Freescale Semiconductor
Technical Data

Document Number: MRF6VP3450H
Rev. 4, 4/2010

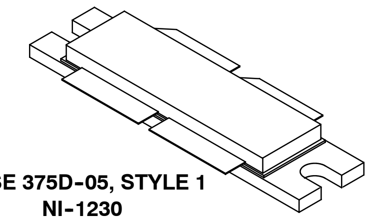
RoHS

# RF Power Field Effect Transistors

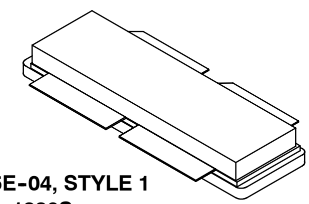
## N-Channel Enhancement-Mode Lateral MOSFETs

**MRF6VP3450HR6**
**MRF6VP3450HR5**
**MRF6VP3450HSR6**
**MRF6VP3450HSR5**

**860 MHz, 450 W, 50 V**
**LATERAL N-CHANNEL**
**BROADBAND**
**RF POWER MOSFETs**



**CASE 375D-05, STYLE 1**
**NI-1230**
**MRF6VP3450HR6(HR5)**



**CASE 375E-04, STYLE 1**
**NI-1230S**
**MRF6VP3450HSR6(HSR5)**

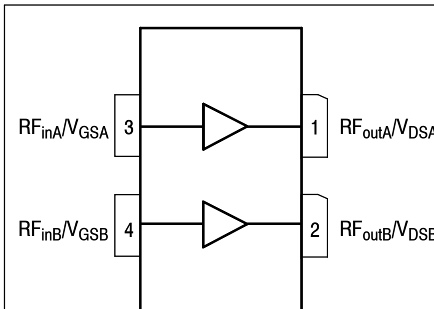
**PARTS ARE PUSH-PULL**

Designed for broadband commercial and industrial applications with frequencies from 470 to 860 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 50 volt analog or digital television transmitter equipment.

- Typical DVB-T OFDM Performance: $V_{DD}$ = 50 Volts, $I_{DQ}$ = 1400 mA, $P_{out}$ = 90 Watts Avg., f = 860 MHz, 8K Mode, 64 QAM
  - Power Gain — 22.5 dB
  - Drain Efficiency — 28%
  - ACPR @ 4 MHz Offset — -62 dBc @ 4 kHz Bandwidth
- Typical Broadband Two-Tone Performance: $V_{DD}$ = 50 Volts, $I_{DQ}$ = 1400 mA, $P_{out}$ = 450 Watts PEP, f = 470-860 MHz
  - Power Gain — 22 dB
  - Drain Efficiency — 44%
  - IM3 — -29 dBc
- Capable of Handling 10:1 VSWR, All Phase Angles, @ 50 Vdc, 860 MHz:
  - 450 Watts CW
  - 90 Watts Avg. (DVB-T OFDM Signal, 10 dB PAR, 7.61 MHz Channel Bandwidth)

### Features

- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Input Matched for Ease of Use
- Qualified Up to a Maximum of 50 $V_{DD}$ Operation
- Integrated ESD Protection
- Designed for Push-Pull Operation
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel. R5 Suffix = 50 Units per 56 mm, 13 inch Reel.




(Top View)

**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 |

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.



freescale semiconductor

## Table 2. Thermal Characteristics

| Characteristic | Symbol | Value (1,2) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>Case Temperature 80°C, 90 W CW<br>Case Temperature 44°C, 450 W CW<br>Case Temperature 62°C, 450 W Pulsed, 50 μsec Pulse Width, 2.5% Duty Cycle | $R_{\theta JC}$<br><br>$Z_{\theta JC}$ | 0.27<br>0.25<br>0.04 | °C/W |

## Table 3. ESD Protection Characteristics

| Test Methodology | Class |
|---|---|
| Human Body Model (per JESD22-A114) | 1B (Minimum) |
| Machine Model (per EIA/JESD22-A115) | B (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 (3)** | | | | | |
| Gate-Source Leakage Current ($V_{GS}$ = 5 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | — | — | 10 | μAdc |
| Drain-Source Breakdown Voltage ($I_D$ = 50 mA, $V_{GS}$ = 0 Vdc) | $V_{(BR)DSS}$ | 110 | — | — | Vdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 50 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current ($V_{DS}$ = 100 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| **On Characteristics** | | | | | |
| Gate Threshold Voltage (3) ($V_{DS}$ = 10 Vdc, $I_D$ = 320 μAdc) | $V_{GS(th)}$ | 1 | 1.6 | 2.5 | Vdc |
| Gate Quiescent Voltage (4) ($V_{DD}$ = 50 Vdc, $I_D$ = 1400 mAdc, Measured in Functional Test) | $V_{GS(Q)}$ | 2 | 2.6 | 3.5 | Vdc |
| Drain-Source On-Voltage (3) ($V_{GS}$ = 10 Vdc, $I_D$ = 1.58 Adc) | $V_{DS(on)}$ | — | 0.25 | — | Vdc |
| **Dynamic Characteristics (3,5)** | | | | | |
| Reverse Transfer Capacitance ($V_{DS}$ = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 0.92 | — | pF |
| Output Capacitance ($V_{DS}$ = 50 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{oss}$ | — | 54.5 | — | pF |
| Input Capacitance ($V_{DS}$ = 50 Vdc, $V_{GS}$ = 0 Vdc ± 30 mV(rms)ac @ 1 MHz) | $C_{iss}$ | — | 373 | — | pF |

**Functional Tests (4)** (In Freescale Broadband Test Fixture, 50 ohm system) $V_{DD}$ = 50 Vdc, $I_{DQ}$ = 1400 mA, $P_{out}$ = 90 W Avg., f = 860 MHz, DVB-T OFDM Single Channel. ACPR measured in 7.61 MHz Channel Bandwidth @ ±4 MHz Offset @ 4 kHz Bandwidth.

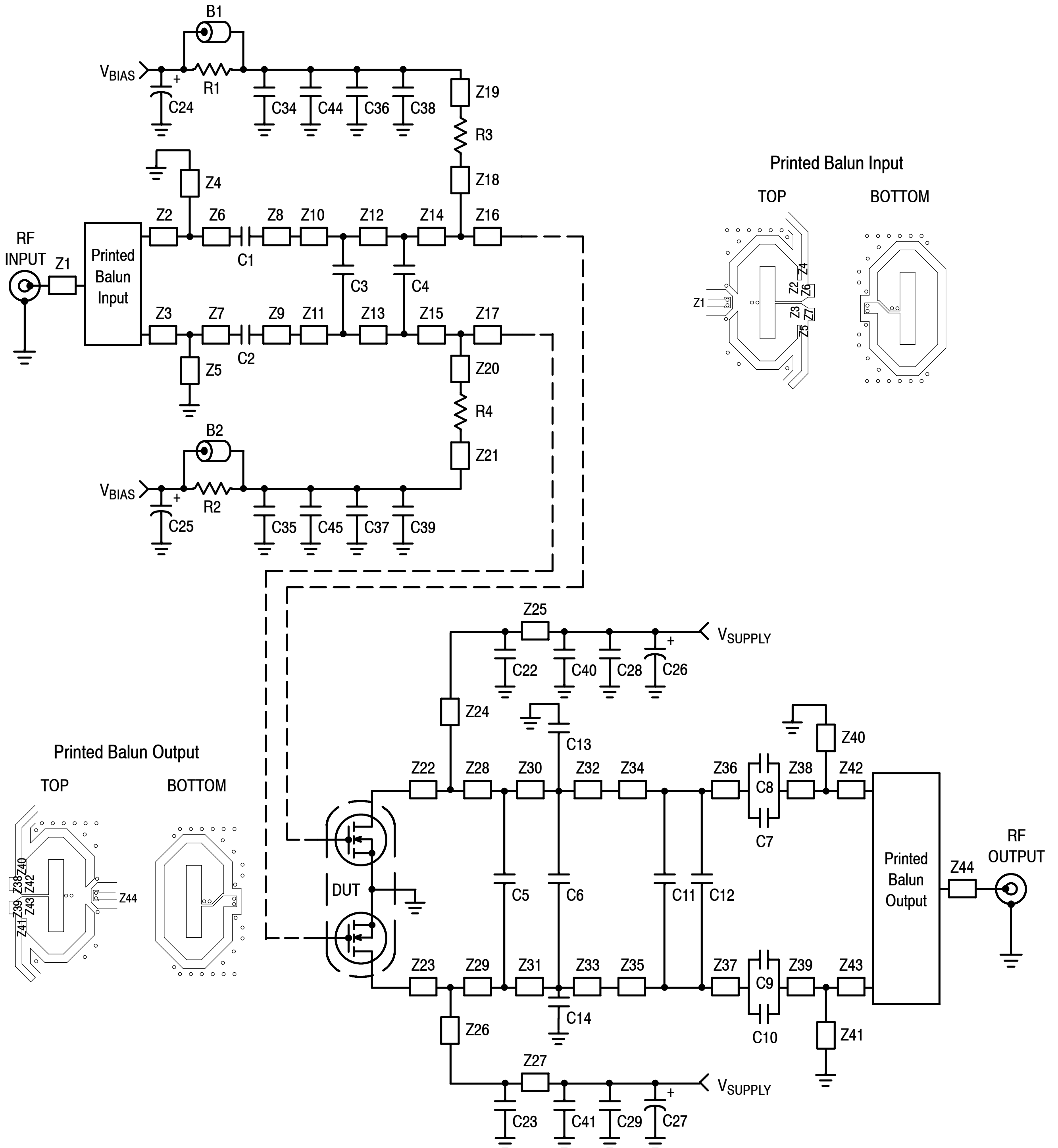
| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Power Gain | $G_{ps}$ | 21.5 | 22.5 | 24.5 | dB |
| Drain Efficiency | $\eta_D$ | 26 | 28 | — | % |
| Adjacent Channel Power Ratio | ACPR | — | -62 | -59 | dBc |
| Input Return Loss | IRL | — | -4 | -2 | dB |

