

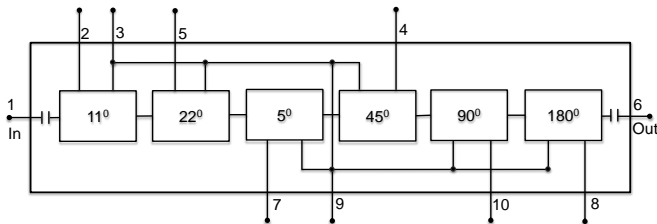
### Product Description

The Qorvo TGP2109 is a 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15μm 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.



### Block Diagram



### 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*

### 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 Ω, 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 μA

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

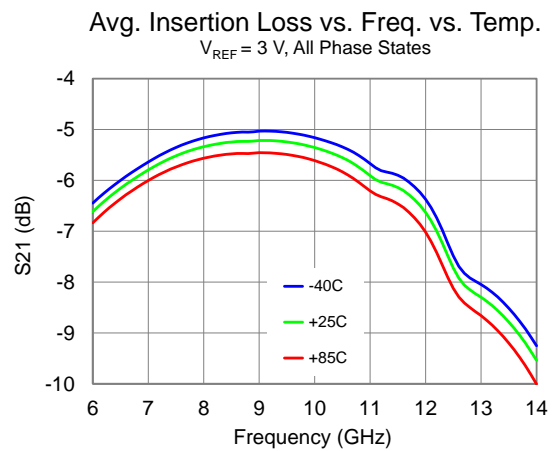
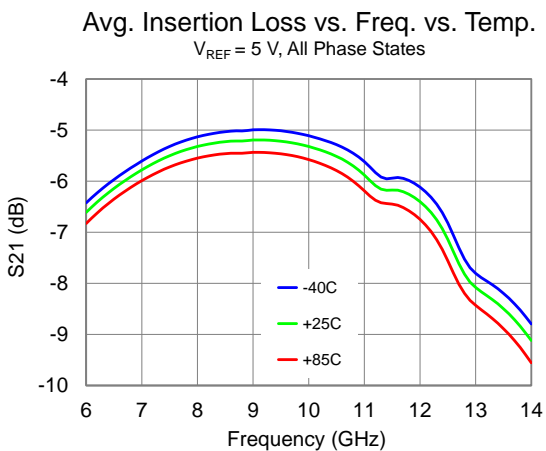
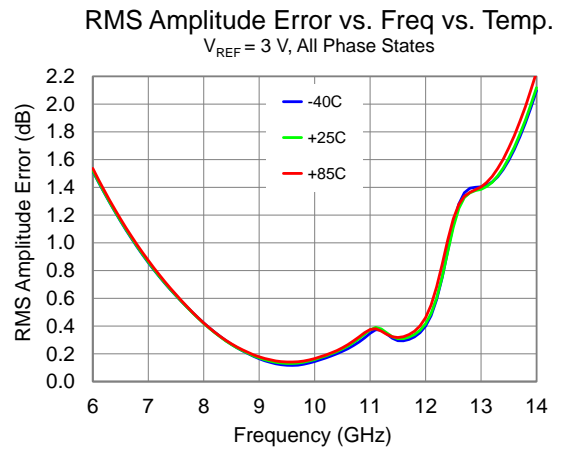
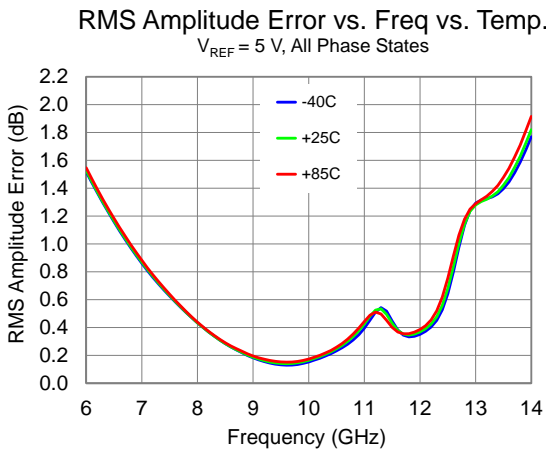
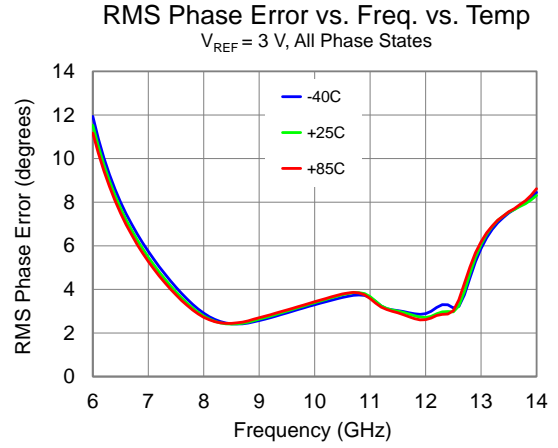
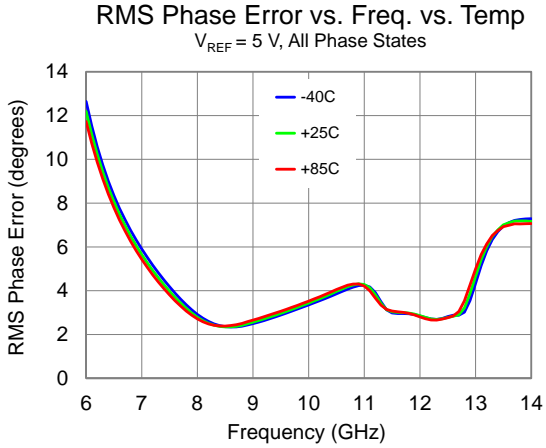
### Bias Truth Table

