Freescale Semiconductor
Technical Data

Document Number: MRF6P23190H
Rev. 3, 12/2008

# 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., f = 2390 MHz, 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

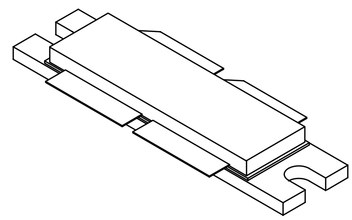
**Features**

- 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.

RoHS

**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 (1,2) | $T_J$ | 225 | °C |
| CW Operation @ $T_C$ = 25°C<br>Derate above 25°C | CW | 250<br>1.3 | W<br>W/°C |

**Table 2. Thermal Characteristics**

| Characteristic | Symbol | Value (2,3) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>Case Temperature 100°C, 160 W CW<br>Case Temperature 83°C, 40 W CW | $R_{\theta JC}$ | <br>0.22<br>0.24 | °C/W |

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.

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**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) |

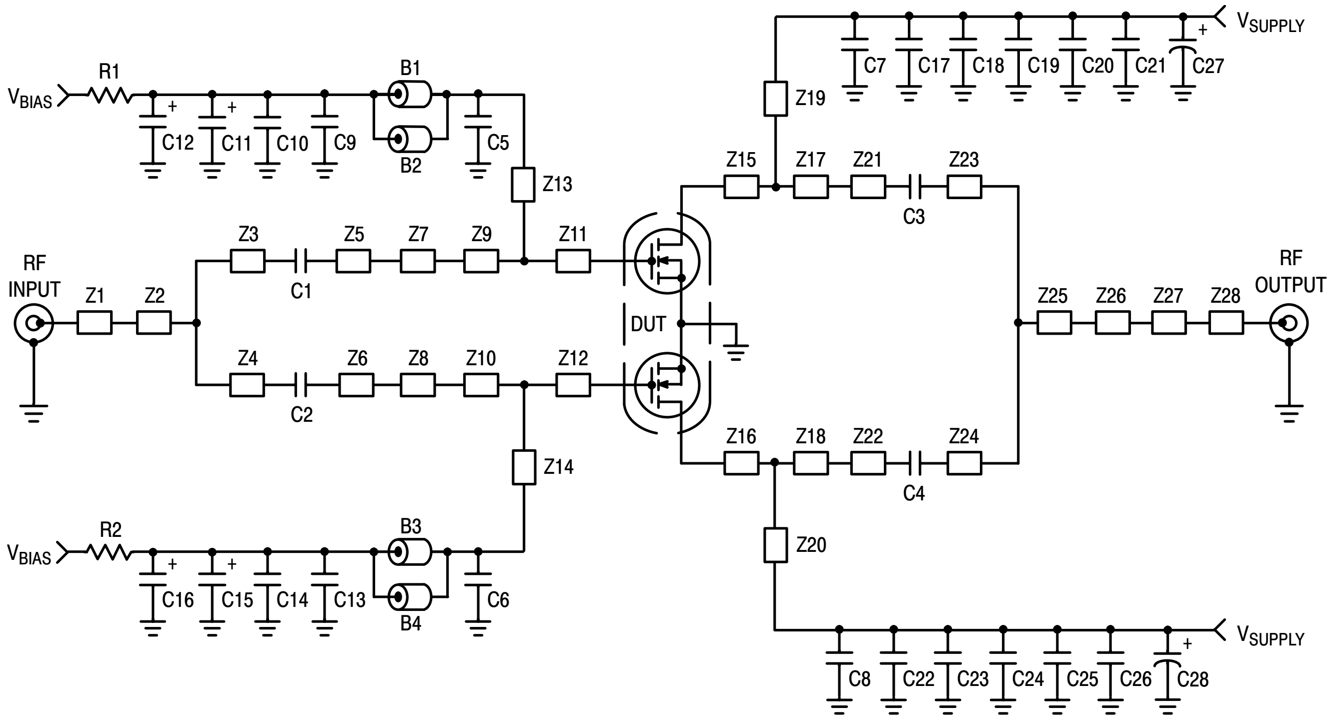
**Table 4. Electrical Characteristics** ($T_C$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics (1)** | | | | | |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 68 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 28 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 1 | μAdc |
| Gate-Source Leakage Current ($V_{GS}$ = 5 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | — | — | 1 | μAdc |
| **On Characteristics** | | | | | |
| Gate Threshold Voltage (1) ($V_{DS}$ = 10 Vdc, $I_D$ = 200 μAdc) | $V_{GS(th)}$ | 1 | 2 | 3 | Vdc |
| Gate Quiescent Voltage (3) ($V_{DD}$ = 28 Vdc, $I_D$ = 1900 mAdc, Measured in Functional Test) | $V_{GS(Q)}$ | 2 | 2.8 | 4 | Vdc |
| Drain-Source On-Voltage (1) ($V_{GS}$ = 10 Vdc, $I_D$ = 2.2 Adc) | $V_{DS(on)}$ | 0.1 | 0.21 | 0.3 | Vdc |
| **Dynamic Characteristics (1,2)** | | | | | |
| Reverse Transfer Capacitance ($V_{DS}$ = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 1.5 | — | pF |

