MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

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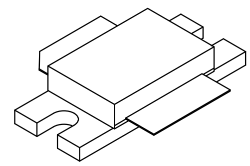
The RF Sub–Micron Bipolar Line
RF Power Bipolar Transistors

MRF20060
MRF20060S

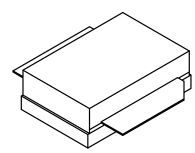
The MRF20060 and MRF20060S are designed for broadband commercial and industrial applications at frequencies from 1800 to 2000 MHz. The high gain, excellent linearity and broadband performance of these devices make them ideal for large–signal, common emitter class A and class AB amplifier applications. These devices are suitable for frequency modulated, amplitude modulated and multi–carrier base station RF power amplifiers.

- Guaranteed Two–tone Performance at 2000 MHz, 26 Volts
  Output Power — 60 Watts (PEP)
  Power Gain — 9 dB
  Efficiency — 33%
  Intermodulation Distortion — –30 dBc
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- S–Parameter Characterization at High Bias Levels
- Excellent Thermal Stability
- Capable of Handling 3:1 VSWR @ 26 Vdc, 2000 MHz, 60 Watts (PEP) Output Power
- Designed for FM, TDMA, CDMA and Multi–Carrier Applications

60 W, 2000 MHz
RF POWER
BROADBAND
NPN BIPOLAR



CASE 451–04, STYLE 1
(MRF20060)



CASE 451A–01, STYLE 1
(MRF20060S)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage (I_B = 0 mA)	V_{CEO}	25	Vdc
Collector–Emitter Voltage	V_{CES}	60	Vdc
Collector–Base Voltage	V_{CBO}	60	Vdc
Collector–Emitter Voltage (R_{BE} = 100 Ohm)	V_{CER}	30	Vdc
Base–Emitter Voltage	V_{EB}	– 3	Vdc
Collector Current – Continuous	I_C	8	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	250 1.43	Watts W/°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

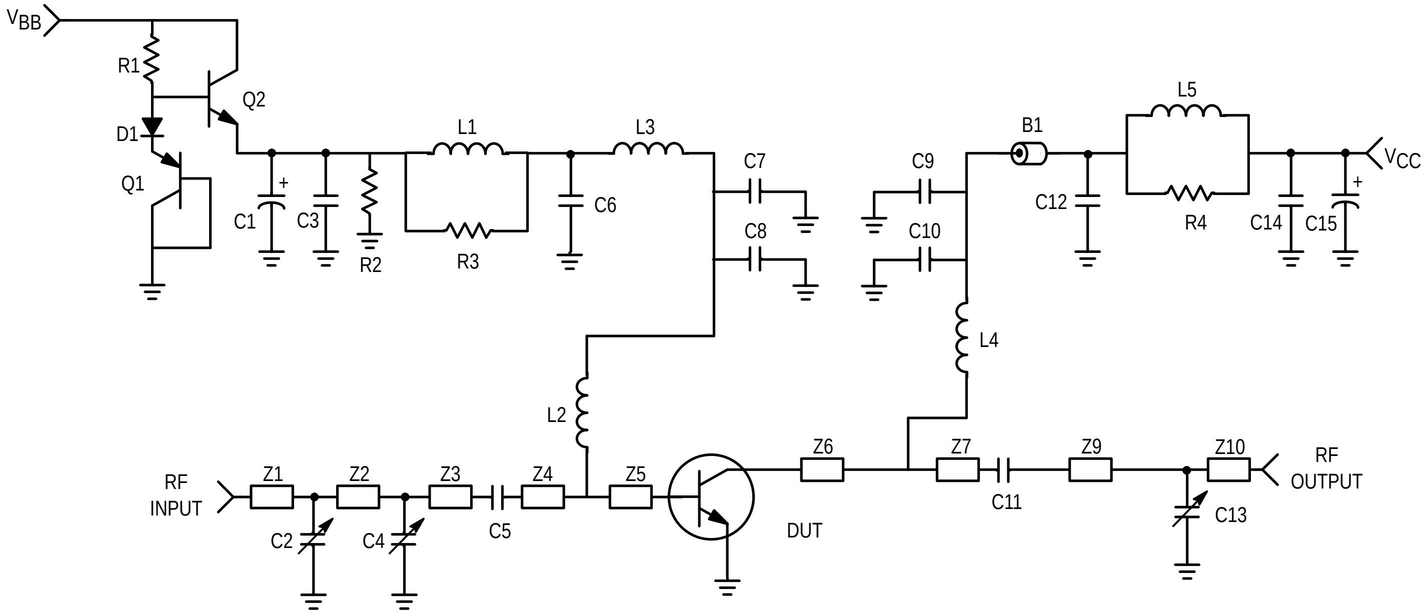
Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.7	°C/W

