



# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for LTE base station applications with frequencies from 2300 to 2400 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,  $I_{DQ} = 800$  mA,  $P_{out} = 28$  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)
2300 MHz	16.0	31.9	6.1	-37.1
2350 MHz	16.3	30.9	6.4	-37.9
2400 MHz	16.6	31.2	6.3	-37.5

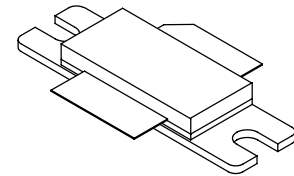
- Capable of Handling 5:1 VSWR, @ 30 Vdc, 2350 MHz, 138 Watts CW <sup>(1)</sup> Output Power (2 dB Input Overdrive from Rated  $P_{out}$ )
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx$  107 Watts CW

### Features

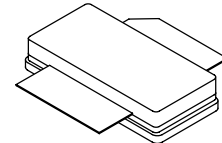
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel.

**MRF8S23120HR3**  
**MRF8S23120HSR3**

**2300-2400 MHz, 28 W AVG., 28 V**  
**LTE**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF8S23120HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF8S23120HSR3**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +65	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 <sup>(2,3)</sup>	$T_J$	225	°C
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	CW	109 0.52	W W/°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value <sup>(3,4)</sup>	Unit
Thermal Resistance, Junction to Case Case Temperature 76°C, 28 W CW, 28 Vdc, $I_{DQ} = 800$ mA, 2400 MHz Case Temperature 80°C, 120 W CW <sup>(1)</sup> , 28 Vdc, $I_{DQ} = 800$ mA, 2400 MHz	$R_{\theta JC}$	0.50 0.47	°C/W

1. Exceeds recommended operating conditions. See CW operation data in Maximum Ratings table.
2. Continuous use at maximum temperature will affect MTTF.
3. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
4. 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. 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 ( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	10	$\mu\text{A}$
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	1	$\mu\text{A}$
Gate-Source Leakage Current ( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )	$I_{GSS}$	—	—	1	$\mu\text{A}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 172\ \mu\text{A}$ )	$V_{GS(th)}$	1.0	1.8	2.5	Vdc
Gate Quiescent Voltage ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 800\text{ mA}$ , Measured in Functional Test)	$V_{GS(Q)}$	1.8	2.6	3.3	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.72\text{ A}$ )	$V_{DS(on)}$	0.1	0.15	0.3	Vdc

**Functional Tests** <sup>(1)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 800\text{ mA}$ ,  $P_{out} = 28\text{ W Avg.}$ ,  $f = 2300\text{ MHz}$ , 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	$G_{ps}$	14.5	16.0	17.5	dB
Drain Efficiency	$\eta_D$	29.0	31.9	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.7	6.1	—	dB
Adjacent Channel Power Ratio	ACPR	—	-37.1	-35.0	dBc
Input Return Loss	IRL	—	-12	-7	dB

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 800\text{ mA}$ ,  $P_{out} = 28\text{ W Avg.}$ , 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)
2300 MHz	16.0	31.9	6.1	-37.1	-12
2350 MHz	16.3	30.9	6.4	-37.9	-19
2400 MHz	16.6	31.2	6.3	-37.5	-18

