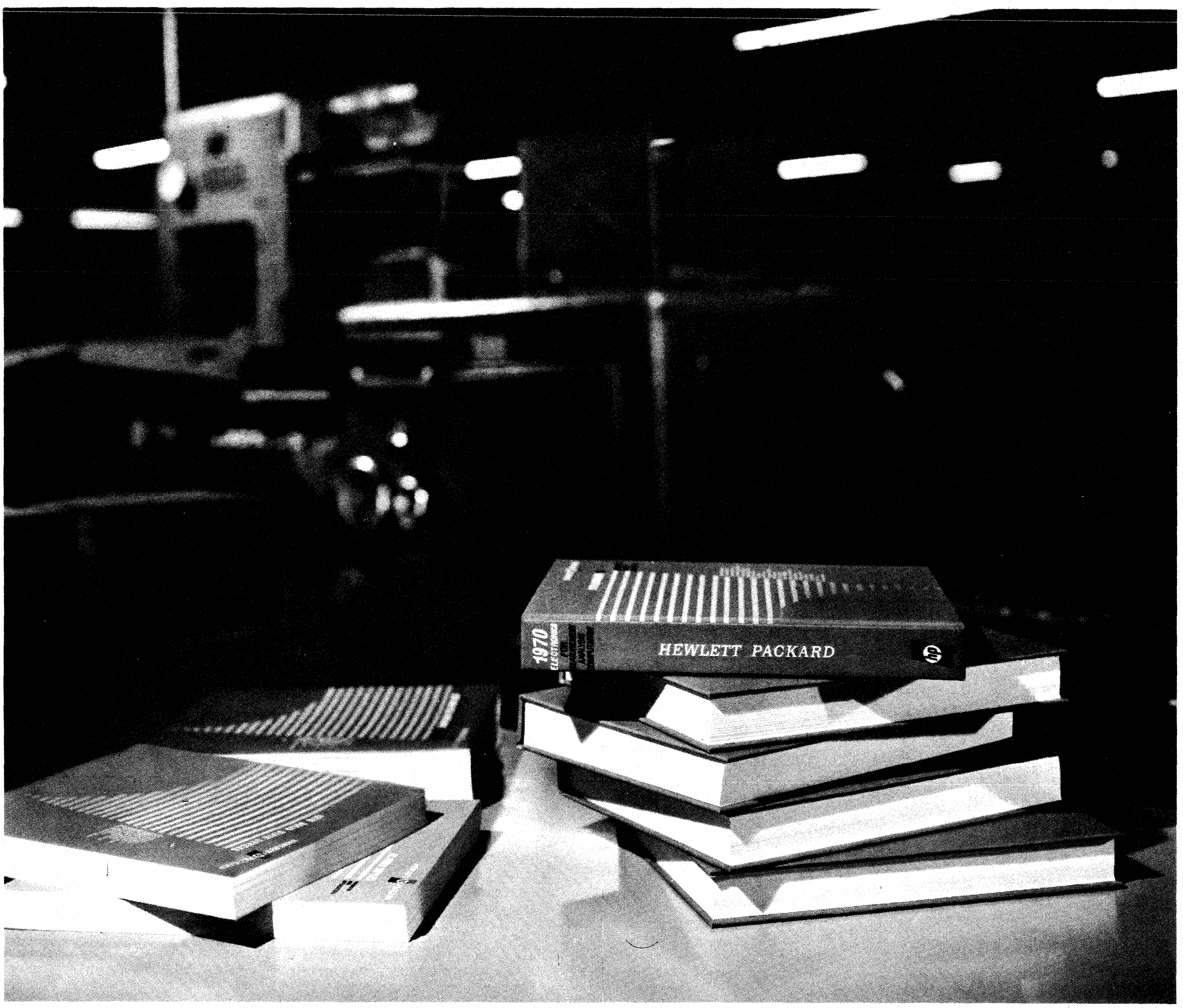
HEWLETT hp PACKARD

1970 SOLID STATE DEVICES CATALOG

Step Recovery Diodes
Hot Carrier Diodes
PIN Diodes
Fast Switching
High Conductance Diodes
High Reliability Devices
Microwave Transistors
Microelectronic Products
Optoelectronic Devices
Light Emitting Diodes
Solid State Numeric
Displays

CATALOGS



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All data in this catalog subject to change without notice.

application note index

AN 904 **The PIN Diode**

The PIN diode is essentially a high-frequency resistance element whose resistance value can be varied by a dc or low-frequency bias signal. This Note describes the important characteristics of the PIN diode and the relationship of these characteristics to its use as a high-frequency switching or attenuating element. Typical application circuits are presented. 16 pages.

AN 907 **The Hot Carrier Diode: Theory, Design And Application**

The Hot Carrier or Schottky barrier diode is virtually an ideal ultra-high-frequency switching device. This Note contains an up-to-date discussion of the physics of its operation, and describes its electrical and physical characteristics. Comparison is made to the PN-junction and point-contact diodes. 14 pages.

AN 909 **Electrical Isolation Using The HP 4310**

In the HP 4310 Photon Coupled Isolator, a gallium arsenide electroluminescent diode is optically coupled to a silicon photodiode but electrically decoupled. Electrical isolation using this technique is described. The Note also gives the equivalent circuit of the device along with suggested applications and their typical circuits. 4 pages.

AN 910 **Optoelectronic Coupling For Coding, Multiplexing, And Channel Switching**

The stream of photons from a gallium arsenide electroluminescent diode carries enough energy to a silicon photodiode to enable operation of isolated electronic switches. Isolated switching, as with a relay, is thus possible and the Note gives design principles and typical circuits using the HP 4310 Photon Coupled Isolator. 2 pages.

AN 912 **An Attenuator Design Using PIN Diodes**

This Note discusses the use of PIN diodes as variable RF resistance elements controlled by dc bias. Through the use of this mechanism a constant impedance R-type attenuator network is developed. Control of attenuation from 1 to 20 dB is obtained through a variable dc bias. 4 pages.

AN 914 **Biasing And Driving Considerations For PIN Diode RF Switches And Modulators**

Discusses application of PIN diodes as RF switches and modulators from the standpoint of the video driving waveforms required, and the means available to generate these waveforms. Emphasis is given to methods of achieving very fast switching speeds or high modulation frequencies. 23 pages.

AN 915 **Threshold Detection And Demodulation Of Visible And Infrared Radiation With PIN Photodiodes**

Solid-state photodetectors, particularly PIN photodiodes, are compared for threshold signal applications with the more traditional multiplier phototubes. Relative functional merits are presented, and a family of spectral sensitivity curves for various types of photodetectors is given. Terminal circuit design principles and realizations are described. 5 pages.

AN 916

HP GaAs Sources

HP Gallium Arsenide EL (electroluminescent) diodes radiate in a narrow band at a wavelength of 9000 Å when forward biased. When properly utilized, the radiation from the EL diode can be switched on and off in less than 100 nanoseconds. AN 916 discusses how the characteristics of this EL diode may be applied to optical circuits and describes design principles for obtaining optimum performance. 2 pages.

AN 917

HP PIN Photodiode

HP silicon planar PIN photodiodes are ultrafast detectors of visible and near infrared radiation. The low dark current of the planar diodes enables detection of very low radiation levels. AN 917 discusses how the characteristics of the HP silicon planar photodiode apply in optical circuits and explains design principles for obtaining optimum performance. 2 pages.

AN 920

Harmonic Generation Using Step Recovery Diodes And SRD Modules

Harmonic frequency multiplication, and "comb" spectrum generation using step recovery diodes, are the topics of this note. It describes the fundamental theoretical considerations and practical design techniques which have been found useful in the design of switching reactance multipliers. It also illustrates many practical multiplier designs. Finally, the note summarizes some important design criteria concerning multiplier noise, bandwidth, and stability. 32 pages.

AN 922

Application Of PIN Diodes

How the PIN diode can be applied to a variety of RF control circuits is the subject of this note. Such applications as attenuating, leveling, amplitude and pulse modulating, switching, and phase shifting are discussed in detail. Also examined are some of the important properties of the PIN diode and how they affect its application. 15 pages.

AN 923

Hot Carrier Diode Video Detectors

A description of the characteristics of Hot Carrier (Schottky barrier) diodes intended for use in video detector or video receiver circuits. It also discusses some design features of such circuits. 8 pages.

AN 928

Ku Band Step Recovery Multipliers

Shows the design of a ×8 single-stage Step Recovery diode multiplier with typical maximum output power of 75 mW at 16 GHz. This note should also be helpful to the reader with different multiplier performance requirements. 8 pages.

AN 929

Fast Switching PIN Diodes

This application note offers a detailed discussion of the various ways to define and measure the switching speed of PIN diodes. 4 pages.

Available at all Hewlett-Packard Sales Offices,
or 620 Page Mill Road, Palo Alto, California (415) 321-8510.

STEP RECOVERY DIODES

Device No.	Page
Microwave Use Tested	
S-Band	
5082-0300	5
C-Band	
5082-0310	5
X-Band	
5082-0320	5
Ku-Band	
5082-0335	5
Design Optimized	
S-Band	
5082-0360, -0365	5
C-Band	
5082-0370	5
X-Band	
5082-0375	5
Ku-Band	
5082-0386	5
UHF to X-Band	
5082-0112 through 5082-0299	5

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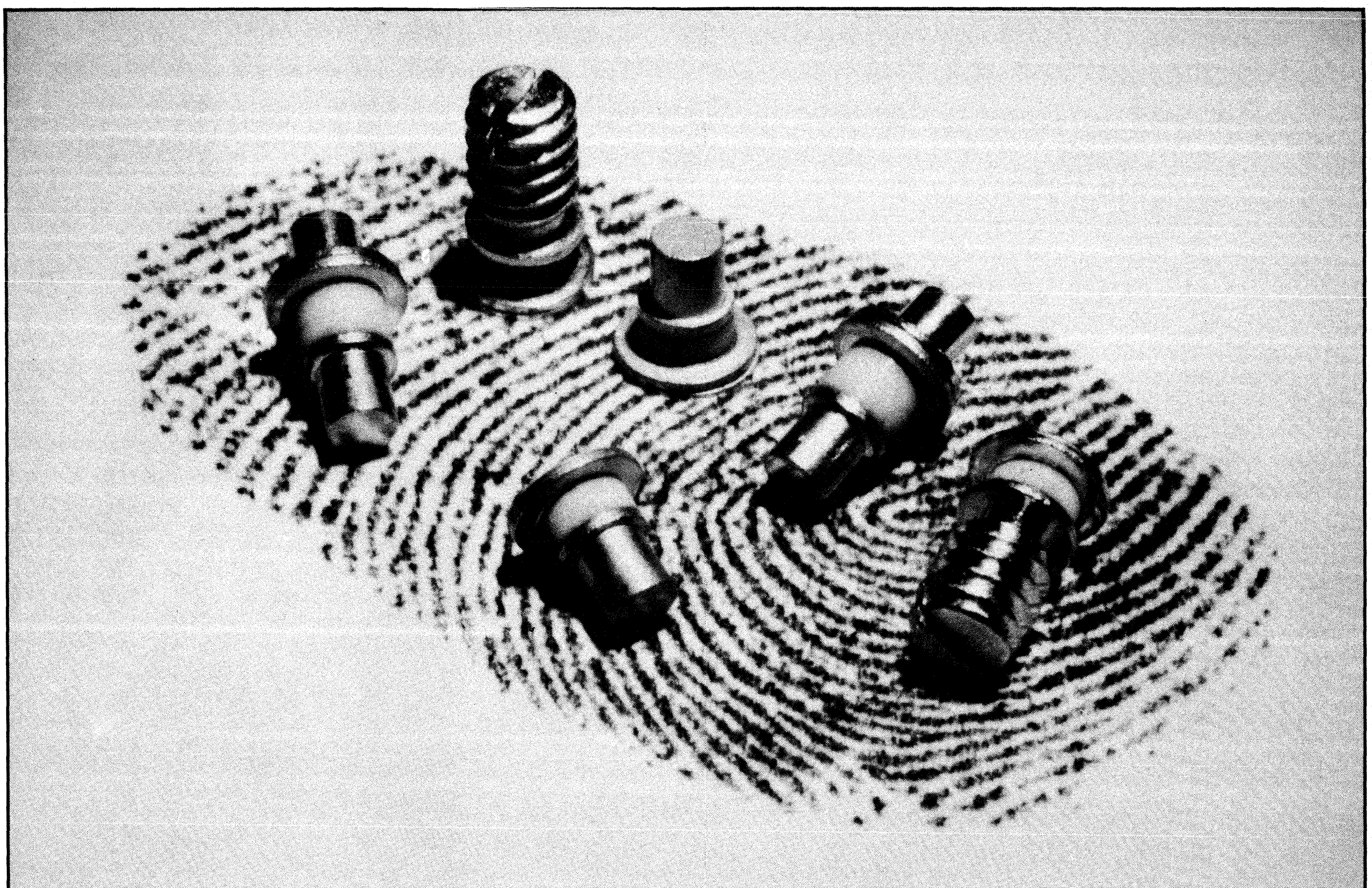
STEP RECOVERY DIODES

FOR HARMONIC GENERATION

SRD-1



Features

S-C-X-KU BAND DIODES

LOW ORDER MULTIPLICATION

- High Power Typically 10 W at 2 GHz to 0.65 W at 17 GHz in Frequency Doubling Applications
- High Efficiency
- Broad Bandwidth
- Transmitter Applications

HIGH ORDER MULTIPLICATION

- Single-Stage Design
- Minimum Diodes Required
- Transmitter and Local Oscillator Applications

RF USE TESTED DIODES

- Guaranteed Output Level

RADIATION RESISTANT

- Use in Nuclear Environment

OPERATION OVER BROAD TEMPERATURE RANGES

Description

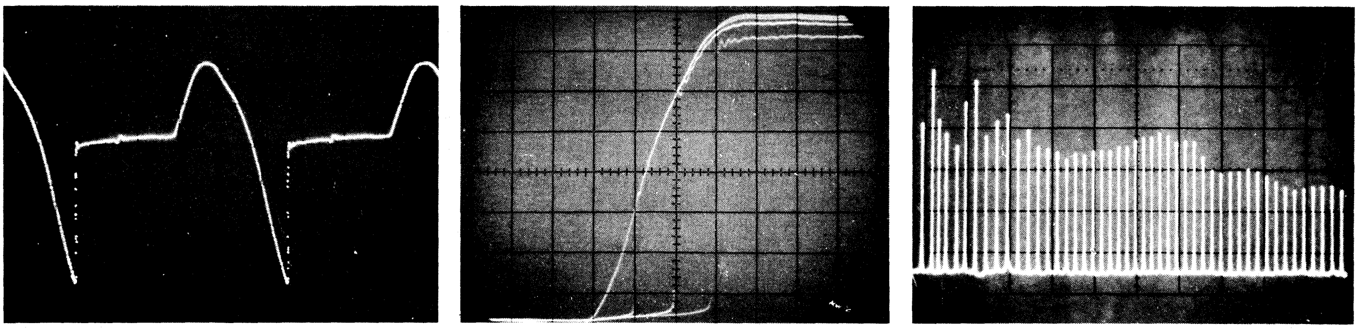
HP step recovery diodes are constructed using advanced epitaxial, passivation, gettering, and dimension control techniques. Contact to the chip is made using the latest methods for low thermal resistance and minimum package inductances. The high resistivity, dimensionally tailored, intrinsic layer assures minimum transition time in conjunction with optimum reverse bias capacitance.

Applications

These devices are intended for use as low and high order harmonic generators requiring the ultimate in performance and reliability. They excel as doublers as well as high order multipliers, because the fast transition time design allows full usage of the forward stored charge effect in improving nonlinearity and efficiency for frequency multiplication. These step recovery diodes have the basic design capability to meet the general reliability requirements of MIL-S-19500, in addition to the special reliability requirements of man-rated space systems.

The step recovery diode, when driven into forward conduction (overdrive), stores charge and appears as a low impedance. When the reverse drive current depletes the stored charge, the diode becomes a high impedance. During this high impedance or open circuit state, a voltage pulse may be generated when the diode is inductively driven. This pulse occurs once for each period of the drive frequency. When this series of pulses is terminated in a resistive load, a comb spectrum is generated (see Figure 1). By terminating the pulses in a resonant load, the spectrum is optimized at the desired output frequency for harmonic generation.

Application Notes 920, 928, and HP Special Information Note No. 4 contain additional detailed information on step recovery diodes and the techniques required to design step recovery diode multipliers.



A B C

Figure 1. The sub-nanosecond transition of the Step Recovery Diode after a period of reverse conduction is seen in (A) where a 10 MHz sine wave has been applied across the diode and the current through the diode is monitored. This transition can be used to shape pulses to provide picosecond rise and fall times (B), or as a very rich source of high order harmonics (C).

ABSOLUTE MAXIMUM RATINGS

UHF through X Band Step Recovery Diodes

T_{OPR}—Operating Temperature Range ......−65°C to +200°C
T_{STG}—Storage Temperature Range ....−65°C to +200°C
P_{DISS}—DC Power Dissipation .... $\dfrac{200°C - T_{CASE}}{\theta_{JC}}$

KU Band Step Recovery Diode

T_{OPR}—Operating Temperature Range ......−65°C to +175°C
T_{STG}—Storage Temperature Range ....−65°C to +175°C
P_{DISS}—DC Power Dissipation .... $\dfrac{175°C - T_{CASE}}{\theta_{JC}}$

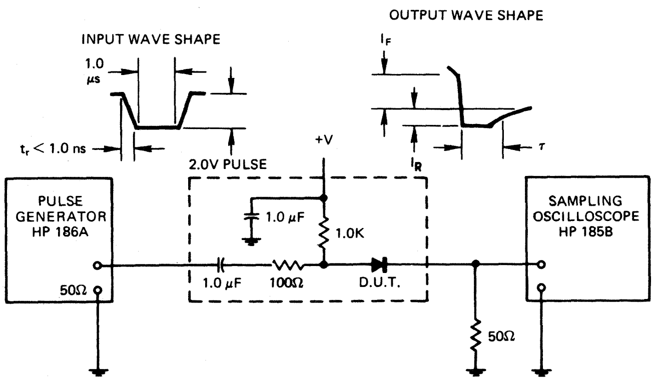


Figure 2. Test circuit for measurement of the effective minority carrier lifetime. The value of the reverse current (I_R) is approximately 6 mA and the forward current (I_F) is 1.7 I_R The lifetime (τ) is measured across the 50% points of the observed wave shape. The input pulse is provided by a pulse generator having a rise time of less than one nanosecond. The output pulse is amplified and observed on a sampling oscilloscope.

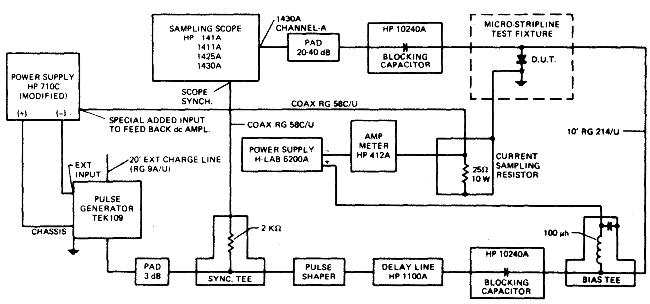


Figure 3. Test circuit for transition time. The microstripline test fixture is described in AN 918. The pulse generator voltage is adjusted to give $I_R = 0.5$ ampere$\left(\dfrac{E_{pulse}}{50\ \Omega} = 0.5\right)$. With no bias ($V_{Bias} = 0$), the 50% point of the pulse risetime is placed at a reference line on the sampling scope. The 50% point is then moved in time by adding dc forward bias for the various stored charge levels, 100, 200, and 600 picocoulombs.

HP STEP RECOVERY DIODE LINE

Tables I, II, and III define the HP Step Recovery Diode line which has been designed for performance in specific frequency ranges for both low and high order multiplication. These devices have been specified for transition time at a stored charge level. This method of measuring transition time accurately defines the maximum frequency of operation for each device, and thereby improves design efficiency.

The devices illustrated in Tables I and II are for use in S-C-X-KU Bands as transmitter drivers and local oscillators. Their characteristics are specified to ensure ease of design and optimum performance in these bands. In addition, the devices specified in Table I are multiplier tested to assure a reproducible and uniform product and give the designer a guarantee of microwave performance.

The UHF to X-band devices specified in Table III have been designed to ensure optimum performance, uniformity, and reproducibility.

TABLE I. ELECTRICAL SPECIFICATIONS AT T_A = 25°C FOR MICROWAVE USE TESTED SRD'S FOR S-C-X-KU BANDS

HP Device Number	Package Outline	f_O (GHz)	N Order	P_O (W) Min.	C_{VR} (pF) Min.	Max.	V_{BR} (volts) Min.	Max.	τ (ns) Lifetime Min.	Max.	t_t (ps) at Q_s (pC) Transition Time Max.	Stored Charge Level	θ_{jc} (°C/W) Max.
5082-0300	40	2.0	10	2.000	3.5	5.5	75	110	100	400	360	2400	14
5082-0310	41	6.0	10	0.400	1.9	3.5	40	60	50	150	160	1000	30
5082-0320	41	10.0	5	0.225	0.65	1.3	20	40	10	60	75	300	50
5082-0335	31	16.0	8	0.030	0.45	0.70	20	30	5	20	60	100	75
Test Conditions	Note 1		Note 2		V_R = 10 V, f = 1.0 MHz Note 3		I_R = 10 μA		Fig. 2 Note 4		Fig. 3		Note 5

TABLE II. ELECTRICAL SPECIFICATIONS AT T_A = 25°C FOR DESIGN OPTIMIZED SRD'S IN S-C-X-KU BANDS

HP Device Number	Package Outline	C_{VR} (pF) Min.	Max.	V_{BR} (volts) Min.	Max.	τ (ns) Lifetime Min.	Max.	t_t (ps) at Q_s (pC) Transition Time Max.	Stored Charge Level	θ_{jc} (°C/W) Max.
5082-0360	40	3.5	5.5	75	110	100	400	360	2400	14
5082-0365	31	2.5	4.1	50	80	80	240	225	1800	25
5082-0370	41	1.9	3.5	40	60	50	150	160	1000	30
5082-0375	41	0.65	1.3	20	40	10	60	75	300	50
5082-0386	31	0.45	0.70	20	30	5	20	60	100	75
Test Conditions	Note 1	V_R = 10 V, f = 1.0 MHz Note 3		I_R = 10 μA		Fig. 2 Note 4		Fig. 3		Note 5

TABLE III. ELECTRICAL SPECIFICATIONS AT T_A = 25°C FOR UHF TO X-BAND SRD'S

HP Device Number	Package Outline	C_{VR} (pF) Max.	V_{BR} (volts) Min.	τ (ns) Lifetime Min.	t_t (ps) at Q_s (pC) Transition Time Max.	Stored Charge Level	θ_{jc} (°C/W) Max.	Suggested Output Frequency (GHz) Max.
5082-0112	11	1.7	35	50	175	1000	300	
5082-0113	11	5.0	35	90	250	1500	300	
5082-0114	11	4.0	35	125	225	1500	300	1.5
5082-0180	11	4.6	50	100	225	1500	300	
5082-0299	11	4.5	50	125	200	1500	300	
5082-0151	15	0.85	15	20	90	200	600	
5082-0152	15	0.85	15	20	90	200	600	3.0
5082-0153	15	0.60	25	20	90	200	600	
5082-0132	31	1.7	35	50	175	1000	100	
5082-0134	31	5.0	35	125	225	1500	75	
5082-0240	31	4.0	65	100	275	1500	60	
5082-0241	31	4.8	65	100	275	1500	60	Note 6
5082-0242	31	1.4	35	30	140	600	100	
5082-0243	31	1.4	35	30	110	600	100	
5082-0251	31	0.95	15	20	100	200	175	
5082-0253	31	0.80	25	20	80	200	175	
Test Conditions	Note 1	V_R = 10 V, f = 1.0 MHz Note 3	I_R = 10 μA	Fig. 2	Fig. 3		Note 5	

NOTE 1. See mechanical specifications for details.

NOTE 2. Guaranteed multiplier tested results for design optimized SRD's.

NOTE 3. These values include package capacitance.

NOTE 4. Lifetime, τ, for Ku Band, 0335 and 0386, is performed per Figure 3 and the Ku Band Data Sheet.

NOTE 5. Thermal resistance test procedures and conditions are described in the October 1967 HP Journal, Pages 2-9.

NOTE 6. The suggested maximum output frequency for the Style 31 diodes is determined by the following formula: $f_{o_{max}} \leq \frac{1}{t_t}$

THE STEP RECOVERY DOUBLER

The step recovery diode is a nearly ideal device for a high power doubler. Its profile has been optimized to make best use of the overdrive principle by providing the fastest switching possible from the forward (essentially infinite capacitance) state to reverse (depletion capacitance) state. Efficiency is substantially improved when effective use of overdrive is possible. SRD's are specifically optimized for this type of operation.

Theoretical estimates have been made of the performance of overdriven doublers.[1] While these estimates do not take into account the losses associated with switching from C_{FWD} to C_{VR}, they are the best available for calculating expected doubler performance.

For an overdriven diode to perform efficiently, it must switch from C_{FWD} to C_{REV} in a time short compared to $\frac{1}{2} f_o$. There is a strong relationship between this switching speed and V_{BR} ($V_{BR} = 140/\sqrt{f_o}$) which has been found empirically[2] and theoretically.[3]

The calculated doubler power output for HPA diodes (0300, 0310, 0320, and 0335) is shown in Figure 4. Several customer verified data points are shown for comparison.

The curves of Figure 4 do not take into account any possible thermal limitations (a thermally limited power output vs. frequency curve would have the opposite slope). Thermal limits depend on the efficiency of the device and its maximum dissipation power rating. The power output shown in the curves are much less than the limiting power determined from thermal consideration and consequently are not shown.

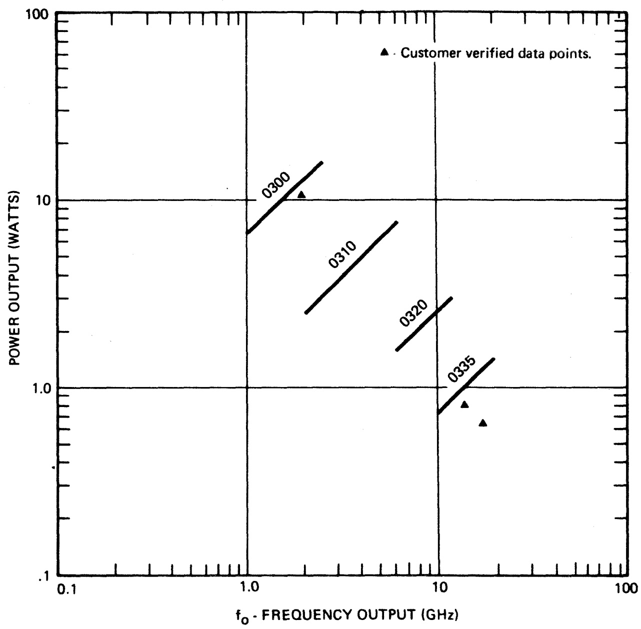
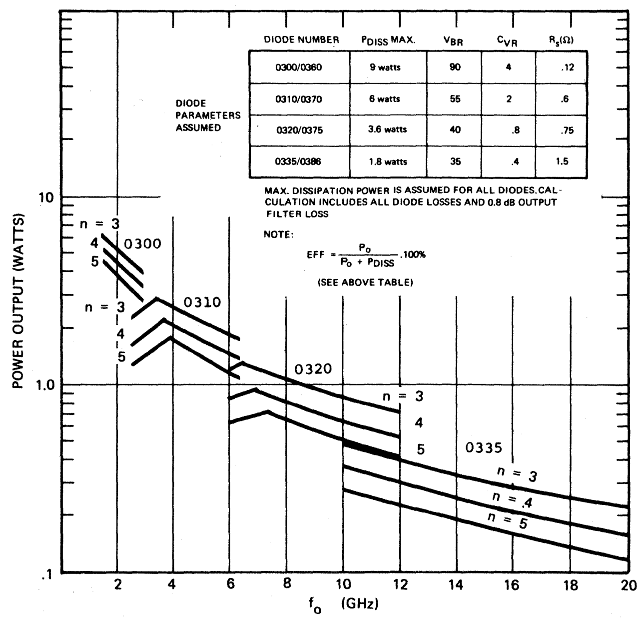


Figure 4. Calculated doubler performance of 03XX step recovery diodes. Calculations were made using Burckhardt analysis—transition losses not considered. Filter and matching circuit losses are assumed to be zero.

TRIPLERS AND HIGHER ORDER STEP RECOVERY MULTIPLIERS

Accurate predictions[4] of maximum practically achievable power output of step recovery multipliers from X3 to X5 have been made using computer optimization programs which incorporate all known loss mechanisms in the step recovery diode. The power output curves of Figure 5 are the results of this program, and have been experimentally verified at many points.



DIODE NUMBER	P_{DISS} MAX.	V_{BR}	C_{VR}	$R_s(\Omega)$
0300/0360	9 watts	90	4	.12
0310/0370	6 watts	55	2	.6
0320/0375	3.6 watts	40	.8	.75
0335/0386	1.8 watts	35	.4	1.5

Figure 5. Power output curves for 03XX step recovery diodes in $\times 3$, $\times 4$, and $\times 5$ multiplier applications. These results were obtained using computer optimization programs.

REFERENCES

(1) C. B. Burckhardt—"Analysis of Frequency Multipliers for Arbitrary Capacitance Variation and Drive Level." BSTJ:44, No. 4, pp. 675-692, April 1965.

(2) S. A. Hamilton and R. D. Hall—"Shunt Mode Harmonic Generation Using Step Recovery Diodes," Microwave Journal, pp. 69-79, April 1967.

(3) J. L. Moll and S. A. Hamilton—"Physical Modeling of the Step Recovery Diode for Pulse and Harmonic Generation Circuits," Proc. IEEE, Vol. 57, No. 7, pp. 1250-1259, July 1969.

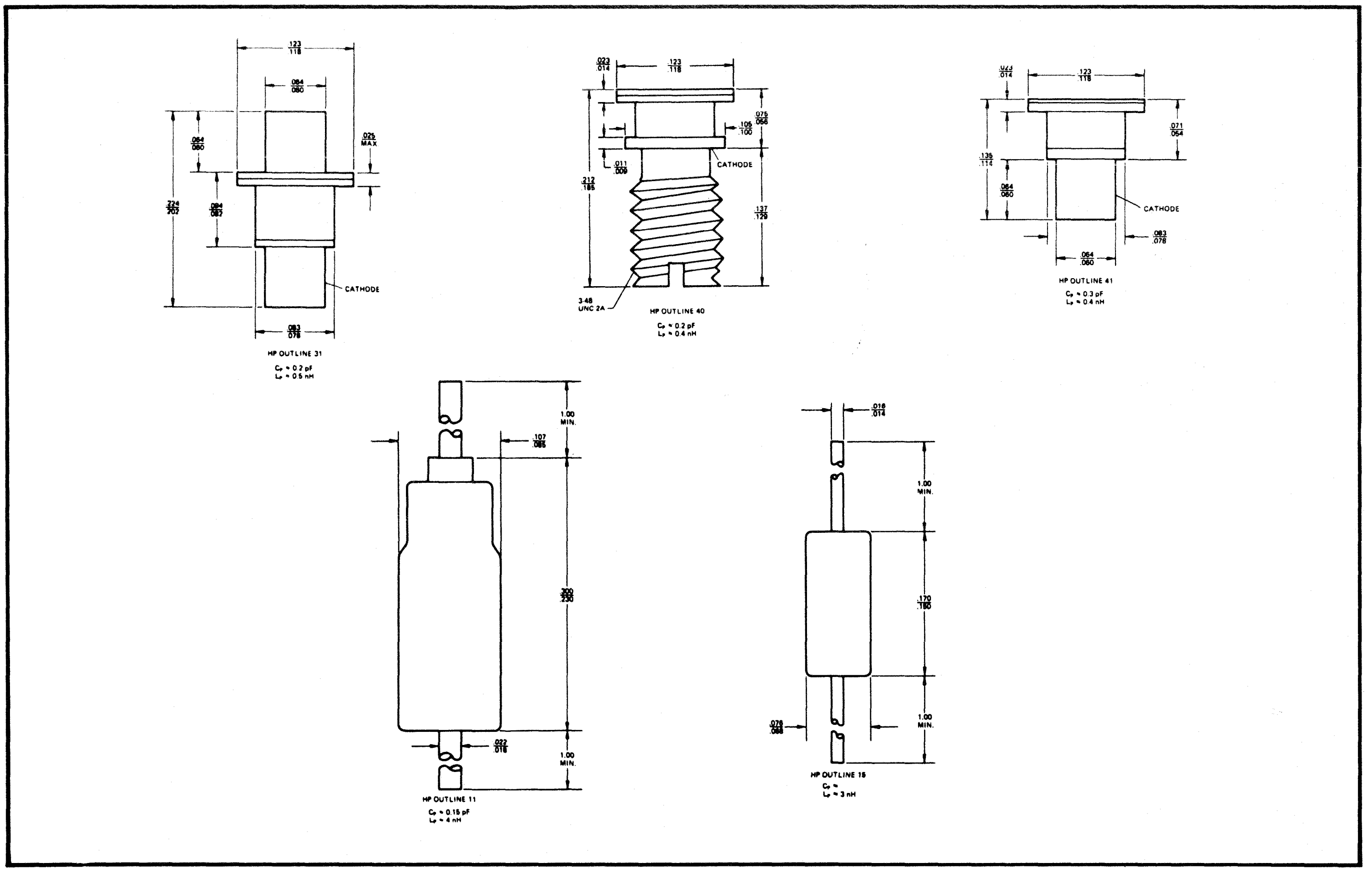
(4) Hewlett-Packard Application Note 920 — "Harmonic Generation Using Step Recovery Diodes and SRD Modules," Hewlett-Packard Associates, 620 Page Mill Road, Palo Alto, California.

MECHANICAL SPECIFICATIONS

Hewlett-Packard's step recovery diodes are available in a variety of packages. Special package configurations are available upon request. Contact your local HP Field Office for additional information.

Glass package marking is by digital coding with a cathode band. Metal-ceramic package marking is by color-coded data on ceramic; clockwise when facing cathode, starting at open space.

The glass packages have a hermetic seal with gold-plated dumet leads. The metal ceramic packages are hermetically sealed. The anode studs and flanges are gold-plated Kovar. The cathode studs are gold-plated copper. The maximum soldering temperature for both the glass and metal-ceramic packages is 230°C ±5°C for 5 seconds.



RELIABILITY

HP step recovery diodes are suitable for high reliability space applications where maximum performance stability under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of HP diodes in major aerospace and national defense programs. Reliability and components engineers are invited to contact HP's Quality and Reliability Assurance Department prior to writing purchase specifications for Hi-Rel components. With proper prescreening and conditioning, the step recovery diode is capable of meeting the following environmental conditions:

MIL-STD 750

	Reference	Conditions
Temperature, Storage	1031	See maximum ratings
Temperature, Operating	—	See maximum ratings
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, see individual specification or rating
Thermal Shock	1056	5 cycles, 0 - 100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, X, Y, Z at 1500 G
Vibration Fatigue	2046	32 hrs, X, Y, Z at 20 G min.
Vibration Variable Frequency	2056	Four 4-min. cycles, X, Y, Z, at 20 G min., 100 to 2000 Hz
Constant Acceleration	2006	X, Y, Z at 20,000 G
Terminal Strength	2036	Package dependent
Salt Atmosphere	1041	35°C fog for 24 hours

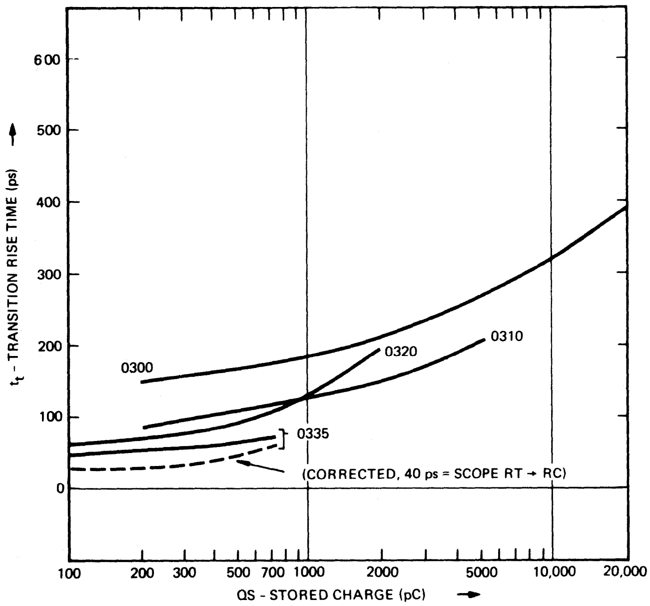


Figure 6. Typical step recovery diode transition time vs. stored charge levels at $T_A = 25°C$.

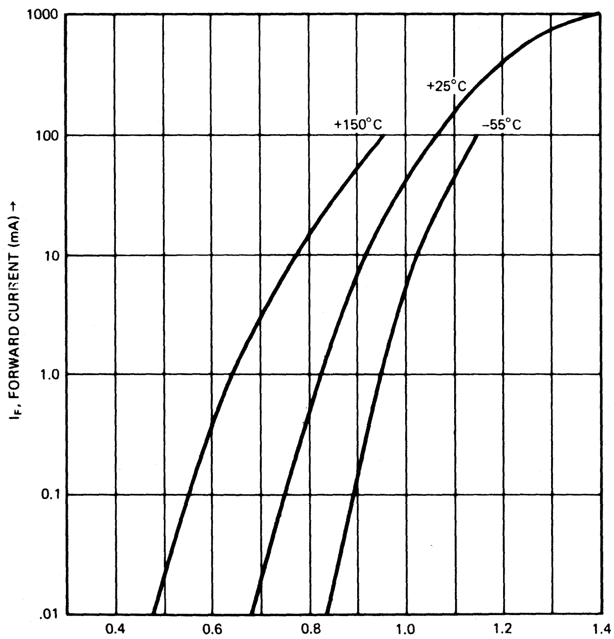


Figure 7. Typical forward current vs. forward voltage characteristics of the HP 5082-0151, 2, 3, and the 5082-0251, 3, at $T_A = -55°C$, $+25°C$, and $+150°C$.

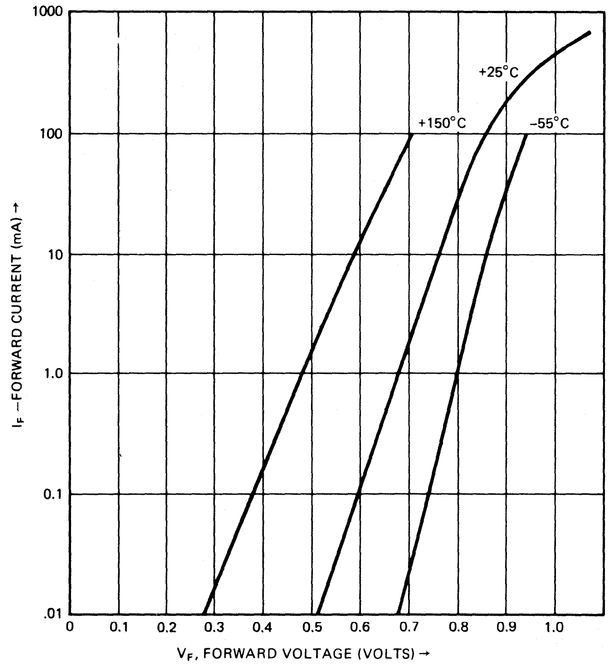


Figure 8. Typical forward current vs. forward voltage characteristics of the HP 5082-0112, 3, 4, and 5082-0132, 4 at $T_A = -55°C$, $+25°C$, and $+150°C$.

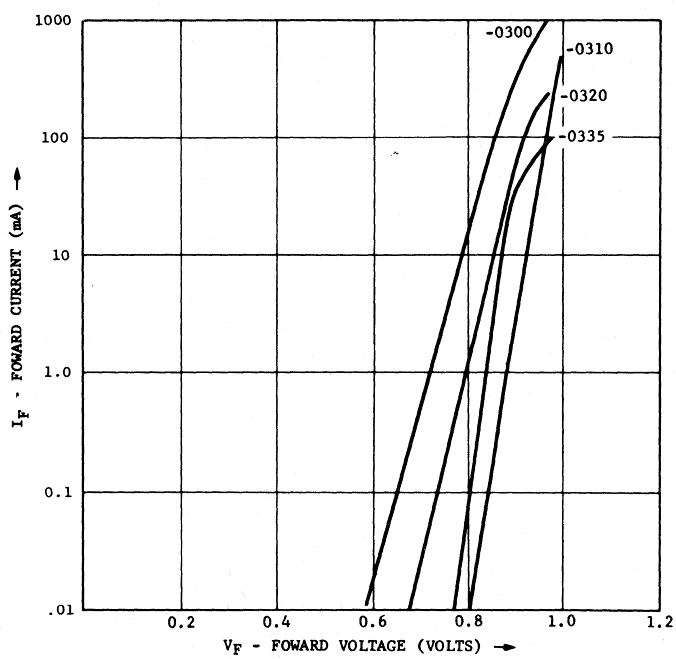


Figure 9. Typical forward current vs. forward voltage characteristics of HP 5082-0300, 0310, 0320 and 0335 at $T_A = 25°C$.

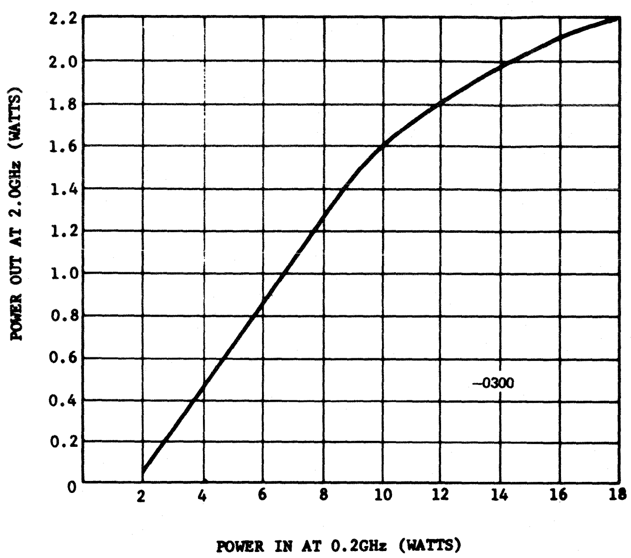


Figure 10. Typical output power vs. input power for HP 5082-0300 in a ×10 multiplier at $T_A = 25°C$.

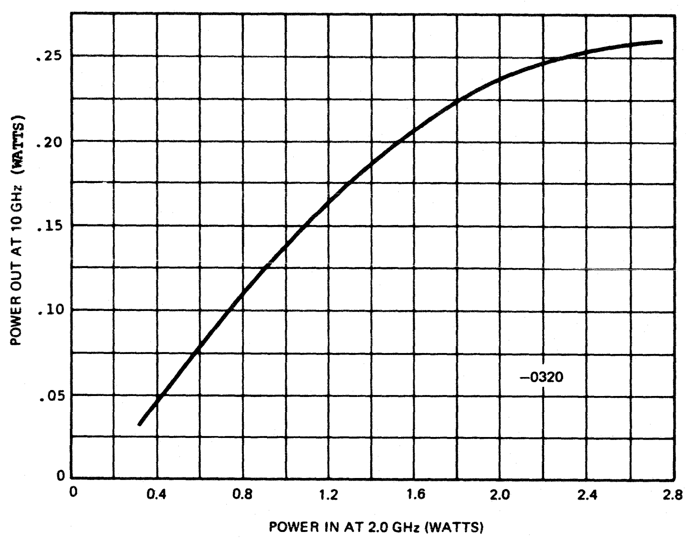


Figure 12. Typical output power vs. input power for HP 5082-0320 in a ×5 multiplier at $T_A = 25°C$.

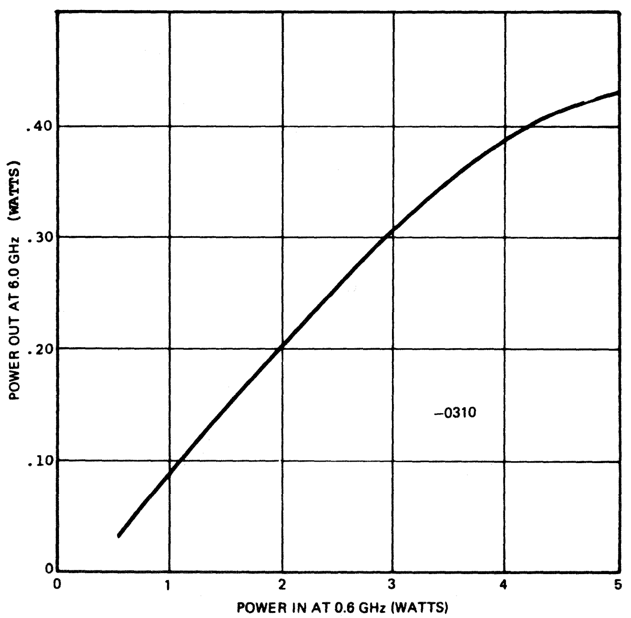


Figure 11. Typical output power vs. input power for HP 5082-0310 in a ×10 multiplier at $T_A = 25°C$.

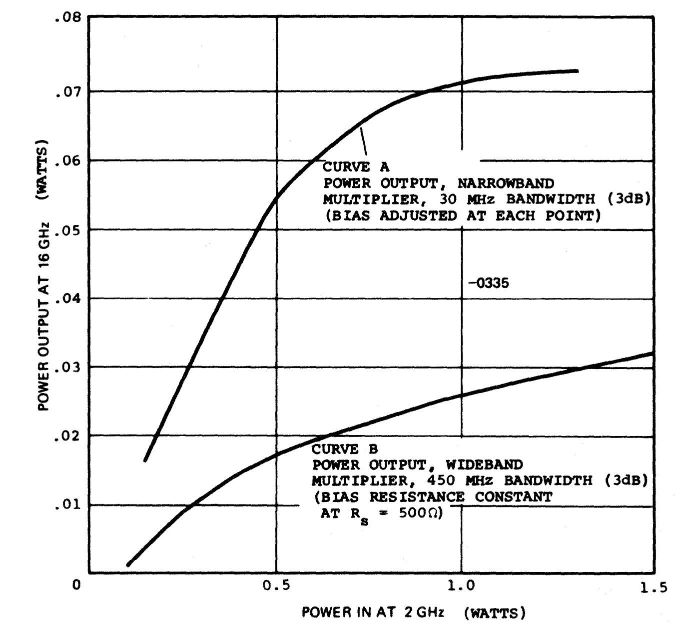


Figure 13. Typical output power vs. input power for the HP 5082-0335 in a ×8 multiplier at $T_A = 25°C$.

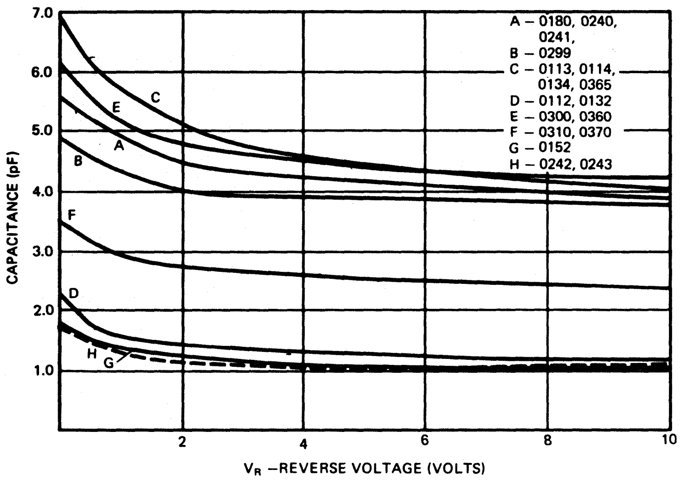


Figure 14. Typical step recovery diode capacitance vs. reverse voltage characteristics at $T_A = 25°C$, $f = 1.0$ MHz.

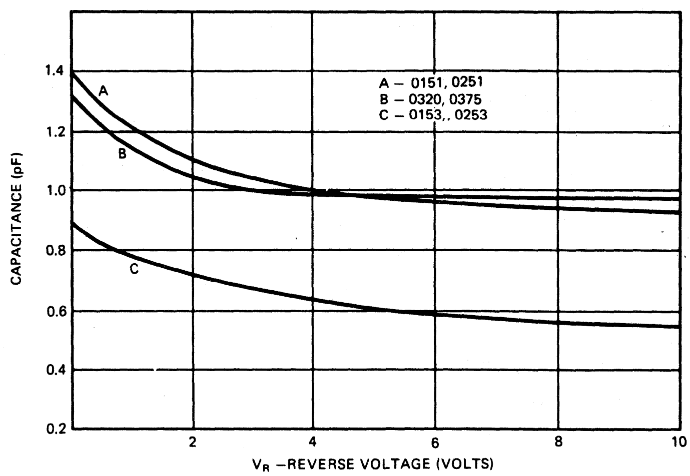


Figure 16. Typical step recovery diode capacitance vs. reverse voltage characteristics at $T_A = 25°C$, $f = 1.0$ MHz.

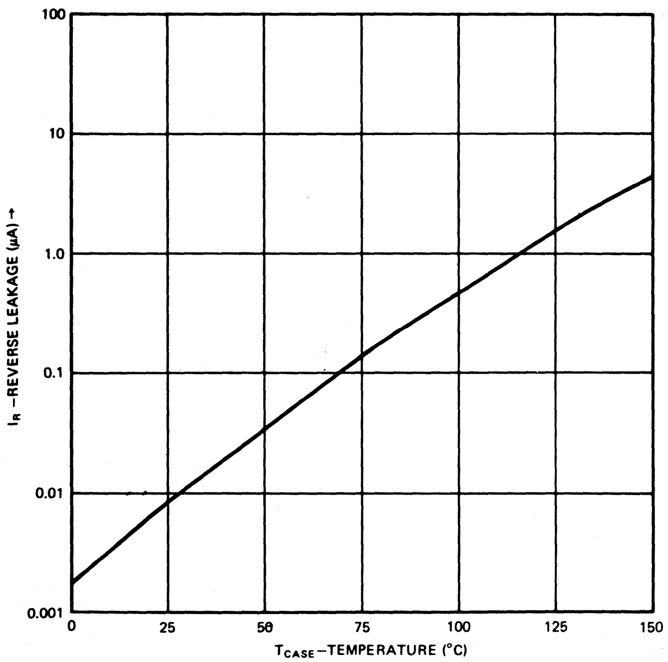


Figure 15. Typical reverse current vs. case temperature for the HP 5082-0112, 3, 4, and 5082-0132, 4 at $V_R = -30$ volts.

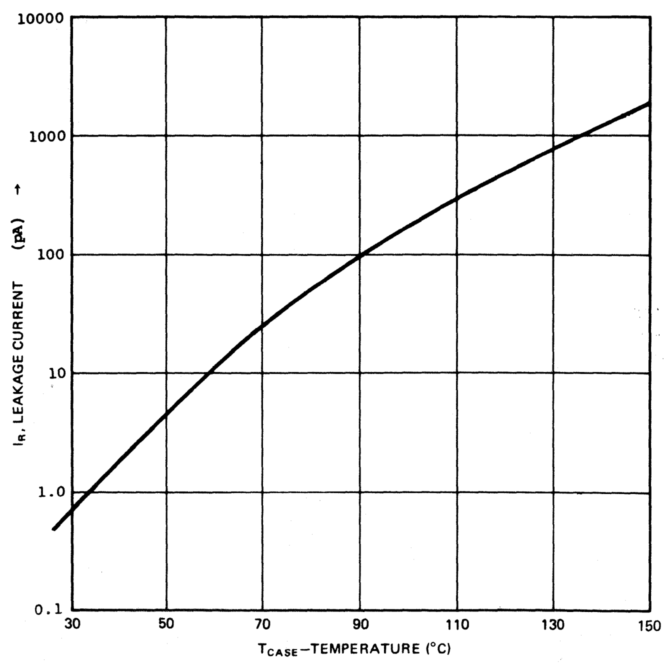


Figure 17. Typical reverse current vs. case temperature for the HP 5082-0151, 2, 3, and the 5082-0251, 3 at $V_R = -10$ volts.

HOT CARRIER DIODES

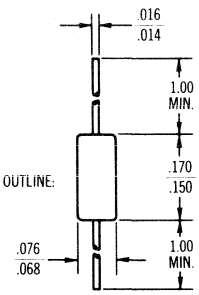
Device No.	Page
Pulse Shaping and Fast Switching	
5082-2301	15
-2800, -2810, -2826	41
-2900	63
L-Band Mixing	
5082-2350, -2400, -2500	21
-2817	49
S-Band Mixing	
5082-2500	21
-2827	57
S-Band Detecting	
5082-2824	51
X-Band Mixing	
5082-2700, -2711	27
X-Band Detecting	
5082-2750	37
Ku-Band Mixing	
5082-2721	33
High Reliability Devices	
5082-2807, -2411, -2412	75

HEWLETT hp PACKARD

HOT CARRIER DIODES

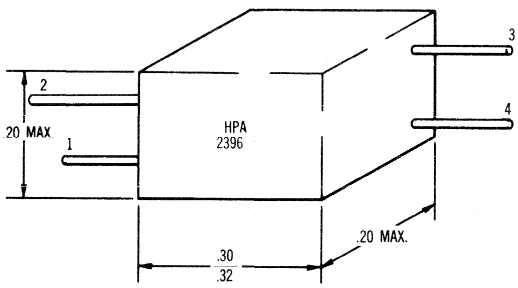
HP 5082-2300 SERIES

HCD-5



OUTLINE 15

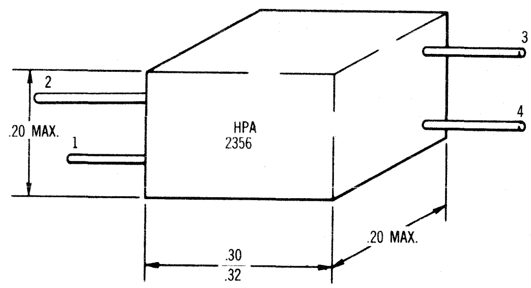
Figure 1a



LEAD LENGTH 0.75 MIN.

Figure 2a

LEAD	COLOR
1	BROWN
2	RED
3	ORANGE
4	YELLOW



LEAD LENGTH 0.75 MIN.

Figure 3a

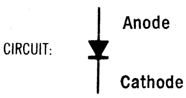


Figure 1b

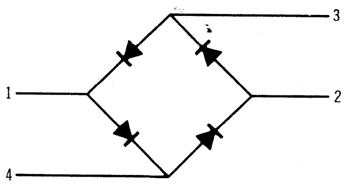


Figure 2b

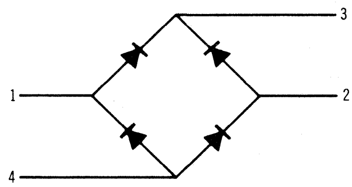


Figure 3b

All dimensions in inches

Features

FAST SWITCHING—Picosecond switching speed for use in high speed digital or logic circuits.

LOW 1/F NOISE—Excellent for use in Doppler or narrow band video receivers.

EXCELLENT ENVIRONMENTAL CAPABILITIES—Proven high reliability in major space and military programs.

Description

The HP 5082-2300 series of hot carrier diodes employ a metal-silicon Schottky barrier junction and utilize electrons for majority carrier conduction. The hot carrier diode's performance conforms closely with theory and can be described as closely approximating the ideal diode. HP Application Note 907 contains additional detailed information.

Applications

This series is intended for use in applications requiring the ultimate in performance and reliability. Extensive testing has shown that these devices exhibit the design capability necessary to meet the special reliability requirements of man-rated space systems in addition to the general requirements of MIL-S-19500.

In pulse operations the diode is ideal for clamping, sampling gates, pulse shaping and general purpose usage requiring fractional picosecond switching times.

In the RF area, the hot carrier diode makes an excellent low noise mixer, high sensitivity small signal detector, large signal detector (power monitor) with broad dynamic range, limiter, discriminator and balanced modulator from low frequencies well into the microwave range.

ELECTRICAL SPECIFICATIONS AT $T_A = 25°C$

Single Diodes

Characteristics	Symbol	HP 2305		HP 2301		HP 2302		HP 2303		Units	Test Conditions
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
Breakdown Voltage	V_{BR}	30	—	30	—	30	—	20	—	V	$I_R = 10\ \mu A$
Reverse Current	I_R	—	300	—	300	—	300	—	500	nA	$V_R = 15$ V
Forward Current	I_{F_1}	1.0	—	1.0	—	1.0	—	1.0	—	mA	$V_{F_1} = 0.4$ V max. (Note 1)
Forward Current	I_{F_2}	75	—	50	—	35	—	35	—	mA	$V_{F_2} = 1.0$ V max. (Note 1)
Capacitance	C_O	—	1.0	—	1.0	—	1.0	—	1.2	pF	$V_R = 0$ V; f = 1.0 MHz
Effective Minority Carrier Lifetime	τ	—	100	—	100	—	100	—	100	ps	Figure 8

Note 1: The test condition and specification are interchanged to make the tabulation easier to read. The actual test condition is forward current; the actual specification is forward voltage. The forward current is limited to prevent thermal runaway.

