**Freescale Semiconductor**
Technical Data

Document Number: MRF21045
Rev. 12, 10/2008

RoHS

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

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.

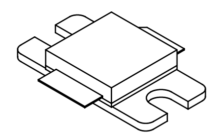
- Typical 2-carrier W-CDMA Performance for $V_{DD}$ = 28 Volts, $I_{DQ}$ = 500 mA, f = 2157.5 MHz, Channel Bandwidth = 3.84 MHz, Adjacent Channels measured over 3.84 MHz Bandwidth at f1 -5 MHz and f2 +5 MHz, Distortion Products measured over a 3.84 MHz Bandwidth at f1 -10 MHz and f2 +10 MHz, Peak/Avg. = 8.3 dB @ 0.01% Probability on CCDF.
  - Output Power — 10 Watts Avg.
  - Efficiency — 23.5%
  - Gain — 15 dB
  - IM3 — -37.5 dBc
  - ACPR — -41 dBc
- Capable of Handling 5:1 VSWR, @ 28 Vdc, 2140 MHz, 45 Watts CW Output Power

**Features**

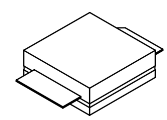
- Internally Matched for Ease of Use
- High Gain, High Efficiency and High Linearity
- Integrated ESD Protection
- Designed for Maximum Gain and Insertion Phase Flatness
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Low Gold Plating Thickness on Leads, 40μ″ Nominal.
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 32 mm, 13 Inch Reel.

**MRF21045LR3**
**MRF21045LSR3**

**2110-2170 MHz, 45 W, 28 V**
**LATERAL N-CHANNEL**
**RF POWER MOSFETs**



**CASE 465E-04, STYLE 1**
**NI-400**
**MRF21045LR3**



**CASE 465F-04, STYLE 1**
**NI-400S**
**MRF21045LSR3**

**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°C<br>Derate above 25°C | $P_D$ | 105<br>0.60 | W<br>W/°C |
| Storage Temperature Range | $T_{stg}$ | - 65 to +150 | °C |
| Case Operating Temperature | $T_C$ | 150 | °C |
| Operating Junction Temperature | $T_J$ | 200 | °C |

**Table 2. Thermal Characteristics**

| Characteristic | Symbol | Value (1) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 1.65 | °C/W |

**Table 3. ESD Protection Characteristics**

| Test Conditions | Class |
|---|---|
| Human Body Model | 1 (Minimum) |
| Machine Model | M2 (Minimum) |

