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The RF MOSFET Line

RF Power Field-Effect Transistor

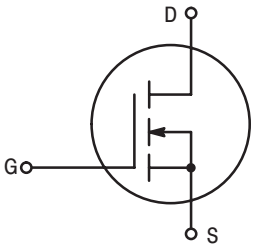
N–Channel Enhancement–Mode

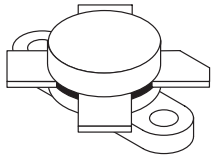
MRF140

Designed primarily for linear large–signal output stages up to 150 MHz frequency range.

- Specified 28 Volts, 30 MHz Characteristics
  Output Power = 150 Watts
  Power Gain = 15 dB (Typ)
  Efficiency = 40% (Typ)
- Superior High Order IMD
- $IMD_{(d3)}$ (150 W PEP) — –30 dB (Typ)
- $IMD_{(d11)}$ (150 W PEP) — –60 dB (Typ)
- 100% Tested For Load Mismatch At All Phase Angles With 30:1 VSWR

**150 W, to 150 MHz
N–CHANNEL MOS
LINEAR RF POWER
FET**





CASE 211–11, STYLE 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DSS}	65	Vdc
Drain–Gate Voltage	V_{DGO}	65	Vdc
Gate–Source Voltage	V_{GS}	±40	Vdc
Drain Current — Continuous	I_D	16	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.7	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	200	°C

THERMAL CHARACTERISTICS

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

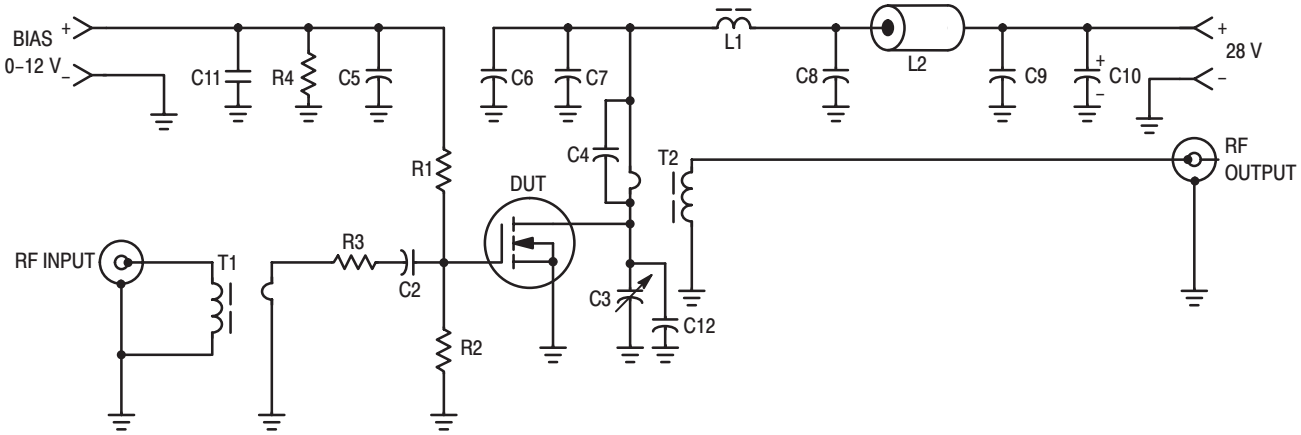
NOTE — **CAUTION** — MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

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

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain–Source Breakdown Voltage (V_{GS} = 0, I_D = 100 mA)	$V_{(BR)DSS}$	65	—	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = 28 Vdc, V_{GS} = 0)	I_{DSS}	—	—	5.0	mAdc
Gate–Body Leakage Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	—	—	1.0	μAdc
ON CHARACTERISTICS					
Gate Threshold Voltage (V_{DS} = 10 V, I_D = 100 mA)	$V_{GS(th)}$	1.0	3.0	5.0	Vdc
Drain–Source On–Voltage (V_{GS} = 10 V, I_D = 10 Adc)	$V_{DS(on)}$	0.1	0.9	1.5	Vdc
Forward Transconductance (V_{DS} = 10 V, I_D = 5.0 A)	g_{fs}	4.0	7.0	—	mhos
DYNAMIC CHARACTERISTICS					
Input Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	—	450	—	pF
Output Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	—	400	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 V, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	—	75	—	pF
FUNCTIONAL TESTS (SSB)					
Common Source Amplifier Power Gain (30 MHz) (V_{DD} = 28 V, P_{out} = 150 W (PEP), I_{DQ} = 250 mA) (150 MHz)	G_{ps}	— —	15 6.0	— —	dB
Drain Efficiency (V_{DD} = 28 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_D (Max) = 6.5 A)	η	—	40	—	%
Intermodulation Distortion (1) (V_{DD} = 28 V, P_{out} = 150 W (PEP), f1 = 30 MHz, f2 = 30.001 MHz, I_{DQ} = 250 mA)	$IMD_{(d3)}$ $IMD_{(d11)}$	— —	–30 –60	— —	dB
Load Mismatch (V_{DD} = 28 V, P_{out} = 150 W (PEP), f = 30; 30.001 MHz, I_{DQ} = 250 mA, VSWR 30:1 at all Phase Angles)	ψ	No Degradation in Output Power			

