Freescale Semiconductor
Technical Data

Document Number: MRF9045N
Rev. 11, 9/2008

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 28 volt base station equipment.

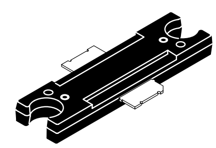
- Typical Performance at 945 MHz, 28 Volts
  - Output Power — 45 Watts PEP
  - Power Gain — 19 dB
  - Efficiency — 41% (Two Tones)
  - IMD — -31 dBc
- Integrated ESD Protection
- Guaranteed Ruggedness @ Load VSWR = 5:1, @ 28 Vdc, 945 MHz, 45 Watts CW Output Power

Features

- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Dual-Lead Boltdown Plastic Package Can Also Be Used As Surface Mount.
- 200°C Capable Plastic Package
- N Suffix Indicates Lead-Free Terminations. RoHS Compliant.
- TO-272-2 Available in Tape and Reel. R1 Suffix = 500 Units per 44 mm, 13 inch Reel.

MRF9045NBR1

945 MHz, 45 W, 28 V
LATERAL N-CHANNEL
BROADBAND
RF POWER MOSFET



CASE 1337-04, STYLE 1
TO-272-2
PLASTIC

ARCHIVE INFORMATION

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	177 1.18	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	$R_{\theta JC}$	0.85	°C/W

Table 3. ESD Protection Characteristics

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

Table 4. Moisture Sensitivity Level

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

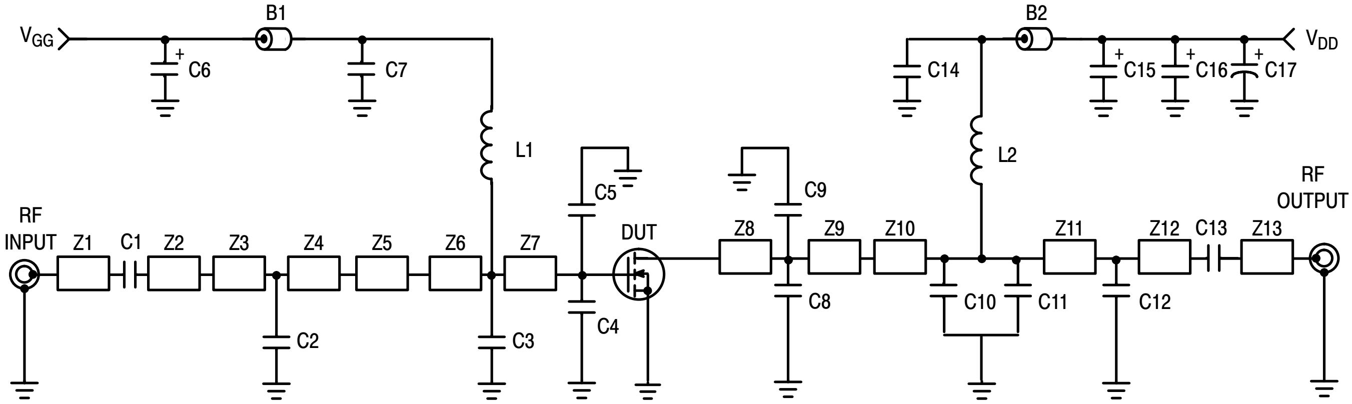
1. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

freescale™ semiconductor

Table 5. Electrical Characteristics (T_C = 25°C unless otherwise noted)

