

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for W-CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for TDMA, CDMA and multicarrier amplifier applications. To be used in Class AB for PCN-PCS/cellular radio and WLL applications.

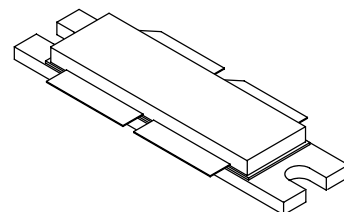
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1900$  mA,  $P_{out} = 44$  Watts Avg.,  $f = 2112.5$  MHz, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.
  - Power Gain — 15.5 dB
  - Drain Efficiency — 26.5%
  - IM3 @ 10 MHz Offset — -37 dBc in 3.84 MHz Channel Bandwidth
  - ACPR @ 5 MHz Offset — -40 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2140 MHz, 190 Watts CW Output Power

### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- Designed for Lower Memory Effects and Wide Instantaneous Bandwidth Applications
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units, 56 mm Tape Width, 13 inch Reel.

**MRF6P21190HR6**

**2110-2170 MHz, 44 W AVG., 28 V  
2 x W-CDMA  
LATERAL N-CHANNEL  
RF POWER MOSFET**



**CASE 375D-05, STYLE 1  
NI-1230**

**Table 1. Maximum Ratings**

Rating	Symbol	Value	Unit
Drain-Source Voltage	$V_{DSS}$	-0.5, +68	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +12	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	$R_{\theta JC}$		°C/W
Case Temperature 80°C, 190 W CW		0.25	
Case Temperature 72°C, 44 W CW		0.27	

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.

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**Table 3. ESD Protection Characteristics**

Test Methodology	Class
Human Body Model (per JESD22-A114)	1C (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	III (Minimum)

**Table 4. Electrical Characteristics** ( $T_A = 25^\circ\text{C}$  unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics</b> <sup>(1)</sup>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 68\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	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 <sup>(1)</sup> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 250\ \mu\text{Adc}$ )	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage <sup>(3)</sup> ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1900\text{ mAdc}$ , Measured in Functional Test)	$V_{GS(Q)}$	2	2.8	4	Vdc
Drain-Source On-Voltage <sup>(1)</sup> ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.2\text{ Adc}$ )	$V_{DS(on)}$	0.1	0.21	0.3	Vdc

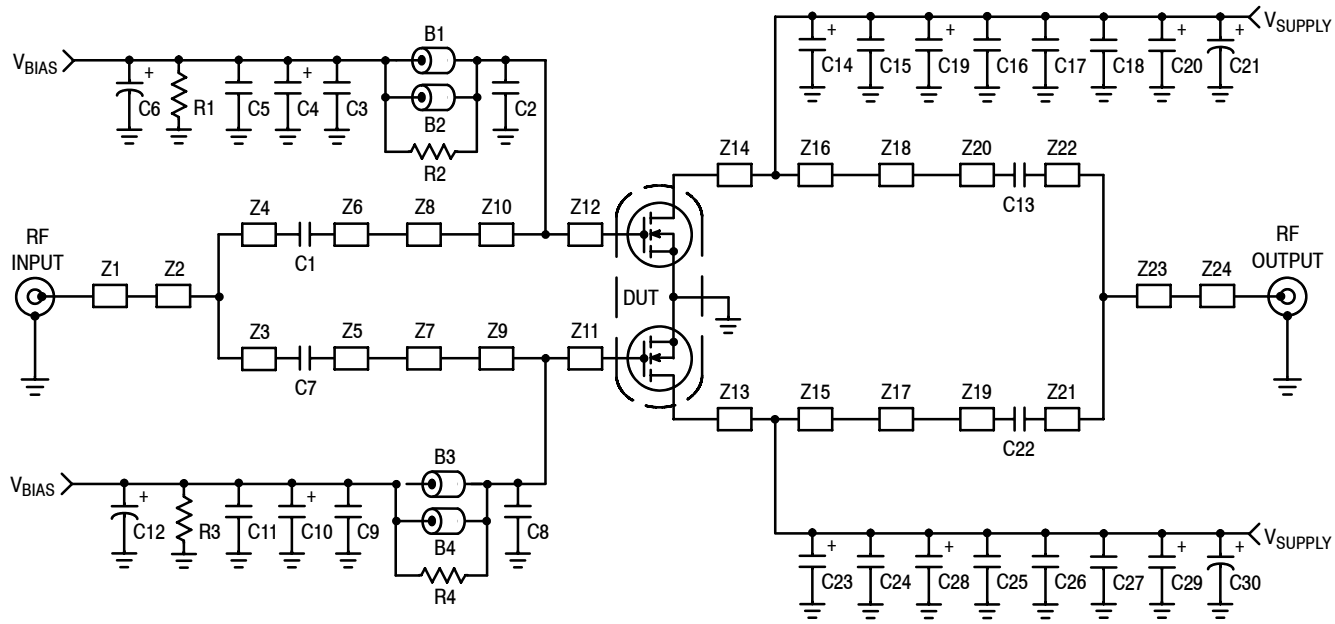
**Dynamic Characteristics** <sup>(1,2)</sup>

