

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for W-CDMA base station applications at 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.

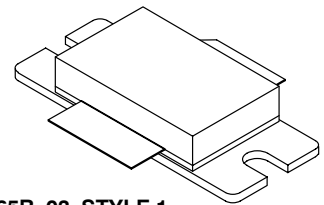
- Typical 2-Carrier W-CDMA Performance:  $V_{DD} = 28$  Volts,  $I_{DQ} = 1200$  mA,  $P_{out} = 28$  Watts Avg., Full Frequency Band, Channel Bandwidth = 3.84 MHz, PAR = 8.5 dB @ 0.01% Probability on CCDF.  
Power Gain — 13.5 dB  
Efficiency — 26%  
IM3 @ 10 MHz Offset — -37 dBc in 3.84 MHz Channel Bandwidth  
ACPR @ 5 MHz Offset — -39 dBc in 3.84 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2140 MHz, 92 Watts CW Output Power

### Features

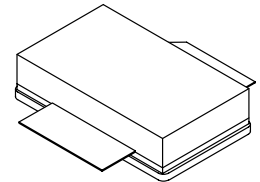
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32  $V_{DD}$  Operation
- Integrated ESD Protection
- Lower Thermal Resistance Package
- Low Gold Plating Thickness on Leads, 40 $\mu$ m Nominal.
- RoHS Compliant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

**MRF5S21130HR3**  
**MRF5S21130HSR3**

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



**CASE 465B-03, STYLE 1**  
**NI-880**  
**MRF5S21130HR3**



**CASE 465C-02, STYLE 1**  
**NI-880S**  
**MRF5S21130HSR3**

**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 $25^\circ\text{C}$ | $P_D$     | 372<br>2.13  | 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        | 100<br>0.54  | W<br>W/ $^\circ\text{C}$ |

**Table 2. Thermal Characteristics**

| Characteristic                                                                                                                         | Symbol          | Value (1,2)  | Unit               |
|----------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------|--------------------|
| Thermal Resistance, Junction to Case<br>Case Temperature $80^\circ\text{C}$ , 92 W CW<br>Case Temperature $76^\circ\text{C}$ , 28 W CW | $R_{\theta JC}$ | 0.44<br>0.47 | $^\circ\text{C/W}$ |

- MTTF calculator available at <http://www.freescale.com/rf>. Select Tools/Software/Application Software/Calculators to access the MTTF calculators by product.
- 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    | 2 (Minimum)  |
| Machine Model       | M4 (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>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 300\text{ }\mu\text{Adc}$ ) | $V_{GS(th)}$ | 2.5 | 2.7  | 3.5 | Vdc |
| Gate Quiescent Voltage<br>( $V_{DS} = 28\text{ Vdc}$ , $I_D = 1200\text{ mAdc}$ )         | $V_{GS(Q)}$  | —   | 3.7  | —   | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 3\text{ Adc}$ )            | $V_{DS(on)}$ | —   | 0.26 | 0.3 | Vdc |
| Forward Transconductance<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 3\text{ Adc}$ )           | $g_{fs}$     | —   | 7.5  | —   | S   |

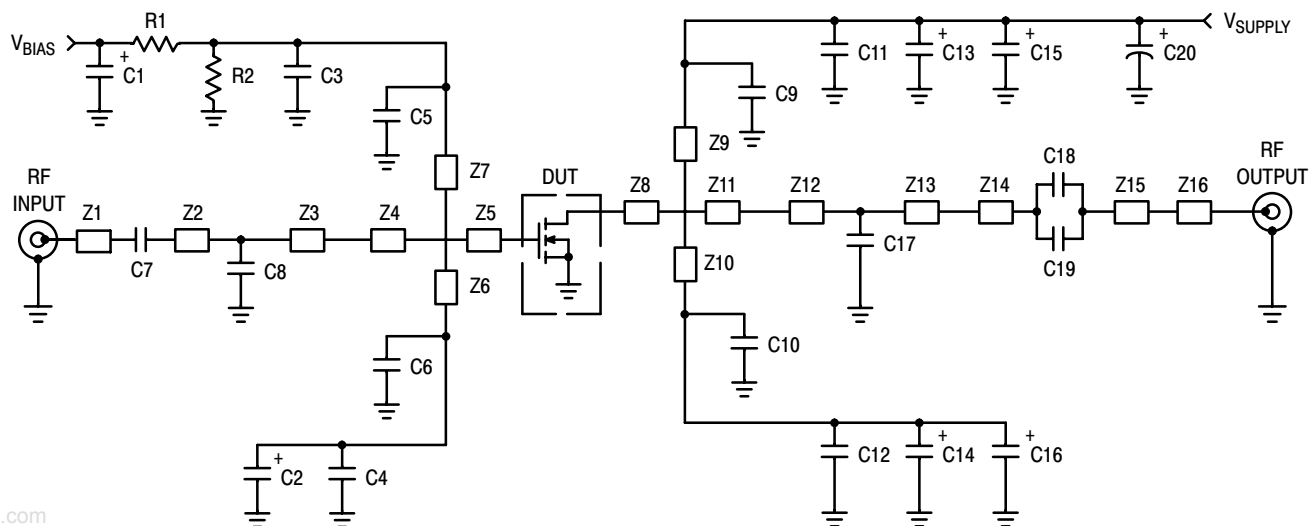
**Dynamic Characteristics <sup>(1)</sup>**

