



# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for CDMA base station applications with frequencies from 2300 to 2400 MHz. Suitable for WiMAX, WiBro and multicarrier amplifier applications. To be used in Class AB and Class C for WLL applications.

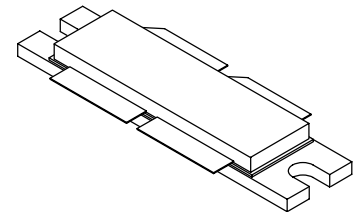
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1900$  mA,  $P_{out} = 40$  Watts Avg., Full Frequency Band, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
 Power Gain — 14 dB  
 Drain Efficiency — 23.5%  
 IM3 @ 10 MHz Offset — -37.5 dBc in 3.84 MHz Channel Bandwidth  
 ACPR @ 5 MHz Offset — -41 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2340 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 per 56 mm, 13 inch Reel.

**MRF6P23190HR6**

**2300-2400 MHz, 40 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	$T_J$	200	°C
CW Operation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	CW	250 1.3	W W/°C

**Table 2. Thermal Characteristics**

Characteristic	Symbol	Value (1,2)	Unit
Thermal Resistance, Junction to Case Case Temperature 100°C, 160 W CW Case Temperature 83°C, 40 W CW	$R_{\theta JC}$	0.22 0.24	°C/W

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.
2. 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)	1C (Minimum)
Machine Model (per EIA/JESD22-A115)	A (Minimum)
Charge Device Model (per JESD22-C101)	III (Minimum)

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>Off Characteristics<sup>(1)</sup></b>					
Zero Gate Voltage Drain Leakage Current ( $V_{DS} = 68\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ )	$I_{DSS}$	—	—	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 <sup>(1)</sup> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 200\ \mu\text{A}$ )	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage <sup>(3)</sup> ( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1900\text{ mA}$ , Measured in Functional Test)	$V_{GS(Q)}$	2	2.8	4	Vdc
Drain-Source On-Voltage <sup>(1)</sup> ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.2\text{ A}$ )	$V_{DS(on)}$	0.1	0.21	0.3	Vdc

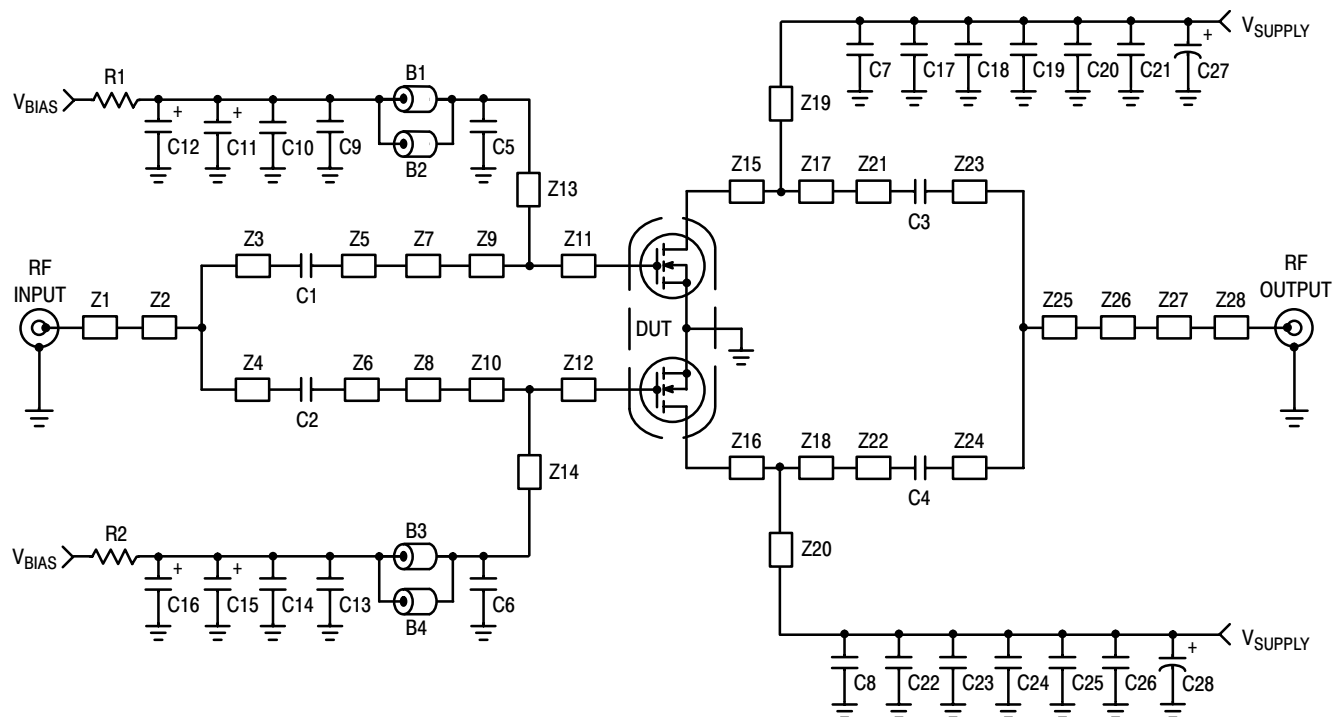
**Dynamic Characteristics<sup>(1,2)</sup>**

