



# TGL2223-SM

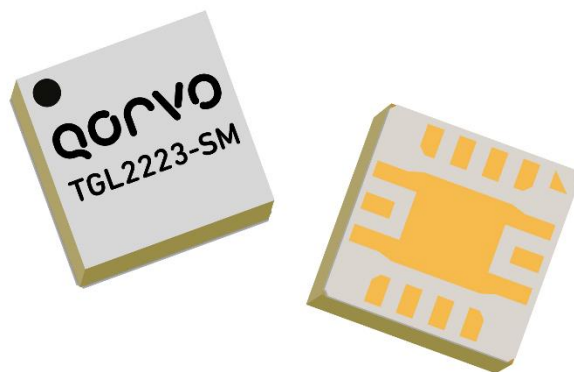
## 1 – 31GHz 5-Bit Digital Attenuator

### 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 of 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.



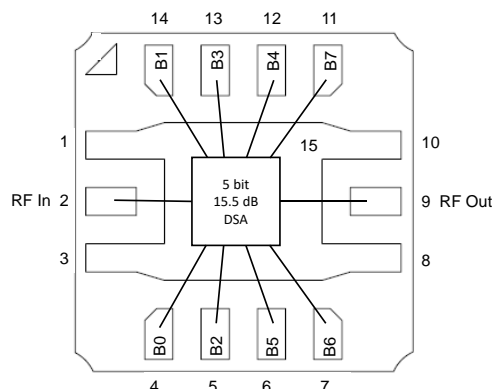
14 Pad 3 x 3 mm Air Cavity QFN Package

### 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 1.45 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-SM	1–31 GHz 5-Bit Digital Attenuator
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 (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.

