# QPA1315

## 15.4 – 17.7 GHz 35 Watt GaN Power Amplifier

## Product Overview

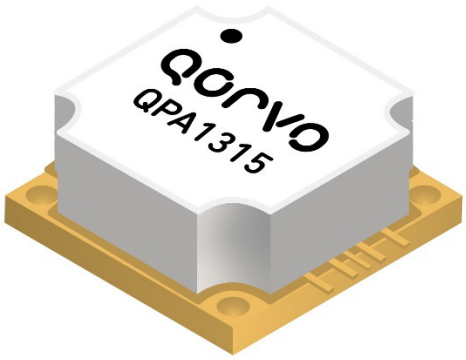
Qorvo's QPA1315 is a packaged high power MMIC amplifier, Ku-K band, fabricated on Qorvo's production 0.15 um GaN on SiC process (QGaN15). QPA1315 is targeted for 15.4 – 17.7 GHz band. It provides 35 W of saturated output power with 21 dB of large signal gain while achieving 20% power-added efficiency.

The QPA1315 is packaged in a 10-lead 15 x 15 mm bolt-down with a Cu base for superior thermal management. To simplify system integration, the QPA1315 is fully matched to 50 ohms with DC grounded I/O ports for optimum ESD performance. Also, there are on-chip blocking capacitors following the DC grounds on the input and output ports.

The QPA1315 is ideal for supporting radar applications in both commercial and military markets.

The QPA1315 is 100% DC and RF tested to ensure compliance to electrical specifications.

Lead-free and RoHS compliant

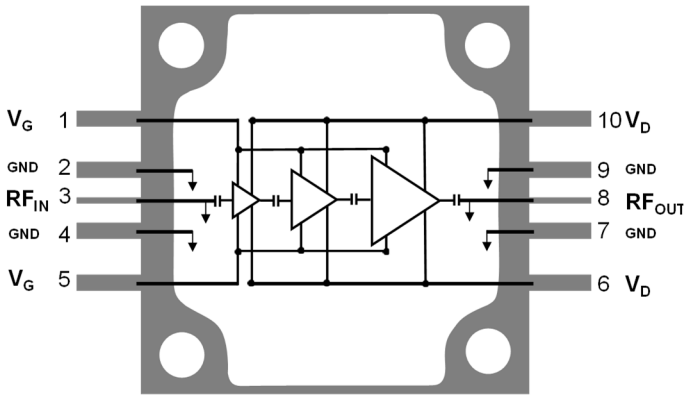



## Key Features

- Frequency Range: 15.4 – 17.7 GHz
- $P_{SAT}$ ($P_{IN}$ = 24 dBm): 45.5 dBm
- PAE ($P_{IN}$ = 24 dBm): 20 %
- Power Gain ($P_{IN}$ = 24 dBm): 21 dB
- Small Signal Gain: 25 dB
- Bias: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, $V_G$ = -2.5 V typ. Range, PW = 100 uS, DC = 10%
- Package Dimensions: 15.2 x 15.2 x 3.5 mm
- Package base is pure Cu offering superior thermal management.

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

## Functional Block Diagram




## Applications

- Radar

## Ordering Information

| Part No. | Description |
|---|---|
| QPA1315 | 15.4 - 17.7 GHz 35 Watt GaN PA |
| QPA1315EVB | Evaluation Board |

## Absolute Maximum Ratings

| Parameter | Value / Range |
|---|---|
| Drain Voltage ($V_D$) | 29.5 V |
| Gate Voltage Range ($V_G$) | -6 V to 0 V |
| Drain Current Total ($I_D$), $T_{BASE}$ = 85 °C | 14 A |
| Gate Current ($I_G$) | See plot page 24 |
| Power Dissipation ($P_{DISS}$), Pulsed, $T_{BASE}$ = 85 °C | 100us/10%: 160W<br>300us/30%: 150W |
| Input Power ($P_{IN}$), 50 Ω, Pulsed, $V_D$ = 28 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $T_{BASE}$ = 85 °C | 34 dBm |
| Input Power ($P_{IN}$), 10:1 VSWR, Pulsed, $V_D$ = 28 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $T_{BASE}$ = 85 °C | 34 dBm |
| Mounting Temperature | Refer to Assembly Notes, page 29 |
| Storage Temperature | -55 to +150 ºC |

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 Operating Conditions

| Parameter | Min | Typ. | Max | Units |
|---|---|---|---|---|
| Drain Voltage ($V_D$), Pulsed[1/] | | 26 | 28[2/] | V |
| Drain Current Quiescent ($I_{DQ}$) | | 640 | | mA |
| Drain Current, RF ($I_{D\_Drive}$) | See plots page 4,5,8,11,14 | | | mA |
| Gate Voltage Typ. Range ($V_G$) | –1.9 to -3.1 | | | V |
| Gate Current, RF ($I_{G\_Drive}$) | See plots page 4,5 | | | mA |
| Input Power @ Saturation ($P_{IN}$)[3/] | $T_{BASE}$ -40°C: 20 | | | dBm |
| | $T_{BASE}$ +25°C: 24 | | | |
| | $T_{BASE}$ +85 °C: 28 | | | |
| Operating Temp. Range ($T_{BASE}$)[4/] | –40 | | +85 | ºC |

