Order this document
by MRF9060/D

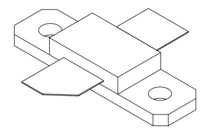
The RF Sub–Micron MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement–Mode Lateral MOSFETs

MRF9060R1
MRF9060SR1

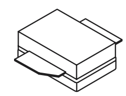
Designed for broadband commercial and industrial applications with frequencies up to 1.0 GHz. The high gain and broadband performance of these devices make them ideal for large–signal, common–source amplifier applications in 26 volt base station equipment.

- 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.

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°C Derate above 25°C	MRF9060R1 MRF9060SR1	P_D	159 0.91 219 1.25	Watts W/°C Watts W/°C
Storage Temperature Range		T_{stg}	–65 to +200	°C
Operating Junction Temperature		T_J	200	°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	MRF9060R1 MRF9060SR1	$R_{\theta JC}$	1.1 0.8	°C/W

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

REV 4

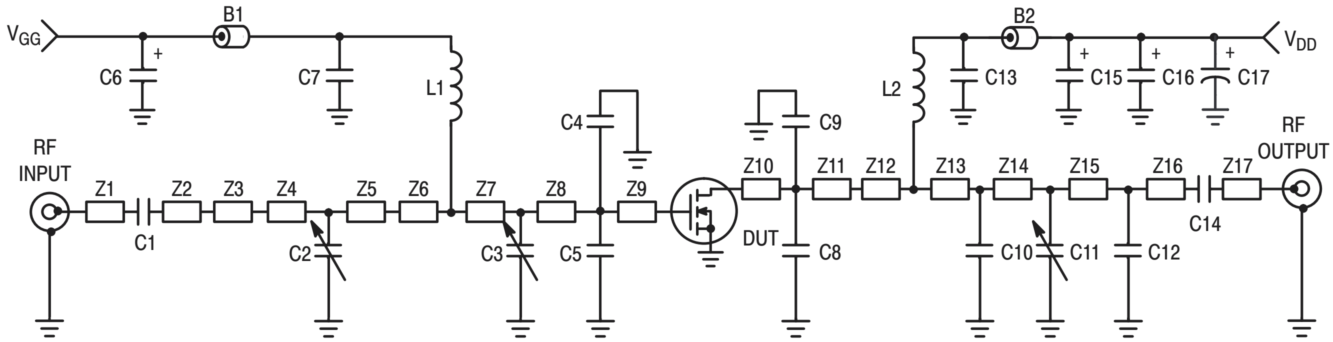
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

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)

ELECTRICAL CHARACTERISTICS — continued (T_C = 25°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 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	—	%
Output Mismatch Stress (V_{DD} = 26 Vdc, P_{out} = 60 W CW, I_{DQ} = 450 mA, f = 945.0 MHz, VSWR = 10:1, All Phase Angles at Frequency of Tests)	Ψ	No Degradation In Output Power			



Z1	0.240″ x 0.060″ Microstrip
Z2	0.240″ x 0.060″ Microstrip
Z3	0.500″ x 0.100″ Microstrip
Z4	0.180″ x 0.270″ Microstrip
Z5	0.350″ x 0.270″ Microstrip
Z6	0.270″ x 0.520 x 0.140″ Taper
Z7	0.170″ x 0.520″ Microstrip
Z8	0.410″ x 0.520″ Microstrip
Z9	0.060″ x 0.520″ Microstrip
Z10	0.360″ x 0.270″ Microstrip
Z11	0.060″ x 0.270″ Microstrip
Z12	0.110″ x 0.060″ Microstrip
Z13	0.330″ x 0.060″ Microstrip
Z14	0.230″ x 0.060″ Microstrip
Z15	0.740″ x 0.060″ Microstrip
Z16	0.130″ x 0.060″ Microstrip
Z17	0.340″ x 0.060″ 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 μF, 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 μF 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®, ε_r = 3.55 Copper Clad, 1 oz Cu	RF–35–0300	Taconic
PCB	Etched Circuit Board	MRF9060 900 MHz, Rev. 2	

