

# 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.

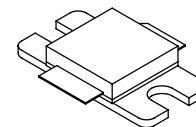
- Typical 2-carrier W-CDMA Performance for  $V_{DD} = 28$  Volts,  $I_{DQ} = 500$  mA,  $f = 2157.5$  MHz, Channel Bandwidth = 3.84 MHz, Adjacent Channels measured over 3.84 MHz Bandwidth at f1 -5 MHz and f2 +5 MHz, Distortion Products measured over a 3.84 MHz Bandwidth at f1 -10 MHz and f2 +10 MHz, 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

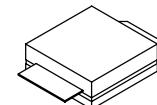
- Internally Matched for Ease of Use
- High Gain, High Efficiency and High Linearity
- Integrated ESD Protection
- Designed for Maximum Gain and Insertion Phase Flatness
- Excellent Thermal Stability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Low Gold Plating Thickness on Leads, 40 $\mu$ " 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 @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$     | 105<br>0.60 | 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         | $^\circ\text{C}$         |

**Table 2. Thermal Characteristics**

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

**Table 3. ESD Protection Characteristics**

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

- Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescale.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

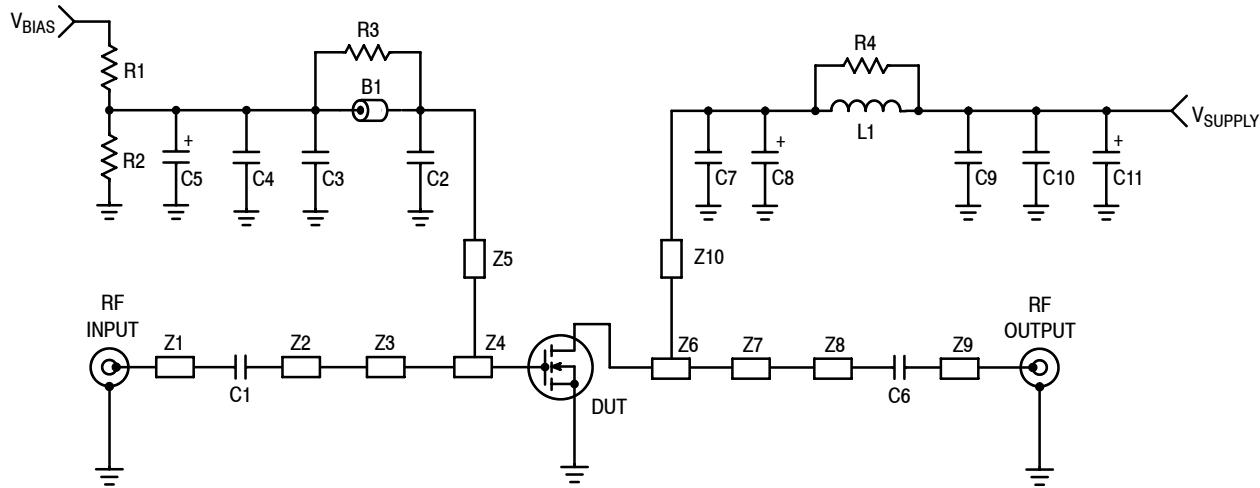
| Characteristic  | Symbol              | Min  | Typ   | Max  | Unit            |
|---|---------------------|------|-------|------|-----------------|
| <b>Off Characteristics</b>  |                     |      |       |      |                 |
| Drain-Source Breakdown Voltage<br>( $V_{GS} = 0 \text{ Vdc}$ , $I_D = 100 \mu\text{Adc}$ )  | $V_{(BR)DSS}$       | 65   | —     | —    | Vdc             |
| Zero Gate Voltage Drain Current<br>( $V_{DS} = 28 \text{ Vdc}$ , $V_{GS} = 0 \text{ Vdc}$ )   | $I_{DSS}$           | —    | —     | 10   | $\mu\text{Adc}$ |
| Gate-Source Leakage Current<br>( $V_{GS} = 5 \text{ Vdc}$ , $V_{DS} = 0 \text{ Vdc}$ )  | $I_{GSS}$           | —    | —     | 1    | $\mu\text{Adc}$ |
| <b>On Characteristics (DC)</b>  |                     |      |       |      |                 |
| Gate Threshold Voltage<br>( $V_{DS} = 10 \text{ Vdc}$ , $I_D = 100 \mu\text{Adc}$ )   | $V_{GS(\text{th})}$ | 2    | —     | 4    | Vdc             |