MOTOROLA

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

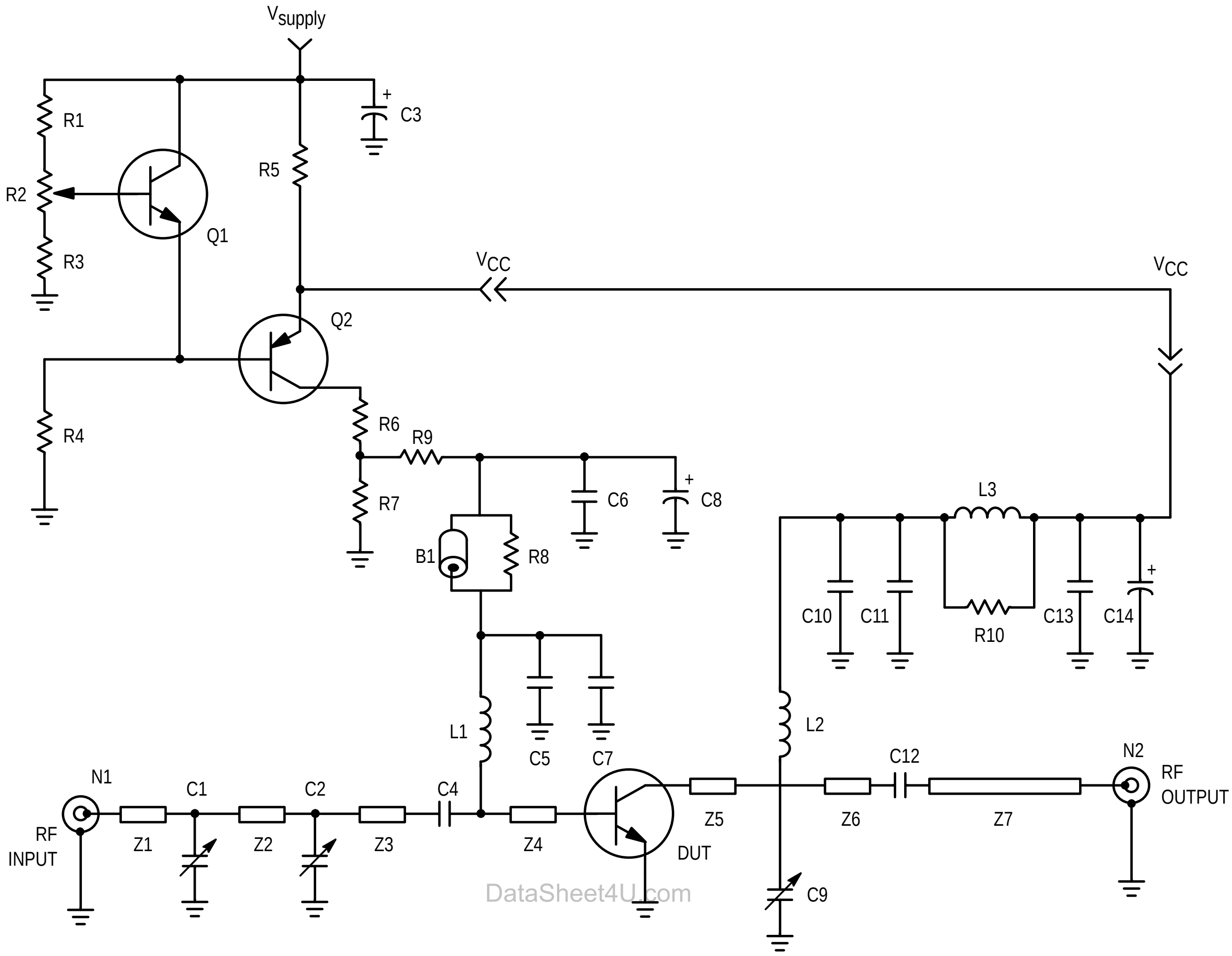
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	$V_{(BR)CEO}$	25	26	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	60	69	—	Vdc
Collector–Base Breakdown Voltage (I_C = 50 mAdc, I_E = 0)	$V_{(BR)CBO}$	60	69	—	Vdc
Reverse Base–Emitter Breakdown Voltage (I_B = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	3	3.5	—	Vdc
Zero Base Voltage Collector Leakage Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	—	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 5 Vdc, I_C = 1 Adc)	h_{FE}	20	40	80	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 26 Vdc, I_E = 0, f = 1.0 MHz) (1)	C_{ob}	—	55	—	pF
FUNCTIONAL TESTS (In Motorola Test Fixture)					
Common–Emitter Amplifier Power Gain (V_{CC} = 26 Vdc, P_{out} = 60 Watts (PEP), I_{CQ} = 200 mA, f_1 = 2000.0 MHz, f_2 = 2000.1 MHz)	G_{pe}	9	9.4	—	dB
Collector Efficiency (V_{CC} = 26 Vdc, P_{out} = 60 Watts (PEP), I_{CQ} = 200 mA, f_1 = 2000.0 MHz, f_2 = 2000.1 MHz)	η	33	35	—	%
Intermodulation Distortion (V_{CC} = 26 Vdc, P_{out} = 60 Watts (PEP), I_{CQ} = 200 mA, f_1 = 2000.0 MHz, f_2 = 2000.1 MHz)	IMD	—	– 33	– 30	dB
Input Return Loss (V_{CC} = 26 Vdc, P_{out} = 60 Watts (PEP), I_{CQ} = 200 mA, f_1 = 2000.0 MHz, f_2 = 2000.1 MHz)	IRL	12	19	—	dB
Output Mismatch Stress (V_{CC} = 26 Vdc, P_{out} = 60 Watts (PEP), I_{CQ} = 200 mA, f_1 = 2000.0 MHz, f_2 = 2000.1 MHz, VSWR = 3:1, All Phase Angles at Frequency of Test)	ψ	No Degradation in Output Power			

