

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for CDMA base station applications with frequencies from 2110 to 2170 MHz. Suitable for CDMA and multicarrier amplifier applications. To be used in Class AB and Class C for PCN - PCS/cellular radio and WLL applications.

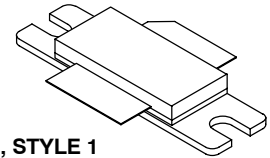
- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1100$  mA,  $P_{out} = 33$  Watts Avg., Full Frequency Band, 3GPP Test Model 1, 64 DPCH with 50% Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 17.3 dB  
Drain Efficiency — 32.5%  
Device Output Signal PAR — 6.1 dB @ 0.01% Probability on CCDF  
ACPR @ 5 MHz Offset — -38 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 2140 MHz, 110 Watts CW Peak Tuned Output Power
- $P_{out}$  @ 1 dB Compression Point  $\geq 110$  Watts CW

### Features

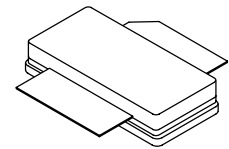
- 100% PAR Tested for Guaranteed Output Power Capability
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- Designed for Digital Predistortion Error Correction Systems
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF7S21110HR3**  
**MRF7S21110HSR3**

**2110-2170 MHz, 33 W AVG., 28 V**  
**SINGLE W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF7S21110HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF7S21110HSR3**

**Table 1. Maximum Ratings**

| Rating                               | Symbol    | Value       | Unit |
|--------------------------------------|-----------|-------------|------|
| Drain-Source Voltage                 | $V_{DSS}$ | -0.5, +65   | Vdc  |
| Gate-Source Voltage                  | $V_{GS}$  | -6.0, +10   | Vdc  |
| Operating Voltage                    | $V_{DD}$  | 32, +0      | 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   |

**Table 2. Thermal Characteristics**

| Characteristic  | Symbol          | Value (2,3)  | Unit |
|---|-----------------|--------------|------|
| Thermal Resistance, Junction to Case<br>Case Temperature 80°C, 109 W CW<br>Case Temperature 78°C, 33 W CW | $R_{\theta JC}$ | 0.37<br>0.41 | °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.

**Table 3. ESD Protection Characteristics**

| Test Methodology                      | Class        |
|---------------------------------------|--------------|
| Human Body Model (per JESD22-A114)    | 1B (Minimum) |
| Machine Model (per EIA/JESD22-A115)   | A (Minimum)  |
| Charge Device Model (per JESD22-C101) | IV (Minimum) |

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

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

**Off Characteristics**

|   |           |   |   |    |                 |
|---|-----------|---|---|----|-----------------|
| 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>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 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<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 270\ \mu\text{Adc}$ )                             | $V_{GS(th)}$ | 1.2  | 2   | 2.7 | Vdc |
| Gate Quiescent Voltage<br>( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1100\ \text{mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 2    | 2.7 | 3.5 | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.7\ \text{Adc}$ )                               | $V_{DS(on)}$ | 0.05 | 0.1 | 0.3 | Vdc |

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

|   |           |   |      |   |    |
|---|-----------|---|------|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )  | $C_{rss}$ | — | 7.95 | — | pF |
| Output Equivalent Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{oss}$ | — | 613  | — | pF |
| Input Capacitance<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\ \text{mV(rms)ac}$ @ 1 MHz)             | $C_{iss}$ | — | 232  | — | pF |

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1100\ \text{mA}$ ,  $P_{out} = 33\ \text{W Avg.}$ ,  $f = 2112.5\ \text{MHz}$  and  $f = 2167.5\ \text{MHz}$ , Single-Carrier W-CDMA, 3GPP Test Model 1, 64 DPCH, 50% Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\ \text{MHz}$  Offset.

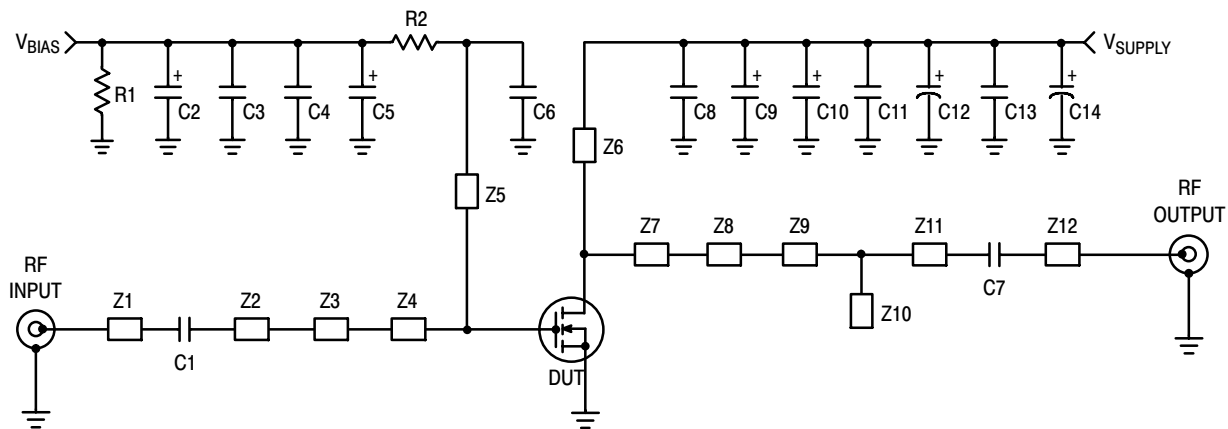
|  |          |      |      |      |     |
|--|----------|------|------|------|-----|
| Power Gain   | $G_{ps}$ | 16.5 | 17.3 | 19.5 | dB  |
| Drain Efficiency   | $\eta_D$ | 31   | 32.5 | 39   | %   |
| Output Peak-to-Average Ratio @ 0.01% Probability on CCDF | PAR      | 5.7  | 6.1  | 6.5  | dB  |
| Adjacent Channel Power Ratio                             | ACPR     | -48  | -38  | -35  | dBc |
| Input Return Loss  | IRL      | —    | -15  | —    | dB  |

