

# RF Power Field Effect Transistor

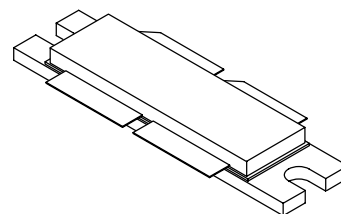
## N-Channel Enhancement-Mode Lateral MOSFET

Designed for 802.16 WiBro and dual mode applications with frequencies from 2300 to 2400 MHz. Suitable for Class AB feedforward and predistortion systems.

- 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 @ 3.84 MHz Channel Bandwidth  
ACPR @ 5 MHz Offset — -41 dBc @ 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2340 MHz, 190 Watts CW Output Power
- 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
- Lower Thermal Resistance Package
- Designed for Lower Memory Effects and Wide Instantaneous Bandwidth Applications
- Low Gold Plating Thickness on Leads, 40 $\mu$ m Nominal.
- Pb-Free and RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel.

**MRF6P23190HR6**

**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
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25 $^\circ\text{C}$	$P_D$	795 4.5	W W/ $^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	- 65 to +150	$^\circ\text{C}$
Operating Junction Temperature	$T_J$	200	$^\circ\text{C}$

**Table 2. Thermal Characteristics**

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

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.

**NOTE - CAUTION** - MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

**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	$\mu\text{Adc}$
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> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 200\ \mu\text{Adc}$ )	$V_{GS(th)}$	1	2	3	Vdc
Gate Quiescent Voltage <sup>(3)</sup> ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1900\text{ mAdc}$ , 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
Forward Transconductance <sup>(1)</sup> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 2\text{ Adc}$ )	$g_{fs}$	—	5.3	—	S

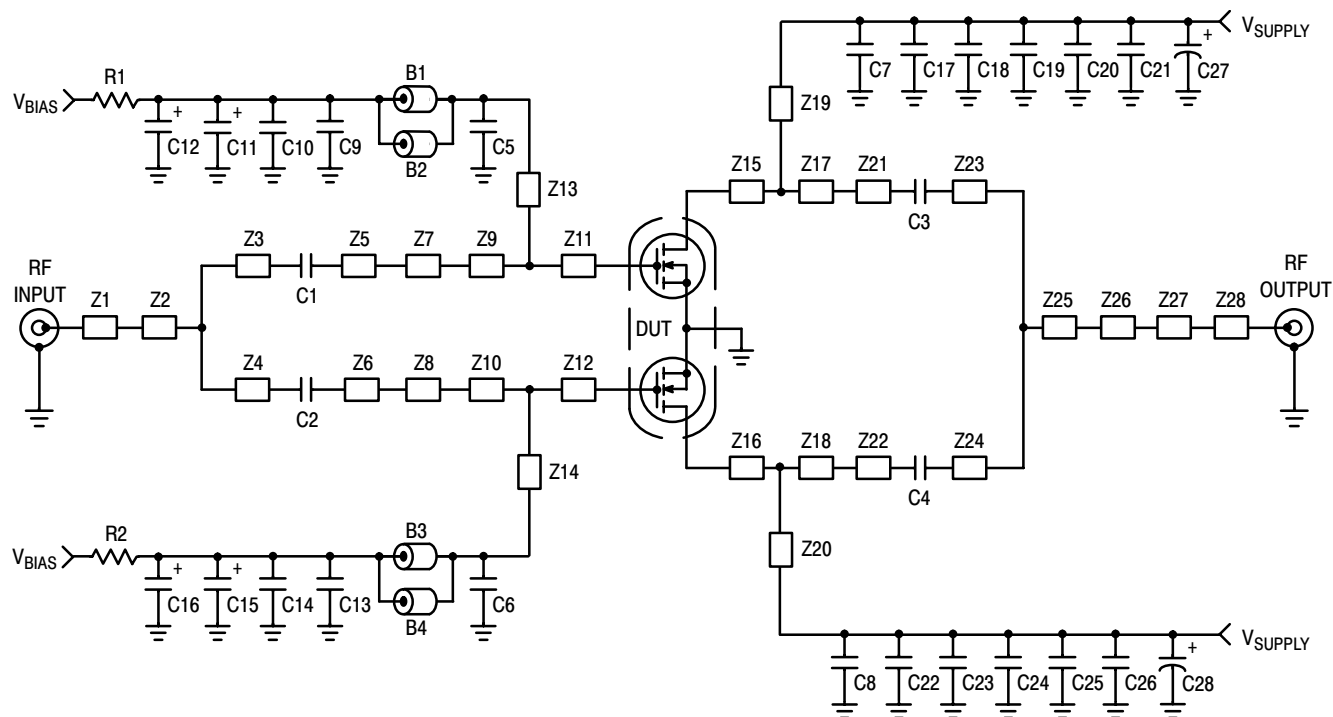
**Dynamic Characteristics<sup>(1,2)</sup>**