|                                                                                                                       |           |   |     |   |    |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|
| Reverse Transfer Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 2.6 | — | pF |
|-----------------------------------------------------------------------------------------------------------------------|-----------|---|-----|---|----|

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 1200\text{ mA}$ ,  $P_{out} = 28\text{ W Avg.}$ ,  $f_1 = 2112.5\text{ MHz}$ ,  $f_2 = 2122.5\text{ MHz}$  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 Channel Bandwidth @  $\pm 10\text{ MHz}$  Offset. PAR = 8.5 dB @ 0.01% Probability on CCDF.

|                              |          |    |      |     |     |
|------------------------------|----------|----|------|-----|-----|
| Power Gain                   | $G_{ps}$ | 12 | 13.5 | —   | dB  |
| Drain Efficiency             | $\eta_D$ | 24 | 26   | —   | %   |
| 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.

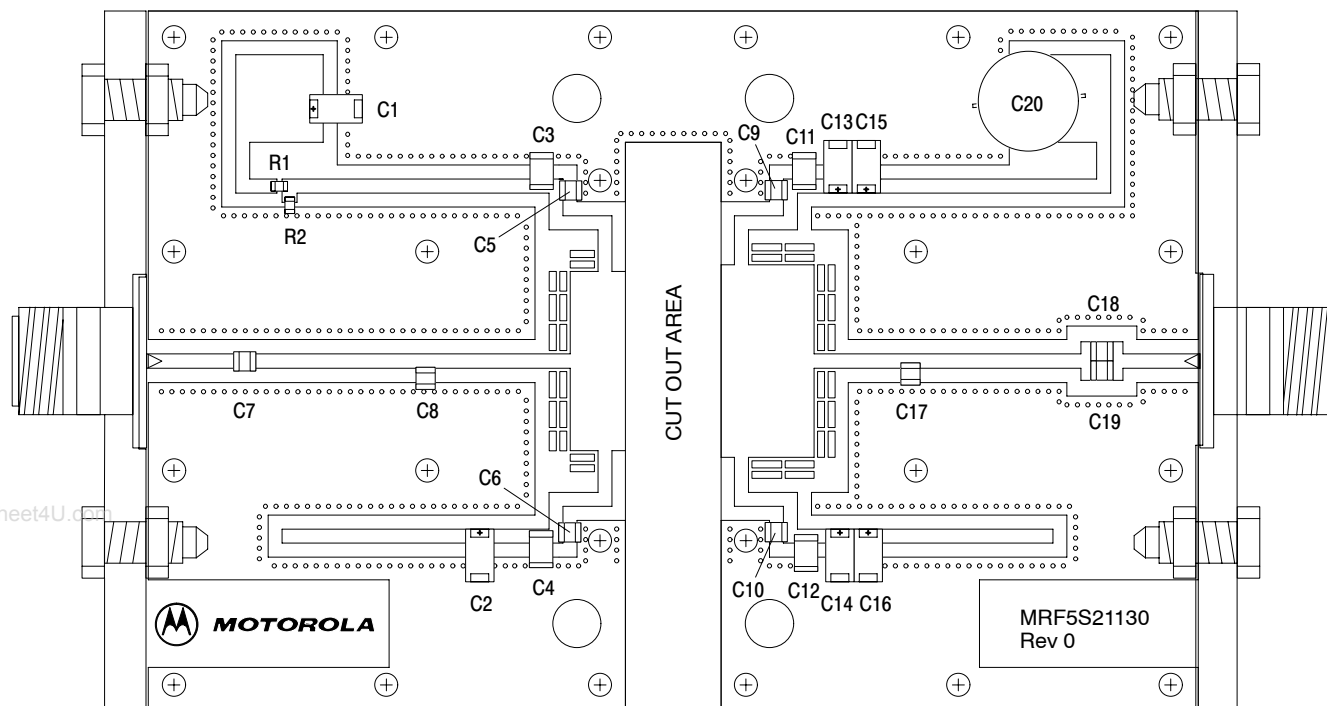


|        |                            |          |                                           |
|--------|----------------------------|----------|-------------------------------------------|
| Z1     | 0.500" x 0.083" Microstrip | Z9, Z10  | 0.709" x 0.083" Microstrip                |
| Z2     | 0.995" x 0.083" Microstrip | Z11      | 0.415" x 1.000" Microstrip                |
| Z3     | 0.905" x 0.083" Microstrip | Z12      | 0.531" x 0.083" Microstrip                |