| Gate Quiescent Voltage<br>( $V_{DS} = 28 \text{ Vdc}$ , $I_D = 500 \text{ mA}$ )  | $V_{GS(Q)}$         | 3    | 3.9   | 5    | Vdc             |
| Drain-Source On-Voltage<br>( $V_{GS} = 10 \text{ Vdc}$ , $I_D = 1 \text{ Adc}$ )  | $V_{DS(\text{on})}$ | —    | 0.19  | 0.21 | Vdc             |
| Forward Transconductance<br>( $V_{DS} = 10 \text{ Vdc}$ , $I_D = 1 \text{ Adc}$ )   | $g_{fs}$            | —    | 3     | —    | S               |
| <b>Dynamic Characteristics (1)</b>  |                     |      |       |      |                 |
| Reverse Transfer Capacitance<br>( $V_{DS} = 28 \text{ Vdc}$ , $V_{GS} = 0$ , $f = 1 \text{ MHz}$ )  | $C_{rss}$           | —    | 1.8   | —    | pF              |
| <b>Functional Tests</b> (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<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 10 \text{ W Avg.}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2157.5 \text{ MHz}$ , $f_2 = 2167.5 \text{ MHz}$ )  | $G_{ps}$            | 13.5 | 15    | —    | dB              |
| Drain Efficiency<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 10 \text{ W Avg.}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2157.5 \text{ MHz}$ , $f_2 = 2167.5 \text{ MHz}$ )  | n                   | 21   | 23.5  | —    | %               |
| Third Order Intermodulation Distortion<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 10 \text{ W Avg.}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2157.5 \text{ MHz}$ , $f_2 = 2167.5 \text{ MHz}$ ; IM3 measured over 3.84 MHz<br>Bandwidth at $f_1 - 10 \text{ MHz}$ and $f_2 + 10 \text{ MHz}$ ) | IM3                 | —    | -37.5 | -35  | dBc             |
| Adjacent Channel Power Ratio<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 10 \text{ W Avg.}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2157.5 \text{ MHz}$ , $f_2 = 2167.5 \text{ MHz}$ ; ACPR measured over 3.84 MHz<br>Bandwidth at $f_1 - 5 \text{ MHz}$ and $f_2 + 5 \text{ MHz}$ )            | ACPR                | —    | -41   | -38  | dBc             |
| Input Return Loss<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 10 \text{ W Avg.}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2157.5 \text{ MHz}$ , $f_2 = 2167.5 \text{ MHz}$ )   | IRL                 | —    | -12   | -9   | dB              |

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

(continued)

