



RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

RF Power transistors designed for applications operating at frequencies between 960 and 1215 MHz. These devices are suitable for use in pulsed applications.

- Typical Pulsed Performance: $V_{DD} = 50$ Volts, $I_{DQ} = 200$ mA, Pulsed Width = 128 μ sec, Duty Cycle = 10%

| Application | P_{out} (W) | f (MHz) | G_{ps} (dB) | η_D (%) |
|-------------|---------------|----------|---------------|--------------|
| Narrowband | 500 Peak | 1030 | 19.7 | 62.0 |
| Broadband | 500 Peak | 960-1215 | 18.5 | 57.0 |

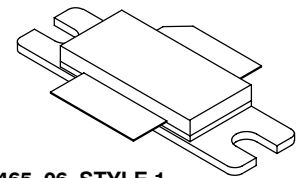
- Capable of Handling 10:1 VSWR, @ 50 Vdc, 1030 MHz, 500 Watts Peak Power

Features

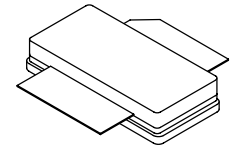
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified Up to a Maximum of 50 V_{DD} Operation
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R3 Suffix = 250 Units per 56 mm, 13 inch Reel.

MRF6V12500HR3
MRF6V12500HSR3

960-1215 MHz, 500 W, 50 V
PULSED
LATERAL N-CHANNEL
RF POWER MOSFETs



CASE 465-06, STYLE 1
NI-780
MRF6V12500HR3



CASE 465A-06, STYLE 1
NI-780S
MRF6V12500HSR3

Table 1. Maximum Ratings

| Rating | Symbol | Value | Unit |
|--------------------------------------|-----------|-------------|--------------|
| Drain-Source Voltage | V_{DSS} | -0.5, +110 | Vdc |
| Gate-Source Voltage | V_{GS} | -6.0, +10 | Vdc |
| Storage Temperature Range | T_{stg} | -65 to +150 | $^{\circ}$ C |
| Case Operating Temperature | T_C | 150 | $^{\circ}$ C |
| Operating Junction Temperature (1,2) | T_J | 225 | $^{\circ}$ C |

Table 2. Thermal Characteristics

| Characteristic | Symbol | Value (2,3) | Unit |
|---|-----------------|-------------|----------------|
| Thermal Resistance, Junction to Case Case Temperature 80 $^{\circ}$ C, 500 W Pulsed, 128 μ sec Pulse Width, 10% Duty Cycle | $Z_{\theta JC}$ | 0.044 | $^{\circ}$ C/W |

- Continuous use at maximum temperature will affect MTTF.
- MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
- 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) | B (Minimum) |
| Charge Device Model (per JESD22-C101) | IV (Minimum) |

Table 4. Electrical Characteristics ($T_A = 25^\circ\text{C}$ unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

Off Characteristics

| | | | | | |
|---|---------------|-----|---|-----|-----------------|
| Gate-Source Leakage Current ($V_{GS} = 5\text{ Vdc}$, $V_{DS} = 0\text{ Vdc}$) | I_{GSS} | — | — | 10 | μAdc |
| Drain-Source Breakdown Voltage ($V_{GS} = 0\text{ Vdc}$, $I_D = 200\text{ mA}$) | $V_{(BR)DSS}$ | 110 | — | — | Vdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS} = 50\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$) | I_{DSS} | — | — | 20 | μAdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS} = 90\text{ Vdc}$, $V_{GS} = 0\text{ Vdc}$) | I_{DSS} | — | — | 200 | μAdc |

On Characteristics

| | | | | | |
|---|--------------|-----|------|-----|-----|
| Gate Threshold Voltage ($V_{DS} = 10\text{ Vdc}$, $I_D = 1.32\text{ mA}$) | $V_{GS(th)}$ | 0.9 | 1.7 | 2.4 | Vdc |
| Gate Quiescent Voltage ($V_{DD} = 50\text{ Vdc}$, $I_D = 200\text{ mA}$, Measured in Functional Test) | $V_{GS(Q)}$ | 1.7 | 2.4 | 3.2 | Vdc |
| Drain-Source On-Voltage ($V_{GS} = 10\text{ Vdc}$, $I_D = 3.26\text{ Adc}$) | $V_{DS(on)}$ | — | 0.25 | — | Vdc |

Dynamic Characteristics (1)

| | | | | | |
|---|-----------|---|------|---|----|
| Reverse Transfer Capacitance ($V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$) | C_{rss} | — | 0.2 | — | pF |
| Output Capacitance ($V_{DS} = 50\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz, $V_{GS} = 0\text{ Vdc}$) | C_{oss} | — | 697 | — | pF |
| Input Capacitance ($V_{DS} = 50\text{ Vdc}$, $V_{GS} = 0\text{ Vdc} \pm 30\text{ mV(rms)ac}$ @ 1 MHz) | C_{iss} | — | 1391 | — | pF |