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

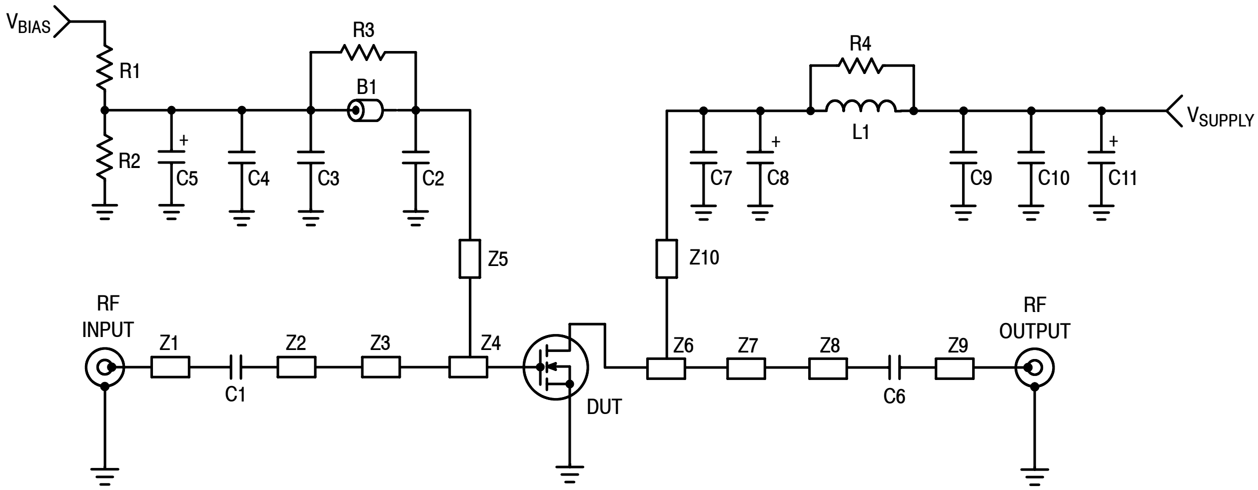
| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics** | | | | | |
| Drain-Source Breakdown Voltage ($V_{GS}$ = 0 Vdc, $I_D$ = 100 μAdc) | $V_{(BR)DSS}$ | 65 | — | — | Vdc |
| Zero Gate Voltage Drain Current ($V_{DS}$ = 28 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Gate-Source Leakage Current ($V_{GS}$ = 5 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | — | — | 1 | μAdc |
| **On Characteristics (DC)** | | | | | |
| Gate Threshold Voltage ($V_{DS}$ = 10 Vdc, $I_D$ = 100 μAdc) | $V_{GS(th)}$ | 2 | — | 4 | Vdc |
| Gate Quiescent Voltage ($V_{DS}$ = 28 Vdc, $I_D$ = 500 mAdc) | $V_{GS(Q)}$ | 3 | 3.9 | 5 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 1 Adc) | $V_{DS(on)}$ | — | 0.19 | 0.21 | Vdc |
| Forward Transconductance ($V_{DS}$ = 10 Vdc, $I_D$ = 1 Adc) | $g_{fs}$ | — | 3 | — | S |
| **Dynamic Characteristics** [1] | | | | | |
| Reverse Transfer Capacitance ($V_{DS}$ = 28 Vdc, $V_{GS}$ = 0, f = 1 MHz) | $C_{rss}$ | — | 1.8 | — | pF |
| **Functional Tests** (In Freescale Test Fixture, 50 ohm system) 2-carrier W-CDMA. Peak/Avg. = 8.3 dB @ 0.01% Probability on CCDF. | | | | | |
| Common-Source Amplifier Power Gain ($V_{DD}$ = 28 Vdc, $P_{out}$ = 10 W Avg., $I_{DQ}$ = 500 mA, f1 = 2157.5 MHz, f2 = 2167.5 MHz) | $G_{ps}$ | 13.5 | 15 | — | dB |
| Drain Efficiency ($V_{DD}$ = 28 Vdc, $P_{out}$ = 10 W Avg., $I_{DQ}$ = 500 mA, f1 = 2157.5 MHz, f2 = 2167.5 MHz) | η | 21 | 23.5 | — | % |
| Third Order Intermodulation Distortion ($V_{DD}$ = 28 Vdc, $P_{out}$ = 10 W Avg., $I_{DQ}$ = 500 mA, f1 = 2157.5 MHz, f2 = 2167.5 MHz; IM3 measured over 3.84 MHz Bandwidth at f1 -10 MHz and f2 +10 MHz.) | IM3 | — | -37.5 | -35 | dBc |
| Adjacent Channel Power Ratio ($V_{DD}$ = 28 Vdc, $P_{out}$ = 10 W Avg., $I_{DQ}$ = 500 mA, f1 = 2157.5 MHz, f2 = 2167.5 MHz; ACPR measured over 3.84 MHz Bandwidth at f1 -5 MHz and f2 +5 MHz.) | ACPR | — | -41 | -38 | dBc |
| Input Return Loss ($V_{DD}$ = 28 Vdc, $P_{out}$ = 10 W Avg., $I_{DQ}$ = 500 mA, f1 = 2157.5 MHz, f2 = 2167.5 MHz) | IRL | — | -12 | -9 | dB |

1. Part is internally matched both on input and output.

(continued)

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Functional Tests** (In Freescale Test Fixture, 50 ohm system) — continued | | | | | |
| Two-Tone Common-Source Amplifier Power Gain ($V_{DD}$ = 28 Vdc, $P_{out}$ = 45 W PEP, $I_{DQ}$ = 500 mA, f1 = 2110 MHz, f2 = 2120 MHz and f1 = 2160 MHz, f2 = 2170 MHz) | $G_{ps}$ | — | 14.9 | — | dB |
| Two-Tone Drain Efficiency ($V_{DD}$ = 28 Vdc, $P_{out}$ = 45 W PEP, $I_{DQ}$ = 500 mA, f1 = 2110 MHz, f2 = 2120 MHz and f1 = 2160 MHz, f2 = 2170 MHz) | $\eta$ | — | 36 | — | % |
| Intermodulation Distortion ($V_{DD}$ = 28 Vdc, $P_{out}$ = 45 W PEP, $I_{DQ}$ = 500 mA, f1 = 2110 MHz, f2 = 2120 MHz and f1 = 2160 MHz, f2 = 2170 MHz) | IMD | — | -30 | — | dBc |
| Two-Tone Input Return Loss ($V_{DD}$ = 28 Vdc, $P_{out}$ = 45 W PEP, $I_{DQ}$ = 500 mA, f1 = 2110 MHz, f2 = 2120 MHz and f1 = 2160 MHz, f2 = 2170 MHz) | IRL | — | -12 | — | dB |
| $P_{out}$, 1 dB Compression Point ($V_{DD}$ = 28 Vdc, $I_{DQ}$ = 500 mA, f = 2170 MHz) | P1dB | — | 50 | — | W |