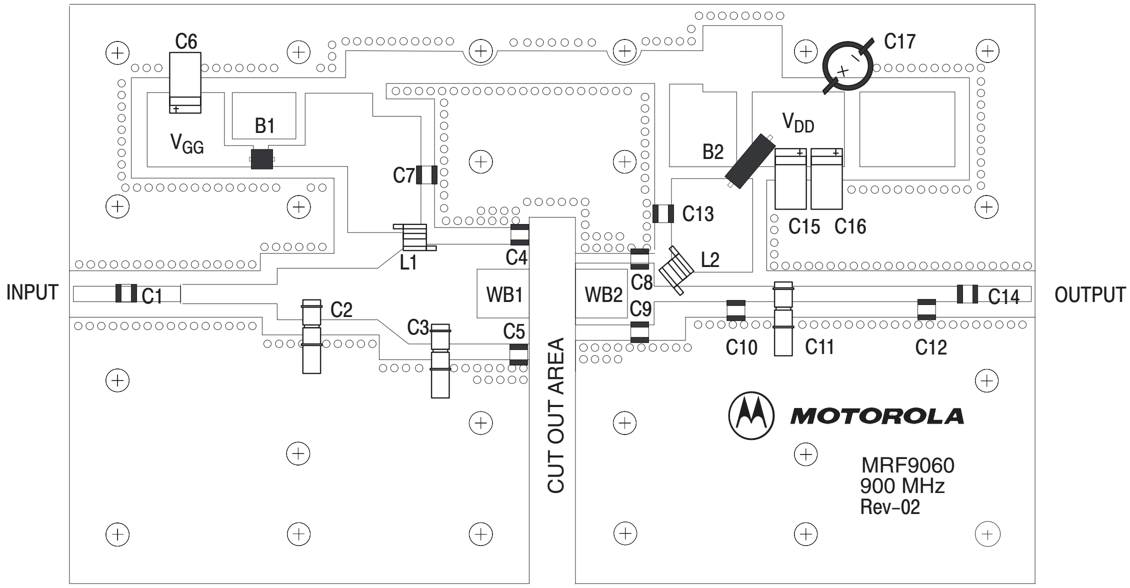


Figure 2. 930 – 960 MHz Broadband Test Circuit Component Layout

TYPICAL CHARACTERISTICS

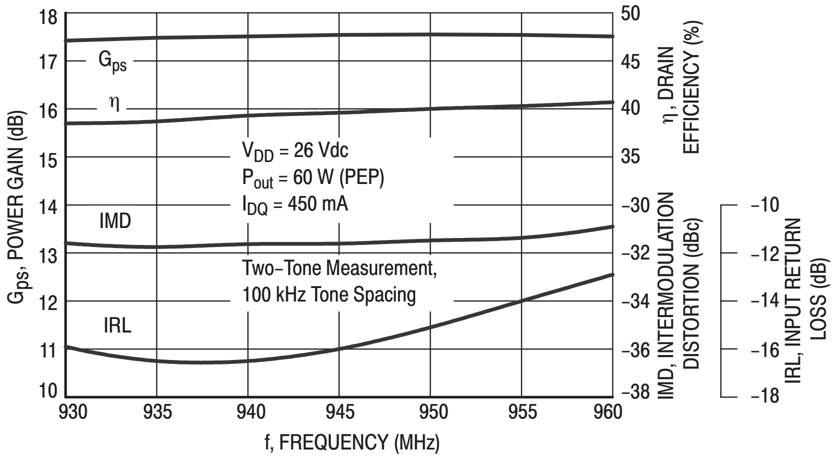


Figure 3. Class AB Broadband Circuit Performance

