RoHS

RF Power Field Effect Transistor

N-Channel Enhancement-Mode Lateral MOSFET

MRF9060LR1

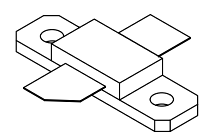
**945 MHz, 60 W, 26 V
LATERAL N-CHANNEL
BROADBAND
RF POWER MOSFET**

Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of this device make it ideal for large-signal, common-source amplifier applications in 26 volt base station equipment.

- Typical Two-Tone Performance at 945 MHz, 26 Volts
  - Output Power — 60 Watts PEP
  - Power Gain — 17 dB
  - Efficiency — 40%
  - IMD — -31 dBc
- Capable of Handling 10:1 VSWR, @ 26 Vdc, 945 MHz, 60 Watts CW Output Power

Features

- Integrated ESD Protection
- Designed for Maximum Gain and Insertion Phase Flatness
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Low Gold Plating Thickness on Leads. L Suffix Indicates 40μ″ Nominal.
- RoHS Compliant
- In Tape and Reel. R1 Suffix = 500 Units per 32 mm, 13 inch Reel.



**CASE 360B-05, STYLE 1
NI-360**

Table 1. Maximum Ratings

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	- 0.5, +65	Vdc
Gate-Source Voltage	V_{GS}	- 0.5, +15	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	159 0.91	W W/°C
Storage Temperature Range	T_{stg}	- 65 to +150	°C
Case Operating Temperature	T_C	150	°C
Operating Junction Temperature	T_J	200	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (1)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.1	°C/W

Table 3. ESD Protection Characteristics

Test Conditions	Class
Human Body Model	1 (Minimum)
Machine Model	M1 (Minimum)

1. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

Table 4. Electrical Characteristics (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 65 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 26 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 200 μAdc)	$V_{GS(th)}$	2	2.9	4	Vdc
Gate Quiescent Voltage (V_{DS} = 26 Vdc, I_D = 450 mAdc)	$V_{GS(Q)}$	—	3.7	—	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1.3 Adc)	$V_{DS(on)}$	—	0.17	0.4	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 4 Adc)	g_{fs}	—	5.3	—	S
Dynamic Characteristics					
Input Capacitance (V_{DS} = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{iss}	—	98	—	pF
Output Capacitance (V_{DS} = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	50	—	pF
Reverse Transfer Capacitance (V_{DS} = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2	—	pF

(continued)