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.

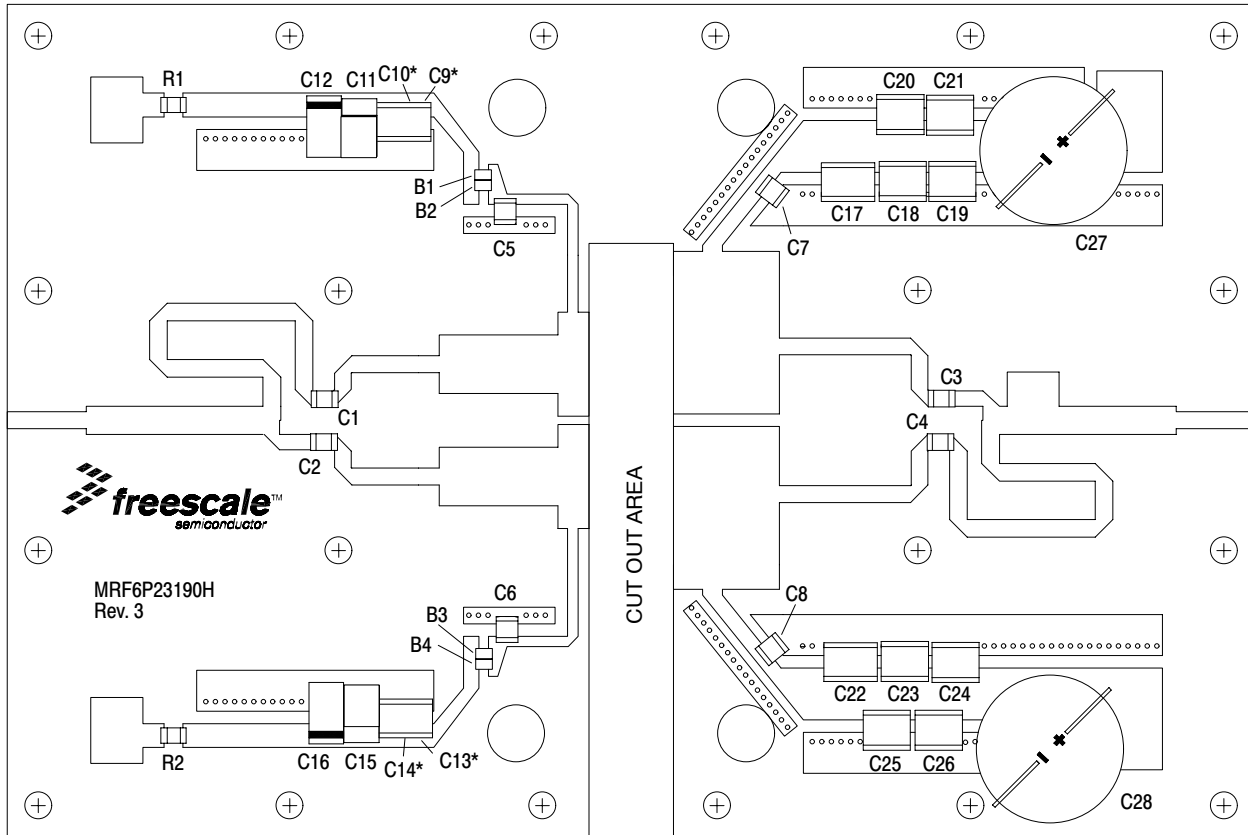


Z1, Z28	0.380" x 0.081" Microstrip	Z17, Z18	0.321" x 0.782" Microstrip
Z2	0.850" x 0.135" Microstrip	Z19, Z20	0.404" x 0.074" Microstrip
Z3	2.244" x 0.081" Microstrip	Z21, Z22	0.918" x 0.081" Microstrip
Z4	0.186" x 0.074" Microstrip	Z23	0.346" x 0.081" Microstrip
Z5, Z6	0.614" x 0.081" Microstrip	Z24	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 (0805)	2508051107Y0	Fair-Rite
C1, C2, C3, C4	5.1 pF 100B Chip Capacitors	100B5R1CP500X	ATC
C5, C6, C7, C8	5.6 pF 100B Chip Capacitors	100B5R6CP500X	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	T491D476K016AS	Kemet
