**Freescale Semiconductor**
Technical Data

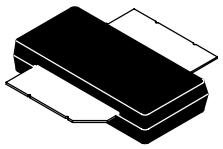
Document Number: MRF8S9170N
Rev. 1, 5/2010

# RF Power Field Effect Transistor

## N-Channel Enhancement-Mode Lateral MOSFET

**MRF8S9170NR3**

**920-960 MHz, 50 W AVG., 28 V
SINGLE W-CDMA
LATERAL N-CHANNEL
RF POWER MOSFET**



**CASE 2021-03, STYLE 1
OM-780-2**

Designed for CDMA base station applications with frequencies from 920 to 960 MHz. Can be used in Class AB and Class C for all typical cellular base station modulation formats.

- Typical Single-Carrier W-CDMA Performance: $V_{DD}$ = 28 Volts, $I_{DQ}$ = 1000 mA, $P_{out}$ = 50 Watts Avg., IQ Magnitude Clipping, Channel Bandwidth = 3.84 MHz, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF.

| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | Output PAR (dB) | ACPR (dBc) |
|---|---|---|---|---|
| 920 MHz | 19.3 | 36.5 | 6.0 | -36.6 |
| 940 MHz | 19.1 | 36.1 | 6.1 | -36.7 |
| 960 MHz | 18.9 | 36.0 | 6.0 | -36.1 |

- Capable of Handling 10:1 VSWR, @ 32 Vdc, 940 MHz, 250 Watts CW Output Power (3 dB Input Overdrive from Rated $P_{out}$), Designed for Enhanced Ruggedness
- Typical $P_{out}$ @ 1 dB Compression Point ≃ 177 Watts CW

**Features**

- 100% PAR Tested for Guaranteed Output Power Capability
- 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
- Designed for Digital Predistortion Error Correction Systems
- Optimized for Doherty Applications
- 225°C Capable Plastic Package
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 32 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 |

**Table 2. Thermal Characteristics**

| Characteristic | Symbol | Value (2,3) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>Case Temperature 78°C, 50 W CW, 28 Vdc, $I_{DQ}$ = 1000 mA<br>Case Temperature 82°C, 170 W CW, 28 Vdc, $I_{DQ}$ = 1000 mA | $R_{\theta JC}$ | <br>0.38<br>0.33 | °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.

**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. Moisture Sensitivity Level**

| Test Methodology | Rating | Package Peak Temperature | Unit |
|---|---|---|---|
| Per JESD22-A113, IPC/JEDEC J-STD-020 | 3 | 260 | °C |

**Table 5. 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, $I_D$ = 355 μAdc) | $V_{GS(th)}$ | 1.5 | 2.3 | 3 | Vdc |
| Gate Quiescent Voltage ($V_{DD}$ = 28 Vdc, $I_D$ = 1000 mAdc, Measured in Functional Test) | $V_{GS(Q)}$ | 2.3 | 3.1 | 3.8 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 2.9 Adc) | $V_{DS(on)}$ | 0.1 | 0.19 | 0.3 | Vdc |
| **Functional Tests** (1) (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1000 mA, $P_{out}$ = 50 W Avg., f = 920 MHz, Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset. | | | | | |
| Power Gain | $G_{ps}$ | 18.0 | 19.3 | 21.0 | dB |
| Drain Efficiency | $\eta_D$ | 34.0 | 36.5 | — | % |
| Output Peak-to-Average Ratio @ 0.01% Probability on CCDF | PAR | 5.5 | 6.0 | — | dB |
| Adjacent Channel Power Ratio | ACPR | — | -36.6 | -34.5 | dBc |
| Input Return Loss | IRL | — | -10 | -7 | dB |

**Typical Broadband Performance** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1000 mA, $P_{out}$ = 50 W Avg., Single-Carrier W-CDMA, IQ Magnitude Clipping, Input Signal PAR = 7.5 dB @ 0.01% Probability on CCDF. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset.

