



# TGL2223-SM

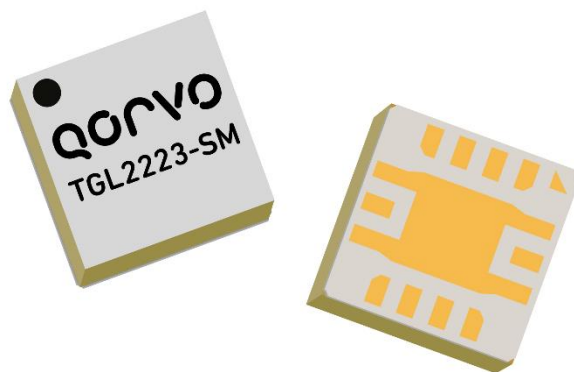
## 1 – 31GHz 5-Bit Digital Attenuator

### Product Description

Qorvo's TGL2223-SM is a wideband, 5-bit digital attenuator fabricated using Qorvo's production 0.15μm GaAs pHEMT process (QPHT15). Operating from 1–31 GHz, the TGL2223-SM offers a low LSB of 0.5 dB and provides 15.5 dB of attenuation range while supporting low RMS step error of less than 0.5 dB.

Using standard, negative control voltages from -3.3 V to -5 V coupled with excellent broadband performance, the TGL2223-SM is ideal for supporting a variety of commercial and military applications.

The TGL2223-SM is packaged in a 3 x 3 (mm) ceramic air-cavity QFN with both RF ports matched to 50 ohms for simple system integration.



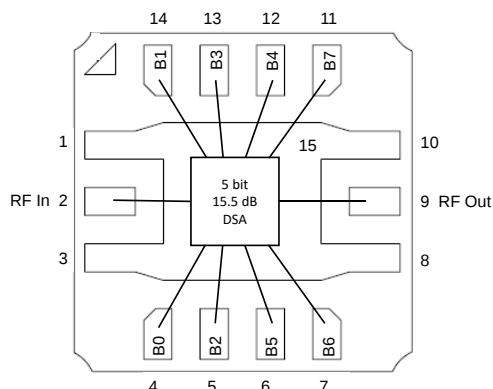
14 Pad 3 x 3 mm Air Cavity QFN Package

### Product Features

- Frequency Range: 1 – 31 GHz
- 5-Bit Digital Attenuator
- Attenuation Step Size (LSB): 0.5 dB
- Attenuation Range: 15.5 dB
- Insertion Loss (Ref. State): 1.8 – 4.2 dB
- RMS Attenuation Error: < 0.9 dB
- RMS Step Error: < 0.5 dB
- Control Voltage: -3.3 to -5.0 V
- Package Size: 3.0 x 3.0 x 1.63 mm

*Performance is typical across frequency. Please reference electrical specification table and data plots for more details.*

### Block Diagram



### Applications

- Commercial and Military Radar
- Electronic Warfare
- Satellite Communications
- Point to Point Radio
- General Purpose

### Ordering Information

| Part No.      | Description                                            |
|---------------|--------------------------------------------------------|
| TGL2223-SMTR7 | 1–31 GHz 5-Bit Digital Attenuator<br>500 Piece 7" Reel |
| 1118396       | TGL2223-SM Evaluation Board                            |

### Absolute Maximum Ratings

| Parameter                                  | Rating        |
|--------------------------------------------|---------------|
| Control Voltage ( $V_C$ )                  | -6 V          |
| Control Current ( $I_C$ )                  | 1 mA          |
| Input Power, ( $P_{IN}$ )                  | 30 dBm        |
| Power Dissipation ( $P_{DISS}$ )           | 0.7 W         |
| Operating Channel Temperature ( $T_{CH}$ ) | 150 °C        |
| Mounting Temperature<br>(30 s max)         | 260 °C        |
| Storage Temperature                        | -40 to 150 °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.

### Recommended Operating Conditions

| Parameter                     | Min | Typ. | Max  | Units |
|-------------------------------|-----|------|------|-------|
| Operating Temperature Range   | -40 | +25  | +85  | °C    |
| Control Voltage (Logic L = 0) |     | -5.0 | -3.3 | V     |
| Control Voltage (Logic H = 1) |     | 0V   |      |       |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.

