Document Number: MRF7S27130H
Rev. 2, 3/2011

RoHS

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

**MRF7S27130HR3**
**MRF7S27130HSR3**

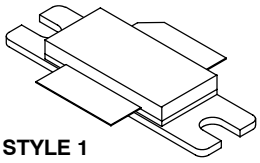
**2500-2700 MHz, 23 W AVG., 28 V**
**WiMAX**
**LATERAL N-CHANNEL**
**RF POWER MOSFETs**

Designed for WiMAX base station applications with frequencies up to 2700 MHz. Suitable for WiMAX, WiBro, BWA, and OFDM multicarrier Class AB and Class C amplifier applications.

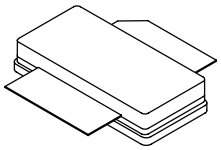
- Typical WiMAX Performance: $V_{DD}$ = 28 Volts, $I_{DQ}$ = 1500 mA, $P_{out}$ = 23 Watts Avg., f = 2700 MHz, 802.16d, 64 QAM $^3/_4$, 4 bursts, 7 MHz Channel Bandwidth, Input Signal PAR = 9.5 dB @ 0.01% Probability on CCDF.
  - Power Gain — 16.5 dB
  - Drain Efficiency — 20%
  - Device Output Signal PAR — 8.2 dB @ 0.01% Probability on CCDF
  - ACPR @ 5.25 MHz Offset — -49 dBc in 0.5 MHz Channel Bandwidth
- Capable of Handling 10:1 VSWR, @ 32 Vdc, 2600 MHz, 105 Watts CW Output Power

**Features**

- 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
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units, 56 mm Tape Width, 13 inch Reel. For R5 Tape and Reel option, see p. 14.



**CASE 465-06, STYLE 1**
**NI-780**
**MRF7S27130HR3**



**CASE 465A-06, STYLE 1**
**NI-780S**
**MRF7S27130HSR3**

**Table 1. Maximum Ratings**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DS}$ | -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 (1,2) | $T_J$ | 225 | °C |
| CW Operation @ $T_C$ = 25°C<br>Derate above 25°C | CW | 150<br>0.83 | W<br>W/°C |

**Table 2. Thermal Characteristics**

| Characteristic | Symbol | Value (2,3) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>Case Temperature 80°C, 104 W CW<br>Case Temperature 69°C, 23 W CW | $R_{\theta JC}$ | <br>0.32<br>0.36 | °C/W |

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.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.

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**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** ($T_A$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics** | | | | | |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 65 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, $I_D$ = 348 μAdc) | $V_{GS(th)}$ | 1.2 | 2 | 2.7 | Vdc |
| Gate Quiescent Voltage ($V_{DS}$ = 28 Vdc, $I_D$ = 1500 mAdc) | $V_{GS(Q)}$ | — | 2.7 | — | Vdc |
| Fixture Gate Quiescent Voltage (1) ($V_{DD}$ = 28 Vdc, $I_D$ = 1500 mAdc, Measured in Functional Test) | $V_{GG(Q)}$ | 4 | 5.4 | 7 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 3.4 Adc) | $V_{DS(on)}$ | 0.1 | 0.24 | 0.3 | Vdc |
| **Dynamic Characteristics** (2) | | | | | |
| Reverse Transfer Capacitance ($V_{DS}$ = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 10.4 | — | pF |
| Output Capacitance ($V_{DS}$ = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{oss}$ | — | 711 | — | pF |
| Input Capacitance ($V_{DS}$ = 28 Vdc, $V_{GS}$ = 0 Vdc ± 30 mV(rms)ac @ 1 MHz) | $C_{iss}$ | — | 326 | — | pF |

**Functional Tests** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1500 mA, $P_{out}$ = 23 W Avg., f = 2700 MHz, WiMAX Signal, 802.16d, 7 MHz Channel Bandwidth, 64 QAM $^3/_4$, 4 Bursts, PAR = 9.5 dB @ 0.01% Probability on CCDF. ACPR measured in 0.5 MHz Channel Bandwidth @ ±5.25 MHz Offset.

| | | | | | |
|---|---|---|---|---|---|
| Power Gain | $G_{ps}$ | 15 | 16.5 | 18.5 | dB |
| Drain Efficiency | $\eta_D$ | 18 | 20 | 23 | % |
| Output Peak-to-Average Ratio @ 0.01% Probability on CCDF | PAR | 7.5 | 8.2 | — | dB |
| Adjacent Channel Power Ratio | ACPR | — | -49 | -46 | dBc |
| Input Return Loss | IRL | — | -8 | -5 | dB |

