

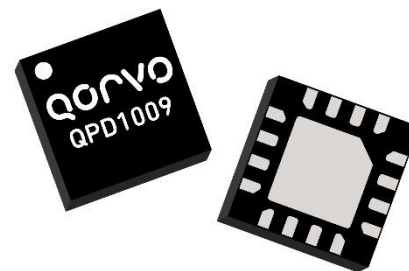
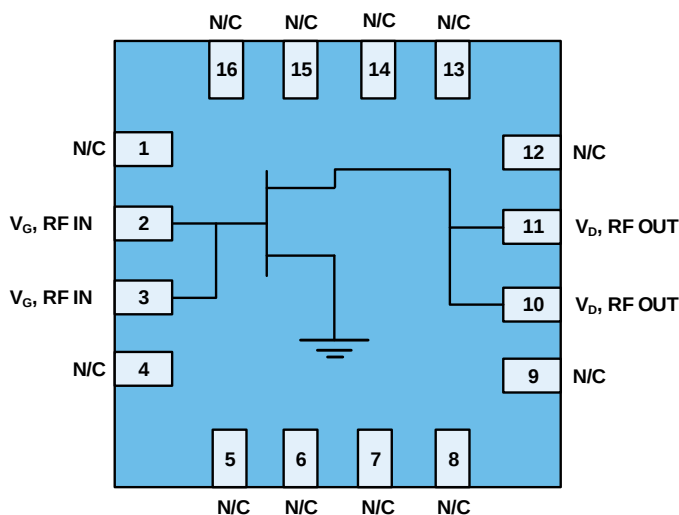
### General Description

Qorvo's QPD1009 is a 15 W ( $P_{3dB}$ ) wideband unmatched discrete GaN on SiC HEMT which operates from DC to 4 GHz and a 50V supply rail. The device is an industry standard 3x3 mm plastic overmold package and is ideally suited to military and civilian radar, land mobile and military radio communications, wireless infrastructure communications, avionics, and test instrumentation. The device can support pulsed, CW and linear operations.

Lead-free and ROHS compliant.

Evaluation boards are available upon request.

### Functional Block Diagram



3 x 3 x 0.100 mm

### Product Features

- Frequency: DC to 4 GHz
- Output Power ( $P_{3dB}$ ): 17 W at 2 GHz
- Linear Gain: 24 dB at 2 GHz
- Typical  $PAE_{3dB}$ : 72% at 2 GHz
- Operating Voltage: 50 V
- Low thermal resistance package
- CW and Pulse capable
- 3 x 3 mm package

### Applications

- Military radar
- Civilian radar
- Land mobile and military radio communications
- Test instrumentation
- Wideband or narrowband amplifiers
- Jammers

### Ordering info

| Part No.     | Description            |
|--------------|------------------------|
| QPD1009      | DC–4 GHz RF Transistor |
| 1132871      | 0.96 – 1.215 GHz EVB   |
| QPD1009EVB02 | 1.1 – 1.7 GHz EVB      |

## Absolute Maximum Ratings<sup>1</sup>

| Parameter                                                         | Rating      | Units            |
|-------------------------------------------------------------------|-------------|------------------|
| Breakdown Voltage, $BV_{DG}$                                      | +145        | V                |
| Gate Voltage Range, $V_G$                                         | -7 to +2    | V                |
| Drain Current, $I_{DSS}$                                          | 1600        | mA               |
| Gate Current Range, $I_G$                                         | See page 4. | mA               |
| Power Dissipation, CW, $P_{DISS}$                                 | 16          | W                |
| RF Input Power at 2 GHz, CW, 50 $\Omega$ , $T = 25^\circ\text{C}$ | +27         | dBm              |
| Mounting Temperature (30 Seconds)                                 | 320         | $^\circ\text{C}$ |
| Storage Temperature                                               | -40 to +150 | $^\circ\text{C}$ |

Notes:

1. . Operation of this device outside the parameter ranges given above may cause permanent damage.

## Recommended Operating Conditions<sup>1</sup>

| Parameter                                           | Min | Typ  | Max  | Units            |
|-----------------------------------------------------|-----|------|------|------------------|
| Operating Temp. Range                               | -40 | +25  | +85  | $^\circ\text{C}$ |
| Drain Voltage Range, $V_D$                          | +12 | +50  | +60  | V                |
| Drain Bias Current, $I_{DQ}$                        | –   | 26   | –    | mA               |
| Drain Current, $I_D$                                | –   | 700  | –    | mA               |
| Gate Voltage, $V_G$                                 | –   | -2.8 | –    | V                |
| Power Dissipation, CW ( $P_D$ ) <sup>2</sup>        | –   | –    | 14.4 | W                |
| Power Dissipation, Pulsed ( $P_D$ ) <sup>2, 3</sup> | –   | –    | 17.5 | W                |

Notes:

1. Electrical performance is measured under conditions noted in the electrical specifications table. Specifications are not guaranteed over all recommended operating conditions.
2. Package at 85  $^\circ\text{C}$
3. Pulse Width = 128  $\mu\text{s}$ , Duty Cycle = 10%

## Pulsed Characterization – Load Pull Performance – Power Tuned

| Parameters                                                   | Typical Values |      |      |      |      | Unit |
|--------------------------------------------------------------|----------------|------|------|------|------|------|
| Frequency, F                                                 | 1              | 2    | 3    | 3.5  | 4    | GHz  |
| Linear Gain, $G_{LIN}$                                       | 27             | 23.7 | 20.9 | 19.7 | 18.7 | dB   |
| Output Power at 3dB compression point, $P_{3dB}$             | 41.9           | 42.4 | 42.4 | 42.2 | 41.8 | dBm  |
| Power-Added-Efficiency at 3dB compression point, $PAE_{3dB}$ | 64.1           | 67.3 | 61.4 | 56.9 | 50.0 | %    |
| Gain at 3dB compression point                                | 24             | 20.7 | 17.9 | 16.7 | 15.7 | dB   |

Notes:

1. Test conditions unless otherwise noted:  $V_D = +50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Temp = +25 °C

## Pulsed Characterization – Load Pull Performance – Efficiency Tuned

| Parameters                                                   | Typical Values |      |      |      |      | Unit |
|--------------------------------------------------------------|----------------|------|------|------|------|------|
| Frequency                                                    | 1              | 2    | 3    | 3.5  | 4    | GHz  |
| Linear Gain, $G_{LIN}$                                       | 26.8           | 24.0 | 21.8 | 20.5 | 19.3 | dB   |
| Output Power at 3dB compression point, $P_{3dB}$             | 40             | 41.9 | 40.9 | 40.7 | 41.2 | dBm  |
| Power-Added-Efficiency at 3dB compression point, $PAE_{3dB}$ | 77.8           | 72.4 | 69.6 | 63.3 | 54.6 | %    |
| Gain at 3dB compression point, $G_{3dB}$                     | 23.8           | 21.0 | 18.8 | 17.5 | 16.3 | dB   |

Notes:

1. Test conditions unless otherwise noted:  $V_D = +50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Temp = +25 °C

## RF Characterization – 0.96 – 1.215 GHz EVB Performance At 1.09 GHz<sup>1</sup>

| Parameter                                               | Min | Typ  | Max | Units |
|---------------------------------------------------------|-----|------|-----|-------|
| Linear Gain, $G_{LIN}$                                  | –   | 19.5 | –   | dB    |
| Output Power at 3dB compression point, $P_{3dB}$        | –   | 41.4 | –   | dBm   |
| Drain Efficiency at 3dB compression point, $DEFF_{3dB}$ | –   | 53.9 | –   | %     |
| Gain at 3dB compression point, $G_{3dB}$                | –   | 16.5 | –   | dB    |

Notes:

1.  $V_D = +50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Temp = +25 °C, Pulse Width = 128  $\mu\text{s}$ , Duty Cycle = 10%

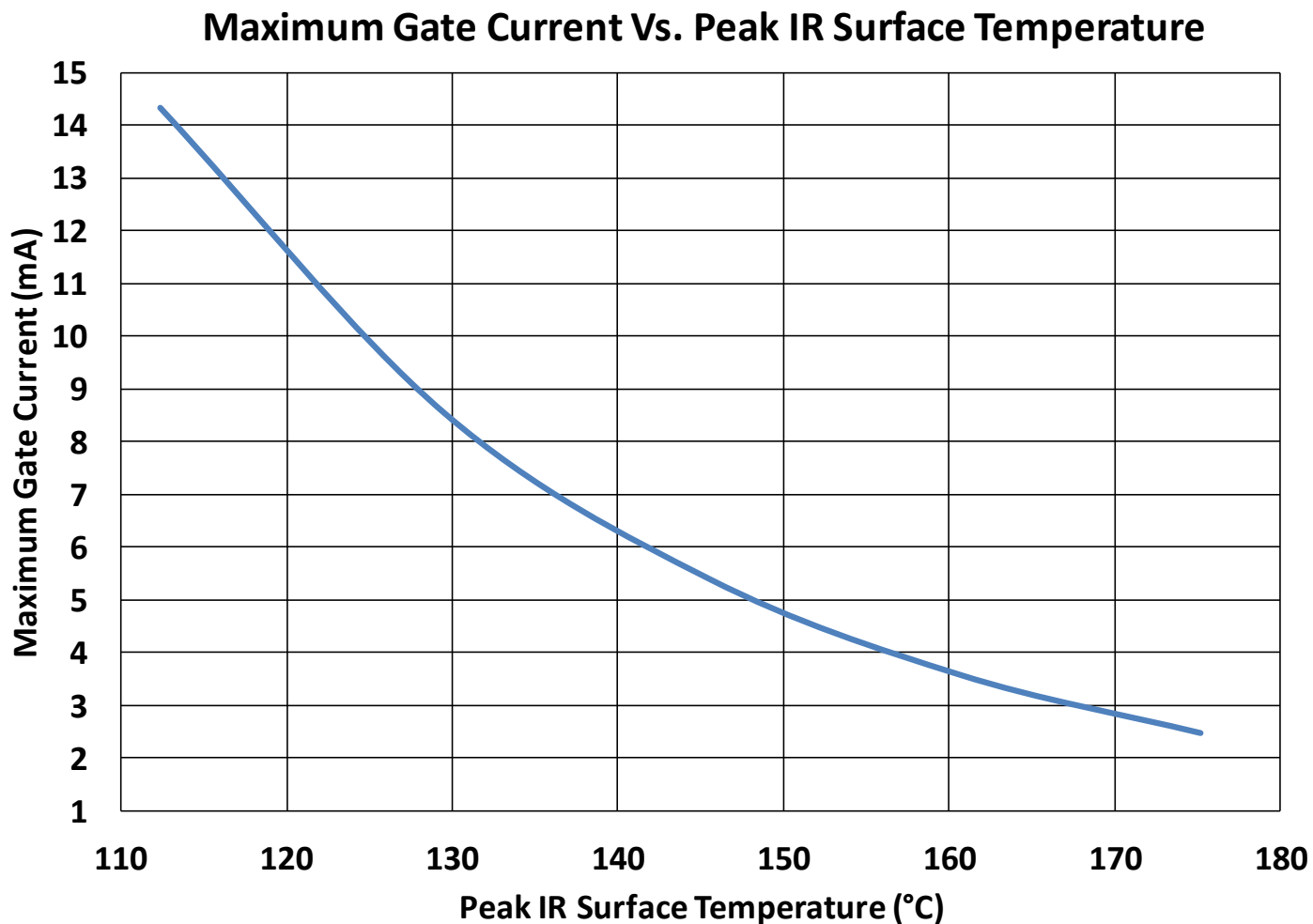
## RF Characterization – Mismatch Ruggedness at 1.09 GHz

| Symbol | Parameter                     | dB Compression | Typical |
|--------|-------------------------------|----------------|---------|
| VSWR   | Impedance Mismatch Ruggedness | 3              | 10:1    |