C18, C19, C20, C21, C23, C24, C25, C26	10 $\mu$ F, 50 V Chip Capacitors (2220)	GRM55DR61H106KA88B	Murata
C27, C28	330 $\mu$ F, 63 V Electrolytic Capacitors	NACZF331M63V	Nippon
R1, R2	240 $\Omega$ , 1/8 W Chip Resistors (1206)		



\*Stacked.

Figure 2. MRF6P23190HR6 Test Circuit Component Layout

## TYPICAL CHARACTERISTICS

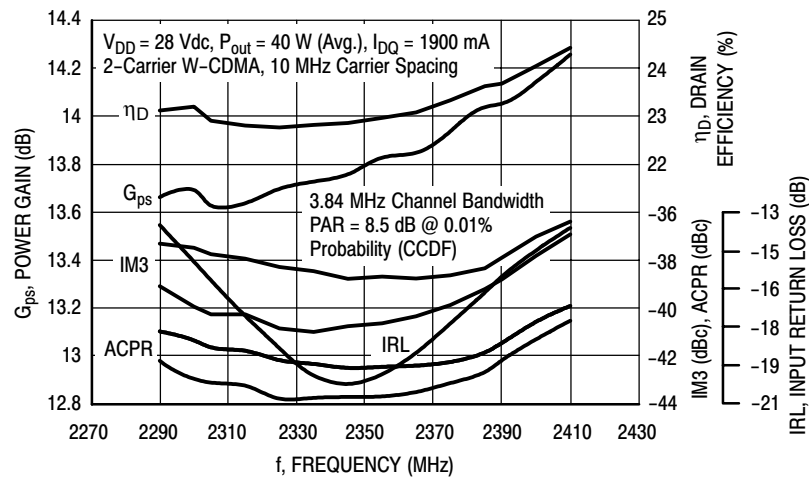


Figure 3. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 40$  Watts Avg.

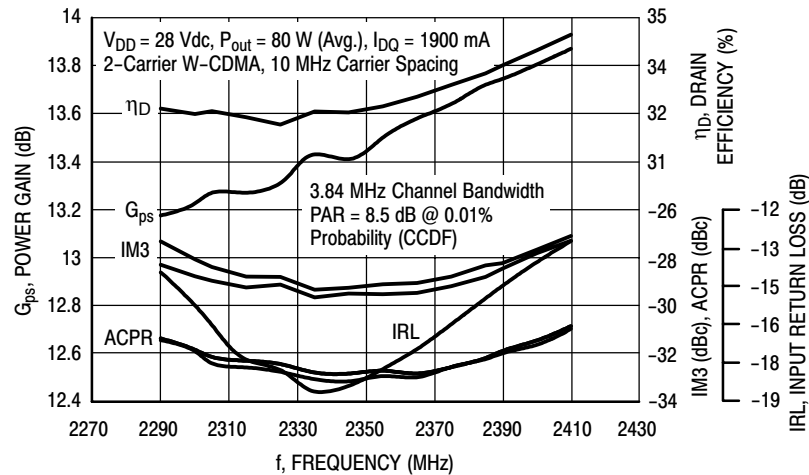


Figure 4. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 80$  Watts Avg.

