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Freescale Semiconductor
Technical Data

Document Number: MRF9045N
Rev. 12, 9/2008

RoHS

RF Power Field Effect Transistor

N-Channel Enhancement-Mode Lateral MOSFET

MRF9045NR1

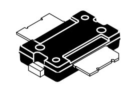
Designed for broadband commercial and industrial applications with frequencies up to 1000 MHz. The high gain and broadband performance of this device make it ideal for large-signal, common-source amplifier applications in 28 volt base station equipment.

- 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

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

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-270-2 Available in Tape and Reel. R1 Suffix = 500 Units per 24 mm, 13 inch Reel.



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	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.

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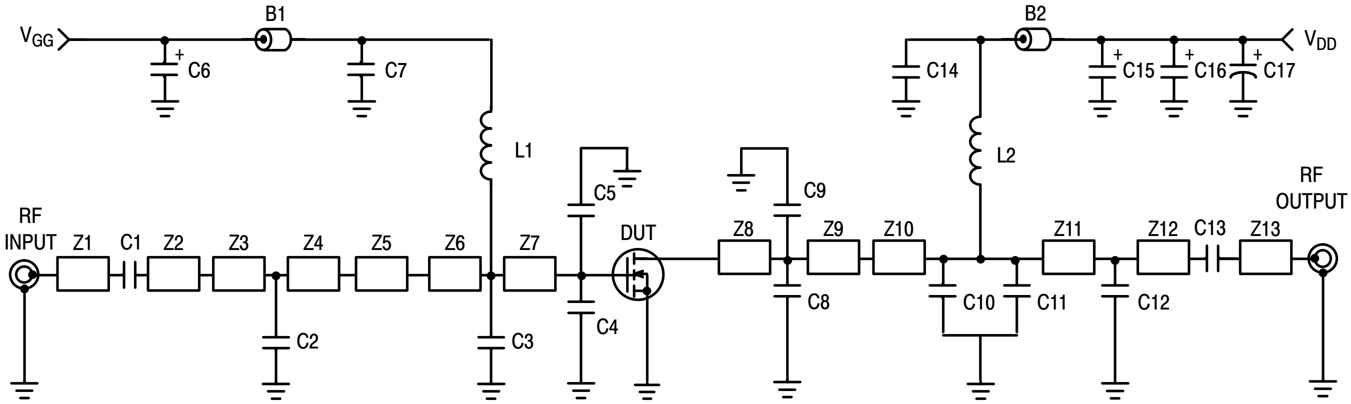
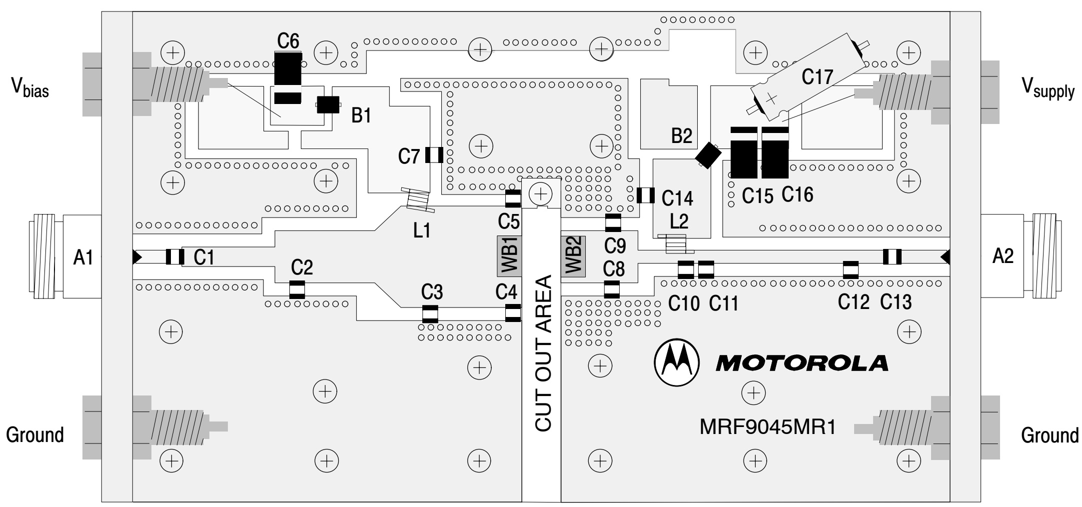
Table 5. Electrical Characteristics (T_C = 25°C unless otherwise noted)

