# QPC2108

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

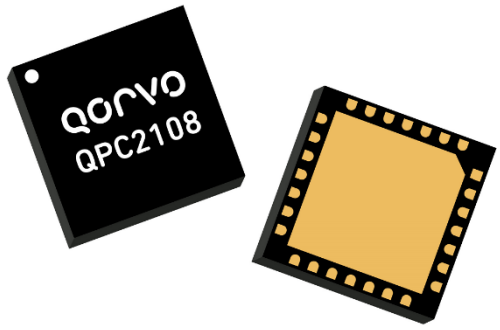
## Product Description

The Qorvo QPC2108 is a packaged 6-bit digital phase shifter fabricated on Qorvo's high performance 0.15 um 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.

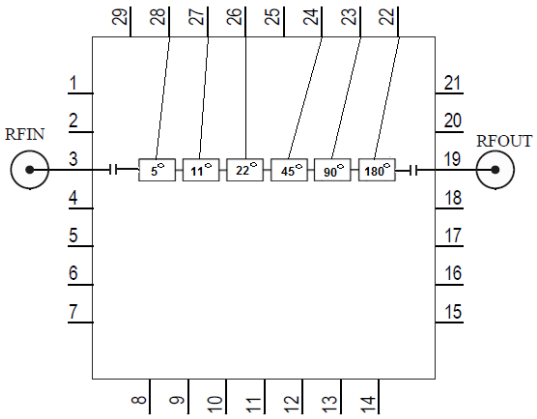



## Product Features

- 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 $P_{0.1dB}$: 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.*

### Block Diagram




### 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, $5^0$, $11^0$, $22^0$, $45^0$, $90^0$, $180^0$) = 0/+5 V; See Bias Truth Table.

| Parameter | Phase | Freq. (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 $P_{0.1dB}$ | | | | 23 | | dBm |
| Input IP3 (Spacing = 10 MHz, Pin/Tone = 10 dBm) | | | | 45 | | dBm |
| Insertion Loss Temperature Coefficient | | | | 0.003 | | dB/°C |

## Recommended Operating Conditions

| Parameter | Value / Range |
|---|---|
| Control Voltage (REF, $5^0$, $11^0$, $22^0$, $45^0$, $90^0$, $180^0$) | 0/+5 V |
| Current ($I_{REF}$, $I_{CTRL}$) | < 0.3 mA |
| Temperature Range | -40 to +85 $^0$C |
| Supply Current ($I_S$) | 100 uA typical |

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

## Bias Truth Table

Logic “0” = 0 V, Logic “1” = +5 V

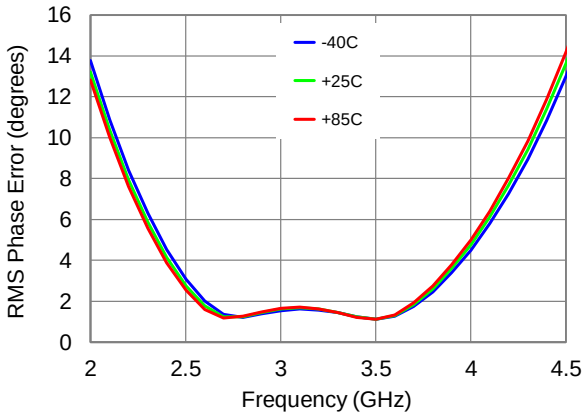
| Phase Shifter | $5^0$ | $11^0$ | $22^0$ | $45^0$ | $90^0$ | $180^0$ | REF |
|---|---|---|---|---|---|---|---|
| 0° (Reference) | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 5° | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11° | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 22° | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 45° | 0 | 0 | 0 | 1 | 0 | 0 | 1 |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

