MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

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by MRF9060M/D

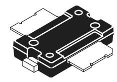
The RF Sub–Micron MOSFET Line
RF Power Field Effect Transistors
N–Channel Enhancement–Mode Lateral MOSFETs

MRF9060MR1
MRF9060MBR1

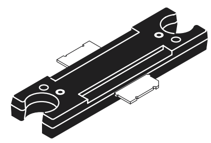
Designed for broadband commercial and industrial applications with frequencies up to 1.0 GHz. The high gain and broadband performance of these devices make them ideal for large–signal, common–source amplifier applications in 26 volt base station equipment.

- Typical Performance at 945 MHz, 26 Volts
  - Output Power — 60 Watts PEP
  - Power Gain — 18.0 dB
  - Efficiency — 40% (Two Tones)
  - IMD — –31.5 dBc
- Integrated ESD Protection
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 945 MHz, 60 Watts CW Output Power
- Excellent Thermal Stability
- Characterized with Series Equivalent Large–Signal Impedance Parameters
- TO–270 Dual Lead Available in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.
- TO–272 Dual Lead Available in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

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



CASE 1265–07, STYLE 1
TO–270 DUAL LEAD
PLASTIC
MRF9060MR1



CASE 1337–01, STYLE 1
TO–272 DUAL LEAD
PLASTIC
MRF9060MBR1

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	P_D	223 1.79	Watts W/°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.56	°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

ESD PROTECTION CHARACTERISTICS

Test Conditions		Class
Human Body Model		1 (Minimum)
Machine Model		M2 (Minimum)
Charge Device Model	MRF9060MR1 MRF9060MBR1	C6 (Minimum) C5 (Minimum)

MOISTURE SENSITIVITY LEVEL

Test Methodology		Rating
Per JESD 22–A113	MRF9060MR1 MRF9060MBR1	1 3

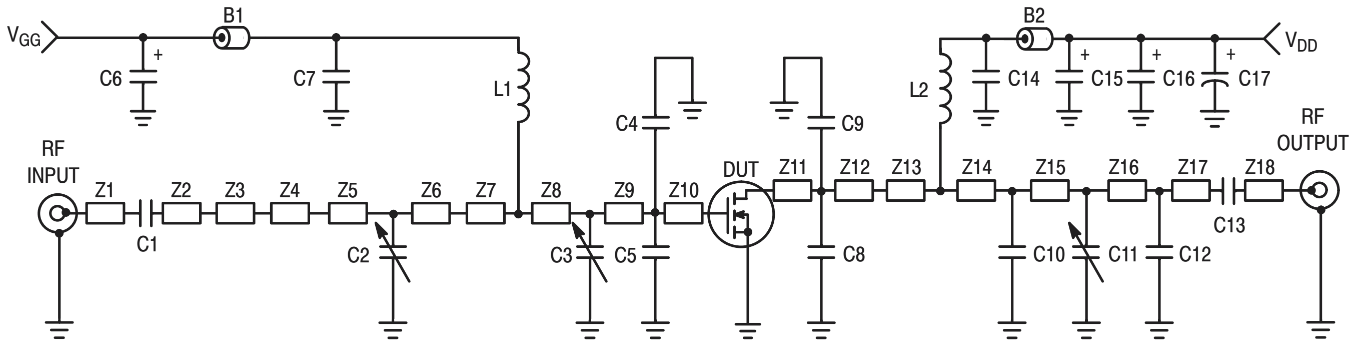
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

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	2.8	4	Vdc
Gate Quiescent Voltage (V_{DS} = 26 Vdc, I_D = 450 mAdc)	$V_{GS(Q)}$	3	3.7	5	Vdc
Drain–Source On–Voltage (V_{GS} = 10 Vdc, I_D = 1.3 Adc)	$V_{DS(on)}$	—	0.21	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}	—	101	—	pF
Output Capacitance (V_{DS} = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	53	—	pF
Reverse Transfer Capacitance (V_{DS} = 26 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	2.5	—	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}	17	18	—	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	37	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	—	–31.5	–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	—	–14.5	–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}	—	18	—	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	—	40	—	%
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	—	–12.5	—	dB