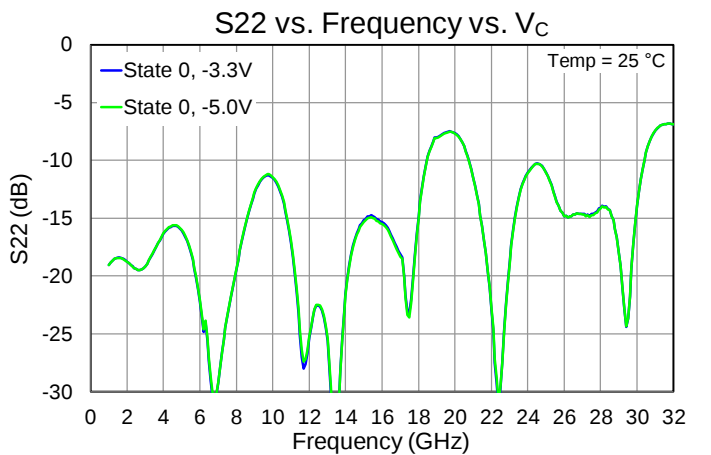
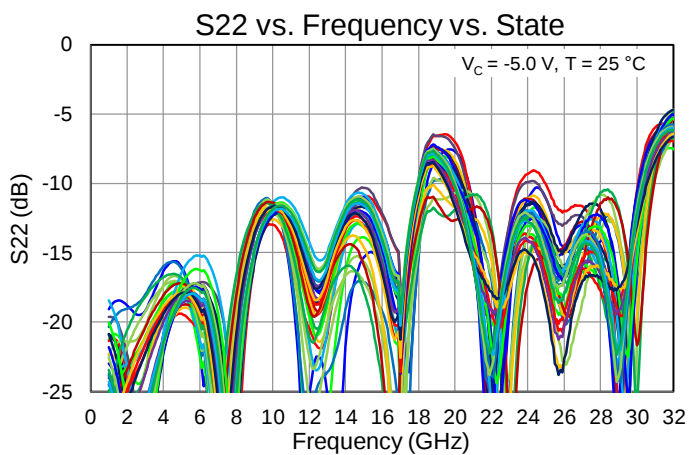
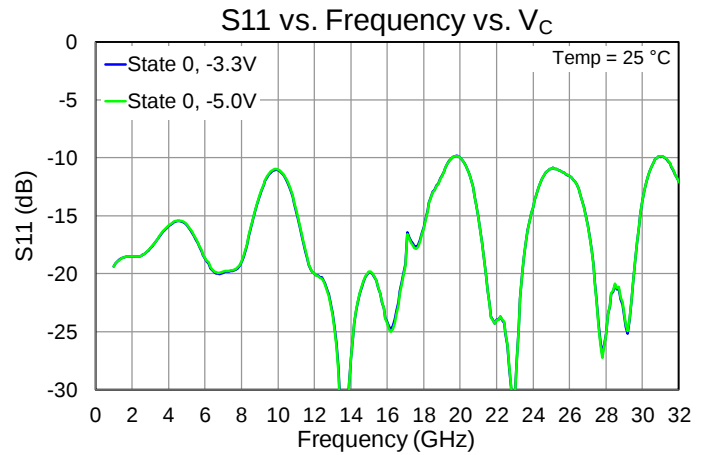
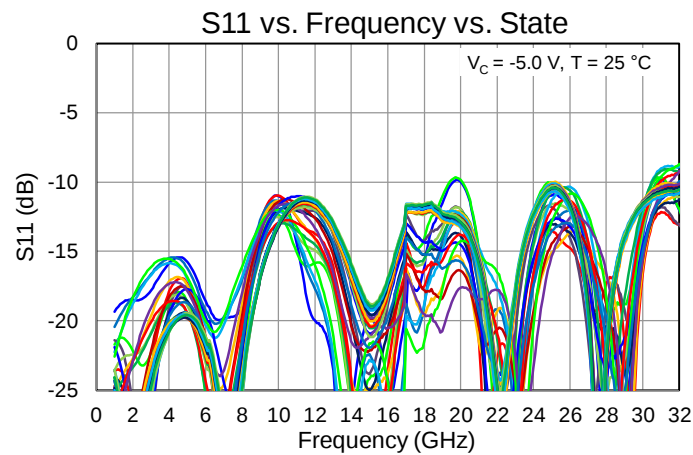
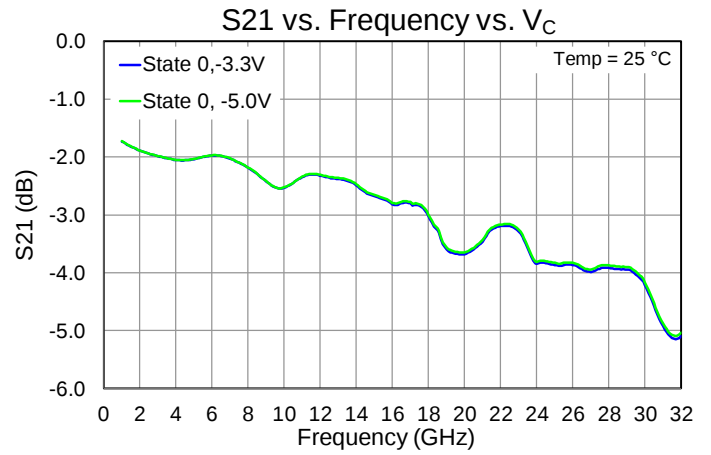
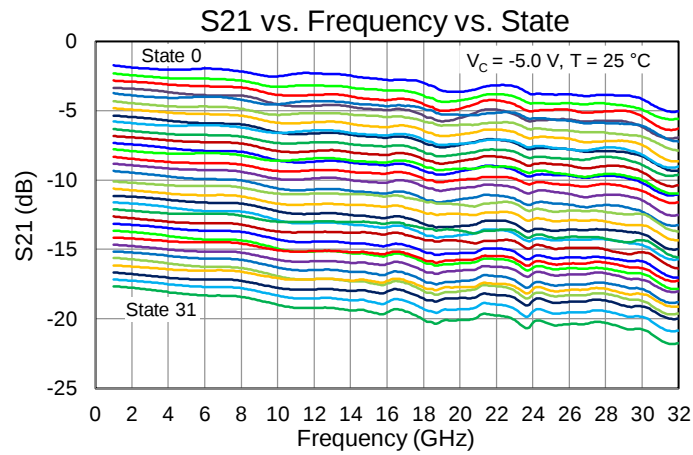
### Electrical Specifications

Test conditions, unless otherwise noted: 25 °C,  $V_C = 0 / -5.0$  V. Tested with DUT on EVB, reference plane at package.

