

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for N-CDMA, GSM and GSM EDGE base station applications with frequencies from 865 to 960 MHz. Suitable for multicarrier amplifier applications.

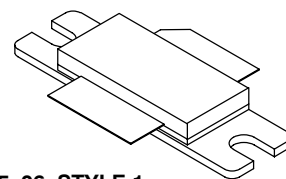
- Typical Single-Carrier N-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 950$  mA,  $P_{out} = 27$  Watts Avg.,  $f = 880$  MHz, IS-95 CDMA (Pilot, Sync, Paging, Traffic Codes 8 Through 13) Channel Bandwidth = 1.2288 MHz. PAR = 9.8 dB @ 0.01% Probability on CCDF.  
Power Gain — 19.2 dB  
Drain Efficiency — 30.5%  
ACPR @ 750 kHz Offset — -47.6 dBc in 30 kHz Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 880 MHz, 3 dB Overdrive, Designed for Enhanced Ruggedness

### Features

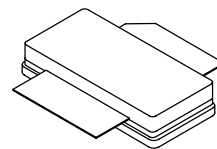
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRFE6S9130HR3**  
**MRFE6S9130HSR3**

**880 MHz, 27 W AVG., 28 V**  
**SINGLE N-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**  
**NI-780**  
**MRFE6S9130HR3**



**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRFE6S9130HSR3**

**Table 1. Maximum Ratings**

| Rating                               | Symbol    | Value        | Unit |
|--------------------------------------|-----------|--------------|------|
| Drain-Source Voltage                 | $V_{DSS}$ | -0.5, +66    | 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   |

**Table 2. Thermal Characteristics**

| Characteristic                                                                                            | Symbol          | Value (2,3)  | Unit |
|-----------------------------------------------------------------------------------------------------------|-----------------|--------------|------|
| Thermal Resistance, Junction to Case<br>Case Temperature 80°C, 130 W CW<br>Case Temperature 75°C, 27 W CW | $R_{\theta JC}$ | 0.45<br>0.51 | °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)    | 1A (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>( $V_{DS} = 66\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 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>( $V_{GS} = 5\text{ Vdc}$ , $V_{DS} = 0\text{ Vdc}$ )              | $I_{GSS}$ | — | — | 10 | $\mu\text{Adc}$ |

**On Characteristics**

|                                                                                                               |              |   |      |     |     |
|---------------------------------------------------------------------------------------------------------------|--------------|---|------|-----|-----|
| Gate Threshold Voltage<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 400\text{ }\mu\text{Adc}$ )                     | $V_{GS(th)}$ | 1 | 2.1  | 3   | Vdc |
| Gate Quiescent Voltage<br>( $V_{DD} = 28\text{ Vdc}$ , $I_D = 950\text{ mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 2 | 2.9  | 4   | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 2.74\text{ Adc}$ )                             | $V_{DS(on)}$ | — | 0.22 | 0.5 | Vdc |

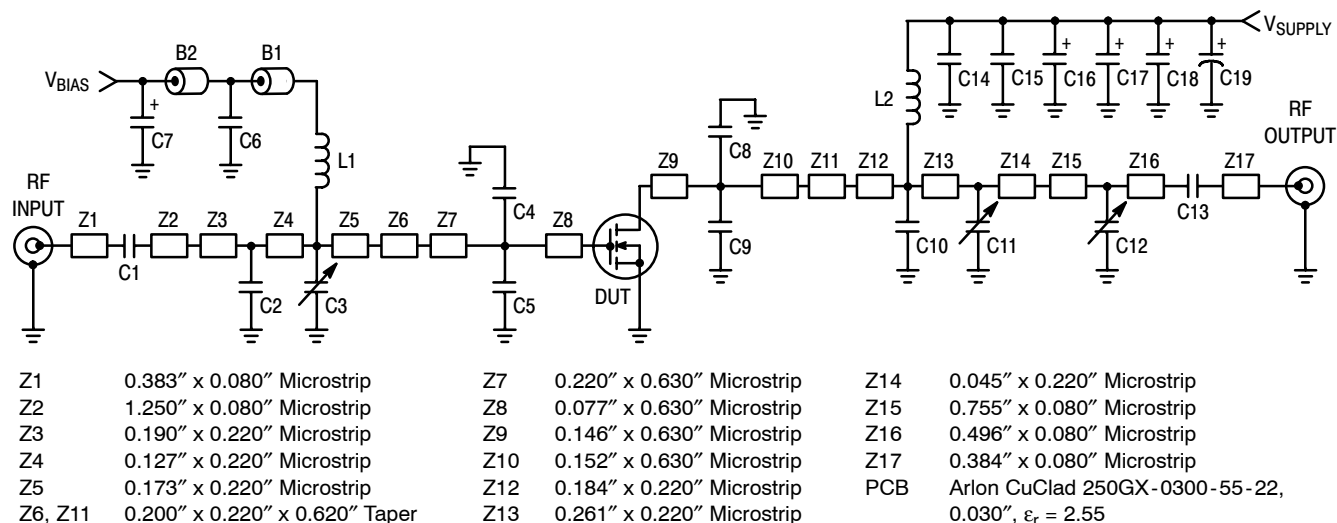
**Dynamic Characteristics <sup>(1)</sup>**

