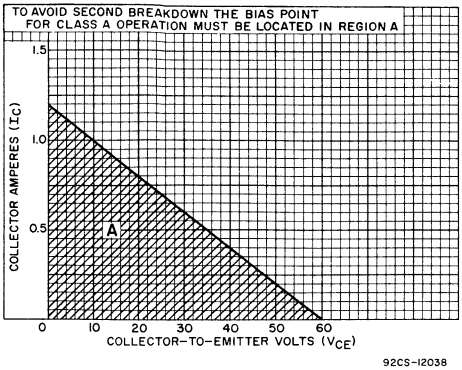


Fig. 1 - Region of Safe Operation (Without second breakdown) in Class A Service for Type 2N2876.

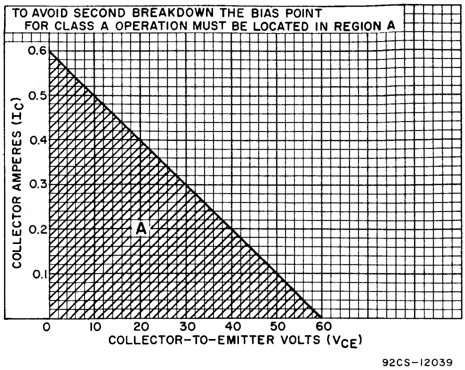


Fig. 2 - Region of Safe Operation (Without second breakdown) in Class A Service for Type 2N2631.

ELECTRICAL CHARACTERISTICS

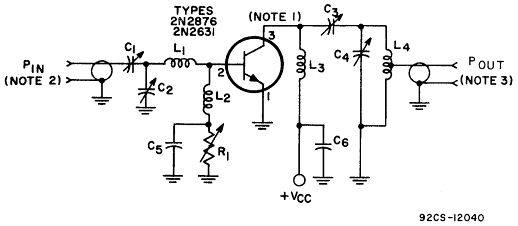
Case Temperature = 25° C Unless Otherwise Specified

Characteristic	Symbol	TEST CONDITIONS						LIMITS				Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)			2N2876		2N2631		
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	Min.	Max.	
Collector-Cutoff Current	I_{CBO}	30			0			-	0.1	-	0.1	μa
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.5	80	-	80	-	volts
Collector-to-Emitter Breakdown Voltage (Sustaining)	$BV_{CEO}(sus)$					0	500*	60	-	60	-	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEV}			-1.5			0.1	80	-	80	-	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4	-	4	-	volts
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					300	1.5 amp	-	-	-	1	volt
						500	2.5 amp	-	1	-	-	volt
Feedback Capacitance (Measured at 140 Kc)	$C_{b'c}$	30			0			-	20	-	20	pf
RF Power Output, Unneutralized (see *Fig.3*):	P_{out}											
Measured at 50 Mc			28				500	10^a	-	-	-	watts
50 Mc			28				375	-	-	7.5^b	-	watts
150 Mc			28				275	3^b	-	3^b	-	watts
Gain-Bandwidth Product	f_T		28				250	200 (typ.)		200 (typ.)		Mc
Base Spreading Resistance (Measured at 400 Mc)	$r_{bb'}$		28				250	6.0 (typ.)		6.0 (typ.)		ohms
Collector-to-Case Capacitance	C_c							-	6	-	-	pf

* Pulsed. Pulse duration $\leq$ 5 μsec; duty factor $\leq$ 1%.

[a] For P_{IN} = 2 watts.

[b] For P_{IN} = 1 watt.



NOTE 1: COLLECTOR GROUNDED TO CASE IN TYPE 2N2631; SEE *TERMINAL DIAGRAM.*

NOTE 2: GENERATOR IMPEDANCE = 50 OHMS.

NOTE 3: LOAD IMPEDANCE = 50 OHMS.

	For 50-Mc Operation		For 150-Mc Operation
$C_1 C_2 C_3 C_4$	8-60 pf	$C_1 C_2 C_3 C_4$	4-40 pf
$C_5 C_6$	0.005 µf	$C_5 C_6$	0.005 µf
L_1	8 turns No. 16 wire, 3/8" ID x 9/16" long	L_1	1 turn No. 16 wire, 1/4" ID x 3/16" long
L_2	Ferrite choke, Z = 750 (±20%) ohms	L_2	Ferrite choke, Z = 750 (±20%) ohms
L_3	10 µh	L_3	1.5 µh
L_4	7 turns No. 14 wire, 1/2" ID x 7/8" long tap 2 turns from ground end	L_4	3 turns No. 14 wire, 3/8" ID x 3/4" long tap 1-1/2 turns from ground end
R_1	5000 ohms	R_1	50 ohms

Fig. 3 - Circuit of Unneutralized Amplifier Used to Measure Power Output of Types 2N2876 and 2N2631.

TYPICAL OPERATION CHARACTERISTICS FOR TYPE 2N2876

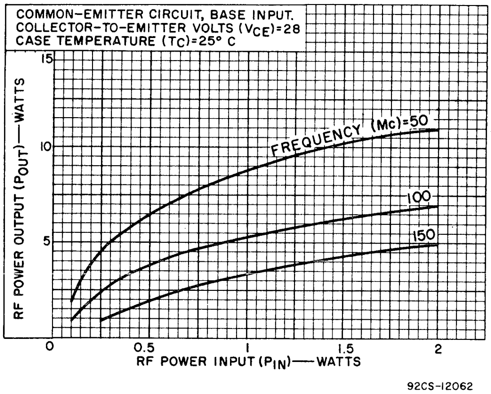


Fig. 4

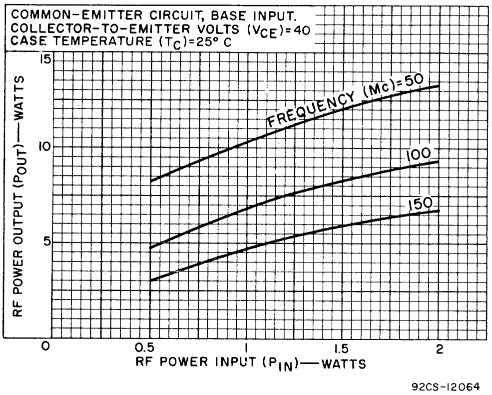
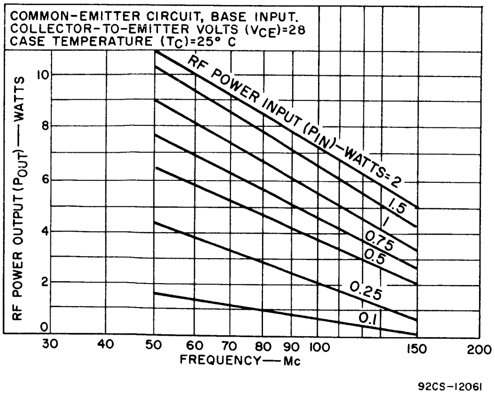
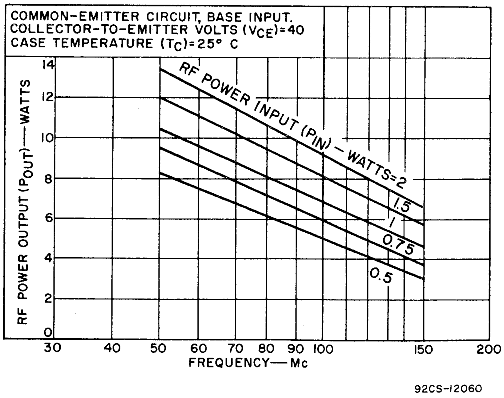


Fig. 6





TYPICAL OPERATION CHARACTERISTICS FOR TYPE 2N2631

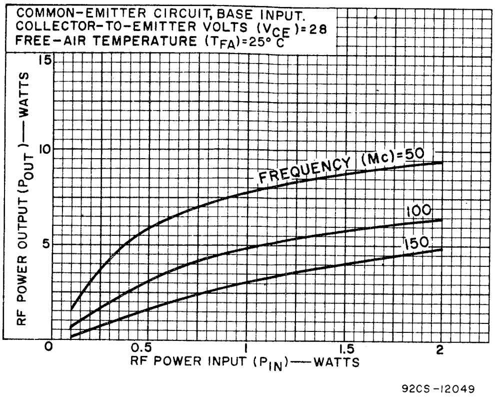


Fig. 8

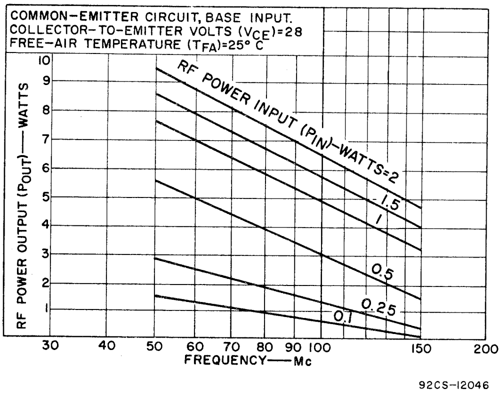


Fig. 9

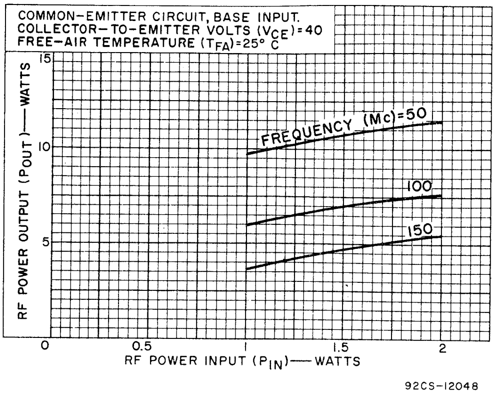


Fig. 10

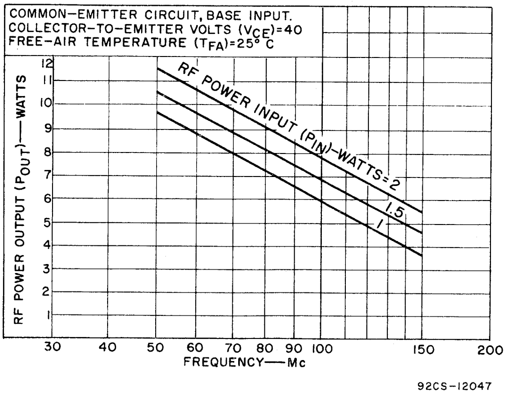
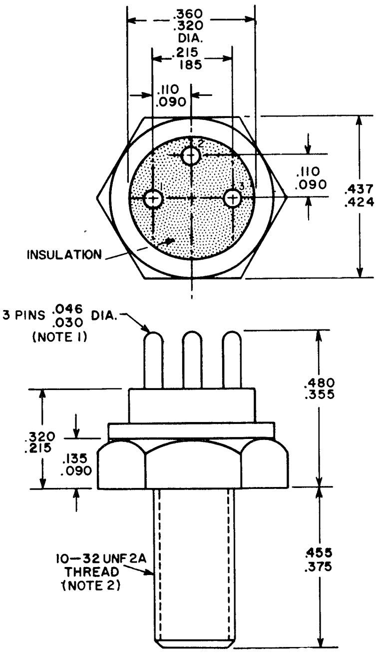


Fig. 11

DIMENSIONAL OUTLINES

2N2876



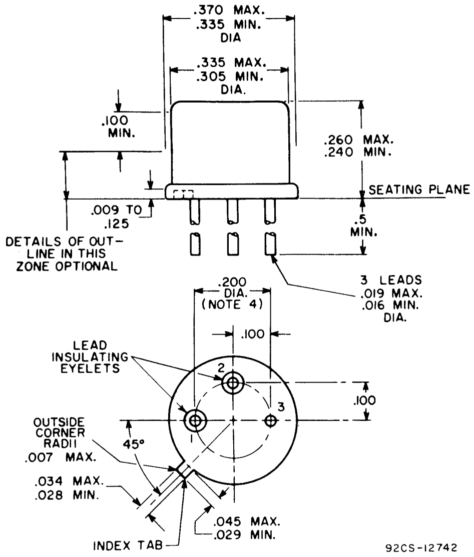
92CS-12045R5

NOTE 1: THE PIN SPACING PERMITS INSERTION IN ANY SOCKET HAVING A PIN-CIRCLE DIAMETER OF 0.200" AND CONTACTS WHICH WILL ACCOMMODATE PINS HAVING A DIAMETER OF 0.035" MIN., 0.045" MAX.

NOTE 2: THE TORQUE APPLIED TO A 10–32 HEX NUT ASSEMBLED ON THE THREAD DURING INSTALLATION SHOULD NOT EXCEED 12 INCH-POUNDS.

NOTE 3: THIS DEVICE MAY BE OPERATED IN ANY POSITION.

2N2631



92CS-12742

NOTE 1: THIS ZONE IS CONTROLLED FOR AUTOMATIC HANDLING. THE VARIATION IN ACTUAL DIAMETER WITHIN THE ZONE SHALL NOT EXCEED 0.010".

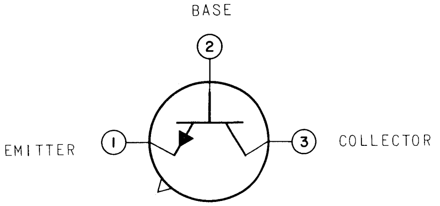
NOTE 2: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050" AND 0.250" FROM THE SEATING PLANE. BETWEEN 0.250" AND 1.5", A MAXIMUM OF 0.021" DIAMETER IS HELD. OUTSIDE OF THESE ZONES THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 3: MEASURED FROM MAX. DIAMETER OF THE ACTUAL DEVICE.

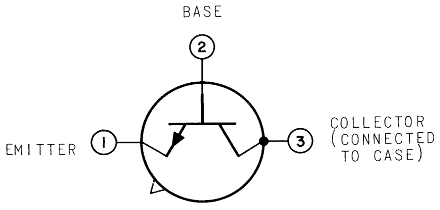
NOTE 4: LEADS HAVING MAXIMUM DIAMETER (0.019") MEASURED IN GAUGING PLANE OF 0.054" + 0.001" – 0.000" BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN 0.007" OF THEIR TRUE LOCATIONS RELATIVE TO A MAXIMUM-WIDTH TAB.

TERMINAL DIAGRAMS
(Bottom View)

2N2876



2N2631



RCA

Solid State
Division

RF Power Transistors

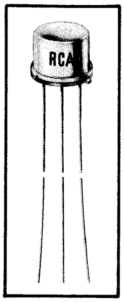
2N3118

RCA-2N3118 is a triple-diffused planar transistor of the silicon n-p-n type intended for use in RF amplifiers in military and industrial HF and VHF communication equipment. It is designed especially for large-signal Class-C and small-signal Class-A service.

Maximum Ratings, *Absolute-Maximum Values:*

Collector-to-Emitter Voltage:		
Reverse bias (V_{CEX})		
For V_{BE} = -1.5 volts.	85 max.	volts
With base open (V_{CEO})	60 max.	volts
Emitter-to-Base Voltage (V_{EBO}). .	4 max.	volts
Collector Current (I_C).	0.5 max.	ampere
Transistor Dissipation (P_T):		
At case temperatures up to 25° C	4 max.	watts
At free-air temperatures up to 25° C	1 max.	watt
At temperatures above 25° C . . . . .See *Fig.1*		
Temperature Range:		
Storage	-65 to +200	°C
Operating (Junction).	-65 to +200	°C

For Large-Signal VHF Class-C and Small-Signal VHF Class-A Amplifier Service



JEDEC TO-5

- High power dissipation — 4 watts at case temperature of 25° C
- High output power — Class-C service; 28-volt operation: 1 watt minimum at 50 Mc; 0.4 watt minimum at 150 Mc
- High collector-to-emitter voltage ratings — V_{CEX} = 85 volts; V_{CEO} = 60 volts
- High gain-bandwidth product — 380 Mc typical
- High power gain — Class-A service, neutralized: 25 db at 50 Mc, 200 mw output

ELECTRICAL CHARACTERISTICS

Characteristics	Symbols	TEST CONDITIONS								LIMITS		Units
		Case Temperature (T_C) °C	Frequency Mc	DC Collector-to-Base Voltage (volts) V_{CB}	DC Collector-to-Emitter Voltage (volts) V_{CE}	DC Emitter-to-Base Voltage (volts) V_{EB}	DC Collector Current (ma) I_C	DC Emitter Current (ma) I_E	DC Base Current (ma) I_B	Min.	Max.	
Collector-Cutoff Current	I_{CBO}	25(T_{FA})▲ 150(T_{FA})▲		30 30				0 0			0.1 100	μa μa
Emitter-to-Base Breakdown Voltage	BV_{EBO}	25					0	0.1		4		volts
Collector-to-Emitter Breakdown Voltage (Sustaining)	BV_{CEO}(sus)	25					10 pulsed□		0	60		volts
Reverse Collector-to-Emitter Breakdown Voltage	BV_{CEX}	25				1.5	0.1			85		volts
Feedback Capacitance	$C_{b'c}$	25	1	28			0				6	pf
$r_{bb'}$ $C_{b'c}$ Product	$r_{bb'}C_{b'c}$	25	50		28		25				60	psec
DC Forward-Current Transfer Ratio□	h_{FE}	25			28		25			50	275	
Small-Signal Forward-Current Transfer Ratio	h_{fe}	25	50		28		25			5		
Real Part of Short-Circuit Input Impedance	$h_{ie(real)}$	25	50		28		25			25	75	ohms
Real Part of Short-Circuit Output Impedance	$1/Y_{22(real)}$	25	50		28		25			500	1000	ohms
Output Power Class-C Service P_{in} = 0.1 watt (with heat sink)	P_{OUT}	25 25	50* 150●		28 28					1.0 0.4		watt watt
Power Gain Class-A Service P_{out} = 0.2 watt (with heat sink)	PG	25	50★		28		25			18		db

▲ T_{FA} = free-air temperature □ Pulse duration, 300 μsec; duty factor, less than 1.8% * See *Fig.5* ● See *Fig.3* ★ See *Fig.13*

RATING CHART

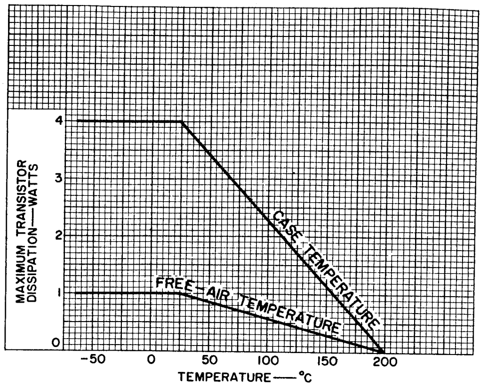


Fig.1

TYPICAL LARGE-SIGNAL OPERATION, CLASS-C SERVICE, 150 MC

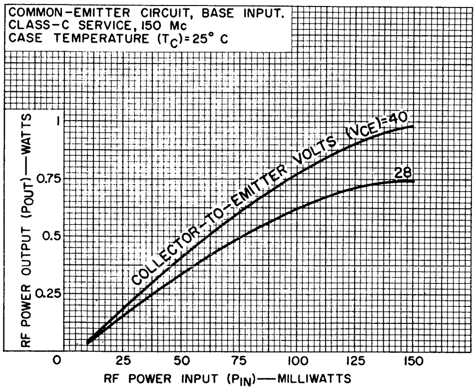
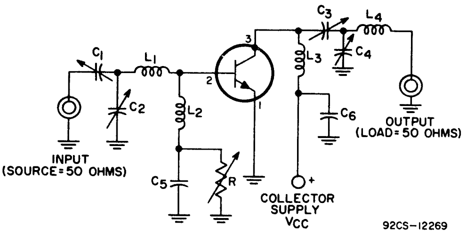


Fig.2



C_1, C_2: 1.5–20 pf
C_3: 4–40 pf
C_4: 7–100 pf
C_5: 1800 pf
C_6: 0.01 μf
R: 100 ohms, variable

L_1: 0.1 μh, 4 turns, No.18 wire, 1/4" ID, closely wound
L_2: 750–ohm ferrite choke
L_3: 0.075 μh, 4 turns, No.16 wire, 1/4" ID x 3/8" long
L_4: 0.055 μh, 3 turns, No.16 wire, 1/4" ID x 1/4" long

Fig.3

TYPICAL LARGE-SIGNAL OPERATION, CLASS-C SERVICE, 50 MC

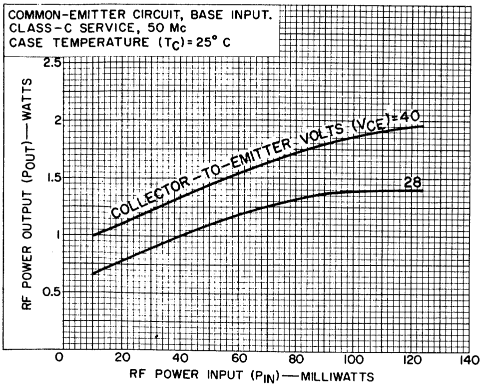
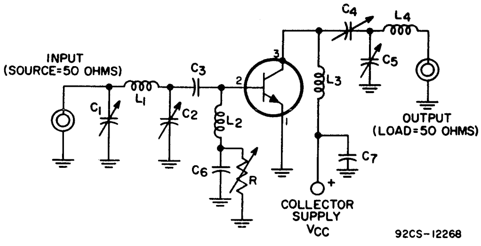


Fig.4 92CS-12272

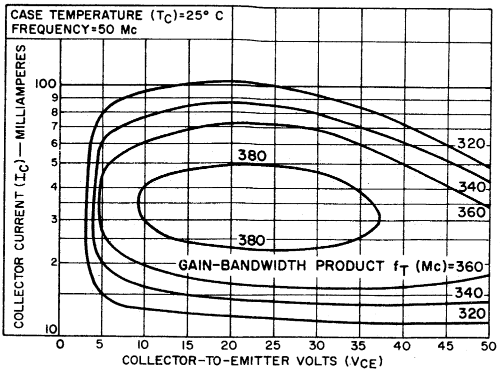


C_1: 70–350 pf
C_2, C_4, C_5: 7–100 pf
C_3: 0.01 μf
C_6: 0.002 μf
C_7: 0.02 μf
R: 1000 ohms, variable

L_1: 0.13 μh, 4 turns, No.18 wire, 1/4" ID, closely wound
L_2: 2.4 μh, choke, Miller Part No.4606
L_3: 0.6 μh, 10 turns, No.18 wire, 3/8" ID, closely wound
L_4: 0.6 μh, 10 turns, No.18 wire, 3/8" ID, closely wound

Fig.5

TYPICAL SMALL-SIGNAL OPERATION CHARACTERISTICS



92CS-12286

Fig.6

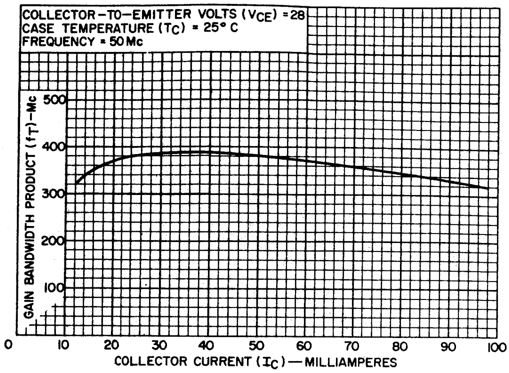
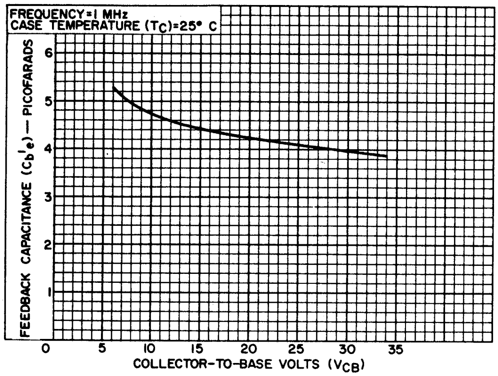


Fig.7

92CS- 12287



92CS-12283R1

Fig.8

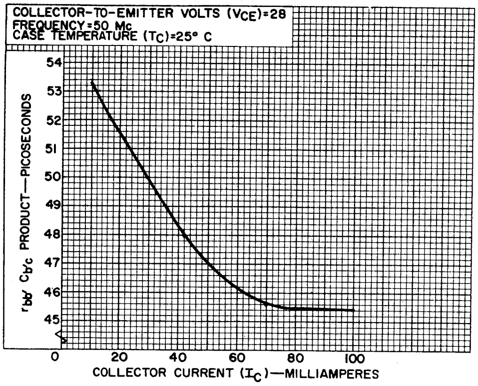


Fig.9

92CS-12284

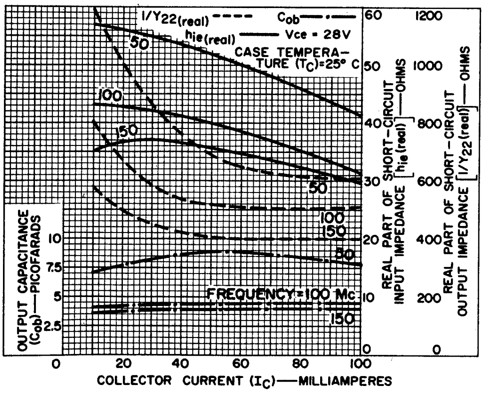


Fig.10

92CS-12289R1

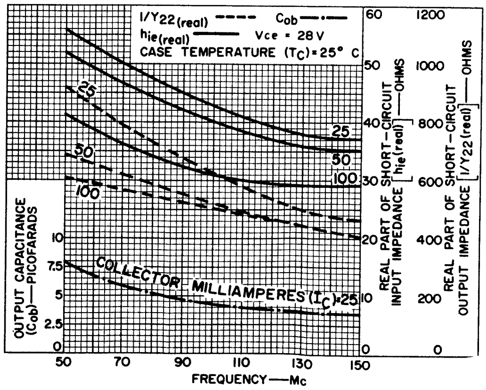


Fig.11

92CS-12288R1

TYPICAL CLASS-A-SERVICE-OPERATION, 50 MC, NEUTRALIZED

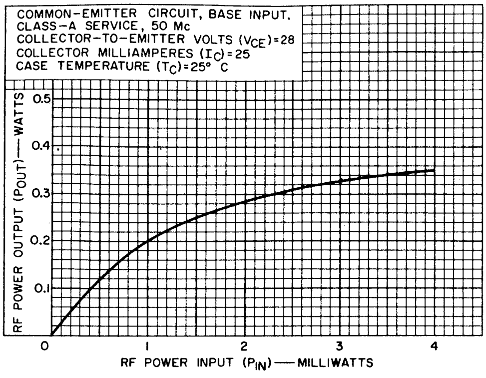
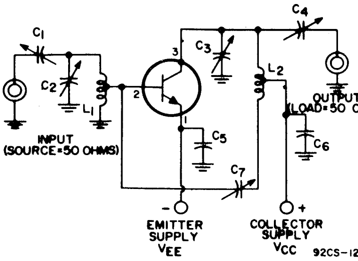


Fig.12



C_1: 7–100 pf
C_2: 8–60 pf
C_3: 14–150 pf
C_4: 6–80 pf
C_5, C_6: 0.005 µf
C_7: 0.9–7 pf

L_1: 0.12 µh, 3 turns, No.16 wire, 7/16" ID x 1/4" long, tap at 1 turn from ground
L_2: 0.23 µh, 5 turns, No.16 wire, 7/16" ID x 1/2" long, tap at 3 turns from collector terminal

Fig.13

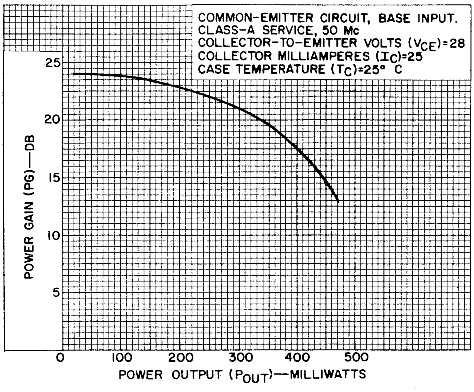


Fig.14

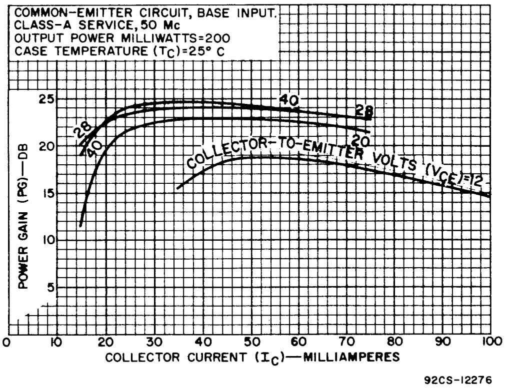
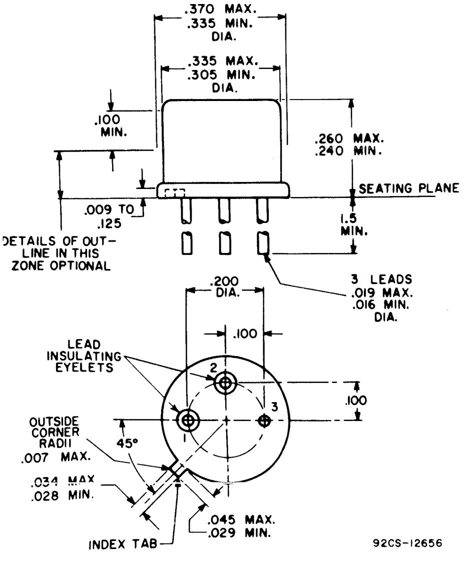


Fig.15

DIMENSIONAL OUTLINE
All Dimensions in Inches
JEDEC No.TO-5



NOTE 1: THIS ZONE IS CONTROLLED FOR AUTOMATIC HANDLING. THE VARIATION IN ACTUAL DIAMETER WITHIN THE ZONE SHALL NOT EXCEED 0.010.

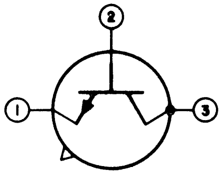
NOTE 2: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050 AND 0.250 FROM THE SEATING PLANE. BETWEEN 0.250 AND 1.5 A MAXIMUM OF 0.021 DIAMETER IS HELD. OUTSIDE OF THESE ZONES THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 3: MEASURED FROM MAX. DIAMETER OF THE ACTUAL DEVICE.

NOTE 4: LEADS HAVING MAXIMUM DIAMETER (0.019) MEASURED IN GAUGING PLANE 0.054 + 0.001 – 0.000 BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN 0.007 OF THEIR TRUE LOCATIONS RELATIVE TO A MAXIMUM-WIDTH TAB.

TERMINAL DIAGRAM

LEAD 1 – EMITTER
LEAD 2 – BASE
LEAD 3 – COLLECTOR, CASE



RCA

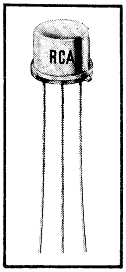
Solid State
Division

RF Power Transistors

2N3119

RCA-2N3119 is a triple-diffused planar transistor of the silicon n-p-n type intended for high-voltage, high-frequency pulse amplifiers and high-voltage saturated switches in military and industrial equipment.

For Switching and Pulse Amplifier Applications



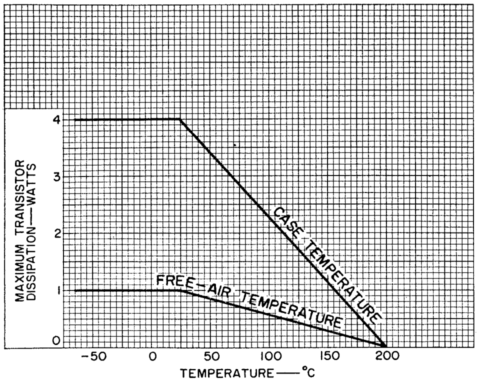
JEDEC TO-5

Maximum Ratings, *Absolute-Maximum Values:*

Collector-to-Base Voltage (V_{CBO})	100 max.	volts
Collector-to-Emitter Voltage:		
With 1.5 volts of reverse bias (V_{CEX})	100 max.	volts
With base open (V_{CEO})	80 max.	volts
Emitter-to-Base Voltage (V_{EBO})	4 max.	volts
Collector Current (I_C)	0.5 max.	ampere
Transistor Dissipation (P_T):		
At case temperatures up to 25° C	4 max.	watts
At free-air temperatures up to 25° C	1 max.	watt
At temperatures above 25° C	See *Fig.1*	
Temperature Range:		
Storage	-65 to +200	°C
Operating (Junction)	-65 to +200	°C
Lead Temperature:		
1/16" ± 1/32" from seating surface for 10 sec. max.	255	°C

- High collector-to-emitter voltage ratings —
  V_{CEX} = 100 volts
  V_{CEO} = 80 volts
- Fast rise time —
  50-volt pulse (1,000-ohm load) with 10 nsec rise time
- High power dissipation —
  4 watts at case temperature of 25° C

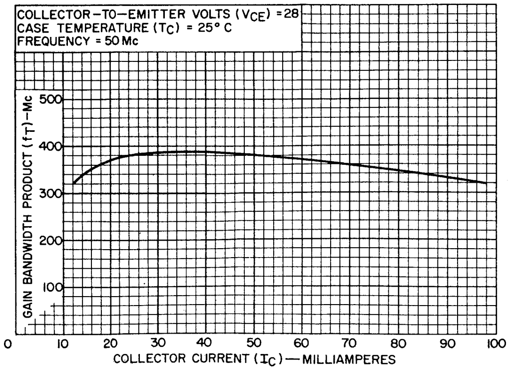
RATING CHART



92CS-12281

Fig.1

TYPICAL GAIN-BANDWIDTH PRODUCT CHARACTERISTIC



92CS-12287

Fig.2

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C Unless Otherwise Specified

Characteristic	Symbol	TEST CONDITIONS						LIMITS		Units
		DC Collector Volts		DC Emitter Volts	DC Current (Milliamperes)			Min.	Max.	
		V_{CB}	V_{CE}	V_{EB}	I_E	I_B	I_C			
Collector-Cutoff Current At T_{FA} = 25° C = 150° C	I_{CBO}	60 60			0 0			- -	50 50	na μa
Emitter-Cutoff Current (At T_{FA} = 25°C)	I_{EBO}			3			0	-	100	na
Collector-to-Emitter Breakdown Voltage (Sustaining)	$BV_{CEO}(sus)$					0	10*	80	-	volts
Reverse Collector-to-Emitter Breakdown Voltage	BV_{CEX}			1.5			0.10	100	-	volts
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.10	100	-	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.10		0	4	-	volts
DC Forward-Current Transfer Ratio	h_{FE}		10 10* 10*				10 100 250	40 50 20	- 200 -	
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					10	100	-	0.5	volt
Base-to-Emitter Saturation Voltage	$V_{BE}(sat)$					10	100	-	1.1	volts
Feedback Capacitance (At 1 Mc)	$C_{b'c}$	28					0	-	6	pf
Gain-Bandwidth Product (At 50 Mc)	f_T		28				25	250	-	Mc
Pulse-Amplifier Rise Time (See *Figs.9 & 10*)	$t_d + t_r$		V_{CC}=80				10	-	20	nsec
Sat. Switch Turn-On Time (delay time + rise time) (See *Figs.7 & 8*)	t_{on}		V_{CC}=28			I_{B1} = 10	100	-	40	nsec
Sat. Switch Turn-Off Time (storage time + fall time) (See *Figs.7 & 8*)	t_{off}		V_{CC}=28			I_{B2}=-10	100	-	700	nsec

* Pulsed; pulse duration = 300 μsec; duty factor = 1.8%.

TYPICAL DC BETA CHARACTERISTIC

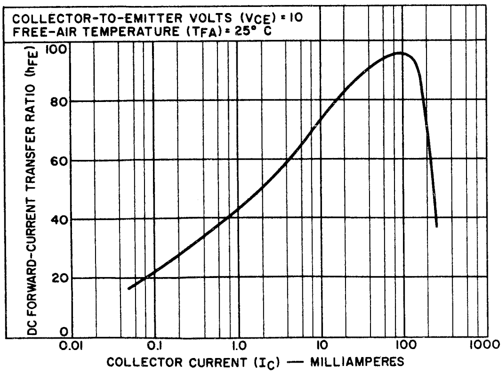


Fig.3

TYPICAL VARIATION OF f_T WITH COLLECTOR CURRENT AND COLLECTOR-TO-EMITTER VOLTAGE

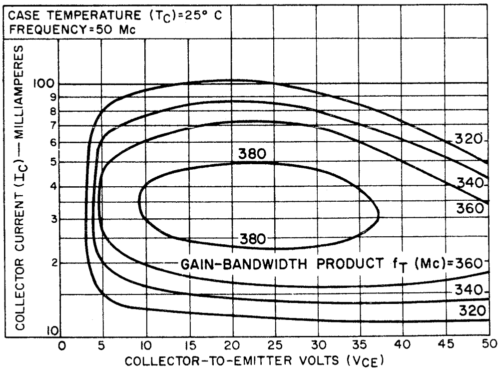


Fig.4

TYPICAL VARIATION OF OUTPUT CAPACITANCE vs. COLLECTOR-TO-BASE VOLTAGE

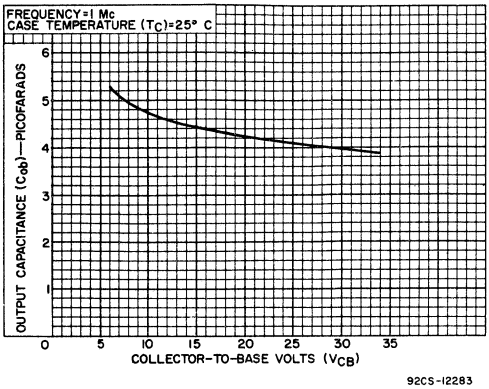


Fig.5

TYPICAL $r_{bb'}C_{b'c}$-PRODUCT vs. COLLECTOR CURRENT

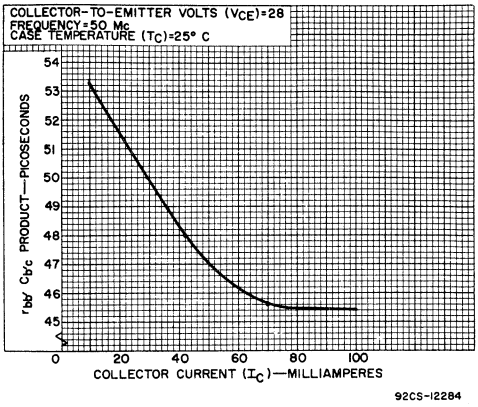
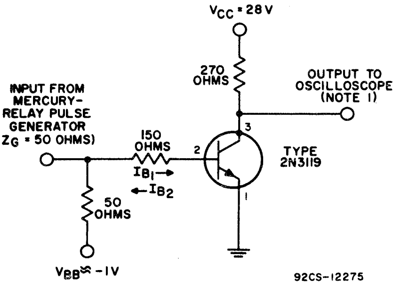


Fig.6

CIRCUIT USED TO MEASURE t_{on} AND t_{off} FOR 2N3119 OPERATING AS A SATURATED SWITCH



INPUT PULSE:

$t_r < 3$ nsec

$t_f < 10$ nsec

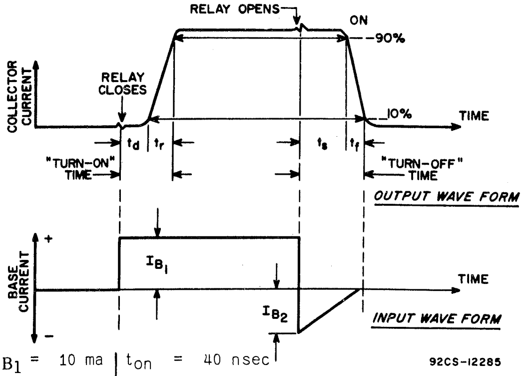
REP. RATE = 120 CPS

PULSE WIDTH = 300 μsec

NOTE 1: WITH $C_{IN} < 1$ pf SHUNTED BY 5,000 OHMS; t_r = 1 nsec.

Fig.7

WAVE FORMS FOR SATURATED SWITCH CIRCUIT SHOWN IN FIG.7



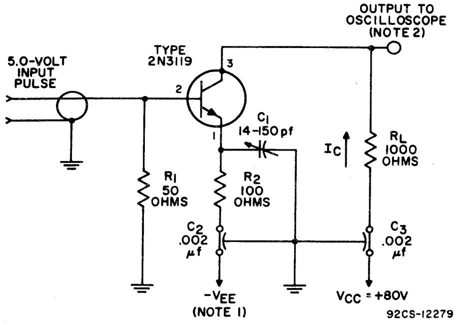
I_{B1} = 10 ma | t_{on} = 40 nsec

I_{B2} = −10 ma | t_{off} = 700 nsec

I_C = 100 ma

Fig.8

PULSE-AMPLIFIER TEST CIRCUIT



NOTE 1: V_{EE} ADJUSTED FOR I_C = 10 ma WITH NO INPUT.

NOTE 2: WITH $C_{IN} < 1$ pf SHUNTED BY 100,000 OHMS; t_r = 1 nsec.

Fig.9

WAVE FORMS FOR PULSE-AMPLIFIER TEST CIRCUIT SHOWN IN FIG.9

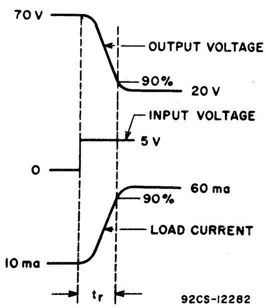
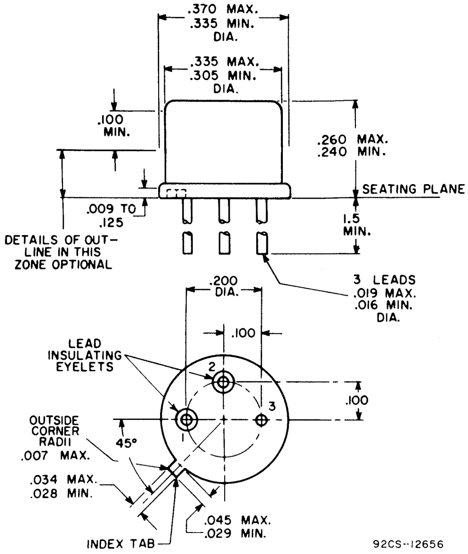


Fig.10

DIMENSIONAL OUTLINE
All Dimensions in Inches
JEDEC No.TO-5



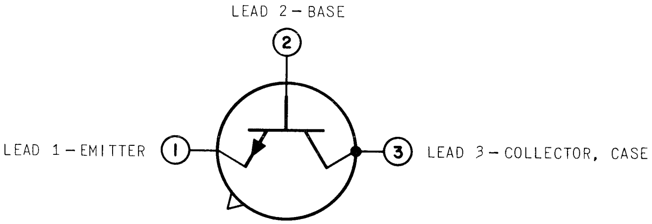
NOTE 1: THIS ZONE IS CONTROLLED FOR AUTOMATIC HANDLING. THE VARIATION IN ACTUAL DIAMETER WITHIN THE ZONE SHALL NOT EXCEED 0.010.

NOTE 2: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050 AND 0.250 FROM THE SEATING PLANE. BETWEEN 0.250 AND 1.5 A MAXIMUM OF 0.021 DIAMETER IS HELD. OUTSIDE OF THESE ZONES THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 3: MEASURED FROM MAX. DIAMETER OF THE ACTUAL DEVICE.

NOTE 4: LEADS HAVING MAXIMUM DIAMETER (0.019) MEASURED IN GAUGING PLANE 0.054 + 0.001 − 0.000 BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN 0.007 OF THEIR TRUE LOCATIONS RELATIVE TO A MAXIMUM-WIDTH TAB.

TERMINAL DIAGRAM



RCA

Solid State
Division

RF Power Transistors

2N3229

RCA-2N3229 is a triple-diffused planar transistor of the silicon n-p-n type. This device is intended for applications in AM, FM, and CW service at frequencies up to 150 Mc.

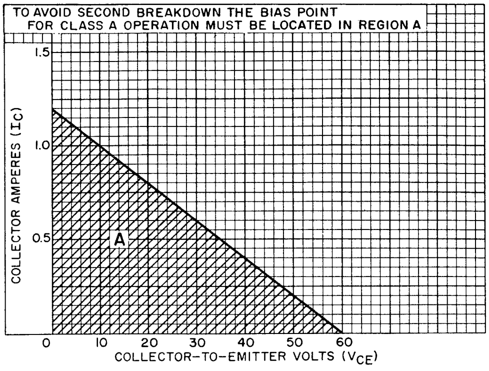
The 2N3229 utilizes a new stud-mounted package which is electrically isolated from all the electrodes and is designed to provide excellent performance at very high frequencies.

RF SERVICE

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE, V_{CBO} . .	105 max.	volts
COLLECTOR-TO-EMITTER VOLTAGE:		
With base open, V_{CEO}	60 max.	volts
With V_{BE} = -1.5 volts, V_{CEV}. . .	105 max.	volts
EMITTER-TO-BASE VOLTAGE, V_{EBO}. . .	4 max.	volts
COLLECTOR CURRENT, I_C.	2.5 max.	amperes
TRANSISTOR DISSIPATION, P_T:		
At case temperatures up to 25° C.	17.5 max.	watts
At case temperatures above 25° C.	Derate linearly 100 mw/°C	
TEMPERATURE RANGE:		
Storage.	-65 to 200	°C
Operating (Junction)	-65 to 200	°C
LEAD TEMPERATURE (During soldering):		
At distances ≥ 1/32" from ceramic wafer for 10 sec. max.	230 max.	°C

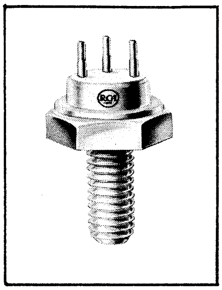
REGION OF SAFE OPERATION (WITHOUT SECOND BREAKDOWN) IN CLASS-A SERVICE FOR TYPE 2N3229



92CS-12038

Fig.1

For Large-Signal, High-Power, VHF Applications in Military and Industrial Communications Equipment



JEDEC TO-60

- High Power Output, Unneutralized (P_{OUT}):
  15 w min. at 50 Mc
  5 w min. at 150 Mc
- High Voltage Ratings:
  V_{CBO} = 105 volts max.
  V_{CEV} = 105 volts max.
  V_{CEO} = 60 volts max.
- 100 per cent tested to assure freedom from second breakdown in class-A operation at maximum ratings
- Low Thermal Resistance (θ_{J-C})—
  high thermal-conductivity ceramic insulation between collector and mounting stud
- Isolated Stud Package:
  all three electrodes electrically isolated from case—for design flexibility

  heavy copper mounting stud—for effective contact with heat sink

  pin terminals arranged on a .200" pin-circle diameter—fit commercially available sockets

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C Unless Otherwise Specified

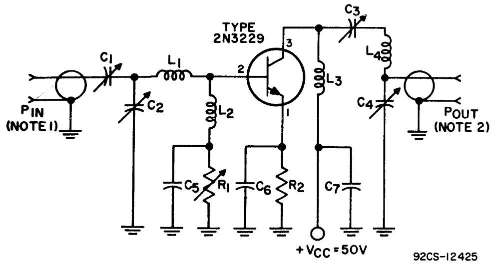
Characteristic	Symbol	TEST CONDITIONS						LIMITS		Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CBO}	30			0			-	0.1	µa
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.5	105	-	volts
Collector-to-Emitter Breakdown Voltage (Sustaining)	$BV_{CEO(sus)}$					0	500*	60	-	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEV}			-1.5			0.1	105	-	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4	-	volts
Collector-to-Emitter Saturation Voltage	$V_{CE(sat)}$					500	2.5 amp	-	1	volt
Feedback Capacitance (Measured at 140 Kc)	$C_{b'c}$	30			0			-	20	pf
RF Power Output, Unneutralized (See *Fig.* 2.):	P_{out}									
Measured at 50 Mc			50				550	15[a]	-	watts
150 Mc			50				250	5[b]	-	watts
Gain-Bandwidth Product	f_T		28				250	200(typ.)		Mc
Base-Spreading Resistance (Measured at 400 Mc)	$r_{bb'}$		28				250	6.0(typ.)		ohms
Collector-to-Case Capacitance	C_c							-	6	pf

* Pulsed. Pulse duration ≦ 5 µsec; duty factor ≦ 1%.

[a] For P_{IN} = 2 watts

[b] For P_{IN} = 1 watt

CIRCUIT OF UNNEUTRALIZED AMPLIFIER USED TO MEASURE POWER OUTPUT OF TYPE 2N3229



NOTE 1: GENERATOR IMPEDANCE = 50 OHMS.

NOTE 2: LOAD IMPEDANCE = 50 OHMS.

For 50-Mc Operation

C_1: 4–40 pf

C_2,C_4: 7–100 pf

C_3: 1.5–20 pf

C_5,C_6,C_7: 0.005 µf

L_1: 5-1/2 turns No.18 wire, 1/4" ID, closely-wound

L_2: Ferrite choke, Z = 750(±20%) ohms

L_3: 6 turns No.18 wire, 3/8" ID, wire spacing = 1 wire dia. (slug-tuned)

L_4: 8 turns No.18 wire, 3/8" ID, closely-wound (slug-tuned)

R_1: 1,000 ohms

R_2: 3.9 ohms (non-inductive)

For 150-Mc Operation

C_1,C_2: 4–40 pf

C_3,C_4: 1.5–20 pf

C_5,C_7: 0.005 µf

L_1: 1-1/2 turns No.16 wire, 1/4" ID, wire spacing = 1 wire dia.

L_2: Ferrite choke, Z = 750(±20%) ohms

L_3: 2.4 µh

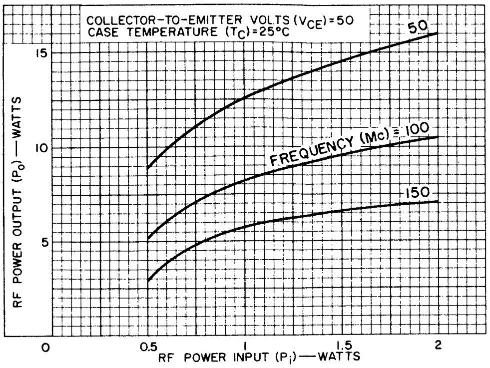
L_4: 6 turns No.16 wire, 3/8" ID, closely-wound

R_1: 100 ohms

R_2: = 0 (Emitter connected to ground)

Fig.2

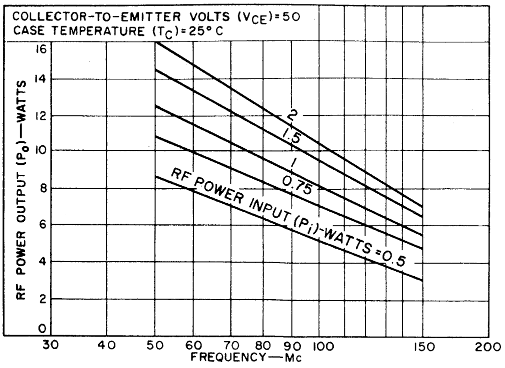
TYPICAL-OPERATION CHARACTERISTICS FOR TYPE 2N3229



92CS-12424

Fig.3

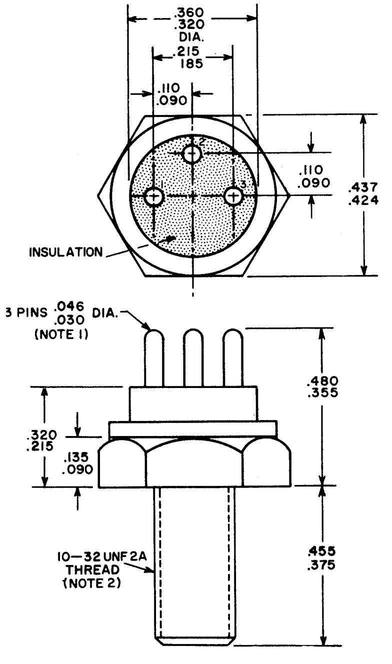
TYPICAL-OPERATION CHARACTERISTICS FOR TYPE 2N3229



92CS-12427

Fig.4

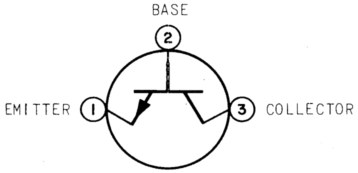
DIMENSIONAL OUTLINE



92CS-12045R5

DIMENSIONS IN INCHES

TERMINAL DIAGRAM



NOTE 1: THE PIN SPACING PERMITS INSERTION IN ANY SOCKET HAVING A PIN-CIRCLE DIAMETER OF 0.200" AND CONTACTS WHICH WILL ACCOMMODATE PINS HAVING A DIAMETER OF 0.035" MIN., 0.045" MAX.

NOTE 2: THE TORQUE APPLIED TO A 10-32 HEX NUT ASSEMBLED ON THE THREAD DURING INSTALLATION SHOULD NOT EXCEED 12 INCH-POUNDS.

NOTE 3: THIS DEVICE MAY BE OPERATED IN ANY POSITION.

RCA

Solid State Division

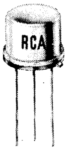
RF Power Transistors

2N3262

For High-Voltage, High-Speed Switching and Pulse-Amplifier Applications

RCA-2N3262 is a triple-diffused planar transistor of the silicon n-p-n type intended for high-voltage, high-frequency pulse amplifiers and high-voltage saturated switches in military and industrial equipment. The high-current switching capability of the 2N3262 makes it especially suitable for memory-core driver applications.

The 2N3262 utilizes the JEDEC TO-39 package which is identical to the JEDEC TO-5 package except its leads have a minimum length of 0.5".



JEDEC TO-39

- High Voltage Ratings —
- Fast Rise Time at High Collector Currents— 20 nsec rise time (max.) at 1 ampere
- High Power Dissipation —
- Low Collector to Emitter Saturation Voltage at High Collector Currents— 0.6 volts (max.) at 1 ampere

Maximum Ratings, *Absolute-Maximum Values:*

Collector-to-Base Voltage, V_{CBO} . . . 100 max. volts

Collector-to-Emitter Voltage

Reverse bias, V_{CEX}

For V_{EB} = 1.5 volts . . . . 100 max. volts

With base open (sustaining voltage), V_{CEO}(sus) . . . . 80 max. volts

Emitter-to-Base Voltage, V_{EBO} . . . . 4 max. volts

Collector Current, I_C . . . . 1.5 max. amperes

Transistor Dissipation, P_T:

At case temperatures up to 25° C . . . . 8.75 max. watts

At case temperatures above 25° C . . . . Derate linearly (50 mw/°C) to 175° C

At free-air temperatures up to 25° C . . . . 1 max. watt

At free-air temperatures above 25° C . . . . . . Derate linearly (5.71 mw/°C) to 175° C

Temperature Range:

Storage . . . . -65 to +200 °C

Operating (Junction). . . . . -65 to +200 °C

Lead Temperature:

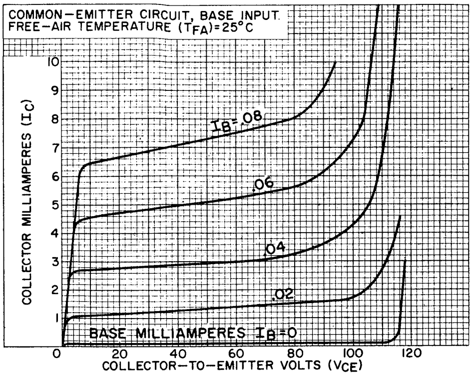
1/16" ± 1/32" from seating surface for 10 sec. max.. . . . . 230 °C

Electrical Characteristics, *Case Temperature = 25° C Unless Otherwise Specified*

Characteristic	Symbol	TEST CONDITIONS						LIMITS		Units
		DC Collector Volts		DC Emitter Volts	DC Current (Milliamperes)			Min.	Max.	
		V_{CB}	V_{CE}	V_{EB}	I_E	I_B	I_C			
Collector-Cutoff Current at T_{FA} = 25° C	I_{CBO}	30			0				0.1	μa
Emitter-Cutoff Current	I_{EBO}			3			0		100	μa
Collector-to-Emitter Sustaining Voltage with External Base-to-Emitter Resistance (R_{BE}) = 10 ohms	V_{CER}(sus)						500*	90		volts
Collector-to-Emitter Sustaining Voltage	V_{CEO}(sus)					0	500*	80		volts
Reverse Collector-to-Emitter Breakdown Voltage	BV_{CEX}			1.5			0.25	100		volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4		volts
Base-to-Emitter Saturation Voltage	V_{BE}(sat)					100	1000		1.4	volts
Collector-to-Emitter Saturation Voltage	V_{CE}(sat)					100	1000		0.6	volts
DC Forward Current Transfer Ratio	h_{FE}		4				500	40		
Input Capacitance (at 1 Mc)	C_{ib}			3			0		300	pf
Feedback Capacitance (at 1 Mc)	$C_{b'c}$	28					0		20	pf
Pulse-Amplifier Rise Time (See Figs. 13 & 14)	t_r		V_{cc}=80				25		20	nsec
Sat. Switch Turn-On Time— Delay Time + Rise Time (See Figs. 8 & 10)	t_{on}		28		$I_{B1}=I_{B2}$ =100		1000		40	nsec
Sat. Switch Turn-Off Time— Storage + Fall Time (See Figs. 8 & 10)	t_{off}		28		$I_{B1}=I_{B2}$ = 100				750	nsec
Forward Current Transfer Ratio (at 50 Mc)	h_{fe}		28				100	3		

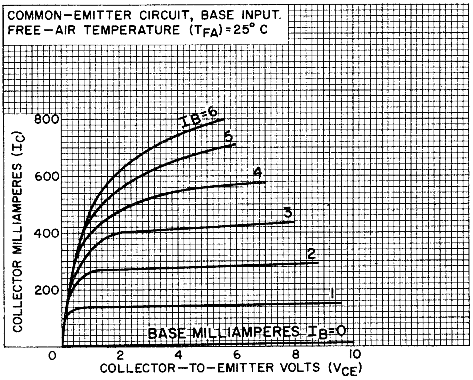
* Pulsed; pulse duration = 15 μsec; duty factor = 0.15%.

TYPICAL TRANSFER CHARACTERISTICS



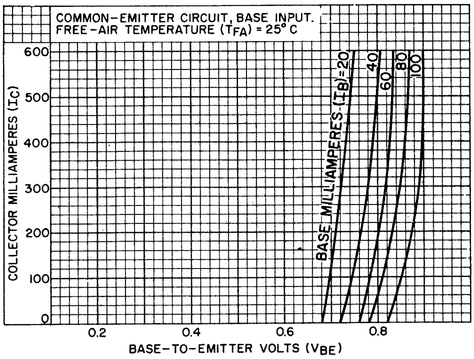
92CS-12454

Fig.1



92CS-12456

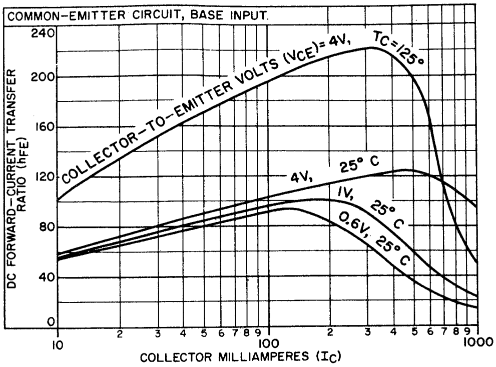
Fig. 3



92CS-12449

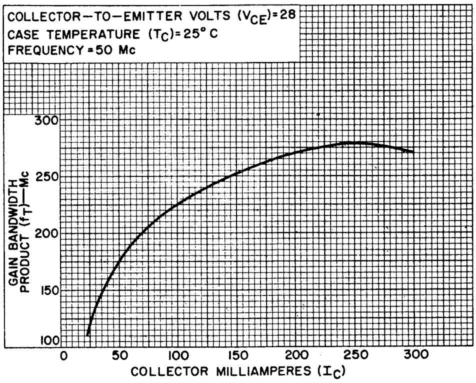
Fig.5

TYPICAL OPERATION CHARACTERISTICS



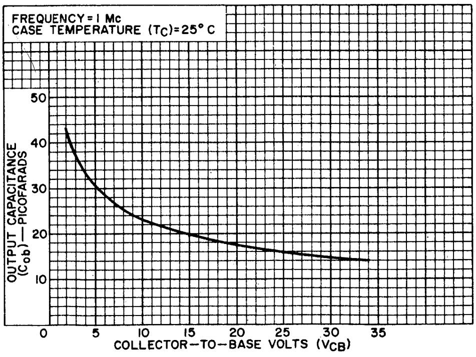
92CS-12450

Fig. 2



92CS-12457

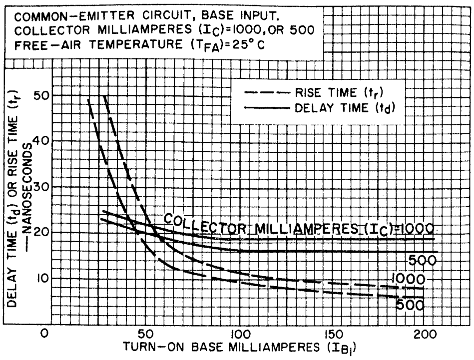
Fig.4



92CS-12453

Fig.6

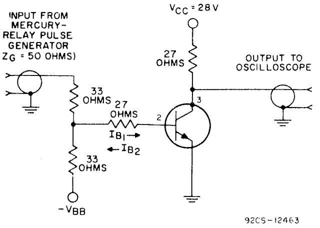
TYPICAL SATURATED-SWITCHING CHARACTERISTICS AND TEST CIRCUIT



92CS-12458

Fig.7

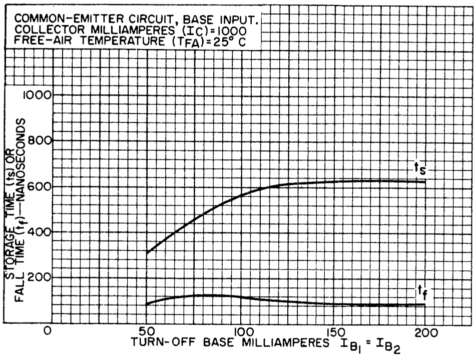
CIRCUIT USED TO MEASURE t_{on} AND t_{off} FOR OPERATION AS A SATURATED SWITCH



INPUT PULSE:

$t_r < 3$ nsec | REP. RATE = 120 CPS
$t_f < 10$ nsec | PULSE WIDTH = 300 μsec

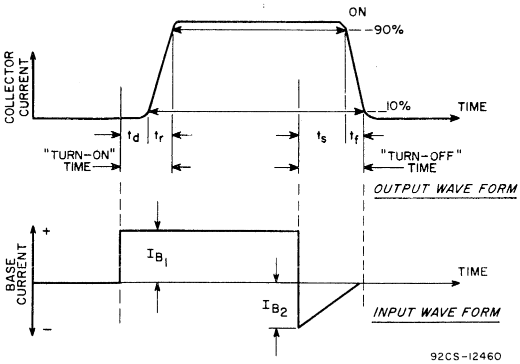
Fig. 8



92CS-12459

Fig.9

WAVE FORMS FOR SATURATED SWITCH CIRCUIT



92CS-12460

I_{B1} = 100 ma | t_{on} = 40 nsec
I_{B2} = -100 ma | t_{off} = 750 nsec
I_C = 1 amp

Fig.10

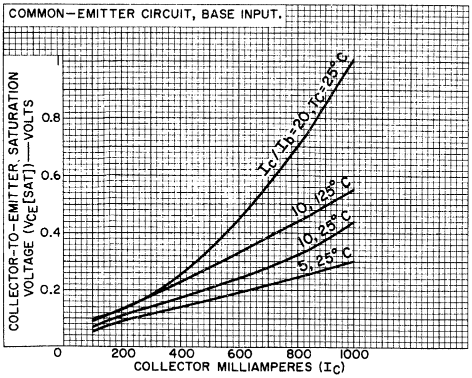


Fig.11

92CS-12461

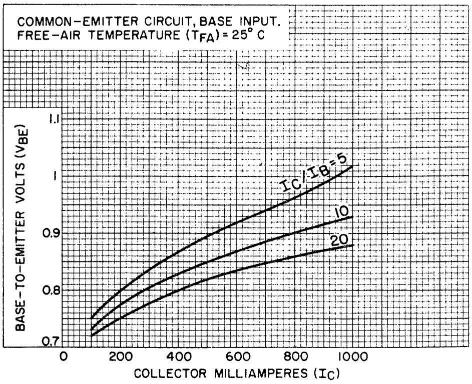
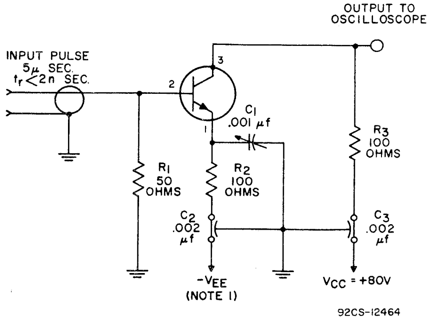


Fig.12

92CS-12451

PULSE-AMPLIFIER TEST CIRCUIT



NOTE 1: V_{EE} ADJUSTED FOR I_E = 35 ma WITH NO INPUT.

Fig.13

WAVE FORM FOR PULSE-AMPLIFIER TEST CIRCUIT

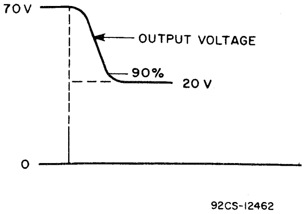
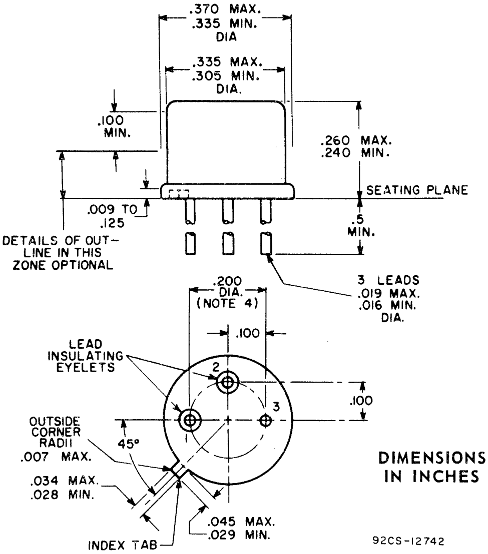


Fig.14

DIMENSIONAL OUTLINE
JEDEC TO-39



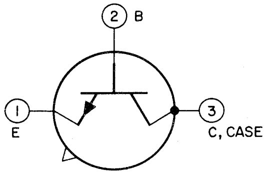
NOTE 1: THIS ZONE IS CONTROLLED FOR AUTOMATIC HANDLING. THE VARIATION IN ACTUAL DIAMETER WITHIN THE ZONE SHALL NOT EXCEED 0.010".

NOTE 2: THE SPECIFIED LEAD DIAMETER APPLIES IN THE ZONE BETWEEN 0.050" AND 0.250" FROM THE SEATING PLANE. BETWEEN 0.250" AND 1.5", A MAXIMUM OF 0.021" DIAMETER IS HELD. OUTSIDE OF THESE ZONES THE LEAD DIAMETER IS NOT CONTROLLED.

NOTE 3: MEASURED FROM MAX. DIAMETER OF THE ACTUAL DEVICE.

NOTE 4: LEADS HAVING MAXIMUM DIAMETER (0.019") MEASURED IN GAUGING PLANE OF 0.054" + 0.001" – 0.000" BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN 0.007" OF THEIR TRUE LOCATIONS RELATIVE TO A MAXIMUM-WIDTH TAB.

TERMINAL DIAGRAM

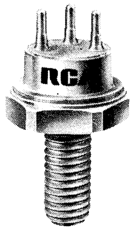


LEAD 1 – EMITTER
LEAD 2 – BASE
LEAD 3 – COLLECTOR,
CASE

RCA
Solid State
Division

RF Power Transistors

2N5071



JEDEC TO-60 H-1307

24-W (CW), 76-MHz Emitter-Ballasted Overlay Transistor

Silicon N-P-N Device for 24-Volt Applications
in VHF Communications Equipment

Features:

- **For class B or class C amplifiers**
- **For 24-V FM (30 to 76 MHz) communications**
- **24 W output at 76 MHz with 9 dB gain (Min.)**
- **Low thermal resistance**

RCA type 2N5071[a] is an epitaxial silicon n-p-n planar transistor featuring overlay emitter electrode construction. This device utilizes many separate emitter elements and has individual ballast resistance in each of the emitter sites for stabilization. It is especially designed as a high-power, class B and C rf amplifier for FM communications with a 24-volt power supply. It is useful for both narrowband and wideband applications in the 30- to 76-MHz frequency range.

The transistor can be operated under a wide range of mismatched load conditions. All units are tested for a load mismatch having a VSWR of 3:1 which is varied through all phases. The test is performed at 30 MHz and 30 watts output.

---

[a] Formerly RCA Dev. No. TA2827.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
*COLLECTOR-TO-EMITTER VOLTAGE	V_{CEO}	30	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
*COLLECTOR CURRENT:			
Continuous	I_C	3.3	A
Peak		10	A
*CONTINUOUS BASE CURRENT	I_B	1	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 25°C		70	W
At case temperatures above 25°C		See Fig. 5	
*TEMPERATURE RANGE:			
Storage and operating (junction)		−65 to 200	°C
*LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. (0.8 mm) from insulating wafer for 10 s max.		230	°C

*In accordance with JEDEC registration data

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C.

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS						LIMITS		UNITS
		DC Collector Voltage-V		DC Base Voltage-V	DC Current mA					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
* Collector-Cutoff Current:	I_{CEV}		60	−1.5				–	10	mA
At T_C = 150°C			60	−1.5				–	10	
With base open	I_{CEO}		30			0		–	5	
With emitter open	I_{CBO}	60						–	10	
* Emitter-Cutoff Current	I_{EBO}			4				–	10	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$				0		200[a]	65	–	V
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$				0		200[a]	30	–	V
* Collector-to-Emitter Sustaining Voltage: With base open	$V_{CEO}(sus)$					0	200[a]	30	–	V
With external base-to-emitter resistance (R_{BE}) = 5 Ω	$V_{CER}(sus)$						200[a]	40	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$					10	0	4	–	V
* DC Forward Current Transfer Ratio	h_{FE}		5 5				3 A 1 A	10 20	100 –	
Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$							–	2.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%; repetition rate ≥ 60 Hz.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS			LIMITS		UNITS
		DC Collector Supply (V_{CC})—V	Input Power (P_{IE})—W	Frequency (f) - MHz	MIN.	MAX.	
Power Output	P_{OE}	24	3	76	24	–	W
Power Gain	G_{PE}	24	3	76	9	–	dB
* Magnitude of Common-Emitter, Small-Signal, Short-Circuit Forward Current Transfer Ratio	$\lvert h_{fe} \rvert$	V_{CE} = 15 V I_C = 1 A		50	2	–	
* Available Amplifier Signal Input Power	P_i	Source impedance (Zg) = 50	P_{OE} = 24 W	76	–	3	W
* Collector Efficiency	η_C	24	3	76	60	–	%
Load Mismatch	LM	24	1.2	30	GO/NO GO VSWR = 3:1		
* Collector-to-Base Capacitance	C_{obo}	V_{CB} = 30 V	–	1	–	85	pF

* In accordance with JEDEC registration data

TYPICAL APPLICATION INFORMATION

APPLICATION	Circuit (Fig.)	DC Collector Supply Voltage (V_{CC})—V	Input Power (P_{IE})—W	Output Power (P_{OE})—W	Collector Efficiency (η_C)— %
76-MHz Amplifier	7	24	3	26	70
30- to 76-MHz Broadband Amplifier (FM)	8	24	0.9 – 2.5	20	48-54

PERFORMANCE DATA

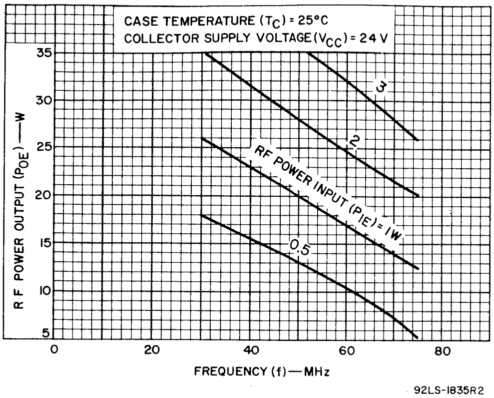


Fig. 1—Typical output power vs. frequency.

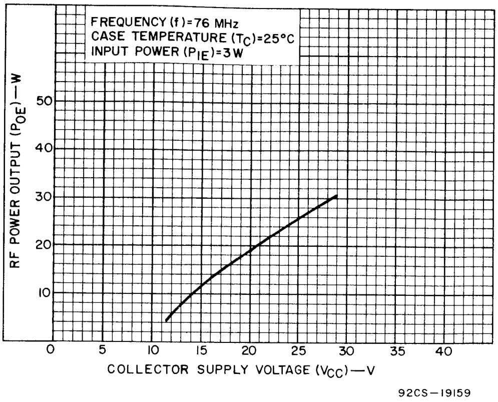


Fig. 2—Typical output power vs. collector supply voltage.

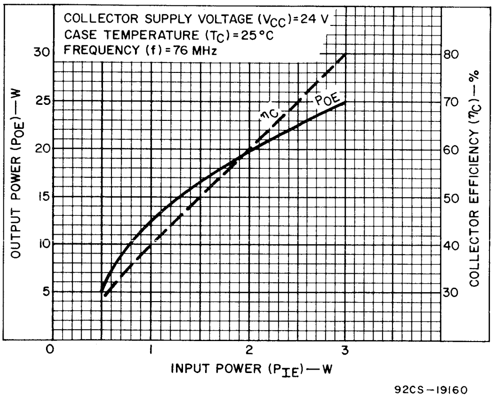


Fig. 3—Typical output power or collector efficiency vs. input power at 76 MHz.

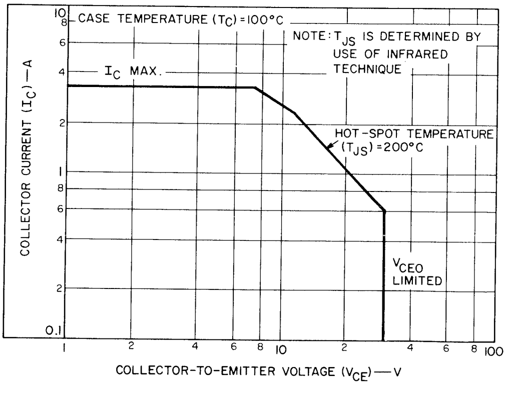


Fig. 4—Safe area for dc operation.

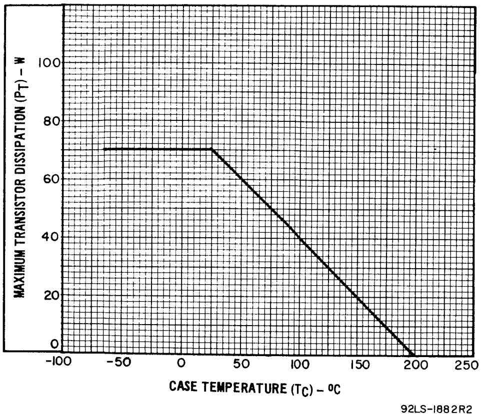


Fig. 5—RF Dissipation derating curve.

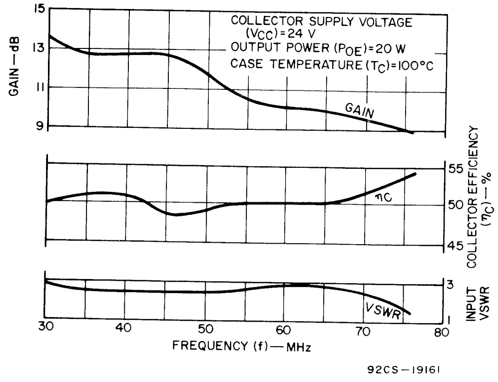


Fig. 6—Typical broadband performance of 2N5071.

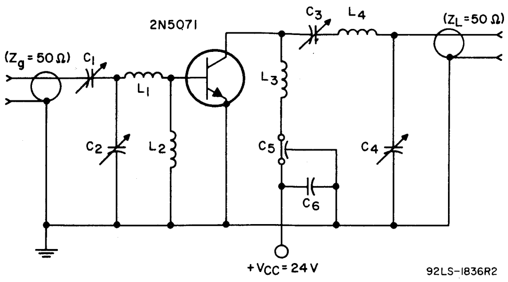


Fig.7—Narrowband rf amplifier circuit for power output test (76-MHz operation).

C_1, C_2: 55-300 pF trimmer capacitor, ARCO 427, or equivalent
C_3, C_4: 32-250 pF trimmer capacitor, ARCO 426, or equivalent
C_5: 1000 pF feedthrough
C_6: 0.1 μF (50V) electrolytic
L_1: 1 turn, No.16 wire, 5/16 in. (7.93 mm) ID
L_2:1 Ferroxcube No.VK200 01-3B, or equivalent
L_3, L_4: 3 turns, No. 10 wire, 5/16 in. (7.93 mm) ID, 1/2 in. (12.7 mm) long

Note: Impedance measurements are made at transistor socket pins.

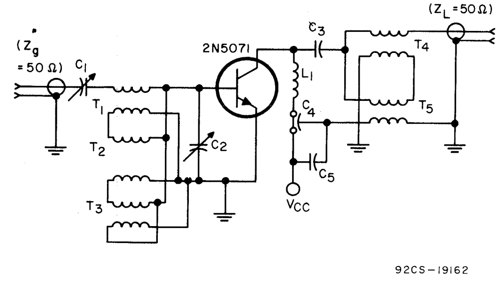
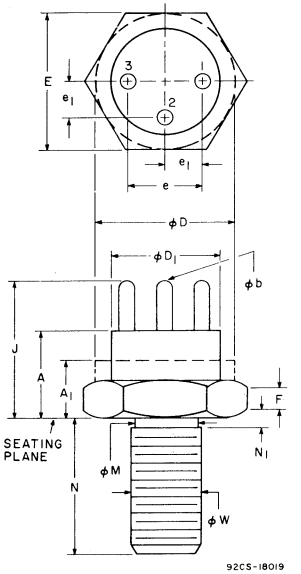


Fig.8—Wideband rf amplifier circuit (30-to-76 MHz).

C_1, C_2: 55-300 pF trimmer capacitor, ARCO 427, or equivalent
C_3, C_5: 0.47 μF ceramic
C_4: 1000 pF feedthrough
L_1: Ferroxcube No.VK200 01-3B, or equivalent
T_1, T_2, T_3: 6 twisted pairs (10 turns/in.) of No. 28 wire connected in parallel. 3 1/2 turns on Indiana General CF-108-Q2 ferrite core, or equivalent.
T_4, T_5: 2 lengths of RE-196A/U cable connected in parallel. 7 turns on Indiana General CF-111-Q1 ferrite core, or equivalent.

DIMENSIONAL OUTLINE JEDEC TO-60



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A_1	–	0.165	–	4.19	2
ϕb	0.030	0.046	0.762	1.17	4
ϕD	0.360	0.437	9.14	11.10	2
ϕD_1	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e_1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
ϕM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N_1	–	0.078	–	1.98	
ϕW	0.1658	0.1697	4.212	4.310	3, 5

NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing perimts insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

TERMINAL CONNECTIONS

Mounting Stud, Case, Pin No. 1 – Emitter
Pin No. 2 – Base
Pin No. 3 – Collector

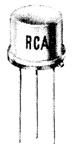
Solid State Division

RF Power Transistors

40080 40446
40081 40581
40082 40582

RCA-40080, 40081, 40082, 40446, *40581*, and *40582* are triple-diffused, silicon planar n-p-n transistors, specifically designed for application in a 5-watt input, 27 megahertz Citizens Band Transmitter.

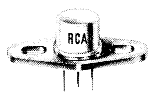
NEW!!



40581

H-1381

Type 40581 is a higher power version of the 40082 and is intended to provide a P_{OUT} = 3.5 W in a 27 MHz Citizens Band Transmitter.

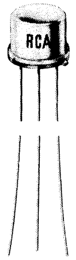


40582

H-1375

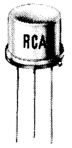
Type 40582 is a higher power version of the 40446. Both have a factory-attached diamond-shaped mounting flange.

Device for Class-C Operation in 27 MHz "CB" Circuits



JEDEC
TO-5

H-1380



JEDEC
TO-39

H-1381

- **OSCILLATOR: 40080 (TO-5)**
- **DRIVER: 40081 (TO-5)**
- **OUTPUT 40082, 40581 (TO-39)**
  40446, 40582 (TO-39 + Flange)

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*		40080	40081	40082 40581	40446 40582	
COLLECTOR-TO-EMITTER VOLTAGE:						
With V_{BE} = −0.5 volts	V_{CEV}	–	60	60	60	V
With base open	V_{CEO}	30	–	–	–	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	–	2.0	2.5	2.5	V
PEAK COLLECTOR CURRENT		0.25	0.25	1.5	1.5	A
TRANSISTOR DISSIPATION	P_T					
At case temperatures up to 25° C		–	2.0	5.0	10	W
At free-air temperatures up to 25°C		0.5	–	–	–	W
At case temperatures above 25°C		← See *Fig. 1.* →				
TEMPERATURE RANGE:						
Storage & Operating (Junction)		← −65 to 200 →				°C
LEAD TEMPERATURE (During soldering):						
At distances ≥ 1/32 in. from insulating wafer for 10 s max.		← 230 →				°C

ELECTRICAL CHARACTERISTICS *Case Temperature (T_C) = 25° C*

Characteristic	Symbol	TEST CONDITIONS							LIMITS						Units
		DC Collector Voltage V			DC Emitter or Base Voltage V	DC Current mA			Type 40080		Type 40081		Types 40581 40582 40082 40446		
		V_{CB}	V_{CE}	V_{CC}	V_{BE}	I_C	I_E	I_B	Min.	Max.	Min.	Max.	Min.	Max.	
Collector-to-Emitter Voltage:	V_{CEO}					10		0	30	–	–	–	–	–	V
	V_{CEV}				-0.5 -0.5	100µA 500µA			–	–	60	–	60	–	V
Emitter-to-Base Voltage:	V_{EBO}					0 0	500µA 500µA		–	–	2.0	–	2.5	–	V
Collector-Cutoff Current:	I_{CBO}	15 15 15					0 0 0		–	10	–	10	–	10	µA
Collector-to-Base Capacitance: (Measured at 1 MHz)	C_{ob}		30 30 30							6		6		20	pF
RF Power Output: Oscillator (f = 27 MHz)	P_{OUT}			12		32			100		–	–	–	–	mW
Driver (f = 27 MHz, P_{IN} = 75 mW)	P_{OUT}			12		85			–	–	400		–	–	mW
Output Amplifier (f = 27 MHz, P_{IN} = 350 mW)	P_{OUT}			12		415							3.0 (min.) [40082, 40446]		W
				12		415							3.5 (min.) [40581, 40582]		
Junction-to-Case Thermal Resistance:	θ_{J-C}								350[a] (typ.)		87.5 (typ.)		17.5 (typ.) [40446, 40582] 35 (typ.) [40082, 40581]		°C/W

[a] Junction-to-Ambient Thermal Resistance, θ_{J-A}

TYPICAL C.B. TRANSMITTER PERFORMANCE (V_{CC} = 13.8 V)

STAGE	RCA TYPE	NO MODULATION		100% MODULATION	
		I_C mA	RF P_{OUT} W	I_C mA	RF P_{OUT} W
Oscillator	40080	15	–	15	–
Driver	40081	55	–	50	–
Output	40082, 40581, 40446, or 40582	330	3.5[a]	330	4.8 (typ.)

[a] Adjusted for maximum legal power output.

DISSIPATION DERATING CURVE

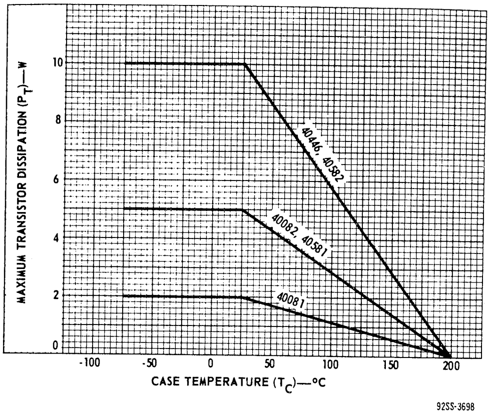
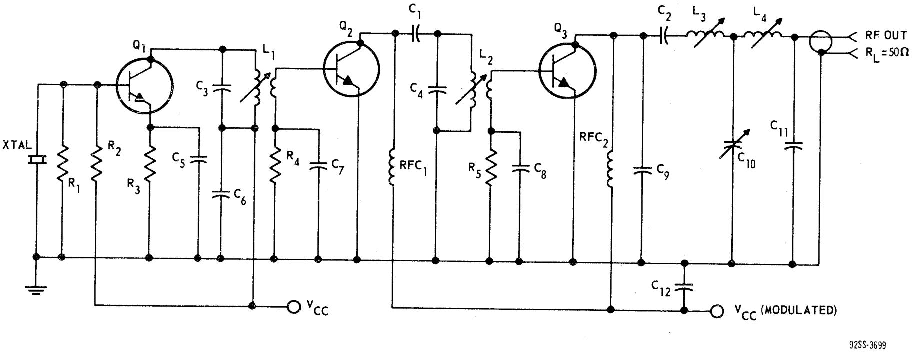


Fig. 1

TYPICAL 27 MHz AMPLIFIER CHAIN



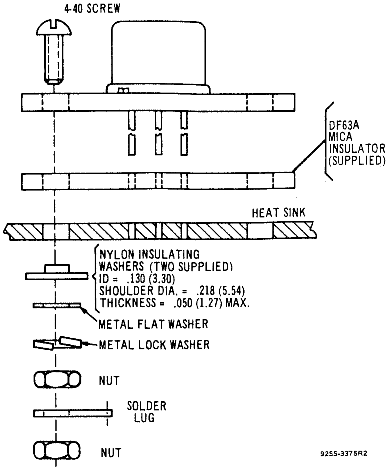
C_1: 47 pF
C_2: 100 pF
C_3: 30 pF
C_4: 51 pF
C_5: 75 pF
C_6, C_{12}: .01 µF
C_7: .001 µF
C_8: .002 µF
C_9: 24 pF
C_{10}: 90-400 pF ARCO No. 429 or equiv.
C_{11}: 220 pF

L_1: 14t:3t # 22 wire ¼" CTC coil form with "green dot" core 0.75–1.2 µhy Q = 100
L_2: 14t:2¾t # 22 wire ¼" CTC coil form with "green dot" core 0.75–1.2 µhy Q = 100
L_3: 11t # 22 wire ¼" CTC coil form with "green dot" core 0.5–0.9 µhy Q = 120
L_4: 7t # 22 wire ¼" CTC coil form with "green dot" core 0.21–0.34 µhy Q = 140
RFC_1,
RFC_2: 15 µhy Miller # 4624 or equiv.

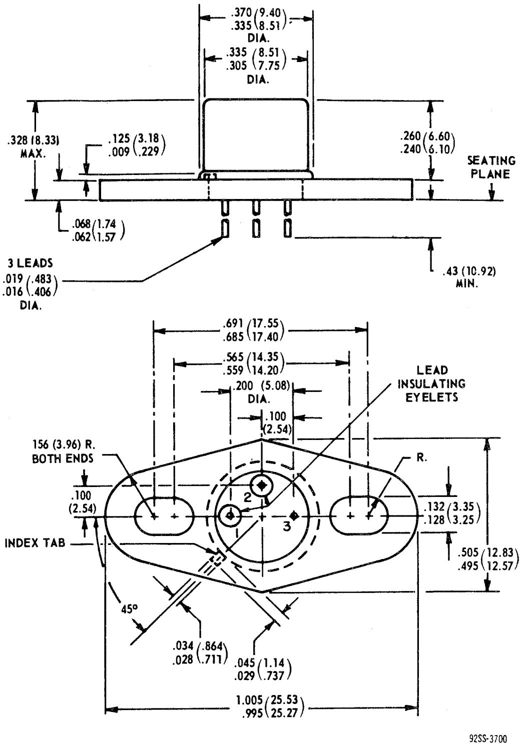
R_1: 510 Ω
R_2: 5,100 Ω
R_3: 51 Ω
R_4: 120 Ω
R_5: 47 Ω
Q_1: RCA–40080
Q_2: RCA–40081
Q_3: RCA–40082, 40446, 40581, 40582
V_{CC}: 11 to 15 V
XTAL: 27 MHz

Fig. 2

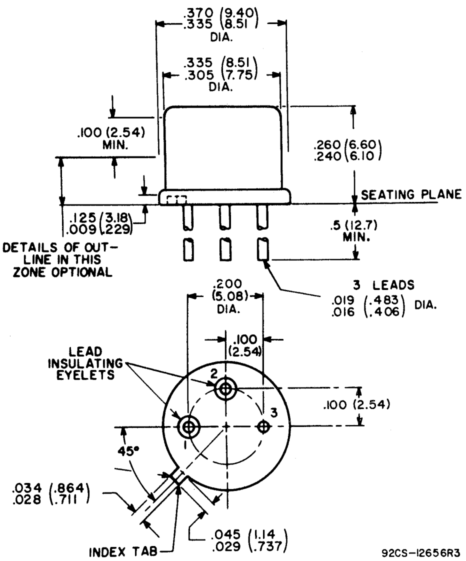
SUGGESTED HARDWARE FOR MOUNTING FLANGED TYPES



DIMENSIONAL OUTLINE FOR TYPES WITH FLANGE (JEDEC TO–39)



DIMENSIONAL OUTLINE (JEDEC TO–39)



TERMINAL CONNECTIONS FOR ALL TYPES

Lead No. 1 – Emitter
Lead No. 2 – Base
Case, Lead No. 3 – Collector

DIMENSIONS IN INCHES AND MILLIMETERS

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

NOTE 1: JEDEC TO–5 dimensions differ only in lead length. Length is 1.5 (38.10) unless a flange is attached. Length is 1.43 (36.32) on units having a flange.

Solid State
Division

RF Power Transistors

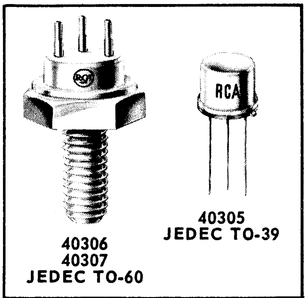
40305
40306
40307

RCA-40305, 40306, and 40307 are high-reliability variants of RCA-2N3553, 2N3375, and 2N3632 epitaxial silicon n-p-n overlay transistors. They are intended for Class-A▲, -B, or -C amplifier, frequency multiplier, or oscillator operation.

These devices are subjected to special preconditioning tests for selection in high-reliability, large-signal, high-power, VHF-UHF applications in Space, Military, and Industrial communications equipment.

High Reliability

High-Power VHF-UHF Amplifier



40306
40307
JEDEC TO-60

40305
JEDEC TO-39

FEATURES

- High-Reliability Assured By Seven (7) Preconditioning Steps
- Data Recorded Before and After "Power-Age Test" and Held to Critical Delta Criteria
- High Voltage Ratings —
  V_{CBO} = 65 volts max.
  V_{CEV} = 65 volts max.
  V_{CEO} = 40 volts max.
- 100 Per-Cent Tested to Assure Freedom from Second Breakdown for Operation in Class-A Applications
- High Power Output, P_{OUT}, Unneutralized Class-C Amplifier —
  At 400 Mc, 3 w min. (40306)
  175 Mc { 13.5 w min. (40307)
  175 Mc { 2.5 w min. (40305)
  100 Mc, 7.5 w min. (40306)

RF SERVICE▲

Maximum Ratings, *Absolute-Maximum Values*

	40305	40306	40307	
COLLECTOR-TO-BASE VOLTAGE, V_{CBO}	65	65	65	volts
COLLECTOR-TO-EMITTER VOLTAGE:				
With base open, V_{CEO}	40	40	40	volts
With V_{BE} = -1.5 volts, V_{CEV}	65	65	65	volts
EMITTER-TO-BASE VOLTAGE, V_{EBO}	4	4	4	volts
COLLECTOR CURRENT, I_C	1.0	1.5	3.0	amperes
TRANSISTOR DISSIPATION, P_T▲:				
At case temperatures up to 25° C	7.0	11.6	23	watts

	40305	40306	40307	
At case temperatures above 25° C . . . . .Derate linearly to 0 watts at 200° C				
TEMPERATURE RANGE:				
Storage		-65 to 200		°C
Operating (Junction)		-65 to 200		°C
PIN OR LEAD TEMPERATURE (During soldering):				
At distances ≧ 1/32" from insulating wafer (TO-60 package) or from seating plane (TO-39 package) for 10 sec. max.		230		°C

▲Secondary breakdown considerations limit maximum DC operating conditions — contact your RCA representative for specific data.

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C

Characteristic	Symbol	TEST CONDITIONS						LIMITS						Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)			40305		40306		40307		
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	Min.	Max.	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		30			0		-	0.1	-	0.1	-	0.25	μamp
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.1	-	-	65	-	-	-	volts
					0		0.3	65	-	-	-	-	-	
					0		0.5	-	-	-	-	65	-	
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4	-	4	-	-	-	volts
					0.25		0	-	-	-	-	4	-	
Collector-to-Emitter Breakdown Voltage	BV_{CEO}					0	0 to 200[a]	40[b]	-	40[b]	-	40[b]	-	volts
	BV_{CEX}			-1.5			0 to 200[a]	65[b]	-	65[b]	-	65[b]	-	volts
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					100	500	-	-	-	1	-	1	volt
						50	250	-	1	-	-	-	-	
DC Forward-Current Transfer Ratio	h_{FE}		5				150	10	-	10	-	-	-	
			5				300	-	-	-	-	10	-	
Collector-to-Base Capacitance Measured at 1 Mc	C_{ob}	30			0			-	10	-	10	-	20	pf
RF Power Output Amplifier, Unneutralized At 100 Mc (See *Fig.2*)	P_{OUT}		28					-	-	7.5[c]	-	-	-	watts
175 Mc (See *Fig.1*)			28					2.5[d]	-	-	-	-	-	
175 Mc (See *Fig.3*)			28					-	-	-	-	13.5[e]	-	
400 Mc (See *Fig.4*)			28					-	-	3[f]	-	-	-	

[a] Pulsed through an inductor (25 mh); duty factor = 50%.

[b] Measured at a current where the breakdown voltage is a minimum.

[c] For P_{IN} = 1.0 w; minimum efficiency = 65%.

[d] For P_{IN} = 1/4 w; minimum efficiency = 50%.

[e] For P_{IN} = 3.5 w; minimum efficiency = 70%.

[f] For P_{IN} = 1.0 w; minimum efficiency = 40%.

RELIABILITY TESTING

RCA types 40305, 40306, and 40307 are electrically similar to RCA-2N3553, 2N3375, and 2N3632 respectively; but they differ in that they have substantially lower collector-cutoff current. I_{CEO} for the 40305 and 40306 is 100 nanoamperes maximum and I_{CEO} for the 40307 is 250 nanoamperes maximum.

Preconditioning (100 Per-Cent Testing of Each Transistor)

1. Helium Leak, 1 x 10^{-8} cc/sec. max.
2. Temperature Cycling-Method 102A of MIL-STD-202, 3 cycles, -65° C to +200° C
3. Methanol Bomb, 70 psig, 16 hours minimum
4. Bake, 72 hours minimum, +200° C
5. Constant Acceleration-Method 2006 of MIL-STD-750, 10,000 G, Y_1 axis
6. Serialization
7. Record I_{CEO}, h_{FE}, $V_{CE}(sat)$
8. Power Age, T_A = 25° C, V_{CB} = 28 V, t = 168 hours, free air
   P_D(40305) = 1 watt
   P_D(40306, 40307) = 2.6 watts

* 9. Record I_{CEO}, h_{FE}, $V_{CE}(sat)$

10. X-Ray Inspection, RCA Spec. 1750326
11. Record Subgroups 2 and 3 of Group A Tests.

* Delta criteria after 168 hours Power Age

I_{CEO}	40305 40306	+100% or +10 nanoamperes whichever is greater
I_{CEO}	40307	+100% or +25 nanoamperes whichever is greater
h_{FE}		±30%
$V_{CE}(sat)$		±0.1 V

Group A Tests

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	SYMBOL	CONDITIONS	LTPD	LIMITS						UNITS
					40305		40306		40307		
					Min.	Max.	Min.	Max.	Min.	Max.	
	Subgroup 1			10							
2071	Visual and Mechanical Examination	-	-	-	-	-	-	-	-	-	-
	Subgroup 2			5							
3041D	Collector-To-Emitter Cutoff Current	I_{CEO}	$V_{CE} = 30$ V, $I_B = 0$	-	-	0.1	-	0.1	-	0.25	μamp
3001D	Collector-To-Base Breakdown Voltage	BV_{CBO}	$I_C = 300\ \mu$a, $I_E = 0$	-	65	-	-	-	-	-	volts
			$I_C = 100\ \mu$a, $I_E = 0$	-	-	-	65	-	-	-	volts
			$I_C = 500\ \mu$a, $I_E = 0$	-	-	-	-	-	65	-	volts
3026D	Emitter-To-Base Breakdown Voltage	BV_{EBO}	$I_E = 100\ \mu$a, $I_C = 0$	-	4	-	4	-	-	-	volts
			$I_E = 250\ \mu$a, $I_C = 0$	-	-	-	-	-	4	-	volts
3011D	Collector-To-Emitter Breakdown Voltage	BV_{CEO}	$I_C = 0$ to 200 ma[a], $I_B = 0$	-	40[b]	-	40[b]	-	40[b]	-	volts
3011A	Collector-To-Emitter Breakdown Voltage	BV_{CEX}	$I_C = 0$ to 200 ma[a], $V_{BE} = -1.5$ V	-	65[b]	-	65[b]	-	65[b]	-	volts
3071	Collector-To-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 250$ ma, $I_B = 50$ ma	-	-	1	-	-	-	-	volts
			$I_C = 500$ ma, $I_B = 100$ ma	-	-	-	-	1	-	1	volts
3076	Forward Current Transfer Ratio	h_{FE}	$I_C = 150$ ma, $V_{CE} = 5$ V	-	10	-	10	-	-	-	
			$I_C = 300$ ma, $V_{CE} = 5$ V	-	-	-	-	-	10	-	
	Subgroup 3			5							
3236	Open Circuit Output Capacitance	C_{ob}	f = 1 Mc, $V_{CB} = 30$ V, $I_E = 0$	-	-	10	-	10	-	20	pf
See Fig.1	R. F. Power Output	P_{OUT}	$V_{CE} = 28$ V, $P_{IN} = 0.25$ watt, f = 175 Mc, Min. Effic. = 50%	-	2.5	-	-	-	-	-	watts
See Fig.2			$V_{CE} = 28$ V, $P_{IN} = 1$ watt, f = 100 Mc, Min. Effic. = 65%	-	-	-	7.5	-	-	-	watts
See Fig.3			$V_{CE} = 28$ V, $P_{IN} = 3.5$ watts, f = 175 Mc, Min. Effic. = 70%	-	-	-	-	-	13.5	-	watts
See Fig.4			$V_{CE} = 28$ V, $P_{IN} = 1$ watt, f = 400 Mc, Min. Effic. = 40%	-	-	-	3	-	-	-	watts
	Subgroup 4			15							
3036D	Collector Cutoff Current	I_{CBO}	$T_A = 150°C \pm 3°C$, $V_{CB} = 30$ V, $I_E = 0$	-	-	100	-	100	-	250	μamp
3076	Forward Current Transfer Ratio	h_{FE}	$T_A = 150°C \pm 3°C$, $I_C = 150$ ma, $V_{CE} = 5$ V	-	-	200	-	200	-	-	
			$T_A = 150°C \pm 3°C$, $I_C = 300$ ma, $V_{CE} = 5$ V	-	-	-	-	-	-	200	

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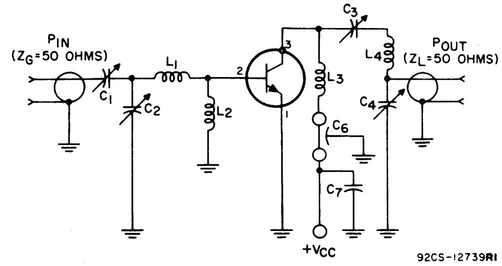
[a] Pulsed through an inductor (25 mh); duty factor = 50%.

[b] Measured at a current where the breakdown voltage is a minimum.

RF AMPLIFIER CIRCUIT FOR 40305 POWER-OUTPUT TEST
(175-Mc Operation)



C_1,C_2,C_3,C_4: 3-35 pf

C_6: 1,000 pf

C_7: 0.005 μf, disc ceramic

L_1: 2 turns No.16 wire, 3/16" ID, 1/4" long

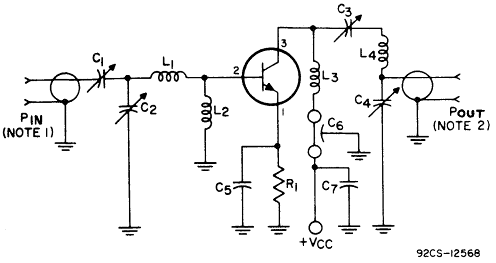
L_2: Ferrite choke, Z = 450 ohms

L_3: 2 turns No.16 wire, 1/4" ID, 1/4" long

L_4: 4 turns No.16 wire, 3/8" ID, 3/8" long

Fig.1

RF AMPLIFIER CIRCUIT FOR 40306 POWER-OUTPUT TEST
(100-Mc Operation)



NOTE 1: GENERATOR IMPEDANCE = 50 OHMS.

NOTE 2: LOAD IMPEDANCE = 50 OHMS.

For 100-Mc Operation:

C_1,C_2: 7-100 pf

C_3,C_4: 4-40 pf

C_5: 330 pf, disc ceramic

C_6: 1500 pf

C_7: 0.005 μf, disc ceramic

L_1: 3 turns No.16 wire, 1/4" ID, 5/16" long

L_2: Ferrite choke, Z = 750(±20%) ohms

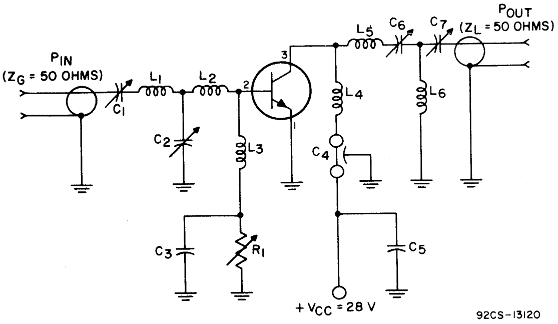
L_3: 2.4-μh choke

L_4: 5 turns No.16 wire, 5/16" ID, 7/16" long

R_1: 1.35 ohms, non-inductive

Fig.2

RF AMPLIFIER CIRCUIT FOR 40307 POWER-OUTPUT TEST
(175-Mc Operation)



For 175-Mc Operation:

C_1,C_6: 3-35 pf

C_2,C_7: 8-60 pf

C_4: 1,000 pf

C_3,C_5: 0.005 μf, disc ceramic

L_1,L_5: 4 turns No.18 wire, 1/4" ID, 3/16" long

L_2: 1 turn No.16 wire, 1/4" ID, 3/16" long

L_3: Ferrite choke, Z = 450 ohms

L_4: RF choke, 1.0 μh

L_6: 2-1/2 turns No.16 wire, 1/4" ID, 1/4" long

R_1: 50 ohms

Fig.3

RF AMPLIFIER CIRCUIT FOR 40306 POWER-OUTPUT TEST
(400-Mc Operation)

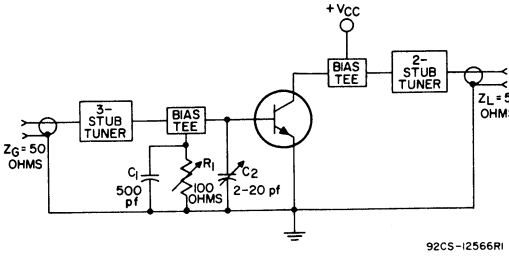
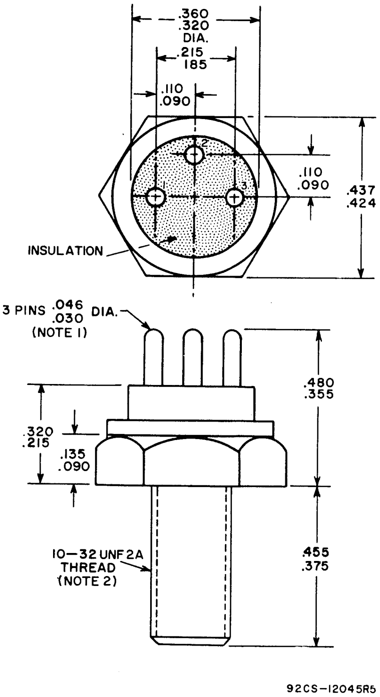


Fig.4

DIMENSIONAL OUTLINES

FOR TYPES 40306, 40307
JEDEC TO-60



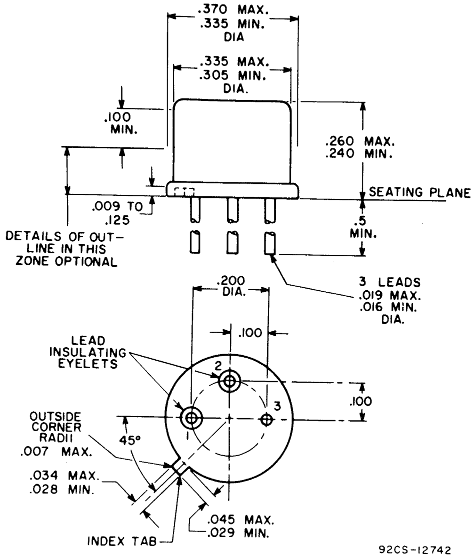
Dimensions in Inches

NOTE 1: THE PIN SPACING PERMITS INSERTION IN ANY SOCKET HAVING A PIN-CIRCLE DIAMETER OF 0.200" AND CONTACTS WHICH WILL ACCOMMODATE PINS HAVING A DIAMETER OF 0.035" MIN., 0.045" MAX.

NOTE 2: THE TORQUE APPLIED TO A 10-32 HEX NUT ASSEMBLED ON THE THREAD DURING INSTALLATION SHOULD NOT EXCEED 12 INCH-POUNDS.

NOTE 3: THIS DEVICE MAY BE OPERATED IN ANY POSITION.

FOR TYPE 40305
JEDEC TO-39



Dimensions in Inches

TERMINAL CONNECTIONS

Pin or Lead No.1 - Emitter

Pin or Lead No.2 - Base

Pin or Lead No.3 - Collector (For 40306, 40307)
Collector, Case (For 40305)

RCA
Solid State
Division

RF Power Transistors

40577

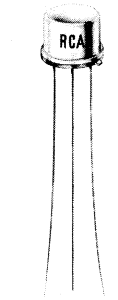
HIGH-RELIABILITY TRANSISTOR

High-Gain Device for Class A or C Operation in VHF Circuits

RCA–40577* is a high-reliability variant of the RCA–2N3118, a triple-diffused transistor. It is especially processed for high reliability. It is intended for Class A and C amplifier, frequency multiplier or oscillator operation in high-reliability, large-signal, high-power VHF applications in Space, Military, and Industrial communications equipment.

High reliability is assured by eight preconditioning steps, including drift temperature measurements after the High Temperature Reverse Bias and Power Age tests. The 40577 also features complete qualification and lot acceptance testing.

- 8 Preconditioning Steps
- Complete Qualification and Lot Acceptance Testing
- 1.0 Watt Output Min. at 50 MHz
- 0.4 Watt Output Min. at 150 MHz



JEDEC TO–5

H–1380

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*Formerly RCA-Dev. No. TA7079

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With $V_{BE} = -1.5$ volts	V_{CEV}	85	V
With base open	V_{CEO}	60	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT	I_C	0.5	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 25° C		3	W
At free-air temperatures up to 25° C		0.5	W
At case temperatures above 25° C		See *Fig.4*	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		–65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. from insulating wafer for 10 s max.		230	°C

TYPICAL POWER OUTPUT vs. POWER INPUT

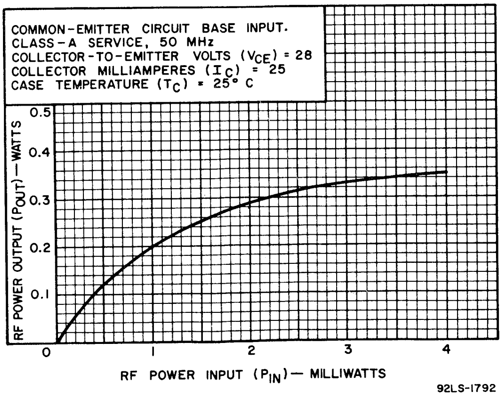


Fig. 1

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C
Except As Indicated

Characteristics	Symbols	TEST CONDITIONS							LIMITS		Units
		Frequency (MHz)	DC Collector-to-Base Voltage (volts)	DC Collector-to-Emitter Voltage (volts)	DC Base Volts	DC Current (Milliamperes)					
		f	V_{CB}	V_{CE}	V_{BE}	I_C	I_E	I_B	Min.	Max.	
Collector-Cutoff Current 25 °C[a] 150 °C[a]	I_{CBO}		30 30				0 0			10 5	nA μA
Emitter-to-Base Breakdown Voltage	BV_{EBO}					0	0.1		4		volts
Collector-to-Emitter Breakdown Voltage (Sustaining)	$BV_{CEO}(sus)$					10 pulsed[b]		0	60		volts
Reverse Collector-to-Emitter Breakdown Voltage	BV_{CEX}				−1.5	0.1			85		volts
Output Capacitance	C_{ob}	1	28			0				6	pF
$r_{bb'}C_{b'c}$ Product	$r_{bb'}C_{b'c}$	50		28		25				60	ps
DC Forward-Current Transfer Ratio[b]	h_{FE}			5		100			50	275	
Small-Signal Forward-Current Transfer Ratio	h_{fe}	50		28		25			5		
Real Part of Short-Circuit Input Impedance	$h_{ie(real)}$	50		28		25			25	75	ohms
Real Part of Short-Circuit Output Impedance	$1/Y_{22(real)}$	50		28		25			500	1000	ohms
Output Power Class-C Service Pin = 0.1 watt (with heat sink)	P_{OUT}	50[c] 150[d]		28 28					1.0 0.4		watt watt
Power Gain Class-A Service P_{out} = 0.2 watt (with heat sink)	PG	50[e]		28		25			18		dB

[a] T_{FA} = free air temperature.
[b] Pulse duration 300 μs; duty factor, less than 1.8%.
[c] See Figure 9.
[d] See Figure 3.
[e] See Figure 5.

TYPICAL LARGE-SIGNAL OPERATION, CLASS-C SERVICE

150 MHz

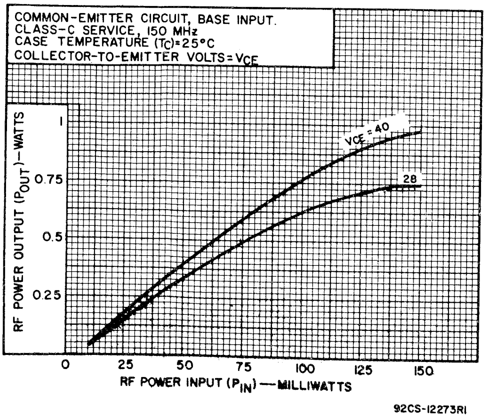
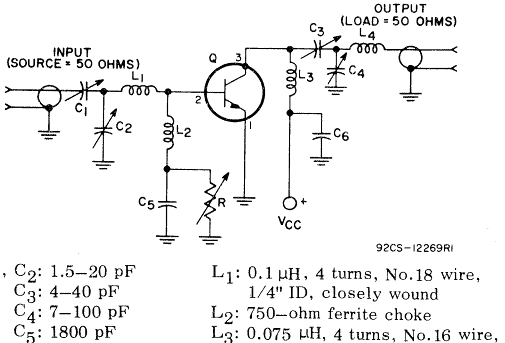


Fig. 2



C_1, C_2: 1.5–20 pF
C_3: 4–40 pF
C_4: 7–100 pF
C_5: 1800 pF
C_6: 0.01 μF
R: 100 ohms, variable

L_1: 0.1 μH, 4 turns, No.18 wire, 1/4" ID, closely wound
L_2: 750–ohm ferrite choke
L_3: 0.075 μH, 4 turns, No.16 wire, 1/4" ID x 3/8" long
L_4: 0.055 μH, 3 turns, No.16 wire, 1/4" ID x 1/4" long
Q: 40577

Fig. 3

RELIABILITY SPECIFICATIONS . . . .

In addition to Preconditioning and Group A tests, a Qualification Approval test series (Group B tests) is performed on each lot.

Preconditioning (100 Per Cent Testing of Each Transistor)

1. Serialization
2. Record I_{CBO}, h_{FE}
3. Temperature Cycling-Method 107B, Cond. C of MIL-STD-202, 5 cycles, −65° C to 200° C
4. Bake, 72 hours minimum, 200° C
5. Constant Acceleration-Method 2006 of MIL-STD-750, 10,000g, Y_1 and Y_2 axes
6. X-Ray
7. Record I_{CBO}, h_{FE}
8. Reverse Bias Age, T_A = 175° C, V_{CB} = 60 V, t = 96 hours

[d]9. Record I_{CBO}, h_{FE}.

10. Power Age, T_A = 25° C, V_{CB} = 28 V, t = 340 hours, P_T = 1 W, free air

[d]11. Record I_{CBO}, h_{FE} at 340 hours

12. Helium Leak, 1 x 10^{-7} cc/sec. max.
13. Gross Leak, MIL-STD-202, Method 112
14. Record Subgroups 2 and 3 of Group A Tests

[d]Delta criteria after 96 hours Reverse Bias Age and 340 hours Power Age.

ΔI_{CBO}	+100% or +5 nanoamperes whichever is greater
Δh_{FE}	±20%

Definitions

Delta (Δ): Delta shall be determined by subtracting the parameter value measured before application of stress from the value measured after the application of stress.

Group A Tests

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS	LTPD	SYMBOL	LIMITS		UNITS
					Min.	Max.	
	Subgroup 1		10				
2071	Visual and Mechanical Examination	—	—	—	—	—	—
	Subgroup 2		5				
3036D	Collector-Cutoff Current	V_{CB} = 30V, I_E = 0	—	I_{CBO}	—	10	nA
3001D	Collector-to-Emitter Breakdown Voltage	I_C = 100 μA, V_{BE} = −1.5 V	—	BV_{CEV}	85[g]	—	volts
3026D	Emitter-to-Base Breakdown Voltage	I_E = 100 μA, I_C = 0	—	BV_{EBO}	4	—	volts
3011D	Collector-to-Emitter Breakdown Voltage	I_C = 10 mA[f] I_B = 0	—	V_{CEO}	60[g]	—	volts
3076	DC Forward-Current Transfer Ratio	I_C = 100 mA, V_{CE} = 5V	—	h_{FE}	50	275	
	Subgroup 3		5				
3236	Output Capacitance	f = 0.1 to 1.0 MHz, V_{CB}=28V, I_E = 0	—	C_{ob}	—	6.0	pF
See *Fig.3*	Power Output	f = 50 MHz, V_{CE} = 28V Pin = 0.1 W	—	P_{OUT}	1.0	—	watts
See *Fig.5*	RF Power Output (Min. Eff. = 45%)	V_{CE} = 28 V, P_{IN} = 0.1 W f = 150 MHz	—	P_{OUT}	0.4	—	watts
3306	Small-Signal Forward-Current Transfer Ratio	I_C = 25 mA, V_{CE} = 28 V f = 50 MHz	—	h_{fe}	—	5.0	
	Subgroup 4		15				
3036D	Collector-Cutoff Current	T_A = 150° C, V_{CB} = 30 V	—	I_{CBO}	—	5	μA
3201	Input Impedance	V_{CE} = 28 V, I_C = 25 mA f = 50 MHz	—	h_{ie}	25	75	ohms
3231	Output Admittance	V_{CE} = 28 V, I_C = 25 mA f = 50 MHz	—	Y_{22}	1	2	mmho

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[f] Pulsed through an inductor (25 μH); duty factor = 50%.

[g] Measured at a current where the breakdown voltage is a minimum.

General Reliability Specifications that are applicable to all rf power transistors are given in booklet RFT-701 and must be used in conjunction with the specific Preconditioning, Group A Tests, and Group B Tests shown below.