Z1	0.240″ x 0.060″ Microstrip	Z10	0.060″ x 0.520″ Microstrip
Z2	0.240″ x 0.060″ Microstrip	Z11	0.360″ x 0.270″ Microstrip
Z3	0.500″ x 0.100″ Microstrip	Z12	0.060″ x 0.270″ Microstrip
Z4	0.100″ x 0.270″ x 0.080″, Taper	Z13	0.130″ x 0.060″ Microstrip
Z5	0.330″ x 0.270″ Microstrip	Z14	0.300″ x 0.060″ Microstrip
Z6	0.120″ x 0.270″ Microstrip	Z15	0.210″ x 0.060″ Microstrip
Z7	0.270″ x 0.520″ x 0.140″, Taper	Z16	0.600″ x 0.060″ Microstrip
Z8	0.240″ x 0.520″ Microstrip	Z17	0.290″ x 0.060″ Microstrip
Z9	0.340″ x 0.520″ Microstrip	Z18	0.340″ x 0.060″ Microstrip

Figure 1. 930–960 MHz Broadband Test Circuit Schematic

Table 1. 930–960 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	11 pF Chip Capacitors, B Case (MRF9060MR1) 10 pF Chip Capacitors, B Case (MRF9060MBR1)	100B110JP 500X 100B100JP 500X	ATC
C6, C15, C16	10 μF, 35 V Tantalum Chip Capacitors	93F2975	Newark
C8, C9	10 pF Chip Capacitors, B Case	100B100JP 500X	Newark
C10	3.9 pF Chip Capacitor, B Case	100B3R9CP 500X	ATC
C12	1.7 pF Chip Capacitor, B Case	100B1R7BP 500X	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	15 mil Brass Wear Blocks		
Board Material	30 mil Glass Teflon®, ε_r = 2.55 Copper Clad, 2 oz Cu	RF–35–0300	Taconic
PCB	Etched Circuit Board	TO–270/TO–272 Surface/Bolt	DSelectronics