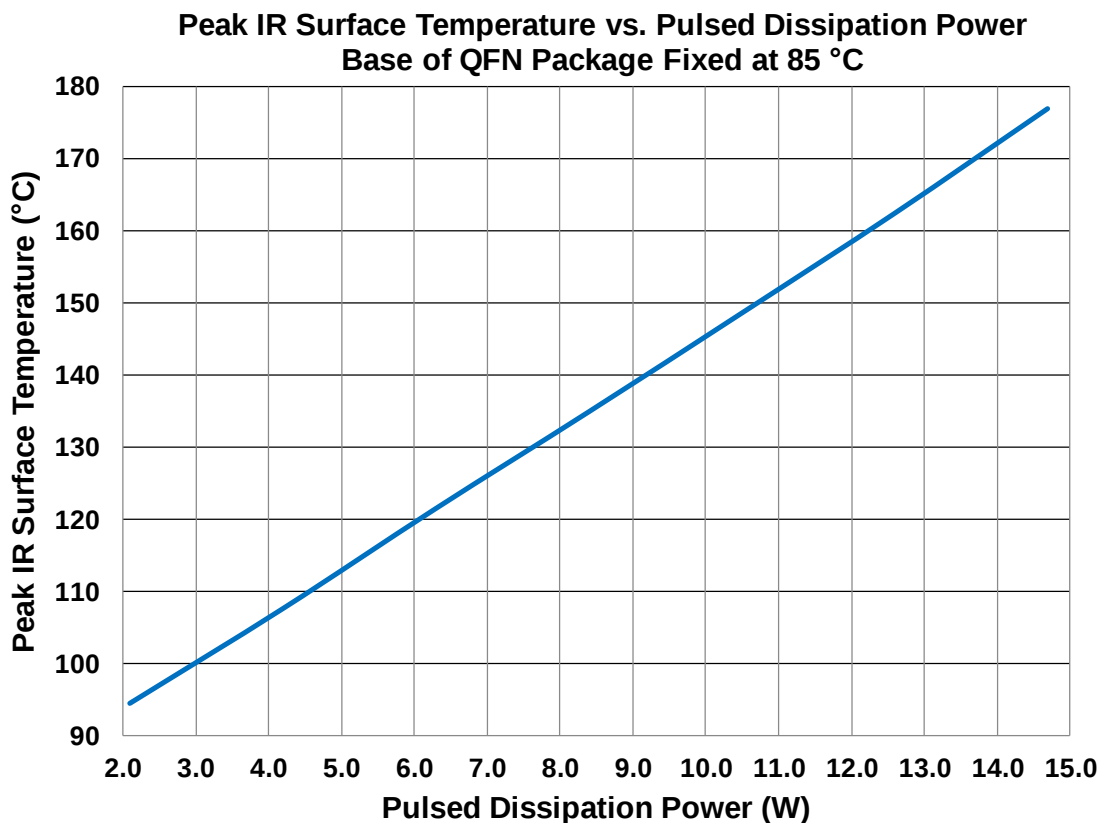
Test conditions unless otherwise noted:  $T_A = 25\text{ °C}$ ,  $V_D = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$

Driving input power is determined at pulsed compression under matched condition at EVB output connector.

Maximum Gate Current



## Thermal and Reliability Information - Pulsed

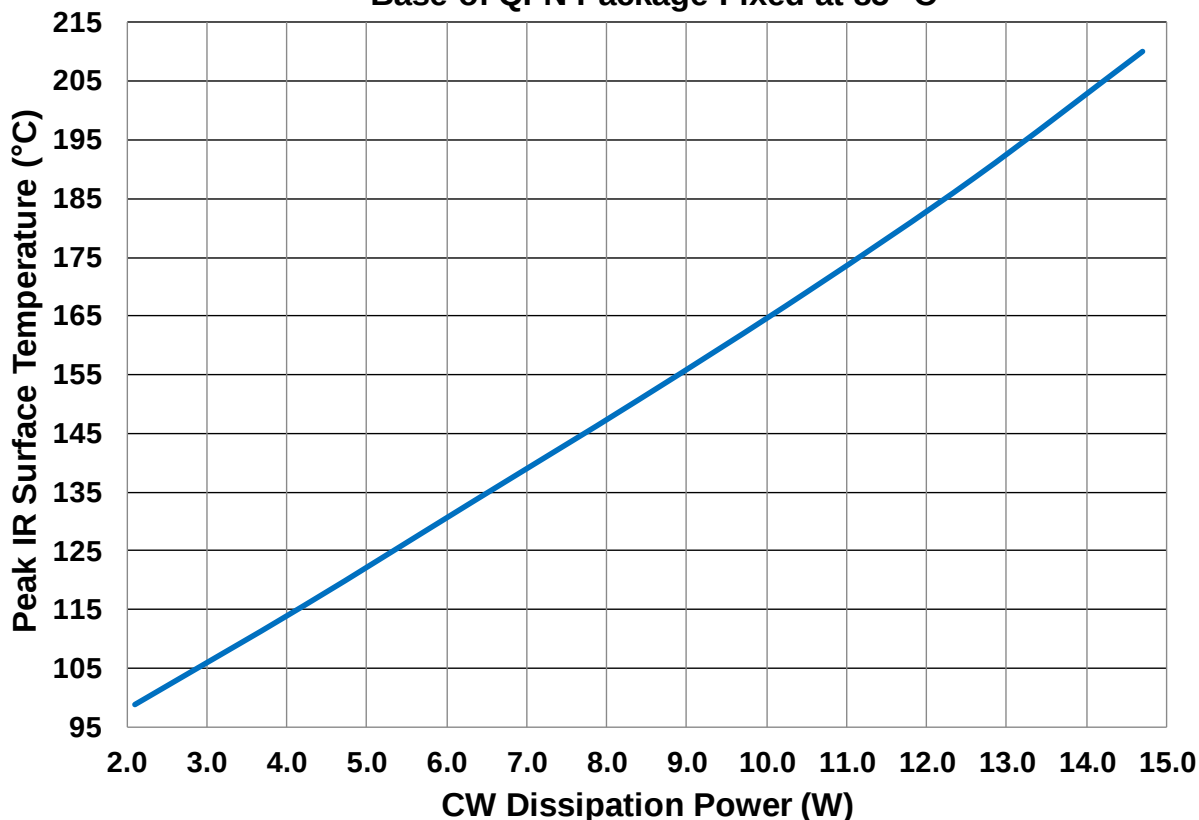


| Parameter                                             | Conditions                   | Values | Units |
|-------------------------------------------------------|------------------------------|--------|-------|
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case                   | 5.48   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 4.2 W Pdiss, 128 uS PW, 10%  | 108    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case                   | 5.87   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 6.3 W Pdiss, 128 uS PW, 10%  | 122    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case                   | 5.95   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 8.4 W Pdiss, 128 uS PW, 10%  | 135    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case                   | 6.10   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 10.5 W Pdiss, 128 uS PW, 10% | 149    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case                   | 6.11   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 12.6 W Pdiss, 128 uS PW, 10% | 162    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case                   | 6.26   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 14.7 W Pdiss, 128 uS PW, 10% | 177    | °C    |

<sup>1</sup>Refer to the following document [GaN Device Channel Temperature, Thermal Resistance, and Reliability Estimates](#)

## Thermal and Reliability Information - CW

**Peak IR Surface Temperature vs. CW Dissipation Power**  
**Base of QFN Package Fixed at 85 °C**



| Parameter                                             | Conditions       | Values | Units |
|-------------------------------------------------------|------------------|--------|-------|
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case       | 7.38   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 4.2 W Pdiss, CW  | 116    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case       | 7.62   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 6.3 W Pdiss, CW  | 133    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case       | 7.86   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 8.4 W Pdiss, CW  | 151    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case       | 8.00   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 10.5 W Pdiss, CW | 169    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case       | 8.25   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 12.6 W Pdiss, CW | 189    | °C    |
| Thermal Resistance, IR <sup>1</sup> ( $\theta_{JC}$ ) | 85 °C Case       | 8.50   | °C/W  |
| Peak IR Surface Temperature <sup>1</sup> ( $T_{CH}$ ) | 14.7 W Pdiss, CW | 210    | °C    |

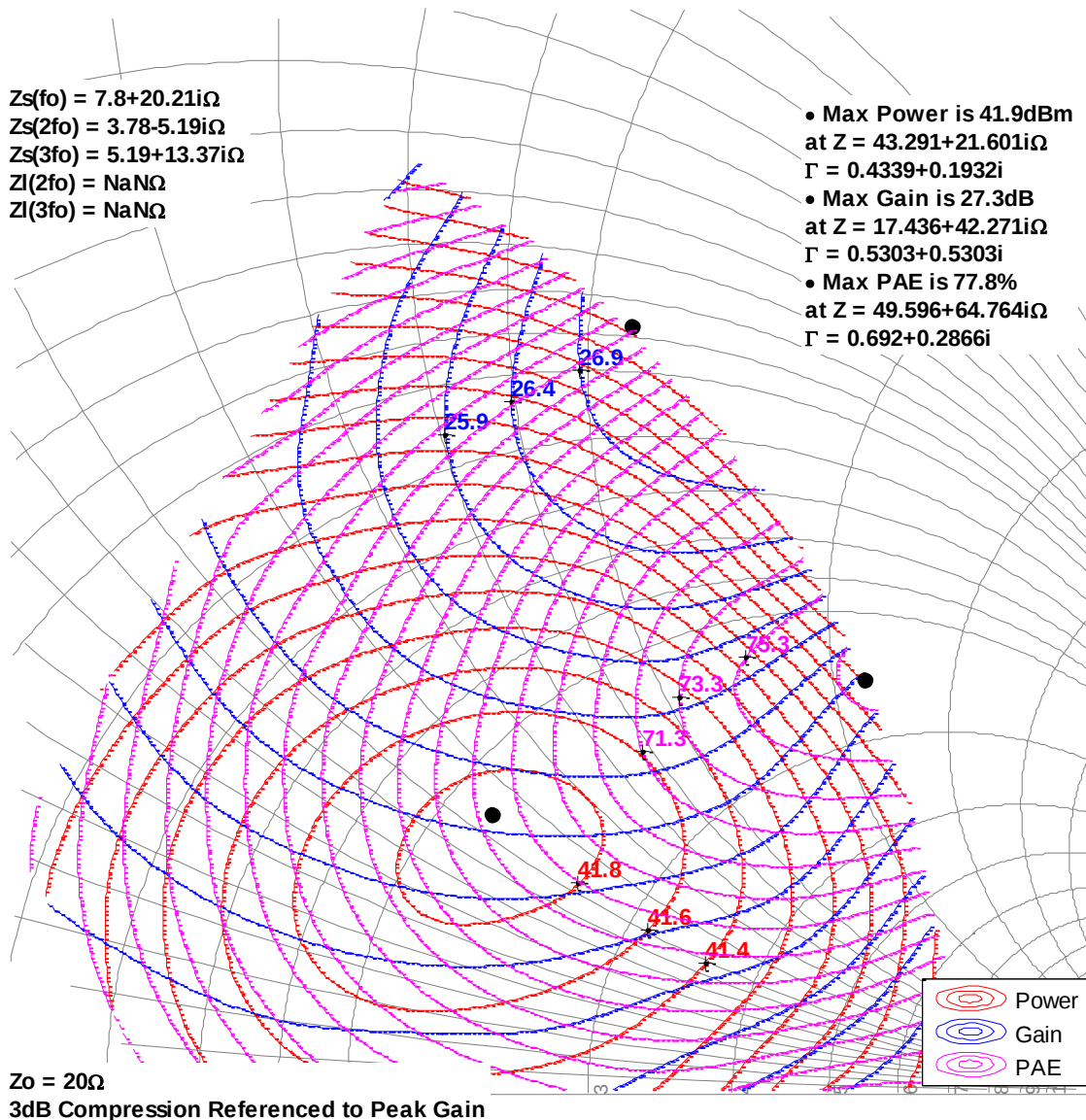
<sup>1</sup>Refer to the following document [GaN Device Channel Temperature, Thermal Resistance, and Reliability Estimates](#)

### Load Pull Smith Charts<sup>1, 2, 3</sup>

Notes:

1.  $V_d = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Pulsed signal with 128  $\mu\text{s}$  pulse width and 10 % duty cycle. Performance is at indicated input power.
2. See page 18 for load pull and source pull reference planes. 20- $\Omega$  load pull TRL fixtures are built with 20-mil RO4350B material.
3. NaN means the impedances are either undefined or varying in load-pull system.

