

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

Designed for W-CDMA base station applications with frequencies from 1930 to 1990 MHz. Suitable for TDMA, CDMA and multicarrier amplifier applications. To be used in Class AB for PCN-PCS/cellular radio and WLL applications.

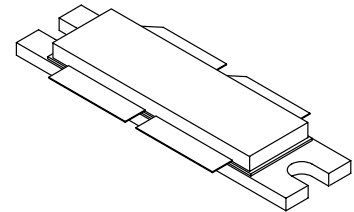
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1600$  mA,  $P_{out} = 38$  Watts Avg., Full Frequency Band, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 14 dB  
Drain Efficiency — 26%  
IM3 @ 10 MHz Offset — -37.5 dBc in 3.84 MHz Channel Bandwidth  
ACPR @ 5 MHz Offset — -41 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 1960 MHz, 120 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.

**MRF5P20180HR6**

**1930-1990 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 @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 530<br>3.0   | W<br>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          | $^\circ\text{C}$         |
| CW Operation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$             | CW        | 185<br>1.2   | W<br>W/ $^\circ\text{C}$ |

**Table 2. Thermal Characteristics**

| Characteristic                                                                                                                          | Symbol          | Value (1,2)  | Unit                      |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------|---------------------------|
| Thermal Resistance, Junction to Case<br>Case Temperature $77^\circ\text{C}$ , 120 W CW<br>Case Temperature $72^\circ\text{C}$ , 38 W CW | $R_{\theta JC}$ | 0.33<br>0.35 | $^\circ\text{C}/\text{W}$ |

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.

**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 |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

**Off Characteristics** <sup>(1)</sup>

|                                                                                                   |           |   |   |    |                 |
|---------------------------------------------------------------------------------------------------|-----------|---|---|----|-----------------|
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 65\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 10 | $\mu\text{Adc}$ |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0$ )            | $I_{DSS}$ | — | — | 1  | $\mu\text{Adc}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )              | $I_{GSS}$ | — | — | 1  | $\mu\text{Adc}$ |

**On Characteristics**

|                                                                                                          |              |     |      |     |     |
|----------------------------------------------------------------------------------------------------------|--------------|-----|------|-----|-----|
| Gate Threshold Voltage <sup>(1)</sup><br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 200\text{ }\mu\text{Adc}$ ) | $V_{GS(th)}$ | 2.5 | 2.7  | 3.5 | Vdc |
| Gate Quiescent Voltage <sup>(3)</sup><br>( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1600\text{ mAdc}$ )         | $V_{GS(Q)}$  | —   | 3.6  | —   | Vdc |
| Drain-Source On-Voltage <sup>(1)</sup><br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2\text{ Adc}$ )            | $V_{DS(on)}$ | —   | 0.26 | 0.3 | Vdc |
| Forward Transconductance <sup>(1)</sup><br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 2\text{ Adc}$ )           | $g_{fs}$     | —   | 5    | —   | S   |

