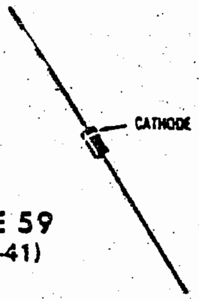
1N4001 thru 1N4007

$V_R = 50\text{-}1000\ V$
$I_O = 1.0\ A$



CASE 59
(DO-41)

Surmetic rectifiers, subminiature size, axial lead mounted rectifiers for general purpose low-power applications.

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	$V_{RM(non\text{-}rep)}$	75	150	300	600	900	1200	1500	Volts
RMS Reverse Voltage	V_r	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 6, $T_A = 75°C$)	I_O	1.0							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 2)	$I_{FM(surge)}$	30 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175							°C

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop ($i_F = 1.0$ Amp, $T_J = 25°C$) Figure 1	V_F	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop ($I_O = 1.0$ Amp, $T_L = 75°C$, 1 inch leads)	$V_{F(AV)}$	0.8	Volts
Maximum Reverse Current (rated dc voltage) $T_J = 25°C$ $T_J = 100°C$	I_R	0.01 0.05	mA
Maximum Full-Cycle Average Reverse Current ($I_O = 1.0$ Amp, $T_L = 75°C$, 1 inch leads)	$I_{R(AV)}$	0.03	mA

MECHANICAL CHARACTERISTICS

CASE: Void free, Transfer Molded

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds at 5 lbs. tension

FINISH: All external surfaces are corrosion-resistant, leads are readily solderable

POLARITY: Cathode indicated by color band

WEIGHT: 0.40 Grams (approximately)

FIGURE 1 — FORWARD VOLTAGE

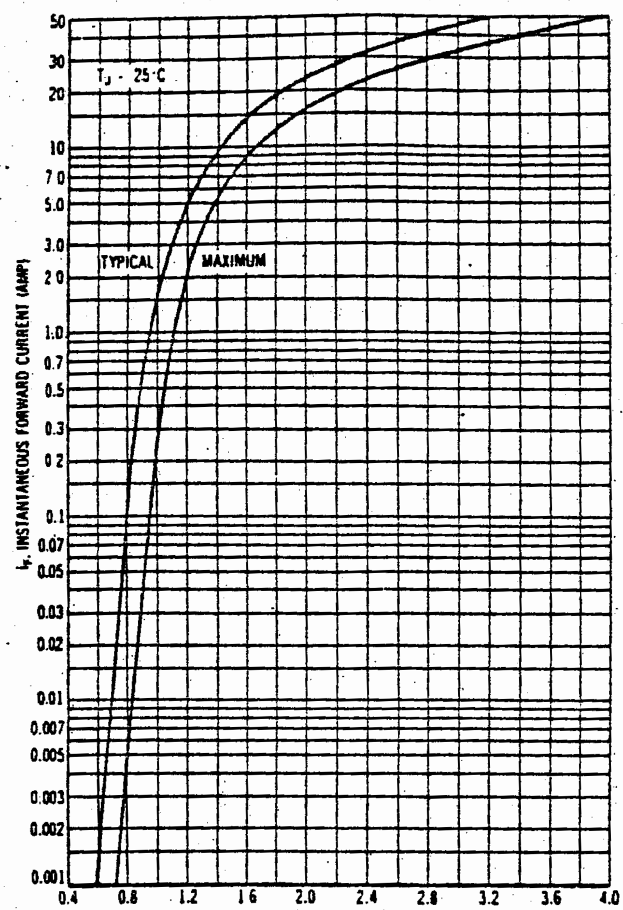


FIGURE 2 — MAXIMUM SURGE CAPABILITY

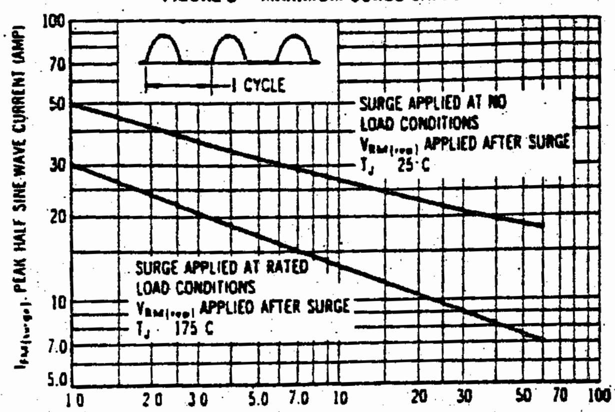


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

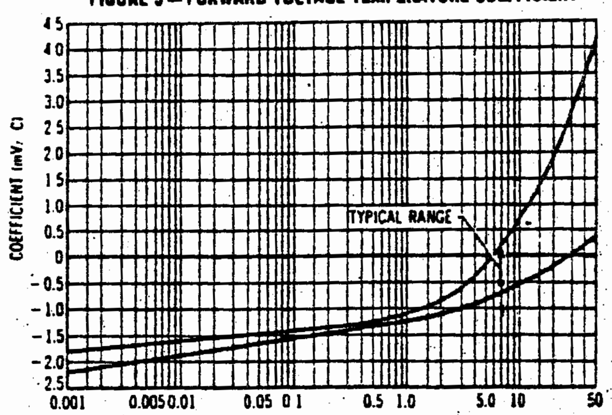
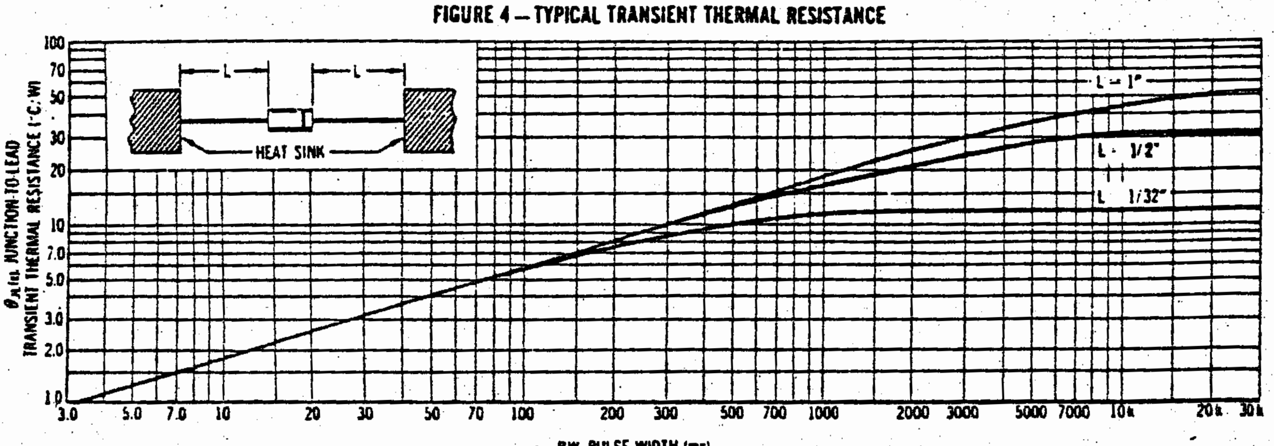


FIGURE 4 — TYPICAL TRANSIENT THERMAL RESISTANCE



FOR $\theta_{JL(t)}$ VALUES AT PULSE WIDTHS LESS THAN 3.0 ms, THE ABOVE CURVE CAN BE EXTRAPOLATED DOWN TO 10 μs AT A CONTINUING SLOPE OF 1/2

FIGURE 5 — LEAD TEMPERATURE DERATING (DC ONLY)

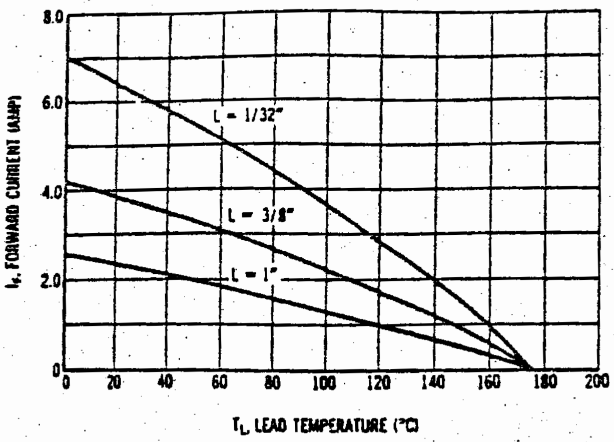


FIGURE 6 — RESISTIVE, INDUCTIVE LOADS

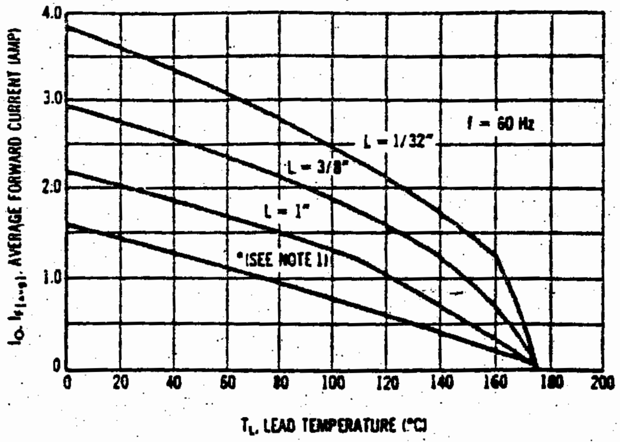


FIGURE 7 — CAPACITIVE LOADS

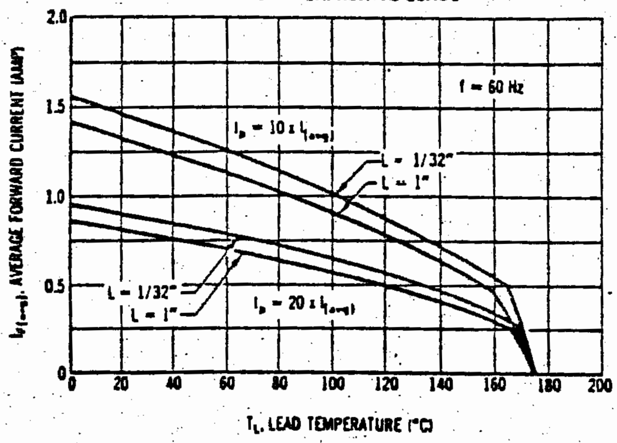
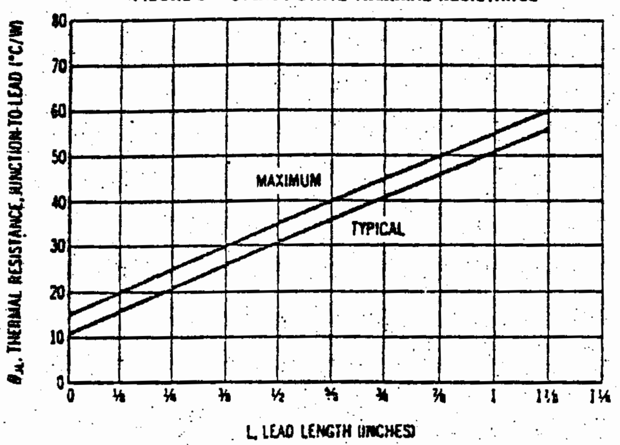


FIGURE 8 — STEADY-STATE THERMAL RESISTANCE

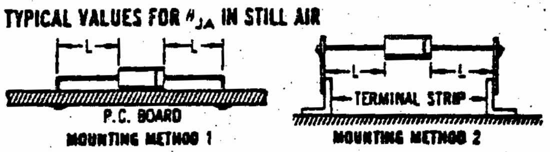


NOTES

NOTE 1

Data shown for thermal resistance junction-to-ambient (θ_{JA}) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

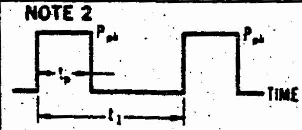
TYPICAL VALUES FOR θ_{JA} IN STILL AIR



MOUNTING METHOD	LEAD LENGTH, L (IN.)			θ_{JA}
	1/32	3/8	1	
1	—	75	85	°C/W
2	55	72	85	°C/W

*Using Mounting Method 1 or 2 with L = 1" the curve marked * in Figure 6 can be used for 60 Hz half-wave resistive/inductive load (Rating vs. Ambient Temperature). The abscissa of Figure 6 then indicates T_A in °C.

NOTE 2



DUTY CYCLE, $D = t_p/t_1$

PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

$$\Delta T_{JL} = P_{pk} \cdot \left[\theta_{JL(\infty)} \cdot D + (1 - D) \cdot \theta_{JL(t_1 + t_p)} + \theta_{JL(t_p)} - \theta_{JL(t_1)} \right]$$

where $\theta_{JL(t)}$ = value of transient thermal resistance at time t, i.e.:

$\theta_{JL(t_1+t_p)}$ = value of $\theta_{JL(t)}$ at time $t_1 + t_p$

$\theta_{JL(t_p)}$ = value of $\theta_{JL(t)}$ at end of pulse width t_p

$\theta_{JL(t_1)}$ = value of $\theta_{JL(t)}$ at time t_1

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 9 — FORWARD RECOVERY TIME

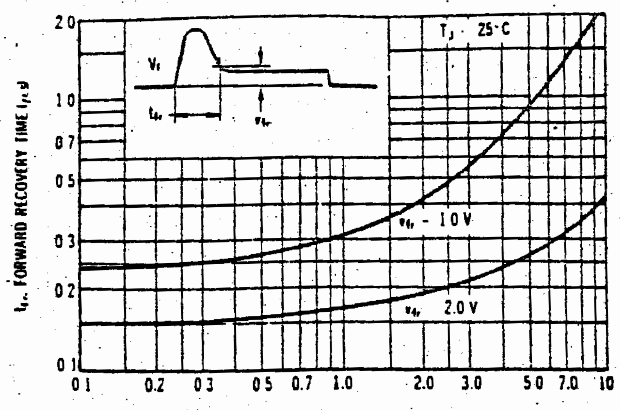


FIGURE 10 — REVERSE RECOVERY TIME

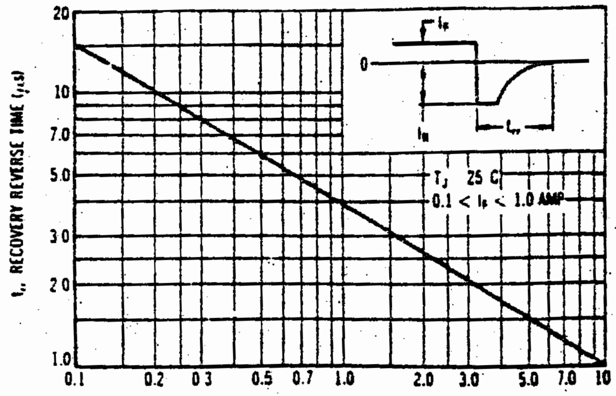


FIGURE 11 — RECTIFICATION WAVEFORM EFFICIENCY

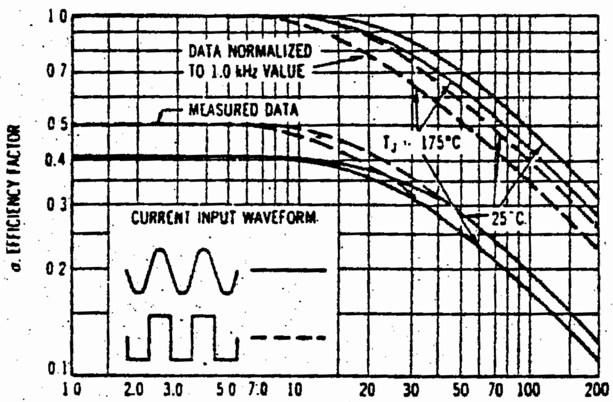
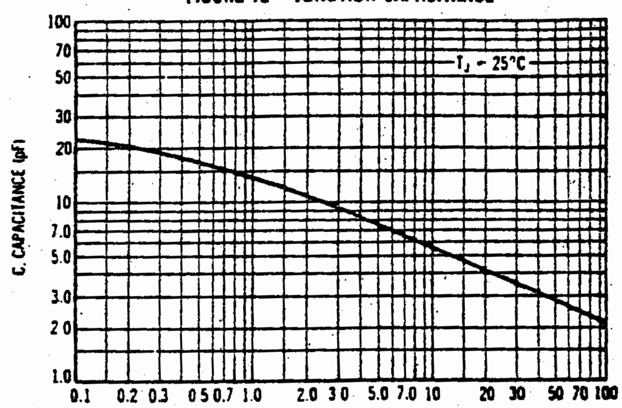
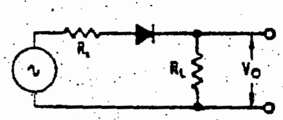


FIGURE 12 — JUNCTION CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 13 — SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 11 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\frac{V^2_{O(dc)}}{R_L}}{\frac{V^2_{O(rms)}}{R_L}} \cdot 100\% = \frac{V^2_{O(dc)}}{V^2_{O(ac)} + V^2_{O(dc)}} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\frac{V^2_m}{2R_L}}{\frac{V^2_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(A full-wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 10) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 11.

