

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for CDMA base station applications with frequencies from 920 to 960 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,  $I_{DQ} = 1400$  mA,  $P_{out} = 58$  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)
920 MHz	19.9	37.7	6.1	-36.2
940 MHz	19.9	37.1	6.1	-36.6
960 MHz	19.5	36.8	6.0	-36.0

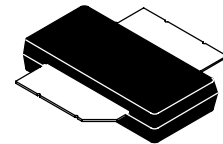
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 940 MHz, 300 Watts CW Output Power (3 dB Input Overdrive from Rated  $P_{out}$ ), Designed for Enhanced Ruggedness
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx 200$  Watts CW

### 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
- 225°C Capable Plastic Package
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 32 mm, 13 inch Reel.

**MRF8S9200NR3**

**920-960 MHz, 58 W AVG., 28 V  
 SINGLE W-CDMA  
 LATERAL N-CHANNEL  
 RF POWER MOSFET**



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

**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, 58 W CW, 28 Vdc, $I_{DQ} = 1400$ mA Case Temperature 80°C, 200 W CW, 28 Vdc, $I_{DQ} = 1400$ mA	$R_{\theta JC}$	0.30 0.25	°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.

**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 ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 400\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.5	2.3	3	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1400\ \text{mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2.3	3	3.8	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 3.3\ \text{Adc}$ )	$V_{DS(on)}$	0.1	0.2	0.3	Vdc

**Functional Tests** <sup>(1)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1400\ \text{mA}$ ,  $P_{out} = 58\ \text{W Avg.}$ ,  $f = 940\ \text{MHz}$ , 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	19.9	21	dB
Drain Efficiency	$\eta_D$	34	37.1	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.8	6.1	—	dB
Adjacent Channel Power Ratio	ACPR	—	-36.6	-35	dBc
Input Return Loss	IRL	—	-22	-9	dB

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1400\ \text{mA}$ ,  $P_{out} = 58\ \text{W Avg.}$ , 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)
920 MHz	19.9	37.7	6.1	-36.2	-14
940 MHz	19.9	37.1	6.1	-36.6	-22
960 MHz	19.5	36.8	6.0	-36.0	-15

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) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 1400\text{ mA}$ , 920–960 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	$P_{1dB}$	—	200	—	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)	$IMD_{sym}$	—	15	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	$VBW_{res}$	—	45	—	MHz
Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 58\text{ W Avg.}$	$G_F$	—	0.7	—	dB
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.012	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.001	—	dBm/ $^\circ\text{C}$