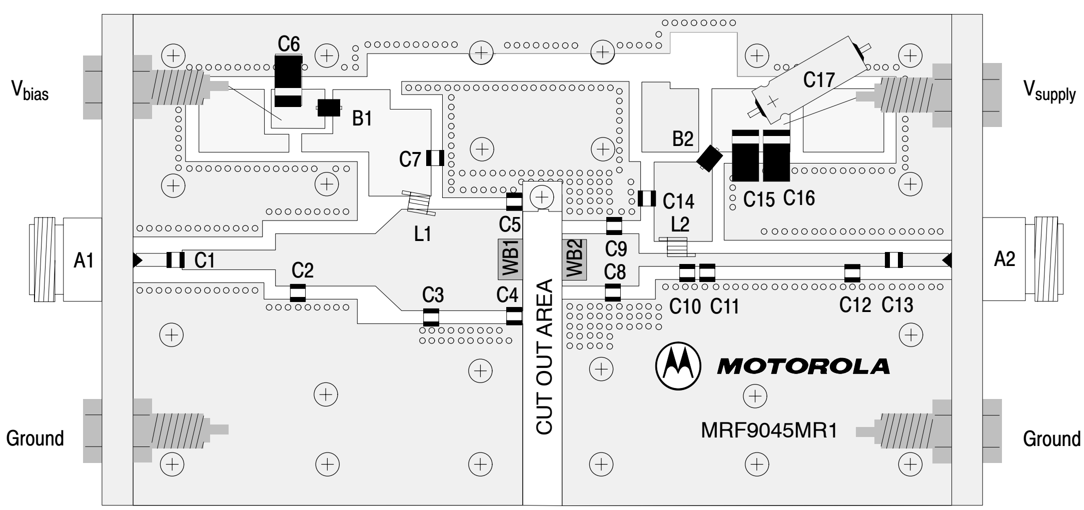
Characteristic	Symbol	Min	Typ	Max	Unit
Off Characteristics					
Zero Gate Voltage Drain Leakage Current (V_{DS} = 65 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	10	μAdc
Zero Gate Voltage Drain Leakage Current (V_{DS} = 28 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	—	—	1	μAdc
Gate-Source Leakage Current (V_{GS} = 5 Vdc, V_{DS} = 0 Vdc)	I_{GSS}	—	—	1	μAdc
On Characteristics					
Gate Threshold Voltage (V_{DS} = 10 Vdc, I_D = 150 μAdc)	$V_{GS(th)}$	2	2.8	4	Vdc
Gate Quiescent Voltage (V_{DS} = 28 Vdc, I_D = 350 mAdc)	$V_{GS(Q)}$	3	3.7	5	Vdc
Drain-Source On-Voltage (V_{GS} = 10 Vdc, I_D = 1 Adc)	$V_{DS(on)}$	—	0.22	0.4	Vdc
Forward Transconductance (V_{DS} = 10 Vdc, I_D = 3 Adc)	g_{fs}	—	4	—	S
Dynamic Characteristics					
Input Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{iss}	—	70	—	pF
Output Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{oss}	—	38	—	pF
Reverse Transfer Capacitance (V_{DS} = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, V_{GS} = 0 Vdc)	C_{rss}	—	1.7	—	pF
Functional Tests (In Freescale Test Fixture, 50 ohm system)					
Two-Tone Common-Source Amplifier Power Gain (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	G_{ps}	17	19	—	dB
Two-Tone Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	η	38	41	—	%
3rd Order Intermodulation Distortion (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	IMD	—	-31	-28	dBc
