

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for W-CDMA and LTE base station applications with frequencies from 2110 to 2170 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,  $I_{DQ} = 850$  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)
2110 MHz	17.4	34.6	6.4	-37.5
2140 MHz	17.5	34.1	6.5	-38.0
2170 MHz	17.6	34.0	6.4	-37.6

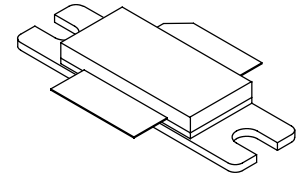
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 2140 MHz, 160 Watts CW (1) Output Power (3 dB Input Overdrive from Rated  $P_{out}$ )
- Typical  $P_{out}$  @ 1 dB Compression Point = 107 Watts CW (1)

### Features

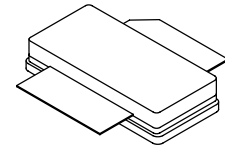
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation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

**MRF8S21120HR3**  
**MRF8S21120HSR3**

**2110-2170 MHz, 28 W AVG., 28 V**  
**W-CDMA, LTE**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF8S21120HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF8S21120HSR3**

**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 (2,3)	$T_J$	225	°C
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	CW	94 0.44	W W/°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (3,4)	Unit
Thermal Resistance, Junction to Case Case Temperature 74°C, 28 W CW, 28 Vdc, $I_{DQ} = 850$ mA, 2140 MHz Case Temperature 80°C, 120 W CW(1), 28 Vdc, $I_{DQ} = 850$ mA, 2140 MHz	$R_{\theta JC}$	0.53 0.51	°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
<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	$\mu\text{Adc}$

**On Characteristics**

Gate Threshold Voltage ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 172\ \mu\text{Adc}$ )	$V_{GS(th)}$	1.2	1.8	2.7	Vdc
Gate Quiescent Voltage ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 850\text{ mAdc}$ )	$V_{GS(Q)}$	—	2.6	—	Vdc
Fixture Gate Quiescent Voltage <sup>(1)</sup> ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 850\text{ mAdc}$ , Measured in Functional Test)	$V_{GG(Q)}$	4.0	5.2	7.0	Vdc
Drain-Source On-Voltage ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.72\text{ Adc}$ )	$V_{DS(on)}$	0.1	0.16	0.3	Vdc

**Functional Tests** <sup>(2)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 850\text{ mA}$ ,  $P_{out} = 28\text{ W Avg.}$ ,  $f = 2170\text{ MHz}$ , 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	$G_{ps}$	17.0	17.6	20.0	dB
Drain Efficiency	$\eta_D$	32.5	34.0	—	%
Output Peak-to-Average Ratio @ 0.01% Probability on CCDF	PAR	5.9	6.4	—	dB
Adjacent Channel Power Ratio	ACPR	—	-37.6	-36.0	dBc
Input Return Loss	IRL	—	-13	-8	dB

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 850\text{ mA}$ ,  $P_{out} = 28\text{ W Avg.}$ , 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)
2110 MHz	17.4	34.6	6.4	-37.5	-22
2140 MHz	17.5	34.1	6.5	-38.0	-18
2170 MHz	17.6	34.0	6.4	-37.6	-13

- $V_{GG} = 2 \times V_{GS(Q)}$ . Parameter measured on Freescale Test Fixture, due to resistive divider network on the board. Refer to Test Circuit schematic.
- 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) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 850\text{ mA}$ , 2110-2170 MHz Bandwidth					
$P_{out}$ @ 1 dB Compression Point, CW	P1dB	—	107 <sup>(1)</sup>	—	W
IMD Symmetry @ 80 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$ (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands $> 2\text{ dB}$ )	IMD <sub>sym</sub>	—	45	—	MHz
VBW Resonance Point (IMD Third Order Intermodulation Inflection Point)	VBW <sub>res</sub>	—	50	—	MHz
Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 28\text{ W Avg.}$	G <sub>F</sub>	—	0.2	—	dB
Gain Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta G$	—	0.015	—	dB/ $^\circ\text{C}$
Output Power Variation over Temperature ( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )	$\Delta P_{1dB}$	—	0.005 <sup>(1)</sup>	—	dBm/ $^\circ\text{C}$

