

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed for CDMA base station applications with frequencies from 1470 to 1510 MHz. Suitable for TDMA, 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,  $I_{DQ} = 600$  mA,  $P_{out} = 23$  Watts Avg.,  $f = 1507.5$  MHz, 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 — 19.5 dB  
Drain Efficiency — 32%  
Device Output Signal PAR — 6.2 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, 1490 MHz, 100 Watts CW Output Power
- Typical  $P_{out}$  @ 1 dB Compression Point  $\approx 100$  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
- Optimized for Doherty Applications
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF7S15100HR3**  
**MRF7S15100HSR3**

**1510 MHz, 23 W AVG., 28 V**  
**SINGLE W-CDMA**  
**LATERAL N-CHANNEL**  
**RF POWER MOSFETs**

**CASE 465-06, STYLE 1**  
**NI-780**  
**MRF7S1500HR3**

**CASE 465A-06, STYLE 1**  
**NI-780S**  
**MRF7S1500HSR3**

**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 <sup>(1)</sup> | $T_J$     | 225          | °C   |

**Table 2. Thermal Characteristics**

| Characteristic                       | Symbol          | Value <sup>(2)</sup> | Unit |
|--------------------------------------|-----------------|----------------------|------|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ |                      | °C/W |
| Case Temperature 80°C, 55 W CW       |                 | 0.65                 |      |
| Case Temperature 77°C, 23 W CW       |                 | 0.74                 |      |

1. Continuous use at maximum temperature will affect MTTF.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.freescal.com/rf>. Select Documentation/Application Notes - AN1955.

**Table 3. ESD Protection Characteristics**

| Test Methodology                      | Class        |
|---------------------------------------|--------------|
| Human Body Model (per JESD22-A114)    | IC (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>( $V_{DD} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc}$ ) | $I_{DSS}$ | — | — | 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>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 174\text{ }\mu\text{Adc}$ )                     | $V_{GS(th)}$ | 1.2 | 2   | 2.7 | Vdc |
| Gate Quiescent Voltage<br>( $V_{DD} = 28\text{ Vdc}$ , $I_D = 600\text{ mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | 2   | 2.7 | 3.5 | Vdc |
| Drain-Source On-Voltage<br>( $V_{GS} = 10\text{ Vdc}$ , $I_D = 1.74\text{ Adc}$ )                             | $V_{DS(on)}$ | 0.1 | 0.2 | 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, $V_{GS} = 0\text{ Vdc}$ ) | $C_{rss}$ | — | 0.6 | — | pF |
| Output Capacitance<br>( $V_{DS} = 28\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$ )           | $C_{oss}$ | — | 300 | — | pF |
| Input Capacitance<br>( $V_{DS} = 28\text{ Vdc}$ , $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz)            | $C_{iss}$ | — | 176 | — | pF |

**Functional Tests** (In Freescale Test Fixture, 50 ohm system)  $V_{DD} = 28\text{ Vdc}$ ,  $I_{DQ} = 600\text{ mA}$ ,  $P_{out} = 23\text{ W Avg.}$ ,  $f = 1507.5\text{ MHz}$ , 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.