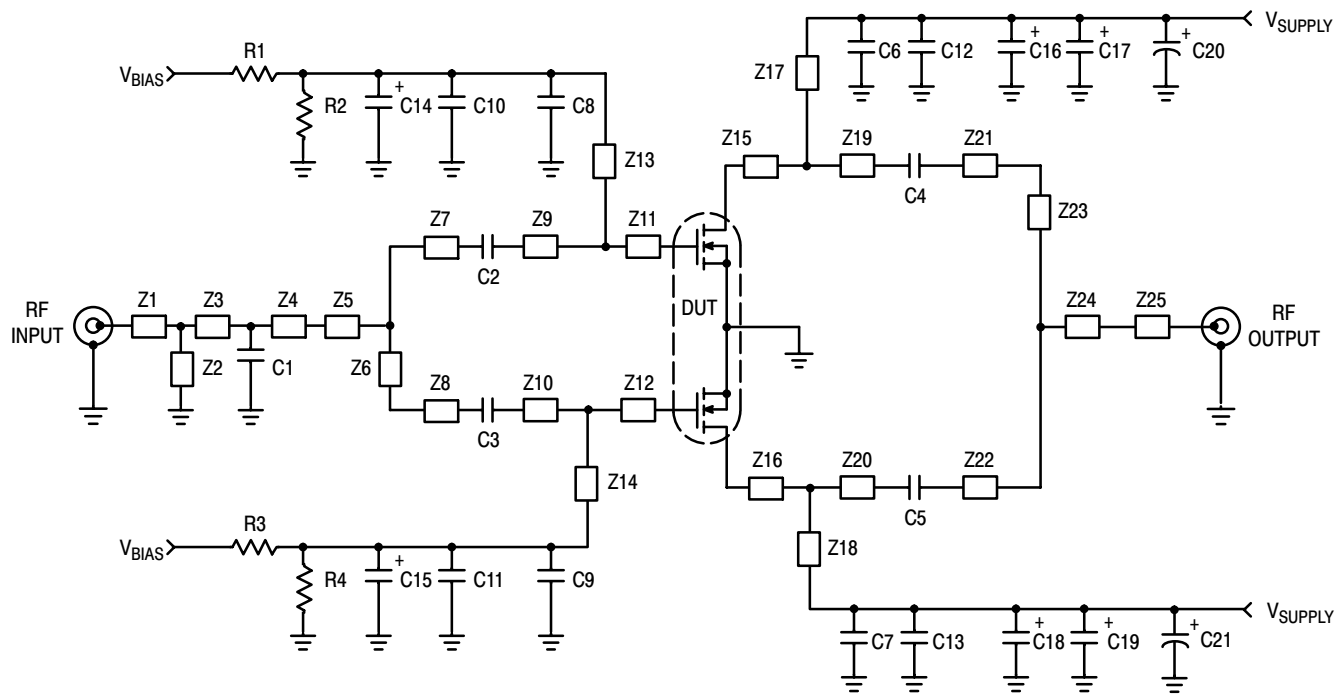
**Dynamic Characteristics** <sup>(1,2)</sup>

|                                                                                                                       |           |   |     |   |    |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 1.7 | — | pF |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|

**Functional Tests** <sup>(3)</sup> (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1600\text{ mA}$ ,  $P_{out} = 38\text{ W Avg.}$ ,  
 $f_1 = 1932.5\text{ MHz}$ ,  $f_2 = 1942.5\text{ MHz}$  and  $f_1 = 1977.5\text{ MHz}$ ,  $f_2 = 1987.5\text{ MHz}$ , 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   | 26    | —   | %   |
| Intermodulation Distortion   | IM3      | —    | -37.5 | -35 | dBc |
| Adjacent Channel Power Ratio | ACPR     | —    | -41   | -38 | dBc |
| Input Return Loss            | IRL      | —    | -16   | -9  | 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.