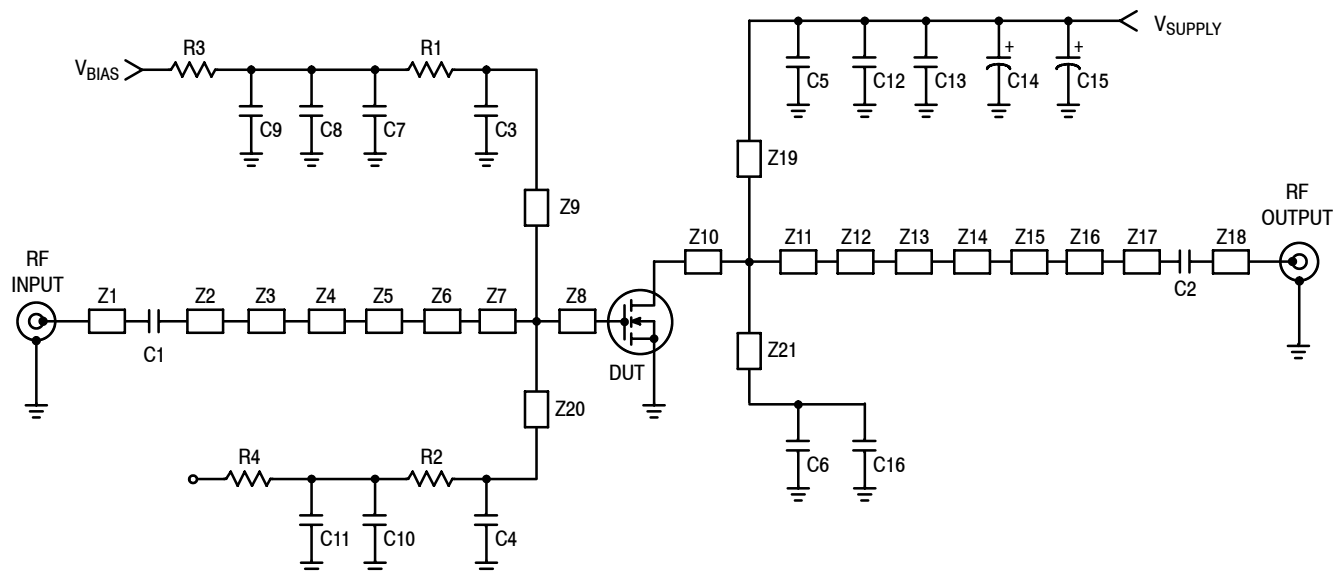
Functional Tests (In Freescale Narrowband Test Fixture, 50 ohm system) $V_{DD} = 50\text{ Vdc}$, $I_{DQ} = 200\text{ mA}$, $P_{out} = 500\text{ W Peak}$ (50 W Avg.), $f = 1030\text{ MHz}$, Pulsed, 128 μsec Pulse Width, 10% Duty Cycle

| | | | | | |
|-------------------|----------|------|------|------|----|
| Power Gain | G_{ps} | 18.5 | 19.7 | 22.0 | dB |
| Drain Efficiency | η_D | 58.0 | 62.0 | — | % |
| Input Return Loss | IRL | — | -18 | -9 | dB |

Typical Broadband Performance — 960-1215 MHz (In Freescale 960-1215 MHz Test Fixture, 50 ohm system) $V_{DD} = 50\text{ Vdc}$, $I_{DQ} = 200\text{ mA}$, $P_{out} = 500\text{ W Peak}$ (50 W Avg.), $f = 960\text{-}1215\text{ MHz}$, Pulsed, 128 μsec Pulse Width, 10% Duty Cycle

| | | | | | |
|------------------|----------|---|------|---|----|
| Power Gain | G_{ps} | — | 18.5 | — | dB |
| Drain Efficiency | η_D | — | 57.0 | — | % |

1. Part internally matched both on input and output.



| | | | |
|---------|----------------------------|----------|--|
| Z1 | 0.457" x 0.080" Microstrip | Z11 | 0.161" x 1.500" Microstrip |
| Z2 | 0.250" x 0.080" Microstrip | Z12 | 0.613" x 1.281" Microstrip |
| Z3 | 0.605" x 0.040" Microstrip | Z13 | 0.248" x 0.865" Microstrip |
| Z4 | 0.080" x 0.449" Microstrip | Z14 | 0.087" x 0.425" Microstrip |
| Z5 | 0.374" x 0.608" Microstrip | Z15 | 0.309" x 0.090" Microstrip |
| Z6 | 0.118" x 1.252" Microstrip | Z16 | 0.193" x 0.516" Microstrip |
| Z7 | 0.778" x 1.710" Microstrip | Z17 | 0.279" x 0.080" Microstrip |
| Z8 | 0.095" x 1.710" Microstrip | Z18 | 0.731" x 0.080" Microstrip |
| Z9, Z20 | 0.482" x 0.050" Microstrip | Z19, Z21 | 0.507" x 0.040" Microstrip |
| Z10 | 0.138" x 1.500" Microstrip | PCB | Arlon CuClad 250GX-0300-55-22, 0.030", $\epsilon_r = 2.55$ |

Figure 1. MRF6V12500HR3(HSR3) Test Circuit Schematic

Table 5. MRF6V12500HR3(HSR3) Test Circuit Component Designations and Values

| Part | Description | Part Number | Manufacturer |
|-------------------|---|----------------------|--------------|
| C1, C2 | 5.1 pF Chip Capacitors | ATC100B5R1CT500XT | ATC |
| C3, C4, C5, C6 | 33 pF Chip Capacitors | ATC100B330JT500XT | ATC |
| C7, C10 | 10 μ F, 50 V Chip Capacitors | GRM55DR61H106KA88L | Murata |
| C8, C11, C13, C16 | 2.2 μ F, 100 V Chip Capacitors | 2225X7R225KT3AB | ATC |
| C9 | 22 μ F, 25 V Chip Capacitor | TPSD226M025R0200 | AVX |
| C12 | 1 μ F, 100 V Chip Capacitor | GRM31CR72A105KA01L | Murata |
| C14, C15 | 470 μ F, 63 V Electrolytic Capacitors | MCGPR63V477M13X26-RH | Multicomp |
| R1, R2 | 56 Ω , 1/4 W Chip Resistors | CRCW120656R0FKEA | Vishay |
| R3, R4 | 0 Ω , 3 A Chip Resistors | CRCW12060000Z0EA | Vishay |