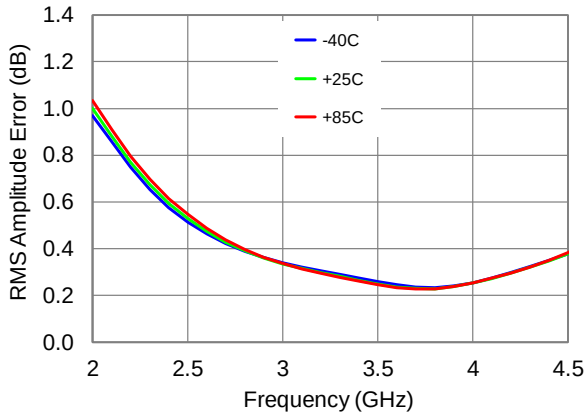
RMS Phase Error vs. Freq. vs. Temp

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



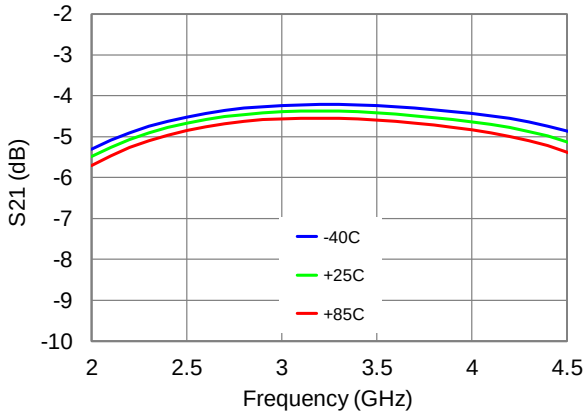

RMS Amplitude Error vs. Freq vs. Temp.

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



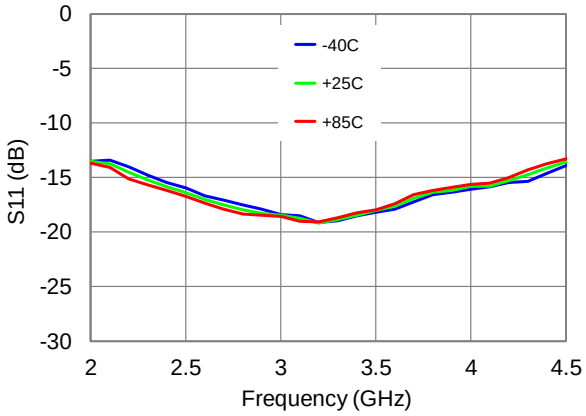

Avg. Insertion Loss vs. Freq. vs. Temp.

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



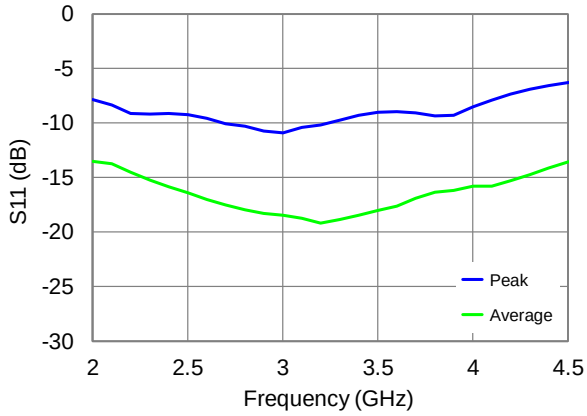

Avg. IRL vs. Freq. vs.Temp.

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




IRL vs. Freq.