**Functional Tests (3)** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1900 mA, $P_{out}$ = 40 W Avg., f = 2390 MHz, 2-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset. IM3 measured in 3.84 MHz Bandwidth @ ±10 MHz Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| 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.

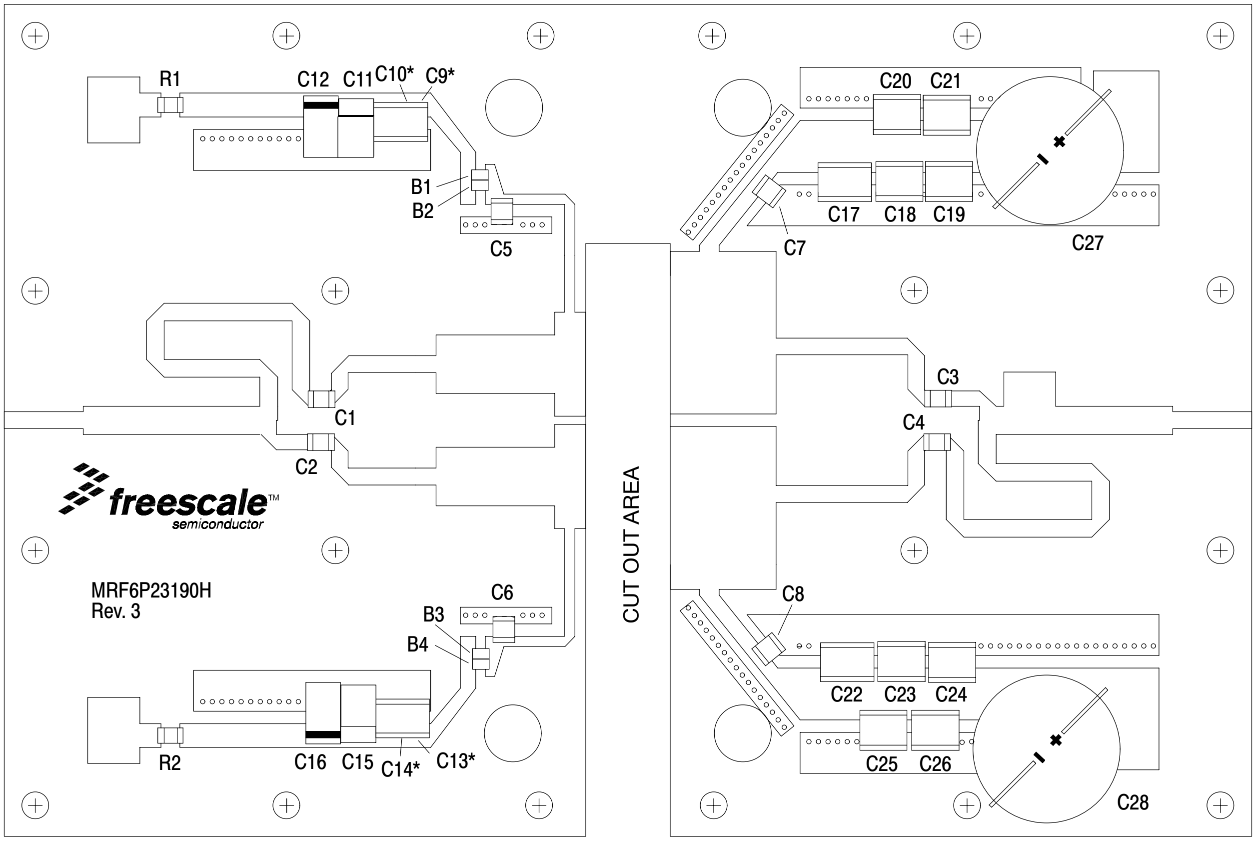



| | | | |
|---|---|---|---|
| Z1, Z28 | 0.380″ x 0.081″ Microstrip | Z17, Z18 | 0.321″ x 0.782″ Microstrip |
| Z2 | 0.850″ x 0.135″ Microstrip | Z19, Z20 | 0.404″ x 0.074″ Microstrip |
| Z3 | 2.244″ x 0.081″ Microstrip | Z21, Z22 | 0.918″ x 0.081″ Microstrip |
| Z4 | 0.186″ x 0.074″ Microstrip | Z23 | 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 CuClad 250GX-0300-55-22, 0.030″, $\varepsilon_r$ = 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 μF, 100 V Chip Capacitors | C1825C103J1RAC | Kemet |
| C10, C14, C17, C22 | 2.2 μF, 50 V Chip Capacitors | C1825C225J5RAC | Kemet |
| C11, C15 | 22 μF, 25 V Tantalum Capacitors | T491D226K025AT | Kemet |
| C12, C16 | 47 μF, 16 V Tantalum Capacitors | T491D476K016AT | Kemet |
| C18, C19, C20, C21, C23, C24, C25, C26 | 10 μF, 50 V Chip Capacitors | GRM55DR61H106KA88B | Murata |
| C27, C28 | 330 μF, 63 V Electrolytic Capacitors | NACZF331M63V | Nippon |
| R1, R2 | 240 Ω, 1/4 W Chip Resistors | CRCW12062400FKEA | Vishay |




*Stacked.

