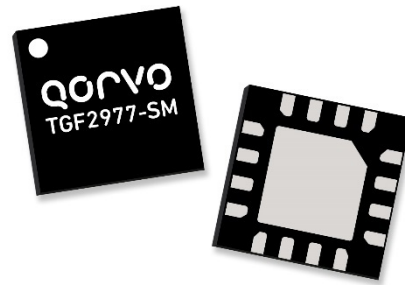


Product Overview

The Qorvo TGF2977-SM is a 5 W (P_{3dB}) discrete GaN on SiC HEMT which operates from DC to 12 GHz and 32 V supply. The device is in an industry standard overmolded package and is ideally suited for avionics, military, marine and weather radar. The device can support pulsed and linear operations.

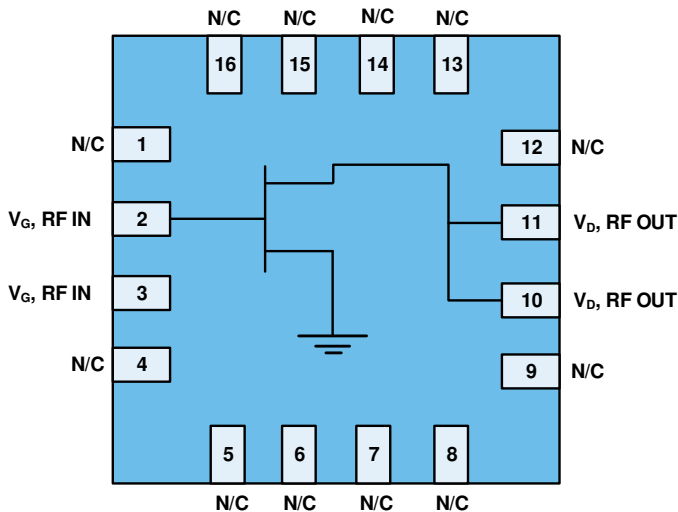
Lead-free and ROHS compliant.

Evaluation boards are available upon request.



3 x 3mm Package

Functional Block Diagram



Key Features

- Frequency: DC to 12 GHz
 - Output Power (P_{3dB})¹: 4.8 W
 - Linear Gain¹: 13 dB
 - Typical PAE_{3dB}¹: 50%
 - Operating Voltage: 32 V
 - CW and Pulse capable
- Note 1: @ 9 GHz Load Pull

Applications

- Military radar
- Commercial radar
 - Avionics
 - Marine
 - Weather

Ordering info

| Part No. | ECCN | Description |
|------------------|-------|-------------------|
| TGF2977-SM | EAR99 | QFN Packaged Part |
| TGF2977-SMEVBP01 | EAR99 | 9 – 10 GHz EVB |
| TGF2977-SMEVBP02 | EAR99 | 2.6 – 4.2 GHz EVB |

Absolute Maximum Ratings¹

| Parameter | Rating | Units |
|--|------------------|------------------|
| Breakdown Voltage, BV_{DG} | +100 | V |
| Gate Voltage Range, V_G | -7 to +2 | V |
| Drain Current, $I_{D_{MAX}}$ | 0.6 | A |
| Gate Current Range, I_G | See page 20. | mA |
| Power Dissipation, CW (P_{DISS}) | 9.3 ² | W |
| RF Input Power, CW, $T_{amb} = 25\text{ }^\circ\text{C}$ | +30 | dBm |
| Channel Temperature, T_{CH} | 275 | $^\circ\text{C}$ |
| Mounting Temperature (30 Seconds) | 320 | $^\circ\text{C}$ |
| Storage Temperature | -65 to +150 | $^\circ\text{C}$ |

Notes:

1. Operation of this device outside the parameter ranges given above may cause permanent damage.
2. Device base temperature = 85 $^\circ\text{C}$.

Recommended Operating Conditions¹

| Parameter | Min | Typ | Max | Units |
|--|-----|------|-----|------------------|
| Operating Temp. Range | -40 | +25 | +85 | $^\circ\text{C}$ |
| Drain Voltage Range, V_D | | +32 | +40 | V |
| Drain Bias Current, I_{DQ} | | 25 | | mA |
| Drain Current, I_D^4 | - | 325 | - | mA |
| Gate Voltage, V_G^3 | - | -2.8 | - | V |
| Channel Temperature (T_{CH}) | - | - | 225 | $^\circ\text{C}$ |
| Power Dissipation (P_D) ^{2,4} | - | - | 9.2 | W |
| Power Dissipation (P_D), CW ² | - | - | 7.4 | 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 base at 85 $^\circ\text{C}$
3. To be adjusted to desired I_{DQ}
4. Pulsed, 100uS PW, 20% DC

Measured Load Pull Performance – Power Tuned¹

| Parameter | Typical Values | | | | | | Units |
|--|----------------|------|------|------|------|------|-------|
| | 5 | 6 | 8 | 9 | 10 | 12 | |
| Frequency, F | 5 | 6 | 8 | 9 | 10 | 12 | GHz |
| Drain Voltage, V_D | 32 | 32 | 32 | 32 | 32 | 32 | V |
| Drain Bias Current, I_{DQ} | 25 | 25 | 25 | 25 | 25 | 25 | mA |
| Output Power at 3dB compression, P_{3dB} | 37.5 | 37.2 | 37.0 | 36.8 | 36.8 | 36.5 | dBm |
| Power Added Efficiency at 3dB compression, PAE_{3dB} | 52.0 | 56.3 | 51.1 | 45.8 | 41.7 | 31.8 | % |
| Gain at 3dB compression, G_{3dB} | 15.2 | 14.4 | 11.4 | 9.8 | 8.3 | 5.3 | dB |

Notes:

1. Pulsed, 100 uS Pulse Width, 20% Duty Cycle
2. Characteristic Impedance, $Z_o = 15\ \Omega$.

Measured Load Pull Performance – Efficiency Tuned¹

| Parameter | Typical Values | | | | | | Units |
|--|----------------|------|------|------|------|------|-------|
| | 5 | 6 | 8 | 9 | 10 | 12 | |
| Frequency, F | 5 | 6 | 8 | 9 | 10 | 12 | GHz |
| Drain Voltage, V_D | 32 | 32 | 32 | 32 | 32 | 32 | V |
| Drain Bias Current, I_{DQ} | 25 | 25 | 25 | 25 | 25 | 25 | mA |
| Output Power at 3dB compression, P_{3dB} | 37.2 | 36.3 | 35.7 | 36.0 | 35.5 | 36.1 | dBm |
| Power Added Efficiency at 3dB compression, PAE_{3dB} | 60.2 | 62.3 | 56.6 | 52.0 | 47.1 | 38.2 | % |
| Gain at 3dB compression, G_{3dB} | 15.5 | 14.8 | 12.0 | 10.4 | 8.9 | 5.8 | dB |

Notes:

1. Pulsed, 100 uS Pulse Width, 20% Duty Cycle
2. Characteristic Impedance, $Z_o = 15\ \Omega$.

9 – 10 GHz EVB 9.4 GHz Performance¹

| Parameter | Min | Typ | Max | Units |
|--|-----|------|-----|-------|
| Linear Gain, G_{LIN} | – | 10.1 | – | dB |
| Output Power at 3dB compression point, P3dB | – | 3.6 | – | W |
| Drain Efficiency at 3dB compression point, DEFF3dB | – | 48.4 | – | % |
| Gain at 3dB compression point, G3dB | – | 7.1 | – | dB |

Notes:

1. $V_D = +32$ V, $I_{DQ} = 35$ mA, Temp = +25 °C, Pulse Width = 100 uS, Duty Cycle = 20%

RF Characterization – Mismatch Ruggedness at 9.4 GHz

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

Test conditions unless otherwise noted: $T_A = 25$ and -40 °C, $V_D = 32$ V, $I_{DQ} = 35$ mA

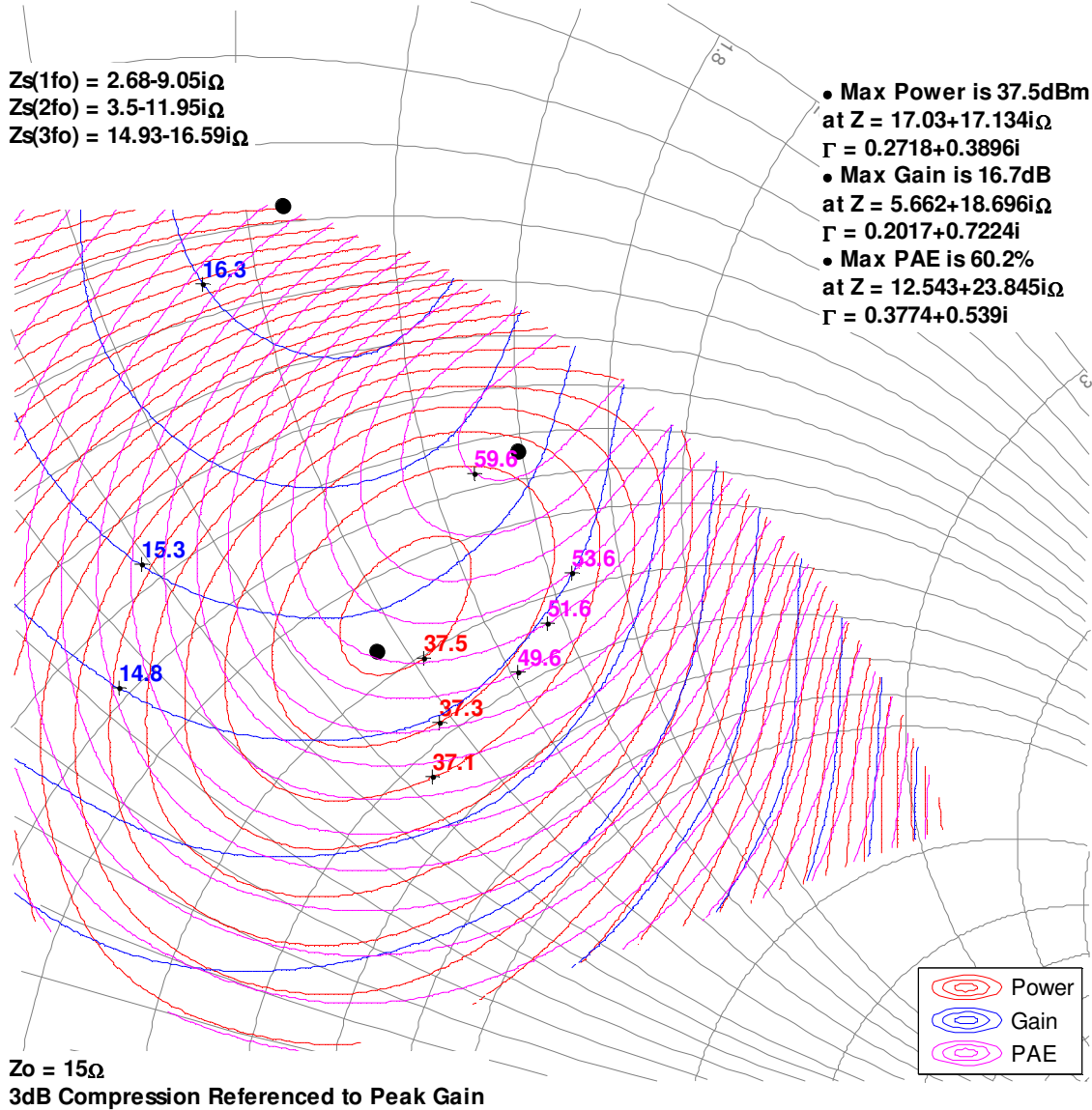
Input drive power is determined at pulsed 3dB compression under matched condition at EVB output connector.

Measured Load-Pull Smith Charts^{1, 2}

Notes:

1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 uS Pulse Width, 20% Duty Cycle
2. See page 21 for load pull reference planes where the performance was measured.

