Freescale Semiconductor
Technical Data

Document Number: MRF8S9100H
Rev. 1, 10/2010

RoHS

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

**MRF8S9100HR3**
**MRF8S9100HSR3**

Designed for GSM and GSM EDGE base station applications with frequencies from 865 to 960 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

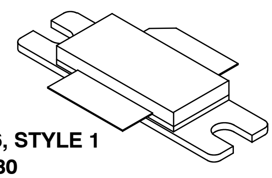
- Typical GSM Performance: $V_{DD}$ = 28 Volts, $I_{DQ}$ = 500 mA, $P_{out}$ = 72 Watts CW

| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) |
|---|---|---|
| 920 MHz | 19.3 | 51.6 |
| 940 MHz | 19.3 | 52.9 |
| 960 MHz | 19.1 | 54.1 |

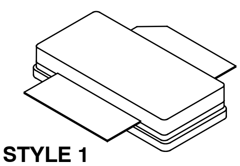
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 940 MHz, 133 Watts CW Output Power (3 dB Input Overdrive from Rated $P_{out}$)
- Typical $P_{out}$ @ 1 dB Compression Point ≃ 108 Watts CW
- Typical GSM EDGE Performance: $V_{DD}$ = 28 Volts, $I_{DQ}$ = 700 mA, $P_{out}$ = 45 Watts Avg.

| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | SR1 @ 400 kHz (dBc) | SR2 @ 600 kHz (dBc) | EVM (% rms) |
|---|---|---|---|---|---|
| 920 MHz | 19.1 | 43 | -64.1 | -74.5 | 1.8 |
| 940 MHz | 19.1 | 44 | -63.6 | -74.6 | 2.0 |
| 960 MHz | 19.0 | 45 | -62.8 | -75.1 | 2.3 |

**920-960 MHz, 72 W CW, 28 V**
**GSM, GSM EDGE**
**LATERAL N-CHANNEL**
**RF POWER MOSFETs**



**CASE 465-06, STYLE 1**
**NI-780**
**MRF8S9100HR3**



**CASE 465A-06, STYLE 1**
**NI-780S**
**MRF8S9100HSR3**

### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters and Common Source S-Parameters
- Internally Matched for Ease of Use
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**Table 1. Maximum Ratings**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | -0.5, +70 | 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 [1,2] | $T_J$ | 225 | °C |

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.

### Table 2. Thermal Characteristics

| Characteristic | Symbol | Value (1,2) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>Case Temperature 80°C, 100 W CW, 28 Vdc, $I_{DQ}$ = 500 mA<br>Case Temperature 81°C, 72 W CW, 28 Vdc, $I_{DQ}$ = 500 mA<br>Case Temperature 82°C, 45 W CW, 28 Vdc, $I_{DQ}$ = 700 mA | $R_{\theta JC}$ | <br>0.60<br>0.65<br>0.69 | °C/W |

### Table 3. ESD Protection Characteristics

| Test Methodology | Class |
|---|---|
| Human Body Model (per JESD22-A114) | 2 (Minimum) |
| Machine Model (per EIA/JESD22-A115) | A (Minimum) |
| Charge Device Model (per JESD22-C101) | IV (Minimum) |

### Table 4. Electrical Characteristics ($T_A$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics** | | | | | |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 70 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 28 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 1 | μAdc |
| Gate-Source Leakage Current ($V_{GS}$ = 5 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | — | — | 1 | μAdc |
| **On Characteristics** | | | | | |
| Gate Threshold Voltage ($V_{DS}$ = 10 Vdc, $I_D$ = 460 μAdc) | $V_{GS(th)}$ | 1.4 | 2.2 | 2.9 | Vdc |
| Gate Quiescent Voltage ($V_{DD}$ = 28 Vdc, $I_D$ = 500 mAdc, Measured in Functional Test) | $V_{GS(Q)}$ | 2.1 | 2.9 | 3.6 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 1.7 Adc) | $V_{DS(on)}$ | 0.1 | 0.17 | 0.3 | Vdc |
| **Functional Tests** (3) (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 500 mA, $P_{out}$ = 72 W CW, f = 920 MHz | | | | | |
| Power Gain | $G_{ps}$ | 18 | 19.3 | 23 | dB |
| Drain Efficiency | $\eta_D$ | 50 | 51.6 | — | % |
| Input Return Loss | IRL | — | -12.4 | -9 | dB |
| $P_{out}$ @ 1 dB Compression Point, CW | P1dB | 100 | — | — | W |

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 500 mA, $P_{out}$ = 72 W CW

| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | IRL (dB) |
|---|---|---|---|
| 920 MHz | 19.3 | 51.6 | -12.4 |
| 940 MHz | 19.3 | 52.9 | -14.3 |
| 960 MHz | 19.1 | 54.1 | -12.2 |

1. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access 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.
3. Part internally input matched.