| Z4     | 0.159" x 1.024" Microstrip | Z13      | 0.994" x 0.083" Microstrip                |
| Z5     | 0.117" x 1.024" Microstrip | Z14, Z15 | 0.070" x 0.220" Microstrip                |
| Z6, Z7 | 0.749" x 0.083" Microstrip | Z16      | 0.430" x 0.083" Microstrip                |
| Z8     | 0.117" x 1.000" Microstrip | PCB      | Taconic TLX8, 0.030", $\epsilon_r = 2.55$ |

**Figure 1. MRF5S21130HR3(SR3) Test Circuit Schematic**

**Table 5. MRF5S21130HR3(SR3) Test Circuit Component Designations and Values**

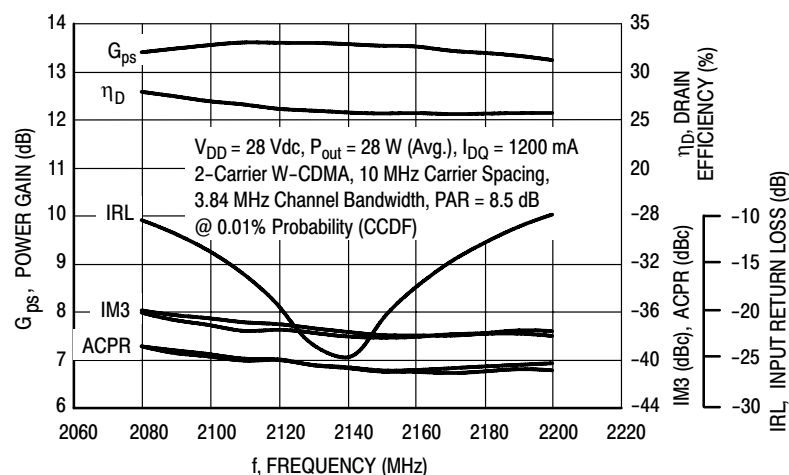
| Part                          | Description                                      | Part Number    | Manufacturer      |
|-------------------------------|--------------------------------------------------|----------------|-------------------|
| C1, C2, C13, C14, C15, C16    | 10 $\mu$ F, 35 V Tantalum Capacitors             | 293D1106X9035D | Vishay - Sprague  |
| C3, C4, C11, C12              | 220 nF Chip Capacitors (1812)                    | 1812Y224KXA    | Vishay - Vitramon |
| C5, C6, C7, C9, C10, C18, C19 | 6.8 pF 100B Chip Capacitors                      | 100B6R8CW      | ATC               |
| C8                            | 0.1 pF 100B Chip Capacitor                       | 100B0R1BW      | ATC               |
| C17                           | 0.5 pF 100B Chip Capacitor                       | 100B0R5BW      | ATC               |
| C20                           | 220 $\mu$ F, 63 V Electrolytic Capacitor, Radial | 13668221       | Philips           |
| R1, R2                        | 1 k $\Omega$ , 1/4 W Chip Resistors              |                |                   |