**Table 4. Electrical Characteristics** ( $T_C = 25^\circ\text{C}$  unless otherwise noted) (continued)

| Characteristic   | Symbol   | Min | Typ  | Max | Unit |
|--|----------|-----|------|-----|------|
| <b>Functional Tests</b> (In Freescale Test Fixture, 50 ohm system) — continued   |          |     |      |     |      |
| Two-Tone Common-Source Amplifier Power Gain<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 45 \text{ W PEP}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2110 \text{ MHz}$ , $f_2 = 2120 \text{ MHz}$ and $f_1 = 2160 \text{ MHz}$ , $f_2 = 2170 \text{ MHz}$ ) | $G_{ps}$ | —   | 14.9 | —   | dB   |
| Two-Tone Drain Efficiency<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 45 \text{ W PEP}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2110 \text{ MHz}$ , $f_2 = 2120 \text{ MHz}$ and $f_1 = 2160 \text{ MHz}$ , $f_2 = 2170 \text{ MHz}$ )                   | $\eta$   | —   | 36   | —   | %    |
| Intermodulation Distortion<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 45 \text{ W PEP}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2110 \text{ MHz}$ , $f_2 = 2120 \text{ MHz}$ and $f_1 = 2160 \text{ MHz}$ , $f_2 = 2170 \text{ MHz}$ )                  | IMD      | —   | -30  | —   | dBc  |
| Two-Tone Input Return Loss<br>( $V_{DD} = 28 \text{ Vdc}$ , $P_{out} = 45 \text{ W PEP}$ , $I_{DQ} = 500 \text{ mA}$ ,<br>$f_1 = 2110 \text{ MHz}$ , $f_2 = 2120 \text{ MHz}$ and $f_1 = 2160 \text{ MHz}$ , $f_2 = 2170 \text{ MHz}$ )                  | IRL      | —   | -12  | —   | dB   |
| $P_{out}$ , 1 dB Compression Point<br>( $V_{DD} = 28 \text{ Vdc}$ , $I_{DQ} = 500 \text{ mA}$ , $f = 2170 \text{ MHz}$ )   | P1dB     | —   | 50   | —   | W    |



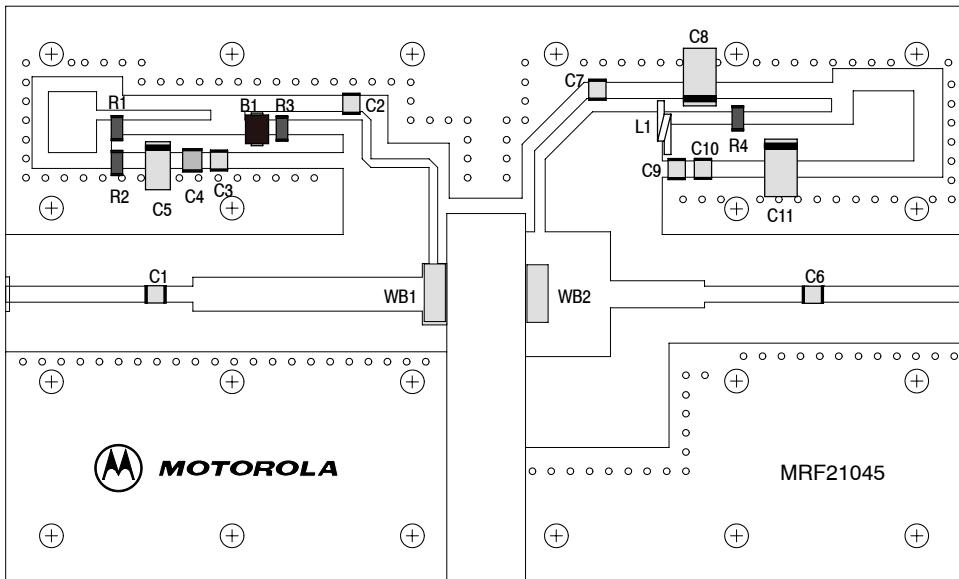
Z1, Z9      0.750" x 0.084" Transmission Line  
 Z2      0.160" x 0.084" Transmission Line  
 Z3      1.195" x 0.176" Transmission Line  
 Z4      0.125" x 0.320" Transmission Line  
 Z5      1.100" x 0.045" Transmission Line  
 Z6      0.442" x 0.650" Transmission Line  
 Z7      0.490" x 0.140" Transmission Line  
 Z8      0.540" x 0.084" Transmission Line  
 Z10      0.825" x 0.055" Transmission Line

Board      0.030" Glass Teflon®,  
 Keene GX-0300-55-22,  $\epsilon_r = 2.55$   
 PCB      Etched Circuit Boards  
 MRF21045 Rev. 3, CMR

