



RF Power LDMOS Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

These RF power transistors are designed for applications operating at frequencies between 960 and 1215 MHz such as distance measuring equipment (DME), transponders and secondary radars for air traffic control. These devices are suitable for use in pulse applications, including Mode S ELM.

- Typical Pulse Performance: $V_{DD} = 50$ Volts, $I_{DQ} = 200$ mA

| Application | Signal Type | $P_{out}^{(1)}$ (W) | Freq. (MHz) | G_{ps} (dB) | η_D (%) |
|---------------------------|--|------------------------|----------------|------------------|-----------------|
| Narrowband Short Pulse | Pulse (128 μ sec, 10% Duty Cycle) | 500 Peak | 1030 | 19.7 | 62.0 |
| Narrowband Mode S ELM | Pulse (48 \times (32 μ sec on, 18 μ sec off), Period 2.4 msec, 6.4% Long-term Duty Cycle) | 500 Peak | 1030 | 19.7 | 62.0 |
| Broadband | Pulse (128 μ sec, 10% Duty Cycle) | 500 Peak | 960-1215 | 18.5 | 57.0 |

1. Minimum output power for each specified pulse condition.

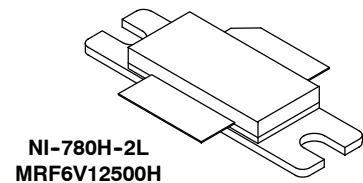
- Capable of Handling 10:1 VSWR @ 50 Vdc, 1030 MHz, 500 Watts Peak Power

Features

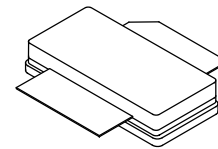
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Matched for Ease of Use
- Qualified up to a Maximum of 50 V_{DD} Operation
- Integrated ESD Protection
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation

MRF6V12500H
MRF6V12500HS
MRF6V12500GS

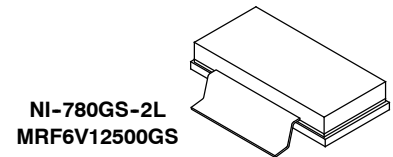
960-1215 MHz, 500 W, 50 V
PULSE
RF POWER LDMOS TRANSISTORS



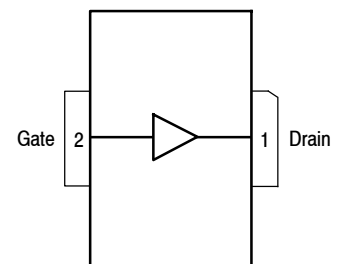
NI-780H-2L
MRF6V12500H



NI-780S-2L
MRF6V12500HS



NI-780GS-2L
MRF6V12500GS



(Top View)

Note: The backside of the package is the source terminal for the transistor.

Figure 1. Pin Connections



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 | °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 Impedance, Junction to Case Case Temperature 80°C, 500 W Peak, 128 μ sec Pulse Width, 10% Duty Cycle | $Z_{\theta JC}$ | 0.044 | °C/W |

Table 3. ESD Protection Characteristics

| Test Methodology | Class |
|---------------------------------------|-------------------|
| Human Body Model (per JESD22-A114) | 2, passes 2600 V |
| Machine Model (per EIA/JESD22-A115) | B, passes 200 V |
| Charge Device Model (per JESD22-C101) | IV, passes 2000 V |

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

On Characteristics

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

Dynamic Characteristics (4)

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

1. Continuous use at maximum temperature will affect MTTF.
2. MTTF calculator available at <http://www.nxp.com/RF/calculators>.
3. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.nxp.com/RF> and search for AN1955.
4. Part internally matched both on input and output.

(continued)

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|--|----------|------|------|------|------|
| 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.), $f = 1030\text{ MHz}$, 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.), $f = 960\text{-}1215\text{ MHz}$, 128 μsec Pulse Width, 10% Duty Cycle

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

Table 5. Ordering Information

| Device | Tape and Reel Information | Package |
|-----------------|--|-------------|
| MRFE6V12500HR5 | R5 Suffix = 50 Units, 56 mm Tape Width, 13-inch Reel | NI-780H-2L |
| MRFE6V12500HSR5 | | NI-780S-2L |
| MRFE6V12500GSR5 | | NI-780GS-2L |