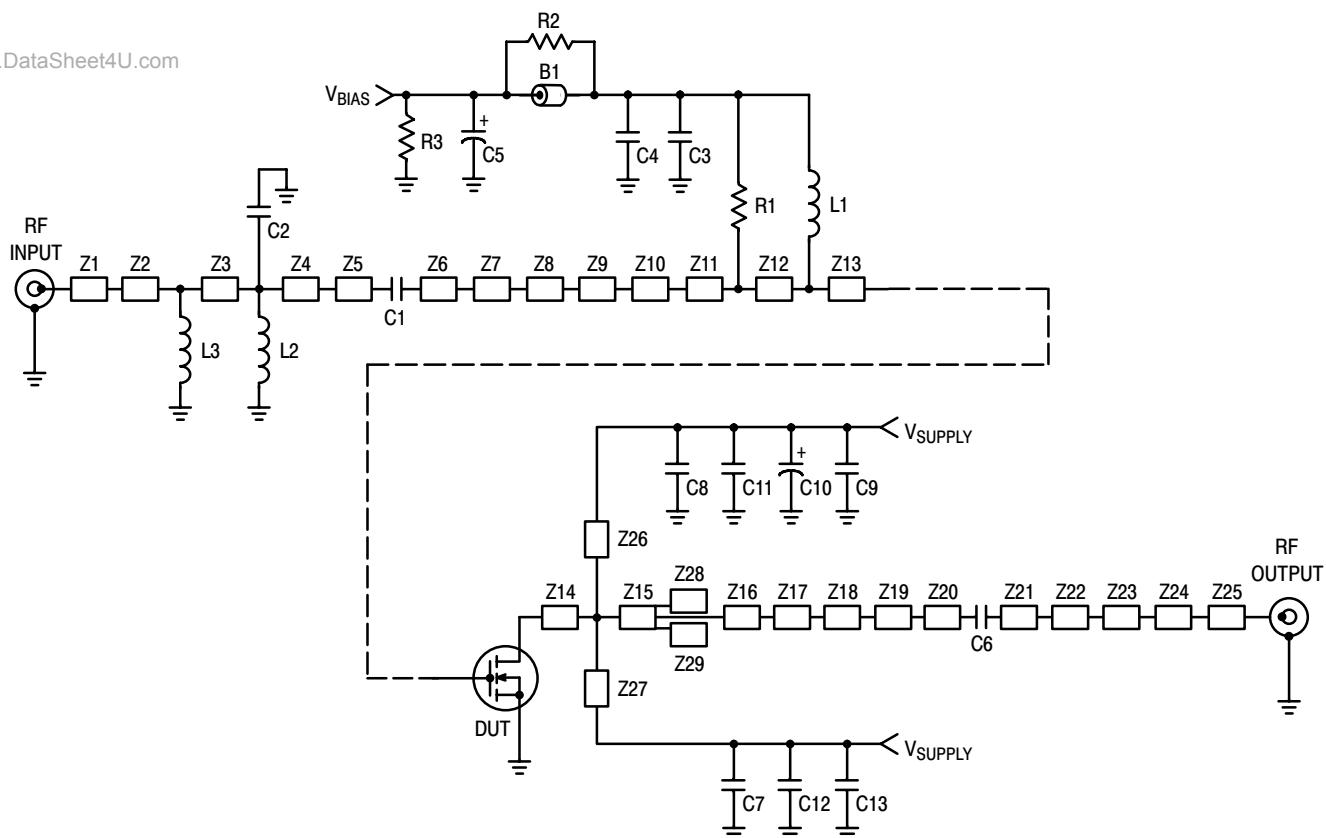
|                                                          |          |     |      |     |     |
|----------------------------------------------------------|----------|-----|------|-----|-----|
| Power Gain                                               | $G_{ps}$ | 18  | 19.5 | 21  | dB  |
| Drain Efficiency                                         | $\eta_D$ | 30  | 32   | —   | %   |
| Output Peak-to-Average Ratio @ 0.01% Probability on CCDF | PAR      | 5.9 | 6.2  | —   | dB  |
| Adjacent Channel Power Ratio                             | ACPR     | —   | -38  | -35 | dBc |
| Input Return Loss                                        | IRL      | —   | -15  | -8  | 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) $V_{DD} = 28\text{ Vdc}$ , $I_{DQ} = 600\text{ mA}$ , 1470-1510 MHz Bandwidth                                         |                  |     |       |     |       |
| $P_{out}$ @ 1 dB Compression Point, CW                                                                                                                                                       | $P_{1dB}$        | —   | 100   | —   | W     |
| IMD Symmetry @ 90 W PEP, $P_{out}$ where IMD Third Order Intermodulation $\cong 30\text{ dBc}$<br>(Delta IMD Third Order Intermodulation between Upper and Lower Sidebands $> 2\text{ dB}$ ) | $IMD_{sym}$      | —   | 40    | —   | MHz   |
| VBW Resonance Point<br>(IMD Third Order Intermodulation Inflection Point)                                                                                                                    | $VBW_{res}$      | —   | 70    | —   | MHz   |
| Gain Flatness in 40 MHz Bandwidth @ $P_{out} = 23\text{ W Avg.}$                                                                                                                             | $G_F$            | —   | 0.2   | —   | dB    |
| Average Deviation from Linear Phase in 40 MHz Bandwidth<br>@ $P_{out} = 100\text{ W CW}$                                                                                                     | $\Phi$           | —   | 4.5   | —   | °     |
| Average Group Delay @ $P_{out} = 100\text{ W CW}$ , $f = 1490\text{ MHz}$                                                                                                                    | Delay            | —   | 1.9   | —   | ns    |
| Part-to-Part Insertion Phase Variation @ $P_{out} = 100\text{ W CW}$ ,<br>$f = 1490\text{ MHz}$ , Six Sigma Window                                                                           | $\Delta\Phi$     | —   | 23    | —   | °     |
| Gain Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )                                                                                                            | $\Delta G$       | —   | 0.010 | —   | dB/°C |
| Output Power Variation over Temperature<br>( $-30^\circ\text{C}$ to $+85^\circ\text{C}$ )                                                                                                    | $\Delta P_{1dB}$ | —   | 0.007 | —   | W/°C  |