5GHz, Load-pull

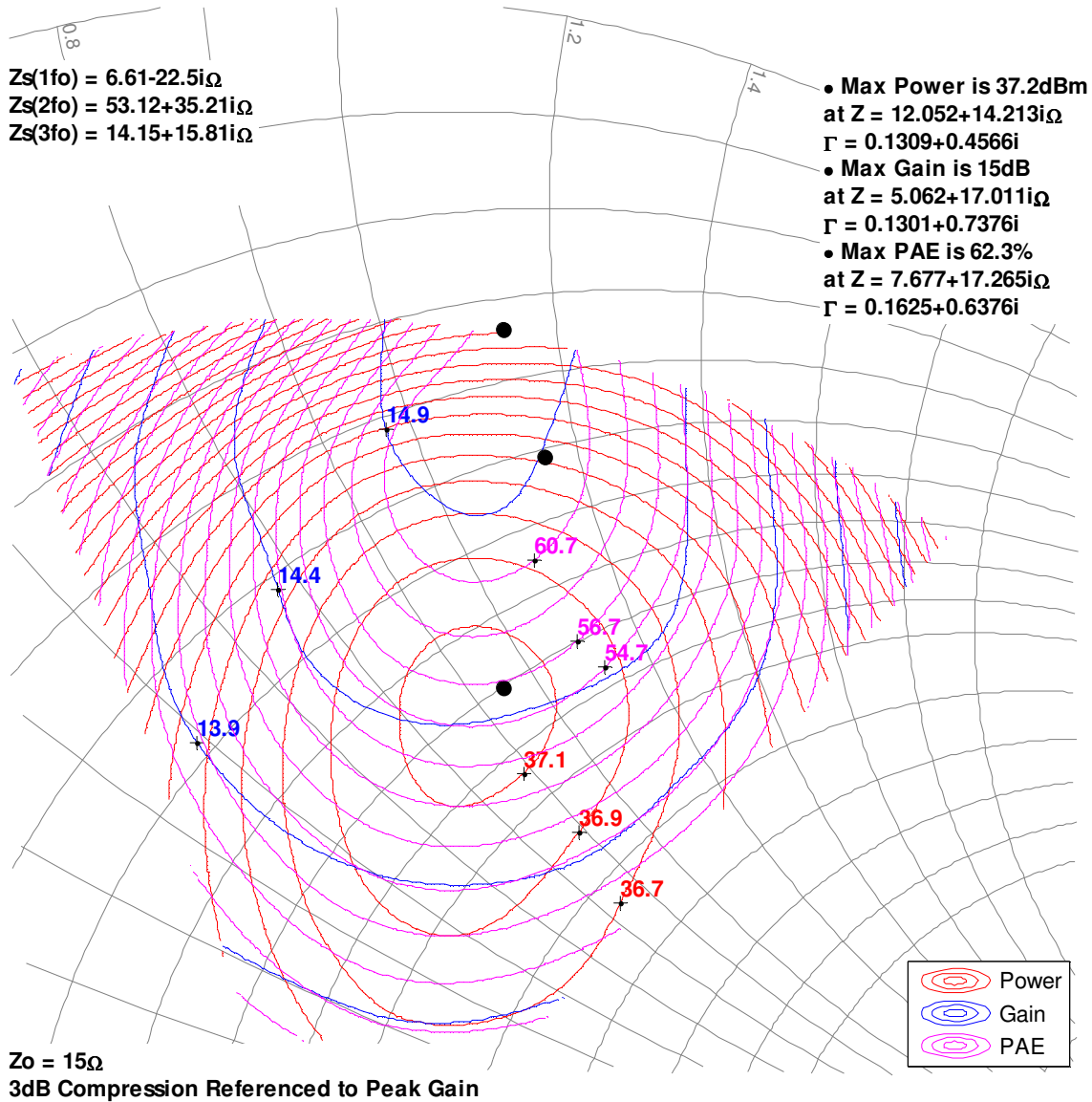


Measured Load-Pull Smith Charts^{1,2}

Notes:

1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 uS Pulse Width, 20% Duty Cycle
2. See page 21 for load pull reference planes where the performance was measured.

6GHz, Load-pull

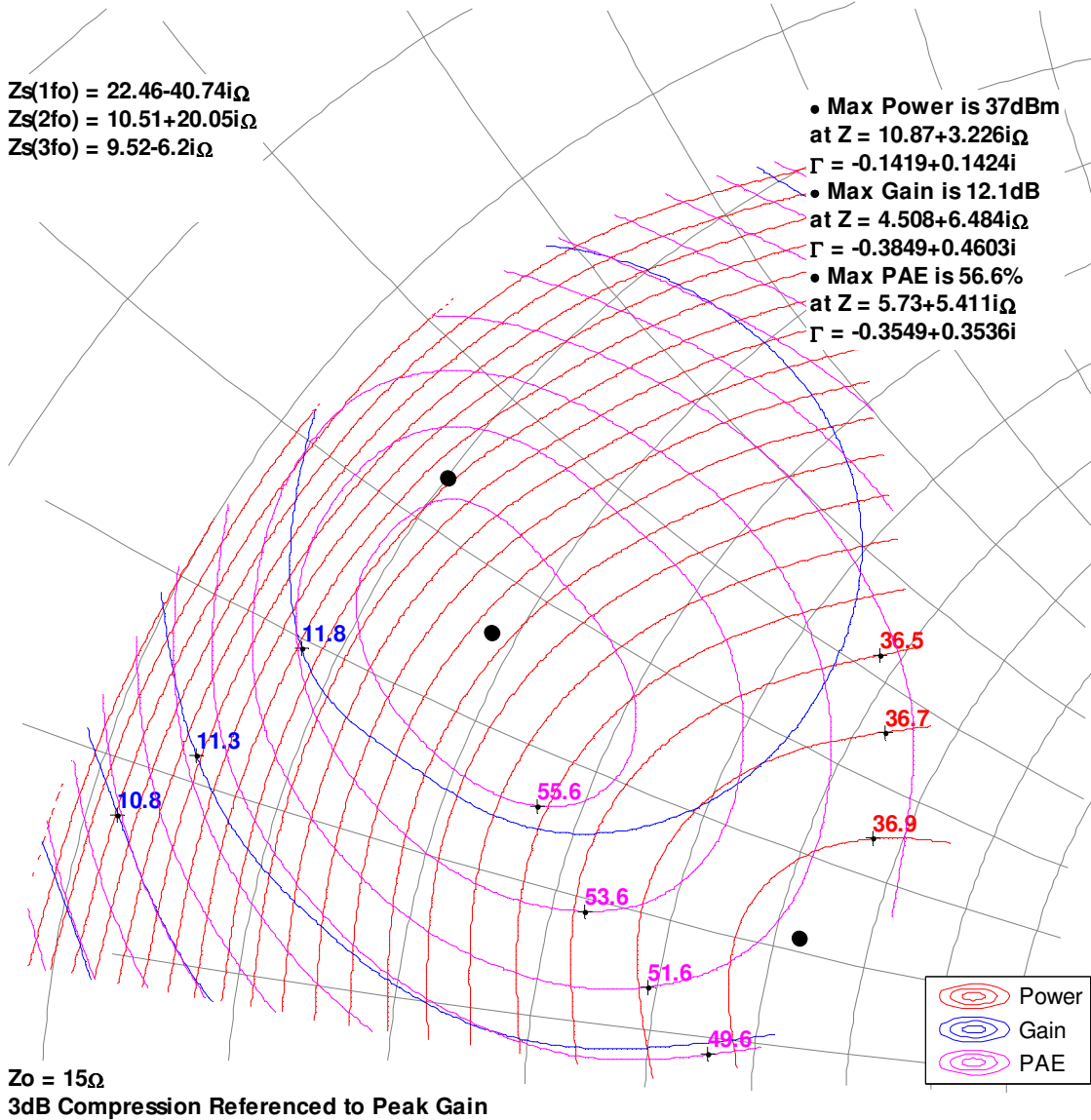


Measured Load-Pull Smith Charts^{1,2}

Notes:

1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 uS Pulse Width, 20% Duty Cycle
2. See page 21 for load pull reference planes where the performance was measured.

8GHz, Load-pull

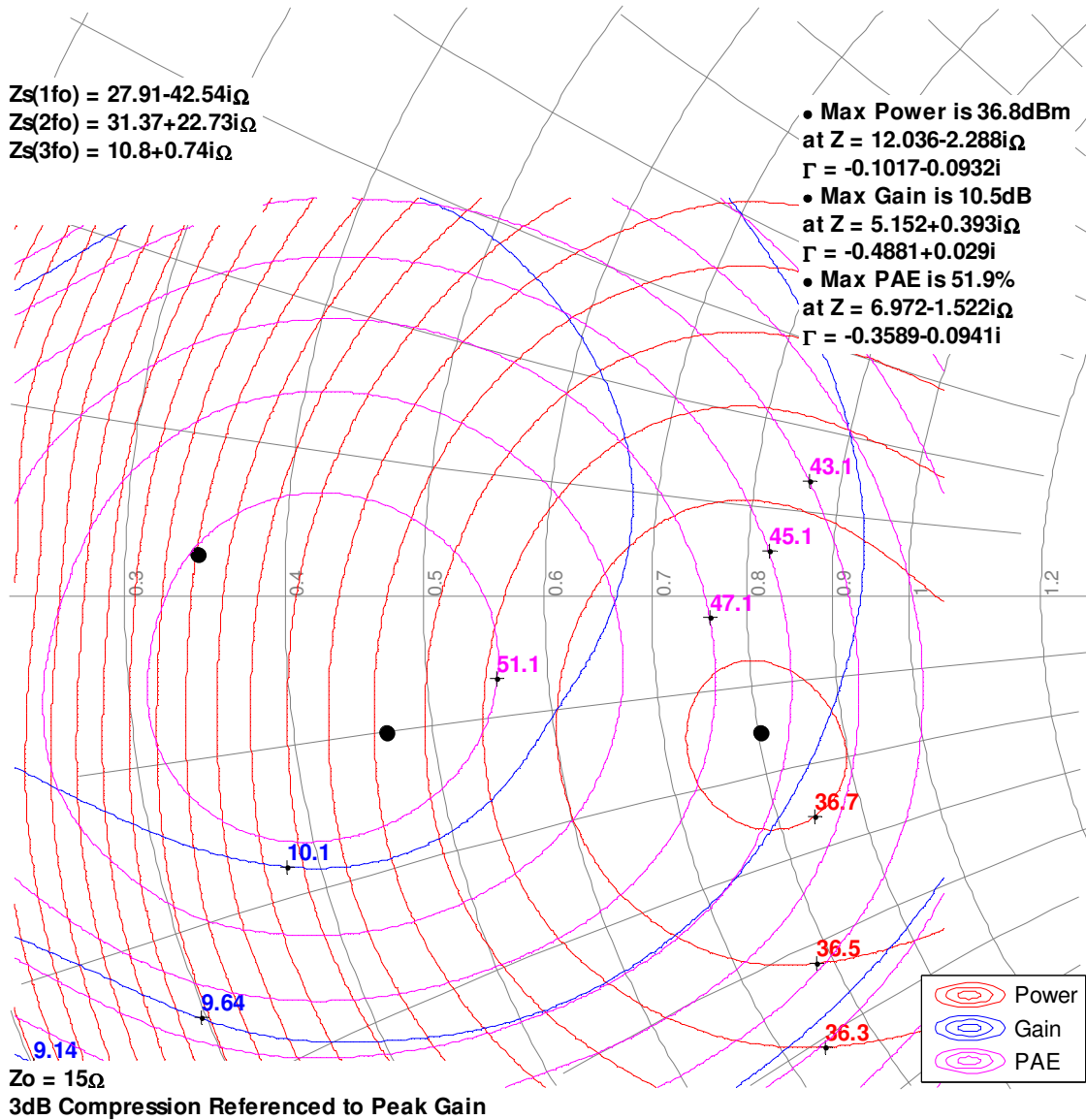


Measured Load-Pull Smith Charts^{1,2}

Notes:

1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 uS Pulse Width, 20% Duty Cycle
2. See page 21 for load pull reference planes where the performance was measured.

9GHz, Load-pull

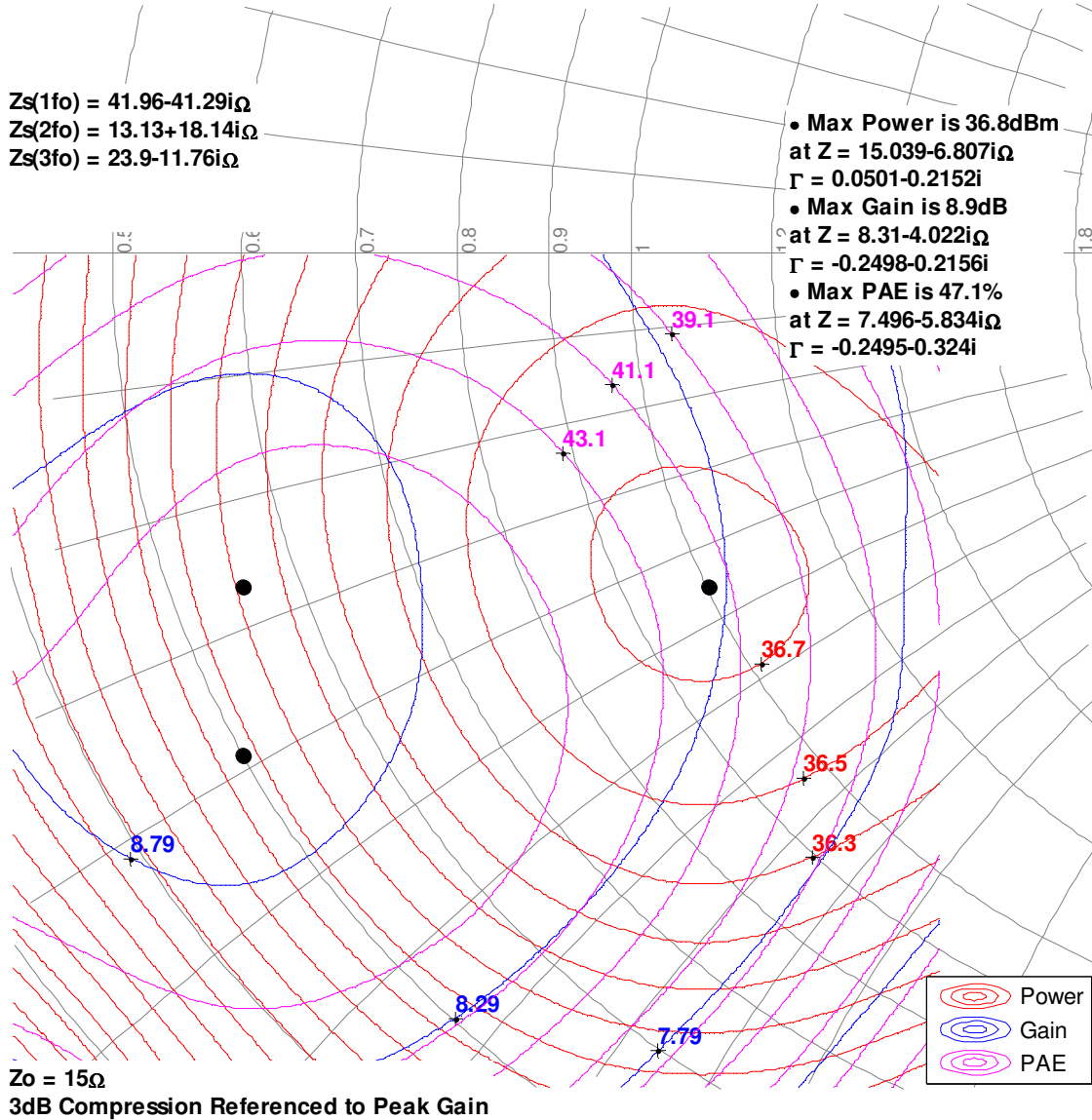


Measured Load-Pull Smith Charts^{1,2}

Notes:

1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 μS Pulse Width, 20% Duty Cycle
2. See page 21 for load pull reference planes where the performance was measured.