|                                                                                                                       |           |   |     |   |    |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 1.6 | — | pF |
| Output Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )           | $C_{oss}$ | — | 66  | — | pF |

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 950\text{ mA}$ ,  $P_{out} = 27\text{ W Avg. N-CDMA}$ ,  $f = 880\text{ MHz}$ , Single-Carrier N-CDMA, 1.2288 MHz Channel Bandwidth Carrier. ACPR measured in 30 kHz Channel Bandwidth @  $\pm 750\text{ kHz}$  Offset. PAR = 9.8 dB @ 0.01% Probability on CCDF.

|                              |          |    |       |     |     |
|------------------------------|----------|----|-------|-----|-----|
| Power Gain                   | $G_{ps}$ | 18 | 19.2  | 21  | dB  |
| Drain Efficiency             | $\eta_D$ | 29 | 30.5  | —   | %   |
| Adjacent Channel Power Ratio | ACPR     | —  | -47.6 | -46 | dBc |
| Input Return Loss            | IRL      | —  | -29   | -9  | dB  |

1. Part internally input matched.



**Figure 1. MRFE6S9130HR3(SR3) Test Circuit Schematic**

**Table 5. MRFE6S9130HR3(SR3) Test Circuit Component Designations and Values**

| Part              | Description                               | Part Number        | Manufacturer     |
|-------------------|-------------------------------------------|--------------------|------------------|
| B1, B2            | Ferrite Beads, Short                      | 2743019447         | Fair Rite        |
| C1, C13, C14      | 47 pF Chip Capacitors                     | ATC100B470JT500XT  | ATC              |
| C2                | 8.2 pF Chip Capacitor                     | ATC100B8R2BT500XT  | ATC              |
| C3, C11           | 0.8-8.0 pF Variable Capacitors, Gigatrim  | 27291SL            | Johanson         |
| C4, C5            | 12 pF Chip Capacitors                     | ATC100B120JT500XT  | ATC              |
| C6                | 20 K pF Chip Capacitor                    | ATC200B203KT50XT   | ATC              |
| C7, C16, C17, C18 | 10 $\mu$ F, 35 V Tantalum Chip Capacitors | T491D106K035AT     | Kemet            |
| C8, C9            | 10 pF Chip Capacitors                     | ATC100B7R5JT500XT  | ATC              |
| C10               | 11 pF Chip Capacitor                      | ATC100B110JT500XT  | ATC              |
| C12               | 0.6-4.5 pF Variable Capacitor, Gigatrim   | 27271SL            | Johanson         |
| C15               | 0.56 $\mu$ F, 50 V Chip Capacitor         | C1825C564J5GAC     | Kemet            |
| C19               | 470 $\mu$ F, 63 V Electrolytic Capacitor  | ESME630ELL471MK25S | United Chemi-Con |
| L1, L2            | 12.5 nH Inductors                         | A04T-5             | Coilcraft        |