### 1GHz, Load-pull

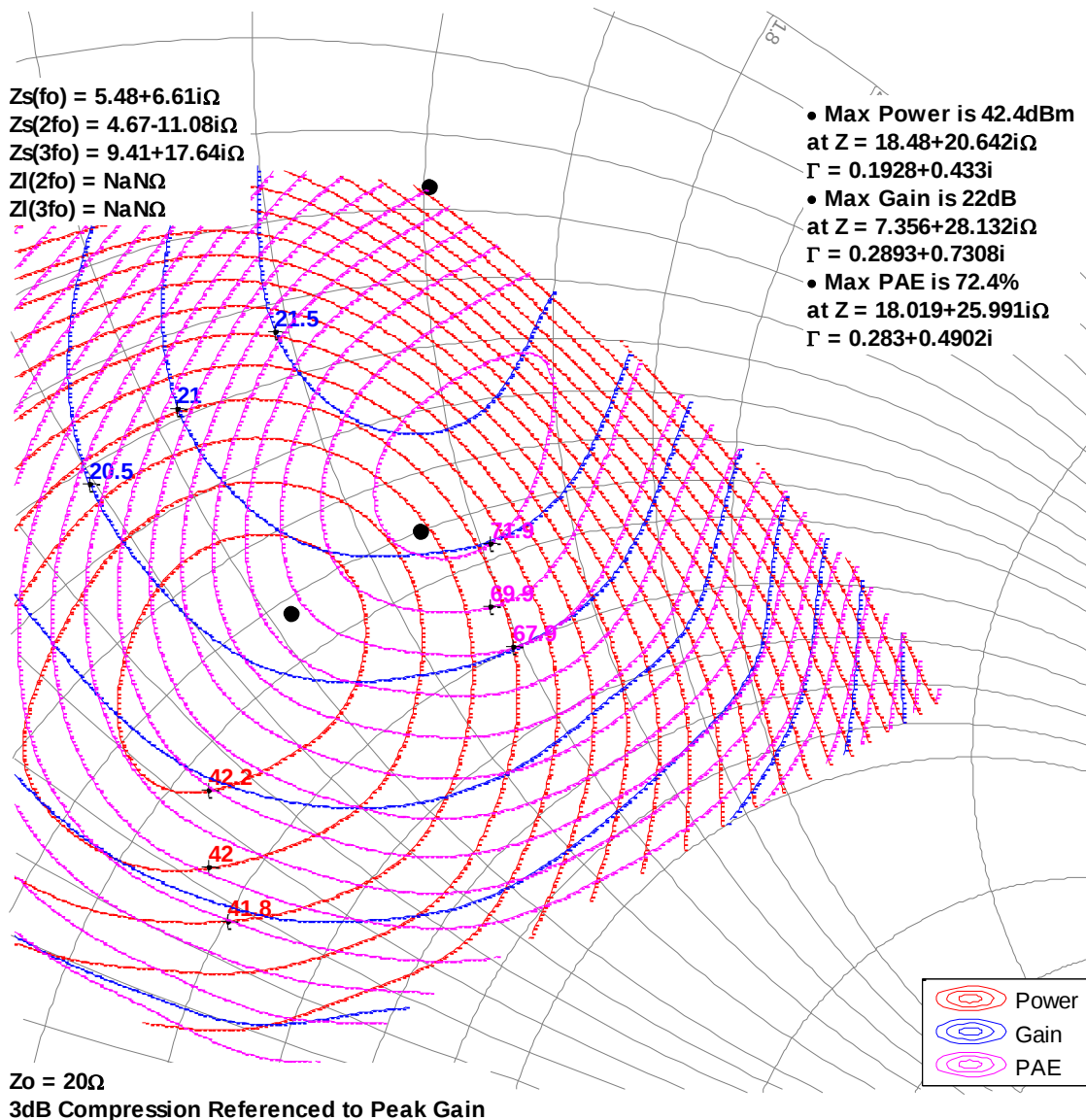


## Load Pull Smith Charts<sup>1, 2, 3</sup>

Notes:

1.  $V_d = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Pulsed signal with 128  $\mu\text{s}$  pulse width and 10 % duty cycle. Performance is at indicated input power.
2. See page 18 for load pull and source pull reference planes. 20- $\Omega$  load pull TRL fixtures are built with 20-mil RO4350B material.
3. NaN means the impedances are either undefined or varying in load-pull system.

### 2GHz, Load-pull

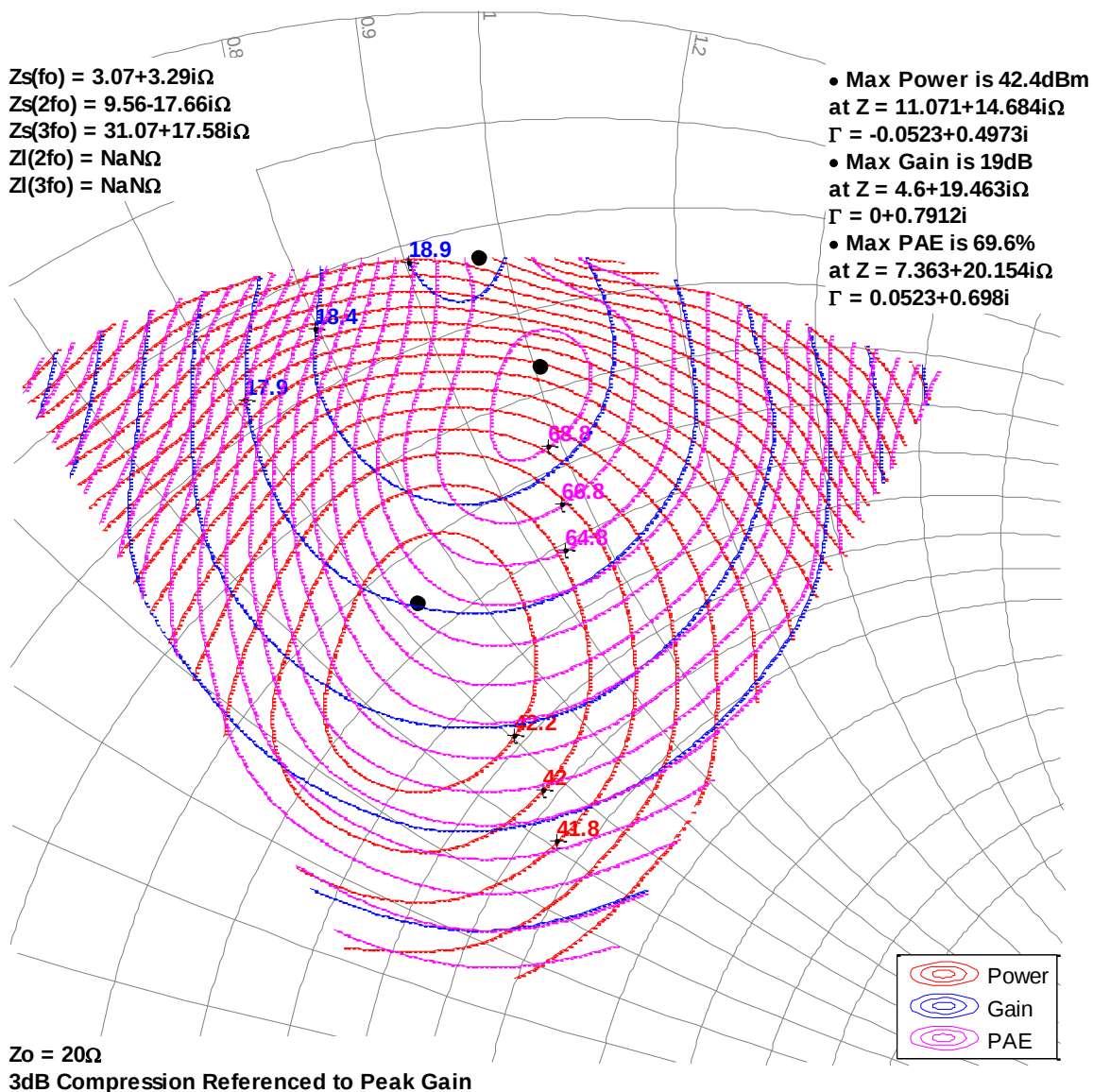


## Load Pull Smith Charts<sup>1, 2, 3</sup>

Notes:

1.  $V_d = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Pulsed signal with 128  $\mu\text{s}$  pulse width and 10 % duty cycle. Performance is at indicated input power.
2. See page 18 for load pull and source pull reference planes. 20- $\Omega$  load pull TRL fixtures are built with 20-mil RO4350B material.
3. NaN means the impedances are either undefined or varying in load-pull system.