Matched Pairs and Quads

HP Type Number	HP 2306	HP 2308	HP 2370	HP 2396	HP 2356
Description	Matched pair of HPA 2301, unencapsulated and unconnected.	Matched pair of HPA 2303, unencapsulated and unconnected.	Matched Quad, unencapsulated and unconnected.	Matched Ring Quad, Epoxy encapsulated.	Matched Bridge Quad, Epoxy encapsulated.
Outline	Fig. 1a	Fig. 1a	Fig. 1a	Fig. 2a	Fig. 3a
Circuit	Fig. 1b	Fig. 1b	Fig. 1b	Fig. 2b	Fig. 3b

Characteristics	Symbol	HP 2306		HP 2308		HP 2370		HP 2396		HP 2356		Units	Test Conditions
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
Breakdown Voltage	V_{BR}	30	—	20	—	20	—	*	—	*	—	V	$I_R = 10\ \mu A$
Reverse Current	I_R	—	300	—	500	—	500	—	*	—	*	nA	$V_R = 15$ V
Forward Current	I_{F_1}	1.0	—	1.0	—	1.0	—	1.0	—	1.0	—	mA	$V_{F_1} = 0.4$ V max. (Note 1)
Forward Current	I_{F_2}	50	—	35	—	35	—	35	—	35	—	mA	$V_{F_2} = 1.0$ V max. (Note 1)
Forward Voltage Match**	ΔV_F	—	20	—	20	—	20	—	20	—	20	mV	$I_F = 0.75$ to 20 mA
Capacitance	C_O	—	1.0	—	1.2	—	1.0	—	*	—	*	pF	$V_R = 0$, f = 1.0 MHz
Capacitance Match**	ΔC_O	—	0.2	—	0.2	—	0.2	—	0.2	—	0.2	pF	$V_R = 0$, f = 1.0 MHz
Effective Minority Carrier Lifetime	τ	—	100	—	100	—	100	—	*	—	*	ps	Figure 8

Note 1: The test condition and specification are interchanged to make the tabulation easier to read. The actual test condition is forward current; the actual specification is forward voltage. The forward current is limited to prevent thermal runaway.

* Breakdown voltage, reverse current, capacitance, and effective minority carrier lifetime cannot be readily verified after assembly and encapsulation because of the shunting effect of the other diodes. The encapsulated quads have the same parameter values as the HP 2370 unencapsulated quad prior to assembly and encapsulation.

** Quads and pairs having additional and/or tighter matching are available upon request. Please contact the local HP field sales office.

ABSOLUTE MAXIMUM RATINGS

T_{OPR}—Operating Temperature Range......— 60°C to + 125°C
T_{STG}—Storage Temperature Range..........— 60°C to + 125°C
P_{DISS}—DC Power Dissipation ($T_A = 25°C$).................125 mW
U—Burnout (3 pulses with a 10 ns maximum pulse width; 20% allowable V_{BR} degradation; $T_A = 25°C$).....................................5 ergs

PACKAGE

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch from the glass body. With this restriction OD-15 package will meet MIL-STD-750, Method 2036, Conditions A and E (4 lbs. tension for 30 minutes). The maximum soldering temperature is 230°C ± 5°C for 5 seconds.

Outline 18 package inductance and capacitance is typically 0.07 pF and 3 nH respectively.

Marking is by digital coding with a cathode band.

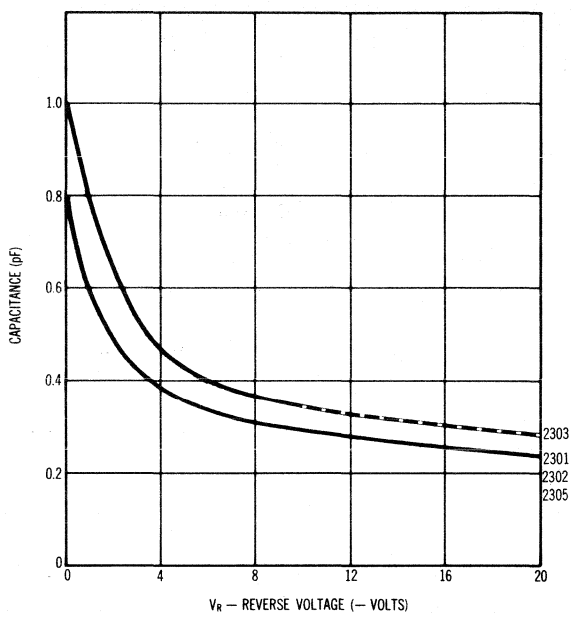


Figure 4. HP 2300 series typical capacitance vs. reverse voltage at $T_A = 25°C$.

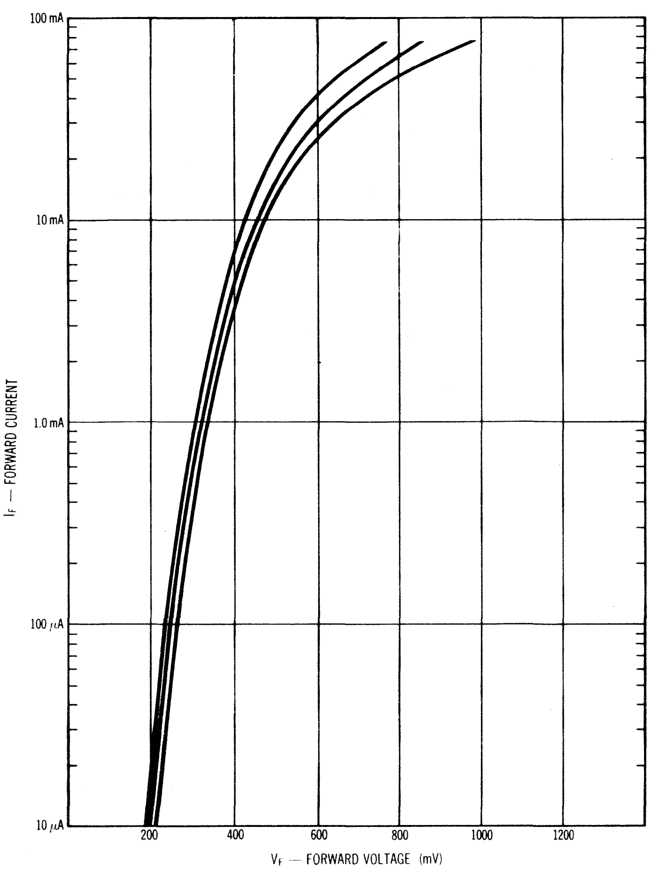


Figure 5a. HP 2305 typical minimum, median, and maximum forward current vs. forward voltage at $T_A = 25°C$.

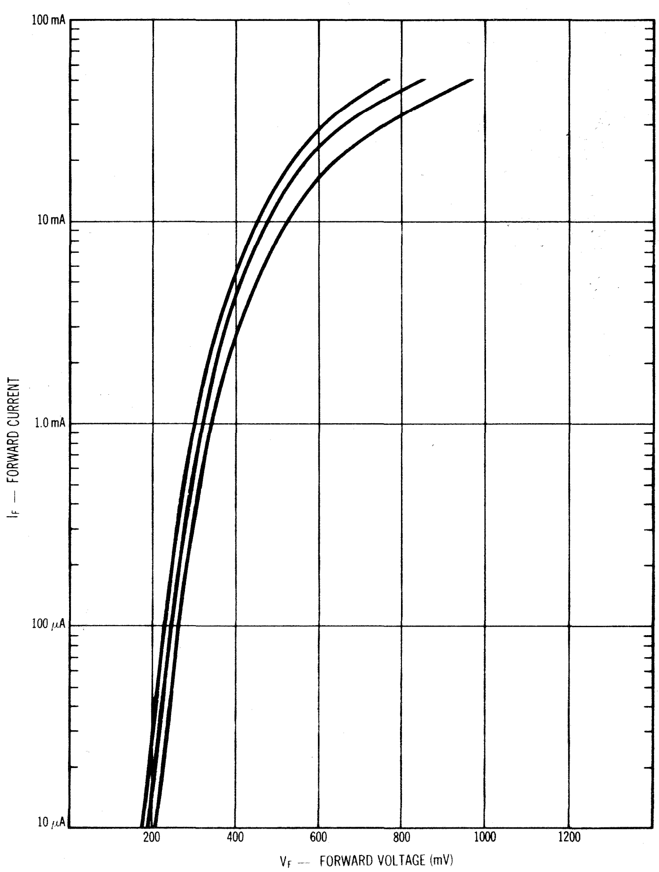


Figure 5b. HP 2301 typical minimum, median, and maximum forward current vs. forward voltage at $T_A = 25°C$.

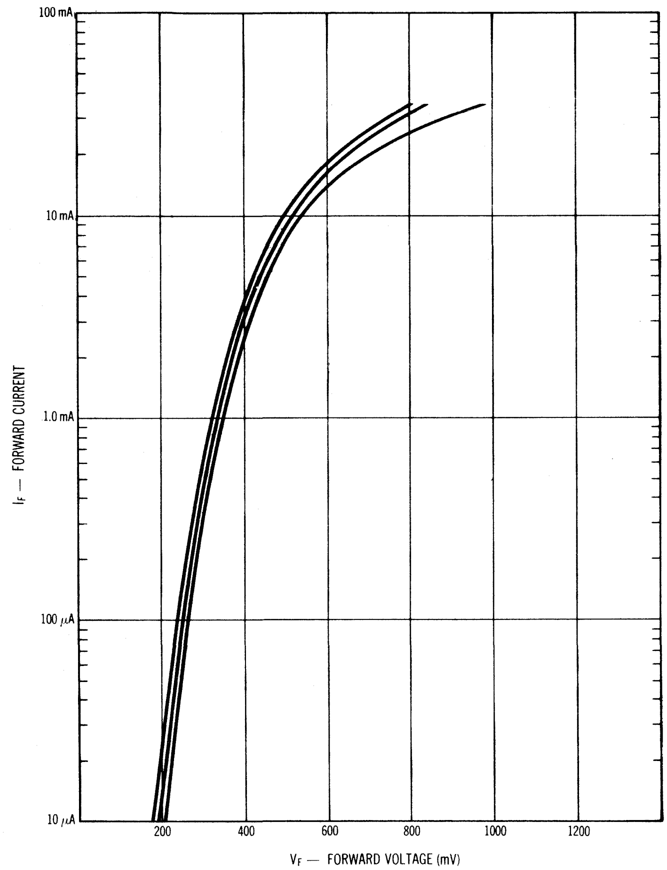


Figure 5c. HP 2302 typical minimum, median, and maximum forward current vs. forward voltage at T_A = 25°C.

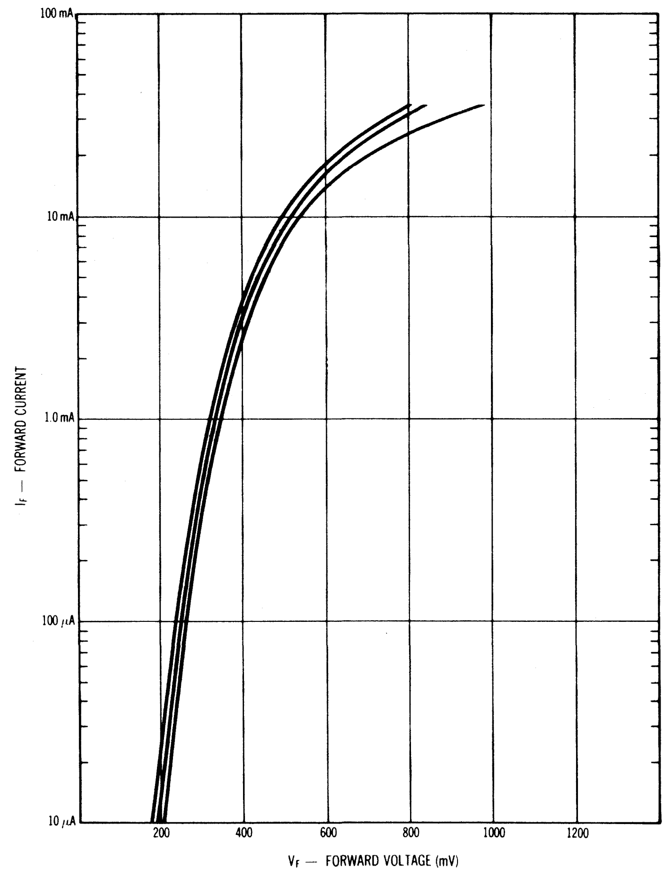


Figure 5d. HP 2303 typical minimum, median, and maximum forward current vs. forward voltage at T_A = 25°C.

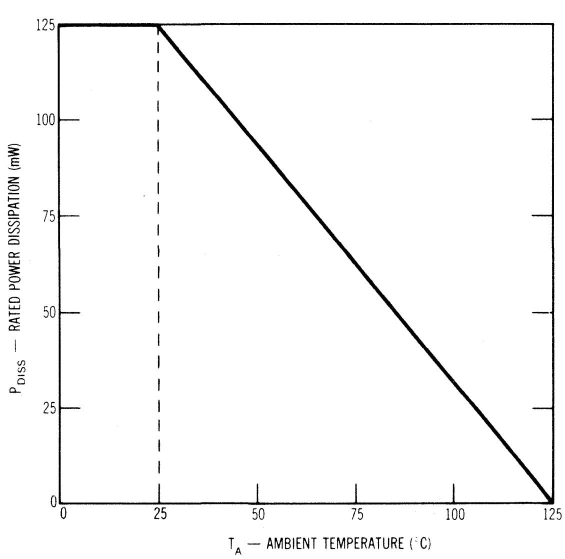


Figure 6. HP 2301 series dc power dissipation characteristics.

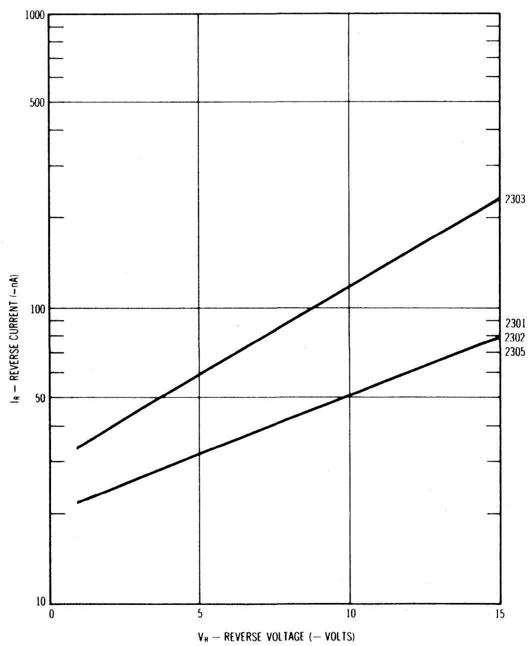


Figure 7. HP 2300 series typical reverse current vs. reverse voltage at T_A = 25°C.

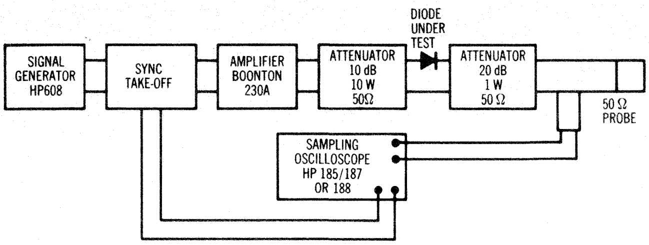


Figure 8a. Test setup.

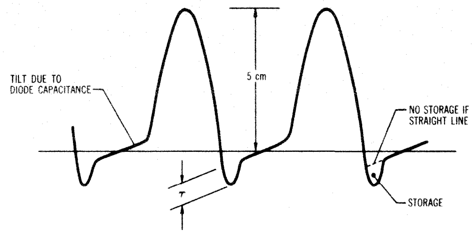


Figure 8b. Resulting oscilloscope display.

Figure 8. Effective minority carrier lifetime measurement.

The signal generator and power amplifier are adjusted to 54 MHz and the output level at 10 V RMS as read on the power amplifier meter. The sampling oscilloscope is adjusted so that the peak deflection corresponding to forward current is 5 cm or 20 mA, where 20 mV/cm = 4.0 mA/cm. Under these conditions, minority carrier lifetime is related to the amplitude designated as "τ" such that 1 cm corresponds to 500 ps. This scale will be linear to about 1.5 cm.

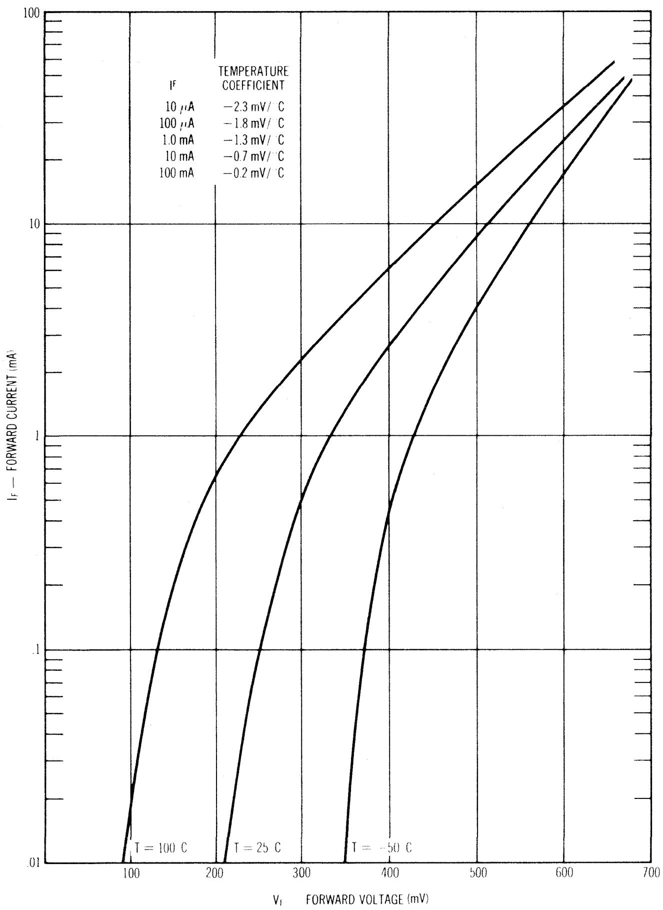
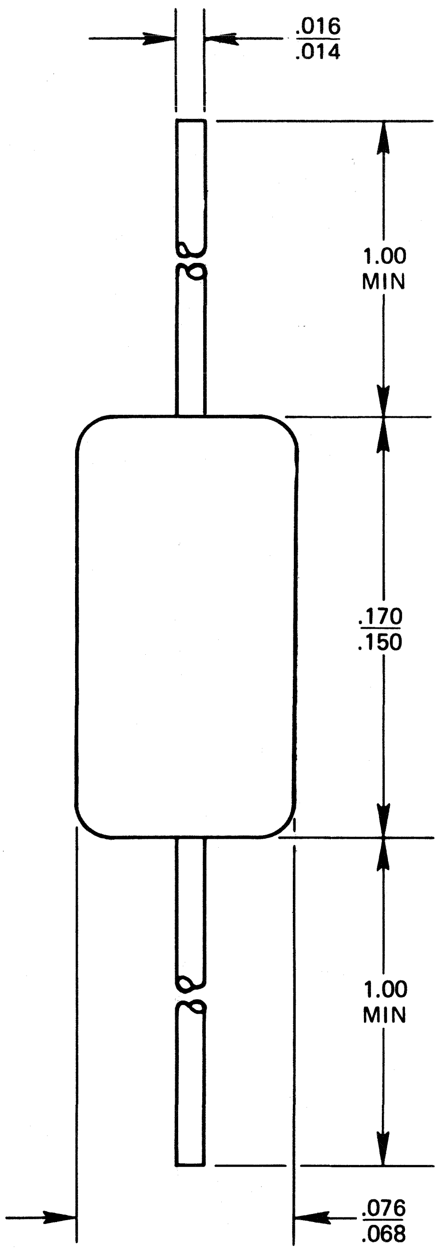


Figure 9. I-V curve showing typical temperature variation for HP 2300 series Hot Carrier Diodes.



HOT CARRIER DIODES

HP 5082-2350 SERIES

HCD-7

TECHNICAL DATA 1 JAN 70

Features

LOW 1/f NOISE—The 2350 series 3 dB 1/f noise temperature ratio at 100 Hz makes it a unique and superior device for narrow band video systems.

LOW NOISE FIGURES—The 6 dB NF attainable in the 2350 series makes it attractive for systems where the ultimate in signal recognition is necessary.

EXCELLENT ENVIRONMENTAL CAPABILITIES

Description

Hot Carrier Diodes employ a metal-silicon Schottky barrier junction and utilize electrons for majority carrier conduction. The hot carrier diode's performance conforms closely with theory and can be described as closely approximating the ideal diode. HP Application Note 907 contains additional detailed information.

Applications

HP's Hot Carrier Mixer and Detector Diodes are intended for use in applications requiring the ultimate in performance and reliability. Extensive testing has shown that these devices exhibit the design capability necessary to meet the general requirements of MIL-S-19500, in addition to the special reliability requirements of man-rated space systems.

As mixers they offer low and stable noise figure as well as high pulse burnout resistance. Their uniform and repeatable RF characteristics allow the designer a great deal of latitude in specifying his RF circuitry.

The diodes are also intended for use as small signal square law detectors, and in large signal power monitor applications.

Mechanical Specifications

The HP Outline 18 package has a glass hermetic seal with dumet leads. The leads on the Outline 18 package should be restricted so that the bend starts at least 1/16 inch from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E (4 lbs. tension for 30 minutes). The maximum soldering temperature is 230°C ± 5°C for 5 seconds. Outline 15 package inductance and capacitance is typically 3 nH and 0.07 pF, respectively.

Marking on all packages is by digital coding with a cathode band. Package style 19 (ferrule tips on the Outline 15 package) and style 20 (mechanically compatible with 1N21/23 cartridge) are also available on special request.

For more information, call your local HP Sales Office or East (201) 265-5000 • Midwest (312) 677-0400 • South (404) 436-6181 West (213) 877-1282. Or, write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe, 1217 Meyrin-Geneva

ABSOLUTE MAXIMUM RATINGS

	Units	2400	2500
Operating Temperature Range	°C	– 60 to + 125	– 60 to + 125
Storage Temperature Range	°C	– 60 to + 125	– 60 to + 125
CW Power Dissipation at $T_A = 25°C$	mW	200	200
Peak Power Dissipation (1 nsec pulse, 0.001 DF at $T_A = 25°C$)	Watt	15	4
Pulse Burnout (3 10-nsec pulses for 1 dB increase in NF_o)	ergs	25	15

HP HOT CARRIER MIXER DIODE SPECIFICATIONS at $T_A = 25°C$

Test Frequency†		2.0 GHz	3.0 GHz
$NF_o = 6.0$ dB	Single	2400	2565
	Pair*	2401	2566
	Quad*	-	-
$NF_o = 6.5$ dB	Single	2365	2550
	Pair*	2418	2551
	Quad*	-	2552
$NF_o = 7.0$ dB	Single	2350	2520‡
	Pair*	2351	2521‡
	Quad*	2374	2522‡
VSWR		1.5	1.5
Z_{IF} (ohms)		150-250	100-250

* Noise Figure Match ΔNF_O 0.3 dB max.
IF Impedance Match ΔZ_{IF} 25 ohms max.

† Test Conditions: The noise figure is measured at the specified test frequency and is a single sideband receiver noise figure using a 30 MHz, 1.5 dB Noise Figure IF amplifier. L.O. power is 1.0 mW.

‡ These units have a maximum guaranteed VSWR of 2.0.

TYPICAL PERFORMANCE CHARACTERISTICS

HP Type	Junction Capacitance C_{JO} pF	Series Resistance R_s ohms	NF_o Temperature Coefficient + dB/°C
2400	0.5 - 0.9	7 - 11	0.004
2500	0.3 - 0.7	3 - 6	0.004

RELIABILITY

Hewlett-Packard Hot Carrier Diodes are suitable for high reliability space applications where maximum performance stability under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of these diodes in major aerospace and national defense programs.

ENVIRONMENTAL CHARACTERISTICS

	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	See maximum ratings
Temperature, Operating	—	See maximum ratings
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, – 65° to + 125°C
Thermal Shock	1056	5 cycles, 0-100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, X_1, Y_1, Y_2, at 1500 G
Vibration Fatigue	2046	32 hrs, X, Y, Z at 20 G min.
Vibration Variable Frequency	2056	4, 4-min. cycles, X, Y, Z, at 20 G min., 100 to 2000 Hz
Constant Acceleration	2006	X_1, Y_1, Y_2 at 20,000 G
Terminal Strength	2036	Package dependent
Salt Atmosphere	1041	35°C fog for 24 hours

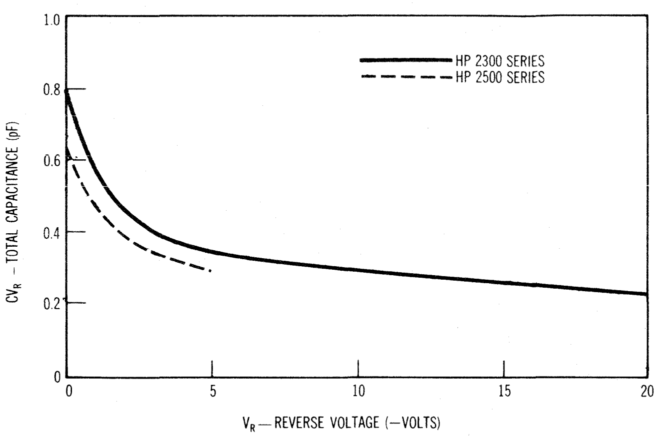


Figure 1. Typical Capacitance vs. Reverse Bias Voltage Characteristics at $T_A = 25°C$.

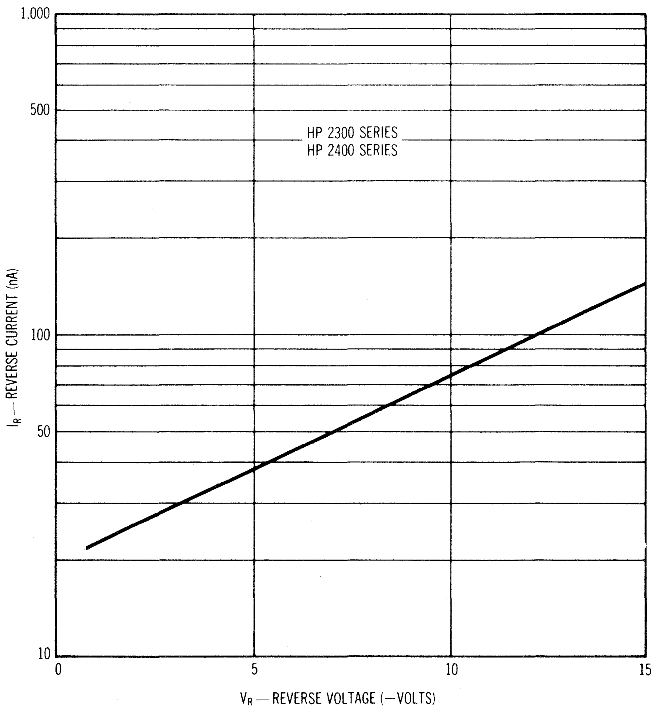


Figure 2. Typical HP 2300 and HP 2400 Series Reverse Current vs. Reverse Voltage Characteristics at $T_A = 25°C$.

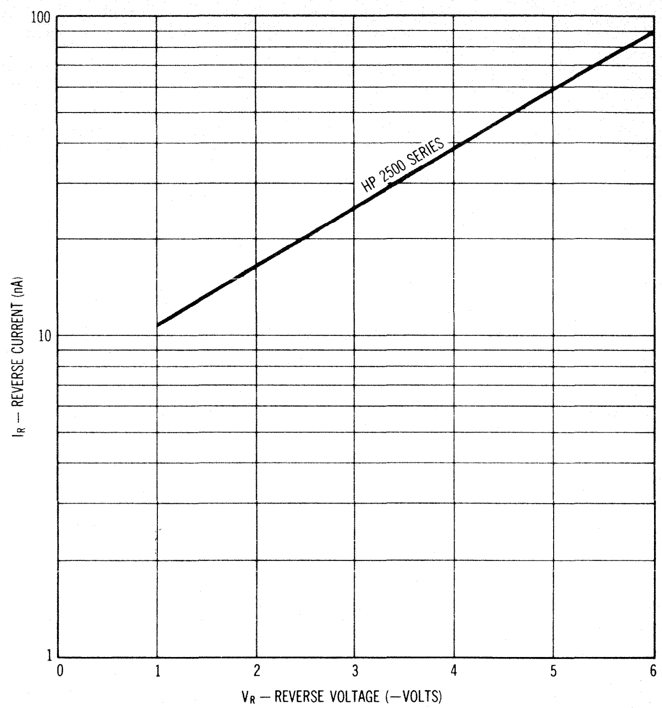


Figure 3. Typical HP 2500 Series Reverse Current vs. Reverse Voltage Characteristics at $T_A = 25°C$.

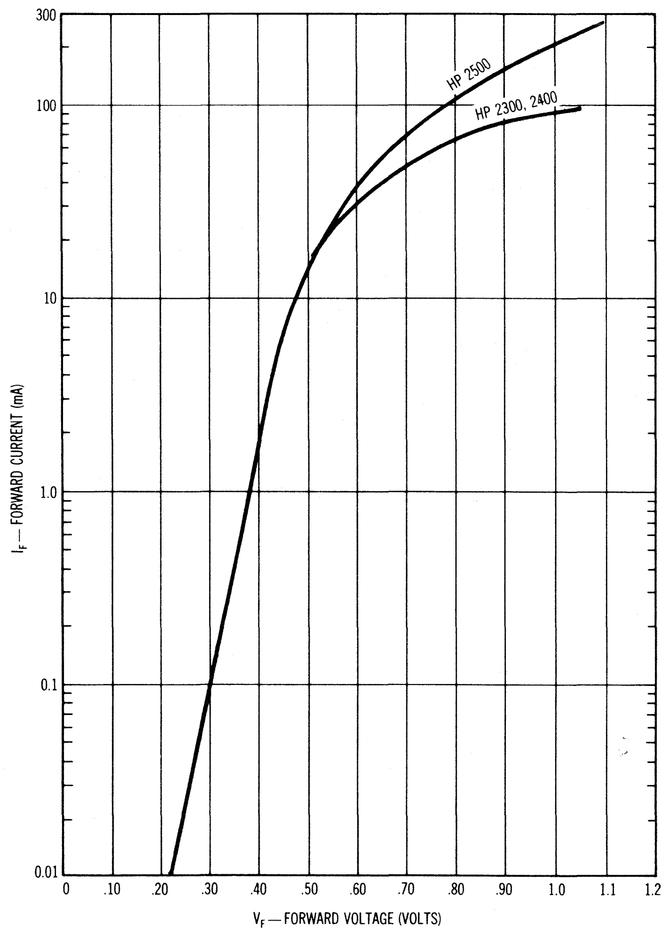


Figure 4. Typical Forward Current vs. Forward Voltage Characteristics at $T_A = 25°C$.

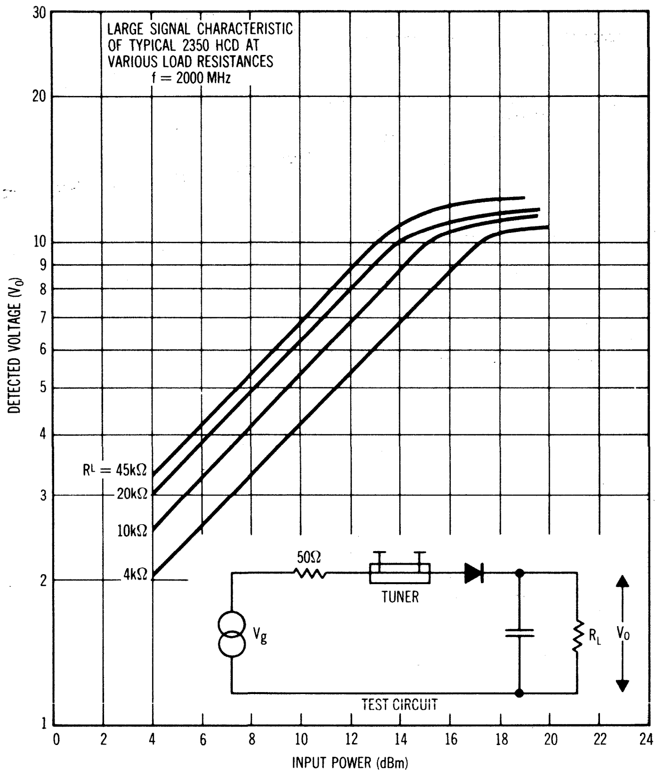


Figure 5. Typical HP 2350 Large Signal Detector Characteristics at $T_A = 25°C$.

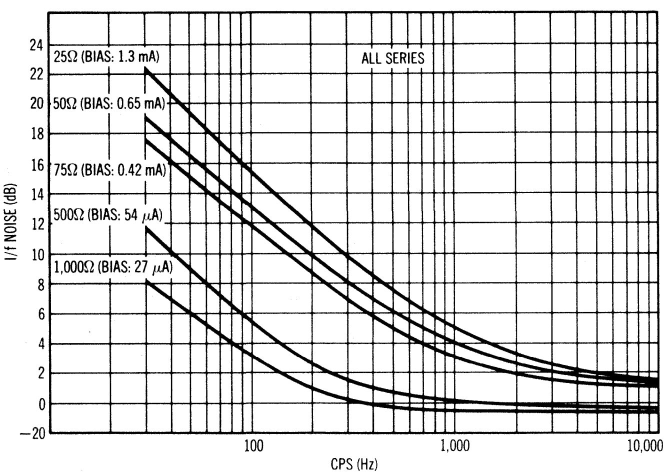


Figure 6. Typical Hot Carrier Diode Flicker (I/f) Noise Characteristics at $T_A = 25°C$.

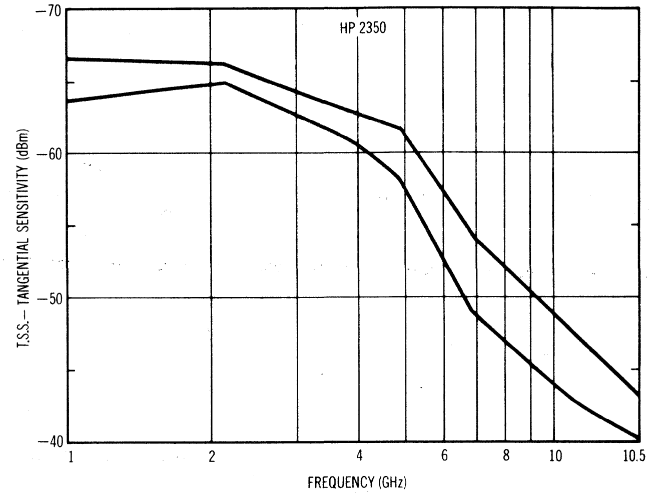


Figure 7. Minimum and Maximum Tangential Sensitivity of 50 Typical HP 2350 Hot Carrier Diodes.

Amplifier Noise Resistance ....200 ohms
Bandwidth ....100 kHz
Input Resistance ....25 k ohms
Input Capacitance ....15 pF

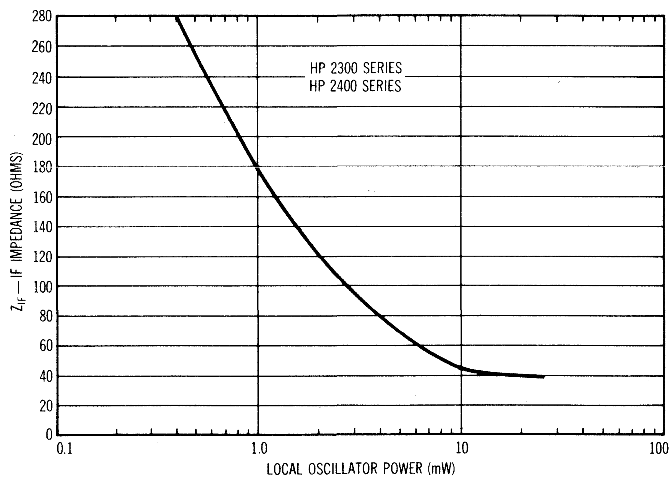


Figure 8. Typical HP 2300 and HP 2400 Series IF Impedance vs. Local Oscillator Power with $f_{LO} = 2.0$ GHz and $f_{IF} = 30$ MHz.

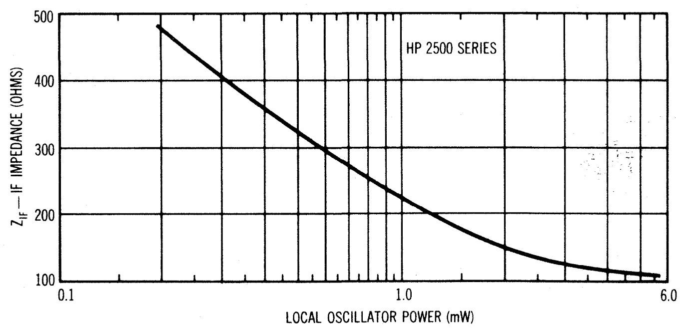


Figure 9. Typical HP 2500 Series IF Impedance vs. Local Oscillator Power at $f_{LO} = 3.0$ GHz and $f_{IF} = 30$ MHz.

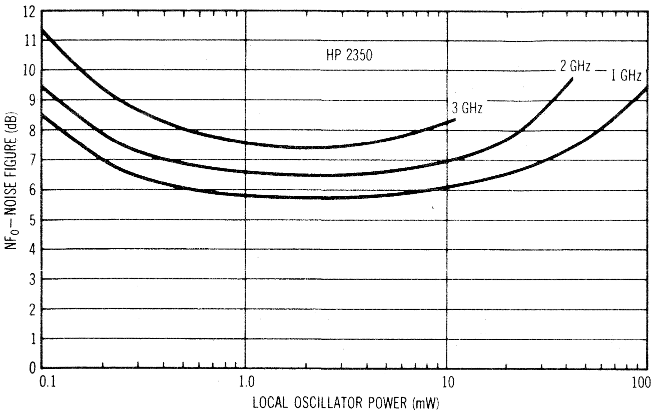


Figure 10. Typical HP 2350 Noise Figure vs. Local Oscillator Power at 1.0, 2.0, and 3.0 GHz with f_{IF} = 30 MHz and NF_{IF} = 1.5 dB.

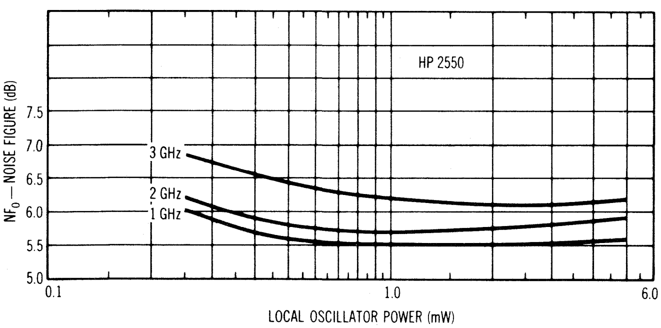


Figure 11. Typical HP 2550 Noise Figure vs. Local Oscillator Power at 1.0, 2.0, and 3.0 GHz with f_{IF} = 30 MHz and NF_{IF} = 1.5 dB.

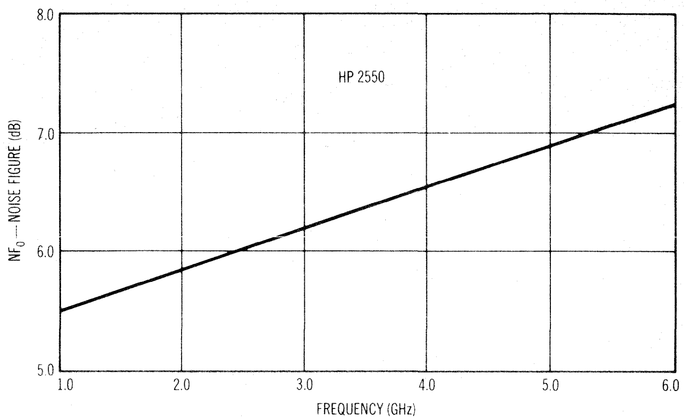


Figure 12. Typical HP 2550 Noise Figure vs. Frequency with P_{LO} = 1.0 mW, f_{IF} = 30 MHz, and NF_{IF} = 1.5 dB.

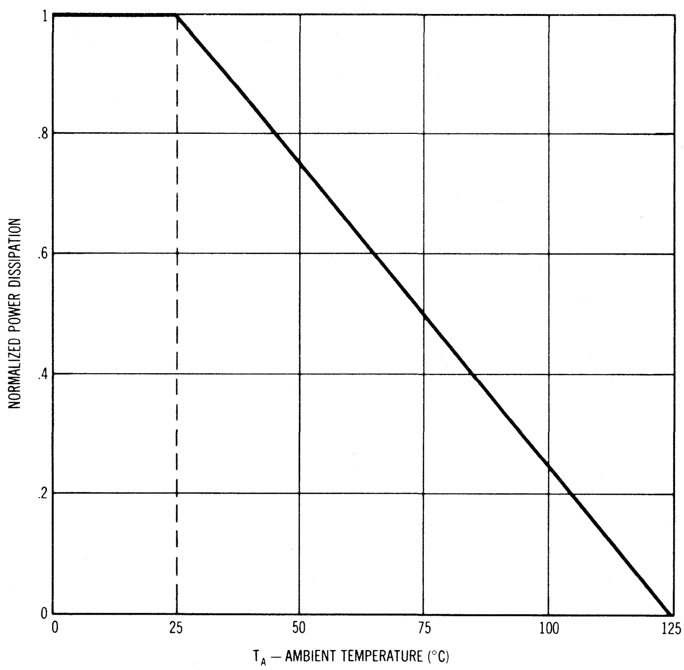


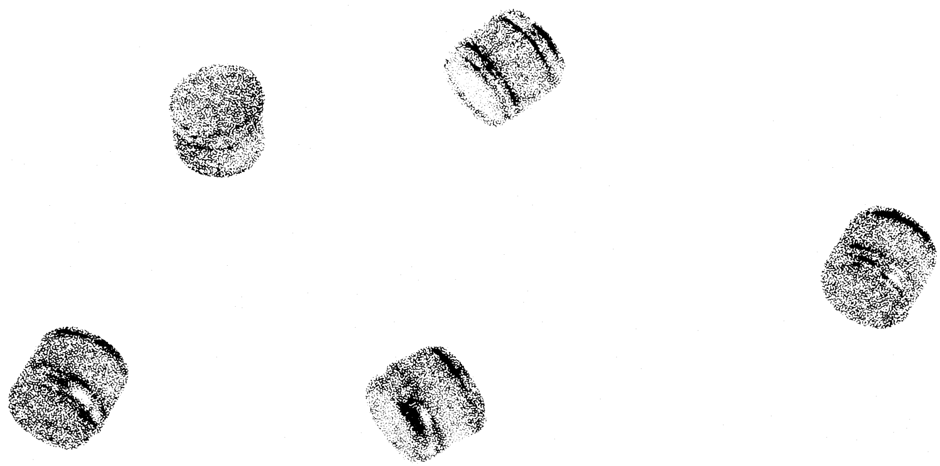
Figure 13. Power Derating Characteristics.

HEWLETT PACKARD

Hot Carrier Diodes

HP 5082-2700 series

X-Band Mixer and Detector Diodes



6.0 dB NF_o at X-band with 1.0 mW L.O. Power

−53 dBm T.S.S. at X-band

Low Parasitic, Symmetrical Microminiature Package

Planar Passivated Construction with Thermo-compression Bond

−60°C to +150°C Storage and Operating Temperature Range

0.13 pF Typical Zero Bias Chip Capacitance

HP 5082-2700 series hot carrier diodes are constructed using a metal semiconductor Schottky barrier junction. Advanced epitaxial techniques and precise process control insure uniformity and repeatability of this planar, . . .

surface-passivated microwave semiconductor. The chip is mounted in a symmetrical, microminiature, hermetically sealed, ceramic package. Anode contact is made by a thermocompression bonded gold-plated ribbon. This construction allows the device to be used in environments requiring reliable performance during high shock and vibration.

APPLICATIONS

Low package inductance and capacitance, typically 0.3 nH and 0.1 pF respectively, make this device especially useful in broadband mixer and small signal detector applications at frequencies above and below X-band. Typical T.S.S. at 10 GHz is − 53 dBm with a 40 μA bias current and using an A.E.L. Model 153A Video Amplifier with 5 MHz bandwidth. The microminiature, symmetrical package meets the design engineer's needs for forward or reverse pairs in balanced mixer configurations and is ideally suited for stripline, coaxial, or waveguide mixer designs.

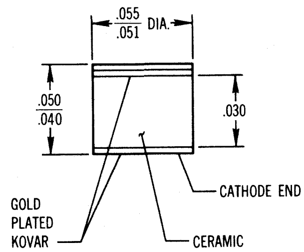
ABSOLUTE MAXIMUM RATINGS

P_{DISS} (1)—CW Power Dissipation ....100 mW
T_{OPR} (2)—Operating Temperature Range − 60°C to + 150°C
T_{STG}—Storage Temperature Range ....− 60°C to + 150°C
(1) At a case temperature of 25°C.
(2) Derates to zero power dissipation at 150°C.

ELECTRICAL SPECIFICATIONS AT T_A = 25°C

Single Sideband Noise Figure*		HP Type Number	Prices 1-9	Prices 10-99
6.0 dB	Single	5082-2701	$ 57.00	$48.00
	Pair†	-2706	117.00	99.00
6.5 dB	Single	-2702	40.00	36.00
	Pair†	-2707	83.00	75.00
7.0 dB	Single	-2703	35.00	32.50
	Pair†	-2708	73.00	67.00

VSWR = 1.5 max. and Z_{IF}** = 250-400 Ω for all types.



Dimensions in inches

Outline 44

* The noise figure is specified at 9.375 GHz and is a single sideband receiver Noise Figure using a 1.5 dB IF amplifier. Local oscillator power is 1.0 mW.
** The IF Impedance is measured at 30 MHz with the diode mounted in a waveguide test fixture and biased with 1.0 mW local oscillator power.
† Noise Figure Match: ΔNF_O = 0.3 dB max.
IF Impedance Match: ΔZ_{IF} = 25 ohms max.

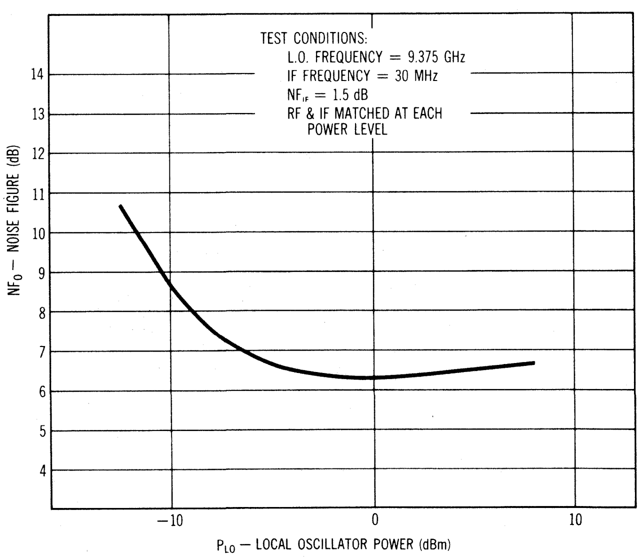


Figure 1. HP 5082-2702 typical noise figure versus local oscillator power.

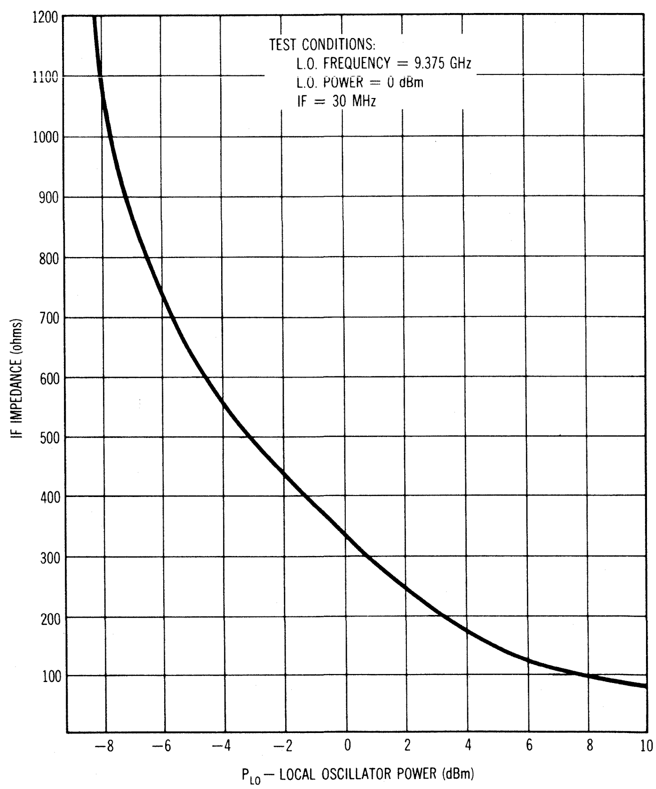


Figure 2. HP 5082-2700 series typical IF impedance versus local oscillator power.

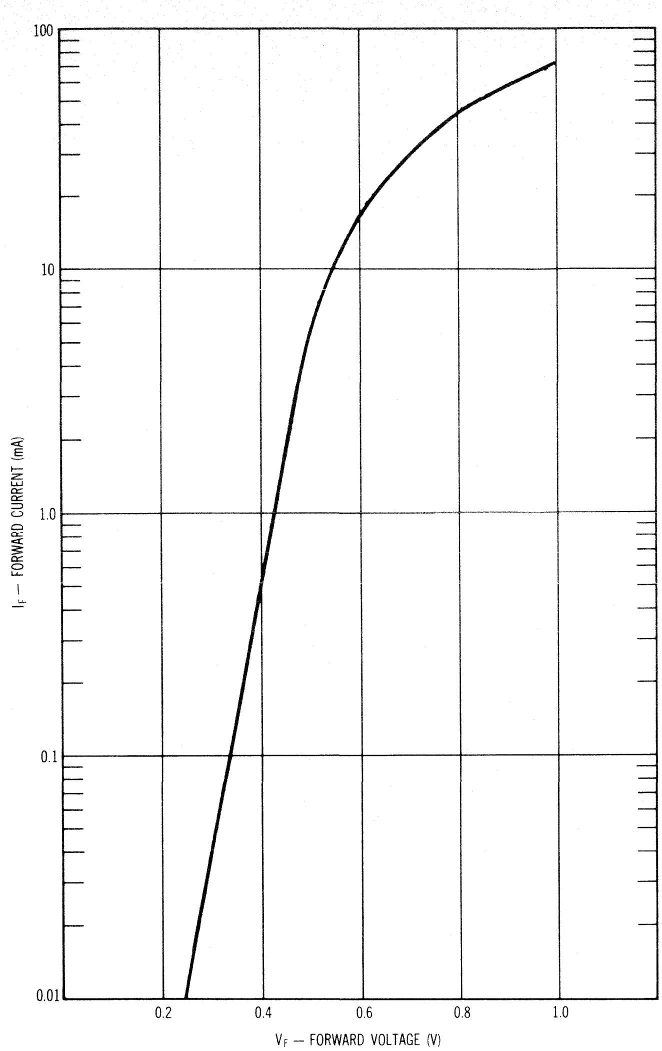


Figure 3. HP 5082-2700 series typical forward current versus forward voltage at $T_A = 25°C$.

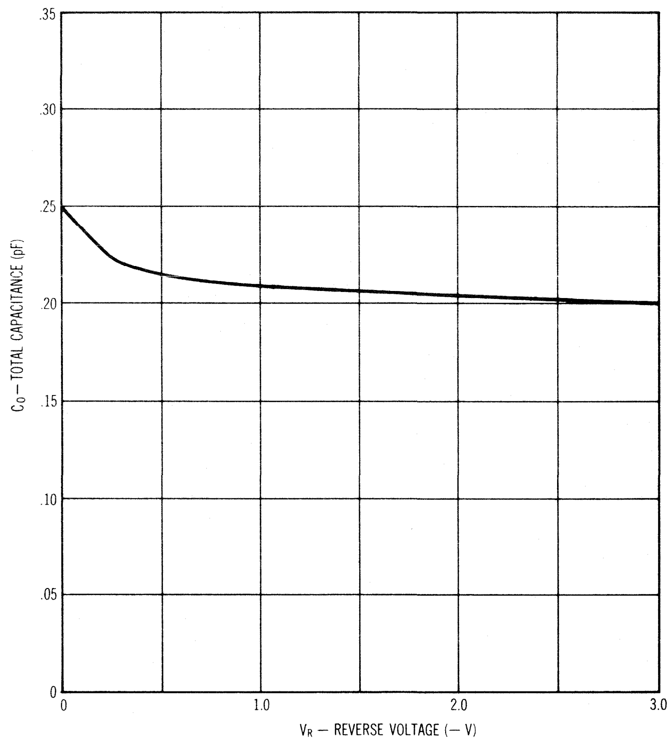


Figure 4. HP 5082-2700 series typical reverse bias capacitance at $T_A = 25°C$.

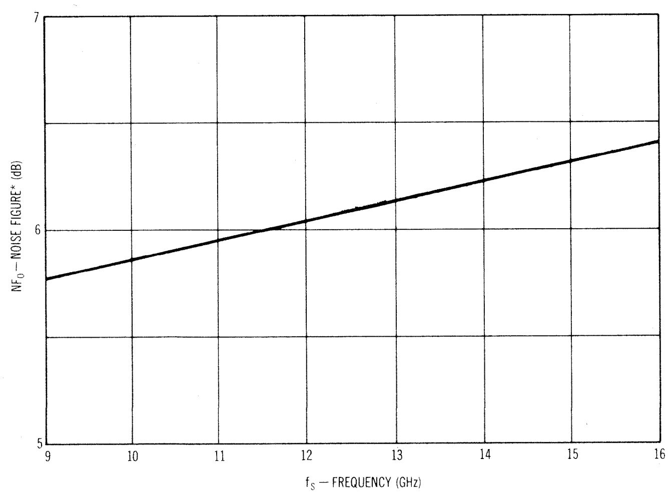
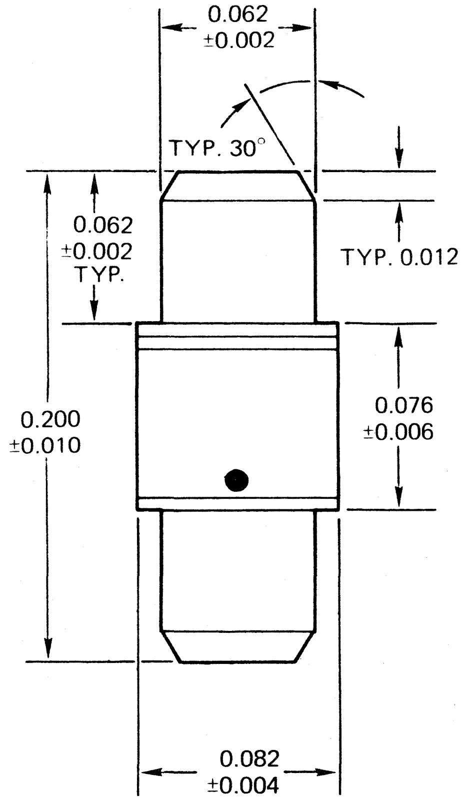


Figure 5. HP 5082-2701 typical single sideband noise figure versus frequency with IF = 30 MHz, $NF_{IF} = 1.5$ dB and $P_{LO} = 1.0$ mW.

HEWLETT hp PACKARD

MICROWAVE MIXER HOT CARRIER DIODES

HP 5082-2711, 2712, 2713, 2714 series



Cathode end indicated by black dot.
All dimensions in inches.

- LOW AND STABLE NOISE FIGURE
  6.0 dB at 10 GHz
- HIGH BURNOUT
  10 erg
- THERMO-COMPRESSION BONDED CHIP
  withstands high shock and vibration
- RUGGED, HERMETICALLY SEALED
  METAL CERAMIC PACKAGE

Description

The HP 5082-2711/12/13/14 diode series are Silicon Hot Carrier (Schottky-barrier) Diodes of planar, epitaxial, passivated structure. A new processing technique is applied to produce a diode family with extremely uniform electrical characteristics. A very tight tolerance in junction capacitance and a minimized series resistance provide a uniform RF-impedance from diode to diode at X-Band frequencies and in addition the low and stable noise figure characteristics are realized.

In the rugged, hermetically sealed metal ceramic package the conventional cat whisker has been replaced by the more reliable thermo-compression bond.

Applications

This series is designed for use in such applications as X-Band ECM and radar receiver front ends where high power and sensitivity are required for either airborne or shipboard use or where nanosecond pulse leakages from dc tubes or antennas are present and which may damage conventional point contact diodes.