1. CW operating requires thermal consideration. CW Applications are up to 7 dBm back off from saturated output power $P_{SAT}$.
2. Pulsed 28V requires thermal consideration
3. See plots page 6,7,18,19
4. $T_{BASE}$ is back side of QPA1315

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

## Electrical Specifications

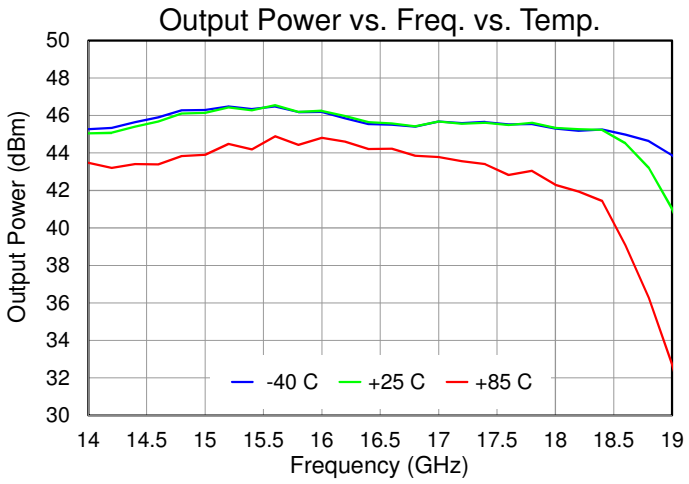
| Parameter | Conditions (1) (2) | Min | Typ. | Max | Units |
|---|---|---|---|---|---|
| Operational Frequency Range | | 15.4 | | 17.7 | GHz |
| Output Power at Saturation, $P_{SAT}$ | $P_{IN}$ = 24 dBm | | 45.5 | | dBm |
| Power Added Efficiency, PAE | $P_{IN}$ = 24 dBm | | 20 | | % |
| Small Signal Gain, S21 | $P_{IN}$ = -25 dBm | | 25 | | dB |
| Input Return Loss, IRL | | | 7 | | |
| Output Return Loss, ORL | | | 7 | | |
| $P_{SAT}$ Temperature Coefficient | $T_{DIFF}$ = 25 ºC to 85 ºC; $P_{IN}$ = 24 dBm | | -0.02 | | dBm/ºC |
| S21 Temperature Coefficient | $T_{DIFF}$ = 25 ºC to 85 ºC | | -0.10 | | dB/ºC |

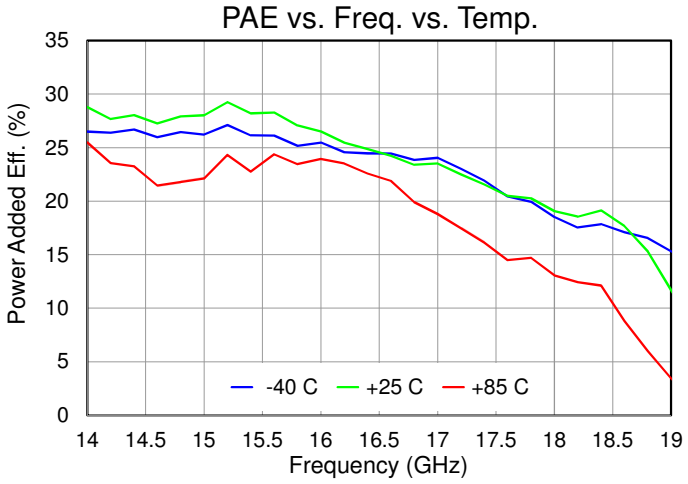
Notes:

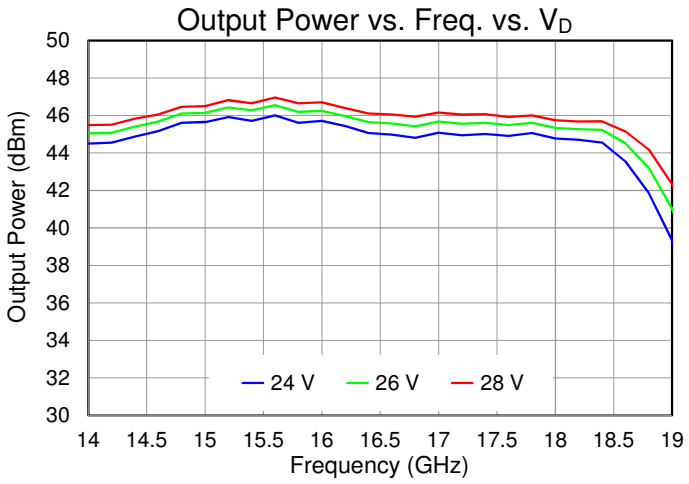
1. Test conditions unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, $V_G$ = -2.5 +/- 0.6 V typical, PW = 100 us, DC = 10%, $T_{BASE}$ = 25ºC, $Z_0$ = 50 Ω
2. $T_{BASE}$ is back side of QPA1315 (not the ambient nor bottom of the board temperature)