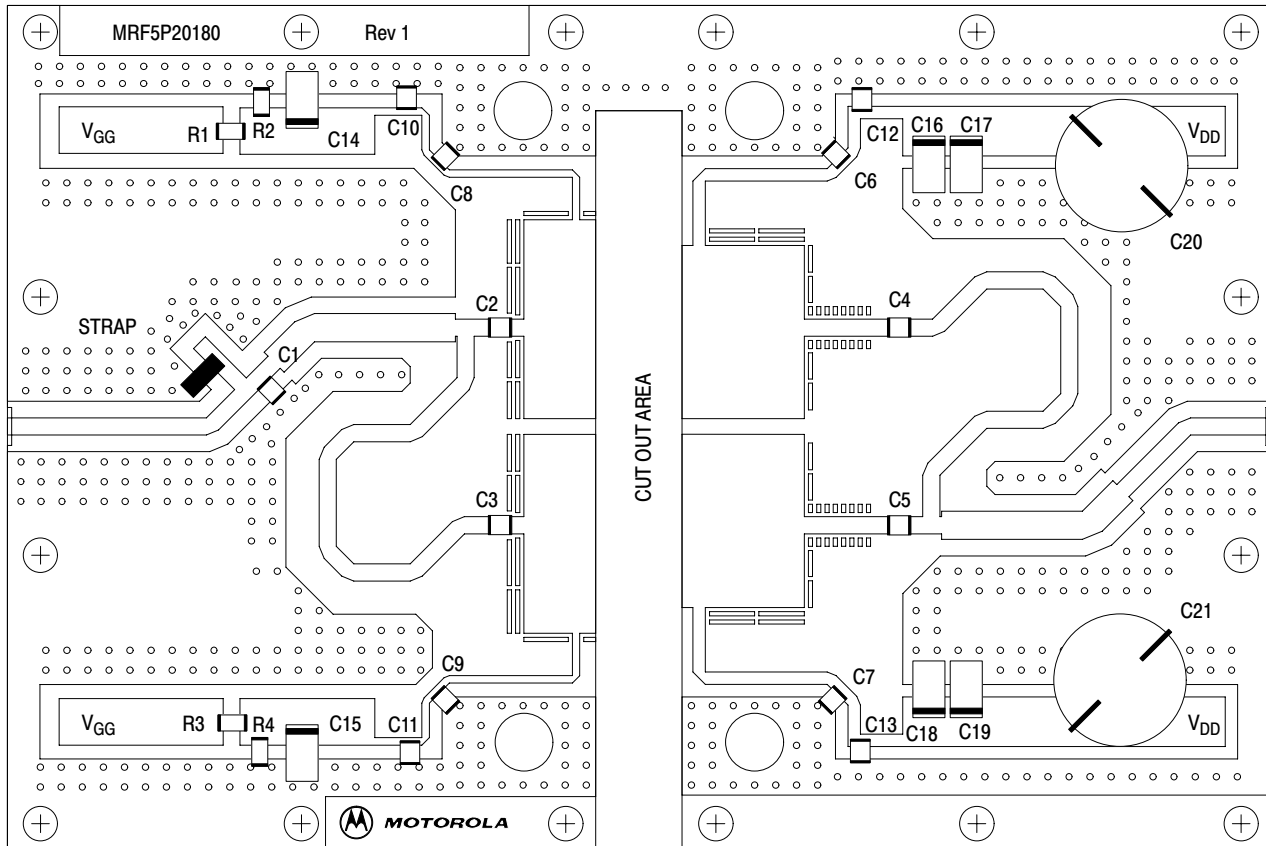


|         |                            |          |                                                |
|---------|----------------------------|----------|------------------------------------------------|
| Z1      | 0.081" x 1.126" Microstrip | Z11, Z12 | 0.341" x 0.945" Microstrip                     |
| Z2      | 0.079" x 0.138" Microstrip | Z13, Z14 | 0.035" x 0.913" Microstrip                     |
| Z3      | 0.081" x 0.091" Microstrip | Z15, Z16 | 0.581" x 0.823" Microstrip                     |
| Z4      | 0.081" x 0.117" Microstrip | Z17, Z18 | 0.059" x 1.057" Microstrip                     |
| Z5, Z24 | 0.134" x 0.874" Microstrip | Z19, Z20 | 0.081" x 0.046" Microstrip                     |
| Z6, Z23 | 0.081" x 2.269" Microstrip | Z21, Z22 | 0.081" x 0.126" Microstrip                     |
| Z7, Z8  | 0.081" x 0.118" Microstrip | Z25      | 0.081" x 0.793" Microstrip                     |
| Z9, Z10 | 0.081" x 0.079" Microstrip | PCB      | Taconic TLX8-0300, 0.030", $\epsilon_r = 2.55$ |