Input Return Loss (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 945.0 MHz, f2 = 945.1 MHz)	IRL	—	-14	-9	dB
Two-Tone Common-Source Amplifier Power Gain (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	G_{ps}	—	19	—	dB
Two-Tone Drain Efficiency (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	η	—	41	—	%
3rd Order Intermodulation Distortion (V_{DD} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 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} = 28 Vdc, P_{out} = 45 W PEP, I_{DQ} = 350 mA, f1 = 930.0 MHz, f2 = 930.1 MHz and f1 = 960.0 MHz, f2 = 960.1 MHz)	IRL	—	-13	—	dB

ARCHIVE INFORMATION



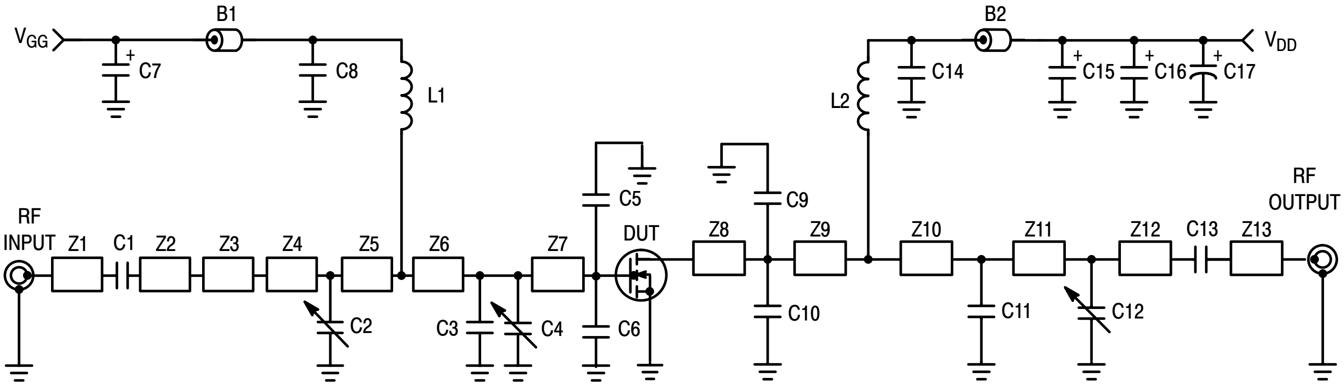
B1, B2	Short Ferrite Beads, Surface Mount	Z3	0.14″ x 0.32″ Microstrip
C1, C7, C13, C14	47 pF Chip Capacitors	Z4	0.47″ x 0.32″ Microstrip
C2, C8	2.7 pF Chip Capacitors	Z5	0.16″ x 0.32″ x 0.62″ Taper
C3	3.9 pF Chip Capacitor	Z6	0.18″ x 0.62″ Microstrip
C4, C5, C8, C9	10 pF Chip Capacitors	Z7	0.56″ x 0.62″ Microstrip
C6, C15, C16	10 μF, 35 V Tantalum Surface Mount Capacitors	Z8	0.33″ x 0.32″ Microstrip
C10	2.2 pF Chip Capacitor	Z9	0.14″ x 0.32″ Microstrip
C11	4.7 pF Chip Capacitor	Z10	0.36″ x 0.08″ Microstrip
C12	1.2 pF Chip Capacitor	Z11	1.01″ x 0.08″ Microstrip
C17	220 μF, 50 V Electrolytic Capacitor	Z12	0.15″ x 0.08″ Microstrip
L1, L2	12.5 nH Inductors	Z13	0.29″ x 0.08″ Microstrip
Z1	0.20″ x 0.08″ Microstrip		
Z2	0.57″ x 0.12″ Microstrip		