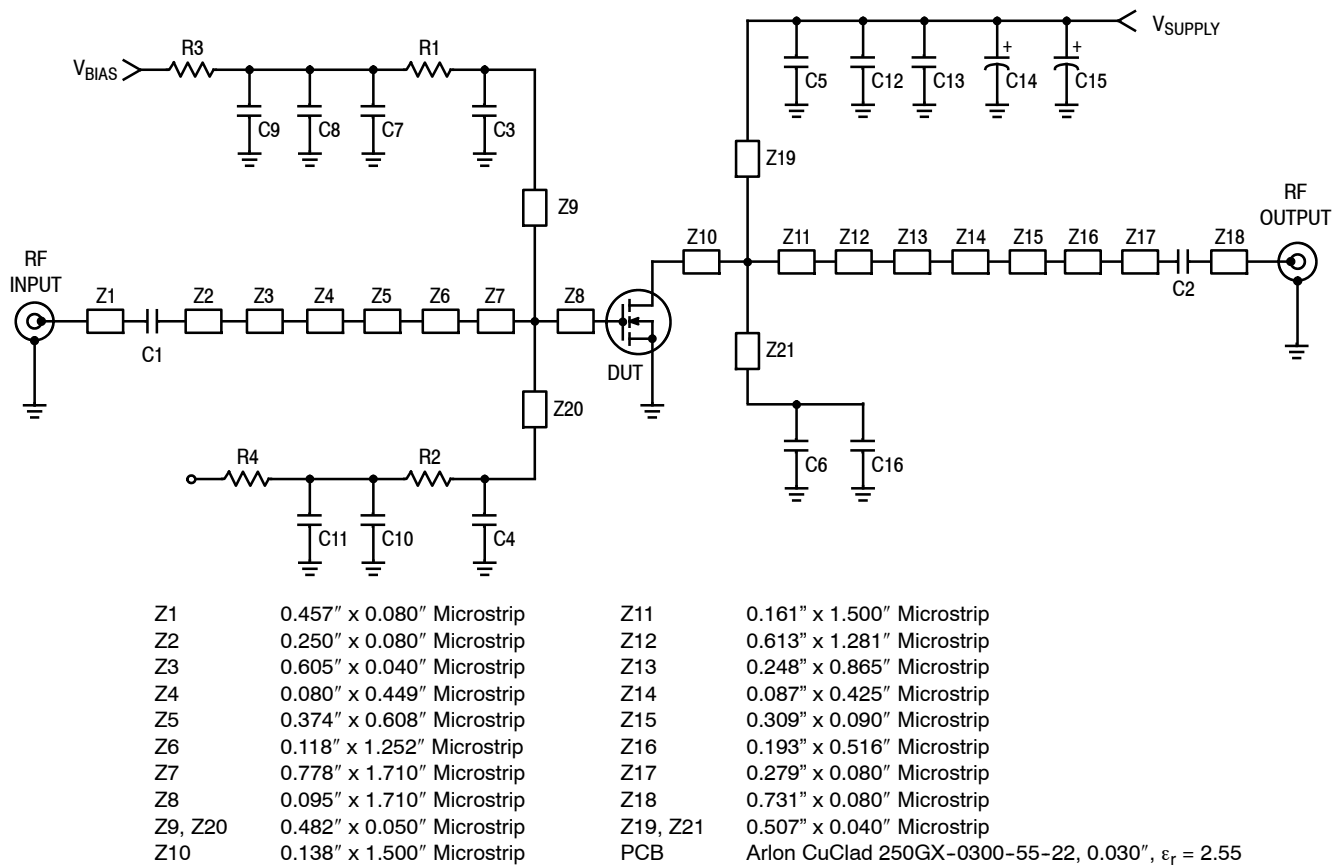


Figure 2. MRF6V12500H(HS) Test Circuit Schematic

Table 6. MRF6V12500H(HS) 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 |

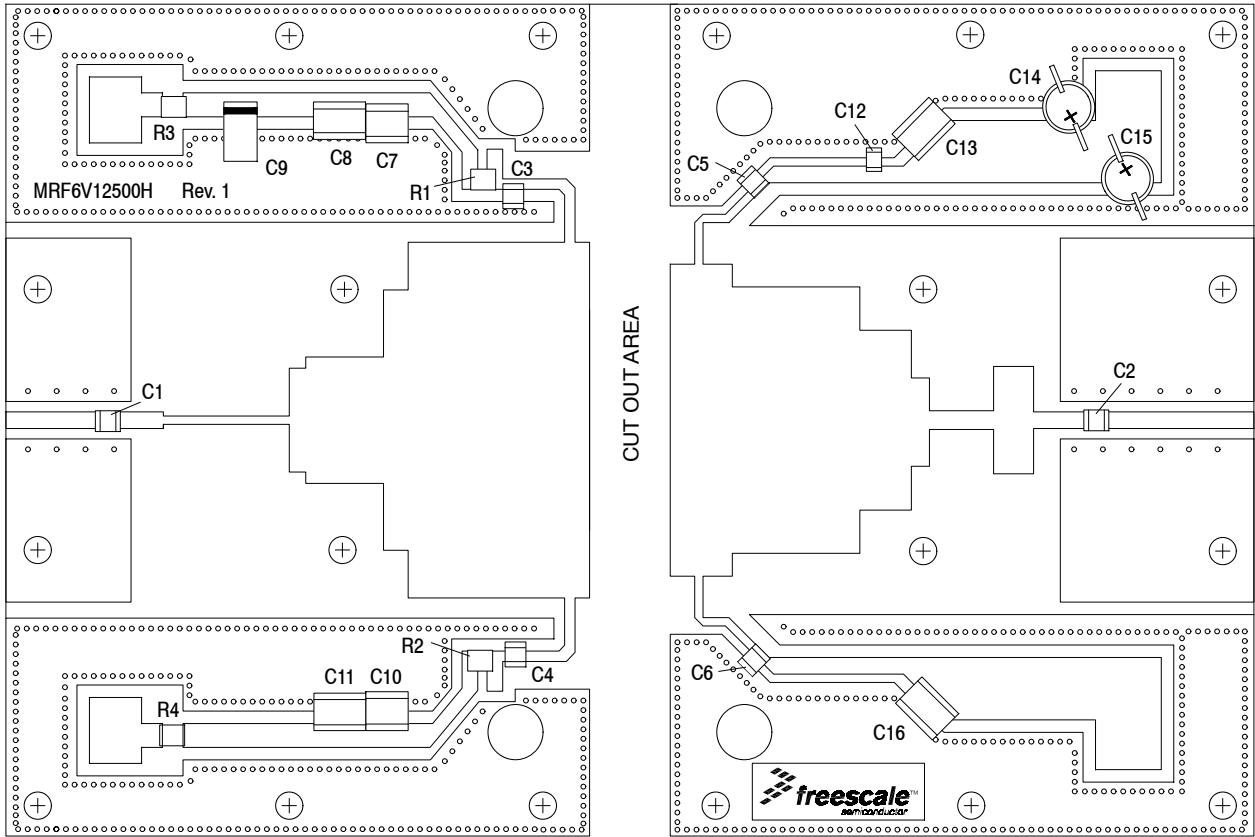


Figure 3. MRF6V12500H(HS) Test Circuit Component Layout

TYPICAL CHARACTERISTICS

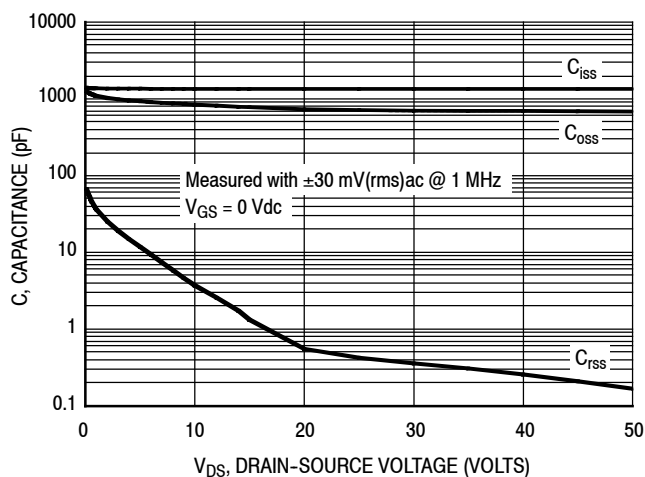


Figure 4. Capacitance versus Drain-Source Voltage

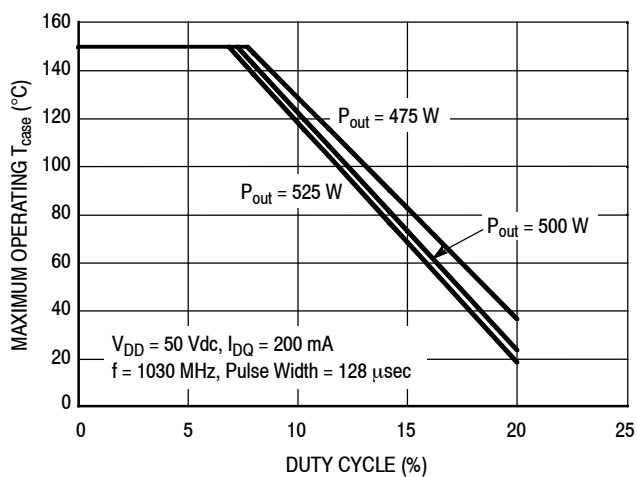