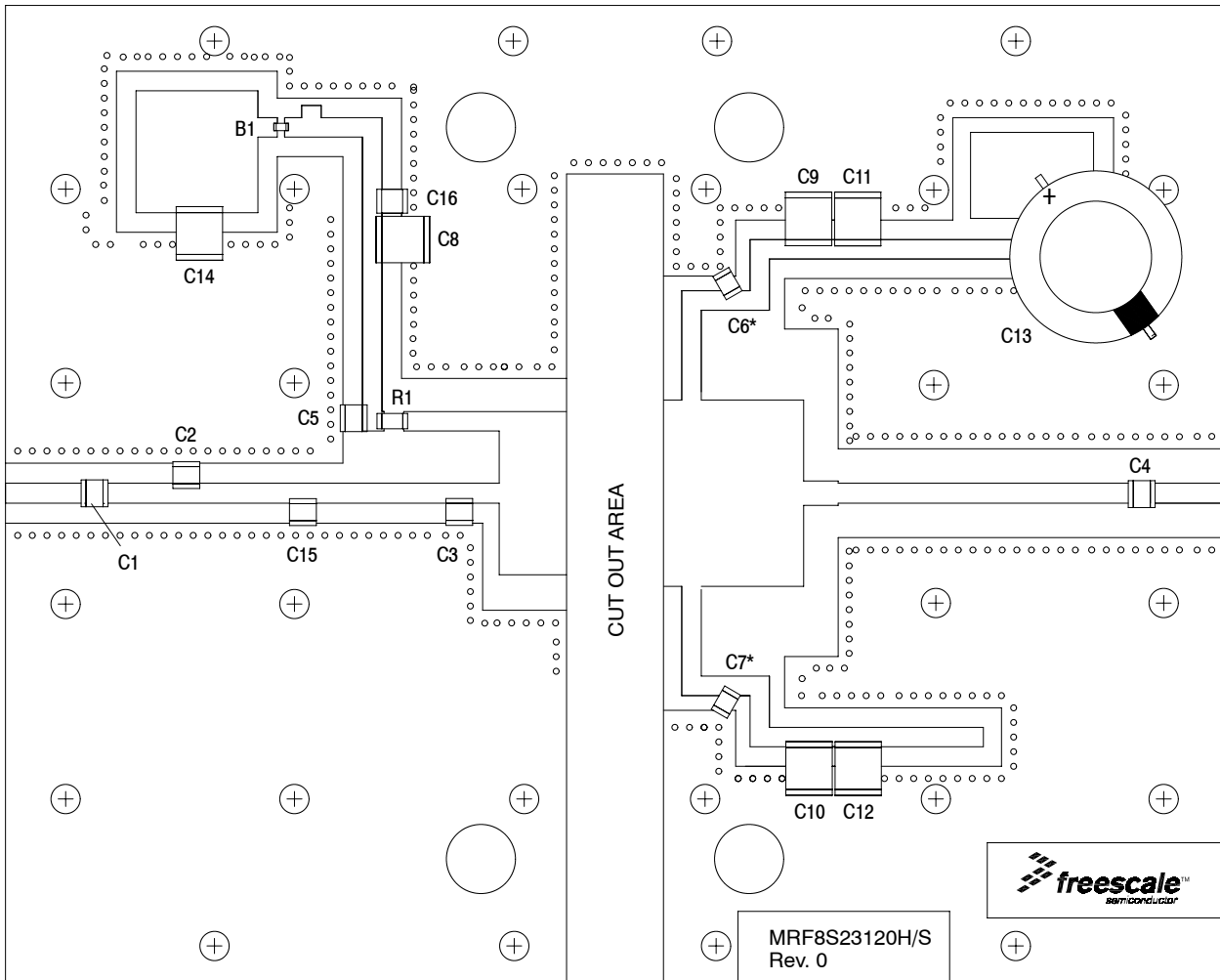
1. Part internally matched both on input and output.

(continued)

**Table 4. 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) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 800\text{ mA}$ , 2300–2400 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	107	—	W
IMD Symmetry @ 84 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 <sub>sym</sub>	—	13	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW <sub>res</sub>	—	62	—	MHz
Gain Flatness in 100 MHz Bandwidth @ $P_{out} = 28\text{ W Avg.}$	G <sub>F</sub>	—	0.6	—	dB
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.002	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ ) (1)	$\Delta P_{1dB}$	—	0.008	—	dB/ $^\circ\text{C}$