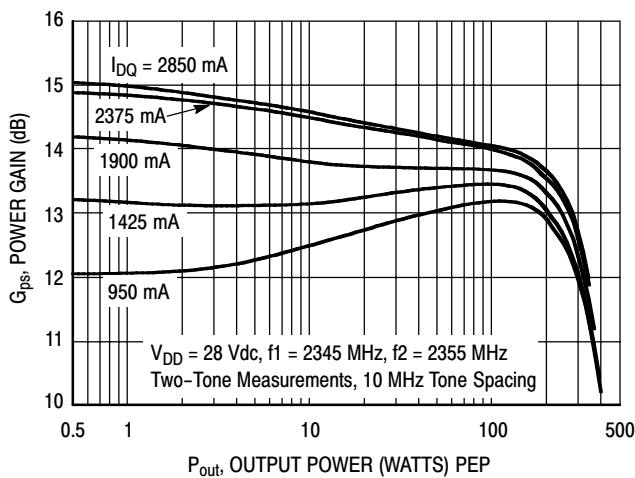


Figure 5. Two-Tone Power Gain versus Output Power

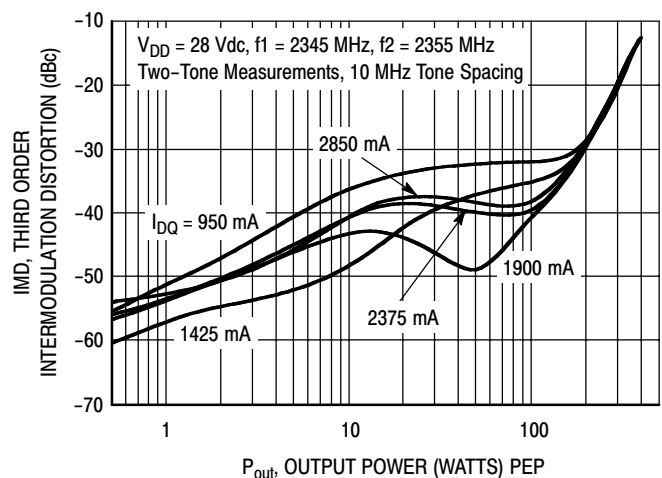
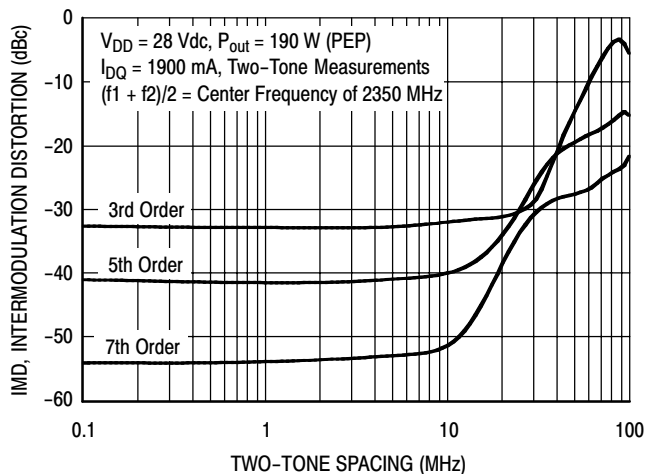
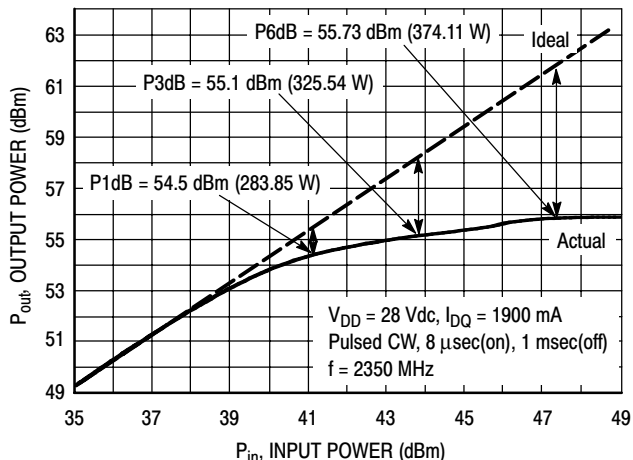