(continued)

**Table 4. Electrical Characteristics** ($T_A$ = 25°C unless otherwise noted) **(continued)**

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Typical Performances** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 500 mA, 920-960 MHz Bandwidth | | | | | |
| $P_{out}$ @ 1 dB Compression Point, CW | P1dB | — | 108 | — | W |
| IMD Symmetry @ 100 W PEP, $P_{out}$ where IMD Third Order Intermodulation ≅ 30 dBc (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB) | $IMD_{sym}$ | — | 4 | — | MHz |
| VBW Resonance Point (IMD Third Order Intermodulation Inflection Point) | $VBW_{res}$ | — | 30 | — | MHz |
| Gain Flatness in 40 MHz Bandwidth @ $P_{out}$ = 72 W CW | $G_F$ | — | 0.13 | — | dB |
| Gain Variation over Temperature (-30°C to +85°C) | ΔG | — | 0.02 | — | dB/°C |
| Output Power Variation over Temperature (-30°C to +85°C) | ΔP1dB | — | 0.005 | — | dB/°C |

**Typical GSM EDGE Performances** (In Freescale GSM EDGE Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 700 mA, $P_{out}$ = 45 W Avg., 920-960 MHz EDGE Modulation

| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | SR1 @ 400 kHz (dBc) | SR2 @ 600 kHz (dBc) | EVM (% rms) |
|---|---|---|---|---|---|
| 920 MHz | 19.1 | 43 | -64.1 | -74.5 | 1.8 |
| 940 MHz | 19.1 | 44 | -63.6 | -74.6 | 2.0 |
| 960 MHz | 19.0 | 45 | -62.8 | -75.1 | 2.3 |