**Figure 1. MRF5P20180HR6 Test Circuit Schematic**

**Table 5. MRF5P20180HR6 Test Circuit Component Designations and Values**

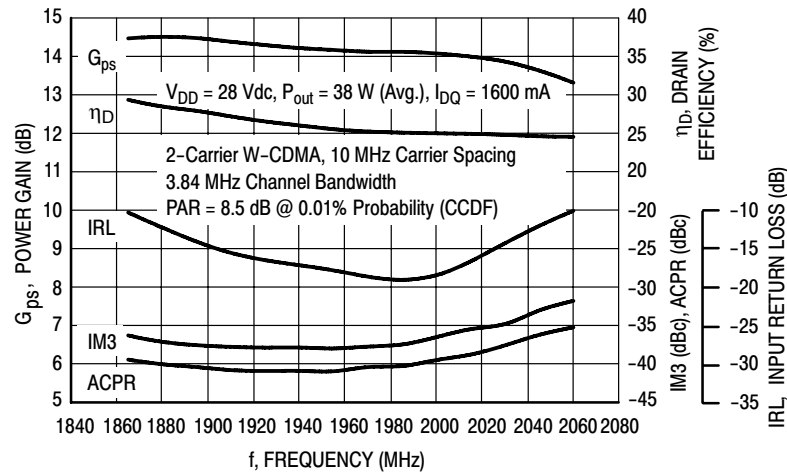
| Part                         | Description                               | Part Number | Manufacturer |
|------------------------------|-------------------------------------------|-------------|--------------|
| C1                           | 1.8 pF 100B Chip Capacitor                | 100B1R8BW   | ATC          |
| C2, C3, C4, C5, C6, C7       | 10 pF 100B Chip Capacitors                | 100B100GW   | ATC          |
| C8, C9                       | 6.8 pF 100B Chip Capacitors               | 100B6R8CW   | ATC          |
| C10, C11, C12, C13           | 10 nF 200B Chip Capacitors                | 200B103MW   | ATC          |
| C14, C15, C16, C17, C18, C19 | 22 $\mu$ F, 35 V Tantalum Capacitors      | TAJE226M035 | AVX          |
| C20, C21                     | 220 $\mu$ F, 63 V Electrolytic Capacitors | 13668221    | Philips      |
| R1, R2, R3, R4               | 10 k $\Omega$ Chip Resistors (1206)       |             |              |



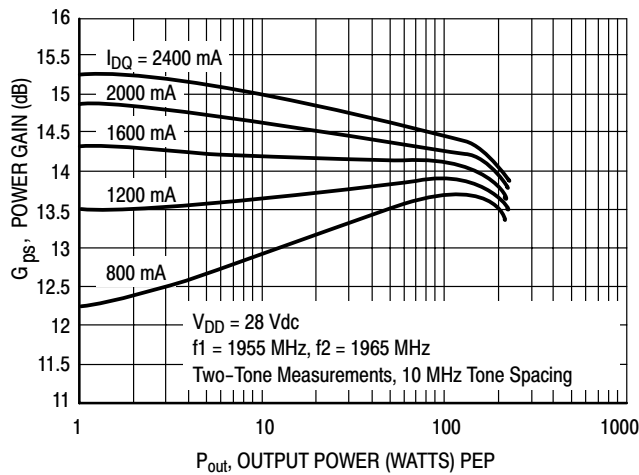
Freescall has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescale Semiconductor signature/logo. PCBs may have either Motorola or Freescale markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. MRF5P20180HR6 Test Circuit Component Layout**

