

# 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.

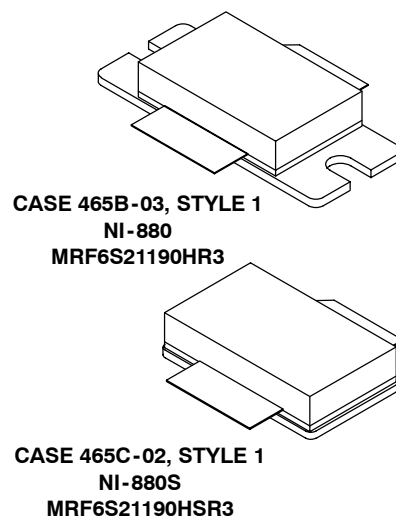
- Typical Single-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1600$  mA,  $P_{out} = 54$  Watts Avg., Full Frequency Band, 3GPP Test Model 1, 64 DPCH with 50% Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 16 dB  
Drain Efficiency — 29%  
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, 175 Watts CW Output Power

### 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
- Designed for Digital Predistortion Error Correction Systems
- Designed for Lower Memory Effects and Wide Instantaneous Bandwidth Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF6S21190HR3**  
**MRF6S21190HSR3**

**2110-2170 MHz, 54 W AVG., 28 V**  
**SINGLE W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**



**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       |
| 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                               | $T_J$     | 200          | °C        |
| CW Operation @ $T_C = 25^\circ\text{C}$<br>Derate above 25°C | CW        | 175<br>1     | W<br>W/°C |

**Table 2. Thermal Characteristics**

| Characteristic                                                                                            | Symbol          | Value (1,2)  | Unit |
|-----------------------------------------------------------------------------------------------------------|-----------------|--------------|------|
| Thermal Resistance, Junction to Case<br>Case Temperature 85°C, 120 W CW<br>Case Temperature 83°C, 56 W CW | $R_{\theta JC}$ | 0.29<br>0.30 | °C/W |

- MTTF calculator available at <http://www.freescal Semiconductor.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
- Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescal Semiconductor.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>( $V_{DS} = 68\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 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>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 420\text{ }\mu\text{Adc}$ )                      | $V_{GS(th)}$ | 1    | 2    | 3    | Vdc |
| Gate Quiescent Voltage<br>( $V_{DD} = 28\text{ Vdc}$ , $I_D = 1600\text{ mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 2    | 2.8  | 4    | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 4.2\text{ Adc}$ )                               | $V_{DS(on)}$ | 0.12 | 0.21 | 0.31 | Vdc |

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

|                                                                                                                        |           |   |     |   |    |
|------------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )  | $C_{rss}$ | — | 2.8 | — | pF |
| Output Equivalent Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{out}$ | — | 185 | — | pF |
| Input Capacitance<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)             | $C_{iss}$ | — | 526 | — | pF |

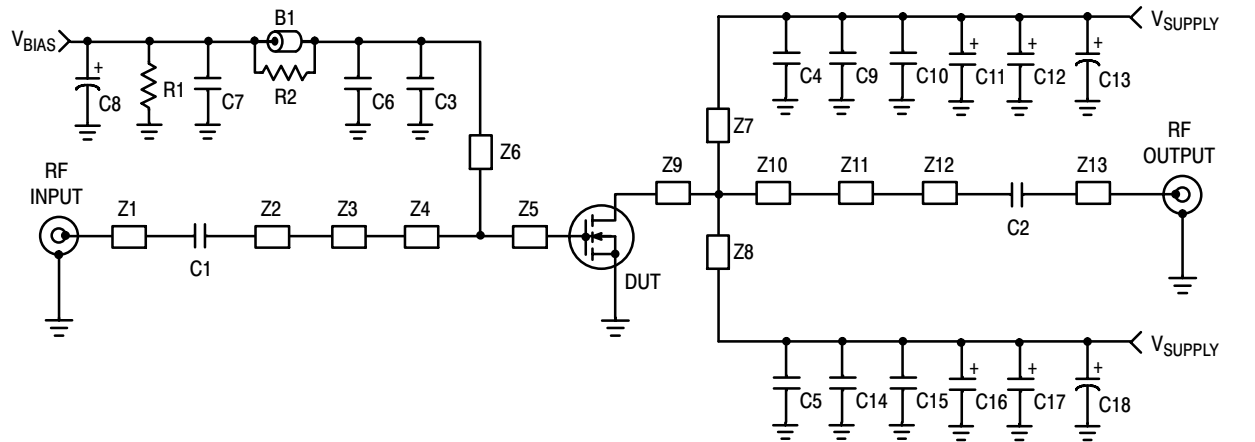
**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1600\text{ mA}$ ,  $P_{out} = 54\text{ W Avg.}$ ,  $f = 2112.5\text{ MHz}$  and  $f = 2167.5\text{ MHz}$ , Single-Carrier W-CDMA, 3GPP Test Model 1, 64 DPCH, 50% Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset.