### 3GHz, Load-pull

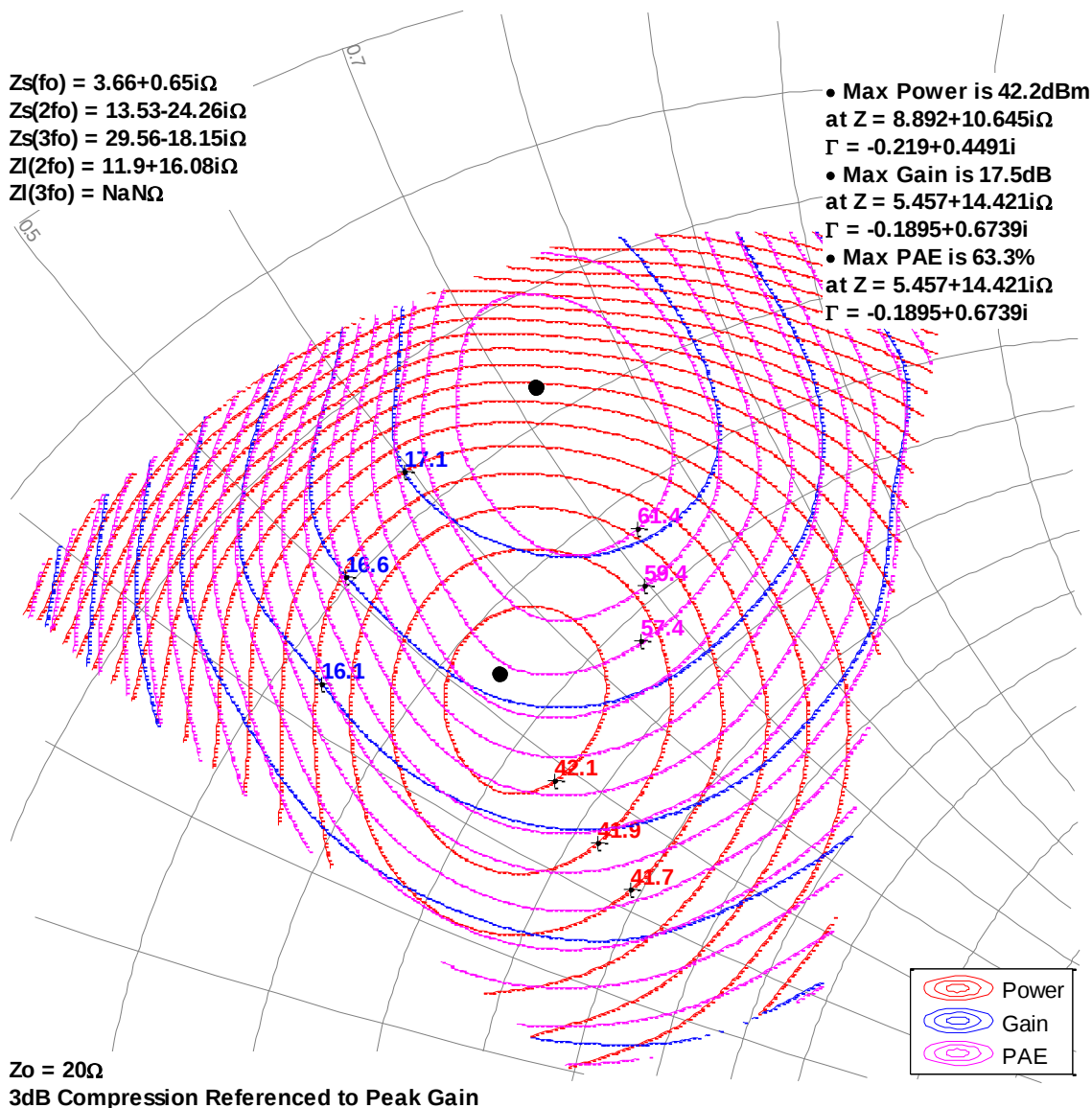


## Load Pull Smith Charts<sup>1, 2, 3</sup>

Notes:

1.  $V_d = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Pulsed signal with 128  $\mu\text{s}$  pulse width and 10 % duty cycle. Performance is at indicated input power.
2. See page 18 for load pull and source pull reference planes. 20- $\Omega$  load pull TRL fixtures are built with 20-mil RO4350B material.
3. NaN means the impedances are either undefined or varying in load-pull system.

### 3.5GHz, Load-pull

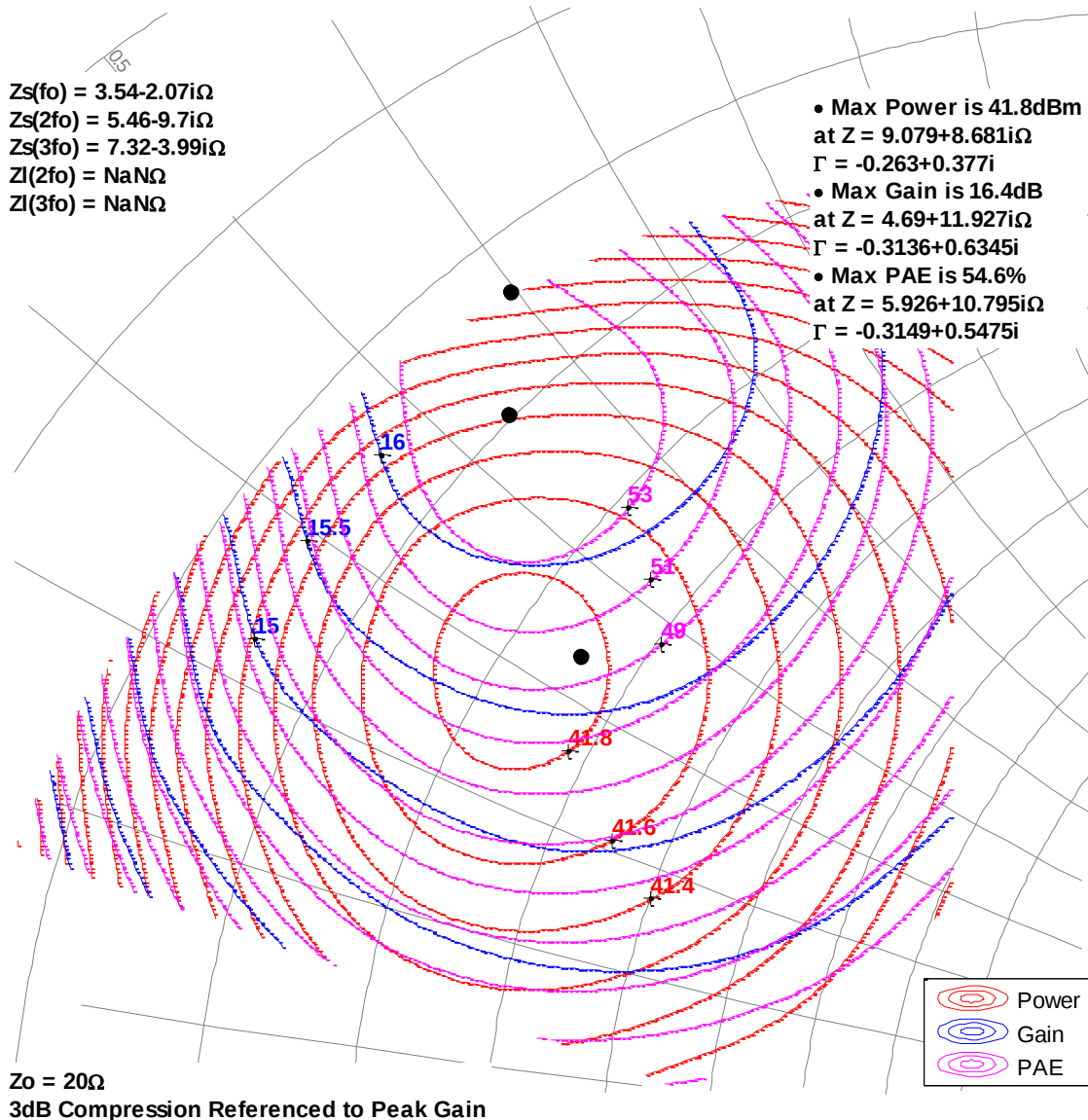


## Load Pull Smith Charts<sup>1, 2, 3</sup>

Notes:

1.  $V_d = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$ , Pulsed signal with 128  $\mu\text{s}$  pulse width and 10 % duty cycle. Performance is at indicated input power.
2. See page 18 for load pull and source pull reference planes. 20- $\Omega$  load pull TRL fixtures are built with 20-mil RO4350B material.
3. NaN means the impedances are either undefined or varying in load-pull system.

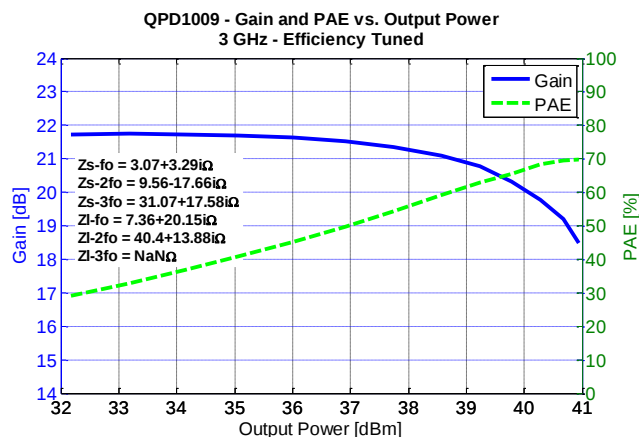
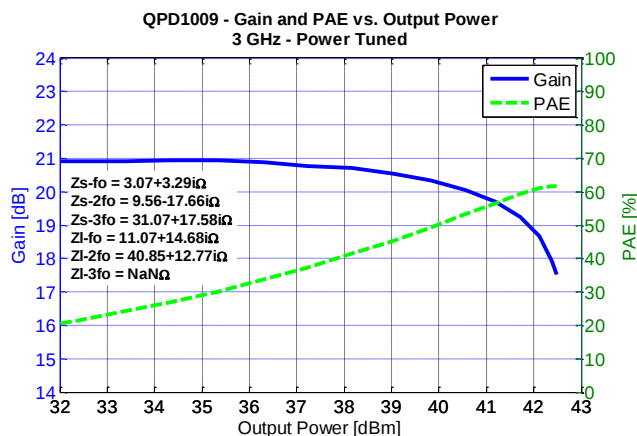
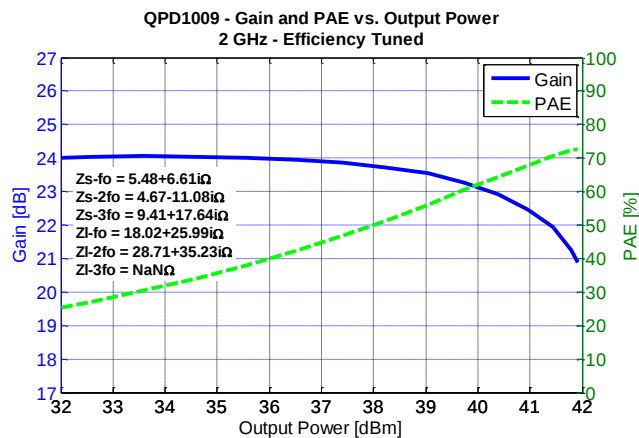
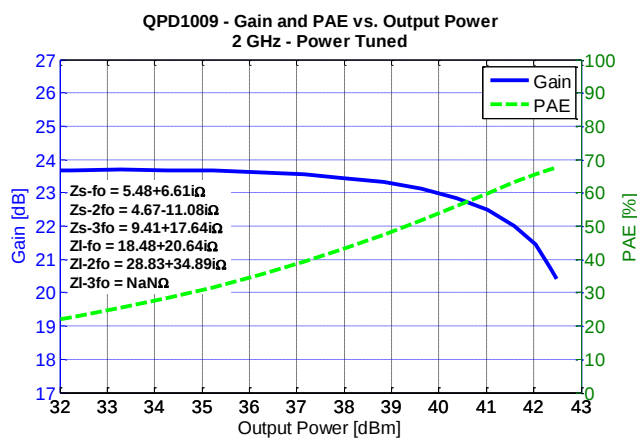
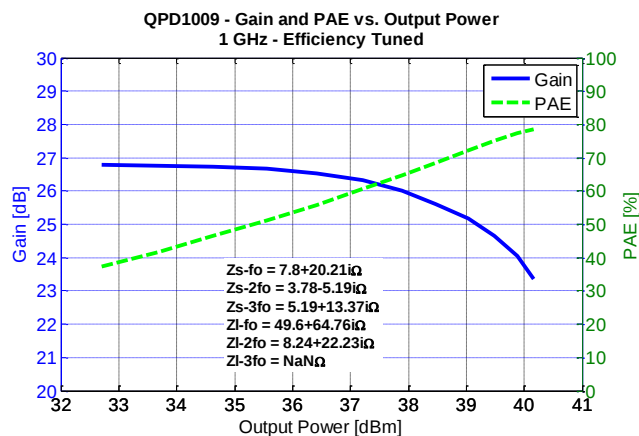
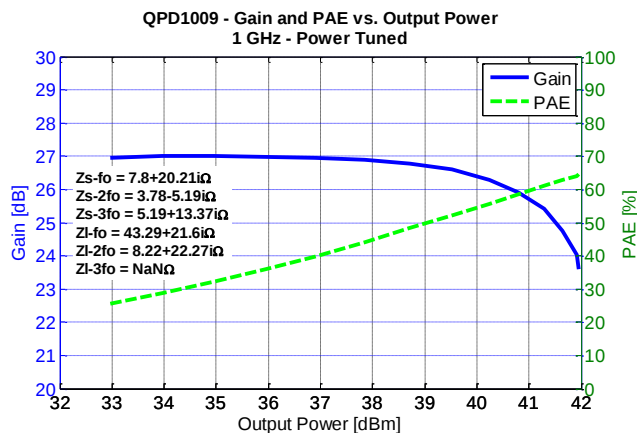
### 4GHz, Load-pull