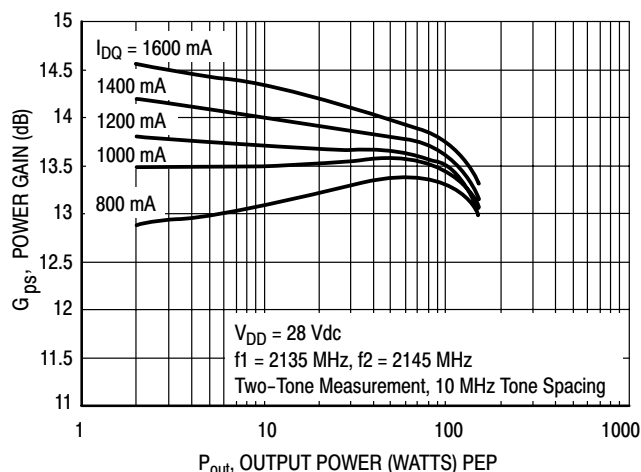
Freescall has begun the transition of marking Printed Circuit Boards (PCBs) with the Freescall Semiconductor signature/logo. PCBs may have either Motorola or Freescall markings during the transition period. These changes will have no impact on form, fit or function of the current product.

**Figure 2. MRF5S21130HR3(SR3) Test Circuit Component Layout**

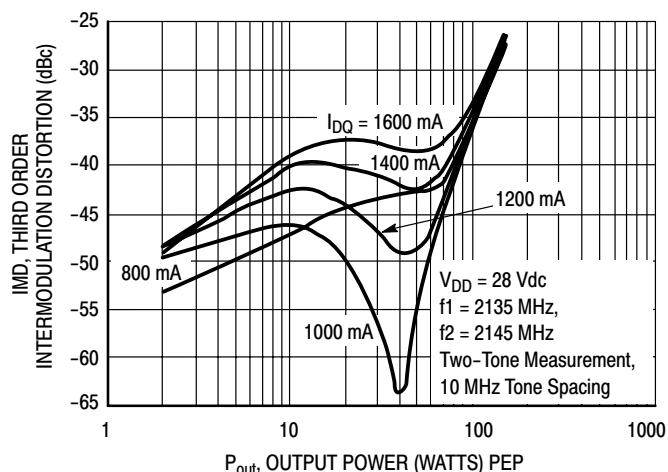
## TYPICAL CHARACTERISTICS



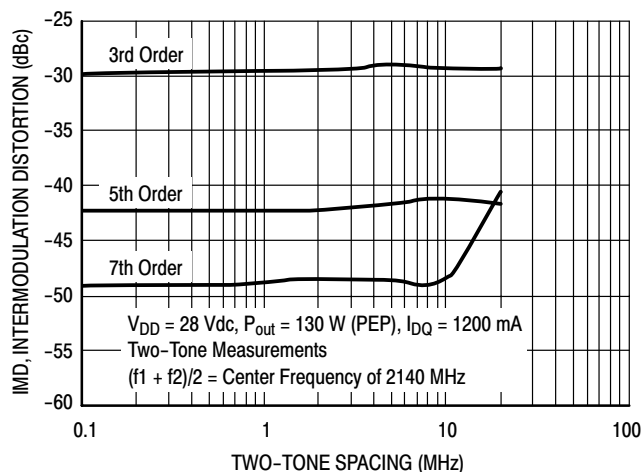
**Figure 3. 2-Carrier W-CDMA Broadband Performance**  
@  $P_{out} = 28$  Watts Avg.



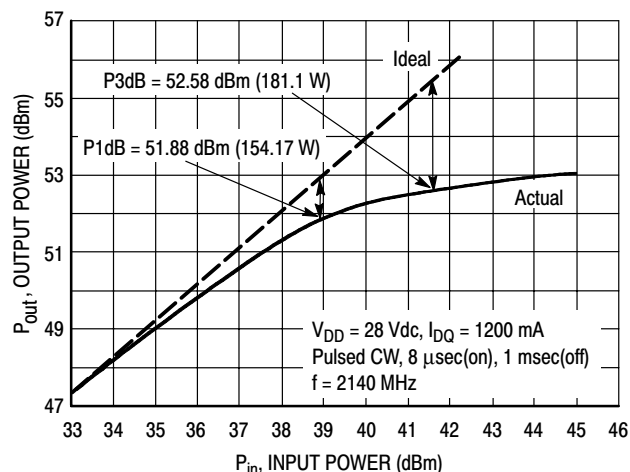
**Figure 4. Two-Tone Power Gain versus Output Power**