|                                                          |          |      |     |      |     |
|----------------------------------------------------------|----------|------|-----|------|-----|
| Power Gain                                               | $G_{ps}$ | 14.5 | 16  | 17.5 | dB  |
| Drain Efficiency                                         | $\eta_D$ | 26   | 29  | —    | %   |
| Output Peak-to-Average Ratio @ 0.01% Probability on CCDF | PAR      | 5.5  | 6.1 | —    | dB  |
| Adjacent Channel Power Ratio                             | ACPR     | —    | -38 | -35  | dBc |
| Input Return Loss                                        | IRL      | —    | -13 | -8   | dB  |

**Typical Performances** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1600\text{ mA}$ , 2110-2170 MHz Bandwidth

|                                                                                                                                                                                                                |              |   |       |   |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---|-------|---|-------|
| Video Bandwidth @ 175 W PEP $P_{out}$ where $IM3 = -30\text{ dBc}$<br>(Tone Spacing from 100 kHz to VBW) $\Delta IM3 = IM3 @ \text{VBW}$<br>frequency - $IM3 @ 100\text{ kHz} < 1\text{ dBc}$ (both sidebands) | VBW          | — | 50    | — | MHz   |
| Gain Flatness in 60 MHz Bandwidth @ $P_{out} = 54\text{ W Avg.}$                                                                                                                                               | $G_F$        | — | 0.16  | — | dB    |
| Average Deviation from Linear Phase in 60 MHz Bandwidth<br>@ $P_{out} = 175\text{ W CW}$                                                                                                                       | $\Phi$       | — | 0.52  | — | °     |
| Average Group Delay @ $P_{out} = 175\text{ W CW}$ , $f = 2140\text{ MHz}$                                                                                                                                      | Delay        | — | 2.1   | — | ns    |
| Part-to-Part Insertion Phase Variation @ $P_{out} = 175\text{ W CW}$ ,<br>$f = 2140\text{ MHz}$                                                                                                                | $\Delta\Phi$ | — | 28    | — | °     |
| Gain Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )                                                                                                                              | $\Delta G$   | — | 0.016 | — | dB/°C |

1. Part internally matched both on input and output.



|        |                            |     |                                                            |
|--------|----------------------------|-----|------------------------------------------------------------|
| Z1     | 0.744" x 0.084" Microstrip | Z9  | 0.145" x 1.320" Microstrip                                 |
| Z2     | 0.632" x 0.084" Microstrip | Z10 | 0.508" x 0.320" Microstrip                                 |
| Z3     | 0.400" x 0.450" Microstrip | Z11 | 0.429" x 0.279" Microstrip                                 |
| Z4     | 0.042" x 0.580" Microstrip | Z12 | 0.322" x 0.084" Microstrip                                 |
| Z5     | 0.322" x 0.580" Microstrip | Z13 | 0.735" x 0.084" Microstrip                                 |
| Z6     | 0.313" x 0.040" Microstrip | PCB | Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$ |
| Z7, Z8 | 0.123" x 0.121" Microstrip |     |                                                            |

**Figure 1. MRF6S21190HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF6S21190HR3(HSR3) Test Circuit Component Designations and Values**

| Part               | Description                               | Part Number        | Manufacturer     |
|--------------------|-------------------------------------------|--------------------|------------------|
| B1                 | Short Ferrite Bead                        | 2743019447         | Fairrite         |
| C1, C4, C5         | 8.2 pF Chip Capacitors                    | ATC100B8R2JT500XT  | ATC              |
| C2                 | 47 pF Chip Capacitor                      | ATC100B470JT500XT  | ATC              |
| C3                 | 10 pF Chip Capacitor                      | ATC100B100JT500XT  | ATC              |
| C6                 | 56 pF Chip Capacitor                      | ATC100B560JT500XT  | ATC              |
| C7, C9, C14        | 0.1 $\mu$ F Chip Capacitors               | CDR33BX104AKYS     | Kemet            |
| C8                 | 10 $\mu$ F, 50 V Electrolytic Capacitor   | EMVY500ADA100MF55G | Nippon Chemi-Con |
| C10, C15           | 10 $\mu$ F Chip Capacitors                | GRM55DR61H106KA88  | Murata           |
| C11, C12, C16, C17 | 22 $\mu$ F Tantalum Capacitors            | T491X226K035AT     | Kemet            |
| C13, C18           | 220 $\mu$ F, 50 V Electrolytic Capacitors | EMVY500ADA221MJA0G | Nippon Chemi-Con |
| R1                 | 1.0 k $\Omega$ , 1/4 W Chip Resistor      | CRCW12061001FKEA   | Vishay           |
| R2                 | 10 $\Omega$ , 1/4 W Chip Resistor         | CRCW120610R0FKEA   | Vishay           |

