

# 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.

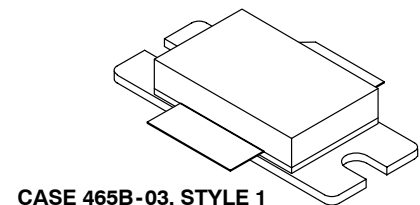
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1300$  mA,  $P_{out} = 33$  Watts Avg., Full Frequency Band, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 12.5 dB  
Efficiency — 25%  
IM3 @ 10 MHz Offset — -37 dBc in 3.84 MHz Channel Bandwidth  
ACPR @ 5 MHz Offset — -39 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2140 MHz, 125 Watts CW Output Power

### Features

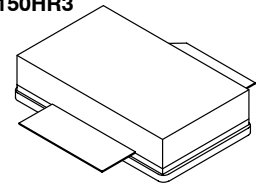
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40 $\mu$ m Nominal.
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF5S21150HR3**  
**MRF5S21150HSR3**

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



**CASE 465B-03, STYLE 1**  
**NI-880**  
**MRF5S21150HR3**



**CASE 465C-02, STYLE 1**  
**NI-880S**  
**MRF5S21150HSR3**

**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 $25^\circ\text{C}$ | $P_D$     | 380<br>2.2   | 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          | $^\circ\text{C}$         |
| CW Operation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$             | CW        | 150<br>0.84  | W<br>W/ $^\circ\text{C}$ |

**Table 2. Thermal Characteristics**

| Characteristic                                                                                                                          | Symbol          | Value (1,2)  | Unit               |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------|--------------------|
| Thermal Resistance, Junction to Case<br>Case Temperature $80^\circ\text{C}$ , 100 W CW<br>Case Temperature $75^\circ\text{C}$ , 33 W CW | $R_{\theta JC}$ | 0.46<br>0.47 | $^\circ\text{C/W}$ |

1. MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.
2. 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 Conditions     | Class        |
|---------------------|--------------|
| Human Body Model    | 1 (Minimum)  |
| Machine Model       | M3 (Minimum) |
| Charge Device Model | C7 (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>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 360\text{ }\mu\text{Adc}$ ) | $V_{GS(th)}$ | 2.5 | —    | 3.5 | Vdc |
| Gate Quiescent Voltage<br>( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1300\text{ mAdc}$ )         | $V_{GS(Q)}$  | —   | 3.7  | —   | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 3.6\text{ Adc}$ )          | $V_{DS(on)}$ | —   | 0.26 | 0.3 | Vdc |
| Forward Transconductance<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 3.6\text{ Adc}$ )         | $g_{fs}$     | —   | 9    | —   | S   |

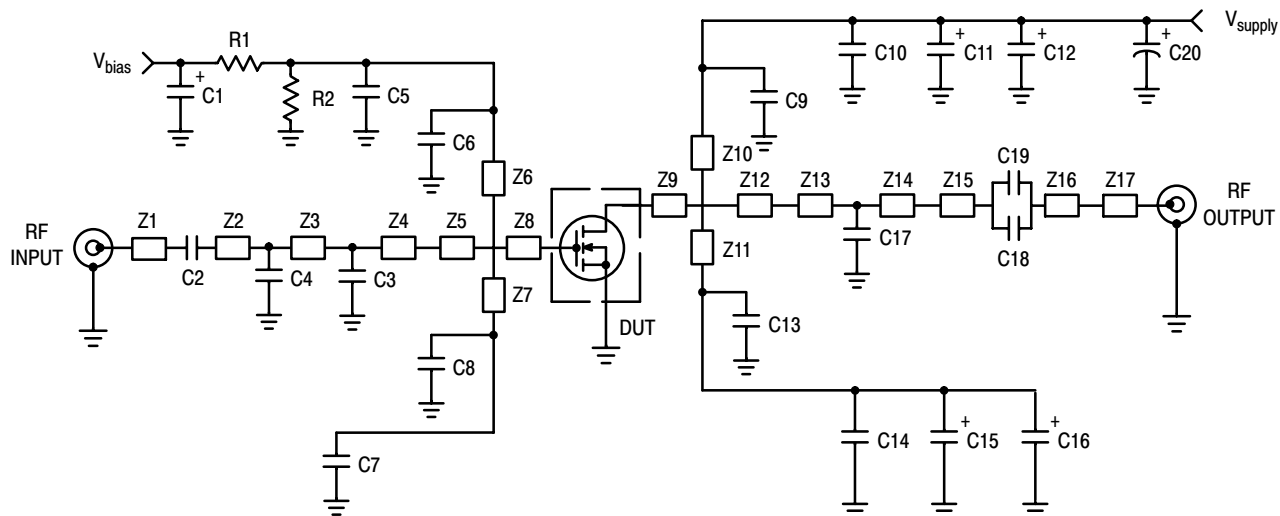
**Dynamic Characteristics <sup>(1)</sup>**