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	1.5	—	pF
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**Functional Tests** <sup>(3)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1900\text{ mA}$ ,  $P_{out} = 44\text{ W Avg.}$ ,  $f_1 = 2112.5\text{ MHz}$ ,  $f_2 = 2122.5\text{ MHz}$ , 2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset. IM3 measured in 3.84 MHz Channel Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	14.5	15.5	17.5	dB
Drain Efficiency	$\eta_D$	25	26.5	—	%
Intermodulation Distortion	IM3	—	-37	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-40	-38	dBc
Input Return Loss	IRL	—	-15	-9	dB

1. Each side of device measured separately.
2. Part is internally matched both on input and output.
3. Measurements made with device in push-pull configuration.

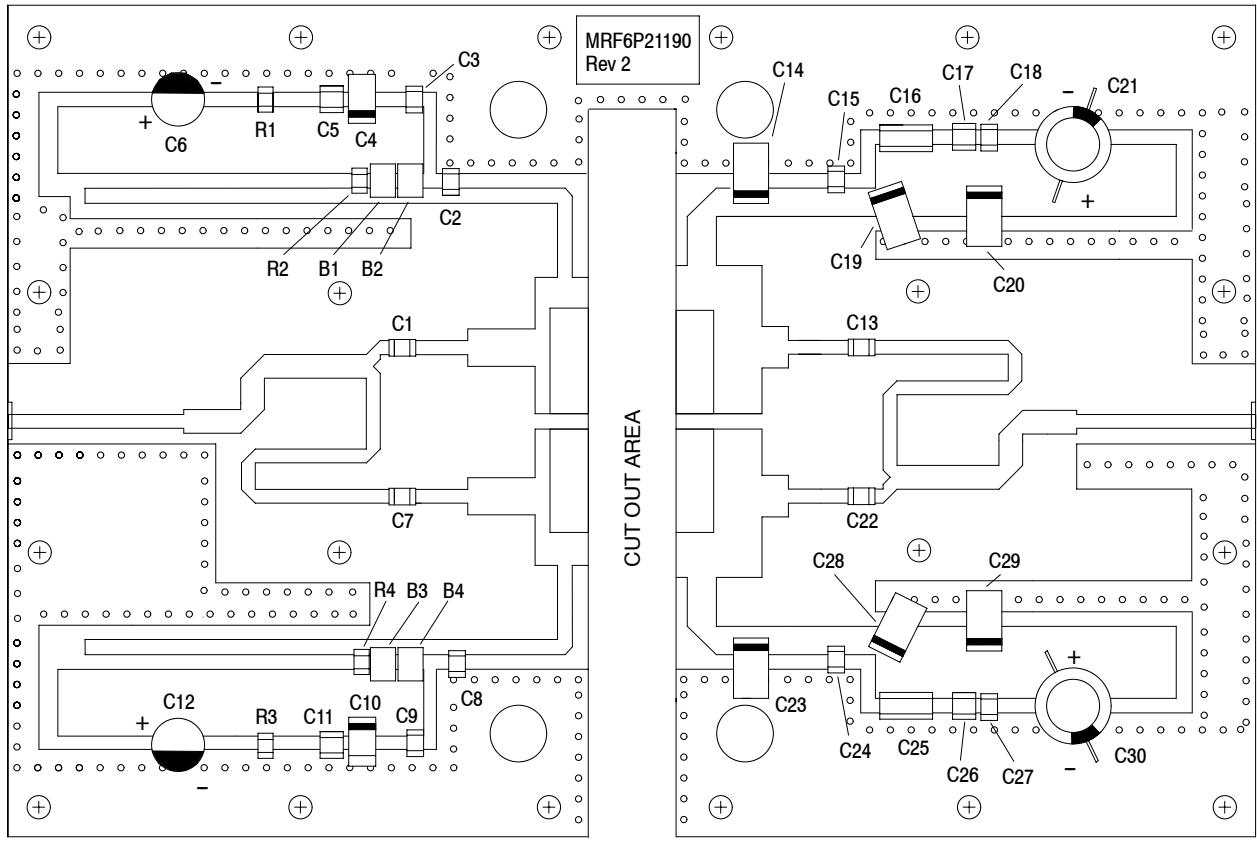


Z1	0.850" x 0.067" Microstrip	Z15, Z16	0.289" x 0.712" Microstrip
Z2	1.140" x 0.114" Microstrip	Z17, Z18	0.127" x 0.200" Microstrip
Z3	1.830" x 0.067" Microstrip	Z19, Z20	0.288" x 0.067" Microstrip
Z4	0.088" x 0.067" Microstrip	Z21	0.088" x 0.067" Microstrip
Z5, Z6	0.250" x 0.067" Microstrip	Z22	1.830" x 0.067" Microstrip
Z7, Z8	0.324" x 0.178" Microstrip	Z23	1.140" x 0.114" Microstrip
Z9, Z10	0.143" x 0.655" Microstrip	Z24	0.850" x 0.066" Microstrip
Z11, Z12	0.111" x 0.655" Microstrip	PCB	Taconic RF-35, 0.030", $\epsilon_r = 3.5$