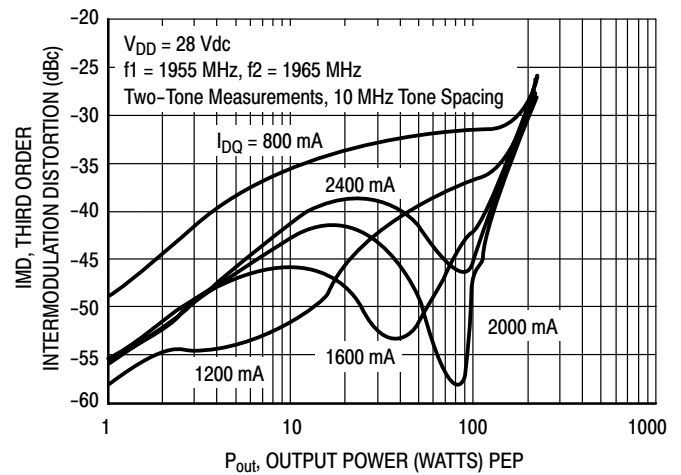
## TYPICAL CHARACTERISTICS



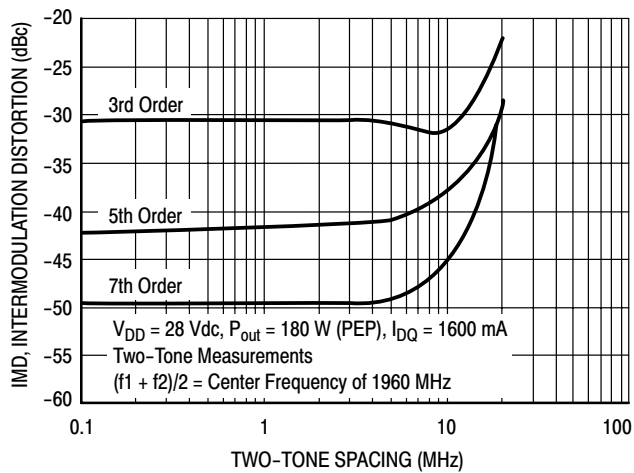
**Figure 3. 2-Carrier W-CDMA Broadband Performance  
@  $P_{out} = 38$  Watts Avg.**



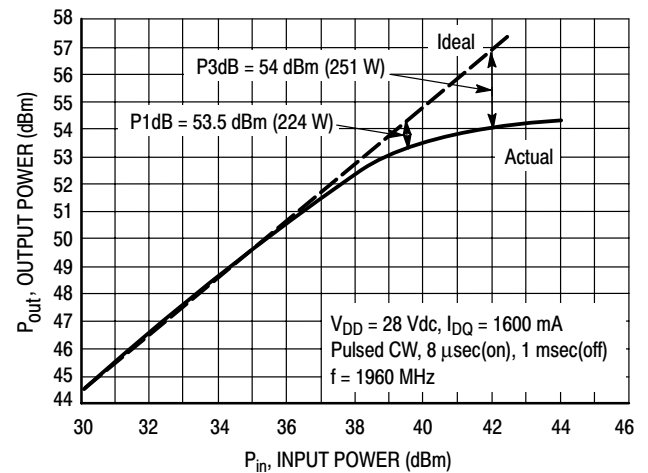
**Figure 4. Two-Tone Power Gain versus  
Output Power**