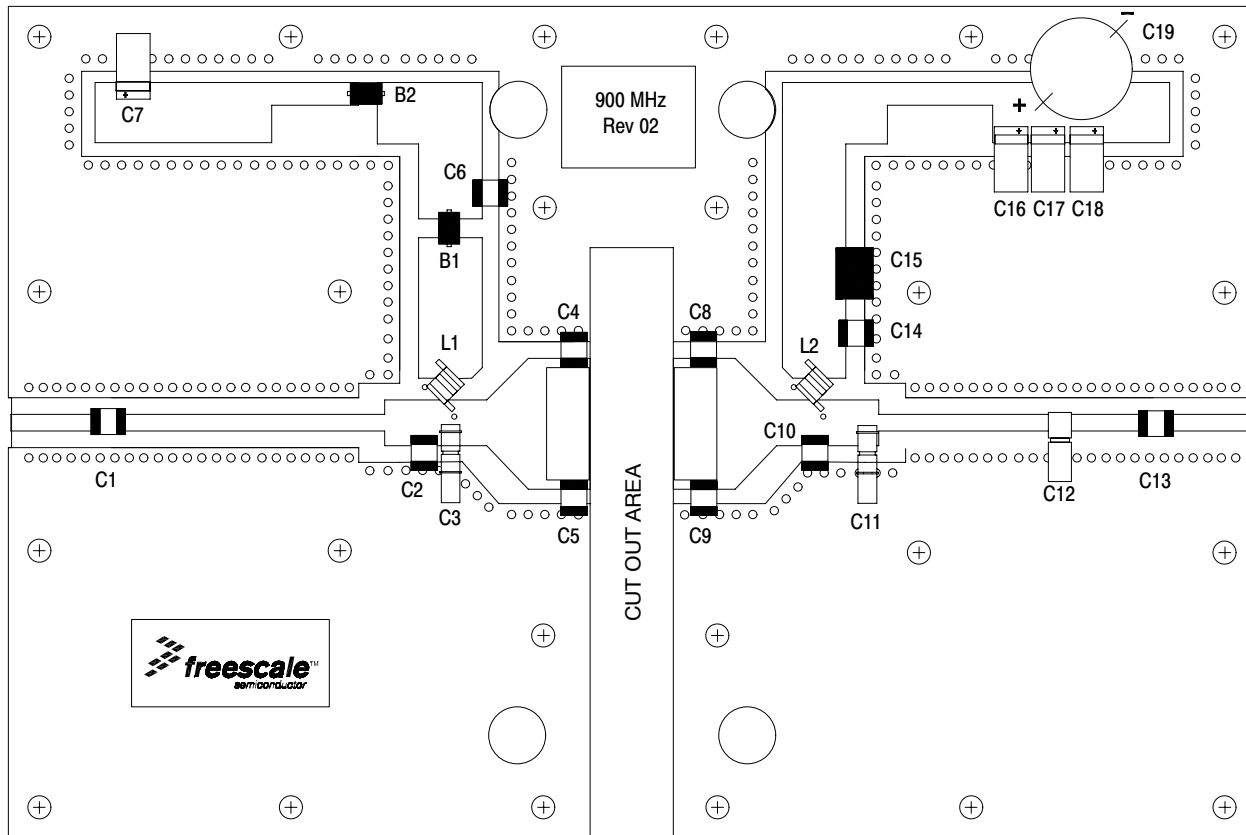


Figure 2. MRFE6S9130HR3(SR3) Test Circuit Component Layout

## TYPICAL CHARACTERISTICS

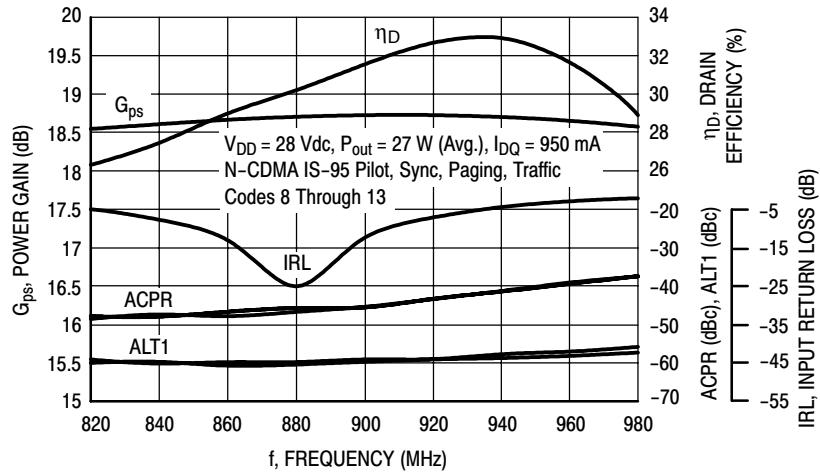


Figure 3. Single-Carrier N-CDMA Broadband Performance @  $P_{out} = 27$  Watts Avg.