1. Part 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>Typical Performances</b> (In Freescale Test Fixture, 50 ohm system) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 1100\text{ mA}$ , 2110-2170 MHz Bandwidth  |                  |     |       |     |        |
| Video Bandwidth @ 90 W PEP $P_{out}$ where $IM3 = -30\text{ dBc}$<br>(Tone Spacing from 100 kHz to VBW)<br>$\Delta IMD3 = IMD3 @ \text{VBW frequency} - IMD3 @ 100\text{ kHz} < 1\text{ dBc}$ (both sidebands) | VBW              | —   | 10    | —   | MHz    |
| Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 33\text{ W Avg.}$   | $G_F$            | —   | 0.325 | —   | dB     |
| Average Deviation from Linear Phase in 60 MHz Bandwidth<br>@ $P_{out} = 110\text{ W CW}$   | $\Phi$           | —   | 0.772 | —   | °      |
| Average Group Delay @ $P_{out} = 110\text{ W CW}$ , $f = 2140\text{ MHz}$  | Delay            | —   | 1.9   | —   | ns     |
| Part-to-Part Insertion Phase Variation @ $P_{out} = 110\text{ W CW}$ ,<br>$f = 2140\text{ MHz}$ , Six Sigma Window   | $\Delta\Phi$     | —   | 39.7  | —   | °      |
| Gain Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )  | $\Delta G$       | —   | 0.011 | —   | dB/°C  |
| Output Power Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )  | $\Delta P_{1dB}$ | —   | 0.028 | —   | dBm/°C |



|    |                             |     |  |
|----|-----------------------------|-----|--|
| Z1 | 1.280" x 0.084" Microstrip  | Z8  | 0.370" x 0.201" Microstrip                                 |
| Z2 | 0.856" x 0.084" Microstrip  | Z9  | 0.386" x 0.084" Microstrip                                 |
| Z3 | 0.240" x 0.280" Microstrip  | Z10 | 0.196" x 0.242" Microstrip                                 |
| Z4 | 0.420" x 0.880" Microstrip  | Z11 | 0.105" x 0.084" Microstrip                                 |
| Z5 | 0.950" x 0.0395" Microstrip | Z12 | 1.267" x 0.084" Microstrip                                 |
| Z6 | 0.526" x 0.0940" Microstrip | PCB | Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$ |
| Z7 | 0.480" x 1.050" Microstrip  |     |  |

**Figure 1. MRF7S21110HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF7S21110HR3(HSR3) Test Circuit Component Designations and Values**

| Part    | Description                              | Part Number       | Manufacturer |
|---------|--|-------------------|--------------|
| C1      | 15 pF, Chip Capacitor                    | ATC100B150JT500XT | ATC          |
| C2      | 47 $\mu$ F, 16 V Tantalum Capacitor      | T491D476K016AT    | Kemet        |
| C3      | 8.2 pF, Chip Capacitor                   | ATC100B8R2CT500XT | ATC          |
| C4, C13 | 2.2 $\mu$ F, 50 V Chip Capacitors        | C1825C225J5RAC    | Kemet        |
| C5      | 1 $\mu$ F, 50 V Tantalum Capacitor       | T491C105K050AT    | Kemet        |
| C6      | 5.1 pF Chip Capacitor                    | ATC100B5R1CT500XT | ATC          |
| C7      | 16 pF Chip Capacitor                     | ATC100B160JT500XT | ATC          |
| C8      | 6.8 pF Chip Capacitor                    | ATC100B6R8BT500XT | ATC          |
| C9, C10 | 22 $\mu$ F, 35 V Tantalum Capacitors     | T491X226K035AT    | Kemet        |
| C11     | 0.1 $\mu$ F Chip Capacitor               | C1206C104K5RAC    | Kemet        |
| C12     | 100 $\mu$ F, 50 V Electrolytic Capacitor | MCR63V477M13X26   | Multicomp    |
| C14     | 470 $\mu$ F, 63 V Electrolytic Capacitor | MCR50V107M8X11    | Multicomp    |
| R1      | 1 K $\Omega$ , 1/4 W Chip Resistor       | CRCW12061001FKEA  | Vishay       |
| R2      | 10 $\Omega$ , 1/3 W Chip Resistor        | CRCW121010R0FKEA  | Vishay       |