Figure 1. MRF9045NBR1 930-960 MHz Broadband Test Circuit Schematic



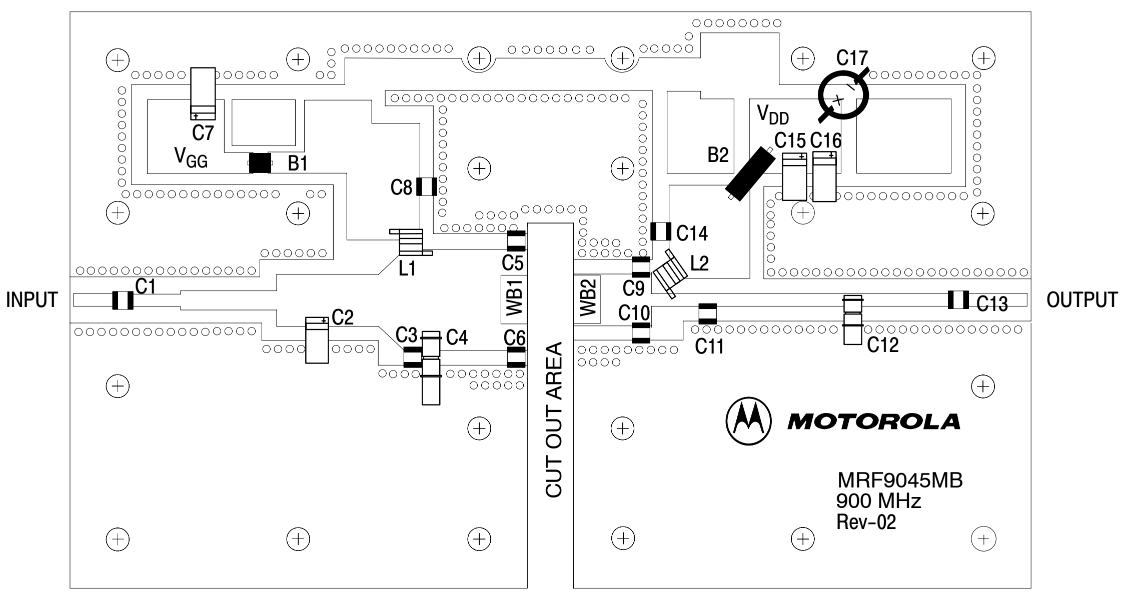
Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

Figure 2. MRF9045NBR1 930-960 MHz Broadband Test Circuit Component Layout



B1	Short Ferrite Bead	Z1	0.260″ x 0.060″ Microstrip
B2	Long Ferrite Bead	Z2	0.240″ x 0.060″ Microstrip
C1, C8, C13, C14	47 pF Chip Capacitors	Z3	0.500″ x 0.100″ Microstrip
C2	0.4-2.5 pF Variable Capacitor, Johanson Gigatrim	Z4	0.215″ x 0.270″ Microstrip
C3	3.6 pF Chip Capacitor	Z5	0.315″ x 0.270″ Microstrip
C4	0.8-8.0 pF Variable Capacitor, Johanson Gigatrim	Z6	0.160″ x 0.270″ x 0.520″ Taper
C5, C6, C9, C10	10 pF Chip Capacitors	Z7	0.285″ x 0.520″ Microstrip
C7, C15, C16	10 μF, 35 V Tantalum Chip Capacitors	Z8	0.140″ x 0.270″ Microstrip
C11	7.5 pF Chip Capacitor	Z9	0.450″ x 0.270″ Microstrip
C12	0.6-4.5 pF Variable Capacitor, Johanson Gigatrim	Z10	0.250″ x 0.060″ Microstrip
C17	220 μF Electrolytic Chip Capacitor	Z11	0.720″ x 0.060″ Microstrip
L1, L2	12.5 nH Surface Mount Inductors	Z12	0.490″ x 0.060″ Microstrip
WB1, WB2	10 mil Brass Wear Blocks	Z13	0.290″ x 0.060″ Microstrip
		Board	Taconic RF-35-0300, $\varepsilon_r = 3.5$