Group B Tests[h]

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS
	Subgroup 1	(13 Samples)
2066	Physical Dimensions	JEDEC TO-5 Pkg.
	Subgroup 2	(13 Samples)
2026	Solderability	Omit aging, Dwell time = 10 s ± 1 s
1051	Thermal Shock (Temp. Cycling)	Test Condition C
1056	Thermal Shock (Glass Strain)	Test Condition B
	Seal (Leak Rate)	Method 112 of MIL-STD-202 Test Cond. C, procedure III; Test Cond. A for gross leaks
1021	Moisture Resistance	
	Subgroup 3	(13 Samples)
2016	Shock	1,500 g, 0.5 ms, 5 blows each orientation: X_1, Y_1, Y_2, Z_1
2046	Vibration Fatigue	Nonoperating
2056	Vibration Var. Freq.	–
2006	Constant Acceleration	20,000 G Y_1, Y_2
	Subgroup 4	(13 Samples)
2036	Terminal Strength (Lead Fatique)	Test Cond. E
	Subgroup 5	(13 Samples)
1041	Salt Atmosphere	
	Subgroup 6	(25 Samples)
1031	High Temperature Life (Non-operating)	$T_{storage} = 200°$ C t = 1000 hrs.
	Subgroup 7	(25 Samples)
1026	Steady-State Operation	$P_T = 1.5$ W, $T_C = 100°$ C t = 1000 hrs. $V_{CB} = 40$ V

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS	SYMBOL	LIMITS		UNITS
				Min.	Max.	
	End Points Subgroups (2, 3, 5, 6)					
3036D	Collector Base Cutoff Current	$V_{CB} = 30$ V, $I_E = 0$	I_{CBO}		1.0	µA
3001D	Collector Base Breakdown Voltage	$V_{BE} = -1.5$ V, $I_C = 100$ µA	BV_{CEV}	80		
3076	DC Forward-Current Transfer Ratio	$I_C = 100$ mA, $V_{CE} = 5$ V	h_{FE}	35	325	–

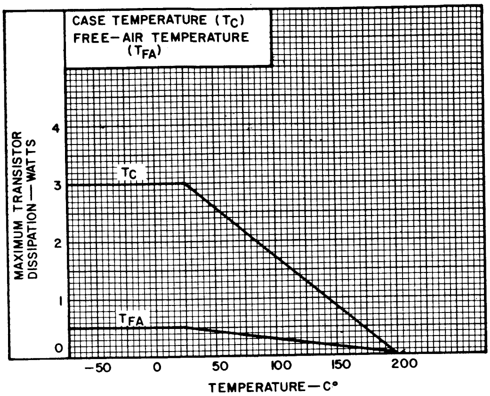
[h] Acceptance/Rejection Criteria of Group B tests: For an LTPD plan of 7% the total sample size is 115 for which the maximum number of rejects allowed is 4. Acceptance is also subject to a maximum of one (1) reject per Sub-group. Group B tests are performed on each lot for Qualification or Lot Acceptance.

[i] Pulsed through an inductor (25 mH); duty factor = 50%.

[k] Measured at a current where the breakdown voltage is a minimum.

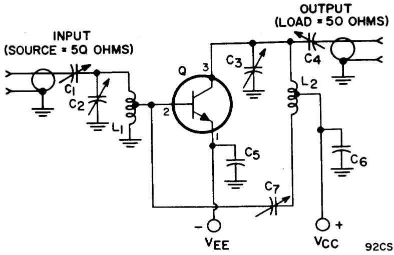
TYPICAL CLASS A-SERVICE OPERATION, 50 MHz NEUTRALIZED

DISSIPATION DERATING CURVE



92CS-12281R1

Fig. 4

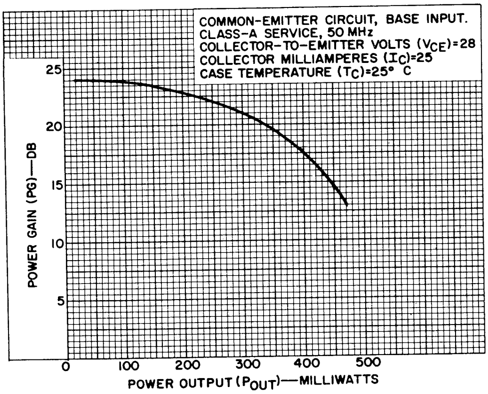


92CS-12270R1

C_1: 7–100 pF
C_2: 8–60 pF
C_3: 14–150 pF
C_4: 6–80 pF
C_5, C_6: 0.005 μF
C_7: 0.9–7 pF

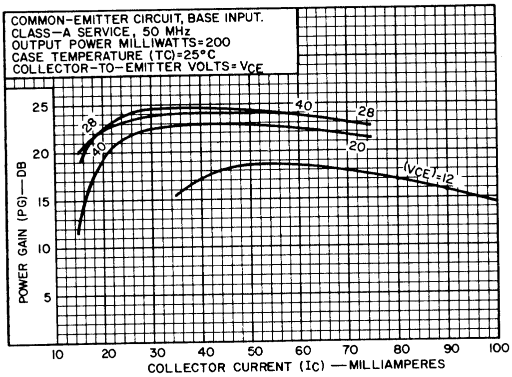
L_1: 0.12 μH, 3 turns, No.16 wire, 7/16" ID x 1/4" long, tap at 1 turn from ground
L_2: 0.23 μH, 5 turns, No.16 wire, 7/16" ID x 1/2" long, tap at 3 turns from collector terminal
Q: 4057

Fig. 5



92CS-12277

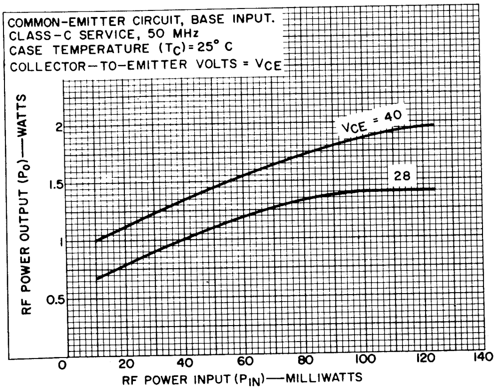
Fig. 6



92CS-12276R1

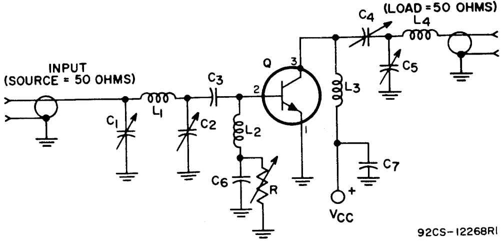
Fig. 7

TYPICAL LARGE-SIGNAL OPERATION, CLASS-C SERVICE, 50 MHz



92CS-12272R1

Fig. 8



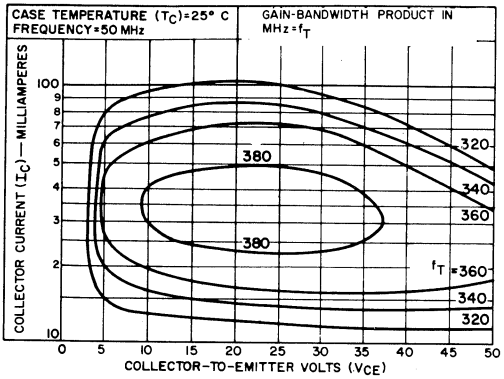
92CS-12268R1

C_1: 70–350 pF
C_2, C_4, C_5: 7–100 pF
C_3: 0.01 μF
C_6: 0.002 μF
C_7: 0.02 μF
R: 1000 ohms, variable

L_1: 0.13 μH, 4 turns, No.18 wire, 1/4" ID, closely wound
L_2: 2.4 μH, choke, Miller Part No.4606
L_3: 0.6 μH, 10 turns, No.18 wire, 3/8" ID, closely wound
L_4: 0.6 μH, 10 turns, No.18 wire, 3/8" ID, closely wound
Q: 40577

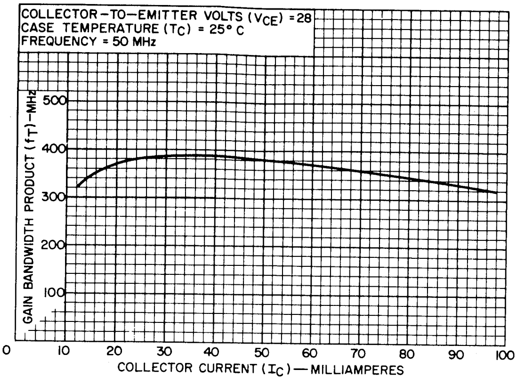
Fig. 9

TYPICAL SMALL-SIGNAL OPERATION CHARACTERISTICS



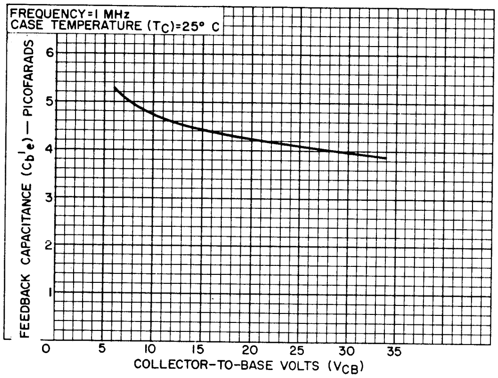
92CS-12286

Fig. 10



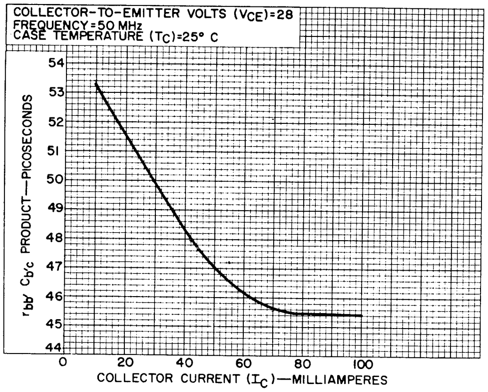
92CS-12287

Fig. 11



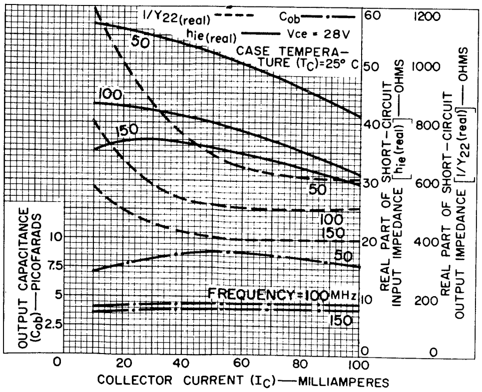
92CS-12283R1

Fig. 12



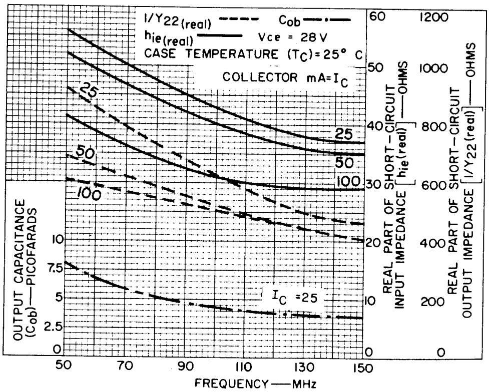
92CS-12284

Fig. 13



92CS-12289R1

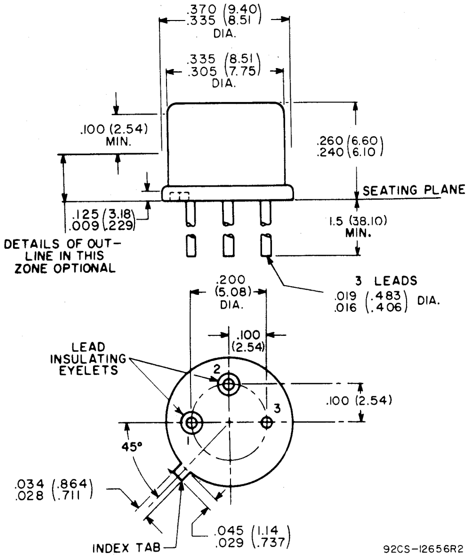
Fig. 14



92CS-12288R2

Fig. 15

DIMENSIONAL OUTLINE
JEDEC No.TO-5



Note *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

TERMINAL CONNECTIONS

Lead 1 – Emitter
Lead 2 – Base
Lead 3 – Collector,
Case

RCA
Solid State Division

40605

RCA-40605* is an epitaxial silicon n-p-n planar transistor featuring "overlay" emitter electrode construction. It is intended for class-A, -B, or -C amplifier, frequency multiplier, and oscillator service in VHF/UHF equipment.

Premium high-reliability type 40605 is identical to RCA-2N3553 but is preconditioned and tested for use in critical aerospace and industrial equipment.

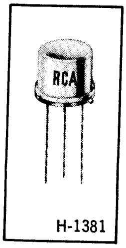
---

*Formerly RCA Dev. Type No. TA7361.

SILICON N-P-N "overlay" TRANSISTOR

"Premium" High-Reliability Type

For Class-A,-B, or -C Service in VHF/UHF Military, Industrial, and Commercial Equipment



JEDEC TO-39

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65 V
COLLECTOR-TO-EMITTER VOLTAGE:		
With -1.5 volts (V_{BE}) of reverse bias & external base-to-emitter resistance (R_{BE}) = 33 Ω	V_{CEX}	65 V
With base open	V_{CEO}	40 V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4 V
CONTINUOUS COLLECTOR CURRENT	I_C	0.33 A
PEAK COLLECTOR CURRENT	I_{Cpk}	1 A
TRANSISTOR DISSIPATION:	P_T	
At case temperatures up to 25°C		7 W
At case temperatures above 25°C derate linearly at		0.04 W/°C
At ambient temperatures up to 25°C		1 W
At ambient temperatures above 25°C derate linearly at		5.71 mW/°C
TEMPERATURE RANGE:		
Storage & Operating (Junction)		-65 to +200°C
LEAD TEMPERATURE (During Soldering):		
At distances ≥ 1/32 in. (0.8 mm) from seating plane for 10 s max		230°C

FEATURES:

- **High Power Output**
  - **Class-C Amplifier . . .**
    2.5-W (min.) at 175 MHz
  - **Oscillator . . .**
    1.5-W (typ.) at 500 MHz

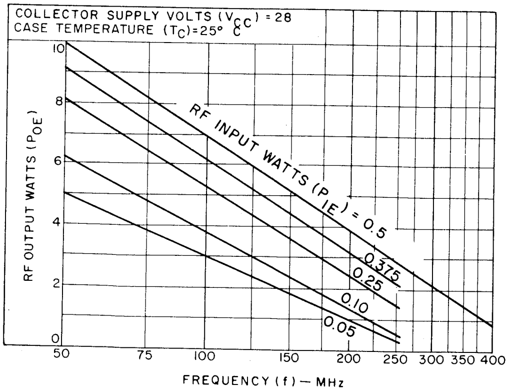


Fig.1 - Typical power output vs. frequency.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS: DC Collector Volts V_{CE}	DC Base Volts V_{BE}	DC Current mA I_E	I_B	I_C	LIMITS MIN.	MAX.	UNITS
Collector-Cutoff Current	I_{CEO}	30			0		–	0.1	µA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.3	65	–	V
Collector-to-Emitter Breakdown Voltage: *(See Fig. 2.)* With base open	$V_{(BR)CEO}$				0	200[a]	40[b]	–	V
With base-emitter junction reverse biased & external base-to-emitter resistance (R_{BE}) = 33 Ω	$V_{(BR)CEX}$		−1.5			200[a]	65[b]	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	4	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				50	250	–	1	V

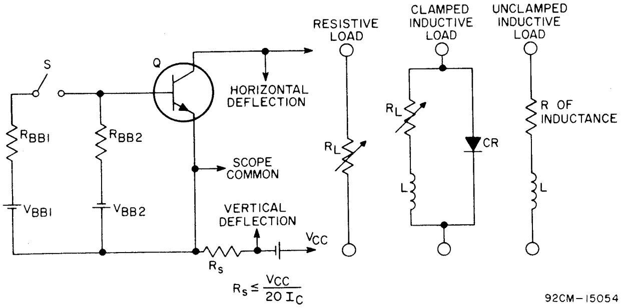
[a] Pulsed through a 25-mH inductor; duty factor = 50%

[b] Measured at a current where the breakdown voltage is a minimum.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS: DC Collector Supply (V_{CC}) – V	Input Power (P_{IE}) – W	Frequency (f) – MHz	LIMITS MIN.	TYP.	UNITS
Power Output *(See Fig. 3.)*	P_{OE}	28	0.25	175	2.5[c]	–	W
Collector-to-Base Capacitance	C_{obo}	V_{CB} = 30 V I_C = 0	–	1	–	10	pF
Gain-Bandwidth Product	f_T	V_{CE} = 28 V I_C = 125 mA	–	–	350	–	MHz

[c] Minimum efficiency = 50%

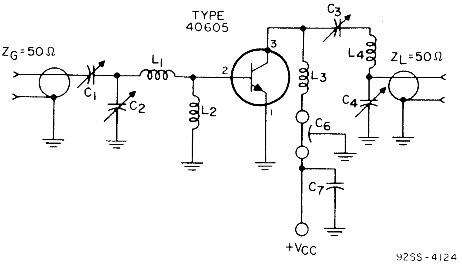


L: 25 mH at 100 mA
R_{BB1}: 150 Ω
R_S: 1 Ω
S: Clare Mercury Relay or equivalent
V_{CC}: 20 V
V_{BB1}: 20 V

$V_{(BR)CEO}$ Measurement	$V_{(BR)CEX}$ Measurement
$R_{BB2} = \infty$	R_{BB2} = 33 Ω
V_{BB2} = 0	V_{BB2} = −1.5 V

R of inductance = 83 Ω

Fig.2 - Circuit used to measure voltages $V_{(BR)CEO}$ and $V_{(BR)CEX}$ (unclamped).



C_1, C_2
C_3, C_4: 3-35 pF
C_5: 100 pF, feed-through
C_6: 0.005 μF, disc-ceramic
L_1: 2 turns No. 16 wire, 3/16 in. ID, ¼ in. long
L_2: Ferrite choke, 450 Ω impedance
L_3: 2 turns No. 16 wire, ¼ in. ID, ¼ in. long
L_4: 4 turns No. 16 wire, 3/8 in. ID, 3/8 in. long

Fig.3 - 175 MHz amplifier test circuit for measurement of power output.

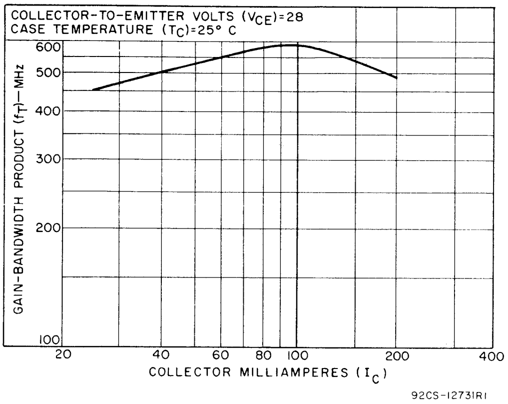


Fig.4 - Typical gain-bandwidth product.

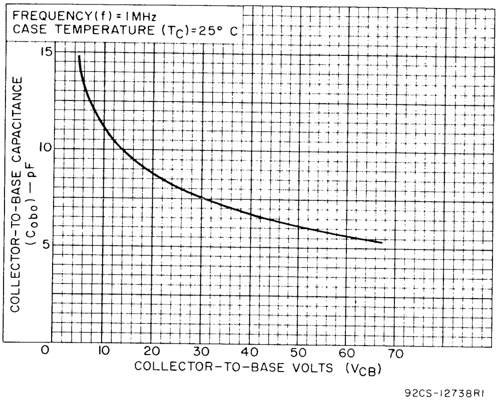


Fig.5 - Typical variation of collector-to-base capacitance.

RELIABILITY SPECIFICATIONS . . .

General Reliability Specifications that are applicable to all rf power transistors are given in booklet RFT-701 and must be used in conjunction with the specific lot screening, Group A Tests, and Group B Tests shown below.

Lot Acceptance Data

Conditioning Screens (100% Testing, see Table I)

a) Attributes Data on Burn-In

b) Attributes Data on Radiographic Inspection

c) Variables Data on Burn-In

Group A (Lot Sampling, see Table II)

a) Variables Data

Group B (Lot Sampling, see Table III)

a) Attributes Data (From a member of the family)

Table 1. Description of Total Lot Screening – 100% Testing

TEST	CONDITIONS	MIL-STD-750		MIL-STD-202	
		METHOD	CONDITIONS	METHOD	CONDITIONS
1. Lot identification	–	–	–	–	–
2. Pre-seal visual inspection	In accordance with RCA's RFT-701 (See note 1)	–	–	–	–
3. Temp. cycling	5 cycles	1051	C	–	–
4. High Temp. storage	72 hrs. min. at $T_A = 200^\circ$ C	–	–	–	–
5. Acceleration	20,000 g min.; Y_1 direction only	2006	–	–	–
6. Fine leak	–	–	–	112	C
7. Gross leak	Fluorocarbon bubble test (See note 2)	–	–	–	–
8. Serialize	–	–	–	–	–
9. Pre burn-in electrical	See Table 1 A	–	–	–	–
10. Burn-in	(See note 3)	–	–	–	–
11. Post burn-in electrical	Delta requirements See table 1 A	–	–	–	–
12. Radiographic inspection	–	–	–	–	–

Note 1: Complete title of RFT-701 is: "General Reliability Specifications of RCA RF Power Transistors".

Note 2: Immersed in fluorochemical FC 78 at 65 psig for 4 hrs, unit is than placed in fluorochemical FC 48 at 80° C (nominal) and observed for bubbles.

Note 3: Burn-in tests:

Reverse bias age – all transistors shall be operated for 96 hrs at $T_A = 150^\circ$ C, $V_{CB} = 50$ V

Power age – all transistors shall be operated for 340 hrs at $T_A = 25^\circ$ C $\pm 3^\circ$ C, $V_{CB} = 30$ V, $P_T = 1$ W.

Table 1A. Pre Burn-In & Post Burn-In Tests and Delta (Δ) Limits

TEST	SYMBOL	MIL-STD-750		LIMITS		UNITS
		METHOD	CONDITIONS	MIN.	MAX.	
Collector-Cutoff Current	I_{CEO}	3041	$V_{CE} = 30$ V, bias cond. D	–	0.1	μA
DC Forward-Current Transfer Ratio	h_{FE}	3076	$V_{CE} = 5$ V, $I_C = 150$ mA pulsed	15	150	—

Delta (Δ) Limits:

I_{CEO} and h_{FE} of Table 1A shall be retested after each burn-in test and the data recorded for all devices in the lot. The tests measured shall not have changed during each burn-in test from the initial value by more than the specified amount as follows:

$\Delta I_{CEO} = \pm 100\%$ or 10 nA, whichever is greater

$\Delta h_{FE} = \pm 20\%$

All transistors that exceed the delta (Δ) limits or the limits of Table 1A after each burn-in test shall be removed from the lot and the quantity removed shall be recorded in the lot history.

Table II. Group A Electrical Sampling Inspection

EXAMINATION OR TEST	MIL-STD-750		LTPD	SYMBOL	LIMITS		UNITS
	METHOD	CONDITIONS			MIN.	MAX.	
Subgroup 1			10				
Visual and Mechanical Examination	2071	–	–	–	–	–	–
Subgroup 2			5				
Collector-Cutoff Current	3041D	$V_{CE} = 30$ V, $I_B = 0$	–	I_{CEO}	–	100	nA
Collector-to-Base Breakdown Voltage	3001D	$I_C = 0.3$ mA	–	$V_{(BR)CBO}$	65	–	V
Emitter-to-Base Breakdown Voltage	3026D	$I_E = 0.1$ mA	–	$V_{(BR)EBO}$	4	–	V
Collector-to-Emitter Breakdown Voltage	3011D See Fig. 2.	$I_C = 200$ mA[a]	–	$V_{(BR)CEO}$	40[b]	–	V
Collector-to-Emitter Breakdown Voltage	3011B See Fig. 2.	$I_C = 200$ mA[a], $V_{BE} = -1.5$ V, $R_{BE} = 33\,\Omega$	–	$V_{(BR)CEX}$	65[b]	–	V
Collector-to-Emitter Saturation Voltage	3071	$I_C = 250$ mA, $I_B = 50$ mA	–	V_{CE} (sat)	–	1	V
DC Forward-Current Transfer Ratio	3076	$I_C = 150$ mA, $V_{CE} = 5$ V	–	h_{FE}	15	150	–
Subgroup 3			5				
Output Capacitance	3236	$V_{CB} = 30$ V, $I_C = 0$	–	C_{obo}	–	10	pF
Extrapolated Unity Gain Frequency	3261	$I_C = 125$ mA, $V_{CE} = 28$ V, f = 100 MHz	–	f_T	350	–	MHz
RF Power Output (Min. Eff. = 50%)	See Fig. 3.	$V_{CE} = 28$ V, $P_{IE} = 0.25$ W, f = 175 MHz	–	P_{OE}	2.5	–	W
Subgroup 4			15				
Collector-Cutoff Current	3036D	$T_A = 150^\circ$ C $\pm 3^\circ$ C, $V_{CB} = 30$ V	–	I_{CBO}	–	100	μA
DC Forward-Current Transfer Ratio	3076	$T_A = -55^\circ$ C $\pm 3^\circ$ C, $I_C = 150$ mA, $V_{CE} = 5$ V	–	h_{FE}	10	–	–

[a] Pulsed through a 25 mH inductor; duty factor = 50%

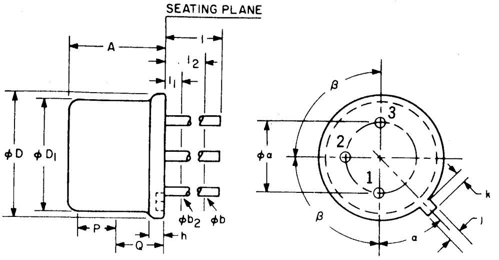
[b] Measured at a current where the breakdown voltage is a minimum

Table III. Group B Environmental Sampling Inspection

EXAMINATION OR TEST	MIL-STD-750		LTPD	SYMBOL	LIMITS		UNITS
	METHOD	CONDITIONS			MIN.	MAX.	
Subgroup 1			20				
Physical Dimensions	2066	–		–	–	–	–
Subgroup 2			15				
Solderability	2026	–		–	–	–	–
Thermal Shock (Temp. Cycling)	1051	Test Condition C		–	–	–	–
Thermal Shock (Glass Strain)	1056	Test Condition B		–	–	–	–
Seal (Leak Rate)	–	Method 112 of MIL-STD-202 Test Cond. C, procedure III a		–	–	1×10^{-7}	atm cc/s
		For Gross Leaks, Refer to Note 1 in Lot Screening sequence		–	–	–	–
Moisture Resistance	1021	–		–	–	–	–
End Points:							
Collector-Cutoff Current	3041D	$V_{CE} = 30$ V, $I_B = 0$		I_{CEO}	–	100	nA
Collector-to-Emitter Breakdown Voltage	3011D See Fig. 2.	$I_C = 200$ mA[a]		$V_{(BR)CEO}$	40	–	V
DC Forward-Current Transfer Ratio	3076	$I_C = 150$ mA, $V_{CE} = 5$ V		h_{FE}	12	–	–
RF Power Output (Min. Eff = 50%)	See Fig. 3	$V_{CE} = 28$ V, $P_{IE} = 0.25$ W, f = 175 MHz		P_{OE}	2.5	–	W
Subgroup 3			15				
Shock	2016	1,500 g, 0.5 ms, 5 blows each orientation: X_1, Y_1, Z_1, Y_2,(15 blows total)		–	–	–	–
Vibration Fatigue	2046	Nonoperating		–	–	–	–
Vibration, Variable Frequency	2056	–		–	–	–	–
Constant Acceleration	2006	20,000 g Y_1, Y_2		–	–	–	–
End Points: (Same as Subgroup 2)							
Subgroup 4			15				
Terminal Strength (Lead Fatigue)	2036E	–		–	–	–	–
Subgroup 5			15				
Salt Atmosphere	1041	–		–	–	–	–
Subgroup 6							
High Temperature Life (Nonoperating)		$T_{stg} = +200^{\circ}$ C, t = 1000 hrs.	–	–	–	–	–
End Points:							
Collector-Cutoff Current	3041D	$V_{CE} = 30$ V, $I_B = 0$	–	I_{CEO}	–	1	μA
Collector-to-Emitter Breakdown Voltage	3011D See Fig. 2.	$I_C = 200$ mA[a]	–	$V_{(BR)CEO}$	40	–	V
DC Forward-Current Transfer Ratio	3076	$I_C = 150$ mA, $V_{CE} = 5$ V	–	h_{FE}	12	–	–
RF Power Output (Min. Eff. = 50%)	See Fig. 3	$V_{CE} = 28$ V, $P_{IE} = 0.25$ W, f = 175 MHz	–	P_{OE}	2.3	–	W

[a] Pulsed through a 25 μH inductor; duty factor = 50%

DIMENSIONAL OUTLINE
JEDEC No.TO-39



92CS-15641

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕa	.190	.210	4.83	5.33	
A	.240	.260	6.10	6.60	
ϕb	.016	.021	.406	.533	2
ϕb_2	.016	.019	.406	.483	2
ϕD	.350	.370	8.89	9.40	
ϕD_1	.315	.335	8.00	8.51	
h	.009	.125	.229	3.18	
j	.028	.034	.711	.864	
k	.029	.040	.737	1.02	3
l	.500		12.70		2
l_1		.050		1.27	2
l_2	.250		6.35		2
P	.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

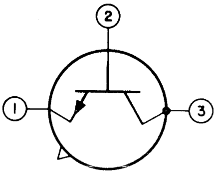
Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed .010 in (.254 mm).

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and .5 in (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond .5 in (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the actual device.

Note 4: Details of outline in this zone optional.

TERMINAL DIAGRAM



LEAD 1 – EMITTER
LEAD 2 – BASE
CASE, LEAD 3 – COLLECTOR

UHF Broadband Types

Solid State Division

RF Power Transistors

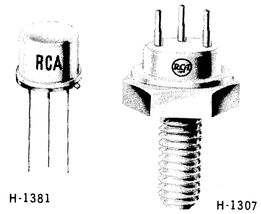
2N3375 2N3632
2N3553 40665
40666

SILICON N-P-N OVERLAY TRANSISTORS

For VHF-UHF Applications

RCA 2N3632, 2N3553, 2N3375, 40665 and 40666 are epitaxial silicon n-p-n transistors of the "overlay" emitter electrode construction. They are intended for use in class A, B, and C amplifiers, frequency multipliers and oscillators. The 2N3375, 2N3553, and 40666 are especially intended for VHF-UHF applications while the 2N3632 and 40665 are designed for use in VHF circuits.

All the pins of the 2N3632 and 2N3375 are electrically isolated from the case. In the 40665 and 40666 (variants of types 2N3632 and 2N3375, respectively), the emitter is connected internally to the case.



2N3553 — JEDEC TO-39

2N3632, 2N3375, 40666, 40665 — JEDEC TO-60

Maximum Ratings, *Absolute-Maximum Values:*

		2N3553	2N3375 40666	2N3632 40665	
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	65	65	V
COLLECTOR-TO-EMITTER VOLTAGE:					
With base open	V_{CEO}	40	40	40	V
With $V_{BE} = -1.5V$	V_{CEV}	65	65	65	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	4	4	V
COLLECTOR CURRENT:					
Peak		1.0	1.5	3.0	A
Continuous	I_C	0.33	0.5	1.0	A
TRANSISTOR DISSIPATION	P_T				
At case temperatures up to 25° C		7.0	11.6	23	W
At case temperature above 25° C		Derate linearly to 0 watts at 200° C			
TEMPERATURE RANGE:					
Storage & Operating (Junction)			-65 to 200		°C
LEAD TEMPERATURE (During soldering): At distances ≥1/32 in. (.793 mm) insulating wafer (TO-60 package) or from seating plane (TO-39 package) for 10 s max			230		°C

- **High Power Output, Class-C Amplifier:**

TYPE	400 MHz	260 MHz	175 MHz	100 MHz
2N3632 40665		10 W Typ.	13.5 W Min.	
2N3553		2.5 W Typ.	2.5 W Min.	
2N3375 40666	3 W Min.			7.5 W Min.

- **High Power Output, Oscillator:**
  2.5W (Typ.) at 500 MHz, (2N3375)
  1.5W (Typ.) at 500 MHz, (2N3553)
- **High Voltage Ratings**
- **Internally Grounded Emitter Types (40665 and 40666) available.**

ELECTRICAL CHARACTERISTICS: *At Case Temperature (T_C) = 25°C*

Characteristic	Symbol	TEST CONDITIONS						LIMITS						Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)			40665 2N3632		2N3553		40666 2N3375		
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	Min.	Max.	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		30			0		-	0.25	-	0.1	-	0.1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)EBO}$				0		0.1	-	-	-	-	65	-	V
					0		0.3	-	-	65	-	-	-	
					0		0.5	65	-	-	-	-	-	
Collector-to-Emitter Breakdown Voltage	$V_{(BR)CEO}$					0	0 to 200[a]	40[b]	-	40[b]	-	40[b]	-	V
	$V_{(BR)CEV}$			−1.5			0 to 200[a]	65[b]		65[b]		65[b]	-	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$				0.1		0	-	-	4	-	4	-	V
					0.25		0	4	-	-	-	-	-	
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					100	500	-	1	-	-	-	1	V
						50	250	-	-	-	1	-	-	
Collector-to-Base Capacitance Measured at 1 MHz	C_{obo}	30			0			-	20	-	10	-	10	pF
RF Power Output Amplifier, Unneutralized At 100 MHz (See Fig. 24)	P_{OE}		28					-	-	-	-	7.5[c]	-	W
175 MHz (See Fig. 22 & 27)			28					13.5[e]	-	2.5[g]	-	-	-	
260 MHz (See Fig.21, 23, & 28)			28					10[f] (typ.)		-	-	-	-	
400 MHz (See Fig. 25) 26)			28					-	-	-	-	3[d]	-	
Gain-Bandwidth Product	f_T		28				100	-	-	500 (typ.)		-	-	MHz
			28				150	400 (typ.)		-		500 (typ.)		
Base-Spreading Resistance Measured at 100 MHz	$r_{bb'}$		28				100	-	-	12.0 (typ.)		-	-	ohms
200 MHz			28				250	6.5 (typ.)		-	-	-	-	
400 MHz			28				250	-	-	-	-	10.0 (typ.)		

[a] Pulsed through an inductor (25 mH); duty factor = 50%.

[b] Measured at a current where the breakdown voltage is a minimum.

[c] For P_{IE} = 1.0 W; minimum efficiency = 65%.

[d] For P_{IE} = 1.0 W; minimum efficiency = 40%.

[e] For P_{IE} = 3.5 W; minimum efficiency = 70%.

[f] For P_{IE} = 3.0 W; typical efficiency = 60%.

[g] For P_{IE} = 1/4 W; minimum efficiency = 50%.

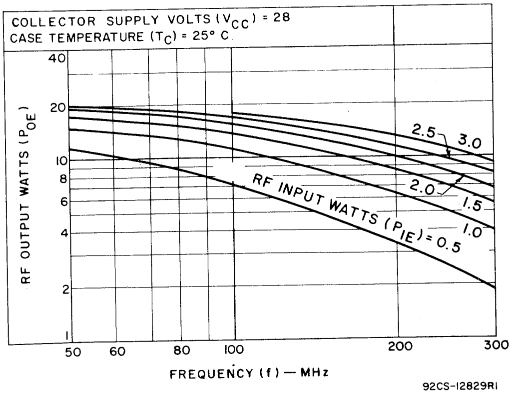


Fig.1 - Power output vs frequency for 2N3632 & 40665

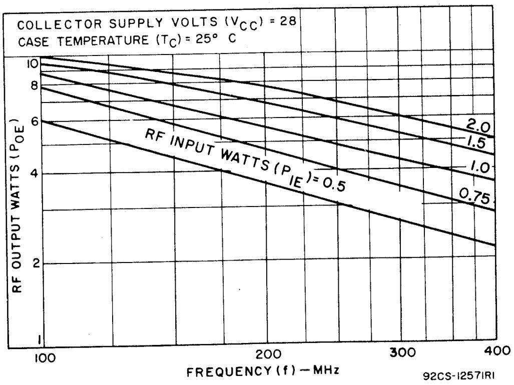


Fig.2 - Power output vs frequency for 2N3375 & 40666

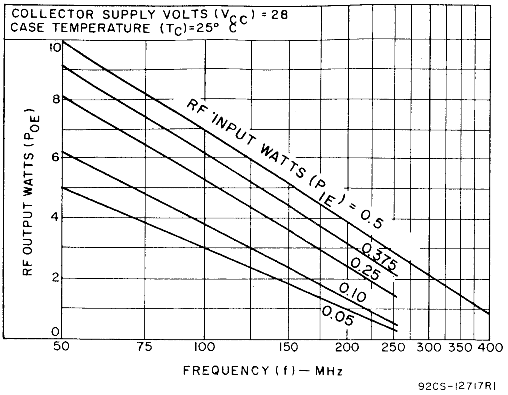


Fig.3 - Power output vs frequency for type 2N3553

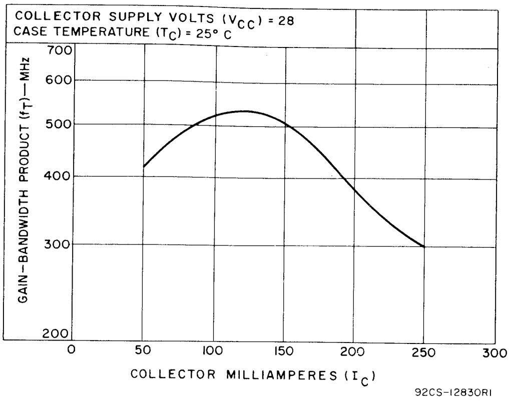


Fig.4 - Gain-bandwidth product vs collector current for types 2N3632 & 40665

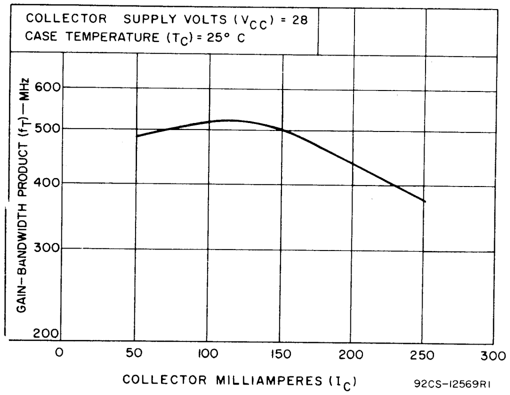


Fig.5 - Gain-bandwidth product vs collector current for types 2N3375 & 40666

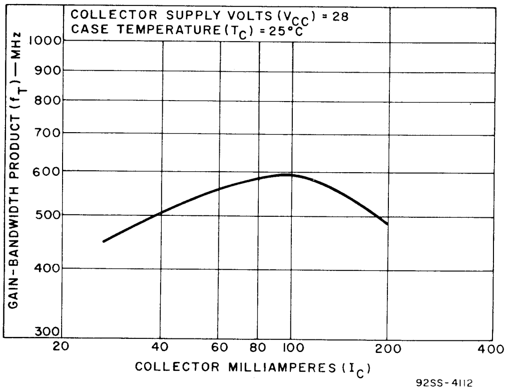


Fig.6 - Gain-bandwidth product vs collector current for 2N3553

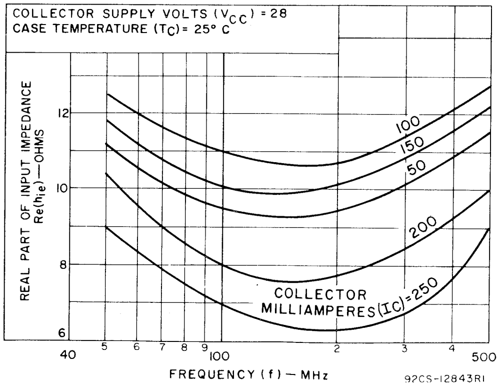


Fig.7 - Series input resistance vs frequency for type 2N3632

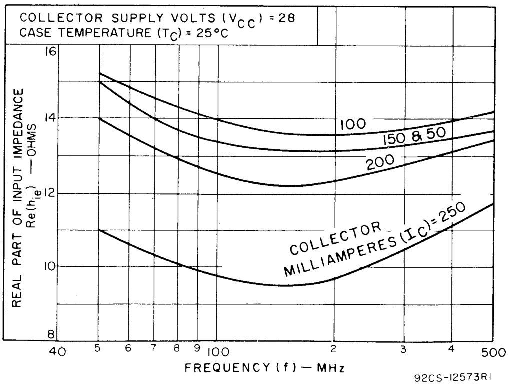


Fig.8 - Series input resistance vs frequency for type 2N3375

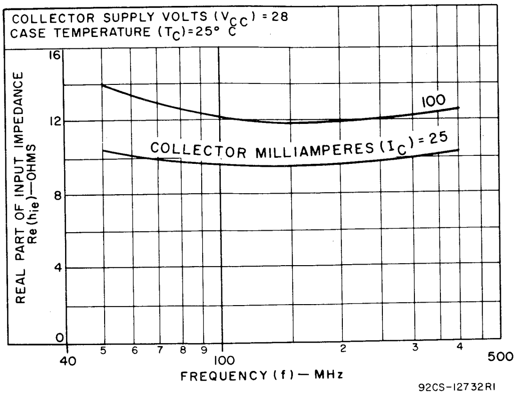


Fig.9 - Series input resistance vs frequency for 2N3553

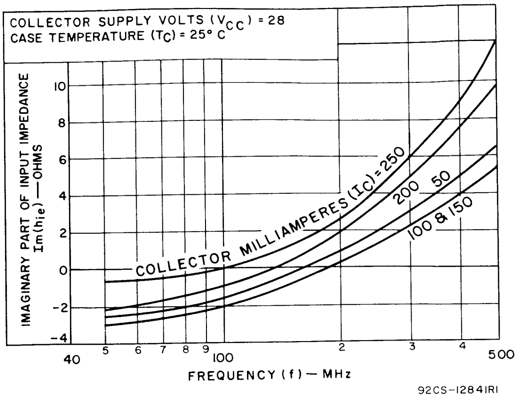


Fig.10 - Series input reactance vs frequency for 2N3632

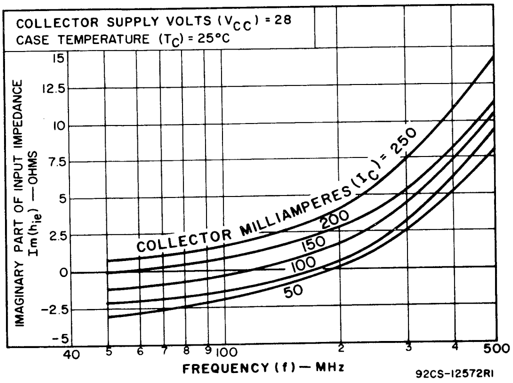


Fig.11 - Series input reactance vs frequency for 2N3375

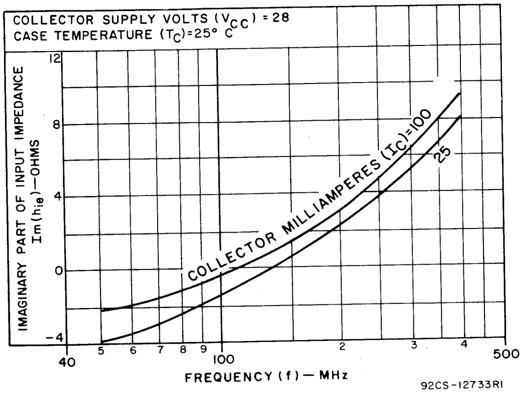


Fig.12 - Series input reactance vs frequency for 2N3553

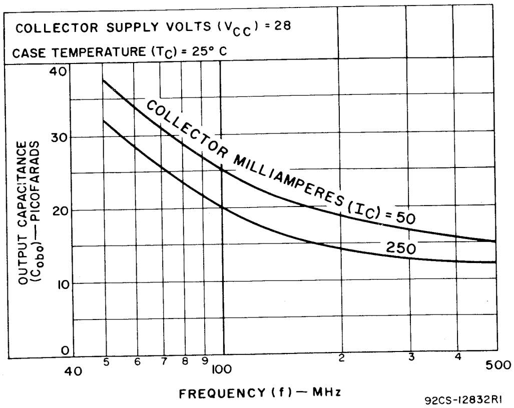


Fig.13 - Parallel output capacitance vs frequency for 2N3632

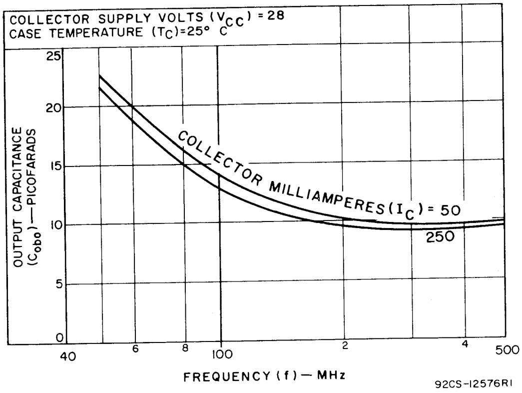


Fig.14 - Parallel output capacitance vs frequency for 2N3375

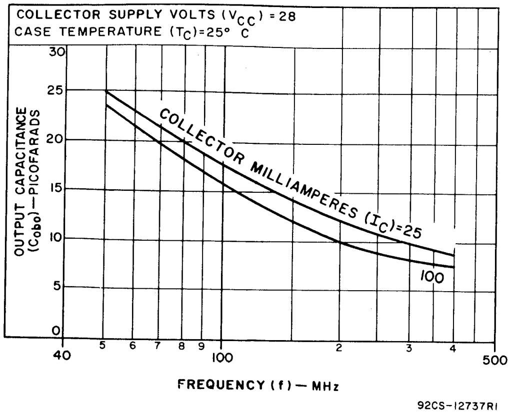


Fig.15 - Parallel output capacitance vs frequency for 2N3553

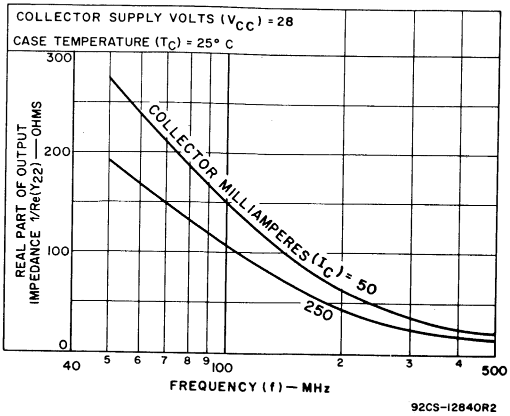


Fig.16 - Parallel output resistance vs frequency for 2N3632

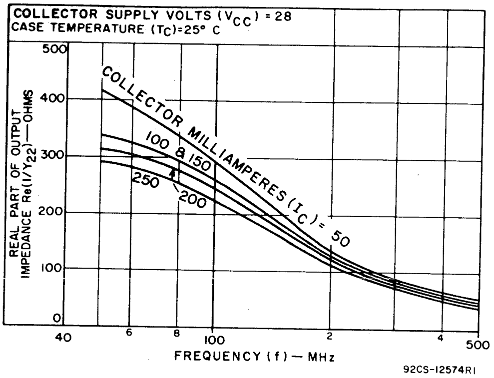


Fig.17 - Parallel output resistance vs frequency for 2N3375

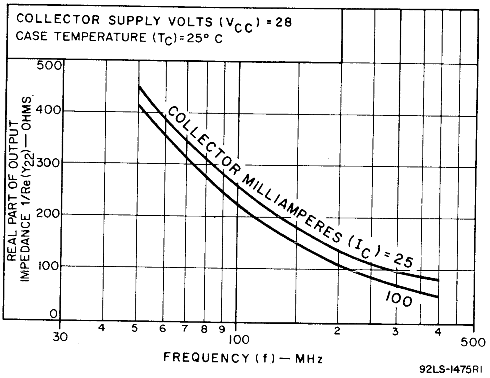


Fig.18 - Parallel output resistance vs frequency for 2N3632

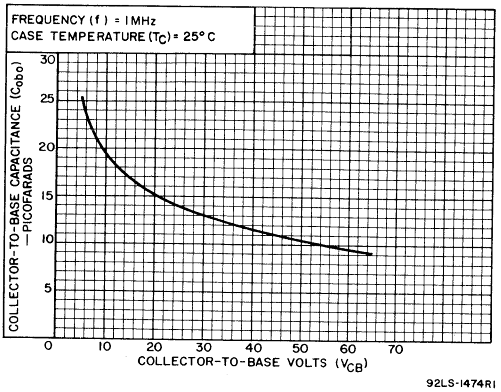


Fig.19 - Collector-to-base capacitance vs collector-to-base voltage for types 2N3632 & 40665

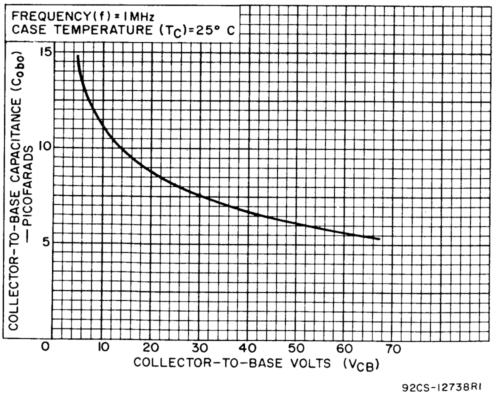
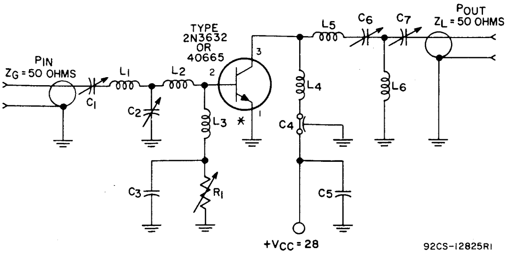


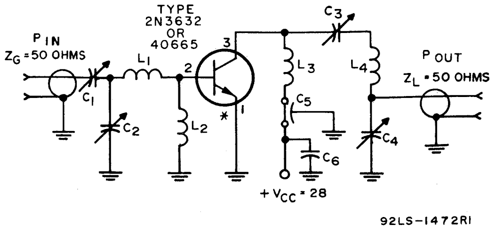
Fig.20 - Collector-to-base capacitance vs collector-to-base voltage for 2N3553



* Emitter in type 40665 is connected internally to case.

C_1: 3-35 pF
C_2, C_7: 8-60 pF
C_3, C_5: 0.005 μF, disc ceramic
C_4: 1000 pF
C_6: 1.5-20 pF
L_1: 3 turns No. 18 wire, 1/4 in. ID, 1/4 in. long
L_2: 3/16 in. wide copper strip, 3/8 in. long
L_3: Ferrite choke, Z = 450 ohms
L_4: RF choke, 0.47 μH
L_5: 3-1/2 turns No. 16 wire, 1/4 in. ID, 7/16 in. long
L_6: 1 turn No. 16 wire, 1/4 in. ID, 3/8 in. long
R_1: 50 ohms

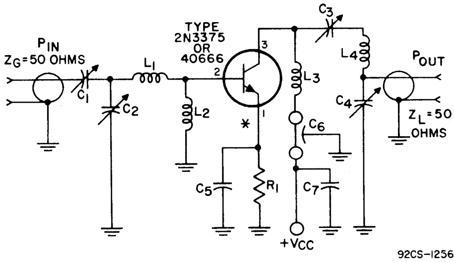
Fig.21 - 260 MHz amplifier test circuit for measurement of power output for 2N3632 & 40665



* Emitter in type 40665 is connected internally to case.

C_1, C_2, C_3, C_4: 7-100 pF
C_5: 1000 pF
C_6: 0.01 μF, disc ceramic
L_1: 1.5 turns No. 16 wire, 3/16 in. ID, 5/16 in. long
L_2: Ferrite choke, Z = 450 ohms
L_3: 1 turn No. 16 wire, 1/4 in. ID, 3/8 in. long
L_4: 2 turns No. 16 wire, 1/4 in. ID, 1/4 in. long

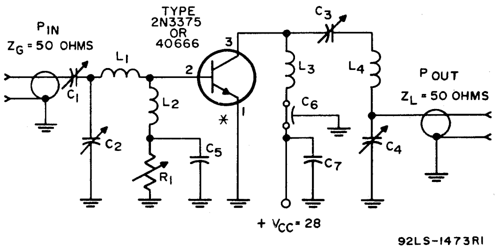
Fig.22 - 175 MHz amplifier test circuit for measurement of power output for 2N3632 & 40665



* Emitter in type 40666 is connected internally to case.

C_5 and R_1: are not used for 40666 test
C_1: 2.25 pF
C_2, C_3, C_4: 4-40 pF
C_5: 50 pF, disc ceramic
C_6: 1500 pF
C_7: 0.005 μF, disc ceramic
L_1: 1 turn No. 16 wire, 1/4 in. ID, 1/8 in. long
L_2: Ferrite choke, Z = 450 (+20%) ohms
L_3: 0.47-μH choke
L_4: 2 turns No. 16 wire, 3/8 in. ID, 7/16 in. long
R_1: 1.35 ohms, non-inductive

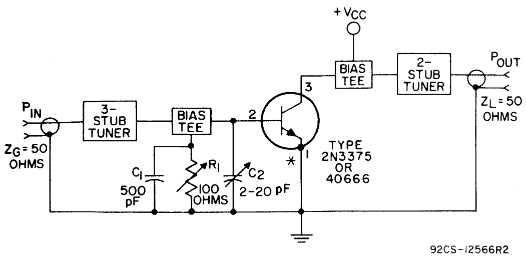
Fig.23 - 260 MHz amplifier test circuit for measurement of power output for 2N3375 & 40666



* Emitter in type 40666 is connected internally to case.

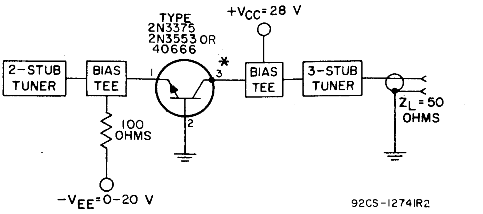
C_1, C_2, C_3, C_4: 7-100 pF
C_5: 0.005 μF, disc ceramic
C_6: 1000 pF
C_7: 0.01 μF, disc ceramic
L_1: 2 turns No. 16 wire, 3/8 in. ID, 3/4 in. long
L_2, L_3: 1.5 μH choke
L_4: 7 turns No. 16 wire, 3/8 in. ID, 1 in. long
R_1: 1000 ohms

Fig.24 - 100 MHz amplifier test circuit for measurement of power output for 2N3375 & 40666



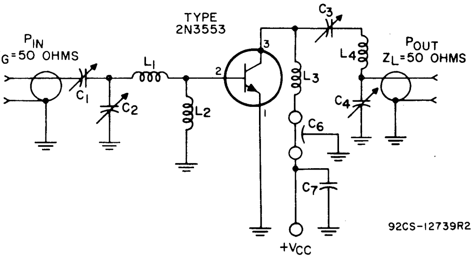
* Emitter in type 40666 is connected internally to case.

Fig.25 - 400 MHz amplifier test circuit for measurement of power output for 2N3375 & 40666



* Collector in type 2N3553 is internally connected to the case.

Fig.26 - 500 MHz oscillator circuit for measurement of power output for 2N3553 & 2N3375



For 50-MHz Operation:

C_1, C_2: 24-200 pF
C_3: 32-250 pF
C_4: 7-100 pF
C_5: 1800 pF, disc ceramic
C_6: 2000 pF
C_7: 0.01 µF, disc ceramic

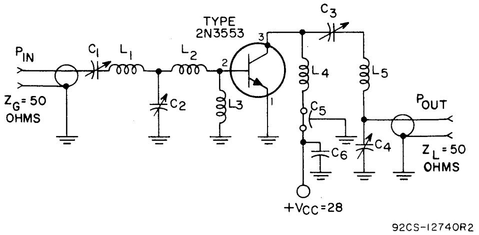
L_1: 5 turns No. 16 wire, 1/4 in. ID, 1/2 in. long
L_2: Ferrite choke, Z = 450 ohms
L_3: 7-µH choke
L_4: 6 turns No. 20 wire on 3/8 in. coil form (slug-tuned), 1-1/8 in. long
R_1: 1.35 ohms, non-inductive

For 175 MHz Operation:

C_1: 2-25 pF
C_2: 4-40 pF
C_3: 1.5-20 pF
C_4: 1.5-20 pF
C_5: 100 pF, disc ceramic
C_6: 2000 pF
C_7: 0.01 µF, disc ceramic

L_1: 1-1/2 turns No. 16 wire, 5/16 in. ID, 1/2 in. long
L_2: Ferrite choke, Z = 750 ohms
L_3: 4 turns No. 16 wire, 5/16 in. ID, 1 in. long
L_4: 7 turns No. 16 wire, 5/16 in. ID, 1-1/8 in. long
R_1: 1.35 ohms, non-inductive

Fig.27 - Amplifier circuit for measurement of power output for 2N3553 at 50 and 175 MHz



C_1, C_4: 1.5-20 pF
C_2, C_3: 3-35 pF
C_5: 1,000 pF
C_6: 0.005 µF, disc ceramic
L_1: 4 turns No. 16 wire, 3/8 in. ID, 3/8 in. long
L_2: 3/16 in. wide copper strip, 7/16 in. long
L_3: Ferrite choke, Z = 450 ohms
L_4: 1/2 turn 3/16 in. wide copper strip, 1/4 in. ID
L_5: 2 turns 3/16 in. wide copper strip, 1/4 in. ID, 1/2 in. long

Fig.28 - 260 MHz amplifier circuit for measurement of power output for 2N3553

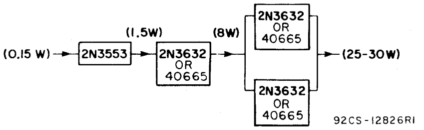


Fig.29 - Typical 175 MHz amplifier chain for P_{OE} of 25 to 30 watts

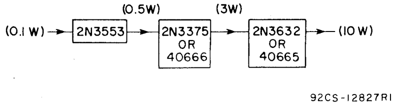
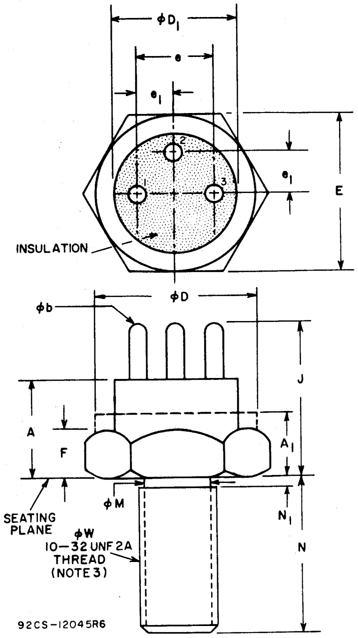


Fig.30 - Typical 260 MHz amplifier chain for P_{OE} of 10 watts

DIMENSIONAL OUTLINES

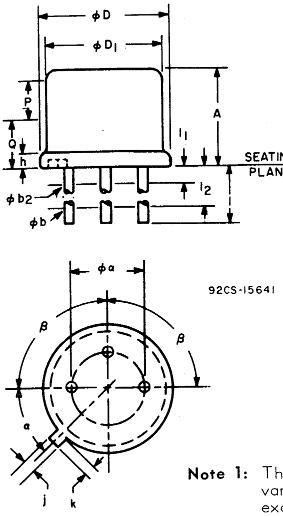
For types 2N3375, 40666
2N3632, 40665

JEDEC TO-60



For type 2N3553

JEDEC TO-39



TO-39

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕa	.190	.210	4.83	5.33	
A	.240	.260	6.10	6.60	
ϕb	.016	.021	.406	.533	2
ϕb_2	.016	.019	.406	.483	2
ϕD	.350	.370	8.89	9.40	
ϕD_1	.315	.335	8.00	8.51	
h	.009	.125	.229	3.18	
j	.028	.034	.711	.864	
k	.029	.040	.737	1.02	3
l	.500		12.70		2
l_1		.050		1.27	2
l_2	.250		6.35		2
P	.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed .010 in (.254 mm).

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and .5 in (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond .5 in (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the actual device.

Note 4: Details of outline in this zone optional.

TO-60

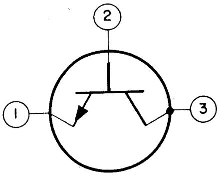
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.215	.320	5.46	8.13	
A_1		.165		4.19	2
ϕb	.030	.046	.762	1.17	
ϕD	.360	.437	9.14	11.10	2
ϕD_1	.320	.360	8.13	9.14	
E	.424	.437	10.77	11.10	
e	.185	.215	4.70	5.46	
e_1	.090	.110	2.29	2.79	
F	.090	.135	2.29	3.43	1
J	.355	.480	9.02	12.19	
ϕM	.163	.189	4.14	4.80	
N	.375	.455	9.53	11.56	
N_1		.078		1.98	
ϕW	.1658	.1697	4.212	4.310	3

NOTES:

1. Dimension does not include sealing flanges.
2. Package contour optional within dimensions specified.
3. Pitch diameter - thread 10-32 UNF-2A (coated). Reference (screw thread standards for federal services - Handbook H-28).

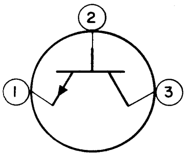
TERMINAL DIAGRAMS

For Type 2N3553
(Bottom View)



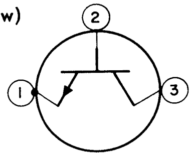
LEAD 1 - EMITTER
LEAD 2 - BASE
LEAD 3 - COLLECTOR, CASE

For Types
2N3632 & 2N3375
(Top View)



PIN 1 - EMITTER
PIN 2 - BASE
PIN 3 - COLLECTOR
STUD - NO CONNECTION

For Types
40665 & 40666
(Top View)



PIN 1 - EMITTER, CASE
PIN 2 - BASE
PIN 3 - COLLECTOR
STUD - EMITTER

RCA

Solid State Division

RF Power Transistors

2N3733

RCA-2N3733 is an epitaxial silicon n-p-n planar transistor. This device is intended for class A, B, & C amplifier, frequency multiplier, or oscillator operation. The 2N3733 was developed for VHF-UHF applications.

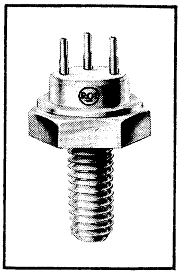
The transistor employs the new "overlay" concept in emitter-electrode design –– an emitter electrode consisting of many microscopic areas connected together through the use of a diffused-grid structure and an overlay of metal which is applied on the silicon wafer by means of a photo-etching technique. This arrangement provides the very high emitter periphery-to-emitter area ratio required for high efficiency at high frequencies.

RF SERVICE

Maximum Ratings, ***Absolute-Maximum Values:***

COLLECTOR-TO-BASE VOLTAGE, V_{CBO} . . .	65 volts
COLLECTOR-TO-EMITTER VOLTAGE:	
With base open, V_{CEO}	40 volts
With $V_{BE} = -1.5$ volts, V_{CEV}	65 volts
EMITTER-TO-BASE VOLTAGE, V_{EBO}	4 volts
PEAK COLLECTOR CURRENT	3.0 amperes
TRANSISTOR DISSIPATION, P_T:	
At case temperatures up to 25°C	23 watts
At case temperatures above 25°C.	Derate linearly to 0 watts at 200°C
TEMPERATURE RANGE:	
Storage	−65 to 200°C
Operating (Junction)	−65 to 200°C
PIN TEMPERATURE (During soldering): At distances $\geq 1/32''$ from insulating wafer for 10 sec. max. . . . . 230 max.	°C

For LargeSignal High-Power VHF-UHF Applications in Military and Industrial Communications Equipment



JEDEC TO–60

FEATURES

- High Power Output, Unneutralized Class C Amplifier
  - at 400 Mc — 10 W minimum
  - at 260 Mc — 14.5 W typical
- High Voltage Ratings ––
  - V_{CBO} = 65 volts max.
  - V_{CEV} = 65 volts max.
  - V_{CEO} = 40 volts max.
- 100 per cent tested to assure freedom from second breakdown for operation in class-A applications
- Low Thermal Resistance ($\theta_{J\text{-}C}$) ––

  High thermal-conductivity ceramic insulation between collector and mounting stud
- New Package Design –– TO-60

  All three electrodes electrically isolated from case –– for design flexibility

  Heavy copper mounting stud –– for effective contact with heat sink

  Pin terminals arranged on a .200" pin-circle diameter –– fit commercially available sockets

ELECTRICAL CHARACTERISTICS

Case Temperature = 25°C

Characteristic	Symbol	TEST CONDITIONS						LIMITS		Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		30			0		–	0.25	ma
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.5	65	–	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEO}					0	0 to 200*	40**	–	volts
	BV_{CEV}			−1.5			0 to 200*	65**	–	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.25		0	4	–	volts
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					100	500	–	1	volt
Collector-to-Base Capacitance Measured at 1 Mc	C_{ob}	30			0			–	20	pf
RF Power Output Amplifier, Unneutralized At 260 Mc (See Fig. 3) 400 Mc (See Fig. 2)	P_{OUT}		28 28					14.5● (typ.) 10▲	 –	watts
Gain-Bandwidth Product	f_T		28				150	400 (typ.)		Mc
Base-Spreading Resistance Measured at 200 Mc	$r_{bb'}$		28				250	6.5 (typ.)		ohms
Collector-to-Case Capacitance	C_s							–	6	pf

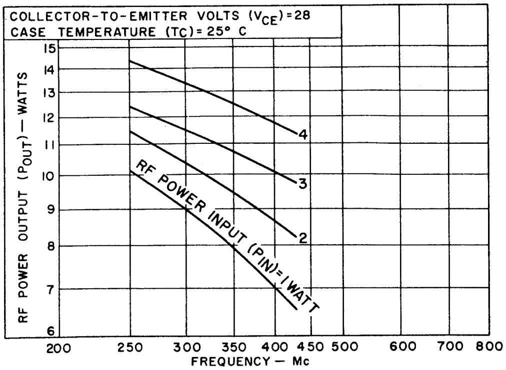
* Pulsed through an inductor (25 mh); duty factor = 50%.

** Measured at a current where the breakdown voltage is a minimum.

● For P_{IN} = 4.0 w; minimum efficiency = 60%.

▲ For P_{IN} = 4.0 w; minimum efficiency = 45%.

POWER OUTPUT vs. FREQUENCY FOR TYPE 2N3733

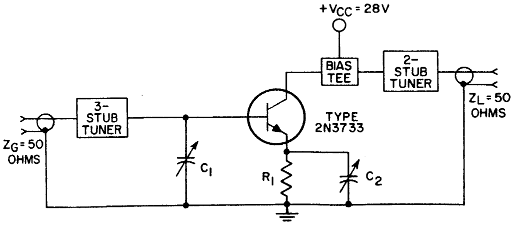


92CS-13134

Fig. 1

RF AMPLIFIER CIRCUIT FOR 2N3733 POWER-OUTPUT TEST

(400-Mc Operation)



92CS-13132

C_1,C_2: 7.8-17 pf R_1: 0.56 ohm

Fig. 2

RF AMPLIFIER CIRCUIT FOR 2N3733 POWER OUTPUT TEST

(260-Mc Operation)

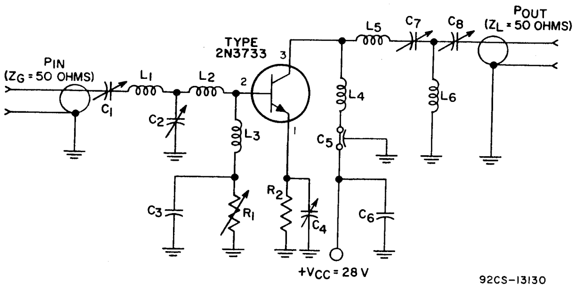


Fig. 3

C_1: 3-35 pf

C_2,C_4,C_8: 8-60 pf

C_3,C_6: 0.005 μf, disc ceramic

C_5: 1,000 pf

C_6: 1.5 - 20 pf

L_1: 3 turns No.18 wire, 1/4" ID, 1/4" long

L_2: 3/16" wide copper strip, 3/8" long

L_3: Ferrite choke, Z = 450 ohms

L_4: RF choke, 0.47 μh

L_5: 3-1/2 turns No.16 wire, 1/4" ID, 7/16" long

L_6: 1 turn No. 16 wire, 1/4" ID, 3/8" long

R_1: 50 ohms

R_2: 0.56 ohms

GAIN-BANDWIDTH PRODUCT vs. COLLECTOR CURRENT FOR TYPE 2N3733

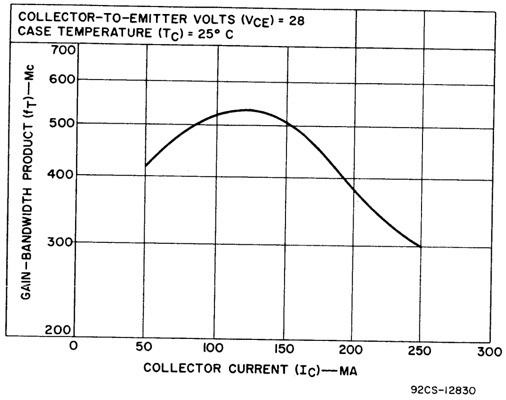


Fig. 4

SERIES INPUT RESISTANCE vs. FREQUENCY FOR TYPE 2N3733

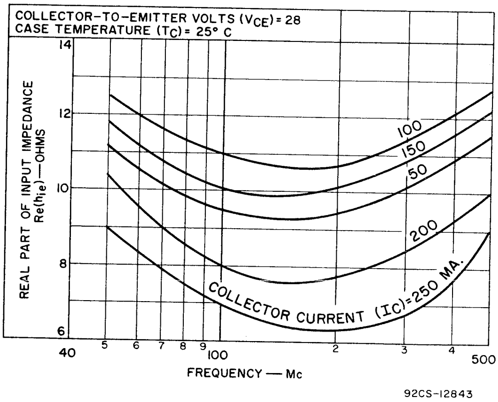


Fig. 6

SERIES INPUT REACTANCE vs. FREQUENCY FOR TYPE 2N3733

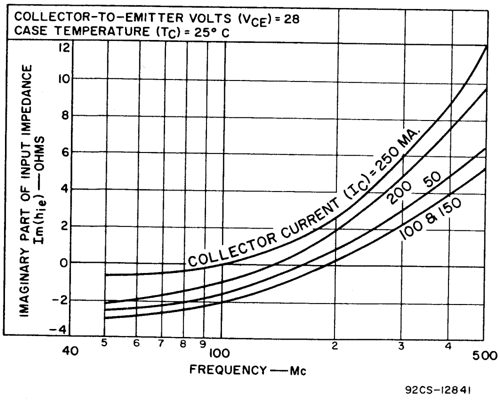


Fig. 5

OUTPUT CAPACITANCE vs. FREQUENCY FOR TYPE 2N3733

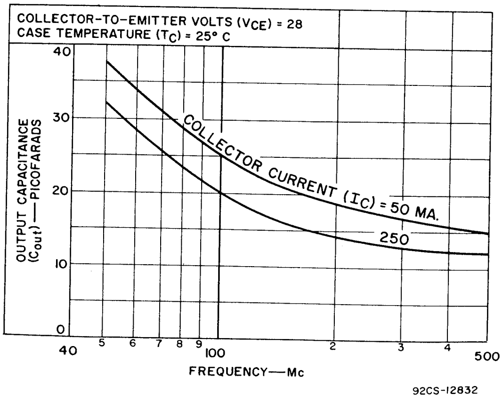
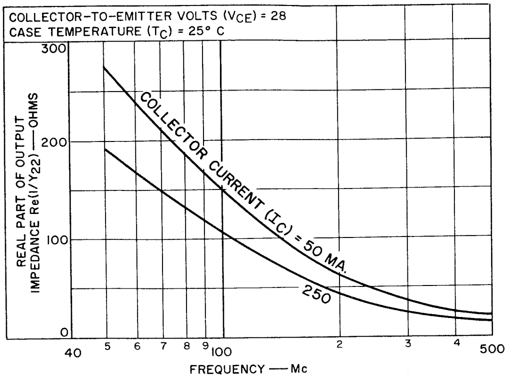


Fig. 7

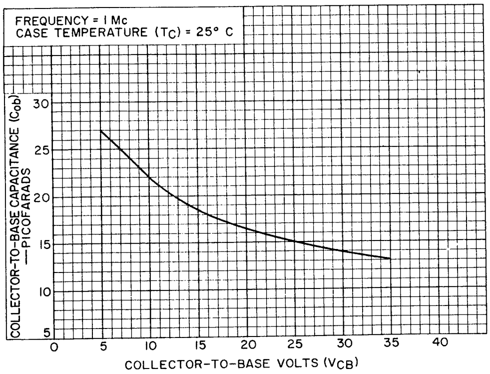
OUTPUT RESISTANCE vs. FREQUENCY
FOR TYPE 2N3733



92CS-12840

Fig. 8

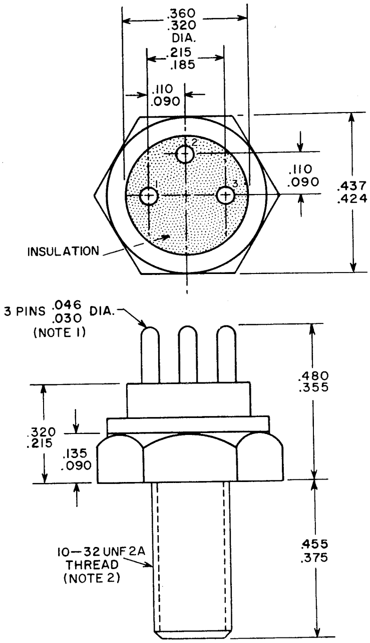
VARIATION OF COLLECTOR-TO-BASE
CAPACITANCE FOR TYPE 2N3733



92CS-12831

Fig. 9

DIMENSIONAL OUTLINE FOR TYPE 2N3733
JEDEC TO-60



92CS-12045R5

Dimensions in Inches

NOTE 1: THE PIN SPACING PERMITS INSERTION IN ANY SOCKET HAVING A PIN-CIRCLE DIAMETER OF 0.200" AND CONTACTS WHICH WILL ACCOMMODATE PINS HAVING A DIAMETER OF 0.035" MIN., 0.045" MAX.

NOTE 2: THE TORQUE APPLIED TO A 10-32 HEX NUT ASSEMBLED ON THE THREAD DURING INSTALLATION SHOULD NOT EXCEED 12 INCH-POUNDS.

NOTE 3: THIS DEVICE MAY BE OPERATED IN ANY POSITION.

TERMINAL CONNECTIONS

Pin No. 1 - Emitter
Pin No. 2 - Base
Pin No. 3 - Collector

RCA
Solid State
Division

RF Power Transistors

2N3866

JEDEC TO-39 H-1381

Silicon N-P-N Overlay Transistor

High-Gain Driver for VHF/UHF Applications
in Military and Industrial Communications Equipment

Features

- **High Power Gain, Unneutralized Class C Amplifier**
  - **1 W output at 400 MHz (10 dB gain)**
  - **1 W output at 250 MHz (15 dB gain)**
  - **1 W output at 175 MHz (17 dB gain)**
  - **1 W output at 100 MHz (20 dB gain)**
- **Low Output Capacitance**
  C_{obo} = 3 pF max.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* COLLECTOR-TO-BASE VOLTAGE . . .	V_{CBO}	55	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance (R_{BE}) = 10Ω.	V_{CER}	55	V
* With base open	V_{CEO}	30	V
* EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
* CONTINUOUS COLLECTOR CURRENT	I_C	0.4	A
* CONTINUOUS BASE CURRENT	I_B	0.4	A
* TRANSISTOR DISSIPATION	P_T		
At case temperature up to 100°C		5	W
At case temperatures above 100°C . . .		See Fig. 4	
* TEMPERATURE RANGE:			
Storage & Operating (Junction).		−65 to +200	°C
* LEAD TEMPERATURE			
At distances ≥ 1/16 in. (1.58 mm) from seating plane for 10 s max.		230	°C

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* In accordance with JEDEC registration data format JS-6 RDF-3.

RCA-2N3866 is an epitaxial silicon n-p-n planar transistor employing an advanced version of the RCA-developed "overlay" emitter-electrode design. This electrode consists of many isolated emitter sites connected together through the use of a diffused-grid structure and a metal overlay which is deposited on a silicon oxide insulating layer by means of a photo-etching technique. This overlay design provides a very high emitter periphery-to-emitter area ratio resulting in low output capacitance, high rf current handling capability, and substantially higher power gain.

The 2N3866 is intended for class-A, -B, or -C amplifier, frequency-multiplier, or oscillator circuits: it may be used in output, driver, or pre-driver stages in vhf and uhf equipment.

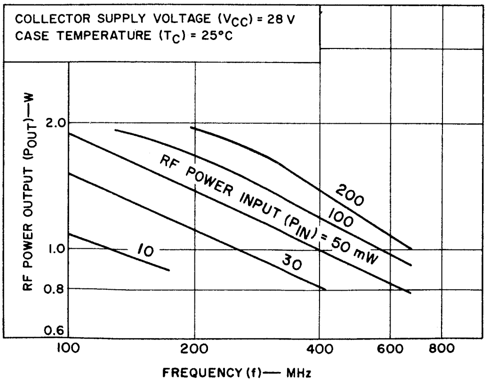
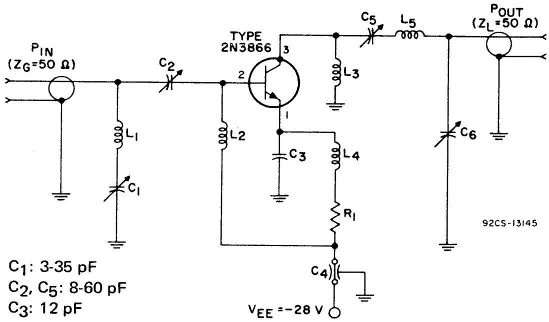


Fig. 1 - Power output vs. frequency



C_1: 3-35 pF
C_2, C_5: 8-60 pF
C_3: 12 pF
C_4: 1,000 pF, feedthrough
C_6: 0.9-7 pF
L_1: 2 turns No. 18 wire, 1/4" ID, 1/8" long
L_2: Ferrite rf choke, 1 turn, Z = 450Ω
L_3, L_4: RF choke, 0.1 μH
L_5: 2-1/2 turns, No. 18 wire, 1/4" ID, 3/16" long
R_1: 5.6Ω, 1 W

Fig. 2 - RF amplifier circuit for power output test (400-MHz operation)

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS DC Voltage (V) V_{CE}	V_{EB}	DC Current (mA) I_E	I_B	I_C	LIMITS Min.	Max.	UNITS
* Collector-Cutoff Current: Base-emitter junction reverse biased	I_{CEX}	55	1.5				–	0.1	mA
T_C = 200°C		30	1.5				–	0.1	
Base open	I_{CEO}	28			0		–	20	µA
* Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.1	55	–	V
* Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$				0	5	30	–	V
With base connected to emitter through 10-ohm resistor	$V_{(BR)CER}$		0			5	55	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
* Emitter-Cutoff Current	I_{EBO}		3.5				–	0.1	mA
* Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				20	100	–	1.0	V
* DC Forward-Current Transfer Ratio	h_{FE}	5 5				360 50	5 10	– 200	
Thermal Resistance: (Junction-to-Case)	$\theta_{J\text{-}C}$						–	35	°C/W

DYNAMIC

TEST & CONDITIONS	SYMBOL	FREQUENCY MHz	LIMITS MINIMUM	MAXIMUM	UNITS
Power Output (V_{CC} = 28 V): P_{IE} = 0.1 W	P_{OE}	400	1.0	–	W
Large-Signal Common-Emitter Power Gain (V_{CC} = 28 V): P_{IE} = 0.1 W	G_{PE}	400	10	–	dB
* Collector Efficiency (V_{CC} = 28 V): P_{IE} = 0.1 W, P_{OE} = 1 W, Source Impedance = 50Ω	η_C	400	45	–	%
* Magnitude of Common-Emitter, Small Signal, Short-Circuit Forward-Current Transfer Ratio I_C = 50 mA, V_{CE} = 15 V	$\lvert h_{fe} \rvert$	200	2.5	–	
* Available Amplifier Signal Input Power, P_{OE} = 1 W, Source Impedance = 50Ω (See Fig. 2)	P_i	400	–	0.1	W
* Common-Base Output Capacitance (V_{CB} = 28 V)	C_{obo}	1	–	3	pF

* In accordance with JEDEC registration data format JS-6 RDF-3

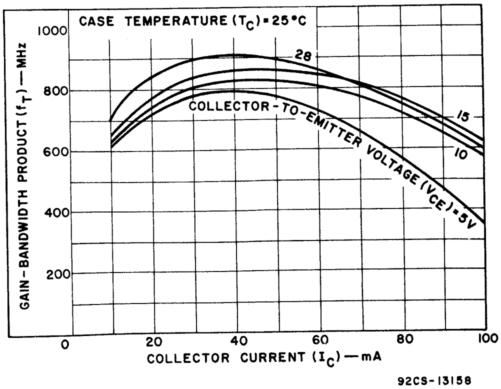


Fig. 3 - Gain-bandwidth product vs. collector current

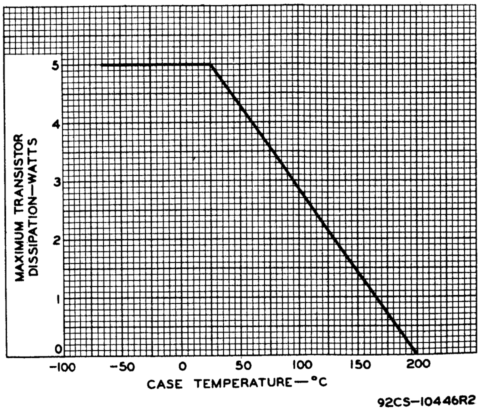


Fig. 4 - Dissipation derating curve

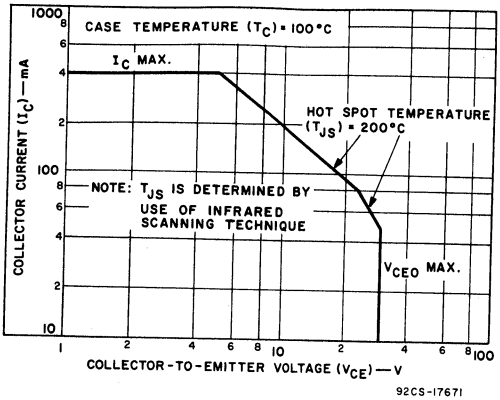


Fig. 5 - Safe area for dc operation

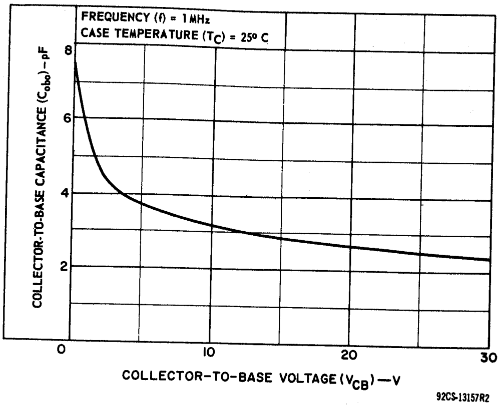


Fig. 6 - Variation of collector-to-base capacitance

DESIGN DATA

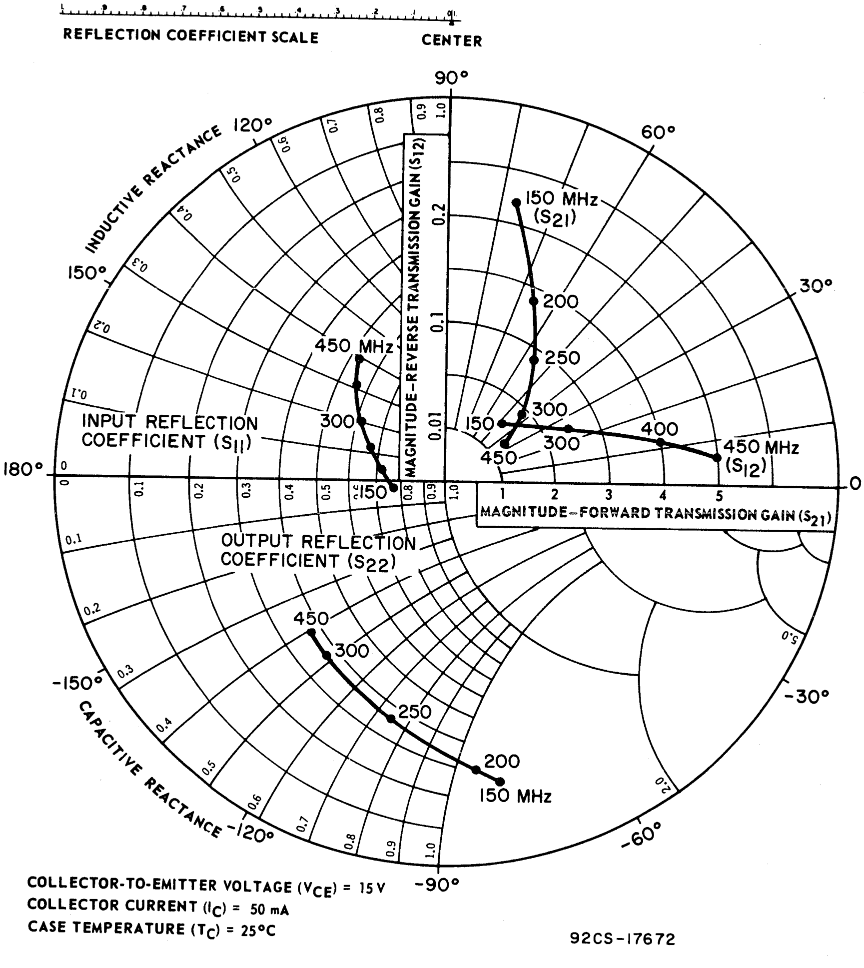


Fig. 7 - Typical S parameters vs. frequency

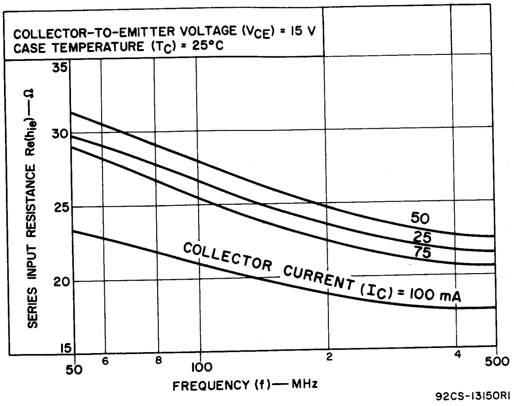


Fig. 8 - Typical series input resistance vs. frequency

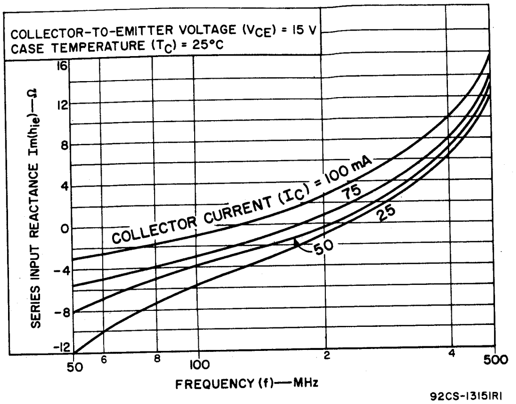


Fig. 9 - Typical series input reactance vs. frequency

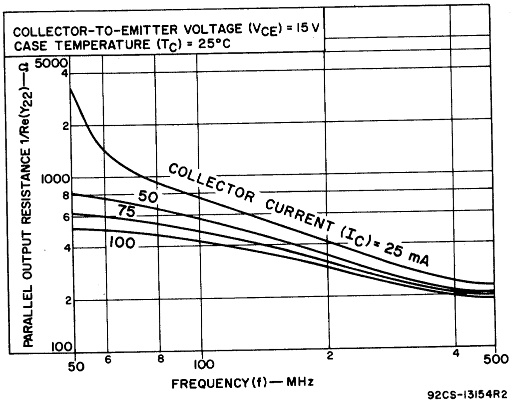


Fig. 10 - Typical parallel output resistance vs. frequency

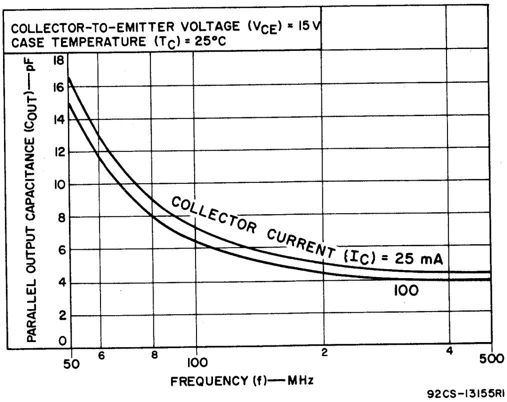
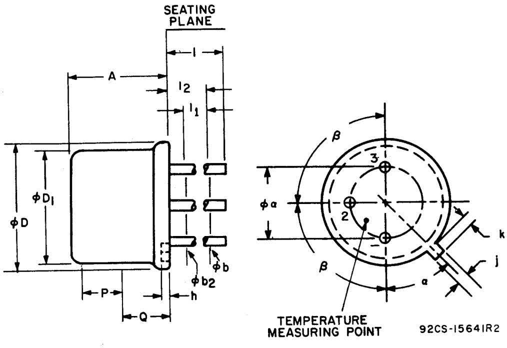


Fig. 11 - Typical parallel output capacitance vs. frequency

DIMENSIONAL OUTLINE
JEDEC No. TO-39



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕa	0.190	0.210	4.83	5.33	
A	0.240	0.260	6.10	6.60	
ϕb	0.016	0.021	0.406	0.533	2
ϕb_2	0.016	0.019	0.406	0.483	2
ϕD	0.350	0.370	8.89	9.40	
ϕD_1	0.315	0.335	8.00	8.51	
h	0.009	0.041	0.229	1.04	
j	0.028	0.034	0.711	0.864	
k	0.029	0.040	0.737	1.02	3
l	0.500	0.562	12.70	14.27	2
l_1		0.050		1.27	2
l_2	0.250		6.35		2
P	0.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010 in (0.254 mm).

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and 0.5 in (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond 0.5 in (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the actual device.

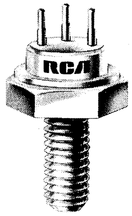
Note 4: Details of outline in this zone optional.

RCA
Solid State Division

2N4012

High-Power Silicon N-P-N Overlay Transistor

For Applications as a Frequency Multiplier Into the UHF or L-Band Range



JEDEC TO-60 H-1307

Features

- 2.5 W output with 4 dB conversion gain (min.) as tripler to 1 GHz
- 3 W output with 4.8 dB conversion gain (typ.) as doubler to 800 MHz
- High voltage ratings
- Freedom from second breakdown

RCA-2N4012 is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter electrode construction. It is especially designed to provide high power as a frequency multiplier into the uhf, or L-band, frequency range for military and industrial communications equipment.

Frequency multiplication — with power amplification — is possible with the overlay structure because the variable collector-to-base capacitance becomes the nonlinear element of a harmonic generator. The collector-to-base capacitance acts like a variable-capacitance diode, or varactor, in parallel with the amplifier section of the transistor.

In the overlay structure, there are a number of individual emitter sites which are all connected in parallel and used in conjunction with a single base and collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, and frequency capability.

The 2N4012 pellet is mounted in a JEDEC TO-60 package electrically isolating all three electrodes from the case for design flexibility and features low lead inductance and thermal resistance. The heavy copper mounting stud provides effective contact with a heat sink.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	40	V
With $V_{BE} = -1.5$ volts...........	V_{CEV}	65	V
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT	I_C	1.5	A
TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 25°C ...		11.6	W
At case temperatures above 25°C ...		See Fig. 12	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to +200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. (0.8 mm) from insulating wafer for 10 s max.		230	°C

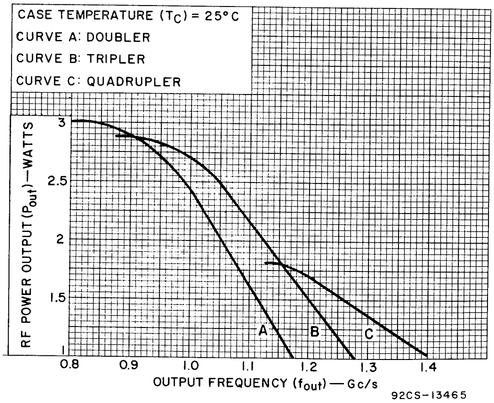


Fig. 1—Output power vs. output frequency

ELECTRICAL CHARACTERISTICS, Case Temperature = 25°C

CHARACTERISTIC	SYMBOL	TEST CONDITIONS						LIMITS		UNITS
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		30			0		–	0.1	mA
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.1	65	–	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEO}					0	0 to 200[a]	40[b]	–	volts
	BV_{CEV}			-1.5			0 to 200[a]	65[b]	–	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4	–	volts
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					100	500	–	1	volt
Collector-to-Base Capacitance (See Fig. 4)	C_{ob}	30			0			–	10	pF
RF Power Output Tripler At 1002 Mc/s (See Fig. 2) Doubler At 800 Mc/s (See Fig. 3)	P_{OUT}		28 28					2.5[c] 3.0[d] (typ.)		watts
Gain-Bandwidth Product	f_T		28				150	500 (typ.)		Mc/s
Collector-to-Base Cutoff Frequency[e]	f_c		28				0	25 (typ.)		Gc/s

[a] Pulsed through an inductor (25 mH); duty factor = 50%.

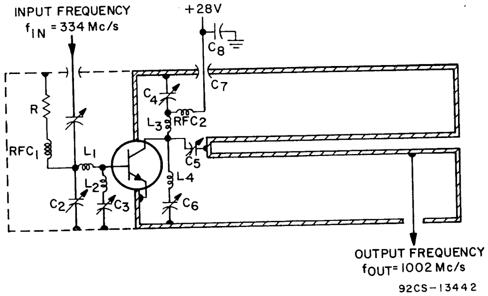
[b] Measured at a current where the breakdown voltage is a minimum.

[c] For P_{IN} = 1.0 W; at 334 Mc/s; minimum collector efficiency = 25%.

[d] For P_{IN} = 1.0 W; at 400 Mc/s; typical collector efficiency = 35%.

[e] Cutoff frequency is determined from Q measurement at 210 Mc/s. The cutoff frequency of the collector-to-base junction of the transistor, $f_c = Q \times 210$ Mc/s.

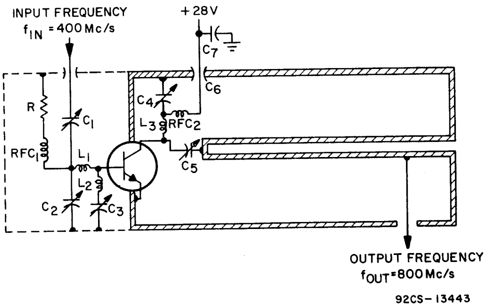
TRIPLER CIRCUIT FOR POWER OUTPUT TEST



C_1 = 0.9 – 7 pF
C_2 = 1 – 10 pF
C_3, C_4, C_5, C_6 = 0.8 – 10 pF
C_7 = 1000 pF
C_8 = 0.2 μF
RFC_1 = 0.22 μH
RFC_2 = 0.33 ohms, W.W. Resistor
L_1 = 2 turns, 3/8" diameter, No. 16 wire
L_2 = 1/16" width copper strip, 3/8" long
L_3 = 2 turns, 3/8" diameter, No. 18 wire
L_4 = 1-1/2 turns, 3/8" diameter, 1/16 copper strip
R = 2.7 ohms
Output Cavity = 1-1/4" x 1-1/4" x 2-1/4"
Center Conductor = 1/4" OD tube
Output direct couple = 1/2" from shorted end

Fig. 2

DOUBLE CIRCUIT FOR POWER OUTPUT TEST



C_1 = 0.9 – 7 pF
C_2 = 1 – 10 pF
C_3, C_4, C_5 = 0.8 – 10 pF
C_6 = 1000 pF
C_7 = 0.2 μF
RFC_1 = 0.22 μH
RFC_2 = 0.33 ohms, W.W. Resistor
R = 2.7 ohms
L_1 = 1 turn, 3/8" diameter, No. 16 wire
L_2 = 1/16" width copper strip, 3/8" long
L_3 = 2 turns, 3/8" diameter, No. 18 wire
Output Cavity = 1-1/4" x 1-1/4" x 2-1/4"
Center Conductor = 1/4" OD tube
Output direct couple = 1/2" from shorted end

Fig. 3

COLLECTOR-TO-BASE CAPACITANCE vs. COLLECTOR-TO-BASE VOLTAGE

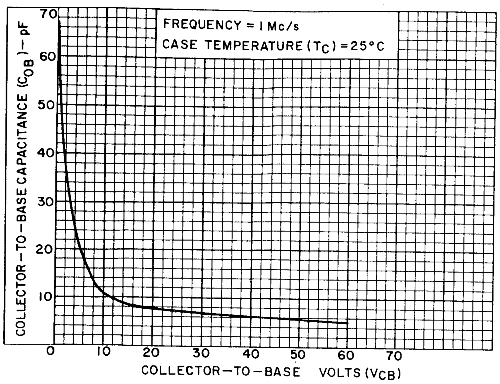


Fig. 4 92CS-13441

POWER OUTPUT vs. POWER INPUT

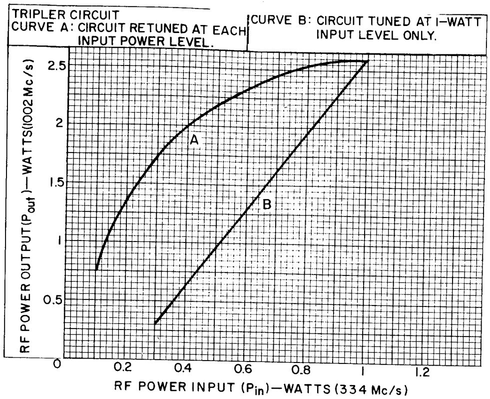


Fig. 5 92CS-13444

POWER OUTPUT vs. COLLECTOR SUPPLY VOLTAGE

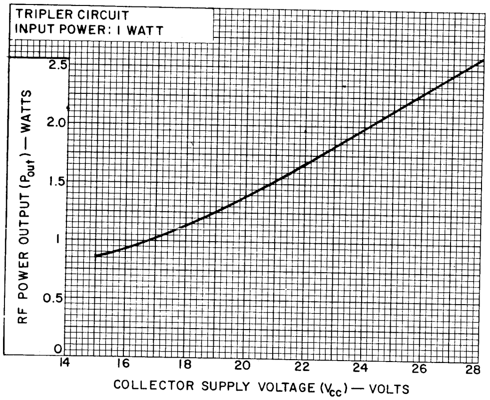
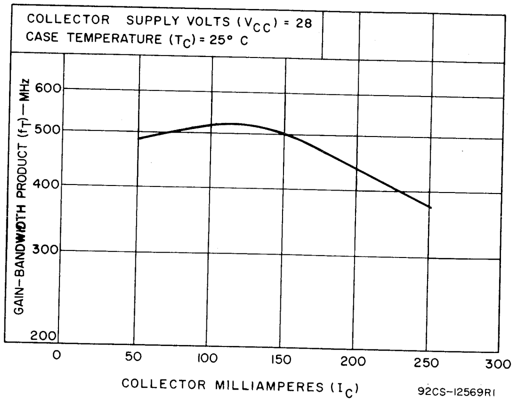


Fig. 6 92CS-13445

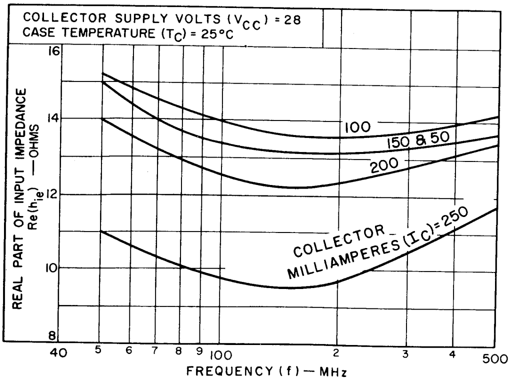
GAIN-BANDWIDTH PRODUCT vs. COLLECTOR CURRENT



92CS-12569R1

Fig. 7

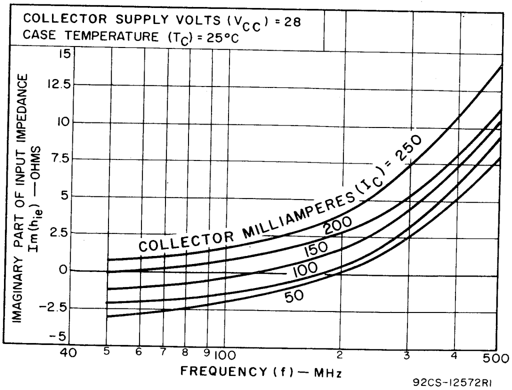
SERIES INPUT RESISTANCE vs. FREQUENCY



92CS-12573R1

Fig. 8

SERIES INPUT REACTANCE vs. FREQUENCY



92CS-12572R1

Fig. 9

PARALLEL OUTPUT CAPACITANCE vs. FREQUENCY

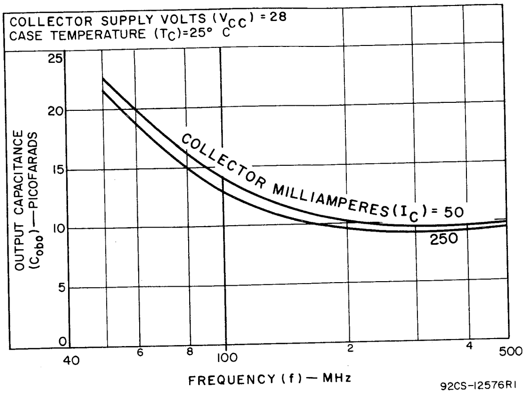


Fig. 10

PARALLEL OUTPUT RESISTANCE vs. FREQUENCY

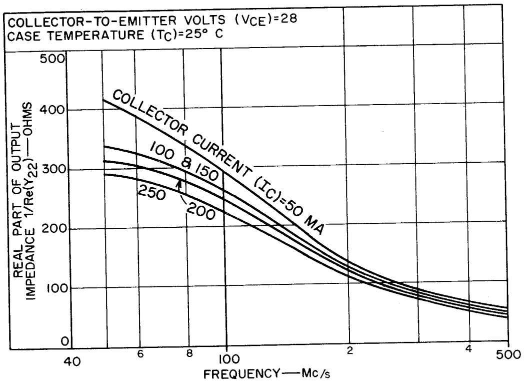


Fig. 11

DISSIPATION DERATING CURVE

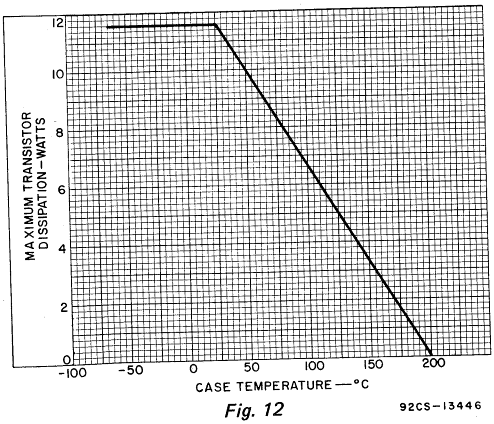
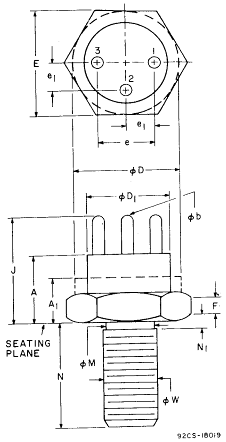


Fig. 12

DIMENSIONAL OUTLINE



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A_1	–	0.165	–	4.19	2
φb	0.030	0.046	0.762	1.17	4
φD	0.360	0.437	9.14	11.10	2
$φD_1$	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e_1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
φM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N_1	–	0.078	–	1.98	
φW	0.1658	0.1697	4.212	4.310	3, 5

NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing perimts insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17 mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

TERMINAL CONNECTIONS

Pin No. 1 – Emitter
Pin No. 2 – Base
Pin No. 3 – Collector

REFERENCES

1. *The Overlay Transistor,* Electronics, August 23, 1965.

   Part I – *New Geometry Boosts Power,* D.R. Carley, P.L. McGeough, and J.F. O'Brien.

   Part II – *Putting the Overlay to Work at Hi-Frequency,* Dr. D.J. Donahue and B.A. Jacoby.

2. Frequency Multiplication Using Transistors, H.C. Lee and R. Minton, RCA Application Note SMA-40.

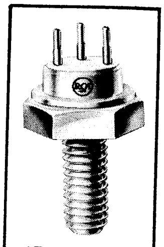
RCA
Solid State
Division

RF Power Transistors

2N4440

RCA-2N4440* is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter electrode construction. It is intended for Class A▲, –B and –C rf amplifier, multiplier, or oscillator operation for military and industrial communications service (175 to 400 MHz).

In the overlay structure, there are a number of individual emitter sites which are all connected in parallel and used in conjunction with a common collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, frequency capability, and linearity.



JEDEC TO-60

For Class A, –B or –C VHF –UHF
Military and Industrial Communications

5 Watts Output Min. at 400 MHz

6.5 Watts Output Typ. at 225 MHz

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*Formerly RCA-Dev. No.TA2875.

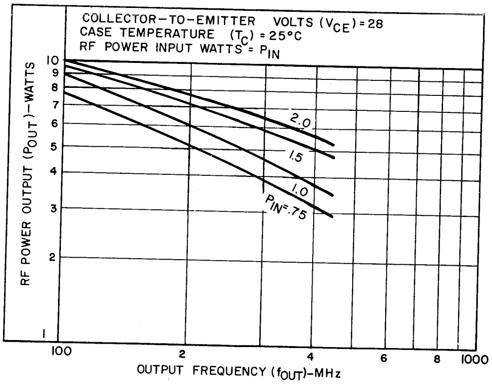
RATINGS▲

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With V_{BE} = –1.5 volts	V_{CEV}	65	V
With base open	V_{CEO}	40	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT	I_C	1.5	A
TRANSISTOR DISSIPATION▲	P_T		
At case temperatures up to 25° C		11.6	W
At case temperatures above 25° C		See *Fig.4*	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		–65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. from insulated wafer for 10 s max.		230	°C

▲Secondary breakdown considerations limit maximum DC operating conditions. . .contact your RCA Representative for specific data.

TYPICAL POWER OUTPUT vs. FREQUENCY



92LS–1571R1

Fig. 1

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C

Characteristic	Symbol	TEST CONDITIONS						Limits		Units
		DC Collector Volts		DC Base Volts	DC Current (Milliamperes)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		30			0		–	0.1	mA
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.1	65	–	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEO}					0	0 to 200[a]	40[b]	–	volts
	BV_{CEV}			−1.5			0 to 200[a]	65[b]	–	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	4	–	volts
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					100	500	–	1	volts
Collector-to-Base Capacitance Measured at 1 MHz	C_{ob}	30			0			–	10	pF
RF Power Output Amplifier, Unneutralized At 225 MHz (See *Fig.2*) 400 MHz (See *Fig.3*)	P_{OUT}		 28 28					 6.5[c] (typ.) 5.0[d]	 –	watts
Gain-Bandwidth Product	f_T		28				150	500 (typ.)		MHz
Base-Spreading Resistance Measured at 400 MHz	$r_{bb'}$		28				250	10 (typ.)		ohms
Collector-to-Case Capacitance	C_s							–	6	pF

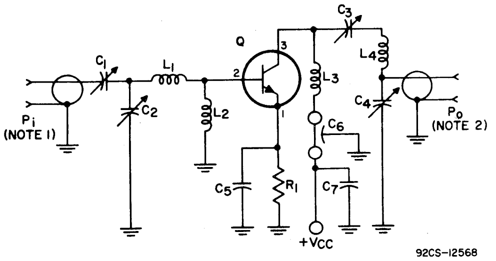
[a] Pulsed through an inductor (25 mH); duty factor = 50%.

[b] Measured at a current where the breakdown voltage is a minimum.

[c] For P_{IN} = 1.7 W; minimum efficiency = 55%.

[d] For P_{IN} = 1.7 W; minimum efficiency = 45%.

RF AMPLIFIER CIRCUIT POWER OUTPUT TEST
(225 MHz operation)



NOTE 1: Generator impedance = 50 ohms.

NOTE 2: Load impedance = 50 ohms.

C_1: 2-25 pF
C_2, C_3, C_4: 4-40 pF
C_5: 50 pF, disc ceramic
C_6: 1500 pF
C_7: 0.005 μF, disc ceramic
L_1: 1 turn No.16 wire, 1/4" ID, 1/8" long
L_2: Ferrite choke, Z = 450 (± 20%) ohms
L_3: 0.47-μH choke
L_4: 2 turns No.16 wire, 3/8" ID, 7/16" long
Q : 2N4440
R_1: 1.35 ohms, non-inductive

Fig. 2

RF AMPLIFIER CIRCUIT POWER OUTPUT TEST
(440 MHz operation)

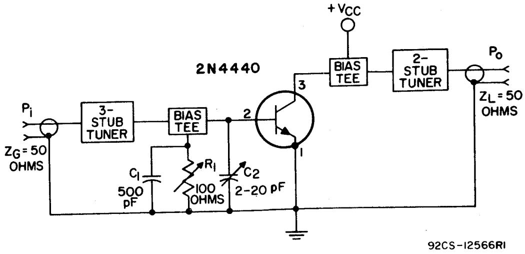


Fig. 3

DISSIPATION DERATING CURVE

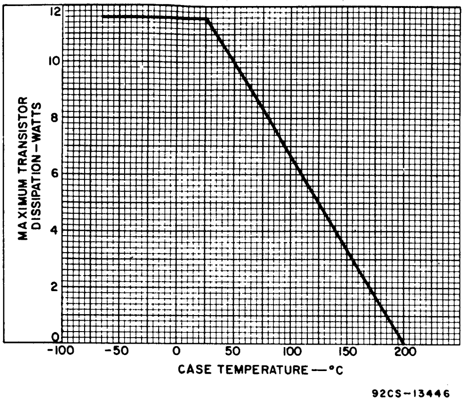


Fig. 4

TYPICAL
SERIES INPUT REACTANCE vs. FREQUENCY

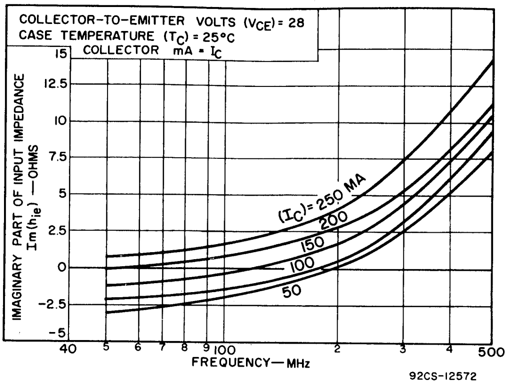


Fig. 5

TYPICAL
OUTPUT CAPACITANCE vs. FREQUENCY

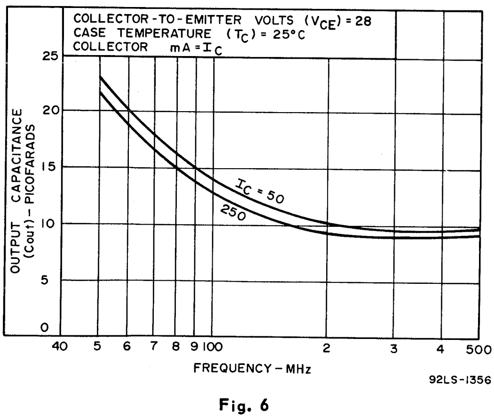


Fig. 6

TYPICAL
SERIES INPUT RESISTANCE vs. FREQUENCY

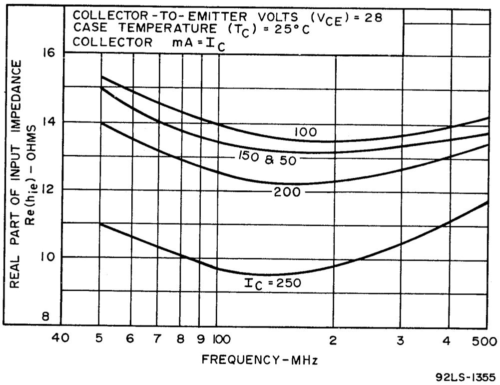


Fig. 7

TYPICAL GAIN-BANDWIDTH PRODUCT vs. COLLECTOR CURRENT

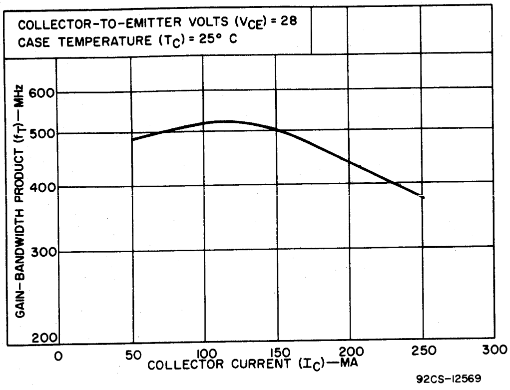


Fig. 8

TYPICAL OUTPUT RESISTANCE vs. FREQUENCY

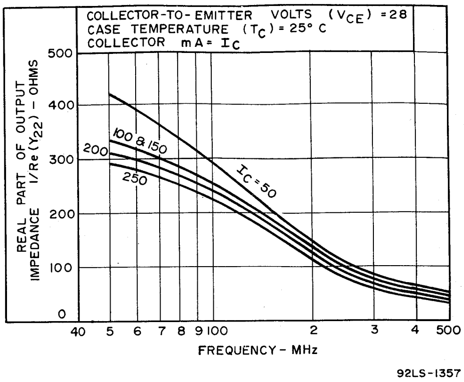
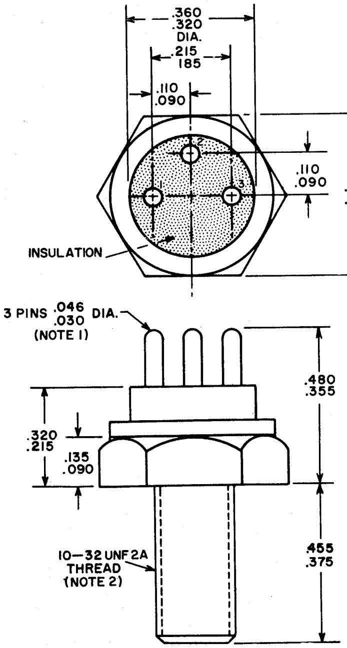


Fig. 9

DIMENSIONAL OUTLINE JEDEC TO-60



92CS–12045R5

NOTE 1: The pin spacing permits insertion in any socket having a pin-circle diameter of 0.200" and contacts which will accommodate pins having a diameter of 0.035" min., 0.045" max.

NOTE 2: The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

NOTE 3: This device may be operated in any position.

TERMINAL CONNECTIONS

Pin No.1 - Emitter
Pin No.2 - Base
Pin No.3 - Collector

REFERENCES

1. *The Overlay Transistor,* Electronics, August 23, 1965.

   Part I - *New Geometry Boosts Power,* D.R. Carley, P.L. McGeough, and J.F. O'Brien.

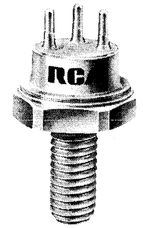
   Part II - *Putting the Overlay to Work at Hi-Frequency,* Dr. D.J. Donahue and B.A. Jacoby.

2. Frequency Multiplication Using Transistors, H.C. Lee and R. Minton, RCA Application Note SMA-40.

RCA
Solid State Division

RF Power Transistors

2N5016



JEDEC TO-60 H-1307

High-Power Silicon N-P-N Overlay Transistor

For VHF/UHF Communications Equipment

Features:

- For class B or C vhf/uhf military and industrial communications
- 15 W output (min.) at 400 MHz
- 23 W output (typ.) at 225 MHz
- Emitter grounded to case

RCA 2N5016* is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter-electrode construction. It is intended for large-signal, high-power, class B and C rf amplifiers for military and industrial communications service (200 to 700 MHz).

In the overlay structure, a number of individual emitter sites are connected in parallel and used in conjunction with a common collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, frequency capability, and linearity.

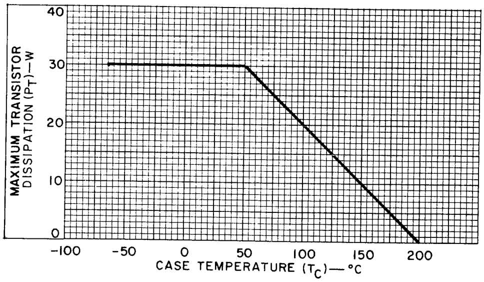


Fig. 1—Dissipation derating curve.

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* Formerly RCA Dev. Type TA2675.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With base-emitter junction reverse-biased, $V_{BE} = -1.5$ V	V_{CEV}	65	V
With external base-to-emitter resistance, $R_{BE} = 30\ \Omega$	V_{CER}	40	V
* With base open	V_{CEO}	30	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
*CONTINUOUS COLLECTOR CURRENT	I_C	4.5	A
*CONTINUOUS BASE CURRENT	I_B	1.5	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 50°C		30	W
At case temperatures above 50°C		See Fig. 1	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to 200	°C
*LEAD TEMPERATURE (During soldering):			
At distances ≥1/32 in. (0.8 mm) from insulating wafer for 10 s max.		230	°C

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*In accordance with JEDEC registration data.

