

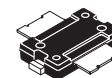
RF Power Field Effect Transistors N-Channel Enhancement-Mode Lateral MOSFETs

Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. 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.

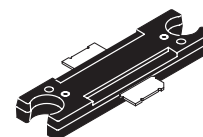
- Typical Performance at 945 MHz, 26 Volts
 - Output Power — 60 Watts PEP
 - Power Gain — 18.0 dB
 - Efficiency — 40% (Two Tones)
 - IMD — -31.5 dBc
- Integrated ESD Protection
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 945 MHz, 60 Watts CW Output Power
- Excellent Thermal Stability
- Characterized with 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.

MRF9060MR1
MRF9060MBR1

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



CASE 1265-08, STYLE 1
TO-270 DUAL LEAD
PLASTIC
MRF9060MR1



CASE 1337-03, STYLE 1
TO-272 DUAL LEAD
PLASTIC
MRF9060MBR1

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 @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	223 1.79	W W/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$
Operating Junction Temperature	T_J	175	$^\circ\text{C}$

Table 2. Thermal Characteristics

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.56	$^\circ\text{C}/\text{W}$

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

Table 3. ESD Protection Characteristics

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

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD 22-A113, IPC/JEDEC J-STD-020	1	260	°C
MRF9060MR1 MRF9060MBR1	3	260	

Table 5. 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 ($V_{DS} = 10\text{ Vdc}$, $I_D = 200\ \mu\text{Adc}$)	$V_{GS(th)}$	2	2.8	4	Vdc
Gate Quiescent Voltage ($V_{DS} = 26\text{ Vdc}$, $I_D = 450\text{ mAdc}$)	$V_{GS(Q)}$	3	3.7	5	Vdc
Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 1.3\text{ Adc}$)	$V_{DS(on)}$	—	0.21	0.4	Vdc
Forward Transconductance ($V_{DS} = 10\text{ Vdc}$, $I_D = 4\text{ Adc}$)	g_{fs}	—	5.3	—	S

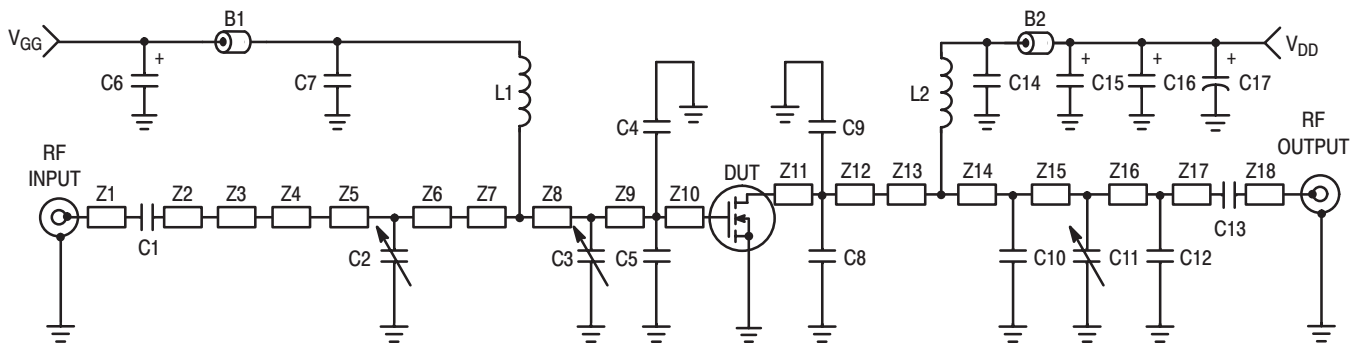
Dynamic Characteristics

Input Capacitance ($V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{iss}	—	101	—	pF
Output Capacitance ($V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{oss}	—	53	—	pF
Reverse Transfer Capacitance ($V_{DS} = 26\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$)	C_{rss}	—	2.5	—	pF

(continued)

Table 5. Electrical Characteristics ($T_C = 25^\circ\text{C}$ 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 ($V_{DD} = 26\text{ Vdc}$, $P_{out} = 60\text{ W PEP}$, $I_{DQ} = 450\text{ mA}$, $f_1 = 945.0\text{ MHz}$, $f_2 = 945.1\text{ MHz}$)	G_{ps}	17	18	—	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	37	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	—	-31.5	-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	—	-14.5	-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}	—	18	—	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	—	40	—	%
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	—	-12.5	—	dB