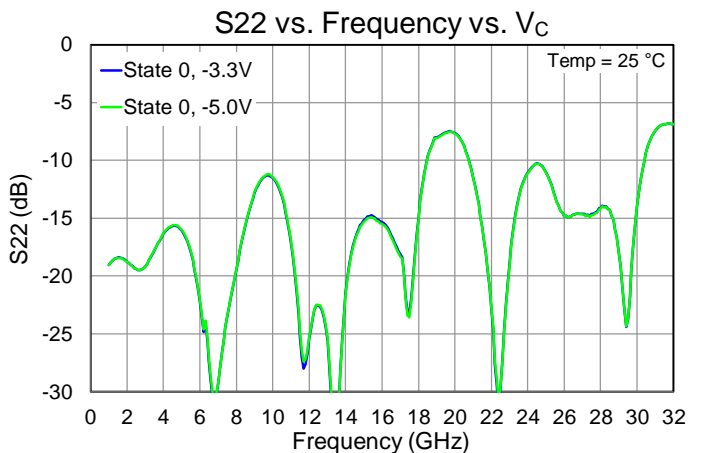
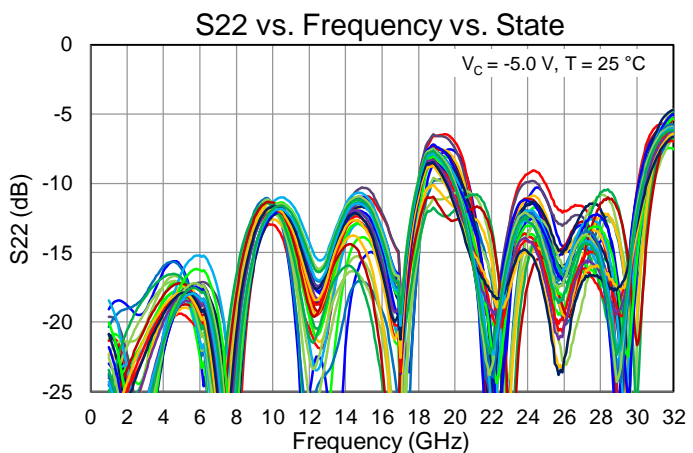
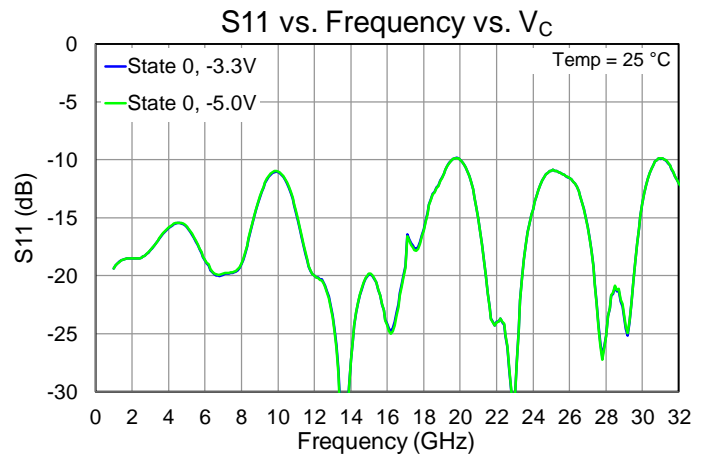
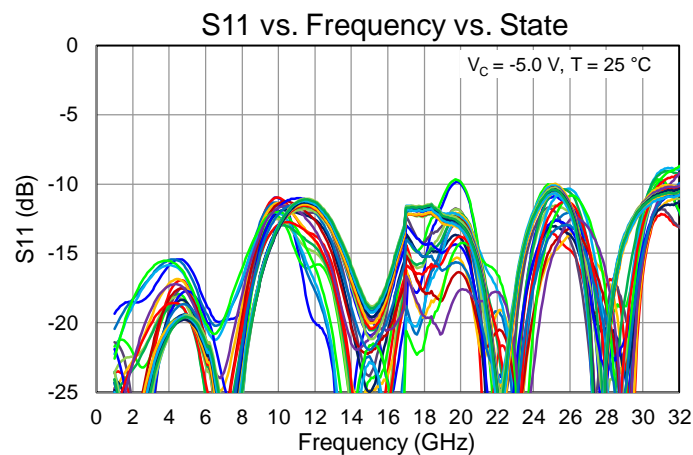
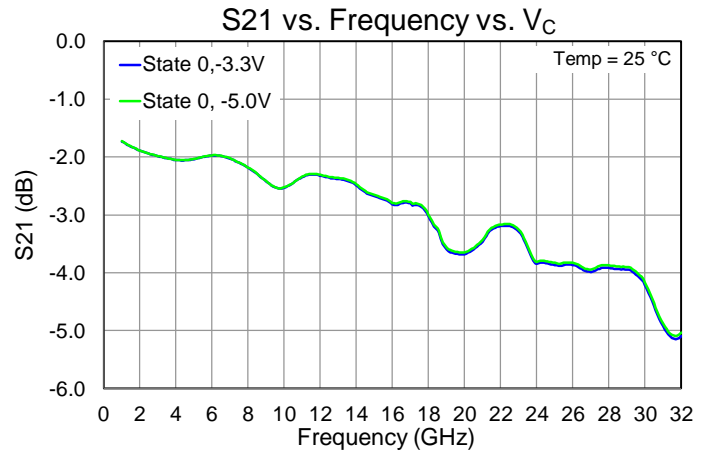
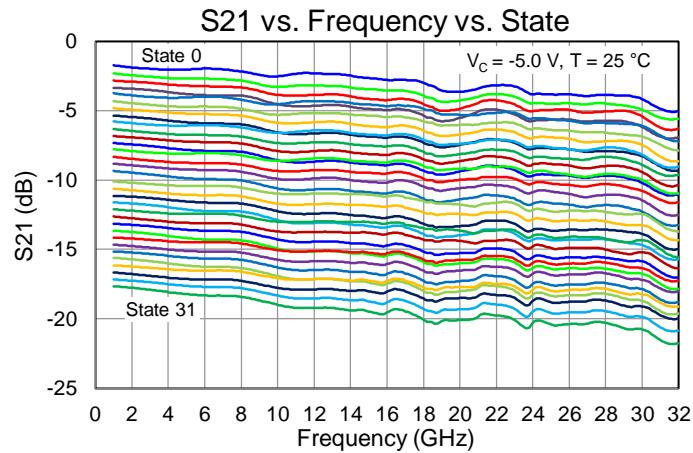
### Electrical Specifications