Typical Electrical Characteristics at 25°C

Breakdown Voltage, at $I_R = 10\ \mu A$ .... 4 V

Forward Current, at $V_F = 1$ V .... 60 mA

Chip Capacitance, at $V_R = 0$ V .... 0.11 pF

Package Capacitance .... 0.15 pF (Note 7)

Series Resistance, at $I_F = 10$ mA .... 5 Ω

Series Inductance .... 1.0 nH (Note 8)

Maximum Ratings at 25°C

Burnout Energy .... 10 erg (Note 1)

CW Power Dissipation (RF) .... 200 mW (Note 2, 3)

DC Forward Current .... 100 mA (Note 3)

Reverse Voltage .... 2 V

Operating Junction Temp. Range .... −60 to +150°C

Storage Temperature Range .... −60 to +150°C

Electrical Specifications at 25°C

Model Number single unit matched pair[6]	5082-2713 5082-2714			5082-2711 5082-2712				
	Min.	Typ.	Max.	Min.	Typ.	Max.	Units	Notes
Noise Figure	—	5.7	6.0	—	6.1	6.5	dB	4 5
VSWR	—	1.3	2.0	—	1.6	2.0	—	4
IF - Impedance	200	250	400	200	280	400	Ω	4

NOTES

1. Single discharge of Torrey Line. During first 2.4 ns current flow in forward direction. Criterion for burnout energy: 3 dB increase in noise figure. The burnout energy for a 1 dB increase in noise figure is typically 5 erg.
2. Power absorbed by the diode. Frequency range: X-band. DC load resistance < 1Ω. Cathode stud is connected to infinite heat sink.
3. Maximum ratings derate linearly for increasing ambient temperature.
4. Measurements are performed on the diode in a fixed mount which has been tuned to an average diode.

Local oscillator power	1 mW
Local oscillator frequency	9.375 GHz
IF - frequency	30 MHz
DC load resistance	< 10 Ω

5. Single sideband receiver noise figure including an IF - amplifier noise figure of 1.5 dB.
6. Noise Figure Match $\Delta\ NF \leq 0.3$ dB
   IF Impedance Match $\Delta\ Z_{IF} \leq 25\ \Omega$
7. The capacitance Cp of this package is defined as
   $$Cp = \Delta C + 0.015 \text{ pF}$$
   where Δ C is the difference of the capacitances between two parallel conducting planes spaced at the distance of 0.076 inch when the diode with open circuited chip (bonding wire in place but not connected) is mounted and when the diode is removed.
8. Series inductance of a coaxial line section consisting of the diode with short circuited chip as inner conductor and an outer conductor of 0.18 inch diameter. The ends of the coaxial line are defined by the planes in which the step in the stud diameter from 0.082 inch to 0.062 inch occurs (geometrical length of line 0.076 inch).

These specifications are based on data taken on preproduction devices. Final specifications are subject to change without prior notice.

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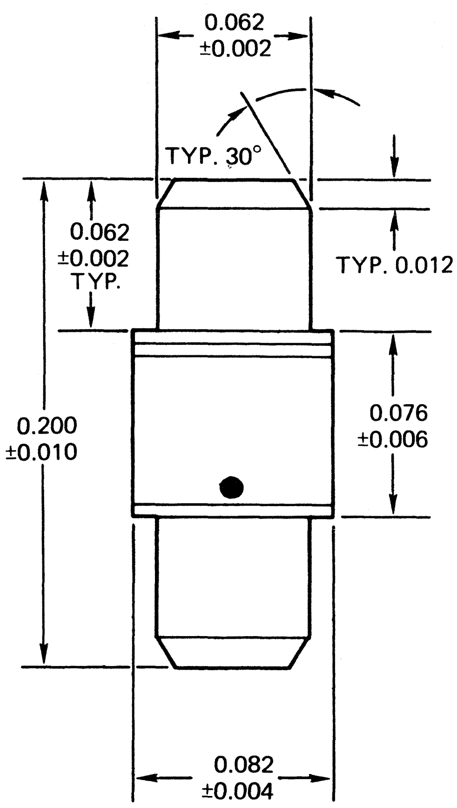
MICROWAVE MIXER HOT CARRIER DIODES

HP 5082-2721, 2722, 2723, 2724 series



Cathode end indicated by black dot.
All dimensions in inches.

- LOW AND STABLE NOISE FIGURE
  6.5 dB at 16 GHz
- HIGH BURNOUT
  10 erg
- THERMO-COMPRESSION BONDED CHIP
  withstands high shock and vibration
- RUGGED, HERMETICALLY SEALED METAL CERAMIC PACKAGE

Description

The HP 5082-2721/22/23/24 diode series are Silicon Hot Carrier (Schottky barrier) Diodes of planar, epitaxial, passivated structure. A new processing technique is applied to produce a diode family with extremely uniform electrical characteristics. A very tight tolerance in junction capacitance and a minimized series resistance provide a uniform RF-impedance from diode to diode at Ku-Band frequencies and in addition the low and stable noise figure characteristics are realized.

In the rugged, hermetically sealed metal ceramic package the conventional cat whisker has been replaced by the more reliable thermo-compression bond.

Applications

This series is designed for use in Ku-band receivers where ultimate sensitivity (low noise figure) is required and where shock and vibration or spikes leaking through the TR-tube might damage a conventional point-contact diode.

The uniform RF-impedance and the symmetrical package make these diodes specially suitable for operation in balanced mixers. Closely matched pairs (2722, 2724) are available.

Typical Electrical Characteristics at 25°C

Breakdown Voltage, at $I_R = 10\ \mu A$ .... 4 V

Forward Current, at $V_F = 1$ V .... 60 mA

Chip Capacitance, at $V_R = 0$ V .... 0.11 pF

Package Capacitance .... 0.15 pF (Note 8)

Series Resistance, at $I_F = 10$ mA .... 5 Ω

Series Inductance .... 1.0 nH (Note 9)

Electrical Specifications at 25°C

Model Number single unit matched pair[7]	5082-2723 5082-2724		5082-2721 5082-2722			
	Min.	Max.	Min.	Max.	Units	Notes
Noise Figure	—	6.5	—	7.0	dB	4 5
VSWR	—	1.5	—	2.0	—	4
IF-Impedance	175	350	175	350	Ω	4 6

Maximum Ratings at 25°C

Burnout Energy .... 10 erg (Note 1)

CW Power Dissipation (RF) .... 200 mW (Note 2, 3)

DC Forward Current .... 100 mA (Note 3)

Reverse Voltage .... 2 V

Operating Junction Temp. Range .... −60 to +150°C

Storage Temperature Range .... −60 to +150°C

NOTES

1. Single discharge of Torrey Line. During first 2.4 ns current flow in forward direction. Criterion for burnout energy: 3 dB increase in noise figure. The burnout energy for a 1 dB increase in noise figure is typically 5 erg.
2. Power absorbed by the diode. Frequency range: Ku-band. DC load resistance $< 1\Omega$. Cathode stud is connected to infinite heat sink.
3. Maximum ratings derate linearly for increasing ambient temperature.
4. Measurements are performed on the diode in a fixed mount which has been tuned to an average diode.

Local oscillator power	1 mW
Local oscillator frequency	16 GHz
IF-frequency	30 MHz
DC load resistance	$< 10\ \Omega$

5. Single sideband receiver noise figure including an IF-amplifier noise figure of 1.5 dB.
6. Measurement performed at 30 MHz.
7. Noise Figure Match $\Delta NF \leq 0.3$ dB
   IF Impedance Match $\Delta Z_{IF} \leq 25\ \Omega$
8. The capacitance Cp of this package is defined as
   $$Cp = \Delta C + 0.015 \text{ pF}$$
   where ΔC is the difference of the capacitances between two parallel conducting planes spaced at the distance of 0.076 inch when the diode with open circuited chip (bonding wire in place but not connected) is mounted and when the diode is removed.
9. Series inductance of a coaxial line section consisting of the diode with short circuited chip as inner conductor and an outer conductor of 0.18 inch diameter. The ends of the coaxial line are defined by the planes in which the step in the stud diameter from 0.082 inch to 0.062 inch occurs (geometrical length of line 0.076 inch).

These specifications are based on data taken on preproduction devices. Final specifications are subject to change without prior notice.

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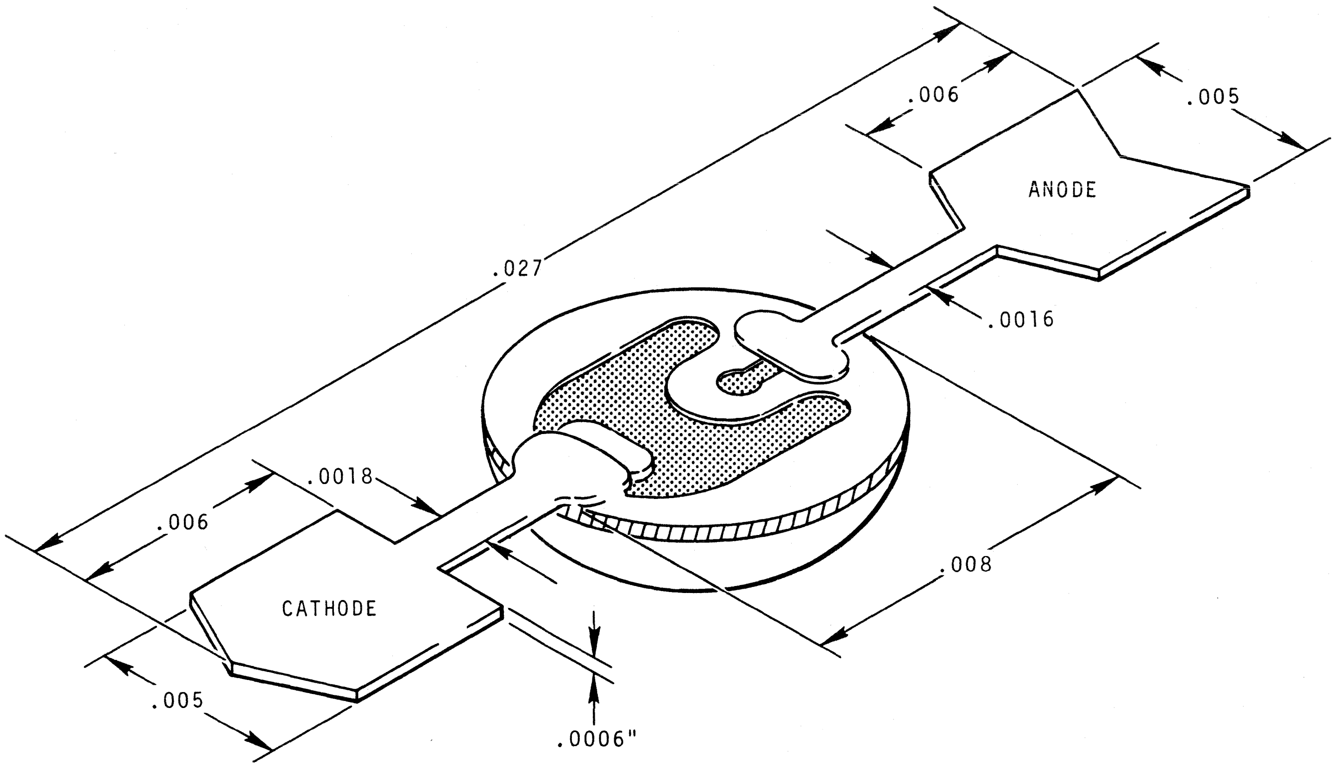
HOT CARRIER DIODE HP 5082-2740



Description

Beam lead Hot Carrier Diodes are constructed using a metal semiconductor Schottky barrier junction. Advanced epitaxial techniques and precise process control insure uniformity and repeatability of this planar surface-passivated microwave semiconductor.

During manufacturing, gold leads are deposited before the wafer is cut into dice. This manufacturing process results in a mechanically rugged unit.

Applications

The diode can be mounted in a stripline or microstrip circuit using conventional soldering, welding, thermal compression bonding, and ultrasonic bonding.

ABSOLUTE MAXIMUM RATINGS:

T_{OPR}—Operating Temperature Range......−60°C to +150°C
T_{STG}—Storage Temperature Range..........−60°C to +150°C
Maximum Pull on Any Lead..2 grams
Diode Mounting Temperature..........220°C for 10 sec. max.

ELECTRICAL CHARACTERISTICS

V_{BR} at $I_R = 10\ \mu A$..3 volts min.
C_O at $V_R = 0$ V, f = 1.0 MHz...................................0.3 pF max.
V_F at $I_F = 30$ mA..1.0 volt max.

TYPICAL CHARACTERISTICS

Single Sideband Noise Figure..................................$\leq$ 6.5 dB

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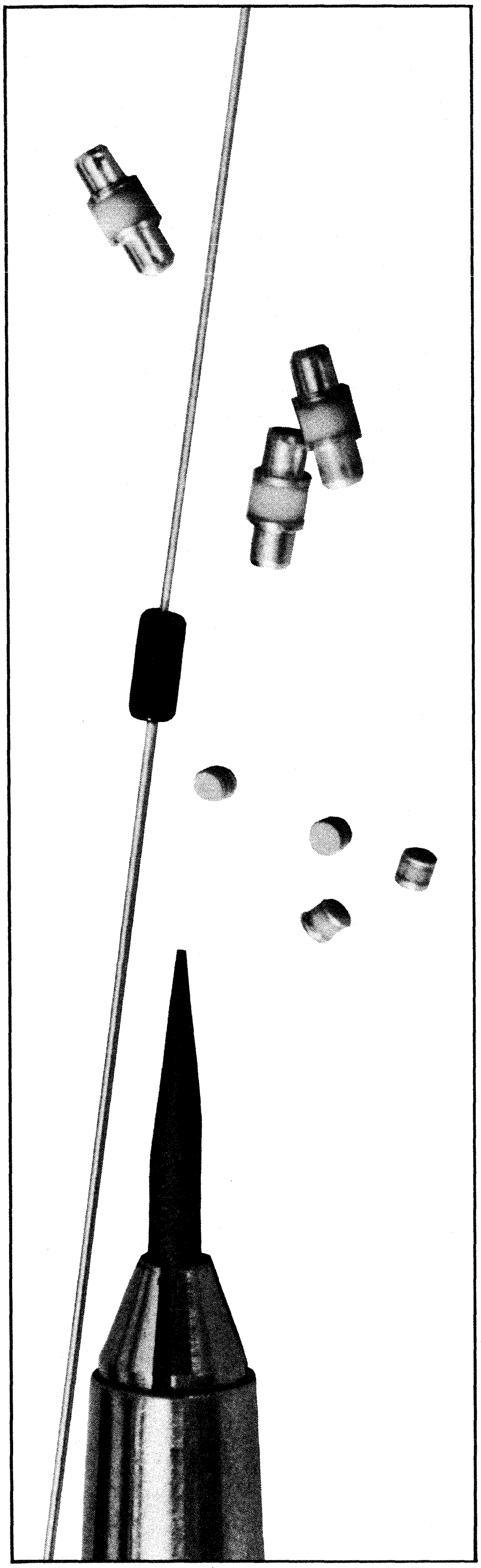
HOT CARRIER DIODES

model 5082-2750 series



- Typical TSS of −60 dBm at 10 GHz
- High peak power handling capability
- Low 1/f noise for zero IF mixer and detectors requiring low frequency response
- Metal-ceramic packages for ease of handling without breakage
- Bonded contacts for operation in rugged environments

Description

The HP 5082-2750 series Hot Carrier Diodes are constructed using a metal semiconductor Schottky barrier junction. Advanced epitaxial techniques and precise process control ensure uniformity and repeatability of this planar, surface-passivated microwave semiconductor.

Applications

Typical applications include video detectors, square-law detectors, peak detectors, power monitors, zero-IF mixers, and RF modulators. Application information for use as video detectors is available in HP Application Note 923.

Absolute Maximum Ratings

P_{DISS}—DC Power Dissipation (Note 1)........................100 mW

T_{OPR}—Operating Temperature Range (Note 2) ....—60° to 150°C

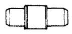
T_{STG}—Storage Temperature Range ....—60° to 150°C

P_{MAX}—Maximum Absorbed RF Peak Pulse Power (Note 3) ....1.0 W

Typical Parameter Values

	Package Outline 18	49	44
C_p—Package Capacitance	0.1 pF	0.15 pF	0.13 pF
L_p—Package Inductance	2 nH	1 nH	0.3 nH
R_s—Series Resistance	25 Ω	25 Ω	25 Ω
R_j—Junction Resistance	—	28/I(mA)	—
$C_{j(o)}$—Junction Capacitance (zero bias)	0.08 pF	0.08 pF	0.08 pF

RF Specifications at $T_A = 25°C$

Package Type		Style	Type Numbers			
	Glass	18	5082-2755		5082-2759	
	Double Stud	49	5082-2751		5082-2752	
	Pill	44	5082-2750		5082-2758	
Parameter	**Symbol**	**Units**	**Min.**	**Max.**	**Min.**	**Max.**
Tangential Signal Sensitivity @ 375 kHz Video Bandwidth	TSS	—dBm	58.5	—	55.5	—
@ 2 MHz Video Bandwidth (Note 4)	TSS	—dBm	55	—	52	—
Voltage Sensitivity (Note 5)	γ	mV/μW	5.0	—	3.5	—
Video Resistance (Note 5)	R_V	kΩ	1.2	1.6	1.1	1.8

Typical Performance Data at 25°C:

Symbol	Parameter	Typical	Units	Conditions
TSS	Tangential Signal Sensitivity	60	dBm	$f_{RF} = 10$ GHz $R_A = 500\ \Omega$ $I_B = 20\ \mu A$ $B_V = 0.375$ MHz
NF_O	Single Sideband Noise Figure	7.0	dB	$P_{LO} = 1.0$ mW $f_{RF} = 9.375$ GHz $f_{IF} = 30$ MHz $NF_{IF} = 1.5$ dB
N_{TR}	Noise Temperature Ratio	5.0 15.0	dB dB	f = 20 kHz f = 1 kHz $R_V = 50\ \Omega$ both cases
V_{BR}	Breakdown Voltage	6.0	V	$I_R = 10\ \mu A$
C_{jo}	Chip Capacitance	0.08	pF	f = 1.0 MHz $V_R = 0$ V
R_s	Series Resistance	25	Ω	$I_F = 50\ \mu A$ to 1.0 mA

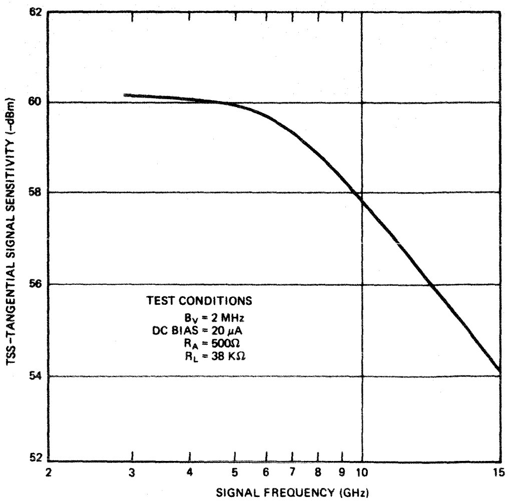


Figure 1. TSS vs. Frequency (typical HP 5082-2755)

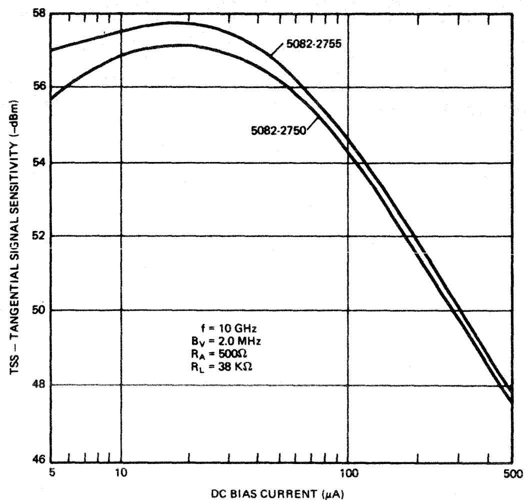


Figure 2. TSS vs. Bias (typical HP 5082-2750 and 2755)

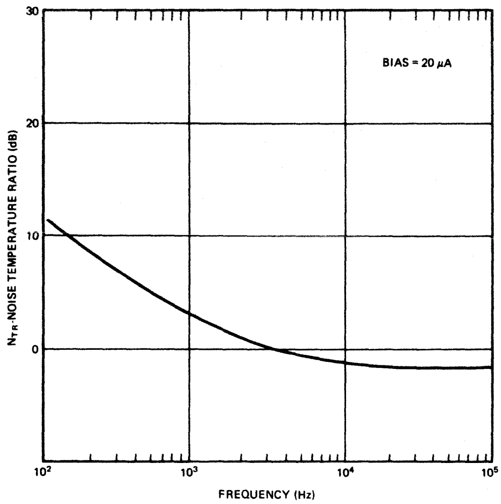


Figure 3. Noise Temperature Ratio vs. Frequency (typical HP 5082-2750 and 2755)

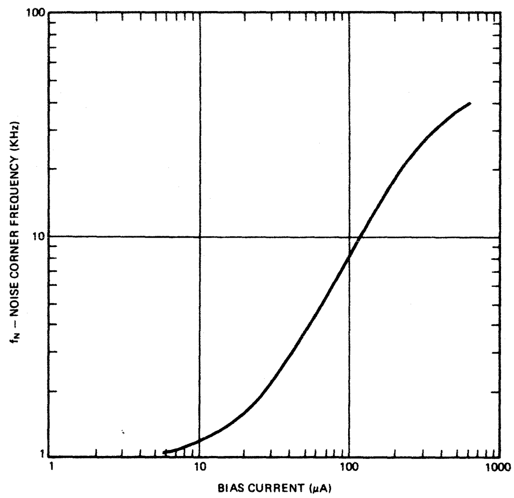


Figure 4. Noise Corner Frequency vs. Bias for Typical Diode

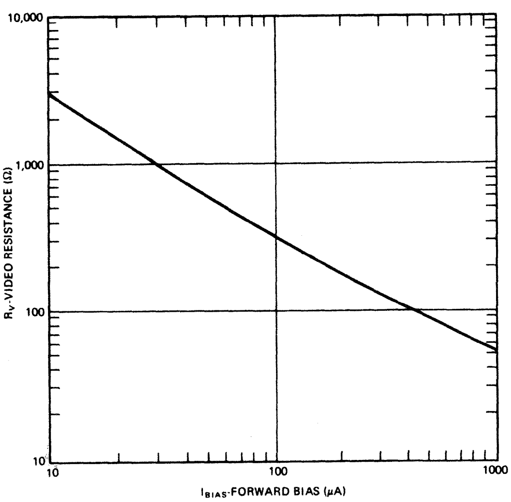


Figure 5. R_V vs. Bias (typical HP 5082-2755)

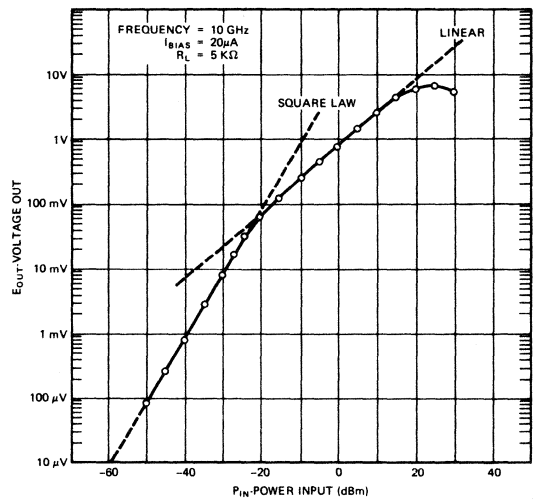


Figure 6. Dynamic Transfer Characteristic (typical HP 5082-2755)

NOTES:

1. At a case temperature of 25°C.
2. Derates linearly to zero power dissipation at 150°C.
3. Pulse width = 1 μs. Repetition Rate = 1000 pps. Test Time = 30 sec. Frequency = 1 - 10 GHz.
4. **Test Conditions for TSS:** RF Signal: 10 GHz, Diode DC. Bias: 20 μA, Video Amplifier Equivalent Noise Resistance: 500 Ω, Test Set-up per Figure 9.
5. **Test Conditions for γ and R_V:** As in Note 4 and at an RF Signal Power level of —40 dBm.

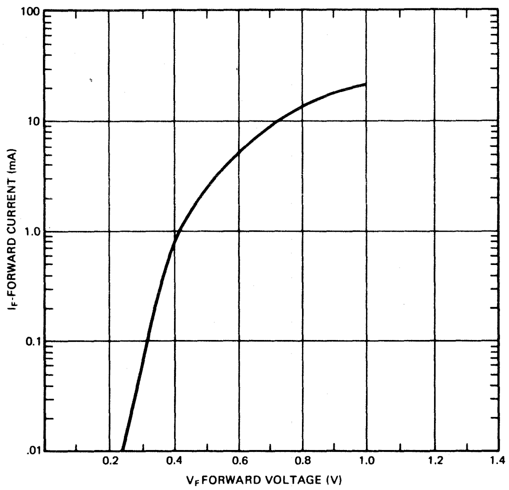


Figure 7. Forward VI Characteristic (typical HP 5082-2750)

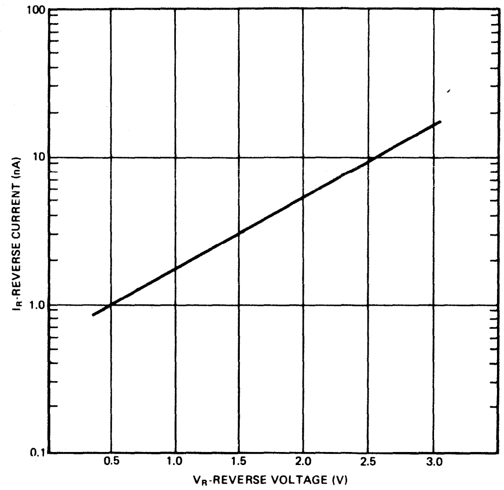


Figure 8. Reverse VI Characteristic (typical HP 5082-2750 @ T = 25°C)

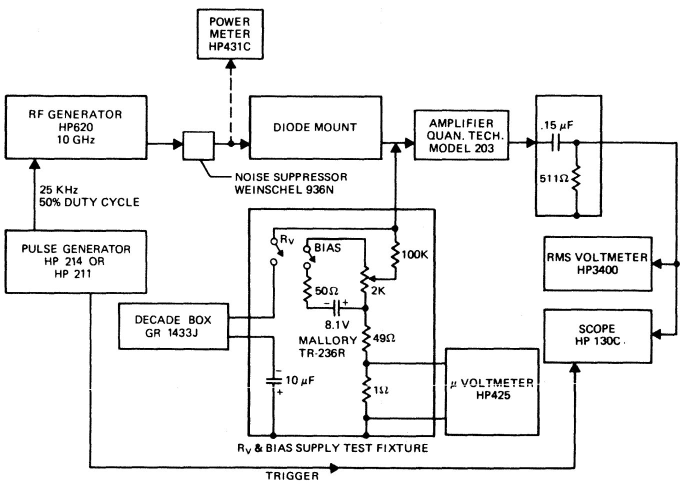


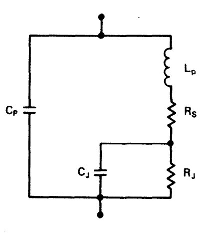
Figure 9. Test Set-up for TSS, γ, and R_V

Package Characteristics

The HP Outline 18 package has a glass hermetic seal with dumet leads which should be restricted so that the bend starts at least 1/16 inch (1,6 mm) from the glass body. With this restriction, it will meet MIL-STD-750, Method 2036, Conditions A and E (4 lb [1,8 kg] tension for 30 minutes). The maximum soldering temperature is 230°C ±5°C for 5 seconds. Marking is by digital coding with a cathode band.

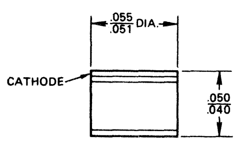
The HP Outline 49 package has a metal-ceramic hermetic seal. The anode and cathode studs are gold-plated Kovar. The maximum soldering temperature is 230°C ±5°C for 5 seconds. Stud-stud T/R is 0.010 inch max. Marking is by color-coded dots on ceramic; clockwise when facing cathode, starting at open space.

The HP Outline 44 package: The anode and cathode are gold-plated Kovar. The maximum soldering temperature is 230°C ±5°C for 5 seconds. This package is not marked.

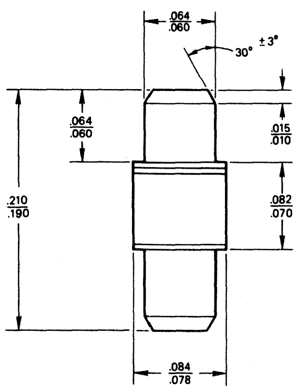


DIODE EQUIVALENT CIRCUIT

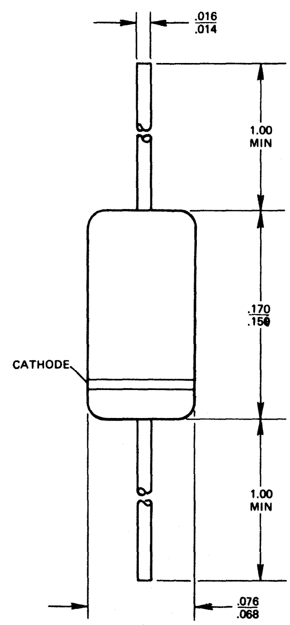
All dimensions in inches



OUTLINE 44



OUTLINE 49



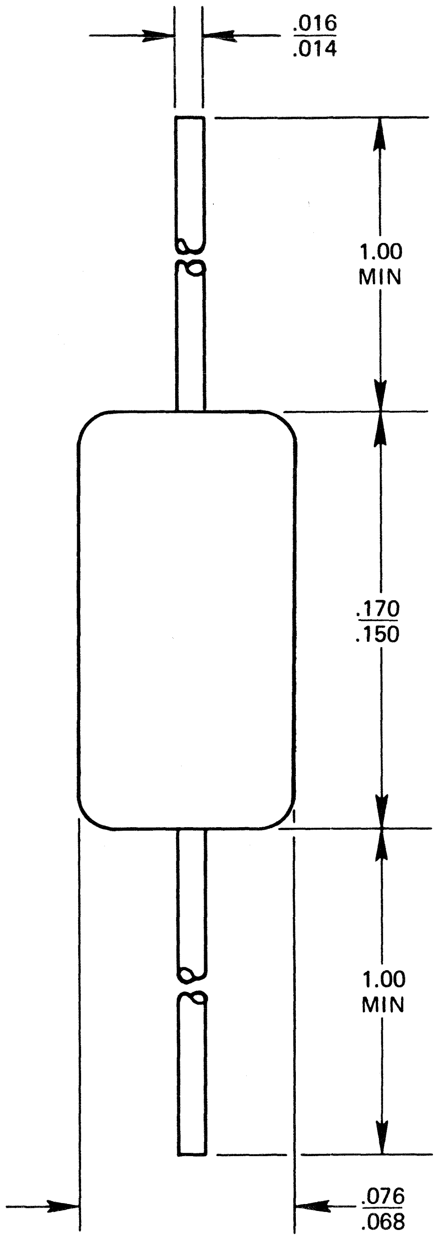
OUTLINE 18

HEWLETT hp PACKARD

HOT CARRIER DIODES

HP 5082-2800 SERIES

HCD-4



Features

LOW PRICE—55¢ at 1000 quantities allows use in any system.

FAST SWITCHING—Picosecond switching speed for high speed digital or logic circuits.

HIGH BREAKDOWN—70 volts breakdown allows high voltages in sampling gates, and wide dynamic range capability as UHF detector.

EXCELLENT ENVIRONMENTAL CAPABILITIES—200°C operating temperature. 20,000 G shock capability and overall ruggedness makes the 2800 family attractive for any military or other high reliability program.

Description

The HP 5082-2800 series is an epitaxial, planar, passivated diode whose construction utilizes a unique combination of both a conventional PN junction and a Schottky barrier. The manufacturing process (Patent No. 3463971), results in a device which has the high breakdown and temperature characteristics of silicon, the turn-on voltage of germanium, and the speed of a Schottky barrier, majority carrier device.

Applications

High level detection, switching, or gating; LOG or A-D converting; sampling or wave shaping are jobs the 2800 family will do better than conventional PN junction diodes. The low turn on voltage and subnanosecond switching makes it extremely attractive in digital circuits for DTL gates, pulse shaping circuits or other low level applications. Its high PIV allows wide dynamic range for fast high voltage sampling gates.

The 2800's low turn-on voltage gives low offsets. The extremely low stored charge minimizes output offsets caused by the charge flow in the storage capacitor. At UHF, the diodes exhibit 95% rectification efficiencies. Both their low loss and their high PIV allow the diodes to be used in mixer and modulator applications which require wide dynamic ranges.

The combination of these technical features with the low price make these devices the prime consideration for any dc or RF circuit requiring nonlinear elements.

ABSOLUTE MAXIMUM RATINGS

5082-2800 Series

P_{diss}	Power Dissipation at $T_A = 25°C$	250 mW (Note 1)
	Derate 1.43 mW/°C for $T_A = 25°C$ to 200°C	
T_A	Operating Temp. Range	−65 to +200°C
T_{STG}	Storage Temp. Range	−65 to +200°C

Note 1. As measured using an infinite heat sink.

MECHANICAL SPECIFICATIONS

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch (1.6 mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E [4 lb (1,8 kg)] tension for 30 minutes. The maximum soldering temperature is 230°C ±5°C for five seconds.

Outline 15 package inductance and capacitance is typically 2.3 nH and 0.17 pF, respectively.

Marking is by digital coding with a cathode band.

ELECTRICAL SPECIFICATIONS AT $T_A = 25°C$

Diode Type	Specification	Symbol	Min	Max	Units	Test Conditions
5082-2800 2810 2811 2833	Breakdown Voltage	V_{BR}	70 20 15 10		Volts	$I_R = 10\ \mu A$
5082-2800 2810 2811 2833	Forward Voltage	V_{FI}		410 410 410 410	mV	$I_{FI} = 1$ mA
5082-2800 2810 2811 2833	Forward Current	I_{FI}	15 35 20 100		mA	$V_{F2} = 1$ volt (note 1)
5082-2800 2810 2811 2833	Reverse Leakage Current	I_R		200 100 100 100	nA	$V_R = 50$ V $V_R = 15$ V $V_R = 8$ V $V_R = 5$ V
5082-2800 2810 2811 2833	Capacitance	$C_{T(o)}$		2.0 1.2 1.2 1.3	pF	$V_R = 0$ V and f = 1 MHz
5082-2800 2810 2811 2833	Effective Minority Carrier Lifetime	τ		100 100 100 100	p sec	$I_F = 20$ mA Krakauer Method

Note 1: The test condition and specification are interchanged to make the tabulation easier to read. The actual test condition is forward current; the actual specification is forward voltage. The forward current is limited to prevent thermal runaway.

MATCHED PAIRS AND QUADS

		5082-2804	5082-2805	5082-2813	5082-2814	5082-2815
Specification	**Symbol**	**Matched Pair Unconnected of 5082-2800**	**Matched Quad Unconnected of 5082-2800**	**Matched Bridge Quad Encapsulated of 5082-2811**	**Matched Ring Quad Encapsulated of 5082-2811**	**Matched Quad Unconnected of 5082-2811**
Forward Voltage Match *	ΔV_F	20 mV at $I_F = 0.5\text{-}5$ mA	20 mV at $I_F = 0.5\text{-}5$ mA	20 mV at $I_F = 1\text{-}10$ mA	20 mV at $I_F = 1\text{-}10$ mA	20 mV at $I_F = 1\text{-}10$ mA
Package Outline		Fig. 1A	Fig. 1A	Fig. 2A	Fig. 3A	Fig. 1A
Circuit		Fig. 1B	Fig. 1B	Fig. 2B	Fig. 3B	Fig. 1B

* Breakdown voltage, reverse current, capacitance, and effective minority carrier lifetime cannot be readily verified after assembly and encapsulated because of the shunting effect of the other diodes. The encapsulated guads have the same parameter values as the HP 5082-2815 unencapsulated quad prior to assembly and encapsulation.

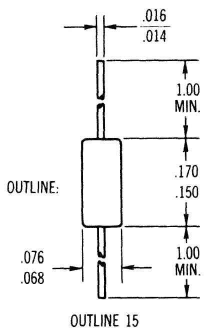


Figure 1A

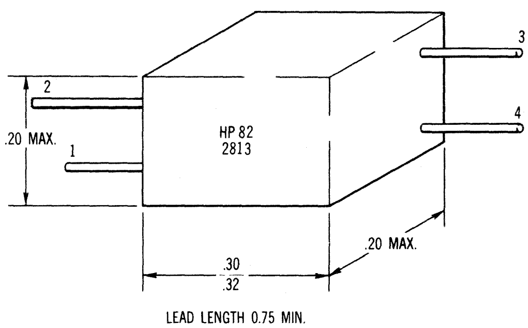


Figure 2A

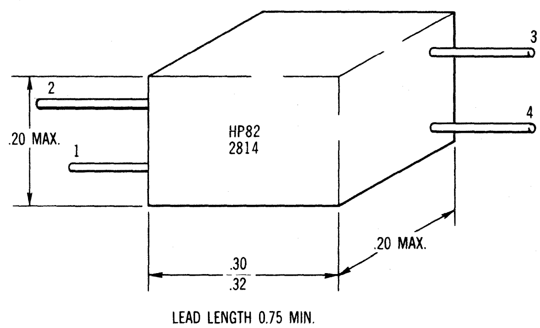


Figure 3A

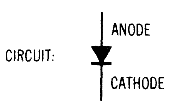


Figure 1B

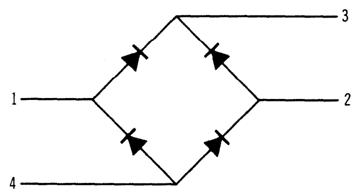


Figure 2B

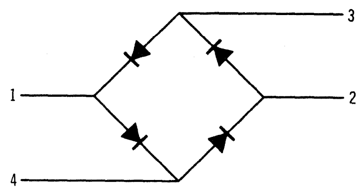


Figure 3B

All dimensions in inches

ENVIRONMENTAL CAPABILITIES

	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	−65°C to +200°C
Temperature, Operating		−65°C to +200°C
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, −65°C to +200°C
Thermal Shock	1056	5 cycles, 0-100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, X_1, Y_1, Y_2 at 1500 G
Vibration Fatigue	2046	32 hrs, X_1, Y_1, Z_1 at 20 G min.
Vibration Variable Frequency	2056	Four 4-min. cycles, X, Y, Z at 20 G min., 100 to 2000 Hz
Constant Acceleration	2006	X_1, Y_1, Y_2, at 20,000 G
Terminal Strength	2036	See mechanical specifications
Salt Atmosphere	1041	35°C fog for 24 hours

RELIABILITY

The HP 5082-2800 series is suitable for high reliability space applications where maximum performance under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of HP diodes in major aerospace and national defense programs.

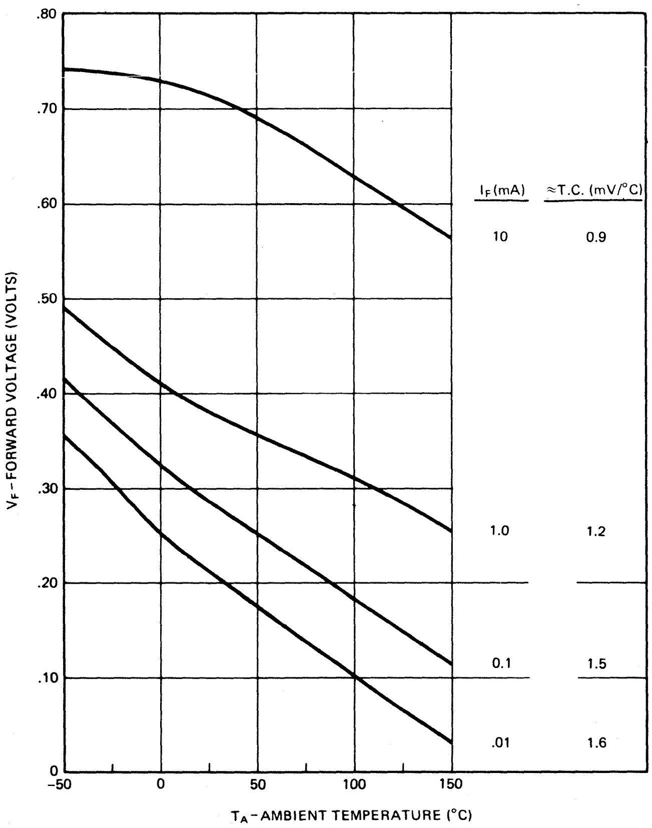


Figure 4. (5082-2800) Typical variation of forward voltage (V_F) vs. temperature (T_A) at various values of forward current (I_F).

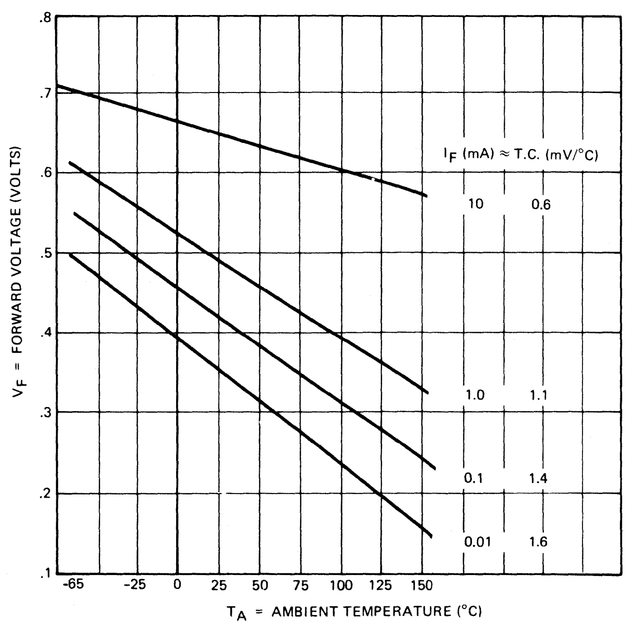


Figure 5. (5082-2810) Typical variations of forward voltage (V_F) vs. temperature (T_A) at various values of forward current (I_F).

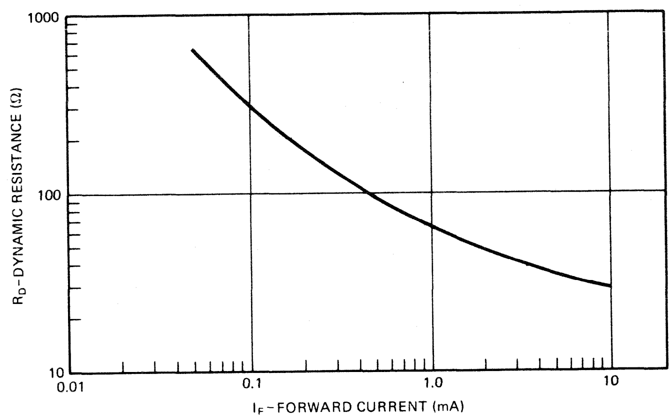


Figure 6. (5082-2800) Typical dynamic resistance (R_D) vs. forward current (I_F) at $T_A = 25°C$.

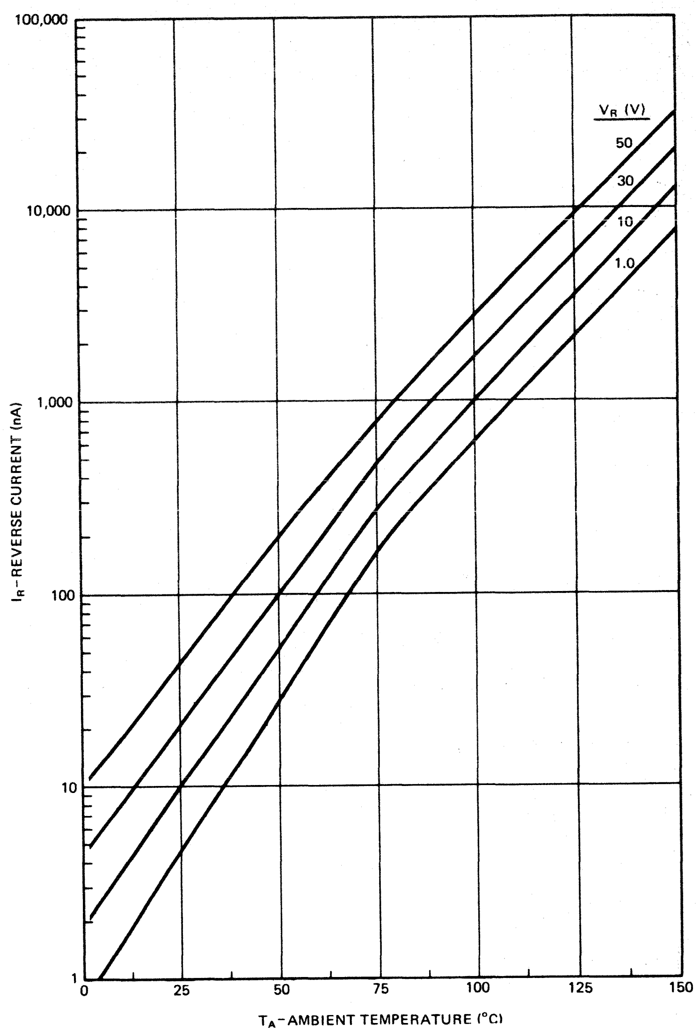


Figure 8. (5082-2800) Typical variation of reverse current (I_R) vs. temperature (T_A) at various values of reverse voltage (V_R).

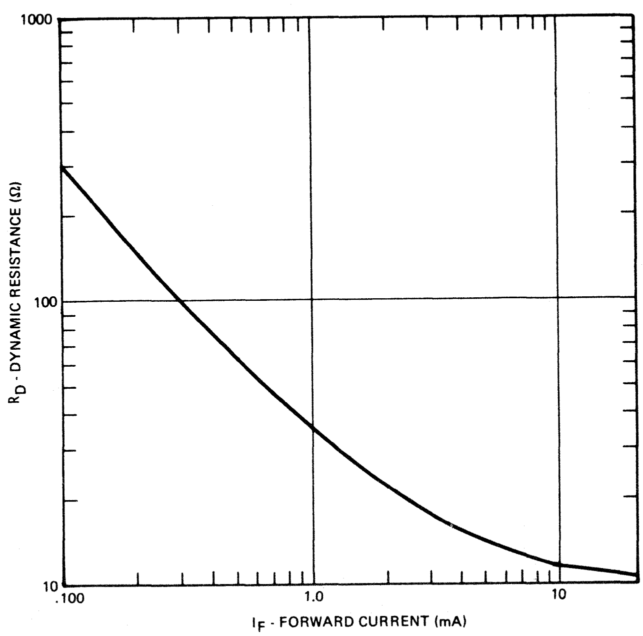


Figure 7. (5082-2810) Typical dynamic resistance (R_D) vs. forward current (I_F) at $T_A = 25°C$.

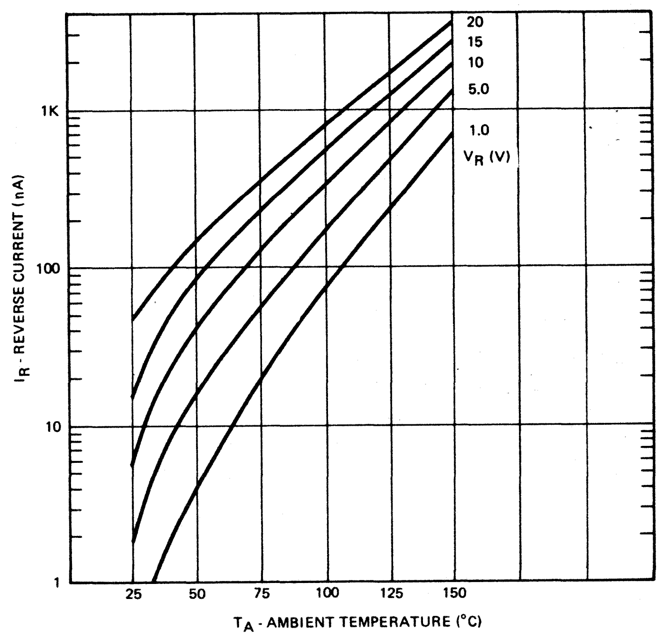


Figure 9. (5082-2810) Typical variation of reverse current (I_R) vs. temperature (T_A) at various values of reverse voltage (V_R).

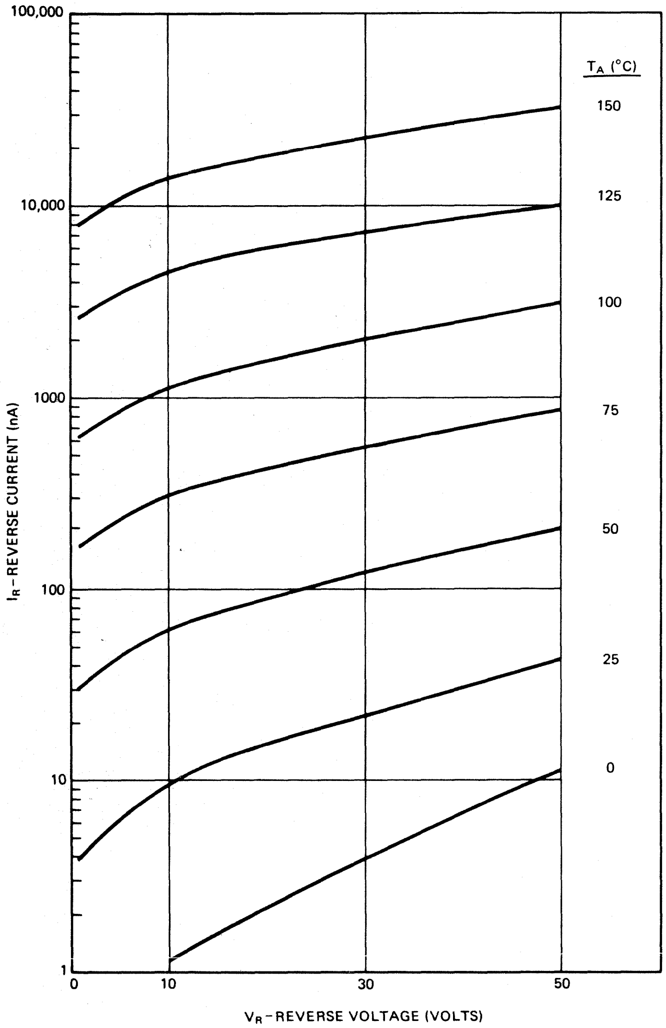


Figure 10. (5082-2800) Typical variation of reverse current (I_R) vs. reverse voltage (V_R) at various temperatures.

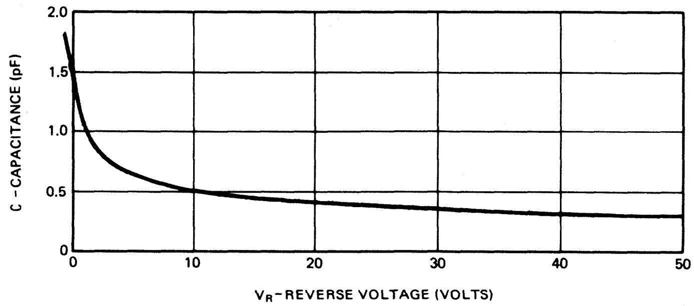


Figure 12. (5082-2800) Typical capacitance (C) vs. reverse voltage (V_R) at $T_A = 25°C$.

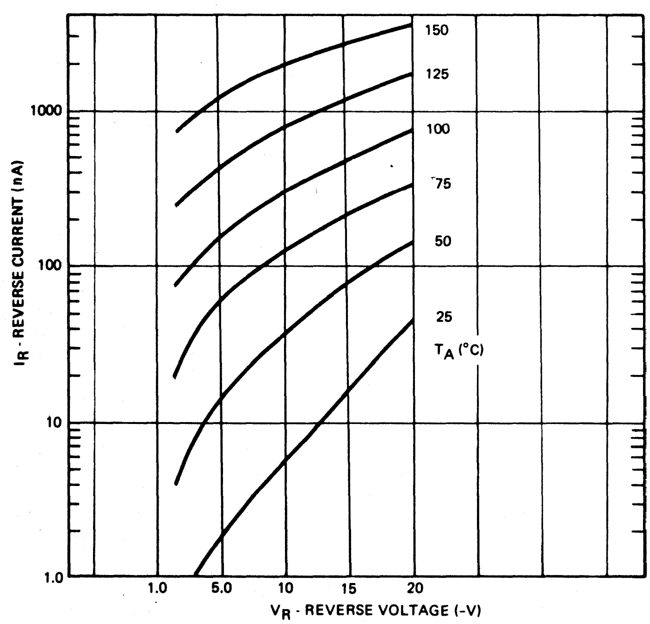


Figure 11. (5082-2810) Typical variation of reverse current (I_R) vs. reverse voltage (V_R) at various temperatures.

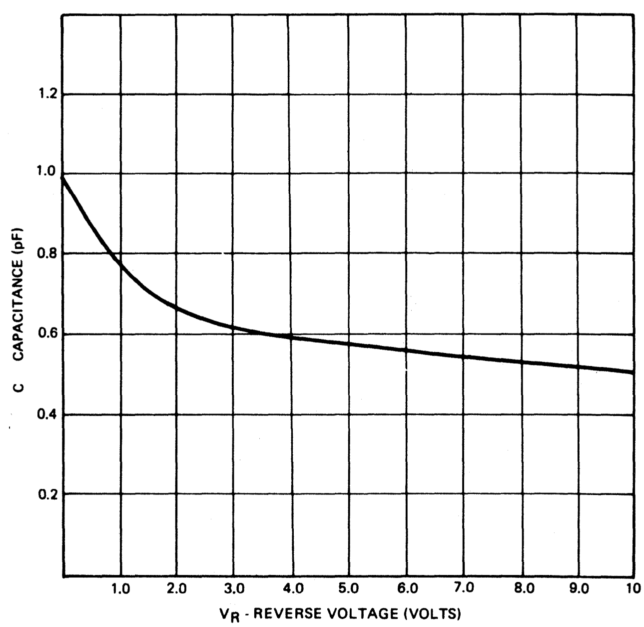


Figure 13. 5082-2810) Typical capacitance (C) vs. reverse voltage (V_R) at $T_A = 25°C$.

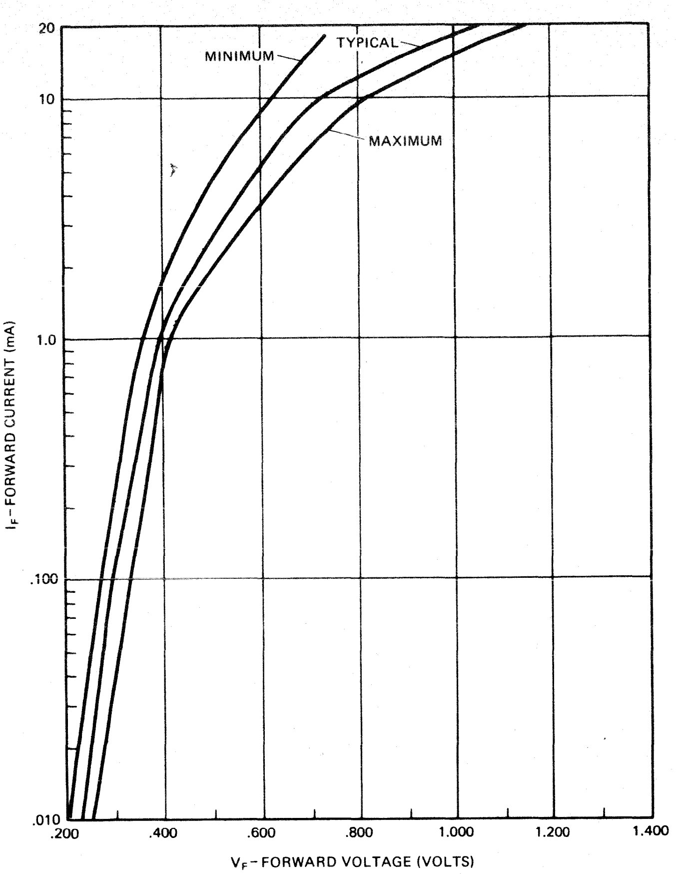


Figure 14. (5082-2800) Typical variation of forward voltage (V_F) vs. forward current (I_F) at $T_A = 25°C$.

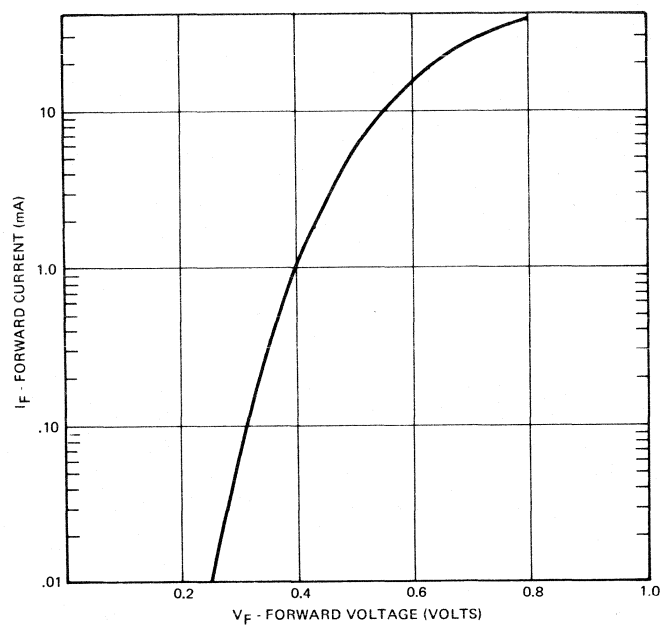


Figure 15. (5082-2810) Typical variation of forward voltage (V_F) vs. forward current (I_F) at $T_A = 25°C$.