| Parameter                                                          | Min | Typ.  | Max | Units |
|--------------------------------------------------------------------|-----|-------|-----|-------|
| Operational Frequency Range                                        | 1   | –     | 31  | GHz   |
| LSB Attenuation                                                    |     | 0.5   |     | dB    |
| Attenuation Range                                                  |     | 15.5  |     | dB    |
| Reference State Insertion Loss: 1 – 6 GHz                          |     | < 2.0 |     | dB    |
| Reference State Insertion Loss: 6 – 18 GHz                         |     | < 3.0 |     | dB    |
| Reference State Insertion Loss: 18 – 30 GHz                        |     | < 4.5 |     | dB    |
| Input Return Loss                                                  |     | > 10  |     | dB    |
| Output Return Loss                                                 |     | > 7   |     | dB    |
| IIP3 ( $\Delta f = 1.0$ MHz, $P_{IN}/\text{Tone} = 5$ dBm, 14 GHz) |     | > 32  |     | dBm   |
| Switching Speed (10%-90%, 90%-10%)                                 |     | < 30  |     | ns    |
| RMS Attenuation Error                                              |     | < 0.9 |     | dB    |
| RMS Step Error                                                     |     | < 0.5 |     | dB    |
| Max. Attenuation Error                                             |     | < 1.5 |     | dB    |

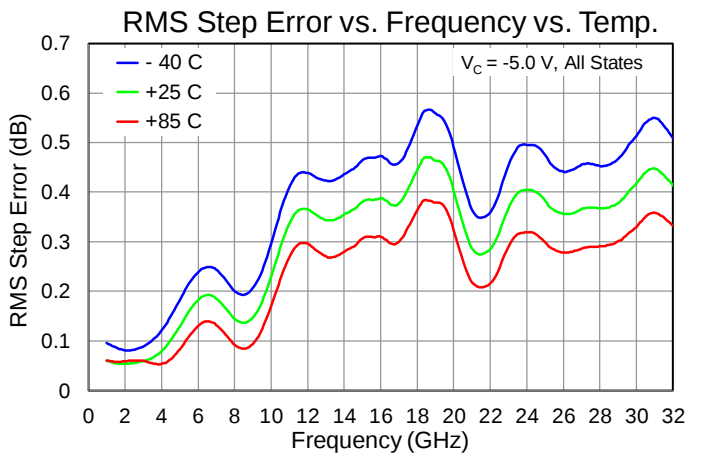
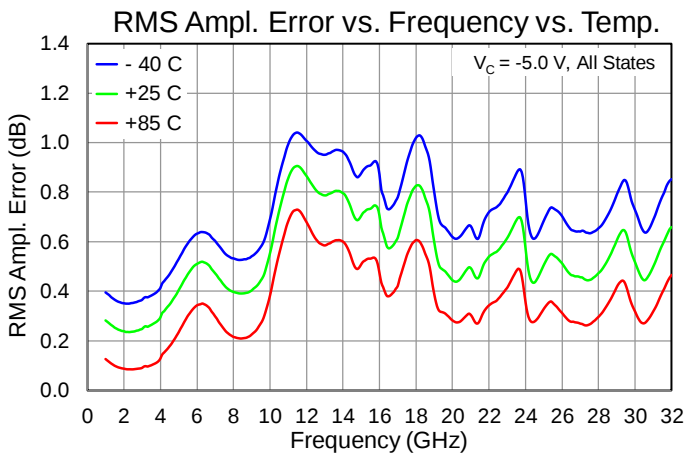
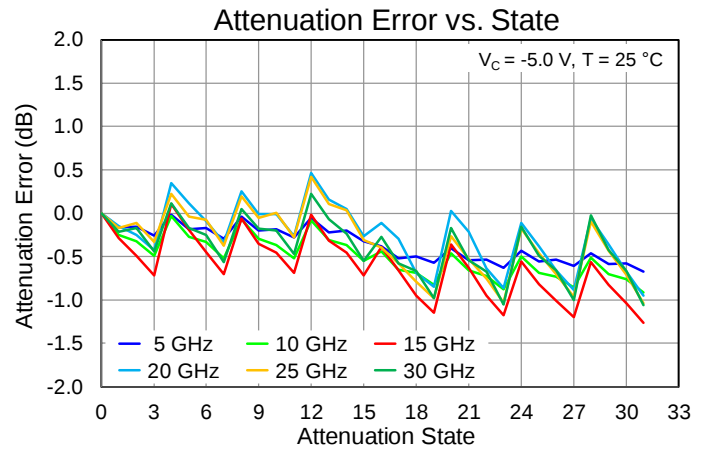
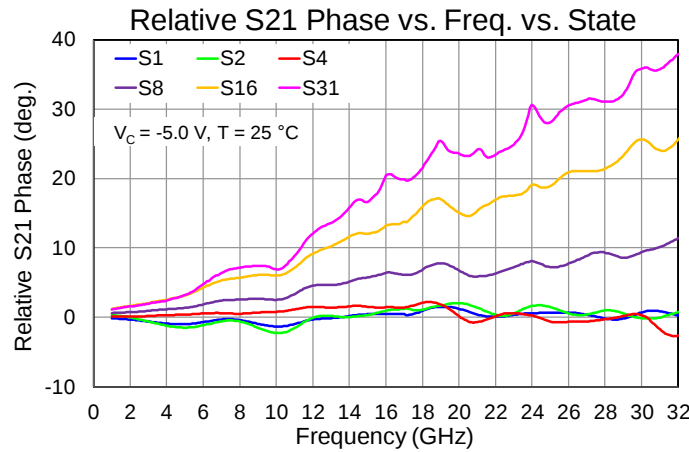
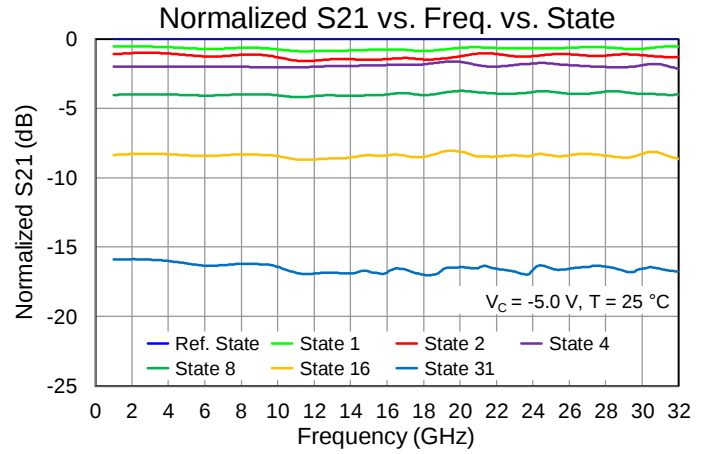
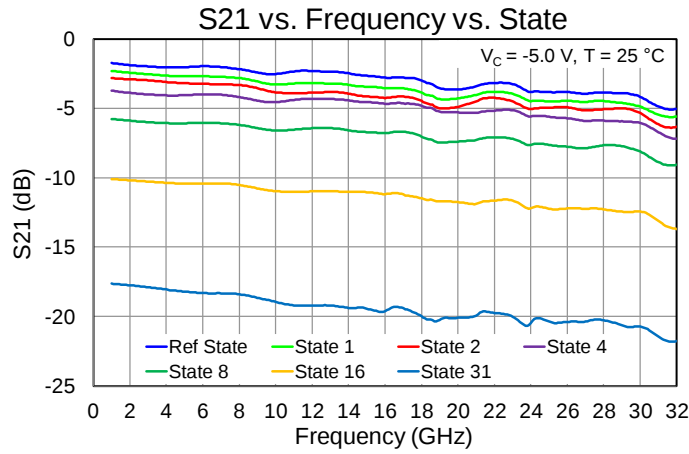
### Performance Plots – Small Signal