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

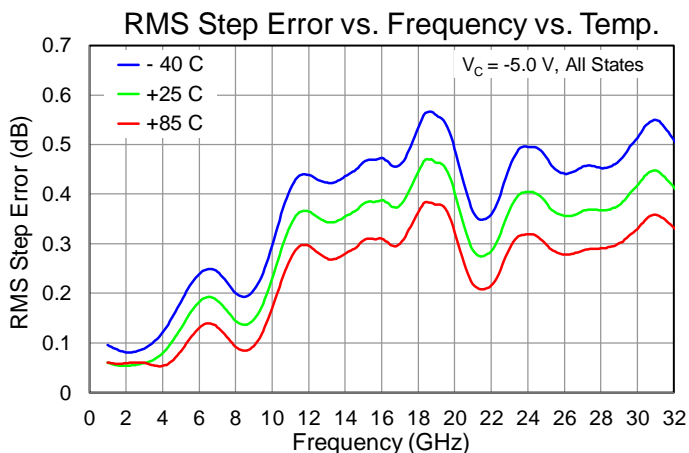
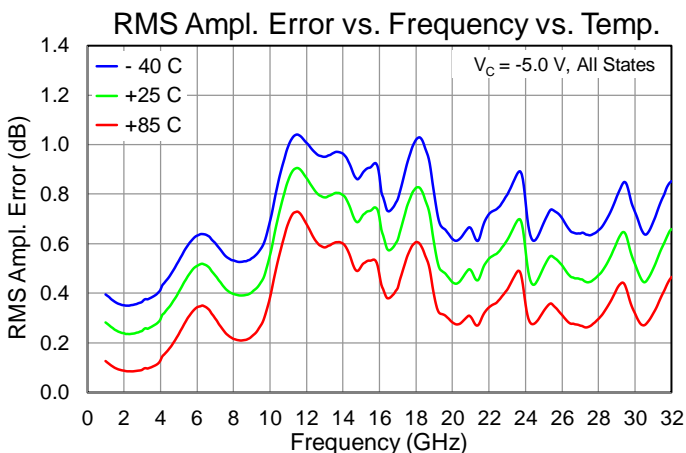
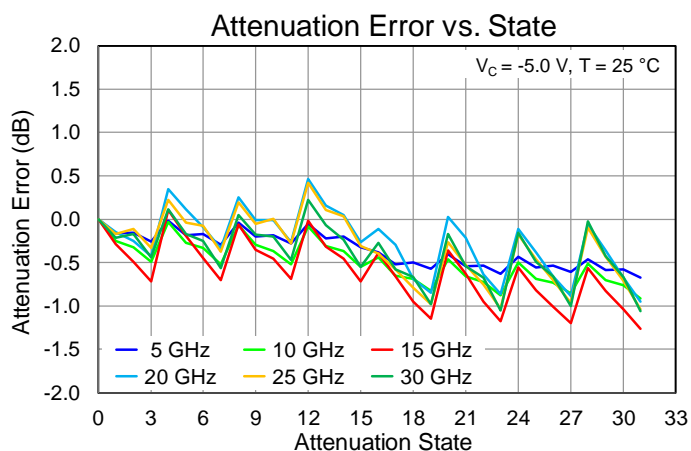
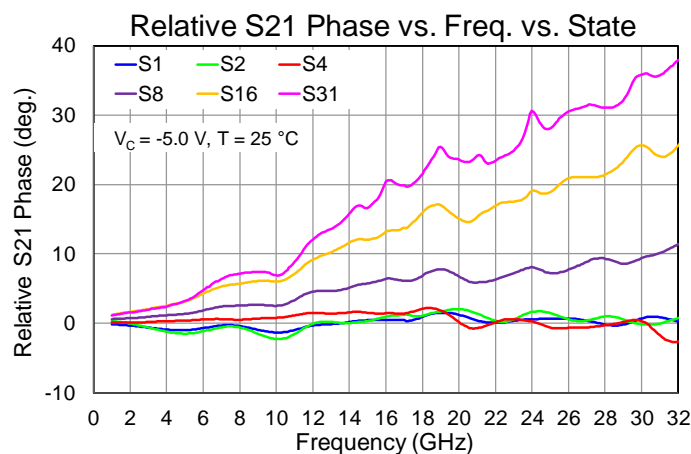
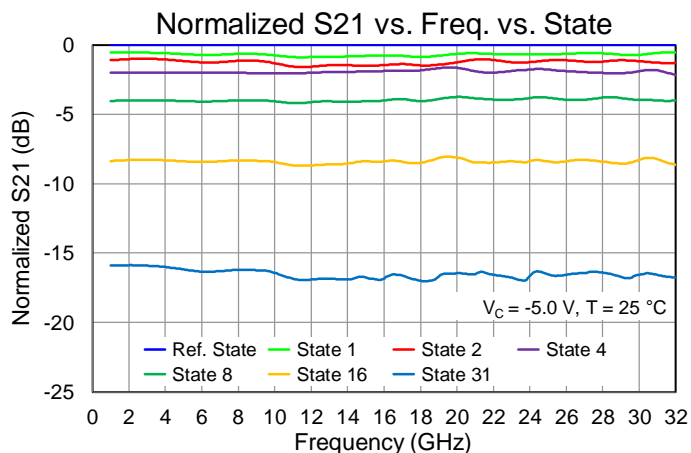
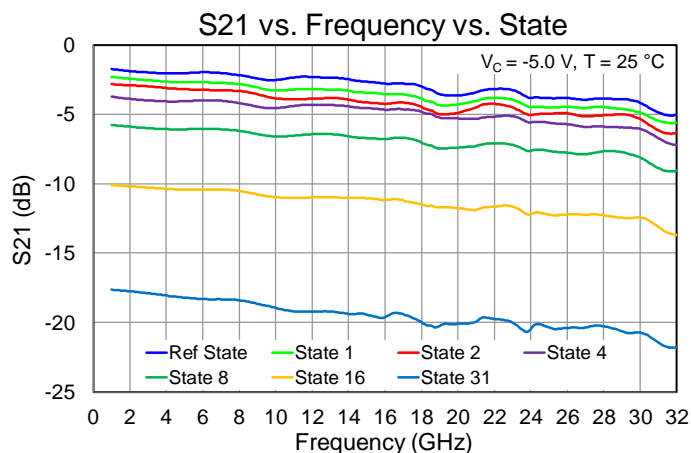
### Performance Plots – Small Signal

