

The RF Sub-Micron MOSFET Line

RF Power Field Effect Transistors

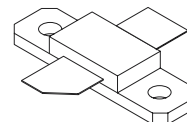
N-Channel Enhancement-Mode Lateral MOSFETs

Designed for broadband commercial and industrial applications with frequencies up to 1.0 GHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 26 volt base station equipment.

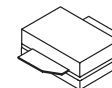
- Typical Two-Tone Performance at 945 MHz, 26 Volts
 - Output Power — 60 Watts PEP
 - Power Gain — 17 dB
 - Efficiency — 40%
 - IMD — -31 dBc
- Integrated ESD Protection
- Designed for Maximum Gain and Insertion Phase Flatness
- Capable of Handling 10:1 VSWR, @ 26 Vdc, 945 MHz, 60 Watts CW Output Power
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- In Tape and Reel. R1 Suffix = 500 Units per 32 mm, 13 inch Reel.

MRF9060R1
MRF9060SR1

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



CASE 360B-05, STYLE 1
NI-360
MRF9060R1



CASE 360C-05, STYLE 1
NI-360S
MRF9060SR1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	65	Vdc
Gate-Source Voltage	V_{GS}	-0.5, +15	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	159 0.91 219 1.25	Watts $\text{W}/^\circ\text{C}$ Watts $\text{W}/^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$
Operating Junction Temperature	T_J	200	$^\circ\text{C}$

ESD PROTECTION CHARACTERISTICS

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

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.1 0.8	$^\circ\text{C}/\text{W}$

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

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 65\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current ($V_{DS} = 26\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$)	I_{DSS}	—	—	1	μAdc
Gate–Source Leakage Current ($V_{GS} = 5\text{ Vdc}$, $V_{DS} = 0\text{ Vdc}$)	I_{GSS}	—	—	1	μAdc

ON CHARACTERISTICS

Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 200\text{ }\mu\text{Adc}$)	$V_{GS(th)}$	2	2.9	4	Vdc
Gate Quiescent Voltage ($V_{DS} = 26\text{ Vdc}$, $I_D = 450\text{ mAdc}$)	$V_{GS(Q)}$	—	3.7	—	Vdc
Drain–Source On–Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 1.3\text{ Adc}$)	$V_{DS(on)}$	—	0.17	0.4	Vdc
Forward Transconductance ($V_{DS} = 10\text{ Vdc}$, $I_D = 4\text{ Adc}$)	g_{fs}	—	5.3	—	S

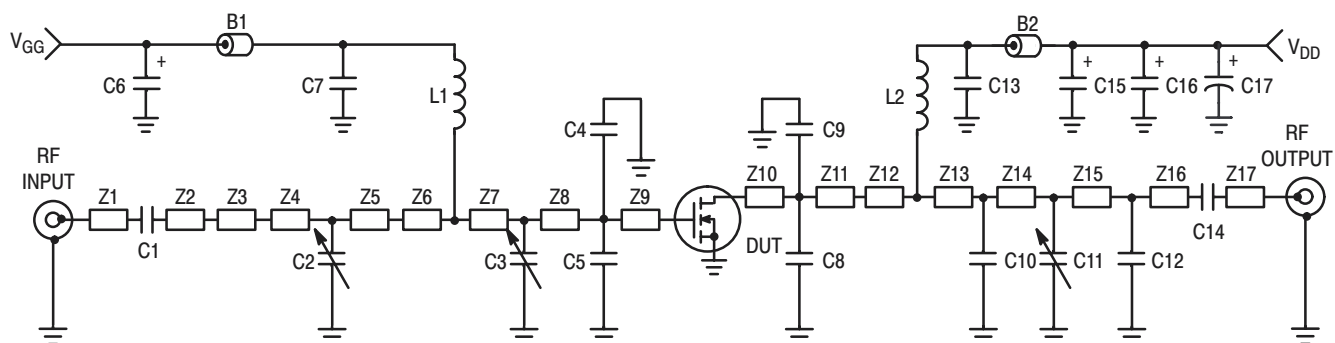
DYNAMIC CHARACTERISTICS

Input Capacitance ($V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{iss}	—	98	—	pF
Output Capacitance ($V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	50	—	pF
Reverse Transfer Capacitance ($V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	2	—	pF

