Freescale Semiconductor
Technical Data

Document Number: MRF9060N
Rev. 13, 6/2009

RoHS

RF Power Field Effect Transistor

N-Channel Enhancement-Mode Lateral 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.

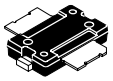
- Typical Performance at 945 MHz, 26 Volts
  Output Power — 60 Watts PEP
  Power Gain — 18.0 dB
  Efficiency — 40% (Two Tones)
  IMD — -31.5 dBc
- Capable of Handling 5:1 VSWR, @ 26 Vdc, 945 MHz, 60 Watts CW Output Power

Features

- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Integrated ESD Protection
- 200°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- TO-270-2 Available in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.

MRF9060NR1

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



**CASE 1265-09, STYLE 1
TO-270-2
PLASTIC**

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	223 1.79	W W/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature	T_J	200	°C

Table 2. Thermal Characteristics

Characteristic	Symbol	Value (1)	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.56	°C/W

Table 3. ESD Protection Characteristics

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

Table 4. Moisture Sensitivity Level

Test Methodology	Rating	Package Peak Temperature	Unit
Per JESD22-A113, IPC/JEDEC J-STD-020	3	260	°C

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

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Table 5. Electrical Characteristics (T_A = 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
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}	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

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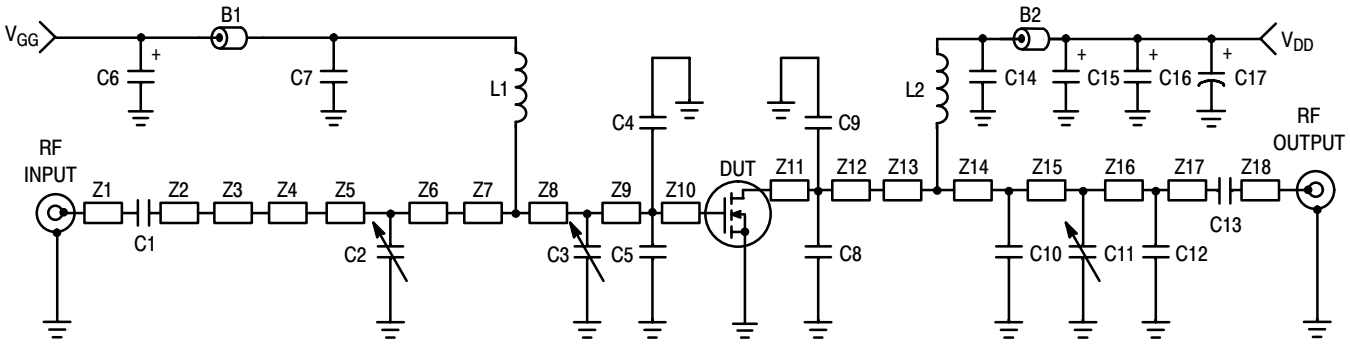

Z1	0.240″ x 0.060″ Microstrip	Z10	0.060″ x 0.520″ Microstrip
Z2	0.240″ x 0.060″ Microstrip	Z11	0.360″ x 0.270″ Microstrip
Z3	0.500″ x 0.100″ Microstrip	Z12	0.060″ x 0.270″ Microstrip
Z4	0.100″ x 0.270″ x 0.080″, Taper	Z13	0.130″ x 0.060″ Microstrip
Z5	0.330″ x 0.270″ Microstrip	Z14	0.300″ x 0.060″ Microstrip
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	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	11 pF Chip Capacitors (MRF9060NR1) 10 pF Chip Capacitors (MRF9060NBR1)	ATC100B110JT500XT ATC100B100JT500XT	ATC
C6, C15, C16	10 μF, 35 V Tantalum Chip Capacitors	T491D106K035AT	Kemet
C8, C9	10 pF Chip Capacitors	ATC100B100JT500XT	Newark
C10	3.9 pF Chip Capacitor	ATC100B3R9CT500XT	ATC
C12	1.7 pF Chip Capacitor	ATC100B1R7BT500XT	ATC
C17	220 μF Electrolytic Chip Capacitor	MCAX63V227M13X22	Multicomp
L1, L2	12.5 nH Inductors	A04T-5	Coilcraft
Board Material	30 mil Glass Teflon®, ε_r = 2.55 Copper Clad, 2 oz Cu	RF-35-0300	Taconic