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

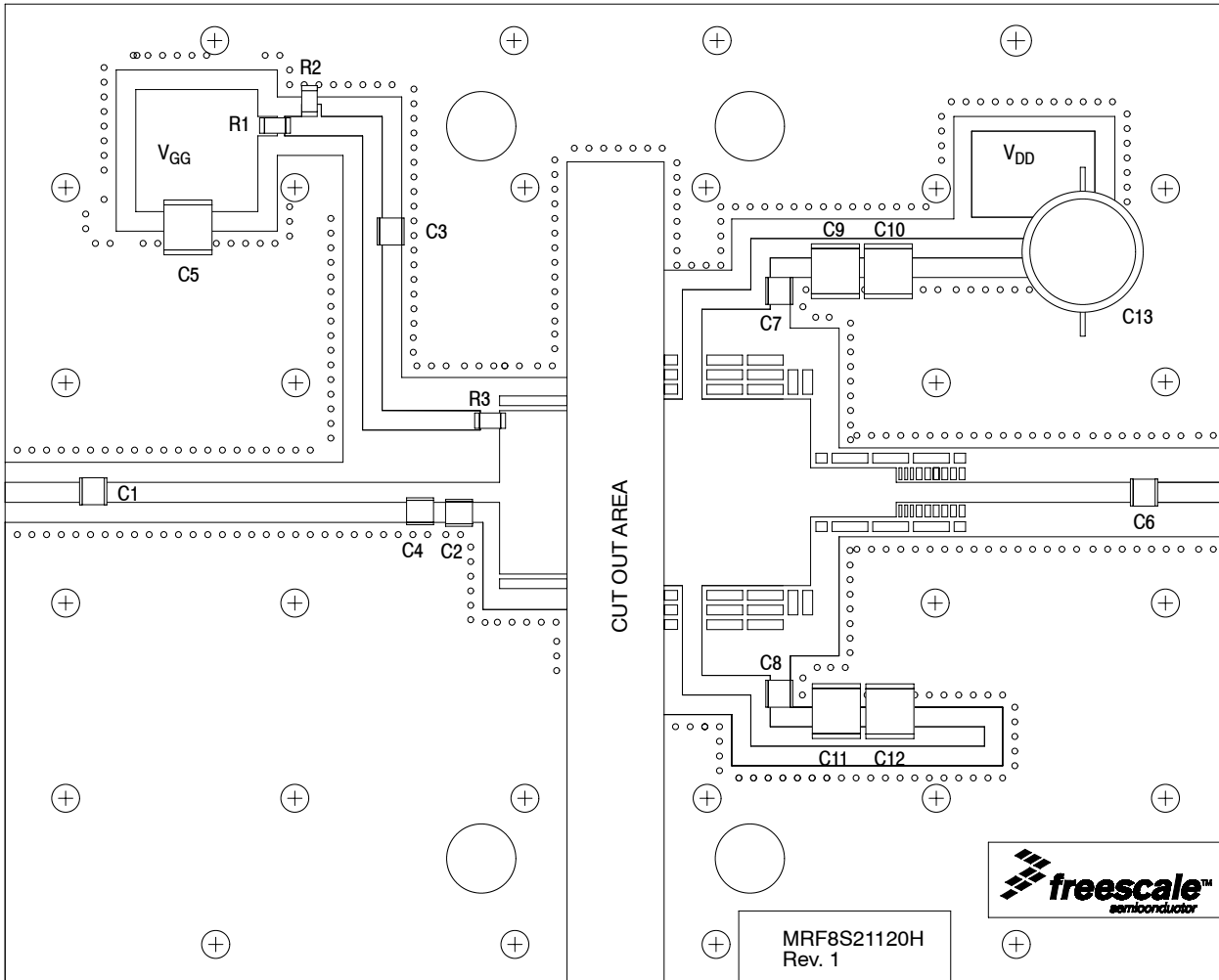
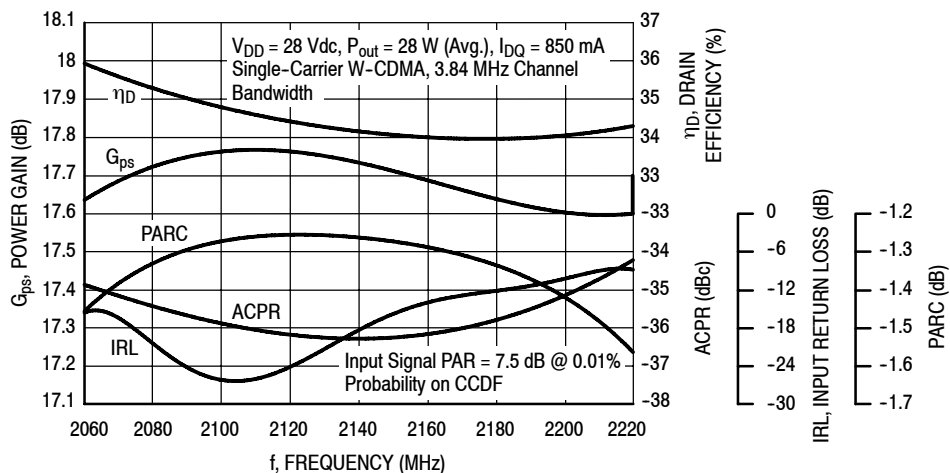