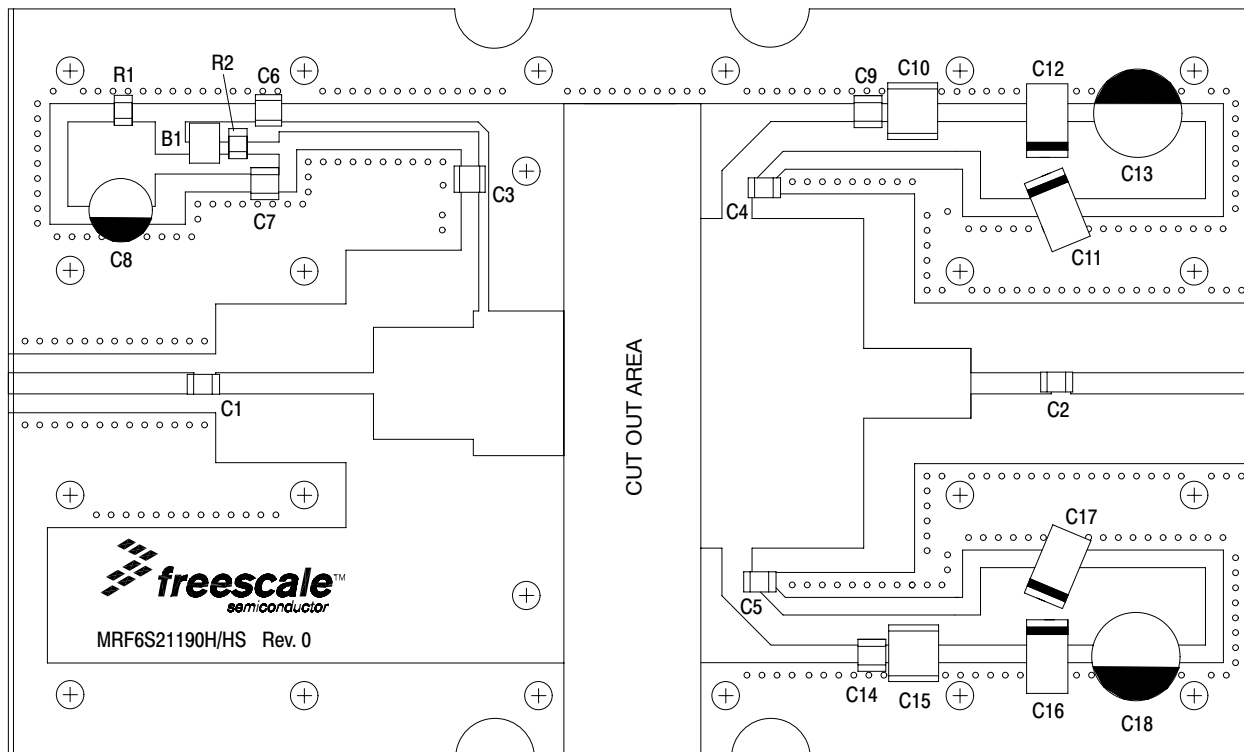
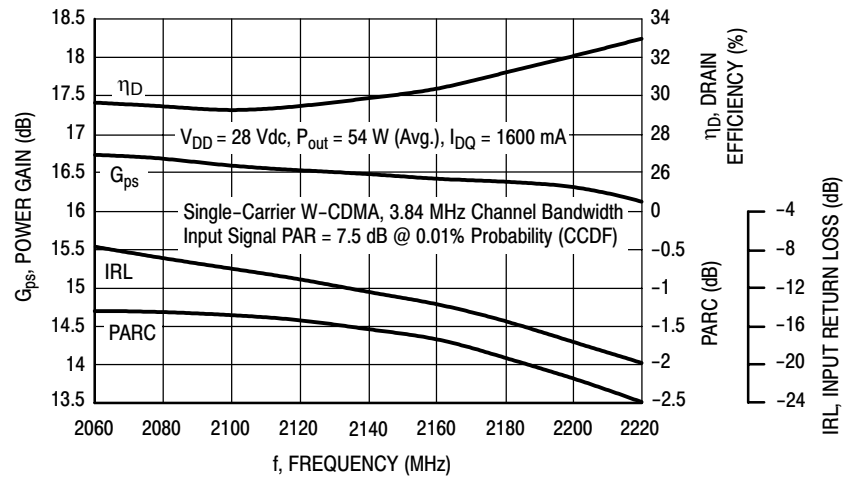
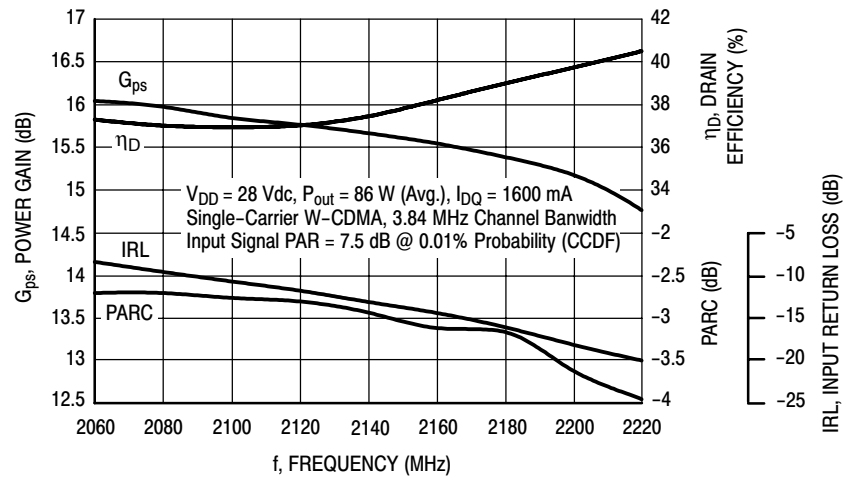