Z13, Z14	0.124" x 0.712" Microstrip		

Figure 1. MRF6P21190HR6 Test Circuit Schematic

Table 5. MRF6P21190HR6 Test Circuit Component Designations and Values

Part	Description	Part Number	Manufacturer
B1, B2, B3, B4	RF Beads	2743019447	Fair-Rite
C1, C7	30 pF Chip Capacitors	ATC100B300JT500XT	ATC
C2, C8, C15, C24	6.8 pF Chip Capacitors	ATC100B6R8CT500XT	ATC
C3, C9, C18, C27	1k pF Chip Capacitors	ATC100B102JT50XT	ATC
C4, C10	1 $\mu$ F, 50 V Tantalum Chip Capacitors	T491C105K050AT	Kemet
C5, C11, C17, C26	0.1 $\mu$ F Chip Capacitors	CDR33BX104AKWT	Kemet
C6, C12	100 $\mu$ F, 50 V Electrolytic Capacitors, Radial	EEEFK1H101P	Panasonic
C13, C22	43 pF Chip Capacitors	ATC100B430JT500XT	ATC
C14, C19, C20, C23, C28, C29	22 $\mu$ F, 35 V Tantalum Chip Capacitors	T491X226K035AT	Kemet
C16, C25	0.56 $\mu$ F Chip Capacitors	C1825C564J5RAC	Kemet
C21, C30	470 $\mu$ F, 63 V Electrolytic Capacitors, Radial	477KXM063M	Illinois Capacitor
R1, R3	1 k $\Omega$ , 1/4 W Chip Resistors	CRCW12061001FKEA	Vishay
R2, R4	12 $\Omega$ , 1/4 W Chip Resistors	CRCW120612R0FKEA	Vishay



Freescale has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. MRF6P21190HR6 Test Circuit Component Layout**

### TYPICAL CHARACTERISTICS

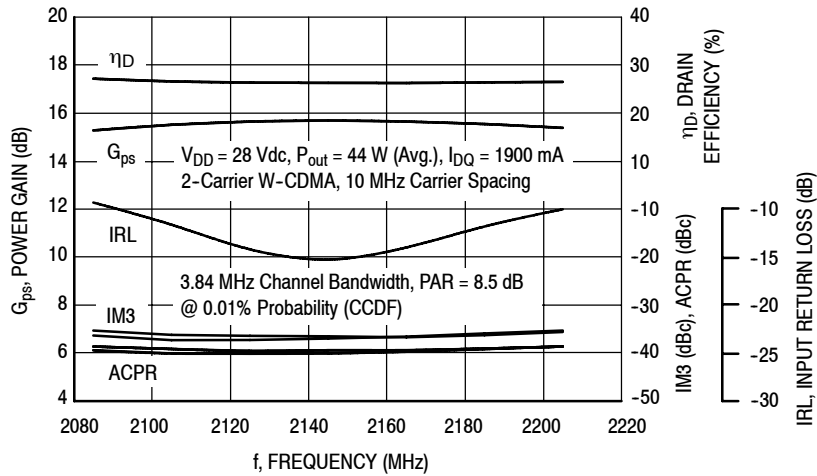


Figure 3. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 44$  Watts Avg.