**Figure 5. Third Order Intermodulation Distortion versus Output Power**

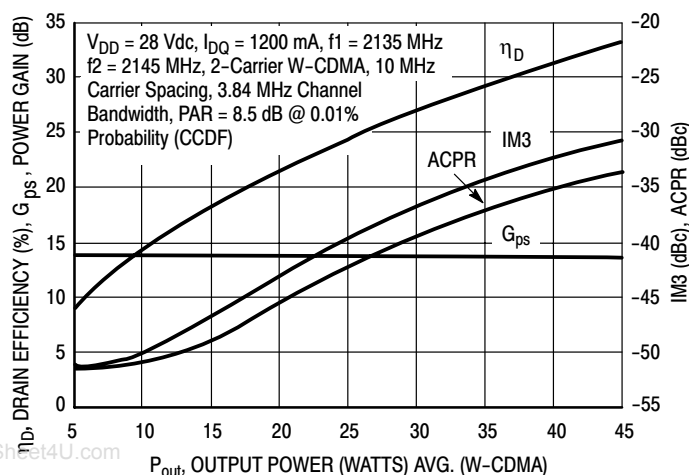


**Figure 6. Intermodulation Distortion Products versus Tone Spacing**

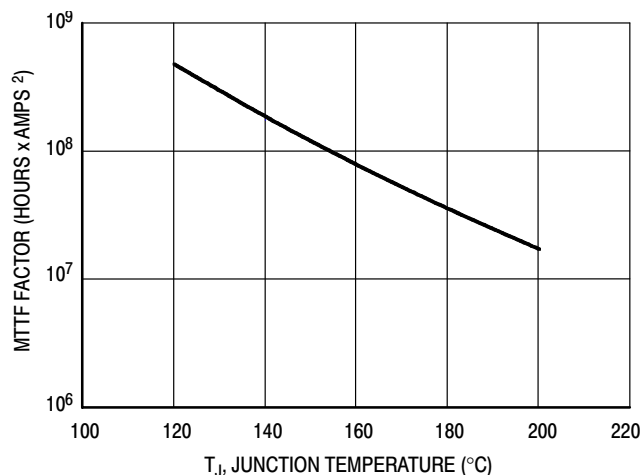


**Figure 7. Pulse CW Output Power versus Input Power**

## TYPICAL CHARACTERISTICS



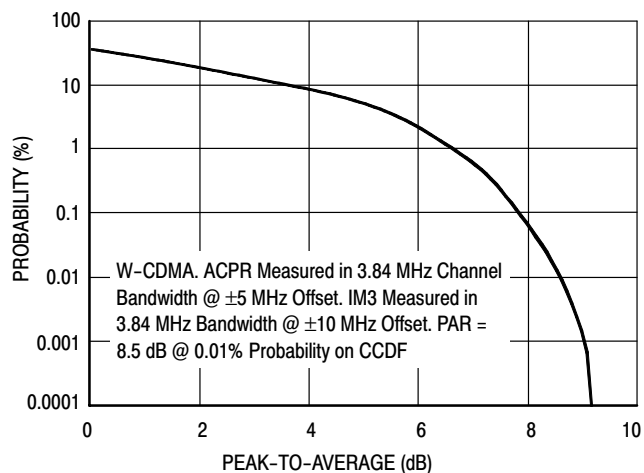
**Figure 8. 2-Carrier W-CDMA ACPR, IM3, Power Gain and Drain Efficiency versus Output Power**



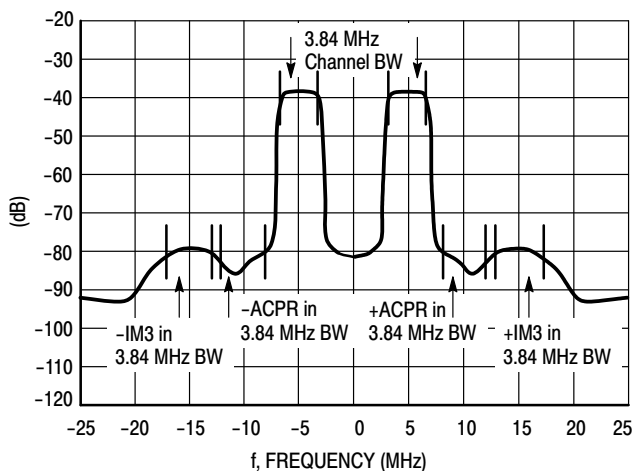
This above graph displays calculated MTTF in hours x ampere<sup>2</sup> drain current. Life tests at elevated temperatures have correlated to better than  $\pm 10\%$  of the theoretical prediction for metal failure. Divide MTTF factor by  $I_D^2$  for MTTF in a particular application.

