

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for base station applications with frequencies from 728 to 768 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1200$  mA,  $P_{out} = 50$  Watts Avg., IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.

Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	Output PAR (dB)	ACPR (dBc)
728 MHz	19.7	37.1	6.2	-38.7
748 MHz	19.5	37.0	6.1	-37.5
768 MHz	19.4	37.9	6.1	-37.8

- Capable of Handling 10:1 VSWR, @ 32 Vdc, 748 MHz, 170 Watts CW Output Power (3 dB Input Overdrive from Rated  $P_{out}$ ), Designed for Enhanced Ruggedness
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx 182$  Watts CW

### Features

- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- 225°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 32 mm, 13 inch Reel.

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +70	Vdc
Gate-Source Voltage	$V_{GS}$	-6.0, +10	Vdc
Operating Voltage	$V_{DD}$	32, +0	Vdc
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Case Operating Temperature	$T_C$	150	°C
Operating Junction Temperature (1,2)	$T_J$	225	°C

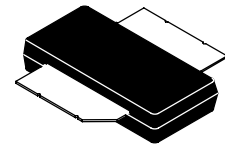
**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (2,3)	Unit
Thermal Resistance, Junction to Case Case Temperature 80°C, 170 W CW, 28 Vdc, $I_{DQ} = 1200$ mA Case Temperature 81°C, 50 W CW, 28 Vdc, $I_{DQ} = 1200$ mA	$R_{\theta JC}$	0.30 0.37	°C/W

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**MRF8S7170NR3**

**728-768 MHz, 50 W AVG., 28 V  
SINGLE W-CDMA  
LATERAL N-CHANNEL  
RF POWER MOSFET**



**CASE 2021-03, STYLE 1  
OM-780-2  
PLASTIC**

**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	2 (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	IV (Minimum)

**Table 4. Moisture Sensitivity Level**

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

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

Characteristic	Symbol	Min	Typ	Max	Unit
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**Off Characteristics**

Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 70\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	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	$\mu\text{Adc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 355\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.5	2.3	3	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1200\text{ mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2.3	3.1	3.8	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.9\text{ Adc}$ )	$V_{DS(on)}$	0.1	0.22	0.3	Vdc

**Functional Tests** <sup>(1)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1200\text{ mA}$ ,  $P_{out} = 50\text{ W Avg.}$ ,  $f = 748\text{ MHz}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

Power Gain	$G_{ps}$	18.0	19.5	21.0	dB
Drain Efficiency	$\eta_D$	34.0	37.0	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.1	—	dB
Adjacent Channel Power Ratio	ACPR	—	-37.5	-35.0	dBc
Input Return Loss	IRL	—	-24	-9	dB

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1200\text{ mA}$ ,  $P_{out} = 50\text{ W Avg.}$ , Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

Frequency	$G_{ps}$ (dB)	$\eta_D$ (%)	Output PAR (dB)	ACPR (dBc)	IRL (dB)
728 MHz	19.7	37.1	6.2	-38.7	-13
748 MHz	19.5	37.0	6.1	-37.5	-24
768 MHz	19.4	37.9	6.1	-37.8	-16

1. Part internally matched both on input and output.

(continued)

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 1200\text{ mA}$ , 728–768 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	$P_{1dB}$	—	182	—	W
IMD Symmetry @ 160 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$ (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB)	$IMD_{sym}$	—	16	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	$VBW_{res}$	—	65	—	MHz
Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 50\text{ W Avg.}$	$G_F$	—	0.5	—	dB
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.017	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.0048	—	dB/ $^\circ\text{C}$