Figure 2. MRF6S21190HR3(HSR3) Test Circuit Component Layout

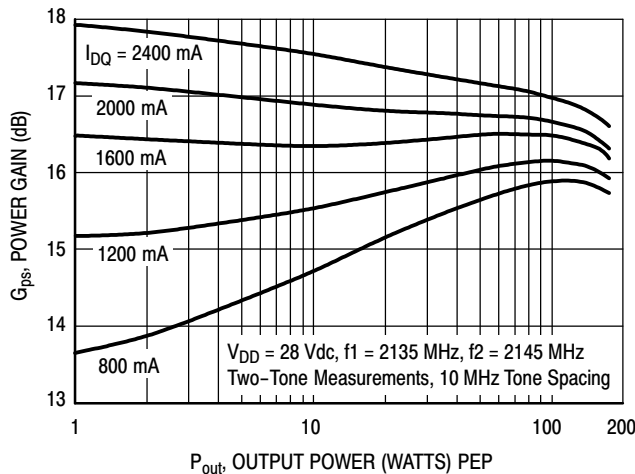
## TYPICAL CHARACTERISTICS



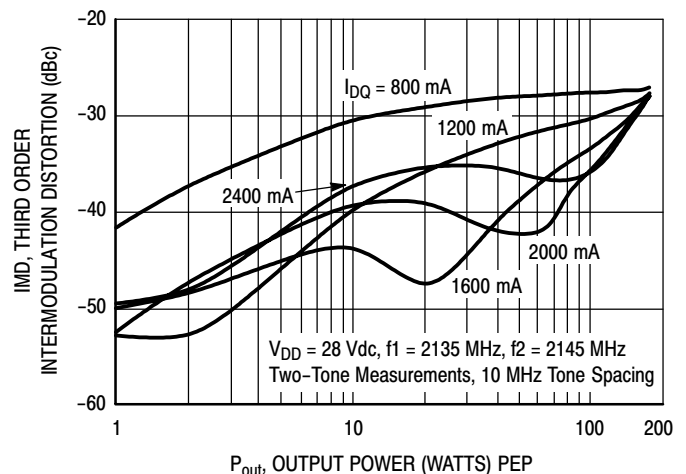
**Figure 3. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 54$  Watts Avg.**



**Figure 4. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @  $P_{out} = 86$  Watts Avg.**



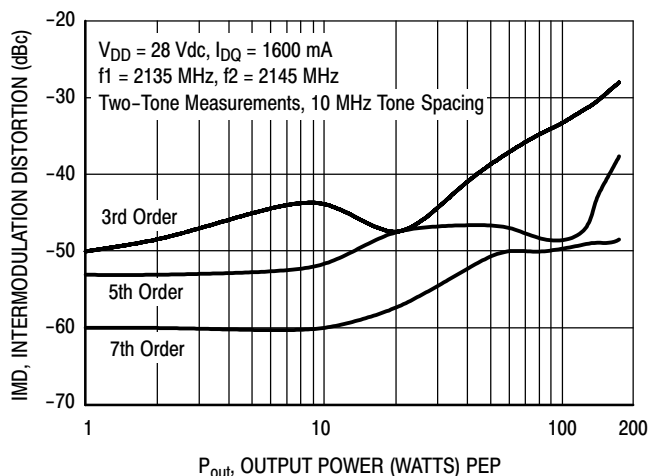
**Figure 5. Two-Tone Power Gain versus Output Power**