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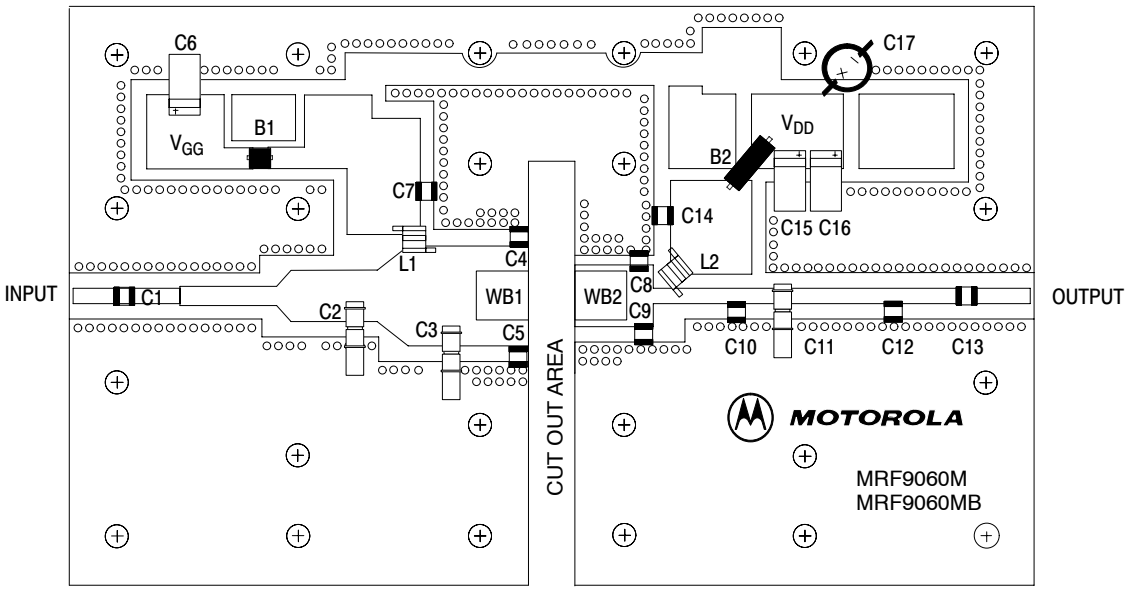


Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

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

TYPICAL CHARACTERISTICS

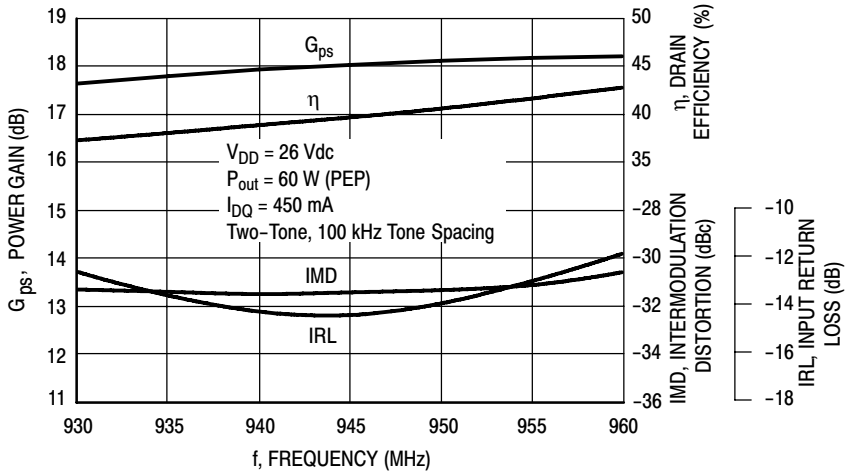


Figure 3. Class AB Broadband Circuit Performance

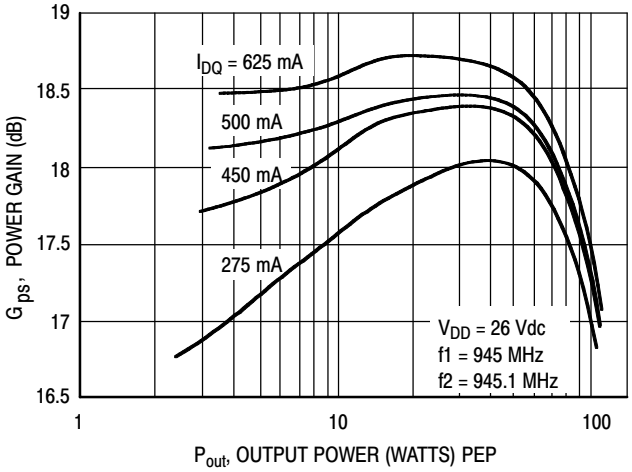


Figure 4. Power Gain versus Output Power

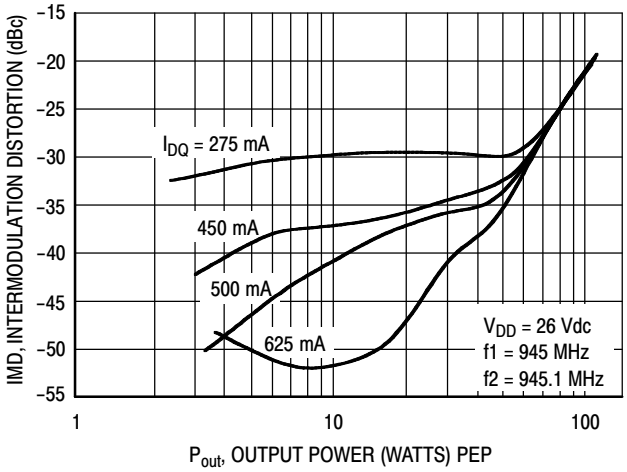


Figure 5. Intermodulation Distortion versus Output Power

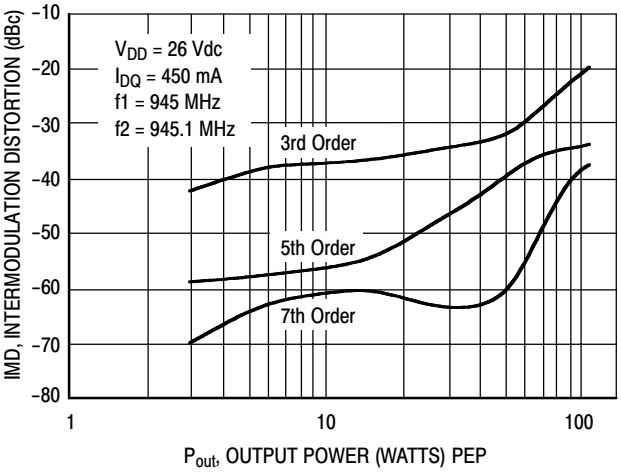


Figure 6. Intermodulation Distortion Products versus Output Power