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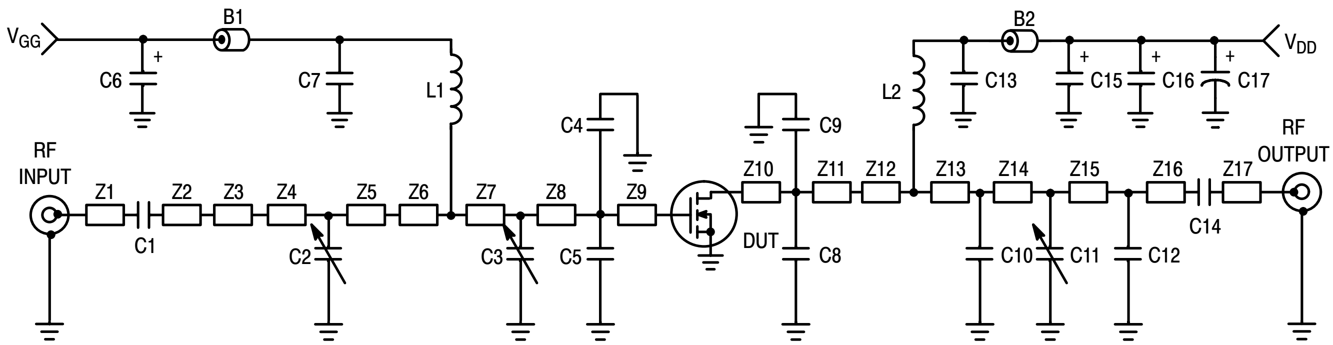
Table 4. Electrical Characteristics (T_C = 25°C unless otherwise noted) **(continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
Functional Tests (In Freescale Test Fixture, 50 ohm system)					
Two-Tone Common-Source Amplifier Power Gain (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	G_{ps}	16	17	—	dB
Two-Tone Drain Efficiency (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	η	36	40	—	%
3rd Order Intermodulation Distortion (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	IMD	—	-31	-28	dBc
Input Return Loss (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	IRL	—	-16	-9	dB
Two-Tone Common-Source Amplifier Power Gain (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	G_{ps}	—	17	—	dB
Two-Tone Drain Efficiency (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	η	—	39	—	%
3rd Order Intermodulation Distortion (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	IMD	—	-31	—	dBc
Input Return Loss (V_{DD} = 26 Vdc, P_{out} = 60 W PEP, I_{DQ} = 450 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	IRL	—	-16	—	dB
Power Output, 1 dB Compression Point (V_{DD} = 26 Vdc, P_{out} = 60 W CW, I_{DQ} = 450 mA, f1 = 945.0 MHz)	P_{1dB}	—	70	—	W
Common-Source Amplifier Power Gain (V_{DD} = 26 Vdc, P_{out} = 60 W CW, I_{DQ} = 450 mA, f1 = 945.0 MHz)	G_{ps}	—	17	—	dB
Drain Efficiency (V_{DD} = 26 Vdc, P_{out} = 60 W CW, I_{DQ} = 450 mA, f1 = 945.0 MHz)	η	—	51	—	%



Z1	0.240″ x 0.060″ Microstrip	Z10	0.360″ x 0.270″ Microstrip
Z2	0.240″ x 0.060″ Microstrip	Z11	0.060″ x 0.270″ Microstrip
Z3	0.500″ x 0.100″ Microstrip	Z12	0.110″ x 0.060″ Microstrip
Z4	0.180″ x 0.270″ Microstrip	Z13	0.330″ x 0.060″ Microstrip
Z5	0.350″ x 0.270″ Microstrip	Z14	0.230″ x 0.060″ Microstrip
Z6	0.270″ x 0.520 x 0.140″ Taper	Z15	0.740″ x 0.060″ Microstrip
Z7	0.170″ x 0.520″ Microstrip	Z16	0.130″ x 0.060″ Microstrip
Z8	0.410″ x 0.520″ Microstrip	Z17	0.340″ x 0.060″ Microstrip
Z9	0.060″ x 0.520″ Microstrip	PCB	Taconic RF-35-0300, 30 mil, ε_r = 3.55

Figure 1. 945 MHz Broadband Test Circuit Schematic

Table 5. 945 MHz Broadband Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Short Ferrite Bead	2743019447	Fair-Rite
B2	Long Ferrite Bead	2743029446	Fair-Rite
C1, C7, C13, C14	47 pF Chip Capacitors	ATC100B470JT500XT	ATC
C2, C3, C11	0.8-8.0 Gigatrim Variable Capacitors	27291SL	Johanson
C4, C5, C8, C9	10 pF Chip Capacitors	ATC100B100JT500XT	ATC
C6, C15, C16	10 μF, 35 V Tantalum Chip Capacitor	T491D106K035AT	Kemet
C10	3.0 pF Chip Capacitor	ATC100B3R0JT500XT	ATC
C12	0.5 pF Chip Capacitor (MRF9060) 0.7 pF Chip Capacitor (MRF9060S)	ATC100B0R5BT500XT ATC100B0R7BT500XT	ATC ATC
C17	220 μF Electrolytic Chip Capacitor	MCAX63V227M13X22	Multicomp
L1, L2	12.5 nH Inductors	A04T-5	Coilcraft