Figure 5. Safe Operating Area

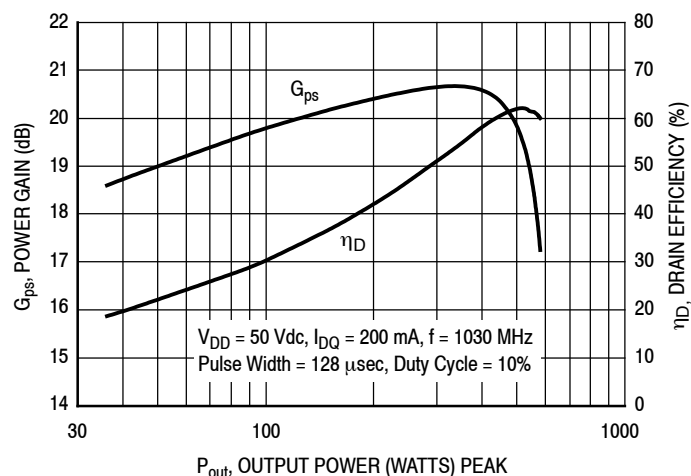


Figure 6. Power Gain and Drain Efficiency versus Output Power

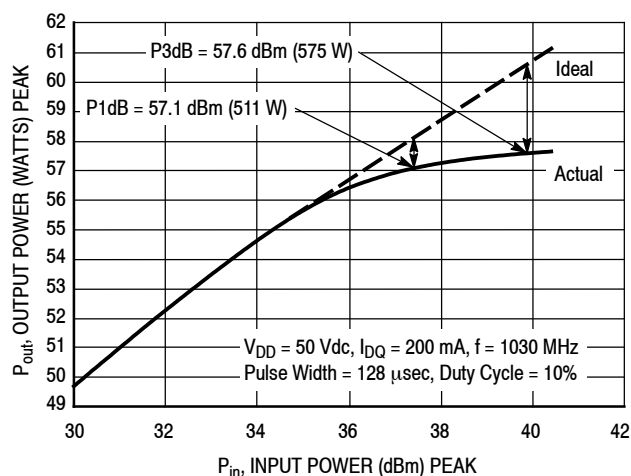


Figure 7. Output Power versus Input Power

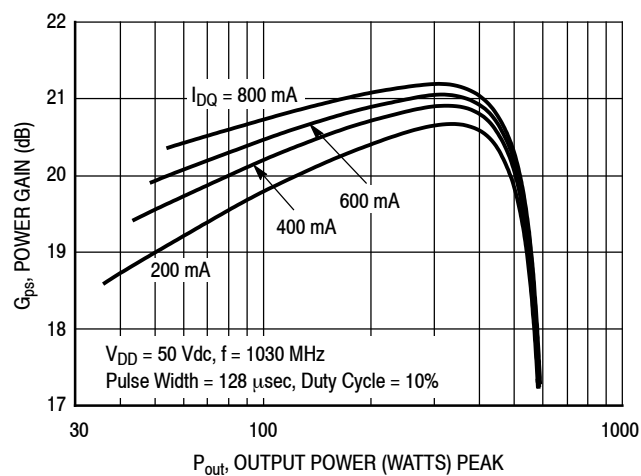


Figure 8. Power Gain versus Output Power

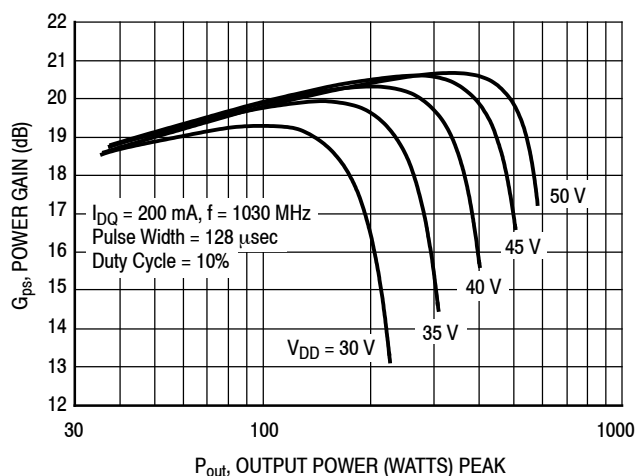


Figure 9. Power Gain versus Output Power

TYPICAL CHARACTERISTICS

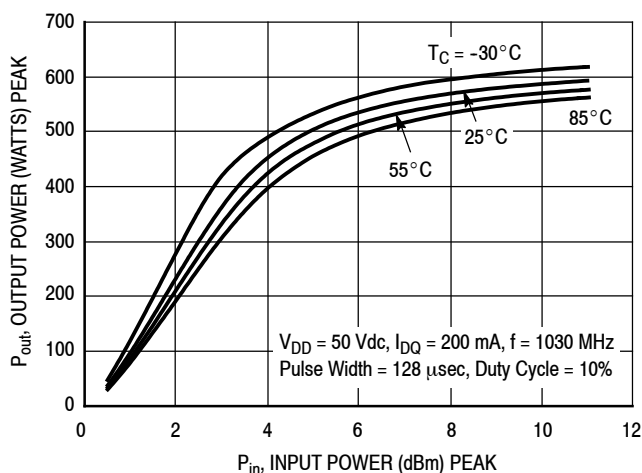