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

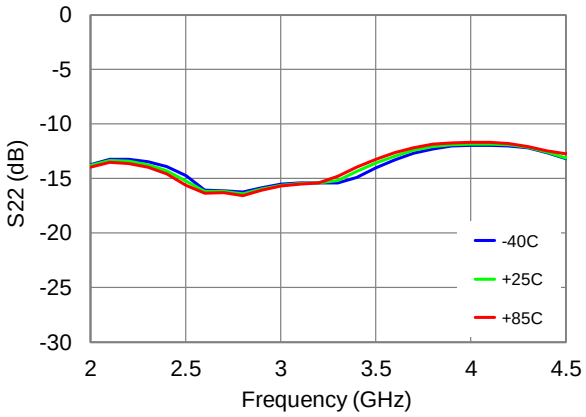


## Performance Plots – Small Signal (Cont.)

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

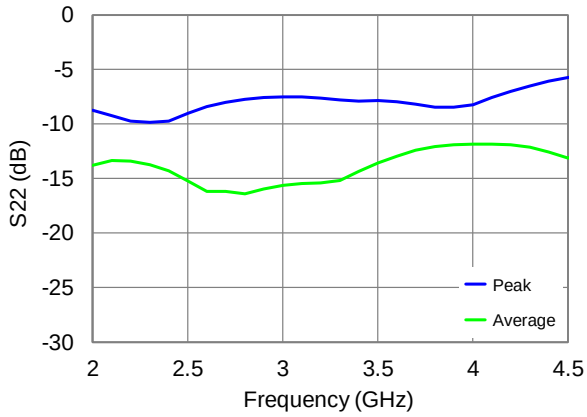
Avg. ORL vs. Freq. vs. Temp

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



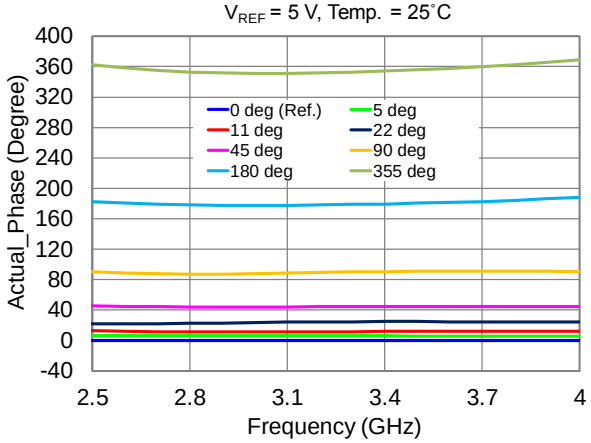

ORL vs. Freq.

$V_{REF}$ = 5 V, All Phase States, 25 $^0$C




Phase Shift vs. Frequency

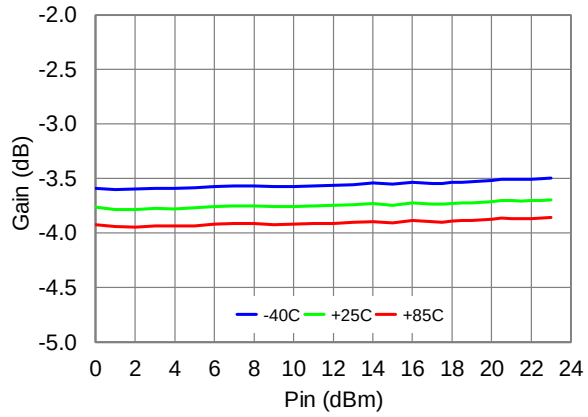
$V_{REF}$ = 5 V, Temp. = 25˚C



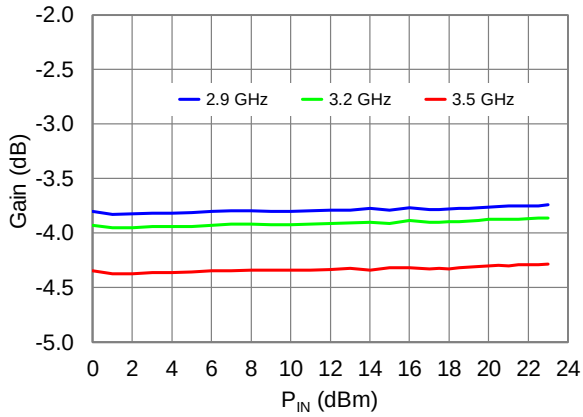
## Performance Plots – Large Signal & Linearity

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

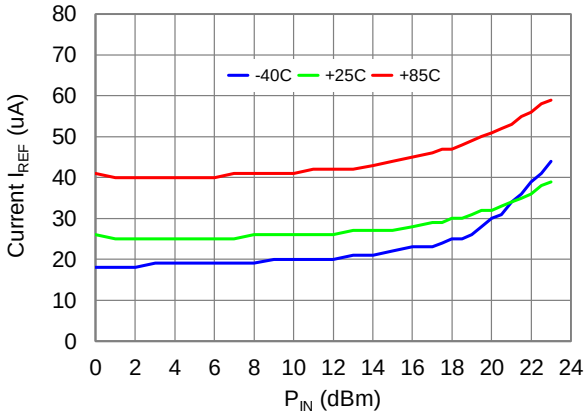
Gain vs. Pin vs. Temperature
$V_{REF}$ = 5 V, Freq. = 3 GHz, Phase State = 0 deg