1. MTTF calculator available at http://www.freescale.com/rf. Select Software & Tools/Development Tools/Calculators to access MTTF calculators by product.
2. Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers.* Go to http://www.freescale.com/rf. Select Documentation/Application Notes - AN1955.
3. Each side of device measured separately.
4. Measurement made with device in push-pull configuration.
5. Part internally input matched.

(continued)

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Typical Pulsed Performances** (In Freescale Broadband Test Fixture, 50 ohm system) $V_{DD}$ = 50 Vdc, $I_{DQ}$ = 1200 mA, $P_{out}$ = 520 W, f = 470-860 MHz, 50 μsec Pulse Width, 2.5% Duty Cycle | | | | | |
| Power Gain | $G_{ps}$ | — | 20.5 | — | dB |
| Drain Efficiency | $\eta_D$ | — | 50 | — | % |
| Input Return Loss | IRL | — | -3 | — | dB |
| $P_{out}$ @ 1 dB Compression Point, Pulsed CW (f = 470-860 MHz) | P1dB | — | 520 | — | W |
| **Typical Two-Tone Performances** (In Freescale Broadband Test Fixture, 50 ohm system) $V_{DD}$ = 50 Vdc, $I_{DQ}$ = 1400 mA, $P_{out}$ = 450 W PEP, f = 470-860 MHz, 100 kHz Tone Spacing | | | | | |
| Power Gain | $G_{ps}$ | — | 22 | — | dB |
| Drain Efficiency | $\eta_D$ | — | 44 | — | % |
| Intermodulation Distortion | IM3 | — | -29 | — | dBc |
| Input Return Loss | IRL | — | -2 | — | dB |




| | | | | | |
|---|---|---|---|---|---|
| Z1 | 0.343″ x 0.065″ Microstrip | Z16, Z17 | 0.172″ x 0.465″ Microstrip | Z32, Z33 | 0.108″ x 0.392″ Microstrip |
| Z2, Z3 | 0.039″ x 0.200″ Microstrip | Z18, Z20 | 0.397″ x 0.059″ Microstrip | Z34, Z35 | 0.212″ x 0.388″ Microstrip |
| Z4, Z5 | 1.400″ x 0.059″ Microstrip | Z19, Z21 | 0.800″ x 0.059″ Microstrip | Z36, Z37 | 0.103″ x 0.388″ Microstrip |
| Z6, Z7 | 0.059″ x 0.118″ Microstrip | Z22, Z23 | 0.276″ x 0.465″ Microstrip | Z38, Z39 | 0.075″ x 0.157″ Microstrip |
| Z8, Z9 | 0.059″ x 0.118″ Microstrip | Z24, Z26 | 0.070″ x 0.157″ Microstrip | Z40, Z41 | 1.412″ x 0.071″ Microstrip |
| Z10, Z11 | 0.150″ x 0.394″ Microstrip | Z25, Z27 | 1.000″ x 0.157″ Microstrip | Z42, Z43 | 0.024″ x 0.087″ Microstrip |
| Z12, Z13 | 0.359″ x 0.394″ Microstrip | Z28, Z29 | 0.103″ x 0.392″ Microstrip | Z44 | 0.550″ x 0.065″ Microstrip |
| Z14, Z15 | 0.308″ x 0.394″ Microstrip | Z30, Z31 | 0.084″ x 0.392″ Microstrip | PCB | Taconic RF35, 0.031″, $\varepsilon_r = 3.5$ |

**Figure 2. MRF6VP3450HR6(HSR6) Test Circuit Schematic**

**Table 5. MRF6VP3450HR6(HSR6) Test Circuit Component Designations and Values**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| B1, B2 | Short Ferrite Beads | 2743019447 | Fair-Rite |
| C1, C2 | 12 pF Chip Capacitors | ATC100B120GT500XT | ATC |
| C3 | 6.8 pF Chip Capacitor | ATC100B6R8BT500XT | ATC |
| C4 | 10 pF Chip Capacitor | ATC100B100GT500XT | ATC |
| C5, C6, C8, C9 | 6.8 pF Chip Capacitors | ATC800B6R8BT500XT | ATC |
| C7, C10, C13, C14 | 10 pF Chip Capacitors | ATC800B100J500XT | ATC |
| C11 | 4.7 pF Chip Capacitor | ATC800B4R7J500XT | ATC |
| C12 | 3.9 pF Chip Capacitor | ATC800B3R9J500XT | ATC |
| C22, C23 | 330 pF Chip Capacitors | ATC100B331GT500XT | ATC |
| C24, C25 | 22 μF Electrolytic Capacitors | UUD1V220MCL1GS | Nichicon |
| C26, C27 | 220 μF, 100 V Electrolytic Capacitors | EEVFK2A221M | Panasonic |
| C28, C29 | 10 μF, 50 V Chip Capacitors | C5750X5R1H106MT | TDK |
| C34, C35 | 39 nF Chip Capacitors | ATC200B393KT50XT | ATC |
| C36, C37 | 1000 pF Chip Capacitors | ATC100B102JT500XT | ATC |
| C38, C39 | 470 pF Chip Capacitors | ATC100B471JT500XT | ATC |
| C40, C41 | 2.2 μF, 100 V Chip Capacitors | HMK432BJ225KM-T | Taiyo Yuden |
| C44, C45 | 2.2 μF, 50 V Chip Capacitors | C3225X7R1H225MT | TDK |
| R1, R2 | 10 Ω, 1/8 W Chip Resistors | CRCW120610R0FKEA | Vishay |
| R3, R4 | 1.5 Ω, 1/8 W Chip Resistors | CRCW12061R50FKEA | Vishay |