(1) For Information Only. This Part Is Collector Matched.



B1	Ferrite Bead, P/N 5659065/3B, Ferroxcube	D1	Diode, Motorola (MUR3160T3)
C1	100 µF, 50 V, Electrolytic Capacitor, Mallory	L1, L5	12 Turns, 22 AWG, 0.140″ Choke
C2, C4, C13	0.6–4.0 pF, Variable Capacitor, Gigatrim, Johanson	L2, L4	.5 inch of 20 AWG, ID Choke
C3, C14	0.1 µF, Chip Capacitor, Kemit	L3	12.5 nH Inductor
C5	15 pF, B Case Chip Capacitor, ATC	R1	2 x 130 Ω, 1/8 W Chip Resistor, Rohm
C6, C12	1000 pF, B Case Chip Capacitor, ATC	R2	2 x 100 Ω, 1/8 W Chip Resistor, Rohm
C7, C9	91 pF, B Case Chip Capacitor, ATC	R3, R4	10 Ω, 1/2 W, Resistor
C8, C10	24 pF, B Case Chip Capacitor, ATC	Q1	Transistor, PNP Motorola (BD136)
C11	13 pF, B Case Chip Capacitor, ATC	Q2	Transistor, NPN Motorola (MJD47)
C15	470 µF, 50 V, Electrolytic Capacitor, Mallory	Board	Glass Teflon®, Arlon GX–0300–55–22, ε_r = 2.55