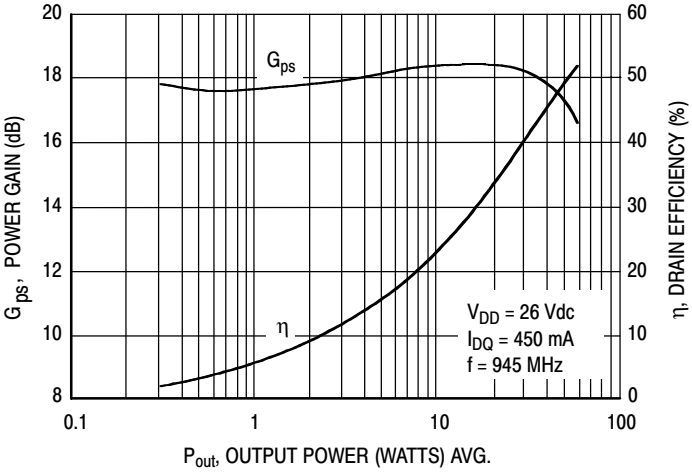


Figure 7. Power Gain and Efficiency versus Output Power

TYPICAL CHARACTERISTICS

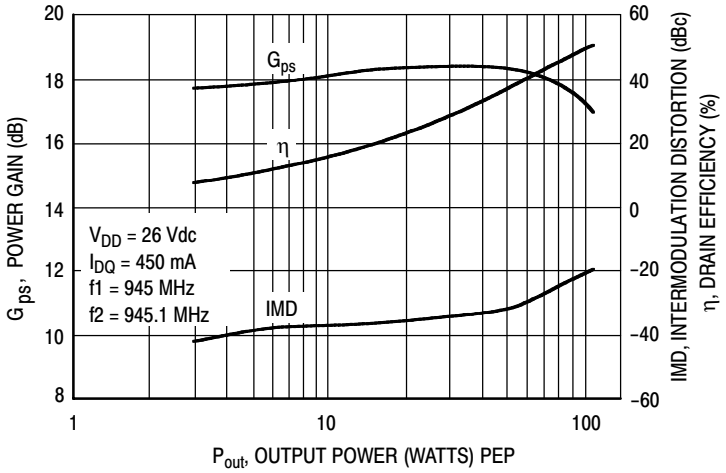
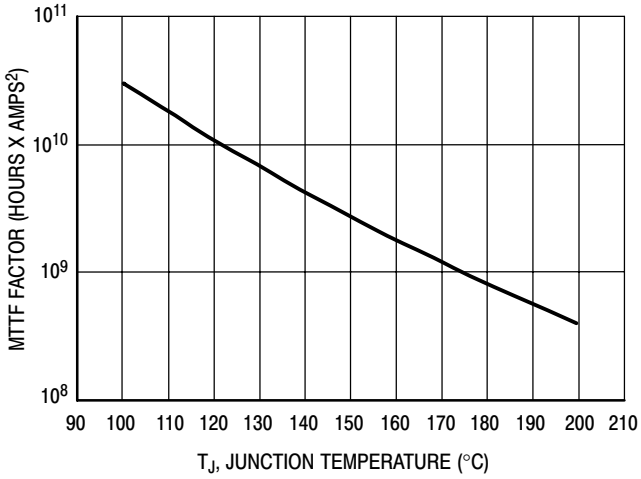
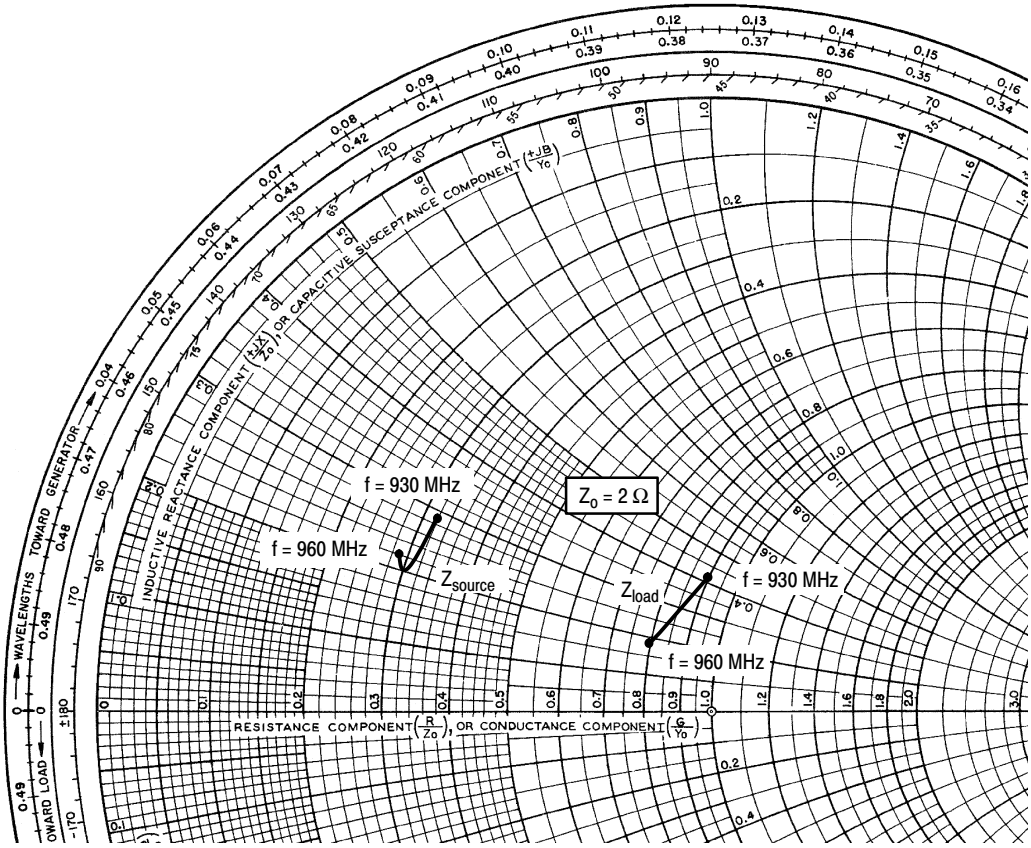


Figure 8. Power Gain, Efficiency, and IMD versus Output Power



This above graph displays calculated MTTF in hours x ampere^2 drain current. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTTF factor by I_D^2 for MTTF in a particular application.