10GHz, Load-pull

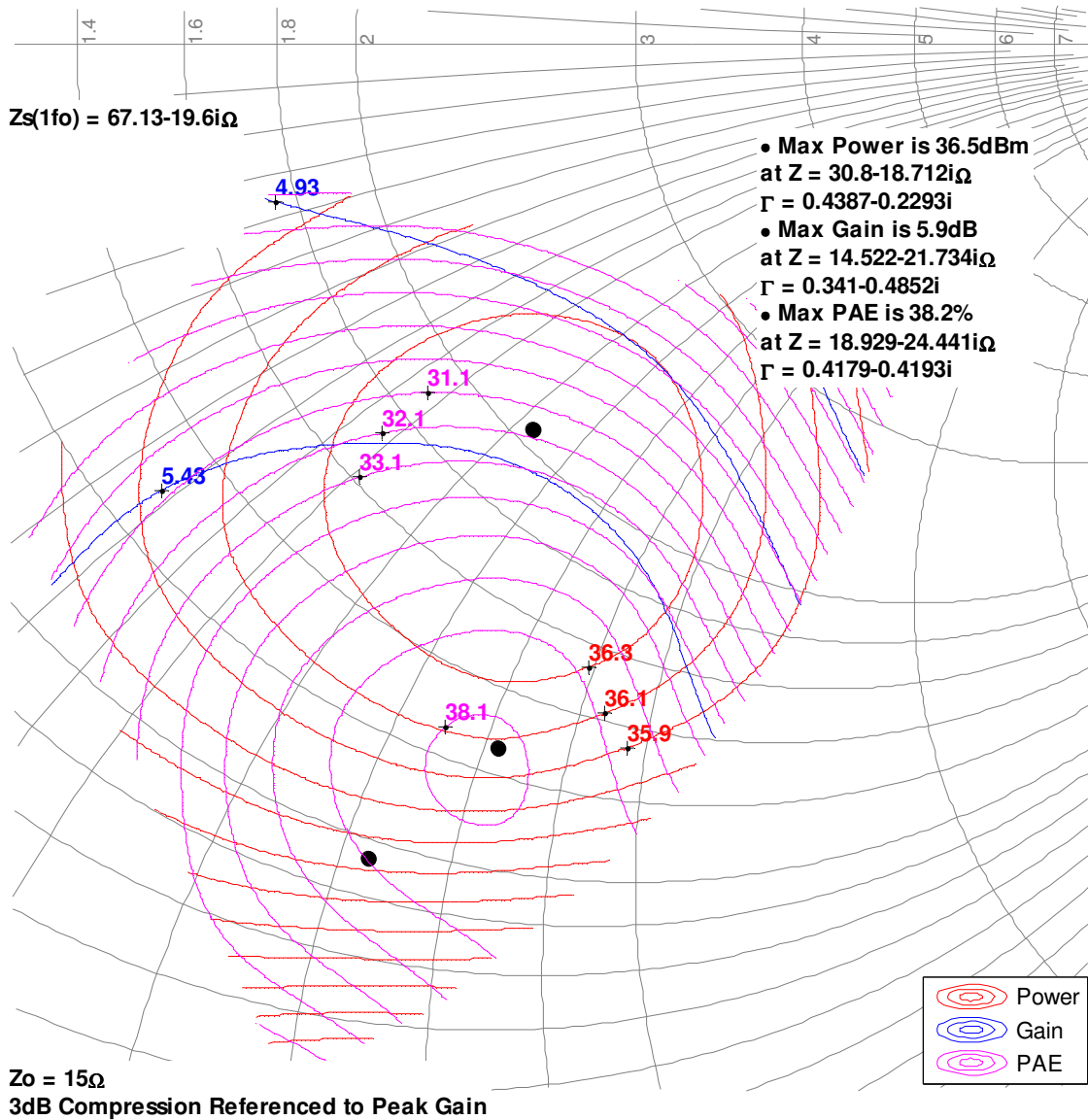


Measured Load-Pull Smith Charts^{1,2}

Notes:

1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 μS Pulse Width, 20% Duty Cycle
2. See page 21 for load pull reference planes where the performance was measured.

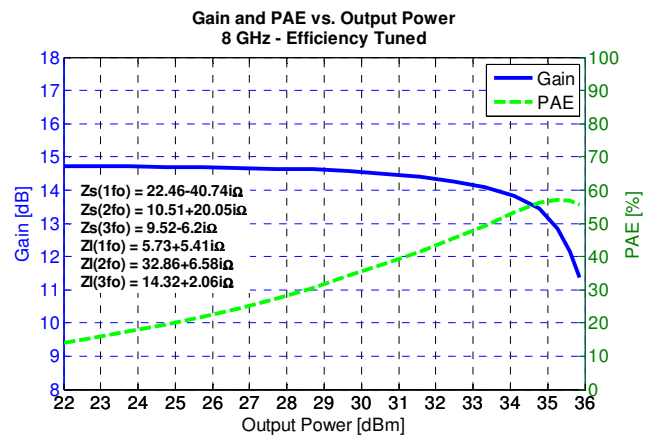
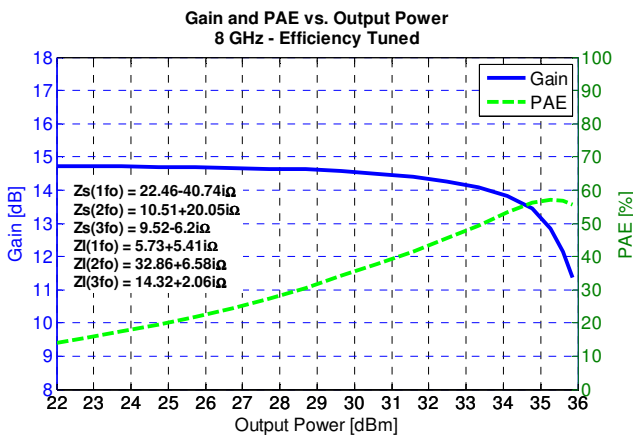
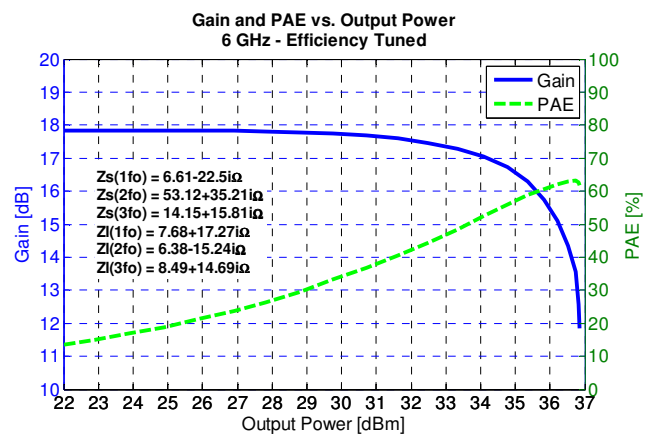
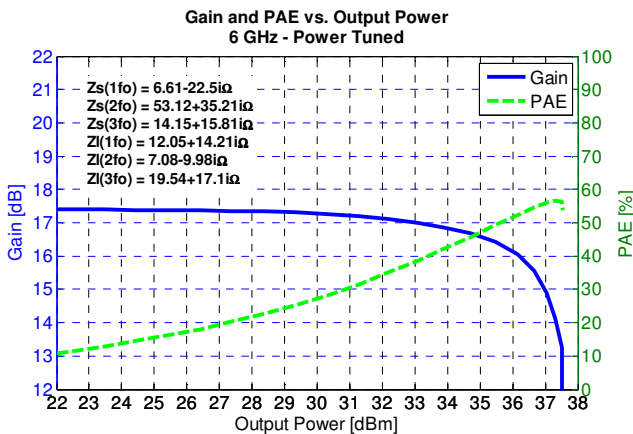
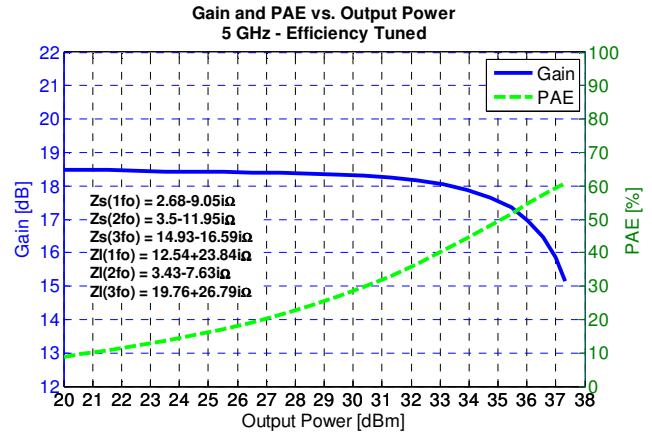
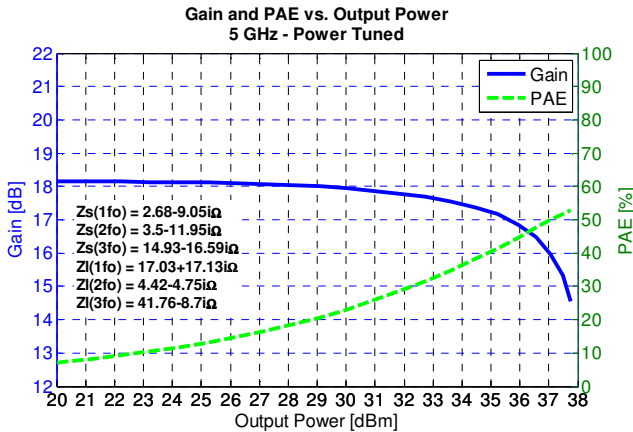
12GHz, Load-pull



Typical Measured Performance – Load-Pull Drive-up^{1, 2}

Notes:

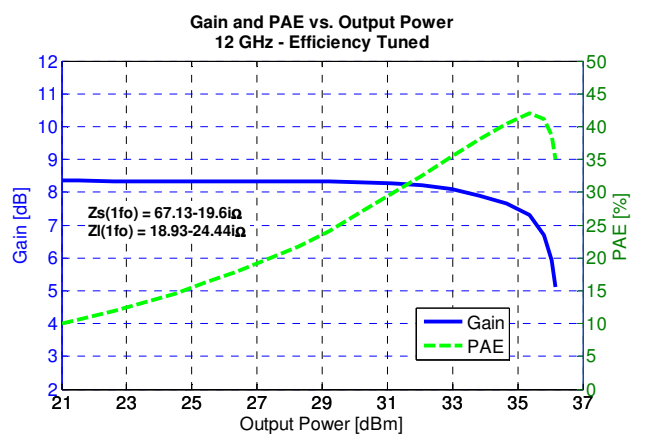
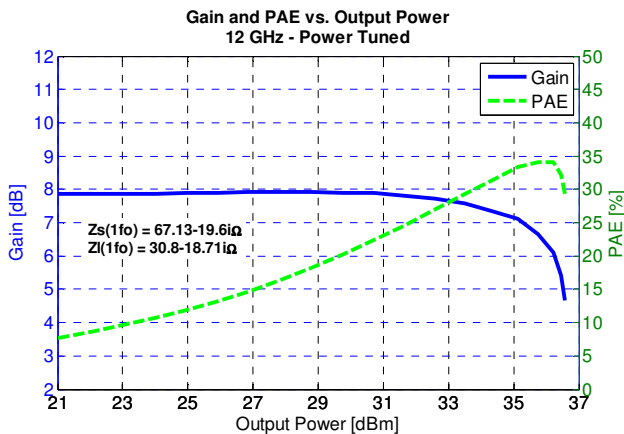
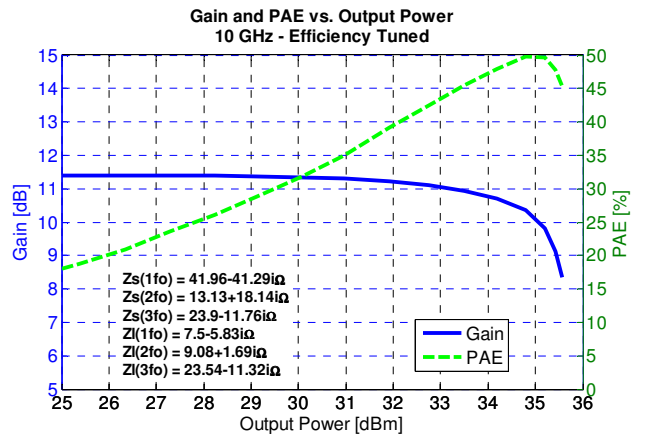
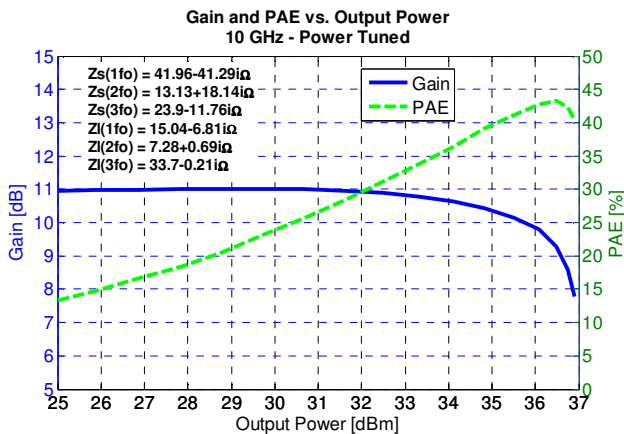
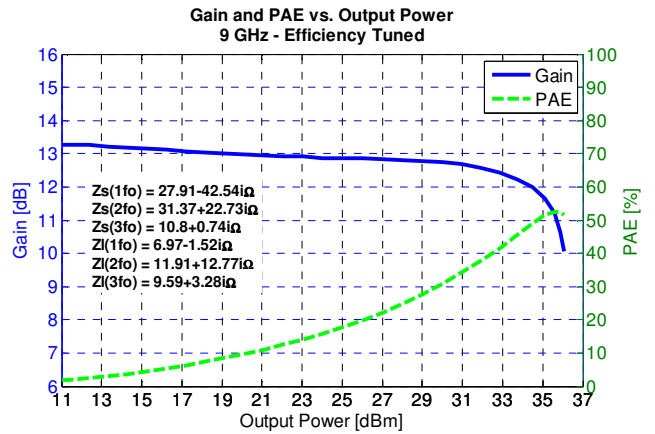
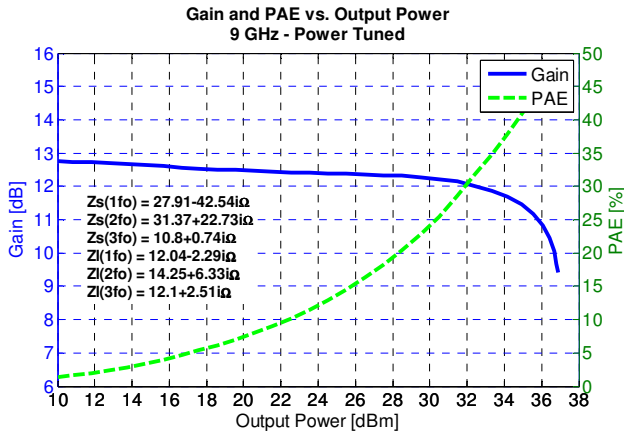
1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 μs Pulse Width, 20% Duty Cycle
2. See page 21 for load-pull and source-pull reference planes PAE where the performance was measured.



Typical Measured Performance – Load-Pull Drive-up^{1, 2}

Notes:

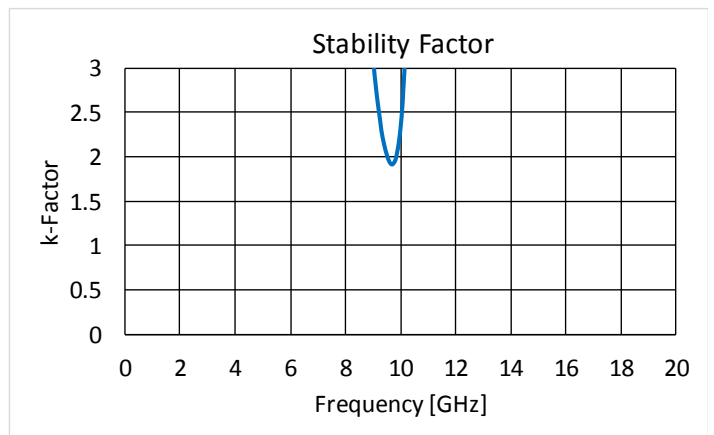
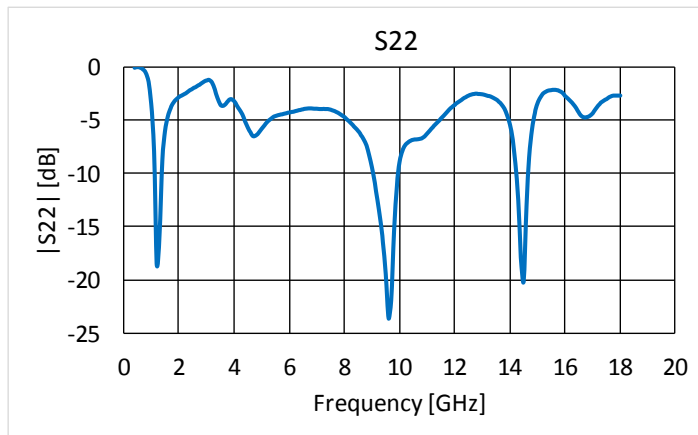
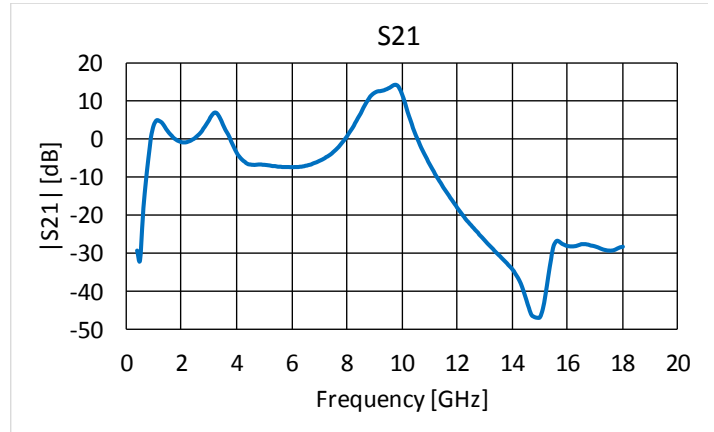
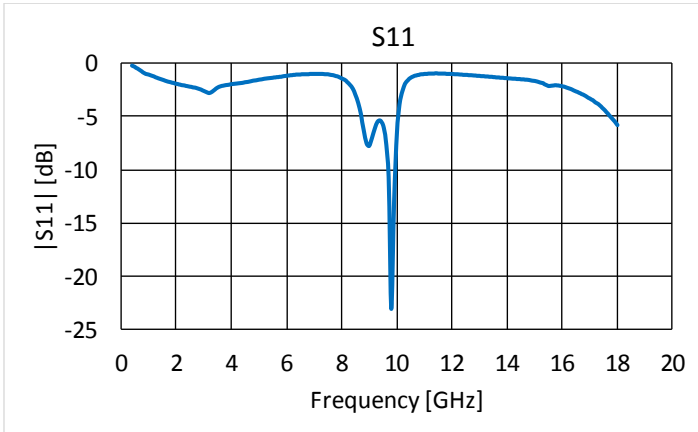
1. C Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 μs Pulse Width, 20% Duty Cycle
2. See page 21 for load-pull and source-pull reference planes where the performance was measured.



S-Parameters Of 9 – 10 GHz EVB at -40°C¹

Notes:

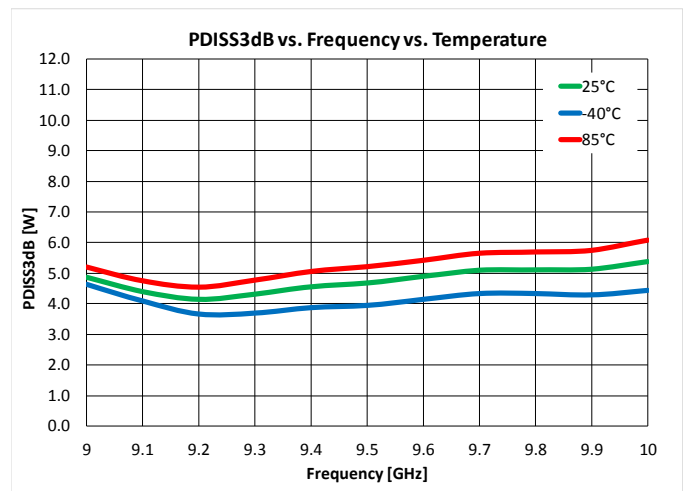
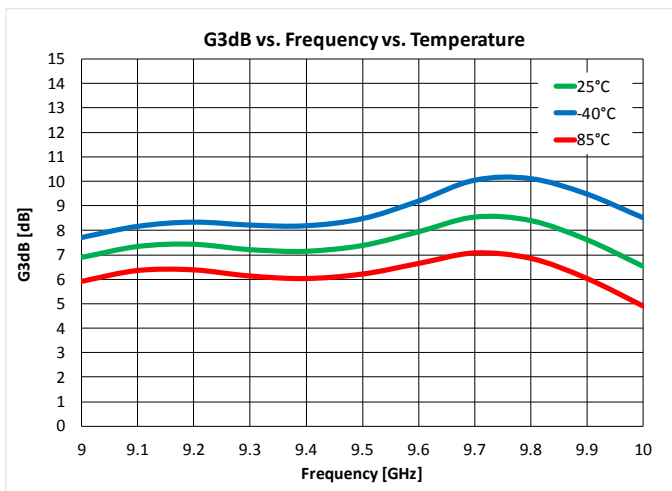
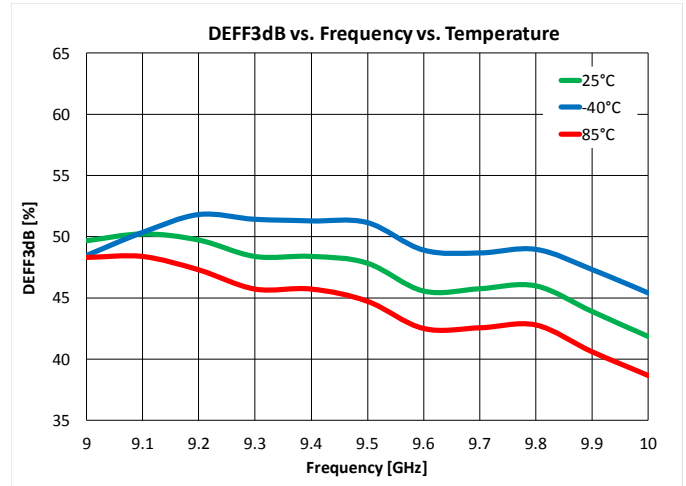
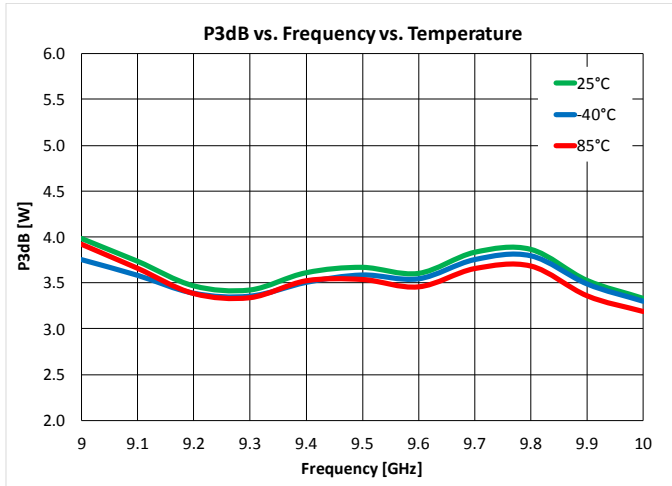
1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 35\text{ mA}$



Power Driveup Performance Over Temperatures Of 9 – 10 GHz EVB^{1,2}

Notes:

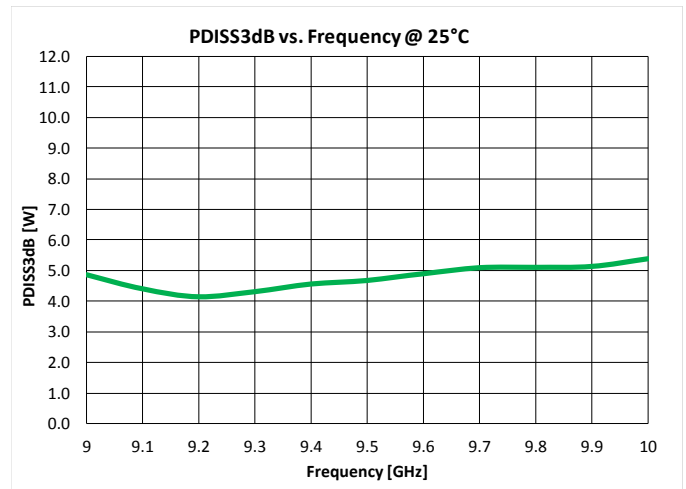
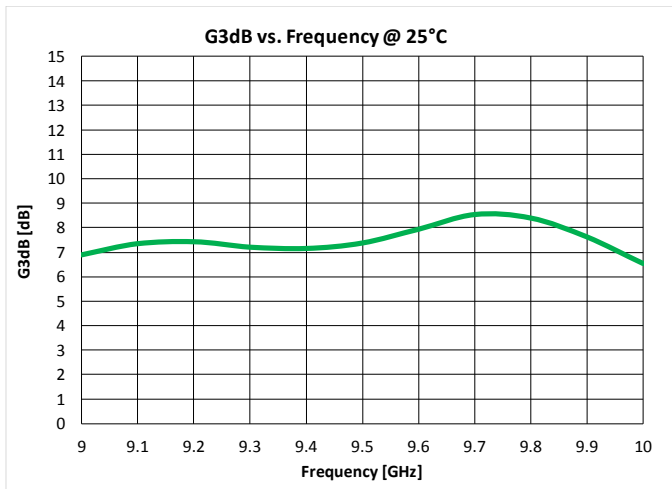
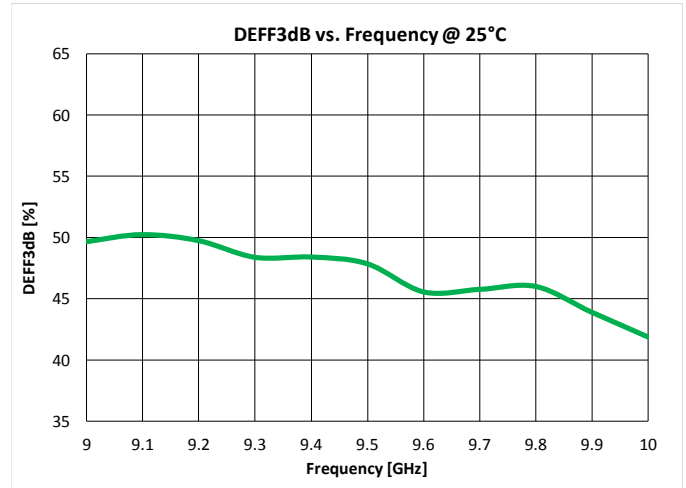
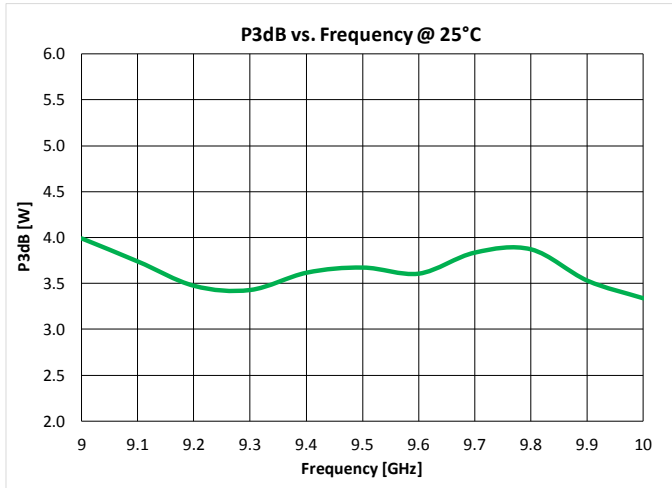
2. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 35\text{ mA}$, 100 uS Pulse Width, 20% Duty Cycle
3. The dissipation power limit is conservative because it is specified at DUT only without accounting for the loss of the output matching network.



Power Driveup Performance At 25°C Of 9 – 10 GHz EVB^{1,2}

Notes:

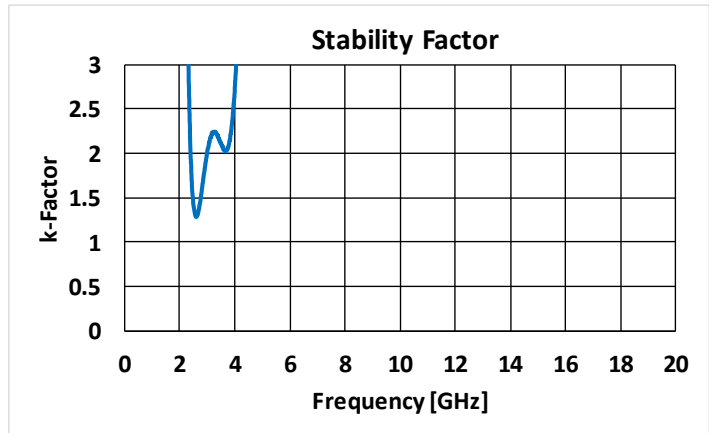
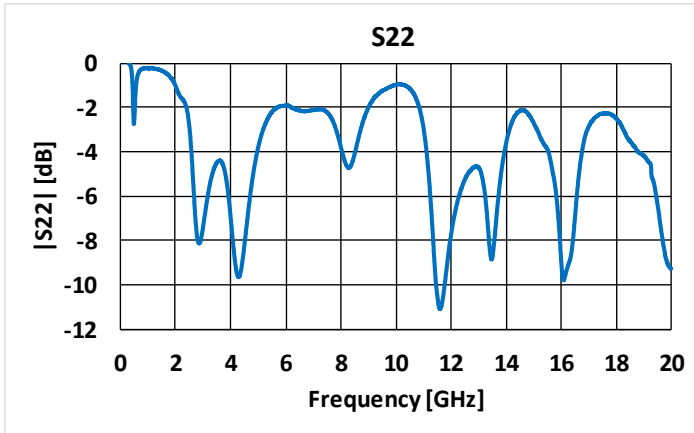
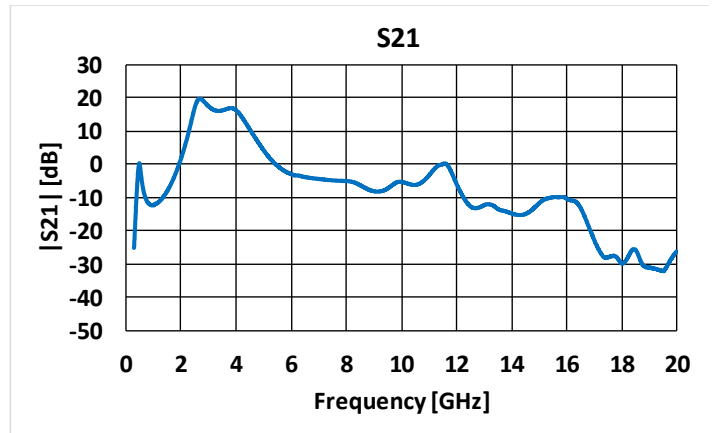
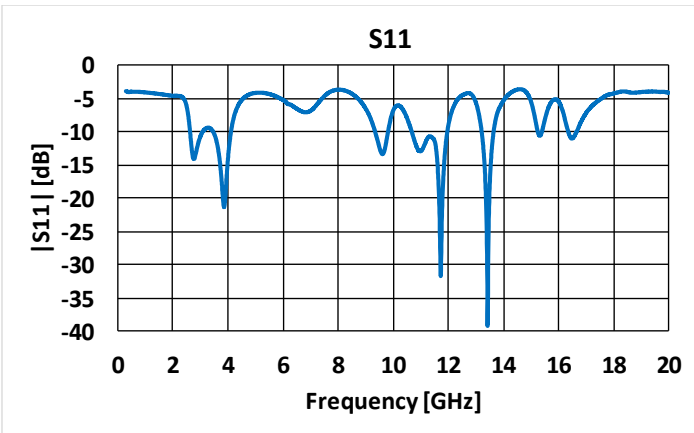
1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 35\text{ mA}$, 100 μs Pulse Width, 20% Duty Cycle
2. The dissipation power is conservative because it is specified at DUT only without accounting for the loss of the output matching network..



S-Parameters Of 2.6 – 4.2GHz EVB¹

Notes:

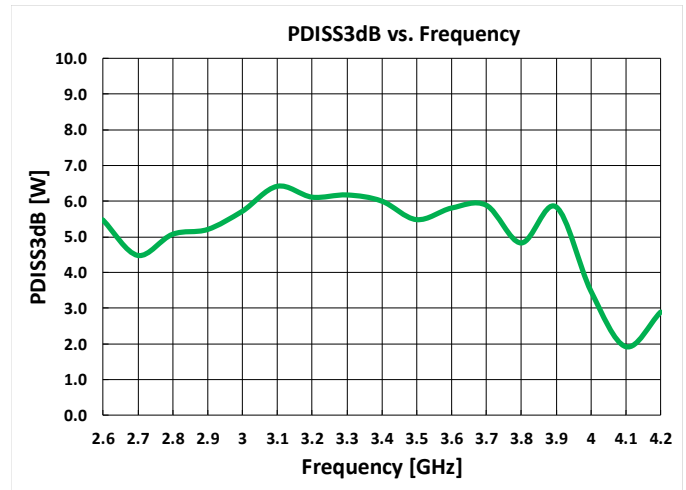
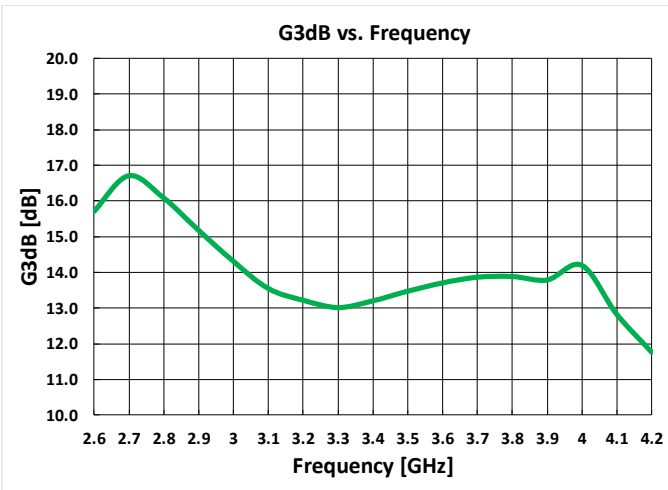
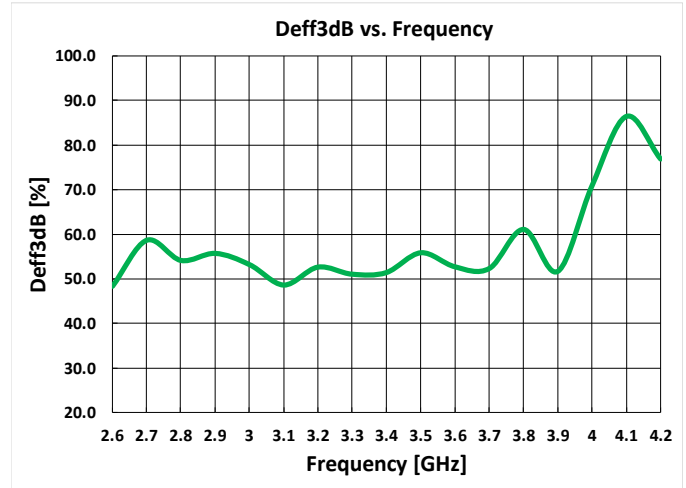
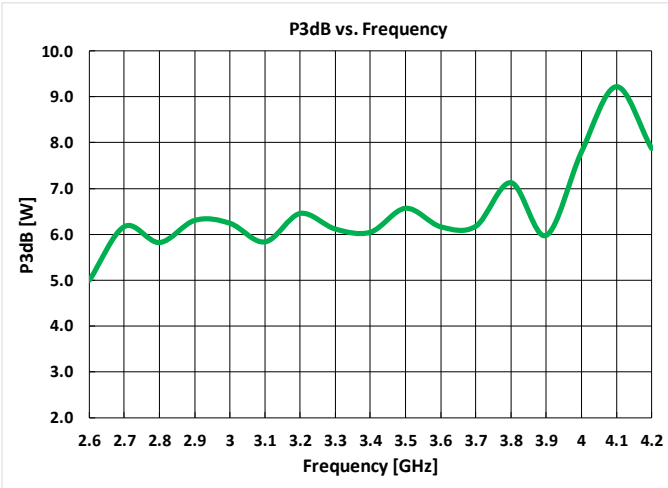
1. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, $T = 25^\circ\text{C}$



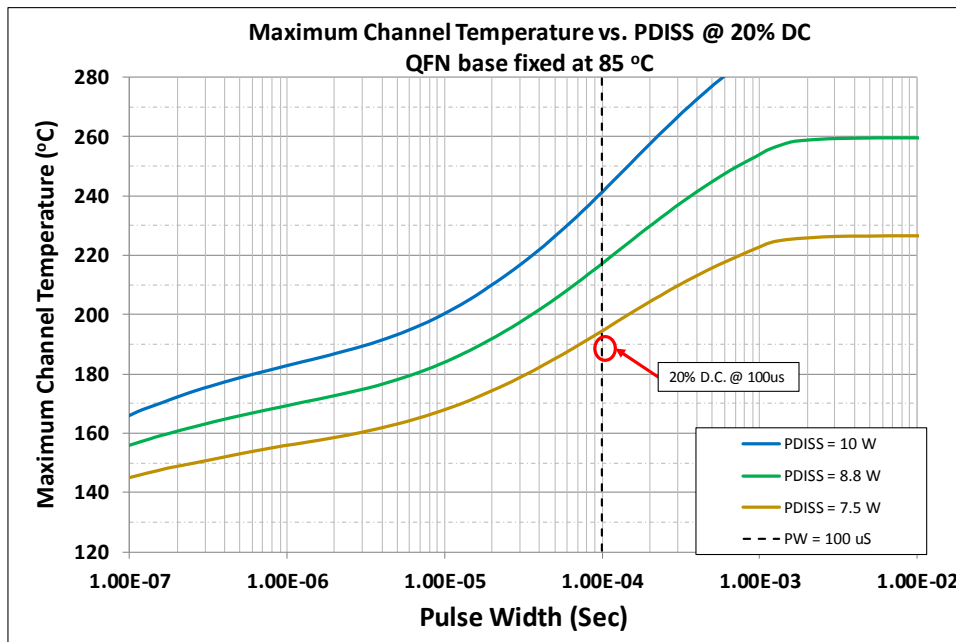
Power Driveup Performance Of 2.6 – 4.2GHz EVB^{1,2}

Notes:

3. Test Conditions: $V_D = 32\text{ V}$, $I_{DQ} = 25\text{ mA}$, 100 μs Pulse Width, 20% Duty Cycle, $T = 25^\circ\text{C}$
4. The dissipation power is conservative because it is specified at DUT only without accounting for the loss of the output matching network..