(continued)

ELECTRICAL CHARACTERISTICS — continued ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
FUNCTIONAL TESTS (In Motorola Test Fixture, 50 ohm system)					
Two-Tone Common-Source Amplifier Power Gain ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$, $f_2 = 945.1\text{ MHz}$)	G_{ps}	16	17	—	dB
Two-Tone Drain Efficiency ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$, $f_2 = 945.1\text{ MHz}$)	η	36	40	—	%
3rd Order Intermodulation Distortion ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$, $f_2 = 945.1\text{ MHz}$)	IMD	—	-31	-28	dBc
Input Return Loss ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$, $f_2 = 945.1\text{ MHz}$)	IRL	—	-16	-9	dB
Two-Tone Common-Source Amplifier Power Gain ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 930.0\text{ MHz}$, $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$, $f_2 = 960.1\text{ MHz}$)	G_{ps}	—	17	—	dB
Two-Tone Drain Efficiency ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 930.0\text{ MHz}$, $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$, $f_2 = 960.1\text{ MHz}$)	η	—	39	—	%
3rd Order Intermodulation Distortion ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 930.0\text{ MHz}$, $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$, $f_2 = 960.1\text{ MHz}$)	IMD	—	-31	—	dBc
Input Return Loss ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 930.0\text{ MHz}$, $f_2 = 930.1\text{ MHz}$ and $f_1 = 960.0\text{ MHz}$, $f_2 = 960.1\text{ MHz}$)	IRL	—	-16	—	dB
Power Output, 1 dB Compression Point ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W CW}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$)	P_{1dB}	—	70	—	W
Common-Source Amplifier Power Gain ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W CW}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$)	G_{ps}	—	17	—	dB
Drain Efficiency ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W CW}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$)	η	—	51	—	%
Output Mismatch Stress ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W CW}$, $I_{DQ} = 450\text{ mA}$, $f = 945.0\text{ MHz}$, $V_{SWR} = 10:1$, All Phase Angles at Frequency of Tests)	Ψ	No Degradation In Output Power			



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		

Figure 1. 945 MHz Broadband Test Circuit Schematic

Table 1. 945 MHz Broadband Test Circuit Component Designations and Values

Part	Description	Value, P/N or DWG	Manufacturer
B1	Short Ferrite Bead	95F786	Newark
B2	Long Ferrite Bead	95F787	Newark
C1, C7, C13, C14	47 pF Chip Capacitors, B Case	100B470JP 500X	ATC
C2, C3, C11	0.8–8.0 Gigatrim Variable Capacitors	44F3360	Newark
C4, C5, C8, C9	10 pF Chip Capacitors, B Case	100B100JP 500X	ATC
C6, C15, C16	10 μ F, 35 V Tantalum Chip Capacitor	93F2975	Newark
C10	3.0 pF Chip Capacitor, B Case	100B3R0JP 500X	ATC
C12	0.5 pF Chip Capacitor, B Case (MRF9060) 0.7 pF Chip Capacitor, B Case (MRF9060S)	100B0R5BP 500X 100B0R7BP 500X	ATC ATC
C17	220 μ F Electrolytic Chip Capacitor	14F185	Newark
L1, L2	12.5 nH Inductors	A04T–5	Coilcraft
N1, N2	N–Type Panel Mount, Stripline	3052–1648–10	Avnet
WB1, WB2	10 mil Brass Wear Blocks		
Board Material	30 mil Glass Teflon [®] , $\epsilon_r = 3.55$ Copper Clad, 1 oz Cu	RF–35–0300	Taconic
PCB	Etched Circuit Board	MRF9060 900 MHz, Rev. 2	

