

# 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.

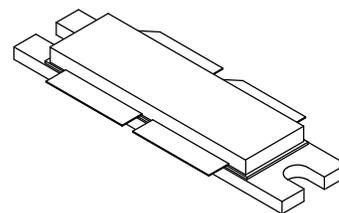
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1600$  mA,  $P_{out} = 38$  Watts Avg., Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
 Power Gain — 14 dB  
 Drain Efficiency — 25.5%  
 IM3 @ 10 MHz Offset — -37.5 dBc in 3.84 MHz Channel Bandwidth  
 ACPR @ 5 MHz Offset — -41 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2140 MHz, 180 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
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40 $\mu$ ” Nominal.
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel.

**MRF5P21180HR6**

**2110-2170 MHz, 38 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, +65	Vdc
Gate-Source Voltage	$V_{GS}$	-0.5, +15	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25 $^\circ\text{C}$	$P_D$	530 3.0	W W/ $^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-65 to +150	$^\circ\text{C}$
Case Operating Temperature	$T_C$	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 80 $^\circ\text{C}$ , 180 W CW Case Temperature 71 $^\circ\text{C}$ , 38 W CW	$R_{\theta JC}$	0.31 0.33	$^\circ\text{C}/\text{W}$

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access 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 Conditions	Class
Human Body Model	2 (Minimum)
Machine Model	M3 (Minimum)
Charge Device Model	C7 (Minimum)

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

Characteristic	Symbol	Min	Typ	Max	Unit
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**Off Characteristics** <sup>(1)</sup>

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 ( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0$ )	$I_{DSS}$	—	—	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> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 200\ \mu\text{A}$ )	$V_{GS(th)}$	2.5	2.8	3.5	Vdc
Gate Quiescent Voltage <sup>(3)</sup> ( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1600\text{ mA}$ )	$V_{GS(Q)}$	—	3.6	—	Vdc
Drain-Source On-Voltage <sup>(1)</sup> ( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2\text{ A}$ )	$V_{DS(on)}$	—	0.26	0.3	Vdc
Forward Transconductance <sup>(1)</sup> ( $V_{DS} = 10\text{ Vdc}$ , $I_D = 2\text{ A}$ )	$g_{fs}$	—	5	—	S

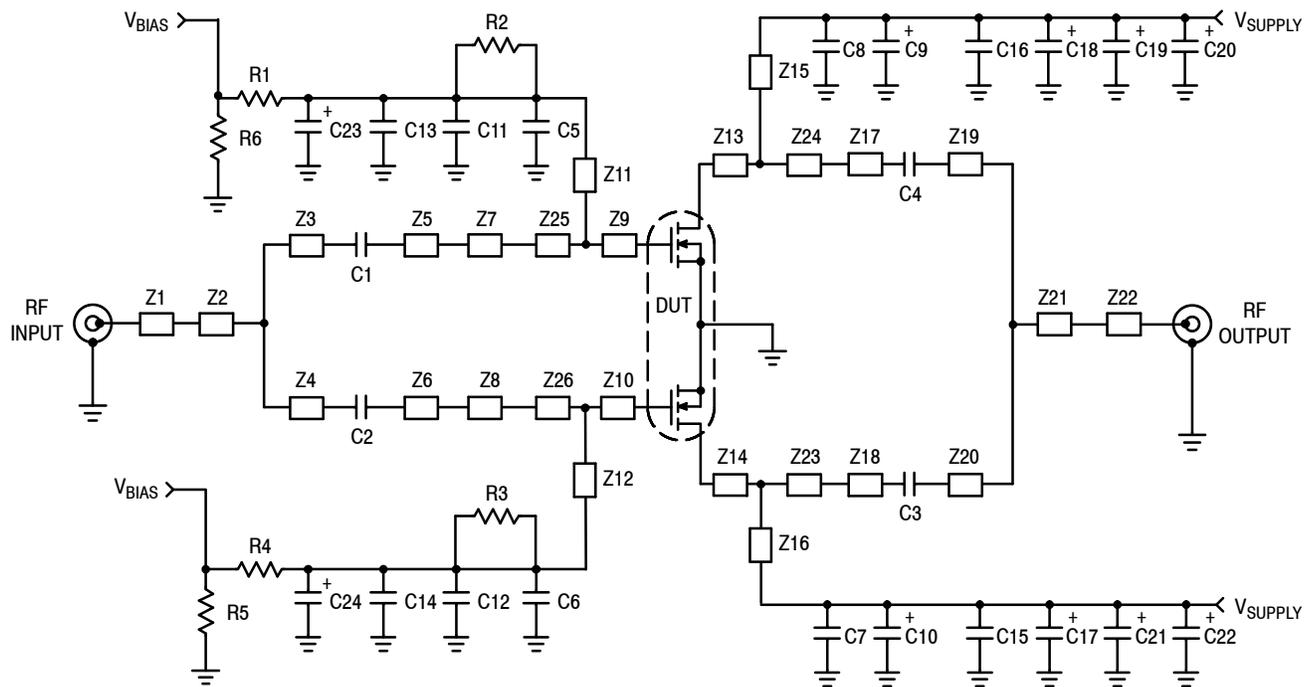
**Dynamic Characteristics** <sup>(1,2)</sup>