|     |                            |          |                                                            |
|-----|----------------------------|----------|------------------------------------------------------------|
| Z1  | 0.084" x 0.078" Microstrip | Z15      | 1.330" x 0.538" Microstrip                                 |
| Z2  | 0.149" x 0.153" Microstrip | Z16      | 0.270" x 0.280" Microstrip                                 |
| Z3  | 0.149" x 0.303" Microstrip | Z17      | 0.187" x 0.150" Microstrip                                 |
| Z4  | 0.149" x 0.065" Microstrip | Z18      | 0.084" x 0.042" Microstrip                                 |
| Z5  | 0.084" x 0.146" Microstrip | Z19      | 0.184" x 0.292" Microstrip                                 |
| Z6  | 0.084" x 0.104" Microstrip | Z20      | 0.084" x 0.066" Microstrip                                 |
| Z7  | 0.218" x 0.080" Microstrip | Z21      | 0.886" x 0.194" Microstrip                                 |
| Z8  | 0.084" x 0.206" Microstrip | Z22      | 0.300" x 0.084" Microstrip                                 |
| Z9  | 0.224" x 0.085" Microstrip | Z23      | 0.084" x 0.215" Microstrip                                 |
| Z10 | 0.084" x 0.369" Microstrip | Z24      | 0.221" x 0.075" Microstrip                                 |
| Z11 | 1.288" x 0.206" Microstrip | Z25      | 0.084" x 0.175" Microstrip                                 |
| Z12 | 1.288" x 0.144" Microstrip | Z26, Z27 | 0.200" x 0.525" Microstrip                                 |
| Z13 | 1.288" x 0.369" Microstrip | Z28, Z29 | 0.235" x 0.102" Microstrip                                 |
| Z14 | 1.330" x 0.112" Microstrip | PCB      | Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$ |

Figure 1. MRF7S15100HR3(HSR3) Test Circuit Schematic

Table 5. MRF7S15100HR3(HSR3) Test Circuit Component Designations and Values

| Part           | Description                               | Part Number       | Manufacturer |
|----------------|-------------------------------------------|-------------------|--------------|
| B1             | Short Ferrite Bead                        | 2743019447        | Fair-Rite    |
| C1, C6, C7, C8 | 15 pF Chip Capacitors                     | ATC100B150JT500XT | ATC          |
| C2             | 0.5 pF Chip Capacitor                     | ATC100B0R5BT500XT | ATC          |
| C3             | 10 pF Chip Capacitor                      | ATC100B100JT500XT | ATC          |
| C4, C9, C13    | 6.8 $\mu$ F, 50 V Chip Capacitors         | C4532JB1H685MT    | TDK          |
| C5, C10        | 100 $\mu$ F, 50 V Electrolytic Capacitors | 222215371101      | Vishay       |
| C11, C12       | 2.2 $\mu$ F, 50 V Chip Capacitors         | C3225JB2A225MT    | TDK          |
| L1, L2, L3     | 7.15 nH Inductors                         | 1606-TLC          | Coilcraft    |
| R1, R2         | 100 $\Omega$ , 1/4 W Chip Resistors       | CRCW12061000FKEA  | Vishay       |
| R3             | 10 K $\Omega$ , 1/4 W Chip Resistor       | CRCW12061002FKEA  | Vishay       |