Figure 3. MRF9045NBR1 930-960 MHz Broadband Test Circuit Schematic



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 4. MRF9045NBR1 930-960 MHz Broadband Test Circuit Component Layout

TYPICAL CHARACTERISTICS

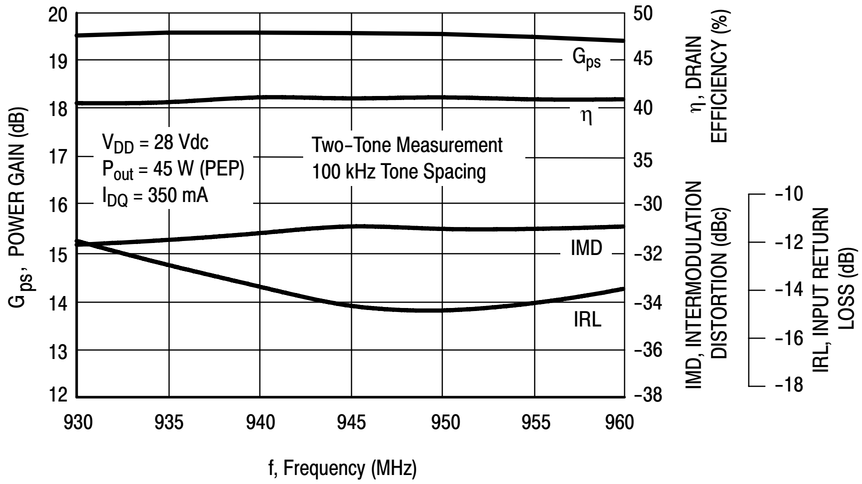


Figure 5. Class AB Broadband Circuit Performance

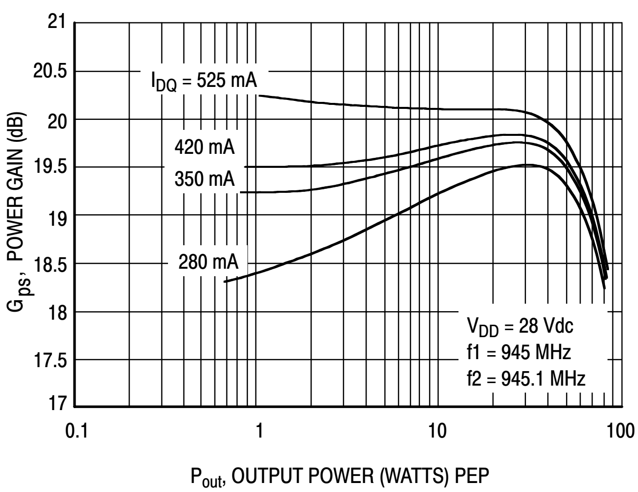


Figure 6. Power Gain versus Output Power

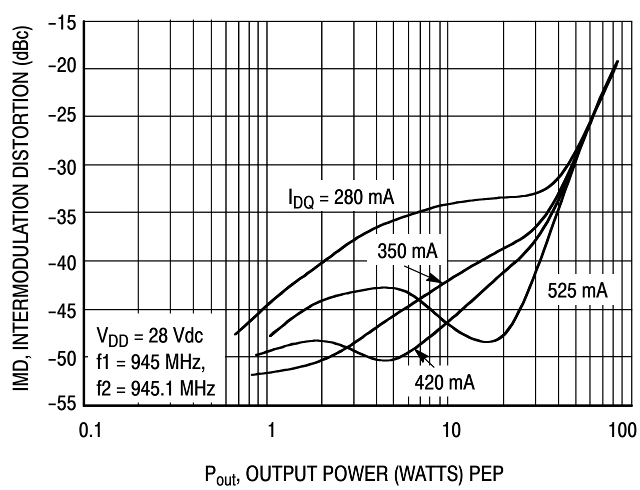