BATCH MATCHED DIODES FOR VOLUME APPLICATIONS HP 5082-2826

Description

The HP 5082-2826 is an epitaxial, planar, passivated diode whose construction utilizes a unique combination of both a conventional PN junction and a Schottky barrier. The manufacturing process (patent applied for) results in a device with the sharp breakdown and high temperature characteristics of silicon, the turn-on voltage of germanium, the speed of a Schottky barrier majority carrier device, and exceptional uniformity. The 5082-2826 is supplied in matched batches of a minimum of 250 diodes. Minimum order quantity is 1000 diodes.

Applications

This diode is specifically intended for applications such as double balanced diode mixers, ring modulators, bridges, sampling gates and the like, where a close match between two, four or more diodes of certain parameters is necessary to obtain maximum performance. Particularly where volume usage of these diodes is intended, the availability of relatively large quantity batches of closely matched individual diodes can result in substantial simplification and cost reduction in manufacturing.

ELECTRICAL SPECIFICATIONS

All diodes in each batch are within the specified ranges for ΔV_F and ΔC_o, and meet all of the electrical specifications of the 5082-2811.

BATCH MATCHED SPECIFICATIONS 5082-2826		
Parameter	**Specification**	**Test Conditions**
ΔV_F	±5 mV	$I_F = 10$ mA
ΔC_o	±0.05 pF	$V_R = 0$, f = 1 MHz

SHIPPING INFORMATION

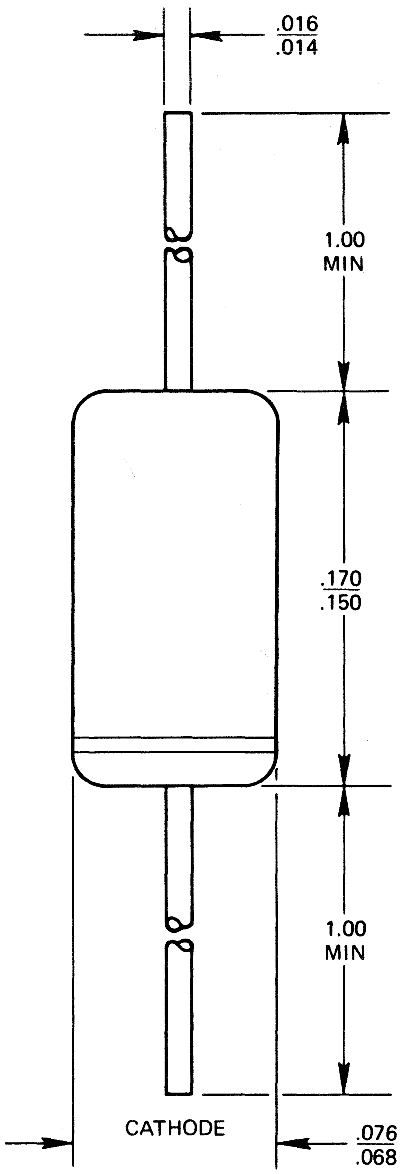
The minimum shipping quantity is 1000 diodes. All diodes are date coded and type numbered. A shipment may or may not consist of more than one batch. Each batch in a shipment will be identified by a distinctive number on the inner container. Individual diodes will not carry batch identification and mixing of diodes from different batches will defeat the purpose of batch identification. Individual containers with the same batch designation in the same shipment only may be combined.

Each batch will contain a minimum of 250 diodes or 10% of the shipping quantity, whichever is larger.

HEWLETT hp PACKARD

HOT CARRIER DIODES

HP 5082-2817/18/19 Series



Features

HIGH BURNOUT—The 2817/18/19 series 8 W and 60 erg burnout capabilities make it ideal for shipboard, airborne, or other systems where high power interference signals are present.

LOW 1/f NOISE—8 kHz noise corner frequency for 1 mA dc current.

LOW NF—6 dB at 1 GHz allows this series to be used in the most sensitive receiver systems.

EXCELLENT ENVIRONMENTAL CAPABILITIES—200°C operating temperature. 20,000 G shock capability and overall ruggedness make this family attractive for any military or other high reliability program.

Description

These microwave silicon hot carrier diodes are epitaxial, planar, passivated devices of hybrid construction which utilizes a unique combination of a conventional pn junction and a Schottky barrier.

This manufacturing process (Patent No. 3463971) results in a diode with greatly increased ruggedness and burnout reliability without sacrificing low noise properties.

Applications

This series is designed for use in receivers from HF up to S-Band. They are especially applicable to airborne or other severe environmental applications due to their high burnout and 20,000 G shock capabilities. Because of their high sensitivity they are eminently suited for receivers which require the ultimate in signal detection.

This sensitivity and protection is now available at a low price.

MAXIMUM RATINGS AT 25°C

Burnout Energy ....50 erg (Note 1)
CW Dissipation ....1 W (Note 2)
Reverse Voltage ....15 V
Operating Junction Temperature Range −65° to +200°C
Storage Temperature Range ....−65° to +200°C

TYPICAL ELECTRICAL CHARACTERISTICS AT 25°C

Chip Capacitance, at $V_f = 0$ V ....0.9 pF
Package Capacitance ....0.17 pF
Series Resistance, at $I_f = 10$ mA ....11 Ω
Series Inductance ....2.3 nH (Note 5)

ELECTRICAL SPECIFICATIONS AT 25°C

	Min.	Max.	Units	Notes
Noise Figure	—	6.0	dB	3, 4
VSWR	1.0	1.8	—	3
IF - Impedance	250	400	Ω	3
Model Number				
5082-2817				single diode
5082-2818				matched pair
ΔF Noise figure match	—	0.3	dB	
ΔZ_{IF} IF - Impedance match	—	25	Ω	
5082-2819				matched quad
ΔF Noise figure match	—	0.3	dB	
ΔZ_{IF} IF - Impedance match	—	25	Ω	

PACKAGE

The HP Outline 15 package has a glass hermetic seal with leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1⁄16 inch (1,6 mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E [4 lb (1,8 kg)] tension for 30 minutes. The maximum soldering temperature is 230°C ±5°C for five seconds.

Marking is by digital coding with a cathode band.

NOTES

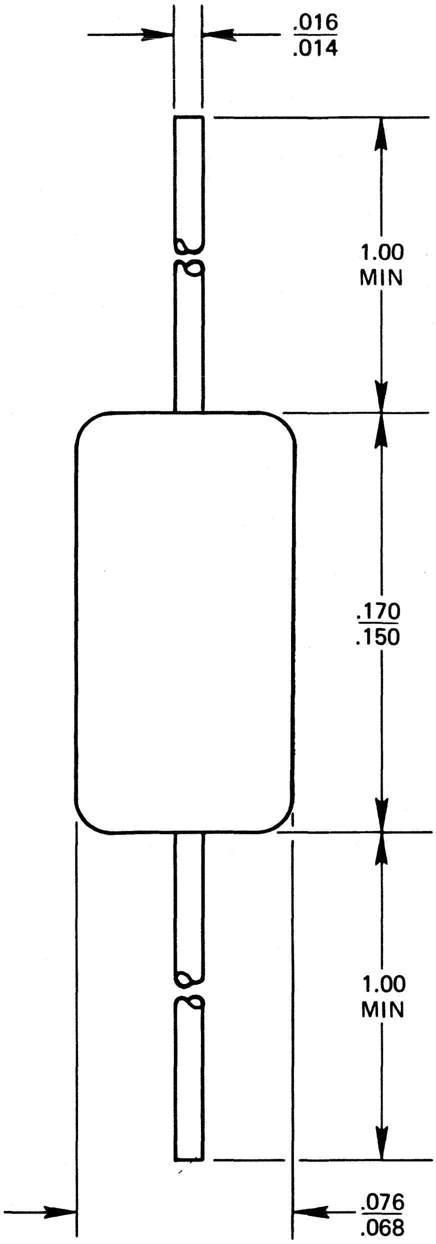
1. Single discharge of Torrey Line. During first 2.4 ns, current flow in forward direction. Criterion for burnout energy: 1 dB increase in noise figure.
2. Power absorbed by the diode, applied for 1 minute. Frequency 1 GHz. DC load resistance < 1 Ω. Cathode lead is connected to an infinite heat sink at the plane where it leaves the glass body.
3. Measurements are performed on the diode in a fixed mount which has been tuned to an average diode. Local oscillator power at 1 mW. Local oscillator frequency 1.0 GHz. DC load resistance 100 Ω.
4. Single sideband receiver noise figure including an IF-amplifier noise figure of 1.5 dB. (Intermediate frequency 30 MHz.)
5. Series inductance of a coaxial line section consisting of the diode (chip short circuited) with terminals at ends of glass body as inner conductor and outer conductor of 0.28 inch diameter.

HEWLETT hp PACKARD

HOT CARRIER DIODES

HP 5082-2824/25 Series

TECHNICAL DATA 1 JAN 70



Features

HIGH BURNOUT—The 2824/25 series 8 W and 60 erg burnout capabilities make it ideal for shipboard, airborne, or other systems where high power interference signals are present.

HIGH TSS—56 dBm at 2 GHz makes this 2800 series the prime choice for those receivers which require the ultimate sensitivity in signal reception.

LOW 1/f NOISE—8 kHz noise corner frequency for 1 mA dc current.

EXCELLENT ENVIRONMENTAL CAPABILITIES—200°C operating temperature. 20,000 G shock capability and overall ruggedness make this family attractive for any military or other high reliability program.

Description

These microwave silicon hot carrier diodes are epitaxial, planar, passivated devices of hybrid construction which utilize a unique combination of a conventional pn junction and a Schottky barrier.

This manufacturing process (Patent No. 3463971) results in a diode with greatly increased ruggedness and burnout reliability without sacrificing low noise properties.

Applications

This series is designed for use in receivers from HF up to S-Band. They are especially applicable to airborne or other severe environmental applications due to their high burnout and 20,000 G shock capabilities. Because of their high sensitivity they are eminently suited for receivers which require the ultimate in signal detection.

This sensitivity and protection is now available at a low price.

MAXIMUM RATINGS at 25°C

Burnout Power .... 8 W (Note 1)
CW-Power Dissipation .... 1 W (Note 2)
Reverse Voltage .... 15 V
Operating Junction
Temperature Range .... −65°C to +200°C
Storage Temperature Range .... −65°C to +200°C

NOTES:

1. Incident peak power of pulse modulated 2.0 GHz signal.

Duty cycle	1/1000
Pulse width	1 μs
DC-bias current	20 μA
Load resistance	38 kΩ

If the stated power is applied to the diode, inserted into a mount which is tuned for maximum TSS, the degradation of tangential signal sensitivity (TSS) is less than 1 dB. At an incident power level of 8 W, the power dissipated in the diode is typically 4.5 W.

2. Power absorbed by the diode, applied for 1 minute.

Frequency	2.0 GHz
DC-load resistance	< 1 Ω

The cathode lead is connected to an infinite heat sink at the plane where it leaves the glass body.

Power derating 5.6 mW/°C (see Figure 1.)

ELECTRICAL SPECIFICATIONS at 25°C

Parameter	Min.	Typ.	Max.	Unit	Notes
Tangential Signal Sensitivity	−56	−58	—	dBm	3, 4
Voltage Sensitivity	6.0	8.5	—	mV/μW	3
Video Output Resistance	1.2	1.35	1.5	kΩ	3

Model Number	Description	Matching Criteria
5082-2824	Single diode	—
5082-2825	Matched pair	Note 5

NOTES:

3. The measurement conditions are:
The diode is inserted into a fix tuned coaxial mount.

Signal frequency	$f_{signal} = 2.0$ GHz
DC-bias current	$I_{bias} = 20$ μA
Video load resistance	$R_L = 38$ kΩ

4. TSS is defined as incident RF power level which yields a signal to noise power ratio of 8.0 dB at the video receiver output.

Video bandwidth	$\Delta f_{video} = 2.0$ MHz
Equivalent noise resistance of video amplifier	$R_A = 500\ \Omega$

5. Voltage sensitivity Match $\Delta\gamma \leq 0.5$ mV/μW
Video resistance Match $\Delta R_V \leq 100\ \Omega$

TYPICAL ELECTRICAL CHARACTERISTICS at 25°C

Parameter	Typical Value	Test Conditions
Tangential Signal Sensitivity at 3 GHz	−55 dBm	Note 3, except $f_{signal} = 3.0$ GHz Note 4
Noise Figure at 2 GHz	5.8 dB	Note 6
Diode Noise Ratio at 1 kHz	0 dB	$I_{bias} = 27$ μA ($R_v = 1$ kΩ)
Upper Limit for Square Law Operation	−23 dBm	Note 7
Breakdown Voltage	19 V	$I_r = 10$ μA
Forward Current	55 mA	$V_f = 1.0$ V
Series Resistance	9 Ω	$I_f = 10$ mA
Chip Capacitance	0.8 pF	$V_r = 0$ V
Package Capacitance	0.17 pF	
Package Inductance	2.3 nH	Note 8

NOTES:

6. Single sideband receiver noise figure including an IF-amplifier noise figure of 1.5 dB.
Measurement conditions:

Local oscillator frequency	2.0 GHz
Local oscillator power	1.0 mW
IF-frequency	30 MHz
DC-load resistance	100 Ω

7. Signal power level at which input power has to be increased by 0.5 dB to give the same output voltage as an ideal square law detector with the same low level sensitivity.

Video load resistance	38 kΩ
DC-bias current	20 μA

8. Series inductance of a coaxial line section consisting of the diode with short circuited chip as inner conductor and an outer conductor of 0.28 inch diameter. The geometrical length of the coaxial line is determined by the length of the glass-package body.

MECHANICAL SPECIFICATIONS

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch (1.6 mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E [4 lb (1,8 kg)] tension for 30 minutes. The maximum soldering temperature is 230°C ±5°C for five seconds.

Marking is by digital coding with a cathode band.

RELIABILITY

The HP 5082-2800 diode is suitable for high reliability space applications where maximum performance under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of HP diodes in major aerospace and national defense programs.

ENVIRONMENTAL CAPABILITIES

	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	−65°C to +200°C
Temperature, Operating		−65°C to +200°C
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, −65°C to +200°C
Thermal Shock	1056	5 cycles, 0-100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, X_1, Y_1, Y_2 at 1500 G
Vibration Fatigue	2046	Four 4-min. cycles, X, Y, Z at
Vibration Variable Frequency	2056	32 hrs, X_1, Y_1, Z_1 at 20 G min. 20 G min., 100 to 2000 Hz
Constant Acceleration	2006	X_1, Y_1, Y_2, at 20,000 G
Terminal Strength	2036	See mechanical specifications
Salt Atmosphere	1041	35°C fog for 24 hours

TYPICAL PERFORMANCE CURVES at 25°C

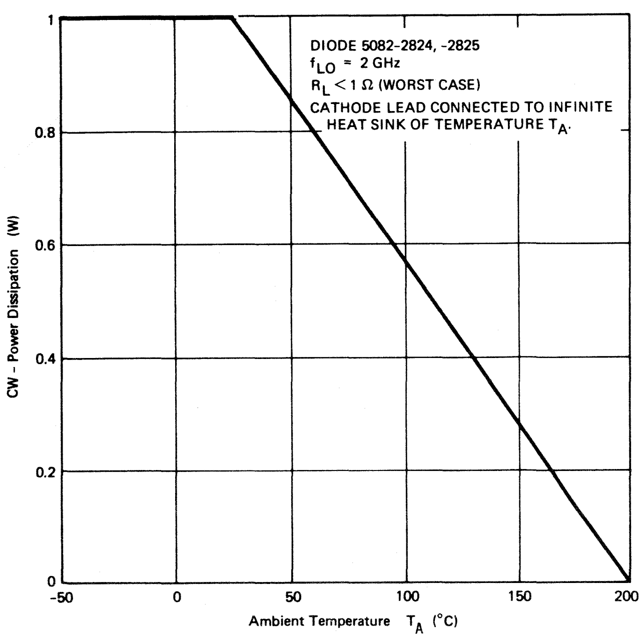


Figure 1. Maximum rating of CW-power dissipation in the diode versus ambient temperature.

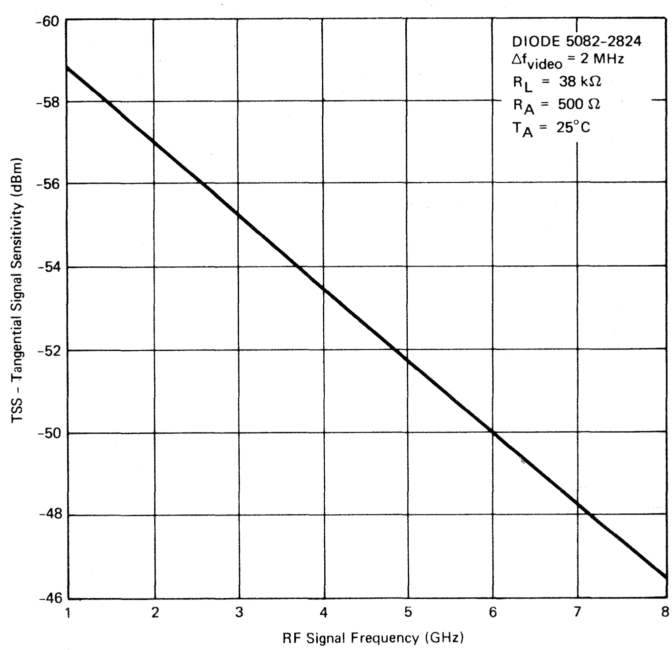


Figure 2. Optimum tangential signal sensitivity versus RF-signal frequency. (At each frequency the bias current was optimized and the mount tuned for maximum signal sensitivity.)

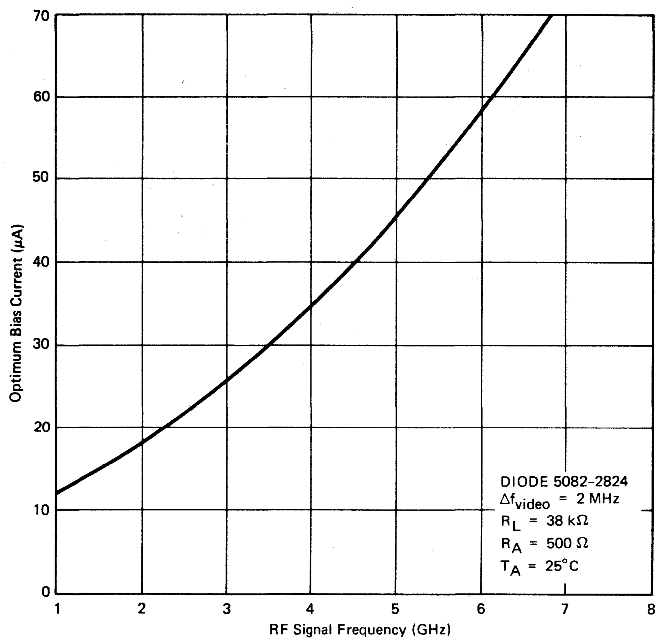


Figure 3. Optimum dc-bias current, which yields maximum signal sensitivity, versus RF-signal frequency.

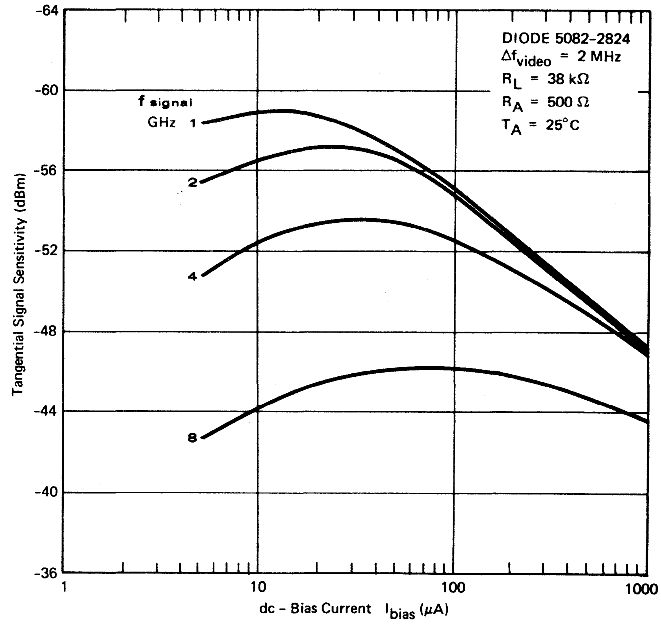


Figure 4. Tangential signal sensitivity versus dc-bias current for various signal frequencies. (At each bias current and frequency the mount was tuned for maximum signal sensitivity.)

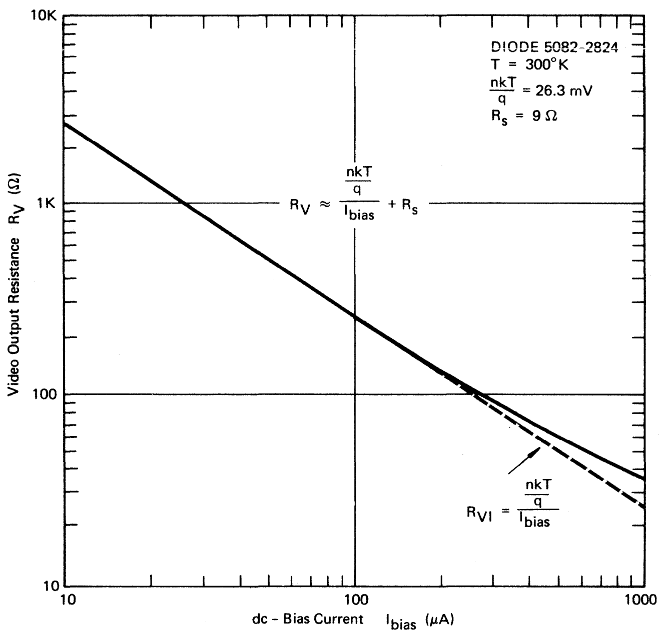


Figure 5. Video output resistance versus dc-bias current.

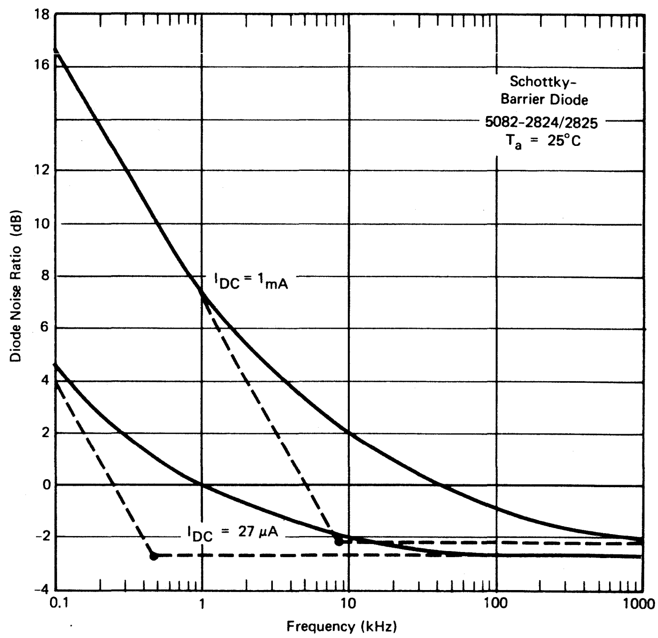


Figure 6. Typical diode noise ratio versus frequency for two dc-current levels.

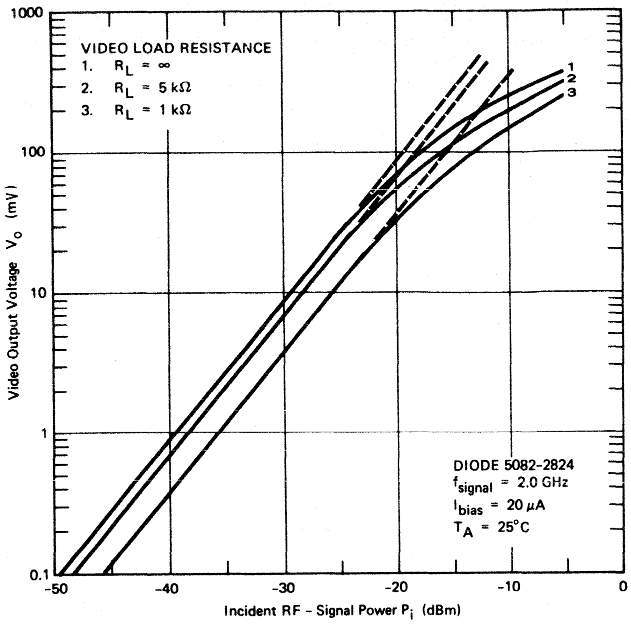


Figure 7. Video Output voltage V_o versus incident RF-signal power P_i for various video load resistances R_L.

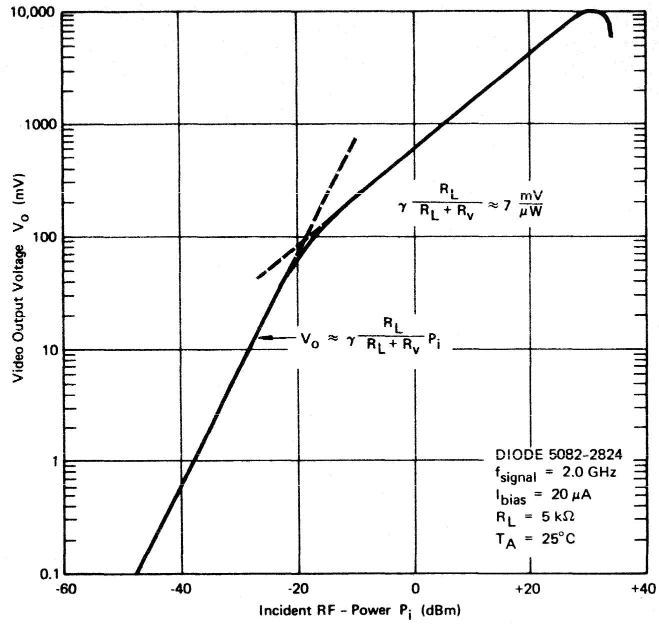


Figure 8. Video Output voltage V_o versus incident RF-signal power P_i.

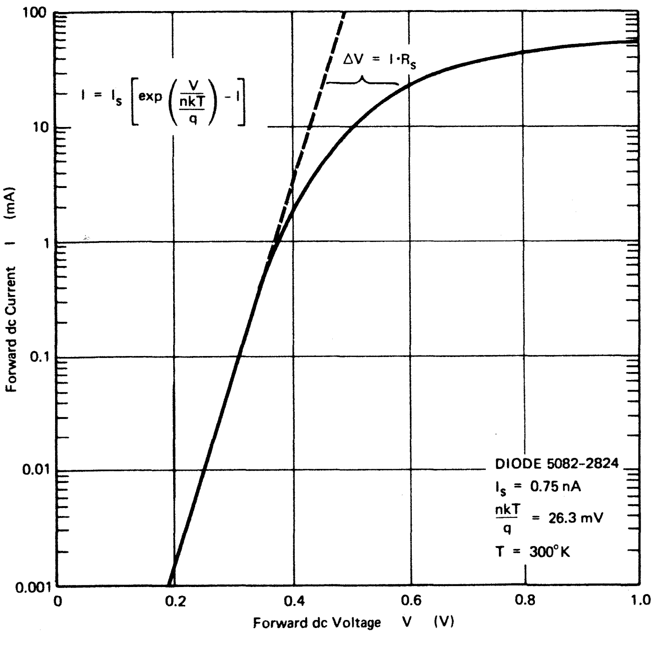


Figure 9. Static forward current versus voltage relationship.

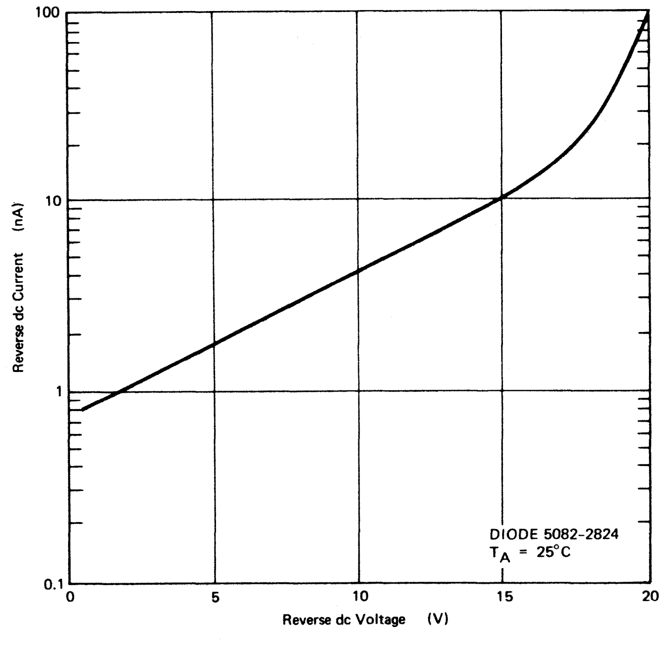


Figure 10. Static reverse current versus voltage relationship.

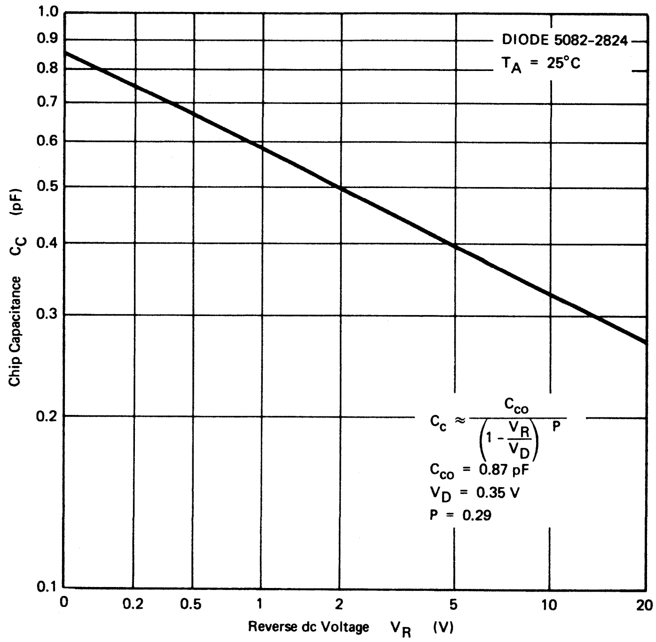


Figure 11. Chip capacitance versus reverse voltage.

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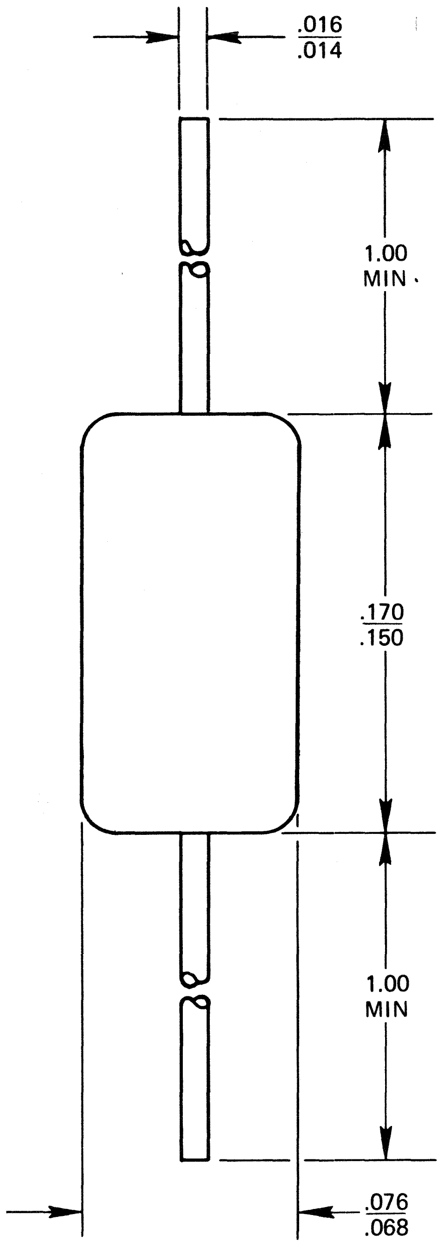
HOT CARRIER DIODES

HP 5082-2827/28/29 Series



Features

HIGH BURNOUT—The 2827/28/29 series 8 W and 60 erg burnout capabilities make it ideal for shipboard, airborne, or other systems where high power interference signals are present.

LOW 1/f NOISE—8 kHz noise corner frequency for 1 mA dc current.

LOW NF—6 dB at 2 GHz allows this series to be used in the most sensitive receiver systems.

EXCELLENT ENVIRONMENTAL CAPABILITIES—200°C operating temperature. 20,000 G shock capability and overall ruggedness make this family attractive for any military or other high reliability program.

Description

These microwave silicon hot carrier diodes are epitaxial, planar, passivated devices of hybrid construction which utilize a unique combination of a conventional pn junction and a Schottky barrier.

This manufacturing process (Patent No. 3463971) results in a diode with greatly increased ruggedness and burnout reliability without sacrificing low noise properties.

Applications

This series is designed for use in receivers from HF up to S-Band. They are especially applicable to airborne or other severe environmental applications due to their high burnout and 20,000 G shock capabilities. Because of their high sensitivity they are eminently suited for receivers which require the ultimate in signal detection.

This sensitivity and protection is now available at a low price.

MAXIMUM RATINGS at 25°C

Burnout Energy ....50 erg (Note 1)
CW-Power Dissipation ....1 W (Note 2)
Reverse Voltage ....15 V
Operating Junction
Temperature Range ....−65°C to +200°C
Storage Temperature Range ....−65°C to +200°C

NOTES:

1. Single discharge of Torrey line. During first 2.5 ns, current flow in forward direction. If the stated energy is applied to the diode, mounted in the standard Torrey-line (108-JAN), the increase in noise figure is less than 1 dB.
2. Power absorbed by the diode, applied for 1 minute. Frequency 2.0 GHz. DC-load resistance <1 Ω. Cathode lead is connected to an infinite heat sink at the plane where it leaves the glass body.
   Power derating 5.6 mW/°C (see Figure 1)
3. Measurement conditions are:
   The diode is inserted into a fix tuned coaxial mount.
   Local oscillator frequency 2.0 GHz
   Local oscillator incident power 1.0 mW
   DC-load resistance 100 Ω

ELECTRICAL SPECIFICATIONS at 25°C

Parameter	Min.	Typ.	Max.	Unit	Notes
Noise Figure	—	5.8	6.0	dB	3, 4
VSWR	1.0	1.3	1.8	—	3
IF-Impedance	250	330	400	Ω	3

Model Number	Description	Matching Criteria
5082-2827	Single diode	
5082-2828	Matched pair	Note 5
5082-2829	Matched quad	Note 5

NOTES:

4. Single sideband receiver noise figure including an IF-amplifier noise figure of 1.5 dB (intermediate frequency 30 MHz).
5. Noise figure match $\Delta F \leq 0.3$ dB
   IF-Impedance match $\Delta Z_{IF} \leq 25\ \Omega$

TYPICAL ELECTRICAL CHARACTERISTICS at 25°

Parameter	Typical Value	Test Conditions
Noise figure at 10 mW	5.3 dB	Note 4 $f_{LO} = 2.0$ GHz $P_{LO} = 10$ mW $f_{IF} = 30$ MHz $R_{DC} = 200\ \Omega$
Noise figure at 3 GHz	6.3 dB	Note 3 except $f_{LO} = 3.0$ GHz Note 4
Conversion loss	4.6 dB	Note 3
Diode noise ratio at 10 kHz	2 dB	$I_{DC} = 1.0$ mA $P_{LO} = 0$ mW
Tangential signal sensitivity	−57 dBm	$f_{RF} = 2.0$ GHz $f_{video} = 2.0$ MHz $I_{DC} = 20\ \mu A$ $R_L = 38$ kΩ $R_{eq} = 500\ \Omega$
Breakdown voltage	19 V	$I_r = 10\ \mu A$
Forward current	55 mA	$V_f = 1.0$ V
Series resistance	9 Ω	$I_f = 10$ mA
Chip capacitance	0.8 pF	$V_r = 0$ V
Package capacitance	0.17 pF	
Package inductance	2.3 nH	Note 6

NOTES:

6. Series inductance of a coaxial line section consisting of the diode with short-circuited chip as inner conductor and an outer conductor of 0.28 inch diameter. The geometrical length of the coaxial line is determined by the length of the glass-package body.

MECHANICAL SPECIFICATIONS

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch (1.6 mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E [4 lb (1,8 kg)] tension for 30 minutes. The maximum soldering temperature is 230°C ±5°C for five seconds.

Marking is by digital coding with a cathode band.

RELIABILITY

The HP 5082-2800 diode is suitable for high reliability space applications where maximum performance under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of HP diodes in major aerospace and national defense programs.

ENVIRONMENTAL CAPABILITIES

	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	−65°C to +200°C
Temperature, Operating		−65°C to +200°C
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, −65°C to +200°C
Thermal Shock	1056	5 cycles, 0-100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, X_1, Y_1, Y_2 at 1500 G
Vibration Fatigue	2046	32 hrs, X_1, Y_1, Z_1 at 20 G min.
Vibration Variable Frequency	2056	Four 4-min. cycles, X, Y, Z at 20 G min., 100 to 2000 Hz
Constant Acceleration	2006	X_1, Y_1, Y_2, at 20,000 G
Terminal Strength	2036	See mechanical specifications
Salt Atmosphere	1041	35°C fog for 24 hours

TYPICAL PERFORMANCE CURVES at 25°C

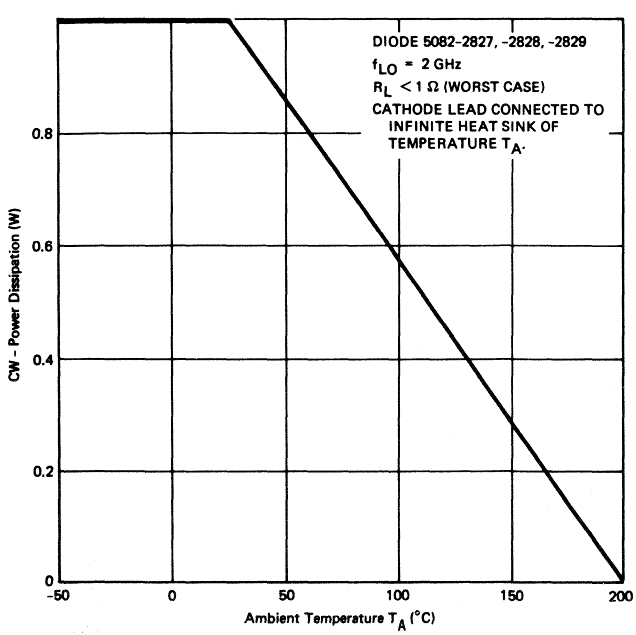


Figure 1. Maximum rating of CW-power dissipation in the diode versus ambient temperature.

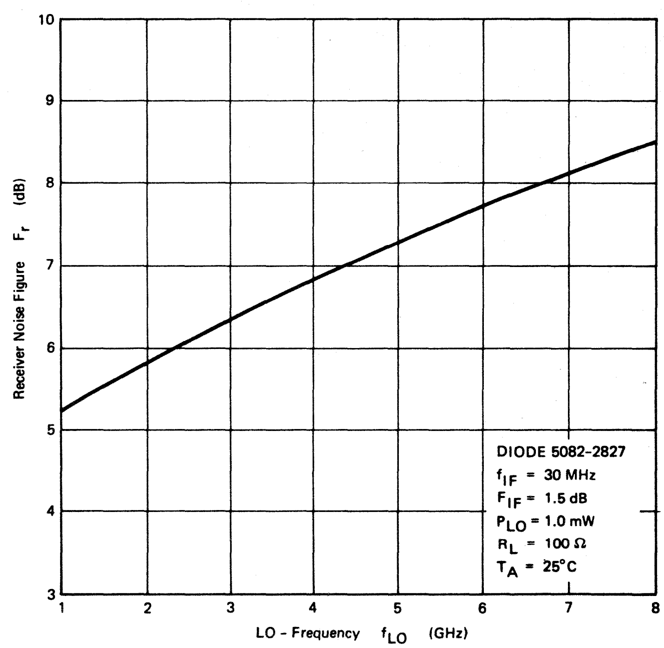


Figure 2. Single sideband receiver noise figure F_r (including an IF-amplifier noise figure of 1.5 dB) versus local-oscillator frequency f_{LO}. (The mount is tuned for minimum noise figure at each frequency.)

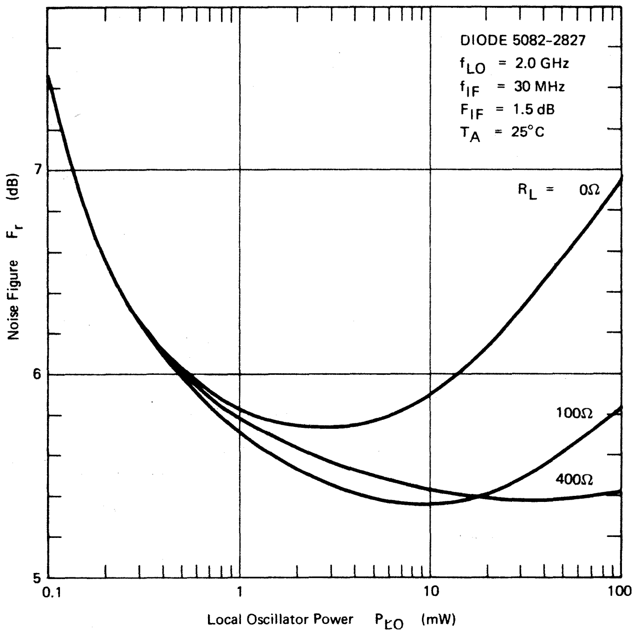


Figure 3. Single sideband receiver noise figure F_r (including an IF-amplifier noise figure of 1.5 dB) versus incident LO-power P_{LO} for various dc-load resistances R_L. (The mount is tuned for minimum noise figure at each LO-power level and for each load resistance.)

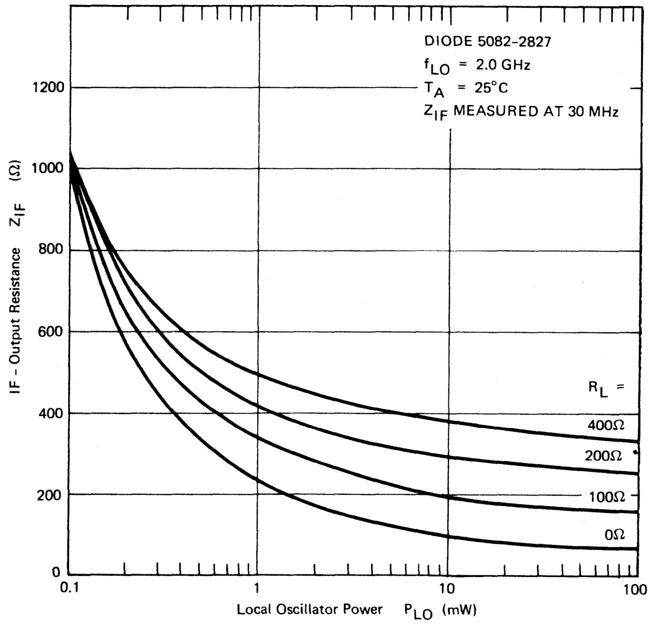


Figure 4. IF-output resistance Z_{IF} versus incident LO-power P_{LO} for various dc-load resistances R_L. (The mount is tuned for minimum noise figure at each LO-power level and for each load resistance.)

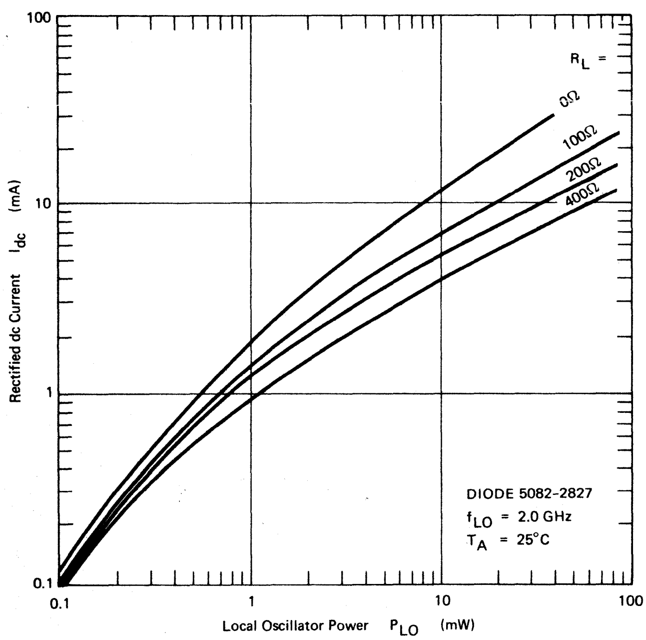


Figure 5. Rectified dc-current I_{DC} versus incident LO-power P_{LO} for various dc-load resistances R_L. (The mount is tuned for minimum noise figure at each LO-power level and for each load resistance.)

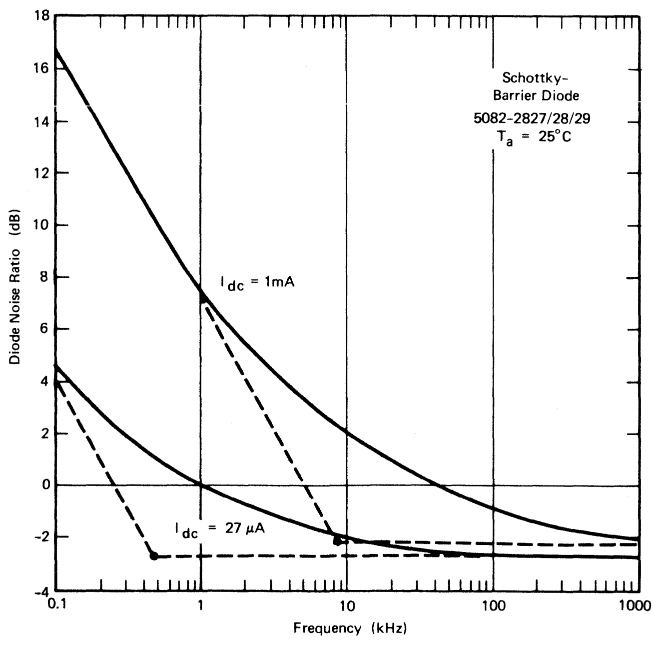


Figure 6. Typical diode noise ratio versus frequency for two dc-current levels.

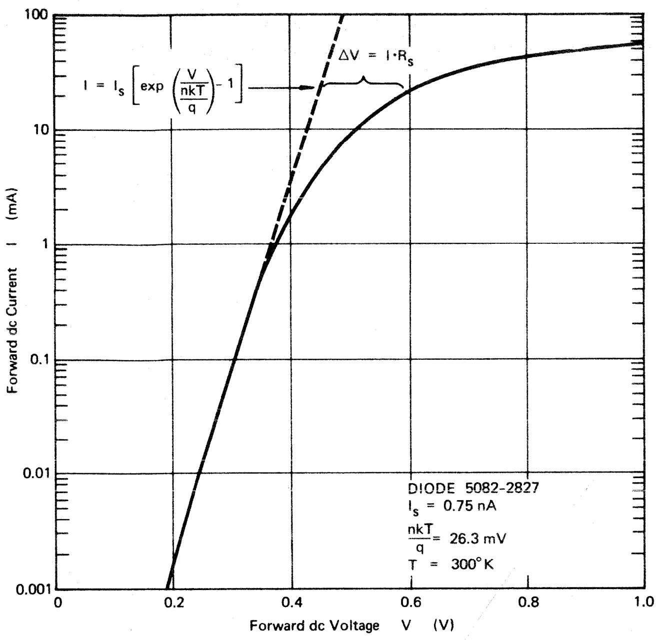


Figure 7. Static forward current versus voltage relationship.

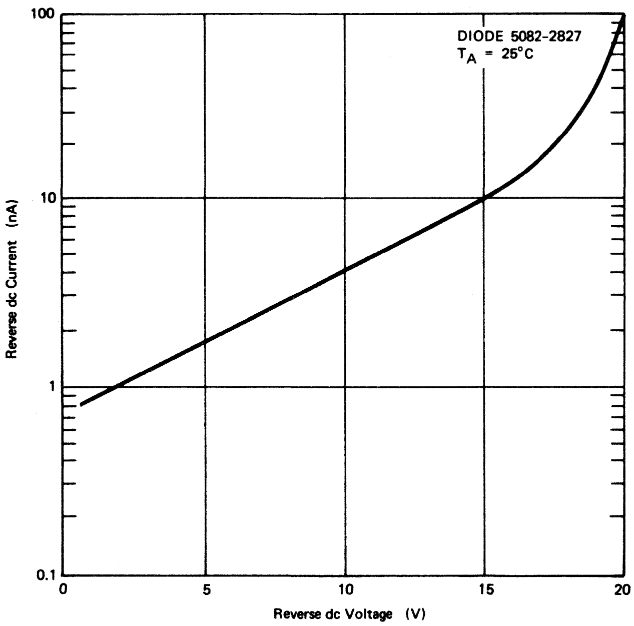


Figure 8. Static reverse current versus voltage relationship.

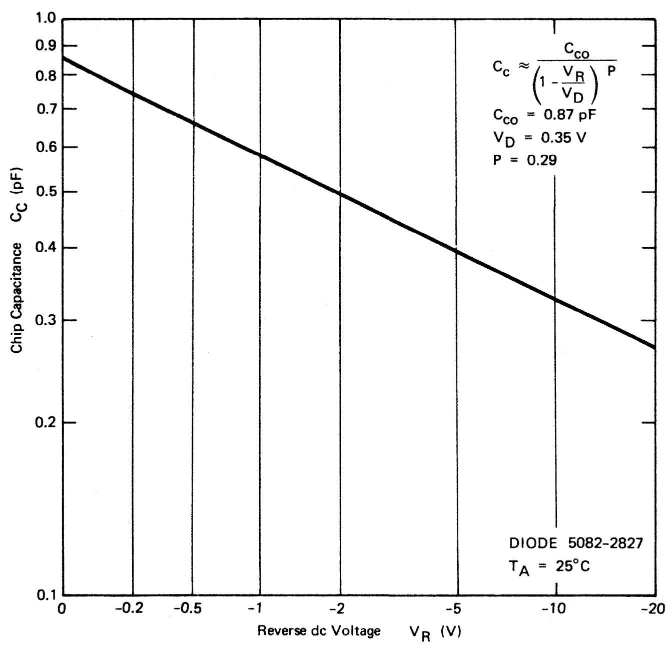


Figure 9. Chip capacitance versus reverse voltage.

HOT CARRIER DIODES

HP 5082-2900 SERIES

HCD-3

HEWLETT PACKARD

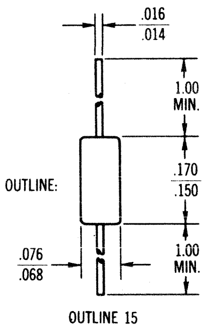


Figure 1a

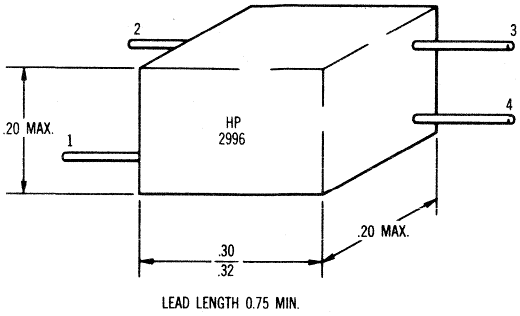


Figure 2a

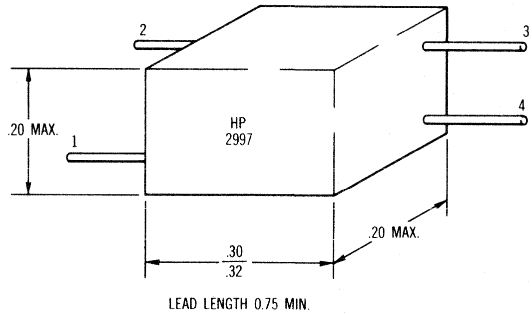


Figure 3a

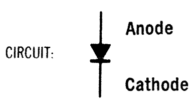


Figure 1b

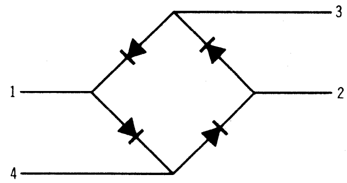


Figure 2b

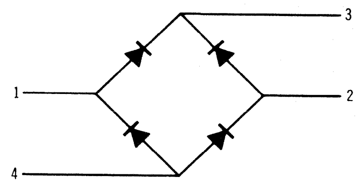


Figure 3b

All dimensions in inches

Low Cost
No-Charge Storage
Pulse Burnout Resistant
Ultrafast Switching
Low 1/f Noise

Description

The HP 5082-2900 series of Hot Carrier Diodes employ a metal-silicon Schottky barrier junction and utilize electrons for majority carrier conduction. The Hot Carrier Diode's performance conforms closely with theory and can be described as closely approximating the ideal diode. HP Application Note 907 contains additional detailed information.

Applications

The HP 5082-2900 series of Hot Carrier Diodes is priced for use in commercial applications.

In pulse operations the diode is ideal for clamping, sampling gates, pulse shaping, and general purpose usage requiring fractional picosecond switching times.

In the RF area the Hot Carrier Diode makes an excellent low noise mixer, high sensitivity, small signal detector, large signal detector (power monitor), limiter, discriminator, and balanced modulator from low frequencies through the UHF range.

The HP 5082-2300 series Hot Carrier Diode—rather than the 5082-2900 series—should be considered for military and space applications requiring high reliability performance.

MATCHED PAIRS AND QUADS

HP Type Number	5082-2900	5082-2912	5082-2970	5082-2996	5082-2997
Description	Single Diode	Matched pair of 5082-2900, unencapsulated and unconnected.	Matched Quad, unencapsulated and unconnected.	Matched Ring Quad, Epoxy encapsulated.	Matched Bridge Quad, Epoxy encapsulated.
Outline	Fig. 1a	Fig. 1a	Fig. 1a	Fig. 2a	Fig. 3a
Circuit	Fig. 1b	Fig. 1b	Fig. 1b	Fig. 2b	Fig. 3b

Characteristics	Symbol	5082-2900 Min.	5082-2900 Max.	5082-2912 Min.	5082-2912 Max.	5082-2970 Min.	5082-2970 Max.	5082-2996 Min.	5082-2996 Max.	5082-2997 Min.	5082-2997 Max.	Units	Test Conditions
Breakdown Voltage	V_{BR}	10	—	10	—	10	—	*	—	*	—	V	$I_R = 10\ \mu A$
Reverse Current	I_R	—	100	—	100	—	100	—	*	—	*	nA	$V_R = 5.0\ V$
Forward Voltage	V_{F1}	—	0.4	—	0.4	—	0.4	—	0.4	—	0.4	V	$I_{F1} = 1.0\ mA$
Forward Voltage	V_{F2}	—	1.0	—	1.0	—	1.0	—	1.0	—	1.0	V	$I_{F2} = 20\ mA$
Forward Voltage Match	ΔV_F	—	—	—	30	—	30	—	30	—	30	mV	$I_F = 1.0$ to 10 mA
Capacitance	C_O	—	1.2	—	1.2	—	1.2	—	*	—	*	pF	$V_R = 0\ V$, $f = 1.0\ MHz$
Effective Minority Carrier Lifetime	τ	—	120	—	120	—	120	—	*	—	*	ps	Krakauer Method

* Breakdown voltage, reverse current, capacitance, and effective minority carrier lifetime cannot be readily verified after assembly and encapsulation because of the shunting effect of the other diodes. The encapsulated quads have the same parameter values as the HP 5082-2970 unencapsulated quad prior to assembly and encapsulation.

ABSOLUTE MAXIMUM RATINGS

T_{OPR}—Operating Temperature Range......— 60°C to + 100°C
T_{STG}—Storage Temperature Range..........— 60°C to + 100°C
P_{DISS}—Power Dissipation ($T_A = 25°C$) ....50 mW
Derate ⅔ mW/°C for T_A from 25°C to 100°C
U—Burnout (3 pulses with a 10 ns maximum pulse width; 20% allowable V_{BR} degradation; $T_A = 25°C$)........5 ergs

PACKAGE

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch from the glass body. With this restriction OD-15 package will meet MIL-STD-750, Method 2036, Conditions A and E (4 lbs. tension for 30 minutes). The maximum soldering temperature is 230°C ± 5°C for 5 seconds.

Outline 15 package inductance and capacitance are typically 3 nH and 0.2 pF respectively.

Marking is by digital coding with a cathode band.