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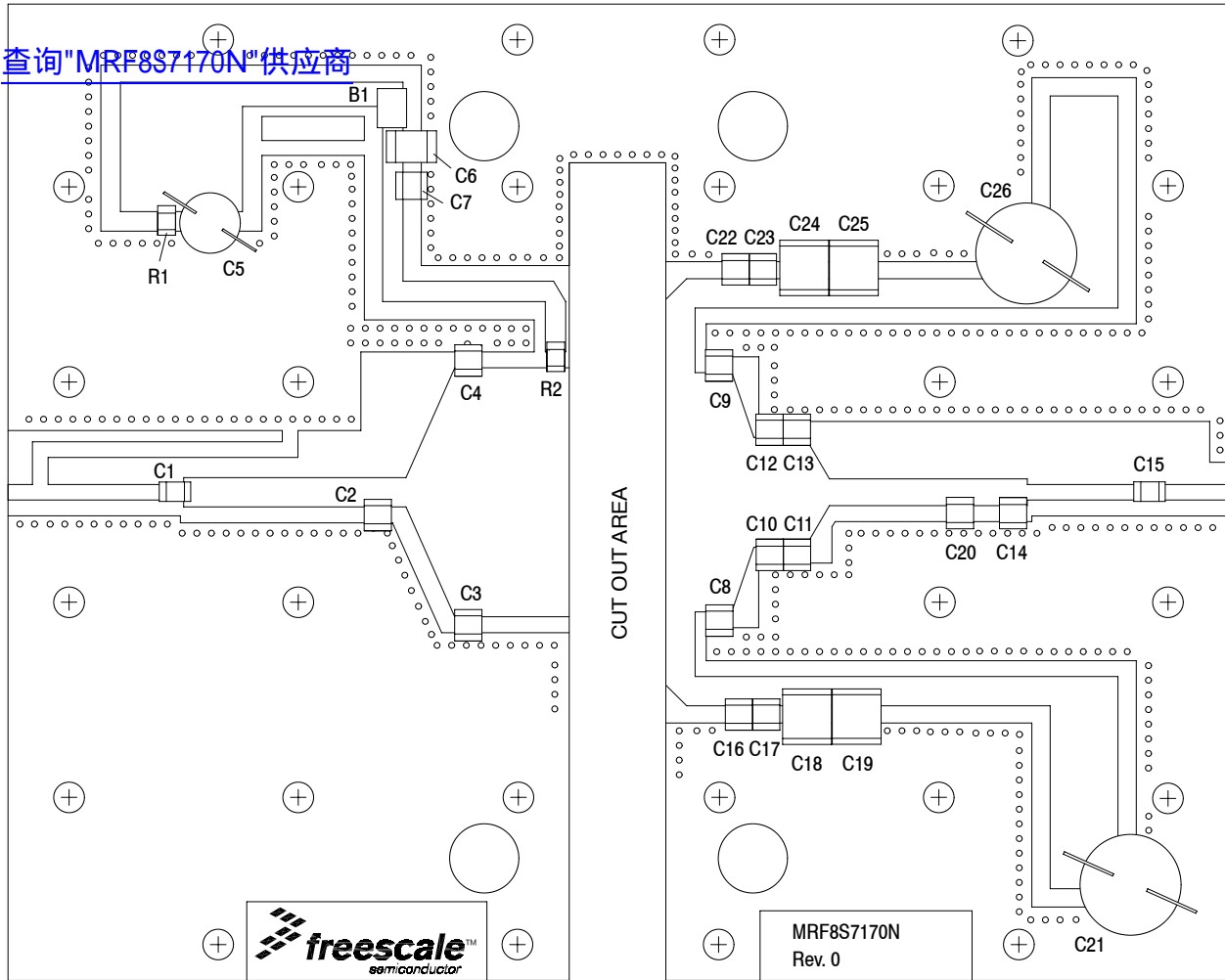


Figure 1. MRF8S7170NR3 Test Circuit Component Layout

Table 6. MRF8S7170NR3 Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Ferrite Bead, Short	2743019447	Fair-Rite
C1	2.7 pF Chip Capacitor	ATC100B2R7BT500XT	ATC
C2	2.2 pF Chip Capacitor	ATC100B2R2JT500XT	ATC
C3, C4	9.1 pF Chip Capacitors	ATC100B9R1CT500XT	ATC
C5	47 $\mu$ F, 63 V Electrolytic Capacitor	476KXM063M	Illinois Capacitor
C6	6.8 $\mu$ F, 100 V Chip Capacitor	C4532X7R1H685KT	TDK
C7	100 pF Chip Capacitor	ATC100B101JT500XT	ATC
C8, C9	11 pF Chip Capacitors	ATC100B110JT500XT	ATC
C10, C12	6.8 pF Chip Capacitors	ATC100B6R8CT500XT	ATC
C11, C13	7.5 pF Chip Capacitors	ATC100B7R5CT500XT	ATC
C14	5.1 pF Chip Capacitor	ATC100B5R1CT500XT	ATC
C15, C16, C17, C22, C23	39 pF Chip Capacitors	ATC100B390JT500XT	ATC
C18, C19, C24, C25	10 $\mu$ F, 25 V Chip Capacitors	C5750X7R1E106KT	TDK
C20	0.8 pF Chip Capacitor	ATC100B0R8BT500XT	ATC
C21, C26	470 $\mu$ F, 63 V Electrolytic Capacitors	477KXM063M	Illinois Capacitor
R1	2K $\Omega$ , 1/4 W Chip Resistor	CRCW12062K00FKEA	Vishay
R2	4.3 $\Omega$ , 1/4 W Chip Resistor	CRCW12064R30FKEA	Vishay
PCB	0.030", $\epsilon_r = 3.5$	RF-35	Taconic

