

### Product Description

Qorvo's TGP2105 is a 6-bit, digital phase shifter fabricated on Qorvo's high performance 0.15 $\mu$ m GaAs pHEMT process. It operates over 6 to 18 GHz and provides 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 4° with 8 dB of insertion loss over all states.

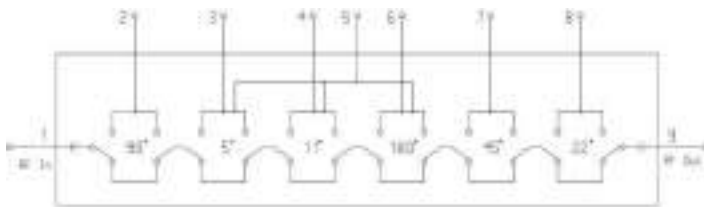
The TGP2105 uses positive switch logic, eliminating the need for a negative voltage rail. That, along with low insertion and a high degree of resolution makes the TGP2105 ideally suited for a variety of wideband phased array applications, including commercial and military radars, satellite-based communication systems and electronic warfare.



### Product Features

- Frequency Range: 6 to 18 GHz
- 6-Bit Digital Phase Shifter
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 4°
- RMS Amplitude Error: 0.45 dB
- Insertion Loss: <10 dB
- Return Loss: >12 dB
- Input P1dB: >25 dBm
- Input IP3: >41 dBm
- Control Voltage: 0/+5 V
- Chip Dimensions: 3.15 x 3.15 x 0.10 mm

### Block Diagram



### Applications

- Phased Array Antenna Systems
- Satellite Communication Systems
- Electronic Warfare

### Ordering Information

| Part No. | Description              |
|----------|--------------------------|
| 1096002  | Waffle Pack, Qty 20      |
| 1101242  | TGP2105 Evaluation Board |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | -15 to +5 mA  |
| Power Dissipation                   | 0.9 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 30 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 320 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                                           | Value            |
|-----------------------------------------------------|------------------|
| Control Voltage (5°, 11°, 22°, 45°, 90°, 180°, REF) | 0/+5 V           |
| Operating Temperature Range                         | -40 °C to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Bias and Truth Table

Control voltage Logic "0" = VL, value between 0 to 0.2 V; Logic "1" = VH, value between +3V to +5V

| Phase Shift    | 5° | 11° | 22° | 45° | 90° | 180° | REF |
|----------------|----|-----|-----|-----|-----|------|-----|
| 0° (Reference) | 0  | 0   | 0   | 0   | 0   | 0    | 1   |
| 5°             | 1  | 0   | 0   | 0   | 0   | 0    | 1   |
| 11°            | 0  | 1   | 0   | 0   | 0   | 0    | 1   |
| 22°            | 0  | 0   | 1   | 0   | 0   | 0    | 1   |
| 45°            | 0  | 0   | 0   | 1   | 0   | 0    | 1   |
| 90°            | 0  | 0   | 0   | 0   | 1   | 0    | 1   |
| 180°           | 0  | 0   | 0   | 0   | 0   | 1    | 1   |
| 355°           | 1  | 1   | 1   | 1   | 1   | 1    | 1   |

### Electrical Specifications

Test conditions unless otherwise noted: 25 °C

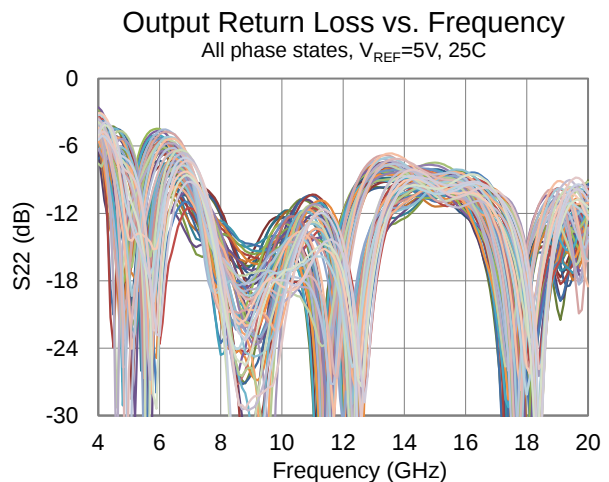
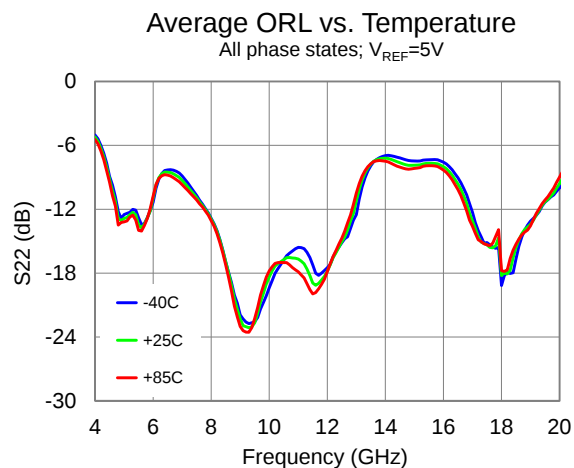
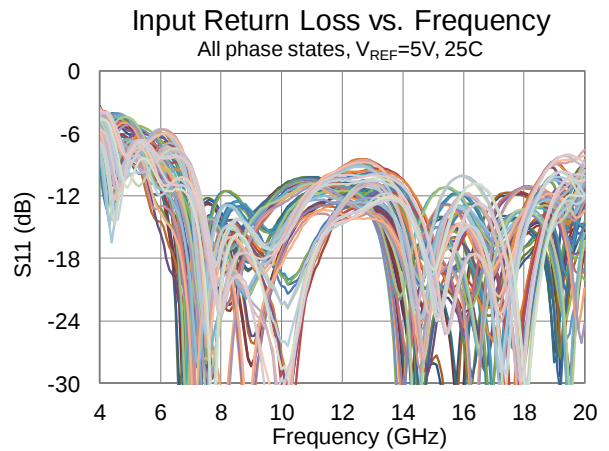
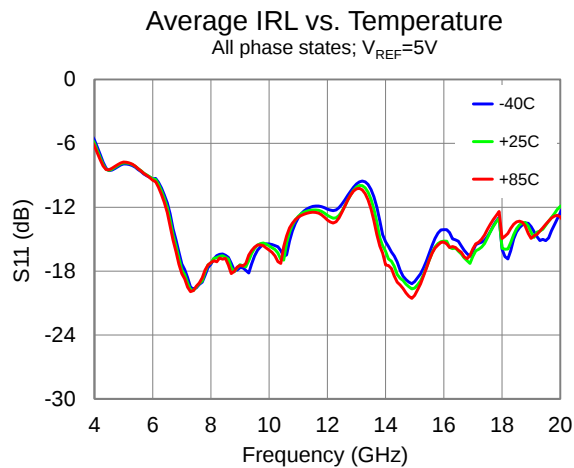
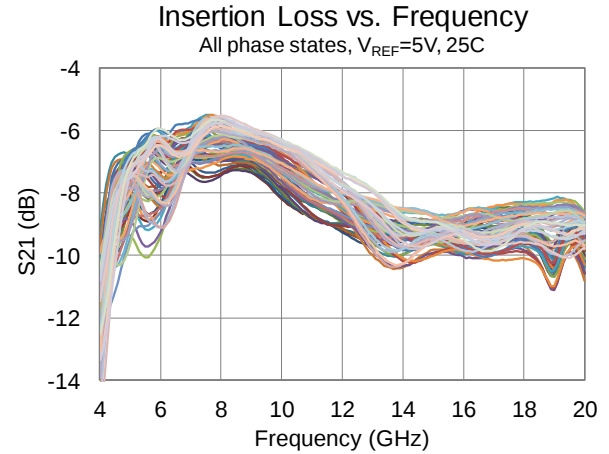
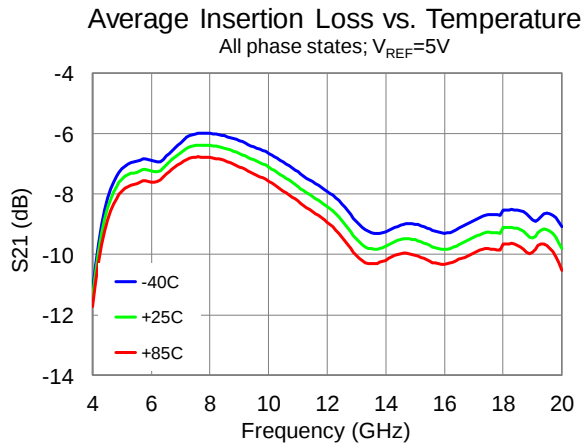
Data de-embedded to device reference planes at end of feeds, data include bond wire effects

Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) VL = 0 V, VH = +5 V; See Bias Truth Table

| Parameter                                           | Min | Typical | Max | Units |
|-----------------------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range                         | 6   |         | 18  | GHz   |
| Insertion Loss                                      |     | 6 - 10  |     | dB    |
| Input Return Loss                                   |     | >12     |     | dB    |
| Output Return Loss                                  |     | >12     |     | dB    |
| RMS Phase Error                                     |     | 4       |     | deg   |
| RMS Amplitude Error                                 |     | 0.45    |     | dB    |
| Input P1dB                                          |     | >25     |     | dBm   |
| Input IP3, Tone spacing = 10 MHz, Pin/Tone = 15 dBm |     | >41     |     | dBm   |
| Insertion Loss Temperature Coefficient              |     | 0.008   |     | dB/°C |

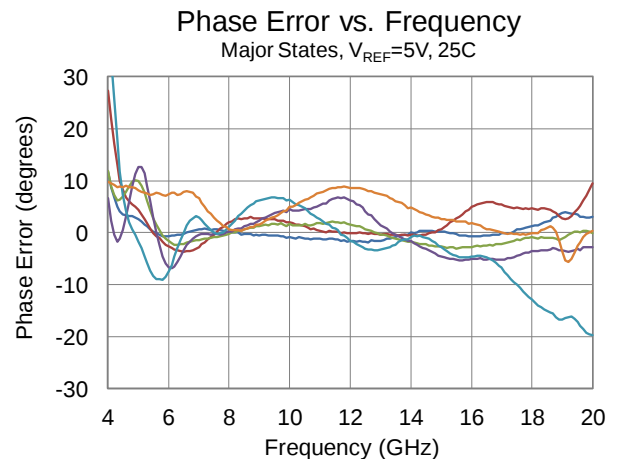
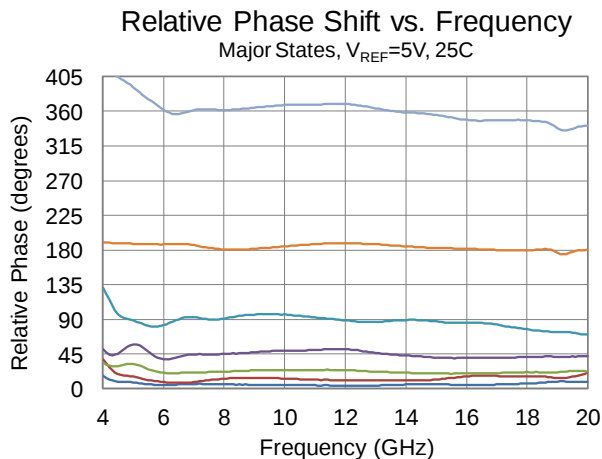
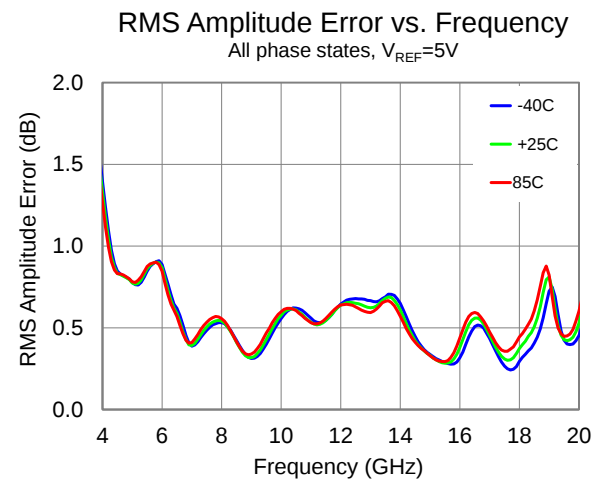
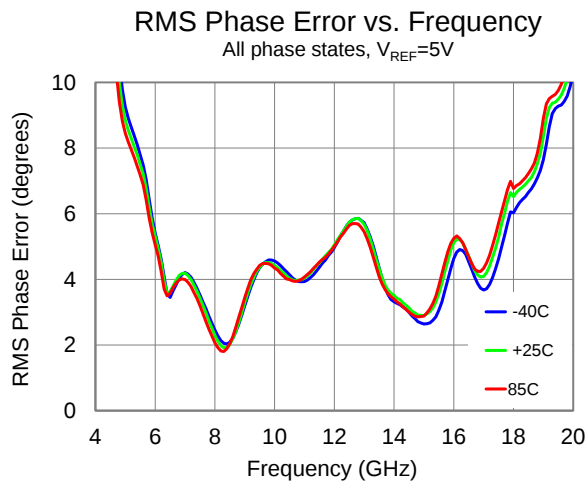
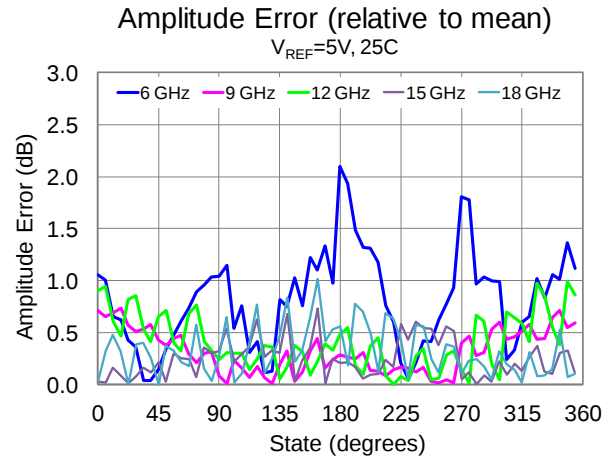
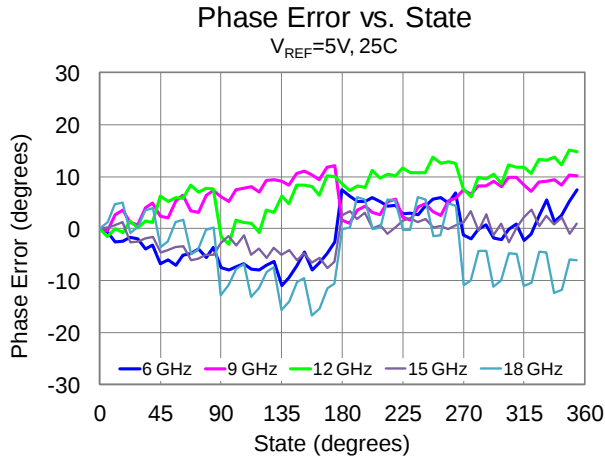
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C



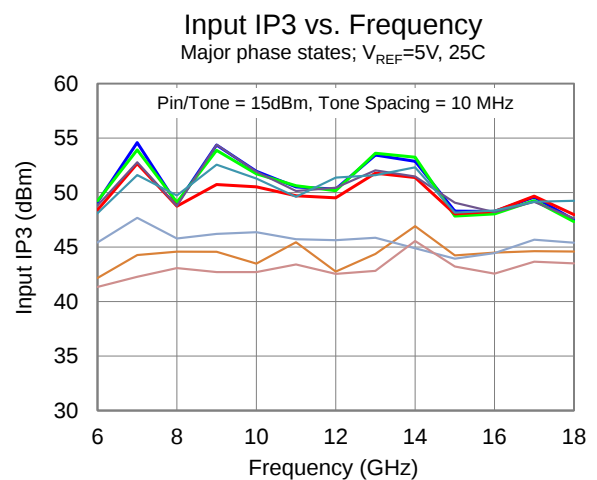
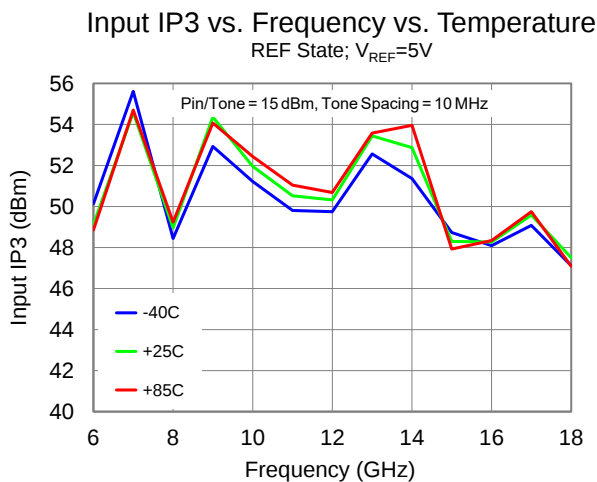
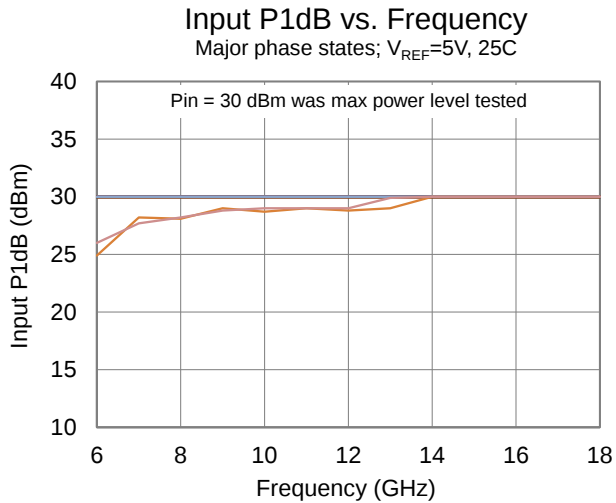
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C

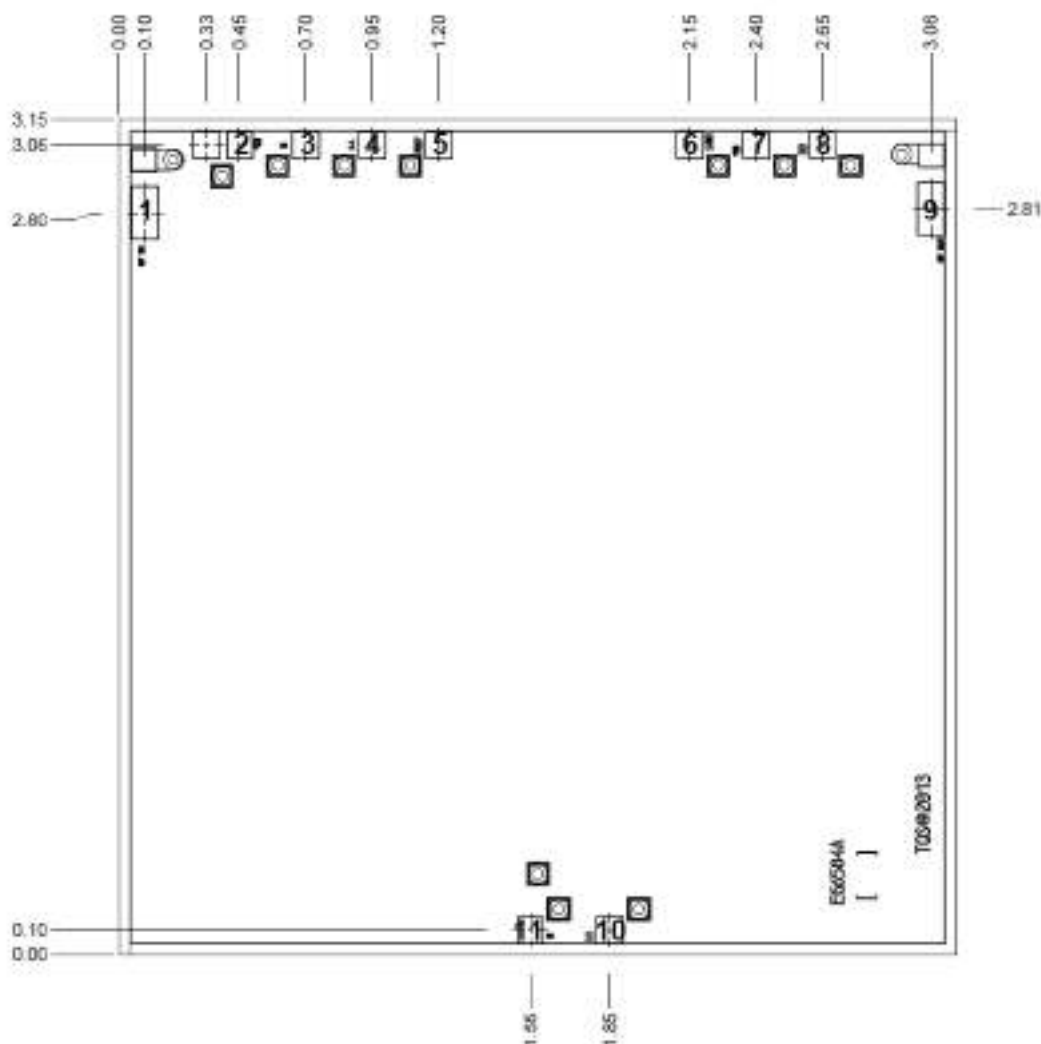


### Performance Plots – Large Signal and Linearity

Test conditions unless otherwise noted: 25 °C



### Mechanical Information and Bond Pad Description

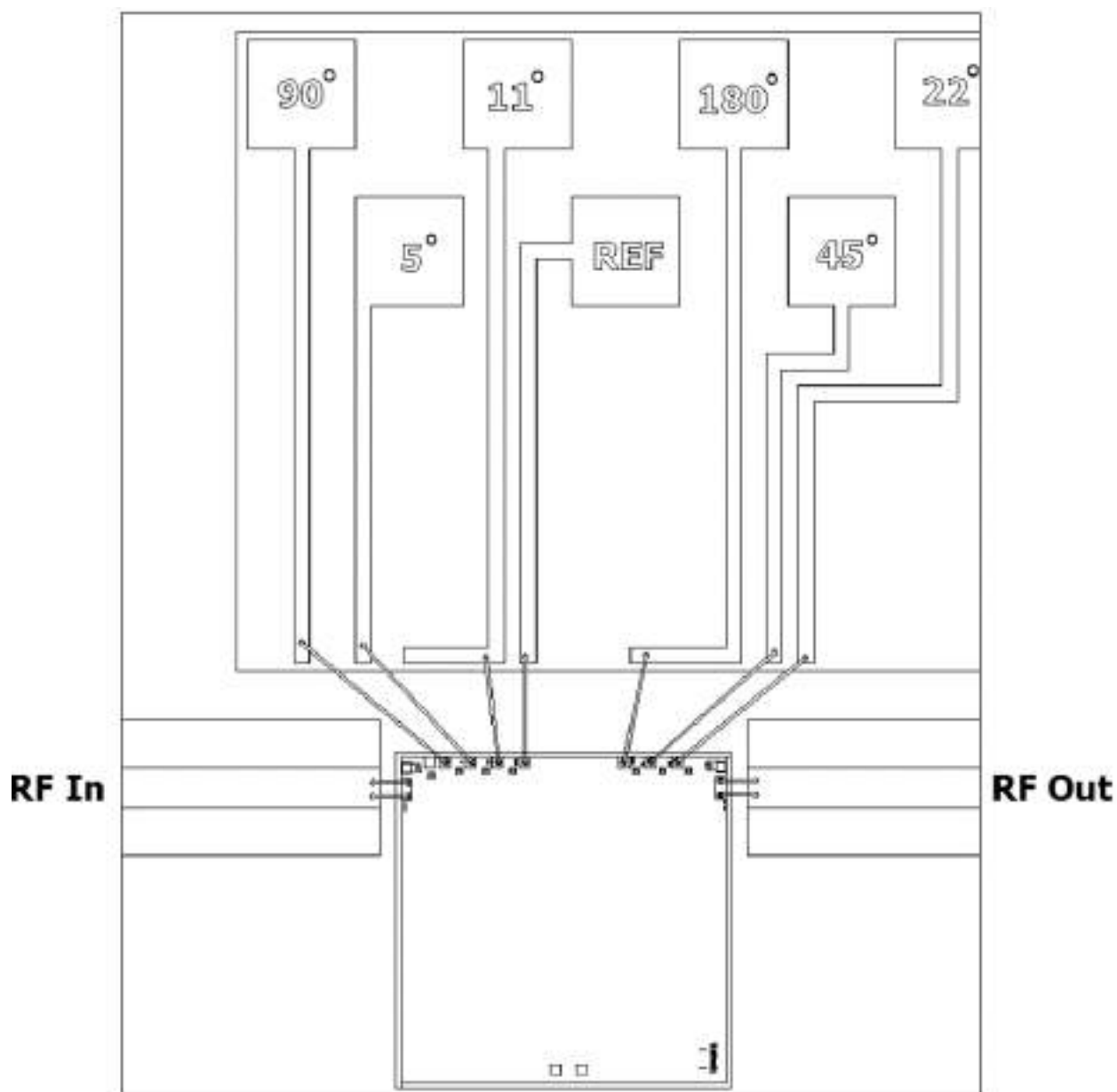


Unit: millimeters, Die thickness: 0.10, Die x, y size tolerance:  $\pm 0.050$   
Chip edge to bond pad dimensions are shown to center of pad, Ground is backside of die

| Bond Pad | Symbol | Description                                 | Pad Size      |
|----------|--------|---------------------------------------------|---------------|
| 1        | RF In  | Input; matched to 50 $\Omega$ ; DC blocked  | 0.200 x 0.100 |
| 2        | 90     | 90° Bit                                     | 0.100 x 0.100 |
| 3, 11    | 5      | 5° Bit                                      | 0.100 x 0.100 |
| 4, 10    | 11     | 11° Bit                                     | 0.100 x 0.100 |
| 5        | REF    | Reference                                   | 0.100 x 0.100 |
| 6        | 180    | 180° Bit                                    | 0.100 x 0.100 |
| 7        | 45     | 45° Bit                                     | 0.100 x 0.100 |
| 8        | 22     | 22° Bit                                     | 0.100 x 0.100 |
| 9        | RF Out | Output; matched to 50 $\Omega$ ; DC blocked | 0.200 x 0.100 |

### Applications Information

1. The spacing between MMIC and TFN at RF In and RF Out is <5 mils typical.
2. RF connections: Bond two 1-mil diameter, <20 mils length gold bond wires at RF In and RF Out for optimum RF performance.



### Assembly Notes

---

#### Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.
- Organic attachment (i.e., conductive epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.

#### Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300°C to 3-4 minutes, maximum.
- Conductive epoxy die attach is recommended for PCB mounting.
- Bonding pads plating: Au.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

#### Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonics are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

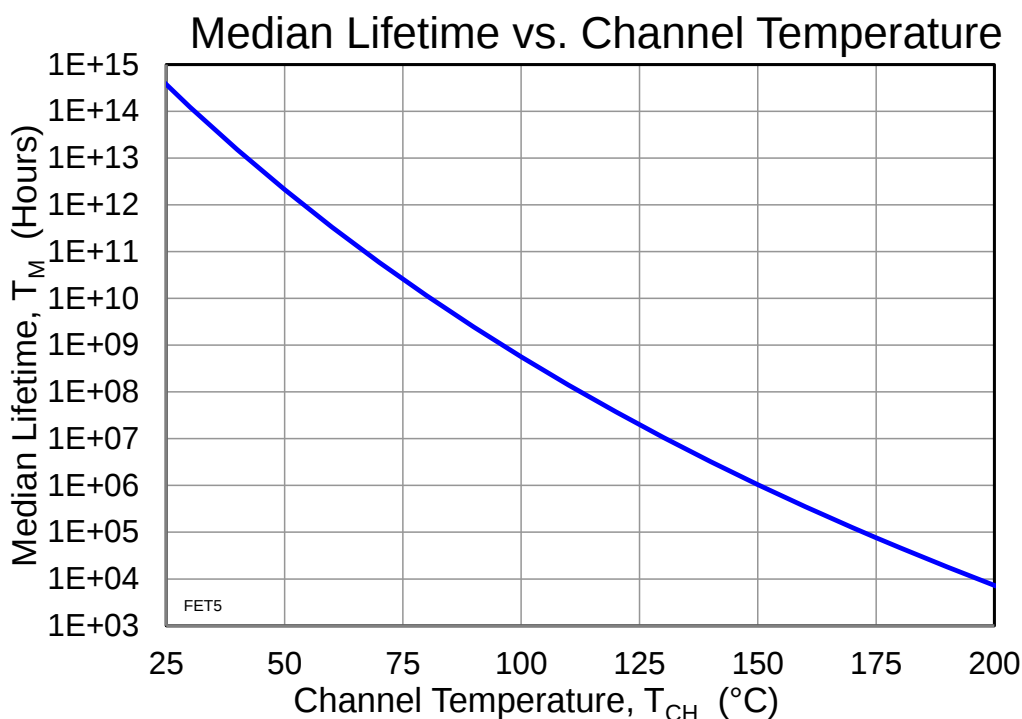
### Thermal and Reliability Information

| Parameter                                           | Test Conditions                                                      | Value  | Units                |
|-----------------------------------------------------|----------------------------------------------------------------------|--------|----------------------|
| Thermal Resistance ( $\theta_{JC}$ ) <sup>(1)</sup> | $P_{DISS} = 0.09\text{ W}$ ,<br>$T_{BASEPLATE} = 85^{\circ}\text{C}$ | 22     | $^{\circ}\text{C/W}$ |
| Channel Temperature, $T_{CH}$ (Under RF)            |                                                                      | 87     | $^{\circ}\text{C}$   |
| Median Lifetime ( $T_M$ )                           |                                                                      | 3.8E09 | Hrs                  |

#### Notes:

1. Thermal resistance measured to back of carrier plate. MMIC mounted on 40 mils thick CuMo carrier using 1.5 mil 80/20 AuSn.

### Median Lifetime



### Handling Precautions

| Parameter                    | Rating   | Standard                 |  | Caution!<br>ESD-Sensitive Device |
|------------------------------|----------|--------------------------|-------------------------------------------------------------------------------------|----------------------------------|
| ESD – Human Body Model (HBM) | Class 1A | ESDA / JEDEC JS-001-2012 |                                                                                     |                                  |

### 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2019 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.



# CMD175P4

## 2-4 GHz 5-Bit Digital Phase Shifter

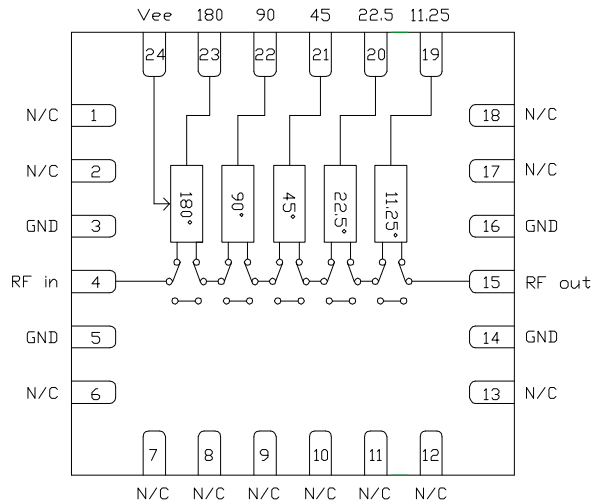
### Features

- Low phase error
- Low insertion loss
- 360° phase shift, LSB = 11.25°
- Single bit negative logic
- Pb-free RoHs compliant 4x4 QFN package

### Description

The CMD175P4 is a GaAs MMIC 5-bit phase shifter housed in a leadless 4x4 mm plastic surface mount package. The CMD175P4 operates from 2 to 4 GHz and provides 0 to 360 degrees of monotonic phase coverage, with a LSB of 11.25 degrees. The device is controlled with single bit negative logic of 0 or -3 V and features an insertion loss of 7 dB and a phase error of  $\pm 5$  degrees. The CMD175P4 is a 50 ohm matched design which eliminates the need for external DC blocks and RF port matching.

### Functional Block Diagram



### Electrical Performance - $V_{ee} = -3$ V, $V_{ctl} = 0/-3$ V, $T_A = 25$ °C, $F = 3$ GHz

| Parameter          | Min   | Typ     | Max | Units |
|--------------------|-------|---------|-----|-------|
| Frequency Range    | 2 - 4 |         |     | GHz   |
| Insertion Loss     |       | 7       |     | dB    |
| Input Return Loss  |       | 18      |     | dB    |
| Output Return Loss |       | 17      |     | dB    |
| Phase Error        |       | +1 / -8 |     | deg   |
| Input P1dB         |       | 24      |     | dBm   |
| Input IP3          |       | 37      |     | dBm   |
| Supply Current     |       | 4       |     | mA    |

ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com



# CMD175P4

## 2-4 GHz 5-Bit Digital Phase Shifter

### Specifications

#### Absolute Maximum Ratings

| Parameter             | Rating        |
|-----------------------|---------------|
| Supply Voltage, Vee   | -8.0 V        |
| RF Input Power        | +30 dBm       |
| Operating Temperature | -40 to 85 °C  |
| Storage Temperature   | -55 to 150 °C |

Exceeding any one or combination of the maximum ratings may cause permanent damage to the device.

#### Recommended Operating Conditions

| Parameter | Min  | Typ | Max  | Units |
|-----------|------|-----|------|-------|
| Vee       | -5.0 |     | -3.0 | V     |
| Iee       |      | 4   |      | mA    |

Electrical performance is measured at specific test conditions. Electrical specifications are not guaranteed over all recommended operating conditions.

#### Truth Table

| Control Voltage Input |      |      |      |      | Phase Shift (degrees) |
|-----------------------|------|------|------|------|-----------------------|
| 11.25                 | 22.5 | 45   | 90   | 180  |                       |
| High                  | High | High | High | High | Reference             |
| Low                   | High | High | High | High | 11.25                 |
| High                  | Low  | High | High | High | 22.5                  |
| High                  | High | Low  | High | High | 45                    |
| High                  | High | High | Low  | High | 90                    |
| High                  | High | High | High | Low  | 180                   |
| Low                   | Low  | Low  | Low  | Low  | 348.75                |

#### Control Voltage

| State | Bias Condition  |
|-------|-----------------|
| High  | Vee $\pm$ 0.3 V |
| Low   | 0 $\pm$ 0.3 V   |

ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com



# CMD175P4

## 2-4 GHz 5-Bit Digital Phase Shifter

### Specifications

**Electrical Specifications -  $V_{ee} = -3.0$  V,  $V_{ctl} = 0/-3$  V,  $T_A = 25$  °C**

| Parameter                | Min   | Typ       | Max      | Min   | Typ       | Max      | Units |
|--------------------------|-------|-----------|----------|-------|-----------|----------|-------|
| Frequency Range          | 2 - 3 |           |          | 3 - 4 |           |          | GHz   |
| Insertion Loss           |       | 7.5       | 10       |       | 7         | 8.5      | dB    |
| Input Return Loss        |       | 15        |          |       | 15        |          | dB    |
| Output Return Loss       |       | 17        |          |       | 17        |          | dB    |
| Phase Error              |       | $\pm 8$   | $\pm 12$ |       | +4 / -8   | +7 / -12 | deg   |
| Insertion Loss Variation |       | $\pm 0.5$ |          |       | $\pm 0.5$ |          | dB    |
| Input P1dB               |       | 24        |          |       | 25        |          | dBm   |
| Input IP3                |       | 36        |          |       | 37        |          | dBm   |
| Supply Current           |       | 4         |          |       | 4         |          | mA    |

Note: Specification applies to major states

ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)

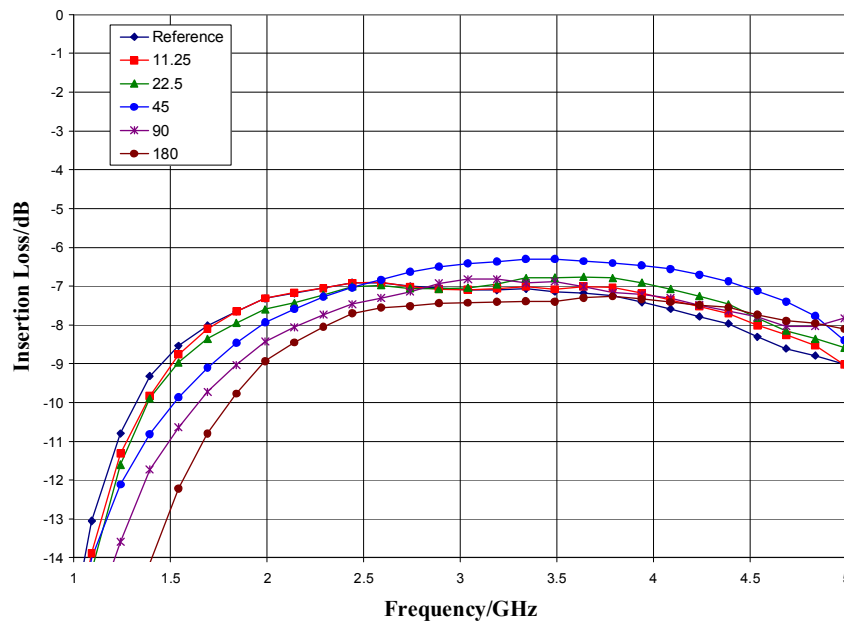


# CMD175P4

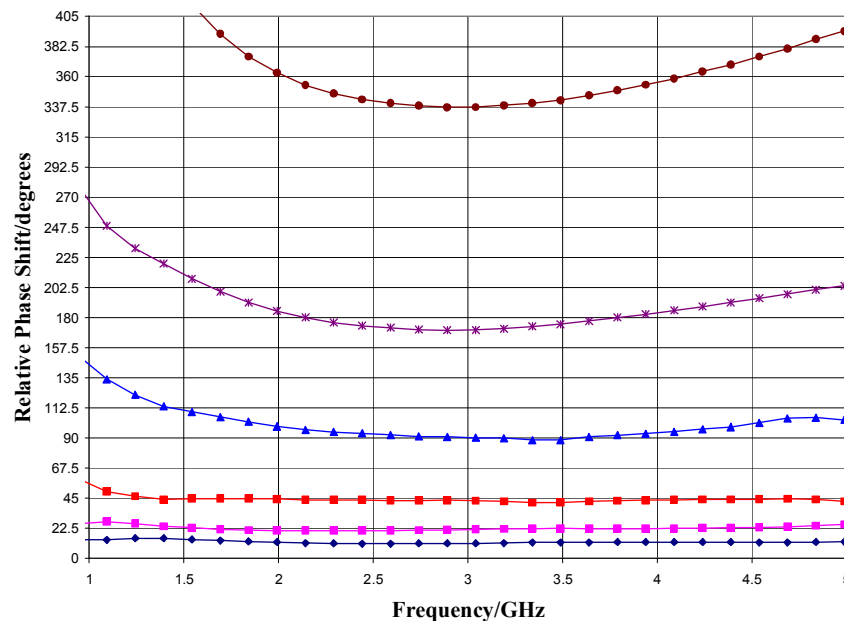
## 2-4 GHz 5-Bit Digital Phase Shifter

### Typical Performance

Insertion Loss, Major States,  $V_{ee} = -3.0$  V,  $T_A = 25$  °C



Relative Phase Shift, Major States and All On State,  $V_{ee} = -3.0$  V,  $T_A = 25$  °C



ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

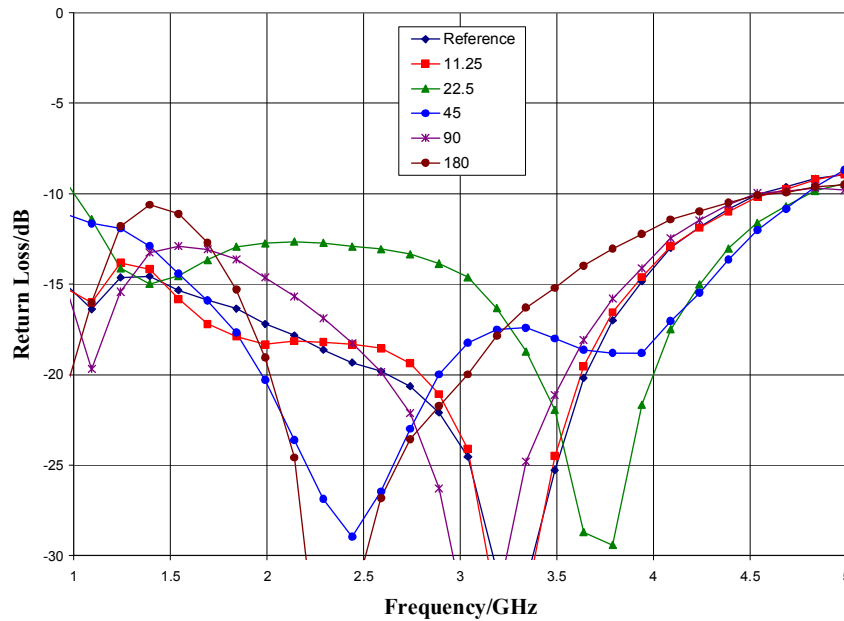


# CMD175P4

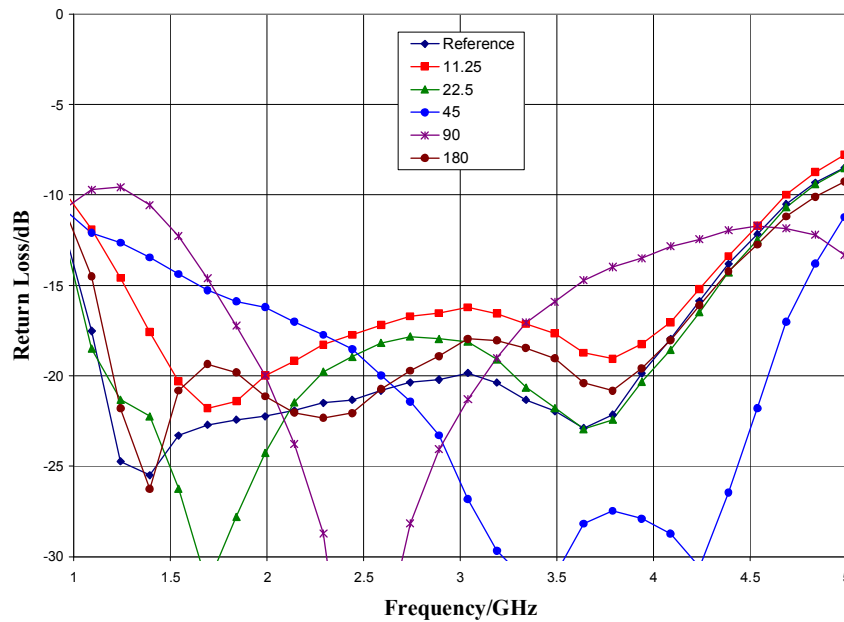
## 2-4 GHz 5-Bit Digital Phase Shifter

### Typical Performance

Input Return Loss, Major States,  $V_{ee} = -3.0$  V,  $T_A = 25$  °C



Output Return Loss, Major States,  $V_{ee} = -3.0$  V,  $T_A = 25$  °C



ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

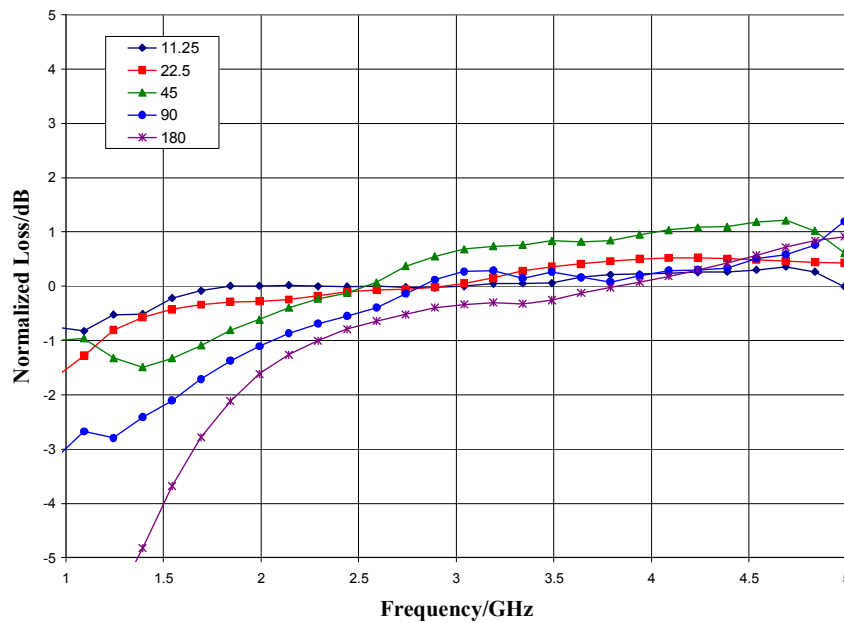


# CMD175P4

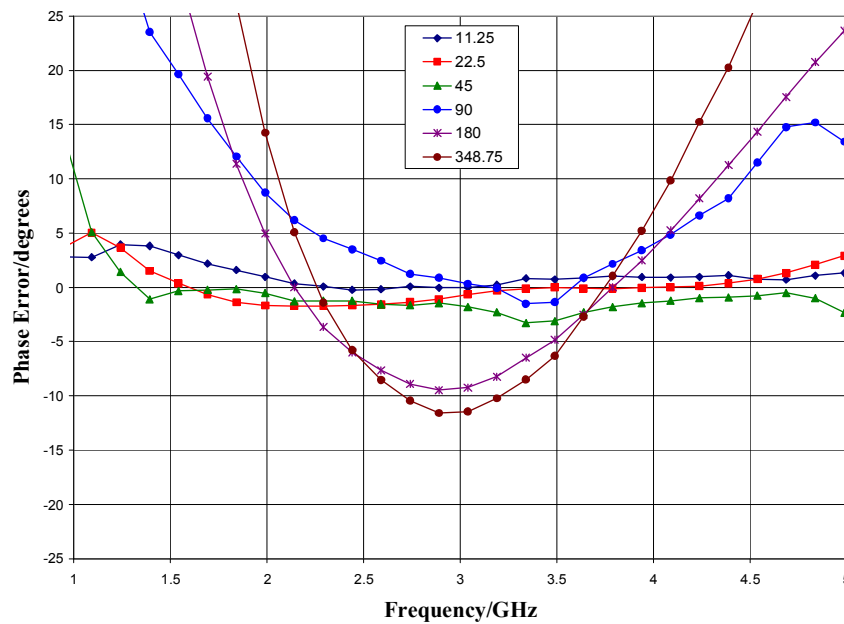
## 2-4 GHz 5-Bit Digital Phase Shifter

### Typical Performance

Normalized Loss, Major States,  $V_{ee} = -3.0$  V



Phase Error, Major States and All On State,  $V_{ee} = -3.0$  V



ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

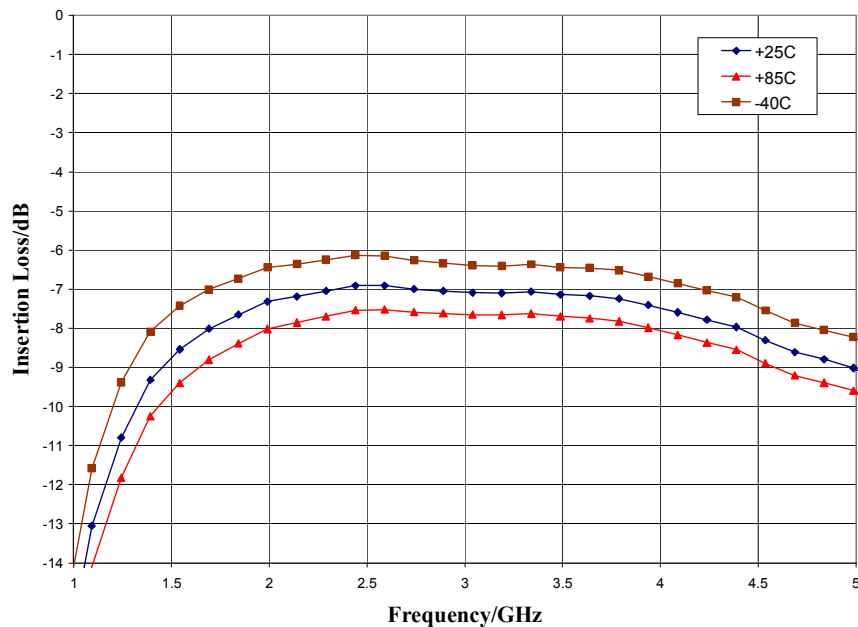


# CMD175P4

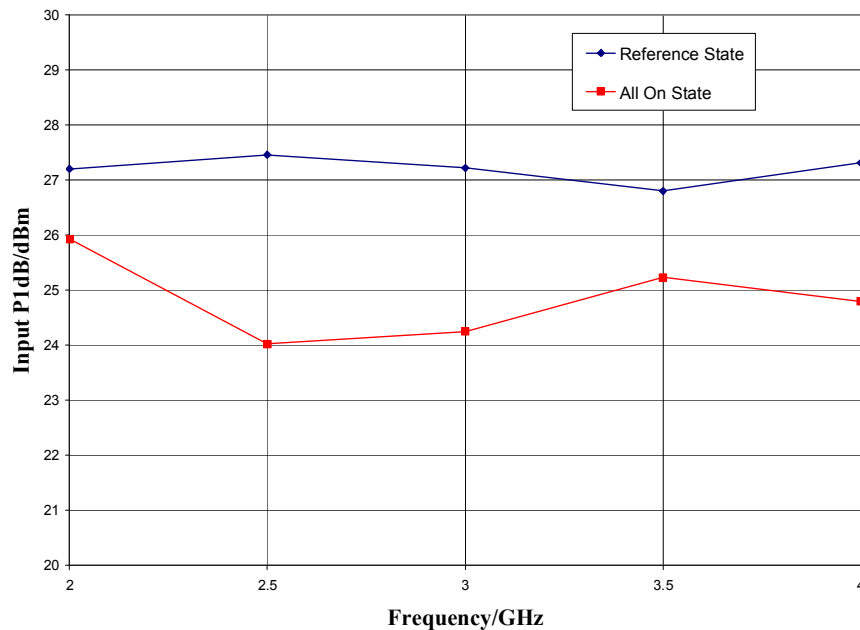
## 2-4 GHz 5-Bit Digital Phase Shifter

### Typical Performance

Insertion Loss vs. Temperature, Reference State,  $V_{ee} = -3.0$  V



Input P1dB,  $V_{ee} = -3.0$  V



ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

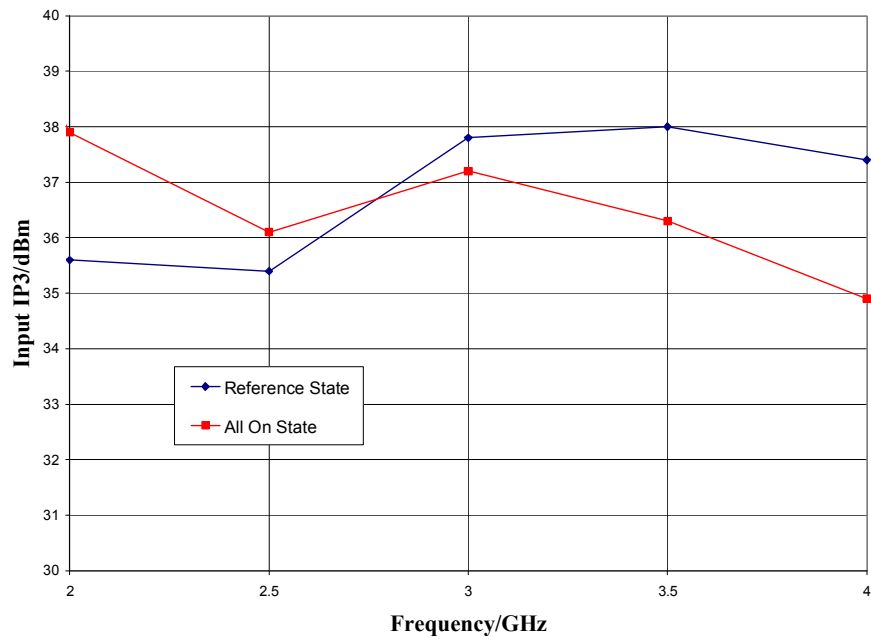


# CMD175P4

## 2-4 GHz 5-Bit Digital Phase Shifter

### Typical Performance

Input IP3,  $V_{ee} = -3.0$  V



ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

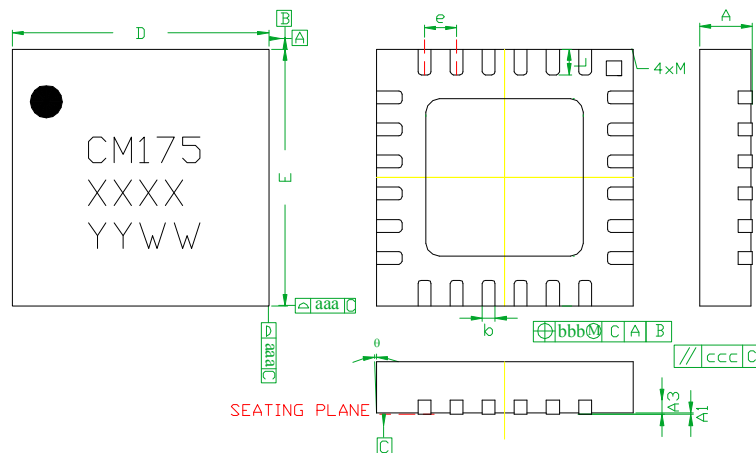


# CMD175P4

## 2-4 GHz 5-Bit Digital Phase Shifter

### Mechanical Information

#### Package Information and Dimensions



| SYMBOLS | DIMENSIONS IN MILLIMETERS |          |      |
|---------|---------------------------|----------|------|
|         | MIN                       | NOM      | MAX  |
| A       | 0.80                      | 0.90     | 1.00 |
| A1      | 0                         | 0.02     | 0.05 |
| A3      | —                         | 0.25REF. | —    |
| b       | 0.18                      | 0.23     | 0.30 |
| D       | 3.85                      | 4.00     | 4.15 |
| D1      | —                         | 2.45BSC  | —    |
| E       | 3.85                      | 4.00     | 4.15 |
| E1      | —                         | 2.45BSC  | —    |
| e       | —                         | 0.50BSC  | —    |
| L       | 0.30                      | 0.40     | 0.50 |
| theta   | 0                         | —        | 12   |
| aaa     | —                         | 0.25     | —    |
| bbb     | —                         | 0.10     | —    |
| ccc     | —                         | 0.10     | —    |
| M       | —                         | —        | 0.05 |

#### NOTES:

1. DIMENSIONS ARE IN MILLIMETERS
2. RoHS COMPLIANT MOLD COMPOUND
3. LEADFRAME MATERIAL: COPPER ALLOY
4. LEAD FINISH: 100% MATTE Sn
5. INDICATED DIMENSION/TOLERANCE APPLIES TO LEADS AND EXPOSED PAD

#### Recommended PCB Land Pattern

Custom MMIC Design Services recommends that the user develop the land pattern that will provide the best design for proper solder reflow and device attach for their specific application. Please review CMDS Application Note AN 105 for a recommended land pattern approach.

#### Recommended Solder Reflow Profile

Custom MMIC Design Services recommends screen printing with belt furnace reflow to ensure proper solder reflow and device attach. Please review CMDS Application Note AN 102 for a recommended solder reflow profile.

**GaAs MMIC devices are susceptible to damage from Electrostatic Discharge. Proper precautions should be observed during handling, assembly and test.**

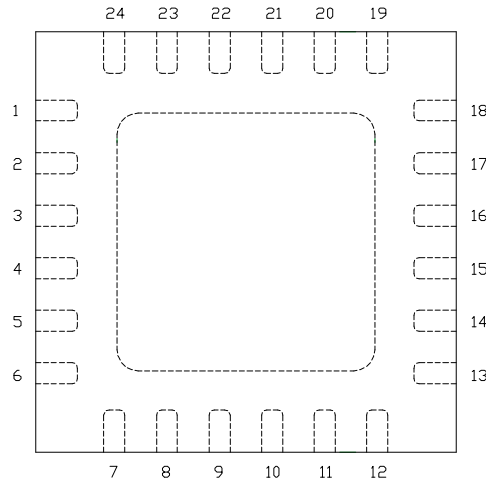
ver 1.4 0518

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

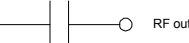
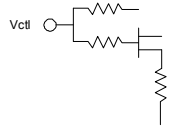
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Pin Description

#### Pin Diagram



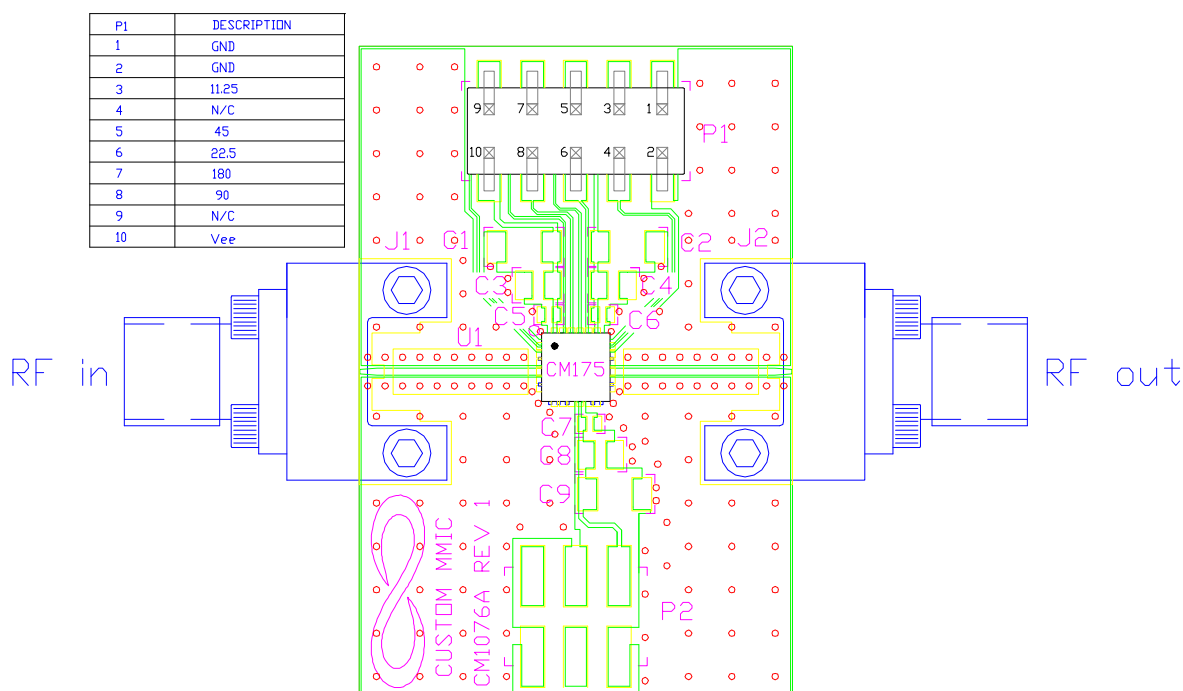
#### Functional Description

| Pad                      | Function | Description                                                           | Schematic                                                                                    |
|--------------------------|----------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| 1, 2, 6-13, 17, 18       | N/C      | No connection required. These pins may be connected to RF / DC ground |                                                                                              |
| 4                        | RF in    | DC blocked and 50 ohm matched                                         | RF in   |
| 15                       | RF out   | DC blocked and 50 ohm matched                                         |  RF out |
| 19                       | 11.25    | 11.25° control input                                                  |         |
| 20                       | 22.5     | 22.5° control input                                                   |                                                                                              |
| 21                       | 45       | 45° control input                                                     |                                                                                              |
| 22                       | 90       | 90° control input                                                     |                                                                                              |
| 23                       | 180      | 180° control input                                                    |                                                                                              |
| 24                       | Vee      | Supply Voltage                                                        |         |
| 3,5,14,16 and die paddle | Ground   | Connect to RF / DC ground                                             |         |

ver 1.4 0518

### Applications Information

### Evaluation Board



### Bill of Material

| Designator | Value | Description                  |
|------------|-------|------------------------------|
| J1, J2     |       | SMA End Launch Connector     |
| P1         |       | 10 Pin DC Header             |
| U1         |       | CMD175P4 5-Bit Phase Shifter |
| PCB        |       | CM1076A Evaluation PCB       |

Please note, all information contained in this data sheet is subject to change without notice.

ver 1.4 0518

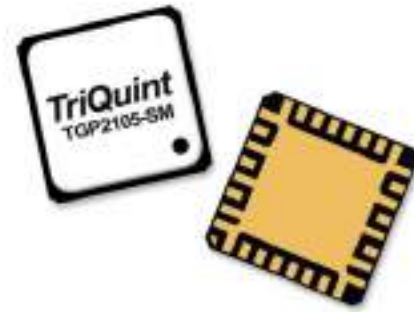
Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

### Product Description

The Qorvo TGP2105-SM is a packaged 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15  $\mu\text{m}$  GaAs pHEMT process. It operates over 6 to 18 GHz while providing 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 4° with 8 dB of insertion loss over all states.

The TGP2105-SM uses positive switch logic, eliminating the need for a negative voltage rail. That, along with low insertion and a high degree of resolution makes the TGP2105-SM ideally suited for a variety of wideband phased array applications, including commercial and military radars, satellite-based communication systems and electronic warfare.

The device is lead-free and RoHS compliant.