Figure 7. Intermodulation Distortion versus Output Power

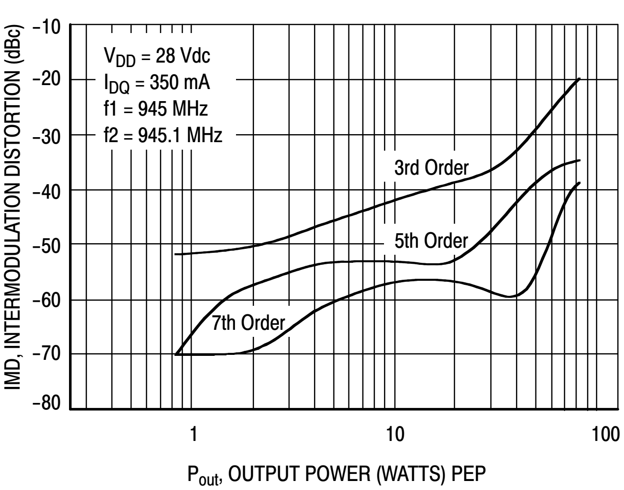


Figure 8. Intermodulation Distortion Products versus Output Power

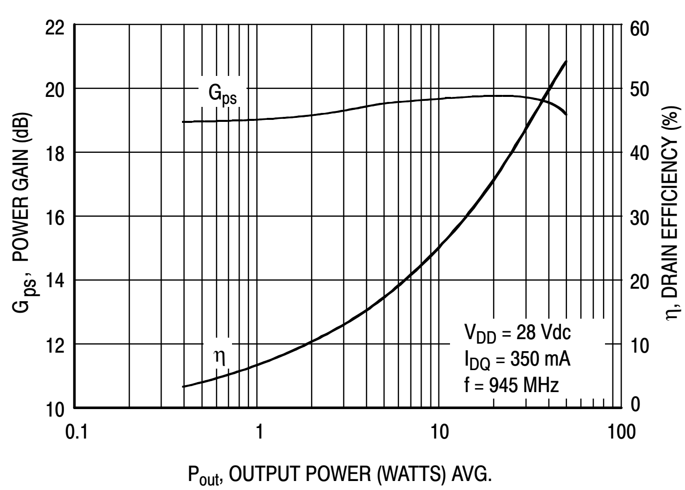


Figure 9. Power Gain and Efficiency versus Output Power

TYPICAL CHARACTERISTICS

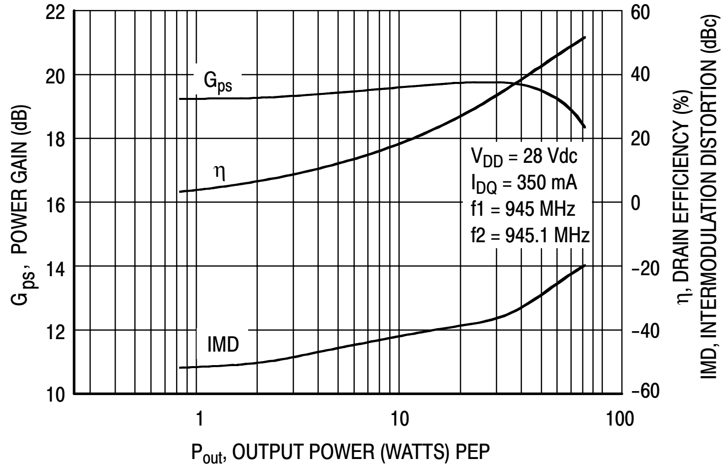
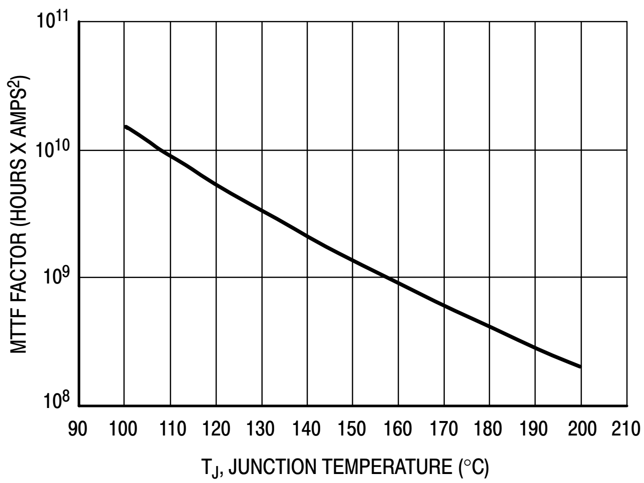
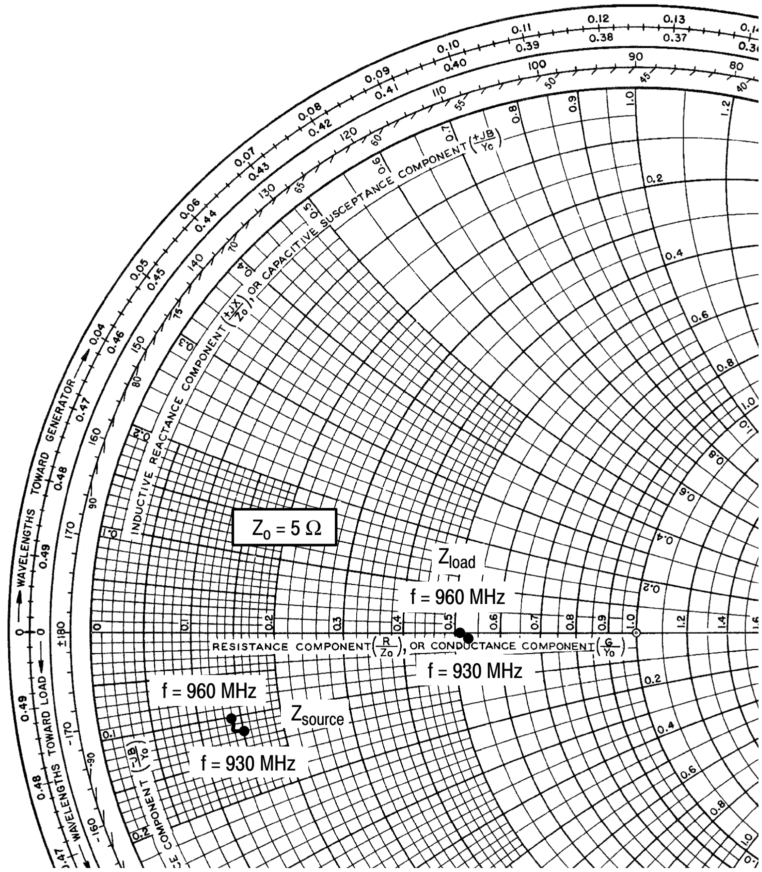


