**Freescale Semiconductor**
Technical Data

Document Number: MRF6S24140H
Rev. 4, 2/2012

# RF Power Field Effect Transistors

## N-Channel Enhancement-Mode Lateral MOSFETs

Designed primarily for large-signal output applications at 2450 MHz. Devices are suitable for use in industrial, medical and scientific applications.

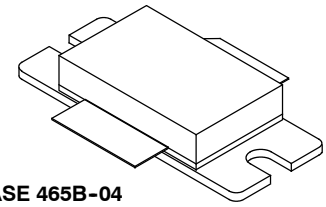
- Typical CW Performance at 2450 MHz, $V_{DD}$ = 28 Volts, $I_{DQ}$ = 1200 mA, $P_{out}$ = 140 Watts
  Power Gain — 13.2 dB
  Drain Efficiency — 45%
- Capable of Handling 10:1 VSWR, @ 28 Vdc, 2390 MHz, 140 Watts CW Output Power

**Features**

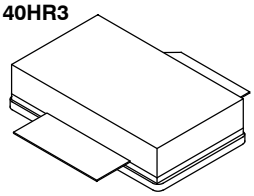
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 32 $V_{DD}$ Operation
- Integrated ESD Protection
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

**MRF6S24140HR3**
**MRF6S24140HSR3**

**2450 MHz, 140 W, 28 V**
**CW**
**LATERAL N-CHANNEL**
**RF POWER MOSFETs**



**CASE 465B-04**
**NI-880**
**MRF6S24140HR3**



**CASE 465C-03**
**NI-880S**
**MRF6S24140HSR3**

**Table 1. Maximum Ratings**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | -0.5, +68 | Vdc |
| Gate-Source Voltage | $V_{GS}$ | -0.5, +12 | 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 82°C, 140 W CW<br>Case Temperature 75°C, 28 W CW | $R_{\theta JC}$ | <br>0.29<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 |
| Machine Model (per EIA/JESD22-A115) | A |
| Charge Device Model (per JESD22-C101) | IV |

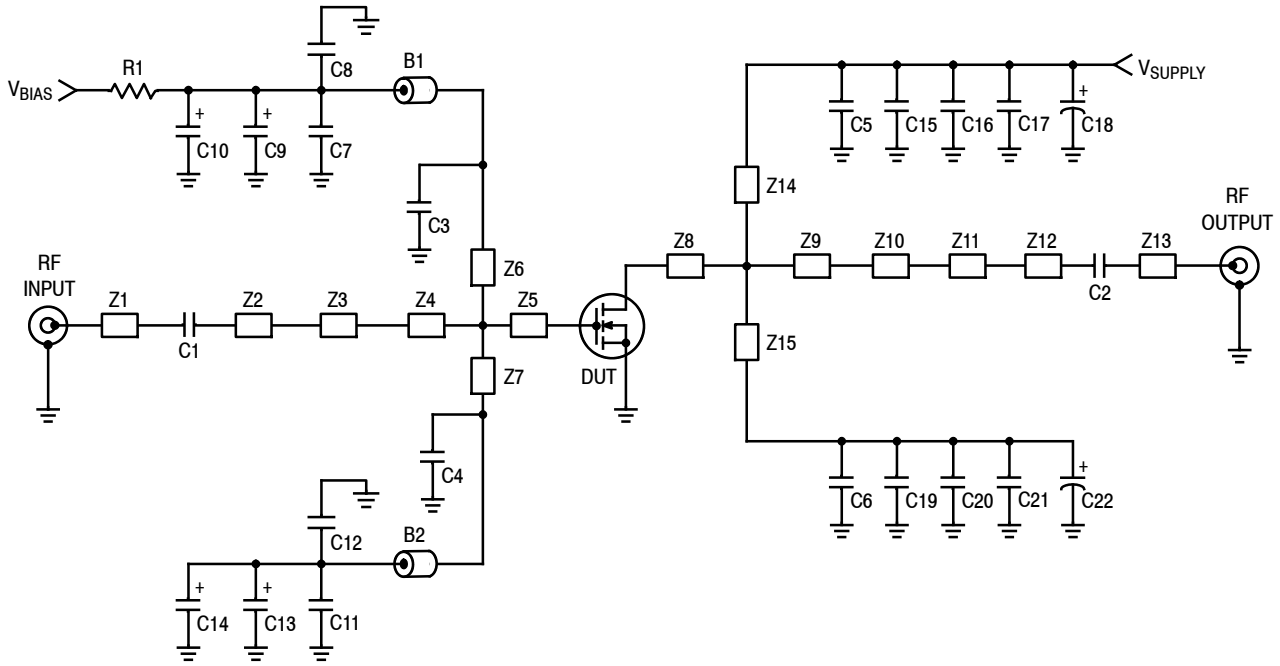
**Table 4. Electrical Characteristics** ($T_A$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics** | | | | | |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 68 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) | $I_{GSS}$ | — | — | 500 | nAdc |
| **On Characteristics** | | | | | |
| Gate Threshold Voltage ($V_{DS}$ = 10 Vdc, $I_D$ = 300 μAdc) | $V_{GS(th)}$ | 1 | 2 | 3 | Vdc |
| Gate Quiescent Voltage ($V_{DD}$ = 28 Vdc, $I_D$ = 1300 mAdc, Measured in Functional Test) | $V_{GS(Q)}$ | 2 | 2.8 | 4 | Vdc |
| Drain-Source On-Voltage ($V_{GS}$ = 10 Vdc, $I_D$ = 3 Adc) | $V_{DS(on)}$ | 0.1 | 0.21 | 0.3 | Vdc |
| **Dynamic Characteristics** (1) | | | | | |
| Reverse Transfer Capacitance ($V_{DS}$ = 28 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 2 | — | pF |