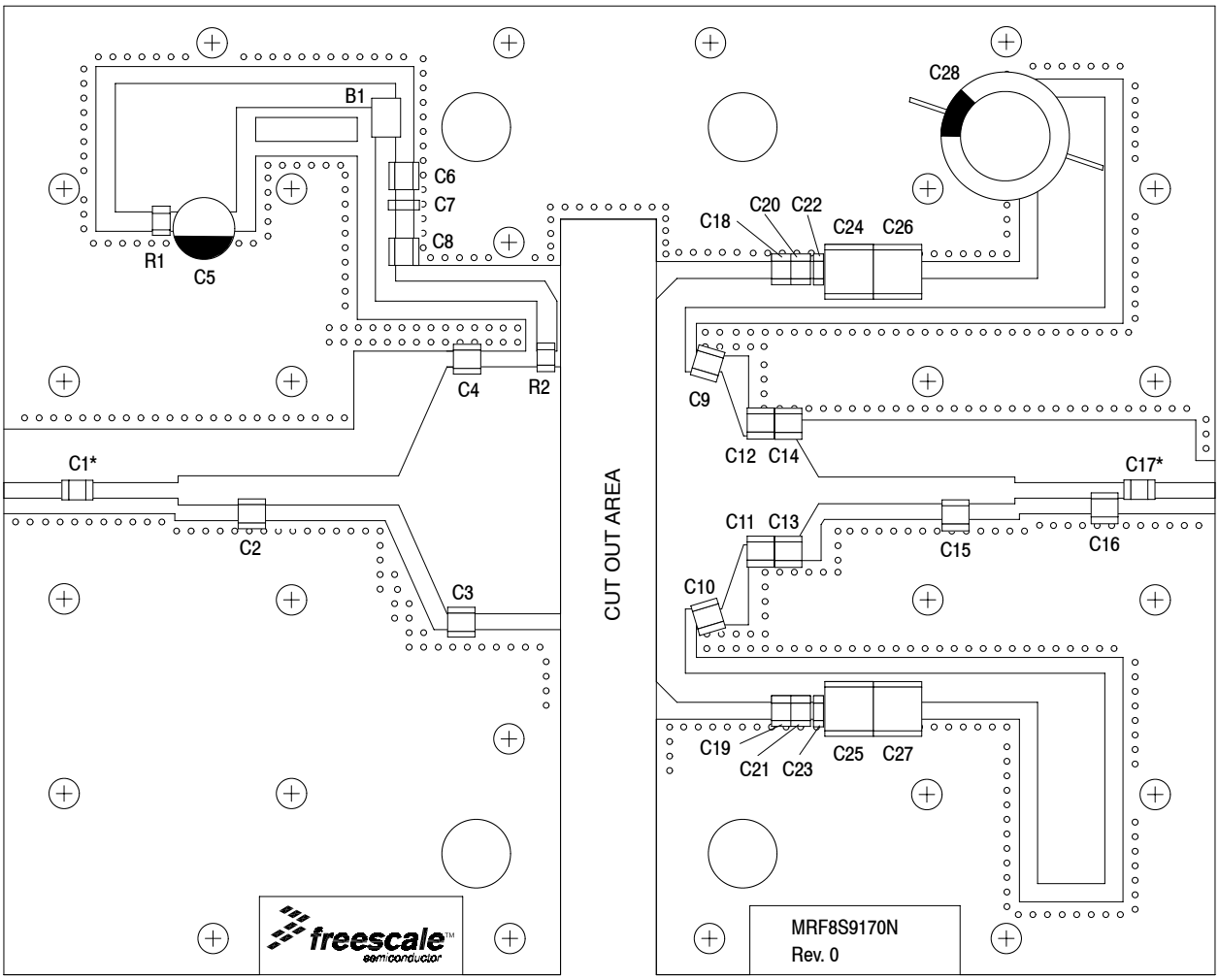
| Frequency | $G_{ps}$ (dB) | $\eta_D$ (%) | Output PAR (dB) | ACPR (dBc) | IRL (dB) |
|---|---|---|---|---|---|
| 920 MHz | 19.3 | 36.5 | 6.0 | -36.6 | -10 |
| 940 MHz | 19.1 | 36.1 | 6.1 | -36.7 | -12 |
| 960 MHz | 18.9 | 36.0 | 6.0 | -36.1 | -16 |

1. Part internally matched both on input and output.

(continued)