Reverse Transfer Capacitance ( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )	$C_{rss}$	—	1.7	—	pF
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**Functional Tests** <sup>(3)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1600\text{ mA}$ ,  $P_{out} = 38\text{ W Avg.}$ ,  $f = 2157.5\text{ MHz}$ , 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 Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

Power Gain	$G_{ps}$	12.5	14	—	dB
Drain Efficiency	$\eta_D$	23	25.5	—	%
Intermodulation Distortion	IM3	—	-37.5	-35	dBc
Adjacent Channel Power Ratio	ACPR	—	-41	-38	dBc
Input Return Loss	IRL	—	-14	-9	dB

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

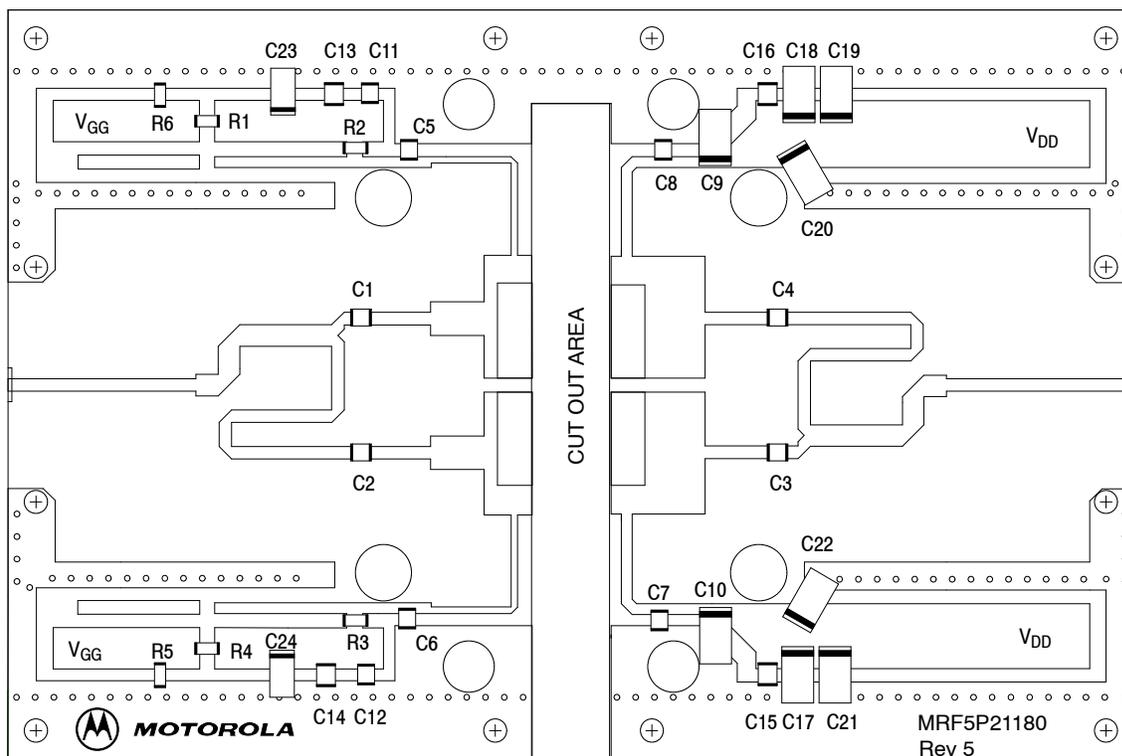


Z1, Z22	1.000" x 0.066" Microstrip	Z11, Z12	1.030" x 0.035" Microstrip
Z2, Z21	0.760" x 0.113" Microstrip	Z13, Z14	0.083" x 0.650" Microstrip
Z3, Z20	0.068" x 0.066" Microstrip	Z15, Z16	0.550" x 0.058" Microstrip
Z4, Z19	1.672" x 0.066" Microstrip	Z17, Z18	0.353" x 0.066" Microstrip
Z5, Z6	0.318" x 0.066" Microstrip	Z23, Z24	0.417" x 0.650" Microstrip
Z7, Z8	0.284" x 0.180" Microstrip	Z25, Z26	0.161" x 0.650" Microstrip
Z9, Z10	0.094" x 0.650" Microstrip	PCB	Taconic RF-35, 0.030", $\epsilon_r = 3.5$

