

# RF Power Field Effect Transistor

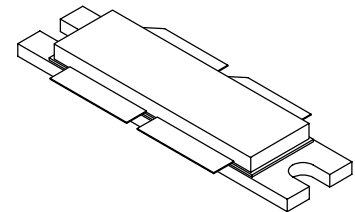
## N-Channel Enhancement-Mode Lateral MOSFET

Designed primarily for large-signal output applications at 2450 MHz. Device is suitable for use in industrial, medical and scientific applications.

- Typical CW Performance at 2450 MHz,  $V_{DD} = 28$  Volts,  $I_{DQ} = 1900$  mA,  $P_{out} = 190$  Watts  
     Power Gain — 13.2 dB  
     Drain Efficiency — 46.2%
- 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
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel.

**MRF6P24190HR6**
**2450 MHz, 190 W, 28 V  
 CW  
 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                               | $T_J$     | 200          | °C        |
| CW Operation @ $T_C = 25^\circ\text{C}$<br>Derate above 25°C | CW        | 250<br>1.3   | W<br>W/°C |

**Table 2. Thermal Characteristics**

| Characteristic   | Symbol          | Value <sup>(1,2)</sup> | Unit |
|--|-----------------|------------------------|------|
| Thermal Resistance, Junction to Case<br>Case Temperature 100°C, 160 W CW<br>Case Temperature 83°C, 40 W CW | $R_{\theta JC}$ | 0.22<br>0.24           | °C/W |

1. MTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTF 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 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 |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

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

|   |           |   |   |    |               |
|---|-----------|---|---|----|---------------|
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 68\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 10 | $\mu\text{A}$ |
| Zero Gate Voltage Drain Leakage Current<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 1  | $\mu\text{A}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )              | $I_{GSS}$ | — | — | 1  | $\mu\text{A}$ |

**On Characteristics**

|   |              |     |      |     |     |
|---|--------------|-----|------|-----|-----|
| Gate Threshold Voltage <sup>(1)</sup><br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 200\ \mu\text{A}$ )                            | $V_{GS(th)}$ | 1   | 2    | 3   | Vdc |
| Gate Quiescent Voltage <sup>(3)</sup><br>( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1900\text{ mA}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 2   | 2.8  | 4   | Vdc |
| Drain-Source On-Voltage <sup>(1)</sup><br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.2\text{ A}$ )                               | $V_{DS(on)}$ | 0.1 | 0.21 | 0.3 | Vdc |

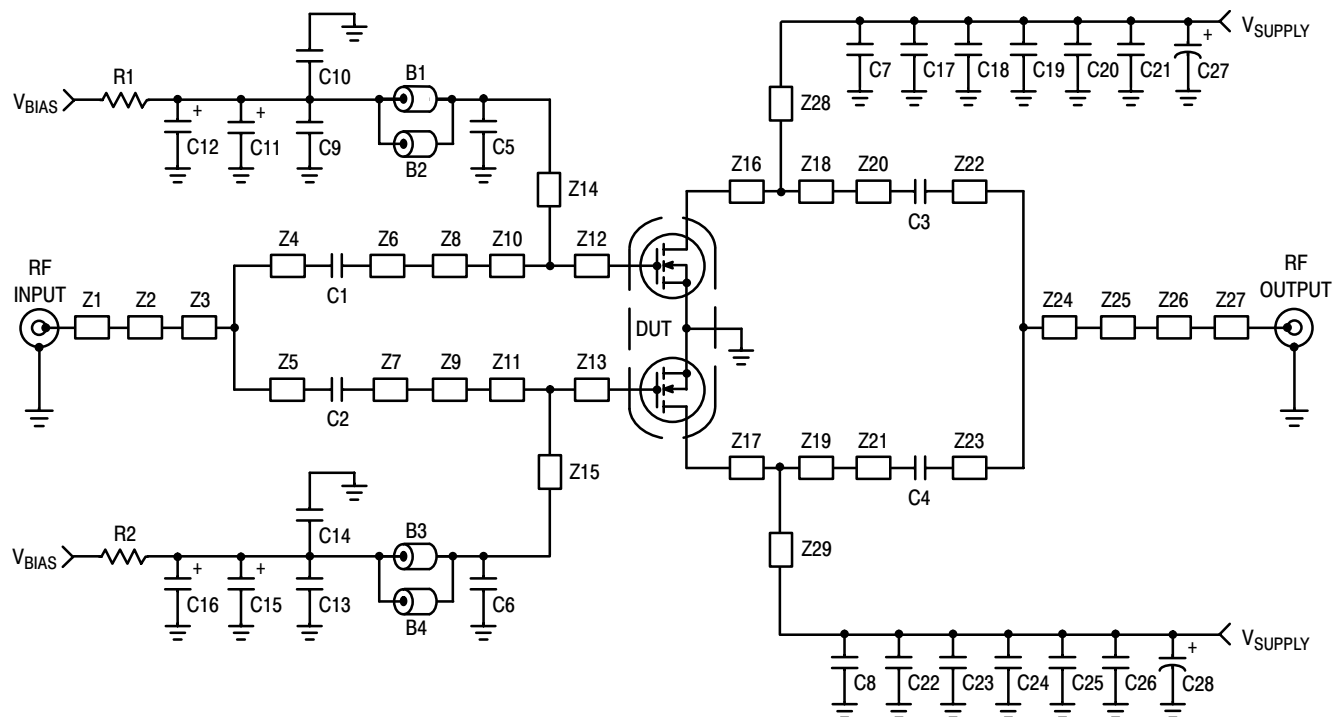
**Dynamic Characteristics** <sup>(1,2)</sup>

