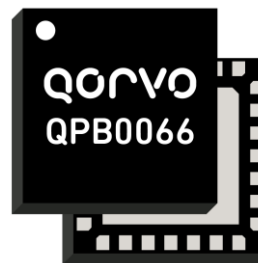


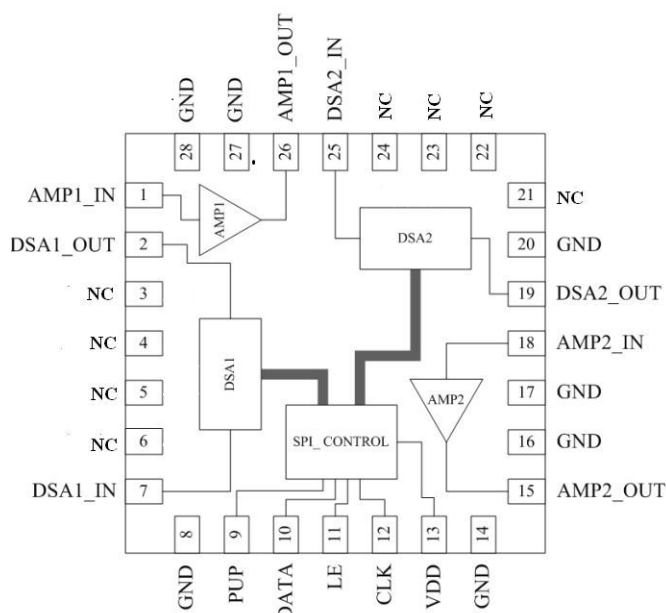
### Product Overview

The QPB0066 is a digital controlled variable gain amplifier featuring high linearity over the entire gain control range with noise figure less of 4.3 dB in its maximum gain state. The gain of the dual 6-bit digital step attenuators programmed with a 12-bit Serial Peripheral Interface (SPI). The QPB0066 is packaged in a small 6.0 mm x 6.0 mm leadless laminate MCM, which contains plated through thermal vias for ultra-low thermal resistance. The module is easy to use with a few external DC blocks and RF chokes.



28-Pin, 6.0 mm x 6.0 mm MCM

### Functional Block Diagram



Top View

### Key Features

- 5 MHz to 500 MHz Operation
- Dual 6-Bit Digital Step Attenuator
- SPI Serial Control Programming
- Max Gain = 44 dB at 100 MHz
- Gain Control Range = 63 dB (0.5 dB Steps)
- High OIP3 / P1dB = +38 dBm / 22.6 dBm
- +5 V Supply for DSA and +8 V Supply for Amplifier with a Drop Resistor
- Small 28-Pin, 6.0 mm x 6.0 mm MCM
- Power-up Programming

### Applications

- High Linearity Power Control
- CATV Drivers
- Transceiver IF DVA
- Cellular, PCS, GSM, UMTS
- Wireless Data, Satellite Terminals

### Ordering Information

| Part Number | Description                           |
|-------------|---------------------------------------|
| QPB0066SQ   | Sample bag with 25 pieces             |
| QPB0066SR   | 7" Reel with 100 pieces               |
| QPB0066TR13 | 13" Reel with 2500 pieces             |
| QPB0066PCK  | 5 – 500 MHz PCBA with 5 pc sample bag |

### Absolute Maximum Ratings

| Parameter                                  | Rating          |
|--------------------------------------------|-----------------|
| Supply Voltage ( $V_{DD}$ ) for DSA        | -0.5 to +5.75 V |
| $VD_{MAX}$ (device voltage at RFOUT pins)  | +7 V            |
| Supply Current ( $I_{CC}$ ) for amplifiers | 340 mA          |
| Power Dissipation for each amplifier       | 1980 mW         |
| Maximum RF Input Power                     | +16 dBm         |
| Operating Temperature Range                | -40 to +85 °C   |
| Storage Temperature Range                  | -65 to +150 °C  |
| Maximum Junction Temperature               | +125 °C         |

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability.

