

## RF Power GaN Transistor

This 125 W RF power GaN transistor is capable of broadband operation from 30 to 2200 MHz and includes input matching for extended bandwidth performance. With its high gain and high ruggedness, this device is ideally suited for CW, pulse and broadband RF applications.

This part is characterized and performance is guaranteed for applications operating in the 30 to 2200 MHz band. There is no guarantee of performance when this part is used in applications designed outside of these frequencies.

**Typical Performance:**  $V_{DD} = 50$  Vdc,  $T_A = 25^\circ\text{C}$

| Frequency (MHz) | Signal Type                                     | $P_{out}$ (W) | $G_{ps}$ (dB) | $\eta_D$ (%) |
|-----------------|-------------------------------------------------|---------------|---------------|--------------|
| 30–940 (1,2)    | CW                                              | 90            | 16.0          | 45.0         |
| 520 (1)         | CW                                              | 125           | 18.0          | 59.1         |
| 940 (1)         | CW                                              | 80            | 18.4          | 44.0         |
| 2200            | Pulse<br>(100 $\mu\text{sec}$ , 20% Duty Cycle) | 200           | 17.0          | 57.0         |

### Load Mismatch/Ruggedness

| Frequency (MHz) | Signal Type                                     | VSWR                       | $P_{in}$ (W)            | Test Voltage | Result                |
|-----------------|-------------------------------------------------|----------------------------|-------------------------|--------------|-----------------------|
| 520 (1)         | Pulse<br>(100 $\mu\text{sec}$ , 20% Duty Cycle) | > 10:1 at All Phase Angles | 3.4<br>(3 dB Overdrive) | 50           | No Device Degradation |

1. Measured in 30–940 MHz wideband reference circuit (page 4).
2. The values shown are the minimum measured efficiency performance numbers across the indicated frequency range.

### Features

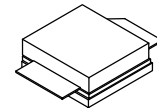
- Advanced GaN on SiC, offering high power density
- Decade bandwidth performance
- Input matched for extended wideband performance
- High ruggedness: > 10:1 VSWR

### Typical Applications

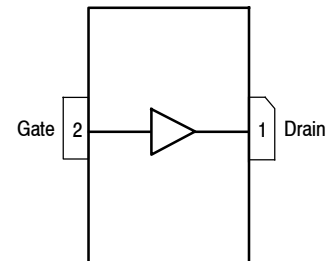
- Ideal for military end-use applications, including the following:
  - Narrowband and multi-octave wideband amplifiers
  - Radar
  - Jammers
  - EMC testing
- Also suitable for commercial applications, including the following:
  - Public mobile radios, including emergency service radios
  - Industrial, scientific and medical
  - Wideband laboratory amplifiers
  - Wireless cellular infrastructure

**MMRF5017HS**

**30–2200 MHz, 125 W CW, 50 V  
WIDEBAND  
RF POWER GaN TRANSISTOR**



**NI-400S-2S**



(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                                                                   | $V_{DSS}$  | 125         | Vdc                      |
| Gate-Source Voltage                                                                    | $V_{GS}$   | -8, 0       | Vdc                      |
| Operating Voltage                                                                      | $V_{DD}$   | 0 to +55    | Vdc                      |
| Maximum Forward Gate Current @ $T_C = 25^\circ\text{C}$                                | $I_{GMAX}$ | 24          | mA                       |
| Storage Temperature Range                                                              | $T_{stg}$  | -65 to +150 | $^\circ\text{C}$         |
| Case Operating Temperature Range                                                       | $T_C$      | -55 to +150 | $^\circ\text{C}$         |
| Operating Junction Temperature Range                                                   | $T_J$      | -55 to +225 | $^\circ\text{C}$         |
| Absolute Maximum Channel Temperature (1)                                               | $T_{MAX}$  | 350         | $^\circ\text{C}$         |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$<br>Derate above $25^\circ\text{C}$ | $P_D$      | 154<br>0.77 | W<br>W/ $^\circ\text{C}$ |