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 $\mu$ F Chip Capacitors, Kemet #CDR33BX104AKWS            |
| C5          | 1.0 $\mu$ F Tantalum Chip Capacitor, Kemet #T491C105M050      |
| C8          | 10 $\mu$ F Tantalum Chip Capacitor, Kemet #T495X106K035AS4394 |
| C11         | 22 $\mu$ F 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 k $\Omega$ , 1/8 W Chip Resistor                          |
| R2          | 180 k $\Omega$ , 1/8 W Chip Resistor                          |
| R3, R4      | 10 $\Omega$ , 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**

## TYPICAL CHARACTERISTICS

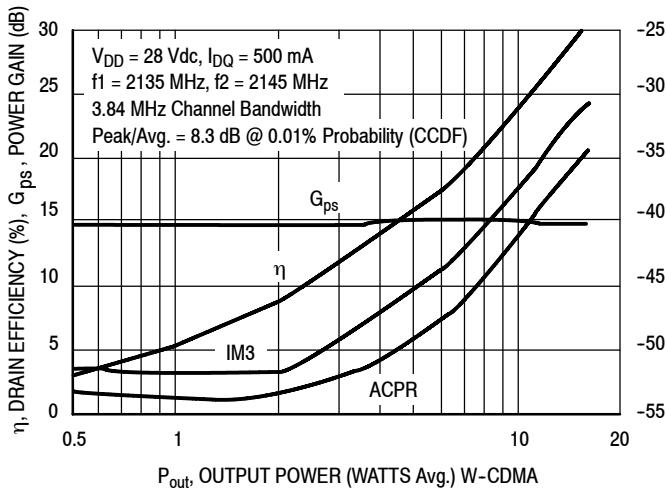