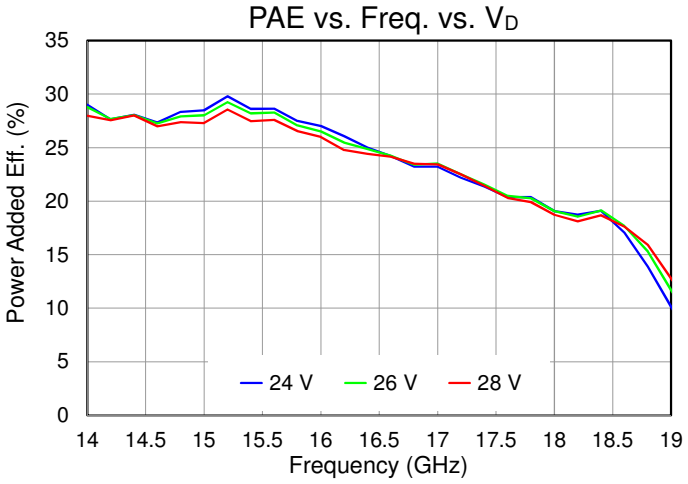
## Performance Plots – Large Signal (Pulsed)

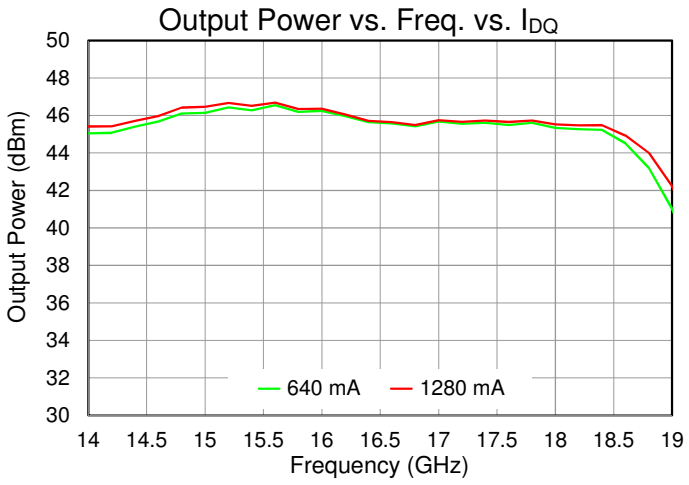
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).

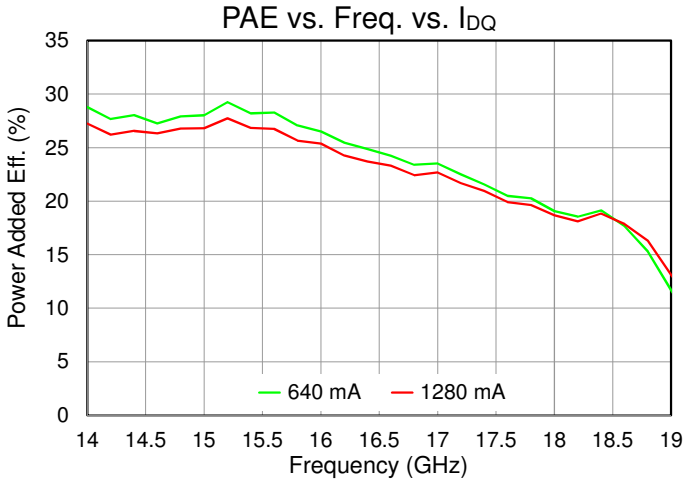


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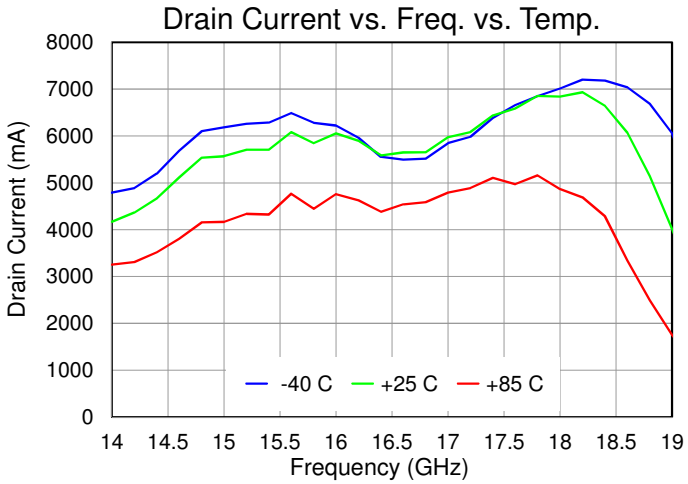