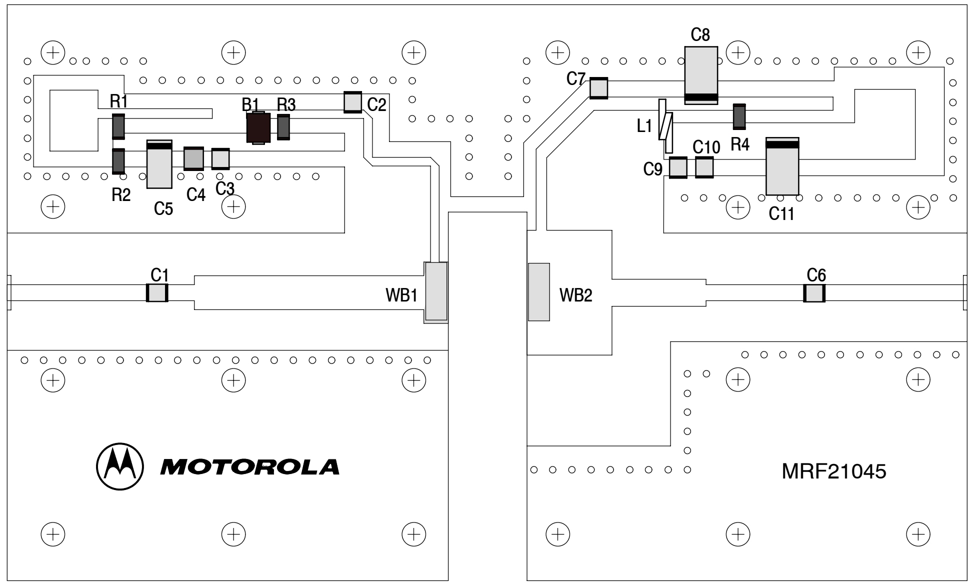



| | | | |
|---|---|---|---|
| Z1, Z9 | 0.750″ x 0.084″ Transmission Line | Board | 0.030″ Glass Teflon®, Keene GX-0300-55-22, $\varepsilon_r$ = 2.55 |
| Z2 | 0.160″ x 0.084″ Transmission Line | PCB | Etched Circuit Boards MRF21045 Rev. 3, CMR |
| Z3 | 1.195″ x 0.176″ Transmission Line | | |
| Z4 | 0.125″ x 0.320″ Transmission Line | | |
| Z5 | 1.100″ x 0.045″ Transmission Line | | |
| Z6 | 0.442″ x 0.650″ Transmission Line | | |
| Z7 | 0.490″ x 0.140″ Transmission Line | | |
| Z8 | 0.540″ x 0.084″ Transmission Line | | |
| Z10 | 0.825″ x 0.055″ Transmission Line | | |

**Figure 1. MRF21045LR3(SR3) Test Circuit Schematic**

**Table 5. MRF21045LR3(SR3) Component Designations and Values**

| Designators | Description |
|---|---|
| B1 | Short Ferrite Bead, Fair Rite, #2743019447 |
| C1, C2, C6 | 43 pF Chip Capacitors, ATC #100B430JCA500X |
| C7 | 5.6 pF Chip Capacitor, ATC #100B5R6JCA500X |
| C3, C9 | 1000 pF Chip Capacitors, ATC #100B102JCA500X |
| C4, C10 | 0.1 μF Chip Capacitors, Kemet #CDR33BX104AKWS |
| C5 | 1.0 μF Tantalum Chip Capacitor, Kemet #T491C105M050 |
| C8 | 10 μF Tantalum Chip Capacitor, Kemet #T495X106K035AS4394 |
| C11 | 22 μF Tantalum Chip Capacitor, Kemet #T491X226K035AS4394 |
| L1 | 1 Turn, #20 AWG, 0.100″ ID |
| N1, N2 | Type N Flange Mounts, Omni Spectra #3052-1648-10 |
| R1 | 1.0 kΩ, 1/8 W Chip Resistor |
| R2 | 180 kΩ, 1/8 W Chip Resistor |
| R3, R4 | 10 Ω, 1/8 W Chip Resistors |