**Figure 1. MRF5P21180HR6 Test Circuit Schematic**

**Table 5. MRF5P21180HR6 Test Circuit Component Designations and Values**

Part	Description	Part Number	Manufacturer
C1, C2, C3, C4	30 pF Chip Capacitors	ATC100B300JT500XT	ATC
C5, C6, C7, C8	5.6 pF Chip Capacitors	ATC100B5R6JT500XT	ATC
C9, C10	10 $\mu$ F Tantalum Capacitors	T495X106K035AT	Kemet
C11, C12	1000 pF Chip Capacitors	ATC100B102JT500XT	ATC
C13, C14, C15, C16	0.1 $\mu$ F Chip Capacitors	CDR33BX104AKYS	Kemet
C17, C18, C19, C20, C21, C22	22 $\mu$ F Tantalum Capacitors	T491X226K035AT	Kemet
C23, C24	1.0 $\mu$ F Tantalum Capacitors	T491C105M050AT	Kemet
R1, R2, R3, R4	10 $\Omega$ , 1/4 W Chip Resistors	CRCW120610R0FKEA	Vishay
R5, R6	1.0 k $\Omega$ , 1/4 W Chip Resistor	CRCW12061001FKEA	Vishay



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

**Figure 2. MRF5P21180HR6 Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS

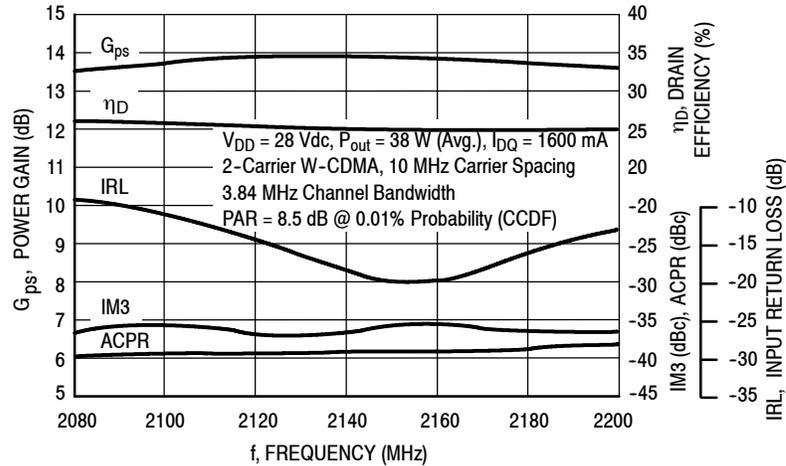


Figure 3. 2-Carrier W-CDMA Broadband Performance

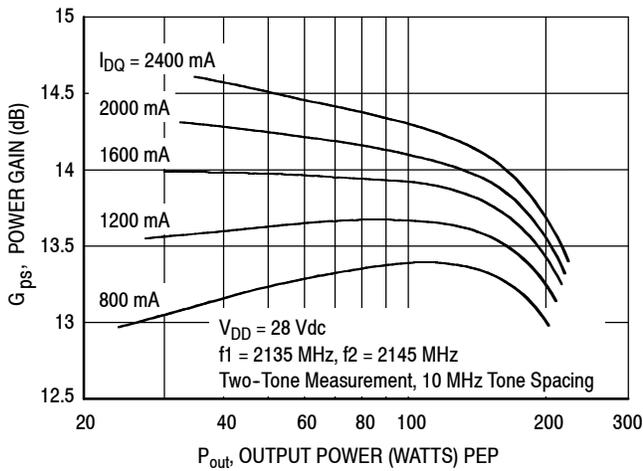


Figure 4. Two-Tone Power Gain versus Output Power

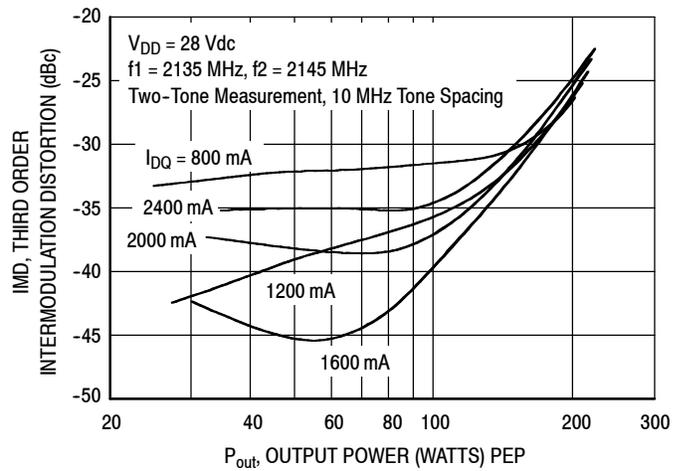


Figure 5. Third Order Intermodulation Distortion versus Output Power

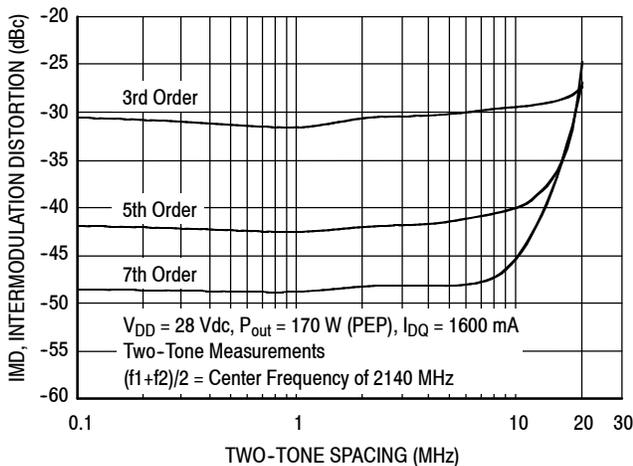


Figure 6. Intermodulation Distortion Products versus Tone Spacing

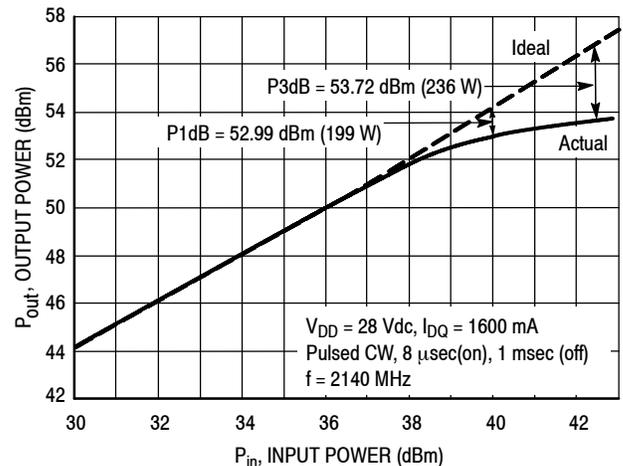
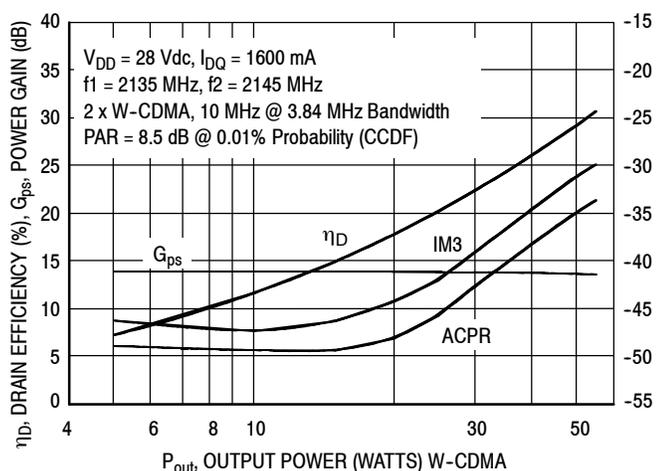
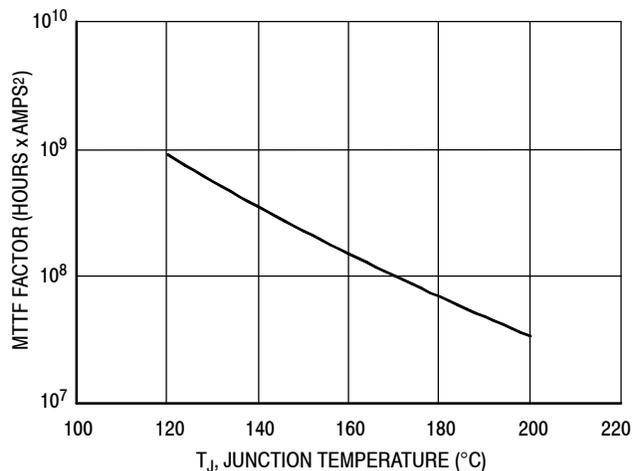