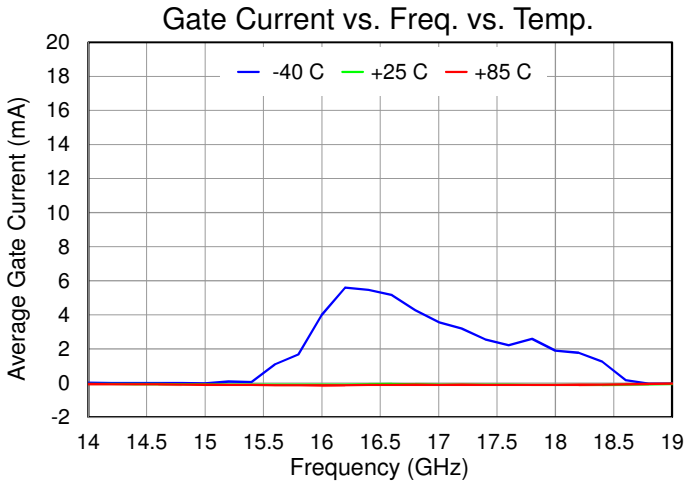


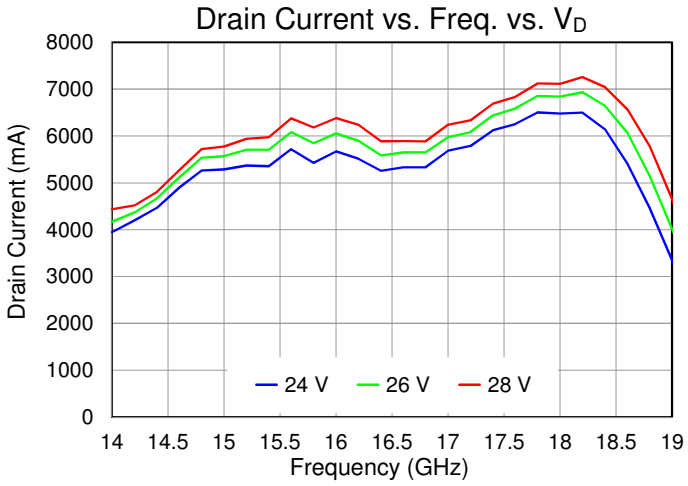


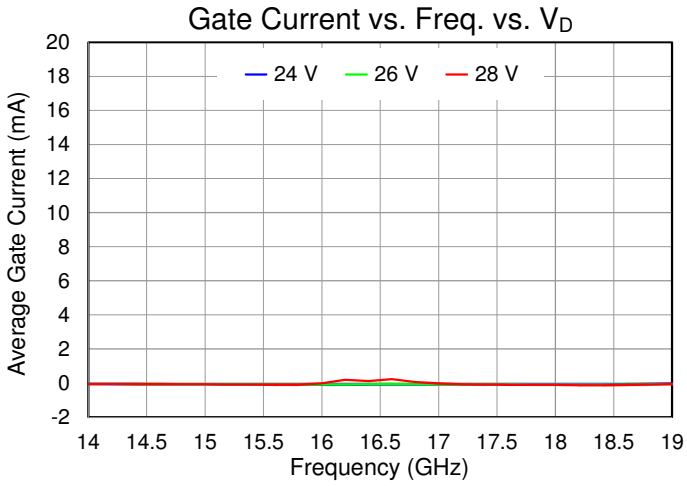


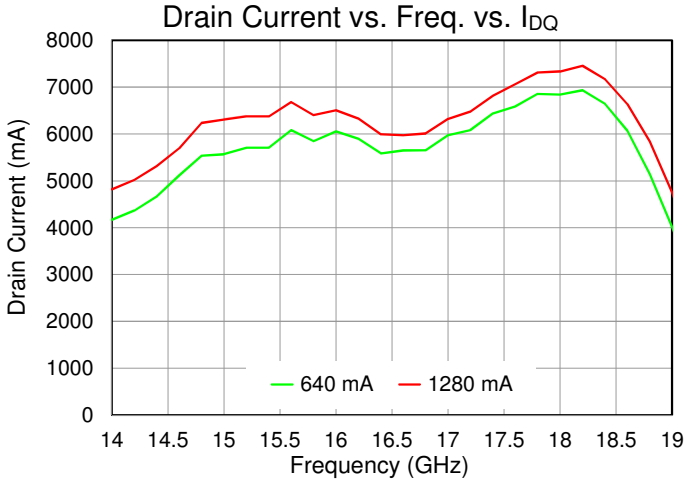