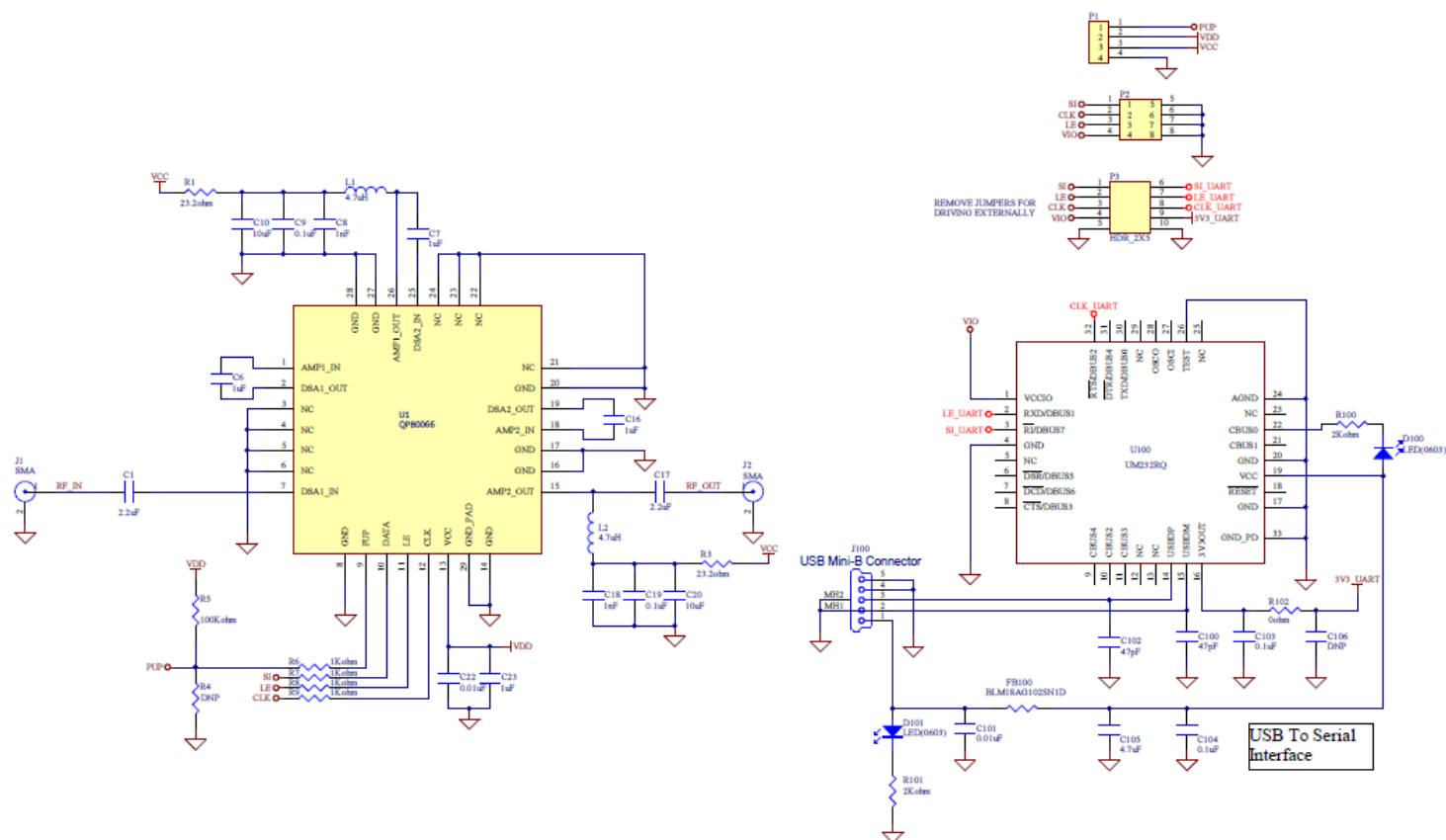
### Electrical Specifications

| Parameter                               | Condition <sup>(1)</sup>                | Min                             | Typ  | Max | Unit   |
|-----------------------------------------|-----------------------------------------|---------------------------------|------|-----|--------|
| Attenuator Supply Voltage               |                                         | 3.0                             | 5.0  | 5.5 | V      |
| Attenuator Supply Current               |                                         |                                 | 500  |     | μA     |
| Amplifier Supply Voltage <sup>(2)</sup> |                                         |                                 | 5.0  |     | V      |
| Amplifier Supply Current                |                                         |                                 | 250  |     | mA     |
| Frequency Range                         |                                         | 5                               |      | 500 | MHz    |
| Max Gain                                | Attenuation = 0 dB                      |                                 | 42   |     | dB     |
| Gain Control Range                      |                                         |                                 | 63.0 |     | dB     |
| Step Accuracy                           | Major state error up to 250 MHz         | +/- 0.2 +4% attenuation setting |      |     | dB     |
| P1dB                                    | Attenuation = 0 dB                      |                                 | 22.5 |     | dBm    |
| Output IP3                              | $P_{OUT} = 0$ dBm / tone, 1 MHz spacing |                                 | 36   |     | dBm    |
| Control Interface                       | SPI Interface                           |                                 | 12   |     | bit    |
| Switching Speed                         | 50% Control to 10%/90% RF               |                                 | 120  |     | ns     |
| Noise Figure                            | Attenuation = 0 dB                      |                                 | 4.3  |     | dB     |
| Impedance                               |                                         |                                 | 50   |     | Ω      |
| Input Return Loss                       | At Maximum Gain                         |                                 | 24   |     | dB     |
| Output Return Loss                      | At Maximum Gain                         |                                 | 12   |     | dB     |
| Thermal Resistance                      | $\Theta_{JC}$                           |                                 | 70   |     | °C / W |

#### Notes:

1. Typical performance at these conditions: Temp = +25 °C,  $V_{DD}$  = +5 V, 50 Ω system, Full band unless otherwise noted
2.  $V_O$  at the RF output pins

### Evaluation Board Schematic (5 – 500 MHz)



#### Notes:

1. QPB0066-4000(B) removes unused capacitor pads and test path from QPB0066-4000(A). All other connections and programming remain the same.