Test conditions unless otherwise noted: Tested with DUT on EVB

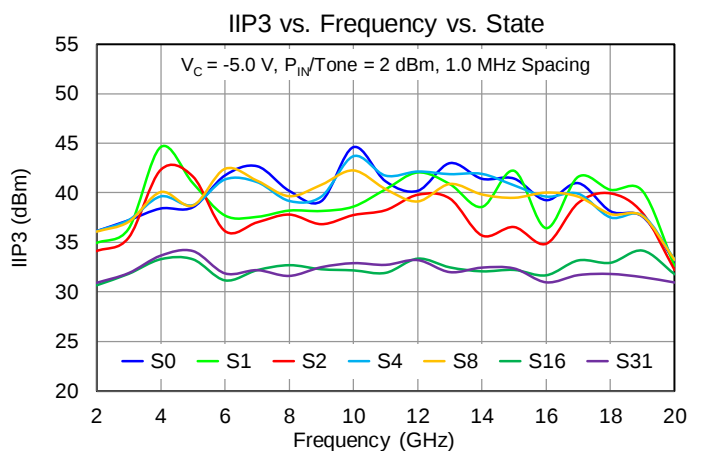
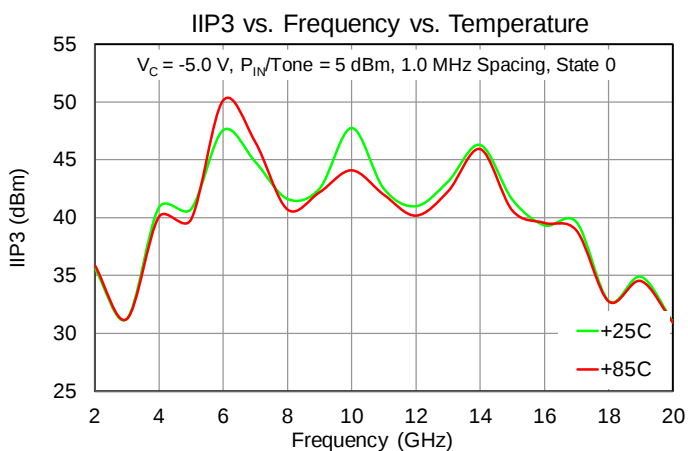
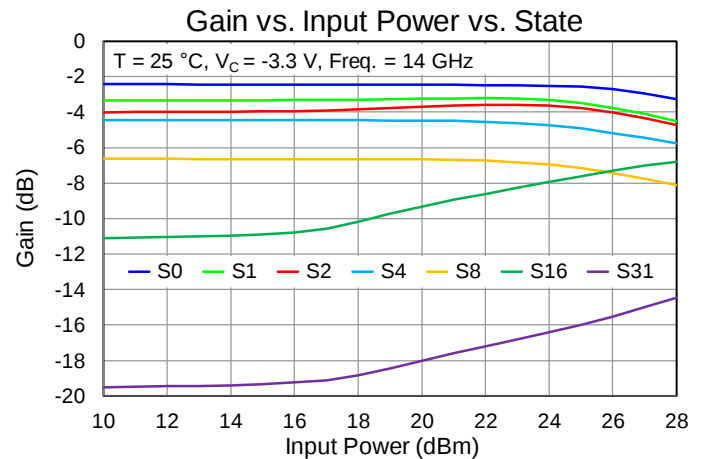
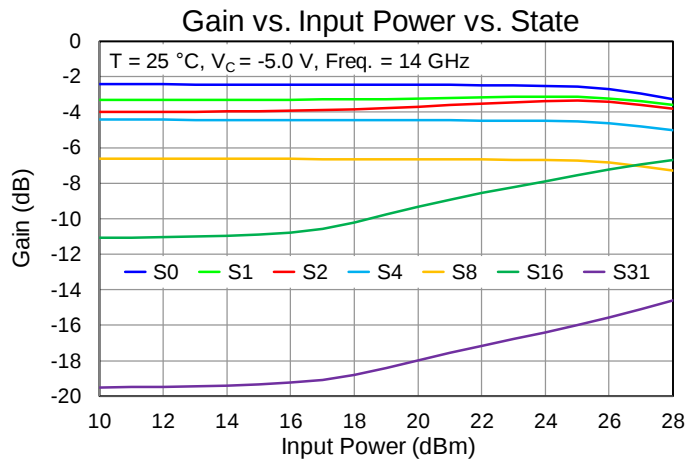
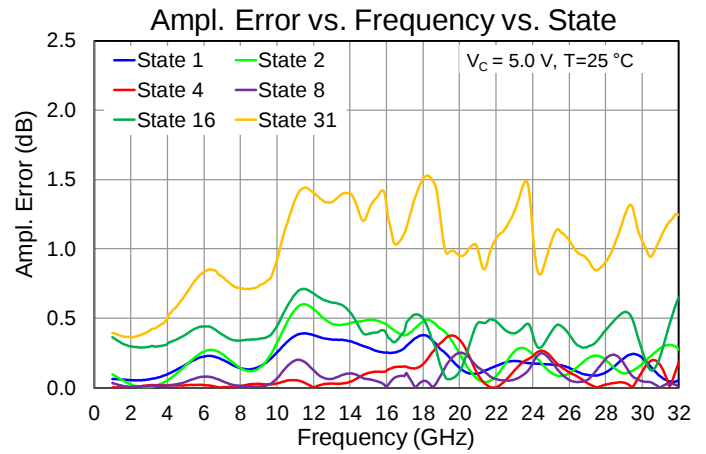
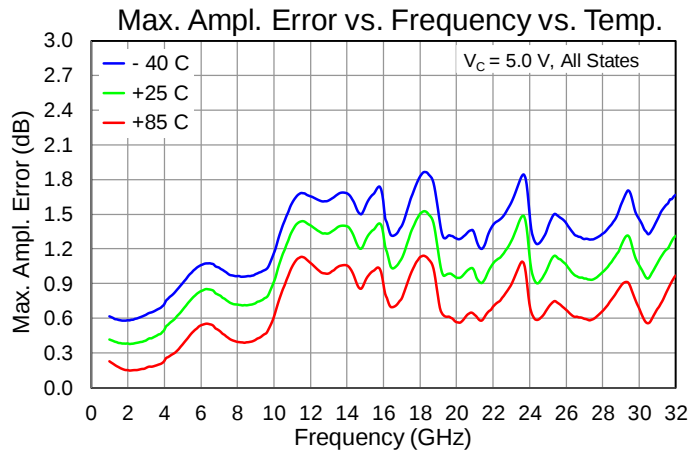