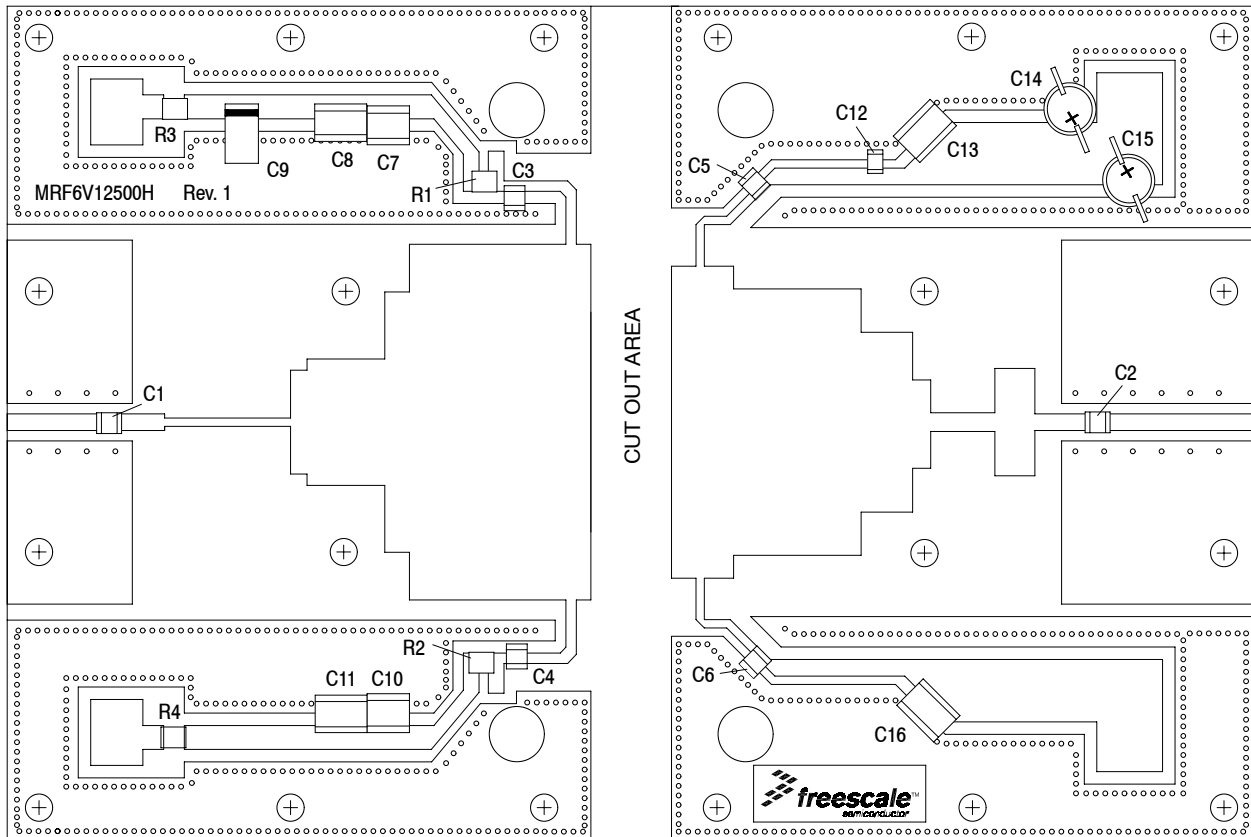


Figure 2. MRF6V12500HR3(HSR3) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