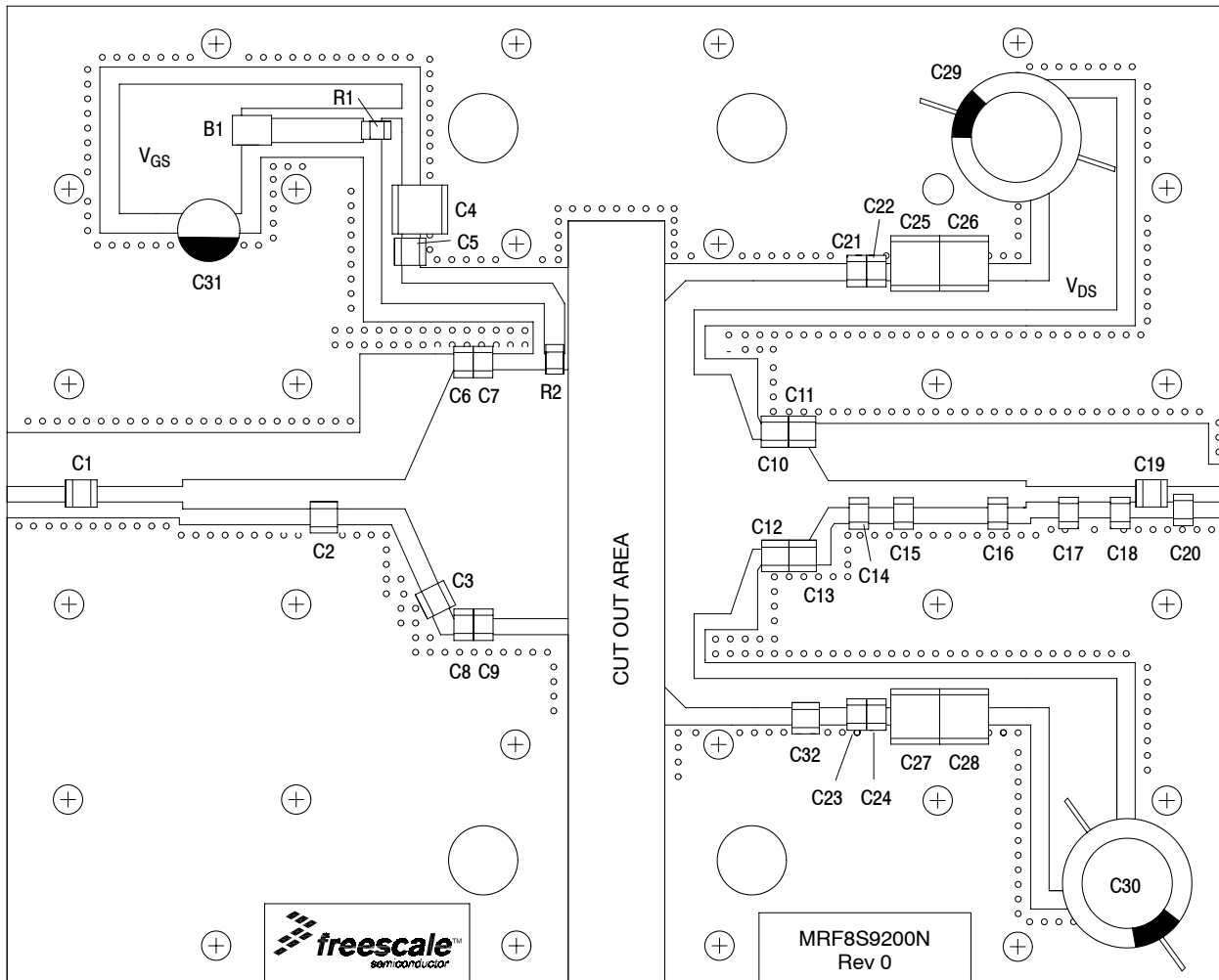
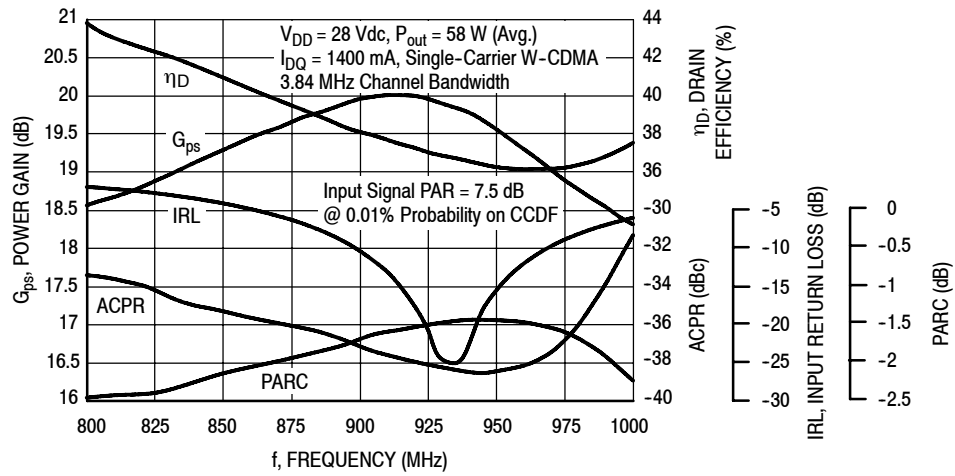