### Performance Plots – Small Signal

Test conditions unless otherwise noted: Tested with DUT on EVB



### Performance Plots – Small, Large Signal & Linearity



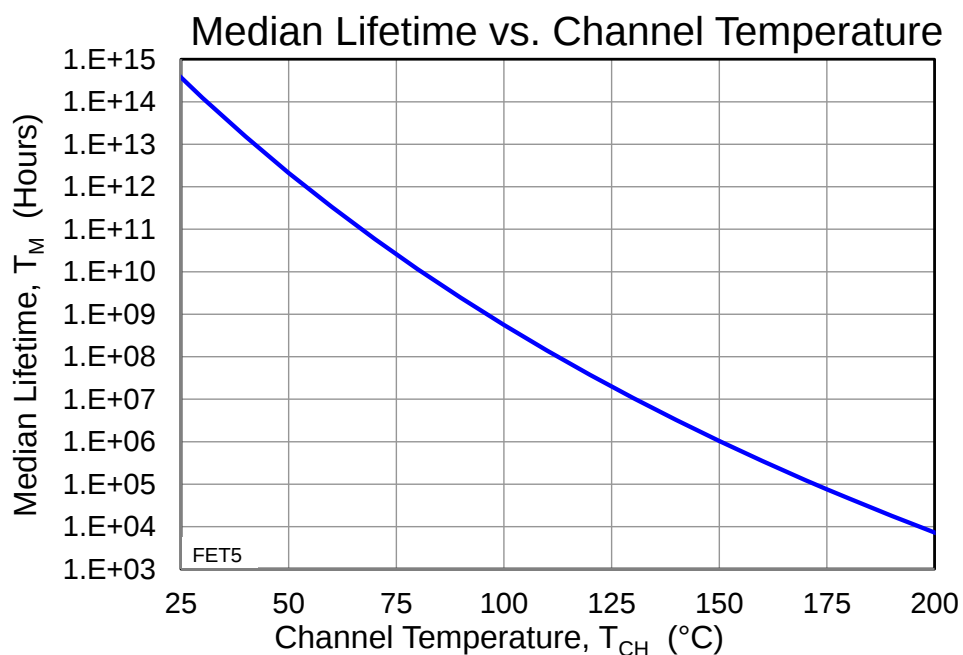
### Thermal and Reliability Information

| Parameter                                           | Test Conditions                                                                               | Value   | Units                |
|-----------------------------------------------------|-----------------------------------------------------------------------------------------------|---------|----------------------|
| Thermal Resistance ( $\theta_{JC}$ ) <sup>(1)</sup> | $T_{BASE} = 85\text{ }^{\circ}\text{C}$ , $V_C = -5.0\text{ V}$ , $P_{DISS} = 0.222\text{ W}$ | 103.6   | $^{\circ}\text{C/W}$ |
| Channel Temperature ( $T_{CH}$ )                    |                                                                                               | 108     | $^{\circ}\text{C}$   |
| Median Lifetime ( $T_M$ )                           |                                                                                               | 2.24E+8 | Hrs                  |

