

# 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 Bolt-down 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.

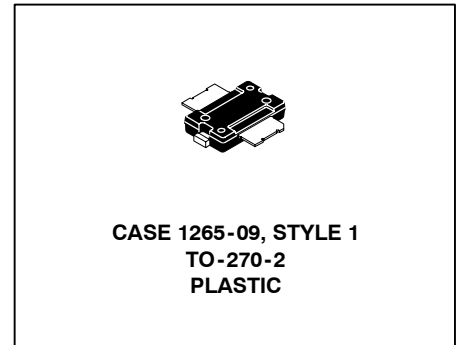
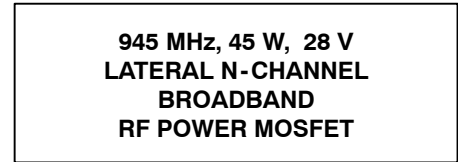


Table 1. Maximum Ratings

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	$P_D$	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

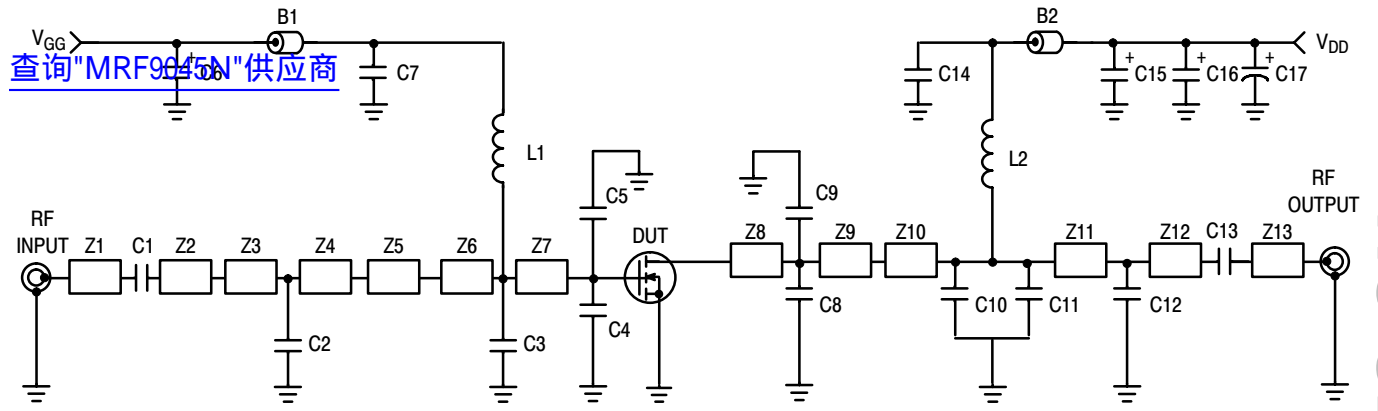
1. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