Figure 9. MTTF Factor versus Junction Temperature



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.

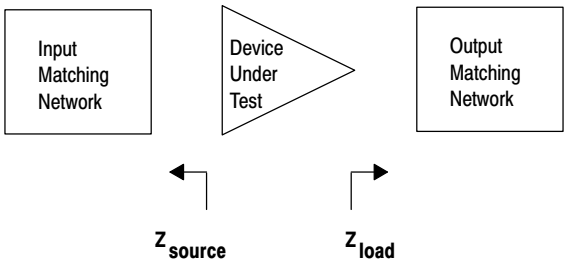
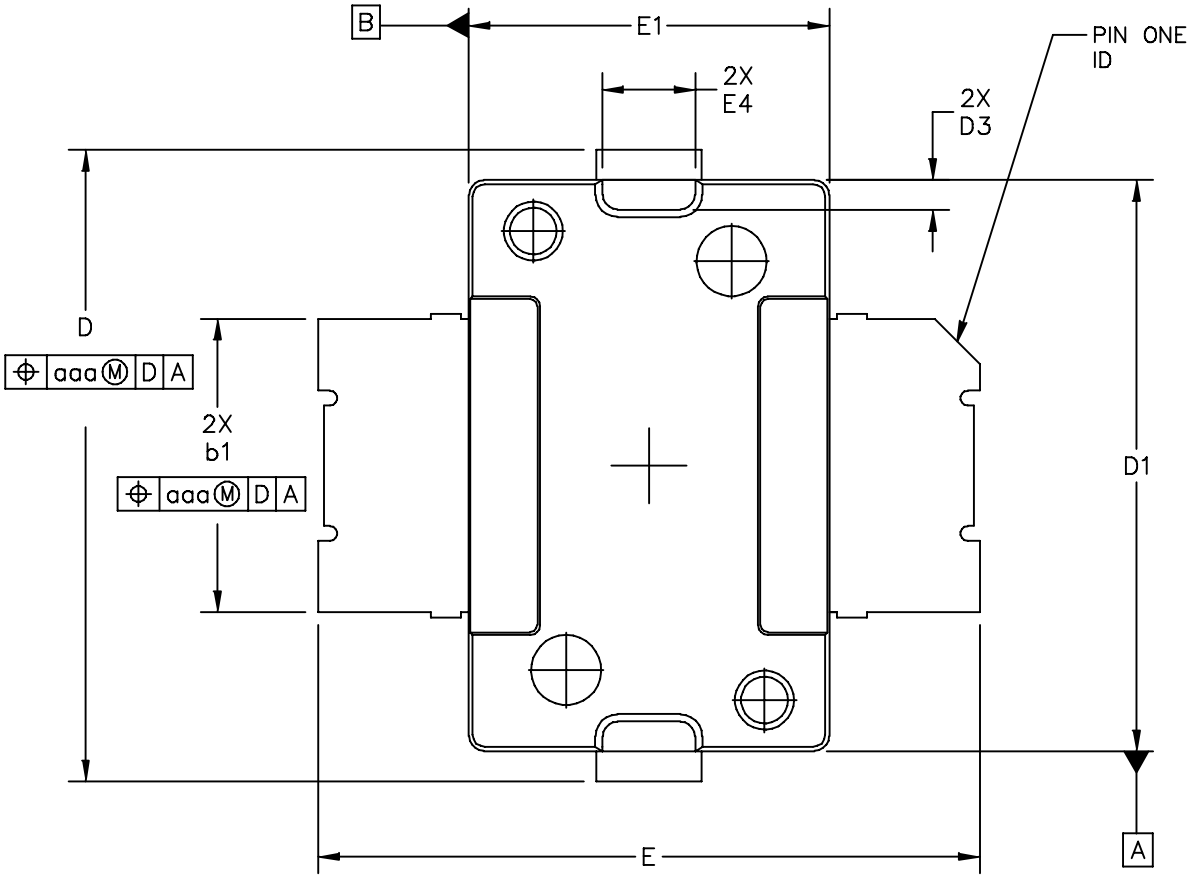
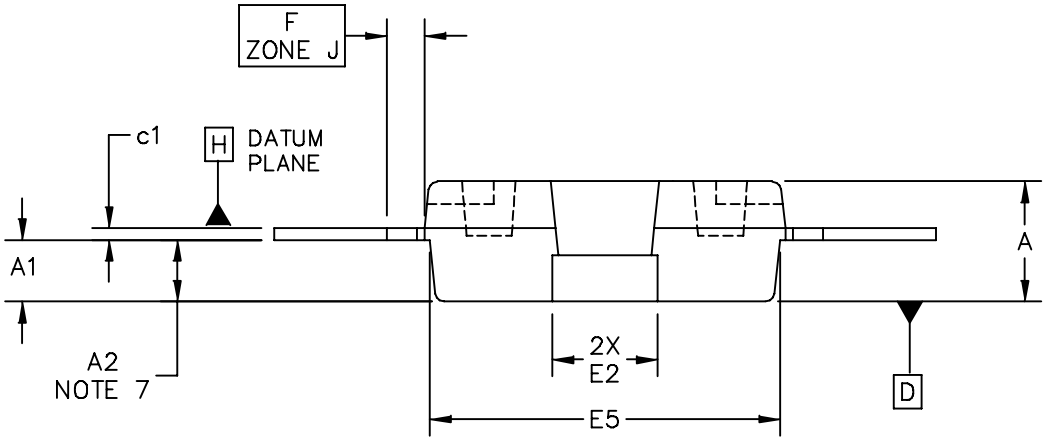