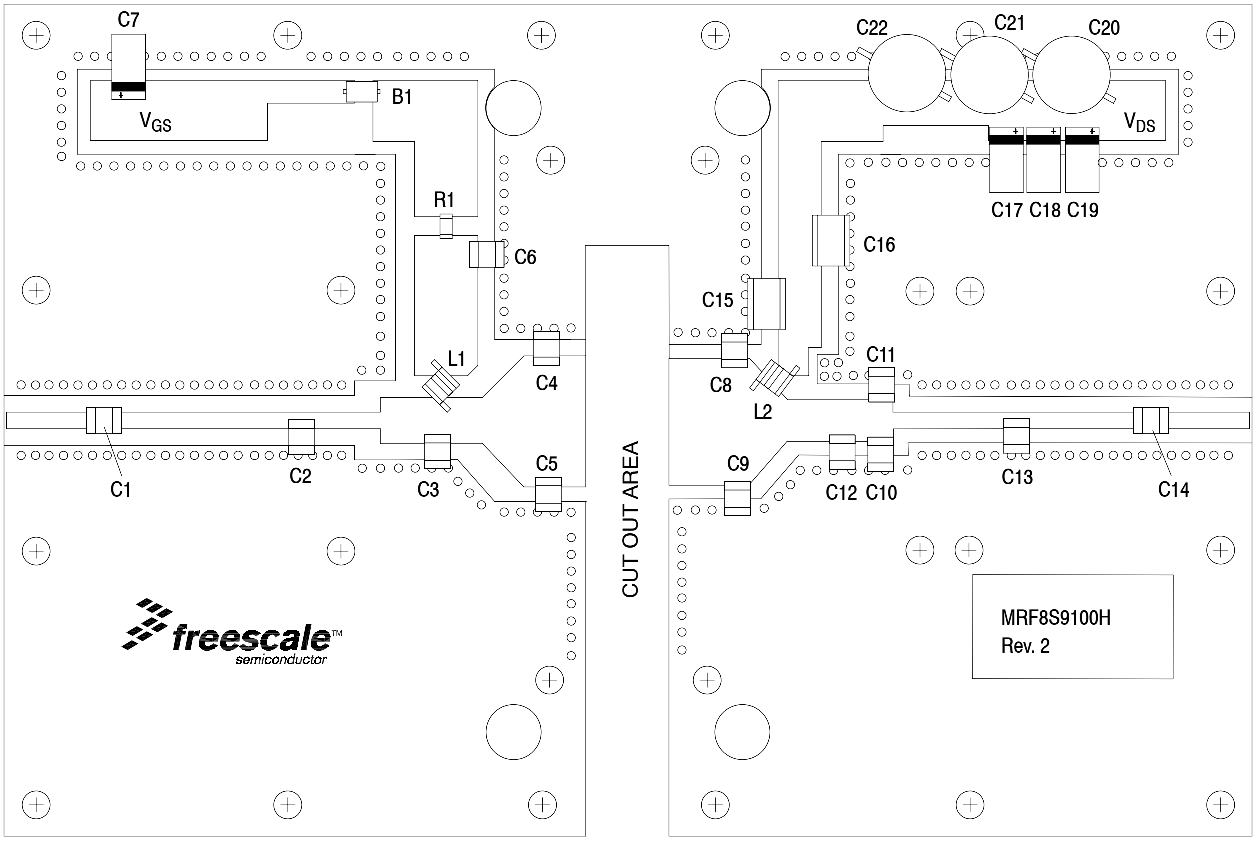



**Figure 1. MRF8S9100HR3(HSR3) Test Circuit Component Layout**

**Table 5. MRF8S9100HR3(HSR3) Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| B1 | Short RF Bead | 2743019447 | Fair-Rite |
| C1, C6 | 47 pF Chip Capacitors | ATC100B470JT500XT | ATC |
| C2 | 5.6 pF Chip Capacitor | ATC100B5R6BT500XT | ATC |
| C3 | 7.5 pF Chip Capacitor | ATC100B7R5BT500XT | ATC |
| C4, C5 | 9.1 pF Chip Capacitors | ATC100B9R1BT500XT | ATC |
| C7, C17, C18, C19 | 10 μF, 35 V Tantalum Capacitors | T491D106K035AT | Kemet |
| C8, C9 | 13 pF Chip Capacitors | ATC100B130BT500XT | ATC |
| C10, C11 | 2.7 pF Chip Capacitors | ATC100B2R7BT500XT | ATC |
| C12 | 6.2 pF Chip Capacitor | ATC100B6R2BT500XT | ATC |
| C13 | 1.8 pF Chip Capacitor | ATC100B1R8BT500XT | ATC |
| C14 | 20 pF Chip Capacitor | ATC100B200JT500XT | ATC |
| C15, C16 | 0.56 μF, 50 V Chip Capacitors | C1825C564J5RAC-TU | Kemet |
| C20, C21, C22 | 470 μF, 63 V Electrolytic Capacitors | MCGPR63V477M13X26-RH | Multicomp |
| L1, L2 | 12.5 nH, 4 Turn Inductors | A04TJLC | Coilcraft |
| R1 | 0 Ω, 3 A Chip Resistor | CRCW12060000Z0EA | Vishay |
| PCB | 0.030″, $\varepsilon_r$ = 2.55 | AD255A-0300-55-11 | Arlon |