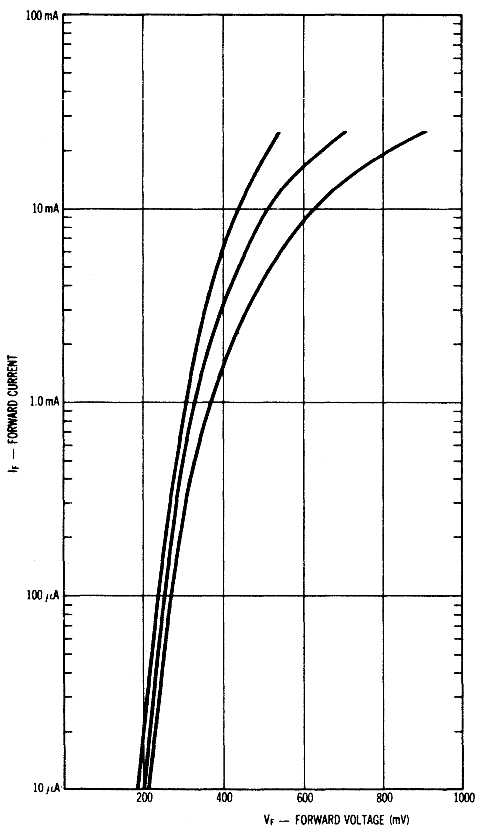


Figure 4. Typical HP 5082-2900 minimum, median and maximum forward current vs. forward voltage characteristics.

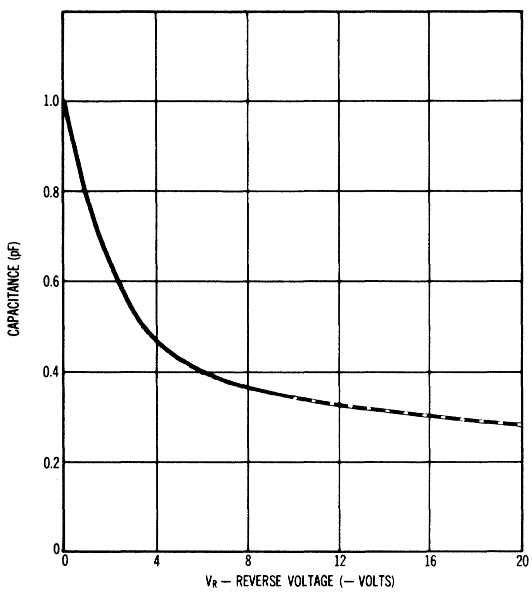


Figure 5. Typical HP 5082-2900 capacitance vs. reverse voltage characteristics at $T_A = 25°C$.

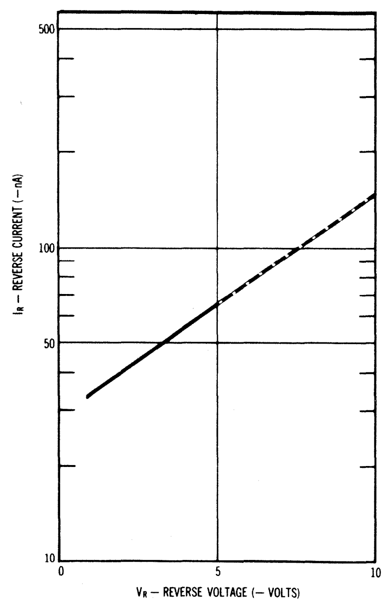


Figure 6. Typical HP 5082-2900 reverse current variation vs. reverse voltage at $T_A = 25°C$.

PIN DIODES

Device No.	Page
Universal 5082-3000 Series	67
Constant Impedance Attenuators 5082-3003	71
High Reliability Qualification 5082-3008, -3009	75
Universal Stripline 5082-3040	79
High Speed Stripline 5082-3041	83
High Speed Switching and Modulating 5082-3042, -3043	83
High Power 5082-3051, -3052	87
Medium Power 5082-3101, -3102, -3201, -3202	68

PIN DIODES
HP 5082-3000 SERIES
PIN 1

HEWLETT hp PACKARD

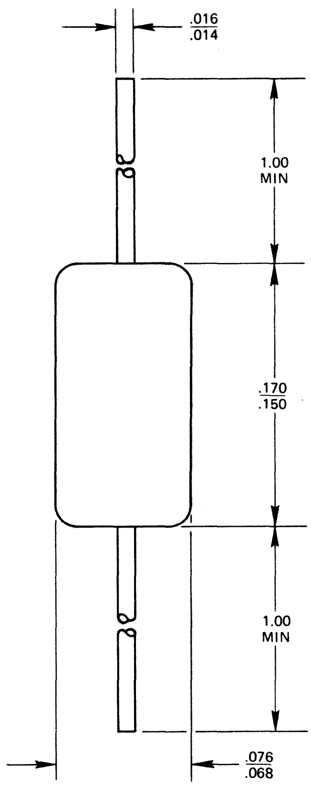
TECHNICAL DATA 1 MAR 69

SIGNAL CONDITIONING AND CONTROL DEVICES

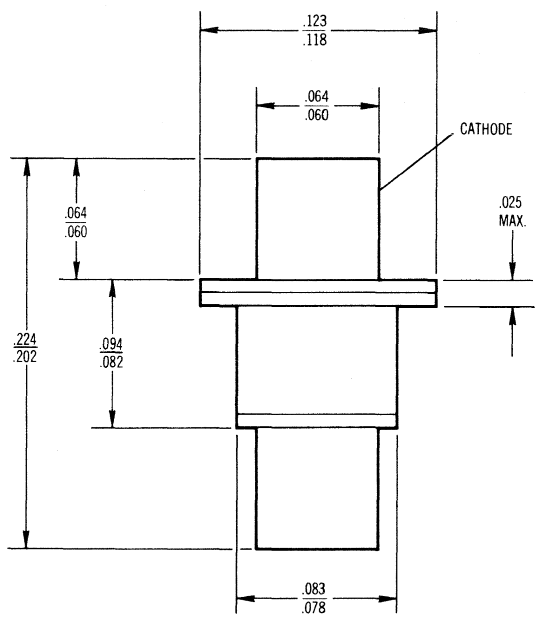
Low saturated forward resistance and high reverse Q giving high isolation to insertion loss ratio.

10,000 to 1 RF forward resistance range for large range of signal control.

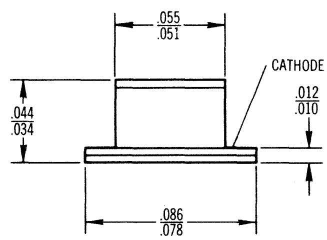
Specified lifetime for low harmonic distortion at VHF.



(Outline 15)



(Outline 31)



(Outline 38)

Dimensions in inches

DESCRIPTION

The HP 5082-3000 Series PIN Diodes are planar silicon devices manufactured using modern processing techniques to provide optimum characteristics for signal conditioning and control applications.

APPLICATIONS

HP PIN diodes are intended for use in signal conditioning and control applications (switching, phase shifting, attenuation) at frequencies well into the microwave region. By varying the dc bias current, the RF resistance may be varied from less than 1.0 ohm to 10,000 ohms. These devices provide turn-on and turn-off times of tens of nanoseconds, and are especially useful where the lowest possible residual series resistance and junction capacitance are required for high ON to OFF switching ratios. Additional information on PIN diodes is contained in HP Application Notes 912 and 922. Applications information on biasing and switching PIN diodes is available in HP Application Note 914. HP Special Information Note Number 5 discusses PIN diode harmonic generation.

ABSOLUTE MAXIMUM RATINGS

T_{OPR}—Operating Temperature Range....– 65°C to + 150°C
T_{STG}—Storage Temperature Range........– 65°C to + 150°C
P_{DISS}—DC Power Dissipation at T_C = 25°C

HP 5082-3001, 5082-3002, 5082-3039..................0.250 W
HP 5082-3101, 5082-3102 ....1.0 W
HP 5082-3201, 5082-3202 ....3.0 W

PACKAGES

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch (1,6 mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E (4 lbs. [1,8 kg.] tension for 30 minutes). The maximum soldering temperature is 230°C ± 5° for 5 seconds. Typical package inductance and capacitance are 2 nH and 0.2 pF, respectively. Marking is by digital coding with a cathode band.

The HP Outline 31 package has a metal-ceramic hermetic seal. The anode stud is gold-plated copper. The cathode stud is gold-plated Kovar. The maximum soldering temperature is 230°C ± 5°C for 5 seconds. Typical package inductance and capacitance is 1.0 nH and 0.2 pF, respectively. Marking is by color-coded dots on ceramic; clockwise when facing anode, starting at open space.

The HP Outline 38 package: The anode and cathode are gold-plated Kovar. The maximum soldering temperature is 230°C ± 5°C for 5 seconds. Typical package inductance and capacitance is 0.4 nH and 0.2 pF. The package is not marked.

ELECTRICAL SPECIFICATIONS AT T_A = 25°C

Characteristic		Breakdown Voltage (min.)	Total Capacitance (max.)	Residual Series Resistance (max.)	Effective Minority Carrier Lifetime (min.)
HP Type Number	Package Outline	V_{BR} (volts)	C_{VR} (pF)	R_S (ohms)	τ (ns)
5082-3001	15	150	0.30	1.25	100
5082-3002	15	200	0.25	1.0	100
5082-3039	15	100	0.30	1.5	100
5082-3101	38	150	0.32	1.5	100
5082-3102	38	200	0.30	1.5	100
5082-3201	31	150	0.35	1.5	100
5082-3202	31	200	0.32	1.5	100
Test Condition		I_R = 10 μA	V_R = 50 V f = 1.0 MHz	I_F = 100 mA f = 0.5 GHz	I_F = 50 mA

ENVIRONMENTAL CAPABILITIES

	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	See Maximum Ratings
Temperature, Operating	—	See Maximum Ratings
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, – 65 to + 125°C
Thermal Shock	1056	5 cycles, 0 to + 100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, X_1, Y_1, Y_2 @ 1500 G
Vibration Fatigue	2046	32 hrs. X, Y, Z, @ 1500 G
Vibration Variable Frequency	2056	Four 4-min cycles, X, Y, Z, @ 20 G Min., 100 to 2000 Hz
Constant Acceleration	2006	X_1, Y_1, Y_2 @ 20,000 G
Terminal Strength	2036	Package Dependent
Salt Atmosphere	1041	35°C fog for 24 hours

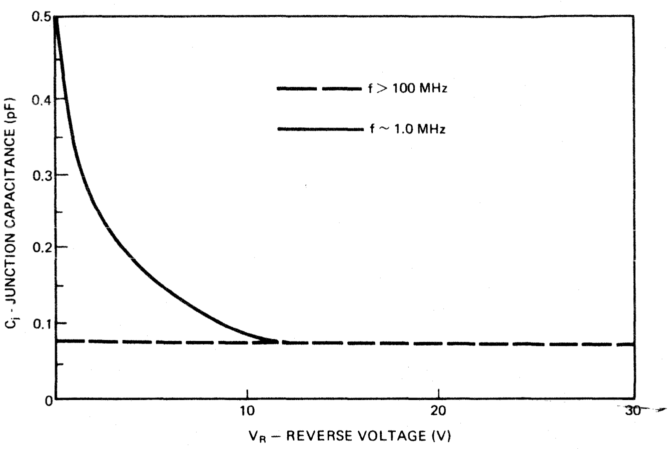


Figure 1. Typical PIN Diode Junction Capacitance versus Reverse Bias Voltage at $T_A = 25°C$.

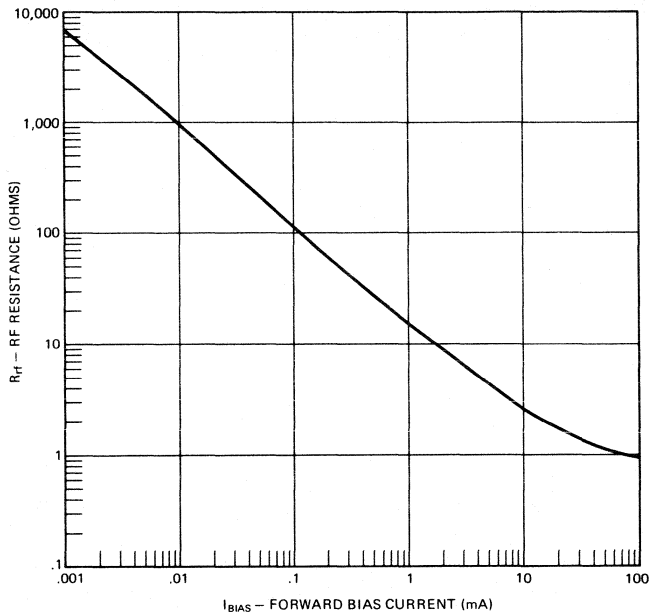


Figure 2. Typical PIN Diode RF Resistance versus Bias Current at f = 500 mHz and $T_A = 25°C$.

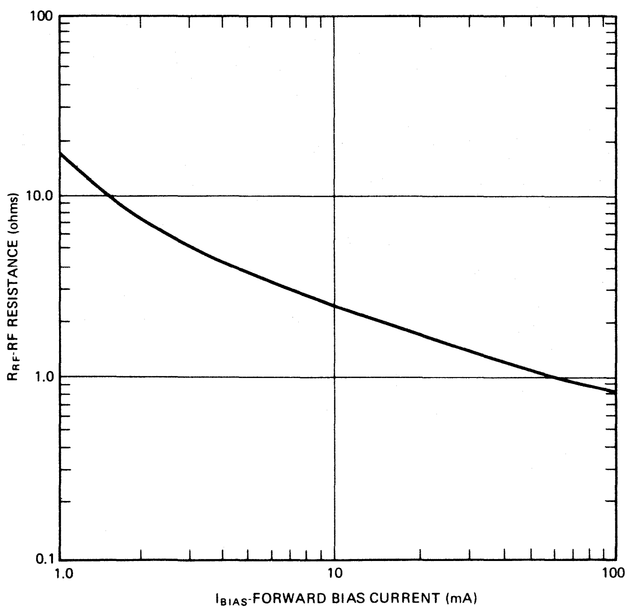
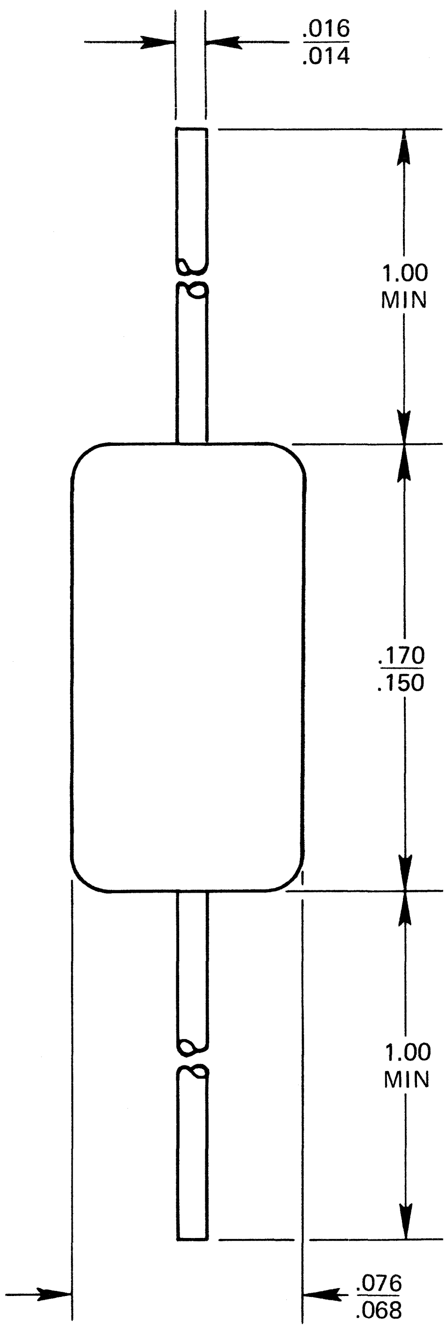


Figure 3. Typical PIN Diode RF Resistance versus Bias Current at f = 500 mHz and $T_A = 25°C$.

HEWLETT PACKARD

CURRENT-CONTROLLED RF RESISTOR

model
5082-3003



- RF resistance variation with bias specified at 500 MHz.
- Large resistance swing (1 Ω - 10,000 Ω typical).
- Long lifetime for low intermodulation.
- Useful application down to 10 MHz.
- Tight resistance tracking between units.
- Low resistance-temperature coefficient at constant current bias.

Description

The current-controlled RF resistor consists of a specially processed and tested silicon PIN diode. The fabrication process is tightly controlled and units are selected on the basis of similarity of RF resistance variation with bias. RF resistance is measured and specified on each unit at 500 MHz and at two bias points. The RF resistance versus bias slope is also specified to tight limits to further assure tracking of individual devices. Long lifetime assures usefulness at operating frequencies down to 10 MHz at small signal levels.

Applications

The current-controlled RF resistor (CCR) is a very useful device for realizing current-controlled RF attenuators, RF AGC circuits, constant impedance leveling circuits, electronically controlled RC circuits, variable Q resonating networks and filters, modulating circuits, and as an element in any circuit that requires the use of a dc or low-frequency control of an RF resistance.

The CCR has a resistance characteristic that is accurately described by $R = KI^{-x}$ in the range of 0.01 mA to 1 mA. When displayed on log-log coordinates, as shown in Figure 1, this characteristic plots as a straight line with a slope of $-x$, and at 1 mA $R = K$. The equation constants for the HP 5082-3003 are typically $K = 20$ and $x = 0.88$.

To assure repeatability of the RF resistance characteristic from unit to unit, the high and low resistance values are specified to within ±20%. To assure tight tracking between units, the slope is also specified to be in the range of 0.9-0.86. This is particularly useful when several CCR's in an attenuator or modulator circuit must track each other closely. For very close tracking, the individual CCR's can be biased with a slight offset with respect to a reference CCR. This is shown in Figure 1.

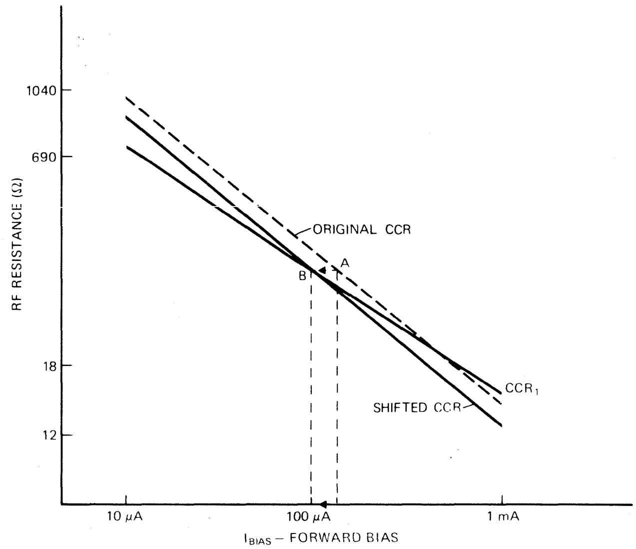


Figure 1. Tracking of Individual CCR's by Bias Current Offset

The characteristic curve of CCR_1 is used as reference. The characteristic curve of CCR_2 is moved over from A to B by a current offset until they intersect at CCR_1's 0.1 mA position.

$$\text{If } R_1 = K_1 I_1^{-x_1}$$
$$\text{and } R_2 = K_2 I_2^{-x_2}$$

then to shift R_2 to any current points on R_1, the following relation would be used:

$$I_2 = \left(\frac{K_2}{K_1}\right)^{\frac{1}{x_2}} I_1^{\frac{x_1}{x_2}}$$

At RF, the equivalent circuit of the CCR can be represented as shown in Figure 2.

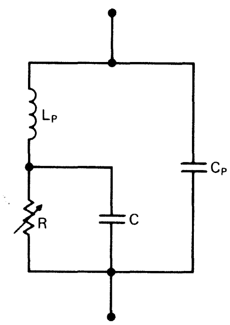


Figure 2. Equivalent RF Equivalent Circuit of CCR

L_P and C_P are the package inductance and capacitance, respectively. The capacitance C is the capacitance of the intrinsic silicon layer of the chip and is typically 0.06 pF. This capacitance does not change with frequency or bias. At constant bias, the RF resistance of the CCR is relatively insensitive to temperature, changing only +15% for a temperature change from 25° to 100°C.

RF Electrical Specifications (T_A = 25°C)

Parameter	Symbol	Max.	Min.	Units	Test Conditions
High Resistance Limit	R_H	1380	920	Ohms	DC bias = 10 μA Test Frequency = 500 MHz
Low Resistance Limit	R_L	24	16	Ohms	DC bias = 1.0 mA Test Frequency = 500 MHz
Resistance vs. Bias Slope	x	−0.9	−0.86	—	DC bias = 10 μA & 1.0 mA Test Frequency = 500 MHz

DC Electrical Specifications (T_A = 25 C)

Parameter	Symbol	Max.	Min.	Units	Test Conditions
Breakdown Voltage	V_{BR}	—	100	Volts	I_R = 10 μA
Reverse Capacitance Note 1	C_{VR}	0.3	—	pF	V_R = 50 V f = 1.0 MHz
Series Resistance	R_S	1.5	—	Ohms	I_F = 100 mA
Effective Minority Carrier Lifetime	τ	—	100	ns	I_F = 50 mA

Note 1. Typical reverse bias junction capacitance is 0.06 pF.

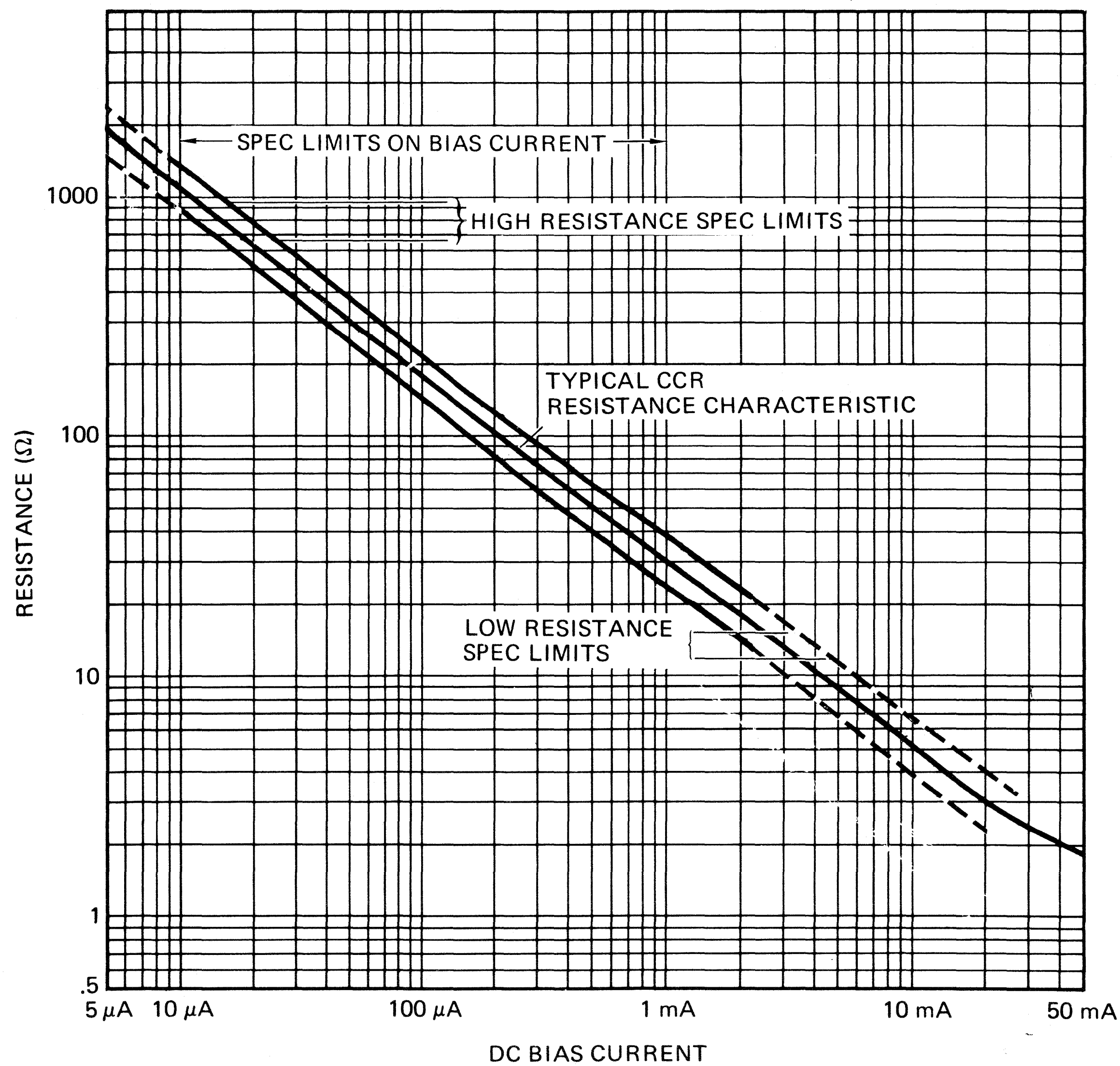
Absolute Maximum Ratings

T_{OPR}—Operating Temperature Range .... −65° to +150°C

T_{STG}—Storage Temperature Range .... −65° to +150°C

P_{DISS}—DC Power Dissipation (at T_A = 25°C) .... 0.250 watts

Figure 3. RF Resistance vs. Bias Characteristic



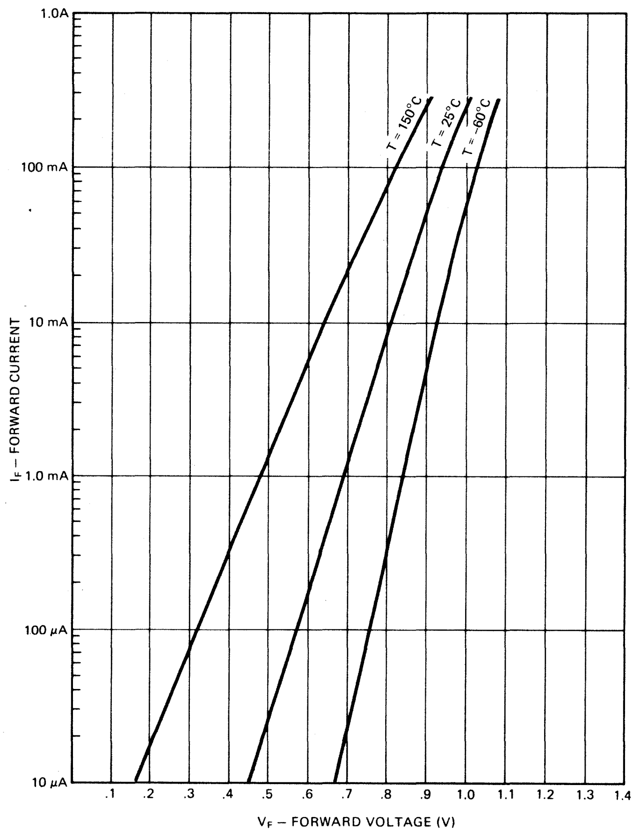


Figure 4. Typical Forward Conduction Characteristics

Typical Mechanical and Environmental Characteristics

PACKAGES

The HP Outline 15 package has a glass hermetic seal with dumet leads. The leads on the Outline 15 package should be restricted so that the bend starts at least 1/16 inch (1,6 mm) from the glass body. With this restriction, Outline 15 package will meet MIL-STD-750, Method 2036, Conditions A and E (4 lb [1,8 kg] tension for 30 minutes). The maximum soldering temperature is 230°C ±5° for 5 seconds. Typical package inductance and capacitance is 2.5 nH and 0.1 pF, respectively. Marking is by digital coding with a cathode band.

RELIABILITY

Hewlett-Packard PIN diodes are suitable for high reliability space applications where maximum performance stability under the most adverse conditions is required. Maintenance of product reliability during manufacture has resulted in the use of HP diodes in major aerospace and national defense programs.

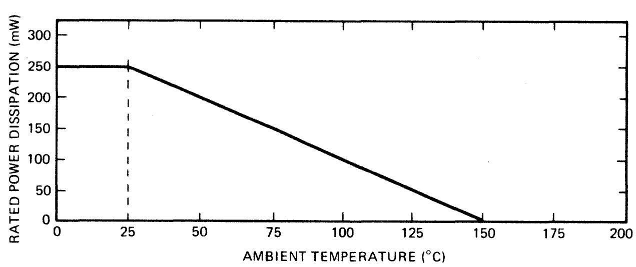


Figure 5. Power Dissipation Derating Characteristics

Environmental Capabilities

	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	See Maximum Ratings
Temperature, Operating	—	See Maximum Ratings
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, −65° to +150°C
Thermal Shock	1056	5 cycles, 0° to +100°C
Moisture Resistance	1021	10 days, 90-98% RH
Shock	2016	5 blows, at 1500 G, X, Y, Z
Vibration Fatigue	2046	32 hrs., X, Y, Z, at 20 G min.
Vibration Variable Frequency	2056	Four 4-min. cycles, X, Y, Z, at 20 G min., 100 to 2000 Hz
Constant Acceleration	2006	20,000 G, X, Y, Z
Terminal Strength	2036	Package Dependent
Salt Atmosphere	1041	35°C fog for 24 hours

HEWLETT hp PACKARD

HIGH RELIABILITY TEST PROGRAM

PIN AND HOT CARRIER DIODES

- 100% PRECONDITIONED AND SCREENED FOR HIGH RELIABILITY
- TWO LEVELS AVAILABLE
- FAST OFF-THE-SHELF DELIVERY FOR LARGE AND SMALL QUANTITIES
- ECONOMICAL HIGH RELIABILITY TESTING
- SIMPLIFIES PREPARATION OF PRODUCT CONTROL SPECS

General

The HP High Reliability Test Program makes available, for immediate delivery from stock, preconditioned and screened PIN and hot carrier diodes for high reliability applications. The HP-designed program is used in testing large lots and gives the user the advantage of much lower unit prices than is possible for small quantities tested to individual user specifications.

The High Reliability Test Program has resulted from over four years experience in producing and evaluating the diode types now available in the program. HP has supplied these high reliability diodes for the most demanding military and aerospace programs. The 100% preconditioning and screening approach to achieving high reliability, rather than sample evaluations, is not only proven by HP experience, it is also consistent with the most advanced practice in the industry.

The program flow chart in Figure 1 shows the specific tests performed for Level I and Level II. The two levels of reliability available will meet the needs of the majority of the application requirements.

Level I provides minimum screening and minimum cost to the user while guaranteeing that a diode lot will meet MIL-S-19500 requirements. This level is suitable for many military and industrial applications.

Level II is Level I plus additional screening and conditioning, with data on every diode taken at the end of the Level I program and the end of the Level II program. These data are supplied with parameter change information. Only those diodes which meet the electrical stability requirements at the end of the program are shipped. The data, therefore, confirm the suitability of these diodes for the more critical reliability applications. Level II is recommended for the requirements of airborne and aerospace programs.

The basic types now available are HP 5082-2301, -2302, and -2800 Hot Carrier Diodes and 5082-3001 and -3002 PIN Diodes. These can be ordered to Level I or Level II by using the corresponding type numbers in Table I.

The following HP program plan and flow chart can be used without change for customer's product control specifications where these documents are necessary. It is recommended, for these specifications, that this program be included as the initial conditioning and screening when additional tests are required. By so specifying the HP program, the user obtains the cost advantage inherent in the program. Typical examples of other tests which may be included at nominal cost increase are operating burn-in, X-ray, shock, vibration, and Group B and C testing.

Packaging

Packaging and packing for shipment is according to MIL-S-19491C, Level C. Each unit package is marked with the diode type number and the quantity in the package. The external shipping container is marked with the diode type number, quantity in the shipment, and the customer order number. Special marking in addition to the foregoing will be supplied according to customer specifications.

TABLE I
HIGH RELIABILITY TEST PROGRAM DIODE TYPE NUMBERS

Product Category	Basic Type No.	Level I Type No.	Level II Type No.
Hot Carrier Diode	5082-2301	5082-2409	5082-2411
Hot Carrier Diode	5082-2302	5082-2410	5082-2412
Hot Carrier Diode	5082-2800	5082-2806	5082-2807
PIN Diode	5082-3001	5082-3008	5082-3006
PIN Diode	5082-3002	5082-3009	5082-3007

DIODE MARKING

The glass bodies of all high reliability diodes are painted black. The type identification is white digital coding and a white cathode band. For example:

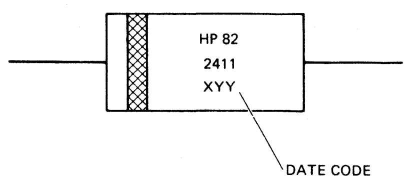


TABLE II
HP 5082-2409, 5082-2410, 5082-2411, 5082-2412

GROUP A
Electrical Specifications at $T_A = 25°C$

Characteristics	Symbol	Units	Min.	Max.	Test Conditions
Breakdown Voltage	V_{BR}	V	30		$I_R = 10\ \mu A$
Reverse Current	I_R	nA		300	$V_R = 15$ V
Forward Voltage	V_{F1}	V		0.4	$I_{F1} = 1.0$ mA
Forward Voltage	V_{F2}	V		1.0	5082-2409, -2411: $I_{F2} = 50$ mA 5082-2410, -2412: $I_{F2} = 35$ mA
Capacitance	C_o	pF		1.0	$V_R = 0$ V, f = 1.0 MHz

TABLE III
HP 5082-2806, 5082-2807

GROUP A
Electrical Specifications at $T_A = 25°C$

Characteristics	Symbol	Units	Min.	Max.	Test Conditions
Breakdown Voltage	V_{BR}	V	70		$I_R = 10\ \mu A$
Reverse Current	I_R	nA		200	$V_R = 50$ V
Forward Voltage	V_{F1}	V		0.41	$I_{F1} = 1.0$ mA
Forward Voltage	V_{F2}	V		1.0	$I_{F2} = 15$ mA
Capacitance	C_o	pF		2.0	$V_R = 0$ V, f = 1.0 MHz

TABLE IV
HP 5082-3006, 5082-3007, 5082-3008, 5082-3009
GROUP A
Electrical Specifications at $T_A = 25°C$

Characteristics	Symbol	Units	5082-3006 & 5082-3008 Min.	5082-3006 & 5082-3008 Max.	5082-3007 & 5082-3009 Min.	5082-3007 & 5082-3009 Max.	Test Conditions
Reverse Current	I_R	μA		1.0		1.0	$V_R = 50$ V
Breakdown Voltage	V_{BR}	V	150		200		$I_R = 10\ \mu A$
Forward Voltage	V_F	V		1.0		1.0	5082-3006, -3008: $I_F = 100$ mA 5082-3007, -3009: $I_F = 150$ mA
Capacitance	C_{VR}	pF		0.30		0.25	$V_R = 50$ V, f = 1 MHz
Lifetime	τ	ns	100		100		$I_F = 50$ mA
Series Resistance	R_S	Ω		2.5		2.5	$I_F = 50$ mA

LEVEL I

All diodes are subjected to all program steps except where sampling inspection (*) is shown.

Program Step	Hot Carriers 5082-2409 5082-2410	Hot Carriers 5082-2806	PIN's 5082-3008 5082-3009
1. Electrical Test, Group A—Table II, III, or IV			
*2. Visual and Mechanical Inspection, 10% LTPD			
3. Hi Rel Gold Plate, 50 μinch minimum			
4. Hi Temp. Storage, 168 hours, MIL-STD-750, Method 1031	125°C Max.	200°C Max.	150°C Max.
*5. Electrical Test, 10% LTPD, Group A—Table II, III, or IV			
6. Body Paint and Mark			
*7. Visual Inspection, 10% LTPD			
8. Electrical Test, Go-NoGo, No Data, Group A—Table II, III, or IV			
9. Ship Level I			

LEVEL II

All diodes are subjected to all program steps except where sampling inspection (*) is shown.

Program Step	Hot Carriers 5082-2411 5082-2412	Hot Carriers 5082-2807	PIN's 5082-3006 5082-3007
1. Electrical Test, Group A—Table II, III, or IV			
*2. Visual and Mechanical Inspection, 10% LTPD			
3. Hi Rel Gold Plate, 50 μinch minimum			
4. Hi Temp. Storage, 168 hours, MIL-STD-750, Method 1031	125°C	200°C	150°C
*5. Electrical Test, 10% LTPD, Group A—Table II, III, or IV			
6. Body Paint and Mark			
*7 Visual Inspection, 10% LTPD			
8. Electrical Test, Serialize and Record Data, Group A—Table II, III, or IV			
9. Temp. Cycling, MIL-STD-750, Method 1051	Cond. B	Cond. C	Cond. F
10. Constant Acceleration, Y_1, MIL-STD-750, Method 2006			
11. Fine Leak Test, MIL-STD-202C, Method 112A, Cond. C, Procedure IIIa			
12. Gross Leak Test, isopropyl alcohol, 90 psi, 1 hour minimum			
13. Test V_{BR} within 2 hours following Gross Leak			
14. Hi Temp. Storage, 168 hours, MIL-STD-750, Method 1031	125°C	200°C	150°C
15. Electrical Test, Record Data, Group A—Table II, III, or IV			
16. Individual Stability			
ΔI_R max.	+50 nA	+50 nA	+250 nA
ΔV_{BR} max.	−3 V	−7 V	−20 V
ΔV_F max	±100 mV	±100 mV	±50 mV
17. Ship Level II			

HP ASSOCIATES
HIGH RELIABILITY TEST PROGRAM

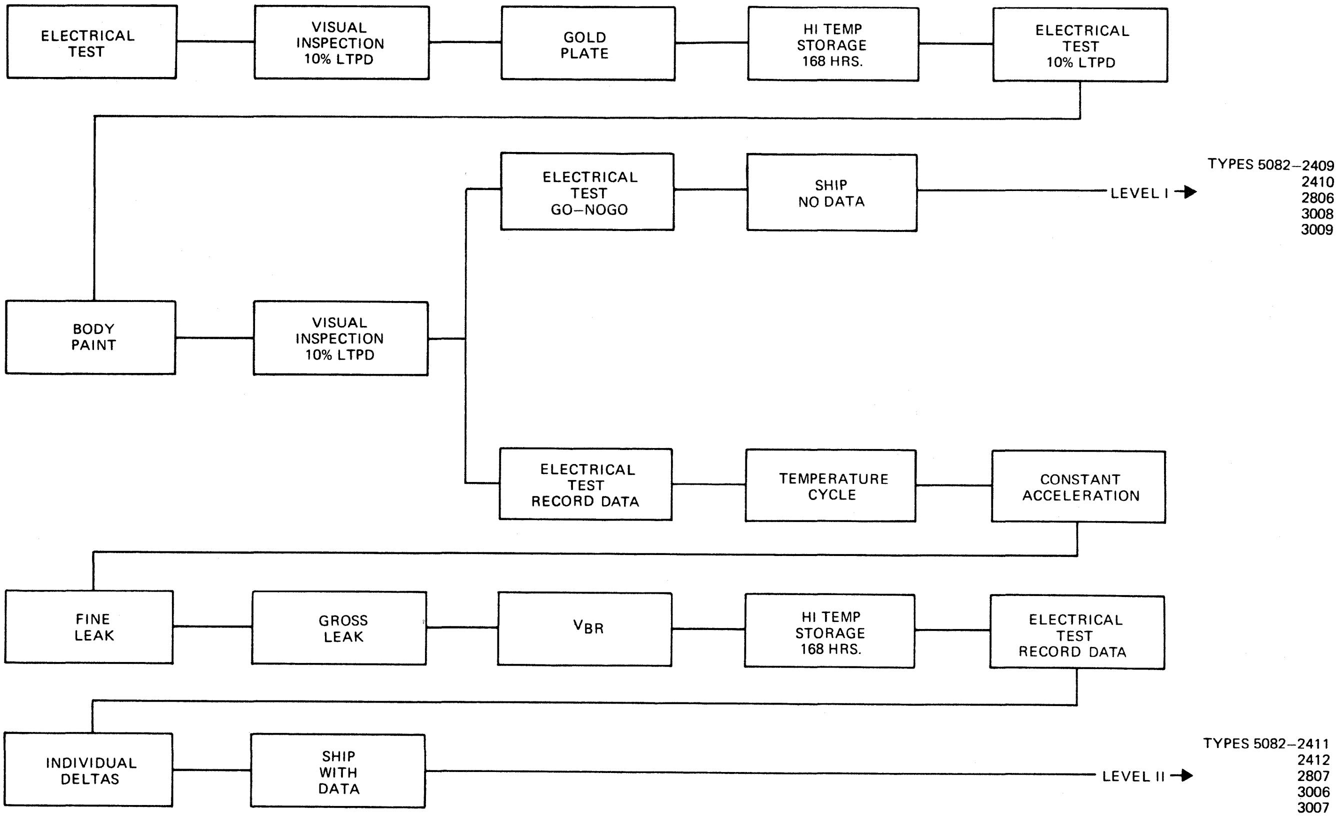
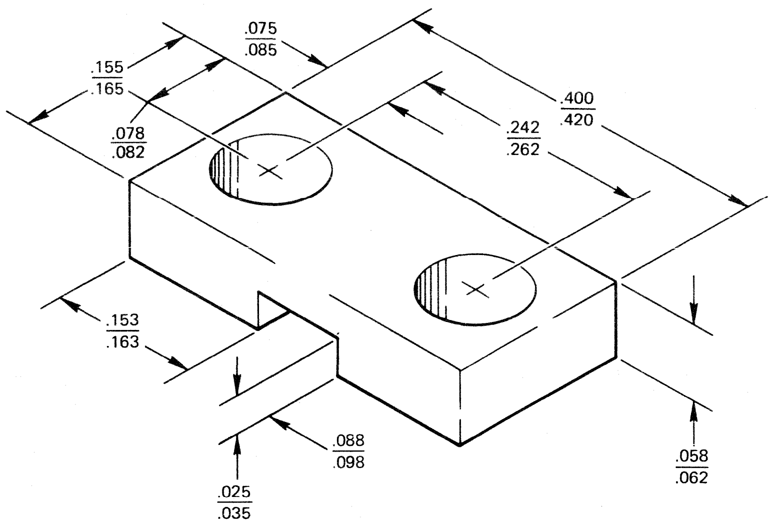


Figure 1. High Reliability Test Program

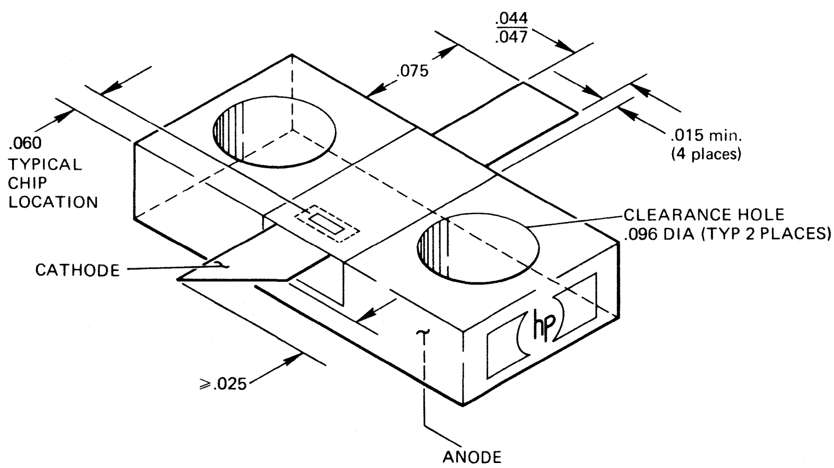
HEWLETT hp PACKARD

STRIPLINE PIN DIODE

HP 5082-3040



Cover plate for balanced stripline applications.



Stripline PIN diode. Dimensions are identical to the cover plate.

Description and Application

The HP 5082-3040 is a silicon planar passivated PIN diode manufactured using modern processing techniques to provide optimum characteristics for stripline signal conditioning and control applications.

Microwave and UHF systems using stripline circuit techniques have the advantages of small size, light weight, and low cost over systems constructed with waveguide and coaxial devices. Additional stripline advantages are mechanical rigidity and operation over wide frequency ranges. Unfortunately, glass packaged devices designed for lumped circuits and double stud ceramic packages useful for waveguide are not optimally configured for use in stripline. This is especially true when very wide bandwidths must be covered.

The HP 5082-3040 is an optimally integrated shunt diode (see Figure 1) intended for use from HF through 18 GHz without the limitations of matching structures. The package, when zero or reverse biased, appears as a 50-ohm microstrip line. The leads allow good continuity of characteristic impedance when used in 50-ohm stripline circuitry. When forward biased, the resistance appearing across the line is a function of the bias level and varies typically as shown in Figure 2.

When used in a balanced stripline application it is important that the cover cap supplied with the diode be used in order to have good electrical continuity from the upper to the lower ground plane through the package base metal (Figure 3). Higher order modes will be excited if this cover is either left off or if poor electrical contact is made to the ground plane. Shims, "ripple" washers, or "fuzz buttons" can be used to assure good contact to the ground planes.

Absolute Maximum Ratings

T_{OPR} Operating Temperature Range..–65°C to +125°C
T_{STG} Storage Temperature Range......–65°C to +125°C
P_{DISS} DC Power Dissipation (T_A = 25°C)............2.5 watts
θ_{JC} Thermal Resistance...50°C/W
V_{BR} Breakdown Voltage..150 volts

Mechanical Specifications

See Outline Drawing 61

Typical Performance Characteristics

From I_F: (mA)	TO V_R: (V)	t_{switch} (ns)
100	10	110
100	50	50
10	10	35

TABLE I. Typical HP 5082-3040 Switching Time at 10 GHz

Electrical Specifications at T_A = 25°C

Symbol	Characteristic	Min.	Max.	Units	Test Conditions
I_S	Isolation @ 10 GHz	20	—	dB	I_{BIAS} = 100 mA
I_L	Insertion Loss @ 10 GHz	—	0.5	dB	$V_R = 0$
VSWR	Voltage Standing Wave Ratio @ 10 GHz	—	1.5	—	$V_R = 0$

Environmental Characteristics

Characteristic	MIL-STD-750 Reference	Conditions
Temperature, Storage	1031	–65°C to +125°C
Temperature, Operating	—	–65°C to +125°C
Solderability	2026	230°C as applicable
Temperature, Cycling	1051	5 cycles, –65 to +125°C
Thermal Shock	1056	5 cycles, 0 to +100°C
Shock	2016	5 blows, X_1, X_2, Y_1, Y_2, Z_1, Z_2, @ 1500 G
Vibration Fatigue	2046	32 hours, X, Y, Z @ 20 G
Vibration Variable Frequency	2056	Four 4-min. cycles, X, Y, Z, @ 20 G Min., 100 to 2000 Hz
Constant Acceleration	2006	20,000 G X_1, X_2, Y_1, Y_2, Z_1, Z_2
Terminal Strength	2036	Tension and lead fatigue
Salt Atmosphere	1041	35°C fog for 24 hours
Barometric Pressure	1001	150,000 feet

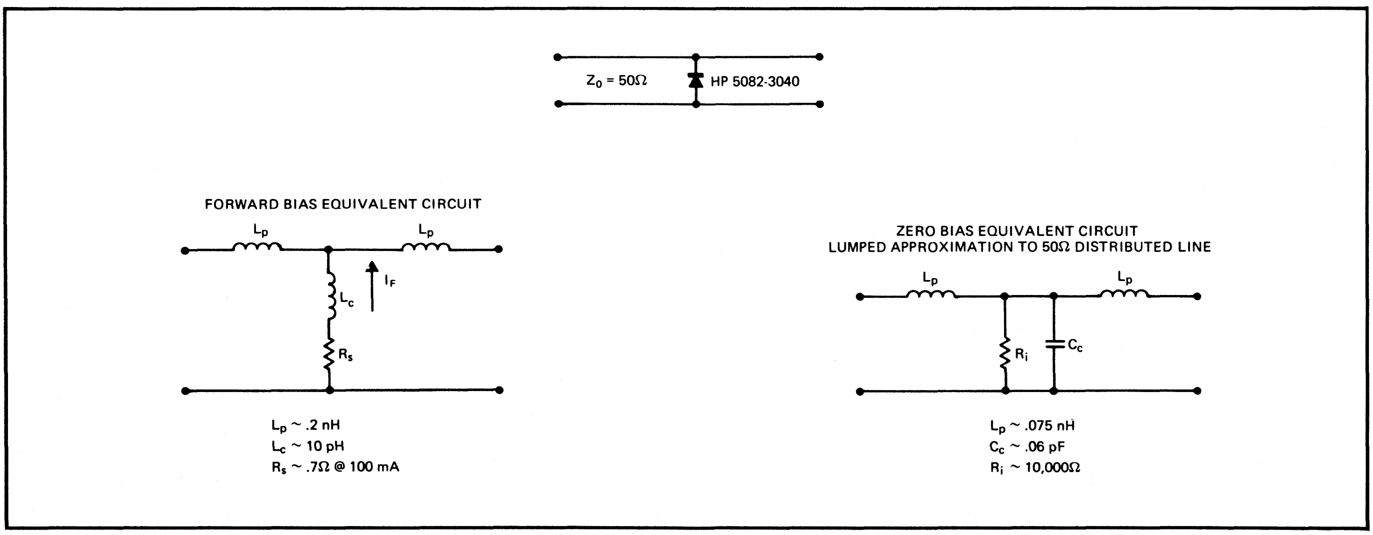


Figure 1. HP 5082-3040 forward and zero bias equivalent circuits.

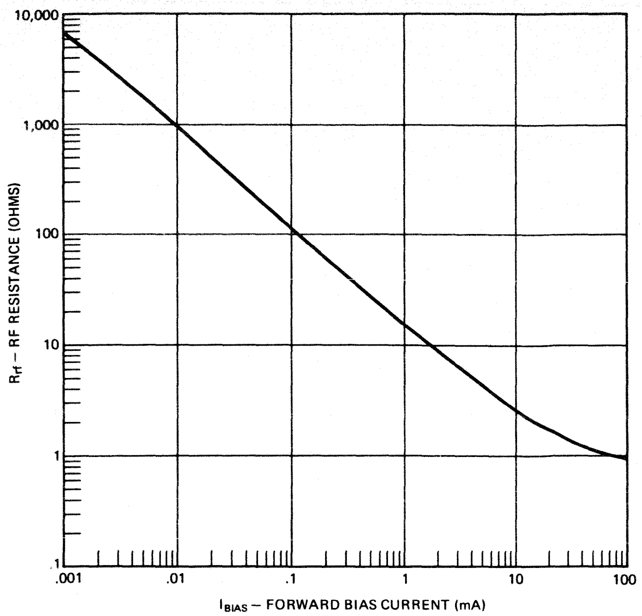


Figure 2. Typical HP 5082-3040 series resistance versus bias current at $T_A = 25°C$.

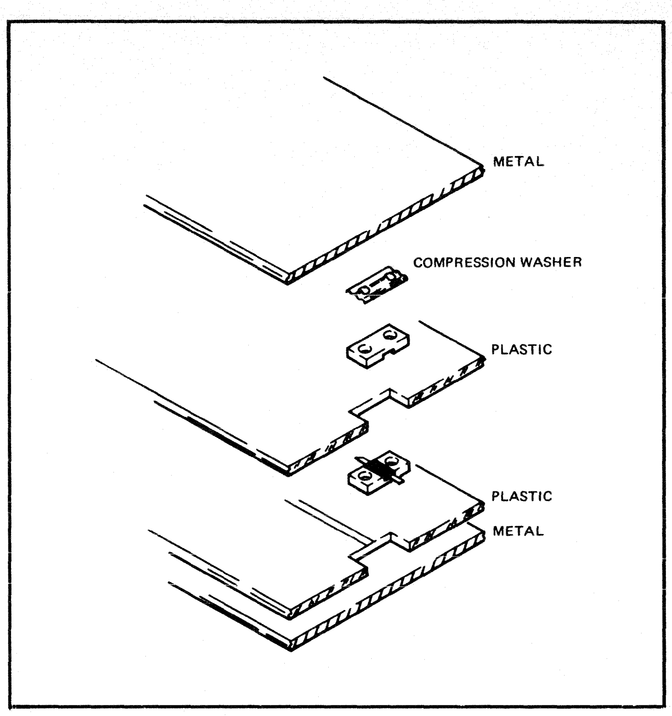


Figure 3. HP 5082-3040 suggested stripline assembly technique. Application Note 922 contains further details.

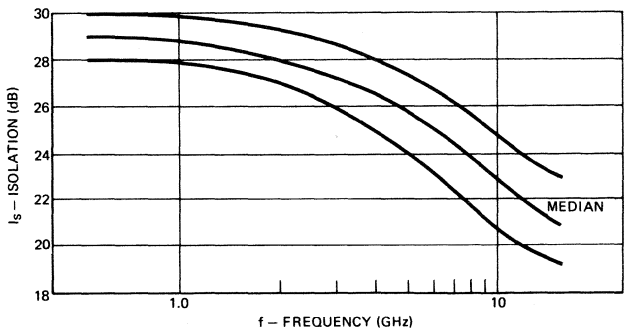


Figure 4. HP 5082-3040 isolation versus frequency at $T_A = 25°C$ and 100 mA bias current.

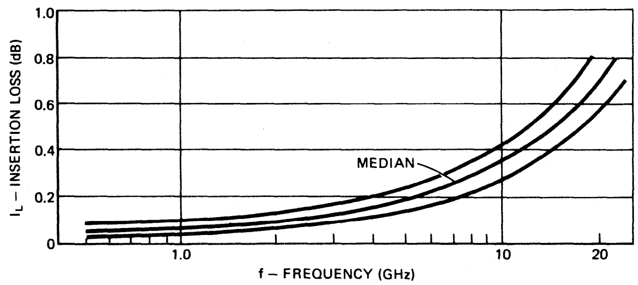


Figure 5. HP 5082-3040 insertion loss versus frequency at $T_A = 25°C$ and zero bias.

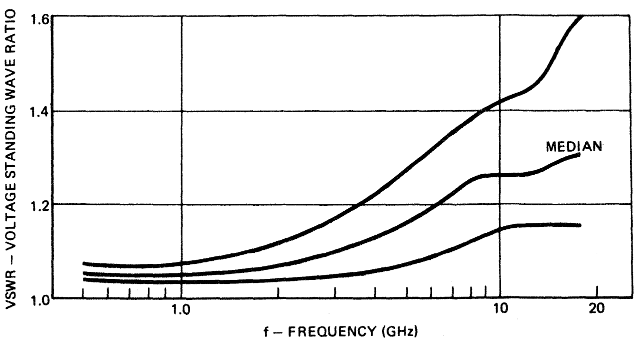


Figure 6. HP 5082-3040 VSWR versus frequency at $T_A = 25°C$ and zero bias.

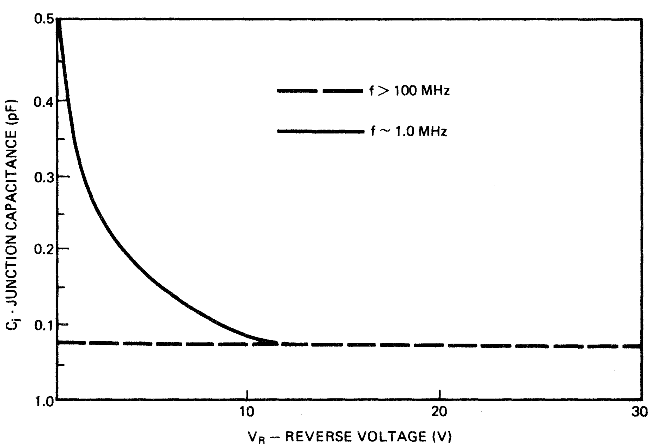


Figure 7. Typical HP 5082-3040 junction capacitance versus reverse bias voltage at $T_A = 25°C$.

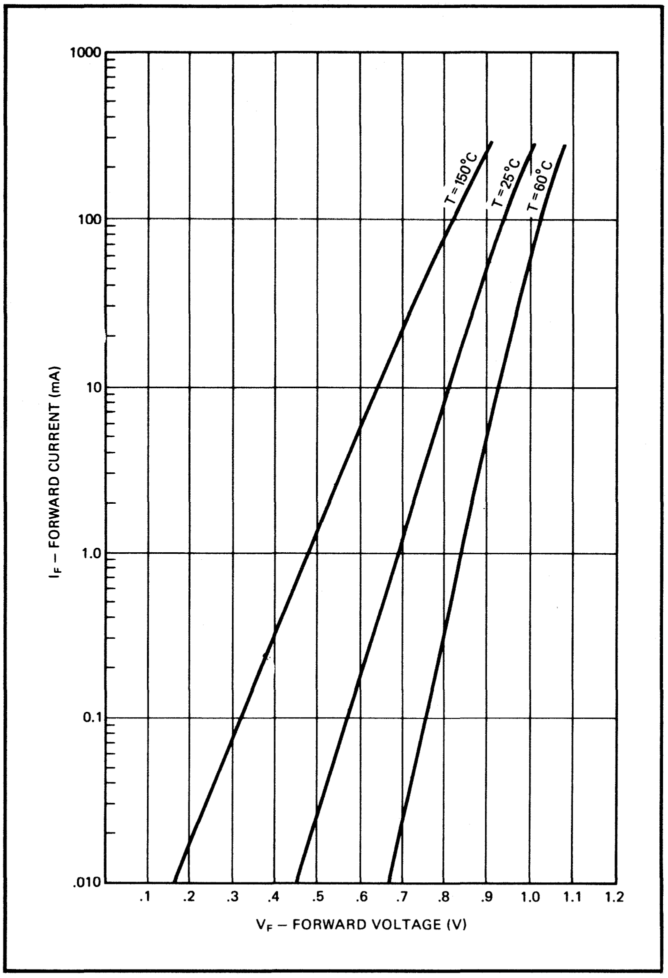


Figure 8. Typical HP 5082-3040 forward conduction characteristics.