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

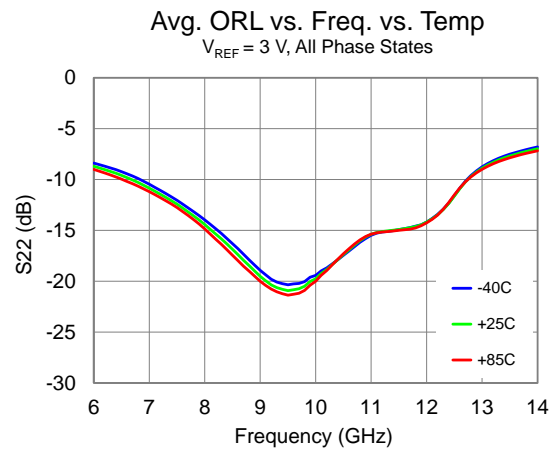
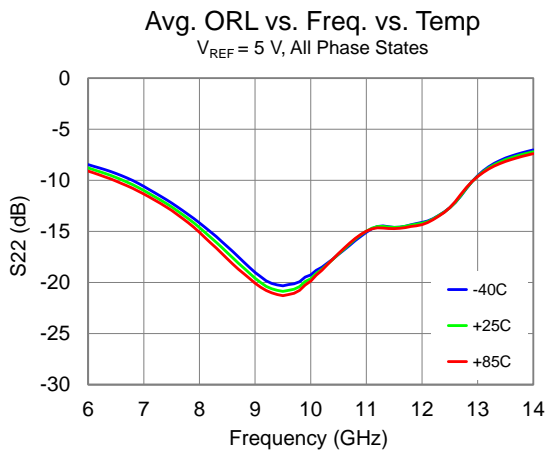
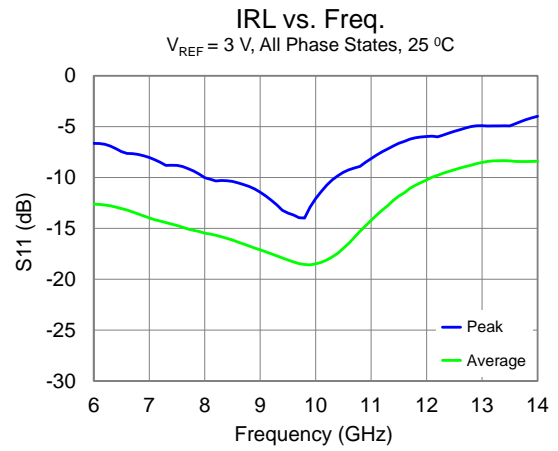
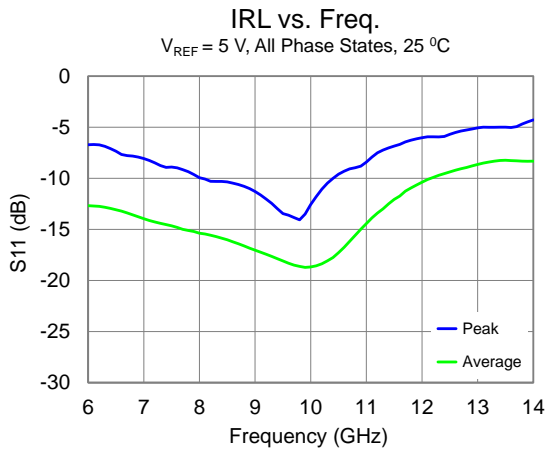
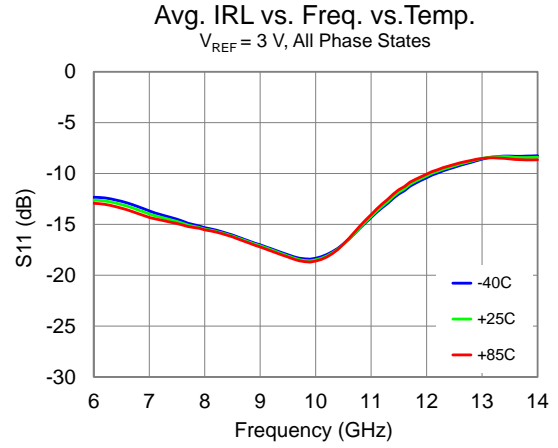
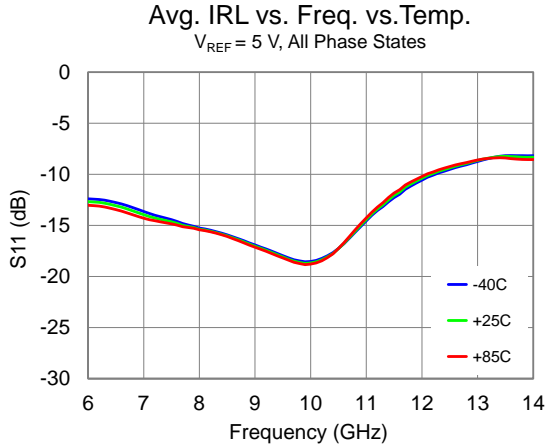
### Performance Plots – Small Signal