**Figure 2. MRF6P23190HR6 Test Circuit Component Layout**

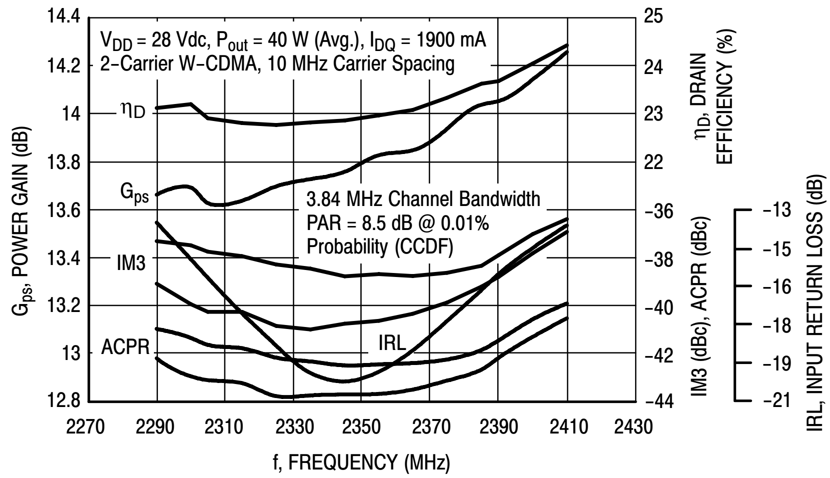



**Figure 3. 2-Carrier W-CDMA Broadband Performance @ $P_{out}$ = 40 Watts Avg.**

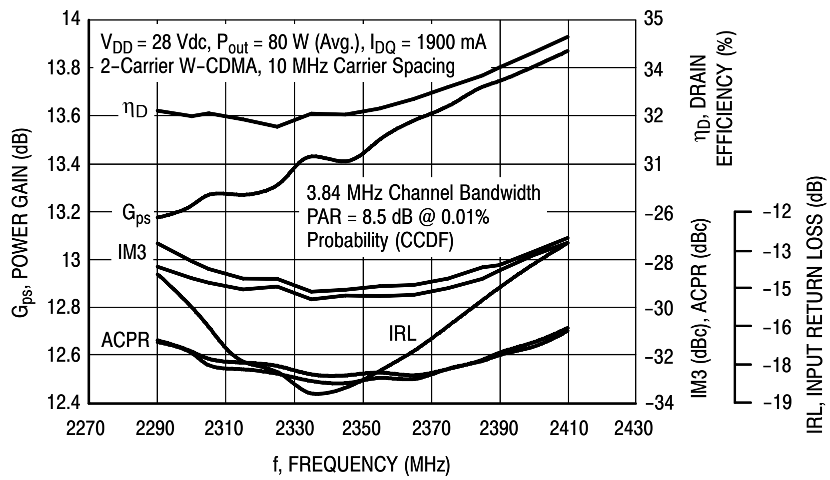



**Figure 4. 2-Carrier W-CDMA Broadband Performance @ $P_{out}$ = 80 Watts Avg.**

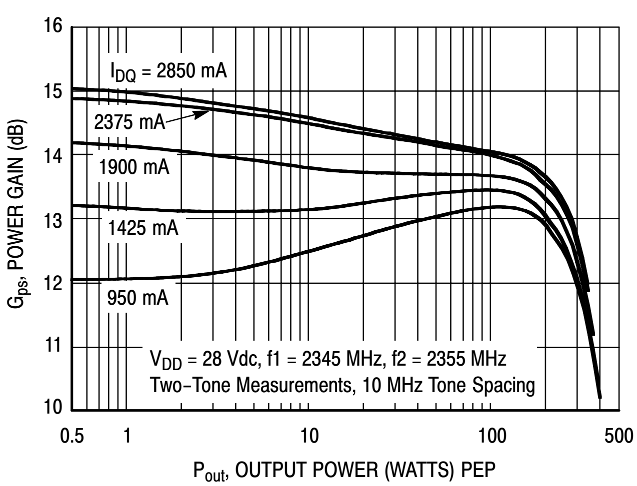