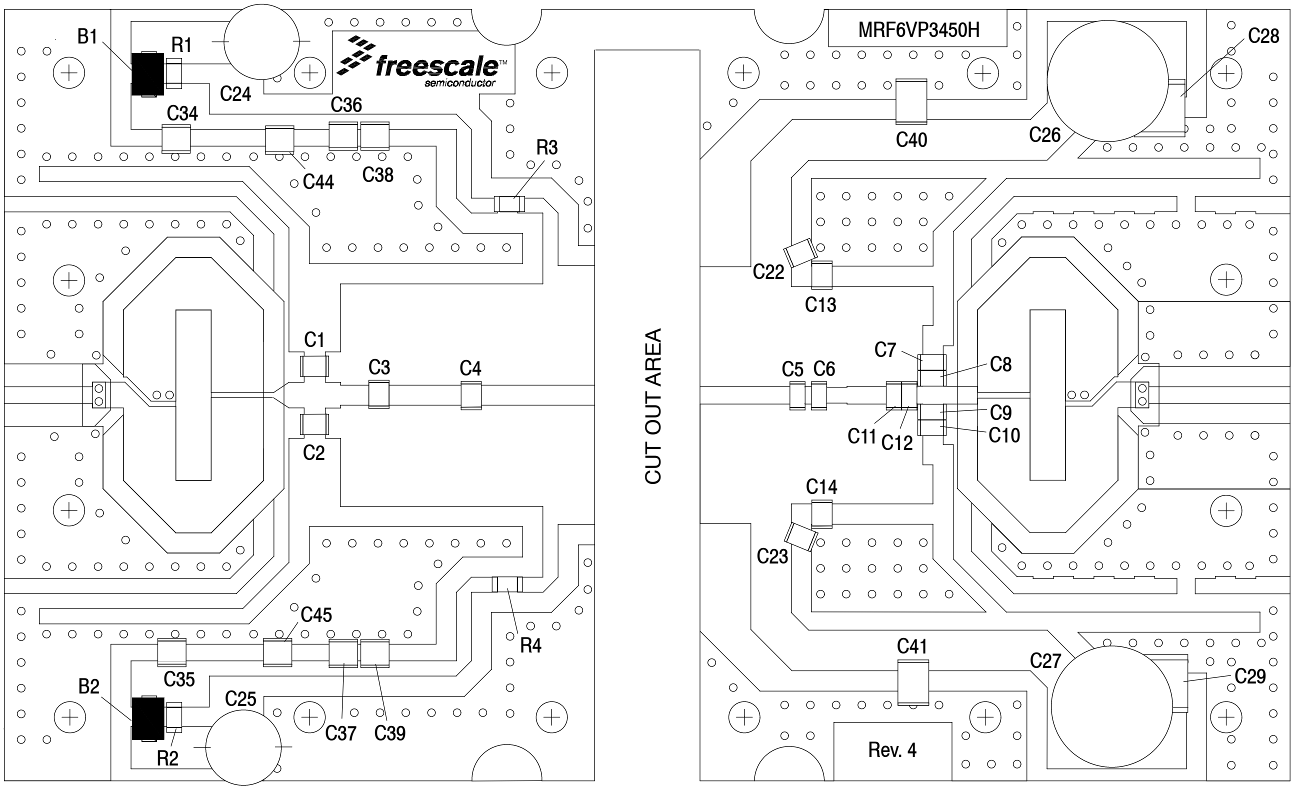



**Figure 3. MRF6VP3450HR6(HSR6) Test Circuit Component Layout — Top**

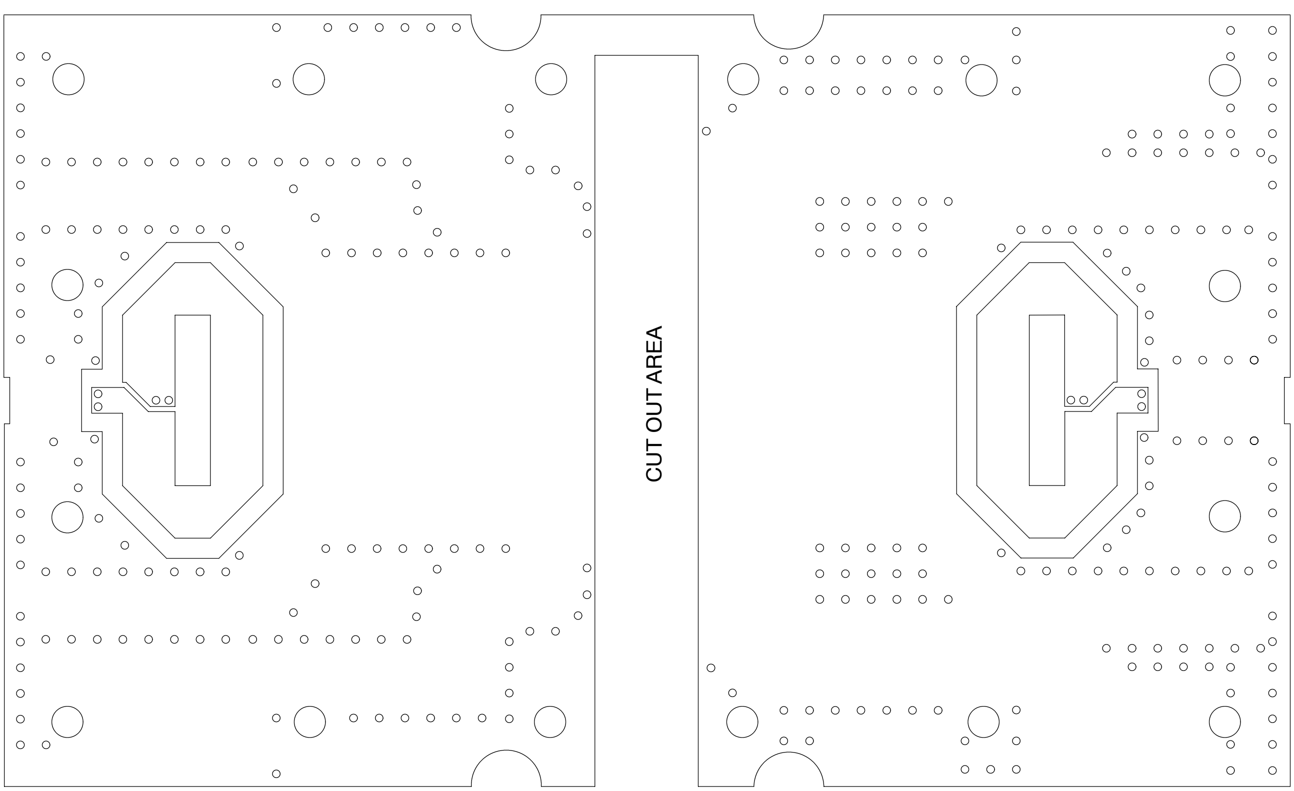
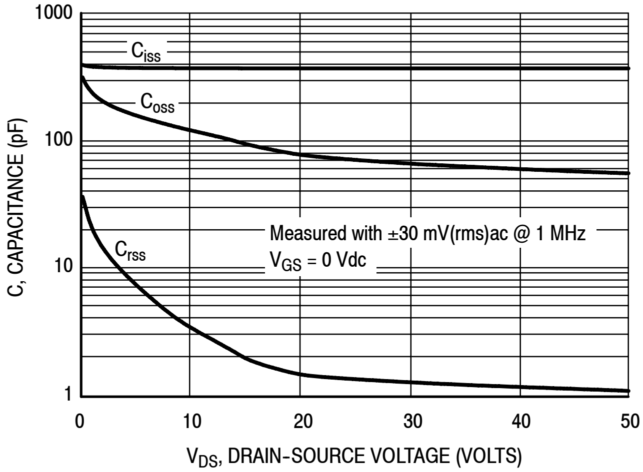
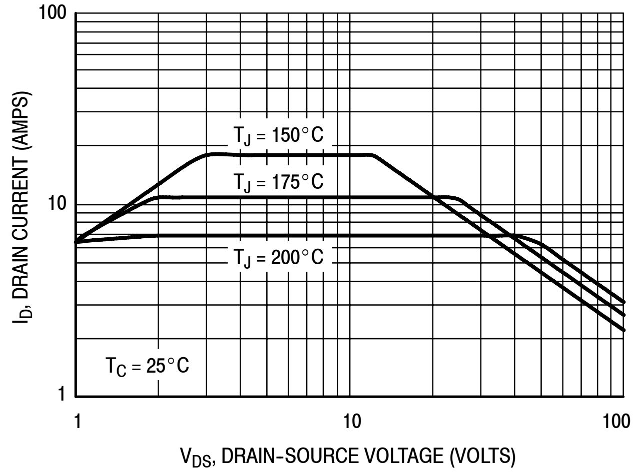