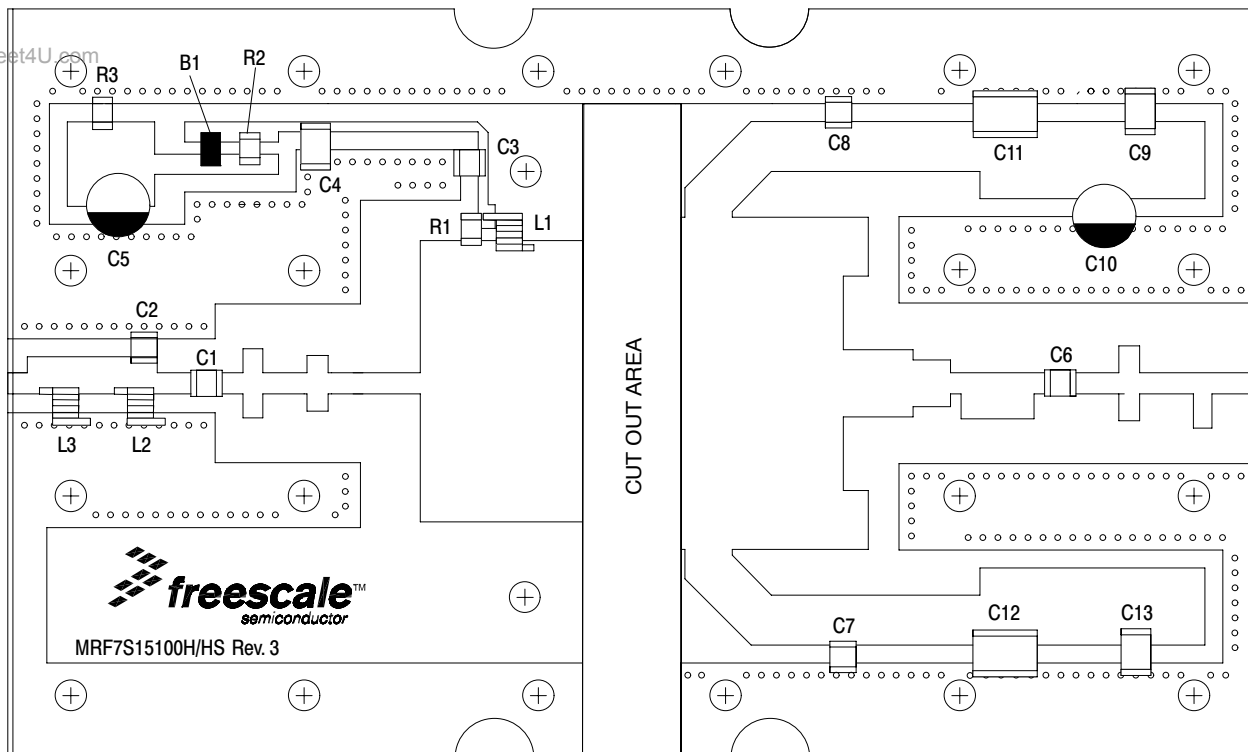
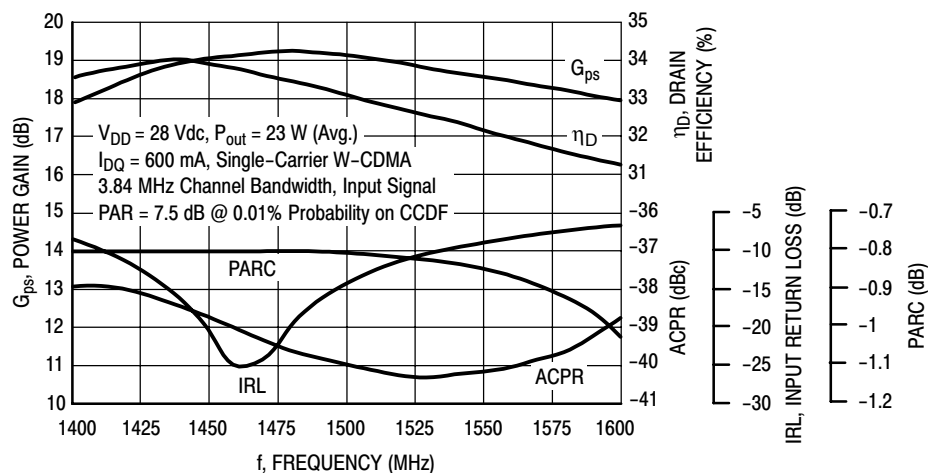
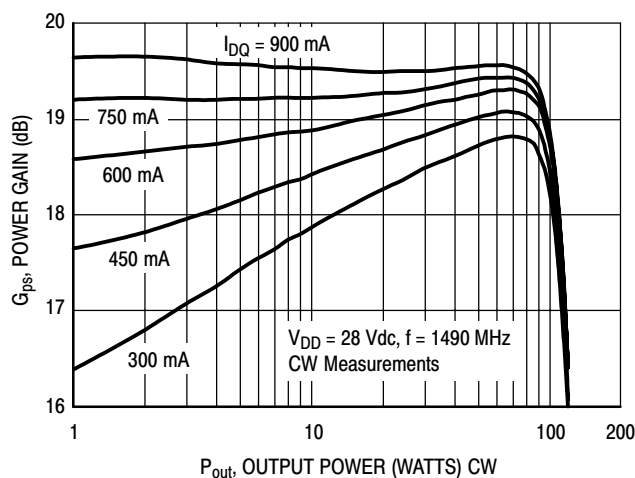