**Figure 5. Two-Tone Power Gain versus Output Power**

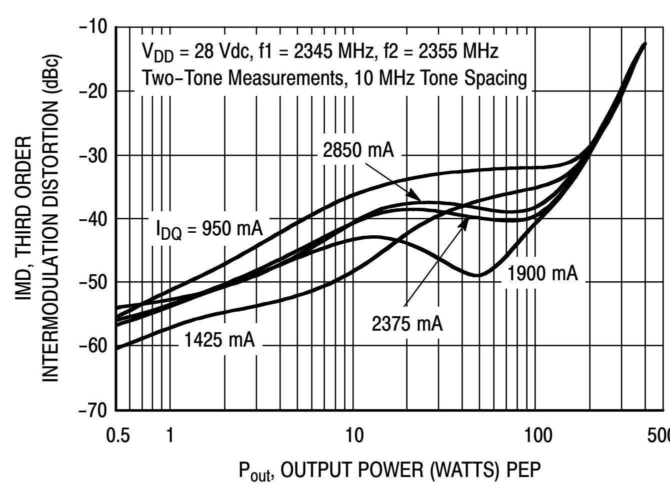



**Figure 6. Third Order Intermodulation Distortion versus Output Power**

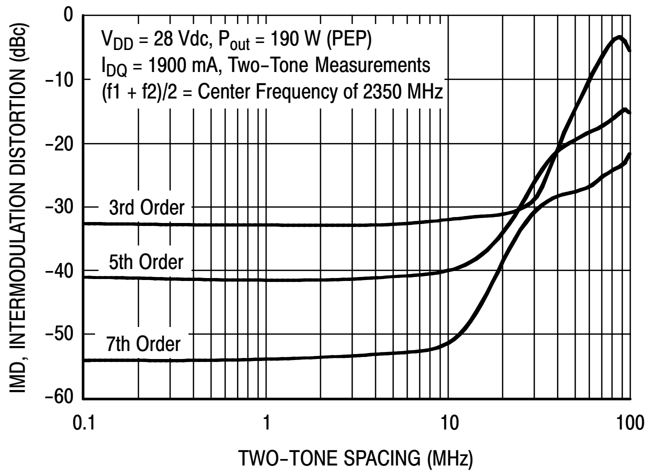



**Figure 7. Intermodulation Distortion Products versus Tone Spacing**

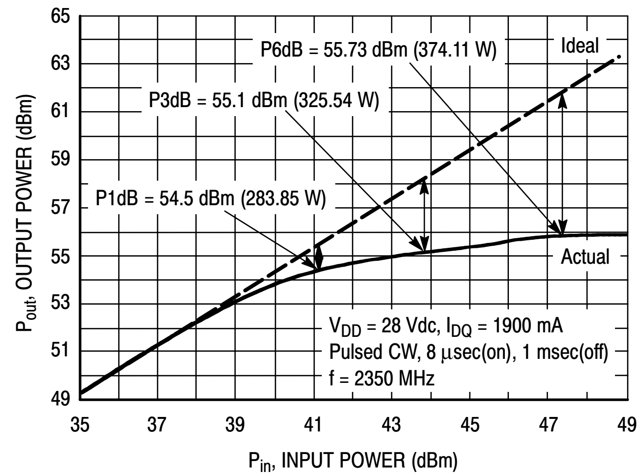