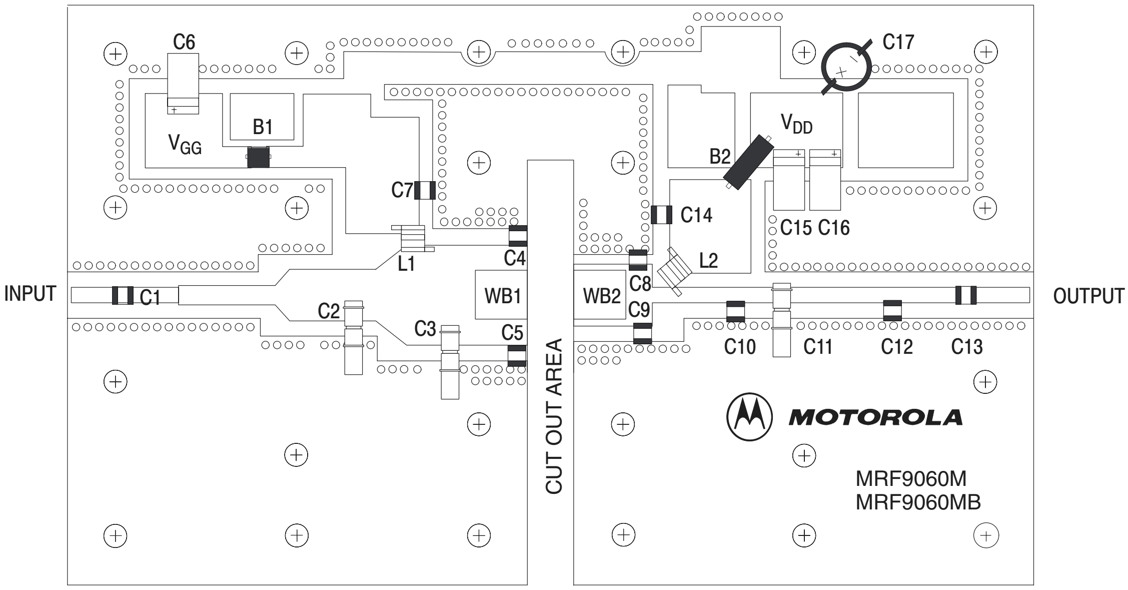


Figure 2. 930–960 MHz Broadband Test Circuit Component Layout

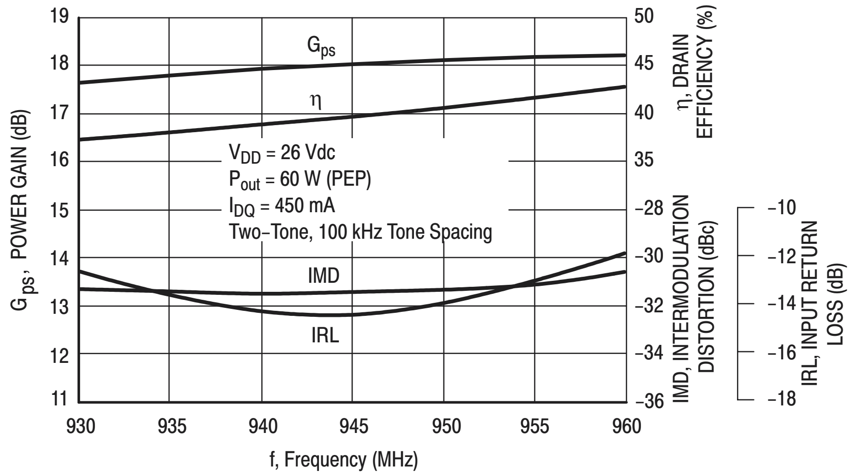


Figure 3. Class AB Broadband Circuit Performance

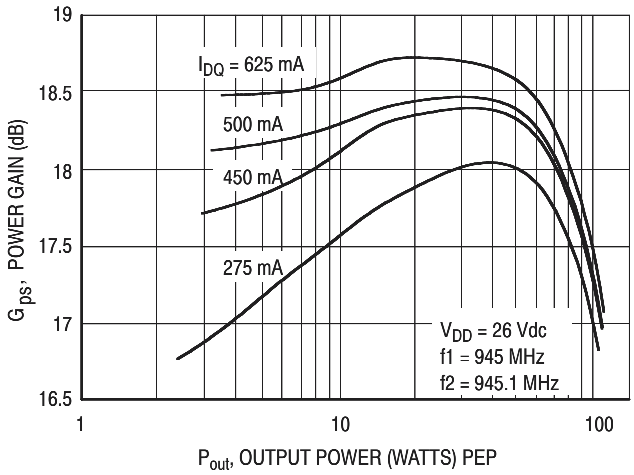


Figure 4. Power Gain versus Output Power

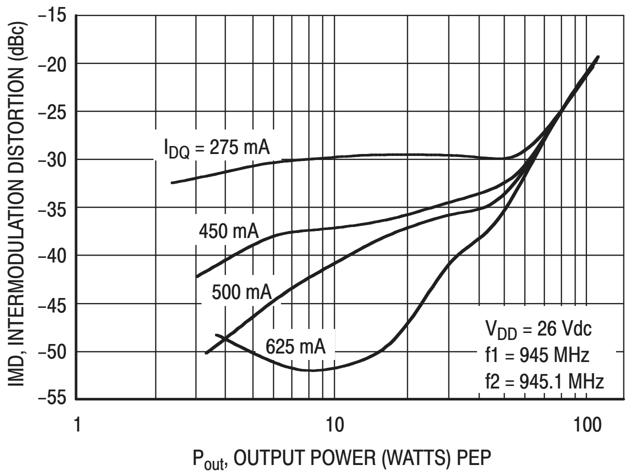


Figure 5. Intermodulation Distortion versus Output Power