## TYPICAL CHARACTERISTICS

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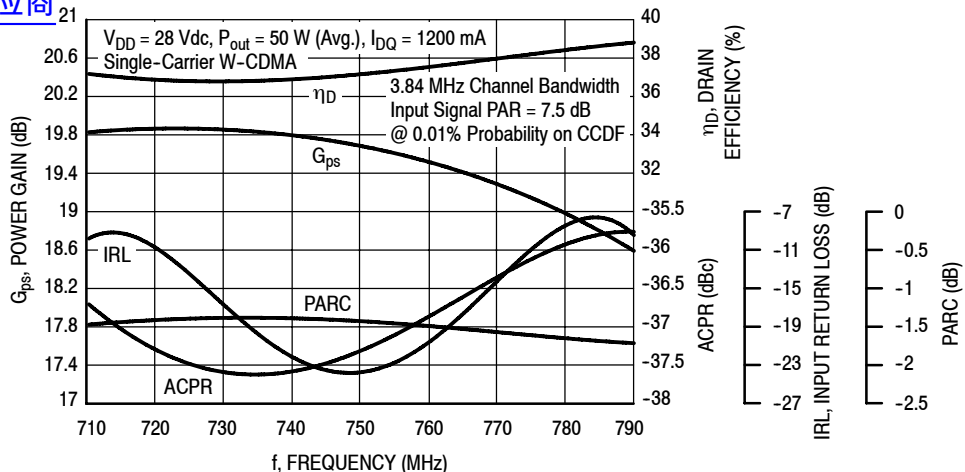


Figure 2. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 50$  Watts Avg.