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



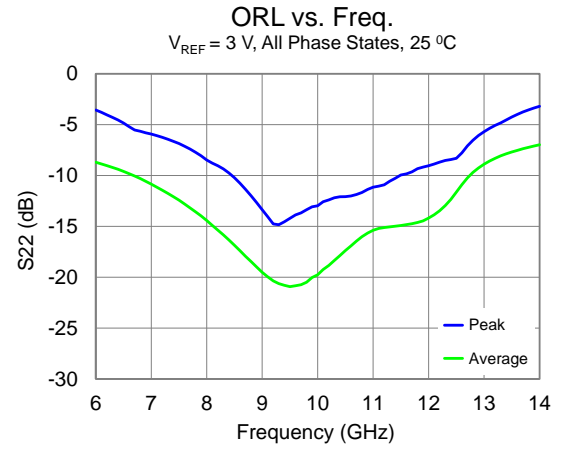
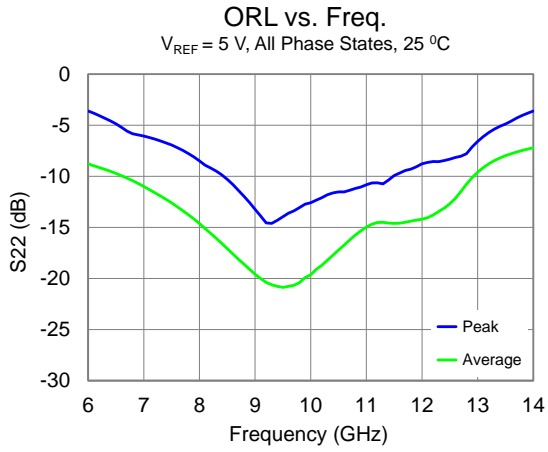
### Performance Plots – Small Signal (Cont.)

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



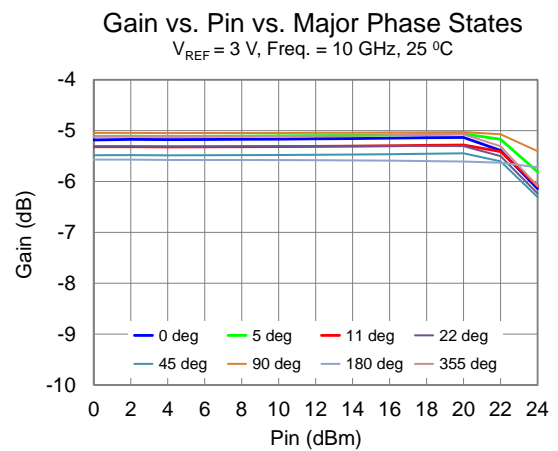
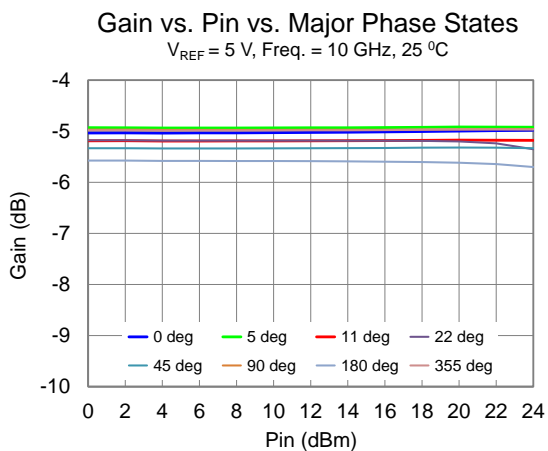
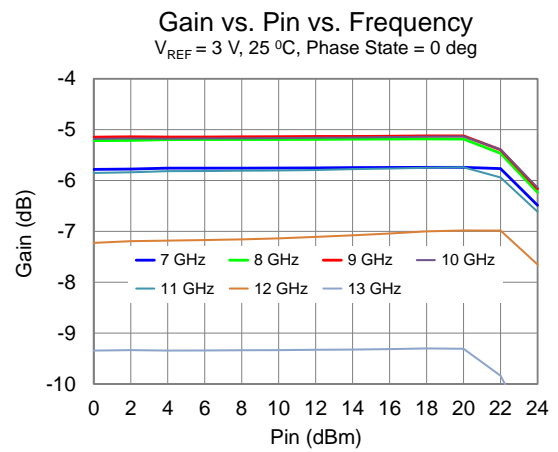
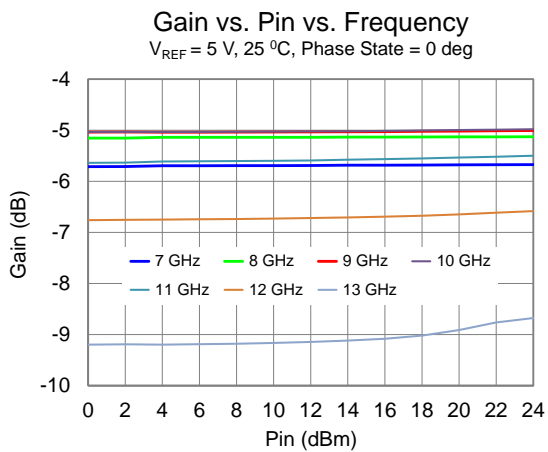
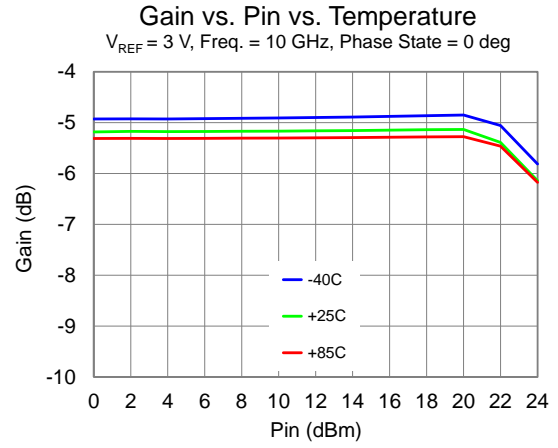
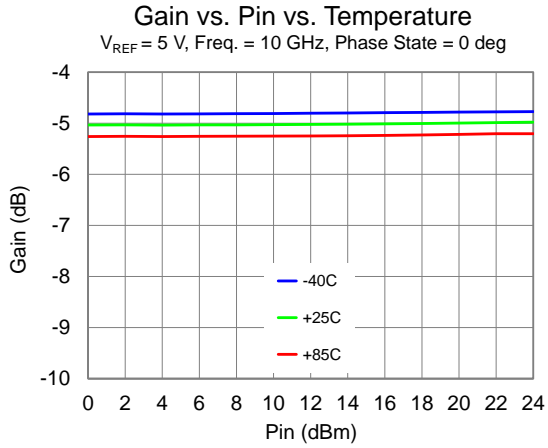
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Test conditions unless otherwise noted: 25 °C; 5V and 3V, 25