Figure 2. MRF7S15100HR3(HSR3) Test Circuit Component Layout

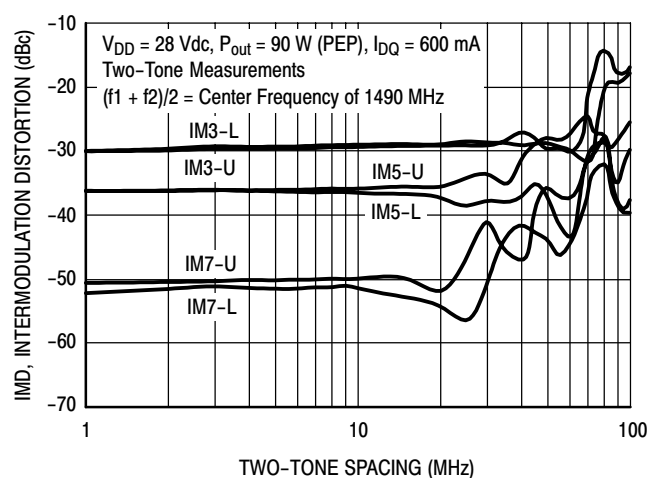
## TYPICAL CHARACTERISTICS



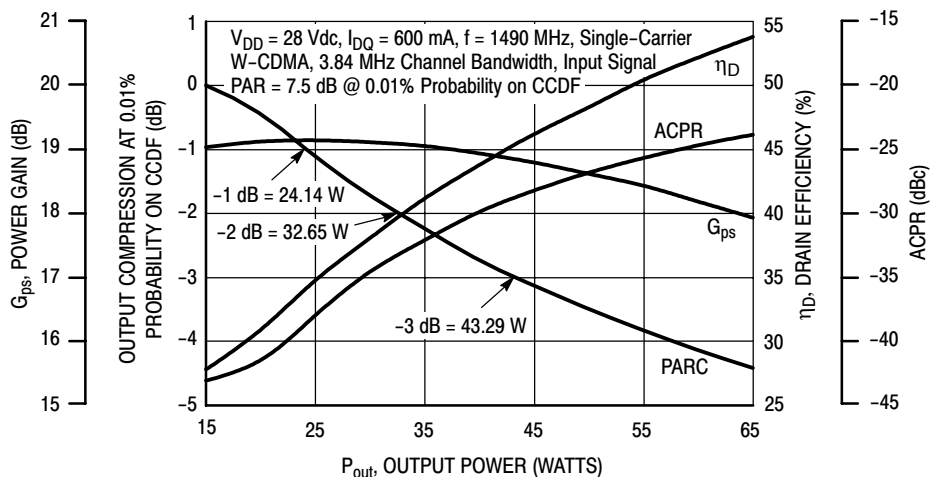
**Figure 3. Output Peak-to-Average Ratio Compression (PARC)  
Broadband Performance @  $P_{out} = 23$  Watts Avg.**