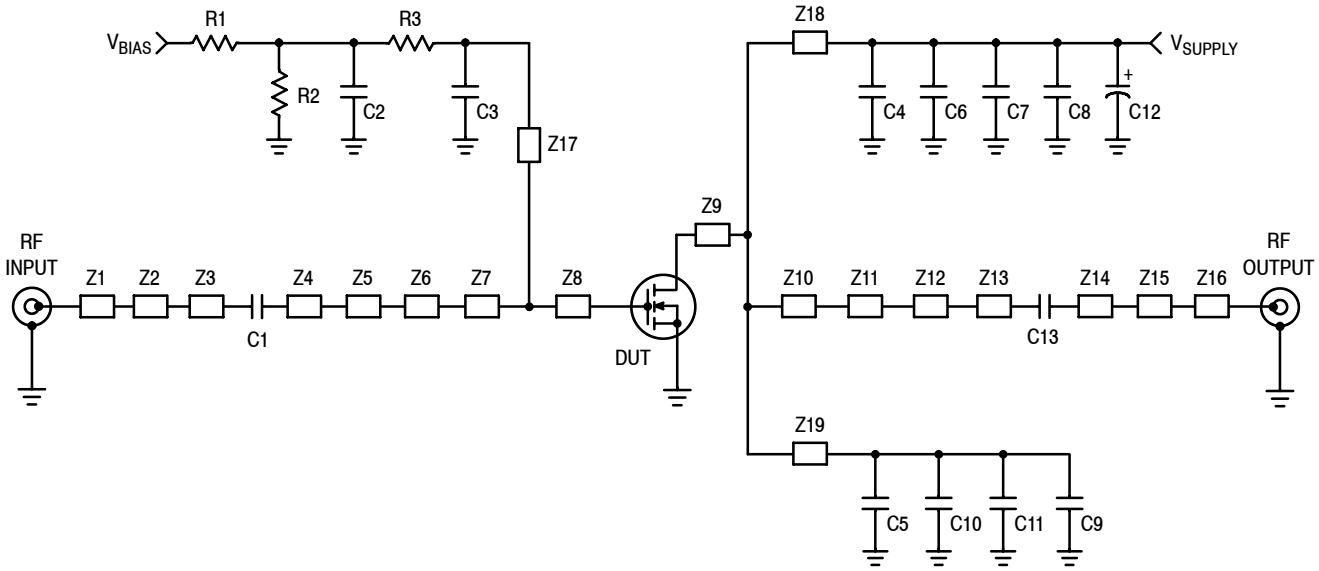
1. $V_{GG}$ = 2 x $V_{GS(Q)}$. Parameter measured on Freescale Test Fixture, due to resistive divider network on the board. Refer to Test Circuit schematic.
2. Part internally matched both on input and output.

(continued)

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Typical Performances OFDM Signal** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1500 mA, $P_{out}$ = 23 W Avg., f = 2500 MHz and f = 2700 MHz, WiMAX Signal, OFDM Single-Carrier, 7 MHz Channel Bandwidth, 64 QAM $^3/_4$, 4 Bursts, PAR = 9.5 dB @ 0.01% Probability on CCDF. | | | | | |
| Mask System Type G @ $P_{out}$ = 23 W Avg.<br>Point B at 3.5 MHz Offset<br>Point C at 5 MHz Offset<br>Point D at 7.4 MHz Offset<br>Point E at 14 MHz Offset<br>Point F at 17.5 MHz Offset | Mask | <br>—<br>—<br>—<br>—<br>— | <br>-27<br>-40<br>-44<br>-60<br>-60 | <br>—<br>—<br>—<br>—<br>— | dBc |
| Relative Constellation Error @ $P_{out}$ = 23 W Avg. (1) | RCE | — | -33 | — | dB |
| Error Vector Magnitude (1)<br>(Typical EVM Performance @ $P_{out}$ = 23 W Avg. with OFDM 802.16d Signal Call) | EVM | — | 2.2 | — | % rms |
| **Typical Performances** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1500 mA, 2500-2700 MHz Bandwidth | | | | | |
| Video Bandwidth @ 105 W PEP $P_{out}$ where IM3 = -30 dBc<br>(Tone Spacing from 100 kHz to VBW)<br>ΔIMD3 = IMD3 @ VBW frequency - IMD3 @ 100 kHz <1 dBc (both sidebands) | VBW | — | 40 | — | MHz |
| Gain Flatness in 200 MHz Bandwidth @ $P_{out}$ = 23 W Avg. | $G_F$ | — | 1.2 | — | dB |
| Average Deviation from Linear Phase in 200 MHz Bandwidth @ $P_{out}$ = 105 W CW | Φ | — | 135 | — | ° |
| Average Group Delay @ $P_{out}$ = 105 W CW, f = 2600 MHz | Delay | — | 1.5 | — | ns |
| Part-to-Part Insertion Phase Variation @ $P_{out}$ = 105 W CW, f = 2600 MHz, Six Sigma Window | ΔΦ | — | 81.3 | — | ° |
| Gain Variation over Temperature (-30°C to +85°C) | ΔG | — | 0.013 | — | dB/°C |
| Output Power Variation over Temperature (-30°C to +85°C) | ΔP1dB | — | 0.01 | — | dB/°C |