Freescale 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. MRF21045LR3(SR3) Test Circuit Component Layout**

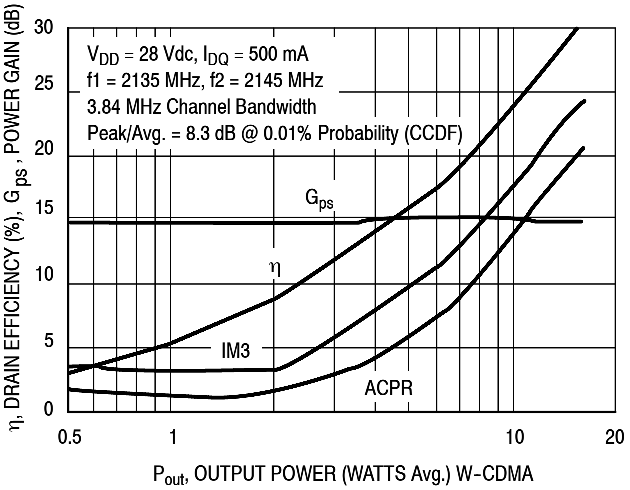



**Figure 3. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**

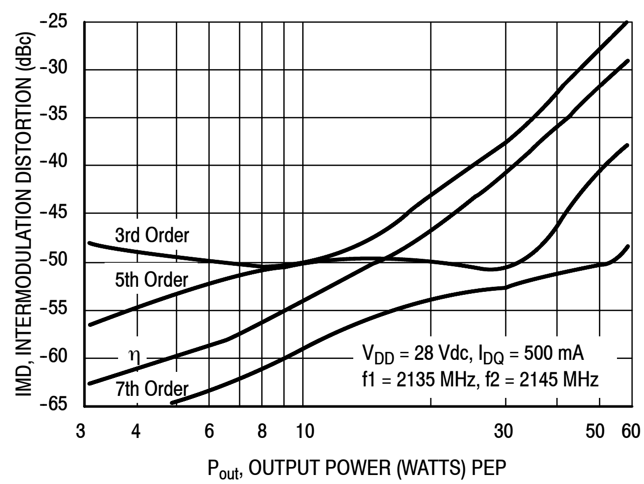



**Figure 4. Intermodulation Distortion Products versus Output Power**

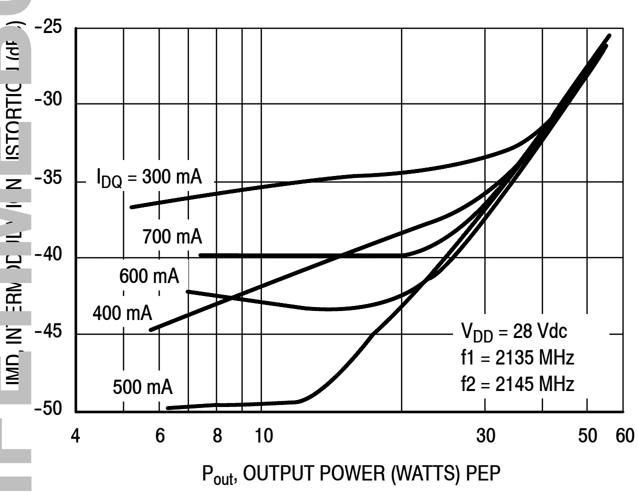