ELECTRICAL CHARACTERISTICS, *Case Temperature (T_C) = 25°C*

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS						LIMITS		UNITS
		DC COLLECTOR OR BASE VOLTAGE – V			DC CURRENT mA					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
Collector-Cutoff Current With base open	I_{CEO}		30			0		–	10	mA
* With base-emitter junction reverse-biased	I_{CEV}		60	-1.5				–	10	
* T_C = 150°C			30	-1.5				–	10	
* Emitter Cutoff Current V_{BE} = 4 V	I_{EBO}							–	5	mA
Collector-to-Emitter Sustaining Voltage * With base open	$V_{CEO}(sus)$					0	200[a]	30	–	V
* With external base-to-emitter resistance (R_{BE}) = 30 Ω	$V_{CER}(sus)$					0	200[a]	40	–	
With base-emitter junction reverse-biased	$V_{CEV}(sus)$			-1.5			200[a]	65	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$				5		0	4	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					400	2000	–	1	V
* DC Forward Current Transfer Ratio	h_{FE}		4 4				4500 500	3 10	– 200	
Thermal Resistance: Junction-to-Case	$R_{\theta J\text{-}C}$							–	5	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	UNITS
* Available Amplifier Signal Input Power (P_{OE} = 15 W, Z_{IN} = 50 Ω, V_{CC} = 28 V, f = 400 MHz) See Fig. 3	P_i							–	5	W
* Collector Efficiency (P_{IE} = 5 W, P_{OE} = 15 W, Z_L = 50 Ω, f = 400 MHz) See Fig. 3	η_C							50	–	%
* Magnitude of Common-Emitter, Small-Signal, Short-Circuit, Forward Current Transfer Ratio (f = 400 MHz)	$\lvert h_{fe} \rvert$		15				500	1.25	–	
Gain-Bandwidth Product	f_T		15				500	600 (typ.)		MHz
* Collector-to-Base Capacitance (f = 1 MHz)	C_{ob}	30			0			–	25	pF

TYPICAL APPLICATION INFORMATION

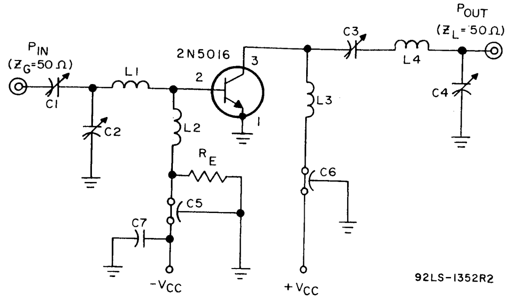
CHARACTERISTIC	SYMBOL	V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	UNITS
RF Power Output Amplifier, Unneutralized At 225 MHz (See Fig.2) 400 MHz (See Fig.3)	P_{OE}		28 28					23[b] (typ.) 15[c]	 –	W
Dynamic Input Impedance at 400 MHz (See Fig.3)	Z_{IN}		28					2.5 + j5 (typ.)[c]		Ω

[a] Pulsed through an inductor (25 mH); duty factor = 50%.

[b] For P_{IE} = 5.0 W; minimum efficiency = 60%.

[c] For P_{IE} = 5.0 W; minimum efficiency = 50%.

*In accordance with JEDEC registration data.



C_1:	4-40 pF trimmer, ARCO 422*
C_2:	7-100 pF trimmer, ARCO 423*
C_3:	3-35 pF trimmer, ARCO 403*
C_4:	8-60 pF trimmer, ARCO 404*
C_5,C_6:	1500 pF feedthrough
C_7:	0.01 μF disc, ceramic
R_E:	0.68 Ω wire-wound 1W
L_1:	1.5 turns No. 16 wire 1/4 in. (6.35 mm) ID, 3/16 in. (4.76 mm) long
L_2:	Ferrite choke, Z = 750 Ω
L_3:	1.5 turns No. 16 wire, 1/4 in. (6.35 mm) ID
L_4:	4.5 turns No. 16 wire, 1/4 in. (6.35 mm) ID, 3 in. (76.20 mm) long

* Or equivalent.

Fig.2--RF amplifier circuit for power output test at 225 MHz.

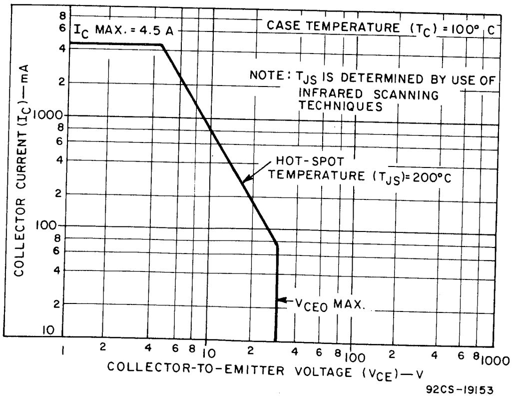
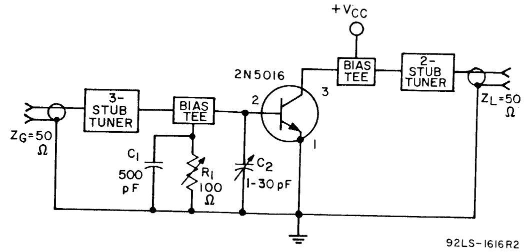


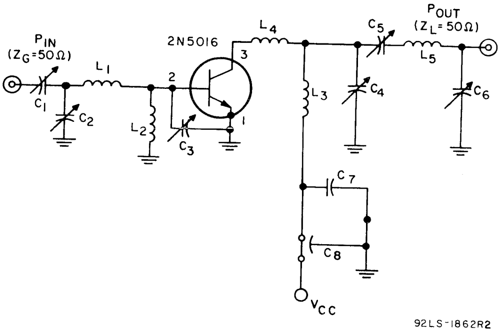
Fig.4—Safe area for dc operation.



Note 1: For optimum performance, C_2 in Fig. 3 should be mounted between emitter and base with minimum lead lengths.

Note 2: The emitter resistor, R_E, in Fig. 2 provides self bias and is recommended for improved stability and collector efficiency.

Fig.3—RF amplifier circuit for power output test at 400 MHz.

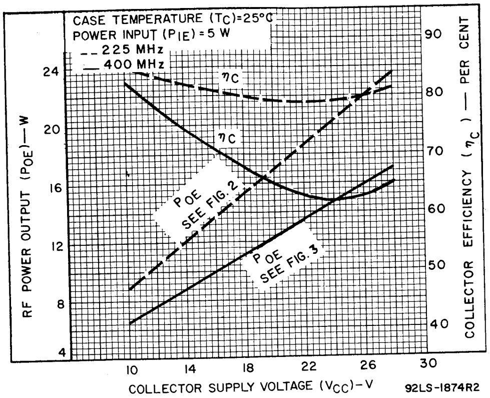


C_1:	0.1-10 pF piston capacitor
C_2,C_3,C_4,C_5,C_6:	1.0-30 pF piston capacitor (Note 2)
C_7:	0.01 μF disc ceramic
C_8:	1000 pF feedthrough
L_1:	1/4 in. (6.35 mm) OD copper tubing; 1-1/4 in. (31.75 mm) long (Note 1)
L_2:	0.12 μH choke
L_3:	0.27 Ω wire-wound
L_4:	1/8 x 1/32 x 5/8 in. (3.17 x 0.79 x 15.87 mm) long copper strap
L_5:	1/4 in. (6.35 mm) OD copper tubing, 2-1/4 in. (57.15 mm) long (Note 1)

Note 1: L_1 and L_5 are mounted coaxially within a 1-5/8 x 1-5/8 x 6 in. (41.27 x 41.27 x 152.40 mm) box.

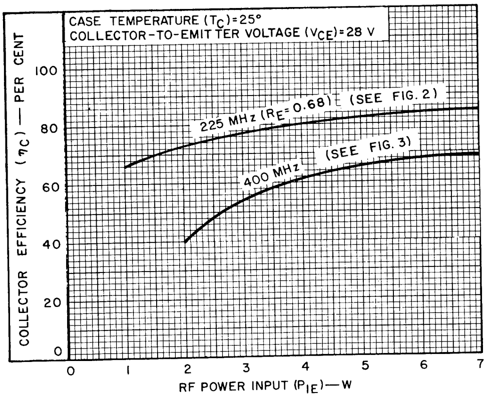
Note 2: For optimum performance, C_3 should be mounted between emitter and base with minimum lead lengths.

Fig.5— Typical 400-MHz rf amplifier circuit,



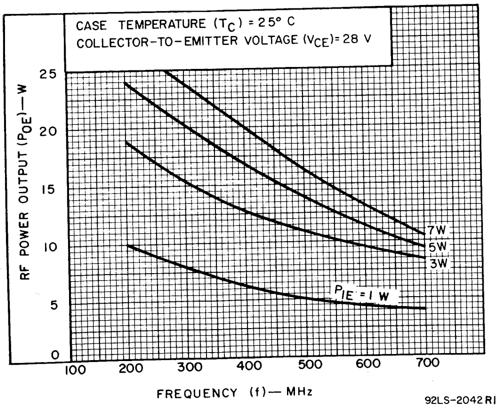
92LS-1874R2

Fig.6—Typical power output and collector efficiency vs. collector supply voltage.



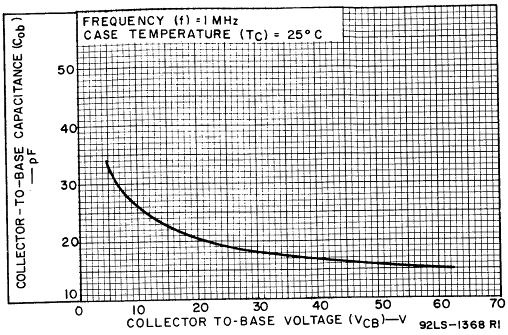
92LS-1875R2

Fig.8—Collector efficiency vs. power input.



92LS-2042R1

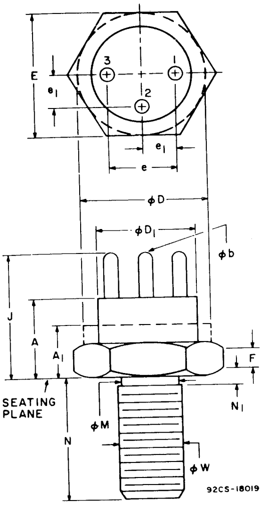
Fig.9—Typical power output vs. frequency.



92LS-1368 R1

Fig.7—Typical variation of collector-to-base capacitance.

DIMENSIONAL OUTLINE
(JEDEC TO-60)



92CS-18019

TERMINAL CONNECTIONS

Case, Pin No. 1 — Emitter
Pin No. 2 — Base
Pin No. 3 — Collector

SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A_1	–	0.165	–	4.19	2
φb	0.030	0.046	0.762	1.17	4
φD	0.360	0.437	9.14	11.10	2
$φD_1$	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e_1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
φM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N_1	–	0.078	–	1.98	
φW	0.1658	0.1697	4.212	4.310	3, 5

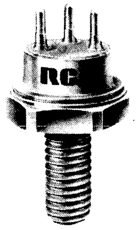
NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing permits insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

Solid State
Division

RF Power Transistors

2N5090



JEDEC TO-60

H-1307

High-Power Silicon N-P-N Overlay Transistor

High-Gain Type for Class A, B, or C Operation in VHF/UHF Circuits

Features:

- **Maximum safe-area-of-operation curve**
- **1.2 W (min.) output at 400 MHz (7.8 dB gain)**
- **1.6 W (typ.) output at 175 MHz (12 dB gain)**
- **Hermetic stud-type package**
- **All electrodes isolated from stud**

RCA-2N5090● is an epitaxial silicon n-p-n planar transistor employing the RCA-developed "overlay" emitter-electrode design. It is intended for rf amplifier, frequency-multiplier, and oscillator service in vhf and uhf communications equipment.

The overlay structure contains many isolated emitter sites connected in parallel by means of a diffused grid structure and a deposited metal overlay. The overlay design provides a very high emitter-periphery-to-emitter-area ratio and results in low output capacitance, high rf-current-handling capability, and high power gain.

●Formerly RCA Dev. No.TA7146.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE . .	V_{CBO}	55	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance, R_{BE} = 10Ω	V_{CER}	55	V
* With base open	V_{CEO}	30	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*CONTINUOUS COLLECTOR CURRENT	I_C	0.4	A
*CONTINUOUS BASE CURRENT.	I_B	0.4	A
*TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 100°C.		4	W
At case temperatures above 100°C. . Derate linearly at 0.04 W/°C			
*TEMPERATURE RANGE:			
Storage & Operating (Junction).		−65 to +200	°C
*LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/16 in. (1.58 mm) from insulating wafer for 10 s max.		230	°C

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*In accordance with JEDEC registration data format JS-6 RDF-3.

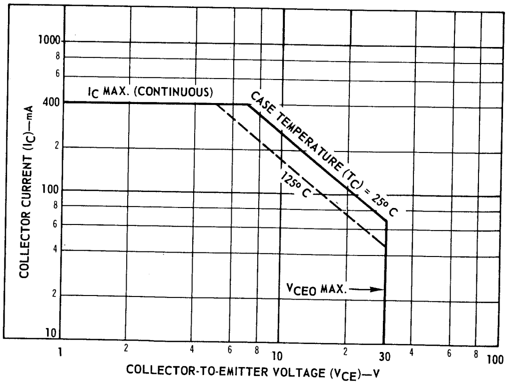


Fig. 1—Safe area for dc operation.

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C

STATIC

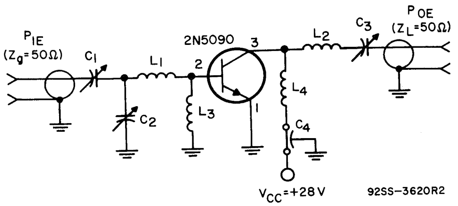
CHARACTERISTIC	SYMBOL	TEST CONDITIONS DC Collector Voltage-V V_{CE}	DC Base Voltage-V V_{BE}	DC Current mA I_E	I_B	I_C	LIMITS MIN.	MAX.	UNITS
* Collector-Cutoff Current: With base open	I_{CEO}	28			0		–	0.02	mA
With base-emitter junction reverse-biased	I_{CEV}	55	−1.5				–	0.1	mA
With base-emitter junction reverse-biased & T_C = 200°C		30	−1.5				–	5	
* Emitter-Cutoff Current	I_{EBO}		3.5				–	0.1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.1	55	–	V
* Collector-to-Emitter Sustaining Voltage: With base-open	$V_{CEO}(sus)$				0	5	30	–	V
With external base-to-emitter resistance (R_{BE}) = 10Ω	$V_{CER}(sus)$					5	55[a]	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
* Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				20	100	–	1.0	V
* DC Forward-Current Transfer Ratio	h_{FE}	5 5				360 50	5 10	– 200	
Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$						–	25	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 0.05%.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS DC Collector Voltage V	Output Power (P_{OE}) W	Input Power (P_{IE}) W	Collector Current (I_C) mA	Frequency (f) MHz	LIMITS MIN.	MAX.	UNITS
Power Output (Class C amplifier, unneutralized) (See Fig. 2)	P_{OE}	V_{CC} = 28		0.2		400	1.2	–	W
Gain-Bandwidth Product	f_T	V_{CE} = 15			50		500	–	MHz
* Magnitude of Common Emitter, Small-Signal, Short-Circuit Forward-Current Transfer Ratio	$\lvert h_{fe} \rvert$	V_{CE} = 15			50		2.5	–	
* Available Amplifier Signal Input Power	P_i		1.2			400	–	0.2	W
* Collector Efficiency	η_C		1.2				45	–	%
* Collector-to-Base Capacitance	C_{obo}	V_{CB} = 30				1	–	3.5	pF

*In accordance with JEDEC registration data format JS-6 RDF-3.



C_1: 0.9-7 pF, ARCO 400, or equivalent
C_2, C_3: 1.5-20 pF, ARCO 402, or equivalent
C_4: 1,000 pF, feedthrough type
L_1: 2 turns No.18 wire, ¼ in. (6.35 mm) ID, 1/8 in. (3.17 mm) long
L_2: 3 turns No.16 wire, ¼ in. (6.35 mm) ID, 3/8 in. (9.52 mm) long
L_3: 0.1 μH, RFC
L_4: 2 turns No.18 wire, 1/8 in. (3.17 mm) ID, 1/8 in. (3.17 mm) long

Fig.2–400-MHz rf amplifier for output power test.

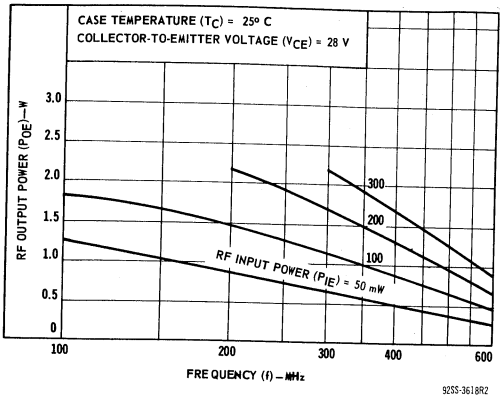


Fig.3—Typical output power vs. frequency.

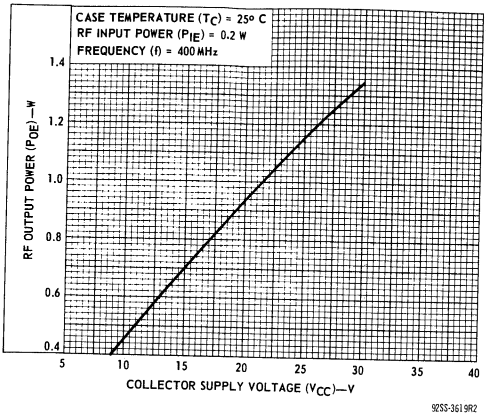


Fig.4—Typical output power vs. collector supply voltage.

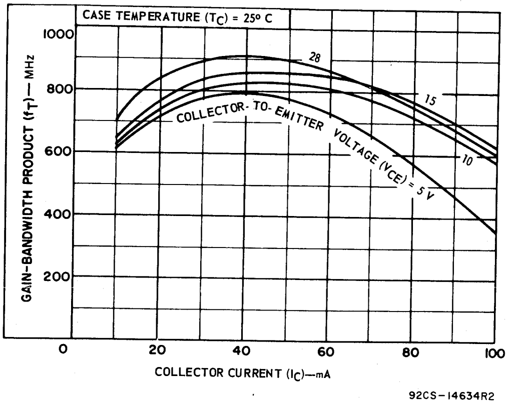


Fig.5—Typical gain-bandwidth product vs. collector current.

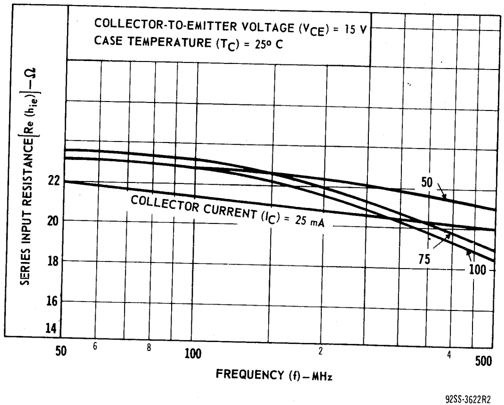


Fig.6—Typical series input resistance vs. frequency.

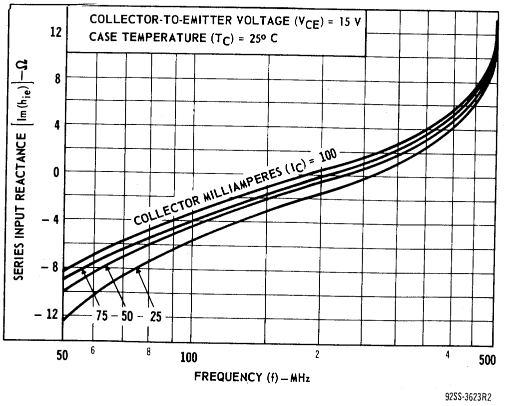


Fig.7—Typical series input reactance vs. frequency.

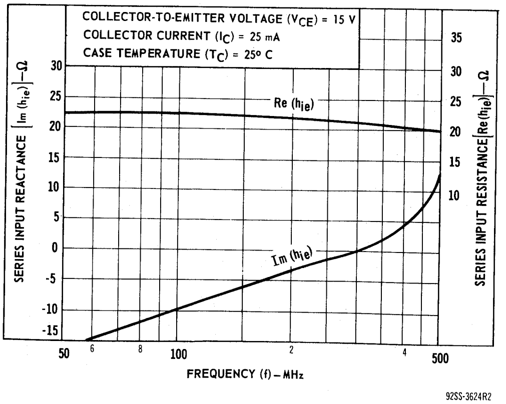


Fig.8—Typical series input resistance and reactance vs. frequency.

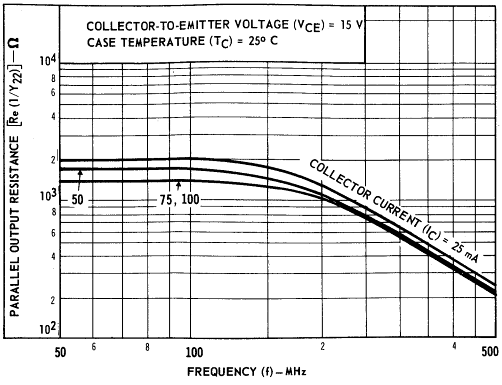


Fig.9—Typical parallel output resistance vs. frequency.

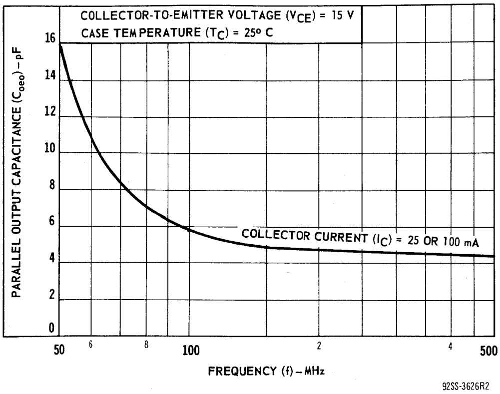


Fig.10—Typical parallel output capacitance vs. frequency.

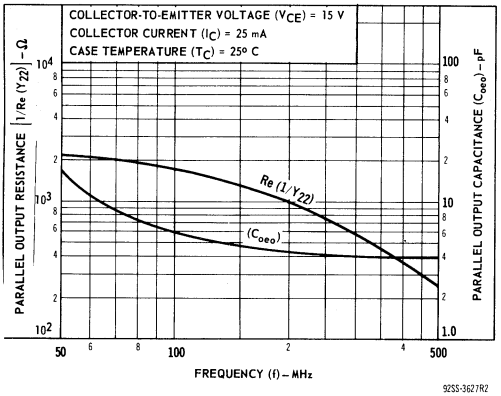


Fig.11—Typical parallel output resistance and capacitance vs. frequency.

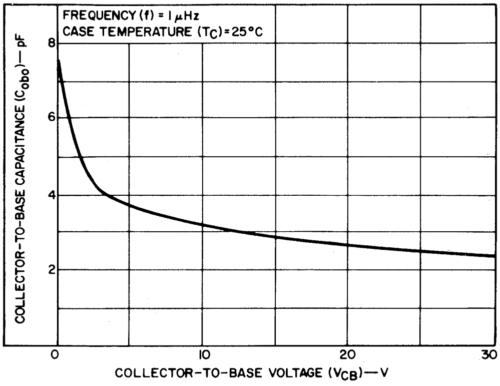
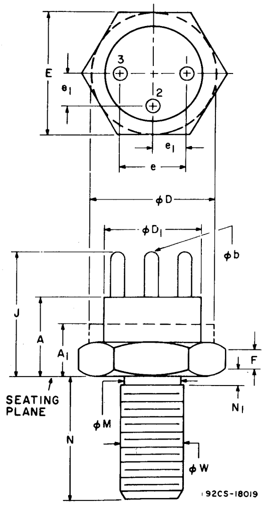


Fig.12—Typical variation of collector-to-base capacitance. with collector-to-base voltage.



DIMENSIONAL OUTLINE, JEDEC TO-60

SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	0.215	0.320	5.46	8.13	
A_1	–	0.165	–	4.19	2
ϕb	0.030	0.046	0.762	1.17	4
ϕD	0.360	0.437	9.14	11.10	2
ϕD_1	0.320	0.360	8.13	9.14	
E	0.424	0.437	10.77	11.10	
e	0.185	0.215	4.70	5.46	
e_1	0.090	0.110	2.29	2.79	
F	0.090	0.135	2.29	3.43	1
J	0.355	0.480	9.02	12.19	
ϕM	0.163	0.189	4.14	4.80	
N	0.375	0.455	9.53	11.56	
N_1	–	0.078	–	1.98	
ϕW	0.1658	0.1697	4.212	4.310	3, 5

NOTES:

1. Dimension does not include sealing flanges
2. Package contour optional within dimensions specified
3. Pitch diameter – 10-32 UNF 2A thread (coated)
4. Pin spacing perimts insertion in any socket having a pin-circle diameter of 0.200 in. (5.08 mm) and contacts which will accommodate pins with a diameter of 0.030 in. (0.762 mm) min., 0.046 in. (1.17mm) max.
5. The torque applied to a 10-32 hex nut assembled on the thread during installation should not exceed 12 inch-pounds.

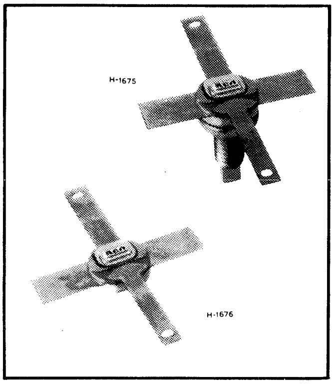
TERMINAL CONNECTIONS

Pin No. 1 – Emitter
Pin No. 2 – Base
Pin No. 3 – Collector
Case—Isolated

RCA
Solid State
Division

RF Power Transistors

2N5916 2N5917



High-Gain Silicon N-P-N Overlay Transistors

For VHF/UHF Communications Equipment

FEATURES

- **Radial leads for microstripline circuits**
- **2 watts (min.) output at 400 MHz (10-dB gain)**
- **2 watts (typ.) output at 1 GHz (5-dB gain)**
- **Low-inductance, ceramic-metal hermetic packages**
- **All electrodes isolated from stud**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

		2N5916 2N5917	
*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	55	V
*COLLECTOR-TO-EMITTER VOLTAGE With base open	V_{CEO}	24	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*CONTINUOUS COLLECTOR CURRENT	I_C	0.2	A
*TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 100°C		4	W
At case temperatures above 100°C		Derate linearly at 0.04 W/°C	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to +200	°C
* CASE TEMPERATURE (During soldering):			
For 10 s max		230	°C

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*In accordance with JEDEC registration data format JS-6, RDF-3/JS-9 RDF-7

RCA 2N5916 and 2N5917▲ are epitaxial silicon n-p-n planar transistors featuring "overlay" emitter electrode construction. They are intended for large-signal and small-signal high-gain rf amplifiers and driver applications for VHF/UHF communications equipment.

Type 2N5916 features a new hermetic, ceramic-metal package having terminals isolated from the mounting stud. These rugged, low-inductance, radial leads are designed for microstripline as well as lumped-constant circuits. 2N5917 is a 2N5916 without the mounting stud.

▲Formerly RCA Dev. Type Nos. TA7411 and TA7852, respectively.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
			DC Collector Voltage	DC Base Voltage	DC Current mA					
			V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
*	Collector-to-Emitter Cutoff Current: Base-emitter junction shorted	I_{CES}	50	0				–	1	mA
*	Collector-to-Emitter Breakdown Voltage:	$V_{(BR)CES}$		0			5^a	55	–	V
	With base open	$V_{(BR)CEO}$					5^a	24	–	
*	Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
	Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				10	100	–	0.5	V
	Thermal Resistance: (Junction-to-Case)	$\theta_{J\text{-}C}$						–	25	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%

DYNAMIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
			DC Collector Supply (V_{CC}) – V	Output Power (P_{OE}) – W	Input Power (P_{IE}) – W	Frequency (f) – MHz	MIN.	MAX.	
*	Power Output (See Fig. 10)	P_{OE}	28		0.2	400	2.0	–	W
*	Power Gain	G_{PE}	28	2		400	10	–	dB
*	Collector Efficiency	η_C	28		0.2	400	50	–	%
*	Collector – Base Capacitance	C_{cb}	30(V_{CB})			1	–	4.5	pF

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

CIRCUIT	Output Power (P_{OE}) – W	Input Power (P_{IE}) – W	Collector Efficiency (η_C) – %	Figure No.
400 – MHz Amplifier	2.2	0.2	60	10
50/450 – MHz Broadband Amplifier	0.1	0.01	–	11
1 – GHz Amplifier	2	0.6	45	12

PERFORMANCE DATA

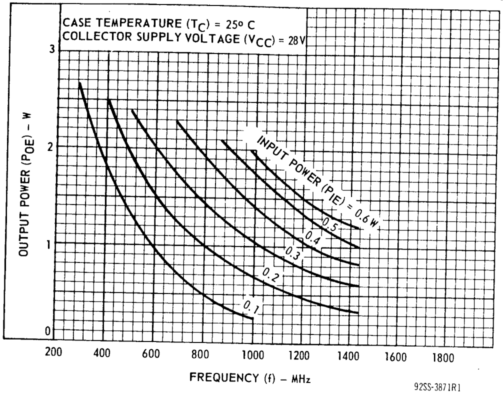


Fig. 1 - Typical power output vs. frequency (for both types).

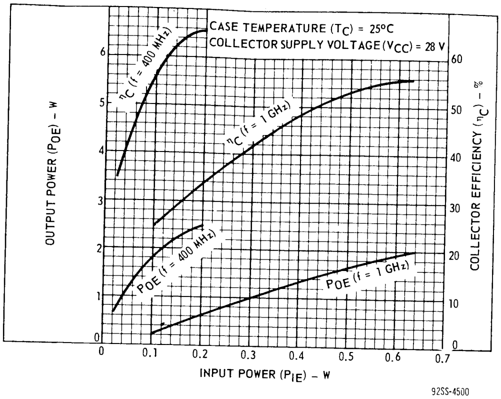


Fig. 2 - Typical power output and collector efficiency vs. power input (for both types).

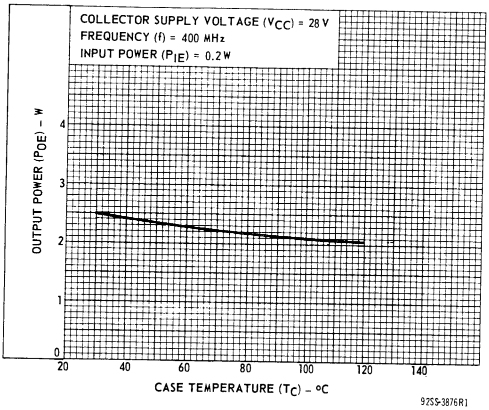


Fig. 3 - Typical power output vs. case temperature (for both types).

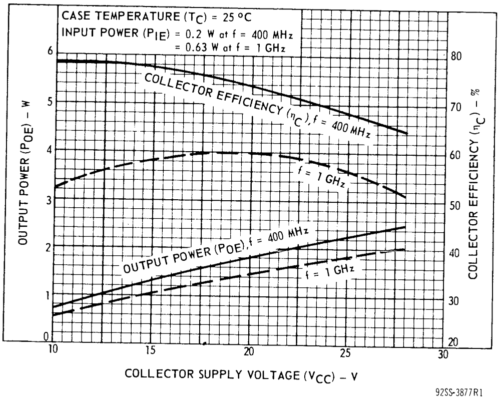


Fig. 4 - Typical power output or collector efficiency vs. collector supply voltage (for both types).

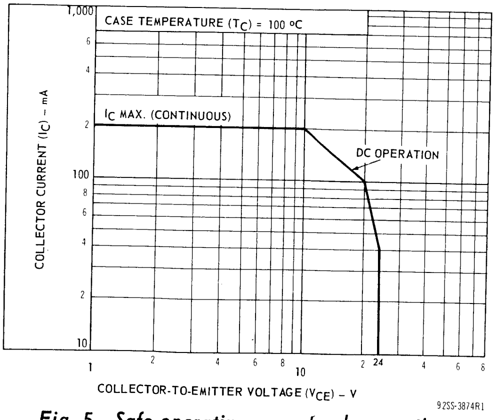


Fig. 5 - Safe operating area, for dc operation (for both types).

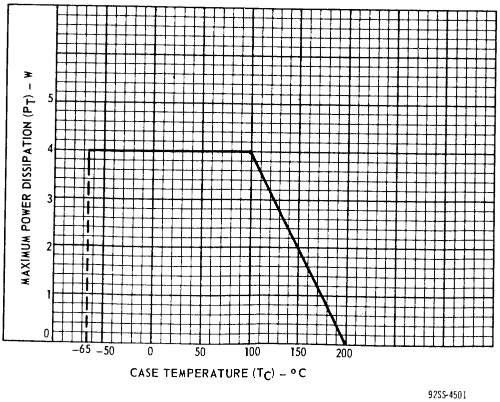


Fig. 6 - Derating curve (for both types).

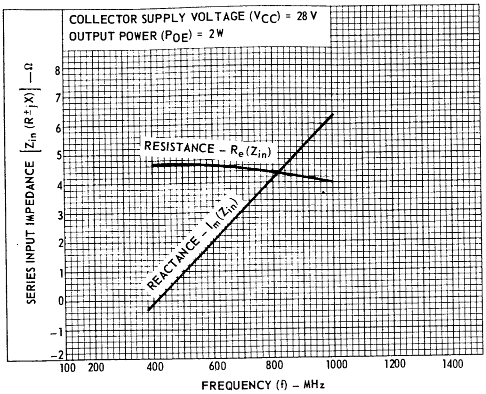


Fig. 7 - Typical large-signal series input impedance vs. frequency (for both types).

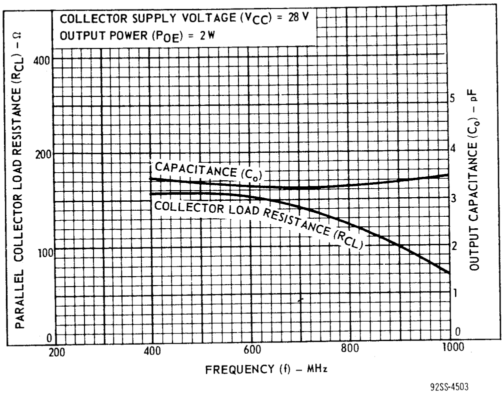
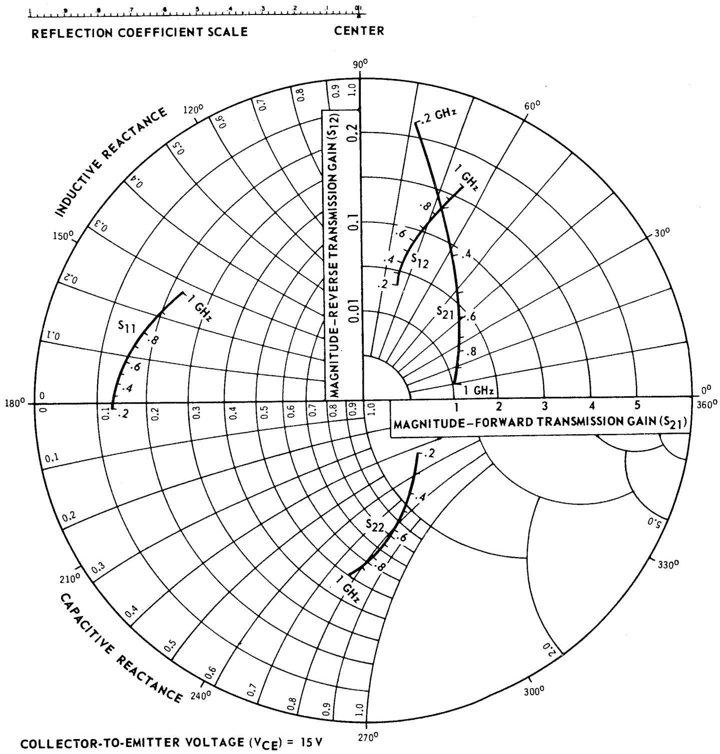


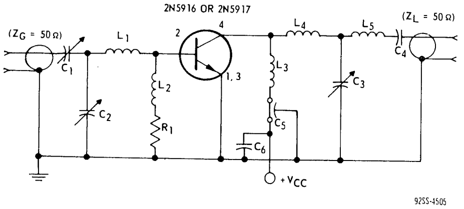
Fig. 8 - Typical large-signal, parallel collector load and parallel output capacitance vs. frequency (for both types).



COLLECTOR-TO-EMITTER VOLTAGE (V_{CE}) = 15 V
COLLECTOR CURRENT (I_C) = 60–100 mA
CASE TEMPERATURE (T_C) = 25°C

92SS-4504

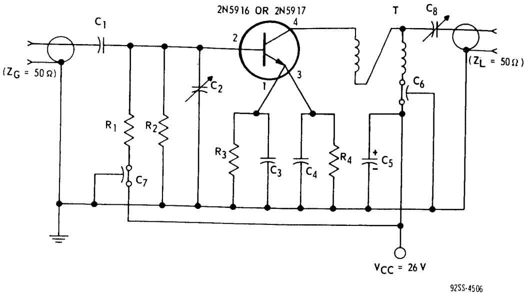
Fig. 9 - Typical S parameters vs. frequency (for both types).



C_1, C_3 – 0.9–7 pF, ARCO 400*
C_2 – 1.5–20 pF, ARCO 402*
C_4 – 0.0015 μF, disc ceramic
C_5 – 1,000 pF, feedthrough type, Allen-Bradley FA5C*
C_6 – 1 μF, electrolytic
L_1, L_5 – 1 turn ▲
L_2 – RFC, .1 μH
L_3 – 3 turns ▲
L_4 – 2 turns ▲
R_1 – 10 Ω, carbon

* Or equivalent
▲All coils 5/32 in. (3.96 mm) I.D. #18 wire, 12 turns per inch

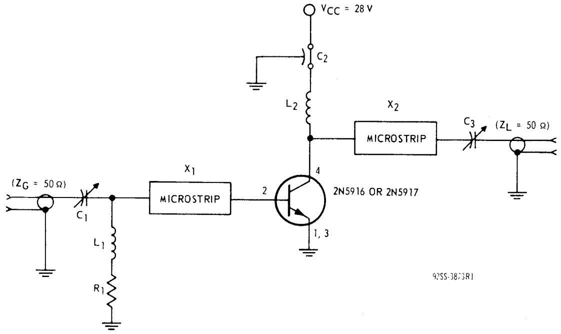
Fig. 10 - 400-MHz amplifier test circuit for measurement of power output.



C_1 – 0.0015 μF, disc ceramic
C_2, C_8 – 2–18 pF, Amperex H.T. 10mA/218, or equivalent
C_3, C_4 – 680 pF, chip cap., Allen-Bradley B166811, or equivalent
C_5 – 1 μF, electrolytic
C_6, C_7 – 1,000 pF, feedthrough type

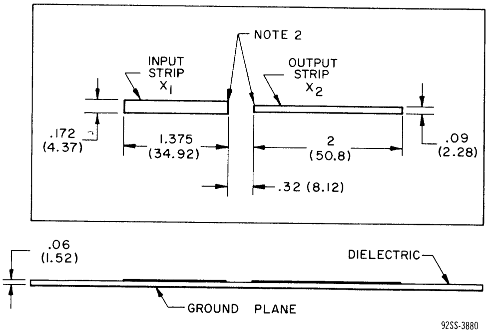
R_1 – 2 kΩ, ½ W, carbon
R_2 – 500Ω, ½ W, carbon
R_3, R_4 – 250Ω, ½ W, carbon
T – Twisted pair of #22 wire, 10 twists, 1 in. long

Fig. 11 - 50/450 – MHz broadband amplifier using type 2N5916 or 2N5917.



C_1, C_3: 0.35-3.5 pF, Johanson 4701, or equivalent
C_2: 470 pF, feed-through type, Allen Bradley FA5C, or equivalent
L_1: 3 turns No. 22 wire 5/32 in. (3.96 mm) ID, 3/8 in. (9.52 mm) long
L_2: 1½ turns No. 22 wire 5/32 in. (3.96 mm) ID, 3/8 in. (9.52 mm) long
R_1: 10-Ω, 1/4-W carbon
X_1, X_2: Microstrip details given in Fig. 13

Fig. 12 - 1 – GHz amplifier using type 2N5916 or 2N5917.

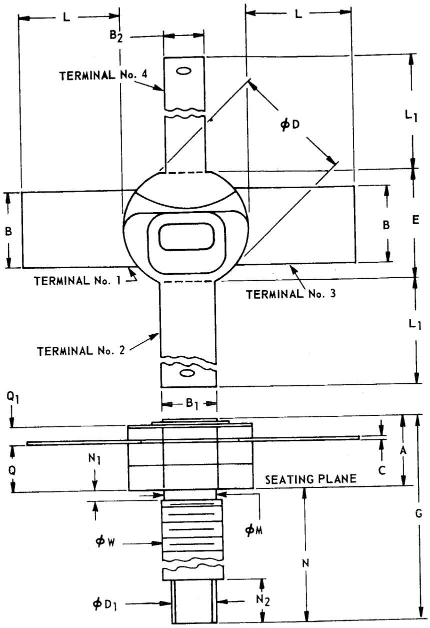


Note 1: Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Note 2: Produced by removing upper layer of double-clad, Teflon board, Budd Co. Polychem Div. Grade 108T, 1 oz. 1/16 in. (1.52 mm) thick, (ϵ = 2.6), or equivalent.

Fig. 13 - Typical microstrip layout for 1-GHz power amplifier circuit shown in Fig. 12.

DIMENSIONAL OUTLINE TYPE 2N5916



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.150	.230	3.81	5.84	–
B	.195	.205	4.96	5.20	–
B_1	.135	.145	3.43	3.68	–
B_2	.095	.105	2.42	2.66	–
C	.004	.010	.11	.25	3
ϕD	.305	.320	7.48	8.12	–
ϕD_1	.110	.130	2.80	3.30	1
E	.275	.300	6.99	7.62	–
G	.590	.705	14.99	17.90	–
L	.265	.290	6.74	7.36	–
L_1	.455	.510	11.56	12.95	–
ϕM	.120	.163	3.05	4.14	–
N	.425	.470	10.80	11.93	–
N_1	–	.078	–	1.98	4
N_2	.110	.150	2.80	3.81	–
Q	.120	.170	3.05	4.31	–
Q_1	.025	.045	.64	1.14	–
ϕW	.1399	.1437	3.531	3.632	2

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

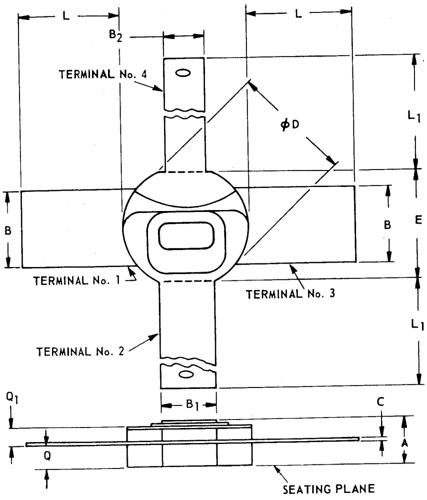
NOTES:
1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

TERMINAL CONNECTIONS

Terminals 1,3 – Emitter
Terminal 2 – Base
Terminal 4 – Collector

DIMENSIONAL OUTLINE TYPE 2N5917



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.090	.135	2.29	3.42	–
B	.195	.205	4.96	5.20	–
B_1	.135	.145	3.43	3.68	–
B_2	.095	.105	2.42	2.66	–
C	.004	.010	.11	.25	1
ϕD	.305	.320	7.48	8.12	–
E	.275	.300	6.99	7.62	–
L	.265	.290	**6.74**	7.36	–
L_1	.455	.510	11.56	12.95	–
Q	.055	.070	1.40	1.77	–
Q_1	.025	.045	.64	1.14	–

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

92SS-4462R1

NOTE: 1. TYPICAL FOR ALL LEADS

TERMINAL CONNECTIONS

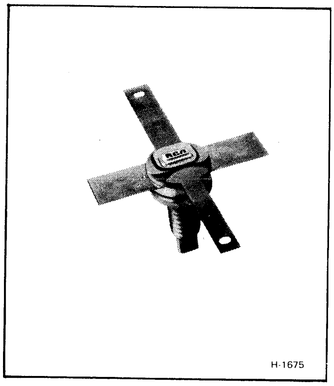
Terminals 1,3 – Emitter
Terminal 2 – Base
Terminal 4 – Collector

"**WARNING:** RCA types 2N5916 and 2N5917 should be handled with care. The ceramic portion of these transistors contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistors because the dust resulting from such action may be hazardous if inhaled."

Solid State
Division

RF Power Transistors

2N5918



10-W, 400-MHz High-Gain Silicon N-P-N Emitter-Ballasted Overlay Transistor

For VHF/UHF Communications Equipment

Features

- **10 W output at 400 MHz (8 dB min. gain)**
- **Emitter-ballasting resistors**
- **Broadband performance (225–400 MHz)**
- **Low-inductance, ceramic-metal hermetic package**
- **All electrodes isolated from stud**
- **Radial leads for stripline circuits**

MAXIMUM RATINGS, *Absolute-Maximum Values.*

* COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	30	V
* COLLECTOR-TO-BASE VOLTAGE . .	V_{CBO}	60	V
* EMITTER-TO-BASE VOLTAGE . . .	V_{EBO}	4	V
* CONTINUOUS COLLECTOR CURRENT	I_C	0.75	A
* TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 75°C . . .		10	W
At case temperatures above 75°C . . .		Derate linearly at 0.08 W/°C	
* TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
* CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

---

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA type 2N5918* is an epitaxial silicon n-p-n planar transistor employing "overlay" emitter-electrode construction. This device features emitter-ballasting resistors which improve ruggedness and overdrive capability, and a hermetic ceramic-metal package with terminals isolated from the mounting stud. The terminals are rugged, low-inductance, radial leads suitable for microstrip as well as lumped-constant circuits.

The 2N5918 is intended for use in large-signal, high-power, broadband and narrow-band amplifiers in vhf/uhf communications equipment.

---

* Formerly RCA Dev. Type No. TA7367.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Collector Voltage	DC Base Voltage	DC Current mA					
		V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
* Collector-to-Emitter Cutoff Current: Base-emitter junction shorted	I_{CES}	30	0				–	5	mA
* Collector-to-Emitter Breakdown Voltage:	$V_{(BR)CES}$		0			100[a]	60	–	V
With base open	$V_{(BR)CEO}$					100[a]	30	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			1		0	4	–	V
Thermal Resistance: (Junction-t o-Case)	$\theta_{J\text{-}C}$						–	12.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor =50%

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Supply (V_{CC})–V	Output Power (P_{OE})–W	Input Power (P_{IE})–W	Frequency (f)–MHz	MIN.	MAX.	
* Power Output (See Fig. 10)	P_{OE}	28		1.59	400	10	–	W
* Power Gain	G_{PE}	28	10		400	8	–	dB
* Collector Efficiency	η_C	28	10		400	60	–	%
* Collector-to-Base Output Capacitance	C_{obo}	30(V_{CB})			1	–	13	pF

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

CIRCUIT	Output Power (P_{OE})–W	Input Power (P_{IE})–W	Collector Efficiency (η_C)–%	Figure No.
400–MHz Amplifier	10.0	1.35	75	10
225/400–MHz Broadband Amplifier	10.0	1.25–1.55	63–81	11

PERFORMANCE DATA

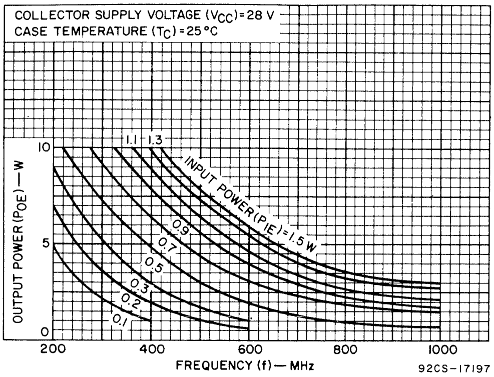


Fig. 1 - Typical output power vs. frequency.

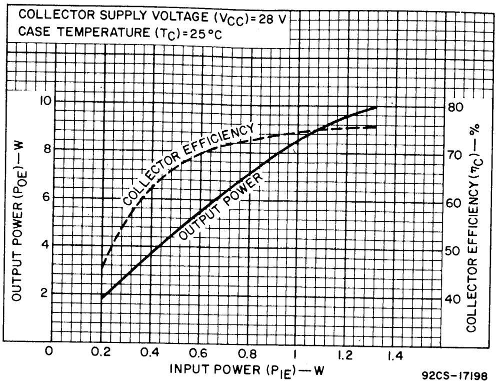


Fig. 2 - Typical output power or collector efficiency vs. input power at 400 MHz.

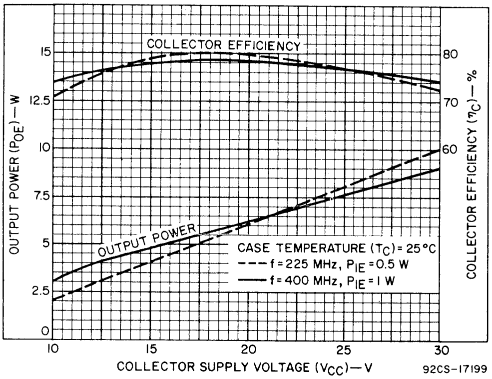


Fig. 3 - Typical output power or collector efficiency vs. collector supply voltage.

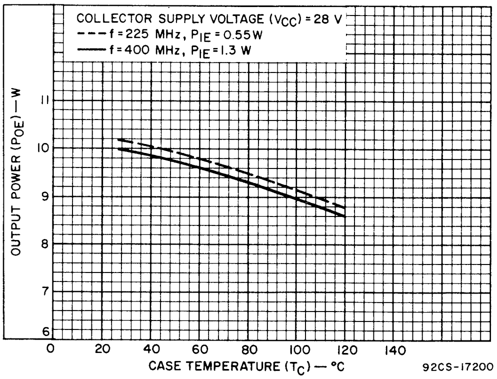


Fig. 4 - Typical output power vs. case temperature.

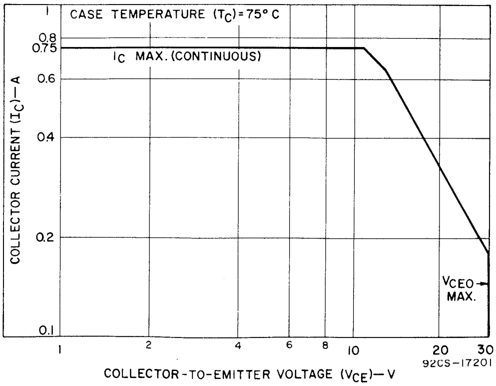


Fig. 5 - Maximum operating area for dc operation.

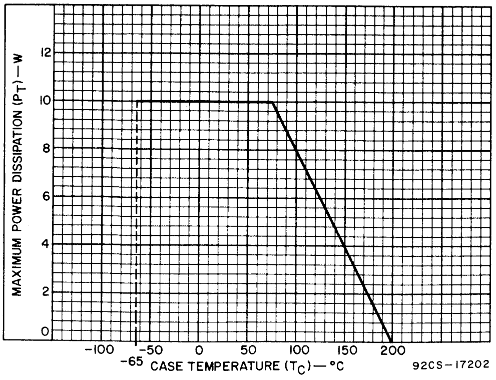


Fig. 6 - Dissipation derating curve for rf class-C operation.

DESIGN DATA

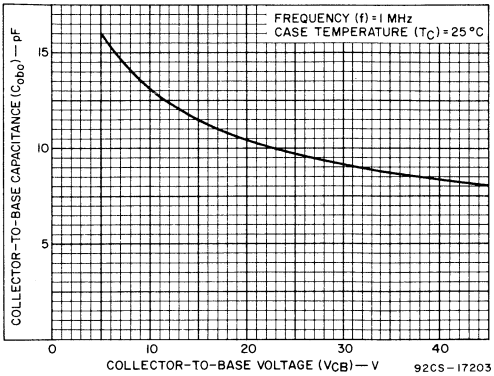


Fig. 7 - Typical variation of collector-to-base capacitance.

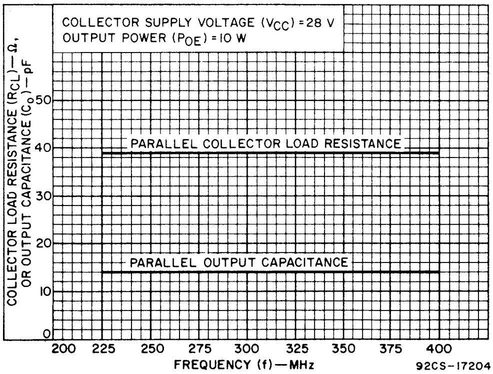


Fig. 8 - Typical large-signal parallel collector load and parallel output capacitance vs. frequency.

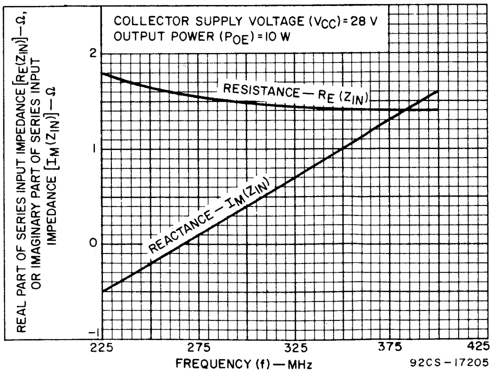
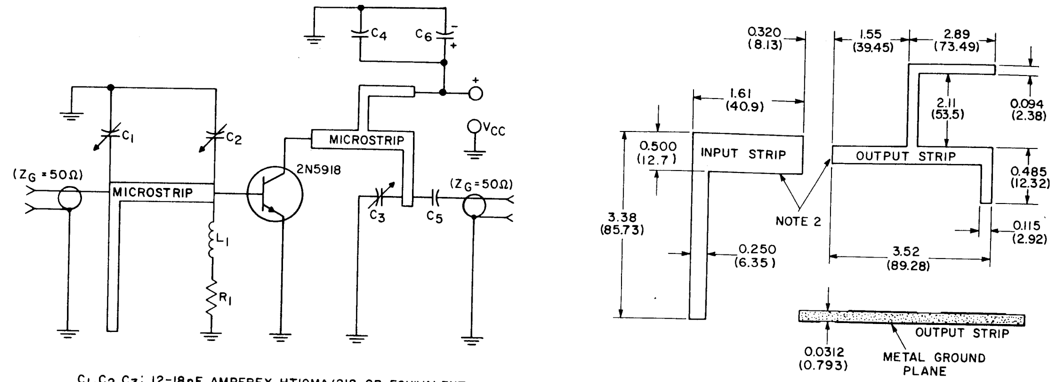


Fig. 9 - Typical large-signal series input impedance $[R_e(Z_{in}) + j\ I_m(Z_{in})]$ vs. frequency.



C1,C2,C3: 12-18pF, AMPEREX HT10MA/218, OR EQUIVALENT
C4, C5: 1000pF, ATC-100, OR EQUIVALENT
C6: 1.0μF, ELECTROLYTIC
L1: 0.12μH RF CHOKE
R1: 5.1Ω, 1/2 W CARBON

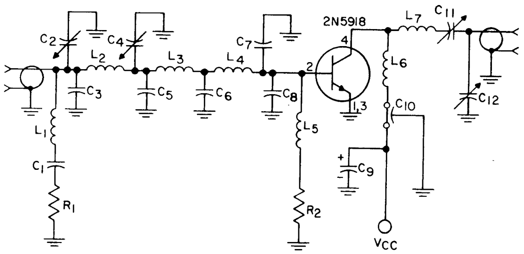
DIMENSIONS IN INCHES AND MILLIMETERS

NOTE 1: DIMENSIONS IN PARENTHESES ARE IN MILLIMETERS AND ARE DERIVED FROM THE BASIC INCH DIMENSIONS AS INDICATED

NOTE 2: PRODUCED BY REMOVING UPPER LAYER OF DOUBLE-CLAD TEFLON BOARD, 1/32 IN. THICK, (ε =2.6).

92CM-17206

Fig. 10 - 400-MHz amplifier test circuit for measurement of power output.



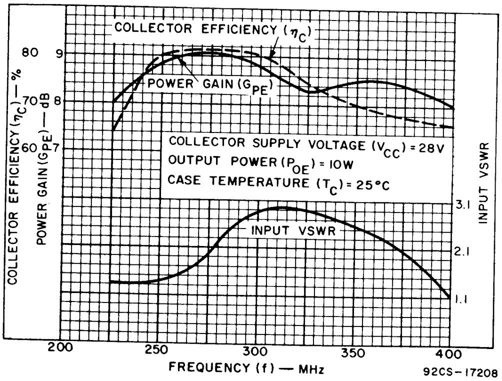
C1 -3pF, ATC-100*
C2 -0.8-10pF, JOHANSON 3957*
C3 -5pF SILVER MICA
C4 -2-18 pF, AMPEREX HT10MA/218*
C5 -24pF, SILVER MICA
C6 -51pF, ATC-100*
C7 -47pF, ATC-100*
C8 -68pF, ATC-100*
C9 -1μF, ELECTROLYTIC
C10-1000 pF, FEEDTHROUGH TYPE, ALLEN-BRADLEY FA5C*
C12-1.5-20 pF, ARCO 402*
C11-0.9-7 pF, ARCO 400*

L1 -0.12μH RFC, NYTRONICS, P. No. DD-0.18*
L2 -No.18 WIRE, 0.64 IN. LONG
L3 -COPPER STRIP 5 MILS THICK, 150 MILS W., 670 MILS L.
L4 -TRANSISTOR BASE LEAD, 0.16 IN. LONG
L5 -0.1μH RFC, NYTRONICS, P. No. DD-0.10*
L6 -No.18 WIRE, 1.08 IN. LONG
L7 -2 TURNS, 5/32 IN. I.D. No.18 WIRE, 12 TURNS PER IN.
R1 -100Ω, 1/2 W, CARBON
R2 -5.1Ω, 1/4 W, CARBON

*OR EQUIVALENT

92CS-17207

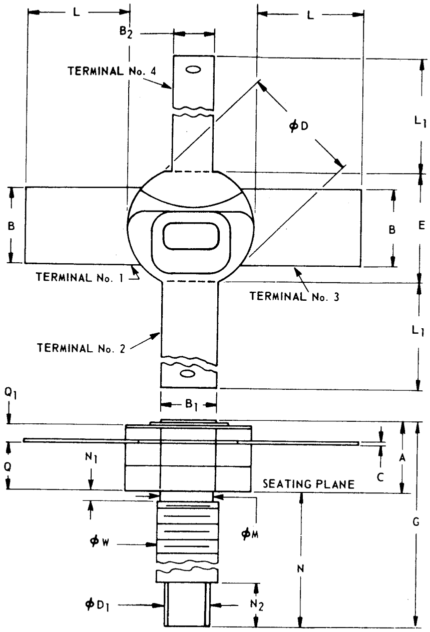
Fig. 11 - 225/400-MHz broadband amplifier using 2N5918.



92CS-17208

Fig. 12 - Typical broadband performance of the 225/400-MHz amplifier circuit shown in Fig. 11.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.150	.230	3.81	5.84	–
B	.195	.205	4.96	5.20	–
B_1	.135	.145	3.43	3.68	–
B_2	.095	.105	2.42	2.66	–
C	.004	.010	.11	.25	3
ϕD	.305	.320	7.48	8.12	–
$ϕD_1$	.110	.130	2.80	3.30	1
E	.275	.300	6.99	7.62	–
G	.590	.705	14.99	17.90	–
L	.265	.290	6.74	7.36	–
L_1	.455	.510	11.56	12.95	–
ϕM	.120	.163	3.05	4.14	–
N	.425	.470	10.80	11.93	–
N_1	–	.078	–	1.98	4
N_2	.110	.150	2.80	3.81	–
Q	.120	.170	3.05	4.31	–
Q_1	.025	.045	.64	1.14	–
ϕW	.1399	.1437	3.531	3.632	2

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

NOTES:
1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

TERMINAL CONNECTIONS

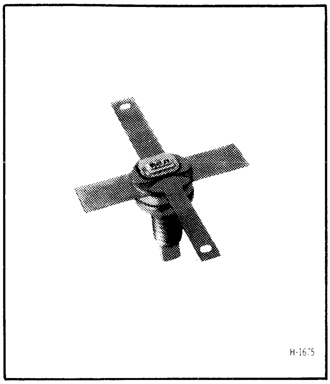
Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

WARNING: RCA Type 2N5918 should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor because of dust resulting from such action may be hazardous if inhaled.

Solid State
Division

RF Power Transistors

2N5919



High-Power Silicon N-P-N Overlay Transistor

For Class-C Service in VHF/UHF Communications Equipment

Features:

- **Radial leads for strip-line circuits**
- **16 watts (min.) output at 400 MHz (6 dB gain)**
- **Broad-band performance (225 – 400 MHz)**
- **Low-inductance, ceramic-metal hermetic package**
- **All electrodes isolated from stud**

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	30	V
*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
*CONTINUOUS COLLECTOR CURRENT	I_C	4.5	A
*TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 75°C		25	W
At case temperatures above 75°C		Derate linearly at 0.2 W/°C	
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (During soldering):			
For 10 s max		230	°C

---

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

RCA Type 2N5919* is an epitaxial silicon n-p-n planar transistor employing "overlay" emitter-electrode construction. It is intended for large-signal, high-power, broadband amplifiers in VHF/UHF communications equipment.

The 2N5919 features a new hermetic, ceramic-metal package having terminals isolated from the mounting stud. These rugged, low-inductance, radial leads are designed for microstrip as well as lumped-constant circuits.

---

* Formerly RCA Dev. Type No. TA7344.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

STATIC

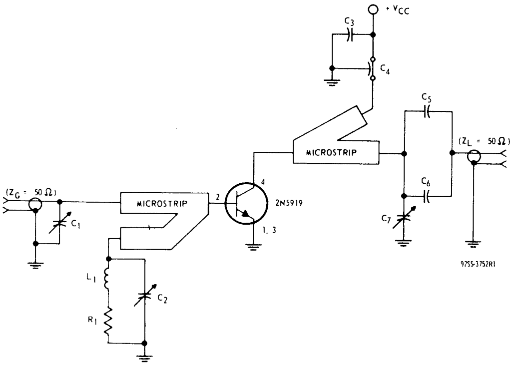
		TEST CONDITIONS							
CHARACTERISTIC	SYMBOL	DC Collector Voltage	DC Base Voltage	DC Current mA			LIMITS		UNITS
		V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
* Collector-to-Emitter Cutoff Current: Base-emitter junction shorted	I_{CES}	30	0				-	10	mA
* Collector-to-Emitter Breakdown Voltage:	$V_{(BR)CES}$		0			200[a]	65	-	V
With base open	$V_{(BR)CEO}$					200[a]	30	-	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			5		0	4	-	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				400	2000	-	1	V
Thermal Resistance: (Junction-to-Case)	$\theta_{J\text{-}C}$						-	5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

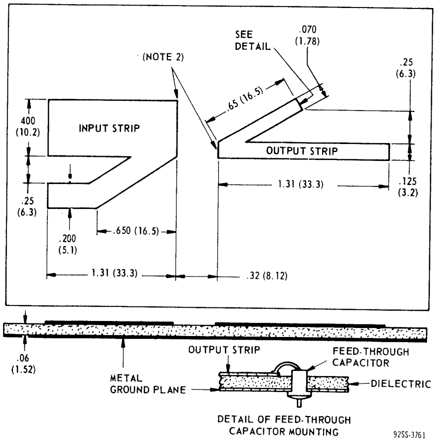
DYNAMIC

		TEST CONDITIONS				LIMITS		
CHARACTERISTIC	SYMBOL	DC Collector Supply (V_{CC}) - V	Power Input (P_{IE}) - W	Power Output (P_{OE}) - W	Frequency (f)- MHz	MIN.	MAX.	UNITS
* Power Output (See Fig. 1)	P_{OE}	28	4		400	16	-	W
* Power Gain	G_{PE}	28		16	400	6	-	dB
* Collector Efficiency	η_C	28	4		400	60	-	%
* Collector-to-Base Output Capacitance	C_{obo}	30 (V_{CB})			1	-	22	pF

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.



C_1, C_2, C_7: 2-18 pF, Amperex HT10MA/218, or equivalent
C_3: 0.03 μF disc type
C_4: 470 pF feed-through type, Allen-Bradley FA5C, or equivalent
C_5, C_6: 0.005 μF disc type
L_1: 0.22 μH rf choke
R_1: 5.1 Ω, 1/2 W carbon



Dimensions in Inches and Millimeters

Note 1: Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Note 2: Produced by removing upper layer of double-clad, Teflon board, Budd Co. Polychem Div. Grade 108T, 1 oz, 1/16 in. thick, (ϵ = 2.6), or equivalent.

Fig. 1 - 400-MHz amplifier test circuit for measurement of power output.

PERFORMANCE DATA

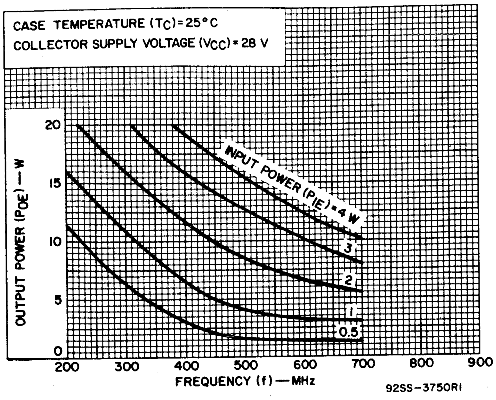


Fig. 2 - Typical power output vs. frequency.

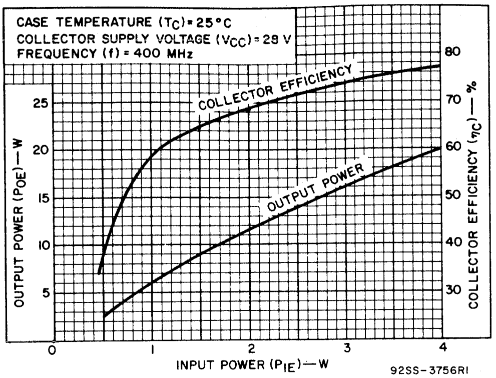


Fig. 3 - Typical power output or collector efficiency vs. power input at 400 MHz.

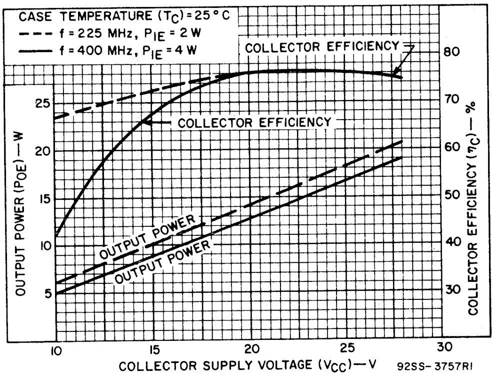


Fig. 4 - Typical power output or collector efficiency vs. collector supply voltage.

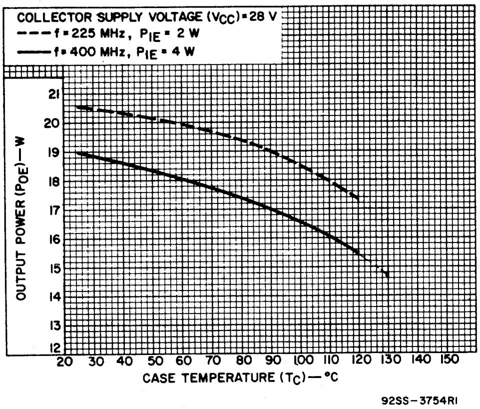


Fig. 5 - Typical power output vs. case temperature.

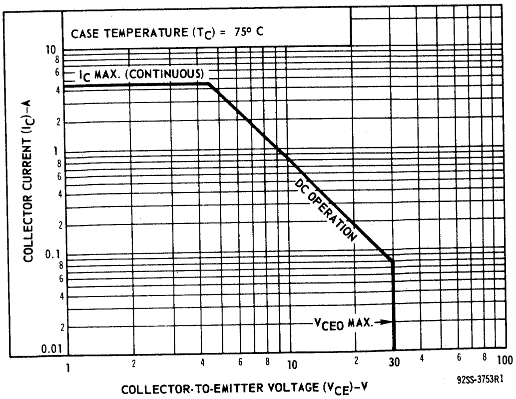


Fig. 6 - Maximum operating area for dc operation.

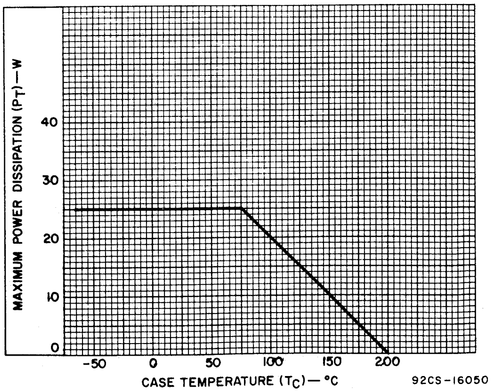


Fig. 7 - Dissipation derating curve.

DESIGN DATA

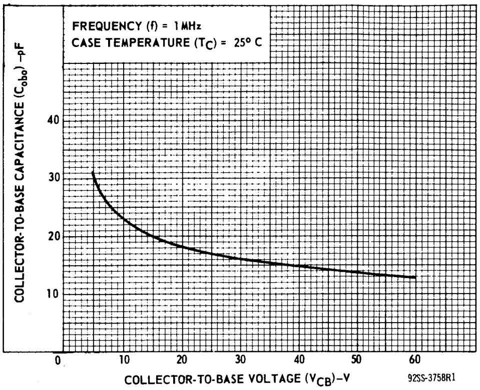


Fig. 8 - Typical variation of collector-to-base capacitance.

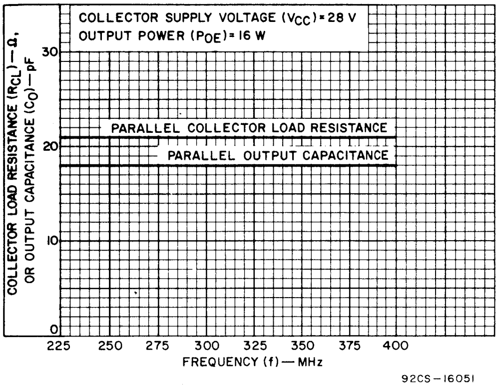


Fig. 9 - Typical large-signal parallel collector load and parallel output capacitance vs. frequency.

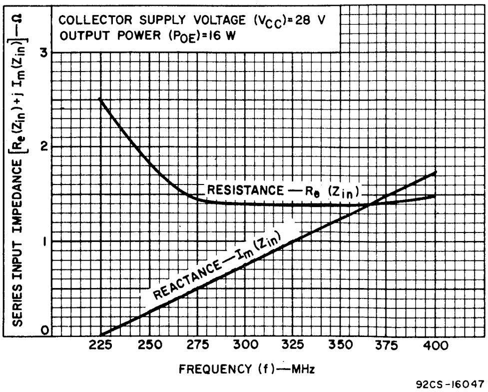
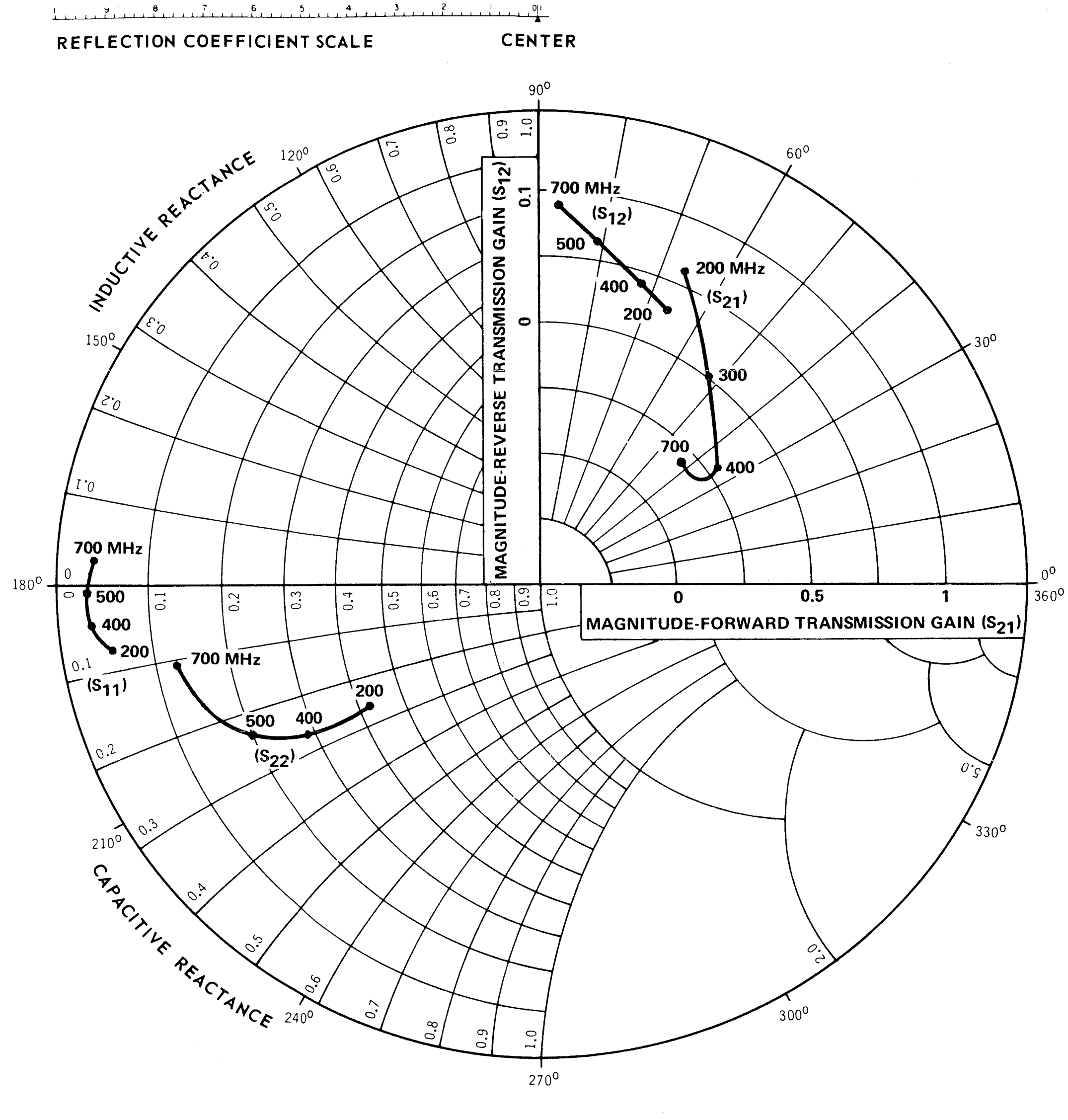


Fig. 10 - Typical large-signal series input impedance vs. frequency.

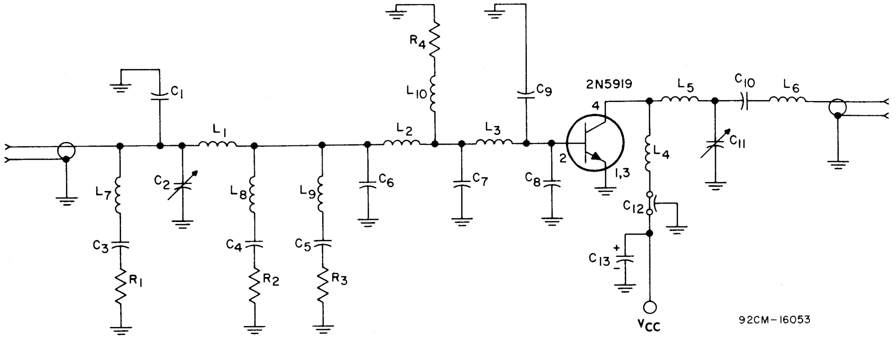


COLLECTOR-TO-EMITTER VOLTAGE (V_{CE}) = 15 V
COLLECTOR CURRENT (I_C) = 500 mA
CASE TEMPERATURE (T_C) = 25°C

92CM-16052

Fig. 11 - Typical S parameters vs. frequency.

APPLICATION DATA



C_1 - 10 pF silver mica
C_2 - 0.8-10 pF, Johanson 3957*
C_3 - 2.2 pF, Quality Components type 10% QC, "gimmick"*
C_4 - 1.0 pF, Quality Components type 10% QC, "gimmick"*
C_5 - 1.5 pF, Quality Components type 10% QC, "gimmick"*
C_6 - 36 pF, ATC-100*
C_7 - 51 pF, ATC-100*
C_8 - 47 pF, ATC-100*
C_9 - 68 pF, ATC-100*
C_{10} - 12 pF, silver mica
C_{11} - 0.8-20 pF, Johanson 4802*
C_{12} - 1000 pF feedthrough type, Allen-Bradley FA5C*
C_{13} - 1 μF electrolytic

L_1 - 1-1/2 turns▲
L_2 - Copper strip 5/8 in. (15.875 mm) L; 5/32 in. (3.96 mm) W
L_3 - Transistor base lead, 3/6 in. (4.74 mm) L
L_4, L_6 - 3 turns▲
L_5 - 2 turns▲
L_7, L_8, L_9 - 0.18 μH RFC, Nytronics, P.#DD-0.18*
L_{10} - 0.1 μH RFC, Nytronics, P.#DD-0.10*
R_1 - 100 Ω, 1 W, carbon
R_2, R_3 - 100 Ω, 1/2 W, carbon
R_4 - 5.1 Ω, 1/2,W, carbon

▲All coils are 5/32 in. (3.96 mm) I. D. #18 wire, 12 turns per inch.

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* Or equivalent
Allen-Bradley Co., Milwaukee, Wis.
American Technical Ceramics, Huntington Station, N. Y. 11746
Johanson Mfg. Corp., Boonton, N. J. 07005
Nytronics, Inc., Berkeley Heights, N. J.

Fig. 12 - 225/400-MHz broadband amplifier using 2N5919.

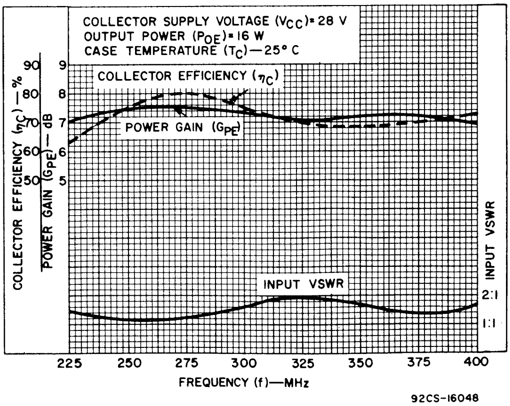
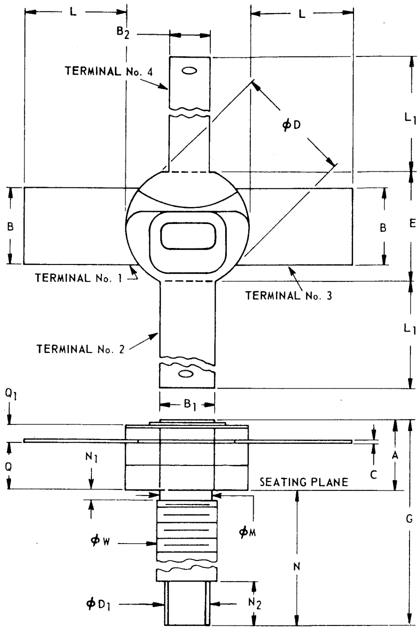


Fig. 13 - Typical broadband performance of the 225/400-MHz amplifier circuit shown in Fig. 12.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.150	.230	3.81	5.84	–
B	.195	.205	4.96	5.20	–
B_1	.135	.145	3.43	3.68	–
B_2	.095	.105	2.42	2.66	–
C	.004	.010	.11	.25	3
ϕD	.305	.320	7.48	8.12	–
ϕD_1	.110	.130	2.80	3.30	1
E	.275	.300	6.99	7.62	–
G	.590	.705	14.99	17.90	–
L	.265	.290	6.74	7.36	–
L_1	.455	.510	11.56	12.95	–
ϕM	.120	.163	3.05	4.14	–
N	.425	.470	10.80	11.93	–
N_1	–	.078	–	1.98	4
N_2	.110	.150	2.80	3.81	–
Q	.120	.170	3.05	4.31	–
Q_1	.025	.045	.64	1.14	–
ϕW	.1399	.1437	3.531	3.632	2

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

NOTES:
1. .053 – .064 INCH (1.35 – 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD. (ASA B1. 1-1960).
3. TYPICAL FOR ALL LEADS
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕ W

92SS-3763R3

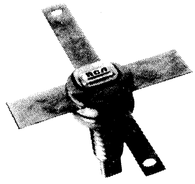
TERMINAL CONNECTIONS

Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

RCA
Solid State Division

RF Power Transistors

2N5919A



JEDEC TO-216AA

H-1693

16-W, 400-MHz, Silicon N-P-N Emitter-Ballasted Overlay Transistor

Improved Version of 2N5919 Features Overdrive Capability of 20-W Output

Features:

- **6-dB gain (min.) at 400 MHz with 16 watts (min.) output**
- **Integral emitter-ballasting resistors**
- **Broadband performance (225-400 MHz)**
- **Low-inductance, ceramic-metal, hermetic package**
- **Radial leads for microstripline circuits**
- **All electrodes isolated from the stud**

RCA Type 2N5919A● is an epitaxial silicon n-p-n planar transistor with "overlay" emitter-electrode construction.

The 2N5919A is unilaterally interchangeable with the 2N5919. Both types employ a construction which features many separate emitter elements; however, for stabilization, the 2N5919A has integral emitter ballast resistance.

The 2N5919A features the same hermetic, ceramic-metal package with rugged, low-inductance radial leads for microstripline as well as lumped-constant circuits.

This transistor is intended for use in large-signal, high-power, broadband and narrowband amplifiers in vhf/uhf equipment.

●Formerly RCA Dev. No.TA7532.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-EMITTER VOLTAGE: With base open	V_{CEO}	30	V
*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
*CONTINUOUS COLLECTOR CURRENT	I_C	4.5	A
*TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 75°C		25	W
At case temperatures above 75°C		Derate at 0.2	W/°C
*TEMPERATURE RANGE: Storage & Operating (Junction)		−65 to +200	°C
*CASE TEMPERATURE (During soldering): For 10 s max.		230	°C

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*In accordance with JEDEC registration data format JS-6 RDF-3/ JS-9 RDF-7.

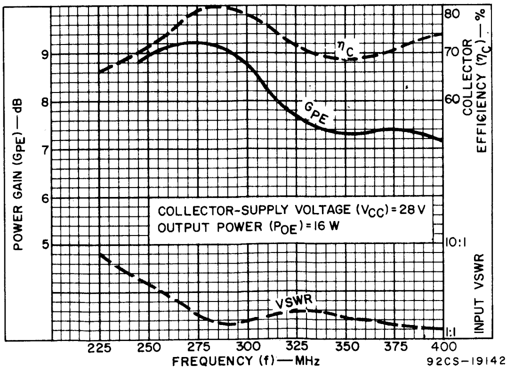


Fig.1—Typical performance of the 225-400-MHz broadband amplifier circuit shown in Fig.12.

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25°C

STATIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
			DC Collector Voltage-V	DC Base Voltage-V	DC Current mA					
			V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
*	Collector-to-Emitter Cutoff Current: With base connected to emitter	I_{CES}	30	0				–	10	mA
*	Collector-to-Emitter Breakdown Voltage: With base connected to emitter	$V_{(BR)CES}$		0			200[a]	65	–	V
	With base open	$V_{(BR)CEO}$					200[a]	30	–	
*	Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			5		0	4	–	V
	Thermal Resistance: (Junction-to-Case)	$R_{\theta JC}$							5.0	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

DYNAMIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
			DC Collector Supply (V_{CC})-V	Input Power (P_{IE})-W	Output Power (P_{OE})-W	Frequency (f)–MHz	MIN.	MAX.	
	Output Power (See Fig. 11)	P_{OE}	28	4.0		400	16	–	W
*	Overdrive Objective Test		28	7.0		400	20		
*	Power Gain	G_{PE}	28		16	400	6	–	dB
*	Collector Efficiency	η_C	28	4.0		400	65	–	%
*	Collector-to-Base Output Capacitance	C_{obo}	30 (V_{CB})			1	–	22	pF

* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

CIRCUIT	COLLECTOR SUPPLY VOLTAGE (V_{CC})–V	OUTPUT POWER (P_{OE})–W	INPUT POWER (P_{IE})–W	COLLECTOR EFFICIENCY (η_C)–%
225-400-MHz Broadband Amplifier (See Fig.12)	28	16	2–3.2	66–80
400-MHz Narrowband Amplifier (See Fig.11)	28	18.5	4.0	78

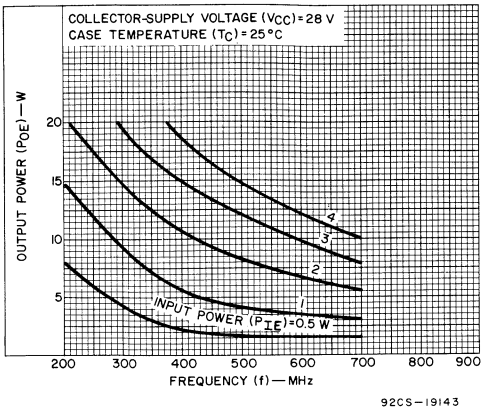


Fig.2—Typical output power vs. frequency.

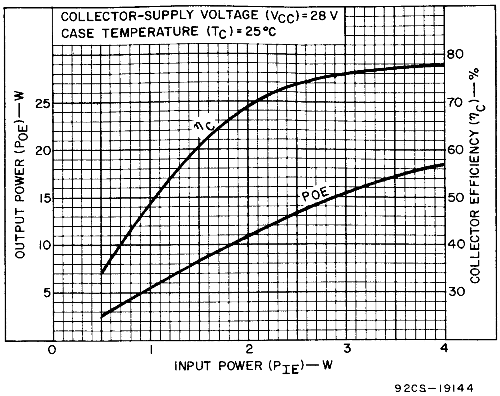


Fig.3—Typical output power and collector efficiency vs. input power.

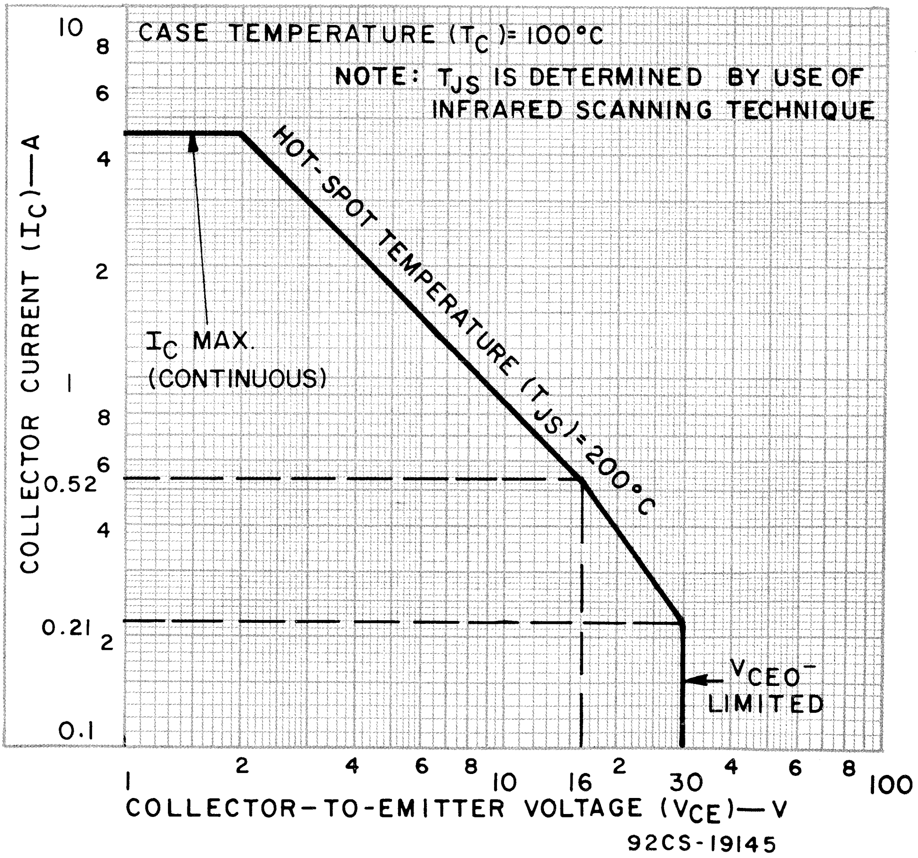


Fig.4—Maximum dc operating area for type 2N5919A.

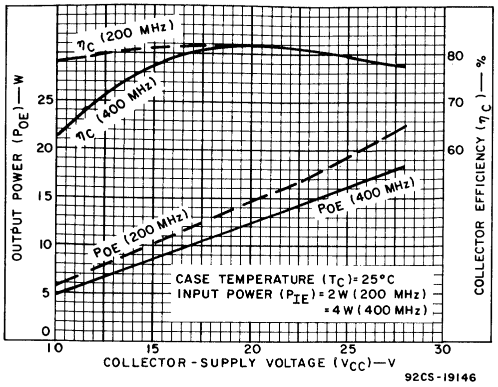


Fig.5—Typical output power and collector efficiency vs. collector-supply voltage.

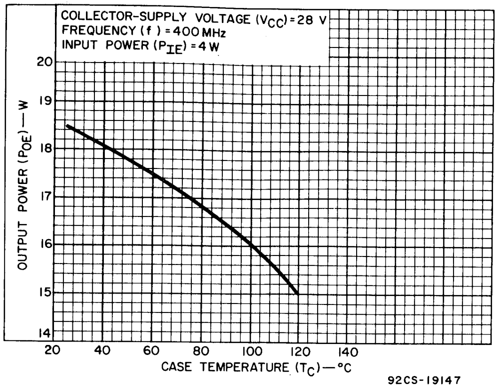


Fig.6—Typical output power vs. case temperature.

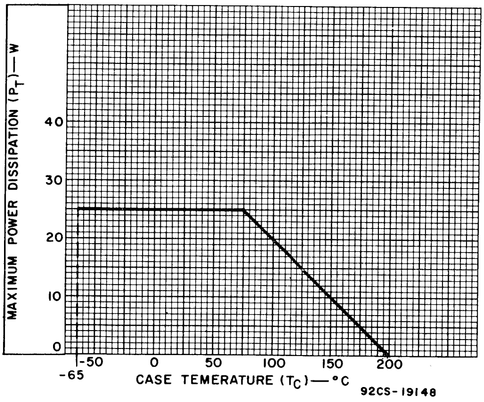


Fig.7—Dissipation-derating curve for class C operation.

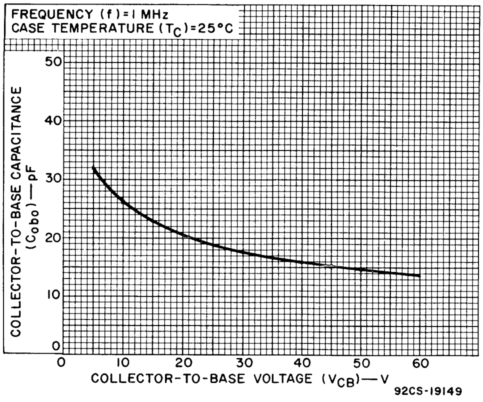


Fig.8—Typical variation of collector-to-base capacitance with collector-to-base voltage.

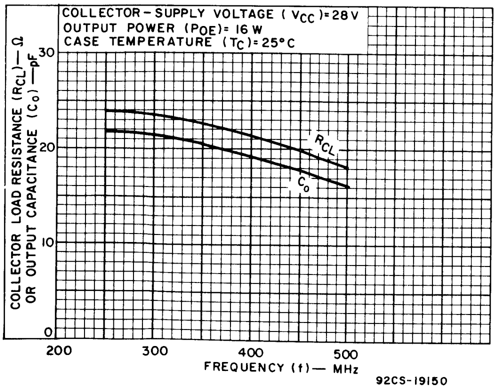


Fig.9—Typical large-signal parallel collector load resistance and parallel output capacitance vs. frequency.

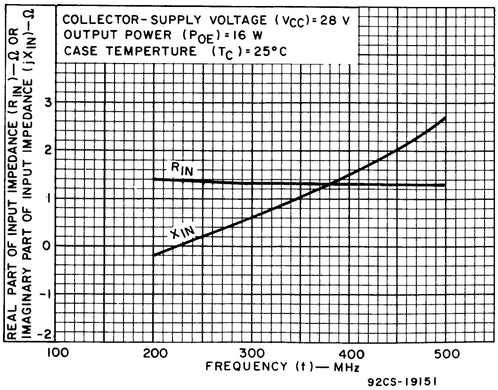
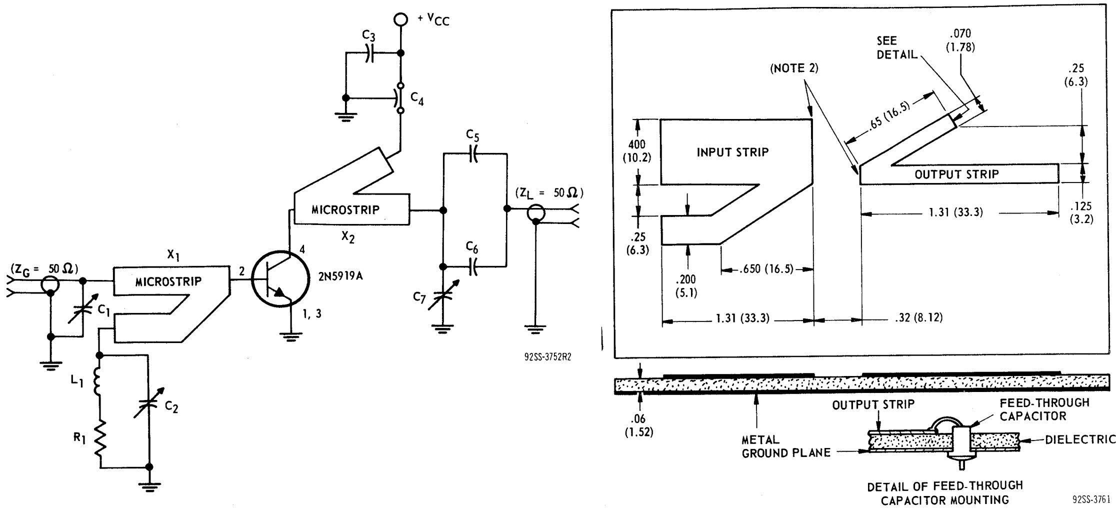


Fig.10—Typical large-signal series input impedance vs. frequency.



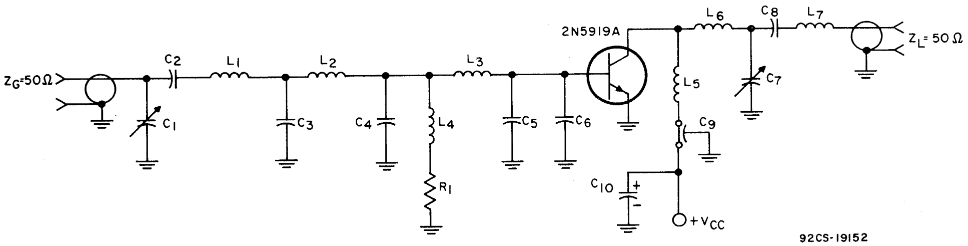
C_1, C_2, C_7: 2-18 pF, Amperex HT10MA/218, or equivalent
C_3: 0.03 μF, disc type
C_4: 470 pF, feed-through type, Allen-Bradley FA5C, or equivalent
C_5, C_6: 0.005 μF, disc type
L_1: 0.22 μH, rf choke
R_1: 5.1 Ω, 1/2 W carbon

Dimensions in Inches and Millimeters

Note 1: Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Note 2: Produced by removing upper layer of double-clad, Teflon board, Budd Co. Polychem Div. Grade 108T, 1 oz, 1/16 in. thick, (ϵ = 2.6), or equivalent.

Fig. 11—400-MHz narrowband amplifier test circuit for measurement of power output.



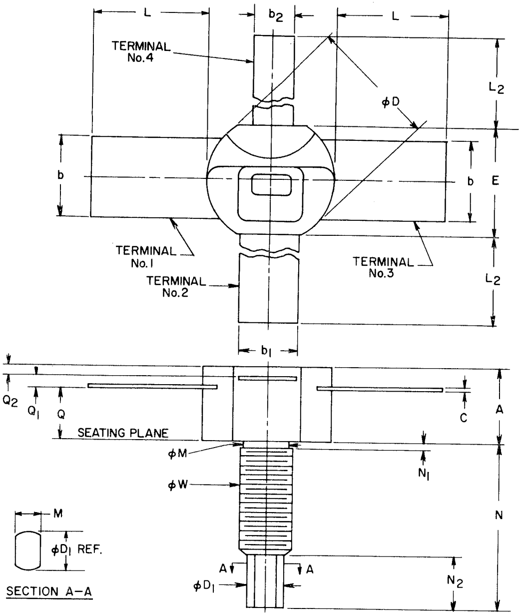
C_1 - 0.8-10 pF, piston type, Johanson• 3957*
C_2 - 18 pF, silver mica
C_3 - 33 pF, chip type, Allen-Bradley• B16*
C_4 - 47 pF, chip type, Allen-Bradley B16*
C_5, C_6 - 62 pF, chip type, American Technical Ceramics• ATC-100*
C_7 - 0.8-20 pF, piston type, Johanson 4802*
C_8 - 15 pF, silver mica
C_9 - 1000 pF, feedthrough, Allen-Bradley FA5C*
C_{10} - 1 μF, electrolytic

L_1, L_5, L_7 - Two turns**
L_2 - 1/2-in. (12.7 mm) length of No.20 wire

L_3 - Inductance of 5/32-in. (3.97 mm) long base lead of 2N5919A
L_4 - 0.1 μH, r-f choke, Nytronics•*
L_6 - 1-1/2 turns**
R_1 - 5.1 Ω, ½-W carbon
* or equivalent
•Johanson Mfg. Corp., Boonton, N. J. 07005
Allen-Bradley Co., Milwaukee, Wisc.
American Technical Ceramics
Huntington Station N.Y. 11746
Nytronics Inc., Berkeley Heights, N.J.
** No.20 wire, 14 turns/inch, 5/32 in. (3.97 mm) ID, 5/32 in. (3.97 mm) leads.

Fig. 12—225 to 400-MHz broadband amplifier circuit.

DIMENSIONAL OUTLINE



92SS-3763R4

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	3
ϕD	0.305	0.320	7.48	8.12	–
ϕD_1	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0.510	11.56	12.95	–
ϕM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
ϕW	–	–	–	–	2

NOTES:

1. 0.053 - 0.064 INCH (1.35 - 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREAD (REF.: UNITED SCREW THREADS ANS B1.1 – 1960). THE APPLIED TORQUE SHOULD NOT EXCEED 5 IN. – LB. CLAMPING FORCES MUST BE APPLIED ONLY TO THE FLAT SURFACES OF THE STUD.
3. TYPICAL FOR ALL LEADS.
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF ϕW.

TERMINAL CONNECTIONS

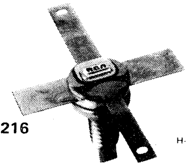
Terminals 1, 3 - Emitter
Terminal 2 - Base
Terminal 4 - Collector

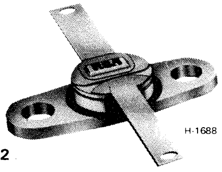
WARNING: The ceramic heat-sink portion of this device contains beryllium oxide. Do not crush, grind, or abrade this portion because the dust resulting from such action may be hazardous if inhaled, Disposal should be by burial.

Solid State
Division

RF Power Transistors

2N6104
2N6105


2N6105
JEDEC TO-216


2N6104
RCA HF-32

30-W, 400-MHz Broadband, Emitter-Ballasted Silicon N-P-N Overlay Transistors

Features:

- 5-dB gain (min.) at 400 MHz with 30 watts (min.) output
- Emitter-ballasting resistors
- Broadband performance (225-400 MHz)
- Low-inductance ceramic-metal hermetic package
- Radial leads for microstripline circuits
- All electrodes isolated from the stud

RCA types 2N6104 and 2N6105● are epitaxial silicon n-p-n planar transistors featuring overlay multiple-emitter-site construction and emitter-ballasting resistors. These transistors are intended for use in large-signal, high-power cw and pulsed amplifiers in vhf/uhf communications equipment up to 600 MHz.

The ceramic-metal hermetic package featuring low parasitic inductances is ideally suited for use in microstripline and lumped-constant broadband and narrow band amplifiers.

● Formerly RCA Dev. Nos. TA7707 and TA7706, respectively.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	30	V
* COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
* EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
* CONTINUOUS COLLECTOR CURRENT	I_C	4.5	A
* TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 75° C		36	W
At case temperatures above 75° C		Derate linearly at 0.288	W/°C
* TEMPERATURE RANGE:			
Storage & Operating (Junction)		– 65 to +200	°C
* CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C

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* In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, *At Case Temperature (T_C) = 25°C*

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Voltage V	DC Base Voltage V	DC Current mA				
		V_{CE}	V_{BE}	I_E	I_C	MIN.	MAX.	
* Collector-to-Emitter Cutoff Current: Base connected to emitter, T_C=55°C	I_{CES}	30	0			–	10	mA
* Collector-to-Emitter Breakdown Voltage: With base connected to emitter	$V_{(BR)CES}$		0		200[a]	65	–	V
With base open	$V_{(BR)CEO}$				200[a]	30	–	
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			5	0	4	–	V
Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$						3.5	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Supply (V_{CC})-V	Input Power (P_{IE})-W	Output Power (P_{OE})-W	Frequency (f)–MHz	Min.	Max.	
Output Power (See Fig. 10)	P_{OE}	28	9.5		400	30	–	W
Overdrive Test (See Fig. 10)	P_{OEO}	28	12.0		400	34	—	
* Power Gain	G_{PE}	28		30	400	5	–	dB
* Collector Efficiency	η_C	28	9.5		400	65	–	%
* Collector-to-Base Output Capacitance	C_{obo}	30 (V_{CB})			1	–	35	pF

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

CIRCUIT	COLLECTOR SUPPLY VOLTAGE (V_{CC})–V	OUTPUT POWER (P_{OE})–W	INPUT POWER (P_{IE})–W	COLLECTOR EFFICIENCY (η_C) – %	FIG. NO.
225-400 MHz (2N6105) Broadband Amplifier	28 20	30 20	5 – 7.5 5 – 7	69 – 77 70 – 82	13 13
400 MHz (2N6104-5) Narrow Band Amplifier	28	34	9.5	78	10

RCA Application Note

AN-4421 "16– and 25–Watt Broadband Power Amplifiers Using RCA–2N5918, 2N5919, and TA7706 UHF/Microwave Power Transistors."

Single copies of this Application Note are available on request from RCA Solid State Division, Box 3200, Somerville, N. J. 08876.

For basic transistor theory, circuits, and application information refer to "RCA Designer's Handbook", SP-52 or "RCA Transistor, Thyristor, & Diode Manual", SC-15.

PERFORMANCE DATA

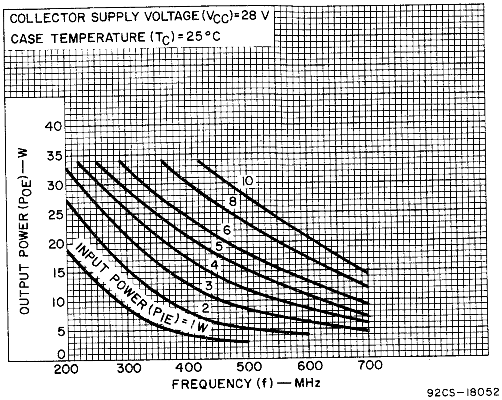


Fig.1—Typical output power vs. frequency for both types.

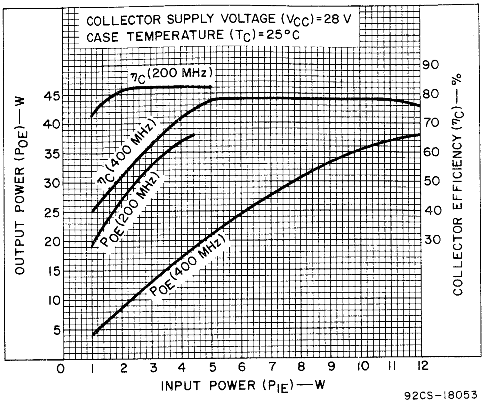


Fig.2—Typical output power or collector efficiency vs. input power for both types.

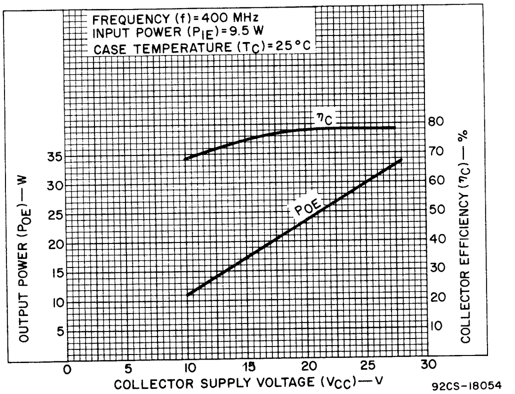


Fig.3—Typical output power or collector efficiency vs. collector supply voltage for both types.

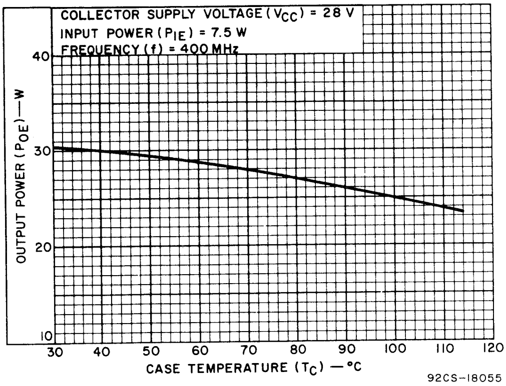


Fig.4—Typical output power vs. case temperature for both types.

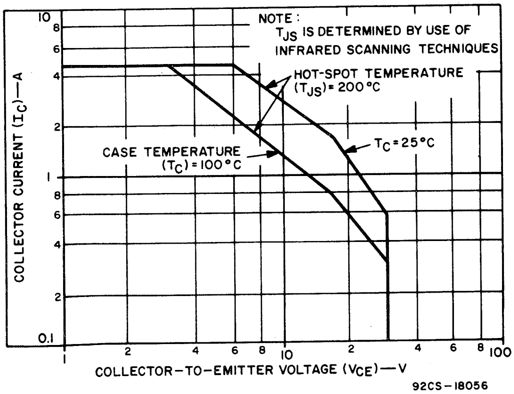


Fig.5—Safe area for dc operation for both types.

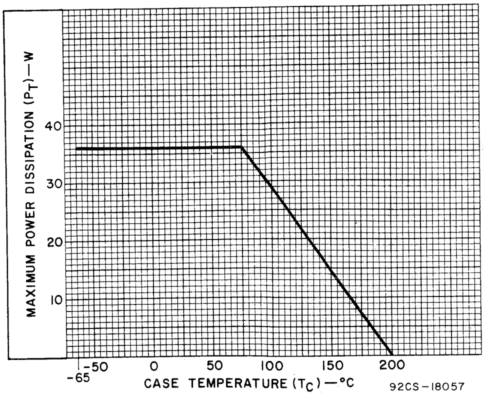


Fig.6—Dissipation derating for class C operation for both types.

DESIGN DATA

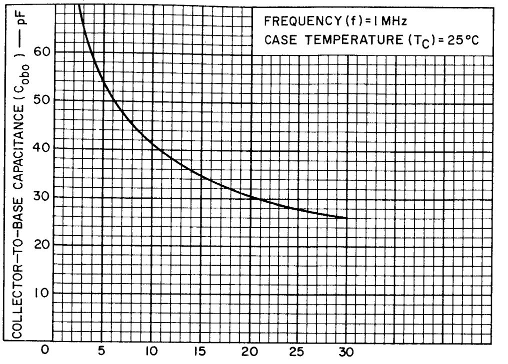


Fig.7—Typical variation of collector-to-base capacitance vs. collector-to-base voltage for both types.

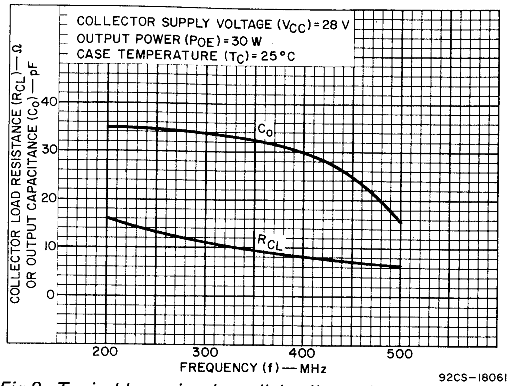


Fig.8—Typical large-signal parallel collector load resistance or parallel output capacitance vs. frequency for both types.

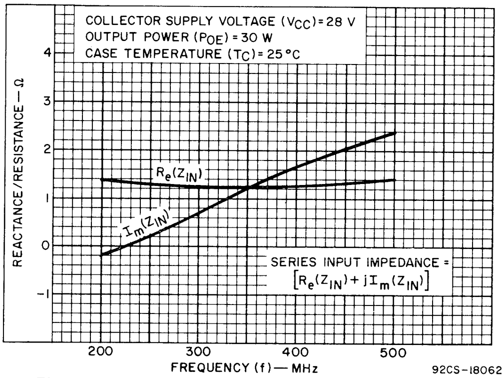
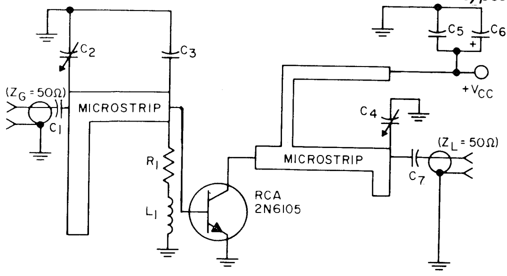


Fig.9—Typical large-signal series input impedance vs. for both types.

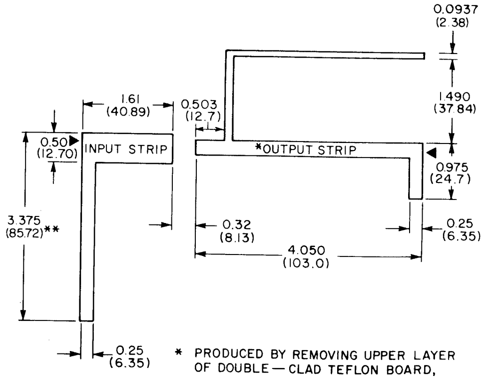


C_1, C_5, C_7 – 1000 pF CHIP, ATC-100■
C_2, C_4 – 1-20 pF AIR VARIABLE, JOHANSON 4802■
C_3 – 15 pF SILVER MICA
C_6 – 1 μF ELECTROLYTIC
L_1 – 0.1 μH RF CHOKE
R_1 – 5.1 Ω 1/2 W

■– OR EQUIVALENT

NOTE: POINTS OF APPLICATION FOR C_1 AND C_7 ARE SHOWN ON THE INPUT AND OUTPUT STRIPS IN THE DRAWING AT RIGHT (▶)

JOHANSON MANUFACTURING CORP. BOOTON, N.J. 07005
AMERICAN TECHNICAL CERAMICS HUNTINGTON STATION, N.Y. 11746



* PRODUCED BY REMOVING UPPER LAYER OF DOUBLE — CLAD TEFLON BOARD, 1 OZ., 1/32 IN. THICK, (e = 2.6), OR EQUIVALENT

** DIMENSIONS IN PARENTHESES ARE MILLIMETERS.

92CS-19156

Fig.10—400-MHz amplifier test circuit for measurement of output power for both types.

APPLICATION DATA

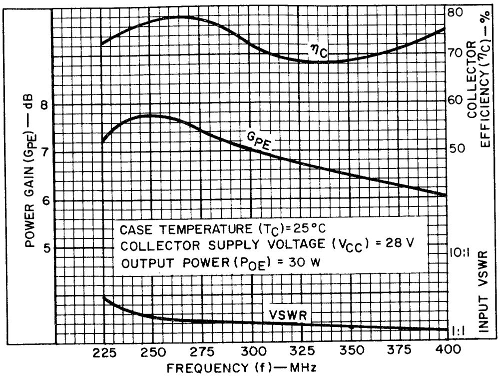


Fig.11—Typical performance of a 225-400 MHz broadband amplifier using RCA 2N6105 at $V_{CC} = 28$ V.

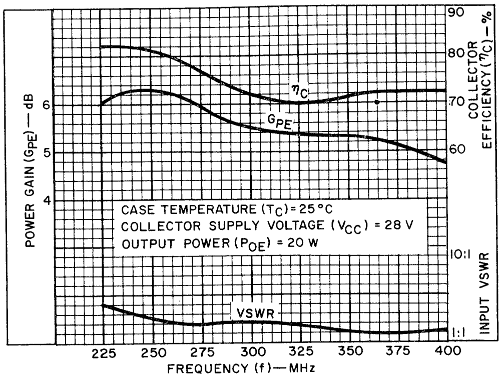
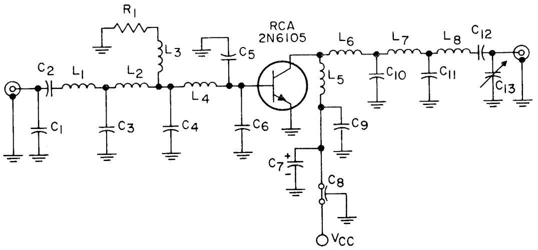


Fig.12—Typical performance of a 225-400 MHz broadband amplifier using RCA 2N6105 at $V_{CC} = 20$ V.



C_1: 8.2 pF chip, Allen-Bradley●
C_2: 18 pF silver mica
C_3: 33 pF chip, Allen-Bradley●
C_4: 47 pF chip, Allen-Bradley●
C_5: 68 pF chip, ATC-100●
C_6: 62 pF chip, ATC-100●
C_7: 1 μF electrolytic
C_8: 1000 pF feedthrough
C_9, C_{12}: 1000 pF chip, Allen-Bradley●
C_{10}: 22 pF chip, Allen-Bradley●
C_{11}: 6.9 pF chip, Allen-Bradley●

C_{13}: 0.8-10 pF variable air, Johanson No.3957●
L_1: 2 turns, 5/32 in. (3.968 mm) I.D. coil
L_2: 17/32 in. (13.49 mm) long wire
L_3: RFC, 0.1 μH, Nytronics●
L_4: 5/32 in. (3.968 mm) long transistor base lead
L_5, L_7: 13/16 in. (20.638 mm) long wire
L_6: 9/16 in. (14.287 mm) long wire
L_8: 7/8 in. (22.225 mm) long wire
R_1: 5.0 Ω, 1/4 W
All wire is No.20 AWG

●Or equivalent.

Fig.13—225-400 MHz broadband amplifier using RCA 2N6105.

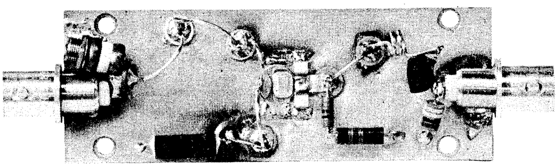
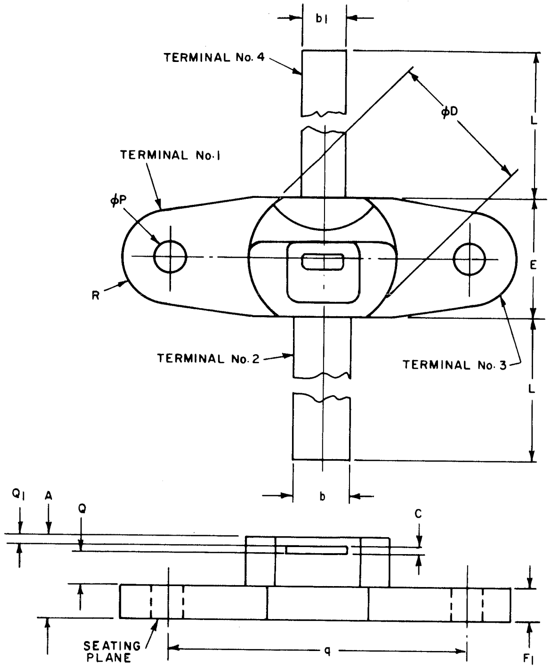


Fig.14—Photograph of 225-400 MHz broadband amplifier.