1. RCE = 20Log(EVM/100)




| | | | |
|---|---|---|---|
| Z1 | 0.320″ x 0.084″ Microstrip | Z11 | 0.251″ x 0.084″ Microstrip |
| Z2 | 0.380″ x 0.240″ Microstrip | Z12 | 0.160″ x 0.162″ Microstrip |
| Z3 | 0.046″ x 0.084″ Microstrip | Z13 | 0.566″ x 0.084″ Microstrip |
| Z4 | 0.273″ x 0.084″ Microstrip | Z14 | 0.059″ x 0.084″ Microstrip |
| Z5 | 0.360″ x 0.600″ Microstrip | Z15 | 0.080″ x 0.123″ Microstrip |
| Z6 | 0.260″ x 0.394″ Microstrip | Z16 | 0.583″ x 0.084″ Microstrip |
| Z7 | 0.145″ x 0.922″ Microstrip | Z17* | 0.950″ x 0.100″ Microstrip |
| Z8 | 0.455″ x 0.922″ Microstrip | Z18, Z19* | 0.560″ x 0.100″ Microstrip |
| Z9 | 0.106″ x 0.716″ Microstrip | PCB | Taconic TLX8-0300, 0.030″, $\varepsilon_r$ = 2.55 |
| Z10 | 0.413″ x 0.716″ Microstrip | | |

* Variable for tuning

**Figure 1. MRF7S27130HR3(HSR3) Test Circuit Schematic**

**Table 5. MRF7S27130HR3(HSR3) Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1 | 2 pF Chip Capacitor | ATC100B2R0BT500XT | ATC |
| C2, C6, C7, C8, C9, C10, C11 | 10 μF, 50 V Chip Capacitors | C5750X5R1H106M | TDK |
| C3 | 3 pF Chip Capacitor | ATC100B3R0BT500XT | ATC |
| C4, C5 | 3.6 pF Chip Capacitors | ATC100B3R6BT500XT | ATC |
| C12 | 470 μF, 63 V Electrolytic Capacitor, Radial | EKME630ELL471MK255 | Multicomp |
| C13 | 5.6 pF Chip Capacitor | ATC100B5R6BT500XT | ATC |
| R1, R2 | 2 KΩ, 1/4 W Chip Resistors | CRCW12062001FKEA | Vishay |
| R3 | 10 Ω, 1/4 W Chip Resistor | CRCW120610R1FKEA | Vishay |