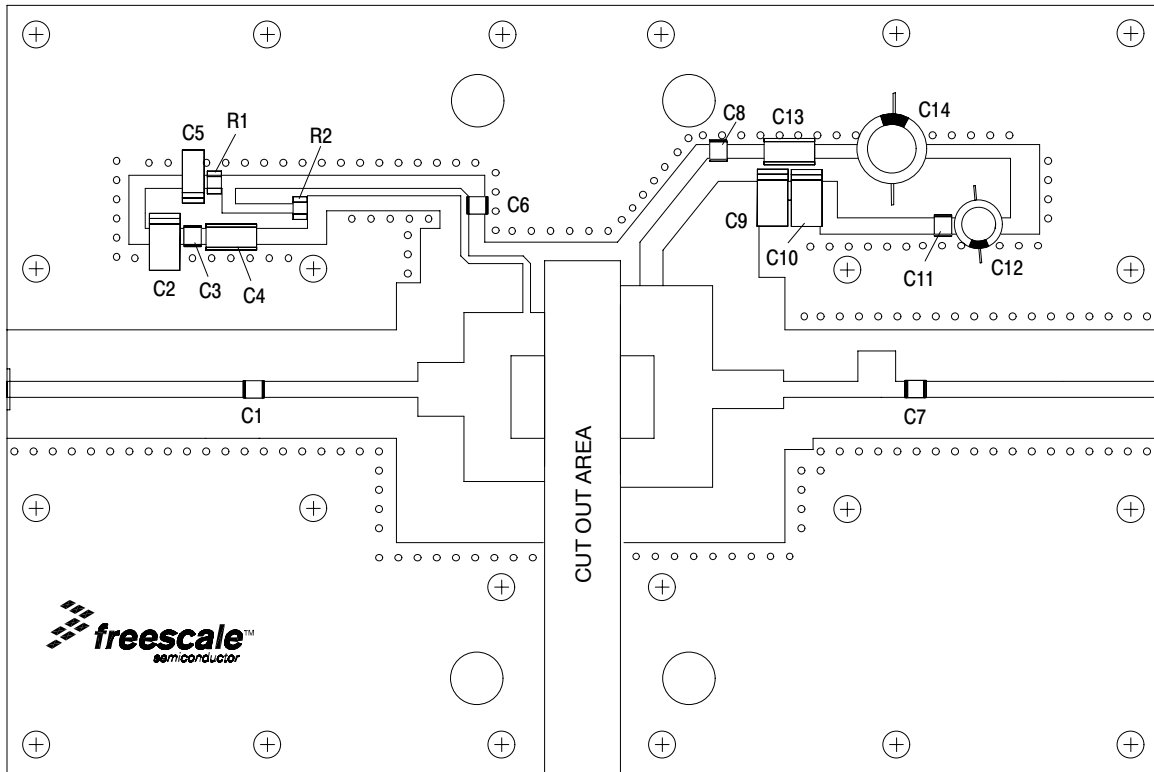
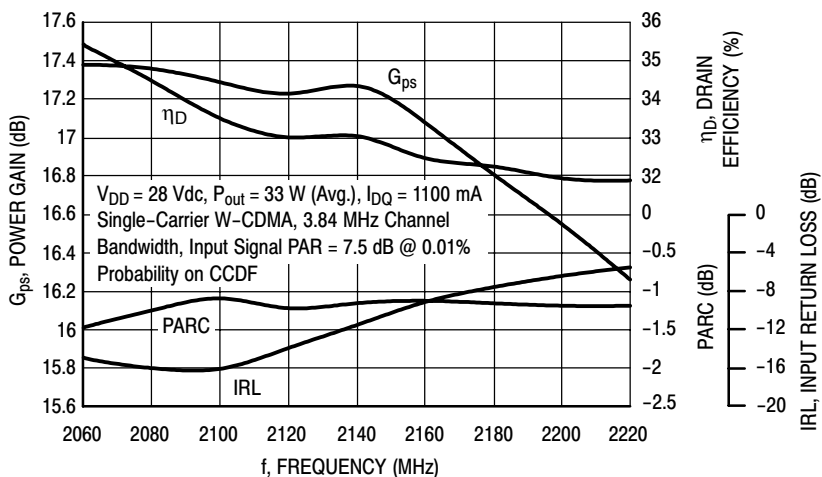
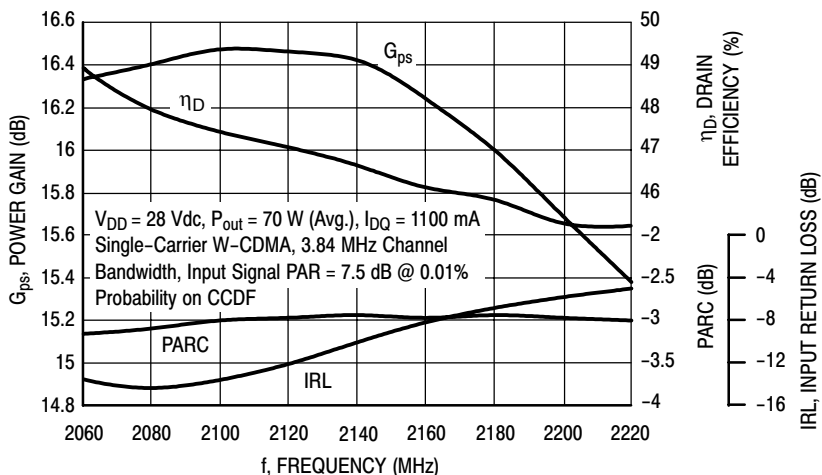