Test conditions unless otherwise noted: Tested with DUT on EVB

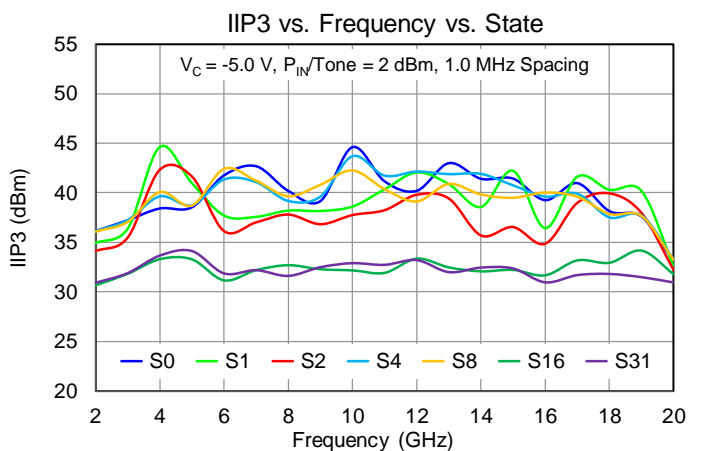
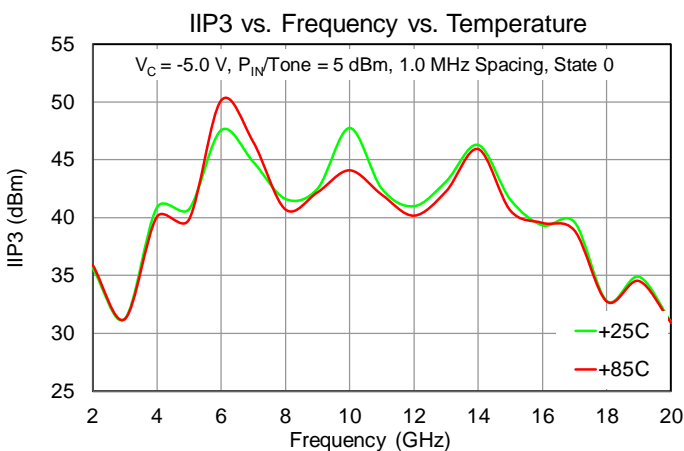