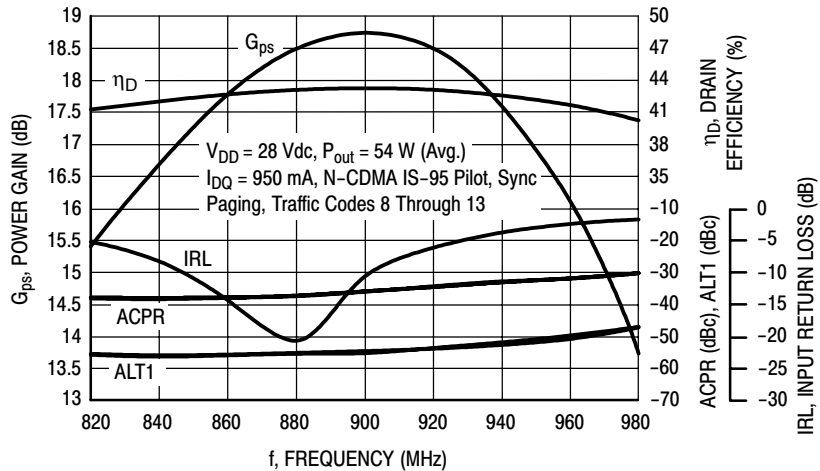


Figure 4. Single-Carrier N-CDMA Broadband Performance @  $P_{out} = 54$  Watts Avg.

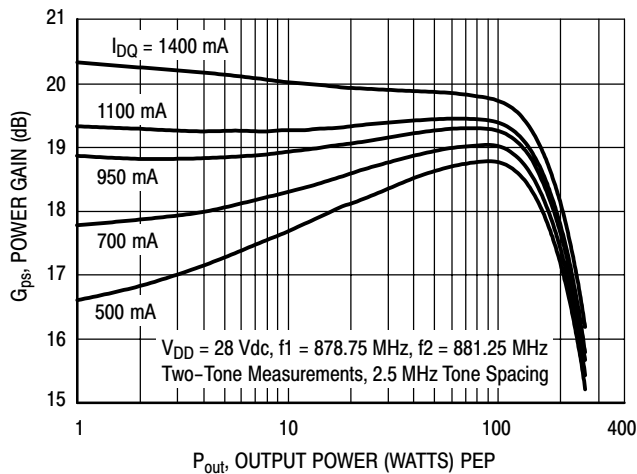


Figure 5. Two-Tone Power Gain versus Output Power

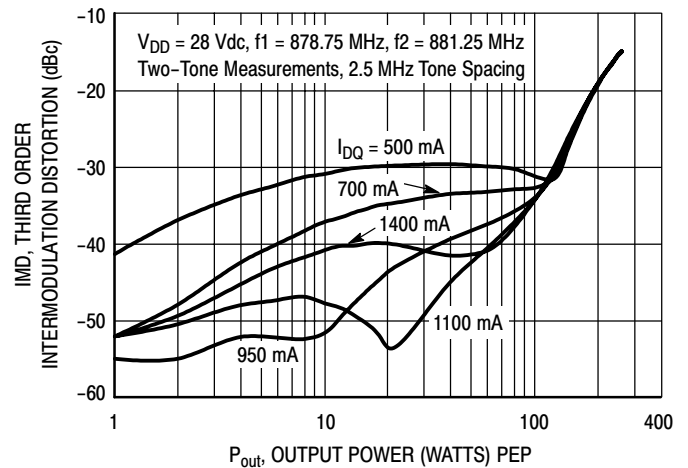
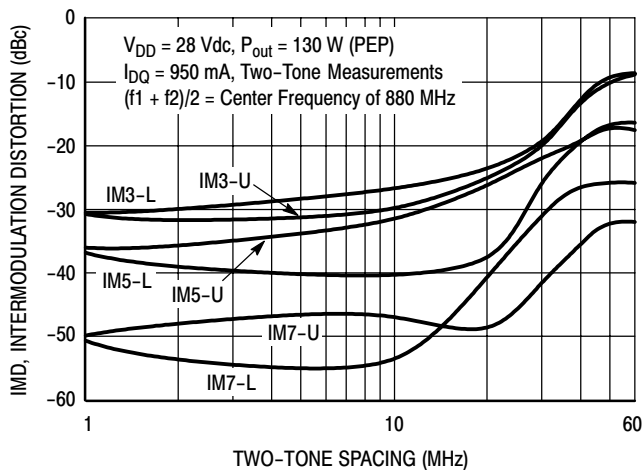
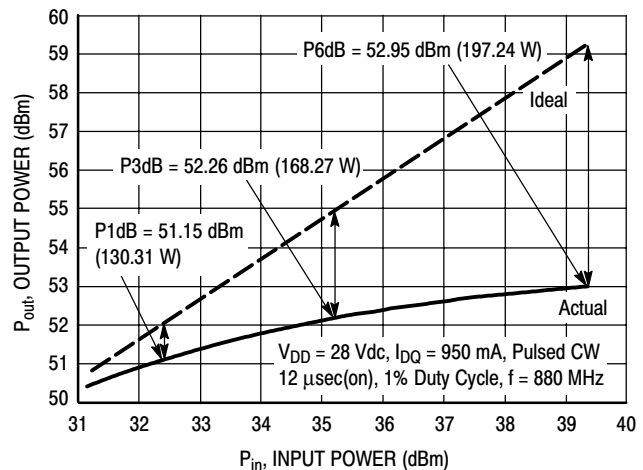