Figure 6. Third Order Intermodulation Distortion versus Output Power

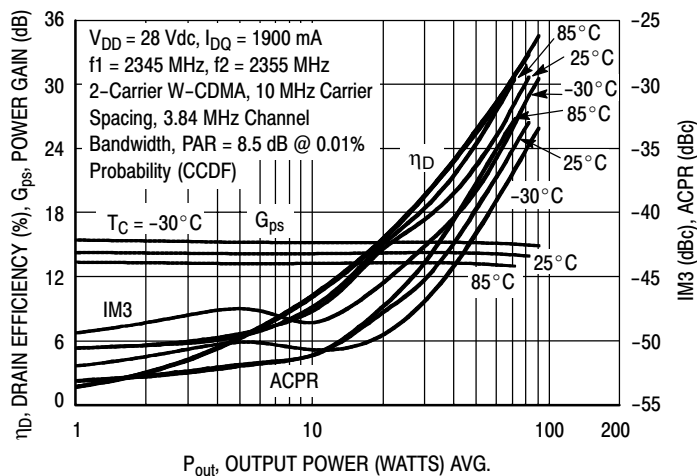
## TYPICAL CHARACTERISTICS



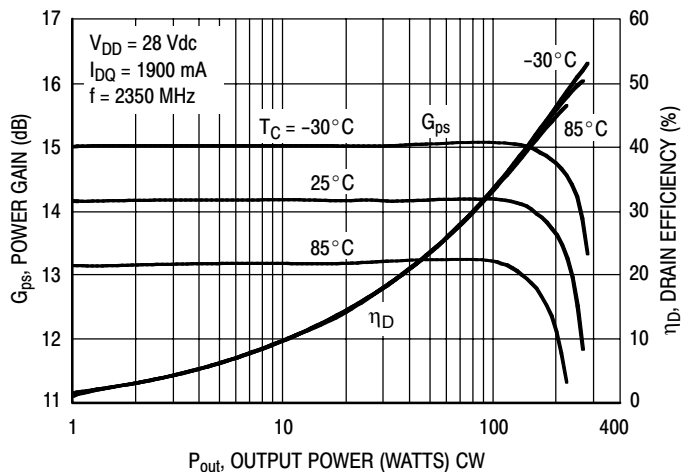
**Figure 7. Intermodulation Distortion Products versus Tone Spacing**



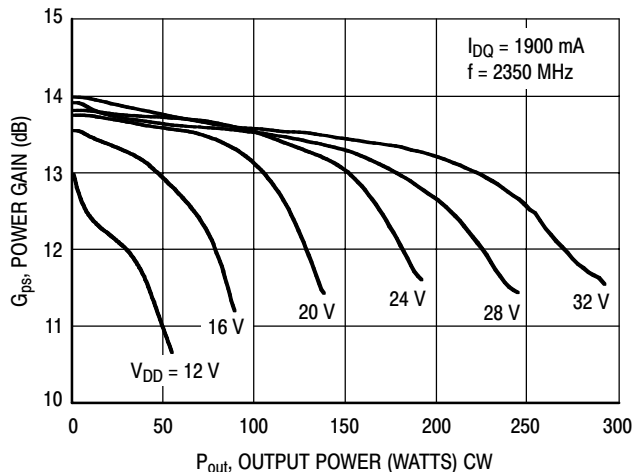
**Figure 8. Pulse CW Output Power versus Input Power**