Figure 1. MRF8S9200NR3 Test Circuit Component Layout

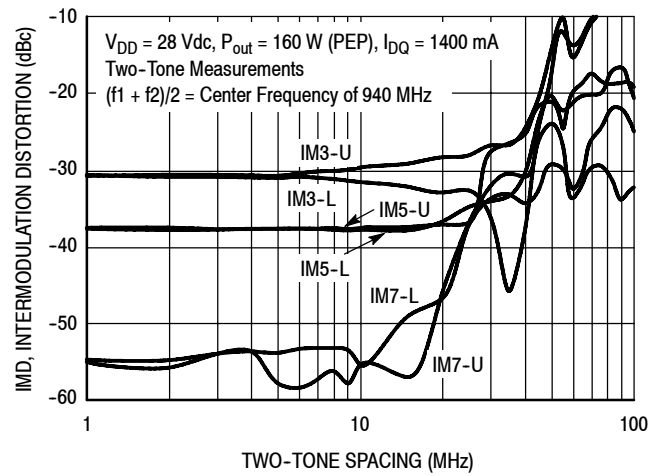
Table 6. MRF8S9200NR3 Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1	Ferrite Beads, Short	2743019447	Fair-Rite
C1, C5, C19, C21, C22, C23, C24	39 pF Chip Capacitors	ATC100B390JT500XT	ATC
C2	2 pF Chip Capacitor	ATC100B2R0BT500XT	ATC
C3	6.2 pF Chip Capacitor	ATC100B6R2BT500XT	ATC
C4	2.2 $\mu$ F Chip Capacitor	C1825C225J5RAC-TU	Kemet
C6, C7, C8, C9	3.3 pF Chip Capacitors	ATC100B3R3CT500XT	ATC
C10, C12	6.8 pF Chip Capacitors	ATC100B6R8CT500XT	ATC
C11, C13	5.1 pF Chip Capacitors	ATC100B5R1CT500XT	ATC
C14, C20	0.8 pF Chip Capacitors	ATC100B0R8BT500XT	ATC
C15, C17	0.5 pF Chip Capacitors	ATC100B0R5BT500XT	ATC
C16	1.5 pF Chip Capacitor	ATC100B1R5BT500XT	ATC
C18	1.2 pF Chip Capacitor	ATC100B1R2BT500XT	ATC
C25, C26, C27, C28	10 $\mu$ F, 50 V Chip Capacitors	GRM55DR61H106KA88L	Murata
C29, C30	470 $\mu$ F, Electrolytic Capacitors	MCGPR63V477M13X26-RH	Multicomp
C31	47 $\mu$ F, 50 V Electrolytic Capacitor	476KXM050M	Illinois Cap.
C32	10 pF Chip Capacitor	ATC100B100JT500XT	ATC
R1	3.3 $\Omega$ , 1/2 W Chip Resistor	P3.3VCT-ND	Panasonic
R2	0 $\Omega$ , 3.5 A Chip Resistor	CRCW12060000Z0EA	Vishay
PCB	0.030", $\epsilon_r = 3.5$	RF-35	Taconic