It should be emphasized that Figure 11 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 11.

1N4057, A thru 1N4085, A

For Specifications, See 1N429 Data.

FAIRCHILD
SEMICONDUCTOR ™

Discrete POWER & Signal Technologies

1N746A - 1N759A Series Half Watt Zeners

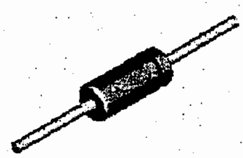
Absolute Maximum Ratings*

TA = 25°C unless otherwise noted

Tolerance: A = 5%

Parameter	Value	Units
Storage Temperature Range	-65 to +200	°C
Maximum Junction Operating Temperature	+ 175	°C
Lead Temperature (1/16" from case for 10 seconds)	+ 230	°C
Total Device Dissipation Derate above 25°C	500 3.33	mW mW/°C

*These ratings are limiting values above which the serviceability of the diode may be impaired.



DO-35

NOTES:
1) These ratings are based on a maximum junction temperature of 200 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Electrical Characteristics

TA = 25°C unless otherwise noted

Device	V_Z (V)	Z_Z (Ω)	@	I_{ZT} (mA)	I_{R1} (µA)	@	V_R (V)	I_{R2} (µA)	@	V_R T_A=150°C (V)	T_C (%/°C)	I_{ZM}* (mA)
1N746A	3.3	28		20	10		1.0	30		1.0	- 0.070	110
1N747A	3.6	24		20	10		1.0	30		1.0	- 0.065	100
1N748A	3.9	23		20	10		1.0	30		1.0	- 0.060	95
1N749A	4.3	22		20	2.0		1.0	30		1.0	+/- 0.055	85
1N750A	4.7	19		20	2.0		1.0	30		1.0	+/- 0.030	75
1N751A	5.1	17		20	1.0		1.0	20		1.0	+/- 0.030	70
1N752A	5.6	11		20	1.0		1.0	20		1.0	+ 0.038	65
1N753A	6.2	7.0		20	0.1		1.0	20		1.0	+ 0.045	60
1N754A	6.8	5.0		20	0.1		1.0	20		1.0	+ 0.050	55
1N755A	7.5	6.0		20	0.1		1.0	20		1.0	+ 0.058	50
1N756A	8.2	8.0		20	0.1		1.0	20		1.0	+ 0.062	45
1N757A	9.1	10		20	0.1		1.0	20		1.0	+ 0.068	40
1N758A	10	17		20	0.1		1.0	20		1.0	+ 0.075	35
1N759A	12	30		20	0.1		1.0	20		1.0	+ 0.077	38

*IZM (Maximum Zener Current Rating) Values shown are based on the JEDEC rating of 400 milliwatts. Where the actual zener voltage (VZ) is known at the operating point, the maximum zener current may be increased and is limited by the derating curve.

SILICON PLANAR NPN

BC 107
BC 108
BC 109

LOW NOISE GENERAL PURPOSE AUDIO AMPLIFIERS

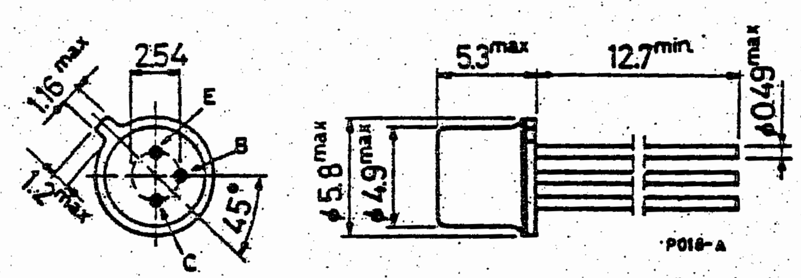
The BC 107, BC 108 and BC 109 are silicon planar epitaxial NPN transistors in TO-18 metal case. They are suitable for use in driver stages, low noise input stages and signal processing circuits of television receivers.
The complementary PNP types are respectively the BC 177, BC 178 and BC 179.

ABSOLUTE MAXIMUM RATINGS

		BC 107	BC 108	BC 109
V_{CBO}	Collector-base voltage ($I_E = 0$)	50 V	30 V	30 V
V_{CEO}	Collector-emitter voltage ($I_B = 0$)	45 V	20 V	20 V
V_{EBO}	Emitter-base voltage ($I_C = 0$)	6 V	5 V	5 V
I_C	Collector current	100 mA		
P_{tot}	Total power dissipation at $T_{amb} \leq 25\ °C$	0.3 W		
	at $T_{case} \leq 25\ °C$	0.75 W		
T_{stg}	Storage temperature	-55 to 175 °C		
T_j	Junction temperature	175 °C		

MECHANICAL DATA

Dimensions in mm



(sim. to TO-18)

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BC 107
BC 108
BC 109

THERMAL DATA

$R_{th\ j-case}$	Thermal resistance junction-case	max	200	°C/W
$R_{th\ j-amb}$	Thermal resistance junction-ambient	max	500	°C/W

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C unless otherwise specified)

Parameter		Test conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cutoff current ($I_E = 0$)	for BC 107				
		V_{CB} = 40 V			15	nA
		V_{CB} = 40 V T_{amb} = 150 °C			15	µA
		for BC 108 - BC 109				
		V_{CB} = 20 V			15	nA
		V_{CB} = 20 V T_{amb} = 150 °C			15	µA
$V_{(BR)CBO}$	Collector-base breakdown voltage ($I_E = 0$)	I_C = 10 µA				
		for BC 107	50			V
		for BC 108	30			V
		for BC 109	30			V
$V_{(BR)CEO}$*	Collector-emitter breakdown voltage ($I_B = 0$)	I_C = 10 mA				
		for BC 107	45			V
		for BC 108	20			V
		for BC 109	20			V
$V_{(BR)EBO}$	Emitter-base breakdown voltage ($I_C = 0$)	I_E = 10 µA				
		for BC 107	6			V
		for BC 108	5			V
		for BC 109	5			V
$V_{CE(sat)}$*	Collector-emitter saturation voltage	I_C = 10 mA I_B = 0.5 mA		70	250	mV
		I_C = 100 mA I_B = 5 mA		200	600	mV
V_{BE}*	Base-emitter voltage	I_C = 2 mA V_{CE} = 5 V	550	650	700	mV
		I_C = 10 mA V_{CE} = 5 V		700	770	mV
$V_{BE(sat)}$*	Base-emitter saturation voltage	I_C = 10 mA I_B = 0.5 mA		750		mV
		I_C = 100 mA I_B = 5 mA		900		mV

ELECTRICAL CHARACTERISTICS (continued)

Parameter		Test conditions	Min.	Typ.	Max.	Unit
h_{FE}*	DC current gain	I_C = 2 mA V_{CE} = 5 V				
		for BC 107	110	230	450	—
		for BC 107 Gr. A	110	180	220	—
		for BC 107 Gr. B	200	290	450	—
		for BC 108	110	350	800	—
		for BC 108 Gr. A	110	180	220	—
		for BC 108 Gr. B	200	290	450	—
		for BC 108 Gr. C	420	520	800	—
		for BC 109	200	350	800	—
		for BC 109 Gr. B	200	290	450	—
		for BC 109 Gr. C	420	520	800	—
		I_C = 10 µA V_{CE} = 5 V				
		for BC 107		120		—
		for BC 107 Gr. A		90		—
		for BC 107 Gr. B	40	150		—
		for BC 108		120		—
		for BC 108 Gr. A		90		—
		for BC 108 Gr. B	40	150		—
		for BC 108 Gr. C	100	270		—
		for BC 109	70	210		—
		for BC 109 Gr. B	40	150		—
		for BC 109 Gr. C	100	270		—
h_{fe}	Small signal current gain	I_C = 2 mA V_{CE} = 5 V f = 1 kHz				
		for BC 107		250		—
		for BC 107 Gr. A		190		—
		for BC 107 Gr. B		300		—
		for BC 108		370		—
		for BC 108 Gr. A		190		—
		for BC 108 Gr. B		300		—
		for BC 108 Gr. C		500		—
		for BC 109		370		—
		for BC 109 Gr. B		300		—
		for BC 109 Gr. C		550		—
		I_C = 10 mA V_{CE} = 10 V f = 100 MHz		2		—
C_{CBO}	Collector-base capacitance	I_E = 0 V_{CB} = 10 V f = 1 MHz		4	6	pF

* Pulsed: pulse duration = 300 µs, duty factor = 1%.

BC 107
BC 108
BC 109

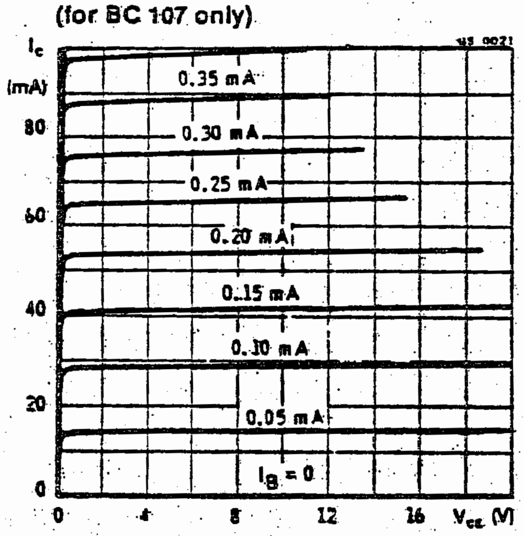
ELECTRICAL CHARACTERISTICS (continued)

	Parameter	Test conditions	Min.	Typ.	Max.	Unit
C_{EBO}	Emitter-base capacitance	I_C = 0 V_{EB} = 0.5 V f = 1 MHz		11.5		pF
NF	Noise figure	I_C = 0.2 mA V_{CE} = 5 V R_g = 2 kΩ f = 1 kHz B = 200 Hz				
		for **BC 107**		2	10	dB
		for **BC 108**		2	10	dB
		for **BC 109**		1.5	4	dB
		I_C = 0.2 mA V_{CE} = 5 V R_g = 2 kΩ f = 10 Hz to 10 kHz B = 15.7 kHz				
		for **BC 109**		1.5	4	dB
h_{ie}	Input impedance	I_C = 2 mA V_{CE} = 5 V f = 1 kHz				
		for **BC 107**		4		kΩ
		for **BC 107** Gr. A		3		kΩ
		for **BC 107** Gr. B		4.8		kΩ
		for **BC 108**		5.5		kΩ
		for **BC 108** Gr. A		3		kΩ
		for **BC 108** Gr. B		4.8		kΩ
		for **BC 108** Gr. C		7		kΩ
		for **BC 109**		5.5		kΩ
		for **BC 109** Gr. B		4.8		kΩ
		for **BC 109** Gr. C		7		kΩ
h_{re}	Reverse voltage ratio	I_C = 2 mA V_{CE} = 5 V f = 1 kHz				
		for **BC 107**		2.2×10^{-4}		—
		for **BC 107** Gr. A		1.7×10^{-4}		—
		for **BC 107** Gr. B		2.7×10^{-4}		—
		for **BC 108**		3.1×10^{-4}		—
		for **BC 108** Gr. A		1.7×10^{-4}		—
		for **BC 108** Gr. B		2.7×10^{-4}		—
		for **BC 108** Gr. C		3.8×10^{-4}		—
		for **BC 109**		3.1×10^{-4}		—
		for **BC 109** Gr. B		2.7×10^{-4}		—
		for **BC 109** Gr. C		3.8×10^{-4}		—

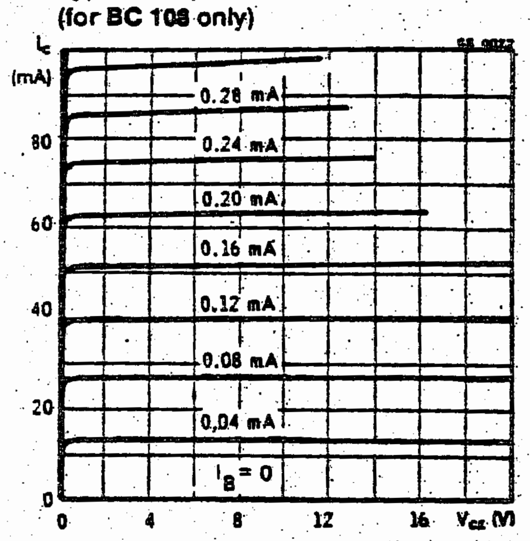
ELECTRICAL CHARACTERISTICS (continued)