**Figure 5. Intermodulation Distortion versus Output Power**

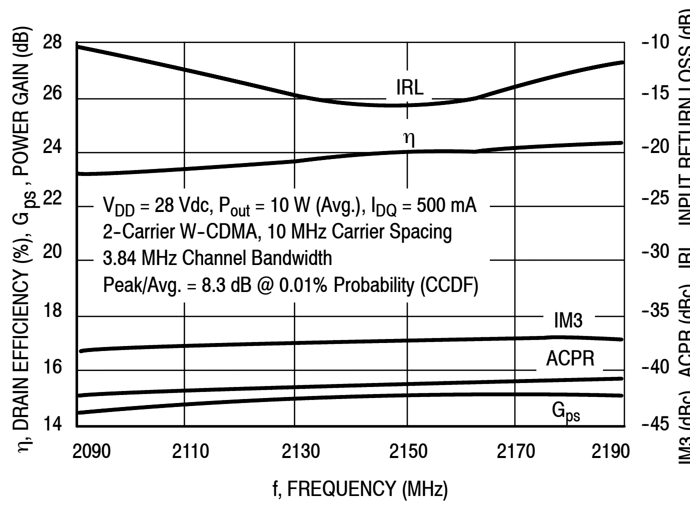



**Figure 6. 2-Carrier W-CDMA Broadband Performance**

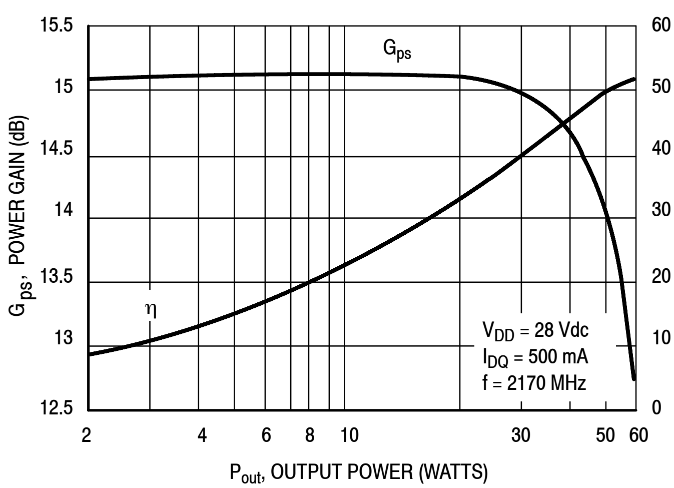



**Figure 7. CW Performance**

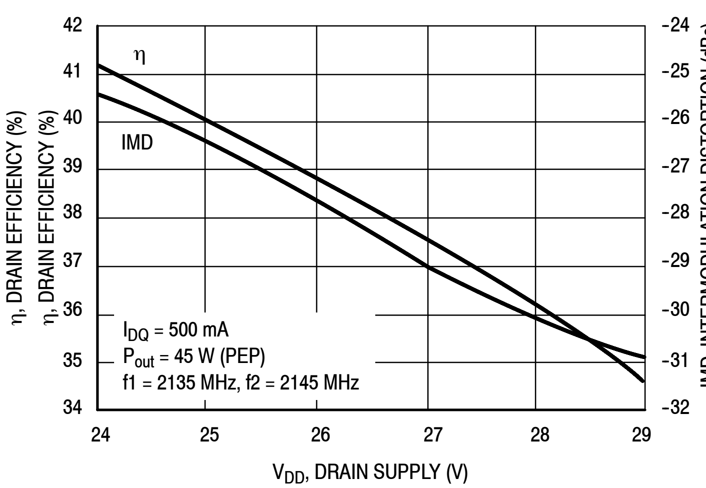



**Figure 8. Two-Tone Intermodulation Distortion and Drain Efficiency versus Drain Supply**

## TYPICAL CHARACTERISTICS

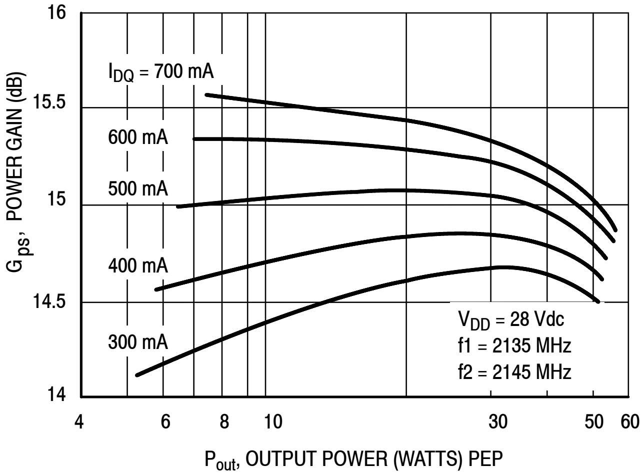