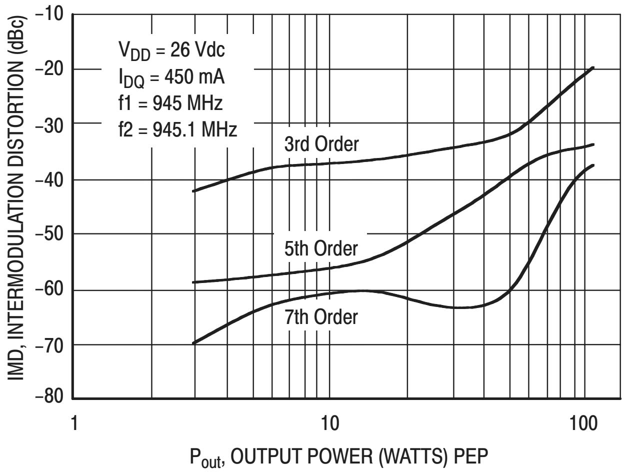


Figure 6. Intermodulation Distortion Products versus Output Power

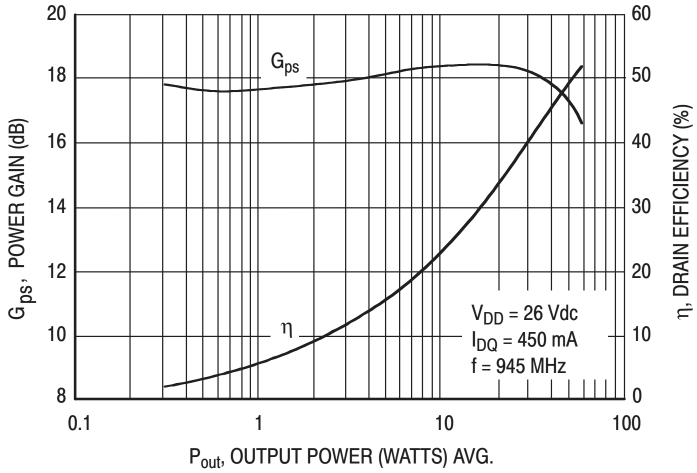


Figure 7. Power Gain and Efficiency versus Output Power

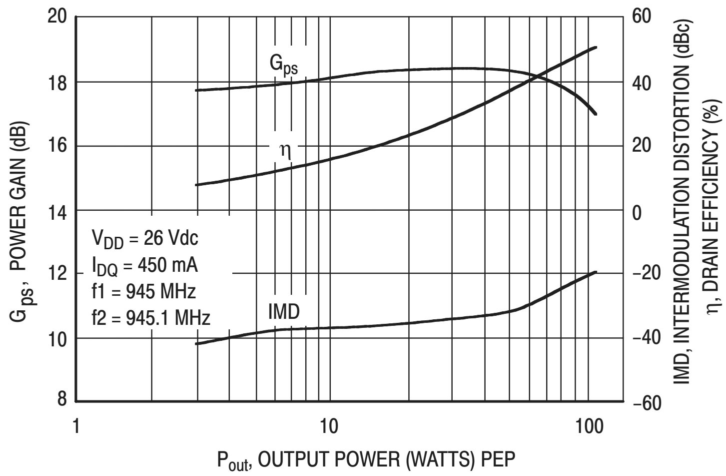
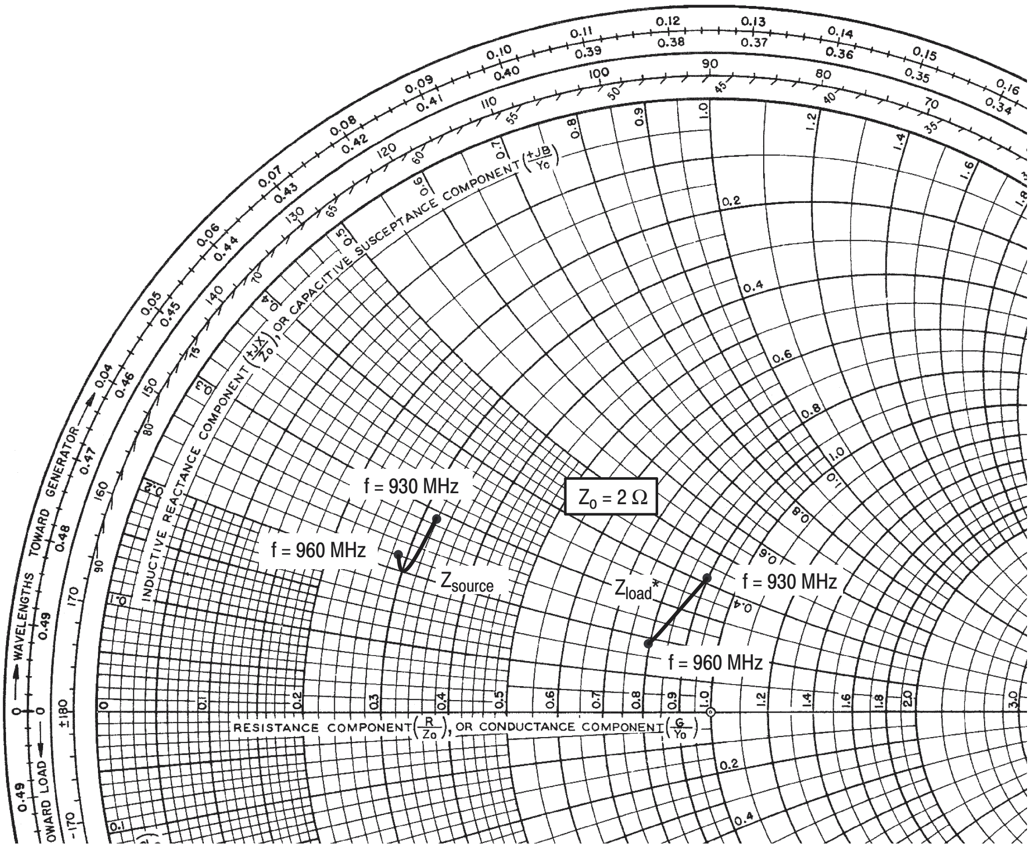


Figure 8. Power Gain, Efficiency, and IMD versus Output Power