Parameter		Test conditions	Min.	Typ.	Max.	Unit
h_{oe}	Output admittance	I_C = 2 mA V_{CE} = 5 V f = 1 kHz				
		for **BC 107**		20		µS
		for **BC 107** Gr. A		13		µS
		for **BC 107** Gr. B		26		µS
		for **BC 108**		30		µS
		for **BC 108** Gr. A		13		µS
		for **BC 108** Gr. B		26		µS
		for **BC 108** Gr. C		34		µS
		for **BC 109**		30		µS
		for **BC 109** Gr. B		26		µS
		for **BC 109** Gr. C		34		µS

Typical output characteristics (for BC 107 only)

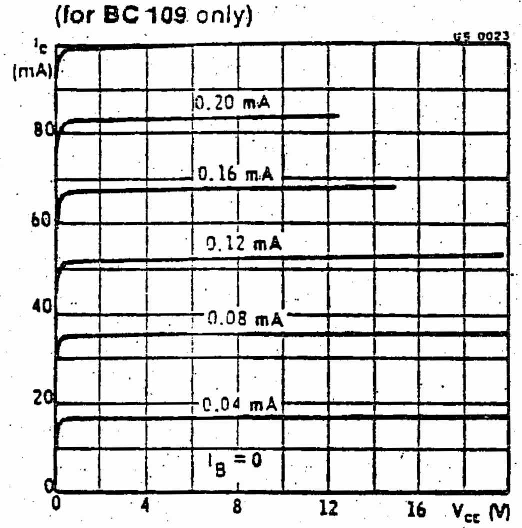


Typical output characteristics (for BC 108 only)

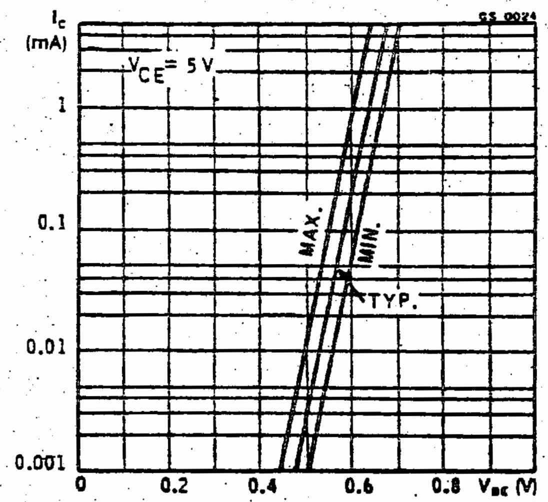


BC 107
BC 108
BC 109

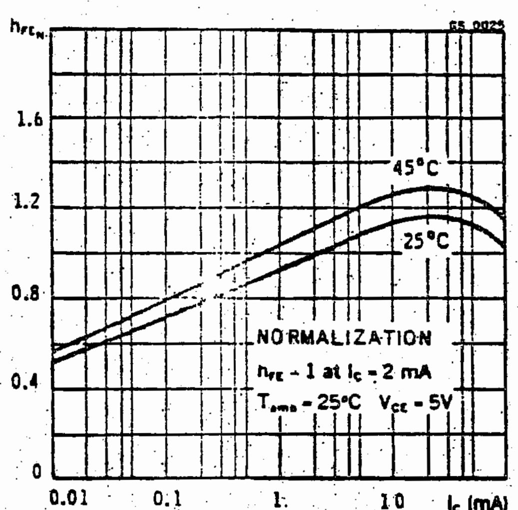
Typical output characteristics (for BC 109 only)



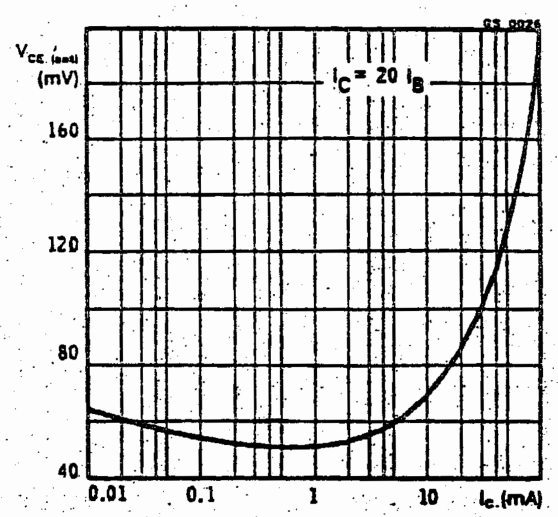
DC transconductance



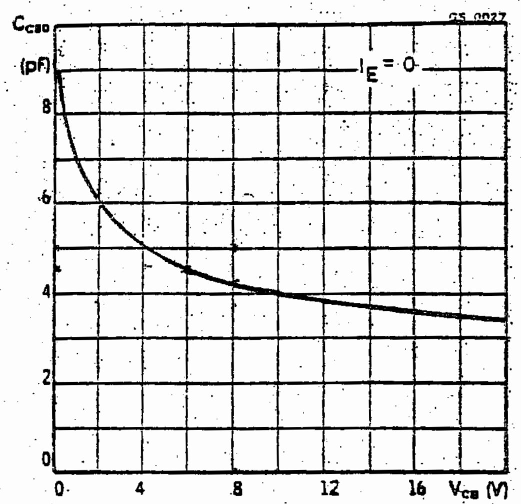
DC normalized current gain



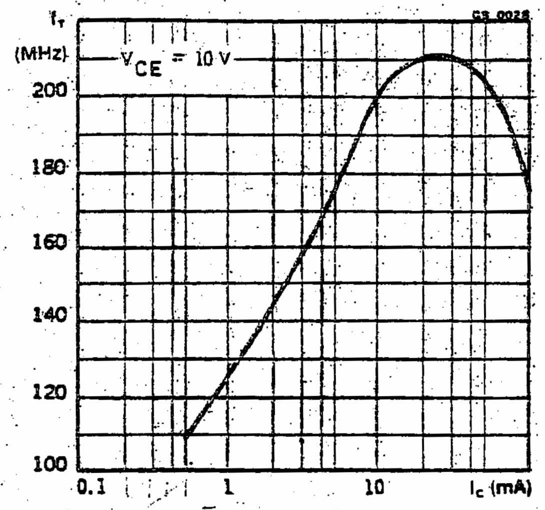
Collector-emitter saturation voltage



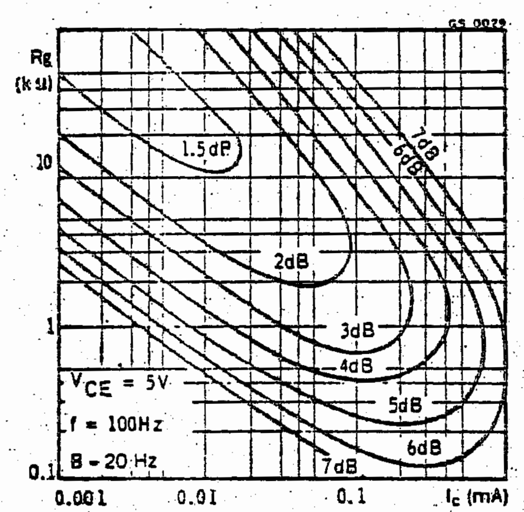
Collector-base capacitance



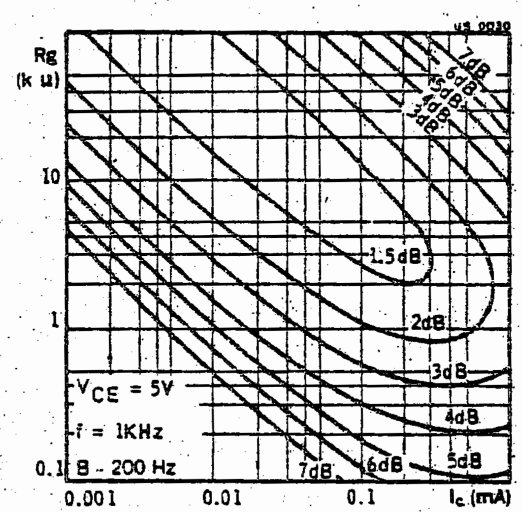
Transition frequency



Noise figure (for BC 109 only)



Noise figure (for BC 109 only)



SILICON PLANAR PNP

BC 177
BC 178
BC 179

LOW NOISE GENERAL PURPOSE AUDIO AMPLIFIERS

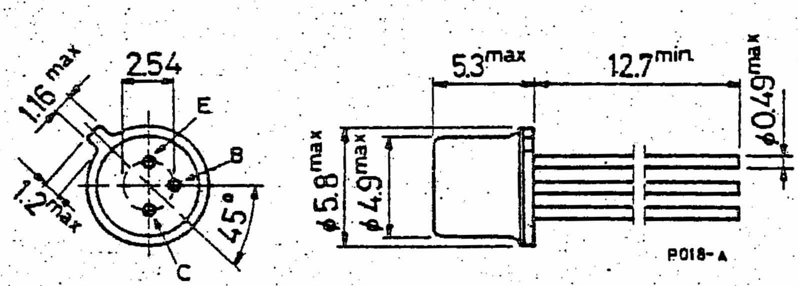
The BC 177, BC 178 and BC 179 are silicon planar epitaxial PNP transistors in TO-18 metal case. They are suitable for use in driver audio stages, low noise input audio stages and as low power, high gain general purpose transistors. The complementary NPN types are respectively the BC 107, BC 108, BC 109.

ABSOLUTE MAXIMUM RATINGS

		BC 177	BC 178	BC 179
V_{CBO}	Collector-base voltage ($I_E = 0$)	-50 V	-30 V	-25 V
→ V_{CES}	Collector-emitter voltage ($V_{BE} = 0$)	-45 V	-25 V	-20 V
V_{CEO}	Collector-emitter voltage ($I_B = 0$)	-45 V	-25 V	-20 V
V_{EBO}	Emitter-base voltage ($I_C = 0$)	-5 V		
→ I_{EM}	Emitter peak current	200 mA		
I_C	Collector current	-100 mA		
→ I_{CM}	Collector peak current	-200 mA		
P_{tot}	Total power dissipation at $T_{amb} \leq 25\,°C$	300 mW		
	at $T_{case} \leq 115\,°C$	300 mW		
T_{stg}	Storage temperature	-65 to 175 °C		
T_j	Junction temperature	175 °C		

MECHANICAL DATA

Dimensions in mm



(sim. to TO-18)

Supersedes issue dated 9/70

5/73

BC 177
BC 178
BC 179

THERMAL DATA

$R_{th\ j-case}$	Thermal resistance junction-case	max	200	°C/W
$R_{th\ j-amb}$	Thermal resistance junction-ambient	max	500	°C/W

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C unless otherwise specified)

	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector cutoff current (V_{BE} = 0)	V_{CE} = -20 V		-1	-100	nA
$V_{(BR)\ CEO}$	Collector-emitter breakdown voltage (I_B = 0)	I_C = -2 mA				
		for BC 177	-45			V
		for BC 178	-25			V
		for BC 179	-20			V
$V_{(BR)\ CES}$	Collector-emitter breakdown voltage (V_{BE} = 0)	I_C = -10 µA				
		for BC 177	-50			V
		for BC 178	-30			V
		for BC 179	-25			V
$V_{(BR)\ EBO}$	Emitter-base breakdown voltage (I_C = 0)	I_E = -10 µA	-5			V
$V_{CE\ (sat)}$	Collector-emitter saturation voltage	I_C = -10 mA, I_B = -0.5 mA		-75	-250	mV
		I_C = -100 mA, I_B = -5 mA		-200		mV
V_{BE}	Base-emitter voltage	I_C = -2 mA V_{CE} = -5 V	-600	-640	-750	mV
$V_{BE\ (sat)}$	Base-emitter saturation voltage	I_C = -10 mA, I_B = -0.5 mA		-720		mV
		I_C = -100 mA, I_B = -5 mA		-860		mV
h_{FE}	DC current gain	I_C = -10 µA V_{CE} = -5 V	30			—

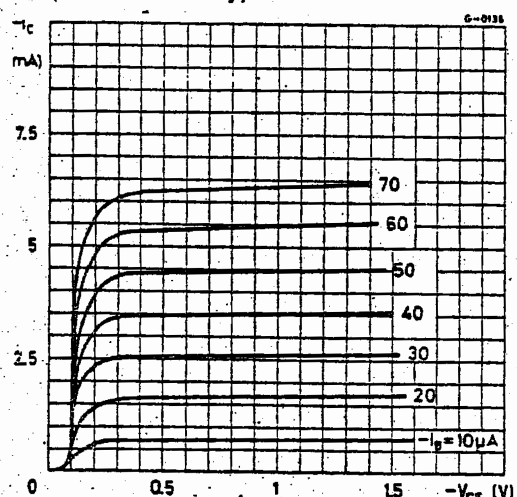
ELECTRICAL CHARACTERISTICS (continued)

	Parameter	Test conditions	Min.	Typ.	Max.	Unit
h_{fe}	Small signal current gain	I_C = -2 mA V_{CE} = -5 V; f = 1 kHz				
		for BC 177 Gr. 6	75		150	—
		for BC 177 Gr. A	125		260	—
		for BC 178 Gr. 6	75		150	—
		for BC 178 Gr. A	125		260	—
		for BC 178 Gr. B	240		500	—
		for BC 179 Gr. A	125		260	—
		for BC 179 Gr. B	240		500	—
f_T	Transition frequency	I_C = -10 mA V_{CE} = -5 V		200		MHz
C_{CBO}	Collector-base capacitance	I_E = 0 V_{CB} = -10 V		5.5		pF
NF	Noise figure	I_C = -0.2 mA V_{CE} = -5 V; R_g = 2 kΩ f = 1 kHz; B = 200 Hz				
		for BC 177		2	10	dB
		for BC 178		2	10	dB
		for BC 179		1.2	4	dB
h_{ie}	Input impedance	I_C = -2 mA V_{CE} = -5 V; f = 1 kHz				
		for BC 177 Gr. 6		1.5		kΩ
		for BC 177 Gr. A		2.7		kΩ
		for BC 178 Gr. 6		1.5		kΩ
		for BC 178 Gr. A		2.7		kΩ
		for BC 178 Gr. B		5.2		kΩ
		for BC 179 Gr. A		2.7		kΩ
		for BC 179 Gr. B		5.2		kΩ
h_{re}	Reverse voltage ratio	I_C = -2 mA V_{CE} = -5 V; f = 1 kHz				
		for BC 177 Gr. 6		1.8×10^{-4}		—
		for BC 177 Gr. A		2.7×10^{-4}		—
		for BC 178 Gr. 6		1.8×10^{-4}		—
		for BC 178 Gr. A		2.7×10^{-4}		—
		for BC 178 Gr. B		4.5×10^{-4}		—
		for BC 179 Gr. A		2.7×10^{-4}		—
		for BC 179 Gr. B		4.5×10^{-4}		—