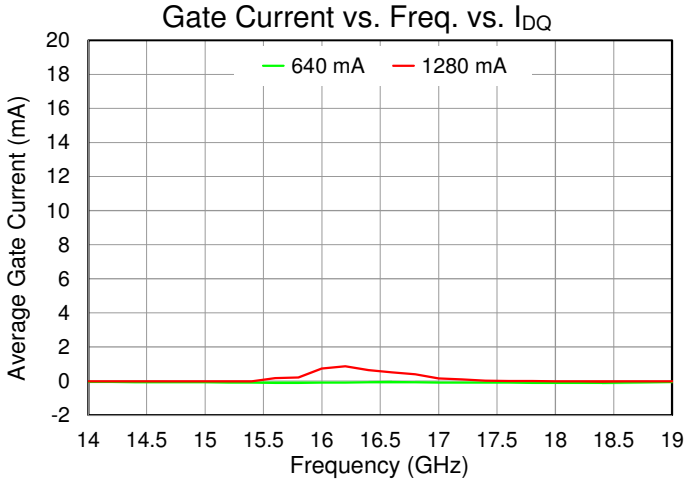

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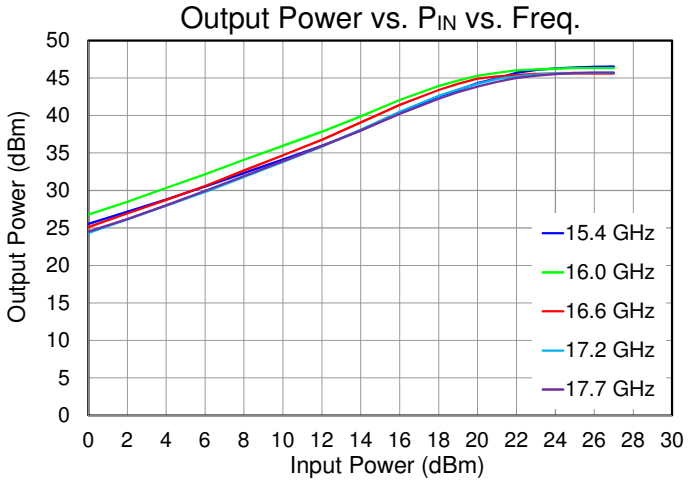