**Figure 3a. MRF6VP3450HR6(HSR6) Test Circuit Component Layout — Bottom**




**Note:** Each side of device measured separately.

**Figure 4. Capacitance versus Drain-Source Voltage**




**Note:** Each side of device measured separately.

**Figure 5. DC Safe Operating Area**

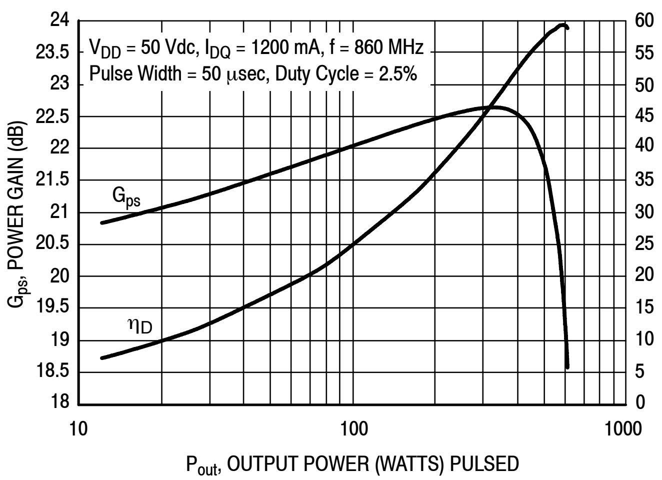



**Figure 6. Pulsed Power Gain and Drain Efficiency versus Output Power**

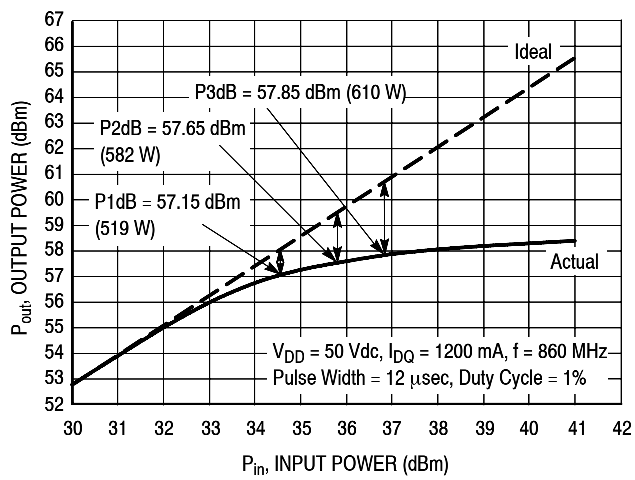



**Figure 7. Pulsed CW Output Power versus Input Power**

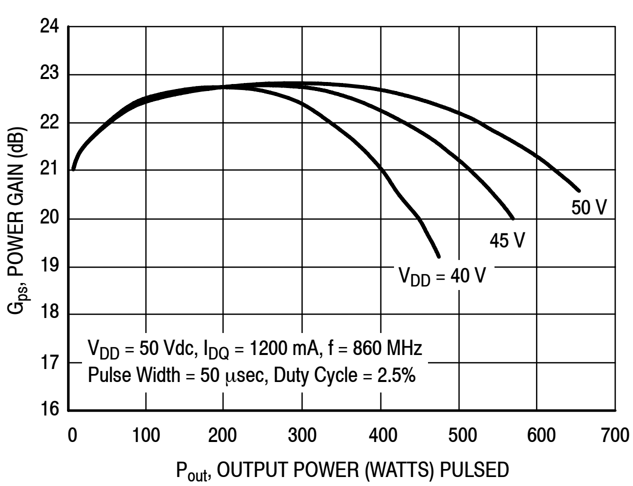



**Figure 8. Pulsed Power Gain versus Output Power**

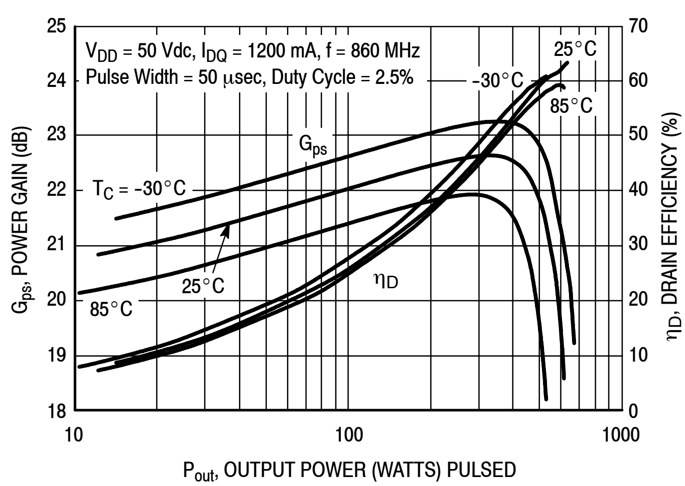



**Figure 9. Pulsed Power Gain and Drain Efficiency versus Output Power**

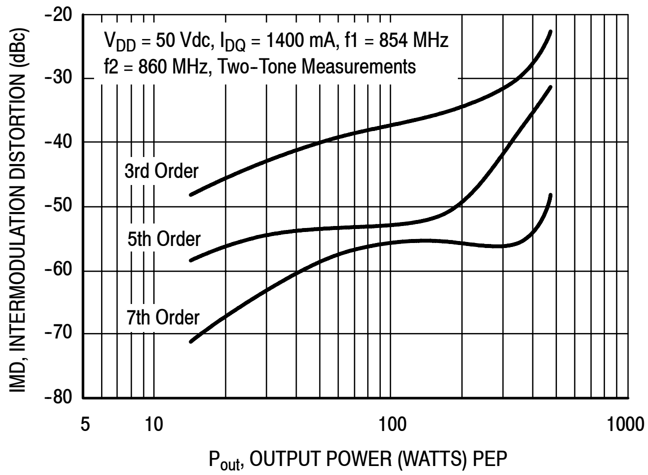