# QPB0066

## Digital Controlled Variable Gain Amplifier (5 – 500 MHz)

### Evaluation Board Bill of Materials

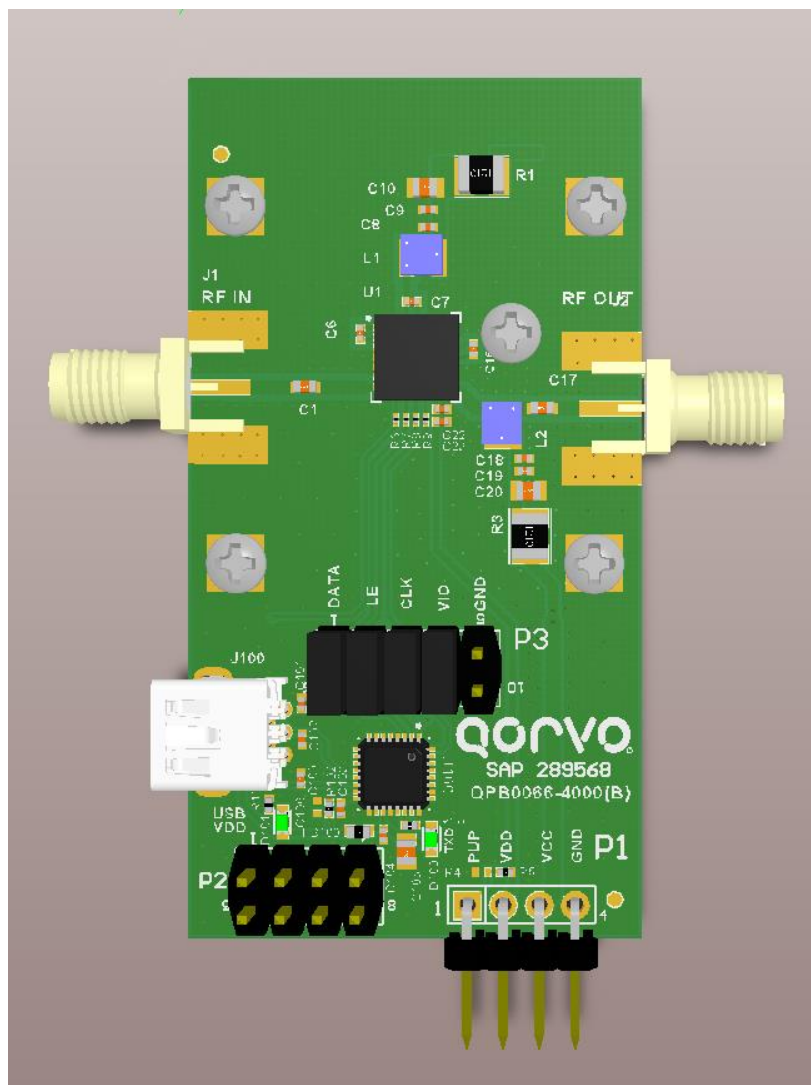
| Designator          | Description                                | Manufacturer                    | Part Number        |
|---------------------|--------------------------------------------|---------------------------------|--------------------|
| PCB                 | QPB0066 PCB Board                          | Qorvo                           | QPB0066-4000(B)    |
| U1                  | Digital Controlled Variable Gain Amplifier | Qorvo                           | QPB0066SB          |
| C1, C17             | CAP, 2.2uF, 10%, 10V, X5R, 0603            | Murata Electronics              | GRM188R61A225KE34D |
| C22, C101           | CAP, 0.01uF, $\pm 10\%$ , 50V, X7R, 0402   | Murata Electronics              | GRM155R71H103KA88D |
| C100, C102          | CAP, 47pF, 5%, 50V, C0G, 0402              | Murata Electronics              | GRM1555C1H470JA01D |
| C8, C18             | CAP, 1000pF, 10%, 50V, X7R, 0402           | Taiyo Yuden (USA), Inc.         | RM UMK105BJ102KV-F |
| C10, C20            | CAP, 10uF, 10%, 16V, TANT-B                | AVX Corporation                 | TAJB106K016R       |
| C9, C19, C103, C104 | CAP, 0.1uF, 10%, 16V, X7R, 0402            | Murata Electronics              | GRM155R71C104KA88D |
| C105                | CAP, 4.7uF, 10%, 16V, X7R, 0805            | AVX Asia Limited                | 0805YC475KAT2A     |
| C6, C7, C16, C23    | CAP, 1uF, 10%, 10V, X7S, 0402              | Murata Electronics              | GRM155C71A105KE11D |
| R6, R7, R8, R9      | RES, 1K, 5%, 1/20W, 0201                   | Kamaya, Inc                     | RMC1/20-102JPA15   |
| R102                | RES, 0 OHM, 5%, 1/10W, 0402                | Kamaya, Inc                     | RMC1/16SJPTH       |
| R5                  | RES, 100K, 5%, 1/16W, 0402                 | Kamaya, Inc                     | RMC1/16S-104JTH    |
| R100, R101          | RES, 2K, 5%, 1/16W, 0402                   | Kamaya, Inc                     | RMC1/16S-202JTH    |
| R1, R3              | RES, 23.2 OHM, 1%, 1/2 W, 1210             | Panasonic Industrial Devices    | ERJ-14NF23R2U      |
| D100, D101          | LED, GRN, CLR, 3.2V, 30mA, 0603            | Wurth Elektronik                | 150060GS75000      |
| L1, L2              | IND, 4.7uH, 5%, 260mA, W/W, 1008           | Coilcraft, Inc.                 | 1008CS-472XJRC     |
| FB100               | FER, BEAD, 1K, 100mA, 0603                 | Murata Electronics              | BLM18AG102SN1D     |
| U100                | IC, USB-UART, 3.3-5.25V, QFN-32            | Future Technology Devices Int'l | FT232RQ            |
| P2                  | CONN, HDR, ST, 2x4, 0.100"                 | Samtec, Inc.                    | TSW-104-14-G-D     |
| J1, J2              | CONN, SMA, EL, FLT, 0.068" SPE-000318      | Amphenol RF Asia Corp           | 901-10426          |
| P1                  | CONN, HDR, RT-ANG, 4 POS, 0.100", T/H      | 3M Interconnect Solutions       | 961104-5604-AR     |
| J100                | CONN, USB, MINI-B, RT ANG, 5-PIN, T/H      | Molex                           | 054819-0519        |
| P3                  | CONN, HDR, ST, 2x5, 0.100"                 | Samtec, Inc.                    | TSW-105-08-L-D     |
| R4, C106            | Not Populated                              | N/A                             | N/A                |