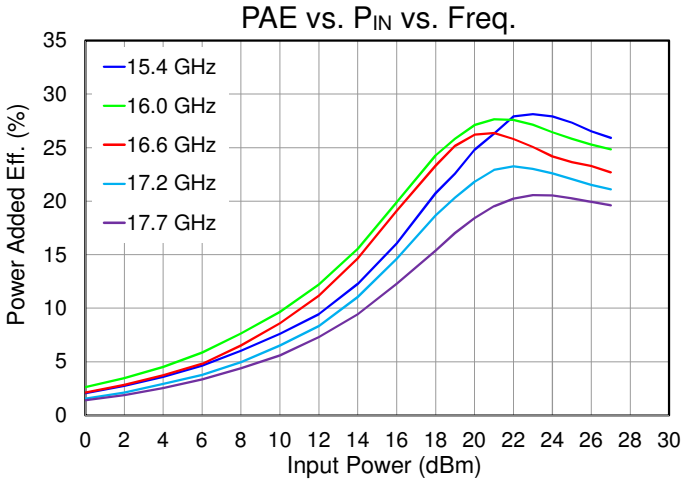


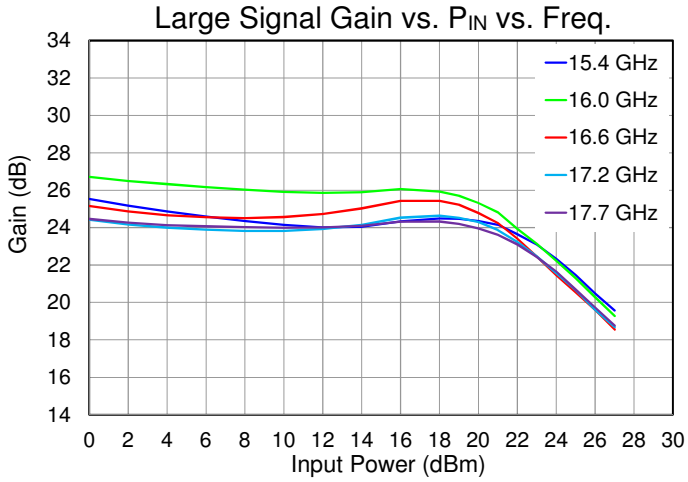


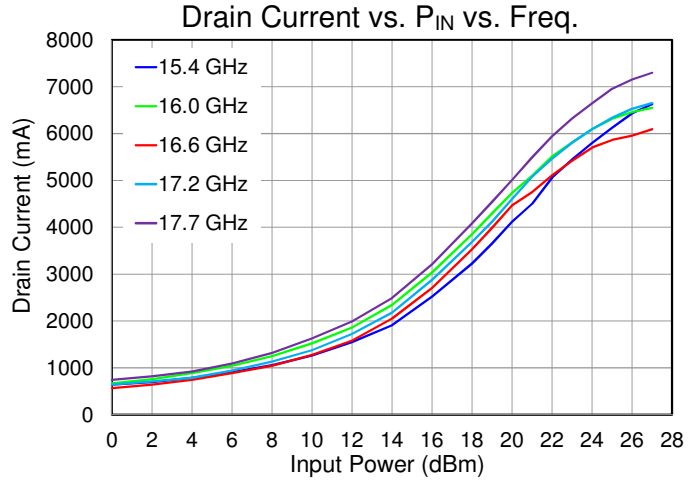


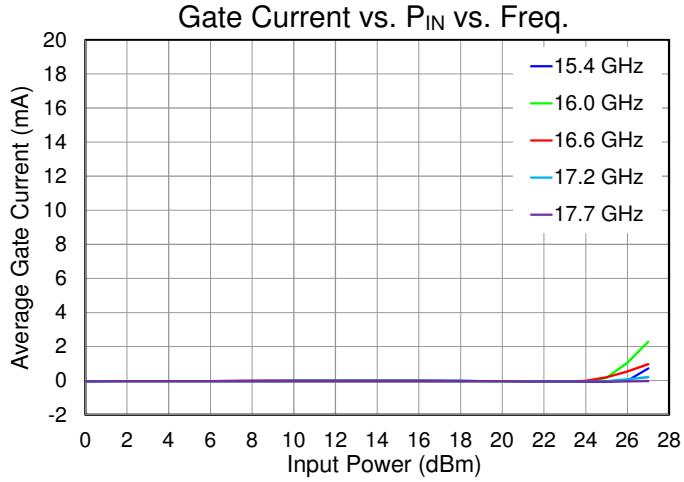

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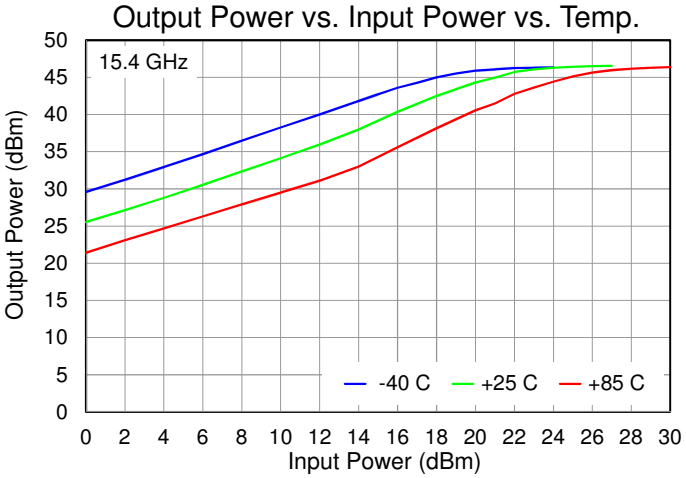