Figure 3. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power

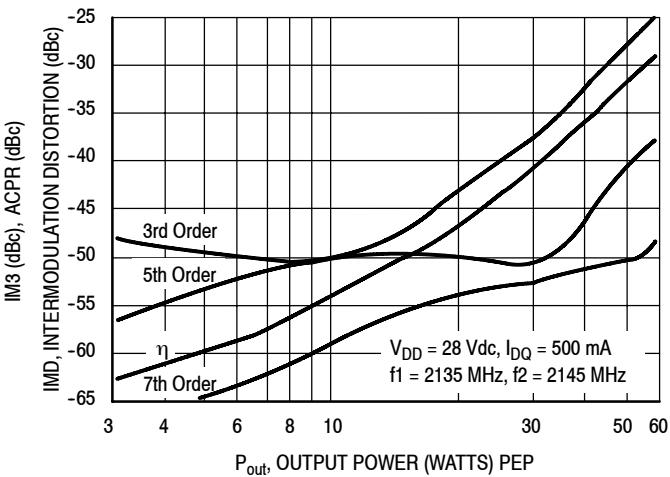


Figure 4. Intermodulation Distortion Products versus Output Power

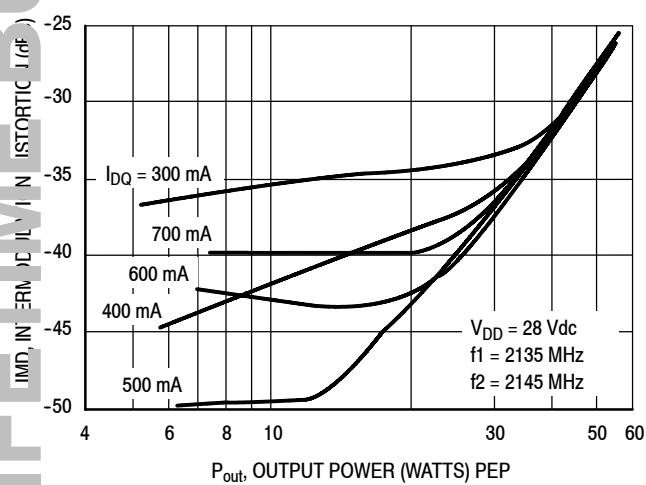


Figure 5. Intermodulation Distortion versus Output Power

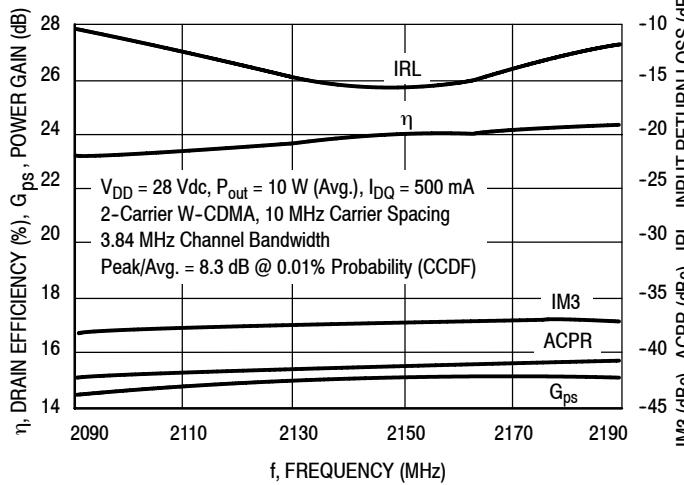


Figure 6. 2-Carrier W-CDMA Broadband Performance

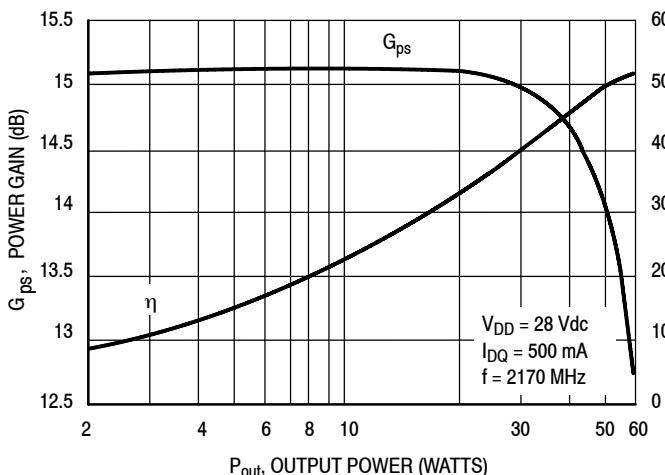


Figure 7. CW Performance

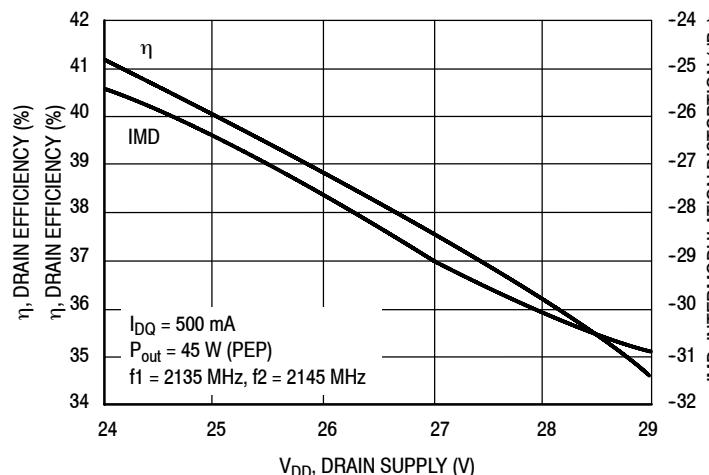


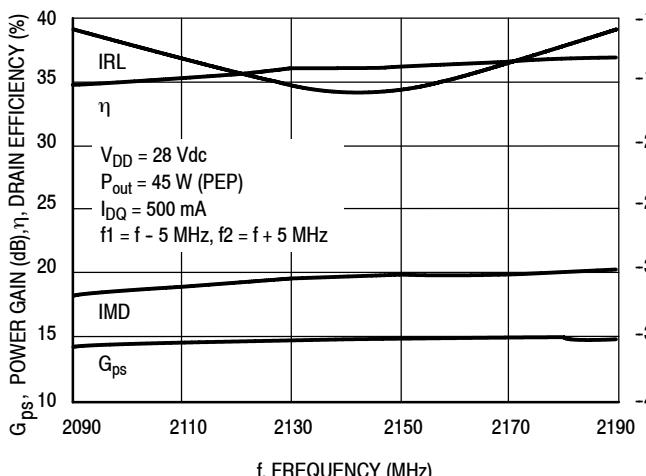
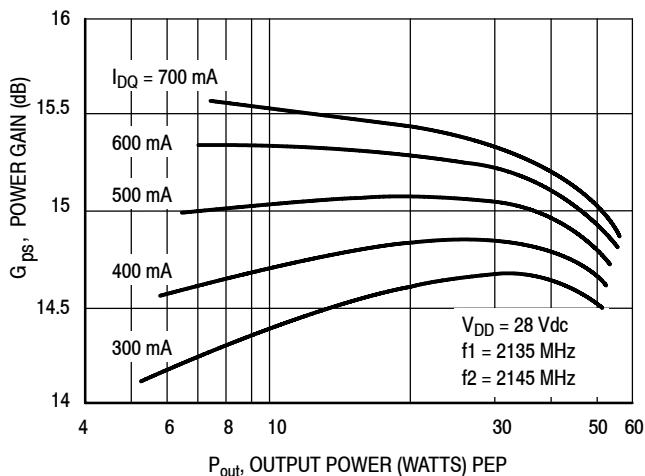
Figure 8. Two-Tone Intermodulation Distortion and Drain Efficiency versus Drain Supply

