Substitution of the MRF448 for the 2SC2652 in the IC-2KL

By Adam Farson, VA7OJ/AB4OJ

The Toshiba 2SC2652 has been discontinued for some time, and is almost unobtainable. Fortunately, however, the MRF448 is a near cross. (View the MRF448 data sheet).

The MRF448's should be ordered as a matched quad from a supplier such as RF Parts Inc. After installing the replacement devices, you will need to realign the amplifier.

In Step 2 (Idle Current), using an oscilloscope having at least 100 MHz bandwidth, you should also check the RF output waveform for minimum crossover distortion after setting the idle current $\mathbf{I_o}$ to 200 mA for each of the two PA modules.

If you have access to a 2-tone generator and an RF spectrum analyser, I would recommend checking the 2-tone IMD3 at 500W PEP.

When using two non-harmonically-related tones, the 3rd-order products should be at least 30 dB below two tones of equal amplitude. . In an audio-frequency passband between 300 and 3000 Hz, for example, a value in the neighbourhood of 700 or 1100 Hz may be chosen for $\mathbf{f_1}$, and in the neighbourhood of 1700 or 2500 Hz for $\mathbf{f_2}$.

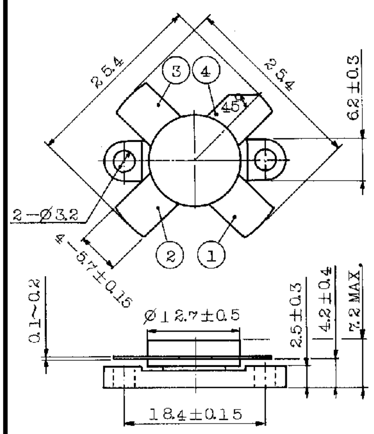
You can try carefully moving the idle-current bias setting back and forth, and adjusting for minimum IMD3. The optimum point for each of the two modules will fall between the point where crossover distortion just starts to increase and that where IMD3 just starts to degrade. The desired range is 150 mA < $\mathbf{I_o}$ < 200 mA.

TOSHIBA TRANSISTOR SILICON NPN EPITAXIAL PLANAR TYPE

2SC2652

2~30MHz SSB LINEAR POWER AMPLIFIER APPLICATIONS
(50V SUPPLY VOLTAGE USE)

Unit in mm



1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

JEDEC	—
EIAJ	—
TOSHIBA	2-13B1A

Weight : 5.2g

- Specified 50V, 28MHz Characteristics
- Output Power : $P_o = 200W_{PEP}$
- Power Gain : $G_p = 13dB$ (Min.)
- Collector Efficiency : $\eta_C = 35\%$ (Min.)
- Intermodulation Distortion : IMD = −30dB (Max.)

MAXIMUM RATINGS (Tc = 25°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	85	V
Collector-Emitter Voltage	V_{CES}	85	V
Collector-Emitter Voltage	V_{CEO}	55	V
Emitter-Base Voltage	V_{EBO}	4	V
Collector Current	I_C	20	A
Collector Power Dissipation	P_C	300	W
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_{stg}	−65~175	°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C)