**Figure 8. Pulsed CW Output Power versus Input Power**

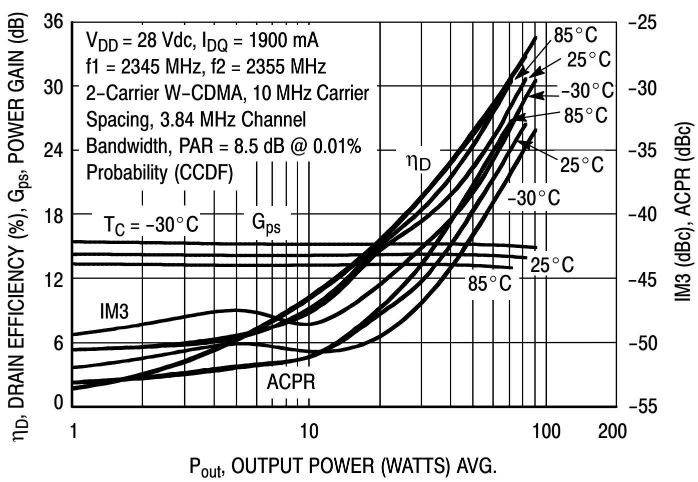



**Figure 9. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**

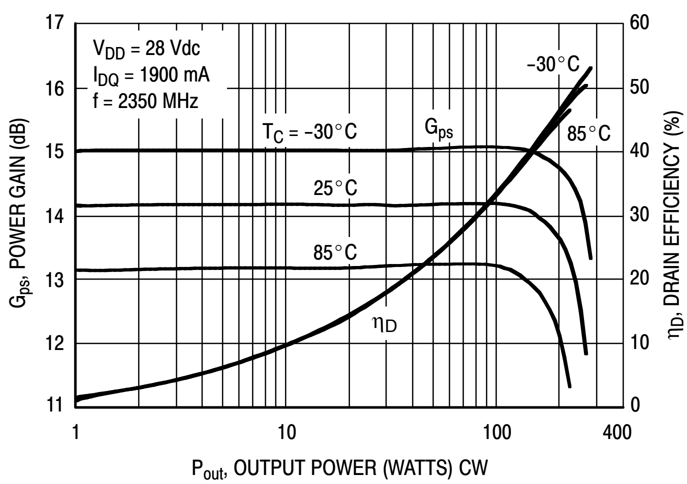



**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**

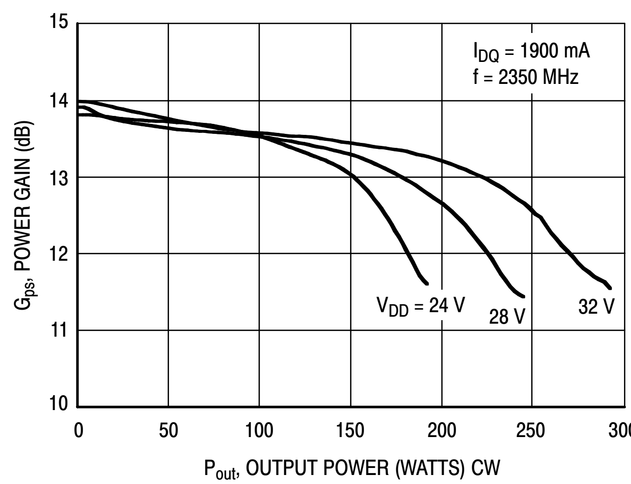
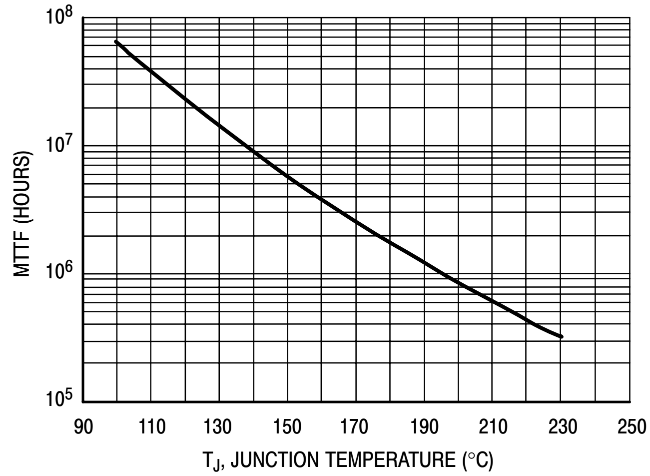