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)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1900\text{ mA}$ ,  $P_{out} = 40\text{ W Avg.}$ ,  $f_1 = 2300\text{ MHz}$ ,  $f_2 = 2310\text{ MHz}$  and  $f_1 = 2390\text{ MHz}$ ,  $f_2 = 2400\text{ MHz}$ , 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 Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	13	14	16	dB
Drain Efficiency	$\eta_D$	22	23.5	—	%
Intermodulation Distortion	IM3	—	-37.5	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-41	-38	dBc
Input Return Loss	IRL	—	-13	—	dB

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

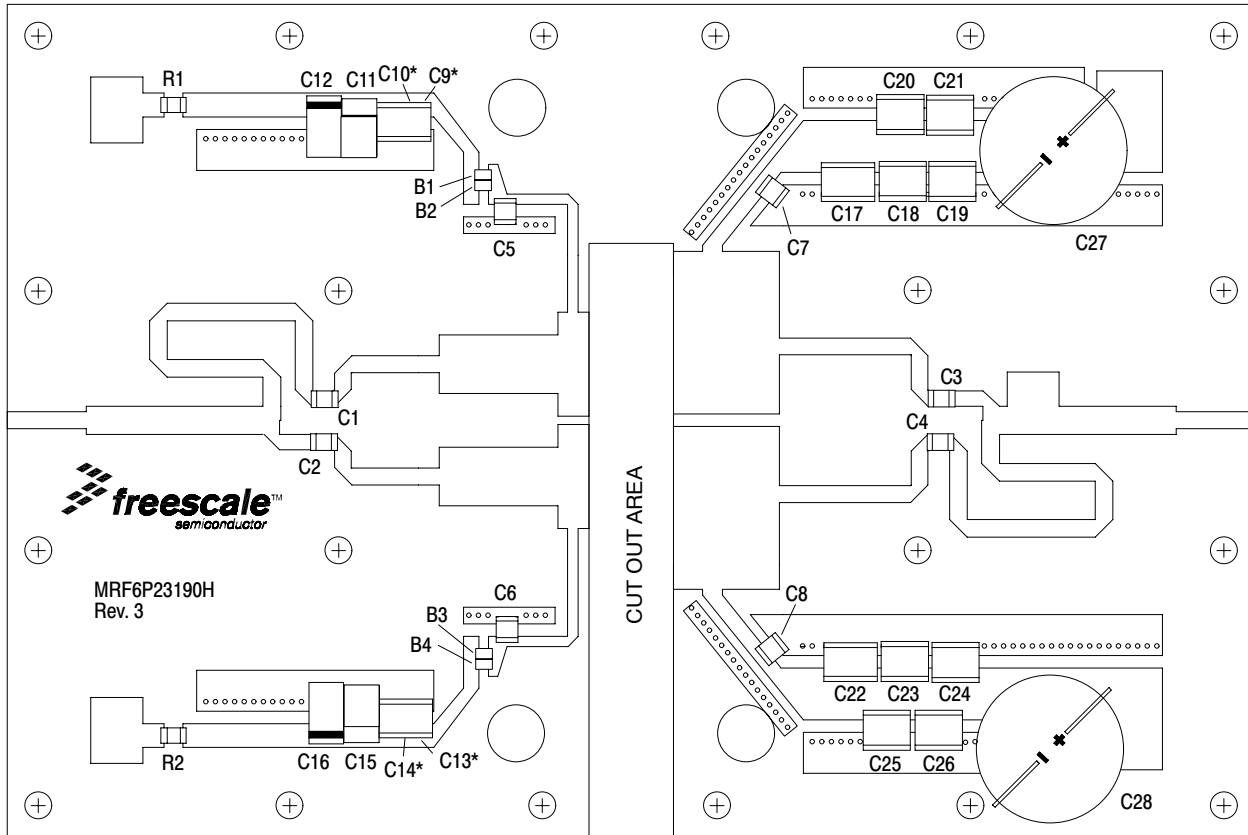


Z1, Z28	0.380" x 0.081" Microstrip	Z17, Z18	0.321" x 0.782" Microstrip
Z2	0.850" x 0.135" Microstrip	Z19, Z20	0.404" x 0.074" Microstrip
Z3	2.244" x 0.081" Microstrip	Z21, Z22	0.918" x 0.081" Microstrip
Z4	0.186" x 0.074" Microstrip	Z23	0.346" x 0.081" Microstrip
Z5, Z6	0.614" x 0.081" Microstrip	Z24	2.103" x 0.081" Microstrip
Z7, Z8	0.570" x 0.282" Microstrip	Z25	0.037" x 0.135" Microstrip