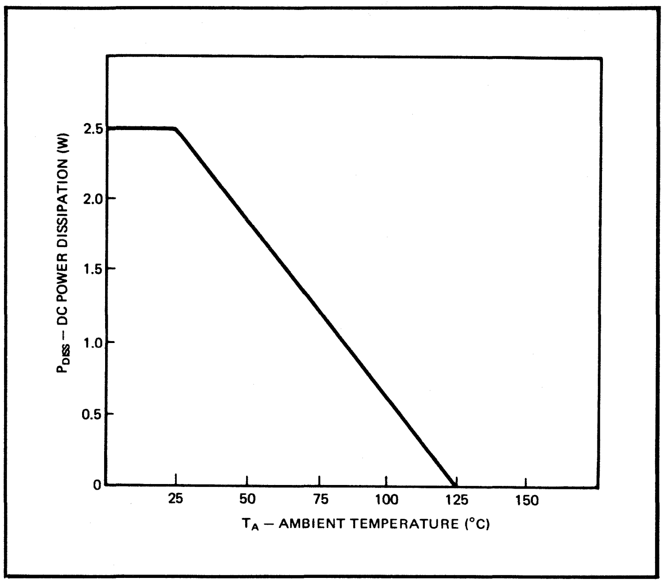
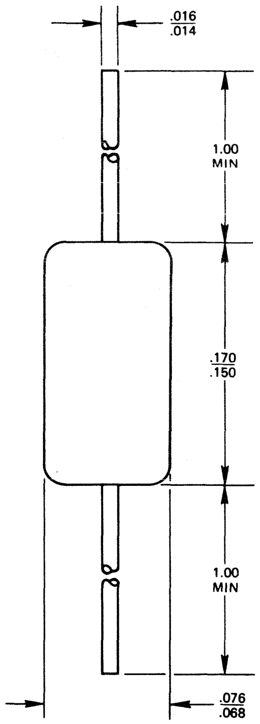


Figure 9. HP 5082-3040 dc power dissipation characteristics.

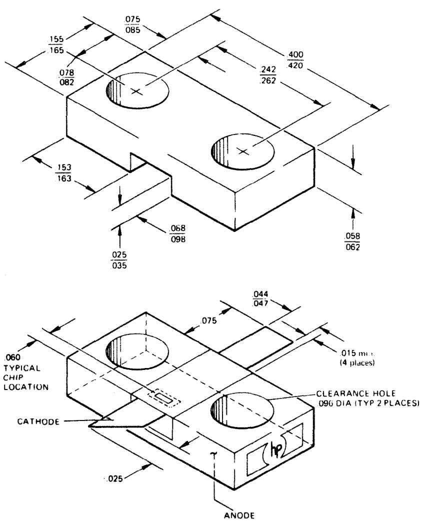
HEWLETT PACKARD

HIGH-SPEED SWITCHING PIN DIODE

models
5082-3041
5082-3042
5082-3043



OUTLINE 15



OUTLINE 61

- **NANOSECOND SWITCHING TIME**
  Less than 5 ns
- **HIGH ISOLATION**
  5082-3041 greater than 20 dB through X-band
- **STRIPLINE OPTIMIZED PACKAGE**
  5082-3041 award-winning HP OD-61 50-ohm stripline package
  5082-3042 and 5082-3043 axial lead miniature glass also available
- **LOW RESIDUAL RF RESISTANCE**
  Less than 1 ohm
- **LOW SWITCHING DRIVE CURRENT REQUIRED**
  Less than 20 mA forward bias current to obtain:
  20 dB isolation, 5082-3041
  1 ohm RF resistance, 5082-3042

Description

The HP 5082-3041, 5082-3042, and 5082-3043 are oxide passivated silicon PIN diodes of mesa construction. The precisely controlled processing provides an exceptional combination of fast RF switching and low residual series resistance.

The combination of features in this family of HP PIN diodes provides unique benefits in the high isolation to insertion loss ratio afforded by the low residual resistance at low bias currents and the ultra-fast recovery realized through lower stored charge. Where low drive power is desired, these diodes provide excellent performance at much lower bias currents than previously available devices.

This process is included in the popular HP stripline package. This package is an optimally integrated shunt diode intended for use from HF through 12.4 GHz without the limitations of matching structures. The package, when zero or reverse biased, appears as a 50-ohm microstrip line. The leads allow good continuity of characteristic impedance when used in 50-ohm stripline or micro-stripline circuitry. When forward biased, the device appears as a current variable RF resistance shunting the 50-ohm line.

Applications

The HP 5082-3041 stripline and the 5082-3042 and 5082-3043 axial lead glass PIN diodes are intended for controlling and processing of a microwave signal up to 12.4 GHz. Typical applications include single and multi-throw switches, pulse modulators, amplitude modulators, phase shifters, duplexers, diplexers, T-R switches, etc.

Absolute Maximum Ratings

Characteristic	Symbol	HP 5082-3041 (61 Package)	HP 5082-3042 (15 Package)	HP 5082-3043 (15 Package)
Operating Temperature Range	T_{OPR}	−65°C to +125°C	−65°C to +150°C	−65°C to +150°C
Storage Temperature Range	T_{STG}	−65°C to +125°C	−65°C to +150°C	−65°C to +150°C
DC Power Dissipation $T_A = 25°C$	P_{DISS}	2.5 W**	0.25 W	0.25 W
Peak Inverse Voltage	PIV	70 V	70 V	50 V
Peak Incident Pulse Power $T_A = 25°C$	P_{IN}*	500 W	—	—

* $t_p = 1\ \mu sec$, f = 10 GHz, DF = 0.001, $Z_o = 50\ \Omega$, $I_F = 20$ mA.
** Diode properly mounted in sufficiently large heat sink

Electrical Specifications at $T_A = 25°C$

HP 5082-3042 and 5082-3043
(Package 15)

Characteristic	Symbol	HP Type Number				Units	Test Conditions
		-3042		-3043			
		Max.	Min.	Max.	Min.		
Series Resistance	R_S	1.0	—	1.5	—	Ohms	f = 500 MHz $I_F = 20$ mA
Breakdown Voltage	V_{BR}	—	70	—	50	Volts	$I_R = 10\ \mu A$
Total Capacitance	C_{VR}	0.4	—	0.4	—	pF	f = 1 MHz $V_R = 20$ V
Reverse Recovery Time	t_{rr}	5.0	—	10	—	nsec	$I_F = 20$ mA to $I_R = 200$ mA peak, recovery to 20 mA

HP 5082-3041
(Package 61)

Characteristic	Symbol	Value		Units	Test Conditions
		Max.	Min.		
Isolation @ 10 GHz	ISO	—	20	dB	f = 8 - 12.4 GHz, $I_F = 20$ mA, P = 0 dBm
Insertion Loss @ 10 GHz	IL	1.0	—	dB	f = 8 - 12.4 GHz, $V_R = 0$ V, P = 0 dBm
Voltage Standing Wave Ratio @ 10 GHz	VSWR	1.5	—	—	f = 8 - 12.4 GHz, $V_R = 0$ V, P = 0 dBm
Reverse Recovery Time	t_{rr}	5.0	—	ns	$I_F = 20$ mA to $I_R = 200$ mA peak, recovery to 20 mA

Typical Operating Characteristics

SERIES RESISTANCE

A plot of RF series resistance for the 5082-3042 (package 15) vs. forward current is shown in Figure 1.

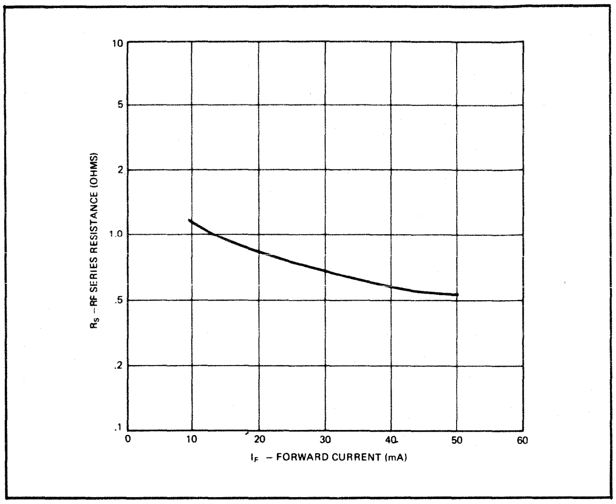


Figure 1. Typical RF Series Resistance at f = 500 MHz vs. Forward DC Current.

REVERSE RECOVERY TIME

In Figure 2 is shown the reverse recovery time t_{rr} vs. forward current I_F for various reverse pulse voltages V_{PR}. The circuit used to measure t_{rr} is shown in Figure 3.

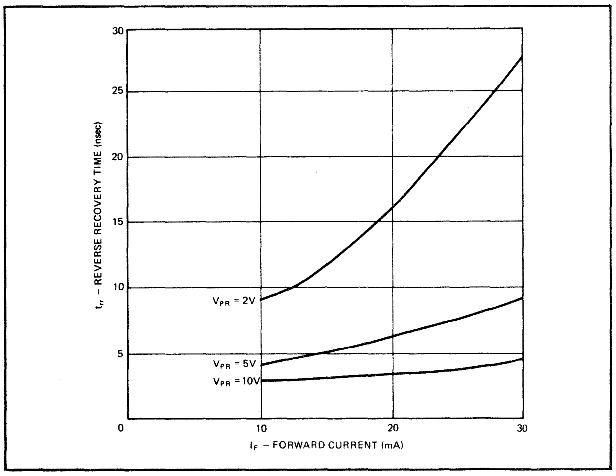


Figure 2. Typical Reverse Recovery Time vs. Forward Current for Various Reverse Driving Voltages.

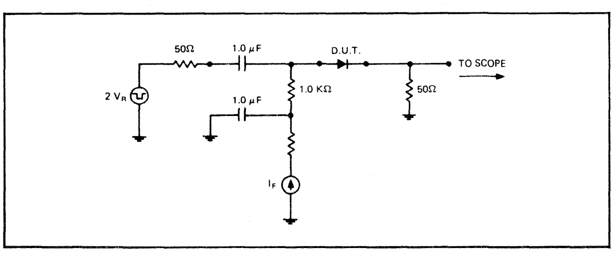


Figure 3. Basic t_{rr} Test Setup.

RF Switching Speed

(HP 5082-3041)

The RF switching speed of the HP 5082-3041 may be considered in terms of the change in RF isolation at 2 GHz. This switching speed is dependent upon the forward bias current, reverse bias drive pulse, and characteristics of the pulse source. The RF switching speed for the shunt-mounted stripline diode in a 50 Ω system is considered for two cases: one driving the diode from the forward bias state to the reverse bias state (isolation to insertion loss), second, driving the diode from the reverse bias state to the forward bias state (insertion loss to isolation).

The test setup is shown in Figure 4, where the pulse generator has a 50-ohm impedance and a one nanosecond risetime. The polyiron load allows RF signal load matching while providing a pulse path having minimum risetime degradation. The effective pulse risetime appearing at the diode is approximately 1.5 nsec.

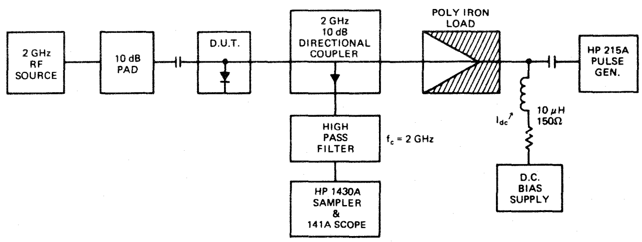


Figure 4. Basic RF Switching Speed Test Setup.

The total time it takes to switch the shunt diode from the isolation state (forward bias) to the insertion loss state (reverse bias) is shown in Figure 5. These curves are for three forward bias conditions with the diode driven in each case with three different reverse voltage pulses (V_{PR}). The total switching time for each case includes the delay time (pulse initiation to 20 dB

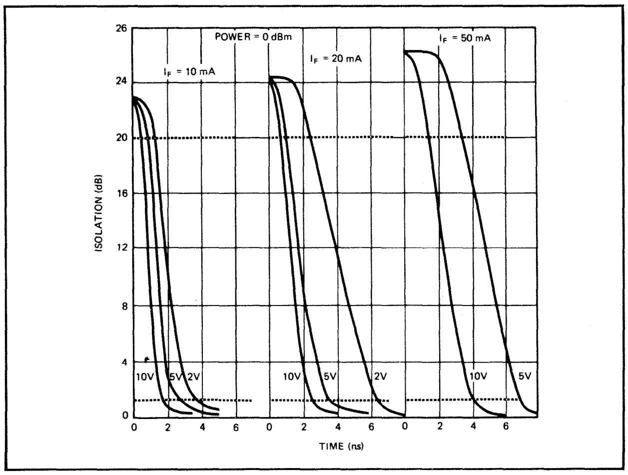


Figure 5. Isolation vs. Time (Turn-on) for HP 5082-3041. Frequency, 2 GHz.

isolation) and transition time (20 dB isolation to 0.9 dB isolation). Slightly faster switching times may be realized by spiking the leading edge of the pulse or using a lower impedance pulse driver.

The time it takes to switch the diode from zero or reverse bias to a given isolation is less than the time from isolation to the insertion loss case. For all cases of forward bias generated by the pulse generator (positive pulse), the RF switching time from the insertion loss state to the isolation state was less than 2 nanoseconds.

Insertion/Isolation Loss

(HP 5082-3041)

Typical curves of insertion loss vs. frequency and isolation vs. frequency are shown in Figures 6 and 7, respectively. These curves are for the stripline diode in a 50-ohm line.

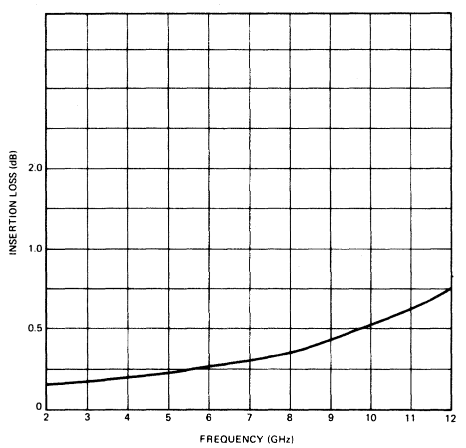


Figure 6. Typical Insertion Loss vs. Frequency for HP 5082-3041.

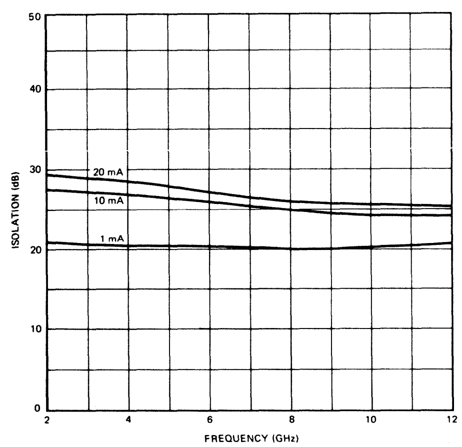


Figure 7. Typical Isolation vs. Frequency for HP 5082-3041.

Mechanical Specifications

The HP outline 15 package is a hermetically sealed unit with a glass body and gold-plated dumet wire leads. Typical package inductance and capacitance is 2 nH and 0.2 pF, respectively.

The HP outline 61 package is designed for stripline use from dc to 12.4 GHz. The leads allow good continuity of characteristic impedance when used in 50 Ω stripline circuitry. When used in balanced stripline applications, it is important that the cover cap supplied with the diode is used in order to have good electrical continuity from the upper to the lower ground plane through the package base metal (Figure 8). Higher order modes will be excited if this cover is either left off or if poor electrical contact is made to the ground planes.

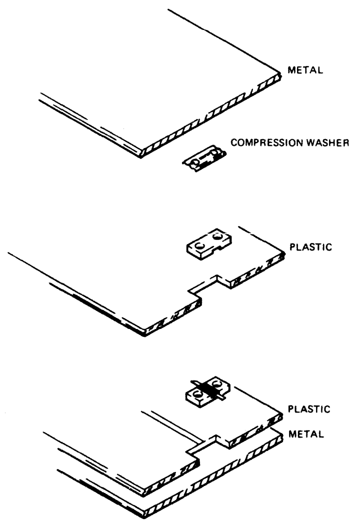


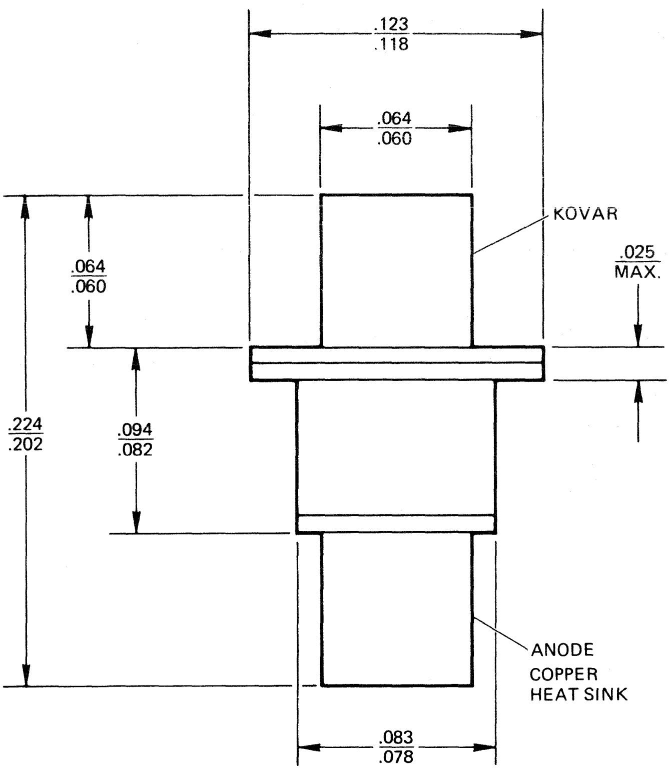
Figure 8. HP 5082-3041 Suggested Stripline Assembly Techniques.

These specifications are based on data taken on preproduction devices. Final specifications are subject to change without prior notice.

HEWLETT hp PACKARD

HIGH POWER PIN DIODE

model 5082-3051 5082-3052



Hermetic, Double Stud Ceramic Package

- High breakdown voltage (> 1000 volts)
- Low saturated forward bias series resistance (typically <0.3 ohm @ 500 mA)
- Extremely low thermal resistance when operating under short pulse width conditions (typically < 0.2°C/W for 1 μs pulse width)
- High peak incident pulse power handling in 50-ohm system (typically > 62 kW @ I_F = 100 mA, 1 μs pulse width, 0.001 duty cycle)
- Silicon oxide-nitride passivation for stability and high reliability

General Description

The HP 5082-3051 and 3052 High Power PIN Diodes are silicon diodes which are passivated with silicon oxide and silicon nitride to assure an extremely stable and high breakdown characteristic. Commensurate with high power application, these diodes feature a low saturated series resistance and a low dc thermal resistance.

Applications

These PIN diodes are intended for high power RF switching, attenuating, modulating, and phase-shifting applications. Because of very low thermal resistances for short pulse widths, they are capable of handling peak pulse powers in the high kilowatt range (see Figure 4). Their low thermal resistance and small forward bias series resistance (see Figure 1) allow the handling of CW signals in the switch on or off modes of several hundred watts. Maximum CW power dissipation at any frequency or bias is 6.5 watts. Because of the properties of a PIN structure, these diodes exhibit a constant capacitance (max. 0.5 pF) at high frequencies for any bias condition.

The switching speed of these diodes depends on the applied dc bias and on the magnitude and shape of the applied switching waveform. Typical switching speeds are shown in Figure 2.

Absolute Maximum Ratings

Characteristic	Symbol	5082-3051, 5082-3052
DC Power Dissipation Derating Characteristic	P_{DISS}	$\frac{150°C - T_{CASE}}{\theta_{JC}}$ See Figure 5
Operating Temperature Range	T_{OPR}	−55°C to +150°C
Storage Temperature Range	T_{STG}	−55°C to +150°C

Electrical Specifications at $T_A = 25°C$

Characteristic	Symbol	HP Type Number				Test Conditions
		5082-3051		5082-3052		
		Max.	Min.	Max.	Min.	
Breakdown Voltage	V_{BR} (V)	—	1000	—	1000	$I_R = 10\ \mu A$
Capacitance (Total)	C_T (pF)	0.5	—	0.5	—	$V_R = 300$ V, f = 1 MHz
Series Resistance	R_S (Ω)	0.6	—	0.9	—	$I_F = 100$ mA, f = 500 MHz
CW Thermal Resistance, Junction to Case	θ_{JC} (°C/W)†	20	—	25	—	

† Measurement as discussed in HP Journal, October 1967, pp. 2-8.

Typical Characteristics

Characteristic	Symbol	Typical Value	Test Conditions
Forward Voltage	V_F	1 volt	$I_F = 500$ mA
Switching Speed	t_t	260 ns	$I_F = 100$ mA to $V_R = 100$ V See Figures 2 and 3
Package Inductance	L_p	750 pH	
Total Device Capacitance	C_T	0.44 pF	At any bias current and at frequencies > 100 MHz
Chip Intrinsic Layer Capacitance	C_I*	0.17 pF	At any bias current and at frequencies > 100 MHz
Pulse Thermal Resistance	θ_{JC}	See Figure 4	
Effective Minority Carrier Lifetime	τ	1 μs	$I_F = 40$ mA

Data is based on evaluation of prototype devices. This data is subject to modification without prior notice. Firm specification will be published after evaluation of devices made in the manufacturing area.

* See HP Application Note 922.

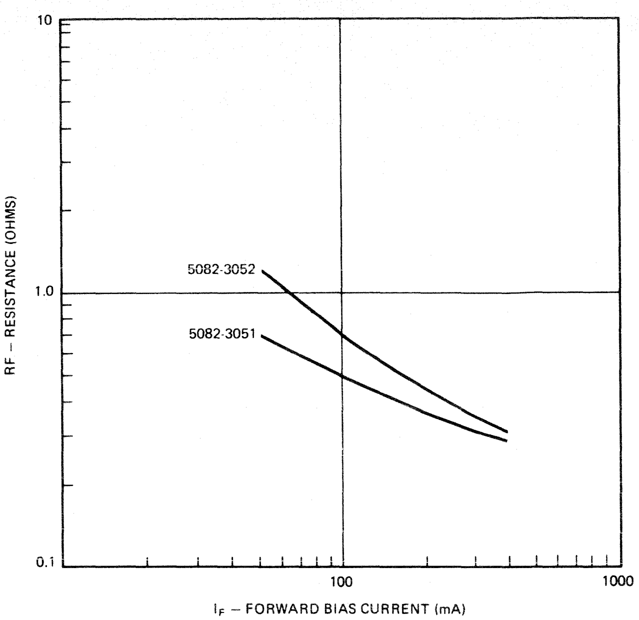


Figure 1. Typical Forward Bias Resistance Characteristics (Note 1)

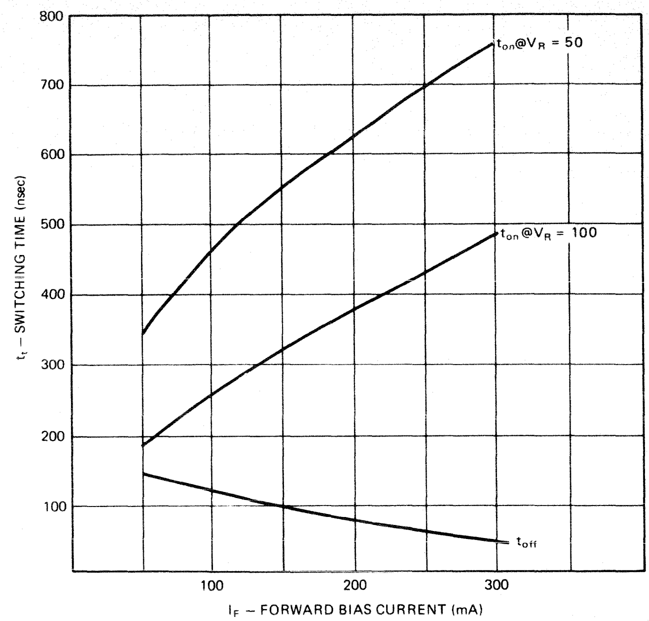


Figure 2. Switching Speed (Note 2) as a Function of Forward Bias and Reverse Bias

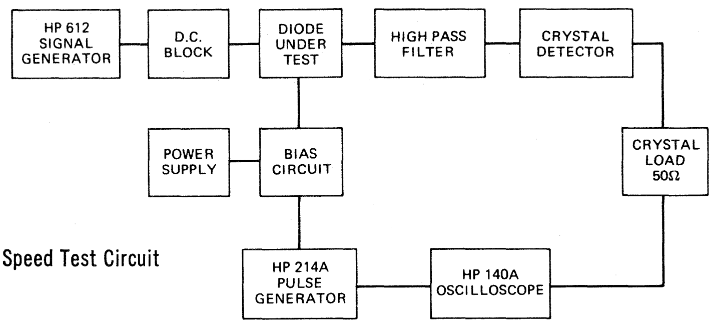


Figure 3. Block Diagram of Switching Speed Test Circuit

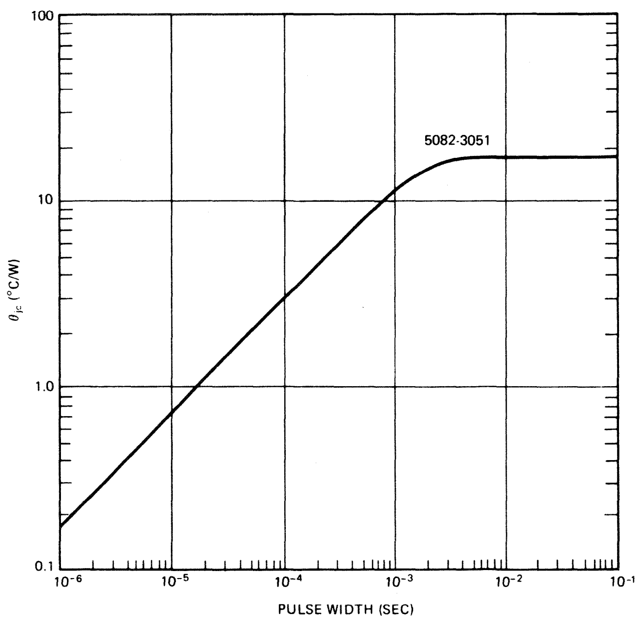


Figure 4. Typical Thermal Resistance vs. Pulse Width for HP 5082-3051

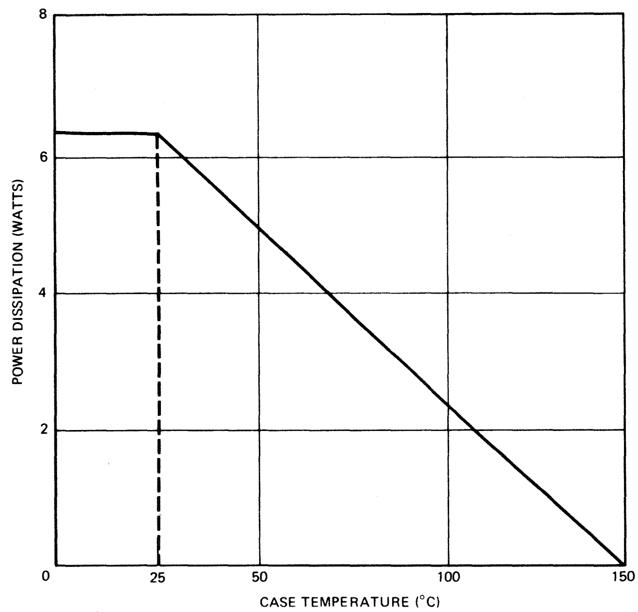


Figure 5. Temperature Derating Curve

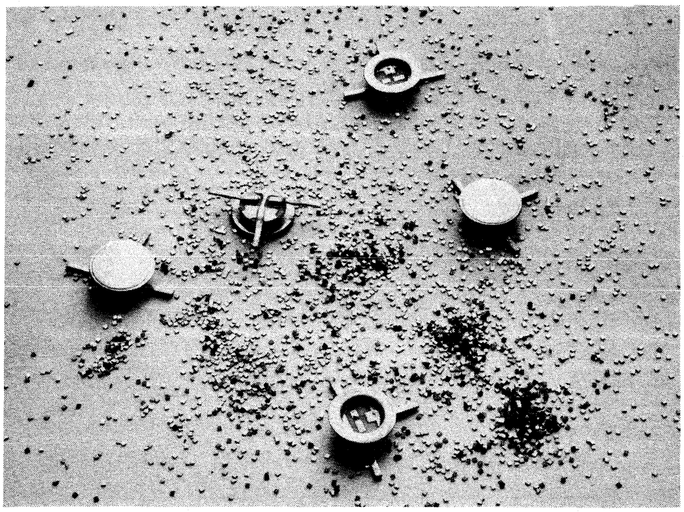
NOTES:
1. Resistance measurements made at 500 MHz.
2. Switching speeds measured using a 1 GHz source and a 14 ns rise-time pulse generator. Times measured from 10% to 90% of detected RF signal.

MICROWAVE COMPONENTS

Device No.	Page
Microwave Transistors General Information	93
Transistor Chips 35810A, 35811A, 35812A, 35813A	95
Packaged Transistors 35803B/E, 35804B/E, 35805B/E, 35806B/E	99
Microelectronic Products	
Amplifiers, Oscillators	103
Switches, Limiters, Attenuators	104
Mixers, Detectors, Frequency Multipliers	105
Modulators	104

HEWLETT hp PACKARD

MICROWAVE TRANSISTORS



- TYPICAL f_{max} TO 7 GHz
- POWER HANDLING TO 200 mW
- HERMETIC PACKAGE OR CHIPS
- ACCURATE CHARACTERIZATION
- UNIFORM PERFORMANCE

Microwave transistors today offer the circuit designer a performance capability at a reasonable price which not only enables him to take a new and better approach to many problems which have existed for microwave systems of the past, but also inspire him to conceive of new applications for the art of microwave.

In spite of the rapid rate of progress in performance capability, it is still a fact that the available gain in a microwave transistor is relatively small in the eyes of a designer who is used to working with low frequency circuits. At low frequencies, the designer can eliminate problems caused by temperature dependent devices and lot-to-lot and device-to-device parameter variations by a variety of negative feedback circuits. Consequently, amplifier gain then is solely dependent upon having at least a minimum device gain and controlled values of associated circuit components (resistors, capacitors and inductors).

The microwave circuit designer cannot afford the luxury of heavy negative feedback at rf frequencies, yet he must work with a device with lower gain and a gain characteristic which is highly frequency dependent.

Until recently, microwave design relied heavily upon "cut-and-try" design techniques with provision for individually tuning each stage of an amplifier. This may be an acceptable method for designing narrow band circuits, and sometimes is valid for wideband circuits. However, the savings in design time (if any) are fully outweighed by the increased time and skill required by production personnel in attempting to duplicate the results. But now it's possible for a designer to work *analytically* with measured rf transistor parameters to design broadband flat amplifiers and octave bandwidth oscillators at microwave frequencies which require no tuning by production personnel. The key element in this new capability is the availability of transistors which are so well "process controlled" that their parameters are uniform from device to device within a wafer, and even from wafer to wafer. Furthermore, the parameters of the device type may be measured at discrete frequencies for the designer under the operating conditions of his choice.

The best parameter set for making accurate measurements in a practical measurement system is the "S" parameters or "scattering" parameters. Having a lossy (50 ohm) termination on both ports of a potentially unstable device greatly increases the probability that the device will be stable while measurements are made. When making measurements in a "Y" parameter system, one must place a lossless termination (short circuit) at one port, while measurements are made at the other port. This is quite likely to cause a device which is potentially unstable to oscillate at some frequency. This will drive the transistor into its large signal region and invalidate measurements made at the intended drive frequency.

Even with unconditionally stable devices, S-parameter measurements offer significant advantages. It is most difficult to design a broadband setup which can provide a short circuit at the one port of the transistor while measurements of voltage and current are made at the other; or to measure current at a short circuited port while driving the other. Accuracy suffers in high frequency systems which attempt to measure Y or Z parameters.

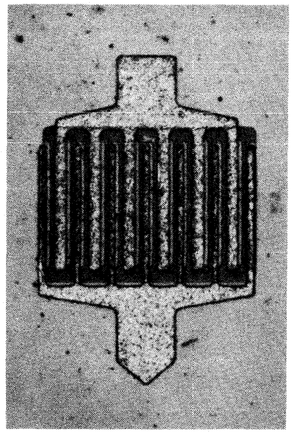
On the other hand, once highly accurate measurements are made in the S-parameter set, conversion can be made using modern computational aids to any other parameter set required by the designer for convenience in his analysis and synthesis of a circuit. The accuracy lost in making such conversion can be reduced to negligible significance by the use of sufficient significant figures in the computation.

For additional information on design techniques using S-parameter characterized microwave transistors, use the reply card in the front of this catalog to request a copy of HP Application Note 95, "S-Parameters . . . . Circuit Design and Analysis".

HEWLETT hp PACKARD

MICROWAVE TRANSISTOR CHIPS

Model
35810A *
35811A *
35812A *
35813A *



NPN EPITAXIAL SILICON TRANSISTOR CHIP

Description

These high frequency, high performance microwave transistor chips offer the key to amplifier and oscillator design in the 500 MHz to 5 GHz range, unhampered by the parasitics and losses associated with packaged transistors.

A new user-oriented non-aluminum metalization system consisting of eutectic gold backing on the chip allows simplified die attachment and unique moly-gold emitter and base contacts permit for the first time extended "soaking" at 400°C for up to ten minutes without degradation of chip performance. This ensures that the guaranteed parameters measured on the chip at the factory will still exist after the user has attached and bonded the die. Ten minutes is more than sufficient time to attach the several chips required for multi-transistor microwave amplifiers and oscillators being designed by today's engineers.

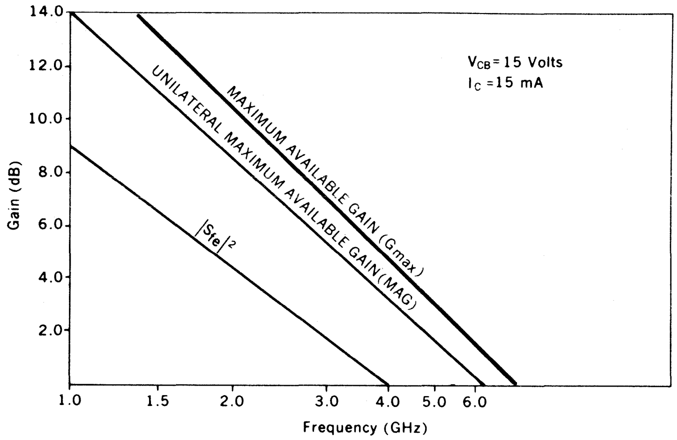
"Windows" of S-parameters taken under typical operating conditions provide a tool to the designer for calculating the insensitivity of his circuit to expected variation in parameters within a given lot and from lot to lot over a period of time. Analytic design can now, to a very great extent, supersede cut-and-try design methods which were forced on the engineer until very recently. Furthermore, he can, if necessary, have chips selected for his application and measured under his own specified operating conditions at nominal extra cost. This has the desired effect of virtually eliminating production line tweaking and tuning.

Four types of transistor chips are available, offering at different frequency ranges and power levels the highest performance/price ratio available anywhere. These are not differentiated by sorting an essentially "out of control" production process; but rather, each has a separate geometry or a carefully controlled difference in the epitaxially grown layer. The diffusion, metalization and passivation processes are identical and carefully controlled to assure highly repeatable transistors within each category.

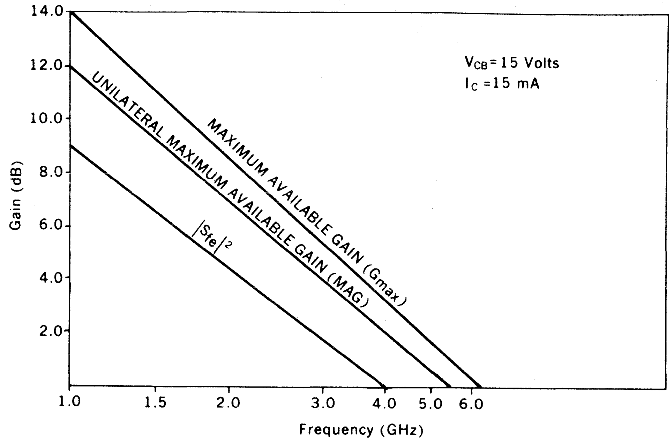
Use the reply card at the front of this catalog to request complete information on HP chip transistors.

*HP has found that the way to give customers the most attractive price on transistor chips is to stock them in packets of ten chips. Each packet of ten chips is considered one 35810A, 35811A, etc.

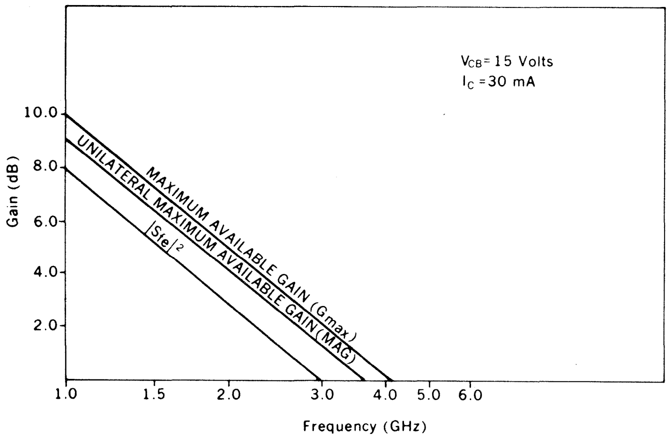
35810A TYPICAL DATA



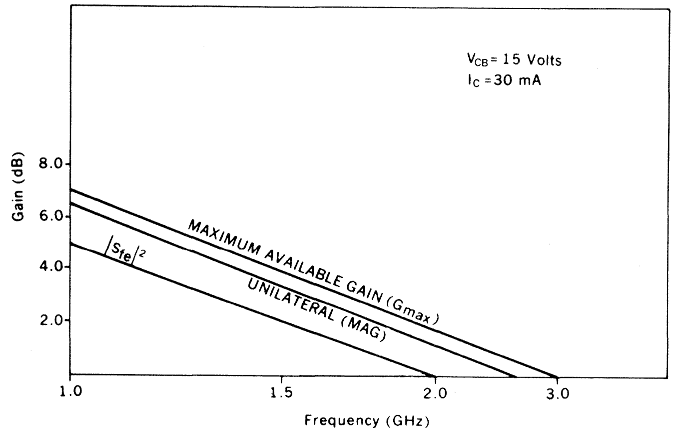
35811A TYPICAL DATA



35812A TYPICAL DATA

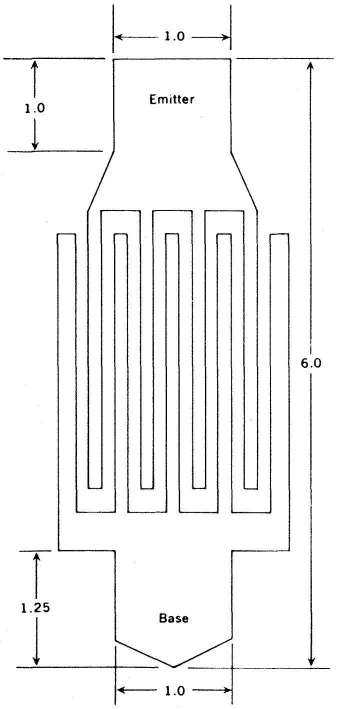


35813A TYPICAL DATA



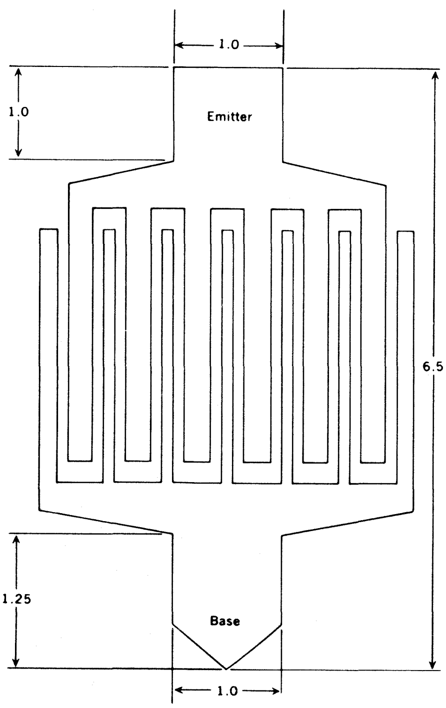
CONTACT GEOMETRY

HP 35810A and 35811A



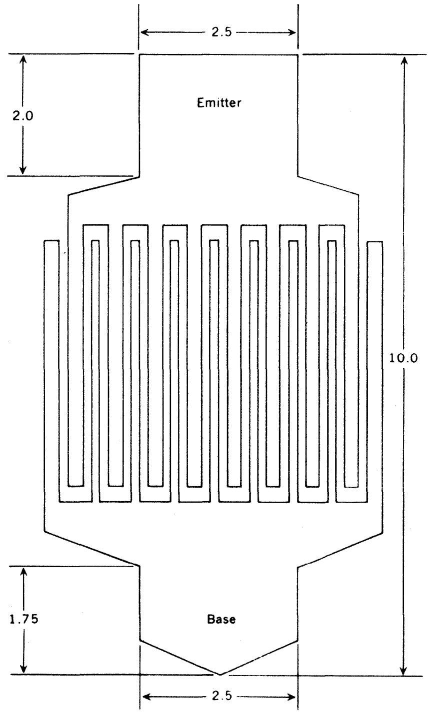
Dimensions in mils

HP 35812A



Dimensions in mils

HP 35813A



Dimensions in mils

NPN Epitaxial Silicon Transistor Chips
PERFORMANCE SUMMARY
(at 25°C free air temperature

		HP 35810A	HP 35811A	HP 35812A	HP 35813A
Typical Power Output:					
Amplifier (common-emitter)		20 mW (@ 2 GHz)	20 mW (@2 GHz)	100 mW (@ 1 GHz)	175 mW (@ 1 GHz)
Oscillator (common-base)		40 mW (@ 4 GHz)	60 mW(@ 4 GHz)	100 MW (@ 3 GHz)	200 mW (@ 2 GHz
f_{max}	min	6.5 GHz	6.0 GHz	4.0 GHz	2.5 GHz
(see Note)	Typ	7.5 GHz	6.5 GHz	4.3 GHz	3.0 GHz
f_T	typ	4.0 GHz	4.0 GHz	3.5 GHz	3.0 GHz
Noise Figure	typ	4.5 dB (@ 2 GHz)	5.5 dB (@ 2 GHz)	5.75 dB (@ 1 GHz)	—
S_{fe}^2	min.	4.3 dB (@ 2 GHz)	4.3 dB (@ 2 GHz)	8 dB (@ 1 GHz)	4.0 dB (@ 1 GHz)
(see Note)		1.5 dB (@ 3 GHz)	1.5 dB (@ 3 GHz)	3.0 dB (@ 3 GHz)	(I_C = 30 & 70 mA)
	Typ	5.2 dB (@ 2 GHz)	5.2 dB (@ 2 GHz)	9 dB (@ 1 GHz)	5.1 dB (@ 1 GHz)
		2.0 dB (@ 3 GHz)	2.0 dB (@ 3 GHz)	3.3 dB (@ 3 GHz)	(I_C = 30 & 70 mA)
G_{max}	min	8.5 dB (@ 2 GHz)	7.5 dB (@ 2 GHz)	10.0 dB (@ 1 GHz)	6.0 dB (@ 1 GHz)
(see Note)		3.0 dB (@ 4 GHz)	2.0 dB (@ 4 GHz)	5.0 dB (@ 2 GHz)	(I_C - 30 & 70 mA)
	Typ	10.5 dB (@ 2 GHz)	8.5 dB (@ 2 GHz)	11.0 dB (@1 GHz)	7.0 dB (@ 1 GHz)
		5.0 dB (@ 4 GHz)	3.0 dB (@ 4 GHz)	6.0 dB (@2 GHz)	(I_C = 30 & 70 mA)
h_{FE}	min	20	15	20	20
BV_{CBO}	min	25V	20V	25V	25V
BV_{CEO}	min	15V	15V	15V	20V
I_C	max	60 mA	60 mA	75 mA	200 mA
I_{CBO}	max (V_{CB} = 15V)	1μA	1μA	1 μA	5 μA
Chip size: Sides		0.015	0.015	0.015	0.020
(inches) thickness		0.004	0.004	0.004	0.004

Maximum Junction Temperature: 200°C (all Models)
Thermal Resistance: 80°C/W (all Models)

NOTE: f_{max} = The frequency where G_{max} = 1 (0 dB); maximum frequency of oscillation

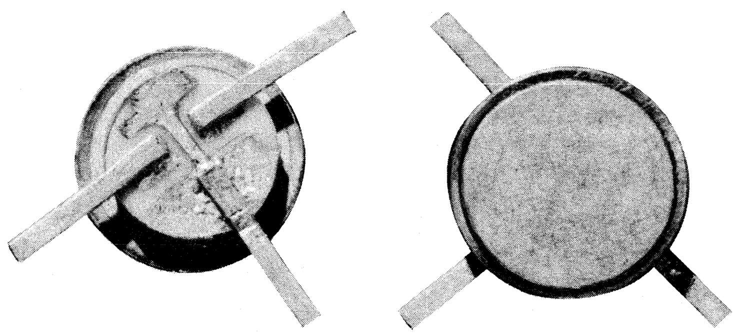
S_{fe}^2 = Transducer power gain in common emitter configuration with 50-ohm source and load impedance

G_{max} = Maximum available power gain (optimum loads)

HEWLETT hp PACKARD

PACKAGED MICROWAVE TRANSISTORS

Model 35803B/E 35804B/E 35805B/E 35806B/E



NPN EPITAXIAL SILICON PACKAGED TRANSISTORS

Description

These convenient, rugged, microwave frequency packaged transistors offer the circuit designer excellent performance in the range from below 500 MHz to 4 GHz in oscillator and amplifier applications. As is the case with HP transistor chips, the high degree of process control assures uniformly consistent high performance from device to device. Circuits can, in many cases, be designed based on the rf parameters, without requiring provision for adjustment to obtain the desired performance. Matching networks designed into the stripline pattern will be correct for all members of a transistor type.

Furthermore, since the parameters of the transistor are known, it is possible to design analytically rather than by the classic "cut-and-try" approach previously required for microwave active circuits. Time-savings in design are substantial.

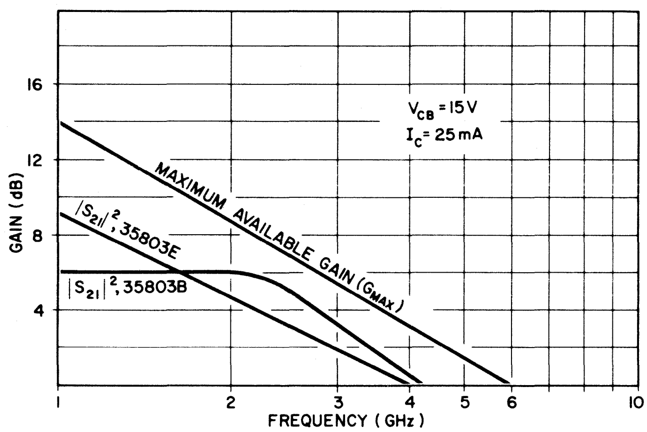
The hermetically sealed metal-ceramic package is optimum for strip transmission line mounting, though successful designs can also be implemented with lumped elements. The low thermal resistance permits full device performance without exceeding the maximum junction temperature rating.

The 35803/4/5/6B have the base of the transistor tied to the conductive disc that forms one face of the package and also to the middle lead on the top of the package. This configuration is commonly used in oscillators. The 35803/4/5/6E has its emitter similarly connected to the disc on the bottom of the transistor and to the common lead on top. This version is usually chosen for amplifier circuits.

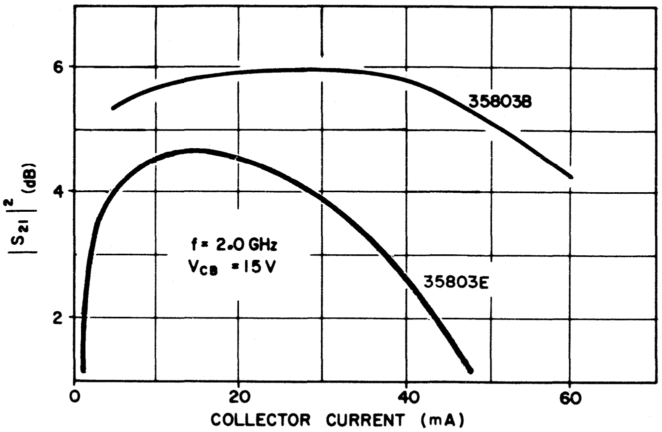
Both common-base and common-emitter transistors are available with typical data on S-parameters under given operating conditions. In addition, actual measurement data at user-specified frequencies and operating conditions can be optionally furnished with these transistors.

Complete information on HP packaged transistors can be obtained by using the reply card in the front of this catalog.

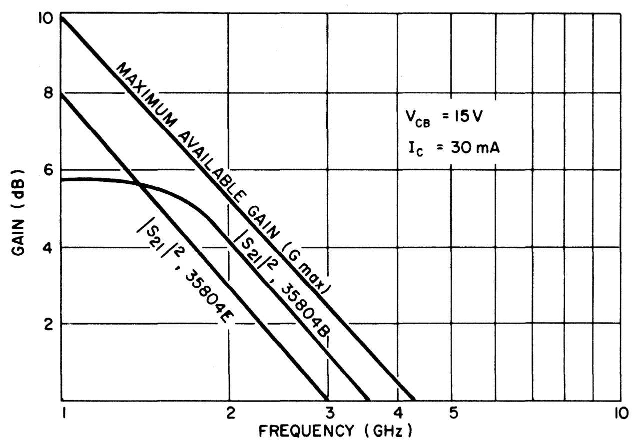
35803B/E TYPICAL DATA



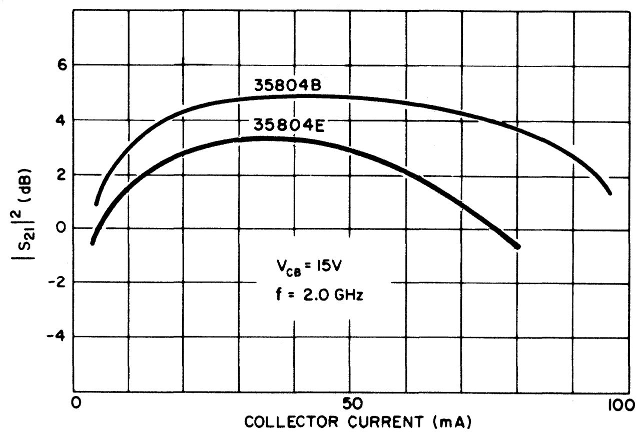
TYPICAL |S21|2 versus COLLECTOR CURRENT



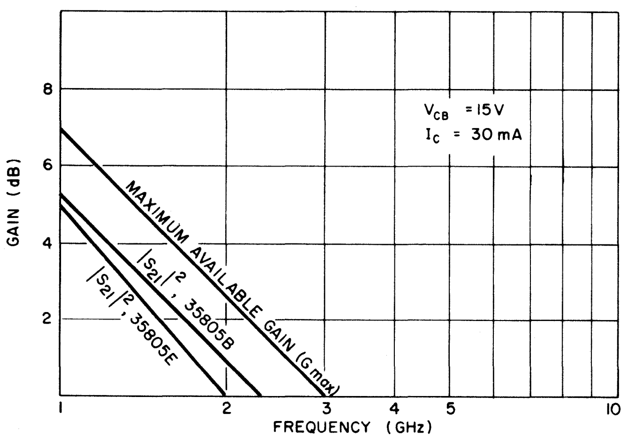
35804B/E TYPICAL DATA



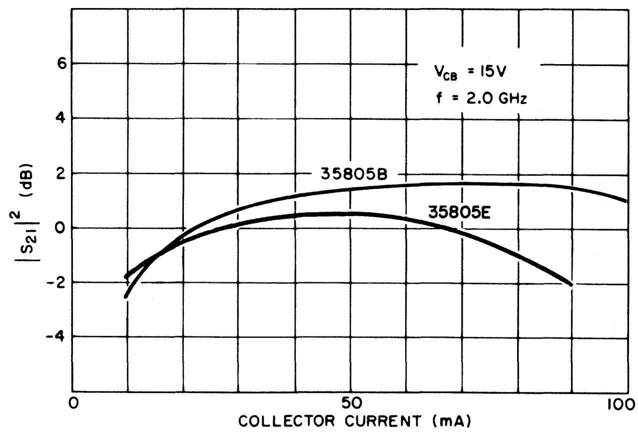
TYPICAL |S21|2 versus COLLECTOR CURRENT



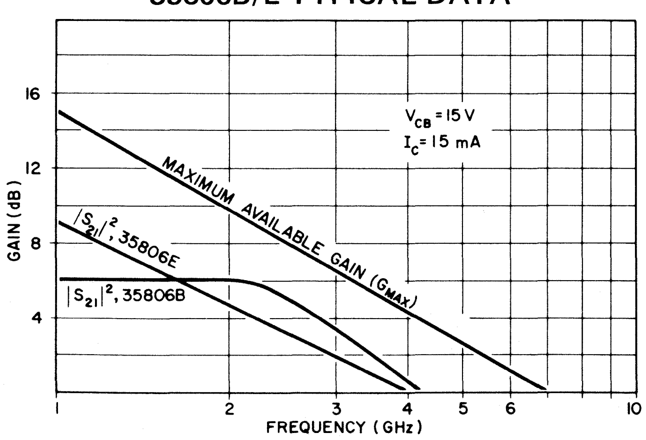
35805B/E TYPICAL DATA



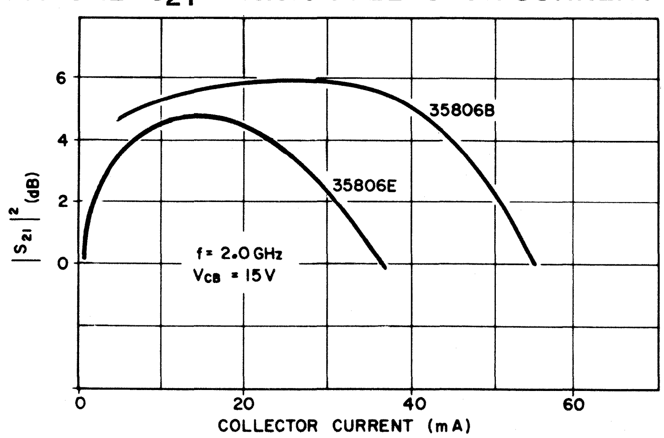
TYPICAL |S21|2 versus COLLECTOR CURRENT



35806B/E TYPICAL DATA



TYPICAL |S21|2 versus COLLECTOR CURRENT



Packaged NPN Epitaxial Silicon Transistors
PERFORMANCE SUMMARY
(at 25°C case temperature)

		HP 35803B/E	HP 35804B/E	HP 35805B/E	HP 35806B/E
As Amplifier ("E"):					
Typical Power		20 mW	100 mW	175 mW	20 mW
Typical Gain		8 dB @ 2 GHz	9.5 dB @ 1 GHz	7 dB @ 1 GHz	10 dB @ 2 GHz
As Oscillator ("B")					
Typical Power		150 mW @ 2 GHz	200 mW @ 1.7 GHz	200 mW @ 2 GHz	20 mW @ 4 GHz
		100 mW @ 4 GHz	100 mW @ 3 GHz		
f_{max} (see Note)	min	5.5 GHz	4.0 GHz	2.3 GHz	6.0 GHz
f_T	typ	4.0 GHz	3.5 GHz	2.0 GHz	4.0 GHz
Noise Figure	Typ	6 dB @ 2 GHz	6 dB @ 1 GHz	—	5 dB @ 2 GHz
S_{fe}^2 (see Note)	min	4.0 dB @ 2 GHz	7.5 dB @ 1 GHz	4.5 dB @ 1 GHz	4.0 dB @ 2 GHz
			2.5 dB @ 2 GHz	(I_C = 30 & 70 mA)	
	Typ	5.0 dB @ 2 GHz	8.5 dB @ 1 GHz	6.0 dB @ 1 GHz	5.0 dB @ 2 GHz
			2.8 dB @ 2 GHz	(I_C = 30 & 70 mA)	
G_{max} (see Note)	min	7.0 dB @ 2 GHz	9.0 dB @ 1 GHz	6.0 dB @ 1 GHz	8.0 dB @ 2 GHz
		2.0 dB @ 4 GHz	5.0 dB @ 2 GHz	(I_C = 30 & 70 mA)	3.0 dB @ 4 GHz
	Typ	8.0 dB @ 2 GHz	10.0 dB @ 1 GHz	7.5 dB @ 1 GHz	10.0 dB @ 2 GHz
		4.0 dB @ 4 GHz	6.0 dB @ 2 GHz	(I_C = 30 & 70 mA)	5.0 dB @ 4 GHz
h_{fe}	min	15	20	20	20
BV_{CBO}	min	20V	25V	25V	25V
BV_{CEO}	min	15V	15V	20V	15V
I_C	max	60 mA	75 mA	200 mA	60 mA
I_{CBO}max (VCBO = 15V)		2 μA	2 μA	10 μA	2 μA

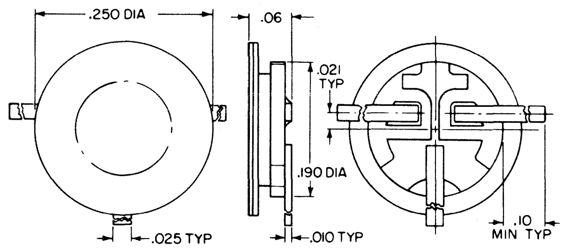
Maximum Junction Temperature: 200°C (all Models)
Thermal Resistance: 100°C/W (all Models)
Dimensions: See Outline Drawing (all Models)

NOTE: f_{max} = The frequency where G_{max} = 1 (0 dB); maximum frequency of oscillation (common base)

S_{fe}^2 = Transducer power gain with 50-ohm source and load impedance (common emitter)

G_{max} = Maximum available power gain (optimum loads)

OUTLINE DRAWING



OPTIONAL CHARACTERIZATION DATA

Each transistor can be supplied with its individual microwave characteristics. Standard data packages include the scattering parameters and several power gains. This data can be supplied at 5, 10 or 15 points, where the measurement frequency or operating point (I_C or V_{CB}) can be varied over wide limits. Nine standard options define the number of data points and variable parameters.

