RoHS

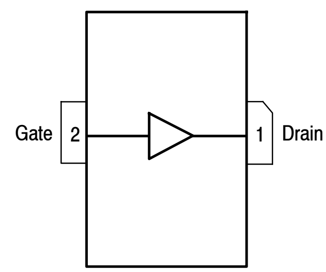
# RF Power LDMOS Transistor

## High Ruggedness N-Channel Enhancement-Mode Lateral MOSFET

**MRFX035H**

**1.8–512 MHz, 35 W CW, 65 V WIDEBAND RF POWER LDMOS TRANSISTOR**

**NI-360H-2SB**




(Top View)

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

**Figure 1. Pin Connections**

This high ruggedness device is designed for use in high VSWR industrial, medical, broadcast, aerospace and mobile radio applications. Its unmatched input and output design supports frequency use from 1.8 to 512 MHz.

**Typical Performance:** $V_{DD}$ = 65 Vdc

| Frequency (MHz) | Signal Type | $P_{out}$ (W) | $G_{ps}$ (dB) | $\eta_D$ (%) |
|---|---|---|---|---|
| 1.8–54 (1,2) | CW | 32 CW | 24.1 | 58.1 |
| 30–400 (2) | CW | 26 CW | 15.1 | 42.3 |
| 230 (3) | CW | 35 CW | 24.8 | 75.8 |

**Load Mismatch/Ruggedness**

| Frequency (MHz) | Signal Type | VSWR | $P_{in}$ (dBm) | Test Voltage | Result |
|---|---|---|---|---|---|
| 230 (3) | CW | > 65:1 at all Phase Angles | 23.5 (3 dB Overdrive) | 65 | No Device Degradation |

1. Measured in 1.8–54 MHz broadband reference circuit (page 5).
2. The values shown are the minimum measured performance numbers across the indicated frequency range.
3. Measured in 230 MHz production test fixture (page 10).

### Features

- Unmatched input and output allowing wide frequency range utilization
- 50 ohm native output impedance
- Qualified up to a maximum of 65 $V_{DD}$ operation
- Characterized from 30 to 65 V for extended power range
- High breakdown voltage for enhanced reliability
- Suitable for linear application with appropriate biasing
- Integrated ESD protection with greater negative gate-source voltage range for improved Class C operation
- Included in NXP product longevity program with assured supply for a minimum of 15 years after launch

### Typical Applications

- Industrial, scientific, medical (ISM)
  - Laser generation
  - Plasma generation
  - Particle accelerators
  - MRI, RF ablation and skin treatment
  - Industrial heating, welding and drying systems
- Radio and VHF TV broadcast
- Aerospace
  - HF communications
  - Radar
- Mobile radio
  - HF and VHF communications
  - PMR base stations

**Table 1. Maximum Ratings**

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | –0.5, +179 | Vdc |
| Gate-Source Voltage | $V_{GS}$ | –6.0, +10 | Vdc |
| Storage Temperature Range | $T_{stg}$ | –65 to +150 | °C |
| Case Operating Temperature Range | $T_C$ | –40 to +150 | °C |
| Operating Junction Temperature Range (1,2) | $T_J$ | –40 to +225 | °C |
| Total Device Dissipation @ $T_C$ = 25°C<br>Derate above 25°C | $P_D$ | 154<br>0.769 | W<br>W/°C |

**Table 2. Thermal Characteristics**

| Characteristic | Symbol | Value (2,3) | Unit |
|---|---|---|---|
| Thermal Resistance, Junction to Case<br>CW: Case Temperature 74.2°C, 35 W CW, 65 Vdc, $I_{DQ}$ = 15 mA, 230 MHz | $R_{\theta JC}$ | 1.3 | °C/W |

**Table 3. ESD Protection Characteristics**

| Test Methodology | Class |
|---|---|
| Human Body Model (per JS-001-2017) | 2, passes 2500 V |
| Charge Device Model (per JS-002-2014) | C3, passes 1200 V |

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Off Characteristics** | | | | | |
| Gate-Source Leakage Current<br>($V_{GS}$ = 5 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSS}$ | — | — | 400 | nAdc |
| Drain-Source Breakdown Voltage<br>($V_{GS}$ = 0 Vdc, $I_D$ = 250 μAdc) | $V_{(BR)DSS}$ | 179 | 193 | — | Vdc |
| Zero Gate Voltage Drain Leakage Current<br>($V_{DS}$ = 65 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 10 | μAdc |
| Zero Gate Voltage Drain Leakage Current<br>($V_{DS}$ = 179 Vdc, $V_{GS}$ = 0 Vdc) | $I_{DSS}$ | — | — | 300 | μAdc |
| **On Characteristics** | | | | | |
| Gate Threshold Voltage<br>($V_{DS}$ = 10 Vdc, $I_D$ = 640 μAdc) | $V_{GS(th)}$ | 1.7 | 2.75 | 3.0 | Vdc |
| Gate Quiescent Voltage<br>($V_{DD}$ = 65 Vdc, $I_D$ = 15 mAdc, Measured in Functional Test) | $V_{GS(Q)}$ | 2.5 | 3.0 | 3.5 | Vdc |
| Drain-Source On-Voltage<br>($V_{GS}$ = 10 Vdc, $I_D$ = 100 mAdc) | $V_{DS(on)}$ | — | 0.17 | — | Vdc |
| **Dynamic Characteristics** | | | | | |
| Reverse Transfer Capacitance<br>($V_{DS}$ = 65 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{rss}$ | — | 0.13 | — | pF |
| Output Capacitance<br>($V_{DS}$ = 65 Vdc ± 30 mV(rms)ac @ 1 MHz, $V_{GS}$ = 0 Vdc) | $C_{oss}$ | — | 13.7 | — | pF |
| Input Capacitance<br>($V_{DS}$ = 65 Vdc, $V_{GS}$ = 0 Vdc ± 30 mV(rms)ac @ 1 MHz) | $C_{iss}$ | — | 42.8 | — | 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.