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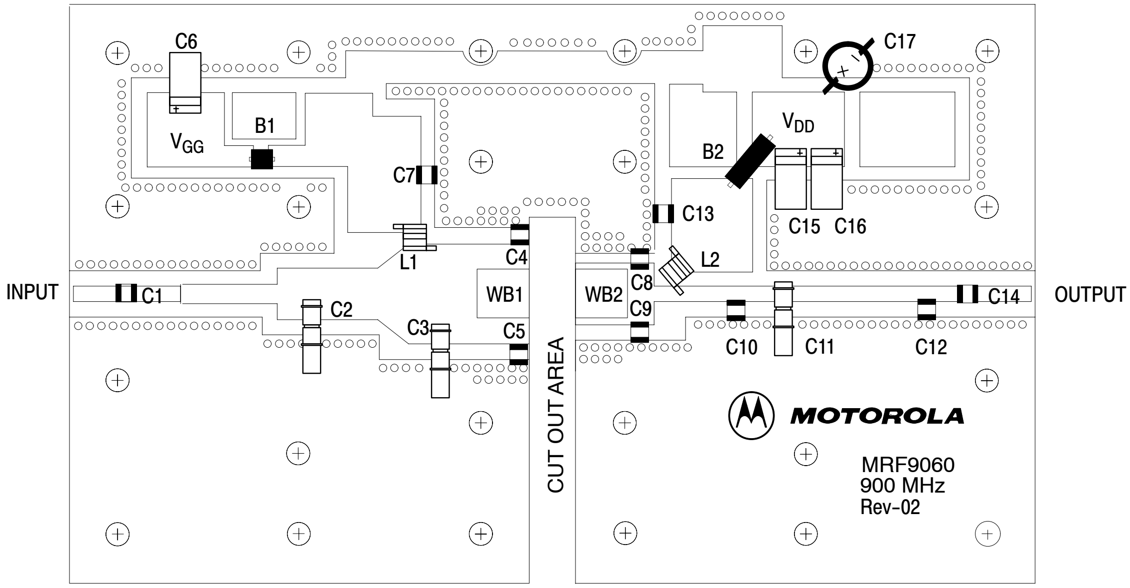

Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

Figure 2. 930 - 960 MHz Broadband Test Circuit Component Layout

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TYPICAL CHARACTERISTICS

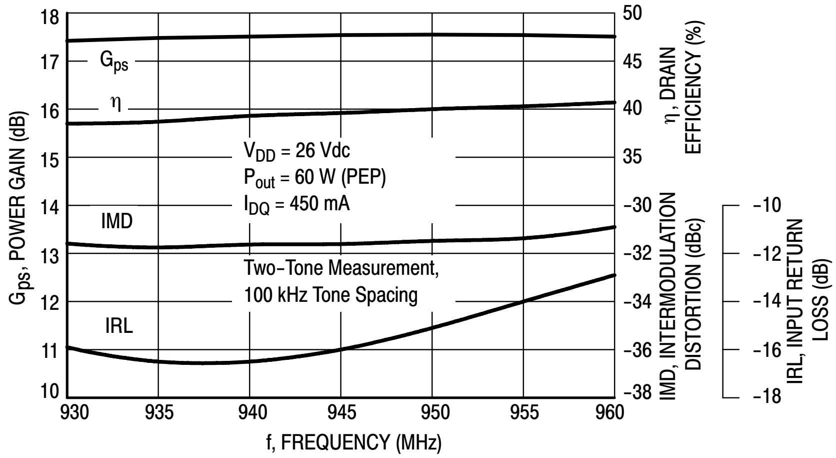

Figure 3. Class AB Broadband Circuit Performance

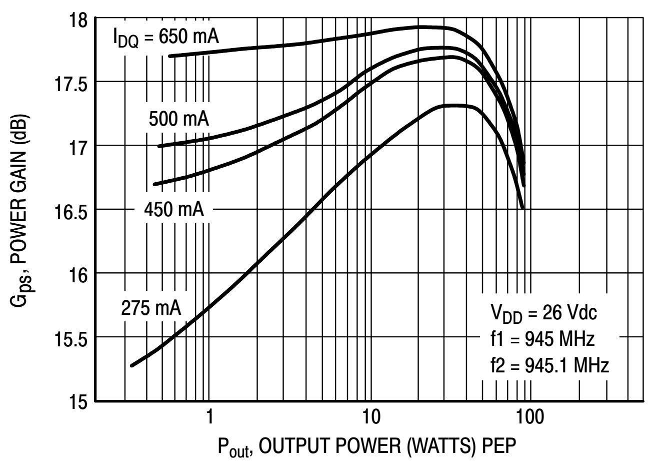

Figure 4. Power Gain versus Output Power

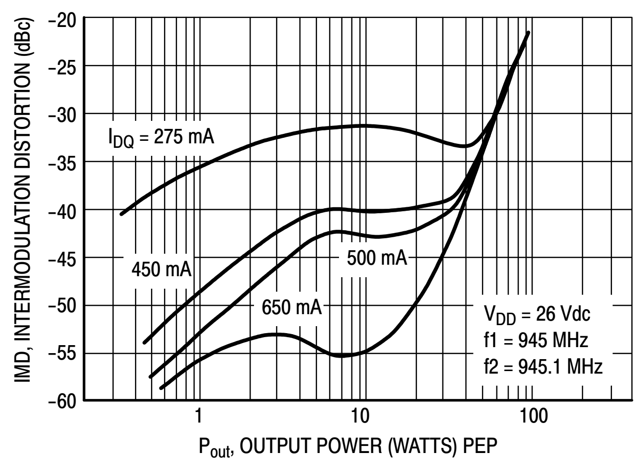

Figure 5. Intermodulation Distortion versus Output Power

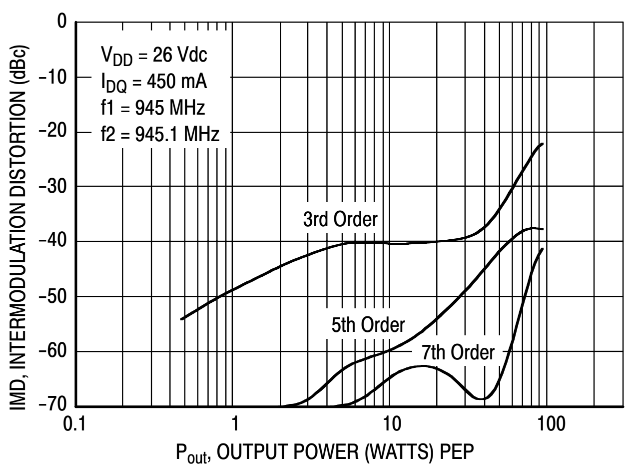

Figure 6. Intermodulation Distortion Products versus Output Power