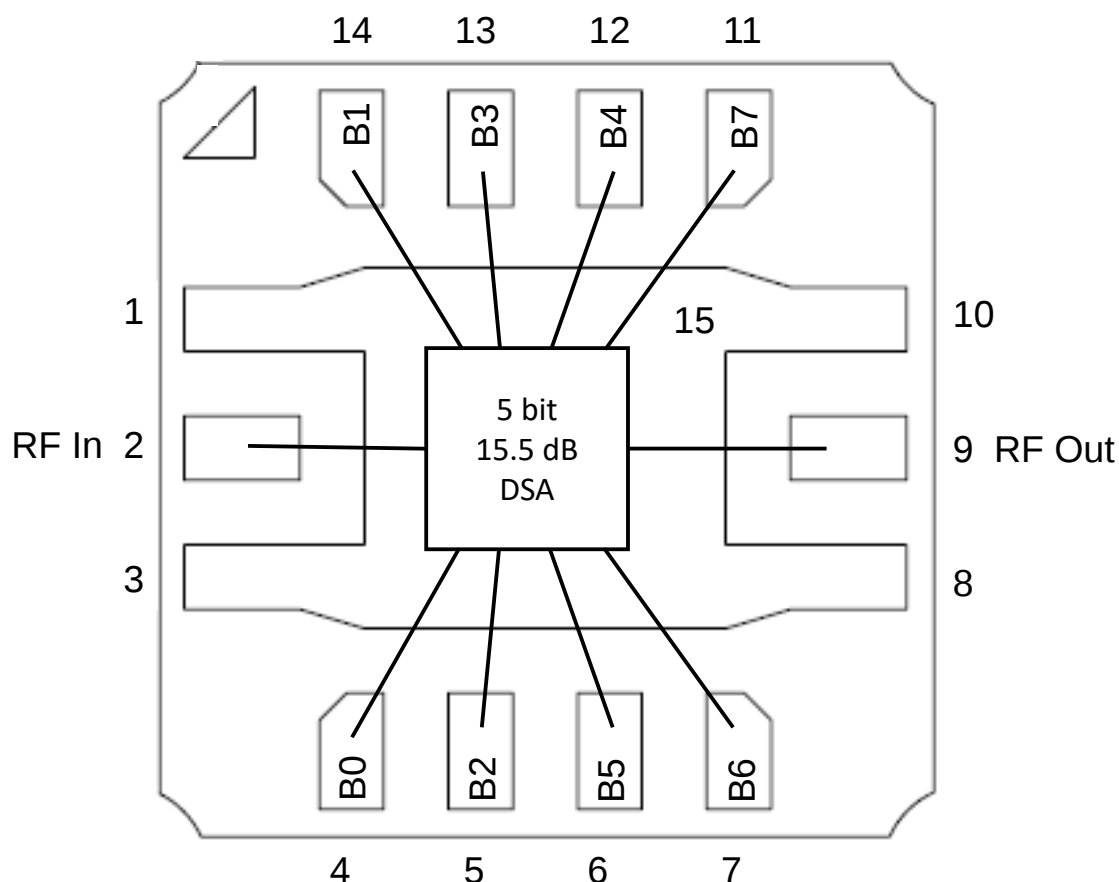
1. Package base backside temperature fixed at 85  $^{\circ}\text{C}$ .