Thermal and Reliability Information – Pulsed^{1, 2, 3, 4}

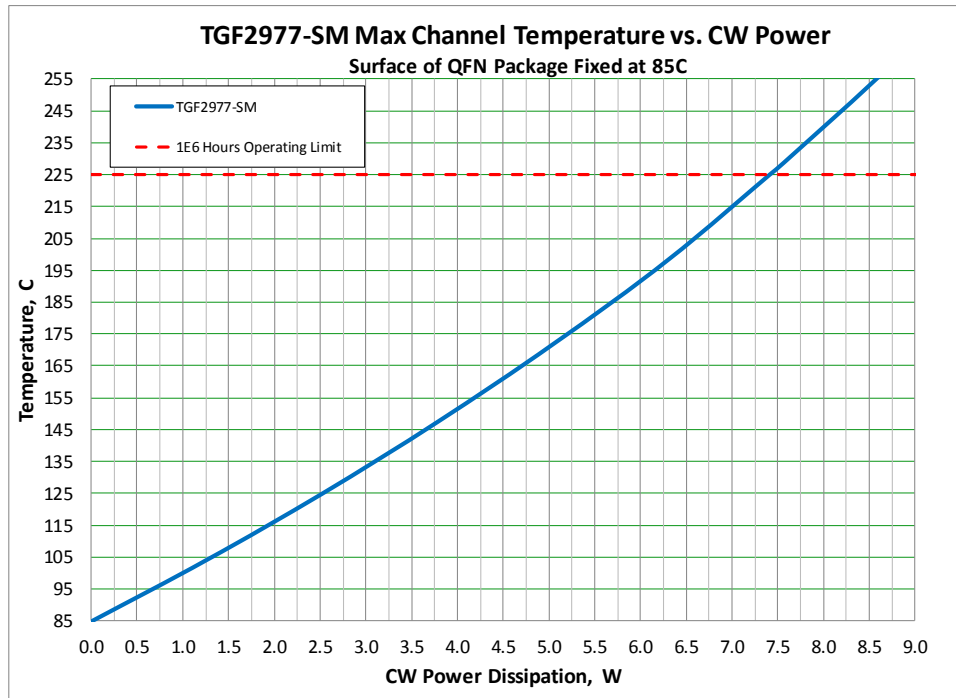


| Parameter | Conditions | Values | Units |
|---|---|--------|-------|
| Thermal Resistance (θ_{JC}) | 85 °C Case 10.1 W Pdiss, 100uS PW, 20% | 15.4 | °C/W |
| Peak Channel Temperature (T_{CH}) | | 241 | °C |
| Median Lifetime (T_M) ¹ | | 2.6E6 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 9.8 | °C/W |
| Max. Channel Temperature, IR (T_{CH}) | | 184 | °C |
| Thermal Resistance (θ_{JC}) | 85 °C Case 9.2 W Pdiss, 100uS PW, 20% | 15.2 | °C/W |
| Peak Channel Temperature (T_{CH}) | | 225 | °C |
| Median Lifetime (T_M) ¹ | | 9.0E06 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 9.8 | °C/W |
| Max. Channel Temperature, IR (T_{CH}) | | 175 | °C |
| Thermal Resistance (θ_{JC}) | 85 °C Case 8.8 W Pdiss, 100uS PW, 20% | 15.0 | °C/W |
| Peak Channel Temperature (T_{CH}) | | 217 | °C |
| Median Lifetime (T_M) ¹ | | 1.8E07 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 9.8 | °C/W |
| Max. Channel Temperature, IR (T_{CH}) | | 171 | °C |
| Thermal Resistance (θ_{JC}) | 85 °C Case 7.6 W Pdiss, 100uS PW, 20% | 14.5 | °C/W |
| Peak Channel Temperature (T_{CH}) | | 195 | °C |
| Median Lifetime (T_M) ¹ | | 1.2E08 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 9.6 | °C/W |
| Max. Channel Temperature, IR (T_{CH}) | | 158 | °C |

Notes:

1. Finite Element Analysis (FEA) thermal values shall be used to determine performance and reliability. Unless otherwise noted, all thermal references are FEA.
2. Infrared (IR) thermal values are for reference only.
3. Thermal resistance measured to backside of package.
4. Median lifetime under pulsed condition is the lifetime under CW condition divided by the duty cycle.

Thermal and Reliability Information – CW^{1, 2, 3}

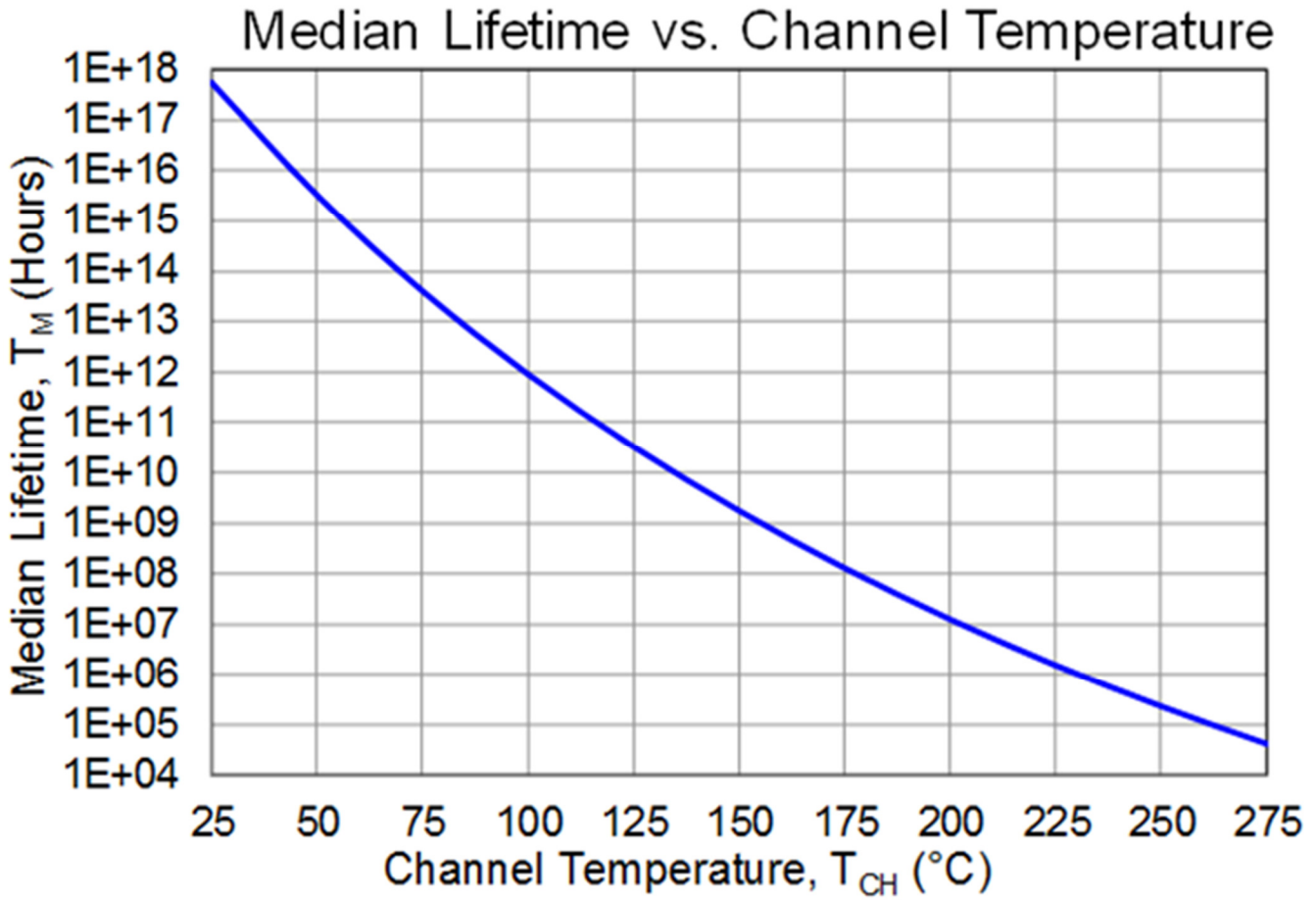


| Parameter | Conditions | Values | Units |
|---|------------|--------|-----------------------------|
| Thermal Resistance (θ_{JC}) | | 20.1 | $^{\circ}\text{C}/\text{W}$ |
| Maximum Channel Temperature (T_{CH}) | | 262 | $^{\circ}\text{C}$ |
| Median Lifetime (T_M) | | 1.1E05 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 12.6 | $^{\circ}\text{C}/\text{W}$ |
| Max. Channel Temperature, IR (T_{CH}) | | 196 | $^{\circ}\text{C}$ |
| Thermal Resistance (θ_{JC}) | | 18.9 | $^{\circ}\text{C}/\text{W}$ |
| Maximum Channel Temperature (T_{CH}) | | 225 | $^{\circ}\text{C}$ |
| Median Lifetime (T_M) | | 1.8E6 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 12.2 | $^{\circ}\text{C}/\text{W}$ |
| Max. Channel Temperature, IR (T_{CH}) | | 175 | $^{\circ}\text{C}$ |
| Thermal Resistance (θ_{JC}) | | 17.9 | $^{\circ}\text{C}/\text{W}$ |
| Maximum Channel Temperature (T_{CH}) | | 198 | $^{\circ}\text{C}$ |
| Median Lifetime (T_M) | | 1.9E07 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 11.7 | $^{\circ}\text{C}/\text{W}$ |
| Max. Channel Temperature, IR (T_{CH}) | | 159 | $^{\circ}\text{C}$ |
| Thermal Resistance (θ_{JC}) | | 17.4 | $^{\circ}\text{C}/\text{W}$ |
| Maximum Channel Temperature (T_{CH}) | | 172 | $^{\circ}\text{C}$ |
| Median Lifetime (T_M) | | 2.3E08 | Hrs |
| Thermal Resistance, IR (θ_{JC}) | | 11.8 | $^{\circ}\text{C}/\text{W}$ |
| Max. Channel Temperature, IR (T_{CH}) | | 144 | $^{\circ}\text{C}$ |

Notes:

1. Finite Element Analysis (FEA) thermal values shall be used to determine performance and reliability. Unless otherwise noted, all thermal references are FEA.
2. Infrared (IR) thermal values are for reference only.
3. Thermal resistance measured to backside of package.

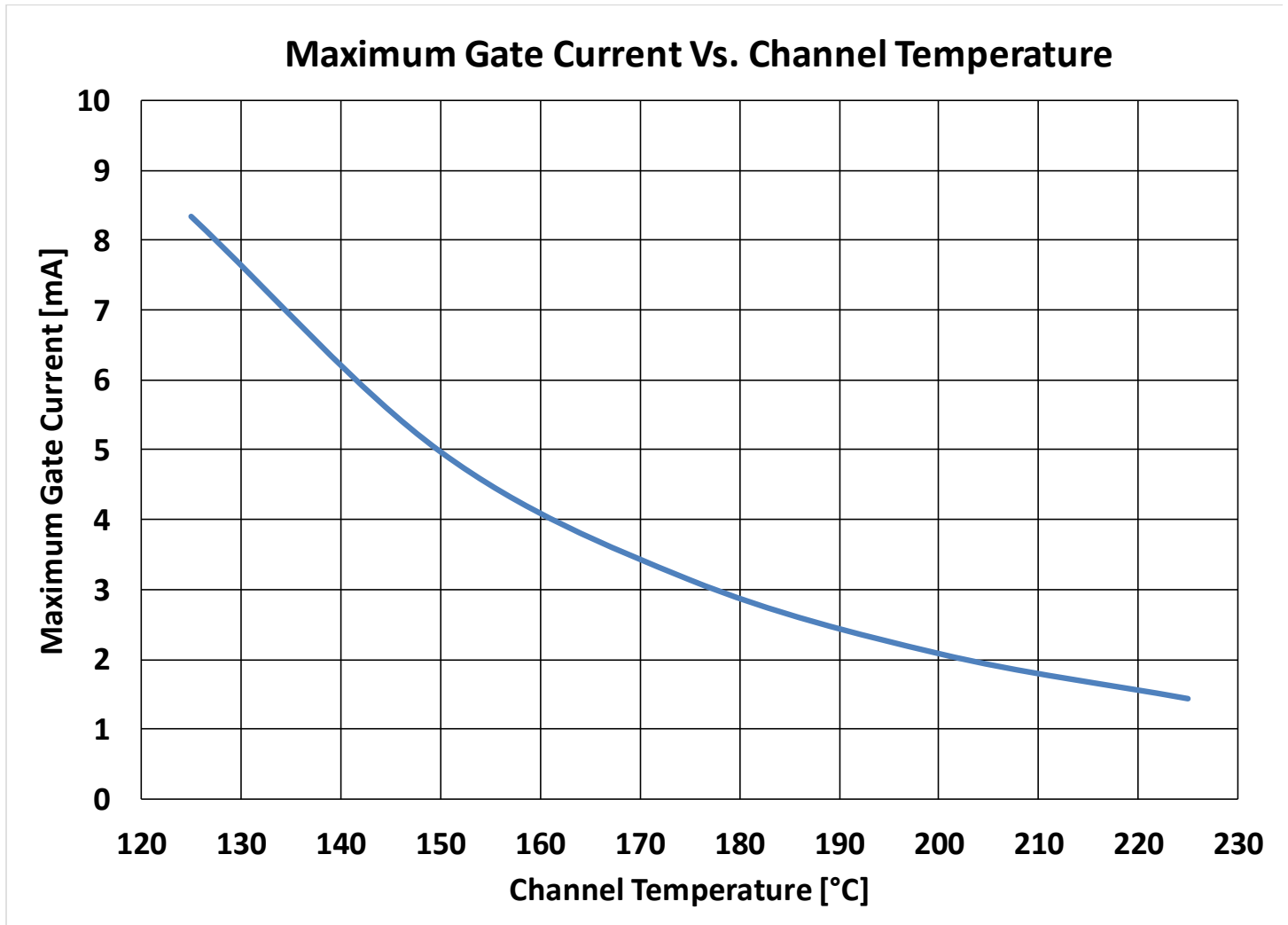
Median Lifetime¹



Notes:

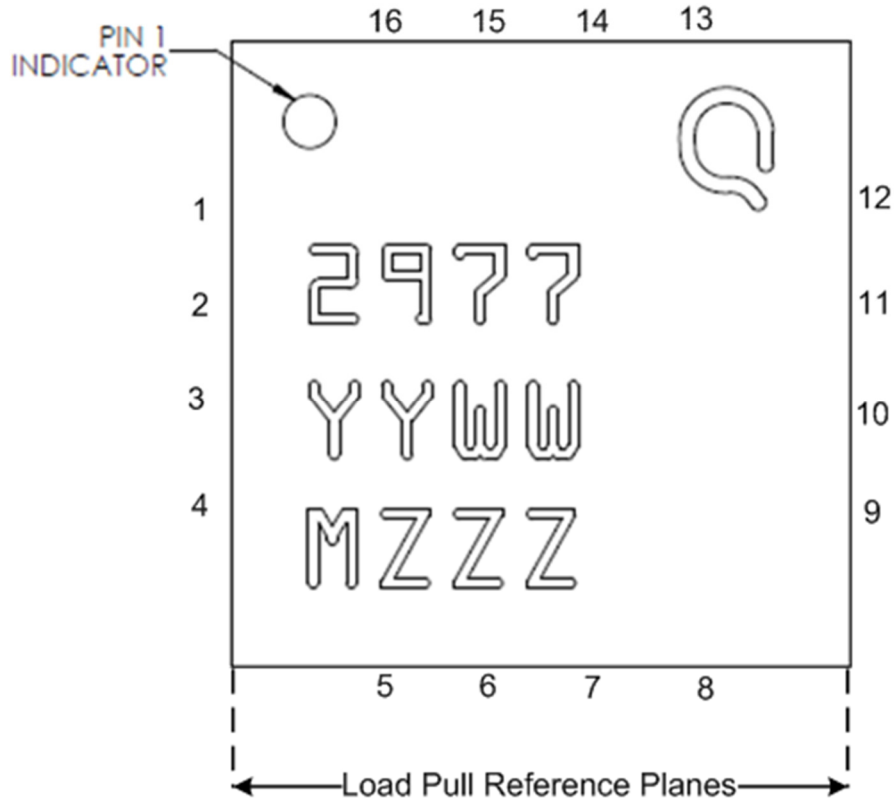
- 1. Test Conditions: $V_D = +32\text{ V}$; Failure Criteria = 10% reduction in I_{D_MAX} during DC Life Testing .

Maximum Gate Current



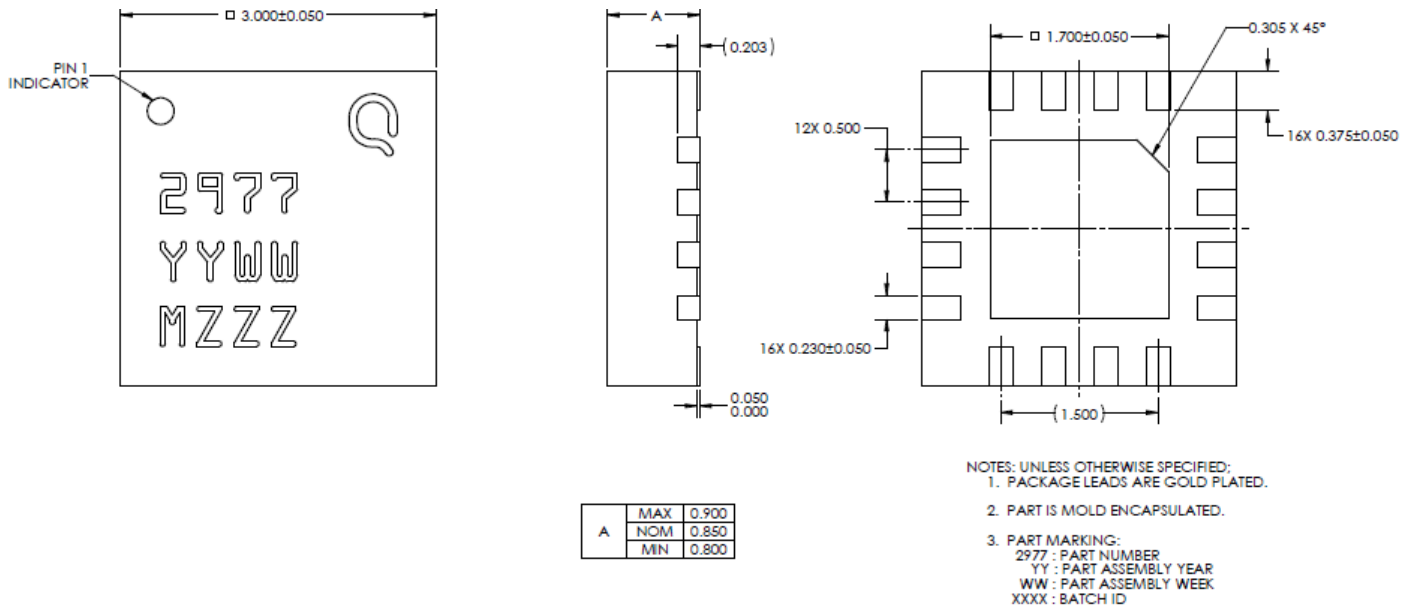
Pin Configuration and Description¹

Note 1: The TGF2977-SM will be marked with the “2977” 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 MZZZ” is the production lot number.



| Pin | Symbol | Description |
|-------------------|-------------------------|------------------------------------|
| 2 | RF IN / V _G | Gate |
| 10 - 11 | RF OUT / V _D | Drain |
| 1, 3 – 9, 12 - 16 | NC | Not Connected |
| Back side | Source | Source / Ground / Backside of part |

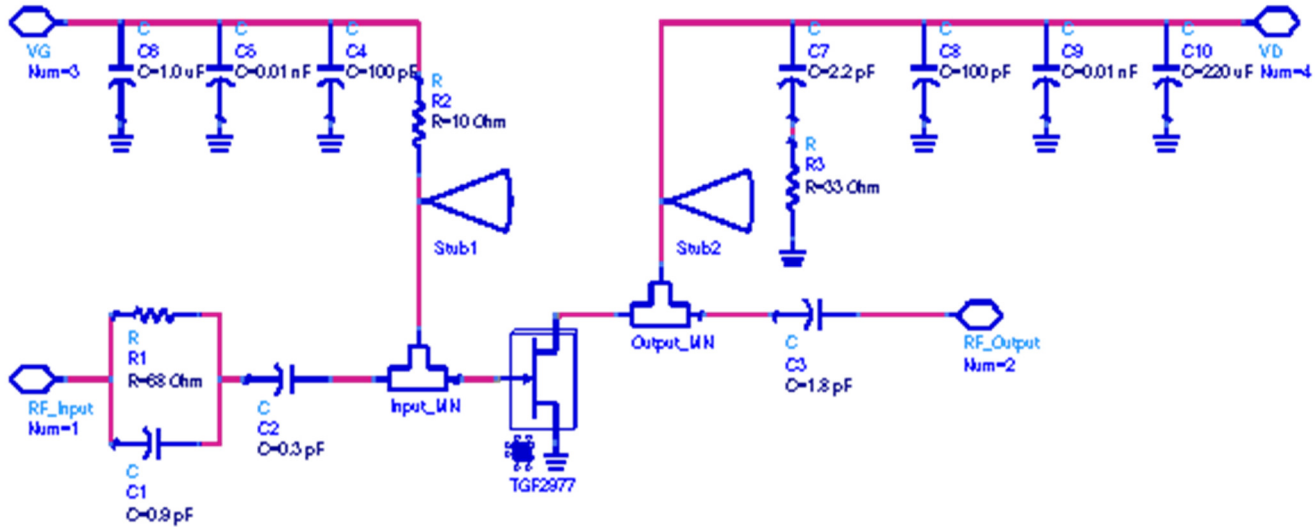
Mechanical Drawing^{1, 2, 3}



Note:

1. All dimensions are in millimeters.
2. Unless otherwise noted, all dimension tolerances are ± 0.127 mm.
3. This package is lead-free/RoHS-compliant. The plating material on the leads is NiAu. It is compatible with both lead-free (maximum 260°C reflow temperature) and tin-lead (maximum 245°C reflow temperature) soldering process.

9 – 10 GHz Application Circuit - Schematic



Bias-up Procedure

1. Set V_G to -4 V.
2. Set I_D current limit to 30 mA.
3. Apply 32 V V_D .
4. Slowly adjust V_G until I_D is set to 25 mA.
5. Set I_D current limit to 0.4 A (Pulsed operation)
6. Apply RF.

Bias-down Procedure

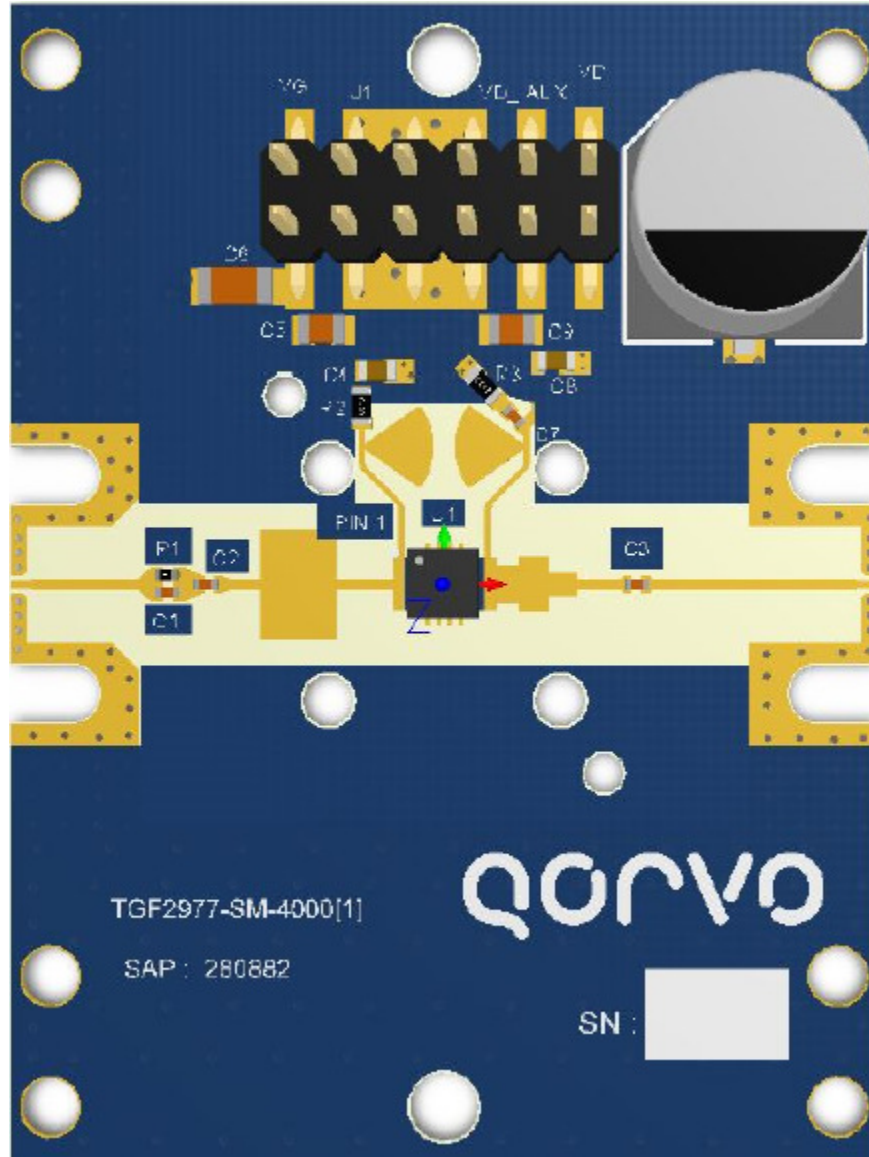
1. Turn off RF signal.
2. Turn off V_D
3. Wait 2 seconds to allow drain capacitor to discharge
4. Turn off V_G