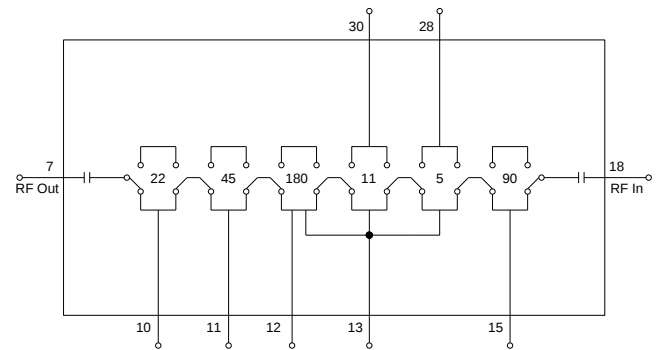
Air Cavity Ceramic QFN 5x5 mm 32L

### Product Features

- Frequency Range: 6 to 18 GHz
- 6-Bit Digital Phase Shifter
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 4°
- RMS Amplitude Error: 0.45 dB
- Insertion Loss: <10 dB
- Return Loss: >12 dB
- Input P1dB: >25 dBm
- Input IP3: >41 dBm
- Control Voltage: 0/+5V
- QFN Package Dimensions: 5.0 x 5.0 x 1.45 mm

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

### Functional Block Diagram



### Applications

- Phased Array Antenna Systems
- Satellite Communication Systems
- Electronic Warfare

### Ordering Information

| Part No.        | Description                          |
|-----------------|--------------------------------------|
| TGP2105-SM      | 6-18 GHz 6-Bit Digital Phase Shifter |
| TGP2105-SMEVB01 | TGP2105-SM Evaluation Board          |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | -15 to +5 mA  |
| Power Dissipation                   | 0.9 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 30 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 260 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                                           | Value            |
|-----------------------------------------------------|------------------|
| Control Voltage (5°, 11°, 22°, 45°, 90°, 180°, REF) | 0/+5 V           |
| Operating Temperature Range                         | -40 °C to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25 °C. Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) = 0/+5 V; See Bias Truth Table.

| Parameter                              | Conditions                                  | Min | Typical | Max | Units |
|----------------------------------------|---------------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range            |                                             | 6   |         | 18  | GHz   |
| Insertion Loss                         |                                             |     | 6 - 10  |     | dB    |
| Input Return Loss                      |                                             |     | >12     |     | dB    |
| Output Return Loss                     |                                             |     | >12     |     | dB    |
| RMS Phase Error                        |                                             |     | 4       |     | deg   |
| RMS Amplitude Error                    |                                             |     | 0.45    |     | dB    |
| Input P1dB                             |                                             |     | > 25    |     | dBm   |
| Input IP3                              | Tone Spacing = 10 MHz,<br>Pin/Tone = 15 dBm |     | > 41    |     | dBm   |
| Insertion Loss Temperature Coefficient |                                             |     | 0.008   |     | dB/°C |

### Bias Truth Table

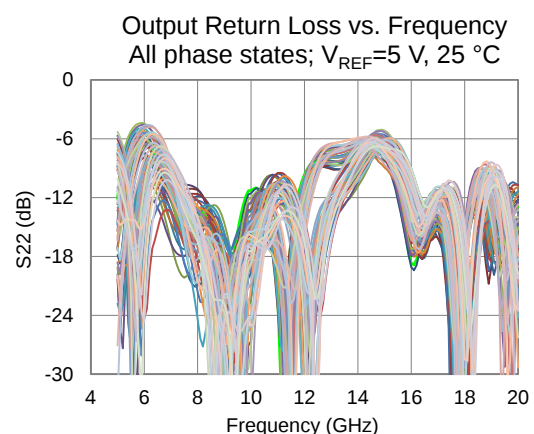
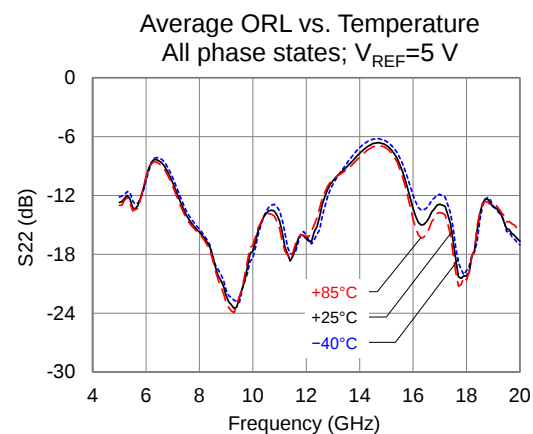
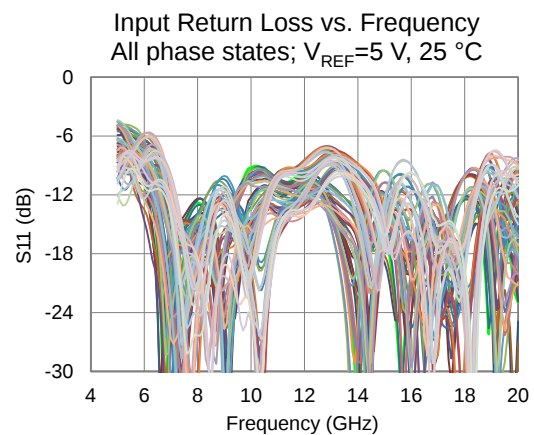
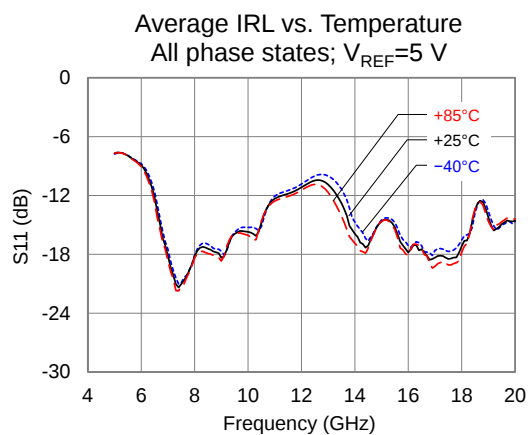
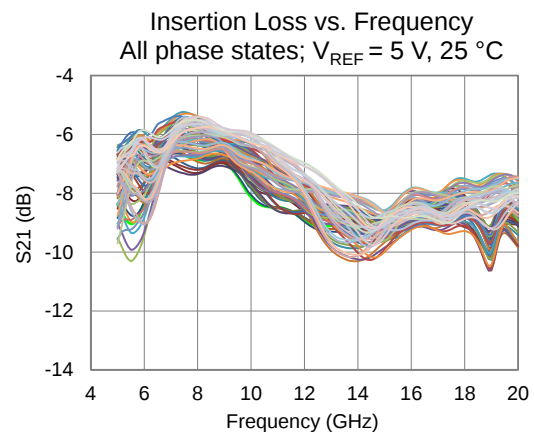
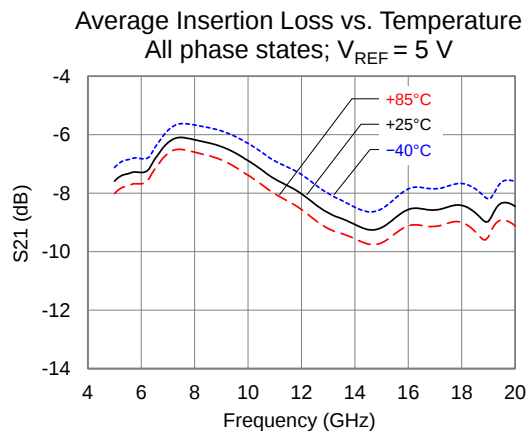
Logic "0" = 0 V, Logic "1" = +5 V

Voltage for Logic "1" of V<sub>CTRL</sub> (5°, 11°, 22°, 45°, 90°, 180°) must be the same with V<sub>REF</sub>

| Phase Shifter  | 5° | 11° | 22° | 45° | 90° | 180° | REF |
|----------------|----|-----|-----|-----|-----|------|-----|
| 0° (Reference) | 0  | 0   | 0   | 0   | 0   | 0    | 1   |
| 5°             | 1  | 0   | 0   | 0   | 0   | 0    | 1   |
| 11°            | 0  | 1   | 0   | 0   | 0   | 0    | 1   |
| 22°            | 0  | 0   | 1   | 0   | 0   | 0    | 1   |
| 45°            | 0  | 0   | 0   | 1   | 0   | 0    | 1   |
| 90°            | 0  | 0   | 0   | 0   | 1   | 0    | 1   |
| 180°           | 0  | 0   | 0   | 0   | 0   | 1    | 1   |
| 355°           | 1  | 1   | 1   | 1   | 1   | 1    | 1   |

### Performance Plots – Small Signal

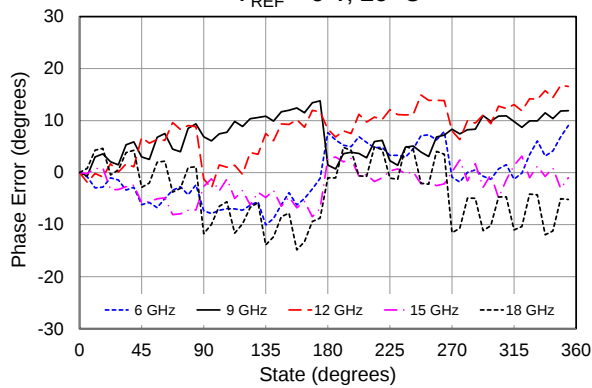
Test conditions unless otherwise noted: 25 °C. Data de-embedded to device reference planes



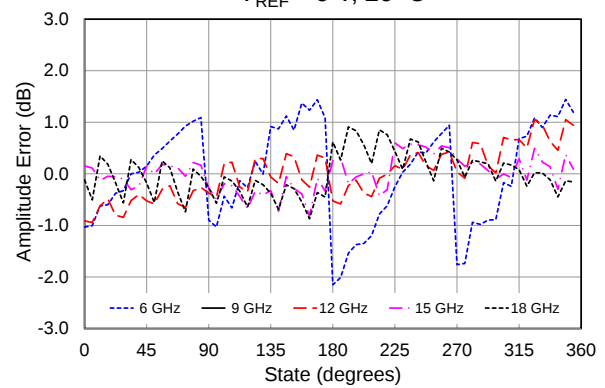
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C. Data de-embedded to device reference planes

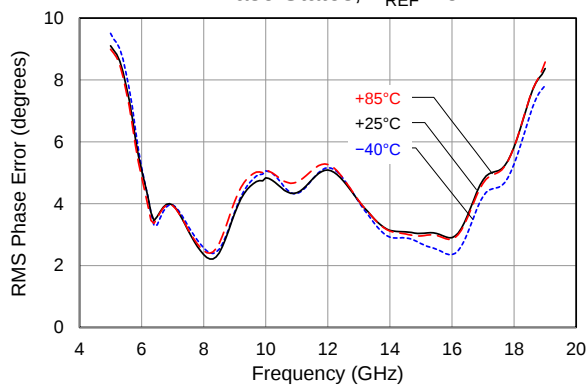
Phase Error vs. State  
 $V_{REF} = 5\text{ V}$ , 25 °C



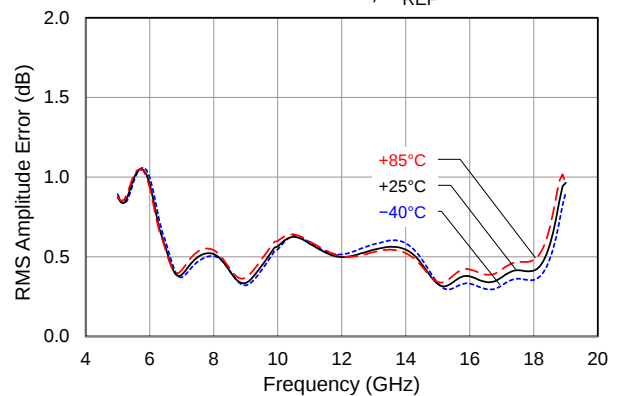
Amplitude Error vs. State  
 $V_{REF} = 5\text{ V}$ , 25 °C



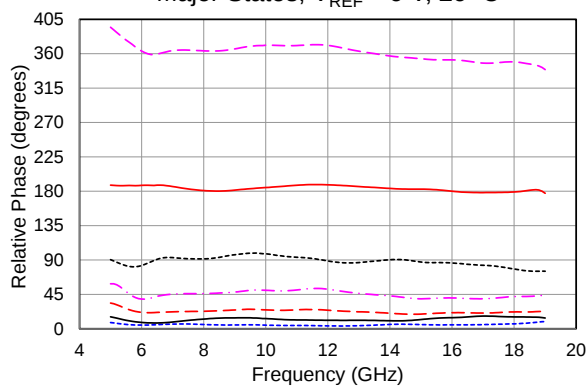
RMS Phase Error vs. Frequency  
All Phase States,  $V_{REF} = 5\text{ V}$



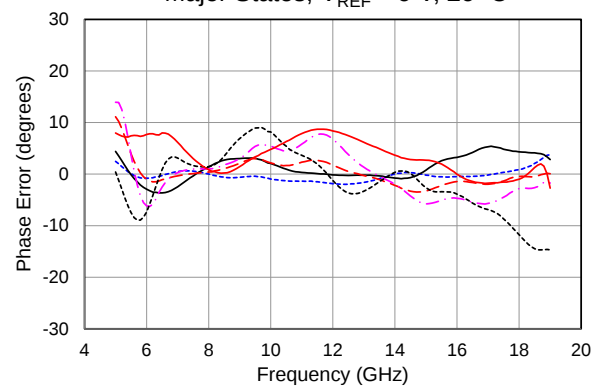
RMS Amplitude Error vs. Frequency  
All Phase States,  $V_{REF} = 5\text{ V}$



Relative Phase Shift vs. Frequency  
Major States,  $V_{REF} = 5\text{ V}$ , 25 °C

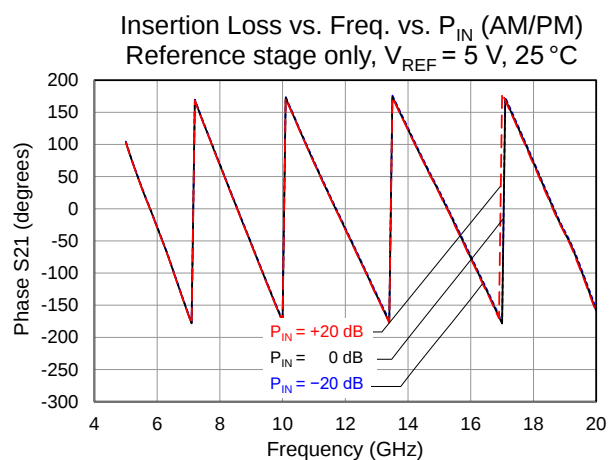
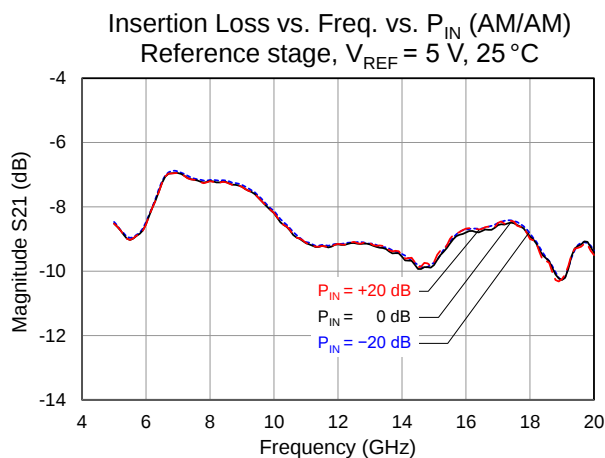


Phase Error vs. Frequency  
Major States,  $V_{REF} = 5\text{ V}$ , 25 °C

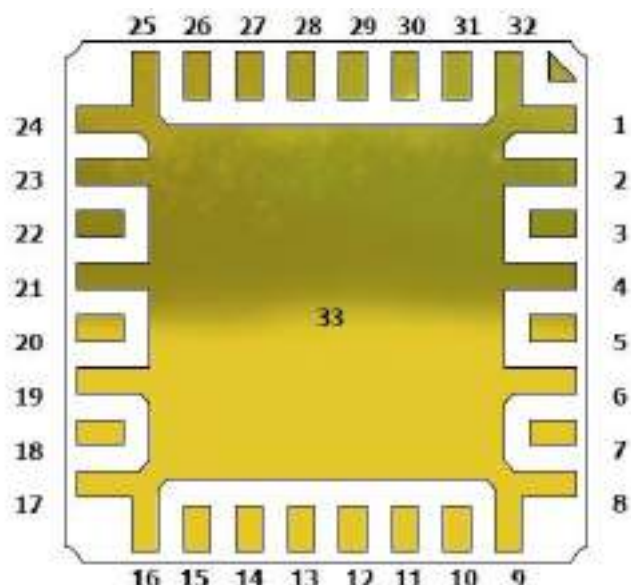


### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C. Data de-embedded to device reference planes



### Package Pin Descriptions

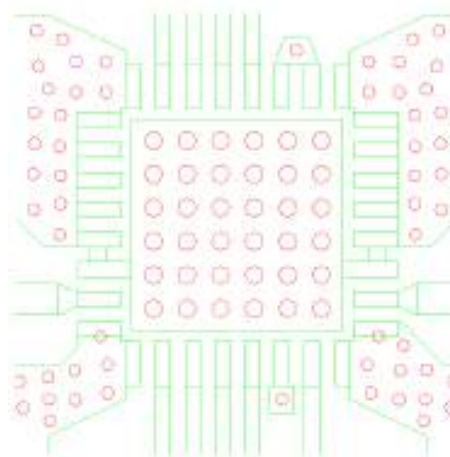
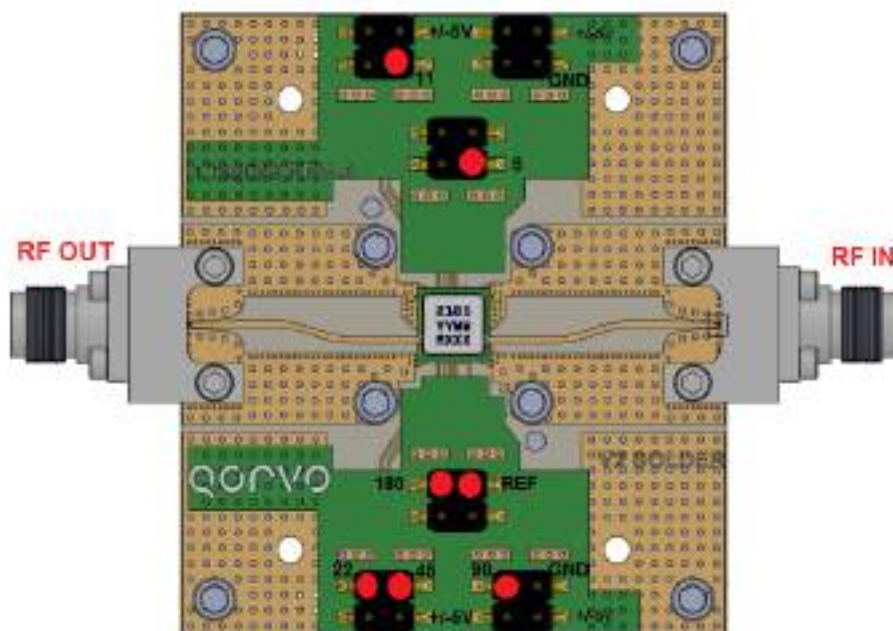


| Package Pad                                   | Symbol | Description                                                                                                                                            |
|-----------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 - 6, 8 - 9, 14, 16,17, 19 - 27, 29, 31 - 32 | GND    | Internal grounding; must be grounded on PCB                                                                                                            |
| 7                                             | RF Out | Output; matched to 50 Ohms; DC blocked                                                                                                                 |
| 10                                            | 22°    | 22° Bit; De-Qing network is not required                                                                                                               |
| 11                                            | 45°    | 45° Bit; De-Qing network is not required                                                                                                               |
| 12                                            | 180°   | 180° Bit; De-Qing network is not required                                                                                                              |
| 13                                            | REF    | Reference; De-Qing network is not required                                                                                                             |
| 15                                            | 90°    | 90° Bit; De-Qing network is not required                                                                                                               |
| 18                                            | RF In  | Input; matched to 50 Ohms; DC blocked                                                                                                                  |
| 28                                            | 5°     | 5° Bit; De-Qing network is not required                                                                                                                |
| 30                                            | 11°    | 11° Bit; De-Qing network is not required                                                                                                               |
| 33                                            | GND    | On PCB; multiple vias should be employed under the center pad (33) to minimize inductance and thermal resistance; see page 8 for suggested vias layout |

All dimensions are in inches and that unless otherwise noted the tolerance is +/- 0.005



#### Evaluation Board (EVB) Layout Assembly



Via Pattern

RF layer is 0.010" thick Rogers RO4350. Metal layers are 1-oz copper. The microstrip line taper at the connector interface is optimized for the Southwest Microwave end-launch connector 1092-01A-5.

Ground / thermal vias under the DUT are critical for the proper performance of this device. The PCB shown herein utilizes copper filled vias under the DUT.

The pad pattern shown has been developed and tested for optimized assembly at Qorvo. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company careful process development is recommended.

### Thermal and Reliability Information

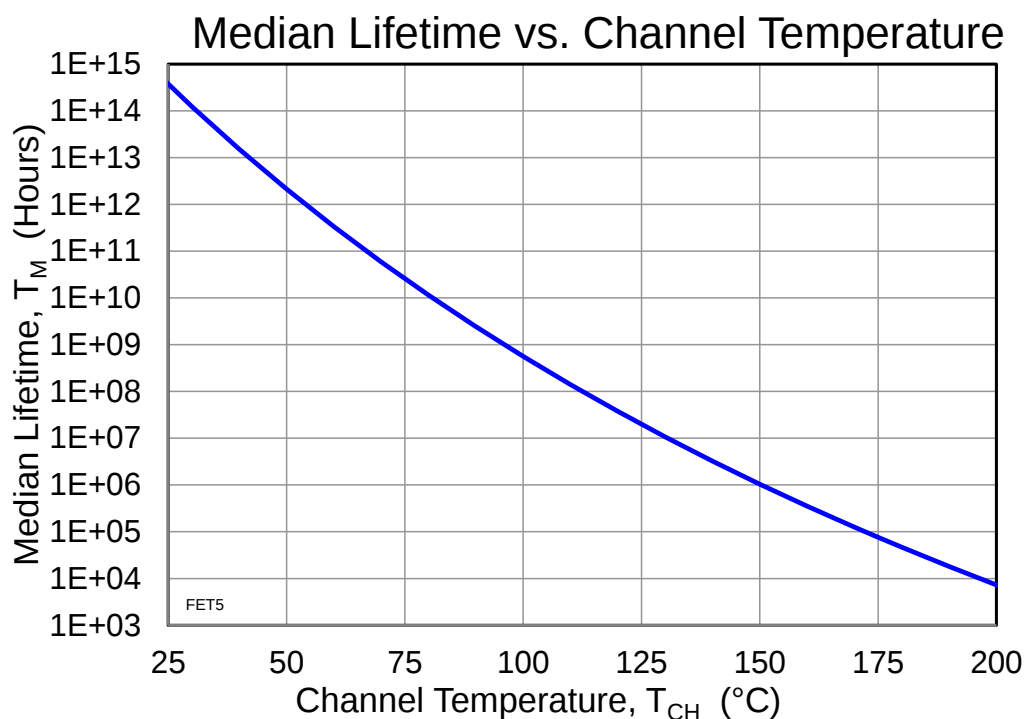
| Parameter                                           | Test Conditions                                                 | Value  | Units                |
|-----------------------------------------------------|-----------------------------------------------------------------|--------|----------------------|
| Thermal Resistance ( $\theta_{JC}$ ) <sup>(1)</sup> | $P_{DISS} = 0.09\text{ W}$ ,<br>$T_{BASE} = 85^{\circ}\text{C}$ | 22     | $^{\circ}\text{C/W}$ |
| Channel Temperature ( $T_{CH}$ ) <sup>(2)</sup>     |                                                                 | 87     | $^{\circ}\text{C}$   |
| Median Lifetime ( $T_M$ )                           |                                                                 | 3.8E+9 | Hrs                  |

Notes:

1. Thermal resistance measured to back of package.
2. Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime

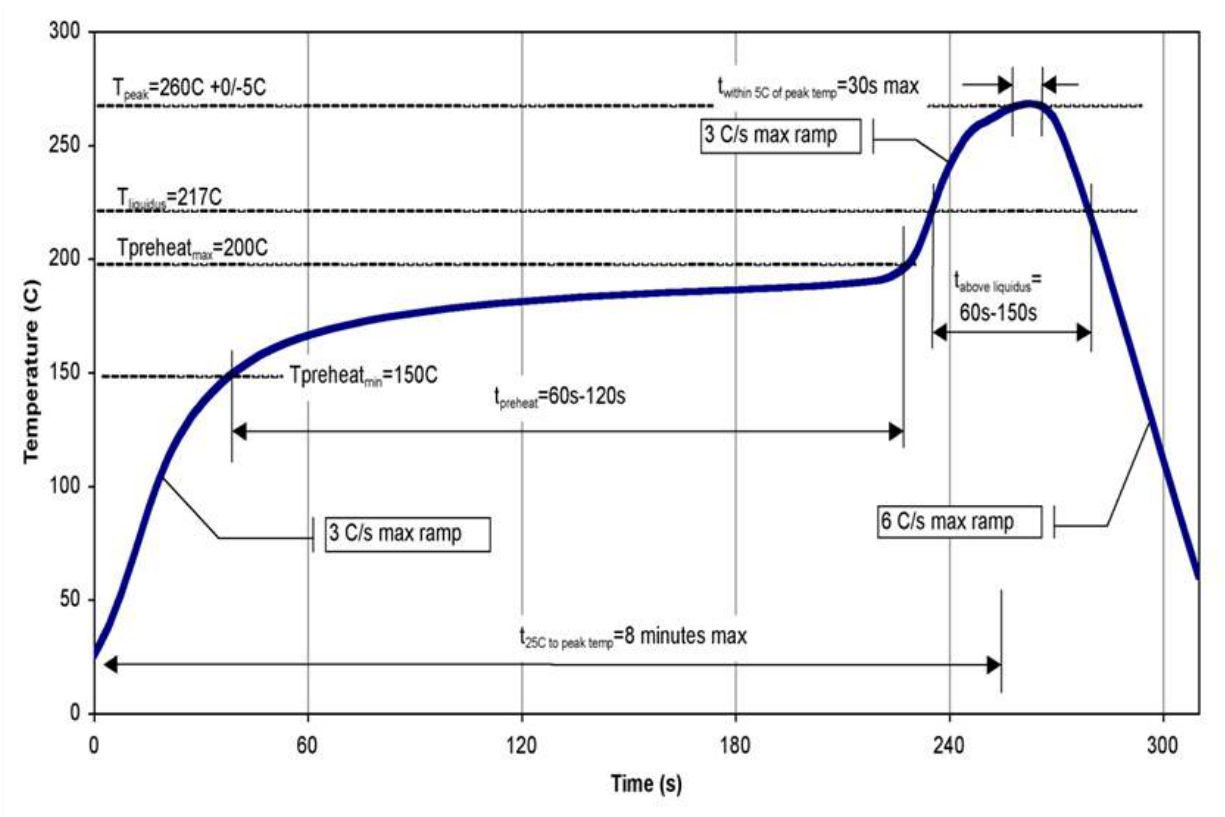
Test Conditions: 6.0 V; Failure Criterion = 10% reduction in  $I_{DQ\_MAX}$



### Solderability

1. Compatible with the latest version of J-STD-020, Lead-free solder, 260 °C
2. The use of no-clean solder to avoid washing after soldering is recommended.
3. Package lead plating: NiAu

### Recommended Soldering Temperature Profile



### Handling Precautions

| Parameter                        | Rating    | Standard                 |
|----------------------------------|-----------|--------------------------|
| ESD – Human Body Model (HBM)     | Class 1A  | ESDA / JEDEC JS-001-2012 |
| ESD – Charge Device Model (CDM)  | Class C2a | JS-002-2014              |
| MSL – Moisture Sensitivity Level | Level 3   | 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
- 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)

For technical questions and application information: **Email:** [appsupport@qorvo.com](mailto:appsupport@qorvo.com)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2018 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.



# CMD176P4

## 13-17 GHz 4-Bit Digital Phase Shifter

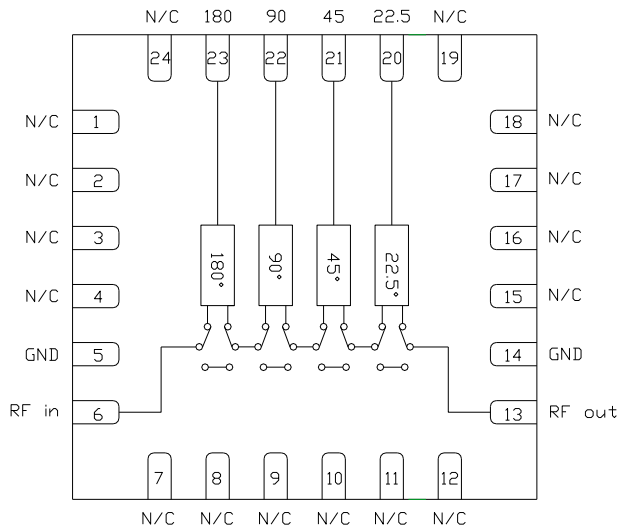
### Features

- Low phase error
- Low insertion loss
- 360° phase shift, LSB = 22.5°
- Single bit positive logic
- Pb-free RoHs compliant 4x4 QFN package

### Description

The CMD176P4 is a GaAs MMIC 4-bit phase shifter housed in a leadless 4x4 mm plastic surface mount package. The CMD176P4 operates from 13 to 17 GHz and provides 0 to 360 degrees of monotonic phase coverage, with a LSB of 22.5 degrees. The device is controlled with single bit positive logic of 0 or +3 V and features an insertion loss of 8 dB and a phase error of  $\pm 5$  degrees. The CMD176P4 is a 50 ohm matched design which eliminates the need for external DC blocks and RF port matching.

### Functional Block Diagram



### Electrical Performance - $V_{ctl} = 0/+3$ V, $T_A = 25$ °C, $F = 15$ GHz

| Parameter          | Min     | Typ     | Max | Units |
|--------------------|---------|---------|-----|-------|
| Frequency Range    | 13 - 17 |         |     | GHz   |
| Insertion Loss     |         | 8       |     | dB    |
| Input Return Loss  |         | 18      |     | dB    |
| Output Return Loss |         | 14      |     | dB    |
| Phase Error        |         | +3 / -1 |     | deg   |
| Input P1dB         |         | 26      |     | dBm   |
| Input IP3          |         | 41      |     | dBm   |

ver 1.5 0719

Custom MMIC  
 300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294  
 Visit us online at [www.custommmic.com](http://www.custommmic.com)

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
 Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)



# CMD176P4

## 13-17 GHz 4-Bit Digital Phase Shifter

### Specifications

#### Absolute Maximum Ratings

| Parameter             | Rating        |
|-----------------------|---------------|
| Control Voltage, Vctl | 8.0 V         |
| RF Input Power        | +30 dBm       |
| Operating Temperature | -40 to 85 °C  |
| Storage Temperature   | -55 to 150 °C |

Exceeding any one or combination of the maximum ratings may cause permanent damage to the device.

#### Recommended Operating Conditions

| Parameter | Min | Typ | Max | Units |
|-----------|-----|-----|-----|-------|
| Vctl      | 3.0 |     | 5.0 | V     |
| Icc       | 0   | 4   | 6   | mA    |

Electrical performance is measured at specific test conditions. Electrical specifications are not guaranteed over all recommended operating conditions.

#### Truth Table

| Control Voltage Input |      |      |      | Phase Shift (degrees) |
|-----------------------|------|------|------|-----------------------|
| 22.5                  | 45   | 90   | 180  |                       |
| Low                   | Low  | Low  | Low  | Reference             |
| High                  | Low  | Low  | Low  | 22.5                  |
| Low                   | High | Low  | Low  | 45                    |
| Low                   | Low  | High | Low  | 90                    |
| Low                   | Low  | Low  | High | 180                   |
| High                  | High | High | High | 337.5                 |

#### Control Voltage

| State | Bias Condition   |
|-------|------------------|
| High  | Vctl $\pm$ 0.3 V |
| Low   | 0 $\pm$ 0.3 V    |

ver 1.5 0719

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294  
Visit us online at [www.custommmic.com](http://www.custommmic.com)

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)



# CMD176P4

## 13-17 GHz 4-Bit Digital Phase Shifter

### Specifications

**Electrical Specifications -  $V_{ctl} = 0/+3\text{ V}$ ,  $T_A = 25\text{ }^{\circ}\text{C}$**

| Parameter                | Min     | Typ       | Max       | Min         | Typ       | Max     | Units |
|--------------------------|---------|-----------|-----------|-------------|-----------|---------|-------|
| Frequency Range          | 13 - 17 |           |           | 14.4 - 15.6 |           |         | GHz   |
| Insertion Loss           |         | 8.5       | 10.5      |             | 8.5       | 9.5     | dB    |
| Input Return Loss        |         | 15        |           |             | 18        |         | dB    |
| Output Return Loss       |         | 10        |           |             | 12        |         | dB    |
| Phase Error              |         | $\pm 5$   | +15 / -10 |             | $\pm 5$   | $\pm 9$ | deg   |
| Insertion Loss Variation |         | $\pm 0.5$ |           |             | $\pm 0.5$ |         | dB    |
| Input P1dB               |         | 26        |           |             | 26        |         | dBm   |
| Input IP3                |         | 40        |           |             | 40        |         | dBm   |

Note: Specification applies to major states

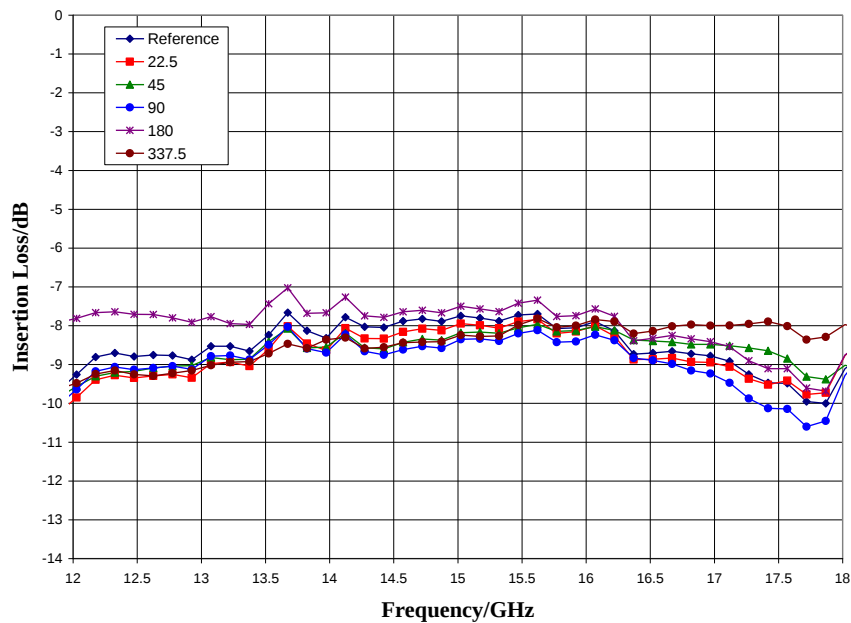
ver 1.5 0719

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294  
Visit us online at [www.custommmic.com](http://www.custommmic.com)

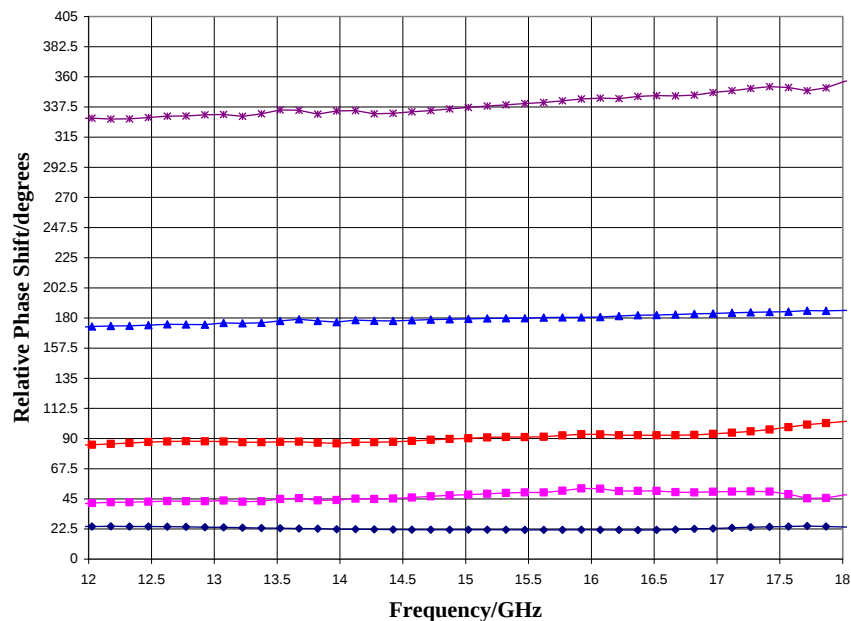
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)

### Typical Performance

Insertion Loss, Major States,  $T_A = 25^\circ\text{C}$



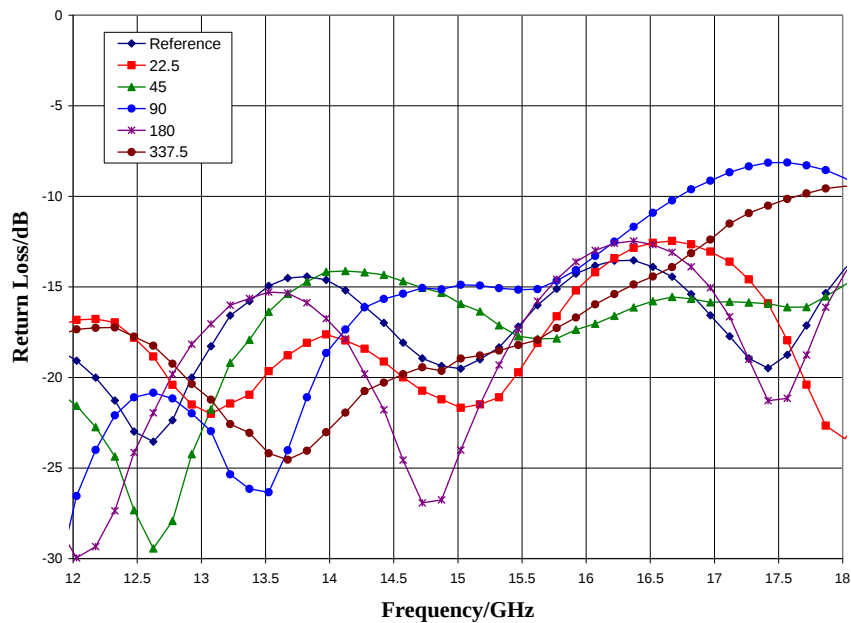
Relative Phase Shift, Major States and All On State,  $T_A = 25^\circ\text{C}$



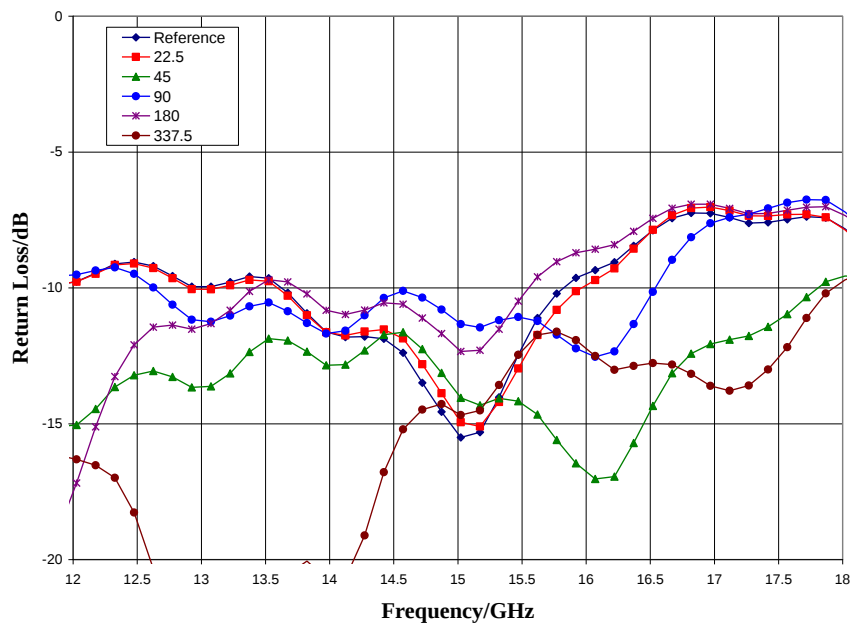
ver 1.5 0719

### Typical Performance

Input Return Loss, Major States,  $T_A = 25^\circ\text{C}$



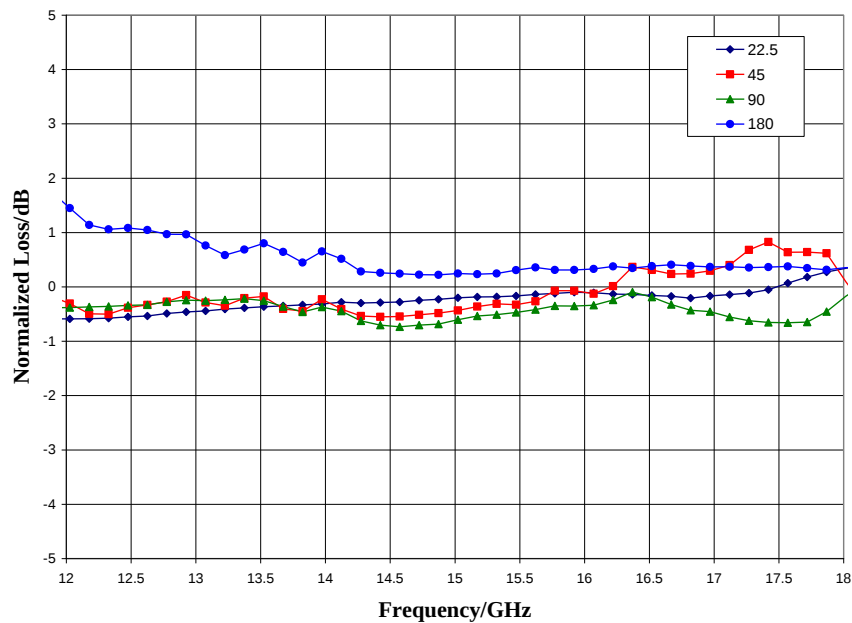
Output Return Loss, Major States,  $T_A = 25^\circ\text{C}$



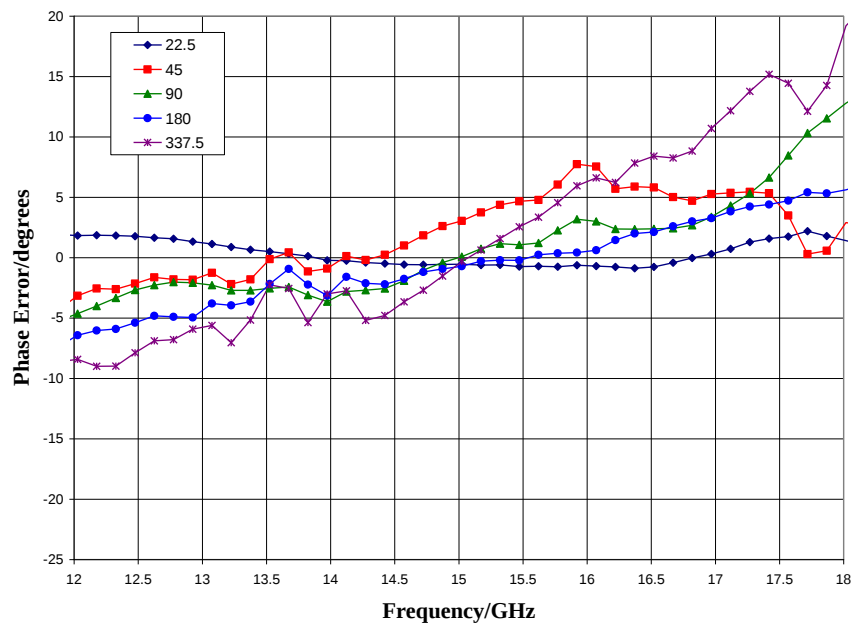
ver 1.5 0719

### Typical Performance

#### Normalized Loss, Major States



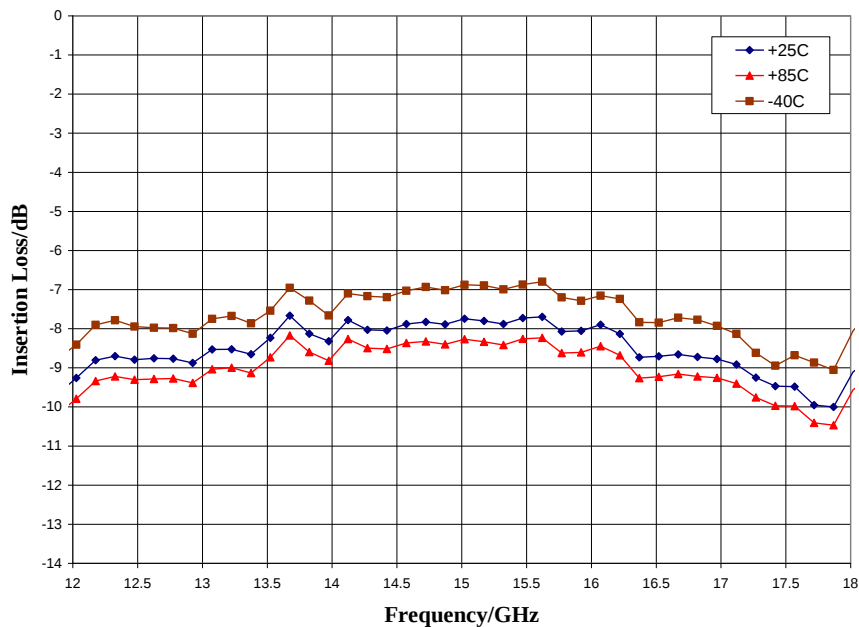
#### Phase Error, Major States and All On State



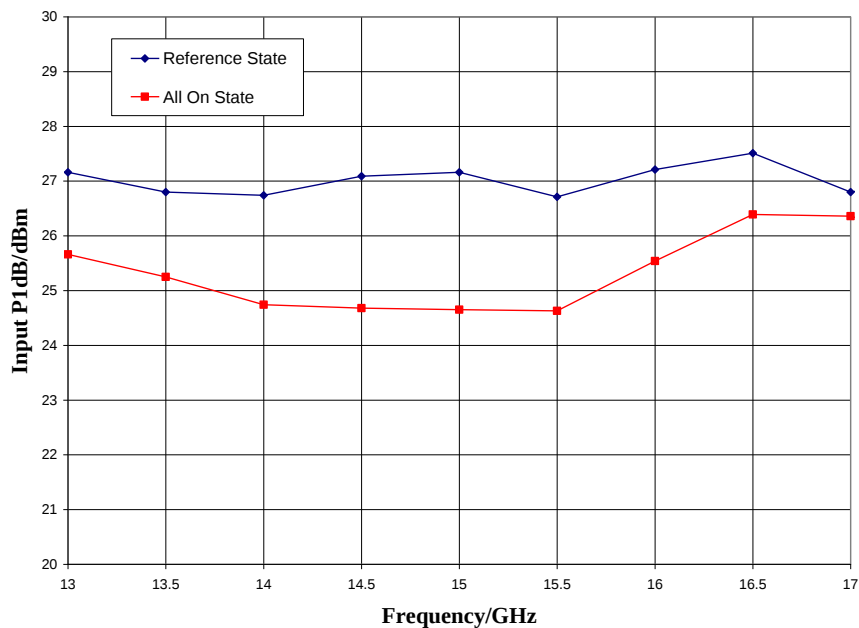
ver 1.5 0719

### Typical Performance

#### Insertion Loss vs. Temperature, Reference State



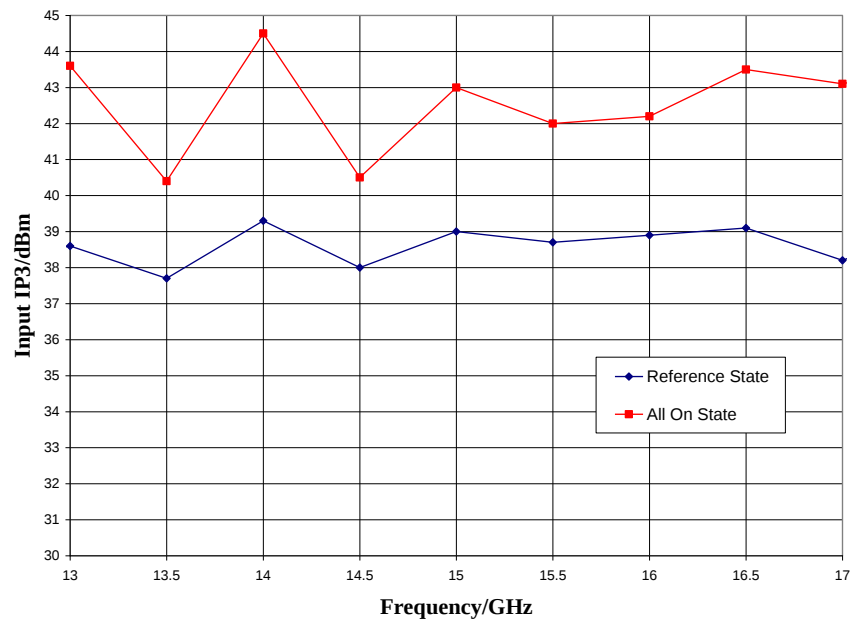
#### Input P1dB



ver 1.5 0719

### Typical Performance

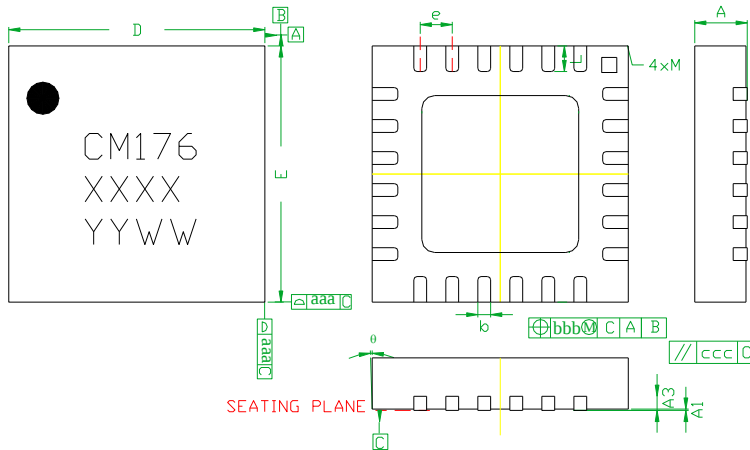
#### Input IP3



ver 1.5 0719

### Mechanical Information

#### Package Information and Dimensions



| SYMBOLS | DIMENSIONS IN MILLIMETERS |          |      |
|---------|---------------------------|----------|------|
|         | MIN                       | NOM      | MAX  |
| A       | 0.80                      | 0.90     | 1.00 |
| A1      | 0                         | 0.02     | 0.05 |
| A3      | —                         | 0.25REF. | —    |
| b       | 0.18                      | 0.23     | 0.30 |
| D       | 3.85                      | 4.00     | 4.15 |
| D1      | —                         | 2.45BSC  | —    |
| E       | 3.85                      | 4.00     | 4.15 |
| E1      | —                         | 2.45BSC  | —    |
| e       | —                         | 0.50BSC  | —    |
| L       | 0.30                      | 0.40     | 0.50 |
| M       | 0                         | —        | 12   |
| aaa     | —                         | 0.25     | —    |
| bbb     | —                         | 0.10     | —    |
| ccc     | —                         | 0.10     | —    |
| M       | —                         | —        | 0.05 |

#### NOTES:

1. DIMENSIONS ARE IN MILLIMETERS
2. RoHS COMPLIANT MOLD COMPOUND
3. LEADFRAME MATERIAL: COPPER ALLOY
4. LEAD FINISH: 100% MATTE Sn
5. INDICATED DIMENSION/TOLERANCE APPLIES TO LEADS AND EXPOSED PAD

#### Recommended PCB Land Pattern

Custom MMIC Design Services recommends that the user develop the land pattern that will provide the best design for proper solder reflow and device attach for their specific application. Please review CMDS Application Note AN 105 for a recommended land pattern approach.

#### Recommended Solder Reflow Profile

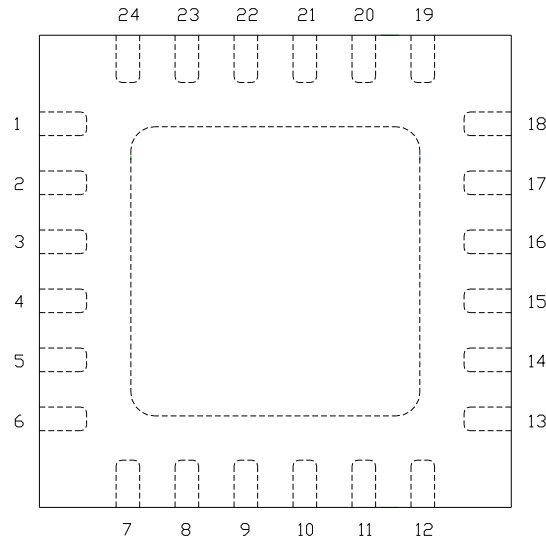
Custom MMIC Design Services recommends screen printing with belt furnace reflow to ensure proper solder reflow and device attach. Please review CMDS Application Note AN 102 for a recommended solder reflow profile.

**GaAs MMIC devices are susceptible to damage from Electrostatic Discharge. Proper precautions should be observed during handling, assembly and test.**

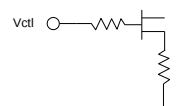
ver 1.5 0719

### Pin Description

### Pin Diagram



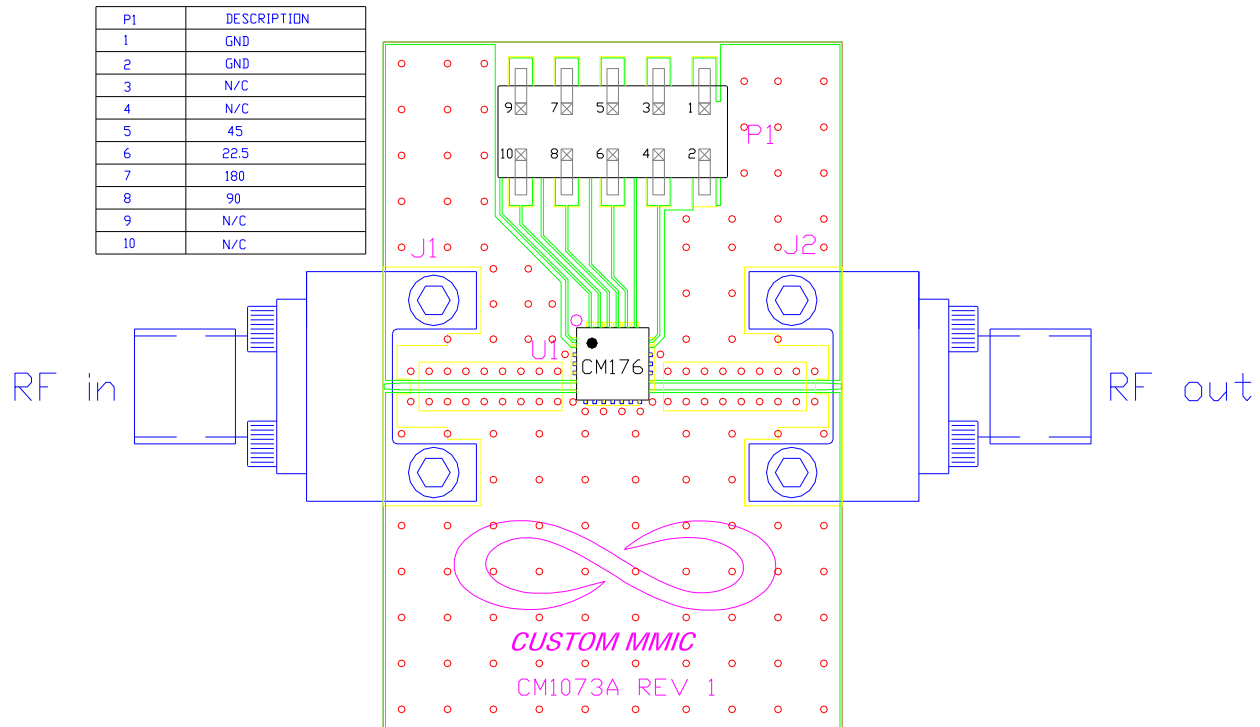
### Functional Description

| Pad                   | Function | Description                                                           | Schematic                                                                                    |
|-----------------------|----------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| 1-4, 7-12, 15-19, 24  | N/C      | No connection required. These pins may be connected to RF / DC ground |                                                                                              |
| 6                     | RF in    | DC blocked and 50 ohm matched                                         | RF in   |
| 13                    | RF out   | DC blocked and 50 ohm matched                                         |  RF out |
| 20                    | 22.5     | 22.5° control input                                                   |         |
| 21                    | 45       | 45° control input                                                     |                                                                                              |
| 22                    | 90       | 90° control input                                                     |                                                                                              |
| 23                    | 180      | 180° control input                                                    |                                                                                              |
| 5, 14 and die pad-dle | Ground   | Connect to RF / DC ground                                             |  GND    |

ver 1.5 0719

### Applications Information

#### Evaluation Board



#### Bill of Material

| Designator | Value | Description                  |
|------------|-------|------------------------------|
| J1, J2     |       | SMA End Launch Connector     |
| P1         |       | 10 Pin DC Header             |
| U1         |       | CMD176P4 4-Bit Phase Shifter |
| PCB        |       | CM1073A Evaluation PCB       |

Please note, all information contained in this data sheet is subject to change without notice.

ver 1.5 0719

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294  
Visit us online at [www.custommmic.com](http://www.custommmic.com)

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)

### Product Description

Qorvo's TGP2107 is a 6-bit, digital phase shifter fabricated on Qorvo's high performance 0.15 $\mu$ m GaAs pHEMT process. It operates over 6 to 18 GHz and provides 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 5° with 8 dB of insertion loss over all states.

The TGP2107 uses negative switch logic, eliminating the need for a reference voltage. That, along with low insertion and a high degree of resolution makes the TGP2107 ideally suited for a variety of wideband phased array applications, including commercial and military radars, satellite-based communication systems and electronic warfare.

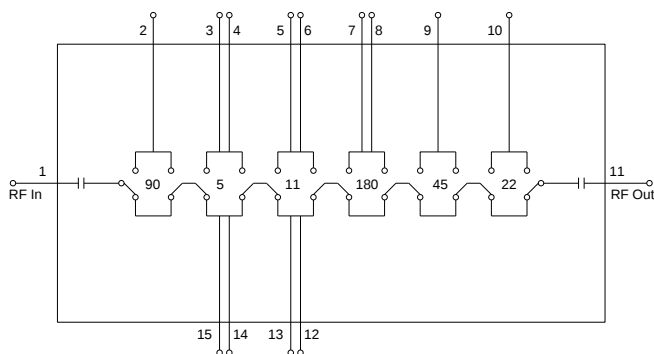


### Product Features

- Frequency Range: 6 to 18 GHz
- 6-Bit Digital Phase Shifter
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 5°
- RMS Amplitude Error: 0.55 dB
- Insertion Loss: <10 dB
- Return Loss: >12 dB
- Input P1dB: >25 dBm
- Input IP3: >41 dBm
- Control Voltage: -5/0 V
- Chip Dimensions: 3.15 x 3.15 x 0.10 mm

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

### Block Diagram



### Applications

- Phased Array Antenna Systems
- Satellite Communication Systems
- Electronic Warfare

### Ordering Information

| Part No. | Description                     |
|----------|---------------------------------|
| 1110743  | Waffle Pack, Qty 20             |
| 1101243  | TGP2107 Evaluation Board, Qty 1 |

### Absolute Maximum Ratings

| Parameter                           | Value      | Units |
|-------------------------------------|------------|-------|
| Control and Reference Voltage       | 6          | V     |
| Control Current                     | -15 to +5  | mA    |
| Power Dissipation                   | 0.9        | W     |
| Input Power, CW, 50 $\Omega$ , 85°C | 30         | dBm   |
| Channel Temperature                 | 200        | °C    |
| Mounting Temperature (30 Seconds)   | 320        | °C    |
| Storage Temperature                 | -55 to 150 | °C    |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied.

### Bias and Truth Table

Control voltage Logic "0" = VL, value between -5 to -3 V; Logic "1" = VH, value between +0 to +0.2 V

| Phase Shift    | 5P | 5N | 11P | 11N | 22 | 45 | 90 | 180P | 180N |
|----------------|----|----|-----|-----|----|----|----|------|------|
| 0° (Reference) | 0  | 1  | 0   | 1   | 0  | 0  | 0  | 0    | 1    |
| 5°             | 1  | 0  | 0   | 1   | 0  | 0  | 0  | 0    | 1    |
| 11°            | 0  | 1  | 1   | 0   | 0  | 0  | 0  | 0    | 1    |
| 22°            | 0  | 1  | 0   | 1   | 1  | 0  | 0  | 0    | 1    |
| 45°            | 0  | 1  | 0   | 1   | 0  | 1  | 0  | 0    | 1    |
| 90°            | 0  | 1  | 0   | 1   | 0  | 0  | 1  | 0    | 1    |
| 180°           | 0  | 1  | 0   | 1   | 0  | 0  | 0  | 1    | 0    |
| 355°           | 1  | 0  | 1   | 0   | 1  | 1  | 1  | 1    | 0    |

### Electrical Specifications

Test conditions unless otherwise noted: 25 °C

Data de-embedded to device reference planes at end of feeds, data include bond wire effects

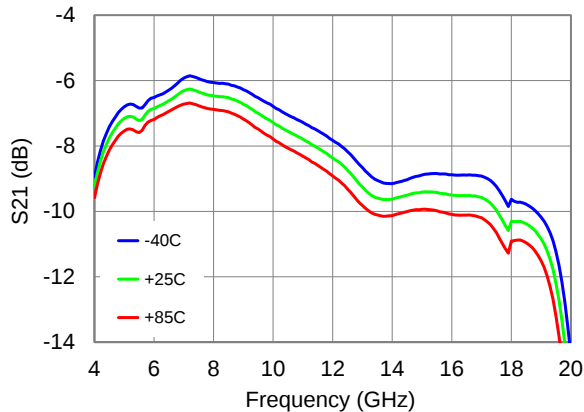
Control Voltage (5N, 5P, 11N, 11P, 22, 45, 90, 180N, 180P) = -5 / 0 V; See Bias Truth Table.

| Parameter                                           | Min | Typical | Max | Units |
|-----------------------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range                         | 6   |         | 18  | GHz   |
| Insertion Loss                                      |     | 6 - 10  |     | dB    |
| Input Return Loss                                   |     | >12     |     | dB    |
| Output Return Loss                                  |     | >12     |     | dB    |
| RMS Phase Error                                     |     | 5       |     | deg   |
| RMS Amplitude Error                                 |     | 0.55    |     | dB    |
| Input P1dB                                          |     | >25     |     | dBm   |
| Input IP3, Tone spacing = 10 MHz, Pin/Tone = 15 dBm |     | >41     |     | dBm   |
| Insertion Loss Temperature Coefficient              |     | 0.008   |     | dB/°C |

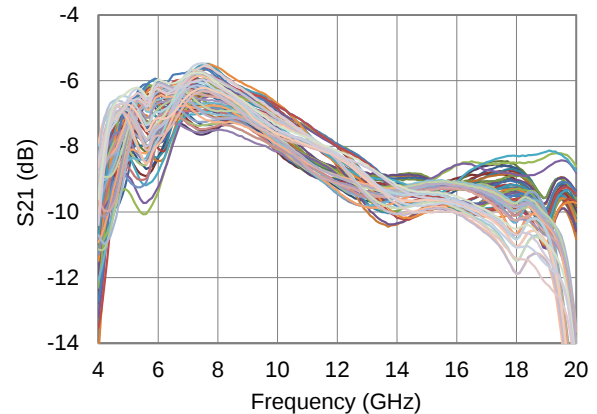
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C

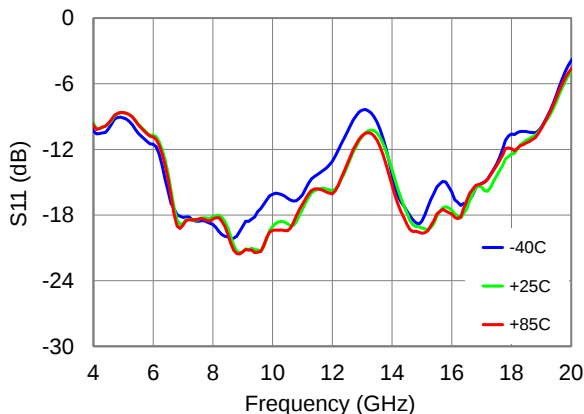
Average Insertion Loss vs. Temperature  
All phase states



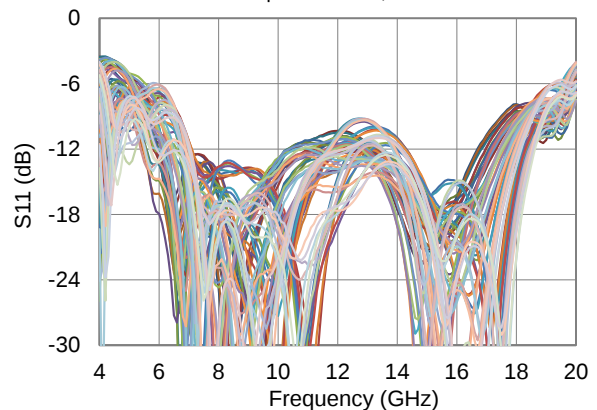
Insertion Loss vs. Frequency  
All phase states



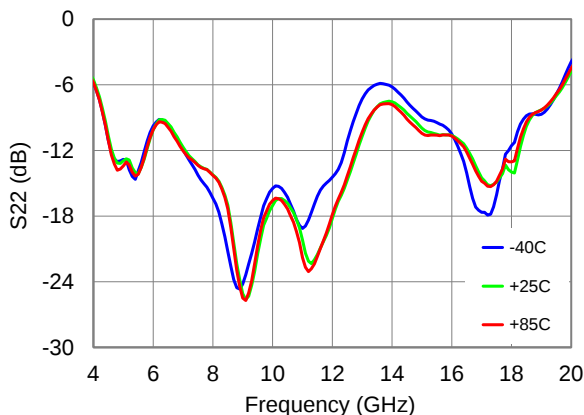
Average IRL vs. Temperature  
All phase states



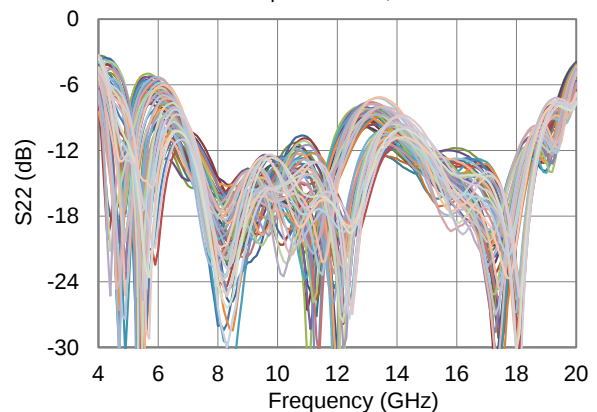
Input Return Loss vs. Frequency  
All phase states, 25C



Average ORL vs. Temperature  
All phase states

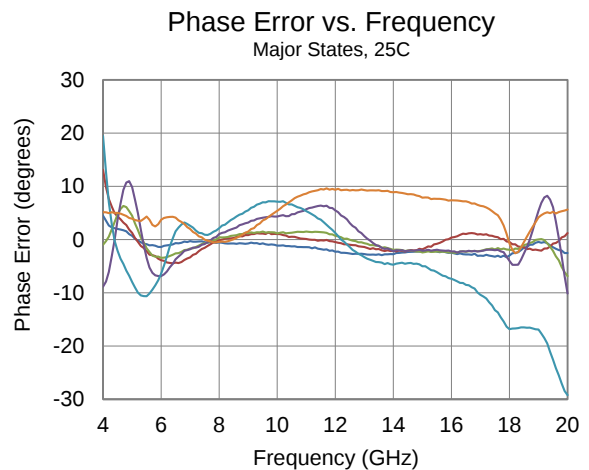
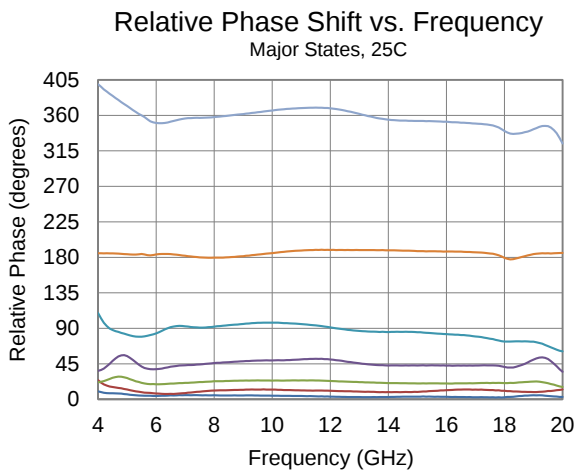
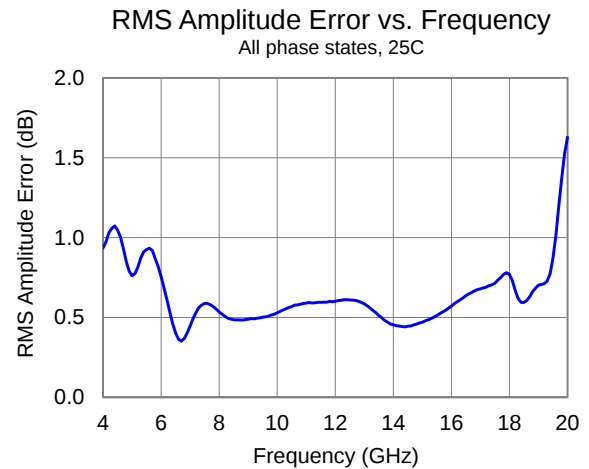
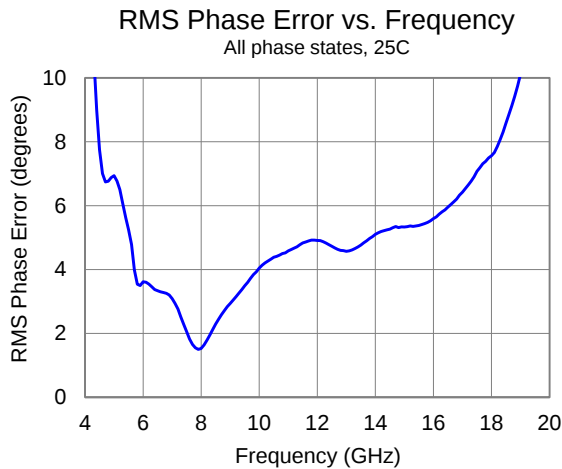
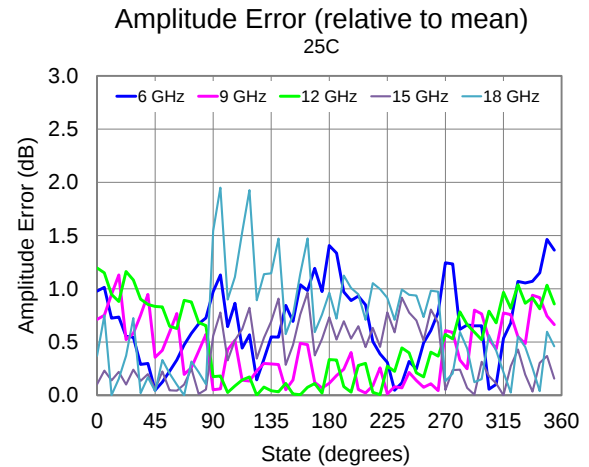
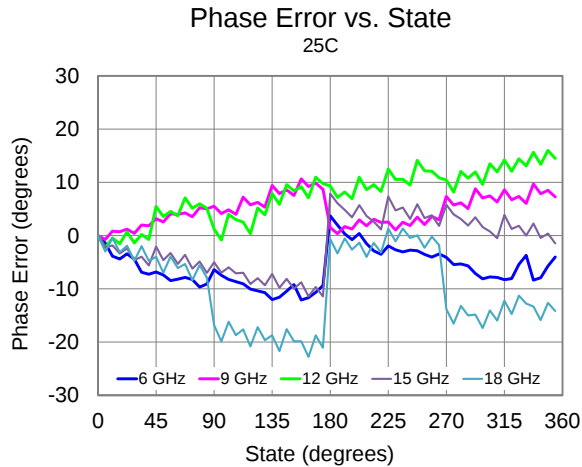


Output Return Loss vs. Frequency  
All phase states, 25C



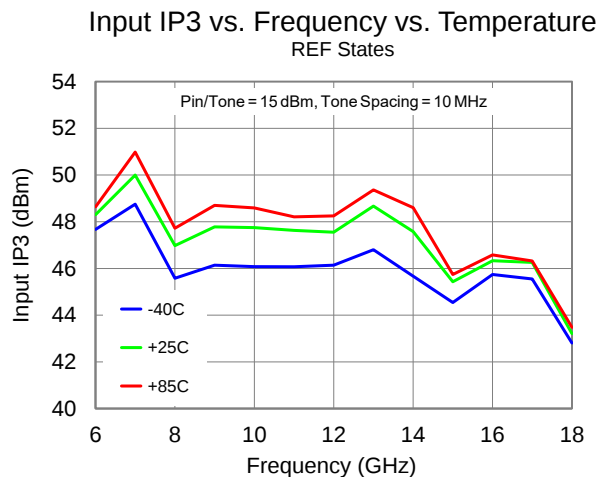
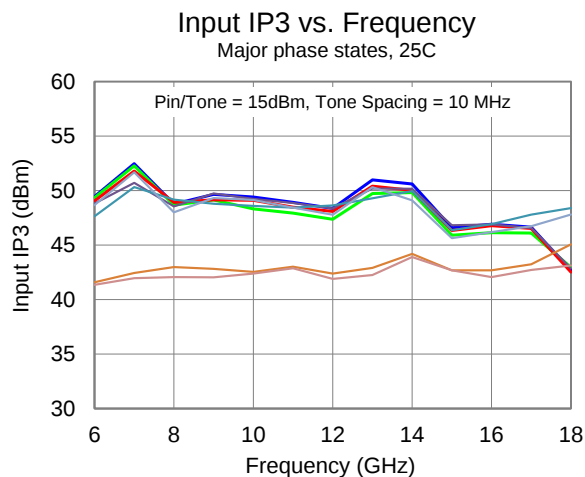
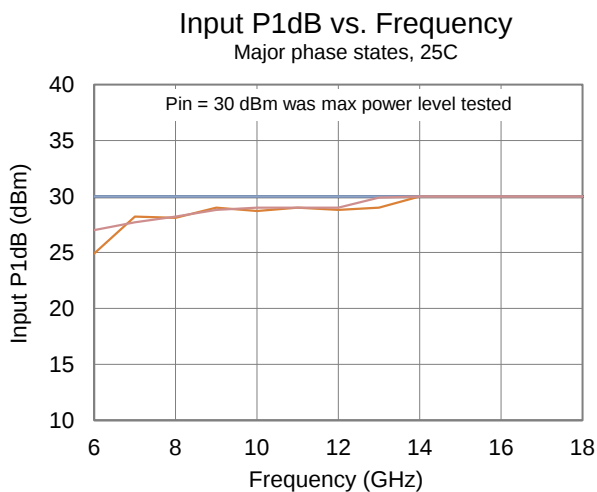
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C

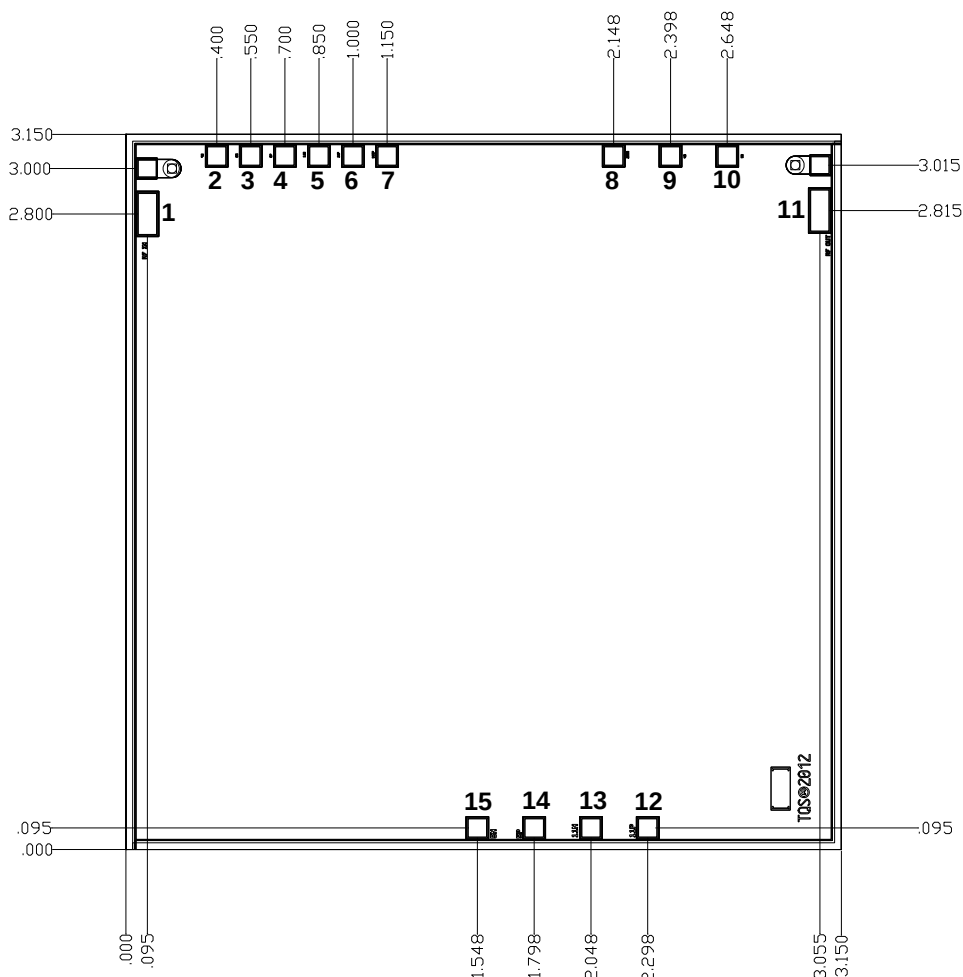


### Performance Plots – Large Signal and Linearity

Test conditions unless otherwise noted: 25 °C



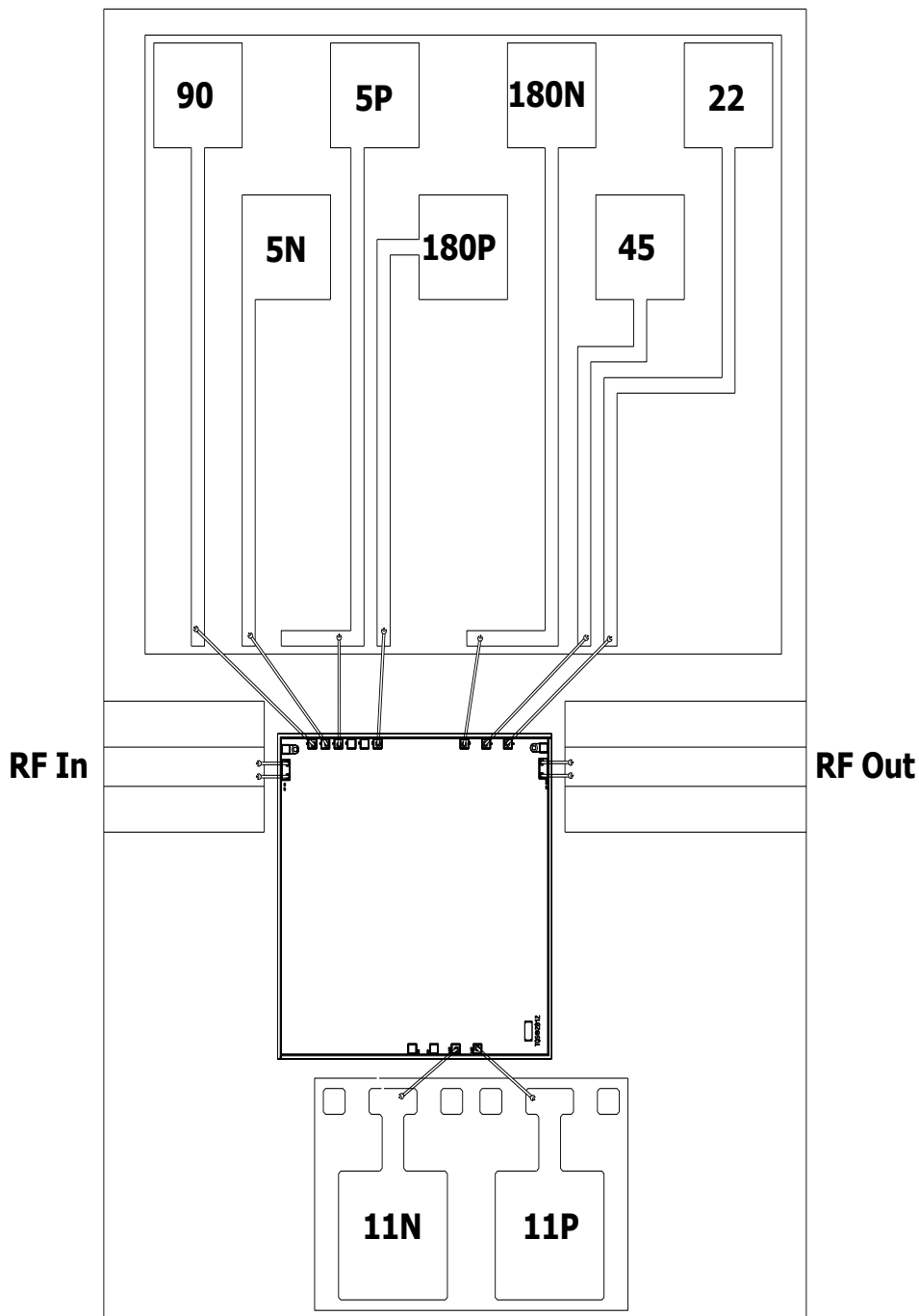
### Mechanical Information and Bond Pad Description



| Bond Pad | Symbol | Description                                 | Pad Size      |
|----------|--------|---------------------------------------------|---------------|
| 1        | RF In  | Input; matched to 50 $\Omega$ ; DC blocked  | 0.200 x 0.100 |
| 2        | 90     | 90° Bit                                     | 0.100 x 0.100 |
| 3, 15    | 5N     | 5N° Bit; use either pad 3 or 15             | 0.100 x 0.100 |
| 4, 14    | 5P     | 5P° Bit; use either pad 4 or 14             | 0.100 x 0.100 |
| 5, 13    | 11N    | 11N° Bit; use either pad 5 or 13            | 0.100 x 0.100 |
| 6, 12    | 11P    | 11P° Bit; use either pad 6 or 12            | 0.100 x 0.100 |
| 7        | 180P   | 180P° Bit                                   | 0.100 x 0.100 |
| 8        | 180N   | 180N° Bit                                   | 0.100 x 0.100 |
| 9        | 45     | 45° Bit                                     | 0.100 x 0.100 |
| 10       | 22     | 22° Bit                                     | 0.100 x 0.100 |
| 11       | RF Out | Output; matched to 50 $\Omega$ ; DC blocked | 0.200 x 0.100 |

### Applications Information

1. The spacing between MMIC and TFN at RF In and RF Out is <5 mils typical.
2. RF connections: Bond two 1-mil diameter, <20 mils length gold bond wires at RF In and RF Out for optimum RF performance.