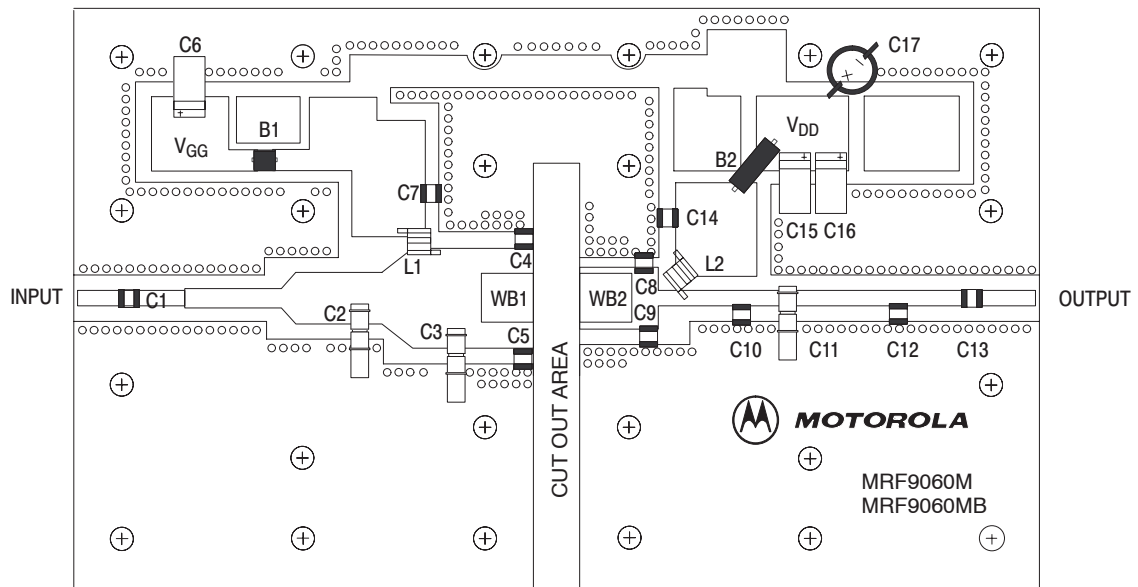


Z1	0.240" x 0.060" Microstrip	Z10	0.060" x 0.520" Microstrip
Z2	0.240" x 0.060" Microstrip	Z11	0.360" x 0.270" Microstrip
Z3	0.500" x 0.100" Microstrip	Z12	0.060" x 0.270" Microstrip
Z4	0.100" x 0.270" x 0.080", Taper	Z13	0.130" x 0.060" Microstrip
Z5	0.330" x 0.270" Microstrip	Z14	0.300" x 0.060" Microstrip
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 6. 930–960 MHz Broadband Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Short Ferrite Bead	95F786	Newark
B2	Long Ferrite Bead	95F787	Newark
C1, C7, C13, C14	47 pF Chip Capacitors	100B470JP 500X	ATC
C2, C3, C11	0.8–8.0 Gigatrim Variable Capacitors	44F3360	Newark
C4, C5	11 pF Chip Capacitors (MRF9060MR1) 10 pF Chip Capacitors (MRF9060MBR1)	100B110JP 500X 100B100JP 500X	ATC
C6, C15, C16	10 μF, 35 V Tantalum Chip Capacitors	93F2975	Newark
C8, C9	10 pF Chip Capacitors	100B100JP 500X	Newark
C10	3.9 pF Chip Capacitor	100B3R9CP 500X	ATC
C12	1.7 pF Chip Capacitor	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