**Figure 9. Two-Tone Power Gain versus Output Power**

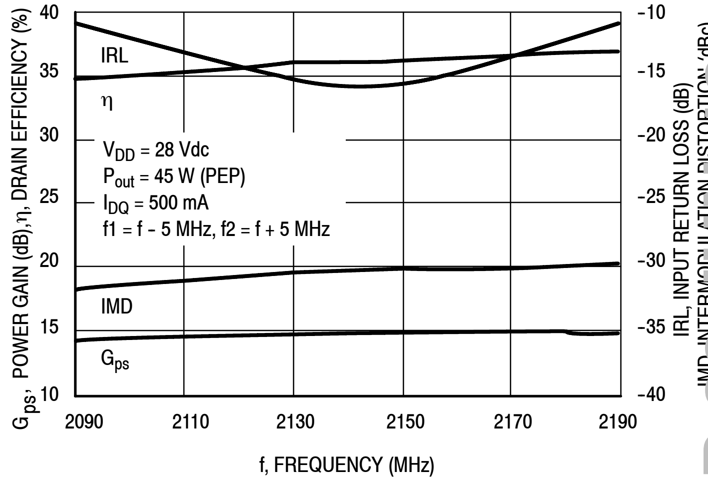



**Figure 10. Two-Tone Broadband Performance**

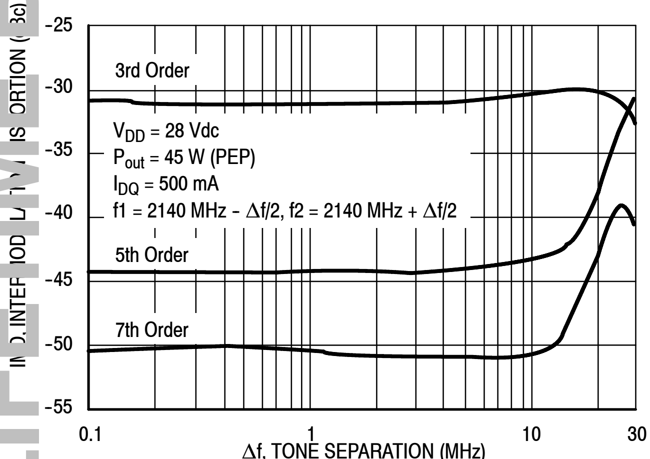



**Figure 11. Intermodulation Distortion Products versus Two-Tone Spacing**

## W-CDMA TEST SIGNAL

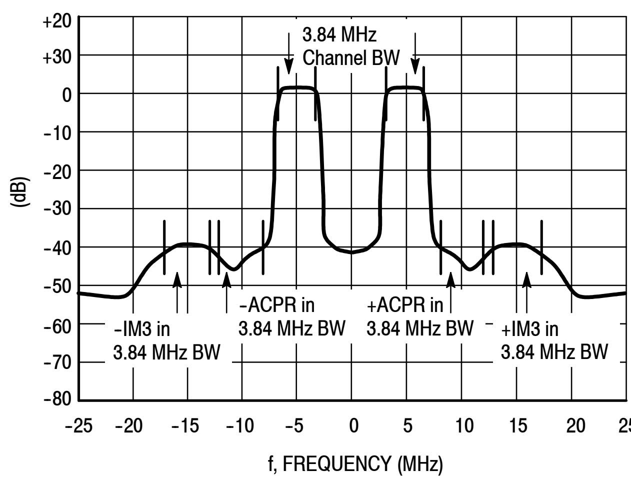
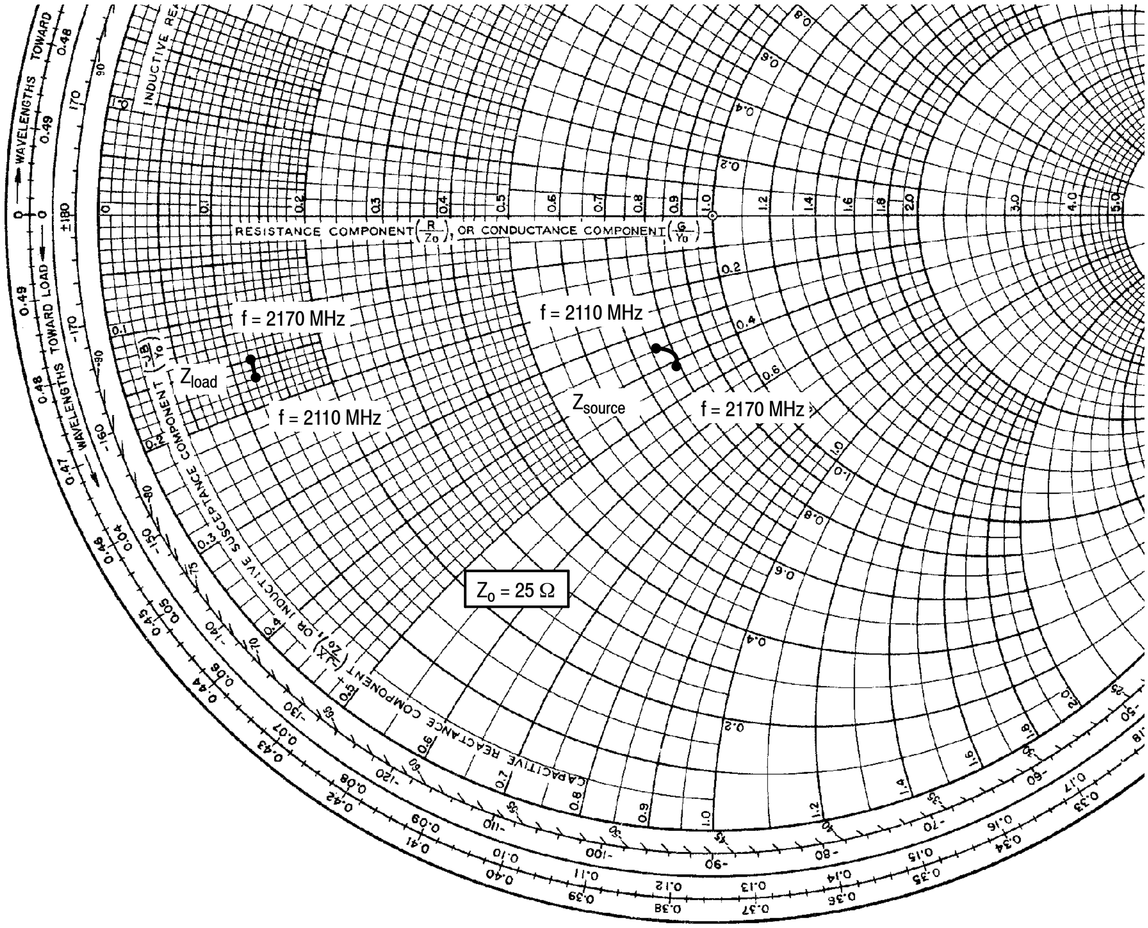