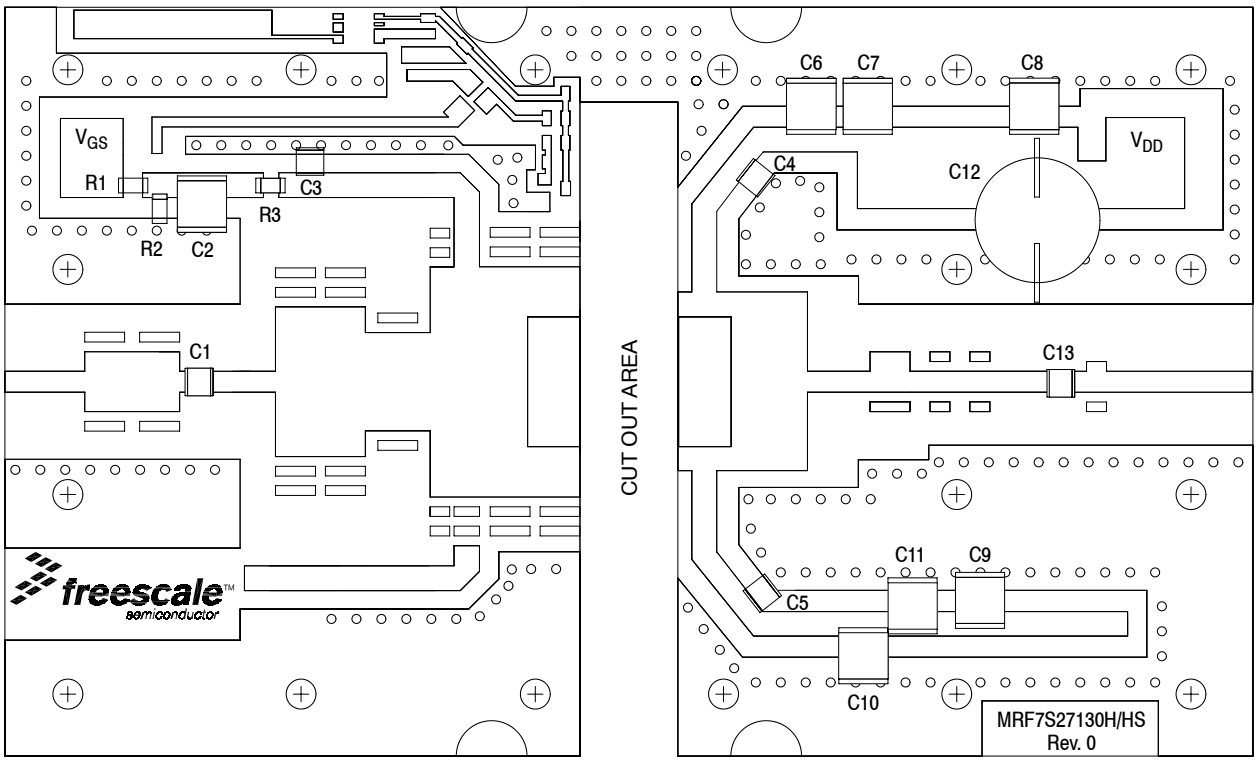



**Figure 2. MRF7S27130HR3(HSR3) Test Circuit Component Layout**

## TYPICAL CHARACTERISTICS

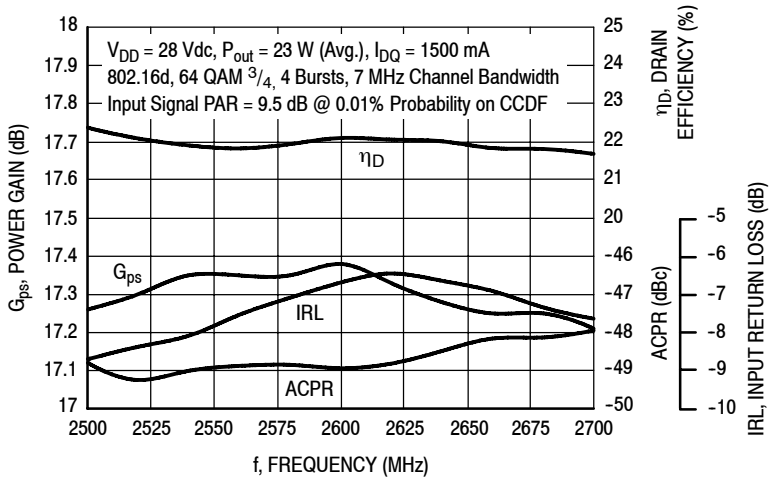



**Figure 3. WiMAX Broadband Performance @ $P_{out}$ = 23 Watts Avg.**

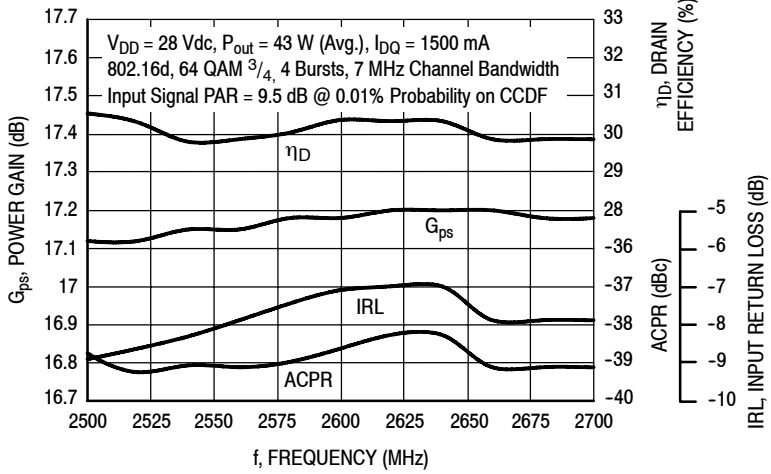



**Figure 4. WiMAX Broadband Performance @ $P_{out}$ = 43 Watts Avg.**

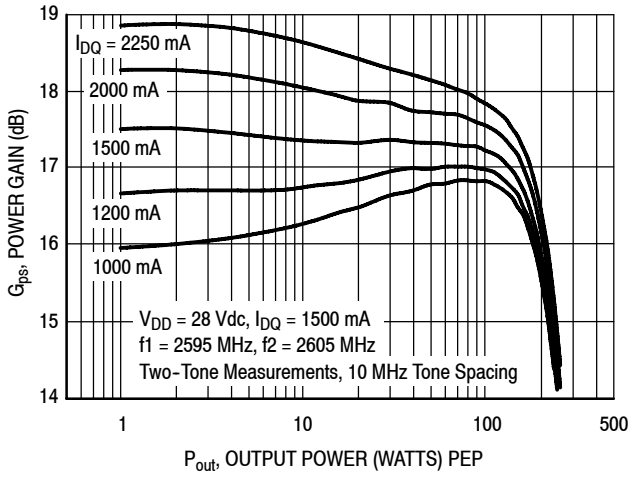