Figure 1. Class AB, 1.93 – 2 GHz Test Fixture Electrical Schematic



B1	Short Bead, Fair Rite
C1, C2	0.6–4.5 pF, Trimmer, Gigatrim, Johanson
C3, C8	100 μF, 50 V Electrolytic, Mallory
C4, C12	12 pF, Chip Capacitor, ATC
C5, C11	91 pF, Chip Capacitor, ATC
C6	0.01 μF, Chip Capacitor, ATC
C7, C10	24 pF, Chip Capacitor, ATC
C9	0.4–2.5 pF, Trimmer, Gigatrim, Johanson
C13	0.1 μF, Chip Capacitor, ATC
C14	470 μF, 63 V Electrolytic, Mallory
L1	2 Turn, 27 AWG, 0.049″ ID Coil
L2	0.041″ dia., 0.7″ Length Wire
L3	11 Turn, 20 AWG, 0.19″ ID Coil
N1, N2	Type N Flange Mount RF 55–22, Connector, Omni Spectra
Q1	Transistor, NPN, Motorola (BD135)
Q2	Transistor, PNP, Motorola (BD136)
R1	270 Ω, Chip Resistor, 1/8 Watt, Rohm
R2	10 KΩ, 1/4 Watt, Potentiometer
R3	4.7 KΩ, Chip Resistor, 1/8 Watt, Rohm
R4	2 x 4.7 KΩ, Chip Resistor, 1/8 Watt, Rohm
R5	1.0 Ω, 25 Watt, 1% Resistor, DALE
R6	38 Ω, Axial Lead, 1 Watt Resistor
R7	4.2 KΩ, Chip Resistor, 1/8 Watt, Rohm
R8	3 x 39 Ω, Chip Resistors, 1/8 Watt, Rohm
R9	2 x 10 Ω, Chip Resistor, 1/8 Watt, Rohm
R10	10 Ω, Axial Lead, 1 Watt Resistor
Board	Glass Teflon®, Arlon GX–0300–55–22, ε_r = 2.55