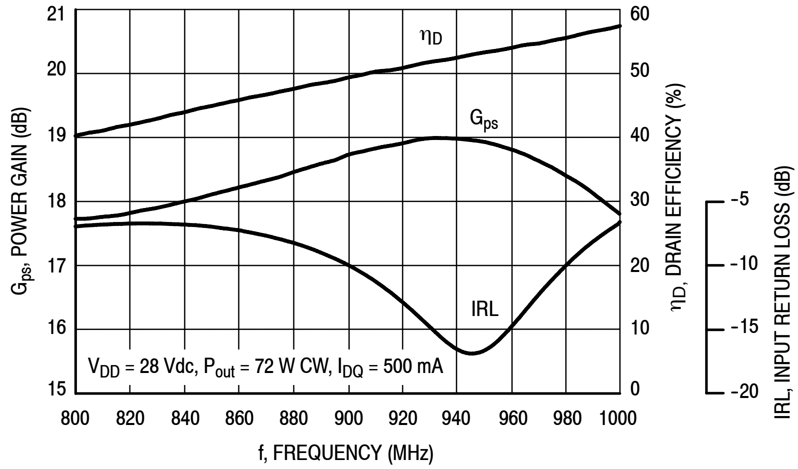



**Figure 2. Power Gain, Input Return Loss and Drain Efficiency versus Frequency @ $P_{out}$ = 72 Watts CW**

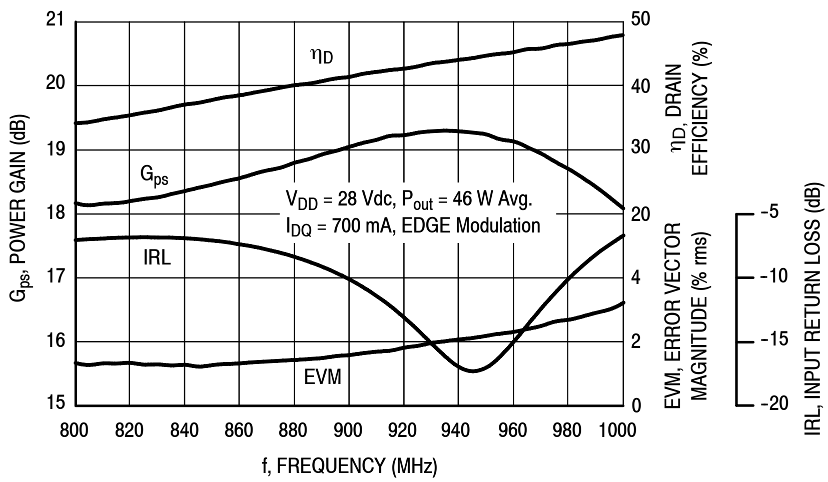



**Figure 3. Power Gain, Input Return Loss, EVM and Drain Efficiency versus Frequency @ $P_{out}$ = 46 Watts Avg.**

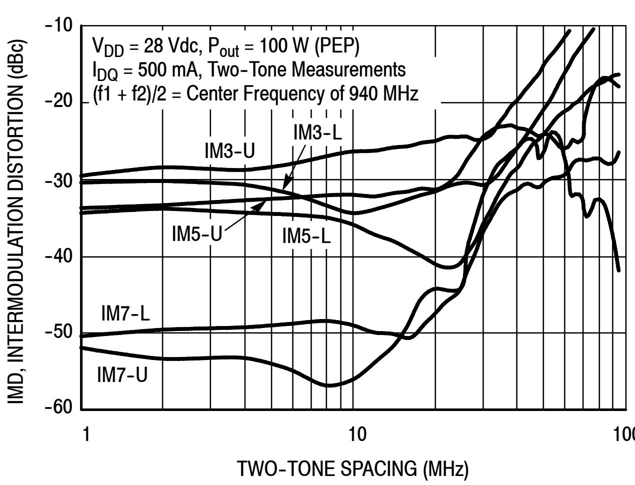



**Figure 4. Intermodulation Distortion Products versus Two-Tone Spacing**

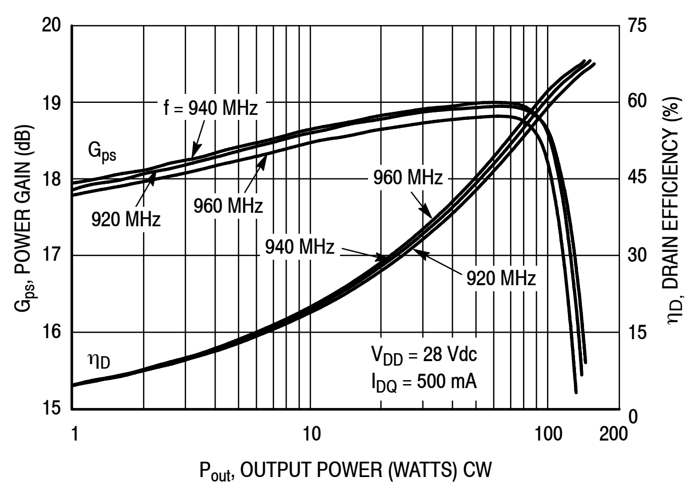



**Figure 5. Power Gain and Drain Efficiency versus Output Power**

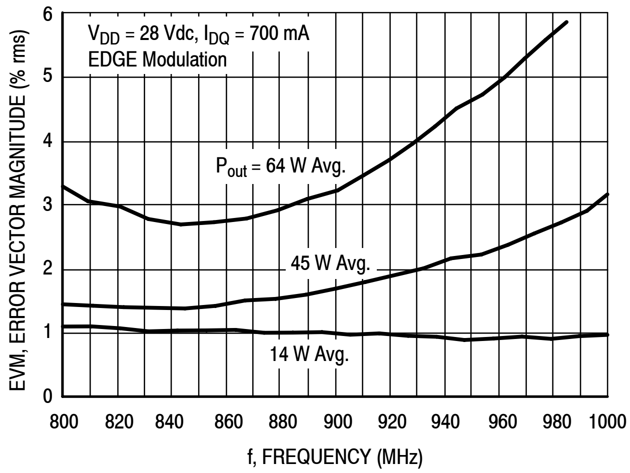



**Figure 6. EVM versus Frequency**

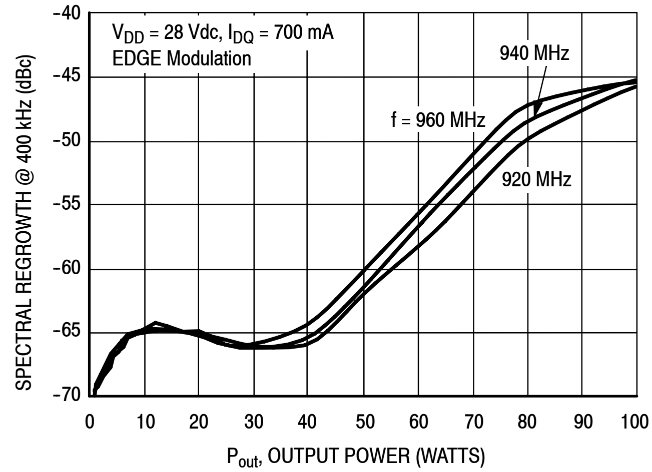



**Figure 7. Spectral Regrowth at 400 kHz versus Output Power**

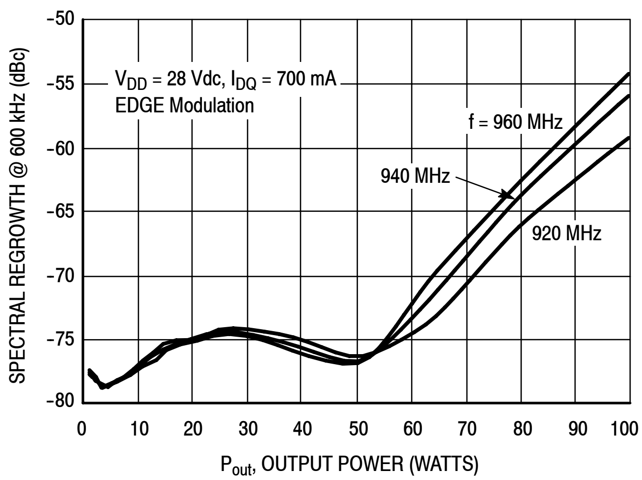