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



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

Figure 1. MRF9045NR1 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. MRF9045NR1 930-960 MHz Broadband Test Circuit Component Layout

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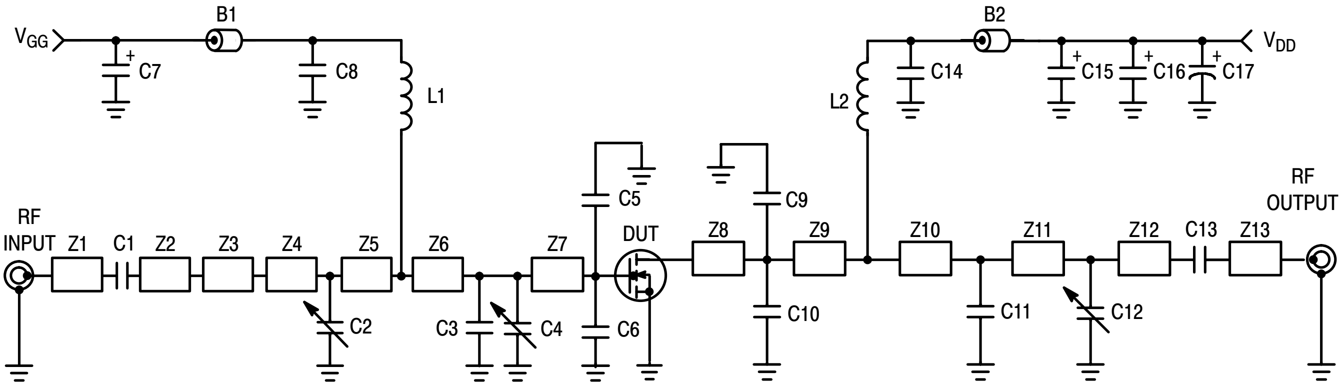

B1	Short Ferrite Bead	Z1	0.260″ x 0.060″ Microstrip
B2	Long Ferrite Bead	Z2	0.240″ x 0.060″ Microstrip
C1, C8, C13, C14	47 pF Chip Capacitors	Z3	0.500″ x 0.100″ Microstrip
C2	0.4-2.5 pF Variable Capacitor, Johanson Gigatrim	Z4	0.215″ x 0.270″ Microstrip
C3	3.6 pF Chip Capacitor	Z5	0.315″ x 0.270″ Microstrip
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, ε_r = 3.5