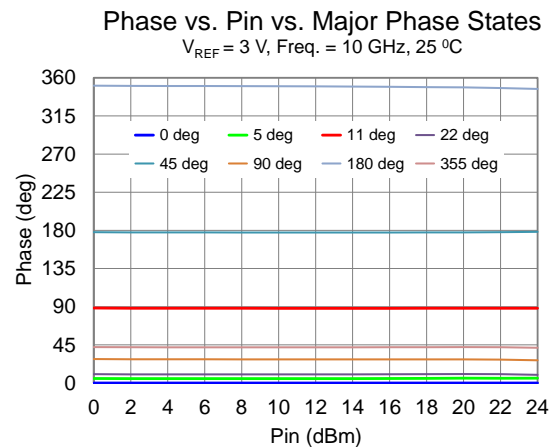
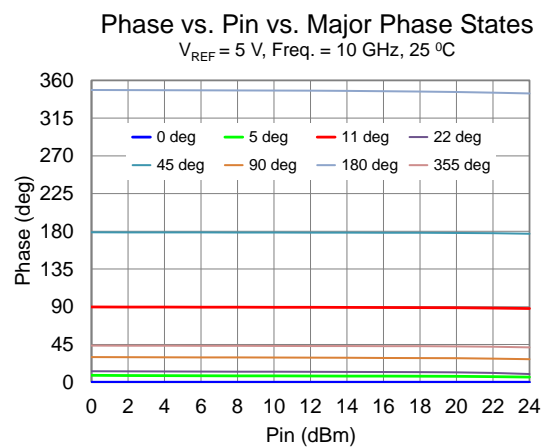
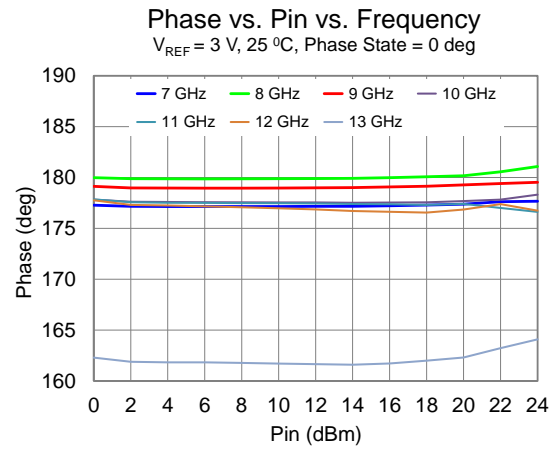
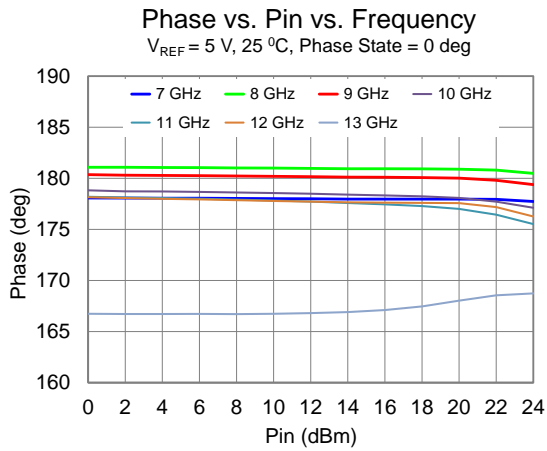
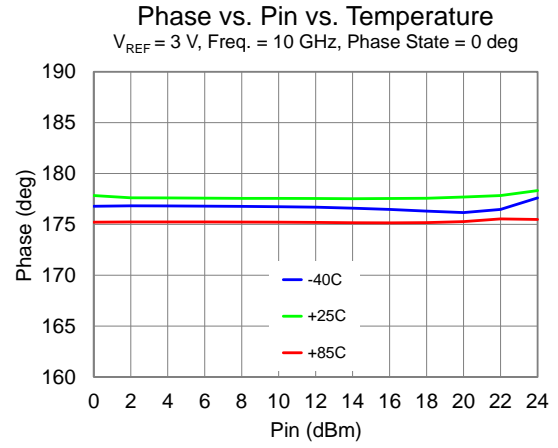
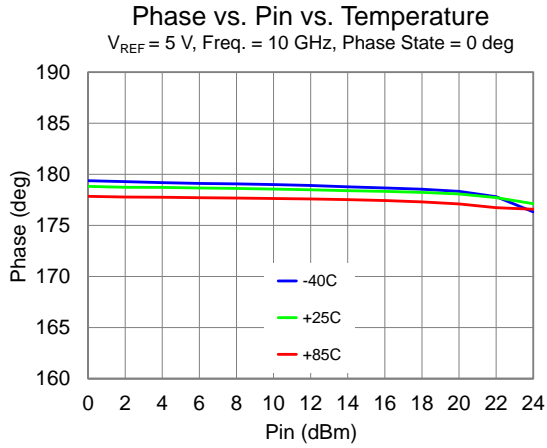
### Performance Plots – Large Signal

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



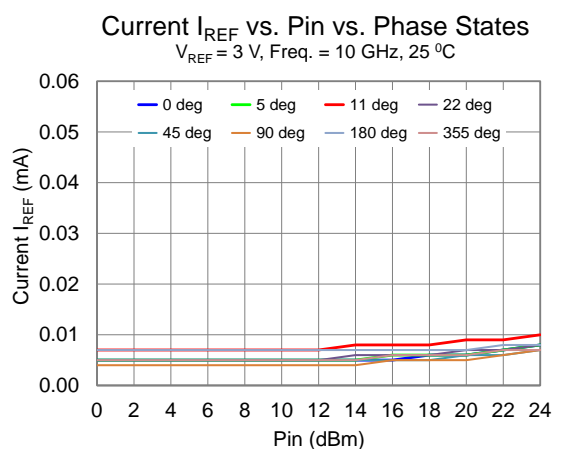
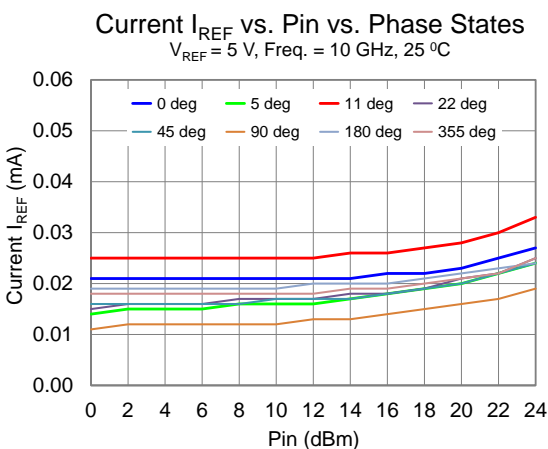
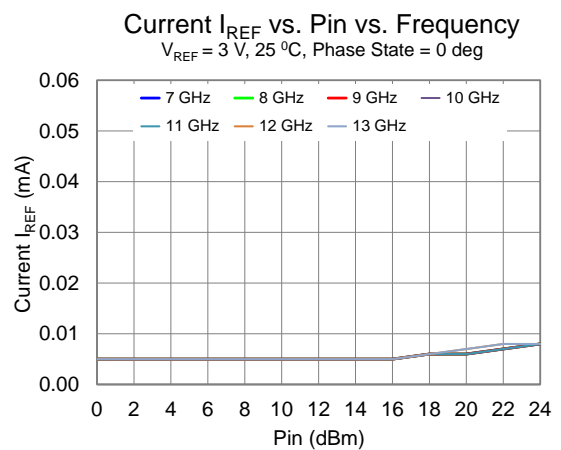
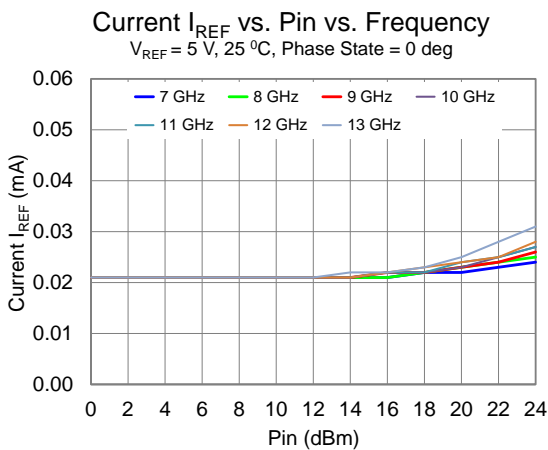
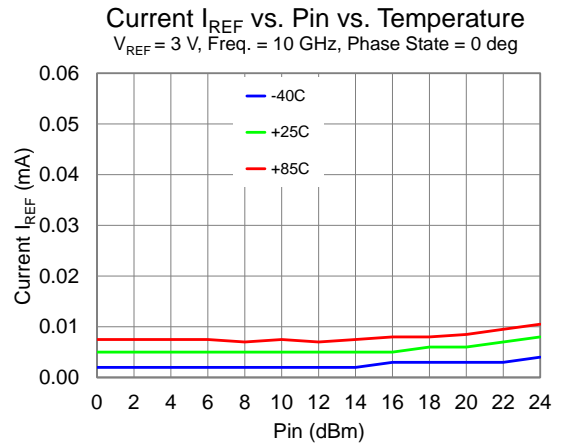
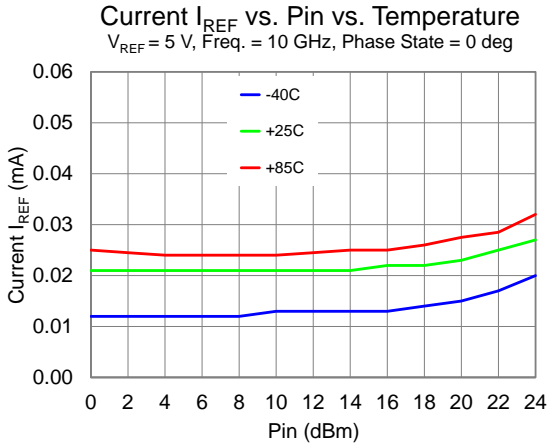
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Test conditions unless otherwise noted: 25 °C; 5V and 3V