NOTE:

1. To MIL–STD–1311 Version A, Test Method 2204B, Two Tone, Reference Each Tone.



C2, C5, C6, C7, C8, C9 — 0.1 μF Ceramic Chip or Monolythic with Short Leads
C3 — Arco 469
C4 — 820 pF Unencapsulated Mica or Dipped Mica with Short Leads
C10 — 10 μF/100 V Electrolytic
C11 — 1 μF, 50 V, Tantalum
C12 — 330 pF, Dipped Mica (Short leads)
L1 — VK200/4B Ferrite Choke or Equivalent, 3.0 μH
L2 — Ferrite Bead(s), 2.0 μH
R1, R2 — 51 Ω/1.0 W Carbon
R3 — 1.0 Ω/1.0 W Carbon or Parallel Two 2 Ω, 1/2 W Resistors
R4 — 1 kΩ/1/2 W Carbon
T1 — 16:1 Broadband Transformer
T2 — 1:25 Broadband Transformer

Figure 1. 30 MHz Test Circuit (Class AB)

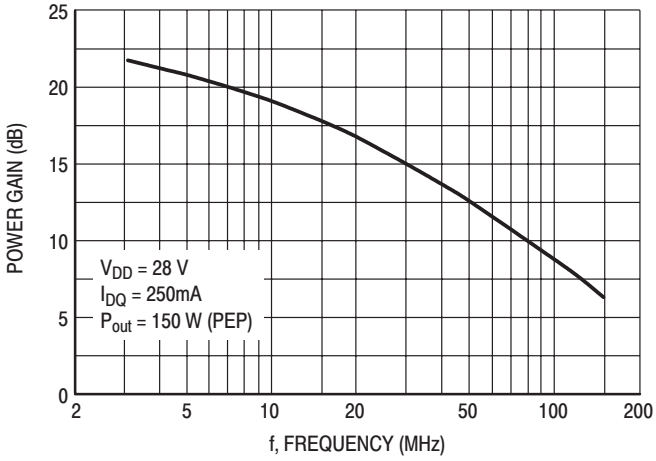


Figure 2. Power Gain versus Frequency

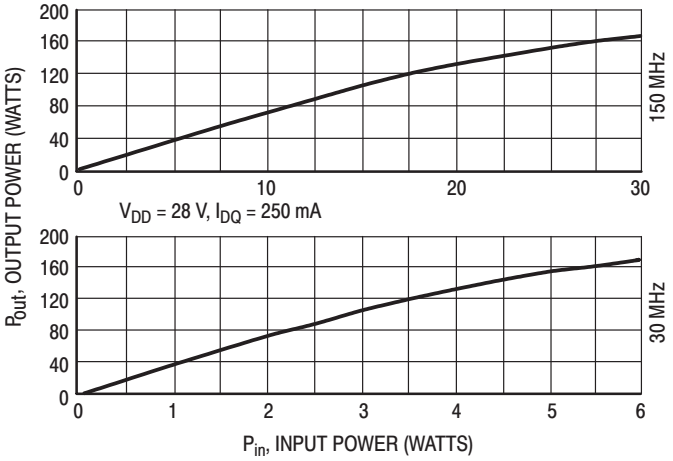


Figure 3. Output Power versus Input Power

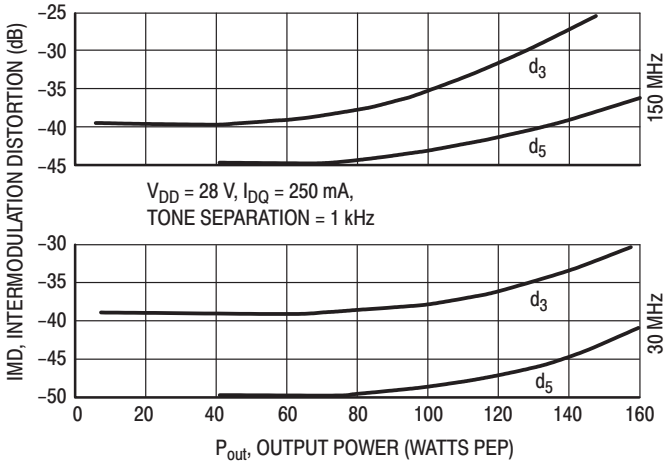


Figure 4. IMD versus P_{out}

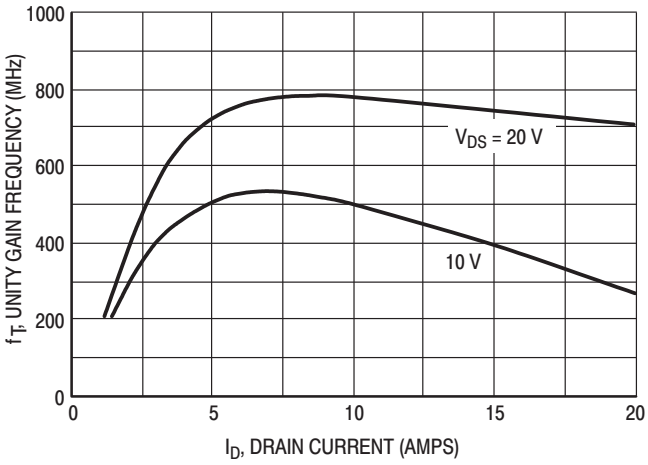


Figure 5. Common Source Unity Gain Frequency versus Drain Current

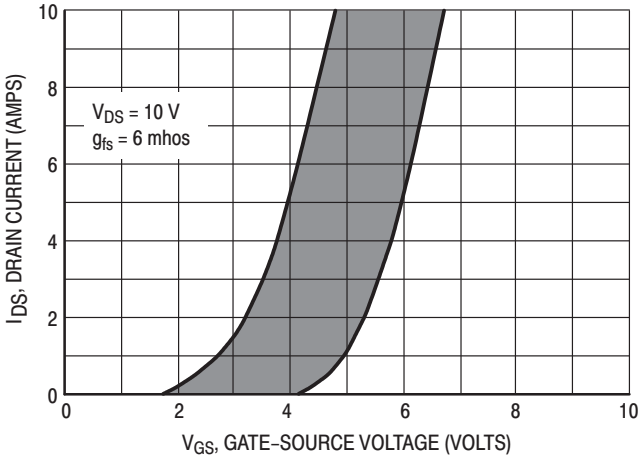
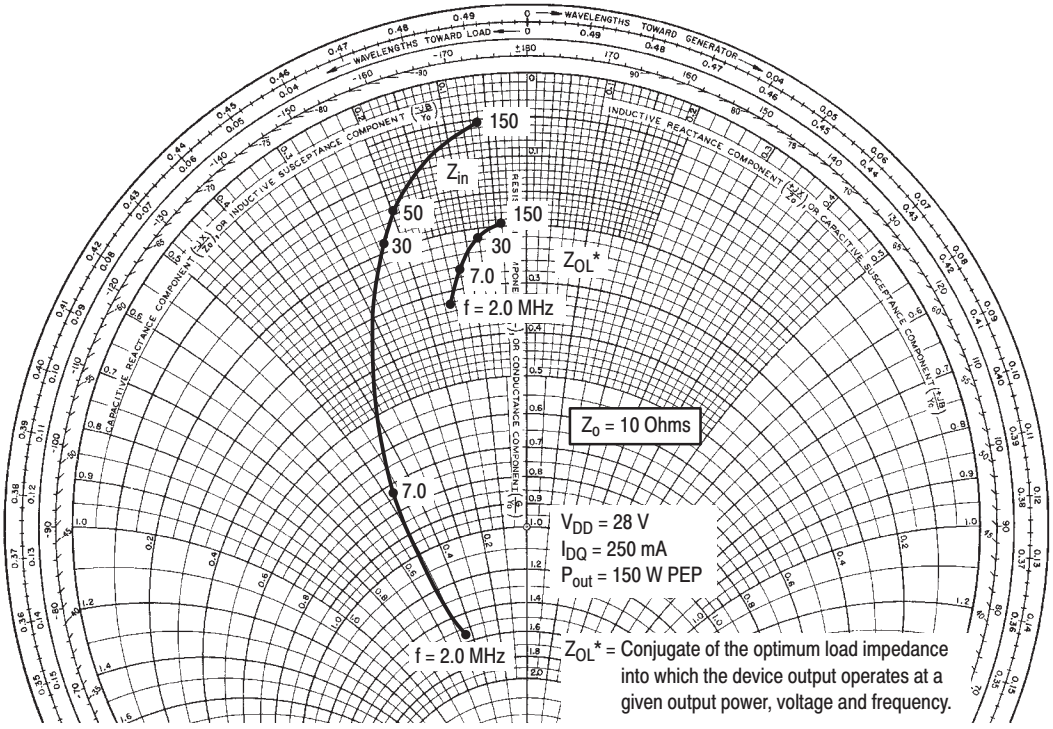
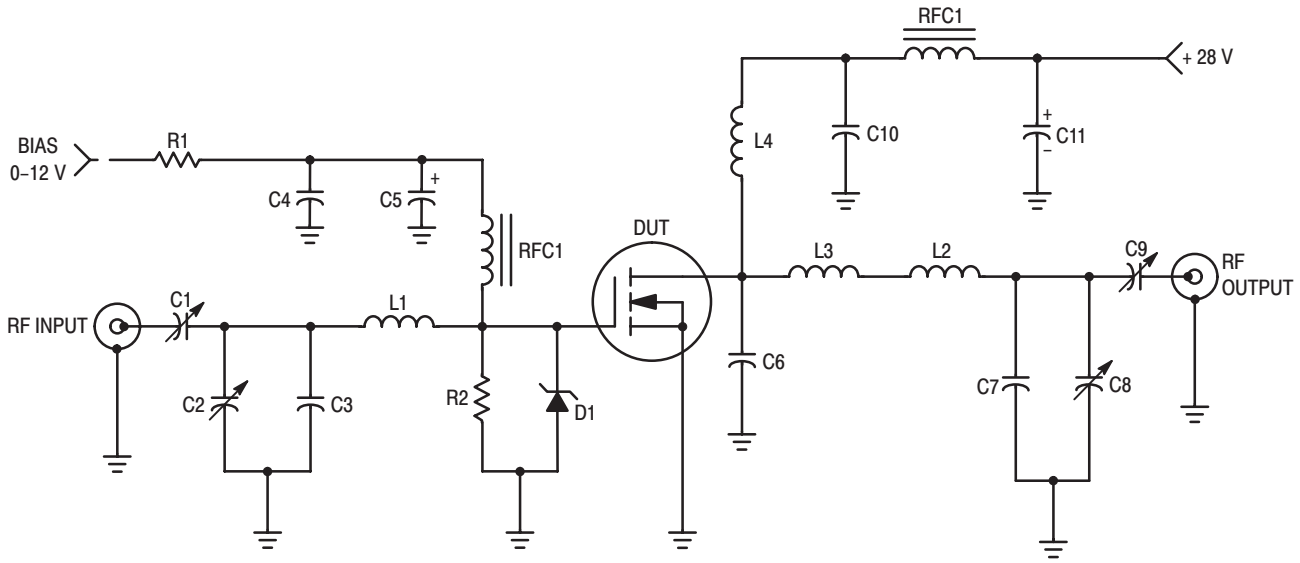


Figure 6. Gate Voltage versus Drain Current



NOTE: Gate Shunted by 25 Ohms.

Figure 7. Series Equivalent Impedance



C1, C2, C8 — Arco 463 or equivalent
C3 — 25 pF, Unelco
C4 — 0.1 µF, Ceramic
C5 — 1.0 µF, 15 WV Tantalum
C6 — 15 pF, Unelco J101
C7 — 25 pF, Unelco J101
C9 — Arco 262 or equivalent
C10 — 0.05 µF, Ceramic
C11 — 15 µF, 35 WV Electrolytic
L1 — 3/4″, #18 AWG into Hairpin
L2 — Printed Line, 0.200″ x 0.500″
L3 — 7/8″, #16 AWG into Hairpin
L4 — 2 Turns, #16 AWG, 5/16 ID
RFC1 — 5.6 µH, Molded Choke
RFC2 — VK200–4B
R1, R2 — 150 Ω, 1.0 W Carbon