Figure 10. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS





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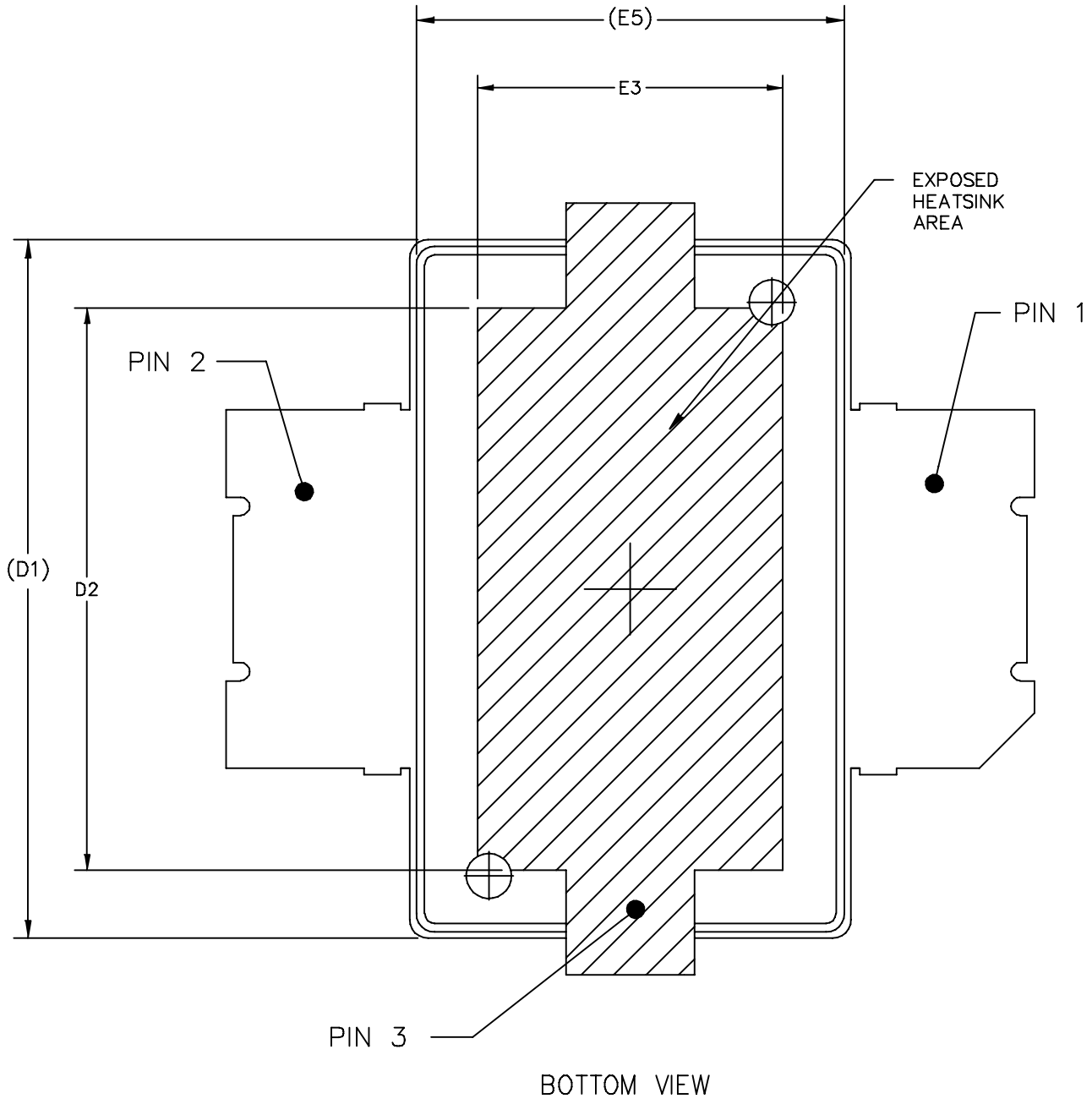
	CASE NUMBER: 1265-09	29 JUN 2007
	STANDARD: JEDEC TO-270 AA	