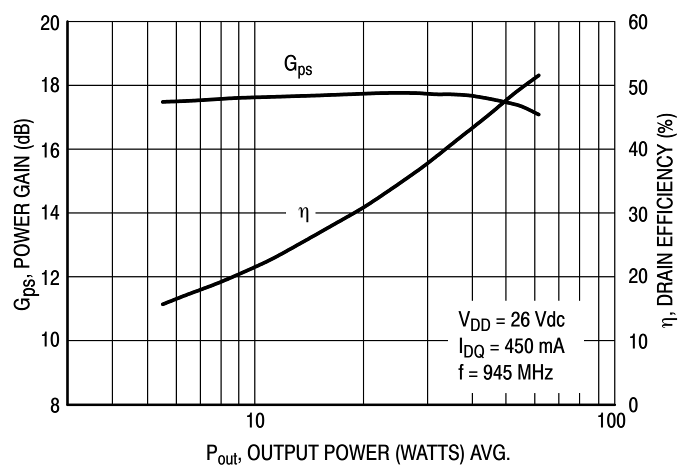

Figure 7. Power Gain and Efficiency versus Output Power

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TYPICAL CHARACTERISTICS

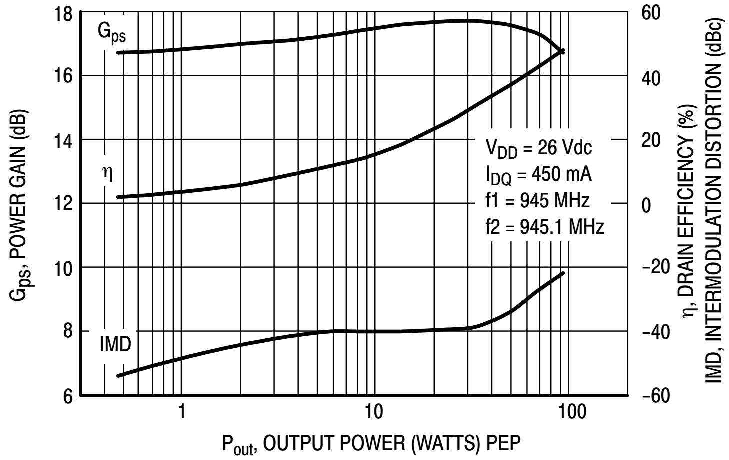
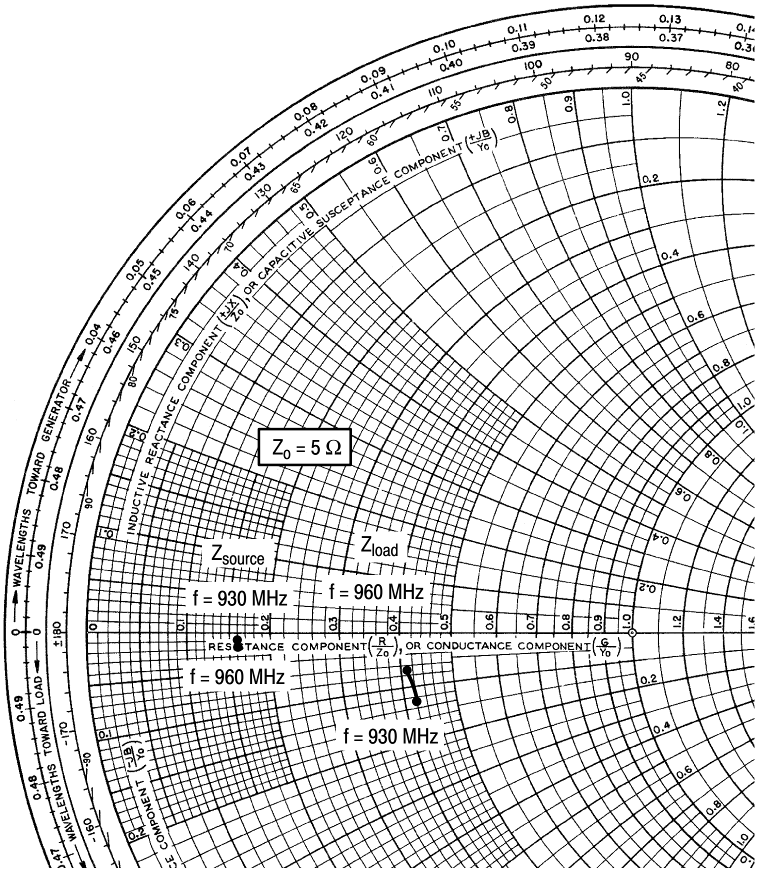


Figure 8. Power Gain, Efficiency, and IMD versus Output Power



V_{DD} = 26 V, I_{DQ} = 450 mA, P_{out} = 60 W PEP

f MHz	Z_{source} Ω	Z_{load} Ω
930	0.80 - j0.10	2.08 - j0.65
945	0.80 - j0.05	2.07 - j0.38
960	0.81 - j0.10	2.04 - j0.37

Z_{source} = Test circuit impedance as measured from gate to ground.