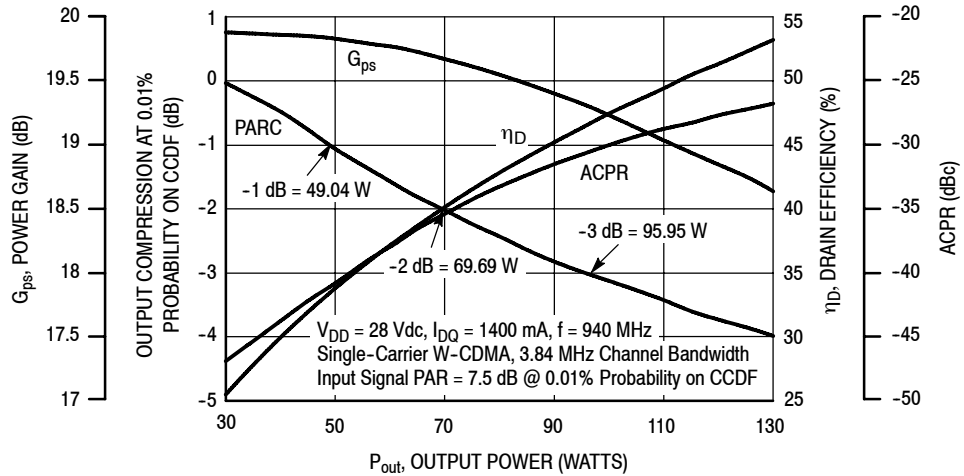
### TYPICAL CHARACTERISTICS



**Figure 2. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 58$  Watts Avg.**

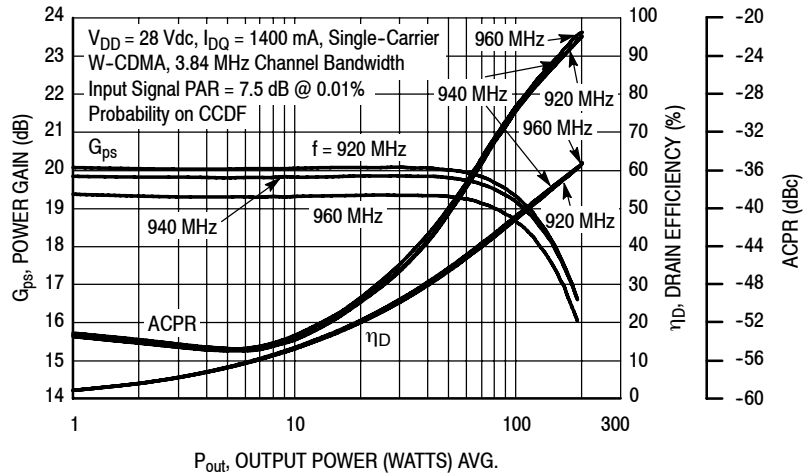


**Figure 3. Intermodulation Distortion Products versus Two-Tone Spacing**

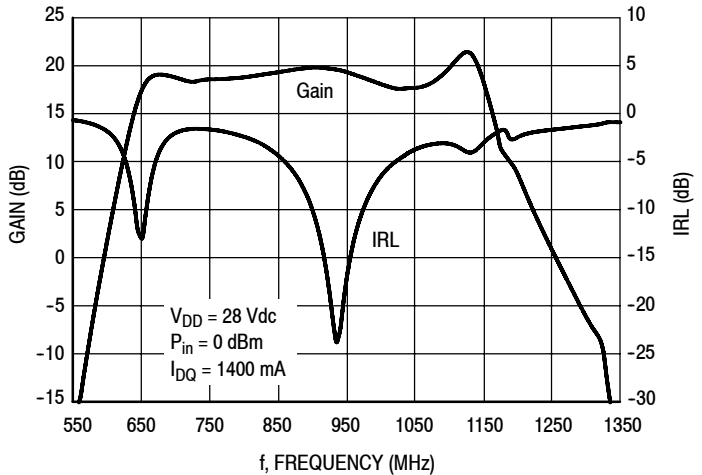


**Figure 4. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

### TYPICAL CHARACTERISTICS

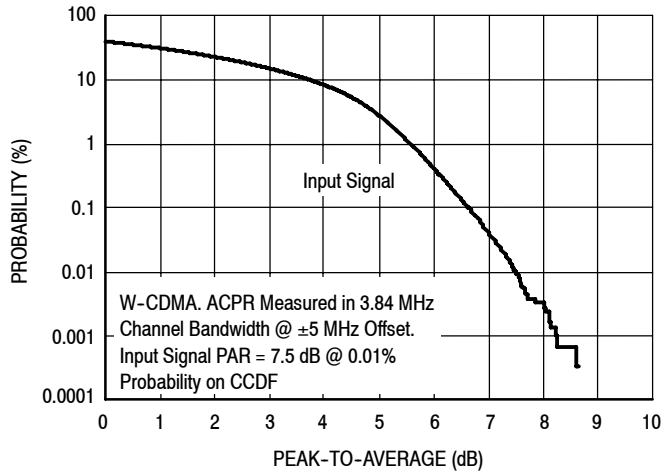


**Figure 5. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

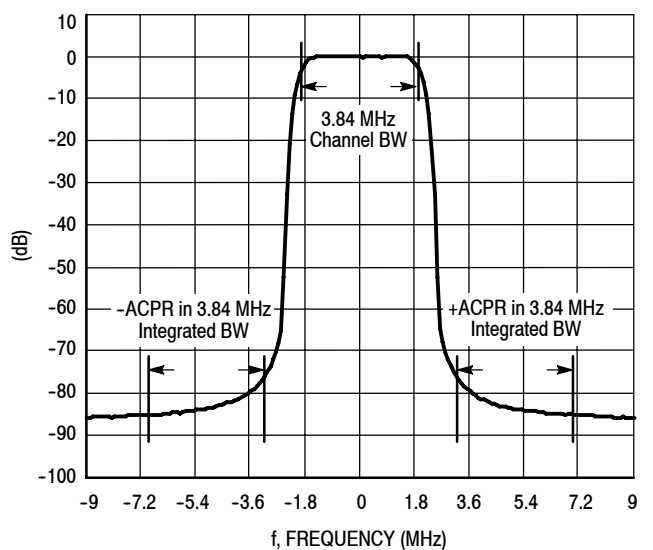


**Figure 6. Broadband Frequency Response**

### W-CDMA TEST SIGNAL



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



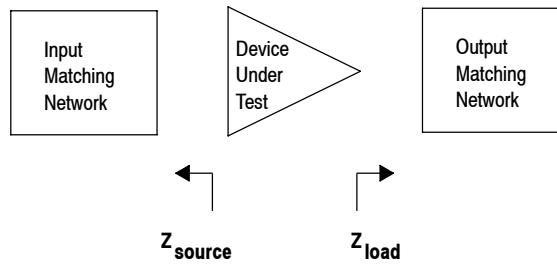