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

TYPICAL CHARACTERISTICS

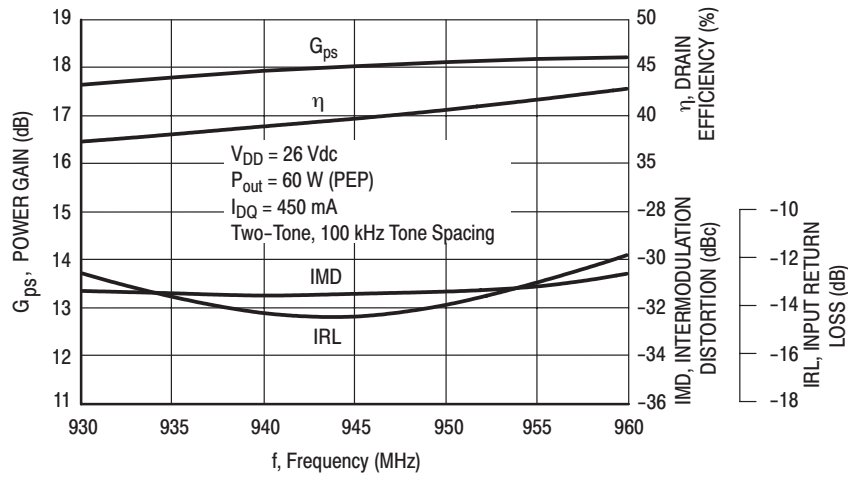


Figure 3. Class AB Broadband Circuit Performance

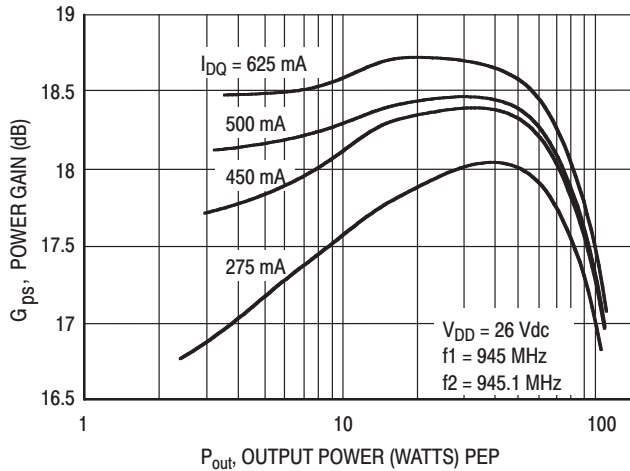


Figure 4. Power Gain versus Output Power

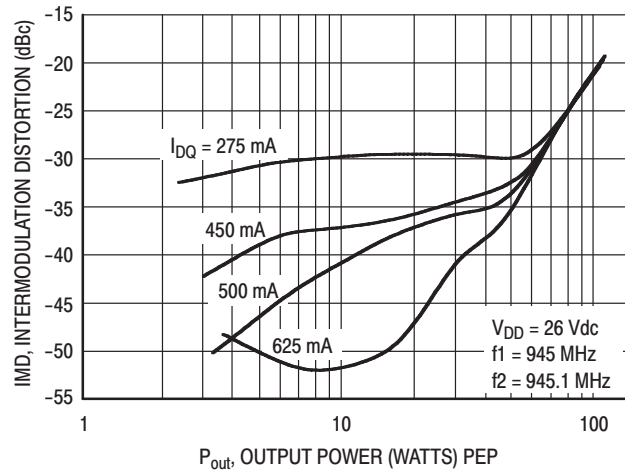


Figure 5. Intermodulation Distortion versus Output Power

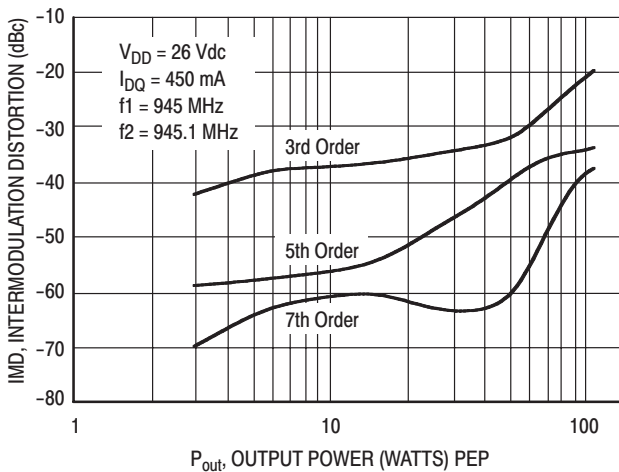