Figure 10. Output Power versus Input Power

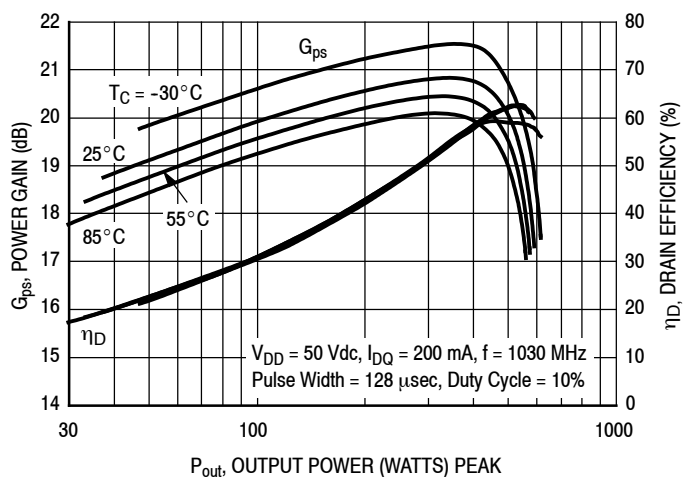
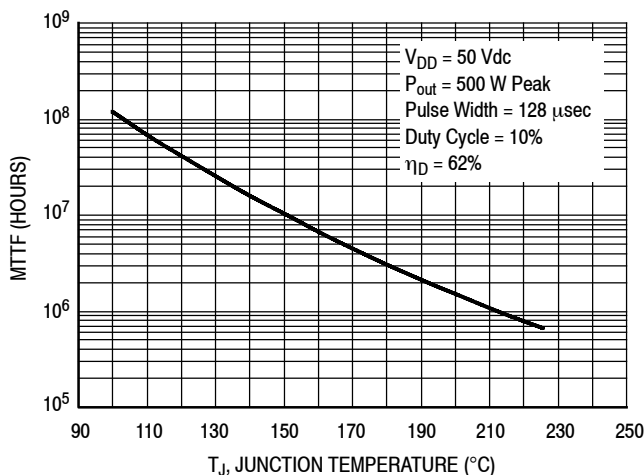


Figure 11. Power Gain and Drain Efficiency versus Output Power



Note: MTTF value represents the total cumulative operating time under indicated test conditions.

MTTF calculator available at <http://www.nxp.com/RF/calculators>.

Figure 12. 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.