1. Exceeds recommended operating conditions. See CW operation data in Maximum Ratings table.



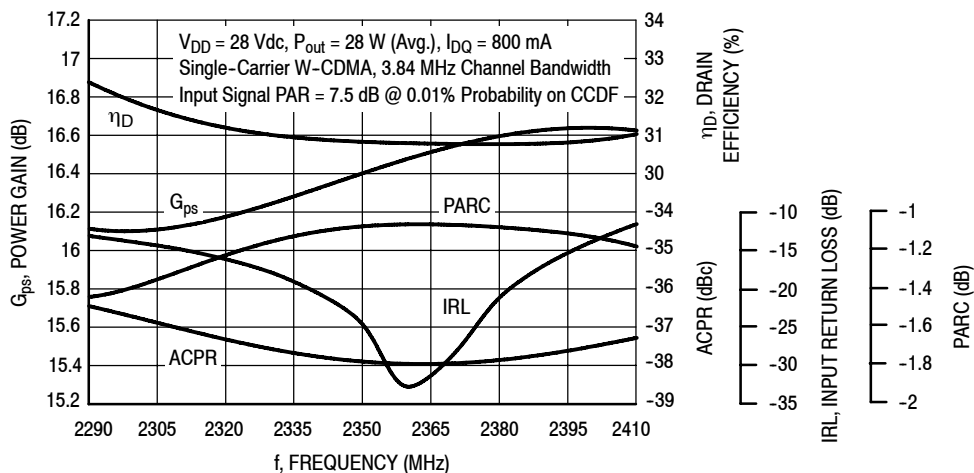
\*C6 and C7 are mounted vertically.

**Figure 1. MRF8S23120HR3(HSR3) Test Circuit Component Layout**

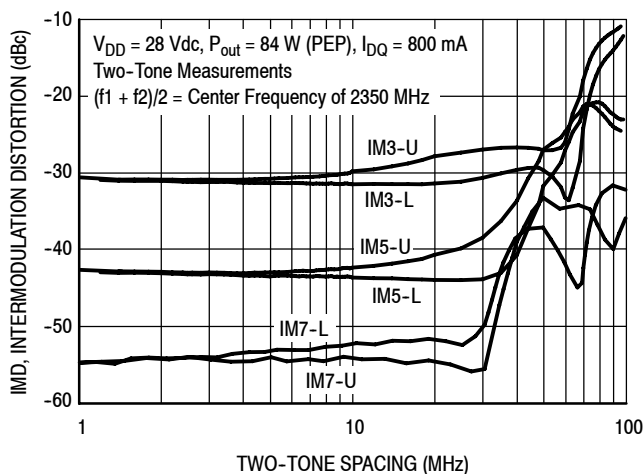
**Table 5. MRF8S23120HR3(HSR3) Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
B1	Ferrite Bead	MPZ2012S300A	TDK
C1, C4	5.6 pF Chip Capacitors	ATC100B5R6CT500XT	ATC
C2, C15	0.5 pF Chip Capacitors	ATC100B0R5BT500XT	ATC
C3	1.8 pF Chip Capacitor	ATC100B1R5BT500XT	ATC
C5, C6, C7	8.2 pF Chip Capacitors	ATC100B8R2CT500XT	ATC
C8	3.3 $\mu$ F, 100 V Chip Capacitor	C5750X7R2A335MT	TDK
C9, C10, C11, C12, C14	10 $\mu$ F, 50 V Chip Capacitors	C5750X7R1H106KT	TDK
C13	470 $\mu$ F, 63 V Electrolytic Capacitor	MCGPR63V477M13X26-RH	Multicomp
C16	330 nF, 100 V Chip Capacitor	C3225JB2A334KT	TDK
R1	4.75 $\Omega$ , 1/4 W Chip Resistor	CRCW12064R75FNEA	Vishay
PCB	0.030", $\epsilon_r = 2.55$	AD255A	Arlon