Figure 6. Intermodulation Distortion Products versus Output Power

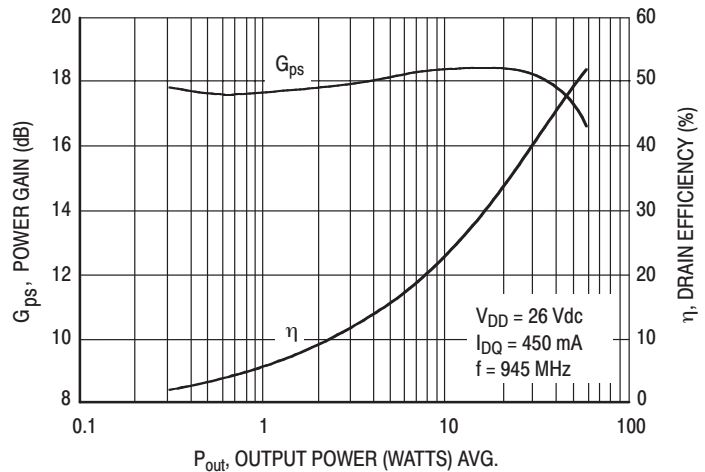


Figure 7. Power Gain and Efficiency versus Output Power

TYPICAL CHARACTERISTICS

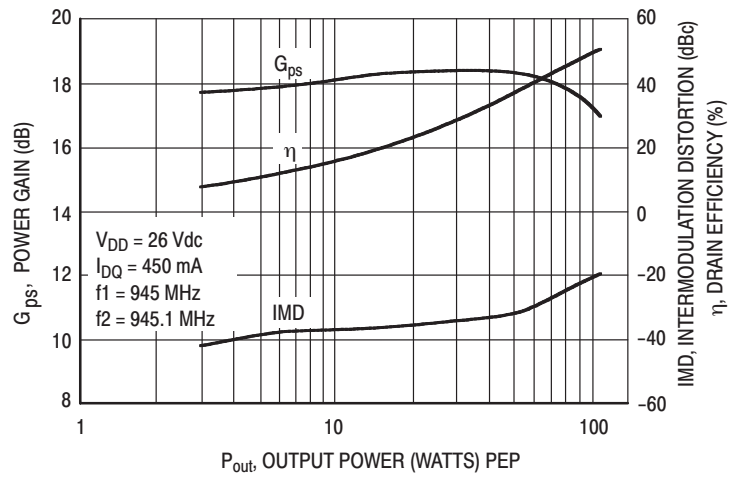
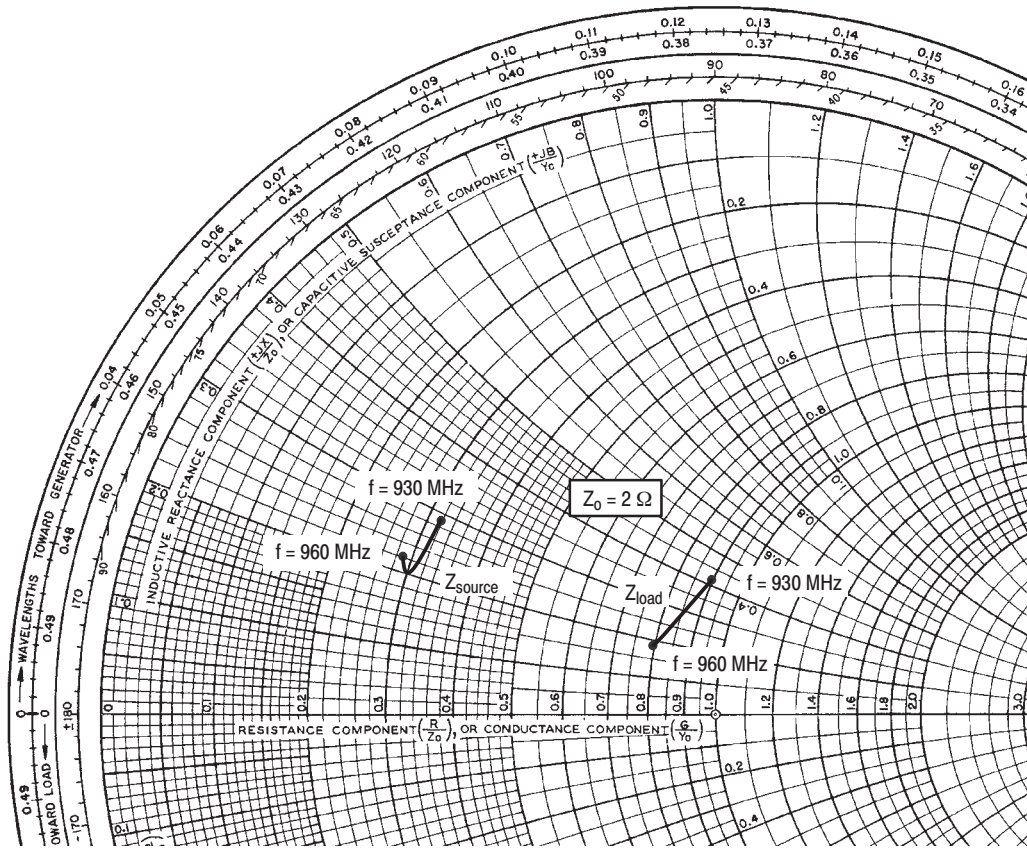


Figure 8. Power Gain, Efficiency, and IMD versus Output Power



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

f MHz	Z_{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.