Figure 1. MRF8S21120HR3(HSR3) Test Circuit Component Layout

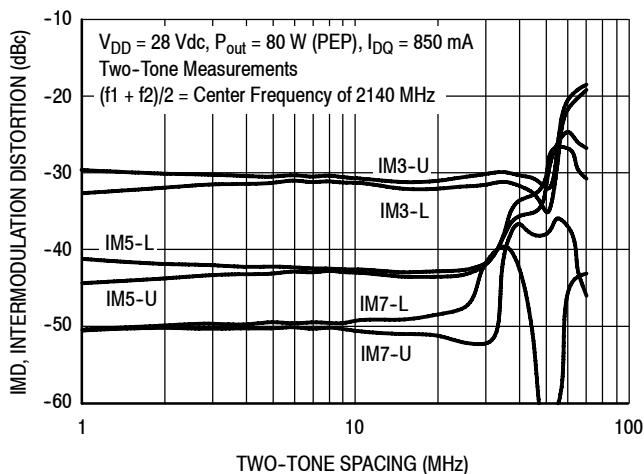
Table 5. MRF8S21120HR3(HSR3) Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
C1, C3, C6, C7, C8	6.8 pF Chip Capacitors	ATC100B6R8BT500XT	ATC
C2	1.2 pF Chip Capacitor	ATC100B1R2BT500XT	ATC
C4	0.2 pF Chip Capacitor	ATC100B0R2BT500XT	ATC
C5, C9, C10, C11, C12	10 $\mu$ F, 50 V Chip Capacitors	C5750X5R1H106MT	TDK
C13	220 $\mu$ F Electrolytic Capacitor	2222 120 18221	Vishay BC Components
R1, R2	2 K $\Omega$ , 1/4 W Chip Resistors	WCR12062K2FI	Welwyn
R3	10 $\Omega$ , 1/4 W Chip Resistor	232272461009	Phycomp
PCB	0.030", $\epsilon_r = 2.55$	AD255A	Arlon