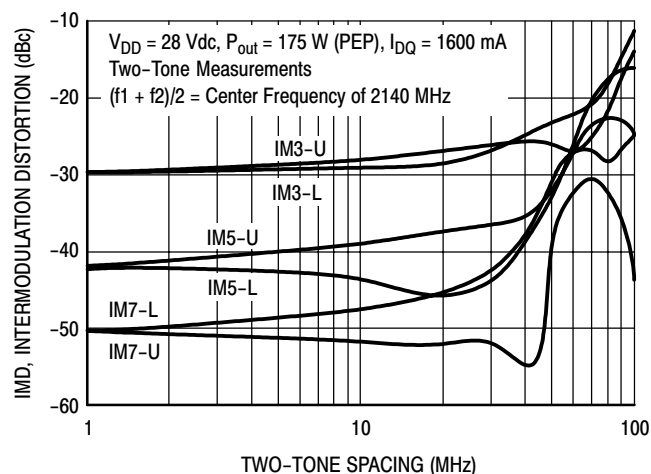
**Figure 6. Third Order Intermodulation Distortion versus Output Power**

MRF6S21190HR3 MRF6S21190HSR3

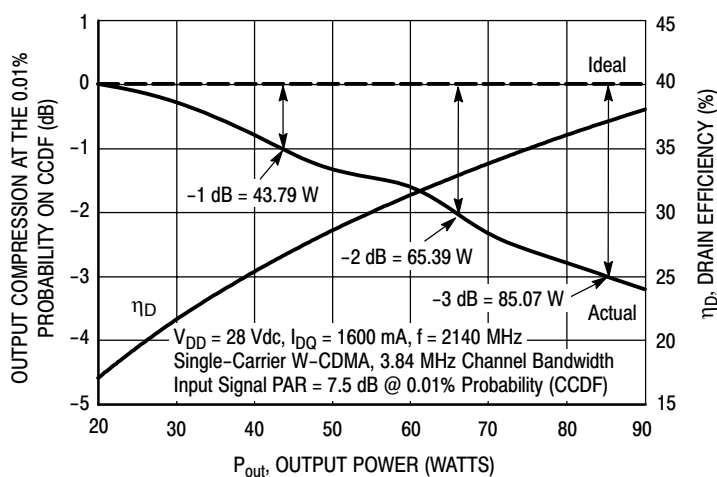
## TYPICAL CHARACTERISTICS



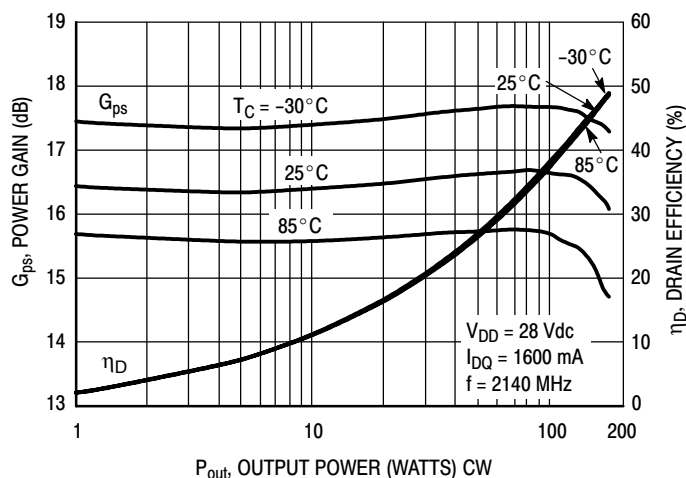
**Figure 7. Intermodulation Distortion Products versus Output Power**



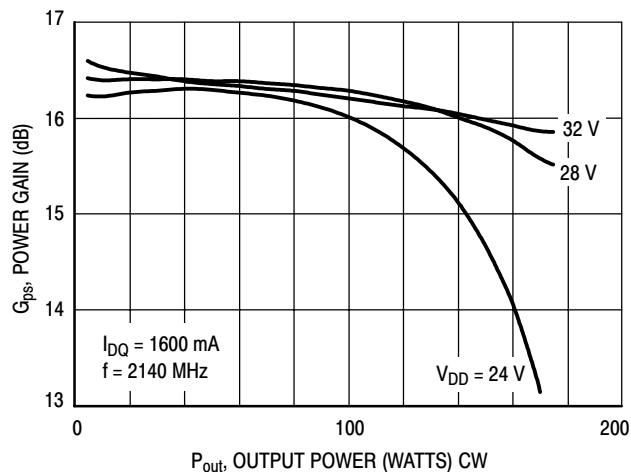
**Figure 8. Intermodulation Distortion Products versus Tone Spacing**



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

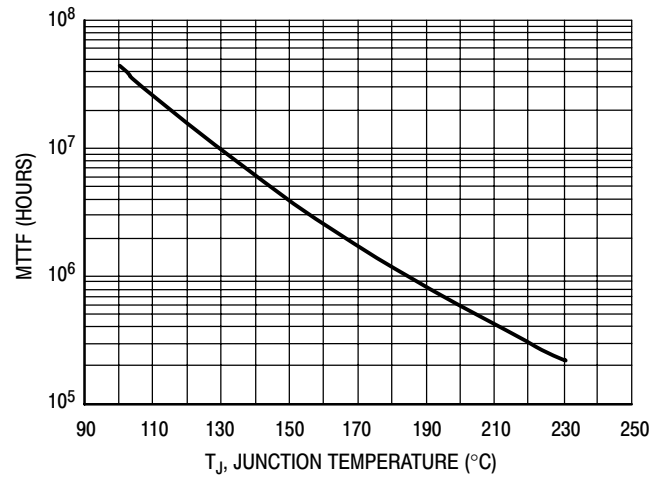


**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**



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

## TYPICAL CHARACTERISTICS

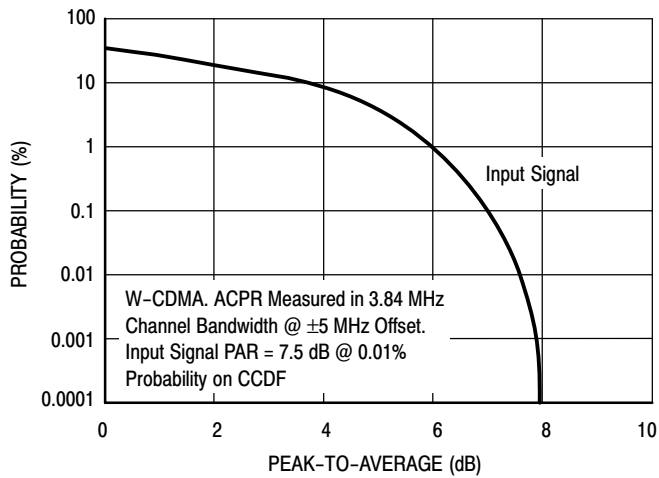


This above graph displays calculated MTTF in hours when the device is operated at  $V_{DD} = 28$  Vdc,  $P_{out} = 54$  W Avg., and  $\eta_D = 29\%$ .

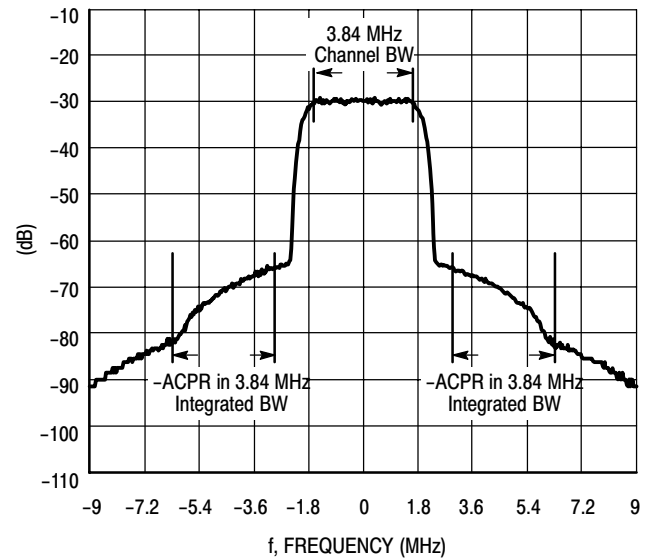
MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