(continued)

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **Functional Tests** (In NXP Production Test Fixture, 50 ohm system) $V_{DD}$ = 65 Vdc, $I_{DQ}$ = 15 mA, $P_{out}$ = 35 W CW, f = 230 MHz | | | | | |
| Power Gain | $G_{ps}$ | 23.5 | 24.8 | 26.5 | dB |
| Drain Efficiency | $\eta_D$ | 72.0 | 75.8 | — | % |
| Input Return Loss | IRL | — | –16 | –11 | dB |

**Load Mismatch/Ruggedness** (In NXP Production Test Fixture, 50 ohm system) $I_{DQ}$ = 15 mA

| Frequency (MHz) | Signal Type | VSWR | $P_{in}$ (dBm) | Test Voltage, $V_{DD}$ | Result |
|---|---|---|---|---|---|
| 230 | CW | > 65:1 at all Phase Angles | 23.5 (3 dB Overdrive) | 65 | No Device Degradation |

**Table 5. Ordering Information**

| Device | Tape and Reel Information | Package |
|---|---|---|
| MRFX035HR5 | R5 Suffix = 50 Units, 32 mm Tape Width, 13-inch Reel | NI-360H-2SB |

## TYPICAL CHARACTERISTICS

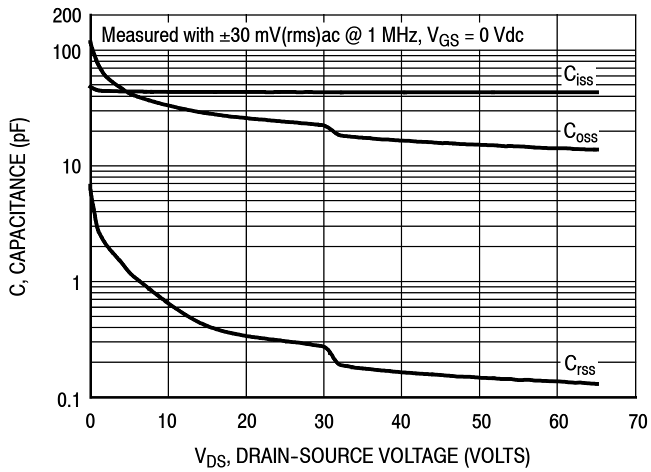
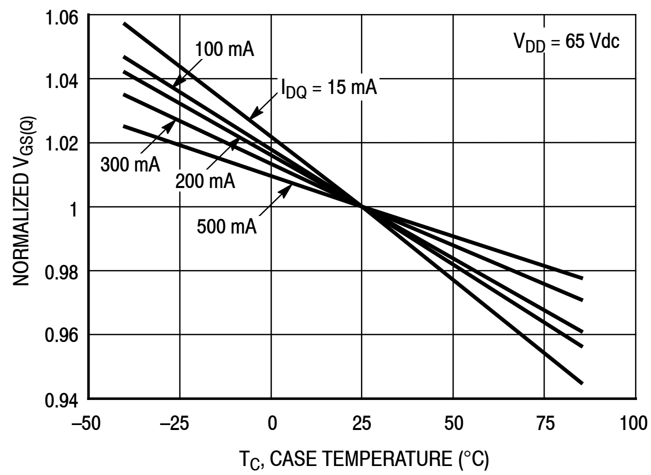
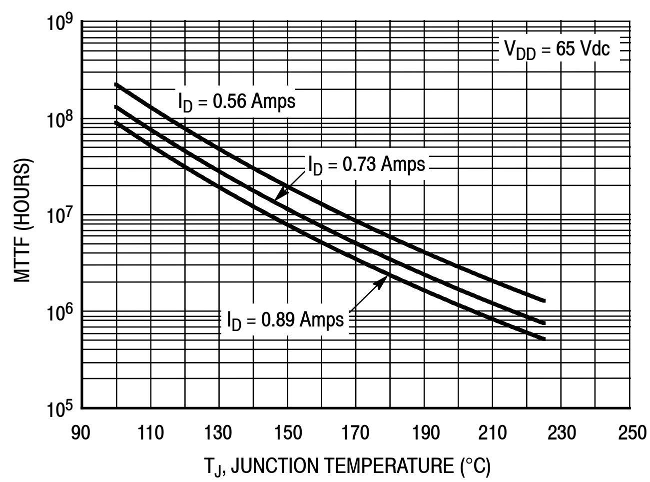



**Figure 2. Capacitance versus Drain-Source Voltage**




| $I_{DQ}$ (mA) | Slope (mV/°C) |
|---|---|
| 15 | –2.88 |
| 100 | –2.32 |
| 200 | –2.16 |
| 300 | –1.76 |
| 500 | –1.36 |