Figure 3. MRF9045NR1 930-960 MHz Broadband Test Circuit Schematic

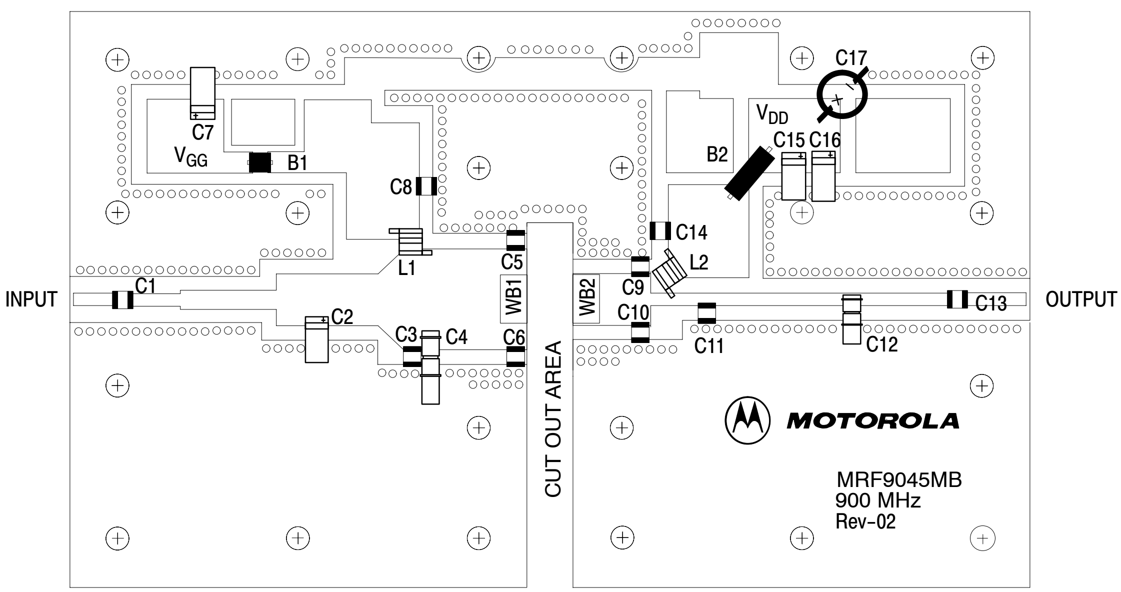

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Figure 4. MRF9045NR1 930-960 MHz Broadband Test Circuit Component Layout