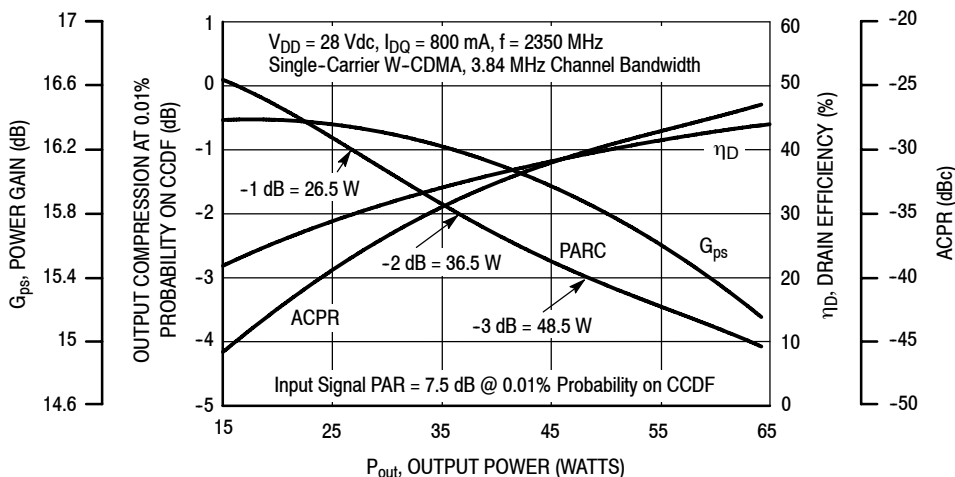
### TYPICAL CHARACTERISTICS



**Figure 2. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 28$  Watts Avg.**

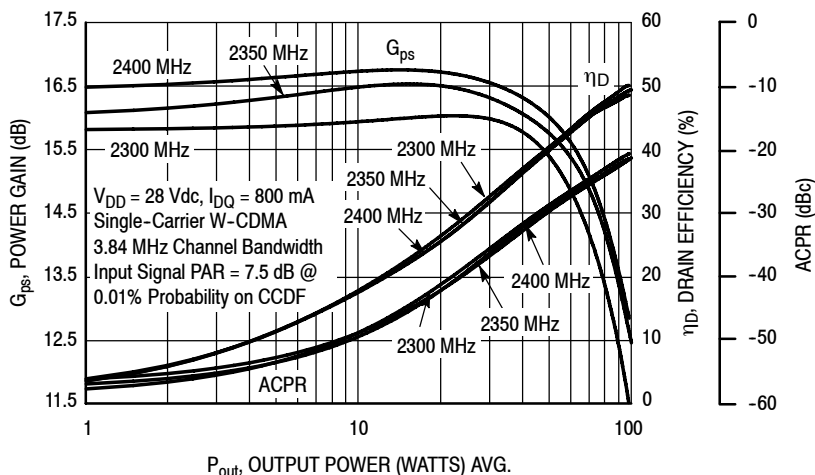


**Figure 3. Intermodulation Distortion Products versus Two-Tone Spacing**

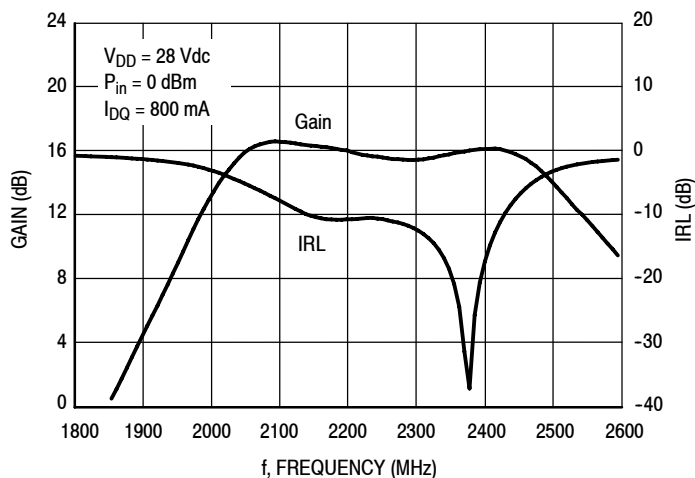


**Figure 4. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

## TYPICAL CHARACTERISTICS

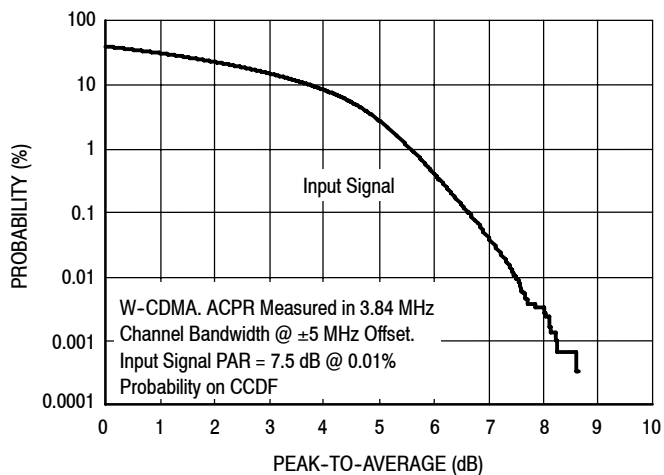


**Figure 5. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

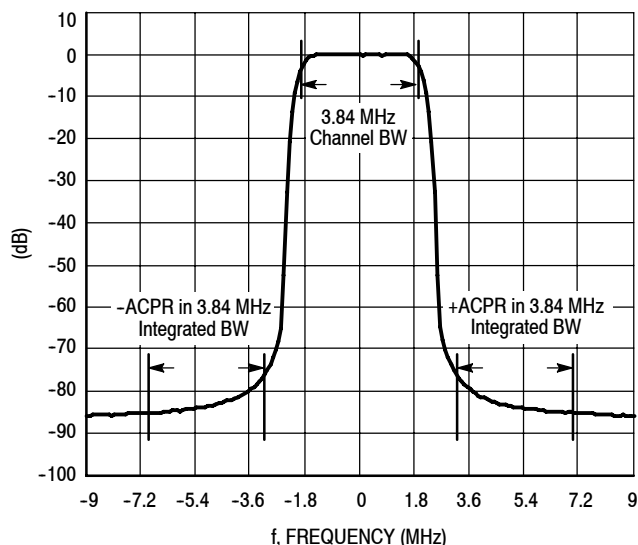


**Figure 6. Broadband Frequency Response**

## W-CDMA TEST SIGNAL



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



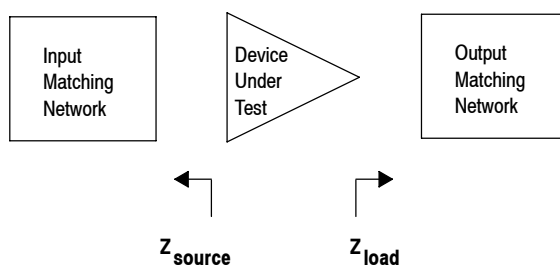