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

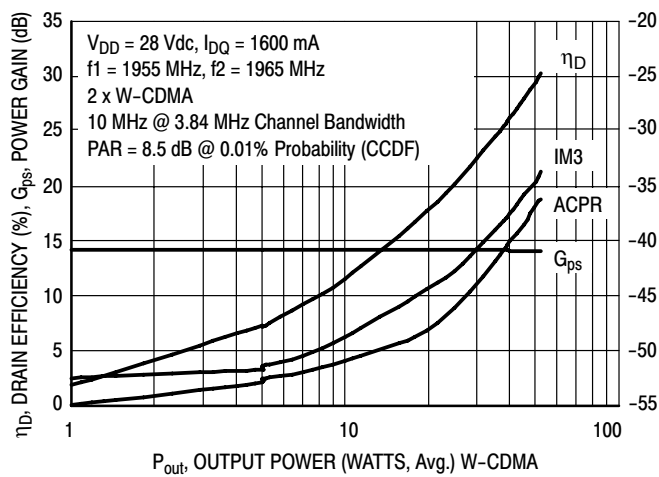


**Figure 6. Intermodulation Distortion Products  
versus Tone Spacing**

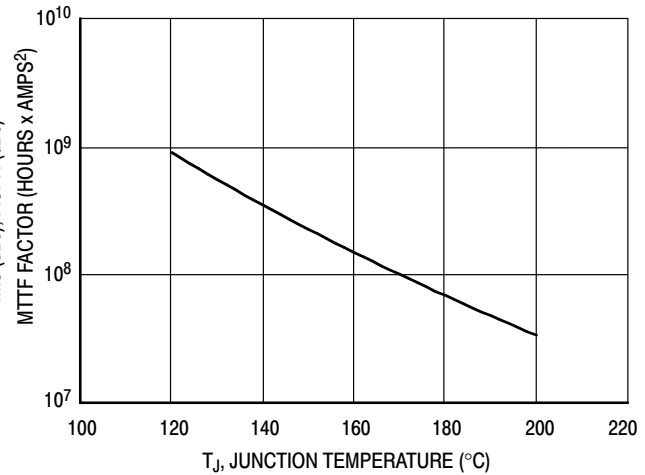


**Figure 7. Pulse CW Output Power versus  
Input Power**

## TYPICAL CHARACTERISTICS



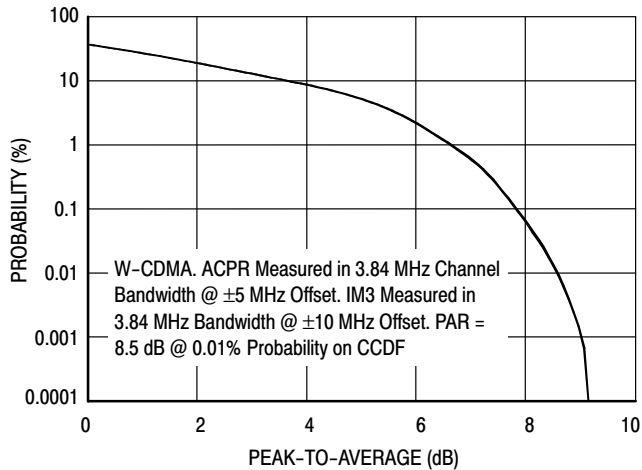
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



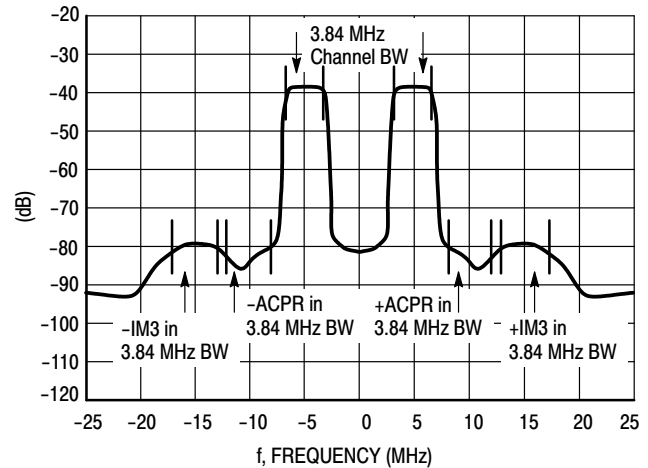
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