**Figure 5. Two-Tone Power Gain versus Output Power**

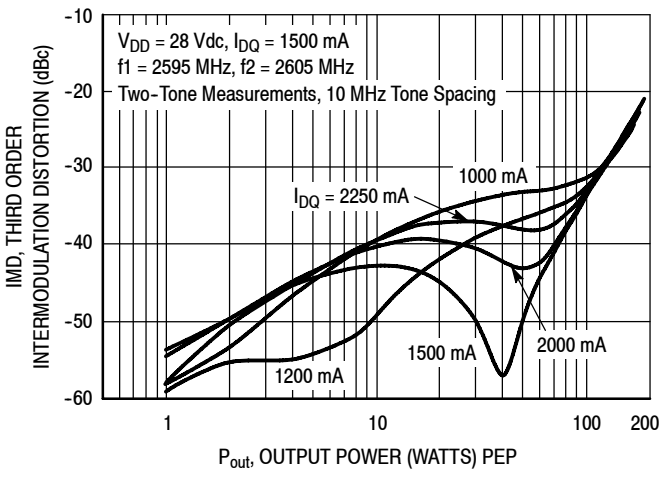



**Figure 6. Third Order Intermodulation Distortion versus Output Power**

## TYPICAL CHARACTERISTICS

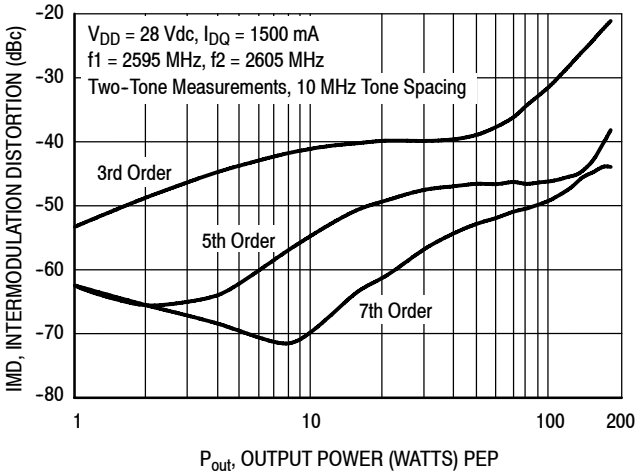



**Figure 7. Intermodulation Distortion Products versus Output Power**

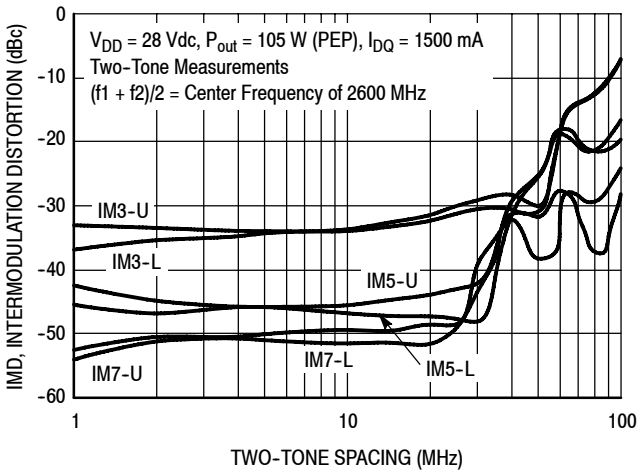



**Figure 8. Intermodulation Distortion Products versus Tone Spacing**

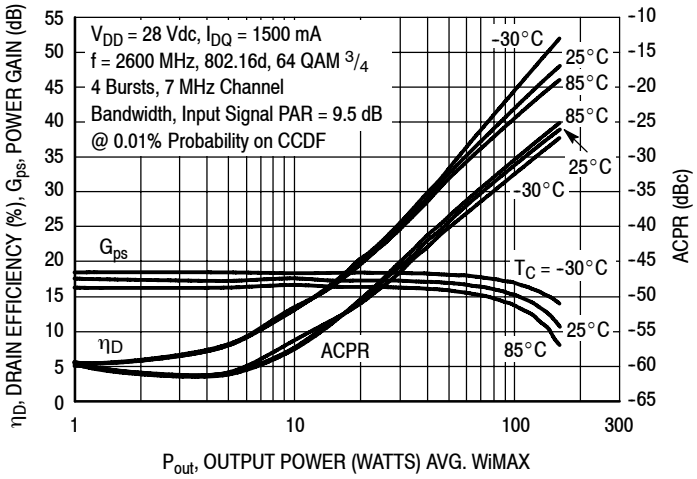