**Figure 8. Single-Carrier W-CDMA Spectrum**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 800 \text{ mA}$ ,  $P_{out} = 28 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2290	$8.41 - j0.97$	$1.86 - j4.43$
2305	$8.58 - j0.55$	$1.83 - j4.28$
2320	$8.78 - j0.14$	$1.80 - j4.14$
2335	$8.99 + j0.29$	$1.77 - j4.01$
2350	$9.21 + j0.72$	$1.74 - j3.88$
2365	$9.45 + j1.17$	$1.72 - j3.77$
2380	$9.71 + j1.62$	$1.69 - j3.66$
2395	$9.99 + j2.10$	$1.66 - j3.54$
2410	$10.28 + j2.60$	$1.65 - j3.43$

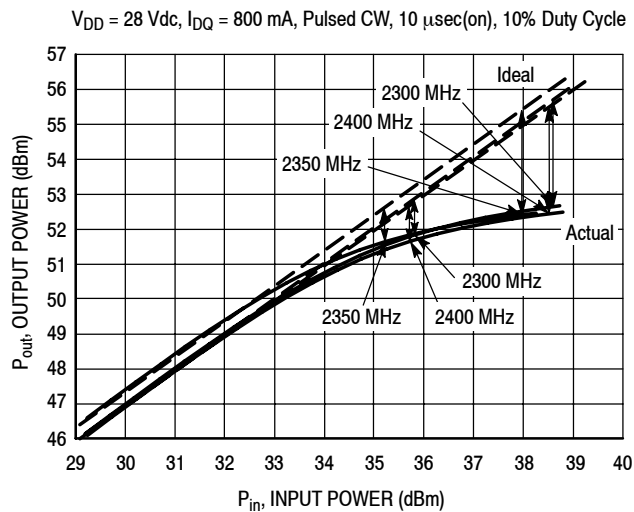
$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = 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
2300	152	51.8	185	52.7
2350	150	51.8	181	52.6
2400	147	51.7	177	52.5