Figure 2. Class A, 1.93 – 2 GHz Test Fixture Electrical Schematic

TYPICAL CHARACTERISTICS

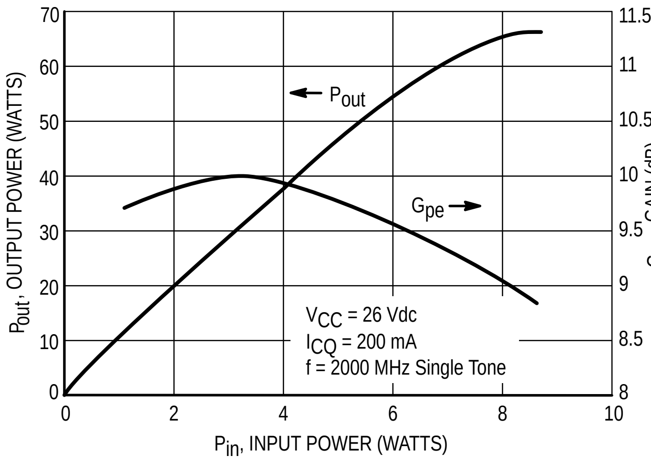


Figure 3. Output Power & Power Gain versus Input Power

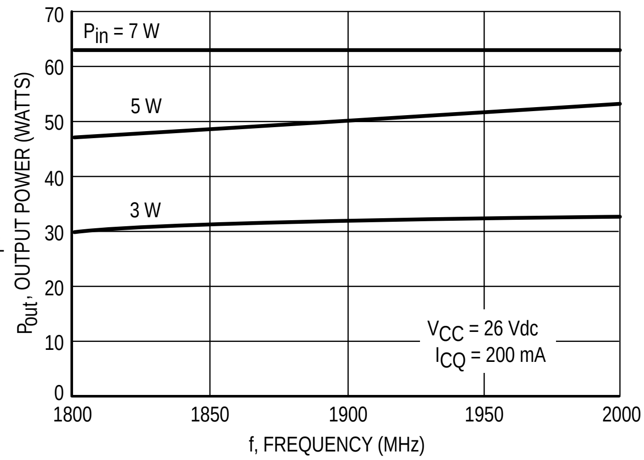


Figure 4. Output Power versus Frequency

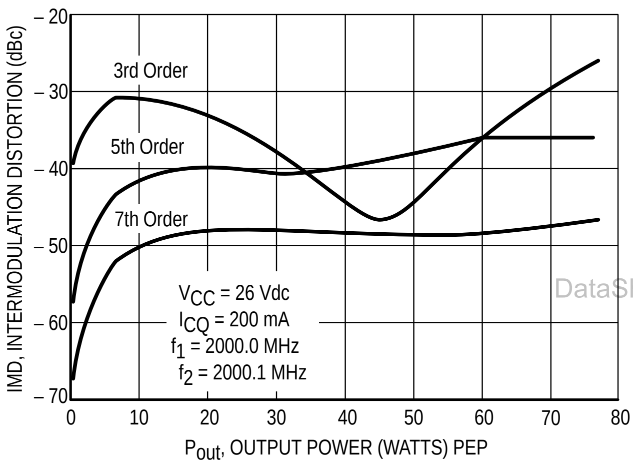


Figure 5. Intermodulation Distortion versus Output Power

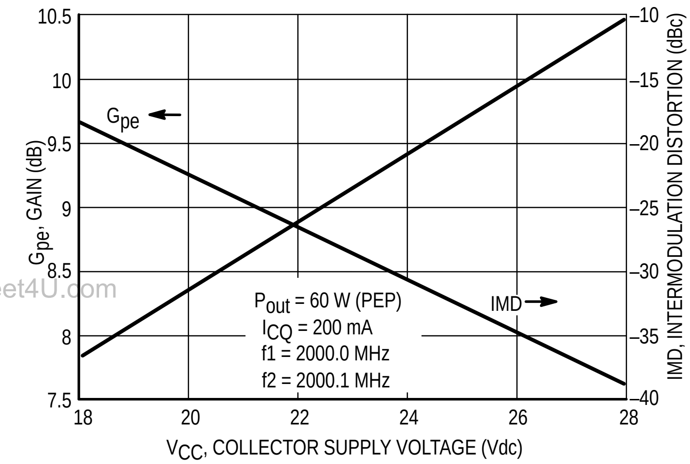


Figure 6. Power Gain and Intermodulation Distortion versus Supply Voltage

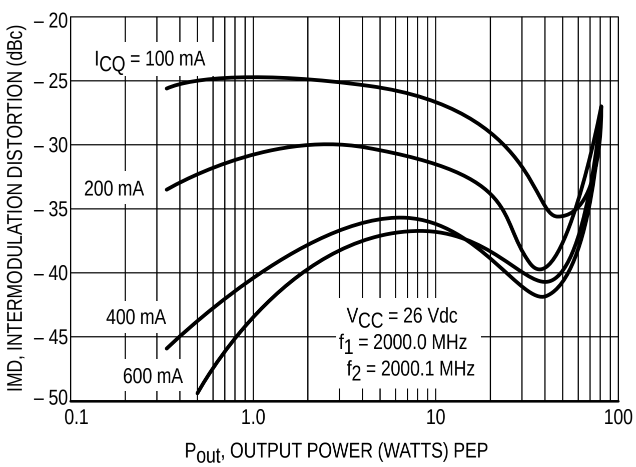


Figure 7. Intermodulation Distortion versus Output Power