Figure 6. Third Order Intermodulation Distortion versus Output Power

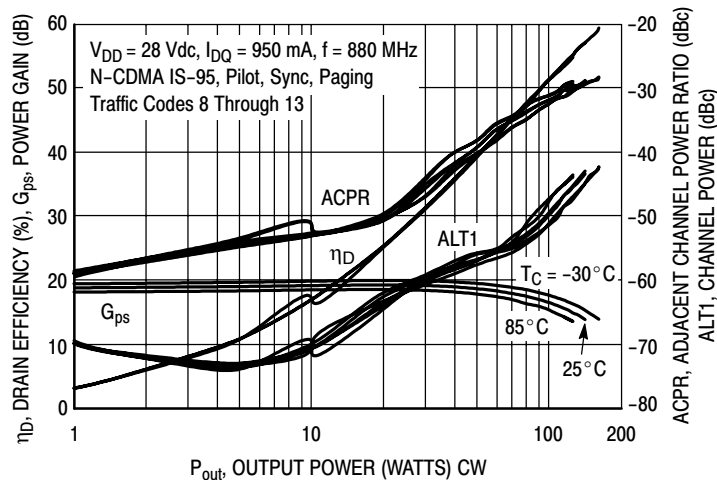
## TYPICAL CHARACTERISTICS



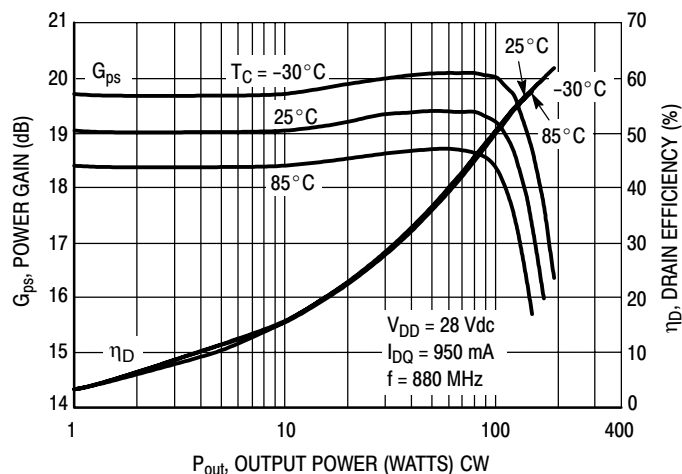
**Figure 7. Intermodulation Distortion Products versus Tone Spacing**