### Assembly Notes

---

#### Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.
- Organic attachment (i.e., conductive epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.

#### Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300°C to 3-4 minutes, maximum.
- Conductive epoxy die attach is recommended for PCB mounting.
- Bonding pads plating: Au.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

#### Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonics are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

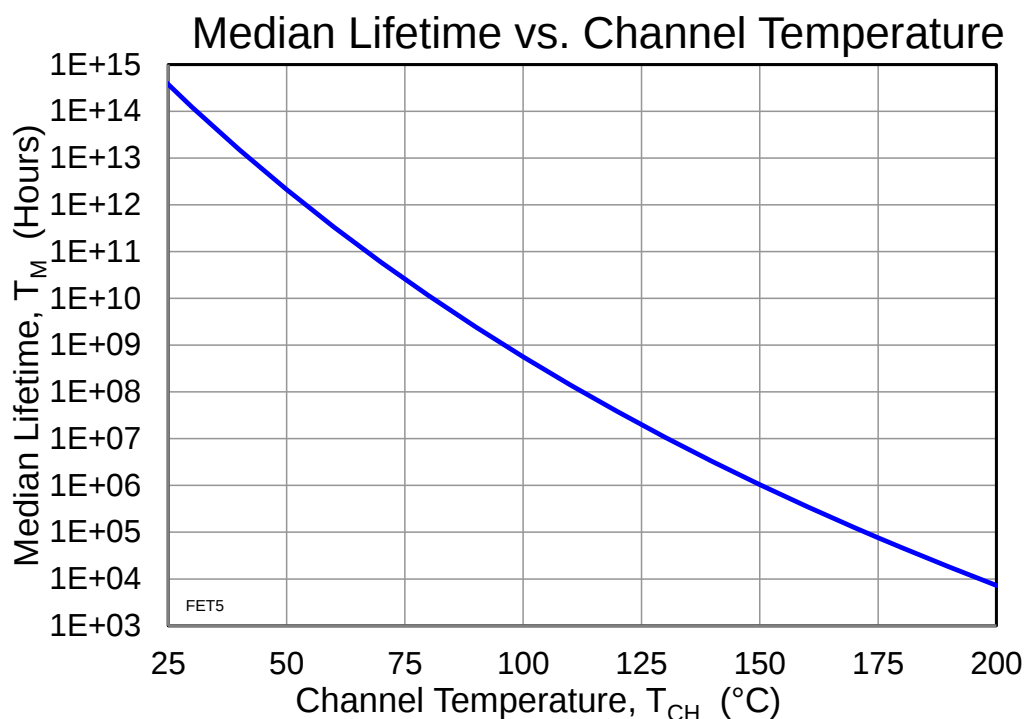
### Thermal and Reliability Information

| Parameter                                           | Test Conditions                                                       | Value  | Units                |
|-----------------------------------------------------|-----------------------------------------------------------------------|--------|----------------------|
| Thermal Resistance ( $\theta_{JC}$ ) <sup>(1)</sup> | $P_{DISS} = 0.09 \text{ W}$ ,<br>$T_{BASEPLATE} = 85^{\circ}\text{C}$ | 22     | $^{\circ}\text{C/W}$ |
| Channel Temperature, $T_{CH}$ (Under RF)            |                                                                       | 87     | $^{\circ}\text{C}$   |
| Median Lifetime ( $T_M$ )                           |                                                                       | 3.8E09 | Hrs                  |

#### Notes:

1. Thermal resistance measured to back of carrier plate. MMIC mounted on 40 mils thick CuMo carrier using 1.5 mil 80/20 AuSn.

### Median Lifetime



### Handling Precautions

| Parameter                    | Rating | Standard                 |  | Caution!<br>ESD-Sensitive Device |
|------------------------------|--------|--------------------------|-------------------------------------------------------------------------------------|----------------------------------|
| ESD – Human Body Model (HBM) | TBD    | ESDA / JEDEC JS-001-2012 |                                                                                     |                                  |

### 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

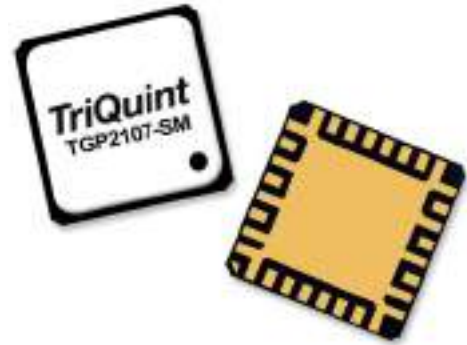
Copyright 2021 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.

### Product Description

The Qorvo TGP2107-SM is a packaged 6-bit digital phase shifter, fabricated on Qorvo's high performance 0.15  $\mu\text{m}$  GaAs pHEMT process. It operates over 6 to 18 GHz and provides 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 5° with 8 dB of insertion loss over all states.

The TGP2107-SM uses negative switch logic, eliminating the need for a reference voltage. That, along with low insertion and a high degree of resolution makes the TGP2107-SM ideally suited for a variety of wideband phased array applications, including commercial and military radars, satellite-based communication systems and electronic warfare.

The device is lead-free and RoHS compliant.



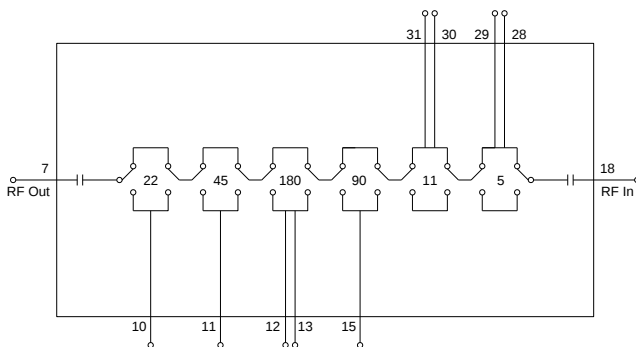
Air Cavity Ceramic QFN 5x5 mm 32L

### Product Features

- Frequency Range: 6 to 18 GHz
- 6-Bit Digital Phase Shifter
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 5°
- RMS Amplitude Error: 0.55 dB
- Insertion Loss: <10 dB
- Return Loss: >12 dB
- Input P1dB: >25 dBm
- Input IP3: >41 dBm
- Control Voltage: -5/0 V
- Package Dimensions: 5.0 x 5.0 x 1.45 mm

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

### Block Diagram



### Applications

- Phased Array Antenna Systems
- Satellite Communication Systems
- Electronic Warfare

### Ordering Information

| Part No.      | Description                                |
|---------------|--------------------------------------------|
| TGP2107-SM    | 6-18 GHz 6-Bit Digital Phase Shifter (-Vc) |
| TGP2107-SMEVB | TGP2107-SM EVAL BOARD                      |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | -15 to +5 mA  |
| Power Dissipation                   | 0.9 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 30 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 260 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                                                     | Value         |
|---------------------------------------------------------------|---------------|
| Control Voltage<br>(5N, 5P, 11N, 11P, 22, 45, 90, 180N, 180P) | -5/0 V        |
| Temperature Range                                             | -40 to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage (5N, 5P, 11N, 11P, 22, 45, 90, 180N, 180P) = 0/+5 V; See Bias Truth Table.

| Parameter                              | Conditions                         | Min | Typical | Max | Units |
|----------------------------------------|------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range            |                                    | 6   |         | 18  | GHz   |
| Insertion Loss                         |                                    |     | 6 to 10 |     | dB    |
| Input Return Loss                      |                                    |     | >12     |     | dB    |
| Output Return Loss                     |                                    |     | >12     |     | dB    |
| RMS Phase Error                        |                                    |     | 5       |     | deg   |
| RMS Amplitude Error                    |                                    |     | 0.55    |     | dB    |
| Input P1dB                             |                                    |     | >25     |     | dBm   |
| Input IP3                              | Spacing = 10 MHz, Pin/Tone = 8 dBm |     | 45      |     | dBm   |
| Insertion Loss Temperature Coefficient |                                    |     | 0.008   |     | dB/°C |

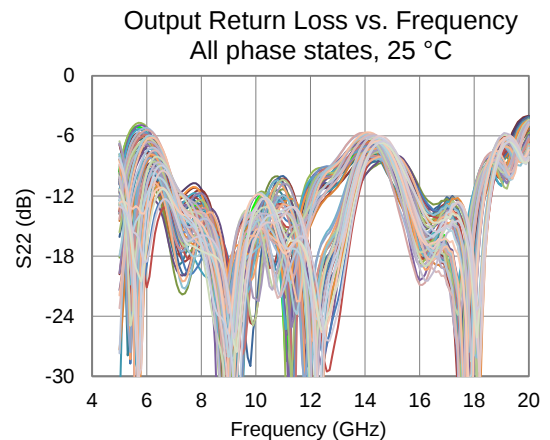
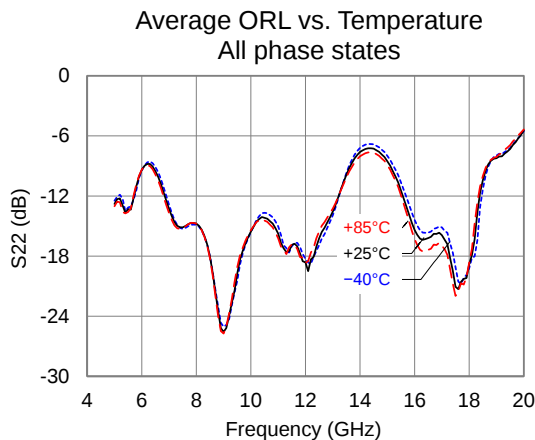
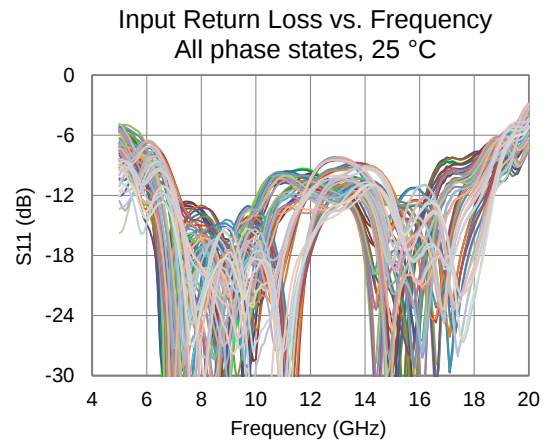
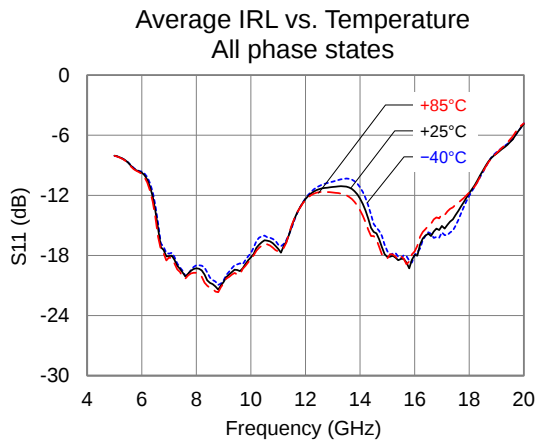
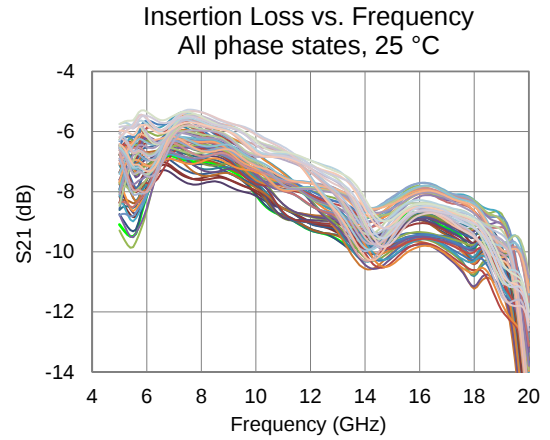
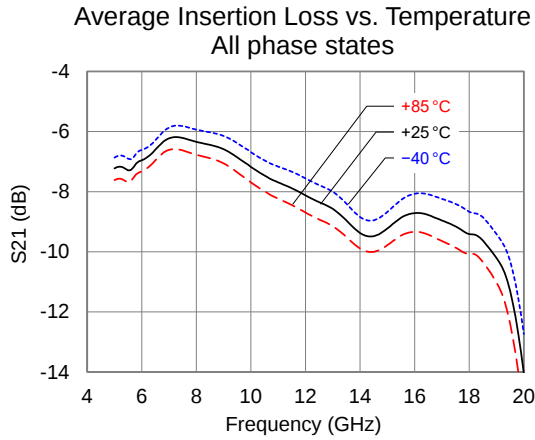
### Bias Truth Table

Logic "0" = -5 V, Logic "1" = 0 V

| Phase Shifter  | 5P | 5N | 11P | 11N | 22 | 45 | 90 | 180P | 180N |
|----------------|----|----|-----|-----|----|----|----|------|------|
| 0° (Reference) | 0  | 1  | 0   | 1   | 0  | 0  | 0  | 0    | 1    |
| 5°             | 1  | 0  | 0   | 1   | 0  | 0  | 0  | 0    | 1    |
| 11°            | 0  | 1  | 1   | 0   | 0  | 0  | 0  | 0    | 1    |
| 22°            | 0  | 1  | 0   | 1   | 1  | 0  | 0  | 0    | 1    |
| 45°            | 0  | 1  | 0   | 1   | 0  | 1  | 0  | 0    | 1    |
| 90°            | 0  | 1  | 0   | 1   | 0  | 0  | 1  | 0    | 1    |
| 180°           | 0  | 1  | 0   | 1   | 0  | 0  | 0  | 1    | 0    |
| 355°           | 1  | 0  | 1   | 0   | 1  | 1  | 1  | 1    | 0    |

### Performance Plots – Small Signal

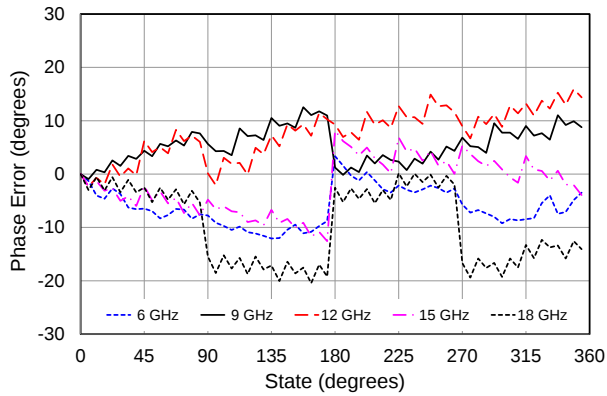
Test conditions unless otherwise noted: -5V, 25 °C



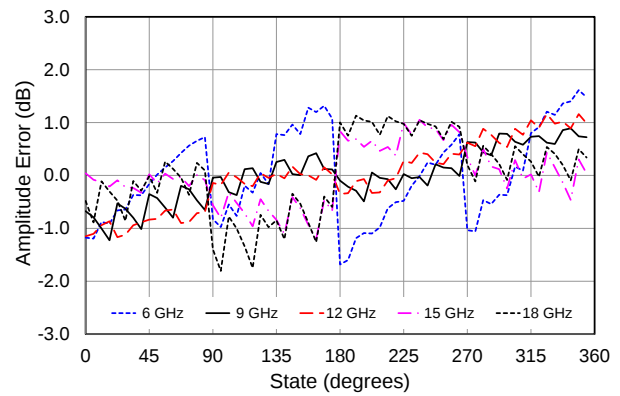
### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: -5V, 25 °C

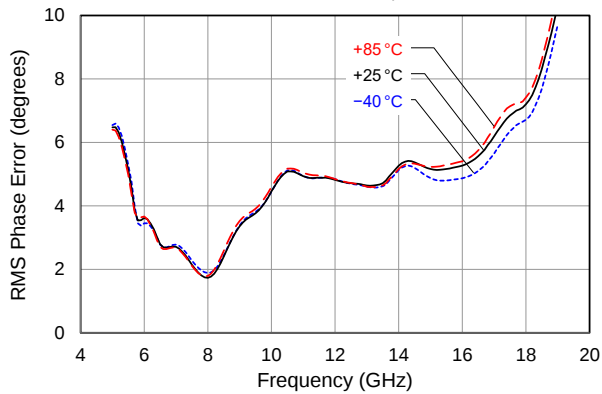
Phase Error vs. State  
25 °C



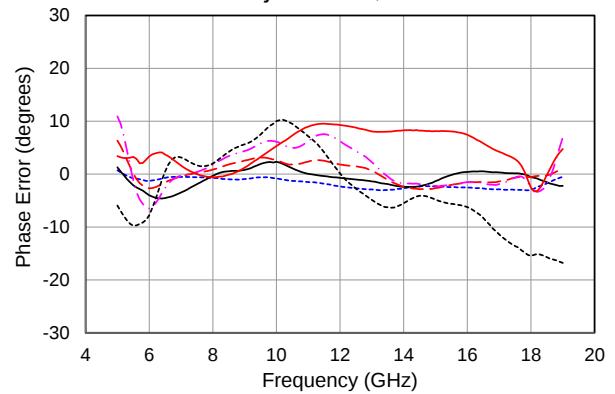
Amplitude Error (relative to mean) vs. State  
25 °C



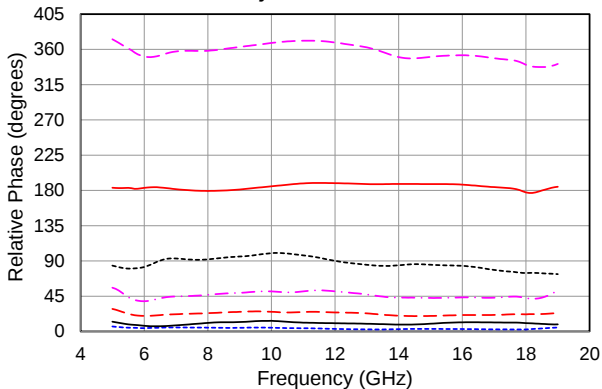
RMS Phase Error vs. Frequency  
All Phase States, 25 °C



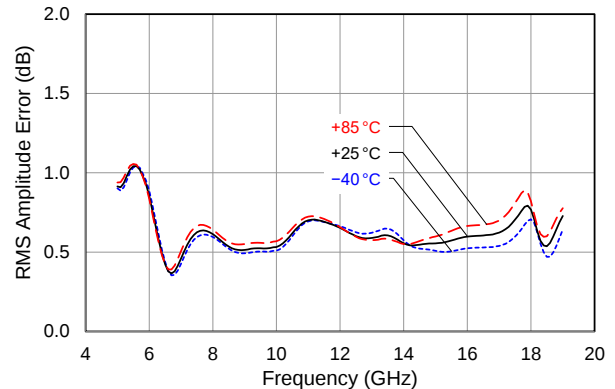
Phase Error vs. Frequency  
Major States, 25 °C



Relative Phase Shift vs. Frequency  
Major States, 25 °C

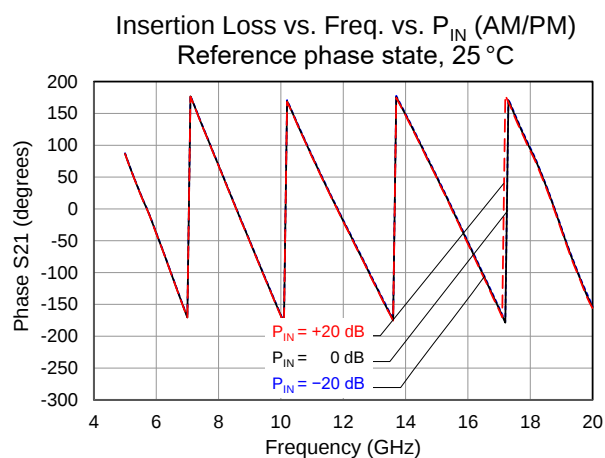
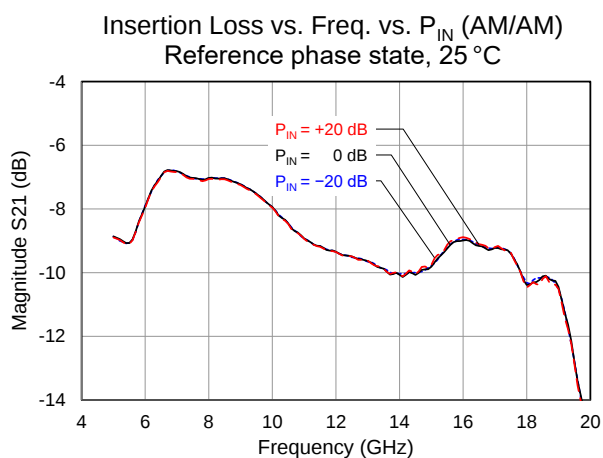


RMS Amplitude Error vs. Frequency  
All Phase States, 25 °C



### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: -5V, 25 °C



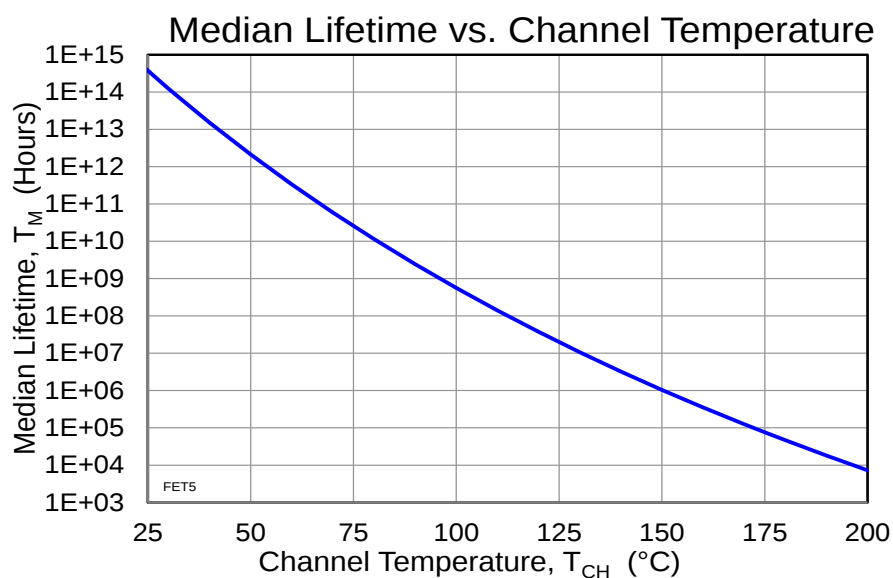
### Thermal and Reliability Information

| Parameter                                           | Test Conditions                                                  | Value  | Units                |
|-----------------------------------------------------|------------------------------------------------------------------|--------|----------------------|
| Thermal Resistance ( $\theta_{JC}$ ) <sup>(1)</sup> | $P_{DISS} = 0.09 \text{ W}$ ,<br>$T_{BASE} = 85^{\circ}\text{C}$ | 22     | $^{\circ}\text{C/W}$ |
| Channel Temperature ( $T_{CH}$ )                    |                                                                  | 87     | $^{\circ}\text{C}$   |
| Median Lifetime ( $T_M$ )                           |                                                                  | 3.8E+9 | Hrs                  |

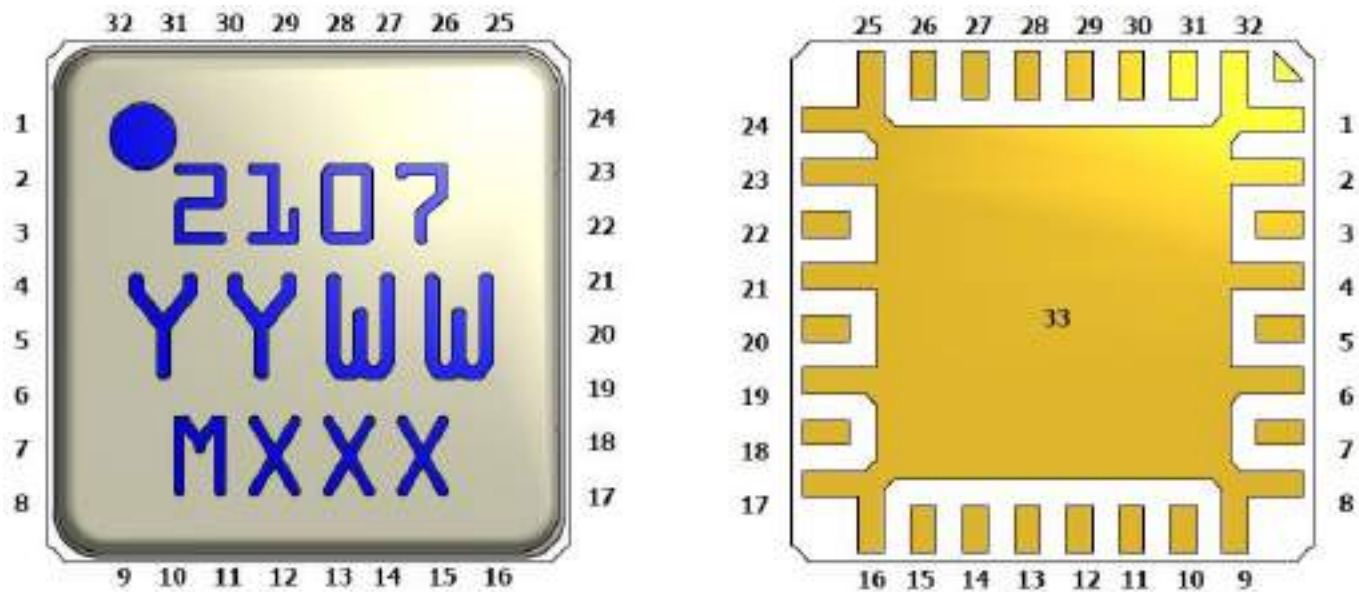
Notes:

1. Thermal resistance measured to back of package.

### Median Lifetime

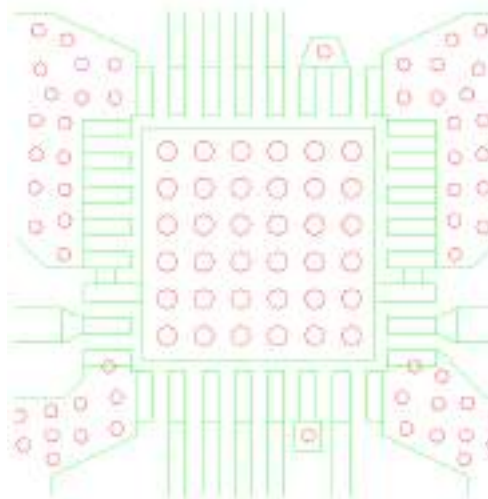
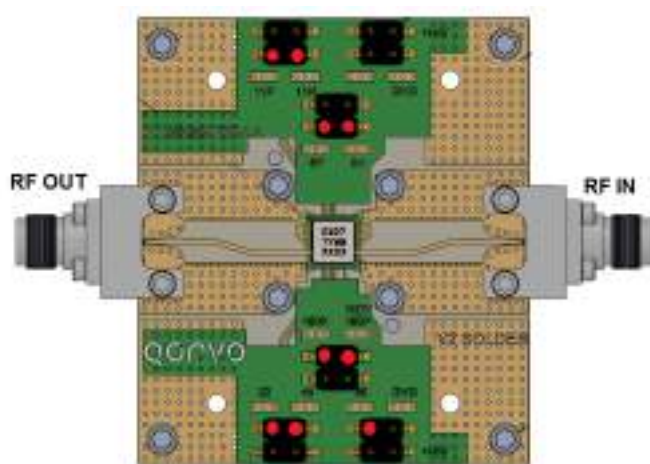


Pin Description



| Pin No.                                | Symbol | Description                                                                                     |
|----------------------------------------|--------|-------------------------------------------------------------------------------------------------|
| 1 - 6, 8 - 9, 14, 16 - 17, 19 – 27, 32 | GND    | Internal grounding; must be grounded on PCB                                                     |
| 7                                      | RF OUT | Output; matched to 50 $\Omega$ ; DC blocked                                                     |
| 10                                     | 22°    | 22° Bit; De-Qing network is not required                                                        |
| 11                                     | 45°    | 45° Bit; De-Qing network is not required                                                        |
| 12                                     | 180N°  | 180N° Bit; De-Qing network is not required                                                      |
| 13                                     | 180P°  | 180P° Bit; De-Qing network is not required                                                      |
| 15                                     | 90°    | 90° Bit; De-Qing network is not required                                                        |
| 18                                     | RF IN  | Input; matched to 50 $\Omega$ ; DC blocked                                                      |
| 28                                     | 5N°    | 5N° Bit; De-Qing network is not required                                                        |
| 29                                     | 5P°    | 5P° Bit; De-Qing network is not required                                                        |
| 30                                     | 11N°   | 11N° Bit; De-Qing network is not required                                                       |
| 31                                     | 11P°   | 11P° Bit; De-Qing network is not required                                                       |
| 33                                     | GND    | Backside Paddle; multiple vias should be employed to minimize inductance and thermal resistance |

#### Evaluation Board (EVB) Layout Assembly



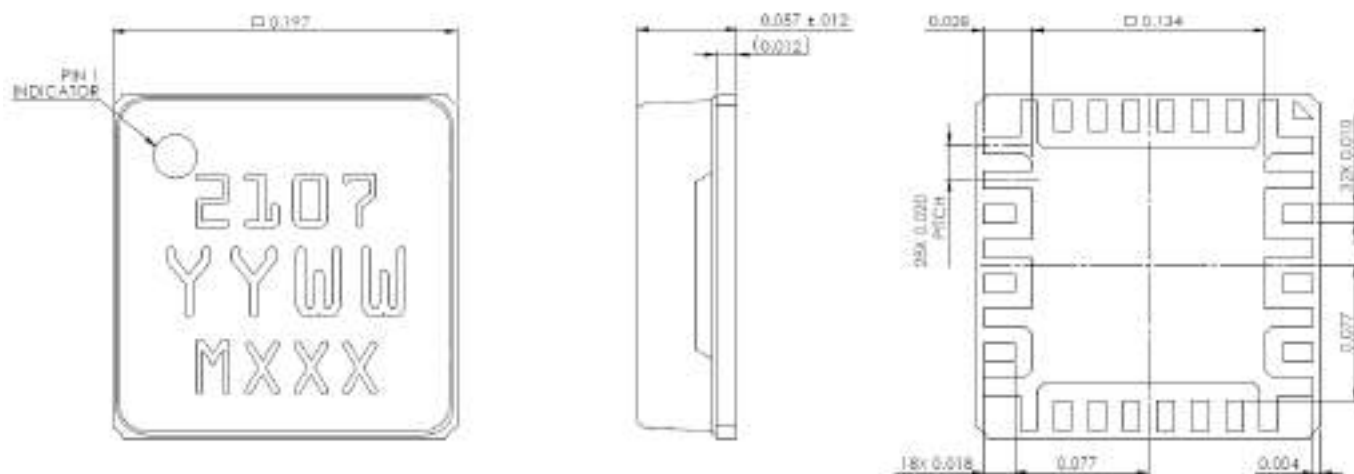
Via pattern

RF layer is 0.010" thick Rogers RO4350. Metal layers are 1-oz copper. The microstrip line taper at the connector interface is optimized for the Southwest Microwave end-launch connector 1092-01A-5.

Ground / thermal vias under the DUT are critical for the proper performance of this device. The PCB shown herein utilizes copper filled vias under the DUT.

The pad pattern shown has been developed and tested for optimized assembly at Qorvo. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company careful process development is recommended.

### Mechanical Information



All dimensions are in inches.

#### NOTES:

1. MATERIALS:  
PACKAGE BASE: CERAMIC  
PACKAGE LID: PLASTIC
2. PACKAGE LID PATTERN IS GOLD PLATED.
3. PART IS EPOXY SEALED.
4. PART MARKING:  
2107 : PART NUMBER  
YY : PART ASSEMBLY YEAR  
WW : PART ASSEMBLY WEEK  
MXXX : BATCH ID

### Assembly Notes

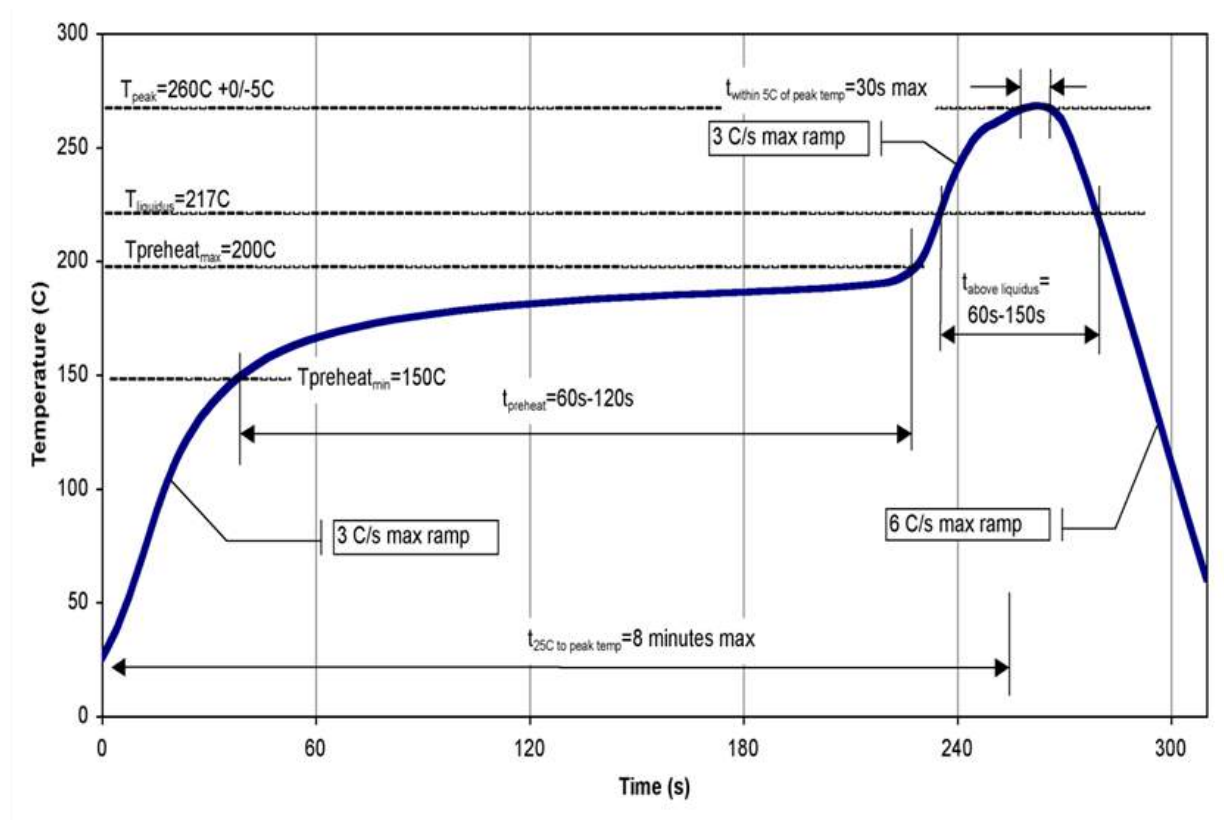
Compatible with both lead-free (260°C peak reflow temp.) and tin/lead (245°C peak reflow temp.) soldering processes.

This package is air-cavity and non-hermetic, and therefore cannot be subjected to aqueous washing. The use of no-clean solder to avoid washing after soldering is highly recommended.

Solder rework not recommended.

Contact plating: Ni-Au.

### Recommended Soldering Temperature Profile



### Handling Precautions

| Parameter                        | Rating   | Standard                 |
|----------------------------------|----------|--------------------------|
| ESD – Human Body Model (HBM)     | Class 0B | ESDA / JEDEC JS-001-2012 |
| ESD – Charge Device Model (CDM)  | Class C1 | JS-002-2014              |
| MSL – Moisture Sensitivity Level | MSL 3    | 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2019 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc



# CMD297

## 5-18 GHz Analog Phase Shifter

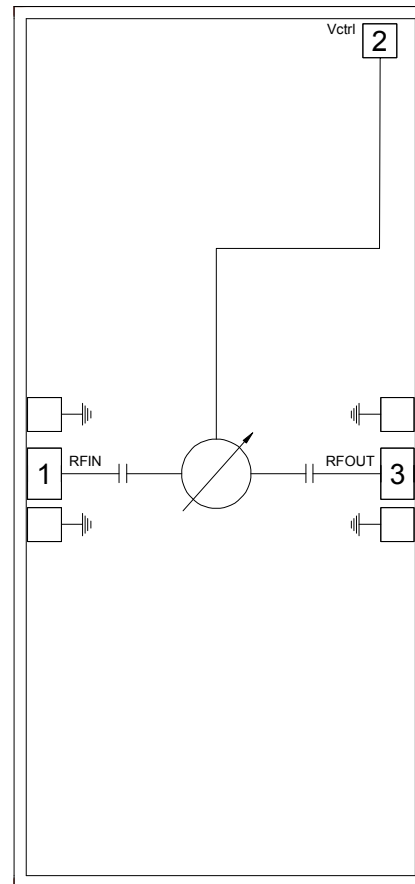
### Features

- Wide bandwidth
- Wide phase shift range
- Single positive control voltage
- Small die size

### Description

The CMD297 is an analog phase shifter die which operates from 5 to 18 GHz. The phase shifter utilizes a single positive control voltage of 0V to +10V to control relative phase shift over a 550 degree range at 7 GHz and a 240 degree range at 12 GHz. The CMD297 has consistent insertion loss versus phase shift and the phase shift is monotonic with respect to control voltage. The phase shifter is a 50 ohm matched design which eliminates the need for external DC blocks and RF port matching. The CMD297 offers full passivation for increased reliability and moisture protection.

### Functional Block Diagram



### Electrical Performance – $V_{ctl} = 0\text{ V to }+10\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$ , $F = 12\text{ GHz}$

| Parameter                 | Min    | Typ | Max | Units      |
|---------------------------|--------|-----|-----|------------|
| Frequency Range           | 5 - 18 |     |     | GHz        |
| Phase Shift Range         |        | 240 |     | degrees    |
| Insertion Loss            |        | 3   |     | dB         |
| Input Return Loss         |        | 10  |     | dB         |
| Output Return Loss        |        | 10  |     | dB         |
| Phase Voltage Sensitivity |        | 24  |     | deg / Volt |

ver 1.0 1218

Custom MMIC

300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294



# CMD297

## 5-18 GHz Analog Phase Shifter

### Specifications

#### Absolute Maximum Ratings

| Parameter                         | Rating        |
|-----------------------------------|---------------|
| Control Voltage, Vctl             | + 11 V        |
| Reverse Current                   | 5 mA          |
| RF Input Power                    | +30 dBm       |
| Channel Temperature, Tch          | 150 °C        |
| Power Dissipation, Pdiss          | 2 W           |
| Thermal Resistance, $\Theta_{JC}$ | 32.2 °C/W     |
| Operating Temperature             | -55 to 85 °C  |
| Storage Temperature               | -55 to 150 °C |

Exceeding any one or combination of the maximum ratings may cause permanent damage to the device.

#### Recommended Operating Conditions

| Parameter | Min | Typ | Max | Units |
|-----------|-----|-----|-----|-------|
| Vctl      | 0   |     | 10  | V     |

Electrical performance is measured at specific test conditions. Electrical specifications are not guaranteed over all recommended operating conditions.

#### Electrical Specifications, Vctl = 0 V to +10 V, T<sub>A</sub> = 25 °C

| Parameter                     | Min    | Typ  | Max | Min     | Typ | Max | Min     | Typ  | Max | Units      |
|-------------------------------|--------|------|-----|---------|-----|-----|---------|------|-----|------------|
| Frequency Range               | 5 - 10 |      |     | 10 - 13 |     |     | 13 - 18 |      |     | GHz        |
| Phase Shift Range             | 240    | 500  |     | 150     | 250 |     | 70      | 150  |     | degrees    |
| Insertion Loss                |        | 7    | 17  |         | 3.5 | 8   |         | 2.5  | 7   | dB         |
| Input Return Loss             |        | 10   |     |         | 10  |     |         | 8    |     | dB         |
| Output Return Loss            |        | 10   |     |         | 10  |     |         | 8    |     | dB         |
| Control Voltage Range         | 0      |      | 10  | 0       |     | 10  | 0       |      | 10  | Volts      |
| Phase Voltage Sensitivity     |        | 57   |     |         | 24  |     |         | 9    |     | deg / Volt |
| Phase Temperature Sensitivity |        | 0.15 |     |         | 0.1 |     |         | 0.05 |     | deg / °C   |

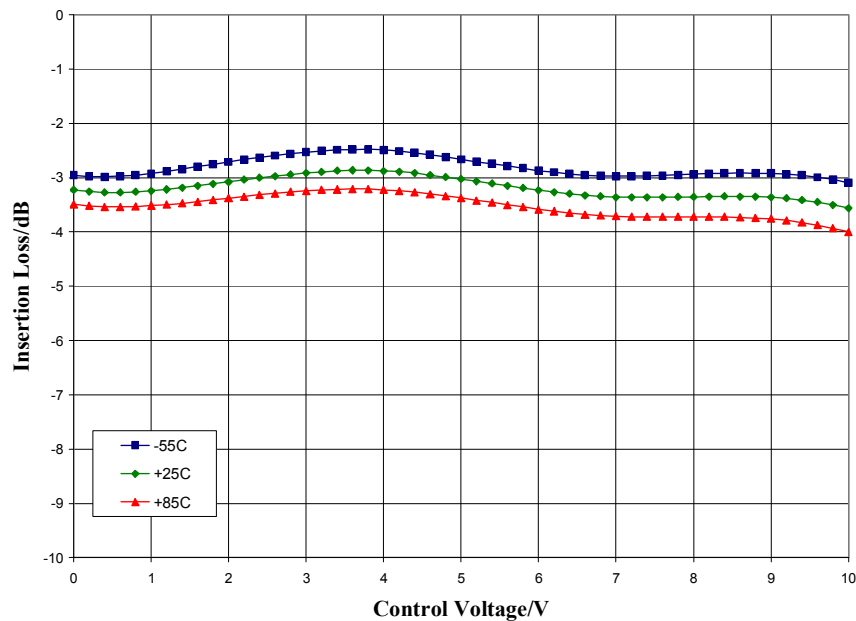
ver 1.0 1218

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

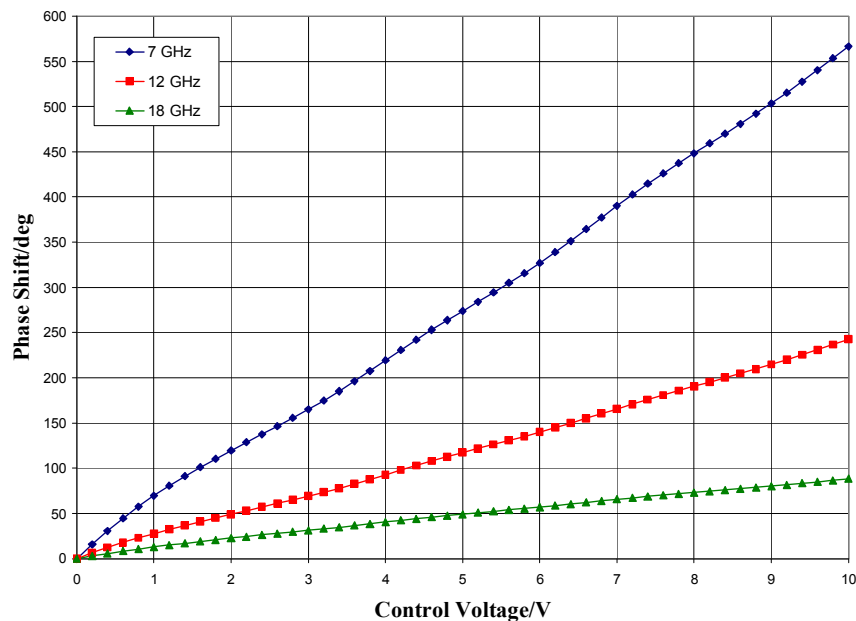
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Typical Performance

#### Insertion Loss vs. Control Voltage @ 12 GHz



#### Phase Shift vs. Control Voltage, $T_A = 25^\circ\text{C}$



ver 1.0 1218

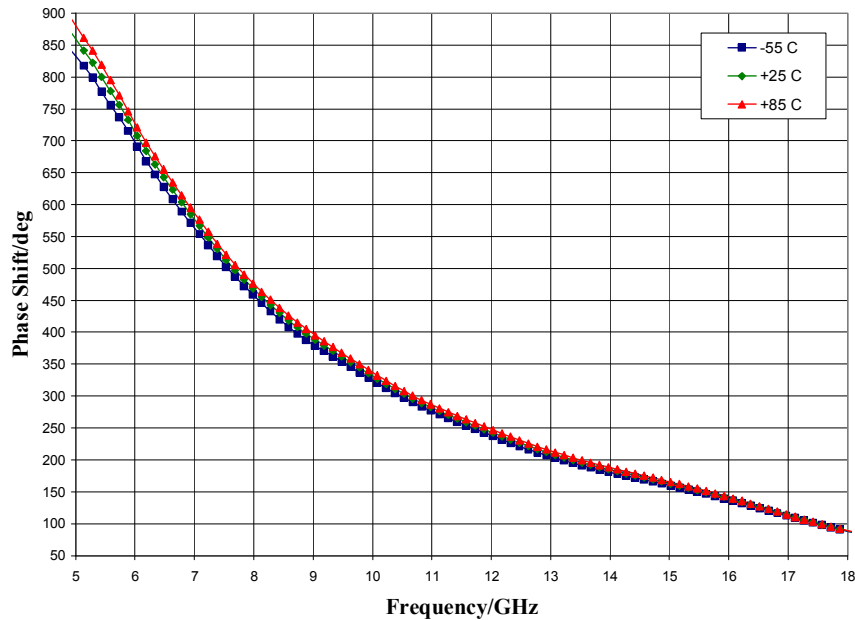


# CMD297

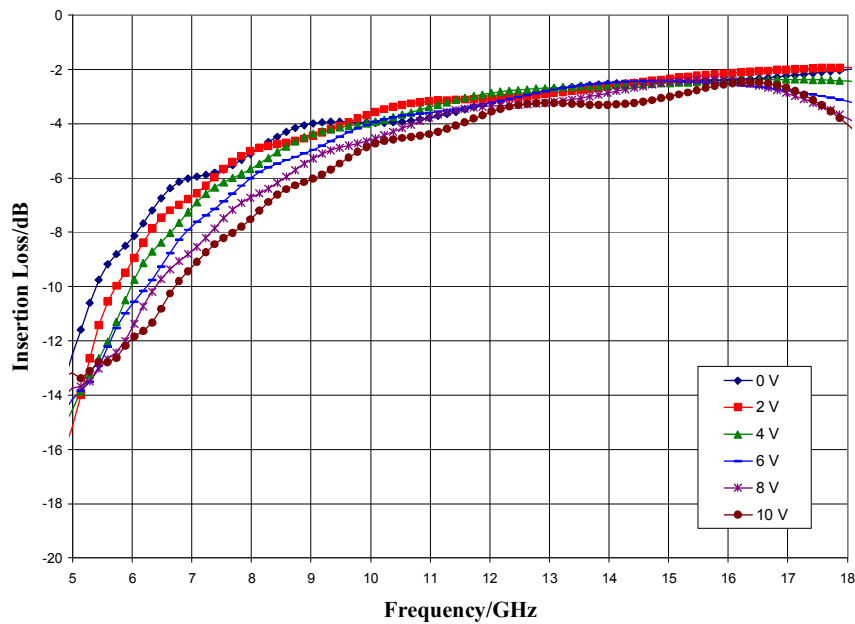
## 5-18 GHz Analog Phase Shifter

### Typical Performance

#### Phase Shift vs. Frequency @ $V_{ctl} = 10V$ (Relative to $V_{ctl} = 0V$ )



#### Insertion Loss vs. Frequency, $T_A = 25\text{ }^{\circ}\text{C}$



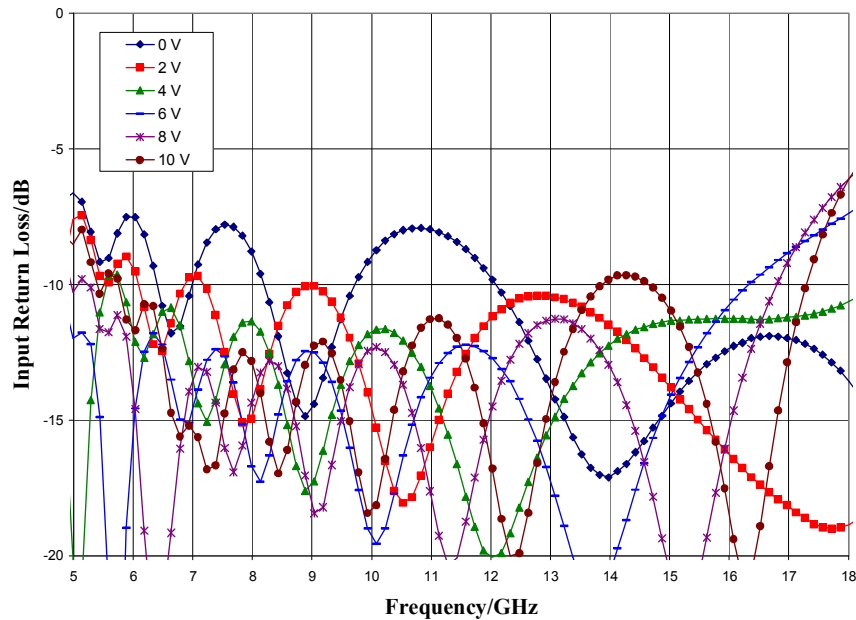
ver 1.0 1218

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

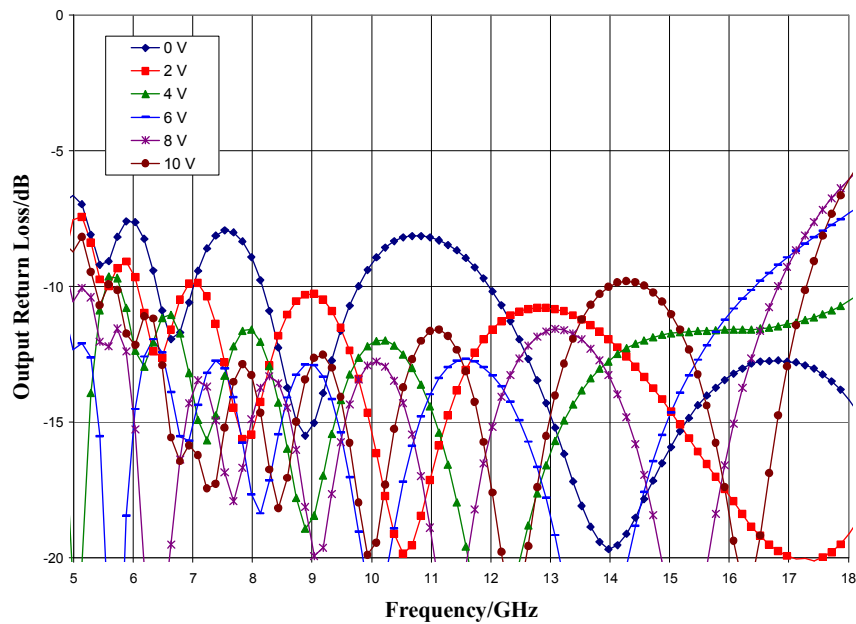
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Typical Performance

Input Return Loss,  $T_A = 25^\circ\text{C}$



Output Return Loss,  $T_A = 25^\circ\text{C}$



ver 1.0 1218

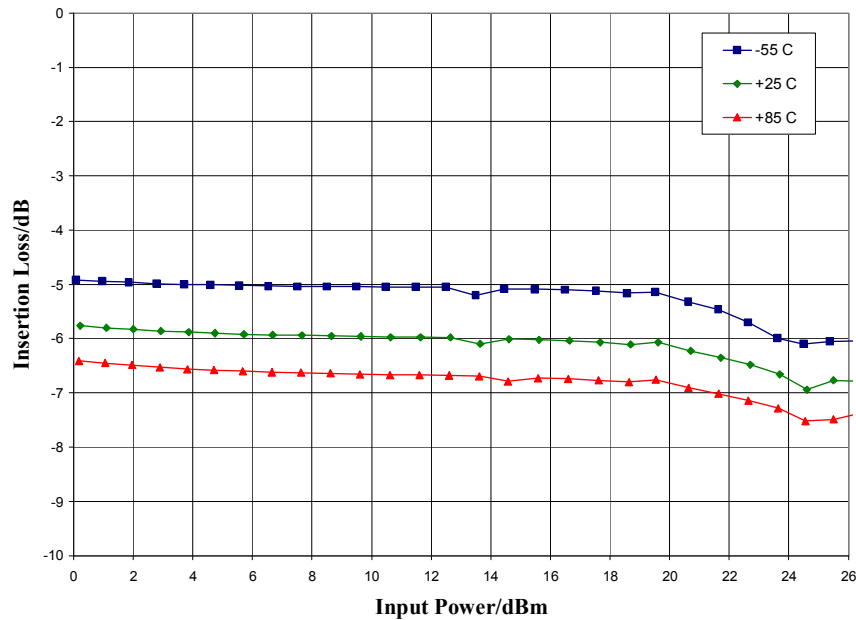


# CMD297

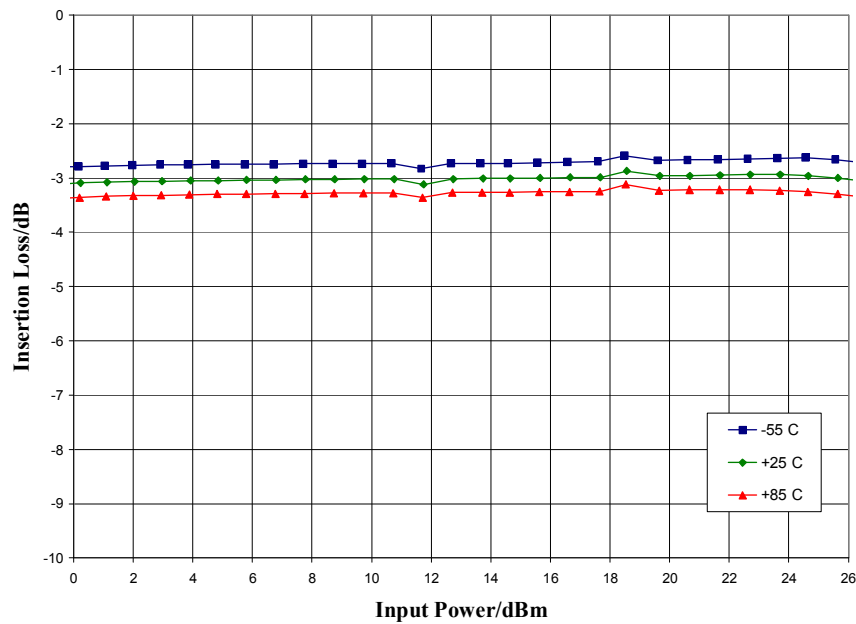
## 5-18 GHz Analog Phase Shifter

### Typical Performance

Insertion Loss vs. Pin @ 7 GHz, Vctl = 0V



Insertion Loss vs. Pin @ 12 GHz, Vctl = 0V



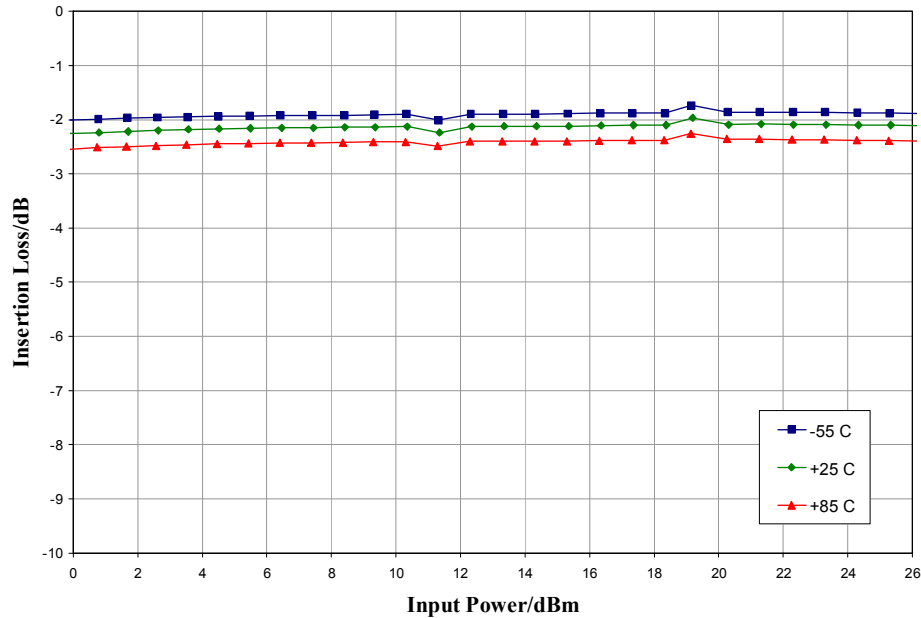
ver 1.0 1218

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

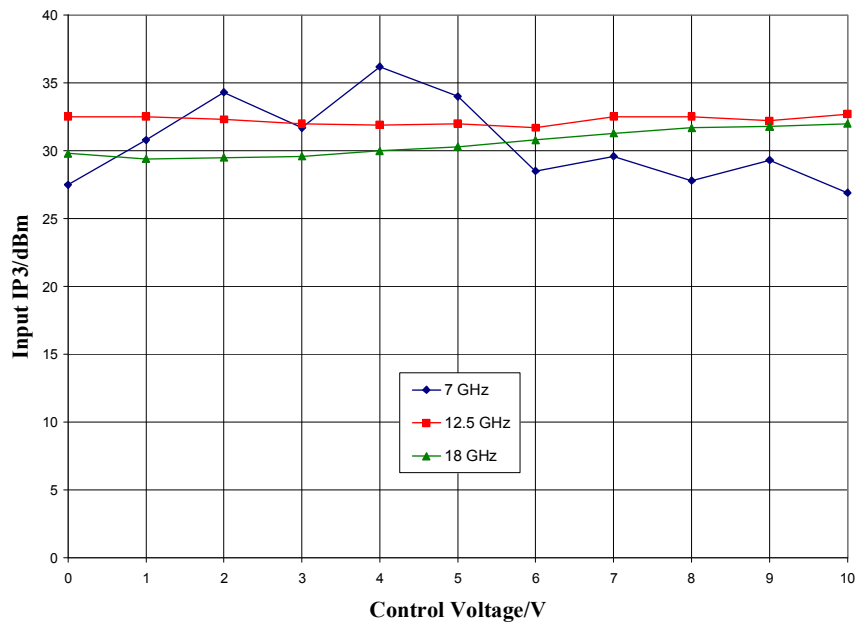
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Typical Performance

Insertion Loss vs. Pin @ 18 GHz, Vctl = 0V



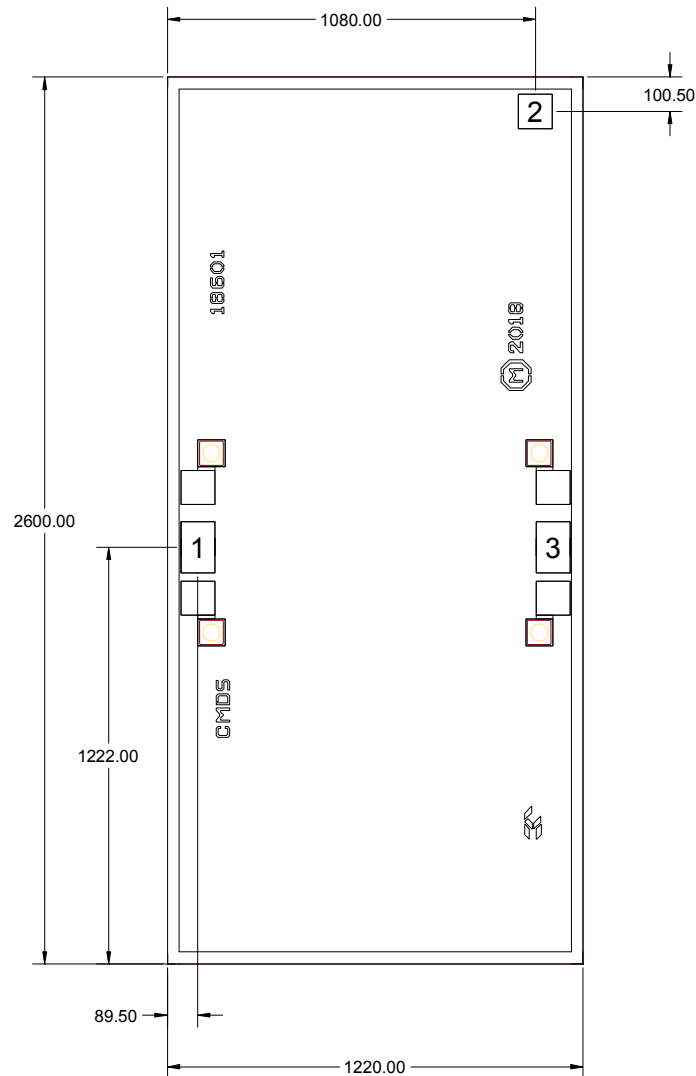
Input IP3 vs. Control Voltage, T<sub>A</sub> = 25 °C



ver 1.0 1218

### Mechanical Information

#### Die Outline (all dimensions in microns)



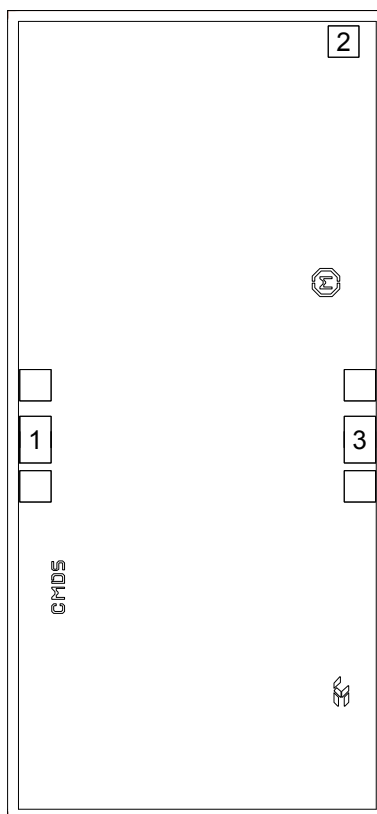
#### Notes:

1. No connection required for unlabeled pads
2. Backside is RF and DC ground
3. Backside and bond pad metal: Gold
4. Die is 100 microns thick
5. DC bond pad (2) is 100 x 100 microns
6. RF bond pads (1, 3) are 100 x 150 microns

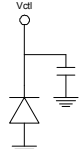
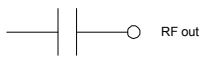
ver 1.0 1218

### Pad Description

### Pad Diagram



### Functional Description

| Pad      | Function | Description                   | Schematic                                                                             |
|----------|----------|-------------------------------|---------------------------------------------------------------------------------------|
| 1        | RF in    | DC blocked and 50 ohm matched |  |
| 2        | Vctrl    | Control voltage               |  |
| 3        | RF out   | DC blocked and 50 ohm matched |  |
| Backside | Ground   | Connect to RF / DC ground     |  |

ver 1.0 1218

### Applications Information

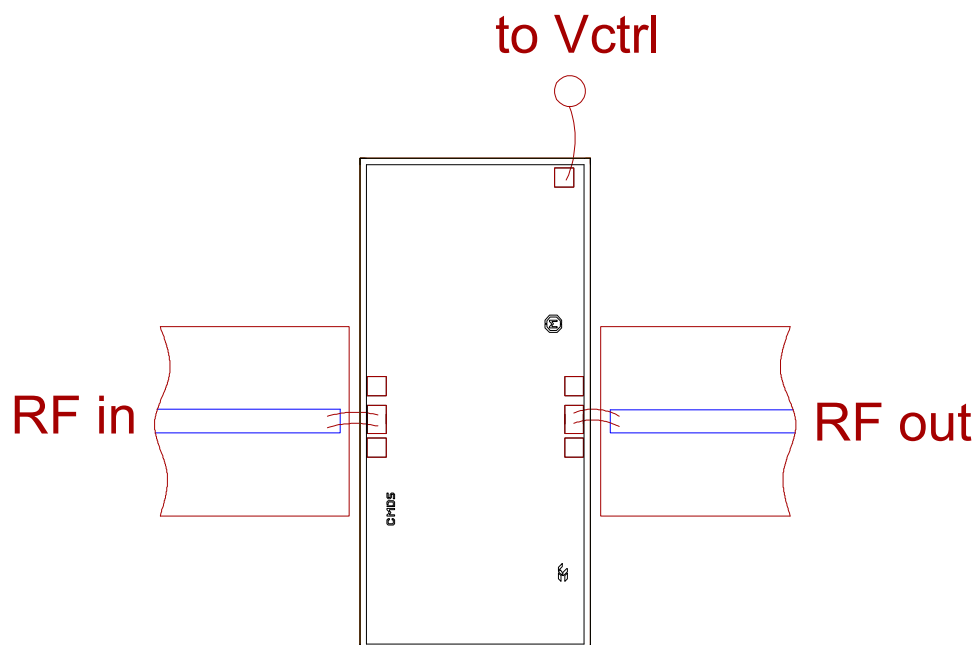
#### Assembly Guidelines

The backside of the CMD297 is RF ground. Die attach should be accomplished with electrically and thermally conductive epoxy only. Eutectic attach is not recommended. Standard assembly procedures should be followed for high frequency devices. The top surface of the semiconductor should be made planar to the adjacent RF transmission lines, and the RF decoupling capacitors placed in close proximity to the DC connections on chip.