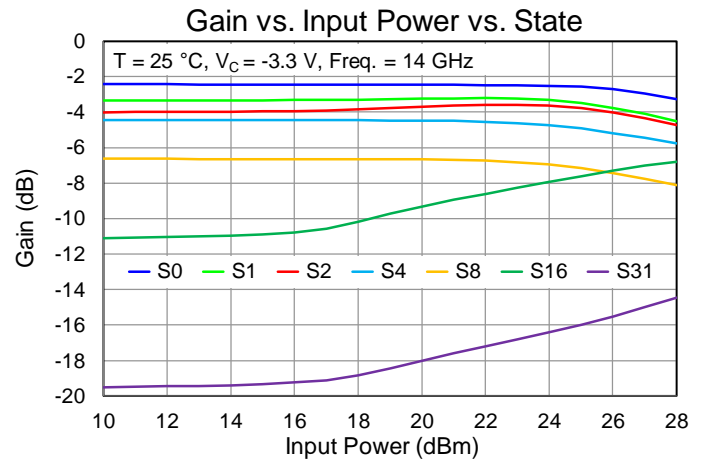
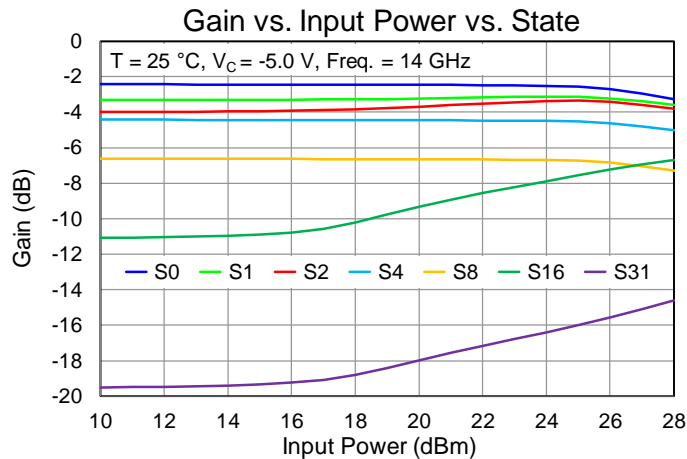
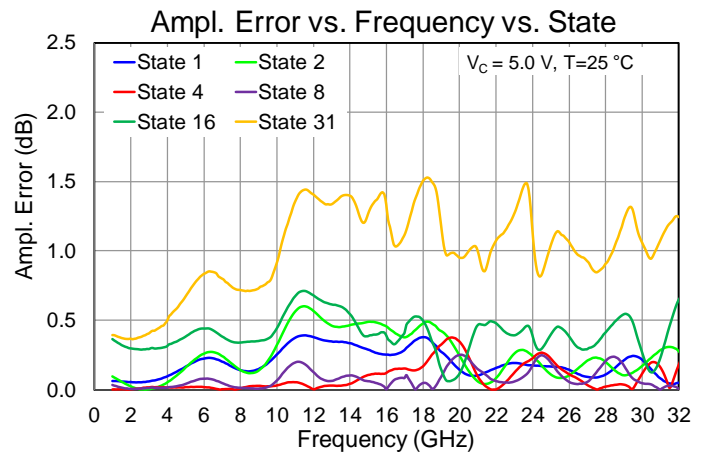
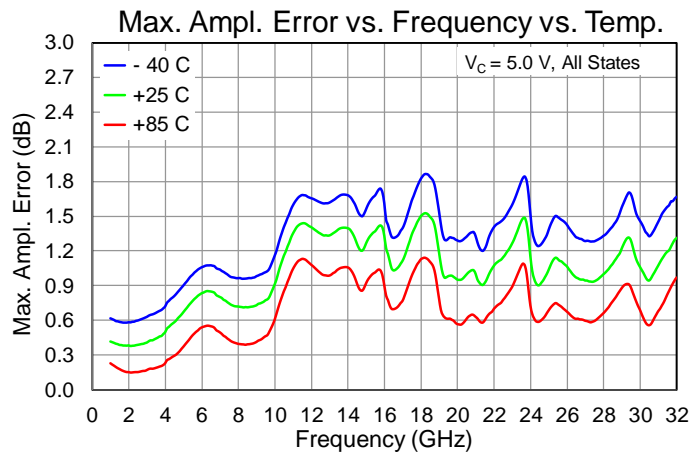