Z9, Z10	0.072" x 0.500" Microstrip	Z26	0.250" x 0.300" Microstrip
Z11, Z12	0.078" x 0.500" Microstrip	Z27	0.563" x 0.135" Microstrip
Z13, Z14	0.861" x 0.050" Microstrip	PCB	Arlon GX-0300-5022, 0.030", $\epsilon_r = 2.55$
Z15, Z16	0.187" x 0.782" Microstrip		

**Figure 1. MRF6P23190HR6 Test Circuit Schematic**

**Table 5. MRF6P23190HR6 Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
B1, B2, B3, B4	Ferrite Beads	2508051107Y0	Fair-Rite
C1, C2, C3, C4	5.1 pF Chip Capacitors	ATC100B5R1CT500XT	ATC
C5, C6, C7, C8	5.6 pF Chip Capacitors	ATC100B5R6CT500XT	ATC
C9, C13	0.01 $\mu$ F, 100 V Chip Capacitors	C1825C103J1RAC	Kemet
C10, C14, C17, C22	2.2 $\mu$ F, 50 V Chip Capacitors	C1825C225J5RAC	Kemet
C11, C15	22 $\mu$ F, 25 V Tantalum Capacitors	ECS-T1ED226R	Panasonic TE series
C12, C16	47 $\mu$ F, 16 V Tantalum Capacitors	T491D476K016AT	Kemet
C18, C19, C20, C21, C23, C24, C25, C26	10 $\mu$ F, 50 V Chip Capacitors	GRM55DR61H106KA88B	Murata
C27, C28	330 $\mu$ F, 63 V Electrolytic Capacitors	NACZF331M63V	Nippon
R1, R2	240 $\Omega$ , 1/4 W Chip Resistors	CRCW12062400FKTA	Vishay



\*Stacked.