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

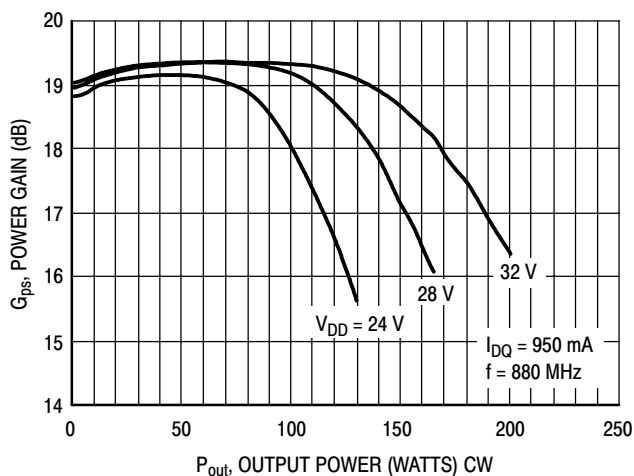


**Figure 9. Single-Carrier N-CDMA ACPR, ALT1, Power Gain and Drain Efficiency versus Output Power**

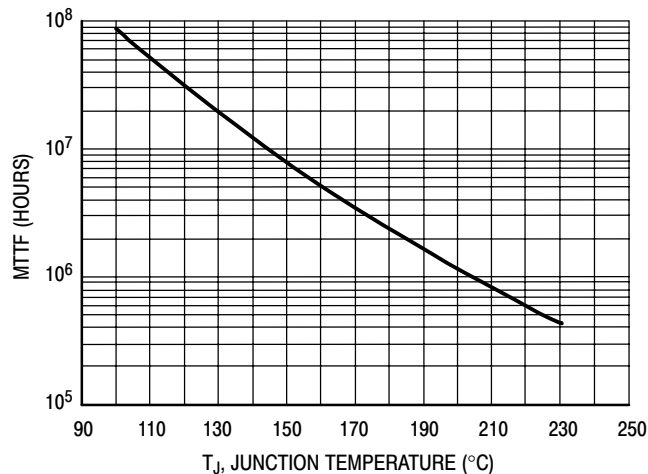


**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**

## TYPICAL CHARACTERISTICS



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

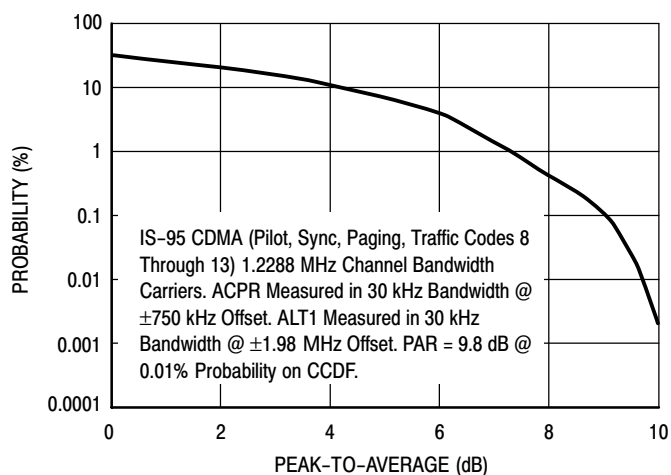


This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 27$  W Avg., and  $\eta_D = 30.5\%$ .

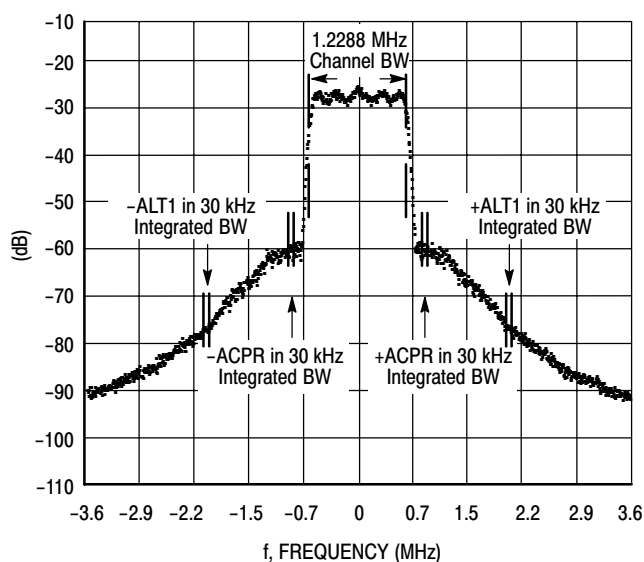
MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