**Figure 8. Single-Carrier W-CDMA Spectrum**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1400 \text{ mA}$ ,  $P_{out} = 58 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
820	1.16 - j2.85	2.29 - j2.08
840	1.09 - j2.63	2.11 - j1.95
860	1.04 - j2.45	1.94 - j1.81
880	0.98 - j2.27	1.76 - j1.68
900	0.93 - j2.08	1.59 - j1.51
920	0.88 - j1.90	1.42 - j1.33
940	0.83 - j1.72	1.28 - j1.13
960	0.79 - j1.55	1.14 - j0.93
980	0.76 - j1.39	1.02 - j0.73

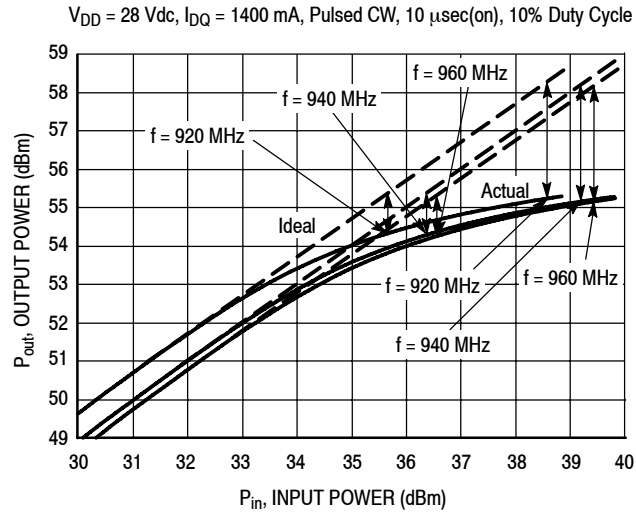
$Z_{source}$  = Test circuit impedance as measured from gate to ground.

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



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

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS



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

f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
920	267	54.3	332	55.2
940	263	54.2	327	55.1
960	261	54.2	327	55.2