TYPICAL CHARACTERISTICS

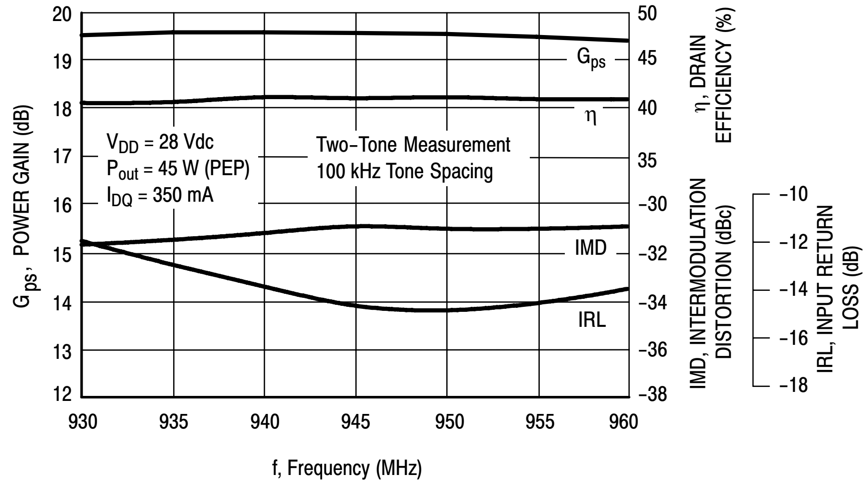


Figure 5. Class AB Broadband Circuit Performance

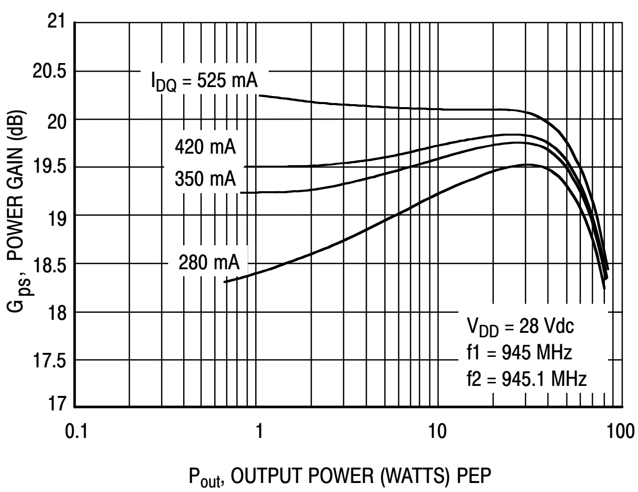


Figure 6. Power Gain versus Output Power

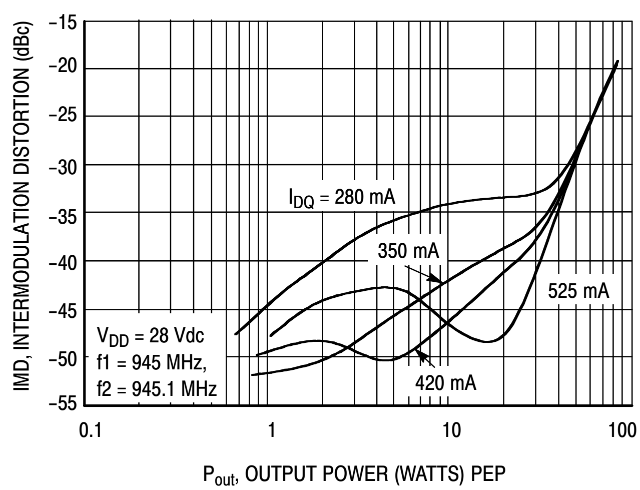


Figure 7. Intermodulation Distortion versus Output Power

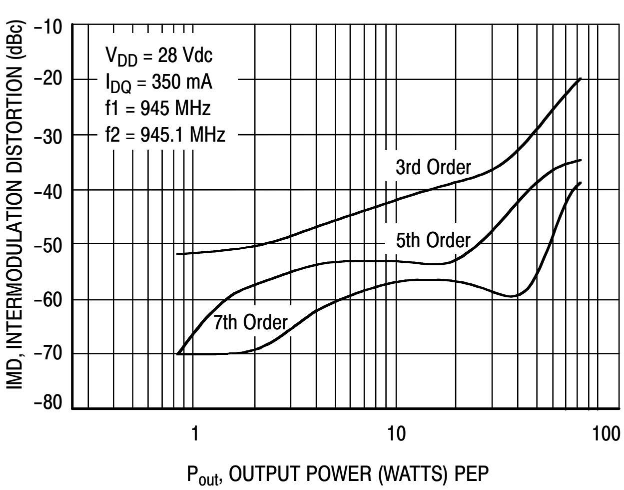


Figure 8. Intermodulation Distortion Products versus Output Power