## Typical Performance – Load Pull Drive-up

Notes:

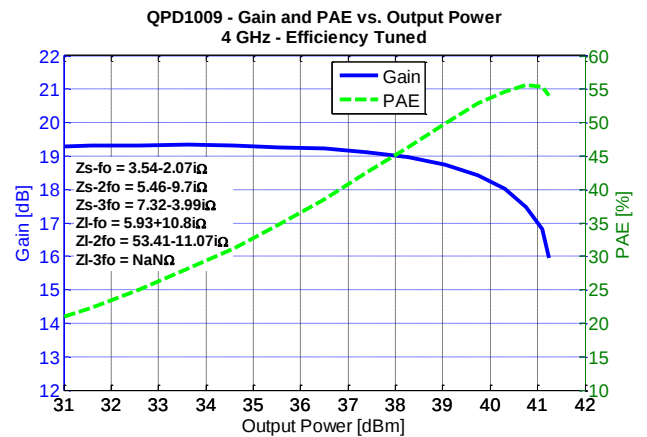
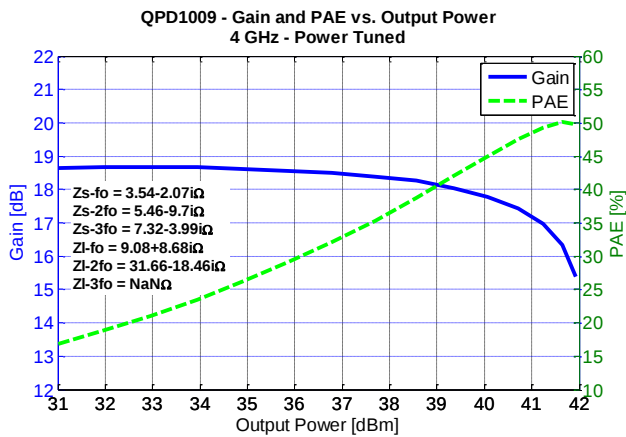
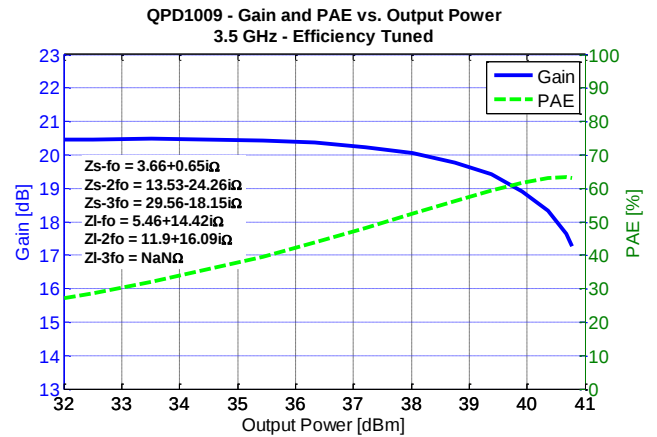
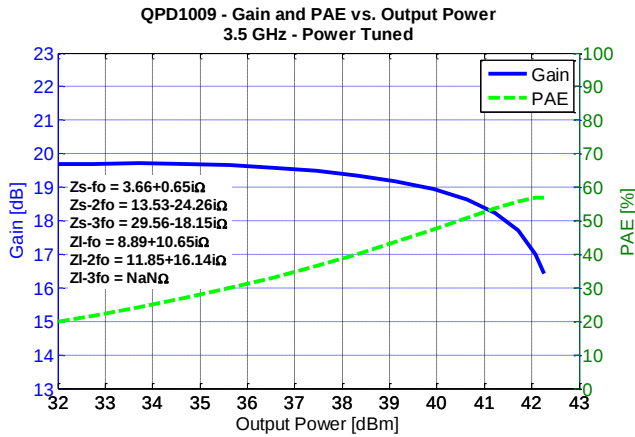
1. Pulsed signal with 128 uS pulse width and 10 % duty cycle,  $V_d = 50$  V,  $I_{DQ} = 26$  mA
2. See page 18 for load pull and source pull reference planes where the performance was measured.



### Typical Performance – Load Pull Drive-up

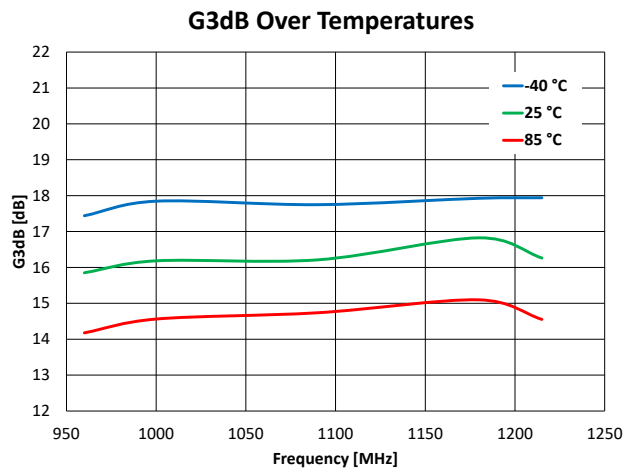
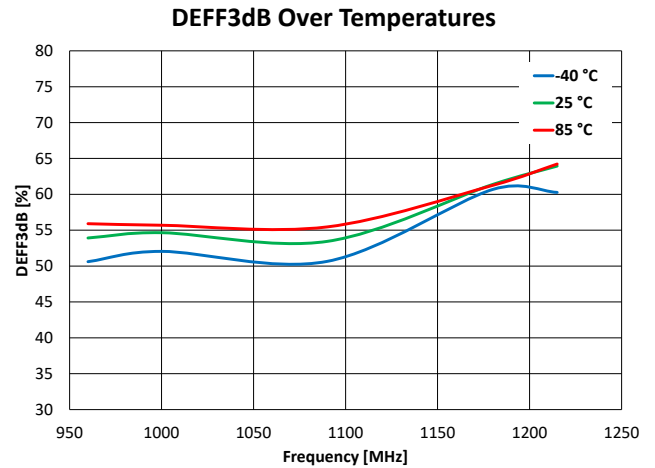
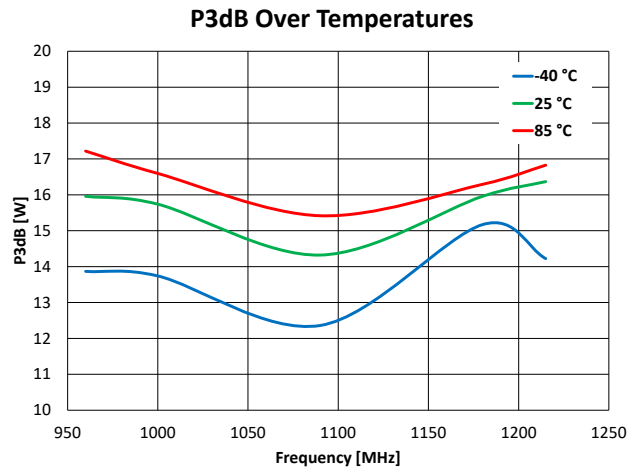
Notes:

- Pulsed signal with 128 uS pulse width and 10 % duty cycle,  $V_d = 50\text{ V}$ ,  $I_{DQ} = 26\text{ mA}$
- See page 18 for load pull and source pull reference planes where the performance was measured.



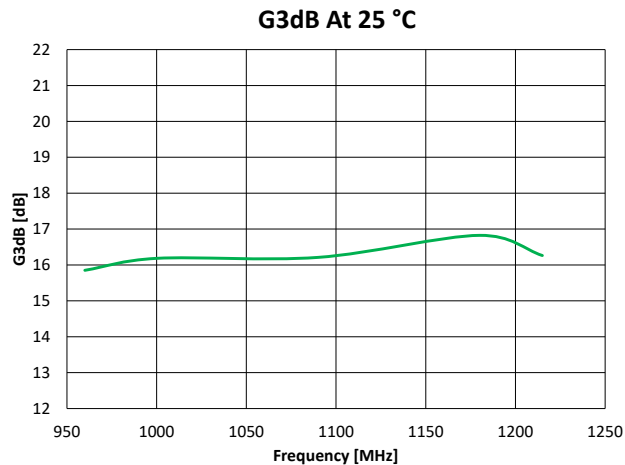
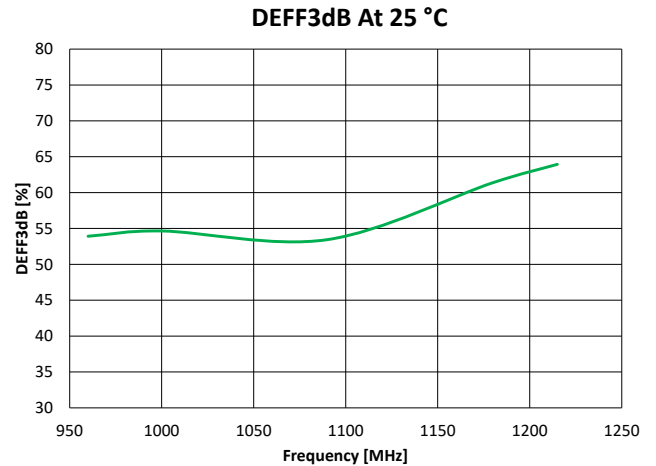
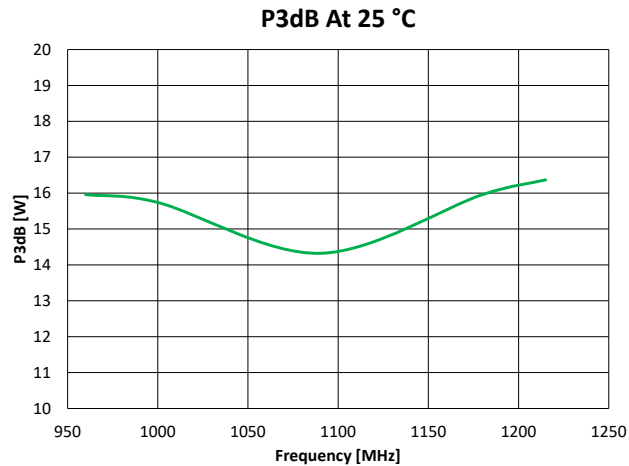
### Power Driveup Performance Over Temperatures Of 0.96 – 1.215 GHz EVB<sup>1</sup>