**Figure 8. Spectral Regrowth at 600 kHz versus Output Power**

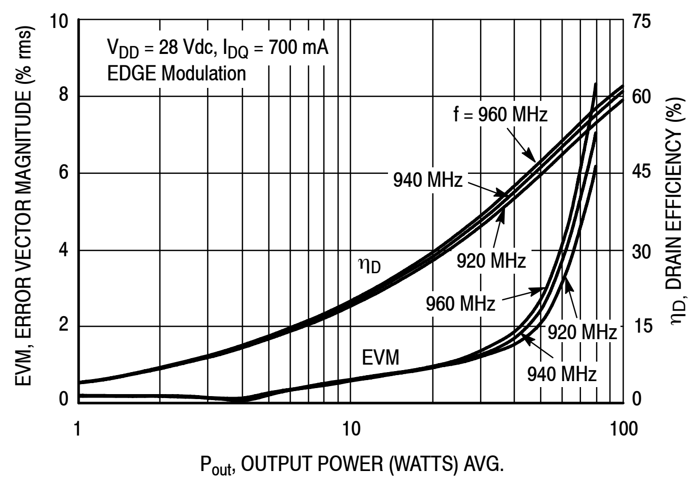



**Figure 9. EVM and Drain Efficiency versus Output Power**

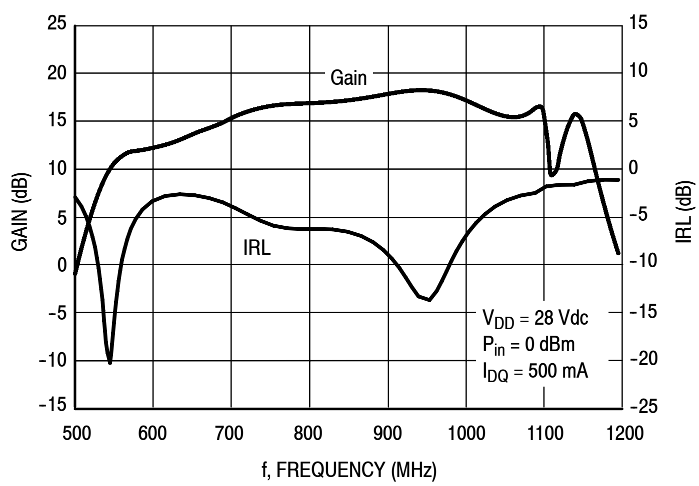



**Figure 10. Broadband Frequency Response**

## GSM TEST SIGNAL

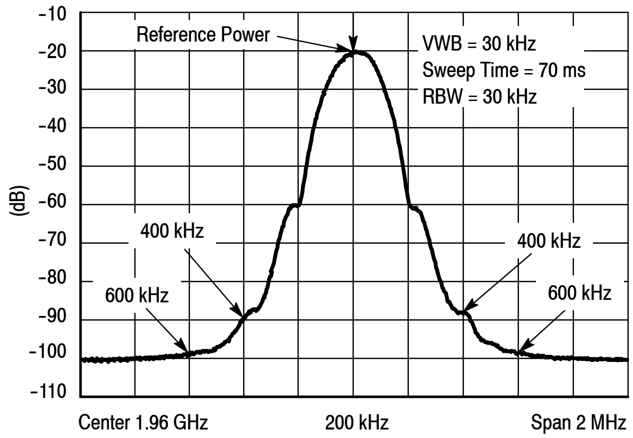



**Figure 11. EDGE Spectrum**

$V_{DD}$ = 28 Vdc, $I_{DQ}$ = 500 mA, $P_{out}$ = 72 W Avg.

| f<br>MHz | $Z_{source}$<br>Ω | $Z_{load}$<br>Ω |
|---|---|---|
| 820 | 3.81 – j1.72 | 1.61 – j0.48 |
| 840 | 3.99 – j1.80 | 1.62 – j0.34 |
| 860 | 4.13 – j1.97 | 1.62 – j0.21 |
| 880 | 4.20 – j2.22 | 1.63 – j0.09 |
| 900 | 4.14 – j2.49 | 1.62 + j0.02 |
| 920 | 3.96 – j2.74 | 1.60 + j0.12 |
| 940 | 3.67 – j2.95 | 1.57 + j0.22 |
| 960 | 3.31 – j3.07 | 1.53 + j0.32 |
| 980 | 2.91 – j3.09 | 1.47 + j0.42 |