|                                                                                                                       |           |   |     |   |    |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 3.2 | — | pF |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1300\text{ mA}$ ,  $P_{out} = 33\text{ W Avg.}$ ,  $f_1 = 2112.5\text{ MHz}$ ,  $f_2 = 2122.5\text{ MHz}$  and  $f_1 = 2157.5\text{ MHz}$ ,  $f_2 = 2167.5\text{ MHz}$ , 2-carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @  $\pm 5\text{ MHz}$  Offset. IM3 measured in 3.84 MHz Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

|                              |          |    |      |     |     |
|------------------------------|----------|----|------|-----|-----|
| Power Gain                   | $G_{ps}$ | 11 | 12.5 | —   | dB  |
| Drain Efficiency             | $\eta_D$ | 23 | 25   | —   | %   |
| Intermodulation Distortion   | IM3      |    | -37  | -35 | dBc |
| Adjacent Channel Power Ratio | ACPR     | —  | -39  | -37 | dBc |
| Input Return Loss            | IRL      | —  | -12  | -9  | dB  |

1. Part internally matched both on input and output.



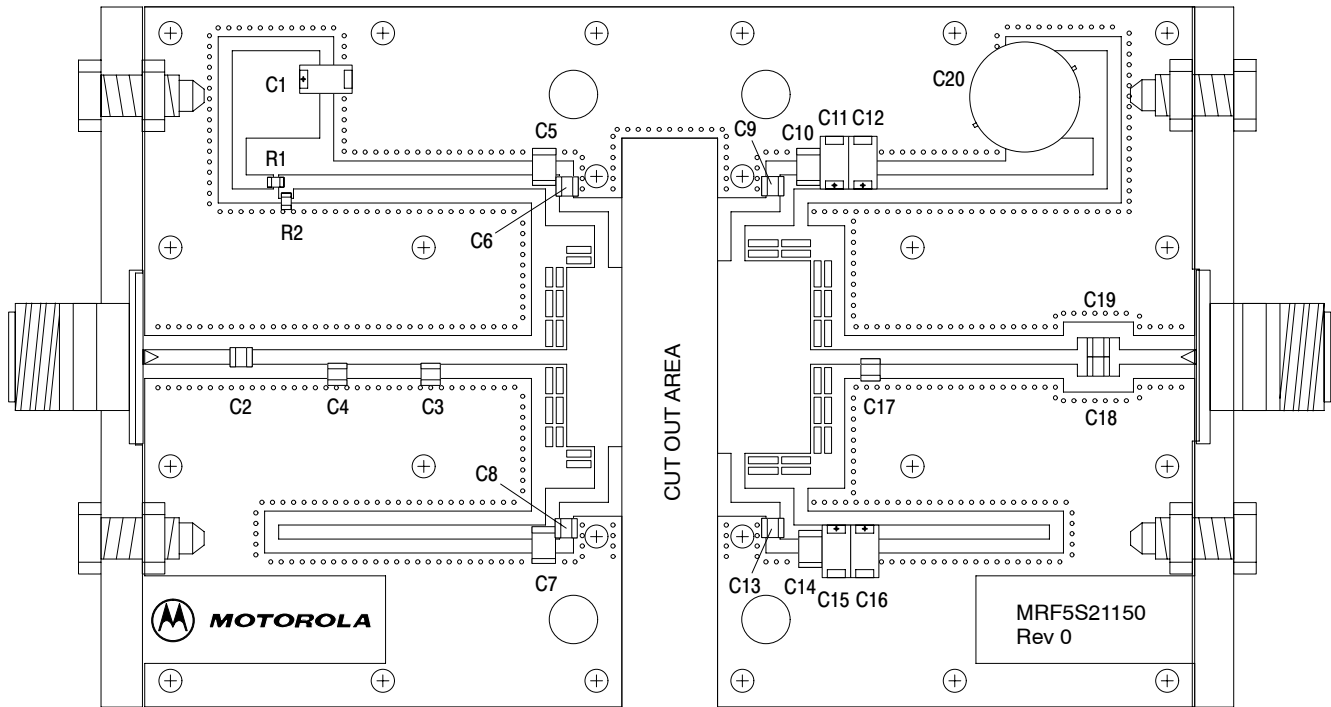
Z1 0.500" x 0.083" Microstrip  
 Z2 0.505" x 0.083" Microstrip  
 Z3 0.536" x 0.083" Microstrip  
 Z4 0.776" x 0.083" Microstrip  
 Z5 0.119" x 1.024" Microstrip  
 Z6, Z7 0.749" x 0.083" Microstrip  
 Z8 0.117" x 1.024" Microstrip  
 Z9 0.117" x 1.100" Microstrip