<sup>1</sup> Vd = 50 V, IdQ = 26 mA, Pulse Width = 128 uS, Duty Cycle = 10 %



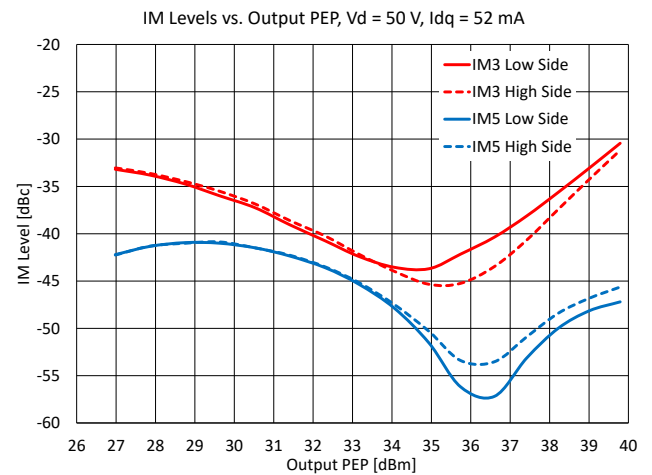
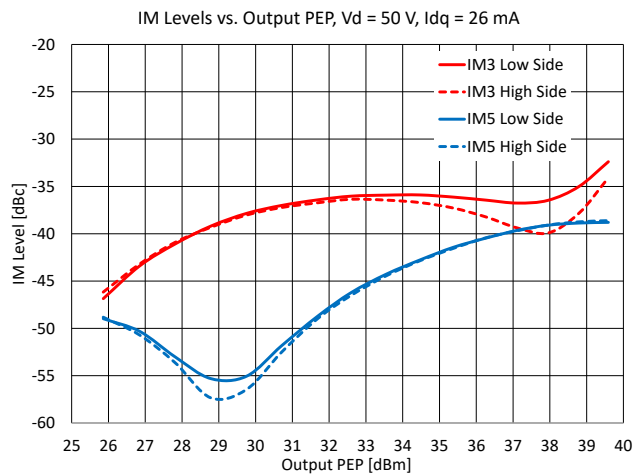
### Power Driveup Performance At 25 °C Of 0.96 – 1.215 GHz EVB<sup>1</sup>

<sup>1</sup> Vd = 50 V, IdQ = 26 mA, Pulse Width = 128 uS, Duty Cycle = 10 %



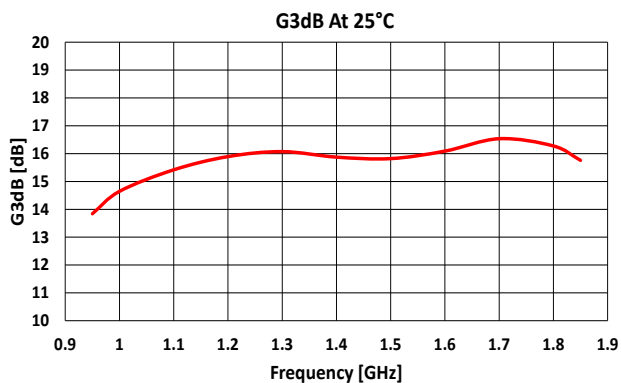
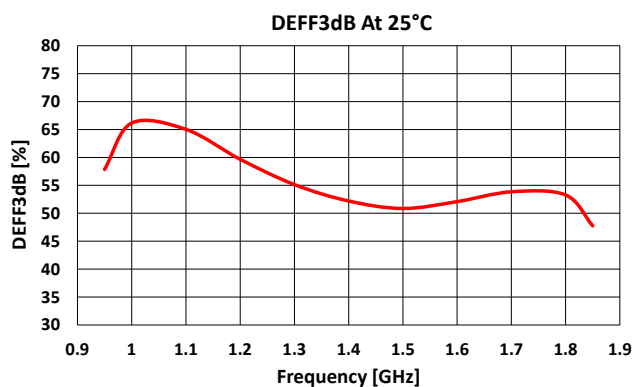
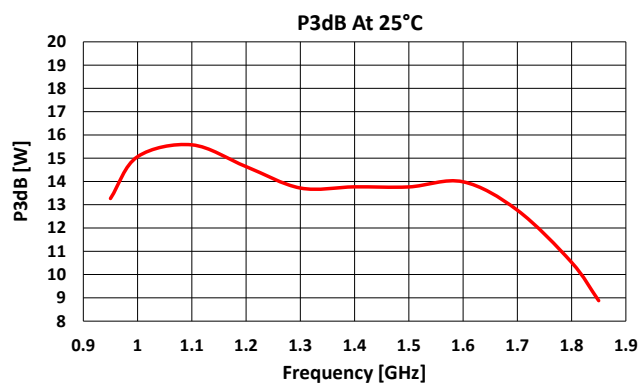
### Two-Tone Performance At 25 °C Of 0.96 – 1.215 GHz EVB<sup>1</sup>

<sup>1</sup> Center frequency = 1.09 GHz, Tone Separation = 1 MHz

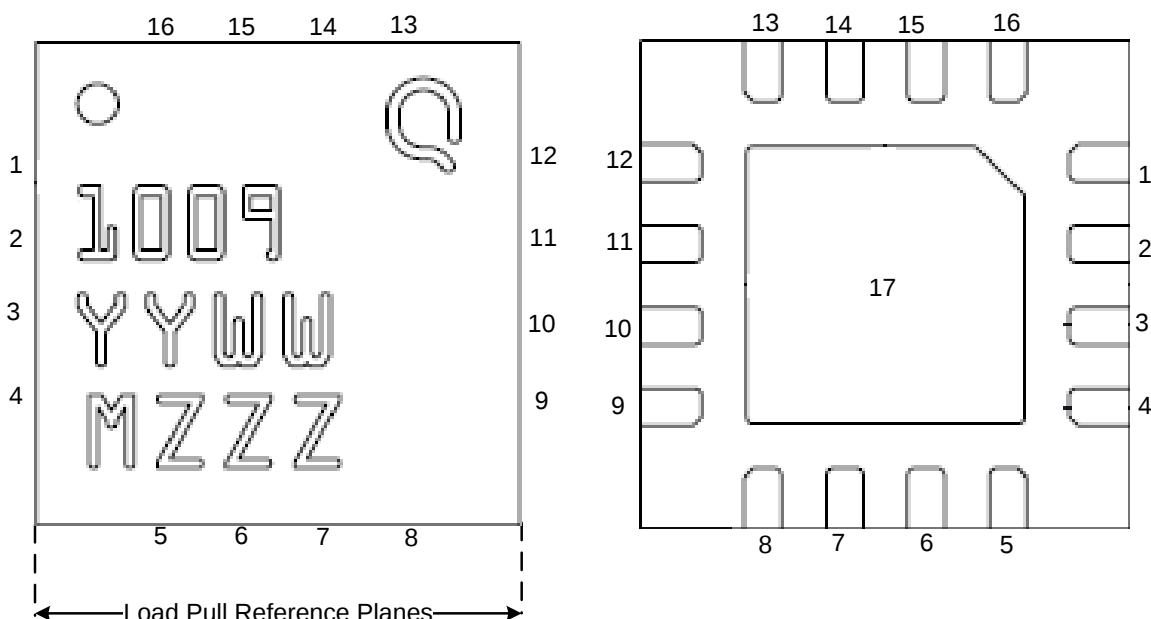


### Power Driveup Performance At 25 °C Of 1.1 – 1.7 GHz EVB<sup>1</sup>

<sup>1</sup> Vd = 50 V, IdQ = 26 mA, Pulse Width = 128 uS, Duty Cycle = 10 %



## Pin Layout <sup>1</sup>



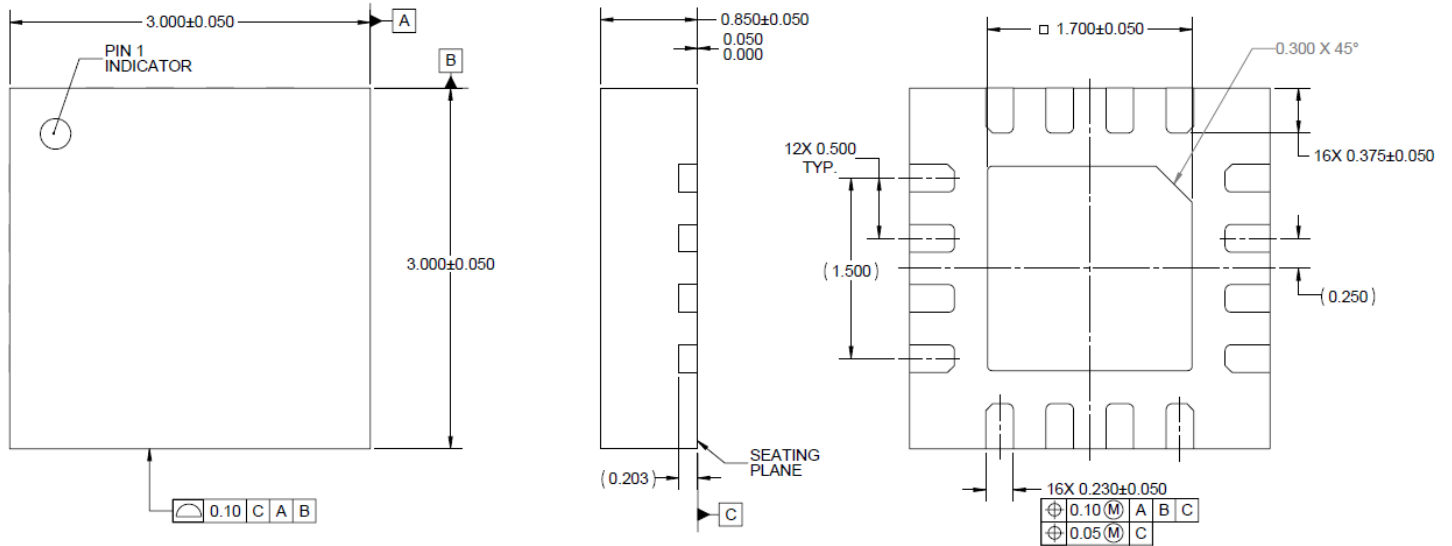
### Notes:

1. The QPD1009 will be marked with the “1009” designator and a lot code marked below the part designator. The “YY” represents the last two digits of the calendar year the part was manufactured, the “WW” is the work week of the assembly lot start, the “MXXX” is the production lot number, and the “ZZZ” is an auto-generated serial number.

## Pin Description

| Pin                     | Symbol      | Description                      |
|-------------------------|-------------|----------------------------------|
| 2, 3                    | VG / RF IN  | Gate voltage / RF Input          |
| 10, 11                  | VD / RF OUT | Drain voltage / RF Output        |
| 1, 4, 5 – 9,<br>12 - 16 | NC          | Not Connected                    |
| 17                      | Flange      | Source to be connected to ground |

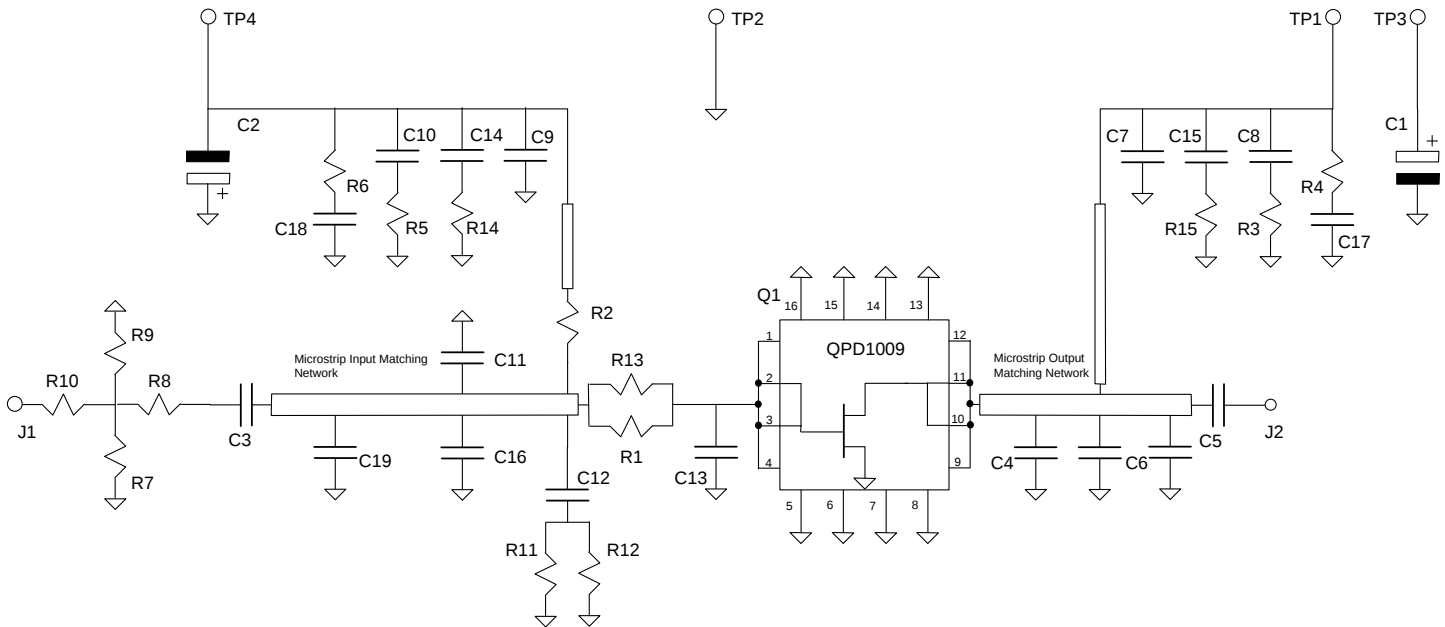
### Mechanical Drawing<sup>1, 2, 3</sup>



#### Notes:

1. All dimensions are in mm. Otherwise noted, the tolerance is  $\pm 0.100$  mm.
2. Package leads are gold plated.
3. Part is mold encapsulated.