**Table 5. Electrical Characteristics** ($T_A$ = 25°C unless otherwise noted) **(continued)**

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Typical Performance** (In Freescale Test Fixture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1000 mA, 920–960 MHz Bandwidth | | | | | |
| $P_{out}$ @ 1 dB Compression Point, CW | P1dB | — | 177 | — | W |
| IMD Symmetry @ 160 W PEP, $P_{out}$ where IMD Third Order Intermodulation ≅ 30 dBc (Delta IMD Third Order Intermodulation between Upper and Lower Sidebands > 2 dB) | $IMD_{sym}$ | — | 17 | — | MHz |
| VBW Resonance Point (IMD Third Order Intermodulation Inflection Point) | $VBW_{res}$ | — | 50 | — | MHz |
| Gain Flatness in 40 MHz Bandwidth @ $P_{out}$ = 50 W Avg. | $G_F$ | — | 0.32 | — | dB |
| Gain Variation over Temperature (–30°C to +85°C) | ΔG | — | 0.01 | — | dB/°C |
| Output Power Variation over Temperature (–30°C to +85°C) | ΔP1dB | — | 0.01 | — | dBm/°C |




*C1 and C17 are mounted vertically.

**Figure 1. MRF8S9170NR3 Test Circuit Component Layout**

**Table 6. MRF8S9170NR3 Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| B1 | Short Ferrite Bead | 2743019447 | Fair-Rite |
| C1, C8, C17, C18, C19, C20, C21 | 39 pF Chip Capacitors | ATC100B390JT500XT | ATC |
| C2 | 2.0 pF Chip Capacitor | ATC100B2R0BT500XT | ATC |
| C3, C4 | 3.3 pF Chip Capacitors | ATC100B3R3CT500XT | ATC |
| C5 | 100 μF, 50 V Electrolytic Capacitor | 476KXM063M | Illinois Cap |
| C6 | 3.3. μF, 100 V Chip Capacitor | C4532JB1H335KT | TDK |
| C7, C22, C23 | 0.1 μF Chip Capacitors | C3216X7R2E104KT | TDK |
| C9, C10 | 6.8 pF Chip Capacitors | ATC100B6R8CT500XT | ATC |
| C11, C12 | 6.2 pF Chip Capacitors | ATC100B6R2BT500XT | ATC |
| C13, C14 | 5.6 pF Chip Capacitors | ATC100B5R6CT500XT | ATC |
| C15 | 4.7 pF Chip Capacitor | ATC100B4R7CT500XT | ATC |
| C16 | 2.2 pF Chip Capacitor | ATC100B2R2JT500XT | ATC |
| C24, C25, C26, C27 | 22 μF, 50 V Chip Capacitors | C5750JF1H226ZT | TDK |
| C28 | 470 μF, 63 V Electrolytic Capacitor | KME63VB471M12x25LL | Chemi-Con |
| R1 | 2 KΩ, 1/4 W Chip Resistor | CRCW12062K00FKEA | Vishay |
| R2 | 5.1 Ω, 1/4 W Chip Resistor | CRCW12065R10FKEA | Vishay |
| PCB | 0.030″, $\varepsilon_r$ = 3.5 | RF-35 | Taconic |