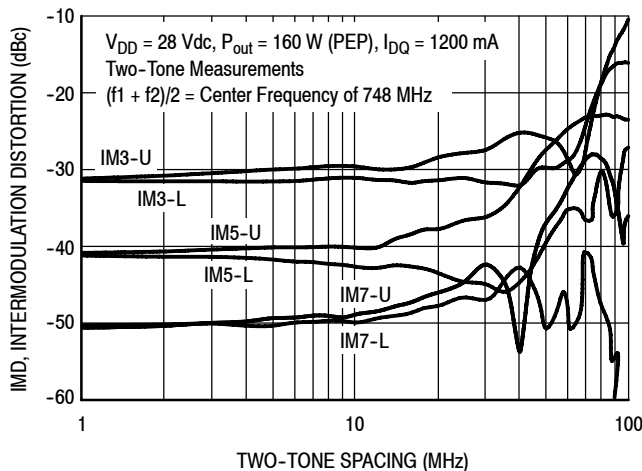


Figure 3. Intermodulation Distortion Products versus Two-Tone Spacing

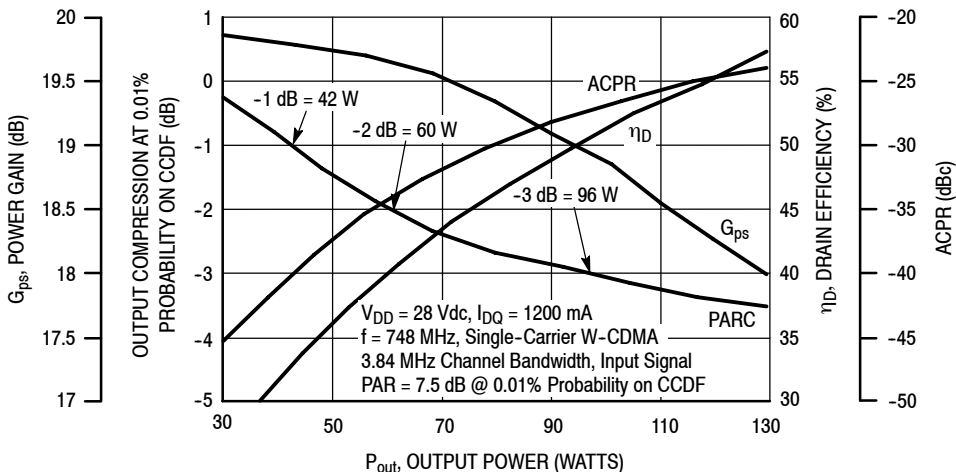
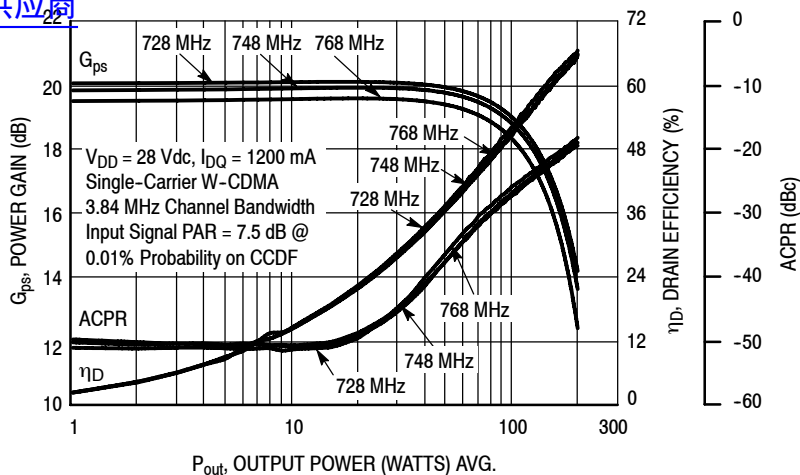


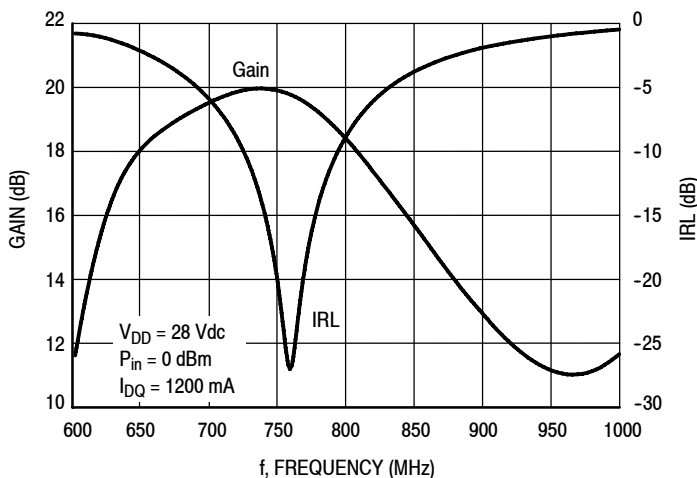
Figure 4. Output Peak-to-Average Ratio Compression (PARC) versus Output Power

## TYPICAL CHARACTERISTICS

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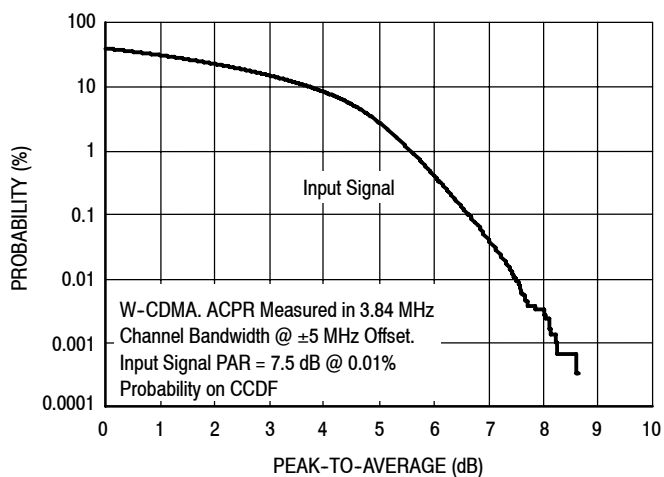