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

f MHz	Z_{source} Ω	Z_{load} Ω
930	0.63 + j0.57	1.8 + j0.84
945	0.60 + j0.41	1.7 + j0.55
960	0.57 + j0.45	1.6 + j0.36

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

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

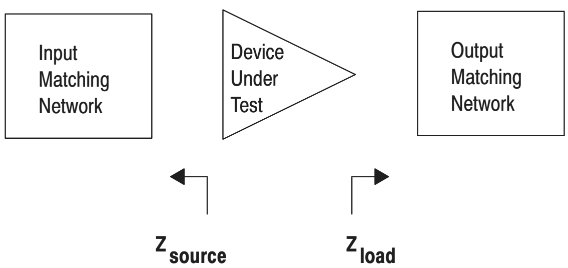
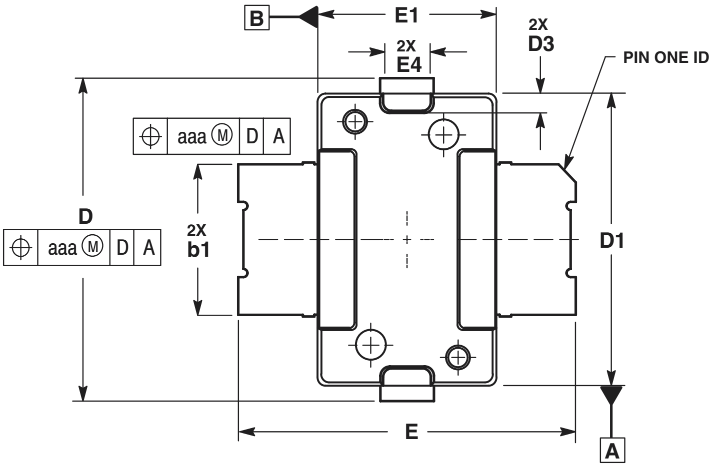
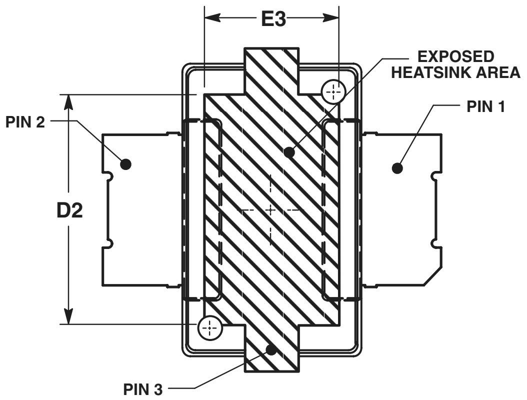