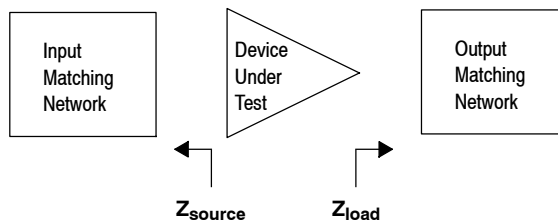


Figure 13. Series Equivalent Source and Load Impedance

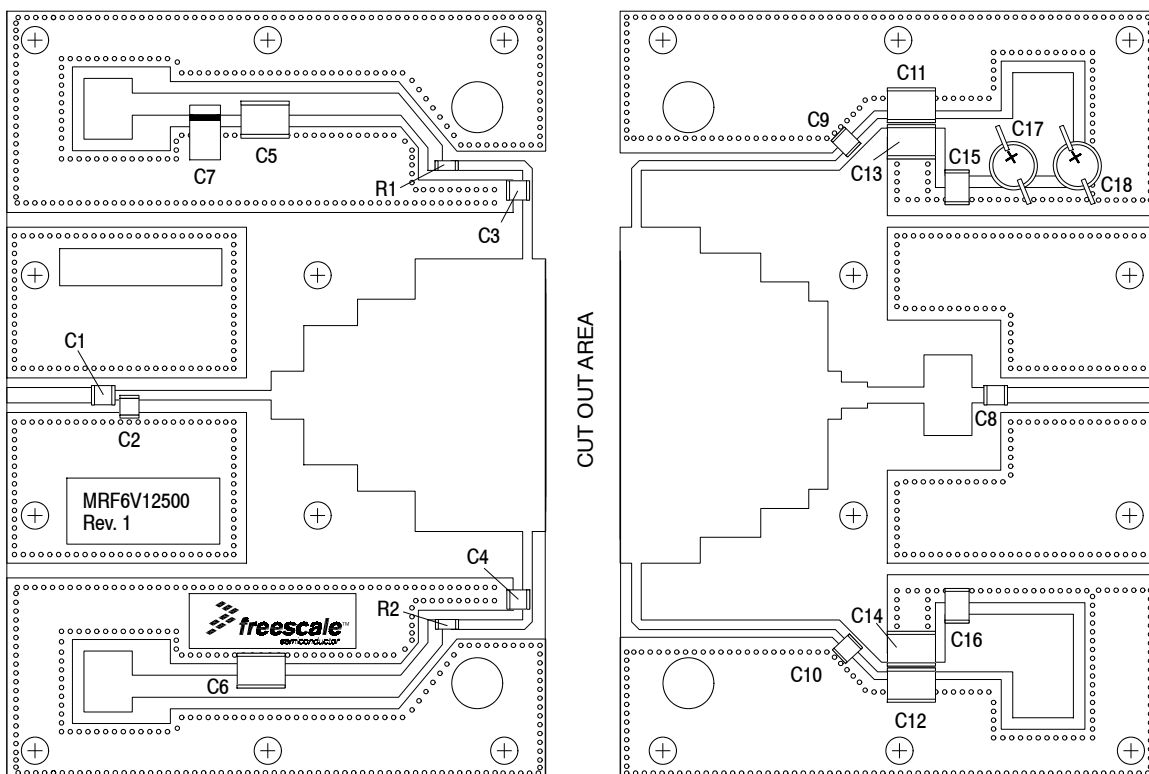


Figure 14. MRF6V12500H(HS) Test Circuit Component Layout — 960-1215 MHz

Table 7. 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

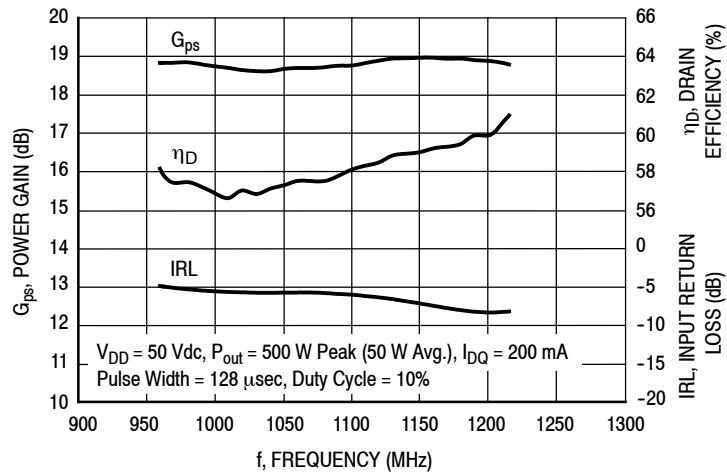


Figure 15. Power Gain, Drain Efficiency and IRL versus Frequency

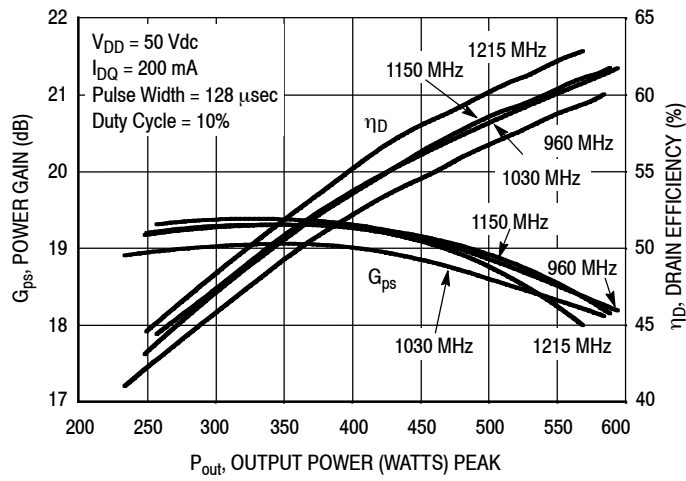
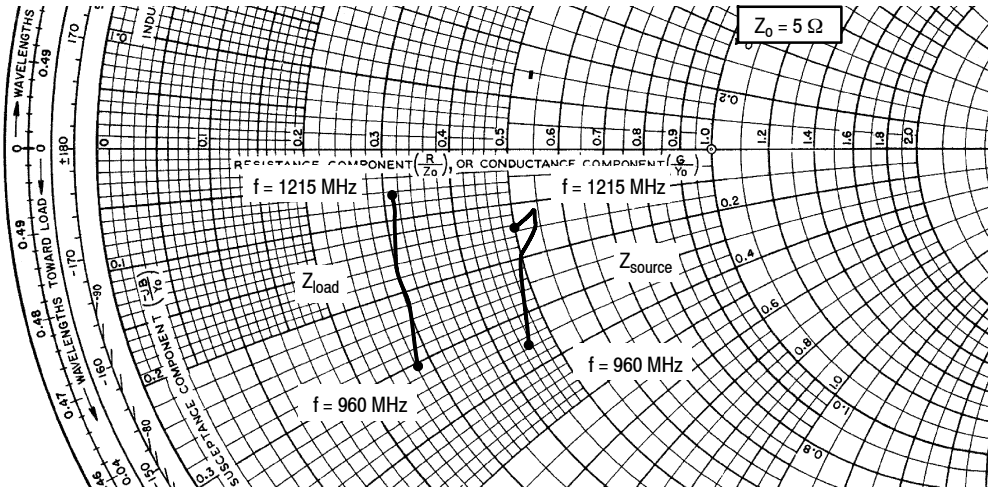


Figure 16. Power Gain and Drain Efficiency versus Output Power