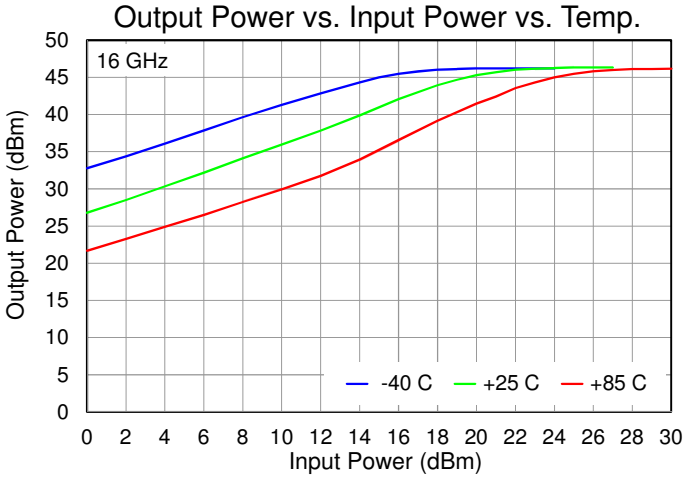


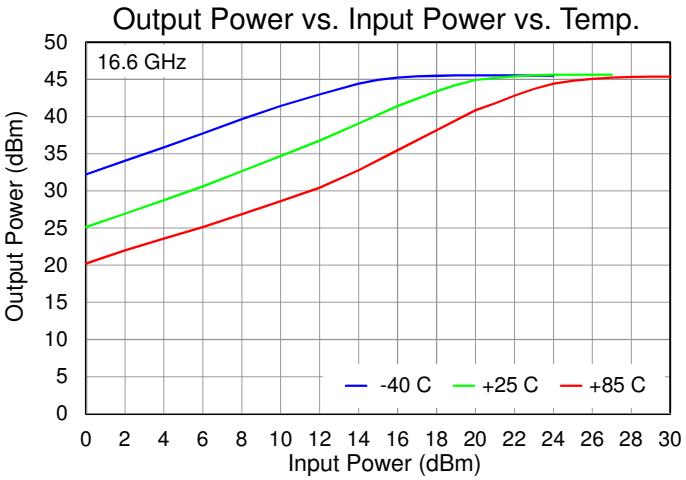


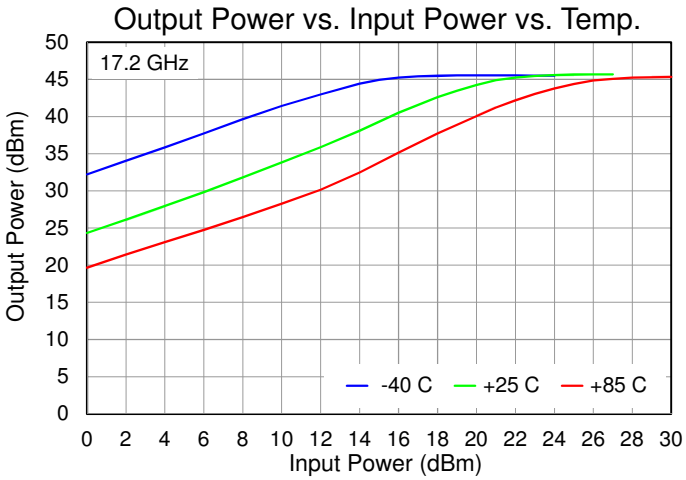


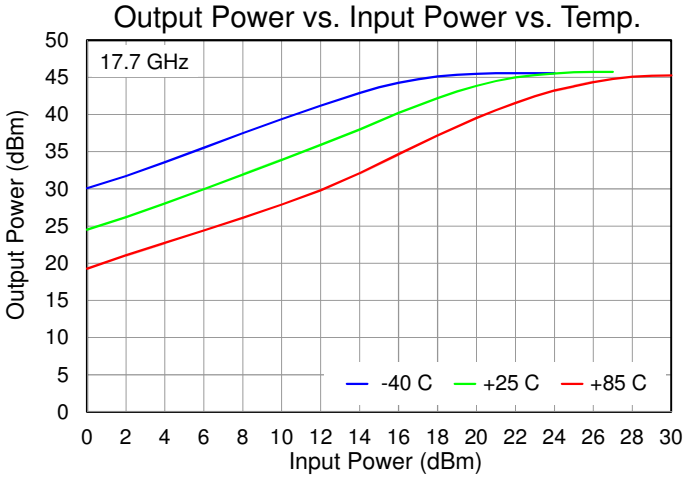

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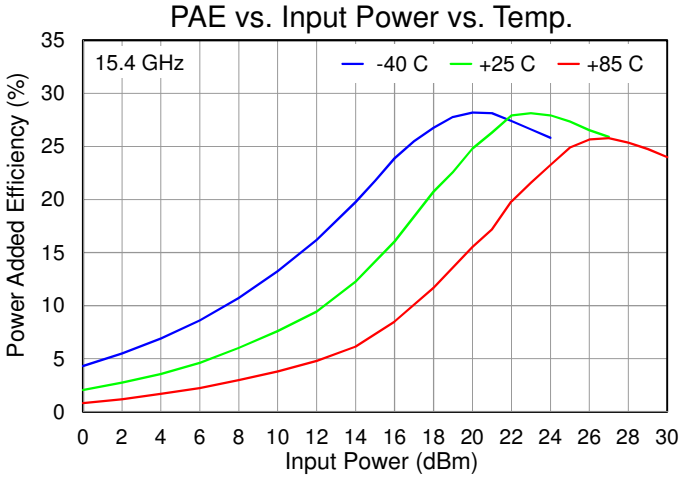