LAST SHIP 30 JUN 12

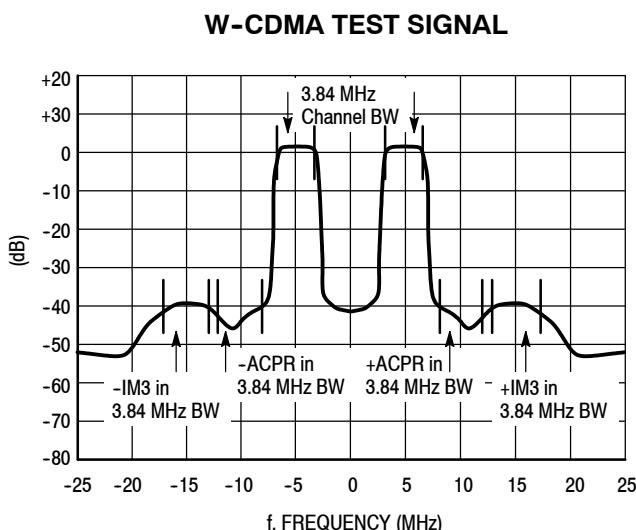
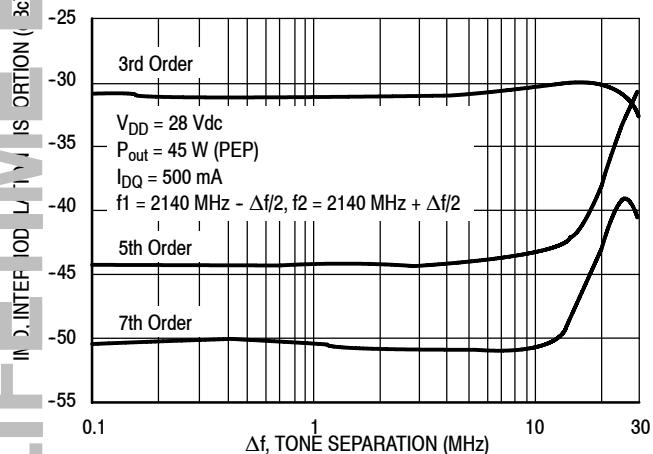