## TYPICAL CHARACTERISTICS

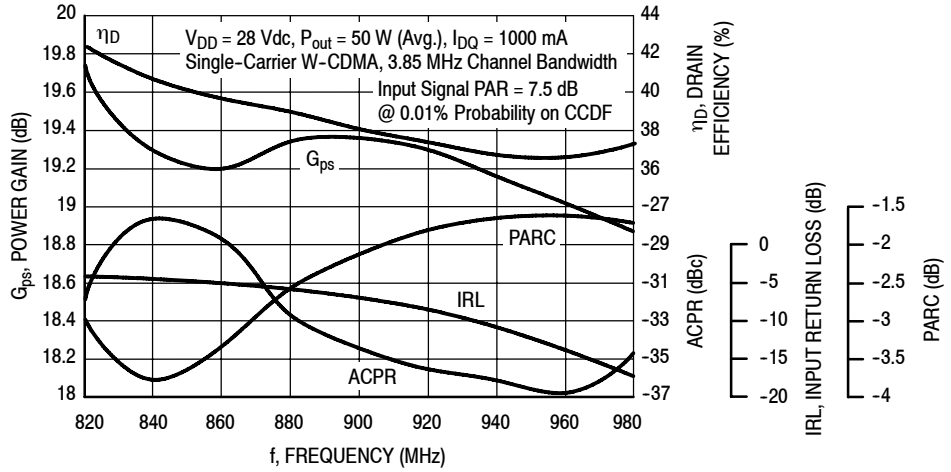



**Figure 2. Output Peak-to-Average Ratio Compression (PARC) Broadband Performance @ $P_{out}$ = 50 Watts Avg.**

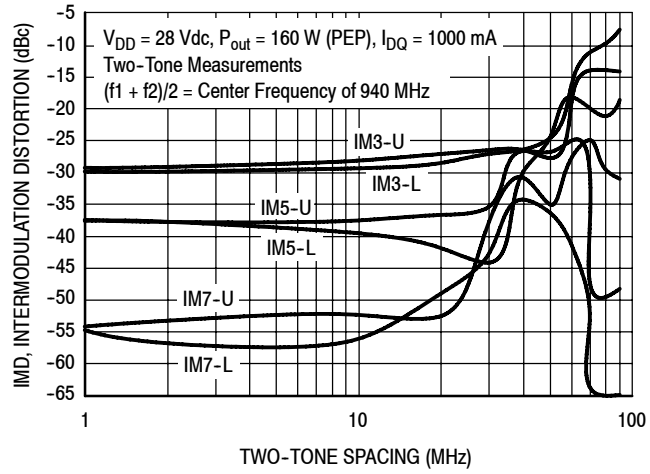



**Figure 3. Intermodulation Distortion Products versus Two-Tone Spacing**

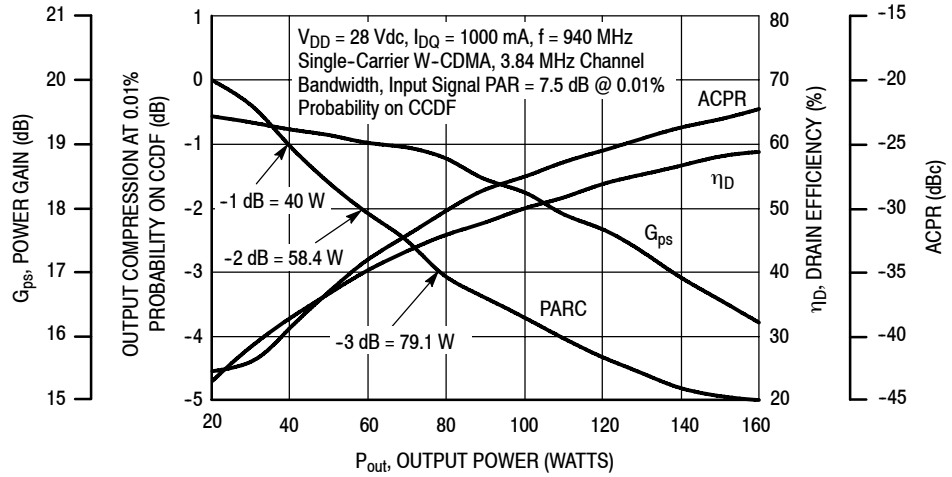



**Figure 4. Output Peak-to-Average Ratio Compression (PARC) versus Output Power**

## TYPICAL CHARACTERISTICS

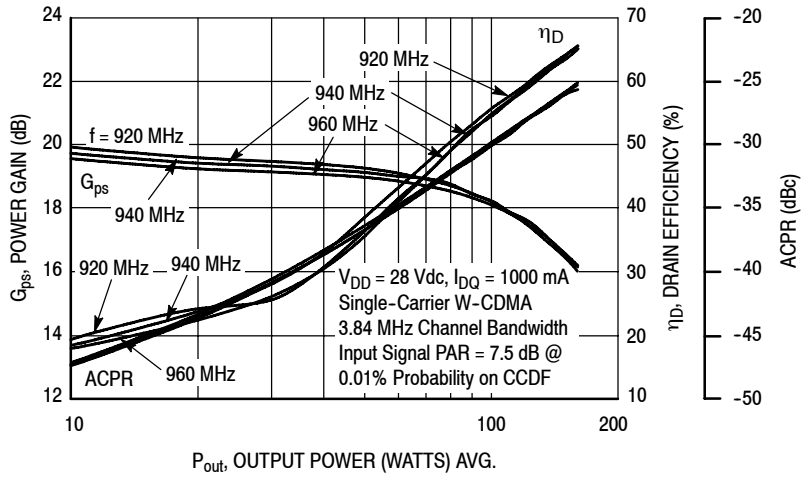



**Figure 5. Single-Carrier W-CDMA Power Gain, Drain Efficiency and ACPR versus Output Power**

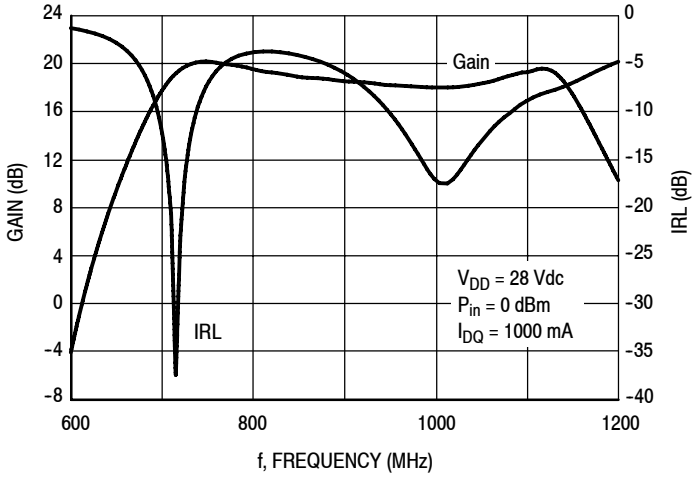



**Figure 6. Broadband Frequency Response**

## W-CDMA TEST SIGNAL

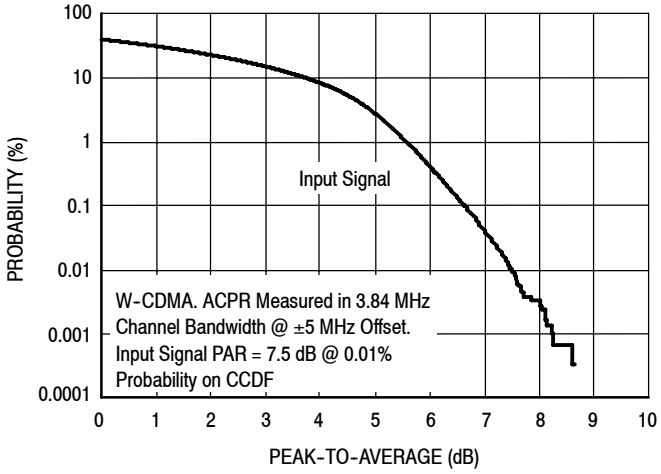