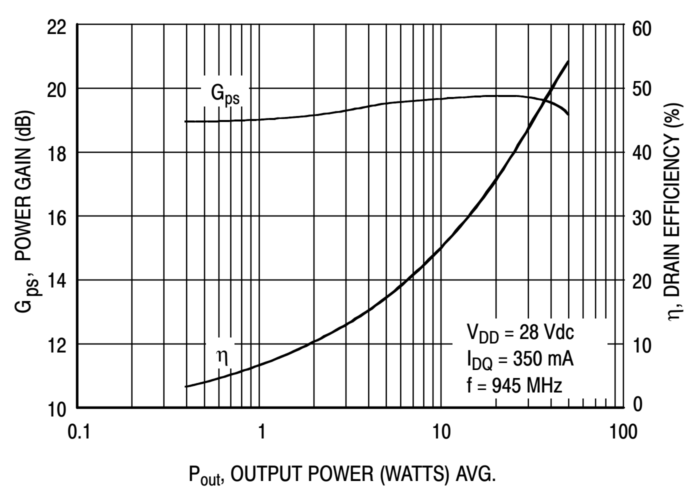


Figure 9. Power Gain and Efficiency versus Output Power

TYPICAL CHARACTERISTICS

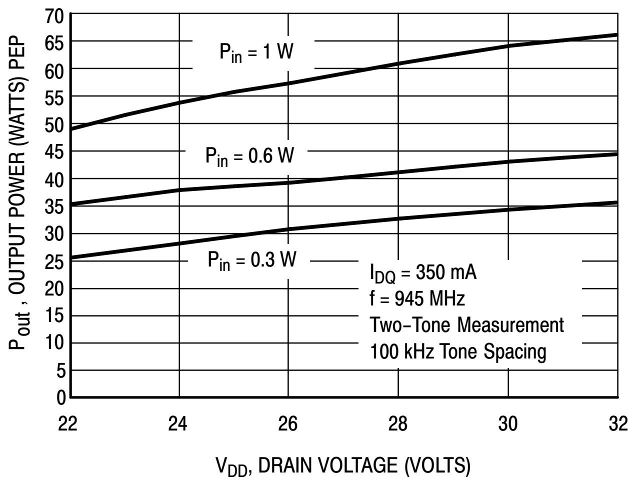
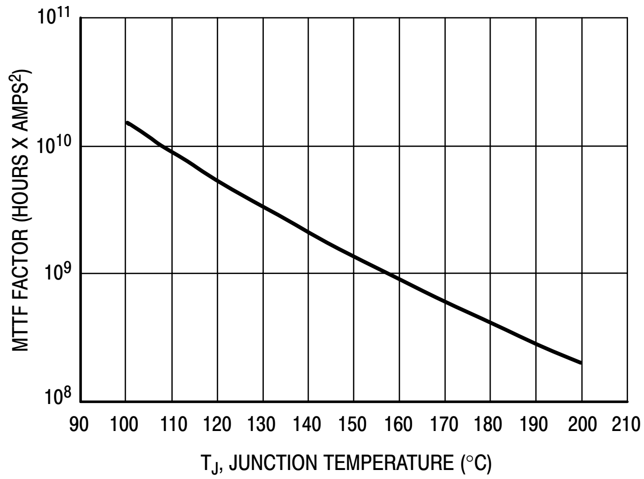
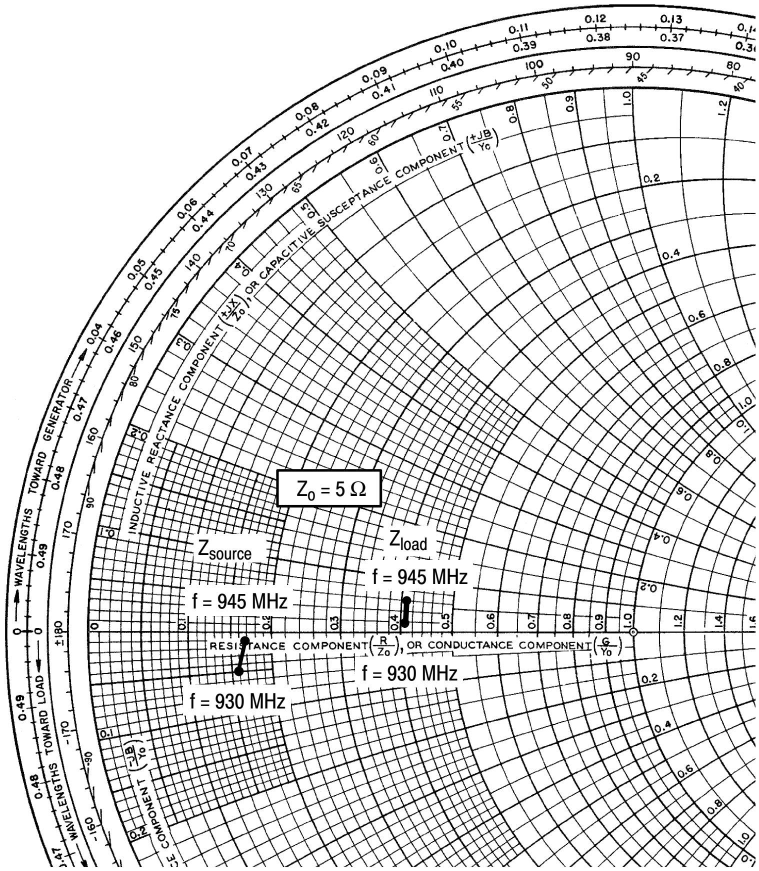


Figure 10. Output Voltage versus Supply Voltage



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	0.81 - j0.25	2.03 + j0.09
945	0.85 - j0.05	2.03 + j0.28