Figure 10. Power Gain, Efficiency and IMD versus Output Power



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 11. MTTF Factor versus Junction Temperature



V_{DD} = 28 V, I_{DQ} = 350 mA, P_{out} = 45 W (PEP)

f MHz	Z_{source} Ω	Z_{load} Ω
930	0.75 - j0.6	2.65 - j0.05
945	0.72 - j0.6	2.60 - j0.05
960	0.70 - j0.5	2.55 - j0.02

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

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

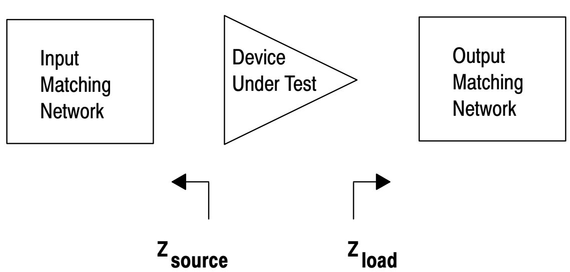
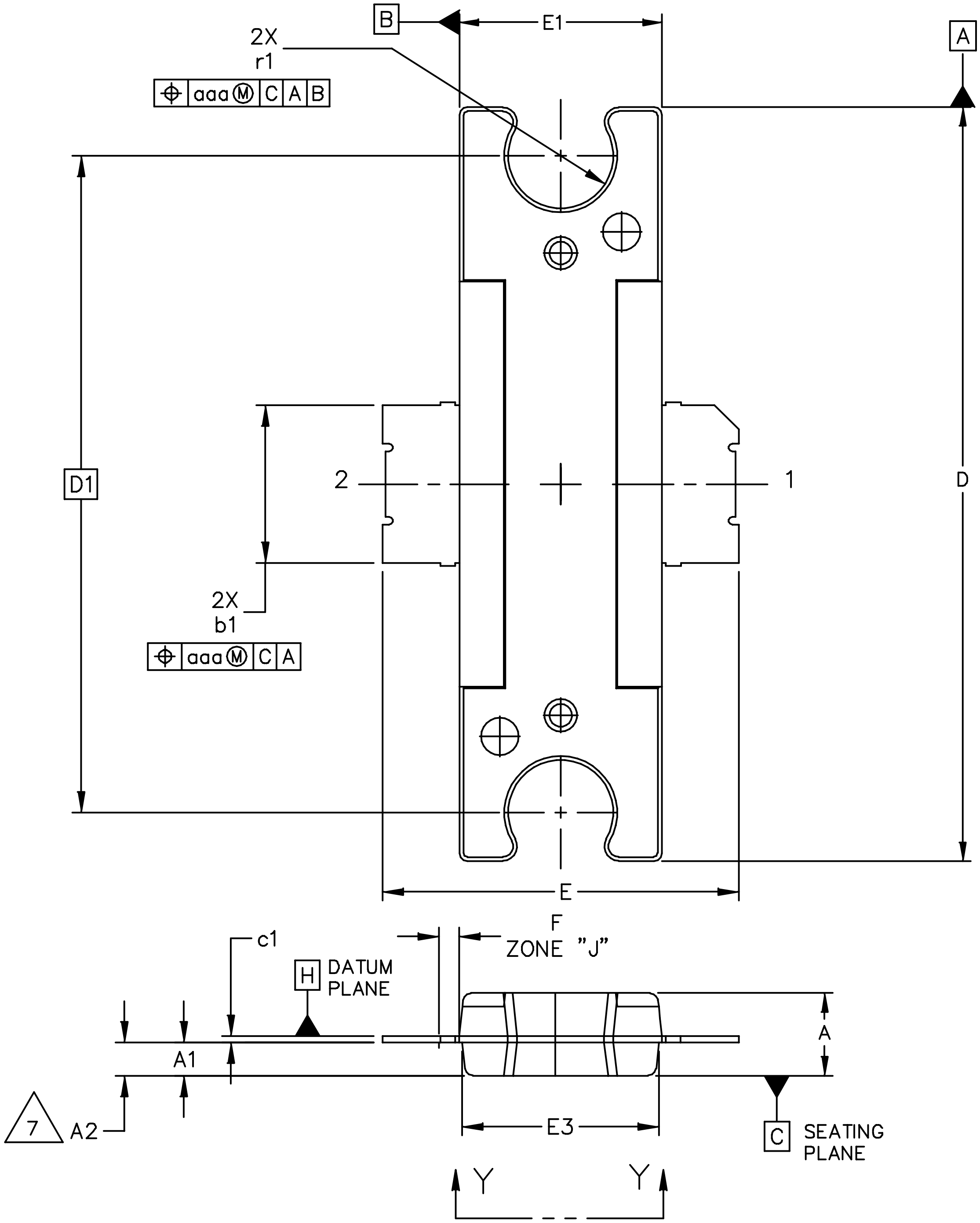