**Figure 5. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

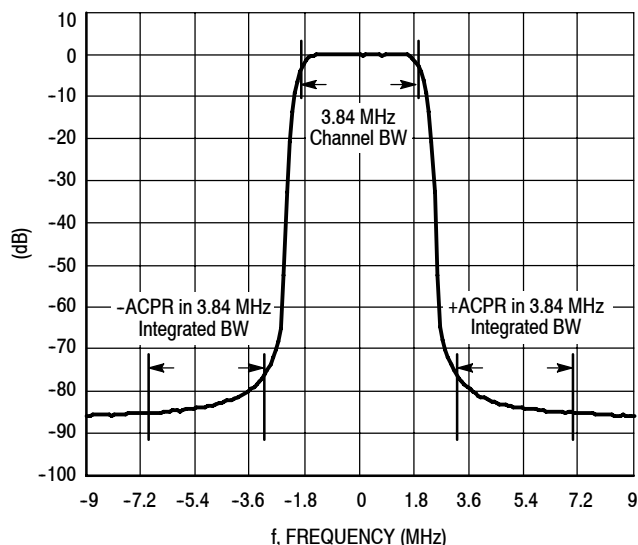


**Figure 6. Broadband Frequency Response**

## W-CDMA TEST SIGNAL



**Figure 7. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal**



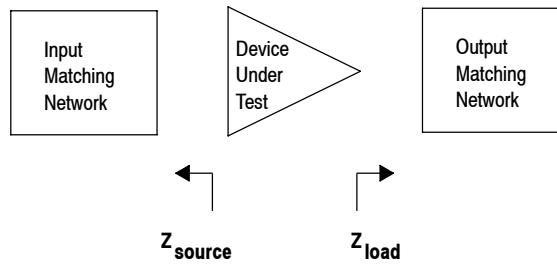
**Figure 8. Single-Carrier W-CDMA Spectrum**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1200 \text{ mA}$ ,  $P_{out} = 50 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
710	$0.876 - j2.237$	$1.685 - j0.887$
720	$0.910 - j2.150$	$1.659 - j0.776$
730	$0.942 - j2.080$	$1.650 - j0.683$
740	$0.970 - j2.032$	$1.660 - j0.610$
750	$0.981 - j2.013$	$1.677 - j0.563$
760	$0.961 - j2.009$	$1.688 - j0.550$
770	$0.911 - j1.996$	$1.687 - j0.551$
780	$0.843 - j1.955$	$1.660 - j0.557$
790	$0.787 - j1.881$	$1.620 + j0.548$

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

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

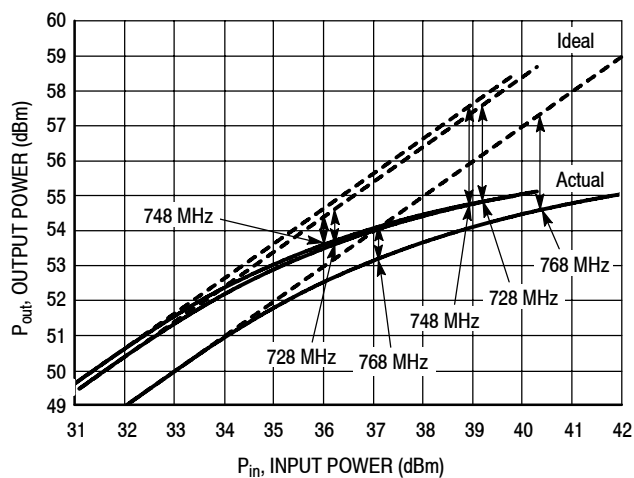


**Figure 9. Series Equivalent Source and Load Impedance**

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS

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$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1200 \text{ mA}$ , Pulsed CW, 10  $\mu\text{sec}(\text{on})$ , 10% Duty Cycle



NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
728	229	53.6	310	54.9
748	227	53.5	303	54.8
768	214	53.3	293	54.6