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

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

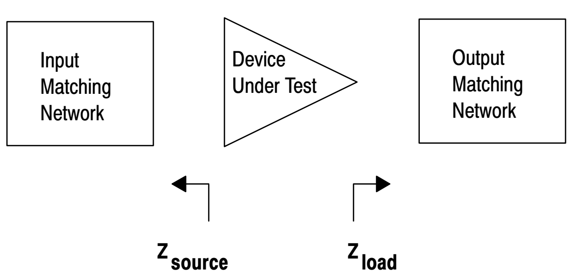
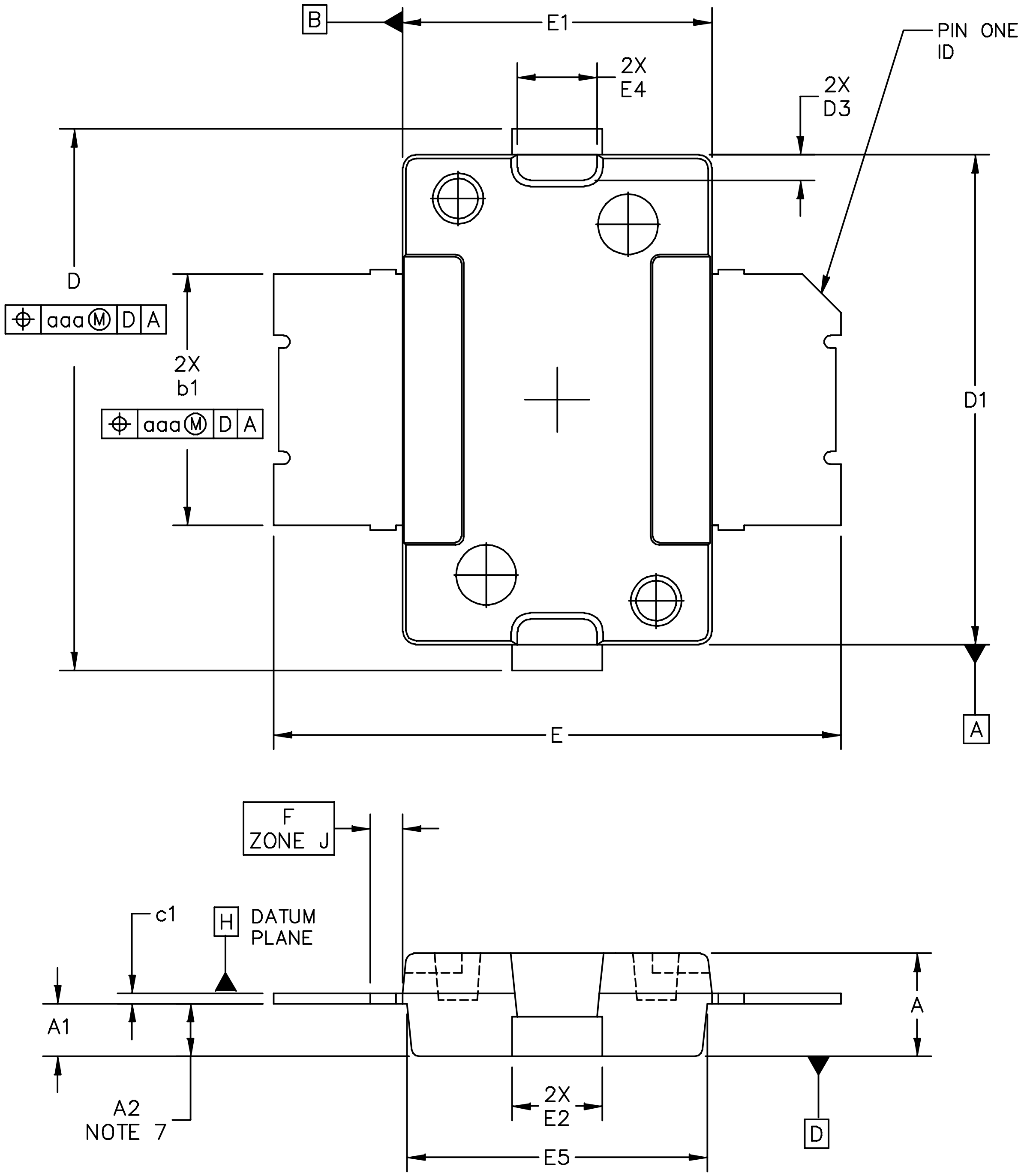