**Figure 12. MTTF versus Junction Temperature**

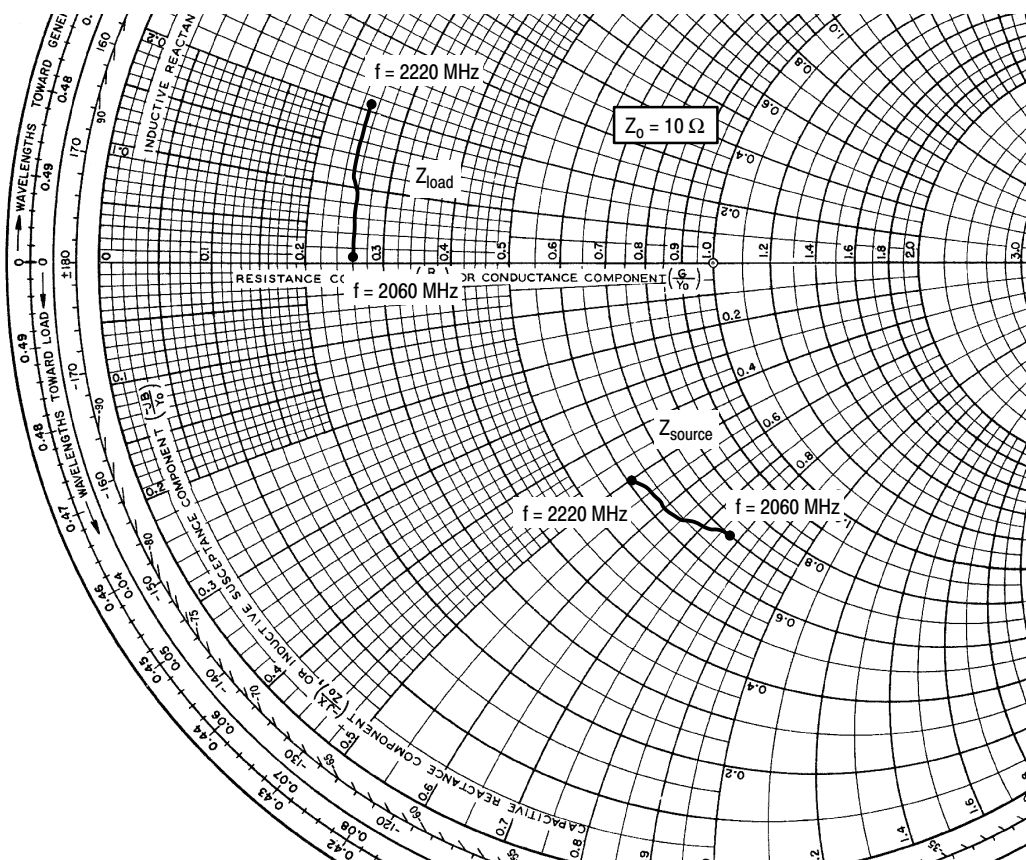
## W-CDMA TEST SIGNAL



**Figure 13. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal**



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



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1600 \text{ mA}$ ,  $P_{out} = 54 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 2060     | $7.001 - j7.706$         | $2.628 + j0.118$       |
| 2080     | $6.859 - j7.408$         | $2.602 + j0.415$       |
| 2100     | $6.710 - j7.052$         | $2.604 + j0.672$       |
| 2120     | $6.573 - j6.707$         | $2.566 + j0.901$       |
| 2140     | $6.446 - j6.355$         | $2.536 + j1.175$       |
| 2160     | $6.339 - j5.987$         | $2.538 + j1.411$       |
| 2180     | $6.251 - j5.653$         | $2.547 + j1.654$       |
| 2200     | $6.170 - j5.272$         | $2.533 + j1.892$       |
| 2220     | $6.138 - j4.974$         | $2.508 + j2.119$       |

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

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

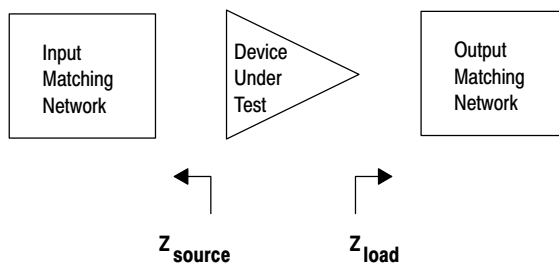
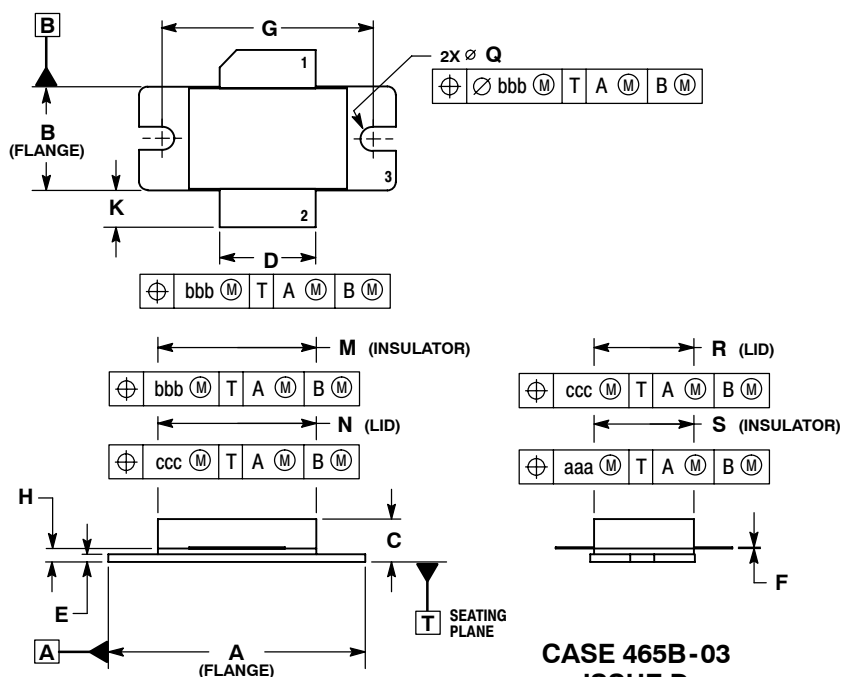