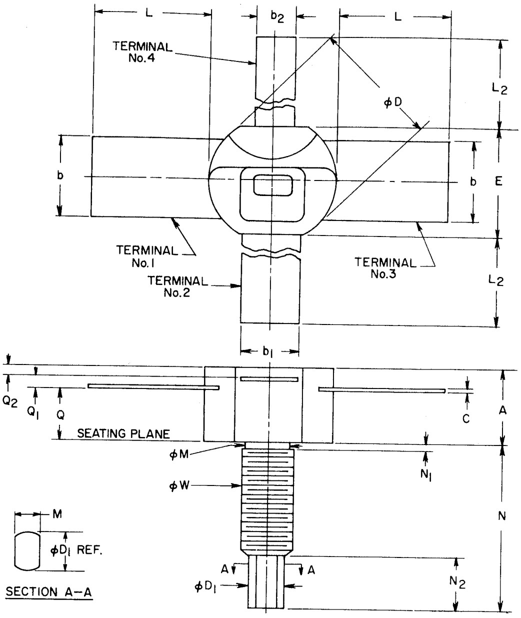
DIMENSIONAL OUTLINE FOR TYPE 2N6104
RCA HF-32



SYMBOL	INCHES		MILIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.160	0.210	4.07	5.33	
b	0.135	0.145	3.429	3.683	
b_1	0.095	0.105	2.413	2.667	
c	0.004	0.010	0.102	0.254	1
φD	0.305	0.320	7.75	8.12	
E	0.275	0.300	6.99	7.62	
F_1	0.057	0.067	1.448	1.701	
L	0.455	0.510	11.56	12.95	
φP	0.115	0.125	2.921	3.175	
Q	0.085	0.105	2.16	2.66	
Q_1	–	–	–	–	2
q	0.590	0.610	14.99	15.49	
R	0.115	0.125	2.921	3.175	

NOTES:
1. TYPICAL TWO LEADS.
2. BODY CONTOUR OPTIONAL WITHIN Q_1, φ D, AND E.

DIMENSIONAL OUTLINE FOR TYPE 2N6105
JEDEC TO-216



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
b	0.195	0.205	4.953	5.207	–
b_1	0.135	0.145	3.429	3.683	–
b_2	0.095	0.105	2.413	2.667	–
C	0.004	0.010	0.102	0.254	3
φD	0.305	0.320	7.75	8.12	5
$φD_1$	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	5
L	0.265	0.290	6.74	7.36	–
L_2	0.455	0.510	11.56	12.95	–
M	0.053	0.064	1.35	1.62	–
φM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
Q_2	–	–	–	–	5
φW	–	–	–	–	2

Millimeter dimensions are derived from original inch dimensions.

NOTES:
1. 0.053 - 0.064 INCH (1.35 - 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREADS (REF: UNITED SCREW THREADS ANS B1.1 - 1960). THE APPLIED TORQUE SHOULD NOT EXCEED 5 IN.-LBS. CLAMPING FORCES MUST BE APPLIED ONLY TO THE FLAT SURFACES OF THE STUD.
3. TYPICAL FOR ALL LEADS.
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF φW.
5. BODY CONTOUR OPTIONAL WITH Q_2, φD, AND E.

TERMINAL CONNECTIONS

2N6104:

Flange – Emitter
Terminal 2 – Base
Terminal 4 – Collector

2N6105:

Terminals 1, 3 – Emitter
Terminal 2 – Base
Terminal 4 – Collector

WARNING: The ceramic heat-sink portions of these devices contain beryllium oxide. Do not crush, grid or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

RCA

Solid State
Division

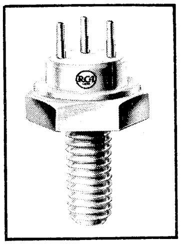
RF Power Transistors

40279

The RCA-40279 is the ultra-high reliability version of the RCA-2N3375 epitaxial silicon N-P-N planar transistor intended for class-A, -B, or -C amplifier, frequency multiplier, or oscillator operation. This device is subjected to special preconditioning tests for selection in ultra-high-reliability, large-signal, high-power, VHF-UHF applications in Space, Military, and Industrial communications equipment.

- **Ultra-High Reliability**
- **Complete Qualification Testing**

High-Power VHF-UHF Amplifier



JEDEC TO-60

RF SERVICE, Maximum Ratings (Absolute-Maximum Values)

Collector-To-Base Voltage, V_{CBO}	65	volts
Collector-To-Emitter Voltage:		
With base open, V_{CEO}	40	volts
With V_{BE} = -1.5 volts, V_{CEV}	65	volts
Emitter-To-Base Voltage, V_{EBO}	4	volts
Collector Current, I_C	1.5	amps.

Transistor Dissipation, P_T:		
At T_C up to 25°C	11.6	watts
At T_C above 25°C	Derate linearly to 0 watts at 200°C	
Temperature Range:		
Storage	-65 to 200	°C
Operating (Junction)	-65 to 200	°C
Lead Temperature (During soldering):		
At distances 1/32" from insulating wafer for 10 sec. max.	230	°C

ELECTRICAL CHARACTERISTICS – Case Temp. = 25°C (Unless Otherwise Specified)

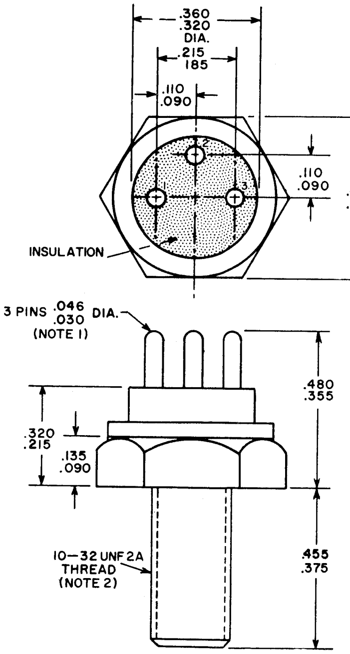
CHARACTERISTIC	SYMBOL	TEST CONDITIONS						LIMITS		UNITS
		DC COLLECTOR VOLTS		DC BASE VOLTS	DC CURRENT (MILLIAMPERES)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}	–	30	–	–	0	–	–	0.1	μa
Collector To-Base Breakdown Voltage	BV_{CBO}	–	–	–	0	–	0.1	65	–	Volts
Collector-To-Emitter Breakdown Voltage	BV_{CEO}	–	–	–	–	0	0 to 200*	40**	–	Volts
Collector-To-Emitter Breakdown Voltage	BV_{CEV}	–	–	−1.5	–	–	0 to 200*	65**	–	Volts
Emitter-To-Base Breakdown Voltage	BV_{EBO}	–	–	–	0.1	–	0	4	–	Volts
Collector-To-Emitter Saturation Voltage	V_{CE}(sat)	–	–	–	–	100	0.5 amp	–	1	Volt
Output Capacitance	C_{ob}	30	–	–	0	–	–	–	10	pf
RF Power Output Amplifier, Unneutralized										
At 100 Mc (See Fig. 1)	P_{OUT}	–	28	–	–	–	–	7.5●	–	Watts
At 400 Mc (See Fig. 2)		–	28	–	–	–	–	3▲	–	Watts
Forward Current Transfer Ratio	h_{FE}	–	5	–	–	–	150	10	–	–

* Pulsed through an inductor (25 mh); duty factor = 50%

** Measured at a current where the breakdown voltage is a minimum.

● For P_{IN} = 1.0 w; minimum efficiency = 65%

▲ For P_{IN} = 1.0 w; minimum efficiency = 40%



TO-60 DIMENSIONAL OUTLINE

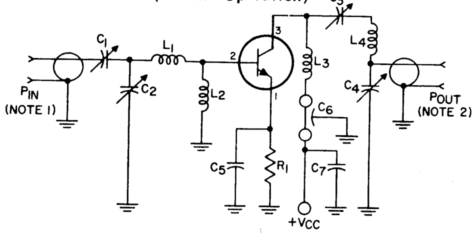


FIGURE 1

RF AMPLIFIER CIRCUIT FOR 40279
POWER-OUTPUT TEST
(100-Mc Operation)

NOTE 1: GENERATOR IMPEDANCE = 50 OHMS.
NOTE 2: LOAD IMPEDANCE = 50 OHMS.

FOR 100-MC OPERATION

C_1, C_2: 7-100 PF
C_3, C_4: 4-40 PF
C_5: 330 PF, DISC CERAMIC
C_6: 1500 PF
C_7: 0.005 µF, DISC CERAMIC
L_1: 3 TURNS NO. 16 WIRE, 1/4" ID, 5/16" LONG
L_2: FERRITE CHOKE, Z = 750 (±20 %) OHMS
L_3: 2.4-µH CHOKE
L_4: 5 TURNS NO. 16 WIRE, 5/16" ID, 7/16" LONG
R_1: 1.35 OHMS, NON-INDUCTIVE

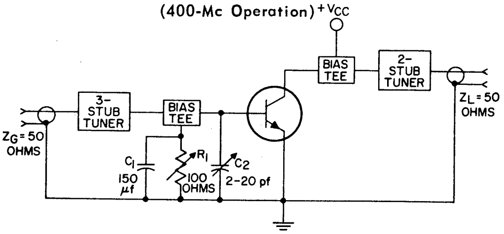


FIGURE 2

RF AMPLIFIER CIRCUIT FOR 40279
POWER-OUTPUT TEST
(400-Mc Operation)

RELIABILITY TESTING

Electrically, the RCA-40279 is similar to the RCA-2N3375; the exception being the 40279 I_{CEO} is 100 nanoamperes maximum. In addition to Preconditioning and Group A tests, a Qualification Approval test series (Group B Tests) is performed on a semi-annual basis. All units are tested to assure freedom from second breakdown in Class-A applications.

Preconditioning (100 Per Cent Testing of Each Transistor)

1. Serialization
2. Record I_{CEO}, h_{FE}, V_{CE}(sat)
3. Temperature Cycling-Method 102A of MIL-STD-202, 5 cycles, -65°C +200°C
4. Bake, 72 hours minimum, +200°C
5. Constant Acceleration-Method 2006 of MIL-STD-750, 10, 000G, Y_1 and Y_2 axes
6. Record I_{CEO}, h_{FE}, V_{CE}(sat)
7. Reverse Bias Age, T_A = 150°C, V_{CB} = 28 V, t = 168 hours

*8. Record I_{CEO}, h_{FE}, V_{CE}(sat)

9. Power Age, T_A = 25°C, V_{CB} = 28 V, t = 500 hours, P_D = 2.6 W, free air

*10. Record I_{CEO}, h_{FE}, V_{CE}(sat) at 168 hours and 500 hours

11. Helium Leak, 1 x 10^{-8} cc/sec. max.
12. Methanol Bomb, 70 psig, 18 to 24 hours
13. X-Ray, RCA spec. 1750326
14. Record Subgroups 2 and 3 of Group A Tests

*
Delta criteria after 168 hours Reverse Bias Age and after 168 hours and 500 hour Power Age

ΔI_{CEO}	+100% or +10 nanoamperes whichever is greater
Δh_{FE}	±30%
ΔV_{CE}(sat)	±0.1 V

Group A Tests

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS	LTPD	SYMBOL	LIMITS		UNITS
					MIN.	MAX.	
	Subgroup 1		10				
2071	Visual and Mechanical Examination	–	–	–	–	–	–
	Subgroup 2		5				
3036D	Collector-To-Emitter Cutoff Current	V_{CE} = 30 V, I_B = 0	–	I_{CEO}	–	100	namps
3001D	Collector-To-Base Breakdown Voltage	I_C = 100 μa, I_E = 0	–	BV_{CBO}	65	–	Volts
3026D	Emitter-To-Base Breakdown Voltage	I_E = 100 μa, I_C = 0	–	BV_{EBO}	4	–	Volts
3011D	Collector-To-Emitter Breakdown Voltage	I_C = 0 to 200 ma (Inductive) I_B = 0	–	BV_{CEO}	40	–	Volts
3011A	Collector-To-Emitter Breakdown Voltage	I_C = 0 to 200 ma (inductive) V_{BE} = -1.5 V	–	BV_{CEV}	65	–	Volts
3071	Collector-To-Emitter Saturation Voltage	I_C = 500 ma, I_B = 100 ma	–	V_{CE}(sat)	–	1	Volt
3076	Forward Current Transfer Ratio	I_C = 150 ma V_{CE} = 5 V	–	h_{FE}	10	–	
	Subgroup 3		5				
3236	Output Capacitance	f = 140 Kc, V_{CB} = 30 V, I_E = 0	–	C_{ob}	–	10	pf
See Fig. 1	R.F. Power Output (Min. Eff. = 65%)	V_{CE} = 28 V P_i = 1 W, f = 100 mc	–	P_{OUT}	7.5	–	Watts
See Fig. 2	R.F. Power Output (Min. Eff. = 40%)	V_{CE} = 28 V, P_i = 1 W, f = 400 mc	–	P_{OUT}	3	–	Watts
	Subgroup 4		15				
3036D	Collector Cutoff Current	T_A = 150°C ± 3°C, V_{CB} = 30 V, I_E = 0	–	I_{CBO}	–	100	μamp
3076	Forward Current Transfer Ratio	T_A = 150°C ± 3°C, I_C = 150 ma, V_{CE} = 5 V	–	h_{FE}	–	200	–

Group B Tests

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS	LTPD*	SYMBOL	LIMITS		UNITS
					MIN.	MAX.	
	Subgroup 1 (10 samples)	–	7	–	–	–	–
2066	Physical Dimensions	TO-60	–	–	–	–	–
202/102A	Temperature Cycle	5~, -65°C, 200°C	–	–	–	–	–
1056B	Thermal Shock	0°C, 100°C	–	–	–	–	–
1021	Moisture Resistance	Omit lead fatigue	–	–	–	–	–
2036D	Torque-To-Stud	1 minute, 12 inch pounds	–	–	–	–	–
	Subgroup 2 (10 samples)		7				
2016	Impact Shock	500G, 5 blows X_1, Y_1, Z_1, 1 msec.	–	–	–	–	–
2046	Vibration Fatigue	–	–	–	–	–	–
2056	Vibration Var. Freq.	–	–	–	–	–	–
	Subgroup 3 (10 samples)		7				
2026	Solderability	–	–	–	–	–	–
1066	Dew Point	25°C, -65°C read I_{CEO}	–	–	–	–	–
1001	Barometric Pressure	100,000 ft. read I_{CEO}	–	–	–	–	–
	Subgroup 4 (25 samples)		7				
1031	Storage Life	200°C, 1000 hr	–	–	–	–	–
2006	Constant Acceleration	20,000G, Y_1, Y_2	–	–	–	–	–
	Subgroup 5 (25 samples)		7				
1026	Operating Life	1000 hrs T_C = 140°C, V_{CB} = 28 V, P_D = 4 W	–	–	–	–	–
	End Points Subgroups 1, 2, 3, 4, 5						
3036D	Collector-Cutoff Current	V_{CE} = 30, I_B = 0	–	I_{CEO}	–	1	μamp
3011A	Collector-To-Emitter Breakdown Voltage	I_C = 0 to 200 ma (inductive) V_{BE} = –1.5 V	–	BV_{CEV}	60	–	Volts
	R.F. Power Output (See Fig. 1)	f = 100 mc, V_{CE} = 28 V, P_i = 1 W	–	P_{OUT}	6.5	–	Watts
3076	Forward Current Transfer Ratio	I_C = 150 ma, V_{CE} = 5 V	–	h_{FE}	9	–	–
3026D	Emitter-To-Base Breakdown Voltage	I_E = 100 μa, I_C = 0	–	BV_{EBO}	3.5	–	Volts

* Acceptance/Rejection Criteria of Group B tests: For an LTPD plan of 7% the total sample size is 80 for which the maximum number of rejects allowed is 2. Acceptance is also subject to a maximum of one (1) reject per Subgroup.

Group B tests are performed once every six months as part of Qualification Approval.

Solid State
Division

RF Power Transistors

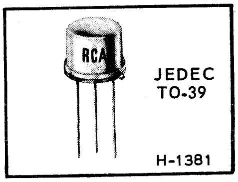
40578

HIGH-RELIABILITY TRANSISTOR

RCA–40578* is a high-reliability variant of the RCA–2N3866, an epitaxial n-p-n planar transistor of "overlay" emitter electrode construction. It is especially processed for high reliability. It is intended for Class A, B, and C amplifier, frequency multiplier, or oscillator operation in high-reliability, driver or pre-driver stages, VHF-UHF applications in Space, Military, and Industrial communications equipment.

High reliability is assured by eight preconditioning steps, including drift temperature measurements after the High Temperature Reverse Bias and Power Age tests. The 40578 also features complete qualification and lot acceptance testing.

High-Gain Device for Class A,B, or C Operation in VHF-UHF Circuits



- **8 Preconditioning Steps**
- **Complete Qualification and Lot Acceptance Testing**
- **High Power Gain, Unneutralized Class C Amplifier**
  At 400 MHz, 1 W output with 10 dB gain (min.)
  250 MHz, 1 W output with 15 dB gain (typ.)
  175 MHz, 1 W output with 17 dB gain (typ.)
  100 MHz, 1 W output with 20 dB gain (typ.)

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* Formerly RCA–Dev. No. TA7080

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	55	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance	V_{CER}	55	V
R_{BE} = 10 ohms			
With base open	V_{CEO}	30	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
COLLECTOR CURRENT	I_C	0.4	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 25° C		5	W
At free-air temperatures up to 25° C		1.0	W
At temperatures above 25° C		See *Fig. 1*	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≧ 1/32 in. from seating plane for 10 s max.		230	°C

DISSIPATION DERATING CURVE

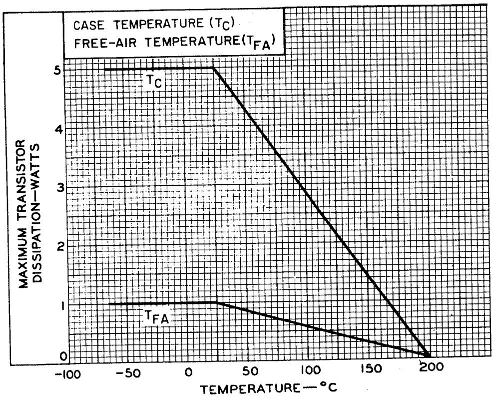


Fig.1

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C

Characteristic	Symbol	TEST CONDITIONS						LIMITS		Units
		DC Collector Volts		DC Base Volts	DC Current (mA)					
		V_{CB}	V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CEO}		28			0		-	100	nA
Collector-to-Base Breakdown Voltage	BV_{CBO}				0		0.1	55	-	V
Collector-to-Emitter Voltage (Sustaining)	$V_{CER}(sus)$[a]						5	55	-	V
	$V_{CEO}(sus)$					0	5	30	-	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}				0.1		0	3.5	-	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$					20	100	-	1.0	V
Collector-to-Base Capacitance (Measured at 1 MHz)	C_{ob}	30			0			-	3.0	pF
RF Power Output Class-C Amplifier, Unneutralized At 100 MHz At 250 MHz At 400 MHz (See Fig.3)	P_{OUT}		28[b] 28[b] 28[b]					1.8 (typ.)[c] 1.5 (typ.)[d] 1.0[e]		W
Gain-Bandwidth Product	f_T		15				50	800 (typ.)		MHz

[a] With external base-emitter resistance (R_{BE}) = 10 Ω.

[b] V_{CC} value.

[c] For P_{IN} = 0.05 W; minimum efficiency = 60%.

[d] For P_{IN} = 0.1 W; minimum efficiency = 50%.

[e] For P_{IN} = 0.1 W; minimum efficiency = 45%.

POWER OUTPUT vs. FREQUENCY

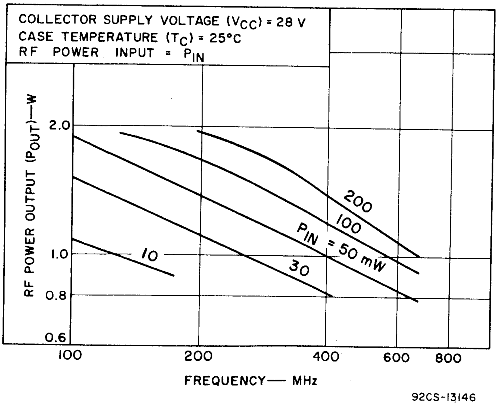
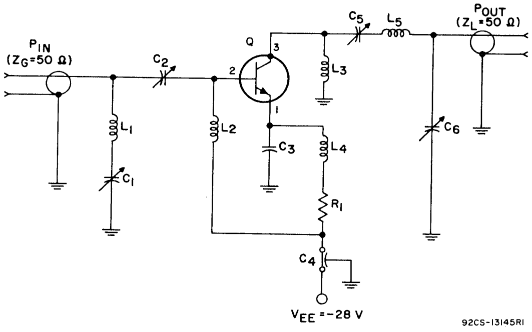


Fig. 2

RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST

(400-MHz Operation)



C1:	3-35 pF
C2,C5:	8-60 pF
C3:	12 pF
C4:	1,000 pF
C6:	0.9-7 pF
L1:	2 turns No.18 wire, 1/4" ID, 1/8" long
L2:	Ferrite rf choke, 1 turn, Z = 450 Ω
L3,L4:	RF choke, 0.1 μH
L5:	2-1/2 turns, No.18 wire, 1/4" ID, 3/16" long
R1:	5.6 Ω, 1 W
Q:	40578

Fig. 3

RELIABILITY SPECIFICATIONS . . . .

In addition to Preconditioning and Group A tests, a Qualification Approval test series (Group B tests) is performed on each lot.

Preconditioning (100 Per Cent Testing of Each Transistor)

1. Serialization
2. Record I_{CEO}, h_{FE}
3. Temperature Cycling-Method 107B Cond. C of MIL-STD-202, 5 cycles, -65° C to 200° C
4. Bake, 72 hours minimum, 200° C
5. Constant Acceleration-Method 2006 of MIL-STD-750, 10,000g, Y_1 and Y_2 axes
6. X-Ray
7. Record I_{CEO}, h_{FE}
8. Reverse Bias Age, $T_A = 200^\circ$ C, $V_{CB} = 50$ V, t = 96 hours
9. [d] Record I_{CEO}, h_{FE}
10. Power Age, $T_A = 25^\circ$ C, $V_{CB} = 28$ V, t = 340 hours, $P_T = 1$ W, free air
11. [d] Record I_{CEO}, h_{FE}, V_{CE} at 340 hours
12. Helium Leak, 1 x 10^{-7} cc/sec. max.
13. Gross Leak, MIL-STD-202, Method 112
14. Record Subgroups 2 and 3 of Group A Tests

[d] Delta criteria after 96 hours Reverse Bias Age and 340 hours Power Age

ΔI_{CEO}	+100% or +20 nanoamperes whichever is greater
Δh_{FE}	±20%

Definitions

Delta (Δ): Delta shall be determined by subtracting the parameter value measured before application of stress from the value measured after the application of stress.

Group A Tests

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS	LTPD	SYMBOL	LIMITS		UNITS
					Min.	Max.	
	Subgroup 1		10				
2071	Visual and Mechanical Examination	–	–	–	–	–	–
	Subgroup 2		5				
3041D	Collector-Cutoff Current	$V_{CE} = 28$ V	–	I_{CEO}	–	100	nA
3001D	Collector-to-Base Breakdown Voltage	$I_C = 100\ \mu A$	–	BV_{CBO}	55	–	volts
3026D	Emitter-to-Base Breakdown Voltage	$I_E = 100\ \mu A$	–	BV_{EBO}	3.5	–	volts
3011D	Collector-to-Emitter Breakdown Voltage	$I_C = 0$ to 5 mA[f]	–	BV_{CEO}	30[g]	–	volts
3011B	Collector-to-Emitter Breakdown Voltage	$I_C = 0$ to 5 mA[f] $R_{BE} = 10\ \Omega$	–	BV_{CER}	55[g]	–	volts
3071	Collector-to-Emitter Saturation Voltage	$I_C = 100$ mA, $I_B = 20$ mA	–	$V_{CE}(sat)$	–	1	volt
3076	DC Forward-Current Transfer Ratio	$I_C = 100$ mA, $V_{CE} = 5$ V	–	h_{FE}	10	–	–
	Subgroup 3		5				
3236	Output Capacitance	$V_{CB} = 30$ V	–	C_{ob}	–	3.0	pF
3261	Extrapolated Unity Gain Frequency	$I_C = 50$ mA, $V_{CE} = 15$ V, f = 200 MHz	–	f_T	500	–	MHz
See *Fig. 3*	RF Power Output (Min. Eff. = 45%)	$V_{CE} = 28$ V, $P_{IN} = .1$ W, f = 400 MHz	–	P_{OUT}	1.0	–	watts
	Subgroup 4		15				
3036D	Collector-Cutoff Current	$T_A = 150^\circ$ C ± 3° C, $V_{CB} = 30$ V	–	I_{CBO}	–	100	μA
3076	DC Forward-Current Transfer Ratio	$T_A = -55^\circ$ C ± 3° C, $I_C = 100$ mA, $V_{CE} = 5$ V	–	h_{FE}	5	–	–

[f] Pulsed through an inductor (25 μH); duty factor = 50%.

[g] Measured at a current where the breakdown voltage is a minimum.

General Reliability Specifications that are applicable to all rf power transistors are given in booklet RFT-701 and must be used in conjunction with the specific Preconditioning, Group A Tests, and Group B Tests shown below.

Group B Tests

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS
	Subgroup 1	(13 Samples)
2066	Physical Dimensions	
	Subgroup 2	(13 Samples)
2026	Solderability	
1051	Thermal Shock (Temp. Cycling)	Test Condition C
1056	Thermal Shock (Glass Strain)	Test Condition B
2036	Terminal Strength (Tension)	Test Condition A, weight = 5 lbs. time = 15 s each terminal
	Seal (Leak Rate)	Method 112 of MIL-STD-202 Test Cond. C, procedure IIIa, Test Cond. A for gross leaks
1021	Moisture Resistance	10-8 cc/s
	Subgroup 3	(13 Samples)
2016	Shock	1,500 g, 0.5 ms, 5 blows each orientation: X_1, Y_1, Z_1, (15 blows total)
2046	Vibration Fatigue	Nonoperating
2056	Vibration Var. Freq.	–
2006	Constant Acceleration	20,000 G Y_1, Y_2
	Subgroup 4	(13 Samples)
2036E	Terminal Strength (Lead Fatigue)	
	Subgroup 5	(13 Samples)
1041	Salt Atmosphere	
	Subgroup 6	(25 Samples)
1031	High Temperature Life (Nonoperating)	$T_{storage} = 200^\circ$ C
	Subgroup 7	(25 Samples)
1026	Steady-State Operation	$T_{FA} = 25^\circ$ C t = 1000 hrs. P_T = 1 W, V_{CB} = 28 V free air, no heat sink

TEST METHOD PER MIL-STD-750	EXAMINATION OR TEST	CONDITIONS	SYMBOL	LIMITS		UNITS
				Min.	Max.	
	End Points **Subgroups (2, 3, 5, 6, 7)**					
3041D	Collector-to-Emitter Cutoff Current	V_{CE} = 28 V	I_{CEO}	–	1.0	μA
3011B	Collector-to-Emitter Breakdown Voltage	I_C = 5 mA (Inductive)[i] R_{BE} = 10	BV_{CER}	50[k]	–	volts
See *Fig. 3*	RF Power Output (Min. Eff. = 45%)	V_{CE} = 28 V, P_{IN} = 0.1 W, f = 400 MHz	P_{OUT}	0.95	–	watts
3076	DC Forward-Current Transfer Ratio	I_C = 100 mA V_{CE} = 5 V	h_{FE}	9	–	–
3026D	Emitter-to-Base Breakdown Voltage	I_E = 100 mA	BV_{EBO}	3.0	–	volts

[h] Acceptance/Rejection Criteria of Group B tests: For an LTPD plan of 7% the total sample size is 115 for which the maximum number of rejects allowed is 4. Acceptance is also subject to a maximum of one (1) reject per Sub-group. Group B tests are performed on each lot for Qualification or Lot Acceptance.

[i] Pulsed through an inductor (25 mH); duty factor = 50%.

[k] Measured at a current where the breakdown voltage is a minimum.

GAIN-BANDWIDTH PRODUCT vs. COLLECTOR CURRENT

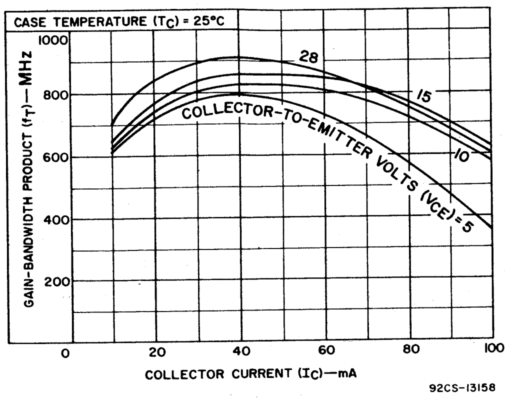


Fig.4

SERIES INPUT RESISTANCE vs. FREQUENCY

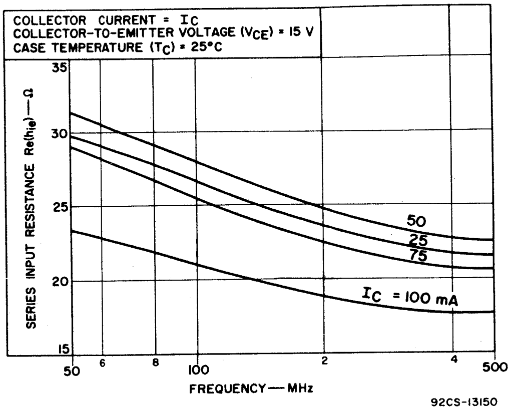


Fig. 5

SERIES INPUT REACTANCE vs. FREQUENCY

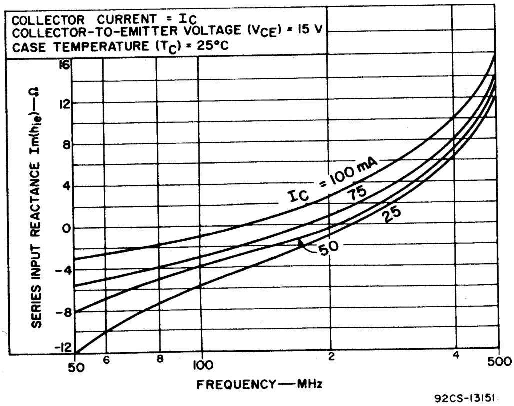


Fig.6

SERIES INPUT RESISTANCE & REACTANCE vs. FREQUENCY

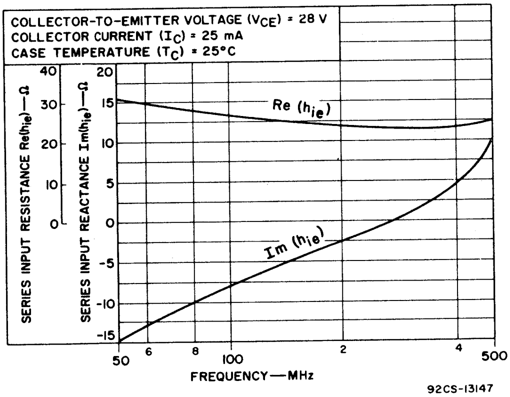
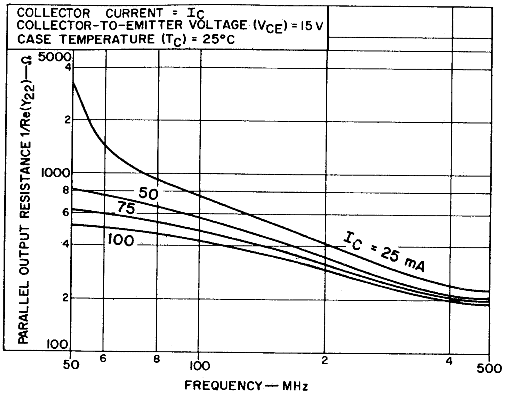


Fig.7

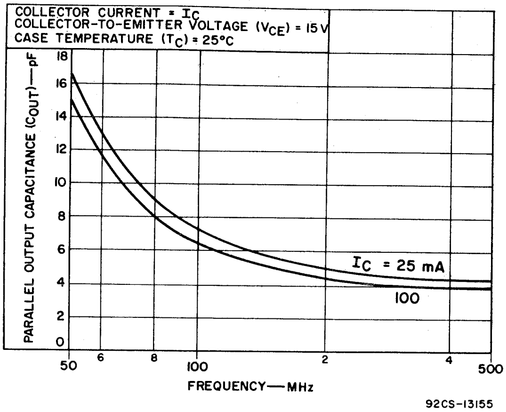
PARALLEL OUTPUT RESISTANCE vs. FREQUENCY



92CS-13154R1

Fig.8

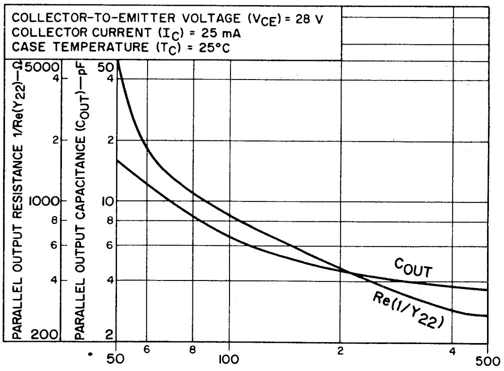
PARALLEL OUTPUT CAPACITANCE vs. FREQUENCY



92CS-13155

Fig.9

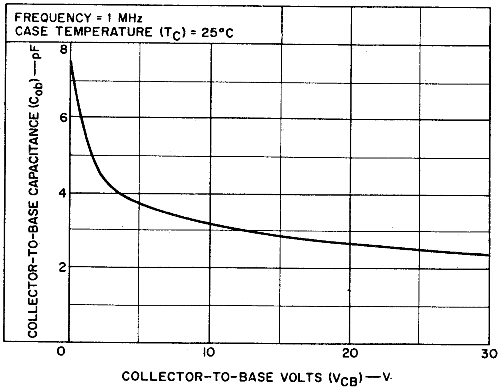
PARALLEL OUTPUT RESISTANCE & CAPACITANCE vs. FREQUENCY



92CS-13149R1

Fig. 10

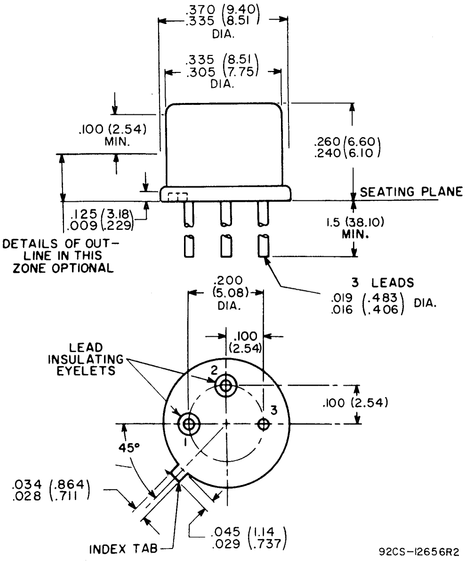
VARIATION OF COLLECTOR-TO-BASE CAPACITANCE



92CS-13157R1

Fig. 11

DIMENSIONAL OUTLINE
JEDEC TO-39



DIMENSIONS IN INCHES AND MILLIMETERS

Note: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

TERMINAL CONNECTIONS

Lead No. 1 – Emitter
Lead No. 2 – Base
Case, Lead No. 3 – Collector

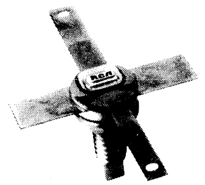
Solid State Division

RF Power Transistors

40940

5-W, 400-MHz Silicon N-P-N Overlay Transistor

For VHF/UHF High-Power Amplifiers



JEDEC TO-216AA H-1693

Features:

- **5 W output at 400 MHz with 5.2 dB power gain**
- 7.5 W **output at 100 MHz with 8.7 dB power gain**
- **Low-inductance, ceramic-metal, hermetic package**
- **All electrodes isolated from the stud**

RCA type 40940* is an epitaxial silicon n-p-n planar transistor with "overlay" emitter-electrode construction. In the overlay structure, a number of individual emitter sites are connected in parallel and used in conjunction with a single base and collector region. This arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter or collector areas for lower input and output capacitances. The overlay structure thus offers greater power output, gain, efficiency, and frequency capability.

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*Formerly RCA Dev. No. TA7982.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	40	V
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	65	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	4	V
COLLECTOR CURRENT:	I_C		
Continuous		1.5	A
Peak		0.5	A
TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		8.33	W
At case temperatures above 75°C, derate linearly at		0.067	W/°C
TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to +200	°C
CASE TEMPERATURE (During Soldering):			
For 10 s max.		230	°C

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC COLLECTOR VOLTAGE-V	DC BASE VOLTAGE-V	DC CURRENT mA					
		V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
Collector-to-Emitter Cutoff Current: With base open	I_{CEO}	30			0		–	0.1	mA
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				100	500	–	1	V
Collector-to-Emitter Breakdown Voltage: With base connected to emitter	$V_{(BR)CES}$		0			200[a]	65	–	V
With base open	$V_{(BR)CEO}$				0	200[a]	40	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	4	–	V
Thermal Resistance: (Junction-to-Case)	$R_{\theta JC}$						–	15	°C/W

[a] Pulsed through a 25-mH inductor; duty factor = 50%.

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC COLLECTOR SUPPLY (V_{CC})-V	INPUT POWER (P_{IE})-W	OUTPUT POWER (P_{OE})-W	FREQUENCY (f)—MHz	MIN.	MAX.	
Output Power (See Fig. 11)	P_{OE}	28	1.5		400	5	–	W
(See Fig. 9)		28	1		100	7.5		
Power Gain	G_{PE}	28		5	400	5.2	–	dB
Collector Efficiency	η_C	28			400	50	–	%
Collector-to-Base Capacitance	C_{obo}	30 (V_{CB})			1	–	11	pF

TYPICAL APPLICATION INFORMATION

CIRCUIT	COLLECTOR SUPPLY VOLTAGE (V_{CC})-V	OUTPUT POWER (P_{OE})-W	INPUT POWER (P_{IE})-W	COLLECTOR EFFICIENCY (η_C)-%
400-MHz Narrowband Amplifier (See Fig. 10)	28	5	1.5	60
100-MHz Narrowband Amplifier (See Fig. 9)	28	7.5	1	70

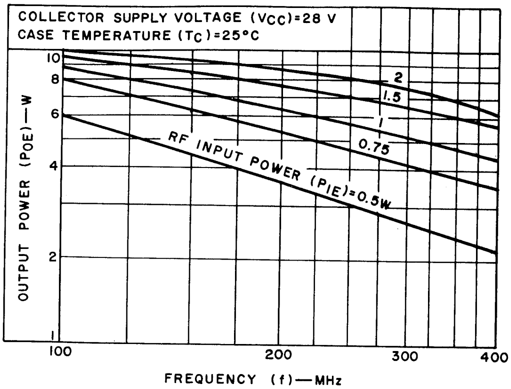


Fig. 1—Output power vs. frequency.

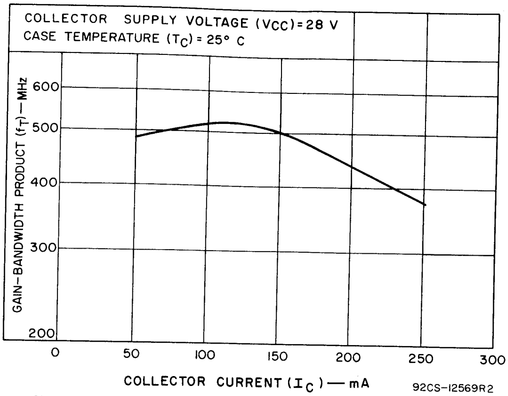


Fig. 2—Gain-bandwidth product vs. collector current.

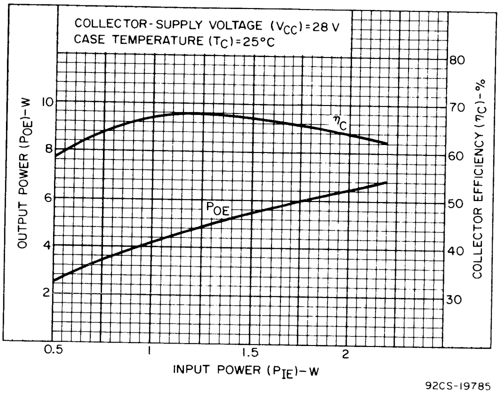


Fig. 3—Typical output power and collector efficiency vs. input power.

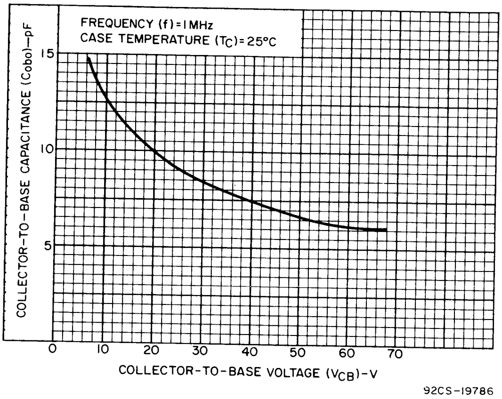


Fig. 4—Collector-to-base capacitance vs. collector-to-base voltage.

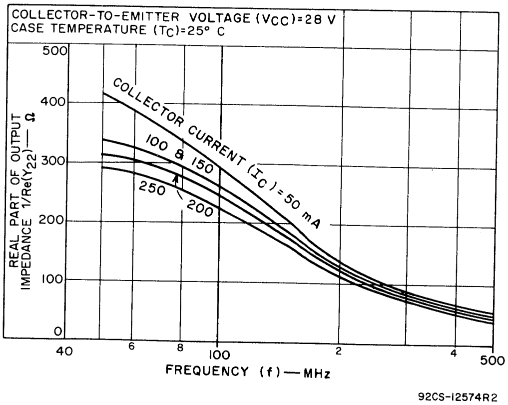


Fig. 5—Parallel output resistance vs. frequency.

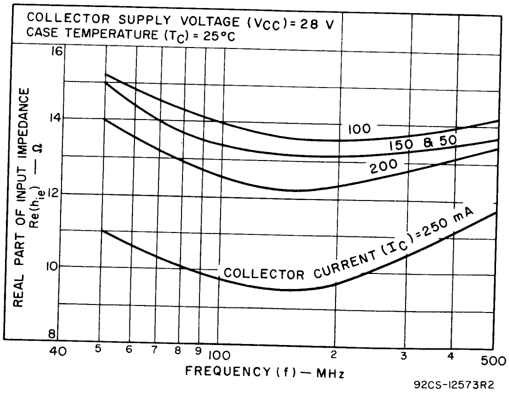


Fig. 6—Series input resistance vs. frequency.

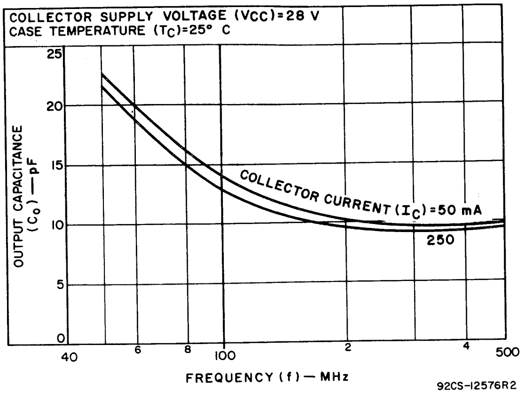


Fig. 7—Parallel output capacitance vs. frequency.

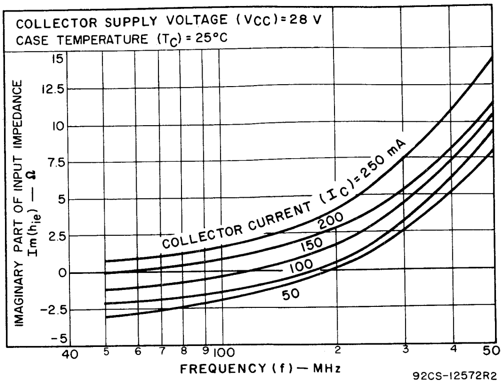
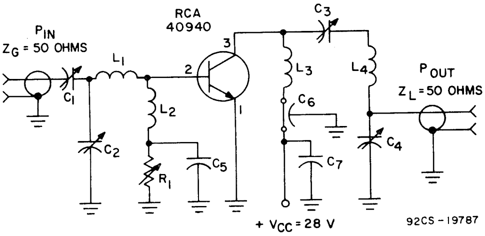
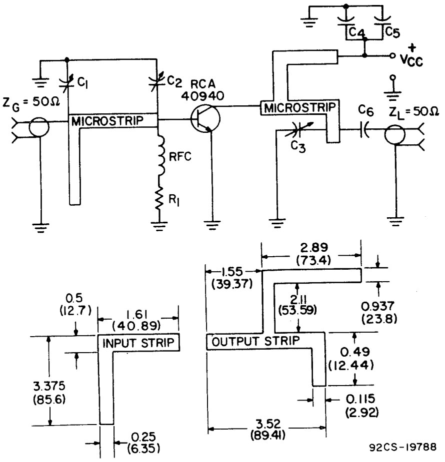


Fig. 8—Series input reactance vs. frequency.



C_1, C_2, C_3, C_4: 7-100 pF
C_5: 0.005 μF disc ceramic
C_6: 1000 pF
C_7: 0.01 μF disc ceramic
L_1: 2 turns No. 16 wire, 0.375 in. (9.5 mm) ID, 0.75 in. (19.05 mm) long
L_2, L_3: 1.5 μH
L_4: 7 turns No. 16 wire, 0.375 in. (9.5 mm) ID, 1 in. (25.4 mm) long
R_1: 1000 Ω

Fig. 9—100-MHz amplifier test circuit for measurement of power output.



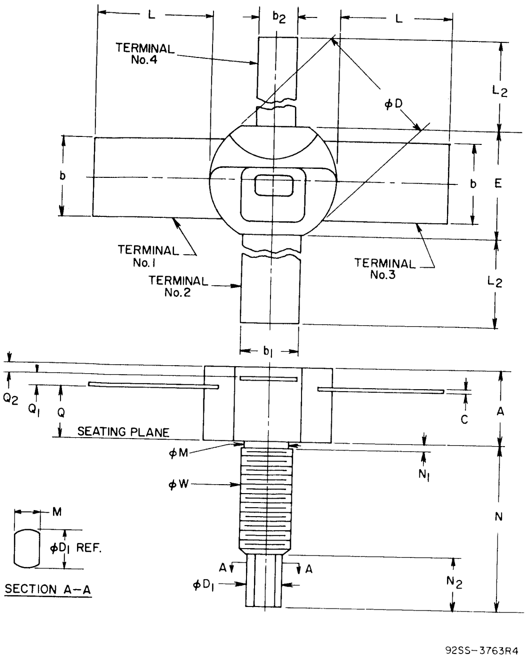
C_1, C_2, C_3: 2-18 pF, Amperex HT10MA/218, or equivalent
C_4, C_5: 1 μF electrolytic
C_6: 1000 pF, ATC-100, or equivalent
R_1: 5.1 Ω, ½ W carbon
RFC: 0.12 μH

NOTES:

1. Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.
2. Produced by removing upper layer of double-clad, Teflon board, Budd Co. Polychem Div. Grade 108T, 1 oz, 1/32 in. (0.79 mm) thick, (ϵ = 2.6), or equivalent.

Fig. 10—400-MHz amplifier test circuit for measurement of power output.

DIMENSIONAL OUTLINE, JEDEC TO-216AA



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.150	0.230	3.81	5.84	–
b	0.195	0.205	4.953	5.207	–
b_1	0.135	0.145	3.429	3.683	–
b_2	0.095	0.105	2.413	2.667	–
C	0.004	0.010	0.102	0.254	3
φD	0.305	0.320	7.75	8.12	5
ϕD_1	0.110	0.130	2.80	3.30	1
E	0.275	0.300	6.99	7.62	5
L	0.265	0.290	6.74	7.36	–
L_2	0.455	0.510	11.56	12.95	–
M	0.053	0.064	1.35	1.62	–
φM	0.120	0.163	3.05	4.14	–
N	0.425	0.470	10.80	11.93	–
N_1	–	0.078	–	1.98	4
N_2	0.110	0.150	2.80	3.81	–
Q	0.120	0.170	3.05	4.31	–
Q_1	0.025	0.045	0.64	1.14	–
Q_2	–	–	–	–	5
φW	–	–	–	–	2

Millimeter dimensions are derived from original inch dimensions.

NOTES:

1. 0.053 - 0.064 INCH (1.35 - 1.62 mm) WRENCH FLAT.
2. PITCH DIA. OF 8-32 UNC-2A COATED THREADS (REF: UNITED SCREW THREADS ANS B1.1 - 1960). THE APPLIED TORQUE SHOULD NOT EXCEED 5 IN.-LBS. CLAMPING FORCES MUST BE APPLIED ONLY TO THE FLAT SURFACES OF THE STUD.
3. TYPICAL FOR ALL LEADS.
4. LENGTH OF INCOMPLETE OR UNDERCUT THREADS OF φW.
5. BODY CONTOUR OPTIONAL WITH Q_2, φD, AND E.

TERMINAL CONNECTIONS

Terminals 1, 3	– Emitter
Terminal 2	– Base
Terminal 4	– Collector

WARNING: The ceramic body of this device contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

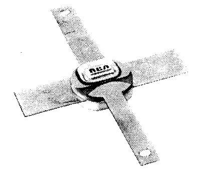
RCA
Solid State Division

RF Power Transistors

40941

Silicon N-P-N Overlay Transistor

High-Gain Driver for VHF/UHF Applications
in Military and Industrial Communications Equipment



RCA HF-31 H-1676

Features:

- **High power gain, unneutralized class C amplifier:**
  - **1 W output at 400 MHz (10 dB gain)**
  - **1 W output at 250 MHz (15 dB gain)**
  - **1 W output at 175 MHz (17 dB gain)**
  - **1 W output at 100 MHz (20 dB gain)**
- **Low output capacitance**
  C_{obo} = 4 pF max.

RCA–40941* is an expitaxial silicon n-p-n planar transistor employing an advanced version of the RCA-developed "overlay" emitter-electrode design. This electrode consists of many isolated emitter sites connected together through the use of a diffused-grid structure and a metal overlay which is deposited on a silicon oxide insulating layer by means of a photo-etching technique. This overlay design provides a very high emitter periphery-to-emitter area ratio resulting in low output capacitance, high rf current handling capability, and substantially higher power gain.

The 40941 is intended for class-A, -B, or -C amplifier, frequency-multiplier, or oscillator circuits: it may be used in output, driver, or pre-driver stages in vhf and uhf equipment.

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*Formerly RCA Dev. No. TA7680.

MAXIMUM RATINGS, *Absolute Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	55	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With base open	V_{CEO}	30	V
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	55	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
COLLECTOR CURRENT:	I_C		
Continuous		0.4	A
TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 75°C		5	W
At case temperatures above 75°C, derate linearly at		0.04	W/°C
TEMPERATURE RANGE:			
Storage & Operating (Junction)		−65 to +200	°C
CASE TEMPERATURE (During soldering):			
For 10 s max		230	°C

ELECTRICAL CHARACTERISTICS, At Case Temperature (T_C) = 25°C unless otherwise specified.

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Voltage (V)		DC Current (mA)					
		V_{CE}	V_{EB}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current: With base-emitter junction reverse-biased	I_{CEX}	55	1.5				–	0.1	mA
At T_C = 200°C		30	1.5				–	0.1	
With base open	I_{CEO}	28			0		–	20	µA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.1	55	–	V
Collector-to-Emitter Breakdown Voltage: With base open	$V_{(BR)CEO}$				0	5	30	–	V
With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$		0			5	55	–	
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
Emitter-Cutoff Current	I_{EBO}		3.5				–	0.1	mA
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				20	100	–	1.0	V
DC Forward-Current Transfer Ratio	h_{FE}	5 5				360 50	5 10	– 200	
Thermal Resistance: (Junction-to-Case)	$R_{\theta JC}$						–	22	°C/W

DYNAMIC

TEST & CONDITIONS	SYMBOL	FREQUENCY MHZ	LIMITS		UNITS
			MINIMUM	MAXIMUM	
Power Output (V_{CC} = 28 V): P_{IE} = 0.1 W (See Fig. 2)	P_{OE}	400	1.0	–	W
Large-Signal Common-Emitter Power Gain (V_{CC} = 28 V): P_{IE} = 0.1 W	G_{PE}	400	10	–	dB
Collector Efficiency (V_{CC} = 28 V): P_{IE} = 0.1 W, P_{OE} = 1 W, Source Impedance = 50 Ω	η_C	400	45	–	%
Magnitude of Common-Emitter, Small Signal, Short-Circuit Forward-Current Transfer Ratio I_C = 50 mA, V_{CE} = 15 V	$\|h_{fe}\|$	200	2.5	–	
Common-Base Output Capacitance (V_{CB} = 28 V)	C_{obo}	1	–	4	pF

PERFORMANCE DATA

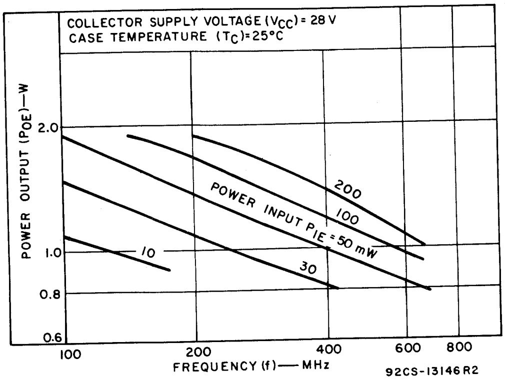
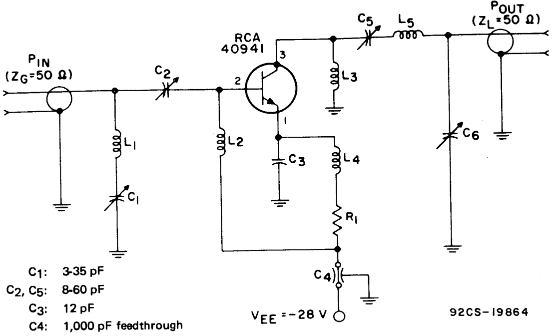


Fig. 1—Power output vs. frequency.



C_1: 3-35 pF
C_2, C_5: 8-60 pF
C_3: 12 pF
C_4: 1,000 pF feedthrough
C_6: 0.9-7 pF
L_1: 2 turns No. 18 wire, 0.25 in. (6.35 mm) ID, 0.125 in. (3.17 mm) long
L_2: Ferrite rf choke, 1 turn, Z = 450 Ω
L_3, L_4: RF choke, 0.1 µH
L_5: 2-1/2 turns, No. 18 wire, 0.25 in. (6.35 mm) ID, 0.187 in. (4.76 mm) long
R_1: 5.6 Ω, 1 W

Fig. 2—RF amplifier circuit for power output test (400-MHz operation).

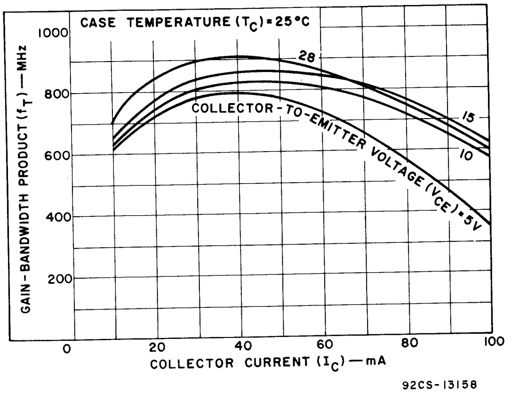


Fig. 3—Gain-bandwidth product vs. collector current.

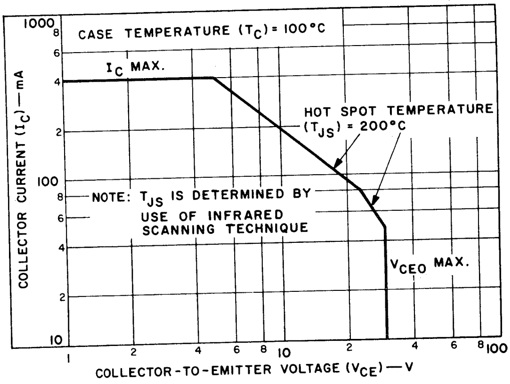


Fig. 4—Safe area for dc operation.

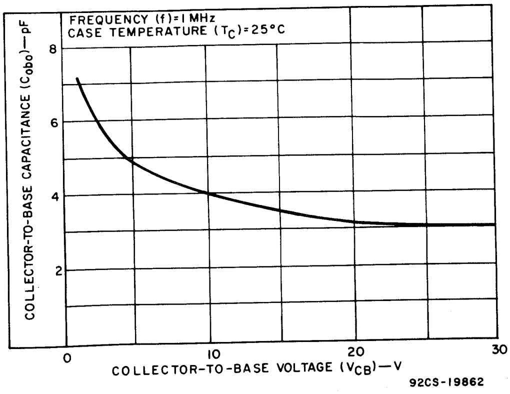


Fig. 5—Variation of collector-to-base capacitance.

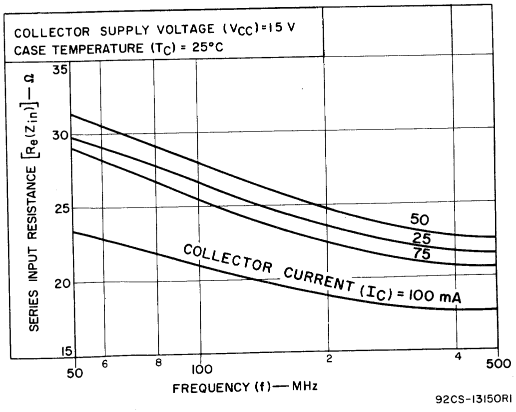
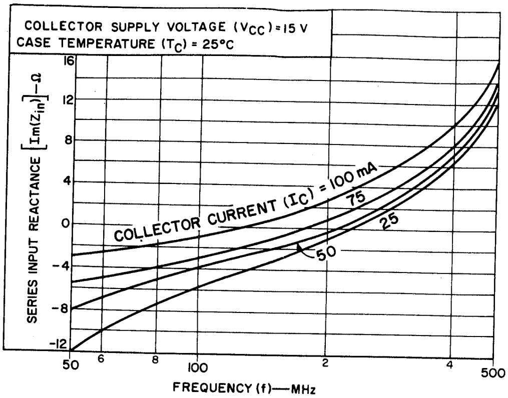
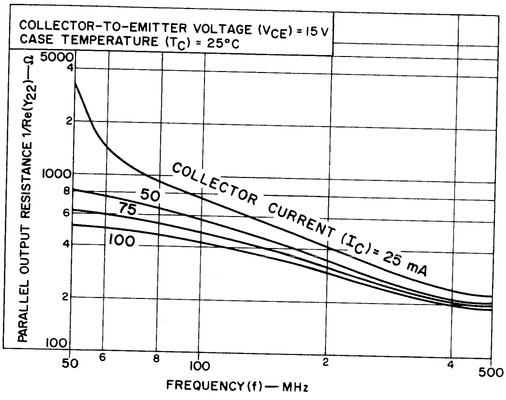


Fig. 6—Typical series input resistance vs. frequency.



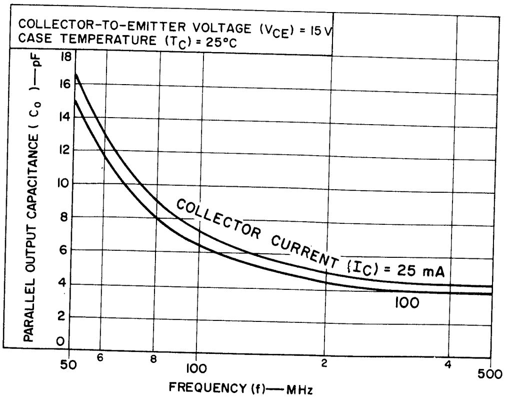
92CS-13151R1

Fig. 7—Typical series input reactance vs. frequency.



92CS-13154R2

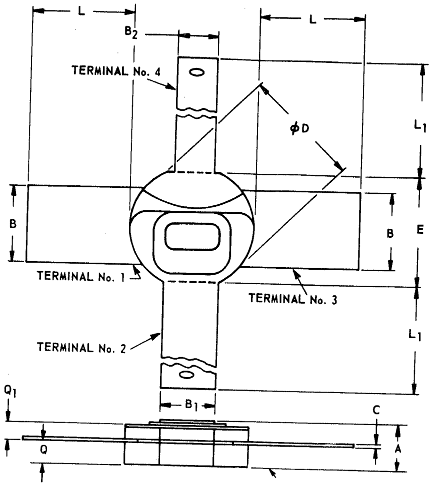
Fig. 8—Typical parallel output resistance vs. frequency.



92CS-13155R1

Fig. 9—Typical parallel output capacitance vs. frequency.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	0.090	0.135	2.29	3.42	–
B	0.195	0.205	4.96	5.20	–
B_1	0.135	0.145	3.43	3.68	–
B_2	0.095	0.105	2.42	2.66	–
C	0.004	0.010	0.11	0.25	1
ϕD	0.305	0.320	7.48	8.12	–
E	0.275	0.300	6.99	7.62	–
L	0.265	0.290	6.74	7.36	–
L_1	0.455	0.510	11.56	12.95	–
Q	0.055	0.070	1.40	1.77	–
Q_1	0.025	0.045	0.64	1.14	–

MILLIMETER DIMENSIONS ARE DERIVED FROM ORIGINAL INCH DIMENSIONS

NOTE: 1. TYPICAL FOR ALL LEADS

92SS-4462 R1

TERMINAL CONNECTIONS

Terminals 1, 3—Emitter
Terminal 2 —Base
Terminal 4 —Collector

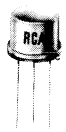
WARNING: **The ceramic body of this device contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.**

CATV Types

RCA
Solid State
Division

RF Power Transistors

2N5109



JEDEC TO-39 H-1381

Silicon N-P-N Overlay Transistor

High Gain for Line Amplifiers in
CATV and MATV Equipment

Features:

- **High gain-bandwidth product**
- **Large dynamic range**
- **Low distortion**
- **Low noise**

RCA-2N5109* is an epitaxial silicon n-p-n planar transistor employing "overlay" emitter electrode construction. It is especially designed to provide large dynamic range, low distortion, and low noise as a wideband amplifier into the vhf range.

A high gain-bandwidth product over a wide range of collector current makes the 2N5109 ideally suited for such applications as CATV and MATV line amplifiers and low-noise linear amplifiers.

---

*Formerly RCA Dev. No. TA2800.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	40	V
COLLECTOR-TO-EMITTER VOLTAGE:			
* With base open	V_{CEO}	20	V
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	40	V
* EMITTER-TO-BASE VOLTAGE..........	V_{EBO}	3	V
* CONTINUOUS COLLECTOR CURRENT...	I_C	0.4	A
* CONTINUOUS BASE CURRENT	I_B	0.4	A
* TRANSISTOR DISSIPATION:	P_T		
At case temperature up to 75°C		2.5	W
At case temperature above 75°C		See Fig. 10	
* TEMPERATURE RANGE:			
Storage and operating (Junction)		-65 to +200	°C
* LEAD TEMPERATURE (During Soldering):			
At distances ≥ 1/32 in. (0.8 mm) from the seating plane for 10 s max		230	°C

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* In accordance with JEDEC registration data

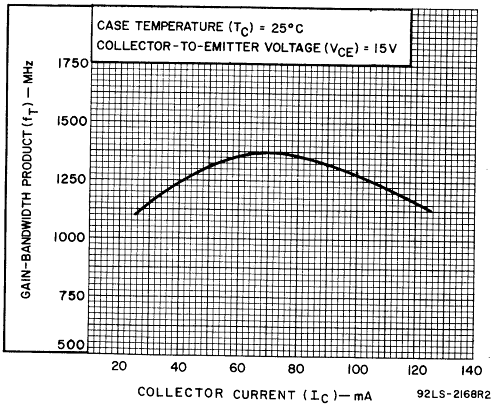


Fig. 1—Gain-bandwidth vs. collector current for type 2N5109.

ELECTRICAL CHARACTERISTICS, Case Temperature (T_C) = 25°C

CHARACTERISTIC	SYMBOL	TEST CONDITIONS DC COLLECTOR OR BASE VOLTAGE – V V_{CB}	V_{BE}	V_{CE}	V_{EB}	DC CURRENT (mA) I_E	I_B	I_C	LIMITS MIN.	MAX.	UNITS
Collector-Cutoff Current: With base open	I_{CEO}			15			0		–	20	μA
* With base-emitter junction reverse-biased	I_{CEV}		-1.5	35					–	5	mA
* T_C = 150°C			-1.5	15					–	5	
* Emitter-Cutoff Current	I_{EBO}				3				–	0.1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$					0		0.1	40	–	V
* Collector-to-Emitter Sustaining Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{CER}(sus)^a$							5	40	–	V
With base open	$V_{CEO}(sus)$						0	5	20	–	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$					0.1		0	3	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$						10	100	–	0.5	V
* Collector-to-Base Capacitance (f = 1 MHz)	C_{cb}	15				0			–	3.5	pF
* DC Forward-Current Transfer Ratio	h_{FE}			15 5				50 360	40 5	120 –	
Small-Signal Common-Emitter Forward Current Transfer Ratio (f = 200 MHz)	h_{fe}			15 15 15				25 50 100	4.8 6 4.8	– – –	
* Magnitude of Common-Emitter Small-Signal Forward Current Transfer Ratio (f = 200 MHz)	$\|h_{fe}\|$			15				50	6	–	
* Available Amplifier Signal Input Power (See Fig. 9) (P_{out} = 1.26 mW, Source Impedance = 50 Ω, f = 200MHz)	P_i	15 (V_{CC})						50	–	0.1	mW
* Voltage Gain, Wideband, 50 to 216 MHz (See Fig. 8.)	G_{VE}			15				50	11		dB
Cross Modulation @ 54 dBmV[b] Output (See Fig.13.)	CM			15				50	–57 (typ.)		dB
Power Gain, Narrowband (f = 200 MHz, P_{IN} = -10 dBm)	G_{PE}			15				10	11		dB
Noise Figure (f = 200 MHz) (See Fig. 9.)	NF			15				10	3 (typ.)		dB

[a] Pulsed through a 25 mH inductor; duty factor = 50%

[b] 0 dBmV = 1 millivolt

* In accordance with JEDEC registration data

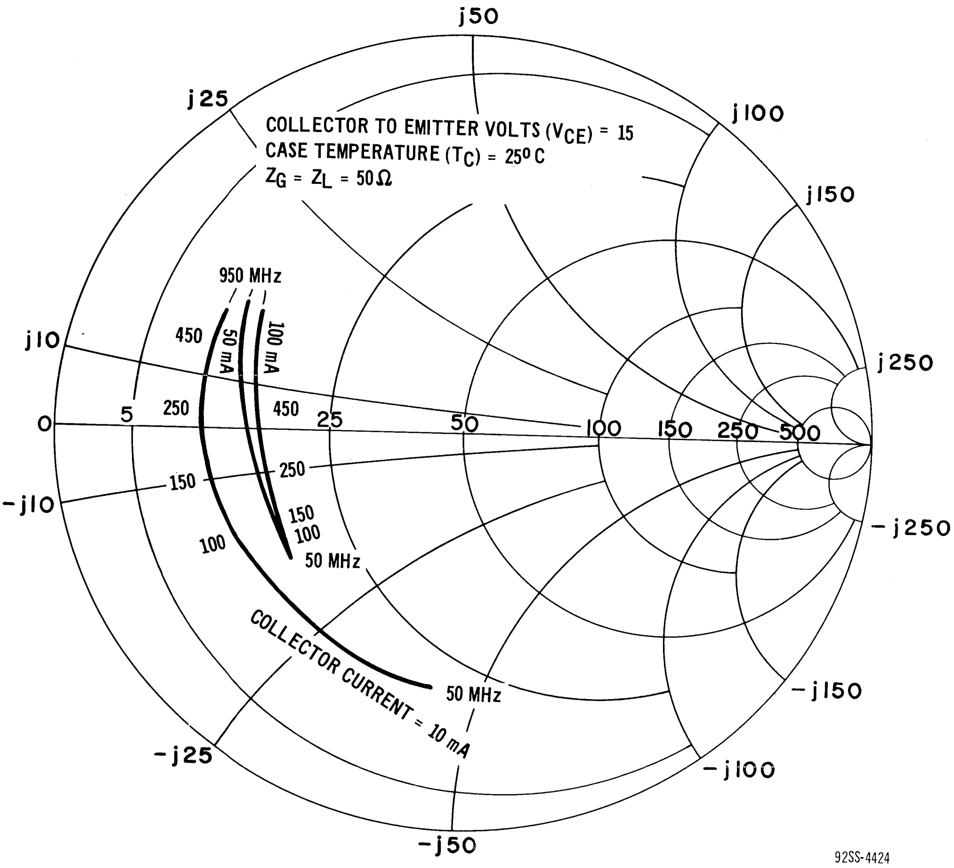


Fig.2—Input reflection coefficient (S'_{11e}) vs. frequency for type 2N5109.

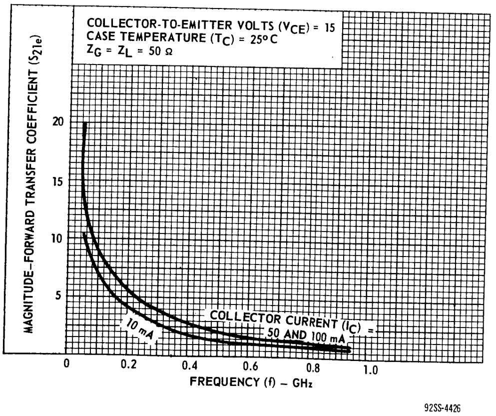


Fig.3—Magnitude of common-emitter forward transfer coefficient (S_{21e}) vs. frequency for type 2N5109.

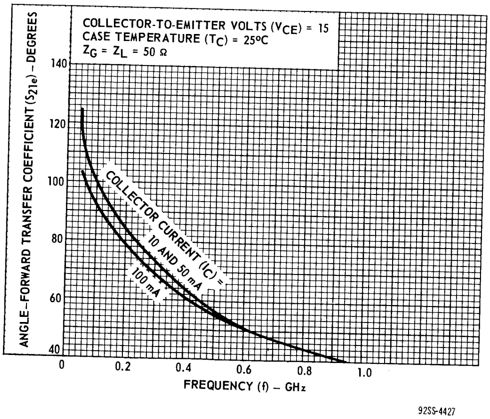


Fig.4—Angle of common-emitter forward transfer coefficient (S_{21e}) vs. frequency for type 2N5109.

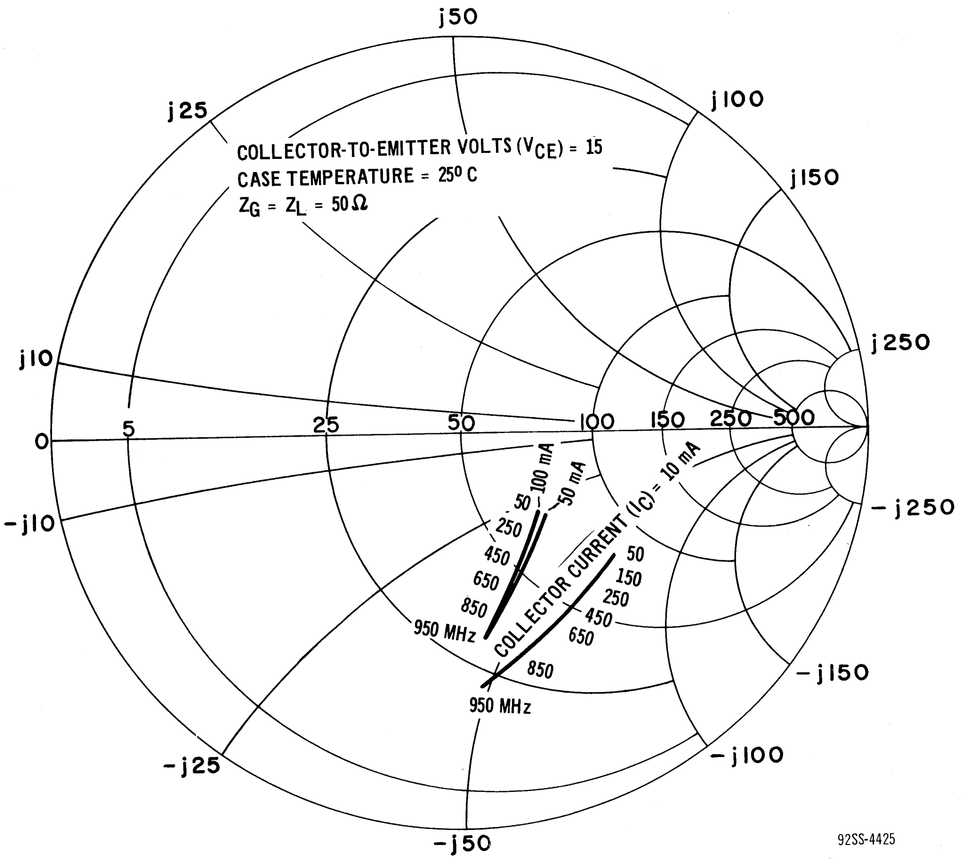


Fig.5—Output reflection coefficient (S_{22e}) vs. frequency for type 2N5109.

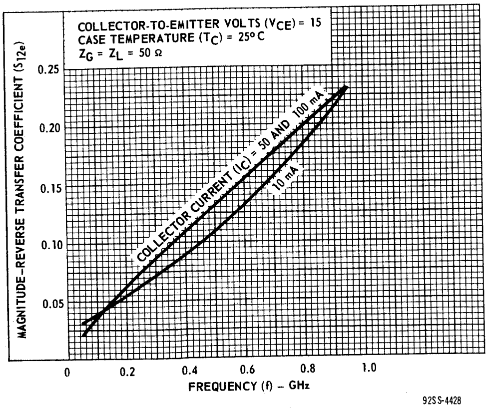


Fig.6—Magnitude of common-emitter, reverse transfer coefficient (S_{12e}) for type 2N5109.

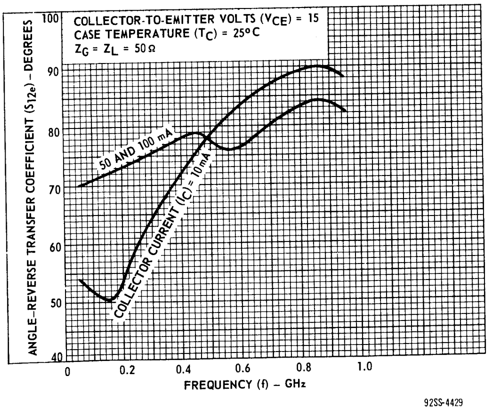
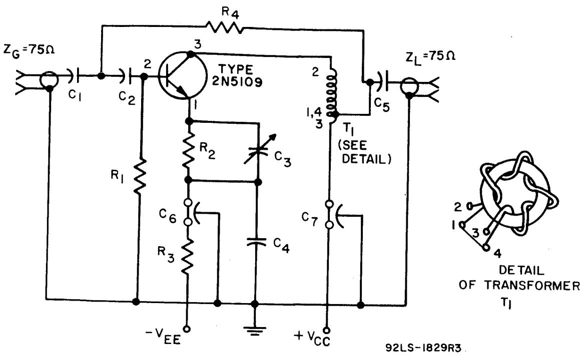


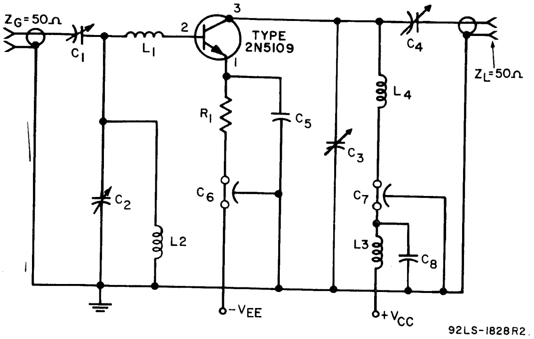
Fig.7—Angle of common-emitter reverse transfer coefficient (S_{12e}) vs. frequency for type 2N5109.



C1, C2, C5: 0.002 μF, disc ceramic
C3: 8–60 pF, ARCO 404, or equivalent
C4: 0.03 μF, disc ceramic
C6, C7: 1,500 pF, feedthrough
R1: 390 Ω, 1/2W, carbon
R2: 6.8 Ω, 1/2W, carbon

R3: 330Ω, 1 W, carbon
R4: 270Ω, 1/2 W, carbon
T1: 4 turns No. 30 wire bifilar wound on "Indiana General" Core No. CF-102-Q1, or equivalent

Fig.8–RF amplifier for voltage-gain testing of type 2N5109.



C1, C2, C3: 1.0–30 pF, mica trimmer, ARCO or equivalent
C4: 1.0–20 pF disc ceramic
C5: 10,000 pF disc ceramic
C6, C7: 1,000 pF disc ceramic
C8: 0.01 μF disc ceramic
L1: 4-1/2 turns, No. 22 wire, 3/16 in. (4.76 mm) I.D.
L4: 3-1/2 turns, No. 22 wire, 3/16 in. (4.76 mm) I.D.
L2, L3: 0.82 μH RFC
R1: 240 Ω, 2 W, carbon

Fig.9–200-MHz amplifier for power-gain and noise-figure testing of type 2N5109.

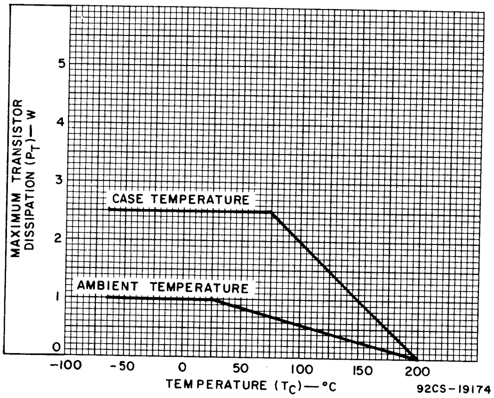


Fig.10–Dissipation derating curve for type 2N5109.

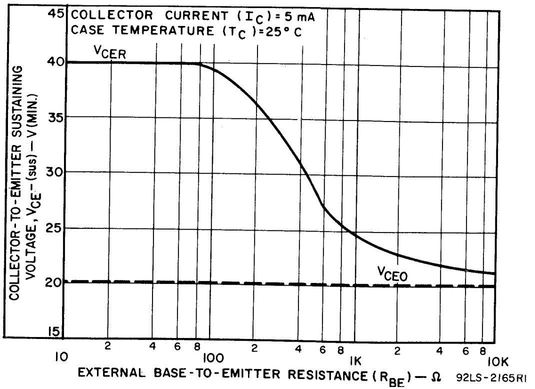


Fig.11–Sustaining voltage vs. base-to-emitter resistance for type 2N5109.

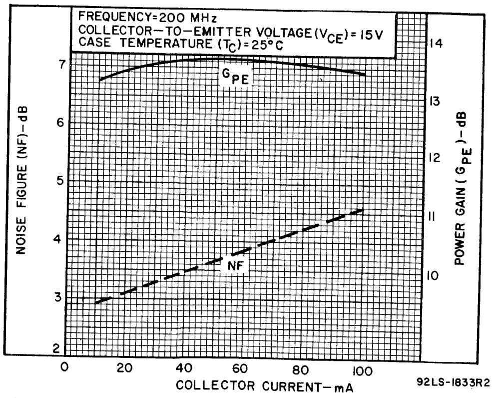
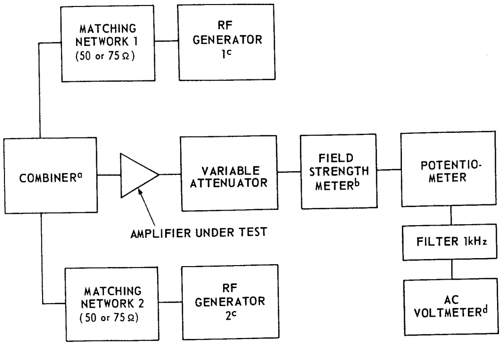


Fig.12–Power gain and noise figure vs. collector current for type 2N5109.



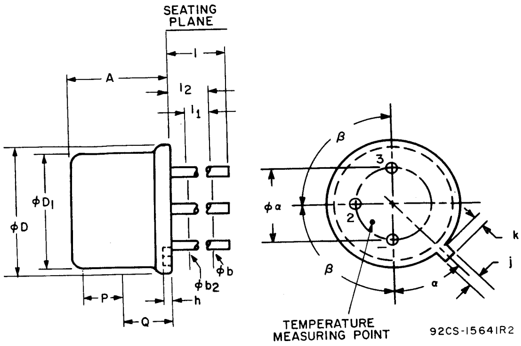
a Provides 20 db isolation between generators
b 50–220 MHz with detector output
c Hewlett–Packard HP 608 D or equivalent
d Ballantine 861 or equivalent

Fig. 13–Test set-up for measuring cross modulation in type 2N5109.

CROSS-MODULATION TEST PROCEDURE:

1. Set up equipment as shown in Fig. 13.
2. Set generator 1 to 150 MHz modulated 30% by 1,000 Hertz, and tune field strength meter to 150 MHz.
3. Adjust output level of generator 1 to give rated output from the amplifier under test.
4. Adjust potentiometer and AC voltmeter for a convenient level. This level then corresponds to 100% cross modulation.
5. Remove modulation. Readjust output level of generator 1 if necessary, to obtain the AC voltmeter "100% level". Do not readjust generator 1 during the following steps.
6. Set generator 2 to 210 MHz modulated 30% by 1,000 Hertz and tune field strength meter to 210 MHz.
7. Adjust output level of generator 2 to give rated output of the amplifier; i.e., the AC voltmeter indicates the " 100% level".
8. Tune field strength meter to 150 MHz CW and read the AC voltmeter (a change of the AC voltmeter scale may be necessary).
9. Calculate percentage of cross modulation by comparing the reading of step 8 to the "100% level".

DIMENSIONAL OUTLINE
JEDEC No. TO-39



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕa	0.190	0.210	4.83	5.33	
A	0.240	0.260	6.10	6.60	
ϕb	0.016	0.021	0.406	0.533	2
ϕb_2	0.016	0.019	0.406	0.483	2
ϕD	0.350	0.370	8.89	9.40	
ϕD_1	0.315	0.335	8.00	8.51	
h	0.009	0.125	0.229	1.04	
j	0.028	0.034	0.711	0.318	
k	0.029	0.040	0.737	1.02	3
l	0.500		12.70		2
l_1		0.050		1.27	2
l_2	0.250		6.35		2
P	0.100		2.54		1
Q					4
α	45° NOMINAL				
β	90° NOMINAL				

Note 1: This zone is controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010 in. (0.254 mm).

Note 2: (Three leads) ϕb_2 applies between l_1 and l_2. ϕb applies between l_2 and 0.5 in. (12.70 mm) from seating plane. Diameter is uncontrolled in l_1 and beyond 0.5 in. (12.70 mm) from seating plane.

Note 3: Measured from maximum diameter of the actual device.

Note 4: Details of outline in this zone optional.

TERMINAL CONNECTIONS

Lead No.1 – Emitter
Lead No.2 – Base
Lead No.3 – Collector
Case – Collector

RCA
Solid State
Division

RF Power Transistors

40608

RCA-40608 is an epitaxial silicon n-p-n planar transistor. It is especially designed for operation as a Class A, wide-band power amplifier in VHF circuits.

The features of high gain-bandwidth product and low cross-modulation make the 40608 especially suited for use in CATV and MATV systems.

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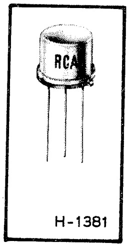
*Formerly RCA Dev. Type No. TA2761

SILICON N-P-N "overlay" TRANSISTOR

For Class A Wide-Band CATV and MATV Applicatiations



JEDEC TO-39

Features:

- High Gain-Bandwidth Product
- Low Cross-Modulation

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	40	V
COLLECTOR-TO-EMITTER VOLTAGE: With external base-to-emitter resistance, $(R_{BE}) = 100\Omega$	V_{CER}	40	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	2	V
COLLECTOR CURRENT	I_C	0.4	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 25°C		3.5	W
At case temperatures above 25°C		See *Fig. 1.*	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to +200	°C
LEAD TEMPERATURE (During soldering):			
At distances ≥ 1/32 in. (0.79 mm) from seating plane for 10 s max.		230	°C

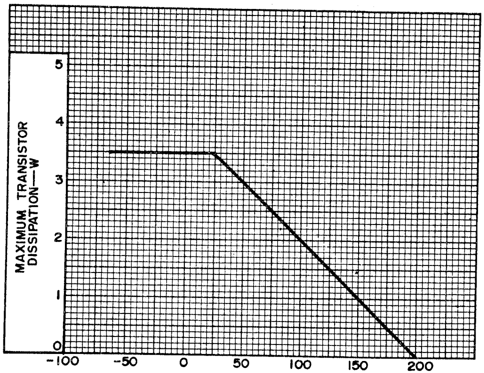
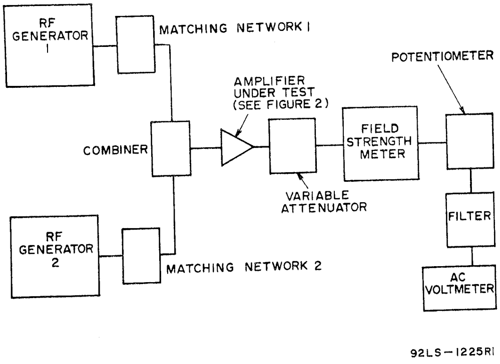


Fig. 1 - Dissipation Derating Curve

ELECTRICAL CHARACTERISTICS, *Case Temperature = 25° C*

Characteristic	Symbol	Test Conditions: DC Collector Volts V_{CB}	V_{CE}	DC Current (mA) I_E	I_B	I_C	Limits Min.	Max.	Units
Collector-Cutoff Current	I_{CEO}		20		0			100	μA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.1	40		V
Collector-to-Emitter Voltage (Sustaining)	$V_{CER}(sus)$					50[a]	40		V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	2		V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				10	50		1.0	V
Collector-to-Base Capacitance (Measured at 1 MHz)	C_{ob}	30		0				3.0	pF
Gain-Bandwidth Product	f_T		15			50	700		MHz
DC Forward-Current Transfer Ratio	h_{FE}		15			50	35	120	
Voltage Gain (See Fig. 2.)	VG		15			50	11		dB
Cross Modulation @46 dBmV (See Fig. 3.)	CM		15			50	−57 (Typ.)		dB

[a] Pulsed through an inductor (20 mH); duty factor = 50%; R_{BE} = 100 Ω.

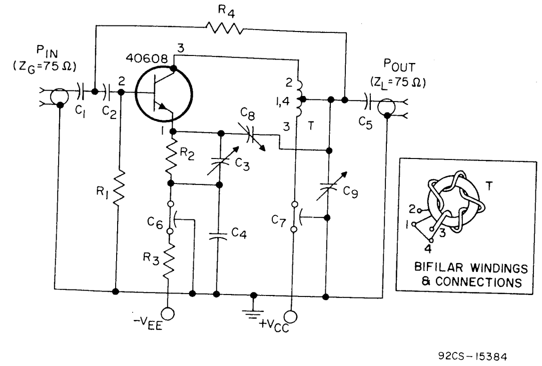


Generator No. 1 & No. 2	Hewlett-Packard, HP608D, or equivalent
Matching Network No. 1 & No. 2:	50 to 75 Ω
Combiner:	20 dB isolation between generators
Variable Attenuator:	As required
Field Strength Meter, with Detector Output:	50-220 MHz
Potentiometer:	100 kΩ
Filter:	1000 Hz
AC Voltmeter:	Ballantine 861, or equivalent

Fig. 2 - Block Diagram for Cross-Modulation Test Set-Up

OPERATING INSTRUCTIONS FOR CROSS-MODULATION TEST

1. Set up equipment as shown in Fig. 2.
2. Set generator No. 1 to 150 MHz modulated 30% by 1000 Hz, and tune field strength meter to 150 MHz.
3. Adjust output of generator No. 1 to give rated output of the amplifier.
4. Adjust potentiometer to calibrate voltmeter for a convenient level. This level then corresponds to 100% cross modulation.
5. Remove modulation.
6. Set generator No. 2 to 210 MHz modulated 30% by 1000 Hz and tune field strength meter to 210 MHz.
7. Adjust output of generator No. 2 to give rated output of the amplifier. (If the amplifier has a flat response then the output of the two signal generators will be equal.)
8. Tune field strength meter to 150 MHz CW and read voltmeter.
9. Turn voltmeter to proper scale for reading. Calculate percentage of cross modulation based upon 100% level set in step 4.



C_1, C_2, C_5: 0.002 µF
C_3: 7-100 pF, ARCO 423, or equivalent
C_4: .03 µF
C_6, C_7: 1,500 pF
C_8, C_9: 8-60 pF, ARCO 404, or equivalent
R_1: 390 Ω, ½ W
R_2: 6.8 Ω, ½ W
R_3: 330 Ω, 1 W
R_4: 270 Ω, ½ W
T: 4 turns No. 30 wire, bifilar wound; toroidal core: 3/8 in. OD, 3/16 in. ID, 1/8 in. thick, IGC* type Q-1, or equivalent.

*Indiana General Corp., Electronics/Ferrites Div., Keasbey, N.J.

Fig. 3 - RF Amplifier Circuit for Voltage Gain Test

TYPICAL ADMITTANCE CHARACTERISTICS

(Common-Emitter Circuit)

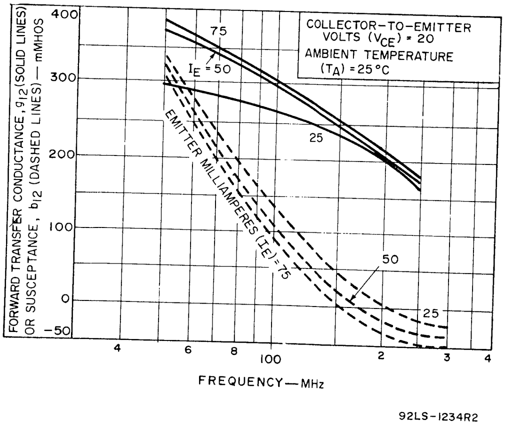


Fig. 4 - Forward Transfer Admittance

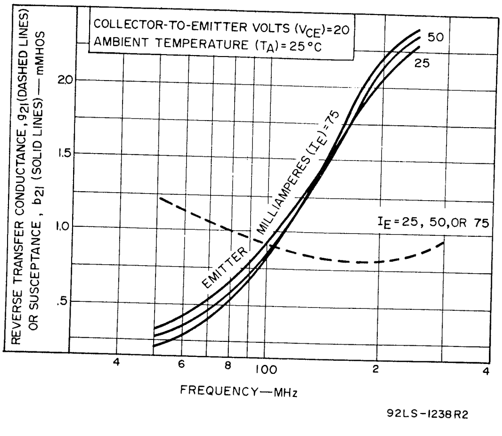


Fig. 5 - Reverse Transfer Admittance

TYPICAL ADMITTANCE CHARACTERISTICS

(Common-Emitter Circuit)

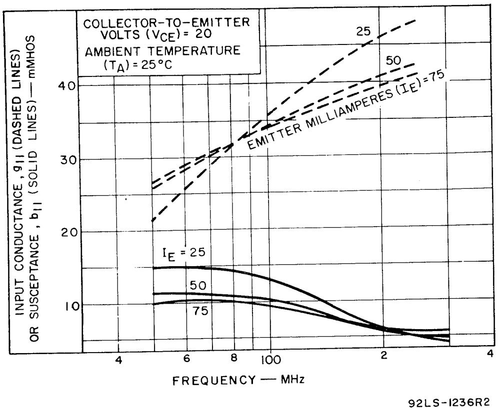


Fig. 6 - Input Admittance

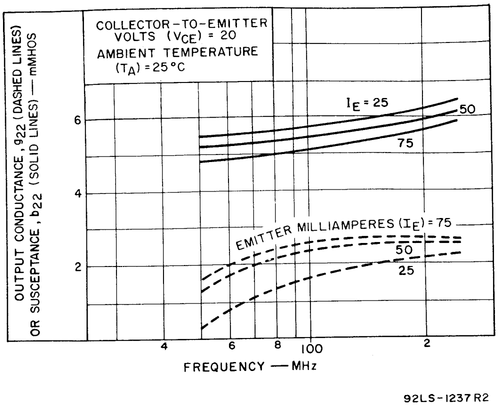
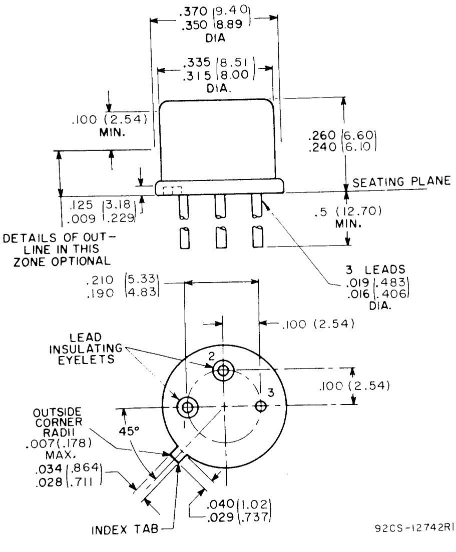


Fig. 7 - Output Admittance

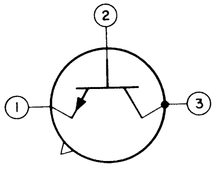
DIMENSIONAL OUTLINE JEDEC TO-39



DIMENSIONS IN INCHES AND MILLIMETERS

Note: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

TERMINAL DIAGRAM



Lead 1 - Emitter

Lead 2 - Base

Lead 3 - Collector, Case

Microwave Types

Solid State Division

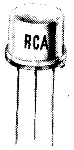
RF Power Transistors

2N5108

High-Gain Device for Class-B or C Operation in UHF Circuits

RCA-2N5108* is an epitaxial silicon n-p-n planar transistor of the "overlay" emitter electrode construction. It is intended as a high power amplifier, fundamental frequency oscillator and frequency multiplier. It may be used in final, driver, and pre-driver amplifier stages in UHF equipment and as a fundamental frequency oscillator at 1.68 GHz.

In the overlay structure, there are a number of individual emitter sites which are all connected in parallel and used in conjunction with a common collector region. When compared with other structures, this arrangement provides a substantial increase in emitter periphery for higher current or power, and a corresponding decrease in emitter and collector areas for lower input and output capacitances. The overlay structure thus provides greater power output, gain, efficiency, frequency capability, and linearity.



JEDEC TO-39

H-1381

- **1 Watt Output Min. at 1 GHz (5 dB Gain)**
- **For Sonde Applications**
  0.3 Watt Output Typ. at 1.68 GHz

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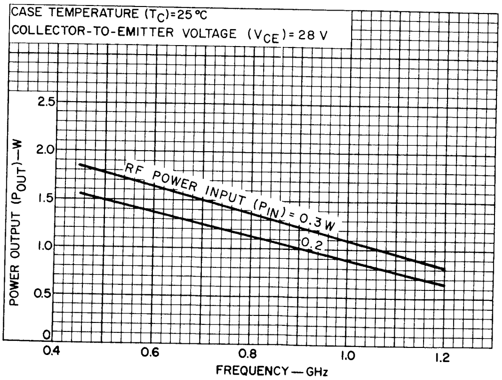
*Formerly RCA-Dev. No.TA2710

RATINGS

Maximum Ratings, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	55	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance, R_{BE} = 10 Ω	V_{CER}	55	V
With base open	V_{CEO}	30	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3	V
COLLECTOR CURRENT	I_C	0.4	A
TRANSISTOR DISSIPATION	P_T		
At case temperatures up to 25° C		3.5	W
At case temperatures above 25° C		See *Fig.7.*	
TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to 200	°C
LEAD TEMPERATURE (During soldering):			
At distance ≥ 1/32 in. from insulating wafer for 10 s max.		230	°C

TYPICAL POWER OUTPUT vs. FREQUENCY



92LS-1841R1

Fig. 1

ELECTRICAL CHARACTERISTICS

Case Temperature = 25° C

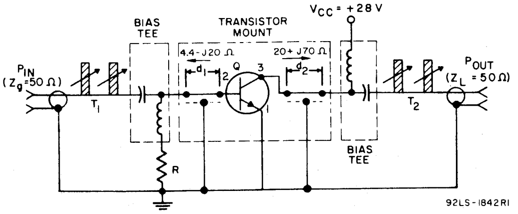
Characteristic	Symbol	Test Conditions: DC Collector Volts V_{CB}	Test Conditions: DC Collector Volts V_{CE}	Test Conditions: DC Current (mA) I_E	Test Conditions: DC Current (mA) I_B	Test Conditions: DC Current (mA) I_C	Limits Min.	Limits Max.	Units
Collector-Cutoff Current	I_{CEO}		15		0		-	20	μA
	I_{CES}		50					1	μA
Collector-to-Base Breakdown Voltage	BV_{CBO}			0		0.1	55	-	V
Collector-to-Emitter Sustaining Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{CER}(sus)$					5	55[a]	–	V
Emitter-to-Base Breakdown Voltage	BV_{EBO}			0.1		0	3	-	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				10	100	-	0.5	V
Collector-to-Base Capacitance (Measured at 1 MHz)	C_{ob}	30		0			-	3.0	pF
Small Signal (Common Emitter) Forward Current Transfer Ratio (Measured at 200 MHz)	$\|h_{fe}\|$		15			50	6.0	-	
RF Power Output Common Emitter Amplifier at 1 GHz (See *Fig.2.*)	P_{OUT}		28				1[b]	-	W
RF Power Output Fundamental Frequency Oscillator at 1.68 GHz (See *Fig.4.*)	P_{OUT}		20				0.3[c] (typ.)		W

[a] Pulsed through an inductor (2.5 mH), duty factor = 50%.

[b] For P_{in} = 0.316 W, minimum efficiency = 35%.

[c] Minimum efficiency = 15%. (V_{EB} = 1.5 V)

RF AMPLIFIER CIRCUIT FOR POWER OUTPUT TEST
(1 -GHz Operation)



d_1: 1" Input line, center conductor width = .280"
d_2: 1" Output line, center conductor width = .125"
Q: 2N5108
R: 3.9 ohms
T_1, T_2: Microlab Double Stub Tuner
Bias Tee: Microlab 08N, or equivalent
Transistor Mount: 1/32" Microstrip board

Note: Imdepance measurements are made of transistor socket pins.

Fig. 2

TYPICAL RF POWER OUTPUT vs. COLLECTOR-TO-EMITTER VOLTAGE

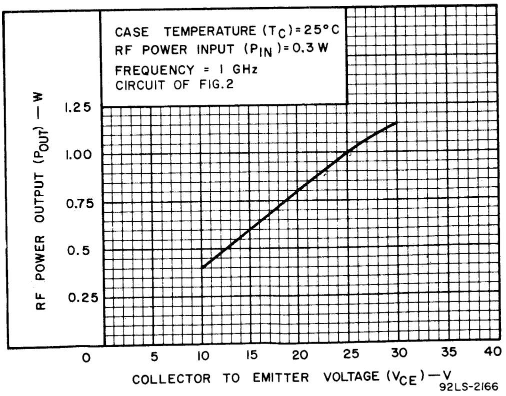
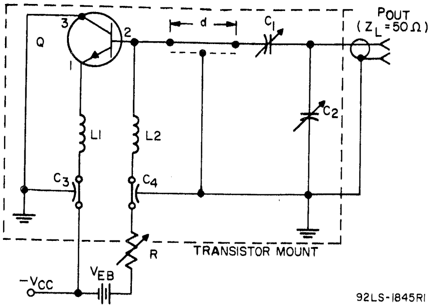


Fig. 3

RF FUNDAMENTAL-FREQUENCY OSCILLATOR CIRCUIT for POWER OUTPUT TEST (1.68-GHz Operation)



C_1, C_2: 0.35-3.5 pF
C_3, C_4: 500 pF feed through 3/4" output line, center
d: 3/4" output line, center conductor width = 0.160"
L_1, L_2: RF choke – 5 turns, No.28 wire, 1/8" dia. x 1/2" long
Q: 2N5108
R: 0-50 ohms
Transistor Mount: 1/16" microstrip board

Fig. 4

TYPICAL OSCILLATOR POWER OUTPUT vs. COLLECTOR SUPPLY VOLTAGE

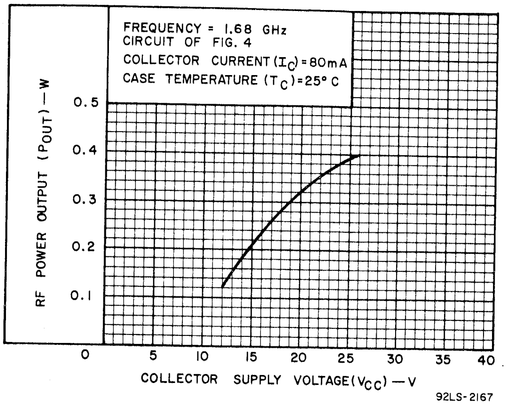


Fig. 5

TYPICAL RF AMPLIFIER CIRCUIT (1-GHz Operation)

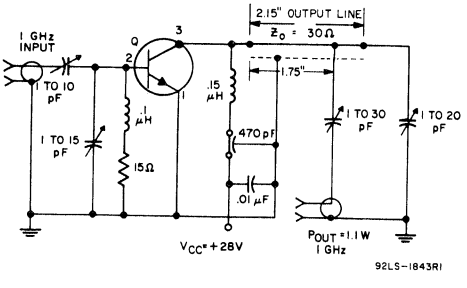


Fig. 6

DISSIPATION DERATING CURVE

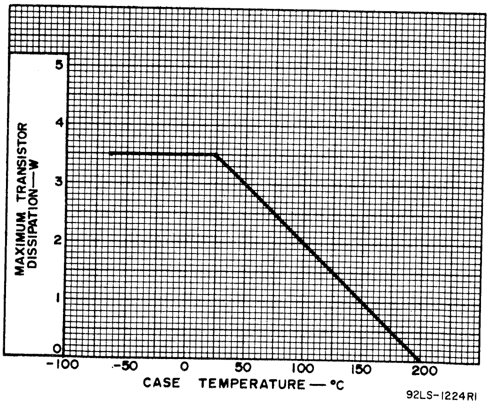
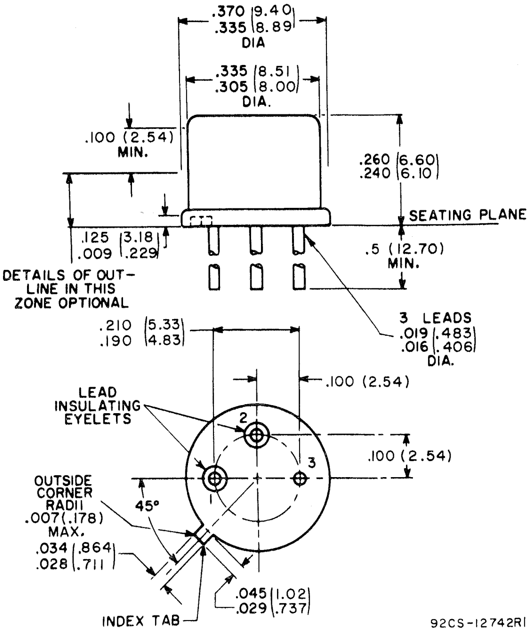


Fig. 7

DIMENSIONAL OUTLINE
JEDEC TO-39



DIMENSIONS IN INCHES AND MILLIMETERS

TERMINAL CONNECTIONS

Lead No.1 - Emitter
Lead No.2 - Base
Case, Lead No.3 - Collector

Note: *Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.*

RCA
Solid State
Division

RF Power Transistors

2N5470

SILICON N-P-N "overlay" TRANSISTOR

RCA-2N5470* is an epitaxial silicon n-p-n planar transistor employing the overlay emitter-electrode construction. It is intended for solid-state microwave radiosonde, communications, and S-band telemetry equipment.

The ceramic-metal coaxial package of the 2N5470 features low parasitic capacitances and inductances which provide for stable operation in the common-base amplifier configuration. This transistor can be used in both large and small-signal applications in coaxial, stripline, and lumped-constant circuits.

For application information on the 2N5470, see RCA Application Note AN3764, "Microwave Amplifiers and Oscillators Using the New RCA 2N5470 Power Transistor," by G. Hodowanec, O.P. Hart, and H.C. Lee.

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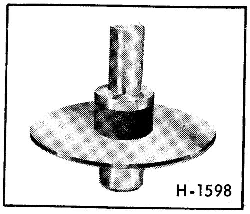
*Formerly RCA Dev. Type No. TA7003

Maximum Ratings, *Absolute-Maximum Values:*

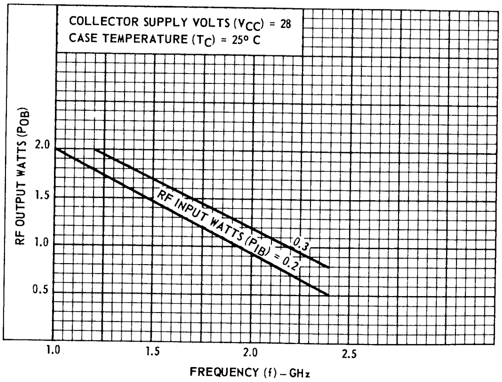
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	55	V
COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	55	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
PEAK COLLECTOR CURRENT		0.4	A
CONTINUOUS COLLECTOR CURRENT . .	I_C	0.2	A
TRANSISTOR DISSIPATION:	P_T		
At case temperatures up to 25 °C		3.5	W
At case temperatures above 25 °C		See Fig. 2.	
TEMPERATURE RANGE:			
Storage and operating (junction)		−65 to +200	°C



For UHF/Microwave Power Amplifiers, Microwave Fundamental-Frequency Oscillators, and Frequency Multipliers

FEATURES

- **1-W output with 5-dB gain (min.) at 2GHz**
- **2-W output with 10-dB gain (typ.) at 1 GHz**
- **Ceramic-metal hermetic package with low inductance and low parasitic capacitances**



92SS-3790

Fig. 1 - Typical Output Power vs. Frequency for Common-Base Power Amplifier

ELECTRICAL CHARACTERISTICS *At Case Temperature (T_C) = 25 °C*

CHARACTERISTICS	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
		DC Collector Voltage (V)		DC Current (mA)					
		V_{CB}	V_{CE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CES}		50		0		–	1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		0.1	55	–	V
Collector-to-Emitter Sustaining Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{CER}(sus)$					5	55	–	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				10	100	–	1.0	V
Collector-to-Base Capacitance (Measured at 1 MHz)	C_{cb}	30		0			–	3.0	pF
RF Power Output (Common-Base Amplifier): At 2 GHz[a] (See Fig. 5.) At 1 GHz[b] (See Fig. 12.)	P_{OB}	28 28					1.0 2.0 (typ.)	–	W W
RF Power Output (Common-Base Oscillator): At 2 GHz (See Fig. 15.)	P_{OB}	24				80	0.3 (typ.)		W

[a] For P_{IB} = 0.316 W; minimum efficiency = 30%

[b] For P_{IB} = 0.20 W; typical efficiency = 50%

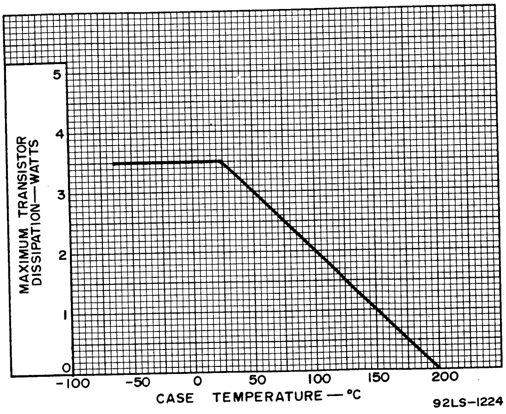


Fig. 2-Dissipation Derating Curve

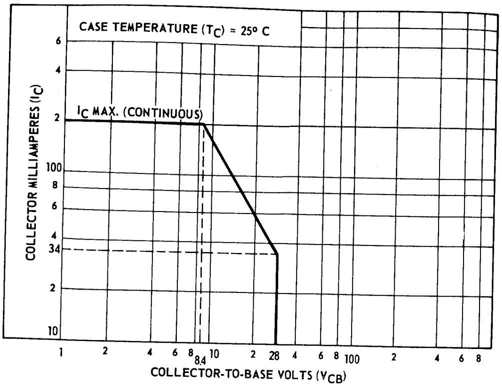


Fig. 3 - Maximum Operating Area for Forward-Bias Operation

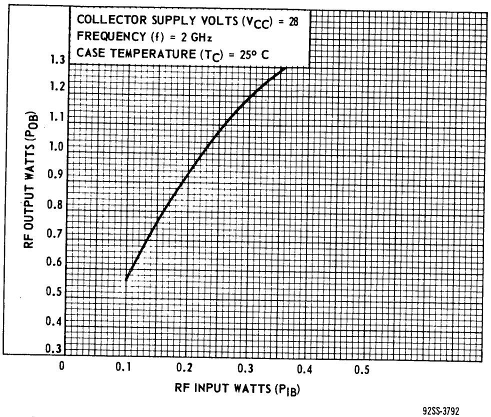


Fig. 4 - Typical Output Power vs. Input Power for 2-GHz Common-Base Power Amplifier

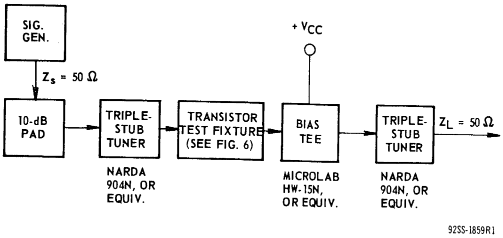
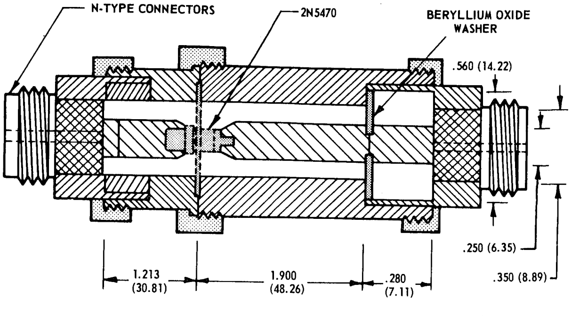


Fig. 5 - Block Diagram of Test Set-up for Measurement of Output Power from 2-GHz Common-Base Amplifier



Dimensions in Inches and Millimeters

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Fig. 6 - Suggested Test Fixture for Test Set-Up Shown in Fig. 5.

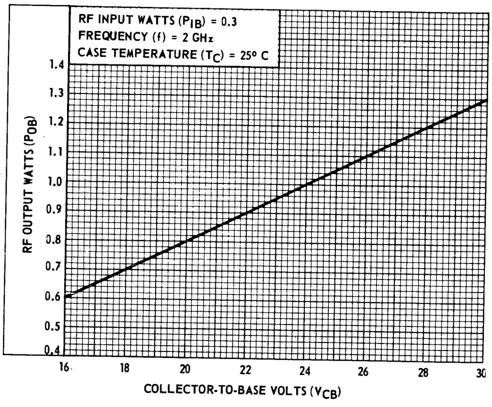


Fig. 7 - Typical Output Power vs. Collector-to-Base Voltage for 2-GHz Common-Base Power Amplifier

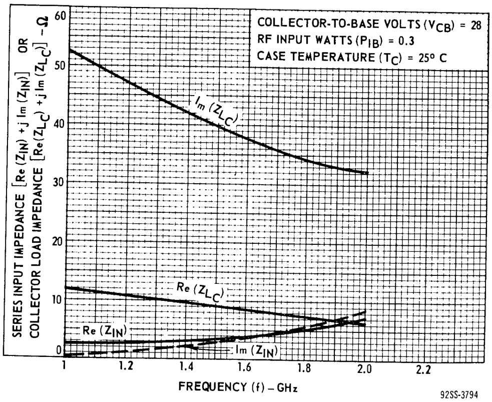


Fig. 8 - Typical Series Input Impedance and Collector Load Impedance vs. Frequency for Common-Base Power Amplifier

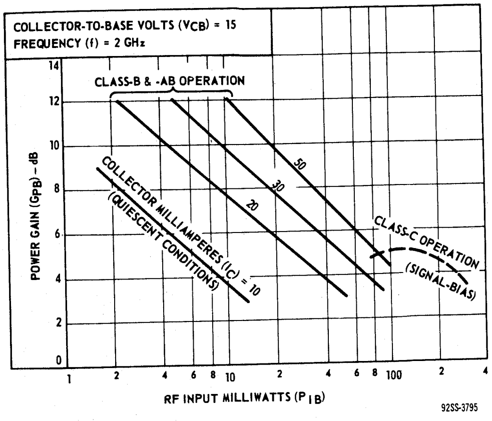
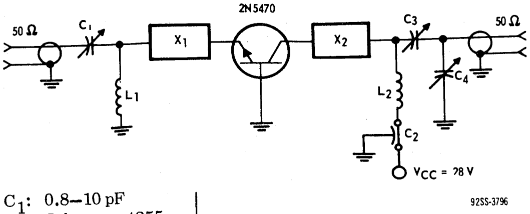


Fig. 9 - Typical Power Gain vs. Input Power for 2-GHz Common-Base Power Amplifier



C_1: 0.8–10 pF Johanson 4355, or equivalent

C_2: 1,000 pF, feed-through, Allen-Bradley FB2B, or equivalent

C_3: 0.3–3.5 pF Johanson 4701, or equivalent

C_4: 0.35–3.5 pF Johanson 4702, or equivalent

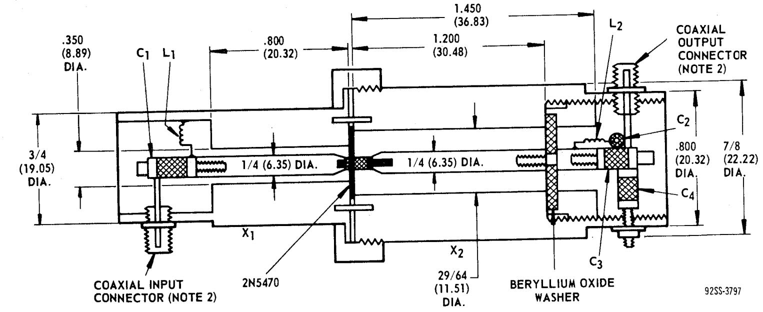
L_1, L_2: RF choke, 3 turns No. 30 wire, 1/16 in. (1.57) ID 3/16 in. (4.75) long

X_1, X_2: Coaxial lines; see Fig. 11 for details.

Dimensions in Inches and Millimeters

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

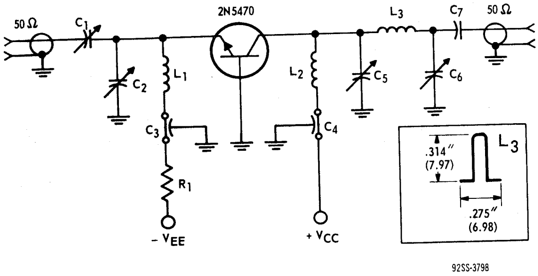
Fig. 10 - Typical Circuit for 2-GHz, Coaxial-Line Power Amplifier Shown in Fig. 11.



Note 1: Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Note 2: Conhex 50-045-0000, Sealectro Corp., or equivalent.

Fig. 11 - Constructional Details of 2-GHz Power Amplifier Shown in Fig. 10.