RF connections should be made as short as possible to reduce the inductive effect of the bond wire. Use of a 0.8 mil thermosonic wedge bonding is highly recommended as the loop height will be minimized. The RF input and output require a single bond wire as shown.

The semiconductor is 100  $\mu\text{m}$  thick and should be handled by the sides of the die or with a custom collet. Do not make contact directly with the die surface as this will damage the monolithic circuitry. Handle with care.

#### Assembly Diagram



**GaAs MMIC devices are susceptible to damage from Electrostatic Discharge. Proper precautions should be observed during handling, assembly and test.**

ver 1.0 1218



# CMD297

## 5-18 GHz Analog Phase Shifter

### *Applications Information*

#### **Biasing and Operation**

The CMD297 has a single control voltage ( $V_{ctrl}$ ). Full phase shift range is achieved when  $V_{ctrl}$  is varied from 0 to +10 V.

RF power can be applied at any time.

*Please note, all information contained in this data sheet is subject to change without notice.*

ver 1.0 1218

*Custom MMIC*  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)



# TGP2108-SM

## 2.5-4GHz 6-Bit Digital Phase Shifter

### Product Description

The Qorvo TGP2108-SM is a packaged 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15  $\mu\text{m}$  GaAs pHEMT process. It operates over 2.5-4 GHz while providing 360 of phase coverage with a LSB of 5.625. The TGP2108-SM offers an exceptional RMS phase error of  $<2^\circ$  and amplitude error of  $<0.4$  dB over most of the operational band. With other equally impressive small signal and linearity characteristics, the TGP2108-SM delivers superior performance for your S-band phased array applications.

Housed in a small 5 x 5 mm plastic overmold QFN package, DC blocked on both ports with bi-directional operation and the use of positive only control logic, the TGP2108-SM supports ease of use and simply system integration. Low DC power consumption also provides the system designer more flexibility in the overall power management of the system.

The device is lead-free and RoHS compliant.

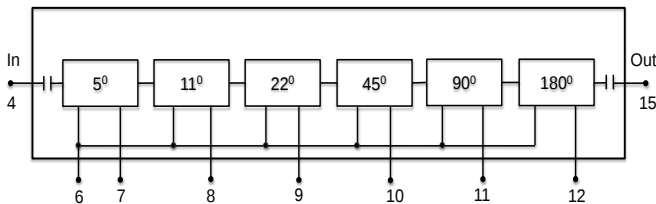


### Product Features

- Frequency Range: 2.5 to 4 GHz
- 6-Bit Digital Phase Shifter
- Bi-Directional
- 360° Coverage, LSB = 5.625°
- RMS Phase Error:  $< 2^\circ$  (2.7 – 3.7 GHz)  
 $< 5^\circ$  (other frequencies)
- RMS Amplitude Error:  $< 0.4$  dB
- Insertion Loss: 5 dB
- Return Loss: 15 dB
- Input P1dB: 29 dBm
- Input IP3: 45 dBm
- Control Voltage: 0 /+3V to +5 V
- QFN Package Dimensions: 5.0 x 5.0 x 0.85 mm

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

### Block Diagram



### Applications

- S-Band Radar

### Ordering Information

| Part No.       | Description                          |
|----------------|--------------------------------------|
| TGP2108-SM     | 2.5-4GHz 6-Bit Digital Phase Shifter |
| TGP2108-SM EVB | TGP2108-SM Evaluation Board          |

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) = 0/+5 V; See Bias Truth Table.

| Parameter                                      | Phase | Freq.<br>(GHz) | Min | Typical | Max | Units  |
|------------------------------------------------|-------|----------------|-----|---------|-----|--------|
| Operational Frequency Range                    |       |                | 2.5 |         | 4   | GHz    |
| Insertion Loss                                 | 5°    |                |     | 5       | 7.5 | dB     |
|                                                | 355°  |                |     |         | 8.5 |        |
| Input Return Loss                              |       |                |     | 15      |     | dB     |
| Output Return Loss                             |       |                |     | 15      |     | dB     |
| RMS Phase Error                                |       | 2.7 – 3.7      |     | < 2     |     | deg    |
|                                                |       | Others         |     | < 5     |     |        |
| RMS Amplitude Error                            |       |                |     | < 0.4   |     | dB     |
| Relative Phase                                 | 5°    | 2.5, 3.5, 4    | 5   | 6       | 8   | degree |
|                                                |       | 3              | 4   | 5       | 7   |        |
|                                                | 11°   | 2.5            | 12  | 13      | 16  |        |
|                                                |       | 3              | 11  | 12      | 14  |        |
|                                                |       | 3.5, 4         | 11  | 12      | 15  |        |
|                                                | 22°   | 2.5, 3         | 20  | 22      | 26  |        |
|                                                |       | 3.5            | 21  | 24      | 28  |        |
|                                                |       | 4              | 22  | 25      | 29  |        |
|                                                | 45°   | 2.5            | 43  | 46      | 52  |        |
|                                                |       | 3              | 41  | 44      | 48  |        |
|                                                |       | 3.5            | 42  | 45      | 49  |        |
|                                                |       | 4              | 44  | 46      | 50  |        |
|                                                | 90°   | 2.5            | 88  | 92      | 99  |        |
|                                                |       | 3              | 84  | 88      | 95  |        |
|                                                |       | 3.5            | 85  | 89      | 96  |        |
|                                                |       | 4              | 88  | 91      | 98  |        |
|                                                | 180°  | 2.5            | 178 | 184     | 196 |        |
|                                                |       | 3              | 172 | 177     | 189 |        |
|                                                |       | 3.5            | 175 | 180     | 192 |        |
|                                                |       | 4              | 184 | 188     | 200 |        |
|                                                | 355°  | 2.5            | 355 | 6       | 26  |        |
|                                                |       | 3              | 342 | 355     | 13  |        |
|                                                |       | 3.5            | 346 | 356     | 16  |        |
|                                                |       | 4              | 358 | 10      | 30  |        |
| Input P1dB                                     |       |                |     | 29      |     | dBm    |
| Input IP3 (Spacing = 10 MHz, Pin/Tone = 8 dBm) |       |                |     | 45      |     | dBm    |
| Insertion Loss Temperature Coefficient         |       |                |     | 0.002   |     | dB/°C  |



# TGP2108-SM

## 2.5-4GHz 6-Bit Digital Phase Shifter

### Absolute Maximum Rating

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | 1 mA          |
| Power Dissipation                   | 1.5 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 33 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 260 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                          | Value               |
|------------------------------------|---------------------|
| Control Voltage                    | 0/+5 V              |
| Reference Voltage ( $V_{REF}$ )    | +5 V                |
| Current ( $I_{REF}$ , $I_{CTRL}$ ) | < 0.3 mA            |
| Supply Current ( $I_S$ )           | 100 $\mu$ A typical |
| Temperature Range                  | -40 to +85 °C       |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

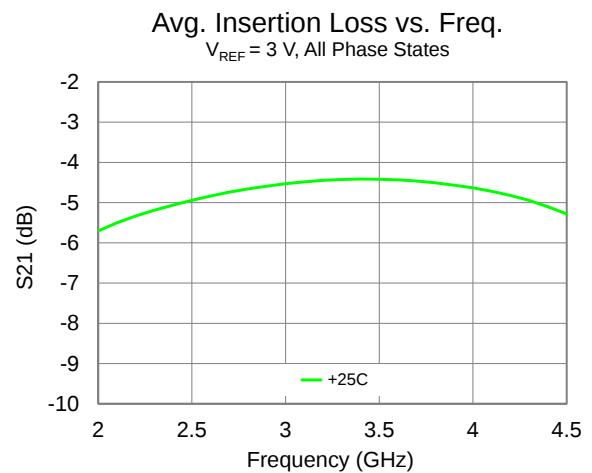
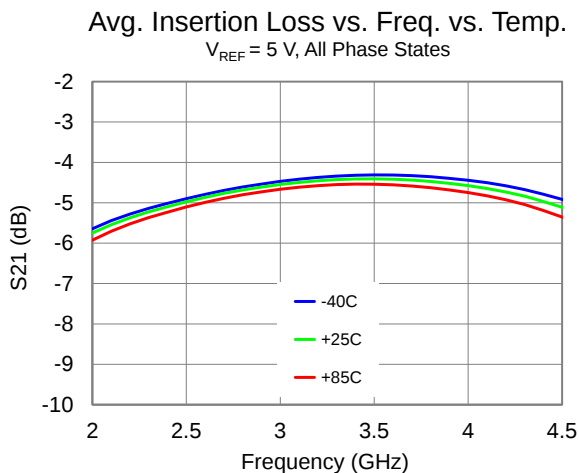
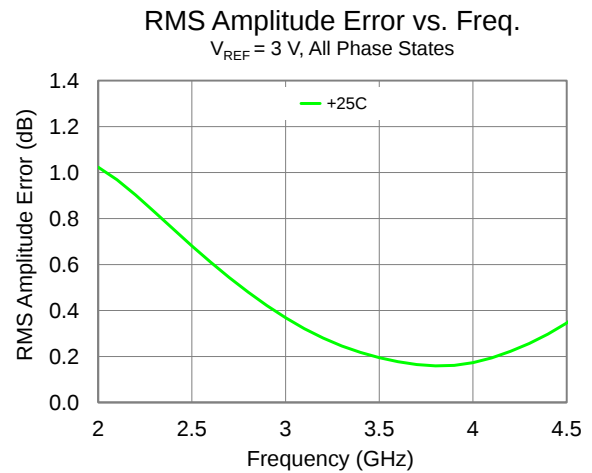
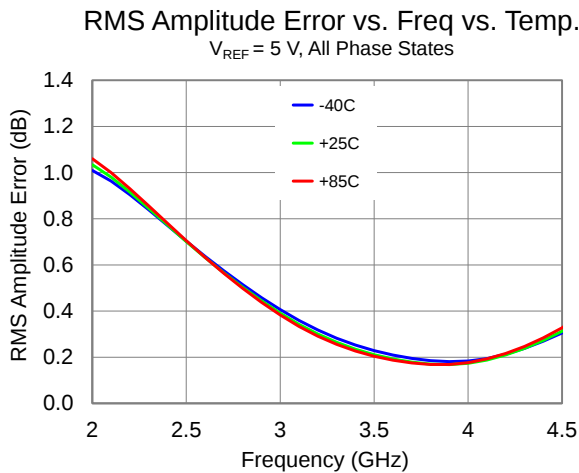
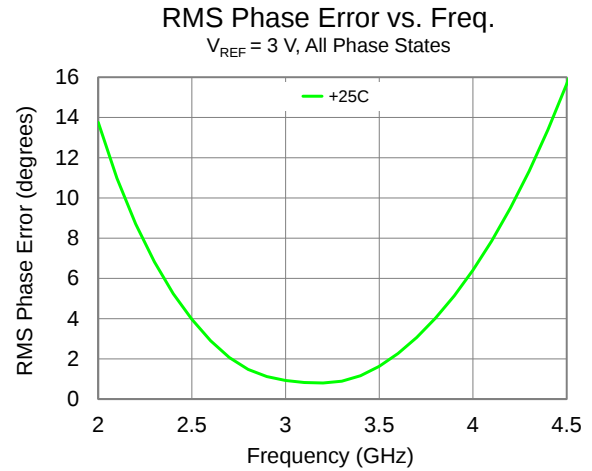
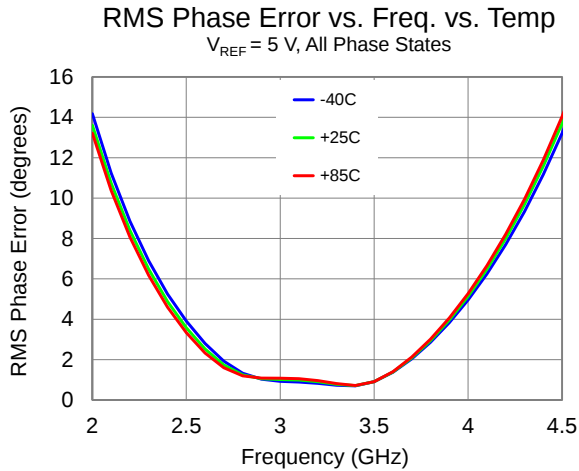
### Bias Truth Table

Logic "0" = 0 V, Logic "1" =  $V_{REF}$  = +3V or +5 V

| Phase Shifter  | 5° | 11° | 22° | 45° | 90° | 180° | REF |
|----------------|----|-----|-----|-----|-----|------|-----|
| 0° (Reference) | 0  | 0   | 0   | 0   | 0   | 0    | 1   |
| 5°             | 1  | 0   | 0   | 0   | 0   | 0    | 1   |
| 11°            | 0  | 1   | 0   | 0   | 0   | 0    | 1   |
| 22°            | 0  | 0   | 1   | 0   | 0   | 0    | 1   |
| 45°            | 0  | 0   | 0   | 1   | 0   | 0    | 1   |
| 90°            | 0  | 0   | 0   | 0   | 1   | 0    | 1   |
| 180°           | 0  | 0   | 0   | 0   | 0   | 1    | 1   |
| 355°           | 1  | 1   | 1   | 1   | 1   | 1    | 1   |

### Performance Plots – Small Signal

Test conditions unless otherwise noted: 5V and 3V, 25 °C

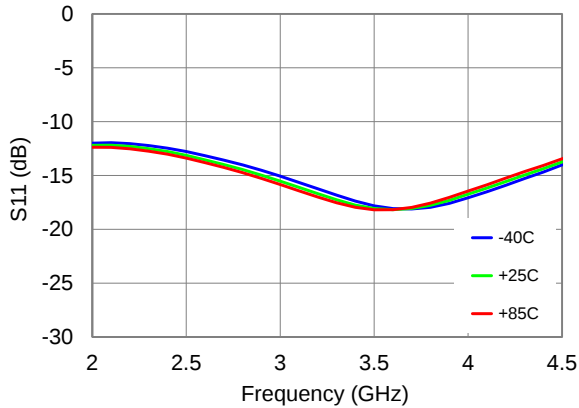


### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: 5V and 3V, 25 °C

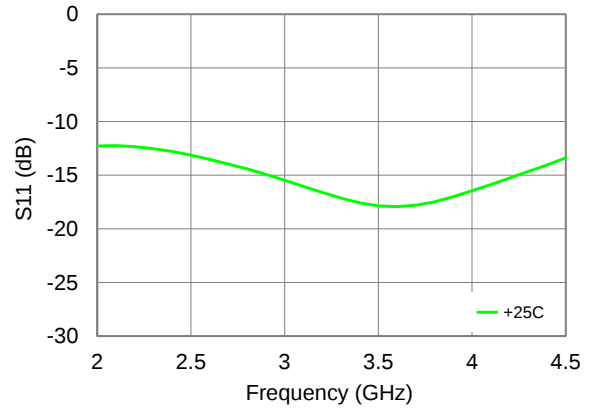
Avg. IRL vs. Freq. vs. Temp.

$V_{REF} = 5\text{ V}$ , All Phase States



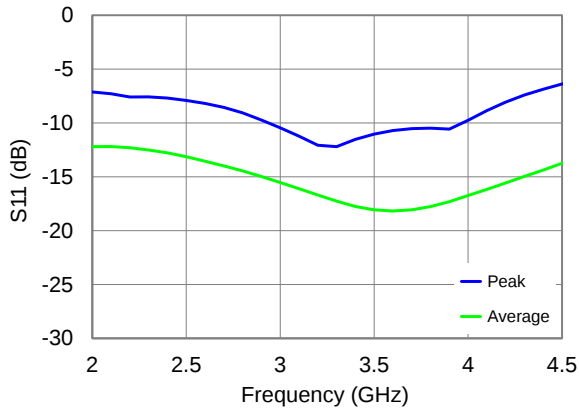
Avg. IRL vs. Freq.

$V_{REF} = 3\text{ V}$ , All Phase States



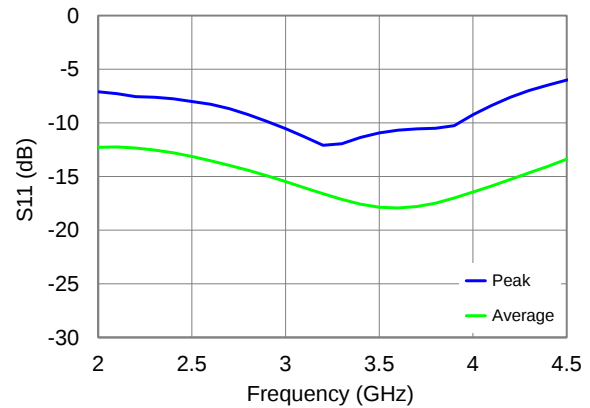
IRL vs. Freq.

$V_{REF} = 5\text{ V}$ , All Phase States, 25 °C



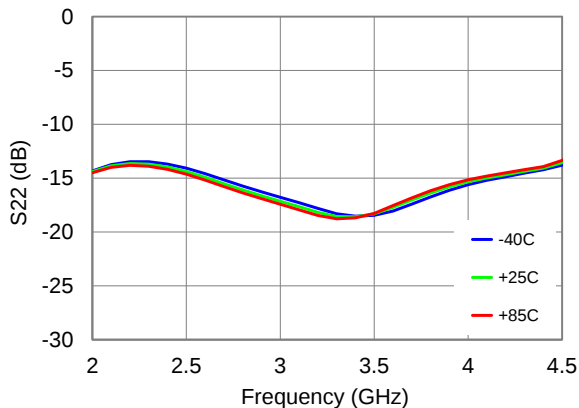
IRL vs. Freq.

$V_{REF} = 3\text{ V}$ , All Phase States, 25 °C



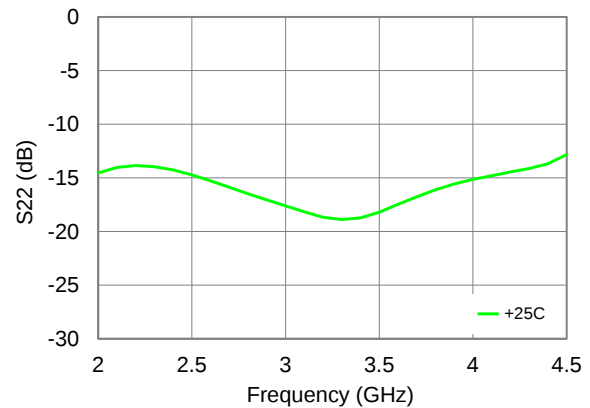
Avg. ORL vs. Freq. vs. Temp

$V_{REF} = 5\text{ V}$ , All Phase States



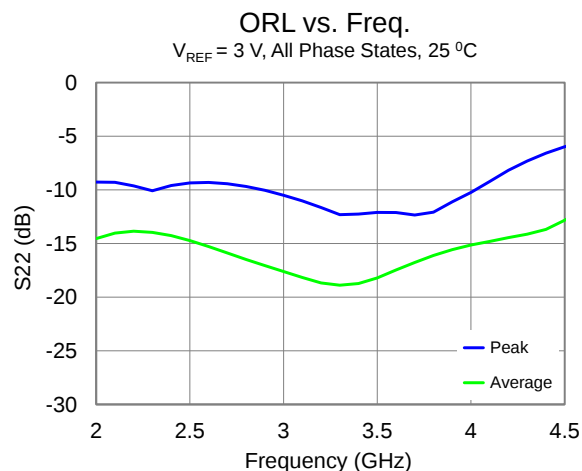
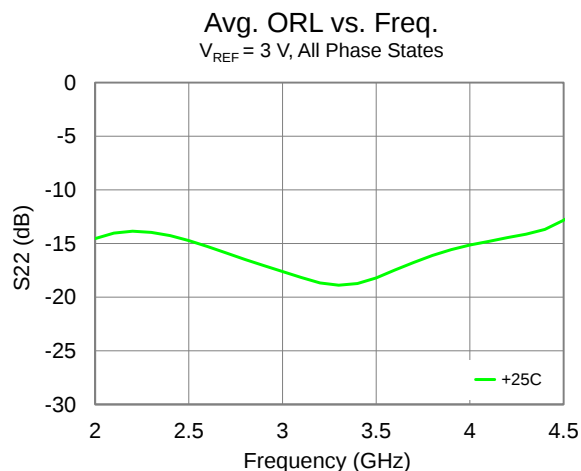
Avg. ORL vs. Freq.

$V_{REF} = 3\text{ V}$ , All Phase States



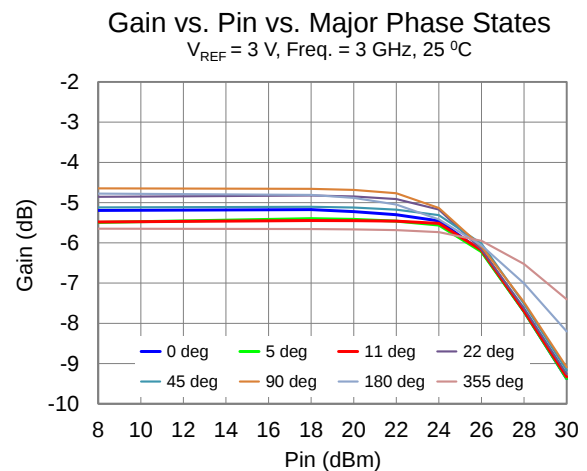
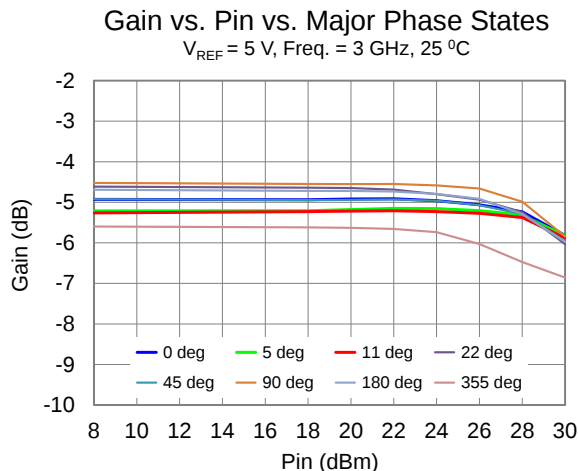
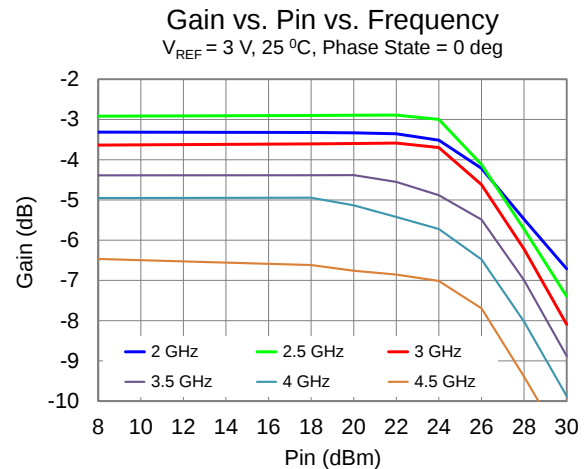
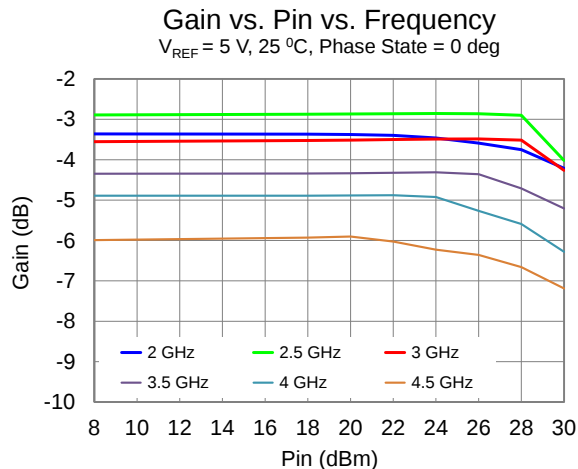
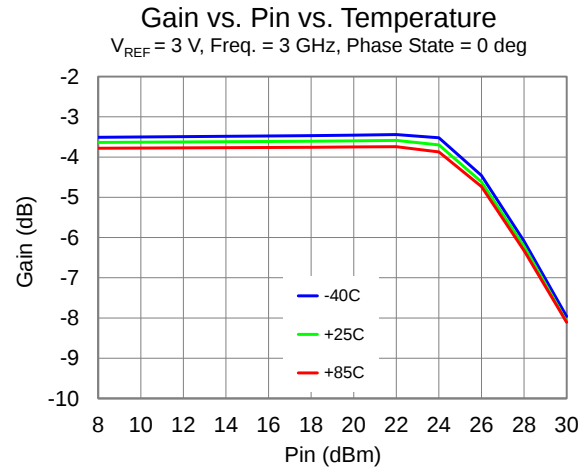
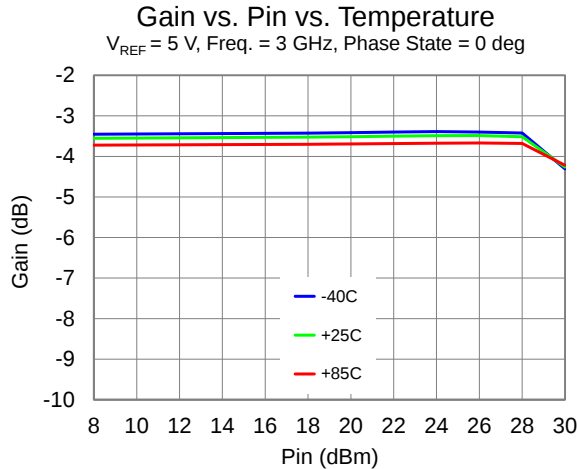
### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: 5V and 3V, 25 °C



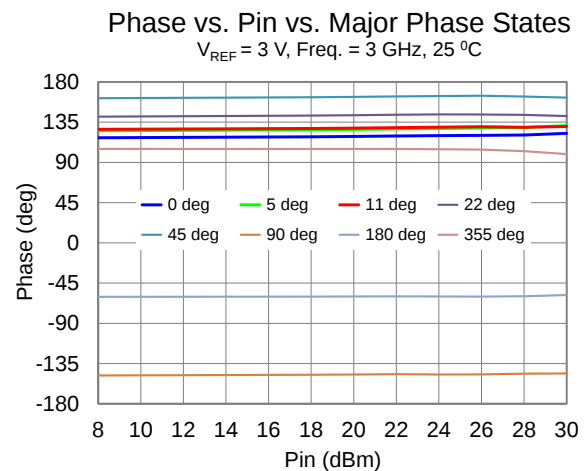
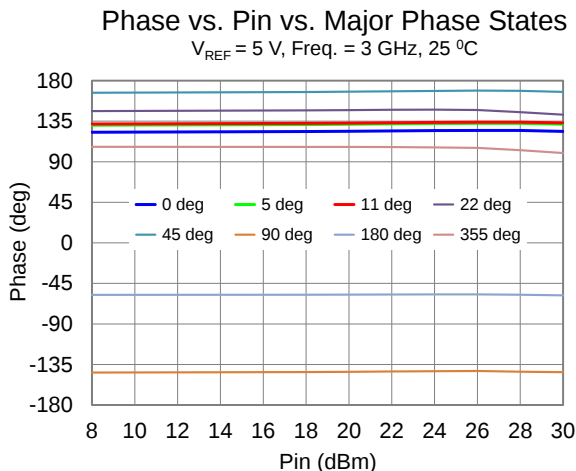
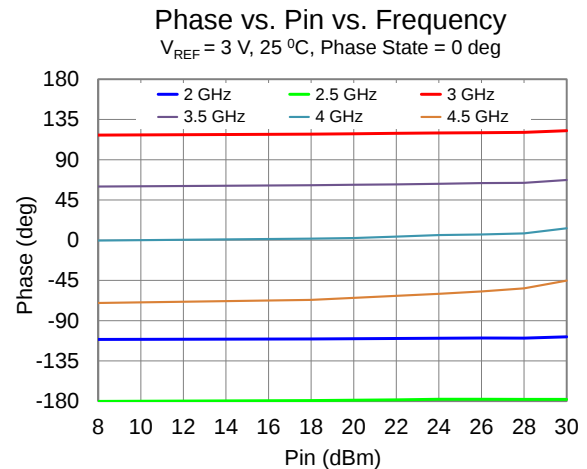
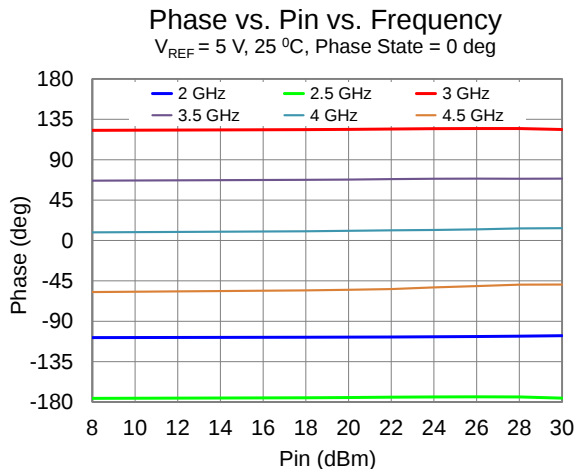
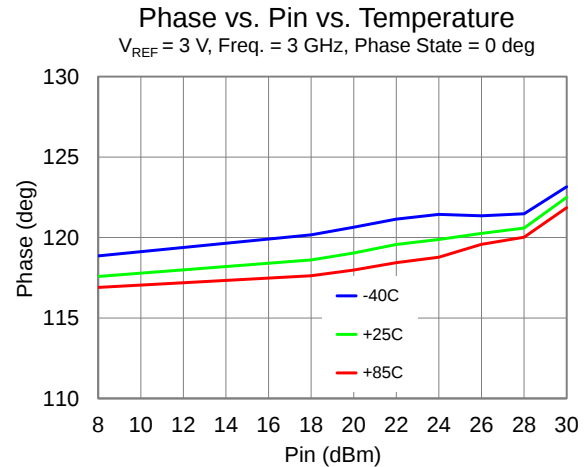
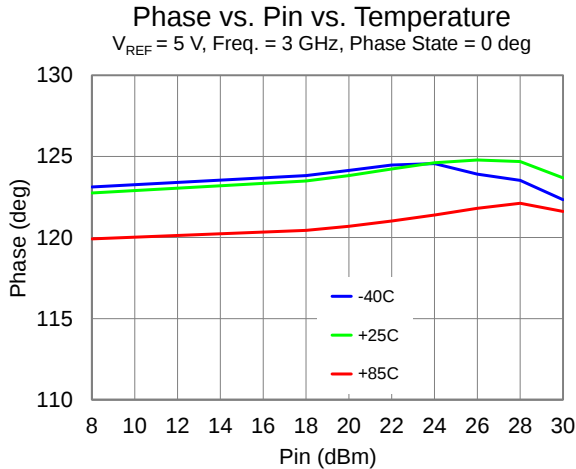
### Performance Plots – Large Signal

Test conditions unless otherwise noted: 5V and 3V, 25 °C



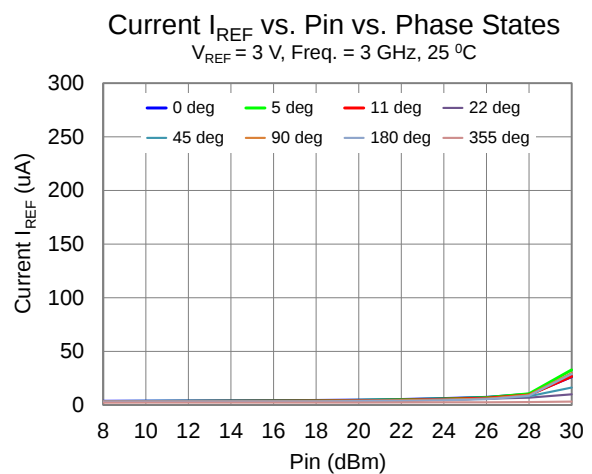
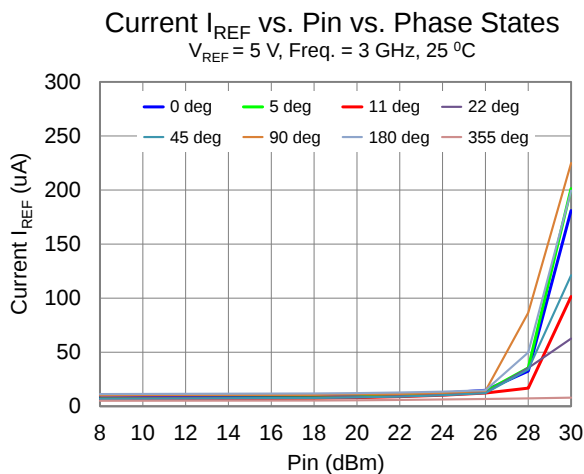
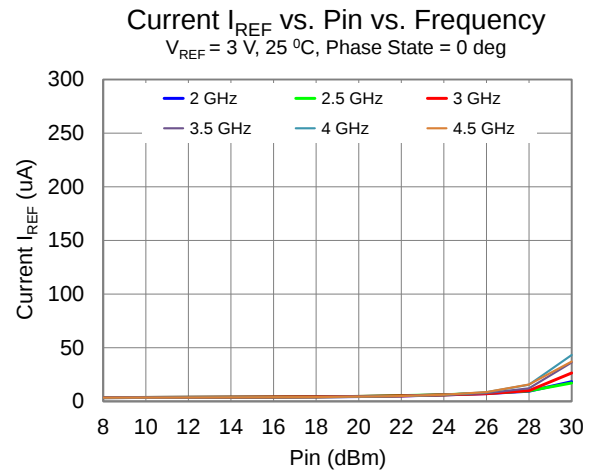
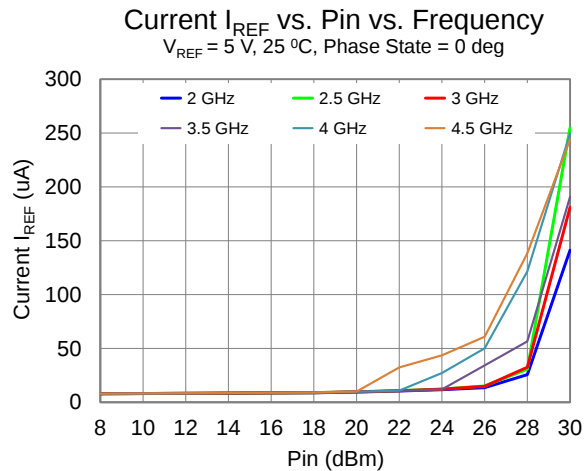
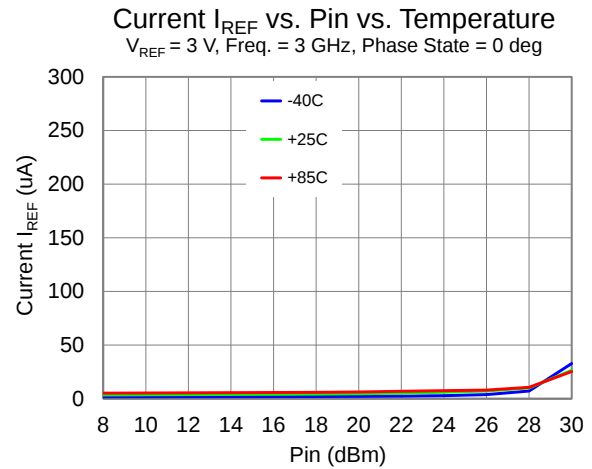
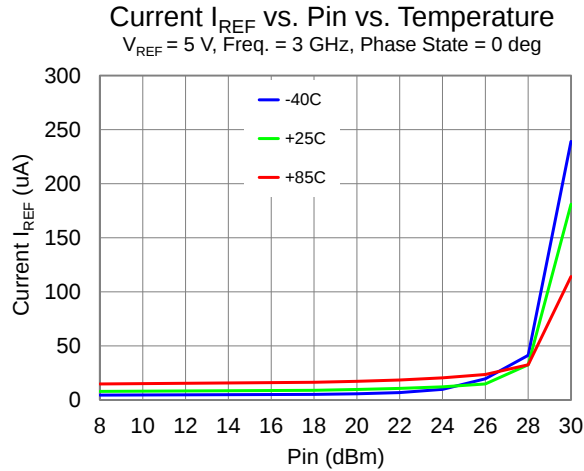
### Performance Plots – Large Signal (Cont.)

Test conditions unless otherwise noted: 5V and 3V, 25 °C



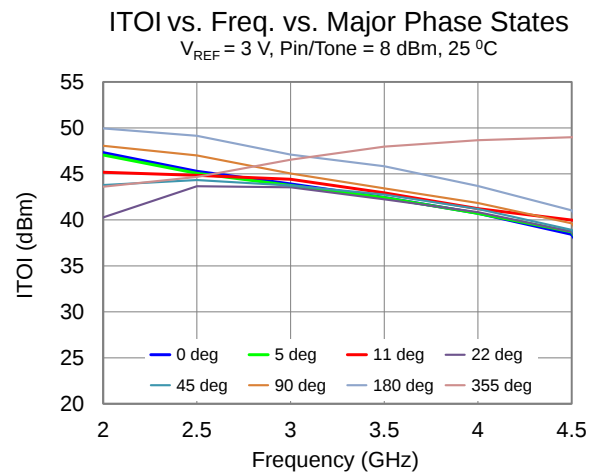
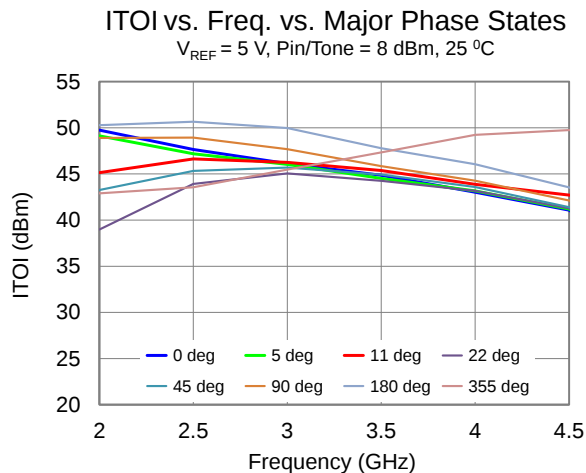
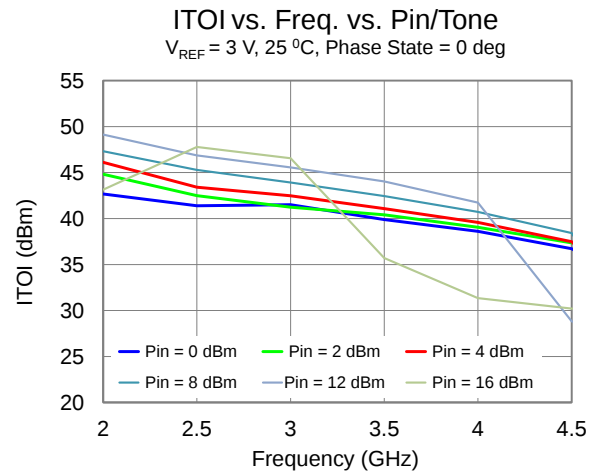
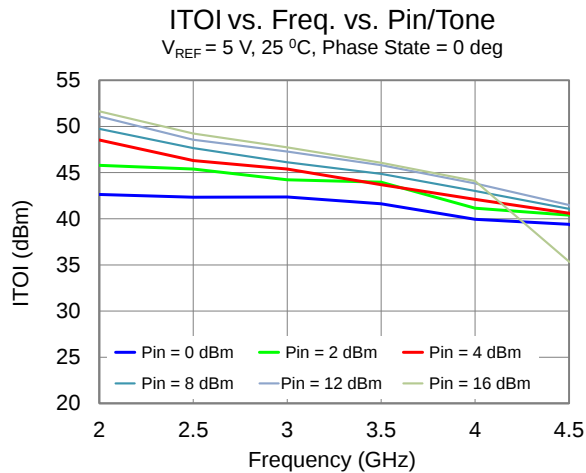
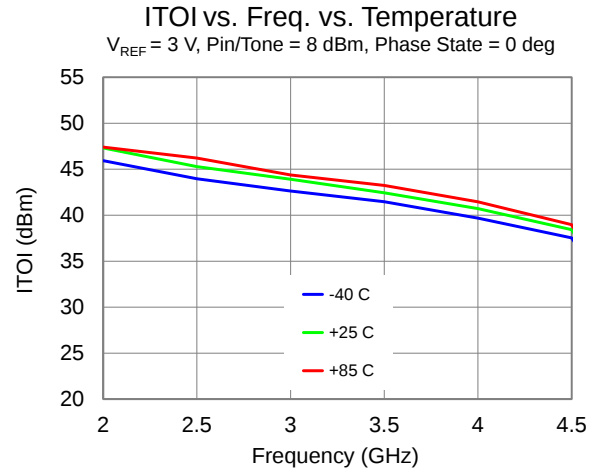
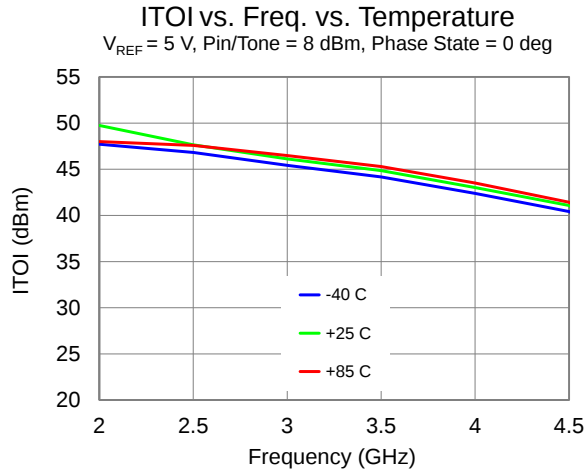
### Performance Plots – Large Signal (Cont.)

Test conditions unless otherwise noted: 5V and 3V, 25 °C



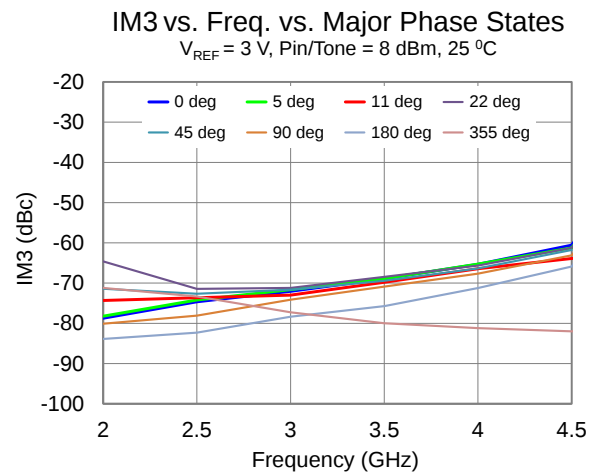
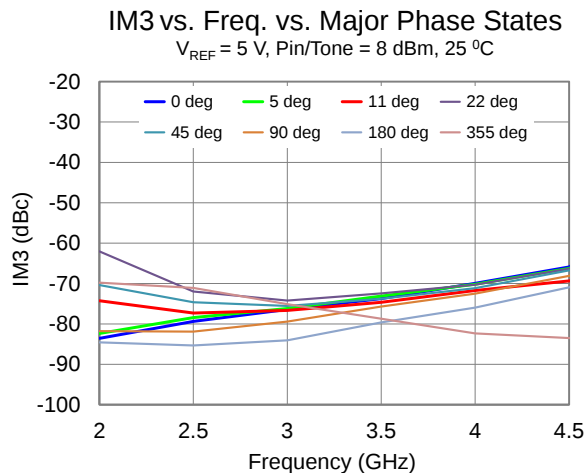
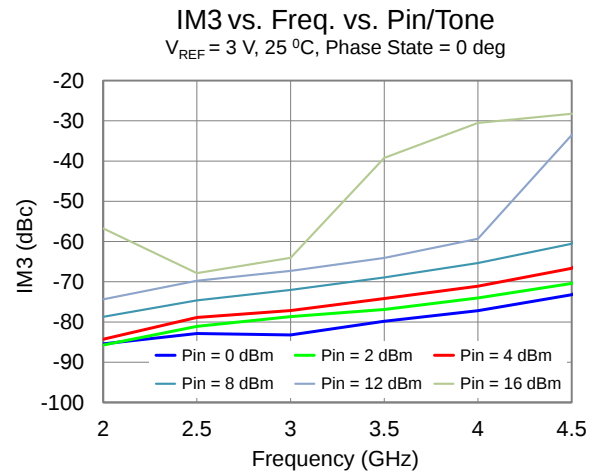
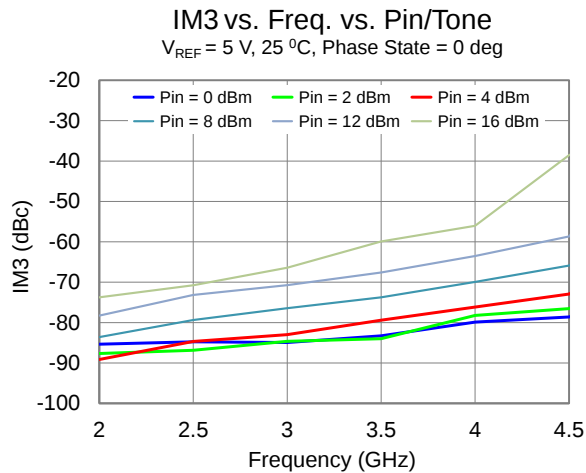
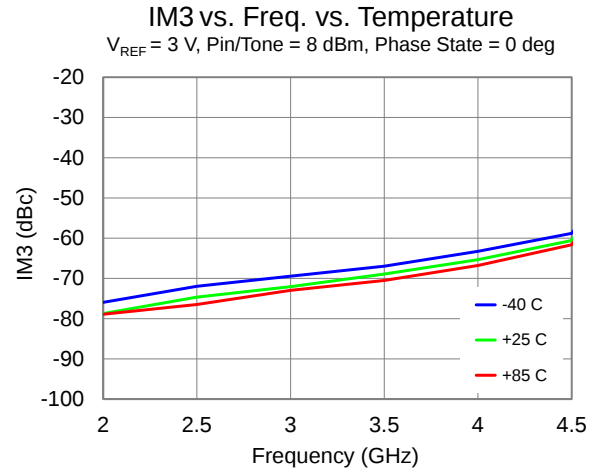
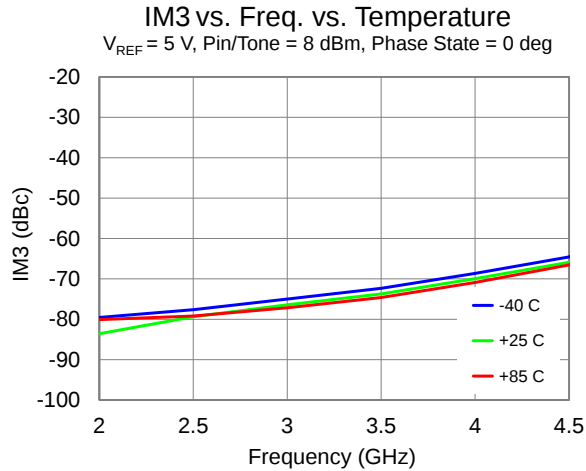
### Performance Plots – Linearity

Test conditions unless otherwise noted: 5V and 3V, Tone Spacing = 10 MHz, 25 °C



### Performance Plots – Linearity (Cont.)

Test conditions unless otherwise noted: 5V and 3V, Tone Spacing = 10 MHz, 25 °C



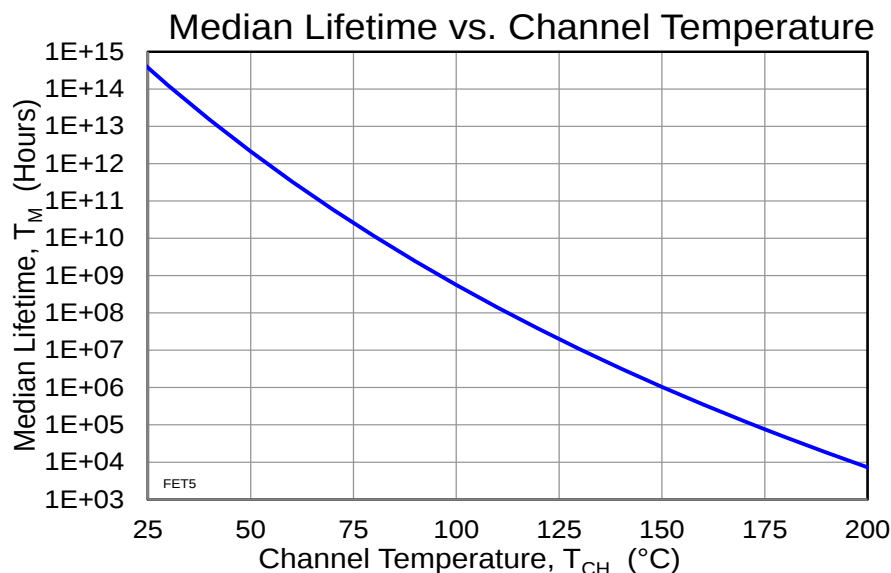
### Thermal and Reliability Information

| Parameter                        | Test Conditions                 | Value  | Units              |
|----------------------------------|---------------------------------|--------|--------------------|
| Channel Temperature ( $T_{CH}$ ) | $T_{BASE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )        |                                 | 5.2E+9 | Hrs                |

Notes:

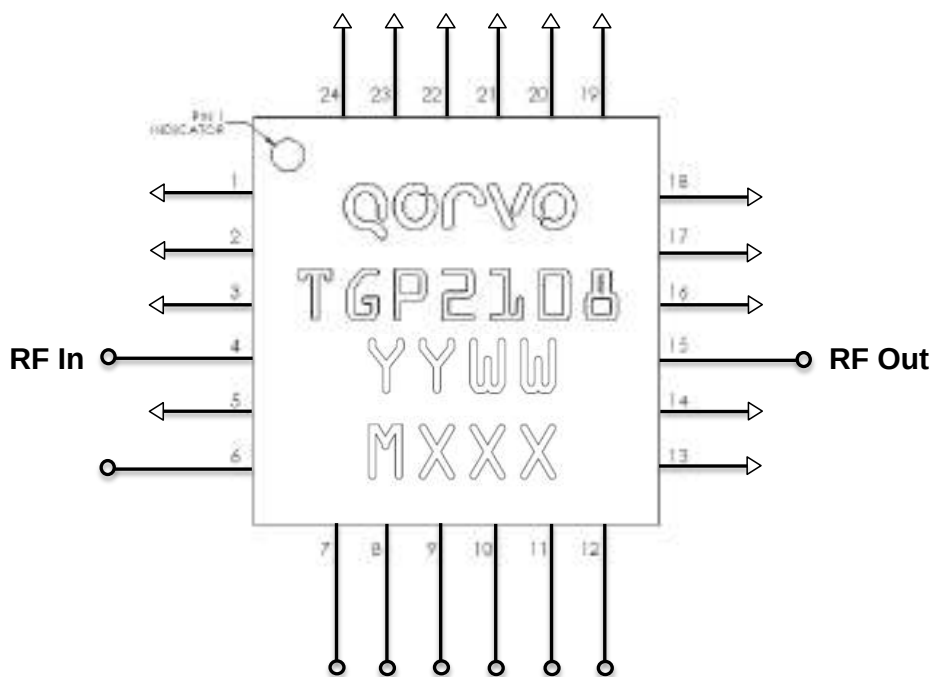
- Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime

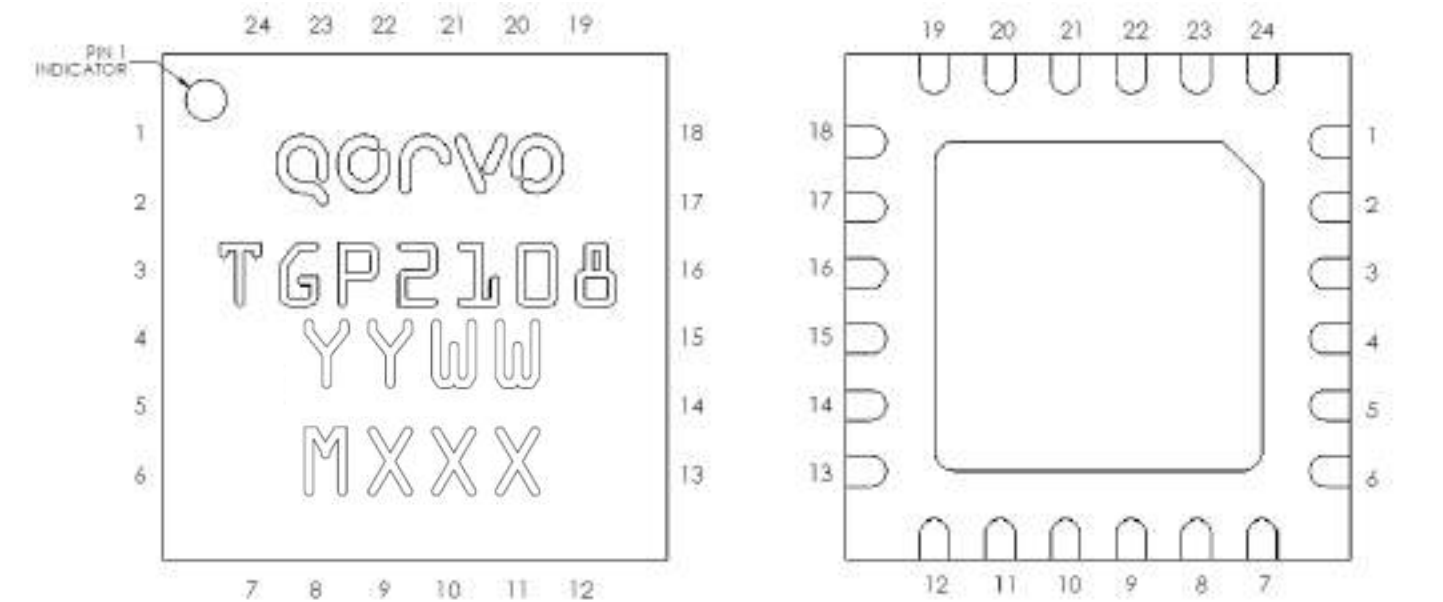


### Applications Circuit

De-Quing network is not required

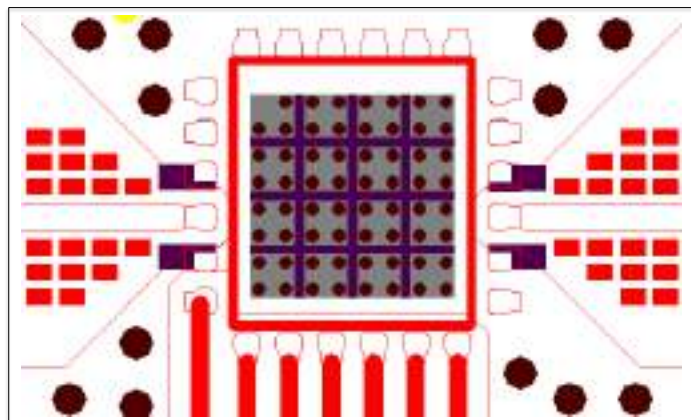
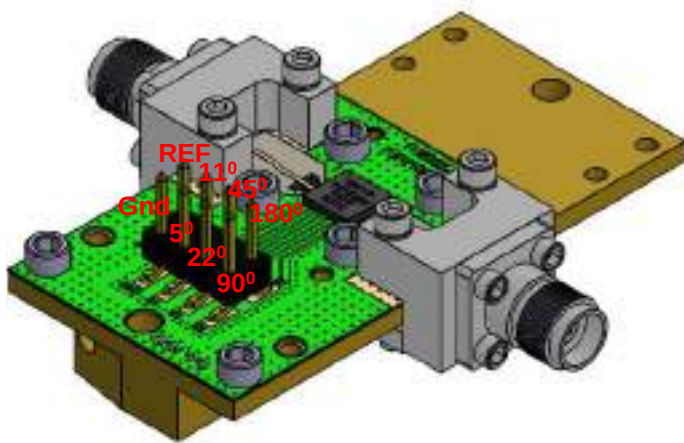


Pin Description



| Pin No.              | Symbol    | Description                                                                                                                                             |
|----------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1-3, 5, 13-14, 16-24 | N/C       | No Connection; recommend GND at the EVB level                                                                                                           |
| 4                    | RF Input  | Input; matched to 50 Ohms; DC blocked; interchangeable to RF Output                                                                                     |
| 6                    | REF       | Reference                                                                                                                                               |
| 7                    | 5°        | 5° Bit                                                                                                                                                  |
| 8                    | 11°       | 11° Bit                                                                                                                                                 |
| 9                    | 22°       | 22° Bit                                                                                                                                                 |
| 10                   | 45°       | 45° Bit                                                                                                                                                 |
| 11                   | 90°       | 90° Bit                                                                                                                                                 |
| 12                   | 180°      | 180° Bit                                                                                                                                                |
| 15                   | RF Output | Output; matched to 50 Ohms; DC blocked; interchangeable to RF Input                                                                                     |
| 25 (Slug)            | GND       | On PCB; multiple vias should be employed under the center pad (25) to minimize inductance and thermal resistance; see page 12 for suggested vias layout |

#### Evaluation Board (EVB) Layout Assembly



Via pattern

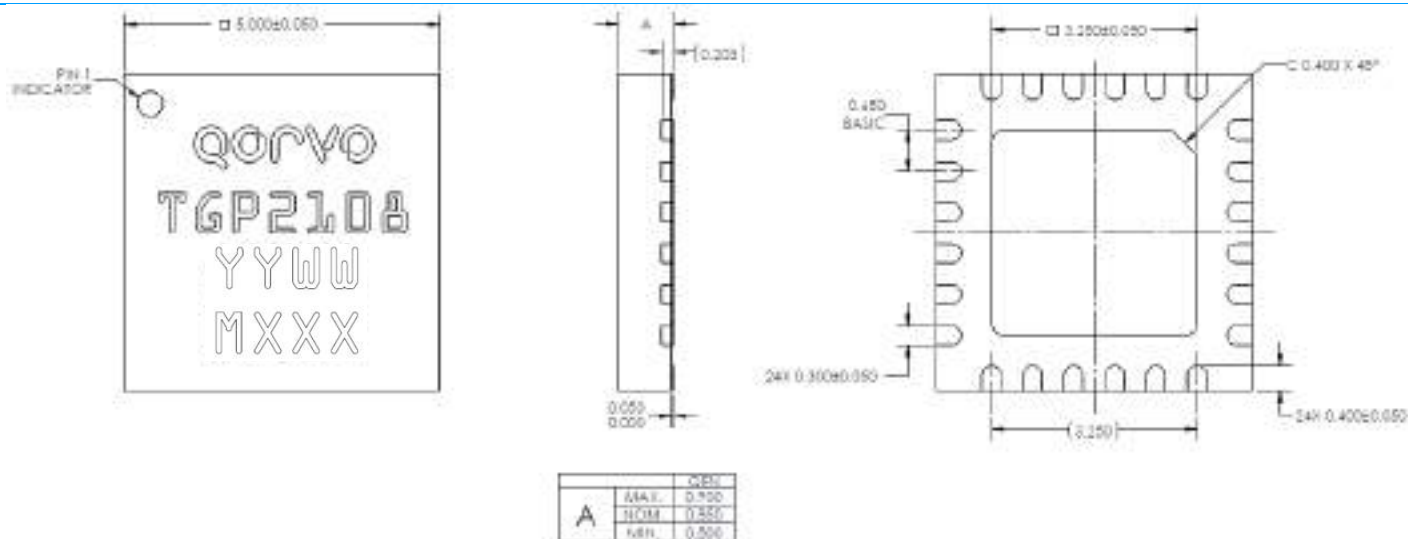
RF layer is 0.008" thick Rogers RO4003C. Metal layers are 0.5-oz copper. Microstrip 50  $\Omega$  line width is 0.050". The microstrip line taper at the connector interface is optimized for the Southwest Microwave end-launch connector 1092-02A-5.

Ground / thermal vias under the DUT are critical for the proper performance of this device. The PCB shown herein utilizes copper filled vias (8 mils diameter) under the DUT.

The pad pattern shown has been developed and tested for optimized assembly at Qorvo. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company careful process development is recommended.

De-Quing network is not required.

### Mechanical Information



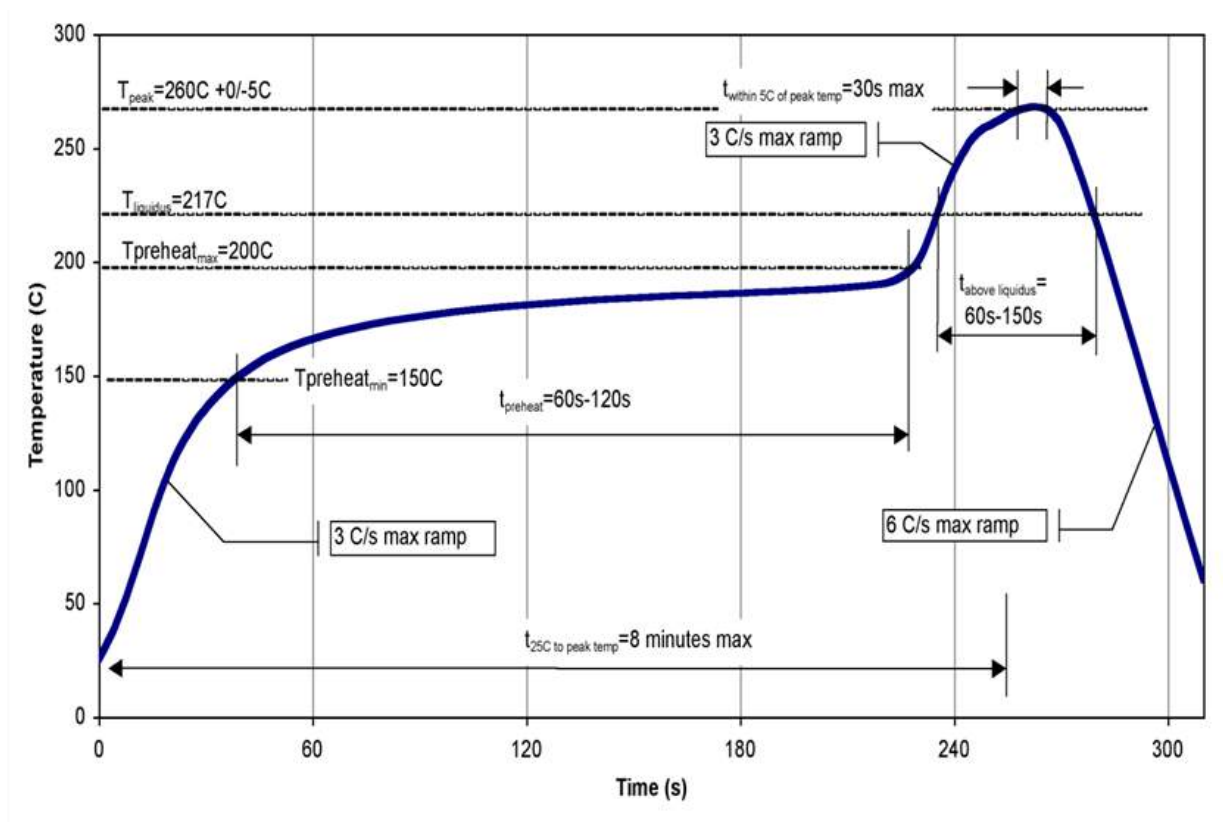
#### Notes:

- All dimensions are in millimeters. Angles are in degrees.  
Tolerances: XX = ± .25  
XXX = ± .127
- Package Leads Are Gold Plated (NiPdAu)
- Part Is Mold Encapsulated
- Part Marking:  
2108: Part Number  
YY: Part assembly Year  
WW: Part Assembly Week  
MXXX: Batch ID

### Solderability

1. Compatible with the latest version of J-STD-020, Lead-free solder, 260 °C.
2. The use of no-clean solder to avoid washing after soldering is recommended.

### Recommended Soldering Temperature Profile



### Handling Precautions

| Parameter                        | Rating    | Standard               |
|----------------------------------|-----------|------------------------|
| ESD – Human Body Model (HBM)     | Class 0B  | ESDA / JEDEC JS-001    |
| ESD – Charge Device Model (CDM)  | Class C0a | ANSI /ESD/JEDEC JS-002 |
| MSL – Moisture Sensitivity Level | MSL 3     | 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
- 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)

For technical questions and application information: **Email:** [appsupport@qorvo.com](mailto:appsupport@qorvo.com)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2019 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.



# CMD297P34

## 5-18 GHz Analog Phase Shifter

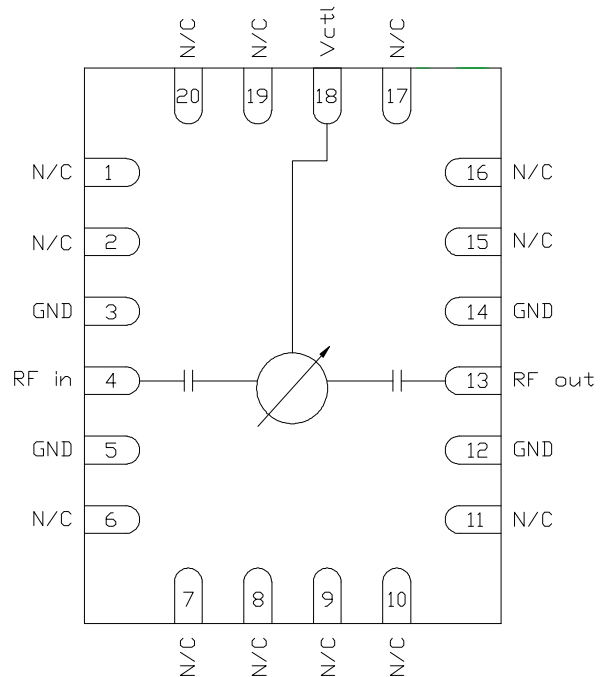
### Features

- Wide bandwidth
- Wide phase shift range
- Single positive control voltage
- Pb-free RoHs compliant 3x4 QFN package

### Description

The CMD297P34 is an analog phase shifter housed in a leadless 3x4 mm plastic surface mount package which operates from 5 to 18 GHz. The phase shifter utilizes a single positive control voltage of 0V to +10V to control relative phase shift over a 530 degree range at 7 GHz and a 220 degree range at 12 GHz. The CMD297P34 has consistent insertion loss versus phase shift and the phase shift is monotonic with respect to control voltage. The phase shifter is a 50 ohm matched design which eliminates the need for external DC blocks and RF port matching.

### Functional Block Diagram



### Electrical Performance – $V_{ctl} = 0\text{ V to }+10\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$ , $F = 12\text{ GHz}$

| Parameter                 | Min    | Typ | Max | Units      |
|---------------------------|--------|-----|-----|------------|
| Frequency Range           | 5 - 18 |     |     | GHz        |
| Phase Shift Range         |        | 220 |     | degrees    |
| Insertion Loss            |        | 3.2 |     | dB         |
| Input Return Loss         |        | 14  |     | dB         |
| Output Return Loss        |        | 13  |     | dB         |
| Phase Voltage Sensitivity |        | 22  |     | deg / Volt |

ver 1.0 1019

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294



# CMD297P34

## 5-18 GHz Analog Phase Shifter

### Specifications

#### Absolute Maximum Ratings

| Parameter                            | Rating        |
|--------------------------------------|---------------|
| Control Voltage, Vctl                | + 11 V        |
| Reverse Current                      | 5 mA          |
| RF Input Power                       | +30 dBm       |
| Channel Temperature, T <sub>ch</sub> | 150 °C        |
| Power Dissipation, P <sub>diss</sub> | 2 W           |
| Thermal Resistance, $\Theta_{JC}$    | 32.2 °C/W     |
| Operating Temperature                | -40 to 85 °C  |
| Storage Temperature                  | -55 to 150 °C |

Exceeding any one or combination of the maximum ratings may cause permanent damage to the device.

#### Recommended Operating Conditions

| Parameter | Min | Typ | Max | Units |
|-----------|-----|-----|-----|-------|
| Vctl      | 0   |     | 10  | V     |

Electrical performance is measured at specific test conditions. Electrical specifications are not guaranteed over all recommended operating conditions.