**Functional Tests** (In Freescale Test Fifxture, 50 ohm system) $V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1300 mA, $P_{out}$ = 28 W Avg., f = 2390 MHz, 2-Carrier W-CDMA, 3.84 MHz Channel Bandwidth Carriers. ACPR measured in 3.84 MHz Channel Bandwidth @ ±5 MHz Offset. IM3 measured in 3.84 MHz Bandwidth @ ±10 MHz Offset. Input Signal PAR = 8.5 dB @ 0.01% Probability on CCDF.

| | | | | | |
|---|---|---|---|---|---|
| Power Gain | $G_{ps}$ | 13 | 15.2 | 17 | dB |
| Drain Efficiency | $\eta_D$ | 23 | 25 | — | % |
| Intermodulation Distortion | IM3 | — | -37 | -35 | dBc |
| Adjacent Channel Power Ratio | ACPR | — | -40 | -38 | dBc |
| Input Return Loss | IRL | — | -15 | — | dB |

1. Part internally matched both on input and output.

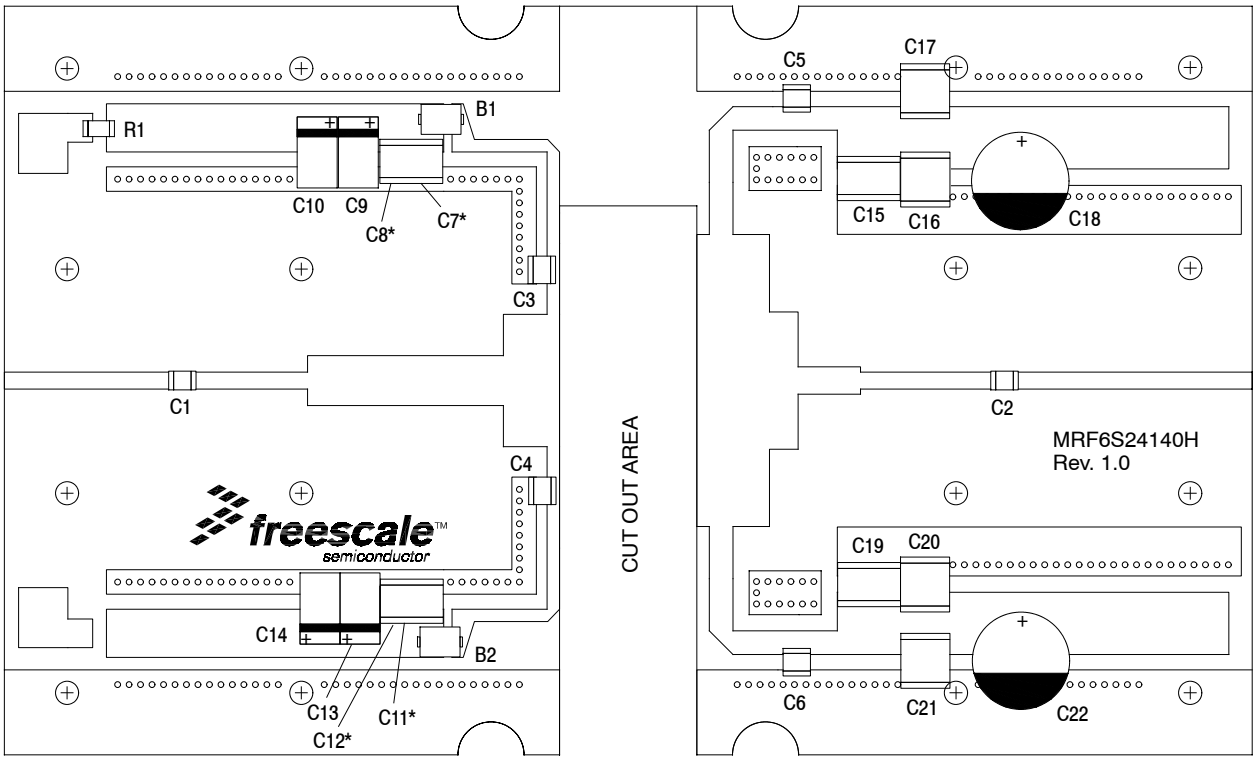



| | | | |
|---|---|---|---|
| Z1 | 0.678″ x 0.068″ Microstrip | Z9 | 0.193″ x 1.170″ Microstrip |
| Z2 | 0.466″ x 0.068″ Microstrip | Z10 | 0.115″ x 0.550″ Microstrip |
| Z3 | 0.785″ x 0.200″ Microstrip | Z11 | 0.250″ x 0.110″ Microstrip |
| Z4 | 0.200″ x 0.530″ Microstrip | Z12 | 0.538″ x 0.068″ Microstrip |
| Z5 | 0.025″ x 0.530″ Microstrip | Z13 | 0.957″ x 0.068″ Microstrip |
| Z6, Z7 | 0.178″ x 0.050″ Microstrip | Z14, Z15 | 0.673″ x 0.095″ Microstrip |
| Z8 | 0.097″ x 1.170″ Microstrip | PCB | Taconic RF-35, 0.030″, $\varepsilon_r$ = 3.5 |

**Figure 1. MRF6S24140HR3(SR3) Test Circuit Schematic — 2450 MHz**

**Table 5. MRF6S24140HR3(SR3) Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| B1, B2 | 47 Ω, 100 MHz Short Ferrite Beads, Surface Mount | 2743019447 | Fair-Rite |
| C1, C2, C3, C4, C5, C6 | 5.6 pF Chip Capacitors | ATC600B5R6BT500XT | ATC |
| C7, C11 | 0.01 μF, 100 V Chip Capacitors | C1825C103J1RAC | Kemet |
| C8, C12, C15, C19 | 2.2 μF, 50 V Chip Capacitors | C1825C225J5RAC | Kemet |
| C9, C13 | 22 μF, 25 V Tantalum Capacitors | T491D226M025AT | Kemet |
| C10, C14 | 47 μF, 16 V Tantalum Capacitors | T491D476K016AT | Kemet |
| C16, C17, C20, C21 | 10 μF, 50 V Chip Capacitors | GRM55DR61H106KA88B | Murata |
| C18, C22 | 220 μF, 50 V Electrolytic Capacitors | 2222-150-95102 | Vishay |
| R1 | 240 Ω, 1/4 W Chip Resistor | CRC12062400FKEA | Vishay |