Figure 7. Pulse CW Output Power versus Input Power

## TYPICAL CHARACTERISTICS



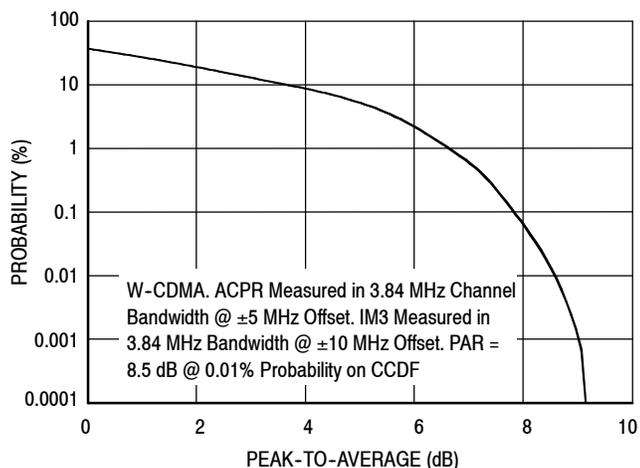
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



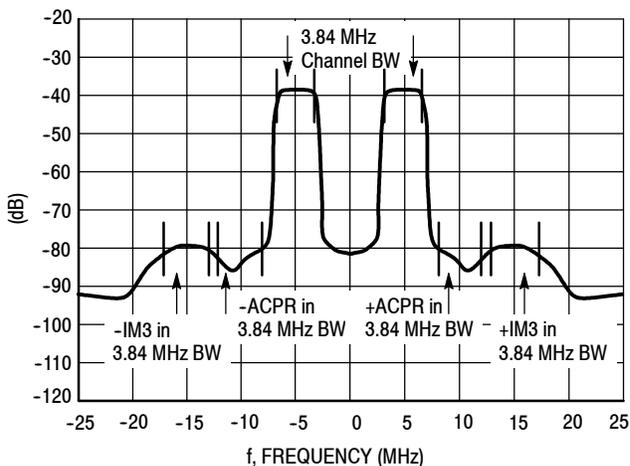
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 9. MTTF Factor versus Junction Temperature**