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

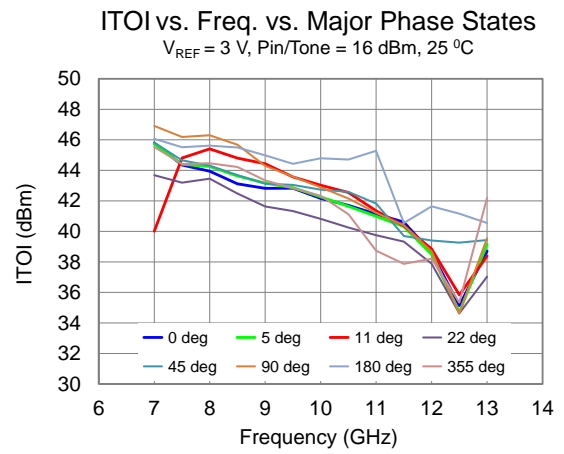
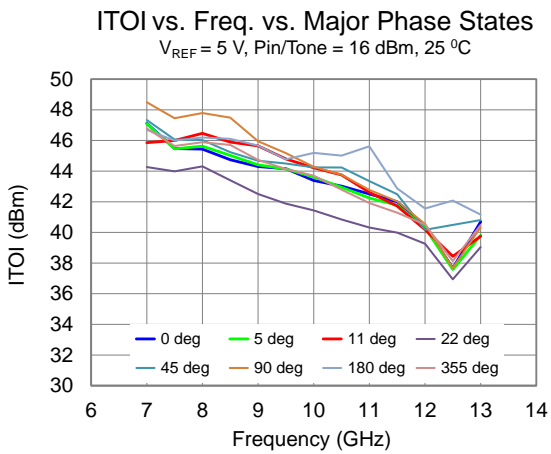
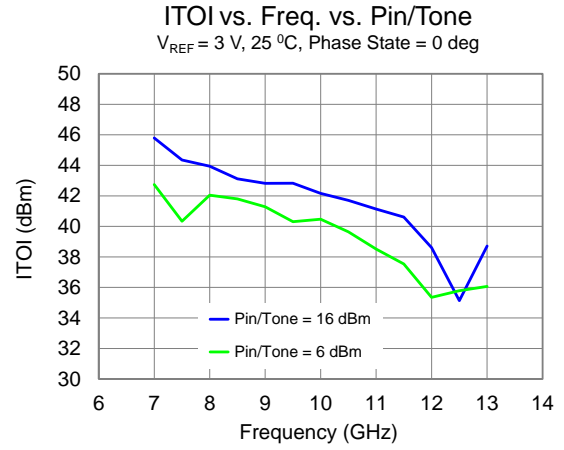
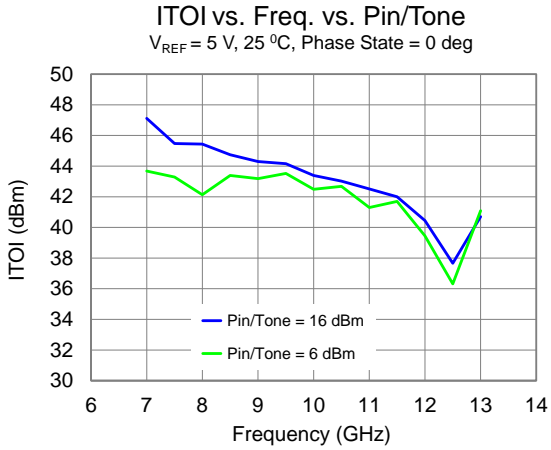
Test conditions unless otherwise noted: 25 °C; 5V and 3V