* Stacked

**Figure 2. MRF6S24140HR3(SR3) Test Circuit Component Layout — 2450 MHz**

## TYPICAL CHARACTERISTICS — 2450 MHz

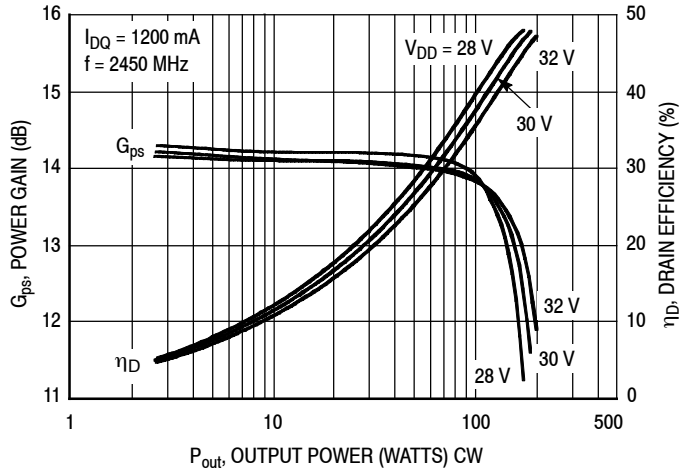



**Figure 3. Power Gain and Drain Efficiency versus CW Output