C_1, C_5, C_6: 1–14 pF, air-dielectric, Johanson 3901, or equivalent

C_2: 0.35–3.5 pF, air-dielectric, Johanson 4701, or equivalent

C_3, C_4: 1000 pF, feed-through, Allen-Bradley FA5C, or equivalent

C_7: 1000 pF, ceramic, leadless

L_1, L_2: RF choke, 0.1 μH, Nytronics Deci-Ductor

L_3: 0.01-in. (.254) thick, 0.157 in. (3.98) wide copper strip shaped as shown in inset drawing

R_1: 100 Ω, ½ W

Dimensions in Inches and Millimeters

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Fig. 12 - Typical Circuit for 1-GHz Power Amplifier

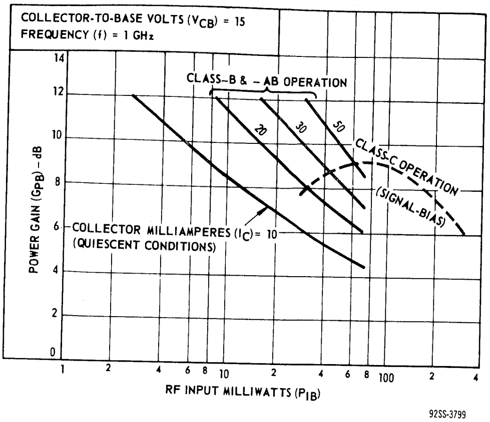
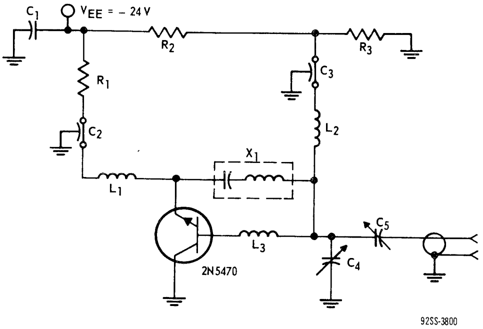


Fig. 13 - Typical Power Gain vs. Input Power for 1-GHz Power Amplifier



C_1: 0.01 μF disc ceramic

C_2, C_3: 100 pF, feed-through, Allen-Bradley FA5C, or equivalent

C_4, C_5: 0.35–3.5 pF, Johanson 4701, or equivalent

L_1, L_2: RF choke, 4 turns, No. 33 wire, 0.062 in. (1.57) ID, 3/16 in. (4.75) long

L_3: 3/64 in. (1.17) length of No. 22 wire

X_1: 0.82 pF, "gimmick", Quality Components type 10% QC, or equivalent

R_1: 5–10 Ω, 1/2 W

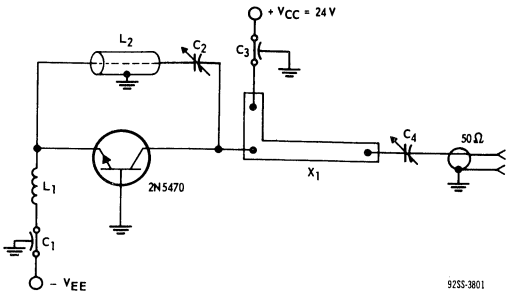
R_2: 51 Ω, 1/2 W

R_3: 1200 Ω, 1/2 W

Dimensions in Inches and Millimeters

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Fig. 14 - Typical Circuit for 2-GHz Grounded-Collector Power Oscillator



C_1, C_3: 100 pF, feed-through, Allen-Bradley FA5C, or equivalent

C_2, C_4: 0.35–3.5 pF, Johanson 4702, or equivalent

L_1: RF choke, 5 turns No. 33 wire, 1/16 in. (1.57) ID, 3/16 in. (4.76) long

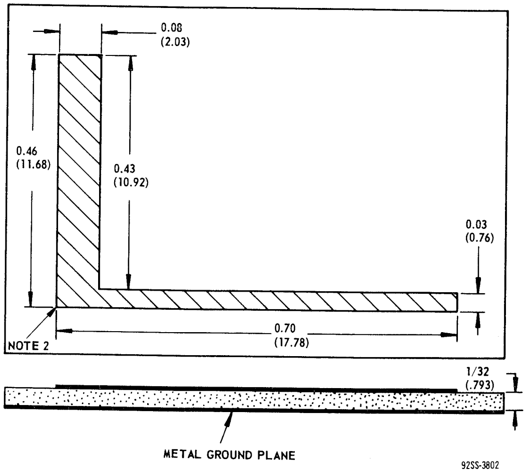
L_2: 50-Ω miniature coaxial line 1.5 in. (38.1) long

X_1: Microstripline circuit; see Fig. 16 for details.

Dimensions in Inches and Millimeters

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

Fig. 15 - Typical Circuit for 2-GHz Grounded-Base Power Oscillator



Dimensions in Inches and Millimeters

Note 1: Dimensions in parentheses are are in millimeters and are derived from the basic inch dimensions as indicated.

Note 2: Produced by removing portion of upper layer of double-clad, Teflon board, Budd Co. Polychem Div. Grade 108T, 1 oz, 1/32 in. (.793) thick, (ϵ = 2.6), or equivalent.

Fig. 16 - Detail Drawing of Microstripline, X_1 Specified in Fig. 15.

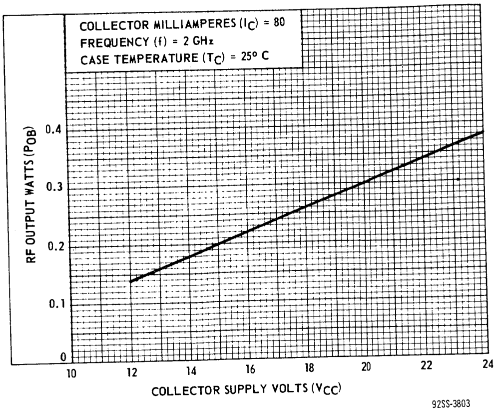
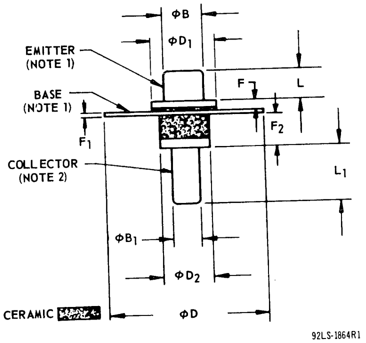


Fig. 17 - Typical Output Power vs. Collector Supply Voltage for 2-GHz Grounded-Base Power Oscillator

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
ΦB	.118	.122	2.997	3.098
$ΦB_1$	.090	.094	2.286	2.387
ΦD	.497	.503	12.624	12.776
$ΦD_1$	.180	NOM.	4.57	NOM.
$ΦD_2$	.162	NOM.	4.11	NOM.
F	.046	.055	1.168	1.397
F_1	.009	.011	.229	.279
F_2	.114	.124	2.90	3.14
L	.099	.103	2.515	2.616
L_1	.179	.191	4.55	4.85

NOTES:

1. Gold-plated KOVAR*
2. Solid silver

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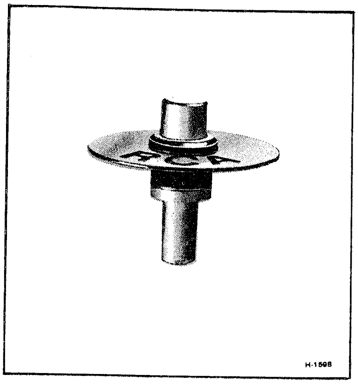
* Trademark, Westinghouse Electric Corp.

RCA

Solid State
Division

RF Power Transistors

2N5920



Silicon N-P-N Overlay Transistor

For UHF/Microwave Power Amplifiers, Microwave Fundamental-Frequency Oscillators and Frequency-Multipliers

Features:

- 2-W output with 10-dB gain (min.) at 2 GHz
- 3-W output with 12-dB gain (typ.) at 1-GHz
- Ceramic-metal hermetic package with low inductance and low parasitic capacitances
- Stable common-base operation
  For coaxial, microstripline, & lumped-constant circuit applications

Maximum Ratings, *Absolute-Maximum Values:*

* COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	50	V
* COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	V
* EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
CONTINUOUS COLLECTOR CURRENT	I_C	0.275	A
* TRANSISTOR DISSIPATION:	P_T		
At case temperature up to 75°C		4.15	W
At case temperature above 75°C		0.033	
* TEMPERATURE RANGE:			
Storage and operating (Junction)		-65 to +200	°C
* CASE TEMPERATURE (During Soldering):			
For 10 s max.		230	°C

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* In accordance with JEDEC registration data format (JS-6-RDF-3/JS-9-RDF-7).

RCA 2N5920● is an epitaxial silicon n-p-n planar transistor featuring the overlay multiple-emitter-site construction. It is intended for solid-state equipment for microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance measuring equipment and collision avoidance systems.

The ceramic-metal coaxial package of the 2N5920 features low parasitic capacitances and inductances which provide for stable operation in the common-base amplifier configuration. Ideal as a driver for the 2N5921, this transistor can also be used in large signal applications in coaxial, stripline and lumped-constant circuits.

● Formerly RCA Dev. Type No. TA7487.

ELECTRICAL CHARACTERISTICS, *at Case Temperature* $(T_C) = 25^oC$

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC COLLECTOR VOLTAGE (V)	DC CURRENT (mA)					
		V_{CE}	I_E	I_B	I_C	MIN.	MAX.	
* Collector-Cutoff Current	I_{CES}	50		0		–	1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$		0		1	50	–	V
* Collector-to-Emitter Sustaining Voltage: With external base-to-emitter resistance (R_{BE})= 10 Ω	$V_{CER}(sus)$				5	50	–	V
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$		0.1		0	3.5	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$			10	100	–	1	V
Thermal Resistance: (Junction-to-collector terminal)	$\theta_{J\text{-}CT}$	10			100	–	30	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	POWER INPUT P_{IB}(W)	POWER OUTPUT P_{OB}(W)	SUPPLY VOLTAGE V_{CC}(V)	FREQUENCY (f) GHz	LIMITS		UNITS
						MIN.	MAX.	
Power Output (See Fig. 5)	P_{OB}	0.2		28	2	2		W
Power Gain	G_{PB}	0.2	2.0	28	2	10		dB
Collector Efficiency	η_C	0.2	2.0	28	2	40		%
Collector-to-Base Capacitance	C_{obo}			30(V_{CB})	1MHz		3	pF

TYPICAL APPLICATION INFORMATION

CIRCUIT & FREQUENCY	DC Collector Supply Voltage (V_{CC}) - V	Input Power (P_{IB}) - W	Output Power (P_{OB}) - W
Coaxial -Line 2 - GHz Amplifier (Fig. 9)	28	.2	2.1
Microstripline Forward - biased 2-GHz amplifier (Figs. 11 & 13)	28	0.075	1.0
Lumped Constant Oscillator (Figs. 15 & 16)	24		.90
Lumped Constant 1 - GHz Amplifier (Fig. 10)	28	0.18	3

* In accordance with JEDEC registration data format (JS-6-RDF-3/JS-9-RDF-7).

PERFORMANCE DATA

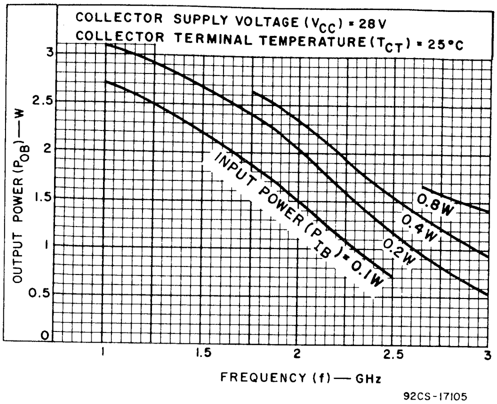


Fig. 1 - Typical output power vs. frequency for common-base amplifier.

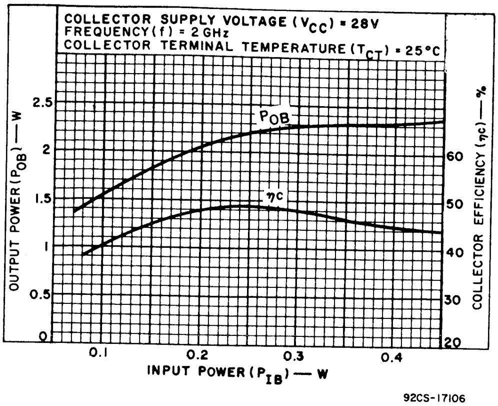


Fig. 2 - Typical output power and collector efficiency vs. input power for 2-GHz common-base power amplifier (Fig. 10)

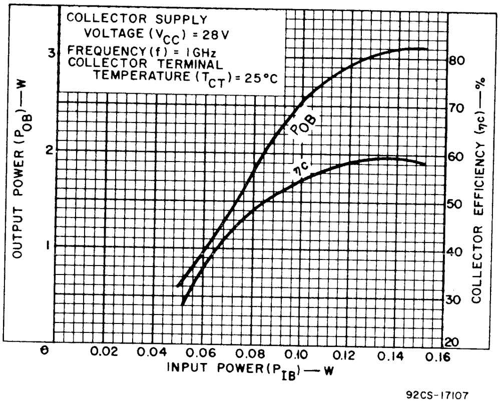


Fig. 3 - Typical output power and collector efficiency vs. input power for 1-GHz common-base power amplifier.

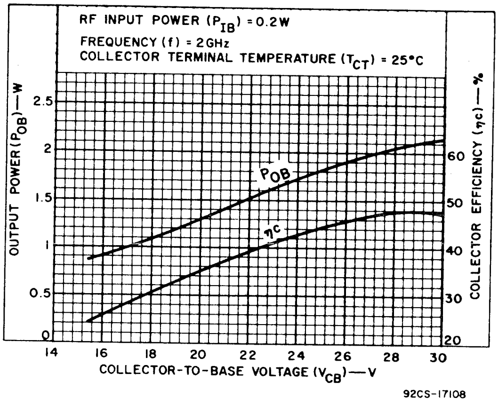


Fig. 4 - Typical output power and collector efficiency vs. collector-to-base voltage in a 2-GHz common-base amplifier.

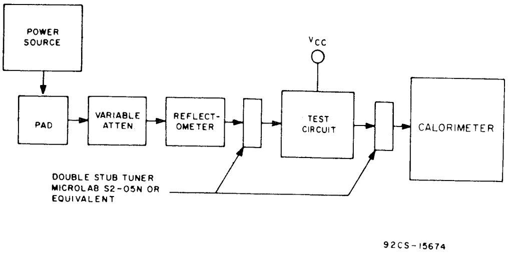


Fig. 5 - Block diagram of test set-up for measurement of output power from 1.0- or 2-GHz common-base amplifier.

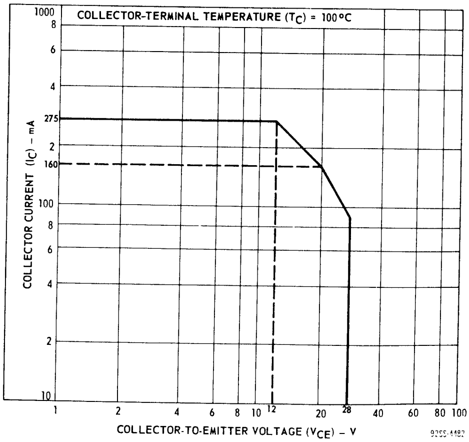


Fig. 6 - Maximum operating area for forward-bias operation.

DESIGN DATA

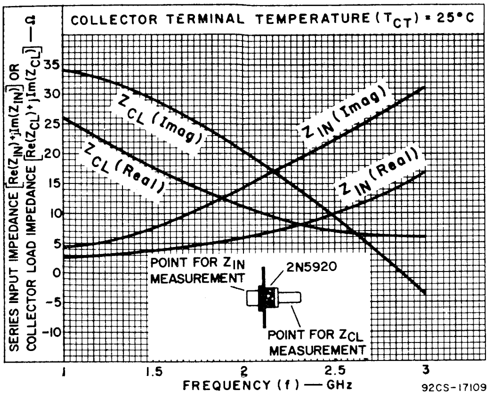


Fig. 7 - Typical large-signal series input impedance or large-signal collector load impedance vs. frequency.

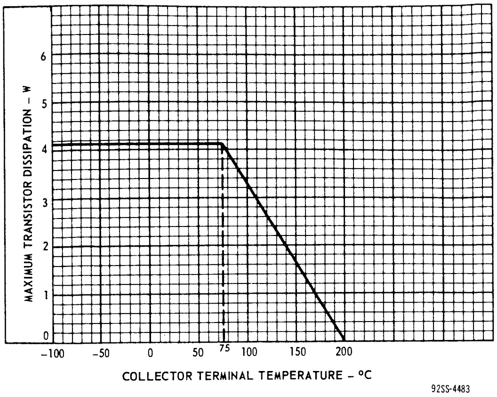


Fig. 8 - Temperature derating of power dissipation of the 2N5920.

APPLICATION DATA

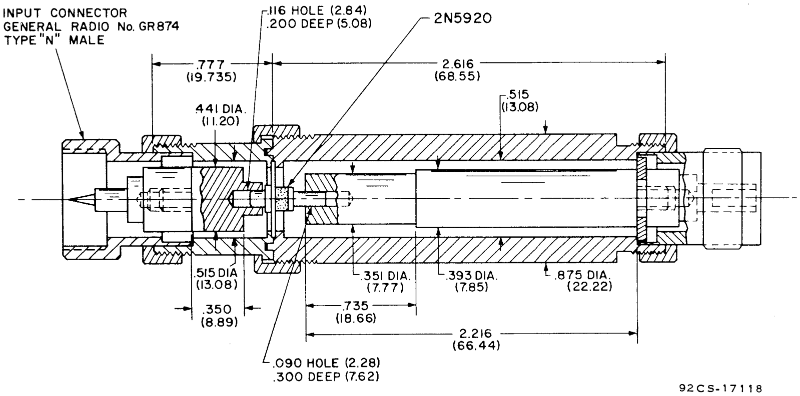
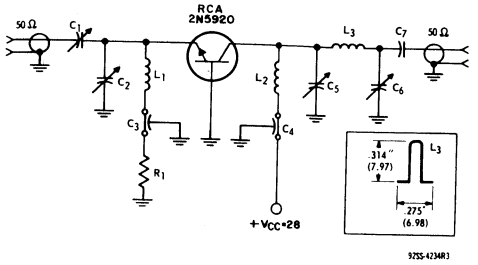


Fig. 9 - Constructional details of 2 GHz power amplifier.

SOLDERING INSTRUCTIONS

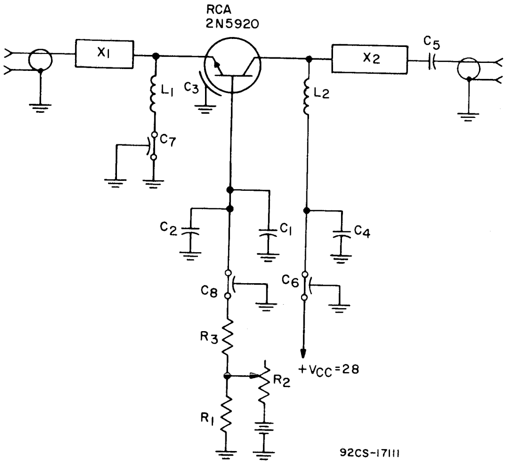
When soldering the 2N5920 into a microstripline or lumped-constant circuit, the collector and emitter terminals of the device must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230°C for a maximum of 10 seconds during tinning and subsequent soldering operations.

APPLICATION DATA(cont'd)



C_1, C_5, C_6: 1-14 pF, air-dielectric, Johanson 3901, or equivalent
C_2: 0.35-3.5 pF, air-dielectric, Johanson 4701, or equivalent
C_3, C_4: 1000 pF, feed-through, Allen-Bradley FA5C, or equivalent
C_7: 1000 pF, ceramic, leadless
L_1, L_2: RF choke, 0.1μH, Nytronics Deci-Ductor
L_3: 0.01-in. (.254) thick, 0.157 in. (3.98) wide copper strip shaped as shown in inset drawing
R_1: 1Ω, ½ W

Fig. 10 - Typical circuit for 1-GHz power amplifier.



C_1, C_2, C_4: 0.005 uf
C_3: This capacitance results from the mounting (See Fig. 12)
C_5: .001 uf ATC
C_6, C_7, C_8: .001 μf feedthrough capacitor
R_1: 75 Ω
R_2: 0-750 Ω potentiometer
R_3: 220 Ω
L_1 & L_2: RF 6 turns No. 28-wire 0,062 in. (1.57) I. D., 3/16 in. (4.75) long

X_1: **UNIFORM MICROSTRIPLINE**
0.107 in. (27. 9mm) wide
0.475 in. (120. 8mm) long
0.005 in. (0.13mm) thick copper

X_2: **UNIFORM MICROSTRIPLINE**
0.065 in. (1.65mm) wide
1.150 in. (29.21mm) long
0.005 in. (0.13mm) thick copper

* Allen - Bradley
■ American Technical Ceramics, Huntington Station, N.Y. 11746

Fig. 11 - Typical forward-biased 2-GHz common-base amplifier using the 2N5920.

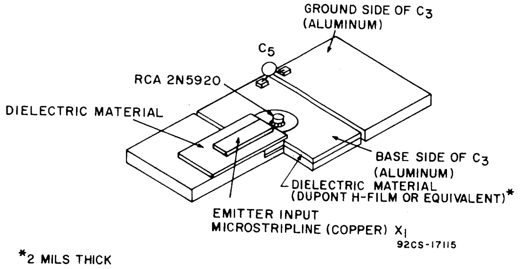


Fig. 12 - Construction details of low inductance base-bypass capacitor C3 shown in Fig. 11.

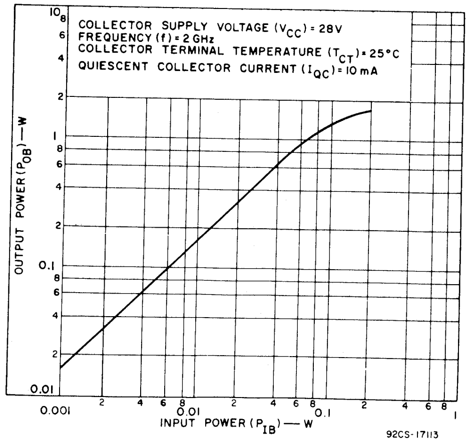


Fig. 13 - Output power vs. input power of 2N5920 in a forward-biased 2-GHz amplifier.

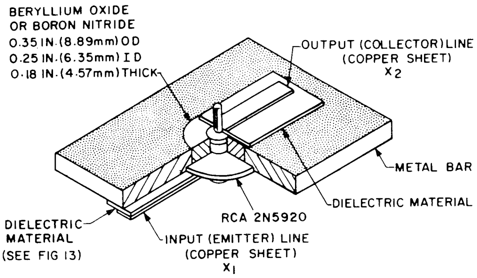


Fig. 14 - Suggested mounting arrangement of the 2N5920 in a microstripline circuit.

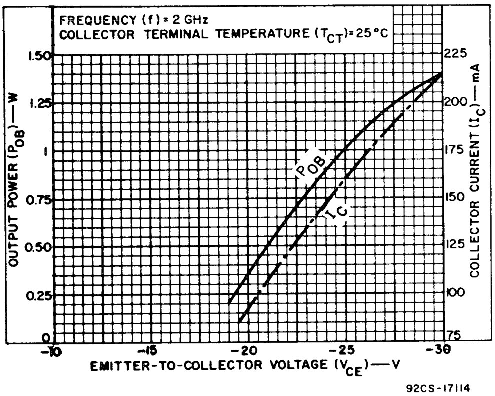
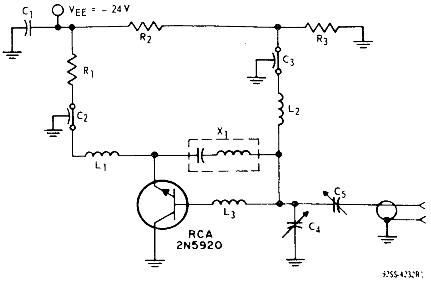


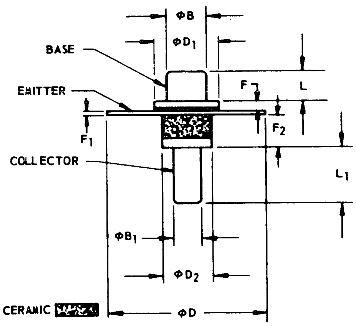
Fig. 16 - Typical output power vs. supply voltage and current for 2-GHz grounded collector oscillator.



C_1: 0.01 µF, disc ceramic
C_2, C_3: 100 pF, feed-through Allen-Bradley FA5C, or equivalent
C_4, C_5: 0.35 – 3.5 pF, Johanson 4701, or equivalent
L_1, L_2: RF choke, 4 turns, No. 33 wire, 0.062 in.(1.57) ID, 3/16 in.(4.75) long
L_3: 3/64 in(1.17) length of No. 22 wire
X_1: 0.82 pF, "gimmick", Quality Components type 10% QC, or equivalent
R_1: 5 – 10 Ω, 1/2 W
R_2: 51 Ω, 1/2 W
R_3: 1200 Ω, 1/2 W

Fig. 15 - Typical circuit for 2-GHz grounded-collector power oscillator.

DIMENSIONAL OUTLINE

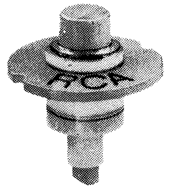


SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕ_B	.117	.123	2.98	3.12	–
ϕ_{B_1}	.090	.094	2.29	2.38	–
ϕ_D	.496	.504	12.60	12.80	–
ϕ_{D_1}	.175	.185	4.44	4.69	–
ϕ_{D_2}	.157	.167	3.98	4.24	–
F	.027	.040	.69	1.01	–
F_1	.009	.012	.23	.30	–
F_2	.114	.127	2.90	3.14	–
L	.098	.105	2.49	2.66	–
L_1	.179	.191	4.55	4.85	–

RCA
Solid State Division

RF Power Transistors

2N5921



H-1629

Silicon N-P-N Overlay Transistor

For UHF/Microwave Power Amplifiers, Microwave Fundamental-Frequency Oscillators and Frequency Multipliers

Features:

- 5-W output with 5.5-dB gain (typ.) at 2.3 GHz
- 5-W output with 7-dB gain (min.) at 2 GHz
- 10-W output with 11-dB gain (typ.) at 1.2 GHz
- Ceramic-metal hermetic package with low inductance and low parasitic capacitances
- Beryllium oxide ceramic for low thermal-resistance path between collector stud & base flange
- Stable common-base operation
- For coaxial, microstripline, & lumped-constant circuit applications

MAXIMUM RATINGS, ***Absolute-Maximum Values:***

*COLLECTOR-TO-BASE VOLTAGE. . . .	V_{CBO}	50	V
*COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*CONTINUOUS DC COLLECTOR CURRENT	I_C	0.7	A
*TRANSISTOR DISSIPATION	P_T		
At case temperature up to 100°C		8.3	W
At case temperatures above 100°C derate linearly		0.083	W/°C
*TEMPERATURE RANGE:			
Storage & Operating (Junction)		-65 to 200	°C
*CASE TEMPERATURE (During soldering):			
For 10 s max.		230	°C
(See Soldering Instructions on page 8.)			

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*In accordance with JEDEC registration data format (JS-6-RDF-3/JS-9-RDF-7).

RCA 2N5921 is an epitaxial silicon n-p-n planar transistor featuring the overlay multiple-emitter-site construction. It is intended for solid-state equipment for microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance measuring equipment and collision avoidance systems.

The ceramic-metal coaxial package of the 2N5921 features low parasitic capacitances and inductances which provide for stable operation in the common-base amplifier configuration. This transistor can be used in large signal applications in coaxial, stripline, and lumped-constant circuits. The 2N5921 can withstand load mismatch conditions at 2 GHz up to VSWR of 10:1 (all phases) in the common-base circuit shown in Fig. 9.

- Formerly RCA Dev. Type No. TA7205.

ELECTRICAL CHARACTERISTICS, *at Case Temperature (T_C) = 25°C*

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Voltage (V)	DC Current (mA)					
		V_{CE}	I_E	I_B	I_C	Min.	Max.	
* Collector-Cutoff Current	I_{CES}	45		0		–	1	mA
	I_{CES} ($T_C = 100°C$)	45				–	5	
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$		0		1	50	–	V
* Collector-to-Emitter Breakdown Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$				10	50	–	V
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$		0.1		0	3.5	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$			20	100	–	1	V
Thermal Resistance: (Junction-to-Flange)	$\theta_{J\text{-}F}$					–	12	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS		LIMITS		UNITS
		Frequency (f) – GHz	DC Collector Supply Voltage (V_{CC}) – V	Min.	Max.	
Output Power P_{IB} = 1 W (See Fig. 9)	P_{OB}	2	28	5	–	W
* Power Gain P_{OB} = 5 W	G_{PB}	2	28	7	–	dB
* Collector Efficiency P_{OB} = 5 W	η_C	2	28	40	–	%
* Collector-to-Base Capacitance V_{CB} = 30 V	C_{obo}	1 MHz	–	–	8.5	pF

*In accordance with JEDEC registration data format (JS-6-RDF-3/JS-9-RDF-7).

TYPICAL APPLICATION INFORMATION

CIRCUIT & FREQUENCY	See Fig.	DC Collector Supply Voltage (V_{CC}) – V	Input Power (P_{IB}) – W	Output Power (P_{OB}) – W
Coaxial-Line				
2-GHz Amplifier	9	28	1	6
1.2-GHz Amplifier		28	0.75	10
Microstripline 2-GHz Amplifier	11	28	1	5
Lumped-Constant				
1.4-GHz Amplifier	15	28	1	6.8
1-GHz Amplifier	14	28	1	10.6
Microstripline 1.2-1.4 GHz Tunable Oscillator	16	28	–	4

For application information on 2N5921 see application note
"Microwave Amplifiers and Oscillators using the RCA-2N5921 Power Transistors"

PERFORMANCE DATA

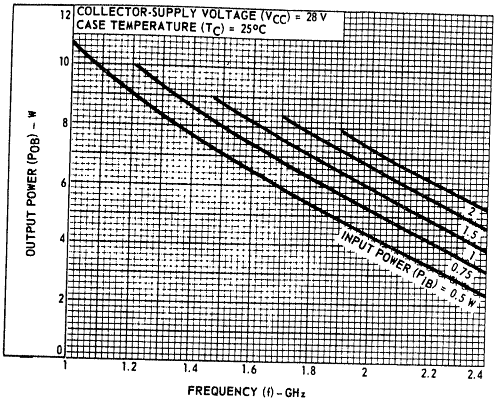


Fig. 1 - Typical output power vs. frequency.

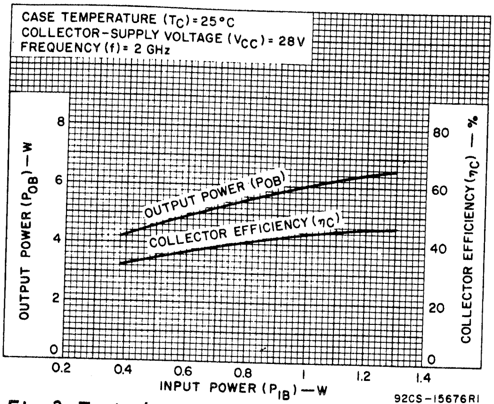


Fig. 2 - Typical power output or collector efficiency vs. power input at 2 GHz for circuit shown in Fig. 9.

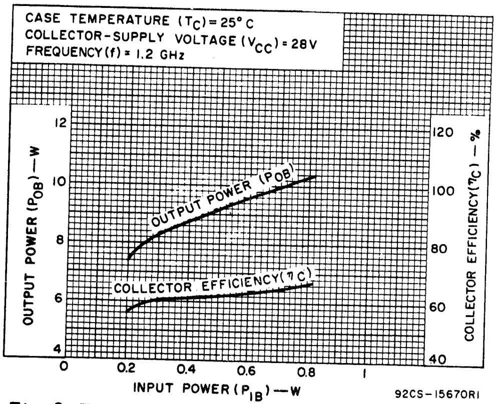


Fig. 3 - Typical power output or collector efficiency vs. power input at 1.2 GHz for circuit shown in Fig. 9.

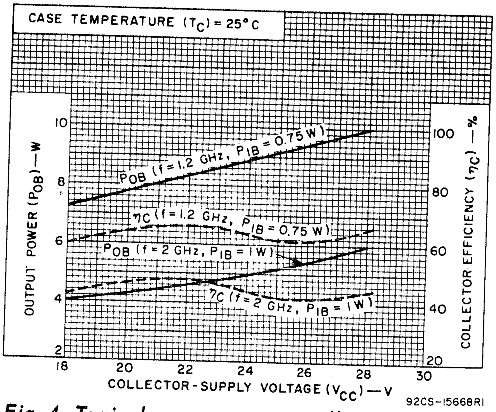


Fig. 4 - Typical power output or collector efficiency vs. collector supply voltage.

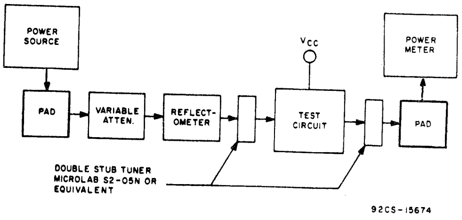


Fig. 5 - Block diagram of test set-up for measurement of output power from 1.2- or 2-GHz common-base amplifier.

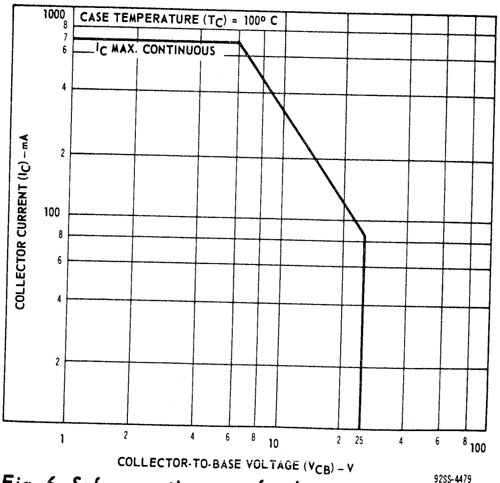


Fig. 6 - Safe operating area for dc operation.

DESIGN DATA

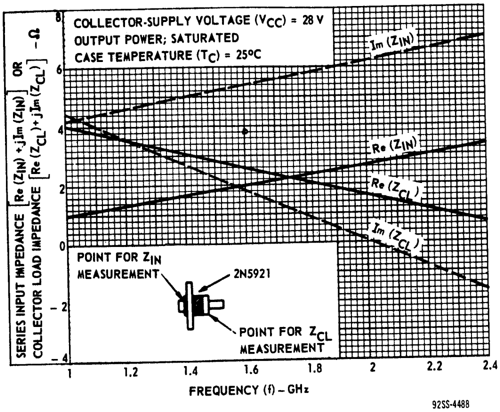


Fig. 7 - Typical large-signal series input impedance or large-signal collector load impedance vs. frequency.

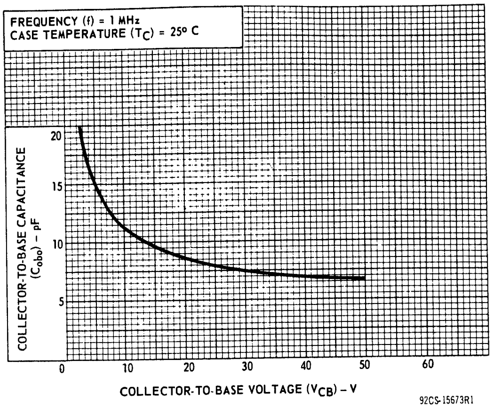
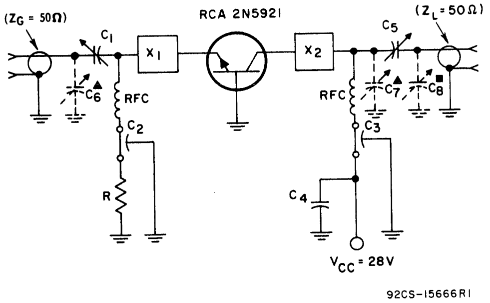


Fig. 8 - Typical collector-to-base capacitance vs. collector-to-base voltage.

APPLICATION INFORMATION



▲ Use only in the 2-GHz coaxial-line power amplifier circuit.

■ Use only in the 1.2-GHz coaxial-line test circuit.

* Johanson Mfg. Corp., Boonton, N.J. 07005

CIRCUIT	C_1 pF	C_2 pF	C_3 pF	C_4 μF	C_5 pF	C_6 pF	C_7 pF	C_8 pF	R Ω
1.2 GHz (Test Circuit)	1-10	1000	1000	0.01	1–10	-	-	0.3-3.5	0.75
2 GHz (Test Circuit)	1-10	470	470	0.01	1–10	-	-	-	0.43
2 GHz (Amplifier)	1-10	470	470	0.01	0.3-3.5	0.3-3.5	0.3-3.5	-	0.43

C_1 & C_5, 1-10pF Range: Johanson 4581, or equivalent*

C_5, C_6, C_7 & C_8, 0.3-3.5pF Range: Johanson 4700, or equivalent*

RFC: For 2-GHz Circuits: 3 turns No.32 wire 1/16 in. (1.59 mm) ID, 3/16 in. (4.76 mm) long.

For 1.2-GHz Circuit: 6 turns No.32 wire 1/16 in. (1.59 mm) ID, 3/16 in. (4.76 mm) long.

X_1, X_2: Coaxial-line circuits, see Fig. 10.

Fig. 9 - 1.2/2 GHz coaxial-line amplifier circuits.

APPLICATION INFORMATION (Cont'd)

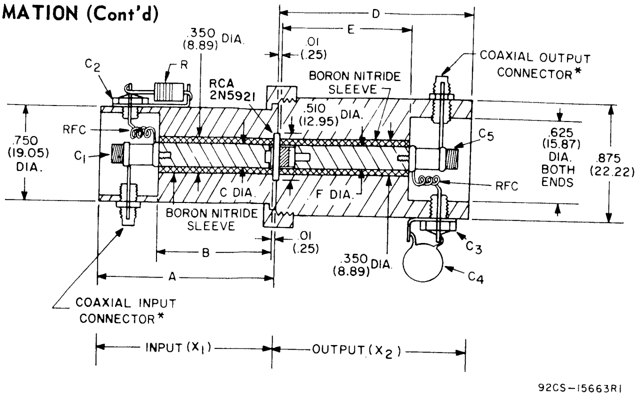


TABLE 1 - Dimensions of coaxial lines X_1 & X_2 for 2 GHz amplifier & 1.2 & 2-GHz test circuit

CIRCUIT	DIMENSIONS							
	INPUT (X_1)				OUTPUT (X_2)			
	A	B	C	Center Conductor	D	E	F	Center Conductor
1.2 GHz (Test Circuit)	1.385 (35.18)	.875 (22.22)	.282 (7.16)	.825 (20.95)	1.778 (45.16)	1.268 (32.21)	.213 (5.41)	1.05 (26.67)
2 GHz (Test Circuit)	.940 (23.88)	.430 (10.92)	.266 (6.76)	.380 (9.65)	1.04 (26.42)	.530 (13.46)	.266 (6.76)	.370 (9.39)
2 GHz (Amplifier)	.860 (21.84)	.350 (8.89)	.265 (6.73)	.300 (7.62)	1.06 (26.92)	.550 (13.97)	.270 (6.86)	.385 (9.78)

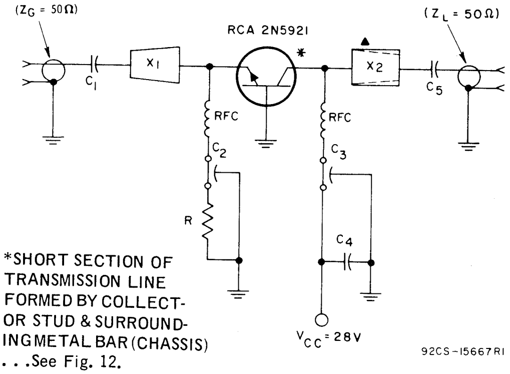
Dimensions in Inches and Millimeters

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

MATERIAL: Center conductor – copper
Outer conductor for input & output – brass

* Conhex 50-045-0000 Sealectro Corp., or equiv.

Fig. 10 - Constructional details of 1.2/2 GHz coaxial-line test circuits.



*SHORT SECTION OF TRANSMISSION LINE FORMED BY COLLECTOR STUD & SURROUNDING METAL BAR (CHASSIS) . . .See Fig. 12.

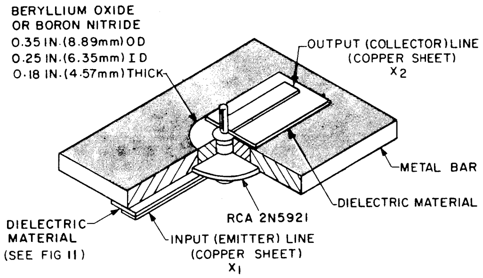
▲WITH SOME DEVICES, LOAD END OF X_2 MAY REQUIRE A SLIGHT TAPER TO INCREASE Z_0 FOR OPTIMUM MATCH CONDITION.

C_1,C_5: 300 pF disc ceramic
C_2,C_3: 470 pF, feed through, Allen-Bradley FA5C, or equivalent
C_4: 0.01 μF, disc ceramic
R: 0.43 Ω
RFC: No.32 wire, 0.4 in. (1.02 mm) long
X_1: TAPERED MICROSTRIPLINE –
0.15 in. (3.81 mm) wide, input end
0.30 in. (7.62 mm) wide, output end
0.525 in. (13.33 mm) long
0.005 in. (0.13 mm) thick, copper
X_2: UNIFORM MICROSTRIPLINE –
0.25 in. (6.35 mm) wide
0.36 in. (9.14 mm) long
0.005 in. (0.13 mm) thick, copper
DIELECTRIC MATERIAL: 0.5 in. (12.7 mm) wide
0.75 in. (19.05 mm) long
0.005 in. (0.13 mm) thick
DuPont H-Film, or equiv.

NOTE: See Fig. 12 for suggested mounting arrangement of 2N5921.

Fig. 11 - Typical circuit for 2-GHz grounded-base microstripline power amplifier.

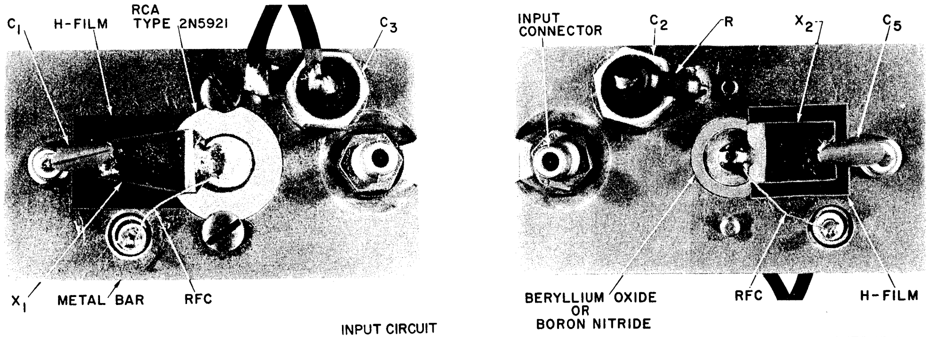
APPLICATION INFORMATION (Cont'd)



NOTE: FOR DIMENSIONS OF X_1 AND X_2 SEE FIG 11

92CS-15669R1

Fig. 12 - Suggested mounting arrangement of the 2N5921 in a microstripline circuit.

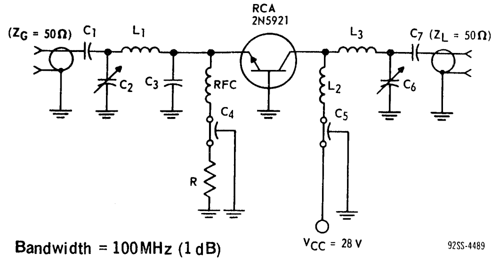


INPUT CIRCUIT

OUTPUT CIRCUIT

Fig. 13 - Suggested mounting arrangement of components for 2-GHz microstripline circuit shown in Fig. 11.

APPLICATION INFORMATION (Cont'd)

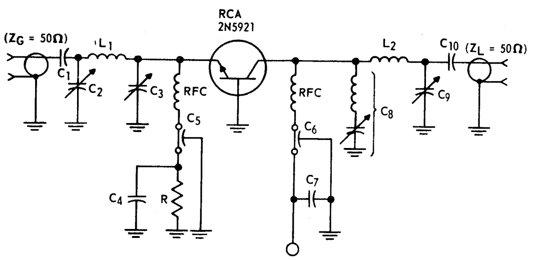


Bandwidth = 100MHz (1 dB)

C_1, C_7: 510 pF, ATC-200*
C_2, C_6: 1-10 pF, Johanson 2954*
C_3: 10 pF, ATC-100*
C_4, C_5: 470 pF, feed-through type, Allen-Bradley FA5C
L_1: 3.7 nH
L_2: 0.8 nH
L_3: 2.3 nH
R: 0.47 Ω
RFC: 5 turns, No. 28 wire, 0.05 in. (1.27 mm) I.D., 0.4 in. (10.16 mm) long.

*Or equivalent
American Technical Ceramics, Huntington Station, N.Y. 11746
Johanson Mfg. Corp., Boonton, N.J. 07005

Fig. 14 - Typical lumped-constant circuit for 1-GHz power amplifier.



C_1, C_{10}: 510 pF, ATC-100*
C_2, C_9: 0.3-35 pF, Johanson 4700*
C_3: Single, parallel-plate variable capacitor approx. 19 pF
C_4, C_7: 0.01 mF, disc ceramic
C_5, C_6: 470 pF, feed-through type, Allen-Bradley FA5C
C_8: 1-10 pF, Johanson 2954* (series resonant in this frequency range and used as a variable inductor)
L_1: 3.4 nH
L_2: 2.5 nH
R: 0.47 Ω
RFC: 5 turns, No. 28 wire, 0.05 in. (1.27 mm) I.D., 0.4 in. (10.16 mm) long.

*Or equivalent
American Technical Ceramics, Huntington Station, N.Y. 11746
Johanson Mfg. Corp., Boonton, N.J. 07005

Fig. 15 - Typical lumped-constant circuit for 1.4 GHz power amplifier.

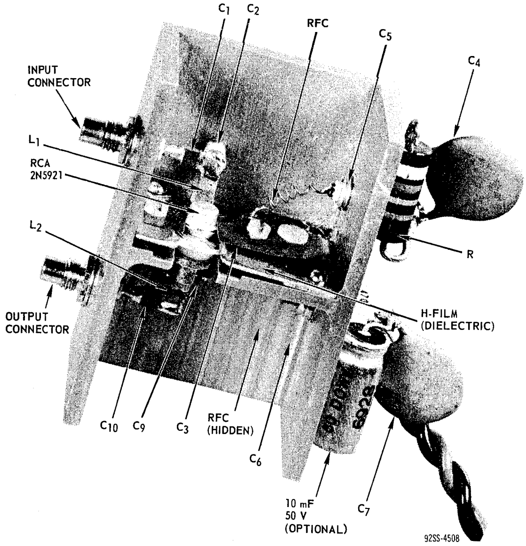
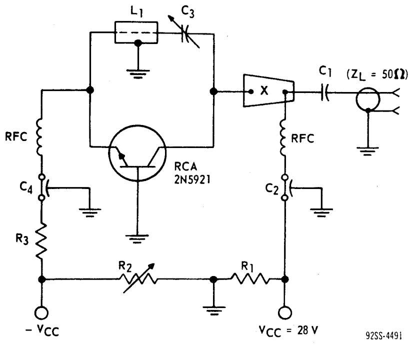


Fig. 16 - Suggested mounting arrangement of components for 1.4-GHz lumped-constant power amplifier circuit shown in Fig. 15.

APPLICATION INFORMATION (Cont'd)



*Johanson Mfg. Corp., Boonton, N.J. 07005

C_1: 300 pF, disc ceramic

C_2, C_4: 470 pF, feed-through type, Allen-Bradley FA5C, or equivalent

C_3: 0.3-3.5 pF, Johanson 4702, or equivalent*

L_1: 1.3 in. (33.02 mm) length of 50 Ω coaxial line

R_1: 1200 Ω

R_2: 0-250 Ω

R_3: 5 Ω

RFC: 3 turns, No. 29 wire, 0.06 in. (1.59 mm) I.D., 0.18 in. (4.77 mm) long.

X: TAPERED MICROSTRIPLINE –
0.1 in. (2.54 mm) wide, input end
0.24 in. (6.09 mm) wide, output end
0.475 in. (12.06 mm) long
0.005 in. (0.13 mm) thick, copper

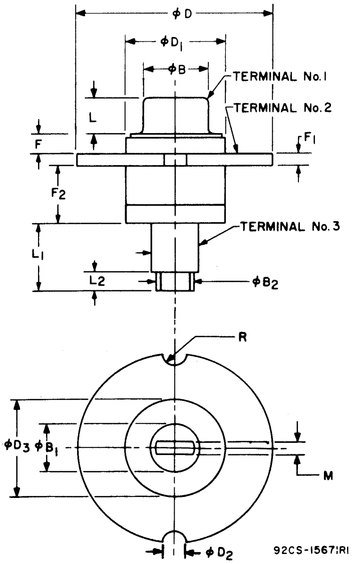
DIELECTRIC MATERIAL: Same as that for Fig. 11 (See Fig. 12 for mounting of output section)

Fig. 17 - Typical circuit for tunable 1.2 - 1.4 GHz, 4-W microstripline power oscillator.

SOLDERING INSTRUCTIONS

When soldering the 2N5921 into a microstripline or lumped-constant circuit, the collector and emitter terminals of the device must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230°C for a maximum of 10 seconds during tinning and subsequent soldering operations.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
ϕB	.165	.175	4.19	4.44
ϕB_1	.115	.125	2.92	3.17
ϕB_2	.090	.110	2.29	2.79
ϕD	.495	.505	12.57	12.83
ϕD_1	.245	.255	6.22	6.48
ϕD_2	.055	.065	1.39	1.65
ϕD_3	.245	.255	6.22	6.48
F	.045	.060	1.14	1.52
F_1	.025	.035	.63	.88
F_2	.145	.175	3.68	4.44
L	.095	.115	2.41	2.92
L_1	.165	.195	4.19	4.95
L_2	.040	.060	1.02	1.52
M	.045	.055	1.14	1.39
R	.027	.033	.68	.83

NOTE: Ceramic material of this device contains BERYLLIUM OXIDE.

TERMINAL CONNECTIONS

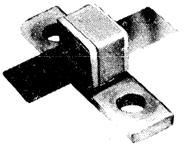
Terminal No. 1 – Emitter
Terminal No. 2 – Base
Terminal No. 3 – Collector

"**WARNING:** This device should be handled with care. The ceramic portion of this transistor contains BERYLLIUM OXIDE as a major ingredient. Do not crush, grind, or abrade these portions of the transistor because the dust resulting from such action may be hazardous if inhaled."

RCA
Solid State
Division

RF Power Transistors

2N6265



RCA HF-28 PACKAGE H-1712

2-W, 2-GHz, Emitter-Ballasted Silicon N-P-N Overlay Transistor

For UHF/Microwave Power Amplifiers, Microwave Fundamental-Frequency Oscillators and Frequency Multipliers

Features:

- **VSWR capability of ∞:1 at 2 GHz**
- **2-W output with 8.2-dB gain (min.) at 2 GHz**
- **3-W output with 12-dB gain (typ.) at 1 GHz**
- **Ceramic-metal hermetic stripline package with low inductance and low parasitic capacitances**
- **For microstripline and lumped-constant circuit applications**

RCA – 2N6265● is an epitaxial silicon n-p-n planar transistor featuring the overlay multiple-emitter-site construction. It is intended for solid-state equipment for microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance measuring equipment, transponder, and collision avoidance systems.

The ceramic-metal stripline package of the 2N6265 features low parasitic capacitances and inductances which provide for stable operation in the common-base amplifier configuration. Ideal as a driver for the 2N6266 or 2N6267, this transistor can also be used in large-signal applications in microstripline, stripline, and lumped-constant circuits.

●Formerly RCA Dev. No. TA7993.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	50	V
*COLLECTOR-TO-EMITTER VOLTAGE: With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*CONTINUOUS COLLECTOR CURRENT	I_C	0.275	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperature up to 75°C		6.25	W
At case temperature above 75°C		Derate linearly at 0.05 W/°C	
*TEMPERATURE RANGE:			
Storage and operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (during soldering) For 10 s max.		230	°C

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*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, *at Case Temperature (T_C) = 25°C* unless otherwise specified

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS DC COLLECTOR OR BASE VOLTAGE (V) V_{CE}	 V_{BE}	DC CURRENT (mA) I_E	 I_B	 I_C	LIMITS MIN.	 MAX.	UNITS
* Collector-Cutoff Current	I_{CES}	45	0				–	2	mA
At T_C = 55°C		40	0				–	2	
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		5	50	–	V
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
* Collector-to-Emitter Breakdown Voltage external base-to-emitter resistance R_{BE}=10Ω	$V_{(BR)CER}$					10	50	–	V
Collector-to-Emitter Saturation Voltage	V_{CE}(sat)				10	100	–	1	V
Thermal Resistance: (Junction-to-Flange)	$R_{\theta JF}$						–	20	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	POWER INPUT P_{IB}(W)	POWER OUTPUT P_{OB}(W)	SUPPLY VOLTAGE V_{CC}(V)	FREQUENCY (f) GHz	LIMITS MIN.	 MAX.	UNITS
Power Output (See Figs. 5 & 12)	P_{OB}	0.3		28	2	2	–	W
* Power Gain	G_{PB}	0.3	2.0	28	2	8.2	–	dB
* Collector Efficiency	η_C	0.3	2.0	28	2	33	–	%
* Collector-to-Base Capacitance	C_{obo}			30(V_{CB})	1 MHz	–	5	pF

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

CIRCUIT AND FREQUENCY	DC COLLECTOR SUPPLY VOLTAGE (V_{CC})–V	INPUT POWER (P_{IB})–W	OUTPUT POWER (P_{OB})–W
Microstripline 2-GHz Amplifier (Fig. 12)	28	0.30	2.1
Lumped Constant 1-GHz Amplifier (Fig. 10)	28	0.15	3.2

PERFORMANCE DATA

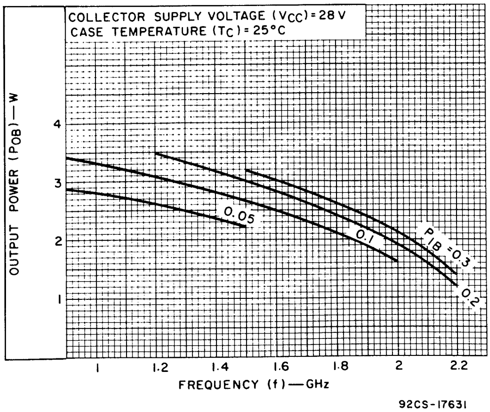


Fig. 1—Typical output power vs. frequency for common-base amplifier in the test set-up of Fig. 5.

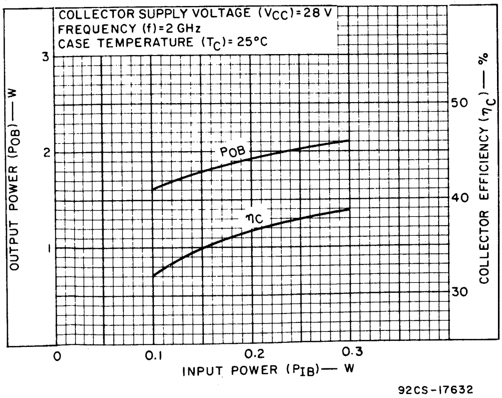
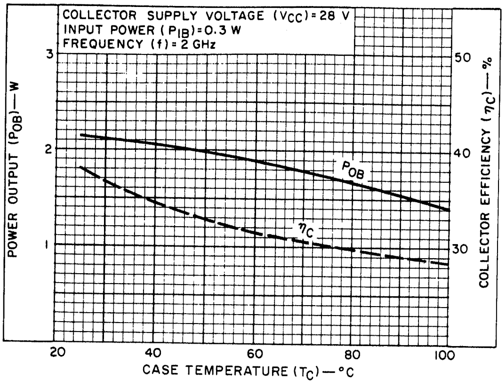


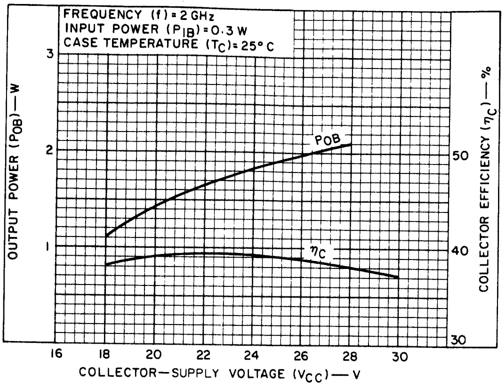
Fig. 2—Typical 2-GHz output power and collector efficiency vs. input power in the test set-up of Fig. 5.

PERFORMANCE DATA (cont'd)



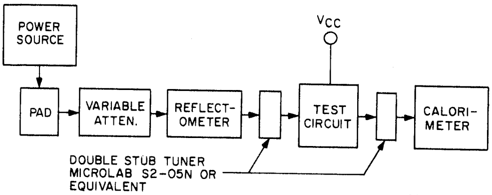
92CS-17633R1

Fig. 3—Typical output power and collector efficiency at 2-GHz vs. case temperature in the test set-up of Fig. 5.



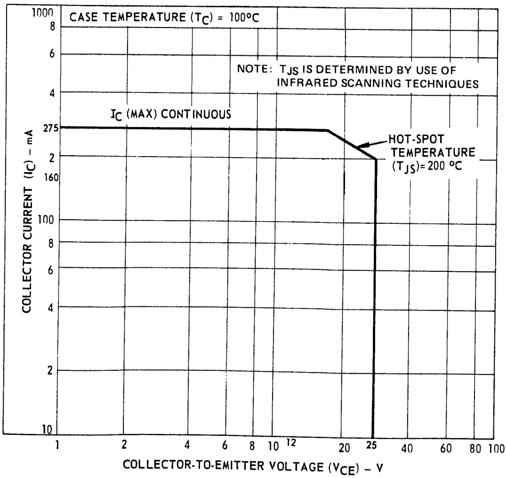
92CS-17634R1

Fig. 4—Typical 2-GHz output power and collector efficiency vs. supply voltage in the test set-up of Fig. 5.



92CS-17659

Fig. 5—Block diagram of test set-up for measurement of performance from 1- or 2-GHz common-base amplifier.



92CS-19858

Fig. 6—Maximum operating area for forward-bias operation.

DESIGN DATA

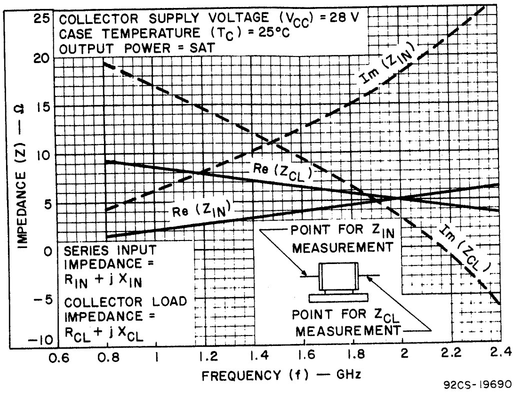


Fig. 7—Typical large-signal series input impedance and large-signal collector load impedance vs. frequency.

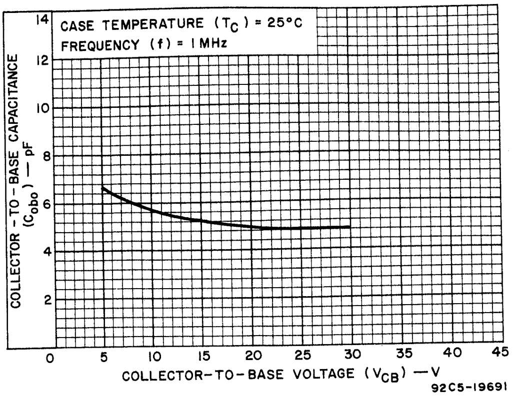
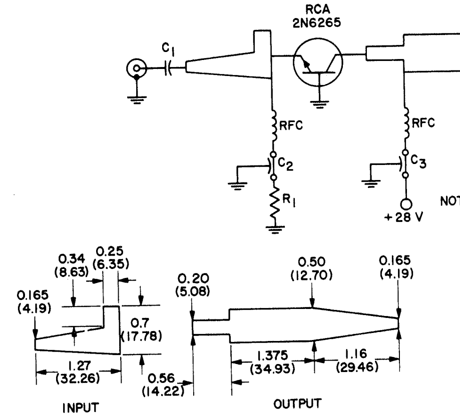


Fig. 8—Typical collector-to-base capacitance vs. collector-to-base voltage.



NOTE: AMPLIFIER MADE ON 1/32 IN. (0.79mm) TEFLON -FIBERGLASS BOARD

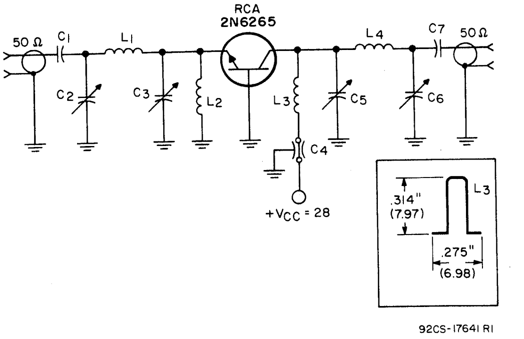
C_1,C_4: 1000 pF CERAMIC, ATC-100, OR EQUIVALENT
C_2,C_3: 0.001 μF FEEDTHROUGH
R_1: 0.24 Ω
RFC: 5 TURNS, NO. 28 WIRE, 0.05 IN. (1.27 mm) ID, 0.04 IN. (1.02mm) LONG

DIMENSIONS IN PARENTHESES ARE IN MILLIMETERS AND ARE DERIVED FROM THE ORIGINAL INCH DIMENSIONS

92CS-19692

Fig. 9—Typical 1-GHz microstripline power amplifier.

APPLICATION DATA



C_1, C_7: 1000 pF, ceramic, leadless
C_2, C_6: 0.35-3.5 pF, air-dielectric, Johanson 4701, or equivalent
C_3, C_5: 1-10 pF, air-dielectric, Johanson 2957, or equivalent
C_4: 1000 pF, feedthrough, Allen-Bradley FA5C, or equivalent
L_1, L_4: 0.01 in. (0.254)* thick, 0.157 in. (3.98)* wide copper strip shaped as shown in inset drawing
L_2, L_3: RF choke, 0.1μH, Nytronics Deci-Ductor, or equivalent

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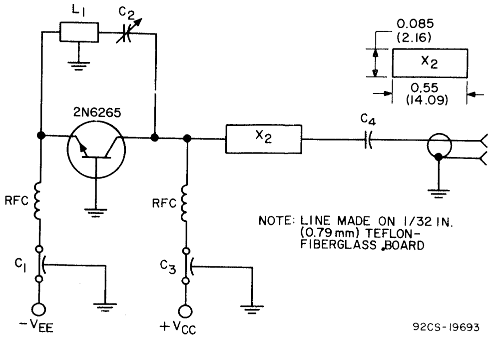
*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

Fig. 10—Typical lumped-element circuit for 1-GHz power amplifier.

APPLICATION DATA (cont'd)



NOTE: LINE MADE ON 1/32 IN. (0.79mm) TEFLON-FIBERGLASS BOARD

92CS-19693

C1,C3: FILTERCON, ALLEN-BRADLEY SMFB-A1, OR EQUIVALENT

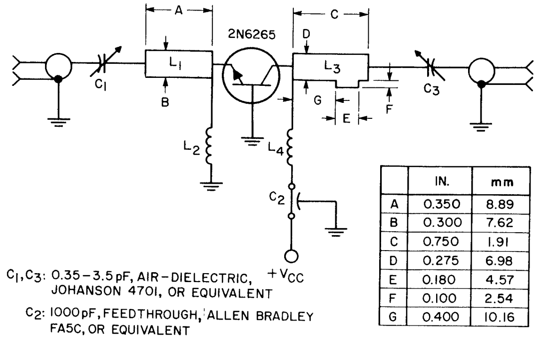
C2: 0.3-3.5 pF, JOHANSON 4700, OR EQUIVALENT

C4: 300 pF, ATC-100, OR EQUIVALENT

L1: 1.0 IN. (25.4mm) SECTION MINIATURE 50 CABLE

RFC: 3 TURNS, NO. 32 WIRE 0.0625 IN. (1.58mm) ID, 0.187 IN. (4.76 mm) LONG.

Fig. 11—Typical 1.7-GHz oscillator circuit.



	IN.	mm
A	0.350	8.89
B	0.300	7.62
C	0.750	1.91
D	0.275	6.98
E	0.180	4.57
F	0.100	2.54
G	0.400	10.16

C1,C3: 0.35–3.5 pF, AIR-DIELECTRIC, JOHANSON 4701, OR EQUIVALENT

C2: 1000 pF, FEEDTHROUGH, ALLEN BRADLEY FA5C, OR EQUIVALENT

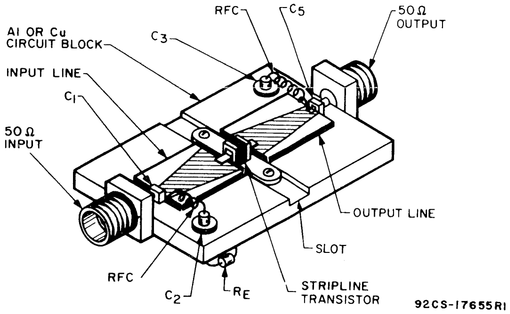
L1,L3: MICROSTRIPLINE, 2 OZ. COPPER-CLAD 1/32 IN. (0.8)* TEFLON-FIBERGLASS

L2,L4: RF CHOKE, 4 TURNS NO. 28 WIRE, 0.062 IN. (1.57)* ID, 3/16 IN. (4.75)* LONG

92CS-19694

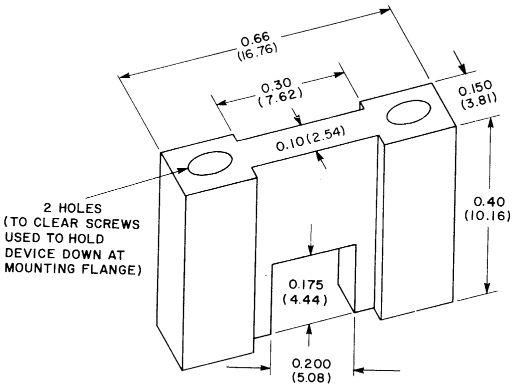
*NOTE: DIMENSIONS IN PARENTHESES ARE IN MILLIMETERS AND ARE DERIVED FROM THE ORIGINAL INCH DIMENSIONS SHOWN.

Fig. 12—Typical circuit for 2-GHz microstripline amplifier.



C1, C5: DC-blocking capacitors
C2, C3: Feedthrough or filter capacitors

(a) Typical circuit



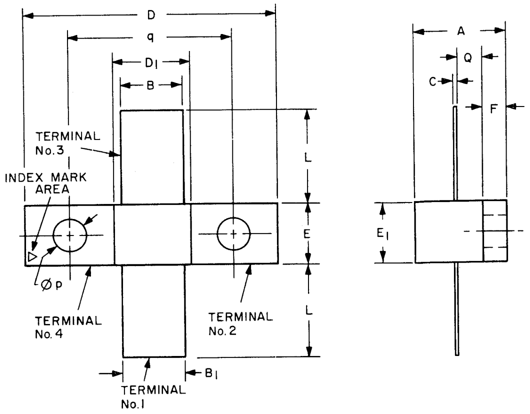
Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

(b) Circuit shield (Place over device and screw down to circuit board).

NOTE: The circuit shield (b) can be made as a part of a ridge in the circuit board (a) instead of the slot shown, and the device can be mounted upside down in a slot in this ridge for equivalent circuit isolation. For operation in the 2-2.4 GHz range, it is recommended that the circuit be completely shielded to prevent losses due to circuit radiation at these frequencies.

Fig. 13—Typical circuit construction.

DIMENSIONAL OUTLINE



NOTE: EMITTER IS GOLD PLATED

92CS-17609

SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.225	0.250	5.72	6.35
B	0.145	0.160	3.69	4.06
B_1	0.165	0.180	4.20	4.57
C	0.004	0.010	0.102	0.254
D	0.657	0.667	16.69	16.94
D_1	0.190	0.210	4.83	5.33
E	0.155	0.165	3.94	4.19
E_1	0.140	0.165	3.56	4.19
F	0.058	0.063	1.48	1.72
L	0.235	0.265	5.97	6.73
ϕp	0.090	0.096	2.286	2.438
Q	0.062	0.077	1.58	1.95
q	0.420	0.440	10.67	11.17

Dimensions in millimeters are derived from the basic inch dimensions as shown.

TERMINAL CONNECTIONS

Terminal 1 – Emitter
Terminals 2 & 4 – Base
Terminal 3 – Collector

SOLDERING INSTRUCTIONS

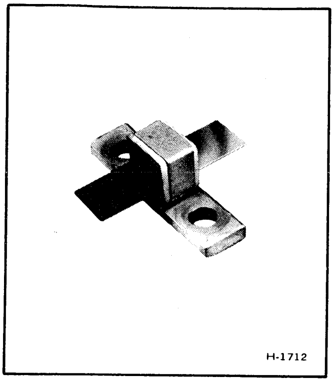
When soldering the 2N6265 into a microstripline or lumped-constant circuit, the collector and emitter terminals of the device must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal-resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230°C for a maximum of 10 seconds during tinning and subsequent soldering operations.

WARNING: The ceramic body of this device contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

Solid State
Division

RF Power Transistors

2N6266



5-W, 2-GHz, Emitter-Ballasted Silicon N-P-N Overlay Transistor

For UHF/Microwave Power Amplifiers,
Microwave Fundamental-Frequency
Oscillators and Frequency Multipliers

Features

- **Emitter-ballasting resistors**
- **VSWR capability of ∞ :1 at 2 GHz**
- **5 W output with 7 dB gain (min.) at 2 GHz**
- **13.5 W output with 11 dB gain (typ.) at 1 GHz**
- **Ceramic-metal hermetic stripline package with low inductance and low parasitic capacitances**
- **Stable common-base operation**
- **For microstripline, stripline, and lumped-constant circuit applications**

RCA – 2N6266• is an epitaxial silicon n-p-n planar transistor featuring the overlay multiple-emitter-site construction and emitter-ballasting resistors. It is intended for solid-state equipment for microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance-measuring equipment, transponder, and collision-avoidance systems. The device can be used in large-signal cw or pulsed applications over the range of 0.5 GHz to 2.4 GHz in stripline, microstripline, or lumped-constant circuits.

The ceramic-metal stripline package of the 2N6266 features low parasitic capacitances and inductances which provide for stable operation in the common-base configuration. The use of emitter-ballasting resistors and the low-thermal-resistance package provide ruggedness and reliability.

•Formerly RCA Dev. No. TA7994.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

* **COLLECTOR-TO-BASE VOLTAGE**	V_{CBO}	50	V
* **COLLECTOR-TO-EMITTER VOLTAGE:**			
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	V
* **EMITTER-TO-BASE VOLTAGE**	V_{EBO}	3.5	V
* **CONTINUOUS COLLECTOR CURRENT**	I_C	1	A
* **TRANSISTOR DISSIPATION:**	P_T		
At case temperature up to 75°C		14.8	W
At case temperature above 75°C		Derate linearly at 0.118 W/°C	
* **TEMPERATURE RANGE:**			
Storage and operating (Junction)		-65 to +200	°C
* **CASE TEMPERATURE** (during soldering)			
For 10 s max.		230	°C

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*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, *at Case Temperature (T_C) = 25°C, unless otherwise specified*

STATIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS		UNITS
			DC Collector or Base Voltage (V)		DC Current (mA)					
			V_{CE}	V_{BE}	I_E	I_B	I_C	Min.	Max.	
*	Collector-Cutoff Current	I_{CES}	45	0				–	2	mA
	At T_C = 55°C		40	0				–	2	
	Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		5	50	–	V
*	Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
*	Collector-to-Emitter Breakdown Voltage With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$					10	50	–	V
	Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				20	100	–	1	V
	Thermal Resistance: (Junction-to-Flange)	$R_{\theta JF}$						–	8.5	°C/W

DYNAMIC

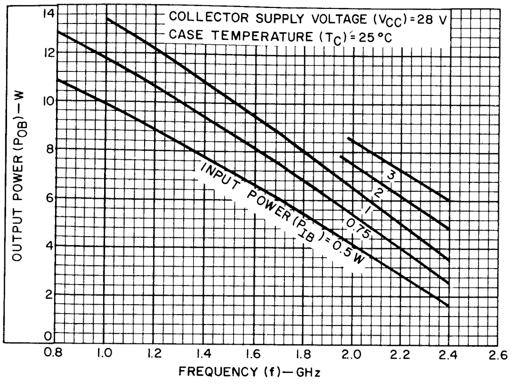
	CHARACTERISTIC	SYMBOL	TEST CONDITIONS		LIMITS		UNITS
			Frequency (f) – GHz	DC Collector Supply Voltage (V_{CC}) – V	Min.	Max.	
	Output Power, P_{IB} = 1 W (See Figs. 7 & 11)	P_{OB}	2	28	5	–	W
*	Power Gain, P_{OB} = 5 W	G_{PB}	2	28	7	–	dB
*	Collector Efficiency, P_{OB} = 5 W	η_C	2	28	33	–	%
*	Collector-to-Base Capacitance V_{CB} = 30 V	C_{obo}	1 MHz	–	–	10	pF

*In accordance with JEDEC registration data format (JS-6 RDF-3/JS-9 RDF-7)

TYPICAL APPLICATION INFORMATION

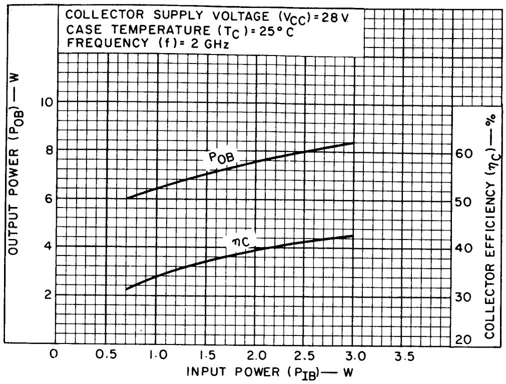
CIRCUIT & FREQUENCY		See Fig.	DC Collector Supply Voltage (V_{CC}) – V	Input Power (P_{IB}) – W	Output Power (P_{OB}) – W
Microstripline 1–GHz Amplifier		10	28	1	13.5
Microstripline 2–GHz Amplifier		11	28	1	6
Microstripline (Broadband) 1.2–1.4-GHz Amplifier	Pulsed Power: Pulse Duration = 1.3 ms Duty Factor = 30%	12	28	1	12
Microstripline 1.7–1.8-GHz Tunable Oscillator		13	28	–	3

PERFORMANCE DATA



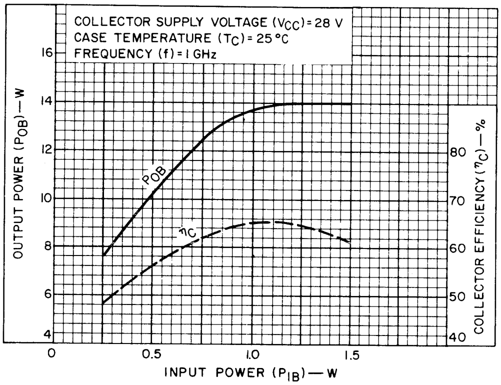
92CS-17643

Fig. 1—Typical output power vs. frequency in test set-up of Fig. 7.



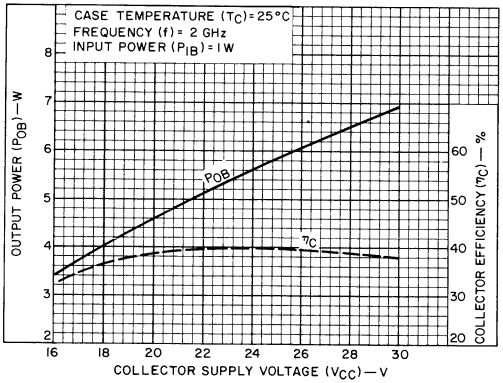
92CS-17644

Fig. 2—Typical output power or collector efficiency vs. input power at 2 GHz in test set-up of Fig. 7.



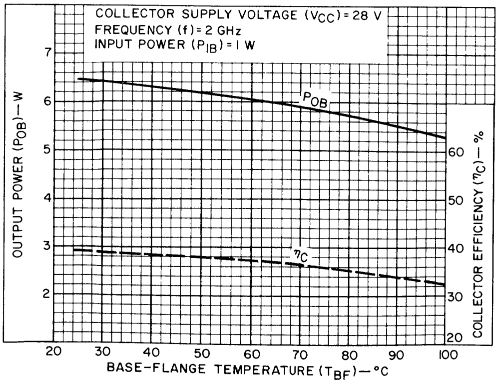
92CS-17645

Fig. 3—Typical output power or collector efficiency vs. input power at 1 GHz in test set-up of Fig. 7.



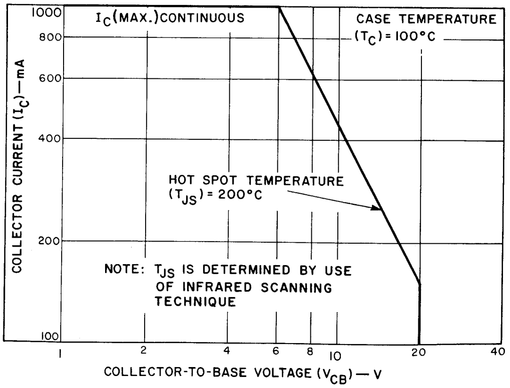
92CS-17646

Fig. 4—Typical output power or collector efficiency vs. collector supply voltage at 2 GHz in test set-up of Fig. 7.



92CS-17647RI

Fig. 5—Typical output power vs. case temperature at 2 GHz.



92CS-17648

Fig. 6—Maximum operating area for forward-bias operation.

PERFORMANCE DATA (Cont'd)

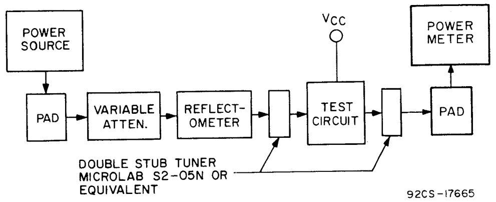


Fig. 7–Block diagram of test set-up for measurement of rf performance from 1- or 2-GHz common-base amplifier.

DESIGN DATA

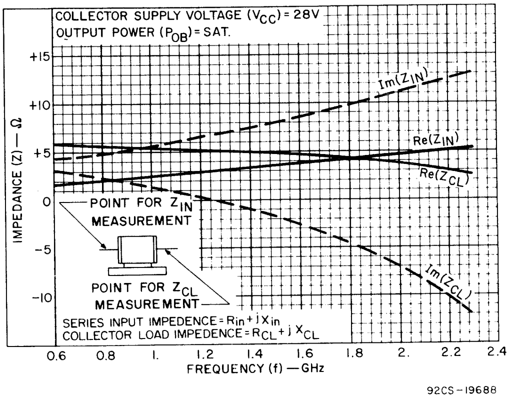
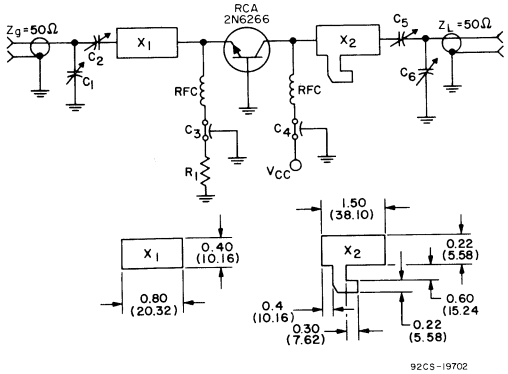


Fig. 8–Typical large-signal series input impedance or large-scale collector load impedance vs. frequency.



C_1, C_2, C_5, C_6: 0.8–10 pF, Johanson 5202, or equivalent
C_3, C_4: Filtercon, Allen-Bradley SMFB-A1, or equivalent
RFC: No. 32 wire, 3 turns, 0.0625 in. (1.58 mm) ID, 0.187 in. (4.76 mm) long
R_1: 1 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

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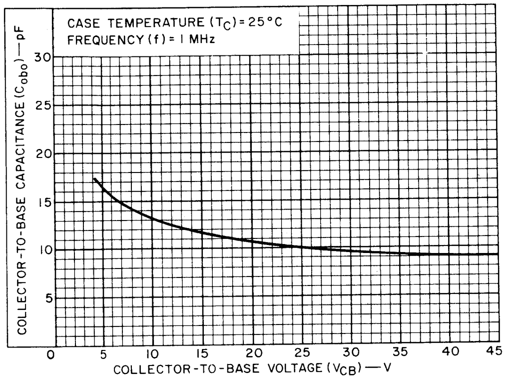
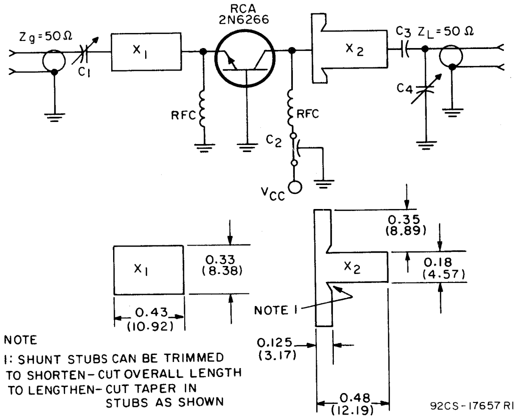
*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

Fig. 10–Typical 1-GHz microstripline power amplifier circuit.



92CS-17649

Fig. 9–Typical collector-to-base capacitance vs. collector-to-base voltage.



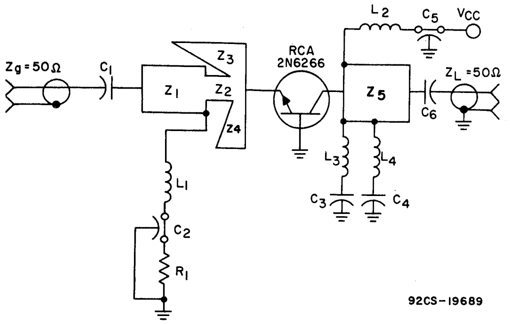
C_1, C_3, C_4: 0.3–3.5 pF, Johanson 4700, or equivalent
C_2: Filtercon, Allen-Bradley SMFB-A1, or equivalent
RFC: No. 32 wire, 0.4 in. (10.16 mm) long

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

---

*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

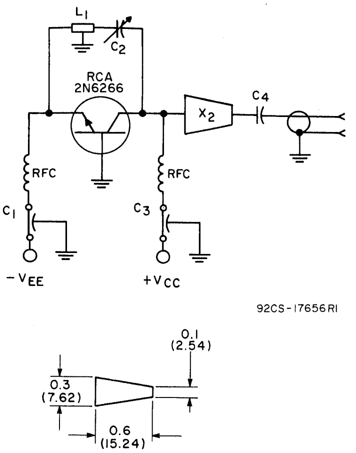
Fig. 11–Typical 2-GHz microstripline power amplifier circuit.



C_1, C_3, C_4, C_6: 1000 pF ceramic, ATC-100, or equivalent
C_2, C_5: 1000 pF feedthrough
L_1, L_2: RFC, 5 turns No. 32 wire, 0.0625 in. (1.58 mm) ID, 0.25 in. (6.35 mm) long
L_3: 0.005 in. (0.127 mm) lead length (C_3 lead)
L_4: 0.250 in. (6.35 mm) lead length (C_4 lead)
R_1: 0.47 Ω
Z_1: 0.34 in. x 0.525 in. (8.63 mm x 13.34 mm)
Z_2: 0.215 in. x 0.235 in. (5.46 mm x 5.97 mm)
Z_3: 0.075 in. x 0.4 in. x 0.77 in. (1.91 mm x 10.16 mm x 19.56 mm)
Z_4: 0.075 in. x 0.575 in. x 0.435 in. (1.91 mm x 14.61 mm x 11.05 mm)
Z_5: 1.12 in. (28.45 mm) x 0.59 in. (14.98 mm)

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

Fig. 12—Typical 1.2–1.4-GHz broadband amplifier circuit.



C_1, C_3: Filtercon, Allen-Bradley SMFB-A1, or equivalent
C_2: 0.3–3.5 pF, Johanson 4700, or equivalent
C_4: 300 pF, ATC–100 or equivalent
L_1: 1.0 in. (25.4 mm) length section miniature 50 Ω cable, or microstrip equivalent
RFC: 3 turns, No. 32 wire, 0.0625 in. (1.59 mm) ID, 0.187 in. (4.76 mm) long
X_2: 0.013 in. (0.33 mm) thick Teflon-Kapton double-clad circuit board (Grade PE-1243 as supplied by Budd Polychem Division, Newark, Delaware), or equivalent.
Line X_2 is exponentially tapered

NOTE: Oscillator is single screw tunable 1.6 GHz to 1.8 GHz

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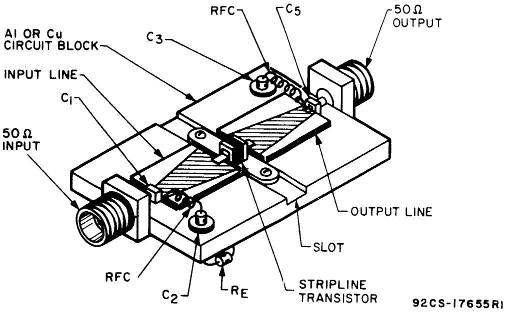
*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

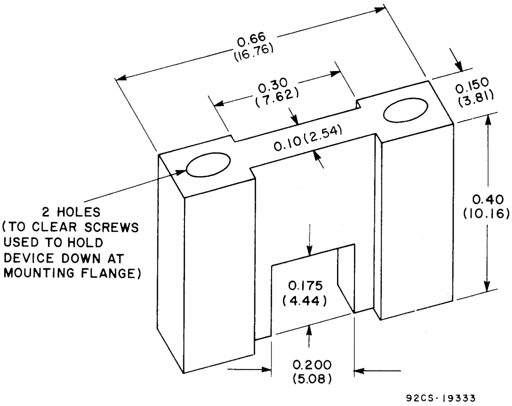
Fig. 13—Typical 1.7-GHz oscillator circuit.



C_1, C_5: DC-blocking capacitors
C_2, C_3: Feedthrough or filter capacitors

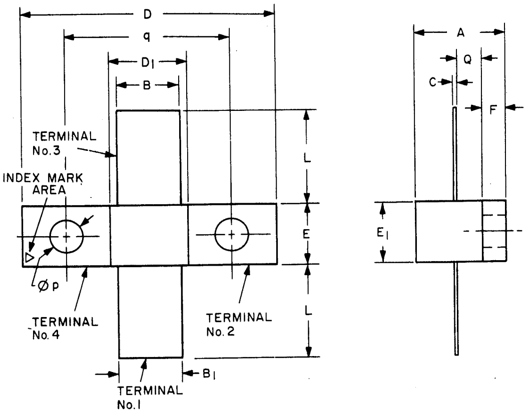
(a) Typical circuit

NOTE: The circuit shield (b) can be made as a part of a ridge in the circuit board (a) instead of the slot shown, and the device can be mounted upside down in a slot in this ridge for equivalent circuit isolation. For operation in the 2-2.4-GHz range, it is recommended that the circuit be completely shielded to prevent losses due to circuit radiation at these frequencies.



(b) Circuit shield (Place over device and screw down to circuit board).

Fig. 14—Typical circuit construction.



NOTE: EMITTER IS GOLD PLATED

92CS-17609

SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.225	0.250	5.72	6.35
B	0.145	0.160	3.69	4.06
B_1	0.165	0.180	4.20	4.57
C	0.004	0.010	0.102	0.254
D	0.657	0.667	16.69	16.94
D_1	0.190	0.210	4.83	5.33
E	0.155	0.165	3.94	4.19
E_1	0.140	0.165	3.56	4.19
F	0.058	0.063	1.48	1.72
L	0.235	0.265	5.97	6.73
ϕp	0.090	0.096	2.286	2.438
Q	0.062	0.077	1.58	1.95
q	0.420	0.440	10.67	11.17

Dimensions in millimeters are derived from the basic inch dimensions as shown.

TERMINAL CONNECTIONS

Terminal 1 - Emitter
Terminals 2 & 4 - Base
Terminal 3 - Collector

SOLDERING INSTRUCTIONS

When the 2N6266 is soldered into a microstripline or lumped-constant circuit, the collector and emitter terminals of the device must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal-resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230°C for a maximum of 10 seconds during tinning and subsequent soldering operations.

WARNING: The ceramic body of this device contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

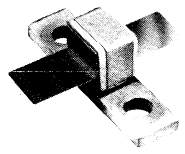
RCA
Solid State
Division

RF Power Transistors

2N6267

10-W, 2-GHz, Emitter-Ballasted Silicon N-P-N Overlay Transistor

For UHF/Microwave Power Amplifiers, Microwave Fundamental-Frequency Oscillators, and Frequency Multipliers



RCA HF-28 PACKAGE

H-1712

Features

- **Emitter-ballasting resistors**
- **10 W output with 7 dB gain (min.) at 2 GHz (28 V)**
- **8 W output with 6 dB gain (typ.) at 2.3 GHz (28 V)**
- **VSWR capability of 10:1 at 2 GHz**
- **Ceramic metal hermetic stripline package with low inductance and low parasitic capacitances**
- **Stable common-base operation**
- **For microstripline, stripline, and lumped-constant circuit applications**

RCA – 2N6267● is an epitaxial silicon n-p-n planar transistor featuring the overlay multiple-emitter-site construction and emitter-ballasting resistors. It is intended for solid-state equipment for microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance-measuring equipment, transponder, and collision-avoidance systems. The device can be used in large-signal cw or pulsed applications over the range of 0.5 GHz to 2.4 GHz in stripline, microstripline, or lumped-constant circuits.

The ceramic-metal stripline package of the 2N6267 features low parasitic capacitances and inductances which afford stable operation in the common-base configuration. The use of emitter-ballasting resistors and the low-thermal-resistance package provide increased ruggedness and reliability.

●Formerly RCA Dev. No. TA7995

MAXIMUM RATINGS, *Absolute-Maximum Values:*

*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	50	V
*COLLECTOR-TO-EMITTER VOLTAGE:			
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
*CONTINUOUS COLLECTOR CURRENT	I_C	1.5	A
*TRANSISTOR DISSIPATION:	P_T		
At case temperature up to 75°C		21	W
At case temperature above 75°C		Derate linearly at 0.168 W/°C	
*TEMPERATURE RANGE:			
Storage and operating (Junction)		-65 to +200	°C
*CASE TEMPERATURE (during soldering)			
For 10 s max.		230	°C

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, *at Case Temperature (T_C) = 25°C* unless otherwise specified

STATIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS: DC COLLECTOR OR BASE VOLTAGE (V)		DC CURRENT (mA)			LIMITS		UNITS
			V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	
*	Collector-Cutoff Current	I_{CES}	45	0				–	2	mA
	At T_C = 55°C		40	0				–	2	
	Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		5	50	–	V
*	Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	V
*	Collector-to-Emitter Breakdown Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$					10	50	–	V
	Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				20	100	–	1	V
	Thermal Resistance: (Junction-to-Flange)	$R_{\theta JF}$						–	6	°C/W

DYNAMIC

	CHARACTERISTIC	SYMBOL	TEST CONDITIONS: FREQUENCY (f) – GHz	TEST CONDITIONS: DC COLLECTOR SUPPLY VOLTAGE (V_{CC}) – V	LIMITS MIN.	LIMITS MAX.	UNITS
	Output Power, P_{IB} = 2 W	P_{OB}	2	28	10	–	W
*	Power Gain, P_{OB} = 10 W	G_{PB}	2	28	7	–	dB
*	Collector Efficiency, P_{OB} = 10 W	η_C	2	28	35	–	%
*	Collector-to-Base Capacitance V_{CB} = 30 V	C_{obo}	1 MHz	–	–	13	pF

*In accordance with JEDEC registration data format (JS-6 RDF-3/JS-9 RDF-7)

TYPICAL APPLICATION INFORMATION

CIRCUIT & FREQUENCY		SEE FIG.	DC COLLECTOR SUPPLY VOLTAGE (V_{CC}) – V	INPUT POWER (P_{IB}) – W	OUTPUT POWER (P_{OB}) – W
Microstripline: 1–GHz Amplifier		14	28	1.5	14
Microstripline: 2–GHz Amplifier		13	28	2	12
Microstripline: 2.3–GHz Amplifier		16	28	2	8
Microstripline: 1.3–GHz Amplifier	Pulsed Power: Pulse Duration = 1.3 ms Duty Factor = 30%	15	28	2	18
Microstripline: 1.6-1.8–GHz Tunable Oscillator		17	20	–	4

PERFORMANCE DATA

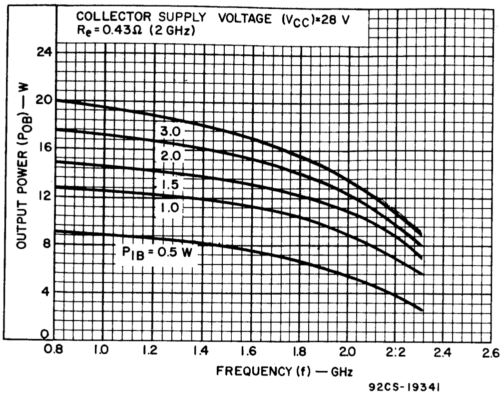


Fig.1— Typical output power vs. frequency in the test set-up of Fig. 8.

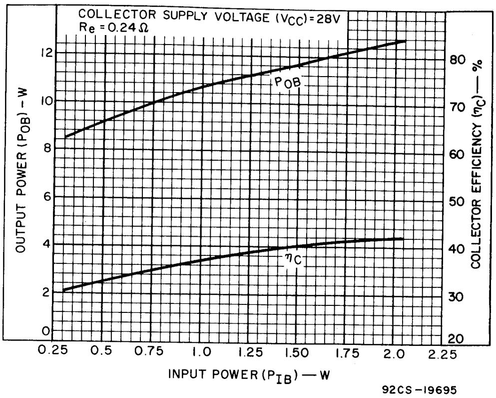


Fig.2—Typical output power and collector effeciency vs. input power at 2 GHz in the test set-up of Fig.8.

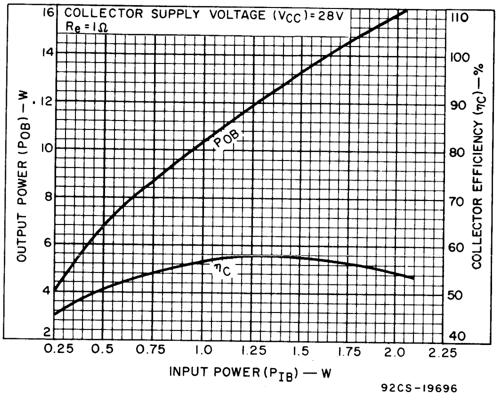


Fig.3—Typical output power and collector efficiency vs. input power at 1 GHz in the test set-up of Fig.8.

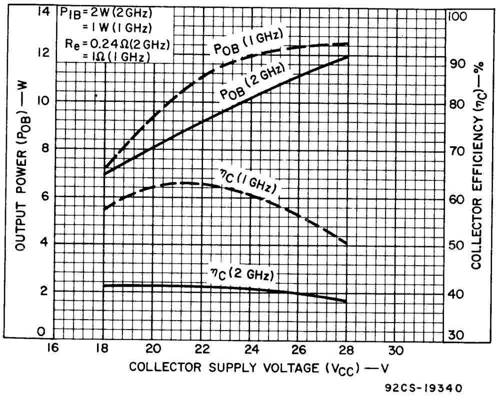


Fig.4—Typical output power and collector efficiency vs. collector supply voltage.

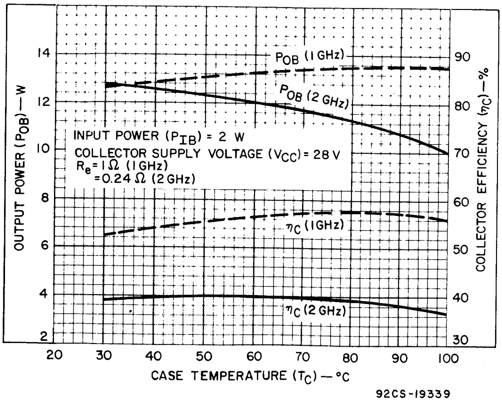


Fig.5—Typical output power vs. case temperature.

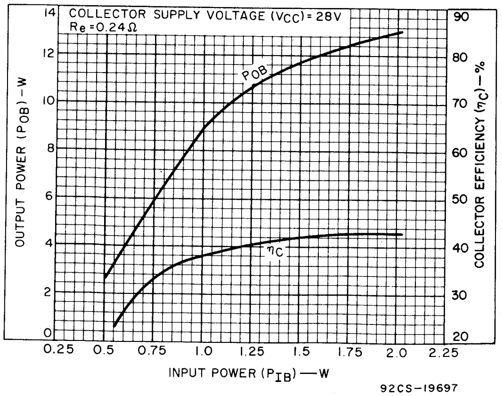


Fig.6—Typical output power and collector efficiency at 2 GHz in circuit of Fig.13.

PERFORMANCE DATA (CONT'D)

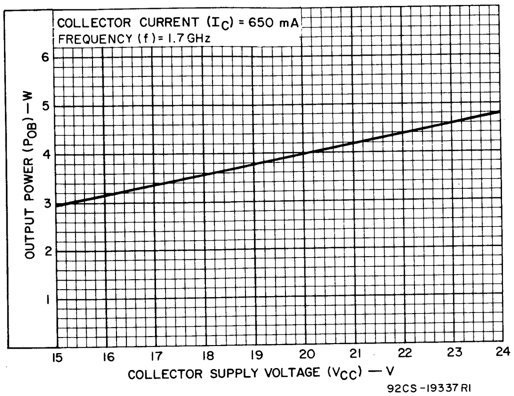


Fig.7–Typical output power in oscillator circuit shown in Fig.17.

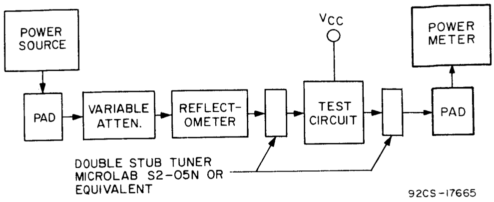


Fig.8–Block diagram of test set-up for measurement of rf performance from 1- or 2-GHz common-base amplifier.

DESIGN DATA

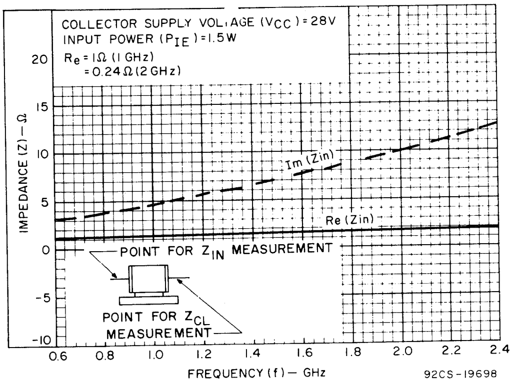


Fig.9–Typical large-signal series input impedance vs. frequency.

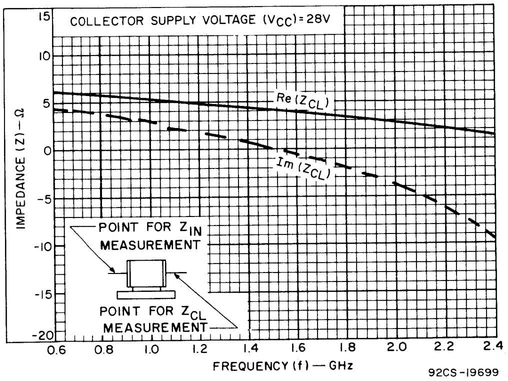


Fig.10–Typical large-signal collector load impedance vs. frequency.

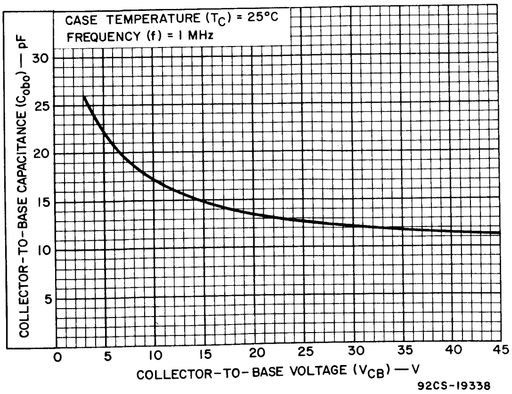


Fig.11–Typical collector-to-base capacitance vs. collector-to-base voltage.

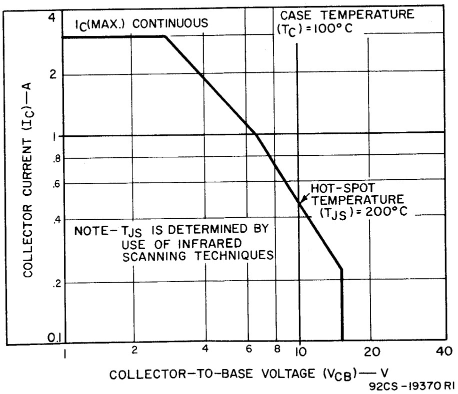
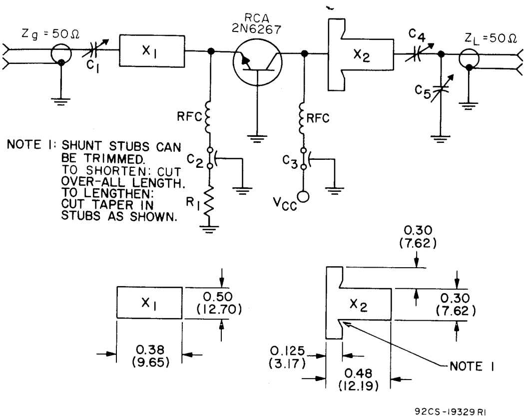


Fig.12–Maximum operating area for forward-bias operation.

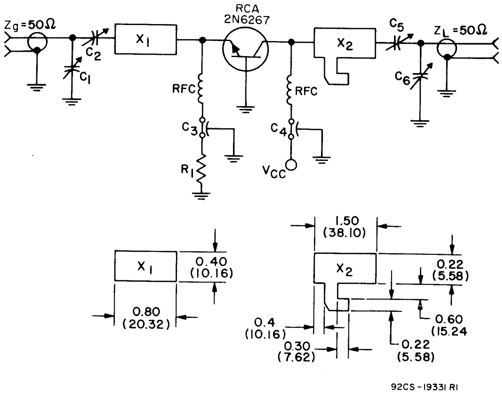
APPLICATION DATA



C_1, C_4, C_5: 0.3–3.5 pF, Johanson 4700, or equivalent
C_2, C_3: Filtercon, Allen-Bradley SMFB-A1, or equivalent
RFC: No. 32, wire, 0.4 in. (10.16 mm) long
R_1: 0.24 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board ($\epsilon = 2.6$). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

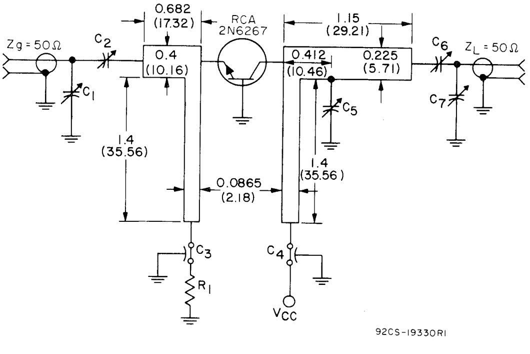
Fig. 13—Typical 2-GHz power amplifier circuit.



C_1, C_2, C_5, C_6: 0.8–10 pF, Johanson 5202, or equivalent
C_3, C_4: Filtercon, Allen-Bradley SMFB-A1, or equivalent
RFC: No. 32 wire, 3 turns, 0.0625 in. (1.58 mm) ID x 0.187 in. (4.76 mm) long
R_1: 1 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board ($\epsilon = 2.6$). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

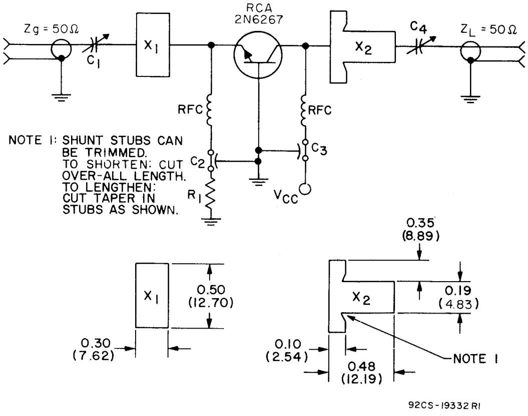
Fig. 14—Typical 1-GHz power amplifier circuit.



C_1, C_2, C_6: 1-10 pF JFD Electronics, MVM010, or equivalent
C_5, C_7: 0.3-3.5 pF, JFD Electronics, MVM003, or equivalent
C_3, C_4: 1000 pF feedthrough, Allen-Bradley FA5C, or equivalent
R_1: 0.75 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board ($\epsilon = 2.6$). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

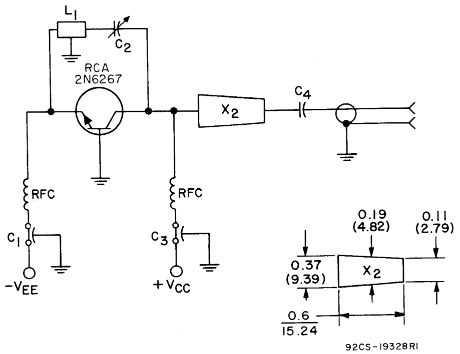
Fig. 15—Typical 1.3-GHz power amplifier circuit.



C_1, C_4: 0.3–3.5 pF, Johanson 4700, or equivalent
C_2, C_3: Filtercon, Allen-Bradley SMFB-A1, or equivalent
RFC: No. 32 wire, 0.4 in. (10.16 mm) long
R_1: 0.24 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board ($\epsilon = 2.6$). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

Fig. 16—Typical 2.3-GHz amplifier circuit.



C_1, C_3: Filtercon, Allen-Bradley SMFB-A1, or equivalent
C_2: 0.3–3.5 pF, Johanson 4700, or equivalent
C_4: 300 pF, ATC–100 or equivalent
L_1: 1.0 in (25.4 mm) length section miniature 50 Ω cable, or microstrip equivalent
RFC: 3 turns, No. 32 wire, 0.0625 in. ID, (1.59 mm) ID, 0.187 in. (4.76 mm) long
X_2: 0.013 in. (0.33 mm)—thick Teflon-Kapton double-clad circuit board (Grade PE-1243 as supplied by Budd Polychem Division, Newark, Delaware), or equivalent.
Line X_2 is exponentially tapered

Dimensions in parentheses are in millimeters and are derived from the original inch dimensions as shown.
NOTE: Oscillator is single screw tunable 1.6 GHz to 1.8 GHz

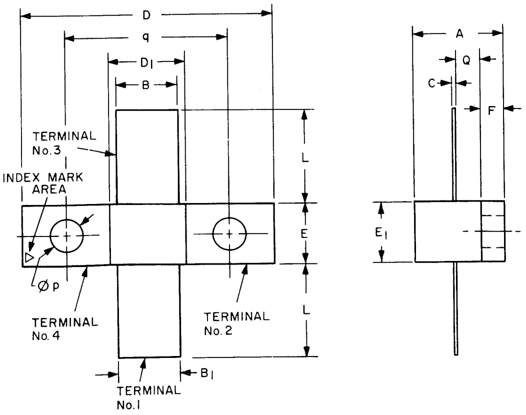
Fig. 17—Typical 1.7-GHz oscillator circuit.

TERMINAL CONNECTIONS

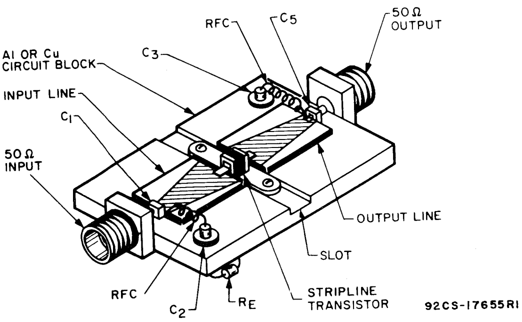
Terminal 1 — Emitter
Terminals 2 & 4 — Base
Terminal 3 — Collector

WARNING: The ceramic body of this device contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

DIMENSIONAL OUTLINE

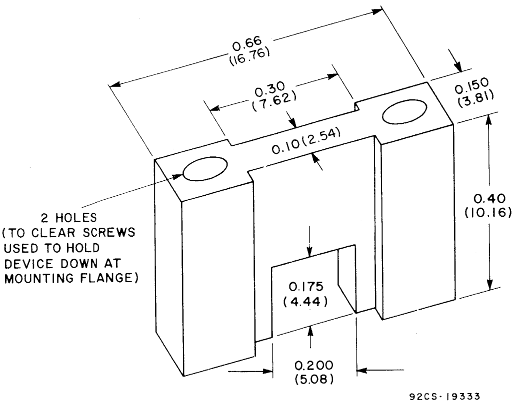


NOTE: EMITTER IS GOLD PLATED



C_1, C_5: DC-blocking capacitors
C_2, C_3: Feedthrough or filter capacitors

(a) Typical circuit



Dimensions in parentheses are in millimeters and are derived from the original inch dimensions as shown.

(b) Circuit shield (Place over device and screw down to circuit board).

NOTE: The circuit shield (b) can be made as a part of a ridge in the circuit board (a) instead of the slot shown, and the device can be mounted upside down in a slot in this ridge for equivalent circuit isolation. For operation in the 2-2.4 GHz range, it is recommended that the circuit be completely shielded to prevent losses due to circuit radiation at these frequencies.

Fig. 18—Typical circuit construction.

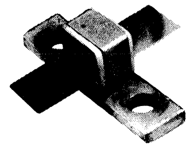
SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.225	0.250	5.72	6.35
B	0.145	0.160	3.69	4.06
B_1	0.165	0.180	4.20	4.57
C	0.004	0.010	0.102	0.254
D	0.657	0.667	16.69	16.94
D_1	0.190	0.210	4.83	5.33
E	0.155	0.165	3.94	4.19
E_1	0.140	0.165	3.56	4.19
F	0.058	0.063	1.48	1.72
L	0.235	0.265	5.97	6.73
ϕp	0.090	0.096	2.286	2.438
Q	0.062	0.077	1.58	1.95
q	0.420	0.440	10.67	11.17

Dimensions in millimeters are derived from the basic inch dimensions as shown.

Solid State
Division

RF Power Transistors

2N6268 2N6269



6.5- and 2-W, 2.3-GHz, Emitter-Ballaste Silicon N-P-N Overlay Transistors

For Use in Microwave Power Amplifiers
Fundamental-Frequency Oscillators, and Frequency Multipliers

Features

- **Designed for 20- to 24-V equipment**
- **Emitter-ballasting resistors**
- **VSWR capability of 10:1 at 2.3 GHz**
- **2-W output with 7 dB gain (min.) at 2.3 GHz (22V) - 2N6268**
- **6.5-W output with 5 dB gain (min.) at 2.3 GHz - 2N6269**
- **Stable common-base operation**
- **Ceramic-metal hermetic stripline package with low inductance and low parasitic capacitances**
- **For stripline, microstripline, and lumped-constant circuit applications**

RCA-2N6268 and 2N6269• are epitaxial silicon n-p-n planar transistors featuring the overlay multiple-emitter-site construction. They are designed especially for equipment using 20- to 24-V collector supplies in microwave communications, S-band telemetry, microwave relay link, phased-array radar, distance-measuring equipment, transponder, and collision-avoidance systems.

The ceramic-metal stripline package of these devices features low parasitic capacitances and inductances, which affords stable operation in the common-base configuration.

Ideal as a driver for the 2N6269, type 2N6268 can also be used in large-signal applications. The use of emitter-ballasting resistors and the low-thermal-resistance package make the 2N6269 especially suitable for large-signal, cw, or pulsed applications over the range of 0.5 GHz to 2.4 GHz in stripline, microstripline, and lumped-constant circuits.

•Formerly RCA Dev. Nos. TA8407 and TA7995A, respectively.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

		2N6268	2N6269	
*COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	45	45	V
*COLLECTOR-TO-EMITTER VOLTAGE:				
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	45	45	V
*EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	3.5	V
*CONTINUOUS COLLECTOR CURRENT	I_C	0.350	1.5	A
*TRANSISTOR DISSIPATION:	P_T			
At case temperature up to 75°C		6.25	21	W
At case temperature above 75°C Derate linearly at		0.05	0.168	W/°C
*TEMPERATURE RANGE:				
Storage and operating (Junction)		−65 to +200		°C
*CASE TEMPERATURE (during soldering)				
For 10 s max.		230		°C

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

ELECTRICAL CHARACTERISTICS, *at Case Temperature (T_C) = 25°C unless otherwise specified.*

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS					LIMITS				UNITS
		DC COLLECTOR OR BASE VOLTAGE (V)		DC CURRENT (mA)			2N6268		2N6269		
		V_{CE}	V_{BE}	I_E	I_B	I_C	MIN.	MAX.	MIN.	MAX.	
* Collector-Cutoff Current	I_{CES}	40	0				–	2	–	2	mA
At T_C = 55°C		30	0				–	1	–	–	
		35	0				–	–	–	2	
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$			0		5	45	–	45	–	V
* Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$			0.1		0	3.5	–	3.5	–	V
* Collector-to-Emitter Breakdown Voltage With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$					10	45	–	45	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$				10	100	–	1	–	–	V
					20	100	–	–	–	1	
Thermal Resistance (Junction-to-Flange)	$R_{\theta JF}$						–	20	–	6	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS		LIMITS				UNITS
		FREQUENCY (f) – GHz	DC COLLECTOR SUPPLY VOLTAGE (V_{CC}) – V	2N6268		2N6269		
				MIN.	MAX.	MIN.	MAX.	
Output Power, P_{IB} = 0.4 W	P_{OB}	2.3	22	2	–	–	–	W
= 2 W		2.3	22	–	–	6.5	–	
* Power Gain, P_{OB} = 2 W	G_{PB}	2.3	22	7	–	–	–	dB
= 6.5 W		2.3	22	–	–	5	–	
* Collector Efficiency, P_{OB} = 2 W	η_C	2.3	22	33	–	–	–	%
= 6.5 W		2.3	22	–	–	32	–	
* Collector-to-Base Capacitance V_{CB} = 30 V	C_{obo}	1 MHz	–	–	5.5	–	13	pF

*In accordance with JEDEC registration data format JS-6 RDF-3/JS-9 RDF-7.

TYPICAL APPLICATION INFORMATION

CIRCUIT & FREQUENCY	SEE FIG.	DC COLLECTOR SUPPLY VOLTAGE (V_{CC}) – V	INPUT POWER (P_{IB}) – W	OUTPUT POWER (P_{OB}) – W
Microstripline: 2.3-GHz Amplifier	28	22	2	7
Microstripline: 2-GHz Amplifier	25	22	2	9
Microstripline: 1.3-GHz Amplifier	27	22	1	11
Microstripline: 2-GHz Amplifier	23	22	0.3	2.1
Microstripline: 1.6–1.8-GHz Tunable Oscillator	29	20	–	3
Lumped Constant: 1-GHz Amplifier	22	22	0.15	3.2

PERFORMANCE DATA

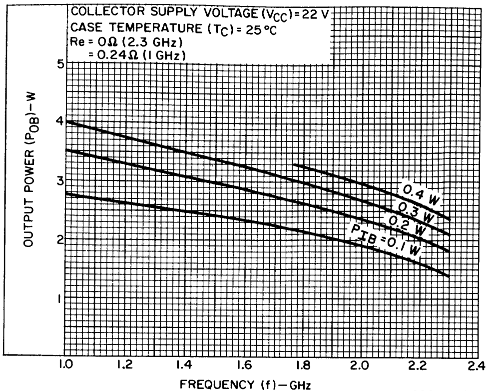


Fig. 1—Typical output power vs. frequency for common-base amplifier in test set-up of Fig. 14 for type 2N6268.

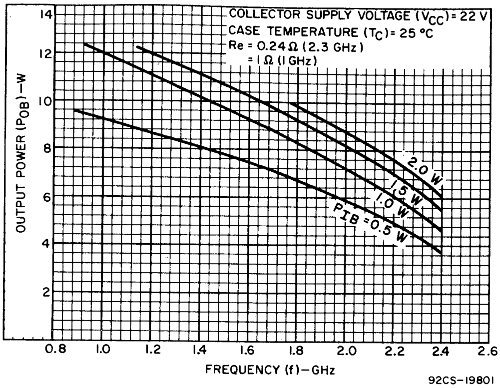


Fig. 2—Typical output power vs. frequency for common-base amplifier in test set-up of Fig. 15 for type 2N6269.

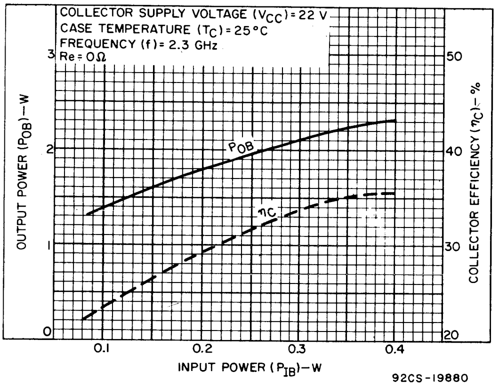


Fig. 3—Typical 2.3-GHz output power and collector efficiency vs. input power in test set-up of Fig. 14 for type 2N6268.

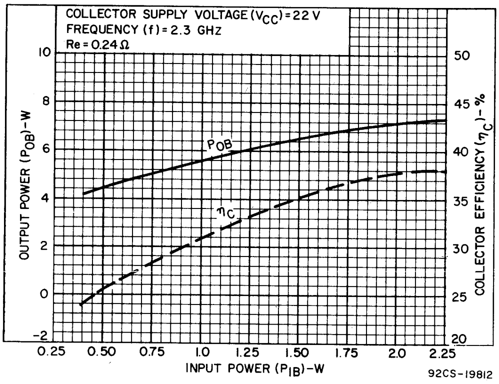


Fig. 4—Typical 2.3-GHz output power and collector efficiency vs. input power in test set-up of Fig. 15 for type 2N6269.