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

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

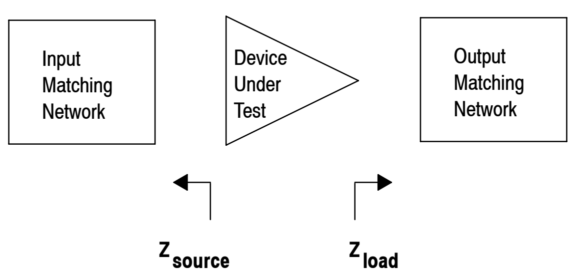
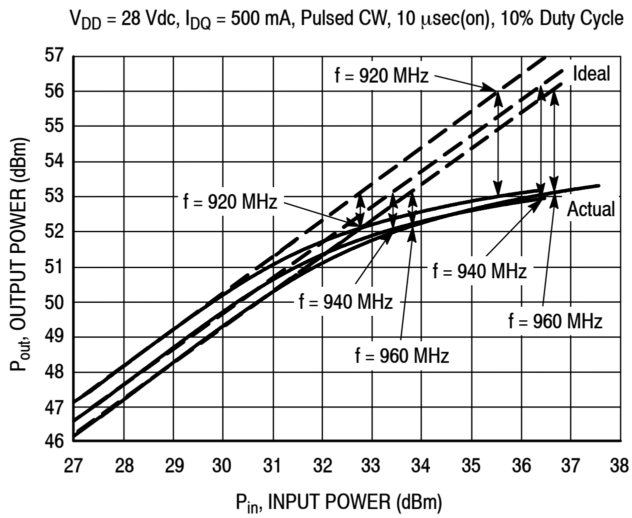



**Figure 12. Series Equivalent Source and Load Impedance**

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS




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

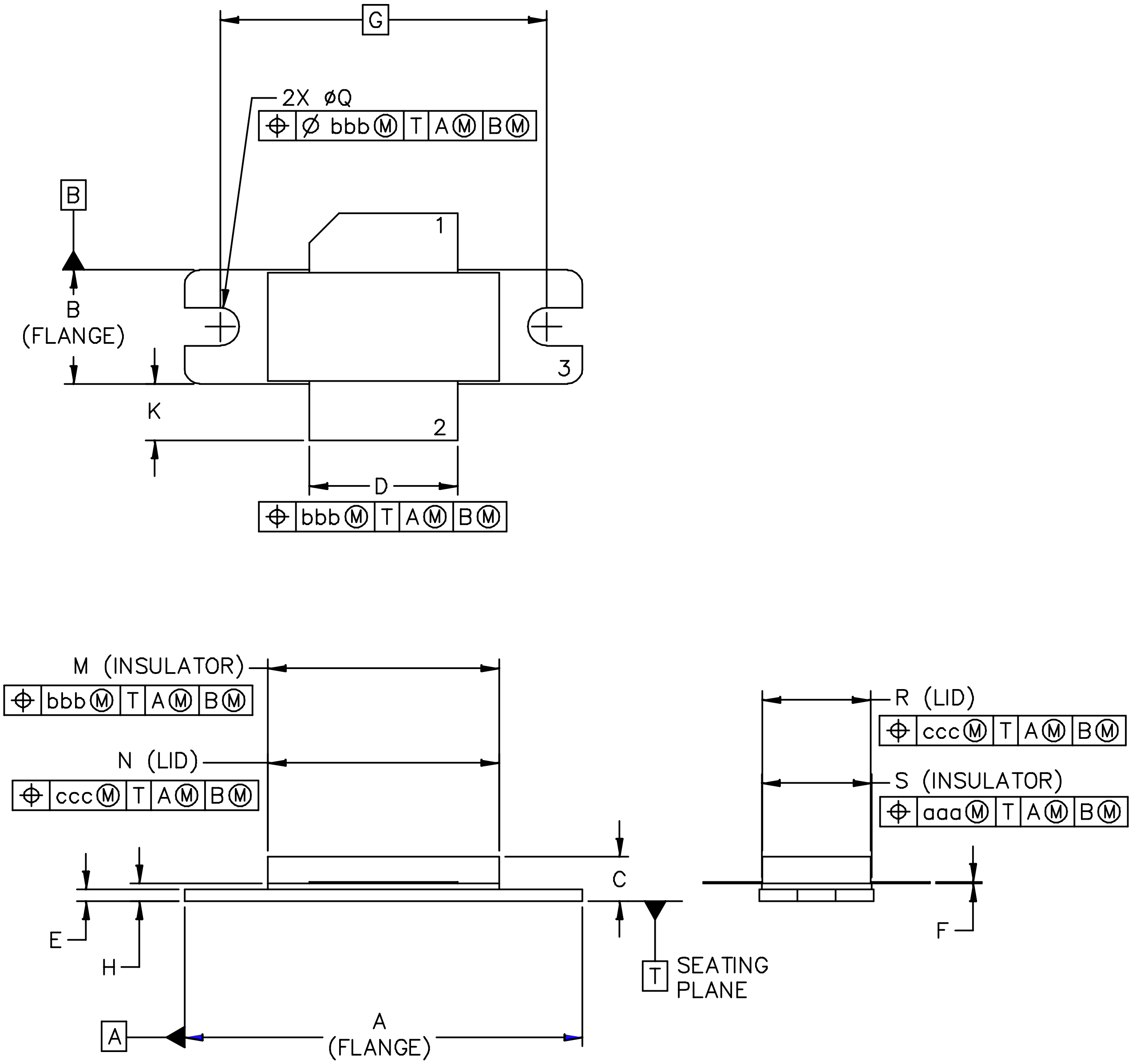
| f (MHz) | P1dB | | P3dB | |
|---|---|---|---|---|
| | Watts | dBm | Watts | dBm |
| 920 | 166 | 52.2 | 199 | 53.0 |
| 940 | 158 | 52.0 | 195 | 52.9 |
| 960 | 166 | 52.2 | 209 | 53.2 |