9 – 10 GHz Application Circuit - Bill Of material

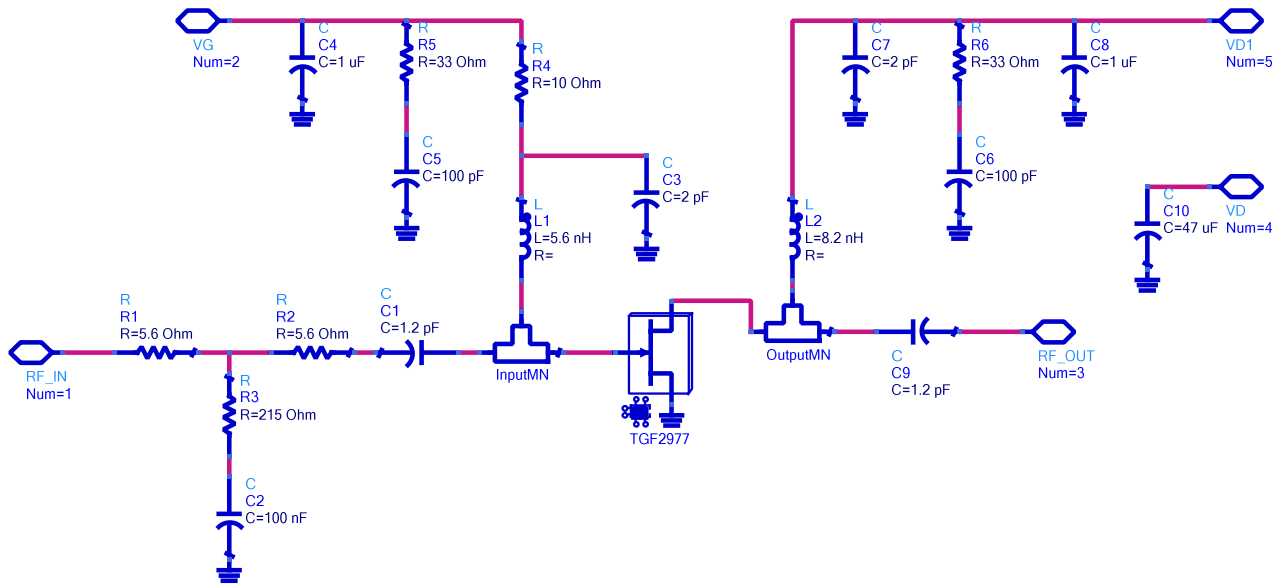
| Description | Ref. Des. | Manufacturer | Part Number |
|---|-----------|-----------------------------|------------------|
| Capacitor 0.9pF, 200V, 0402 | C1 | American Technical Ceramics | 600L0R3AT200T |
| Capacitor 0.3 pF, 200V, 0402 | C2 | American Technical Ceramics | 600L0R3AT200T |
| Capacitor 1.8 pF, 200V, 0402 | C3 | American Technical Ceramics | 600L1R8AT200T |
| Capacitor 2.2 pF, 200V, 0402 | C7 | American Technical Ceramics | 600L2R2BT200T |
| Capacitor 100 pF, 200V, 0603 | C4, C8 | Carpax Technologies | 0603G101J201S |
| Capacitor 0.1 nF, 200V, 0603 | C5, C9 | Digi-Key | C0805C103K5RACTU |
| Capacitor 1 uF, 200V, 1206 | C6 | Digi-Key | C1206C105K4RACTU |
| Capacitor, Electrolytic, 47 uF, 50V, 10mm SMD | C16 | Panasonic | EEETG1H470P |
| Resistor, 68 Ohm, 0402 | R1 | Panasonic | ERJ-2RKF68R0X |
| Resistor, 10 Ohm, 0603 | R2 | | Generic 0603 |
| Resistor, 33 Ohm, 0603 | R3 | | Generic 0603 |

9 – 10 GHz Application Circuit - Layout

Board material is RO4003C 0.008" thickness with 1oz copper cladding. Overall EVB size is 1.5" x 2".



2.6 – 4.2 GHz Application Circuit - Schematic



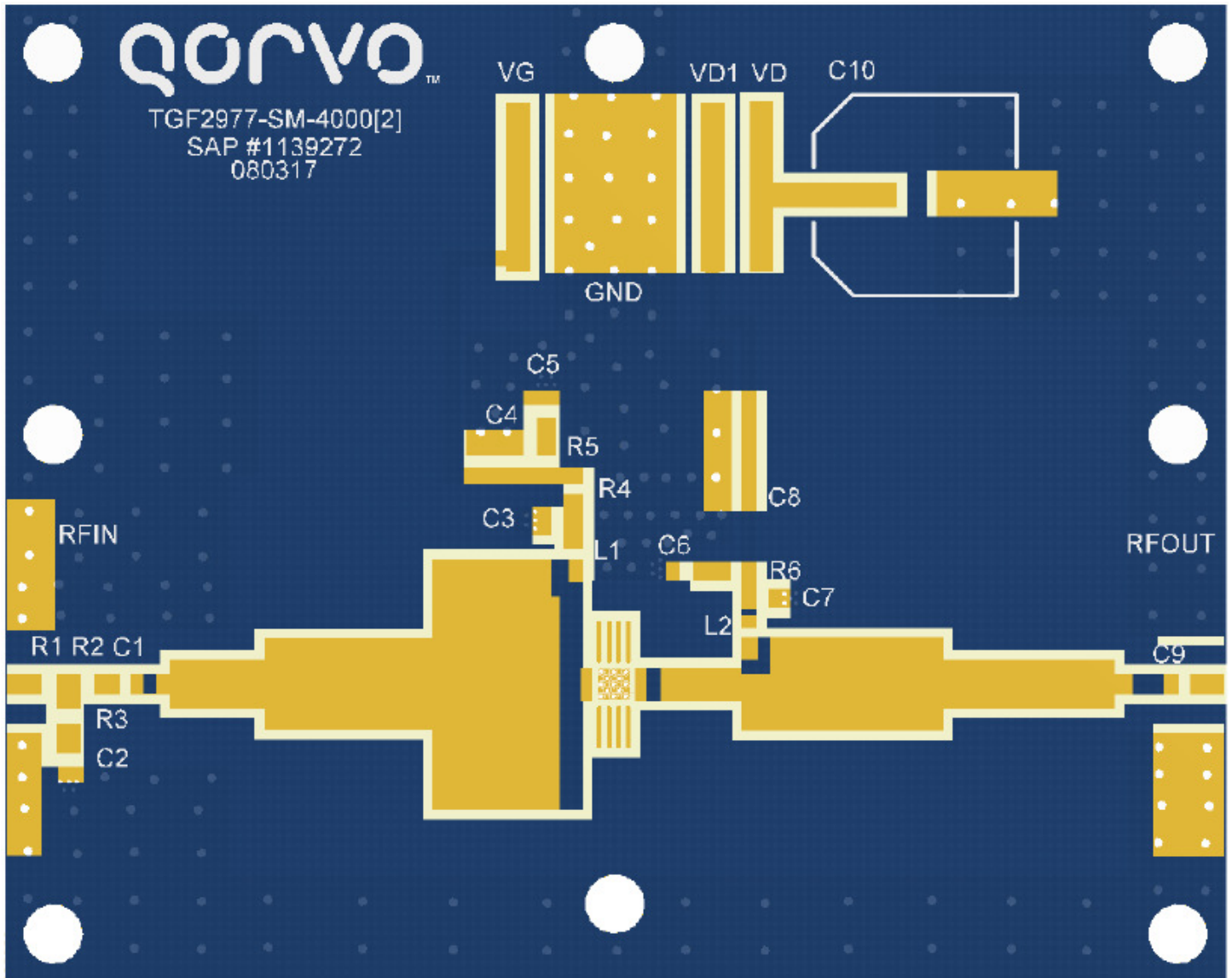
| Bias-up Procedure | Bias-down Procedure |
|--|---|
| 1. Set V_G to -4 V. | 1. Turn off RF signal. |
| 2. Set I_D current limit to 30 mA. | 2. Turn off V_D |
| 3. Apply 32 V V_D . | 3. Wait 2 seconds to allow drain capacitor to discharge |
| 4. Slowly adjust V_G until I_D is set to 25 mA. | 4. Turn off V_G |
| 5. Set I_D current limit to 0.5 A (Pulsed operation) | |
| 6. Apply RF. | |

2.6 – 4.2 GHz Application Circuit - Bill Of material

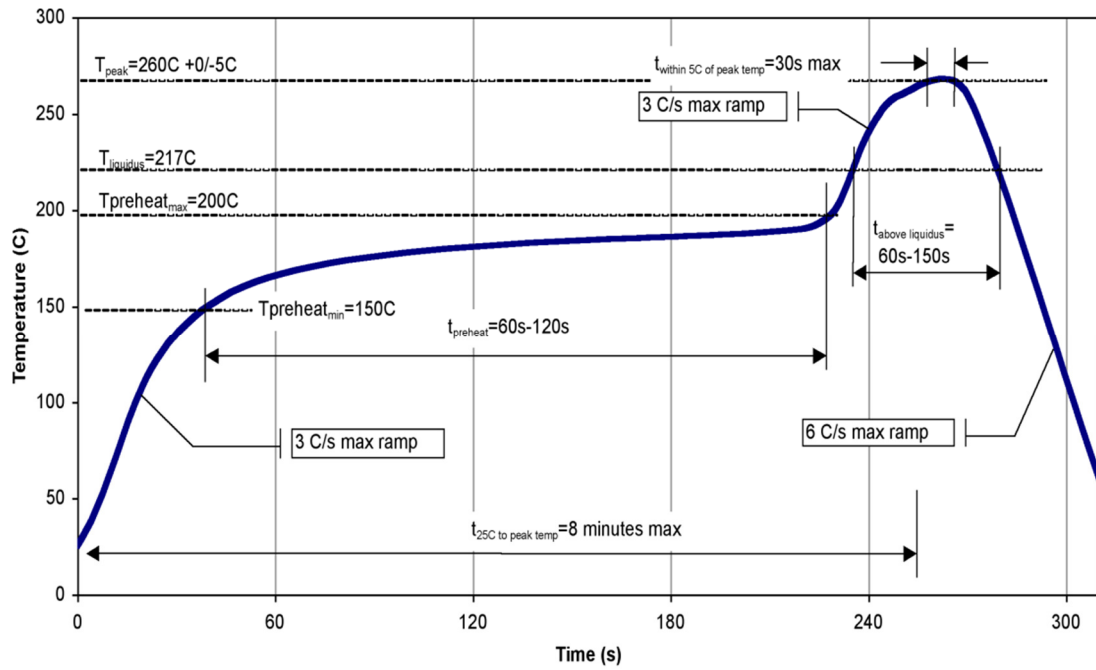
| Description | Ref. Des. | Manufacturer | Part Number |
|-------------------------------------|-----------|--------------------|---------------------|
| Capacitor 1.2pF, 250V, 0603 | C1, C9 | ATC | 600S1R2AT250XT |
| Capacitor 0.1 uF, 100V, 0603 | C2 | AVX | 0603YC104KAT2A |
| Capacitor 2.2 pF, 250V, 0603 | C3, C7 | ATC | 600S2R2BT250T |
| Capacitor 100 pF, 200V, 0603 | C5, C6 | Capax Technologies | 0603G101J201S |
| Capacitor 1 uF, 200V, 0805 | C4, C8 | TTI Inc. | C2012X7S2A105M125AB |
| Capacitor, Electrolytic, 47 uF, 50V | C10 | Panasonic | EEETG1H470P |
| Inductor 5.6 nH, 0603 | L1 | Coilcraft | 0603CS-5N6XJEW |
| Inductor 8.2 nH, 0603 | L2 | Coilcraft | 0603HP-8N2XJLW |
| Resistor, 5.6 Ohm, 0603 | R1, R2 | TTI | CRCW06035R60JNEA |
| Resistor, 215 Ohm, 0603 | R3 | Digi-Key | CRCW0603215RFKEA |
| Resistor, 33.2 Ohm, 0603 | R5, R6 | TTI | CRCW060333R2FKTA |
| Resistor, 10 Ohm, 0603 | R4 | TTI | CRCW060310R0JNTA |

2.6 – 4.2 GHz Application Circuit - Layout

Board material is RO4350B 0.020" thickness with 1oz copper cladding. Overall EVB size is 2" x 2.5".



Recommended Solder Temperature Profile



Handling Precautions

| Parameter | Rating | Standard |
|----------------------------------|------------|--------------------------|
| ESD – Human Body Model (HBM) | 500 V, 1B | ESDA / JEDEC JS-001-2012 |
| ESD – Charged Device Model (CDM) | 1000 V, C3 | JEDEC JESD22-C101F |
| MSL – Moisture Sensitivity Level | TBD | 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.

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 (C₁₅H₁₂Br₄O₂) Free
- PFOS Free
- SVHC Free



Contact Information

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