### Performance Plots – Small Signal

Test conditions unless otherwise noted: Tested with DUT on EVB



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



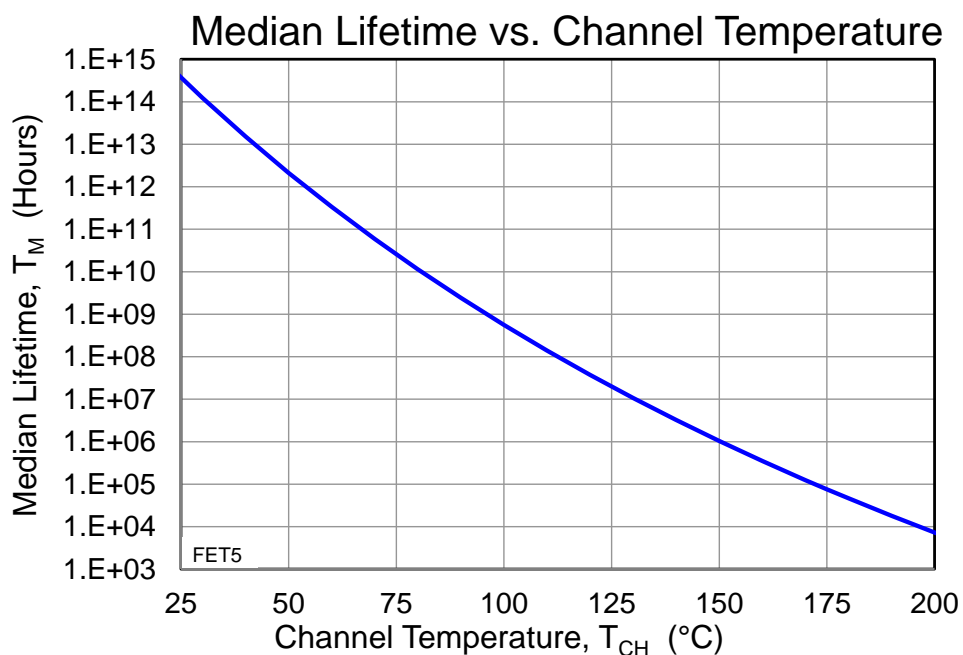
### Thermal and Reliability Information

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

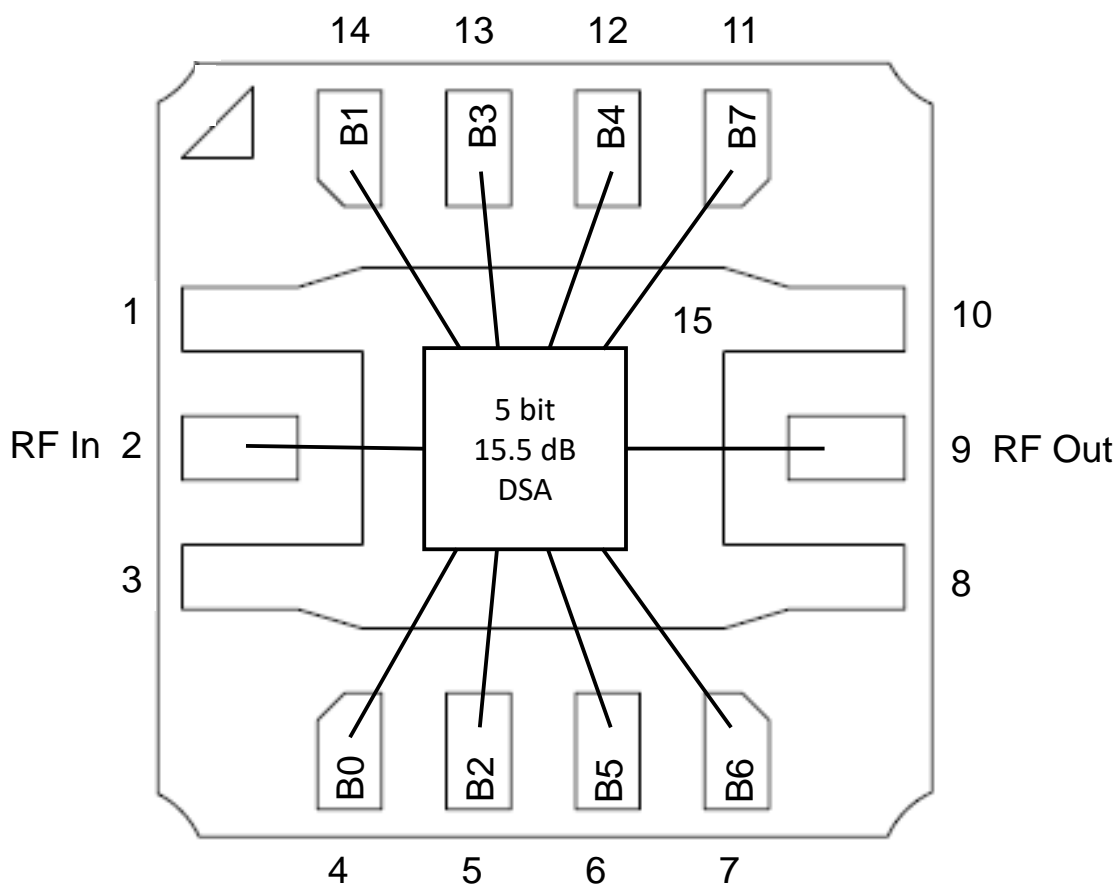
1. Package base backside temperature fixed at 85  $^{\circ}\text{C}$ .