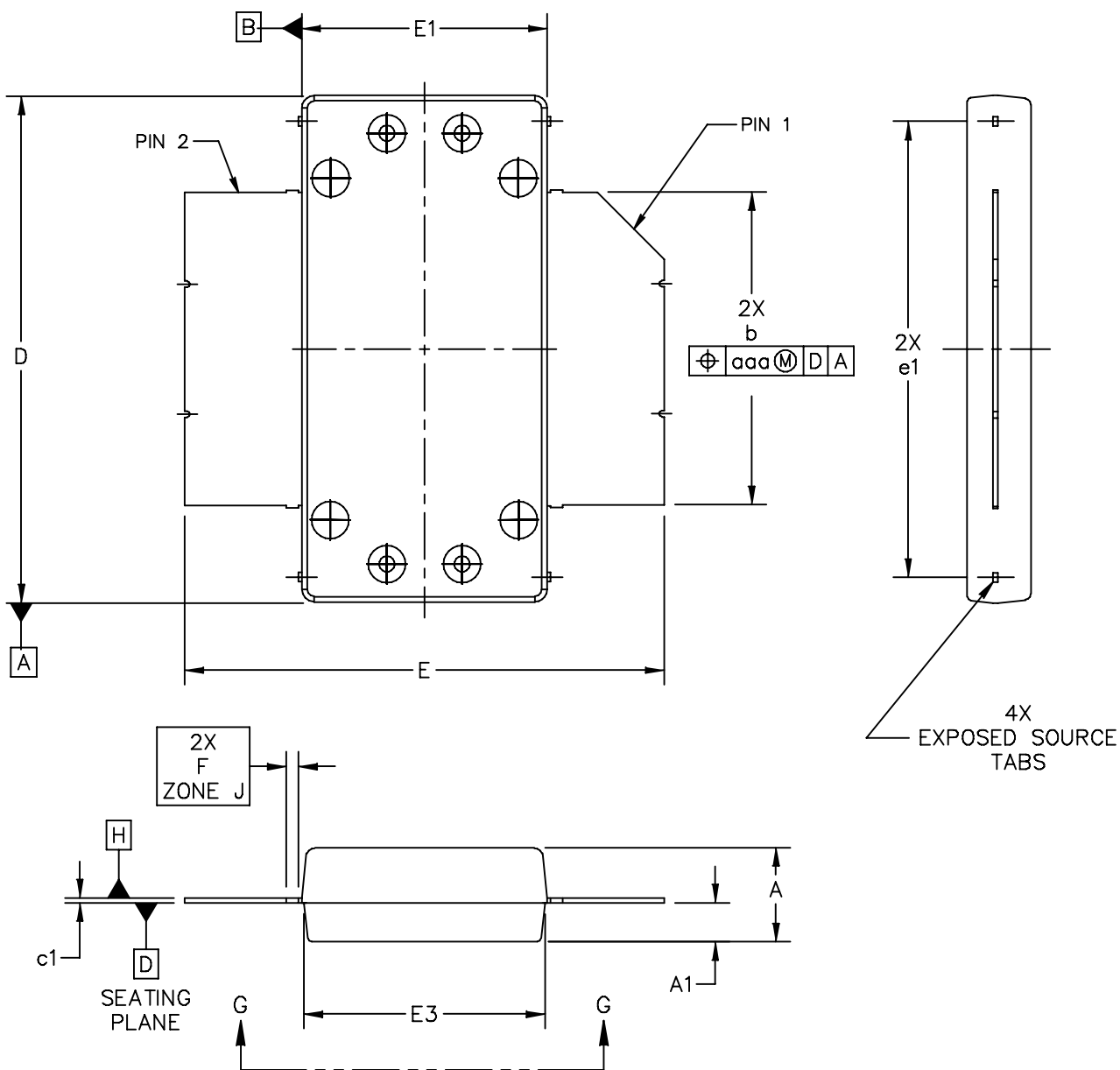
Test Impedances per Compression Level

f (MHz)		$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
920	P1dB	$0.70 - j1.66$	$0.82 - j1.52$
940	P1dB	$0.68 - j1.85$	$0.73 - j1.60$
960	P1dB	$0.87 - j1.99$	$0.76 - j1.70$