**Figure 11. Power Gain versus Output Power**

## 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 Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

**Figure 12. MTTF versus Junction Temperature**

## W-CDMA TEST SIGNAL

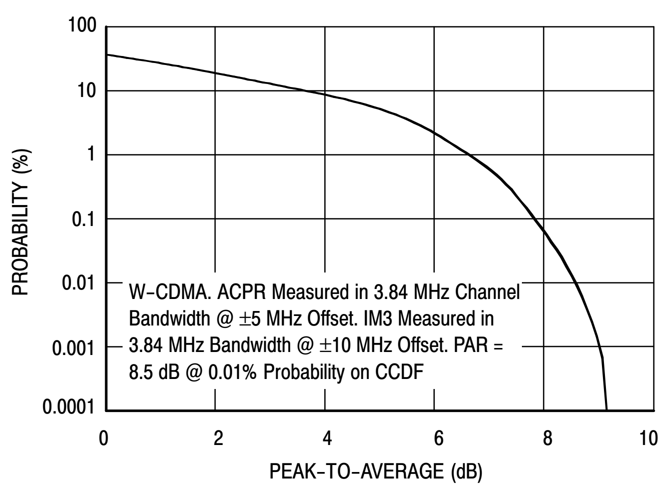



**Figure 13. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal**

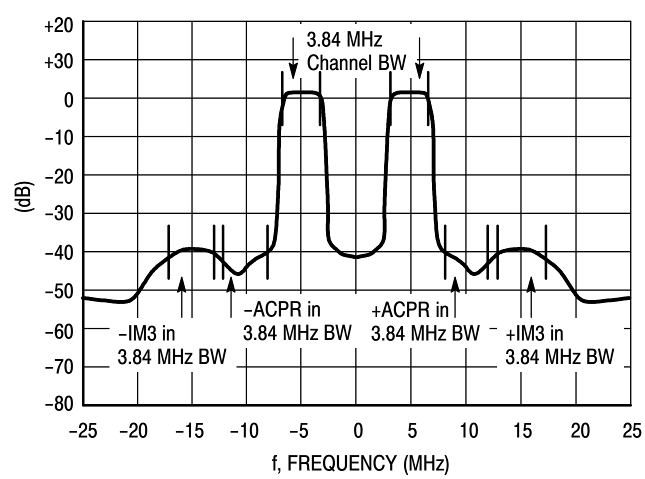
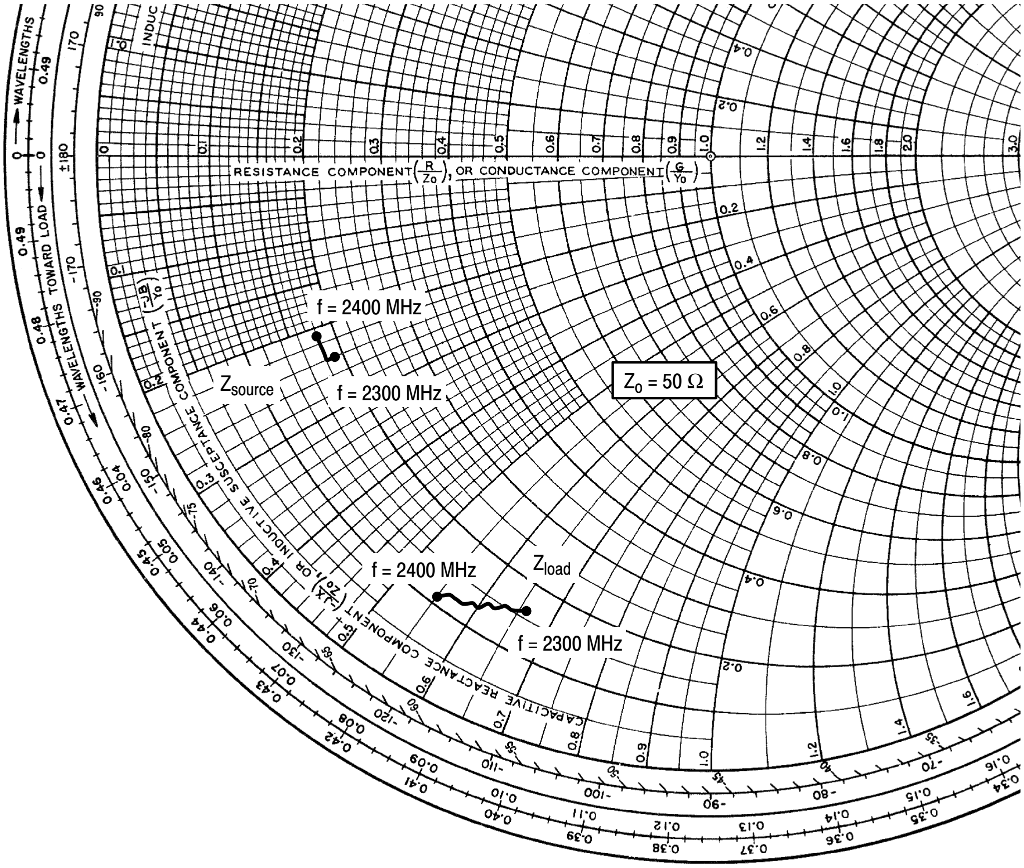



**Figure 14. 2-Carrier W-CDMA Spectrum**




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

| f<br>MHz | $Z_{source}$<br>Ω | $Z_{load}$<br>Ω |
|---|---|---|
| 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.