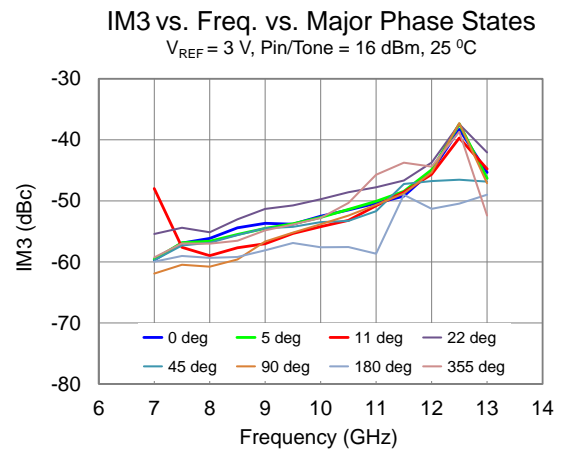
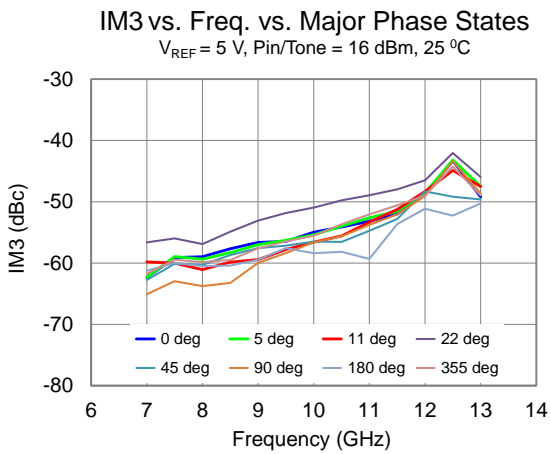
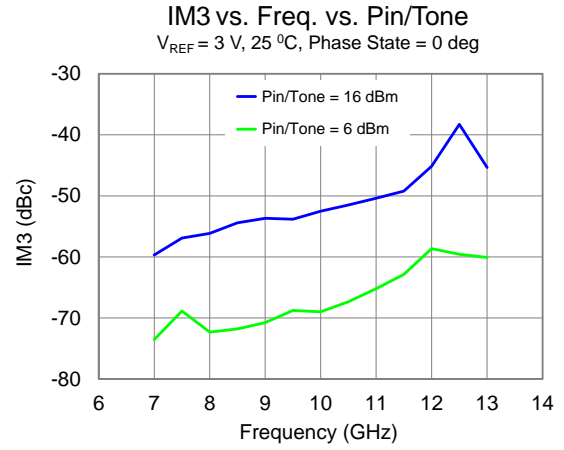
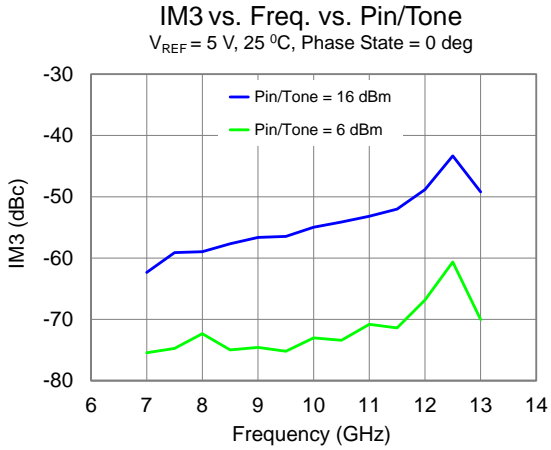
### Performance Plots – Linearity