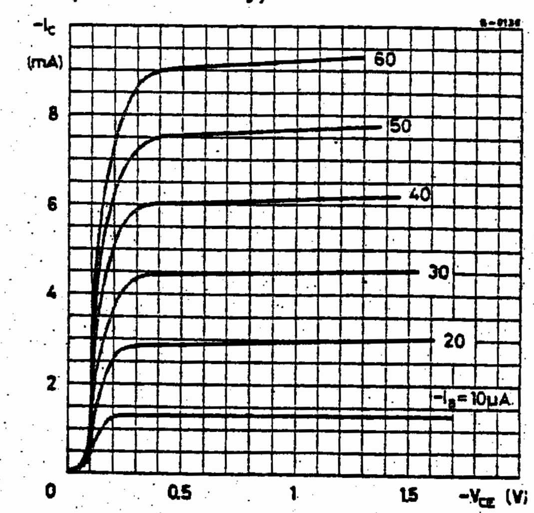
ELECTRICAL CHARACTERISTICS (continued)

Parameter		Test conditions	Min.	Typ.	Max.	Unit
h_{oe}	Output admittance	I_C = -2 mA V_{CE} = -5 V f. = 1 kHz				
		for BC 177 Gr. 6		20		µS
		for BC 177 Gr. A		25		µS
		for BC 178 Gr. 6		20		µS
		for BC 178 Gr. A		25		µS
		for BC 178 Gr. B		35		µS
		for BC 179 Gr. A		25		µS
		for BC 179 Gr. B		35		µS

Typical output characteristics
(for BC 177 only)

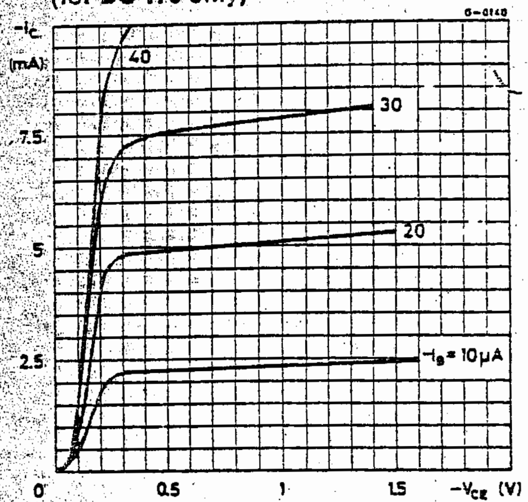


Typical output characteristics
(for BC 178 only)

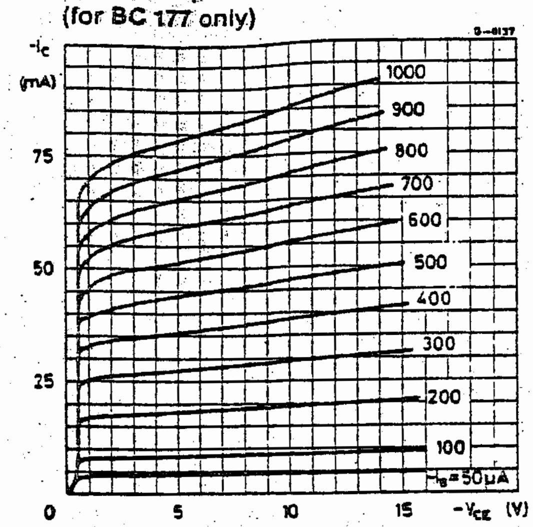


16

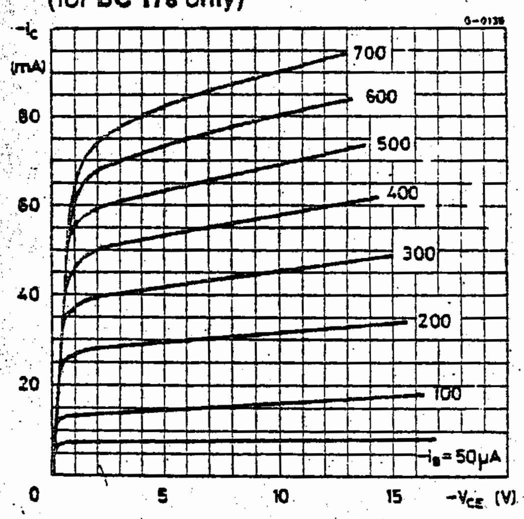
Typical output characteristics
(for BC 179 only)



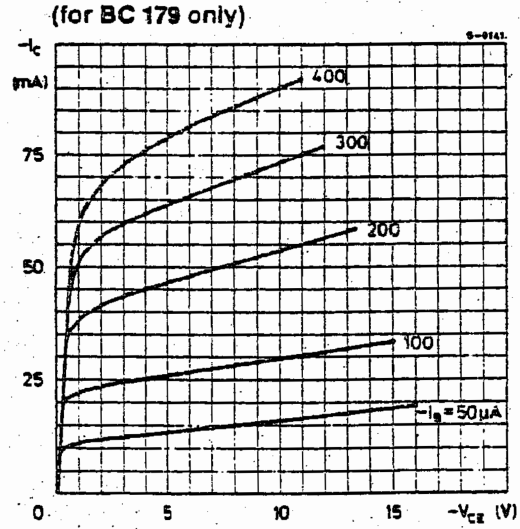
Typical output characteristics
(for BC 177 only)



Typical output characteristics
(for BC 178 only)

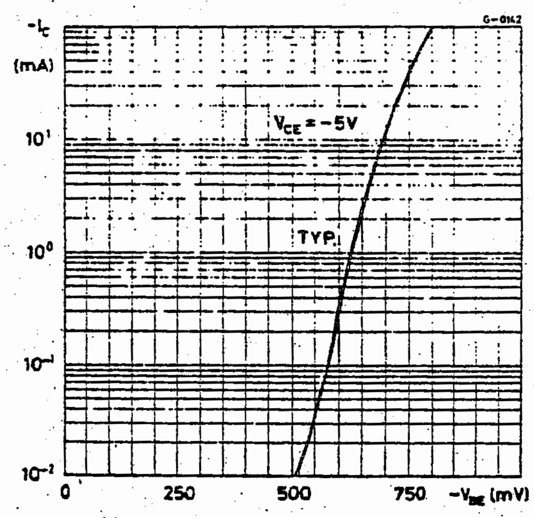


Typical output characteristics
(for BC 179 only)

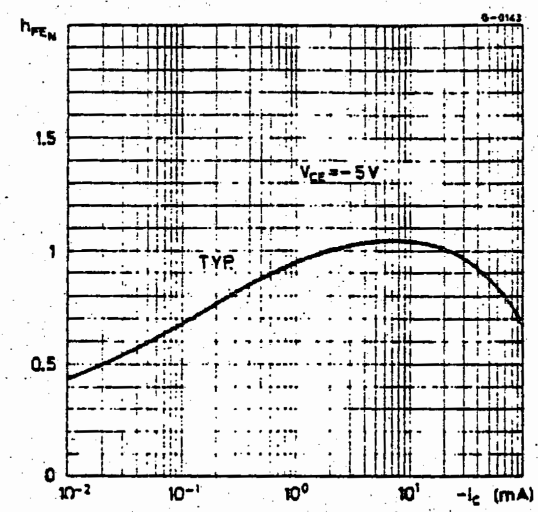


BC 177
BC 178
BC 179

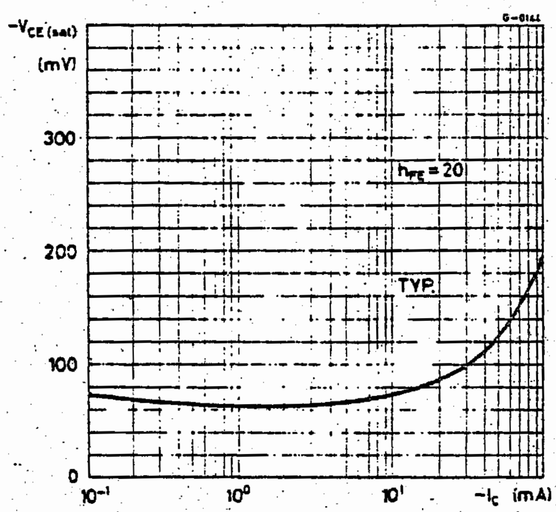
DC transconductance



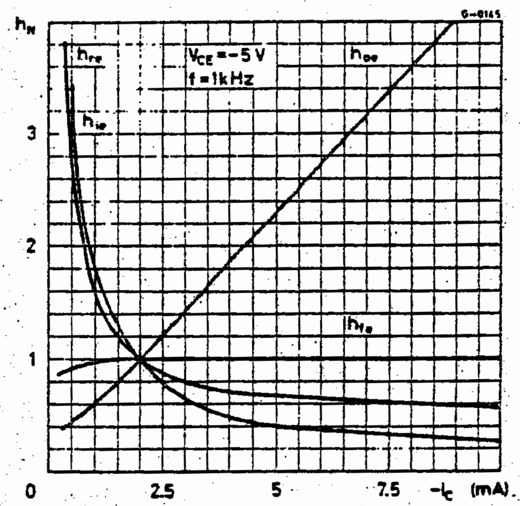
DC normalized current gain



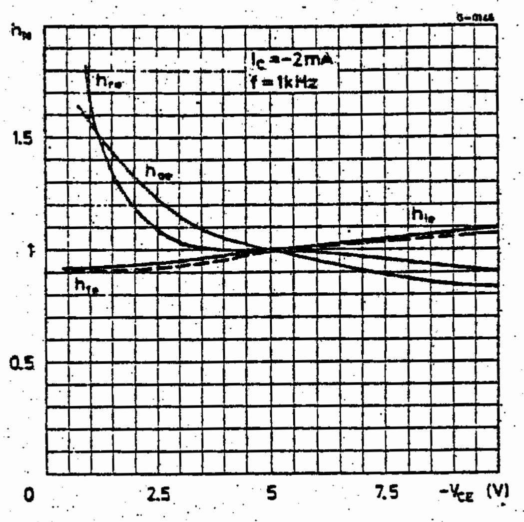
Collector-emitter saturation voltage



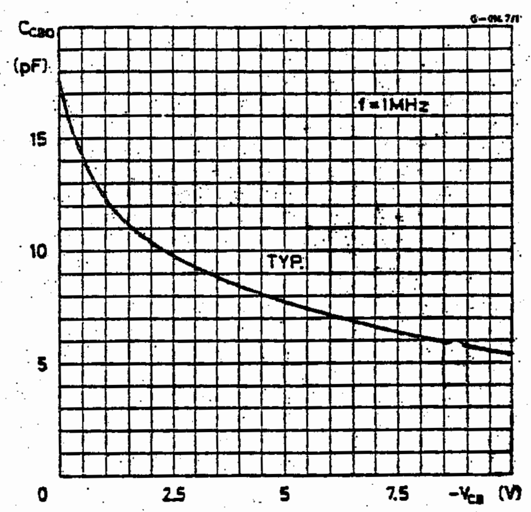
Typical normalized h parameters



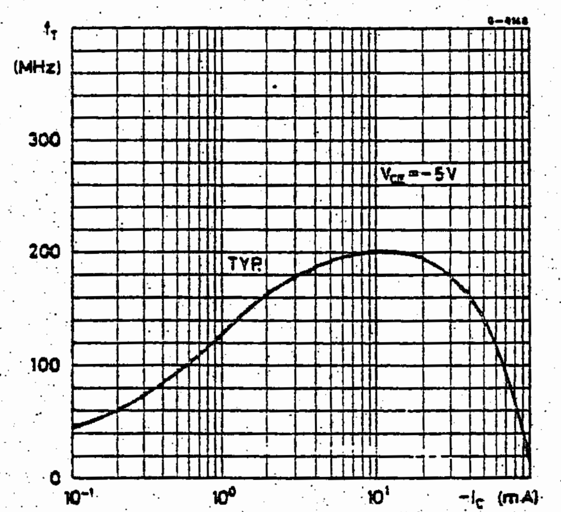
Typical normalized h parameters



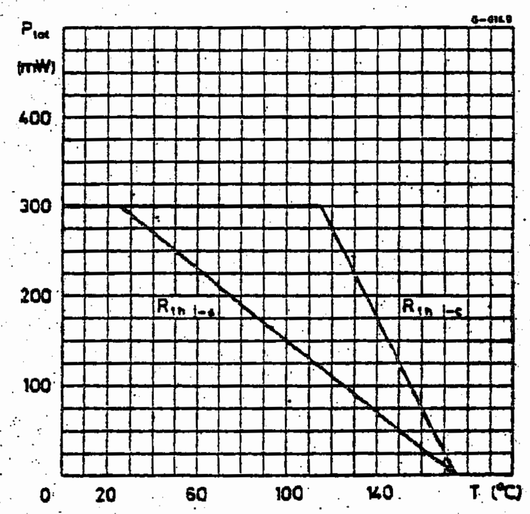
Collector-base capacitance



Transition frequency



Power rating chart



TEMIC

Siliconix

2N3819

N-Channel JFETs

Product Summary

$V_{GS(off)}$ (V)	$V_{(BR)GSS}$ Min (V)	g_{fs} Min (mS)	I_{DSS} Min (mA)
≤ −8	−25	2	2

Features

- Excellent High-Frequency Gain: Gps 11 dB @ 400 MHz
- Very Low Noise: 3 dB @ 400 MHz
- Very Low Distortion
- High ac/dc Switch Off-Isolation
- High Gain: A_V = 60 @ 100 μA

Benefits

- Wideband High Gain
- Very High System Sensitivity
- High Quality of Amplification
- High-Speed Switching Capability
- High Low-Level Signal Amplification

Applications

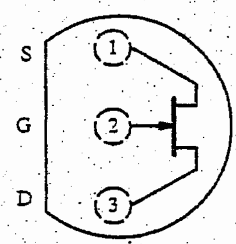
- High-Frequency Amplifier/Mixer
- Oscillator
- Sample-and-Hold
- Very Low Capacitance Switches

Description

The 2N3819 is a low-cost, all-purpose JFET which offers good performance at mid-to-high frequencies. It features low noise and leakage and guarantees high gain at 100 MHz.

Its TO-226AA (TO-92) package is compatible with various tape-and-reel options for automated assembly (see Packaging Information). For similar products in TO-206AF (TO-72) and TO-236 (SOT-23) packages, see the 2N4416/2N4416A/SST4416 data sheet.