Z_{load} = Test circuit impedance as measured from drain to ground.

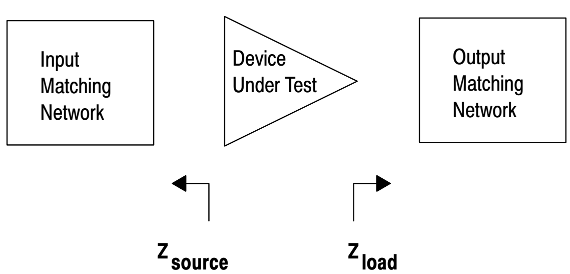


Figure 9. Series Equivalent Source and Load Impedance

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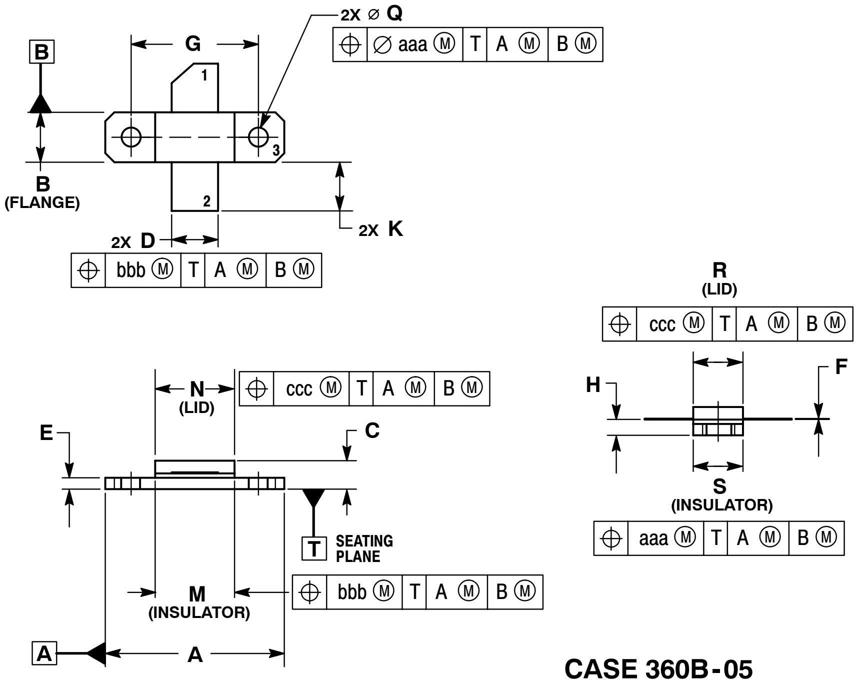
PACKAGE DIMENSIONS



NOTES:
1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.795	0.805	20.19	20.45
B	0.225	0.235	5.72	5.97
C	0.125	0.175	3.18	4.45
D	0.210	0.220	5.33	5.59
E	0.055	0.065	1.40	1.65
F	0.004	0.006	0.10	0.15
G	0.562 BSC		14.28 BSC	
H	0.077	0.087	1.96	2.21
K	0.220	0.250	5.59	6.35
M	0.355	0.365	9.02	9.27
N	0.357	0.363	9.07	9.22
Q	0.125	0.135	3.18	3.43
R	0.227	0.233	5.77	5.92
S	0.225	0.235	5.72	5.97
aaa	0.005 REF		0.13 REF	
bbb	0.010 REF		0.25 REF	
ccc	0.015 REF		0.38 REF	

STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 360B-05
ISSUE G
NI-360
MRF9060LR1

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PRODUCT DOCUMENTATION

Refer to the following documents to aid your design process.

Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
11	Sept. 2008	• Data sheet revised to reflect part status change, p. 1, including use of applicable overlay. • Updated Part Numbers in Table 5, Component Designations and Values, to RoHS compliant part numbers, p. 4 • Added Product Documentation and Revision History, p. 10

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