|  |           |   |     |   |    |
|--|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)}$ ac @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 1.5 | — | pF |
|--|-----------|---|-----|---|----|

**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.

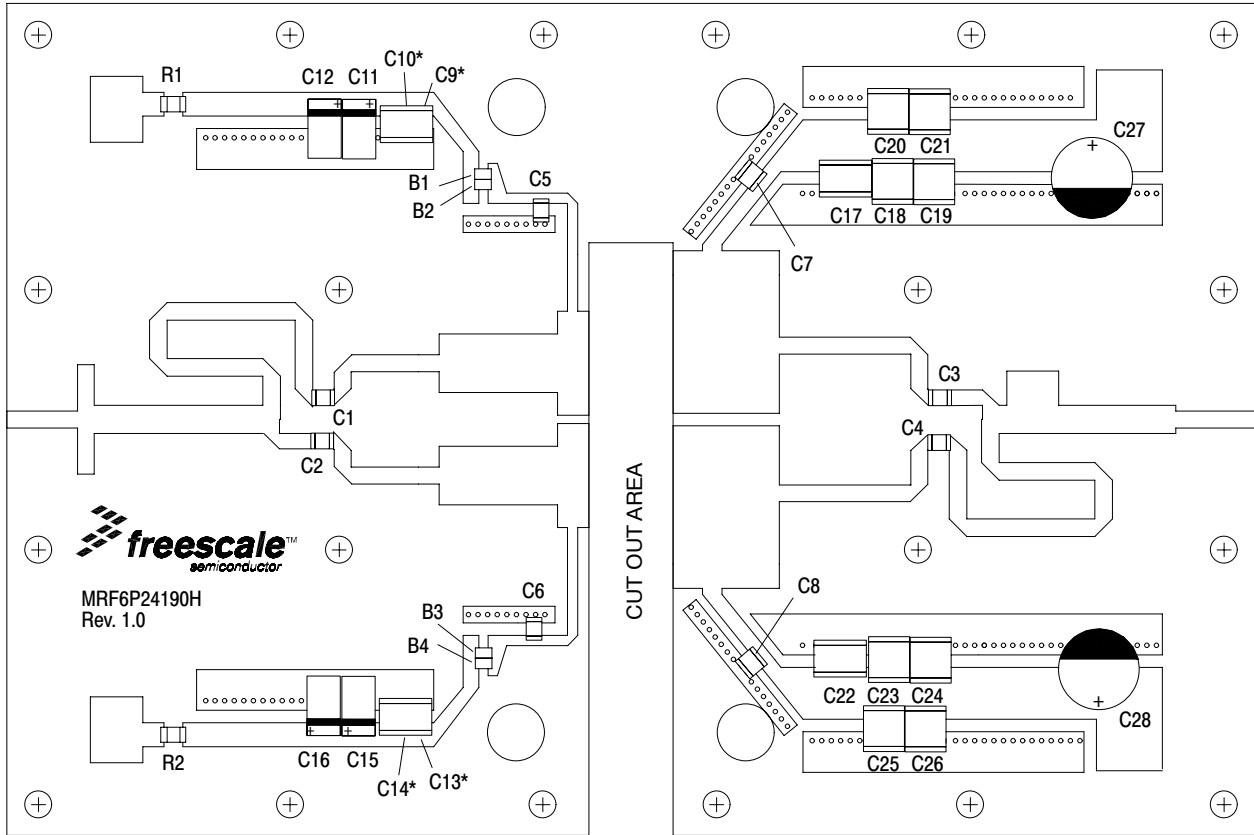


|          |                            |          |   |
|----------|----------------------------|----------|---|
| Z1       | 0.340" x 0.081" Microstrip | Z16, Z17 | 0.189" x 0.782" Microstrip                      |
| Z2       | 0.080" x 0.526" Microstrip | Z18, Z19 | 0.321" x 0.782" Microstrip                      |
| Z3       | 0.895" x 0.135" Microstrip | Z20, Z21 | 0.630" x 0.081" Microstrip                      |
| Z4       | 1.736" x 0.074" Microstrip | Z22      | 0.150" x 0.081" Microstrip                      |
| Z5       | 0.151" x 0.074" Microstrip | Z23      | 1.728" x 0.085" Microstrip                      |
| Z6, Z7   | 0.505" x 0.081" Microstrip | Z24      | 0.122" x 0.135" Microstrip                      |
| Z8, Z9   | 0.570" x 0.282" Microstrip | Z25      | 0.250" x 0.300" Microstrip                      |
| Z10, Z11 | 0.072" x 0.500" Microstrip | Z26      | 0.563" x 0.135" Microstrip                      |
| Z12, Z13 | 0.078" x 0.500" Microstrip | Z27      | 0.380" x 0.081" Microstrip                      |
| Z14      | 0.664" x 0.050" Microstrip | Z28, Z29 | 0.305" x 0.057" Microstrip                      |
| Z15      | 0.680" x 0.050" Microstrip | PCB      | Arlon GX0300-55-22, 0.030", $\epsilon_r = 2.55$ |

**Figure 1. MRF6P24190HR6 Test Circuit Schematic — 2450 MHz**

**Table 5. MRF6P24190HR6 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 $\mu$ 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      | T491D476K016AT     | Kemet               |
| C18, C19, C20, C21, C23, C24, C25, C26 | 10 $\mu$ F, 50 V Chip Capacitors          | GRM55DR61H106KA88B | Murata              |
| C27, C28                               | 330 $\mu$ F, 63 V Electrolytic Capacitors | NACZF331M63V       | Nippon              |
| R1, R2                                 | 240 $\Omega$ , 1/4 W Chip Resistors       | CRCW12062400FKTA   | Vishay              |