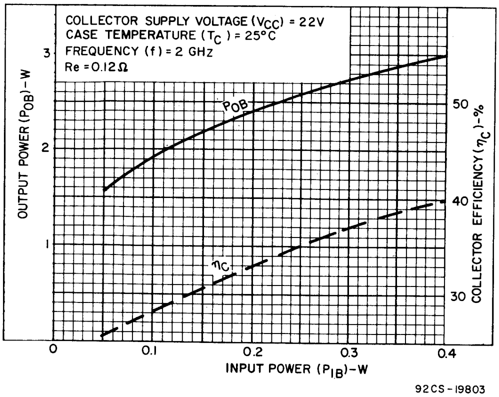


Fig. 5—Typical 2-GHz output power and collector efficiency vs. input power in test set-up of Fig. 14 for type 2N6268.

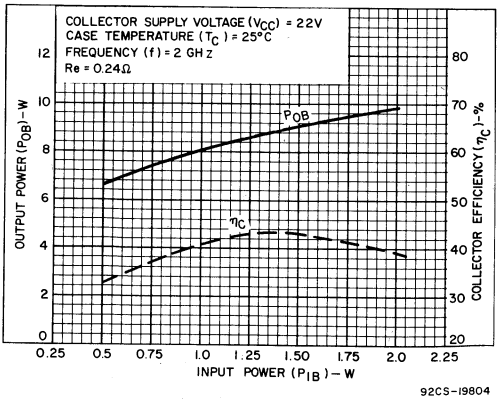


Fig. 6—Typical 2-GHz output power and collector efficiency vs. input power in test set-up of Fig. 15 for type 2N6269.

PERFORMANCE DATA

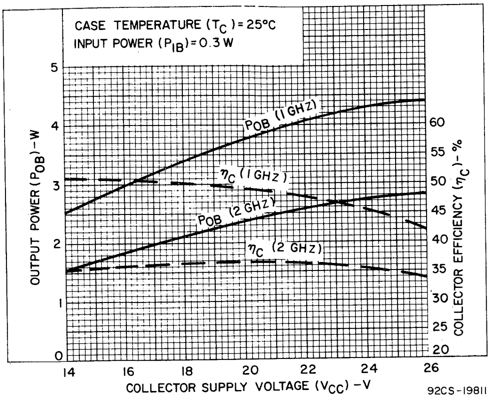


Fig. 7–Typical 1- and 2-GHz output power and collector efficiency vs. supply voltage for type 2N6268.

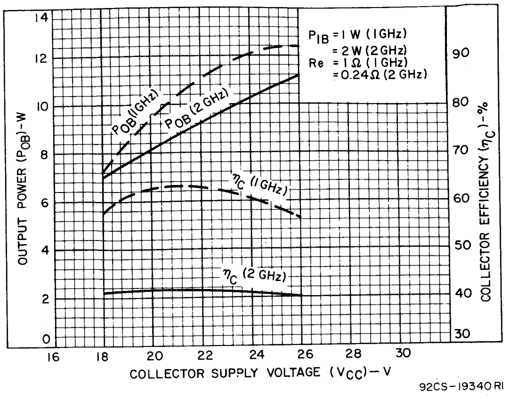


Fig. 8–Typical 1- and 2-GHz output power and collector efficiency vs. supply voltage for type 2N6269.

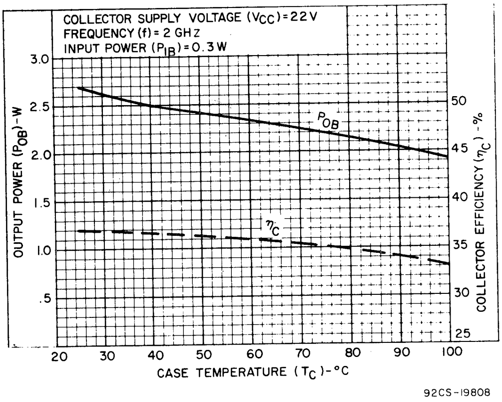


Fig. 9–Typical output power and collector efficiency vs. case temperature for type 2N6268 at 2 GHz.

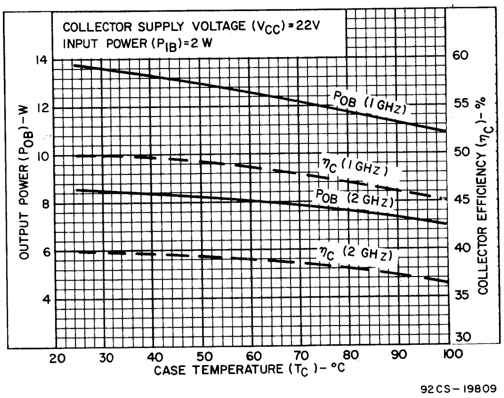


Fig. 10–Typical output power and collector efficiency vs. case temperature for type 2N6269 at 2 GHz.

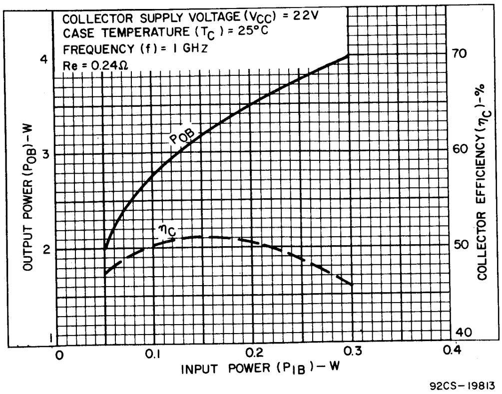


Fig. 11–Typical 1-GHz output power and collector efficiency vs. input power in test set-up of Fig. 14 for type 2N6268.

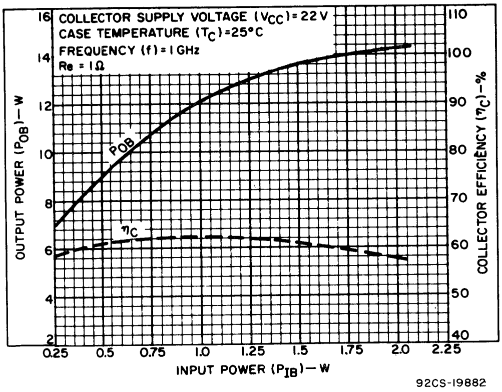


Fig. 12–Typical 1-GHz output power and collector efficiency vs. input power in test set-up of Fig. 15 for type 2N6269.

PERFORMANCE DATA

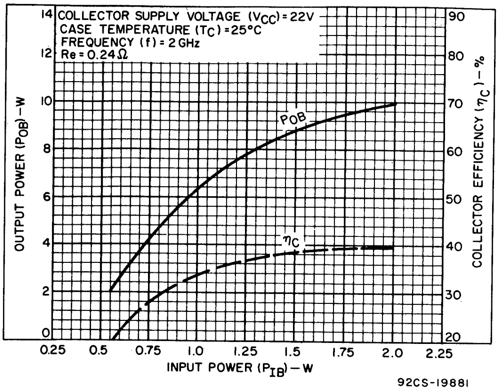


Fig. 13—Typical 2-GHz output power and collector efficiency for type 2N6269 in the circuit of Fig. 25.

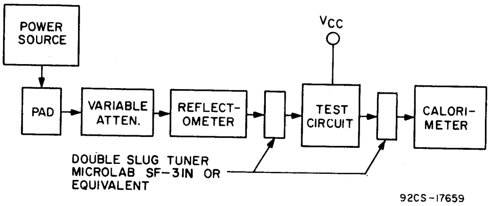


Fig. 14—Block diagram of test set-up for measurement of performance from 1- or 2-GHz common-base amplifier for type 2N6268.

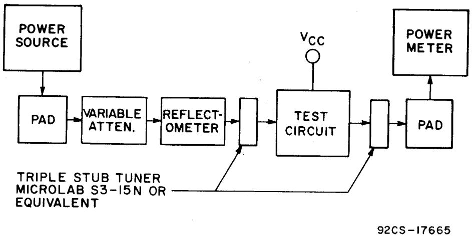


Fig. 15—Block diagram of test set-up for measurement of rf performance from 1- or 2-GHz common-base amplifier for type 2N6269.

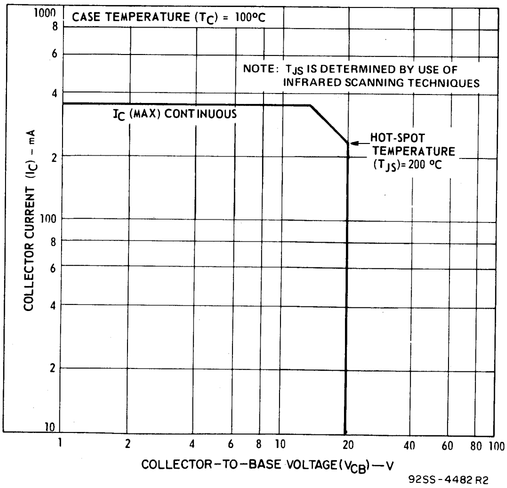


Fig. 16—Maximum operating area for forward-bias operation of type 2N6268.

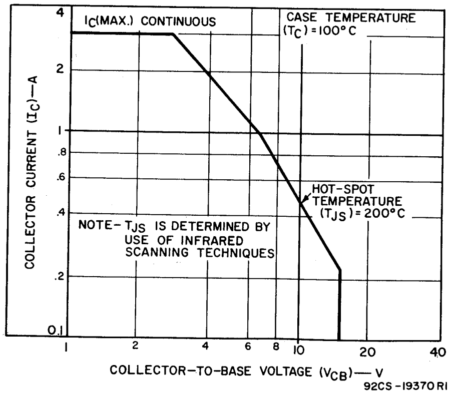


Fig. 17—Maximum operating area for forward-bias operation of type 2N6269.

DESIGN DATA

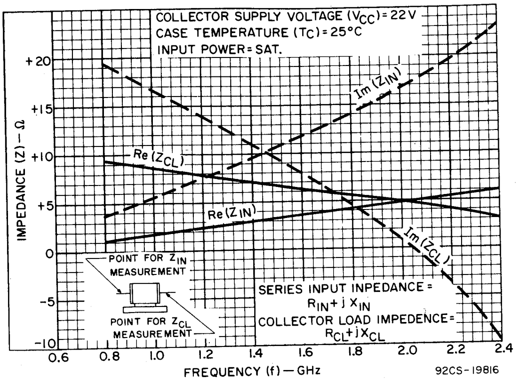


Fig. 18—Typical large-signal series input impedance and large-signal collector load impedance vs. frequency for type 2N6268.

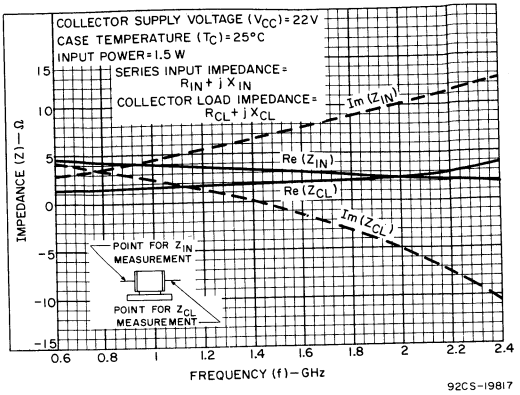


Fig. 19—Typical large-signal series input impedance and large-signal collector load impedance vs. frequency for type 2N6269.

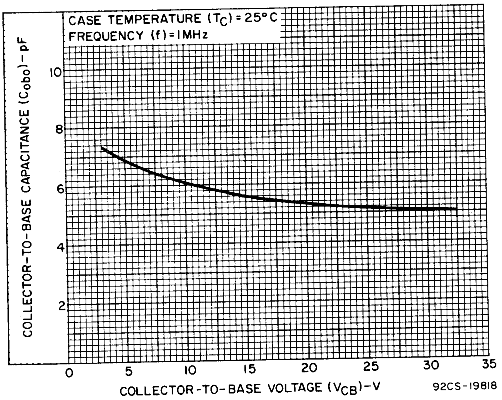


Fig. 20—Typical collector-to-base capacitance vs. collector-to-base voltage for type 2N6268.

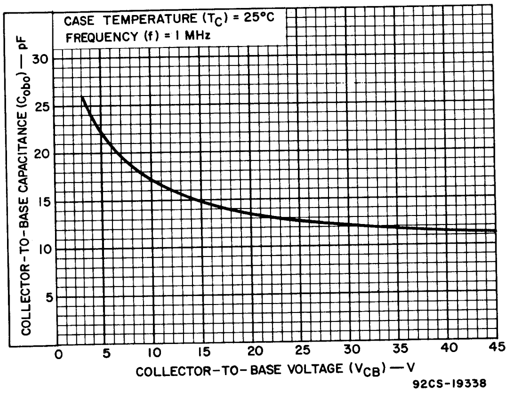
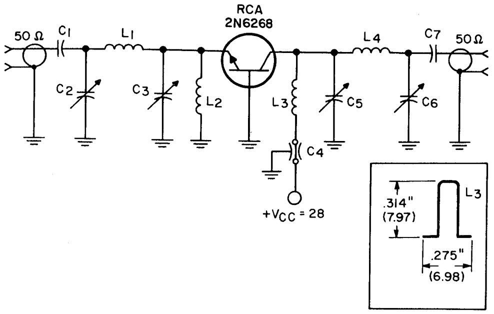


Fig. 21—Typical collector-to-base capacitance vs. collector-to-base voltage for type 2N6269.

2N6268 APPLICATION DATA



C_1, C_7: 1000 pF, ceramic, leadless

C_2, C_6: 0.35-3.5 pF, air-dielectric, Johanson 4701•

C_3, C_5: 1-10 pF, air-dielectric, Johanson 2957 •

C_4: 1000 pF, feedthrough, Allen-Bradley FA5C•

L_1, L_4: 0.01 in. (0.254)* thick, 0.157 in. (3.98)* wide copper strip shaped as shown in inset drawing

L_2, L_3: RF choke, 0.1µH, Nytronics Deci-Ductor•

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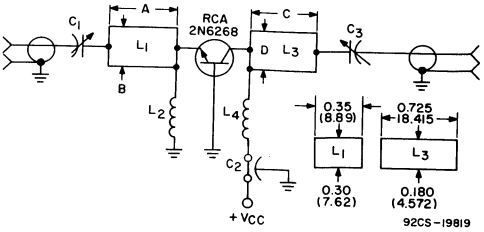
*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

•or equivalent

Fig. 22—Typical lumped-element circuit for 1-GHz power amplifier.



C_1 C_3: 0.35-3.5 pF, air-dielectric, Johanson 4701•

C_2: 1000 pF, feedthrough, Allen-Bradley FA5C•

L_1, L_3: Microstripline, 2 oz. copper-clad 1/32 in (0.8)* Teflon-fiberglass

L_2, L_4: RF choke, 4 turns, No. 28 wire, 0.062 in. (1.57)* ID, 0.187 in. (4.75)* long

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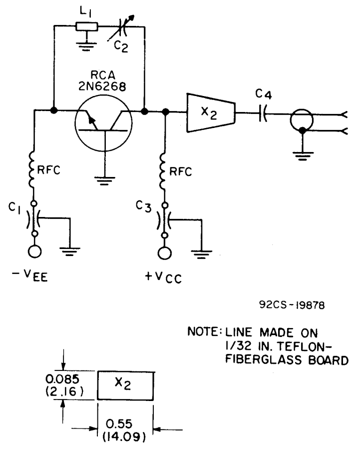
*Note: Dimension in parentheses are in millimeters and are derived from the original inch dimensions shown.

•or equivalent

Fig. 23—Typical circuit for 2-GHz microstripline amplifier.



NOTE: LINE MADE ON
1/32 IN. TEFLON-
FIBERGLASS BOARD

C_1, C_3: Filtercon, Allen-Bradley SMFB-A1•

C_2: 0.3-3.5 pF, Johanson 4700•

C_4: 300 pF, ATC 100•

L_1: 1.0 in. (25.4)* section miniature 50 cable

RFC: 3 turns, No. 32 wire, 0.062 in (1.57)* ID,0.187 in (4.75)* long

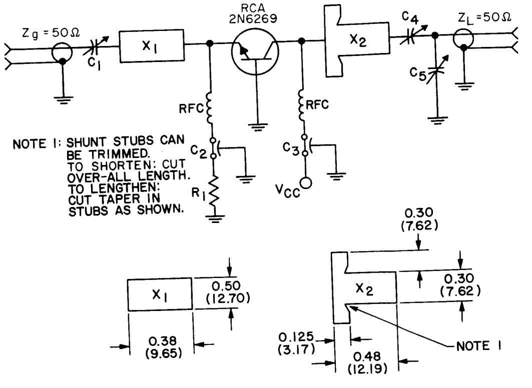
---

*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

•or equivalent

Fig. 24—Typical 1.7-GHz oscillator circuit.

2N6269 APPLICATION DATA

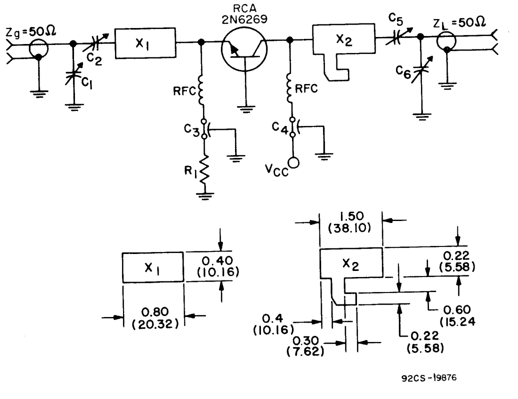


C_1, C_4, C_5: 0.3–3.5 pF, Johanson 4700●
C_2, C_3: Filtercon, Allen-Bradley SMFB-A1●
RFC: No. 32, wire, 0.4 in. (10.2)* long
R_1: 0.24 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.
●or equivalent

Fig. 25—Typical 2-GHz power amplifier circuit.



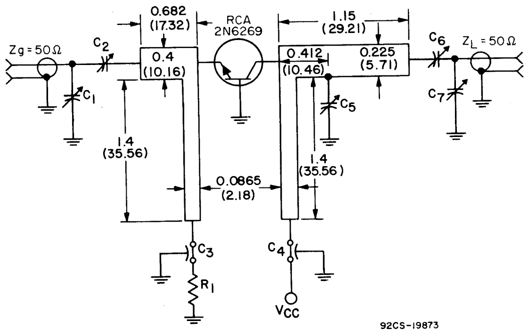
C_1, C_2, C_5, C_6: 0.8–10 pF, Johanson 5202●
C_3, C_4: Filtercon, Allen-Bradley SMFB-A1●
RFC: No. 32 wire, 3 turns 0.062 in. (1.58)* ID x 0.187 in. (4.76)* long
R_1: 1Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

---

*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.
●or equivalent

Fig. 26—Typical 1-GHz power amplifier circuit.



C_1, C_2, C_6: 1–10 pF JFD Electronics, MVM010●
C_5, C_7: 0.3–3.5 pF, JFD Electronics, MVM003●
C_3, C_4: 1000 pF feedthrough, Allen-Bradley FA5C●
R_1: 0.75 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

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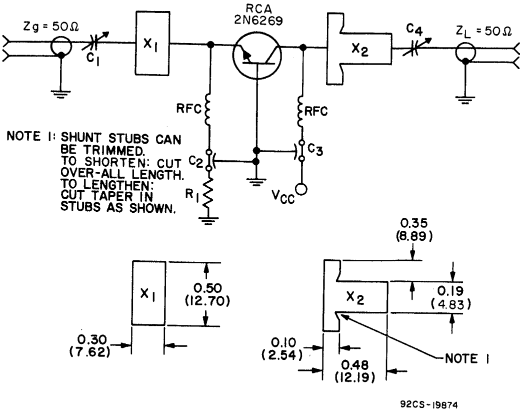
*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.
●or equivalent

Fig. 27—Typical 1.3-GHz power amplifier circuit.

2N6269 APPLICATION DATA



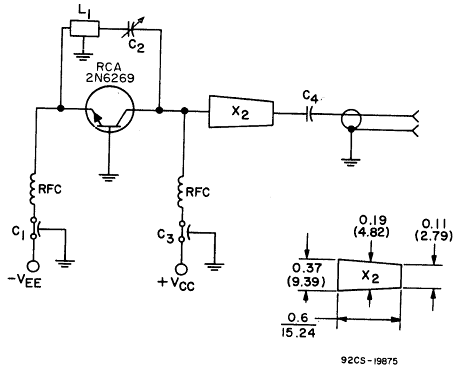
C_1, C_4: 0.3–3.5 pF, Johanson 4700•
C_2, C_3: Filtercon, Allen-Bradley SMFB-A1•
RFC: No. 32 wire, 0.4 in. (10.2)* long
R_1: 0.24 Ω

Dielectric material: 1/32 in. (0.79 mm) thick Teflon-fiberglass double-clad circuit board (ϵ = 2.6). Lines X_1 and X_2 are produced by removing upper copper layer to dimensions shown.

---

*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.
•or equivalent

Fig. 28—Typical 2.3-GHz amplifier circuit.



C_1, C_3: Filtercon, Allen-Bradley SMFB-A1•
C_2: 0.3–3.5 pF, Johanson 4700•
C_4: 300 pF, ATC—100•
L_1: 1.0 in (25.4)* section miniature 50 Ω cable, or microstrip equivalent
RFC: 3 turns, No. 32 wire, 0.062 in (1.57)* ID, 0.187 in. (4.75)* long
X_2: 13-mil thick Teflon-Kapton double-clad circuit board (Grade PE-1243 as supplied by Budd Polychem Division, Newark, Delaware), or equivalent.
Line X_2 is exponentially tapered
Oscillator is single screw tunable 1.6 GHz to 1.8 GHz

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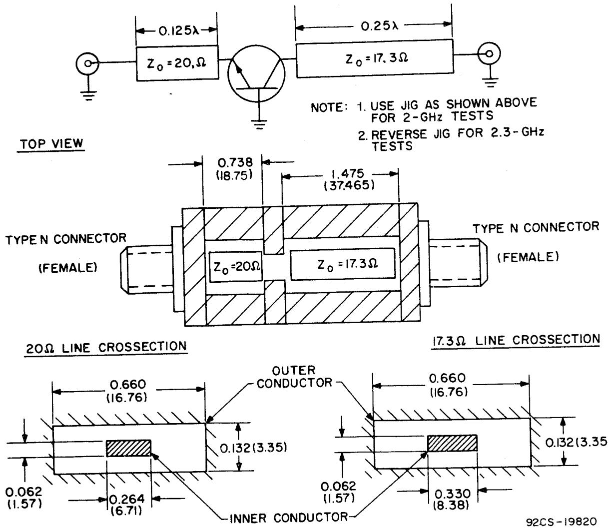
*Note: Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.
•or equivalent

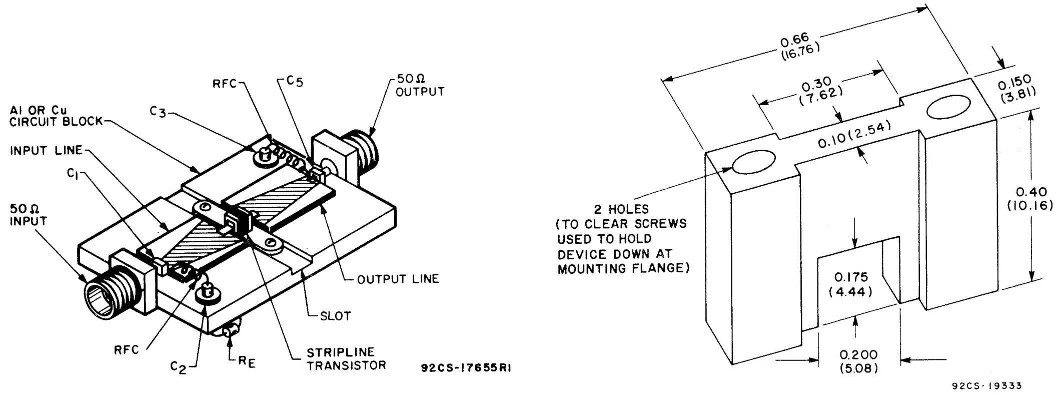
Fig. 29—Typical 1.7-GHz oscillator circuit.

2N6268 & 2N6269 APPLICATION DATA



Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

Fig. 30–Typical circuit for 2- or 2.3-GHz stripline test jig for measurement of performance from 2- or 2.3-GHz common-base amplifier for 2N6268.



C_1, C_5: DC-blocking capacitors
C_2, C_3: Feedthrough or filter capacitors

(a) Typical circuit

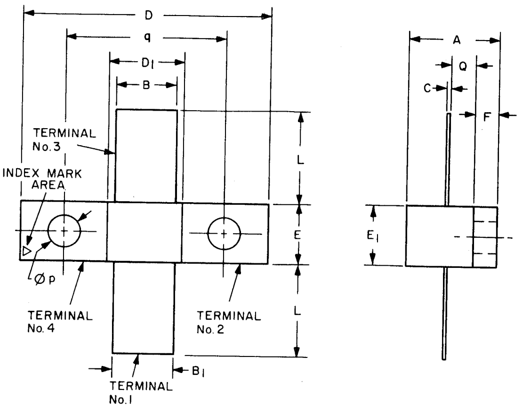
Dimensions in parentheses are in millimeters and are derived from the original inch dimensions shown.

(b) Circuit shield (Place over device and screw down to circuit board).

NOTE: The circuit shield (b) can be made as a part of a ridge in the circuit board (a) instead of the slot shown, and the device can be mounted upside down in a slot in this ridge for equivalent circuit isolation. For operation in the 2-2.4 GHz range, it is recommended that the circuit be completely shielded to prevent losses due to circuit radiation at these frequencies.

Fig. 31–Typical circuit construction using 2N6268 or 2N6269.

DIMENSIONAL OUTLINE FOR 2N6268 & 2N6269



NOTE: EMITTER IS GOLD PLATED

SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.225	0.250	5.72	6.35
B	0.145	0.160	3.69	4.06
B_1	0.165	0.180	4.20	4.57
C	0.004	0.010	0.102	0.254
D	0.657	0.667	16.69	16.94
D_1	0.190	0.210	4.83	5.33
E	0.155	0.165	3.94	4.19
E_1	0.140	0.165	3.56	4.19
F	0.058	0.063	1.48	1.72
L	0.235	0.265	5.97	6.73
ϕp	0.090	0.096	2.286	2.438
Q	0.062	0.077	1.58	1.95
q	0.420	0.440	10.67	11.17

Dimensions in millimeters are derived from the basic inch dimensions as shown.

TERMINAL CONNECTIONS

Terminal 1 – Emitter
Terminals 2 & 4 – Base
Terminal 3 – Collector

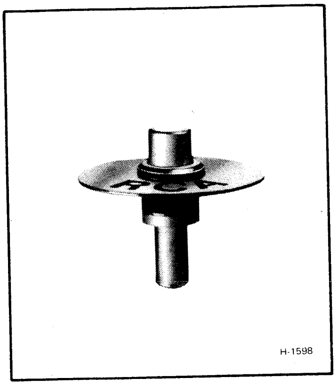
SOLDERING INSTRUCTIONS

When the 2N6268 or 2N6269 are soldered into a micro-stripline of lumped-costant circuit, the collector and emitter terminals of the devices must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal-resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230 °C for a maximum of 10 seconds during tinning and subsequent soldering operations.

WARNING: The ceramic bodies of these devices contain beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

RCA
Solid State
Division

RF Power Transistors
40836
40837



High-Frequency Overlay Power Transistors

For Oscillators And Amplifiers In UHF/Microwave Equipment

Features

- 0.5 W (min.) oscillator output at 2.0 GHz (40836)
- 1.25 W (min.) oscillator output at 2.0 GHz (40837)
- Ceramic-metal hermetic coaxial package with low inductances and low parasitic capacitances
- Emitter connected to flange (for increased internal feedback) for higher efficiency at S-band frequencies in Colpitts oscillator circuits
- For coaxial, stripline, and lumped-constant circuits

RCA-40836 and 40837* are epitaxial silicon n-p-n planar transistors employing the "overlay" emitter-electrode construction. These devices feature a low-loss, ceramic-metal, coaxial package and are intended primarily for power oscillator applications in the L- and S-band frequency ranges.

If the safe-area-of-operation conditions are not exceeded, they may be used in class A amplifiers.

Applications

- L- and S-band power oscillators
- Common-emitter Class A amplifier

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*Formerly RCA-Dev. types TA7403 and TA7679, respectively.

MAXIMUM RATINGS, *Absolute-Maximum Values:*		40836	40837	
COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	50	50	V
COLLECTOR-TO-EMITTER VOLTAGE:				
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	50	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	3.5	V
DC COLLECTOR CURRENT (CONTINUOUS)	I_C	0.2	0.275	A
TRANSISTOR DISSIPATION:	P_T			
At case temperatures up to 75°C		2.5	4.15	W
At case temperatures above 75°C		See Fig. 5	See Fig. 6	
For point of measurement of temperature (on collector terminal), see dimensional outline.				
TEMPERATURE RANGE:				
Storage and Operating (Junction)		← −65 to + 200 →		°C

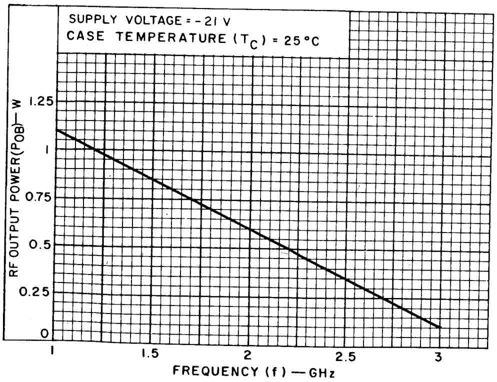
ELECTRICAL CHARACTERISTICS, *at Case Temperature (T_C) = 25°C*

Static

CHARACTERISTIC	SYMBOL	TEST CONDITIONS: DC COLLECTOR VOLTAGE (V) V_{CE}	TEST CONDITIONS: DC CURRENT (mA) I_E	I_B	I_C	LIMITS 40836 MIN.	40836 MAX.	40837 MIN.	40837 MAX.	UNITS
Collector-Cutoff Current	I_{CES}	45		0		–	1	–	1	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$		0 0		0.1 1	50 –	– –	– 50	– –	V
Collector-to-Emitter Sustaining Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{CER}(sus)$				5	50	–	50	–	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$		0.1		0	3.5	–	3.5	–	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$			10 20	100 200	– –	1 –	– –	– 1	V
Thermal Resistance: (Junction-to-Collector Terminal)	$R_{\theta JCT}$					–	50	–	30	°C/W

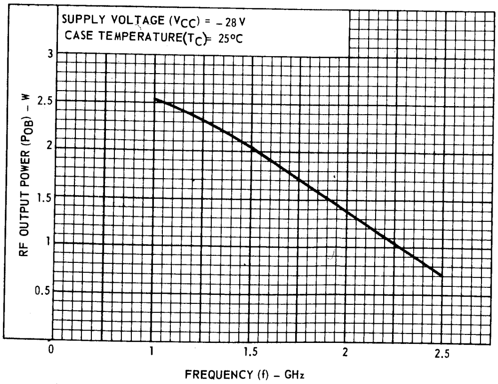
Dynamic

CHARACTERISTIC	SYMBOL	POWER OUTPUT (P_{OB})–W	SUPPLY VOLTAGE (V_{CC})–V	FREQUENCY GHz	LIMITS 40836 MIN.	40836 TYP.	40837 MIN.	40837 TYP.	UNITS
Common-Collector Oscillator Output Power	P_{OB}		21 28	2 2	0.5 –	0.65 –	– 1.25	– 1.35	W
Oscillator Circuit Efficiency (See Fig. 11)	η_o	0.5 1.25	21 28	2 2	20 –	– –	– 20	– –	%
Collector-to-Base Capacitance	C_{obo}		30(V_{CB})	1 MHz	3.0 (Max.)		3.0 (Max.)		pF



92SS-3828

Fig.1—Typical power output vs. frequency for grounded collector power oscillator for 40836.



92SS-4481

Fig.2—Typical power output vs. frequency for grounded collector power oscillator for 40837.

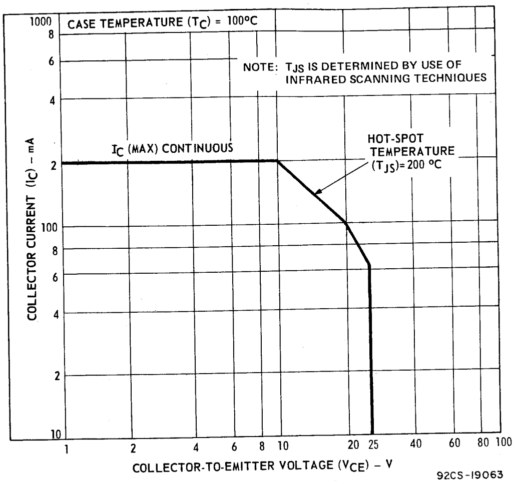


Fig.3—Maximum operating area for forward-bias operation for type 40836.

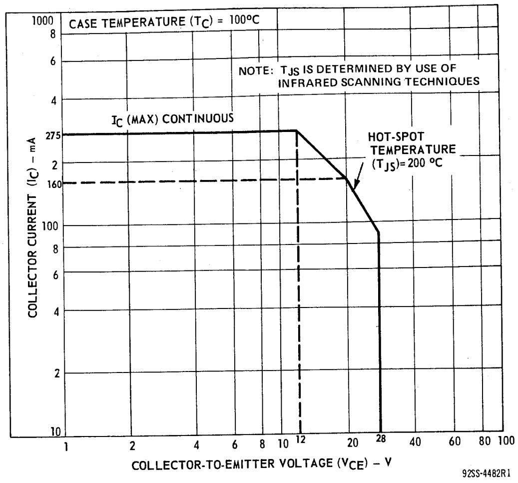


Fig.4—Maximum operating area for forward-bias operation for type 40837.

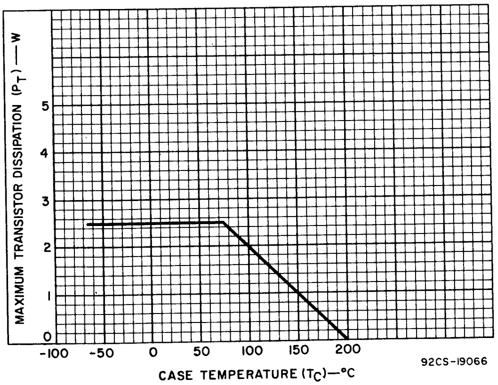


Fig.5—Dissipation derating curve for type 40836.

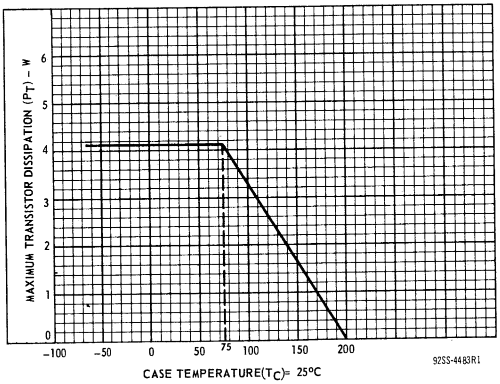


Fig.6—Dissipation derating curve for type 40837.

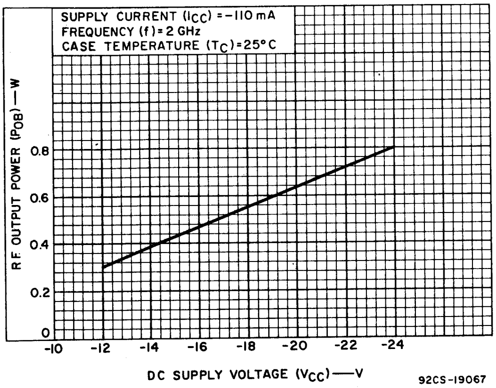


Fig.7—Typicaloutput power vs. supply voltage for the 2-GHz, grounded-collector oscillator (Fig.11) for type 40836.

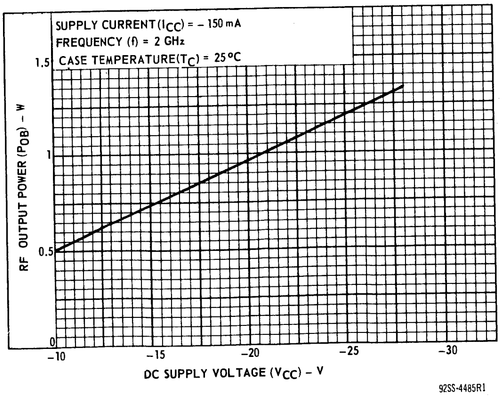


Fig.8—Typical output power vs. supply voltage for the 2-GHz, grounded-collector oscillator (Fig. 11) for type 40837.

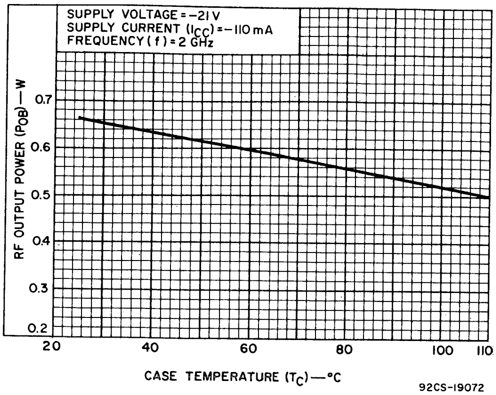


Fig.9—Typical output power vs. collector-terminal temperature for 40836 (circuit shown in Fig.11).

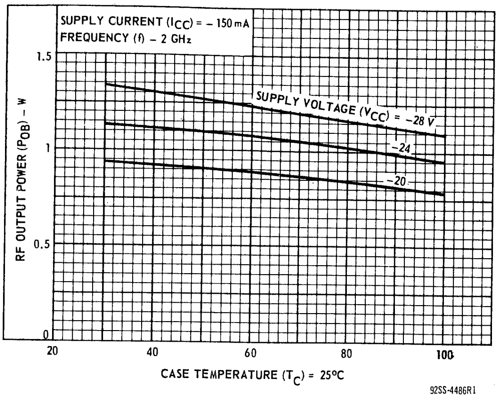
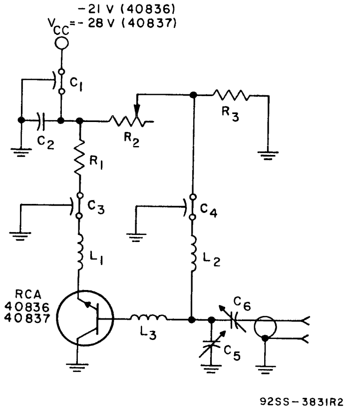


Fig.10—Typical output power vs. collector-terminal temperature for 40837 (circuit shown in Fig. 11).

APPLICATION DATA



C_1, C_3, C_4: 470 pF, feedthrough Allen-Bradley FA4C, or equivalent

C_2: 0.2μF, disc ceramic

C_5, C_6: 0.35 to 3.5 pF, Johanson 4702, or equivalent

L_1, L_2: RF choke, 0.5 in. (12.70 mm) length of No. 32 wire

L_3: Copper strip:
0.005 in (0.127)mm) thick
0.18 in. (0.457 mm) wide
0.3 in (0.76 mm) long

R_1: 10 Ω, ½ W

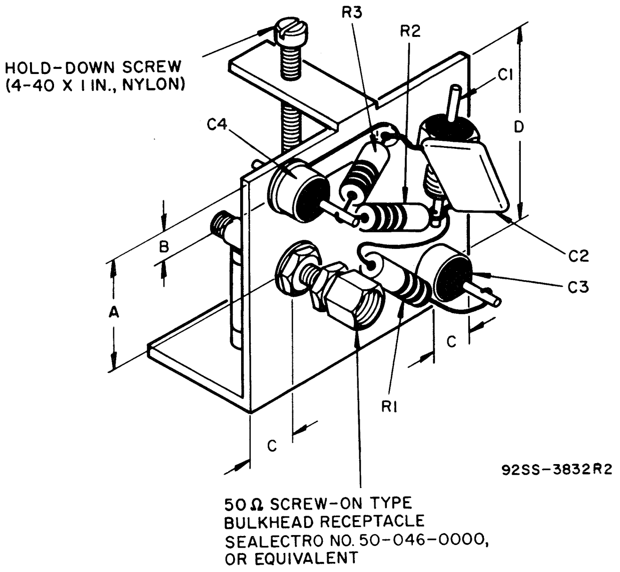
R_2: 0 to 500 Ω, 2 W

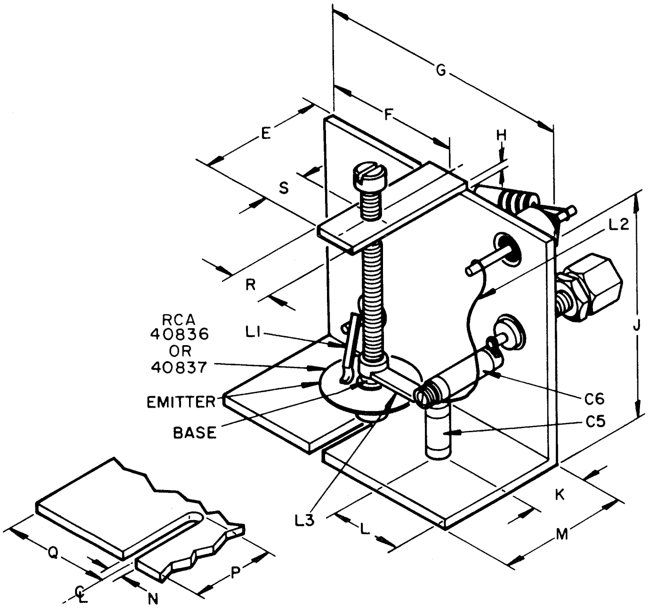
R_3: 1200 Ω, ½ W

NOTES:

1. The circuit shown above is tunable over the range of 1.8 GHz to 2.1 GHz.
2. For operation below 1.8 GHz, increase emitter-base capacitance and the value of L_3.
3. For operation between 2.1 GHz and 2.3 GHz, increase the collector-base capacitance and decrease the value of L_3.

Fig.11—Typical 2-GHz, grounded-collector power oscillator.



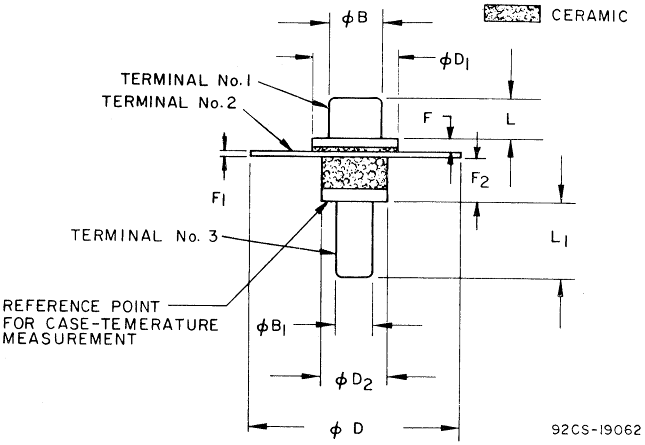


SYMBOL	INCHES	MILLIMETERS
A	0.53	1.35
B	0.16	0.41
C	0.25	0.63
D	0.75	1.90
E	0.75	19.05
F	0.625	15.87
G	1.25	28.57
H	0.062	1.57
J	1.0	25.4
K	0.375	9.52
L	0.281	7.14
M	0.75	19.05
N	0.93	2.36
P	0.421	10.69
Q	0.625	15.87
R	0.25	6.63
S	0.375	9.52
T	0.75	19.05

NOTE:
MATERIAL: 1/16 (1.52) THICK COPPER

Fig.12–Constructional details of 2-GHz power oscillator shown in Fig.11.

DIMENSIONAL OUTLINE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
ϕB	0.118	0.122	2.997	3.098	1
ϕB_1	0.090	0.094	2.286	2.387	2
ϕD	0.497	0.503	12.624	12.776	3
ϕD_1	0.180	NOM.	4.57	NOM.	
ϕD_2	0.162	NOM.	4.11	NOM.	
F	0.028	0.039	0.71	0.99	
F_1	0.009	0.011	0.229	0.279	
F_2	0.114	0.126	2.90	3.20	
L	0.098	0.104	2.49	2.64	
L_1	0.179	0.191	4.55	4.85	

NOTES:

1. Silver or KOVAR*
2. Solid silver
3. Gold-plated KOVAR

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*Trademark, Westinghouse Electric Corp.

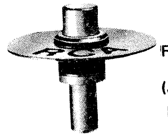
TERMINAL CONNECTIONS

Terminal No. 1 – Emitter
Terminal No. 2 – Base
Terminal No. 3 – Collector

RCA
Solid State
Division

RF Power Transistors

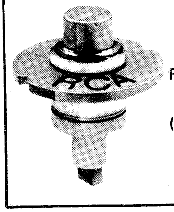
40898
40899



RCA-40898

(JEDEC TO-215AA Package)

H-1598



RCA-40899

(JEDEC TO-201AA Package)

H-1629

6- and 2-W, 2.3-GHz Emitter-Ballasted Silicon N-P-N Overlay Transistors

For Microwave Power Amplifiers, Fundamental-Frequency Oscillators, and Frequency Multipliers

Features:

- Designed for 20- to 24-V equipment
- Emitter-ballasting resistors
- 6-W output with 6-dB gain (min.) at 2.3 GHz, 22 V – 40899
- 2-W output with 7-dB gain (min.) at 2.3 GHz, 22 V – 40898
- Stable common-base operation
- Ceramic-metal hermetic packages with low inductances and low parasitic capacitances
- For coaxial, microstripline, and lumped-constant circuit applications

The RCA-40898 and 40899* are epitaxial silicon n-p-n planar transistors with overlay multiple-emitter-site construction, designed especially for 20- to 24-volt operation. They are intended for solid-state equipment in microwave communications, S-band telemetry, microwave relay links, phased-array radar, distance-measuring equipment, and collision-avoidance systems in the frequency range from 0.5 to 2.4 GHz.

The ceramic-metal packages of the 40898 and 40899 have low parasitic capacitances and inductances for stable operation in the common-base amplifier configuration. The use of emitter-ballasting resistors provides ruggedness and reliability.

These transistors can be used in large-signal applications in coaxial, stripline, and lumped-constant circuits. The 40898 is a good driver for a 40899 output stage.

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*Formerly RCA Dev. Nos. TA8439 and TA8440.

MAXIMUM RATINGS, *Absolute-Maximum Values:*

		40898	40899	
COLLECTOR-TO-BASE VOLTAGE:	V_{CBO}	45	45	V
COLLECTOR-TO-EMITTER VOLTAGE:				
With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	45	45	V
EMITTER-TO-BASE VOLTAGE:	V_{EBO}	3.5	3.5	V
CONTINUOUS COLLECTOR CURRENT:	I_C	0.35	1.5	A
TRANSISTOR DISSIPATION:	P_T			
At case temperatures up to 75°C		4.15	14.8	W
At case temperatures above 75°C, derate linearly		0.033	0.118	W/°C
TEMPERATURE RANGE:				
Storage & Operating (Junction)		–65 to +200		°C
CASE TEMPERATURE (During soldering):				
For 10 s max (See Soldering Instructions on page 7.)		230		°C

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25°C

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS				UNITS
		DC VOLTAGE V	DC CURRENT mA			40898		40899		
		V_{CE}	I_E	I_B	I_C	MIN.	MAX.	MIN.	MAX.	
Collector-Cutoff Current	I_{CES}	40				–	2	–	2	mA
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$		0		5	45	–	45	–	V
Collector-to-Emitter Breakdown Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$				10	45	–	45	–	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$		0.1		0	3.5	–	3.5	–	V
Collector-to-Emitter Saturation Voltage	V_{CE}(sat)			10 20	100 100	– –	1 –	– –	– 1	V
Thermal Resistance: (Junction-to-Collector-Terminal)	$R_{\theta JCT}$						30	–	8.5	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS				UNITS
		INPUT POWER (P_{IB})-W	OUTPUT POWER (P_{OB})-W	SUPPLY VOLTAGE (V_{CC})-V	FREQUENCY (f)-GHz	40898		40899		
						MIN.	MAX.	MIN.	MAX.	
Output Power (See Fig. 17)	P_{OB}	0.4 1.5		22 22	2.3 2.3	2.0 –	– –	– 6.0	– –	W
Power Gain	G_{PB}	0.4 1.5	2 6	22 22	2.3 2.3	7.0 –	– –	– 6.0	– –	dB
Collector Efficiency	η_C	0.4 1.5	2 6	22 22	2.3 2.3	35 –	– –	– 35	– –	%
Collector-to-Base Capacitance	C_{obo}			30 (V_{CB})	1 MHz	–	4	–	11.5	pF

TYPICAL APPLICATION INFORMATION

CIRCUIT & FREQUENCY	SEE FIG.	SUPPLY VOLTAGE (V_{CC})-V	40898		40899	
			INPUT POWER (P_{IB})-W	OUTPUT POWER (P_{OB})-W	INPUT POWER (P_{IB})-W	OUTPUT POWER (P_{OB})-W
Coaxial-Line 2.3-GHz Amplifier	17 21	22 22	0.4 –	2.1 –	– 1.5	– 6.5
Coaxial-Line 1.2-GHz Amplifier	21	22	–	–	1	13.5
Lumped-Constant 1-GHz Amplifier	19	22	0.21	3.8	–	–
Lumped-Constant 2-GHz Oscillator	18	22		0.75	–	–

PERFORMANCE DATA

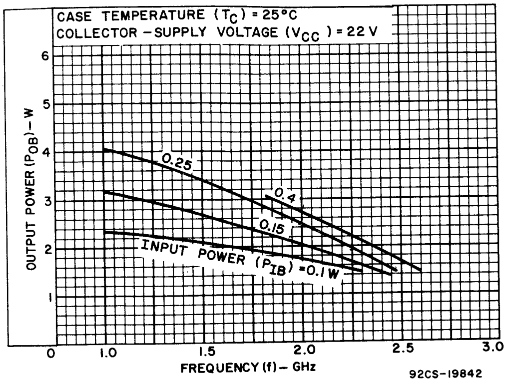


Fig. 1—Typical output power vs. frequency for type 40898 measured in the test set-up of Fig. 17.

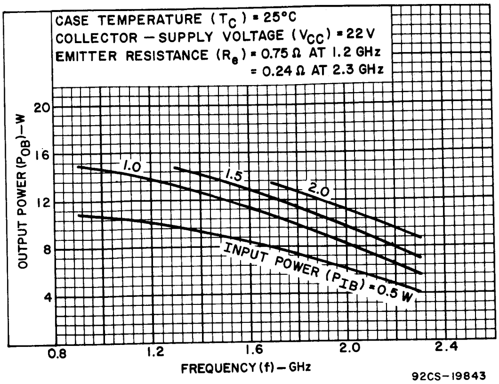


Fig. 2—Typical output power vs. frequency for type 40899, measured in the test set-up of Fig. 17.

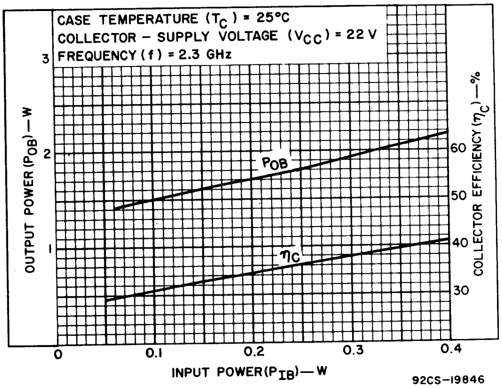


Fig. 3—Typical output power and collector efficiency vs. input power at 2.3 GHz for type 40898.

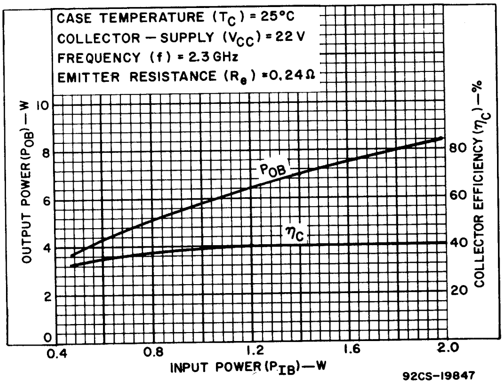


Fig. 4—Typical output power and collector efficiency vs. input power at 2.3 GHz for type 40899.

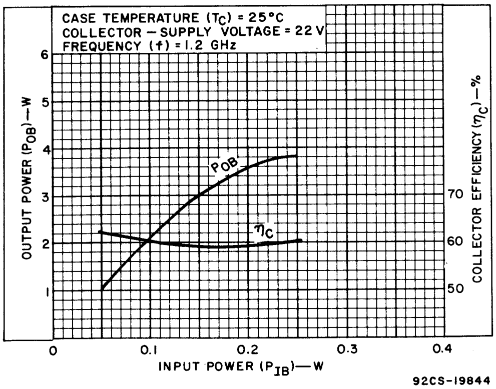


Fig. 5—Typical output power and collector efficiency vs. input power at 1.2 GHz, for type 40898 in common-base coaxial-line amplifier circuit.

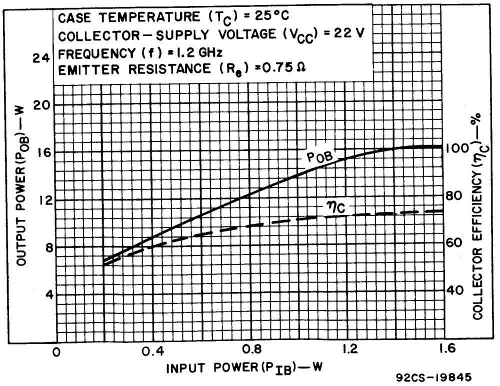


Fig. 6—Typical output power and collector efficiency vs. input power at 1.2 GHz for type 40899.

PERFORMANCE DATA (cont'd.)

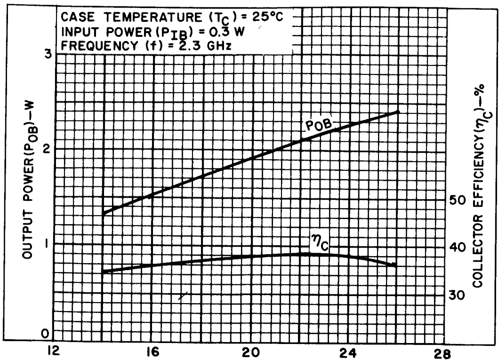


Fig. 7—Typical output power and collector efficiency vs. collector-supply voltage at 2.3 GHz for type 40898.

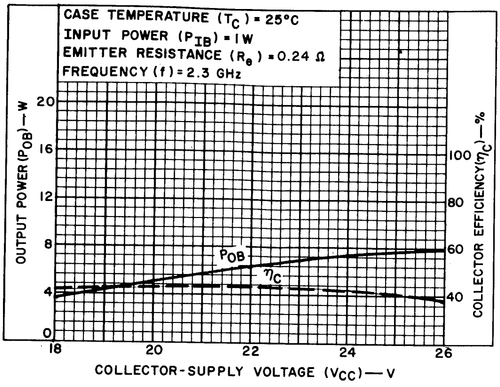


Fig. 8—Typical output power and collector efficiency vs. collector supply voltage at 2.3 GHz for type 40899.

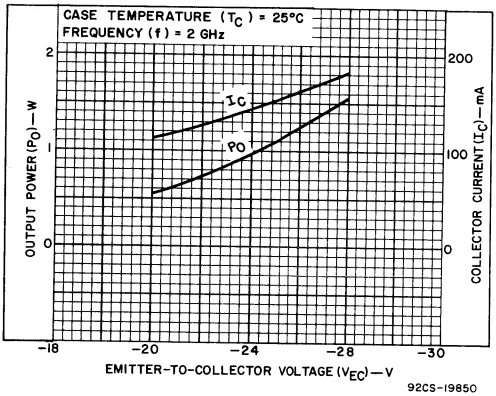


Fig. 9—Typical output power and collector current vs. emitter-to-collector voltage, for type 40898 in 2-GHz grounded-collector oscillator circuit shown in Fig. 18.

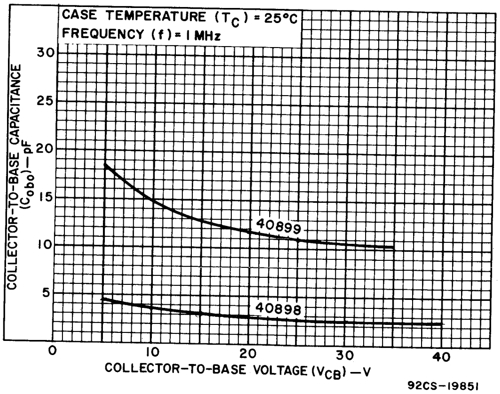


Fig. 10—Typical collector-to-base capacitance vs. collector-to-base voltage for types 40898 and 40899.

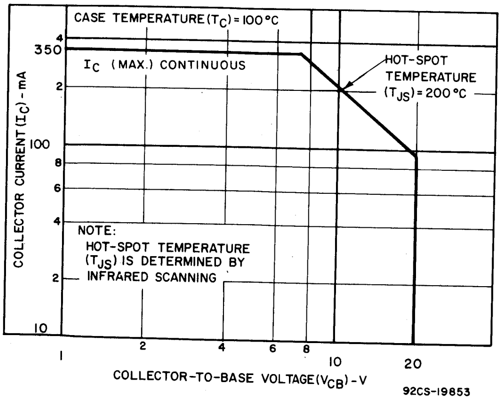


Fig. 11—Safe area for dc operation of type 40898.

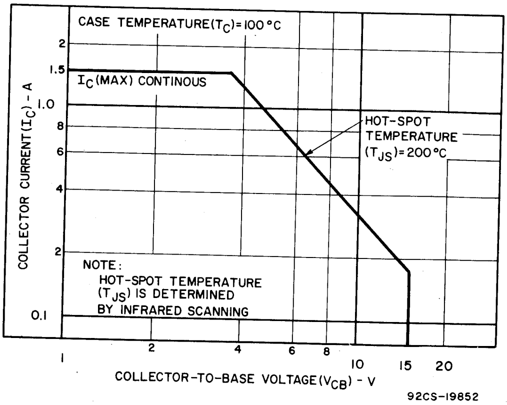


Fig. 12—Safe area for dc operation of type 40899.

DESIGN DATA

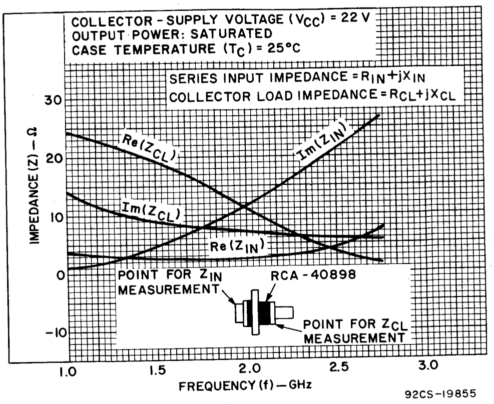


Fig. 13—Typical large-signal input impedance and large-signal collector load impedance vs. frequency for type 40898.

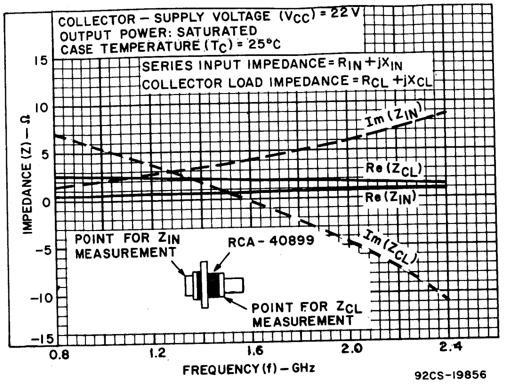


Fig. 14—Typical large-signal series input impedance and large-signal collector load impedance vs. frequency for type 40899.

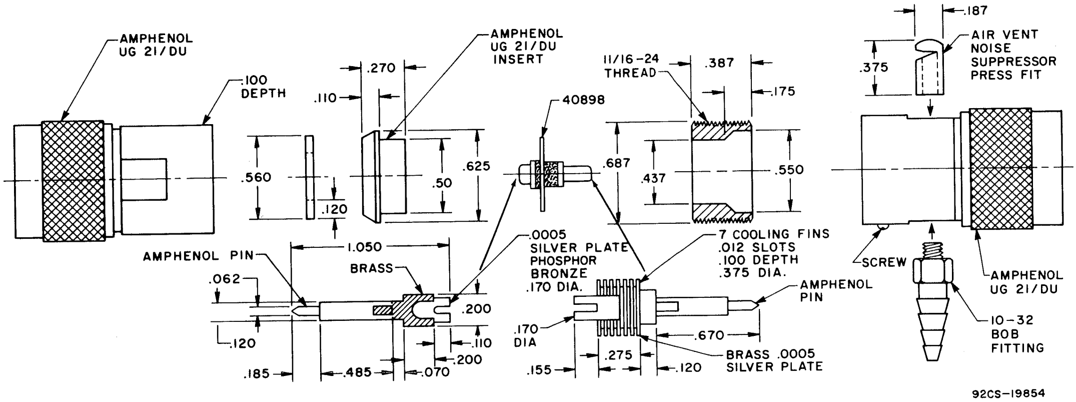
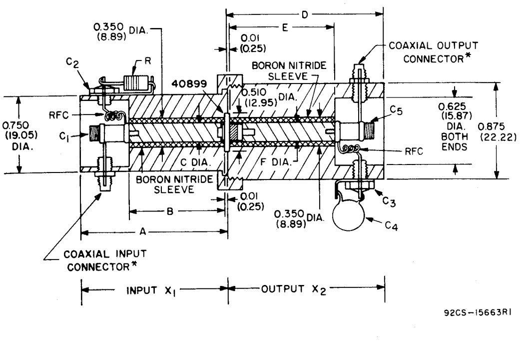


Fig. 15—Type 40898 in coaxial-line test fixture for 1.2- and 2.3-GHz amplifiers.



CIRCUIT	DIMENSIONS							
	INPUT (X_1)				OUTPUT (X_2)			
	A	B	C	Center Conductor	D	E	F	Center Conductor
1.2-GHz Amplifier	1.385 (35.18)	0.875 (22.22)	0.282 (7.16)	0.825 (20.95)	1.778 (45.16)	1.268 (32.21)	0.213 (5.41)	1.05 (26.67)
2.3-GHz Amplifier	0.772 (19.61)	0.262 (6.65)	0.265 (6.73)	0.212 (5.39)	0.922 (23.49)	0.412 (10.42)	0.270 (6.88)	0.245 (6.22)

DIMENSIONS IN INCHES AND MILLIMETERS

Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated.

MATERIAL: Center conductor—copper
Outer conductor for input & output—brass

*Conhex 50-045-0000 (Sealectro Corp.), or equivalent.

Fig. 16— Type 40899 in coaxial-line test fixture for 1.2- and 2.3-GHz amplifiers. See Fig. 21 for component values.

APPLICATION INFORMATION

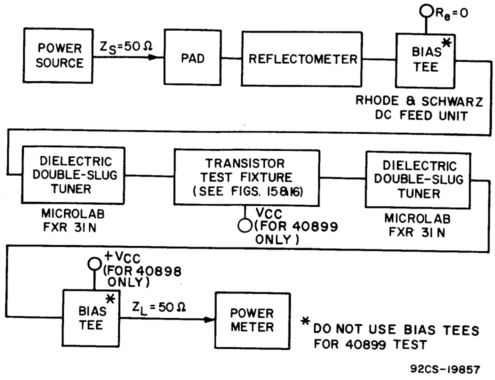
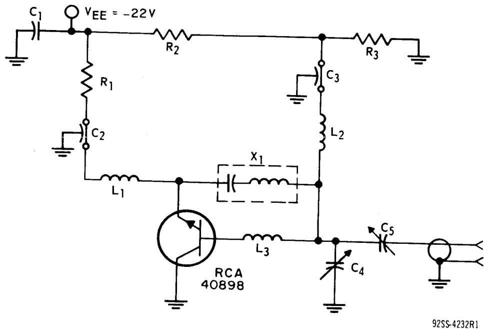
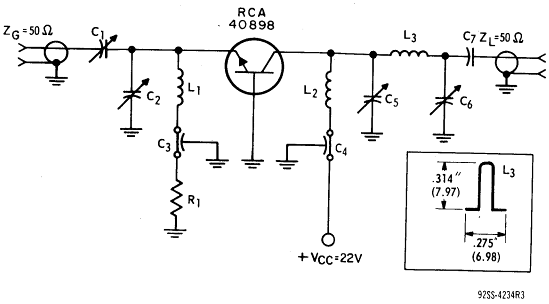


Fig. 17—Block diagram of test set-up used for measurement of output power from 1.2- and 2.3-GHz common-base amplifiers.



C_1: 0.01 μF, disc ceramic
C_2,C_3: 100 pF, feed-through, Allen-Bradley FA5C, or equivalent
C_4,C_5: 0.35 – 3.5 pF, Johanson 4701, or equivalent
L_1, L_2: RF choke, 4 turns, No. 33 wire, 0.062 in. (1.57 mm) ID, 3/16 in. (4.75 mm) long
L_3: 3/64-in. (1.17 mm) length of No. 22 wire
X_1: 0.82 pF, "gimmick", Quality Components type 10% QC, or equivalent
R_1: 5 – 10 Ω, 1/2 W
R_2: 51 Ω, 1/2 W
R_3: 1200 Ω, 1/2 W

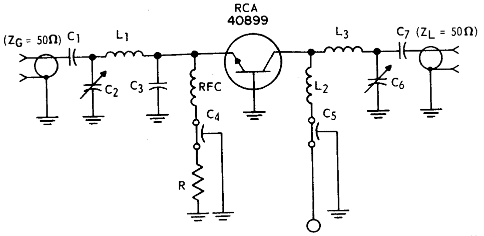
Fig. 18—Typical circuit for 2-GHz grounded-collector power oscillator using type 40898.



C_1,C_5,C_6: 1-14 pF, air-dielectric, Johanson 3901, or equivalent
C_2: 0.35–3.5 pF, air-dielectric, Johanson 4701, or equivalent
C_3,C_4: 1000 pF, feed-through, Allen-Bradley FA5C, or equivalent
C_7: 1000 pF, ceramic, leadless
L_1,L_2: RF choke, 0.1 μH, Nytronics Deci-Ductor
L_3: 0.01-in. (0.254 mm) thick, 0.157-in. (3.98 mm) wide copper strip shaped as shown in inset drawing
R_1: 1 Ω, 1/2 W

Fig. 19—Typical circuit for 1-GHz power amplifier using type 40898.

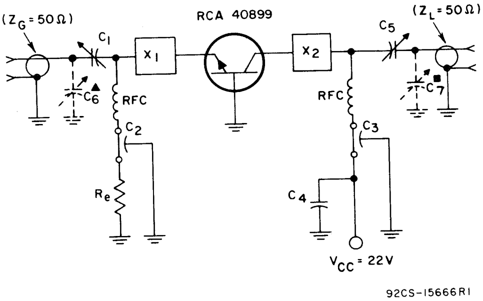
APPLICATION INFORMATION (cont'd)



1-dB Bandwidth = 100 MHz

C1,C7: 510 pF, ATC-200 or equivalent
C2,C6: 1-10 pF, Johanson 2954 or equivalent
C3: 10 pF, ATC-100 or equivalent
C4,C5: 470 pF, feed-through type, Allen-Bradley FA5C
L1: 3.7 nH
L2: 0.8 nH
L3: 2.3 nH
R: 0.47 Ω
RFC: 5 turns, No. 28 wire, 0.05 in. (1.27 mm) ID, 0.4-in. (10.16 mm) long

Fig. 20—Typical lumped-constant circuit for 1-GHz power amplifier using type 40899.



CIRCUIT	C1 pF	C2 pF	C3 pF	C4 μF	C5 pF	C6 pF	C7 pF	Re Ω
1.2-GHz Amplifier	1-10	1000	1000	0.01	1-10	–	0.3-3.5	0.75
2.3-GHz Amplifier	1-10	470	470	0.01	0.3-3.5	0.3-3.5	–	0.24

C1 & C5: 1-10 pF Johanson 4581 or equivalent
C5, C6 & C7: 0.3-3.5 pF Johanson 4700 or equivalent
RFC: For 2.3-GHz circuit, 3 turns No. 32 wire 1/16 in. (1.59 mm) ID, 3/16 in. (4.76 mm) long.
For 1.2-GHz circuit, 6 turns No. 32 wire 1/16 in. (1.59 mm) ID, 3/16 in. (4.76 mm) long.
X1, X2: Coaxial-line circuits; see Fig. 16.

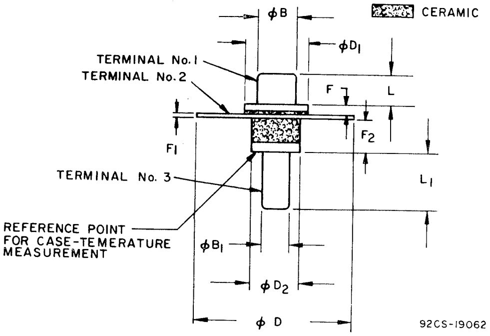
▲ Use only in the 2.3-GHz coaxial-line power amplifier circuit.
■ Use only in the 1.2-GHz coaxial-line power amplifier circuit.

Fig. 21—Coaxial-line amplifier circuits using type 40899 for operation at 1.2- and 2.3-GHz.

SOLDERING INSTRUCTIONS

When the 40898 or 40899 is to be soldered into a microstrip-line or lumped-constant circuit, the terminals of the device must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal-resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230°C for a maximum of 10 seconds during tinning and subsequent soldering operations.

DIMENSIONAL OUTLINE OF RCA-40898

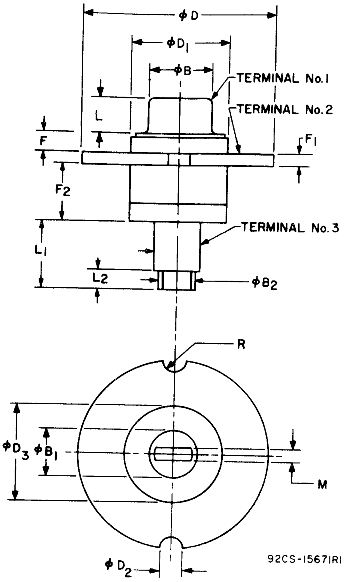


SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
ϕB	0.118	0.122	2.997	3.098
ϕB_1	0.090	0.094	2.286	2.387
ϕD	0.497	0.503	12.624	12.776
ϕD_1	0.180	NOM.	4.57	NOM.
ϕD_2	0.162	NOM.	4.11	NOM.
F	0.028	0.039	0.71	0.99
F_1	0.009	0.011	0.229	0.279
F_2	0.114	0.126	2.90	3.20
L	0.098	0.104	2.49	2.64
L_1	0.179	0.191	4.55	4.85

TERMINAL CONNECTIONS

Terminal No. 1—Emitter
Terminal No. 2—Base
Terminal No. 3—Collector

DIMENSIONAL OUTLINE OF RCA-40899



SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
ϕB	0.165	0.175	4.19	4.44
ϕB_1	0.115	0.125	2.92	3.17
ϕB_2	0.090	0.110	2.29	2.79
ϕD	0.495	0.505	12.57	12.83
ϕD_1	0.245	0.255	6.22	6.48
ϕD_2	0.055	0.065	1.39	1.85
ϕD_3	0.245	0.255	6.22	6.48
F	0.045	0.060	1.14	1.52
F_1	0.025	0.035	0.63	0.88
F_2	0.145	0.175	3.68	4.44
L	0.095	0.115	2.41	2.92
L_1	0.165	0.195	4.19	4.95
L_2	0.040	0.060	1.02	1.52
M	0.045	0.055	1.14	1.39
R	0.027	0.033	0.68	0.83

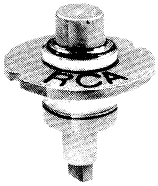
TERMINAL CONNECTIONS

Terminal No. 1—Emitter
Terminal No. 2—Base
Terminal No. 3—Collector

WARNING: The ceramic body of the RCA-40899 contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

RCA
Solid State Division

40909


H-1629

JEDEC TO-201AA PACKAGE

2-W, 2-GHz Emitter-Ballasted Silicon N-P-N Overlay Transistor

For Microwave Fundamental-Frequency Oscillators

Features:

- **Emitter-ballasting resistors**
- **2-W (min.) output at 2 GHz**
- **4-W (typ.) output at 1 GHz**
- **Emitter connected to flange (for increased internal feedback) for higher efficiency at S-band frequencies in Colpitts oscillator circuits**
- **Beryllium-oxide ceramic for low thermal resistance between collector stud and emitter flange**
- **For coaxial, stripline, and lumped-constant circuit applications**

RCA-40909▲ is an epitaxial silicon n-p-n transistor with overlay multiple-emitter-site construction. It is designed for use in power oscillators at microwave frequencies. The ceramic-metal coaxial package of the 40909 has low parasitic capacitances and inductances, and lends itself to mounting in coaxial, stripline, or lumped-constant circuits. Intended applications for this transistor include microwave communications, relay links, distance-measuring equipment, and collision-avoidance systems.

▲Formerly RCA Dev. No. TA7943

MAXIMUM RATINGS, *Absolute-Maximum Values:*

COLLECTOR-TO-BASE VOLTAGE	V_{CBO}	50	V
COLLECTOR-TO-EMITTER VOLTAGE: With external base-to-emitter resistance (R_{BE}) = 10 Ω	V_{CER}	50	V
EMITTER-TO-BASE VOLTAGE	V_{EBO}	3.5	V
CONTINUOUS DC COLLECTOR CURRENT	I_C	0.7	A
TRANSISTOR DISSIPATION	P_T		
At case temperature up to 75°C		10.4	W
At case temperatures above 75°C derate linearly		0.083	W/°C
TEMPERATURE RANGE: Storage & Operating (Junction)		−65 to 200	°C
CASE TEMPERATURE (During soldering): For 10 s max. (See Soldering Instructions on page 4.)		230	°C

ELECTRICAL CHARACTERISTICS, at Case Temperature (T_C) = 25°C unless otherwise specified.

STATIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS				LIMITS		UNITS
		DC Collector Voltage (V)	DC Current (mA)					
		V_{CE}	I_E	I_B	I_C	Min.	Max.	
Collector-Cutoff Current	I_{CES}	45				-	2	mA
	I_{CES} (T_C = 100°C)	45				-	5	
Collector-to-Base Breakdown Voltage	$V_{(BR)CBO}$		0		5	50	-	V
Collector-to-Emitter Breakdown Voltage: With external base-to-emitter resistance (R_{BE}) = 10 Ω	$V_{(BR)CER}$				10	50	-	V
Emitter-to-Base Breakdown Voltage	$V_{(BR)EBO}$		0.1		0	3.5	-	V
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$			20	100	-	1	V
Thermal Resistance: (Junction to Collector-Stud)	$R_{\theta JCT}$					-	8.5	°C/W

DYNAMIC

CHARACTERISTIC	SYMBOL	TEST CONDITIONS		LIMITS		UNITS
		Frequency (f) – GHz	DC Emitter Supply Voltage (V_{EE}) – V	Min.	Max.	
Oscillator Output Power (See Fig. 6)	P_O	2	25	2.0	-	W
Oscillator Circuit Efficiency	η	2	25	20	-	%

TYPICAL APPLICATION INFORMATION

Application	Collector Current (I_C) – mA	DC Emitter Supply Voltage (V_{EE}) – V	Output Power (P_O) – W
2-GHz Oscillator	400	25	2.5
1-GHz Oscillator	400	25	4.0

PERFORMANCE DATA

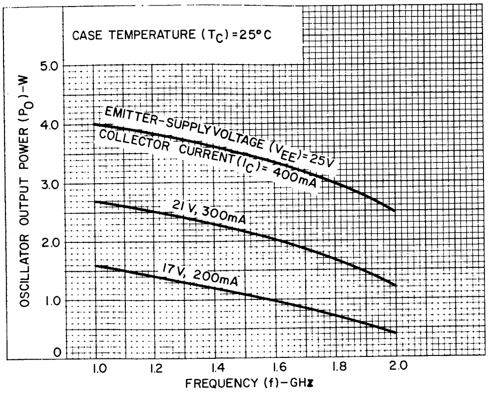


Fig. 1—Typical oscillator output power vs. frequency for the test set-up of Fig. 5.

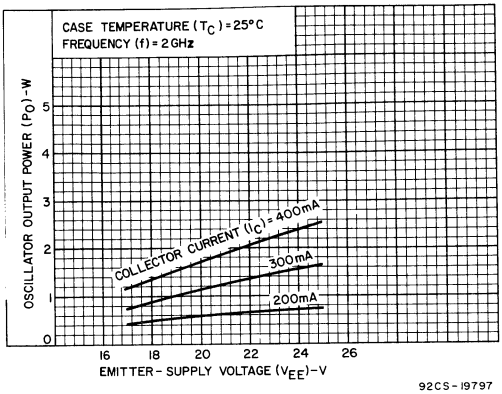


Fig. 2—Typical 2-GHz oscillator output power vs. emitter-supply voltage.

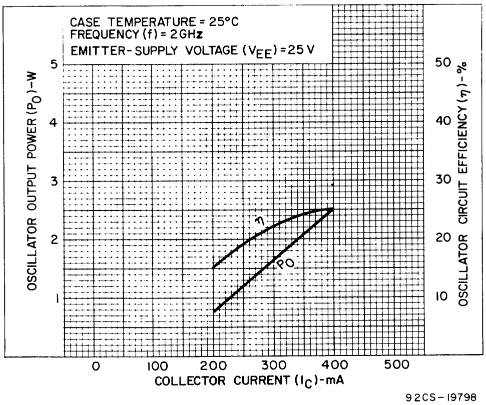


Fig. 3—Typical oscillator output power and circuit efficiency vs. collector current.

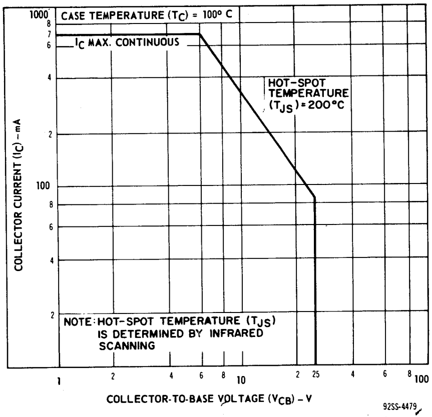


Fig. 4—Safe operating area for dc operation.

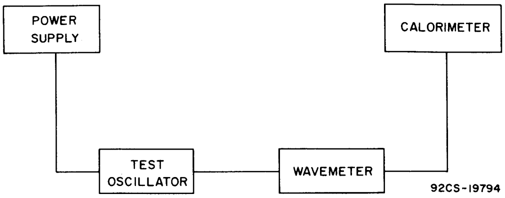
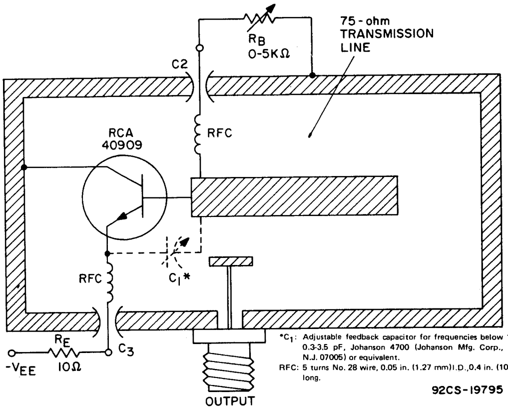


Fig. 5—Block diagram of test set-up for measurement of oscillator output power.



*C_1: Adjustable feedback capacitor for frequencies below 1.4 GHz, 0.3-3.5 pF, Johanson 4700 (Johanson Mfg. Corp., Boonton, N.J. 07005) or equivalent.

RFC: 5 turns No. 28 wire, 0.05 in. (1.27 mm) I.D., 0.4 in. (10.16 mm) long.

Fig. 6—Schematic diagram of basic oscillator circuit.

UNIVERSAL BREADBOARD OSCILLATOR CIRCUIT FOR OPTIMIZING MECHANICAL DIMENSIONS

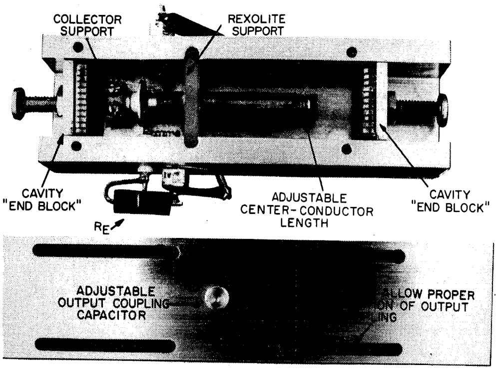


Fig. 7—Top view of test oscillator with cover removed.

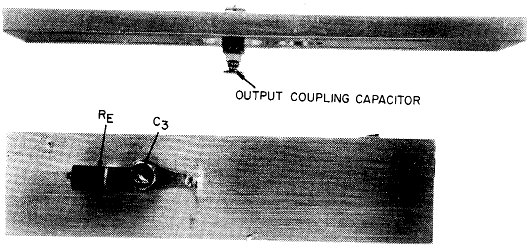
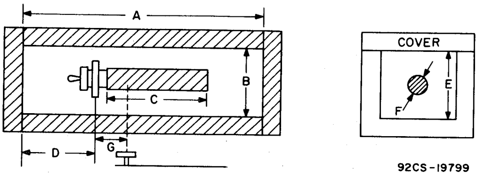


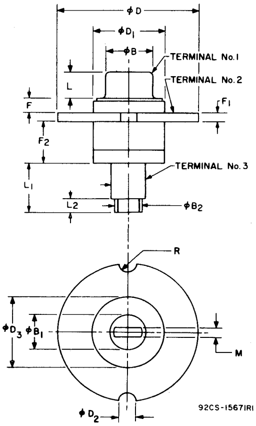
Fig. 8—Side view of test oscillator with cover removed.



Oscillation Frequency	A	B	C	D	E	F	G
1 GHz	3.10 (78.74)	0.775 (19.69)	2.30 (58.42)	0.600 (15.24)	0.775 (19.69)	0.250 (6.35)	1.20 (30.48)
2 GHz	2.00 (50.80)	0.775 (19.69)	0.975 (24.77)	0.160 (4.06)	0.775 (19.69)	0.250 (6.35)	0.600 (15.24)

Dimensions in parentheses are in millimeters, derived from the basic inch dimensions shown.

Fig. 9—Drawing (inside view) of oscillator, showing dimensions.



SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
ϕB	0.165	0.175	4.19	4.44
ϕB_1	0.115	0.125	2.92	3.17
ϕB_2	0.090	0.110	2.29	2.79
ϕD	0.495	0.505	12.57	12.83
ϕD_1	0.245	0.255	6.22	6.48
ϕD_2	0.055	0.065	1.39	1.65
ϕD_3	0.245	0.255	6.22	6.48
F	0.045	0.060	1.14	1.52
F_1	0.025	0.035	0.63	0.88
F_2	0.145	0.175	3.68	4.44
L	0.095	0.115	2.41	2.92
L_1	0.165	0.195	4.19	4.95
L_2	0.040	0.060	1.02	1.52
M	0.045	0.055	1.14	1.39
R	0.027	0.033	0.68	0.83

TERMINAL CONNECTIONS

Terminal No. 1 — Base
Terminal No. 2 — Emitter
Terminal No. 3 — Collector

WARNING: The ceramic body of this device contains beryllium oxide. Do not crush, grind, or abrade these portions because the dust resulting from such action may be hazardous if inhaled. Disposal should be by burial.

SOLDERING INSTRUCTIONS

When the RCA-40909 is soldered into a circuit, the terminals must be pretinned in the region where soldering is to take place. The device should be held in a high-thermal-resistance support for this tinning operation. A 60/40 resin-core solder and a low-wattage (47 watts) soldering iron are suggested for the pretinning operation. The case temperature should not exceed 230°C for a maximum of 10 seconds during tinning and subsequent soldering operations.

Types Not Recommended For New Equipment Design

RCA

Solid State
Division

Solid State Devices

Discontinued Types

This bulletin gives basic data for RCA Solid State Devices not recommended for new equipment design. These devices are classified into two categories:

(1) Devices that are no longer being manufactured by RCA and are available only to the extent of limited inventory.

(2) Devices that have recently been discontinued and are not available from RCA.

Transistors

RCA Type No.	Material	Pkg.	V_{CE}(sat)• or V_{CEO} max. V	P_T max. W	f_T min. MHz	h_{FE} or h_{fe}■ min.	Term. Diagrams Pg. 4
2N176	Ge	TO-3	−30	10	–	65	C
2N217	Ge	TO-1	−18	0.16	–	50	A
2N270□	Ge	TO-7	−25	0.25	–	70	N
2N351	Ge	TO-3	−30	10	–	65	C
2N370	Ge	TO-7	−15	0.08	30	60	H
2N372	Ge	TO-7	−15	0.08	30	60	H
2N376	Ge	TO-3	−50	10	–	78	C
2N388	Ge	TO-5	15	0.15	5	60	G
2N388A	Ge	TO-5	15	0.15	5	60	G
2N398	Ge	TO-5	–	0.05	50	20	F
2N398A	Ge	TO-5	–	0.15	150	20	F
2N398B	Ge	TO-5	–	0.25	250	20	F
2N404	Ge	TO-5	−0.15•	0.15	4	20	F
2N404A	Ge	TO-5	−0.15•	0.15	4	30	F
2N405	Ge	TO-40	−18	0.15	–	55	K
2N406	Ge	TO-1	−20	0.15	–	40	A
2N407	Ge	TO-40	−18	0.15	–	65	K
2N408	Ge	TO-1	−20	0.15	–	55	A
2N412□	Ge	TO-1	–	0.08	–	75	A
2N414	Ge	TO-5	−14	0.15	8	80■	F
2N585	Ge	TO-5	0.2•	0.12	3	20	F
2N591	Ge	TO-1	−32	0.09	–	40■	A
2N647□	Ge	TO-1	25	0.1	–	50	B
2N649□	Ge	TO-1	18	0.3	–	30	B
2N706	Si	TO-18	0.6•	0.3	200	20	I
2N706A	Si	TO-18	0.6•	0.3	200	20	I
2N709	Si	TO-18	0.3•	0.3	600	20	I
2N718	Si	TO-18	32	1.8	–	40	I
2N720A	Si	TO-18	80	1.8	–	40	I
2N834	Si	TO-18	0.25•	1	350	25	I
2N917□	Si	TO-72	–	0.3	600	30	N
2N1066	Ge	TO-33	–	0.12	–	20■	J

Transistors

RCA Type No.	Material	Pkg.	V_{CE}(sat)• or V_{CEO} max. V	P_T max. W	f_T min. MHz	h_{FE} or h_{fe}■ min.	Term. Diagrams Pg. 4
2N1090□	Ge	TO-5	0.2•	0.12	5	30	B
2N1091□	Ge	TO-5	0.2•	0.12	10	40	B
2N1177	Ge	TO-45	–	0.08	–	100■	L
2N1178	Ge	TO-45	–	0.08	–	40■	L
2N1179	Ge	TO-45	–	0.08	–	80■	L
2N1180	Ge	TO-45	–	0.08	–	80■	L
2N1224	Ge	TO-33	–	0.12	–	20■	J
2N1225	Ge	TO-33	–	0.12	–	20■	J
2N1226	Ge	TO-33	–	0.12	–	20■	J
2N1285	–	–	–	–	–	–	–
2N1300	Ge	TO-5	−12	0.15	25	30	F
2N1301	Ge	TO-5	−12	0.15	25	40	F
2N1302	Ge	TO-5	0.2•	0.15	3	20	G
2N1303	Ge	TO-5	−0.2•	0.15	3	20	E
2N1304	Ge	TO-5	0.2•	0.15	5	40	G
2N1305	Ge	TO-5	−0.2•	0.15	5	40	E
2N1306	Ge	TO-5	0.2•	0.15	10	60	G
2N1307	Ge	TO-5	−0.2•	0.15	10	60	E
2N1308	Ge	TO-5	0.2•	0.15	15	80	G
2N1309	Ge	TO-5	−0.2•	0.15	15	80	E
2N1395	Ge	TO-33	–	0.12	–	50■	J
2N1396	Ge	TO-33	–	0.12	–	50■	J
2N1397	Ge	TO-33	–	0.12	–	50■	J
2N1524□	Ge	TO-1	–	0.08	33	54	A
2N1526□	Ge	TO-1	–	0.08	33	49	A
2N1605	Ge	TO-5	0.15•	0.15	4	40	G
2N1605A	Ge	TO-5	0.15•	0.2	4	40	G
2N1631□	Ge	TO-40	–	0.08	–	80■	K
2N1632□	Ge	TO-1	–	0.08	45	48	A
2N1637□	Ge	TO-1	–	0.08	45	48	A
2N1638□	Ge	TO-1	–	0.08	40	61	A
2N1639□	Ge	TO-1	–	0.08	45	37	A

□ Not available from RCA

Transistors

RCA Type No.	Material	Pkg.	$V_{CE(sat)}$● or V_{CEO} max. V	P_T max. W	f_T min. MHz	h_{FE} or h_{fe}■ min.	Term. Diagrams Pg. 4
2N1683	Ge	TO-5	–12	0.15	50	50	F
2N2369A	Si	TO-18	0.2●	1.2	500	200	I
2N2475	Si	TO-18	0.4●	0.3	600	30	I
2N2476	Si	TO-5	0.75●	2	250	20	I
2N2477	Si	TO-5	0.65●	2	250	4	I
2N2613□	Ge	TO-1	–	0.12	–	120■	A
2N2614□	Ge	TO-1	–40	0.12	–	100■	A
2N2708□	Si	TO-72	20	0.3	700	30	N
2N2953□	Ge	TO-1	–30	0.12	–	200■	A
2N3241A□	Si	TO-104	25	0.5	175	100	O
2N3242A□	Si	TO-104	40	0.5	175	125	O
2N3261	Si	TO-52	0.35●	1	600	40	I
2N3512	Si	TO-5	0.4●	4	250	10	I
2N3932□	Si	TO-104	20	0.2	750	40	N
2N3933□	Si	TO-104	30	0.2	750	60	N
2N4068□	Si	TO-104	3●	0.5	50	30	I
2N4069□	Si	TO-104	3●	1	600	30	I
2N4074□	Si	TO-104	40	0.5	50	50	O
2N4259□	Si	TO-104	30	0.18	750	11.5	N
2N4390□	Si	TO-104	120	0.5	50	20	I
2N5180□	Si	TO-104	15	0.18	650	20	N
2N5183□	Si	TO-104	18	0.5	125	40	I
2N5184□	Si	TO-104	120	0.5	50	10	I
2N5185□	Si	TO-104	120	1	50	10	I
2N5186	Si	TO-52	0.3●	0.3	400	25	I
2N5187	Si	TO-52	0.25●	1	400	30	I
2N5188	Si	TO-39	0.5●	4	250	20	I
40231□	Si	TO-104	18	0.5	60	55■	O
40232□	Si	TO-104	18	0.5	60	90■	O
40233□	Si	TO-104	18	0.5	60	90■	O

□ Not available from RCA

Transistors

RCA Type No.	Material	Pkg.	$V_{CE(sat)}$● or V_{CEO} max. V	P_T max, W	f_T min. MHz	h_{FE} or h_{fe}■ min.	Term. Diagrams Pg. 4
40234□	Si	TO-104	40	0.5	50	75	O
40235□	Si	TO-104	45	0.18	1000	40	N
40236□	Si	TO-104	45	0.18	1000	40	N
40237□	Si	TO-104	45	0.18	1000	27	N
40238□	Si	TO-104	45	0.18	800	45	N
40239□	Si	TO-104	45	0.18	800	45	N
40240□	Si	TO-104	45	0.18	800	45	N
40242□	Si	TO-104	45	0.18	–	38	N
40243□	Si	TO-104	45	0.18	–	38	N
40244□	Si	TO-104	45	0.18	–	27	N
40245□	Si	TO-104	45	0.18	–	51	N
40246□	Si	TO-104	45	0.18	–	51	N
40295□	Si	TO-72	20	0.3	700	10	M
40329	Ge	TO-1	–0.25●	0.12	–	50	A
40354□	Si	TO-104	150	0.5	50	55	I
40355□	Si	TO-104	150	1	50	55	I
40359□	Ge	TO-1	–20	0.12	–	40■	A
40395□	Ge	TO-1	–20	0.12	60	170■	N
40396	Ge	TO-1	–18	0.3	—	50	B
40397□	Si	TO-104	25	0.5	50	100	I
40398□	Si	TO-104	25	0.5	50	50	I
40399□	Si	TO-104	18	0.5	50	100	I
40400□	Si	TO-104	18	0.5	50	50	I
40405□	Si	TO-52	16	1	300	20	I
40413□	Si	TO-72	20	0.3	700	10	N
40414	Si	TO-72	15	0.3	1000	30	N
40458□	Si	TO-104	40	0.5	150	100	I
40519	Si	TO-52	16	0.3	–	3■	I
40637	Si	TO-52	–	1	300	–	I

Linear Integrated Circuits – (Operational) Amplifiers

RCA Type No.	Pkg.	Typ. Characteristics @ V_{CC} = +12 V, V_{EE} = –6V, T_A = 25°C				
		A_{OL} dB	C_{MR} dB	R_{OUT} Ω	V_{IO} mV	P_T mW
CA3031/702A	8L TO-5	70	85	130	2	85
CA3032/702C	8L TO-5	70	80	200	5	90

Diodes

RCA Type No.	Pkg.	Max. Ratings			Term. Diagrams Pg. 4
		i_{FM} (peak) A	$I_{F(AV)}$ A	V_{RM} V	
IN2326	–	0.2	0.1	–1	P
IN4785	TO-3	10	7	320	D

Digital Integrated Circuits

RCA Type No.	Pkg.	Function *	Output Voltage		Propagation Delay Time		
			V_{OL} max. V	V_{OH} min. V	t_{PHL} min. ns	t_{PLH} min. ns	t_{PHL}, t_{PLH} typ. ns
CD2200	14L FP	1	0.1	3.4	–	–	55
CD2200D	14L DIC	1	0.1	3.4	–	–	55
CD2201	14L FP	3	0.1	3.4	–	–	55
CD2201D	14L DIC	3	0.1	3.4	–	–	55
CD2202	14L FP	1	0.1	3.4	–	–	48
CD2202D	14L DIC	1	0.1	3.4	–	–	48
CD2203	14L FP	7	0.1	3.4	–	–	130
CD2203D	14L DIC	7	0.1	3.4	–	–	130
CD2204	14L FP	8	For input expansion of CD2200, CD2202, and CD2205 gates capable of expanding fan-in to more than 20.				
CD2204D	14L DIC	8					
CD2205	14L FP	9	0.1	3.4	–	–	71
CD2205D	14L DIC	9	0.1	3.4	–	–	71
CD2300/930	14L FP	1	0.4	2.6	10	25	–
CD2300D/930	14 L DIC	1	0.4	2.6	10	25	–
CD2300E/830	14L DIP	1	0.45	2.6	10	25	–
CD2301/961	14L FP	1	0.4	3.8	10	15	–
CD2301D/961	14L DIC	1	0.4	3.8	10	15	–
CD2301E/861	14L DIP	1	0.45	4.3	10	15	–
CD2302/946	14L FP	3	0.4	2.6	10	25	–
CD2302D/946	14L DIC	3	0.4	2.6	10	25	–
CD2302E/846	14L DIP	3	0.45	2.6	10	25	–
CD2303/949	14L FP	3	0.4	2.6	10	15	–
CD2303D/949	14L DIC	3	0.4	2.6	10	15	–
CD2303E/849	14L DIP	3	0.45	2.6	10	15	–
CD2304/945	14L FP	10	0.4	3.1	30	35	–
CD2304D/945	14L DIC	10	0.4	3.1	30	35	–
CD2304E/845	14L DIP	10	0.45	3.1	30	35	–
CD2305/948	14L FP	10	0.4	4	30	30	–
CD2305D/948	14L DIC	10	0.4	4	30	30	–
CD2305E/848	14L DIP	10	0.45	4.3	30	30	–
CD2306/932	14L FP	1	0.4	2.6	15	25	–
CD2306D/932	14L DIC	1	0.4	2.6	15	25	–
CD2306E/832	14L DIP	1	0.45	2.6	15	25	–
CD2307/944	14L FP	1	0.4	6	10	15	–
CD2307D/944	14L DIC	1	0.4	6	10	15	–
CD2307E/844	14L DIP	1	0.45	6	10	15	–

Digital Integrated Circuits

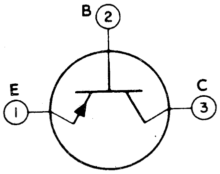
RCA Type No.	Pkg.	Function *	Output Voltage		Propagation Delay Time	
			V_{OL} max. V	V_{OH} min. V	t_{PHL} min. ns	t_{PLH} min. ns
CD2308/962	14L FP	2	0.4	2.6	10	30
CD2308D/962	14L DIC	2	0.4	2.6	10	30
CD2308E/862	14L DIP	2	0.45	2.6	10	30
CD2309/963	14L FP	2	0.4	3.8	10	15
CD2309D/963	14L DIC	2	0.4	3.8	10	15
CD2309E/863	14L DIP	2	0.45	4.3	10	15
CD2310/936	14L FP	4	0.4	2.6	10	25
CD2310D/936	14L DIC	4	0.4	2.6	10	25
CD2310E/836	14L DIP	4	0.45	2.6	10	25
CD2311/937	14L FP	4	0.4	3.8	10	15
CD2311D/937	14L DIC	4	0.4	3.8	10	15
CD2311E/837	14L DIP	4	0.5	4.3	10	15
CD2312	14L FP	4	0.4	2.6	10	25
CD2312D	14L DIC	4	0.4	2.6	10	25
CD2312E	14L DIP	4	0.45	2.6	10	25
CD2313	14L FP	4	0.4	3.8	10	15
CD2313D	14L DIC	4	0.4	3.8	10	15
CD2313E	14L DIP	4	0.5	4.3	10	15
CD2314/933	14L FP	5	Input Fwd Volt/Diode = 0.7V min.			
CD2314D/933	14L DIC	5	= 0.7V min.			
CD2314E/833	14L DIP	5	= 0.68V min.			
CD2315	14L FP	7	0.4	3.1	30	35
CD2315D	14L DIC	7	0.4	3.1	30	35
CD2315E	14L DIP	7	0.45	3.1	30	35
CD2316	14L FP	7	0.4	3.1	30	30
CD2316D	14L DIC	7	0.4	3.1	30	30
CD2316E	14L DIP	7	0.45	3.1	30	30
CD2317	14L FP	7	0.4	3.1	30	35
CD2317D	14L DIC	7	0.4	3.1	30	35
CD2317E	14L DIP	7	0.45	3.1	30	35
CD2318	14L FP	7	0.4	4	30	30
CD2318D	14L DIC	7	0.4	4	30	30
CD2318E	14L DIP	7	0.45	4.3	30	30

* FUNCTION

1. Dual 4-Input NAND Gates
2. Triple 3-Input NAND Gates
3. Quad 2-Input NAND Gates
4. Hex Inverters
5. Dual 4-Diode Input Expanders
6. Clocked R-S Flip Flops
7. Dual Clocked J-K Flip Flops
8. Dual 4-Input Gate Expander
9. Dual 3-Input Expandable AND/OR/NOT Gate
10. Clocked RS Flip Flop with J-K Capability

TRANSISTOR AND DIODE TERMINAL DIAGRAMS

A



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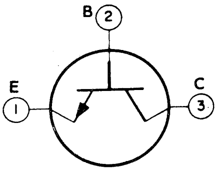

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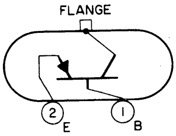

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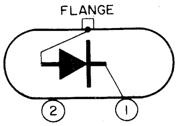

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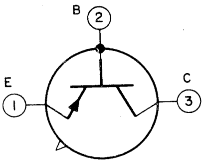

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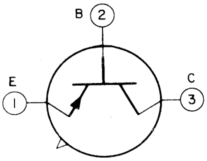

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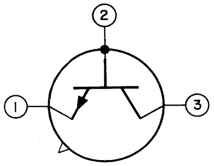

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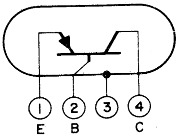

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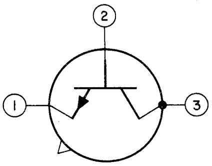

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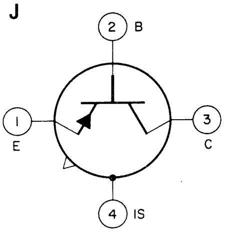

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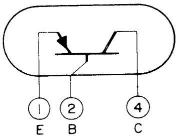

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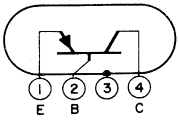

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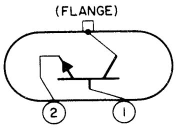

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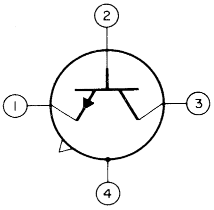

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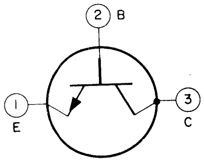

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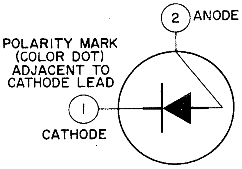

SYMBOL DEFINITIONS

A_{OL}	voltage gain, open loop
CMR	common-made rejection ratio
f_T	gain-bandwidth product
h_{FE}	static forward current transfer ratio
h_{fe}	small-signal forward current transfer ratio
i_{FM}	peak forward current
P_T	transistor dissipation
R_{OUT}	output resistance
t_{PHL}	high-to-low level propagation delay time
t_{PLH}	low-to-high level propagation delay time
V_{CEO}	collector-to-emitter voltage
$V_{CE(sat)}$	collector-to-emitter saturation voltage
V_{IO}	input offset voltage
V_{OH}	high-level output voltage
V_{OL}	low-level output voltage
V_{RM}	peak reverse voltage

Application Notes for RF Power Devices

RCA
Solid State
Division

RF Power Transistors

Application Note
1CE-402

Operating Considerations for RCA Solid State Devices

Solid state devices are being designed into an increasing variety of electronic equipment because of their high standards of reliability and performance. However, it is essential that equipment designers be mindful of good engineering practices in the use of these devices to achieve the desired performance.

This Note summarizes important operating recommendations and precautions which should be followed in the interest of maintaining the high standards of performance of solid state devices.

The ratings included in RCA Solid State Devices data bulletins are based on the Absolute Maximum Rating System, which is defined by the following Industry Standard (JEDEC) statement:

Absolute-Maximum Ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

It is recommended that equipment manufacturers consult RCA whenever device applications involve unusual electrical, mechanical or environmental operating conditions.

GENERAL CONSIDERATIONS

The design flexibility provided by these devices makes possible their use in a broad range of applications and under many different operating conditions. When incorporating these devices in equipment, therefore, designers should anticipate the rare possibility of device failure and make certain that no safety hazard would result from such an occurrence.

The small size of most solid state products provides obvious advantages to the designers of electronic equipment. However, it should be recognized that these compact devices usually provide only relatively small insulation area between adjacent leads and the metal envelope. When these devices are used in moist or contaminated atmospheres, therefore, supplemental protection must be provided to prevent the development of electrical conductive paths across the relatively small insulating surfaces. For specific information on voltage creepage, the user should consult references such as the JEDEC Standard No. 7 "Suggested Standard on Thyristors," and JEDEC Standard RS282 "Standards for Silicon Rectifier Diodes and Stacks".

The metal shells of some solid state devices operate at the collector voltage and for some rectifiers and thyristors at the anode voltage. Therefore, consideration should be given to the possibility of shock hazard if the shells are to operate at voltages appreciably above or below ground potential. In general, in any application in which devices are operated at voltages which may be dangerous to personnel, suitable precautionary measures should be taken to prevent direct contact with these devices.

Devices should not be connected into or disconnected from circuits with the power on because high transient voltages may cause permanent damage to the devices.

TRANSISTORS WITH FLEXIBLE LEADS

Flexible leads are usually soldered to the circuit elements. It is desirable in all soldering operations to provide some slack or an expansion elbow in each lead, to prevent excessive tension on the leads. It is important during the soldering operation to avoid excessive heat in order to prevent possible damage to the devices. Some of the heat can be absorbed if the flexible lead of the device is grasped between the case and the soldering point with a pair of pliers.

TRANSISTORS WITH MOUNTING FLANGES

The mounting flanges of JEDEC-type packages such as the TO-3 or TO-66 often serve as the collector or anode terminal. In such cases, it is essential that the mounting flange be securely fastened to the heat sink, which may be the equipment chassis. UNDER NO CIRCUMSTANCES, HOWEVER, SHOULD THE MOUNTING FLANGE BE SOLDERED DIRECTLY TO THE HEAT SINK OR CHASSIS BECAUSE THE HEAT OF THE SOLDERING OPERATION COULD PERMANENTLY DAMAGE THE DEVICE.

Such devices can be installed in commercially available sockets. Electrical connections may also be made by soldering directly to the terminal pins. Such connections may be soldered to the pins close to the pin seals provided care is taken to conduct excessive heat away from the seals; otherwise the heat of the soldering operation could crack the pin seals and damage the device.

During operation, the mounting-flange temperature is higher than the ambient temperature by an amount which depends on the heat sink used. The heat sink must have sufficient thermal capacity to assure that the heat dissipated in the heat sink itself does not raise the device mounting-flange temperature above the rated value. The heat sink or chassis may be connected to either the positive or negative supply.

In many applications the chassis is connected to the voltage-supply terminal. If the recommended mounting hardware shown in the data bulletin for the specific solid-state device is not available, it is necessary to use either an anodized aluminum insulator having high thermal conductivity or a mica insulator between the mounting-flange and the chassis. If an insulating aluminum washer is required, it should be drilled or punched to provide the two mounting holes for the terminal pins. The burrs should then be removed from the washer and the washer anodized. To insure that the anodized insulating layer is not destroyed during mounting, it is necessary to remove the burrs from the holes in the chassis.

It is also important that an insulating bushing, such as glass-filled nylon, be used between each mounting bolt and the chassis to prevent a short circuit. However, the insulating bushing should not exhibit shrinkage or softening under the operating temperatures encountered. Otherwise the thermal resistance at the interface between transistor and heat sink may increase as a result of decreasing pressure.

PLASTIC POWER TRANSISTORS AND THYRISTORS

RCA power transistors and thyristors (SCR's and triacs) in molded-silicone-plastic packages are available in a wide range of power-dissipation ratings and a variety of package configurations. The following paragraphs provide guidelines for handling and mounting of these plastic-package devices, recommend forming of leads to meet specific mounting requirements, and describe various mounting arrangements, thermal considerations, and cleaning methods. This information is intended to augment the data on electrical characteristics, safe operating area, and performance capabilities in the technical bulletin for each type of plastic-package transistor or thyristor.

Lead-Forming Techniques

The leads of the RCA VERSAWATT in-line plastic packages can be formed to a custom shape, provided they are not indiscriminately twisted or bent. Although these leads can be formed, they are not flexible in the general sense, nor are they sufficiently rigid for unrestrained wire wrapping

Before an attempt is made to form the leads of an in-line package to meet the requirements of a specific application, the desired lead configuration should be determined, and a lead-bending fixture should be designed and constructed. The use of a properly designed fixture for this operation eliminates the need for repeated lead bending. When the use of a special bending fixture is not practical, a pair of long-nosed pliers may be used. The pliers should hold the lead firmly between the bending point and the case, but should not touch the case.

When the leads of an in-line plastic package are to be formed, whether by use of long-nosed pliers or a special bending fixture, the following precautions must be observed to avoid internal damage to the device:

1. Restrain the lead between the bending point and the plastic case to prevent relative movement between the lead and the case.
2. When the bend is made in the plane of the lead (spreading), bend only the narrow part of the lead.
3. When the bend is made in the plane perpendicular to that of the leads, make the bend at least 1/8 inch from the plastic case.
4. Do not use a lead-bend radius of less than 1/16 inch.
5. Avoid repeated bending of leads.

The leads of the TO-220AB VERSAWATT in-line package are not designed to withstand excessive axial pull. Force in this direction greater than 4 pounds may result in permanent damage to the device. If the mounting arrangement tends to impose axial stress on the leads, some method of strain relief should be devised.

Wire wrapping of the leads is permissible, provided that the lead is restrained between the plastic case and the point of the wrapping. Soldering to the leads is also allowed. The maximum soldering temperature, however, must not exceed 275°C and must be applied for not more than 5 seconds at a distance not less than 1/8 inch from the plastic case. When wires are used for connections, care should be exercised to assure that movement of the wire does not cause movement of the lead at the lead-to-plastic junctions.

The leads of RCA molded-plastic high-power packages are not designed to be reshaped. However, simple bending of the leads is permitted to change them from a standard vertical to a standard horizontal configuration, or conversely. Bending of the leads in this manner is restricted to three 90-degree bends; repeated bendings should be avoided.

Mounting

Recommended mounting arrangements and suggested hardware for the VERSAWATT transistors are given in the data bulletins for specific devices and in RCA Application Note AN-4124. When the transistor is fastened to a heat sink, a rectangular washer (RCA Part No. NR231A) is recommended to minimize distortion of the mounting flange. Excessive distortion of the flange could cause damage to the transistor. The washer is particularly important when the size of the mounting hole exceeds 0.140 inch (6-32 clearance). Larger holes are needed to accommodate insulating bushings; however, the holes should not be larger than necessary to provide hardware clearance and, in any case, should not exceed a diameter of 0.250 inch.

Flange distortion is also possible if excessive torque is used during mounting. A maximum torque of 8 inch-pounds is specified. Care should be exercised to assure that the tool used to drive the mounting screw never comes in contact with the plastic body during the driving operation. Such contact can result in damage to the plastic body and internal device connections. An excellent method of avoiding this problem is to use a spacer or combination spacer-isolating bushing which raises the screw head or nut above the top surface of the plastic body. The material used for such a spacer or spacer-isolating bushing should, of course, be carefully selected to avoid "cold flow" and consequent reduction in mounting force. Suggested materials for these bushings are diallphtalate, fiberglass-filled nylon, or fiberglass-filled polycarbonate. Unfilled nylon should be avoided.

Modification of the flange can also result in flange distortion and should not be attempted. The transistor should not be soldered to the heat sink by use of lead-tin solder because the heat required with this type of solder will cause the junction temperature of the transistor to become excessively high.

The TO-220AA plastic transistor can be mounted in commercially available TO-66 sockets, such as UID Electronics Corp. Socket No. PTS-4 or equivalent. For testing purposes, the TO-220AB in-line package can be mounted in a Jetron Socket No. CD74-104 or equivalent. Regardless of the mounting method, the following precautions should be taken:

1. Use appropriate hardware.
2. Always fasten the transistor to the heat sink before the leads are soldered to fixed terminals.
3. Never allow the mounting tool to come in contact with the plastic case.
4. Never exceed a torque of 8 inch-pounds.
5. Avoid oversize mounting holes.
6. Provide strain relief if there is any probability that axial stress will be applied to the leads.
7. Use insulating bushings to prevent hot-creep problems. Such bushings should be made of diallphthalate, fiberglass-filled nylon, or fiberglass-filled polycarbonate.

The maximum allowable power dissipation in a solid state device is limited by the junction temperature. An important factor in assuring that the junction temperature remains below the specified maximum value is the ability of the associated thermal circuit to conduct heat away from the device.

When a solid state device is operated in free air, without a heat sink, the steady-state thermal circuit is defined by the junction-to-free-air thermal resistance given in the published data for the device. Thermal considerations require that a free flow of air around the device is always present and that the power dissipation be maintained below the level which would cause the junction temperature to rise above the maximum rating. However, when the device is mounted on a heat sink, care must be taken to assure that all portions of the thermal circuit are considered.

To assure efficient heat transfer from case to heat sink when mounting RCA molded-plastic solid state power devices, the following special precautions should be observed:

1. Mounting torque should be between 4 and 8 inch-pounds.
2. The mounting holes should be kept as small as possible.
3. Holes should be drilled or punched clean with no burrs or ridges, and chamfered to a maximum radius of 0.010 inch.
4. The mounting surface should be flat within 0.002 inch/inch.
5. Thermal grease (Dow Corning 340 or equivalent) should always be used on both sides of the insulating washer if one is employed.
6. Thin insulating washers should be used. (Thickness of factory-supplied mica washers range from 2 to 4 mils).
7. A lock washer or torque washer, made of material having sufficient creep strength, should be used to prevent degradation of heat sink efficiency during life.

A wide variety of solvents is available for degreasing and flux removal. The usual practice is to submerge components in a solvent bath for a specified time. However, from a reliability stand point it is extremely important that the solvent, together with other chemicals in the solder-cleaning system (such as flux and solder covers), do not adversely affect the life of the component. This consideration applies to all non-hermetic and molded-plastic components.

It is, of course, impractical to evaluate the effect on long-term transistor life of all cleaning solvents, which are marketed with numerous additives under a variety of brand names. These solvents can, however, be classified with respect to their component parts, as either acceptable or unacceptable. Chlorinated solvents tend to dissolve the outer package and, therefore, make operation in a humid atmosphere unreliable. Gasoline and other hydrocarbons cause the inner encapsulant to swell and damage the transistor. Alcohol and unchlorinated freons are acceptable solvents. Examples of such solvents are:

1. Freon TE
2. Freon TE-35
3. Freon TP-35 (Freon PC)
4. Alcohol (isopropanol, methanol, and special denatured alcohols, such as SDA1, SDA30, SDA34, and SDA44)

Care must also be used in the selection of fluxes for lead soldering. Rosin or activated rosin fluxes are recommended, while organic or acid fluxes are not. Examples of acceptable fluxes are:

1. Alpha Reliaros No. 320-33
2. Alpha Reliaros No. 346
3. Alpha Reliaros No. 711
4. Alpha Reliafoam No. 807
5. Alpha Reliafoam No. 809
6. Alpha Reliafoam No. 811-13
7. Alpha Reliafoam No. 815-35
8. Kester No. 44

If the completed assembly is to be encapsulated, the effect on the molded-plastic transistor must be studied from both a chemical and a physical standpoint.

RECTIFIERS AND THYRISTORS

A surge-limiting impedance should always be used in series with silicon rectifiers and thyristors. The impedance value must be sufficient to limit the surge current to the value specified under the maximum ratings. This impedance may be provided by the power transformer winding, or by an external resistor or choke.

A very efficient method for mounting thyristors utilizing packages such as the JEDEC TO-5 and "modified TO-5" is to provide intimate contact between the heat sink and at least one half of the base of the device opposite the leads. These packages can be mounted to the heat sink mechanically with glue or an epoxy adhesive, or by soldering. Soldering to the heat sink is preferable because it is the most efficient method.

The use of a "self-jigging" arrangement and a solder preform is recommended. Such an arrangement is illustrated in RCA Publication MHI-300B, "Mounting Hardware Supplied with RCA Semiconductor Devices". If each unit is soldered individually, the heat source should be held on the heat sink and the solder on the unit. Heat should be applied only long enough to permit solder to flow freely. For more detailed thyristor mounting considerations, refer to Application Note AN3822, "Thermal Considerations in Mounting of RCA Thyristors".

MOS FIELD-EFFECT TRANSISTORS

Insulated-Gate Metal Oxide-Semiconductor Field-Effect Transistors (MOS FETs), like bipolar high-frequency transistors, are susceptible to gate insulation damage by the electrostatic discharge of energy through the devices. Electrostatic discharges can occur in an MOS FET if a type with an unprotected gate is picked up and the static charge, built in the handler's body capacitance, is discharged through the device. With proper handling and applications procedures, however, MOS transistors are currently being extensively used in production by numerous equipment manufacturers in military, industrial, and consumer applications, with virtually no problems of damage due to electrostatic discharge.

In some MOS FETs, diodes are electrically connected between each insulated gate and the transistor's source. These diodes offer protection against static discharge and in-circuit transients without the need for external shorting mechanisms. MOS FETs which do not include gate-protection diodes can be handled safely if the following basic precautions are taken:

1. Prior to assembly into a circuit, all leads should be kept shorted together either by the use of metal shorting springs attached to the device by the vendor, or by the insertion into conductive material such as "ECCOSORB* LD26" or equivalent.
   (NOTE: Polystyrene *insulating* "SNOW" is not sufficiently conductive and should not be used.)
2. When devices are removed by hand from their carriers, the hand being used should be grounded by any suitable means, for example, with a metallic wristband.
3. Tips of soldering irons should be grounded.
4. Devices should never be inserted into or removed from circuits with power on.