Figure 2. MRF6P23190HR6 Test Circuit Component Layout

## TYPICAL CHARACTERISTICS

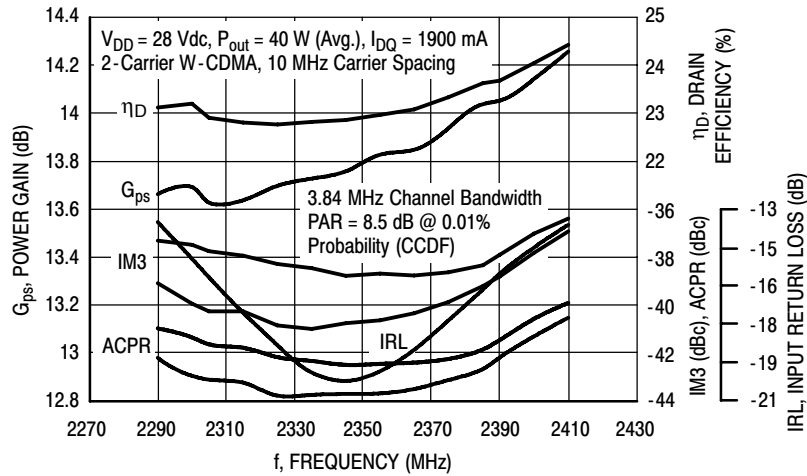


Figure 3. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 40$  Watts Avg.

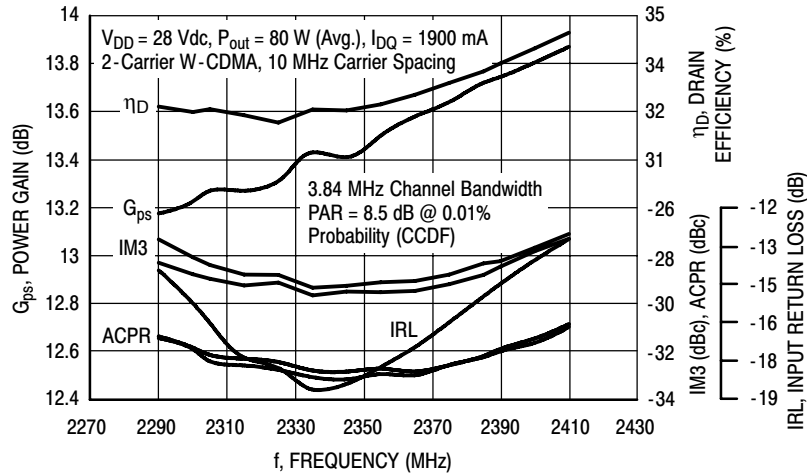


Figure 4. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 80$  Watts Avg.