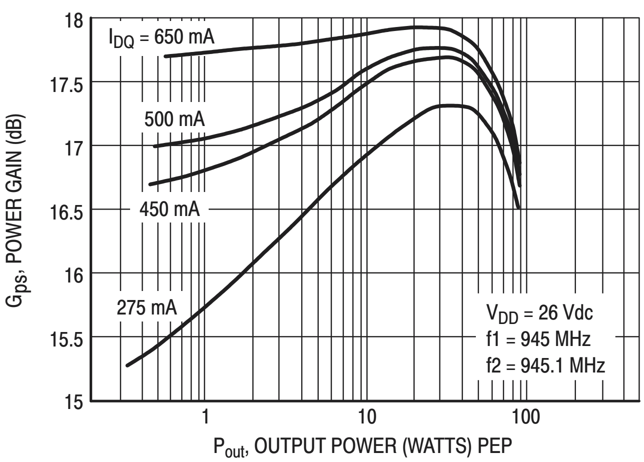


Figure 4. Power Gain versus Output Power

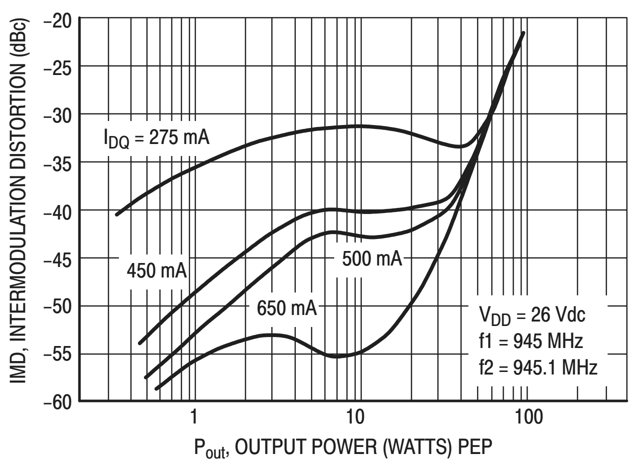


Figure 5. Intermodulation Distortion versus Output Power

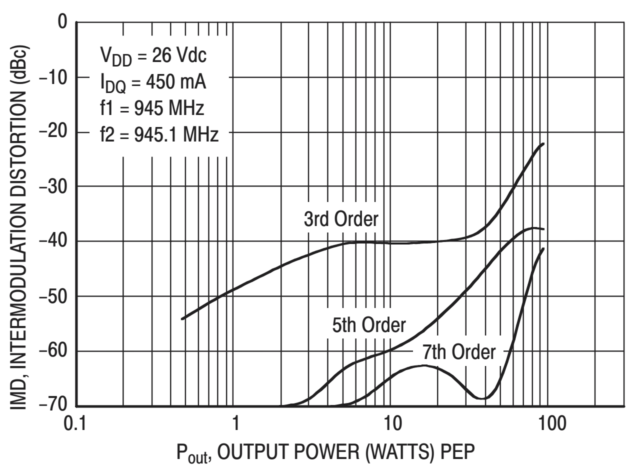