### Median Lifetime

Test Conditions: 6.0 V; Failure Criterion = 10% reduction in  $I_{D\text{ MAX}}$



## Applications Circuit



## Function Table – Major States

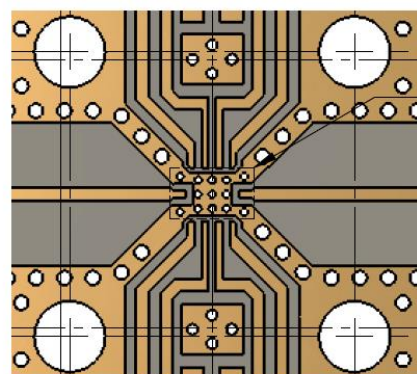
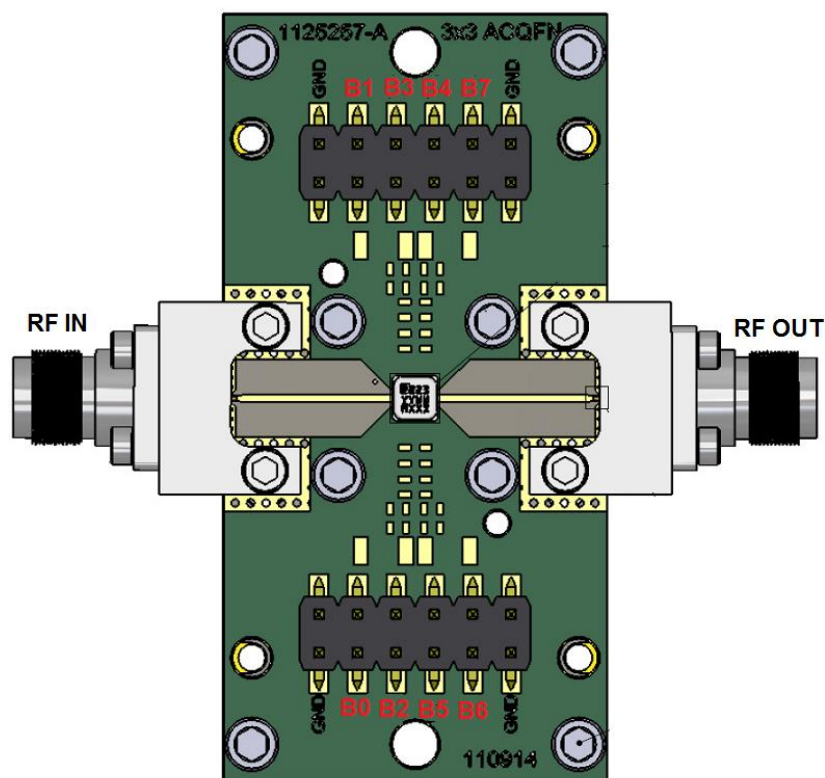
| Parameter                       | State    | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---------------------------------|----------|----|----|----|----|----|----|----|----|
| 0.0 dB Attenuation (Ref. State) | State 0  | 1  | 0  | 0  | 0  | 1  | 0  | 1  | 0  |
| 0.5 dB Attenuation              | State 1  | 1  | 0  | 1  | 0  | 1  | 0  | 1  | 0  |
| 1.0 dB Attenuation              | State 2  | 1  | 0  | 0  | 0  | 1  | 1  | 1  | 0  |
| 2.0 dB Attenuation              | State 4  | 1  | 0  | 0  | 1  | 0  | 0  | 1  | 0  |
| 4.0 dB Attenuation              | State 8  | 1  | 0  | 0  | 0  | 1  | 0  | 0  | 1  |
| 8.0 dB Attenuation              | State 16 | 0  | 1  | 0  | 0  | 1  | 0  | 1  | 0  |
| 15.5 dB Attenuation             | State 31 | 0  | 1  | 1  | 1  | 0  | 1  | 0  | 1  |

Intermediate attenuation states are combinations of the above major states.

Logic H = 1 = 0 V. Logic L = 0 = -3.3 to -5.0 V

Note: RF Input and RF Output are both DC coupled.

## Evaluation Board (EVB) Layout Assembly & Mounting Detail



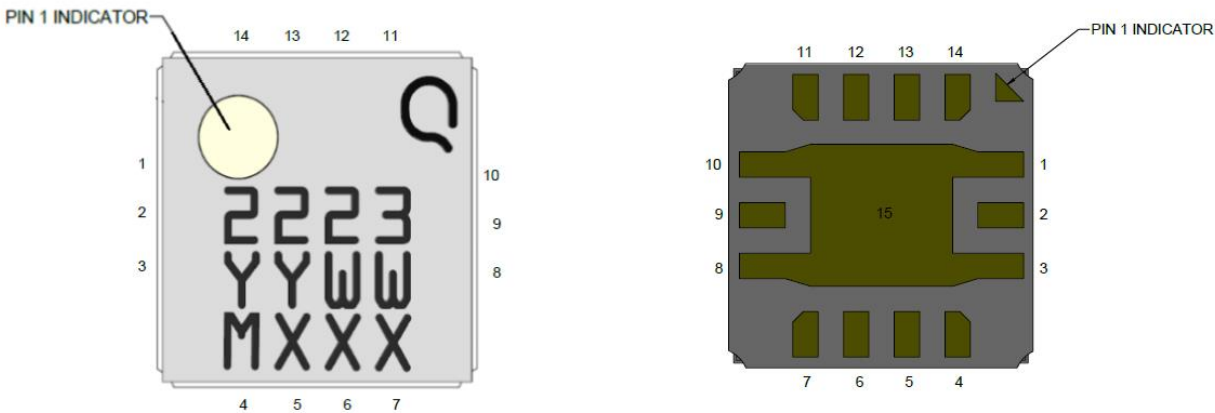
MOUNTING DETAIL

RF Layer is 0.008" thick Rogers Corp. RO4003C,  $\epsilon_r = 3.38$ . Metal layers are 0.5 oz. copper. The micro strip line at the connector interface is optimized for the Southwest Microwave end launch connector 1092-01A-5.

Reference plane is at the package.

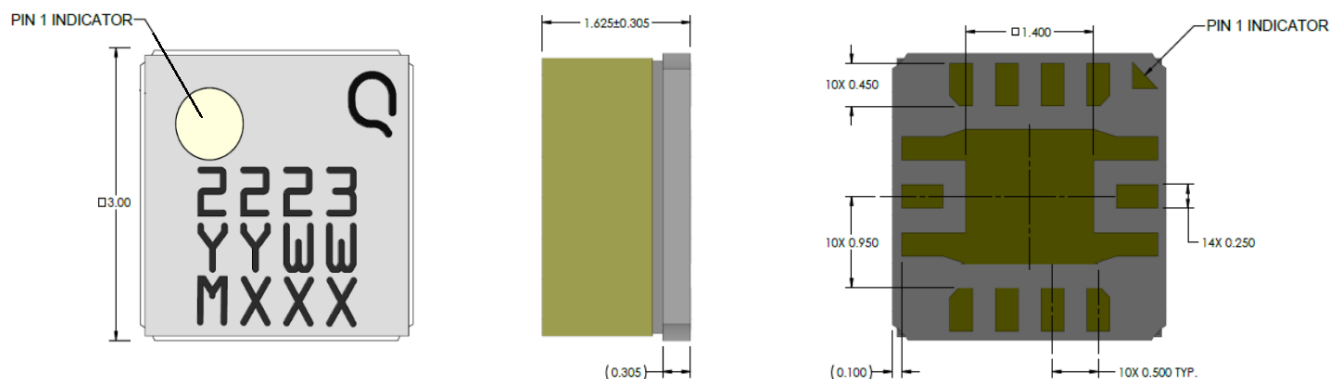
Note: Multiple vias should be employed under die to minimize inductance and thermal resistance.