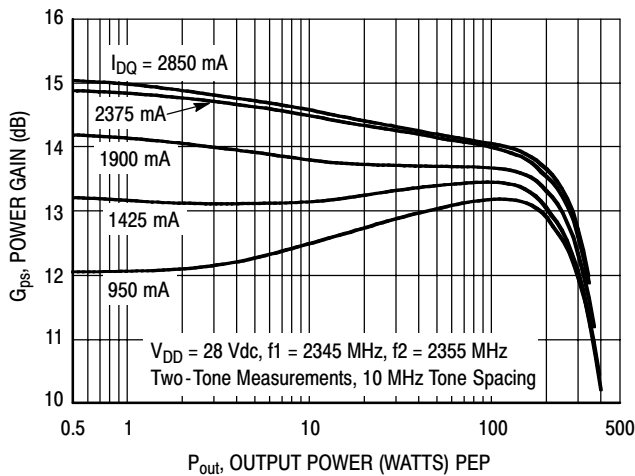


Figure 5. Two-Tone Power Gain versus Output Power

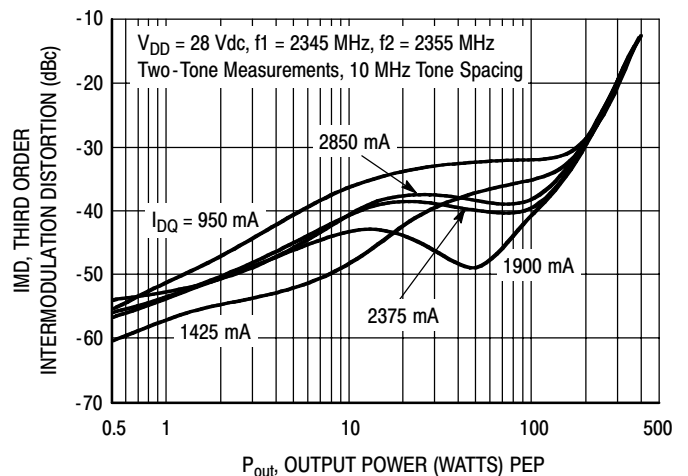
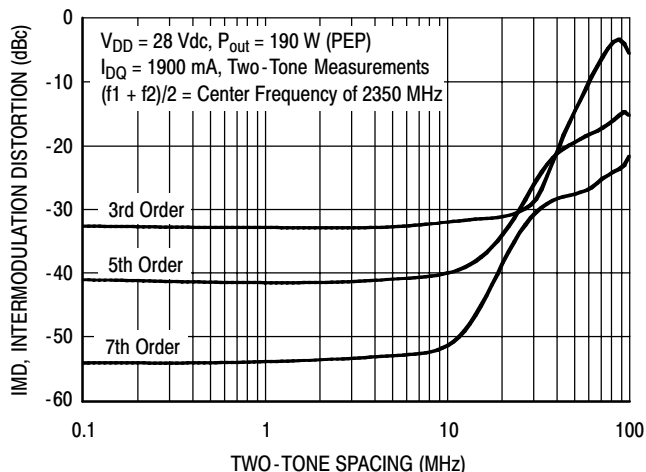
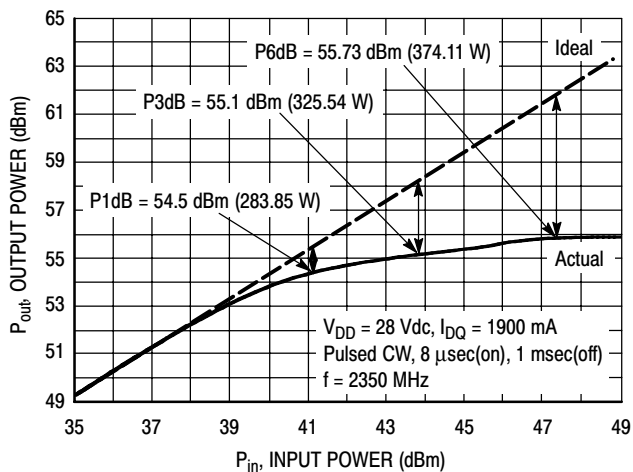