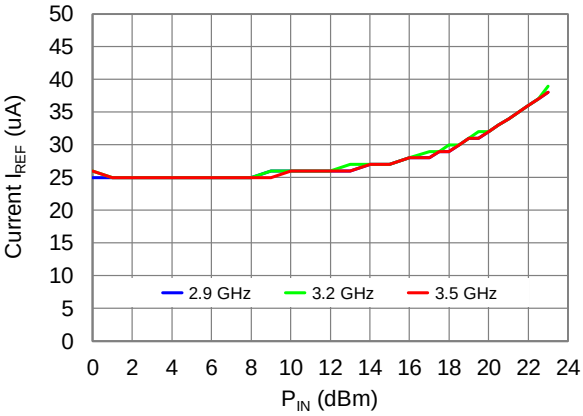

Gain vs. $P_{IN}$ vs. Frequency
$V_{REF}$ = 5 V, 25 °C, Phase State = 0 deg



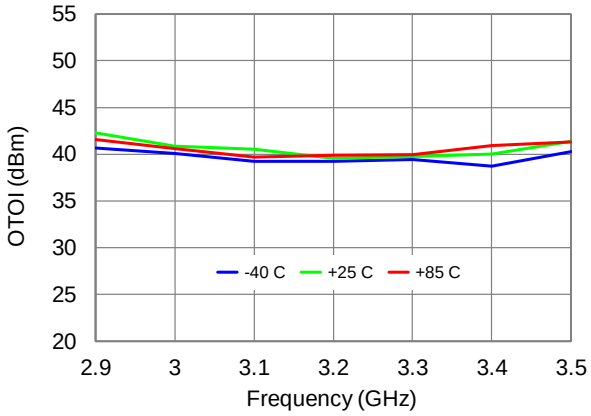

Current $I_{REF}$ vs. $P_{IN}$ vs. Temperature
$V_{REF}$ = 5 V, Freq. = 3 GHz, Phase State = 0 deg



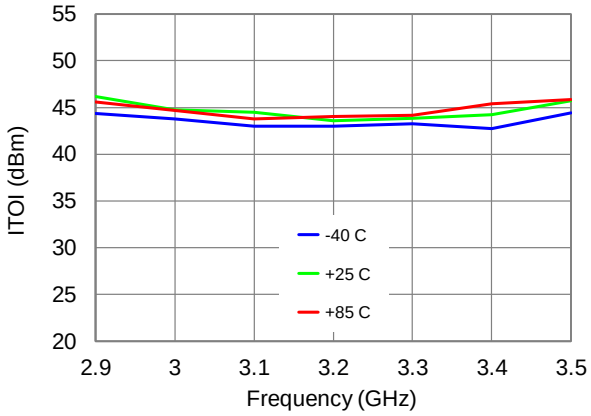

Current $I_{REF}$ vs. $P_{IN}$ vs. Frequency
$V_{REF}$ = 5 V, 25 °C, Phase State = 0 deg




OTOI vs. Freq. vs. Temperature
$V_{REF}$ = 5 V, $P_{IN}$/Tone = 10 dBm, Phase State = 0 deg




ITOI vs. Freq. vs. Temperature
$V_{REF}$ = 5 V, $P_{IN}$/Tone = 10 dBm, Phase State = 0 deg