TO-226AA
(TO-92)



Top View

Absolute Maximum Ratings

Gate-Source/Gate-Drain Voltage .... −25 V
Forward Gate Current .... 10 mA
Storage Temperature .... −55 to 150°C
Operating Junction Temperature .... −55 to 150°C

Lead Temperature (1/16" from case for 10 sec.) .... 300°C
Power Dissipation[a] .... 350 mW

Notes
a. Derate 2.8 mW/°C above 25°C

P-37407—Rev. B (07/04/94)

TEMIC
Siliconix

Specifications[a]

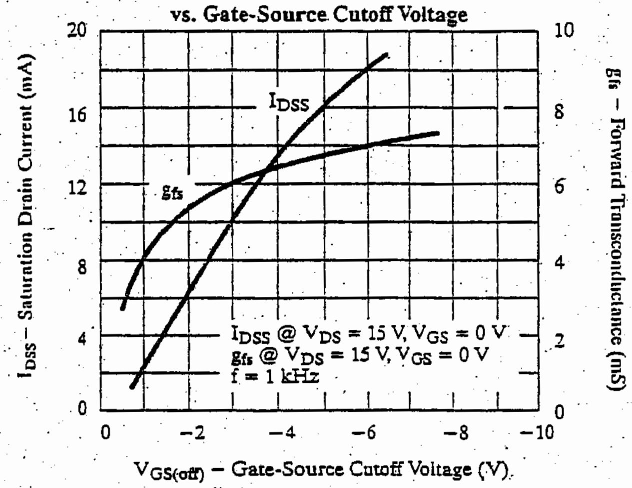
Parameter	Symbol	Test Conditions	Limits Min	Limits Typ[b]	Limits Max	Unit
Static						
Gate-Source Breakdown Voltage	$V_{(BR)GSS}$	$I_G = -1\ \mu A$, $V_{DS} = 0$ V	−25	−35		V
Gate-Source Cutoff Voltage	$V_{GS(off)}$	$V_{DS} = 15$ V, $I_D = 2$ nA		−3	−8	V
Saturation Drain Current[c]	I_{DSS}	$V_{DS} = 15$ V, $V_{GS} = 0$ V	2	10	20	mA
Gate Reverse Current	I_{GSS}	$V_{GS} = -15$ V, $V_{DS} = 0$ V		−0.002	−2	nA
		$T_A = 100°C$		−0.002	−2	µA
Gate Operating Current[d]	I_G	$V_{DG} = 10$ V, $I_D = 1$ mA		−20		pA
Drain Cutoff Current	$I_{D(off)}$	$V_{DS} = 10$ V, $V_{GS} = -8$ V		2		pA
Drain-Source On-Resistance	$r_{DS(on)}$	$V_{GS} = 0$ V, $I_D = 1$ mA		150		Ω
Gate-Source Voltage	V_{GS}	$V_{DS} = 15$ V, $I_D = 200\ \mu A$	−0.5	−2.5	−7.5	V
Gate-Source Forward Voltage	$V_{GS(F)}$	$I_G = 1$ mA, $V_{DS} = 0$ V		0.7		V
Dynamic						
Common-Source Forward Transconductance[d]	g_{fs}	$V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1 kHz	2	5.5	6.5	mS
		$V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 100 MHz	1.6	5.5		mS
Common-Source Output Conductance[d]	g_{os}	$V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1 kHz		15	50	µS
Common-Source Input Capacitance	C_{iss}	$V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1 MHz		2.2	8	pF
Common-Source Reverse Transfer Capacitance	C_{rss}	$V_{DS} = 15$ V, $V_{GS} = 0$ V, f = 1 MHz		0.7	4	pF
Equivalent Input Noise Voltage[d]	$\bar{e}_n$	$V_{DS} = 10$ V, $V_{GS} = 0$ V, f = 100 Hz		6		nV/√Hz

Notes
a. $T_A = 25°C$ unless otherwise noted.
b. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
c. Pulse test: PW ≤300 µs, duty cycle ≤2%.
d. This parameter not registered with JEDEC.

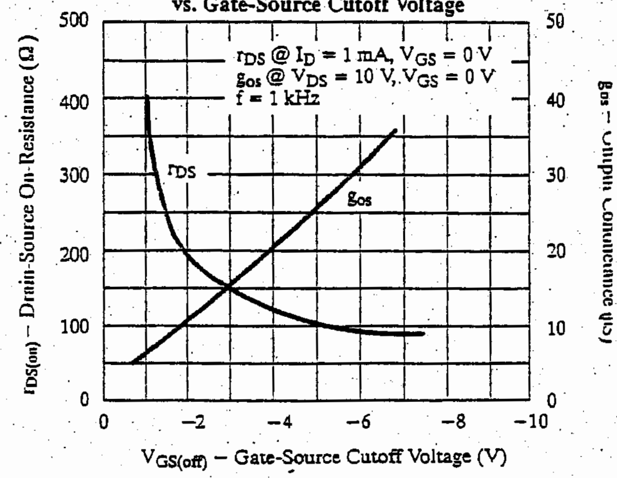
NH

Typical Characteristics

Drain Current and Transconductance vs. Gate-Source Cutoff Voltage

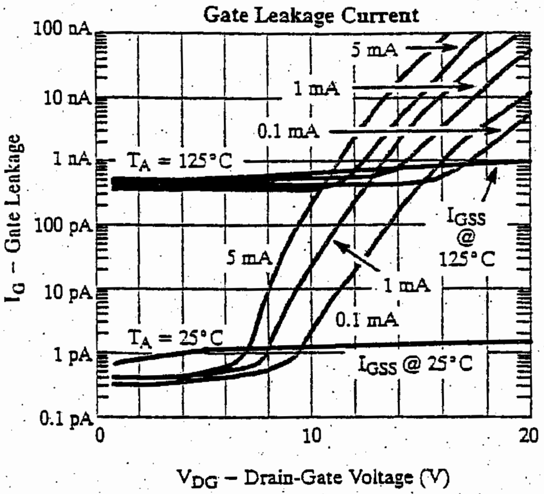


On-Resistance and Output Conductance vs. Gate-Source Cutoff Voltage

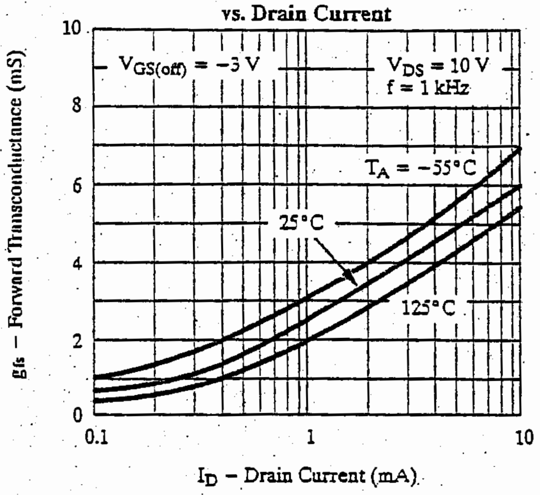


Typical Characteristics (Cont'd)

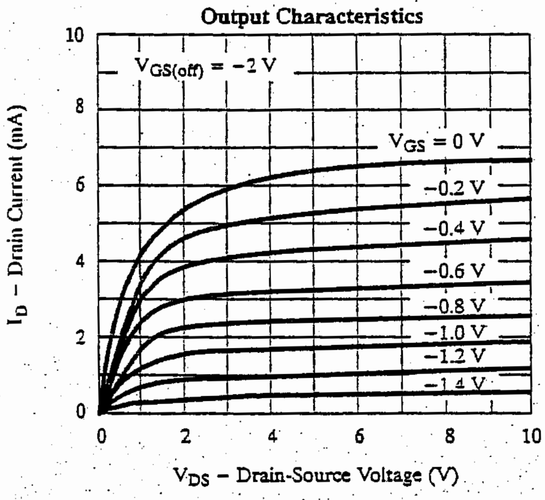
Gate Leakage Current



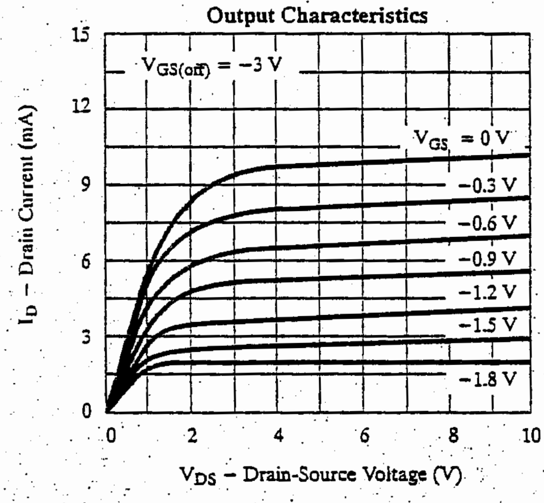
Common-Source Forward Transconductance vs. Drain Current



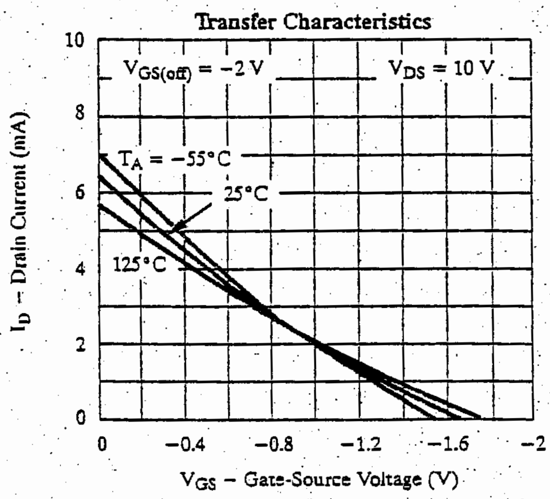
Output Characteristics



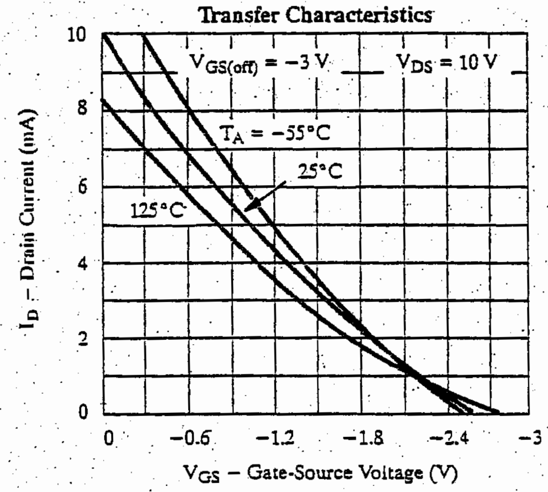
Output Characteristics



Transfer Characteristics



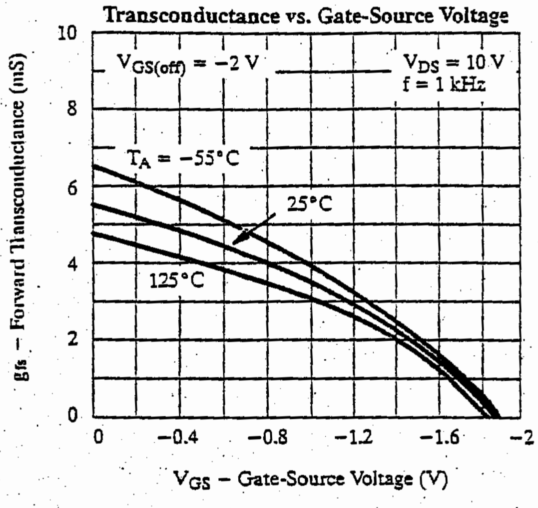
Transfer Characteristics



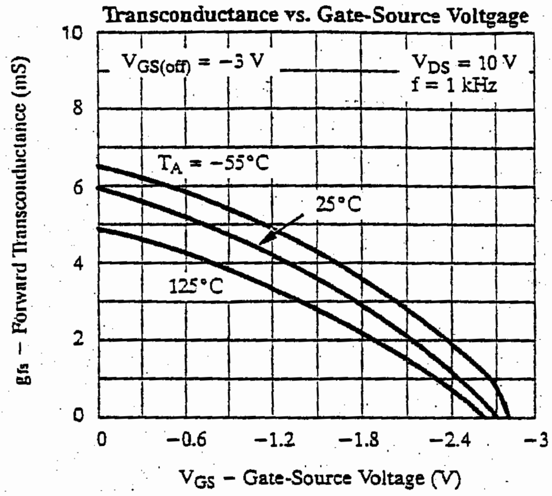
2N3819

Typical Characteristics (Cont'd)

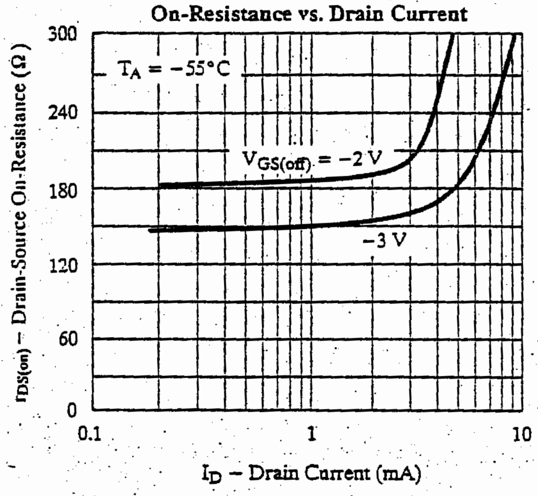
Transconductance vs. Gate-Source Voltage



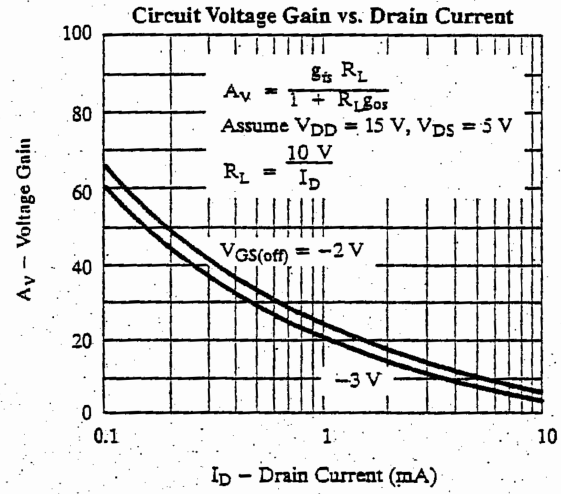
Transconductance vs. Gate-Source Voltgage