Figure 6. Third Order Intermodulation Distortion versus Output Power

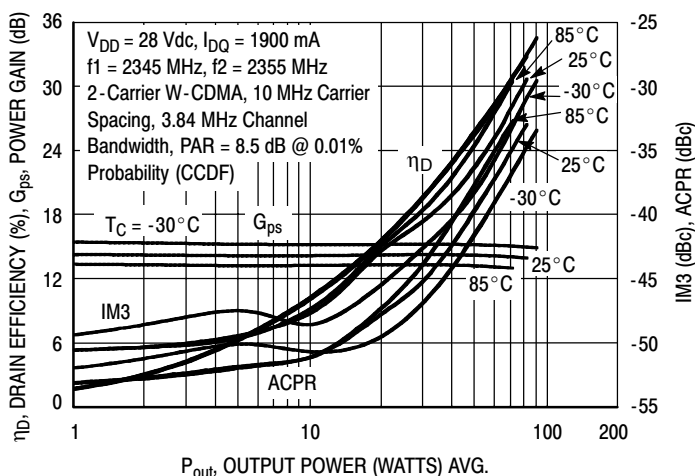
## TYPICAL CHARACTERISTICS



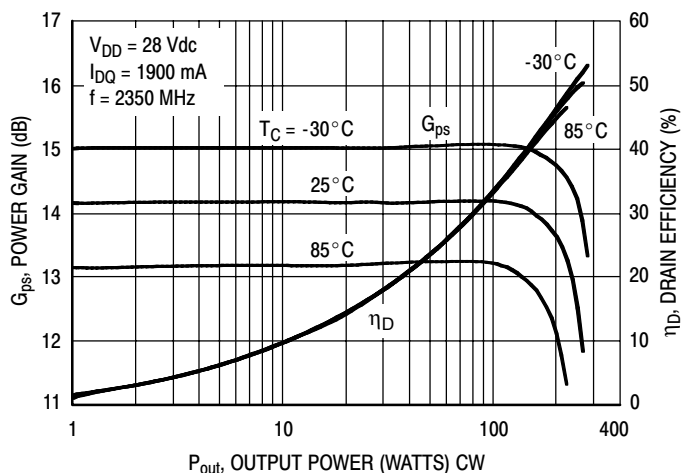
**Figure 7. Intermodulation Distortion Products versus Tone Spacing**



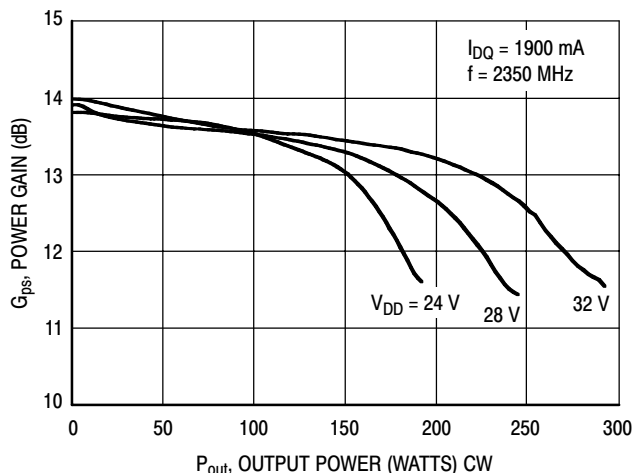
**Figure 8. Pulsed CW Output Power versus Input Power**



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

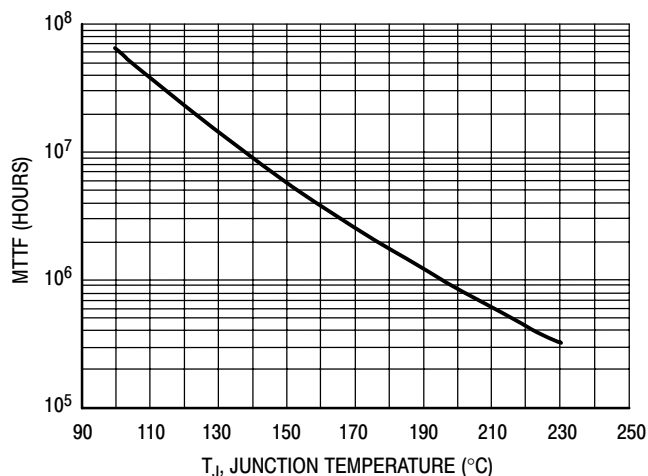


**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**



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

## TYPICAL CHARACTERISTICS

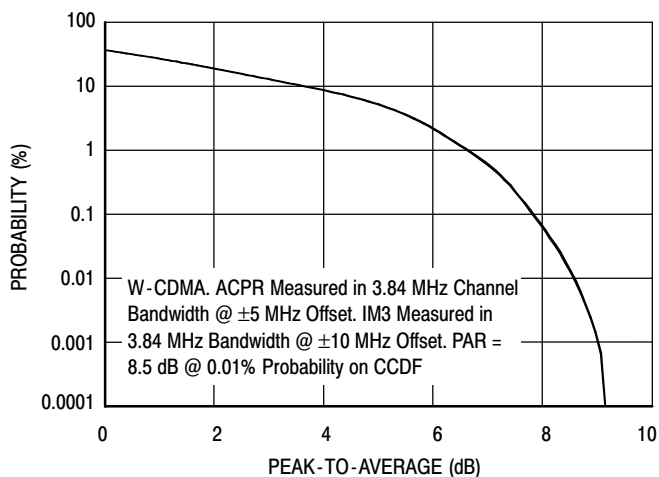


This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 40$  W Avg., and  $\eta_D = 23.5\%$ .