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

| 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.

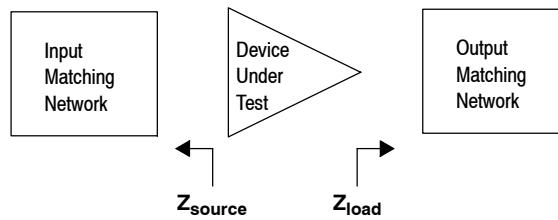
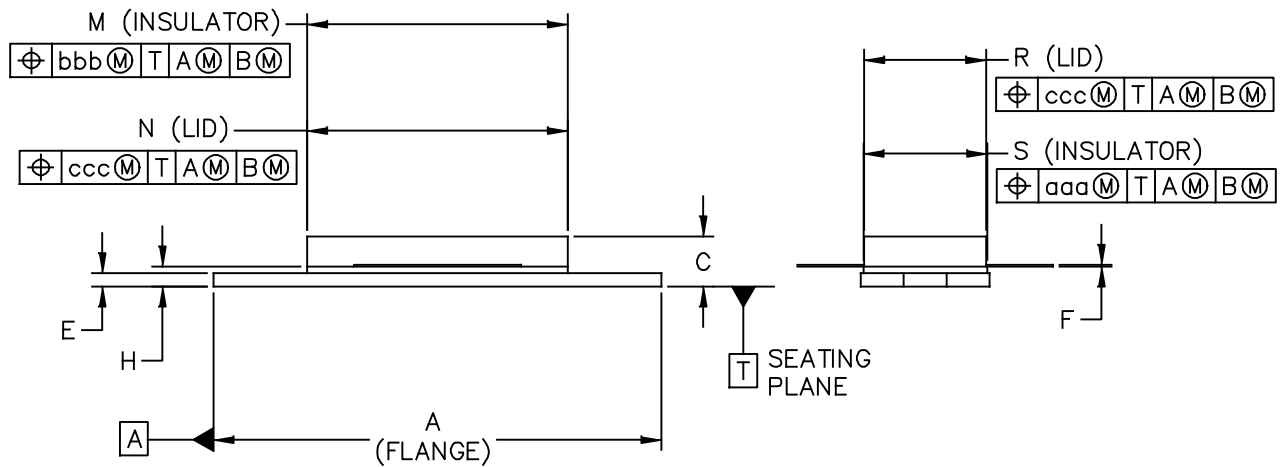
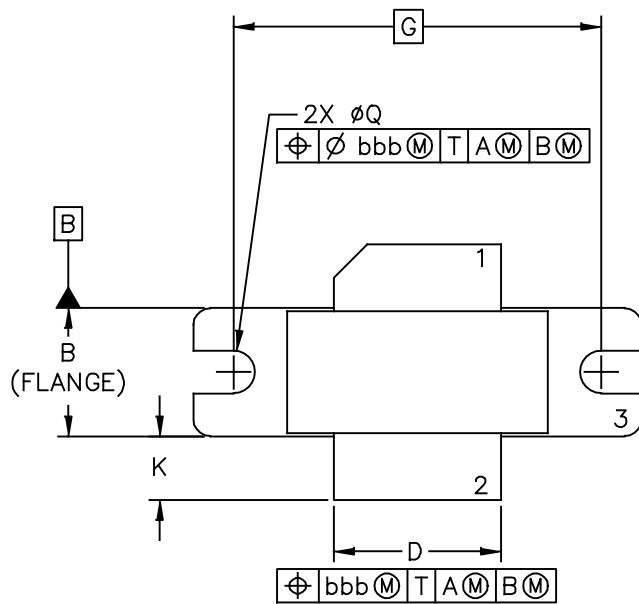


Figure 17. Series Equivalent Source and Load Impedance — 960-1215 MHz

PACKAGE DIMENSIONS



| | | |
|---|--------------------------------------|----------------------------|
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| TITLE: NI-780 | DOCUMENT NO: 98ASB15607C REV: H | |
| | STANDARD: NON-JEDEC | |
| | SOT1792-1 | 14 MAR 2016 |