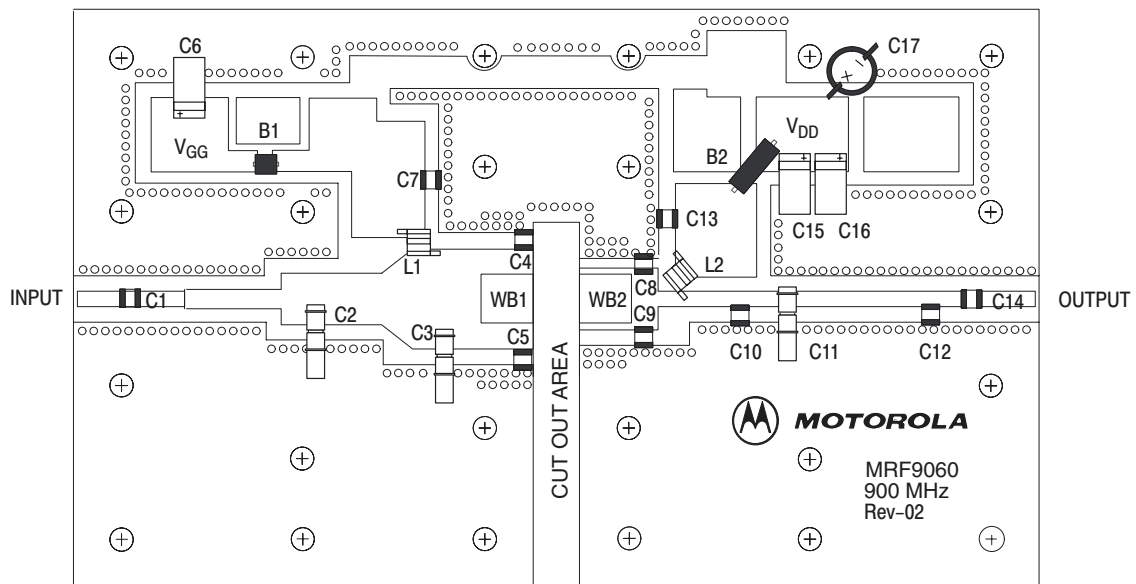


Figure 2. 930 – 960 MHz Broadband Test Circuit Component Layout

TYPICAL CHARACTERISTICS

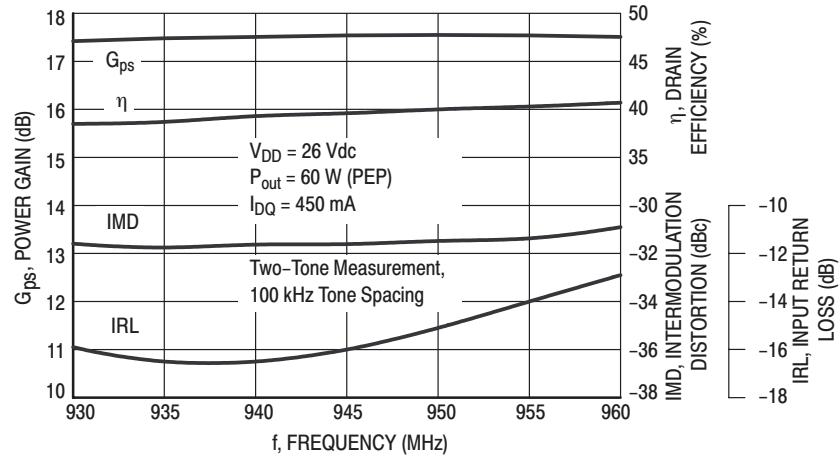


Figure 3. Class AB Broadband Circuit Performance

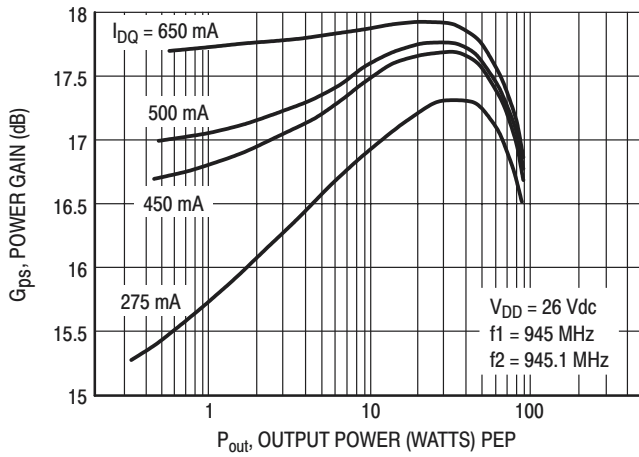


Figure 4. Power Gain versus Output Power

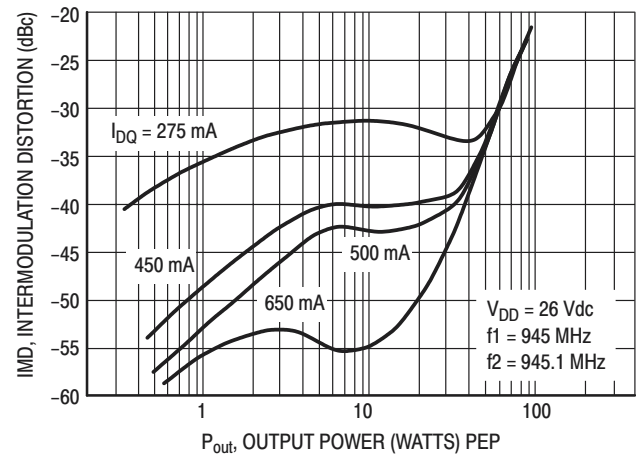


Figure 5. Intermodulation Distortion versus Output Power