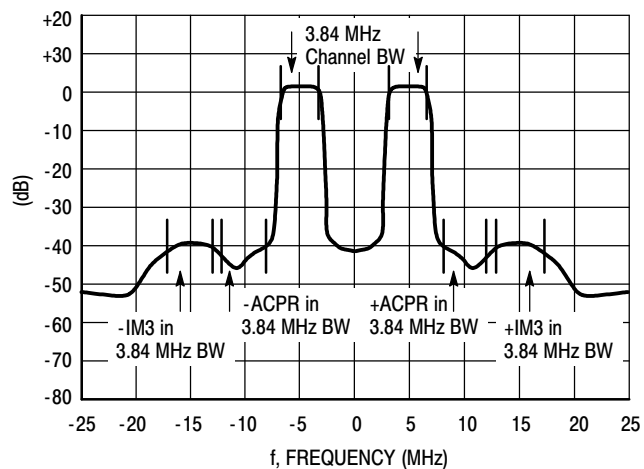
MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.

**Figure 12. MTTF versus Junction Temperature**

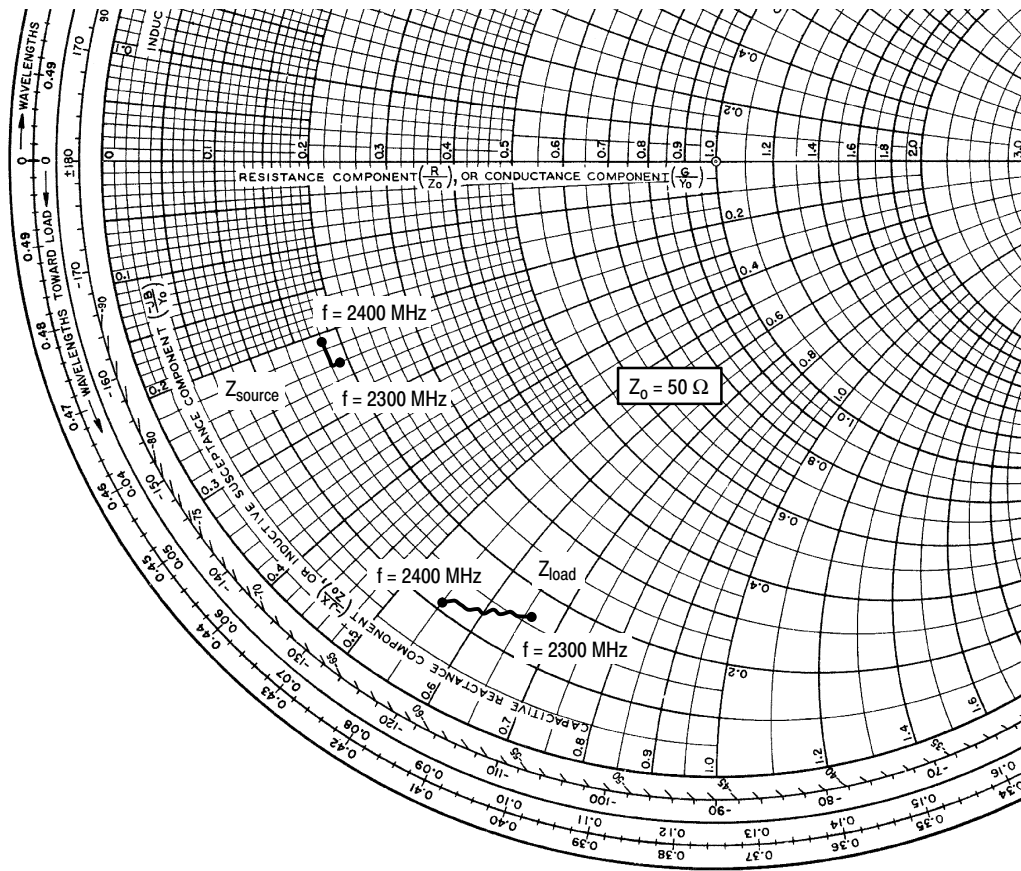
## W-CDMA TEST SIGNAL



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



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



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1900 \text{ mA}$ ,  $P_{out} = 40 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2300	9.31 - j12.12	7.89 - j32.78
2310	9.27 - j11.93	7.61 - j32.19
2320	9.24 - j11.75	7.35 - j31.62
2330	9.21 - j11.57	7.10 - j31.06
2340	9.18 - j11.40	6.86 - j30.53
2350	9.16 - j11.23	6.64 - j30.01
2360	9.14 - j11.06	6.43 - j29.51
2370	9.13 - j10.90	6.23 - j29.02
2380	9.12 - j10.75	6.04 - j28.55
2390	9.11 - j10.59	5.86 - j28.09
2400	9.11 - j10.45	5.68 - j27.64

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

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

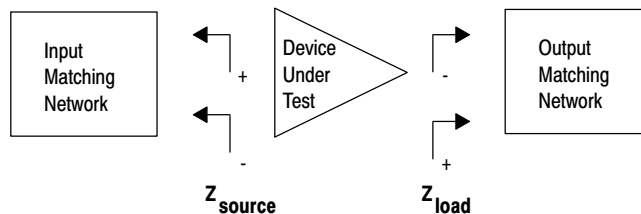