Figure 9. Series Equivalent Input and Output Impedance

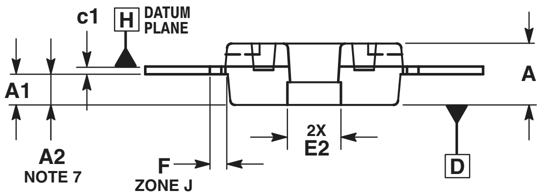
NOTES

PACKAGE DIMENSIONS





BOTTOM VIEW



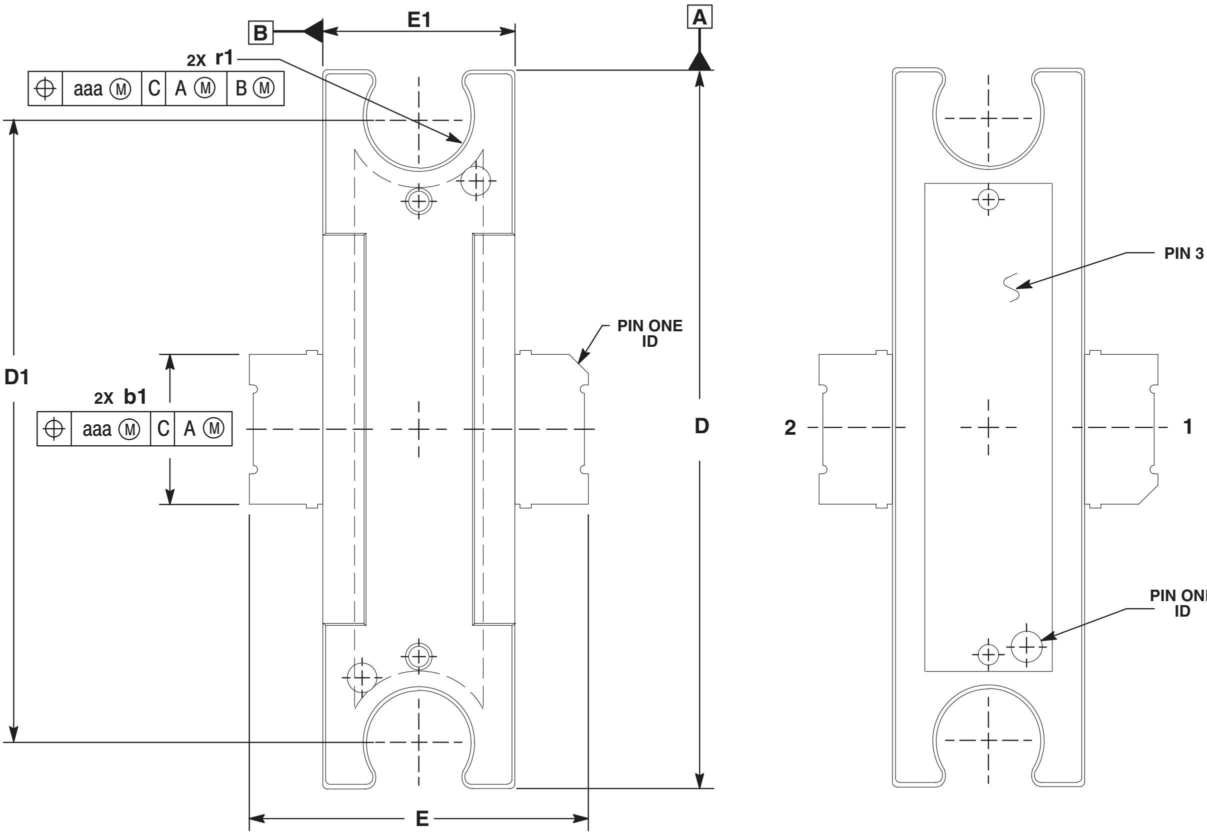
NOTES:
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.
3. DATUM PLANE –H– IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D1" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D1" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –H–.
5. DIMENSION b1 DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE b1 DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS –A– AND –B– TO BE DETERMINED AT DATUM PLANE –H–.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.
8. DIMENSIONS "D" AND "E2" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .003 PER SIDE. DIMENSIONS "D" AND "E2" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –D–.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.076	.084	1.93	2.13
A1	.038	.044	0.96	1.12
A2	.040	.042	1.02	1.07
D	.416	.424	10.57	10.77
D1	.376	.384	9.55	9.75
D2	.290	.320	7.37	8.13
D3	.016	.024	0.41	0.61
E	.436	.444	11.07	11.28
E1	.236	.244	5.99	6.20
E2	.066	.074	1.68	1.88
E3	.150	.180	3.81	4.57
E4	.058	.066	1.47	1.68
F	.025 BSC		0.64 BSC	
b1	.193	.199	4.90	5.06
c1	.007	.011	0.18	0.28
aaa	.004		0.10	