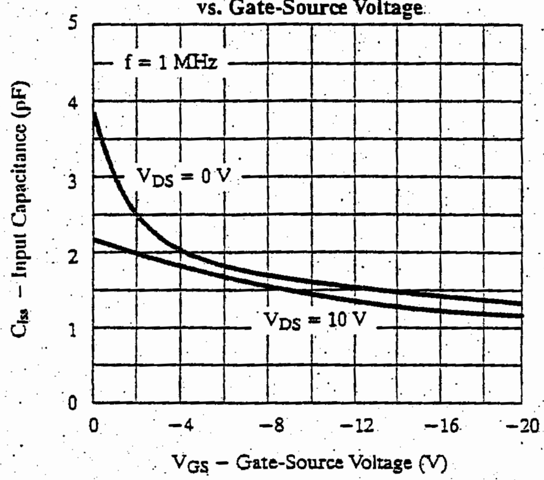
On-Resistance vs. Drain Current



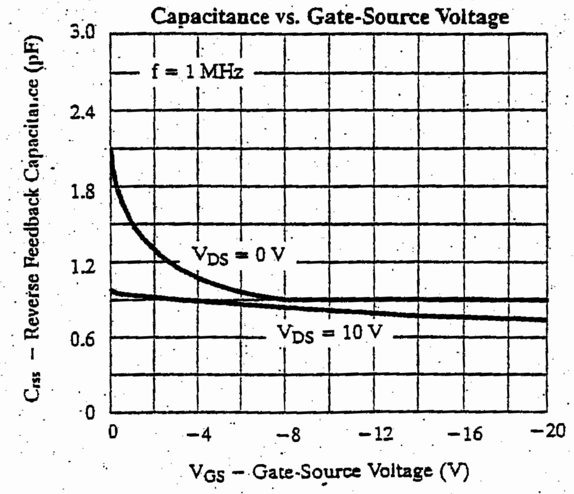
Circuit Voltage Gain vs. Drain Current



Common-Source Input Capacitance vs. Gate-Source Voltage

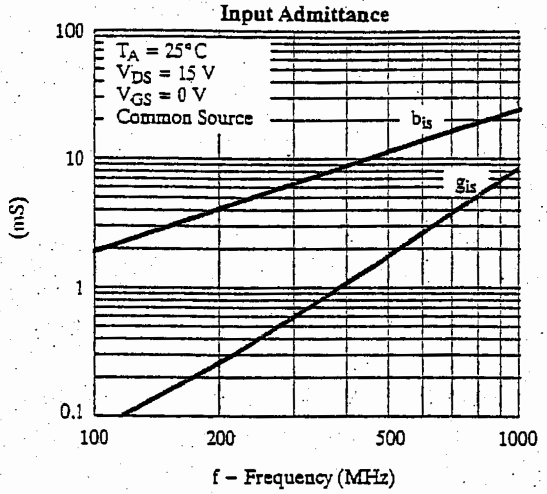


Common-Source Reverse Feedback Capacitance vs. Gate-Source Voltage

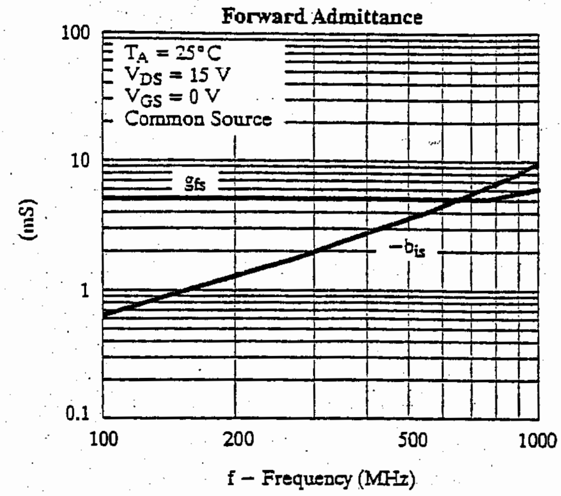


Typical Characteristics (Cont'd)

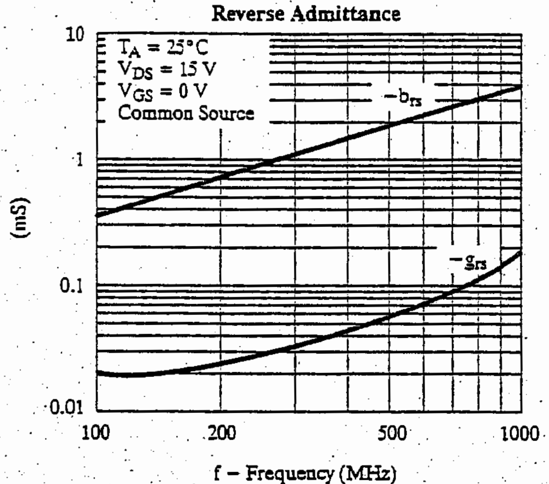
Input Admittance



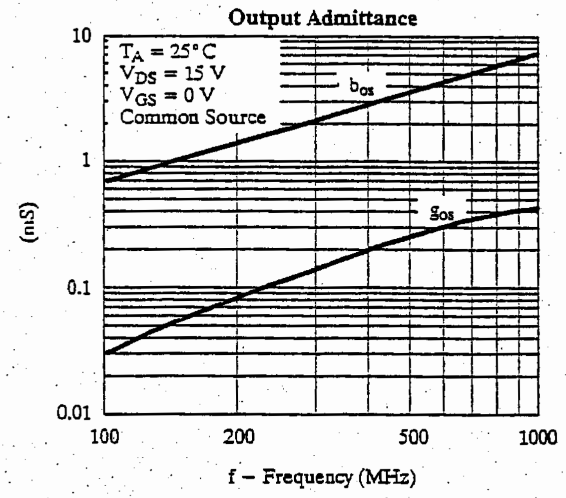
Forward Admittance



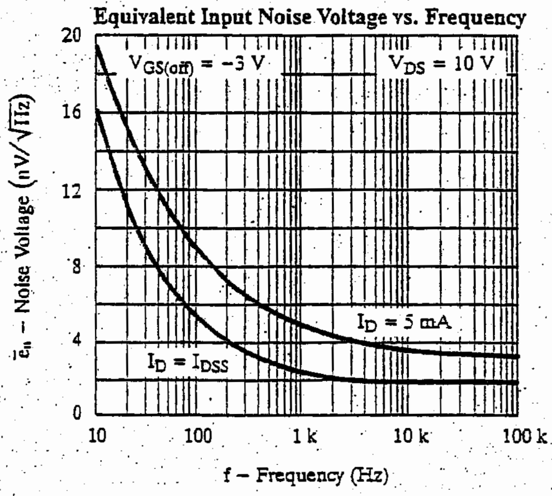
Reverse Admittance



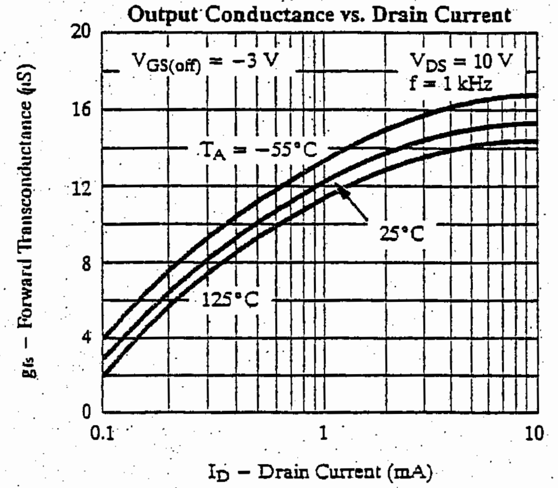
Output Admittance



Equivalent Input Noise Voltage vs. Frequency



Output Conductance vs. Drain Current



N-Channel 60-V (D-S) MOSFET

PRODUCT SUMMARY				
Part Number	$V_{(BR)DSS}$ Min (V)	$r_{DS(on)}$ Max (Ω)	$V_{GS(th)}$ (V)	I_D (A)
2N7000	60	5 @ V_{GS} = 10 V	0.8 to 3	0.2
2N7002		7.5 @ V_{GS} = 10 V	1 to 2.5	0.115
VQ1000J		5.5 @ V_{GS} = 10 V	0.8 to 2.5	0.225
VQ1000P		5.5 @ V_{GS} = 10 V	0.8 to 2.5	0.225
BS170		5 @ V_{GS} = 10 V	0.8 to 3	0.5

FEATURES

- Low On-Resistance: 2.5 Ω
- Low Threshold: 2.1 V
- Low Input Capacitance: 22 pF
- Fast Switching Speed: 7 ns
- Low Input and Output Leakage

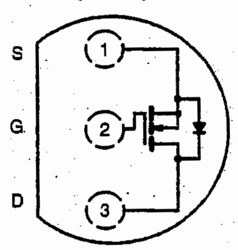
BENEFITS

- Low Offset Voltage
- Low-Voltage Operation
- Easily Driven Without Buffer
- High-Speed Circuits
- Low Error Voltage

APPLICATIONS

- Direct Logic-Level Interface: TTL/CMOS
- Drivers: Relays, Solenoids, Lamps, Hammers, Displays, Memories, Transistors, etc.
- Battery Operated Systems
- Solid-State Relays

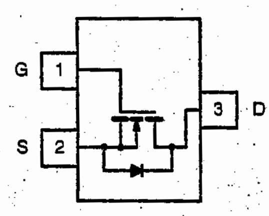
TO-226AA (TO-92)



Top View

2N7000

TO-236 (SOT-23)

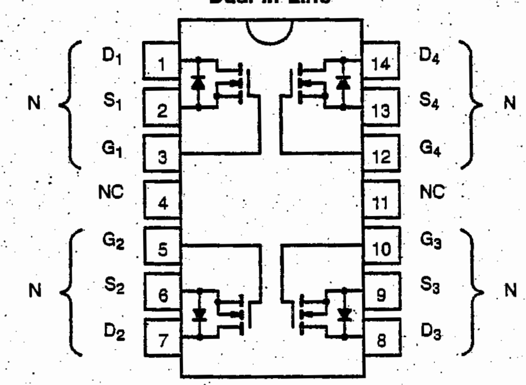


Top View

Marking Code: 72*wll*

72 = Part Number Code for 2N7002
w = Week Code
ll = Lot Traceability

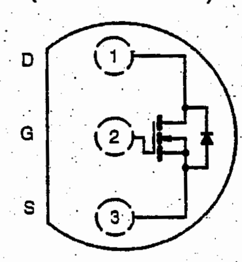
Dual-In-Line



Top View

Plastic: VQ1000J
Sidebraze: VQ1000P

TO-92-18RM (TO-18 Lead Form)



Top View

BS170

VISHAY

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C UNLESS OTHERWISE NOTED)

Parameter		Symbol	2N7000	2N7002	Single VQ1000J	Single VQ1000P	Total Quad VQ1000J/P	BS170	Unit
Drain-Source Voltage		V_{DS}	60	60	60	60		60	V
Gate-Source Voltage—Non-Repetitive		V_{GSM}	±40	±40	±30			±25	V
Gate-Source Voltage—Continuous		V_{GS}	±20	±20	±20	±20		±20	V
Continuous Drain Current (T_J = 150°C)	T_A= 25°C	I_D	0.2	0.115	0.225	0.225		0.5	A
	T_A= 100°C		0.13	0.073	0.14	0.14		0.175	A
Pulsed Drain Current[a]		I_{DM}	0.5	0.8	1	1			A
Power Dissipation	T_A= 25°C	P_D	0.4	0.2	1.3	1.3	2	0.83	W
	T_A= 100°C		0.16	0.08	0.52	0.52	0.8		W
Thermal Resistance, Junction-to-Ambient		R_{thJA}	312.5	625	96	96	62.5	156	°C/W
Operating Junction and Storage Temperature Range		T_J, T_{stg}	–55 to 150						°C

Notes
a. Pulse width limited by maximum junction temperature.
b. $t_p \leq 50$ µs.

SPECIFICATIONS—2N7000 AND 2N7002 (T_A = 25°C UNLESS OTHERWISE NOTED)

Parameter	Symbol	Test Conditions		Typ[a]	Limits 2N7000 Min	2N7000 Max	2N7002 Min	2N7002 Max	Unit
Static									
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	V_{GS} = 0 V, I_D = 10 µA		70	60		60		V
Gate-Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 1 mA		2.1	0.8	3			V
		V_{DS} = V_{GS}, I_D = 0.25 mA		2.0			1	2.5	V
Gate-Body Leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ±15 V				±10			nA
		V_{DS} = 0 V, V_{GS} = ±20 V						±100	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 48 V, V_{GS} = 0 V				1			µA
			T_C = 125°C			1000			µA
		V_{DS} = 60 V, V_{GS} = 0 V						1	µA
			T_C = 125°C					500	µA
On-State Drain Current[b]	$I_{D(on)}$	V_{DS} = 10 V, V_{GS} = 4.5 V		0.35	0.075				A
		V_{DS} = 7.5 V, V_{GS} = 10 V		1			0.5		A
Drain-Source On-Resistance[b]	$r_{DS(on)}$	V_{GS} = 4.5 V, I_D = 0.075 A		4.5		5.3			Ω
		V_{GS} = 5 V, I_D = 0.05 A		3.2				7.5	Ω
			T_C = 125°C	5.8				13.5	Ω
		V_{GS} = 10 V, I_D = 0.5 A		2.4		5		7.5	Ω
			T_J = 125°C	4.4		9		13.5	Ω
Forward Transconductance[b]	g_{fs}	V_{DS} = 10 V, I_D = 0.2 A			100		80		mS
Common Source Output Conductance[b]	g_{os}	V_{DS} = 5 V, I_D = 0.05 A		0.5					mS
Dynamic									
Input Capacitance	C_{iss}	V_{DS} = 25 V, V_{GS} = 0 V, f = 1 MHz		22		60		50	pF
Output Capacitance	C_{oss}			11		25		25	pF
Reverse Transfer Capacitance	C_{rss}			2		5		5	pF

g_m $\frac{1}{r_d}$ C_{gs} C_{ds} C_{gd}

$$\beta_n = \frac{g_m^2}{2 I_D} = 0.025\ A/V^2$$

$$\lambda^{-1} = r_d I_D = 100\ V$$

$$r_d = 2\ k\Omega$$

SPECIFICATIONS—2N7000 AND 2N7002 (T_A = 25°C UNLESS OTHERWISE NOTED)								
				Limits				
				2N7000		2N7002		
Parameter	Symbol	Test Conditions	Typ[a]	Min	Max	Min	Max	Unit
Switching[d]								
Turn-On Time	t_{ON}	V_{DD} = 15 V, R_L = 25 Ω I_D ≅ 0.5 A, V_{GEN} = 10 V, R_G = 25 Ω	7		10			ns
Turn-Off Time	t_{OFF}		7		10			
Turn-On Time	t_{ON}	V_{DD} = 30 V, R_L = 150 Ω I_D ≅ 0.2 A, V_{GEN} = 10 V, R_G = 25 Ω	7				20	
Turn-Off Time	t_{OFF}		11				20	

SPECIFICATIONS—VQ1000J/P AND BS170 (T_A = 25°C UNLESS OTHERWISE NOTED)								
				Limits				
				VQ1000J/P		BS170		
Parameter	Symbol	Test Conditions	Typ[a]	Min	Max	Min	Max	Unit
Static								
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	V_{GS} = 0 V, I_D = 100 µA	70	60		60		V
Gate-Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 1 mA	2.1	0.8	2.5	0.8	3	V
Gate-Body Leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ±10 V			±100			nA
		T_J = 125°C			±500			
		V_{DS} = 0 V, V_{GS} = ±15 V					±10	
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 25 V, V_{GS} = 0 V					0.5	µA
		V_{DS} = 48 V, V_{GS} = 0 V, T_J = 125°C			500			
		V_{DS} = 60 V, V_{GS} = 0 V			10			
On-State Drain Current[b]	$I_{D(on)}$	V_{DS} = 10 V, V_{GS} = 10 V	1	0.5				A
Drain-Source On-Resistance[b]	$r_{DS(on)}$	V_{GS} = 5 V, I_D = 0.2 A	4		7.5			Ω
		V_{GS} = 10 V, I_D = 0.2 A	2.3				5	
		V_{GS} = 10 V, I_D = 0.3 A	2.3		5.5			
		T_J = 125°C	4.2		7.6			
Forward Transconductance[b]	g_{fs}	V_{DS} = 10 V, I_D = 0.2 A				100		mS
		V_{DS} = 10 V, I_D = 0.5 A		100				
Common Source Output Conductance[b]	g_{os}	V_{DS} = 5 V, I_D = 0.05 A	0.5					
Dynamic								
Input Capacitance	C_{iss}	V_{DS} = 25 V, V_{GS} = 0 V f = 1 MHz	22		60		60	pF
Output Capacitance	C_{oss}		11		25			
Reverse Transfer Capacitance	C_{rss}		2		5			
Switching[d]								
Turn-On Time	t_{ON}	V_{DD} = 15 V, R_L = 23 Ω I_D ≅ 0.6 A, V_{GEN} = 10 V, R_G = 25 Ω	7		10			ns
Turn-Off Time	t_{OFF}		7		10			
Turn-On Time	t_{ON}	V_{DD} = 25 V, R_L = 125 Ω I_D ≅ 0.2 A, V_{GEN} = 10 V, R_G = 25 Ω	7				10	
Turn-Off Time	t_{OFF}		7				10	

Notes
a. For DESIGN AID ONLY, not subject to production testing.
b. Pulse test: PW ≤80 µs duty cycle ≤1%.
c. This parameter not registered with JEDEC.
d. Switching time is essentially independent of operating temperature.