#### Electrical Specifications, Vctl = 0 V to +10 V, T<sub>A</sub> = 25 °C

| Parameter                     | Min    | Typ  | Max | Min     | Typ | Max | Min     | Typ  | Max | Units      |
|-------------------------------|--------|------|-----|---------|-----|-----|---------|------|-----|------------|
| Frequency Range               | 5 - 10 |      |     | 10 - 13 |     |     | 13 - 18 |      |     | GHz        |
| Phase Shift Range             | 230    | 480  |     | 140     | 240 |     | 45      | 130  |     | degrees    |
| Insertion Loss                |        | 7.3  | 17  |         | 3.7 | 7   |         | 2.7  | 9   | dB         |
| Input Return Loss             |        | 10   |     |         | 13  |     |         | 7    |     | dB         |
| Output Return Loss            |        | 10   |     |         | 13  |     |         | 7    |     | dB         |
| Control Voltage Range         | 0      |      | 10  | 0       |     | 10  | 0       |      | 10  | Volts      |
| Phase Voltage Sensitivity     |        | 47   |     |         | 24  |     |         | 13   |     | deg / Volt |
| Phase Temperature Sensitivity |        | 0.15 |     |         | 0.1 |     |         | 0.05 |     | deg / °C   |

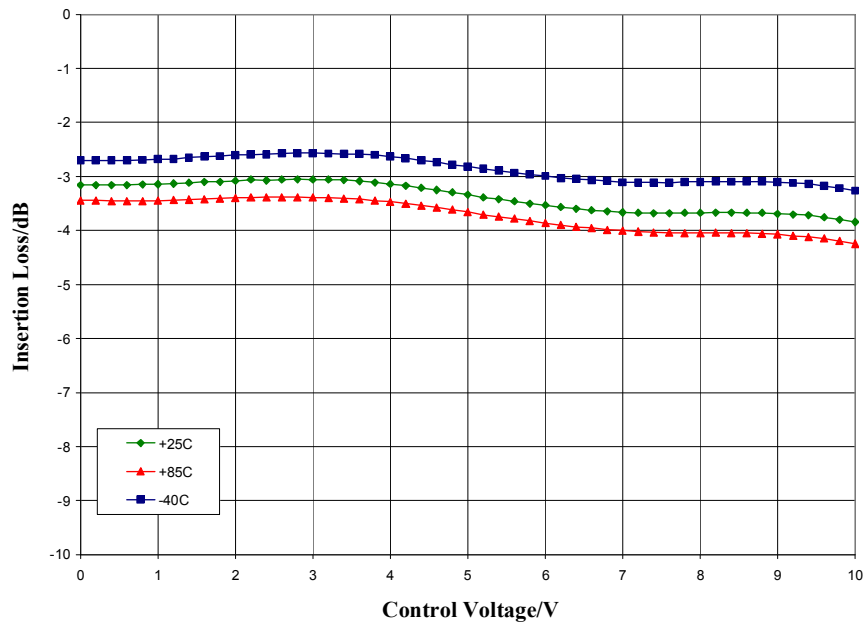
ver 1.0 1019

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

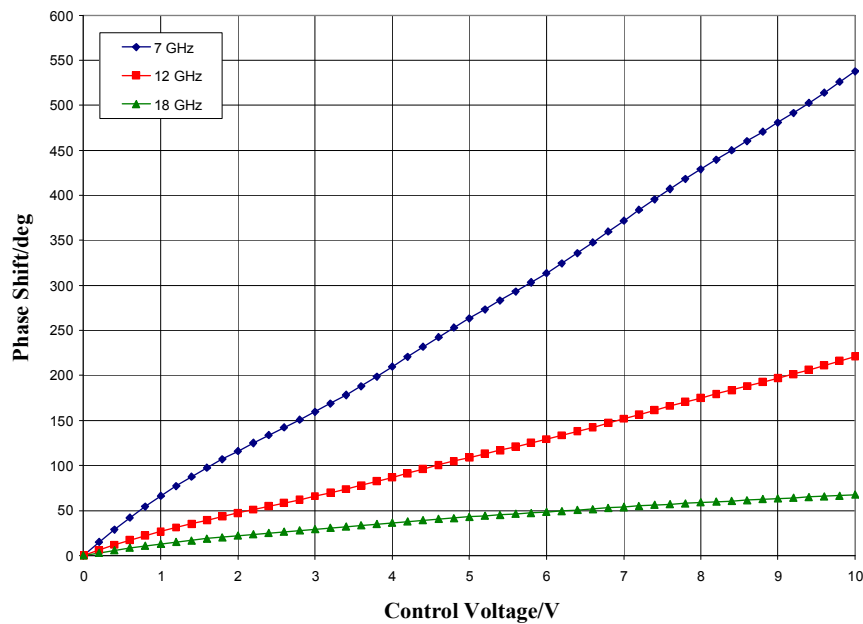
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Typical Performance

#### Insertion Loss vs. Control Voltage @ 12 GHz



#### Phase Shift vs. Control Voltage, $T_A = 25^\circ\text{C}$



ver 1.0 1019

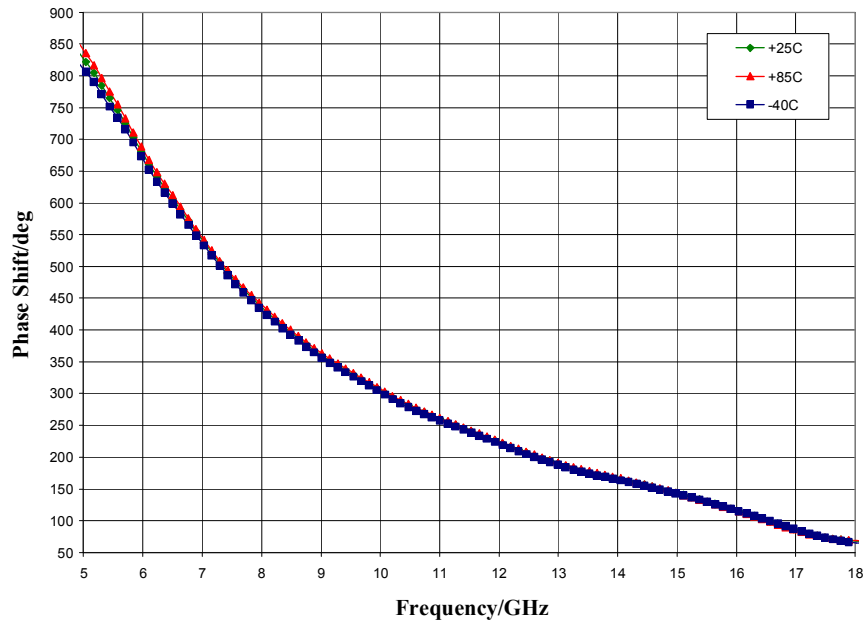


# CMD297P34

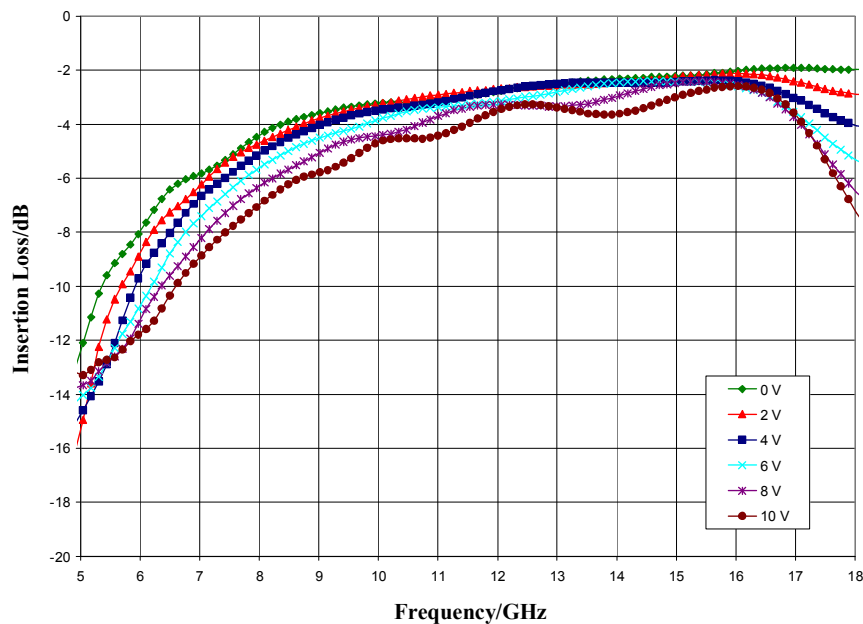
## 5-18 GHz Analog Phase Shifter

### Typical Performance

#### Phase Shift vs. Frequency @ $V_{ctl} = 10V$ (Relative to $V_{ctl} = 0V$ )



#### Insertion Loss vs. Frequency, $T_A = 25^\circ C$



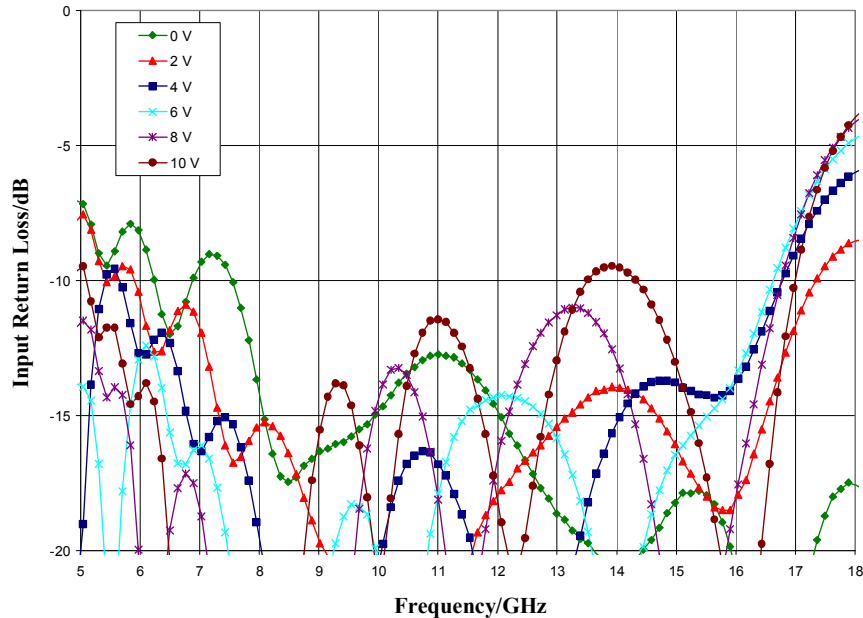
ver 1.0 1019

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

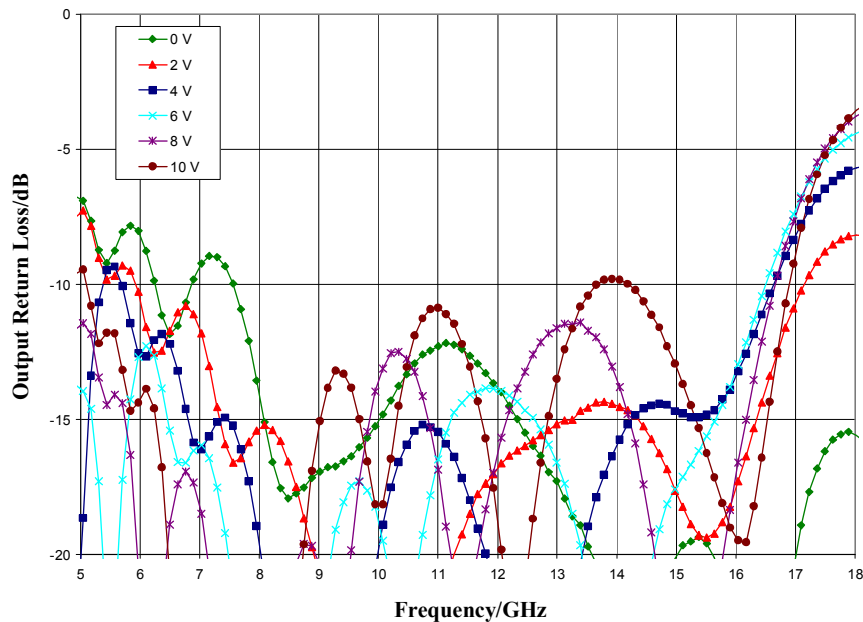
ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Typical Performance

Input Return Loss,  $T_A = 25^\circ\text{C}$



Output Return Loss,  $T_A = 25^\circ\text{C}$



ver 1.0 1019

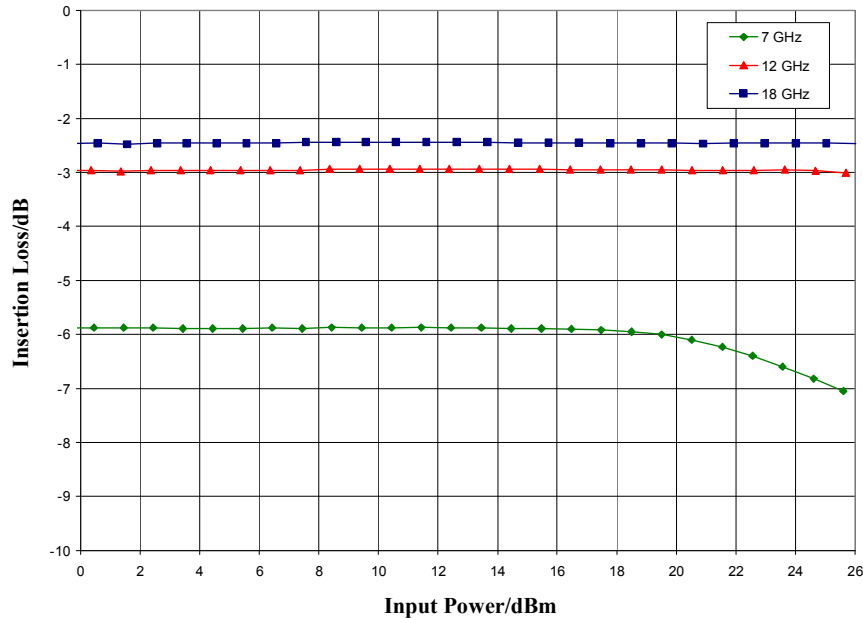


# CMD297P34

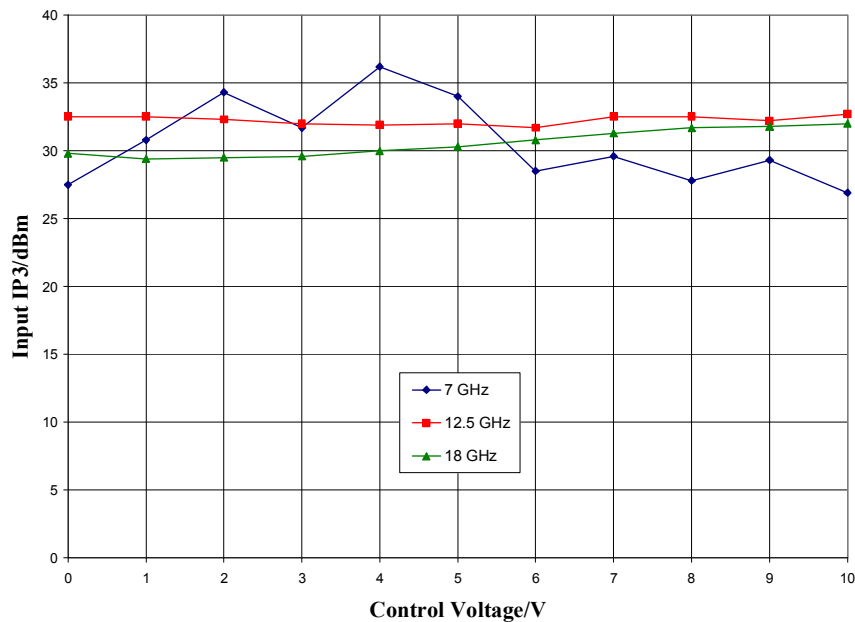
## 5-18 GHz Analog Phase Shifter

### Typical Performance

Insertion Loss vs. Pin, Vctl = 0V, T<sub>A</sub> = 25 °C



Input IP3 vs. Control Voltage, T<sub>A</sub> = 25 °C



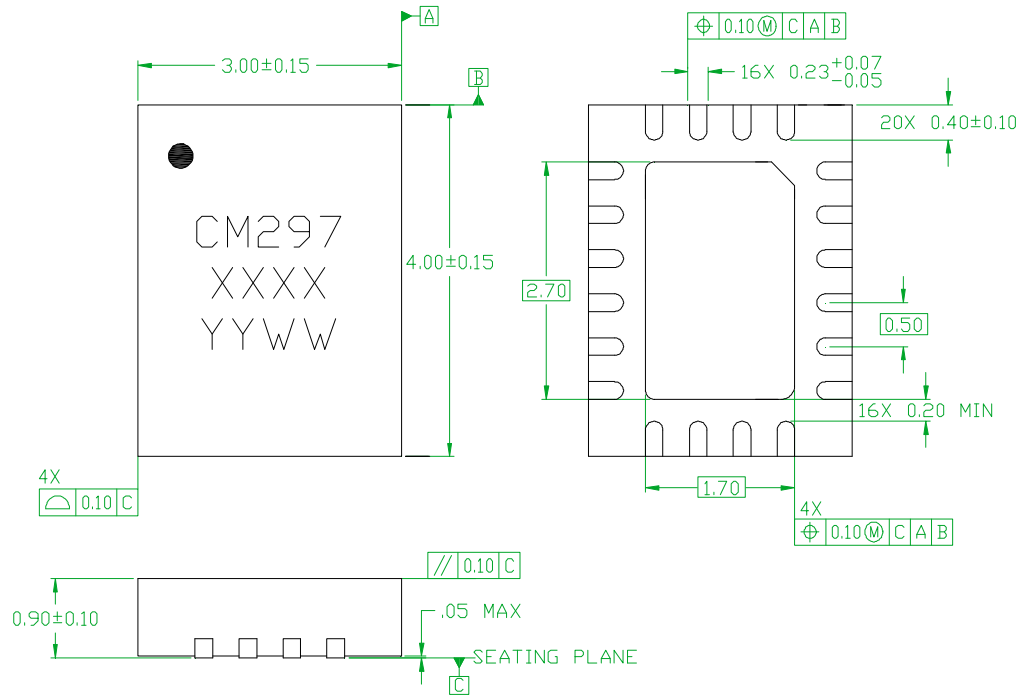
ver 1.0 1019

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: hyper@es-france.com - Site Web: www.es-france.com

### Mechanical Information

#### Package Information and Dimensions



#### NOTES:

1. DIMENSIONS ARE IN MILLIMETERS
2. RoHS COMPLIANT MOLD COMPOUND
3. LEADFRAME MATERIAL: COPPER ALLOY
4. LEAD FINISH: 100% MATTE Sn
5. INDICATED DIMENSION/TOLERANCE APPLIES TO LEADS AND EXPOSED PAD

#### Recommended PCB Land Pattern

Custom MMIC recommends that the user develop the land pattern that will provide the best design for proper solder reflow and device attach for their specific application. Please review Custom MMIC Application Note AN 105 for a recommended land pattern approach.

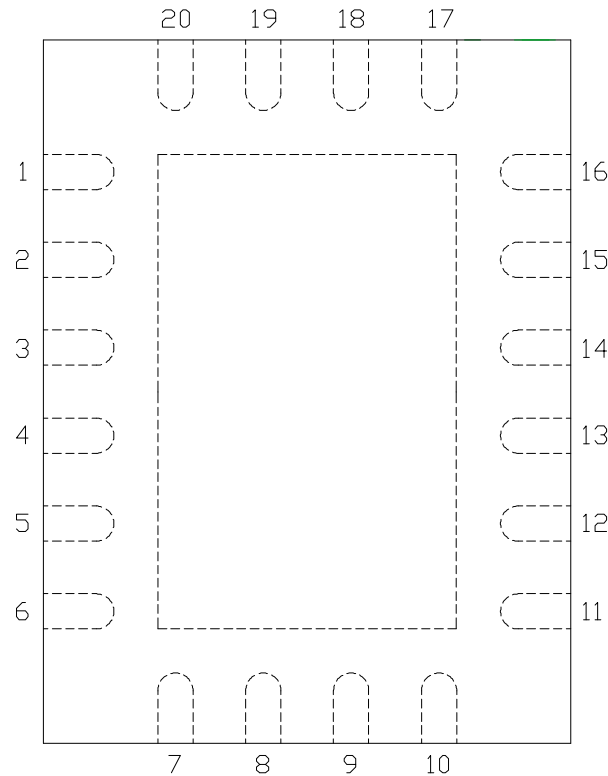
#### Recommended Solder Reflow Profile

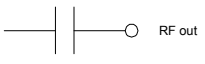
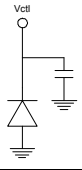
Custom MMIC recommends screen printing with belt furnace reflow to ensure proper solder reflow and device attach. Please review Custom MMIC Application Note AN 102 for a recommended solder reflow profile.

ver 1.0 1019

### Pin Description

### Pin Diagram



| Pin                            | Function | Description                                                         | Schematic                                                                                    |
|--------------------------------|----------|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| 1, 2, 6-11,<br>15-17, 19, 20   | N/C      | No connection required. These pins may be connected to RF/DC ground |                                                                                              |
| 4                              | RF in    | DC blocked and 50 ohm matched                                       | RF in   |
| 13                             | RF out   | DC blocked and 50 ohm matched                                       |  RF out |
| 18                             | Vctl     | Control voltage                                                     |         |
| 3, 5, 12, 14 and<br>die paddle | Ground   | Connect to RF / DC ground                                           |         |

ver 1.0 1019

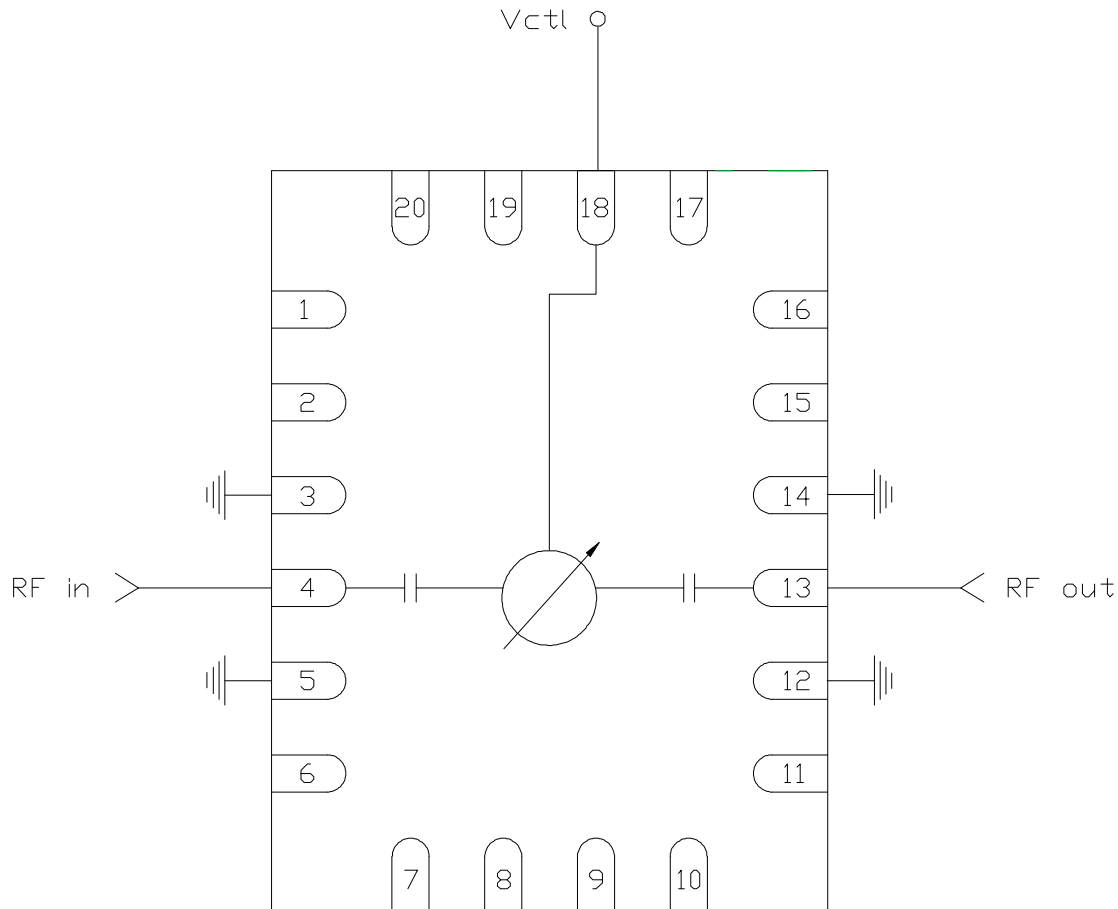


# CMD297P34

## 5-18 GHz Analog Phase Shifter

### Applications Information

#### Application Circuit



#### Biasing and Operation

The CMD297P34 has a single control voltage ( $V_{ctrl}$ ). Full phase shift range is achieved when  $V_{ctrl}$  is varied from 0 to +10 V.

RF power can be applied at any time.

**GaAs MMIC devices are susceptible to damage from Electrostatic Discharge. Proper precautions should be observed during handling, assembly and test.**

ver 1.0 1019

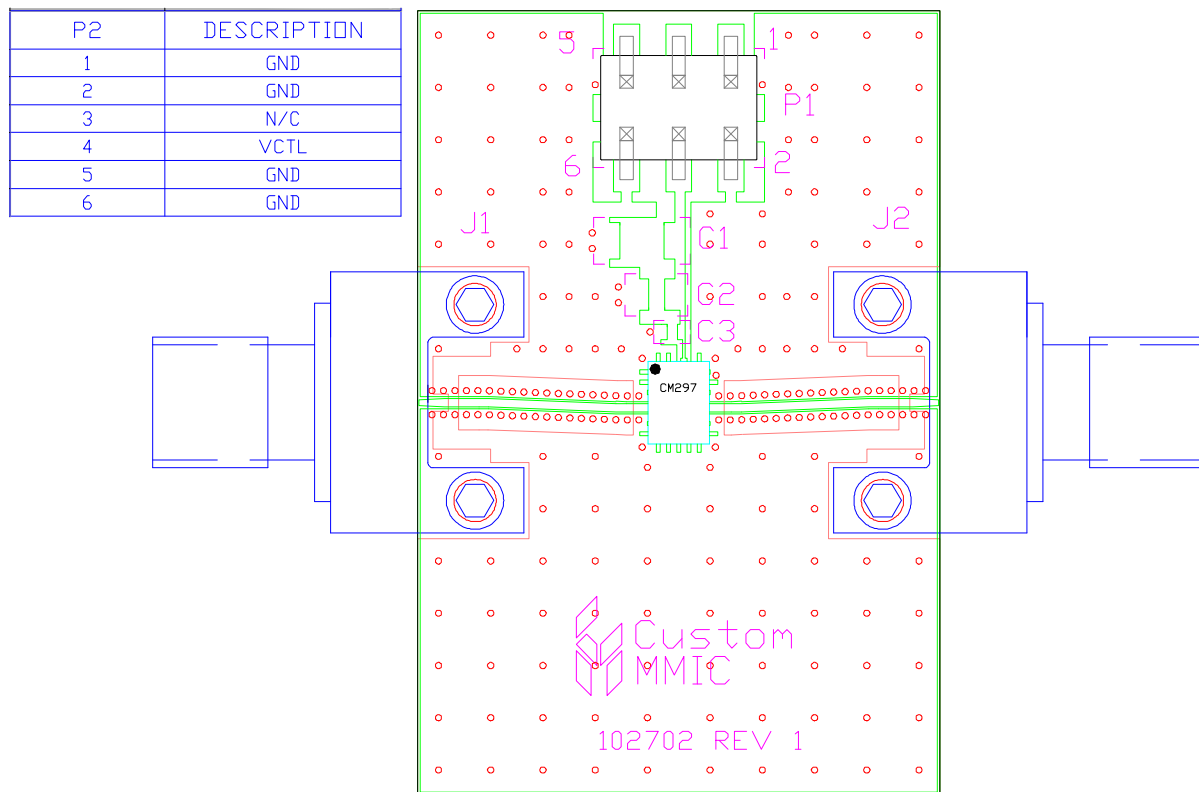
Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

ES France - Département RF & Hyperfréquences - 127 rue de Buzenval BP 26 - 92380 Garches  
Tél. 01 47 95 99 60 - Fax. 01 47 01 16 22 - e-mail: [hyper@es-france.com](mailto:hyper@es-france.com) - Site Web: [www.es-france.com](http://www.es-france.com)

### Applications Information

#### Evaluation Board

The circuit board shown has been developed for optimized assembly at Custom MMIC. A sufficient number of via holes should be used to connect the top and bottom ground planes. As surface mount processes vary, careful process development is recommended.



#### Bill of Material

| Designator | Value | Description                    |
|------------|-------|--------------------------------|
| J1, J2     |       | SMA End Launch Connector       |
| P1         |       | 6 Pin Header                   |
| U1         |       | CMD297P34 Analog Phase Shifter |
| PCB        |       | 102702 Evaluation PCB          |

Please note, all information contained in this data sheet is subject to change without notice.

ver 1.0 1019

Custom MMIC  
300 Apollo Drive Chelmsford, MA 01824 Phone (978) 467-4290 Fax (978) 467-4294

### Product Description

The Qorvo TGP2109 is a 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15 $\mu$ m GaAs pHEMT process. It operates over 8 to 12 GHz and provides 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 4° with 6 dB of insertion loss.

The TGP2109 was developed for simply system integration. It uses positive only switch logic; eliminating the need for a negative voltage rail. In addition, both ports are matched to 50 ohms with DC blocking capacitors. Ease of use along with low insertion loss and a high degree of resolution makes the TGP2109 ideally suited for a variety of x-band phased array applications including commercial and military radars and phase array communication systems.

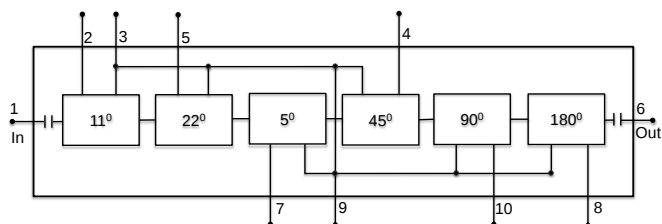


### Product Features

- Frequency Range: 8 to 12 GHz
- 6-Bit Digital Phase Shifter
- Bi-Directional
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 4°
- RMS Amplitude Error: 0.5 dB
- Insertion Loss: 6 dB
- Return Loss: 10 dB IRL; 15 dB ORL
- Input P1dB: 29 dBm
- Input IP3: >40 dBm
- IM3: <-50 dBc
- Control Voltage: 0/5 V
- Chip Dimensions: 2.2 x 2.2 x 0.1 mm

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

### Block Diagram



### Applications

- X-Band Radar
- Satellite Communication Systems

### Ordering Information

| Part No.    | Description                                 |
|-------------|---------------------------------------------|
| TGP2109     | 8-12 GHz X-Band 6 Bit Digital Phase Shifter |
| TGP2109 EVB | TGP2109 Evaluation Board                    |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | 0.5 mA        |
| Power Dissipation                   | 1.5 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 33 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 320 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                          | Value        |
|------------------------------------|--------------|
| Control Voltage                    | 0/+5 V       |
| Reference Voltage ( $V_{REF}$ )    | +5 V         |
| Current ( $I_{REF}$ , $I_{CTRL}$ ) | < 50 $\mu$ A |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) = 0/+5 V; see Bias Truth Table.

| Parameter                                            | Min | Typical | Max | Units |
|------------------------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range                          | 8   |         | 12  | GHz   |
| Insertion Loss                                       |     | 6       |     | dB    |
| Input Return Loss                                    |     | 10      |     | dB    |
| Output Return Loss                                   |     | 15      |     | dB    |
| RMS Phase Error                                      |     | 4       |     | deg   |
| RMS Amplitude Error                                  |     | 0.5     |     | dB    |
| Input P1dB                                           |     | 29      |     | dBm   |
| Input IP3 (Tone Spacing = 10 MHz, Pin/Tone = 16 dBm) |     | > 40    |     | dBm   |
| IM3 (Tone Spacing = 10 MHz, Pin/Tone = 16 dBm)       |     | < -50   |     | dBc   |
| Insertion Loss Temperature Coefficient               |     | 0.004   |     | dB/°C |

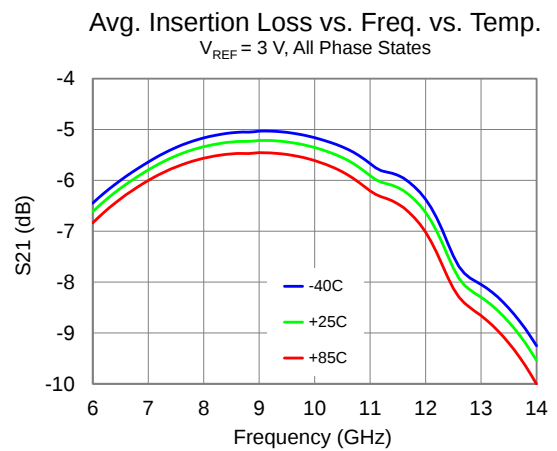
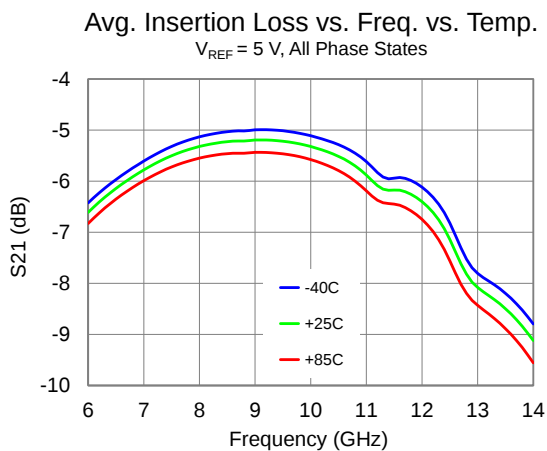
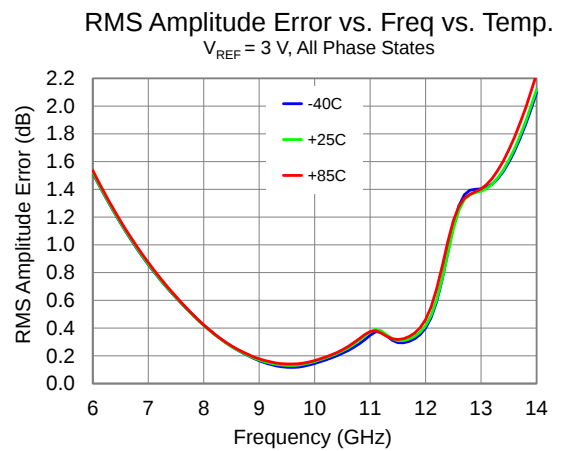
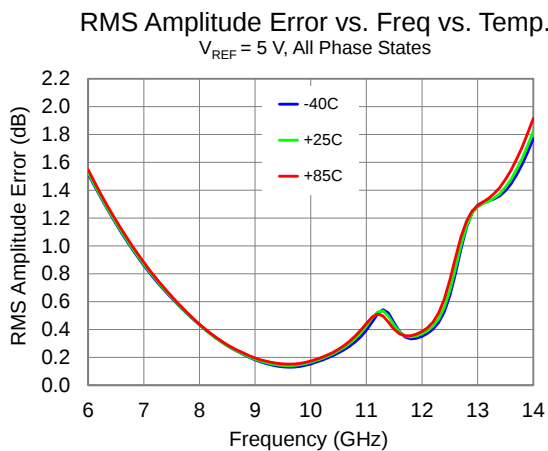
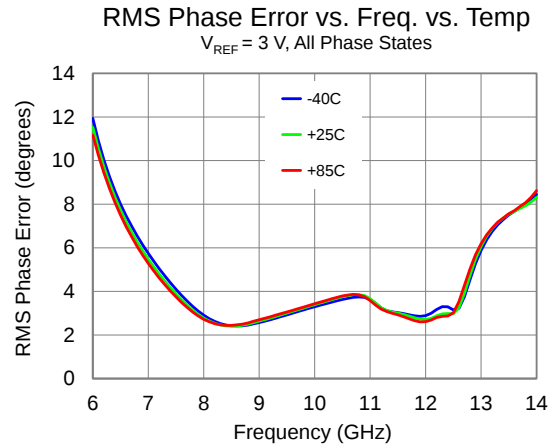
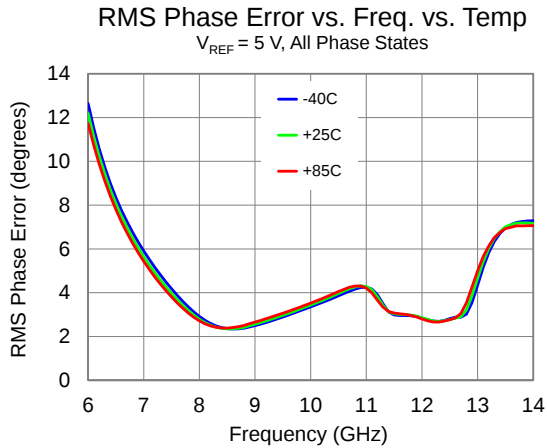
### Bias Truth Table

Logic "0" = 0 V, Logic "1" =  $V_{REF}$  = +5 V

| Phase Shifter  | B1 | B2 | B3 | B4 | B5 | B6 | VREF |
|----------------|----|----|----|----|----|----|------|
| 0° (Reference) | 0  | 0  | 1  | 1  | 1  | 1  | 1    |
| 5°             | 1  | 0  | 1  | 1  | 1  | 1  | 1    |
| 11°            | 0  | 1  | 1  | 1  | 1  | 1  | 1    |
| 22°            | 0  | 0  | 0  | 1  | 1  | 1  | 1    |
| 45°            | 0  | 0  | 1  | 0  | 1  | 1  | 1    |
| 90°            | 0  | 0  | 1  | 1  | 0  | 1  | 1    |
| 180°           | 0  | 0  | 1  | 1  | 1  | 0  | 1    |
| 355°           | 1  | 1  | 0  | 0  | 0  | 0  | 1    |

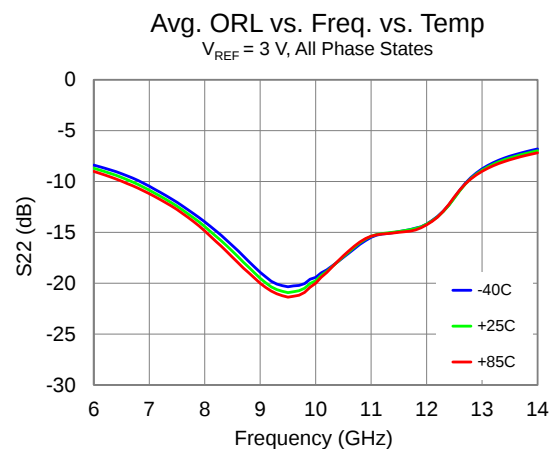
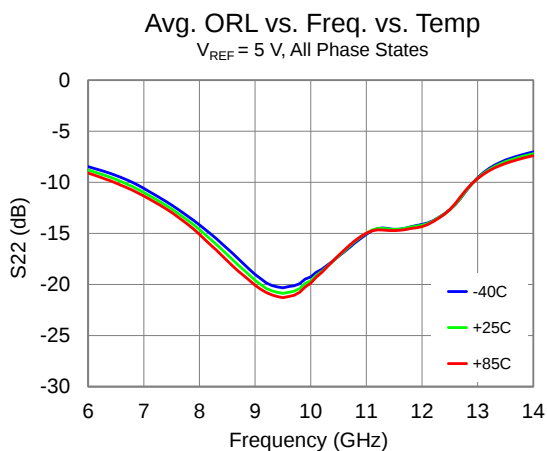
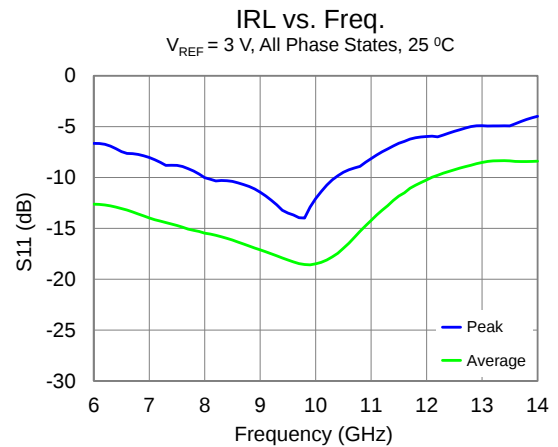
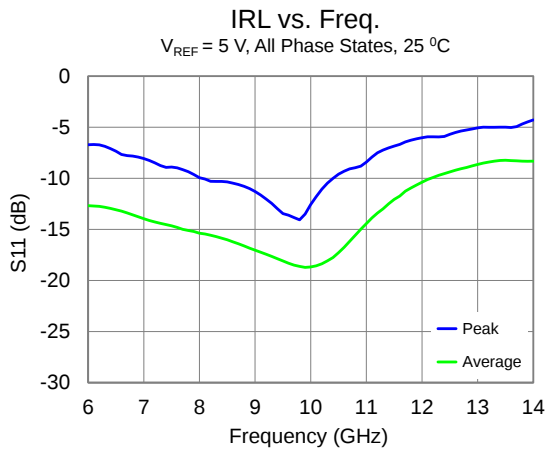
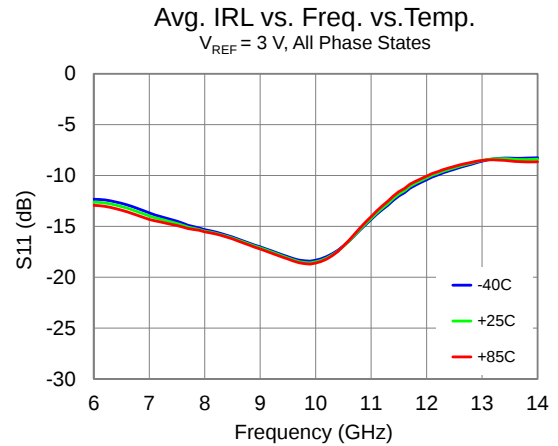
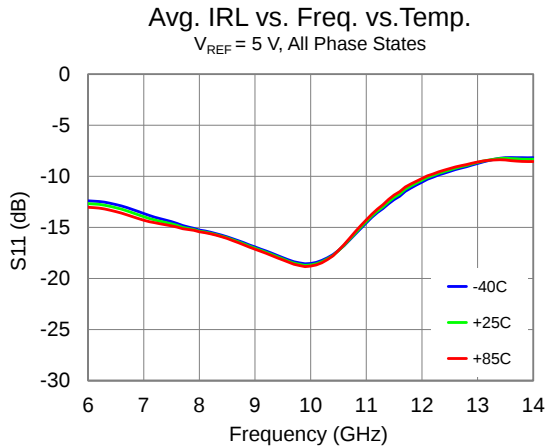
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C; 5V and 3V



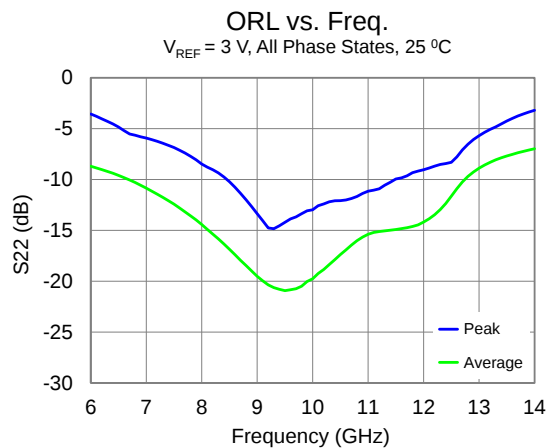
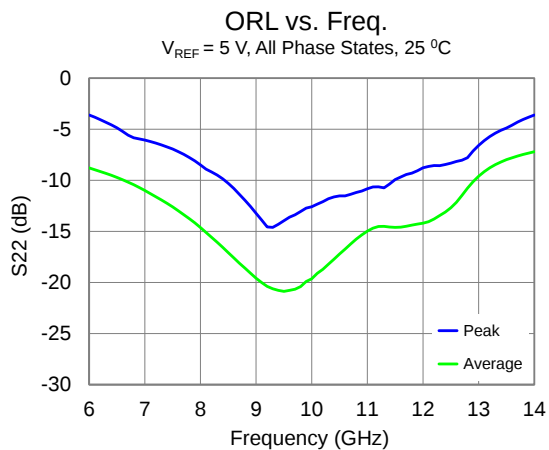
### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: 25 °C; 5V and 3V



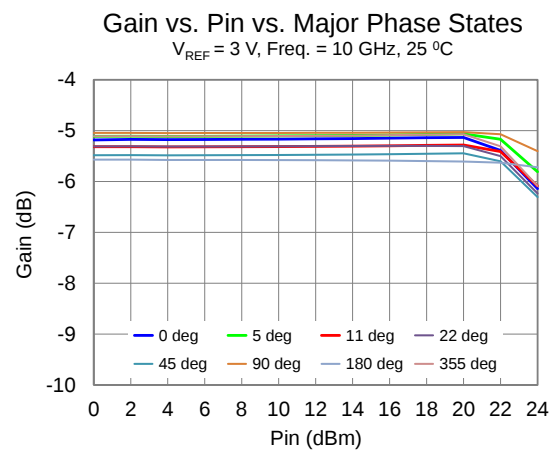
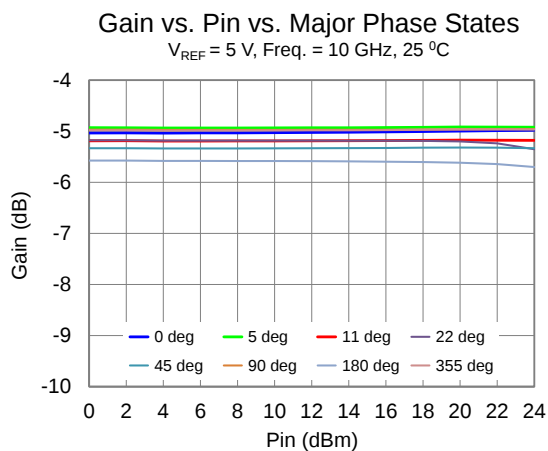
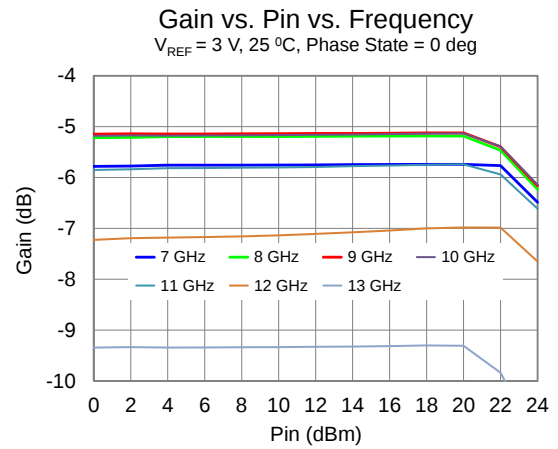
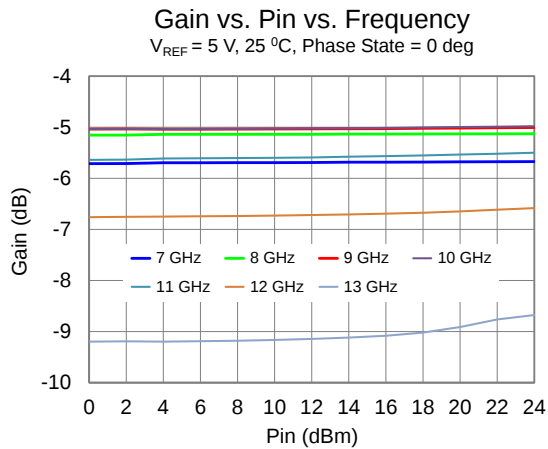
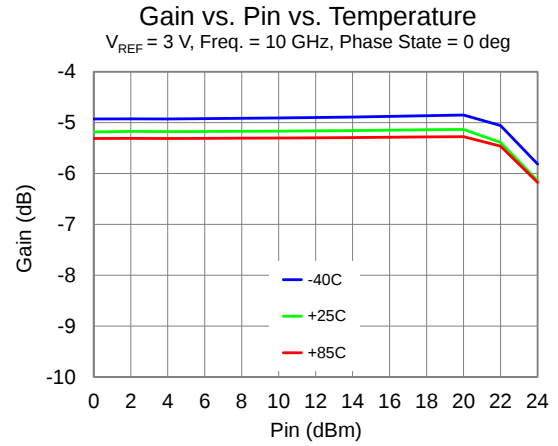
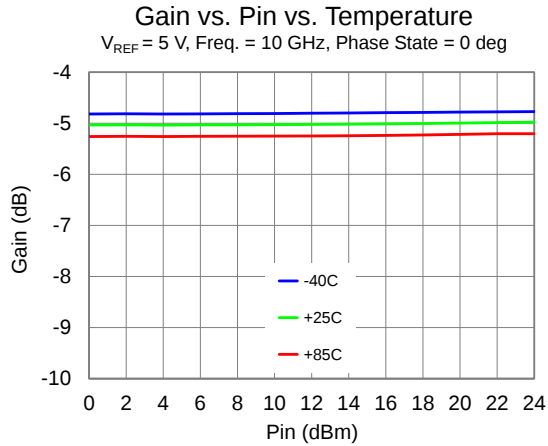
### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: 25 °C; 5V and 3V, 25



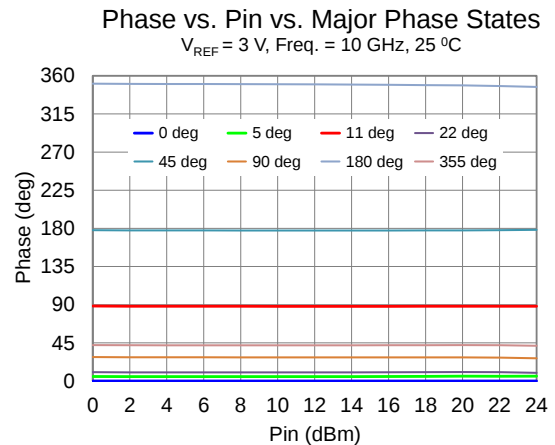
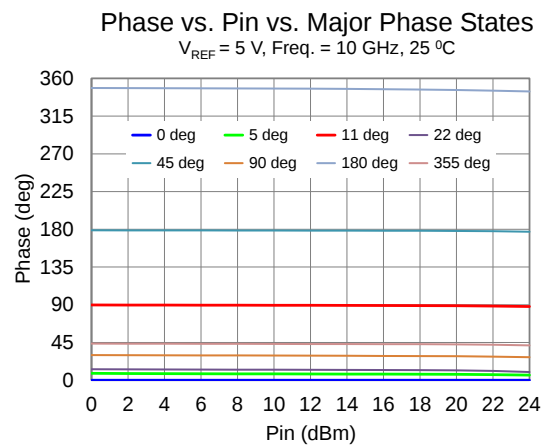
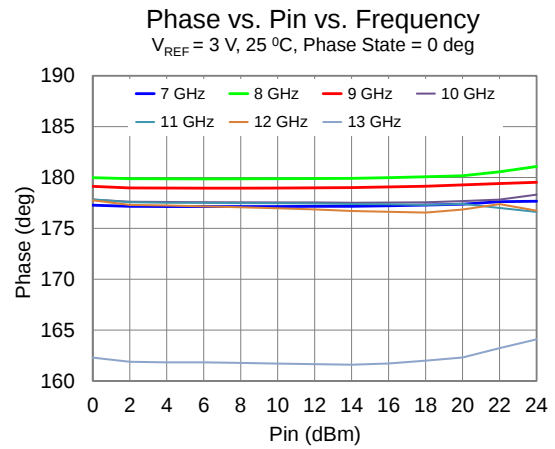
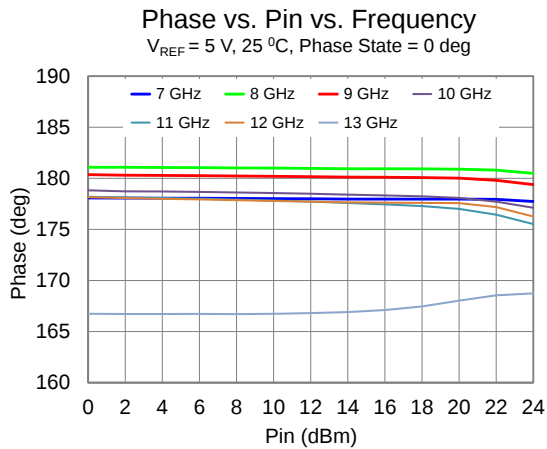
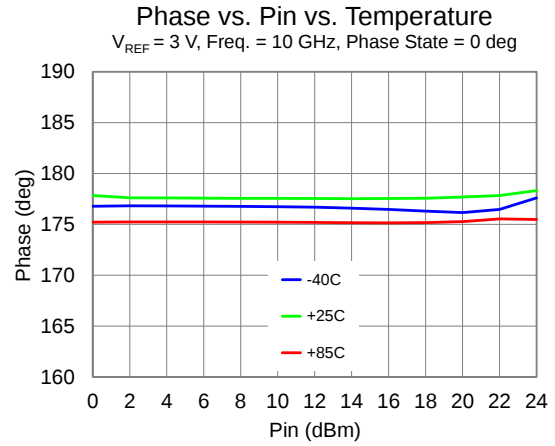
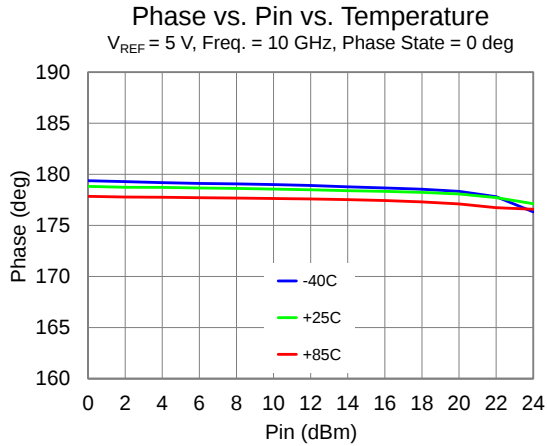
### Performance Plots – Large Signal

Test conditions unless otherwise noted: 25 °C; 5V and 3V



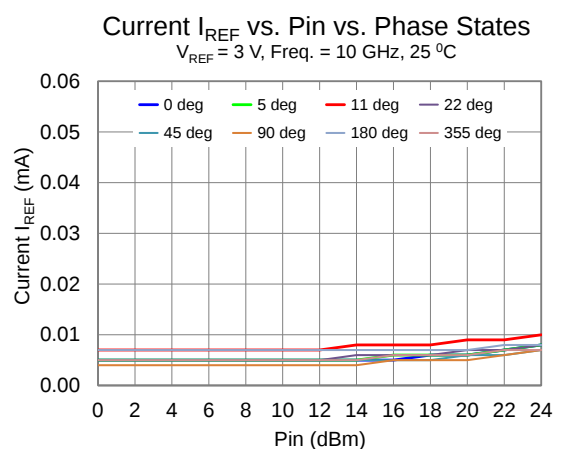
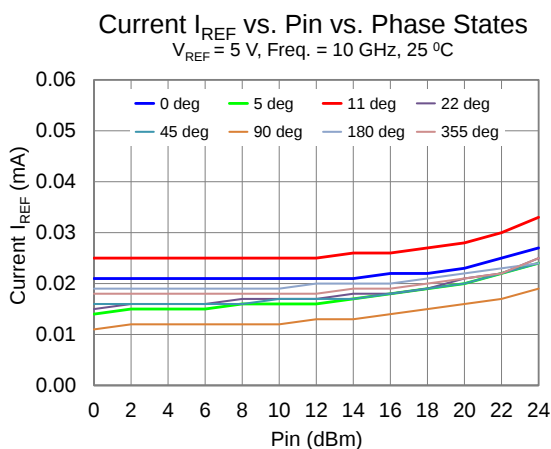
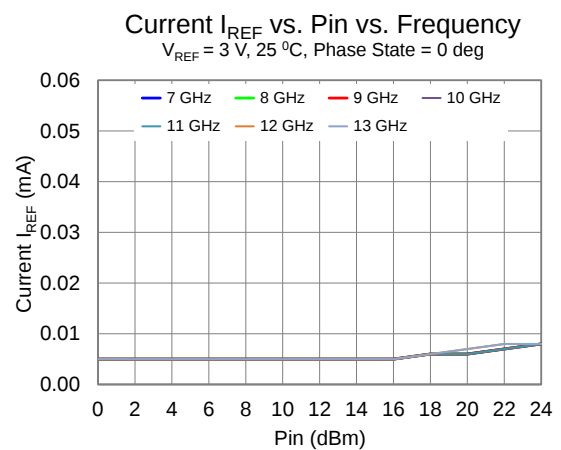
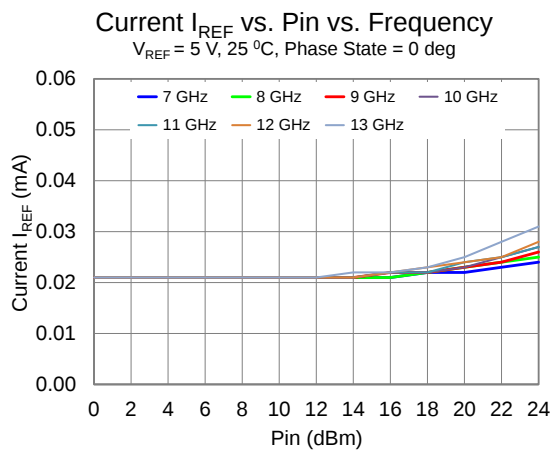
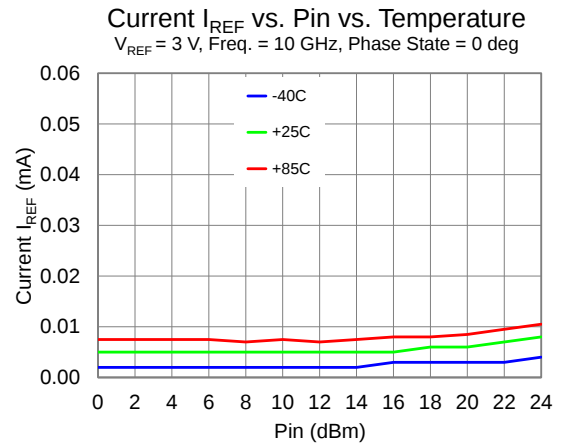
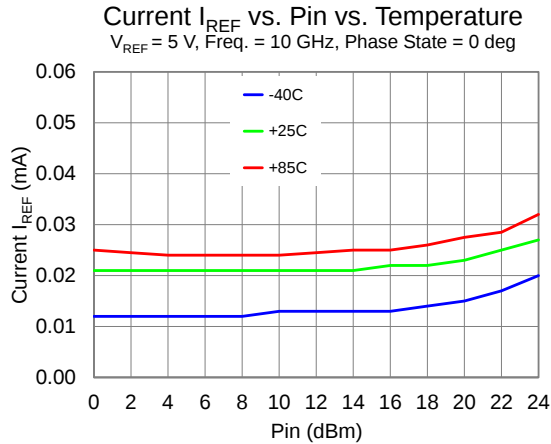
### Performance Plots – Large Signal (Cont.)

Test conditions unless otherwise noted: 25 °C; 5V and 3V



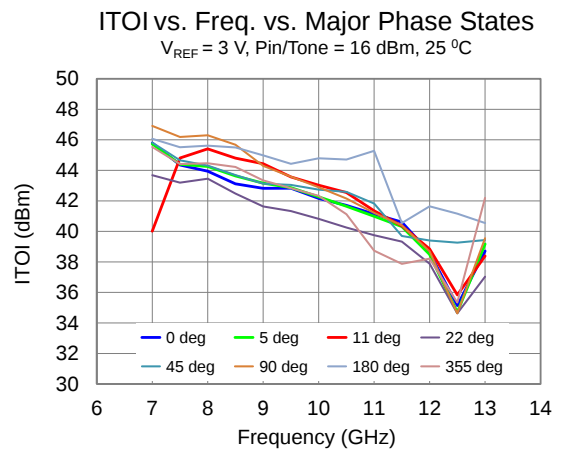
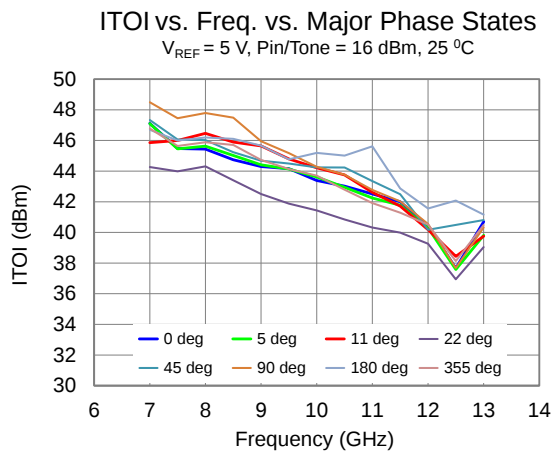
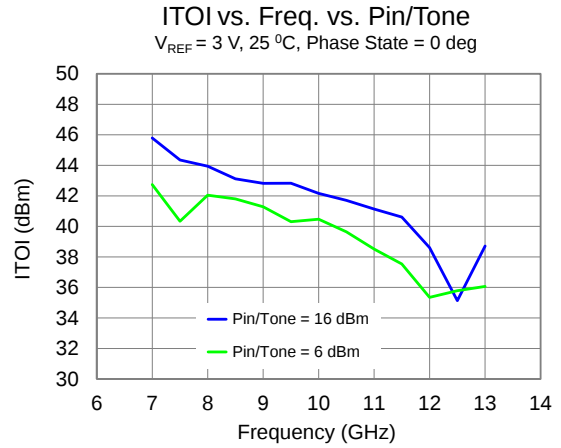
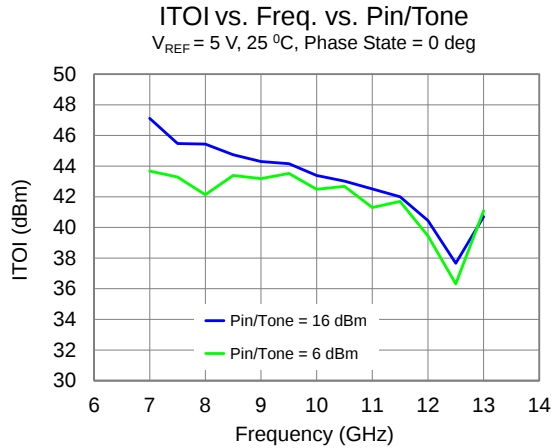
### Performance Plots – Large Signal (Cont.)

Test conditions unless otherwise noted: 25 °C; 5V and 3V



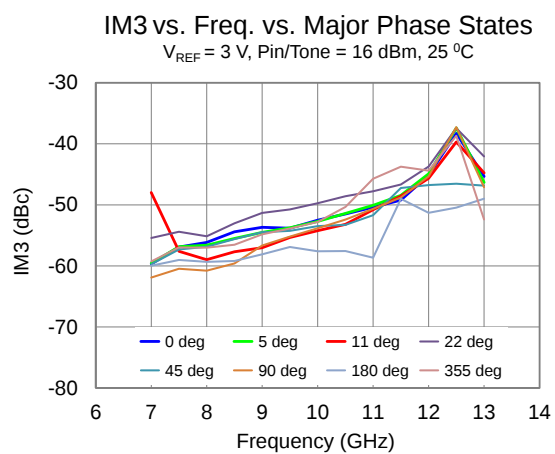
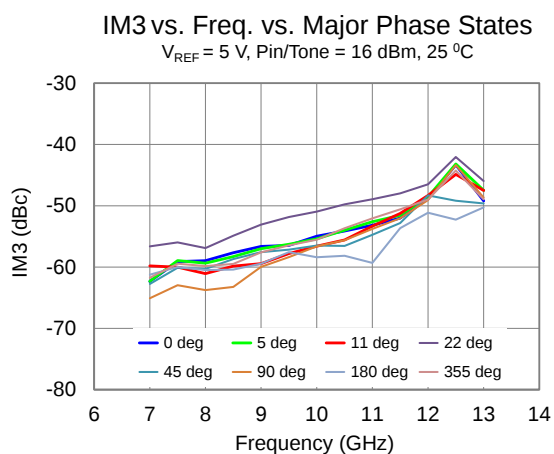
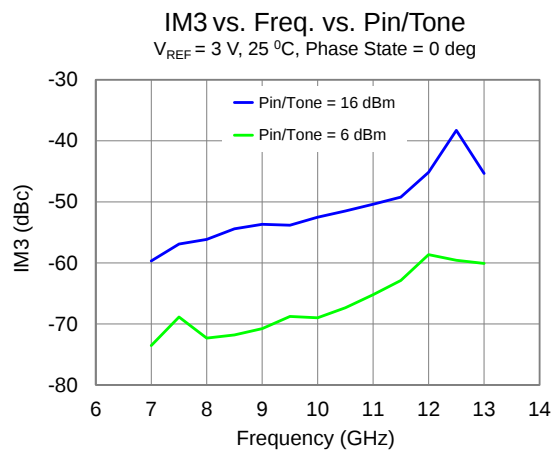
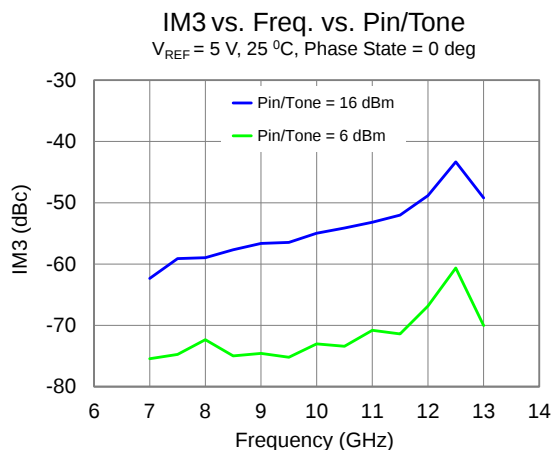
### Performance Plots – Linearity

Test conditions unless otherwise noted: 25 °C; 5V and 3V, Tone Spacing = 10 MHz

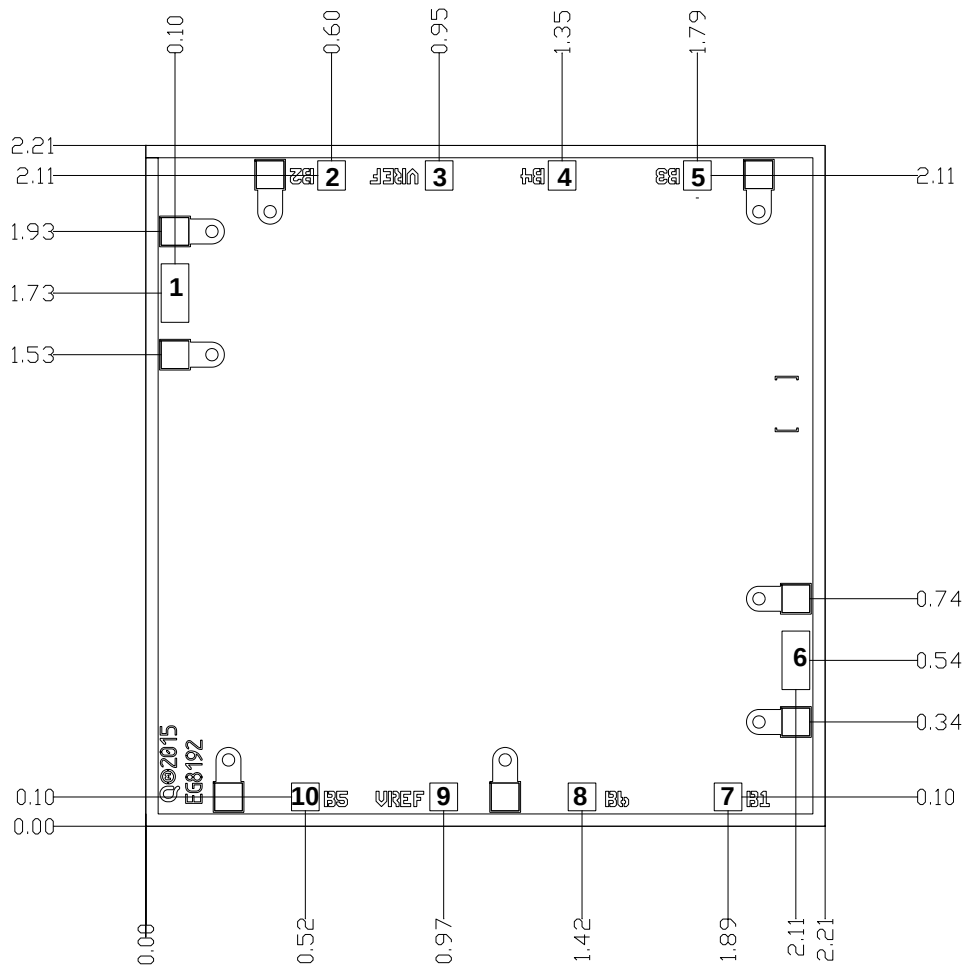


### Performance Plots – Linearity (Cont.)

Test conditions unless otherwise noted: 25 °C; 5V and 3V, Tone Spacing = 10 MHz



### Mechanical Information and Bond Pad Description

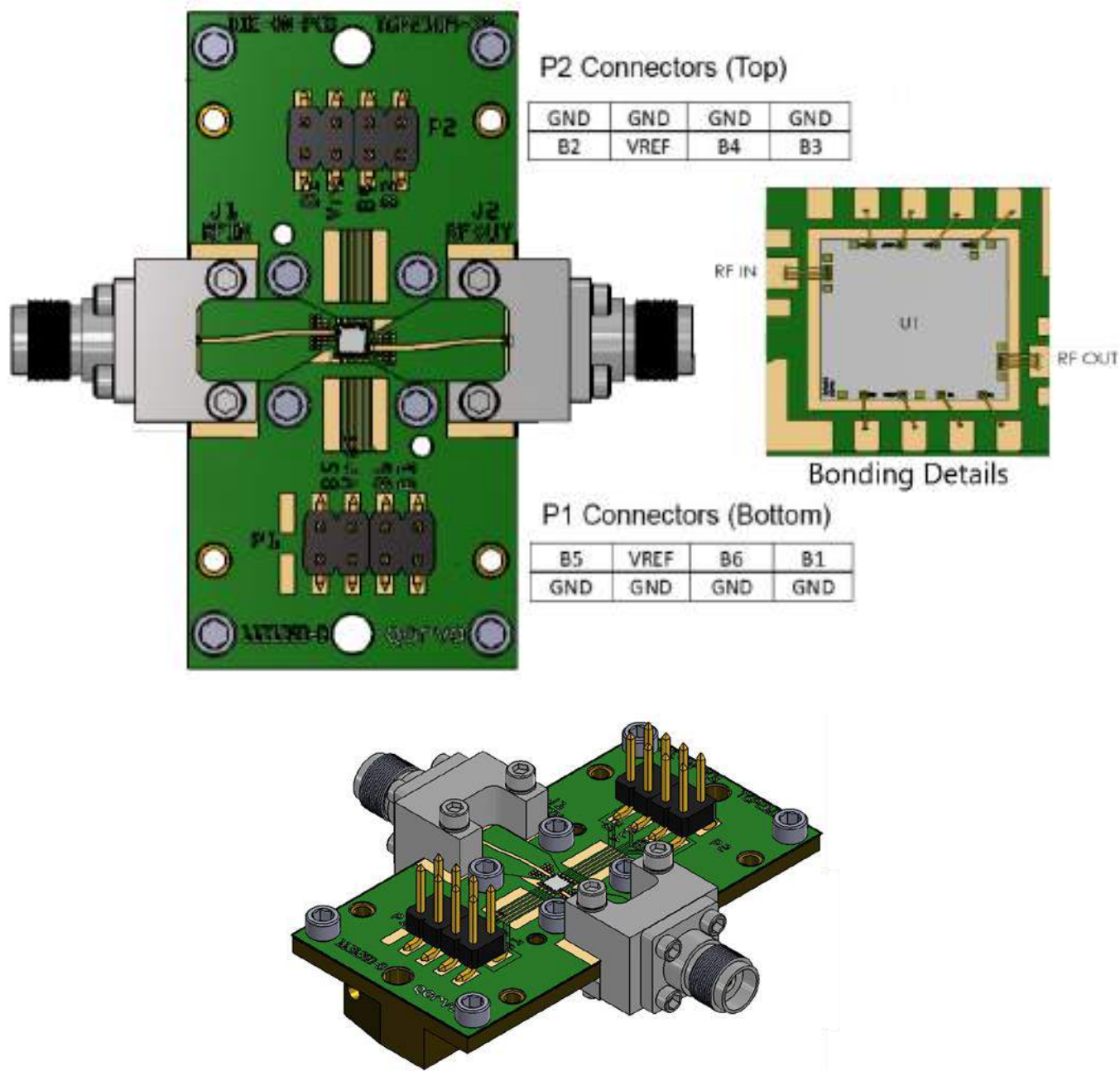


Unit: millimeters, Die thickness: 0.10, Die x, y size tolerance:  $\pm 0.050$   
Chip edge to bond pad dimensions are shown to center of pad, Ground is backside of die

| Bond Pad | Symbol | Description                                                              | Pad Size      |
|----------|--------|--------------------------------------------------------------------------|---------------|
| 1        | RF In  | Input; matched to 50 $\Omega$ ; DC blocked; interchangeable to RF Output | 0.200 x 0.100 |
| 2        | B2     | 11° Bit                                                                  | 0.100 x 0.100 |
| 3, 9     | REF    | Reference; $V_{REF}$ can be applied to either pad                        | 0.100 x 0.100 |
| 4        | B4     | 45° Bit                                                                  | 0.100 x 0.100 |
| 5        | B3     | 22° Bit                                                                  | 0.100 x 0.100 |
| 6        | RF Out | Output; matched to 50 $\Omega$ ; DC blocked; interchangeable to RF Input | 0.200 x 0.100 |
| 7        | B1     | 5° Bit                                                                   | 0.100 x 0.100 |
| 8        | B6     | 180° Bit                                                                 | 0.100 x 0.100 |
| 10       | B5     | 90° Bit                                                                  | 0.100 x 0.100 |

#### Assembly Notes

1. De-Quing network is not required;  $V_{REF}$  can be applied to either side of the MMIC (pad # 3 or #9)
2. The spacing between MMIC and TFN at RF In and RF Out is <5 mils typical.
3. RF connections: Bond three 1-mil diameter, <20 mils length gold bond wires at RF In and RF Out for optimum RF performance.