\*Stacked

Figure 2. MRF6P24190HR6 Test Circuit Component Layout — 2450 MHz

TYPICAL CHARACTERISTICS — 2450 MHz

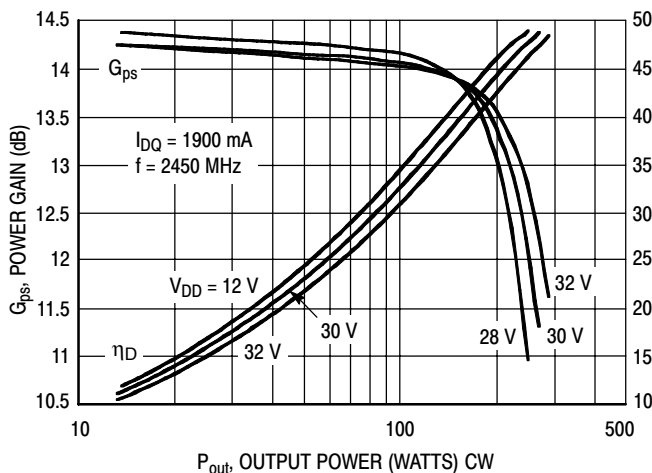


Figure 3. Power Gain and Drain Efficiency versus CW Output Power

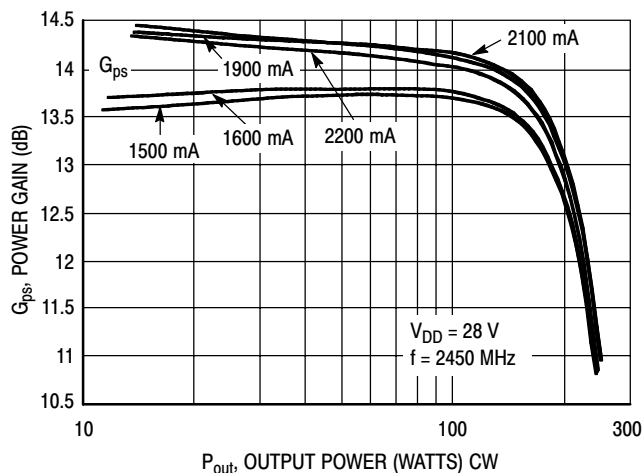