Z10, Z11 0.709" x 0.083" Microstrip  
 Z12 0.415" x 1.100" Microstrip  
 Z13 0.874" x 0.083" Microstrip  
 Z14 1.182" x 0.083" Microstrip  
 Z15, Z16 0.070" x 0.220" Microstrip  
 Z17 0.430" x 0.083" Microstrip  
 PCB Taconic TLX8, 0.030",  $\epsilon_r = 2.55$

**Figure 1. MRF5S21150HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF5S21150HR3(HSR3) Test Circuit Component Designations and Values**

| Part                          | Description                                      | Part Number    | Manufacturer      |
|-------------------------------|--------------------------------------------------|----------------|-------------------|
| C1                            | 22 $\mu$ F, 35 V Tantalum Capacitor              | TAJE226M035R   | AVX               |
| C2, C6, C8, C9, C13, C18, C19 | 6.8 pF 100B Chip Capacitors                      | 100B6R8CW      | ATC               |
| C3, C4                        | 1.8 pF 100B Chip Capacitors                      | 100B1R8BW      | ATC               |
| C5, C7, C10, C14              | 220 nF Chip Capacitors (1812)                    | 1812Y224KXA    | Vishay - Vitramon |
| C11, C12, C15, C16            | 10 $\mu$ F, 35 V Tantalum Capacitors             | 293D1106X9035D | Vishay - Sprague  |
| C17                           | 0.3 pF Chip Capacitor                            | 100B0R3BW      | ATC               |
| C20                           | 470 $\mu$ F, 63 V Electrolytic Capacitor, Radial | 13661471       | Philips           |
| R1, R2                        | 10 k $\Omega$ , 1/4 W Chip Resistors             |                |                   |



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**Figure 2. MRF5S21150HR3(HSR3) Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS

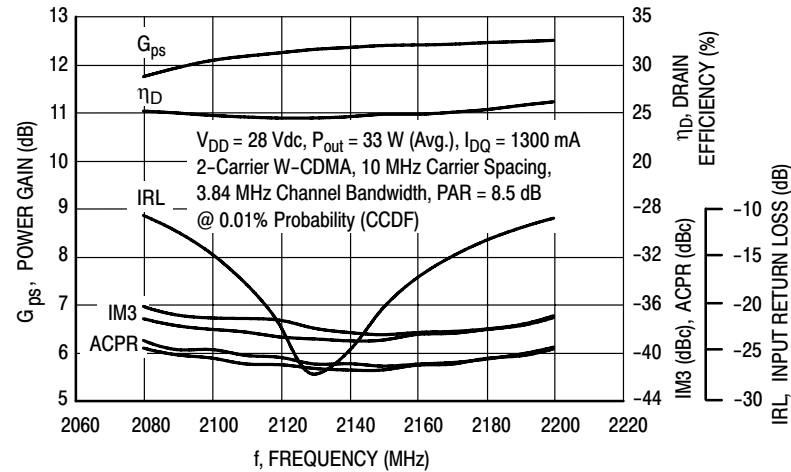


Figure 3. 2-Carrier W-CDMA Broadband Performance @  $P_{out} = 33$  Watts Avg.