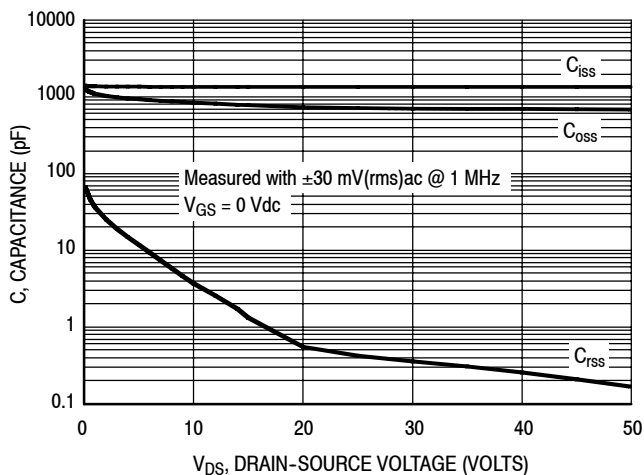


Figure 3. Capacitance versus Drain-Source Voltage

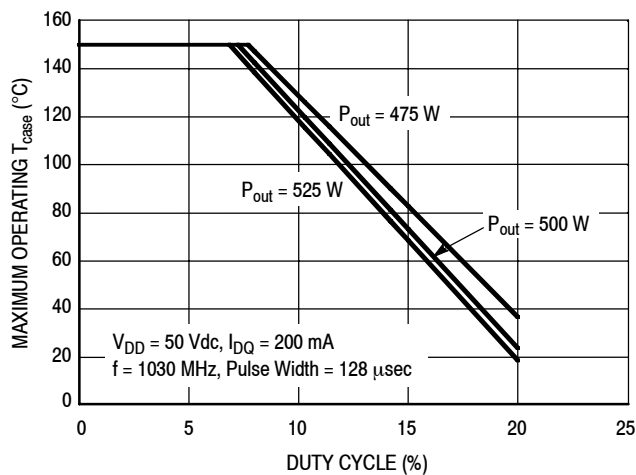


Figure 4. Safe Operating Area

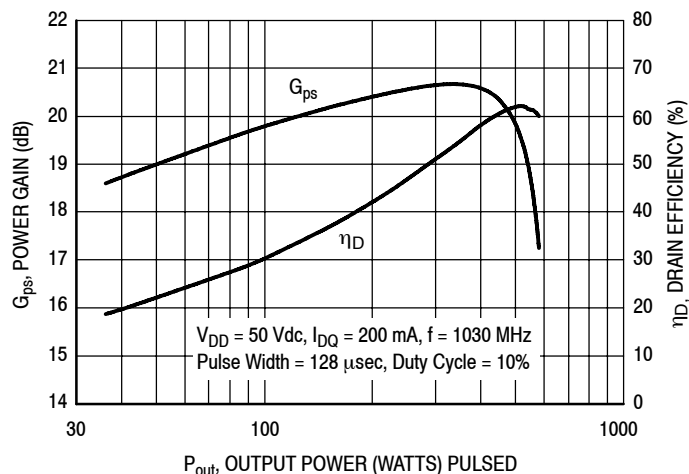


Figure 5. Pulsed Power Gain and Drain Efficiency versus Output Power

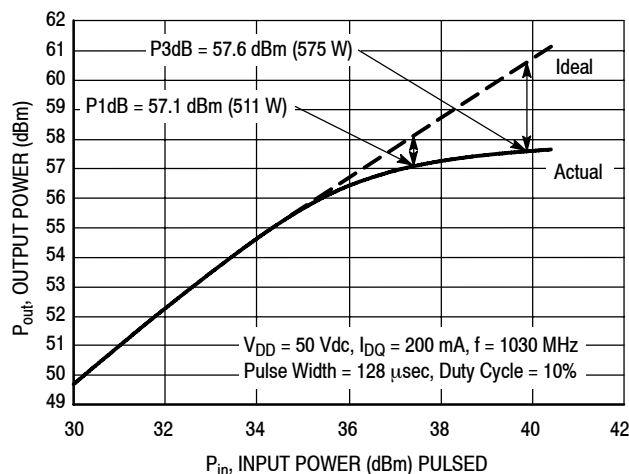


Figure 6. Pulsed Output Power versus Input Power

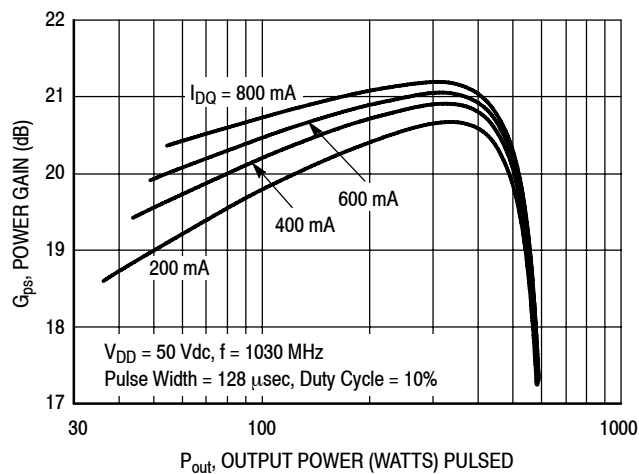


Figure 7. Pulsed Power Gain versus Output Power

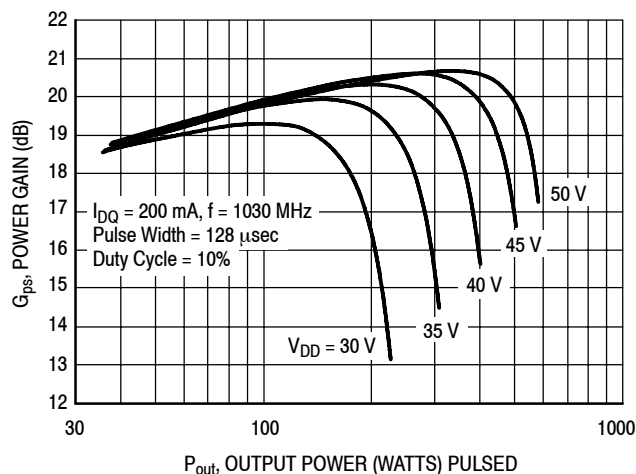


Figure 8. Pulsed Power Gain versus Output Power

TYPICAL CHARACTERISTICS

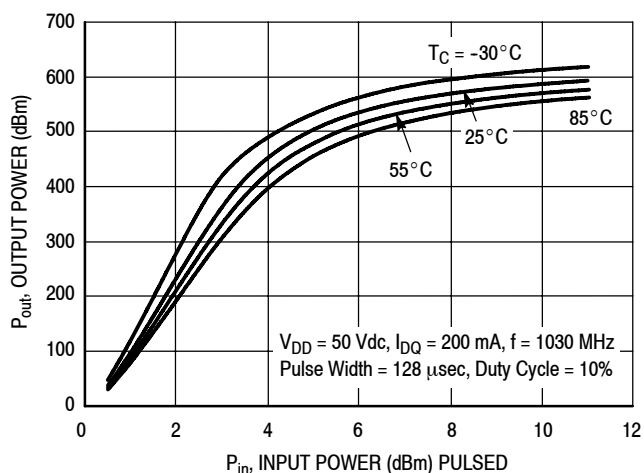


Figure 9. Pulsed Output Power versus Input Power

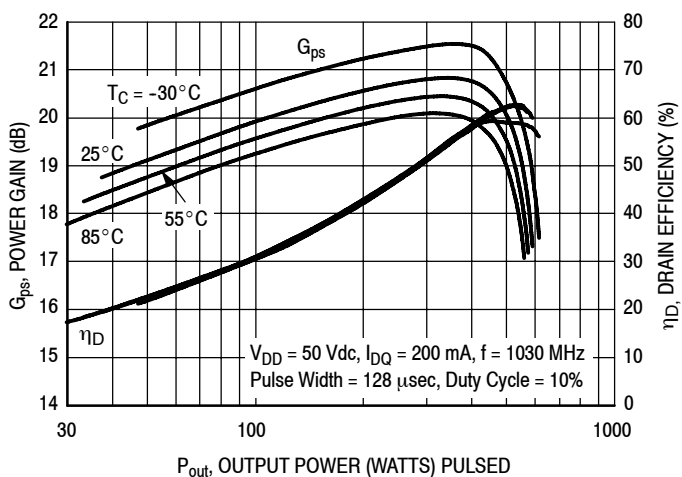
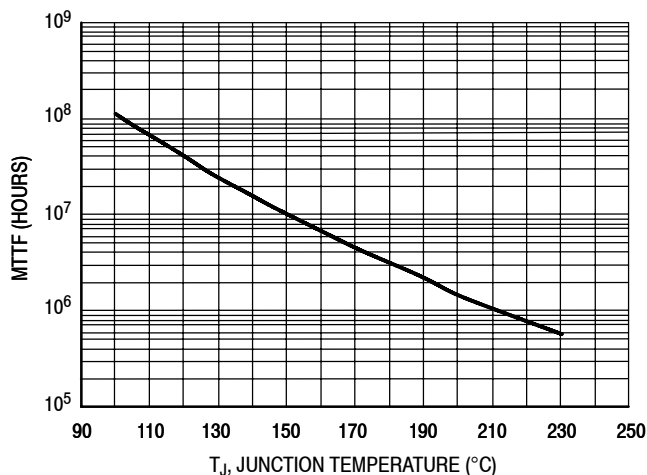


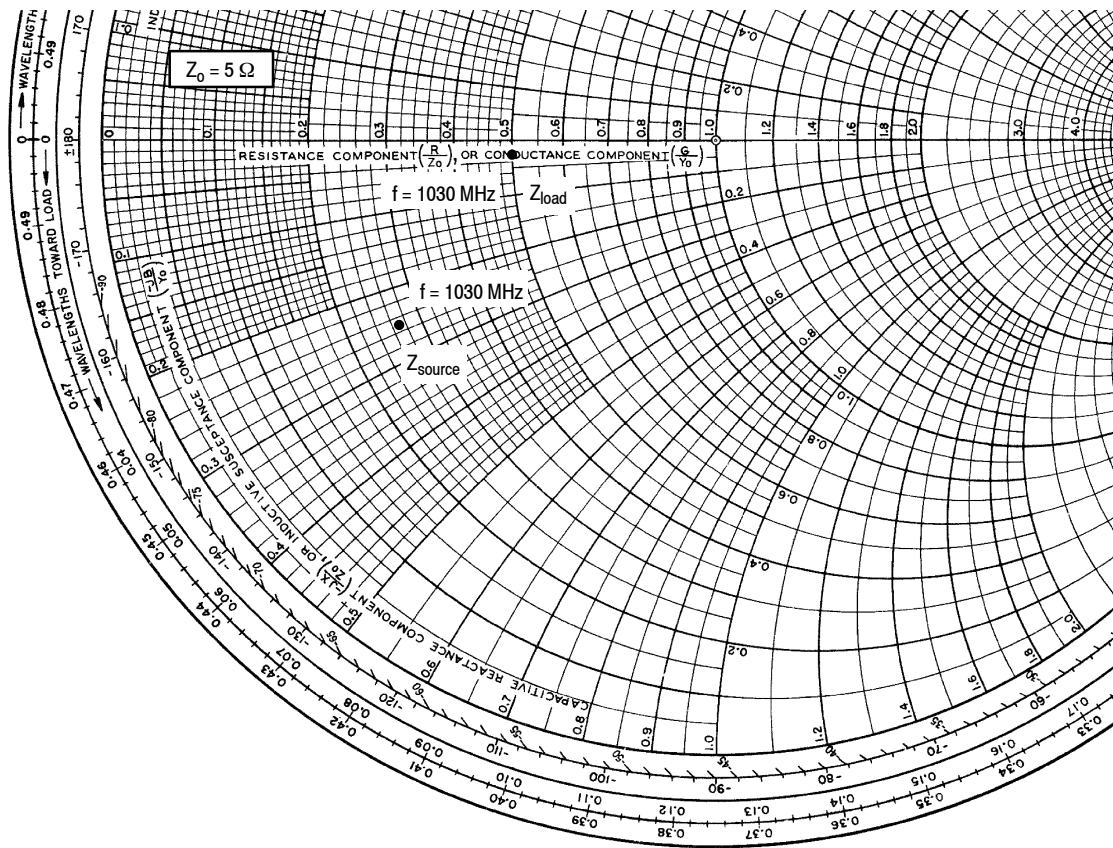
Figure 10. Pulsed Power Gain and Drain Efficiency versus Output Power



This above graph displays calculated MTTF in hours when the device is operated at $V_{DD} = 50$ Vdc, $P_{out} = 500$ W Peak, Pulse Width = 128 μ sec, Duty Cycle = 10%, and $\eta_D = 62\%$.

MTTF calculator available at <http://www.freescale.com/rf>. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.

Figure 11. MTTF versus Junction Temperature



$V_{DD} = 50 \text{ Vdc}$, $I_{DQ} = 200 \text{ mA}$, $P_{out} = 500 \text{ W Peak}$

| f MHz | Z_{source} Ω | Z_{load} Ω |
|----------|-------------------|-----------------|
| 1030 | $1.36 - j1.27$ | $2.50 - j0.17$ |

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

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

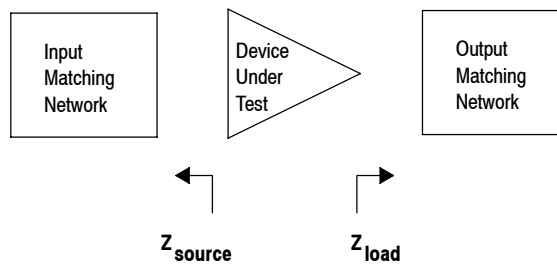


Figure 12. Series Equivalent Source and Load Impedance

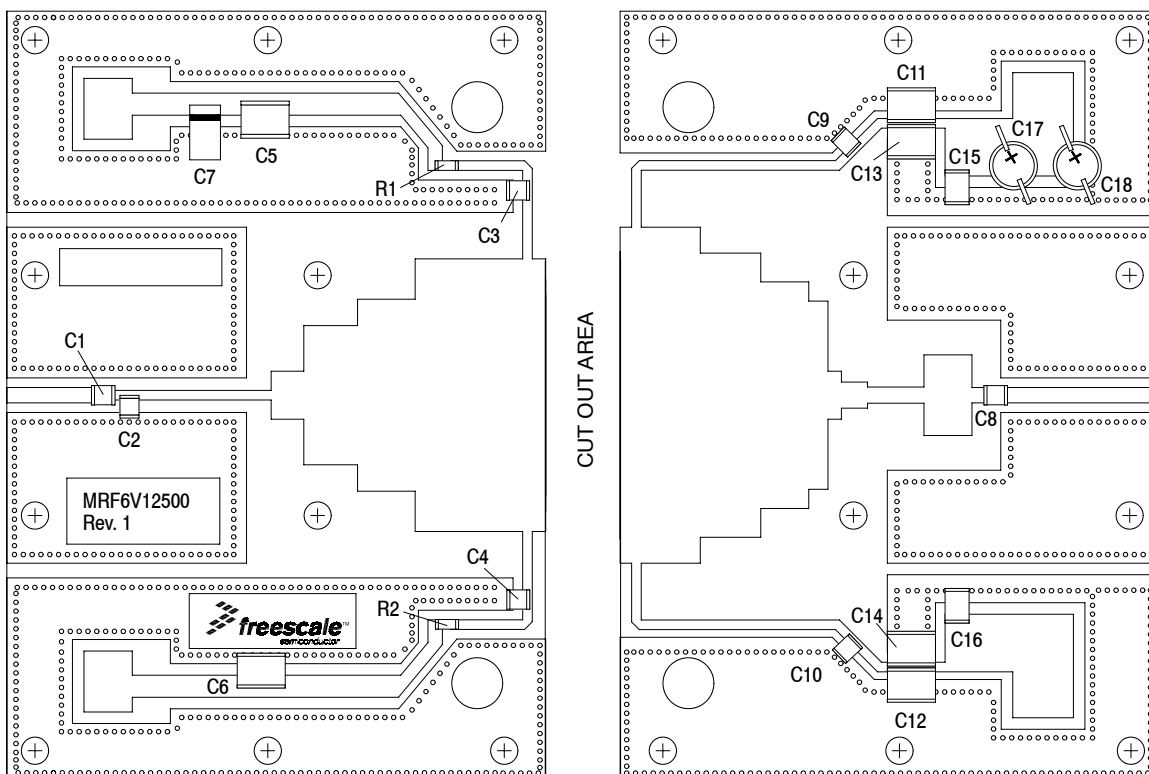


Figure 13. MRF6V12500H(HS) Test Circuit Component Layout — 960-1215 MHz

Table 6. MRF6V12500H(HS) Test Circuit Component Designations and Values — 960-1215 MHz

| Part | Description | Part Number | Manufacturer |
|------------------|---|----------------------|--------------|
| C1 | 2.2 pF Chip Capacitor | ATC100B2R2JT500XT | ATC |
| C2 | 0.2 pF Chip Capacitor | ATC100B0R2BT500XT | ATC |
| C3, C4 | 33 pF Chip Capacitors | ATC100B330JT500XT | ATC |
| C5, C6, C11, C12 | 2.2 μ F, 100 V Chip Capacitors | G2225X7R225KT3AB | ATC |
| C7 | 22 μ F, 35 V Tantalum Capacitor | T491X226K035AT | Kemet |
| C8 | 8.2 pF Chip Capacitor | ATC100B8R2CT500XT | ATC |
| C9, C10 | 39 pF Chip Capacitors | ATC100B390JT500XT | ATC |
| C13, C14 | 0.022 μ F, 100 V Chip Capacitors | C1825C223K1GAC | Kemet |
| C15, C16 | 0.10 μ F, 100 V Chip Capacitors | C1812F104K1RAC | Kemet |
| C17, C18 | 470 μ F, 63 V Electrolytic Capacitors | MCGPR63V477M13X26-RH | Multicomp |
| R1, R2 | 22 Ω , 1/4 W Chip Resistors | CRCW120622R0FKEA | Vishay |
| PCB | 0.030", $\epsilon_r = 2.55$ | AD255A | Arlon |