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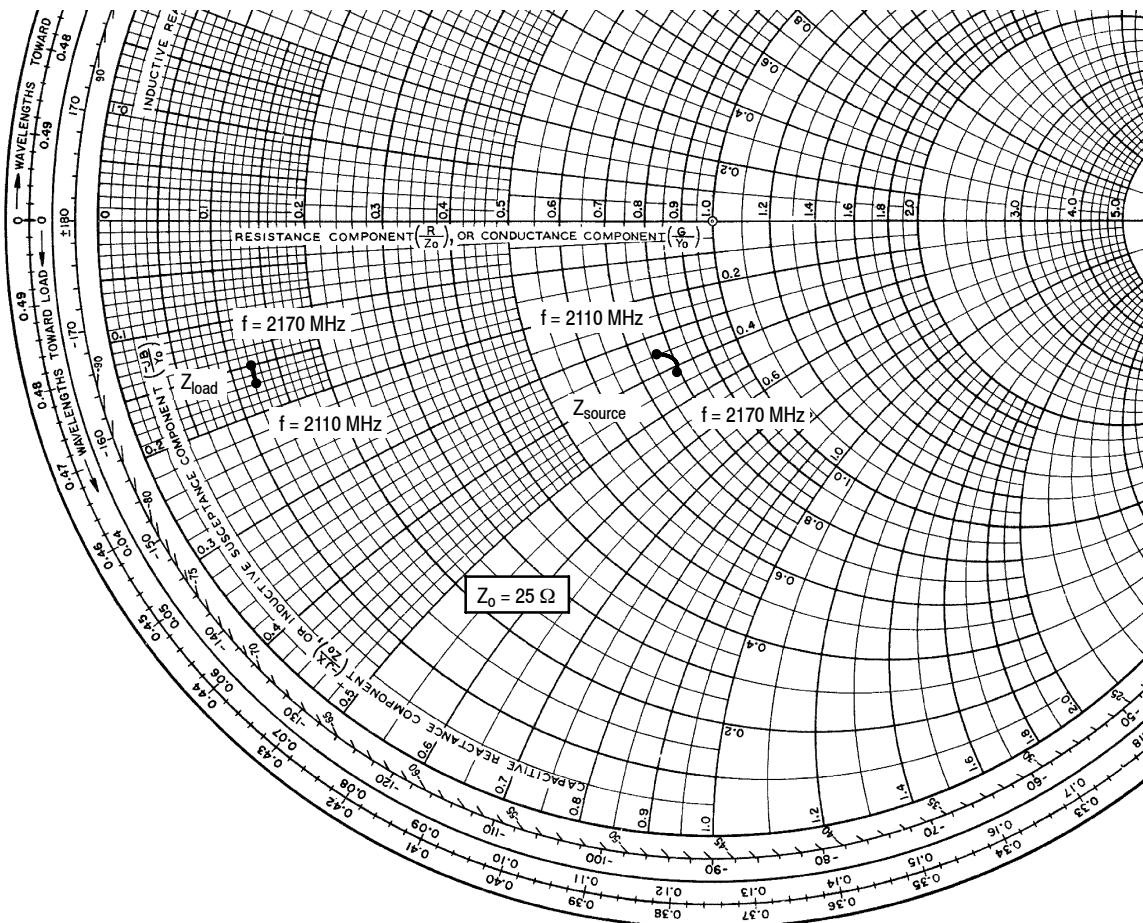
LIFETIME BUY