**Table 2. Thermal Characteristics**

| Characteristic (2)                                                                                                                                                      | Symbol                 | Value    | Unit               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------|--------------------|
| Thermal Resistance by Infrared Measurement, Active Die Surface-to-Case<br>CW: Case Temperature $81^\circ\text{C}$ , 80 W CW, 50 Vdc, $I_{DQ} = 200\text{ mA}$ , 940 MHz | $R_{\theta JC}$ (IR)   | 1.3 (3)  | $^\circ\text{C/W}$ |
| Thermal Resistance by Finite Element Analysis, Channel-to-Case<br>Case Temperature $90^\circ\text{C}$ , $P_D = 96\text{ W}$                                             | $R_{\theta CHC}$ (FEA) | 1.77 (4) | $^\circ\text{C/W}$ |

**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) | II, passes 200 V |

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

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

**Off Characteristics**

|                                                                                         |               |     |   |   |     |
|-----------------------------------------------------------------------------------------|---------------|-----|---|---|-----|
| Drain-Source Breakdown Voltage<br>( $V_{GS} = -8\text{ Vdc}$ , $I_D = 20\text{ mAdc}$ ) | $V_{(BR)DSS}$ | 150 | — | — | Vdc |
|-----------------------------------------------------------------------------------------|---------------|-----|---|---|-----|

**On Characteristics**

|                                                                                                               |              |      |      |      |      |
|---------------------------------------------------------------------------------------------------------------|--------------|------|------|------|------|
| Gate Threshold Voltage<br>( $V_{DS} = 10\text{ Vdc}$ , $I_D = 20\text{ mAdc}$ )                               | $V_{GS(th)}$ | -3.8 | -3.0 | -2.3 | Vdc  |
| Gate Quiescent Voltage<br>( $V_{DD} = 48\text{ Vdc}$ , $I_D = 200\text{ mAdc}$ , Measured in Functional Test) | $V_{GS(Q)}$  | -3.6 | -3.1 | -2.3 | Vdc  |
| Gate-Source Leakage Current<br>( $V_{DS} = 0\text{ Vdc}$ , $V_{GS} = -5\text{ Vdc}$ )                         | $I_{GSS}$    | -7.5 | —    | —    | mAac |

**Table 5. Ordering Information**

| Device       | Tape and Reel Information                            | Package    |
|--------------|------------------------------------------------------|------------|
| MMRF5017HSR5 | R5 Suffix = 50 Units, 32 mm Tape Width, 13-inch Reel | NI-400S-2S |

- Reliability tests were conducted at  $225^\circ\text{C}$ . Operation with  $T_{MAX}$  at  $350^\circ\text{C}$  will reduce median time to failure.
- Characterized in 30–940 MHz reference circuit at 940 MHz and 80 W CW output power.
- Refer to AN1955, *Thermal Measurement Methodology of RF Power Amplifiers*. Go to <http://www.nxp.com/RF> and search for AN1955.
- $R_{\theta CHC}$  (FEA) must be used for purposes related to reliability and limitations on maximum channel temperature. MTTF may be estimated by the expression  $MTTF (\text{hours}) = 10^{[A + B/(T + 273)]}$ , where  $T$  is the channel temperature in degrees Celsius,  $A = -10.3$  and  $B = 8260$ .

## **NOTE: Correct Biasing Sequence for GaN Depletion Mode Transistors**

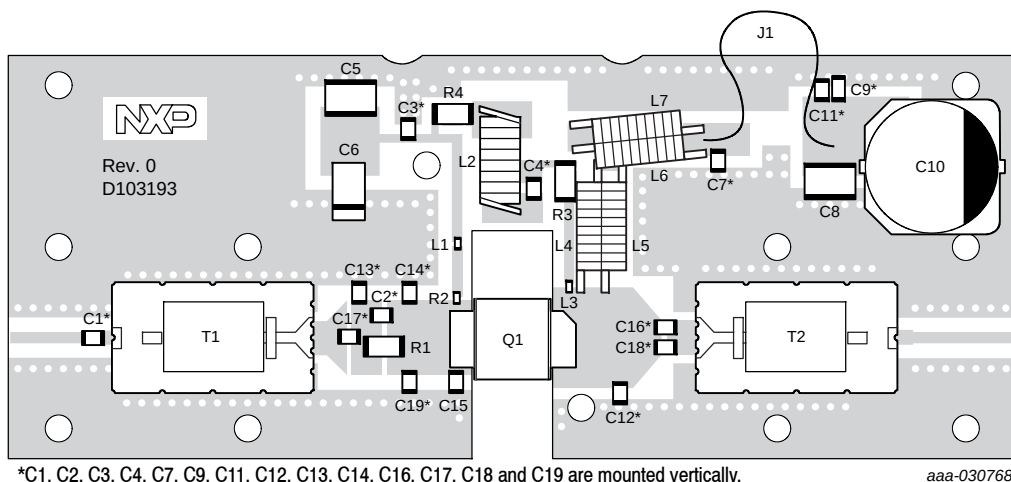
### **Turning the device ON**

1. Set  $V_{GS}$  to  $-5\text{ V}$
2. Turn on  $V_{DS}$  to nominal supply voltage ( $50\text{ V}$ )
3. Increase  $V_{GS}$  until  $I_{DS}$  current is attained
4. Apply RF input power to desired level

### **Turning the device OFF**

1. Turn RF power off
2. Reduce  $V_{GS}$  down to  $-5\text{ V}$
3. Reduce  $V_{DS}$  down to  $0\text{ V}$  (Adequate time must be allowed for  $V_{DS}$  to reduce to  $0\text{ V}$  to prevent severe damage to device.)
4. Turn off  $V_{GS}$

# 30–940 MHz WIDEBAND REFERENCE CIRCUIT — 2.0" × 5.0" (5.1 cm × 12.7 cm)

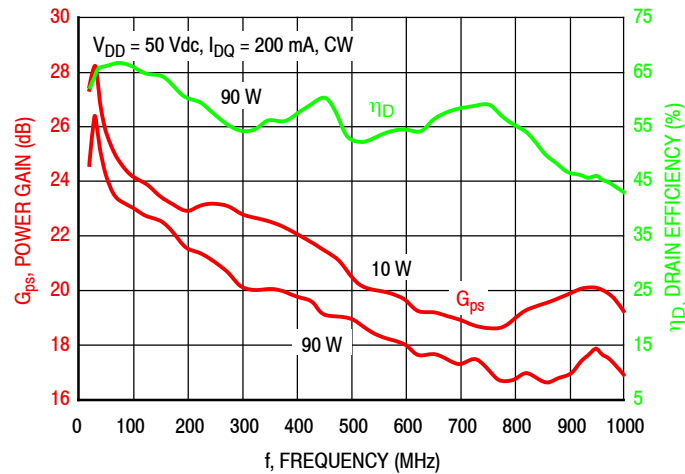


**Figure 2. MMRF5017HS Wideband Reference Circuit Component Layout — 30–940 MHz**

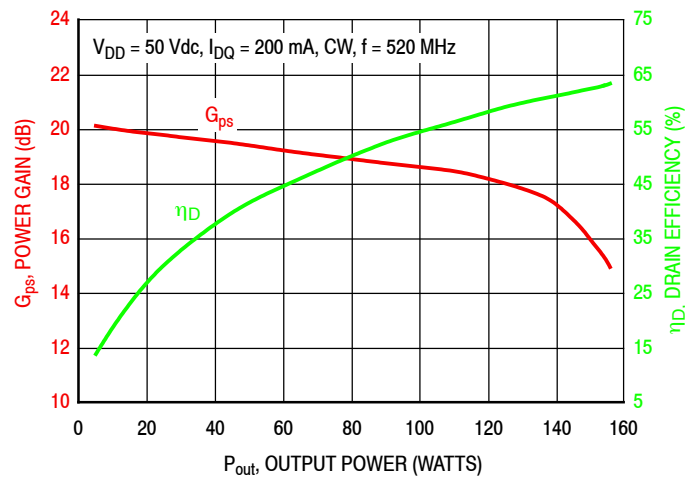
**Table 6. MMRF5017HS Wideband Reference Circuit Component Designations and Values — 30–940 MHz**

| Part           | Description                                                       | Part Number       | Manufacturer  |
|----------------|-------------------------------------------------------------------|-------------------|---------------|
| C1             | 1500 pF Chip Capacitor                                            | ATC700B152JT50XT  | ATC           |
| C2             | 100 pF Chip Capacitor                                             | ATC800B101JT500XT | ATC           |
| C3, C7         | 39 pF Chip Capacitor                                              | ATC800B390JT500XT | ATC           |
| C4             | 680 pF Chip Capacitor                                             | ATC800B681JT50XT  | ATC           |
| C5, C8         | 2.2 $\mu$ F Chip Capacitor                                        | C3225X7R2A225KT   | TDK           |
| C6             | 22 $\mu$ F, 25 V Tantalum Capacitor                               | TPSD226M025R0200  | AVX           |
| C9             | 0.1 $\mu$ F Chip Capacitor                                        | C1206C104K1RACTU  | Kemet         |
| C10            | 220 $\mu$ F, 100 V Electrolytic Capacitor                         | EEV-FK2A221M      | Panasonic-ECG |
| C11            | 220 pF Chip Capacitor                                             | ATC100B221JT200XT | ATC           |
| C12            | 2.2 pF Chip Capacitor                                             | ATC800B2R2BT500XT | ATC           |
| C13, C14, C19  | 5.6 pF Chip Capacitor                                             | ATC800B5R6CT500XT | ATC           |
| C15            | 10 pF Chip Capacitor                                              | ATC800B100JT500XT | ATC           |
| C16, C18       | 470 pF Chip Capacitor                                             | ATC800B471JT200XT | ATC           |
| C17            | 330 pF Chip Capacitor                                             | ATC800B331JT200XT | ATC           |
| J1             | #16 AWG, Magnetic Wire, Length = 2.5"                             | 8074              | Belden        |
| L1             | 270 nH Inductor                                                   | 0603AF-271XJRU    | Coilcraft     |
| L2             | 422 nH inductor                                                   | 132-18SMJL        | Coilcraft     |
| L3             | 240 nH Inductor                                                   | 0603AF-241XJRU    | Coilcraft     |
| L4, L5, L6, L7 | 1.3 $\mu$ H Inductor                                              | 4310LC-132KE      | Coilcraft     |
| Q1             | RF Power GaN Transistor                                           | MMRF5017HS        | NXP           |
| R1             | 51 $\Omega$ , 1/2 W Chip Resistor                                 | CRCW201051R0JNEF  | Vishay        |
| R2             | 10 $\Omega$ , 1/4 W Chip Resistor                                 | CRCW080510R0FKEA  | Vishay        |
| R3, R4         | 100 $\Omega$ , 4 W Chip Resistor                                  | CW12010T0100GBK   | ATC           |
| T1, T2         | High Power Transformer, 30–1000 MHz, 50 $\Omega$ to 12.5 $\Omega$ | XMT0310B5012      | Anaren        |
| PCB            | Shengyi S1000-2, 0.031", $\epsilon_r = 4.8$                       | D103193           | MTL           |

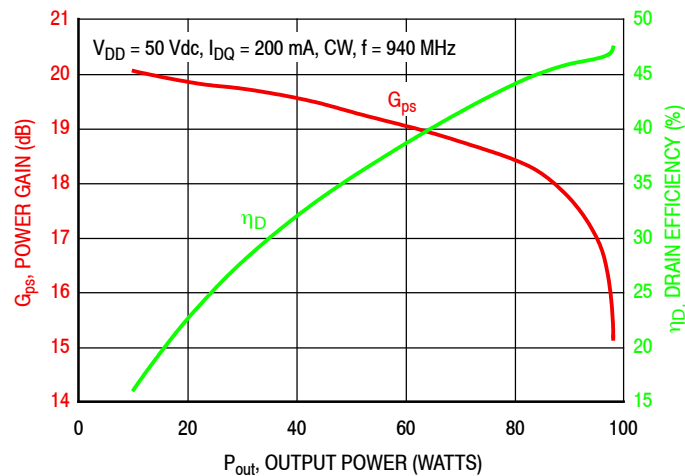
## TYPICAL CHARACTERISTICS — 30–940 MHz WIDEBAND REFERENCE CIRCUIT



**Figure 3. Power Gain and Drain Efficiency versus Output Power and Frequency**



**Figure 4. Power Gain and Drain Efficiency versus CW Output Power – 520 MHz**



**Figure 5. Power Gain and Drain Efficiency versus CW Output Power – 940 MHz**

## 30–940 MHz WIDEBAND REFERENCE CIRCUIT

| f<br>MHz | $Z_{\text{source}}$<br>$\Omega$ | $Z_{\text{load}}$<br>$\Omega$ |
|----------|---------------------------------|-------------------------------|
| 20       | $39.0 + j23.1$                  | $11.3 - j5.0$                 |
| 30       | $59.6 - j3.7$                   | $11.0 - j3.1$                 |
| 50       | $28.3 - j28.7$                  | $11.1 - j1.8$                 |
| 70       | $15.5 - j22.2$                  | $11.2 - j1.3$                 |
| 90       | $11.1 - j17.3$                  | $11.3 - j1.1$                 |
| 136      | $7.9 - j11.3$                   | $10.7 - j1.4$                 |
| 174      | $7.0 - j8.9$                    | $10.0 - j0.3$                 |
| 360      | $6.2 - j5.0$                    | $11.9 - j0.2$                 |
| 440      | $6.0 - j4.6$                    | $11.9 - j0.0$                 |
| 520      | $5.5 - j4.7$                    | $12.3 - j0.1$                 |
| 760      | $2.5 - j4.0$                    | $14.4 - j1.2$                 |
| 850      | $1.7 - j2.9$                    | $16.2 - j3.5$                 |
| 940      | $1.1 - j1.8$                    | $15.9 - j7.9$                 |
| 1000     | $1.0 - j1.1$                    | $13.2 - j10.6$                |

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

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

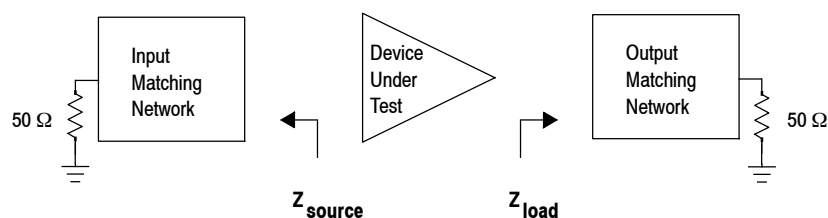
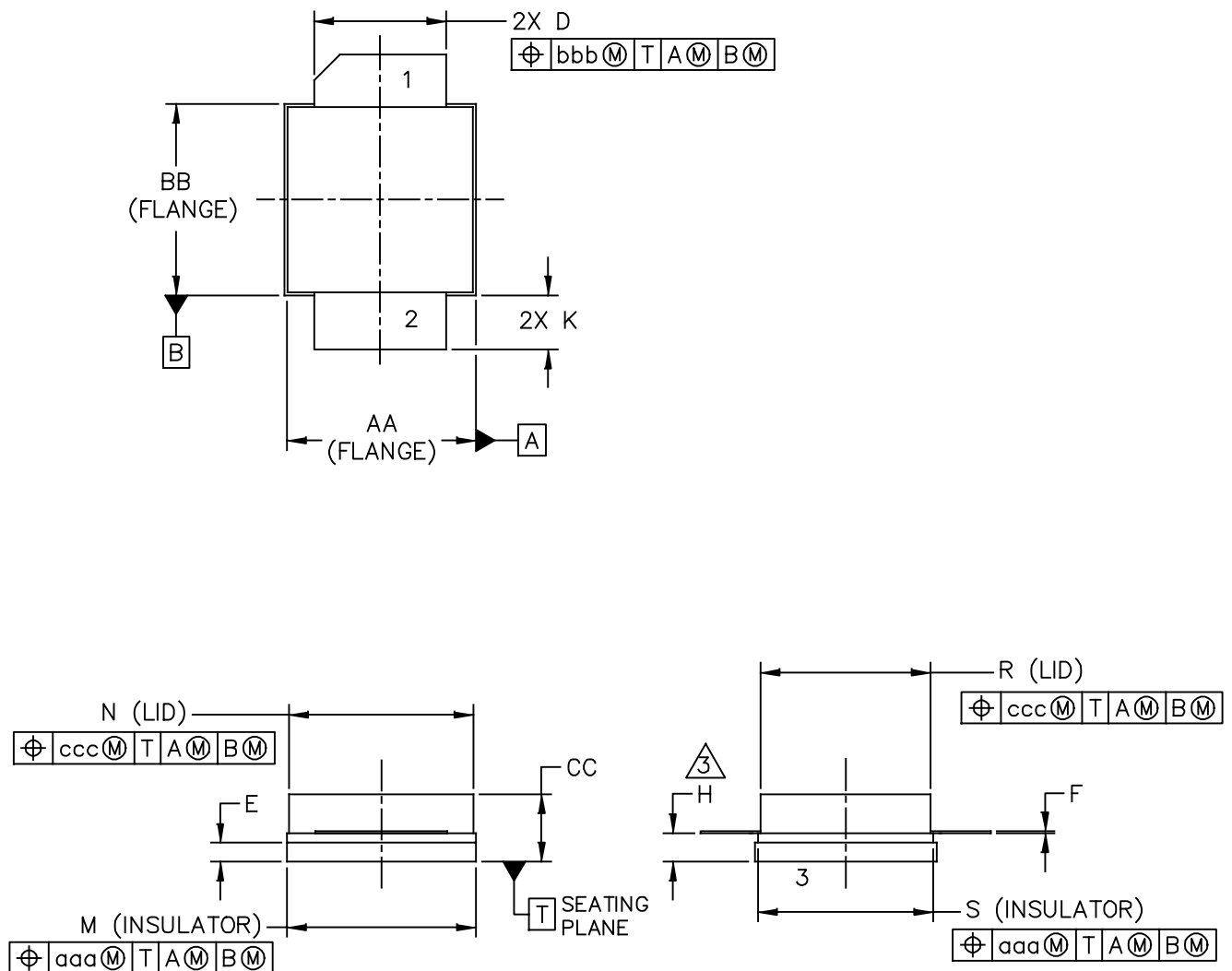


Figure 6. Wideband Series Equivalent Source and Load Impedance — 30–940 MHz

## PACKAGE DIMENSIONS



|                                                  |                          |                            |
|--------------------------------------------------|--------------------------|----------------------------|
| © NXP SEMICONDUCTORS N.V.<br>ALL RIGHTS RESERVED | MECHANICAL OUTLINE       | PRINT VERSION NOT TO SCALE |
| TITLE:<br><br>NI-400S-2S                         | DOCUMENT NO: 98ASA10732D | REV: C                     |
|                                                  | STANDARD: NON-JEDEC      |                            |
|                                                  | SOT1828-1                | 13 JAN 2016                |

NOTES:

1. CONTROLLING DIMENSION: INCH
2. INTERPRET DIMENSIONS AND TOLERANCES  
PER ASME Y14.5M–1994.

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.

4. INPUT & OUTPUT LEADS (PIN 1 & 2) MAY HAVE SMALL FEATURES SUCH AS SQUARE HOLES OR NOTCHES FOR MANUFACTURING CONVENIENCE.

| DIM                                              | INCH  |       | MILLIMETER         |       | DIM                                                  | INCH                       |     | MILLIMETER |     |
|--------------------------------------------------|-------|-------|--------------------|-------|------------------------------------------------------|----------------------------|-----|------------|-----|
|                                                  | MIN   | MAX   | MIN                | MAX   |                                                      | MIN                        | MAX | MIN        | MAX |
| AA                                               | .395  | .405  | 10.03              | 10.29 | aaa                                                  | .005                       |     | 0.13       |     |
| BB                                               | .382  | .388  | 9.70               | 9.86  | bbb                                                  | .010                       |     | 0.25       |     |
| CC                                               | .125  | .163  | 3.18               | 4.14  | ccc                                                  | .015                       |     | 0.38       |     |
| D                                                | .275  | .285  | 6.98               | 7.24  |                                                      |                            |     |            |     |
| E                                                | .035  | .045  | 0.89               | 1.14  |                                                      |                            |     |            |     |
| F                                                | .004  | .006  | 0.10               | 0.15  |                                                      |                            |     |            |     |
| H                                                | .057  | .067  | 1.45               | 1.70  |                                                      |                            |     |            |     |
| K                                                | .0995 | .1295 | 2.53               | 3.29  |                                                      |                            |     |            |     |
| M                                                | .395  | .405  | 10.03              | 10.29 |                                                      |                            |     |            |     |
| N                                                | .385  | .395  | 9.78               | 10.03 |                                                      |                            |     |            |     |
| R                                                | .355  | .365  | 9.02               | 9.27  |                                                      |                            |     |            |     |
| S                                                | .365  | .375  | 9.27               | 9.53  |                                                      |                            |     |            |     |
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| TITLE:<br><br>NI-400S-2S                         |       |       |                    |       | DOCUMENT NO: 98ASA10732D                      REV: C |                            |     |            |     |
|                                                  |       |       |                    |       | STANDARD: NON-JEDEC                                  |                            |     |            |     |
|                                                  |       |       |                    |       | SOT1828-1                                            |                            |     |            |     |



## PRODUCT DOCUMENTATION 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

### 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        | June 2018 | <ul style="list-style-type: none"><li>• Initial release of data sheet</li></ul> |

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