**Figure 9. WiMAX, ACPR, Power Gain and Drain Efficiency versus Output Power**

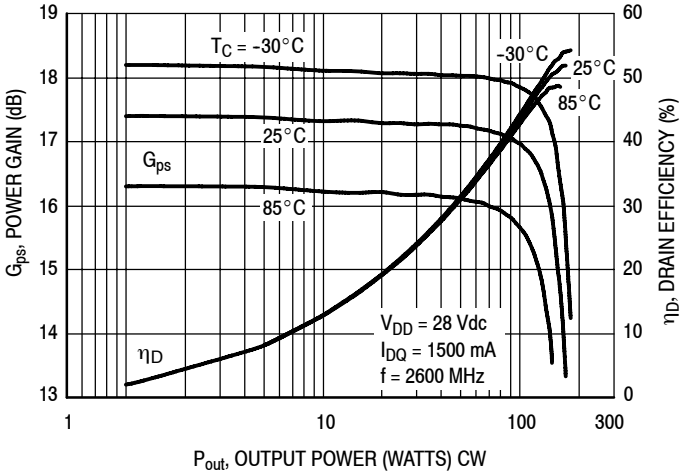



**Figure 10. Power Gain and Drain Efficiency versus CW Output Power**

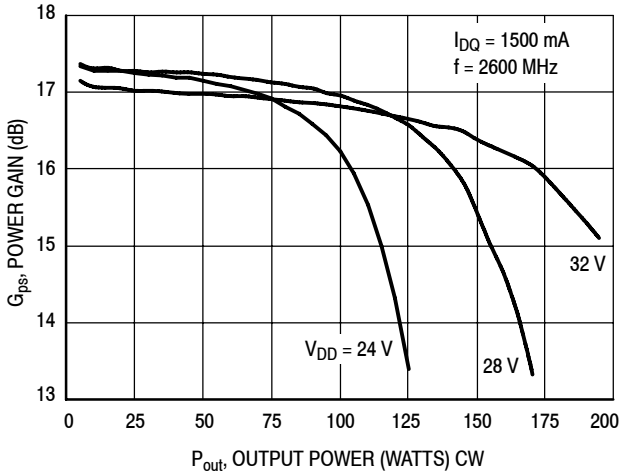



**Figure 11. Power Gain versus Output Power**

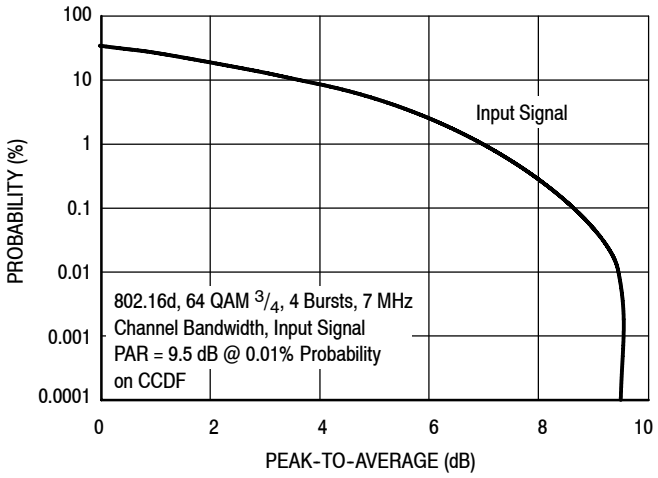



**Figure 12. OFDM 802.16d Test Signal**

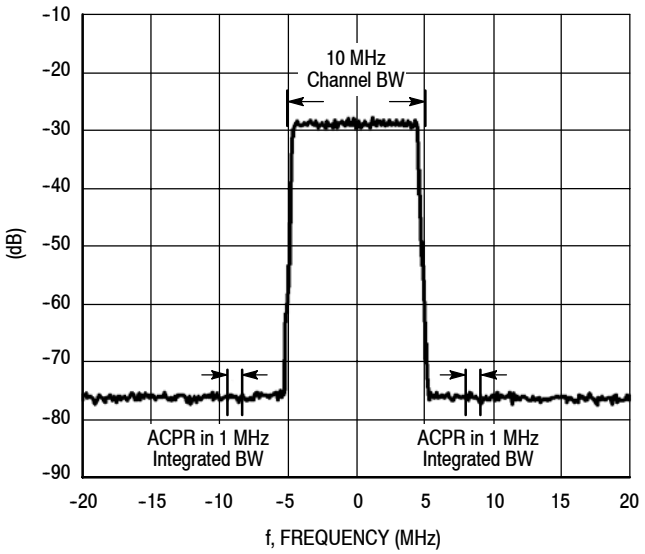
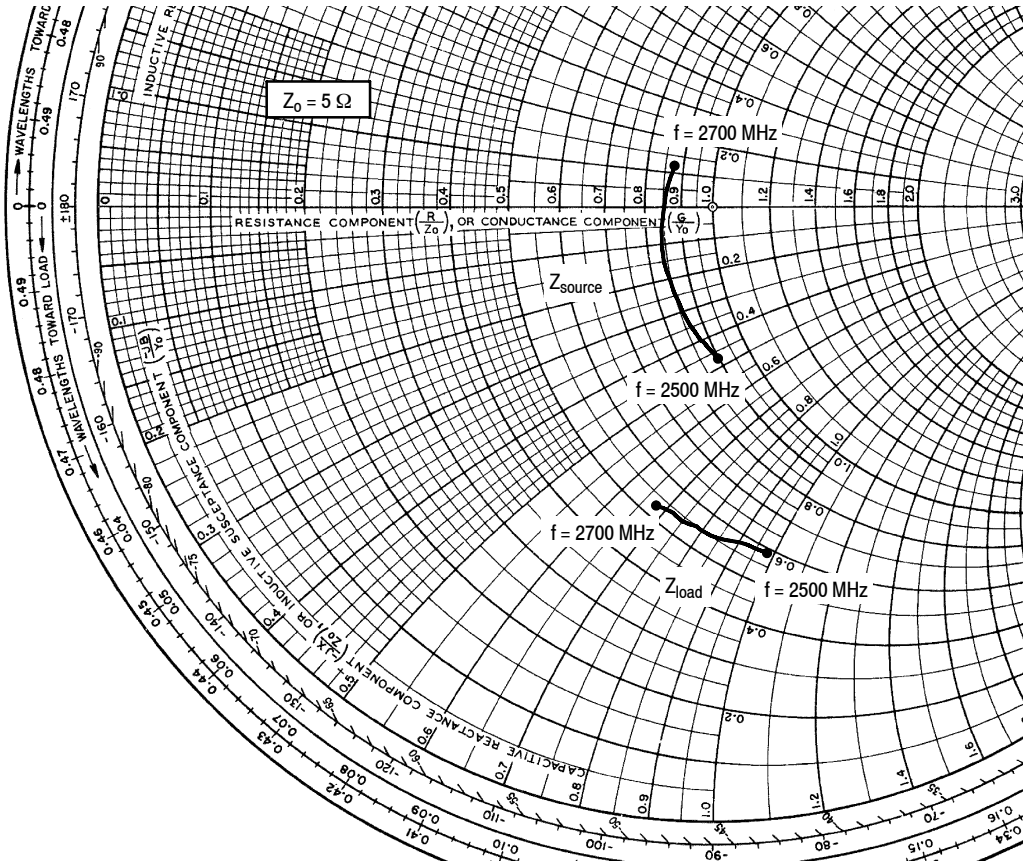