### Assembly Notes

---

#### Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.
- Organic attachment (i.e., conductive epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.

#### Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300°C to 3-4 minutes, maximum.
- Conductive epoxy die attach is recommended for PCB mounting.
- Bonding pads plating: Au.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

#### Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonics are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

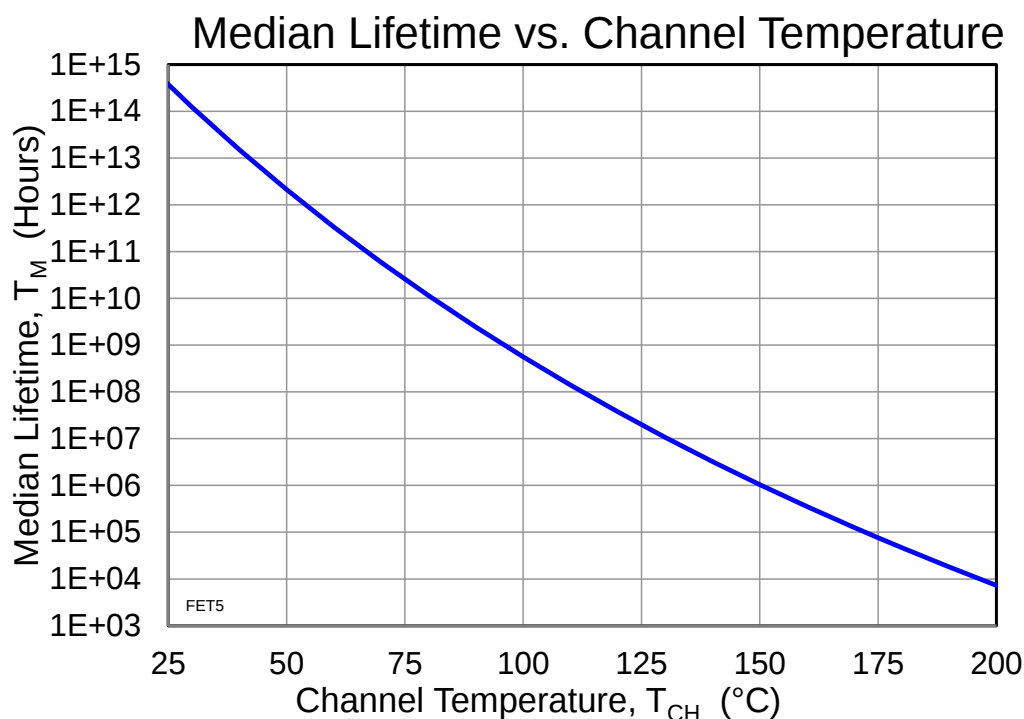
### Thermal and Reliability Information

| Parameter                                | Test Conditions                      | Value  | Units              |
|------------------------------------------|--------------------------------------|--------|--------------------|
| Channel Temperature, $T_{CH}$ (Under RF) | $T_{BASEPLATE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )                |                                      | 5.2E09 | Hrs                |

#### Notes:

Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime



### Handling Precautions

| Parameter                    | Rating  | Standard                 |  | Caution!<br>ESD-Sensitive Device |
|------------------------------|---------|--------------------------|-------------------------------------------------------------------------------------|----------------------------------|
| ESD – Human Body Model (HBM) | Class 0 | ESDA / JEDEC JS-001-2012 |                                                                                     |                                  |

### 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2021 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.

### Product Description

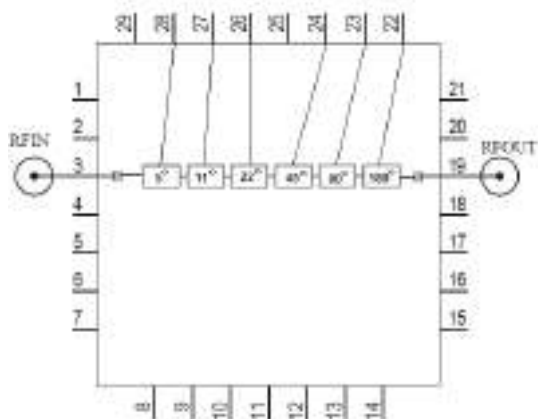
The Qorvo QPC2108 is a packaged 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15  $\mu\text{m}$  GaAs pHEMT process. It operates over 2.5-4 GHz while providing 360° of phase coverage with a LSB of 5.625°. The QPC2108 offers an exceptional RMS phase error of <2.8 degrees and amplitude error of <0.4 dB over most of the operational band. With other equally impressive small signal and linearity characteristics, the QPC2108 delivers superior performance for your S-band phased array applications.

Housed in a small 6 x 6 mm plastic overmold QFN package, DC blocked on both ports with bi-directional operation and the use of positive only control logic, the QPC2108 supports ease of use and simply system integration. Low DC power consumption also provides the system designer more flexibility in the overall power management of the system.

The device is lead-free and RoHS compliant.

Evaluation Boards are available upon request.

### Block Diagram



### Product Features

- Frequency Range: 2.5 to 4 GHz
- 6-Bit Digital Phase Shifter
- Bi-Directional
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: < 2.8° (2.5 – 3.8 GHz)  
< 5° (3.9 – 4 GHz)
- RMS Amplitude Error: < 0.4 dB
- Insertion Loss: 5 dB
- Return Loss: 16 dB
- Input  $P_{0.1\text{dB}}$ : 23 dBm
- Input IP3: 45 dBm
- Switching Speed: < 100 ns
- Control Voltage: 0 /+5 V
- QFN Package Dimensions: 6.0 x 6.0 x 0.79 mm

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

### Applications

- S-Band Radar

### Ordering Information

| Part No.     | ECCN  | Description                           |
|--------------|-------|---------------------------------------|
| QPC2108      | EAR99 | 2.5-4 GHz 6-Bit Digital Phase Shifter |
| QPC2108EVB01 |       | Evaluation Board                      |

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) = 0/+5 V; See Bias Truth Table.

| Parameter                                       | Phase | Freq.<br>(GHz) | Min | Typical | Max | Units  |
|-------------------------------------------------|-------|----------------|-----|---------|-----|--------|
| Operational Frequency Range                     |       |                | 2.5 |         | 4   | GHz    |
| Insertion Loss                                  | 5°    |                |     | 5       |     | dB     |
|                                                 | 355°  |                |     |         |     |        |
| Input Return Loss                               |       |                |     | 16      |     | dB     |
| Output Return Loss                              |       |                |     | 13      |     | dB     |
| RMS Phase Error                                 |       | 2.5, 3.8       |     | < 2.8   |     | degree |
|                                                 |       | 2.6 – 3.7      |     | < 2     |     |        |
|                                                 |       | 3.9, 4         |     | < 5     |     |        |
| RMS Amplitude Error                             |       |                |     | < 0.5   |     | dB     |
| Relative Phase                                  | 5°    | 2.5            |     | 6.2     |     | degree |
|                                                 |       | 2.9            |     | 6.5     |     |        |
|                                                 |       | 3.5, 4         |     | 5.8     |     |        |
|                                                 | 11°   | 2.5            |     | 12.5    |     |        |
|                                                 |       | 2.9            |     | 11      |     |        |
|                                                 |       | 3.5, 4         |     | 11.7    |     |        |
|                                                 | 22°   | 2.5            |     | 21.5    |     |        |
|                                                 |       | 2.9            |     | 22.8    |     |        |
|                                                 |       | 3.5            |     | 24.6    |     |        |
|                                                 |       | 4              |     | 24      |     |        |
|                                                 | 45°   | 2.5            |     | 45.4    |     |        |
|                                                 |       | 2.9            |     | 43.8    |     |        |
|                                                 |       | 3.5            |     | 44.4    |     |        |
|                                                 |       | 4              |     | 44.2    |     |        |
|                                                 | 90°   | 2.5            |     | 90.4    |     |        |
|                                                 |       | 2.9            |     | 87.2    |     |        |
|                                                 |       | 3.5            |     | 91      |     |        |
|                                                 |       | 4              |     | 90.3    |     |        |
|                                                 | 180°  | 2.5            |     | 182.4   |     |        |
|                                                 |       | 2.9            |     | 177.5   |     |        |
|                                                 |       | 3.5            |     | 180.2   |     |        |
|                                                 |       | 4              |     | 188.3   |     |        |
|                                                 | 355°  | 2.5            |     | 362.5   |     |        |
|                                                 |       | 2.9            |     | 351.4   |     |        |
|                                                 |       | 3.5            |     | 355.6   |     |        |
|                                                 |       | 4              |     | 369     |     |        |
| Switching Speed                                 |       |                |     | < 100   |     | ns     |
| Input P <sub>0.1dB</sub>                        |       |                |     | 23      |     | dBm    |
| Input IP3 (Spacing = 10 MHz, Pin/Tone = 10 dBm) |       |                |     | 45      |     | dBm    |
| Insertion Loss Temperature Coefficient          |       |                |     | 0.003   |     | dB/°C  |

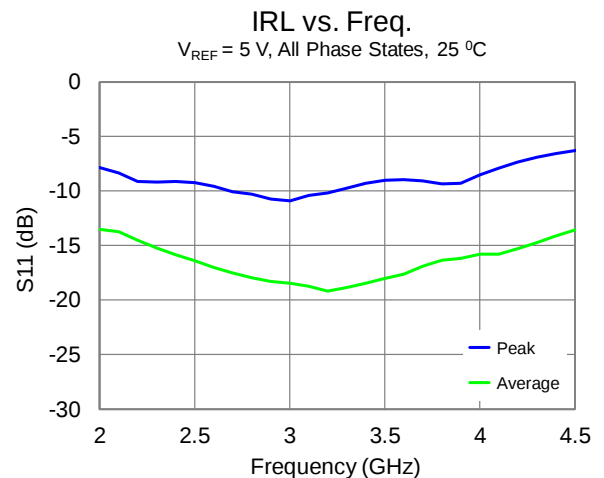
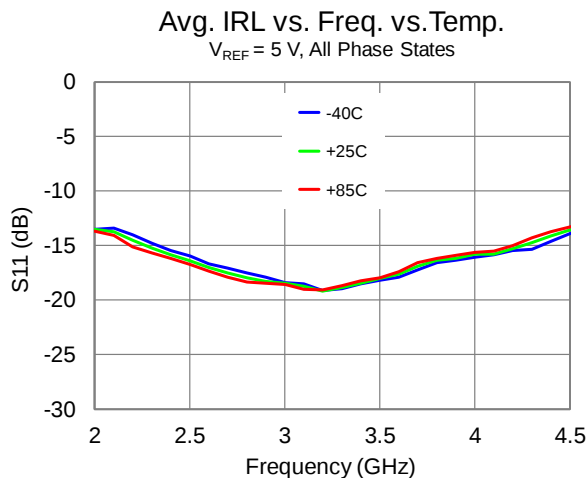
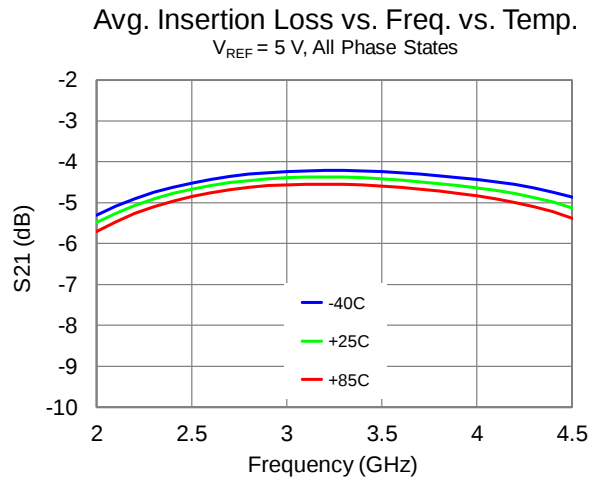
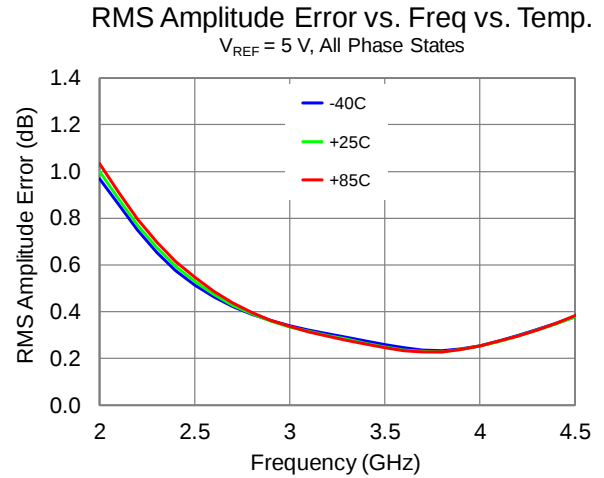
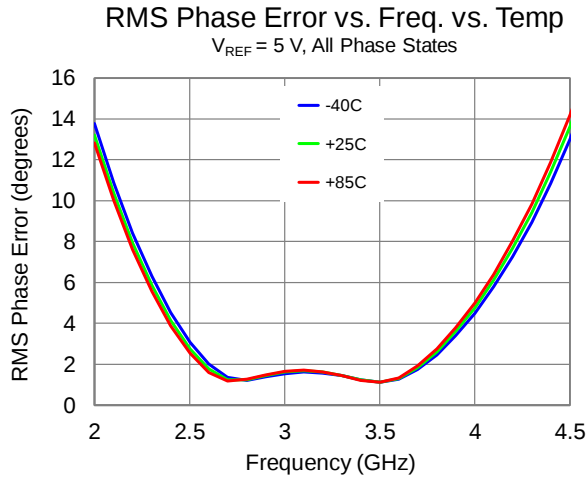
| Parameter                                                                                                                         | Value / Range  |
|-----------------------------------------------------------------------------------------------------------------------------------|----------------|
| Control Voltage (REF, 5 <sup>0</sup> , 11 <sup>0</sup> , 22 <sup>0</sup> , 45 <sup>0</sup> , 90 <sup>0</sup> , 180 <sup>0</sup> ) | 0/+5 V         |
| Current (I <sub>REF</sub> , I <sub>CTRL</sub> )                                                                                   | < 0.3 mA       |
| Temperature Range                                                                                                                 | -40 to +85 °C  |
| Supply Current (I <sub>S</sub> )                                                                                                  | 100 uA typical |

## Bias Truth Table

| Logic "0" = 0 V, Logic "1" = +5 V |    |     |     |     |     |      |     |
|-----------------------------------|----|-----|-----|-----|-----|------|-----|
| Phase Shifter                     | 5° | 11° | 22° | 45° | 90° | 180° | REF |
| 0° (Reference)                    | 0  | 0   | 0   | 0   | 0   | 0    | 1   |
| 5°                                | 1  | 0   | 0   | 0   | 0   | 0    | 1   |
| 11°                               | 0  | 1   | 0   | 0   | 0   | 0    | 1   |
| 22°                               | 0  | 0   | 1   | 0   | 0   | 0    | 1   |
| 45°                               | 0  | 0   | 0   | 1   | 0   | 0    | 1   |
| 90°                               | 0  | 0   | 0   | 0   | 1   | 0    | 1   |
| 180°                              | 0  | 0   | 0   | 0   | 0   | 1    | 1   |
| 355°                              | 1  | 1   | 1   | 1   | 1   | 1    | 1   |

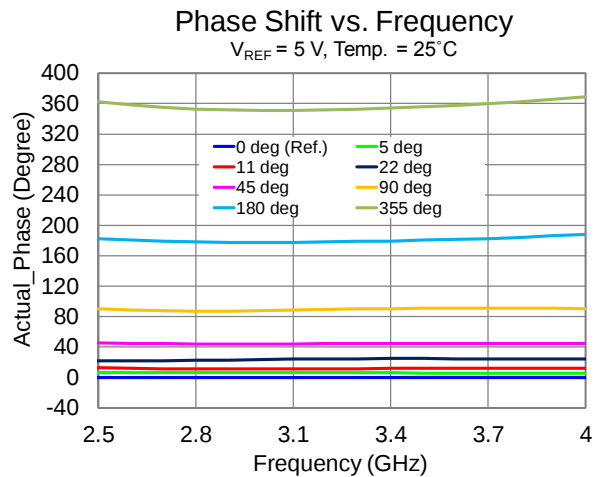
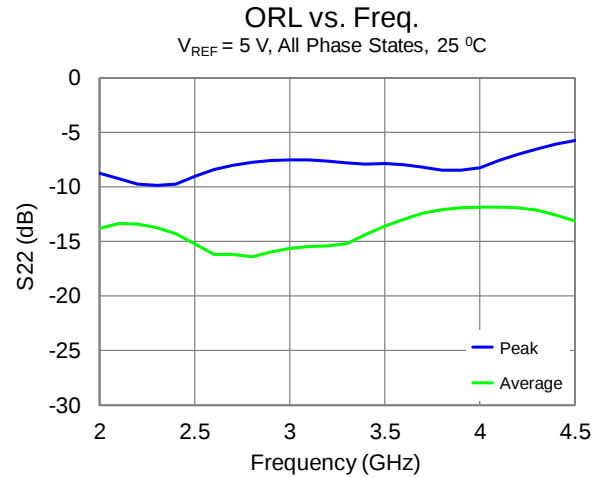
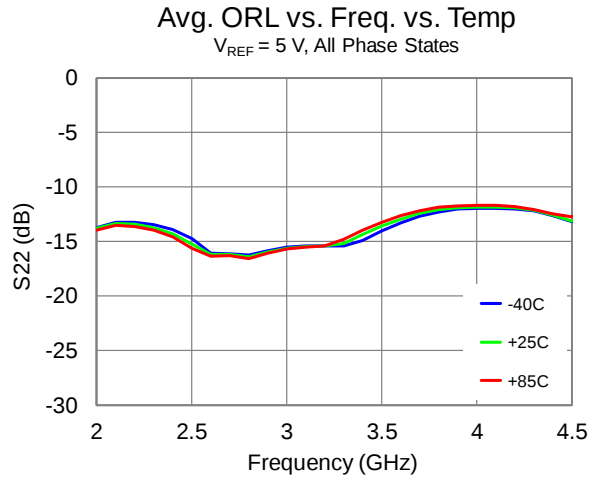
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 5V, 25 °C



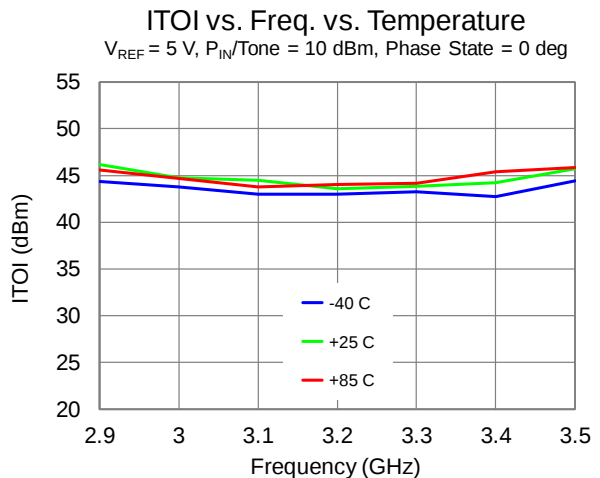
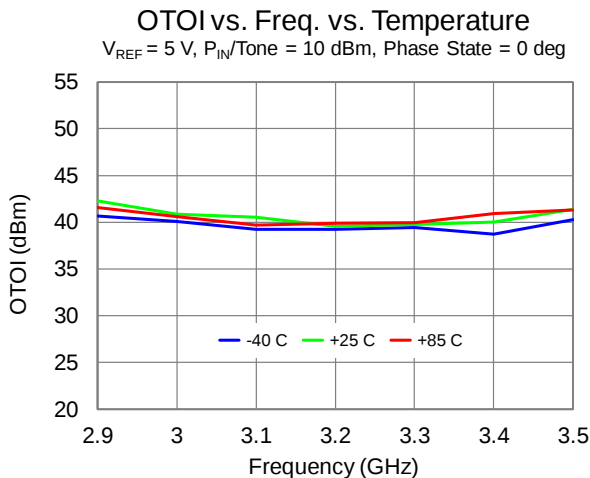
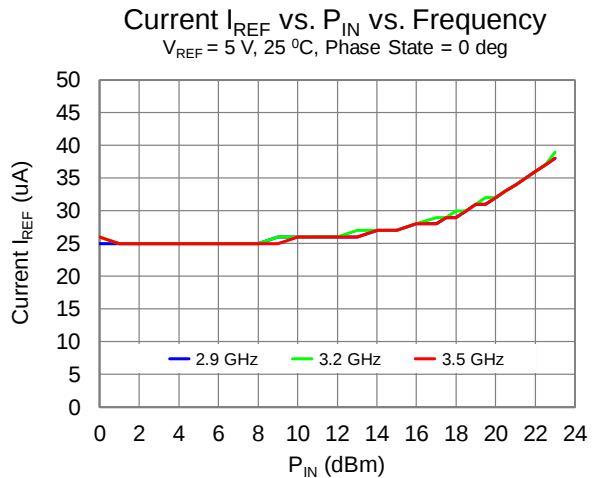
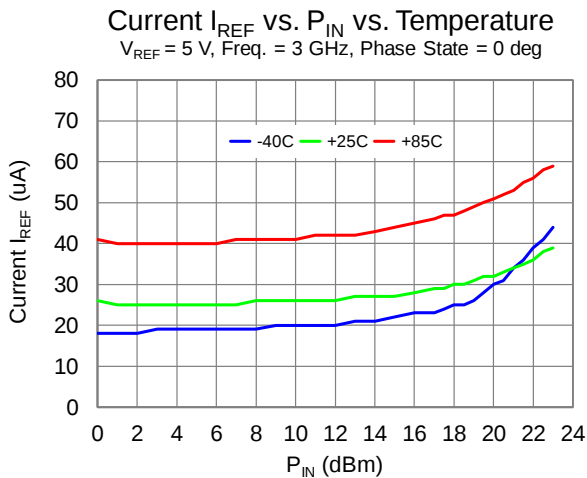
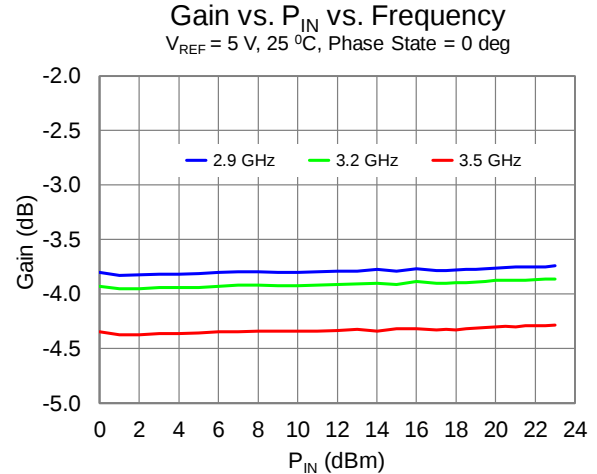
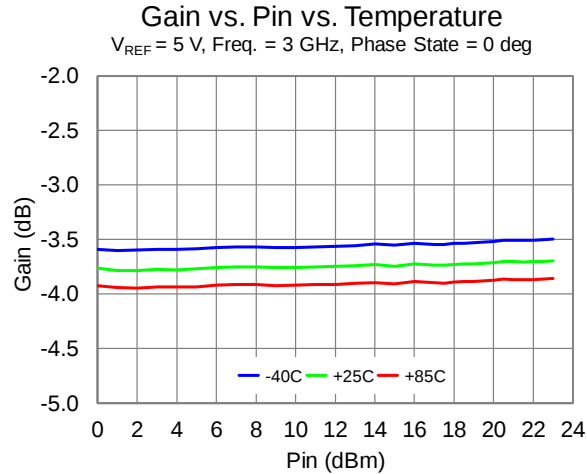
### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: 5V, 25 °C



### Performance Plots – Large Signal & Linearity

Test conditions unless otherwise noted: 5V, 25 °C



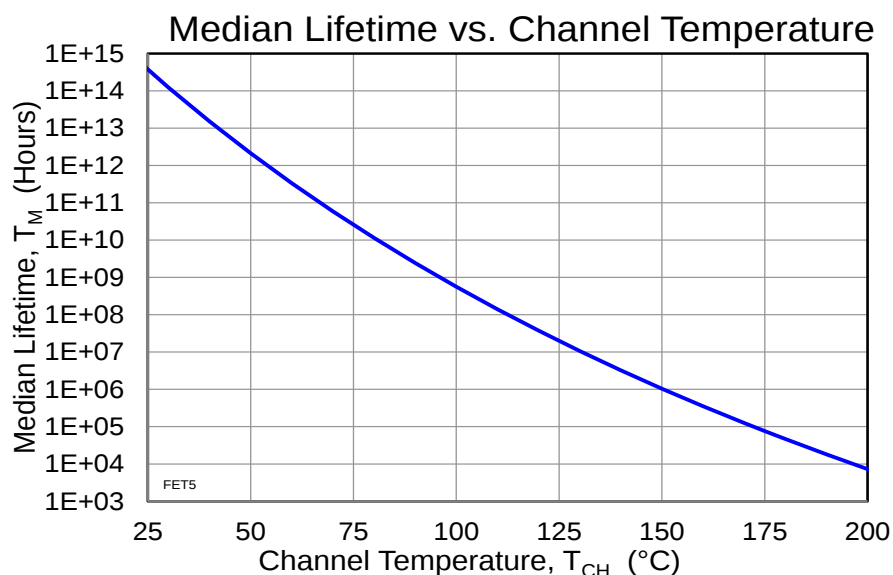
### Thermal and Reliability Information

| Parameter                        | Test Conditions                 | Value  | Units              |
|----------------------------------|---------------------------------|--------|--------------------|
| Channel Temperature ( $T_{CH}$ ) | $T_{BASE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )        |                                 | 5.2E+9 | Hrs                |

Notes:

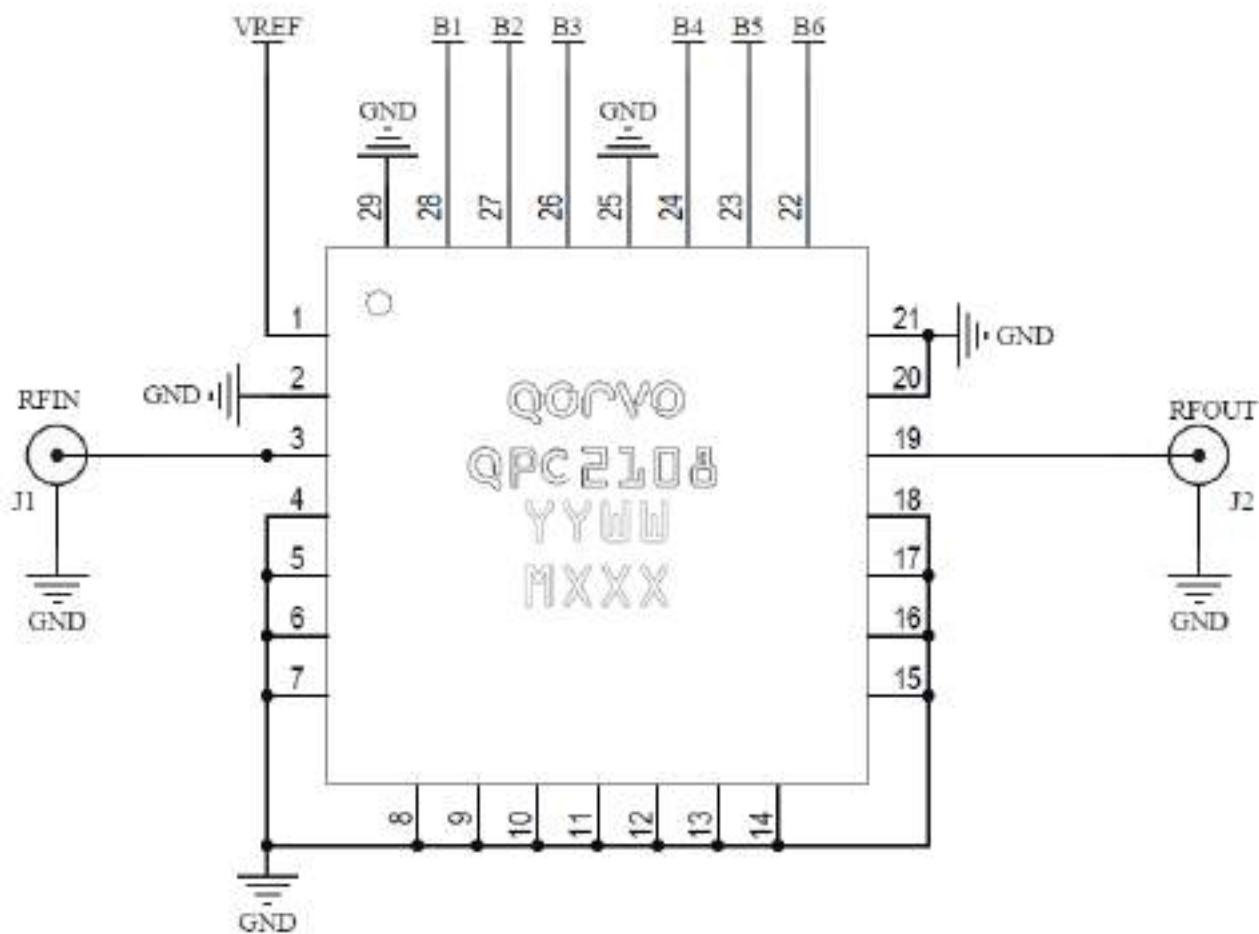
- Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime

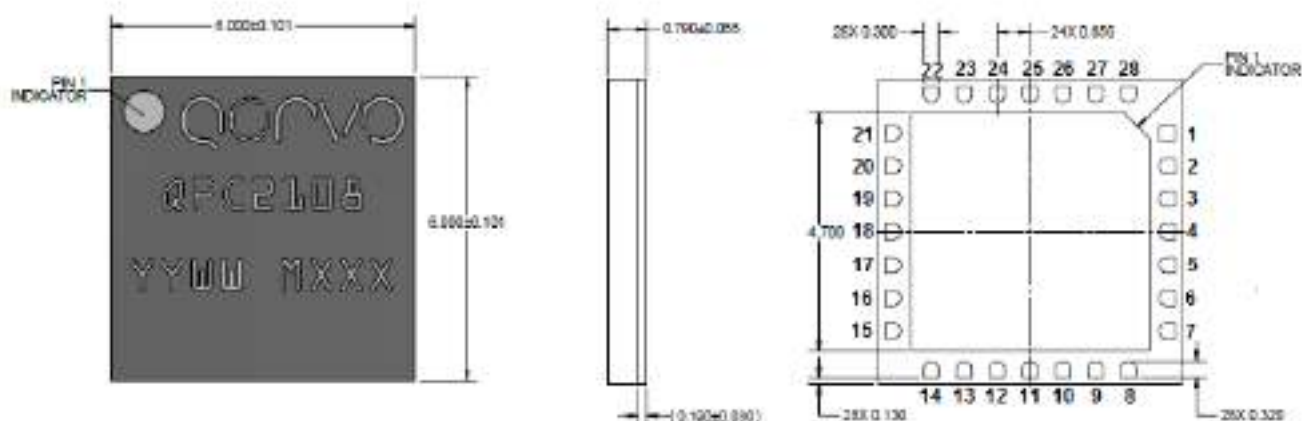


## Applications Circuit

De-Quing network is not required



### Mechanical Information



Units: millimeters

Materials:

Base: Laminate

Packaged Exposed Metallization is gold plated

Marking:

QPC2108: Part number

YY: Part Assembly year

WW: Part Assembly week

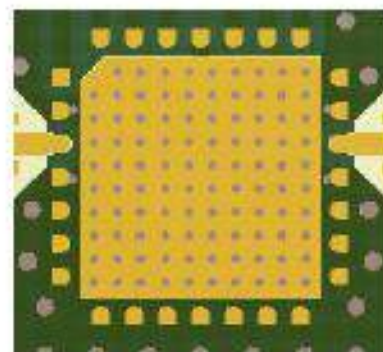
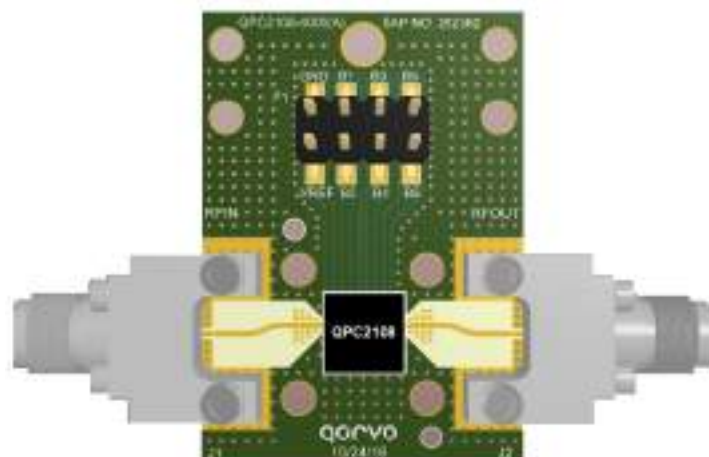
MXXX: Batch ID

### Pin Description

| Pin No.               | Symbol | Description                                                         |
|-----------------------|--------|---------------------------------------------------------------------|
| 1                     | V REF  | Voltage Reference                                                   |
| 2, 4 – 18, 20, 21, 25 | GND    | Ground.                                                             |
| 3                     | RF IN  | Input; matched to 50 Ohms; DC blocked; interchangeable to RF Output |
| 19                    | RF OUT | Output; matched to 50 Ohms; DC blocked; interchangeable to RF Input |
| 22                    | 180°   | 180° Bit                                                            |
| 23                    | 90°    | 90° Bit                                                             |
| 24                    | 45°    | 45° Bit                                                             |
| 26                    | 22°    | 22° Bit                                                             |
| 27                    | 11°    | 11° Bit                                                             |
| 28                    | 5°     | 5° Bit                                                              |
| 29                    | GND    | Package Base Ground                                                 |

### Evaluation Board (EVB) Layout Assembly

---



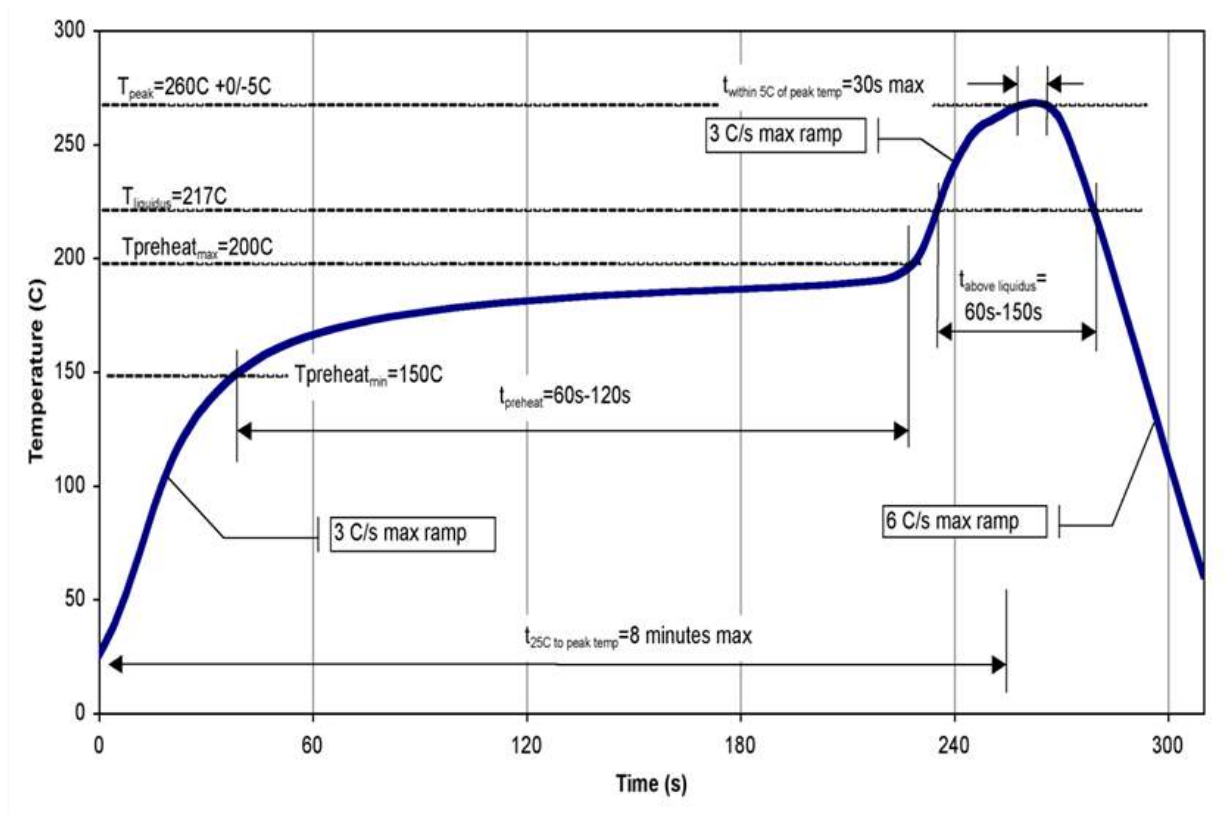
**MOUNTING DETAIL**

### Absolute Maximum Ratings

| Parameter                           | Value / Range |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | 1 mA          |
| Power Dissipation                   | 1.5 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 33 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 260 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied.

### Recommended Soldering Temperature Profile



### Handling Precautions

| Parameter                        | Rating   | Standard                 |
|----------------------------------|----------|--------------------------|
| ESD – Human Body Model (HBM)     | Class 0B | ESDA / JEDEC JS-001-2012 |
| 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.

### 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
- 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
- Qorvo Green



### 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)

For technical questions and application information: **Email:** [appsupport@qorvo.com](mailto:appsupport@qorvo.com)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2016 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.

### Product Description

Qorvo's TGP2109-SM is a packaged 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15 $\mu$ m GaAs pHEMT process. It operates over 8 to 12 GHz and provides 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 4° with 6 dB of insertion loss.

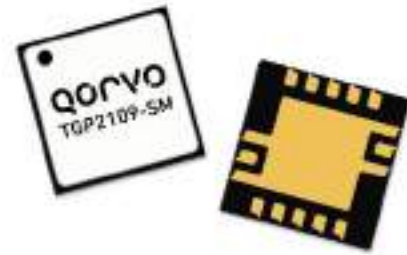
The TGP2109-SM was developed for simple system integration. It uses positive only switch logic eliminating the need for a negative voltage rail. In addition, both ports are matched to 50 ohms with DC blocking capacitors. Ease of use along with low insertion loss and a high degree of resolution makes the TGP2109-SM ideally suited for a variety of x-band phased array applications including commercial and military radars and phase array communication systems.

The device is lead-free and RoHS compliant.

### Product Features

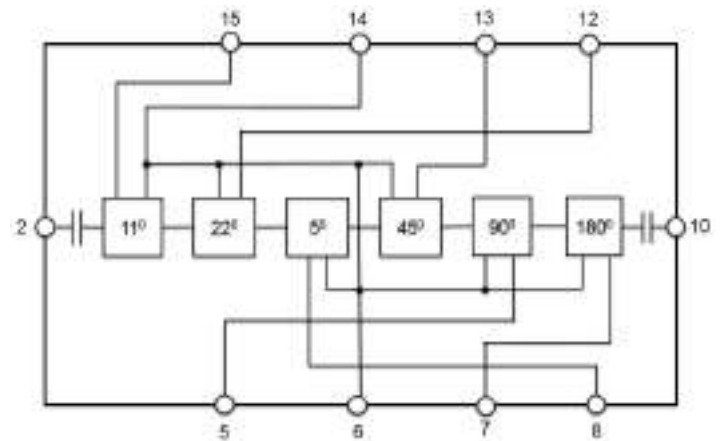
- Frequency Range: 8 to 12 GHz
- 6-Bit Digital Phase Shifter
- Bi-Directional
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 4°
- RMS Amplitude Error: 0.5 dB
- Insertion Loss: 6 dB
- Return Loss: 10 dB IRL; 15 dB ORL
- Input P1dB: 29 dBm
- Input IP3: >40 dBm
- IM3: <-50 dBc
- Control Voltage: VL: 0V to +0.2V, VH: +3V to +5V
- QFN Package Dimensions: 4.0 x 4.0 x 1.64 mm

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



QFN 4x4 mm 16L

### Functional Block Diagram



### Applications

- X-Band Radar
- Satellite Communication Systems

### Ordering Information

| Part No.       | Description                          |
|----------------|--------------------------------------|
| TGP2109-SM     | 8-12 GHz 6-Bit Digital Phase Shifter |
| TGP2109-SM EVB | TGP2109-SM Evaluation Board          |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | 0.5 mA        |
| Power Dissipation                   | 1.5 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 33 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 260 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter               | Value         |
|-------------------------|---------------|
| Control Voltage $V_H$   | +3 V to +5 V  |
| Control Voltage $V_L$   | 0 V to +0.2 V |
| Control Current (Total) | < 100 $\mu$ A |
| Temperature Range       | -40 to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage:  $V_L$  = 0 V,  $V_H$  = +5 V, see Bias Truth Table.

| Parameter                                                 | Min | Typical | Max | Units |
|-----------------------------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range                               | 8   |         | 12  | GHz   |
| Insertion Loss                                            |     | 6       |     | dB    |
| Input Return Loss                                         |     | 10      |     | dB    |
| Output Return Loss                                        |     | 15      |     | dB    |
| RMS Phase Error                                           |     | 4       |     | deg   |
| RMS Amplitude Error                                       |     | 0.5     |     | dB    |
| Input P1dB                                                |     | 29      |     | dBm   |
| Input IP3 (Tone Spacing = 10 MHz, $P_{in}/Tone$ = 16 dBm) |     | > 40    |     | dBm   |
| IM3 (Tone Spacing = 10 MHz, $P_{in}/Tone$ = 16 dBm)       |     | < -50   |     | dBc   |
| Insertion Loss Temperature Coefficient                    |     | 0.004   |     | dB/°C |

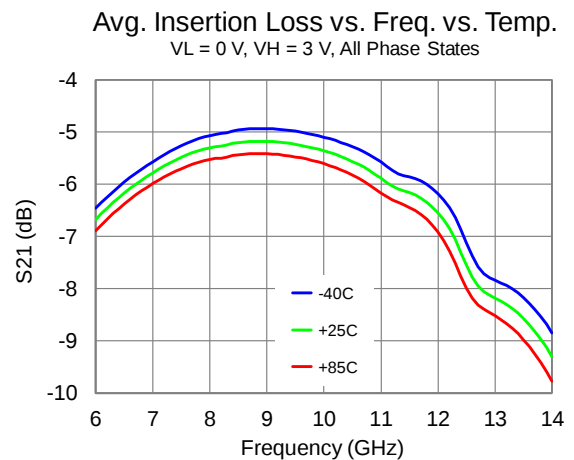
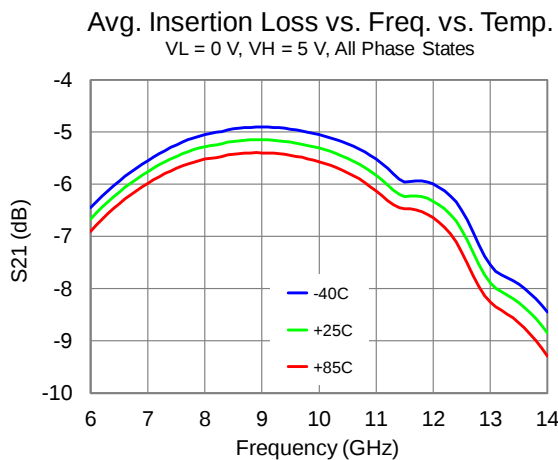
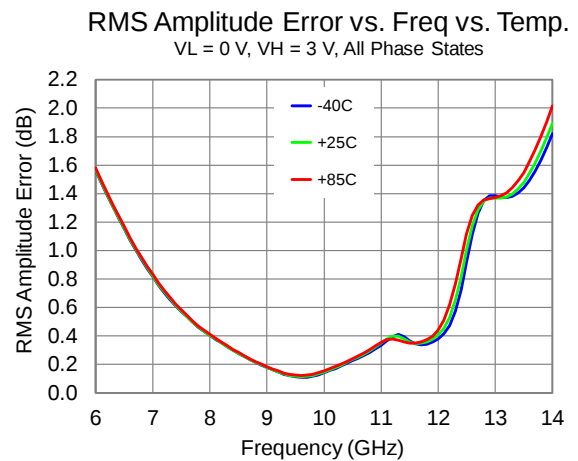
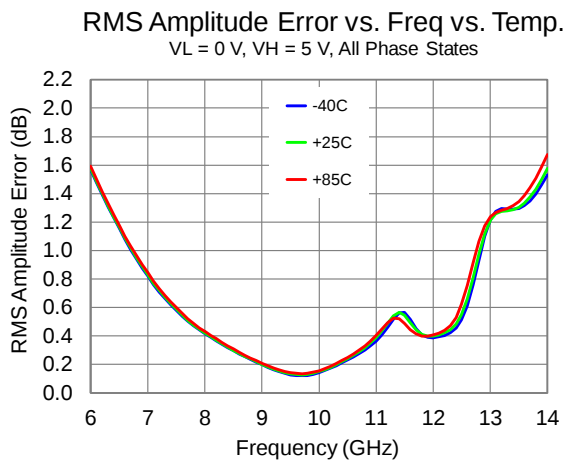
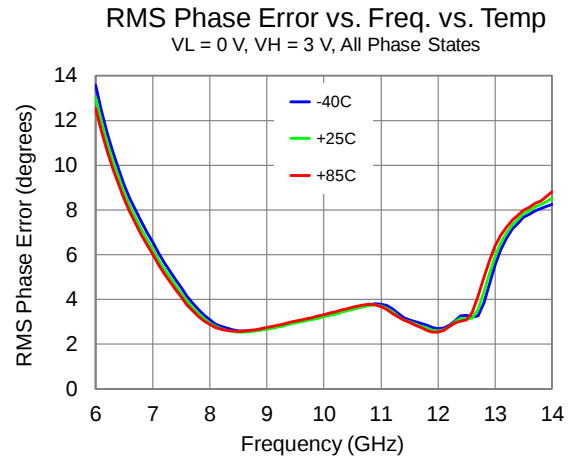
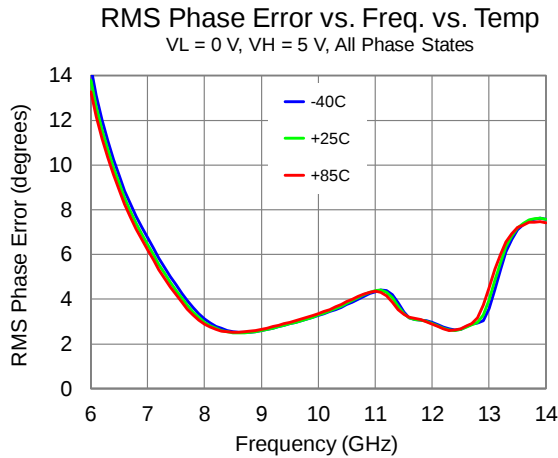
### Bias Truth Table

Logic "0" =  $V_L$ , value from 0 to +0.2 V; Logic "1" =  $V_H$  =  $V_{REF}$ , value from +3 V to +5 V

| Phase Shifter  | B1 | B2 | B3 | B4 | B5 | B6 | $V_{REF}$ |
|----------------|----|----|----|----|----|----|-----------|
| 0° (Reference) | 0  | 0  | 1  | 1  | 1  | 1  | 1         |
| 5°             | 1  | 0  | 1  | 1  | 1  | 1  | 1         |
| 11°            | 0  | 1  | 1  | 1  | 1  | 1  | 1         |
| 22°            | 0  | 0  | 0  | 1  | 1  | 1  | 1         |
| 45°            | 0  | 0  | 1  | 0  | 1  | 1  | 1         |
| 90°            | 0  | 0  | 1  | 1  | 0  | 1  | 1         |
| 180°           | 0  | 0  | 1  | 1  | 1  | 0  | 1         |
| 355°           | 1  | 1  | 0  | 0  | 0  | 0  | 1         |

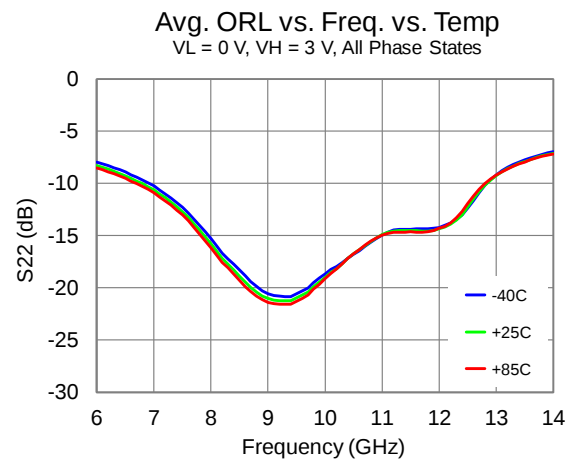
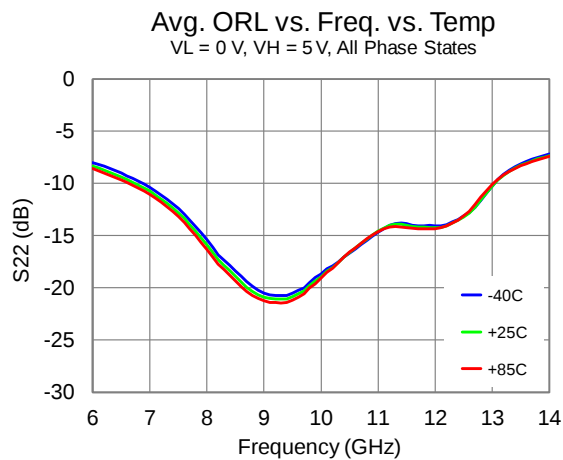
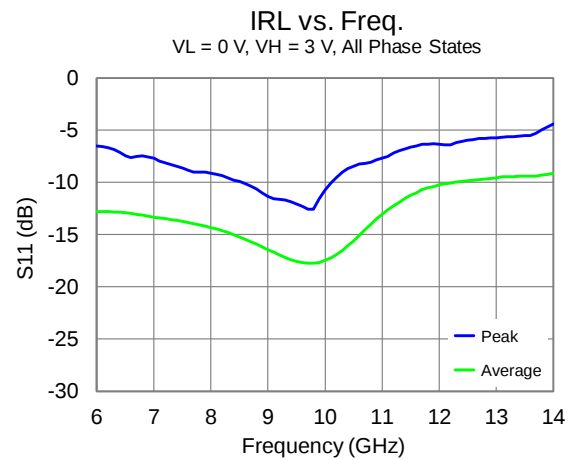
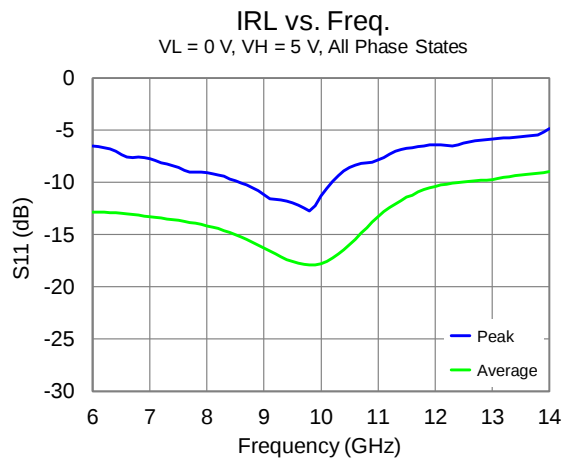
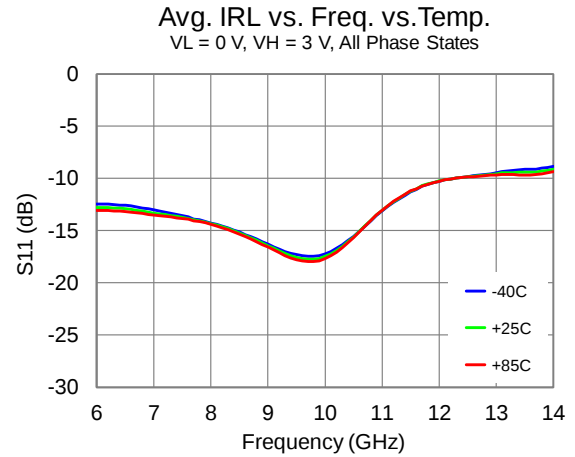
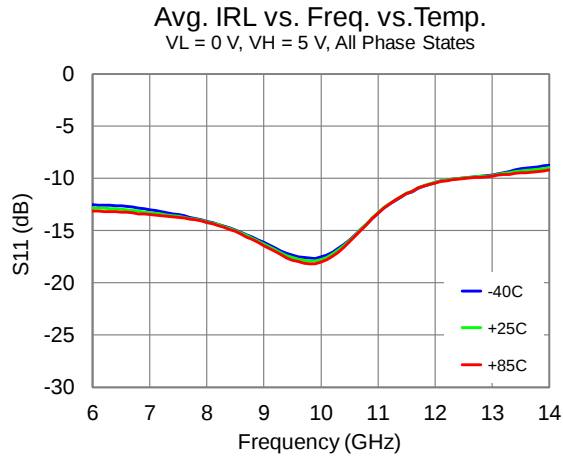
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C. Data de-embedded to device reference planes



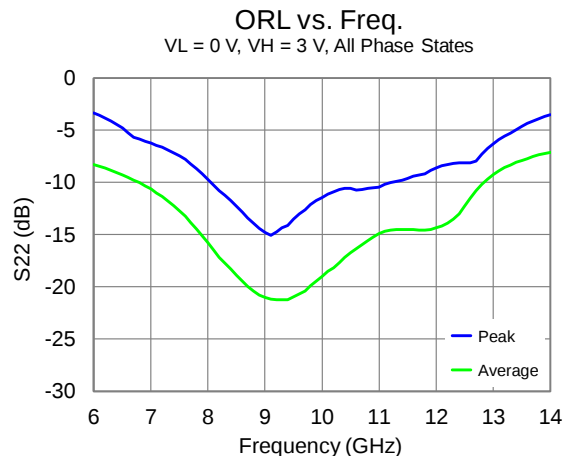
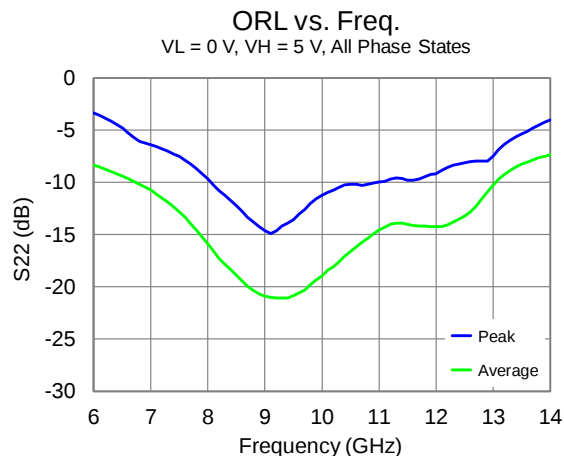
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C. Data de-embedded to device reference planes



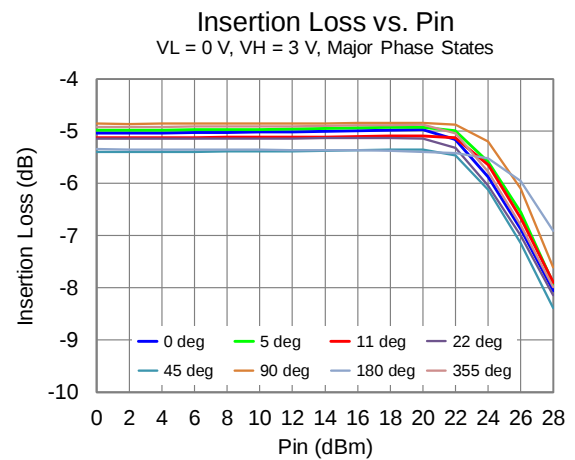
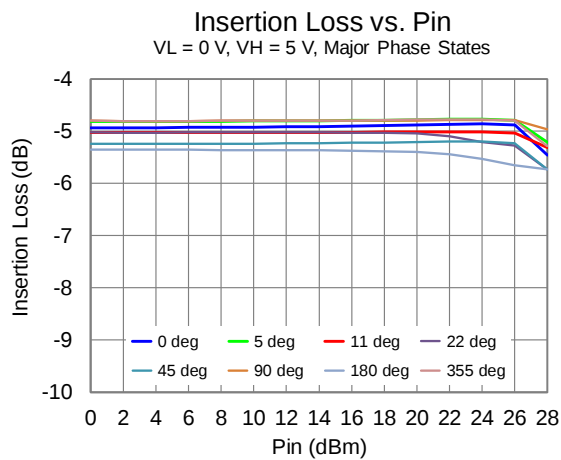
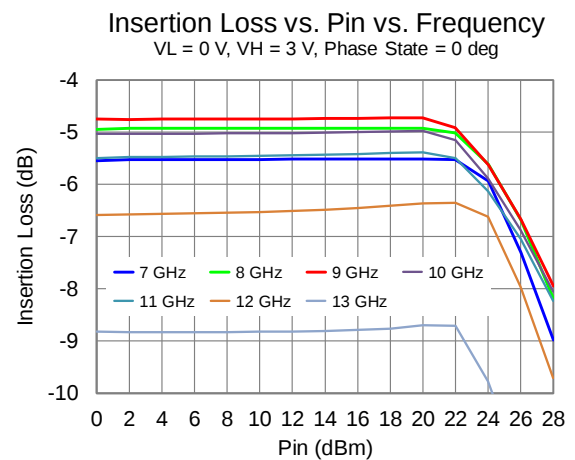
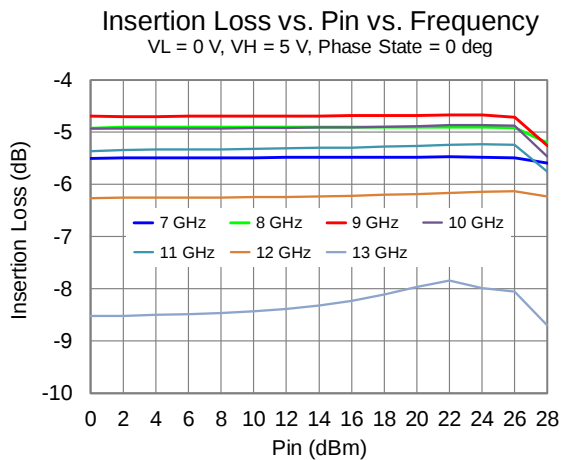
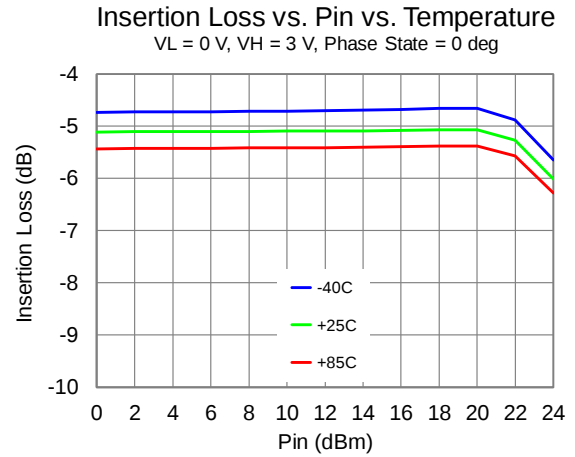
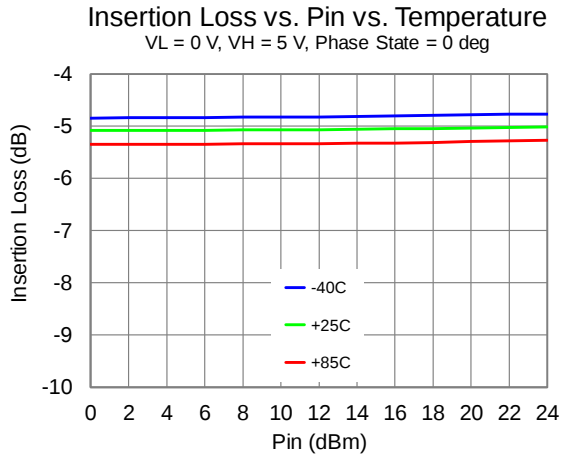
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C. Data de-embedded to device reference planes



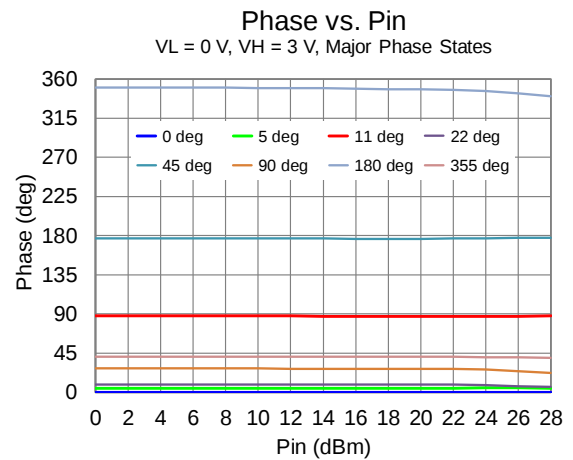
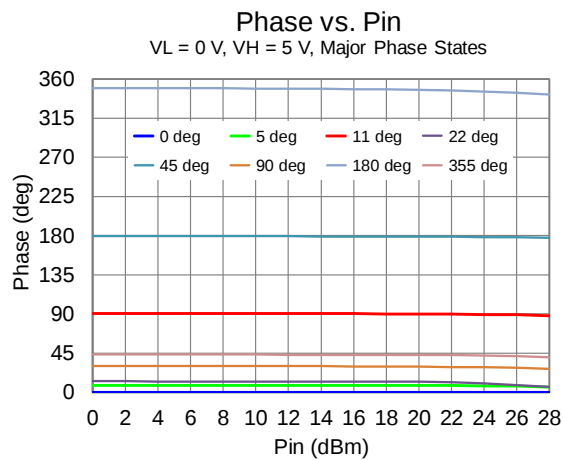
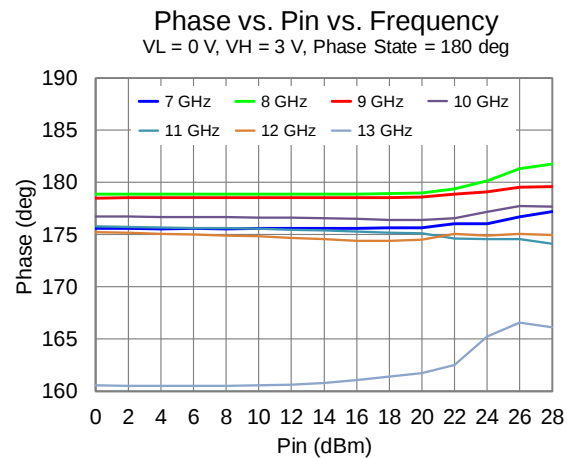
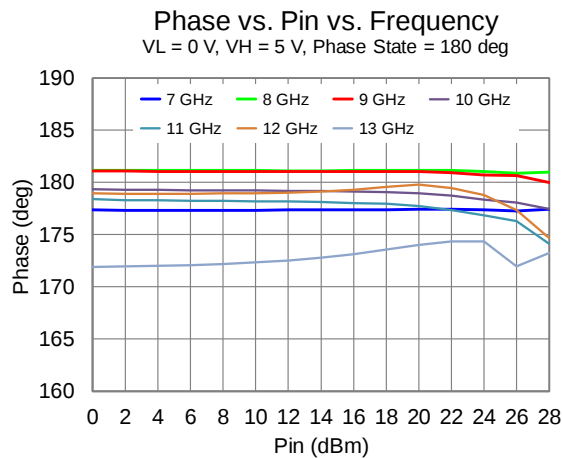
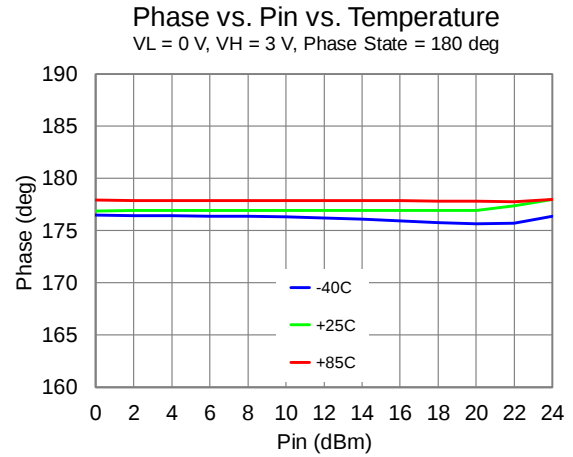
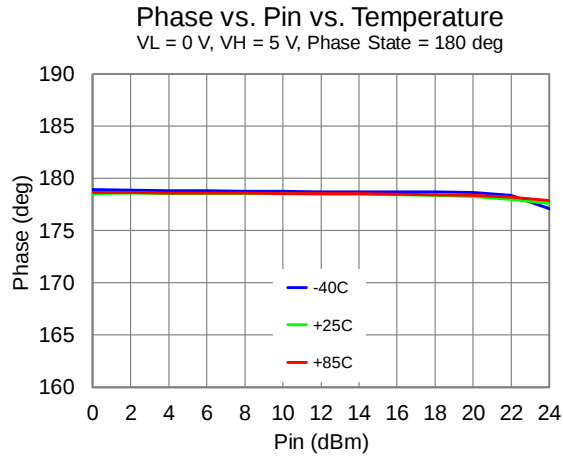
### Performance Plots – Large Signal

Test conditions unless otherwise noted: Freq = 10 GHz, 25 °C. Data de-embedded to device reference planes



### Performance Plots – Large Signal

Test conditions unless otherwise noted: Freq = 10 GHz, 25 °C. Data de-embedded to device reference planes

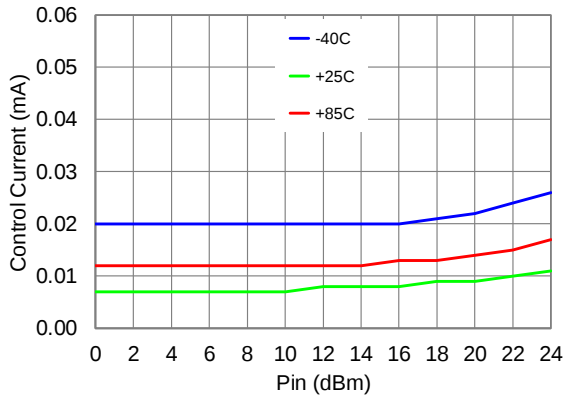


### Performance Plots – Large Signal

Test conditions unless otherwise noted: Total current of VH, Freq = 10 GHz, 25 °C