**Figure 7. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal**

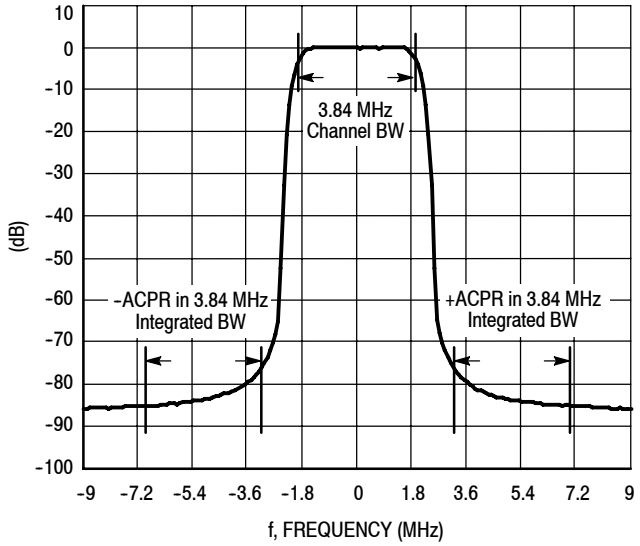



**Figure 8. Single-Carrier W-CDMA Spectrum**

$V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1000 mA, $P_{out}$ = 50 W Avg.

| f MHz | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|
| 820 | 2.34 – j3.90 | 2.08 – j1.11 |
| 840 | 2.51 – j3.75 | 2.07 – j1.05 |
| 860 | 2.54 – j3.77 | 2.01 – j1.09 |
| 880 | 2.37 – j3.71 | 1.81 – j1.11 |
| 900 | 2.26 – j3.50 | 1.58 – j1.02 |
| 920 | 2.27 – j3.33 | 1.43 – j0.89 |
| 940 | 2.28 – j3.26 | 1.27 – j0.77 |
| 960 | 2.24 – j3.19 | 1.10 – j0.64 |
| 980 | 2.21 – j3.10 | 0.94 – j0.47 |