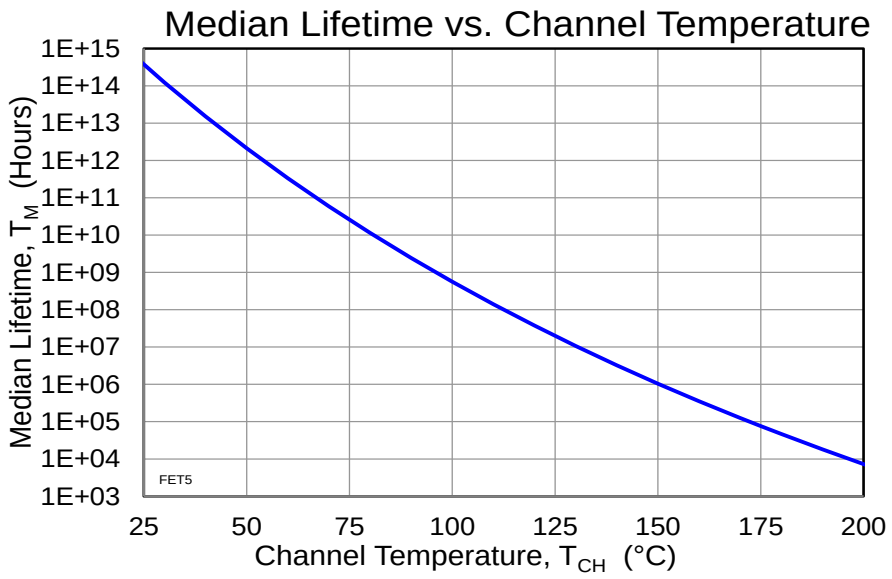


## Thermal and Reliability Information

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

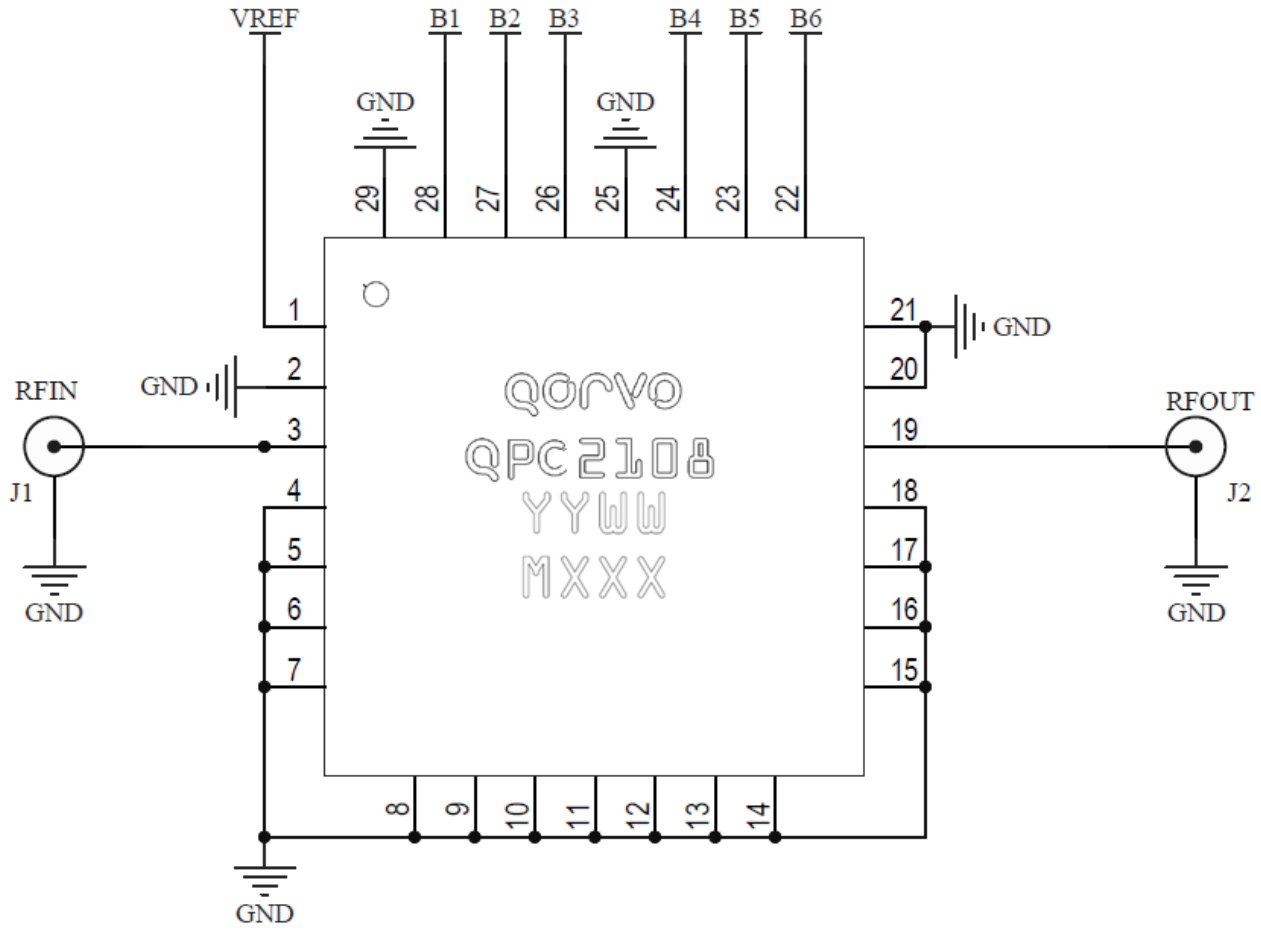
Notes:
1. Under normal (lifetime) operating conditions, self-heating is not a significant contributor to channel temperature.