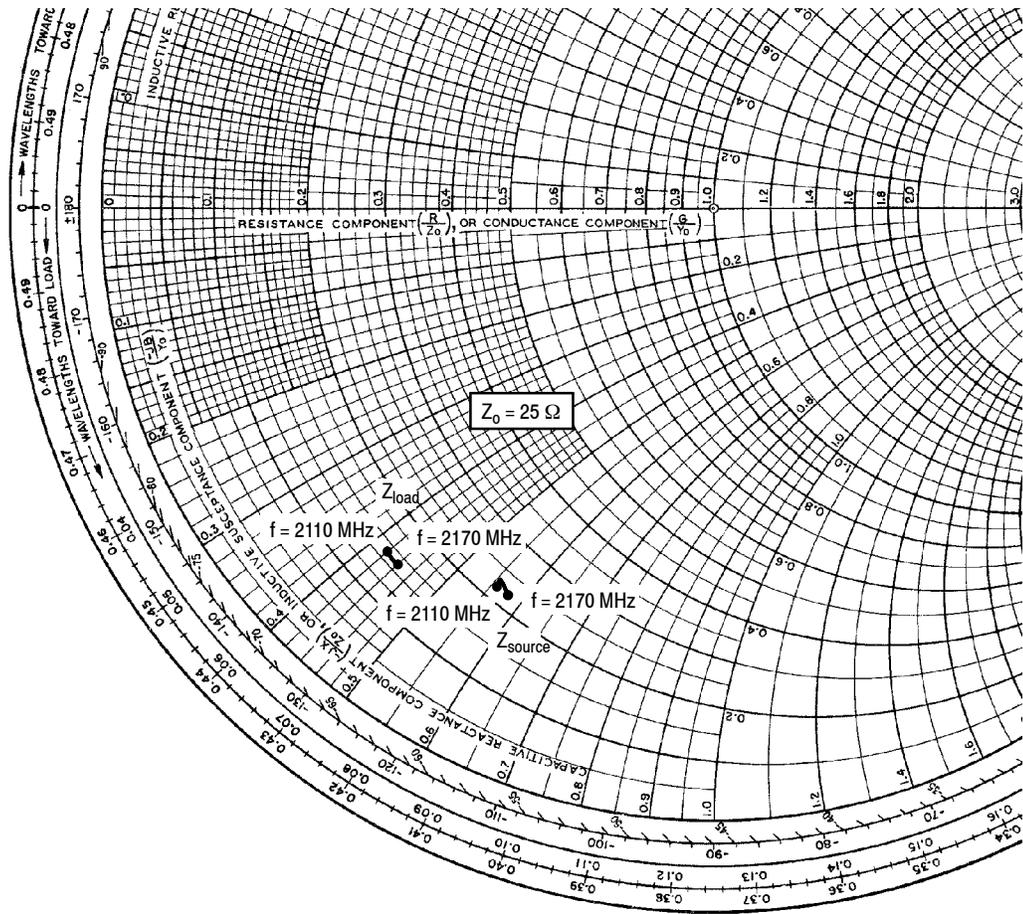
## W-CDMA TEST SIGNAL



**Figure 10. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single Carrier Test Signal**



**Figure 11. 2-Carrier W-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1600 \text{ mA}$ ,  $P_{out} = 38 \text{ W Avg.}$

f MHz	$Z_{source}$ $\Omega$	$Z_{load}$ $\Omega$
2110	$5.39 - j13.89$	$3.69 - j10.51$
2140	$5.66 - j13.99$	$3.81 - j10.66$
2170	$5.53 - j14.51$	$3.79 - j11.05$

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

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

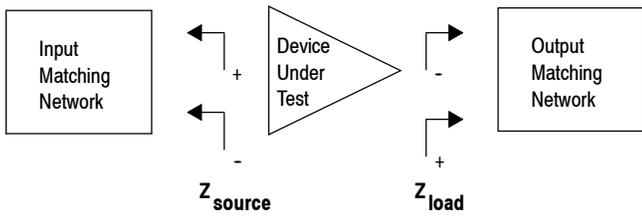
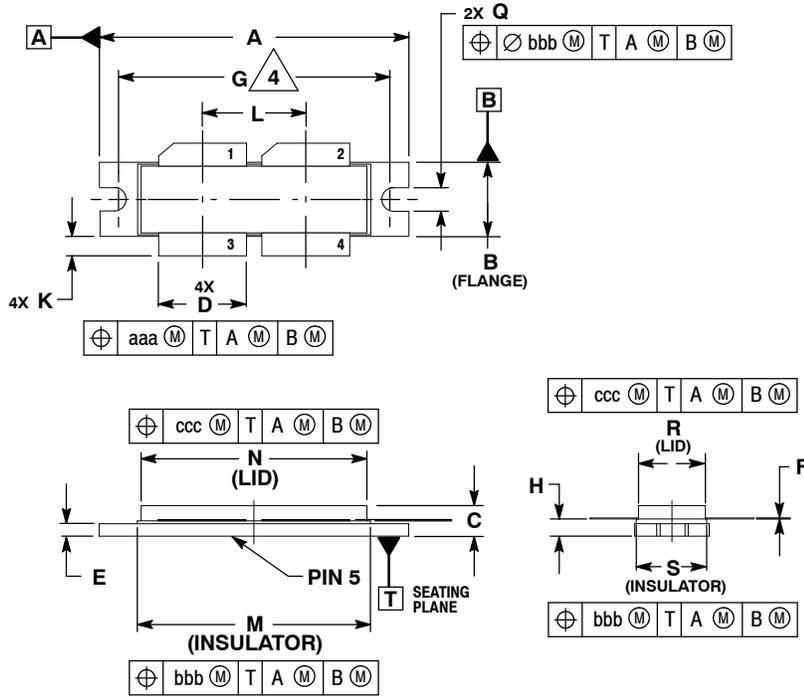


Figure 12. Series Equivalent Source and Load Impedance

## 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
- DRAIN
- GATE
- GATE
- 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
3	Oct. 2008	<ul style="list-style-type: none"> <li>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN12779, p. 1, 2</li> <li>• Updated Part Numbers in Table 5, Component Designations and Values, to RoHS compliant part numbers, p. 3</li> <li>• Added Product Documentation and Revision History, p. 9</li> </ul>

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