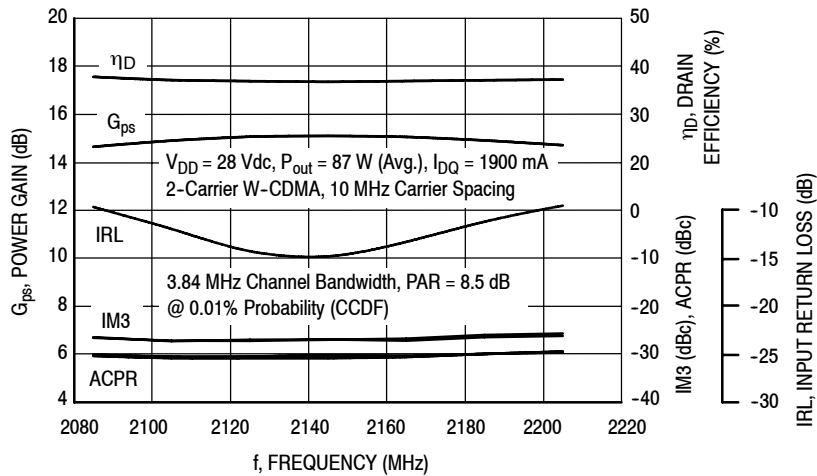


Figure 4. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 87$  Watts Avg.

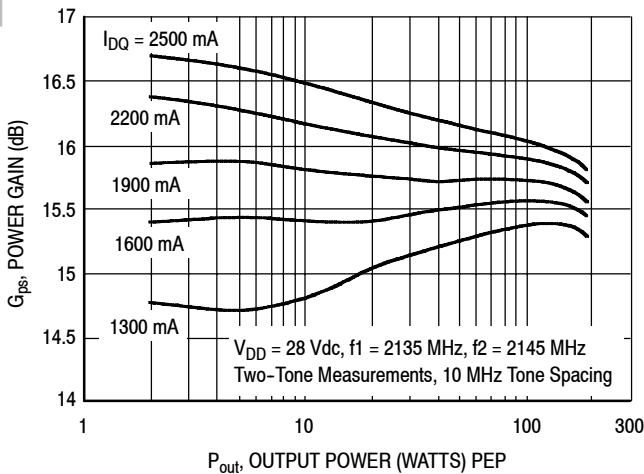


Figure 5. Two-Tone Power Gain versus Output Power

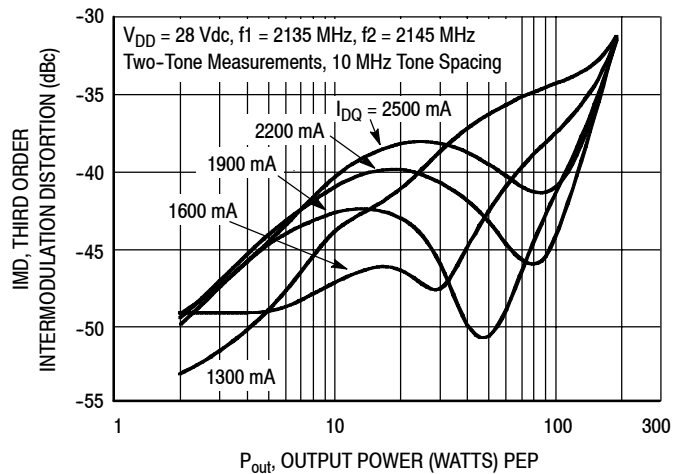
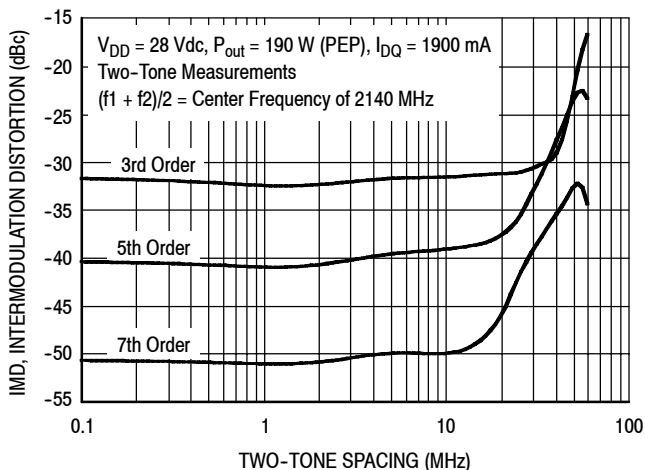