**Figure 13. WiMAX Spectrum Mask Specifications**




$V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1500 mA, $P_{out}$ = 23 W Avg.

| f MHz | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|
| 2500 | 4.499 – j2.335 | 2.936 – j4.876 |
| 2525 | 4.382 – j1.944 | 2.885 – j4.666 |
| 2550 | 4.294 – j1.567 | 2.838 – j4.467 |
| 2575 | 4.234 – j1.194 | 2.797 – j4.273 |
| 2600 | 4.209 – j0.820 | 2.763 – j4.084 |
| 2625 | 4.219 – j0.447 | 2.733 – j3.903 |
| 2650 | 4.248 – j0.090 | 2.706 – j3.732 |
| 2675 | 4.304 + j0.261 | 2.678 – j3.570 |
| 2700 | 4.390 + j0.612 | 2.652 – j3.410 |

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

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

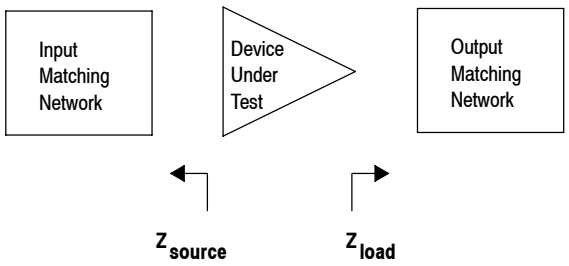
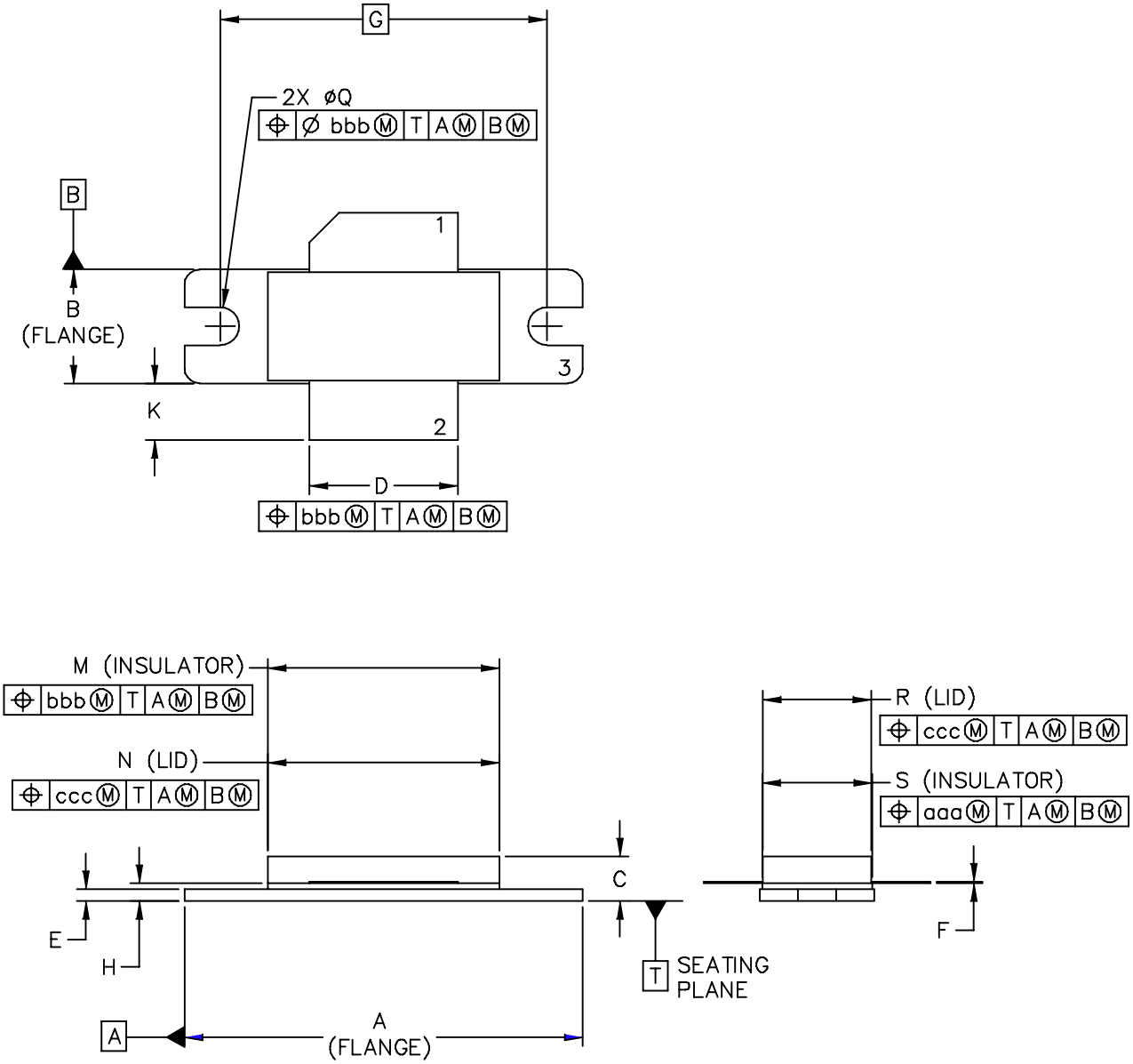