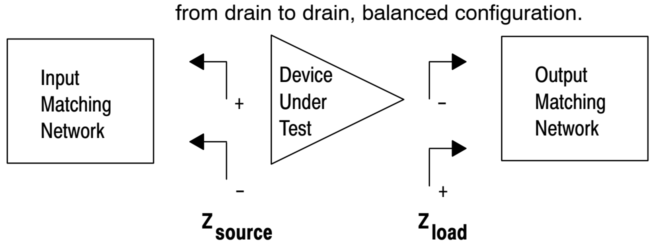
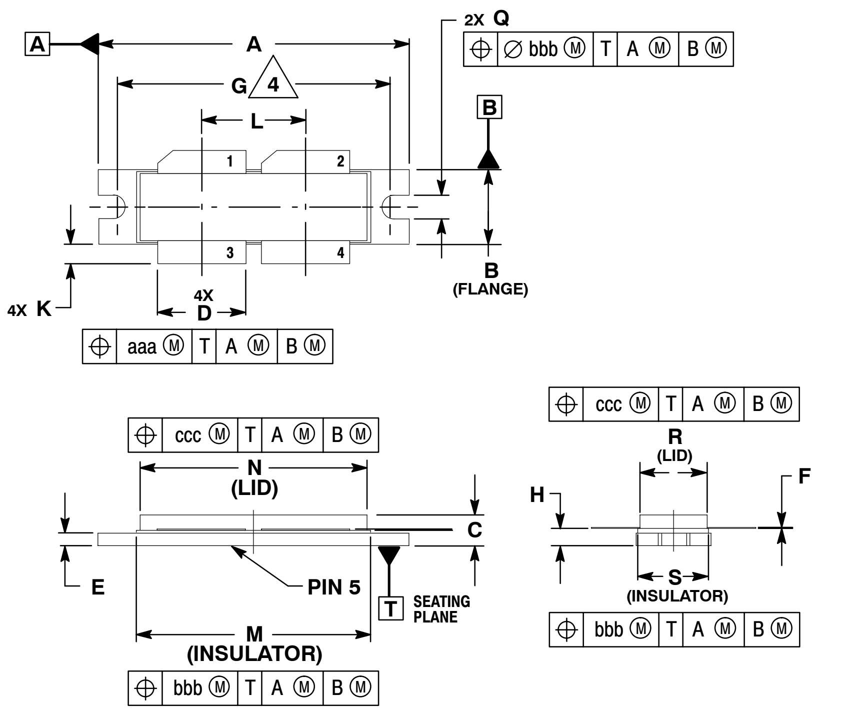



**Figure 15. Series Equivalent Source and Load Impedance**

## 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 MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS 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 | • Removed Lower Thermal Resistance and Low Gold Plating bullets from Features section as functionality is standard, p. 1<br>• Removed Total Device Dissipation from Max Ratings table as data was redundant (information already provided in Thermal Characteristics table), p. 1<br>• Added maximum CW operation limitation and derating values to the Maximum Rating table to prevent a 200°C+ hot wire operating condition, p. 1<br>• Corrected $V_{DS}$ to $V_{DD}$ in the RF test condition voltage callout for $V_{GS(Q)}$, On Characteristics table, p. 2<br>• Removed Forward Transconductance from On Characteristics table as it no longer provided usable information, p. 2<br>• Updated Part Numbers in Table 5, Component Designations and Values, to RoHS compliant part numbers, p. 3<br>• Removed lower voltage tests from Fig. 11, Power Gain versus Output Power, due to fixed tuned fixture limitations, p. 6<br>• Replaced Fig. 12, MTTF versus Junction Temperature with updated graph. Removed $Amps^2$ and listed operating characteristics and location of MTTF calculator for device, p. 7<br>• Added Product Documentation and Revision History, p. 10 |
| 3 | Dec. 2008 | • Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, p. 1, 2<br>• Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table, related “Continuous use at maximum temperature will affect MTTF” footnote added, p. 1<br>• Updated PCB information to show more specific material details, Fig. 1, Test Circuit Schematic, p. 3<br>• Updated Part Numbers in Table 5, Component Designations and Values, to latest RoHS compliant part numbers, p. 3 |

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