**Figure 3. Normalized $V_{GS}$ versus Quiescent Current and Case Temperature**




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

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

**Figure 4. MTTF versus Junction Temperature — CW**

## 1.8–54 MHz BROADBAND REFERENCE CIRCUIT — 2.0″ × 3.0″ (5.1 cm × 7.6 cm)

**Table 6. 1.8–54 MHz HF Broadband Performance** (In NXP Reference Circuit, 50 ohm system)
$V_{DD}$ = 65 Vdc, $I_{DQ}$ = 25 mA, $P_{in}$ = 22 dBm, CW

| Frequency (MHz) | $P_{out}$ (W) | $G_{ps}$ (dB) | $\eta_D$ (%) |
|---|---|---|---|
| 1.8 | 39 | 24.9 | 65.7 |
| 7.2 | 42 | 25.2 | 69.3 |
| 14.2 | 43 | 25.3 | 70.3 |
| 54 | 32 | 24.1 | 58.1 |

## 1.8–54 MHz BROADBAND REFERENCE CIRCUIT — 2.0″ × 3.0″ (5.1 cm × 7.6 cm)

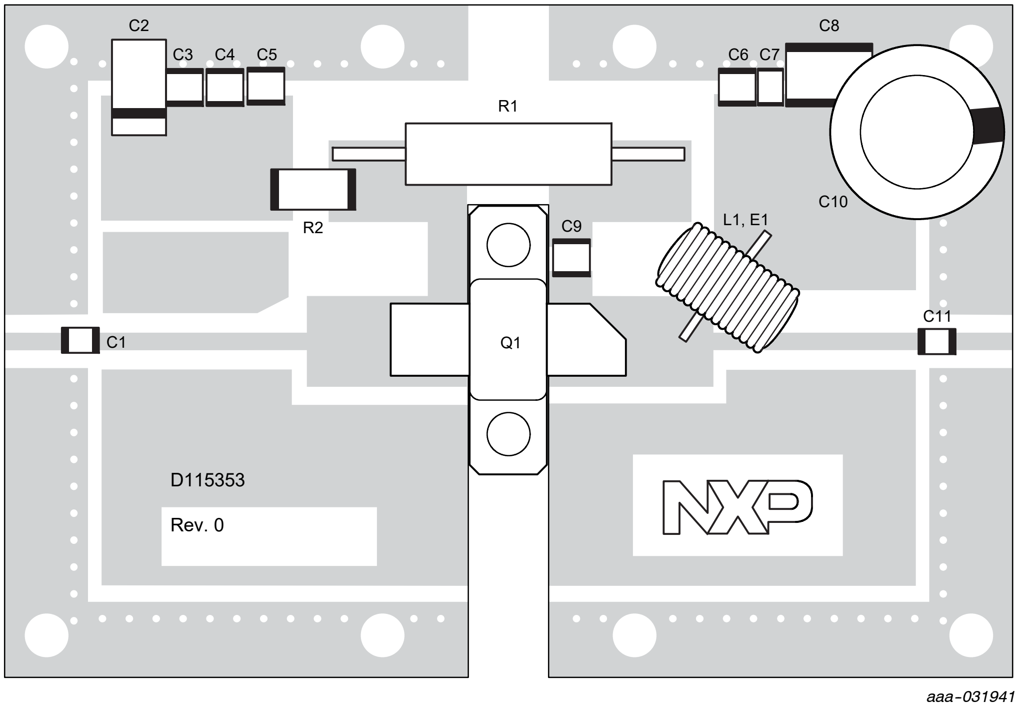



**Figure 5. MRFX035H Broadband Reference Circuit Component Layout — 1.8–54 MHz**

**Table 7. MRFX035H Broadband Reference Circuit Component Designations and Values — 1.8–54 MHz**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| C1, C5, C6, C9, C11 | 22 nF Chip Capacitor | C3216NP02A223J160AA | TDK |
| C2 | 10 μF, 35 V Tantalum Capacitor | T491D106K035AT | Kemet |
| C3 | 0.1 μF Chip Capacitor | C1206C104K1RACTU | Kemet |
| C4 | 2.2 μF Chip Capacitor | C3225X7R1H225K | TDK |
| C7 | 0.1 μF Chip Capacitor | C3216C0G2A104J160AE | TDK |
| C8 | 2.2 μF Chip Capacitor | G2225X7R225KT3AB | ATC |
| C10 | 220 μF, 100 V Electrolytic Capacitor | MCGPR100V227M16X26 | Multicomp |
| E1 | 61 Ferrite Toroid | 5961001101 | Fair-Rite |
| L1 | 26 Turns, 23 AWG, Toroid Transformer with Ferrite E1 | MW0454 Copper Magnet Wire | Temco |
| Q1 | RF Power LDMOS Transistor | MRFX035H | NXP |
| R1 | 1 kΩ, 3 W Axial Leaded Resistor | CPF31K0000FKE14 | Vishay |
| R2 | 330 Ω, 1 W Chip Resistor | RMCF2512JT330R | Stackpole Electronics |
| PCB | FR4 0.30″, $\varepsilon_r$ = 4.8, 1 oz. Copper | D115353 | MTL |