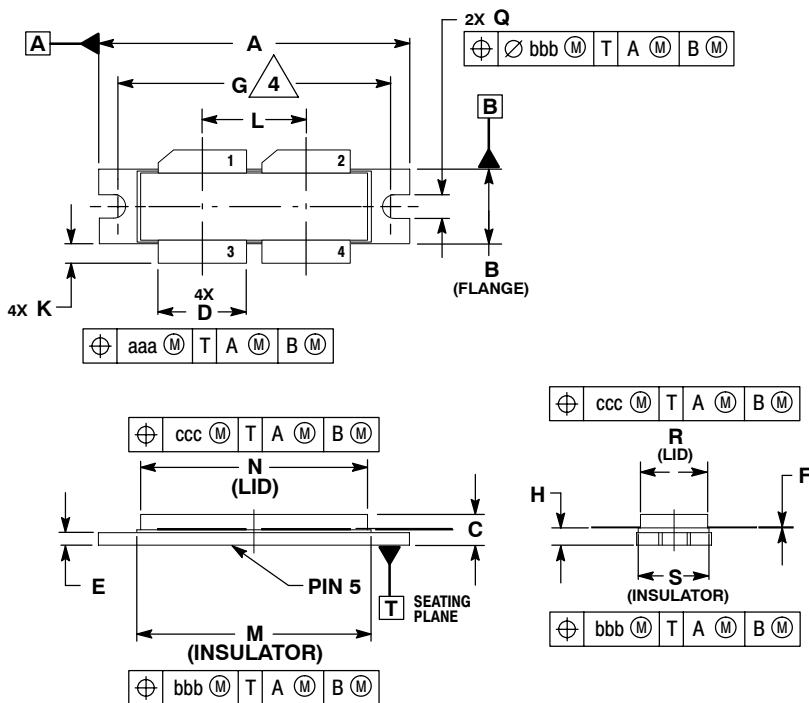


Figure 15. Series Equivalent Source and Load Impedance



# 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:  
 PIN 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
2	Mar. 2007	<ul style="list-style-type: none"><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>• Added maximum CW operation limitation and derating values to the Maximum Rating table to prevent a 200°C+ hot wire operating condition, 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>, 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 RoHS compliant part numbers, p. 3</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 Figure 12, MTF versus Junction Temperature with updated graph. Removed <math>Amps^2</math> and listed operating characteristics and location of MTF calculator for device, p. 7</li><li>• Added Product Documentation and Revision History, p. 10</li></ul>

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