### Schematic - 0.96 – 1.215 GHz EVB



#### Bias-up Procedure

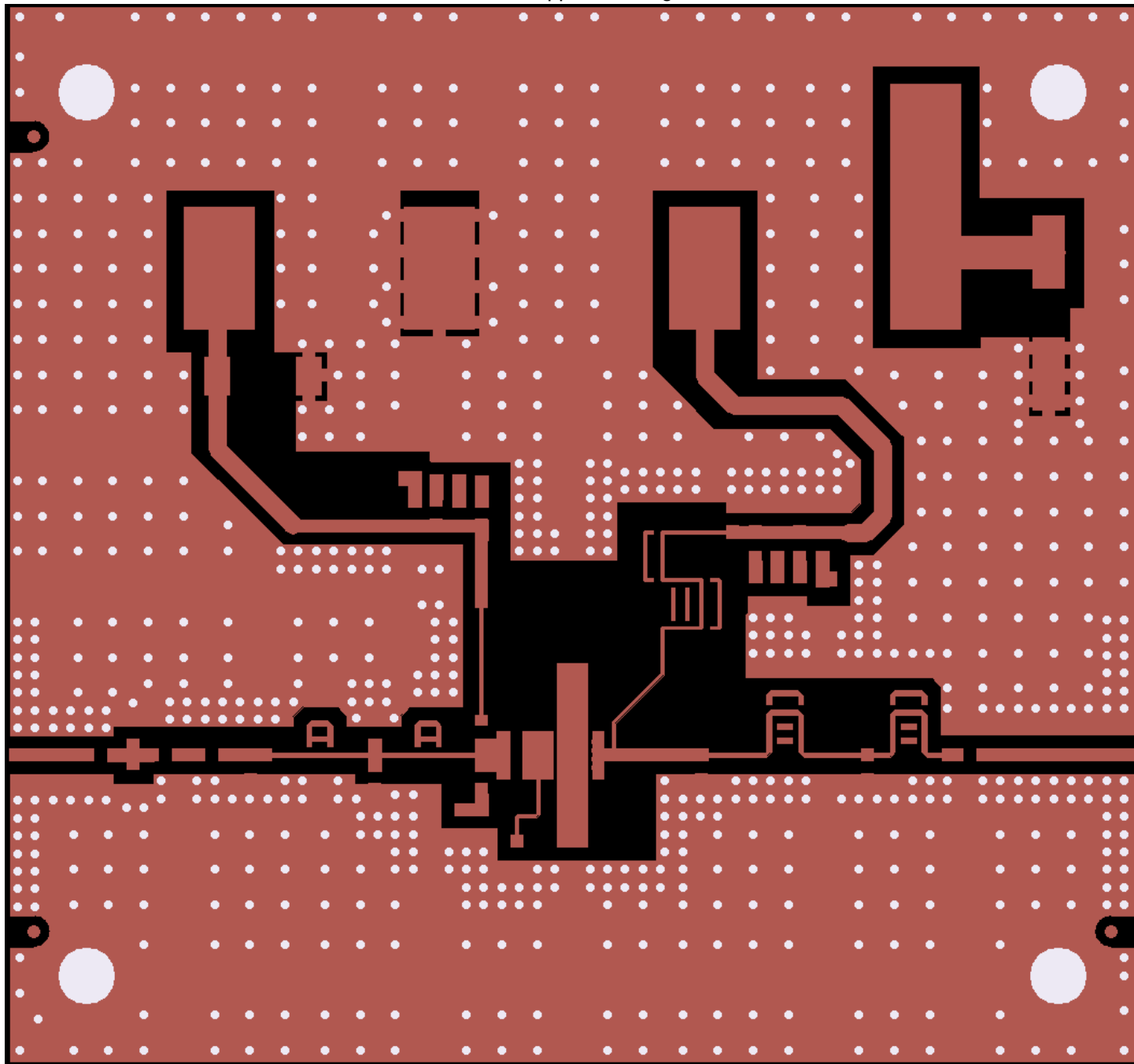
1. Set  $V_G$  to -4 V.
2. Set  $I_D$  current limit to 30 mA.
3. Apply 50 V  $V_D$ .
4. Slowly adjust  $V_G$  until  $I_D$  is set to 26 mA.
5. Set  $I_D$  current limit to 1.5 A
6. Apply RF.

#### Bias-down Procedure

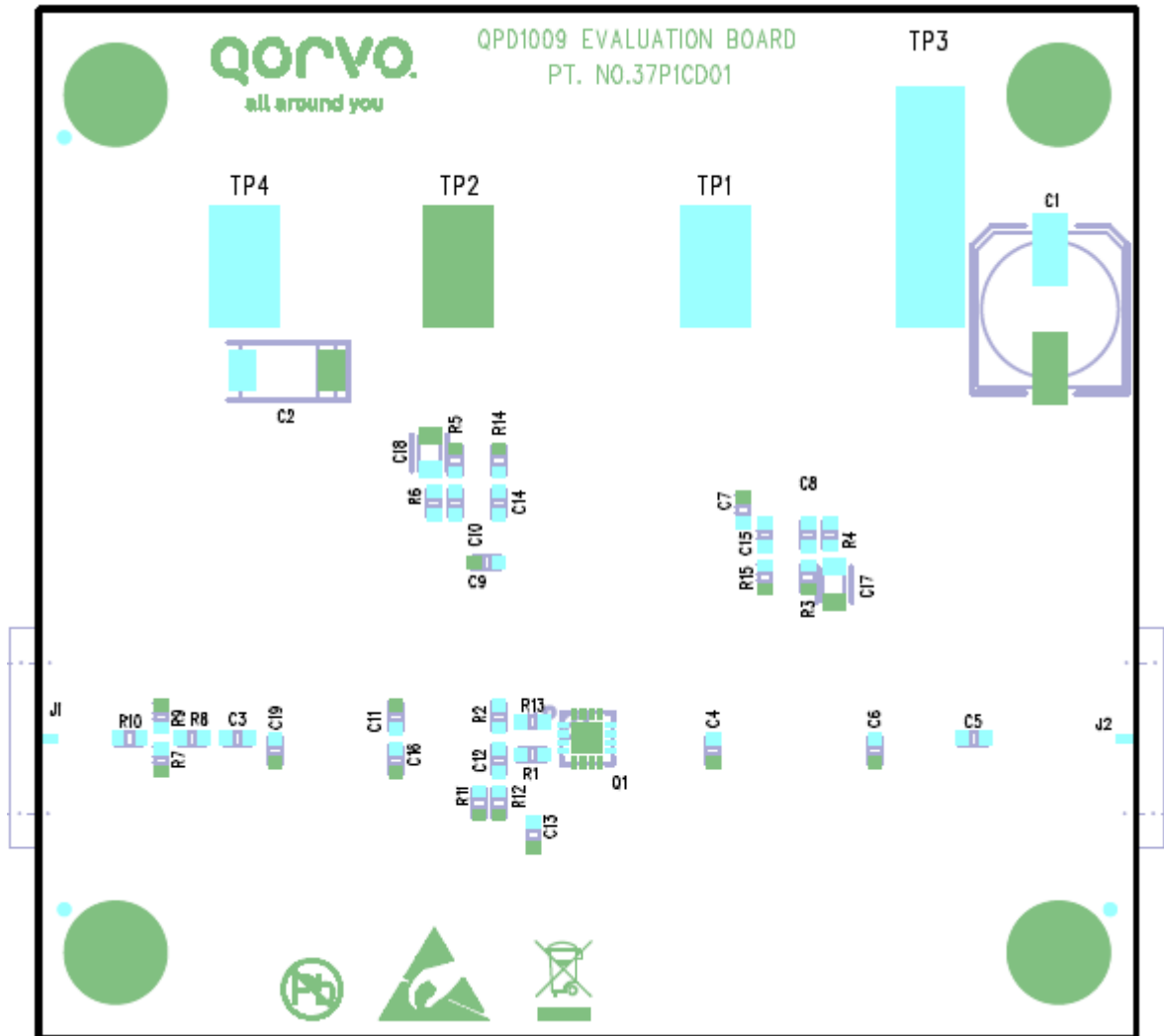
1. Turn off RF signal.
2. Turn off  $V_D$
3. Wait 2 seconds to allow drain capacitor to discharge
4. Turn off  $V_G$

**PCB Layout - 0.96 – 1.215 GHz EVB**

Board material is RO4360G2 0.020" thickness with 1 oz copper cladding.



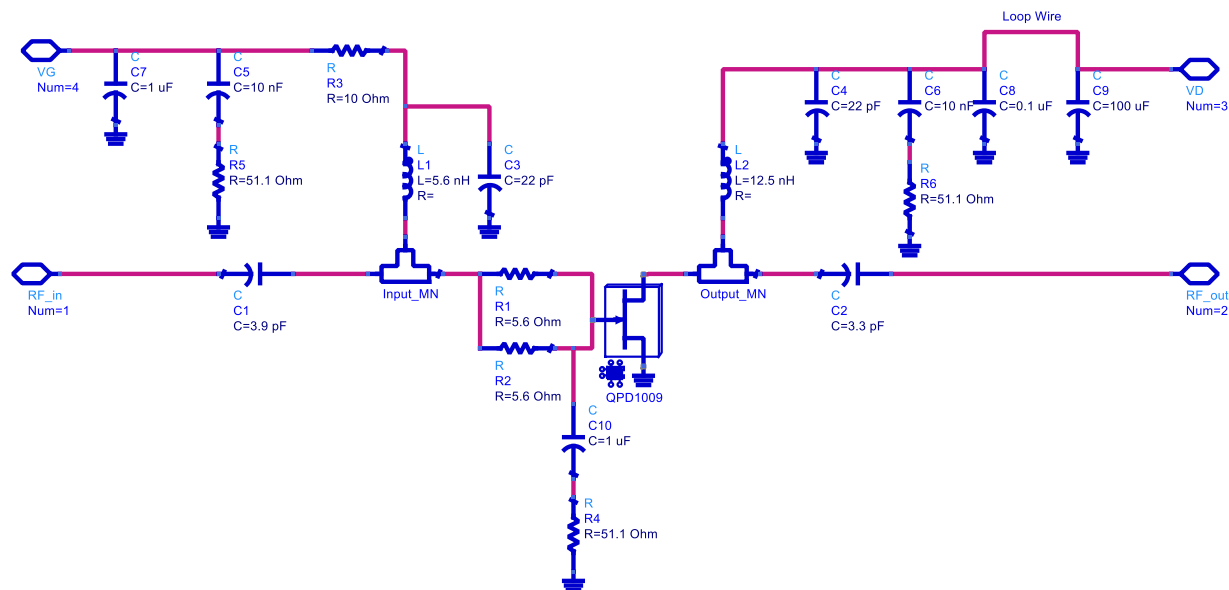
### Component Placement - 0.96 – 1.215 GHz EVB