INTEGRATED CIRCUITS

In any method of mounting integrated circuits which involves bending or forming of the device leads, it is extremely important that the lead be supported and clamped between the bend and the package seal, and that bending be done with care to avoid damage to lead plating. In no case should the radius of the bend be less than the diameter of the lead, or in the case of rectangular leads,such as those used in RCA 14-lead and 16-lead flat-packages, less than the lead thickness. It is also extremely important that the ends of the bent leads be straight to assure proper insertion through the holes in the printed-circuit board.

COS/MOS (Complementary-Symmetry MOS) Integrated Circuits

Although protection against electrostatic effects is provided by built-in circuitry, the following precautions should be taken in handling these circuits:

1. Soldering-iron tips and test equipment should be grounded.
2. Devices should not be inserted in non-conductive containers such as conventional plastic snow or trays. A conductive material such as "ECCOSORB LD26" or equivalent should be used.

Low-source-impedance pulse generators connected to the inputs of these devices must be disconnected before the dc power supply is turned off. All unused input leads must be connected to either V_{SS} or V_{DD}, whichever is appropriate for the logic circuit operation desired.

SOLID STATE CHIPS

Solid state chips, unlike packaged devices, are non-hermetic devices, normally fragile and small in physical size, and therefore, require special handling considerations as follows:

1. Chips must be stored under proper conditions to insure that they are not subjected to a moist and/or contaminated atmosphere that could alter their electrical, physical, or mechanical characteristics. After the shipping container is opened, the chip must be stored under the following conditions:
   A. Storage temperature, 40°C max.
   B. Relative humidity, 50% max.
   C. Clean, dust-free environment.
2. The user must exercise proper care when handling chips to prevent even the slightest physical damage to the chip.
3. During mounting and lead bonding of chips the user must use proper assembly techniques to obtain proper electrical, thermal, and mechanical performance.
4. After the chip has been mounted and bonded, any necessary procedure must be followed by the user to insure that these non-hermetic chips are not subjected to

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*Trade Mark: Emerson and Cumming, Inc.

moist or contaminated atmosphere which might cause the development of electrical conductive paths across the relatively small insulating surfaces. In addition, proper consideration must be given to the protection of these devices from other harmful environments which could conceivably adversely affect their proper performance.

SOLID STATE LASERS AND EMITTING DIODES

Optoelectronic devices should employ the same mounting and heat-sink procedures utilized with other solid state devices. The temperature ratings established for storing, mounting, and operating these devices must not be exceeded to avoid damaging the emitters. Because the extremely small size and high driving-current requirements of some of these devices preclude the use of polarity marks on the housing and package configurations, care must be taken to insure that voltage is always applied in the proper direction. It is important, therefore, to refer to the data bulletin for the proper polarity before applying voltage to the device. Pulse driving circuitry should be designed to prevent transients (positive or negative) or momentary surges from exceeding drive conditions. The following suggestions are offered:

1. High-speed clipping diodes should be placed at terminals to bypass negative transients.
2. High-speed, sense-and-clamp circuitry should be used to prevent overdrive in peak or average current by clamping or disconnect techniques. For short pulses, ordinary thermal fuses should not be used because they do not provide adequate device protection.

The characteristics of solid state emitters vary substantially with changes in ambient temperature. Threshold, the point at which lasing starts, is highly dependent on temperature and requires compensation of drive current in applications where operation over a wide temperature range is a design requirement. A room-temperature laser can be damaged if a constant drive current is maintained while the ambient temperature is reduced to cryogenic levels. Published data bulletins for individual devices specify safe levels of operation.

In most cases, the voltage drop across a solid state emitter is of comparatively low amplitude; however, the required drive current may be many amperes. As in the case of other high-operating-current devices, therefore, clean and low-impedance contacts are required in all applications.

High voltage may be present in pulse-driven circuits utilizing these devices. Therefore, consideration should be given to the possibility of shock hazard which may result from contact with these high voltages. In general, where devices are operating at potentials which may be dangerous to personnel, suitable precautionary measures should be taken to prevent direct contact with these devices.

Radiation Safety Considerations

Injection laser diodes emit electromagnetic radiation at wavelengths which may be invisible to the human eye. Suitable precautions must be taken to avoid possible damage to the eye from overexposure to this radiant energy. Precautionary measures include the following:

1. *In Systems with No External Lens* – Avoid viewing the laser source at close range. Since the emitted beam is not collimated, increasing the distance to the laser source greatly reduces the risk of overexposure.
2. *In Systems Utilizing External Optics* – Avoid viewing the emitter directly along the optical axis of the radiated beam.
3. *Reflections From Surfaces* – Minimize unwanted specular reflections in the system.

ADDITIONAL DATA

Additional information on handling, mounting, and operating RCA Solid State Devices is given in the following publications which are available on request from RCA/ Commercial Engineering, Harrison, N.J. 07029.

MHI-300B	"RCA Mounting Hardware Supplied with RCA Semiconductor Devices"
1CE-338	"RCA Integrated Circuits Mounting and Connection Techniques"
AN-3822	"Thermal Considerations in Mounting of RCA Thyristors"
AN-4124	"Handling and Mounting of RCA Molded-Plastic Transistors and Thyristors"

Solid State
Division

RF Power Transistors
Application Note

AN-3749

40-Watt Peak-Envelope-Power Transistor Amplifier for AM Transmitters in the Aircraft Band (118 to 136 MHz)

By

Boris Maximow

This Note describes a broadband amplifier for use in amplitude-modulated (AM) transmitters operating in the aircraft communication band (118 to 136 MHz). The amplifier circuit is simple and easy to duplicate and requires a minimum of adjustments. The design leaves ample room for modification, improvement, or adaptation to specific needs. Fig.1 shows the schematic diagram of the amplifier, Fig.2 shows its performance over the aircraft band, and Table I lists its features.

The amplifier shown in Fig.1 uses RCA 2N3866, 40290, 40291, and 40292 epitaxial silicon planar transistors of the "overlay" emitter-electrode construction. These transistors are intended for low-voltage, high-power operation in amplitude-modulated class C amplifiers. In addition to standard breakdown-voltage ratings, the 40290, 40291, and 40292 transistors have rf breakdown-voltage characteristics which assure safe operation with high rf voltages on the collector. The 40292 transistors used in the final amplifier stage are 100-per-cent tested for load mismatch at a VSWR of 3:1. During this test, the transistor is fully modulated to simulate actual operation for added reliability.

The amplifier is capable of delivering peak envelope power of 40 watts at a modulation of 95 per cent with a collector voltage of 12.5 volts dc. Unmodulated drive of 5 milliwatts is required at the input. The over-all efficiency of the amplifier is 48 to 53 per cent, and the envelope distortion is less than 5 per cent for amplitude modulation of 95 per cent.

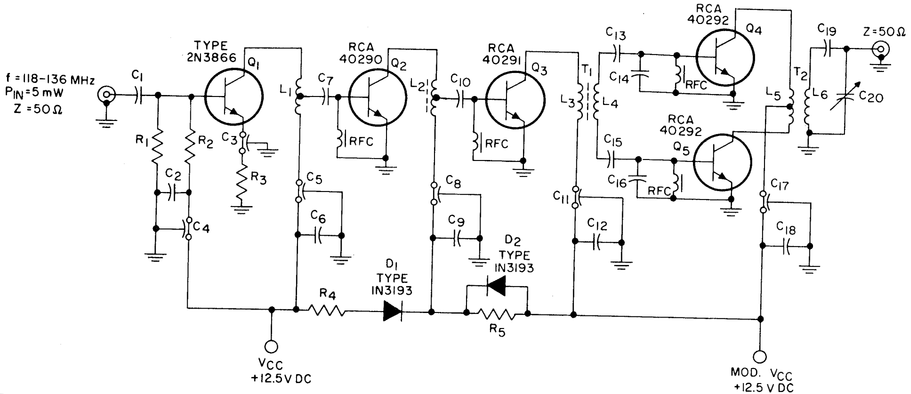
Load Mismatch Test

The suitability of 40292 transistors for use in the output stages of amplitude-modulated transmitters is determined by means of a load mismatch test which simulates the adverse load conditions that may occur in actual practice. The test setup is shown in Fig.3. The choice of C and L in the load circuit is dictated by practical values of these components. The circuit should resonate with the variable capacitor half-way in. With a variable reactive load, the impedance moves along the outer circle of a Smith Chart so that the loading changes between short and open circuit with intermediate values of capacitive and inductive reactances. The VSWR at the output of the transistor is limited to 3:1 by the 3-dB pad inserted between the variable load and the output of the test circuit. The transistor under test and the input drive are modulated to assure that the transistor operates near its full peak power capability.

At the start of the test cycle, the variable capacitor begins to rotate through its 360-degree range. When the capacitor plates are 50-per-cent engaged, the tuned circuit resonates. The resonant circuit presents an apparent short or open circuit to the 3-dB pad, depending on whether the $\lambda/4$ line is in or out of the circuit. All intermediate positions present reactances of varying amplitudes.

Output Power and Modulation

Because the only useful power in an AM transmitter is sideband power, it is reasonable to use this power as



C_1 – 300 pF, silver mica, ARCO, or equiv.
C_2 – 0.005 μF ceramic
C_3 C_4 C_5 C_8 C_{11} C_{17} – 1000 pF feedthrough
C_6 C_9 C_{12} C_{18} – 0.5 μF ceramic
C_7 – 50 pF, silver mica, ARCO, or equiv.
C_{10} C_{13} C_{15} – 82 pF, silver mica, ARCO, or equiv.
C_{14} C_{16} C_{19} – 150 pF, silver mica, ARCO, or equiv.
C_{20} – 8-60 pF, ARCO # 404, or equiv.
R_1 – 470 ohms 0.5 W
R_2 – 1500 ohms 0.5 W
R_3 – 47 ohms 0.5 W
R_4 – 15 ohms 0.5 W
R_5 – 33 ohms 0.5 W
L_1 – 7T. # 22-13/64" dia. 9/19" L. tap 1.5 T.
L_2 – 5.5T. # 22-13/64" dia. Closely Wound tap 2.0 T.
L_3 – 6T. # 22-13/64" dia. interwind W/L4
L_4 – 4T. # 22-13/64" dia. interwind W/L3
Cambion IRN-9 core mat'l or equiv.
L_5 – 5T. # 22-13/64" dia. C.T. interwind W/L6
L_6 – 5T. # 22-13/64" dia. interwind W/L5
R.F.C. – 1T. # 28 ferrite bead Ferroxcube # 56-590-65/4B or equiv.

Fig.1 - A 40-watt peak envelope power transistor amplifier.

TABLE I - PERFORMANCE FEATURES OR 40-WATT PEAK ENVELOPE POWER TRANSISTOR AMPLIFIER

DC Supply Voltage	12.5	V
Peak Envelope Power	40	W
Modulation	95	%
Efficiency	48-53	%
Envelope Distortion for 95% AM	< 5	%
Second Harmonic	> 10	dB down

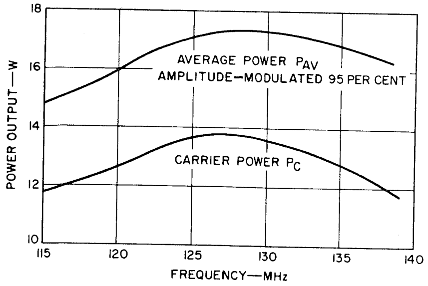


Fig.2 - Typical output power as a function of frequency.

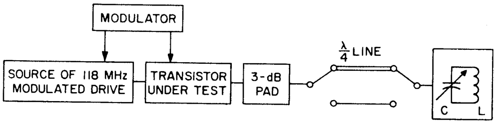


Fig.3 - Load mismatch test setup.

a reference in evaluation of the transmitter. When a single-tone sinusoidal modulating signal is used, the total sideband power P_{SB} in a modulated wave is given by

$$P_{SB} = P_{AV}\left(\frac{m^2}{2 + m^2}\right) \qquad (1)$$

where P_{AV} is the average power and m is the modulation index. This relationship is convenient to use because P_{AV} is easy to measure and

$$P_{SB} = \frac{P_{AV}}{3}$$

for 100-per-cent modulation.

The performance of an AM transmitter can also be expressed in terms of peak envelope power P_{PE}. The peak envelope power is equal to 2.66 P_{AV} in a 100-per-cent modulated wave. The value of P_{PE} indicates the ultimate peak power-handling capabilities of the transistors being used.

It is unfortunate that carrier power is sometimes used as a reference in evaluation of the performance of AM transmitters, especially transistorized transmitters. Unlike the sideband power P_{SB}, the carrier power P_C does not always have a definite relationship to P_{AV} and P_{PE}. When the carrier is used for a reference, "carrier shift" and "upward modulation" must be considered. Use of these terms in conjunction with P_C to define transmitter modulation only complicates the definition of per-cent amplitude modulation. For example, Fig.4 shows an amplitude-modulated wave. The amplitude modulation AM in per cent is defined as follows:

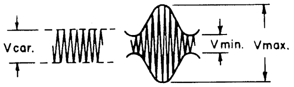


Fig.4 - The amplitude modulated wave; V_{car} is the amplitude of carrier before modulation.

$$AM = \left(\frac{V_{max} - V_{min}}{V_{max} + V_{min}}\right) \times 100 \qquad (2)$$

Use of this equation indicates that when $V_{min} = 0$, the wave is 100-per-cent modulated without reference to the carrier. The following expressions are based on carrier amplitude V_{car} or carrier power P_C:

$$AM = \left(\frac{V_{max}}{V_{car}} - 1\right) \text{ X } 100 \qquad (3)$$

$$P_{AV} = P_C\left(1 + \frac{m^2}{2}\right) \qquad (4)$$

These expressions contain the tacit assumption that carrier level must not vary from the unmodulated state, which may not be the case. If the modulation is adjusted to 100 per cent by the use of Eq. (2) and P_{AV} is measured, values can easily be computed for P_{SB}, P_{PE}, and even P_C.

Design Considerations

The need for wideband performance in aircraft transmitters precludes the use of sharply tuned circuits to reduce harmonic power in the output; instead, low-pass filters are used. Any configuration of active devices that reduces the harmonic content in the output helps to ease the requirements placed upon these filters. One such configuration is a push-pull amplifier, which inherently has low even harmonics in the output. The higher input impedance of a push-pull stage as compared to a single-ended parallel combination of two transistors is also advantageous for obtaining wider bandwidths because only one-half as much current is injected into the input of push-pull transistors as into parallel devices during one-half cycle.

The coupling circuits in the amplifier of Fig.1 are basically double-tuned interstage circuits, as shown in Fig.5. R_1 and C_1 represent the collector output resistance and the collector output capacitance of the driver transistor. L_i and R_i represent the input series inductance and the input series resistance of a transistor. (For simplicity, coil resistances are omitted.) Q values for the two circuits shown in Fig.5 are expressed as follows:

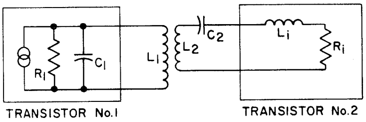


Fig.5 - A double-tuned interstage.

$$Q_1 = \frac{R_1}{\omega L_1} \qquad (5)$$

$$Q_2 = \frac{\omega (L_2 + L_i)}{R_i} \qquad (6)$$

For large bandwidths, it is desirable that Q_1 be much larger than Q_2. L_2, C_2, and L_i are series resonant at some frequency f_o within the bandwidth; L_1 and C_1 can then be determined as follows:

$$L_1 C_1 = \frac{1}{(\omega_o)^2} \qquad (7)$$

In practice, the resonant frequency f_o may not be exactly the center frequency of the passband, but may tend toward the high end of the bandwidth to compensate for degradation of the frequency response of the transistor itself. Normally, there is no problem obtaining relatively high values of Q_1 because transistors have large collector output resistance R_1. However, it is more difficult to obtain a low value of Q_2 in a transistor double-tuned interstage circuit because high-power transistors have low series input resistance R_i. The ontribution of the inductive series input reactance L_i may be sufficient to raise the value of Q_i to undesirable levels and thereby limit the obtainable bandwidth.

This problem can be solved by use of an L-section and its transforming properties. The inductive input impedance of a transistor may be represented by the solid lines of Fig.6.

The definite Q value associated with this input impedance may be represented as Q_i. If a capacitor C_i is added to the transistor input of Fig.6, as shown by the dotted line, the resistance R_i can be transformed up by the L-section to a new value R_T, as follows:

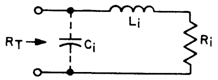


Fig.6 - Transistor input as an L-section.

$$R_T + R_i \; (Q_i^2 + 1) \tag{8}$$

The value of the capacitor C_i is calculated as follows:

$$C_i = \frac{1}{\omega R_T} \sqrt{\frac{R_T}{R_i} - 1} = \frac{L_i}{\omega^2 L_i^2 + R_i^2} \tag{9}$$

When an L-section is used in conjunction with a double-tuned interstage circuit, the value Q_2' of the second circuit is given by

$$Q_2' = \frac{\omega L_2}{R_T} \tag{10}$$

This value is, of course, lower than that shown in Eq. (6). Consequently, an L-section can be used to match resistances of not-too-different magnitudes and at the same time maintain low values of Q. The value of L_i in the circuit is given by

$$L_i = \frac{R_i}{\omega} \sqrt{\frac{R_T}{R_i} - 1} \tag{11}$$

There are limits to the results that can be accomplished with this type of transformation. For some combination of L_i and R_i, the required value of C_i may be too large to be practically realizable. In addition, R_T is a frequency-dependent parameter. For very low values of Q_i, the capacitor C_i loses its effectiveness because R_T becomes very nearly equal to R_i.

Double-tuned interstage coupling circuits were used throughout the amplifier shown in Fig.1. When it was necessary to use a two-winding transformer, as in the case of T_1 and T_2, bifiliar windings were employed for tighter coupling. In other cases, autotransformers with their high coefficient of coupling were used quite successfully. Eq. (7) was used as the starting point for determination of the inductances in the primaries of the double-tuned interstages; the collector to base capacitance C_{CB} of the transistor was substituted for C_1. Turn ratios were determined by the impedance levels to be transformed. The load resistance R_L for each stage was determined as follows:

$$R_L = \frac{(V_{CC})^2}{2Po} \tag{12}$$

where V_{CC} is the collector supply voltage and P_o is the power output. The collector-emitter saturation voltage is omitted for simplicity.

A single 40292 transistor is capable of delivering 6 watts of output power with an input of 2 watts and a supply of 12.5 volts dc at 135 MHz. For these conditions, the load resistance R_L is given by

$$R_L = \frac{(12.5)^2}{12} = 13 \text{ ohms}$$

This value of 13 ohms from one-half of the primary winding of T_2 is transformed to 50 ohms in the secondary winding. This impedance level allows the use of a 1:1 transformer, which is convenient for bifilar winding. For 40292 transistors, R_i is approximately 6 ohms and X_{Li} is about 3 ohms. An L-section is used in the inputs to the 40292 transistors in the push-pull amplifier. To maintain a low value of Q_i, the leads on the base-to-emitter capacitors (C_{14} and C_{16}) were kept short and the capacitors were placed as close to the base and the emitter as possible. The values of C_{14} and C_{16} of Fig.1 were determined empirically. The effective capacitances may differ appreciably from the nominal value of 150 picofarads shown.

Drive power of about 3 to 3.5 watts is required for the push-pull amplifier. This power is provided by the 40291 driver transistor operating into a 24-ohm load,

$$\left[R_L = \frac{(V_{CE})^2}{2P_o} = (12.5)^2/65 \right]$$

Because the input resistance to the driver is sufficiently high (12 ohms), no L-section is used. The load resistance for the 40290 pre-driver transistor is selected to provide the required input to the driver of about 0.6 watt. The 100-milliwatt input required for the pre-driver stage is supplied by the 2N3866 class A input stage. Again, a double-tuned interstage circuit is used for coupling. The class A amplifier is biased to a quiescent current of 40 milliamperes for maximum gain, and has a load line of approximately 300 ohms, which is computed from

$$R_{\text{load line}} = \frac{V_{CC}}{I_C} \tag{13}$$

An autotransformer is used to transform the 300-ohm load down to about 12 ohms at the predriver. The input of the 2N3866 stage is matched to the 50-ohm source. This stage has a gain of about 13 dB which increases the power from the 5-milliwatt input. The problem of subharmonic generation was solved by use of cores in the interstage transformers. Stable operation is obtained if the stages are kept 1.25 inches apart.

The final amplifier and the driver are modulated symmetrically about the carrier level. The predriver is modulated more in a positive direction as a result of the resistor-diode arrangement (R_4,R_5,D_1,D_2) shown in the circuit diagram.

Several precautions should be taken to avoid conditions which may lead to the destruction of transistors. For example, over-modulation should not be allowed to occur because excessive negative excursions of the collector voltage may forward-bias the collector-to-base junction to a destructive point. Also, when a transmitter is keyed off, a steady-state current flow of the order of 2 amperes is suddenly interrupted in the modulation transformer. The resulting transient voltages may easily exceed the transistor breakdown ratings. Use of a zener diode rated at twice the supply voltage in the collector circuit provides a protection from this type of transient. Finally, if the 3:1 VSWR in the output is likely to be exceeded, a load-mismatch protective device such as a VSWR detector circuit (described in Ref. 1) should be used.

Performance and Adjustment

The curves of Fig.2 show typical values of average modulated power P_{AV} at an amplitude modulation of 95 per cent, and carrier power P_C, as measured by a a bolometer-type power meter. The peak envelope power P_{PE} is computed as follows:

$$P_{PE} = P_{AV} \frac{(1 + m^2)}{1 + \frac{m^2}{2}}$$

Output-power variation across the aircraft band is about 0.5 dB for both curves shown in Fig.2. For this performance, the coil L_1 was stretched or compressed for maximum power output at 136 MHz and optimum bandwidth, and the trimmer C_{20} was adjusted for the best combination of output flatness and efficiency. Efficiency is somewhat better at higher than lower frequency; harmonic rejection is better at lower frequencies, and may be as good as 20 dB. A spectrum analyzer is required for detection of subharmonics when the slugs in L_2 and T_1 are adjusted.

Conclusion

Because of the normal variation in the transistor parameters, weaker drivers should be paired with "hotter" output transistors and vice versa for better uniformity in the output power. Because of their adaptability to broadband circuits, low working voltages, and small size, the above transistors are the logical choice for aircraft transmitters. The use of these transistors in aircraft transmitter requires no expensive tuning mechanisms such as those used with tubes that have inherently high-Q circuits and, consequently, narrow bandwidth.

RCA

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RF Power Transistors
Application Note

AN-3755

UHF Power Generation Using RF Power Transistors

by H.C. Lee

One major usage of rf power transistors is in uhf/microwave power generation. RF power transistors are widely used for both narrowband and broadband power amplification. Transistors suitable for power amplification must be capable of delivering power efficiently with sufficient gain at the frequency band of interest. The usefulness of an rf power transistor is not measured by its power-frequency product or its emitter geometry, but rather by its ability to meet cost limitations and over-all performance objectives including reliability requirements in a given application or circuit.

This Note discusses the use of rf power transistors in high-power generation that uses multiple transistors, pulse operation, and broadband power amplifiers. Operational principles and design approaches for these applications are presented, and practical and reliability aspects are discussed. The selection of an rf power transistor for a given application involves two steps: (1) determination of the rf capability of the device, and (2) establishment of the reliability of the device for its actual operation.

RF Performance Criteria

The important rf performance criteria in transistor power-amplifier circuits are power output, power gain, efficiency, and bandwidth. State-of-the-art single overlay transistors, as shown in Fig.1, can now produce cw power as follows:

Frequency (MHz)	Power (W)	Gain (dB)	Efficiency (%)
76	100	7	90
400	50	6	70
1200	10	10	50
2300	7	6	40

When transistor performances are compared, it is important to consider gain and efficiency, as well as power output and frequency, because additional gain can be achieved only at the expense of collector efficiency with the use of additional transistors. For example, Fig.2 demonstrates the use of two transistors which have the same power output, but different gain and collector efficiency. The high-gain unit shown in Fig.2(a) is capable of delivering an output of 2.5 watts at 1 GHz with a gain of 10 dB and a collector efficiency of 50 per cent. The low-gain unit shown in Fig.2(b) is also capable of 2.5 watts output at 1 GHz, but has a gain of only 5 dB and a collector efficiency of only 30 per cent. As shown in Fig.2, two low-gain transistors are required to provide the same performance as the high-gain, high-efficiency unit. Besides the use of an additional transistor, the system of Fig.2(b) requires twice as much dc power as that of Fig.2(a). In this case, the additional gain of 5 dB is achieved at the expense of 5.9 watts of dc power. From the practical point of view, the system of Fig.2(b) is more complex, and the dissipation of the output transistor is higher.

Package Considerations

The package is an integral part of an rf power transistor. A suitable package for uhf applications should have good thermal properties and low parasitic reactance. Package parasitic inductances and resistive losses have significant effects on circuit performance characteristics such as power gain, bandwidth, and stability. The most critical parasitics are the emitter and base lead inductances. Table I gives the inductances of some of the more important commercially available rf power-transistor packages. Photographs of the packages are shown in Fig.3. The TO-60 and TO-39 packages

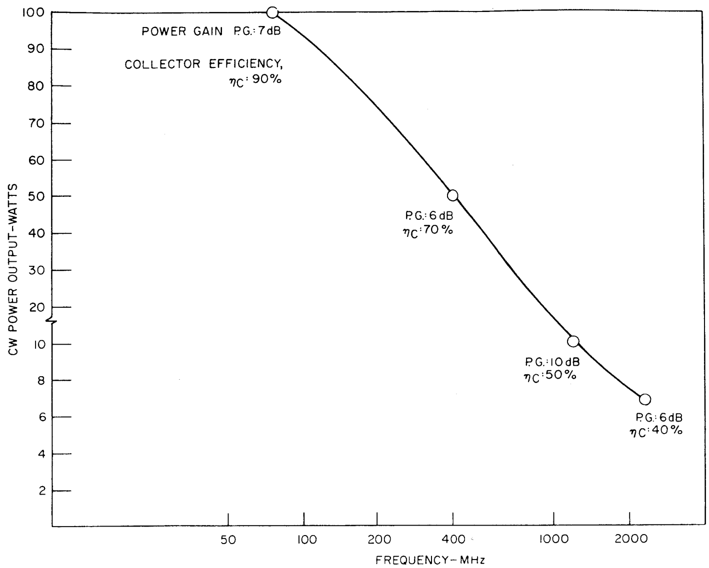


Fig.1 - State-of-the art power output of single rf power transistor as a function of frequency.

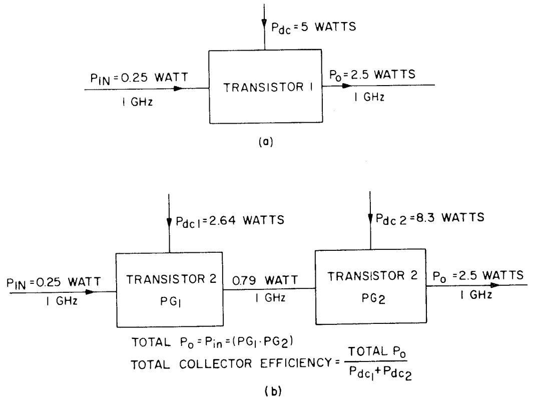


Fig.2 - A comparison of one-and two-transistor systems that have the same output power but different gain and collector efficiencies.

TABLE I - Inductances of Packages shown in Fig.3.

Package	Lead Inductances - nH L_e	L_b
TO - 39	3	3
TO - 60 (isolated emitter)	3	3
TO - 60 (grounded emitter)(2N5016)	0.6	2
HF - 19 (hermetic stripline)	Approximately Same	
HF - 11 (coaxial case) (2N5470)	0.1	0.1

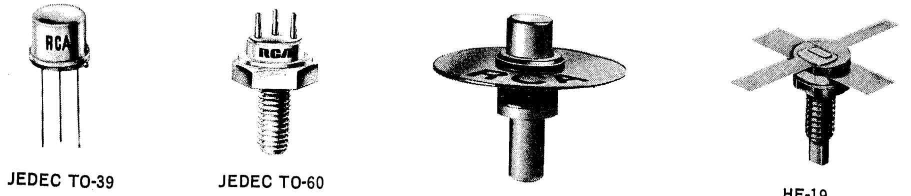

JEDEC TO-39 JEDEC TO-60 HF-11 Coaxial Package HF-19 Hermetic Strip-Line Type Ceramic-to-Metal Package (Isolated Electrodes)

Fig.3 - Commercially available rf power transistor packages.

were first used in devices such as the 2N3375 and the 2N3866. The base and emitter parasitic inductance for both TO-60 and TO-39 packages is in the order of 3 nanohenries; this inductance represents a reactance of 7.5 ohms at 400 MHz. If the emitter is grounded internally to a TO-60 package (as in the 2N5016), the emitter lead inductance can be reduced to 0.6 nanohenry. The plastic stripline package (used in the 2N5017) has an emitter lead inductance of 0.4 nanohenry and a base lead inductance of 0.6 nanohenry. The main advantage of the rf plastic package is that a substantial reduction in parasitic inductance is achieved because the emitter and base leads can be placed closer to the transistor chip. Hermetic low-inductance radial-lead packages are also available. The HF-19 package introduced by RCA utilizes ceramic-to-metal seals and has rf performance comparable to that of an rf plastic package. The parasitic inductances can be reduced further in a hermetic coaxial package. The HF-11 package used in the 2N5470 has parasitic inductances in the order of 0.1 nanohenry.

Table II compares the performance of the TO-39 package, the HF-19 hermetic stripline package, and the HF-11 coaxial package with the same transistor chip. At a frequency of 1 GHz and an input power of 0.3 watt, the coaxial package performs significantly better than either the stripline or the TO-39 package. The coaxial package results in an increase of output power by a factor of two as compared to the TO-39 package. In addition, the coaxial-package transistor is capable of delivering an output of more than 1 watt with a gain of 5 dB at 2 GHz. A well-designed coaxial package outperforms any other rf package currently available.

TABLE II - Package Inductances with same transistor chip.

Using Same Transistor Chip

	f-GHz	Pin-W	Po-W	P.G.-dB	η_c (28 V)-%
TO - 39	1	0.3	1	5	35
HF - 19	1	0.3	1.5	7	45
HF - 11	1	0.3	2.2	8.6	50
HF - 11	2	0.3	1	5	35

Reliability Consideration

When the rf capability of a transistor has been established, the next step is to establish the reliability of the device for its actual application. The typical acceptable failure rate for transistors used in commercial equipment is 1 per cent per 1,000 hours (10,000 MTBF); for transistors used in military and high-reliability equipment, it is 0.01 to 0.1 per cent per 1000 hours. Because it is not practical to test transistors under actual use conditions, dc or other stress tests are normally used to simulate rf stresses encountered in class B or class C circuits at the operating frequencies. Information derived from these tests is then used to predict the failure rate for the end use equipment. The tests generally used to insure reliability include high-temperature storage tests, dc and rf operating life tests, dc stress step tests, burn-in, temperature cycling, relative humidity, and high-humidity reverse bias. The end-point measurement for these tests should include collector-to-emitter voltage V_{CEO}, in addition to the common end points collector-to-emitter current I_{CEO}, collector-to-base voltage V_{CBO}, collector-to-emitter saturation voltage V_{CE}(sat), power output, and power gain.

One of the common failure modes in uhf/microwave power transistors is degradation of the emitter-to-base junction. The high-temperature storage life test and the dc and rf operating life tests can excite this failure mode. The failure mode can be detected by measurement of V_{EBO}, which is not included in most life-test end-point specifications.

Plastic uhf power transistors are more sensitive to emitter-to-base-junction degradation than similar hermetic devices. It is believed that the enhancement of this failure mode in plastic devices is caused by moisture penetration into the very close geometries used in uhf power transistors. Temperature cycling is also a problem that affects the reliability of uhf plastic power transistors because large thermal-expansion differences exist between the plastic and the fine bonding wires (usually 1 mil) used in the devices.

UHF power transistors are complex electrical, thermal, chemical, and mechanical systems. The well-designed uhf power transistor is a systems solution to the integration of these parameters. It appears that the plastic environment is a less viable solution to this systems problem than a hermetic approach. Although a plastic environment has been an excellent systems solution for low-frequency and vhf power transistors, in which much larger bonding wires, metallic strips, and rugged device geometries are used, it is not a completely satisfactory solution for uhf power transistors.

Safe-Area Curves for RF Operation

The important parameters of a transistor which are directly related to reliability and rf performance include rf breakdown voltages, thermal characteristic, and load-mismatch capability.

Although a safe-area curve to avoid second breakdown on the collector-current-vs-collector-to-emitter voltage (I_C - V_{CE}) plane can be established for forward-bias or class A operation, such a curve for class B, class C, or pulsed operation is difficult to define because the breakdown voltages under rf conditions are considerably higher than the dc breakdown voltages, and the thermal resistance is a function of V_{CE} and I_C. The safe operating area for class B or C conditions at rf frequencies is a function of these parameters, as well as the thermal time constant of the device. In general, the safe operating area for class C or B operation can be expected to be higher than that for dc conditions.

VSWR capability, or the ability of an rf power transistor to withstand a high VSWR load, is another important consideration. VSWR capability is a function of frequency of operation, operating voltage, and circuit configuration. A well-designed circuit operated at low supply voltage at a frequency at which power gain is not excessive is less prone to VSWR mismatch. Four modes of difficulty are experienced in the load-mismatch test, as follows:

(1) slow thermal failure as a result of low rf swing and very poor efficiency;

(2) high-speed failure as a result of the high positive peak value of rf swing;

(3) an instability (non-destructive) which occurs because the high value of V_{CE} causes avalanching (such a condition in the common-emitter configuration produces a negative resistance characteristic and results in a spurious signal generator);

(4) an instability caused by the negative overswing which can severely forward-bias the collector-base junction and trigger a low-frequency oscillation which resembles a motorboating or squelched oscillation.

Additional work is required for further characterization of transistor parameters, as related to VSWR capability, rf breakdown, and safe operating area.

Pulse Operation of RF Power Transistors

A large potential application for rf power transistors is in pulse equipments such as DME (distance measuring equipment), CAS (collision avoidance system), and radar. The ratio of peak to average or cw power obtainable with a transistor is much less than that which can be obtained with a vacuum tube because a transistor is a current-amplification device, while a vacuum tube is a voltage-amplification device. The ability of an rf power transistor to deliver higher pulsed output power than cw power depends on the transistor current-handling capability, thermal capability, and rf voltage capability. No significant improvement in power output or gain can be achieved if an rf power transistor is operated under pulse input conditions at the same supply voltage and the same input power level used under cw conditions. Fig.4 shows curves of peak output power as a function of duty cycle for two transistor types: the 2N5016 measured at 225 MHz and 400 MHz, and the 2N5470 measured at 2 GHz. These measurements were performed with a constant supply voltage of 28 volts and constant input-power pulses of 5-microsecond duration applied at various pulse repetition rates (PRR). At the same peak input power level, the gain and power output remain approximately the same for duty cycles ranging from 100 per cent (cw) down to 0.1 per cent.

Fig.5 shows the 2-GHz amplifier circuit used for the measurements shown in Fig.4. The 2N5470 transistor is placed in series with the center conductor of the line, or cavity, and its base is properly grounded to separate the input and output cavities. The input section consists of a 20-ohm line section and a capacitance C_1. The output section consists of a 36-ohm line section and capacitances C_2 and C_3. Direct coupling is used at both

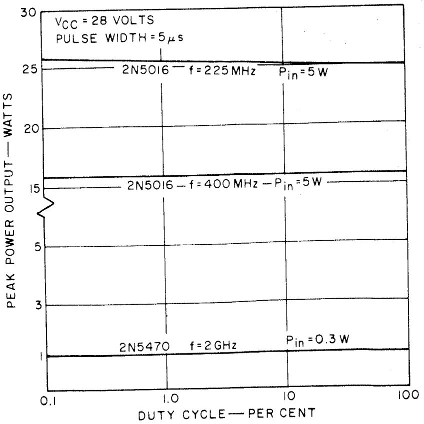


Fig.4 - Peak output power as a function of duty cycle for the 2N5016 and 2N5470 transistors at selected frequencies.

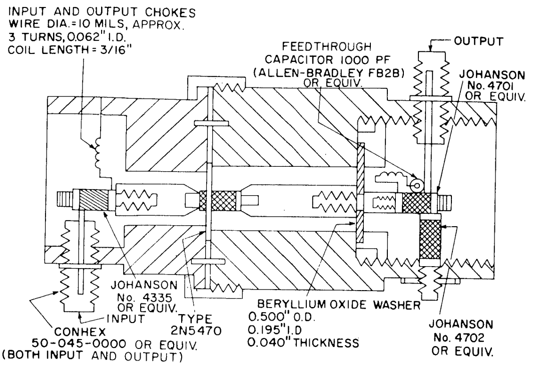
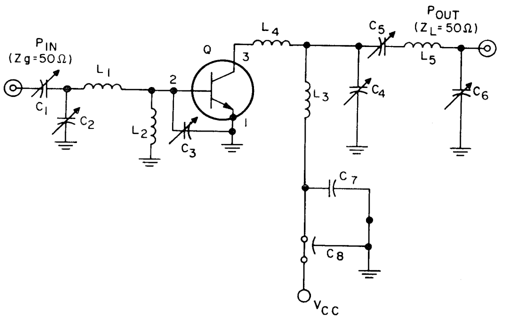


Fig.5 - A 2-GHz coaxial amplifier circuit that uses 2N5470 transistor.

input and output. Fig.6 shows the 400-MHz lumped-element amplifier circuit used for the 2N5016 pulse measurements.



C_1 = 1 to 10 pF, piston capacitor

C_2, C_3, C_4, C_5, C_6 = 1 to 30 pF, piston capacitors

C_7 = 0.01 μF, disc, ceramic

C_8 = 1000 pF, feedthrough

L_1 = 1/4-inch O.D. copper tubing; 1-1/4-inches long

L_2 = 12 μH, choke

L_3 = 0.27 ohm, wire wound

L_4 = 1/8-by 1/32-by 5/8-inch long copper strip

L_5 = 1/4-inch O.D. copper tubing, 2-1/4-inches long

Note 1 - L_1 and L_5 are mounted coaxially within a 1-5/8-by 1-5/8-by 6-inch box.

Note 2 - For optimum performance C_8 should be mounted between emitter and base with minimum lead lengths.

Fig.6 - A 400-MHz amplifier circuit that uses a 2N5016 transistor.

The major difference between cw and pulse operation, however, is that the input drive level can be increased substantially under pulsed input conditions.

Fig.7 shows peak power output as a function of duty cycle for the 2N5470 at a frequency of 2 GHz and a constant supply voltage of 28 volts with input power as a parameter. Under cw operation in the 2-GHz amplifier circuit shown in Fig.5, an increase of input power from 0.3 to 0.5 watt does not result in an increase of power output, i.e., the power output seems to be saturated at 1.1 watts. However, under pulsed input conditions of 5-microsecond pulse duration and 10-per-cent duty cycle, the output power increases substantially from 1.1 watts to 1.9 watts as the input power increases from 0.3 to 0.7 watt. These requirements indicate that the power input to the 2N5470 transistor at 2 GHz under cw conditions is limited by thermal capability rather than by peak current or periphery. This transistor appears to be capable of operating at much higher peak current under pulse conditions than would be permissible under cw conditions. This improvement is possible because the pulse duration of 5 microseconds is probably smaller than the thermal time constant of the transistor, and the junction temperature is more a function of average device dissipation than of peak dissipation. A similar improvement in peak power output and gain can be obtained by pulse operation of the 2N5016 at 225 MHz, as shown in Fig.8, but the improvement is not as great as that obtained for the 2N5470.

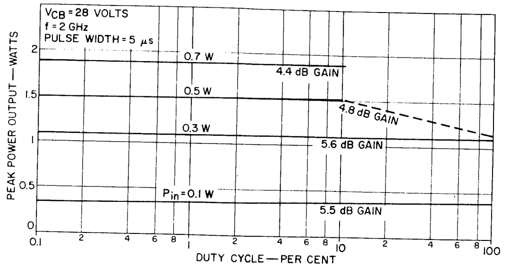


Fig.7 - Peak output power as a function of duty cycle for the 2N5470 transistor operating at 2 GHz.

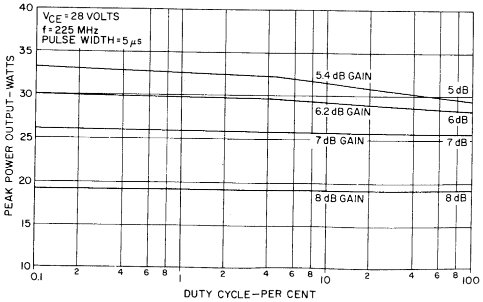


Fig.8 - Peak output power as a function of duty cycle for pulse operation of the 2N5016 transistor at 225 MHz.

A second major difference between cw and pulse operations is that a transistor can be operated at much higher voltage under pulse conditions. Fig.9 shows peak power output as a function of supply voltage V_{CC} for the same transistor types (the 2N5016 measured at 225 MHz and 400 MHz, and the 2N5470 measured at 2 GHz). These measurements were performed with constant peak input power pulses at 1-per-cent duty cycle and 5-microsecond pulse duration. At an input power level of 0.5 watt, the 2-GHz power output of the 2N5470 increases from 1.9 watts at 28 volts to 2.5 watts at 45 volts. At an input power of 9 watts, the 400-MHz power output of the 2N5016 increases from 25.5 watts at 28 volts to 40 watts at 45 volts. At 225 MHz, the increase in power is even greater. These results indicate that rf power transistors can be operated at much higher voltage under pulse conditions, and, consequently, can deliver more pulsed power. It appears that rf power transistors can withstand much higher voltage under short-pulse conditions without operating in the second-breakdown region. The average current resulting from short-pulse operation is much lower than that of cw operation.

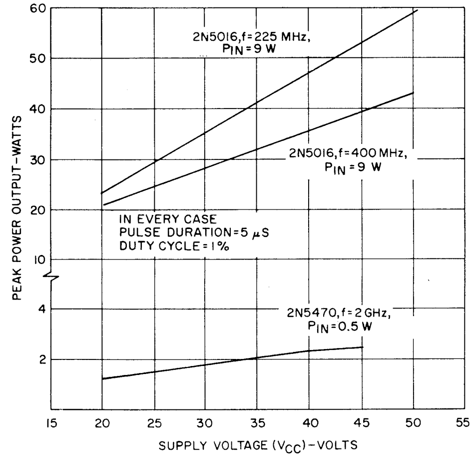


Fig.9 - Peak output power as a function of supply voltage V_{CC} for the 2N5470 and 2N5016 transistors at selected frequencies.

Broadband Power Amplifier

RF power transistors are often used in broadband amplifier circuits for commercial and military applications. Transistor transmitters are superior to tube transmitters with respect to broadband capability, reliability, size, and weight. The aircraft communication bands of 116 to 152 MHz and 225 to 400 MHz are of interest for both military and commercial applications. Another area of interest is ECM (electronic countermeasures) applications. Transistors suitable for broadband applications must be capable of providing both the required power output within the entire frequency range of interest and constant gain within the passband. The bandwidth of a transistor power amplifier is limited by the following: intrinsic transistor structure, transistor parasitic elements, and external circuits such as input and output circuits.

Intrinsic Transistor Structure

The parameters which determine the inherent bandwidth of a transistor intrinsic structure are the emitter-to-collector transit time, the collector depletion-layer capacitance, and the base-spreading resistance. The emitter-to-collector transit time, which represents the sum of the emitter-capacitance charging delay, the base transit time, and the collector depletion-layer transit time, affects the over-all time of response to an input signal. Of particular importance is the emitter-capacitance charging delay, which is current-dependent and equal to $1/f_T$, where f_T is the gain-bandwidth product of the transistor. A high f_T is essential for broadband operation; in addition, a constant f_T with current level is required for large-signal operation. The ratio of the f_T to the product of the base-spreading resistance and the collector depletion-layer capacitance (r_bC_c) comprises the gain function of a transistor.

Under conjugate-matched input and output conditions, the power gain as a function of frequency (which is equal to $f_T/8\pi f^2 r_b C_c$) falls off at a rate of 6 dB per octave. In a power amplifier, the power gain usually decreases by less than 6 dB per octave, as shown in Fig.10(a), because the load resistance R_L presented to the collector is not equal to the output resistance of

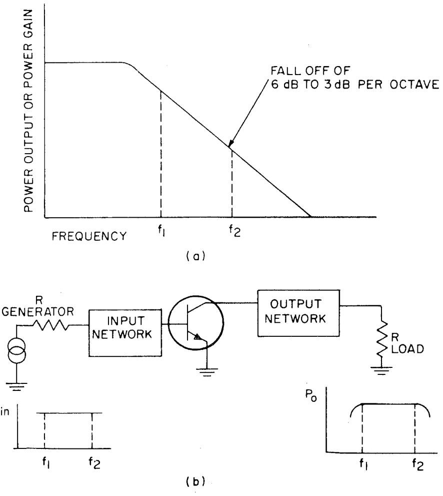


Fig.10(a) - Output power as a function of frequency in a power amplifier; (b) equivalent broadband amplifier.

the transistor, but is dictated by the required power output and the collector voltage swing. The curve in Fig.10(a) indicates that one approach for achieving a broadband transistor amplifier is to optimize the matching at the higher end of the frequency band and to introduce mismatch in the input, or output, or both at the lower end of the band so that a constant power output is obtained from f_1 to f_2, as shown in Fig.10(b). The power output that can be obtained in a transistor broadband amplifier is comparable to that measured at the high end of the band in a narrowband amplifier; efficiency and power gain are slightly lower than in a narrowband amplifier because the load and source impedance cannot be ideally matched to the transistor over a broad frequency band.

The disadvantage of this approach for broadbanding is the relatively high input VSWR at the low end of the band. A more sophisticated approach for achieving broadband performance is to consider the intrinsic transistor structure, the transistor parasitic elements, and the external circuits as part of the over-all band-pass structure, in which the input and output circuits are coupled together by the transistor feedback capacitance. This combined structure reproduces the power-output or power-gain curve of Fig.10(a) from f_1 to f_2. External feedback is then applied to control the input drive to flatten the power output over a broad frequency band.

Parasitic Limitations

Any discrete transistor contains parasitic elements which impose further limitations on bandwidth. The most critical parasitics are the emitter lead inductance L_e and the base inductance L_b. These parasitic inductances range from 0.1 to 3 nanohenries in commercially available rf power transistors. In the simple representation of a common-emitter equivalent transistor input circuit at high frequency shown in Fig.11, the inductance L_{in} represents the sum of the base parasitic inductance and the reflected emitter parasitic inductance, and R_{in} is the dynamic input resistance. The real part R_{in} is inversely proportional to the collector area and, therefore, the power-output capability of the device; the higher the power output, the lower the value of R_{in}. A low ratio of the reactance of L_{in} to R_{in} is important as the first step in broadbanding and for ease of circuit design. Unless the reactance of L_{in} is appreciably lower than the input resistance R_{in}, the reactance must be tuned out and thus the bandwidth limited.

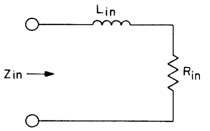


Fig.11 - Equivalent input circuit of an rf power transistor.

External Circuits

For a broadband amplifier circuit to deliver constant power output over the frequency range of interest, a proper collector load must be maintained to provide the necessary voltage and current swings, and the input matching network must be capable of transforming the low input impedance of the transistor to a relatively high source impedance.

Suitable output circuits for broadband amplifiers include constant-K low-pass filters, Chebyshev filters (both transmission-line and lumped-constant), baluns, and tapered lines. Fig.12(a) shows a conventional constant-K low-pass filter. The input impedance Z_{11} is substantially constant at frequencies below the cut-off frequency $\omega_c = 1/\sqrt{L_K C_K}$. A constant collector load resistance can be obtained if the shunt arm (1-1) of C_K is split into two capacitances, as shown in Fig.12(b); part of the capacitance represents the C_{ob} of the transistor, and the other part has a value which makes the total capacitance equal to C_K. Further improvement of bandwidth can be obtained by cascading of more sections.

Fig.12(c) shows a short-step microstrip impedance transformer which consists of short lengths of relatively-high-impedance transmission line alternating with short lengths of relatively-low-impedance transmission line. The sections of transmission line are all exactly the same length; the length of each is $\lambda/16$. A constant load resistance can be maintained across the collector-emitter terminals over a wide frequency band if the circuit is designed to have a Chebyshev transmission characteristic[1,2]. Fig.12(d) shows a lumped-equivalent

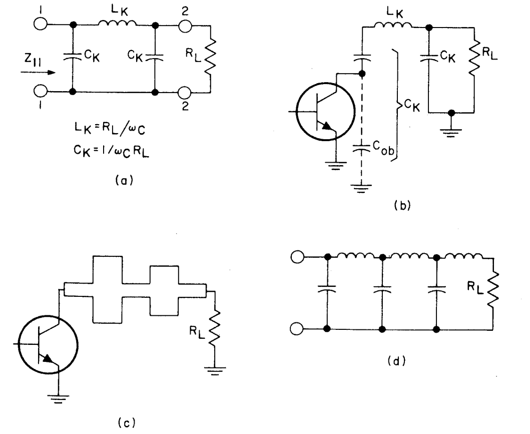


Fig.12(a) - A conventional constant-K low-pass filter; (b) a method of obtaining a constant-collector load resistance; (c) a short step microstrip impedance transformer; (d) a lumped-equivalent Chebyshev impedance transformer.

Chebyshev impedance transformer which consists of a ladder network using series inductances and shunt capacitances. Transmission-line as well as strip line baluns with different step-down ratios (4:1, 9:1, 16:1) can also be used in the output to provide the broadband impedance transformation.

One difficulty in broadbanding a transistor power amplifier is to maintain the desired bandwidth in an input circuit which provides the required impedance transformation from the extremely low input impedance of a transistor to a relatively high source impedance. The design of the input circuit depends on the approach chosen: optimizing the matching at the high end only, or using the transistor parasitic elements as part of a low-pass structure. A simple way of optimizing the matching at the high end is to introduce a capacitance between the base and the emitter terminals of the transistor to tune out the reactive part of the parallel equivalent input impedance of the transistor. The networks in Fig.13 show that the lower the inductance L_{in} or Q_{in}, the less frequency-sensitive is the equivalent parallel resistance R_{eq}. This arrangement also provides a first step-up transformation for the real part of the input impedance of the transistor. When a capacitance is connected to the network of Fig.13(a), the circuit has the same form as a half-section of a constant-K low-pass filter. If the cutoff frequency $\omega_c = 1/\sqrt{L_{in}C}$ is high as compared to the frequency of interest (f_2 in Fig.10), the total input impedance of the transistor input and the capacitance C combination is approximately equal to $R_{in}/(1-\omega^2/\omega_c^2)$ and is constant if $(\omega^2/\omega_c^2) \angle\angle 1$.

The remaining step is to design a proper network to provide the necessary impedance transformation over the entire frequency band. Circuits suitable for the input include multi-section constant-K filters, Chebyshev filters, and tapered lines. A more sophisticated approach to obtain a broadband transformation in the input is to treat the parasitic inductance L_{in} of Fig.11 as part of the transformation network. For example, L_{in} can be considered as one arm of the Chebyshev low-pass filter of Fig.12(d). For a given bandpass characteristic, the number of sections increases with the value of L_{in}. Again, therefore,- low package parasitic inductance is important.

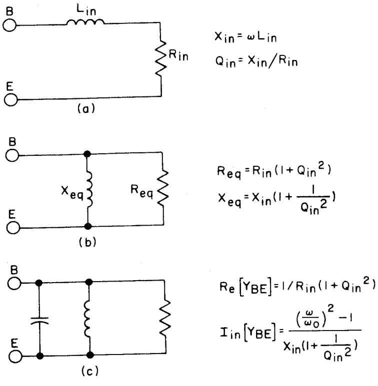


Fig.13(a) - Series equivalent input circuit of an rf power transistor; (b) equivalent parallel input; (c) equivalent parallel input circuit with external base-emitter capacitance.

The RCA Dev. No. TA7344 Transistor

At present, plastic uhf power transistors are used exclusively in 225-to-400-MHz broadband applications. UHF plastic packages have substantially lower parasitic inductances than either TO-60 or TO-39 packages, as discussed previously.

The introduction of the RCA hermetic low-inductance stripline package makes it possible to design broadband power amplifiers without compromising reliability. This new radial-lead package utilizing ceramic-to-metal seals is superior to uhf plastic packages in two respects: it has lower parasitic inductances, and it is hermetically sealed. For example, the RCA Dev. No. TA7344 transistor, first in a series of hermetic radial-lead devices, has a dynamic input impedance of 1.5 + j1.2 at 400 MHz. Fig.14 shows typical curves of power output and efficiency as a function of input power for the TA7344 at a frequency of 400 MHz and a collector-to-emitter voltage of 28 volts. This transistor is capable of delivering an output of 19 to 20 watts with gain of 6.5 dB and collector efficiency approaching 70 per cent at 400 MHz. One important feature of this device is that the power gain is linear within 1.6 dB at power levels between 7 and 20 watts. The TA7344 is also capable of an output of 20 watts with gain of more than 10 dB at 225 MHz, as shown in Fig.15.

High-Power Generation

When more rf power is required than can be provided by a single transistor, combining techniques must be used. Two of the more commonly used methods of combining transistors to obtain high power are: (1) the "brute-force" method of paralleling several transistors at a single point, and (2) the use of hybrids to combine several individual amplifier chains or modules.

RF power transistors can be directly paralleled at a single point, as shown in Fig.16. All collectors and bases are connected together, and a single input matching circuit and a single output matching circuit are used. Although this arrangement offers circuit simplicity, it has several disadvantages. First, the transistors used must be matched for power output and power gain at the desired frequency to obtain good load sharing. Second, direct paralleling of a large number of transistors at a single point leads to poor reliability; a failure of one transistor usually causes a total failure of the over-all amplifier circuit.

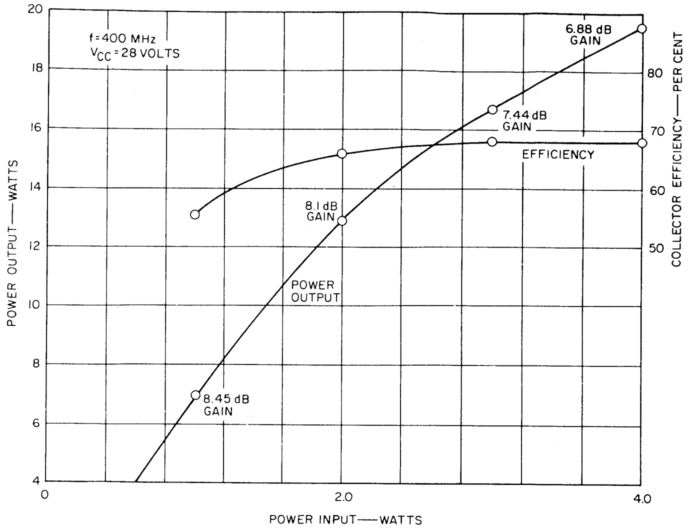


Fig.14 - Output power and efficiency as functions of input power for the RCA Dev. No. TA7344 transistor at 400 MHz and 28 volts.

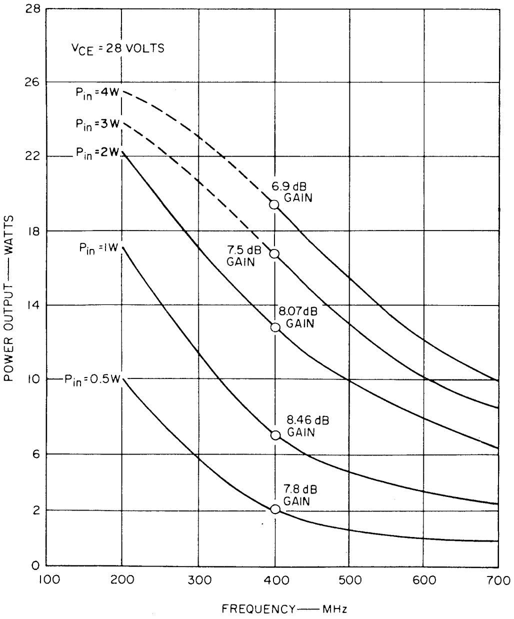


Fig.15 - Output power as a function of frequency in the RCA Dev. No. TA7344 at 28 volts.

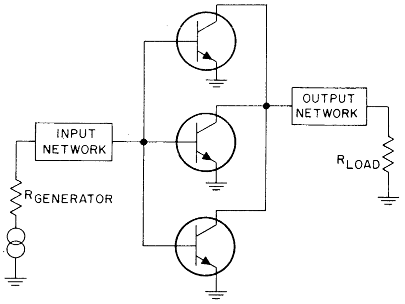


Fig.16 - A method of paralleling rf power transistors at a single point.

Of particular importance is the reduction in both input and output impedances resulting from paralleling transistors. The impedance level can be of the same order as the rf losses in the input and output elements. The input resistance of an rf power transistor at 400 MHz is typically 1 to 5 ohms. If a 0.1-microhenry inductor with an unloaded Q of 150 is used in the input circuit, the rf loss in the inductor at 400 MHz is 1.6 ohms ($R_{loss} = \omega L/Q$). This rf loss increases as more transistors are paralleled. Consequently, the total power output which can be obtained from several transistors paralleled at a single point is less than the calculated total power output.

Fig.17 shows the paralleling efficiency as a function of the number of transistors in direct parallel[3]. Paralleling efficiency is defined as the ratio of the measured total power output to the calculated total power output (i.e., the number of units multiplied by the power output of an individual unit). The paralleling efficiency decreases rapidly as the number of transistors increases. For example, when the 2N5016 is used at a frequency of 400 MHz and a collector-to-emitter voltage of 28 volts, the paralleling efficiency is 95 per cent for two transistors connected in parallel, 90 per cent for three transsistors, 85 per cent for four units, and 55 per cent for eight units.

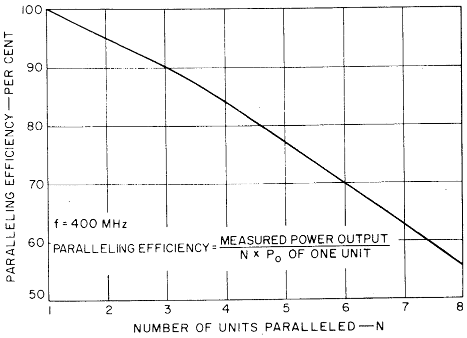


Fig.17 - Efficiency as a function of the number of transistor in parallel.

Most of the disadvantages of the "brute-force" direct-paralleling method can be avoided by a more sophisticated approach, shown in Fig.18, in which several amplifier modules or chains are combined by the use of an input hybrid divider and an output hybrid combiner. This arrangement provides a reliable and efficient method of achieving high vhf/uhf power. Reliable operation results because of the isolating properties of the hybrid. A failure of one amplifier chain or module reduces the total power output, but does not cause failure of the other amplifier chains or modules. In addition, this arrangement provides a highly efficient method of combining vhf/uhf power because the insertion loss of a hybrid is small.

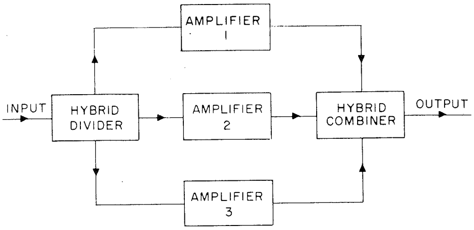
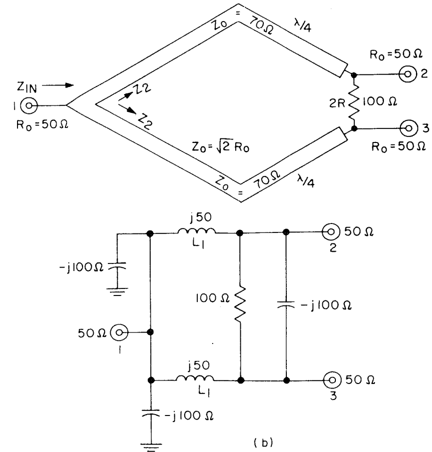


Fig.18 - Use of hybrids to combine several individual amplifiers.

A hybrid is an n-port network used as a constant-impedance circuit for power summing and dividing. It maintains phase and amplitude equality between any number of outputs, and also provides isolation between matched outputs. Fig.19(a) shows a two-way transmission-line hybrid power divider which consists of two quarter-wave transmission lines, each having a characteristic impedance of $Z_0 = \sqrt{2}\, R_0$.[4] The generator port 1 and distribution ports 2 and 3 are terminated by resistors R_0. A lumped resistor of value R_0 is connected from each of the distribution ports to a common point. When a signal is fed into the power divider (port 1), it divides by virtue of symmetry into two equiphase and equi-amplitude ports. No power is dissipated by the resistance R when matched loads are connected to the outputs because port 2 and 3 are at the same potential. The input (port 1) of the power divider is also matched when the conditions for isolation between the two outputs are satisfied. The input impedance of port 1 is the parallel combination of the two output loads R_0 after each has been transformed through a quarter-wavelength of the line Z_0. If a reflection or mismatch occurs at one of the output ports, the reflected signal splits; part travels directly to the input, splits again, and then returns to the remaining output port. Thus, the reflected wave arrives at the remaining output port in two parts; the path-length difference between the two paths of travel is 180 degrees out of phase when the lines are $\lambda/4$ in length. The value of the resistor R is properly chosen ($R = R_0$) so that the two parts of the reflected wave are equal in amplitude and 180 degrees out of phase; thus, complete cancellation occurs. The hybrid shown in Fig.19(a) can also be used as a two-way combiner (i.e., power introduced at ports 2 and 3 will combine or add at port 1). The lumped equivalent of the quarter-wave transmission-line hybrid is shown in Fig.19(b).



(b)

Fig.19(a)-A two-way, transmission-line, hybrid power divider; (b) a lumped-constant equivalent of this power divider.

The technique illustrated in Fig.19 can be extended to an n-way power divider or combiner, as shown in Fig.20.[4] The characteristic impedance of each quarter-wave line should have a characteristic impedance of $Z_o = \sqrt{n}\ R_o$, and the resistor R should have a value of R_o.

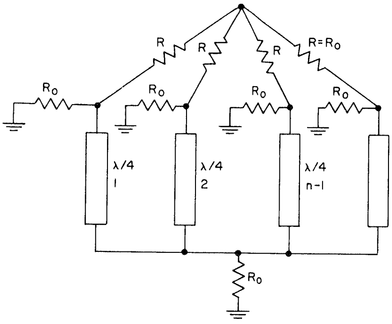


Fig.20 - N-way, quarter-wave hybrid.

Fig.21(a) shows another hybrid, the 6 λ/4 ring. Each port is separated from the adjacent port by a λ/4 section, except for the 3 λ/4 section between ports 3 and 4. Because of this arrangement, power introduced at port 1 appears at equal levels at the adjacent ports (2 and 4), but does not appear at the opposite port 3. In a similar way, power introduced at ports 2 and 4 combines or adds at port 1.

The VSWR and the isolation of both the 6 λ/4 hybrid ring of Fig.21(a) and the λ/4 hybrid of Fig.20 are sensitive to frequency deviations. A version of the hybrid ring which is less sensitive to frequency deviation is the quadrature hybrid, shown in Fig.21(b), in which the 3 λ/4 arm of the 6 λ/4 hybrid ring is replaced by a frequency-insensitive reversal of phase. Because the balance of this ring is not a function of frequency, its bandwidth can be expected to be wide. The quadrature hybrid accepts an input signal at any of its four ports, and distributes half to a second port and half to a third port with 90-degree or quadrature phase difference. The fourth port is isolated.

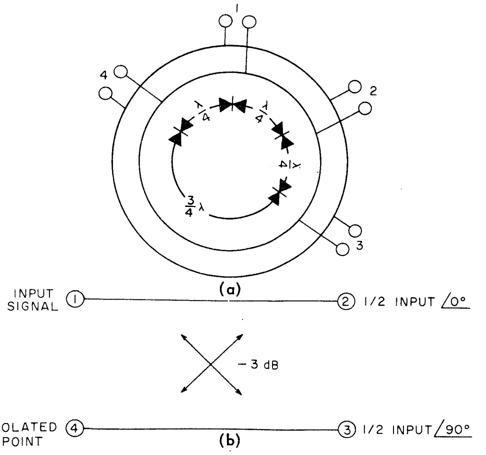


Fig.21(a) - A 6 λ/4 ring hybrid; (b) a quadrature hybrid.

The choice between hybrids and single-point paralleling for high-power generation depends on the required over-all performance, size, and cost. The most effective system usually employs hybrids to combine several amplifier chains in which several transistors are connected in parallel. Consideration must be given to both the paralleling efficiency (shown in Fig.17) and the insertion loss of the hybrid. As a rule of thumb, direct single-point paralleling should be used for applications in which maximum power output is essential up to a point where the reduction of output power caused by decreasing paralleling efficiency approaches that results from the insertion loss of the hybrids. Fig.22 demonstrates the use of such techniques to generate cw power of 200 watts at 400 MHz. The system consists of a four-to-one hybrid divider, four amplifier chains or modules, and a four-way hybrid combiner. Each individual amplifier module utilizes four 2N5016 units connected in parallel and driven by a single 2N5016. With a supply voltage of 28 volts, each module is capable of delivering output power of 54 watts at 400 MHz with gain of 12.4 dB and collector efficiency of 50 per cent. The four-to-one hybrid combines the output of four modules to produce cw power of 200 watts at 400 MHz.

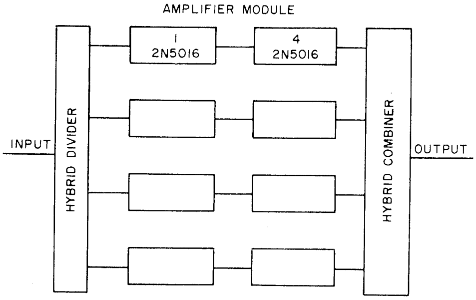


Fig.22 - Block diagrams of single-point paralleled and hybrid systems used to generate 200 watts of cw power at 400 MHz.

A similar technique has been used successfully to generate cw power of more than 1000 watts at 400 MHz by use of sixty-four 2N5016 units, and power of 10 watts at 2.3 GHz by use of sixteen 2N5470's.[5] The use of hybrids in conjunction with single-point paralleling has become an accepted technique for generating vhf/uhf high power. Such techniques are now found in practical systems that deliver output power up to 300 watts in the low uhf range.

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RCA
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**RF Power Transistors
Application Note
AN-3764**

Microwave Amplifiers and Oscillators Using the New RCA-2N5470 Power Transistor

by

G. Hodowanec, O. P. Hart, and H. C. Lee

The RCA-2N5470, the first commercially available 1-watt 2-GHz coaxial transistor, is designed for use in uhf/microwave power amplifiers, microwave fundamental-frequency oscillators, and frequency multipliers. Projected uses of this device should include sophisticated military and commercial applications such as L- and S-band power circuits, small-signal amplifiers, and microwave power oscillators.

This Note describes the capabilities and some of the uses of the 2N5470 in uhf/microwave amplifiers and oscillators which are the essential building blocks for solid-state microwave, radiosonde, and S-band telemetry equipment. Device and package construction and reliability considerations are discussed along with large- and small-signal operation at microwave frequencies. Detailed designs and performance data are given for practical circuits incorporating the 2N5470.

Device and Package Construction

An efficient microwave power transistor has a surface geometry and cross-sectional structure optimized for gain at a specific frequency, and is enclosed in a low-loss low-inductance package. The surface geometry of the 2N5470 is optimized for gain at 2 GHz; a 16-emitter-stripe overlay geometry is used in conjunction with shallow diffusions and thin epitaxial material. Although emitter and collector areas are minimized, enough emitter periphery is maintained to insure adequate current-handling capability at microwave frequencies.

The 2N5470 is hermetically sealed in the specially designed coaxial package shown in Fig. 1. This package is mechanically strong and has low parasitic inductance, low interelectrode capacitance, and good thermal properties. The top section of the package consists of a solid silver stud that serves as the collector terminal. An Al_2O_3 disc insulates the collector from the gold-plated Kovar flange which serves as the base terminal. Another Al_2O_3 disc separates the base flange and the gold-plated nickel emitter cap.

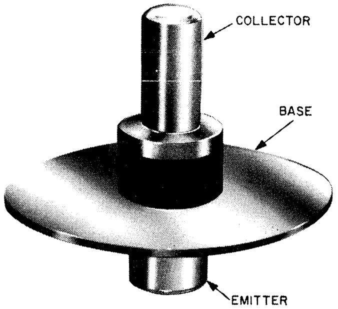


Fig. 1 - Specially designed, hermetically sealed, coaxial package for the 2N5470 rf power transistor.

Fig. 2 shows the bonding arrangement for the 2N5470. The pellet is mounted on the collector stud and is oriented to allow for two emitter- and two base-lead connections. Because each pair of leads is 180 degrees apart, mutual coupling is minimized between the leads and lead inductance is decreased. The base flange shields the collector output circuits from the emitter input circuits. The base parasitic inductance is of the order of 0.1 nanohenry; the emitter parasitic inductance is slightly higher. The interelectrode capacitances are 0.7 picofarad between collector and base, 1.5 picofarads between emitter and base, and 0.1 picofarad between collector and emitter. The extremely low parasitic feedback capacitance between collector and emitter makes the 2N5470 an ideal device for amplifier applications. In oscillator applications, the feedback required to sustain oscillation must be provided externally between collector and emitter.

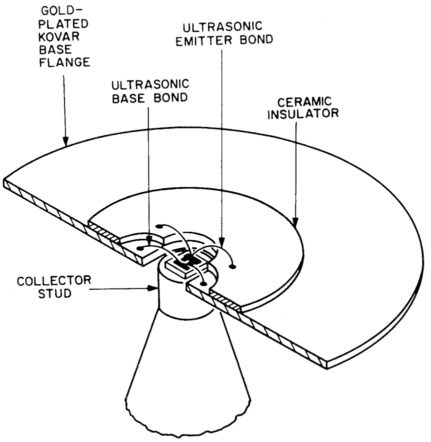


Fig. 2 - Bonding arrangement for the 2N5470.

RF Performance of the 2N5470

The introduction of the RCA-2N5470 transistor makes possible the design of class C amplifier circuits which supply a minimum power output of 1 watt at a frequency of 2 GHz with gain of 5 dB and collector efficiency of 35 per cent, or 2 watts at 1 GHz with gain of 10 dB and collector efficiency of 50 per cent. Fig. 3 shows typical power output and power gain as functions of frequency for a 2N5470 transistor in a common-base amplifier configuration. Fig. 4 shows power output as a function of collector-to-base voltage at 2 GHz for a 2N5470 in the same configuration. The 2N5470 provides higher gain and is more stable in the common-base amplifier configuration than in the common-emitter configuration.

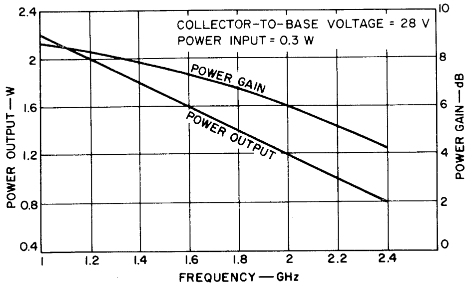


Fig. 3 - Power output and power gain as functions of frequency for a 2N5470 in a common-base amplifier configuration.

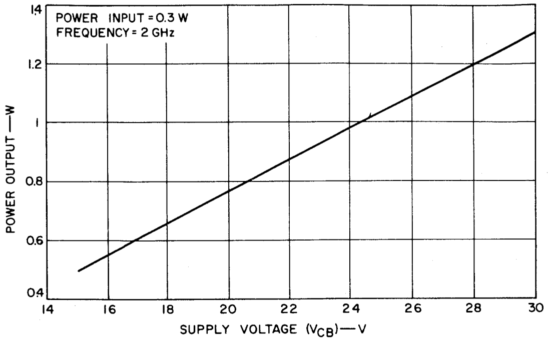


Fig. 4 - Power output as a function of collector-to-base voltage at 2 GHz for a 2N5470 in a common-base amplifier configuration.

In both high-power and small-signal operation at uhf and microwave frequencies, package parasitics must be considered an integral part of the transistor characteristics. In a common-emitter configuration, the relatively high extrinsic collector-to-base feedback capacitance can produce a negative input impedance. However, the degenerating effect of the emitter parasitic inductance helps to stabilize the feedback effect. The extrinsic collector-to-base feedback of the transistor chip can be overcome by use of the transistor in a common-base configuration in which the extrinsic collector-to-base capacitance is in shunt with the output circuit. In such arrangements, however, the degenerating effect of the base parasitic inductance can also produce a negative input impedance. Therefore, common-base operation of a transistor is possible only when the base-lead inductance is minimized as in the 2N5470.

An additional advantage of common-base operation of the 2N5470 is that burn-outs due to low-frequency oscillation are minimized. Low-frequency oscillations can occur in microwave transistors in any configuration because the gain of the transistor is much higher at low frequencies than at the operating frequency; however, the common-emitter configuration is particularly susceptible to the production of low-frequency oscillations because the gain at low frequency is much higher than that of the common-base configuration and the highly capacitive base-emitter junction and the input rf choke form a resonant circuit at low frequency. Low-frequency instability is minimized in the common-base configuration because the power gain of the transistor is substantially lower in this configuration than in the common-emitter configuration.

Because the 2N5470 is a stable amplifier device, fundamental-frequency oscillation must be sustained by the use of external feedback. In fundamental-frequency oscillator circuits such as those described in this Note, the 2N5470 can provide an output of 0.5 watt at 2 GHz and 1 watt at 1 GHz. The 2N5470 can also be used in class A linear amplifiers in which a wide dynamic range is required. Forward bias of the emitter-to-base junction is required for operation at input power levels below 50 milliwatts. When forward-biased, the 2N5470 should be operated at a supply voltage less than the 28 volts normally used for class C operation. The exact voltage value depends on the collector current to be used.

Reliability

Reliability of the 2N5470 is assured through environmental and mechanical tests including temperature-cycling, moisture-resistance, shock, constant-acceleration, vibration-fatigue, and vibration variable-frequency tests. Life tests include high-temperature storage, dc operation, and rf operation at 2 GHz. The rf life-test arrangement, shown in Fig. 5, consists of a 2-GHz fundamental-frequency oscillator with an output of 300 milliwatts followed by a 2-GHz amplifier with an output power of 1 watt.

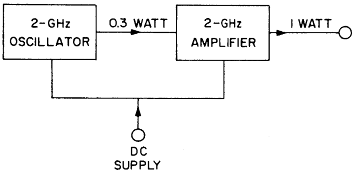


Fig. 5 - RF life-test arrangement for the 2N5470.

Large-Signal Amplifier Operation

The design of any large-signal rf power-amplifier circuit involves two steps: (1) the determination of load and input impedance under dynamic operating conditions, and (2) the design of properly distributed filtering and matching networks required for optimum circuit performance.

The large-signal impedances for the RCA-2N5470 transistor shown in Fig. 6 were measured under conditions of optimum circuit performance with the transistor connected in the common-base configuration. Slotted-line impedance determinations were made over the range of 1 to 2.3 GHz. Confirming vector voltmeter measurements were also made in the range of 1 to 1.4 GHz.

Microwave Power-Amplifier Design

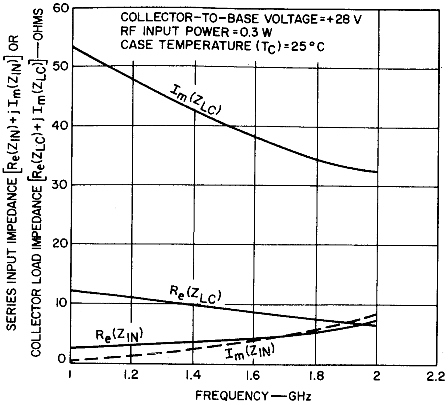


Fig. 6 - Dynamic impedance as a function of frequency for the 2N5470 in a common-base configuration.

One-step transformation network designs can be used in most narrow-band amplifier applications. However, most broadband amplifiers require two or more step transformations capable of transforming a large impedance ratio over a wider frequency range. In both instances, distributed-line design techniques are preferred.

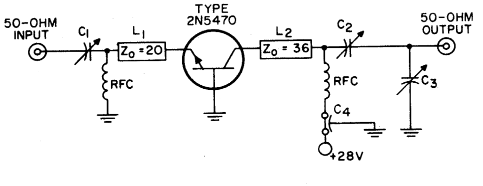
The use of quarter-wave or eighth-wave uniform transmission-line techniques results in simplified circuit designs which yield performance advantages. For example, quarter-wave transformer techniques may be used to transform the small, real parts of the dynamic impedances of the 2N5470 closer to that of the source (or load) resistance provided that the reactive parts of the impedances are tuned out. When the characteristic impedance of an eighth-wave line section is made equal to the magnitude of the complex terminating impedance, a complex impedance can be transformed to a real value with minimum line VSWR and, thus, minimum line loss. In some cases, it is advantageous to use shorter line sections which may transform a complex impedance directly to 50 ohms, where feasible, or to 50 ohms with an imaginary component which can be tuned out. Because the line lengths are generally very short, the higher line VSWR's in such cases do not necessarily result in excessive line losses. A Smith Chart is useful in determining the line lengths.

Direct complex-to-50-ohm transformations (by use of transmission-line techniques) usually have a 3-dB bandwidth of 10 per cent. When an additional transformation step is needed (e.g., a reactive divider network may be needed to match a real component which is not exactly 50 ohms to the 50-ohm source or load), the 3-dB bandwidth is generally reduced to about 5 to 6 per cent. Tapered transmission lines may be used for wider frequency-band response; these lines can be tapered directly to a desired real impedance. In addition, because of the nature of the TEM mode of propagation in these lines, substantial reductions in line lengths are possible. However, techniques required to accomplish this transformation are complex and only a circuit description is given in this Note.

The design principles discussed thus far are illustrated in the circuit designs given in the following pages.

2-GHz Coaxial-Line Power Amplifier

A coaxial-line circuit using the 2N5470 at 2 GHz is shown in Fig. 7. This circuit operates at 28 volts and can develop a power output of 1.2 watts with a drive power of 0.3 watt. Collector efficiency is in the order of 40 per cent. The coaxial transistor is in series with the center conductors of the coaxial air lines, and the base is grounded in such a way that the input and output lines are separated as shown in Fig. 8. In Fig. 7, the input line L_1 has a characteristic impedance Z_O of 20 ohms and is approximately 0.80 inch long. This line length (including the effects of the capacitive loading at the base flange and the fringe line effects introduced by capacitor C_1) is $0.21\lambda_g$ (where λ_g is the wavelength for a given circuit) and transforms the input impedance of 7.5 + j8 ohms to about 53 ohms of real resistance. Capacitor C_1, in conjunction with the small fringe capacitance at the input end of the input line, acts as a reactive divider network for the final transformation to the 50-ohm resistance of the driving source.



C_1 — 0-10 pF; Johanson 4355 or equiv.
C_2 — 0.35-3.5 pF; Johanson 4701 or equiv.
C_3 — 0.35-3.5 pF; Johanson 4702 or equiv.
C_4 — 1000 pF, feedthrough; Allen-Bradley FB2B or equiv.
RF chokes — 3 turns No. 30 wire, 1/16 in. (1.59 mm) ID, 3/16 in. (4.75 mm) long
L_1 L_2 — coaxial lines; see Fig. 8 for details

Fig. 7 - A 2-GHz coaxial-line power-amplifier circuit.

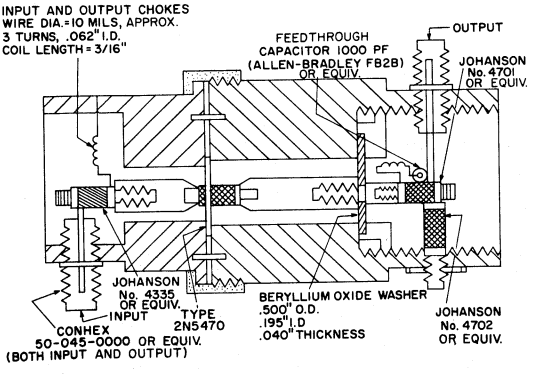


Fig. 8 - Construction details for the 2-GHz coaxial-line power amplifier shown in Fig. 7.

The output load impedance required for the 1.2-watt output is approximately 6.5 + j35 ohms at 2 GHz and is transformed by L_2, which has an electrical length of approximately $\tfrac{3}{8}\lambda_g$ and an impedance of 36 ohms. The electrical length of L_2 is approximately 110 degrees when correction is made for capacitive loading effects at the collector end of the line, dielectric loading effects of the beryllium oxide heat-sink washer shown in Fig. 8, and fringing field effects at output capacitors C_2 and C_3. A $\tfrac{3}{8}\lambda$ line section was used in the output circuit in this particular design, rather than an eighth-wave section because of the difficulty of incorporating capacitor C_3 near the end of L_2 (which would be required for the step-up needed with the $\lambda/8$ line). The $\tfrac{3}{8}\lambda$ line section performs in the same manner as the eighth-wave line length, but has somewhat increased line losses as a result of the large increase in line length. Typical performance curves for a 2N5470 transistor in the circuit of Fig. 7 are shown in Fig. 9. Because a network transformation is used in this circuit, the 3-dB bandwidth is only of the order of 6 per cent.

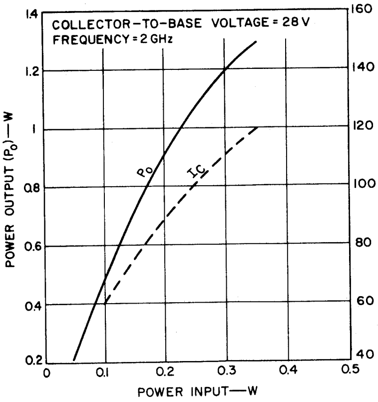


Fig. 9 - Typical performance curves for the 2N5470 in the 2-GHz coaxial-line power amplifier of Fig. 7.

1-GHz Coaxial-Line Power Amplifier

The design of a 1-GHz coaxial-line amplifier circuit is similar to that for the 2-GHz circuit and fixture shown in Fig. 7 and 8. However, because of the increased device dissipation at 1 GHz, the coaxial lines are loaded with boron nitride insulation to reduce the thermal resistance between the active device and the external heat sink as represented by the outer coaxial-line cylinder in Fig. 8. Boron nitride has thermal and electrical properties similar to those of Al_2O_3, and has the additional advantages of being readily machinable and non-toxic.

The input line of a 1-GHz coaxial-line power amplifier has an electrical length equal to 23 per cent of a wavelength and transforms the input impedance of approximately $3 + j1$ ohms to a real component of about 49 ohms. Capacitor C_1 is used in conjunction with input stray capacitance to match the value of 49 ohms to the 50-ohm driving source. The actual line length, corrected for capacitive and dielectric loading effects as well as fringe line effects, is about 1 inch. The characteristic impedance of the line is about 30 ohms for an air line or about 13 ohms when the line is loaded with the boron nitride dielectric.

The output line is basically a $\frac{3}{8}\lambda$ transformer which transforms the complex output load impedance of about $12 + j53$ ohms to a real component of about 270 ohms. Capacitors C_2 and C_3 are reactive dividers and step down this resistance to the 50 ohms required at the output. The actual line length, again corrected for loading and fringe field effects is about 1.64 inches The loaded output line impedance is approximately 27 ohms.

The use of the boron nitride dielectric makes possible the design of a 1-GHz coaxial-line amplifier circuit comparable in size to the 2-GHz coaxial-line circuit designed with air lines. Therefore, a substantial reduction in the size of the 2-GHz amplifier circuit is possible when the dielectric loading technique is used. In addition, improvement in power gain and efficiency can be expected because of the improved thermal resistance between the active device and the final heat sink.

The construction of a 1-GHz amplifier is, as mentioned above, similar to that shown in Fig. 8 except that the beryllium oxide washer is not used; press-fit boron nitride cylinders form the dielectric portion of the coaxial lines. In both circuits, the fixture is built with separate coaxial-line cavities for input and output; the cavities are locked together across the 2N5470 base flange by means of a locking nut. Although tuning of the amplifiers is not critical, some adjustment of the wire rf chokes (by spreading or closing of turns) may be required for optimum performance at each frequency. Thus, the rf chokes can be used as a fine adjustment of the terminating impedance.

1.6-GHz Stripline Power Amplifier

Although the 2N5470 transistor is designed primarily for coaxial-line use, it can also be adapted to stripline and microstripline circuits. Fig. 10 shows an experimental microstrip circuit capable of developing a power output of 900 milliwatts over the range of 1.6 to 2 GHz with a drive power of about 200 milliwatts. Collector efficiency at 1.6 GHz is of the order of 50 per cent with a collector supply voltage of 28 volts.

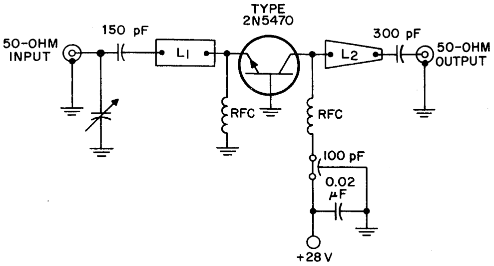


Fig. 10 - An experimental 1.6-to-2-GHz broadband microstripline amplifier.

The input line of this circuit has a characteristic impedance of 8 ohms, and is constructed of 5-mil copper sheet mounted on the circuit ground plane with 5-mil Dupont H-Film* as the dielectric. A conducting strip of the copper only $\frac{3}{16}$ inch wide is sufficient to provide the 8-ohm line impedance. The physical line length of 0.4 inch is equivalent to an electrical length of an eighth wave and transforms the complex input impedance of approximately $5.3 + j6$ ohms to a real component of about 21 ohms. Capacitor C_1, a copper strip 5 mils thick located in the vicinity of the 150-picofarad dc blocking capacitor is used to reactively match the value of 21 ohms to the 50-ohm source impedance.

The output line is a tapered line section constructed of $\frac{1}{32}$-inch teflon-fiberglass board. The characteristic impedance at the collector end is 35 ohms and is approximately equal to the magnitude of the complex load impedance of the device at 2 GHz (under circuit operating conditions). The eighth-wave line section (approximately 0.3 inch long) is tapered to a characteristic impedance of 50 ohms at the output end of the line and thus matches the output directly; the 300-picofarad capacitor is used for dc-blocking purposes only.

The VSWR is low at both input and output ports over the range of 1.6 to 2 GHz. Below 1.6 GHz, the input and output VSWR increases because of mismatch conditions; however, circuit power output remains essentially constant because of increased device gain at the lower frequencies. As a result, the experimental 1.6-GHz stripline power amplifier exhibits a relatively flat output response of 900 milliwatts (with a 200-milliwatt drive) over the range of 1.2 to 2 GHz.

Pulse Operation of the 2N5470

One major difference between cw and pulse operation of a transistor is the substantial increase in input drive level possible under pulsed input conditions. The ability of a transistor to deliver higher pulsed-output power than cw power depends on the transistor

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current-handling, thermal, and rf-voltage capabilities. No significant improvement in power output or gain can be achieved by operation of an rf power transistor under pulse input conditions at the same supply voltage and input power level used under cw conditions.

Fig. 11 shows peak power output as a function of duty cycle for the 2N5470 operating under pulse conditions. Peak power was measured at a frequency of 2 GHz; the constant supply voltage was 28 volts. Under pulsed input conditions with pulses of 2-microsecond duration and 10-per-cent duty cycle, the output power of a 2-GHz amplifier circuit such as the one shown in Fig. 8 increases substantially from 1.1 to 1.9 watts as the input power increases from 0.3 to 0.7 watt. When the same circuit operates under cw conditions, an increase in input power from 0.3 to 0.5 watt does not increase power output; in fact, power output stabilizes at 1.1 watts. These measurements indicate that the power input at 2 GHz under cw conditions is limited by thermal considerations rather than peak-current capabilities or emitter periphery. The 2N5470 transistor is thus be capable of operating at much higher peak current under pulse conditions than would be permissible under cw conditions.

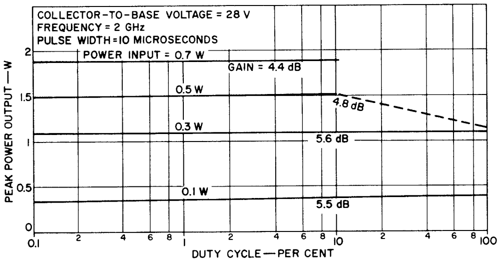


Fig. 11 - Peak power output as a function of duty cycle for the 2N5470 operating under pulsed conditions.

A second major difference between cw and pulse operation of a transistor is the much higher voltage at which the transistor can be operated under pulse conditions. Fig. 12 shows the peak power output measured at 2 GHz as a function of supply voltage for the 2N5470. The measurements were performed at a constant peak input power with pulses of 10-microsecond duration and duty cycles of 1, 10, and 30 per cent. At 2 GHz and an input power level of 0.5 watt, the power output of the 2N5470 increases from 1.9 watts at 28 volts to 2.5 watts at 45 volts. These measurements indicate that the 2N5470 transistor can be operated at much higher voltage under pulse conditions than under cw conditions and, consequently, can deliver more pulsed power.

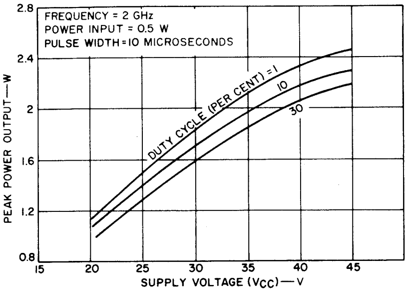


Fig. 12 - Peak power output at 2 GHz as a function of supply voltage for the 2N5470.

Microwave Power-Oscillator Design

The 2N5470 transistor is suitable for use in microwave power oscillators at L-band and low S-band frequencies. The 2N5470 has high power amplification, a necessary condition for good oscillator performance; however, because of the high degree of isolation that exists between the transistor chip and the case as a result of the coaxial design, an external feedback path must be provided to assure reliable oscillation at microwave frequencies. Except for this feedback loop, the design of oscillator circuits is similar to that discussed for amplifier circuits.

Fig. 13 shows the 2N5470 in its basic oscillator configuration, a Colpitts oscillator circuit. In this circuit, the collector is grounded for maximum heat dissipation; therefore, power output is taken from the base circuit.

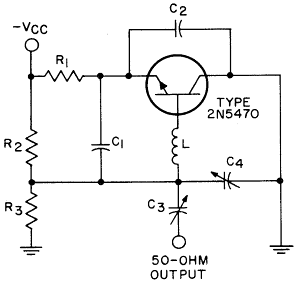


Fig. 13 - Basic oscillator configuration for the 2N5470, a Colpitts oscillator circuit.

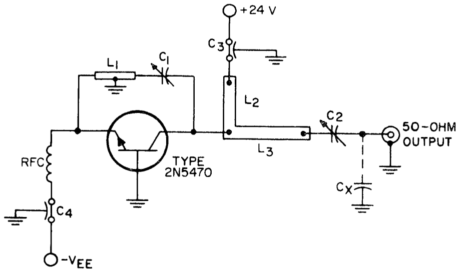
The parasitic elements of the 2N5470 (the parasitic inductance L and the parasitic capacitances C_1 and C_2) can be made use of in oscillator design. The internal package capacitance C_2 is usually insufficient to sustain oscillation and must be increased externally. The Colpitts circuit shown in Fig. 13 can be changed to a Hartley oscillator circuit if L and C_1 are made external components and C_1 is connected to the center point of the inductor.

Reliable starting conditions are assured by use of a slight forward bias in the common-base oscillator circuit through the bias network formed by resistors R_2 and R_3. Once oscillations have been started, the circuit is biased toward class C operation by the base current flowing through resistors R_1 and R_2. Resistor R_1 also serves as a limiting resistance which tends to maintain the bias point at stable oscillator power-output levels.

Although many oscillator designs are possible, the two circuits described in the following paragraphs are descriptive of the types employing the 2N5470 transistor.

2-GHz Microstripline Oscillator

The circuit shown in Fig. 14 is a 2-GHz microstripline oscillator which can deliver 300 to 350 milliwatts of rf power with a 24-volt collector supply. Although separate bias supplies are shown, a single "floating" bias supply can also be used.



C_1 C_2 — 0.35-3.5 pF; Johanson 4702 or equiv.
C_3 C_4 — 100 pF, feedthrough; Allen-Bradley FA5C or equiv.
L_1 — 50-ohm miniature coaxial line, 1.5 in. (38.1 mm) long
L_2 — microstrip line, $\frac{1}{32}$ in. teflon-fiberglass, 0.08 in. wide, 0.43 in. long
L_3 — microstrip line, $\frac{1}{32}$ in. teflon-fiberglass, 0.03 in. wide, 0.7 in. long
RF choke — 5 turns No. 33 wire, $\frac{1}{16}$ in. (1.59 mm) ID, $\frac{3}{16}$ in. (4.75 mm) long

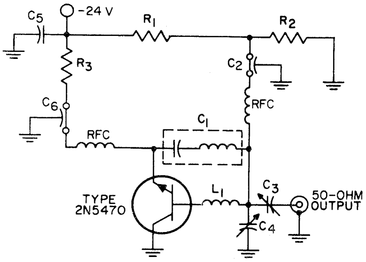
Fig. 14 - A 2-GHz microstripline oscillator.

A grounded-base configuration is used in the circuit; output power is taken from the collector circuit in the conventional manner. L_2 is a section of microstripline which provides the susceptance required to tune out the output capacitance of the 2N5470. The real part of the output load impedance (about 225 ohms) is transformed by a quarter-wave section of microstripline to a real component of about 53 ohms. Capacitor C_2, in conjunction with some stray capacitance C_x, is used to match the circuit output to the 50-ohm load. Correctly phased feedback is provided by the loop circuit formed by L_1 and C_1. Frequency adjustment over the range of 1.8 to 2.1 GHz is controlled by capacitor C_1.

The circuit of Fig. 14 is fabricated on a $\frac{1}{32}$-inch teflon-fiberglass board. The 2N5470 is mounted with the base flange flat against the ground plane of the board; a beryllium oxide washer provides a thermal path between the collector post and the ground plane. The 1.5-inch line section L_1 is used to contact the base of the 2N5470 on the other side of the board.

2-GHz Lumped-Constant Power Oscillator

The circuit shown in Fig. 15 has a single bias supply and makes use of a grounded collector for better heat dissipation. The circuit is tunable over the range of 1.8 to 2.1 GHz and can deliver 300 milliwatts of output power at 2 GHz with a 21-volt power supply. Circuit operation is similar to that of a Hartley oscillator, with L_1 and the parasitic inductance of capacitor C_1 comprising the tapped inductance used in the feedback loop. Tuning is provided largely by capacitor C_4; C_3 is adjusted for optimum match to the load of 50 ohms. Resistor R_1 can be made variable (0 to 100 ohms) to permit optimum adjustment of bias conditions. Output power can be adjusted without great effect on the oscillator frequency by variation of the value of resistor R_3. A minimum supply of about 15 volts is sufficient for stable circuit operation.



C_1 — 0.82 pF, "gimmick"; Quality Components type 10% QC or equiv.
C_2 C_6 — 100 pF, feedthrough; Allen-Bradley FA5C or equiv.
C_3 C_4 — 0.35-3.5 pF, Johanson 4701 or equiv.
C_5 — 0.01 μF, disc, ceramic
L_1 — No. 22 wire, $\frac{3}{64}$ in. (1.17 mm) long
RF chokes — 4 turns No. 33 wire, $\frac{1}{16}$ in. (1.59 mm) ID, $\frac{3}{16}$ in. (4.75 mm) long
R_1 — 51 ohms, 0.5 W
R_2 — 1200 ohms, 0.5 W
R_3 — 5-10 ohms, 0.5 W

Fig. 15 - A 2-GHz lumped-constant oscillator circuit.

Wideband Power Oscillator Circuits

Although the basic Colpitts oscillator circuit shown in Fig. 12 can be made a varactor-tuned wideband oscillator by use of a high-Q varactor in place of the inductance L, a simpler technique can be used with the 2N5470. Fig. 16 shows a proposed circuit using the 2N5470 which is capable of wideband single-screw tuning. Basically, the circuit is the oscillator arrangement of Fig. 14 with the broadband tapered-line output section of Fig. 10. Capacitor C_2 is selected for best output match at the center oscillator frequency desired, and capacitor C_1 is used to control the oscillator over a bandwidth of approximately 20 per cent.

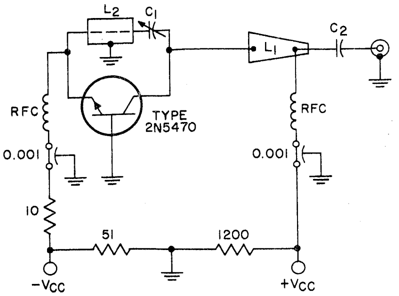


Fig. 16 - A wideband single-screw-tuned oscillator circuit.

Biasing Arrangement for Class A and Class B Operation

In addition to class C operation, the 2N5470 can be used in class A or B service when large dynamic range is required. Only common-base operation is discussed in this Note because the 2N5470 is constructed with the base connected to the flange. In such an arrangement, positive voltage must be supplied to the collector and negative voltage to the emitter to permit forward-biased operation. A 100- to 200-ohm resistor should be connected in series with the emitter to bias the emitter and to prevent excessive collector-current flow.

If one power supply with a grounded negative or positive line is used, the base of the 2N5470 must be dc-isolated from ground. One method of accomplishing this isolation is to use a thin tape material, such as 1-mil Mylar* tape, between the ground plane and the flange or base of the transistor. The resulting capacitance between the flange and the ground plane through the tape dielectric provides a satisfactory bypass for the base. A low-frequency bypass must also be provided along the base power-supply line. This biasing arrangement is shown in Fig. 17.

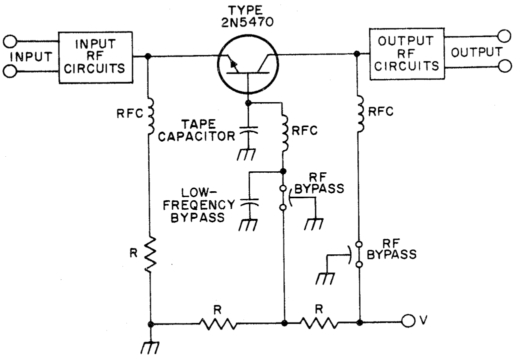


Fig. 17 - A bias circuit with the transistor base grounded.

Class A and Class B Power Gain

Figs. 18 and 19 show the power gain of a 2N5470 transistor in a common-base amplifier configuration at 1 and 2 GHz, respectively. In each case, a class C curve measured at a supply voltage of 15 volts is included for reference.

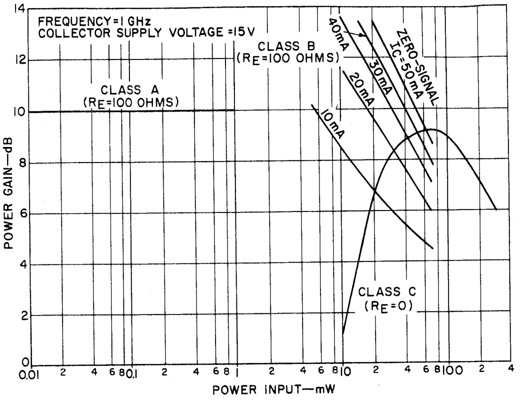


Fig. 18 - Power gain as a function of power input in a 1-GHz common-base amplifier configuration.

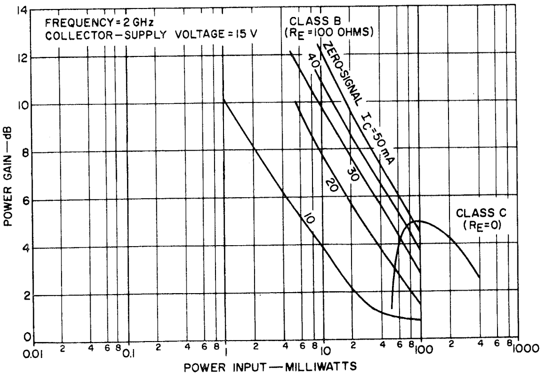


Fig. 19 - Power gain as a function of power input in a 2-GHz common-base amplifier configuration.

The collector-current values shown for class B operation represent quiescent current levels set for each test prior to the application of rf power. The true collector current for each test level is somewhat higher, the amount depending upon the level of the applied rf power. The circuit was returned for each test point to provide maximum power output and, therefore, maximum power gain.

Class A performance was measured with collector

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currents from 10 to 50 milliamperes. At these levels, class A gains exceeding the values shown can be readily obtained.

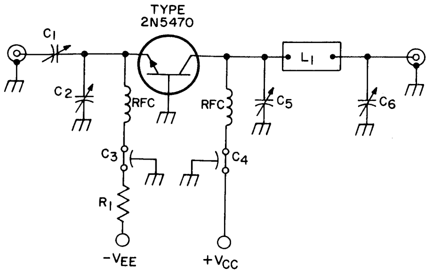
At 1 GHz with a supply voltage of 15 volts, the maximum class C power gain for a 2N5470 transistor is about 9 dB; maximum gain occurs with an input drive of about 75 milliwatts applied to the device. At 2 GHz with a 15-volt supply, the maximum class C power gain is about 5 dB with about 90 milliwatts of input power.

The selection of class B or class C operation and the appropriate operating conditions for a circuit in which power gain is important can be made for frequencies of 1 or 2 GHz with the help of the curves in Figs. 18 and 19. Class B gains in excess of 10 dB can be obtained at either frequency; however, the stability of the amplifier must also be considered.

1- and 2-GHz Lumped-Constant Common-Base Amplifiers

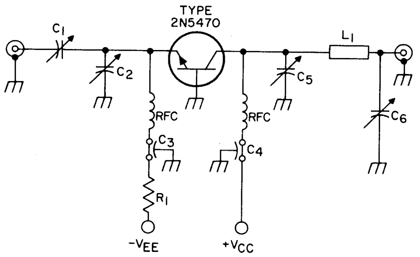
Lumped-constant common-base amplifiers using the 2N5470 have been designed for 1- and 2-GHz operation; circuit diagrams are shown in Figs. 20 and 21, respectively. Both amplifiers are designed for operation either with two power supplies or with one supply with neither positive nor negative line grounded. Both amplifiers are tuned by means of emitter terminal inductances and Johanson air-type dielectric tuning capacitors. These components step the impedance down from 50 ohms to that required by the transistor. The tuning range of the capacitors is sufficient to permit tuning for maximum gain or minimum noise.

A pi network is used in the output circuit of each amplifier so that the output impedance can be varied and thus the degree of mismatch controlled. With the line lengths shown, the circuits can be tuned to the desired frequencies with a large mismatch and provide stable class A operation. In class B or class C operation, when either a slight mismatch or matched conditions are needed, a reduction in the series inductance changes the transformed output impedance to a value closer to that required for matched conditions.



C_1 C_5 C_6 — 1-14 pF, air dielectric trimmer capacitor, Johanson 3901 or equiv.
C_2 — 0.35-3.5 pF; Johanson 4701 or equiv.
C_3 C_4 — 1000 pF, feedthrough
L_1 — 10-mil copper wire, 0.4 cm wide, 2.2 cm long, formed into open loop
RF chokes — 0.1 μH, Nytronics or equiv.

Fig. 20 - A 1-GHz lumped-constant common-base amplifier.



C_1 C_2 C_5 C_6 — 0.35-3.5 pF; Johanson 4701 or equiv.
C_3 C_4 — 1000 pF, feedthrough
L_1 — 10-mil copper strip, 0.3 cm wide, 1.3 cm long

Fig. 21 - A 2-GHz lumped-constant common-base amplifier.

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Application Note
AN-4025

The Use of Coaxial-Package Transistors In Microstripline Circuits

by

H. C. Lee and G. Hodowanec

It is generally accepted that a well-designed coaxial transistor package (such as that used for the 2N5470) outperforms other transistor packages (including stripline packages) at the microwave frequencies. This performance is based on the low values of the parasitic elements and the excellent isolation between the input and output circuits associated with the coaxial configuration. As a result, microstrip or stripline amplifier circuits using the 2N5470 coaxial-package transistor can have thermal and electrical performance equal to that of coaxial-line circuits.

This Note describes the design, construction, and performance of microstripline circuits using 2N5470 coaxial transistors. Two complete circuits are described: a 1.5-GHz amplifier which can provide 1.5 watts of output power with 8.0-dB power gain and 50-per-cent collector efficiency and a 2-GHz amplifier which can provide 1.2 watts of output power with 6-dB power gain and 40-per-cent collector efficiency.

MOUNTING ARRANGEMENT

Fig.1 shows the circuit mounting arrangement of the 2N5470 coaxial transistor in microstripline and lumped-element circuits. The transistor is mounted vertically through a hole in the metal block which serves as both a heat sink and ground for the device. The bottom side of the metal block is counter-bored so that the base flange of the transistor is level with the surface of the block. The hole through the metal block has a somewhat larger diameter than that of the ceramic portion of the transistor which separates the base flange and the collector stud. This larger diameter permits insertion of a press-fit cylindrical sleeve of beryllium oxide or boron nitride between the transistor and the metal block to provide a heat-conducting path from the collector stud to the block. The diameters of the hole through the metal block and the cylinder of beryllium oxide (or boron nitride) are determined by the desired characteristic impedance of the short coaxial-line section which is formed by this mounting technique. Beryllium oxide and boron nitride have excellent heat conductivity and low electrical losses and thus provide satisfactory heat dissipation from the coaxial transistor without adversely affecting the rf performance.

The circuit arrangement shown in Fig.1 is excellent for isolation of the input and output circuits. The out-

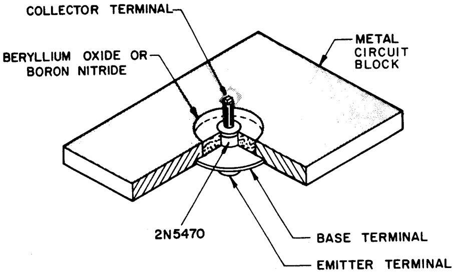

Fig.1 - Mounting arrangement for the 2N5470 in a microstripline circuit.

put circuit is constructed on the top portion of the metal block and the input circuit on the bottom portion. Fig.2 shows the construction of the microstripline circuit. The output circuit is constructed of standard microstripline mounted to the top surface of the metal block. The input circuit is constructed of another microstripline placed directly over the bottom surface of the metal block. A stripline circuit can be formed by placing another strip of dielectric material and ground plane above the conductor strips of Fig. 2.

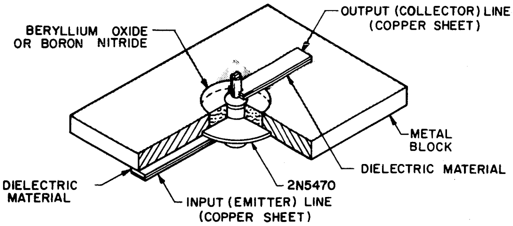

Fig.2 - Construction of the microstripline circuit.

DESIGN OF MICROSTRIP AMPLIFIER CIRCUITS

Fig.3 shows a basic microstripline transistor power-amplifier circuit. The input circuit consists of a line section ℓ_1 with a characteristic impedance Z_{01} and a capacitor C_1. The length of line ℓ_1 in conjunction with the capacitance C_1 transforms the input impedance of the transistor to the driving-source resistance of 50 ohms. The output circuit consists of a line section ℓ_2 with a characteristic impedance Z_{02} and a capacitor C_2. The combination of the line ℓ_2 and capacitance C_2 transforms the load resistance of 50 ohms to the required collector load impedance of the transistor, which is determined by the required power output at the frequency of interest. The two rf chokes and a small emitter resistance R_E complete the biasing arrangement of the transistor power amplifier.

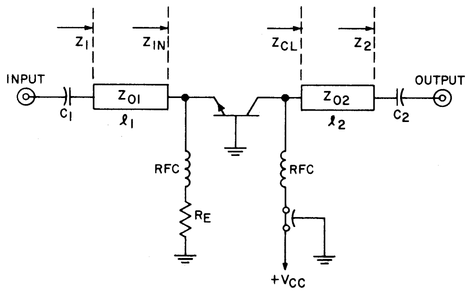

Fig.3 - Schematic of a basic microstripline transistor power amplifier.

The first step in the design of a 2-GHz power amplifier is to determine the input impedance Z_{in} and the collector load impedance Z_{CL} of the 2N5470 at 2 GHz under dynamic operating conditions. These values, obtained from the published values in the data sheet, are as follows:

$$Z_{in} = 7.5 + j8 \text{ ohms} \tag{1}$$

$$Z_{CL} = 6.5 + j33 \text{ ohms} \tag{2}$$

For the design of the input circuit, a characteristic impedance Z_0 of 19.4 ohms is chosen. This value of Z_{01} is calculated by use of the quarterwave transformer equation. The input impedance Z_{in} is normalized with respect to the characteristic impedance, as follows:

$$Z'_{in} = Z_{in}/Z_{01} = (7.5 + j8)/19.4 = 0.386 + j0.414 \tag{3}$$

This impedance value point Z'_{in} is located on the Smith Chart shown in Fig.4. The point is then rotated about the constant VSWR circle toward the generator to the intersection of the 2.57 constant-resistance circle (the normalized 50-ohm driving-source resistance). This point is designated as Z_1' and has the value

$$Z_1' = 2.57 + j1.1 \tag{4}$$

The actual impedance Z_1 is then equal to

$$Z_1 = Z_{01}\,Z_1' = 19.4\,(2.57 + j1.1) = 50 + j21.3 \text{ ohms} \tag{5}$$

The line length required to transform the transistor input impedance from 7.5 + j8 ohms to a driving-source resistance of 50 ohms or from 50 ohms to 7.5 - j8 ohms, as determined from Fig.4, is equal to 0.155 λ_ϵ, where λ_ϵ is the wavelength in the dielectric. At 2 GHz, λ_ϵ is equal to 3.66 inches (for a dielectric constant $\epsilon = 2.6$); therefore, the length of the input line section ℓ_1 is calculated to be 0.56 inch. The width of the line for a characteristic impedance of 19.4 ohms when a 1/32-inch teflon* fiberglass board is used in determined[1] to be 0.27 inch. A capacitor C_1 with a reactance of 21.3 ohms is needed to complete the input circuit. This capacitor also provides dc isolation for the input bias network.

Fig.4 shows that a direct transformation between the input impedance of the transistor (7.5 + j8 ohms) and the driving source resistance of 50 ohms is also possible by proper choice of the characteristic impedance Z_{01} and the length of the input line. The value of Z_{01} can be determined from the Smith Chart. Because the input impedance Z_{in} at 2 GHz is inductive, the input line ℓ_1 must be less than a quarter-wave long to provide the necessary impedance transformation. The input

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* Trademark of DuPont de Nemours, Inc.

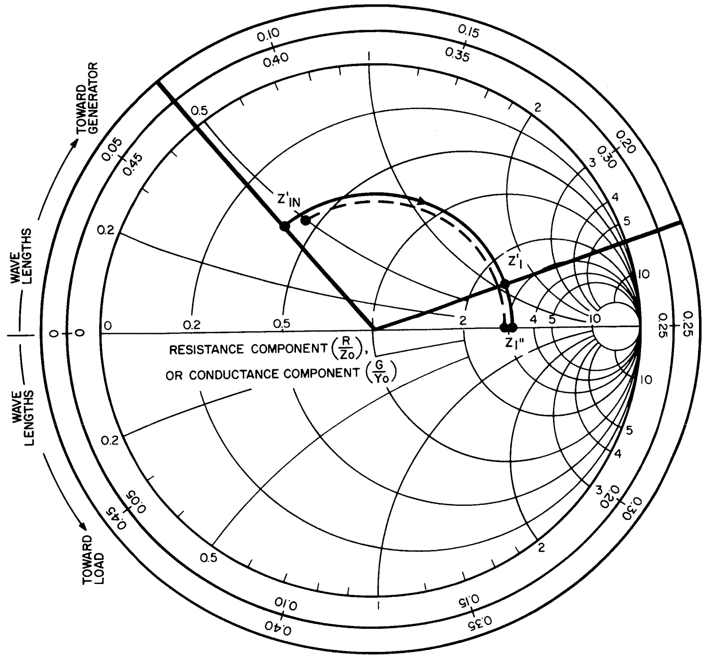

Fig.4 - Smith Chart diagram showing the direct transformation between the transistor input impedance and the driving source resistance made possible by proper selection of the characteristic impedance and length of the input line.

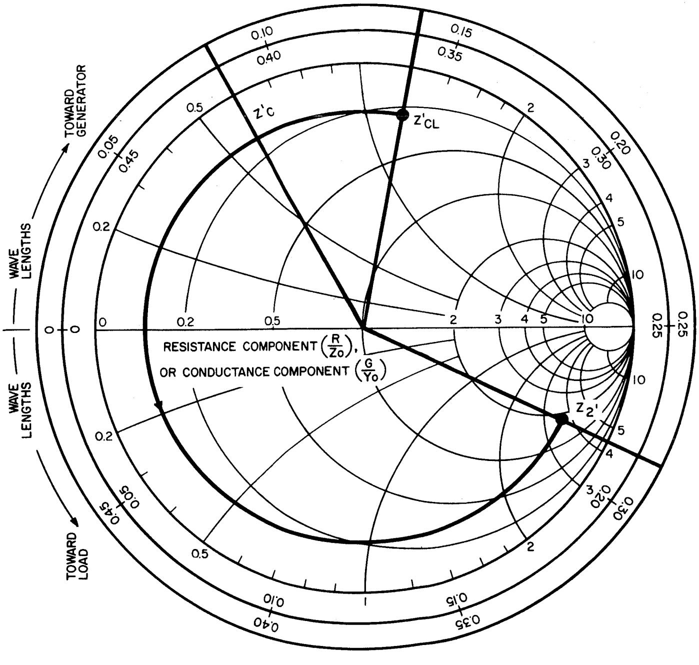

Fig.5 - Smith Chart diagram showing the length of line required to achieve the desired transformation between the transistor collector load impedance and the load-termination resistance.

impedance Z'_{in} is then rotated on the Smith Chart of Fig.4 toward the generator to intersect the zero-reactance line at point Z_1''. The normalized impedance at point Z_1'' is 3.1 ohms and, therefore, the impedance Z_1 is 60 ohms (3.1 x 19.4). The use of a value of Z_{o1} of 19.4 ohms results from direct transformation from 7.5 + j8 ohms to 60 ohms, which is 10 ohms higher than the required value. The reduction of Z_{o1} to 17.5 ohms with $\ell_1 = 0.17\ \lambda_\epsilon$, however, provides a direct transformation from 7.5 + j8 to 50 ohms.

The characteristic impedance Z_o and length ℓ of the transmission line required to provide direct transformation from a pure resistance R_1 to an impedance $Z_2 = R_2 + jX_2$ can also be determined by use of the following equations:

$$Z_o = \sqrt{R_1 R_2}\ \sqrt{1 - \frac{X_2^2}{R_2 (R_1 - R_2)}} \qquad (6)$$

$$\tan \beta\ell = Z_o \frac{R_1 - R_2}{R_1 X_2} \qquad (7)$$

If the impedance Z_2 is a resistance (i.e., $X_2 = 0$), Eq. (6) reduces to the quarter-wave transformer equation and $\ell = \lambda/4$.

For the design of the output circuit, direct transformation using a simple transmission line from 50 ohms to the required collector load impedance of Eq.(2) is not possible because the term $X_2^2/R_2\ (R_1 - R_2)$ of Eq.(6) is larger than unity. The characteristic impedance and the length of the output line must be chosen so that the capacitance C_2 shown in Fig.3 can have a reasonable value. The characteristic impedance Z_{o2} is chosen to be 28 ohms. The transistor collector load impedance Z_{CL} is first normalized as follows:

$$Z'_{CL} = Z_{CL}/Z_{o2} = (6.5 + j33)/28$$
$$= 0.232 + j1.18 \qquad (8)$$

The Z'_{CL} point is then located on the Smith Chart shown in Fig.5. The chart is then rotated about the constant VSWR circle toward the load to the point of intersection with the 1.78 constant-resistance circle (the normalized 50-ohm load resistance). This value, designated Z_2', is 1.78 - j3.6. The actual load impedance therefore, is equal to

$$Z_2 = Z_2' \cdot Z_{o2} = 28\ (1.78 - j3.6)$$
$$= 50 - j100 \text{ ohms} \qquad (9)$$

The line length required to transform the 50-ohm load to the required collector load impedance Z_{CL} of 6.5 + j33 ohms is determined from Fig.5 to be $0.352\ \lambda_\epsilon$. The width of the microstripline for 28-ohms characteristic impedance on a 1/32-inch teflon fiberglass board is 0.17 inch. A capacitor C_2 with a reactance value equal to 100 ohms again is needed to complete the output circuit.

The output circuit actually consists of two line sections: the short coaxial-line section formed by the transistor collector section mounted in the circuit block, as shown in Figs.1 and 2, and the output microstripline section shown in Fig.2. In the power amplifier shown in Fig.3, the output microstripline section ℓ_2 has a characteristic impedance of 28 ohms. To avoid complicated transformation determinations, it is desirable to make the characteristic impedance of the coaxial-line section as nearly equal to a nominal impedance of 28 ohms as practical.