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

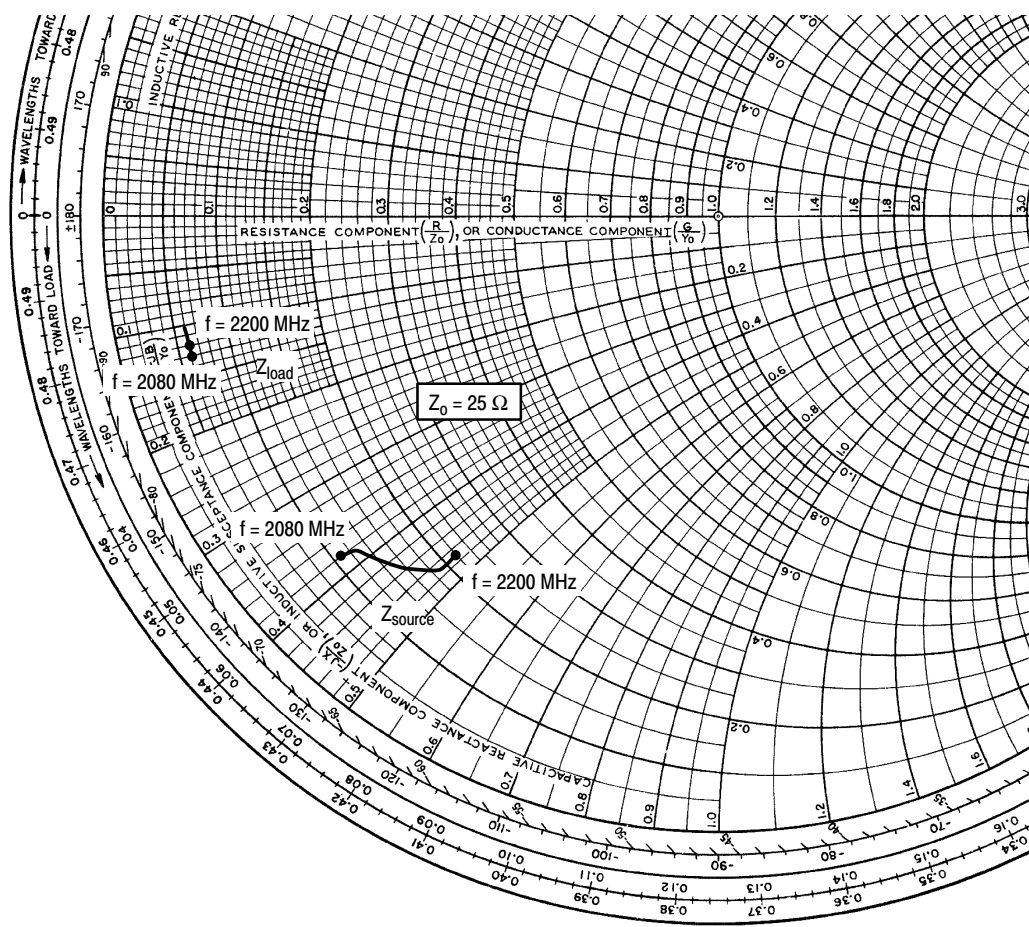
## W-CDMA TEST SIGNAL



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



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



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 1200 \text{ mA}$ ,  $P_{out} = 28 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 2080     | $2.87 - j9.49$           | $1.51 - j2.97$         |
| 2110     | $3.13 - j9.86$           | $1.52 - j2.54$         |
| 2140     | $4.05 - j10.90$          | $1.59 - j2.68$         |
| 2170     | $4.80 - j11.75$          | $1.62 - j2.70$         |
| 2200     | $5.55 - j11.87$          | $1.54 - j3.13$         |