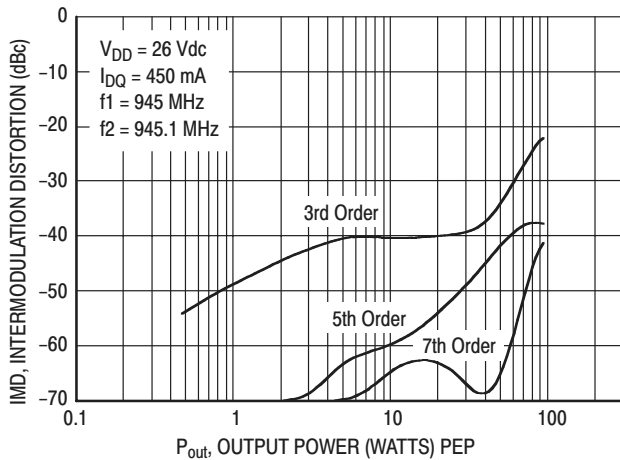


Figure 6. Intermodulation Distortion Products versus Output Power

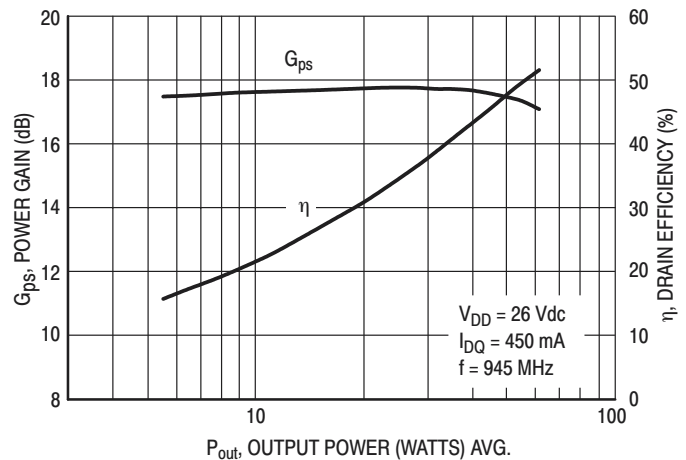


Figure 7. Power Gain and Efficiency versus Output Power

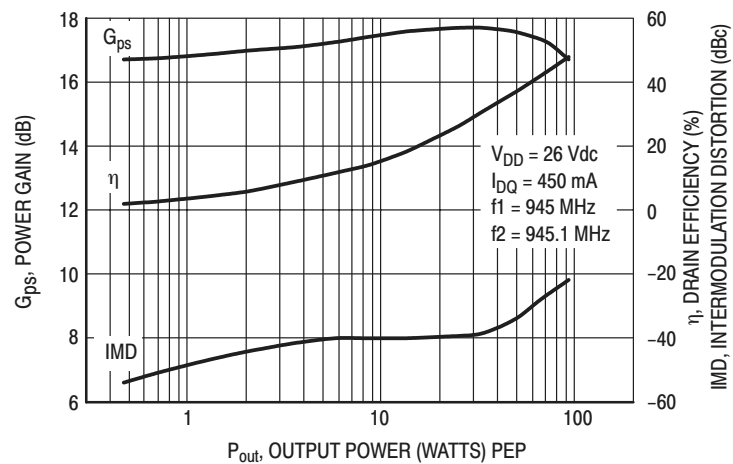
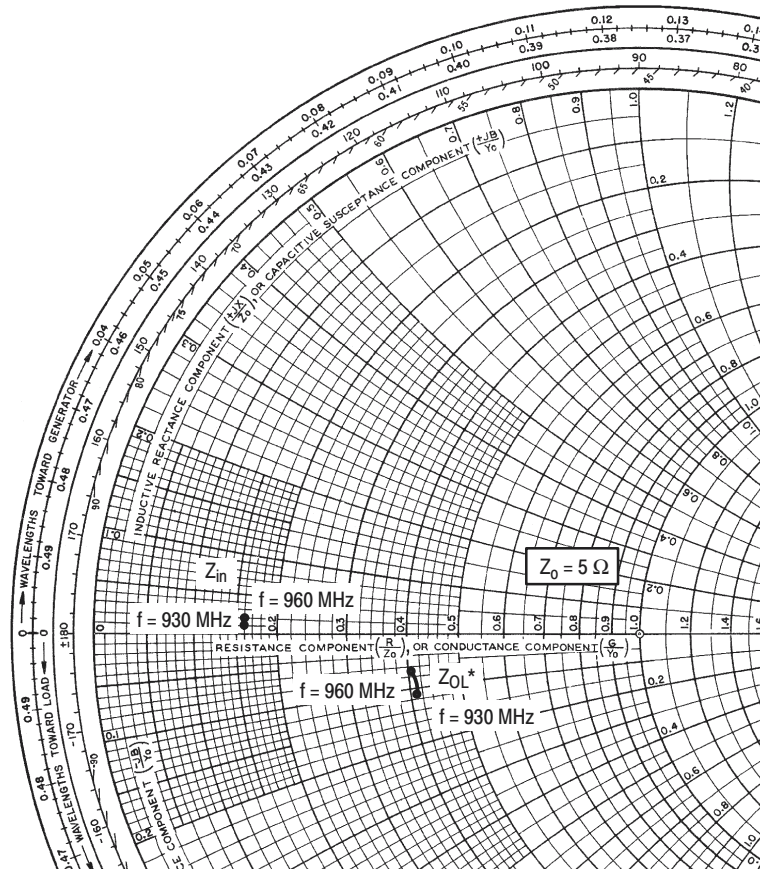


Figure 8. Power Gain, Efficiency, and IMD versus Output Power



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

f MHz	Z_{in} Ω	Z_{OL}^* 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_{in} = Complex conjugate of source impedance.

Z_{OL}^* = Complex conjugate of the optimum load impedance at a given output power, voltage, IMD, bias current and frequency.

Note: Z_{OL}^* was chosen based on tradeoffs between gain, output power, drain efficiency and intermodulation distortion.