Figure 15. Series Equivalent Source and Load Impedance

## PACKAGE DIMENSIONS

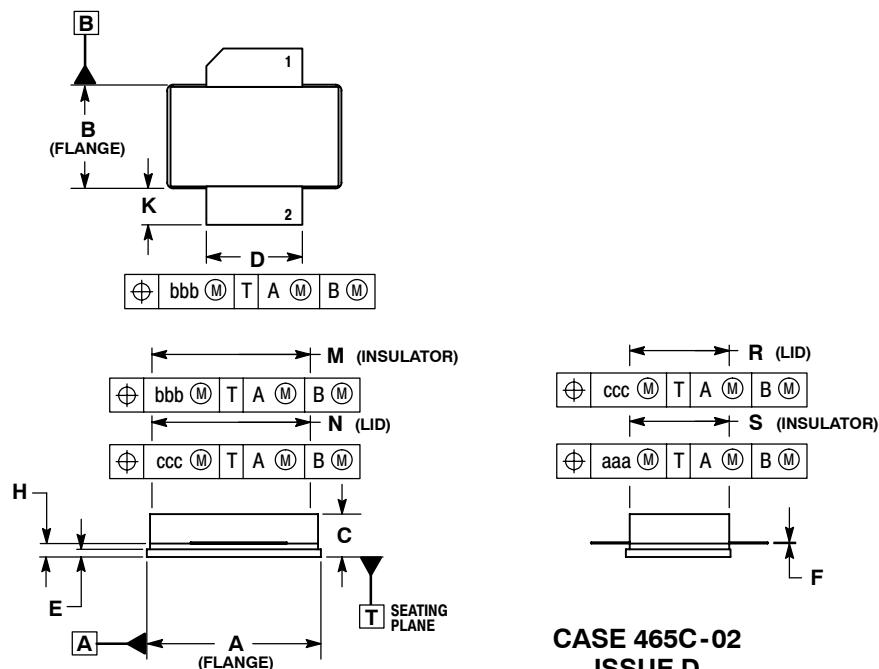


**CASE 465B-03  
ISSUE D  
NI-880  
MRF6S21190HR3**

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

| DIM | INCHES |       | MILLIMETERS |        |
|-----|--------|-------|-------------|--------|
|     | MIN    | MAX   | MIN         | MAX    |
| A   | 1.335  | 1.345 | 33.91       | 34.16  |
| B   | 0.535  | 0.545 | 13.6        | 13.8   |
| C   | 0.147  | 0.200 | 3.73        | 5.08   |
| 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   | 0.872  | 0.888 | 22.15       | 22.55  |
| N   | 0.871  | 0.889 | 19.30       | 22.60  |
| Q   | Ø.118  | Ø.138 | Ø.3.00      | Ø.3.51 |
| R   | 0.515  | 0.525 | 13.10       | 13.30  |
| S   | 0.515  | 0.525 | 13.10       | 13.30  |
| aaa | 0.007  | REF   | 0.178       | 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 465C-02  
ISSUE D  
NI-880S  
MRF6S21190HSR3**

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

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.905  | 0.915 | 22.99       | 23.24 |
| B   | 0.535  | 0.545 | 13.60       | 13.80 |
| C   | 0.147  | 0.200 | 3.73        | 5.08  |
| 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   | 0.872  | 0.888 | 22.15       | 22.55 |
| N   | 0.871  | 0.889 | 19.30       | 22.60 |
| R   | 0.515  | 0.525 | 13.10       | 13.30 |
| S   | 0.515  | 0.525 | 13.10       | 13.30 |
| aaa | 0.007  | REF   | 0.178       | REF   |
| bbb | 0.010  | REF   | 0.254       | REF   |
| ccc | 0.015  | REF   | 0.381       | REF   |

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

## 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        | Feb. 2008 | • Initial Release of Data Sheet                         |
| 1        | Mar. 2008 | • Added Fig. 12, MTTF versus Junction Temperature, p. 7 |

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Japan  
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