MRF6V12500H MRF6V12500HS MRF6V12500GS

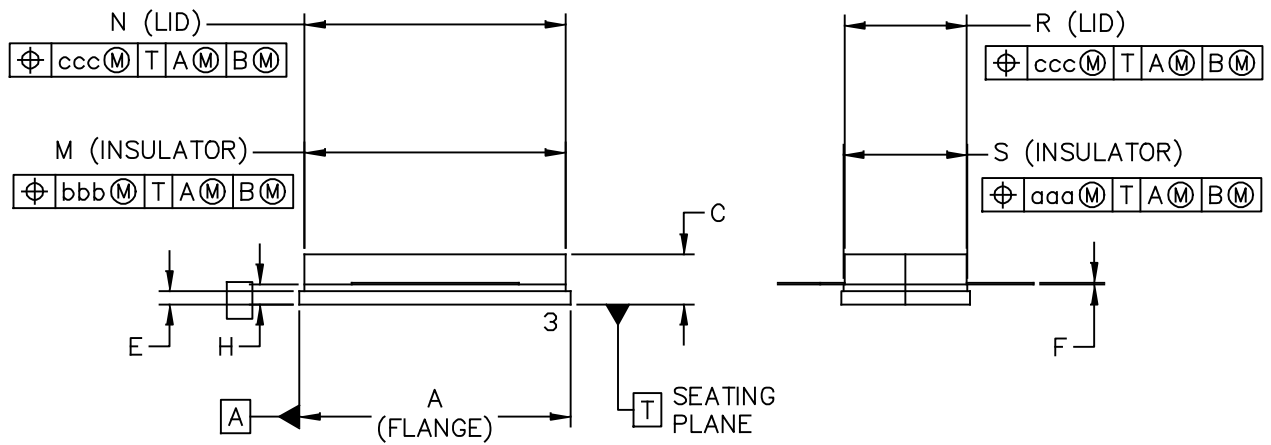
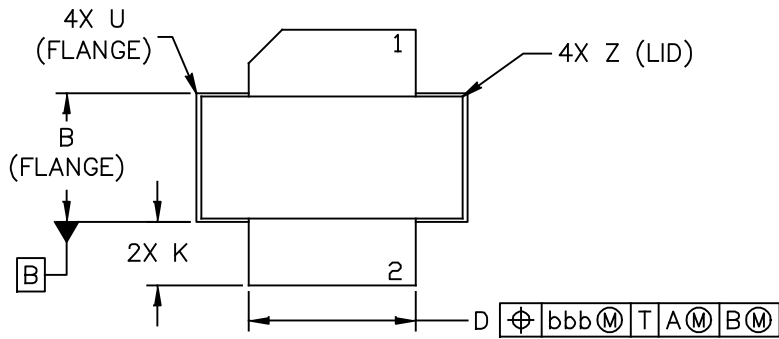
NOTES:

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 | ∅.118 | – ∅.138 | ∅3 | – ∅3.51 | – | – | – | – | – |
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| | | | | | STANDARD: NON-JEDEC | | | | |
| | | | | | SOT1792-1 | | | 14 MAR 2016 | |



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| TITLE: NI-780S | DOCUMENT NO: 98ASB16718C | REV: J |
| | STANDARD: NON-JEDEC | |
| | SOT1793-1 | 15 MAR 2016 |

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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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MECHANICAL OUTLINE

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TITLE:

NI–780S

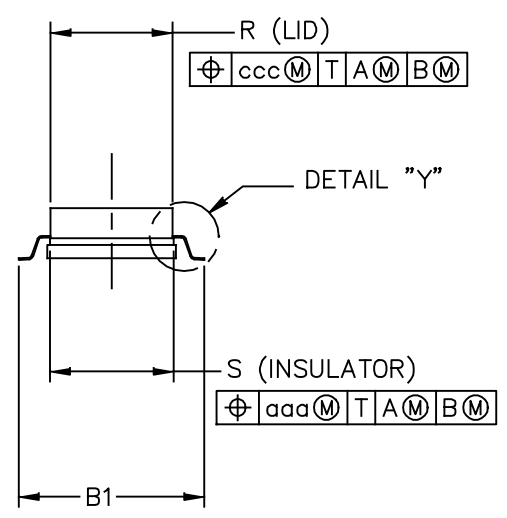
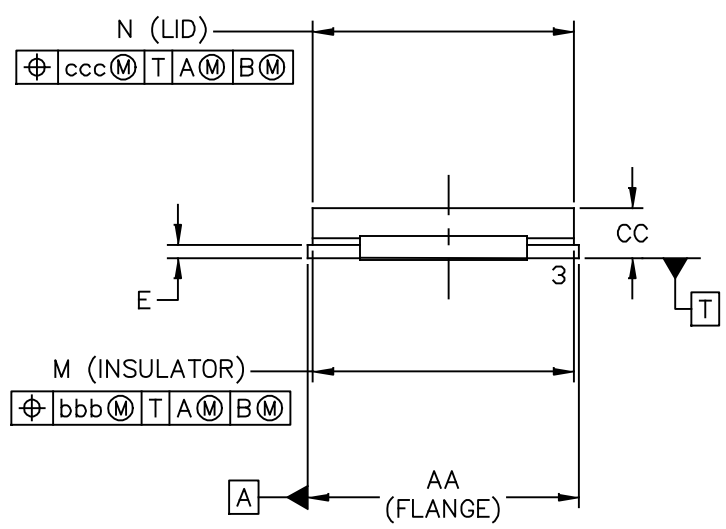
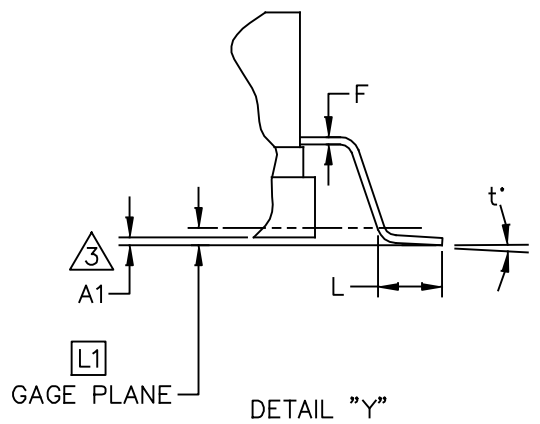
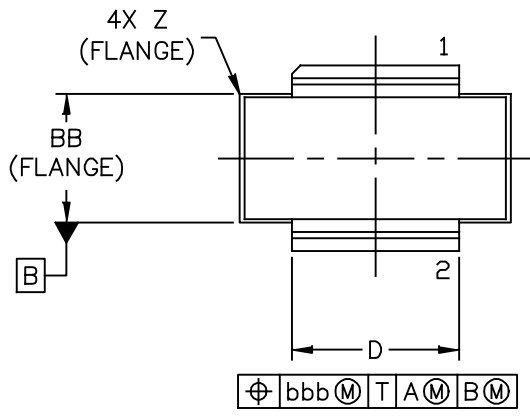
DOCUMENT NO: 98ASB16718C