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

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

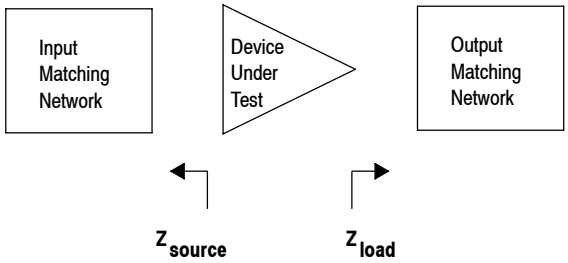
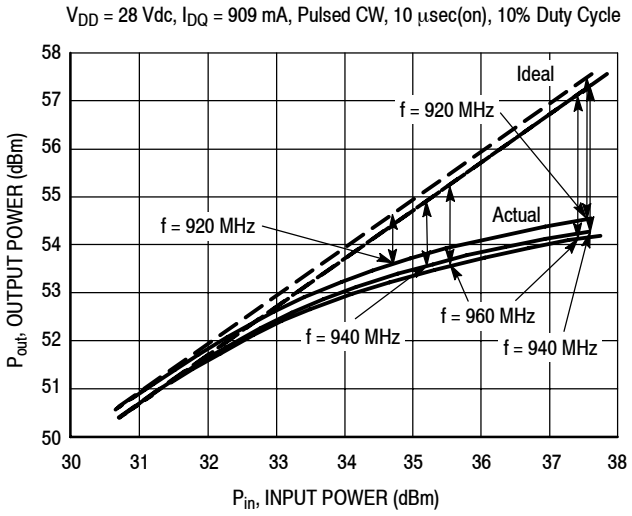



**Figure 9. Series Equivalent Source and Load Impedance**

## ALTERNATIVE PEAK TUNE LOAD PULL CHARACTERISTICS




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

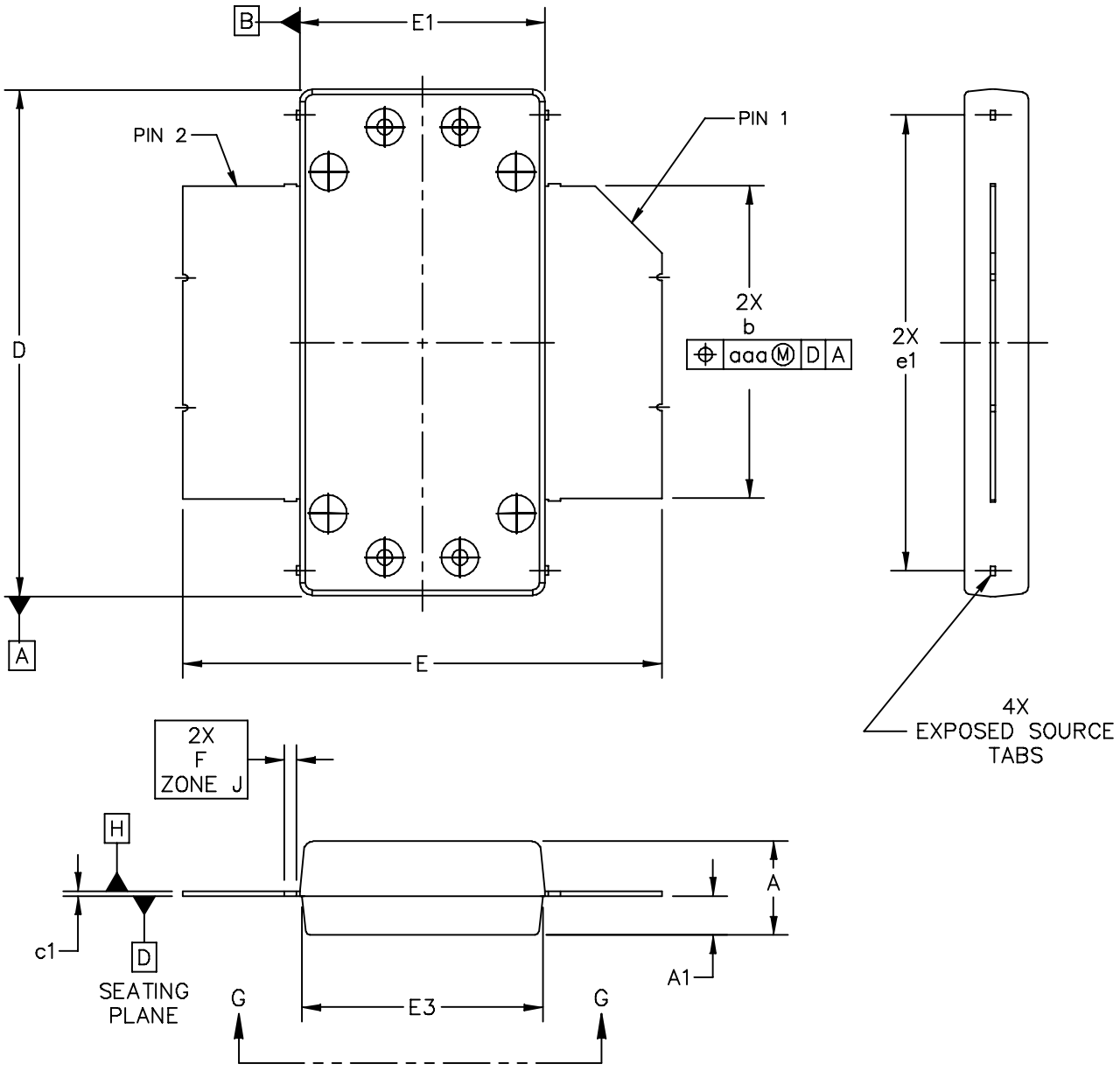
| f (MHz) | P1dB | | P3dB | |
|---|---|---|---|---|
| | Watts | dBm | Watts | dBm |
| 920 | 229 | 53.6 | 285 | 54.6 |
| 940 | 217 | 53.6 | 269.2 | 54.3 |
| 960 | 205 | 53.1 | 259 | 54.1 |