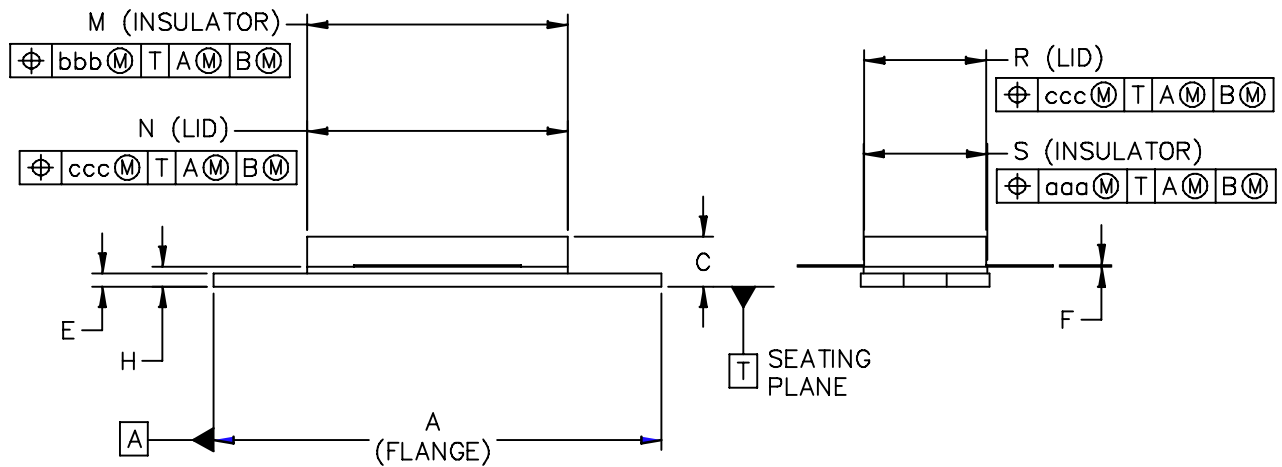
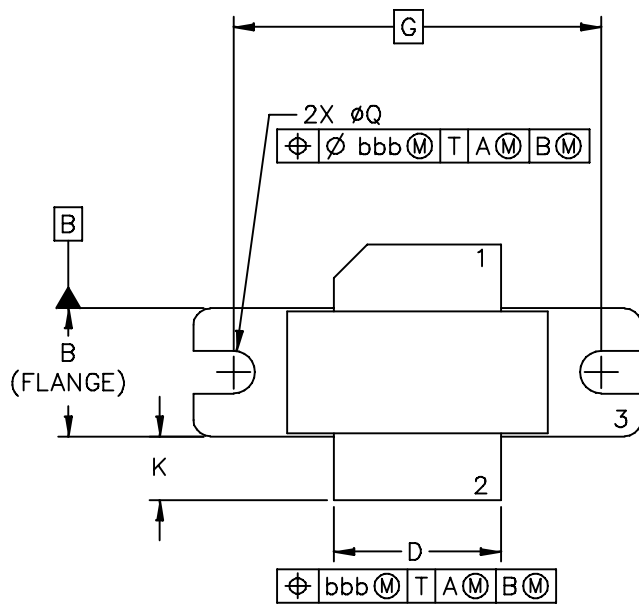
Test Impedances per Compression Level

f (MHz)		$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2300	P1dB	$4.03 - j5.45$	$2.24 + j0.08$
2350	P1dB	$4.63 - j6.15$	$2.21 + j0.35$
2400	P1dB	$5.57 - j5.96$	$2.36 + j0.47$