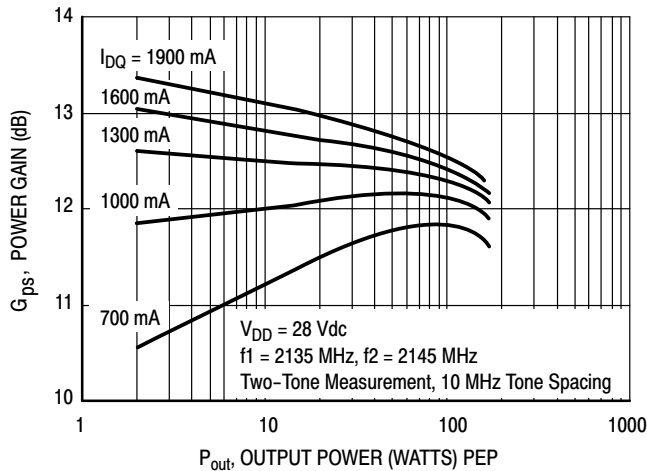


Figure 4. Two-Tone Power Gain versus Output Power

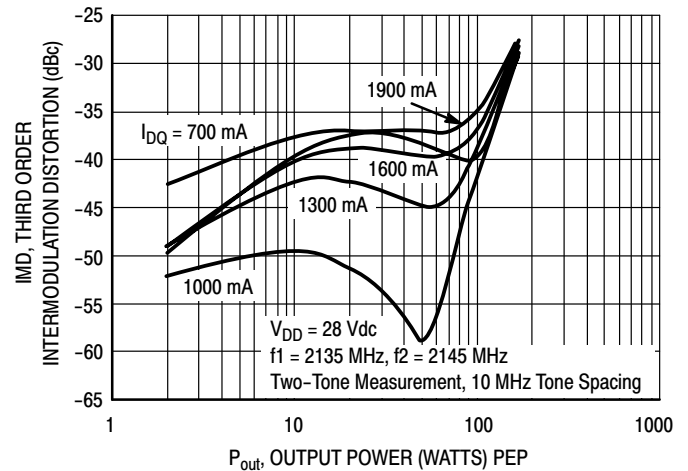


Figure 5. Third Order Intermodulation Distortion versus Output Power

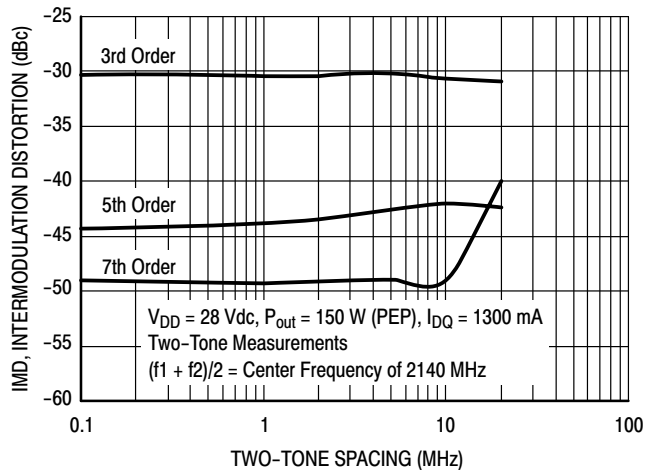


Figure 6. Intermodulation Distortion Products versus Tone Spacing

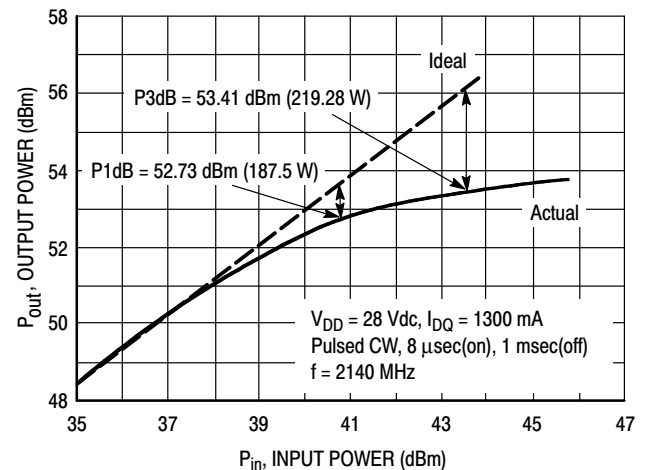