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

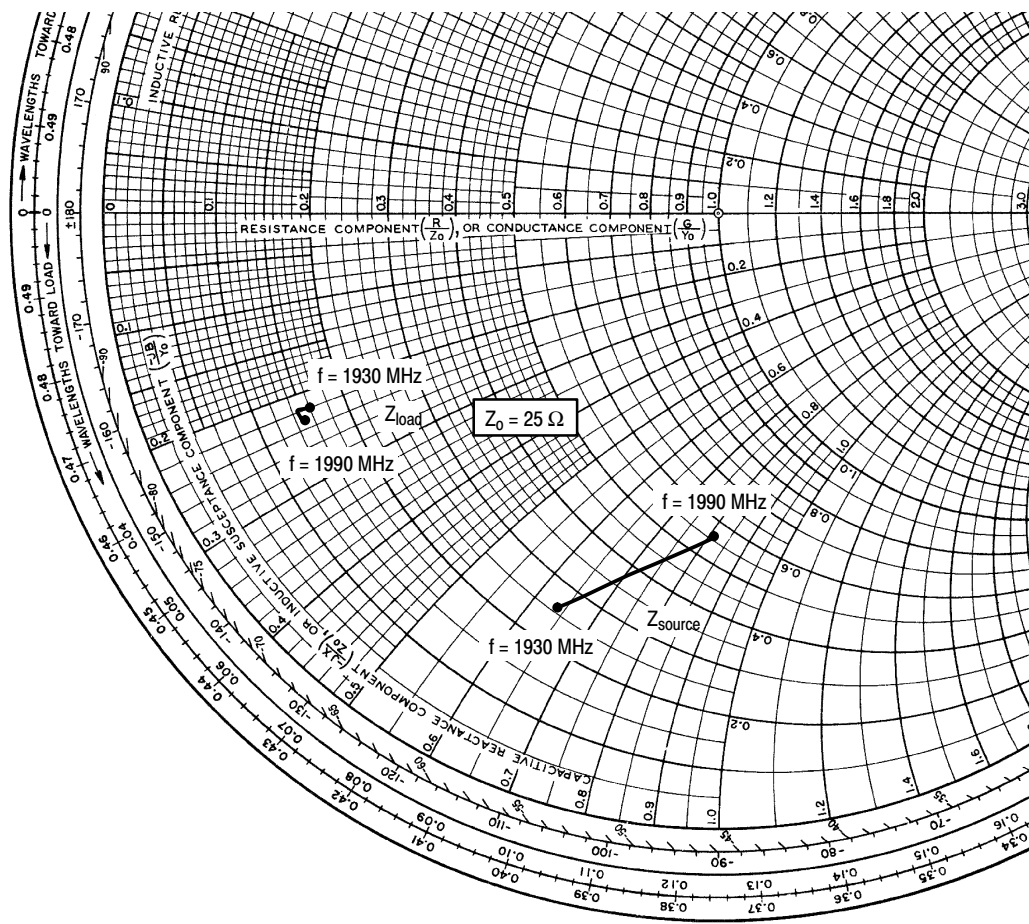
## W-CDMA TEST SIGNAL



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



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



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

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 1930     | $6.54 - j16.04$          | $4.06 - j5.56$         |
| 1960     | $9.70 - j17.92$          | $3.70 - j5.48$         |
| 1990     | $13.88 - j20.46$         | $3.64 - j5.76$         |

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

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

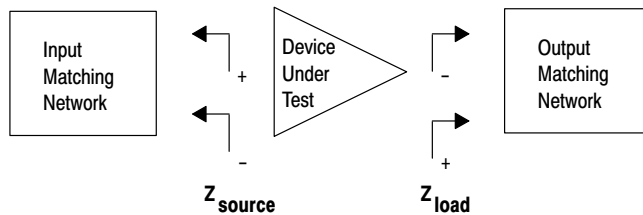


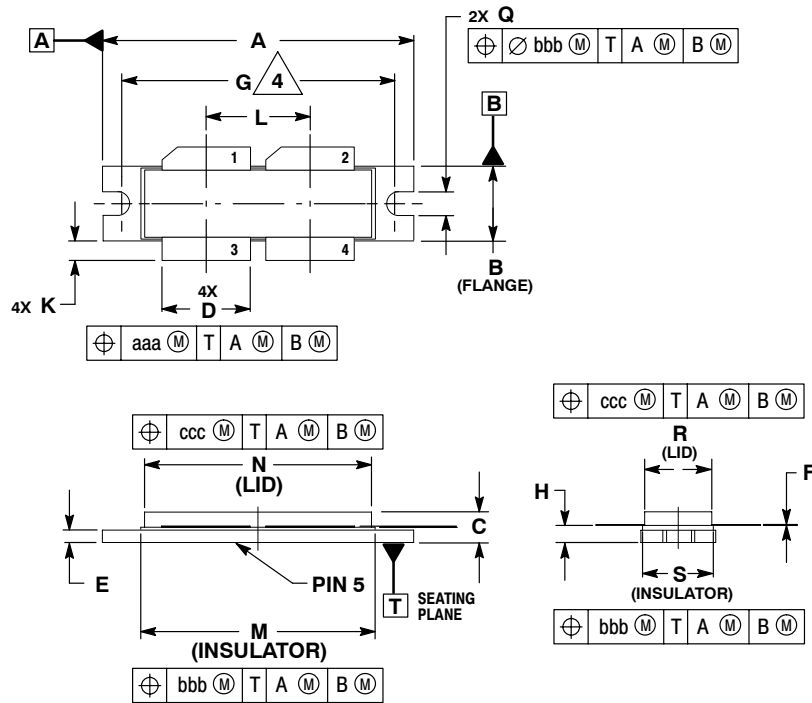
Figure 12. Series Equivalent Source and Load Impedance

## NOTES

# 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:

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

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

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