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	STANDARD: JEDEC TO−270 AA	

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. OVERALL LENGTH INCLUDING MOLD PROTRUSION SHOULD NOT EXCEED 0.430 INCH FOR DIMENSION "D" AND 0.080 INCH FOR DIMENSION "E2". DIMENSIONS "D" AND "E2" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –D–.

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

	INCH		MILLIMETER			INCH		MILLIMETER	
DIM	MIN	MAX	MIN	MAX	DIM	MIN	MAX	MIN	MAX
A	.078	.082	1.98	2.08	F	.025 BSC		0.64 BSC	
A1	.039	.043	0.99	1.09	b1	.193	.199	4.90	5.06
A2	.040	.042	1.02	1.07	c1	.007	.011	0.18	0.28
D	.416	.424	10.57	10.77	aaa	.004		0.10	
D1	.378	.382	9.60	9.70					
D2	.290	----	7.37	----					
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	----	3.81	----					
E4	.058	.066	1.47	1.68					
E5	.231	.235	5.87	5.97					

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PRODUCT DOCUMENTATION, TOOLS AND SOFTWARE

Refer to the following documents to aid your design process.

Application Notes

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Plastic Packages
- AN1955: Thermal Measurement Methodology of RF Power Amplifiers
- AN3789: Clamping of High Power RF Transistors and RFICs in Over-Molded Plastic Packages

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

Software

- Electromigration MTTF Calculator

For Software and Tools, do a Part Number search at http://www.freescale.com, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
12	Sept. 2008	• Data sheet revised to reflect part status change, p. 1, including use of applicable overlay. • Replaced Case Outline 1265-08 with 1265-09, Issue K, p. 1, 8-10. Corrected cross hatch pattern in bottom view and changed its dimensions (D2 and E3) to minimum value on source contact (D2 changed from Min-Max .290-.320 to .290 Min; E3 changed from Min-Max .150-.180 to .150 Min). Added JEDEC Standard Package Number. • Updated Part Numbers in Table 6, Component Designations and Values, to RoHS compliant part numbers, p. 3 • Added Product Documentation and Revision History, p. 11
13	June 2009	• Modified data sheet to reflect MSL rating change from 1 to 3 as a result of the standardization of packing process as described in Product and Process Change Notification number, PCN13516, p. 1 • Added Electromigration MTTF Calculator availability to Product Documentation, Tools and Software, p. 11

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For information on Freescale’s Environmental Products program, go to http://www.freescale.com/epp.

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