**Figure 4. CW Power Gain versus Output Power**



**Figure 5. Intermodulation Distortion Products  
versus Tone Spacing**



**Figure 6. Output Peak-to-Average Ratio  
Compression (PARC) versus Output Power**

## TYPICAL CHARACTERISTICS

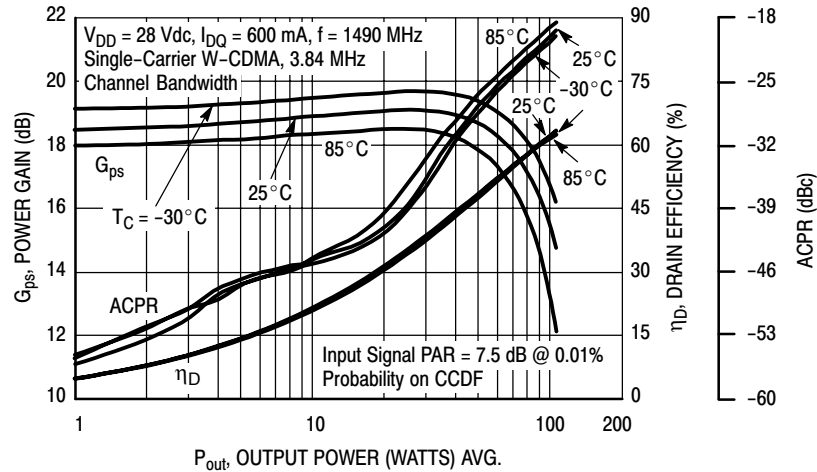


Figure 7. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power

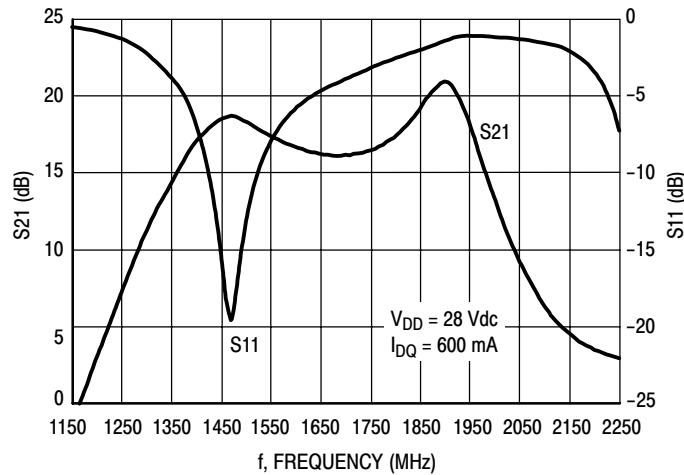


Figure 8. Broadband Frequency Response

## W-CDMA TEST SIGNAL

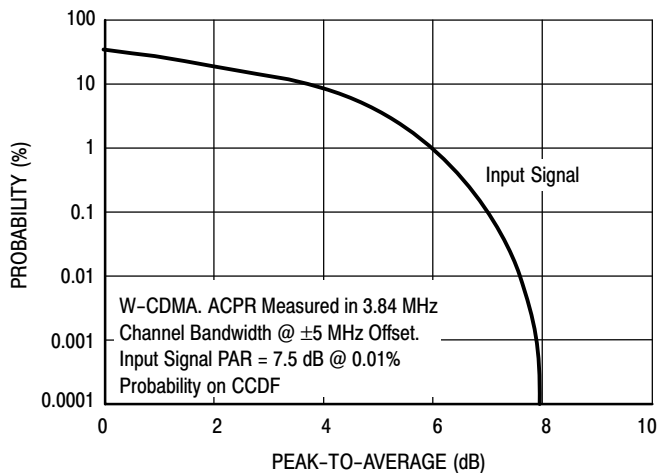


Figure 9. CCDF W-CDMA 3GPP, Test Model 1, 64 DPCH, 50% Clipping, Single-Carrier Test Signal

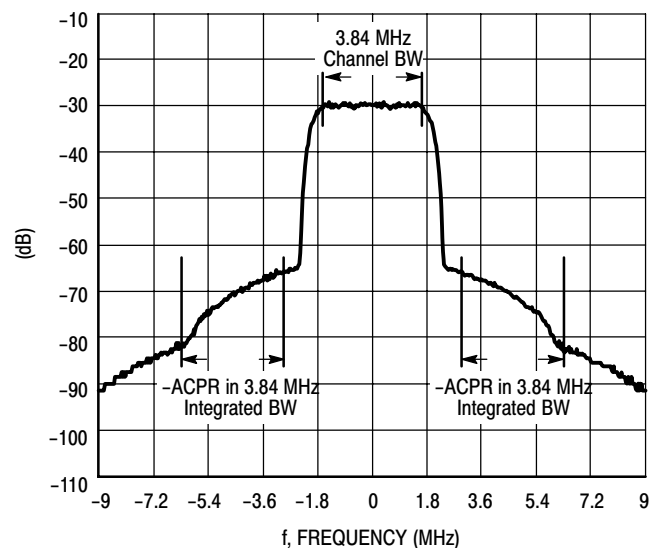
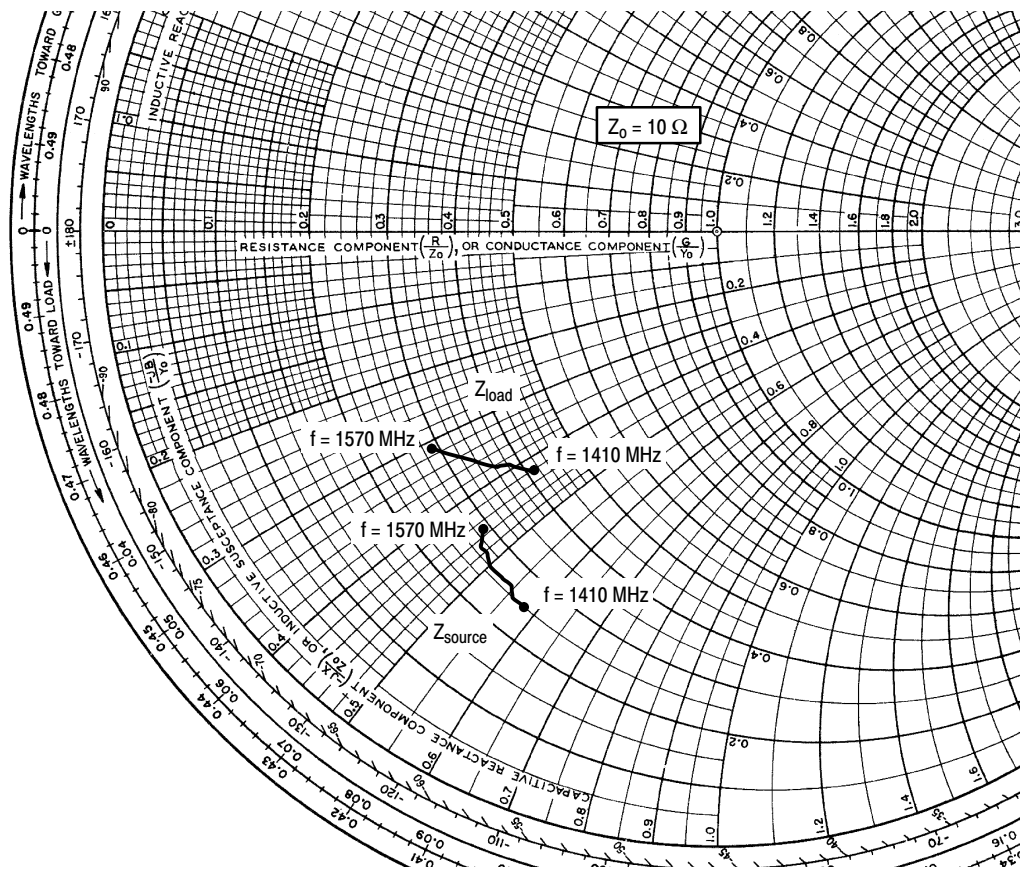