Pad Configuration and Description



| Pin No.         | Symbol | Description                               |
|-----------------|--------|-------------------------------------------|
| 1, 3, 8, 10, 15 | GND    | Package Ground                            |
| 2               | RF IN  | RF Input                                  |
| 4               | B0     | Complementary control line for 8.0 dB bit |
| 5               | B2     | Control Line for 0.5 dB bit               |
| 6               | B5     | Control Line for 1.0 dB bit               |
| 7               | B6     | Complementary control line for 4.0 dB bit |
| 9               | RF OUT | RF Output                                 |
| 11              | B7     | Complementary control line for 4.0 dB bit |
| 12              | B4     | Complementary control line for 2.0 dB bit |
| 13              | B3     | Complementary control line for 2.0 dB bit |
| 14              | B1     | Complementary control line for 8.0 dB bit |

### Package Marking and Dimensions



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS.  
TOLERANCE IS: .XX =  $\pm 0.25$ ; .XXX =  $\pm 0.127$ , and ANGLES =  $0.5^\circ$

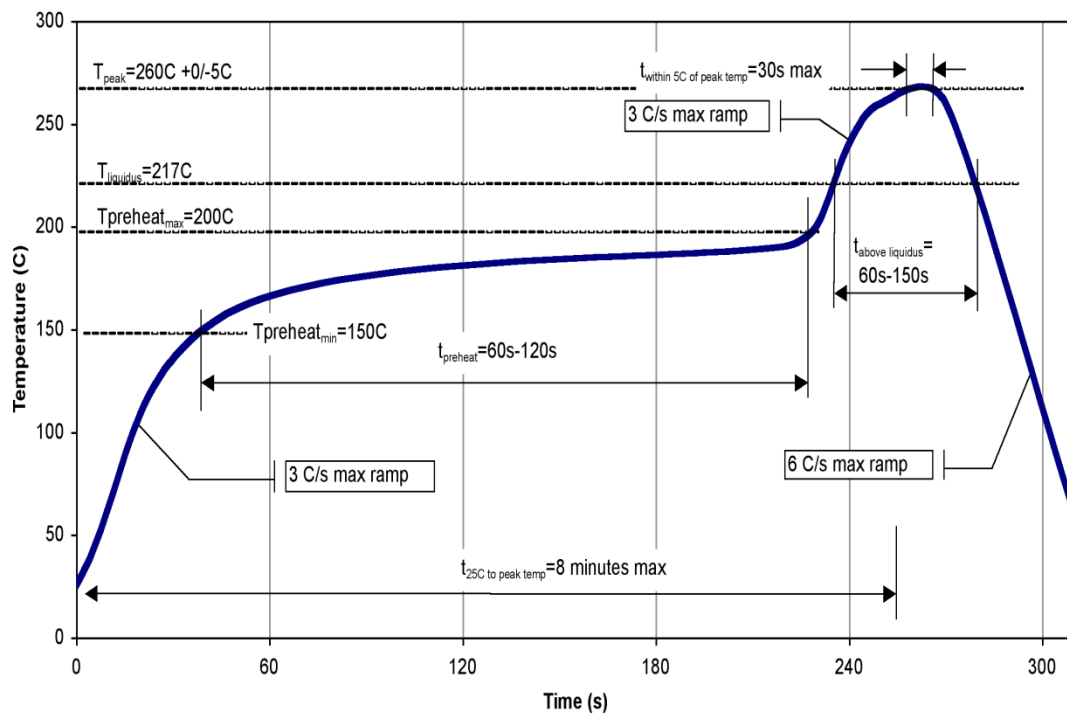
#### NOTES:

1. MATERIAL:
  - PACKAGE BASE: CERAMIC
  - PACKAGE LID: LAMINATE
2. PART IS EPOXY SEALED
3. ALL METALIZED FEATURES ARE GOLD PLATED:
4. PART MARKING:
  - 2223: PART NUMBER
  - YY: PART ASSY YEAR
  - WW: PART ASSY WEEK
  - MXXX: BATCH ID

### Assembly Notes

- Compatible with lead-free soldering process with 260°C peak reflow temperature.
- This package is non-hermetic and therefore cannot be subjected to aqueous washing. The use of no-clean solder to avoid washing after soldering is recommended
- Contact plating: Ni-Au

### Recommended Soldering Profile



### Handling Precautions

| Parameter                        | Rating   | Standard                 |
|----------------------------------|----------|--------------------------|
| ESD – Human Body Model (HBM)     | Class 0A | ESDA / JEDEC JS-001-2012 |
| ESD – Charge Device Model (CDM)  | Class C1 | EIA/JESD22-C101E         |
| MSL – Moisture Sensitivity Level | Level 5a | IPC/JEDEC J-STD-020      |



Caution!  
ESD-Sensitive Device

### RoHS Compliance

This product is compliant with the 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
- 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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