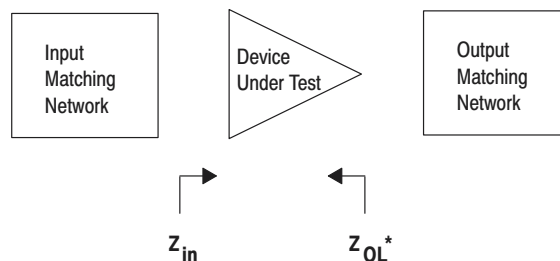
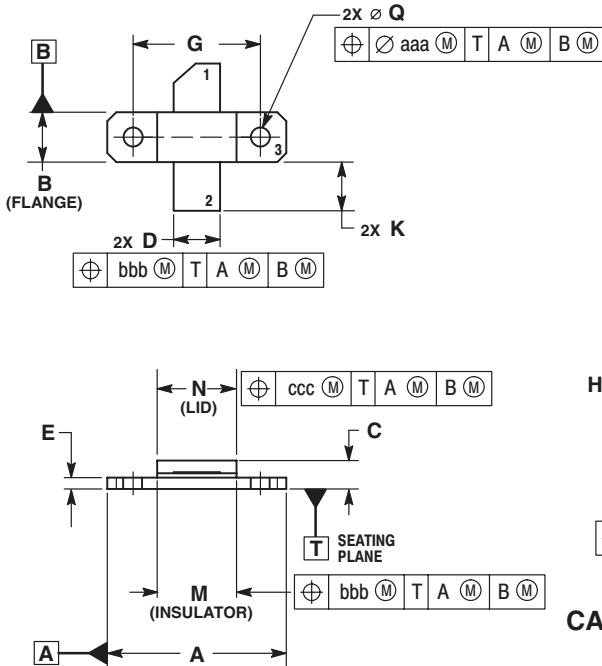


Figure 9. Series Equivalent Input and Output Impedance

NOTES

NOTES

PACKAGE DIMENSIONS



NOTES:

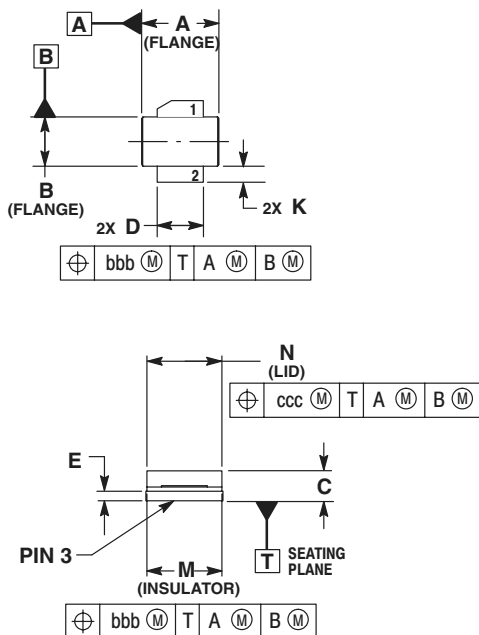
1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

DIM	INCHES		MILLIMETERS	
	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
- GATE
- SOURCE

**CASE 360B-05
ISSUE F
NI-360
MRF9060R1**



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.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.375	0.385	9.53	9.78
B	0.225	0.235	5.72	5.97
C	0.105	0.155	2.67	3.94
D	0.210	0.220	5.33	5.59
E	0.035	0.045	0.89	1.14
F	0.004	0.006	0.10	0.15
H	0.057	0.067	1.45	1.70
K	0.085	0.115	2.16	2.92
M	0.355	0.365	9.02	9.27
N	0.357	0.363	9.07	9.22
R	0.227	0.23	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
- GATE
- SOURCE

**CASE 360C-05
ISSUE D
NI-360S
MRF9060SR1**

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USA/EUROPE/Locations Not Listed: Motorola Literature Distribution; P.O. Box 5405, Denver, Colorado 80217. 1-303-675-2140 or 1-800-441-2447

JAPAN: Motorola Japan Ltd.; SPS, Technical Information Center, 3-20-1, Minami-Azabu. Minato-ku, Tokyo 106-8573 Japan. 81-3-3440-3569

ASIA/PACIFIC: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Centre, 2 Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong. 852-26668334

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