Test Impedances per Compression Level

| f (MHz) | | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|---|
| 920 | P1dB | 3.96 – j2.74 | 1.60 + j0.12 |
| 940 | P1dB | 3.67 – j2.95 | 1.57 + j0.22 |
| 960 | P1dB | 3.31 – j3.07 | 1.53 + j0.32 |

**Figure 13. Pulsed CW Output Power versus Input Power @ 28 V**

## PACKAGE DIMENSIONS

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| TITLE: NI−780 | DOCUMENT NO: 98ASB15607C | REV: G |
| | CASE NUMBER: 465−06 | 31 MAR 2005 |
| | STANDARD: NON−JEDEC | |

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M−1994.
2. CONTROLLING DIMENSION: INCH.
3. DELETED
4. DIMENSION H IS MEASURED .030 (.762) AWAY FROM PACKAGE BODY.

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

| DIM | INCH | | | MILLIMETER | | | DIM | INCH | | | MILLIMETER | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | | MAX | MIN | | MAX | | MIN | | MAX | MIN | | MAX |
| A | 1.335 | – | 1.345 | 33.91 | – | 34.16 | R | .365 | – | .375 | 9.27 | – | 9.53 |
| B | .380 | – | .390 | 9.65 | – | 9.91 | S | .365 | – | .375 | 9.27 | – | 9.52 |
| C | .125 | – | .170 | 3.18 | – | 4.32 | aaa | – | .005 | – | – | 0.127 | – |
| D | .495 | – | .505 | 12.57 | – | 12.83 | bbb | – | .010 | – | – | 0.254 | – |
| E | .035 | – | .045 | 0.89 | – | 1.14 | ccc | – | .015 | – | – | 0.381 | – |
| F | .003 | – | .006 | 0.08 | – | 0.15 | – | – | – | – | – | – | – |
| G | 1.100 BSC | | | 27.94 BSC | | | – | – | – | – | – | – | – |
| H | .057 | – | .067 | 1.45 | – | 1.7 | – | – | – | – | – | – | – |
| K | .170 | – | .210 | 4.32 | – | 5.33 | – | – | – | – | – | – | – |
| M | .774 | – | .786 | 19.66 | – | 19.96 | – | – | – | – | – | – | – |
| N | .772 | – | .788 | 19.6 | – | 20 | – | – | – | – | – | – | – |
| Q | ø.118 | – | ø.138 | ø3 | – | ø3.51 | – | – | – | – | – | – | – |