**Figure 12. MTTF versus Junction Temperature**

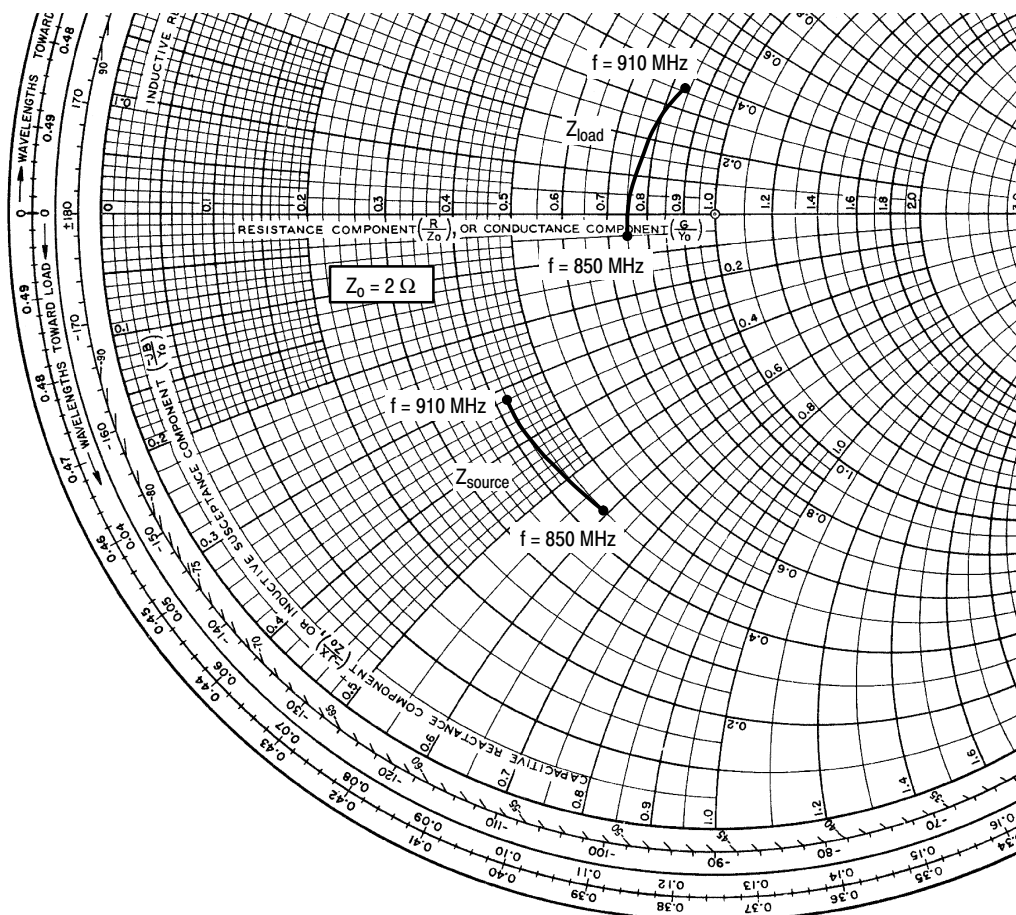
## N-CDMA TEST SIGNAL



**Figure 13. Single-Carrier CCDF N-CDMA**



**Figure 14. Single-Carrier N-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 950 \text{ mA}$ ,  $P_{out} = 27 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 850      | $0.89 - j1.18$           | $1.50 - j0.09$         |
| 865      | $0.87 - j1.03$           | $1.52 + j0.11$         |
| 880      | $0.85 - j0.89$           | $1.55 + j0.31$         |
| 895      | $0.83 - j0.75$           | $1.60 + j0.51$         |
| 910      | $0.84 - j0.64$           | $1.68 + j0.71$         |