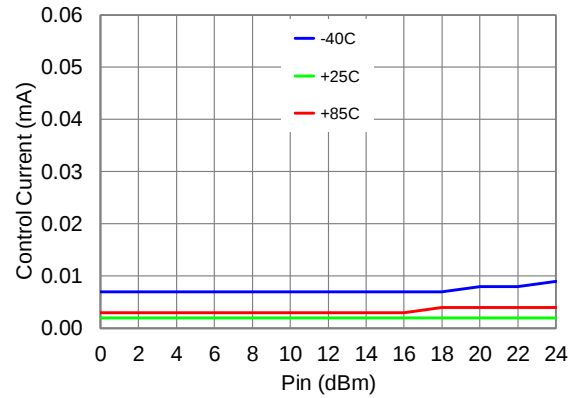
Control Current vs. Pin vs. Temperature

VL = 0 V, VH = 5 V, Phase State = 0 deg



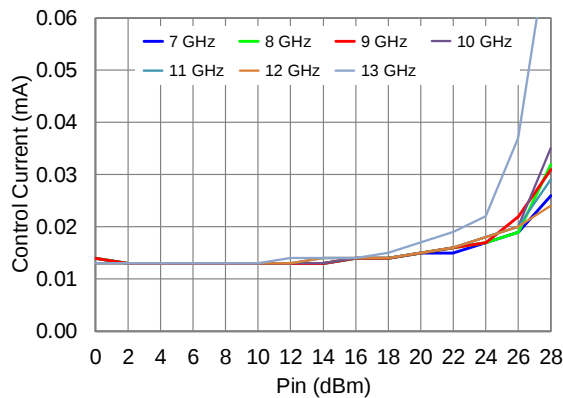
Control Current vs. Pin vs. Temperature

VL = 0 V, VH = 3 V, Phase State = 0 deg



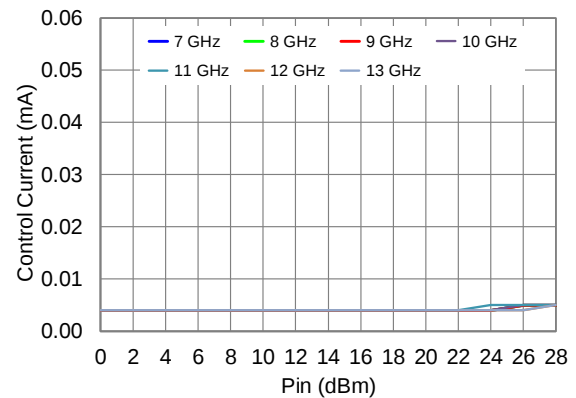
Control Current vs. Pin vs. Frequency

VL = 0 V, VH = 5 V, Phase State = 0 deg



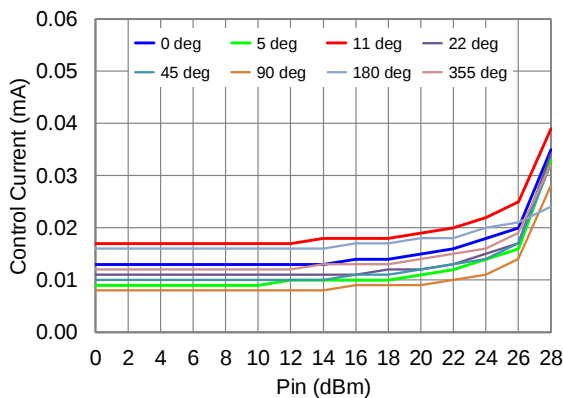
Control Current vs. Pin vs. Frequency

VL = 0 V, VH = 3 V, Phase State = 0 deg



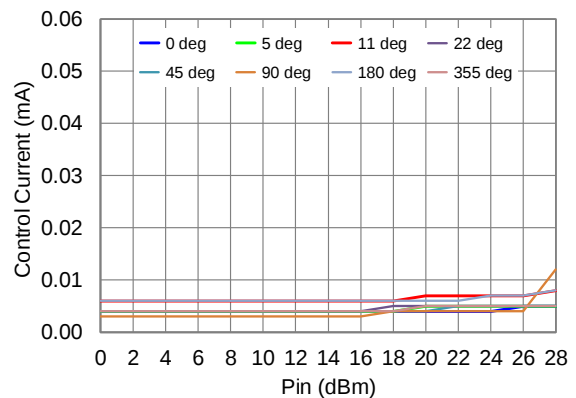
Control Current vs. Pin vs. Phase States

VL = 0 V, VH = 5 V



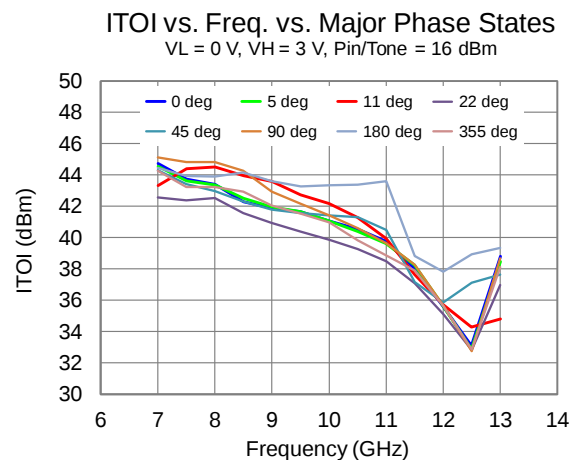
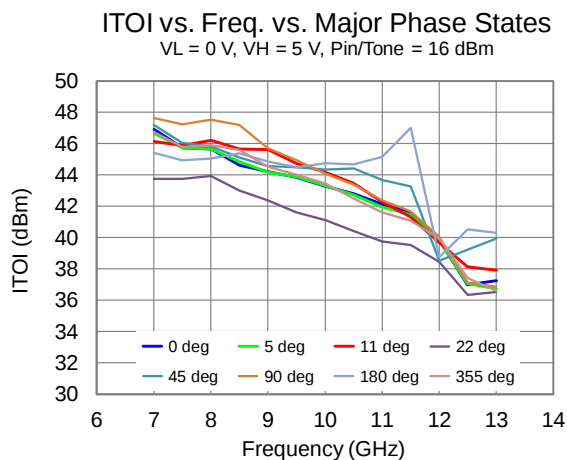
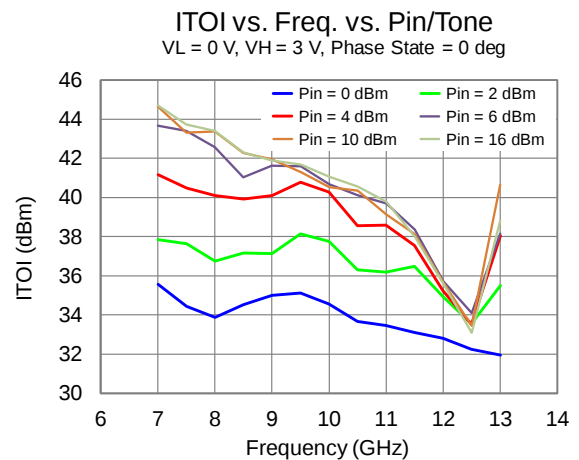
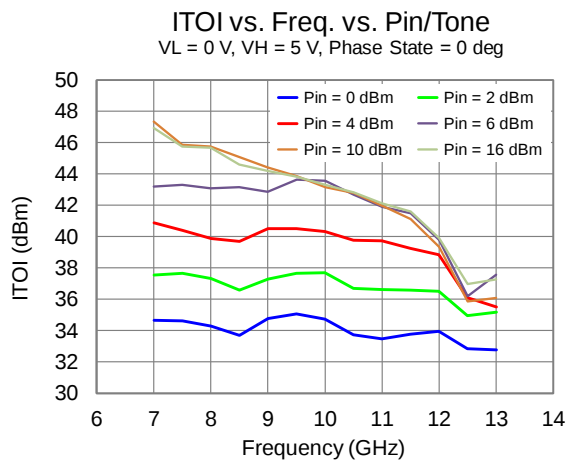
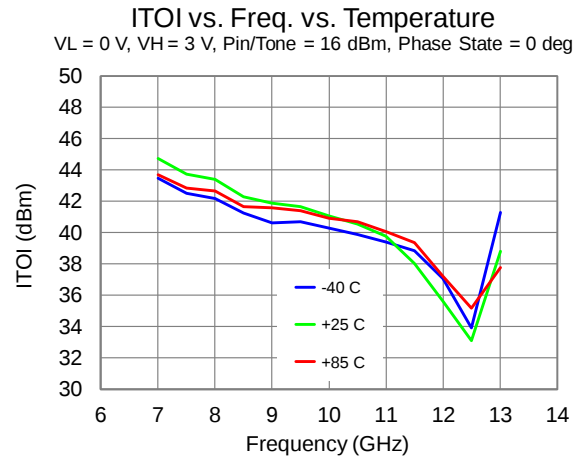
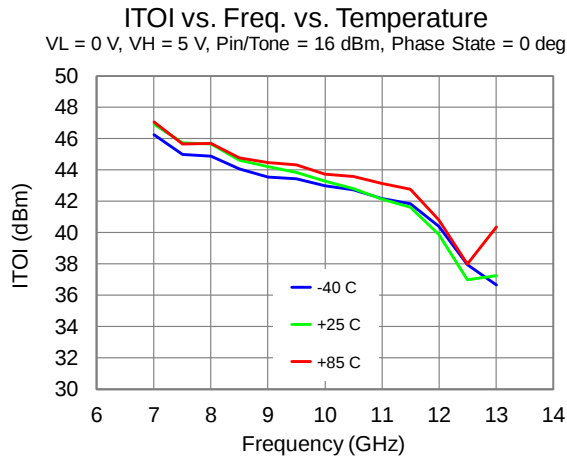
Control Current vs. Pin vs Phase States

VL = 0 V, VH = 3 V



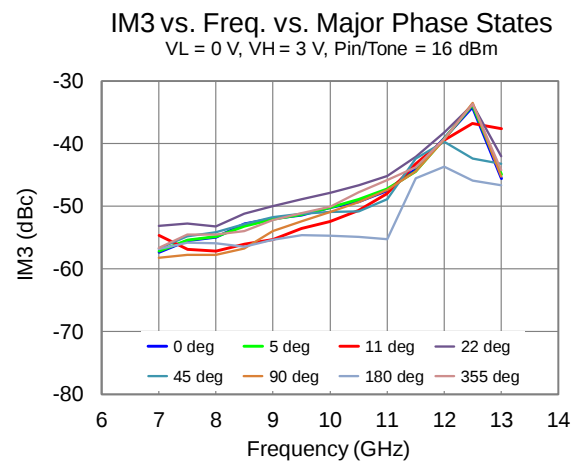
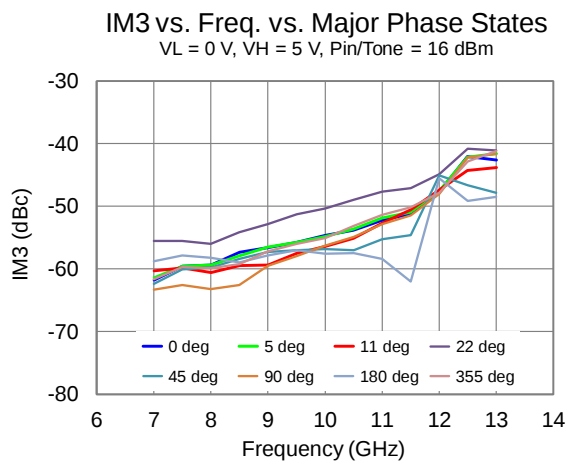
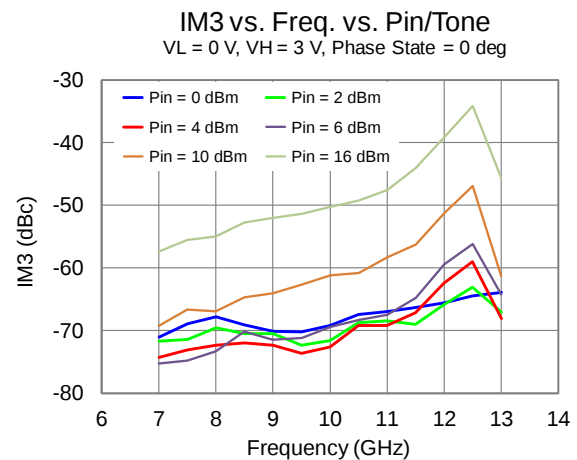
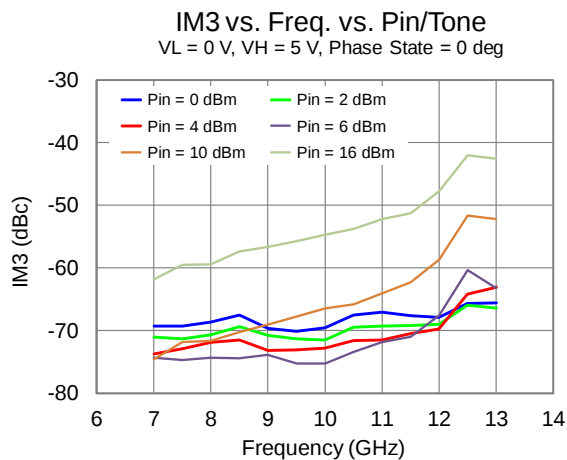
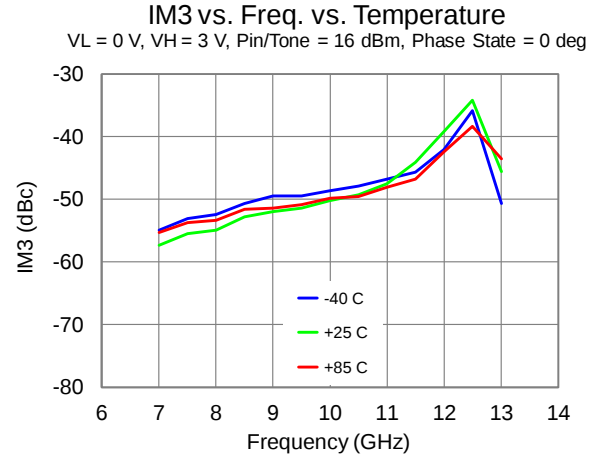
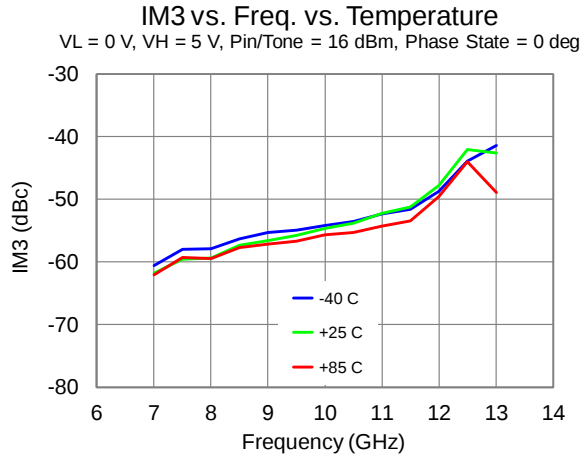
### Performance Plots – Linearity

Test conditions unless otherwise noted: Tone Spacing = 10 MHz, 25 °C. Data de-embedded to device reference planes

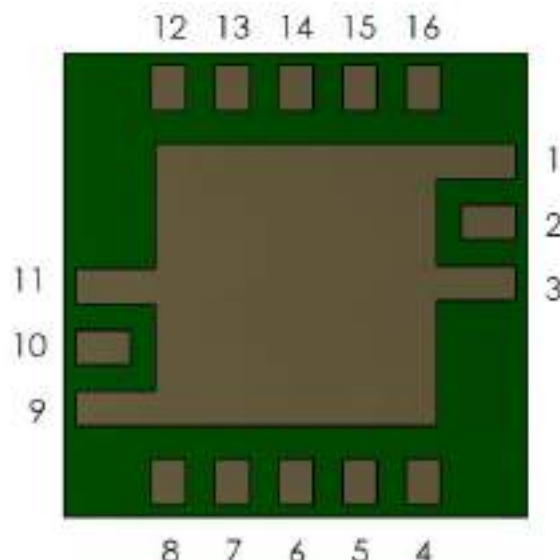


### Performance Plots – Linearity

Test conditions unless otherwise noted: Tone Spacing = 10 MHz, 25 °C. Data de-embedded to device reference planes

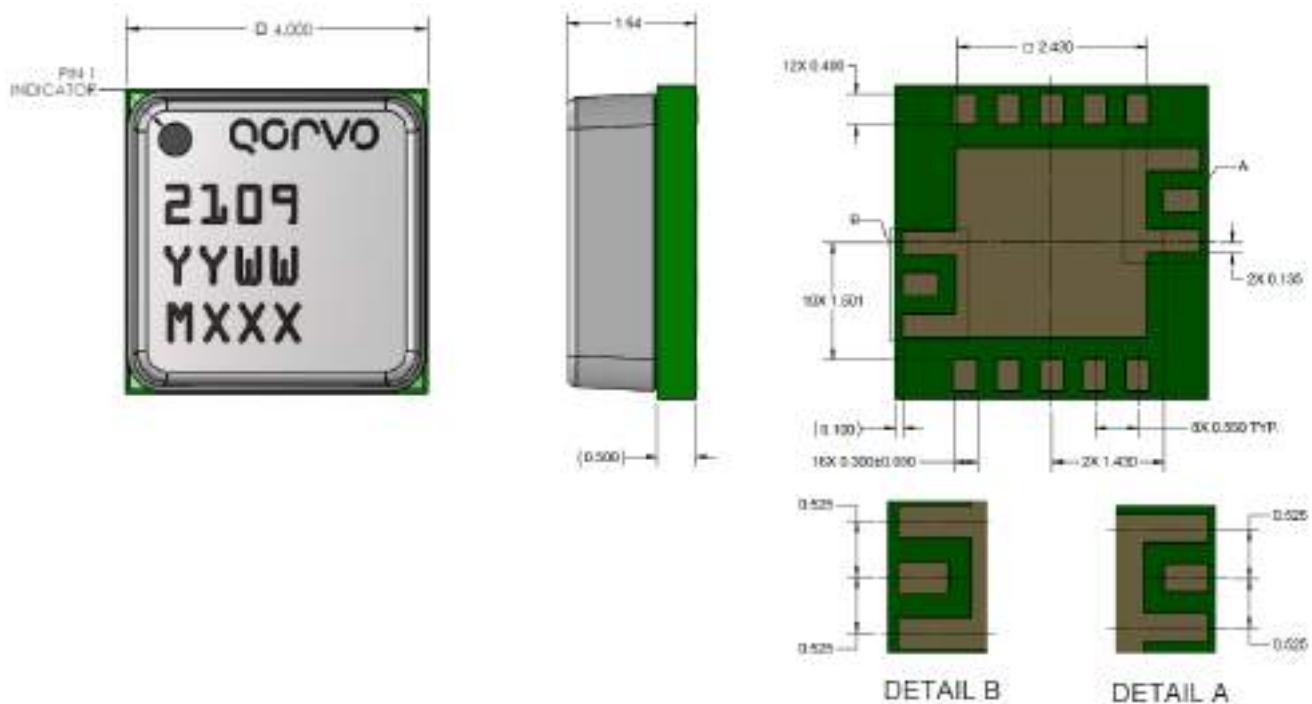


### Package Pin Descriptions



| Package Pad | Symbol    | Description                                                                                                                                             |
|-------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 3, 9, 11 | GND       | Internal grounding; must be grounded on PCB                                                                                                             |
| 2           | RF Input  | Input; matched to 50 Ohms; DC blocked; interchangeable to RF Output                                                                                     |
| 4, 16       | N/C       | No Connection; recommend GND at the EVB level                                                                                                           |
| 5           | B5        | 90° Bit                                                                                                                                                 |
| 6, 14       | REF       | Reference; VREF can be biased to either side of the package                                                                                             |
| 7           | B6        | 180° Bit                                                                                                                                                |
| 8           | B1        | 5° Bit                                                                                                                                                  |
| 10          | RF Output | Output; matched to 50 Ohms; DC blocked; interchangeable to RF Input                                                                                     |
| 12          | B3        | 22° Bit                                                                                                                                                 |
| 13          | B4        | 45° Bit                                                                                                                                                 |
| 15          | B2        | 11° Bit                                                                                                                                                 |
| 17 (Slug)   | GND       | On PCB; multiple vias should be employed under the center pad (17) to minimize inductance and thermal resistance; see page 13 for suggested vias layout |

### Package Mechanical Drawing and Dimensions



Units: mm

Tolerances: unless specified

.xx =  $\pm 0.25$

.xxx =  $\pm 0.100$

Angles =  $0.5^\circ$

Materials:

Lid: Plastic

Base: Laminate

Plating: All metalized features are NiAu plated

The part is epoxy sealed

Marking:

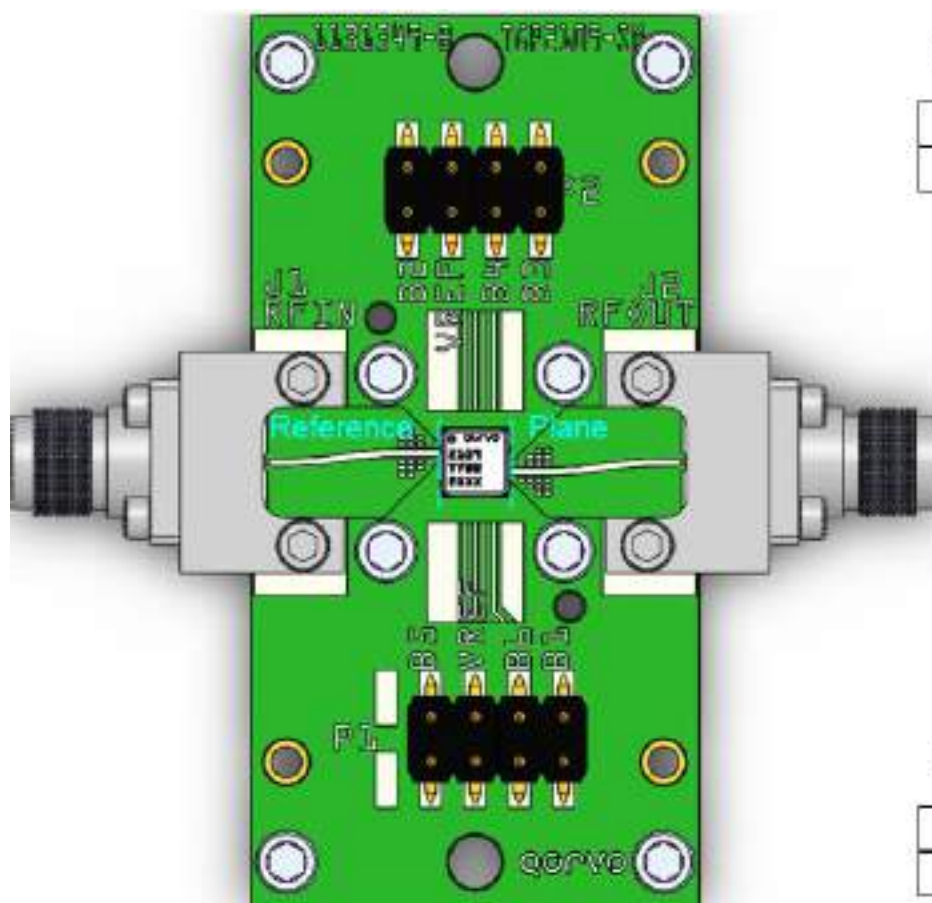
2109: Part number

YY: Part Assembly year

WW: Part Assembly week

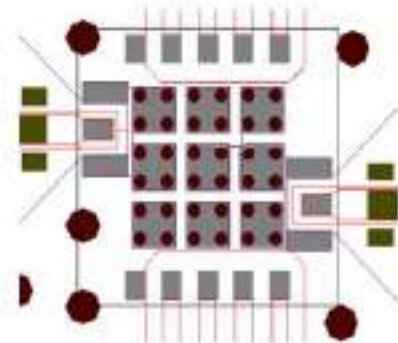
MXXX: Batch ID

#### Applications and EVB Information



P2 Connectors (Top)

|     |      |     |     |
|-----|------|-----|-----|
| GND | GND  | GND | GND |
| B2  | VREF | B4  | B3  |



P1 Connectors (Bottom)

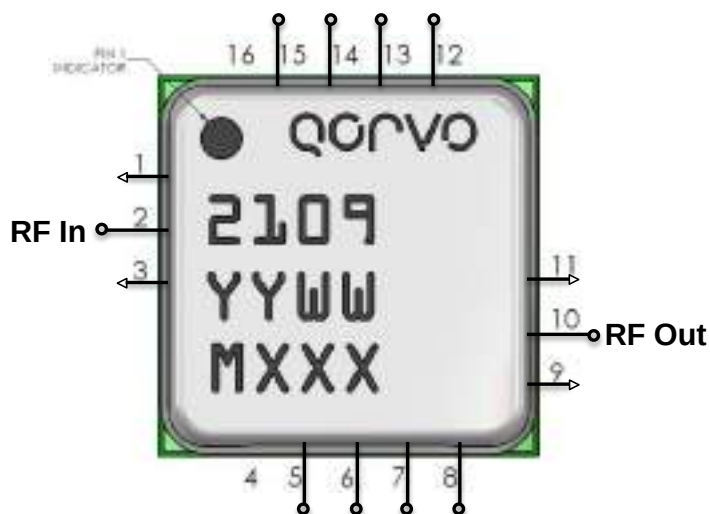
|     |      |     |     |
|-----|------|-----|-----|
| B5  | VREF | B6  | B1  |
| GND | GND  | GND | GND |

RF layer is 0.008" thick Rogers RO4003C. Metal layers are 0.5-oz copper. The microstrip line taper at the connector interface is optimized for the Southwest Microwave end-launch connector 1092-02A-5.

Ground / thermal vias under the DUT are critical for the proper performance of this device. The PCB shown herein utilizes copper filled vias (8 mils diameter) under the DUT.

The pad pattern shown has been developed and tested for optimized assembly at Qorvo. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company, careful process development is recommended.

De-Quing network is not required; VREF can be biased to either side of the package (pin #6 or #14).



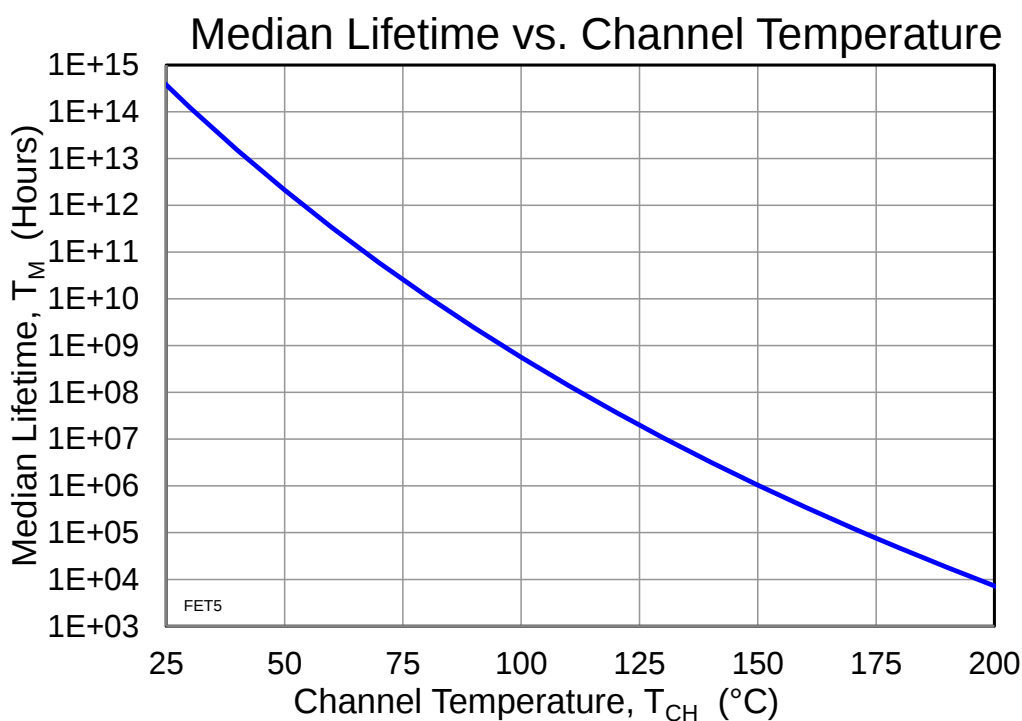
### Thermal and Reliability Information

| Parameter                        | Test Conditions                 | Value  | Units              |
|----------------------------------|---------------------------------|--------|--------------------|
| Channel Temperature ( $T_{CH}$ ) | $T_{BASE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )        |                                 | 5.2E+9 | Hrs                |

Notes:

- Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

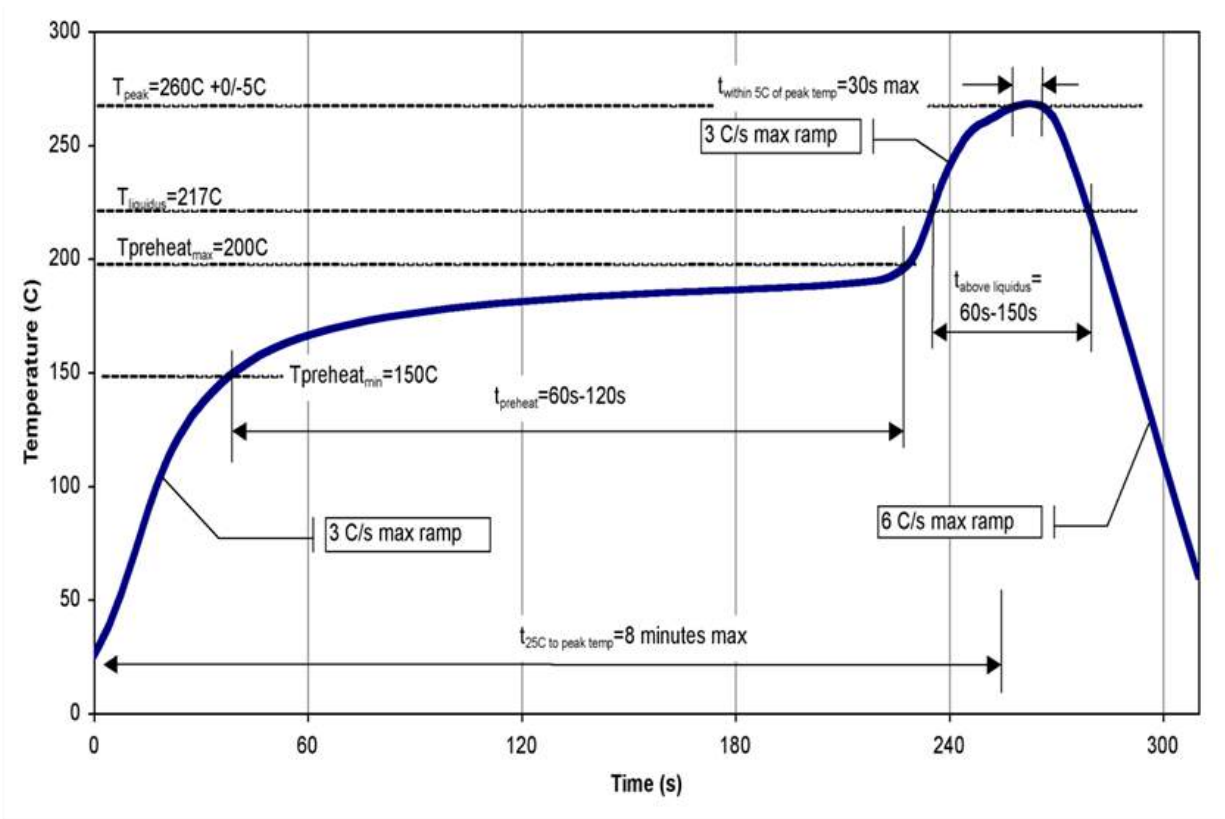
### Median Lifetime



### Solderability

1. Compatible with the latest version of J-STD-020, Lead-free solder, 260 °C.
2. The use of no-clean solder to avoid washing after soldering is recommended.
3. Package lead plating is NiAu.

### Recommended Soldering Temperature Profile



### Handling Precautions

| Parameter                        | Rating   | Standard                 |
|----------------------------------|----------|--------------------------|
| ESD – Human Body Model (HBM)     | Class 0  | ESDA / JEDEC JS-001-2012 |
| ESD – Charge Device Model (CDM)  | Class C2 | JS-002-2014              |
| MSL – Moisture Sensitivity Level | Level 3  | 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
- 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

### 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2019 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.

### Product Description

The Qorvo TGP2100 is a 5-bit digital phase shifter MMIC design using Qorvo's proven 0.25  $\mu\text{m}$  power pHEMT process to support a variety of Ka-Band phased array applications including military radar.

The 5-bit design utilizes a compact topology that achieves a 1.41 mm<sup>2</sup> die area and high performance. The TGP2100 provides a 5-bit digital phase shift function with a nominal 7 dB insertion loss and 5° RMS phase shift error over a bandwidth of 28 – 32 GHz.

The TGP2100 requires a minimum of off-chip components and operates with a +5 V control voltage. Each device is RF tested on-wafer to ensure performance compliance. The device is available in chip form.

The device is lead-free and RoHS compliant.

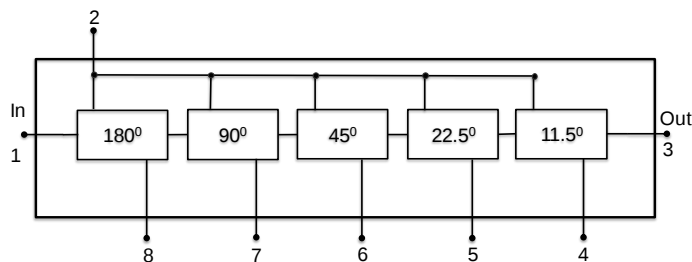


### Product Features

- Frequency Range: 28 to 32 GHz
- 5-Bit Digital Phase Shifter
- RMS Phase Error: 5°
- RMS Amplitude Error: 0.5 dB
- Insertion Loss: 7 dB
- Return Loss: 18 dB IRL; 14 dB ORL
- Positive Control Voltage: 0/+5 V
- Single-Ended logic
- CMOS Compatible
- Chip Dimensions: 1.88 x 0.75 x 0.10 mm

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

### Functional Block Diagram



### Applications

- Military Radar
- Transit / Receive

### Ordering Information

| Part No. | Description                                                  |
|----------|--------------------------------------------------------------|
| TGP2100  | 28-32 GHz 5 Bit Digital Phase Shifter, Waffle Pack 25 pieces |

### Absolute Maximum Ratings

| Parameter                         | Value         |
|-----------------------------------|---------------|
| Control and Supply Voltages       | 8 V           |
| Control Current                   | 1 mA          |
| Power Dissipation                 | 0.1 W         |
| Input Power, CW                   | 20 dBm        |
| Channel Temperature               | 150 °C        |
| Mounting Temperature (30 Seconds) | 320 °C        |
| Storage Temperature               | -65 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                          | Value         |
|------------------------------------|---------------|
| Control Voltage ( $V_C$ )          | 0/+5 V        |
| Reference Voltage ( $V_{SUPPLY}$ ) | +5 V          |
| Operating Temperature Range        | -40 to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C.  $V_{SUPPLY} = +5$  V,  $V_C = 0/+5$  V; see State Table.

| Parameter                   | Min | Typical | Max | Units |
|-----------------------------|-----|---------|-----|-------|
| Operational Frequency Range | 28  | 30      | 32  | GHz   |
| Insertion Loss              |     | 7       |     | dB    |
| Input Return Loss           |     | 18      |     | dB    |
| Output Return Loss          |     | 14      |     | dB    |
| Peak Phase Shift Error      |     | 10      |     | deg   |
| RMS Phase Shift Error       |     | 5       |     | deg   |
| Peak Amplitude Error        |     | 1       |     | dB    |
| RMS Amplitude Error         |     | 0.5     |     | dB    |

Notes: The data are from the typical devices as determined by fixtured measurements.

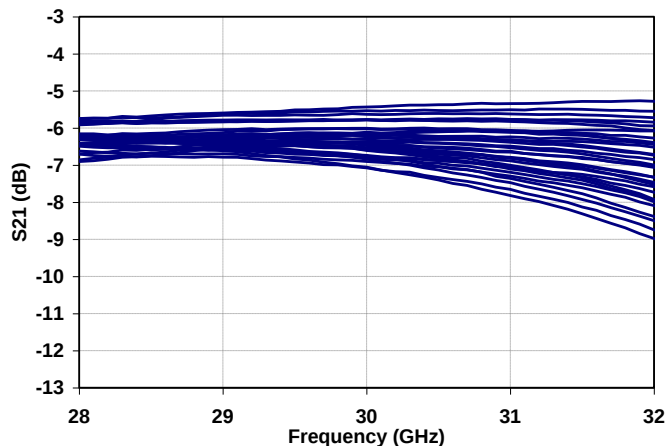
### State Table

| State | V-Supply | V-11.25 | V-22.5 | V-45 | V-90 | V-180 | Phase Shift |
|-------|----------|---------|--------|------|------|-------|-------------|
| 0     | +5 V     | 0 V     | 0 V    | 0 V  | 0 V  | 0 V   | Reference   |
| 1     | +5 V     | +5 V    | 0 V    | 0 V  | 0 V  | 0 V   | 11.25 °     |
| 2     | +5 V     | 0 V     | +5 V   | 0 V  | 0 V  | 0 V   | 22.5 °      |
| 3     | +5 V     | +5 V    | +5 V   | 0 V  | 0 V  | 0 V   | 33.75 °     |
| 4     | +5 V     | 0 V     | 0 V    | +5 V | 0 V  | 0 V   | 45 °        |
| 5     | +5 V     | +5 V    | 0 V    | +5 V | 0 V  | 0 V   | 56.25 °     |
| 6     | +5 V     | 0 V     | +5 V   | +5 V | 0 V  | 0 V   | 67.5 °      |
| 7     | +5 V     | +5 V    | +5 V   | +5 V | 0 V  | 0 V   | 78.75 °     |
| 8     | +5 V     | 0 V     | 0 V    | 0 V  | +5 V | 0 V   | 90 °        |
| 9     | +5 V     | +5 V    | 0 V    | 0 V  | +5 V | 0 V   | 101.25 °    |
| 10    | +5 V     | 0 V     | +5 V   | 0 V  | +5 V | 0 V   | 112.5 °     |
| 11    | +5 V     | +5 V    | +5 V   | 0 V  | +5 V | 0 V   | 123.75 °    |
| 12    | +5 V     | 0 V     | 0 V    | +5 V | +5 V | 0 V   | 135 °       |
| 13    | +5 V     | +5 V    | 0 V    | +5 V | +5 V | 0 V   | 146.25 °    |
| 14    | +5 V     | 0 V     | +5 V   | +5 V | +5 V | 0 V   | 157.5 °     |
| 15    | +5 V     | +5 V    | +5 V   | +5 V | +5 V | 0 V   | 168.75 °    |
| 16    | +5 V     | 0 V     | 0 V    | 0 V  | 0 V  | 0 V   | 180 °       |
| 17    | +5 V     | +5 V    | 0 V    | 0 V  | 0 V  | +5 V  | 191.25 °    |
| 18    | +5 V     | 0 V     | +5 V   | 0 V  | 0 V  | +5 V  | 202.5 °     |
| 19    | +5 V     | +5 V    | +5 V   | 0 V  | 0 V  | +5 V  | 213.75 °    |
| 20    | +5 V     | 0 V     | 0 V    | +5 V | 0 V  | +5 V  | 225 °       |
| 21    | +5 V     | +5 V    | 0 V    | +5 V | 0 V  | +5 V  | 236.25 °    |
| 22    | +5 V     | 0 V     | +5 V   | +5 V | 0 V  | +5 V  | 247.5 °     |
| 23    | +5 V     | +5 V    | +5 V   | +5 V | 0 V  | +5 V  | 258.75 °    |
| 24    | +5 V     | 0 V     | 0 V    | 0 V  | +5 V | +5 V  | 270 °       |
| 25    | +5 V     | +5 V    | 0 V    | 0 V  | +5 V | +5 V  | 281.25 °    |
| 26    | +5 V     | 0 V     | +5 V   | 0 V  | +5 V | +5 V  | 292.5 °     |
| 27    | +5 V     | +5 V    | +5 V   | 0 V  | +5 V | +5 V  | 303.75 °    |
| 28    | +5 V     | 0 V     | 0 V    | +5 V | +5 V | +5 V  | 315 °       |
| 29    | +5 V     | +5 V    | 0 V    | +5 V | +5 V | +5 V  | 326.25 °    |
| 30    | +5 V     | 0 V     | +5 V   | +5 V | +5 V | +5 V  | 337.5 °     |
| 31    | +5 V     | +5 V    | +5 V   | +5 V | +5 V | +5 V  | 348.75 °    |

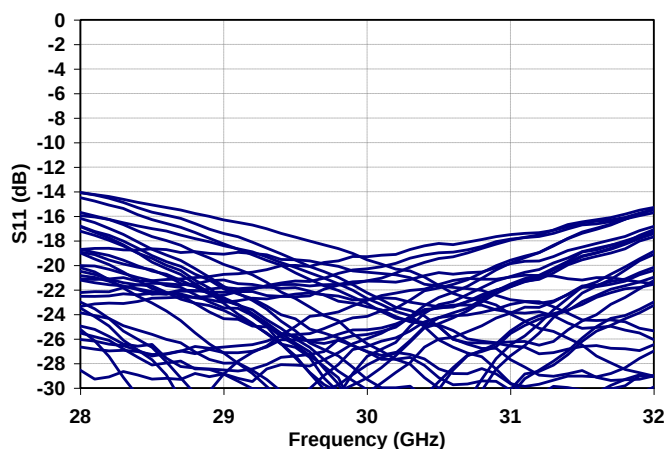
### Performance Plots – All States

Test conditions unless otherwise noted: 25 °C

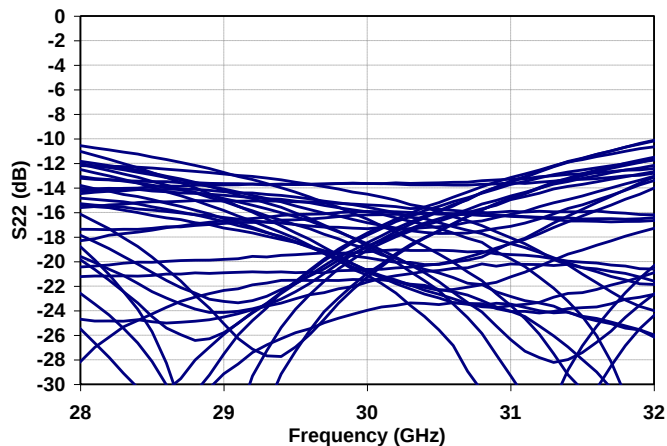
Insertion Loss vs. Frequency



Input Return Loss vs. Frequency

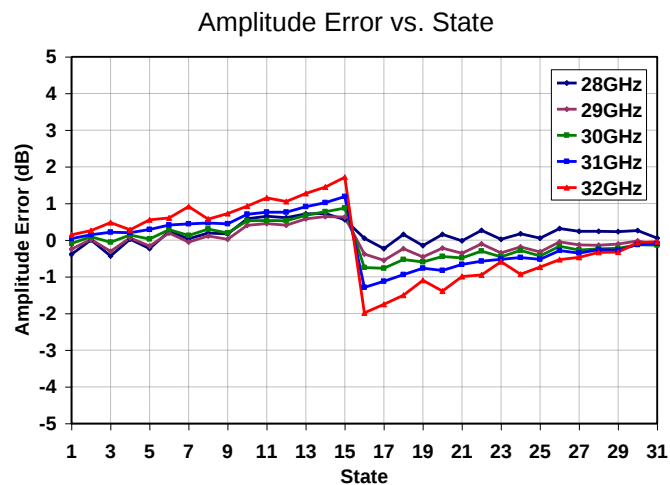
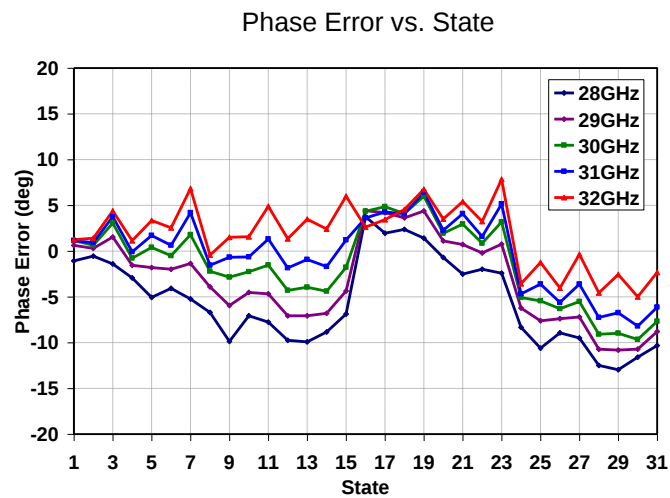
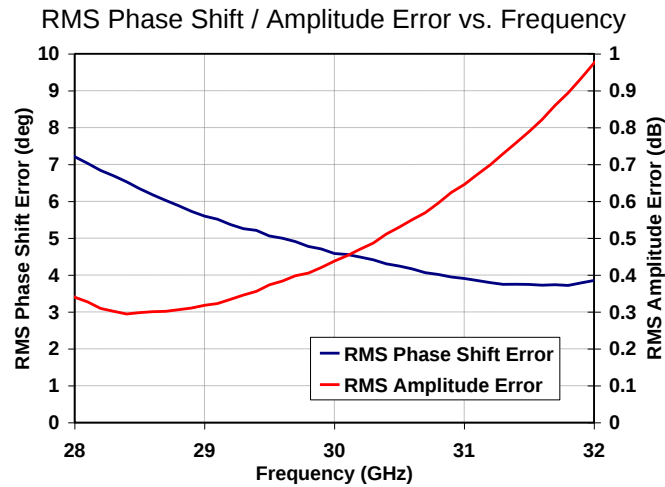


Output Return Loss vs. Frequency

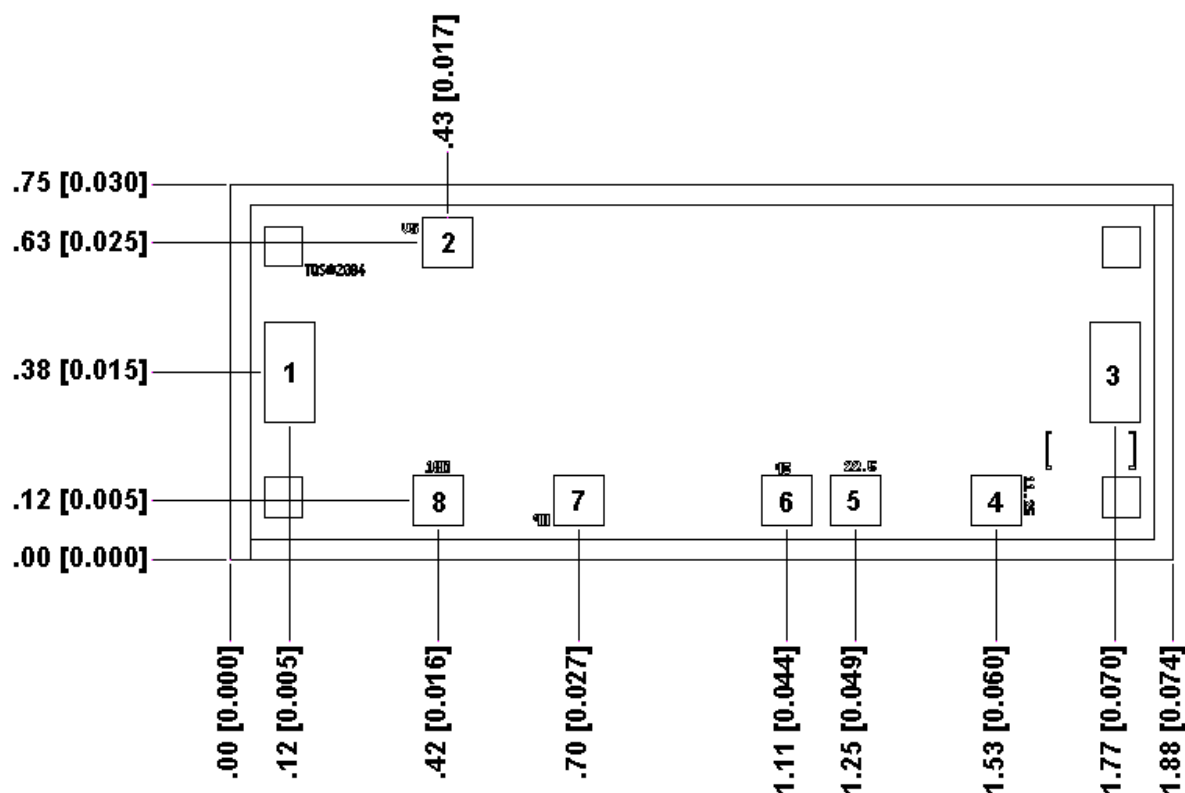


### Performance Plots –

Test conditions unless otherwise noted: 25 °C



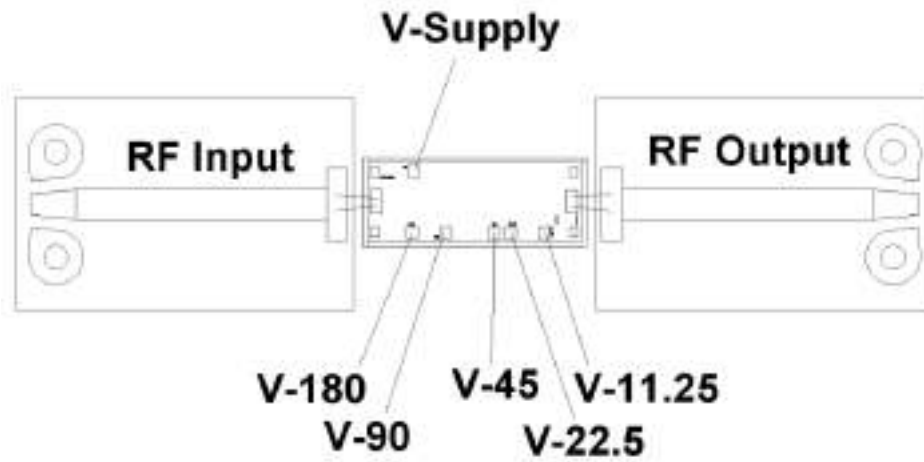
### Mechanical Information and Bond Pad Description



Unit: millimeters (inches)  
 Thickness: 0.10 [0.004] (reference only)  
 Chip edge to bond pad dimensions are shown to center of bond pads  
 Chip size tolerance:  $\pm 0.05$  [0.002]  
 RF ground through backside

| Bond Pad | Symbol             | Pad Size(mm) | Pad Size[in]  |
|----------|--------------------|--------------|---------------|
| 1        | RF Input           | 0.10 x 0.20  | 0.004 x 0.008 |
| 2        | V-Supply (+5V)     | 0.10 x 0.10  | 0.004 x 0.004 |
| 3        | RF Output          | 0.10 x 0.20  | 0.004 x 0.008 |
| 4        | V-11.25 (On V=+5V) | 0.10 x 0.10  | 0.004 x 0.004 |
| 5        | V-22.5 (On V=+5V)  | 0.10 x 0.10  | 0.004 x 0.004 |
| 6        | V-45 (On V=+5V)    | 0.10 x 0.10  | 0.004 x 0.004 |
| 7        | V-90 (On V=+5V)    | 0.10 x 0.10  | 0.004 x 0.004 |
| 8        | V-180 (On V=+5V)   | 0.10 x 0.10  | 0.004 x 0.004 |

### Die Assembly & Bonding Diagram



#### Notes:

1. Device were tested with 500  $\Omega$  resistors in series with control lines.
2. Input and output stubs are 0.007" x 0.024" on 0.010" alumina substrate.

### Assembly Notes

#### Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.
- Organic attachment (i.e., conductive epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.
- Devices must be stored in a dry nitrogen atmosphere.

#### Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300°C to 3-4 minutes, maximum.
- Conductive epoxy die attach is recommended for PCB mounting.
- Bonding pads plating: Au.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

#### Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonics are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

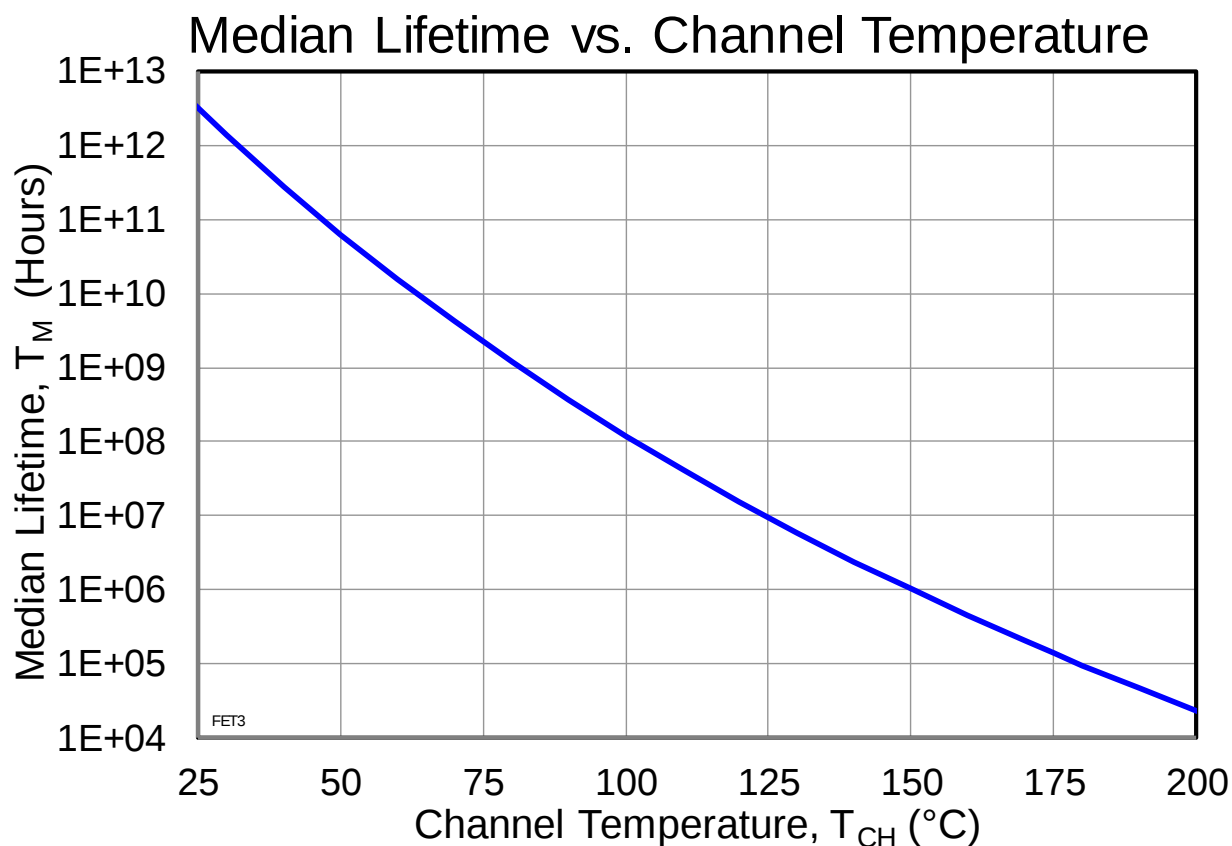
### Thermal and Reliability Information

| Parameter                                | Test Conditions                      | Value  | Units              |
|------------------------------------------|--------------------------------------|--------|--------------------|
| Channel Temperature, $T_{CH}$ (Under RF) | $T_{BASEPLATE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )                |                                      | 6.6E08 | Hrs                |

**Notes:**

Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime



### Handling Precautions

| Parameter                    | Rating | Standard                 |  | Caution!<br>ESD-Sensitive Device |
|------------------------------|--------|--------------------------|-------------------------------------------------------------------------------------|----------------------------------|
| ESD – Human Body Model (HBM) | TBD    | ESDA / JEDEC JS-001-2012 |                                                                                     |                                  |

### 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2021 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.

### Product Description

Qorvo's TGP2102 is a 5-bit digital phase shifter MMIC design using Qorvo's proven 0.25  $\mu\text{m}$  power pHEMT process to support a variety of Ka-Band phased array applications including military radar.

The 5-bit design utilizes a compact topology that achieves a 1.41 mm<sup>2</sup> die area and high performance. The TGP2102 provides a 5-bit digital phase shift function with a nominal 7 dB insertion loss and 5° RMS phase shift error over a bandwidth of 32 – 37 GHz.

The TGP2102 requires a minimum of off-chip components and operates with a -5 V control voltage. Each device is RF tested on-wafer to ensure performance compliance. The device is available in chip form.

The device is lead-free and RoHS compliant.

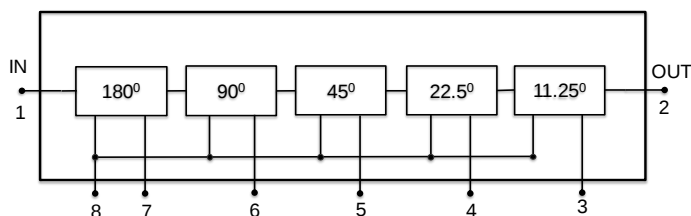


### Product Features

- Frequency Range: 32 to 37 GHz
- 5-Bit Digital Phase Shifter
- RMS Phase Error: 3.5° @ 35 GHz
- RMS Amplitude Error: 0.4 dB @ 35 GHz
- Insertion Loss: 7 dB
- Return Loss: 14 dB IRL; 7 dB ORL
- Negative Control Voltage: -5/0 V
- Single-Ended logic
- CMOS Compatible
- Chip Dimensions: 1.88 x 0.75 x 0.10 mm

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

### Functional Block Diagram



### Applications

- Military Radar
- Transit / Receive
- Massive MIMO

### Ordering Information

| Part No. | Description                                                  |
|----------|--------------------------------------------------------------|
| TGP2102  | 32-37 GHz 5 Bit Digital Phase Shifter, Waffle Pack 25 pieces |

### Absolute Maximum Ratings

| Parameter                         | Value         |
|-----------------------------------|---------------|
| Control and Supply Voltages       | -8 V          |
| Control Current                   | 1 mA          |
| Power Dissipation                 | 0.1 W         |
| Input Power, CW                   | 20 dBm        |
| Channel Temperature               | 150 °C        |
| Mounting Temperature (30 Seconds) | 320 °C        |
| Storage Temperature               | -65 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                          | Value         |
|------------------------------------|---------------|
| Control Voltage ( $V_C$ )          | -5/0 V        |
| Reference Voltage ( $V_{SUPPLY}$ ) | -5 V          |
| Operating Temperature Range        | -40 to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C.  $V_{SUPPLY} = -5$  V,  $V_C = -5/0$  V; see State Table.

| Parameter                   | Min | Typical | Max | Units |
|-----------------------------|-----|---------|-----|-------|
| Operational Frequency Range | 32  |         | 37  | GHz   |
| Insertion Loss              |     | 7       |     | dB    |
| Input Return Loss           |     | 14      |     | dB    |
| Output Return Loss          |     | 7       |     | dB    |
| Peak Phase Shift Error      |     | 5       |     | deg   |
| RMS Phase Shift Error       |     | 4       |     | deg   |
| Peak Amplitude Error        |     | 1       |     | dB    |
| RMS Amplitude Error         |     | 0.7     |     | dB    |

Notes: The data are from the typical devices as determined by fixtured measurements.

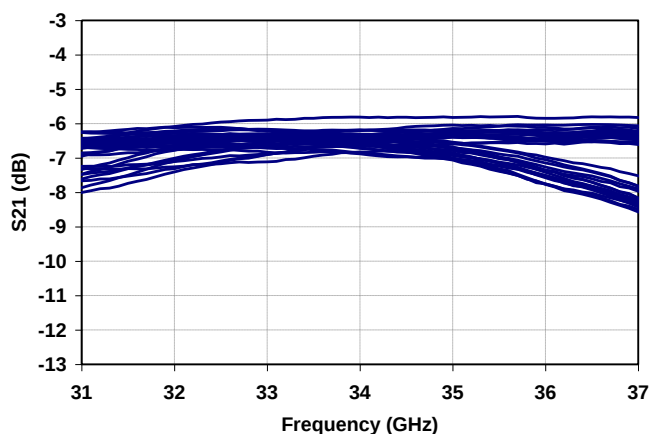
### State Table

| State | V-Supply | V-11.25 | V-22.5 | V-45 | V-90 | V-180 | Phase Shift |
|-------|----------|---------|--------|------|------|-------|-------------|
| 0     | -5 V     | 0 V     | 0 V    | 0 V  | 0 V  | 0 V   | Reference   |
| 1     | -5 V     | -5 V    | 0 V    | 0 V  | 0 V  | 0 V   | 11.25 °     |
| 2     | -5 V     | 0 V     | -5 V   | 0 V  | 0 V  | 0 V   | 22.5 °      |
| 3     | -5 V     | -5 V    | -5 V   | 0 V  | 0 V  | 0 V   | 33.75 °     |
| 4     | -5 V     | 0 V     | 0 V    | -5 V | 0 V  | 0 V   | 45 °        |
| 5     | -5 V     | -5 V    | 0 V    | -5 V | 0 V  | 0 V   | 56.25 °     |
| 6     | -5 V     | 0 V     | -5 V   | -5 V | 0 V  | 0 V   | 67.5 °      |
| 7     | -5 V     | -5 V    | -5 V   | -5 V | 0 V  | 0 V   | 78.75 °     |
| 8     | -5 V     | 0 V     | 0 V    | 0 V  | -5 V | 0 V   | 90 °        |
| 9     | -5 V     | -5 V    | 0 V    | 0 V  | -5 V | 0 V   | 101.25 °    |
| 10    | -5 V     | 0 V     | -5 V   | 0 V  | -5 V | 0 V   | 112.5 °     |
| 11    | -5 V     | -5 V    | -5 V   | 0 V  | -5 V | 0 V   | 123.75 °    |
| 12    | -5 V     | 0 V     | 0 V    | -5 V | -5 V | 0 V   | 135 °       |
| 13    | -5 V     | -5 V    | 0 V    | -5 V | -5 V | 0 V   | 146.25 °    |
| 14    | -5 V     | 0 V     | -5 V   | -5 V | -5 V | 0 V   | 157.5 °     |
| 15    | -5 V     | -5 V    | -5 V   | -5 V | -5 V | 0 V   | 168.75 °    |
| 16    | -5 V     | 0 V     | 0 V    | 0 V  | 0 V  | 0 V   | 180 °       |
| 17    | -5 V     | -5 V    | 0 V    | 0 V  | 0 V  | -5 V  | 191.25 °    |
| 18    | -5 V     | 0 V     | -5 V   | 0 V  | 0 V  | -5 V  | 202.5 °     |
| 19    | -5 V     | -5 V    | -5 V   | 0 V  | 0 V  | -5 V  | 213.75 °    |
| 20    | -5 V     | 0 V     | 0 V    | -5 V | 0 V  | -5 V  | 225 °       |
| 21    | -5 V     | -5 V    | 0 V    | -5 V | 0 V  | -5 V  | 236.25 °    |
| 22    | -5 V     | 0 V     | -5 V   | -5 V | 0 V  | -5 V  | 247.5 °     |
| 23    | -5 V     | -5 V    | -5 V   | -5 V | 0 V  | -5 V  | 258.75 °    |
| 24    | -5 V     | 0 V     | 0 V    | 0 V  | -5 V | -5 V  | 270 °       |
| 25    | -5 V     | -5 V    | 0 V    | 0 V  | -5 V | -5 V  | 281.25 °    |
| 26    | -5 V     | 0 V     | -5 V   | 0 V  | -5 V | -5 V  | 292.5 °     |
| 27    | -5 V     | -5 V    | -5 V   | 0 V  | -5 V | -5 V  | 303.75 °    |
| 28    | -5 V     | 0 V     | 0 V    | -5 V | -5 V | -5 V  | 315 °       |
| 29    | -5 V     | -5 V    | 0 V    | -5 V | -5 V | -5 V  | 326.25 °    |
| 30    | -5 V     | 0 V     | -5 V   | -5 V | -5 V | -5 V  | 337.5 °     |
| 31    | -5 V     | -5 V    | -5 V   | -5 V | -5 V | -5 V  | 348.75 °    |

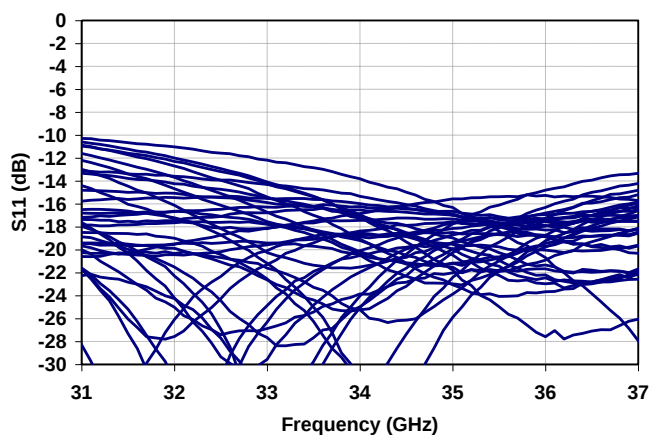
### Performance Plots – All States

Test conditions unless otherwise noted: 25 °C

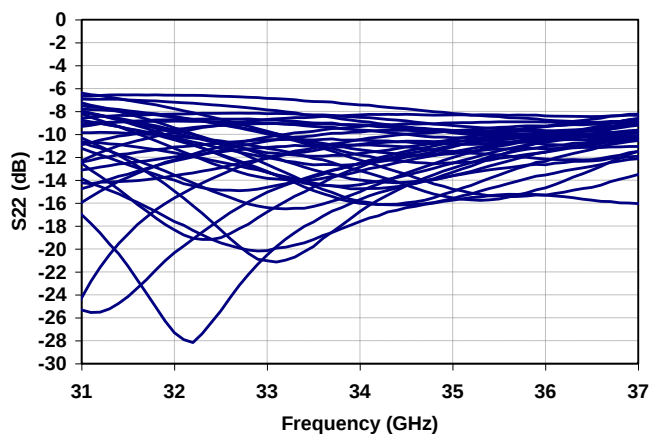
Insertion Loss vs. Frequency



Input Return Loss vs. Frequency

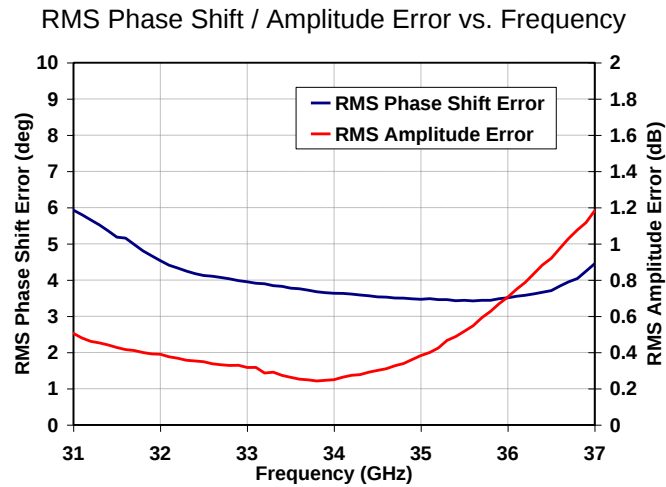


Output Return Loss vs. Frequency

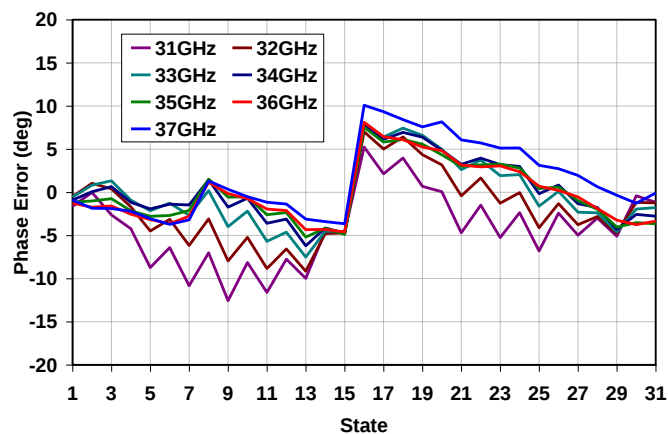


### Performance Plots –

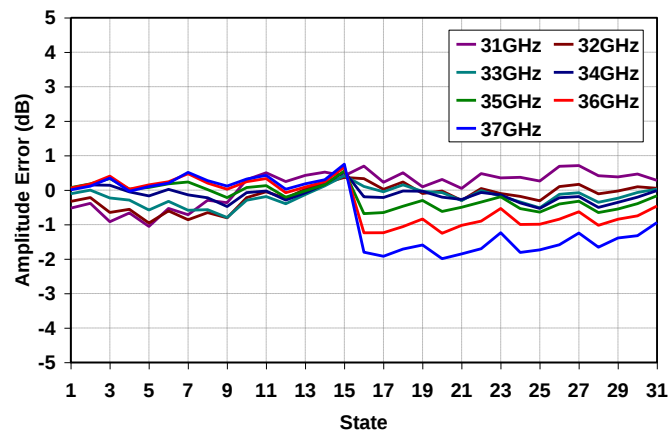
Test conditions unless otherwise noted: 25 °C



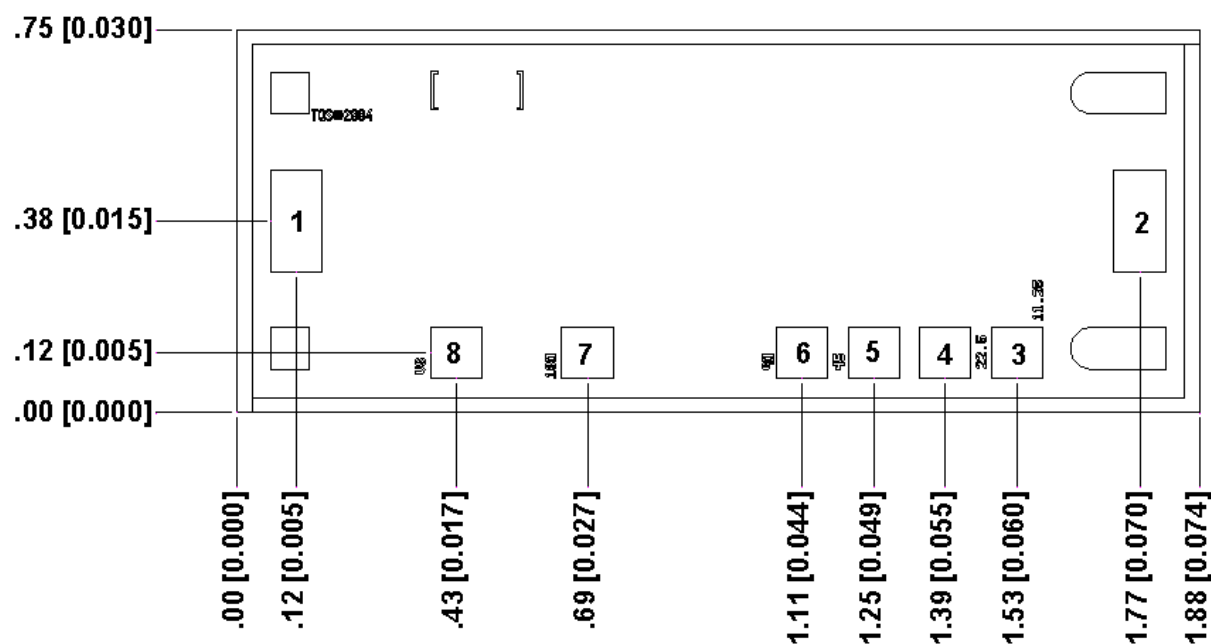
Phase Error vs. State



Amplitude Error vs. State



### Die Assembly & Bonding Diagram



Unit: millimeters (inches)

Thickness: 0.10 [0.004] (reference only)

Chip edge to bond pad dimensions are shown to center of bond pads

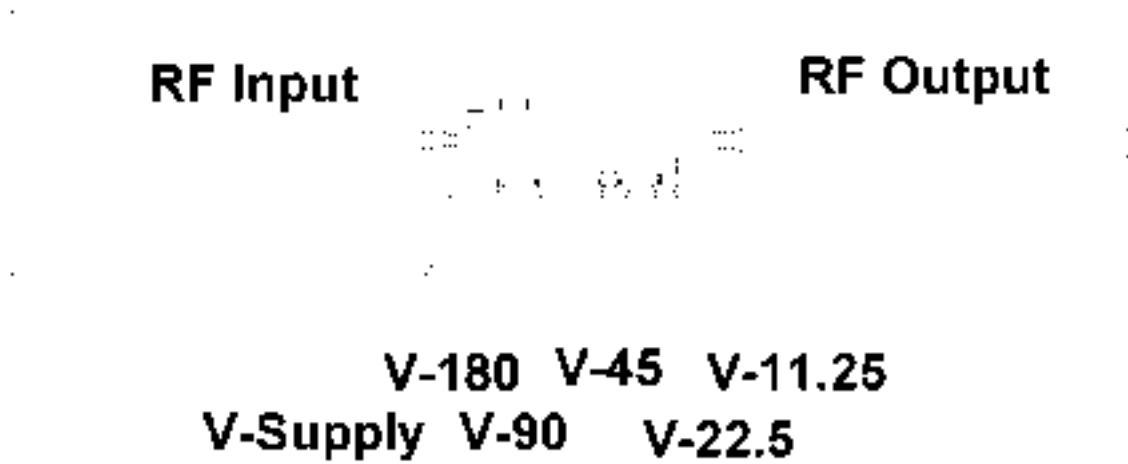
Chip size tolerance:  $\pm 0.05$  [0.002]

RF ground through backside

| Bond Pad | Symbol             | Pad Size(mm) | Pad Size[in]  |
|----------|--------------------|--------------|---------------|
| 1        | RF Input           | 0.10 x 0.20  | 0.004 x 0.008 |
| 2        | RF Output          | 0.10 x 0.20  | 0.004 x 0.008 |
| 3        | V-11.25 (On V=-5V) | 0.10 x 0.10  | 0.004 x 0.004 |
| 4        | V-22.5 (On V=-5V)  | 0.10 x 0.10  | 0.004 x 0.004 |
| 5        | V-45 (On V=-5V)    | 0.10 x 0.10  | 0.004 x 0.004 |
| 6        | V-90 (On V=-5V)    | 0.10 x 0.10  | 0.004 x 0.004 |
| 7        | V-180 (On V=-5V)   | 0.10 x 0.10  | 0.004 x 0.004 |
| 8        | V-Supply (-5V)     | 0.10 x 0.10  | 0.004 x 0.004 |

### Die Assembly & Bonding Diagram

---



#### Notes:

1. Device were tested with 500  $\Omega$  resistors in series with control lines.
2. Input and output stubs are 0.007" x 0.024" on 0.010" alumina substrate.