Figure 2. MRF7S2110HR3(HSR3) Test Circuit Component Layout

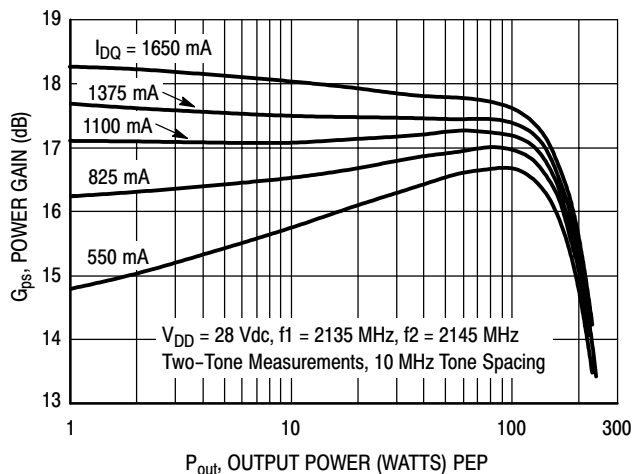
## TYPICAL CHARACTERISTICS



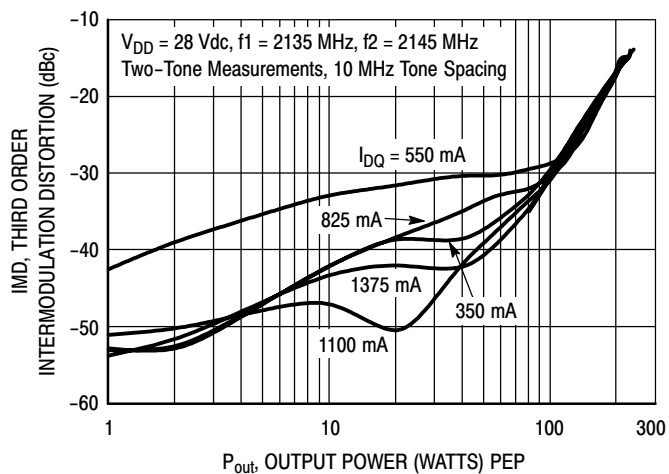
**Figure 3. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 33$  Watts Avg.**



**Figure 4. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 70$  Watts Avg.**

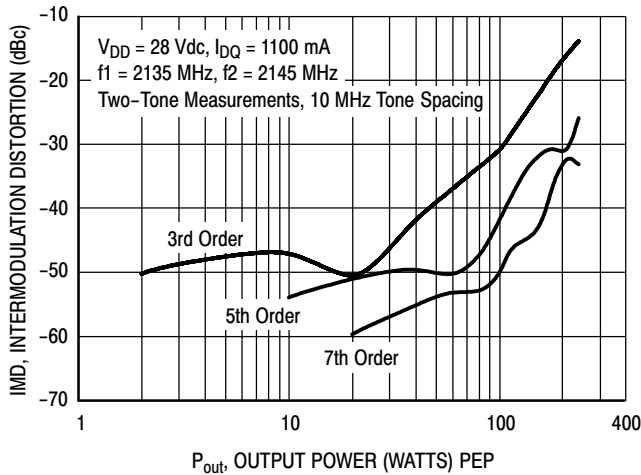


**Figure 5. Two-Tone Power Gain versus Output Power**

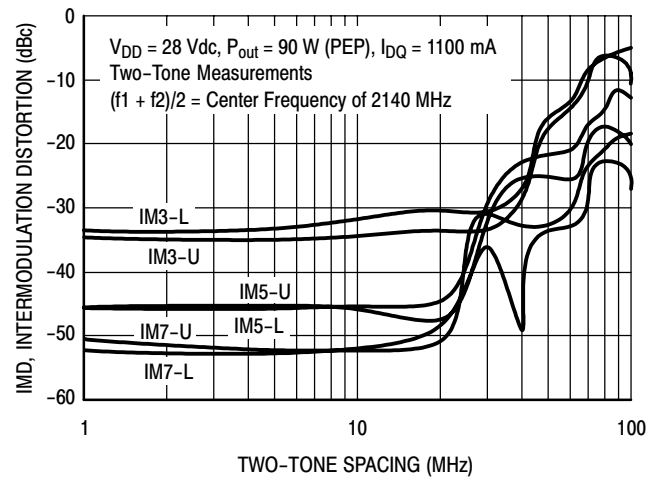


**Figure 6. Third Order Intermodulation Distortion versus Output Power**

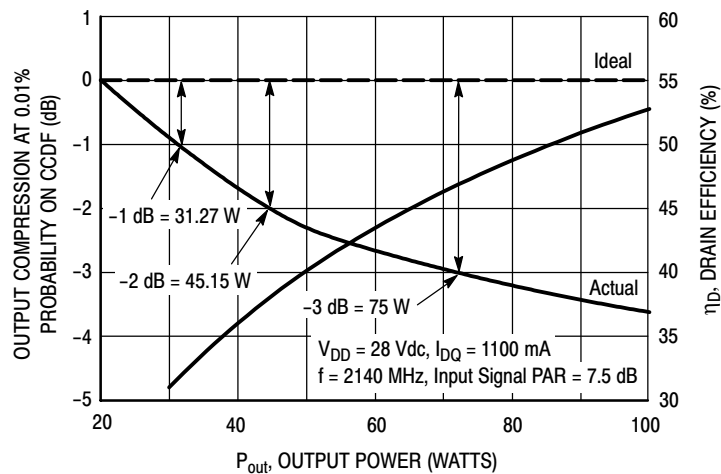
## TYPICAL CHARACTERISTICS



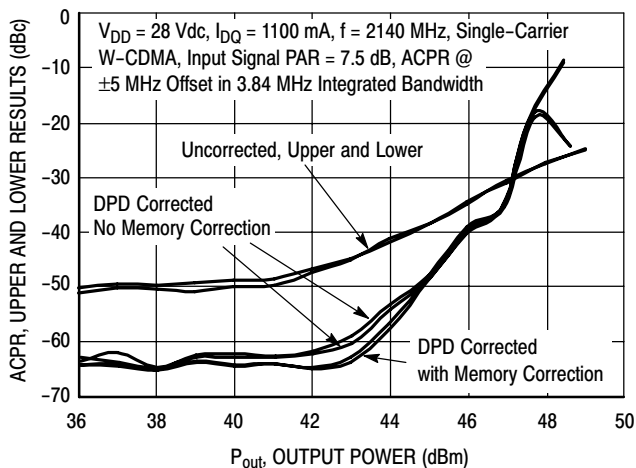
**Figure 7. Intermodulation Distortion Products versus Output Power**



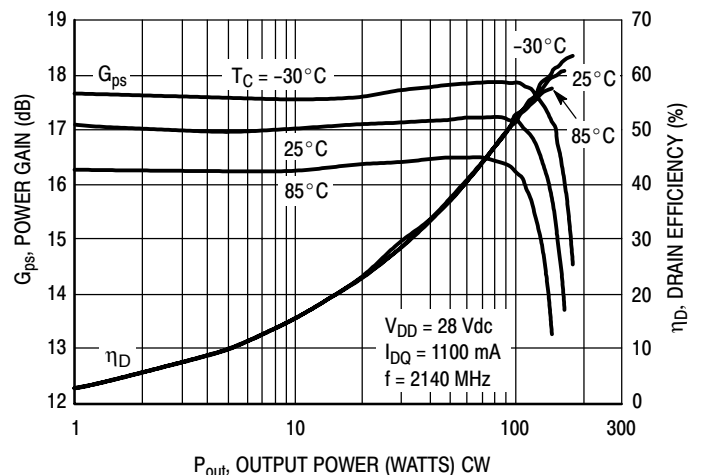
**Figure 8. Intermodulation Distortion Products versus Tone Spacing**



**Figure 9. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**



**Figure 10. Digital Predistortion Correction versus ACPR and Output Power**



**Figure 11. Power Gain and Drain Efficiency versus CW Output Power**

MRF7S21110HR3 MRF7S21110HSR3

## TYPICAL CHARACTERISTICS

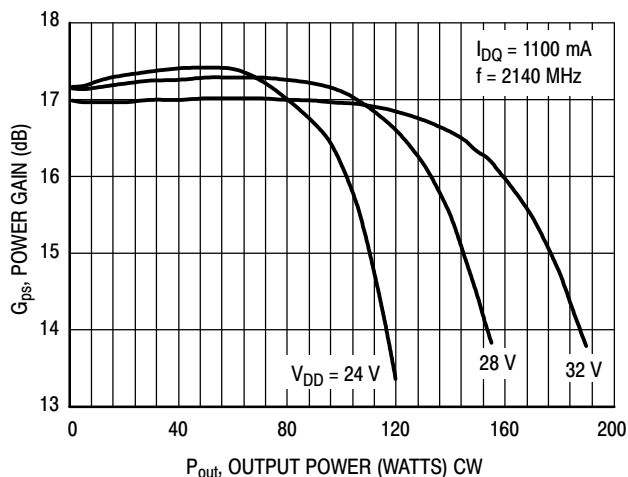
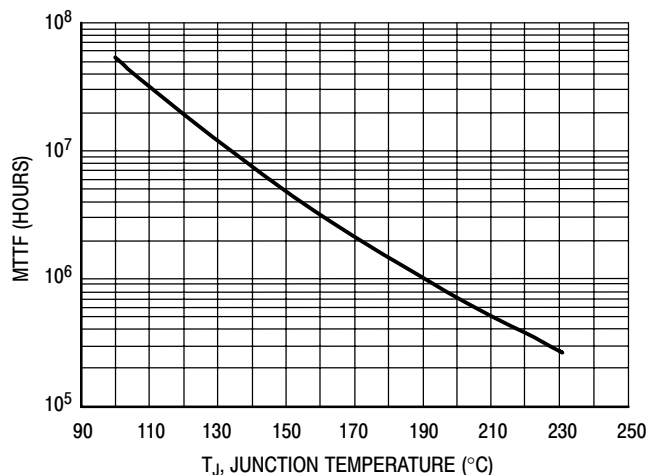