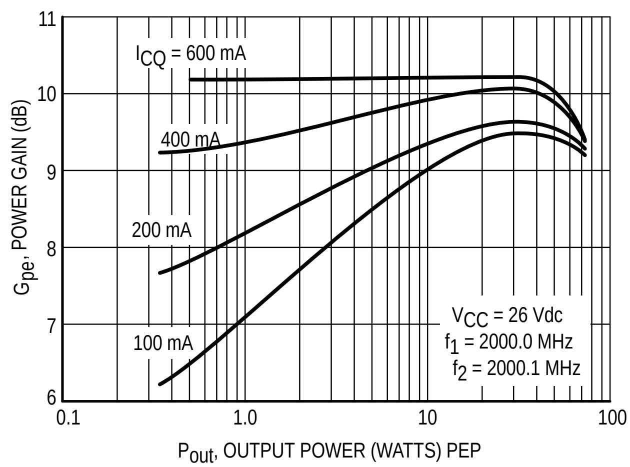


Figure 8. Power Gain versus Output Power

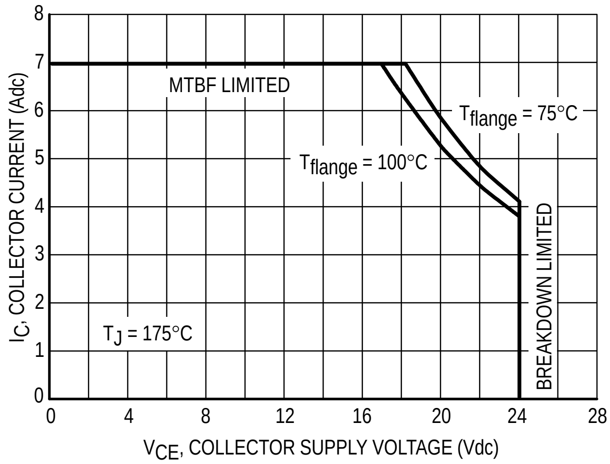


Figure 9. Class A DC Safe Operating Area

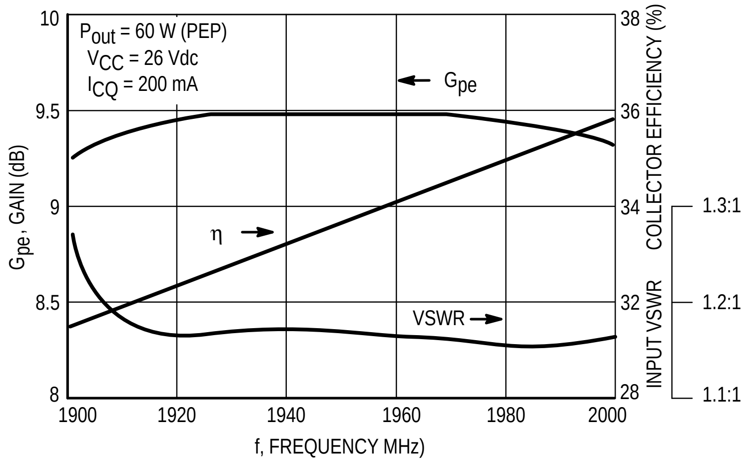


Figure 10. Performance in Broadband Circuit

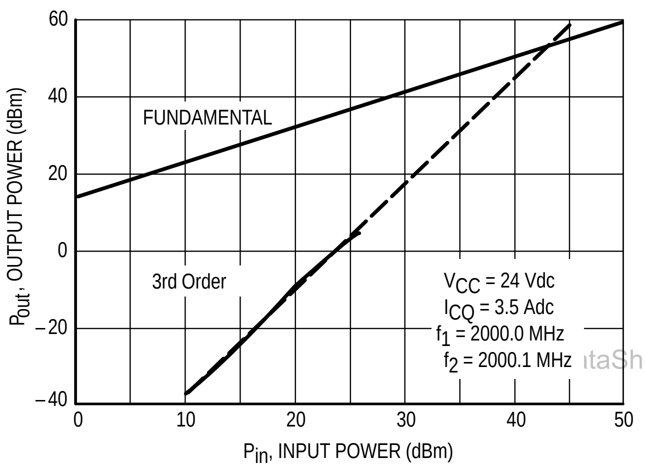
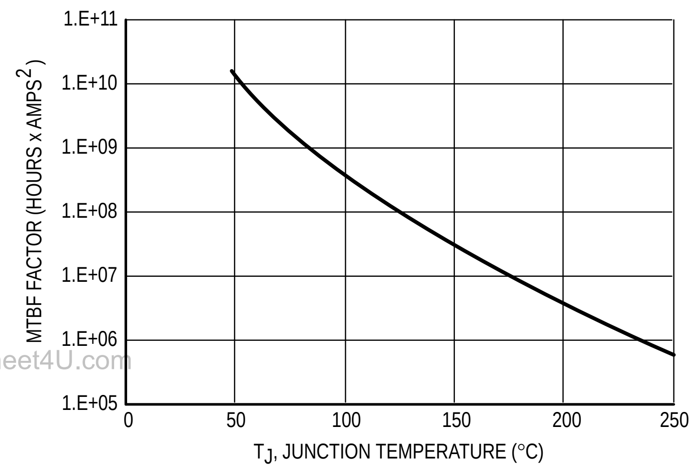
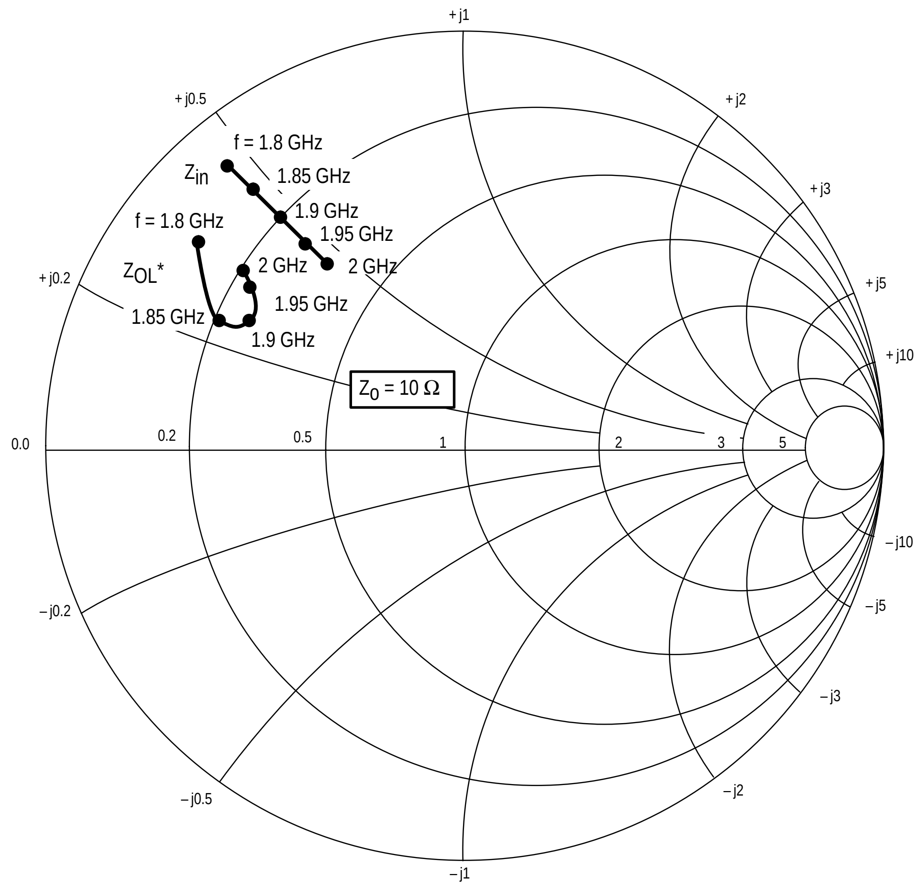


Figure 11. Class A Third Order Intercept Point



This above graph displays calculated MTBF in hours x ampere^2 emitter curent. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTBF factor by I_C^2 for MTBF in a particular application.