Figure 10. Single-Carrier W-CDMA Spectrum



$V_{DD} = 28 \text{ Vdc}$ ,  $I_{DQ} = 600 \text{ mA}$ ,  $P_{out} = 23 \text{ W Avg.}$

| f<br>MHz | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|----------|--------------------------|------------------------|
| 1410     | $2.51 - j5.82$           | $4.12 - j4.20$         |
| 1430     | $2.53 - j5.58$           | $3.95 - j4.07$         |
| 1450     | $2.55 - j5.36$           | $3.78 - j3.94$         |
| 1470     | $2.58 - j5.15$           | $3.61 - j3.80$         |
| 1490     | $2.62 - j4.97$           | $3.45 - j3.65$         |
| 1510     | $2.67 - j4.81$           | $3.30 - j3.51$         |
| 1530     | $2.73 - j4.68$           | $3.15 - j3.37$         |
| 1550     | $2.79 - j4.57$           | $3.00 - j3.22$         |
| 1570     | $2.85 - j4.49$           | $2.87 - j3.06$         |

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

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

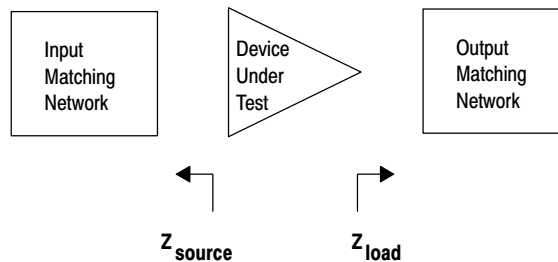
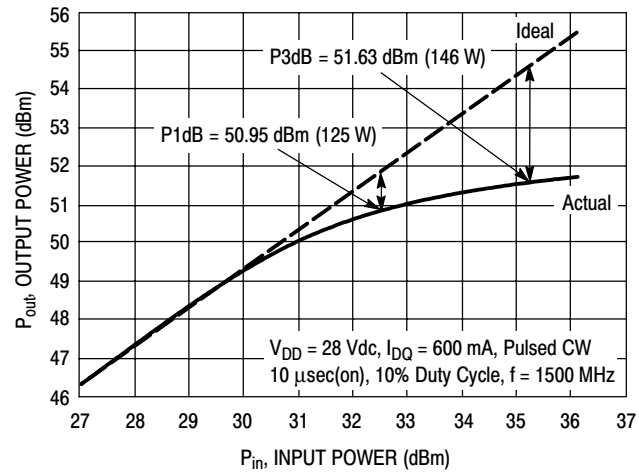


Figure 11. Series Equivalent Source and Load Impedance

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS

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NOTE: Load Pull Test Fixture Tuned for Peak P1dB Output Power @ 28 V