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



## PACKAGE DIMENSIONS



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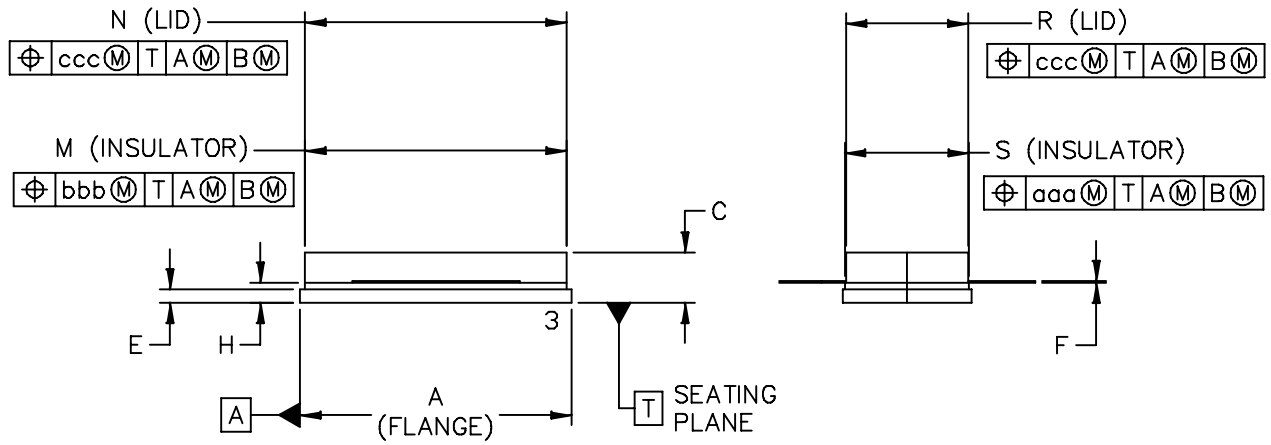
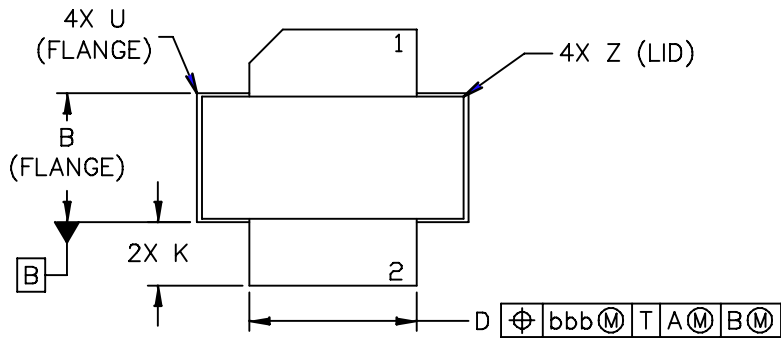
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN  
 2. GATE  
 3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	1.335	– 1.345	33.91	– 34.16	R	.365	– .375	9.27	– 9.53
B	.380	– .390	9.65	– 9.91	S	.365	– .375	9.27	– 9.52
C	.125	– .170	3.18	– 4.32	aaa	– .005	–	–	0.127 –
D	.495	– .505	12.57	– 12.83	bbb	– .010	–	–	0.254 –
E	.035	– .045	0.89	– 1.14	ccc	– .015	–	–	0.381 –
F	.003	– .006	0.08	– 0.15	–	–	–	–	–
G	1.100 BSC		27.94 BSC		–	–	–	–	–
H	.057	– .067	1.45	– 1.7	–	–	–	–	–
K	.170	– .210	4.32	– 5.33	–	–	–	–	–
M	.774	– .786	19.66	– 19.96	–	–	–	–	–
N	.772	– .788	19.6	– 20	–	–	–	–	–
Q	∅.118	– ∅.138	∅3	– ∅3.51	–	–	–	–	–
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2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

STYLE 1:

- PIN 1. DRAIN
2. GATE
3. SOURCE

DIM	INCH		MILLIMETER		DIM	INCH		MILLIMETER	
	MIN	MAX	MIN	MAX		MIN	MAX	MIN	MAX
A	.805	– .815	20.45	– 20.7	U	–	– .040	–	– 1.02
B	.380	– .390	9.65	– 9.91	Z	–	– .030	–	– 0.76
C	.125	– .170	3.18	– 4.32	aaa	–	.005 –	–	0.127 –
D	.495	– .505	12.57	– 12.83	bbb	–	.010 –	–	0.254 –
E	.035	– .045	0.89	– 1.14	ccc	–	.015 –	–	0.381 –
F	.003	– .006	0.08	– 0.15	–	–	– –	–	– –
H	.057	– .067	1.45	– 1.7	–	–	– –	–	– –
K	.170	– .210	4.32	– 5.33	–	–	– –	–	– –
M	.774	– .786	19.61	– 20.02	–	–	– –	–	– –
N	.772	– .788	19.61	– 20.02	–	–	– –	–	– –
R	.365	– .375	9.27	– 9.53	–	–	– –	–	– –
S	.365	– .375	9.27	– 9.52	–	–	– –	–	– –

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## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents and software 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

### 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	Nov. 2010	<ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>

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