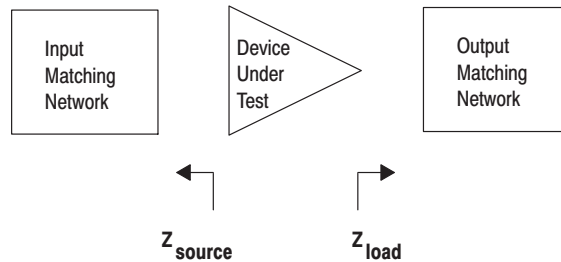
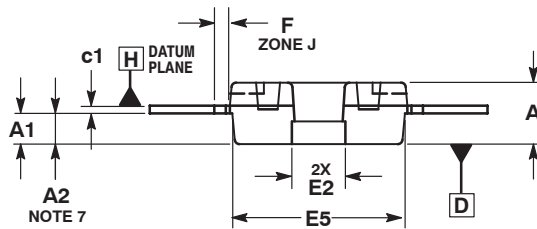
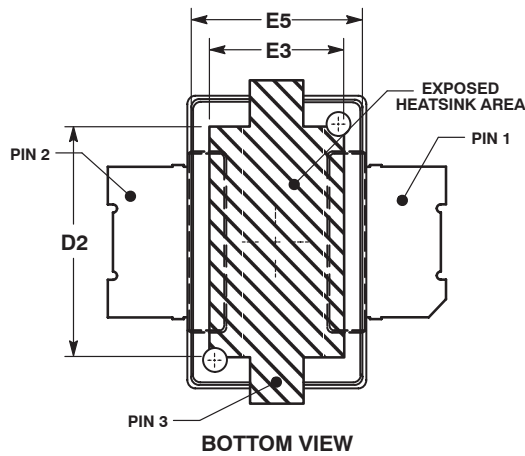
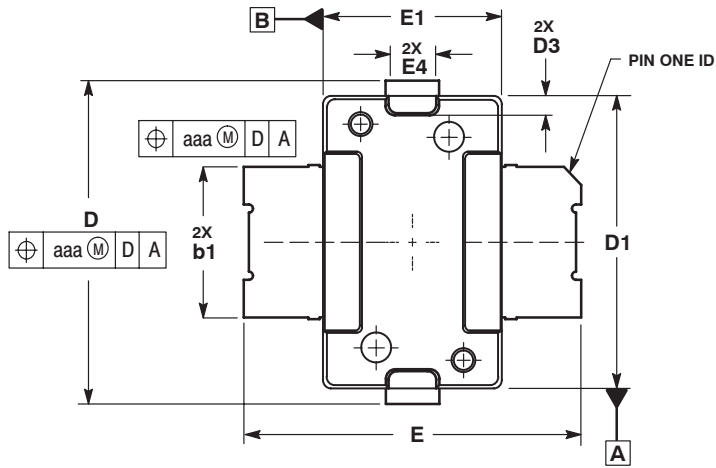


Figure 9. Series Equivalent Source and Load Impedance



NOTES

PACKAGE DIMENSIONS



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-.