**Figure 10. Intermodulation Distortion Products versus Output Power**

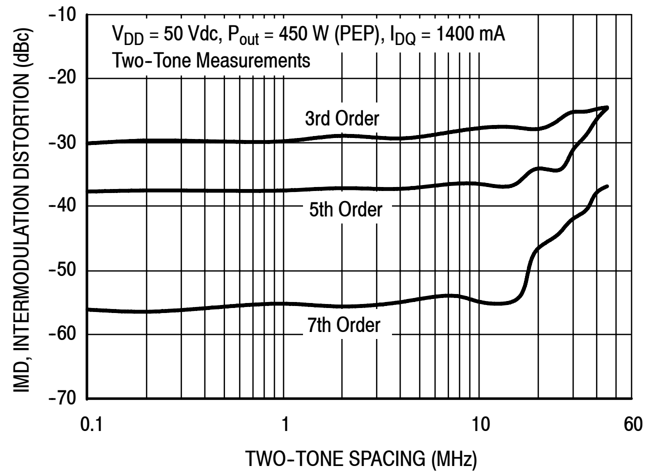



**Figure 11. Intermodulation Distortion Products versus Tone Spacing**

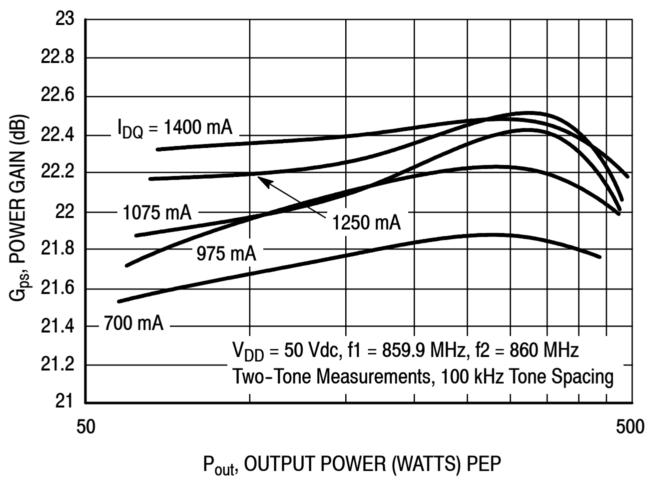



**Figure 12. Two-Tone Power Gain versus Output Power**

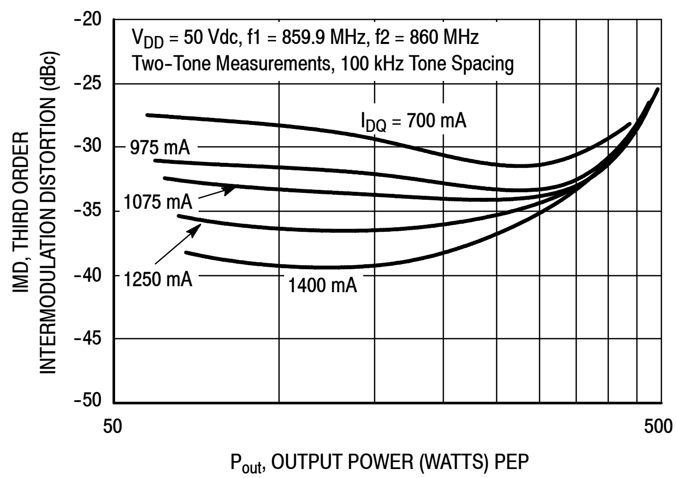



**Figure 13. Third Order Intermodulation Distortion versus Output Power**

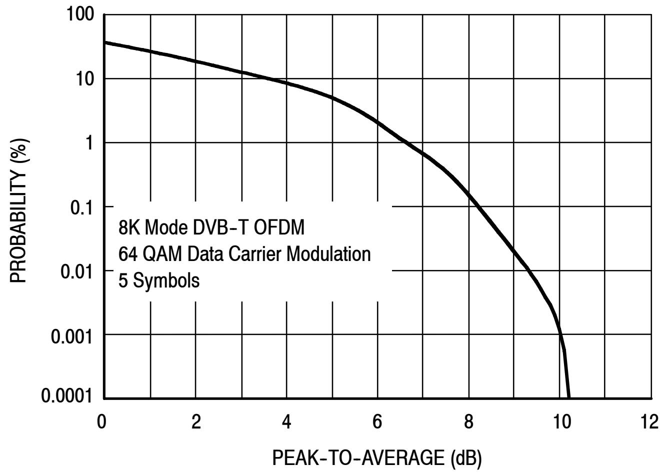



**Figure 14. Single-Carrier DVB-T OFDM**

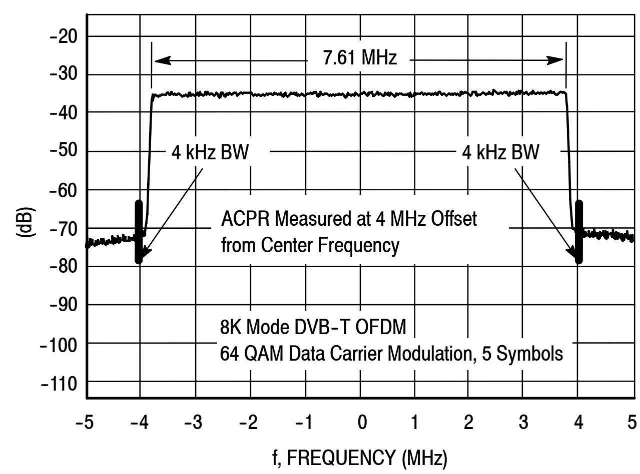



**Figure 15. 8K Mode DVB-T OFDM Spectrum**

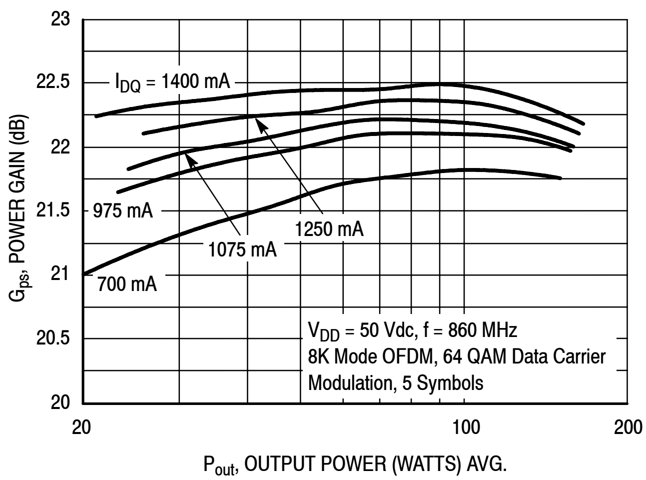



**Figure 16. Single-Carrier DVB-T OFDM Power Gain versus Output Power**

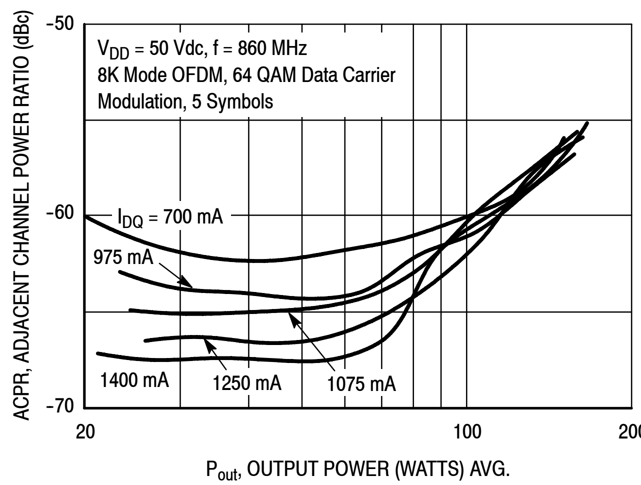