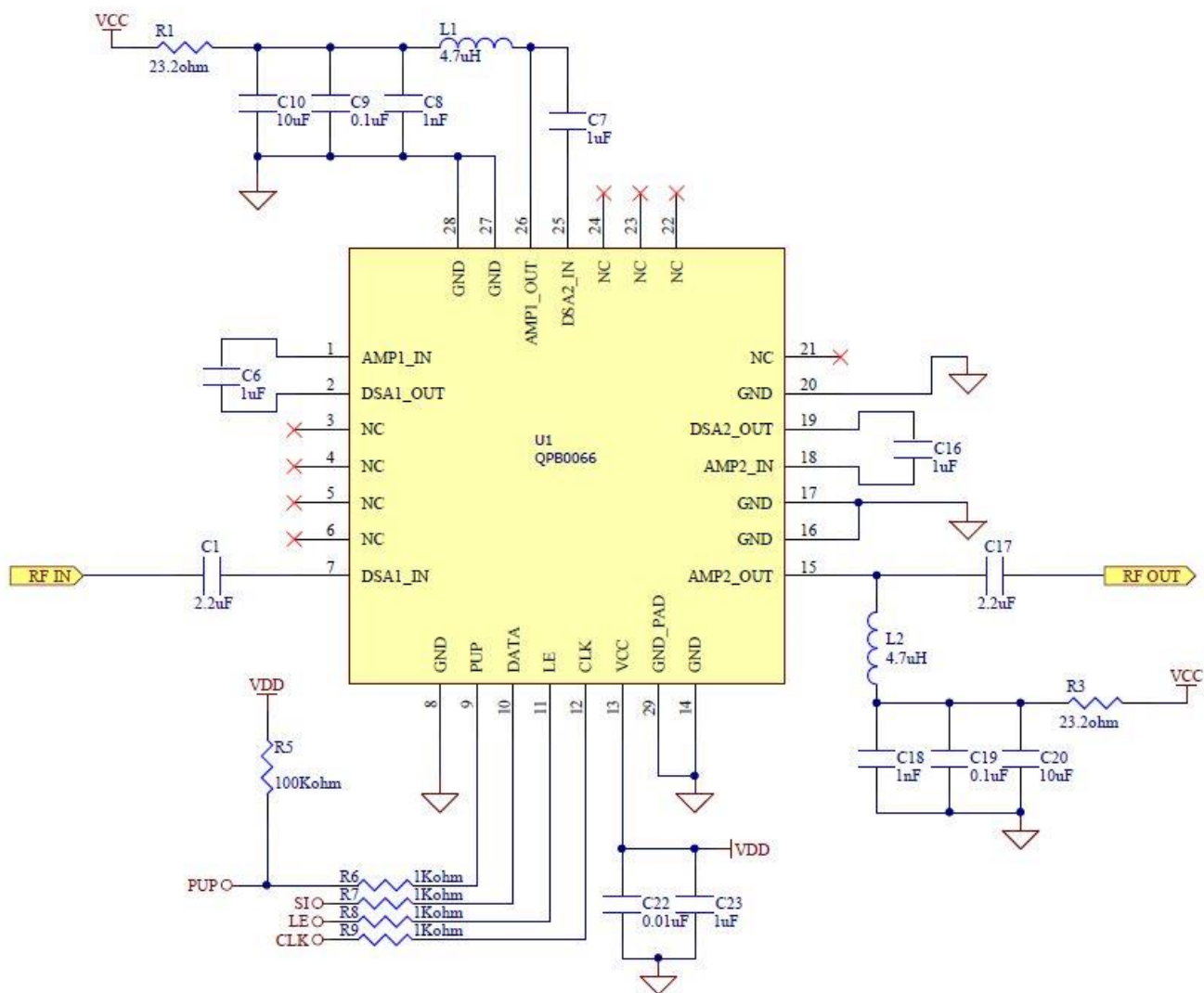
# QPB0066

## Digital Controlled Variable Gain Amplifier (5 – 500 MHz)

### Evaluation Board Assembly Drawing



### Typical Application Schematic (5-500MHz)



Required Bias Resistance for  $I_{CC} = 125\text{ mA}$  (one amplifier):

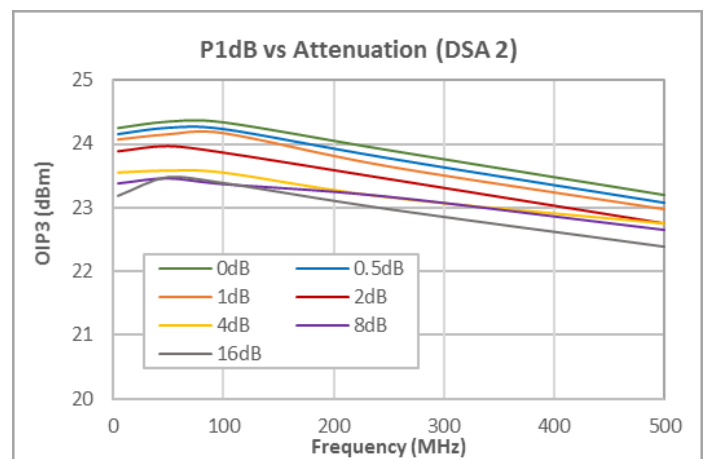
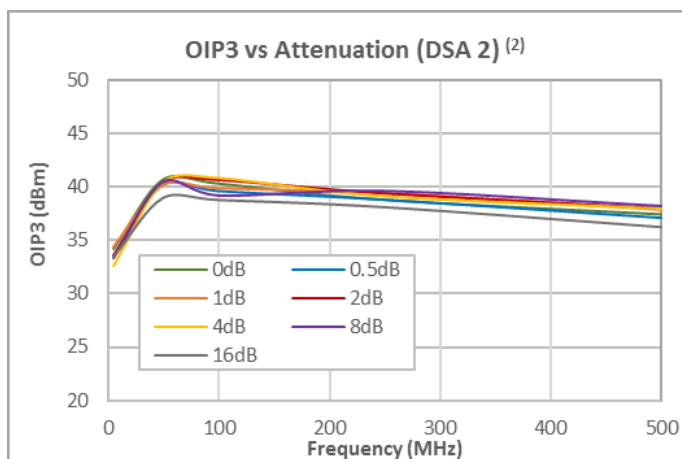
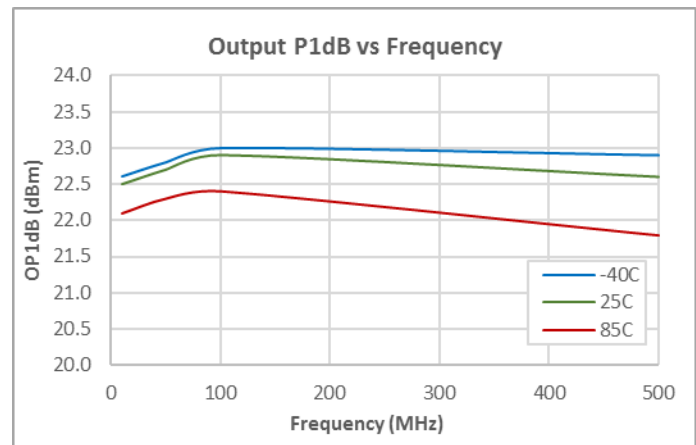
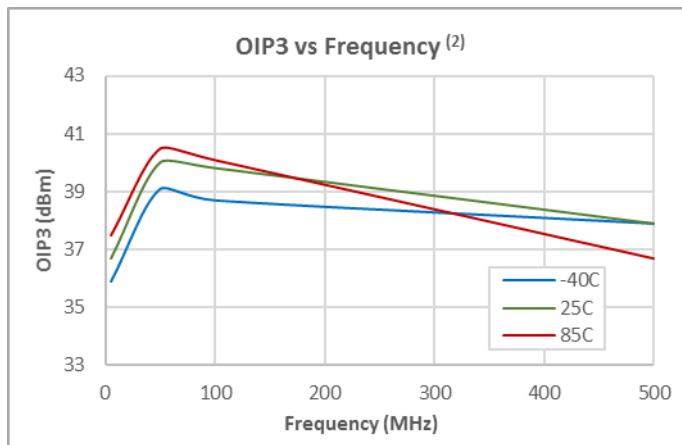
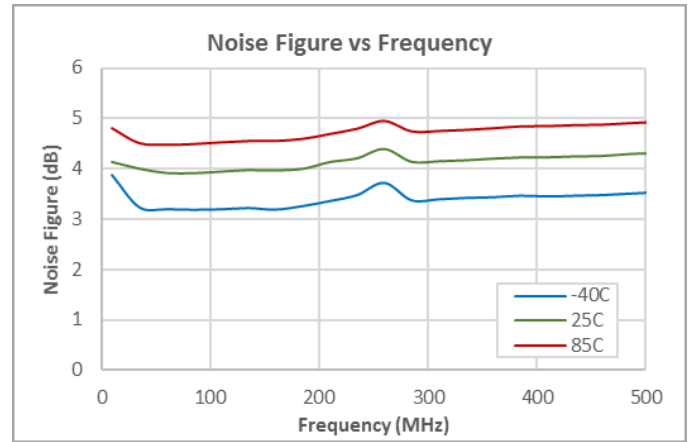
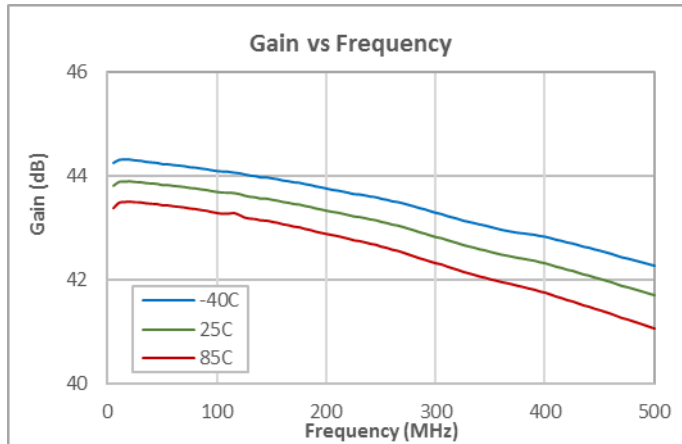
$$\text{Bias Resistance} = R_{\text{BIAS}} + R_{\text{CHOKE}} = (V_{\text{CC}} - V_{\text{DD}}) / I_{\text{CC}}$$