## Median Lifetime

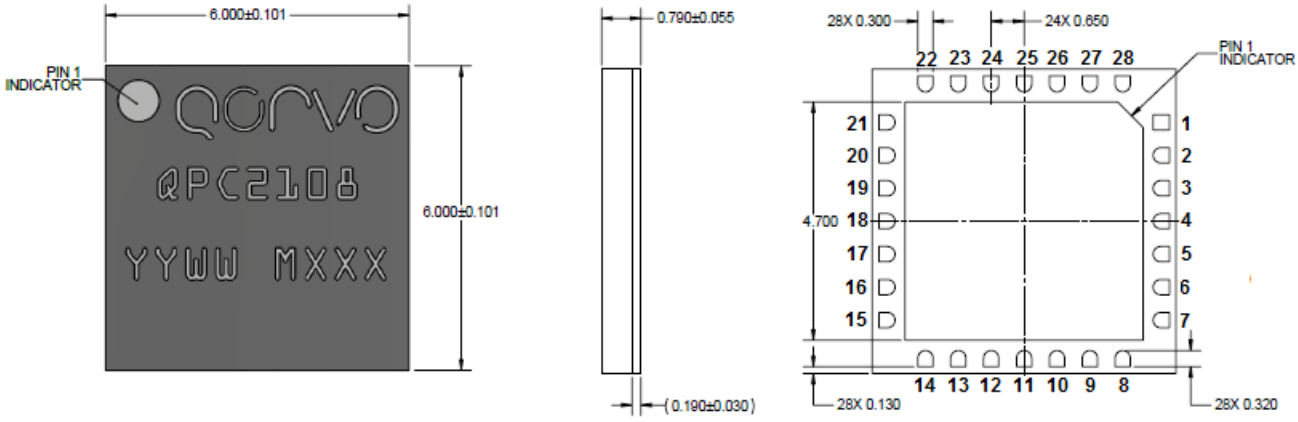


## Applications Circuit

De-Quing network is not required



## Mechanical Information

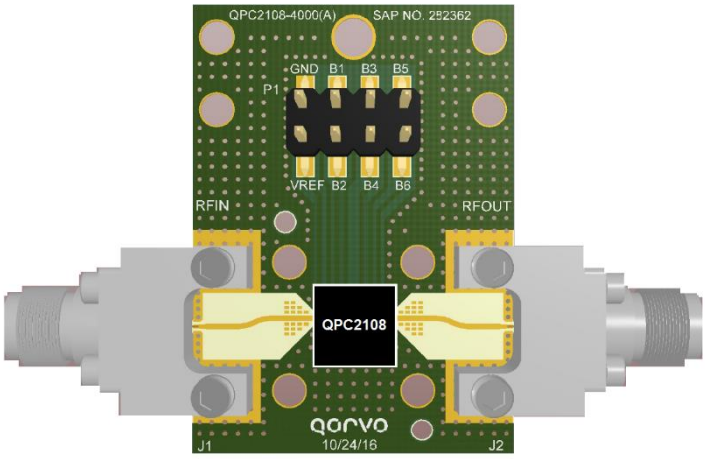


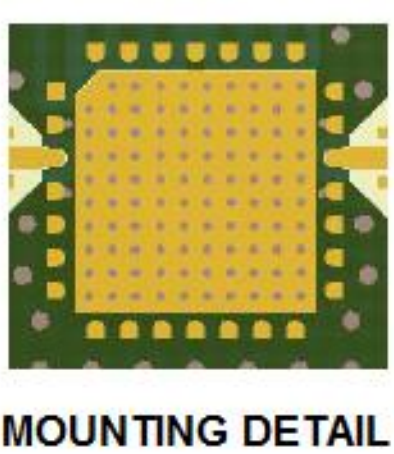

Units: millimeters
Materials:
Base: Laminate
Packaged Exposed Metallization is gold plated
Marking:
QPC2108: Part number
YY: Part Assembly year
WW: Part Assembly week
MXXX: Batch ID

## 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



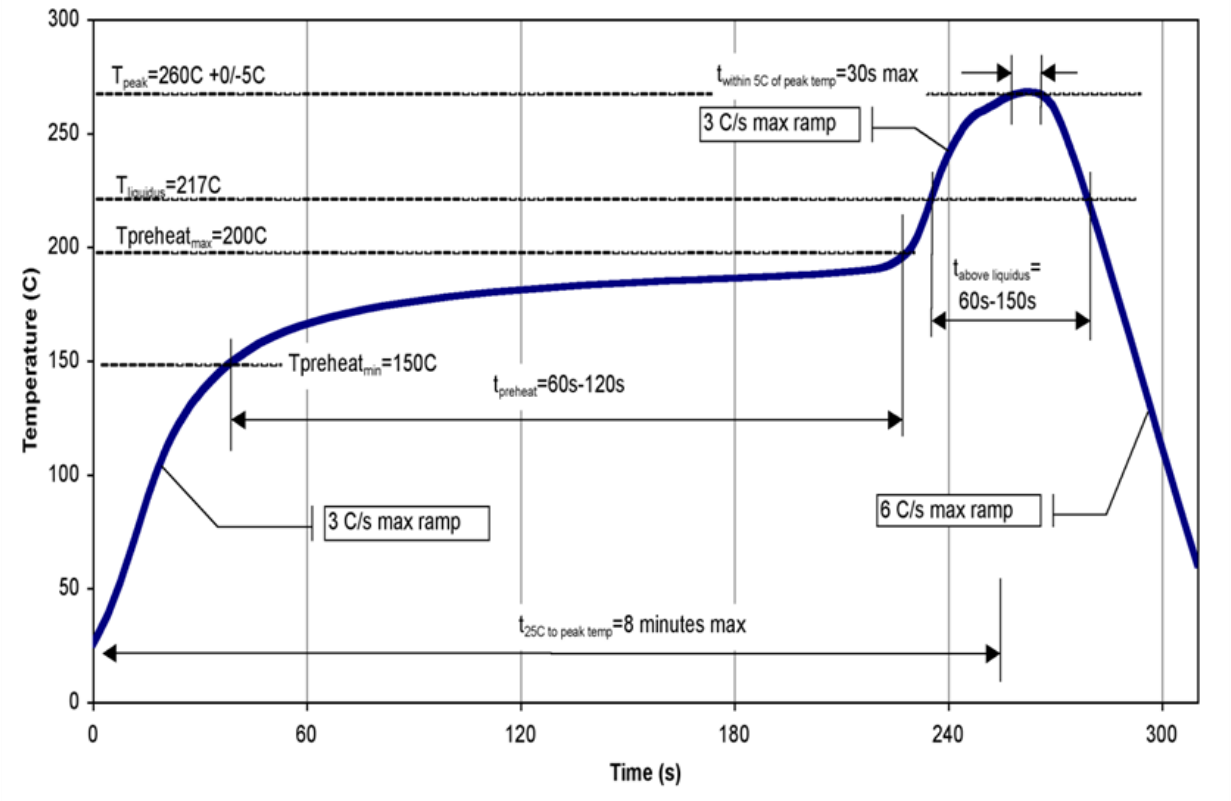
MOUNTING DETAIL

## 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 Ω, 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 ($C_{15}H_{12}Br_4O_2$) 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**

**Email:** customer.support@qorvo.com

For technical questions and application information: **Email:** appsupport@qorvo.com

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