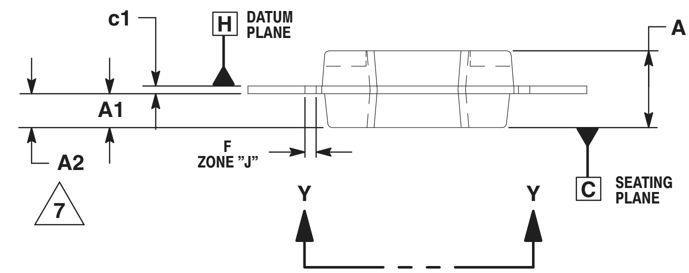
STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

CASE 1265–07
ISSUE F
TO–270 DUAL LEAD
PLASTIC
MRF9060MR1

PACKAGE DIMENSIONS



VIEW Y–Y



NOTES:
1. CONTROLLING DIMENSION: INCH.
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3. DATUM PLANE –H– IS LOCATED AT THE TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.
4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D" AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –H–.
5. DIMENSION "b1" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE "b1" DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS –A– AND –B– TO BE DETERMINED AT DATUM PLANE –H–.
7. DIMENSION A2 APPLIES WITHIN ZONE "J" ONLY.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	.098	.110	2.49	2.79
A1	.038	.044	0.96	1.12
A2	.040	.042	1.02	1.07
D	.926	.934	23.52	23.72
D1	.810 BSC		20.57 BSC	
E	.438	.442	11.12	11.23
E1	.246	.254	6.25	6.45
F	.025 BSC		0.64 BSC	
b1	.193	.199	4.90	5.05
c1	.007	.011	.18	.28
r1	.063	.068	1.60	1.73
aaa	.004		.10	

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

CASE 1337–01
ISSUE O
TO–272 DUAL LEAD
PLASTIC
MRF9060MBR1

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