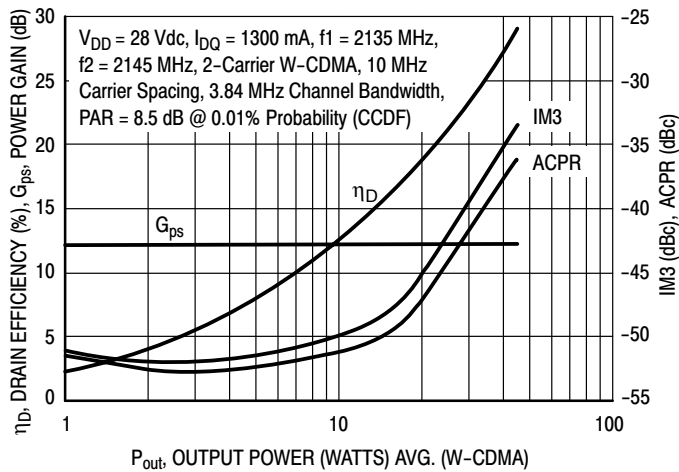
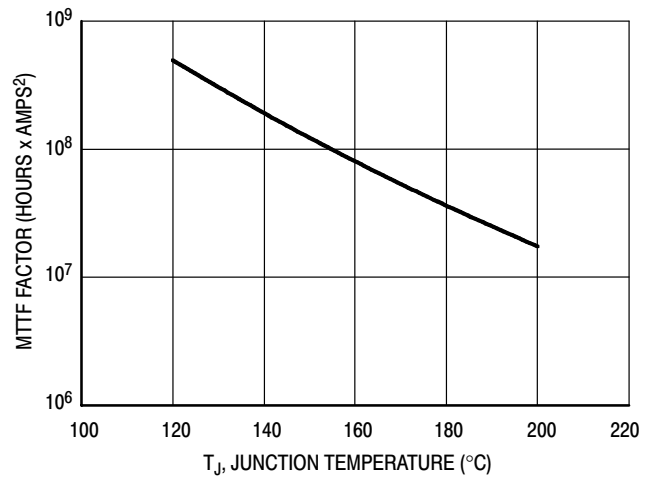


Figure 7. Pulse CW Output Power versus Input Power

## TYPICAL CHARACTERISTICS



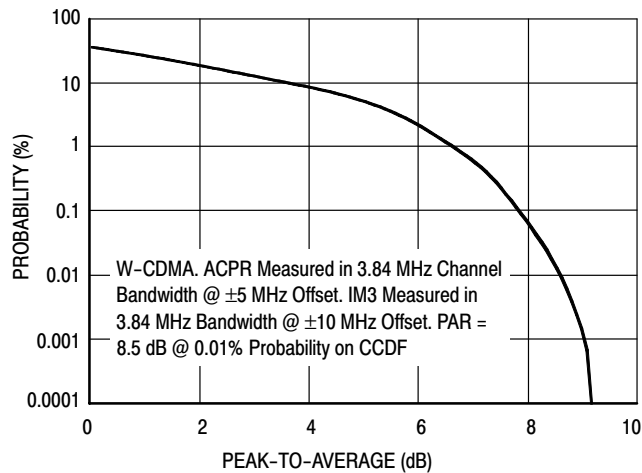
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



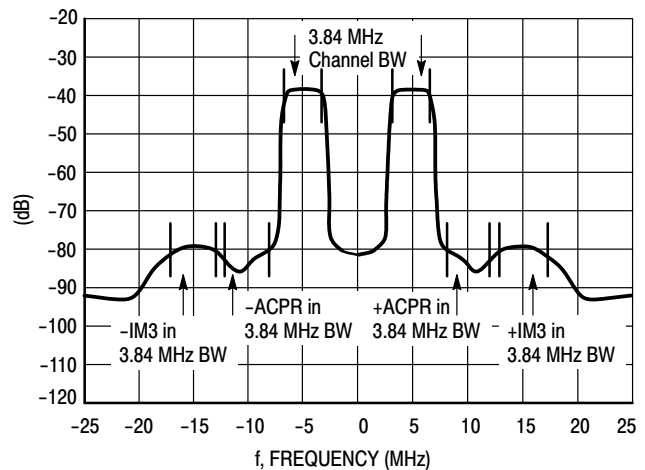
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