Figure 6. Third Order Intermodulation Distortion versus Output Power

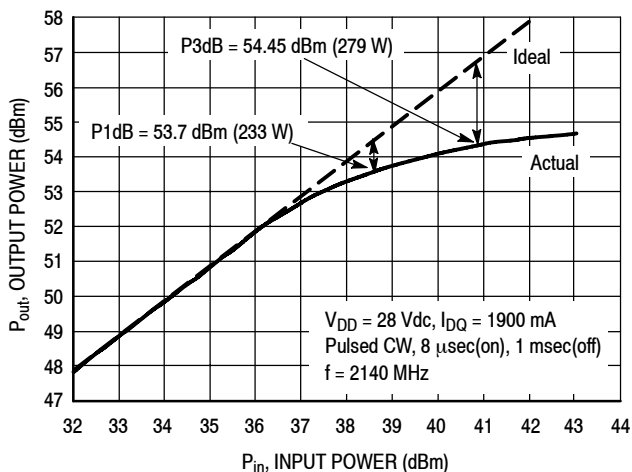
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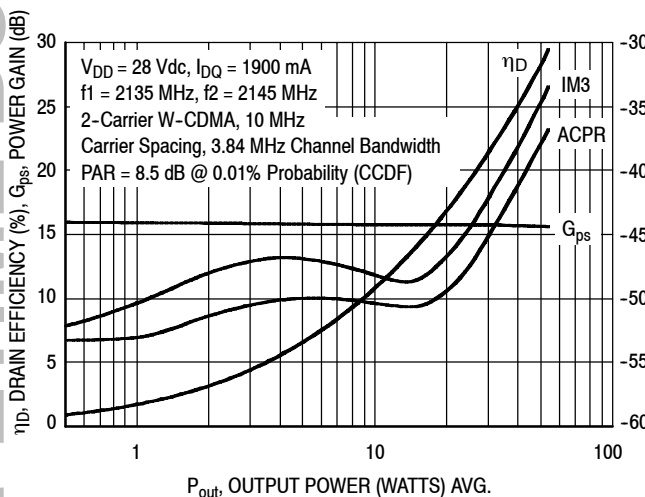
### TYPICAL CHARACTERISTICS



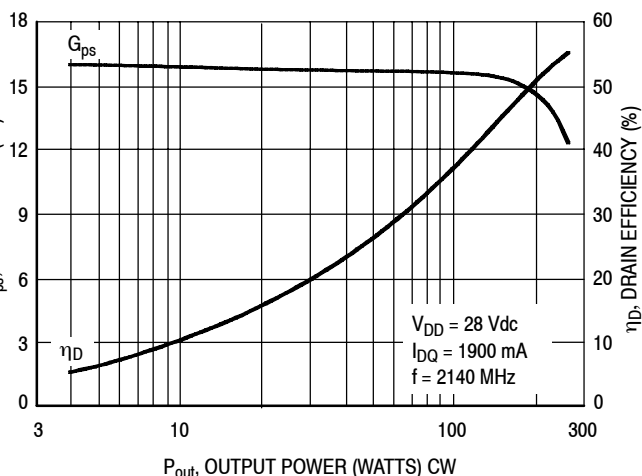
**Figure 7. Intermodulation Distortion Products versus Tone Spacing**



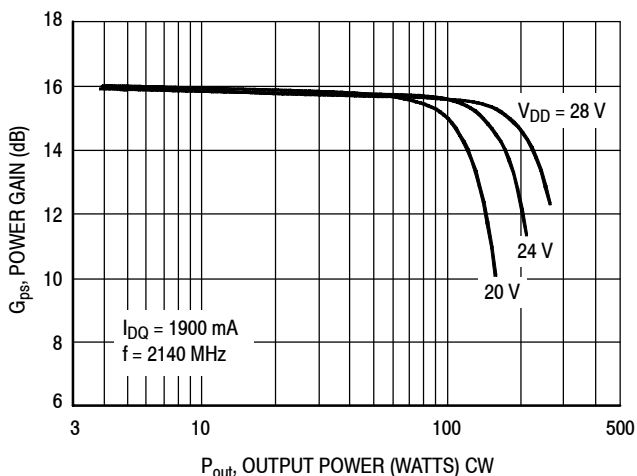
**Figure 8. Pulsed CW Output Power versus Input Power**