( $V_{\text{CC}}$ : Amplifier supply voltage;  $V_{\text{D}}$ : Amplifier device voltage at the RF output -4.75 to 5.0 V;  $R_{\text{BIAS}}$ : Bias Resistor;  $R_{\text{CHOKE}}$ : DCR of Bias Choke)

### Total Bias Resistance ( $R_{\text{BIAS}} + R_{\text{CHOKE}}$ )

| Supply Voltage  | 7V   | 8V   | 9V   | 10V  |
|-----------------|------|------|------|------|
| Bias Resistance | 18.0 | 26.0 | 34.0 | 58.0 |

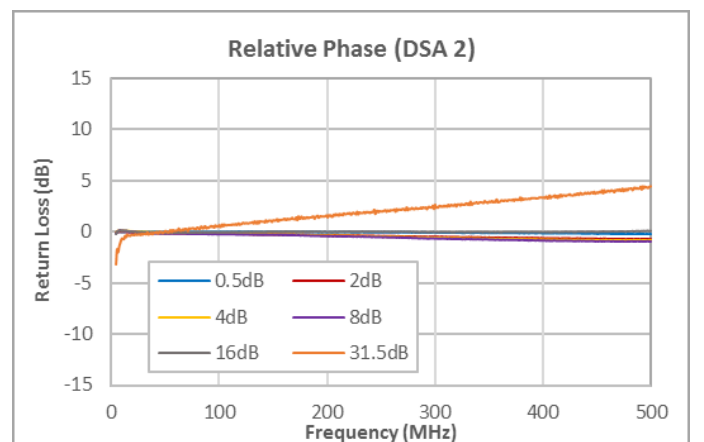
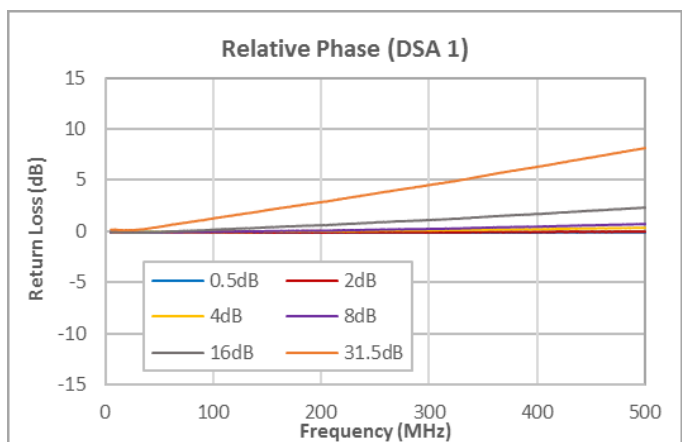
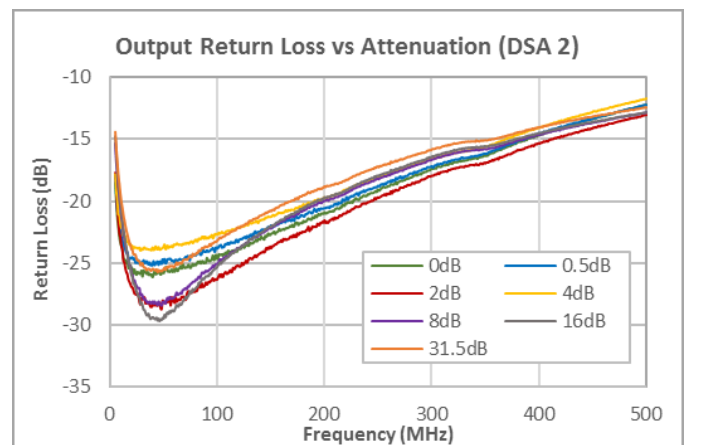
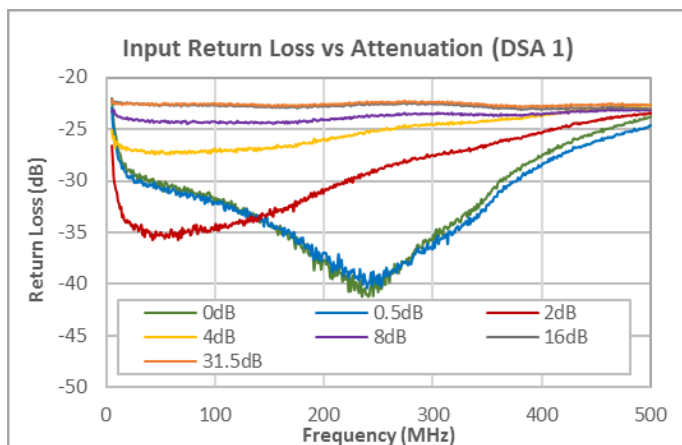
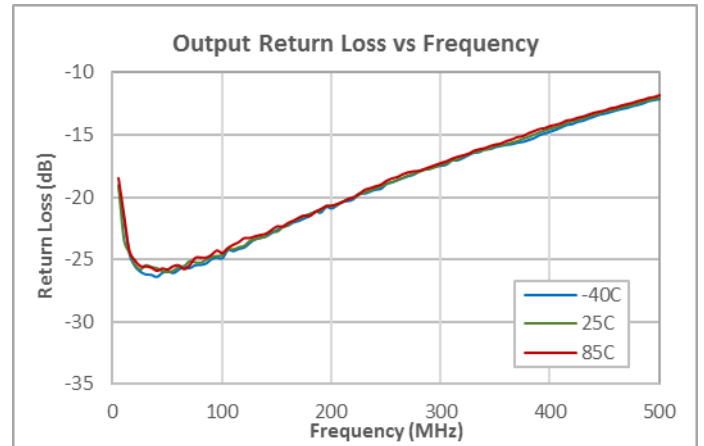
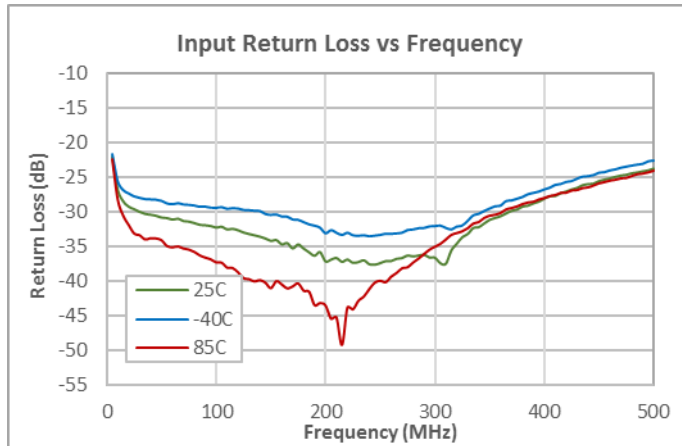
### Performance Data: 5 – 500 MHz Broadband Application Circuit <sup>(1)</sup>