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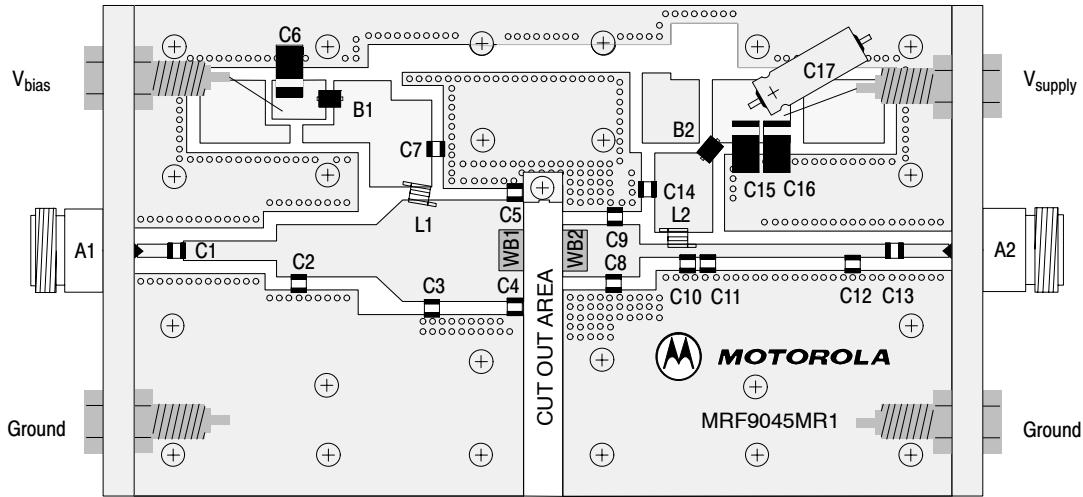
**Table 5. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics</b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{Adc}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{Adc}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{Adc}$
<b>On Characteristics</b>					
Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 150\ \mu\text{Adc}$ )	$V_{GS(th)}$	2	2.8	4	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 350\ \text{mA}$ )	$V_{GS(Q)}$	3	3.7	5	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1\ \text{A}$ )	$V_{DS(on)}$	—	0.22	0.4	Vdc
Forward Transconductance ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 3\ \text{A}$ )	$g_{fs}$	—	4	—	S
<b>Dynamic Characteristics</b>					
Input Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{iss}$	—	70	—	pF
Output Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{oss}$	—	38	—	pF
Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	1.7	—	pF
<b>Functional Tests</b> (In Freescale Test Fixture, 50 ohm system)					
Two-Tone Common-Source Amplifier Power Gain ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 945.0\ \text{MHz}$ , $f_2 = 945.1\ \text{MHz}$ )	$G_{ps}$	17	19	—	dB
Two-Tone Drain Efficiency ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 945.0\ \text{MHz}$ , $f_2 = 945.1\ \text{MHz}$ )	$\eta$	38	41	—	%
3rd Order Intermodulation Distortion ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 945.0\ \text{MHz}$ , $f_2 = 945.1\ \text{MHz}$ )	IMD	—	-31	-28	dBc
Input Return Loss ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 945.0\ \text{MHz}$ , $f_2 = 945.1\ \text{MHz}$ )	IRL	—	-14	-9	dB
Two-Tone Common-Source Amplifier Power Gain ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 930.0\ \text{MHz}$ , $f_2 = 930.1\ \text{MHz}$ and $f_1 = 960.0\ \text{MHz}$ , $f_2 = 960.1\ \text{MHz}$ )	$G_{ps}$	—	19	—	dB
Two-Tone Drain Efficiency ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 930.0\ \text{MHz}$ , $f_2 = 930.1\ \text{MHz}$ and $f_1 = 960.0\ \text{MHz}$ , $f_2 = 960.1\ \text{MHz}$ )	$\eta$	—	41	—	%
3rd Order Intermodulation Distortion ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 930.0\ \text{MHz}$ , $f_2 = 930.1\ \text{MHz}$ and $f_1 = 960.0\ \text{MHz}$ , $f_2 = 960.1\ \text{MHz}$ )	IMD	—	-31	—	dBc
Input Return Loss ( $V_{DD} = 28\text{ Vdc}$ , $P_{out} = 45\ \text{W PEP}$ , $I_{DQ} = 350\ \text{mA}$ , $f_1 = 930.0\ \text{MHz}$ , $f_2 = 930.1\ \text{MHz}$ and $f_1 = 960.0\ \text{MHz}$ , $f_2 = 960.1\ \text{MHz}$ )	IRL	—	-13	—	dB



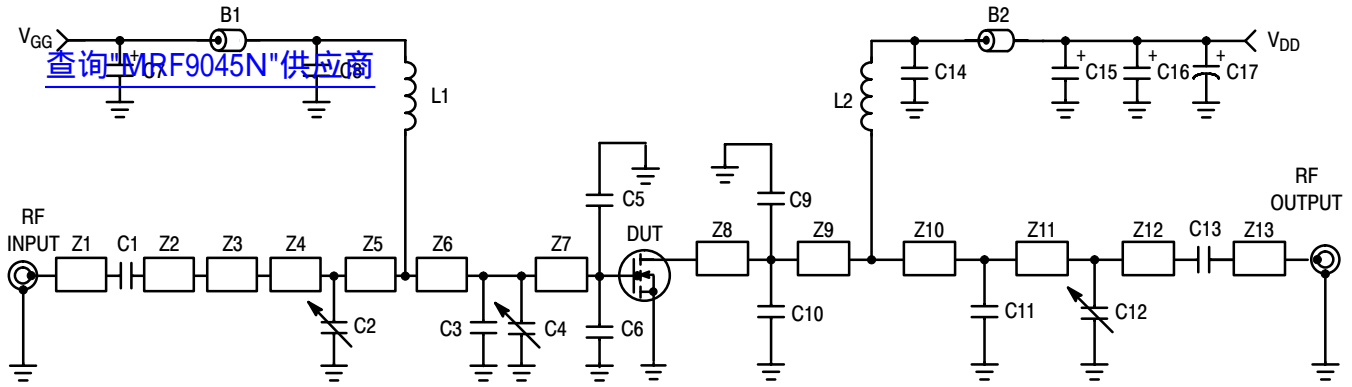
B1, B2	Short Ferrite Beads, Surface Mount	Z3	0.14" x 0.32" Microstrip
C1, C7, C13, C14	47 pF Chip Capacitors	Z4	0.47" x 0.32" Microstrip
C2, C8	2.7 pF Chip Capacitors	Z5	0.16" x 0.32" x 0.62" Taper
C3	3.9 pF Chip Capacitor	Z6	0.18" x 0.62" Microstrip
C4, C5, C8, C9	10 pF Chip Capacitors	Z7	0.56" x 0.62" Microstrip
C6, C15, C16	10 $\mu$ F, 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 $\mu$ F, 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. MRF9045NR1 930-960 MHz Broadband Test Circuit Schematic



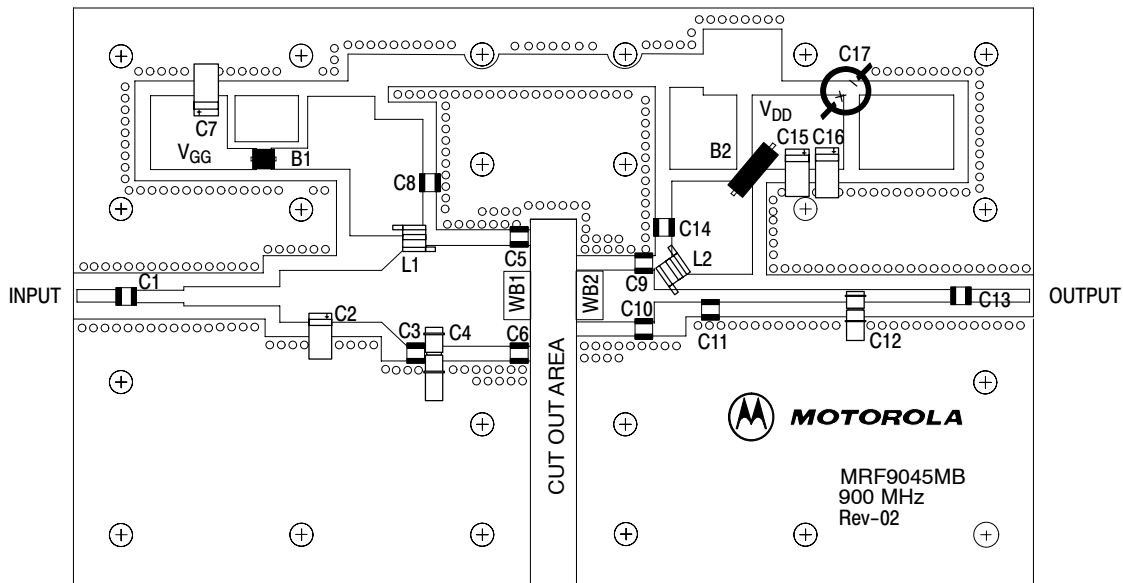
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Figure 2. MRF9045NR1 930-960 MHz Broadband Test Circuit Component Layout



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, ε <sub>r</sub> = 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