Power as a Function of $V_{DD}$**

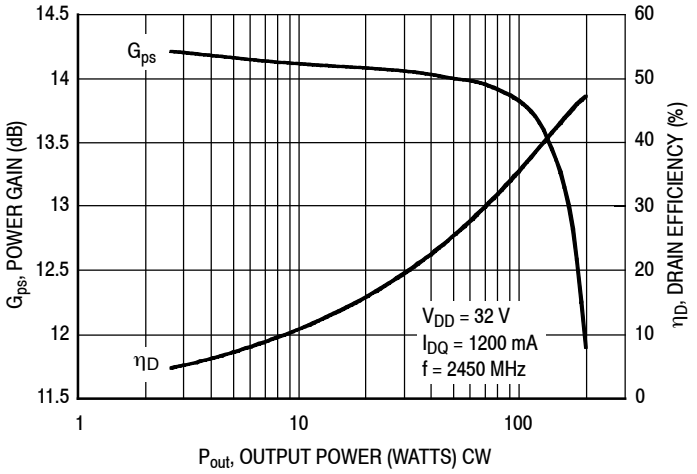



**Figure 4. Power Gain and Drain Efficiency versus CW Output Power**

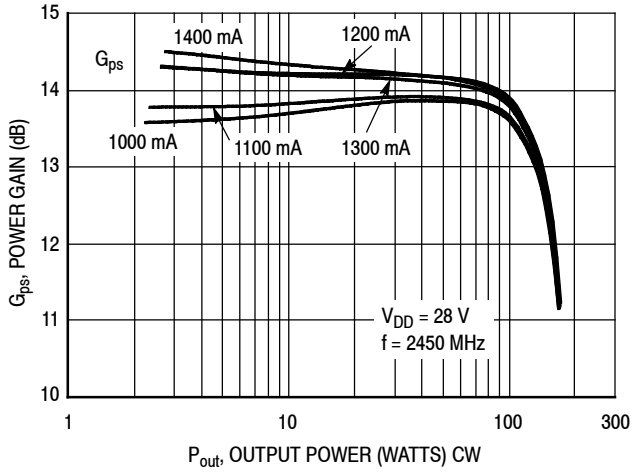
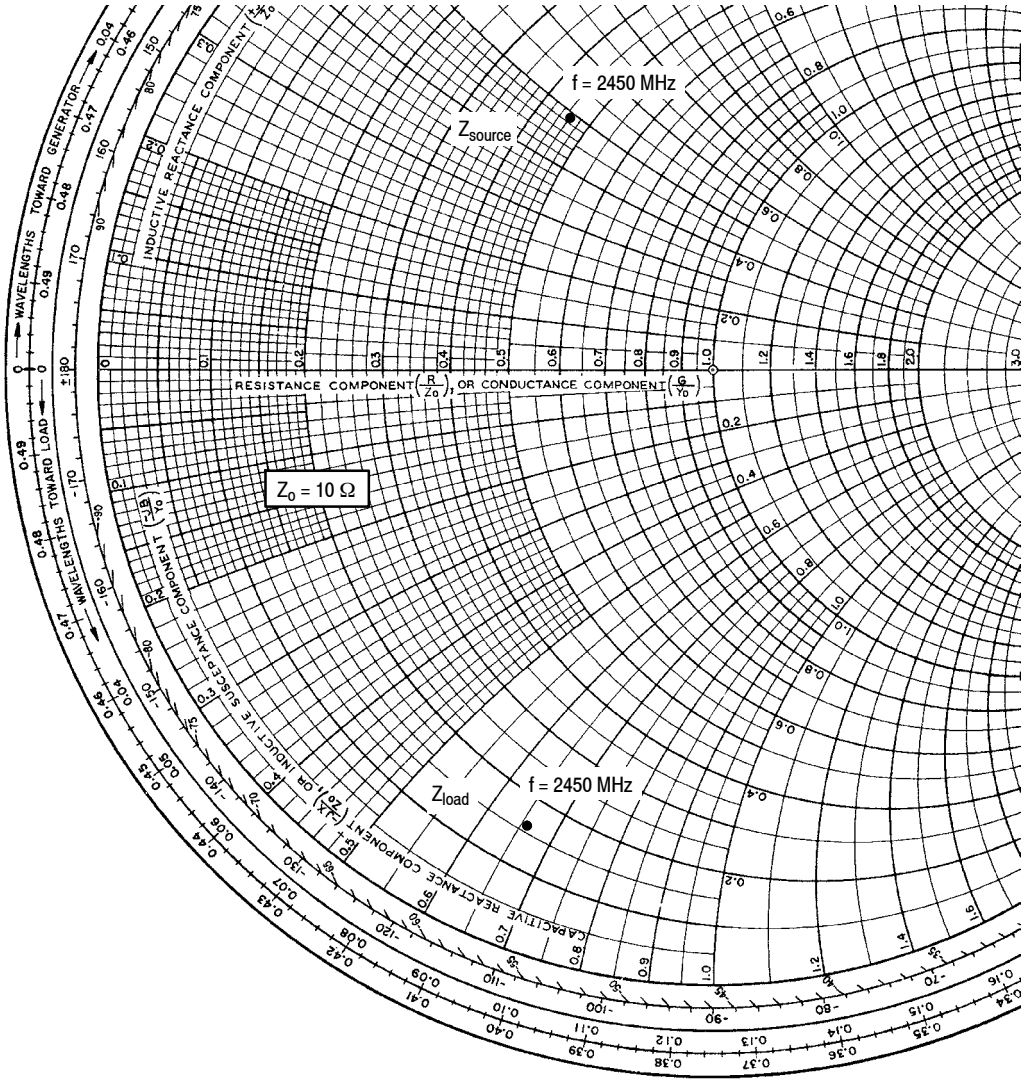