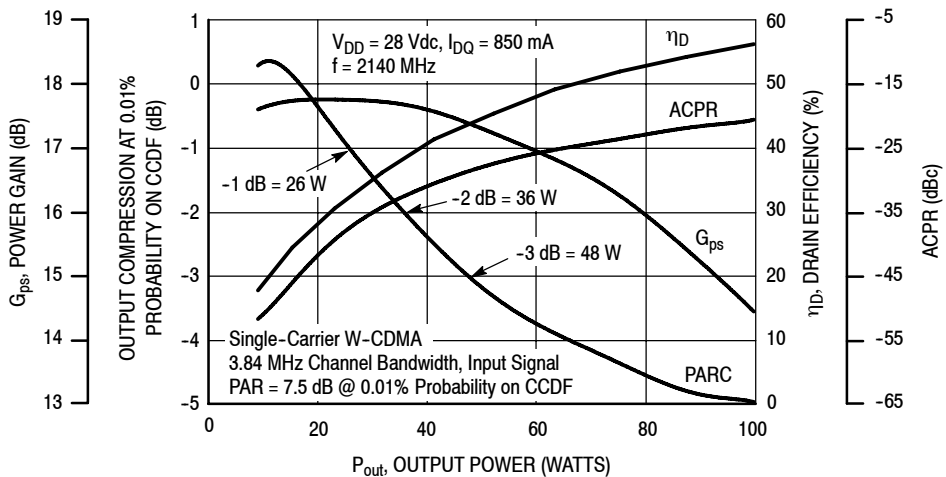
### TYPICAL CHARACTERISTICS



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

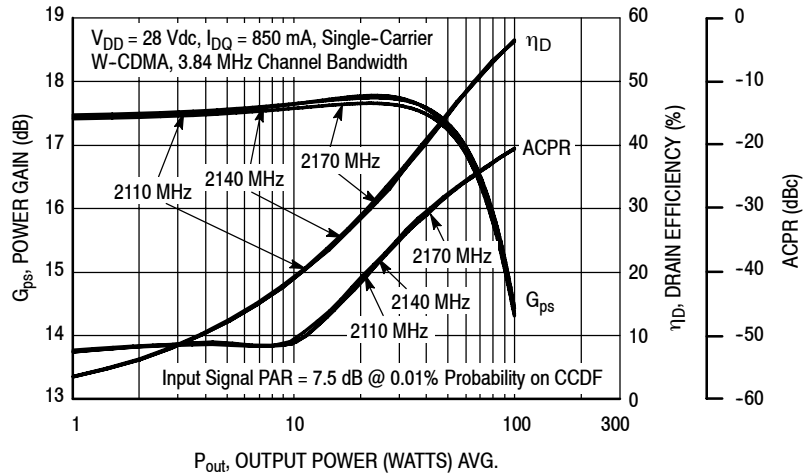


**Figure 3. Intermodulation Distortion Products versus Two-Tone Spacing**

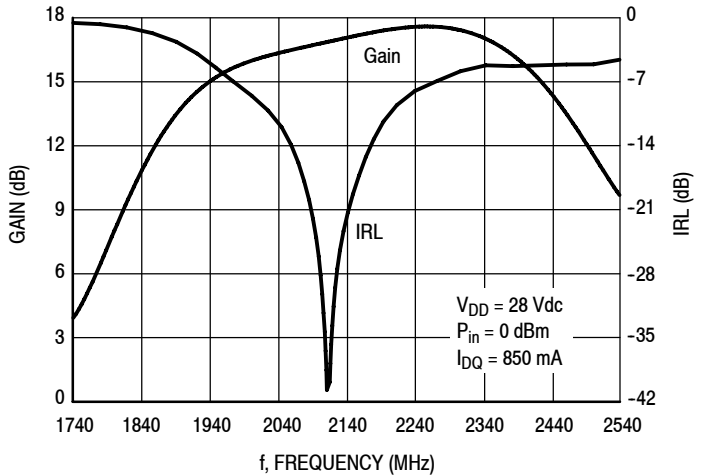


**Figure 4. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

### TYPICAL CHARACTERISTICS

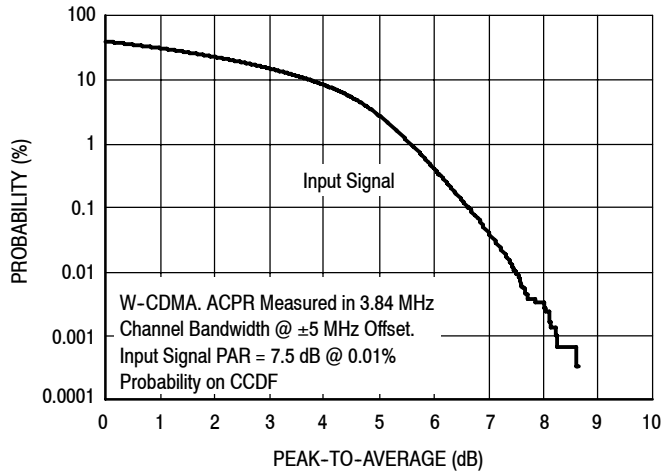


**Figure 5. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

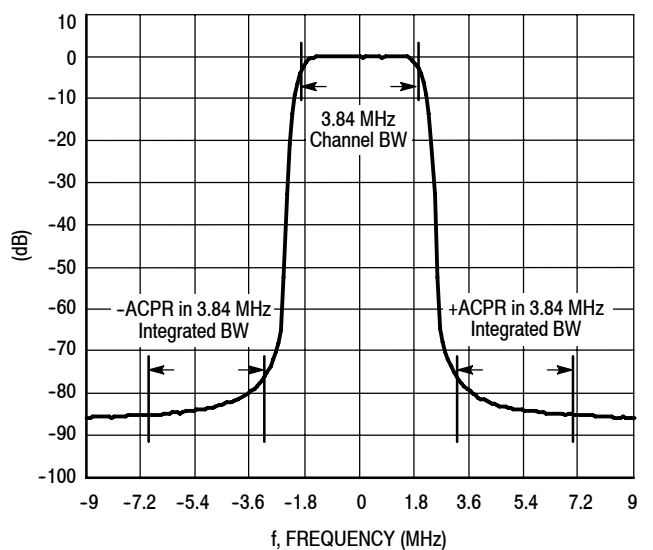


**Figure 6. Broadband Frequency Response**

### W-CDMA TEST SIGNAL



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



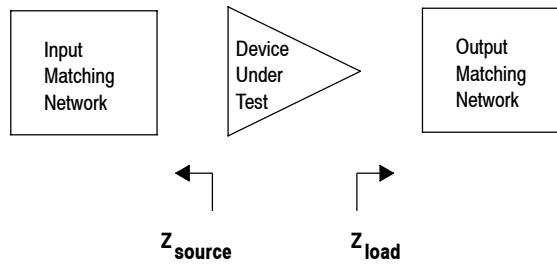
**Figure 8. Single-Carrier W-CDMA Spectrum**

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 850 \text{ mA}$ ,  $P_{out} = 28 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2060	4.33 - j7.00	1.85 - j4.10
2080	4.30 - j6.60	1.90 - j3.90
2100	4.28 - j6.40	1.95 - j3.70
2120	4.24 - j6.00	2.05 - j3.45
2140	4.22 - j5.80	2.09 - j3.30
2160	4.22 - j5.60	2.50 - j3.05
2180	4.21 - j5.20	2.70 - j2.90
2200	4.20 - j5.00	3.00 - j2.70
2220	4.15 - j4.80	3.20 - j2.60