Test Impedances per Compression Level

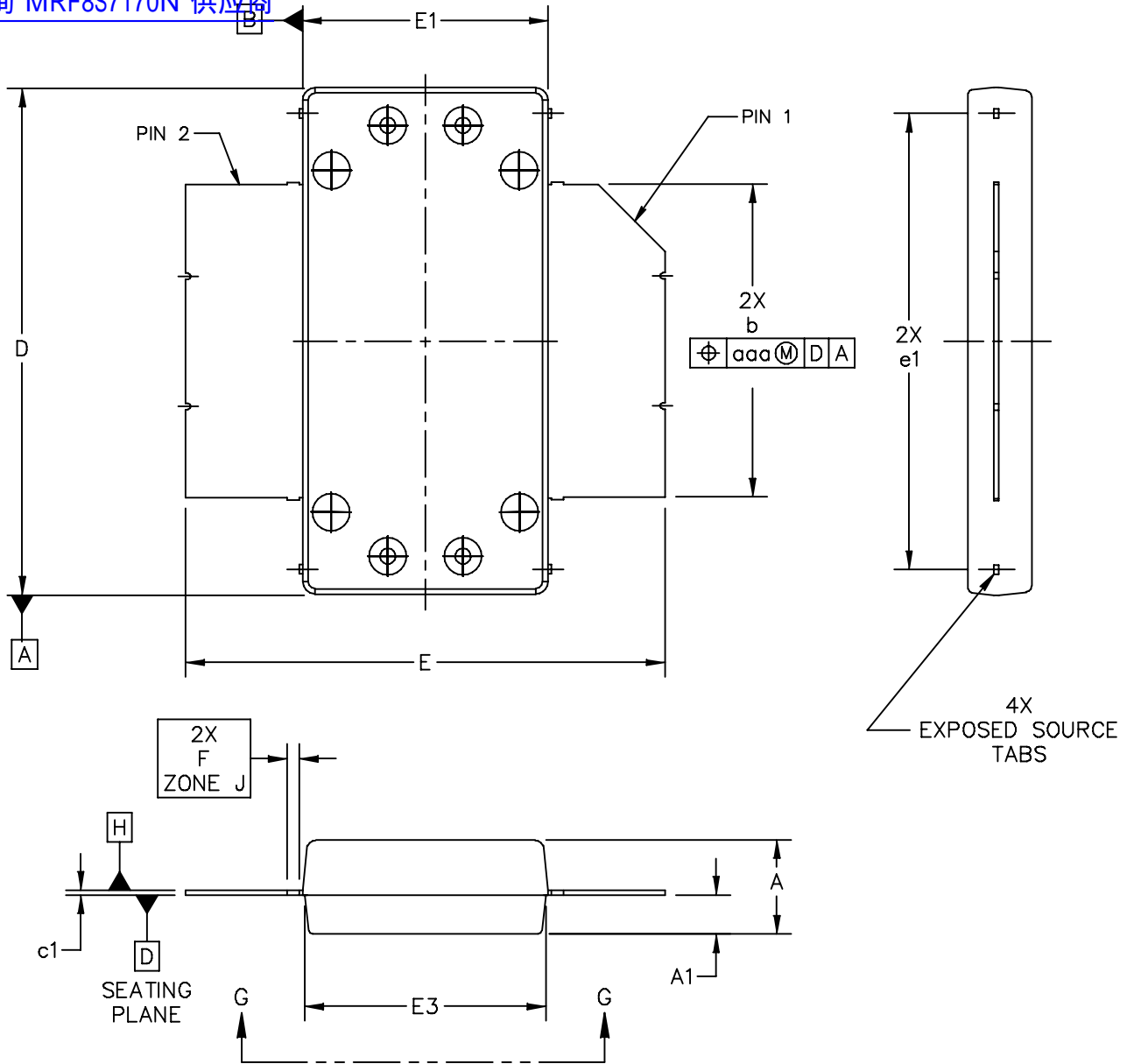
f (MHz)		$Z_{\text{source}}$ $\Omega$	$Z_{\text{load}}$ $\Omega$
728	P1dB	0.61 - j2.32	0.72 - j1.32
748	P1dB	0.73 - j2.60	0.81 - j1.27
768	P1dB	0.72 - j2.82	0.58 - j1.46