Figure 12. Power Gain versus Output Power



This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 33$  W Avg., and  $\eta_D = 32.5\%$ .

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

Figure 13. MTTF versus Junction Temperature

## W-CDMA TEST SIGNAL

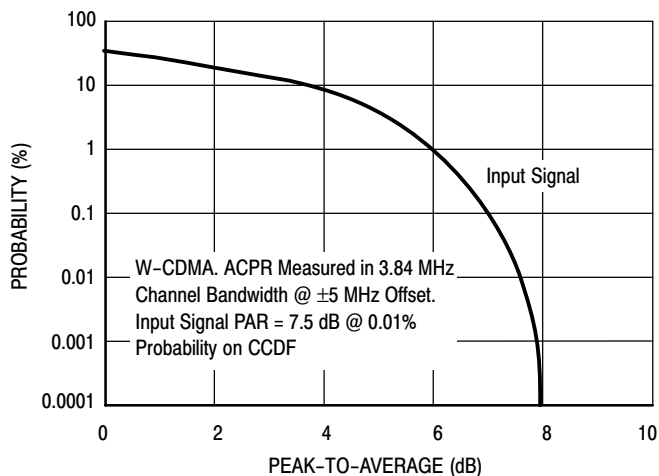


Figure 14. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal

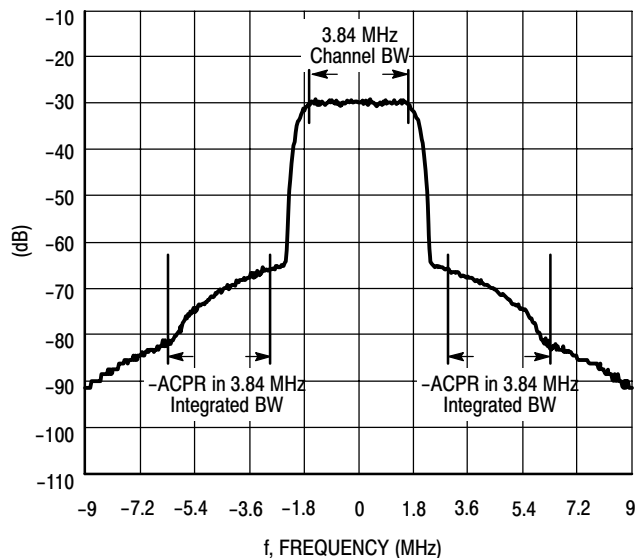
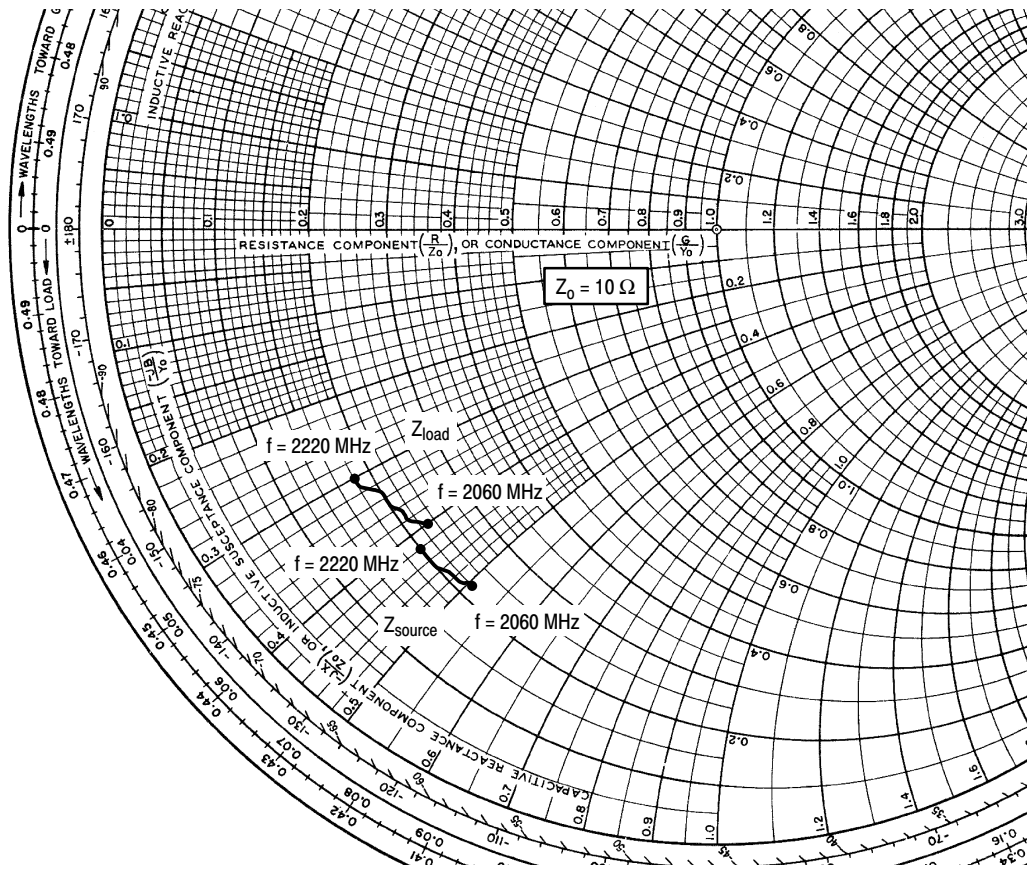