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TYPICAL CHARACTERISTICS

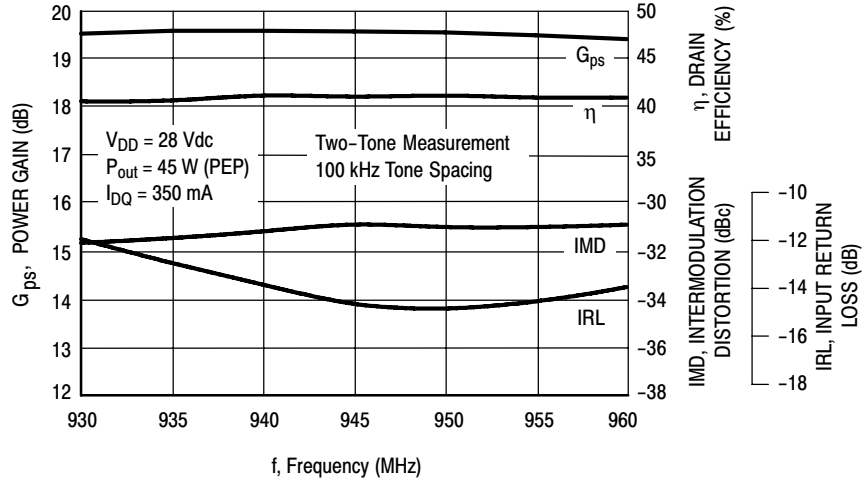


Figure 5. Class AB Broadband Circuit Performance

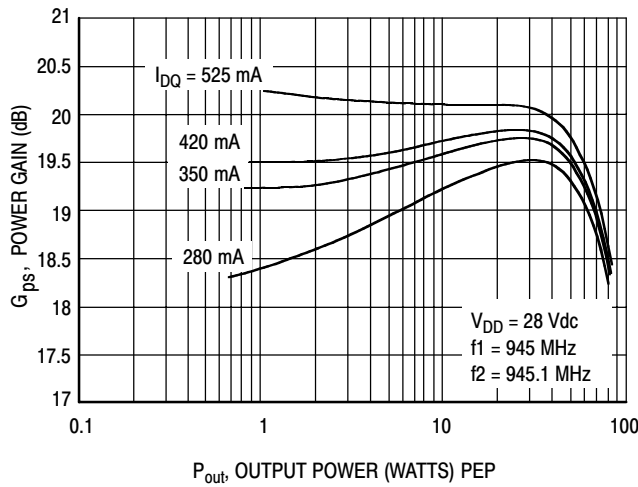


Figure 6. Power Gain versus Output Power