**Figure 5. Power Gain and Drain Efficiency versus CW Output Power as a Function of Total $I_{DQ}$**




$V_{DD}$ = 28 Vdc, $I_{DQ}$ = 1200 mA, $P_{out}$ = 140 W CW

| f MHz | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|
| 2450 | 4.55 + j4.9 | 1.64 – j6.57 |

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

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

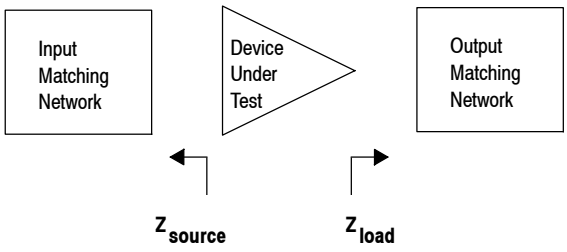
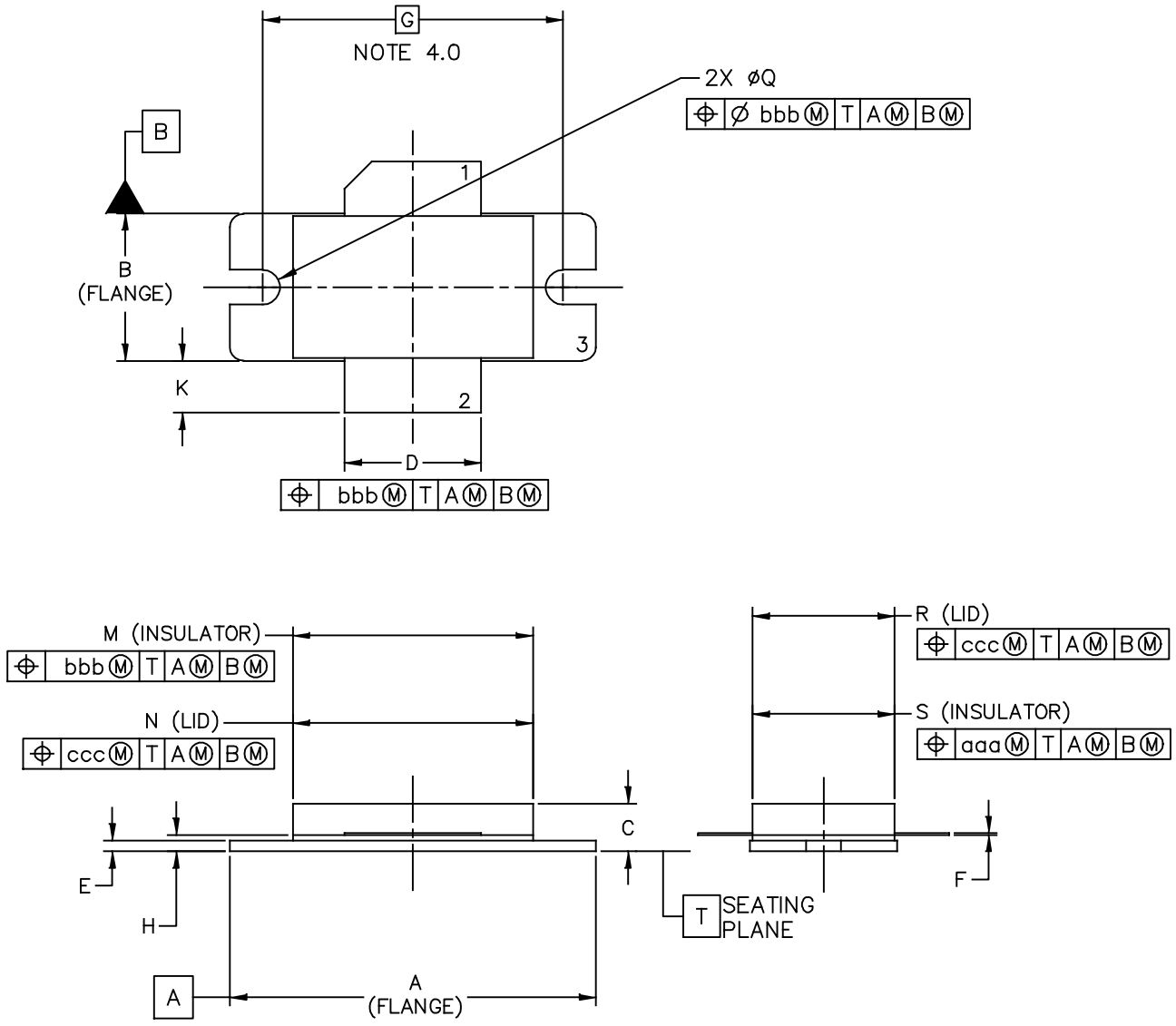



**Figure 6. Series Equivalent Source and Load Impedance**

## PACKAGE DIMENSIONS




| © FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED. | MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE |
|---|---|---|
| TITLE: NI–880 | DOCUMENT NO: 98ARB18493C | REV: F |
| | CASE NUMBER: 465B–04 | 26 MAY 2011 |
| | STANDARD: NON–JEDEC | |

NOTES:
1.0 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M–1994.

2.0 CONTROLLING DIMENSION: INCH.

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

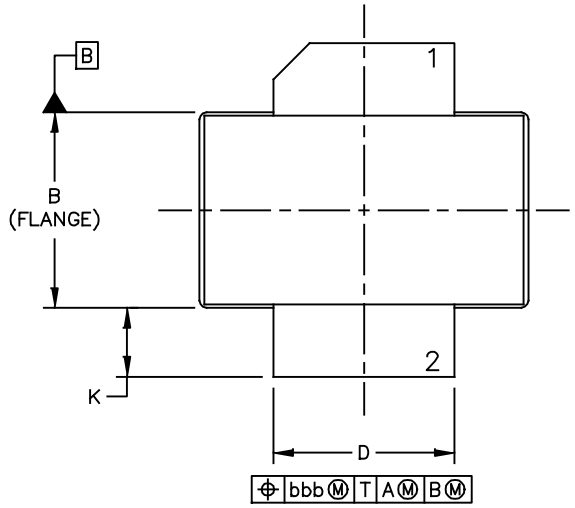
4.0 RECOMMENDED BOLT CENTER DIMENSION OF 1.16 (29.57) BASED ON M3 SCREW.