TYPICAL CHARACTERISTICS — 960-1215 MHz

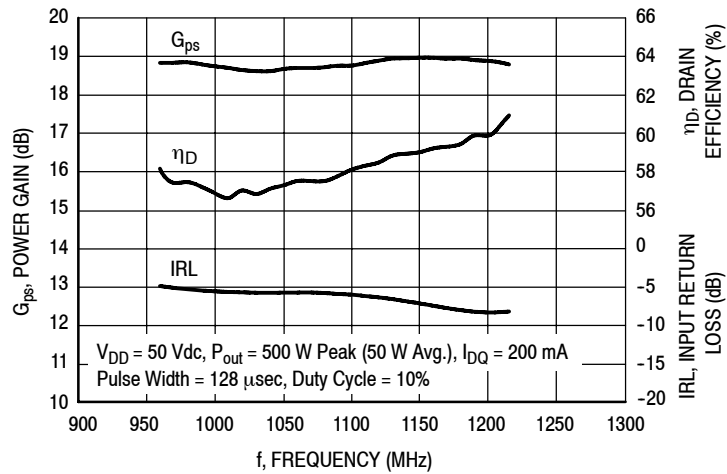


Figure 14. Pulsed Power Gain, Drain Efficiency and IRL versus Frequency

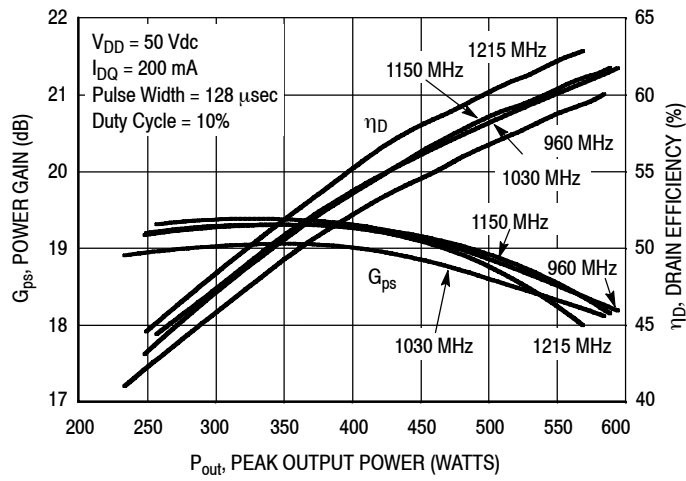
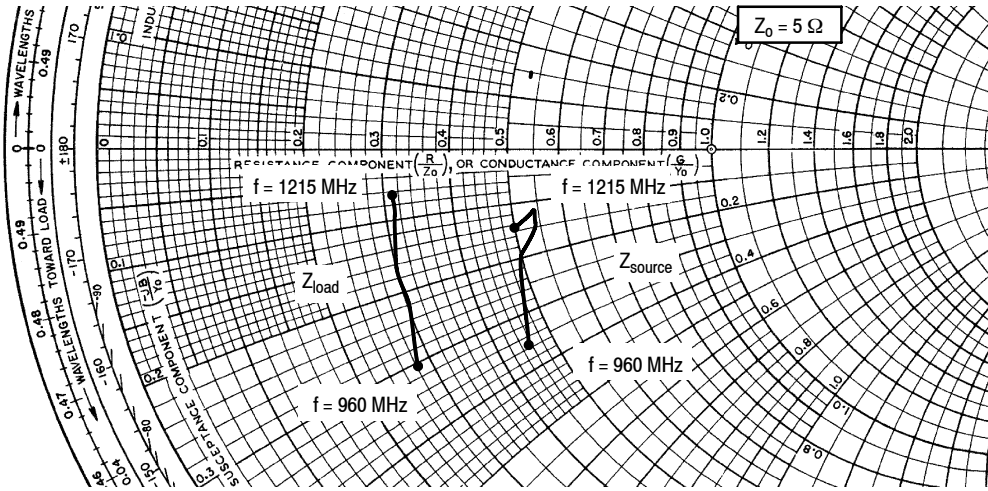


Figure 15. Power Gain and Drain Efficiency versus Output Power



$V_{DD} = 50 \text{ Vdc}$, $I_{DQ} = 200 \text{ mA}$, $P_{out} = 500 \text{ W Peak}$

| f MHz | Z_{source} Ω | Z_{load} Ω |
|----------|--------------------------|------------------------|
| 960 | $2.25 - j1.78$ | $1.38 - j1.53$ |
| 1030 | $2.51 - j1.02$ | $1.48 - j1.11$ |
| 1090 | $2.69 - j0.73$ | $1.51 - j0.78$ |
| 1150 | $2.71 - j0.65$ | $1.53 - j0.49$ |
| 1215 | $2.48 - j0.76$ | $1.53 - j0.33$ |