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

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

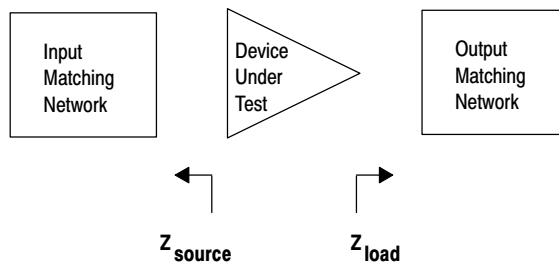
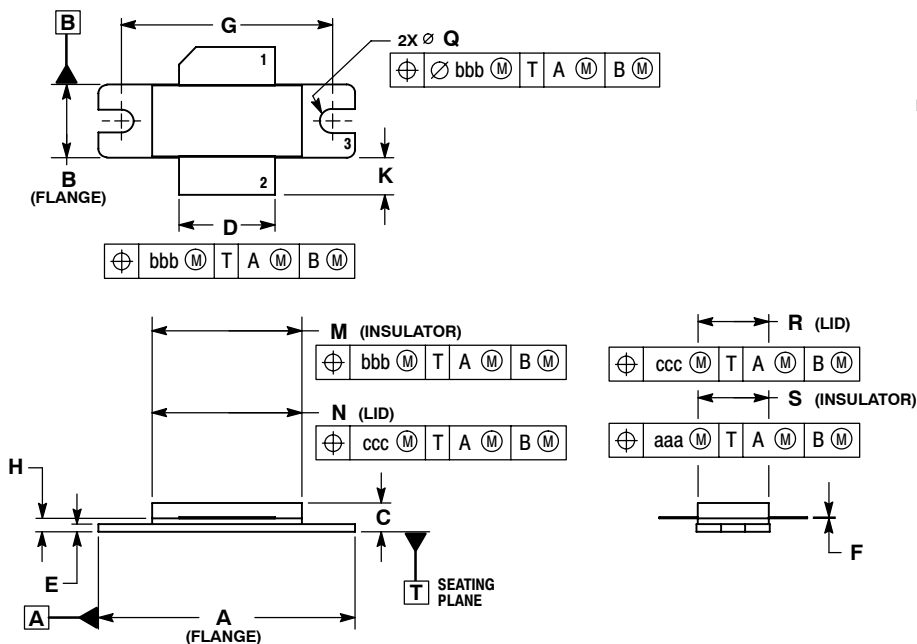


Figure 15. Series Equivalent Source and Load Impedance

## PACKAGE DIMENSIONS



### NOTES:

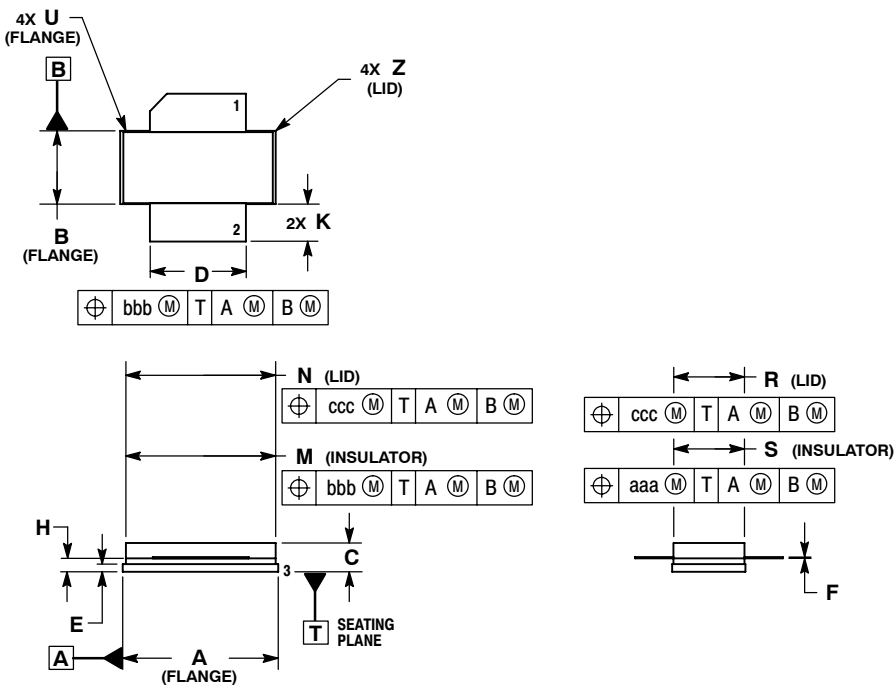
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

| 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   | Ø 0.118   | Ø 0.138 | Ø 3.00      | Ø 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
- GATE
- SOURCE

**CASE 465-06  
ISSUE G  
NI-780  
MRFE6S9130HR3**



### 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
- GATE
- SOURCE

**CASE 465A-06  
ISSUE H  
NI-780S  
MRFE6S9130HSR3**

## 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        | April 2007 | <ul style="list-style-type: none"> <li>• Initial Release of Data Sheet</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 1        | Dec. 2008  | <ul style="list-style-type: none"> <li>• Updated Full Frequency Band in Typical Performance bullet to <math>f = 880</math> MHz to match actual production test, p. 1</li> <li>• Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related "Continuous use at maximum temperature will affect MTTF" footnote added, 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>• Updated PCB information to show more specific material details, Fig. 1, Test Circuit Schematic, p. 3</li> </ul> |

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