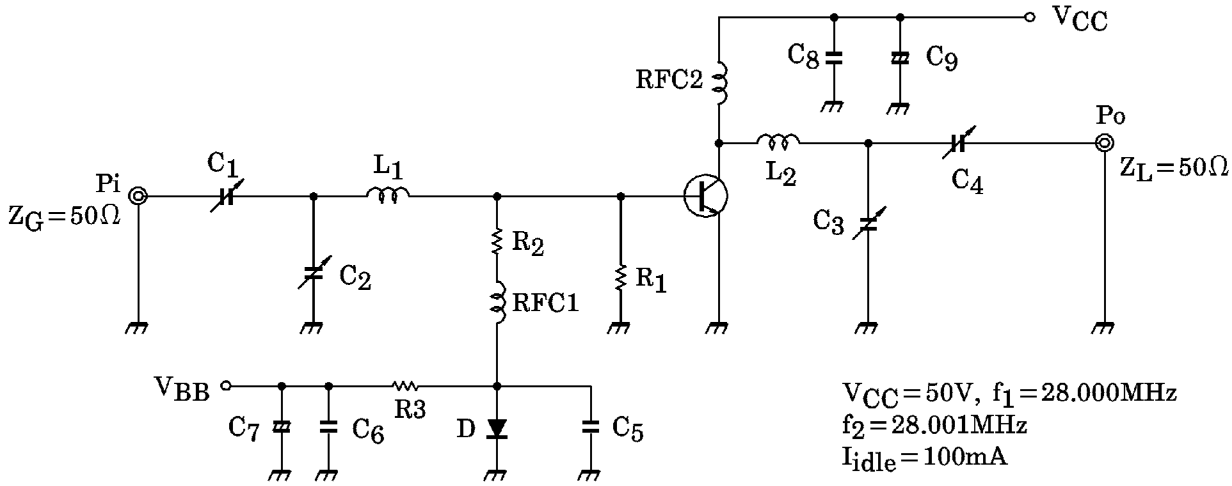
CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	$I_C = 100mA$, $I_B = 0$	55	—	—	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CES}$	$I_C = 100mA$, $V_{BE} = 0$	85	—	—	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	$I_E = 1mA$, $I_C = 0$	4	—	—	V
DC Current Gain	h_{FE}	$V_{CB} = 5V$, $I_C = 10A$ *	10	—	150	
Collector Output Capacitance	C_{ob}	$V_{CB} = 50V$, $I_E = 0$ f = 1MHz	—	300	—	pF
Power Gain	G_p	$V_{CC} = 50V$, $f_1 = 28.000MHz$ $f_2 = 28.001MHz$ $I_{idle} = 100mA$ $P_o = 200W_{PEP}$.(Fig.)	13.0	15.2	—	dB
Input Power	Pi		—	6	10	W_{PEP}
Collector Efficiency	η_C		35	—	—	%
Intermodulation Distortion	IMD		—	—	−30	dB
Series Equivalent Input Impedance	Z_{in}	$V_{CC} = 50V$, f = 28MHz $\Delta f = 1kHz$, $P_o = 200W_{PEP}$	—	1.15 −j1.15	—	Ω
Series Equivalent Output Impedance	Z_{out}		—	5.4 −j2.0	—	Ω

* Pulse Test : Pulse Width ≦ 100μs, Duty Cycle ≦ 3%

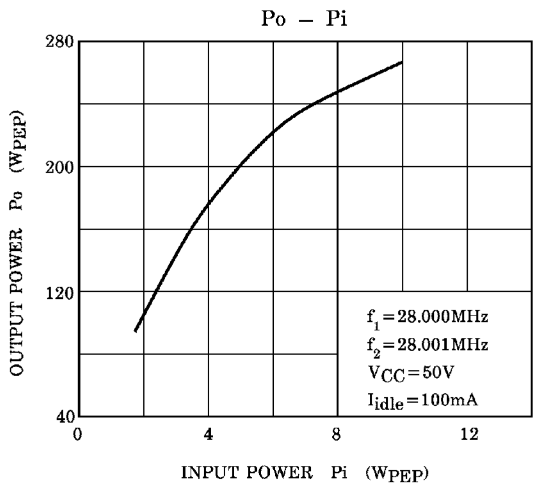
CAUTION

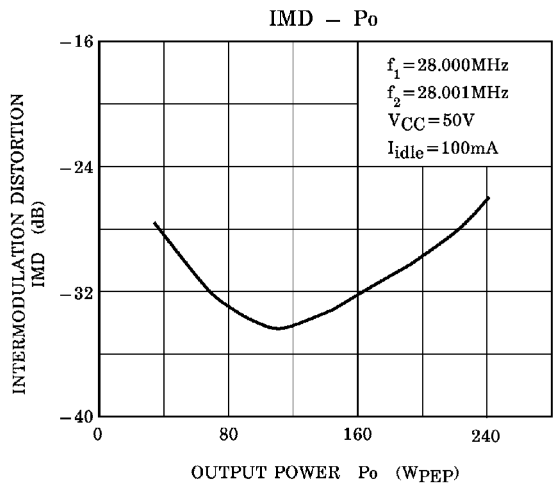
Beryllia Ceramics is used in this product. The dust or vapor can be dangerous to humans. Do not break, cut, crush or dissolve chemically. Dispose of this propely according to law. Do not intermingle with normal industrial or domestic waste.