**Figure 17. Single-Carrier DVB-T OFDM ACPR versus Output Power**

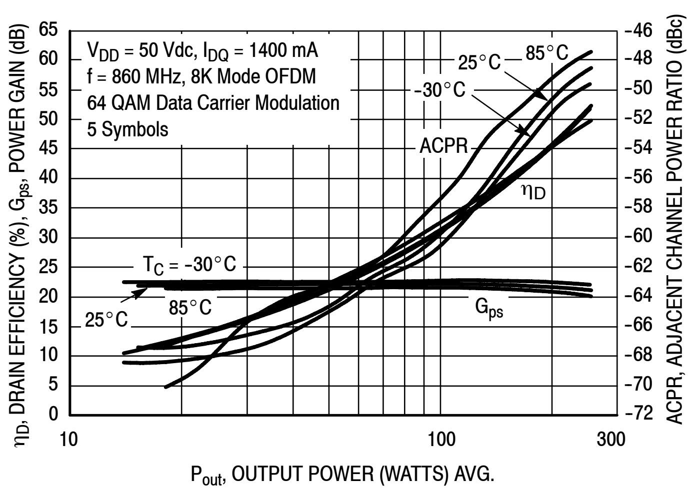



**Figure 18. Single-Carrier DVB-T OFDM ACPR Power Gain and Drain Efficiency versus Output Power**

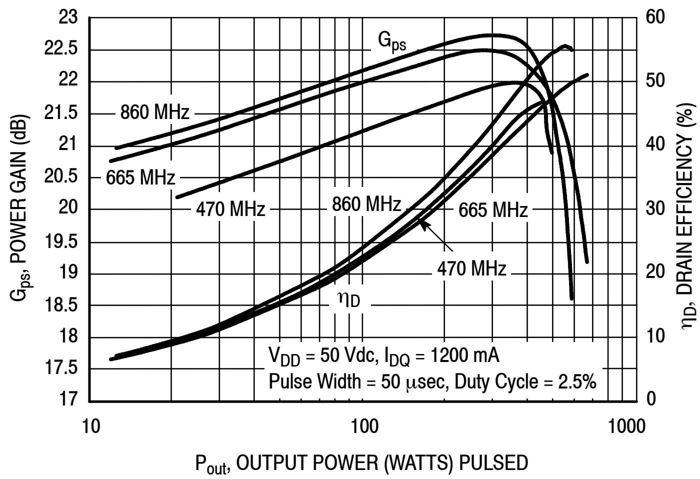



**Figure 19. Broadband Pulsed Power Gain and Drain Efficiency versus Output Power — 470-860 MHz**

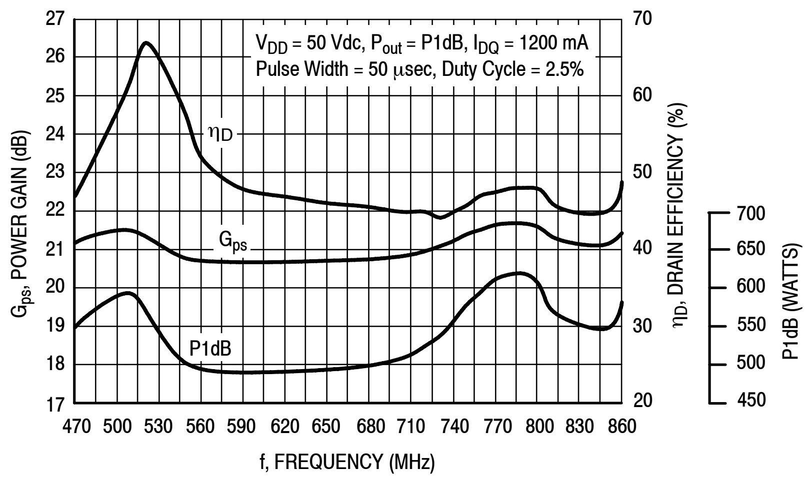



**Figure 20. Pulsed Power Gain and Drain Efficiency versus Frequency at P1dB — 470-860 MHz**

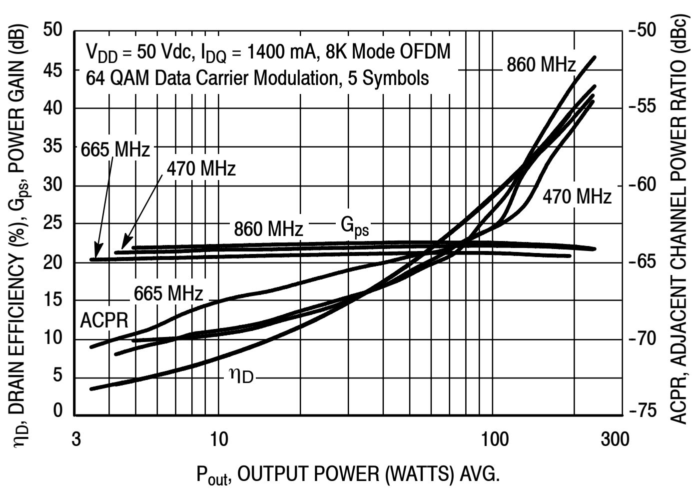



**Figure 21. Single-Carrier DVB-T OFDM ACPR, Power Gain and Drain Efficiency versus Output Power — 470-860 MHz**

## TYPICAL CHARACTERISTICS — 470-860 MHz

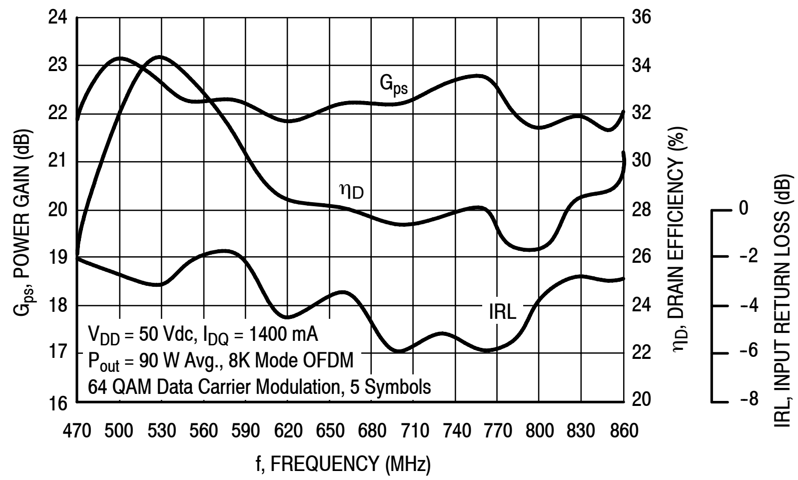
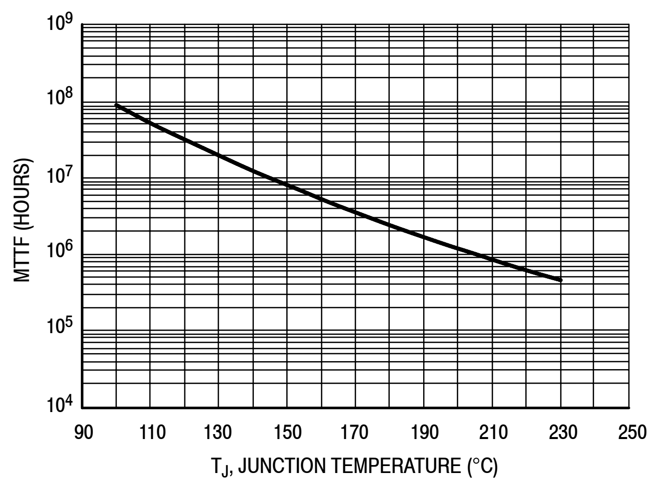