Figure 4. Power Gain and Drain Efficiency versus CW Output Power

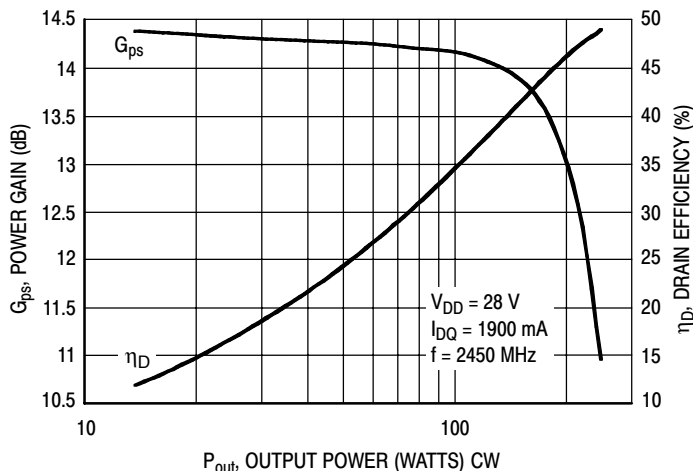
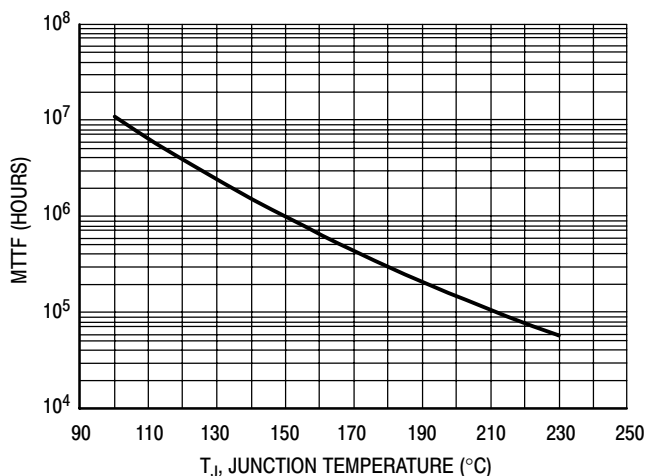


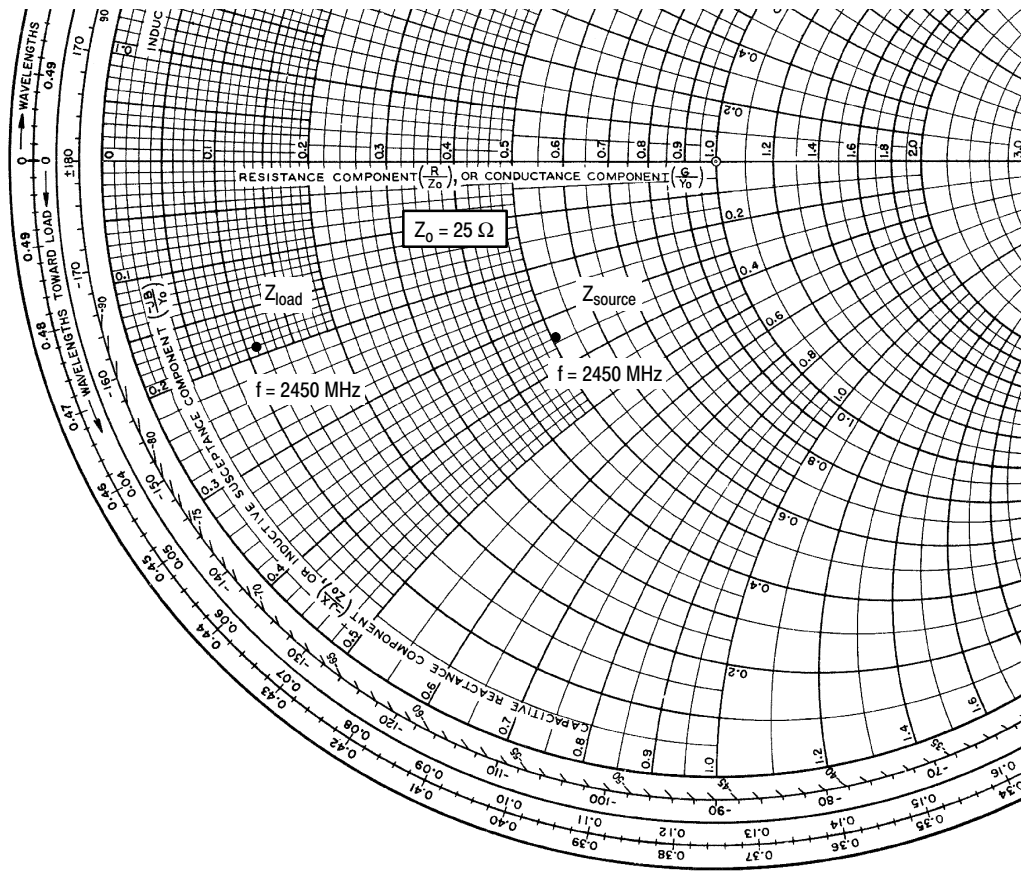
Figure 5. Power Gain and Drain Efficiency versus CW Output Power