Fig. Pi TEST CIRCUIT



C_1, C_2	:	7~150pF	L_1	:	ϕ0.8 ENAMEL COATED COPPER WIRE, 14ID, 4T, 4P
C_3, C_4	:	7~150pF 2KWV	L_2	:	ϕ1.2 ENAMEL COATED COPPER WIRE, 14ID, 3 1 / 2T, 3P
C_5, C_6	:	0.022μF	RFC_1	:	ϕ0.8 ENAMEL COATED COPPER WIRE, 10ID, 9T (Ferrite Core TDK K2)
C_7	:	47μF 10WV			
C_8	:	0.044μF	RFC_2	:	ϕ0.8 ENAMEL COATED COPPER WIRE, 14ID, 20T
C_9	:	100μF 50WV	R_1	:	10Ω (1W)
			R_2	:	2Ω (1 / 2W)
			R_3	:	10Ω (5W)
			D	:	1S1555





CAUTION

These are only typical curves and devices are not necessarily guaranteed at these curves.

M/A-COM
SEMICONDUCTOR TECHNICAL DATA

Order this document
by MRF448/D

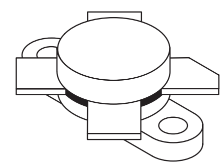
The RF Line
NPN Silicon RF Power Transistor

MRF448

Designed primarily for high–voltage applications as a high–power linear amplifier from 2.0 to 30 MHz. Ideal for marine and base station equipment.

- Specified 50 Volt, 30 MHz Characteristics
  Output Power = 250 W
  Minimum Gain = 12 dB
  Efficiency = 45%
- Intermodulation Distortion @ 250 W (PEP) —
  IMD = –30 dB (Max)
- 100% Tested for Load Mismatch at all Phase Angles with 3:1 VSWR

**250 W, 30 MHz
RF POWER
TRANSISTOR
NPN SILICON**



CASE 211–11, STYLE 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector–Emitter Voltage	V_{CEO}	50	Vdc
Collector–Base Voltage	V_{CBO}	100	Vdc
Emitter–Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	16	Adc
Withstand Current — 10 s	—	20	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	290 1.67	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	$V_{(BR)CEO}$	50	—	—	Vdc
Collector–Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	$V_{(BR)CES}$	100	—	—	Vdc
Collector–Base Breakdown Voltage (I_C = 100 mAdc, I_E = 0)	$V_{(BR)CBO}$	100	—	—	Vdc
Emitter–Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	$V_{(BR)EBO}$	4.0	—	—	Vdc

NOTE:
1. P_D is a measurement reflecting short term maximum condition. See SOAR curve for operating conditions.

(continued)

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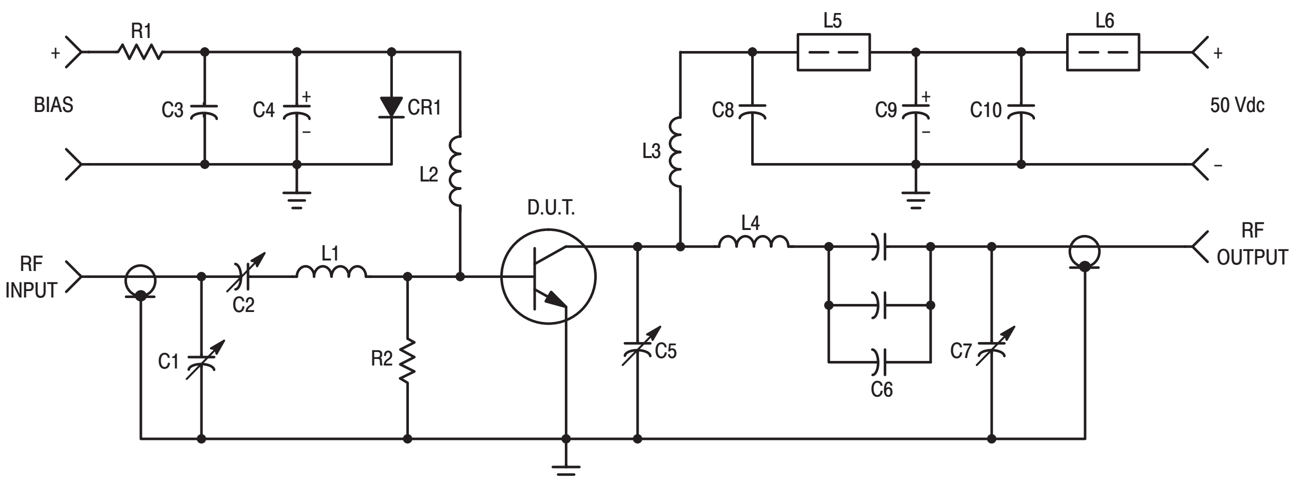
ELECTRICAL CHARACTERISTICS — continued (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	10	30	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 50 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	350	450	pF
FUNCTIONAL TESTS					
Common–Emitter Amplifier Power Gain (V_{CC} = 50 Vdc, P_{out} = 250 W CW, f = 30 MHz, I_{CQ} = 250 mA)	G_{PE}	12	14	—	dB
Collector Efficiency (V_{CC} = 50 Vdc, P_{out} = 250 W, f = 30 MHz, I_{CQ} = 250 mA)	η	— —	45 65	— —	% (PEP) % (CW)
Intermodulation Distortion (2) (V_{CE} = 50 Vdc, P_{out} = 250 W (PEP), I_{CQ} = 250 mA, f = 30 MHz)	IMD	—	–33	–30	dB
Electrical Ruggedness (V_{CC} = 50 Vdc, P_{out} = 250 W CW, f = 30 MHz, VSWR 3:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:
2. To Mil–Std–1311 Version A, Test Method 2204, Two Tone, Reference each Tone.