**Figure 12. 2-Carrier W-CDMA Spectrum**




$V_{DD}$ = 28 Vdc, $I_{DQ}$ = 500 mA, $P_{out}$ = 10 W Avg.

| f<br>MHz | $Z_{source}$<br>Ω | $Z_{load}$<br>Ω |
|---|---|---|
| 2110 | 18.88 - j8.86 | 3.11 - j4.18 |
| 2140 | 19.80 - j9.93 | 3.09 - j3.87 |
| 2170 | 19.68 - j10.44 | 3.12 - j3.72 |

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

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

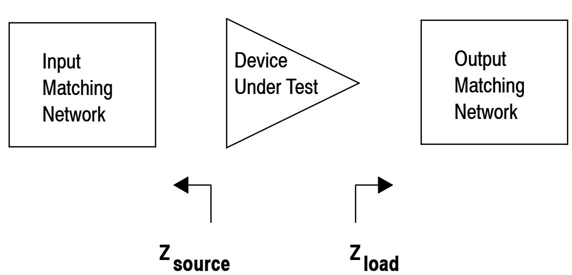
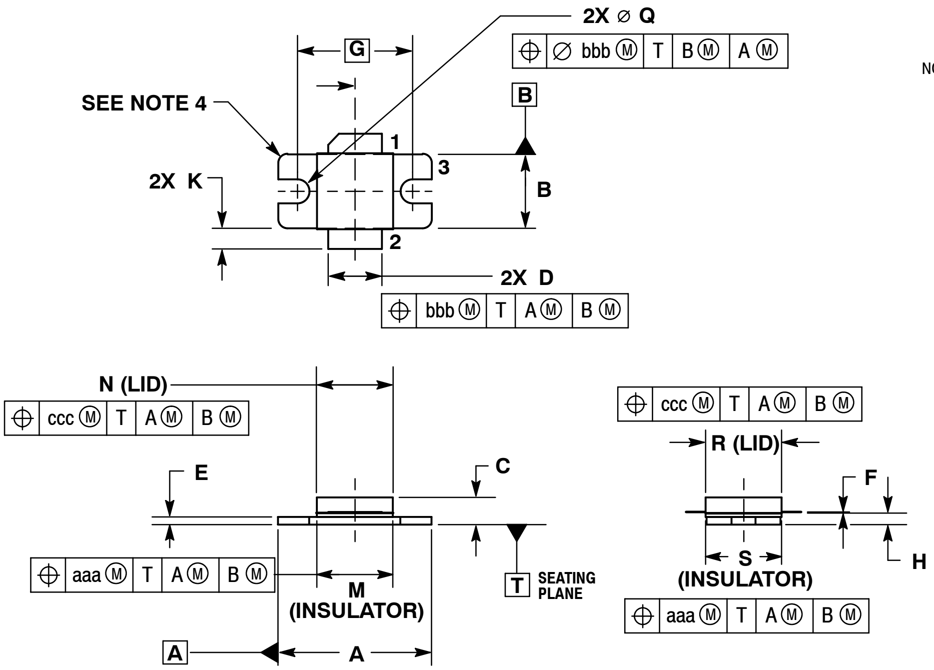