**Figure 10. Pulsed CW Output Power versus Input Power @ 28 V**



PACKAGE DIMENSIONS

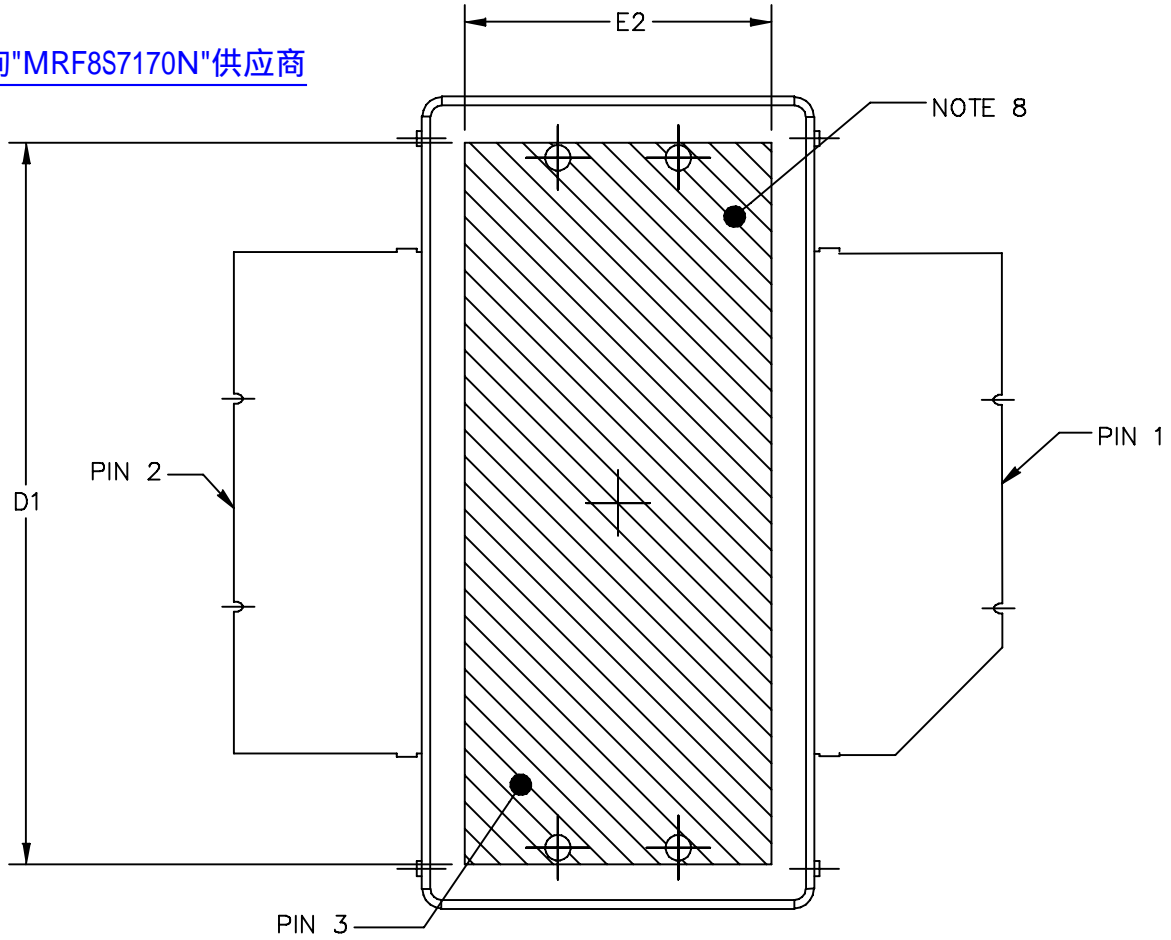
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BOTTOM VIEW  
VIEW G-G

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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 "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 b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION A1 APPLIES WITHIN ZONE "J" ONLY
8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.

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	0.148	.152	3.76	3.86	b	.497	.503	12.62	12.78
A1	.059	.065	1.50	1.65	c1	.007	.011	0.18	0.28
D	.808	.812	20.52	20.62	e1	.721	.729	18.31	18.52
D1	.720	----	18.29	----					
E	.762	.770	19.36	19.56	aaa	.004		0.10	
E1	.390	.394	9.91	10.01					
E2	.306	----	7.77	----					
E3	.383	.387	9.73	9.83					
F	.025 BSC		0.635 BSC						

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## PRODUCT DOCUMENTATION AND SOFTWARE

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Refer to the following documents, tools and software 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
- RF High Power Model
- .s2p File

For Software, 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
0	Feb. 2010	• Initial Release of Data Sheet
1	Oct. 2010	• Changed Human Body Model ESD rating from Class 1C to Class 2 to reflect recent ESD test results of the device, p. 2.

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