**Figure 22. Single-Carrier DVB-T OFDM Power Gain, Drain Efficiency and IRL versus Frequency — 470-860 MHz**

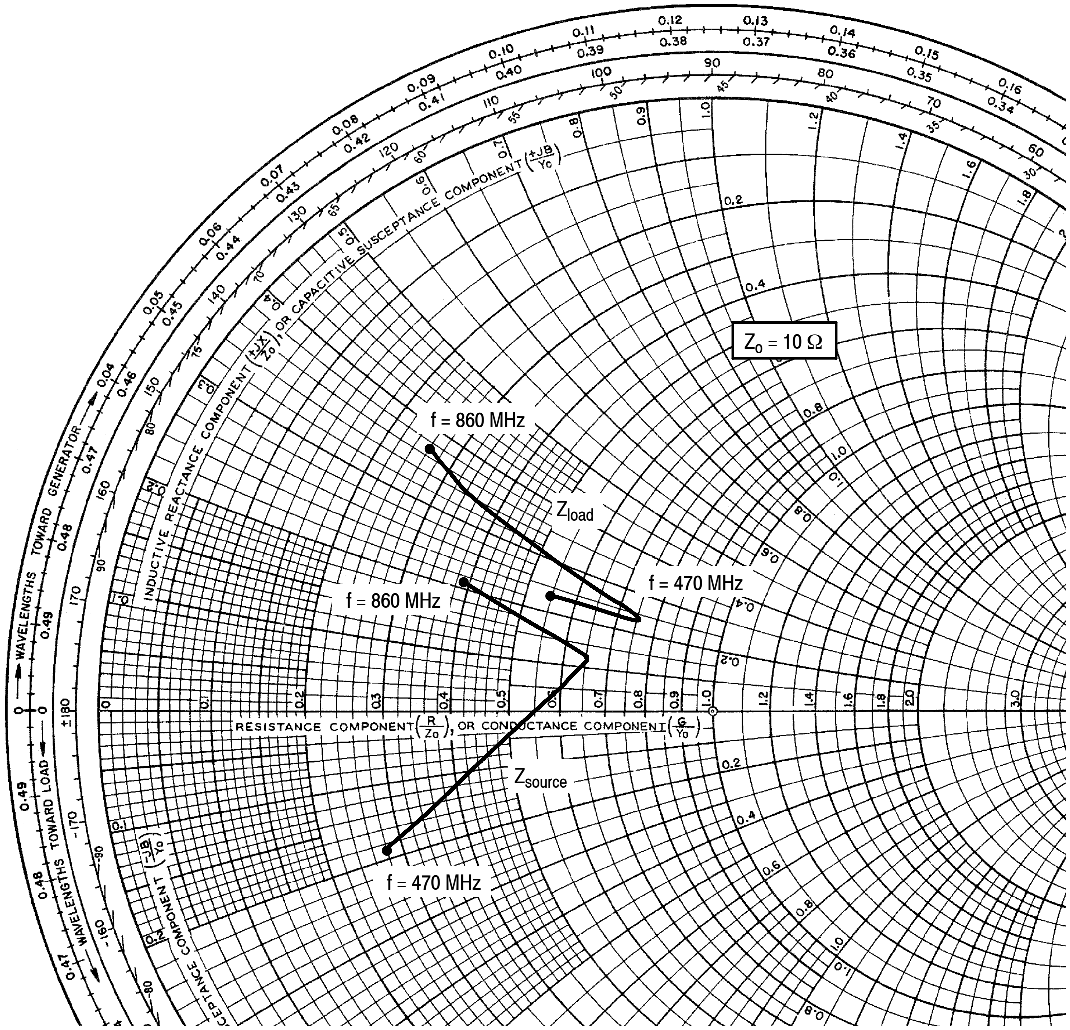
## TYPICAL CHARACTERISTICS




This above graph displays calculated MTTF in hours when the device is operated at $V_{DD}$ = 50 Vdc, $P_{out}$ = 90 W Avg., and $\eta_D$ = 28%.

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

**Figure 23. MTTF versus Junction Temperature**




$V_{DD}$ = 50 Vdc, $I_{DQ}$ = 1400 mA, $P_{out}$ = 90 W Avg.

| f MHz | $Z_{source}$ Ω | $Z_{load}$ Ω |
|---|---|---|
| 470 | 2.81 - j1.88 | 5.52 + j2.34 |
| 650 | 6.46 + j1.21 | 7.46 + j2.26 |
| 860 | 3.90 + j2.09 | 2.60 + j3.73 |

$Z_{source}$ = Test circuit impedance as measured from gate to gate, balanced configuration.

$Z_{load}$ = Test circuit impedance as measured from drain to drain, balanced configuration.

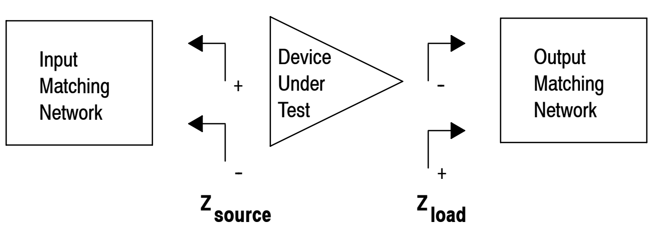
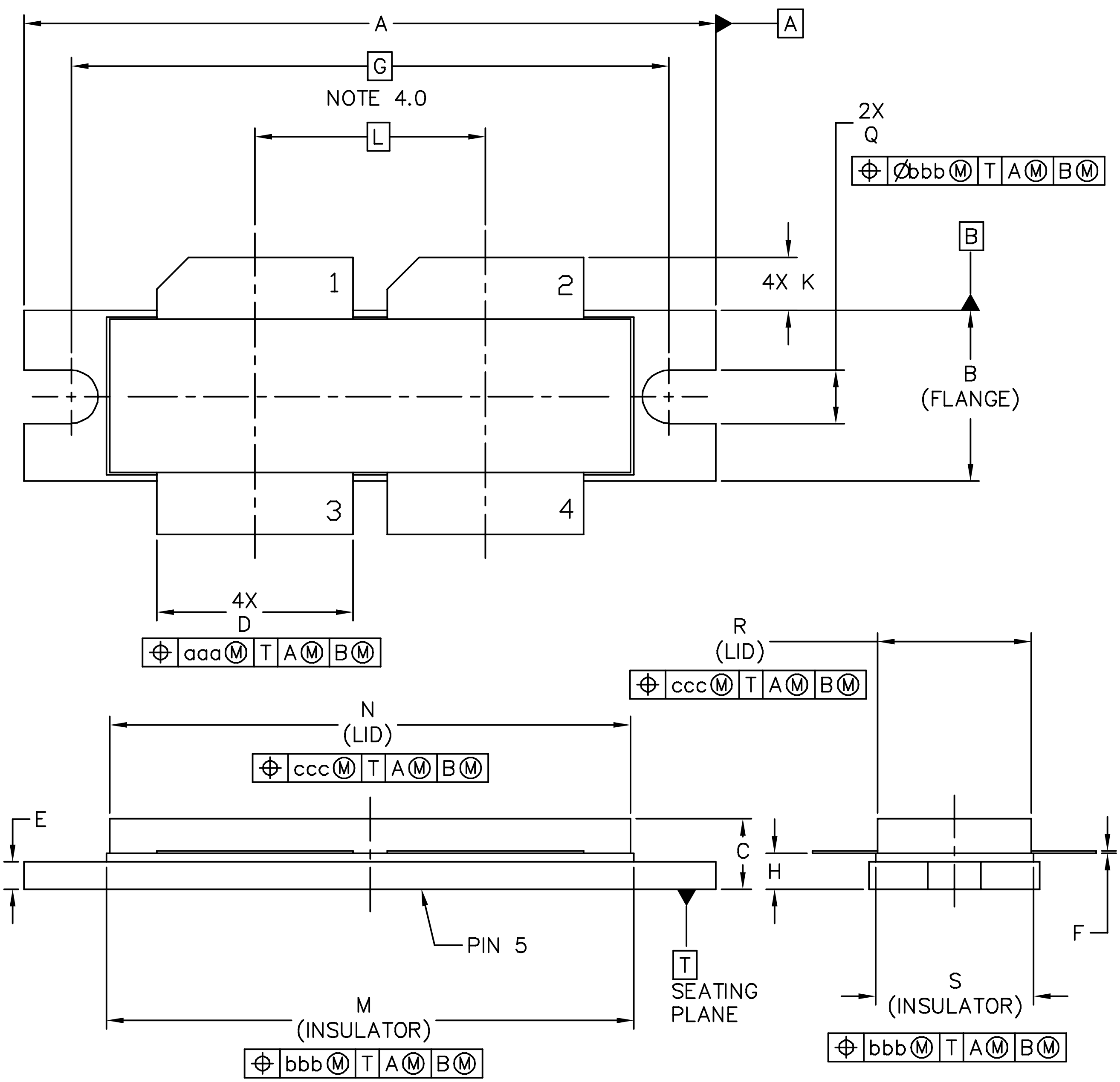



**Figure 24. Series Equivalent Source and Load Impedance**

## PACKAGE DIMENSIONS




| | | | |
|---|---|---|---|
| © FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED. | MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE | |
| TITLE: NI–1230 | DOCUMENT NO: 98ASB16977C | | REV: E |
| | CASE NUMBER: 375D–05 | | 31 MAR 2005 |
| | STANDARD: NON–JEDEC | | |

NOTES:

1.0 INTERPRET DIMENSIONS AND TOLERANCES
PER ASME 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
1.52 (38.61) BASED ON M3 SCREW.