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

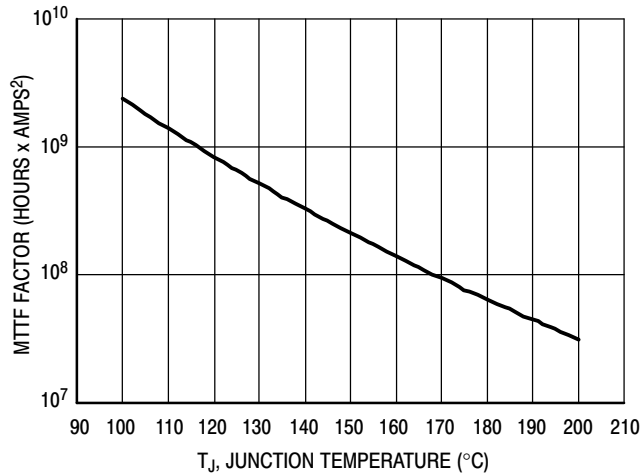


**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**



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

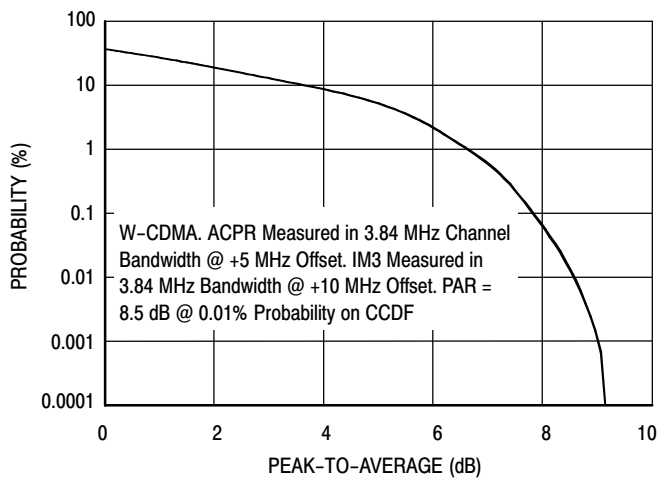
## TYPICAL CHARACTERISTICS



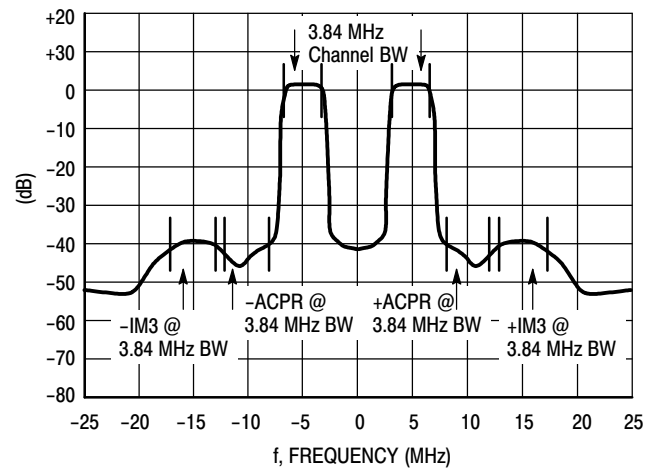
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than ±10% of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