Figure 12. MTBF Factor versus Junction Temperature



V_{CC} = 26 V, I_{CQ} = 200 mA, P_{out} = 60 W (PEP)

f MHz	Z_{in}(1) Ω	Z_{OL}* Ω
1800	1.0 + j4.8	1.7 + j3.3
1850	1.5 + j4.8	2.2 + j2.7
1900	2.0 + j4.7	2.4 + j3.0
1950	2.5 + j4.7	2.3 + j3.2
2000	3.5 + j4.7	2.0 + j3.4

Z_{in}(1) = Conjugate of fixture base terminal impedance.

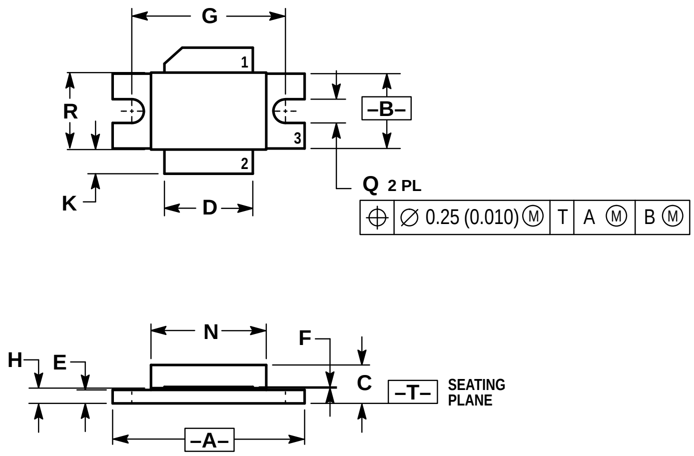
Z_{OL}* = Conjugate of the optimum load impedance at given output power, voltage, bias current and frequency.