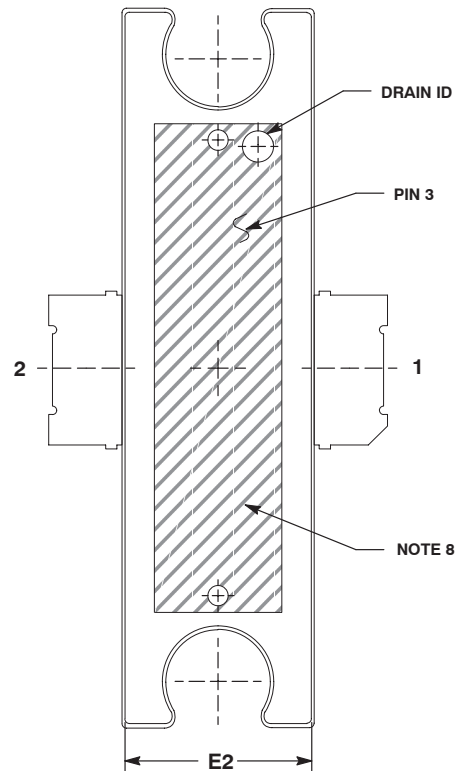
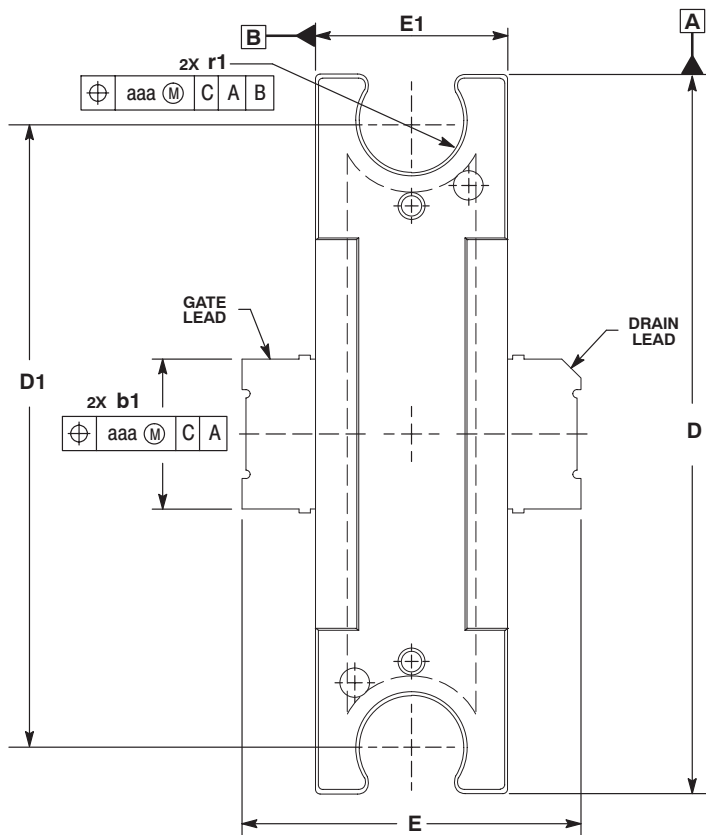
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.078	.082	1.98	2.08
A1	.039	.043	0.99	1.09
A2	.040	.042	1.02	1.07
D	.416	.424	10.57	10.77
D1	.378	.382	9.60	9.70
D2	.290	.320	7.37	8.13
D3	.016	.024	0.41	0.61
E	.436	.444	11.07	11.28
E1	.238	.242	6.04	6.15
E2	.066	.074	1.68	1.88
E3	.150	.180	3.81	4.57
E4	.058	.066	1.47	1.68
E5	.231	.235	5.87	5.97
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:

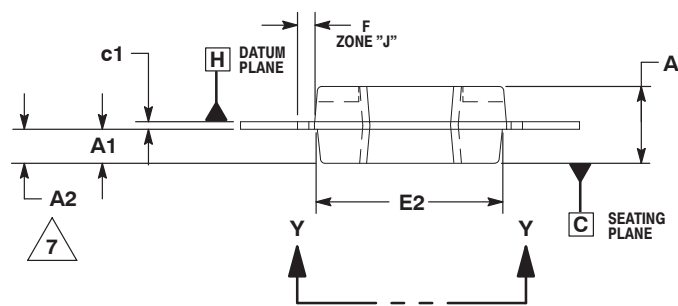
- PIN 1. DRAIN
2. GATE
3. SOURCE

**CASE 1265-08
ISSUE G
TO-270 DUAL LEAD
PLASTIC
MRF9060MR1**

PACKAGE DIMENSIONS



VIEW Y-Y



- NOTES:
1. CONTROLLING DIMENSION: INCH.
 2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
 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.
 8. CROSSHATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.100	.104	2.54	2.64
A1	.039	.043	0.99	1.09
A2	.040	.042	1.02	1.07
D	.928	.932	23.57	23.67
D1	.810 BSC		20.57 BSC	
E	.438	.442	11.12	11.23
E1	.248	.252	6.30	6.40
E2	.241	.245	6.12	6.22
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 1337-03
ISSUE B
TO-272 DUAL LEAD
PLASTIC
MRF9060MR1**

MRF9060MR1 MRF9060MR1

How to Reach Us:

Home Page:

www.freescale.com

E-mail:

support@freescale.com

USA/Europe or Locations Not Listed:

Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
+1-800-521-6274 or +1-480-768-2130
support@freescale.com

Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:

Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:

Freescale Semiconductor Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447 or 303-675-2140
Fax: 303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals", must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners.
© Freescale Semiconductor, Inc. 2005. All rights reserved.