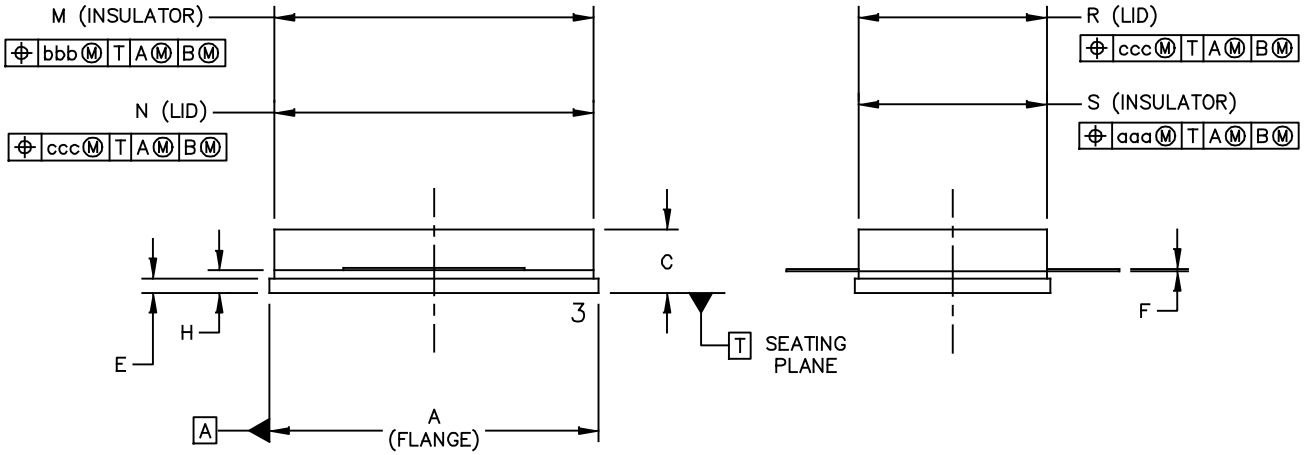
| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | 1.335 | 1.345 | 33.91 | 34.16 | R | .515 | .525 | 13.08 | 13.34 |
| B | .535 | .545 | 13.59 | 13.84 | S | .515 | .525 | 13.08 | 13.34 |
| C | .147 | .200 | 3.73 | 5.08 | aaa | – | .007 | – | 0.178 |
| 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 | 1.70 | – | – | – | – | – |
| K | .175 | .205 | 4.45 | 5.21 | – | – | – | – | – |
| M | .872 | .888 | 22.15 | 22.56 | – | – | – | – | – |
| N | .871 | .889 | 22.12 | 22.58 | – | – | – | – | – |
| Q | ø.118 | ø.138 | ø3.00 | ø3.51 | – | – | – | – | – |



MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

| TITLE: | DOCUMENT NO: 98ARB18493C | REV: F |
|---|---|---|
| NI–880 | CASE NUMBER: 465B–04 | 26 MAY 11 |
| | STANDARD: NON–JEDEC | |




| © FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED. | MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE |
|---|---|---|
| TITLE: NI–880S | DOCUMENT NO: 98ARB18660C | REV: E |
| | CASE NUMBER: 465C–03 | 26 MAY 2011 |
| | STANDARD: NON–JEDEC | |

NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M–1994.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION H IS MEASURED .030 (0.762) AWAY FROM PACKAGE BODY.

| DIM | INCH MIN | | INCH MAX | MILLIMETER MIN | | MILLIMETER MAX | DIM | INCH MIN | | INCH MAX | MILLIMETER MIN | | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | .905 | – | .915 | 22.99 | – | 23.24 | aaa | – | .007 | – | – | 0.178 | – |
| B | .535 | – | .545 | 13.59 | – | 13.84 | bbb | – | .010 | – | – | 0.254 | – |
| C | .147 | – | .200 | 3.73 | – | 5.08 | ccc | – | .015 | – | – | 0.381 | – |
| D | .495 | – | .505 | 12.57 | – | 12.83 | – | – | – | – | – | – | – |
| E | .035 | – | .045 | 0.89 | – | 1.14 | – | – | – | – | – | – | – |
| F | .003 | – | .006 | 0.08 | – | 0.15 | – | – | – | – | – | – | – |
| H | .057 | | .067 | 1.45 | | 1.70 | – | – | – | – | – | – | – |
| K | .170 | – | .210 | 4.32 | – | 5.33 | – | – | – | – | – | – | – |
| M | .872 | – | .888 | 22.15 | – | 22.56 | – | – | – | – | – | – | – |
| N | .871 | – | .889 | 22.12 | – | 22.58 | – | – | – | – | – | – | – |
| R | .515 | – | .525 | 13.08 | – | 13.34 | – | – | – | – | – | – | – |
| S | .515 | – | .525 | 13.08 | – | 13.34 | – | – | – | – | – | – | – |



| MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE |
|---|---|

| TITLE: | DOCUMENT NO: 98ARB18660C | REV: E |
|---|---|---|
| NI–880S | CASE NUMBER: 465C–03 | 26 MAY 2011 |
| | STANDARD: NON–JEDEC | |