**Figure 9. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**

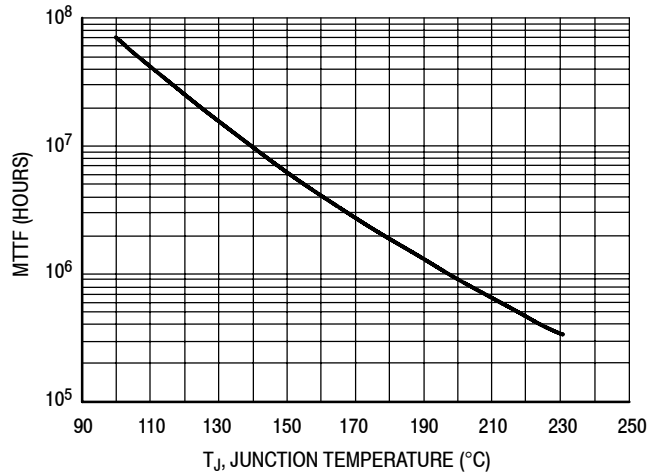


**Figure 11. Power Gain versus Output Power**

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### TYPICAL CHARACTERISTICS



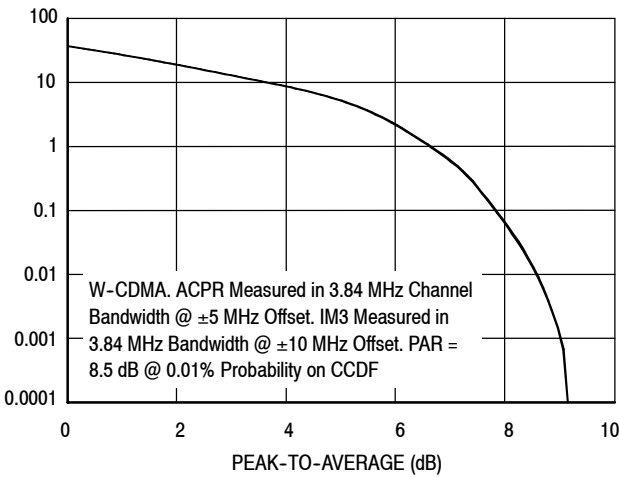
This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 44$  W Avg., and  $\eta_D = 26.5\%$ .

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

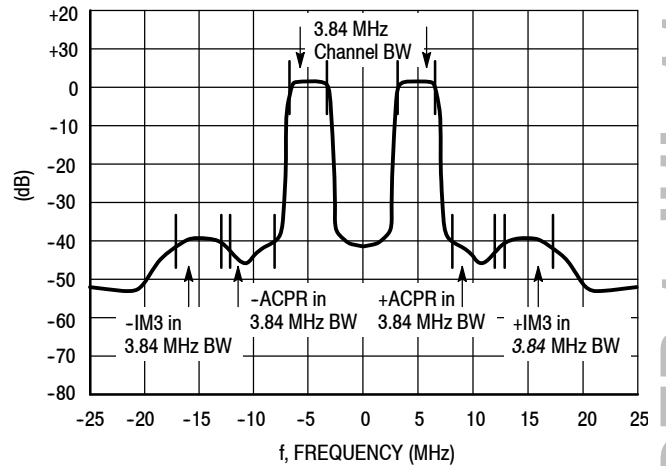
**Figure 12. MTTF Factor versus Junction Temperature**