C1, C2, C5, C7 — 170–780 pF, Arco 469
C3, C8, C9 — 0.1 µF, 100 V Erie
C4 — 500 µF @ 6.0 V
C6 — 360 pF, 3 x 120 pF 3.0 kV in parallel
C10 — 10 µF, 100 V
R1 — 10 Ω, 10 Watt
R2 — 10 Ω, 1.0 Watt
CR1 — 1N4997 or equivalent
L1 — 3 Turns, #16 Wire, 0.4″ I.D., 0.3″ Long
L2 — 0.8 µH, Ohmite Z–235 or equivalent
L3 — 12 Turns, #16 Enameled Wire Closewound 0.25″ I.D.
L4 — 4 Turns, 1/8″ Copper Tubing, 0.6″ I.D., 1.0″ Long
L5, L6 — 2.0 µH, Fair–Rite 2643021801 Ferrite bead each or equivalent

Figure 1. 30 MHz Test Circuit Schematic

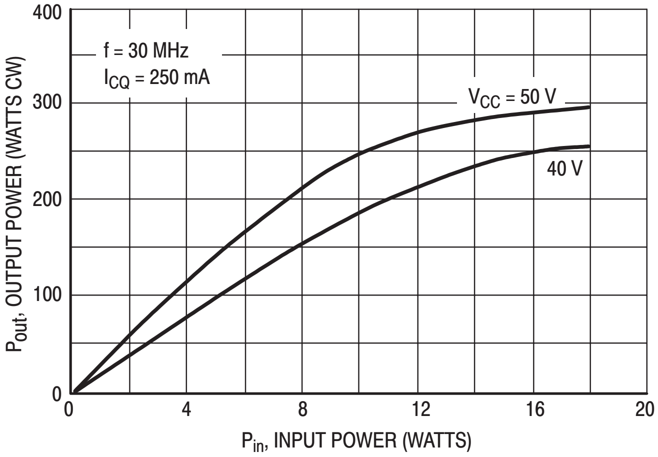


Figure 2. Output Power versus Input Power

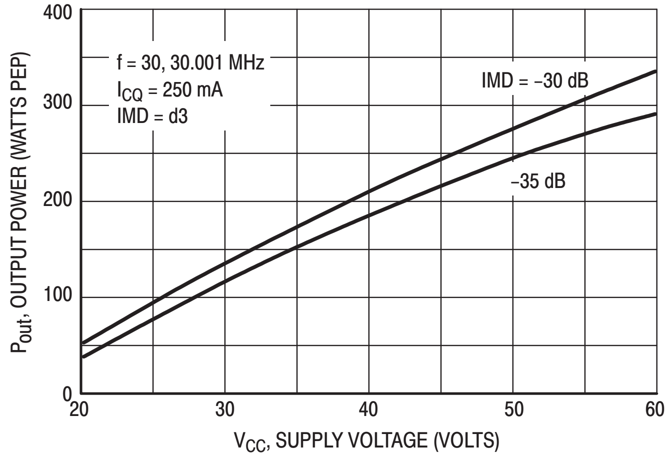