Figure 8. 150 MHz Test Circuit (Class AB)

Table 1. Common Source S–Parameters (V_{DS} = 28 V, I_D = 5 A)

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
30	0.957	180	1.88	86	0.008	22	0.938	–178
40	0.956	180	1.46	81	0.010	23	0.940	179
50	0.956	180	1.17	78	0.012	33	0.936	179
60	0.956	179	1.00	76	0.013	44	0.936	177
70	0.957	179	0.86	73	0.012	54	0.960	177
80	0.957	179	0.73	72	0.010	53	0.970	179
90	0.957	179	0.64	71	0.011	45	0.952	180
100	0.957	178	0.58	67	0.015	44	0.934	178
110	0.956	178	0.55	64	0.018	53	0.947	176
120	0.957	178	0.48	64	0.019	67	0.961	177
130	0.957	178	0.43	61	0.017	75	0.973	178
140	0.958	177	0.41	60	0.016	73	0.964	178
150	0.958	177	0.37	59	0.017	60	0.978	179
160	0.957	177	0.36	56	0.023	58	0.934	178
170	0.959	177	0.34	54	0.026	67	0.923	176
180	0.958	177	0.31	51	0.028	75	0.974	175
190	0.958	176	0.30	53	0.026	82	0.986	175
200	0.959	176	0.27	52	0.024	77	0.986	176
210	0.958	176	0.27	54	0.026	67	0.988	177
220	0.960	176	0.28	52	0.032	67	0.951	175
230	0.962	176	0.24	45	0.039	70	1.020	172
240	0.960	176	0.24	44	0.038	76	0.988	171
250	0.962	175	0.21	47	0.038	81	0.980	175
260	0.962	175	0.21	44	0.036	77	0.994	175
270	0.960	175	0.20	44	0.038	72	0.980	173
280	0.963	175	0.20	43	0.043	71	0.962	172
290	0.964	175	0.19	40	0.046	74	0.952	170
300	0.965	175	0.20	42	0.049	78	0.945	170
310	0.966	174	0.18	42	0.046	79	1.010	172
320	0.963	174	0.18	45	0.049	74	0.971	170
330	0.964	174	0.16	42	0.053	74	0.930	170
340	0.966	174	0.18	46	0.055	71	0.947	169

Table 1. Common Source S–Parameters (V_{DS} = 28 V, I_D = 5 A) continued

f	S_{11}		S_{21}		S_{12}		S_{22}	
MHz	$\|S_{11}\|$	$\angle\phi$	$\|S_{21}\|$	$\angle\phi$	$\|S_{12}\|$	$\angle\phi$	$\|S_{22}\|$	$\angle\phi$
350	0.965	174	0.17	43	0.059	74	0.964	169
360	0.967	173	0.16	43	0.061	74	1.010	167
370	0.968	173	0.15	43	0.063	70	1.010	167
380	0.967	173	0.16	41	0.065	70	0.952	168
390	0.968	173	0.16	45	0.068	72	0.970	168
400	0.968	172	0.15	42	0.069	77	0.957	170
410	0.967	172	0.15	44	0.070	72	1.000	165
420	0.969	172	0.14	43	0.070	68	0.986	164
430	0.968	172	0.13	45	0.078	65	0.980	166
440	0.968	171	0.14	47	0.086	68	0.953	166
450	0.969	171	0.15	45	0.087	74	0.981	166
460	0.968	171	0.14	48	0.076	73	0.971	163
470	0.965	171	0.13	41	0.046	75	0.980	163
480	0.958	170	0.13	40	0.017	115	1.050	162
490	0.954	170	0.13	37	0.041	113	1.050	163
500	0.956	170	0.13	35	0.070	74	1.040	162

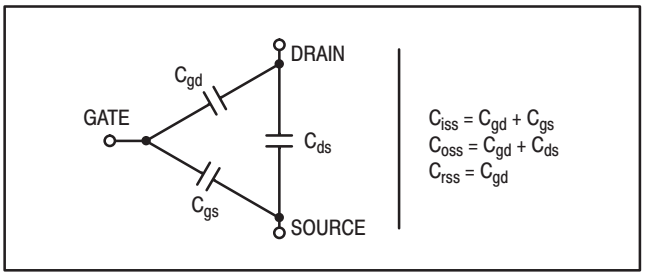
RF POWER MOSFET CONSIDERATIONS

MOSFET CAPACITANCES

The physical structure of a MOSFET results in capacitors between the terminals. The metal oxide gate structure determines the capacitors from gate–to–drain (C_{gd}), and gate–to–source (C_{gs}). The PN junction formed during the fabrication of the RF MOSFET results in a junction capacitance from drain–to–source (C_{ds}).