Figure 15. Single-Carrier W-CDMA Spectrum





$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1100 \text{ mA}$ ,  $P_{out} = 33 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 2060     | 2.2 - j5.1               | 2.3 - j4.0             |
| 2080     | 2.2 - j5.0               | 2.2 - j3.9             |
| 2100     | 2.1 - j4.9               | 2.1 - j3.8             |
| 2120     | 2.1 - j4.8               | 2.1 - j3.7             |
| 2140     | 2.1 - j4.7               | 2.0 - j3.5             |
| 2160     | 2.0 - j4.5               | 2.0 - j3.4             |
| 2180     | 2.0 - j4.4               | 2.0 - j3.3             |
| 2200     | 2.0 - j4.3               | 1.8 - j3.1             |
| 2220     | 2.0 - j4.2               | 1.8 - j3.0             |

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

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

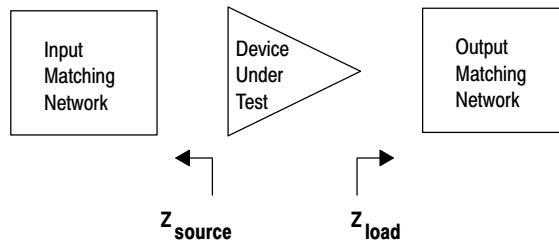
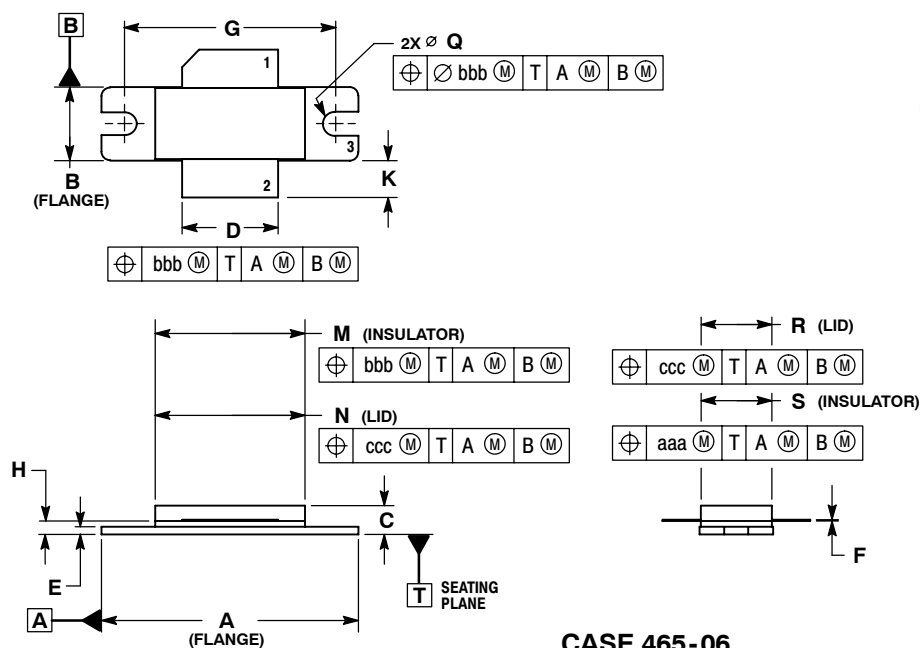