Figure 3. Output Power versus Supply Voltage

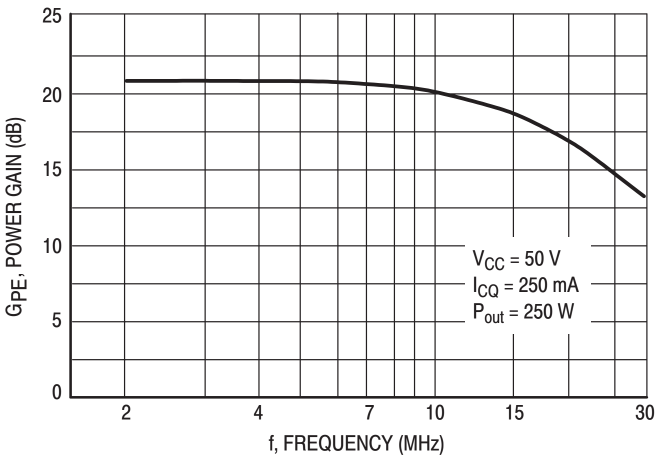


Figure 4. Power Gain versus Frequency

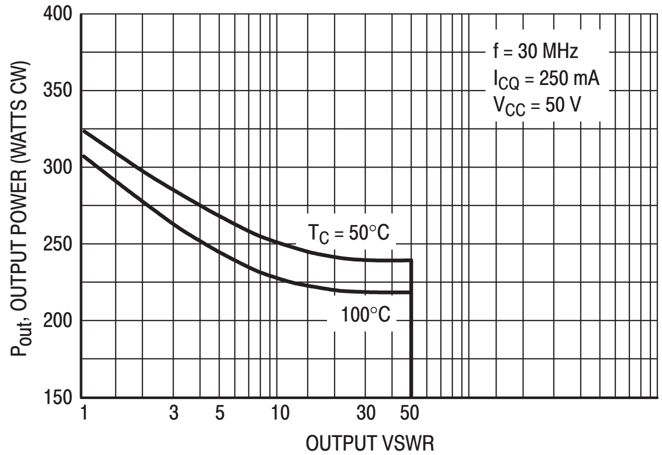


Figure 5. RF SOAR (Class AB)
P_{out} versus Output VSWR

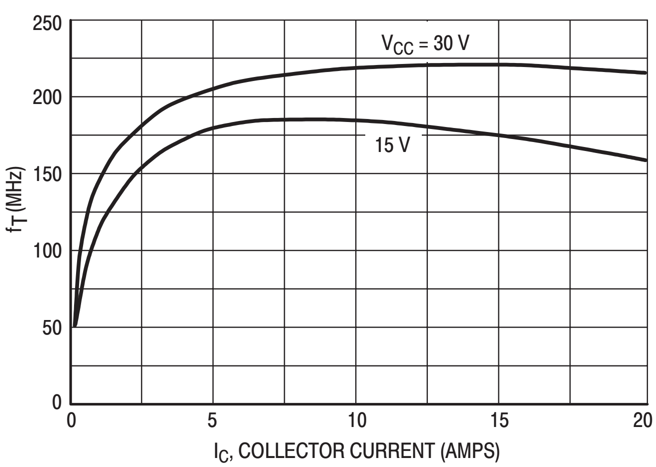


Figure 6. f_T versus Collector Current

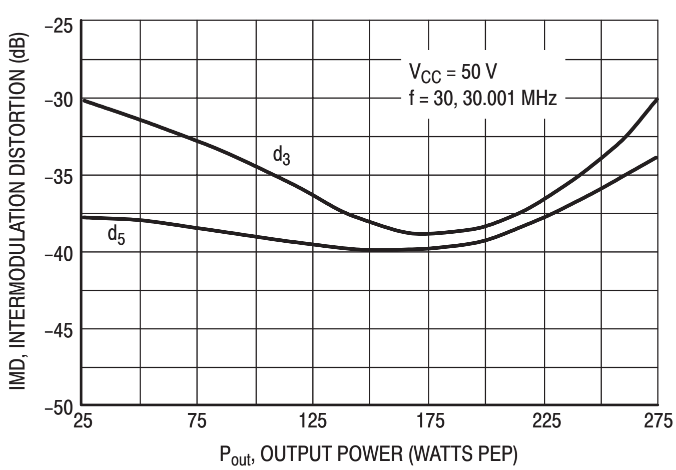


Figure 7. IMD versus P_{out}

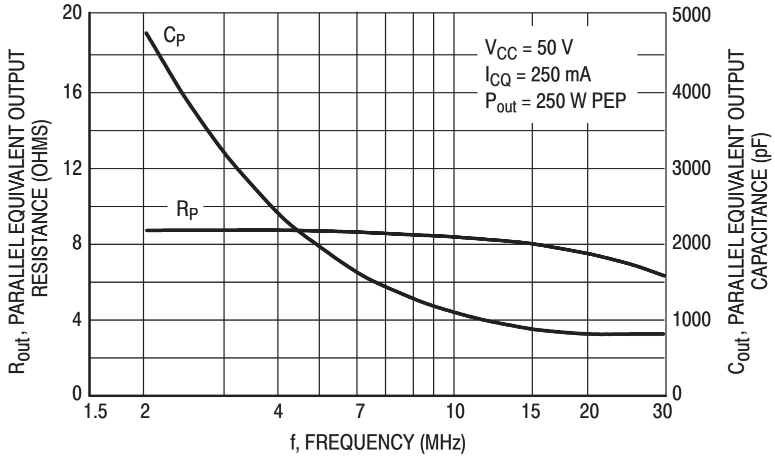
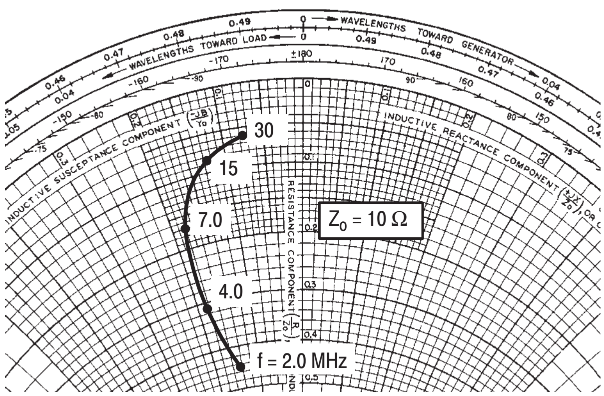


Figure 8. Output Resistance and Capacitance versus Frequency

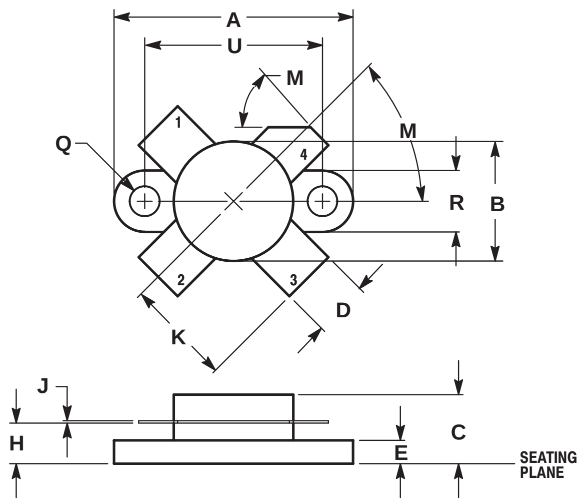


V_{CC} = 50 V
I_{CQ} = 150 mA
P_{out} = 250 W PEP

f MHz	Z_{in} Ohms
2.0	4.50 – j1.40
4.0	3.10 – j1.80
7.0	1.70 – j1.75
15	0.80 – j1.25
30	0.60 – j0.75

Figure 9. Series Equivalent Impedance

PACKAGE DIMENSIONS



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

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.960	0.990	24.39	25.14
B	0.465	0.510	11.82	12.95
C	0.229	0.275	5.82	6.98
D	0.216	0.235	5.49	5.96
E	0.084	0.110	2.14	2.79
H	0.144	0.178	3.66	4.52
J	0.003	0.007	0.08	0.17
K	0.435	---	11.05	---
M	45°NOM		45°NOM	
Q	0.115	0.130	2.93	3.30
R	0.246	0.255	6.25	6.47
U	0.720	0.730	18.29	18.54

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

CASE 211–11
ISSUE N