**Figure 13. Series Equivalent Source and Load Impedance**

## PACKAGE DIMENSIONS

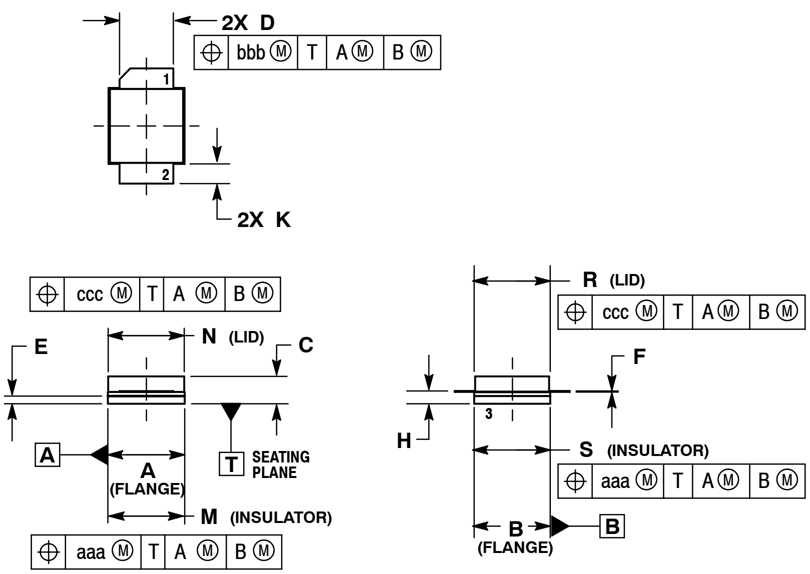



NOTES:
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
4. INFORMATION ONLY: CORNER BREAK (4X) TO BE .060±.005 (1.52±0.13) RADIUS OR .06±.005 (1.52±0.13) x 45° CHAMFER.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | .795 | .805 | 20.19 | 20.44 |
| B | .380 | .390 | 9.65 | 9.9 |
| C | .125 | .163 | 3.17 | 4.14 |
| D | .275 | .285 | 6.98 | 7.24 |
| E | .035 | .045 | 0.89 | 1.14 |
| F | .004 | .006 | 0.10 | 0.15 |
| G | .600 BSC | | 15.24 BSC | |
| H | .057 | .067 | 1.45 | 1.7 |
| K | .092 | .122 | 2.33 | 3.1 |
| M | .395 | .405 | 10 | 10.3 |
| N | .395 | .405 | 10 | 10.3 |
| Q | ⌀ .120 | ⌀ .130 | ⌀ 3.05 | ⌀ 3.3 |
| R | .395 | .405 | 10 | 10.3 |
| S | .395 | .405 | 10 | 10.3 |
| aaa | .005 BSC | | 0.127 BSC | |
| bbb | .010 BSC | | 0.254 BSC | |
| ccc | .015 BSC | | 0.381 BSC | |

STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

**CASE 465E-04**
**ISSUE F**
**NI-400**
**MRF21045LR3**




NOTES:
1. CONTROLLING DIMENSION: INCH.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M-1994.
3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | .395 | .405 | 10.03 | 10.29 |
| B | .395 | .405 | 10.03 | 10.29 |
| C | .125 | .163 | 3.18 | 4.14 |
| D | .275 | .285 | 6.98 | 7.24 |
| E | .035 | .045 | 0.89 | 1.14 |
| F | .004 | .006 | 0.10 | 0.15 |
| H | .057 | .067 | 1.45 | 1.70 |
| K | .092 | .122 | 2.34 | 3.10 |
| M | .395 | .405 | 10.03 | 10.29 |
| N | .395 | .405 | 10.03 | 10.29 |
| R | .395 | .405 | 10.03 | 10.29 |
| S | .395 | .405 | 10.03 | 10.29 |
| aaa | .005 REF | | 0.127 REF | |
| bbb | .010 REF | | 0.254 REF | |
| ccc | .015 REF | | 0.38 REF | |

STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

**CASE 465F-04**
**ISSUE E**
**NI-400S**
**MRF21045LSR3**

## 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 |
|---|---|---|
| 12 | Oct. 2008 | • Data sheet revised to reflect part status change, p. 1, including use of applicable overlay.<br>• Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN12779, p. 1, 2<br>• Added Product Documentation and Revision History, p. 10 |

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