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### W-CDMA TEST SIGNAL

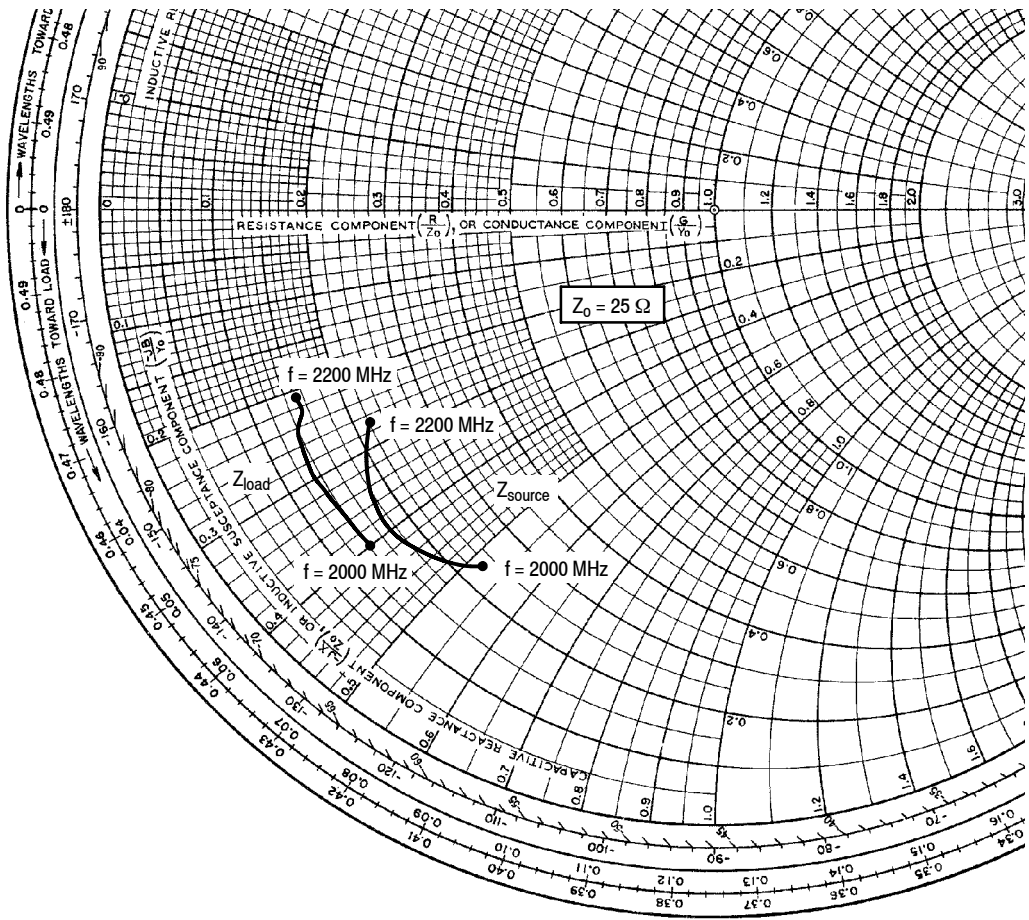


**Figure 13. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal**



**Figure 14. 2-Carrier W-CDMA Spectrum**

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$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1900 \text{ mA}$ ,  $P_{out} = 44 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2000	$5.63 - j12.88$	$3.43 - j10.06$
2110	$4.36 - j10.02$	$3.22 - j7.13$
2140	$4.56 - j8.49$	$3.39 - j6.07$
2170	$5.11 - j7.41$	$3.76 - j5.45$
2200	$5.42 - j6.67$	$3.69 - j5.16$

$Z_{source}$  = Test circuit impedance as measured from gate to gate, balanced configuration.

$Z_{load}$  = Test circuit impedance as measured from drain to drain, balanced configuration.