VNBF06

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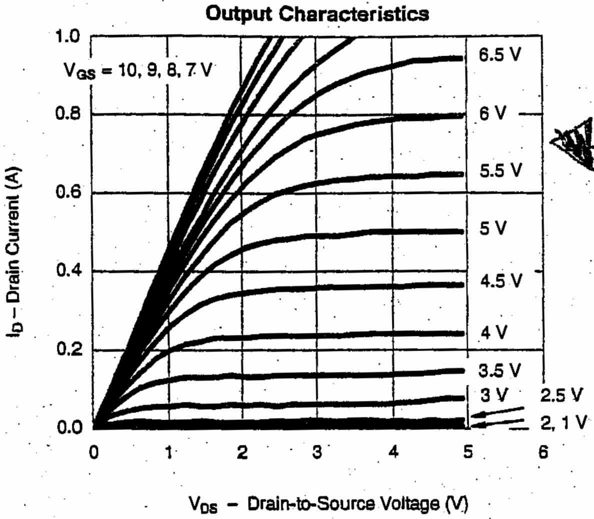
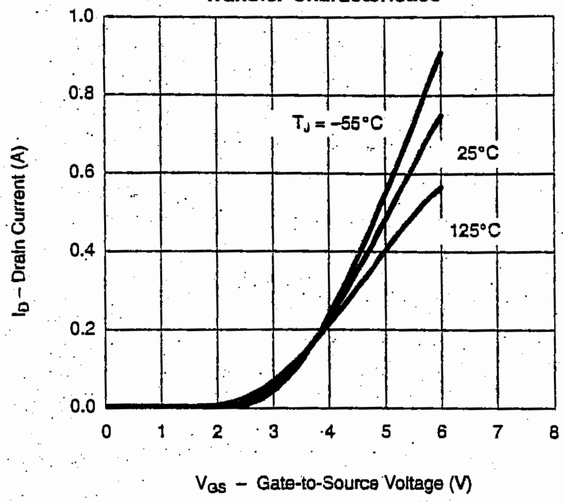
TYPICAL CHARACTERISTICS (T_A = 25°C UNLESS OTHERWISE NOTED)

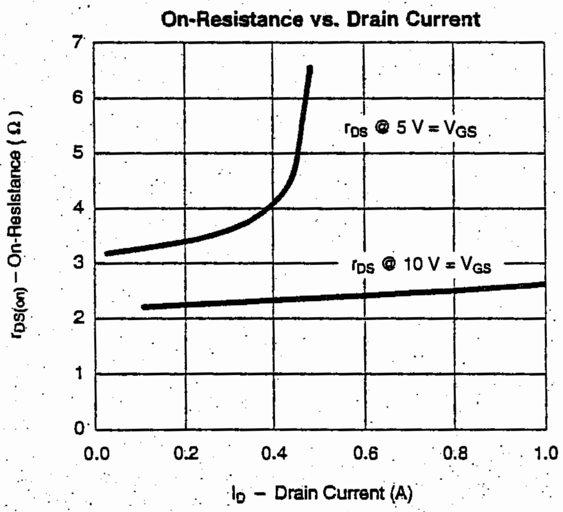
Output Characteristics



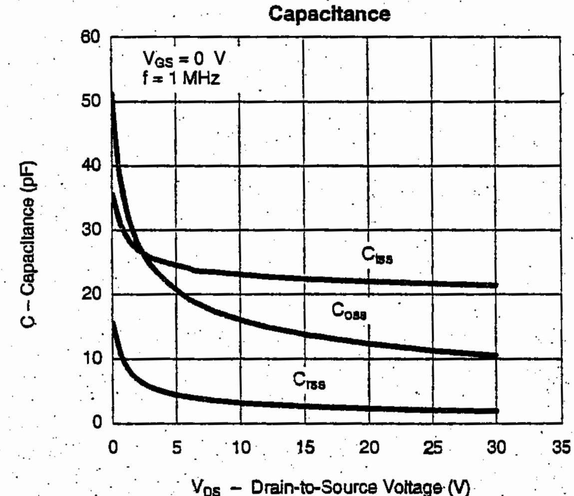
Transfer Characteristics



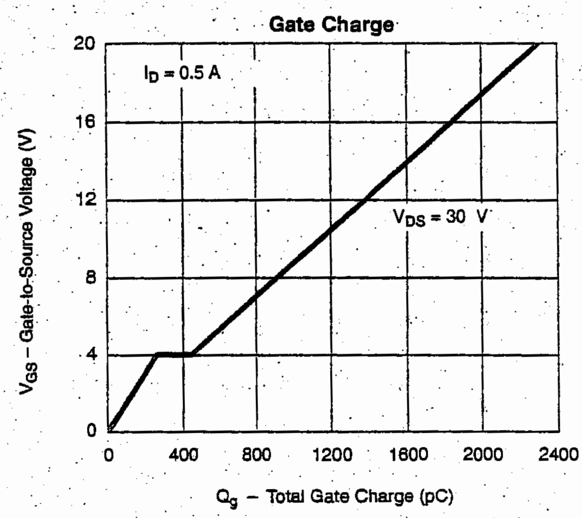
On-Resistance vs. Drain Current



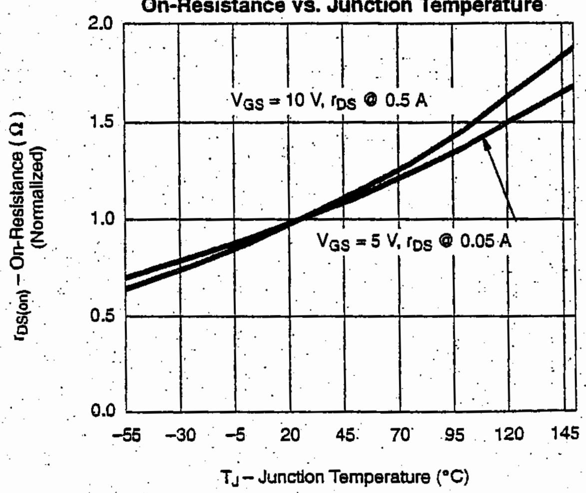
Capacitance



Gate Charge

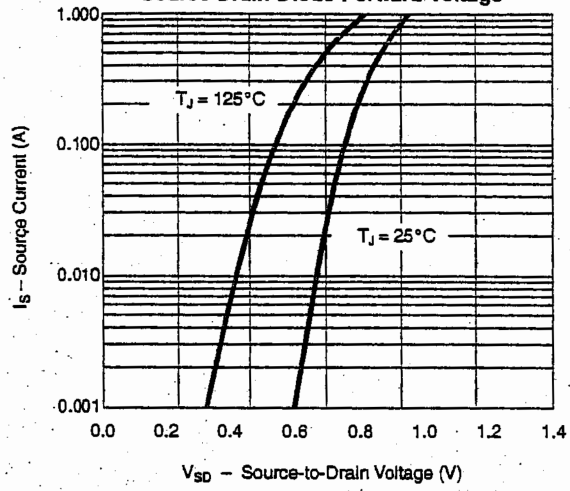


On-Resistance vs. Junction Temperature

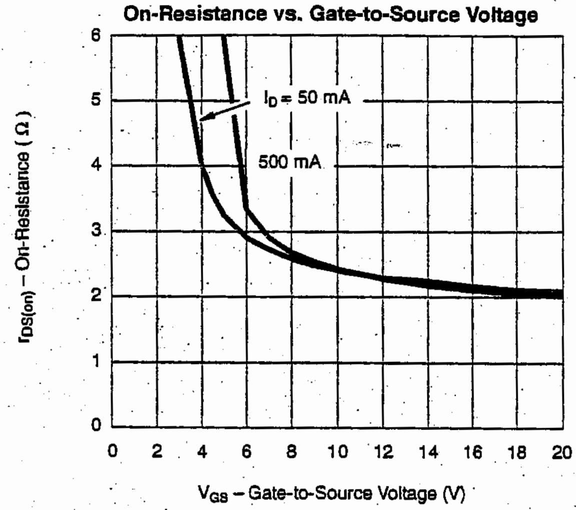


TYPICAL CHARACTERISTICS (T_A = 25°C UNLESS OTHERWISE NOTED)

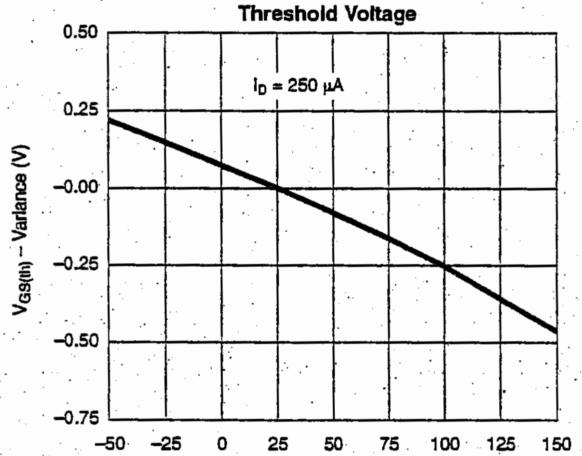
Source-Drain Diode Forward Voltage



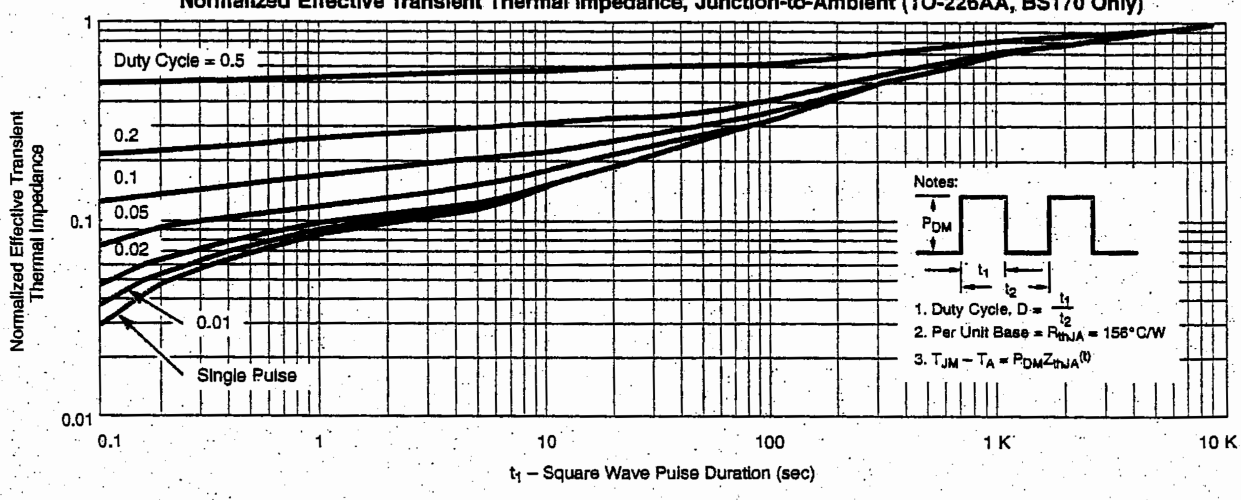
On-Resistance vs. Gate-to-Source Voltage



Threshold Voltage



Normalized Effective Transient Thermal Impedance, Junction-to-Ambient (TO-226AA, BS170 Only)



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P-Channel 60-V (D-S) MOSFET

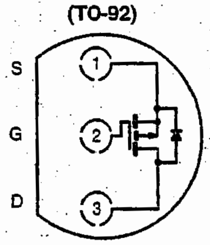
PRODUCT SUMMARY				
Part Number	$V_{(BR)DSS}$ Min (V)	$r_{DS(on)}$ Max (Ω)	$V_{GS(th)}$ (V)	I_D (A)
TP0610L	−60	10 @ V_{GS} = −10 V	−1 to −2.4	−0.18
TP0610T	−60	10 @ V_{GS} = −10 V	−1 to −2.4	−0.12
VP0610L	−60	10 @ V_{GS} = −10 V	−1 to −3.5	−0.18
VP0610T	−60	10 @ V_{GS} = −10 V	−1 to −3.5	−0.12
BS250	−60	10 @ V_{GS} = −10 V	−1 to −3.5	−0.18

FEATURES
- High-Side Switching
- Low On-Resistance: 8 Ω
- Low Threshold: −1.9 V
- Fast Switching Speed: 16 ns
- Low Input Capacitance: 15 pF

BENEFITS
- Ease in Driving Switches
- Low Offset (Error) Voltage
- Low-Voltage Operation
- High-Speed Switching
- Easily Driven Without Buffer

APPLICATIONS
- Drivers: Relays, Solenoids, Lamps, Hammers, Displays, Memories, Transistors, etc.
- Battery Operated Systems
- Power Supply, Converter Circuits
- Motor Control

TO-226AA (TO-92)



Top View

TP0610L
VP0610L

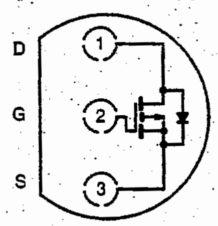
Device Marking Front View

TP0610L: "S" TP 0610L xxll

VP0610L: "S" VP 0610L xxll

"S" = Siliconix Logo
xxll = Date Code

TO-92-18RM (TO-18 Lead Form)



Top View

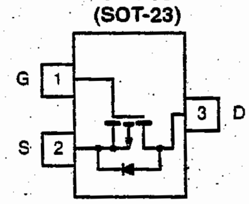
BS250

Device Marking Front View

BS250: "S" BS 250 xxll

"S" = Siliconix Logo
xxll = Date Code

TO-236 (SOT-23)



Top View

TP0610T
VP0610T

Marking Code:
TP0610T: TO*wll*
VP0610T: VO*wll*
w = Week Code
ll = Lot Traceability

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C UNLESS OTHERWISE NOTED)								
Parameter		Symbol	TP0610L	TP0610T	VP0610L	VP0610T	BS250	Unit
Drain-Source Voltage		V_{DS}	−60	−60	−60	−60	−60	V
Gate-Source Voltage		V_{GS}	±20	±20	±20	±20	±20	
Continuous Drain Current (T_J = 150°C)	T_A = 25°C	I_D	−0.18	−0.12	−0.18	−0.12	−0.18	A
	T_A = 100°C		−0.11	−0.07	−0.11	−0.07		
Pulsed Drain Current[a]		I_{DM}	−0.8	−0.4	−0.8	−0.4		
Power Dissipation	T_A = 25°C	P_D	0.8	0.36	0.8	0.36	0.83	W
	T_A = 100°C		0.32	0.14	0.32	0.14		
Thermal Resistance, Junction-to-Ambient		R_{thJA}	156	350	156	350	150	°C/W
Operating Junction and Storage Temperature Range		T_J, T_{stg}	−55 to 150					°C

Notes
a. Pulse width limited by maximum junction temperature.
For applications information see AN804.