#### Notes:

1. Typical performance at these conditions: Temp = +25 °C,  $V_{DD}$  = +5V,  $V_{CC}$  = +8V, Maximum Gain, 50  $\Omega$  system, Full band unless otherwise noted.
2. 0 dBm / tone.

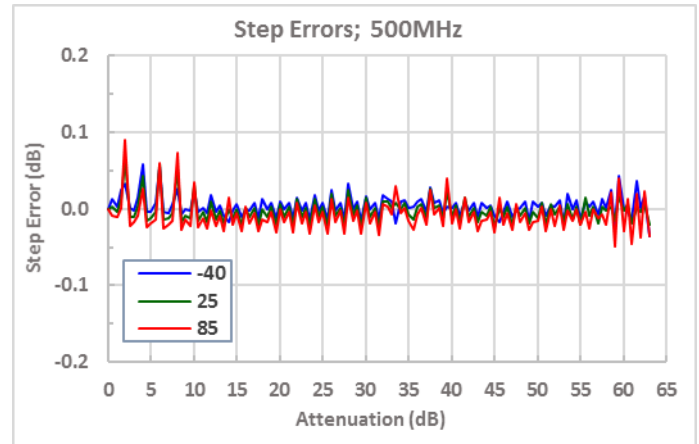
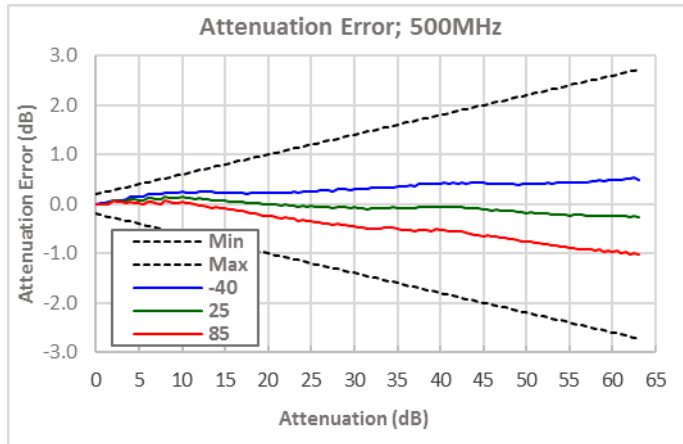
### Performance Data: 5 – 500 MHz Broadband Application Circuit <sup>(1)</sup>



#### Notes:

- (1) Typical performance at these conditions: Temp = +25 °C,  $V_{DD}$  = +5V,  $V_{CC}$  = +8V, Maximum Gain, 50  $\Omega$  system, Full band unless otherwise noted.

### Performance Data: 5 – 500 MHz Broadband Application Circuit <sup>(1)</sup>



#### Notes:

- (1) Typical performance at these conditions: Temp = +25°C,  $V_{DD}$  = +5V,  $V_{CC}$  = +8V, Maximum Gain, 50  $\Omega$  system, Full band unless otherwise noted.

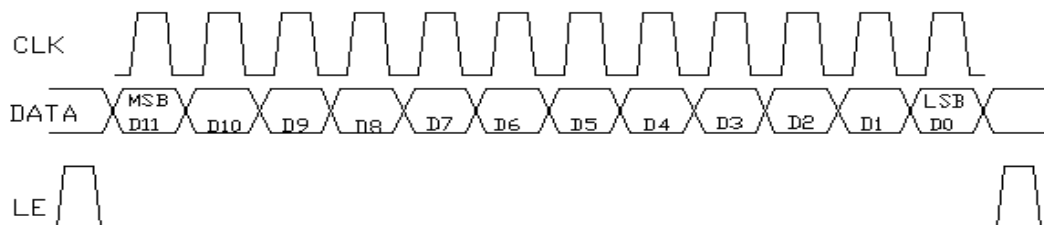
### Truth Table: DSA1 Control Bit

| D5 | D4 | D3 | D2 | D1 | D0 | Gain Relative to Maximum Gain |
|----|----|----|----|----|----|-------------------------------|
| 1  | 1  | 1  | 1  | 1  | 1  | 0 dBm                         |
| 1  | 1  | 1  | 1  | 1  | 0  | -0.5 dBm                      |
| 1  | 1  | 1  | 1  | 0  | 1  | -1 dBm                        |
| 1  | 1  | 1  | 0  | 1  | 1  | -2 dBm                        |
| 1  | 1  | 0  | 1  | 1  | 1  | -4 dBm                        |
| 1  | 0  | 1  | 1  | 1  | 1  | -8 dBm                        |
| 0  | 1  | 1  | 1  | 1  | 1  | -16 dBm                       |
| 0  | 0  | 0  | 0  | 0  | 0  | -31.5 dBm                     |