### Median Lifetime

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



## Applications Circuit



## Function Table – Major States

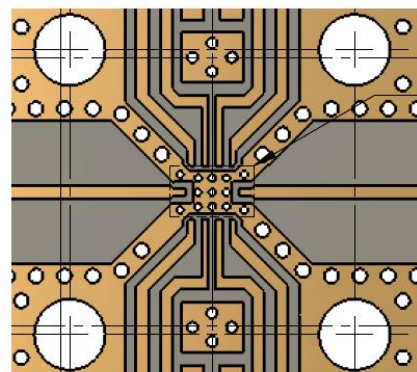
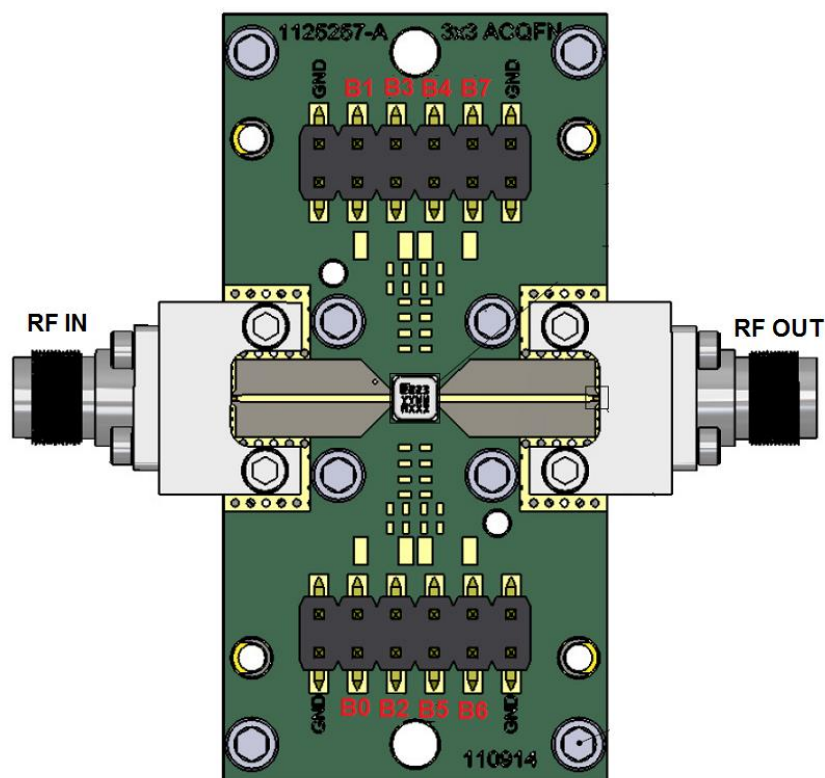
Parameter	State	B0	B1	B2	B3	B4	B5	B6	B7
0.0 dB Attenuation (Ref. State)	State 0	1	0	0	0	1	0	1	0
0.5 dB Attenuation	State 1	1	0	1	0	1	0	1	0
1.0 dB Attenuation	State 2	1	0	0	0	1	1	1	0
2.0 dB Attenuation	State 4	1	0	0	1	0	0	1	0
4.0 dB Attenuation	State 8	1	0	0	0	1	0	0	1
8.0 dB Attenuation	State 16	0	1	0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