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

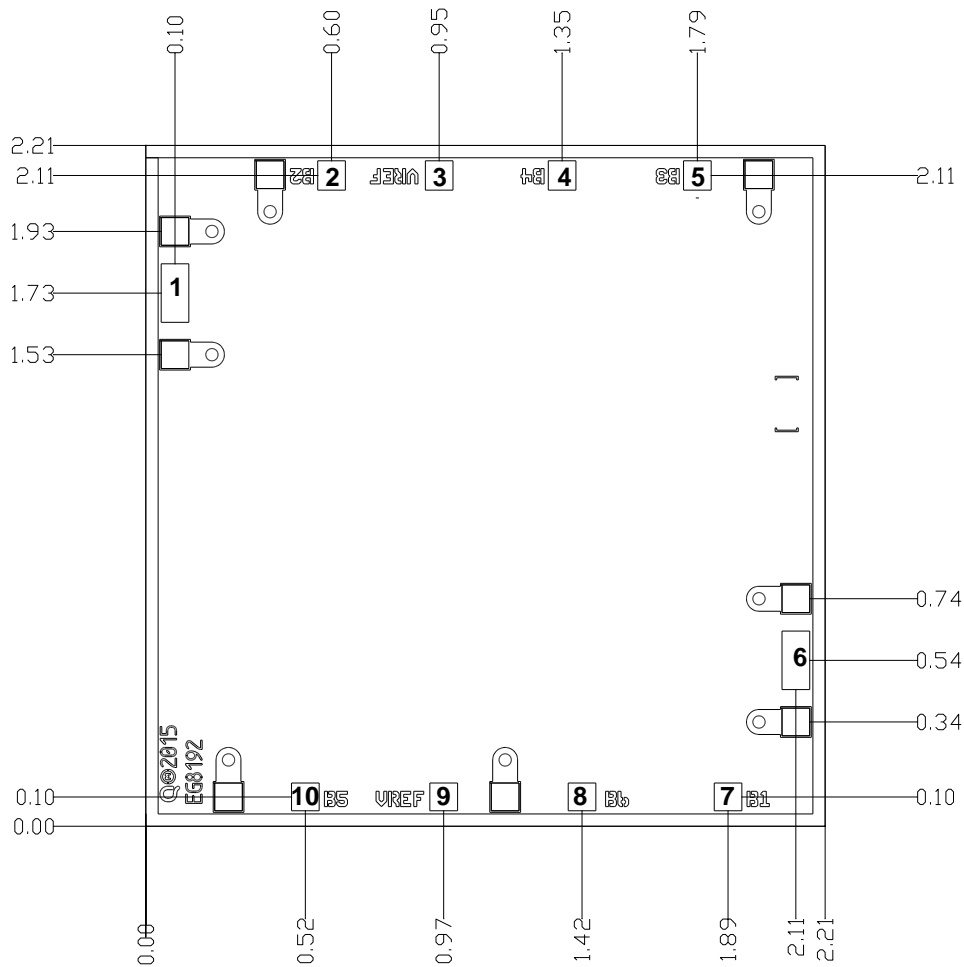


### Performance Plots – Linearity (Cont.)

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



### Mechanical Information and Bond Pad Description

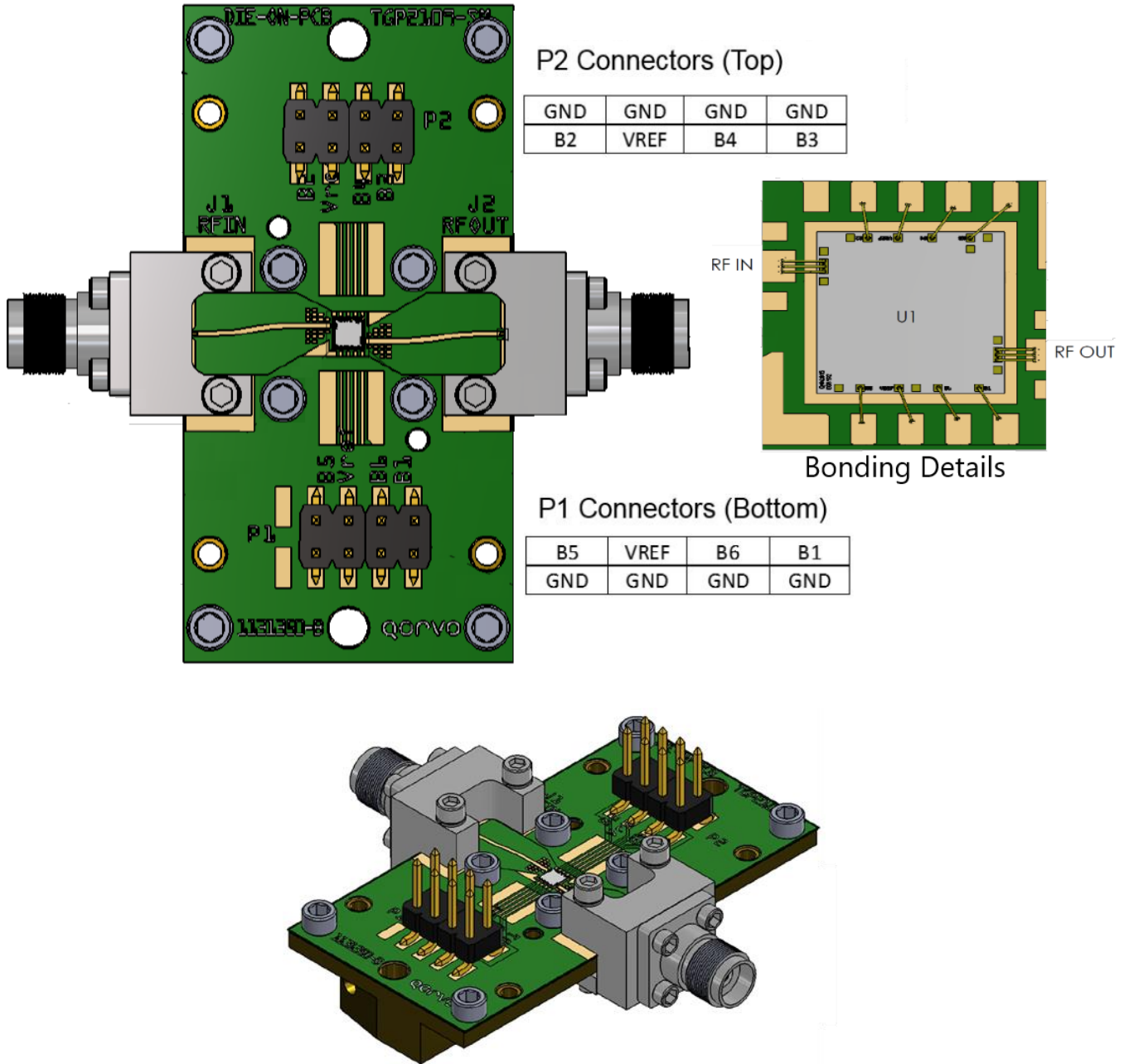


Unit: millimeters, Die thickness: 0.10, Die x, y size tolerance:  $\pm 0.050$   
 Chip edge to bond pad dimensions are shown to center of pad, Ground is backside of die

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 $^\circ$ 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 $^\circ$ Bit	0.100 x 0.100
5	B3	22 $^\circ$ 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 $^\circ$ Bit	0.100 x 0.100
8	B6	180 $^\circ$ Bit	0.100 x 0.100
10	B5	90 $^\circ$ 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

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### 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)	$T_{BASEPLATE} = 85^{\circ}C$	85	$^{\circ}C$
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