### Truth Table: DSA2 Control Bit

| D5 | D4 | D3 | D2 | D1 | D0 | Gain Relative to Maximum Gain |
|----|----|----|----|----|----|-------------------------------|
| 1  | 1  | 1  | 1  | 1  | 1  | 0 dBm                         |
| 1  | 1  | 1  | 1  | 1  | 0  | -0.5 dBm                      |
| 1  | 1  | 1  | 1  | 0  | 1  | -1 dBm                        |
| 1  | 1  | 1  | 0  | 1  | 1  | -2 dBm                        |
| 1  | 1  | 0  | 1  | 1  | 1  | -4 dBm                        |
| 1  | 0  | 1  | 1  | 1  | 1  | -8 dBm                        |
| 0  | 1  | 1  | 1  | 1  | 1  | -16 dBm                       |
| 0  | 0  | 0  | 0  | 0  | 0  | -31.5 dBm                     |

### Programming Example - 12 Bit



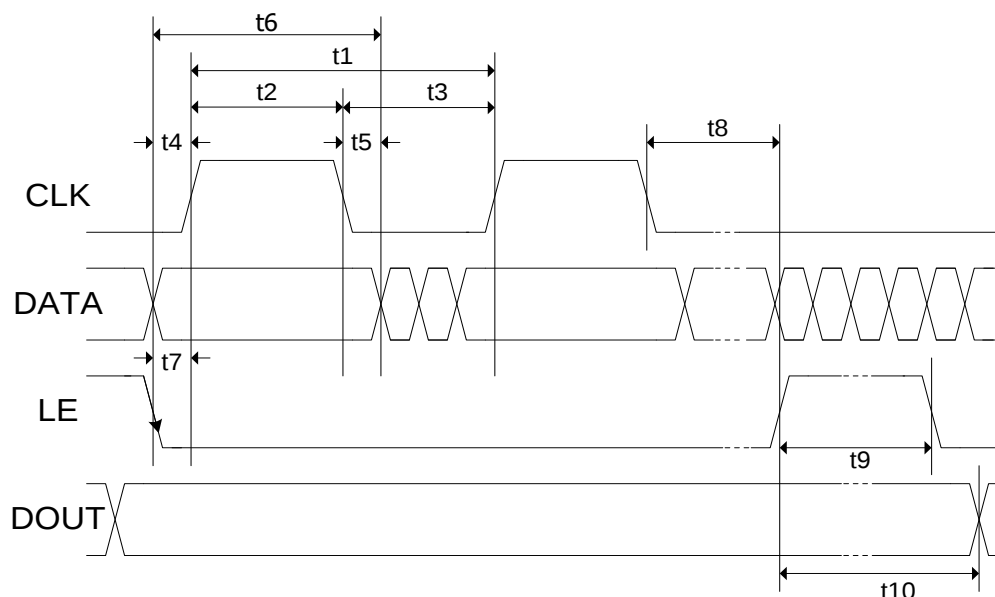
**Power-up Programming Truth Table**

| PUP  | Attenuator Setting |
|------|--------------------|
| Low  | Maximum = 63 dB    |
| High | Minimum = 0 dB     |

**Logic Voltage Levels**

| State | Logic        |
|-------|--------------|
| Low   | 0 to 0.8 V   |
| High  | 2.0 to 5.0 V |