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DOCUMENT NO: 98ASB15607C

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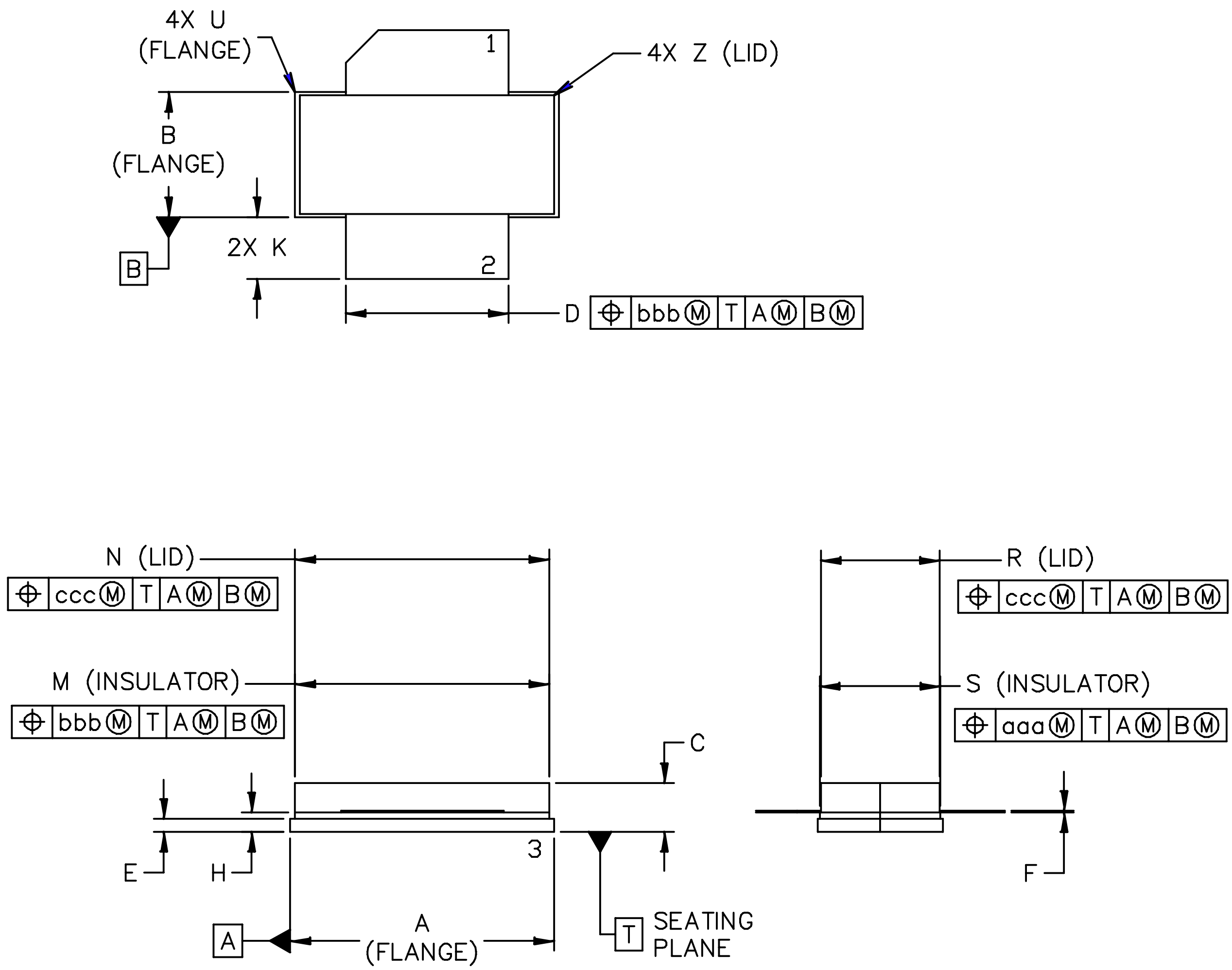


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| | STANDARD: NON–JEDEC | |

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M−1994.

2. CONTROLLING DIMENSION: INCH.

3. DELETED

4. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

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

| DIM | INCH | | | MILLIMETER | | | DIM | INCH | | | MILLIMETER | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | | MAX | MIN | | MAX | | MIN | | MAX | MIN | | MAX |
| A | .805 | − | .815 | 20.45 | − | 20.7 | U | − | − | .040 | − | − | 1.02 |
| B | .380 | − | .390 | 9.65 | − | 9.91 | Z | − | − | .030 | − | − | 0.76 |
| C | .125 | − | .170 | 3.18 | − | 4.32 | aaa | − | .005 | − | − | 0.127 | − |
| D | .495 | − | .505 | 12.57 | − | 12.83 | bbb | − | .010 | − | − | 0.254 | − |
| E | .035 | − | .045 | 0.89 | − | 1.14 | ccc | − | .015 | − | − | 0.381 | − |
| F | .003 | − | .006 | 0.08 | − | 0.15 | − | − | − | − | − | − | − |
| H | .057 | − | .067 | 1.45 | − | 1.7 | − | − | − | − | − | − | − |
| K | .170 | − | .210 | 4.32 | − | 5.33 | − | − | − | − | − | − | − |
| M | .774 | − | .786 | 19.61 | − | 20.02 | − | − | − | − | − | − | − |
| N | .772 | − | .788 | 19.61 | − | 20.02 | − | − | − | − | − | − | − |
| R | .365 | − | .375 | 9.27 | − | 9.53 | − | − | − | − | − | − | − |
| S | .365 | − | .375 | 9.27 | − | 9.52 | − | − | − | − | − | − | − |



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|---|---|---|
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| | STANDARD: NON−JEDEC | |

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents, tools and software 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

**Software**

- Electromigration MTTF Calculator
- RF High Power Model
- .s2p File

For Software, do a Part Number search at http://www.freescale.com, and select the “Part Number” link. Go to the Software & Tools tab on the part’s Product Summary page to download the respective tool.

## REVISION HISTORY

The following table summarizes revisions to this document.

| Revision | Date | Description |
|---|---|---|
| 0 | Sept. 2009 | • Initial Release of Data Sheet |
| 1 | Oct. 2010 | • Changed Human Body Model ESD rating from Class 1C to Class 2 to reflect recent ESD test results of the device, p. 2. |

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