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VISHAY

SPECIFICATIONS (T_A = 25°C UNLESS OTHERWISE NOTED)

Parameter	Symbol	Test Conditions	Typ[a]	Limits TP0610L/T Min	TP0610L/T Max	VP0610L/T Min	VP0610L/T Max	BS250 Min	BS250 Max	Unit
Static										
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	V_{GS} = 0 V, I_D = −10 µA		−60		−60				V
		V_{GS} = 0 V, I_D = −100 µA						−60		
Gate-Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = −250 µA		−1	−2.4	−1	−3.5	−1	−3.5	
Gate-Body Leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ±10 V			±200		±200			nA
		V_{DS} = 0 V, V_{GS} = ±10 V, T_J = 125°C			±500					
		V_{DS} = 0 V, V_{GS} = ±5 V							±100	
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = −48 V, V_{GS} = 0 V			−1		−1			µA
		V_{DS} = −48 V, V_{GS} = 0 V, T_J = 125°C			−200		−200			
		V_{DS} = −25 V, V_{GS} = 0 V							−0.5	
On-State Drain Current[b]	$I_{D(on)}$	V_{DS} = −10 V, V_{GS} = −4.5 V		−50						mA
		V_{DS} = −10 V, V_{GS} = −10 V	−600			−600				
Drain-Source On-Resistance[b]	$r_{DS(on)}$	V_{GS} = −4.5 V, I_D = −25 mA			25					Ω
		V_{GS} = −10 V, I_D = −0.5 A			10		10			
		V_{GS} = −10 V, I_D = −0.5 A, T_J = 125°C			20		20			
		V_{GS} = −10 V, I_D = −0.2 A			10		10		14	
Forward Transconductance[b]	g_{fs}	V_{DS} = −10 V, I_D = −0.5 A	20	80						mS
Diode Forward Voltage	V_{SD}	I_S = −0.5 A, V_{GS} = 0 V	−1.1		−1.4					V
Dynamic										
Input Capacitance	C_{iss}	V_{DS} = −25 V, V_{GS} = 0 V, f = 1 MHz	23		60		60			pF
Output Capacitance	C_{oss}		10		25		25			
Reverse Transfer Capacitance	C_{rss}		5		5		5			
Switching[c]										
Turn-On Time	t_{ON}	V_{DD} = −25 V, R_L = 133 Ω, I_D ≅ −0.18 A, V_{GEN} = −10 V, R_G = 25 Ω	20							ns
Turn-Off Time	t_{OFF}		35							

Notes
a. For DESIGN AID ONLY, not subject to production testing.
b. Pulse test: PW ≤300 µs duty cycle ≤2%.
c. Switching time is essentially independent of operating temperature.

VPDS06

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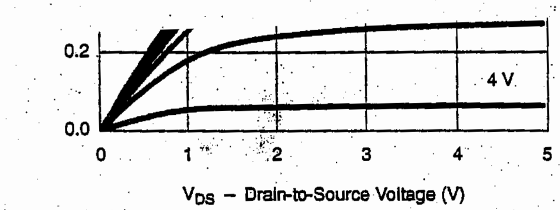
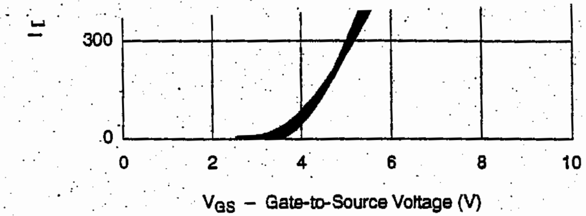
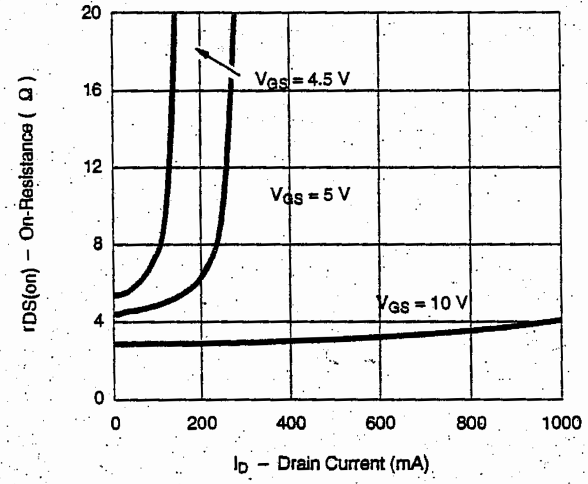
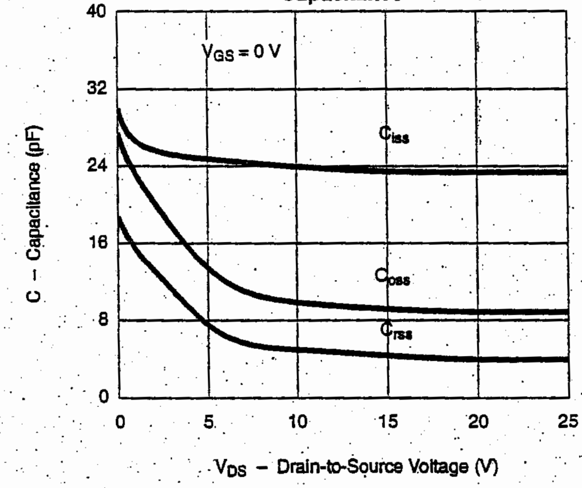




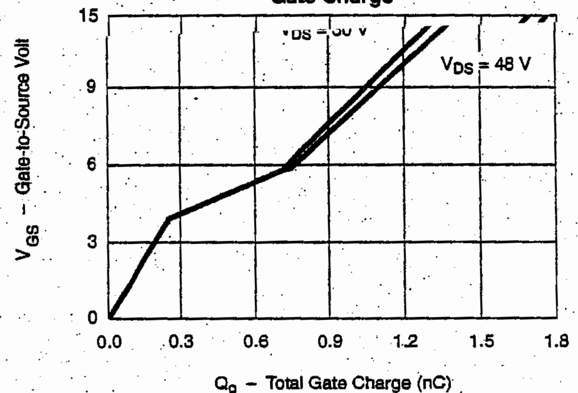
On-Resistance vs. Drain Current



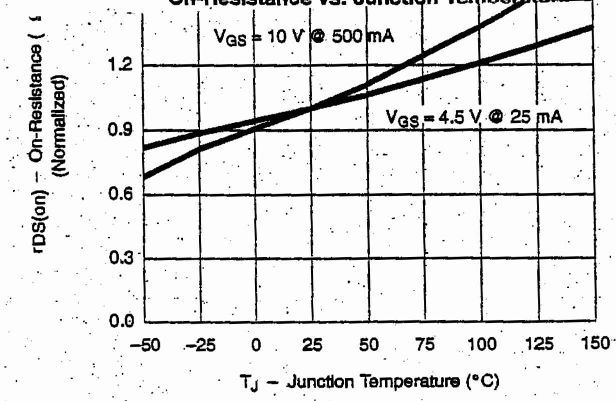
Capacitance



Gate Charge

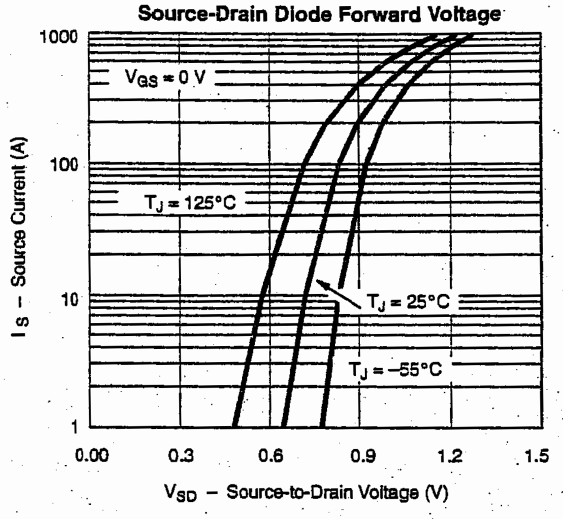


On-Resistance vs. Junction Temperature

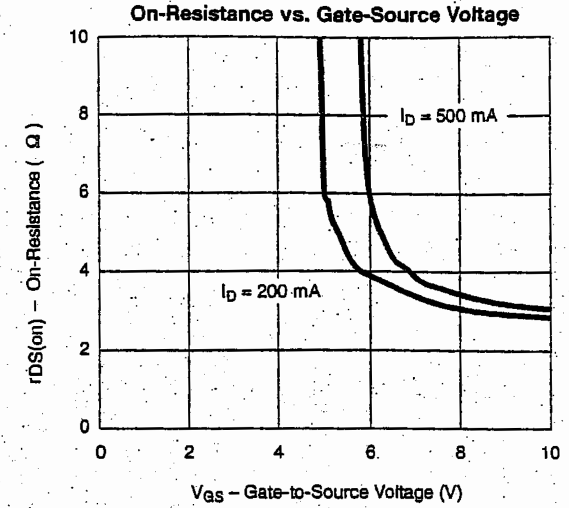


TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)

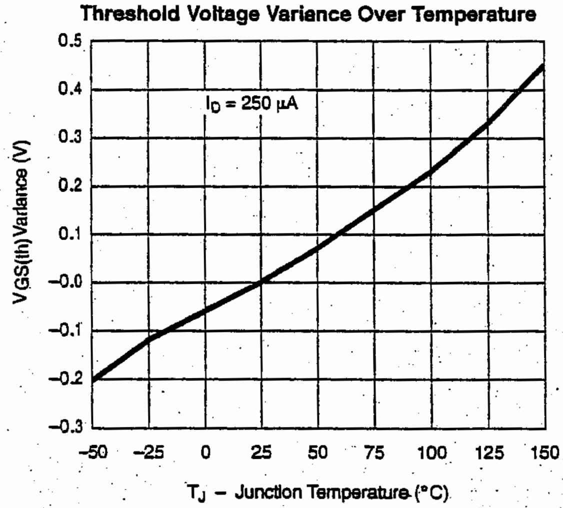
Source-Drain Diode Forward Voltage



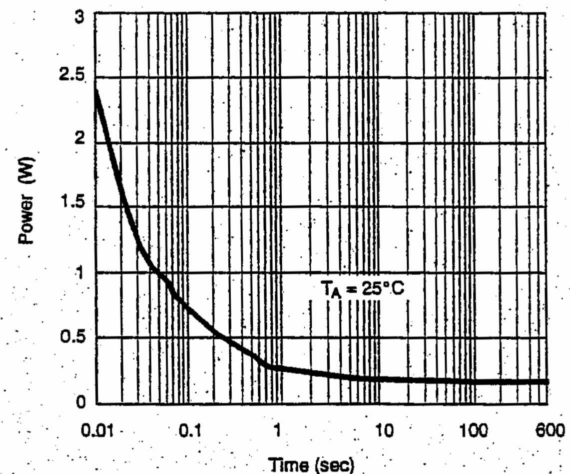
On-Resistance vs. Gate-Source Voltage



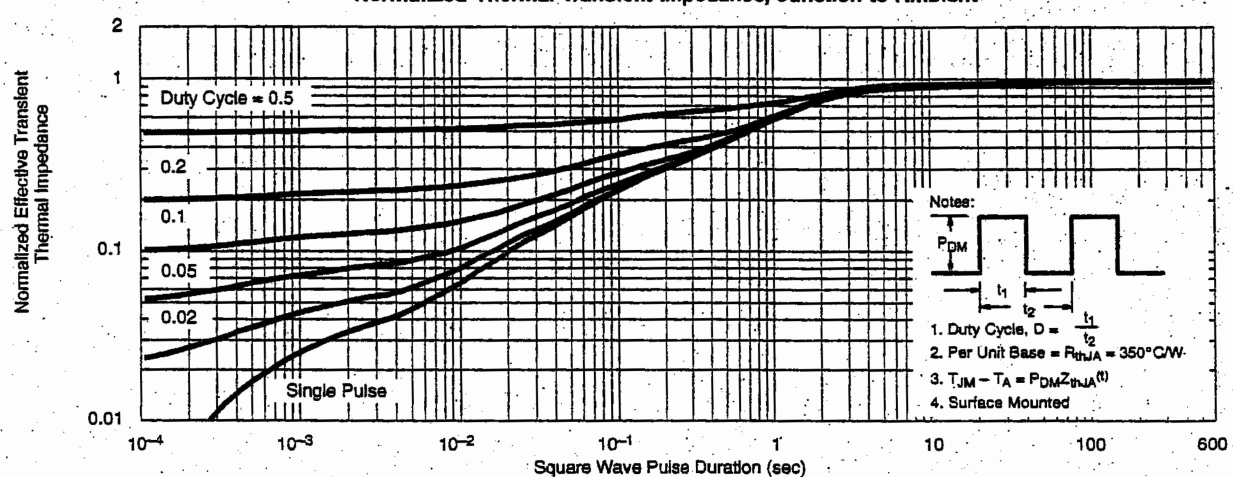
Threshold Voltage Variance Over Temperature



Single Pulse Power, Junction-to-Ambient



Normalized Thermal Transient Impedance, Junction-to-Ambient



Document Number: 70209
S-04623—Rev. G, 03-Sep-01

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