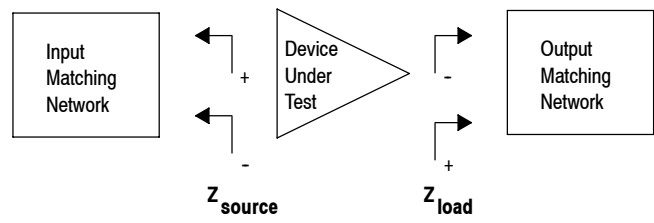
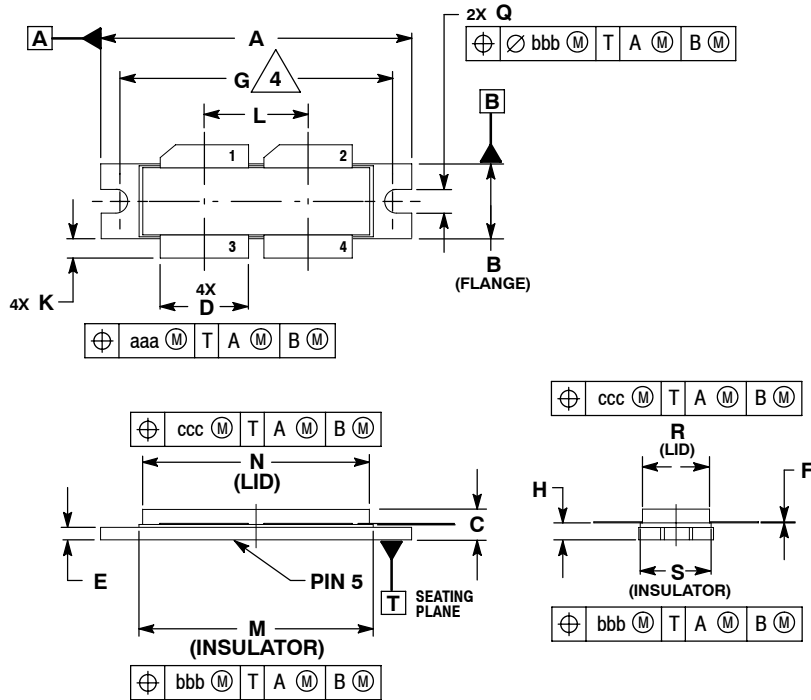


Figure 15. Series Equivalent Source and Load Impedance



## PACKAGE DIMENSIONS



### NOTES:

1. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
4. RECOMMENDED BOLT CENTER DIMENSION OF 1.52 (38.61) BASED ON M3 SCREW.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	1.615	1.625	41.02	41.28
B	0.395	0.405	10.03	10.29
C	0.150	0.200	3.81	5.08
D	0.455	0.465	11.56	11.81
E	0.062	0.066	1.57	1.68
F	0.004	0.007	0.10	0.18
G	1.400 BSC		35.56 BSC	
H	0.082	0.090	2.08	2.29
K	0.117	0.137	2.97	3.48
L	0.540 BSC		13.72 BSC	
M	1.219	1.241	30.96	31.52
N	1.218	1.242	30.94	31.55
Q	0.120	0.130	3.05	3.30
R	0.355	0.365	9.01	9.27
S	0.365	0.375	9.27	9.53
aaa	0.013 REF		0.33 REF	
bbb	0.010 REF		0.25 REF	
ccc	0.020 REF		0.51 REF	

### STYLE 1:

1. DRAIN
2. DRAIN
3. GATE
4. GATE
5. SOURCE

## CASE 375D-05 ISSUE E NI-1230

## PRODUCT DOCUMENTATION

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
4	Dec. 2008	<ul style="list-style-type: none"> <li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, p. 1, 2</li> <li>• Removed Lower Thermal Resistance and Low Gold Plating bullets from Features section as functionality is standard, p. 1</li> <li>• Removed Total Device Dissipation from Max Ratings table as data was redundant (information already provided in Thermal Characteristics table), p. 1</li> <li>• Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related "Continuous use of maximum temperature will affect MTTF" footnote added, p. 1</li> <li>• Corrected <math>V_{DS}</math> to <math>V_{DD}</math> in the RF test condition voltage callout for <math>V_{GS(Q)}</math>, and added "Measured in Functional Test", On Characteristics table, p. 2</li> <li>• Removed Forward Transconductance from On Characteristics table as it no longer provided usable information, p. 2</li> <li>• Updated Part Numbers in Table 5, Component Designations and Values, to latest RoHS compliant part numbers, p. 3</li> <li>• Adjusted scale for Fig. 5, Two-Tone Power Gain versus Output Power and Fig. 6, Third Order Intermodulation Distortion versus Output Power, to better match the device's capabilities, p. 5</li> <li>• Removed lower voltage tests from Fig. 11, Power Gain versus Output Power, due to fixed tuned fixture limitations, p. 6</li> <li>• Replaced Fig. 12, MTTF versus Junction Temperature with updated graph. Removed Amps<sup>2</sup> and listed operating characteristics and location of MTTF calculator for device, p. 7</li> <li>• Added Product Documentation and Revision History, p. 10</li> </ul>
5	Dec. 2010	<ul style="list-style-type: none"> <li>• Corrected data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, and Product Discontinuance Notification number, PCN14260, adding applicable overlay, p. 1, 2</li> </ul>

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