## TYPICAL CHARACTERISTICS — 1.8–54 MHz BROADBAND REFERENCE CIRCUIT

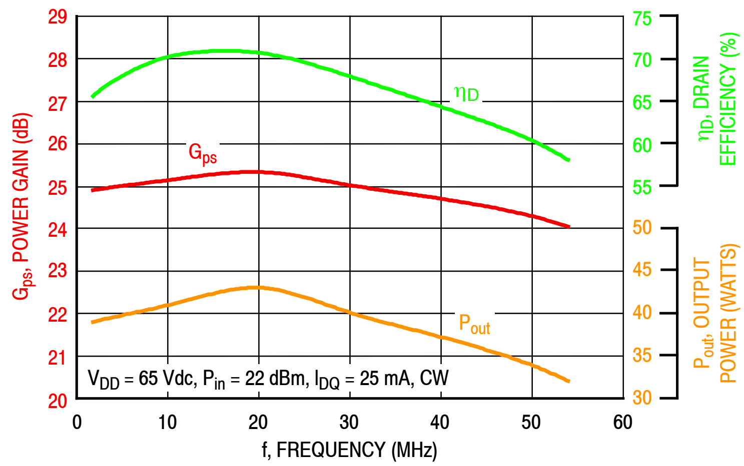



**Figure 6. Power Gain, Drain Efficiency and CW Output Power versus Frequency at a Constant Input Power**

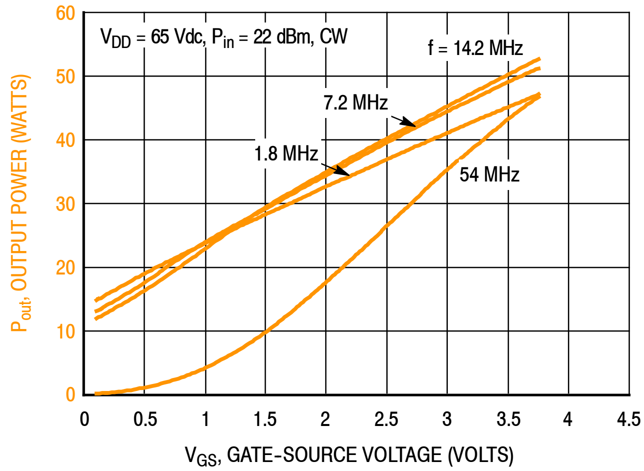
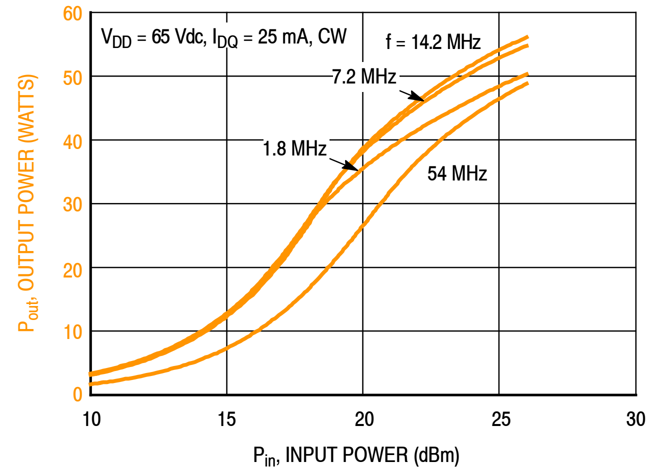



**Figure 7. CW Output Power versus Gate-Source Voltage at a Constant Input Power**




| f (MHz) | P1dB (W) | P3dB (W) |
|---|---|---|
| 1.8 | 36.4 | 44.6 |
| 7.2 | 43.7 | 51.3 |
| 14.2 | 44.5 | 52.4 |
| 54 | 38.7 | 47.7 |

**Figure 8. CW Output Power versus Input Power**

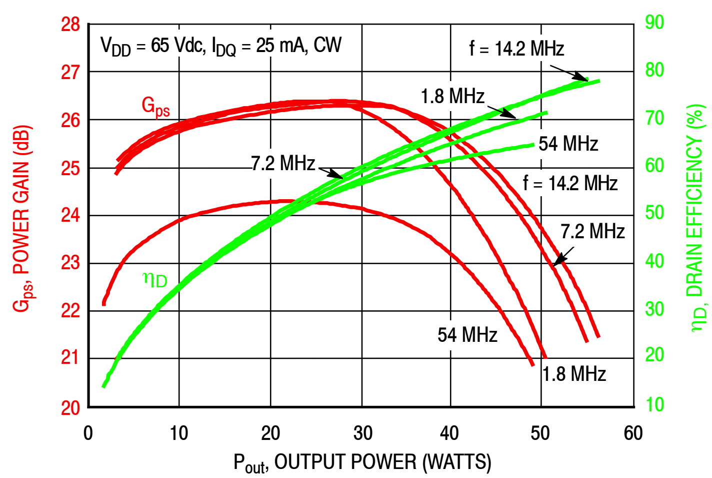



**Figure 9. Power Gain and Drain Efficiency versus CW Output Power and Frequency**

## TYPICAL CHARACTERISTICS — 1.8–54 MHz BROADBAND REFERENCE CIRCUIT — TWO-TONE [1]

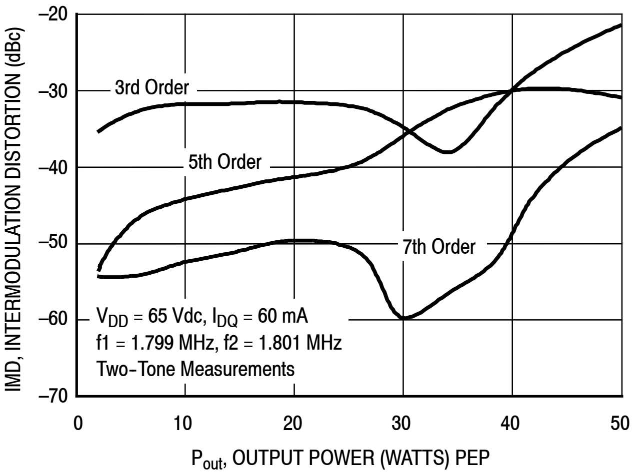



**Figure 10. Intermodulation Distortion Products versus Output Power — 1.8 MHz**

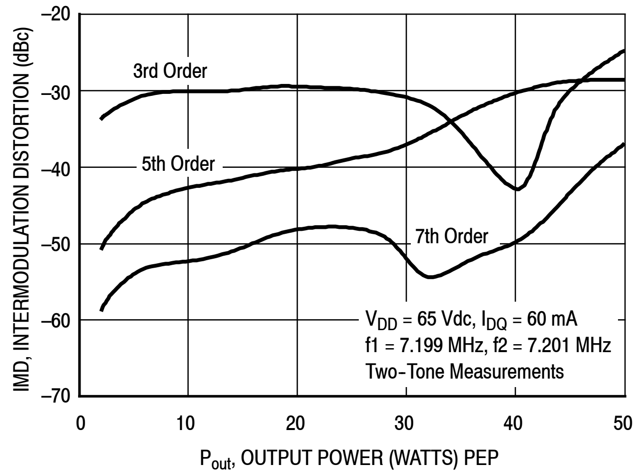



**Figure 11. Intermodulation Distortion Products versus Output Power — 7.2 MHz**

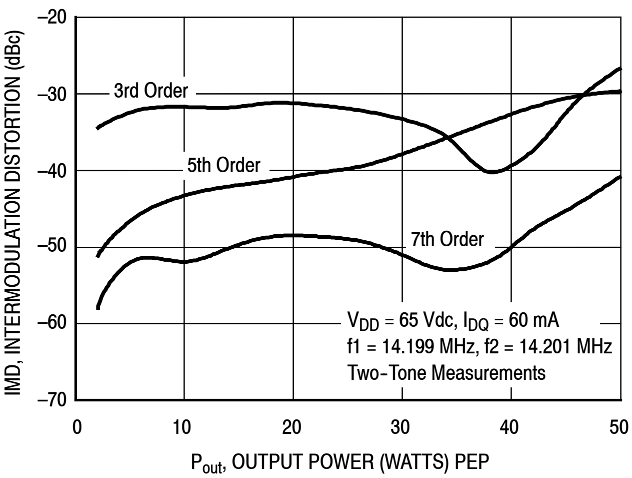



**Figure 12. Intermodulation Distortion Products versus Output Power — 14.2 MHz**

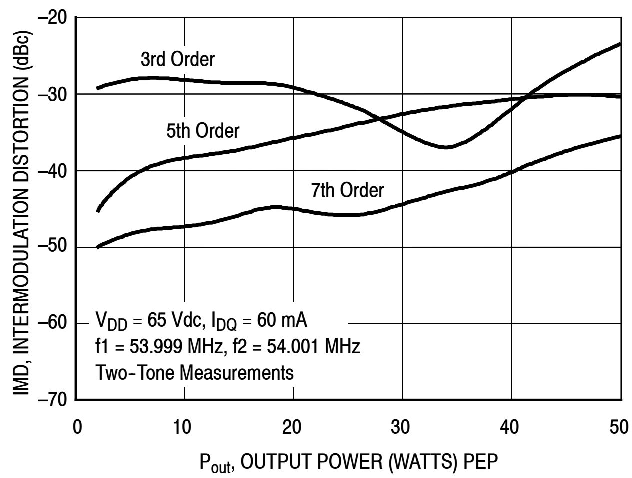



**Figure 13. Intermodulation Distortion Products versus Output Power — 54 MHz**

1. The distortion products are referenced to one of the two tones and the peak envelope power (PEP) is 6 dB above the power in a single tone.

## 1.8–54 MHz BROADBAND REFERENCE CIRCUIT

| f<br>MHz | $Z_{source}$<br>Ω | $Z_{load}$<br>Ω |
|---|---|---|
| 1.8 | 42.6 – j2.98 | 48.8 + j0.18 |
| 7.2 | 42.5 – j1.78 | 48.5 – j1.37 |
| 14.2 | 42.4 – j2.46 | 48.3 – j2.80 |
| 54 | 41.3 – j8.14 | 46.5 – j10.59 |

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

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

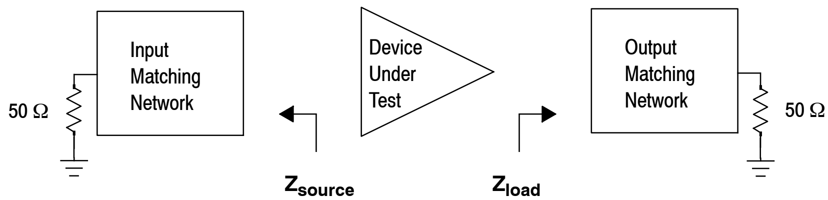



**Figure 14. Broadband Series Equivalent Source and Load Impedance — 1.8–54 MHz**

## 230 MHz PRODUCTION TEST FIXTURE — 3.0″ × 5.0″ (7.6 cm × 12.7 cm)

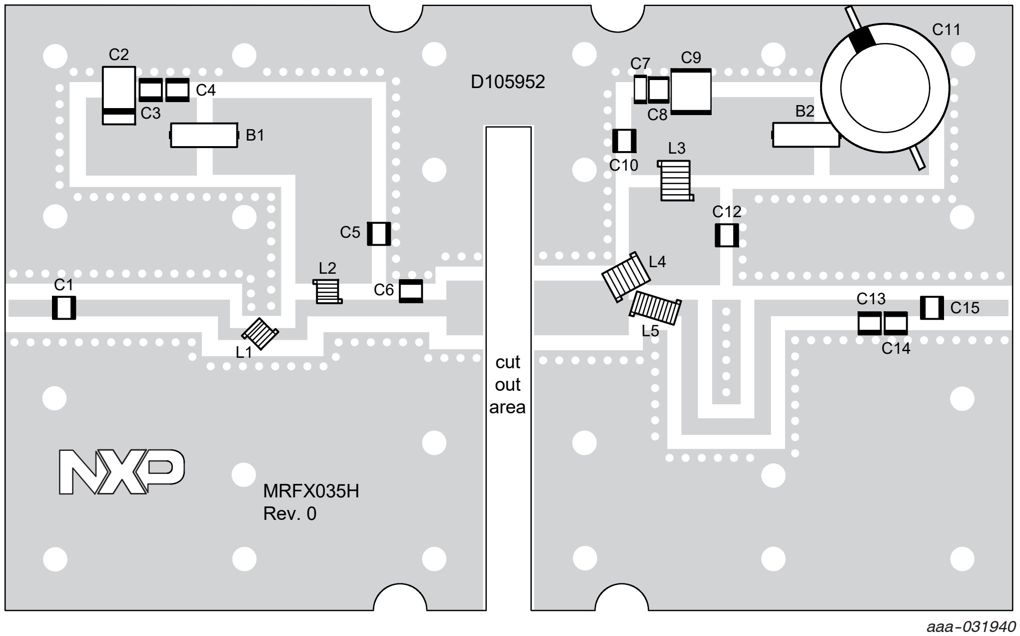



**Figure 15. MRFX035H Production Test Fixture Component Layout — 230 MHz**

**Table 8. MRFX035H Production Test Fixture Component Designations and Values — 230 MHz**

| Part | Description | Part Number | Manufacturer |
|---|---|---|---|
| B1, B2 | Long RF Bead | 2743021447 | Fair-Rite |
| C1 | 15 pF Chip Capacitor | ATC100B150JT500XT | ATC |
| C2 | 22 μF, 35 V Tantalum Capacitor | T491X226K035AT | Kemet |
| C3 | 2.2 μF Chip Capacitor | C3225X7R1H225K250AB | TDK |
| C4 | 0.1 μF Chip Capacitor | CDR33BX104AKWS | AVX |
| C5, C10, C12, C15 | 1000 pF Chip Capacitor | ATC100B102JT50XT | ATC |
| C6 | 5.1 pF Chip Capacitor | ATC100B5R1CT500XT | ATC |
| C7 | 0.1 μF Chip Capacitor | C1206C104K1RACTU | Kemet |
| C8 | 1 μF Chip Capacitor | C3225JB2A105K200AA | TDK |
| C9 | 15 μF Chip Capacitor | C5750X7S2A156M230KB | TDK |
| C11 | 470 μF, 100 V Electrolytic Capacitor | MCGPR100V477M16X32 | Multicomp |
| C13, C14 | 5.6 pF Chip Capacitor | ATC100B5R6C500XT | ATC |
| L1 | 5.0 nH, 2 Turn Inductor | A02TJLC | Coilcraft |
| L2 | 8.0 nH, 3 Turn Inductor | A03TJLC | Coilcraft |
| L3 | 120 nH Inductor | 1812SMS-R12JLC | Coilcraft |
| L4 | 100 nH Inductor | 1812SMS-R10JLC | Coilcraft |
| L5 | 28 nH, 8 Turn Inductor | B08TJLC | Coilcraft |
| PCB | Rogers AD255C, 0.030″, $\varepsilon_r$ = 2.55, 1 oz. Copper | D105952 | MTL |

## TYPICAL CHARACTERISTICS — 230 MHz, $T_C$ = 25°C
## PRODUCTION TEST FIXTURE

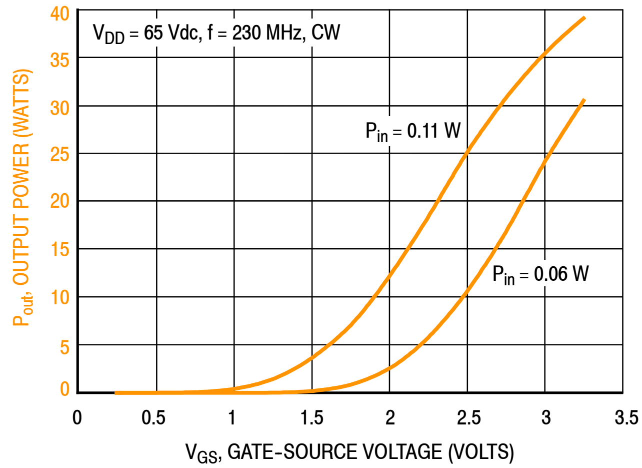
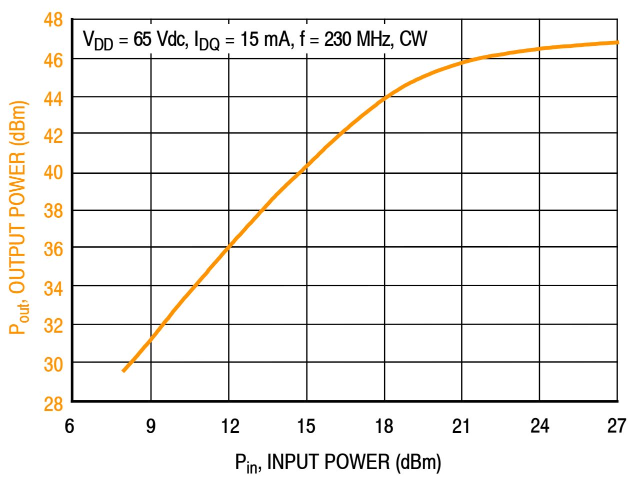



**Figure 16. Output Power versus Gate-Source Voltage at a Constant Input Power**




| f (MHz) | P1dB (W) | P3dB (W) |
|---|---|---|
| 230 | 37 | 43 |

**Figure 17. Output Power versus Input Power**

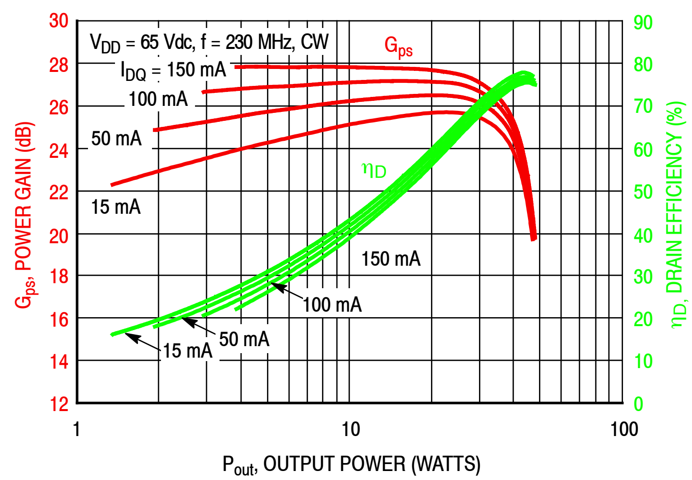



**Figure 18. Power Gain and Drain Efficiency versus Output Power and Quiescent Current**

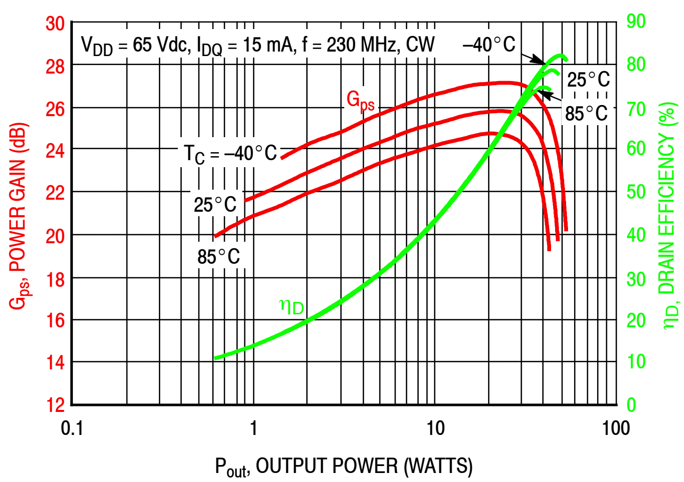



**Figure 19. Power Gain and Drain Efficiency versus Output Power**

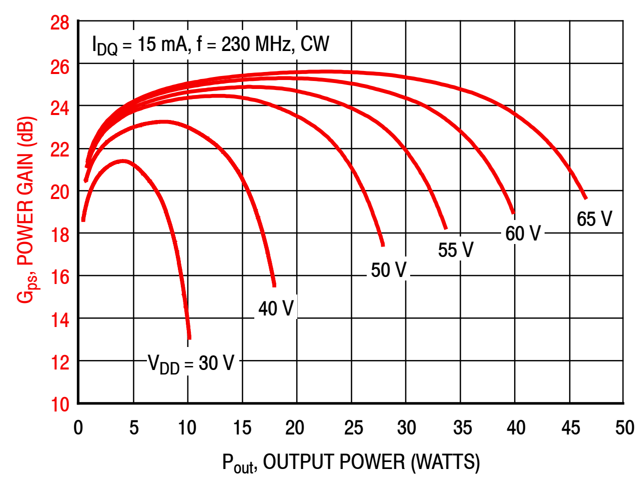



**Figure 20. Power Gain versus Output Power and Drain-Source Voltage**

## 230 MHz PRODUCTION TEST FIXTURE

| f<br>MHz | $Z_{source}$<br>Ω | $Z_{load}$<br>Ω |
|---|---|---|
| 230 | 3.1 + j27.0 | 16.2 + j39.5 |

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

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

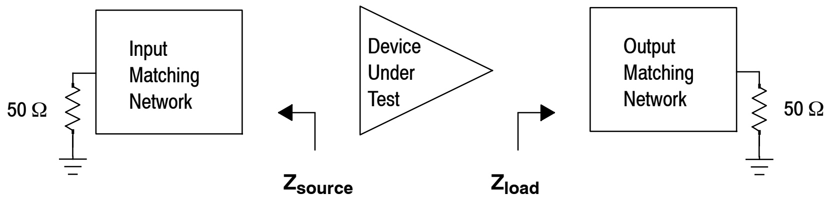
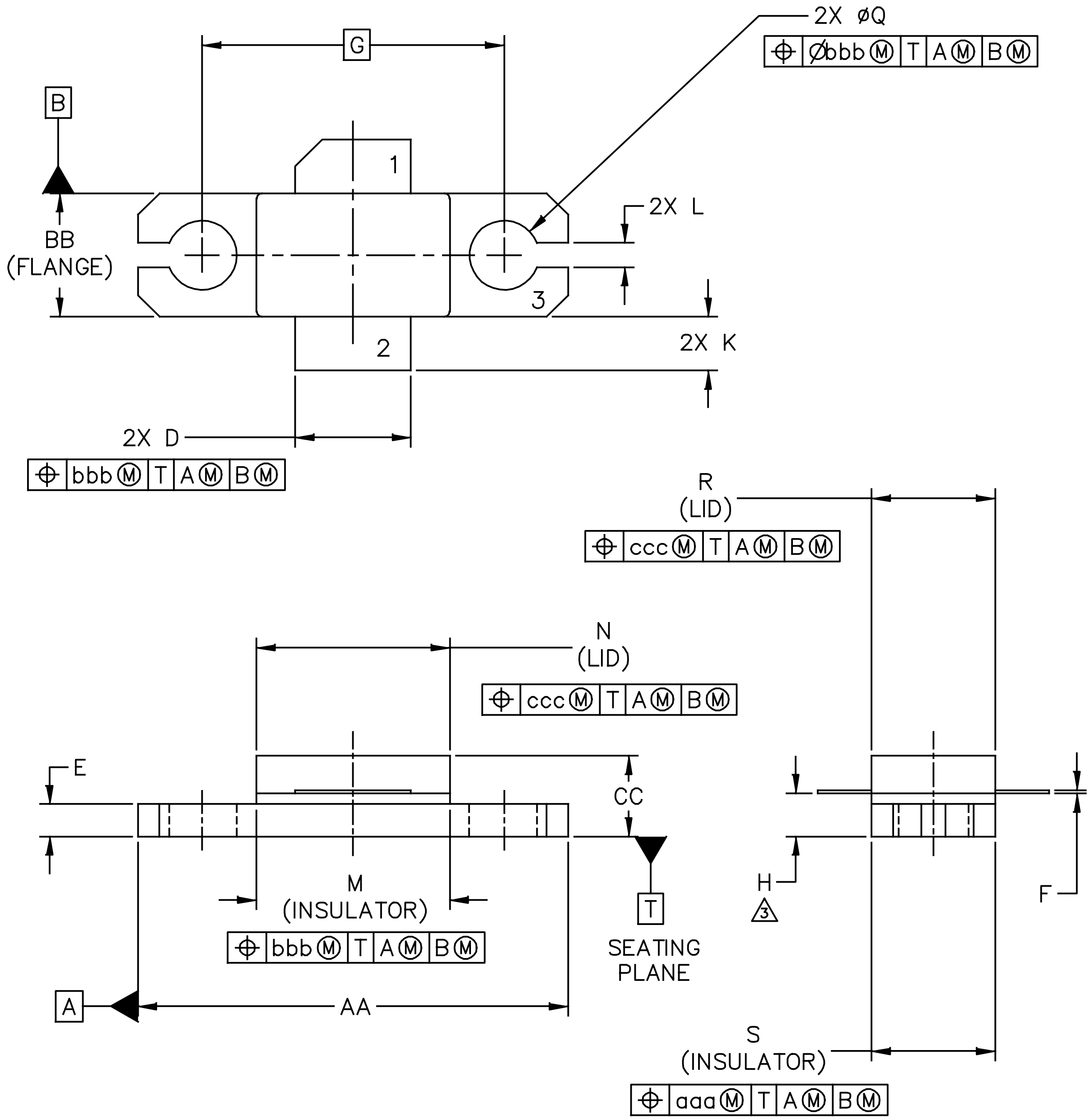



**Figure 21. Series Equivalent Source and Load Impedance — 230 MHz**

## PACKAGE DIMENSIONS




| | | |
|---|---|---|
|  | MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE |
| TITLE: NI–360H–2SB | DOCUMENT NO: 98ASA00795D REV: A | |
| | STANDARD: NON–JEDEC | |
| | SOT1791–1 17 FEB 2016 | |

NOTES:

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

2. CONTROLLING DIMENSION: INCH

3. DIMENSION H IS MEASURED .030 INCH (0.762 MM) AWAY FROM THE FLANGE TO CLEAR THE EPOXY FLOW OUT REGION PARALLEL TO DATUM B.

| DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX | DIM | INCH MIN | INCH MAX | MILLIMETER MIN | MILLIMETER MAX |
|---|---|---|---|---|---|---|---|---|---|
| AA | .795 | .805 | 20.19 | 20.45 | N | .357 | .363 | 9.07 | 9.22 |
| BB | .225 | .235 | 5.72 | 5.97 | Q | .125 | .135 | 3.18 | 3.43 |
| CC | .125 | .175 | 3.18 | 4.45 | R | .227 | .233 | 5.77 | 5.92 |
| D | .210 | .220 | 5.33 | 5.59 | S | .225 | .235 | 5.72 | 5.97 |
| E | .055 | .065 | 1.40 | 1.65 | | | | | |
| F | .004 | .006 | 0.10 | 0.15 | aaa | .005 | | 0.13 | |
| G | .562 BSC | | 14.28 BSC | | bbb | .010 | | 0.25 | |
| H | .077 | .087 | 1.96 | 2.21 | ccc | .015 | | 0.38 | |
| K | .085 | .115 | 2.16 | 2.92 | | | | | |
| L | .040 | .050 | 1.02 | 1.27 | | | | | |
| M | .355 | .365 | 9.02 | 9.27 | | | | | |



MECHANICAL OUTLINE | PRINT VERSION NOT TO SCALE

TITLE: NI–360H–2SB

DOCUMENT NO: 98ASA00795D REV: A

STANDARD: NON–JEDEC

SOT1791–1 17 FEB 2016

## PRODUCT DOCUMENTATION, SOFTWARE AND TOOLS

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
- .s2p File

### Development Tools

- Printed Circuit Boards

### 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 | Dec. 2018 | • Initial release of data sheet |

## *How to Reach Us:*

**Home Page:**
nxp.com

**Web Support:**
nxp.com/support



Document Number: MRFX035H
Rev. 0, 12/2018