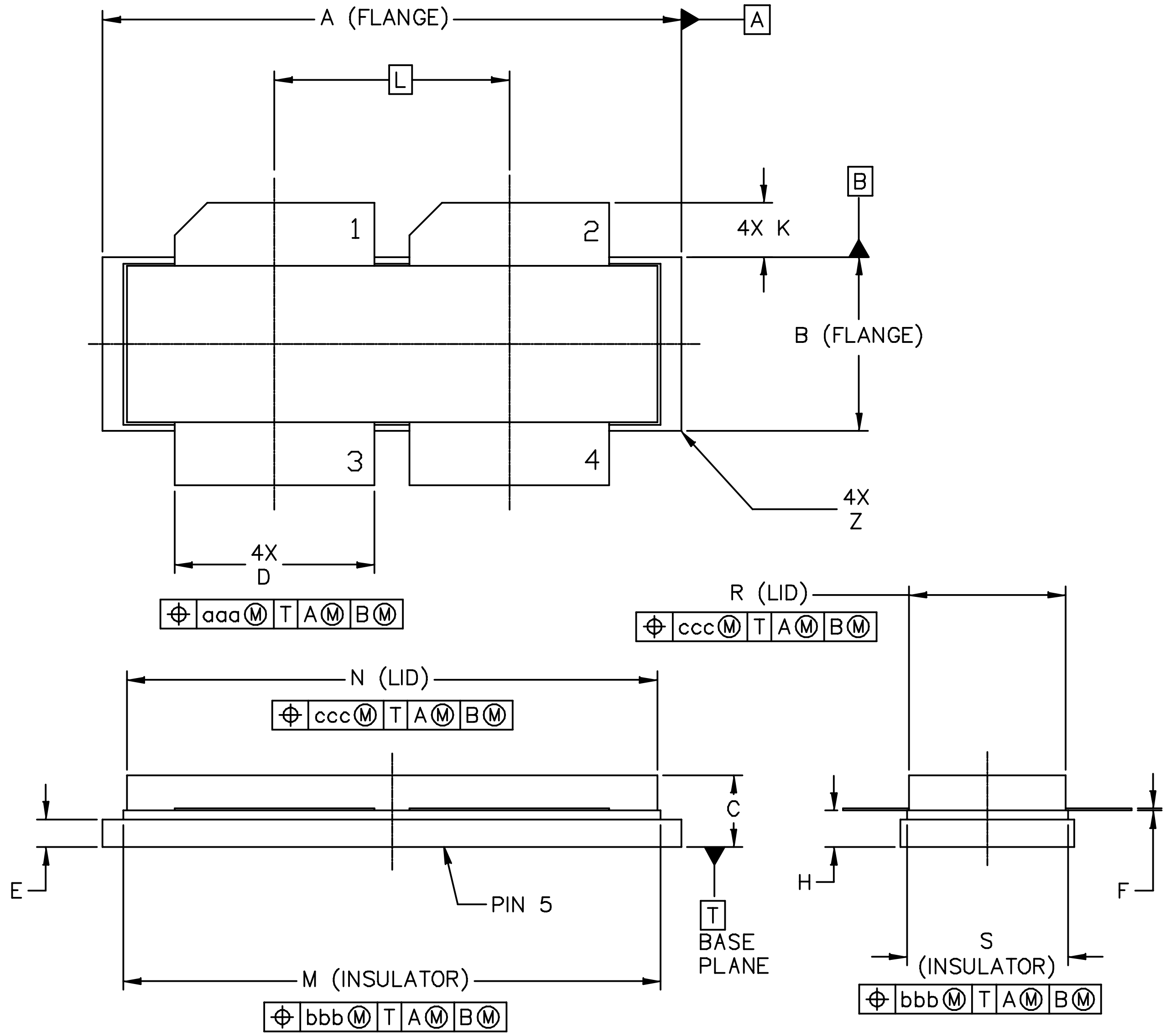
STYLE 1:
PIN 1 - DRAIN
2 - DRAIN
3 - GATE
4 - GATE
5 - SOURCE

| DIM | INCH | | MILLIMETER | | DIM | INCH | | MILLIMETER | |
|---|---|---|---|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | | MIN | MAX | MIN | MAX |
| A | 1.615 | 1.625 | 41.02 | 41.28 | N | 1.218 | 1.242 | 30.94 | 31.55 |
| B | .395 | .405 | 10.03 | 10.29 | Q | .120 | .130 | 3.05 | 3.3 |
| C | .150 | .200 | 3.81 | 5.08 | R | .355 | .365 | 9.01 | 9.27 |
| D | .455 | .465 | 11.56 | 11.81 | S | .365 | .375 | 9.27 | 9.53 |
| E | .062 | .066 | 1.57 | 1.68 | | | | | |
| F | .004 | .007 | 0.1 | 0.18 | | | | | |
| G | 1.400 BSC | | 35.56 BSC | | aaa | .013 | | 0.33 | |
| H | .082 | .090 | 2.08 | 2.29 | bbb | .010 | | 0.25 | |
| K | .117 | .137 | 2.97 | 3.48 | ccc | .020 | | 0.51 | |
| L | .540 BSC | | 13.72 BSC | | | | | | |
| M | 1.219 | 1.241 | 30.96 | 31.52 | | | | | |



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

| | | |
|---|---|---|
| TITLE: NI-1230 | DOCUMENT NO: 98ASB16977C | REV: E |
| | CASE NUMBER: 375D-05 | 31 MAR 2005 |
| | STANDARD: NON-JEDEC | |

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| TITLE: NI–1230S | DOCUMENT NO: 98ARB18247C | REV: F |
| | CASE NUMBER: 375E–04 | 05 AUG 2005 |
| | STANDARD: NON–JEDEC | |

NOTES:

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

2. CONTROLLING DIMENSION: INCH

3. DIMENSION H IS MEASURED .030 AWAY FROM PACKAGE BODY

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

| DIM | INCHES MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS MAX | DIM | INCHES MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | 1.265 | 1.275 | 32.13 | 32.38 | R | .355 | .365 | 9.01 | 9.27 |
| B | .395 | .405 | 10.03 | 10.29 | S | .365 | .375 | 9.27 | 9.53 |
| C | .150 | .200 | 3.81 | 5.08 | Z | --- | .040 | --- | 1.02 |
| D | .455 | .465 | 11.56 | 11.81 | | | | | |
| E | .062 | .066 | 1.57 | 1.68 | aaa | .013 | | 0.33 | |
| F | .004 | .007 | 0.1 | 0.18 | bbb | .010 | | 0.25 | |
| H | .082 | .090 | 2.08 | 2.29 | ccc | .020 | | 0.51 | |
| K | .117 | .137 | 2.97 | 3.48 | | | | | |
| L | .540 BSC | | 13.72 BSC | | | | | | |
| M | 1.219 | 1.241 | 30.96 | 31.52 | | | | | |
| N | 1.218 | 1.242 | 30.94 | 31.55 | | | | | |

| | | |
|---|---|---|
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| TITLE: NI–1230S | DOCUMENT NO: 98ARB18247C | REV: F |
| | CASE NUMBER: 375E–04 | 05 AUG 2005 |
| | STANDARD: NON–JEDEC | |

## PRODUCT DOCUMENTATION 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, 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 | July 2008 | • Initial Release of Data Sheet |
| 1 | Aug. 2008 | • Corrected component designation part number for C34, 35 in Table 5. Test Circuit Component Designation and Values, p. 5<br>• Added Note to Fig. 4, Capacitance versus Drain-Source Voltage and Fig. 5, DC Safe Operating Area to denote that each side of device is measured separately, p. 7<br>• Adjusted imaginary component signs in Fig. 24, Series Equivalent Source and Load Impedance data table and replotted data, p. 12 |
| 2 | Sept. 2008 | • Fig. 24, Series Equivalent Source and Load Impedance, corrected $Z_{source}$ copy to read ”Test circuit impedance as measured from gate to gate, balanced configuration” and $Z_{load}$ copy to read ”Test circuit impedance as measured from gate to gate, balanced configuration”, p. 12 |
| 2.1 | Nov. 2008 | • Corrected Fig. 24 Revision History $Z_{load}$ copy to read ”Test circuit impedance as measured from drain to drain, balanced configuration”, p. 12 |
| 3 | July 2009 | • Added capability of handling 10:1 VSWR @ 50 Vdc, 850 MHz, 450 Watts CW, p. 1<br>• Added thermal resistance at 450 W CW, Thermal Characteristics table, p. 2<br>• Corrected Fig. 23, MTTF versus Junction Temperature, to match values given by the MRF6VP3450H/HS MTTF calculator, p. 11<br>• Added Electromigration MTTF Calculator and RF High Power Model availability to Product Software, p. 17 |
| 4 | Apr. 2010 | • 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>• Reporting of pulsed thermal data now shown using the $Z_{\theta JC}$ symbol, p. 2<br>• Fig. 2, Test Circuit Schematic, Z-list, corrected Z4, Z5 from 1.400″ x 0.590″ Microstrip to 1.400″ x 0.059″ Microstrip, p. 4 |

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