**Figure 9. MTTF Factor versus Junction Temperature**

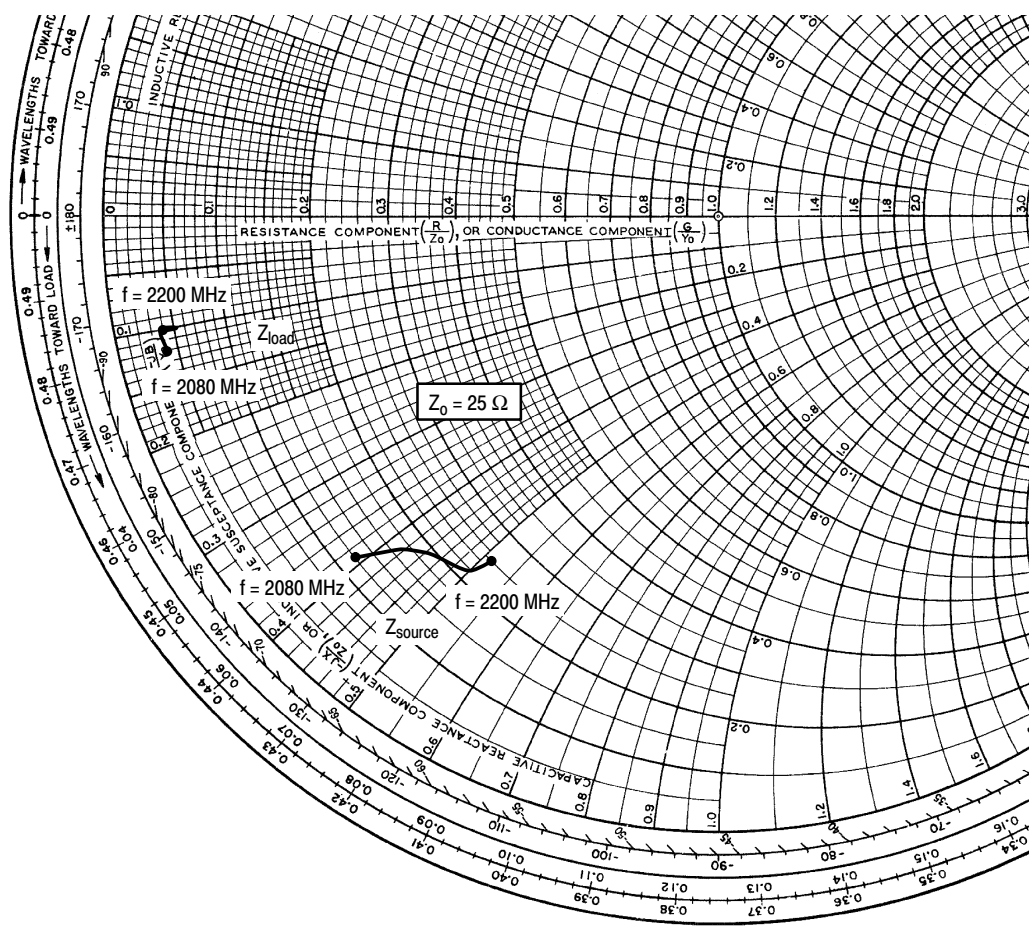
## W-CDMA TEST SIGNAL



**Figure 10. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 67% Clipping, Single-Carrier Test Signal**



**Figure 11. 2-Carrier W-CDMA Spectrum**



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1300 \text{ mA}$ ,  $P_{out} = 33 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 2080     | $3.05 - j9.66$           | $1.02 - j2.94$         |
| 2110     | $3.97 - j10.31$          | $1.09 - j2.51$         |
| 2140     | $4.70 - j11.03$          | $1.16 - j2.46$         |
| 2170     | $5.45 - j12.41$          | $1.16 - j2.58$         |
| 2200     | $6.18 - j13.04$          | $1.02 - j2.55$         |