### SPI Timing Diagram



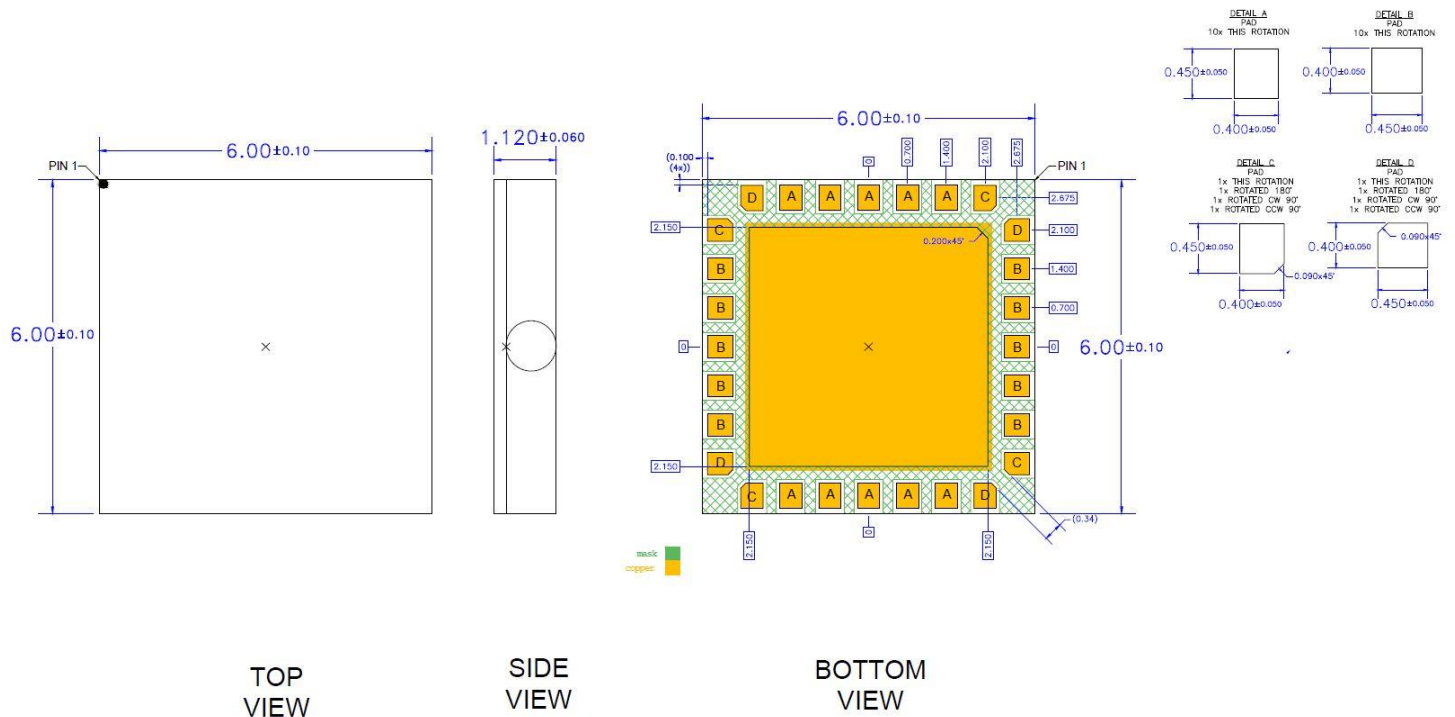
### SPI Timing Diagram Specifications

| Parameter | Limit | Unit    | Comment                |
|-----------|-------|---------|------------------------|
| t1        | 25    | MHz max | CLK Frequency          |
| t2        | 20    | ns min  | CLK High               |
| t3        | 20    | ns min  | CLK Low                |
| t4        | 5     | ns min  | DATA to CLK Setup Time |
| t5        | 5     | ns min  | DATA to CLK Hold Time  |
| t6        | 30    | ns min  | DATA Valid             |
| t7        | 5     | ns min  | LE to CLK Setup Time   |
| t8        | 5     | ns min  | CLK to LE Setup Time   |
| t9        | 10    | ns min  | LE Pulse Width         |
| t10       | 20    | ns max  | Output Set             |

### Pin Configuration and Description

| Pin Number | Label    | Description                            |
|------------|----------|----------------------------------------|
| 1          | AMP1_IN  | AMP1 Input                             |
| 2          | DSA1_OUT | DSA1 Output                            |
| 3          | NC       | Not Connected Internally               |
| 4          | NC       | Not Connected Internally               |
| 5          | NC       | Not Connected Internally               |
| 6          | NC       | Not Connected Internally               |
| 7          | DSA1_IN  | DSA1 Input                             |
| 8          | GND      | RF/DC Ground Connection                |
| 9          | PUP      | Power Up Programming Pin               |
| 10         | DATA     | Serial Data Input                      |
| 11         | LE       | Serial Latch Enable                    |
| 12         | CLK      | Serial Clock Input                     |
| 13         | VDD      | Supply Voltage for DSA and SPI Control |
| 14         | GND      | RF/DC Ground Connection                |
| 15         | AMP2_OUT | AMP2 OUT and Bias Pin                  |
| 16         | GND      | RF/DC Ground Connection                |
| 17         | GND      | RF/DC Ground Connection                |
| 18         | AMP2_IN  | AMP2 Input                             |
| 19         | DSA2_OUT | DSA2 Output                            |
| 20         | GND      | RF/DC Ground Connection                |
| 21         | NC       | Not Connected Internally               |
| 22         | NC       | Not Connected Internally               |
| 23         | NC       | Not Connected Internally               |
| 24         | NC       | Not Connected Internally               |
| 25         | DSA2_IN  | DSA2 Input                             |
| 26         | AMP1_OUT | AMP1 Output and Bias Pin               |
| 27         | GND      | RF/DC Ground Connection                |
| 28         | GND      | RF/DC Ground Connection                |

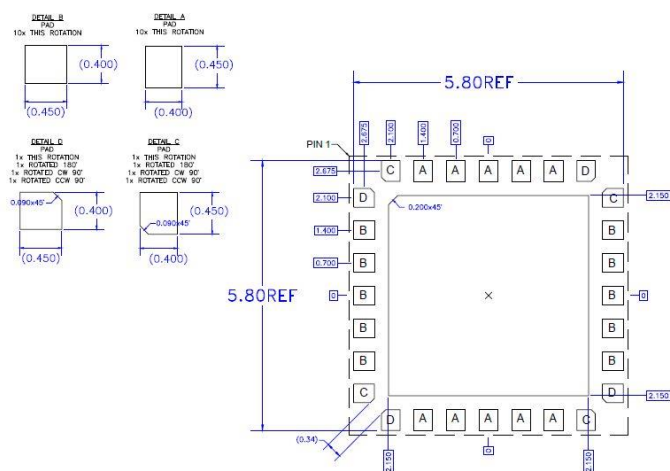
## Package Outline



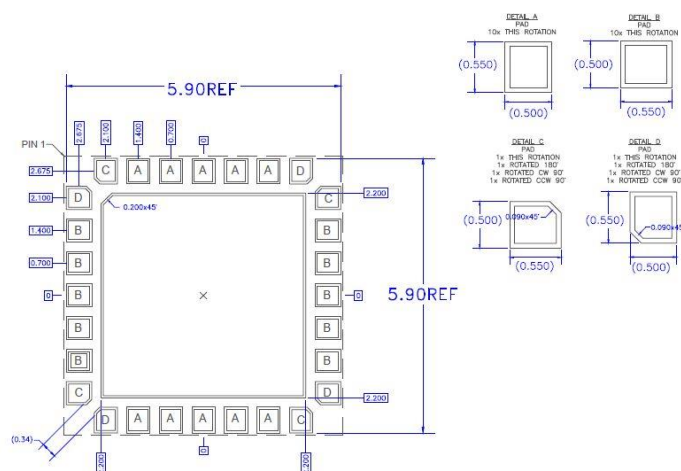
Notes:

1. Dimensions in millimeters.

## Package Dimensions



## RECOMMENDED LAND PATTERN



## RECOMMENDED LAND PATTERN MASK

Notes:

1. Dimensions in millimeters



### Handling Precautions

| Parameter                        | Rating           | Standard               |
|----------------------------------|------------------|------------------------|
| ESD – Human Body Model (HBM)     | Class C3 (1000V) | ANSI/ESDA/JEDEC JS-001 |
| ESD – Charged Device Model (CDM) | Class 3 (1000V)  | ANSI/ESDA/JEDEC JS-002 |
| MSL – Moisture Sensitivity Level | Level 3          | IPC/JEDEC J-STD-020    |



Caution!  
ESD-Sensitive Device

### Solderability

Compatible with both lead-free (260 °C max. reflow temp.) and tin/lead (245 °C max. reflow temp.) soldering processes.  
Solder profiles available upon request.

Contact plating: NiPdAu

### RoHS Compliance

This part is compliant with 2011/65/EU RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) as amended by Directive 2015/863/EU.

This product also has the following attributes:

- Lead Free
- Halogen Free (Chlorine, Bromine)
- Antimony Free
- TBBP-A (C<sub>15</sub>H<sub>12</sub>Br<sub>4</sub>O<sub>2</sub>) Free
- PFOS Free
- SVHC Free



### Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

Tel: 1-844-890-8163

Web: [www.qorvo.com](http://www.qorvo.com)

Email: [customer.support@qorvo.com](mailto:customer.support@qorvo.com)

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