Figure 12. Series Equivalent Source and Load Impedance

PACKAGE DIMENSIONS



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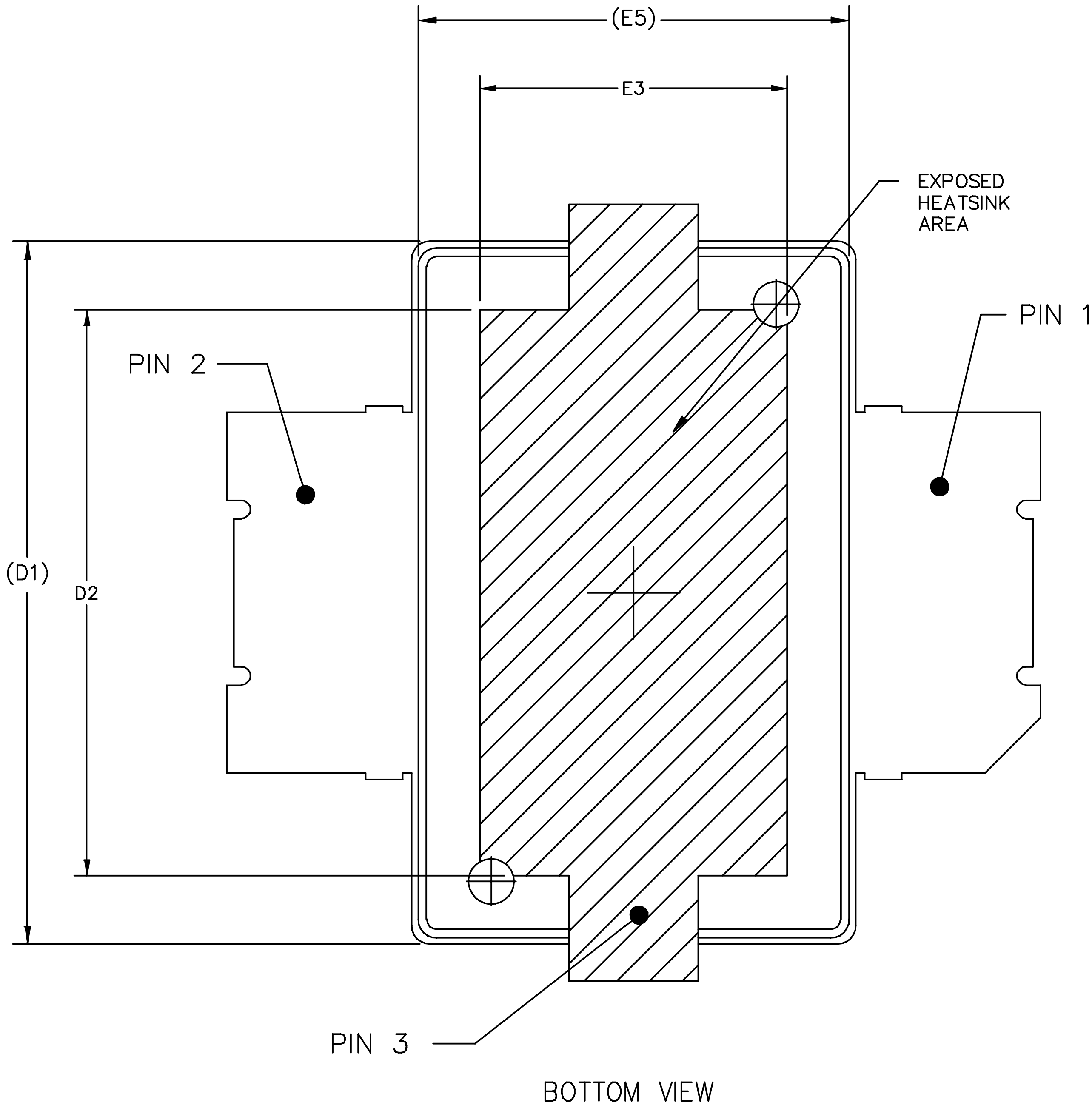

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NOTES:

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

DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER MAX	DIM	INCH MIN	INCH MAX	MILLIMETER MIN	MILLIMETER 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					

MECHANICAL OUTLINE	PRINT VERSION NOT TO SCALE	
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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
12	Sept. 2008	• Data sheet revised to reflect part status change, 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. • Added Product Documentation and Revision History, p. 11

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