**Figure 14. Series Equivalent Source and Load Impedance**

## 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.

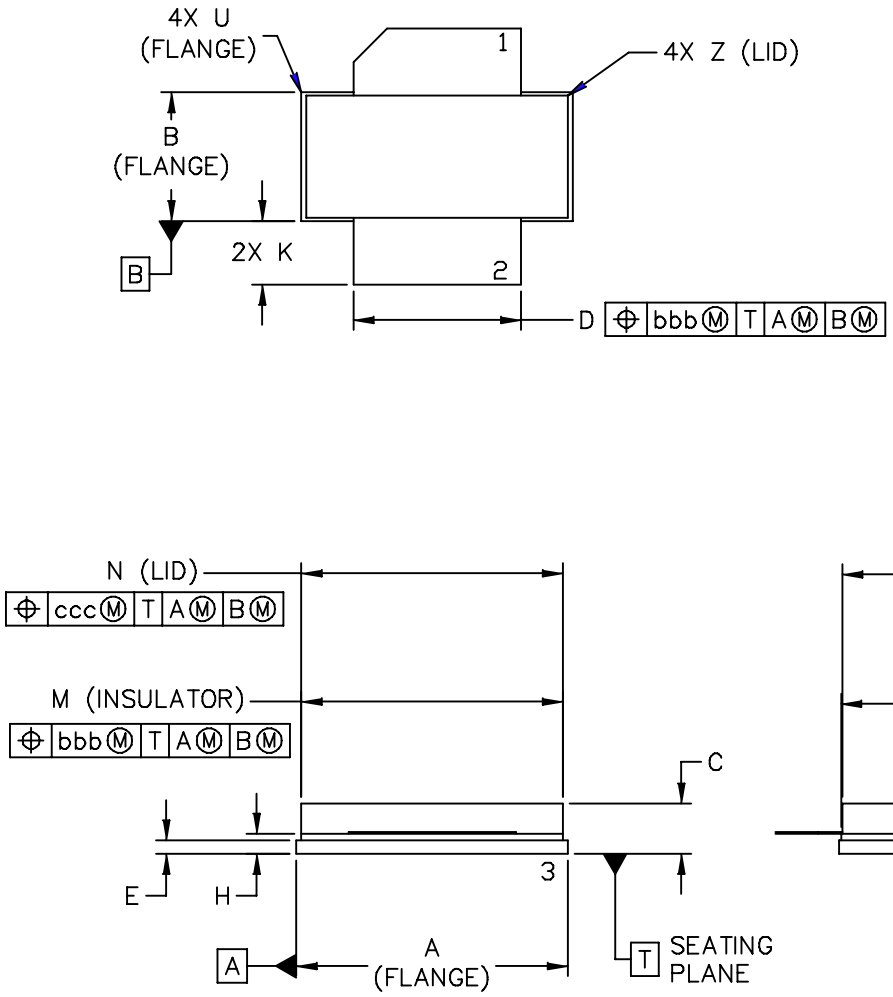
STYLE 1:
PIN 1. DRAIN
2. GATE
3. SOURCE

| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER 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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| | CASE NUMBER: 465A-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 (0.762) AWAY FROM PACKAGE BODY.

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

| DIM | INCH MIN | | MAX | MILLIMETER MIN | | MAX | DIM | INCH MIN | | MAX | MILLIMETER 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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| TITLE: | DOCUMENT NO: 98ASB16718C | REV: H |
|---|---|---|
| NI–780S | CASE NUMBER: 465A–06 | 31 MAR 2005 |
| | STANDARD: NON–JEDEC | |

## PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following documents 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

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.

## R5 TAPE AND REEL OPTION

R5 Suffix = 50 Units, 56 mm Tape Width, 13 inch Reel.

The R5 tape and reel option for MRF7S27130H and MRF7S27130HS parts will be available for 2 years after release of MRF7S27130H and MRF7S27130HS. Freescale Semiconductor, Inc. reserves the right to limit the quantities that will be delivered in the R5 tape and reel option. At the end of the 2 year period customers who have purchased these devices in the R5 tape and reel option will be offered MRF7S27130H and MRF7S27130HS in the R3 tape and reel option.

## REVISION HISTORY

The following table summarizes revisions to this document.

| Revision | Date | Description |
|---|---|---|
| 0 | Sept. 2007 | • Initial Release of Data Sheet |
| 1 | Dec. 2008 | • Modified Fig. 13 to display Input Signal only, p. 8<br>• Updated Fig. 14, WiMAX Spectrum Mask Specification, to reflect the distortion free input test signal versus the distortion loaded output signal, p. 8 |
| 2 | Mar. 2011 | • Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13628, p. 1, 2<br>• Fig. 12, MTTF versus Junction Temperature removed, p. 8. Refer to the device’s MTTF Calculator available at freescale.com/RFpower. Go to Design Resources > Software and Tools.<br>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 14 |

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