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

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

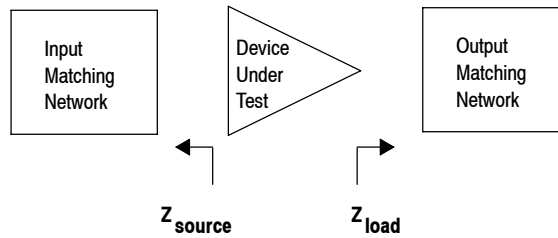
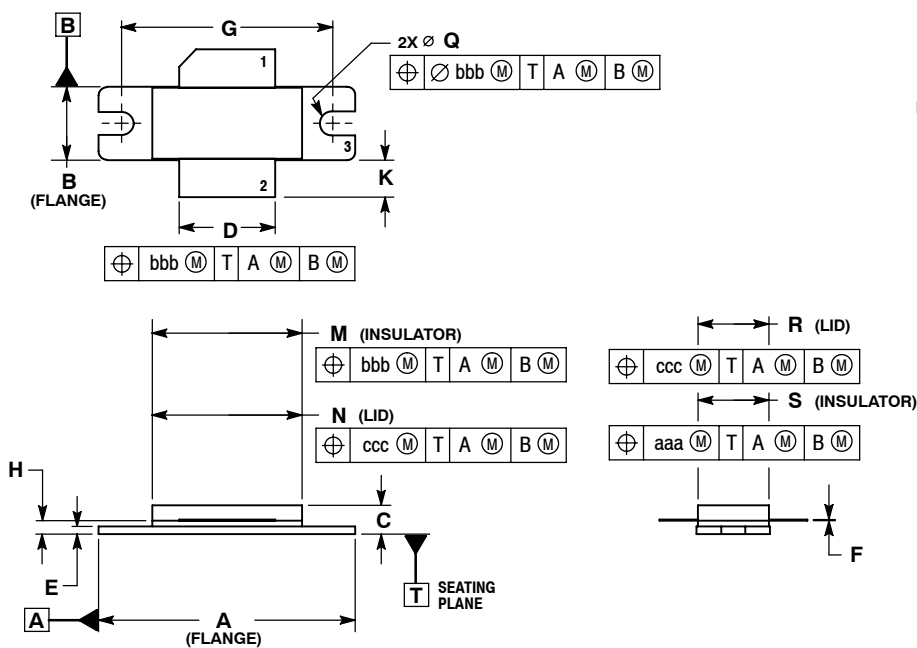


Figure 16. Series Equivalent Source and Load Impedance — 960-1215 MHz

PACKAGE DIMENSIONS

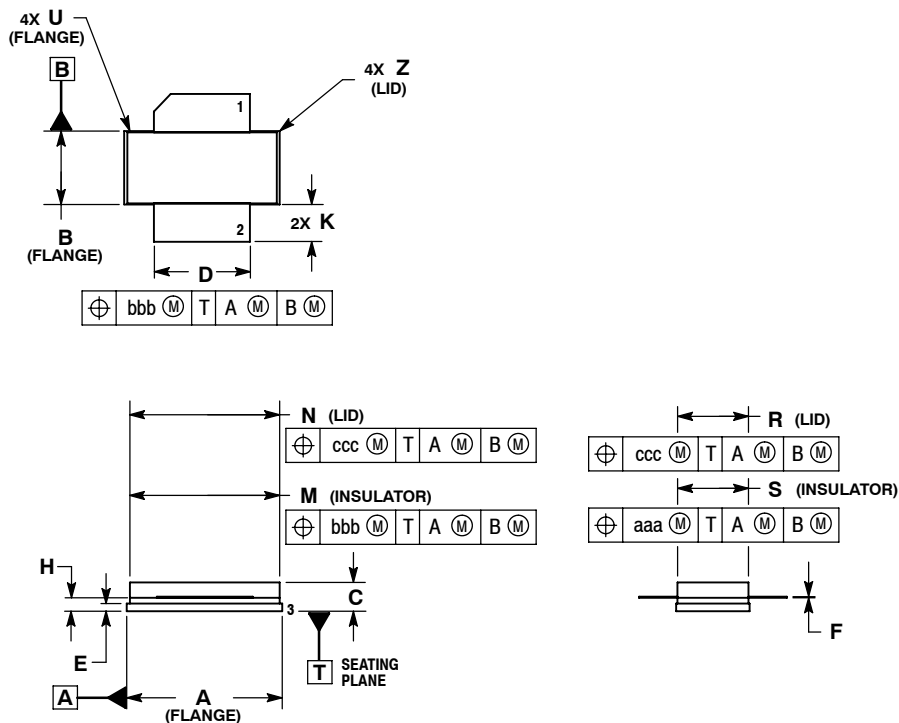


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1994.
 2. CONTROLLING DIMENSION: INCH.
 3. DELETED
 4. DIMENSION H IS MEASURED 0.030 (0.762) AWAY FROM PACKAGE BODY.

| 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 3.00 | Ø 3.51 |
| 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:
 PIN 1. DRAIN
 2. GATE
 3. SOURCE

**CASE 465-06
 ISSUE G
 NI-780
 MRF6V12500HR3**



- 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 |
| H | 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:
 PIN 1. DRAIN
 2. GATE
 5. SOURCE

**CASE 465A-06
 ISSUE H
 NI-780S
 MRF6V12500HSR3**

MRF6V12500HR3 MRF6V12500HSR3

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

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 | <ul style="list-style-type: none">• Initial Release of Data Sheet |
| 1 | Apr. 2010 | <ul style="list-style-type: none">• 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• Added RF High Power Model availability to Product Software, p. 9 |
| 2 | Sept. 2010 | <ul style="list-style-type: none">• Maximum Ratings table: corrected V_{DSS} from -0.5, +100 to -0.5, +110 Vdc, p. 2• Added 960-1215 MHz Broadband application as follows:<ul style="list-style-type: none">- Typical Performance, p. 1, 2- Fig. 13, Test Circuit Component Layout and Table 6, Test Circuit Component Designations and Values, p. 8- Fig. 14, Pulsed Power Gain, Drain Efficiency and IRL versus Frequency, p. 9- Fig. 15, Power Gain and Drain Efficiency versus Output Power, p. 9- Fig. 16, Series Equivalent Source and Load Impedance, p. 10 |

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