**Bill Of material - 0.96 – 1.215 GHz EVB**

| Ref Des                  | Value   | Description                           | Manufacturer | Part Number       |
|--------------------------|---------|---------------------------------------|--------------|-------------------|
| C14, 15                  | 100 pF  | C0G 100V 5% 0603 Capacitor            | AVX          | 06031A101JAT2A    |
| C8 - 10                  | 1 nF    | X7R 100V 5% 0603 Capacitor            | AVX          | 06031C102JAT2A    |
| C17 - 18                 | 100 nF  | X7R 100V 5% 0805 Capacitor            | AVX          | 08051C104JAT2A    |
| C4                       | 0.2 pF  | RF NPO 250VDC $\pm$ 0.05 pF Capacitor | ATC          | ATC600S0R2AT250X  |
| C13                      | 1.0 pF  | RF NPO 250VDC $\pm$ 0.05 pF Capacitor | ATC          | ATC600S1R0AT250X  |
| C6                       | 1.5 pF  | RF NPO 250VDC $\pm$ 0.05 pF Capacitor | ATC          | ATC600S1R5AT250X  |
| C19                      | 6.8 pF  | RF NPO 250VDC $\pm$ 0.1 pF Capacitor  | ATC          | ATC600S6R8BT250X  |
| C11, 16                  | 7.5 pF  | RF NPO 250VDC $\pm$ 0.1 pF Capacitor  | ATC          | ATC600S7R5BT250X  |
| C3, 5, 7, 9, 12          | 56 pF   | RF NPO 250VDC 1% Capacitor            | ATC          | ATC600S5650FT250X |
| C1                       | 33 uF   | 80V SVP Capacitor                     | Panasonic    | EEEFK1K330P       |
| C2                       | 10 uF   | 16V Tantalum Capacitor                | AVX          | TPSC106KR0500     |
| J1 - 2                   |         | SMA Panel Mount 4-hole Jack           | Gigalane     | PSF-S00-000       |
| R4, 6                    | 1 Ohm   | 0603 1% Thick Film Resistor           | ANY          |                   |
| R1, 2, 8, 10, 13, 14, 15 | 5.1 Ohm | 0603 1% Thick Film Resistor           | ANY          |                   |
| R3, 5                    | 33 Ohm  | 0603 1% Thick Film Resistor           | ANY          |                   |
| R11, 12                  | 150 Ohm | 0603 1% Thick Film Resistor           | ANY          |                   |
| R7, 9                    | 430 Ohm | 0603 1% Thick Film Resistor           | ANY          |                   |

### Schematic – 1.1 – 1.7 GHz EVB



#### Bias-up Procedure

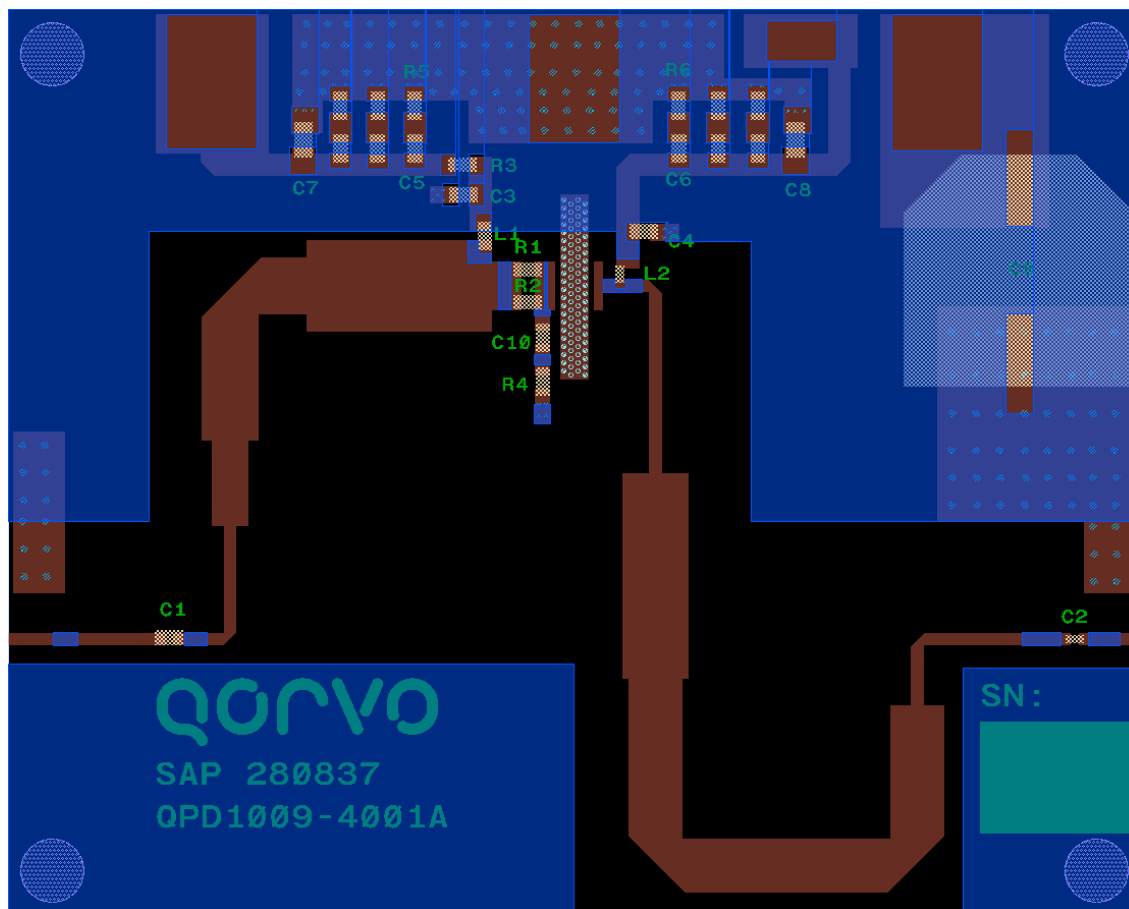
2. Set  $V_G$  to -4 V.
4. Set  $I_D$  current limit to 30 mA.
5. Apply 50 V  $V_D$ .
6. Slowly adjust  $V_G$  until  $I_D$  is set to 26 mA.
8. Set  $I_D$  current limit to 1.5 A
9. Apply RF.

#### Bias-down Procedure

3. Turn off RF signal.
4. Turn off  $V_D$
5. Wait 2 seconds to allow drain capacitor to discharge
7. Turn off  $V_G$

### PCB Layout – 1.1 – 1.7 GHz EVB

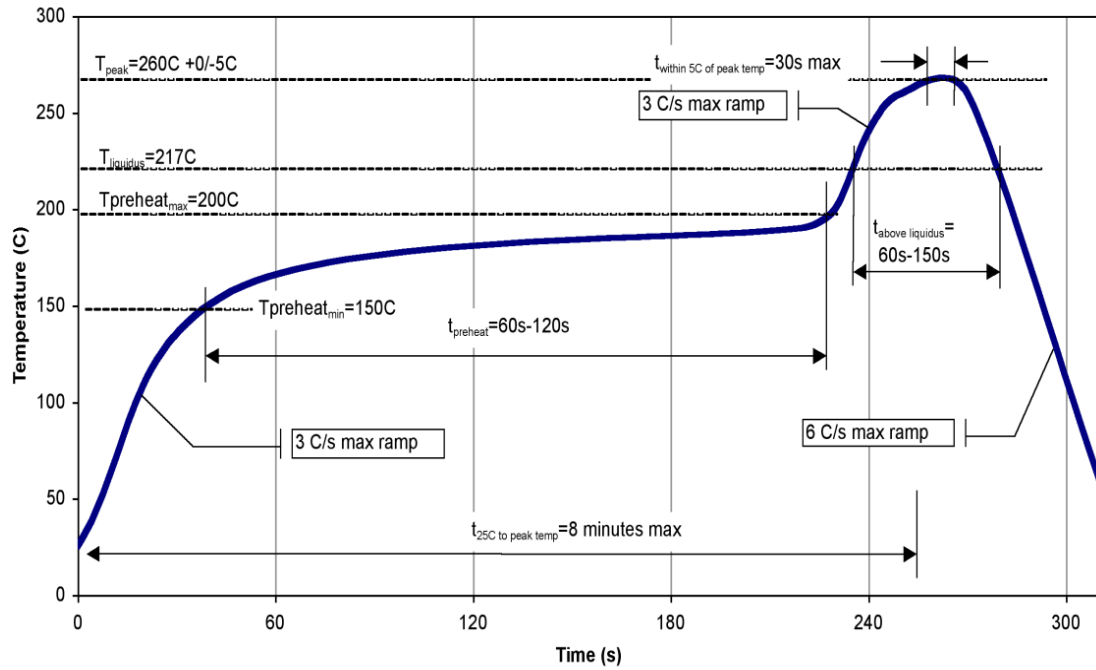
Board material is RO4360G2 0.020" thickness with 1 oz copper cladding.



## Bill Of material – 1.1 – 1.7 GHz EVB

| Comp. Desig. | Value         | Quantity | Part number                   | Manufacturer |
|--------------|---------------|----------|-------------------------------|--------------|
| C1           | 3.9 pF        | 1        | 600S3R9AT250XT                | ATC          |
| C2           | 3.3 pF        | 1        | 600S3R3AT250XT                | ATC          |
| C3, C4       | 22 pF         | 2        | 600S220FT250XT                | ATC          |
| C5, C6       | 0.01 uF       | 2        | ECJ-2VB2A103K                 | Panasonic    |
| C7           | 1 uF, 25 V    | 1        | GCM21BR71E105KA56L            | Murata       |
| C8           | 0.1 uF, 100 V | 1        | 08051C104JAT2A                | AVX          |
| C9           | 100 uF, 63 V  | 1        | EEETG1J101UP                  | Panasonic    |
| C10          | 1 uF, 16 V    | 1        | GCM188R71C105KA64D            | Murata       |
| L1           | 5.6 nH        | 1        | 0603CS-5N6XJEW                | Coilcraft    |
| L2           | 5.6 nH        | 1        | 0603HP-5N6XJLW                | Coilcraft    |
| R1, R2       | 5.6 Ohm       | 2        | CRCW06035R60JNEA              | Vishay       |
| R4, R5, R6   | 51.1 Ohm      | 3        | CRCW060351R1FKTA              | Vishay       |
| R3           | 10 Ohm        | 1        | CRCW060310R0JNTA              | Vishay       |
| PCB          |               | 1        | RO4360G2, 32 mil, 1 oz copper | Rogers       |

## Recommended Solder Temperature Profile



## Handling Precautions

| Parameter                        | Rating            | Standard              |
|----------------------------------|-------------------|-----------------------|
| ESD – Human Body Model (HBM)     | Class 1A          | ANSI/ESD/JEDEC JS-001 |
| ESD – Charged Device Model (CDM) | Class C2B, 1000 V | ANSI/ESD/JEDEC JS-002 |
| MSL – Moisture Sensitivity Level | MSL3              | JESD 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.

Contact plating: NiPdAu

## RoHS Compliance

This part is compliant with 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, and information about Qorvo:

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