Figure 13. Series Equivalent Input and Output Impedence

Table 1. Common Emitter S–Parameters at V_{CE} = 24 Vdc, I_C = 3.5 Adc

f GHz	S_{11}		S_{21}		S_{12}		S_{22}	
	$\|S_{11}\|$	∠ φ	$\|S_{21}\|$	∠ φ	$\|S_{12}\|$	∠ φ	$\|S_{22}\|$	∠ φ
1.5	0.986	168	0.32	81	0.031	60	0.923	169
1.55	0.985	167	0.35	76	0.031	63	0.918	169
1.6	0.981	167	0.40	70	0.032	61	0.908	169
1.65	0.973	166	0.45	63	0.030	53	0.897	169
1.7	0.968	165	0.52	56	0.033	50	0.889	168
1.75	0.951	163	0.62	46	0.028	47	0.880	169
1.8	0.914	161	0.76	32	0.027	39	0.871	170
1.85	0.851	161	0.91	12	0.024	26	0.863	171
1.9	0.789	164	1.02	–15	0.015	5	0.888	174
1.95	0.810	170	0.94	–44	0.005	–7	0.931	174
2	0.880	172	0.75	–68	0.006	–151	0.953	172
2.05	0.934	170	0.57	–85	0.010	152	0.967	170
2.1	0.964	168	0.45	–98	0.015	158	0.965	169
2.15	0.977	165	0.36	–109	0.022	164	0.955	168
2.2	0.975	163	0.30	–118	0.033	165	0.950	167
2.25	0.961	161	0.25	–128	0.049	160	0.947	167
2.3	0.942	160	0.22	–139	0.066	149	0.938	166
2.35	0.919	157	0.19	–149	0.077	142	0.931	165
2.4	0.860	156	0.17	–163	0.100	137	0.922	165
2.45	0.821	159	0.15	177	0.128	122	0.914	165
2.5	0.781	161	0.14	157.0	0.156	108	0.907	165

PACKAGE DIMENSIONS

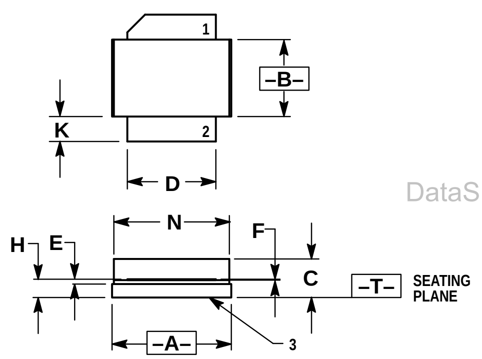


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.995	1.005	25.27	25.53
B	0.380	0.390	9.65	9.91
C	0.170	0.205	4.32	5.21
D	0.455	0.465	11.56	11.81
E	0.060	0.075	1.52	1.91
F	0.004	0.006	0.10	0.15
G	0.800 BSC		20.32 BSC	
H	0.078	0.090	1.98	2.29
K	0.117	0.137	2.97	3.48
N	0.595	0.605	15.11	15.37
Q	0.120	0.130	3.05	3.30
R	0.395	0.410	10.03	10.41

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

CASE 451–04
ISSUE D



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.615	0.625	15.62	15.88
B	0.395	0.410	10.03	10.41
C	0.170	0.205	4.32	5.21
D	0.455	0.465	11.56	11.81
E	0.060	0.075	1.52	1.91
F	0.004	0.006	0.10	0.15
H	0.078	0.090	1.98	2.29
K	0.117	0.137	2.97	3.48
N	0.595	0.605	15.11	15.37

STYLE 1:
PIN 1. COLLECTOR
2. BASE
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CASE 451A–01
ISSUE O

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