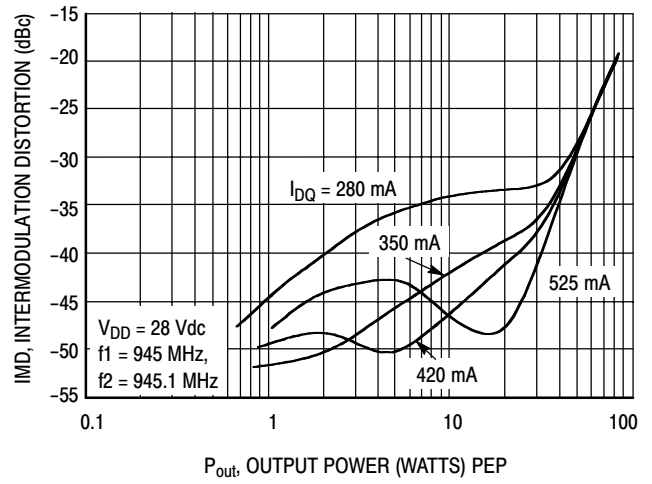


Figure 7. Intermodulation Distortion versus Output Power

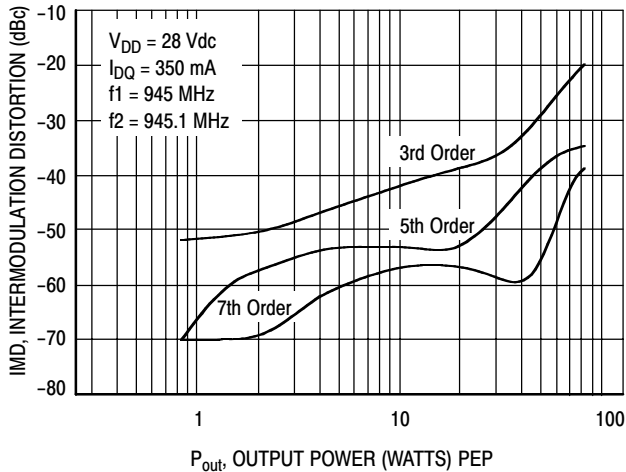


Figure 8. Intermodulation Distortion Products versus Output Power

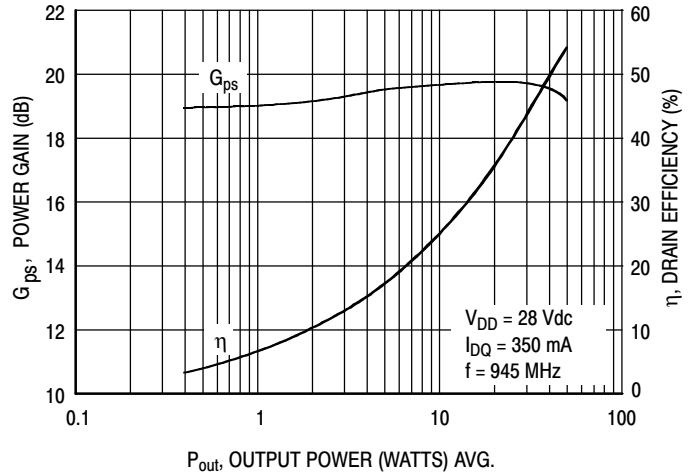