## PRODUCT DOCUMENTATION, TOOLS AND SOFTWARE

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

**Software**

- Electromigration MTTF Calculator
- RF High Power Model

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 | Mar. 2007 | • Initial Release of Data Sheet |
| 1 | Apr. 2008 | • Operating Junction Temperature increased from 200°C to 225°C in Maximum Ratings table and related “Continuous use at maximum temperature will affect MTTF” footnote added, p. 1<br>• Corrected $V_{DS}$ to $V_{DD}$ in the RF test condition voltage callout for $V_{GS(Q)}$, and added “Measured in Functional Test”, On Characteristics table, p. 2<br>• Updated PCB information to show more specific material details, Fig. 1, Test Circuit Schematic, p. 3 |
| 2 | Feb. 2009 | • Modified data sheet to reflect RF Test Reduction described in Product and Process Change Notification number, PCN13232, p. 2 |
| 3 | Mar. 2010 | • Fig. 1, Test Circuit Schematic, Z-list, corrected PCB information to reflect Taconic as manufacturer, p. 3<br>• Fig. 4, Power Gain and Drain Efficiency versus CW Output Power, corrected 28 V to read 32 V, p. 5<br>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 8 |
| 4 | Feb. 2012 | • Table 3, ESD Protection Characteristics, removed the word “Minimum” after the ESD class rating. ESD ratings are characterized during new product development but are not 100% tested during production. ESD ratings provided in the data sheet are intended to be used as a guideline when handling ESD sensitive devices, p. 2.<br>• Fig. 6, MTTF versus Junction Temperature removed, p. 5. Refer to the device’s MTTF Calculator available at freescale.com/RFpower. Go to Design Resources > Software and Tools.<br>• Replaced Case Outline 465B-03, Issue D, with 465B-04, Issue F, p. 1, 7-8. Deleted Style 1 pin note on Sheet 2. On Sheet 2, changed dimension B in mm from 13.6-13.8 to 13.59-13.84, changed dimension H in mm from 1.45-1.7 to 1.45-1.70, changed dimension K in mm from 4.44-5.21 to 4.45-5.21, changed dimension M in mm from 22.15-22.55 to 22.15-22.56, changed dimension N in mm from 19.3-22.6 to 22.12-22.58, changed dimension Q in mm from 3-3.51 to 3.00-3.51, changed dimension R and S in mm from 13.1-13.3 to 13.08-13.34.<br>• Replaced Case Outline 465C-02, Issue D, with 465C-03, Issue E, p. 1, 9-10. Deleted Style 1 pin note on Sheet 2. On Sheet 2, changed dimension B in mm from 13.6-13.8 to 13.59-13.84, changed dimension H in mm from 1.45-1.7 to 1.45-1.70, changed dimension M in mm from 22.15-22.55 to 22.15-22.56, changed dimension N in mm from 19.3-22.6 to 22.12-22.58, changed dimension R and S in mm from 13.1-13.3 to 13.08-13.34. |

## *How to Reach Us:*

**Home Page:**
www.freescale.com

**Web Support:**
http://www.freescale.com/support

**USA/Europe or Locations Not Listed:**
Freescale Semiconductor, Inc.
Technical Information Center, EL516
2100 East Elliot Road
Tempe, Arizona 85284
1-800-521-6274 or +1-480-768-2130
www.freescale.com/support

**Europe, Middle East, and Africa:**
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
www.freescale.com/support

**Japan:**
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

**Asia/Pacific:**
Freescale Semiconductor China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 10 5879 8000
support.asia@freescale.com

***For Literature Requests Only:***
Freescale Semiconductor Literature Distribution Center
1-800-441-2447 or +1-303-675-2140
Fax: +1-303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com



Document Number: MRF6S24140H
Rev. 4, 2/2012