Figure 16. Series Equivalent Source and Load Impedance

## PACKAGE DIMENSIONS

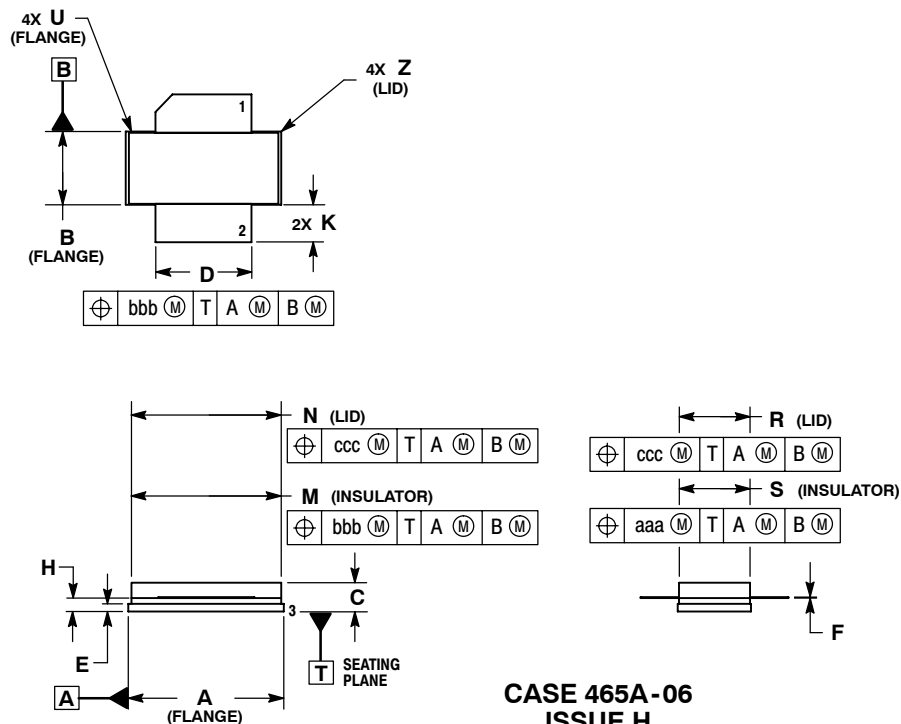


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DELETED
  4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

| DIM | INCHES    |         | MILLIMETERS |        |
|-----|-----------|---------|-------------|--------|
|     | MIN       | MAX     | MIN         | MAX    |
| A   | 1.335     | 1.345   | 33.91       | 34.16  |
| B   | 0.380     | 0.390   | 9.65        | 9.91   |
| C   | 0.125     | 0.170   | 3.18        | 4.32   |
| D   | 0.495     | 0.505   | 12.57       | 12.83  |
| E   | 0.035     | 0.045   | 0.89        | 1.14   |
| F   | 0.003     | 0.006   | 0.08        | 0.15   |
| G   | 1.100 BSC |         | 27.94 BSC   |        |
| H   | 0.057     | 0.067   | 1.45        | 1.70   |
| K   | 0.170     | 0.210   | 4.32        | 5.33   |
| M   | 0.774     | 0.786   | 19.66       | 19.96  |
| N   | 0.772     | 0.788   | 19.60       | 20.00  |
| Q   | ∅ 1.118   | ∅ 1.138 | ∅ 3.00      | ∅ 3.51 |
| R   | 0.365     | 0.375   | 9.27        | 9.53   |
| S   | 0.365     | 0.375   | 9.27        | 9.52   |
| aaa | 0.005 REF |         | 0.127 REF   |        |
| bbb | 0.010 REF |         | 0.254 REF   |        |
| ccc | 0.015 REF |         | 0.381 REF   |        |

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

**CASE 465-06  
 ISSUE G  
 NI-780  
 MRF7S21110HR3**



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DELETED
  4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.805     | 0.815 | 20.45       | 20.70 |
| B   | 0.380     | 0.390 | 9.65        | 9.91  |
| C   | 0.125     | 0.170 | 3.18        | 4.32  |
| D   | 0.495     | 0.505 | 12.57       | 12.83 |
| E   | 0.035     | 0.045 | 0.89        | 1.14  |
| F   | 0.003     | 0.006 | 0.08        | 0.15  |
| H   | 0.057     | 0.067 | 1.45        | 1.70  |
| K   | 0.170     | 0.210 | 4.32        | 5.33  |
| M   | 0.774     | 0.786 | 19.61       | 20.02 |
| N   | 0.772     | 0.788 | 19.61       | 20.02 |
| R   | 0.365     | 0.375 | 9.27        | 9.53  |
| S   | 0.365     | 0.375 | 9.27        | 9.52  |
| U   | ---       | 0.040 | ---         | 1.02  |
| Z   | ---       | 0.030 | ---         | 0.76  |
| aaa | 0.005 REF |       | 0.127 REF   |       |
| bbb | 0.010 REF |       | 0.254 REF   |       |
| ccc | 0.015 REF |       | 0.381 REF   |       |

- STYLE 1:  
 PIN 1. DRAIN  
 2. GATE  
 5. SOURCE

**CASE 465A-06  
 ISSUE H  
 NI-780S  
 MRF7S21110HSR3**

## 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        | Sept. 2007 | <ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul>  |
| 1        | July 2008  | <ul style="list-style-type: none"><li>• Added Input Signal in front of PAR for consistency throughout data sheet p. 2, 6, 7, 8</li><li>• Corrected Table 4, Typical Performances, Output Power Variation over Temperature value from 0.276 to 0.028, p. 3</li><li>• Updated Fig. 14, CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal, to better represent production test signal, p. 8</li></ul> |

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