Figure 9. Power Gain and Efficiency versus Output Power

TYPICAL CHARACTERISTICS

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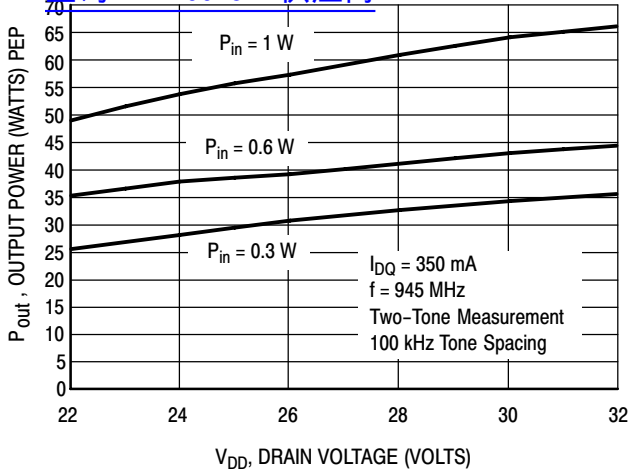
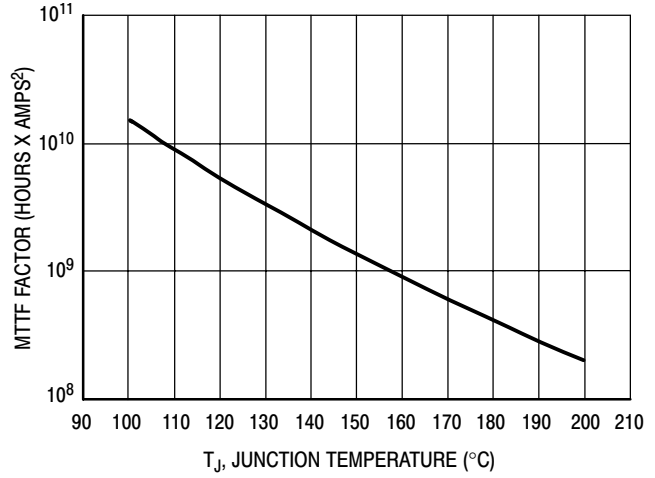
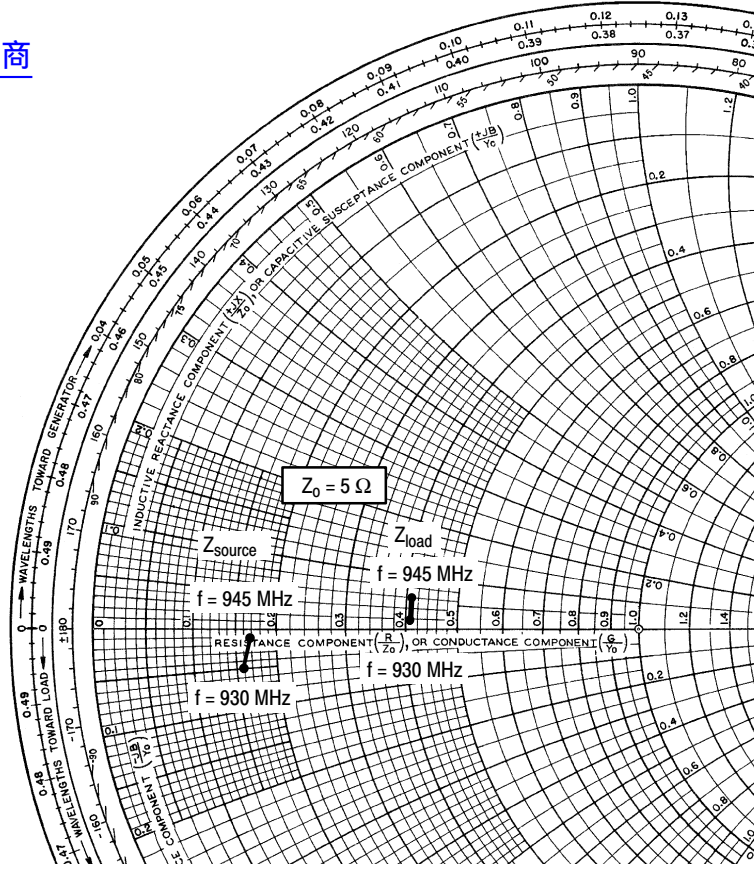