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

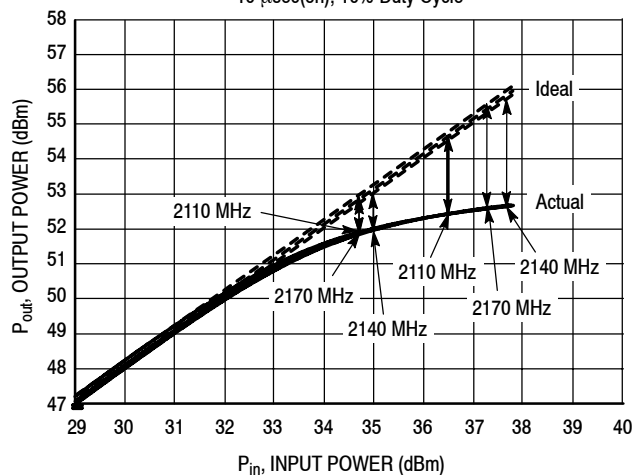
$Z_{load}$  = Test circuit impedance as measured from drain to ground.



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

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS

$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 850 \text{ mA}$ , Pulsed CW,  
 $10 \mu\text{sec(ON)}$ , 10% Duty Cycle



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

f (MHz)	P1dB		P3dB	
	Watts	dBm	Watts	dBm
2110	155	51.9	174	52.4
2140	158	52.0	186	52.7
2170	155	51.9	182	52.6

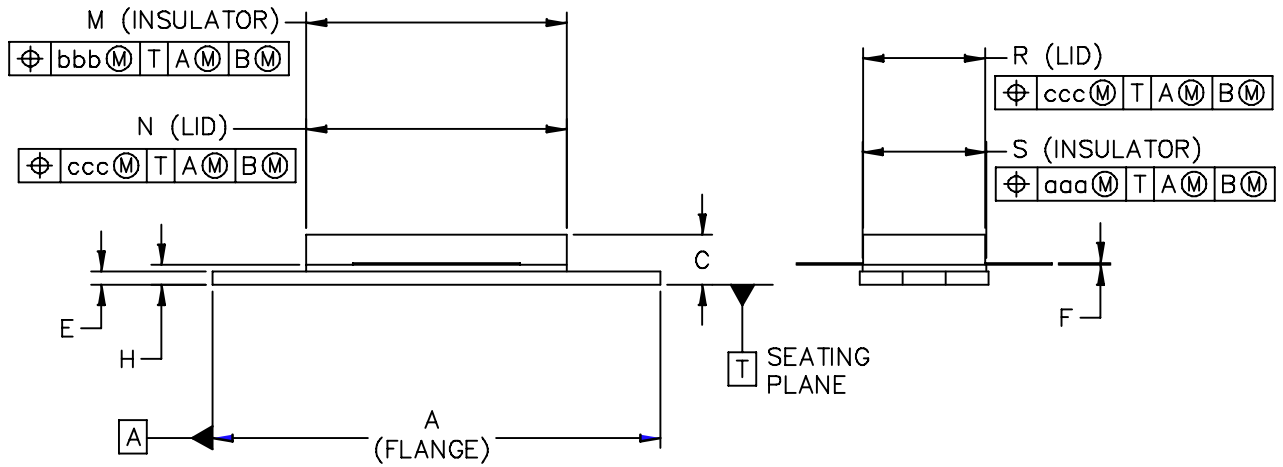
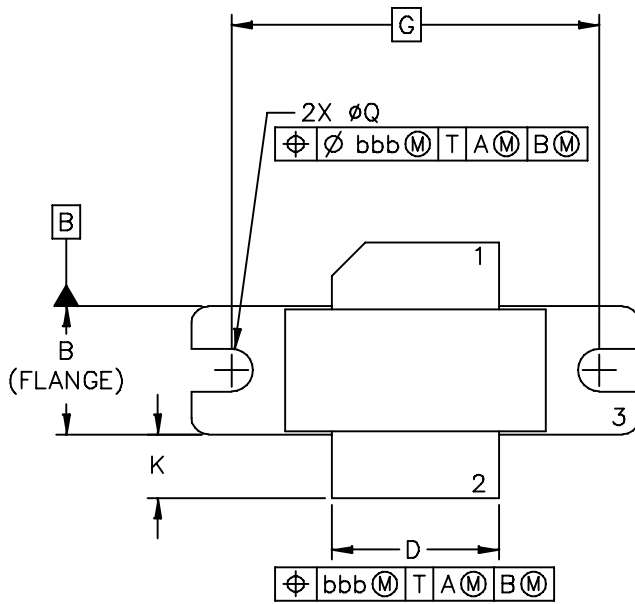
Test Impedances per Compression Level