This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 190$  W CW, and  $\eta_D = 46.2\%$ .

MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.

Figure 6. MTTF versus Junction Temperature



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1900 \text{ mA}$ ,  $P_{out} = 190 \text{ W CW}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 2450     | $12.72 - j8.48$          | $2.75 - j4.85$         |

$Z_{source}$  = Test circuit impedance as measured from gate to ground.

$Z_{load}$  = Test circuit impedance as measured from drain to ground.

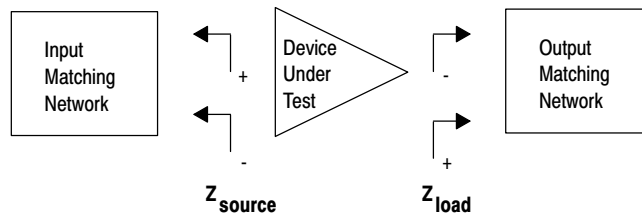
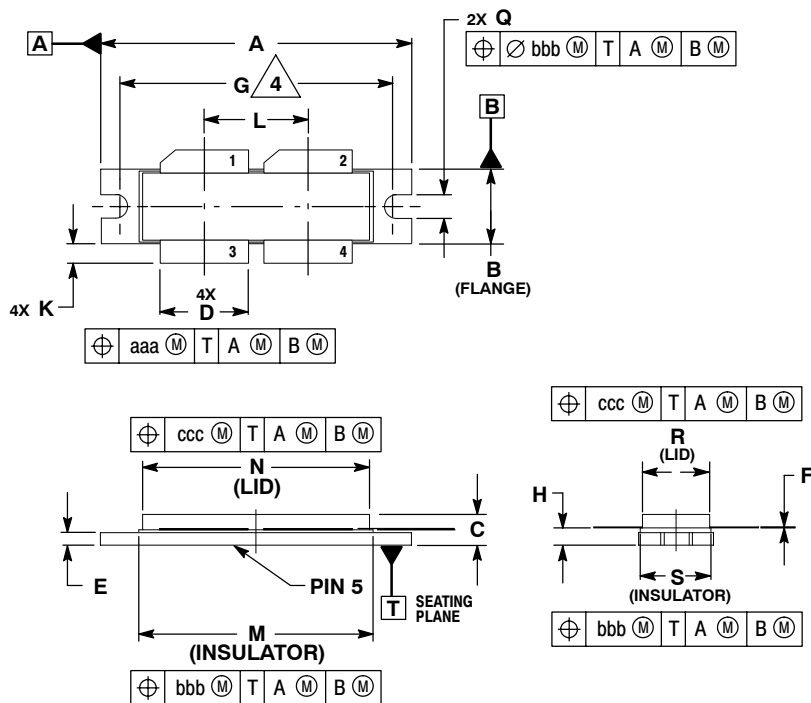


Figure 7. Series Equivalent Source and Load Impedance

# 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  
 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  |
|----------|-----------|--|
| 0        | Dec. 2006 | <ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>  |
| 1        | Mar. 2007 | <ul style="list-style-type: none"><li>• Removed Lower Thermal Resistance and Low Gold Plating bullets from Features section as functionality is standard, p. 1</li><li>• Added maximum CW operation limitation and derating values to the Maximum Rating table to prevent a 200°C+ hot wire operating condition, p. 1</li><li>• Corrected <math>V_{DS}</math> to <math>V_{DD}</math> in the RF test condition voltage callout for <math>V_{GS(Q)}</math>, On Characteristics table, p. 2</li><li>• Added frequency to title of schematic, component part layout and typical characteristic curves, p. 3-5</li><li>• Added Fig. 6, MTTF versus Junction Temperature graph, p. 5</li></ul> |



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