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

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

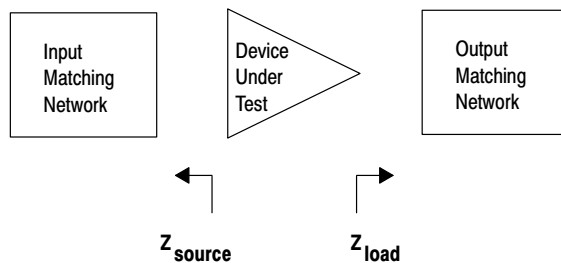


Figure 12. Series Equivalent Source and Load Impedance

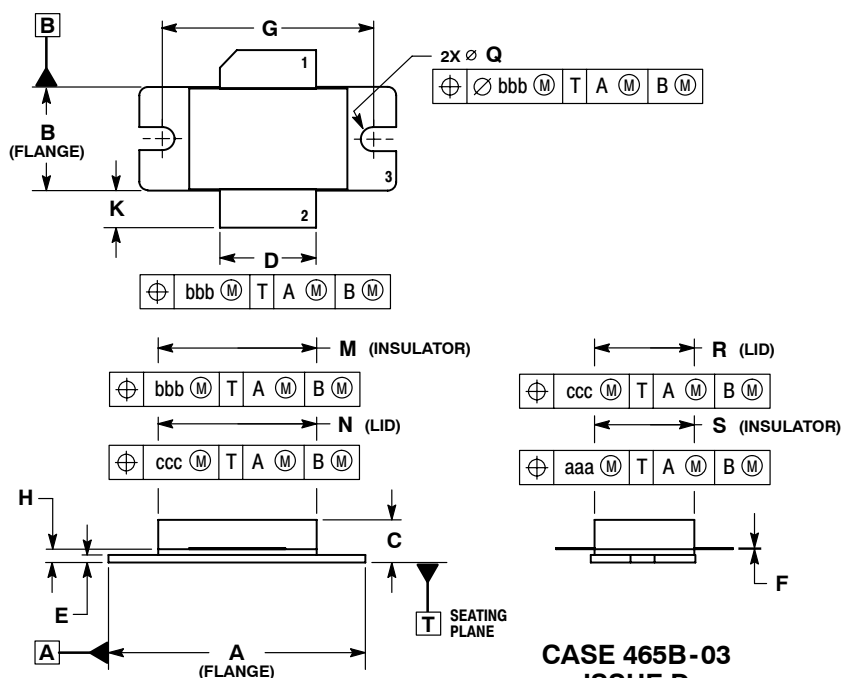
MRF5S21150HR3 MRF5S21150HSR3

## NOTES

# NOTES

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## PACKAGE DIMENSIONS

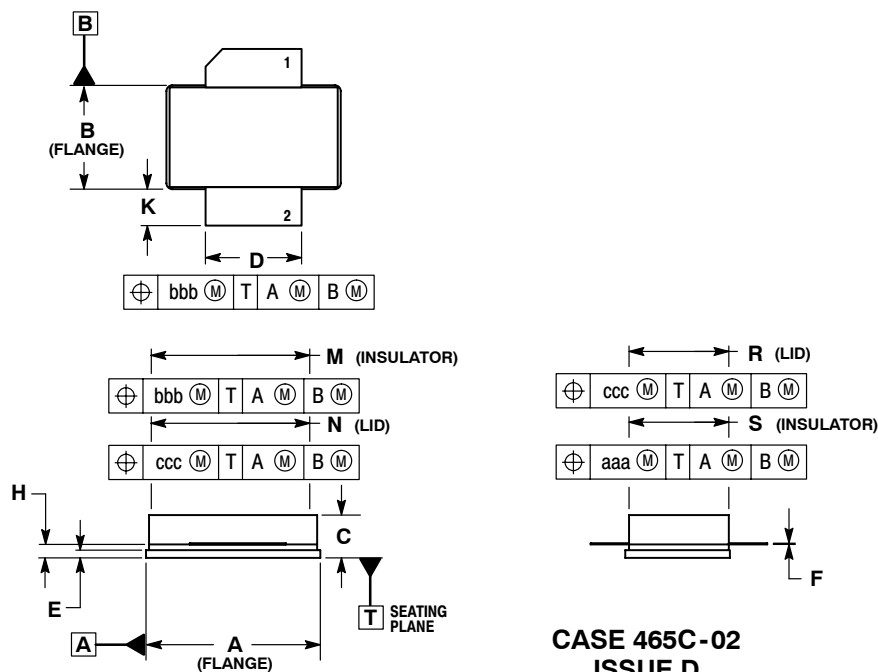


**CASE 465B-03  
ISSUE D  
NI-880  
MRF5S21150HR3**

- 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       |       |
| 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 | Ø3.00       | Ø3.51 |
| 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  
MRF5S21150HSR3**

- 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

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