Figure 12. Series Equivalent Source and Load Impedance

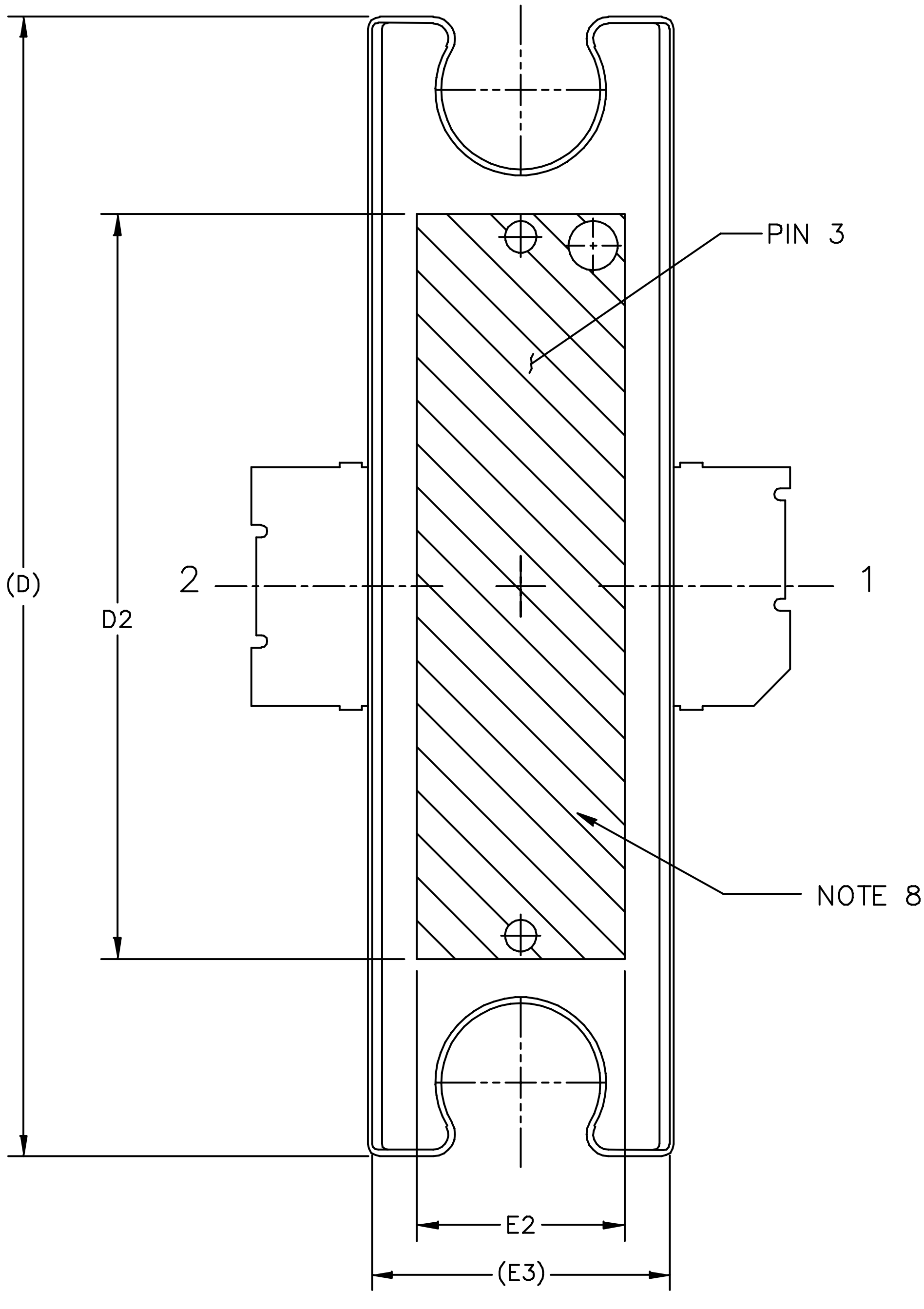
ARCHIVE INFORMATION

PACKAGE DIMENSIONS



ARCHIVE INFORMATION

© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE	
TITLE: TO–272 2 LEAD	DOCUMENT NO: 98ASA99191D		REV: E
	CASE NUMBER: 1337–04		10 SEP 2007
	STANDARD: JEDEC TO–272 BC		



VIEW Y–Y

ARCHIVE INFORMATION

© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE
TITLE: TO–272 2 LEAD	DOCUMENT NO: 98ASA99191D	REV: E
	CASE NUMBER: 1337–04	10 SEP 2007
	STANDARD: JEDEC TO–272 BC	

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. DIMENSIONS "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. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG.

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX
A	.100	.104	2.54	2.64	b1	.193	.199	4.90	5.05
A1	.039	.043	0.99	1.09	c1	.007	.011	0.18	0.28
A2	.040	.042	1.02	1.07	r1	.063	.068	1.60	1.73
D	.928	.932	23.57	23.67	aaa	.004		0.1	
D1	.810 BSC		20.57 BSC						
D2	.604	----	15.34	----					
E	.438	.442	11.12	11.23					
E1	.248	.252	6.30	6.40					
E2	.162	----	4.11	----					
E3	.241	.245	6.12	6.22					
F	.025 BSC		0.64 BSC						

MECHANICAL OUTLINE

PRINT VERSION NOT TO SCALE

TITLE:	DOCUMENT NO: 98ASA99191D	REV: E
TO-272 2 LEAD	CASE NUMBER: 1337-04	10 SEP 2007
	STANDARD: JEDEC TO-272 BS	

PRODUCT DOCUMENTATION

Refer to the following documents to aid your design process.

Application Notes

- AN1955: Thermal Measurement Methodology of RF Power Amplifiers

Engineering Bulletins

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
11	Sept. 2008	• Data sheet revised to reflect part status change, including use of applicable overlay. • Replaced Case Outline 1337-03 with 1337-04, p. 1, 8-10. Issue D: Removed Drain-ID label from View Y-Y on Sheet 2. Renamed E2 to E3. Added cross-hatch region dimensions D2 and E2. Added JEDEC Standard Package Number. Issue E: Corrected document number 98ASA99191D on Sheet 3. • Added Product Documentation and Revision History, p. 11

How to Reach Us:

Home Page:
www.freescale.com

Web Support:
http://www.freescale.com/support

USA/Europe or Locations Not Listed:
Freescale Semiconductor, Inc.
Technical Information Center, EL516
2100 East Elliot Road
Tempe, Arizona 85284
1-800-521-6274 or +1-480-768-2130
www.freescale.com/support

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)
www.freescale.com/support

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 China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 10 5879 8000
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 +1-303-675-2140
Fax: +1-303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

ARCHIVE INFORMATION

RoHS-compliant and/or Pb-free versions of Freescale products have the functionality and electrical characteristics of their non-RoHS-compliant and/or non-Pb-free counterparts. For further information, see http://www.freescale.com or contact your Freescale sales representative.

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

Document Number: MRF9045N
Rev. 11, 9/2008