### Assembly Notes

---

#### Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.
- Organic attachment (i.e., conductive epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.
- Devices must be stored in a dry nitrogen atmosphere.

#### Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300°C to 3-4 minutes, maximum.
- Conductive epoxy die attach is recommended for PCB mounting.
- Bonding pads plating: Au.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

#### Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonics are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

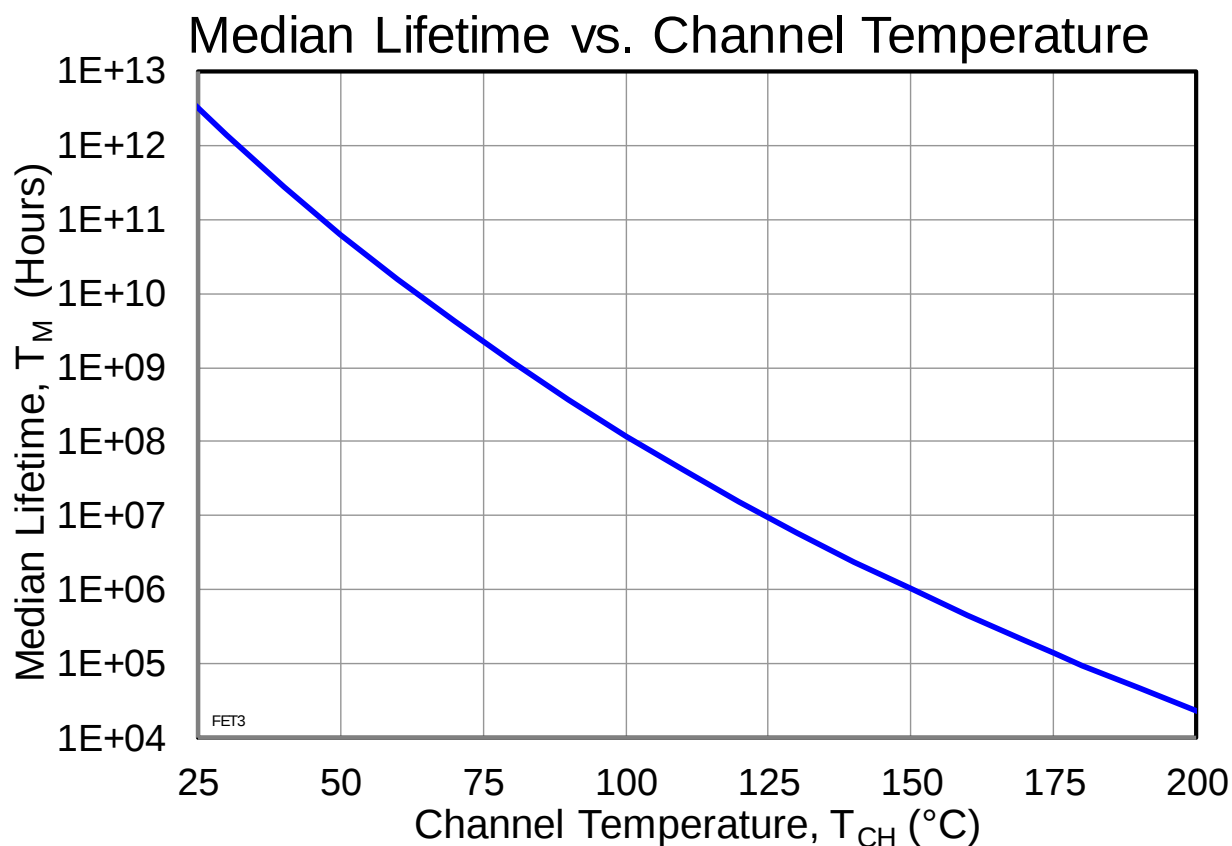
### Thermal and Reliability Information

| Parameter                                | Test Conditions                      | Value  | Units              |
|------------------------------------------|--------------------------------------|--------|--------------------|
| Channel Temperature, $T_{CH}$ (Under RF) | $T_{BASEPLATE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )                |                                      | 6.6E08 | Hrs                |

Notes:

Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime



### Handling Precautions

| Parameter                    | Rating | Standard                 |  | Caution!<br>ESD-Sensitive Device |
|------------------------------|--------|--------------------------|-------------------------------------------------------------------------------------|----------------------------------|
| ESD – Human Body Model (HBM) | TBD    | ESDA / JEDEC JS-001-2012 |                                                                                     |                                  |

### 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2021 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.

### Product Description

Qorvo's TGP2615 is a 6-bit digital phase shifter fabricated on Qorvo's high-performance 0.15- $\mu\text{m}$  GaAs pHEMT process. It operates over 15 to 19 GHz and provides 360° of phase coverage with an LSB of 5.625°. It also achieves a low RMS phase error of 4°, with 8 dB average insertion loss over all states.

The TGP2615 uses positive switch logic, eliminating the need for a negative voltage rail. This combined with low insertion loss and a high degree of resolution makes the TGP2615 ideally suited for phased-array radar and satellite communications applications.

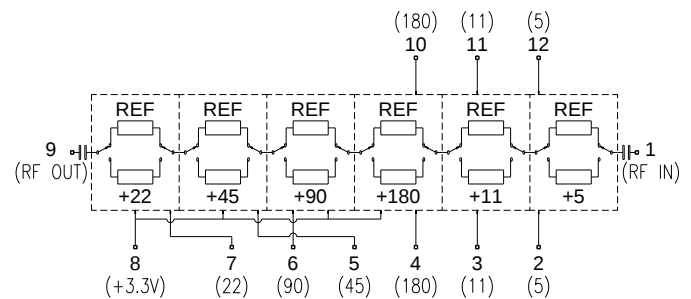


### Product Features

- 6-Bit Digital Phase Shifter
- Frequency Range: 15 to 19 GHz
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 4°
- RMS Amplitude Error: 1 dB
- Insertion Loss: 7 dB
- Input Return Loss: >10 dB
- Output Return Loss: >9 dB
- Input IP3: >34 dBm
- Input P1dB: >24 dBm
- Control Voltage: 0/+3.3 V
- Chip Dimensions: 2.11 x 1.47 x 0.10 mm

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

### Block Diagram



### Applications

- Phased Array Radar
- Satellite Communications

### Ordering Information

| Part No.    | Description                                                 |
|-------------|-------------------------------------------------------------|
| TGP2615     | TGP2615 15-19 GHz 6-Bit Phase Shifter, Waffle Pack, Qty 100 |
| TGP2615 EVB | TGP2615 Evaluation Board                                    |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltages      | 6 V           |
| Control Current                     | 1 mA          |
| Power Dissipation                   | 0.8 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 30 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 320 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                                      | Value        |
|------------------------------------------------|--------------|
| Control Voltage (5°, 11°, 22°, 45°, 90°, 180°) | 0/+3.3 V     |
| Reference Voltage ( $V_{REF}$ )                | +3.3 V       |
| Current ( $I_{REF}$ , $I_{CTRL}$ )             | 10 $\mu$ A   |
| Temperature Range                              | -40 to 85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) = 0/+3.3 V; See Bias Truth Table.

| Parameter                              | Conditions                                 | Min | Typical | Max | Units |
|----------------------------------------|--------------------------------------------|-----|---------|-----|-------|
| Operational Frequency Range            |                                            | 15  |         | 19  | GHz   |
| Insertion Loss                         | Average across all phase states            |     | 6 - 8   |     | dB    |
| Input Return Loss                      | Average across all phase states            |     | >10     |     | dB    |
| Output Return Loss                     | Average across all phase states            |     | >9      |     | dB    |
| RMS Phase Error                        |                                            |     | 4       |     | deg   |
| RMS Amplitude Error                    |                                            |     | 1       |     | dB    |
| Input P1dB                             |                                            |     | >24     |     | dBm   |
| Input IP3                              | Tone spacing = 10 MHz<br>Pin/Tone = 15 dBm |     | >34     |     | dBm   |
| Insertion Loss Temperature Coefficient | Average all phase states, 19 GHz           |     | 0.002   |     | dB/°C |

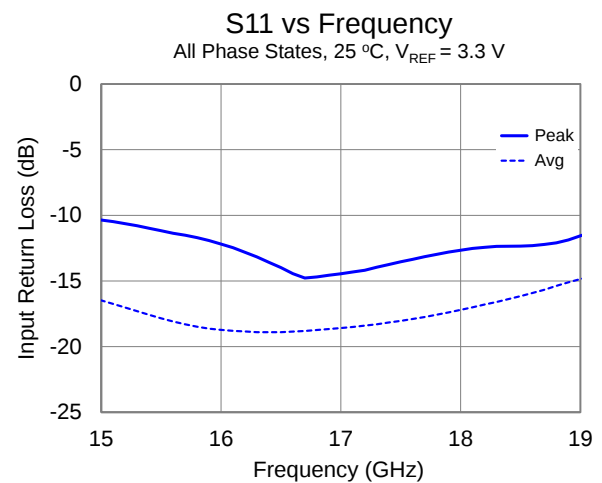
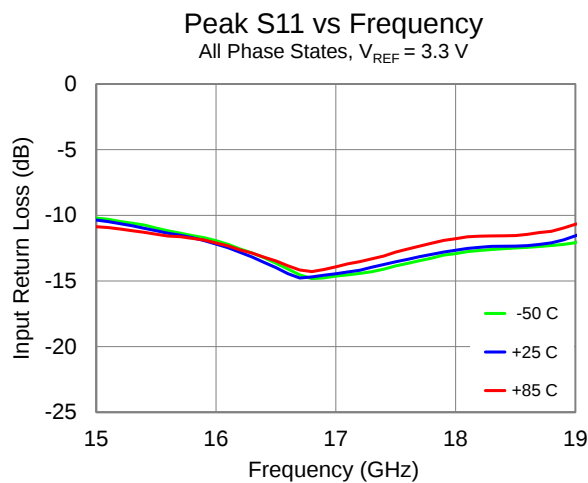
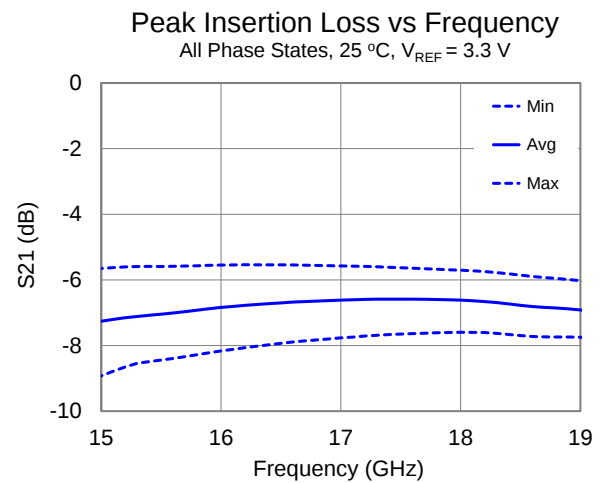
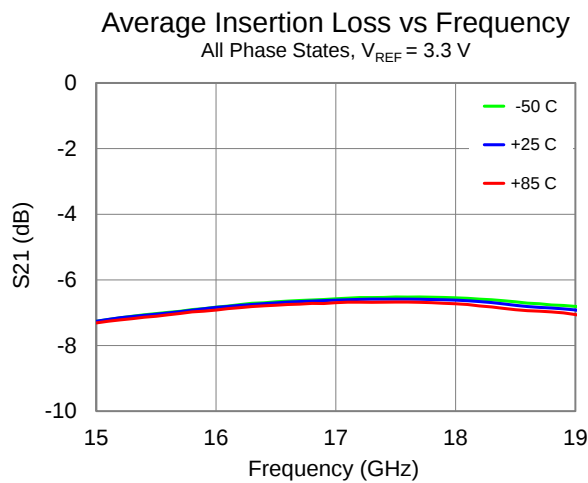
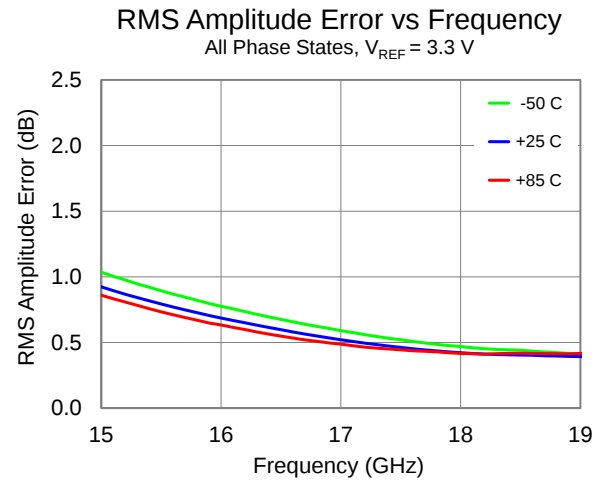
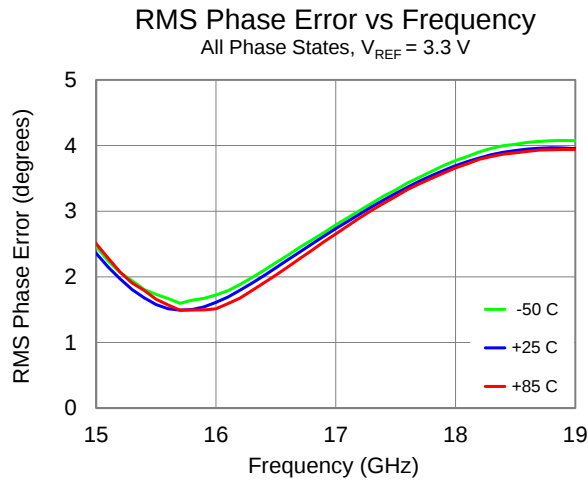
### Bias and Truth Table

Control voltage Logic "0" = +0 to +0.2 V; Logic "1" = +3.3 to +5 V

| Phase Shift    | 5° | 11° | 22° | 45° | 90° | 180° | REF |
|----------------|----|-----|-----|-----|-----|------|-----|
| 0° (Reference) | 0  | 0   | 0   | 0   | 0   | 0    | 1   |
| 5°             | 1  | 0   | 0   | 0   | 0   | 0    | 1   |
| 11°            | 0  | 1   | 0   | 0   | 0   | 0    | 1   |
| 22°            | 0  | 0   | 1   | 0   | 0   | 0    | 1   |
| 45°            | 0  | 0   | 0   | 1   | 0   | 0    | 1   |
| 90°            | 0  | 0   | 0   | 0   | 1   | 0    | 1   |
| 180°           | 0  | 0   | 0   | 0   | 0   | 1    | 1   |
| 355°           | 1  | 1   | 1   | 1   | 1   | 1    | 1   |

### Performance Plots – Small Signal

Test conditions unless otherwise noted: 25 °C

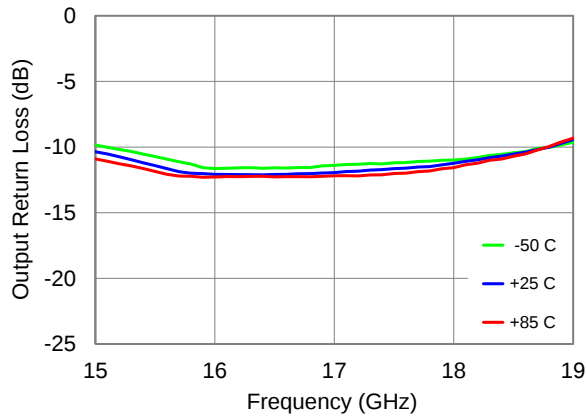


### Performance Plots – Small Signal & Large Signal

Test conditions unless otherwise noted: 25 °C

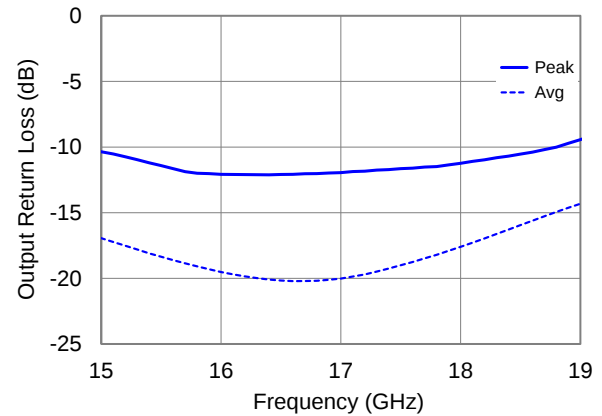
Peak S22 vs Frequency

All Phase States,  $V_{REF} = 3.3\text{ V}$



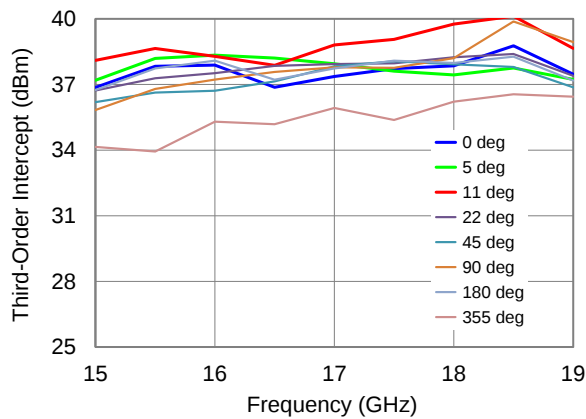
S22 vs Frequency

All Phase States, 25 °C,  $V_{REF} = 3.3\text{ V}$



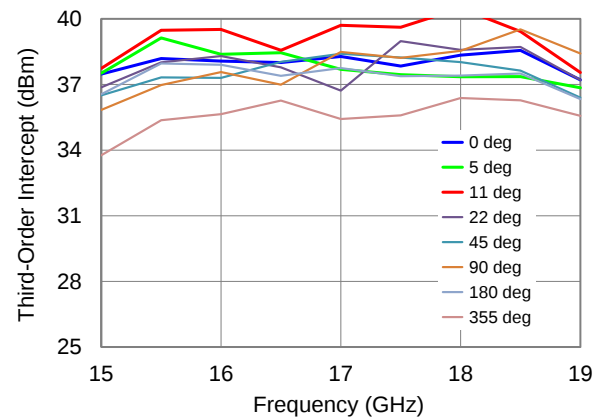
Input TOI vs Frequency

Major Phase States, 25 °C,  $V_{REF} = 3.3\text{ V}$



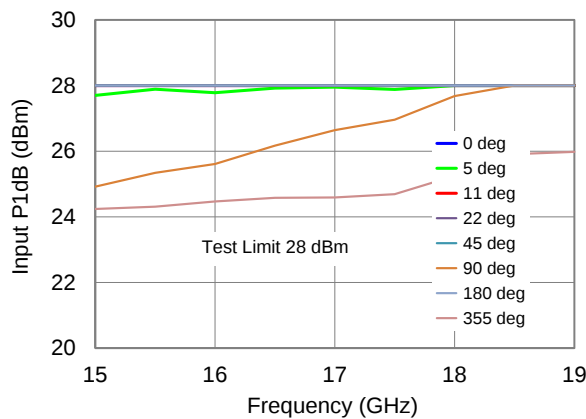
Input TOI vs Frequency

Major Phase States, 85 °C,  $V_{REF} = 3.3\text{ V}$



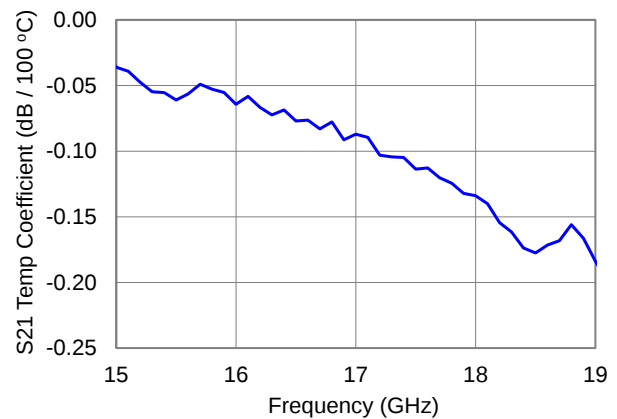
Input P1dB vs Frequency

Major Phase States, 25 °C,  $V_{REF} = 3.3\text{ V}$

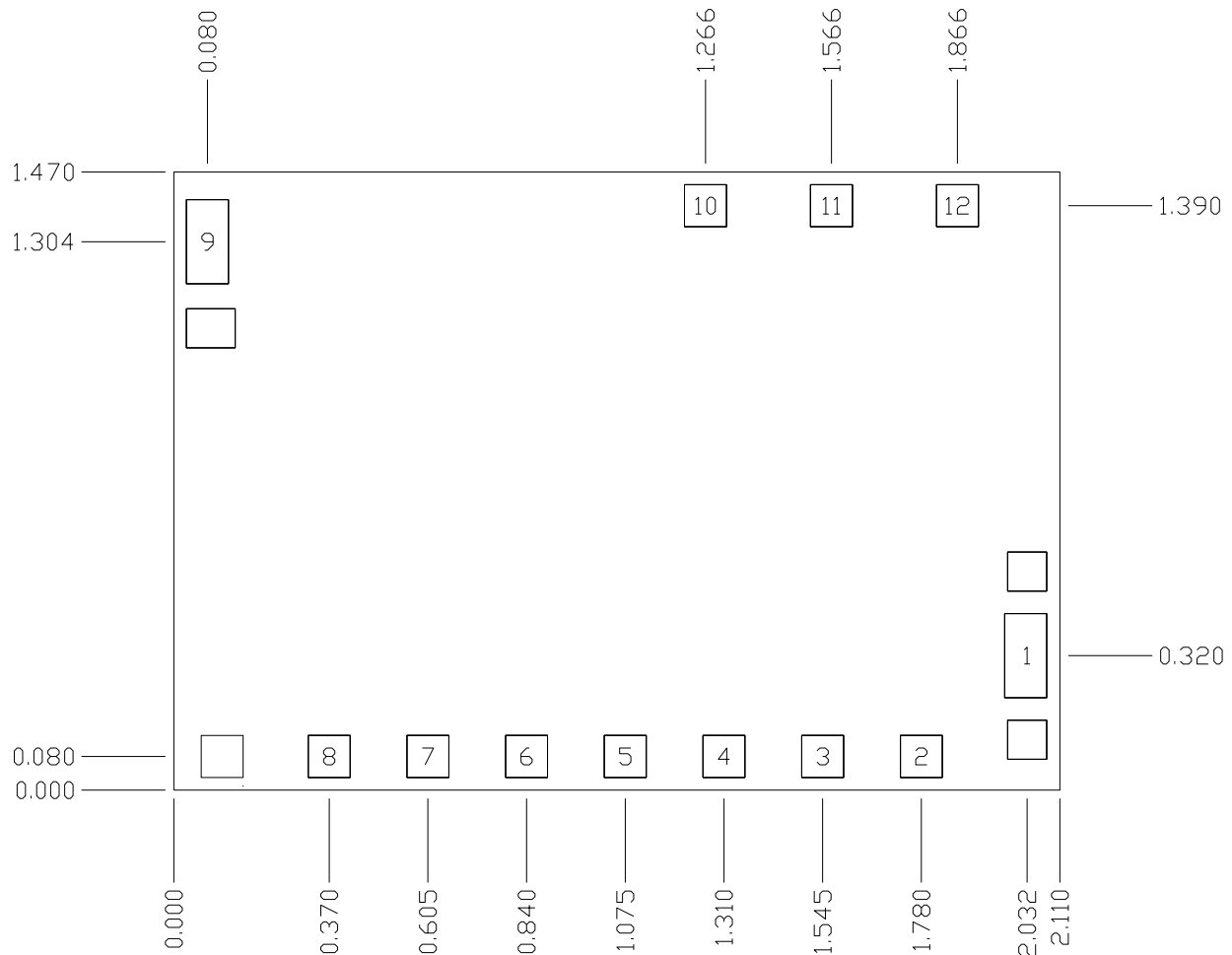


Loss Temperature Coefficient vs Frequency

All Phase States, -50 to +85 °C,  $V_{REF} = 3.3\text{ V}$



### Mechanical Information and Bond Pad Description

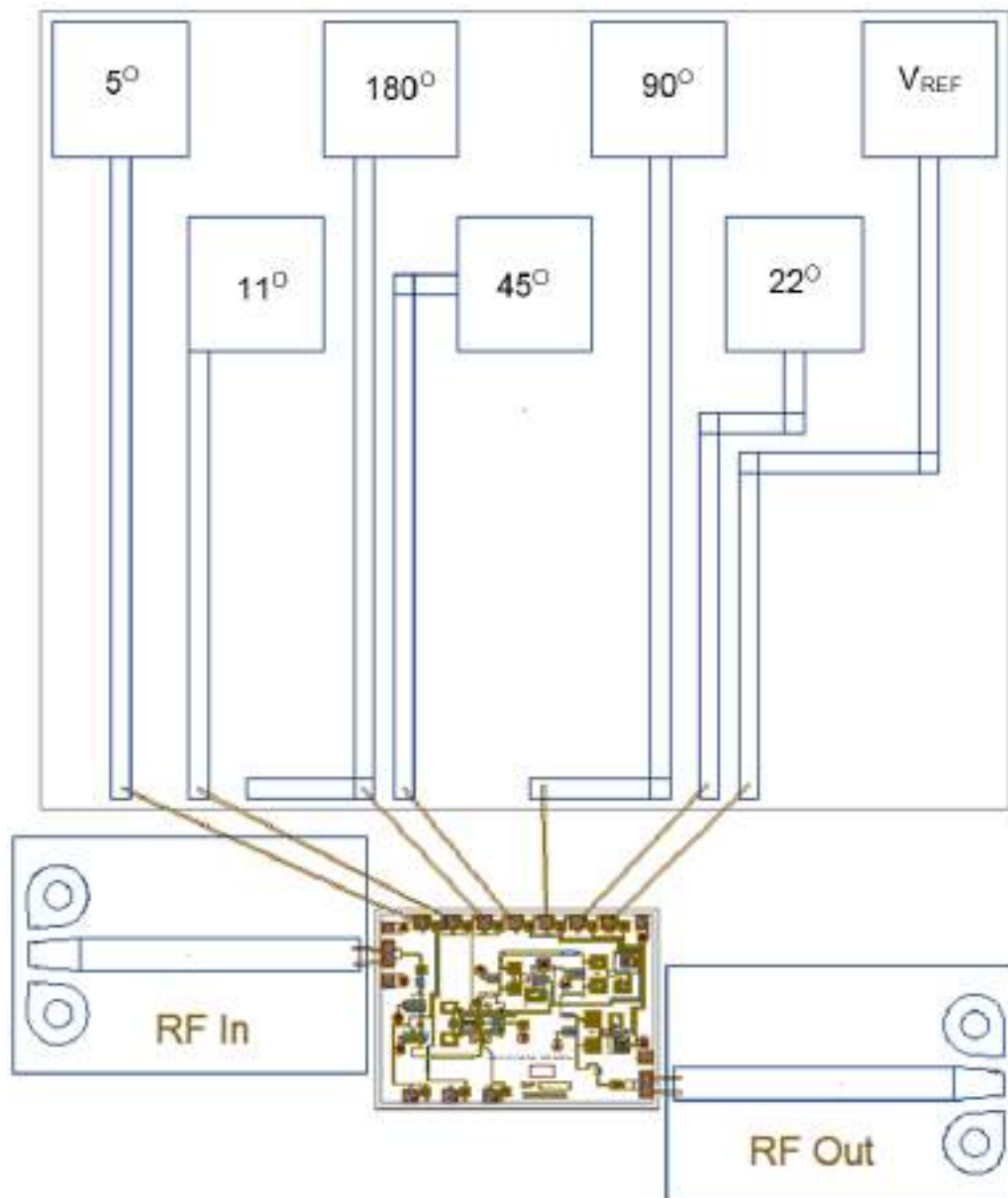


Unit: millimeters, Die thickness: 0.10, Die x, y size tolerance:  $\pm 0.050$   
 Chip edge to bond pad dimensions are shown to center of pad, Ground is backside of die

| Bond Pad | Symbol           | Description                         | Pad Size      |
|----------|------------------|-------------------------------------|---------------|
| 1        | RF IN            | RF Input; 50 $\Omega$ ; DC-Blocked  | 0.100 x 0.200 |
| 2        | 5°               | 5° Bit Control                      | 0.100 x 0.100 |
| 3        | 11°              | 11° Bit Control                     | 0.100 x 0.100 |
| 4        | 180°             | 180° Bit Control                    | 0.100 x 0.100 |
| 5        | 45°              | 45° Bit Control                     | 0.100 x 0.100 |
| 6        | 90°              | 90° Bit Control                     | 0.100 x 0.100 |
| 7        | 22°              | 22° Bit Control                     | 0.100 x 0.100 |
| 8        | V <sub>REF</sub> | Reference voltage for logic "1"     | 0.100 x 0.100 |
| 9        | RF OUT           | RF Output; 50 $\Omega$ ; DC-Blocked | 0.100 x 0.200 |
| 10       | 180°             | 180° Bit Alternate Control          | 0.100 x 0.100 |
| 11       | 11°              | 11° Bit Alternate Control           | 0.100 x 0.100 |
| 12       | 5°               | 5° Bit Alternate Control            | 0.100 x 0.100 |

### Assembly Drawing and Application Information

1. The spacing between MMIC and TFN at RF In and RF Out is <5 mils typical.
2. RF connections: Bond two 1-mil diameter, <20 mils length gold bond wires at RF In and RF Out for optimum RF performance.
3. For fixtured testing, device was rotated 180 degrees from orientation in the page-1 chip photograph.



### Assembly Notes

---

#### Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.
- Organic attachment (i.e., conductive epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.

#### Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300°C to 3-4 minutes, maximum.
- Conductive epoxy die attach is recommended for PCB mounting.
- Bonding pads plating: Au.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

#### Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonic are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

### Thermal and Reliability Information

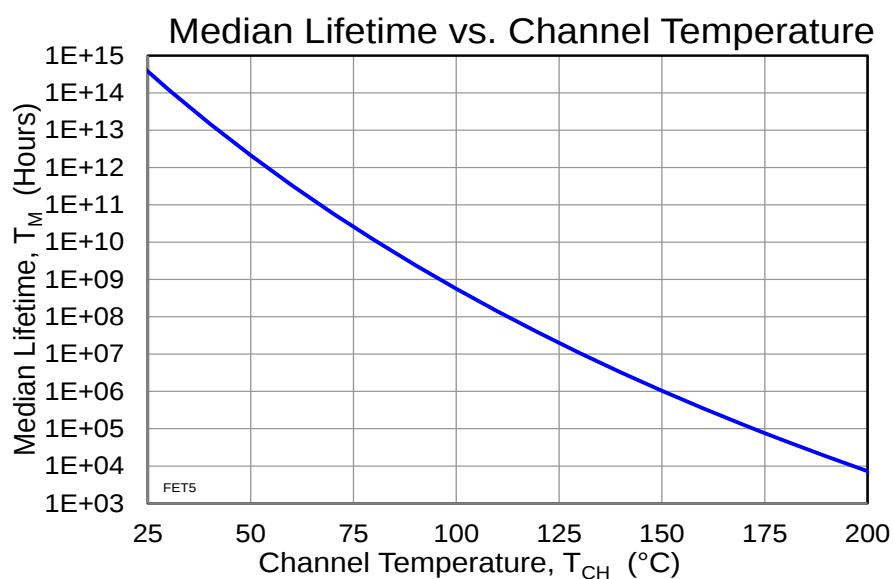
| Parameter                        | Test Conditions                      | Value  | Units              |
|----------------------------------|--------------------------------------|--------|--------------------|
| Channel Temperature ( $T_{CH}$ ) | $T_{BASEPLATE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )        |                                      | 5.2E+9 | Hrs                |

Notes:

- Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime

Test Conditions: 6.0 V; Failure Criterion = 10% reduction in  $I_{DQ\_MAX}$



### Handling Precautions

| Parameter                    | Rating   | Standard                 |  | Caution!<br>ESD-Sensitive Device |
|------------------------------|----------|--------------------------|-------------------------------------------------------------------------------------|----------------------------------|
| ESD – Human Body Model (HBM) | Class 0B | ESDA / JEDEC JS-001-2014 |                                                                                     |                                  |

### 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2021 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.



# TGP2615-SM

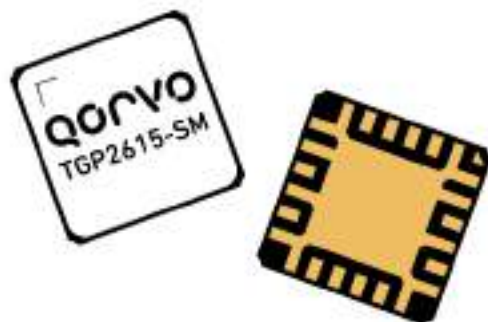
## 15-19GHz 6-Bit Digital Phase Shifter

### Product Description

The Qorvo TGP2615-SM is a packaged 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15  $\mu\text{m}$  GaAs pHEMT process. It operates over 15 to 19 GHz while providing 360° of phase coverage with a LSB of 5.625°. It also achieves a low RMS phase error of 4°, with 7 dB average insertion loss over all states.

The TGP2615-SM uses positive single-control-line switch logic, eliminating the need for a negative voltage rail or complimentary logic. This, combined with low insertion loss and a high degree of resolution makes the TGP2615-SM ideally suited for applications in phased-array radar and satellite communications.

The device is lead-free and RoHS compliant.



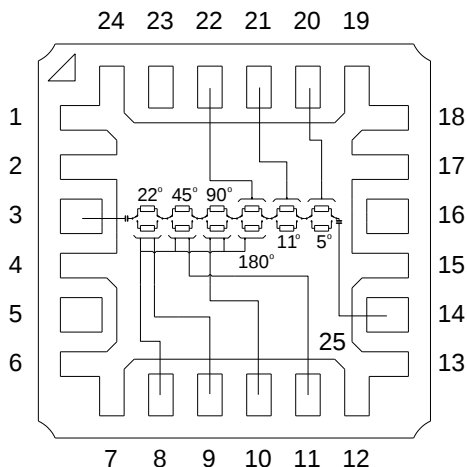
Air Cavity Ceramic QFN 4x4 mm 24L

### Product Features

- Frequency Range: 15 to 19 GHz
- 6-Bit Digital Phase Shifter
- 360° Coverage, LSB = 5.625°
- RMS Phase Error: 4°
- RMS Amplitude Error: 0.85 dB
- Insertion Loss: 7 dB
- Input Return Loss: >10 dB
- Output Return Loss: >9 dB
- Input P1dB: >23 dBm
- Positive Control Logic: 0 / +3.3 V
- Package Dimensions: 4.0 x 4.0 x 1.45 mm

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

### Block Diagram



### Applications

- Phased-Array Radar
- Satellite Communications

### Ordering Information

| Part No.      | Description                           |
|---------------|---------------------------------------|
| TGP2615-SM    | 15-19 GHz 6-Bit Digital Phase Shifter |
| TGP2615-SMEVB | TGP2615-SM EVAL BOARD                 |

### Absolute Maximum Ratings

| Parameter                           | Value         |
|-------------------------------------|---------------|
| Control and Reference Voltage       | 6 V           |
| Control Current                     | 1 mA          |
| Power Dissipation                   | 0.8 W         |
| Input Power, CW, 50 $\Omega$ , 85°C | 30 dBm        |
| Channel Temperature                 | 200 °C        |
| Mounting Temperature (30 Seconds)   | 260 °C        |
| Storage Temperature                 | -55 to 150 °C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied. Extended application of Absolute Maximum Rating conditions may reduce device reliability.

### Recommended Operating Conditions

| Parameter                                      | Value         |
|------------------------------------------------|---------------|
| Control Voltage (5°, 11°, 22°, 45°, 90°, 180°) | 0/+3.3 V      |
| Reference Voltage ( $V_{REF}$ )                | +3.3 V        |
| Current ( $I_{REF}$ , $I_{CTRL}$ )             | 10 $\mu$ A    |
| Temperature Range                              | -40 to +85 °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed overall operating conditions.

### Electrical Specifications

Test conditions unless otherwise noted: 25°C. Control Voltage (REF, 5°, 11°, 22°, 45°, 90°, 180°) = 0/+3.3 V; See Bias Truth Table

| Parameter                              | Conditions                       | Min | Typical | Max | Units |
|----------------------------------------|----------------------------------|-----|---------|-----|-------|
| Operational Frequency Range            |                                  | 15  |         | 19  | GHz   |
| Insertion Loss                         | Average across all phase states  |     | 6 - 8   |     | dB    |
| Input Return Loss                      | Average across all phase states  |     | >10     |     | dB    |
| Output Return Loss                     | Average across all phase states  |     | >9      |     | dB    |
| RMS Phase Error                        |                                  |     | 4       |     | deg   |
| RMS Amplitude Error                    |                                  |     | 0.85    |     | dB    |
| Input P1dB                             |                                  |     | >23     |     | dBm   |
| Insertion Loss Temperature Coefficient | Average all phase states, 19 GHz |     | 0.002   |     | dB/°C |

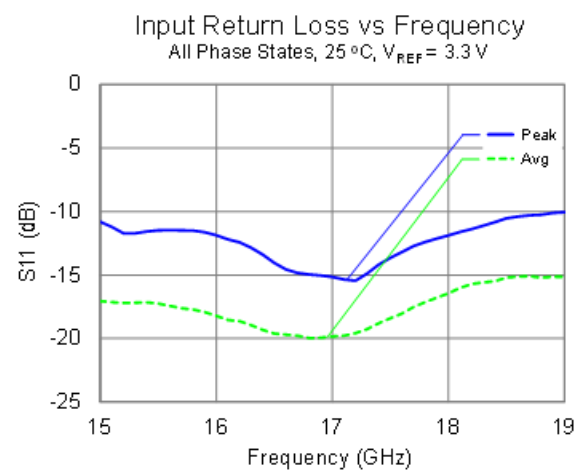
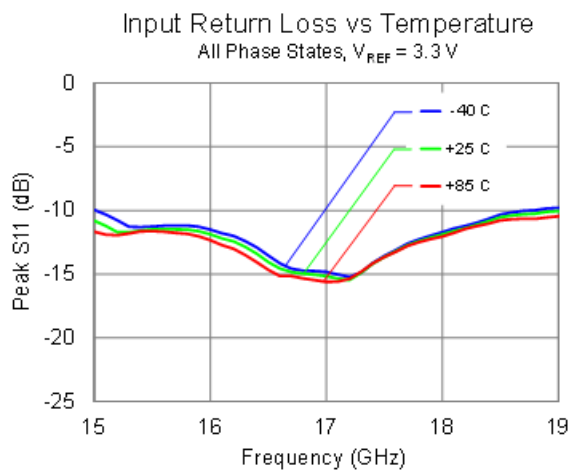
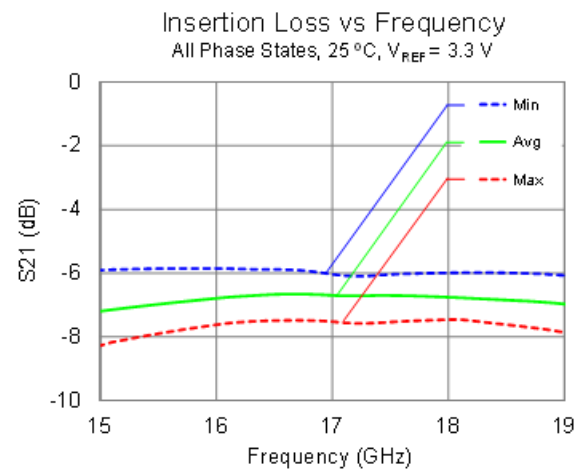
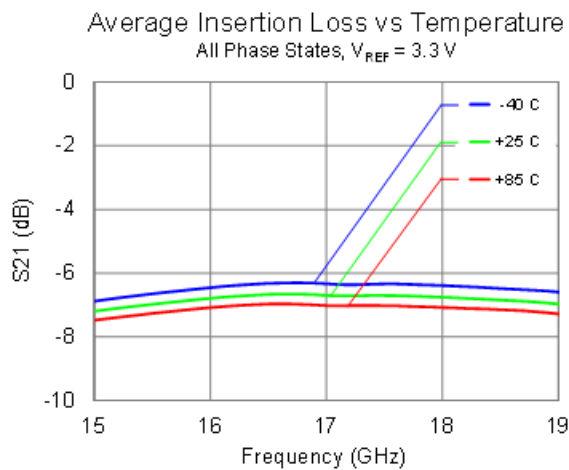
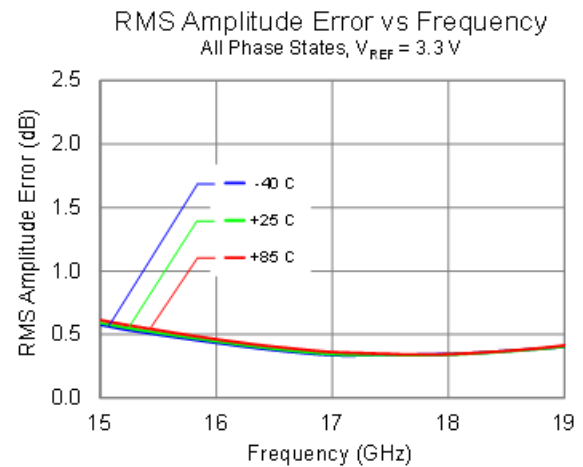
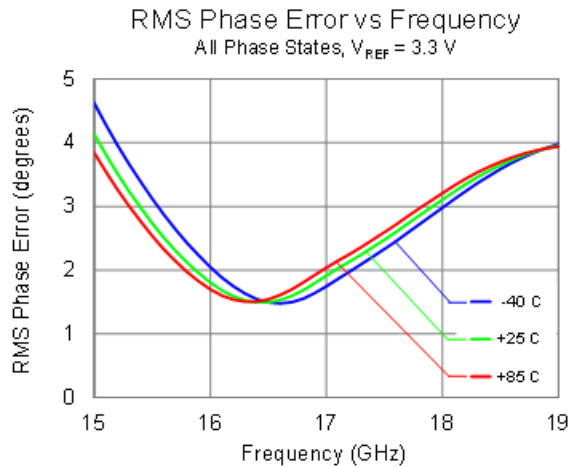
### Bias Truth Table

Logic "0" = 0 V, Logic "1" =  $V_{REF}$  = +3.3 V

| Phase Shifter Setting | 5° | 11° | 22° | 45° | 90° | 180° | REF |
|-----------------------|----|-----|-----|-----|-----|------|-----|
| 0° (Reference)        | 0  | 0   | 0   | 0   | 0   | 0    | 1   |
| 5°                    | 1  | 0   | 0   | 0   | 0   | 0    | 1   |
| 11°                   | 0  | 1   | 0   | 0   | 0   | 0    | 1   |
| 22°                   | 0  | 0   | 1   | 0   | 0   | 0    | 1   |
| 45°                   | 0  | 0   | 0   | 1   | 0   | 0    | 1   |
| 90°                   | 0  | 0   | 0   | 0   | 1   | 0    | 1   |
| 180°                  | 0  | 0   | 0   | 0   | 0   | 1    | 1   |
| 355°                  | 1  | 1   | 1   | 1   | 1   | 1    | 1   |

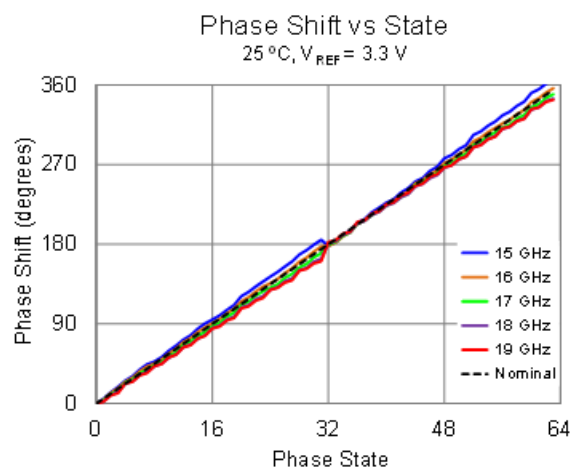
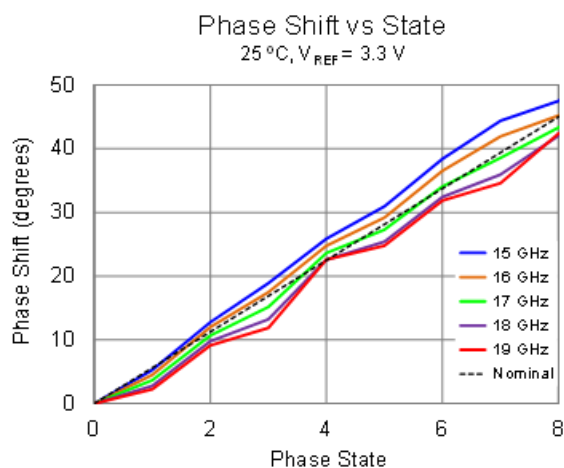
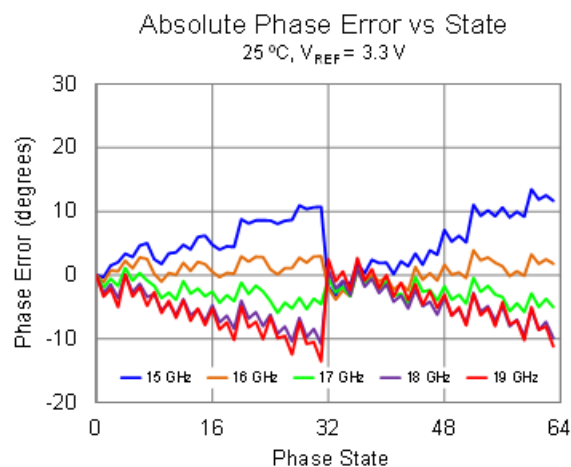
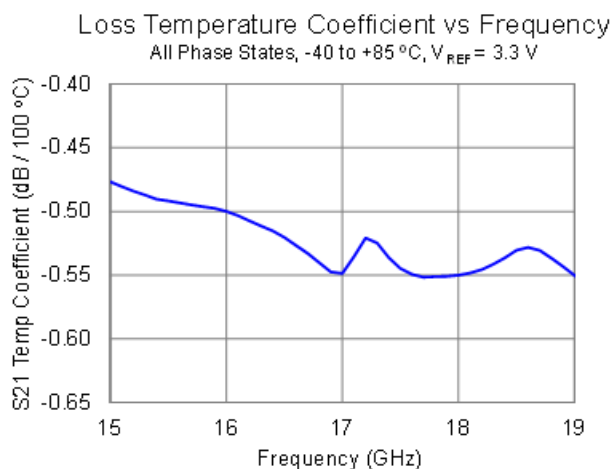
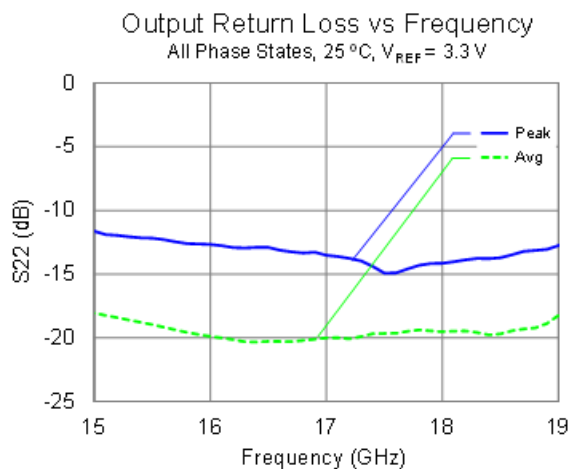
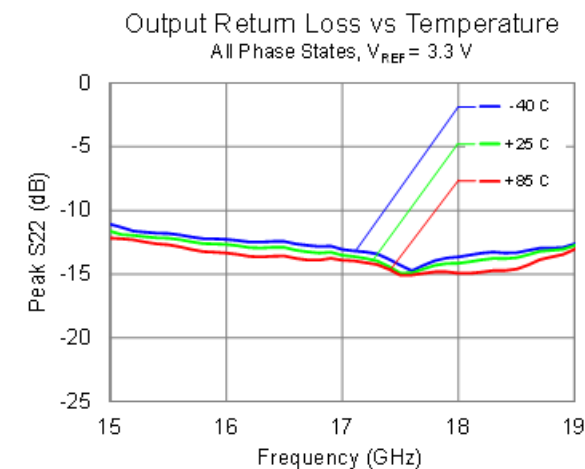
### Performance Plots – Small Signal

Test conditions unless otherwise noted: 3.3 V, 25 °C



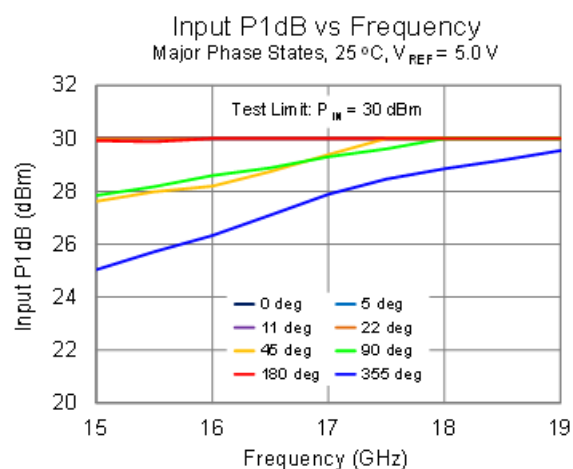
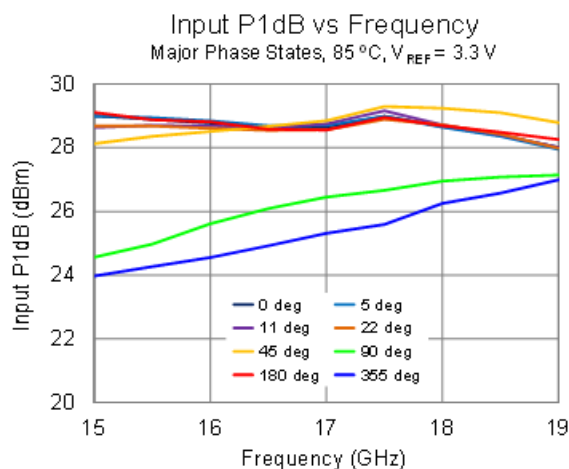
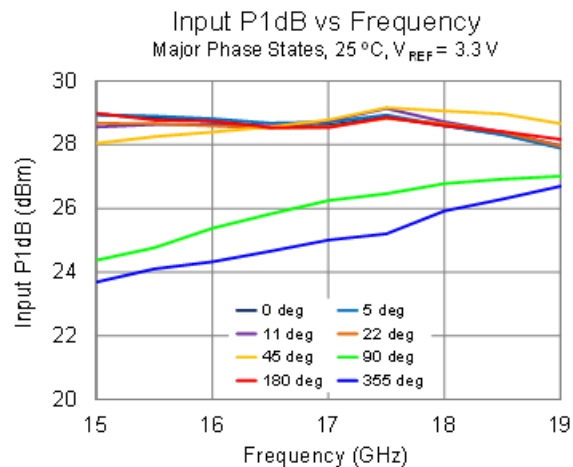
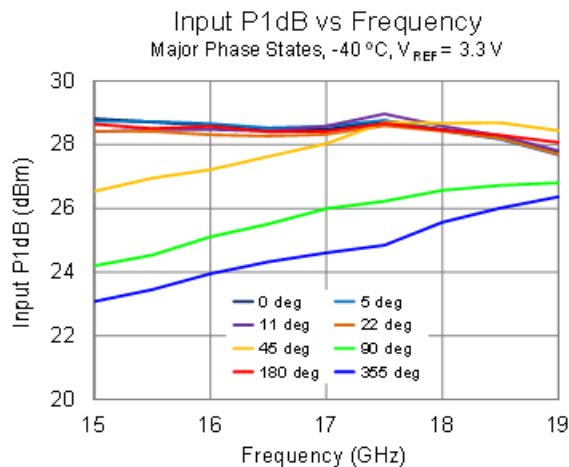
### Performance Plots – Small Signal (Cont.)

Test conditions unless otherwise noted: 3.3 V, 25 °C



## Performance Plots – Large Signal

Test conditions unless otherwise noted: 3.3 V, 25 °C



### Thermal and Reliability Information

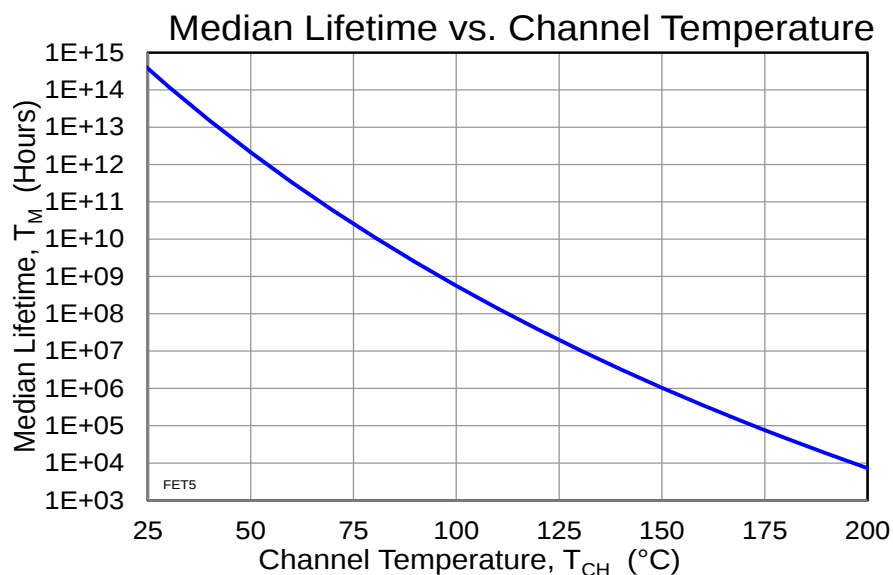
| Parameter                        | Test Conditions                      | Value  | Units              |
|----------------------------------|--------------------------------------|--------|--------------------|
| Channel Temperature ( $T_{CH}$ ) | $T_{BASEPLATE} = 85^{\circ}\text{C}$ | 85     | $^{\circ}\text{C}$ |
| Median Lifetime ( $T_M$ )        |                                      | 5.2E+9 | Hrs                |

Notes:

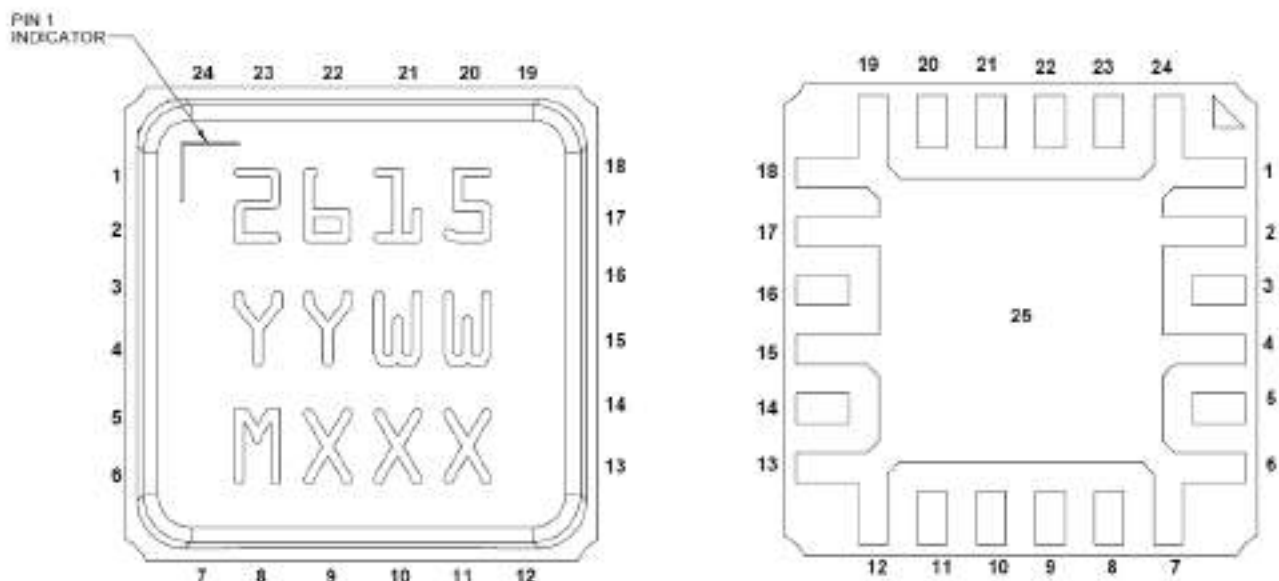
- Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

### Median Lifetime

Test Conditions: 6.0 V; Failure Criterion = 10% reduction in  $I_{DQ\_MAX}$

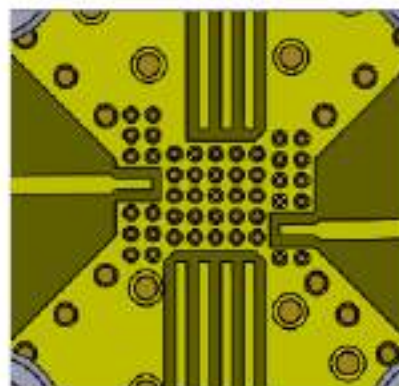
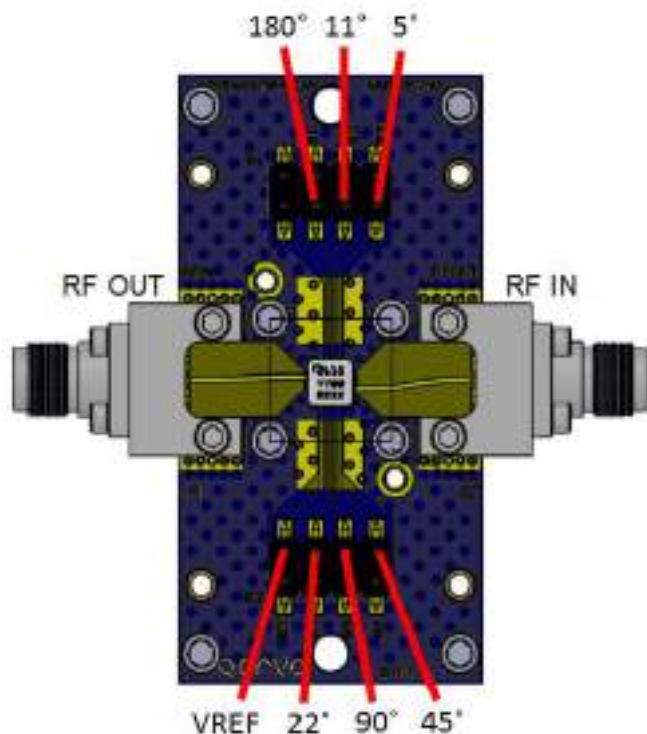


### Pin Description



| Pin No.                              | Symbol           | Description                                                                                        |
|--------------------------------------|------------------|----------------------------------------------------------------------------------------------------|
| 1, 2, 4, 6, 7, 12, 13, 15, 17-19, 24 | GND              | Internal grounding and shielding, must be grounded on PCB                                          |
| 3                                    | RF OUT           | RF Output, 50 $\Omega$ , DC-Blocked                                                                |
| 5, 16, 23                            | NC               | No Connection, Pin Not Used                                                                        |
| 8                                    | V <sub>REF</sub> | Reference Voltage for Logic "1" (Nominal 3.3 V)                                                    |
| 9                                    | 22°              | 22° Bit Control                                                                                    |
| 10                                   | 90°              | 90° Bit Control                                                                                    |
| 11                                   | 45°              | 45° Bit Control                                                                                    |
| 14                                   | RF IN            | RF Input, 50 $\Omega$ , DC-Blocked                                                                 |
| 20                                   | 5°               | 5° Bit Control                                                                                     |
| 21                                   | 11°              | 11° Bit Control                                                                                    |
| 22                                   | 180°             | 180° Bit Control                                                                                   |
| 25 (Slug)                            | GND              | Backside Paddle; multiple vias should be used on PCB to minimize inductance and thermal resistance |

## Evaluation Board (EVB) Layout Assembly



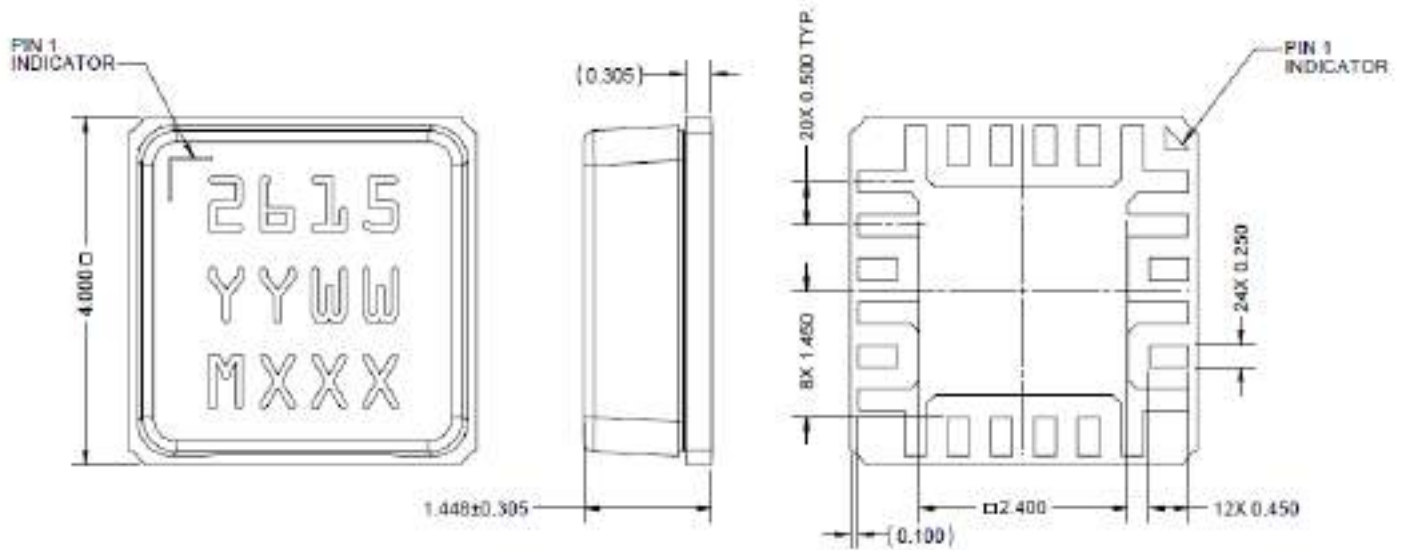
VIA PATTERN

RF layer is 0.008" thick Rogers RO4003C. Metal layers are 0.5-oz copper. Microstrip 50  $\Omega$  line width is 0.050". The microstrip line taper at the connector interface is optimized for the Southwest Microwave end-launch connector 1092-01A-5.

Ground / thermal vias under the DUT are critical for the proper performance of this device. The PCB shown herein utilizes copper filled vias (8 mils diameter) under the DUT.

The pad pattern shown has been developed and tested for optimized assembly at Qorvo. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company careful process development is recommended.

## Mechanical Information



NOTES:

1. PACKAGE BASE: CERAMIC
2. PACKAGE LID: PLASTIC
3. ALL METALIZED FEATIRES ARE GOLD PLATED
4. THE PART IS EPOXY SEALED
5. PART MARKING:  
2615: PART NUMBER  
YY: PART ASSEMBLY YEAR  
WW: PART ASSEMBLY WEEK  
MXXX: BATCH ID

### Assembly Notes

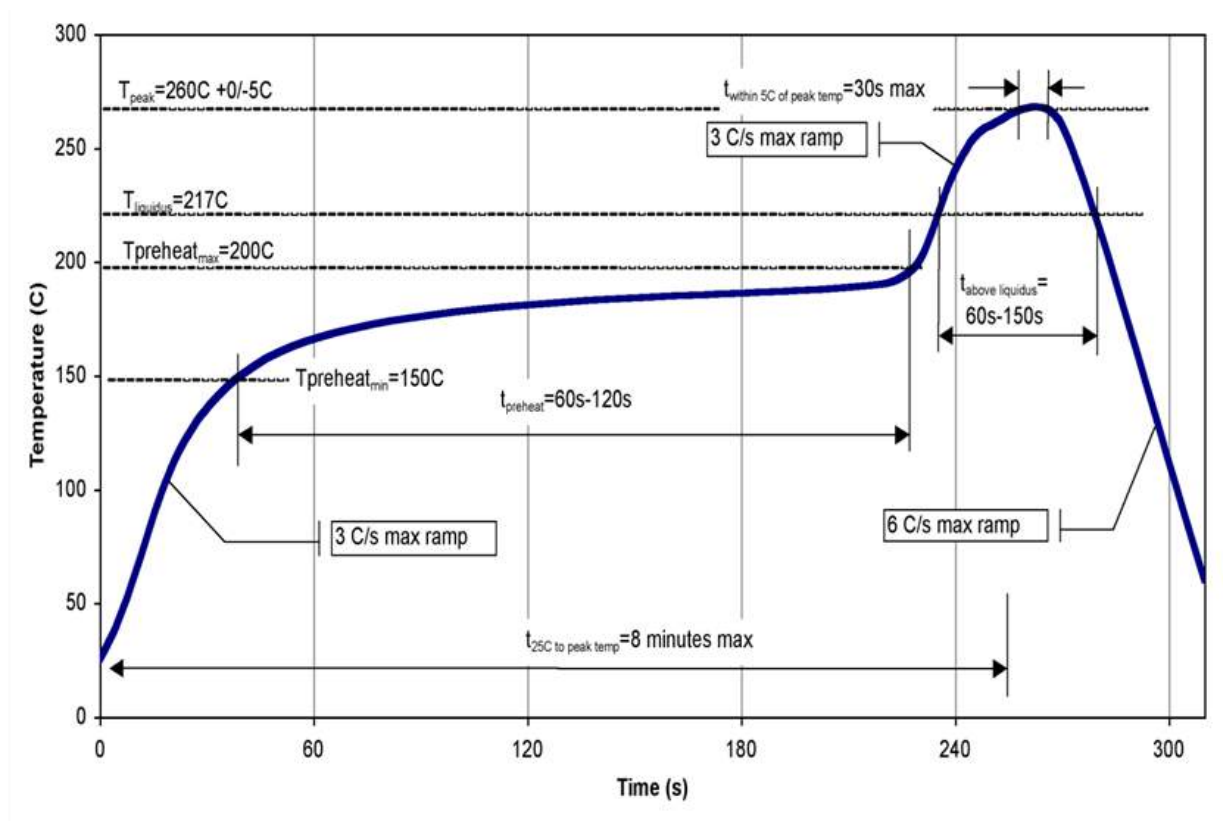
Compatible with both lead-free (260°C peak reflow temp.) and tin/lead (245°C peak reflow temp.) soldering processes.

This package is air-cavity and non-hermetic, and therefore cannot be subjected to aqueous washing. The use of no-clean solder to avoid washing after soldering is highly recommended.

Solder rework not recommended.

Contact plating: Ni-Au.

### Recommended Soldering Temperature Profile



### Handling Precautions

| Parameter                        | Rating    | Standard                 |
|----------------------------------|-----------|--------------------------|
| ESD – Human Body Model (HBM)     | Class 0B  | ESDA / JEDEC JS-001-2014 |
| ESD – Charge Device Model (CDM)  | Class C2A | ESDA / JEDEC JS-002-2014 |
| MSL – Moisture Sensitivity Level | MSL 3     | 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
- 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)

### Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2019 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc