

# 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.

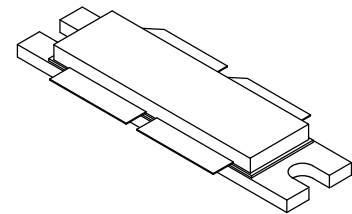
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1600$  mA,  $P_{out} = 38$  Watts Avg., Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
 Power Gain — 14 dB  
 Drain Efficiency — 25.5%  
 IM3 @ 10 MHz Offset — -37.5 dBc in 3.84 MHz Channel Bandwidth  
 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
<b>Off Characteristics</b> <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

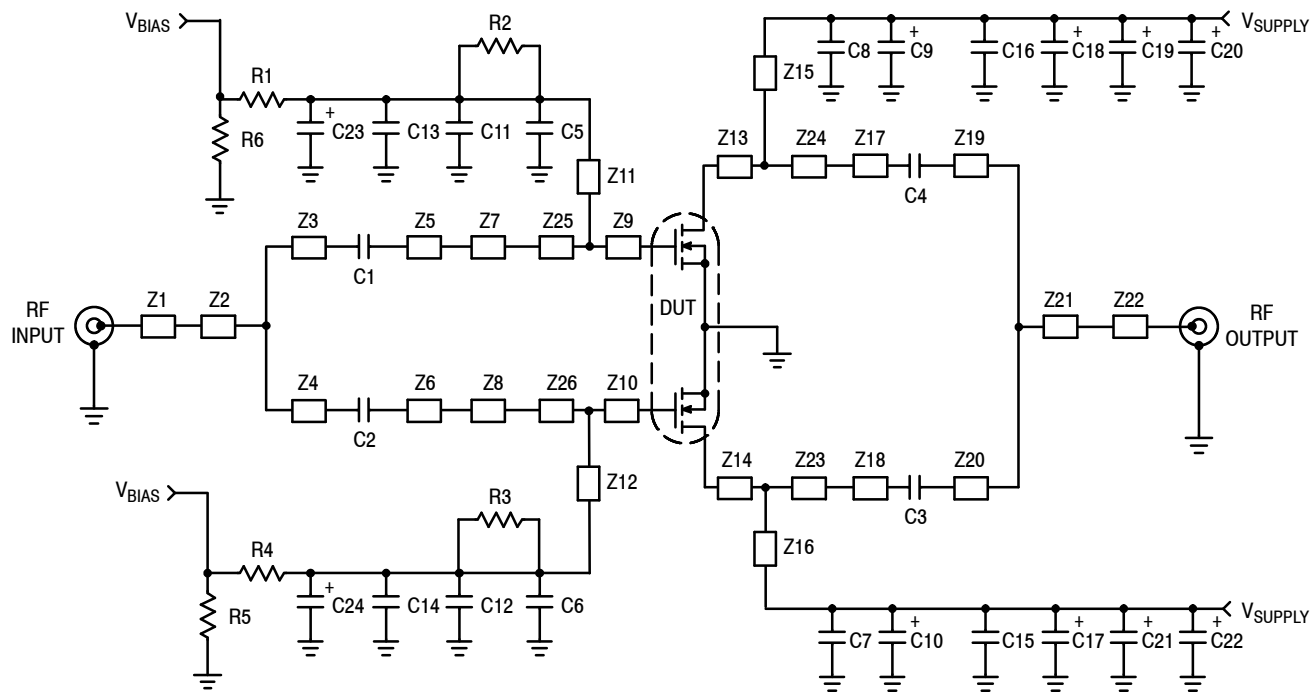
**Dynamic Characteristics** <sup>(1,2)</sup>

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.

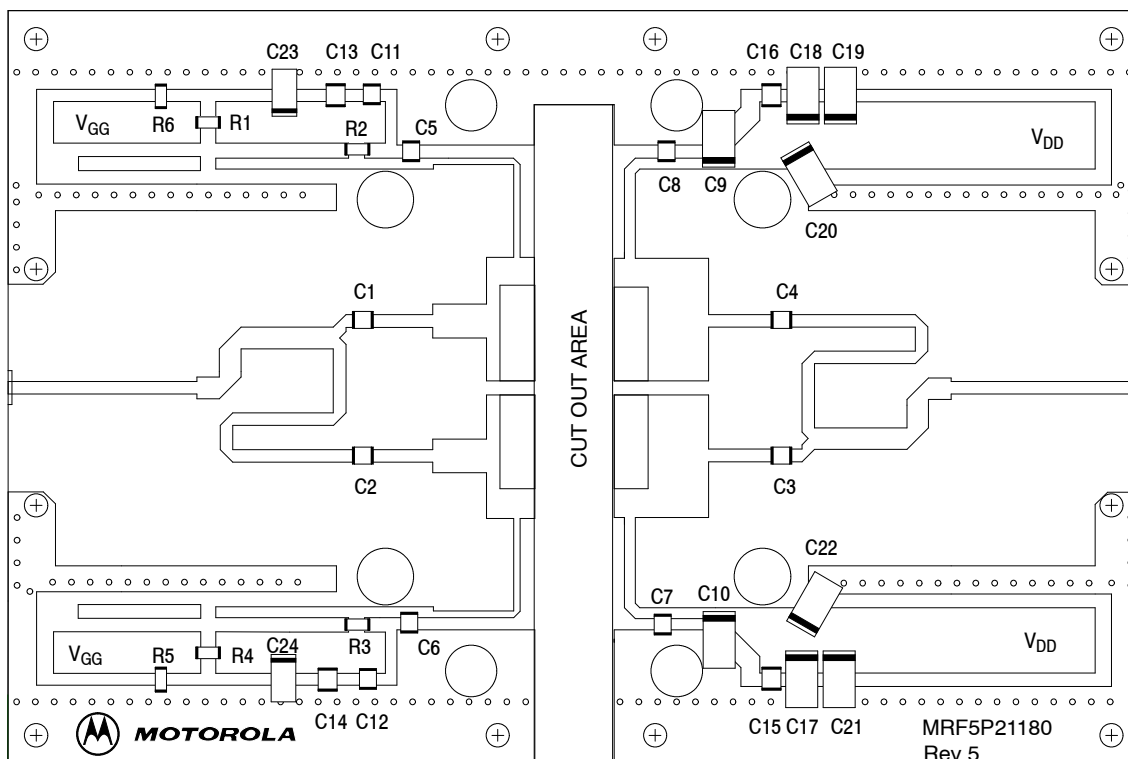


Z1, Z22	1.000" x 0.066" Microstrip	Z11, Z12	1.030" x 0.035" Microstrip
Z2, Z21	0.760" x 0.113" Microstrip	Z13, Z14	0.083" x 0.650" Microstrip
Z3, Z20	0.068" x 0.066" Microstrip	Z15, Z16	0.550" x 0.058" Microstrip
Z4, Z19	1.672" x 0.066" Microstrip	Z17, Z18	0.353" x 0.066" Microstrip
Z5, Z6	0.318" x 0.066" 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**

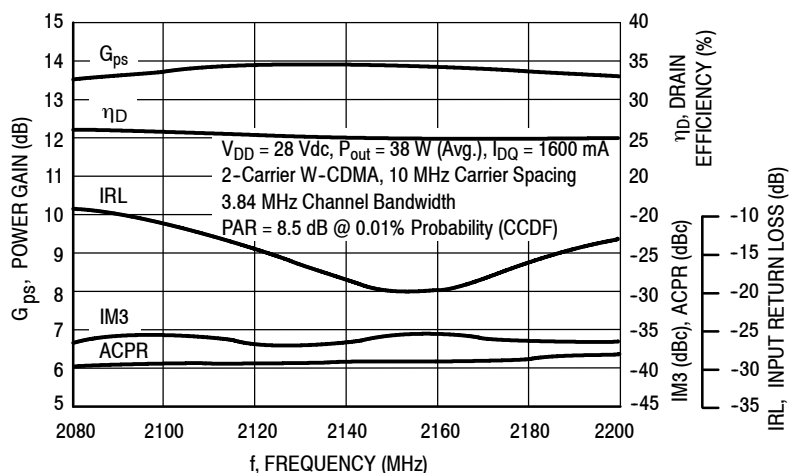
Part	Description	Part Number	Manufacturer
C1, C2, C3, C4	30 pF Chip Capacitors	ATC100B300JT500XT	ATC
C5, C6, C7, C8	5.6 pF Chip Capacitors	ATC100B5R6JT500XT	ATC
C9, C10	10 $\mu$ F Tantalum Capacitors	T495X106K035AT	Kemet
C11, C12	1000 pF Chip Capacitors	ATC100B102JT500XT	ATC
C13, C14, C15, C16	0.1 $\mu$ 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



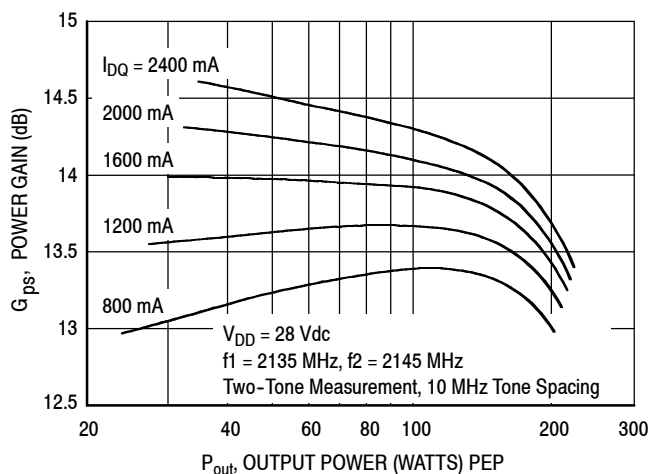
Freescal has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescal Semiconductor signature/logo. PCBs may have either Motorola or Freescal markings during the transition period. These changes will have no impact on form, fit or function of the current product.

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

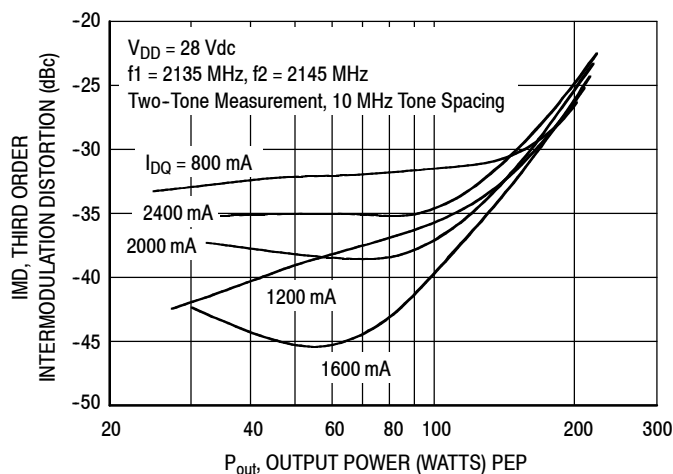
### TYPICAL CHARACTERISTICS



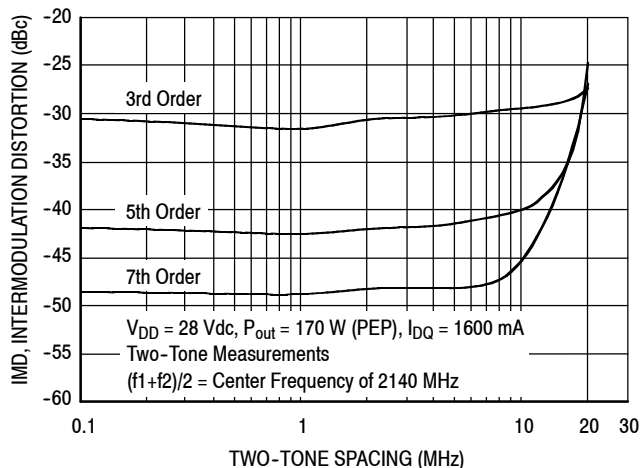
**Figure 3. 2-Carrier W-CDMA Broadband Performance**



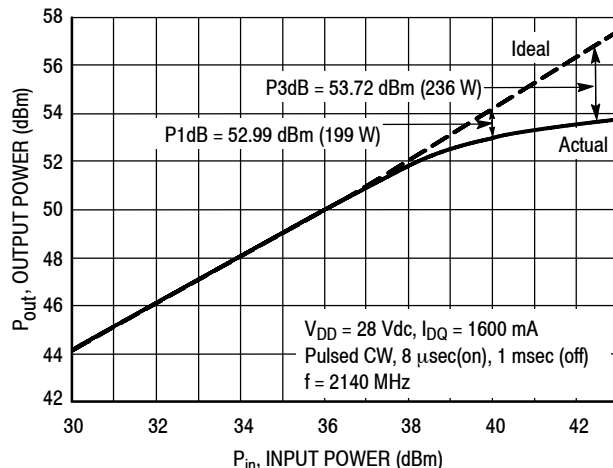
**Figure 4. Two-Tone Power Gain versus Output Power**



**Figure 5. Third Order Intermodulation Distortion versus Output Power**

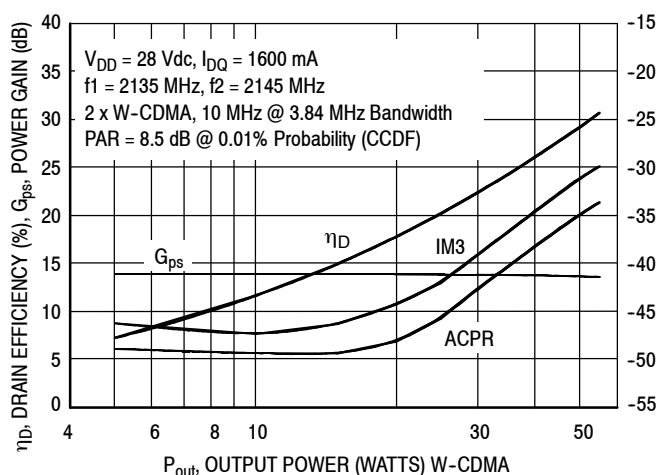


**Figure 6. Intermodulation Distortion Products versus Tone Spacing**

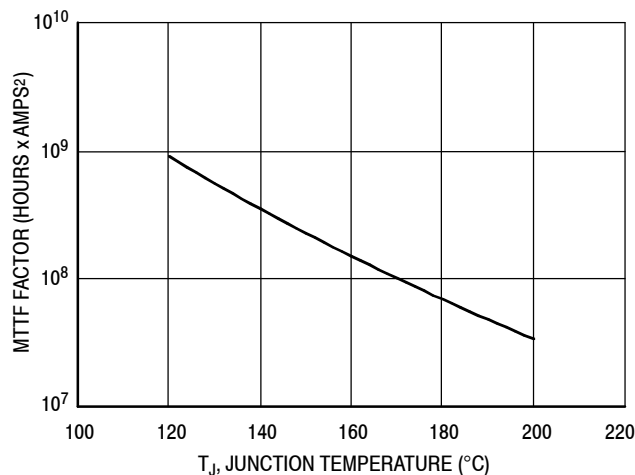


**Figure 7. Pulse CW Output Power versus Input Power**

### TYPICAL CHARACTERISTICS



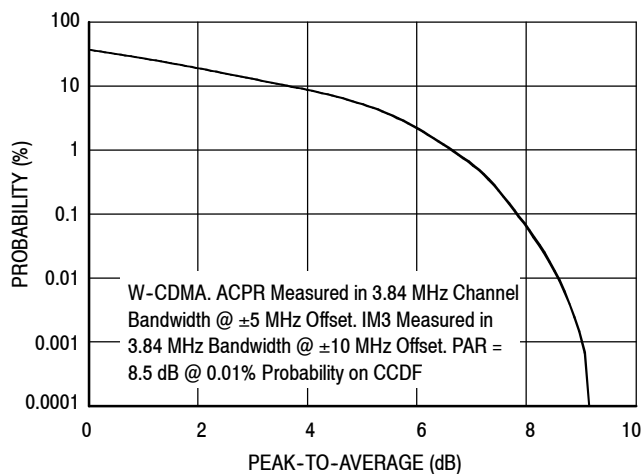
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



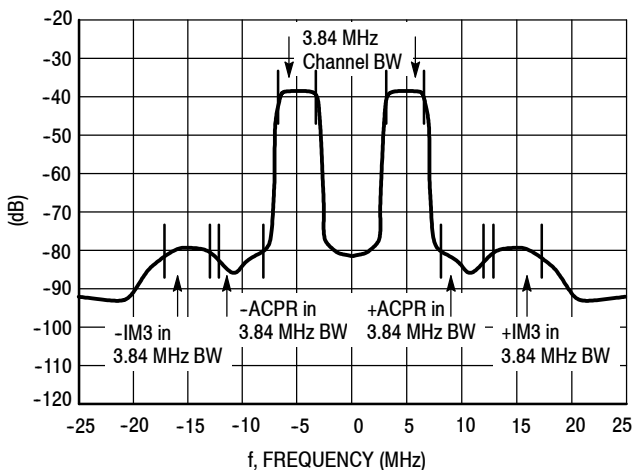
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