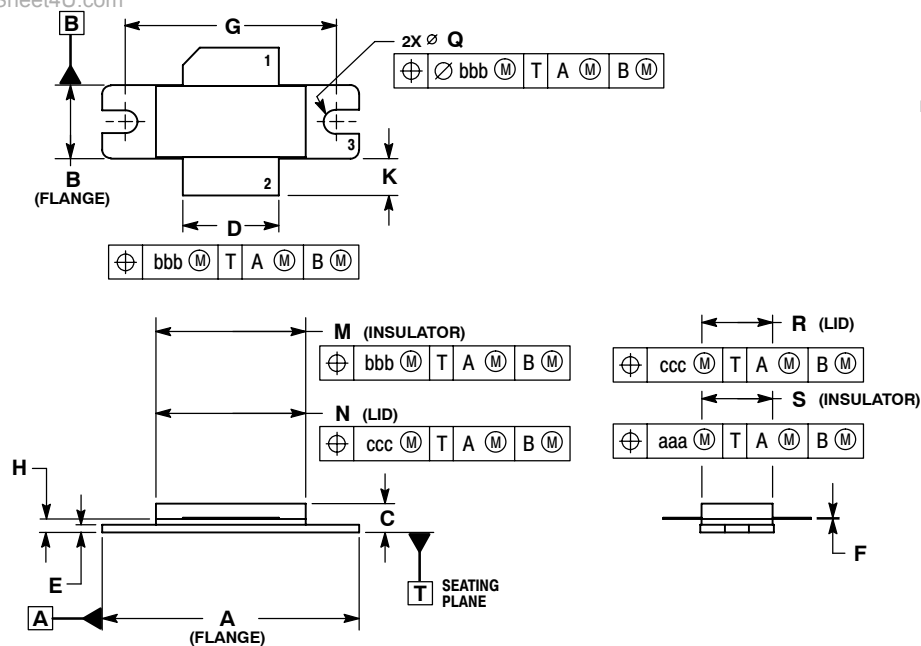
Test Impedances per Compression Level

|      | $Z_{source}$<br>$\Omega$ | $Z_{load}$<br>$\Omega$ |
|------|--------------------------|------------------------|
| P1dB | $2.02 + j6.21$           | $2.00 - j3.65$         |

Figure 12. Pulsed CW Output Power versus Input Power @ 28 V

## PACKAGE DIMENSIONS

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### NOTES:

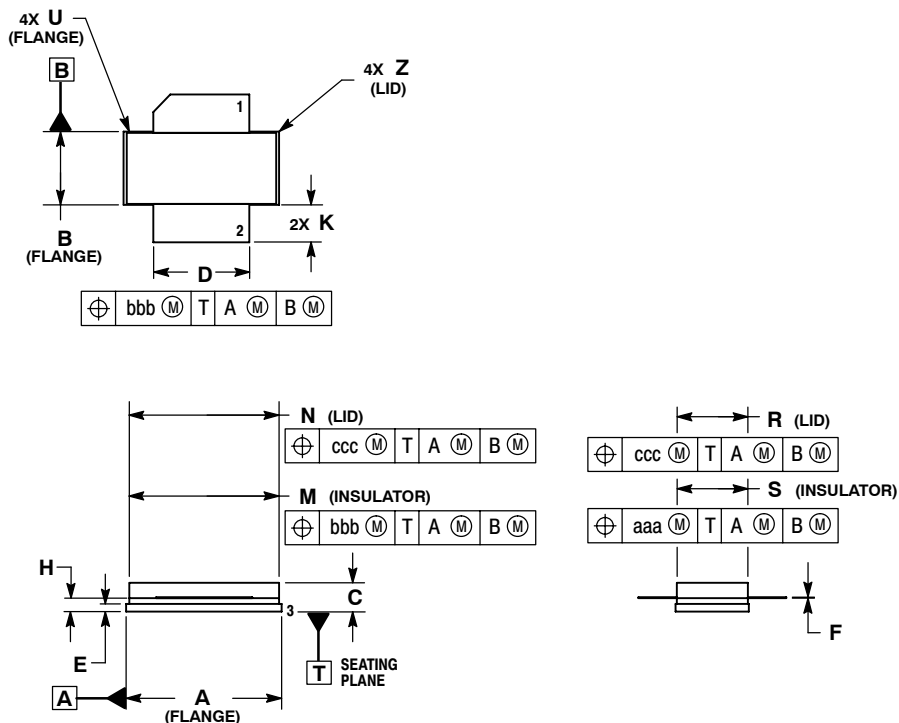
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

| 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.118     | Ø.138 | Ø.300       | Ø.351 |
| 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:

1. DRAIN
2. GATE
3. SOURCE

**CASE 465-06  
ISSUE G  
NI-780  
MRF7S15100HR3**



### 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  |
| G   | 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:

1. DRAIN
2. GATE
5. SOURCE

**CASE 465A-06  
ISSUE H  
NI-780S  
MRF7S15100HSR3**

MRF7S15100HR3 MRF7S15100HSR3

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Freescale Semiconductor

## PRODUCT DOCUMENTATION

[www.DataSheet4U.com](http://www.DataSheet4U.com)

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        | July 2008 | <ul style="list-style-type: none"><li>• Initial Release of Data Sheet</li></ul> |

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