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

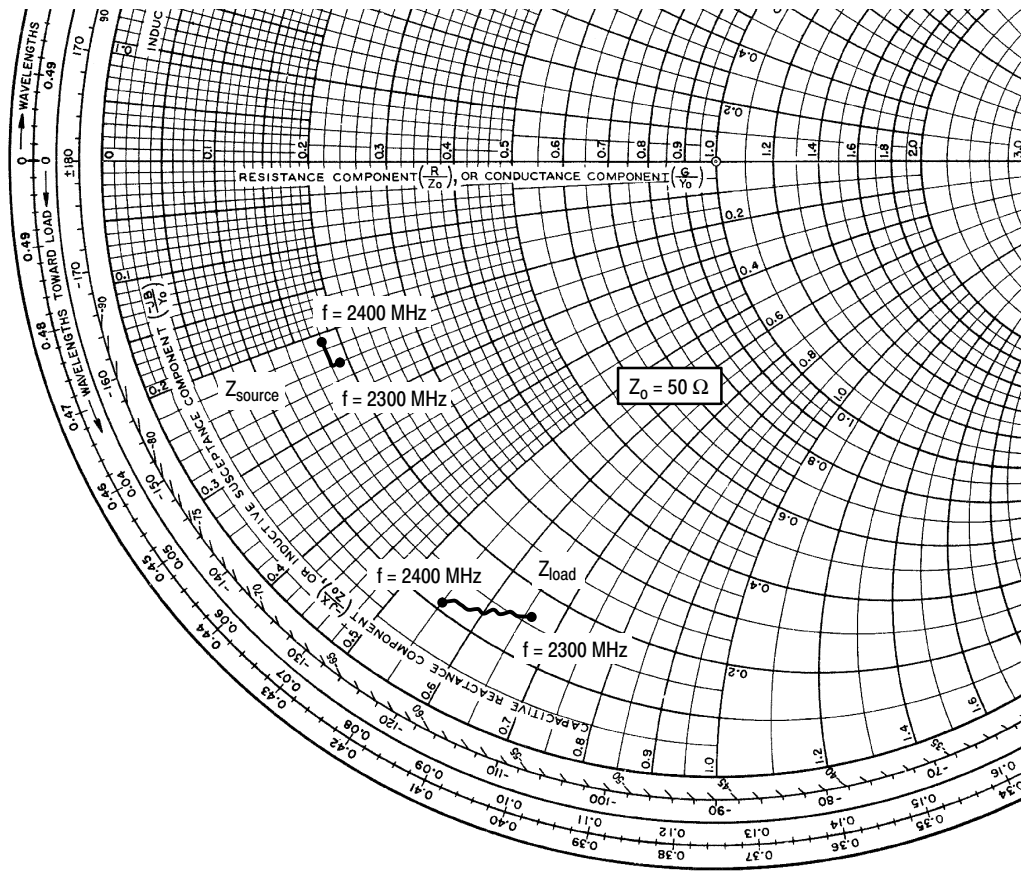
## W-CDMA TEST SIGNAL



**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.

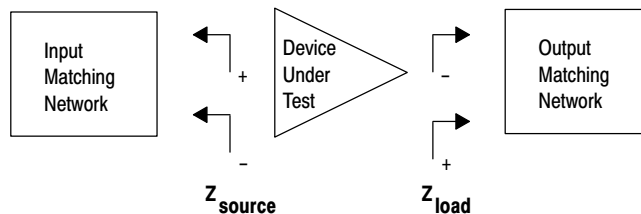


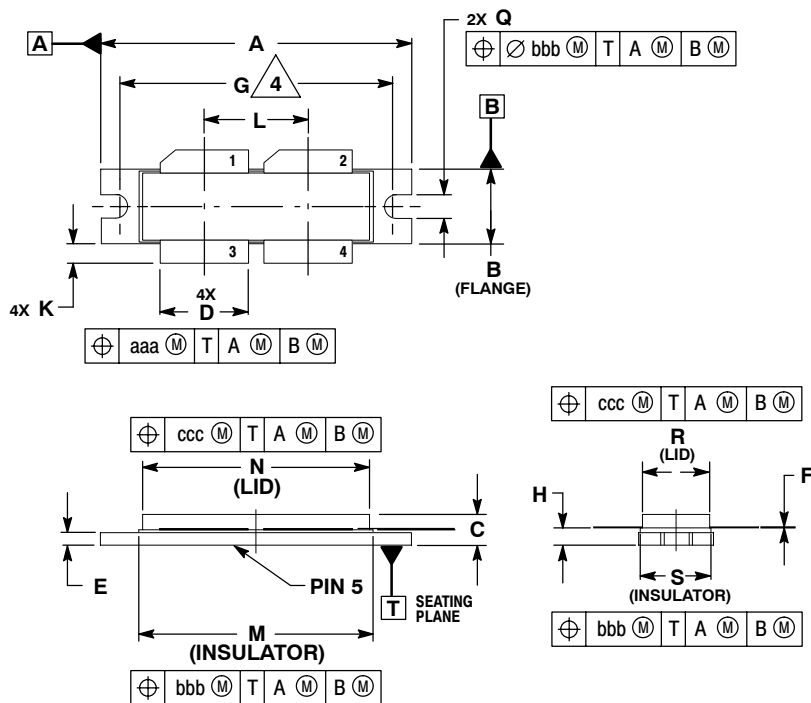
Figure 15. Series Equivalent Source and Load Impedance



# NOTES

# NOTES

## 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
- DRAIN
- GATE
- GATE
- SOURCE

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

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