Fig.6 shows a cross-sectional view of the 2N5470. The internal structure of the line section consists of a tapered-line section and a very short uniform line section ℓ_u. The tapered-line section is surrounded by an air space which is enclosed by the Al_2O_3 ceramic insulator of the 2N5470 package and the boron nitride sleeve*. The section designated ℓ_u extends directly to the boron nitride sleeve. For the dimensions shown in Fig.6, a characteristic impedance in the order of 28 ohms requires that the outer conductor of the line section ℓ_u have an

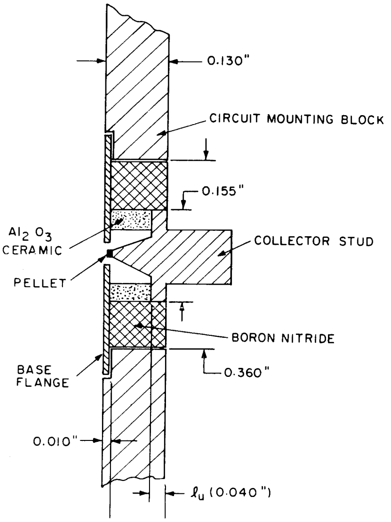

Fig. 6 - Cross-sectional view of the RCA 2N5470 transistor (output section).

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* An average characteristic impedance and electrical length can be calculated for this tapered-line section, or this section can be considered as contributing a small inductive component which can be calculated from its physical dimensions.

inside diameter of the order of 0.36 inch.[1] This coaxial-line section transforms the normalized load impedance Z'_{CL} to the point Z'_C, as shown on the Smith Chart of Fig.5. This transformation length must also be considered in designing the output network. The length of microstripline needed to continue the transformation between points Z'_C and Z_2' of Fig.5, therefore, is 0.300 λ_ϵ. For the 1/32-inch teflon fiberglass board, the length 0.300 λ_ϵ corresponds to 1.10 inches.

Fig.7 shows the complete schematic for the 2-GHz amplifier. In practice, the calculated lengths of the input and output microstriplines are reduced by 20 per cent to account for the fringe-line effects resulting from the length of piston-type capacitors C_1 and C_2, and the inductance effects caused by the connecting leads of the device to the stripline sections.

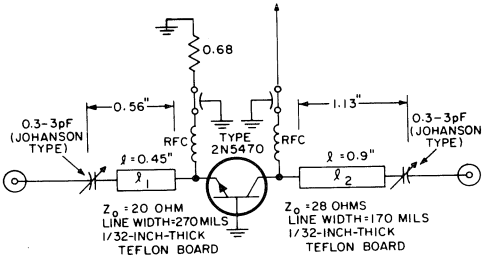


Fig.7 - Schematic of a 2-GHz microstripline transistor amplifier.

PERFORMANCE OF THE 2-GHz AMPLIFIER

The 2-GHz amplifier is constructed by use of the layout shown in Fig. 1 and the configuration and dimensions shown in Fig.7. The metal block is aluminum. The input and output circuits are constructed on 1/32-inch teflon fiberglass board, which is mounted atop the aluminum so that the input and output lines are on opposite sides of the aluminum block. Fig.8 shows a photograph of the output-circuit section. When operated at 28 volts, this circuit can deliver cw power output of 1.2 watts with a gain of 6 dB and a collector efficiency of 43 per cent. The 3-dB bandwidth is 12 per cent. The performance of this microstripline amplifier is equivalent to that of a cavity or coaxial-line amplifier circuit.

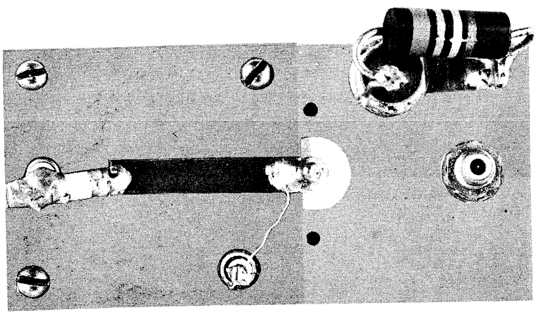


Fig.8 - Photograph of the output-circuit section of the 2-GHz amplifier shown in Fig.7.

PERFORMANCE OF THE 1.5-GHz AMPLIFIER

The same procedure was used to design the 1.5-GHz amplifier circuit shown in Fig.9. The output circuit, as shown in Fig.10, is constructed on 1/16-inch teflon board which is mounted on one surface of an aluminum block. The input line is constructed on the opposite side of the aluminum block, which serves as the ground plane of the line. The input line is formed by mounting a 5-mil copper sheet over a 5-mil-thick dielectric material (DuPont H-film) which is placed directly over the aluminum-block surface. The width of required input line can be determined from Fig. 9. The required line impedance must be increased about 6 per cent to allow for fringe-field effects resulting from the use of a 5-mil line thickness.

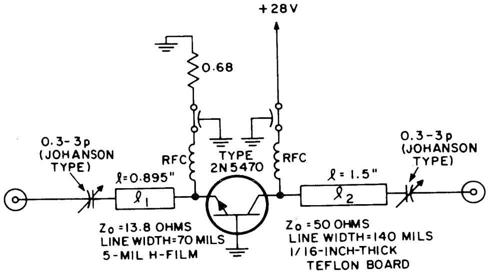


Fig.9 - Schematic of a 1.5-GHz microstripline transistor amplifier.

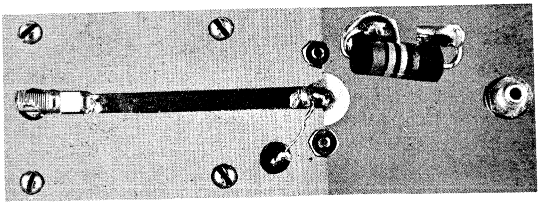


Fig.10 - Photograph of the output-circuit section of the amplifier shown in Fig.9.

This amplifier circuit, which operates at 28 volts and uses a typical 2N5470 transistor, provides 1.5 watts of output power with 8.0-dB gain and 50-per-cent collector efficiency. The 3-dB bandwidth of this amplifier is in the order of 10 per cent.

CONCLUSION

The performance of the two amplifier circuits described in this Note clearly demonstrates the advantages offered by coaxial-packaged transistors in microstrip or stripline circuits. The coaxial package provides thermal and electrical performance equal to that of coaxial-line circuits. In addition, the mounting arrangement of coaxial-package transistors results in a built-in heat sink for the device and improved isolation between inputs and outputs. Similar techniques have been used successfully to obtain 6 watts of cw output power at 2.0 GHz by use of a coaxial-package higher-power transistor, RCA-2N5921.

REFERENCE

1. Reference Data for Radio Engineers, International Telephone and Telegraph Corp., New York, N.Y. March 1957.

RCA
Solid State
Division

RF Power Transistors
Application Note
AN-4421

16- and 25-Watt Broadband Power Amplifiers Using RCA-2N5918, 2N5919, and TA7706 UHF/Microwave Power Transistors

by C. Leuthauser and B. Maximow

The advent of uhf power transistors has made possible broadband amplification of large rf signals without use of ganged tuned circuits, which have very limited bandwidths and mechanical complexity. Wide bandwidths are now attainable as a result of improved intrinsic transistor characteristics, as well as package design. In a 225-to-400-MHz broadband high-power amplifier, good transistor package design is of special importance. Low parasitic inductances are essential because the real part of the transistor input impedance is inherently low.

The RCA-2N5918, 2N5919, and Dev. No. TA7706, which feature a stripline package, are examples of improved rf power transistors designed specifically for use in high-power broadband amplifiers in the 225-to-400-MHz frequency range. The development of rf transistor packages has progressed from the early hermetic TO-60-style configuration through the stripline plastic package, to the highly reliable, ceramic-to-metal, hermetic stripline package used in these types. This Note discusses general design considerations for broadband rf amplifiers, and describes the design of a 2N5919 amplifier that provides a constant power output of 16 watts with gain variation within 1 dB over a bandwidth of 225 to 400 MHz. The 2N5919 amplifier can be connected in direct cascade with a 2N5918 driver amplifier, or two 2N5919 amplifiers can be connected in parallel, to provide a constant power output of 25 watts from 225 to 400 MHz. A single TA7706 can be used in a similar configuration to provide 25 to 30 watts of rf power across the same frequency band.

The schematic diagram for the 2N5919 amplifier is shown in Fig. 1, and broadband performance of the 2N5919 in the circuit is shown in Fig. 2. Performance is shown for class C operation, which is basic for high-power amplification. In the case of an amplitude-modulated system, linearity requirements are met by either envelope correction or slight forward-biasing, or both.

GENERAL DESIGN CONSIDERATIONS

Broadbanding a transistor rf amplifier is difficult because changes in output loading affect the input impedance and may cause errors in the input-network design if the design is based on narrowband input-impedance information. The design of a broadband amplifier, therefore, should begin with the output network.

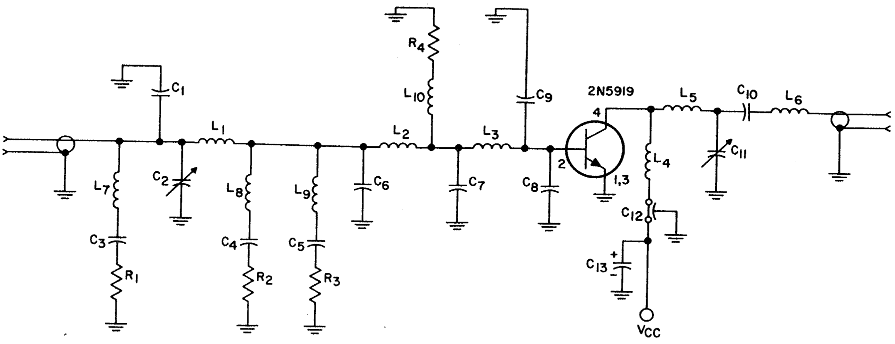
Evaluation Circuit

A quick method of evaluating the design of an output network is to construct an amplifier which uses the particular output circuit and a tunable narrowband input circuit. Over the required frequency band, the resulting amplifier should display smooth gain and collector-efficiency characteristics. Sharp changes in either of these characteristics indicate improper loading of the collector and can result in higher thermal resistance than would normally be anticipated. Under improper loading conditions, the transistor dissipation is not spread uniformly across the device pellet; as a result there is heat concentration and an equivalent increase in thermal resistance.

The interim circuit described above can also be used to determine the broadband input impedance of the rf transistor by measuring the input-circuit impedance at the device terminals at each frequency of interest. In each case, the input network should present a good 50-ohm match to the generator during tuneup and should be terminated (source side) by 50 ohms when the impedance measurement is made. The device impedance is then the conjugate of the circuit impedance.

Package Design

If the upper frequency of operation is in the uhf range, the imaginary part of the input impedance usually appears inductive. For good broadband performance, package



C_1 - 10 pF silver mica
C_2 - 0.8-10 pF, Johanson 3957*
C_3 - 2.2 pF, Quality Components type 10% QC, "gimmick"*
C_4 - 1.0 pF, Quality Components type 10% QC, "gimmick"*
C_5 - 1.5 pF, Quality Components type 10% QC, "gimmick"*
C_6 - 36 pF, ATC-100*
C_7 - 51 pF, ATC-100*
C_8 - 47 pF, ATC-100*
C_9 - 68 pF, ATC-100*
C_{10} - 12 pF, silver mica
C_{11} - 0.8-20 pF, Johanson 4802*
C_{12} - 1000 pF feedthrough type, Allen-Bradley FA5C*
C_{13} - 1 μF electrolytic

L_1 - 1-1/2 turns▲
L_2 - Copper strip 5/8 in. (15.875 mm) L; 5/32 in. (3.96 mm) W
L_3 - Transistor base lead, 3/6 in. (4.74 mm) L
L_4, L_6 - 3 turns▲
L_5 - 2 turns▲
L_7, L_8, L_9 - 0.18 μH RFC, Nytronics, P.#DD-0.18
L_{10} - 0.1 μH RFC, Nytronics, P.#DD-0.10
R_1 - 100 Ω, 1 W, carbon
R_2, R_3 - 100 Ω, 1/2 W, carbon
R_4 - 5.1 Ω, 1/2,W, carbon

* Or equivalent
Allen-Bradley Co., Milwaukee, Wis.
American Technical Ceramics, Huntington Station, N. Y. 11746
Johanson Mfg. Corp., Boonton, N. J. 07005
Nytronics, Inc., Berkeley Heights, N. J.

▲ All coils are 5/32 in. (3.96 mm) I. D. =18 wire, 12 turns per inch.

Fig. 1 – 16-watt broadband amplifier circuit using the 2N5919.

parasitics must be low enough to allow the series input inductance to be used by the first section of the input matching network. If the inductance is lower than the input network requires, additional inductance (a little extra lead) can be added; however, excess inductance cannot be removed.

The 2N5919 package is designed to provide reliable hermetic-package performance with parasitics low enough for suitable broadband performance. In comparison with earlier metal and plastic packages housing the same pellet, the input inductance has been reduced by a factor of four and the gain increased by 1.5 dB. The present package consists of alternate layers of ceramic and metal in a hermetic sandwich structure. Prior to assembly, all electrical parts are silverplated. The heat-sinking stud is brazed to the bottom-layer ceramic (beryllium oxide), which serves to isolate the pellet (collector) from the stud and yet provide good heat transfer. The emitter lead is then sandwiched by another ceramic piece that serves as an insulator and support for the base and collector leads. Electrical connection for the collector is made with a pin through a small hole in the top ceramic; this hole is sealed by the collector lead itself. A larger hole in both the top ceramic and the base lead serves for electrical and physical access to the transistor pellet. A solid silver cap covers the hole in the base lead and provides the final seal.

Gain and VSWR Control

Various approaches may be used to achieve low input VSWR and power-gain flatness in a broadband amplifier. Roll-off of transistor gain can be compensated for by designing a given amount of mismatch into the input network. However, this technique also increases the input VSWR at the low end of the band and results in stressing of the lower-level driving stages. An alternate method is to employ a gain-leveling loop around the entire amplifier chain to compensate for the low-end turnover, and to design each stage for minimum input VSWR. The gain-leveling loop may also be used for envelope correction when low-distortion amplitude modulation is required.

Lossy input-network design can also be used to provide gain and VSWR control. In this case, dissipative loss is introduced in the input network at lower frequencies of operation by selective RLC networks. This method should be reserved for the input circuits, and preferably for lower-level stages, to avoid excessive heat generation.

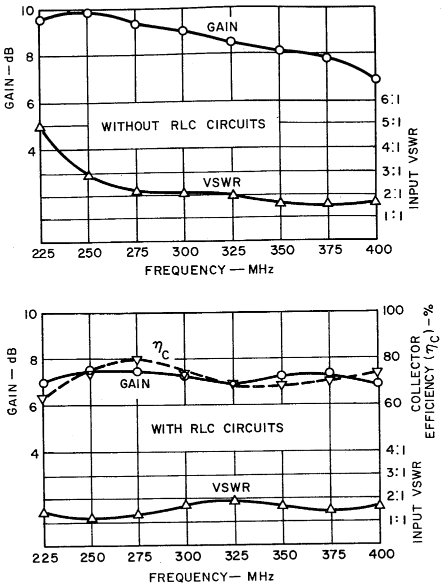


Fig. 2 – Typical performance of circuit of Fig. 1 from 225 to 400 MHz.

Hybrid Combiners

Four-port hybrid combiners have been the most successful approach to higher-power broadband structures. Combination of power at the 50-ohm level is more easily accomplished than direct paralleling of transistors and design of matching networks to accommodate a lower impedance. Hybrid combining also provides isolation between the paralleled amplifiers and avoids destruction of adjacent transistors in the event of a single transistor failure.

Two forms of hybrid junctions can be used to provide various phasing between the paralleled amplifiers. The "Magic T" combiner, when connected for zero-degree phasing, sums (or splits) the powers of the two side ports. The fourth port is terminated to dissipate any power unbalance. The Magic T can also be connected so that the two side ports are 180 degrees out of phase. A pair of amplifiers paralleled in this mode operates in push-pull, and all even harmonics are dissipated in the fourth port.

A quadrature combiner sums or splits signals 90 degrees out of phase. When used at the input and output of two parallel amplifiers, this hybrid junction delivers the input reflected power of each amplifier to the fourth port of the input combiner. The input to the amplifier pair then appears matched and presents no problem to the driving amplifier. Because of this characteristic, quadrature hybrid junctions are the most widely used combiners in the 225-to-400-MHz band.

Amplitude Modulation

A majority of amplifiers used in the 225-to-400-MHz band must handle amplitude modulation. Low-level modulation followed by linear amplification is generally preferred to high-level collector modulation because (1) collector modulation can result in circuit instability as a result of varying collector supply voltage, and (2) low-level modulation does not require a high-power modulator and can, therefore, result in a size and weight reduction. Linear amplification for AM signals is efficiently accomplished by class AB operation, in which the transistor emitter-base junction is slightly forward-biased during a zero-signal (quiescent) condition. In some cases, the forward bias is sufficient to cause a quiescent collector-current flow. The bias must be allowed to degenerate under peak drive conditions to allow efficient operation and to avoid device destruction. Bias degeneration can be provided by use of dc emitter or base resistance; it must be temperature-compensated to match the device transconductance changes with temperature.

CIRCUIT DESIGN

Output Circuit

The design of the output circuit of a broadband rf power transistor amplifier depends on two basic premises: (1) that the real part of the collector load is of constant (frequency-independent) magnitude, determined by the collector voltage and the output power, and (2) that the output capacitance is also of constant (frequency-independent) magnitude, determined by the collector-to-base capacitance C_{obo}. These premises have theoretical foundation and have been verified experimentally at least to the first-order approximation. The collector load resistance for a particular transistor and its large-signal parallel equivalent output capacitance are usually specified in published data. If these values are not available, the following well known approximations can be used for the output-network design:

$$R_L = \frac{[V_{CC} - V_{CE}\,(sat)]^2}{2P_o}$$

where R_L is the parallel equivalent of the real part of the collector load, V_{CC} is the supply voltage, V_{CE} (sat) is the high-frequency collector-to-emitter saturation voltage, and P_o is the expected output power. The value of V_{CE} (sat) usually is not known, but a value of 3 volts is a good approximation for the power level of the 2N5919. The large-signal parallel equivalent output capacitance C_o is given by $C_o = K\ C_{obo}$, where C_{obo} is the collector-to-base capacitance and the constant K is between 1 and 1.5 for class C operation.

The design of the output circuit then reduces to the matching of two resistances over a given frequency band: the real load presented to the collector, which is usually the smaller of the two resistances for an rf power-transistor amplifier, and the 50-ohm load. The choice of circuit configuration to be used for this purpose is somewhat restricted by the presence of a capacitance across the smaller resistance. Fig. 3 shows a circuit which transforms a smaller

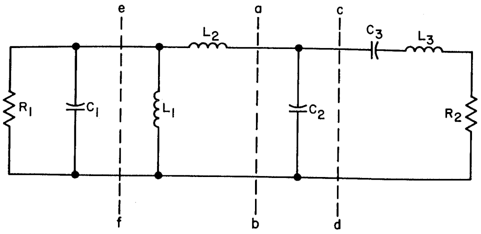


Fig. 3 – Broadband transformation circuit.

resistance R1 into a larger resistance R2 over almost an octave. Although the transformation is not complete with large bandwidths, the circuit can be designed to favor the higher frequencies of the band. The small degree of mismatch at lower frequencies can be compensated by the higher gain of the transistor.

It is often advantageous to consider a network problem qualitatively, even with an oversimplification at first, so that the physical phenomena can be perceived before they become obscured by the formulas, tabulations, and graphs which may be required in exact numerical analysis. This approach can also provide a starting point for an exact solution, indicate the type of circuit, and yield approximate magnitudes and the range of component values to be used. As an example, the following paragraphs discuss the design of the output circuit of the 16-watt broadband amplifier shown in Fig. 1.

Perhaps the simplest way to explain the operation of the output circuit is to consider an L-section such as that shown in Fig. 4. For transformation of R1 into R2, the magnitudes of the reactances X_L and X_C are determined solely by R1 and R2, regardless of frequency, as follows:

$$X_L = \left(R1\ R2 - R1^2\right)^{1/2}$$

$$X_C = R2\left(\frac{R1}{R2 - R1}\right)^{1/2}$$

If it is desired to transform R1 into R2 over a band of frequencies, therefore, X_L and X_C should be kept constant over the band. Although this conclusion is an apparent contradiction of the fact that $X_L = WL$ and $X_C = 1/WC$ are frequency-dependent parameters, the circuits of Figs. 5 and 6 provide the steps for an approximate solution to the problem.

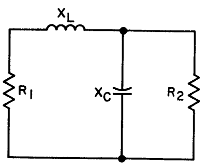


Fig. 4 – L-section.

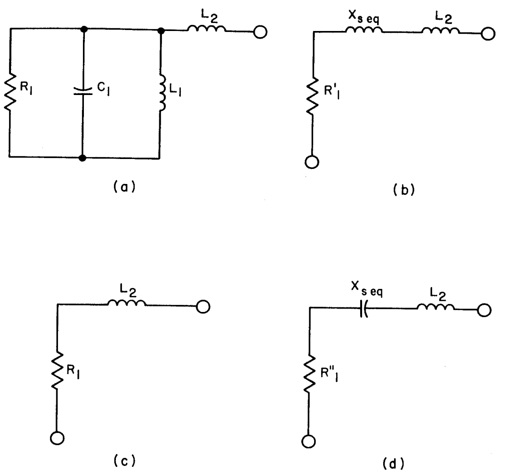


Fig. 5 – Frequency effect on the parallel-to-series transformation: (a) physical circuit, (b) series equivalent circuit below resonance, (c) series equivalent circuit at resonance, (d) series equivalent circuit above resonance.

In the circuit of Fig. 5 (a), if C1 and L1 are selected to resonate within the band, the effective value of the series inductance is increased below resonance, as shown in Fig. 5 (b); it remains equal to L2 at resonance, as shown in Fig. 5 (c), and is decreased above resonance, as shown in Fig. 5 (d). Because of the presence of C1 and L1, R1 is transformed into lower series equivalent values (R1′, R1″, R1‴, and so on) which are different at each frequency. At resonance, R1 retains its original value in the series equivalent circuit. Although the exact conditions of Fig. 4 are not met, the general trend in the variation of the equivalent series reactance is in a favorable direction, i.e., toward greater effective inductance at the lower end of the band and smaller effective inductance at the upper end of the band.

A shunt capacitance can also be made to vary by use of a series resonant circuit, as shown in Fig. 6. C3 and L3 in the circuit of Fig. 6 (a) are selected to resonate at the high end of the band and have no effect at that point, as shown in Fig. 6 (b). Below resonance, C3 and L3 provide a net parallel equivalent capacitance C_p, as shown in Fig. 6 (c), which adds to C2 of Fig. 3. As the frequency is decreased, C_p assumes greater effective values.

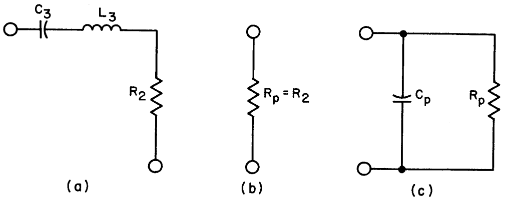


Fig. 6 – Frequency effect on the series-to-parallel transformation: (a) physical circuit, (b) parallel equivalent circuit at resonance, (c) parallel equivalent circuit below resonance.

The circuits of Figs. 5 and 6 can be combined to form the circuit shown in Fig. 3. The component values are selected in the following manner:

R1 is the real part of the collector load.

C1 is the shunt output capacitance of the transistor.

L1 is selected to resonate with C1 around mid-band.

L2 and C2 are selected to make the L-section transformation at the frequency where the best matching is desirable, i.e., 400 MHz.

L3 and C3 are selected to resonate at the highest frequency and to provide the maximum equivalent parallel capacitance at the lowest frequency.

When the component values have been selected, the L-section transformation can be computed at any frequency for the part of the circuit of Fig. 3 which is to the left of the a-b line. The resultant L-section is shown in Fig. 7. Table I lists the results of computer solution for component values at 25-MHz intervals. R_P is the value of parallel resistance into which the collector load is transformed by the resultant L-section for given values of C1, L1, and L2. The capacitance C_P is the value of capacitance necessary to make the transformation complete.

The extent to which the part of the circuit to the right of the c - d line in Fig. 3 is effective in providing a variable capacitor is shown in Table II. Values for equivalent parallel resistances and capacitance are computed at 25-MHz intervals. Comparison of the results in Tables I and II is helpful in determining the component values for the circuit of Fig. 3.

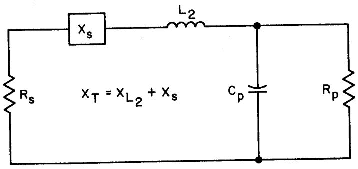


Fig. 7 – Resultant L-section for left part of Fig. 3.

TABLE I – Transformed Component Values for L-Section shown in Fig. 7. (For $R_1 = 20\Omega$, $C_1 = 16$ pF, $L_1 = 13$ nH, $L_2 = 11$ nH in Fig. 3)

F-MHz	Rs-Ω	Xs-Ω	XT-Ω	Q	Rp-Ω	Cp-pF
225	14.24	9.06	24.61	1.73	56.76	21.53
250	16.30	7.77	25.05	1.54	54.80	17.86
275	17.06	6.06	25.07	1.40	52.95	15.26
300	19.13	4.08	24.81	1.30	51.30	13.41
325	19.80	1.98	24.44	1.23	49.97	12.10
350	20.00	-0.08	24.11	1.21	49.06	11.17
375	19.80	-2.00	23.92	1.21	48.69	10.53
400	19.29	-3.71	23.94	1.24	49.00	10.08

TABLE II – Transformed Component Values for Circuit shown in Fig. 6(c) (For $R_2 = 50\Omega$, $L_3 = 13$ nH, $C_3 = 12$ pF in Fig. 3)

F-MHz	Rp-Ω	Cp-pF
225	82.91521	6.95
250	71.29604	5.85
275	63.27814	4.75
300	57.76598	3.62
325	54.06837	2.58
350	51.73186	1.63
375	50.44882	0.80
400	50.00470	0.08

Table III gives the transformed admittance/impedance values for the entire circuit of Fig. 3 to the right of the e - f line. These values represent the collector load applied to the transistor over the 225-to-400-MHz band and are given as parallel and series equivalent values.

Circuit Impedances

Knowledge of the input and output impedances of a transistor is an invaluable aid in designing rf amplifiers and is essential when broadband operation is required. However, transistors operating in class C or class B at high frequencies are not readily adaptable to equivalent-circuit analysis in which input, output, and transfer parameters are specified. Fortunately, this problem can be resolved by specifying the circuit impedances of the input and the output networks of an amplifier. These impedances are measured at the transistor terminals after the amplifier has been optimized, the transistor removed, and the circuit terminated with 50 ohms. Because transistor input impedance depends to some extent upon the output circuit, some variation of impedances obtained in this manner should be expected in different circuit configurations.

The Input Circuit

The input impedance of the 2N5919 transistor varies from 2.5 + j0 ohms at 225 MHz to 1.5 + 1.7 ohms at 400 MHz. In matching this varying impedance to a 50-ohm source, certain assumptions and approximations facilitate the problem by using already developed techniques. One such technique is the "Tables of Chebyshev Impedance-Transforming Networks of Low-Pass Filter Form" compiled by George L. Matthaei.[1] These tables permit selection of values for the filter elements to obtain a given performance. The tables assume constant impedances across the band. Although the input impedance of an rf power transistor varies with frequency (especially its reactance), the tables provide a good starting point. The following discussion is based on the Matthaei Tables.

For this discussion, R_i represents a real part of the transistor input impedance and R_s a resistive source impedance of 50 ohms. It is assumed that R_i has a value of 1.65 ohms and is constant across the band of interest. The value of 1.65 ohms is selected because it falls between 1.5

TABLE III – Transformed Admittance/Impedance Values for Circuit shown in Fig. 3. (For $R_2 = 50\Omega$, $C_3 = 12$ pF, $C_2 = 10$ pF, $L_1 = 13$ nH, $L_2 = 11$ nH, $L_3 = 13$ nH in Fig. 3.)

F-MHz	G-mhos	B-mhos	Rp-Ω	Xp-Ω	Rs-Ω	Xs-Ω
225	0.03	-0.02	35.62	40.48	20.08	17.66
250	0.04	-0.02	27.39	47.85	20.63	11.81
275	0.04	-0.02	22.61	47.54	18.44	8.77
300	0.05	-0.02	20.08	41.42	16.26	7.88
325	0.05	-0.03	19.00	34.94	14.66	7.97
350	0.05	-0.03	18.82	30.28	13.58	8.44
375	0.05	-0.04	19.17	27.29	12.84	9.02
400	0.05	-0.04	19.78	25.41	12.31	9.59

and 2.5 ohms, the real parts of the transistor input impedance at 400 MHz and 225 MHz, and yields an impedance transformation ratio of 30, for which the values for the filter elements can be taken directly from the tables without the need of interpolation.

The parameters to be used are the transformation ratio r; the fractional bandwidth w, and the number of filter elements n. The bandwidth w is defined as follows:

$$w = \frac{f_b - f_a}{f_m}$$

where f_a is the low-frequency cutoff, f_b is the high-frequency cutoff, and f_m is the midband frequency.

Table IV gives values for the filter elements as computed from the Matthaei Tables for values of w = 0.8, n = 8, and r = 30, where L's and C's are as defined in Fig. 8. The value of 0.8 was selected for the fractional bandwidth rather than a smaller value to permit computation of filter-element values for midband frequencies of both 310 MHz and 400 MHz. It is often useful to try other values for n.

Several observations can be made from Table IV. First, the value of L1 is so low that C1 must be placed as close as possible to the transistor base so that the inductive part of the transistor input impedance at 400 MHz is part of L1. Second, the values of C1 and C2 are so high that hardly any inductance can be tolerated in series with these capacitors. Third, L2 and L3 are very small and appear to be critical. Physical dimensions of commercially available components make it difficult to separate two capacitors with an inductor of 3.2 or 2.5 nanohenries. Therefore, some experimentation may be required before acceptable performance can be obtained. For example, a copper strip 0.14 inch wide and 0.4 inch long has an inductance of about 5 nanohenries. When lower values of inductance are needed, the length of the strip becomes about the same as the width. This fact, coupled with the physical size of the capacitors, makes experimentation unavoidable.

TABLE IV – Values for Filter Elements of Input Circuit as Computed from Matthaei Tables[1] (L's and C's are defined in Fig. 8)

f_m	310	400	MHz
L_1	1.07	0.4	nH
C_1	200	157	pF
L_2	3.2	2.48	nH
C_2	98.4	77	pF
L_3	8.1	6.27	nH
C_3	39	30	pF
L_4	16.6	12.8	nH
C_4	13	10.3	pF

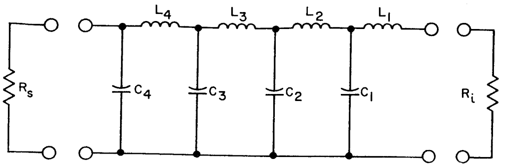


Fig. 8 – Definition of filter elements for values given in Table IV.

Plotting the values of Table IV on a Smith Chart shows the impedance variations along the filter from R_{in} to R_s. Fig. 9 shows such a plot for three frequencies: 225 MHz, 310 MHz, and 400 MHz. This chart can be used to study the effect of each element in the filter on the over-all matching. For example, reducing L4 improves matching at 400 MHz and 225 MHz, but has an opposite effect in matching at 310 MHz. The component values in the practical circuit shown in Fig. 1 were selected to be closer to those computed for 400 MHz in Table IV because it was desired to optimize the gain at that frequency.

Reducing VSWR

The amplifier designed by use of the procedure described has much higher gain at 225 MHz than at 400 MHz. For full utilization of the transistor gain capabilities at 400 MHz, the amplifier is adjusted for the best match at 400 MHz. Inevitably some VSWR appears at other frequencies. Ideally, the circuit is designed for the highest VSWR at the frequency where maximum gain occurs (i.e., 225 MHz). The forward power, as well as the reflected power, is then attenuated by introducing a resistive element in shunt with a node in the input network. The greater the ratio of the forward power to the reflected power, the smaller the VSWR. The attenuator is made frequency-selective, i.e., it is a series RLC circuit. These RLC networks can be staggered in frequency. By selection of R's and L's, the amount of attenuation and Q's can be controlled. However, a series LC circuit appears to be capacitive below resonance and may limit the maximum size of a capacitor. For this reason, shunt RLC circuits which resonate at frequencies higher than 225 MHz are placed at the second node where the shunt capacitor is larger.

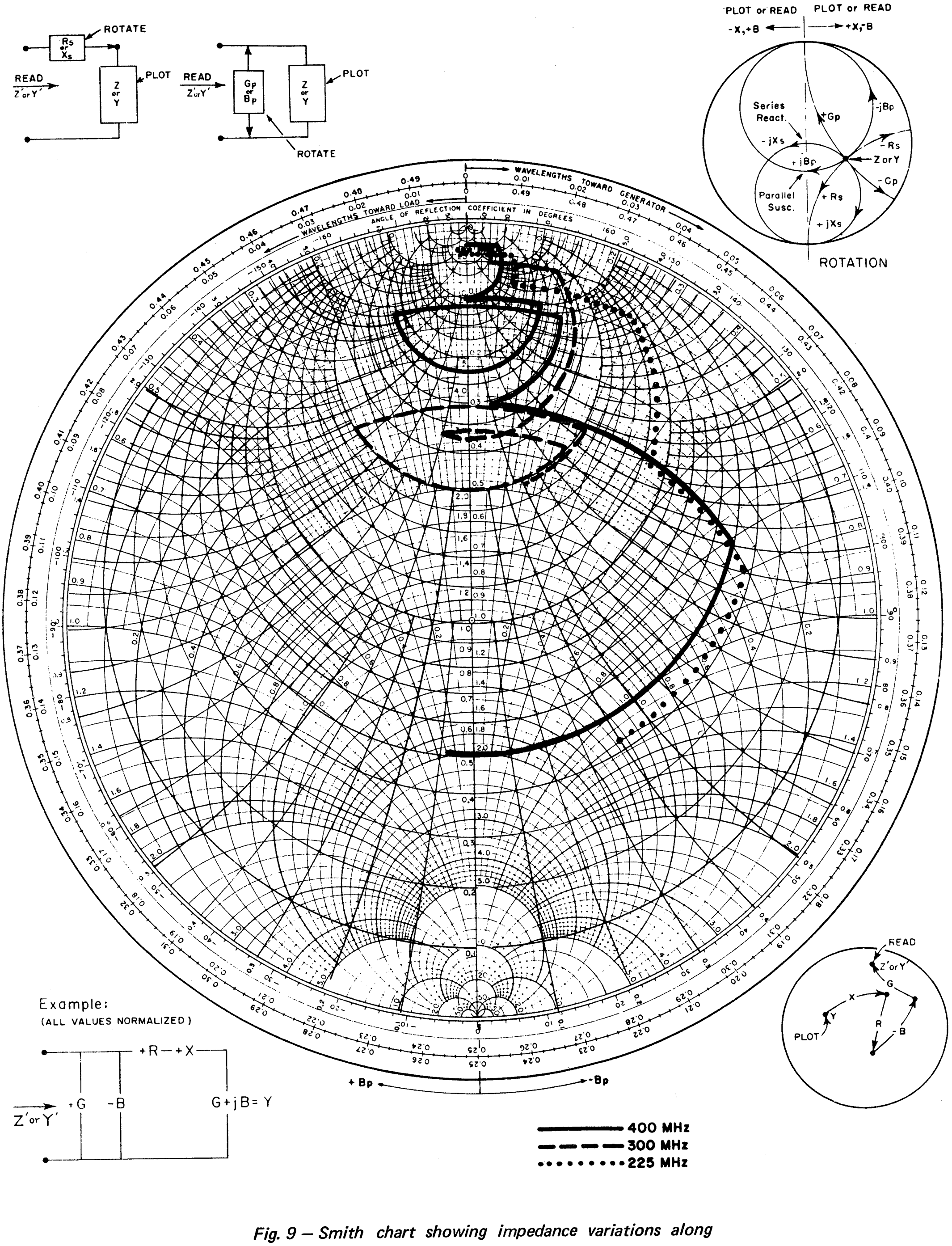


Fig. 9 – Smith chart showing impedance variations along filter from R_{in} to R_s

CIRCUIT PERFORMANCE

The basic amplifier developed by use of the technique described is a 16-watt, one-stage, 225-to-400-MHz broadband amplifier using the 2N5919 transistor. This circuit requires a driving power of 3 to 4 watts, which would normally be supplied by a cascaded chain of transistors. The performance of two amplifiers in cascade is also described to demonstrate this technique. When the required power exceeds the capability of the largest transistor in the chain, paralleling can be used to develop larger outputs.

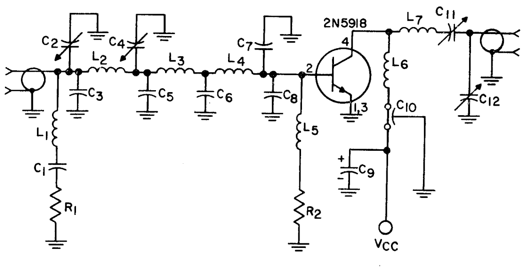
16-Watt Amplifier

Fig. 1 shows the schematic diagram of the 2N5919 amplifier, which can be considered the main "building block" of the chain. Typical amplifier performance is shown in Fig. 2. For a constant power output of 16 watts, response is fairly flat; the gain variation is within 1 dB across the band. Maximum input VSWR is 2:1. Such flatness of response and low input VSWR were obtained by designing for the best possible match across the band and then dissipating some of the power at the low end of the band through dissipative RLC networks. The effectiveness of this technique can be evaluated by comparison of the gain and input VSWR curves in Fig. 2 (a) with those in Fig. 2 (b). The flatter the response, the smaller the dynamic range required in the output leveling system. Low input VSWR is necessary for protection of the driving stage in a cascade connection. The collector efficiency is not constant, but has a minimum value of about 63 per cent. The second harmonic of the 225-MHz signal is 12 dB down and that of the 400-MHz signal is 30 dB down from the fundamental. Further reduction of the second harmonic of the 225-MHz signal is difficult to obtain because the amplifier bandwidth covers almost an octave.

Cascade and Parallel Connections

In a cascade arrangement, a lower-power transistor, the 2N5918, is used to drive the 2N5919. The output circuit for the driver is modified to accommodate a higher collector load. The input circuit remains essentially the same as for the 2N5919. The 2N5918 amplifier schematic is shown in Fig. 10, and the performance of the two amplifiers connected in cascade is shown in Fig. 11. When the two stages are connected together, the broadband characteristics of the amplifiers minimize the number of adjustments required.

A parallel combination of two 2N5919 transistors can be achieved by use of two quadrature couplers, as shown in Fig. 12 (a). Fig. 12 (b) shows gain and efficiency curves for such a combination for a constant power output of 25 watts. The input VSWR curve is omitted because it is very small and independent of the magnitude of the reflected power at each amplifier input as a result of the properties of the 90-degree combiners.



C_1 -3 pF, ATC-100*
C_2 -0.8-10 pF, JOHANSON 3957*
C_3 -5 pF SILVER MICA
C_4 -2-18 pF, AMPEREX HT10MA/218*
C_5 -24 pF, SILVER MICA
C_6 -51 pF, ATC-100*
C_7 -47 pF, ATC-100*
C_8 -68 pF, ATC-100*
C_9 -1 μF, ELECTROLYTIC
C_{10}-1000 pF, FEEDTHROUGH TYPE, ALLEN-BRADLEY FA5C*
C_{12}-1.5-20 pF, ARCO 402*
C_{11}-0.9-7 pF, ARCO 400*

L_1 -0.12 μH RFC, NYTRONICS, P. No. DD-0.18*
L_2 -No. 18 WIRE, 0.64 IN. LONG
L_3 -COPPER STRIP 5 MILS THICK, 150 MILS W., 670 MILS L.
L_4 -TRANSISTOR BASE LEAD, 0.16 IN. LONG
L_5 -0.1 μH RFC, NYTRONICS, P. No. DD-0.10*
L_6 -No. 18 WIRE, 1.08 IN. LONG
L_7 -2 TURNS, 5/32 IN. I.D. No. 18 WIRE, 12 TURNS PER IN.
R_1 -100Ω, 1/2 W, CARBON
R_2 -5.1Ω, 1/4 W, CARBON

*OR EQUIVALENT

Fig. 10 – Driver amplifier using the 2N5918.

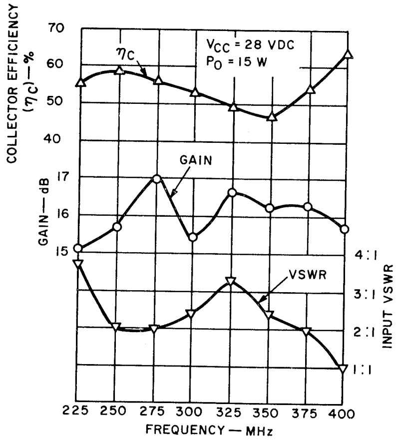
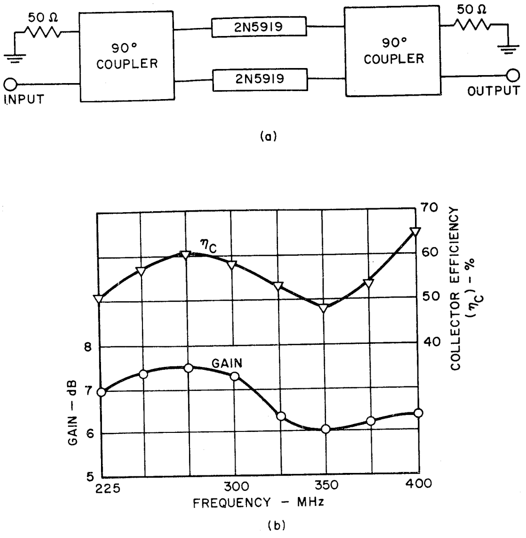


Fig. 11 – Performance characteristics of amplifiers shown in Figs. 1 and 10 connected in cascade.



(a)

(b)

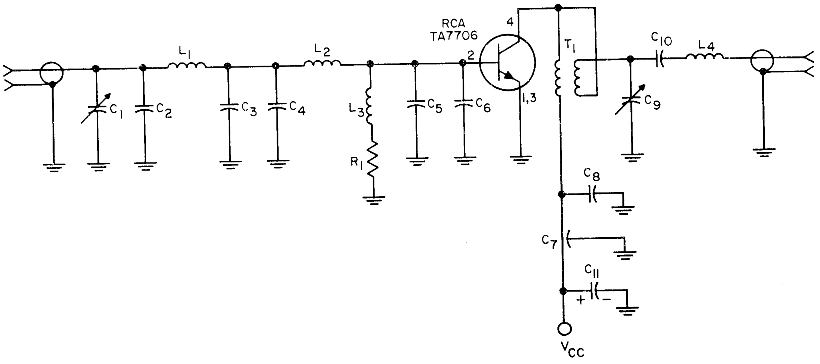
Fig. 12 – Performance of two 2N5919 transistors connected in parallel by use of quadrature couplers.

TA7706 25-Watt Amplifier

Fig. 13 shows the schematic diagram of a 25-watt, 225-to-400-MHz broadband amplifier using a developmental 30-watt, 400-MHz transistor, the RCA Dev. No. TA7706. Amplifier performance is shown in Fig. 14.

This amplifier includes some modifications in the matching circuits which represent a somewhat different design approach. For example, the input Chebyshev filter uses three sections rather than four. As a result, there is a poorer match at 225 MHz, with a resulting increase in the input VSWR and a consequent loss of gain. Some loss of amplifier gain can be tolerated at 225 MHz because of the transistor gain reserve at that frequency. The increased input VSWR is not a problem if the amplifier is used in conjunction with quadrature couplers because low input VSWR is then not nearly as important as in a direct cascade connection.

The collector load resistance for the TA7706 should be about 10 ohms, half of that for the 2N5919. Therefore it appears that a 4:1 transformer can be used in the output. The circuit shown in Fig. 13 uses a twisted wire pair connected as a 4:1 autotransformer. The length of the transformer is determined primarily by the amount of



C_1 – 2-18 pF AMPEREX

C_2,C_3 – 10 pF, SILVER MICA

C_4 – 33 pF ATC-100■

C_5 – 61.5 pF ATC-100■

C_6 – 66 pF ATC-100■

C_7 – 1000 pF FEED THROUGH ALLEN-BRADLEY FA5C■

C_8 – 1000 pF ATC-100■

C_9 – 1-20 pF JOHANSON 4882■

C_{10} – 12 pF, SILVER MICA

C_{11} – 1 μF ELECTROLYTIC

R_1 – 5.1 Ω 1/2 WATT

T_1 – TWISTED PAIR OF No. 20 ENAMELED WIRE, 8 TWISTS, 15 TWISTS PER INCH, CROSS CONNECTED AND FORMED IN A LOOP

L_1 – 1 TURN No. 20 WIRE, WOUND IN 9/64 IN. ID.

L_2 – INDUCTANCE OF BASE LEAD 5/16 IN. LONG.

L_3 – 0.12 μH RFC

L_4 – 2 TURNS No. 20 WIRE, WOUND IN 9/64 IN. DIA.

■ – OR EQUIVALENT
ALLEN-BRADLEY Co., MILWAUKEE, WIS.
AMERICAN TECHNICAL CERAMICS, HUNTINGTON STATION, N.Y. 11746
JOHANSON MFG. CORP., BOONTON, N.J. 07005

Fig. 13 – TA7706 broadband amplifier circuit.

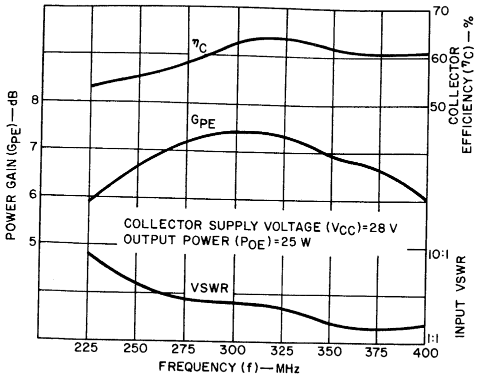


Fig. 14 – Performance of TA7706 in the circuit of Fig. 13.

inductance required to tune out the output capacitance at 400 MHz. Collector efficiency is somewhat poorer at the 225-MHz end of the band as a result of incomplete tuning out of the output capacitance at the lower frequencies. Although twisted-wire transformers are rather difficult to analyze, experiments have shown that they have large bandwidths and can be successfully used in the output of high-power broadband amplifiers.

References

1. G.L. Matthaei, "Tables of Chebyshev Impedance – Transforming Neworks of Low-Pass Filter Form," *Proceedings of the IEEE*, August 1964.

Solid State
Division

RF Power Transistors
Application Note
AN-4591

Use of the RCA-2N6093 HF Power Transistor in Linear Applications

by Z.F. Chang and J.F. Locke

The rapidly growing technology in semiconductor devices has resulted in the development of power transistors designed especially for use in hf single-sideband (SSB) equipment. Unlike most commercially available rf power transistors, which are designed primarily for class C operation, the RCA-2N6093 provides a high degree of linearity for class AB operation, emitter ballast resistance for stabilization and low distortion, and an internally mounted temperature-sensing diode for bias compensation.

This Note discusses the advantages of single-sideband operation, some basic transistor characteristics and trade-offs involved in the choice of a transistor for linear applications, broadband matching networks, and the basic performance of the RCA-2N6093 in narrowband and broadband applications. The design features that make this device suitable for linear amplification are described.

SINGLE SIDEBAND

Single-sideband communication systems have many advantages over AM and FM systems.[1] In applications where reliability of transmission and power conservation are of prime concern, SSB transmitters are usually employed. Advantages of SSB include reduced power consumption for effective transmission and reduced channel width, which permits more transmitters to be operated within a given frequency range. Any discussion of SSB operation includes the terms "intermodulation distortion" and "peak envelope power"; these terms are defined below.

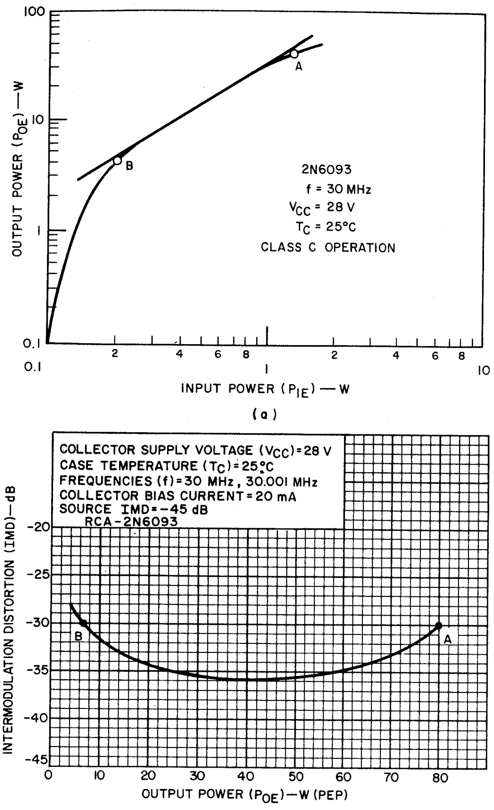
Intermodulation Distortion

For an amplifier to be linear, the output power must be directly proportional to the input power at all signal amplitudes. Alternatively, for a fixed load the amplifier must maintain a constant gain within its useful power range. An approximate check on the linearity of an rf power amplifier is a curve of power output as a function of power input. The curve in Fig. 1(a) shows two regions that depart from linear operation: region A, high-power operation with current saturation; and region B, low-power operation with insufficient forward bias.

The P_O-P_{IN} graph requires measurement at several power levels, which is cumbersome and time-consuming, and yields results that are only approximate. For final equipment testing, the most widely accepted test method requires the use of a two-tone signal. The two tones have equal amplitude and are separated by an audio frequency. The output waveforms can be displayed on a spectrum analyzer to show the two tones and the intermodulation-distortion (IMD) product. The ratio of the amplitude of the strongest distortion product to the amplitude of one of the test signals is called the IMD ratio. A distortion specification of -30 dB, for example, means that the strongest distortion product will be less than 0.1 per cent of a signal output level for any two-tone signal at power levels up to the peak envelope power rating of the amplifier. Fig. 1(b) is a typical curve of IMD as a function of output power; the increased distortion in regions A and B are readily noted.

The important intermodulation-distortion products are those close to the desired output frequencies, because they fall within the passband and cannot be filtered out by normal tuned circuits. If f_1 and f_2 are the two desired output signals, third-order IMD products take the form $(2f_1 - f_2)$ and $(2f_2 - f_1)$. The other third-order terms, $(2f_1 + f_2)$ and $(2f_2 + f_1)$, correspond to frequencies near the third-harmonic output of the amplifier and are greatly attenuated by tuned circuits. It is important to note that only odd-order distortion products appear near the fundamental frequencies. The frequency spectrum shown in Fig. 2 illustrates the frequency relationship of some distortion products to the test signal.

Even-order distortion products do not occur near the desired frequencies f_1 and f_2; all are either in the difference-frequency region or in the harmonic regions of the original frequencies. Therefore, filters following the nonlinear elements can effectively remove all products generated by the even-order components of curvature, and the second-order component that produces second harmonics will produce no distortion in an SSB linear amplifier.



(a)

(b)

Fig. 1— Two ways to evaluate power amplifier linearity: (a) output power as a function of input power; (b) intermodulation distortion as a function of output power.

Peak-Envelope-Power Rating

The maximum power that a device can deliver is usually limited by its current and voltage ratings. When a cw signal is used, the output is a constant, undistorted, sinusoidal waveform that is not suitable for linearity testing. If a two-tone signal is used in which the amplitude of each tone equals one half of the cw amplitude, and if the two tones are separated by a small frequency, the two tones add or subtract depending on the phase relationship. When in phase, the two tones add to yield an amplitude equal to the cw amplitude. When out of phase, the two tones subtract; the resultant amplitude becomes zero. Essentially the resultant is an undulating wave that varies from zero to maximum amplitude at the rate of the difference frequency. Because each tone of the two-tone signal has an amplitude equal to one half of the cw amplitude, the power contained in one tone is only one quarter of the power in the cw signal. The total average power in a two-tone signal, therefore, is one half of the power in the cw wave. Because peak power occurs when the two tones are in phase, the peak-envelope-power (PEP) rating of an amplifier is equal to twice the average reading obtained from a power meter such as a calorimeter. For a signal of three equal-amplitude tones, the PEP-to-average-power ratio is 3 to 1.

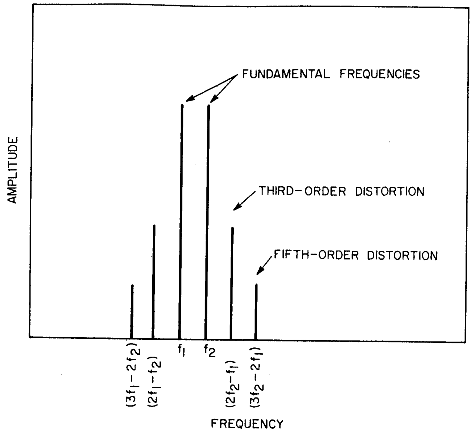


Fig. 2— Frequency spectrum of intermodulation-distortion products.

TRANSISTOR OPERATION

In a class B amplifier the transistor conducts half of the time and the average collector current is directly proportional to the amplitude of the signal voltage. This fact implies that the circuit is linear for the fundamental components. A class A amplifier conducts all of the time. It provides the most linear amplification and is characterized by high gain, low distortion, and low efficiency. The low-level stages of a power-amplifier chain commonly operate in class A. Because of its high quiescent collector current, class A operation is seldom used for a power amplifier, particularly in portable equipment where high efficiency and light weight are the design goals. Therefore, if the primary design goal is to achieve low IMD with the highest efficiency possible, the transistor should be operated at a power level low enough to avoid the nonlinear saturation region, and a bias level beyond the nonlinear base-to-emitter "turn-on" region. Fig. 3 shows the reduction in IMD with increase in bias. When the 2N6093 is operated at a PEP output level of 50 watts, it can have an IMD of less than -40 dB.

For bias currents above 60 milliamperes, the reduction in IMD becomes less significant. To avoid catastrophic transistor failures caused by forward-bias second breakdown, the bias current should not be set much beyond the level required to meet the power and distortion design objectives. Furthermore, once the bias current has been established the designer must make sure that the collector quiescent point is within the safe dc operating curve of the transistor.

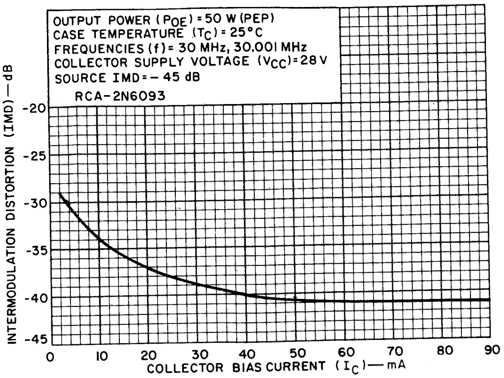


Fig. 3— Typical intermodulation-distortion as a function of collector bias current for the RCA-2N6093.

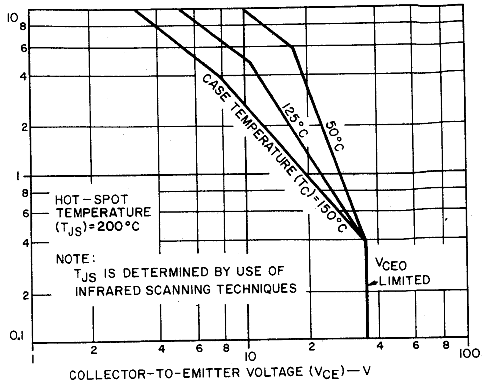


Fig. 4— Safe area for dc operation of the RCA-2N6093.

TRANSISTOR SELECTION

To date, most high-frequency power transistors have been designed for class C operation. Forward-biasing into class B or class AB places such devices in a region where second breakdown may occur. The susceptibility of a transistor to second breakdown is frequency-dependent; experimental results indicate that the higher the frequency response of a transistor, the more severe its second-breakdown limitations. Physically, second breakdown is a local thermal-runaway effect induced by severe current concentrations. Improving the safe dc operating region of a transistor, therefore, must be the first step in providing a rugged device suitable for SSB application.

The RCA-2N6093 is a power transistor designed specially for use as a linear amplifier. This transistor can be forward-biased into class AB and has a good high-frequency response. Improvement of second breakdown is accomplished by subdividing the emitter and resistively ballasting the individual sites. The transistor has an overlay[2,3] structure, with the emitter sites interconnected by metal fingers in parallel. Current-limiting resistors are placed in series with each emitter site between the metallization and emitter-to-base junction.

The maximum operating area of a forward-biased 2N6093 is illustrated in Fig. 4 for various case temperatures. If the device is operated within the curves of Fig. 4 under dc conditions, second breakdown will not occur and the junction temperature will not exceed 200°C at any point. The hot-spot temperature for these curves were determined by infrared scanning.

Emitter Ballast Resistance

To show the effect of emitter ballast resistance on second breakdown, three groups of high-V_{CEO}(sus) overlay transistors were made with different ballast-resistor values. The collector-to-emitter voltage needed to cause each transistor to go into second breakdown at a collector current of one ampere, measured on a curve tracer with a single base step, is shown in Table I. These data indicate that the addition of resistors improves device second-breakdown capability. A relatively large value of ballast resistance prevents second breakdown, improves thermal stability, and provides linear transfer characteristics. However, excessive ballasting can seriously degrade the rf performance of the transistor. The ballast resistors are in series with the load; therefore, in a high-frequency power amplifier with low supply voltage, the emitter resistance can be an appreciable portion of the reflected load at the collector, and thereby limit the output power. The power loss in the emitter resistance should be taken into account when the resistance value is decided; a compromise must be made empirically to obtain sufficient second-breakdown protection without seriously affecting rf performance. The ballast resistance can be measured by use of a Tektronix 576 curve tracer equipped with a Kelvin probe.

Because the value of V_{BE} at the transistor base-to-emitter terminals includes the voltage drop across the ballast resistance, the transistor transconductance is affected by the value of ballast resistance. The curves of I_C as a function of V_{BE} in Fig. 5 for three different values of resistance show that ballast resistance improves the linearity of the device; the resistance also reduces the input Q.

The adverse effects of high ballast resistance are reduced rf output power and increased saturation voltage. Viewed

Table I - Effect of Emitter Resistance on Second-Breakdown Voltage

Total Emitter Resistance (ohms)	Second-Breakdown Voltage (volts)
0.005	50
0.013	65
0.08	108

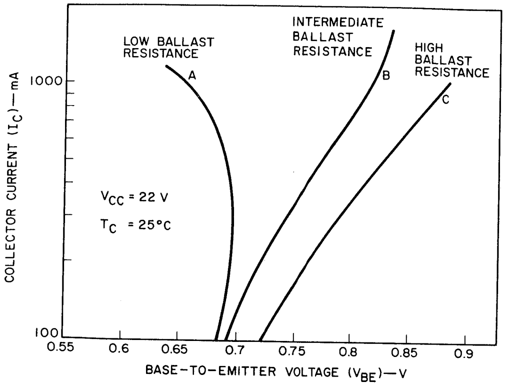


Fig. 5— Current-voltage characteristics at various ballast-resistance levels.

externally, the total saturation voltage includes the voltage drop across the ballast resistance. This additional voltage makes the "soft" output characteristics of a transistor at high current even softer. As a result, it limits the available linear region through which the signal can swing.

An attempt to make a transistor more linear by increasing the forward bias causes the collector efficiency to decrease and results in increased transistor dissipation. Dissipation produces heat, which causes V_{BE} to decrease at the rate of about 0.002 volt per ^oC, and can cause thermal runaway unless temperature compensation is used to maintain collector current relatively constant over a wide temperature range.

As discussed above, some transistors fail when the bias current is increased for class AB operation. Investigations of the failures revealed that these devices exhibited a maximum V_{BE} and then went into a negative-resistance region as shown in Fig. 6. The onset of negative resistance, called bend-back, results in a runaway condition that ultimately destroys the transistor.

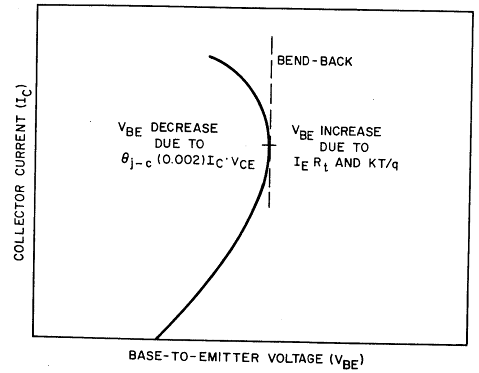


Fig. 6— The bend-back phenomenon.

In most linear applications where the operating point of the device is biased with a voltage source, this I_C-V_{BE} curve becomes an accurate means of predicting device stability. It is difficult to maintain a stable quiescent point of a transistor with low bend-back. Laboratory results indicate that a minimum bend-back current of 1 ampere at 22 volts is needed for a transistor to operate safely at 40-per-cent efficiency with approximately 50 watts of dissipation.

Bend-back occurs when the increase of V_{BE} with collector current is just balanced by the decrease in V_{BE} caused by junction-temperature rise. Therefore at bend back

$$KT/_q + I_E R_t = \theta_{j\text{-}c}(0.002V/_{^oC})\, I_C \;\; V_{CE} \qquad (1)$$

where

$KT/q = 0.032$ volt @ 100^oC

R_t = total ballast resistance

$\theta_{j\text{-}c}$ = junction-to-case thermal resistance

$0.002V/_{^oC}$ = base-to-emitter junction temperature coefficient

I_E = emitter current

I_C = collector current

V_{CE} = collector-to-emitter voltage

If $I_C = I_E$, Eq (1) can be solved to find I_E at bend-back:

$$I_E = \frac{-KT/_q}{R_t - \theta_{j\text{-}c}\,(0.002V/^oC)V_{CE}} \qquad (2)$$

Thermal runaway can be attributed to the fact that the base-to-emitter junction of a transistor has a negative temperature coefficient. For example, the RCA-2N6093 transistor is forward-biased by 0.65 volts to produce a quiescent collector current of about 20 milliamperes at V_{CC} = 28 volts. This operating point is shown as point A in Fig. 7. When rf drive is applied, the collector current increases to 3 amperes. If the efficiency is 40 per cent, the power dissipated in the transistor is given by

$$P_{diss.} = 28 \times 3\,(1 - 0.40) = 50 \text{ watts.}$$

If the ambient temperature is 25^oC, the case temperature is 50^oC, and the thermal resistance is 1.5 ^oC per watt, the junction temperature is given by

$$T_j = T_{case} + P_{diss.}\,\theta_{j\text{-}c}$$

$$= 50 + 50 \times 1.5 = 125^oC.$$

The junction temperature is thus 100^oC above ambient temperature. At this junction temperature the V_{BE} required to maintain a collector current of 20 milliamperes is only

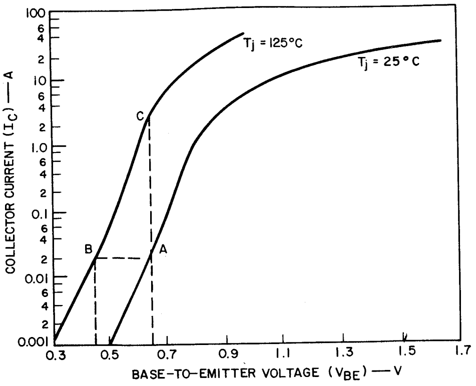


Fig. 7– Collector current as a function of base-to-emitter voltage in the RCA-2N6093 for two values of junction temperature.

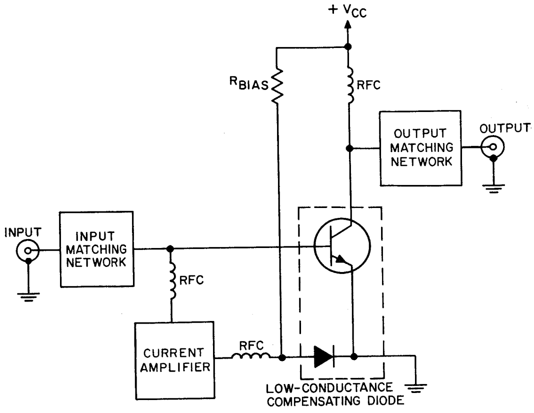


Fig. 8– Block diagram of 30-MHz amplifier with temperature compensation.

0.65 − 100 x 0.002 = 0.45 volt, as shown at point B. If the bias voltage is fixed at 0.65 volt, however, and the drive is removed instantaneously, the quiescent current will no longer be 20 milliamperes. Instead, the collector current will move to point C, where the operating point falls outside of the safe area of Fig. 4. Therefore catastrophic failure will occur as a result of thermal runaway.

Compensating Diode

To provide a bias voltage that varies with temperature in the same manner as V_{BE} of the transistor, the 2N6093 incorporates a compensating diode as shown in Fig. 8. To insure fast thermal response time, this diode is mounted on the same beryllia disc as the transistor chip. The diode, forward-biased through R_{Bias}, serves as a temperature-sensing element. The voltage developed across the diode is amplified to provide a "stiff" bias-voltage source.

A bias-compensation circuit is included in the 30-MHz, 75-watt (PEP) amplifier shown in Fig. 9. The current amplifier uses Q1 and Q2 in a differential-amplifier arrangement so that the output voltage is independent of ambient-temperature variations. Q3 and Q4 provide the necessary current amplification. The bias current in rf transistor Q5 can be adjusted by varying R1.

As shown in Fig. 10, with no rf signal the forward-biased transistor is statically stable up to a case temperature of 160°C. The dashed line in Fig. 10 shows that without temperature compensation the transistor tends to thermal runaway around 80°C. To further show the effectiveness of compensation, the third-order distortion and output power are plotted as a function of case temperature in Fig. 11. The decrease in output power at high temperatures is caused by a drop in high-frequency gain and an increase in rf saturation voltage. The decrease in h_{fe} produces a soft saturation knee that causes the degradation of distortion.

BROADBAND CIRCUIT DESIGN

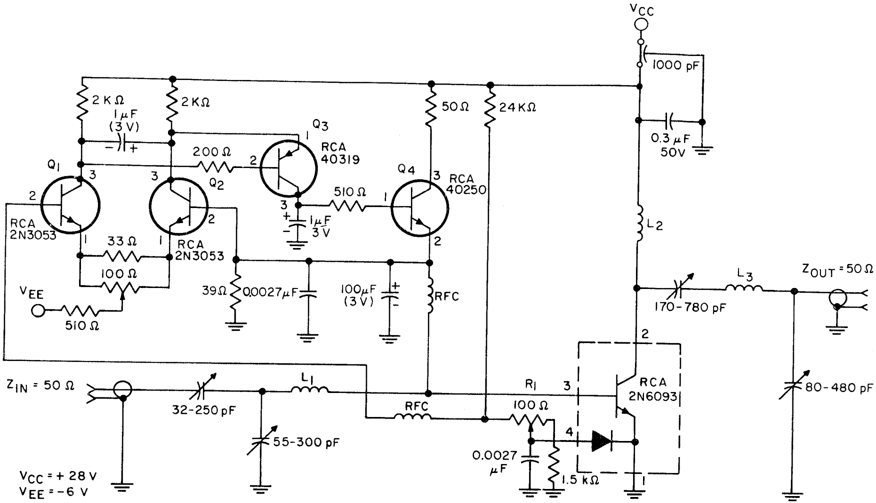
Transistor Parameters

Before any circuit can be designed, the transistor input impedance and the collector load impedance over the required frequency band and at the desired levels of output power, IMD, case temperature, and collector supply voltage must be known or measured. The circuit designer must also know the transistor power gain over the same band. Curves of these characteristics for the RCA-2N6093 are shown in Figs. 12-14. A broadband transistor should be selected for minimal impedance variation and low input Q across the frequency band. A transistor with f_t well above the highest operating frequency, if available, can provide constant gain under broadband operation; such a transistor eliminates the need for additional gain-leveling circuitry. Because circuit optimization becomes more difficult with high-power broadband operation, the need for thermal stability becomes more acute and the necessity of diode compensation at high output powers becomes greater. To provide this stability, the transistor should have an internally mounted compensating diode.

The advantages which especially suit the 2N6093 for broadbanding are its low input Q and its internally mounted compensating diode. Its main disadvantage is a 15-dB gain decrease from 2-30 MHz due to operation on a power-gain slope of 6 dB per octave.

Transmission Line Transformers[4,5,6]

After selection of the transistor and measurement of its broadband parameters, the next step is to select the circuit approach. The most practical broadbanding method to provide an effective impedance transformation over four octaves (2-30 MHz) is a transmission-line-transformer/ferrite-core combination. The major disadvantage of a transmission line transformer is the limited number of impedance



L1 3T No. 14 WIRE 1/4 I.D. 1/2 LONG
L2 3T No 10 WIRE 1/2 I.D. 3/8 LONG
L3 3 1/2T No. 10 WIRE 5/8 I.D. 1/2 LONG
RFC: FERROXCUBE No. VK200-01-3B OR EQUIVALENT

ALL RESISTORS 1/2 WATT

Fig. 9— Use of the RCA-2N6093 in a 30-MHz, 75-watt (PEP) amplifier with temperature compensation.

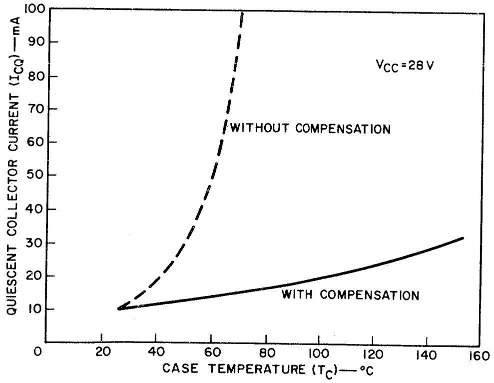


Fig. 10— Quiescent collector current in the RCA-2N6093 as a function of case temperature with and without temperature compensation.

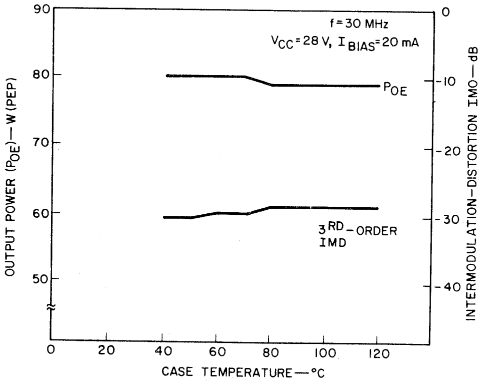


Fig. 11— Output power and intermodulation-distortion as a function of case temperature for the RCA-2N6093 amplifier shown in Fig. 9.

transformations available: 1:1, 4:1, 9:1, etc. The two fundamental configurations are the 1:1 reversing transformer and the 4:1 impedance transformer shown in Fig. 15.

Ferrite Cores

At low frequencies, a high primary reactance can be obtained with a few turns of transmission line on a high-permeability ferrite core. At high frequencies where length becomes critical the permeability of the core decreases, thereby maintaining approximately the same levels of reactance with a short length of transmission line. Ferramic-Q core material[7] is available in three high-frequency grades; a tabulation of their useful properties is given in Table II. Because the transformer performance is less

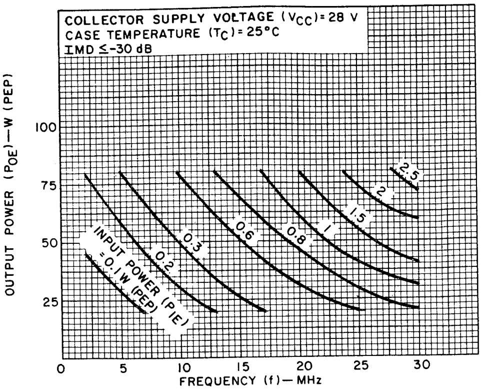


Fig. 12— Typical output power as a function of frequency for the RCA-2N6093.

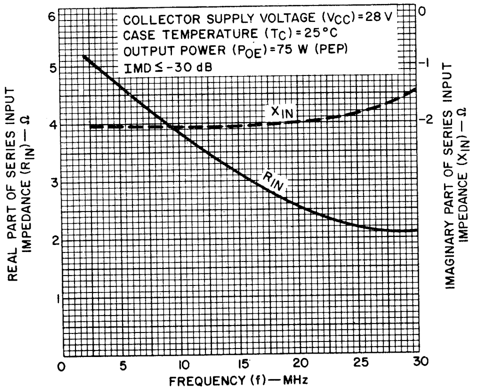


Fig. 13— Typical large-signal series input impedance (R_{in} + jX_{in}) as a function of frequency for the RCA-2N6093.

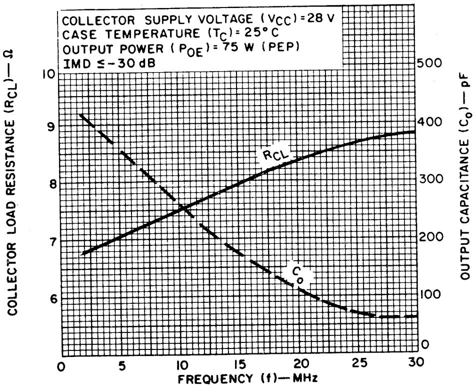


Fig. 14— Typical large-signal parallel collector load resistance and parallel output capacitance as a function of frequency for the RCA-2N6093.

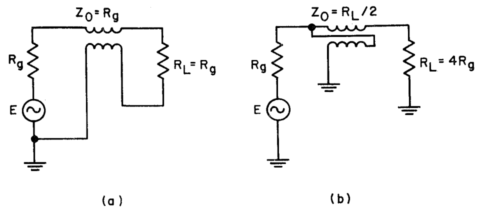


Fig. 15— Transmission-line transformers: (a) 1:1 reversing/isolating transformer; (b) 4:1 impedance transformer.

Table II - Permeability and Frequency Dependence of Ferramic-Q Materials

Material	Permeability	Approximate Frequency at which core losses increase by a factor of 10 (MHz)
Q-1	125	10
Q-2	40	90
Q-3	16	225

dependent on core material at the higher-frequency end of its useful range, the poor intrinsic Q of Q-1 material above 20 MHz does not degrade the transformer operation at 30 MHz. Q-2 material, having lower permeability, requires more turns for operation at the lower frequencies.

Hybrid Combiner/Dividers

Hybrid combiner/dividers can be made by use of combinations of the 1:1 and 4:1 transformers on ferrite cores to provide high impedance transformation ratios[6]. As an example, Fig. 16 shows a 180°-phase hybrid divider that matches a 50-ohm source to a 3.12-ohm push-pull configuration. Two 1:1 transformers are used to make the 4:1 transformation, rather than one 4:1 transformer, to provide the balanced output needed for a push-pull configuration. An equivalent transformation also can be made with one 1:1 transformer and one 4:1 transformer, as shown in Fig. 17.

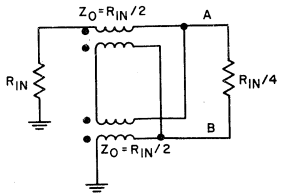


Fig. 16— A 4:1 broadband transformation network that uses two 1:1 transformers to provide a balanced output.

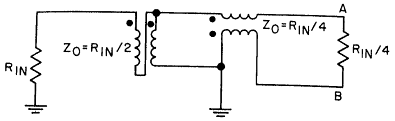


Fig. 17– A 4:1 broadband transformation network that uses a 1:1 transformer and a 4:1 transformer to provide a balanced output.

Fig. 18 shows a 16:1 broadband transformation network for a push-pull configuration. The circuitry to the left of V2 is the same as in Fig. 16; to the right of V2, an extra transformer and dissipating resistor have been added. Points A and B are transistor base inputs, R2 represents the resistive input to a conducting transistor, and R3 is a resistor much larger than R2 that is connected in shunt with each base-to-emitter junction. (Thus A-to-ground represents a conducting transistor, while B-to-ground represents a cut-off transistor, in Fig. 18.) R1 dissipates any imbalances in power or phasing.

To find the input resistance to the network of Fig. 18, the network equations are written as follows:

$I_1 = I_2 = I_3 = I_4$

$I_5 = I_6 = 2I_1$

$I_7 = I_5 - I_8$

$I_8 = I_9$

$I_{11} = I_9 + I_6$

$I_{10} = I_8 + I_9$

$V_2 - V_4 = V_4 - V_3$

$V_1 = 2(V_2 - V_3)$

$V_4 = R_1 I_{10}$

$V_2 = I_7 R_2$

$V_3 = R_3 I_{11}$

These equations yield V_1/I_1 as a function of R_1, R_2, and R_3:

$$R_{IN} = \frac{V_1}{I_1} = 16\left(\frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{4R_1 + R_2 + R_3}\right)$$

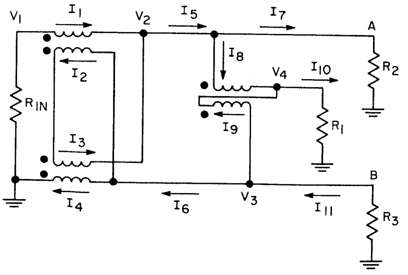


Fig. 18– A 16:1 broadband transformation network with balanced output.

If $R_1 = 1/2\ R_2$ and $R_3 = 5R_2$, $R_{IN} = 16\ R_2$. Thus the 3.12-ohm transistor resistance is transformed to 50 ohms.

Because of symmetrical loading, the same hybrid configuration provides an 8:1 impedance transformation when used as a 180°-phase power combiner at the transistor collectors. This combiner operation of the network is shown in Fig. 19; the output resistance is given by

$$R_{OUT} = \frac{V_{OUT}}{I_{OUT}} = 16\left(\frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{4R_1 + R_2 + R_3}\right)$$

If the collector load-line resistance is R_L, let $R_1 = \frac{1}{2}R_L$ and $R_2 = R_3 = R_L$. Then

$$R_{OUT} = 8R_L$$

Thus each collector is provided with a 6.25-ohm load-line for R_{OUT} = 50 ohms. The inductance of the transmission line and its connectors is utilized to tune out both input and output negative reactances.

2-to30-MHz Broadband Circuit Design

The push-pull configuration is used not only because the 180°-phase hybrids provide a high transformation ratio, but also because this configuration suppresses second harmonics and thus minimizes filter requirements at the output. Knowing the output power level and the input and output impedance values at that power level, the circuit designer can use a combination of 180°-phase hybrids, hybrid resistance values, and additional transmission-line transformers to complete the proper transformation at the input and output. After the transformation closest to optimum match at the highest operating frequency has been selected, individual transformers are wound and measured over the desired frequency band. The HP 4815A vector impedance meter, RX Boonton Meter, or a similar instrument can be used for these measurements.

A 150-watt (PEP) linear amplifier for the 2-to-30-MHz frequency range has been built with a pair of RCA-2N6093 transistors in push-pull, 180°-phase hybrid power combiner/dividers, and single-ended 4:1 transformers. The block diagram of this amplifier is shown in Fig. 20, and the circuit diagram and parts list are given in Fig. 21.

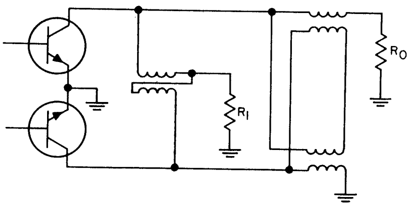


Fig. 19– The network of Fig. 18 used as a 180°-phase power combiner.

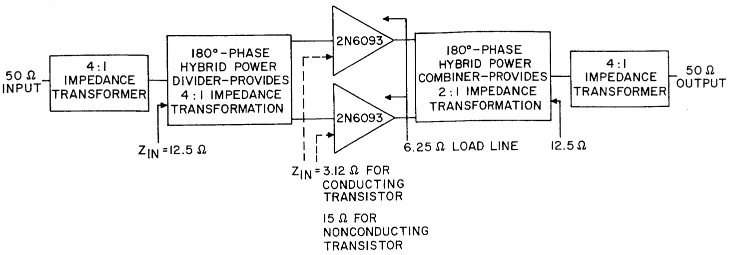
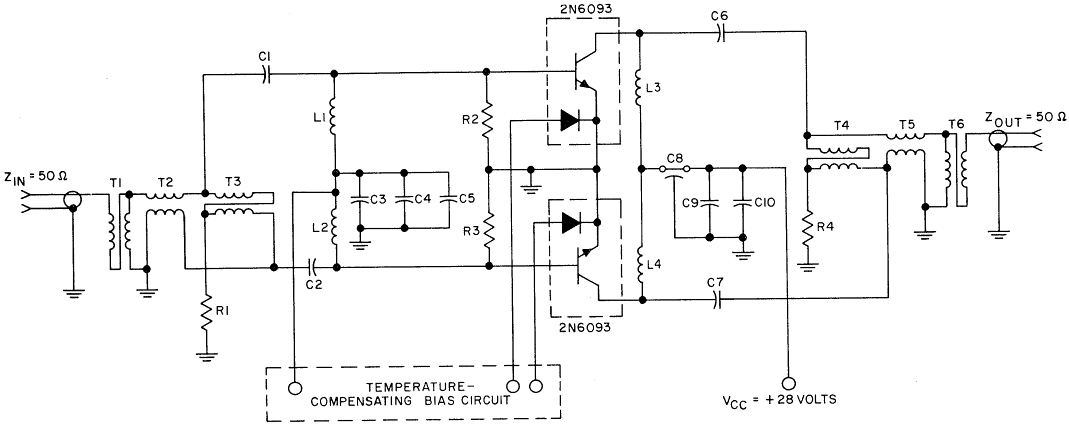


Fig. 20– Block diagram of push-pull linear amplifier that provides 150 watts PEP at 2 to 30 MHz.



C1 = C2 = 0.15 μF ELECTROLYTIC
C3 = C9 = 0.04 μF CERAMIC
C4 = 0.0027 μF CERAMIC
C5 = 100 μF ELECTROLYTIC
C6 = C7 = 0.1 μF ELECTROLYTIC
C8 = 1000 pF FEEDTHROUGH ALLEN BRADLEY FA5C
C10 = 5 μF ELECTROLYTIC

R1 = 2.7 Ω, 0.5 WATT PARALLELED WITH 3.3 Ω, 0.5 WATT
R2 = R3 = 30 Ω, 0.5 WATT PARALLELED WITH 30 Ω, 0.5 WATT
R4 = 2.7 Ω, 1 WATT

L1 = L2 = 0.75 μH RFC
L3 = L4 = 7 TURNS NO. 20 WIRE ON Q1 CF 111 INDIANA GENERAL FERRITE CORE.

T1 = T2 = T6 = NO. 26 WIRE. TWO TWISTED PAIRS (9 TURNS/IN.) PARALLELED (8 TURNS/IN.) 8" TOTAL LENGTH. FIVE TURNS ON Q1 CF 111 INDIANA GENERAL CORP. FERRITE CORE.

T3 = T4 = T5 = TWO COPPER STRIPS (WIDTH = 85 MILS, THICKNESS = 8 MILS PARALLELED, 3.5" TOTAL LENGTH). FIVE TURNS ON Q1 CF 106 INDIANA GENERAL CORP. FERRITE CORE.

Fig. 21– Circuit diagram and parts list for 150-watt, 2-to-30-MHz push-pull linear amplifier.

Typical performance of this amplifier across the hf band is shown in Fig. 22. The power gain exhibits the same 6-dB-per-octave slope at mid-band and low-frequency roll-off noted in the narrowband measurements (Fig. 12). Total gain variation is approximately 15 dB.

The intermodulation distortion exceeds -30 dB at frequencies below 6 MHz. The circuit is capable of -35 dB IMD over a good portion of the band if operated at the reduced output power of 100 to 110 watts PEP, as would be expected from the curve of Fig. 3. If the same circuit components and transformation networks are utilized, the efficiency is somewhat reduced at the reduced power level because the collector circuit is optimized for higher power.

The efficiency of the amplifier is 40 to 50 per cent across the band. When operated at 150 watts PEP with V_{CC} of 28 volts, the amplifier becomes current limited at frequencies below 3 MHz. The increase in VSWR is related to the increase in the real part of the transistor input impedance (see Fig. 13).

Fig. 23 shows the performance of the 150-watt PEP amplifier as a function of case temperature at 30 MHz.

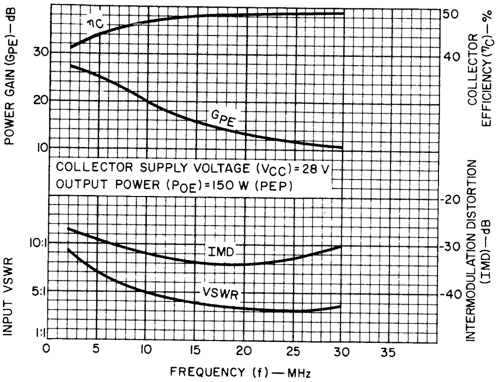


Fig. 22– Typical performance of the broadband 150-watt (PEP) amplifier with two RCA-2N6093 transistors.

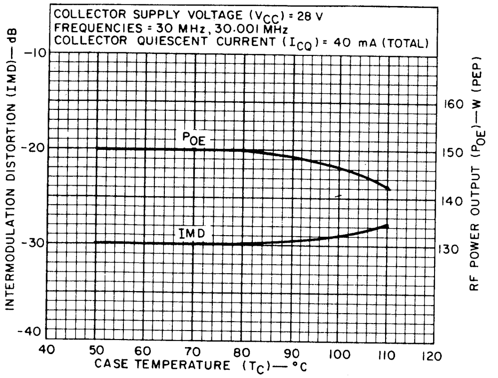


Fig. 23– Performance of the 150-watt PEP amplifier as a function of case temperature at 30 MHz.

The main advantages of this type of circuit are its simplicity and compactness. The disadvantages are lack of gain leveling and low efficiency at lower frequencies because of increased VSWR.

Because the real value of the transistor input impedance increases with decreasing frequency, which affects both VSWR and IMD, a resistance-inductance series combination placed in parallel with the 50-ohm input or placed from base to base aids the transformation network in making a practical match at low frequencies. The impedance match is improved and some input power is absorbed at low frequencies; therefore the VSWR improves and some gain leveling occurs. Other methods of gain leveling include collector-to-base feedback and loop feedback; for high-power circuits, the loop feedback system shown in Fig. 24 would be the most effective. In this system, input and output signals are compared and gain differences are compensated by commensurate increases in input attenuation.

For higher powers, modules of push-pull pairs can be pyramided by the same hybrid-combining techniques.

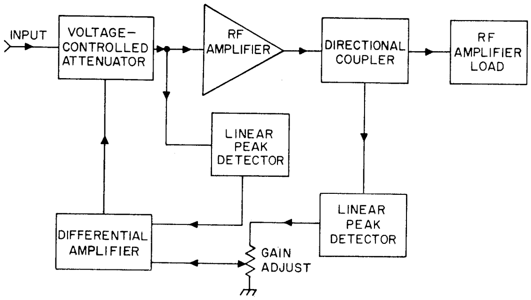


Fig. 24-- A loop feedback system for gain-leveling.

Solid State
Division

RF Power Transistors

Application Note
AN-4774

Hotspotting in RF Power Transistors

by C. B. Leuthauser

Some rf power transistors can suffer a long-term deterioration of performance during linear operation (class A or AB) or when operated with high collector supply voltage or into a high load VSWR, even though the dissipation is within the limit set by the classical junction-to-case thermal resistance. This performance degradation is caused by a localized heating effect called "hotspotting". Hotspotting results from local current concentrations in the active areas of the transistor; it can cause catastrophic thermal runaway as well as long-term failure.

The presence of hotspots can make virtually useless the present method of calculating junction temperature by measurements of average thermal resistance, case temperature, and power dissipation. However, by use of an infrared microscope, the spot temperature of a small portion of an rf transistor pellet can be determined accurately under actual or simulated device operating conditions. The resultant peak temperature information is used to characterize the device thermally in terms of junction-to-case hotspot thermal resistance, $\Theta_{JS\text{-}C}$.

The hotspot thermal resistance can be used in reliability predictions, particularly for devices involved in linear or mismatch service.

DC Safe Area

The safe area determined by infrared techniques represents the locus of all current and voltage combinations within the maximum ratings of a device that produce a specified spot temperature (usually 200°C) at a fixed case temperature. The shape of this safe area is very similar to the conventional safe area in that there are four regions, as shown in Fig. 1: constant current, constant power, derating power, and constant voltage. The dotted lines denote a three-region form of safe-area plot, in which the fourth region is outside of V_{CEO} or $I_C(\max)$.

Regions I and IV, the constant-current and constant-voltage regions, respectively, are determined by the maximum collector current and V_{CEO} ratings of the device. Region II is dissipation-limited; in the classical safe area curve, this region is determined by the following relationship:

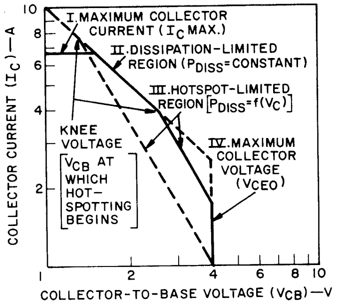


Fig. 1– Safe area curve for an rf power transistor, determined by infrared techniques.

$$P_{\max} = \frac{T_J(\max) - T_C}{\Theta_{J\text{-}C}} \tag{1}$$

where $T_J(\max)$ is the maximum allowed junction temperature, T_C is the case temperature, and $\Theta_{J\text{-}C}$ is the junction-to-case thermal resistance.

This relationship holds true for the infrared safe area; $P_{\max}$ may be slightly lower because the reference temperature $T_J(\max)$ is a peak value rather than an average value. The hotspot thermal resistance ($\Theta_{JS\text{-}C}$) may be calculated from the infrared safe area by use of the following definition:

$$\Theta_{JS\text{-}C} = \frac{T_{JS} - T_C}{P_{diss}} \tag{2}$$

where T_{JS} is highest spot temperature [$T_J(\max)$ for the safe area] and P_{diss} is the dissipated power (=I x V product in Region II).

The collector voltage at which regions II and III intersect, called the knee voltage V_k, indicates the collector voltage at which power constriction and resulting hotspot formation begins. For voltage levels above V_k, the allowable power decreases. Region III is very similar to the second-breakdown region in the classical safe area curve except for magnitude. For many rf power transistors, the hotspot-limited region can be significantly lower than the second-breakdown locus. Generally V_k decreases as the size of the device is increased.

Fig. 2 shows the temperature profiles of two transistors with identical junction geometries that operate at the same dc power level. If devices are operated on the dissipation-limited line of their classical safe areas, the profiles show that the temperature of the unballasted device rises to values 130°C in excess of the 200°C rating. Temperatures of this magnitude, although not necessarily destructive, seriously reduce the lifetime of the device.

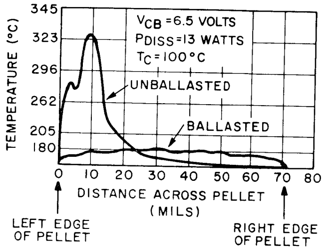


Fig. 2— Thermal profiles of a ballasted and an unballasted power transistor during dc operation.

Emitter Ballasting

The profiles shown in Fig. 2 also demonstrate the effectiveness of emitter ballasting in the reduction of power (current) constriction. In the ballasted device, a biasing resistor is introduced in series with each emitter or small groups of emitters. If one region draws too much current, it will be biased towards cutoff, allowing a redistribution of current to other areas of the device.

The amount of ballasting affects the knee voltage, V_k, as shown in Fig. 3. A point of diminishing returns is reached as V_k approaches V_{CEO}.

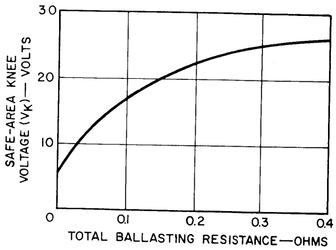


Fig. 3— Safe-area knee voltage for an rf power transistor as a function of total ballasting resistance.

RF Operation

In normal class C rf operation the hotspot thermal resistance is approximately equal to the classical average thermal resistance. If the proper collector loading (match) is maintained, $\Theta_{JS\text{-}C}$ is independent of output power at values below the saturated- or slumping-power level, and is independent of collector supply voltage at values within +30 per cent of the recommended operating level.

Power constriction in rf service normally occurs only for collector load VSWR's greater than 1:1. A transistor that has a mismatched load experiences temperatures far in excess of device ratings, as shown in Fig. 4 for VSWR of 3:1. For comparison, the temperature profile for the matched condition is also shown in Fig. 4.

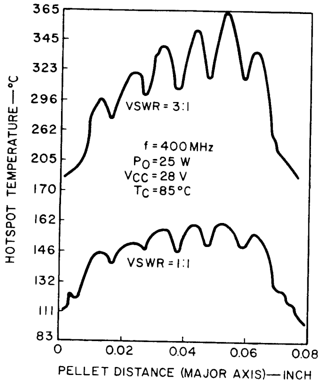


Fig. 4— Thermal profile of a power transistor during rf operation under mismatched conditions and under matched conditions.

Fig. 5 is a typical family of thermal resistance curves that indicate the response of a device to various levels of VSWR and collector supply voltage. $\Theta_{JS\text{-}C}$ responds to even slight increases in VSWR above 1:1 and saturates at a VSWR in the range of 3:1 to 6:1. The saturated level increases with increasing supply voltage. Devices with high knee voltages tend to show smaller changes of $\Theta_{JS\text{-}C}$ with VSWR and supply voltage. $\Theta_{JS\text{-}C}$ under mismatch is independent of frequency and power level, and reaches its highest values at load angles that produce maximum collector current. Power level does, however, influence the temperature rise and probability of failure.

Device failure can also occur at a load angle that produces minimum collector current. Under this condition, collector voltage swing is near its maximum, and an avalanche breakdown can result. This mechanism is sensitive to frequency and power level, and becomes predominant at lower frequencies because of the decreasing rf-breakdown capability of the device.

Broadband Operation

The amount of hotspotting produced by wideband operation of a transistor depends upon both device and

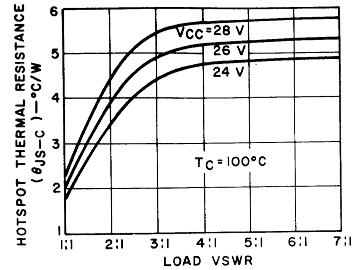


Fig. 5— Mismatch-stress thermal characteristics for the RCA-2N5071.

network characteristics. The output network in a broadband rf amplifier usually does not provide ideal collector loading across the entire range of frequencies. Therefore the hotspot thermal performance is characterized for these devices when terminated by a specified output network.

The RCA-2N5071 is a 24-watt transistor developed for wideband applications in the frequency band from 30 to 76 MHz. In the wideband circuit shown in Fig. 6, this transistor has a nominal collector efficiency of 50 per cent and an rf gain that varies from 13.5 dB at 30 MHz to 9 dB at 76 MHz for a power output of 20 watts. The hotspot thermal characteristics for the 2N5071 in this circuit are shown in Fig. 7 for a matched load and for a 3:1 VSWR (worst-case phase angle) load condition. The high case temperature, 100°C, simulates actual environmental conditions.

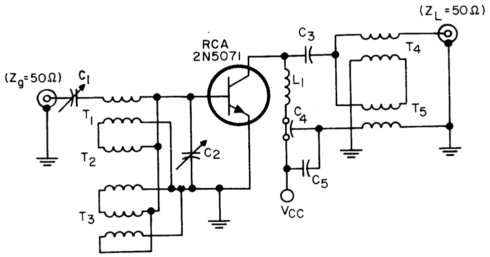
The RCA-2N6105, a 30-watt transistor, is similarly characterized for use in the 225-to-400-MHz band. In the wideband circuit shown in Fig. 8 this device has a nominal collector efficiency of 75 per cent and an rf gain that varies from 7.5 dB at 250 MHz to 6 dB at 400 MHz for a power output of 30 watts. The hotspot thermal performance of the 2N6105 is shown in Fig. 9 for matched and 3:1 VSWR load conditions with a case temperature of 85°C.

Case-Temperature Effects

The thermal resistance of both silicon and beryllium oxide, two materials that are commonly used in rf power transistors, increases about 70 per cent as the temperature increases from 25 to 200°C. Other package materials such as steel, kovar, copper, or silver, exhibit only minor increases in thermal resistance (about 5 per cent). The over-all increase in $\Theta_{JS\text{-}C}$ of a device depends on the relative amounts of these materials used in the thermal path of the device; typically the increase of $\Theta_{JS\text{-}C}$ ranges from 5 per cent to 70 per cent. Fig. 10 shows the rf and dc thermal resistance coefficients for two typical rf transistors. For both cases, the coefficient is referenced to a 100°C case and is defined as follows:

$$K_{\Theta 100} = \frac{\Theta_{JS\text{-}C}}{\Theta_{JS-C} \text{ at } T_C = 100^{\circ}\mathrm{C}} \qquad (3)$$

The rf coefficient changes more than the dc coefficient, because of power constriction that occurs in rf operation at elevated case temperature.



C1, C2:	55-300 pF trimmer capacitor, ARCO 427, or equivalent
C3, C5:	0.47 μF ceramic
C4:	1000 pF feedthrough
L1:	Ferroxcube No. VK200 01-3B, or equivalent
T1, T2, T3:	6 twisted pairs (10 turns/in.) of No. 28 wire connected in parallel. 3 1/2 turns on Indiana General CF-108-02 ferrite core, or equivalent
T4, T5:	2 lengths of RG-196A/U cable connected in parallel. 7 turns on Indiana General CF-111-Q1 ferrite core, or equivalent.

Fig. 6— Wideband rf amplifier circuit for operation from 30 to 76 MHz.

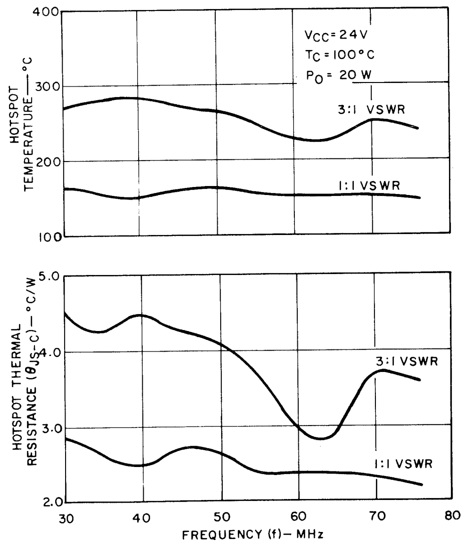
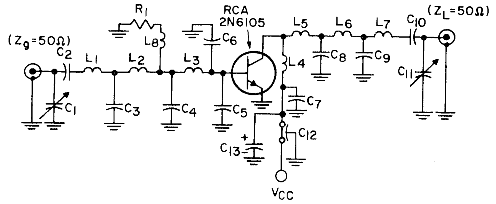


Fig. 7— Broadband thermal performance of the RCA-2N5071 in the circuit of Fig. 6.



C1: 0.8-10 pF, Johanson 2954*

C2: 15 pF silver mica

C3: 33 pF chip, Allen-Bradley B163301*

C4: 47 pF chip, Allen-Bradley B164701*

C5: 62 pF chip, ATC-100*

C6: 68 pF chip, ATC-100*

C7, C10: 1000 pF chip, Allen-Bradley B161021*

C8: 22 pF chip, Allen-Bradley B162201*

C9: 6.7 pF chip, Allen-Bradley B166791*

C11: 1-20pF, Johanson 5502*

C12: 1000 pF feedthrough

C13: 1 μF electrolytic

L1: 2 turns, 5/32-in. I.D. No. 20 wire

L2: 17/32-in. length No. 20 wire

L3: 5/32-in. length transistor base lead

L4, L6: 13/16-in. length No. 20 wire

L5: 9/16-in. length No. 20 wire

L7: 7/8-in. length No. 20 wire

L8: RFC 1 μH Nytronics*

R1: 5.1 ohms, 0.25 watt

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* or equivalent

Fig. 8— Wideband rf amplifier circuit for operation from 225 to 400 MHz.

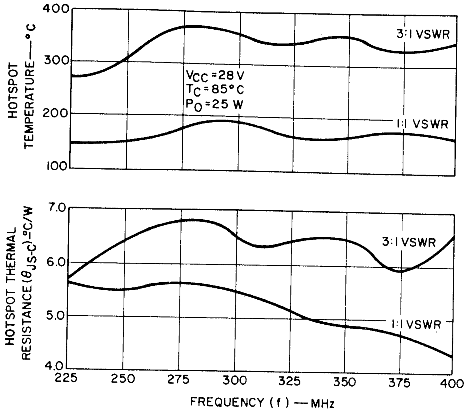

Fig. 9— Broadband thermal performance of the RCA-2N6105 in the circuit of Fig. 8.

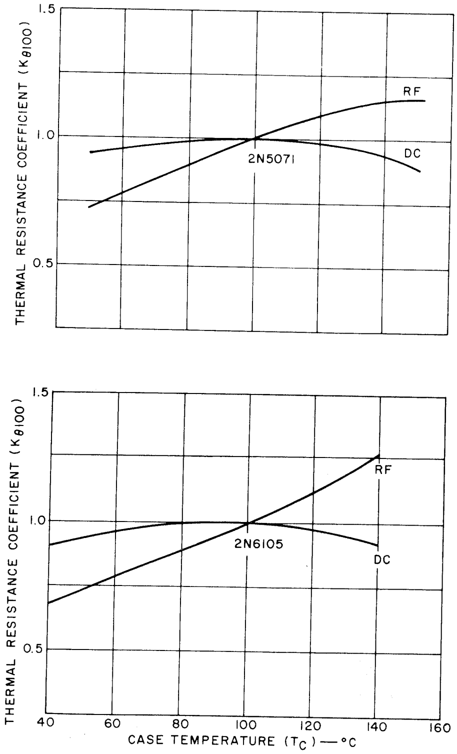

Fig. 10— Thermal resistance coefficients of the RCA-2N5071 and RCA-2N6105.

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40395	14	ALL
40396	14	ALL
40397	14	ALL
40398	14	ALL
40399	14	ALL
40400	14	ALL
40405	14	ALL
40406	219	204
40407	219	204
40408	219	204
40409	219	204
40410	219	204
40411	219	204
40412	211	204
40412VI	211	204
40412V2	211	204
40413	14	ALL
40414	14	ALL
40421	115	204
40428	115	206
40429	351	206
40430	351	206
40431	477	206
40432	477	206
40439	205	204
40440	205	204
40446	301	205
40458	14	ALL
40462	220	204
40467A	324	201
40468A	323	201

Type No.	File No.	Data-Book	Type No.	File No.	Data-Book	Type No.	File No.	Data-Book	Type No.	File No.	Data-Book	Type No.	File No.	Data-Book
40485	352	206	40628	358	204	40710	406	206	40780	443	206	40897	548	205
40486	352	206	40629	358	204	40711	406	206	40781	443	206	40898	538	205
40502	351	206	40630	358	204	40712	406	206	40782	443	206	40899	538	205
40503	351	206	40631	358	204	40713	406	206	40783	443	206	40900	540	206
40504	266	206	40632	358	204	40714	406	206	40784	443	206	40901	540	206
40505	266	206	40633	358	204	40715	406	206	40785	443	206	40902	540	206
40506	266	206	40634	358	204	40716	406	206	40786	443	206	40909	547	205
40507	265	206	40635	358	204	40717	406	206	40787	487	206	40910	527	204
40508	265	206	40636	358	204	40718	406	206	40788	487	206	40911	527	204
40509	352	206	40637	14	ALL	40719	406	206	40789	487	206	40912	529	204
40510	352	206	40638	352	206	40720	406	206	40790	487	206	40913	529	204
40511	477	206	40639	352	206	40721	406	206	40791	487	206	40916	549	206
40512	477	206	40640	354	206	40722	406	206	40792	487	206	40917	549	206
40513	244	204	40641	354	206	40723	406	206	40793	487	206	40918	549	206
40514	244	204	40642	354	206	40724	406	206	40794	487	206	40919	549	206
40519	14	ALL	40643	354	206	40725	406	206	40795	457	206	40920	549	206
40525	470	206	40644	354	206	40726	406	206	40796	457	206	40921	549	206
40526	470	206	40654	496	206	40727	406	206	40797	458	206	40922	549	206
40527	470	206	40655	496	206	40728	406	206	40798	458	206	40923	549	206
40528	470	206	40656	496	206	40729	406	206	40799	457	206	40924	549	206
40529	470	206	40657	496	206	40730	406	206	40800	457	206	40925	456	206
40530	470	206	40658	496	206	40731	406	206	40801	457	206	40926	456	206
40531	470	206	40659	496	206	40732	406	206	40802	458	206	40927	456	206
40532	470	206	40660	459	206	40733	406	206	40803	458	206	40934	550	205
40533	470	206	40661	459	206	40734	406	206	40804	458	206	40935	550	205
40534	470	206	40662	459	206	40735	408	206	40805	459	206	40936	551	205
40535	470	206	40663	459	206	40737	417	206	40806	459	206	40937	94	206
40536	470	206	40664	375	206	40738	417	206	40807	459	206	40938	94	206
40537	302	204	40665	386	205	40739	417	206	40808	449	206	40939	552	205
40538	302	204	40666	386	205	40740	417	206	40809	449	206	40940	553	205
40539	303	204	40667	375	206	40741	417	206	40810	473	206	40941	554	205
40542	304	204	40668	364	206	40742	417	206	40811	473	206	44001	495	206
40543	304	204	40669	364	206	40743	417	206	40812	473	206	44002	495	206
40544	303	204	40671	459	206	40744	417	206	40813	473	206	44003	495	206
40553	306	206	40672	459	206	40745	417	206	40819	463	201	44004	495	206
40554	306	206	40673	381	201	40746	417	206	40820	464	201	44005	495	206
40555	306	206	40680	409	206	40747	417	206	40821	464	201	44006	495	206
40559A	323	201	40681	409	206	40748	417	206	40822	465	201	44007	495	206
40575	300	206	40682	409	206	40749	418	206	40823	465	201	45190	559	204
40576	300	206	40683	409	206	40750	418	206	40833	496	206	45191	559	204
40577	297	205	40684	414	206	40751	418	206	40834	496	206	45192	559	204
40578	298	205	40685	414	206	40752	418	206	40835	496	206	45193	559	204
40581	301	205	40686	414	206	40753	418	206	40836	497	205	45194	559	204
40582	301	205	40687	414	206	40754	418	206	40837	497	205	45195	559	204
40583	329	206	40688	456	206	40755	418	206	40841	489	201	CA3000	121	201
40594	358	204	40689	456	206	40756	418	206	40842	493	206	CA3000/1	368	201
40595	358	204	40690	456	206	40757	418	206	40850	498	204	CA3000/2	368	201
40600	333	201	40691	431	206	40758	418	206	40851	498	204	CA3000/3	368	201
40601	333	201	40692	431	206	40759	418	206	40852	498	204	CA3000/4	368	201
40602	333	201	40693	406	206	40760	418	206	40853	498	204	CA3000H	516	201
40603	334	201	40694	406	206	40761	431	206	40854	498	204	CA3001	122	201
40604	334	201	40695	406	206	40762	431	206	40867	501	206	CA3001/1	369	201
40605	389	205	40696	406	206	40766	431	206	40868	501	206	CA3001/2	369	201
40608	356	205	40697	406	206	40767	431	206	40869	501	206	CA3001/3	369	201
40611	358	204	40698	406	206	40768	476	206	40885	508	204	CA3001/4	369	201
40612	358	204	40699	406	206	40769	441	206	40886	508	204	CA3001H	516	201
40613	358	204	40700	406	206	40770	441	206	40887	508	204	CA3002	123	201
40616	358	204	40701	406	206	40771	441	206	40888	522	206	CA3002/1	398	201
40618	358	204	40702	406	206	40772	441	206	40889	522	206	CA3002/2	398	201
40621	358	204	40703	406	206	40773	442	206	40890	522	206	CA3002/3	398	201
40622	358	204	40704	406	206	40774	442	206	40891	522	206	CA3002/4	398	201
40623	358	204	40705	406	206	40775	443	206	40892	522	206	CA3002H	516	201
40624	358	204	40706	406	206	40776	443	206	40893	514	205	CA3004	124	201
40625	358	204	40707	406	206	40777	443	206	40894	548	205	CA3005	125	201
40626	358	204	40708	406	206	40778	443	206	40895	548	205	CA3005H	516	201
40627	358	204	40709	406	206	40779	443	206	40896	548	205	CA3006	370	201

Type No.	File No.	Data-Book
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CA3008	316	201
CA3008A	310	201
CA3010	316	201
CA3010A	310	201
CA3011	128	201
CA3012	128	201
CA3012H	516	201
CA3013	129	201
CA3014	129	201
CA3015	316	201
CA3015A	310	201
CA3015A/1	371	201
CA3015A/2	371	201
CA3015A/3	371	201
CA3015A/4	371	201
CA3015H	516	201
CA3015L	515	201
CA3016	316	201
CA3016A	310	201
CA3018	338	201
CA3018A	338	201
CA3018H	516	201
CA3018L	515	201
CA3019	236	201
CA3020	339	201
CA3020A	339	201
CA3020H	516	201
CA3021	243	201
CA3022	243	201
CA3023	243	201
CA3023H	516	201
CA3026	388	201
CA3026H	516	201
CA3028A	382	201
CA3028AH	516	201
CA3028AL	515	201
CA3028B	382	201
CA3028B/1	400	201
CA3028B/2	400	201
CA3028B/3	400	201
CA3028B/4	400	201
CA3029	316	201
CA3029A	310	201
CA3030	316	201
CA3030A	310	201
CA3031/702A	14	ALL
CA3031/702C	14	ALL
CA3033	360	201
CA3033A	360	201
CA3033H	516	201
CA3035	274	201
CA3035H	516	201
CA3035VI	274	201
CA3036	275	201
CA3037	316	201
CA3037A	310	201
CA3038	316	201
CA3038A	310	201
CA3039	343	201
CA3039L	515	201
CA3040	363	201
CA3041	318	201
CA3042	319	201
CA3043	331	201
CA3043H	516	201
CA3044	340	201
CA3044Y1	340	201
CA3045	341	201
CA3045/1	401	201
CA3045/2	401	201
CA3045/3	401	201
CA3045/4	401	201
CA3045H	516	201
CA3045L	515	201
CA3046	341	201
CA3047	360	201
CA3047A	360	201
CA3048	377	201
CA3048H	516	201
CA3049	378	201
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CA3050	361	201
CA3051	361	201
CA3052	387	201
CA3053	382	201
CA3054	388	201
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CA3054L	515	201
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CA3059H	516	201
CA3060AD	537	201
CA3060BD	537	201
CA3060D	537	201
CA3060E	537	201
CA3060H	516	201
CA3062	421	201
CA3064	396	201
CA3065	412	201
CA3066	466	201
CA3067	466	201
CA3068	467	201
CA3070	468	201
CA3071	468	201
CA3072	468	201
CA3075	429	201
CA3075H	516	201
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CA3078AT	535	201
CA3078H	516	201
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CA3082H	516	201
CA3083	481	201
CA3083H	516	201
CA3084	482	201
CA3084H	516	201
CA3084L	515	201
CA3085	491	201
CA3085A	491	201
CA3085B	491	201
CA3085H	516	201
CA3086	483	201
CA3088E	560	201
CA3089E	561	201
CA3090Q	502	201
CA3091D	534	201
CA3093E	533	201
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CA3118T	532	201
CA3146AE	532	201
CA3146E	532	201
CA3183AE	532	201
CA3183E	532	201
CA3458T	531	201
CA3541D	536	201
CA3558T	531	201
CA3741CH	516	201
CA3741CT	531	201
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CA3741T	531	201
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CA3747CT	531	201
CA3747E	531	201
CA3747T	531	201
CA3748CT	531	201
CA3748T	531	201
CA6741T	530	201
CD2150	308	—
CD2151	308	—
CD2152	308	—
CD2153	308	—
CD2154	402	—
CD2155D	403	—
CD2200	14	ALL
CD2200D	14	ALL
CD2201	14	ALL
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CD2202	14	ALL
CD2202D	14	ALL
CD2203	14	ALL
CD2203D	14	ALL
CD2204	14	ALL
CD2204D	14	ALL
CD2205	14	ALL
CD2205D	14	ALL
CD2300/930	14	ALL
CD2300D/930	14	ALL
CD2300E/830	14	ALL
CD2301/961	14	ALL
CD2301D/961	14	ALL
CD2301E/861	14	ALL
CD2302/946	14	ALL
CD2302D/946	14	ALL
CD2302E/846	14	ALL
CD2303/949	14	ALL
CD2303D/949	14	ALL
CD2303E/849	14	ALL
CD2304/945	14	ALL
CD2304D/945	14	ALL
CD2304E/845	14	ALL
CD2305/948	14	ALL
CD2305D/948	14	ALL
CD2305E/848	14	ALL
CD2306/932	14	ALL
CD2306D/932	14	ALL
CD2306E/832	14	ALL
CD2307/944	14	ALL
CD2307D/944	14	ALL
CD2308D/962	14	ALL
CD2308E/862	14	ALL
CD2309/963	14	ALL
CD2309D/963	14	ALL
CD2309E/863	14	ALL
CD2310/936	14	ALL
CD2310D/936	14	ALL
CD2310E/836	14	ALL
CD2311/937	14	ALL
CD2311D/937	14	ALL
CD2311E/837	14	ALL
CD2312	14	ALL
CD2312D	14	ALL
CD2312E	14	ALL
CD2313	14	ALL
CD2313D	14	ALL
CD2313E	14	ALL
CD2314/933	14	ALL
CD2314D/933	14	ALL
CD2314E/833	14	ALL
CD2315	14	ALL
CD2315D	14	ALL
CD2315E	14	ALL
CD2316	14	ALL
CD2316D	14	ALL
CD2316E	14	ALL
CD2317	14	ALL
CD2317D	14	ALL
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CD2318	14	ALL
CD2318D	14	ALL
CD2318E	14	ALL
CD2500E	392	—
CD2501E	392	—
CD2502E	392	—
CD2503E	392	—
CD4000AD	479	203
CD4000AE	479	203
CD4000AH	517	203
CD4000AK	479	203
CD4001AD	479	203
CD4001AE	479	203
CD4001AH	517	203
CD4001AK	479	203
CD4002AD	479	203
CD4002AE	479	203
CD4002AH	517	203
CD4002AK	479	203
CD4006AD	479	203
CD4006AE	479	203
CD4006AH	517	203
CD4006AK	479	203
CD4007AD	479	203
CD4007AE	479	203
CD4007AH	517	203
CD4007AK	479	203
CD4008AD	479	203
CD4008AE	479	203
CD4008AH	517	203
CD4008AK	479	203
CD4009AD	479	203
CD4009AE	479	203
CD4009AH	517	203
CD4009AK	479	203
CD4010AD	479	203
CD4010AE	479	203
CD4010AH	517	203
CD4010AK	479	203
CD4011AD	479	203
CD4011AE	479	203
CD4011AH	517	203
CD4011AK	479	203
CD4012AD	479	203
CD4012AE	479	203
CD4012AH	517	203
CD4012AK	479	203
CD4013AD	479	203
CD4013AE	479	203
CD4013AH	517	203
CD4013AK	479	203
CD4014AD	479	203
CD4014AE	479	203
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CD4014AK	479	203
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CD4015AH	517	203
CD4015AK	479	203
CD4016AD	479	203
CD4016AE	479	203
CD4016AH	517	203
CD4016AK	479	203
CD4017AD	479	203
CD4017AE	479	203

Type No.	File No.	Data-Book
CD4017AH	517	203
CD4017AK	479	203
CD4018AD	479	203
CD4018AE	479	203
CD4018AH	517	203
CD4018AK	479	203
CD4019AD	479	203
CD4019AE	479	203
CD4019AH	517	203
CD4019AK	479	203
CD4020AD	479	203
CD4020AE	479	203
CD4020AH	517	203
CD4020AK	479	203
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CD4021AE	479	203
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CD4022AD	479	203
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CD4023AK	479	203
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CD4025AD	479	203
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CD4032AK	503	203
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CD4038AH	517	203
CD4038AK	503	203
CH2102	469	204
CH2270	469	204
CH2405	469	204
CH3053	469	204
CH3439	469	204
CH3440	469	204
CH4036	469	204
CH4037	469	204
CH5320	469	204
CH5321	469	204
CH5322	469	204
CH5323	469	204
CR101	84	206
CR102	84	206
CR103	84	206
CR104	84	206
CR105	84	206
CR106	84	206
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CR108	84	206
CR109	84	206
CR110	84	206
CR201	86	206
CR203	86	206
CR204	86	206
CR206	86	206
CR208	86	206
CR210	86	206
CR212	86	206
CR273/ 8008	100	206
CR274/ 872A	100	206
CR275/ 866A/3B28	100	206
CR280	86	206
CR301	60	206
CR302	60	206
CR303	60	206
CR304	60	206
CR305	60	206
CR306	60	206
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CR351	60	206
CR352	60	206
CR353	60	206
CR354	60	206
HC1000	461	204
HC2000	506	204
HC3000	539	204

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