Figure 10. Output Voltage versus Supply Voltage



This above graph displays calculated MTTF in hours x ampere<sup>2</sup> 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<sub>D</sub><sup>2</sup> for MTTF in a particular application.

Figure 11. MTTF Factor versus Junction Temperature



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

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
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.

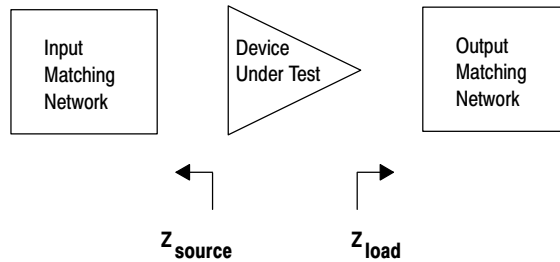
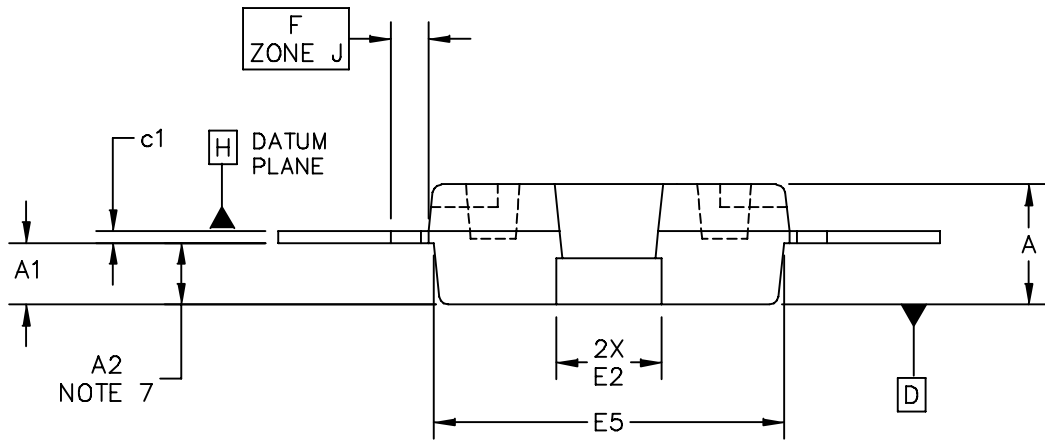
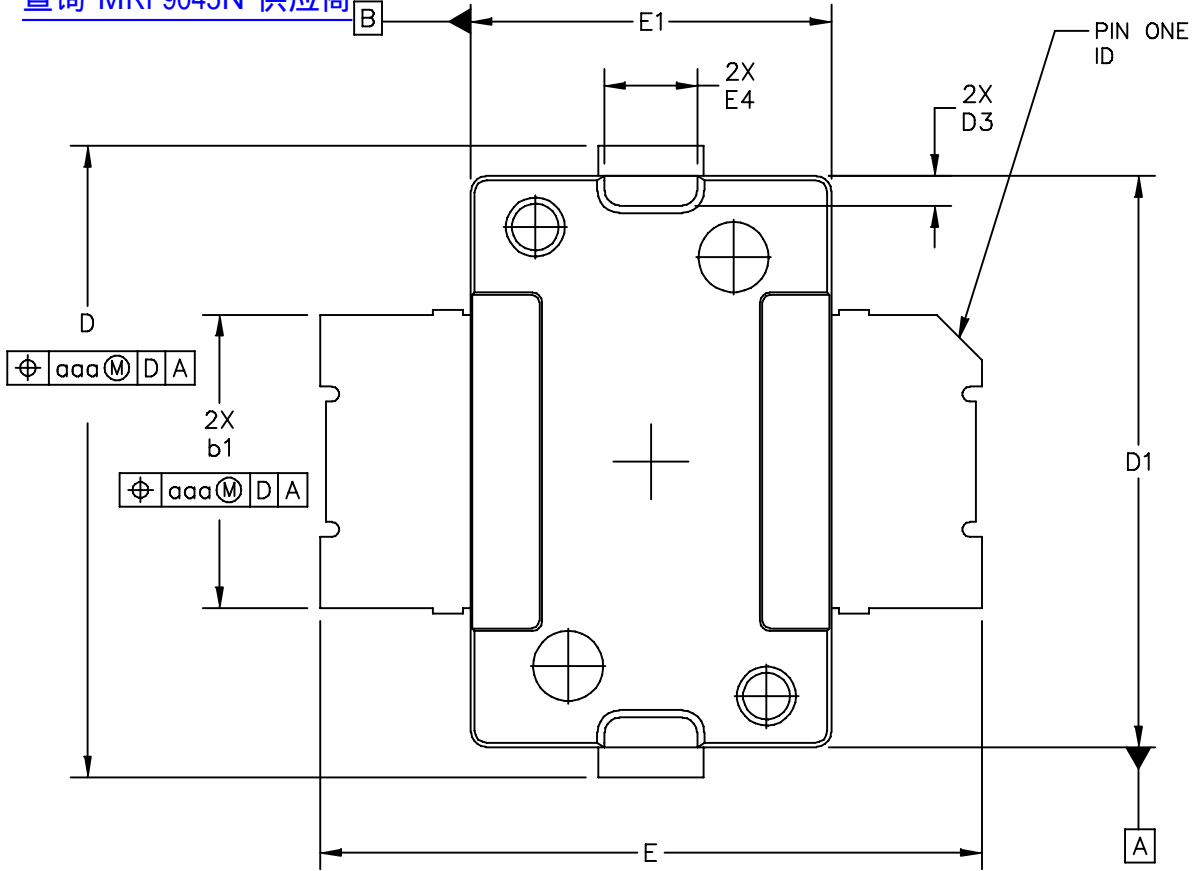