Test Impedances per Compression Level

| f (MHz) | | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|---|
| 920 | P1dB | 4.6 – j2.8 | 0.8 – j1.6 |
| 940 | P1dB | 4.7 – j2.1 | 0.8 – j1.6 |
| 960 | P1dB | 5.2 – j3.4 | 1.0 – j1.7 |

**Figure 10. Pulsed CW Output Power versus Input Power @ 28 V**

## PACKAGE DIMENSIONS

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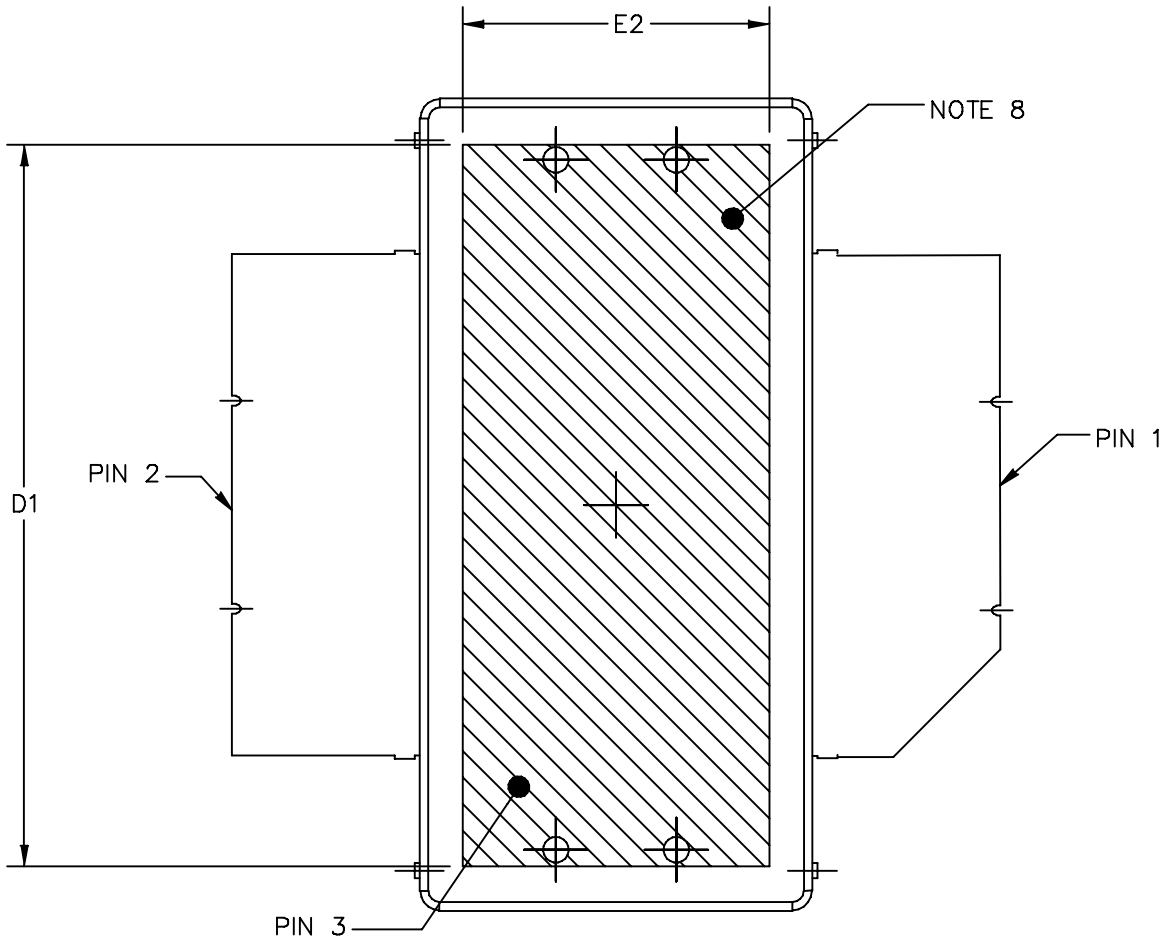