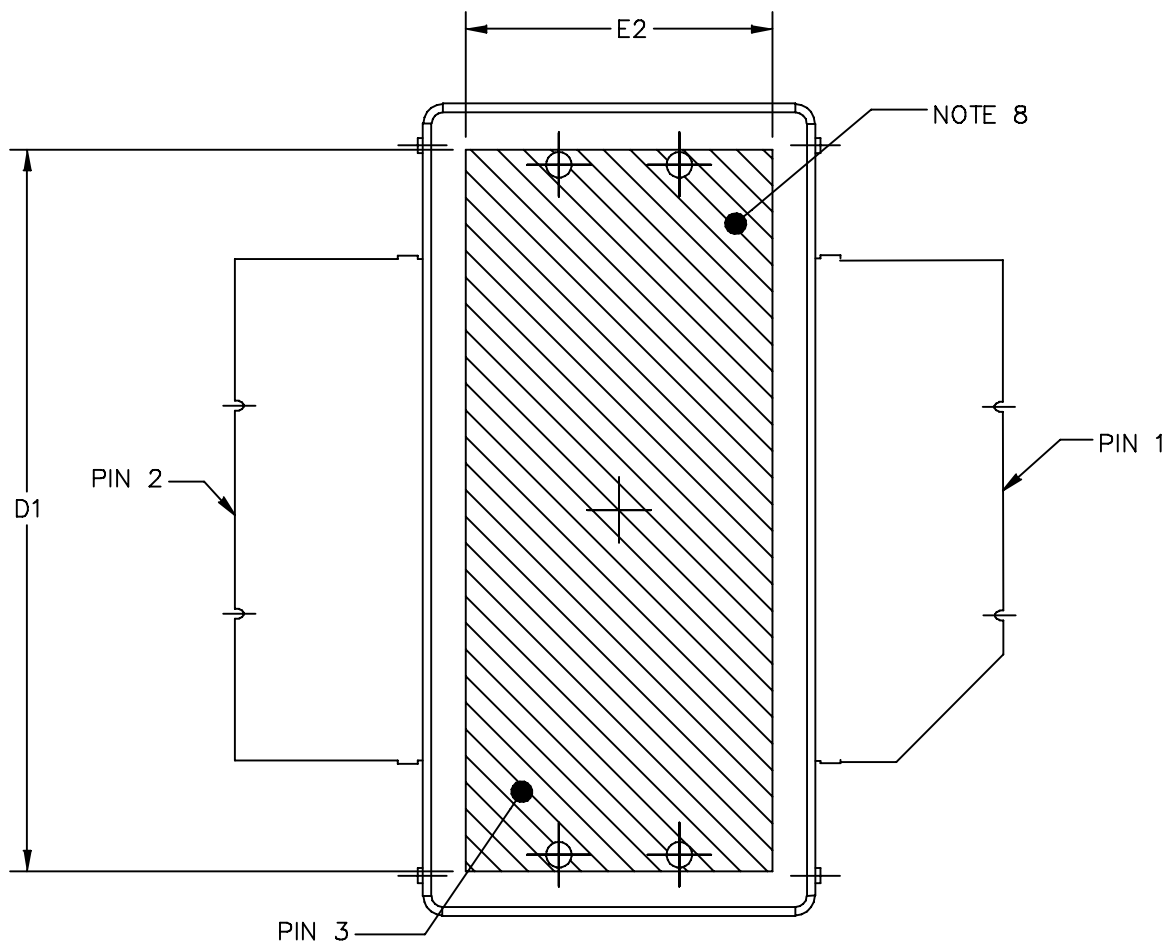
**Figure 10. Pulsed CW Output Power versus Input Power @ 28 V**



**PACKAGE DIMENSIONS**



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		CASE NUMBER: 2021-03		22 OCT 2009	
		STANDARD: NON-JEDEC			



BOTTOM VIEW  
VIEW G-G

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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 "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	----	aaa	.004		0.10	
E	.762	.770	19.36	19.56					
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, TOOLS AND SOFTWARE

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

### Development Tools

- Printed Circuit Boards

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
0	Aug. 2009	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>
1	May 2010	<ul style="list-style-type: none"> <li>• Revised VSWR statement to correct output power from 200 Watts CW to 300 Watts CW, p. 1</li> <li>• Replaced Case Outline 2021-01, Issue O, with 2021-03, Issue B, p. 1, 9-11. Changed “Drain Lead” to “Pin 1” and “Gate Lead” to “Pin 2” on Sheet 1. Corrected “A2” to “A1” in Note 7, and changed dimension A1 from 0.061”-0.063” (1.55-1.60 mm) to 0.059”-0.065” (1.50-1.65 mm) on Sheet 3. Added 4 exposed source tabs at dimension e1 on Sheets 1 and 2. Added dimension e1 0.721”-0.729” (18.31-18.52 mm) in the table, revised D1 minimum dimension from 0.730” (18.54 mm) to 0.720” (18.29 mm), revised dimension E2 from 0.312” (7.92 mm) to 0.306” (7.77 mm), and revised wording of Note 8 on Sheet 3.</li> <li>• Changed Human Body Model ESD rating from Class 1C to Class 2 to reflect recent ESD test results of the device, p. 2</li> </ul>

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