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

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

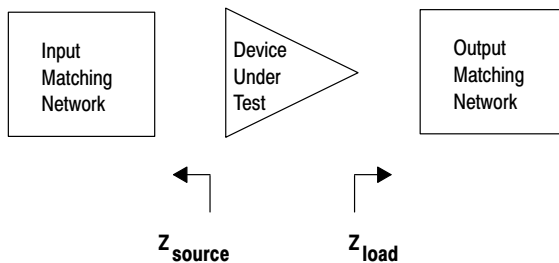


Figure 12. Series Equivalent Source and Load Impedance

# NOTES

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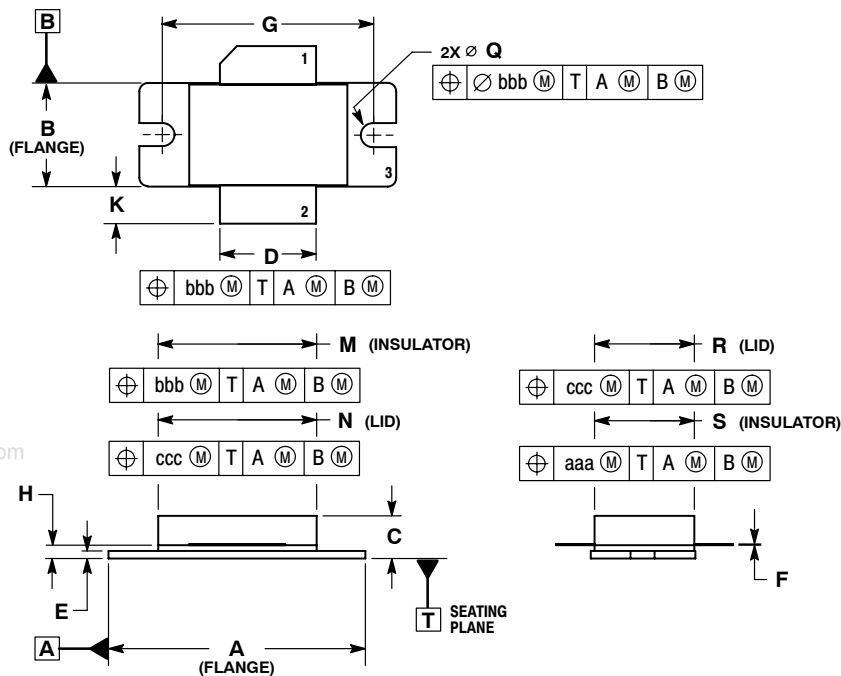
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# NOTES

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## PACKAGE DIMENSIONS

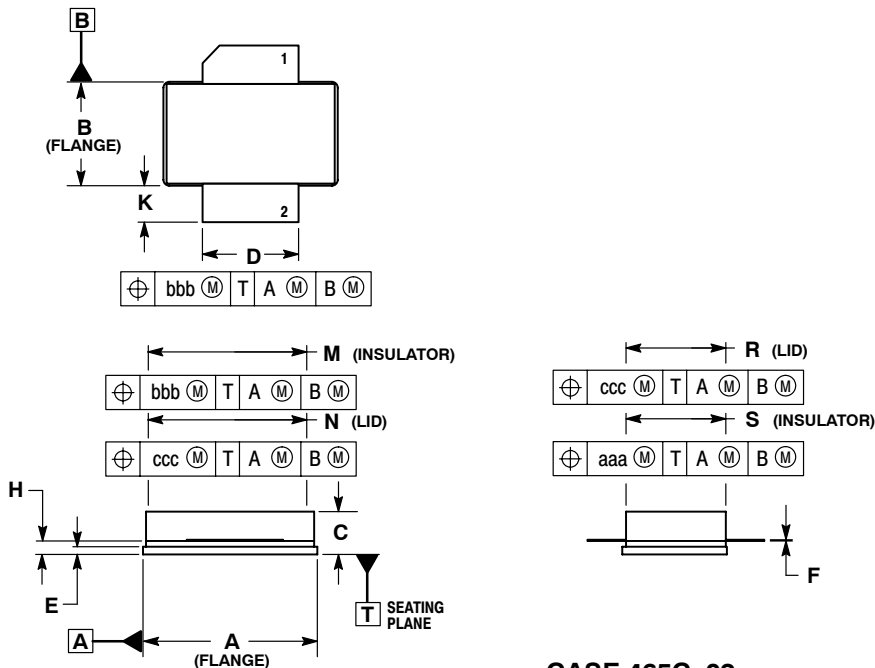


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.
  4. DELETED

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

**CASE 465B-03  
ISSUE D  
NI-880  
MRF5S21130HR3**



- 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  |
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- STYLE 1:
- PIN 1. DRAIN
  - GATE
  - SOURCE

**CASE 465C-02  
ISSUE D  
NI-880S  
MRF5S21130HSR3**

**MRF5S21130HR3 MRF5S21130HSR3**

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