These capacitances are characterized as input (C_{iss}), output (C_{oss}) and reverse transfer (C_{rss}) capacitances on data sheets. The relationships between the inter–terminal capacitances and those given on data sheets are shown below. The C_{iss} can be specified in two ways:

1. Drain shorted to source and positive voltage at the gate.
2. Positive voltage of the drain in respect to source and zero volts at the gate. In the latter case the numbers are lower. However, neither method represents the actual operating conditions in RF applications.



LINEARITY AND GAIN CHARACTERISTICS

In addition to the typical IMD and power gain data presented, Figure 5 may give the designer additional information on the capabilities of this device. The graph represents the small signal unity current gain frequency at a given drain current level. This is equivalent to f_T for bipolar transistors. Since this test is performed at a fast sweep speed, heating of the device does not occur. Thus, in normal use, the higher temperatures may degrade these characteristics to some extent.

DRAIN CHARACTERISTICS

One figure of merit for a FET is its static resistance in the full–on condition. This on–resistance, $V_{DS(on)}$, occurs in the linear region of the output characteristic and is specified under specific test conditions for gate–source voltage and drain current. For MOSFETs, $V_{DS(on)}$ has a positive temperature coefficient and constitutes an important design consideration at high temperatures, because it contributes to the power dissipation within the device.

GATE CHARACTERISTICS

The gate of the RF MOSFET is a polysilicon material, and is electrically isolated from the source by a layer of oxide. The input resistance is very high — on the order of 10^9 ohms — resulting in a leakage current of a few nanoamperes.

Gate control is achieved by applying a positive voltage slightly in excess of the gate–to–source threshold voltage, $V_{GS(th)}$.

Gate Voltage Rating — Never exceed the gate voltage rating. Exceeding the rated V_{GS} can result in permanent damage to the oxide layer in the gate region.

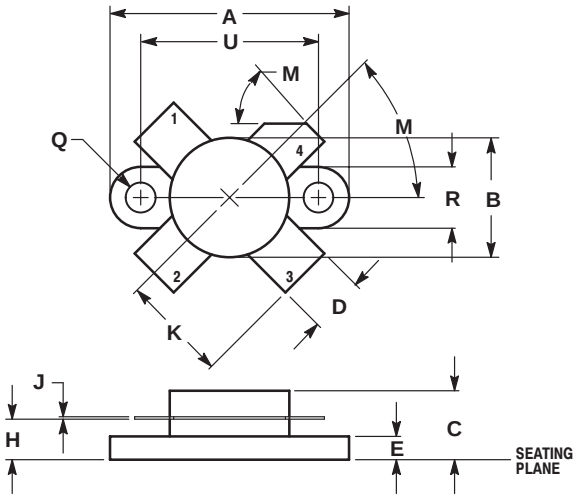
Gate Termination — The gates of these devices are essentially capacitors. Circuits that leave the gate open–circuited or floating should be avoided. These conditions can result in turn–on of the devices due to voltage build–up on the input capacitor due to leakage currents or pickup.

Gate Protection — These devices do not have an internal monolithic zener diode from gate–to–source. If gate protection is required, an external zener diode is recommended.

EQUIVALENT TRANSISTOR PARAMETER TERMINOLOGY

Collector	Drain
Emitter	Source
Base	Gate
$V_{(BR)CES}$	$V_{(BR)DSS}$
V_{CBO}	V_{DGO}
I_C	I_D
I_{CES}	I_{DSS}
I_{EBO}	I_{GSS}
$V_{BE(on)}$	$V_{GS(th)}$
$V_{CE(sat)}$	$V_{DS(on)}$
C_{ib}	C_{iss}
C_{ob}	C_{oss}
h_{fe}	g_{fs}
$R_{CE(sat)} = \frac{V_{CE(sat)}}{I_C}$	$r_{DS(on)} = \frac{V_{DS(on)}}{I_D}$

PACKAGE DIMENSIONS



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

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.960	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 2:
PIN 1. SOURCE
2. GATE
3. SOURCE
4. DRAIN

CASE 211–11
ISSUE N

Specifications subject to change without notice.

- **North America:** Tel. (800) 366-2266, Fax (800) 618-8883
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