BOTTOM VIEW
VIEW G–G

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NOTES:
1. CONTROLLING DIMENSION: INCH

2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M–1994.

3. DATUM PLANE –H– IS LOCATED AT TOP OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE TOP OF THE PARTING LINE.

4. DIMENSIONS "D" AND "E1" DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS .006 PER SIDE. DIMENSIONS "D AND "E1" DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE –H–.

5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE .005 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.

6. DATUMS –A– AND –B– TO BE DETERMINED AT DATUM PLANE –H–.

7. DIMENSION A1 APPLIES WITHIN ZONE "J" ONLY

8. HATCHING REPRESENTS THE EXPOSED AREA OF THE HEAT SLUG. THE DIMENSIONS D1 AND E2 REPRESENT THE VALUES BETWEEN THE TWO OPPOSITE POINTS ALONG THE EDGES OF EXPOSED AREA OF HEAT SLUG.

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

| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | 0.148 | .152 | 3.76 | 3.86 | b | .497 | .503 | 12.62 | 12.78 |
| A1 | .059 | .065 | 1.50 | 1.65 | c1 | .007 | .011 | 0.18 | 0.28 |
| D | .808 | .812 | 20.52 | 20.62 | e1 | .721 | .729 | 18.31 | 18.52 |
| D1 | .720 | ---- | 18.29 | ---- | | | | | |
| E | .762 | .770 | 19.36 | 19.56 | aaa | .004 | | 0.10 | |
| E1 | .390 | .394 | 9.91 | 10.01 | | | | | |
| E2 | .306 | ---- | 7.77 | ---- | | | | | |
| E3 | .383 | .387 | 9.73 | 9.83 | | | | | |
| F | .025 BSC | | 0.635 BSC | | | | | | |



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|---|---|---|
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| | STANDARD: NON–JEDEC | |

## PRODUCT DOCUMENTATION, TOOLS AND SOFTWARE

Refer to the following documents, tools and software to aid your design process.

**Application Notes**

- AN1907: Solder Reflow Attach Method for High Power RF Devices in Plastic Packages
- AN1955: Thermal Measurement Methodology of RF Power Amplifiers
- AN3789: Clamping of High Power RF Transistors and RFICs in Over-Molded Plastic Packages

**Engineering Bulletins**

- EB212: Using Data Sheet Impedances for RF LDMOS Devices

**Software**

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

For Software and Tools, 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 | May 2010 | • Replaced Case Outline 2021-02, Issue A, with 2021-03, Issue B, p. 1, 9-11. Added 4 exposed source tabs at dimension e1 on Sheets 1 and 2. Added dimension e1 0.721″-0.729″ (18.31-18.52 mm) in the table, revised D1 minimum dimension from 0.730″ (18.54 mm) to 0.720″ (18.29 mm), revised dimension E2 from 0.312″ (7.92 mm) to 0.306″ (7.77 mm), and revised wording of Note 8 on Sheet 3.<br>• 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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