Data Points: Measurements can be made at the following frequencies and bias points:

Frequency: 500, 750, 1000, . . . 6000 MHz.
Collector Current: 2, 4, 6, 8, . . . 100 mA.
Collector-Base Voltage: 3, 4, 5, 6, . . . 17V.

Options 001—003 provide data vs. frequency for one bias point. Options 004—006 provide data vs. collector current for one collector-base voltage and at a single frequency. Options 007—009 provide data vs. collector-base voltage for one collector current and at a single frequency. More than one optional data package can be ordered with each device.

Option 001: Data taken at five frequencies. Specify start frequency (MHz), frequency increment (MHz), collector current (mA) and collector-base voltage (volts).

Option 002: Data taken at ten frequencies. Specify as outlined in Option 001.

Option 003: Data taken at 15 frequencies. Specify as outlined in Option 001.

Option 004: Data taken at five collector currents. Specify frequency (MHz), start collector current (mA), current increment (mA) and collector-base voltage (volts).

Option 005: Data taken at ten collector currents. Specify as outlined in Option 004.

Option 006: Data taken at 15 collector currents. Specify as outlined in Option 004.

Option 007: Data taken at five collector-base voltages, Specify frequency (MHz), collector current (mA), start collector-base voltage (volts) and voltage increment (volts).

Option 008: Data taken at ten collector-base voltages. Specify as outlined in Option 007.

Option 009: Data taken at 15 collector-base voltages. Specify as outlined in Option 007.

EXAMPLES:

Option 001, 1000, 250, 10, 15 will provide data at 1000, 1250, 1500, 1750 and 2000 MHz with I_C = 10 mA and V_{CB} = 15V.

Option 005, 2000, 6, 2, 10 will provide data at 2000 MHz with I_C = 6, 8, 10, . . . 22, 24 mA and V_{CB} = 10V.

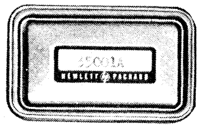
AMPLIFIERS, OSCILLATORS

Microcircuit Amplifiers

VHF Pre/Power Amplifiers, Models 35000A/35001A

- 0.1 - 100 MHz Bandwidth
- PreAmp with >30 dB Gain, 3 mW Maximum Output
- Power Amp with >20 dB Gain, 80 mW Maximum Output
- Flat Gain, Low Distortion

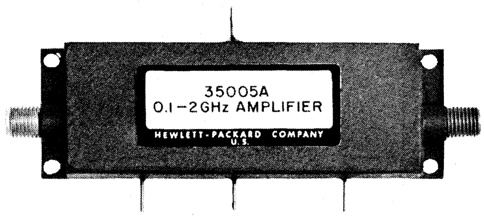
35000A



35001A

Low Noise VHF Pre-Amplifier, Model 35002A

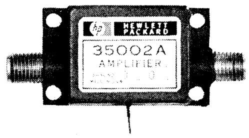
- 0.1 - 400 MHz Bandwidth
- Flat Gain: 20 ±0.5 dB
- Low Noise Figure: <5 dB
- Low Distortion: Harmonics Typically 40 dB Down at 1 mW Output
- Options with Extended Frequency Range Available (Ex: 17 dB Min. Gain at 650 MHz)



35005A

Ultra Broadband Microwave Amplifier, Model 35005A

- Cover VHF, UHF, L Band With One 0.1 - 2.0 GHz Amplifier
- High Gain: >40 dB
- High Output: >20 mW
- Low Distortion: Harmonics >30 dB Dokn at +10 dBm Out



35002A

Microcircuit Oscillators

S Band, YIG Tuned Oscillator, Model 35009A

- Linear Tuning, 2.0 - 4.0 GHz
- High, Flat Output: >10 mW, ±1.5 dB
- Good Load Immunity: Δf <±.075% For Any Load
- Linear FM: dc - 100 KHz, Deviations to >10 MHz
- Good Spectral Purity
- Built In Magnetic Shielding

35009A

For more information please call your local Hewlett-Packard office for a data sheet with complete specifications.

SWITCHES, LIMITERS, MODULATORS, ATTENUATORS

SPST Switches

Low Cost, Broadband 33100 Series (1)

- Cover 0.1 - 18 GHz With A Single Switch
- On-Off Ratios To 80 dB
- Volume Prices From Under $100
- Solid State For Speed, Reliability

High Performance, Octave Band 33600 Series (2)

- Models For Bands From 1 - 18 GHz
- Low VSWR, Insertion Loss
- Isolation To 80 dB
- Broad Choice of Connectors: SMA, TNC, N, BNC
- Solid State For Speed, Reliability

Other SPST Switch Families (3)

- High Performance, Broadband Series, 0.2 - 18 GHz
- Stripline and Coax Modules, 0.1 - 18 GHz

SPDT Switches

High Performance, Broadband Model 33006A (4)

- One Switch For 0.1 - 18 GHz Range
- Low Insertion Loss: 1.5 dB to 8 GHz, 3 dB to 18 GHz
- High Isolation: 60 dB to 8 GHz, 50 dB to 18 GHz
- Solid State
- Also Available For Stripline Applications, 33007A

Precision Electromechanical Models 8761A,B (5)

- Broadband: dc - 18 GHz
- Less Than 0.8 dB Loss to 18 GHz
- VSWR Less Than 1.3:1 to 18 GHz
- Choice of Any Combination of SMA, N, or 7 mm Connectors
- Available With Built-on Termination

Limiters

Broadband Model 33711A (6)

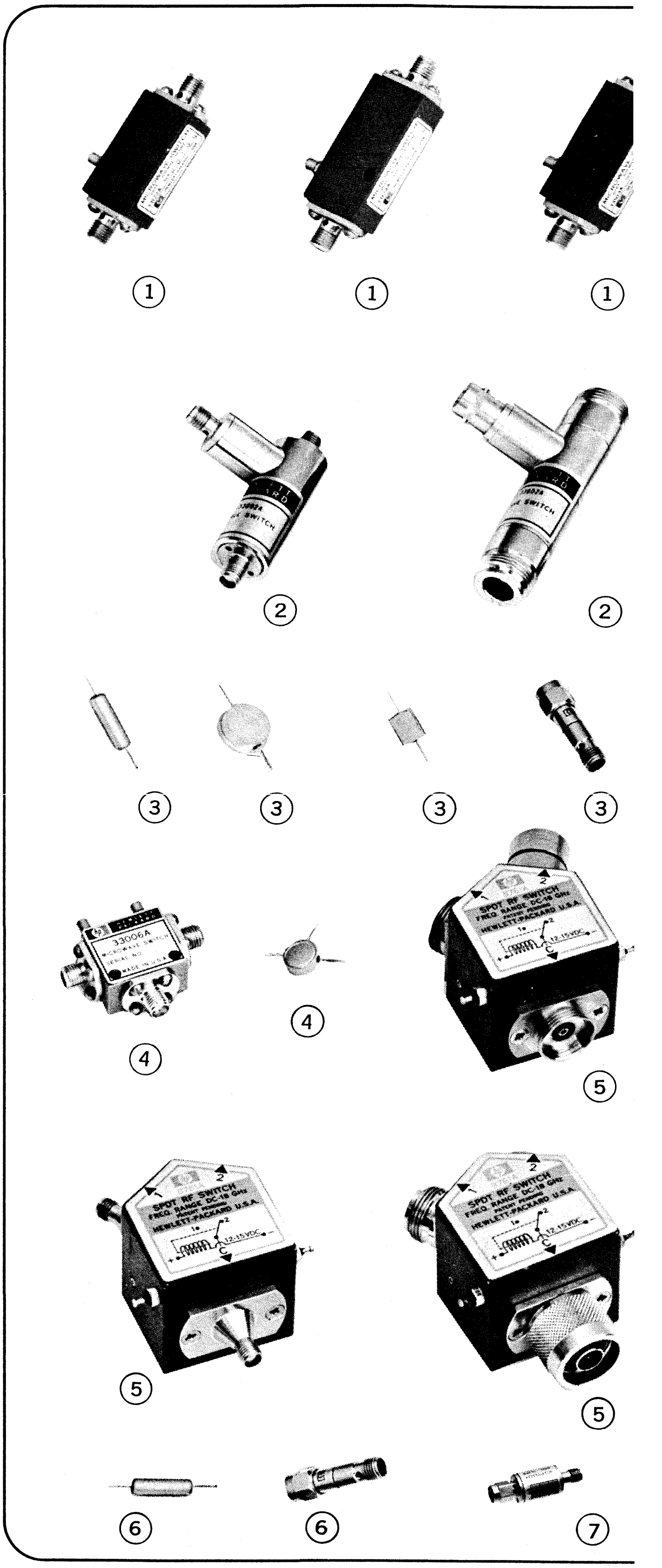
- 0.4 - 12.4 GHz
- High Power: Safely Handles 75 Watt Peak, 1 Watt Average
- +10 dBm Limiting Threshold
- Also Available Without Connectors, 33701A

Attenuators

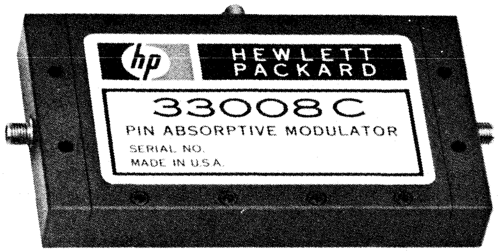
Flat, Low VSWR Model 33900A (7)

- dc - 18 GHz
- 3, 6, 10, 20, or 30 dB Attenuations
- Volume Prices From Under $50.00

For more information please call your local Hewlett-Packard office for a data sheet with complete specifications.



MIXERS, DETECTORS, FREQUENCY MULTIPLIER



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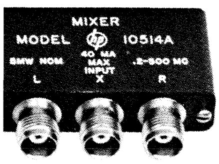

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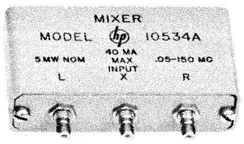

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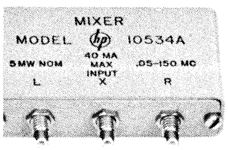

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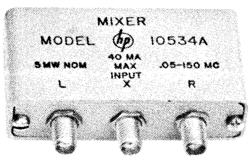

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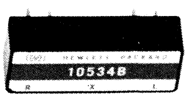

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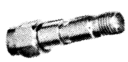

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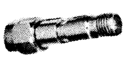

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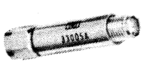

(12)

(12)

Modulators

(8) Models 33000, 33001, 33008C/D

- Covering Greater Than Octave Bands, 1 - 18 GHz
- On Off Ratios To 80 dB
- Matched At All Attenuations

Mixers

(9) Double Balanced Models to 500 MHz

- Model 10514: 0.2 - 500 MHz
- Model 10534: 0.05 - 150 MHz
- Both Models Available in Three Package Styles (A,B,C)
- Both Feature Low Conversion Loss, Good Balance, require only +7 dBm Local Oscillator Power

(10) Microwave Models 33801, 33802, 33803A/B

- Broadband: 2 - 12.4 GHz
- Low Noise Figure, 8.5 dB to 12.4 GHz
- Well Matched: VSWR <2.5:1 to 12.4 GHz
- Choice of Output Polarity, Matched Pairs Available
- Also Available as Microwave Detector

Detectors

(11) Burn Out Protected X - Band Model 33820A/B

- Built In Limiter Protects Detector to 100 Watts Peak
- Covers 7 - 11 GHz Band
- High Sensitivity: —54 dBm TSS @ 10 GHz
- Small, Light, Rugged

Frequency Multipliers

(12) Comb Generator Models 33002-5A/B

- Four Models Optimized For 100, 250, 500, or 1000 MHz Input
- Flat Spectra Extending to 12.4 GHz
- High Efficiency at 0.5 Watt Input Level
- Well Matched at Input Port at 0.5 Watt Level
- Available With or Without Connectors

For more information please call your local Hewlett-Packard office for a data sheet with complete specifications.

OPTOELECTRONIC DEVICES

Device No.	Page
GaAs Infrared Sources 5082-4100 Series	109
PIN Photodiodes 5082-4200 Series	113
Photon Coupled Isolators 5082-4300 Series	117
Solid State Visible Emitter 5082-4400	121

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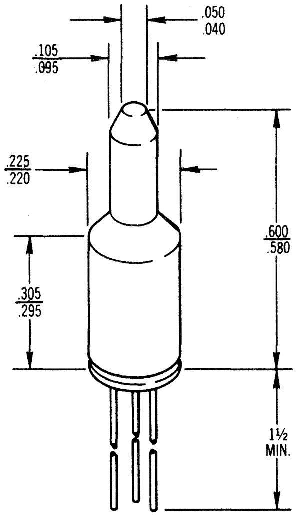
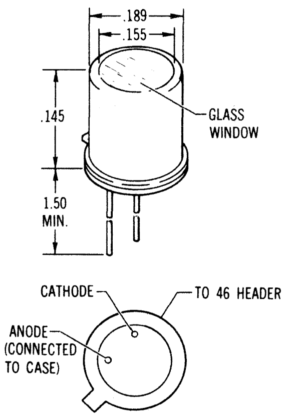
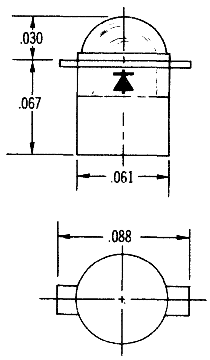
GaAs INFRARED SOURCE

HP 5082-4100 series



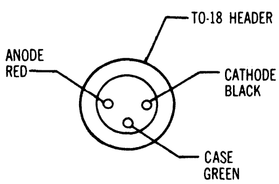


HP 5082-4120



HP 5082-4107

Dimensions in inches



HP 5082-4104

HPA gallium arsenide electroluminescent diodes radiate in a narrow band at a wavelength of 9000Å when forward biased. This radiation may be switched on or off in nanoseconds.

The light source may be used in conjunction with HPA ultra-fast photodiodes as a fast infrared photon-coupled circuit, or as an optical transducer. Other applications include tape or card readers and optical shaft encoders.

The 5082-4104 has a hermetically sealed, glass fiber-optic light guide which effectively places the 0.020 inch diameter round emitting source at the end surface of the device. By this means the available radiation is increased by a factor of twenty.

The 5082-4120 is packaged on a TO-46 header with a plane glass window cap. The 0.024 inch square radiation source is located 0.100 inch behind the 0.155 inch diameter window. The anode is grounded to the case.

The 5082-4107 has a low capacitance Kovar and ceramic package of very small dimensions with a hemispherical lens. The diode chip is located 0.060 inch behind the front surface of the lens.

Price	**5082-4104**	**5082-4120**	**5082-4107**
Quantity 1-9	\$60.00	\$10.00	\$21.00
10-99	50.00	8.50	18.00

NOTES:

1. Maximum Peak Pulse Current:

$I_{avg.\ max.}$ = maximum allowed average current at a specified temperature. ($I_{avg.\ max.}$ = 100 mA for the 5082-4120 and 5082-4107 at 25°C.)

I_{peak} = maximum peak (rectangular pulse) current.

$$N_I = \frac{I_{peak}}{I_{avg.\ max.}}$$

N_I must meet all the following conditions:

(A) $N_I \leq 20$

(B) $N_I < \frac{1}{50t}$

(C) $N_I < \frac{1}{ft}$

where t = pulse duration in seconds
and f = pulse repetition frequency (Hz)

2. Irradiance Calculation:

J_o is the radiation vector along the axis of the infrared source. Using J_o the irradiance H, at any distance d from the source is obtained from:

$$H = \frac{J_o}{d_2}$$

Where J_o is in μwatt/steradian
d is distance in centimeters
and H is in μwatts/cm²

To calculate the irradiance at a point not on the axis, the radiation vector J_o must be multiplied by a reduction factor obtained from the radiation pattern at the particular angle in question.
For example, the μwatts/steradian at an angle of 30° from the normal, $P_{30°}$, for the 4120 would be 0.82 x J_o. The irradiance at a distance, d, can now be found by using $H = \frac{P_{30°}}{d_2}$.

3. 5082-4107 Mounting Recommendations (see Figure 7):

a. The 5082-4107 device is intended to be soldered to a printed circuit board having a thickness of from 0.020 to 0.060 inch (0.051 to 0.152 cm).

b. Soldering temperature should be controlled so that at no time does the case temperature approach 280°C. The lowest solder melting-point in the device is 280°C (gold-tin eutectic). If this temperature is approached, the solder will soften, and the lens may fall off. Lead-tin solder is recommended for mounting the package, and should be applied with a small soldering iron, for the shortest possible time, to avoid the temperature approaching 280°C.

c. Contact to the lens end should be made by soldering to one or both of the tabs provided. Care should be exercised to prevent solder from coming in contact with the lens.

d. If printed circuit board mounting is not convenient, wire leads may be soldered or welded to the device using the precautions noted above.

	LIGHT EMISSION CHARACTERISTICS @ 25°C		
Characteristic	Total Power Output		Axial Radiation Intensity (See Note 2)
Symbol	P	P	J_o
Units	μW	μW	μW/Steradian
Test Conditions	I = 70 mA	I = 100 mA	I = 50 mA
5082-4104			
Min.			
Typ.	120		50
Max.			
5082-4120			
Min.		150	
Typ.		200	100
Max.			
5082-4107			
Min.		75	
Typ.		150	200
Max.			

* Not isolated from header.

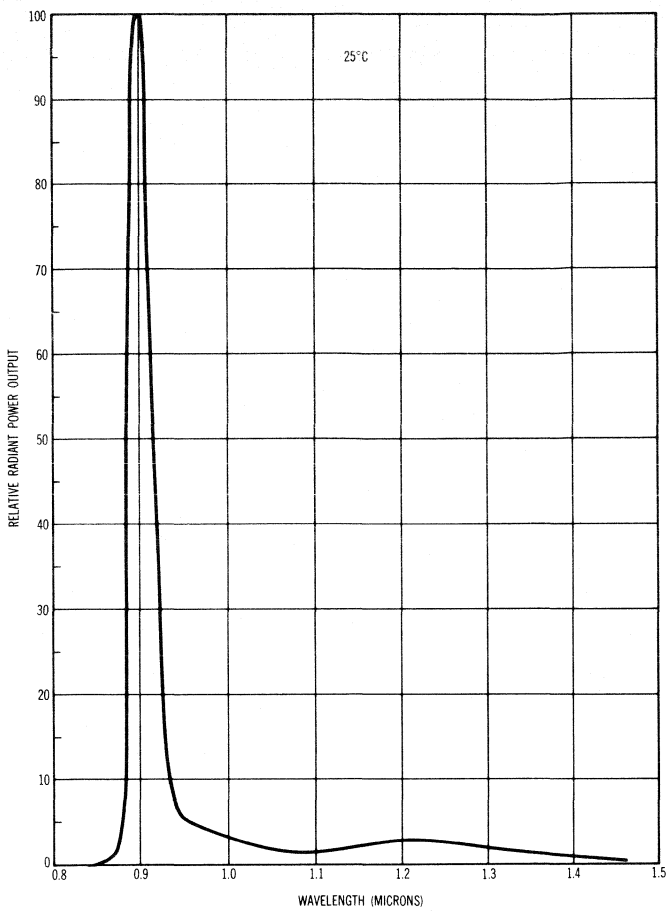


Figure 1. Emission spectrum.

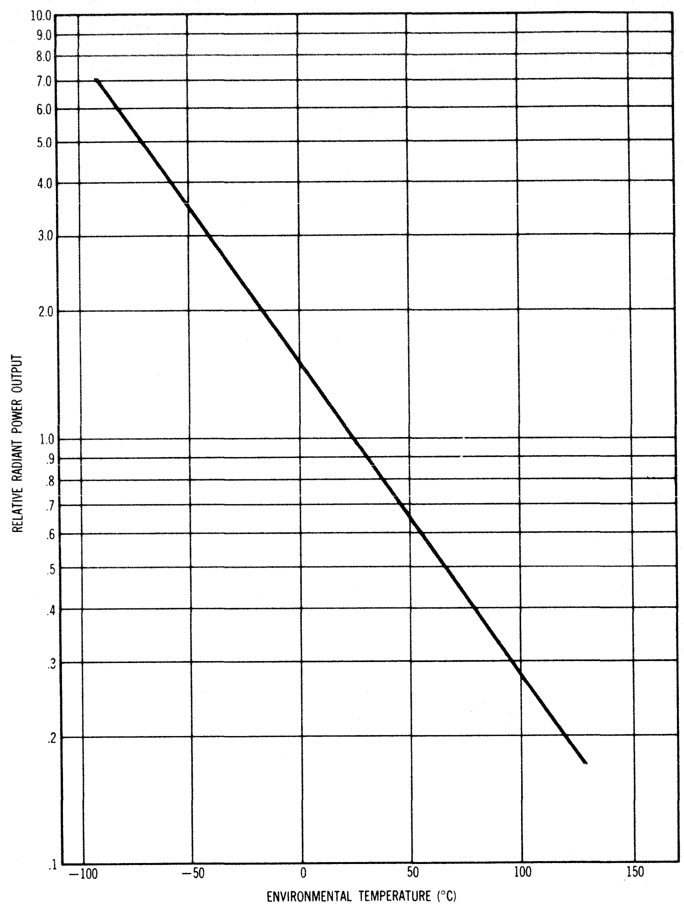


Figure 2. Temperature dependence of radiant power output.

ELECTRICAL CHARACTERISTICS @ 25°C							ABSOLUTE MAX. RATINGS
Forward Voltage		Breakdown Voltage	Zero Bias Capacitance	Rise Time	Diode to Header Resistance	Diode to Header Capacitance	Maximum Current
V_F	V_F	V_{BR}	C_O				
Volts	Volts	Volts	pF	nsec	ohms	pF	mA
$I_F = 70$ mA	$I_F = 100$ mA	$I_R = 100\ \mu A$	f = 1 MHz	$I_F = 30$ mA			25°C
		5					
			120	70	10^9	2	
1.3							70
		3					
			250	100	*	*	
	1.4						100
		5					
			250	100	*	*	
	1.3						100

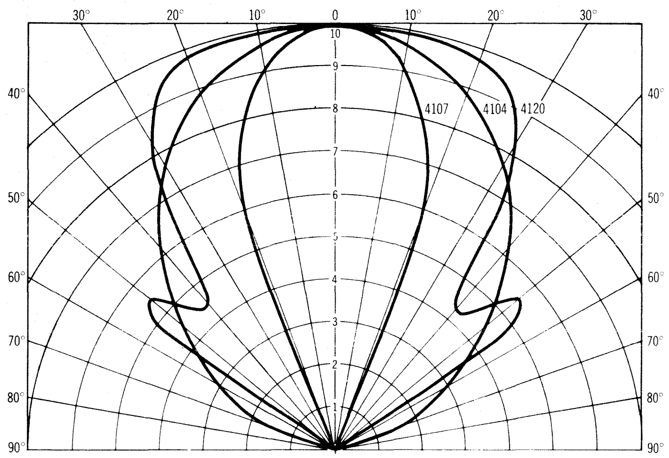


Figure 3. Radiation pattern.

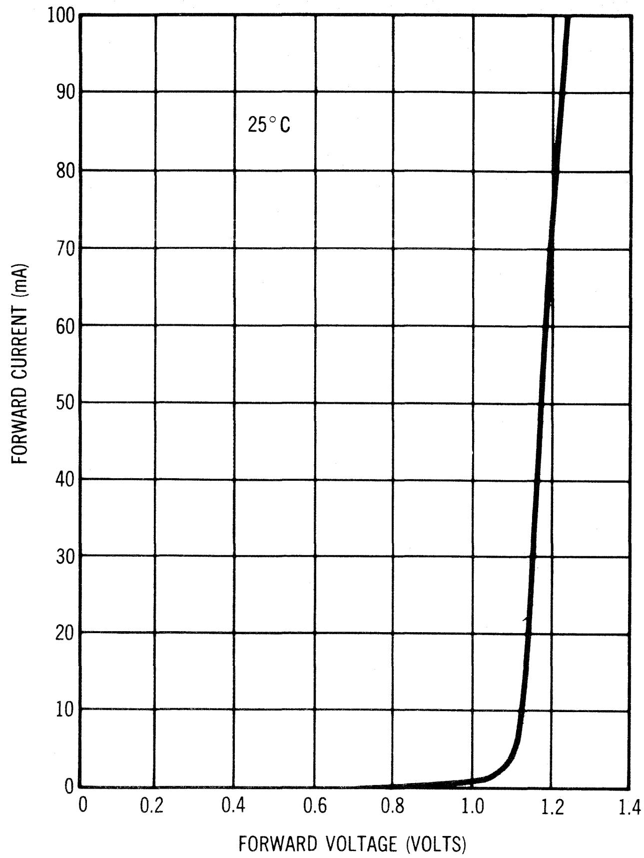


Figure 5. Typical V-I characteristics.

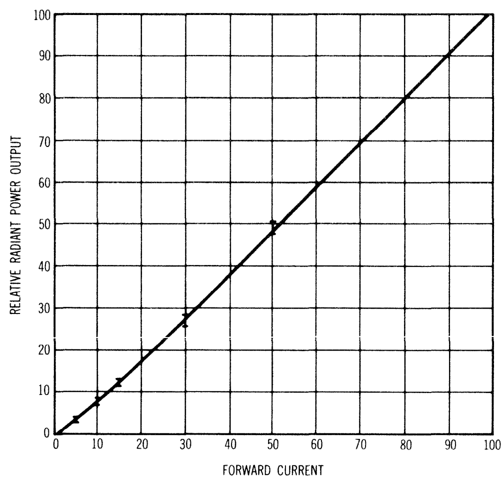


Figure 4. Typical transfer characteristics.

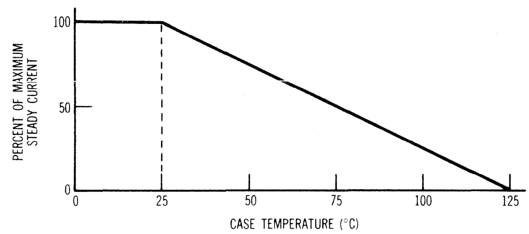


Figure 6. Recommended maximum steady current.

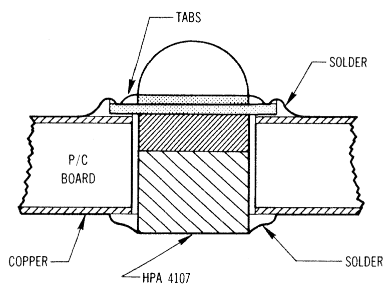


Figure 7. Recommended mounting of HP 5082-4107.

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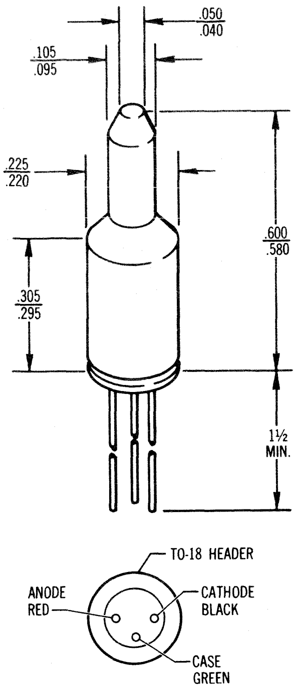
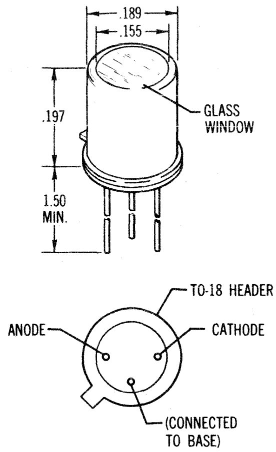
PIN PHOTODIODE

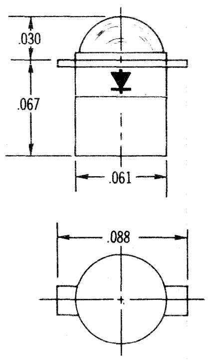
HP
5082-4200
series



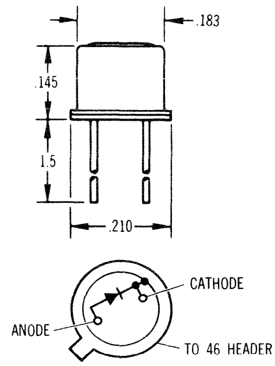
HP 5082-4201



HP 5082-4203, -4204, -4207



HP 5082-4205



HP 5082-4220

Dimensions in inches

The HP silicon planar PIN photodiodes are ultrafast light detectors for visible and near infrared radiation. Their response to blue and violet is unusually good for low dark current silicon photodiodes.

The speed of response of these detectors is less than one nanosecond. Laser pulses shorter than 0.1 nanosecond may be observed. The frequency response extends from dc to 1 GHz.

The low dark current of these planar diodes enables detection of very low light levels. The quantum detection efficiency is constant over six decades of light intensity, providing an excellent dynamic range.

The 5082-4201 has an integral glass fiber-optic light guide which places the 0.020 inch diameter sensitive zone optically on the end surface of the device. Both photodiode terminals are electrically insulated from the header.

The 5082-4203, -4204, and -4207 are packaged on a standard TO-18 header with a plane glass window cap. For versatility of circuit connection, they are electrically insulated from the header. The light sensitive area of the 5082-4203 and -4204 is 0.020 inch (0,508 mm) in diameter and is located 0.075 inch (1,905 mm) behind the window. The light sensitive area of the 5082-4207 is 0.040 inch (1,016 mm) in diameter and is also located 0.075 inch (1,905 mm) behind the window.

The 5082-4205 is in a low capacitance Kovar and ceramic package of very small dimensions, with a hemispherical lens.

The 5082-4220 is packaged on a TO-46 header with the 0.020 inch (0,508 mm) diameter sensitive area located 0.100 inch (2,540 mm) behind a flat glass window.

NOISE FREE PROPERTIES

The noise current of the PIN diodes is negligible. This is a direct result of the exceptionally low leakage current, in accordance with the shot noise formula $I_N = (2qI_R\Delta f)^{1/2}$. Since the leakage current does not exceed 400 picoamps for the 5082-4204 at a reverse bias of 10 volts, shot noise current is less than 1.2×10^{-14} amp $Hz^{-1/2}$ at this voltage.

Quantity 1-9
10-99

Excess noise is also very low, appearing only at frequencies below 100 Hz, and varying approximately as 1/f. When the output of the diode is observed in a load, thermal noise of the load resistance (R_L) is $1.28 \times 10^{-10} (R_L)^{-1/2} \times (\Delta f)^{1/2}$ at 25°C, and far exceeds the diode shot noise for load resistances less than 100 megohms (see Figure 6). Thus in high frequency operation where low values of load resistance are required for high cut-off frequency, all PIN photodiodes contribute virtually no noise to the system (see Figures 6 and 7).

Ultra-fast operation is possible because the HP PIN photodiodes are capable of a response time less than one nanosecond. A significant advantage of the device is that this great speed of response is exhibited at relatively low reverse bias (−10 to −20 volts).

Because of its high sensitivity over a wide spectral range, unprecedented speed of response, unrivaled low-noise performance, and low capacitance, the HP PIN photodiodes are the most useful and versatile silicon photodiodes available.

NOTES:

1. Peak Pulse Power
   When exposing the diode to high level irradiance the following photocurrent limits must be observed:

   $$I_P\,(avg) < \frac{0.1}{E_P}$$

   and

   $$I_P\,(peak) < 500\text{ mA} \quad \text{or}$$

   $$< \frac{1000\text{ Amps}}{t(\mu sec)} \quad \text{or}$$

   $$< \frac{I_p\,(avg)}{ft}$$

   whichever of the above three conditions is least.
   I_P—photocurrent
   E_P—supply voltage
   t—pulse duration
   f—pulse repetition rate
2. Current Responsivity
   Response of the photodiode to a uniform field of irradiance H, parallel to the polar axis is given by

OPTICAL CHARACTERISTICS AT 25°C

Characteristics		Response at 7700 Å (1) β_H	Sensitive Area	Diameter		Speed of Response	D*	Noise Equivalent Power
Units		μA/mW/cm²	cm²	Inches	mm	nsec	cm Hz$^{1/2}$/watt	NEP
Test Conditions		V = −20 R_L = 1 MΩ				V = −20 R_L = 50Ω	(0.8, 100, 6)	Watts
5082-4201	Min.						0.9×10^{12}	
	Typ.	1.0	2×10^{-3}	0.020	0,508	<1		
	Max.							5.1×10^{-14}
5082-4203	Min.						0.9×10^{12}	
	Typ.	1.0	2×10^{-3}	0.020	0,508	<1		
	Max.							5.1×10^{-14}
5082-4204	Min.						4.1×10^{12}	
	Typ.	1.0	2×10^{-3}	0.020	0,508	<1		
	Max.							1.2×10^{-14}
5082-4205	Min.						3.95×10^{12} (2)	
	Typ.	1.5 (2)	3×10^{-3} (2)	0.010	0,254	<1		
	Max.							1.4×10^{-14}
5082-4207	Min.						2.5×10^{12}	
	Typ.	4.0	8×10^{-3}	0.040	1,016	<1		
	Max.							3.6×10^{-14}
5082-4220	Min.						0.57×10^{12}	
	Typ.	1.0	2×10^{-3}	0.020	0,508	<1		
	Max.							8×10^{-14}

NOTES:
(1) Response at 7700 Å can be specified as 0.75 electrons/photon and 0.5 μA/μW for all devices.
(2) Specification includes lens effect.

$I = \beta_H \times H$ for 7700 Å. The response from a field not parallel to the axis can be found by multiplying β_H by a normalizing factor obtained from the radiation pattern at the angle in question. For example, the multiplying factor for the 5082-4207 with irradiance H, at an angle of 40° from the polar axis is 0.8. If H $= 1$ mW/cm^2, then $I = k \times \beta_H \times H$; $I = 0.8 \times 4.0 \times 1 = 3.2$ μamps.

To obtain the response at a wavelength other than 7700 Å, the relative spectral response must be considered. Referring to the spectral response curve, Figure 1, obtain response, X, at the wavelength desired. Then the ratio of the response at the desired wavelength to response at 7700 Å is given by:

$$\text{Ratio} = \frac{X}{0.5}$$

Multiplying this ratio by the current response at 7700 Å will give the current response at the desired wavelength.

3. 5082-4205 Mounting Recommendations
   a. The 5082-4205 is intended to be soldered to a printed circuit board having a thickness of from 0.020 to 0.060 inch (0,051 to 0,152 cm).
   b. Soldering temperature should be controlled so that at no time does the case temperature approach 280°C. The lowest solder melting point in the device is 280°C (gold-tin eutectic). If this temperature is approached, the solder will soften, and the lens may fall off. Lead-tin solder is recommended for mounting the package, and should be applied with a small soldering iron, for the shortest possible time, to avoid the temperature approaching 280°C.
   c. Contact to the lens end should be made by soldering to one or both of the tabs provided. Care should be exercised to prevent solder from coming in contact with the lens.
   d. If printed circuit board mounting is not convenient, wire leads may be soldered or welded to the devices using the precautions noted above.

ELECTRICAL CHARACTERISTICS AT 25°C							**MAXIMUM RATINGS**		
Junction Capacitance		**Capacitance to Shield**		**Dark Current**		**Series Resistance**	**Steady Reverse Voltage**	**Peak Inverse Voltage**	**Power Dissipation**
pF	pF	pF	pF	pA	pA	Ω	Volts	Volts	mW
$V_R = -10$ V	$V_R = -25$ V	$V_R = -10$ V	$V_R = -25$ V	$V_R = -10$ V	$V_R = -25$ V				25°C
	1.5		2						
					2000	50	50	200	100
	1.5		2						
					2000	50	50	200	100
2.0		2							
				400		50	20	200	100
0.7		*							
				150		50	50	200	50
5.5		2							
				2000		50	20	200	100
2.0		*							
					5000	50	50	200	100

* Not isolated from header.

Exceeding the peak inverse voltage may cause permanent damage to the diode. Forward current is harmless to the diode, within the power dissipation limit. For optimum performance, the diode should be reverse biased at between 5 and 20 volts.

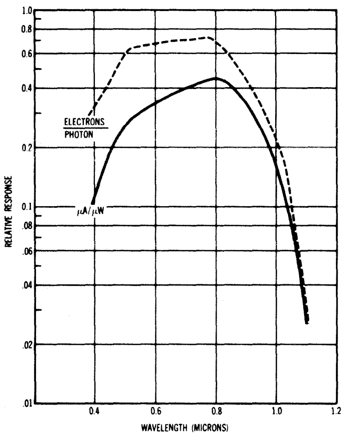


Figure 1. Spectral response.

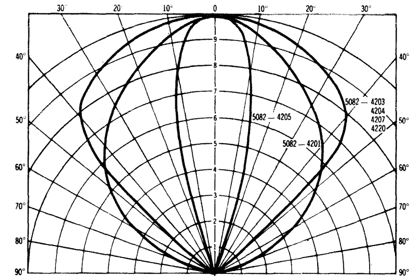


Figure 2. Relative directional sensitivity of the PIN Photodiodes.

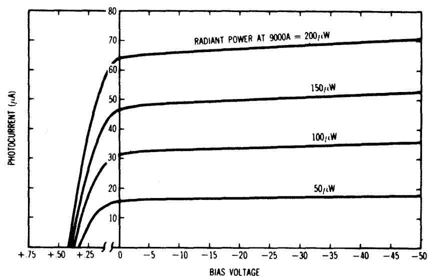


Figure 3. Typical output characteristics at 7700 Å.

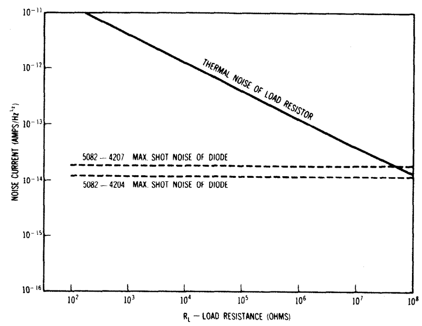


Figure 6. Noise vs. load resistance.

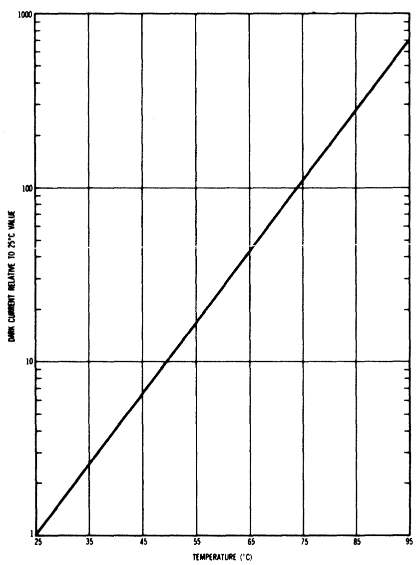


Figure 4. Dark current at —10 V bias vs. temperature.

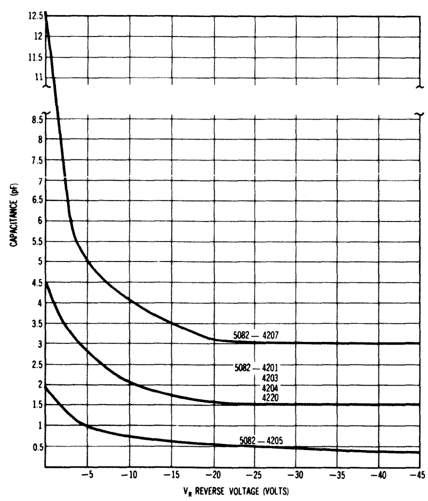


Figure 5. Typical capacitance variation with applied voltage.

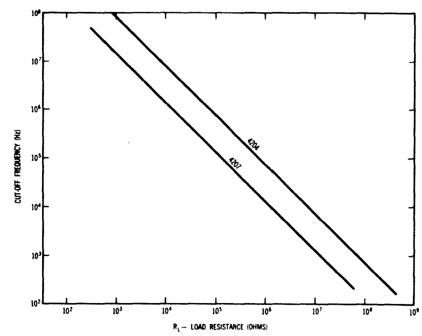


Figure 7. Photodiode cut-off frequency vs. load resistance (C = 2 pF).

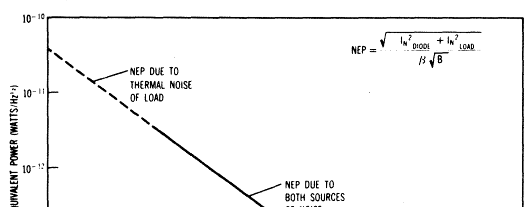


Figure 8. Noise equivalent power vs. load resistance.

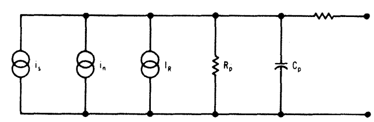


Figure 9.

i_s = Signal current ≈ 0.5 μA/μW

i_n = Shot noise current

< 1.2 × 10^{-14} amps/$Hz^{1/2}$ (5082-4204)

< 4 × 10^{-14} amps/$Hz^{1/2}$ (5082-4207)

I_R = Dark current

< 400 × 10^{-12} amps at —10 V dc (5082-4204)

< 2000 × 10^{-12} amps at —10 V dc (5082-4207)

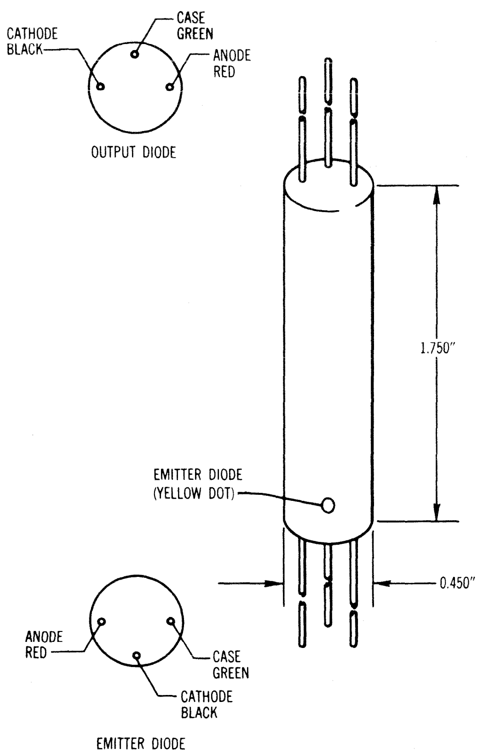
$R_P = 10^{11}\ \Omega$

R_S = < 50 Ω

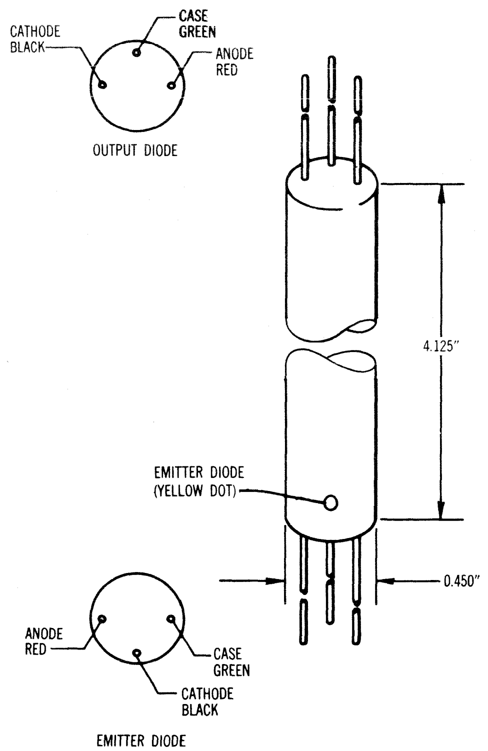
HEWLETT hp PACKARD

PHOTON COUPLED ISOLATORS

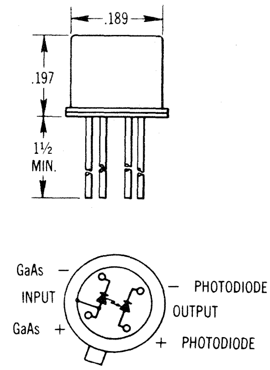
HP 5082-4300 series



HP 5082-4303



HP 5082-4309



HP 5082-4310

Dimensions in inches

The HP Photon Coupled Isolators are wide bandwidth signal coupling elements each comprised of a gallium arsenide electroluminescent diode infrared source and a silicon PIN photodetector. Electrical input signals are applied to the GaAs diode, which emits infrared radiation in proportion to the instantaneous forward current. The radiation from the GaAs diode is guided via a light pipe into the PIN photodiode in the 4303 and 4309. In the 4310 and 4320 the source and detector are separated by a thin optically transparent insulator. The electrical signals resulting at the photodiode can thereby be controlled from an input which may be in a separate and electrically isolated circuit.

The insulation resistance between input and output for the 4303 and 4309 exceeds 10^{11} ohms, shunted by less than 0.01 pF. The 4303 can withstand 20,000 volts between input and output, and the 4309 50,000 volts. Separate headers and shields on the input and output sections permit a high degree of circuit isolation. Applications include replacing video pulse transformers, RF signal couplers and switches.

The insulation resistance between input and output for the 4310 and 4320 is typically 10^{11} ohms shunted by 2 pF. The 4310 and 4320 can withstand 200 volts between input and output. The isolator is packaged on a TO-18 header with four leads, and the anode of the input diode is electrically connected to the case.

INPUT CHARACTERISTICS (GaAs Diode) at 25°C

	5082-4303			5082-4309			5082-4310/4320			Units	Test Conditions
	Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
Forward Voltage			1.3			1.3				Volts	I_F = 50 mA
									1.4	Volts	I_F = 100 mA
Series Resistance		2			2			2		Ohms	I_F = 50 mA
Breakdown Voltage	5			5			3			Volts	I_R = – 100 μA
Capacitance Zero Bias		120			120			250		pF	
Modulation Rise Time		70			70			100		nsec	I = 30 mA
Diode to Header Resistance		10^9			10^9					Ohms	

MAXIMUM RATINGS

Maximum DC Forward Current @ 25°C			70			70			100	mA	
Maximum Operating Temperature			125°C			125°C			125°C		

OUTPUT CHARACTERISTICS (Silicon PIN Photodiode) at 25°C

	5082-4303		5082-4309		5082-4310		5082-4320		Units	Test Conditions
	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.		
Dark Current		2		2		10		50	nA	V = – 25 V
Series Resistance		50		50		50		50	ohms	V = + 1 V
Junction Cap	2		2		2.5		2.5		pF	V = – 20 V
Capacitance to Shield	2		2						pF	

MAXIMUM RATINGS

Steady Reverse Voltage		50		50		50		50	Volts	
Peak Inverse Voltage*		200		200		100		100	Volts	
Steady State Power Dissipation		100		100		100		100	mWatts	

* **Note:** Exceeding the peak inverse voltage may cause permanent damage to the diode. Forward current is harmless to the diode within the power dissipation limit. For optimum performance the diode should be reverse biased at between 5 and 20 volts.

Price:		5082-4303	5082-4309	5082-4310	5082-4320
Quantity	1 - 9	$90.00	$130.00	$40.00	$20.00
	10 - 99	76.50	110.00	34.00	17.00

TRANSFER CHARACTERISTICS at 25°C

	5082-4303		5082-4309		5082-4310/4320			
	Typ.	Min.	Typ.	Min.	Typ.	Min.	**Units**	**Test Conditions**
DC Current Transfer Ratio I_2/I_1	0.0002		0.0002					$I_1 = 2$ mA $V = -25$ V
I_2/I_1	0.0004		0.0004					$I_1 = 30$ mA $V = -25$ V
I_2/I_1					0.002	0.0015		$I_1 = 100$ mA $V = -25$ V
Cutoff Frequency of Current Transfer	7.0		7.0		3.5		MHz	
Capacitance Coupling, Shield Grounded	0.01		0.01		2*		pF	
Breakdown Voltage Case to Case		20,000		50,000			Volts	
Breakdown Voltage Emitter to Detector						200	Volts	

* Case grounded.

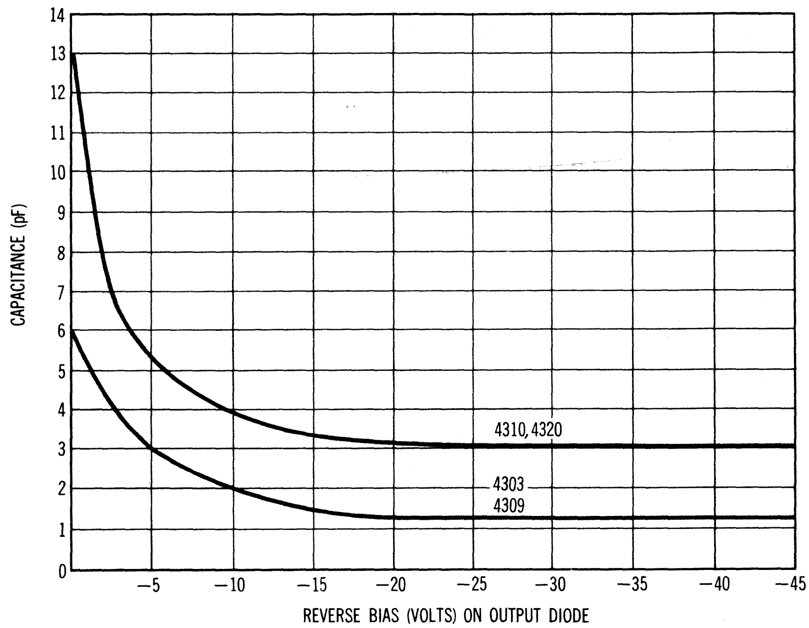


Figure 1. Typical capacitance variation with reverse bias (t = 1 ms, f = 1 MHz).

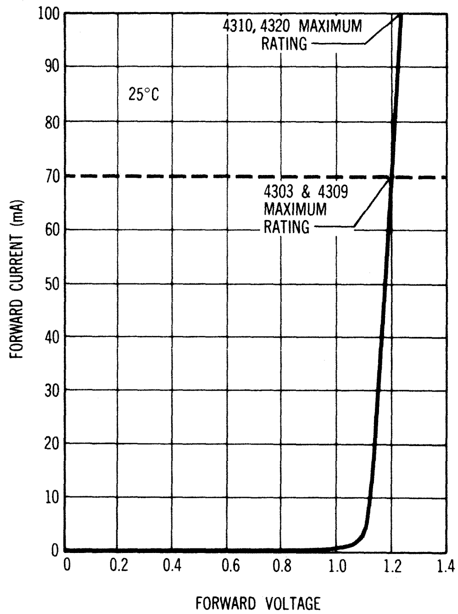


Figure 3. Typical input diode V-I characteristics.

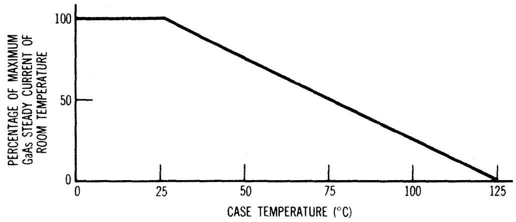


Figure 2. Derating curve.

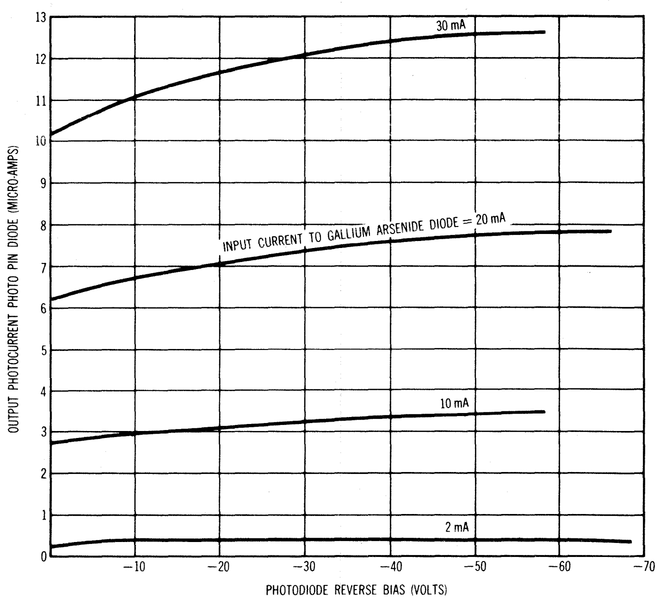


Figure 4. Typical output characteristics 4303 and 4309 Isolators.

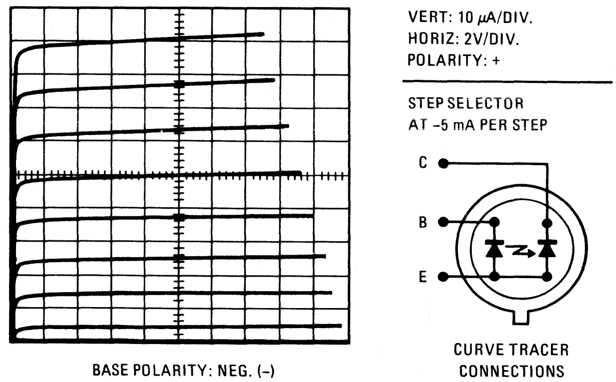


Figure 5. Curve tracer connections and display of current transfer characteristics of the HP 4310 and 4320 Isolator.

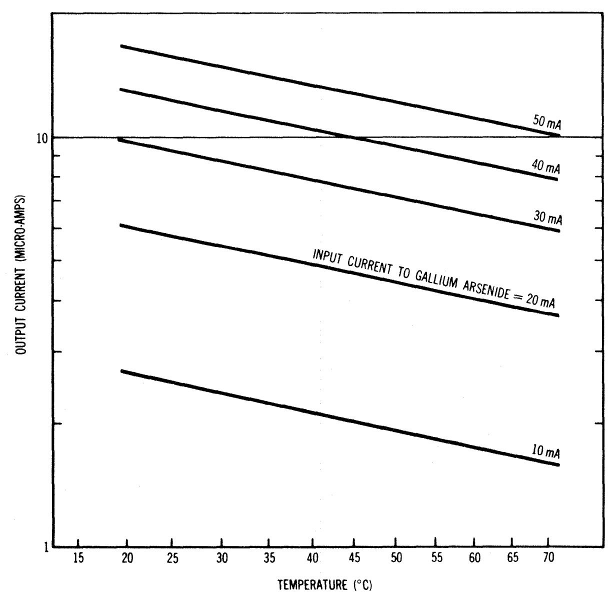


Figure 6. Temperature variation of current transfer for the 4303 and 4309.

(Note: The 4310 and 4320 have temperature dependence curves similar to the 4303 and 4309.)