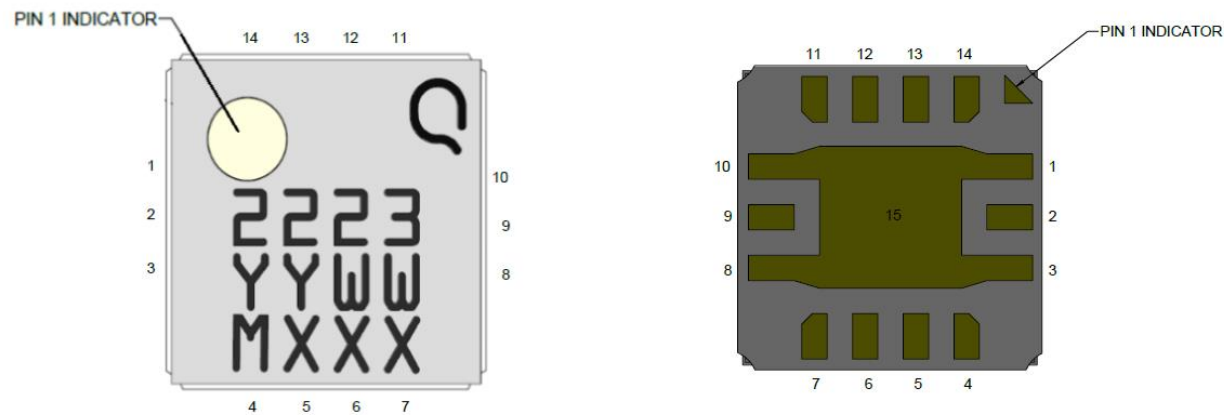




TGL2223-SM

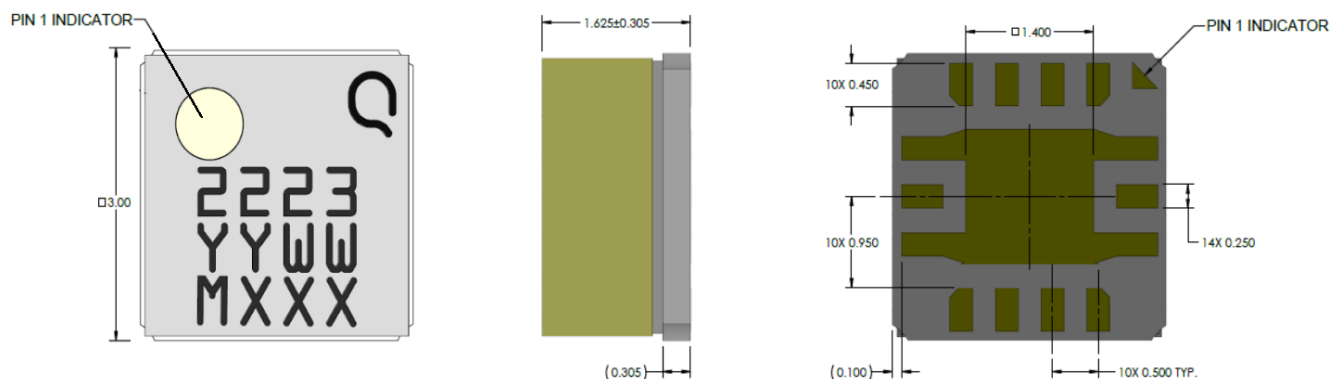
1 – 31GHz 5-Bit Digital Attenuator

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 =  $0.5^\circ$

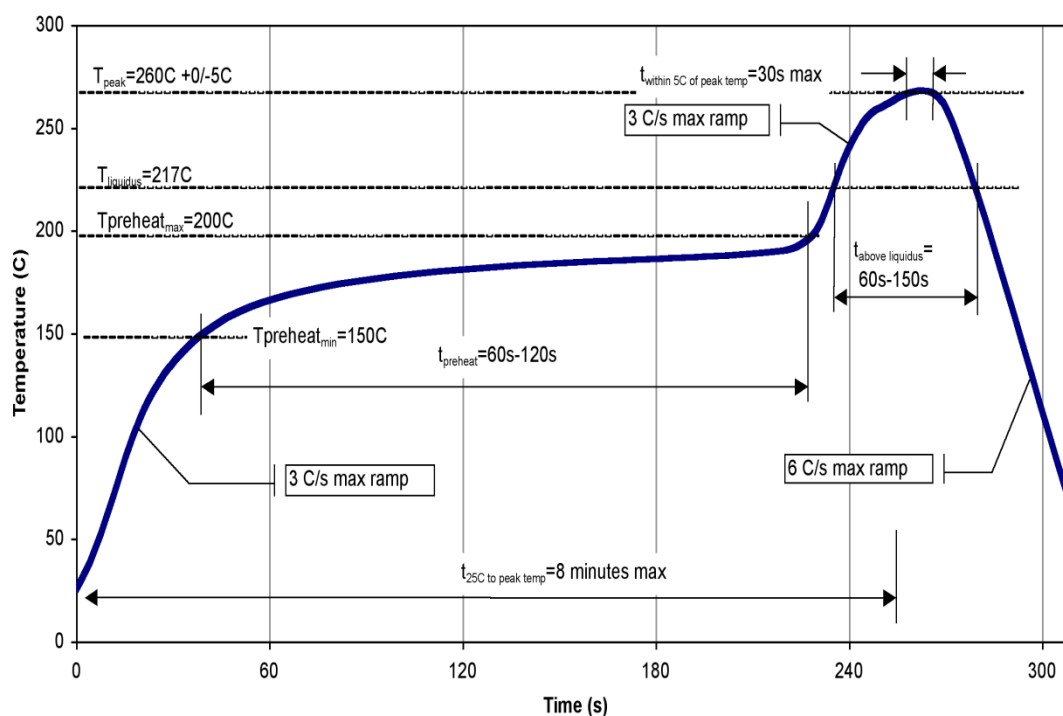
#### NOTES:

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
- Solder rework not 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:

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

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

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