REV: J

STANDARD: NON–JEDEC

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15 MAR 2016



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| | STANDARD: NON-JEDEC | |
| | SOT1802-1 | 22 FEB 2016 |

NOTES:

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

2. CONTROLLING DIMENSION: INCH.

3. DIMENSION A1 IS MEASURED WITH REFERENCE TO DATUM T. THE POSITIVE VALUE IMPLIES THAT THE PACKAGE BOTTOM IS HIGHER THAN THE LEAD BOTTOM.

| DIM | INCH | | MILLIMETER | | DIM | INCH | | MILLIMETER | |
|--|----------|------|--------------------|-------|--------------------------------------|----------------------------|-------------|------------|-------|
| | MIN | MAX | MIN | MAX | | MIN | MAX | MIN | MAX |
| AA | .805 | .815 | 20.45 | 20.70 | Z | R.000 | R.040 | R0.00 | R1.02 |
| A1 | .002 | .008 | 0.05 | 0.20 | t | 0 | 8 | 0 | 8 |
| BB | .380 | .390 | 9.65 | 9.91 | | | | | |
| B1 | .546 | .562 | 13.87 | 14.27 | | | | | |
| CC | .125 | .170 | 3.18 | 4.32 | aaa | .005 | | 0.13 | |
| D | .495 | .505 | 12.57 | 12.83 | bbb | .010 | | 0.25 | |
| E | .035 | .045 | 0.89 | 1.14 | ccc | .015 | | 0.38 | |
| F | .003 | .006 | 0.08 | 0.15 | | | | | |
| L | .038 | .046 | 0.97 | 1.17 | | | | | |
| L1 | .010 BSC | | 0.25 BSC | | | | | | |
| M | .774 | .786 | 19.66 | 19.96 | | | | | |
| N | .772 | .788 | 19.61 | 20.02 | | | | | |
| R | .365 | .375 | 9.27 | 9.53 | | | | | |
| S | .365 | .375 | 9.27 | 9.53 | | | | | |
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| TITLE: NI–780GS–2L | | | | | DOCUMENT NO: 98ASA00193D REV: C | | | | |
| | | | | | STANDARD: NON–JEDEC | | | | |
| | | | | | SOT1802–1 | | 22 FEB 2016 | | |

PRODUCT DOCUMENTATION AND SOFTWARE

Refer to the following resources to aid your design process.

Application Notes

- AN1908: Solder Reflow Attach Method for High Power RF Devices in Air Cavity Packages
- 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

To Download Resources Specific to a Given Part Number:

1. Go to <http://www.nxp.com/RF>
2. Search by part number
3. Click part number link
4. Choose the desired resource from the drop down menu

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 |
| 3 | June 2012 | <ul style="list-style-type: none">• Table 3, ESD Protection Characteristics: added the device’s ESD passing level as applicable to each ESD class, p. 2• Modified figure titles and/or graph axes labels to clarify application use, p. 5, 6, 9• Fig. 6, Output Power versus Input Power: corrected P_{out}, Output Power unit of measure to watts, p. 5• Fig. 9, Output Power versus Input Power: corrected P_{out}, Output Power unit of measure to watts, p. 6• Fig. 11, MTTF versus Junction Temperature: MTTF end temperature on graph changed to match maximum operating junction temperature, p. 6 |
| 4 | Mar. 2015 | <ul style="list-style-type: none">• MRF6V12500HR3 tape and reel option replaced with MRF6V12500HR5 and MRF6V12500HSR3 tape and reel option replaced with MRF6V12500HSR5 per PCN15551• Modified figure titles and/or graph axes labels to clarify application use, pp. 6, 7, 9• Typical performance table: added Narrowband Mode S ELM application data, p. 1 |
| 5 | July 2016 | <ul style="list-style-type: none">• Added part number MRF6V12500GS, pp. 1, 3• Added NI-780GS-2L package isometric, p. 1, and Mechanical Outline, pp. 15-16 |

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