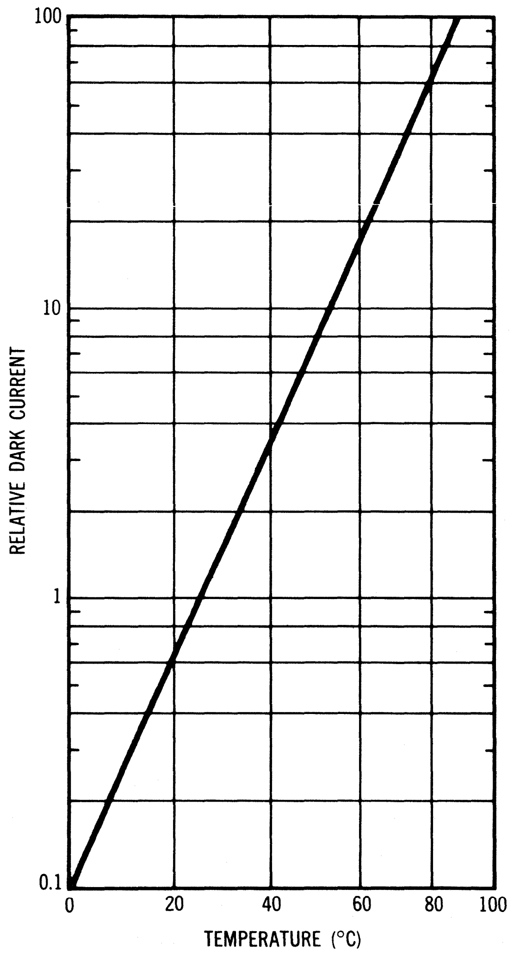
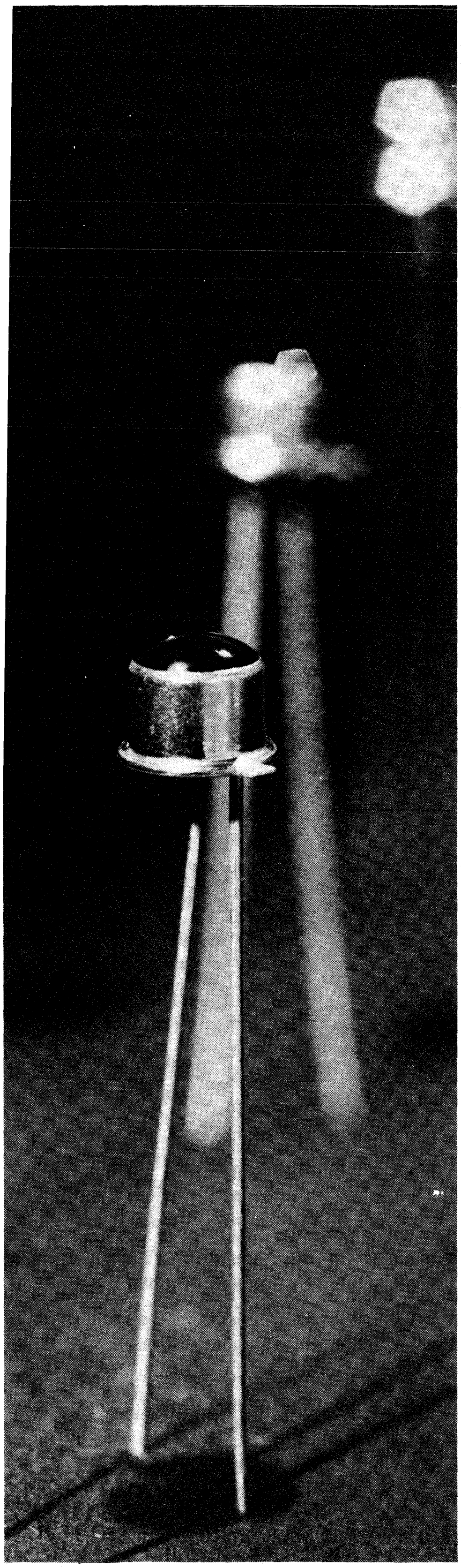


Figure 7. Typical dark current of PIN vs. temperature normalized.

HEWLETT PACKARD

SOLID STATE VISIBLE EMITTER

model 5082-4400



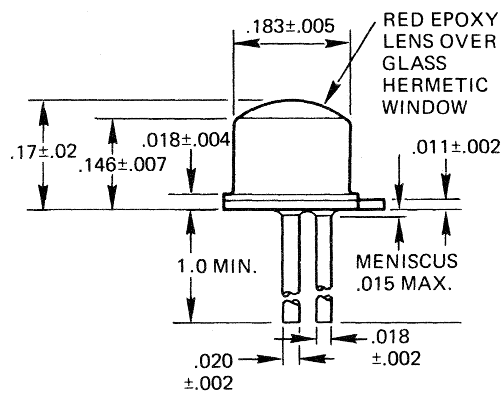
VISIBLE IN ROOM LIGHT WITH 10 mA DRIVE AT 1.5 V

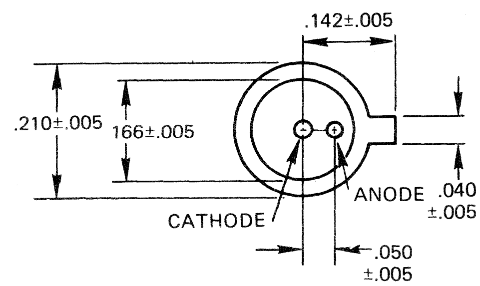
- LOW DRIVE POWER
- HIGH RELIABILITY
- SMALL SIZE

The Hewlett-Packard 5082-4400 Solid State Emitter is an efficient red light source which offers the benefits of high reliability, long life, isolation mounting, and hermetic packaging. It consists of a planar-passivated Gallium-Arsenide-Phosphide diode mounted in a package of modified TO-46 outline with a red lens to enhance visibility.

This source is intended for indicator applications where visibility is the primary measure of performance. The dark background and red lens improve the contrast, thereby enhancing visibility. With the contrast achieved in the 5082-4400, a source brightness of 50 footlamberts is adequate for satisfactory viewing under normal room light conditions. This level of brightness requires only 10 mA drive current (15 mW).

Low drive power, small size, high reliability, long life, resistance to shock, vibration and catastrophic failure uniquely qualify this device for circuit status and panel indicator applications.





Notes on Mounting and Operation

Heat sinking is an essential consideration in mounting because of the temperature dependence of the diode's emission. In a typical operation, most of the excess heat dissipated in the diode is borne away through the leads, which should therefore be as short as possible.

Mounting position is unrestricted so far as gravity is concerned, but orientation for convenient viewing should be considered. This may, in some applications, require mounting the diode with its axis parallel to the plane of the circuit in which it is connected.

Temperature compensation is not always necessary, primarily because the sensation of luminous intensity by the human eye varies logarithmically with level, and secondarily because the diode is usually operated in the same thermal environment as the viewer, so that wide extremes of temperature are not encountered. When desired, temperature compensation can be easily achieved using a drive circuit as shown in Figure 5(a).

For a fixed input, the collector current of the transistor has a positive temperature coefficient which may be greater in magnitude than the negative temperature coefficient (Figure 2) of the light emitter diode's luminous intensity. By adjusting the emitter's series resistance, a value is found [see Figures 5(b), 5(c)] at which the overall temperature coefficient approaches zero.

Circuit status indicator applications are especially appropriate for the light emitting diode due to its low power consumption. In some circuits, such as TTL logic, the available drive voltages or currents are too low to operate the light emitting diode directly. The drive circuit shown in Figure 5(a) will usually provide ample power gain to operate the light emitter diode at satisfactory levels while requiring no more signal input power than one additional TTL gate.

Specifications (at 25°C, unless otherwise stated):

Maximum Ratings

Parameter	Units	Max.
Free Air Power Dissipation, Continuous	mW	85
Peak Forward Current—Note 1 gives limits on pulse duration	A	1.0
Continuous Forward Current, I_c Derating Formula: $I_c = 0.7\ (100°C - T_{ambient})$ mA	mA	50
Operating and Storage Temperature Range	°C	−55 to 100
Max. Voltage—Anode or Cathode to Case at 100°C	V	500

Electrical Characteristics

Parameter	Units	Min.	Typ.	Max.
Forward Voltage @ 20 mA	V		1.6	
Reverse Breakdown Voltage @ 10 μA	V	4V		
Capacitance (V = 0, f = 1 MHz)	pF		200	300

Emission Characteristics

Parameter	Units	Min.	Typ.	Max.
Luminance (Brightness) of Emitting Surface of Diode @ 20 mA	fL	100	250	
Axial Luminous Intensity @ 20 mA	μcd	85	210	
Speed of Response—Note 2	ns			10
Peak Wavelength	nm		660	
Spectral Line Halfwidth	nm		30	

fL = footlambert, cd = candela, nm = nanometer = 10 Ångstrom

NOTES:

1. Rectangular pulse limitations:
   Amplitude: $I_p/I_c < 20$
   Duration: $I_p/I_c < 1/(2000\ t)$
   Duty Factor: $I_p/I_c < 1/ft$
   where I_c = maximum continuous forward current (mA)
   I_p = peak pulse current (mA)
   t = pulse duration (sec)
   f = repetition rate (pulses per second)
2. Time for 10%-90% change of light intensity with step change in current, either increase or decrease.

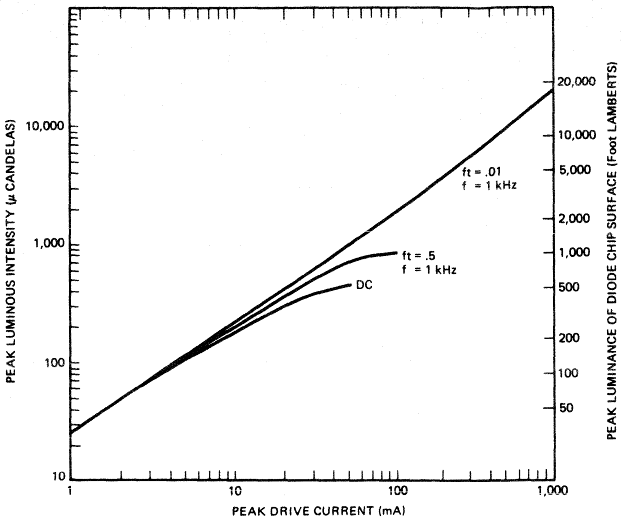


Figure 1. Brightness (Luminance) and Luminous Intensity vs. Drive Current.

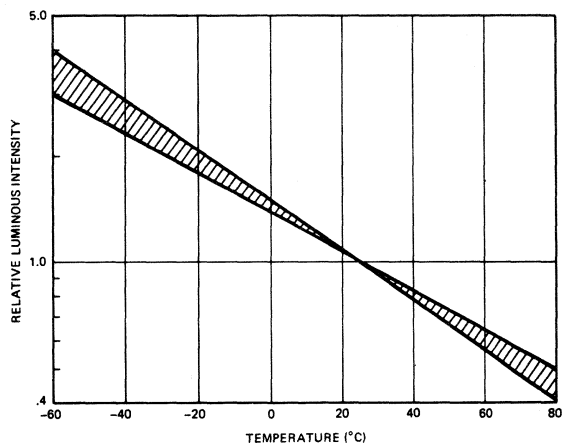


Figure 2. Luminous Intensity vs. Case Temperature at Fixed Drive Current.

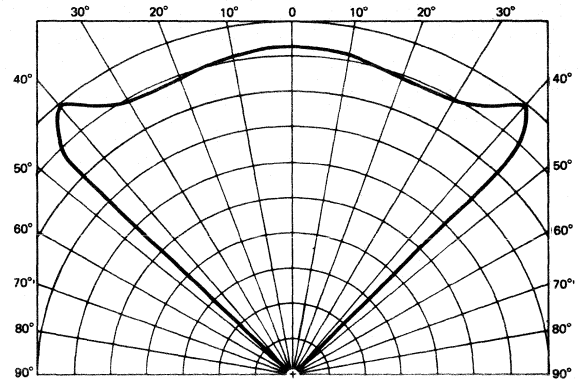


Figure 3. Radiation Pattern of Luminous Intensity.

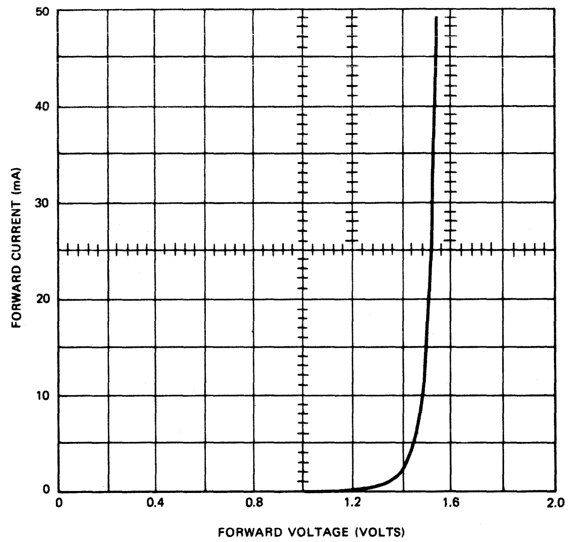
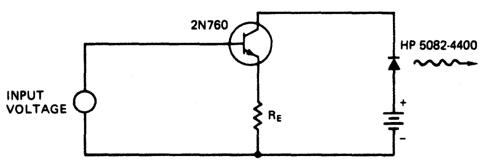
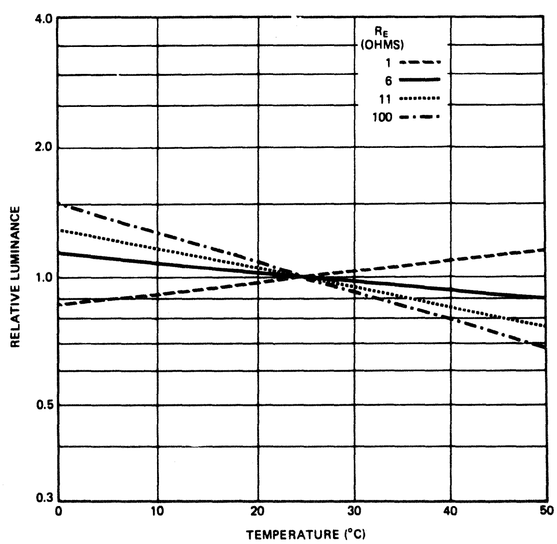


Figure 4. Forward Current—Voltage Characteristic.

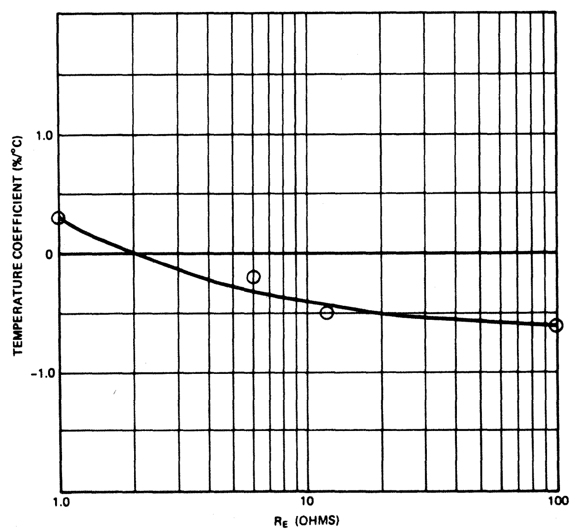
Figure 5. Drive Circuit and Temperature Compensation.



(a) TYPICAL DRIVE CIRCUIT



(b) RELATIVE LUMINANCE vs. TEMPERATURE



(c) TEMPERATURE COEFFICIENT vs. EMITTER RESISTANCE

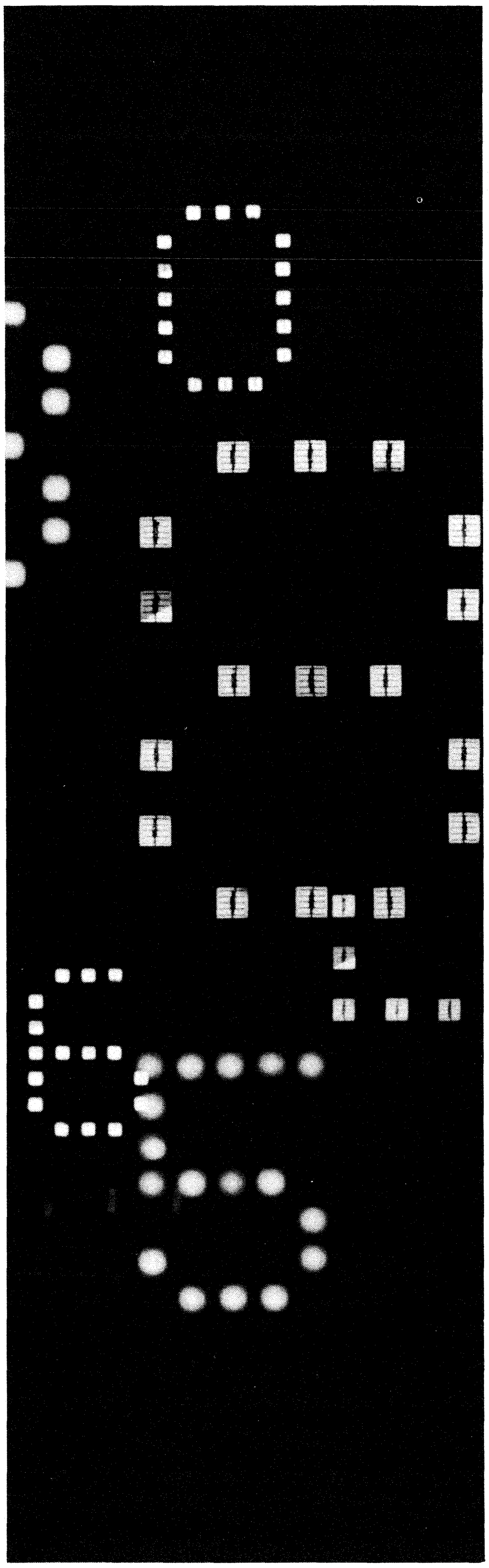
SOLID STATE INDICATORS

Device No.	Page
Solid State Numeric Indicators 5082-7000, -7001	127
Solid State Plus/Minus Sign 5082-7018	127
Indicator Mounting Hardware 5082-7003 through -7017	127

HEWLETT PACKARD

SOLID STATE NUMERIC INDICATOR

HP 5082-7000 THRU 5082-7018



- IC COMPATIBLE — 5 V dc
- INCLUDES DECODER/DRIVER — 8421 BCD INPUT
- 5 x 7 DOT MATRIX CHARACTER — HUMAN FACTORS ENGINEERED
- BRIGHTNESS CONTROLLABLE — LED VOLTAGE 1.6 TO 4.2 V
- LONG OPERATING LIFE
- SMALL SIZE — 1.06 x 0.59 x 0.15 INCHES
- RELIABLE — DESIGNED TO MEET MIL STANDARDS

The Hewlett-Packard Solid State Numeric Indicator is a rugged display module providing solid state reliability and long life to numeric information display. Designed with several unique features, the display is ideal for conventional numeric indicator requirements as well as allowing many new applications in the display of digital information.

Typical areas of application for the display include airborne or shipboard equipment, fire control systems, and combat information centers; portable battery operated equipment, such as hand-held radar, electronic clocks and calculators; computer readouts; numeric controlled machine tools; and test equipment such as counters and DVM's.

IC COMPATIBLE / LOGIC INCLUDED

The HP Solid State Numeric Indicator is a small, rugged, and IC compatible display module. Complete with decoder/driver, the display requires only four input connections using standard 8421 four-line negative logic BCD for the selection of the character set 0 through 9.

The many unique features which make it ideal for conventional display applications also allow for new types of information displays not previously possible. A listing of the features along with information as to how they might solve your display requirements is given below.

IC COMPATIBLE

The highest voltage required by the display is 5 volts dc. This eliminates the need for a separate high voltage power supply with corresponding savings in weight, space, and expense. In addition, the RFI associated with switching high voltages and necessary shielding is also eliminated.

INCLUDES DECODER/DRIVER LOGIC

A decoder/driver is included as an integral part of each display module. This eliminates the need for separate decoder/driver procurement, additional circuit design, and fabrication expense. In addition, the space normally required by external logic is also eliminated, allowing for smaller, more compact display panels.

For the selection of the character set 0 through 9, all that is required is a standard 8421 four-line negative logic BCD input to the display. Logic levels are completely IC compatible and can be driven directly from TTL, DTL, or transistors.

5 x 7 DOT MATRIX CHARACTER

The 5 x 7 dot matrix format gives a pleasant, easily read ¼-inch character. This qualitative characteristic (very important in human factor considerations) makes the Hewlett-Packard numeric especially valuable in critical applications where ease of reading and reliability of transmitted information are the objectives. The problem of a false reading, possible with a one-segment failure of a seven-segment display, is eliminated.

VARIABLE BRIGHTNESS

Brightness of the display can be easily adjusted by varying the LED voltage between 1.6 and 4.2 volts. This allows for selection of the optimum display brightness for varying ambient light levels to give maximum display readability.

LONG LIFE

The solid state display elements coupled with a rugged design give the numeric indicator long life. Since the failure mechanism of the display is a gradual decrease in light output with time rather than a catastrophic failure, replacement, if necessary, can be accomplished without a previous loss of information. Initial tests indicate display half brightness life conservatively at 100,000 to 500,000 hours with estimates up to 1 million hours. (Half brightness life is defined as the point in time when the display brightness is down 50% from its original value.) So for most applications, the life of the display will exceed the life of the equipment in which it is used, eliminating the necessity of allowing for replacement of display elements.

SMALL SIZE

The space required by the display measures only 1.06 in. high x 0.59 in. wide x 0.15 in. deep. This small size allows for the compact presentation of digital information. Not only is there a saving of front panel space, but the thinness of the display greatly conserves on the volume normally used behind the front panel in display installations. This savings can be used to build smaller, lighter weight equipments.

HERMETICALLY SEALED, RUGGED DESIGN

The display module is **hermetically** sealed and of rugged design. It is suitable for environments with high shock and vibration, humidity, salt spray, and temperature fluctuation. Units have been tested to MIL-STD-750 and MIL-STD-202C with excellent results.

Detailed test data is available upon request.

LOW POWER

High GaAsP and IC efficiencies make the numeric indicator suitable for many applications where display power requirements are a consideration. In portable instruments or other applications where power requirements need to be minimized, the display voltage and brightness can be reduced with corresponding power savings. For applications where the power requirements are critical, the display can be used with a "push to read" button to turn on the display only when information readout is necessary.

SINGLE PLANE / WIDE ANGLE VIEWING

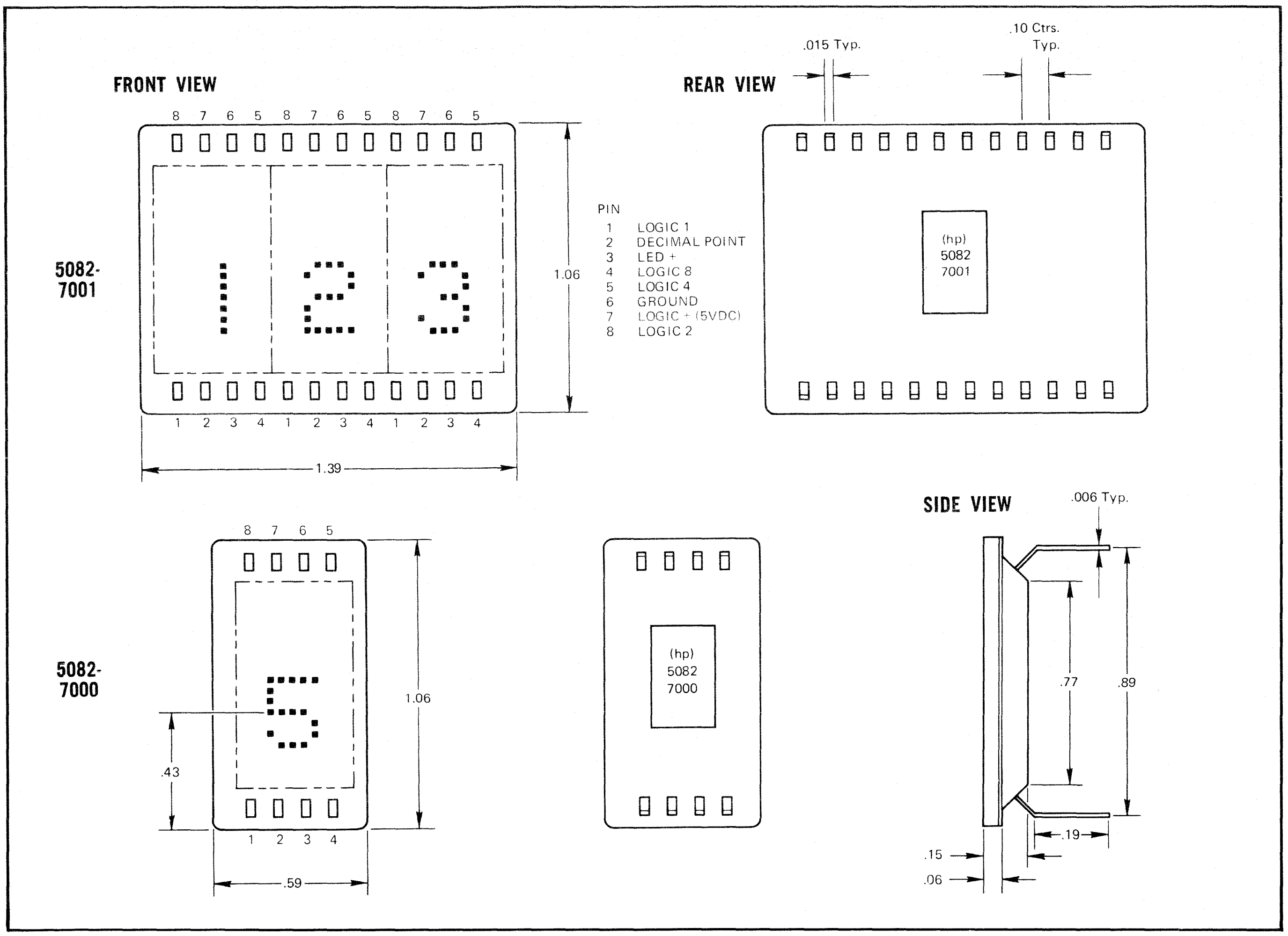
The Lambertian light-emitting surface of the display LED's arrayed in a single plane provides greater than 120° of useful viewing angles (>60° from either side of normal) with constant brightness. This allows for one viewer to obtain display information from a large number of differing angles or for several viewers to watch the display at the same time.

SOLID STATE PLUS / MINUS SIGN

For display applications requiring ± designation, the 5082-7018 solid state plus/minus sign is available. This display module comes in the same package as the 5082-7000 numeric indicator and is completely compatible with it. Plus or minus information can be indicated by supplying 4 volts to one (minus sign) or two (plus sign) input leads. A third lead is provided for the ground connection. Brightness is variable by changing dc drive from 1.6 to 4.0 volts. As with the numeric indicator, the 7018 plus/minus sign is completely IC compatible, small in size, and rugged in design.

PREMOUNTED NUMERIC INDICATORS

Premounted HP 5082-7000, 7001, and 7018 displays are also available. These premounted displays are designed to save time and money when prototyping new instruments or when small quantity runs do not justify the design and shop time to create mounting hardware. The premounted display package is completely assembled, wired, and soldered at the factory (associated display modules must be ordered at the same time as the mounting hardware). All that is required for installation of the premounted displays is the cutting of an appropriate hole in the instrument front panel and mounting the premounted display package.



SPECIFICATIONS (5082-7000/7001)

Power and logic inputs referred to common (GND)
IC supply voltage (max.) .... 5.25 V dc
LED (light emitting diodes) supply voltage (max.) .... 4.2 V dc
Logic input: 4-line BCD negative logic
2.8 V ≤ "0" ≤ 5 V dc
0 V ≤ "1" ≤ 0.8 V dc
Temperature—Storage .... −65°C to +100°C
Temperature—Operating .... −55°C to +95°C
Luminance of emitting surface at 4.2 V LED .... 100 fL (min.)
Decimal point (requires external current limiting) @ 1.6 V dc .... 10 mA (max.)

TYPICAL CHARACTERISTICS

IC supply current at 5 V dc .... 25 mA
LED supply current at 3.5 V dc (displaying No. 6) .... 150 mA
at 4.2 V dc .... 225 mA
Logic input current at 0.8 V dc input for "1" state .... <2.0 mA
at 5 V dc input for "0" state .... <0.2 mA
Power dissipation (depending on LED voltage) .... 250 mW - 1 W
Luminance of emitting surface at 3.5 V LED .... 100 fL
at 4.2 V LED .... 200 fL
Peak wavelength .... 655 nm
Spectral line halfwidth .... 30 nm
Character response time ("on" or "off") .... <1 μs
Display weight (7000) .... 3.1 grams, 0.108 oz.

OPERATING CONSIDERATIONS (5082-7000/7001)

Electrical

The electrical drive requirements for the solid state display module are:

(1) 5 V dc filtered power supply with adequate regulation to prevent over-voltage conditions (>5.5 V) to provide typically 25 mA per character for integrated circuit logic operation,

(2) A 3.5 V dc supply providing up to 180 mA per character,* or alternatively a voltage-variable supply from 2.5 to 4.2 V to permit display brightness variation,

(3) 4-line BCD negative logic (2.8 V ≤ "0" ≤ 5.0 V: 0 V ≤ "1" ≤ 0.8 V), TTL, DTL compatible—drive current ≤ 2 mA

(4) A 10 mA **current limited** sink to excite the separately driven decimal point. The decimal point is not current protected. All signals and power supplies are referred to a common ground connection. References to the package outline drawing will indicate electrical connections to the case leads.

The binary code truth table is shown in Figure 4; it is in conformity with the ASCII coding. No memory has been provided in the integrated circuit, therefore the display will conform to the input coding with a character change interval of $<1\ \mu s$ and typically less than 200 nanoseconds. This high character change rate coupled with all light character forming elements being in a common plane, makes this device an excellent consideration for photographic film recording. No over-voltage protection is provided with this package and it is critical that the display be protected from voltage transients in excess of 5.5 V either on the BCD lines or on the integrated circuit power supply lead.

The integrated circuit in this module is compatible with 5 V TTL and DTL logic. Drive levels typically will not exceed 2 mA.

---

* The power supply used for the LED drive may alternatively be a 60-cycle or higher frequency full wave rectified unfiltered source providing low cost independent power supply for the display.

MECHANICAL/THERMAL MOUNTING

A solid state display unit normally operates with approximately ½ watt dissipation. This ½ watt of power, dissipated as heat, can result in substantial temperature rise (typically 50°C) above ambient, with resulting hazard to the device unless thermal sinking is provided. It is expected that the usual mounting technique will combine mechanical support and thermal heat sinking in a common structure. The devices may normally be operated without forced-air cooling where thermal conduction access to the front panel of the instrument is available. The absolute temperature increase above ambient will, of course, be a function of the number of units mounted in the display, but mounting should limit the thermal differential between the hottest display module and the front panel mounting points to less than 10°C. A suggested structure with this capability is shown in Figure 5. With this arrangement, leads are attached to printed circuit boards by hand soldering. Silicone grease should be applied between the back of the case and the mounting strap to provide a thermal path from the display module case. Where additional mechanical rigidity of mounting is required, a silicone pad, GE RTV815 or equivalent, may be inserted between the clear front glass window of the module and the glass or plastic optical filter forming the front window of the display. The front window is also mounted by the hardware shown in Figure 5. This is only a suggested mounting and other mounting techniques may be dictated by operating environment conditions, as severe shock, vibration, or other operational needs. It is obvious that the plain glass window of the package makes care in handling a necessary consideration for installation.

If the suggested mounting is of interest to you, Hewlett-Packard has available premounted assemblies, eliminating the need for subassembly handling in your facility.

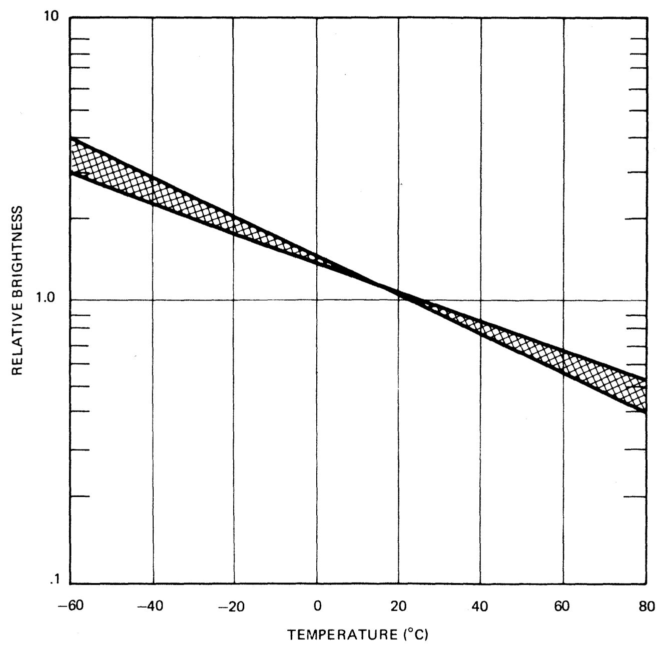


Figure 2. Light emitting diode brightness vs. case temperature at fixed current level.

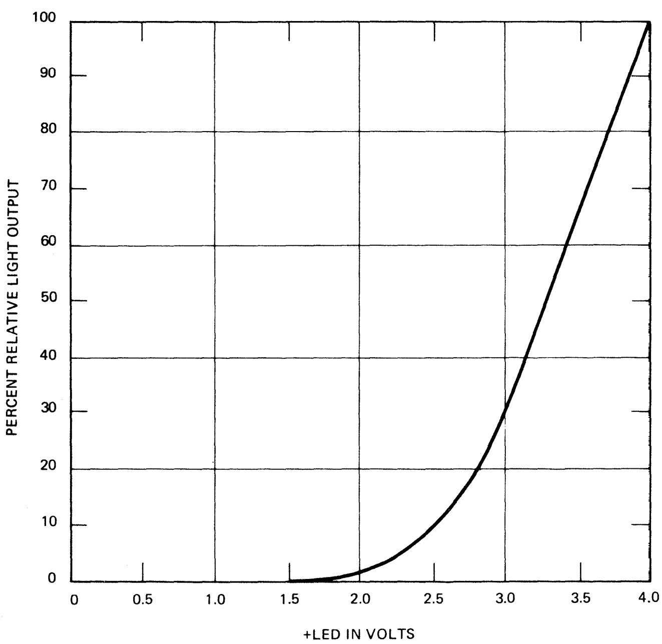


Figure 1. Relative light output as a function of LED voltage. Typical display held at 25°C case temperature.

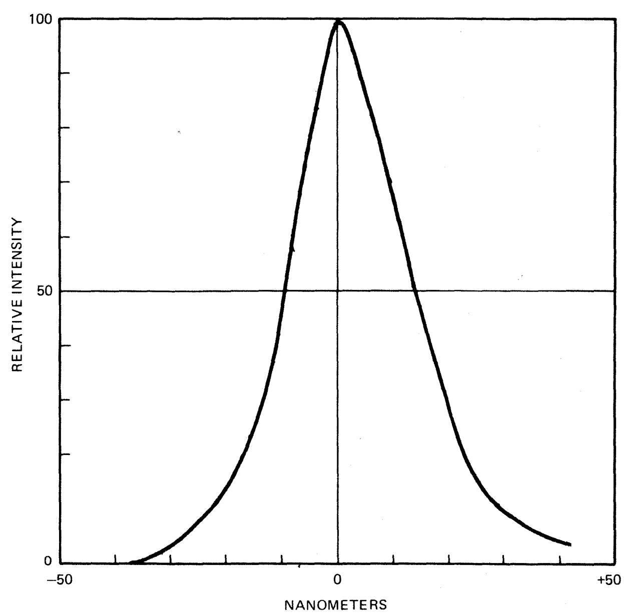


Figure 3. Spectral bandwidth of electroluminescent emission.

Figure 4. Truth table for 5082-7000 and 7001 solid state numeric display.

H = 5.0 Volts
L = 0 Volts

	LOGIC					LOGIC			
NUMERIC	1	2	4	8	NUMERIC	1	2	4	8
0	H	H	H	H	8	H	H	H	L
1	L	H	H	H	9	L	H	H	L
2	H	L	H	H	BLANK	H	L	H	L
3	L	L	H	H	BLANK	L	L	H	L
4	H	H	L	H	BLANK	H	H	L	L
5	L	H	L	H	BLANK	L	H	L	L
6	H	L	L	H	BLANK	H	L	L	L
7	L	L	L	H	BLANK	L	L	L	L

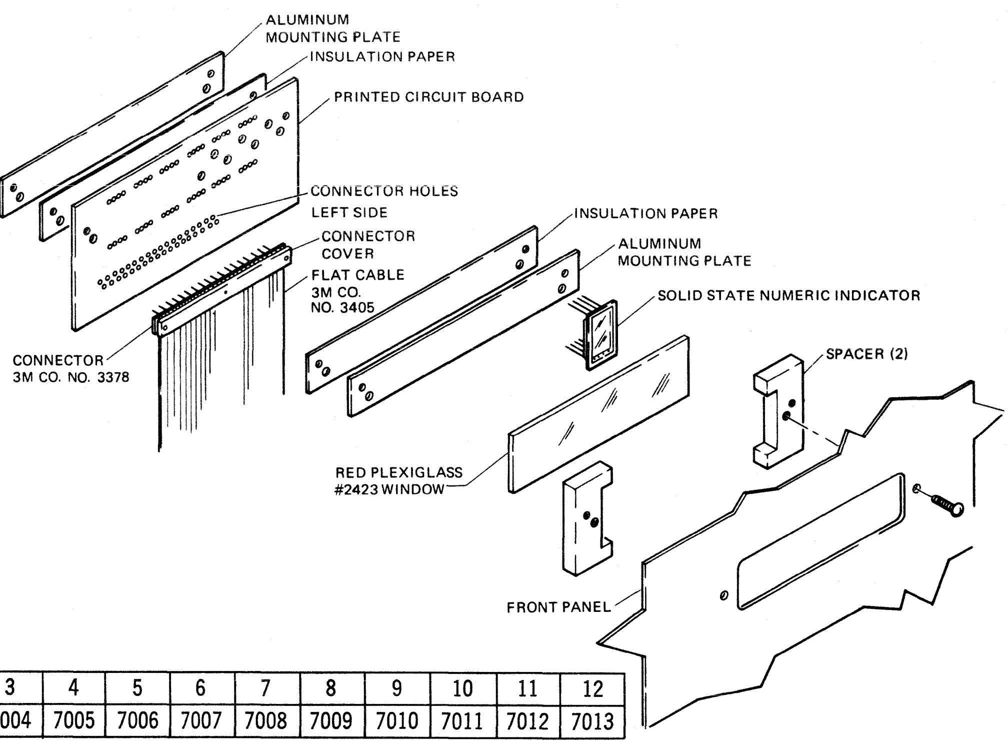
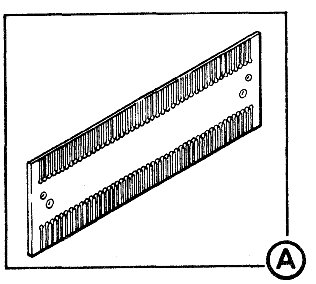


Figure 5. Mounting hardware for HP 5082-7000 solid state numeric display.

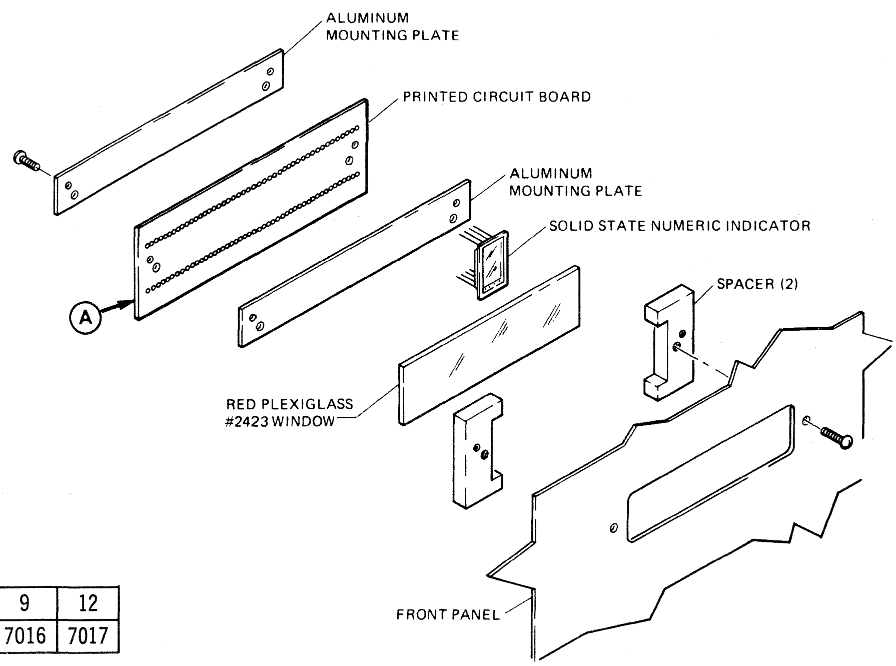
PREMOUNTED
5082-7000

Number of Digits	2	3	4	5	6	7	8	9	10	11	12
Hardware Number 5082-	7003	7004	7005	7006	7007	7008	7009	7010	7011	7012	7013

Figure 6. Mounting hardware for HP 5082-7001 solid state numeric display.



ROTATED 180°



PREMOUNTED
5082-7001

Number of Digits	3	6	9	12
Hardware Number 5082-	7014	7015	7016	7017

A/B DIMENSIONS FOR 5082-7000

NO. OF DIGITS	2	3	4	5	6	7	8	9	10	11	12
DIMENSIONS A	1.600	2.200	2.800	3.400	4.000	4.600	5.200	5.800	6.400	7.000	7.600
DIMENSIONS B	2.100	2.700	3.300	3.900	4.500	5.100	5.700	6.300	6.900	7.500	8.100

A/B DIMENSIONS FOR 5082-7001

NO. OF DIGITS	3	6	9	12
DIMENSIONS A	2.200	3.400	4.600	6.400
DIMENSIONS B	2.700	3.900	5.100	6.900

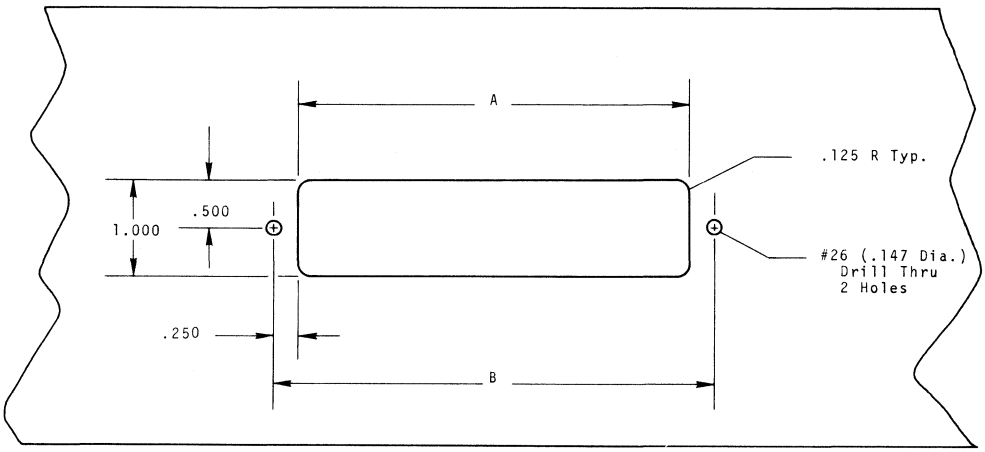
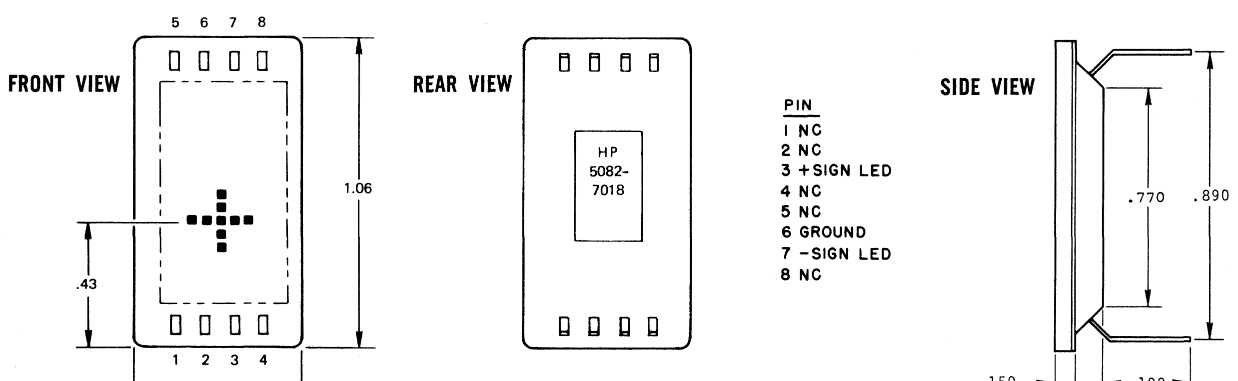


Figure 7. Dimensions for front panel hole and mounting.



5082-7018 PLUS/MINUS SIGN

SPECIFICATIONS (5082-7018)

LED (Light Emitting Diodes) Voltage (max.) ....4.2 V dc
Storage Temperature Range ....−65°C to +100°C
Operating Temperature Range ....−55°C to +95°C

TYPICAL CHARACTERISTICS

Luminance of Emitting Surface at 4.2 V LED +........200 fL
Power Dissipation at 200 fL ....360 mW
Peak Wavelength ....655 nm
Spectral Line Halfwidth ....30 nm
Character Response Time ("on" or "off")................<10 ns
LED Current at 4 V dc (LED + to ground)................120 mA

OPERATING CONSIDERATIONS

Electrical

The electrical drive requirements for the solid state display module are:

A 3.5 V dc supply providing up to 90 mA per character,* or alternatively a voltage-variable supply from 2.5 to 4.2 V to permit display brightness variation.

All signals and power supplies are referred to a common ground connection. References to the package outline drawing will indicate electrical connections to the case leads.

To light the minus sign, voltage should be placed on pin No. 7. To light the plus sign, voltage should be placed on both pin No. 7 and pin No. 3.

* The power supply used for the LED drive may alternatively be a 60-cycle or higher frequency full wave rectified unfiltered source providing low cost independent power supply for the display.

GENERAL NOTES

OPTICAL

Color:

The color of the Hewlett-Packard solid state display module is red (655 nanometers). The material used in diode fabrication is GaAsP. It is a characteristic of GaAsP that the luminous efficiency, i.e., light output as viewed by the eye, is a function of the wavelength of light emitted. By varying the alloy composition, the light emitted may vary from infrared at 910 nanometers, to green at 555 nanometers. The alloy ratio is, of course, determined at the time of device material synthesis. Therefore, high controllability of the desired dominant emitted light wavelength is attainable. However, in providing the alloy compositional change from the infrared to the green, there is substantial loss of efficiency at the green end of the spectrum. Conversely, the sensitivity of the eye to emitted light has a substantial degradation going from the green-yellow sensitivity peak toward the infrared. There exists a natural cross-over point where maximized luminous efficiency results, and this cross-over point has been the determinant in the selection of the red used in the numeric indicator. Figure 8 is descriptive of the relative efficiencies of colors, the eye response curve, and the cross-over point of response.

Red was chosen as the color of the light emitted by the new solid state indicators because the electroluminous efficiency of HP's gallium arsenide phosphide alloy is highest for that color. Electroluminous efficiency is a measure of visual brightness per unit diode current. It is a function of the alloy composition, that is, the value of x in the formula $GaAs_{1-x}P_x$. Typical diodes have junction areas of 0.002 cm^2 and electroluminous efficiencies of 30 $fL/Amp/cm^2$; this is equivalent to a brightness of 150 fL at 10 mA.

Viewing Angle:

There are two general display operating conditions:

(1) The bench-mounted instrument situation where wide angle viewing is highly desirable to permit the observation of a number of instruments by a single operator, or groups of operators, and

(2) Aircraft pilot situations wherein the head is held in a relatively fixed position with respect to the display to be viewed and where it is usually desirable to trade off wide angle viewability for ambient light reflection minimization.

For the first of these, the Hewlett-Packard display module may be viewed from angles in excess of 60° from the normal to the display, vertically or horizontally, with good readability. The only precaution must be that no mechanical obstruction is provided by the mechanical mounting or the panel opening of the instrument.

For Condition (2), it is frequently desirable to artificially constrain the radiation pattern to take advantage of the light emission optimization and to use the pilot's head as a block to panel illumination from ambient lighting conditions. Figure 9 illustrates a method by which this may be adapted. There always exists the possibility of obtaining increased apparent character size and/or light emittance by optical enhancement techniques at the cost of viewing angle.

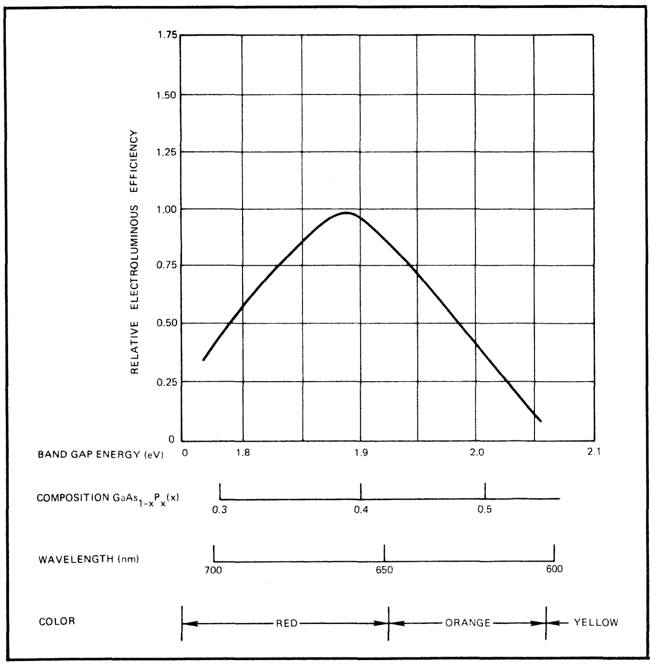


Figure 8. Electroluminous efficiency of gallium arsenide phosphide.

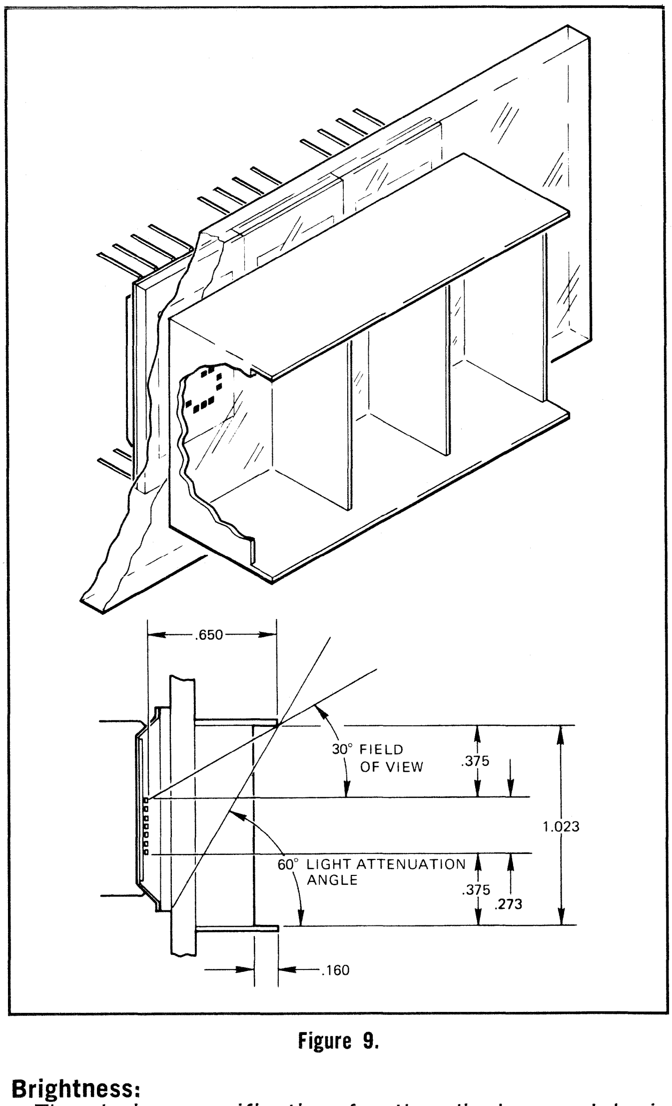


Figure 9.

Brightness:

The design specification for the display module is that 100 fL or more will be provided (diode average) when 4.0 dc is applied to the plus LED lead. It is possible by varying the LED voltage to control the brightness of the display. The typical response curve is shown in Figure 1. The power input to the display is reduced substantially when reduced voltage is applied to the plus LED lead. A twelve-digit display has been operated with 250 mW total power applied to the LED display (not including the integrated circuit logic power requirement) with adequate brightness for comfortable reading in a subdued lighting room. The use of a display in this mode for dark room operation is suggested. Also, reduced-brightness space vehicle operation, where power conservation is of prime importance, may be provided by this module feature.

Contrast:
Contrast is defined to be the ratio of luminous value of a lighted die to the surround of the display, usually within the window area. This contrast ratio should usually be well in excess of 10. (Color contrasting display may also be provided.) Contrast in this display device is enhanced by the front window. Reasons behind this may be seen by looking through the clear window of the package. The ceramic substrate and the metallic interconnect striping on the ceramic provide reflection surfaces to external light. The reflection of these surfaces is controlled by selection of a filter used as a front window for this package. Therefore, the observed contrast ratio is a function of the transmittance of the window both at the color of the light emitting die and the rest of the visible spectrum. One would ideally, for maximum contrast, have full transmittance of the narrow band color produced by the light emitting die and a transmission density of 3.0 or greater for the balance of the spectrum. While filters of this type may be provided, the cost is substantially greater than a simple filter with a long wave pass band characteristic such as Plexiglass 2423. The transmittance spectrum of this Plexiglass material is shown in Figure 10. It is not within the control of Hewlett-Packard to guarantee that Plexiglass 2423 will always exhibit this characteristic, but this curve was generated by a representative sample.

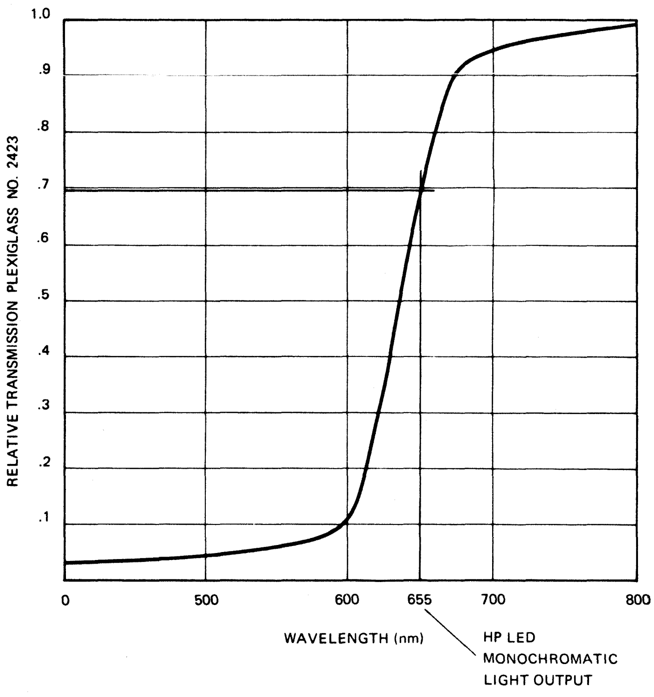


Figure 10. Relative transmission of Plexiglass 2423.

Another device for contrast enhancement is the use of anti-reflective coating at reflection producing surfaces between the lighted die and the outside of the case. Such a coating should be hard to permit window cleaning and is comprised of a coating applied where the glass or plastic, with a typical reflective index of 1.5, interfaces with air, with a typical refractive index of 1.0. Reflection at each of these surfaces is reduced roughly by a factor of two, providing a display where the surround to the lighted dot is substantially "blacker" than would otherwise attain. The blackness of this surround is determined by the ambient brightness level, the directional properties of the ambient room lighting, the position of the lighting with respect to the instrument and the viewer, and the reflectivity of the elements of the package. Reflection from surfaces behind the "red" front window of the display are sharply attenuated because of the limited band pass ability of the filter, with the resulting double attenuation of light not within the pass band.

Size:
The character size of both the 5082-7000 and 5082-7001 display modules is ¼ inch. It is an interesting aside that most observers will estimate the size to be larger by about 50%. This is a subjective effect produced by the light emitting properties (high contrast) of this display. The ¼-inch size has been selected after study of larger and smaller sizes in various display applications. The individual display modules (7000) would normally be mounted on a 0.600-inch center-to-center spacing. The minimum spacing is limited by the package width. To permit closer character spacing and to provide groups of three, commonly used in numeric display, the 7001 package is provided. Character center-to-center spacing within this package is 0.400 inch. Minimum vertical character center-to-center spacing would be about 1¼ inches. The front-to-back space required using the suggested mechanical mounting structure and including the colored glass filter in the front of the package is $\frac{7}{16}$ inch.

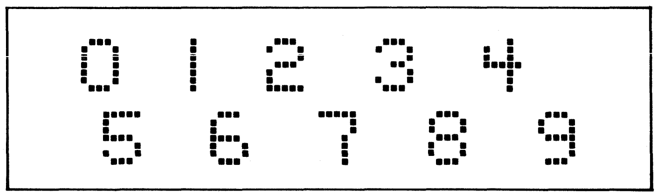


Figure 11. Character set.

Character Font:
The character font or style used in the Hewlett-Packard solid state display has been selected on the basis of readability without ambiguity, freedom from reading error in the case of a device burnout, and production economy that can be obtained by using a slightly stylized character set. The character set is presented above and in the display figures.

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* LEVEL I TESTED HIGH RELIABILITY UNITS
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