Figure 6. Intermodulation Distortion Products versus Output Power

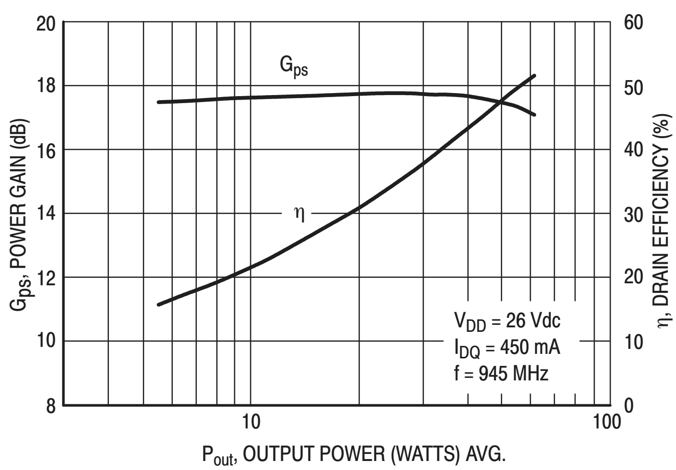


Figure 7. Power Gain and Efficiency versus Output Power

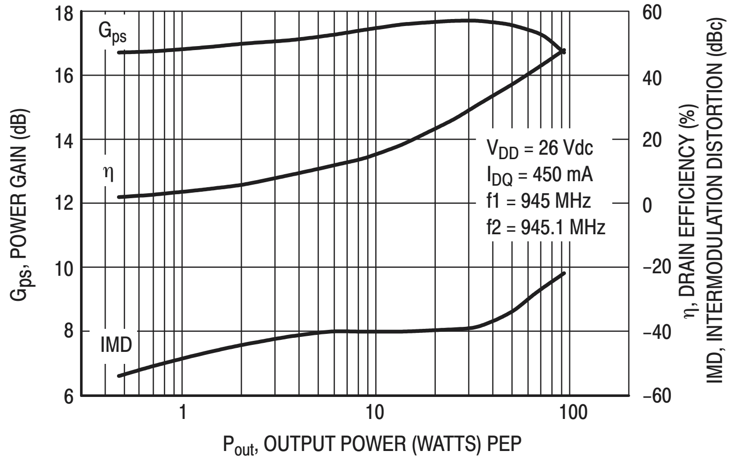
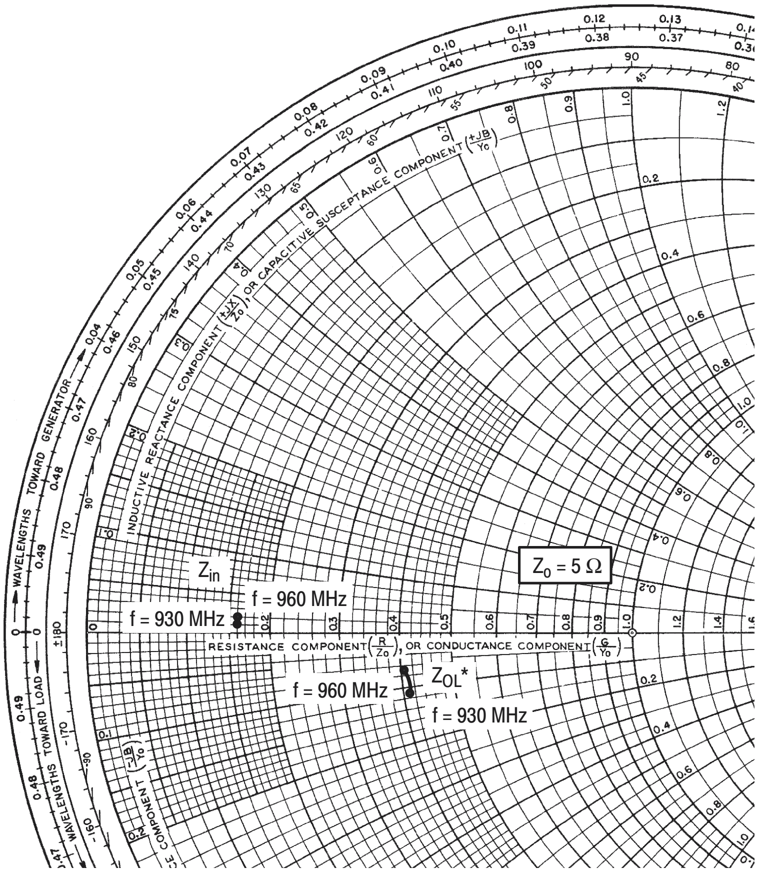