## TYPICAL CHARACTERISTICS



LIFETIME BUY





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

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

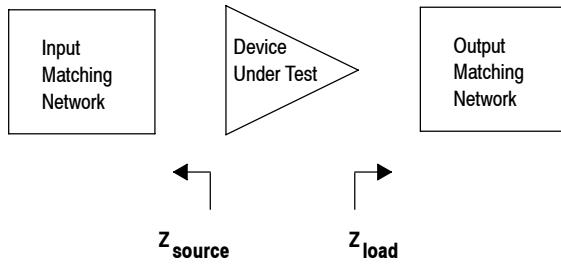
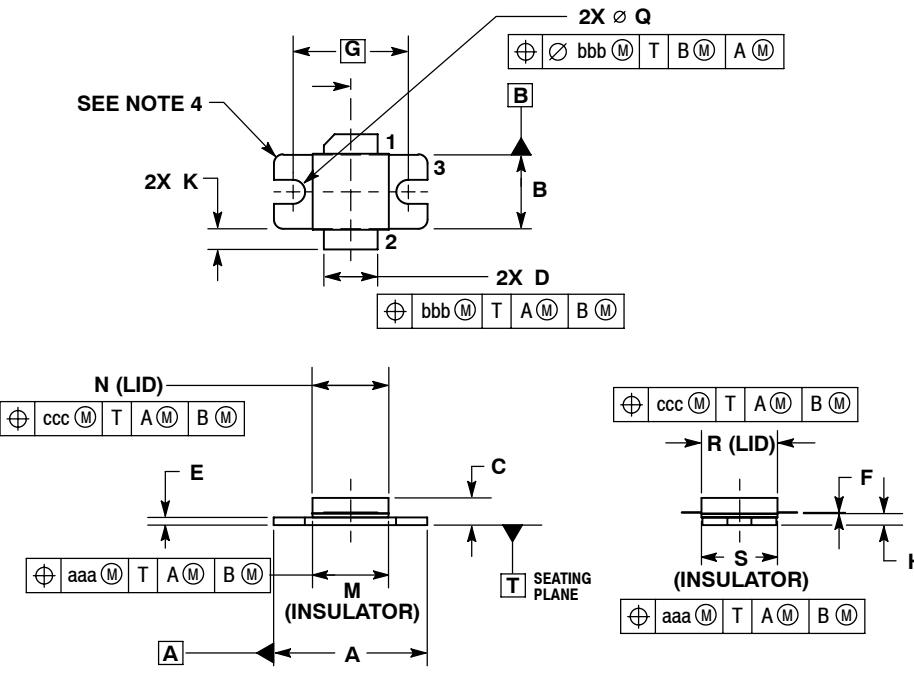


Figure 13. Series Equivalent Source and Load Impedance

## PACKAGE DIMENSIONS



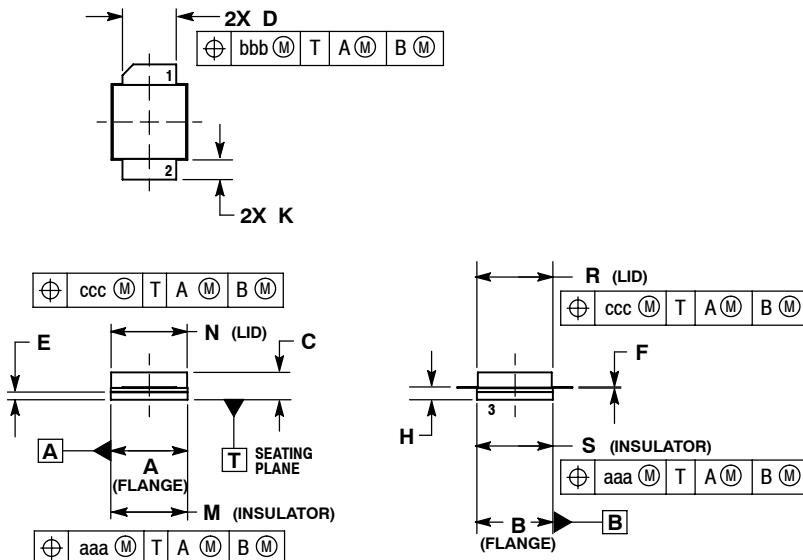
**NOTES:**

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.

| DIM | INCHES |        | MILLIMETERS |       |
|-----|--------|--------|-------------|-------|
|     | 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   | Ø .120 | Ø .130 | Ø 3.05      | Ø 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.

| DIM | INCHES |      | MILLIMETERS |       |
|-----|--------|------|-------------|-------|
|     | 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**

**MRF21045LR3 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 | <ul style="list-style-type: none"><li>Data sheet revised to reflect part status change, p. 1, including use of applicable overlay.</li><li>Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN12779, p. 1, 2</li><li>Added Product Documentation and Revision History, p. 10</li></ul> |

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