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

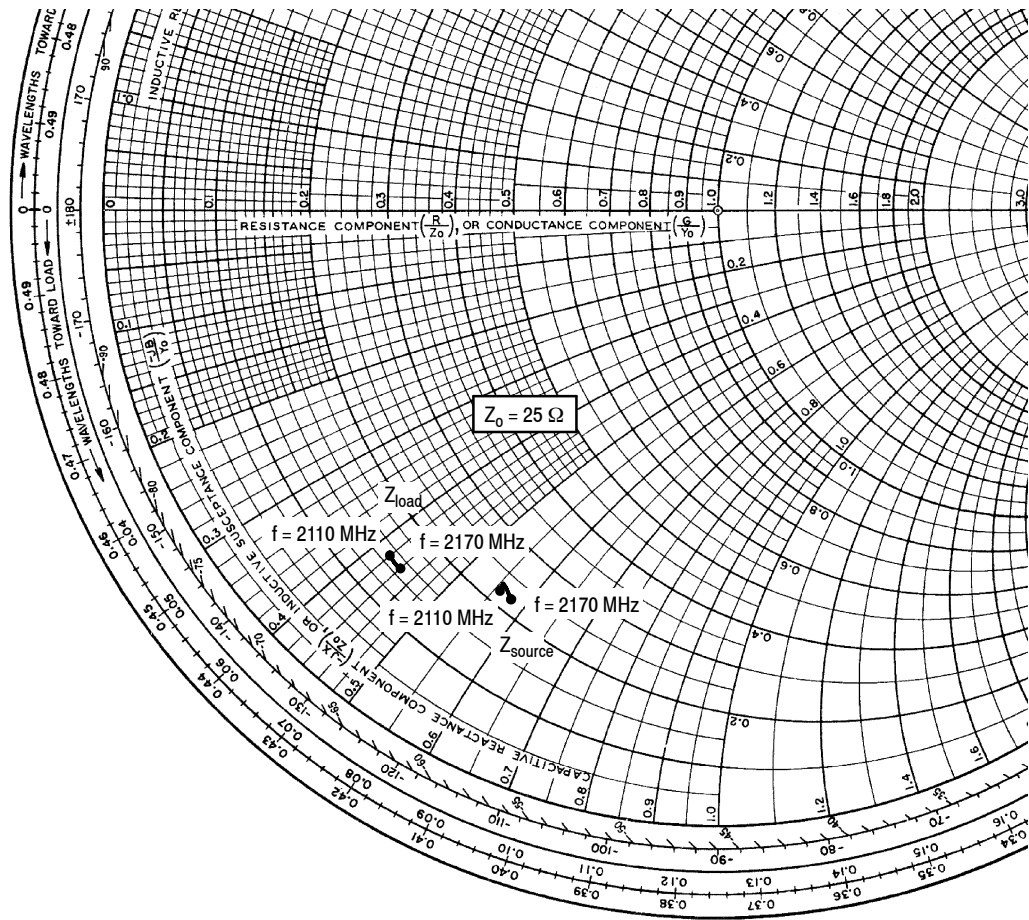
### W-CDMA TEST SIGNAL



**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.

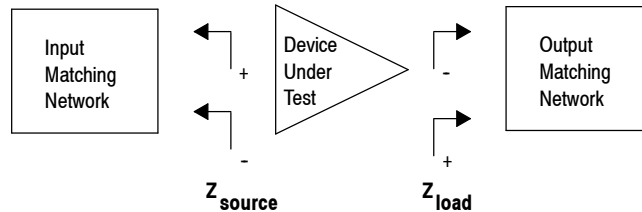
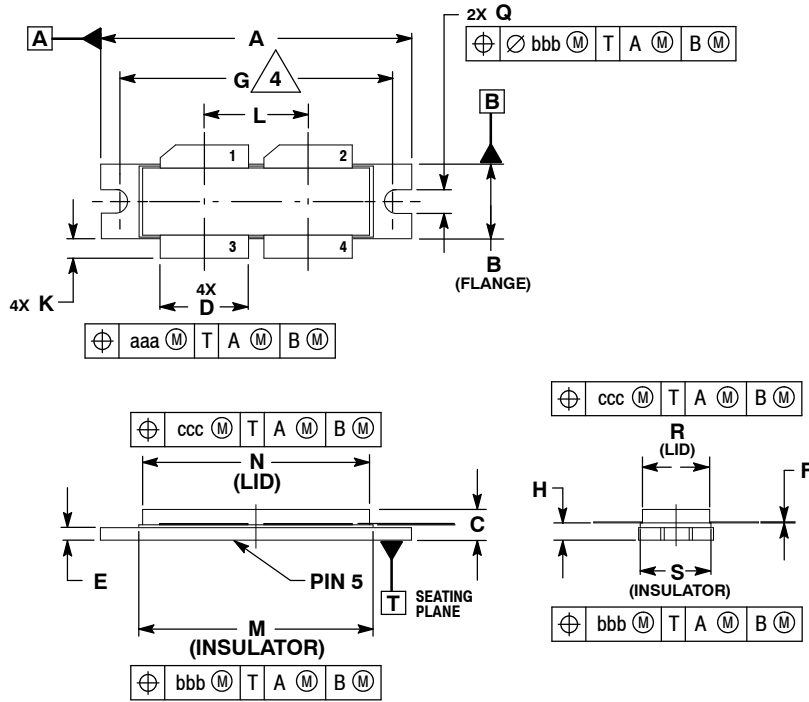


Figure 12. Series Equivalent Source and Load Impedance

## 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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