Figure 8. Power Gain, Efficiency, and IMD versus Output Power



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

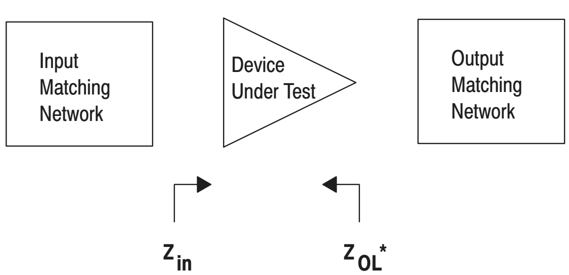
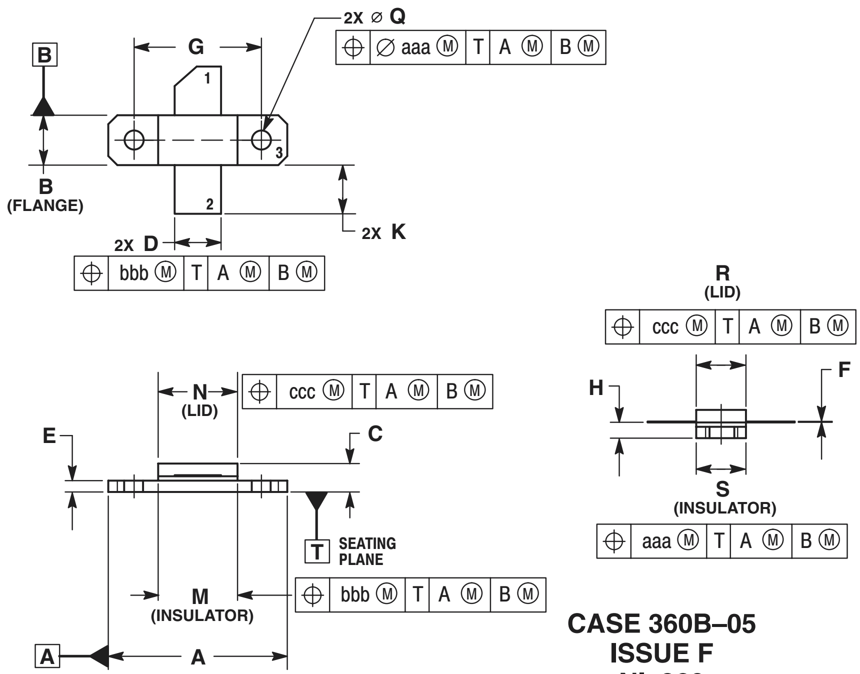


Figure 9. Series Equivalent Input and Output Impedance

NOTES

NOTES

PACKAGE DIMENSIONS

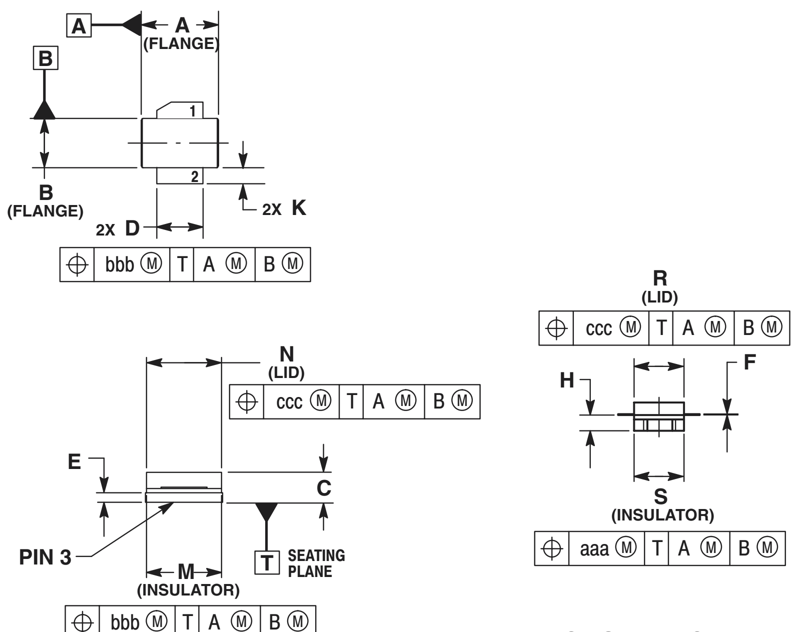


CASE 360B–05
ISSUE F
NI–360
MRF9060R1

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.

	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 360C–05
ISSUE D
NI–360S
MRF9060SR1

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	0.375	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
2. GATE
3. SOURCE

How to reach us:
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

Technical Information Center: 1–800–521–6274

HOME PAGE: http://www.motorola.com/semiconductors/

MOTOROLA