Figure 12. Series Equivalent Source and Load Impedance

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PACKAGE DIMENSIONS

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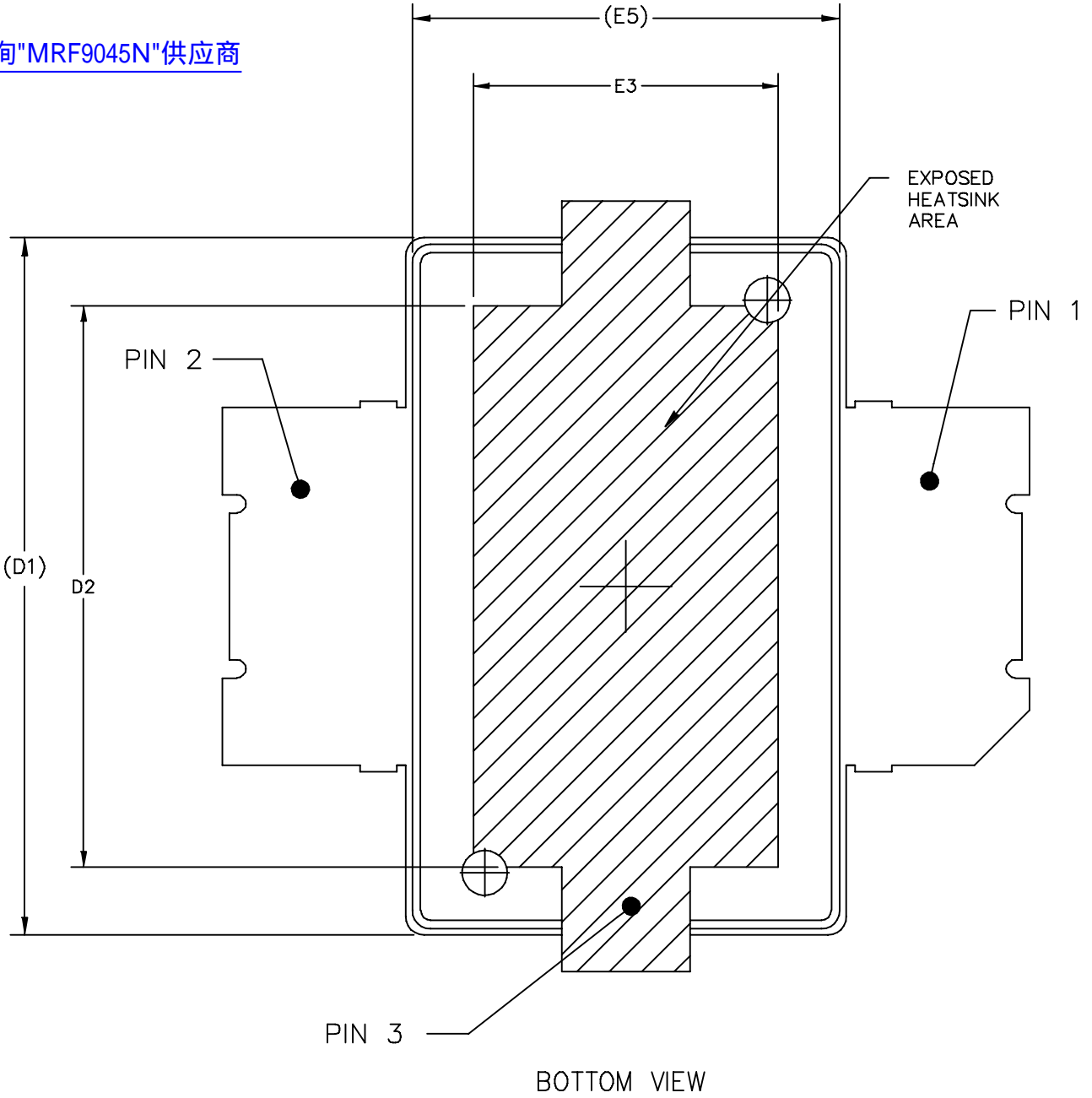


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		CASE NUMBER: 1265-09		29 JUN 2007	
		STANDARD: JEDEC TO-270 AA			

MRF9045NR1

NOTES:

1. CONTROLLING DIMENSION: INCH

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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		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		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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MECHANICAL OUTLINE

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TITLE:

TO-270  
SURFACE MOUNT

DOCUMENT NO: 98ASH98117A

REV: K

CASE NUMBER: 1265-09

29 JUN 2007

STANDARD: JEDEC TO-270 AA

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## PRODUCT DOCUMENTATION

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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	<ul style="list-style-type: none"><li>• Data sheet revised to reflect part status change, including use of applicable overlay.</li><li>• 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.</li><li>• Added Product Documentation and Revision History, p. 11</li></ul>

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