f (MHz)		$Z_{\text{source}}$ $\Omega$	$Z_{\text{load}}$ $\Omega$
2110	P1dB	$3.73 - j8.14$	$1.29 - j3.01$
2140	P1dB	$4.93 - j8.59$	$1.32 - j3.16$
2170	P1dB	$7.50 - j9.37$	$1.40 - j3.28$

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



**PACKAGE DIMENSIONS**



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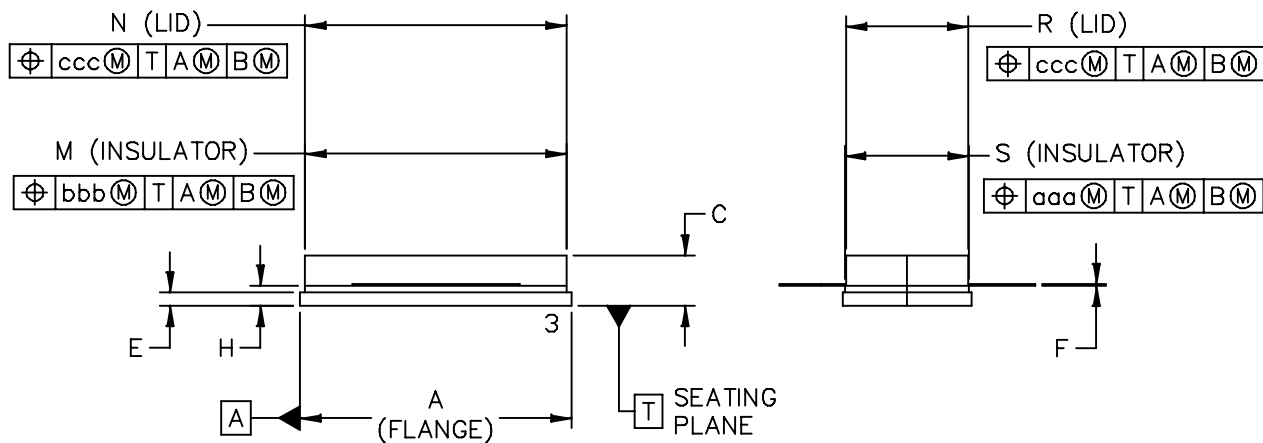
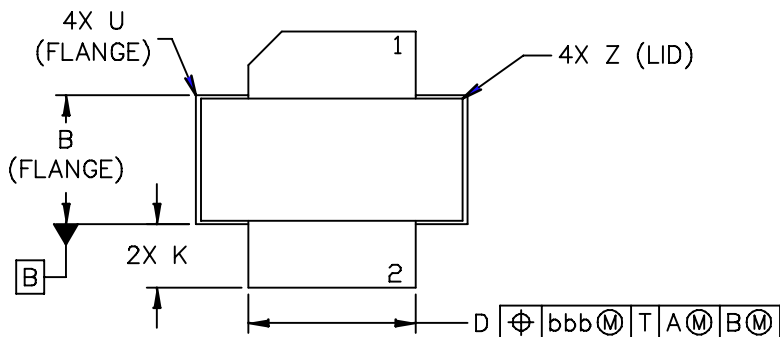
NOTES:

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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		STANDARD: NON–JEDEC			

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents, tools 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	May 2010	<ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>

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