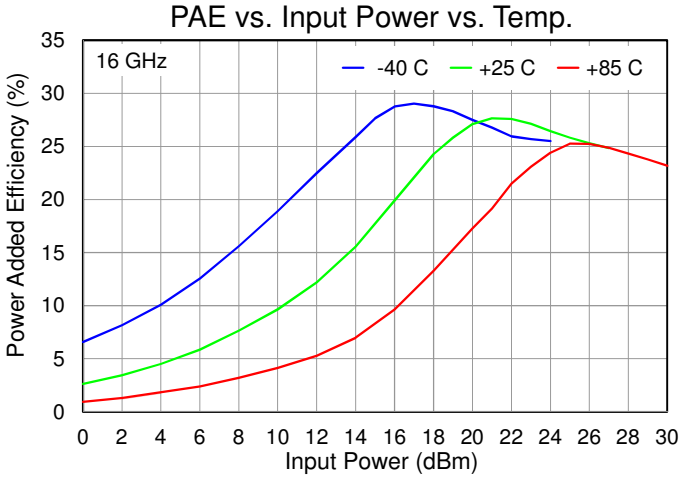


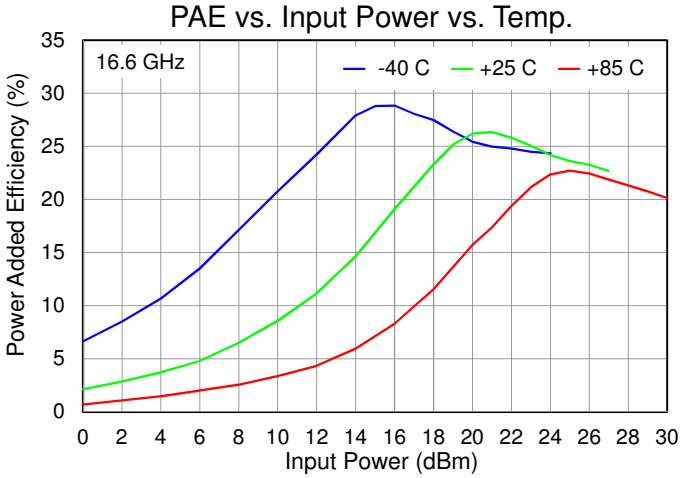


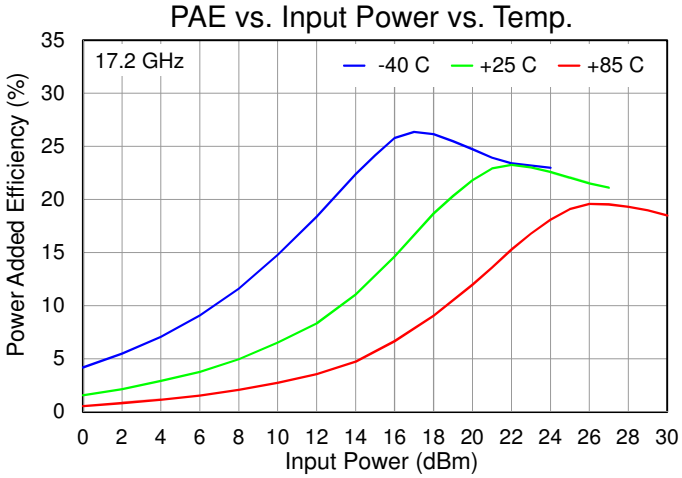


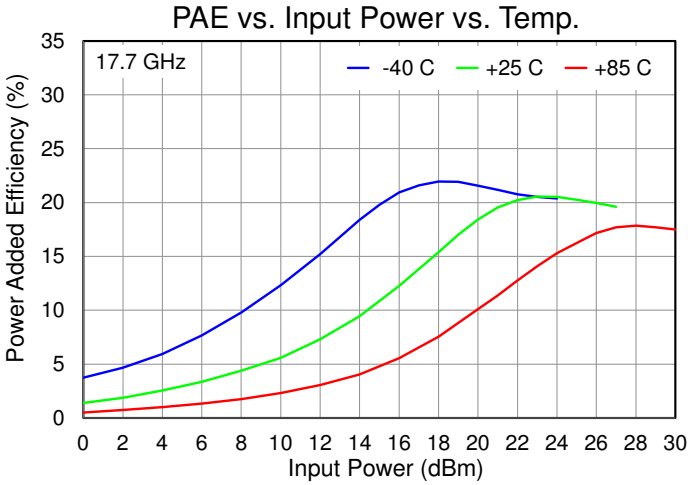

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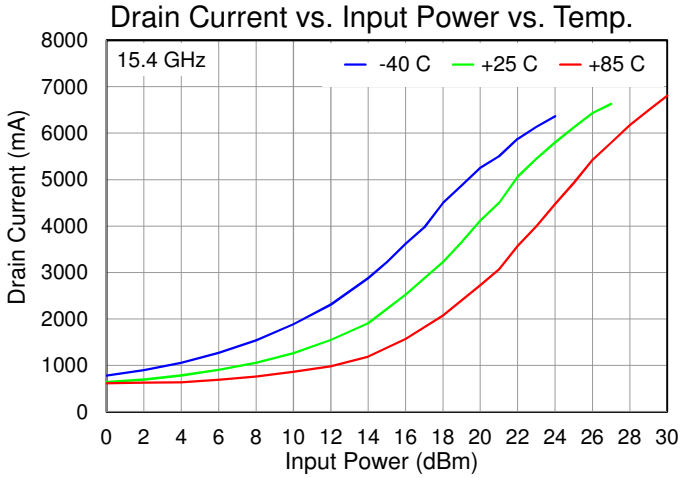


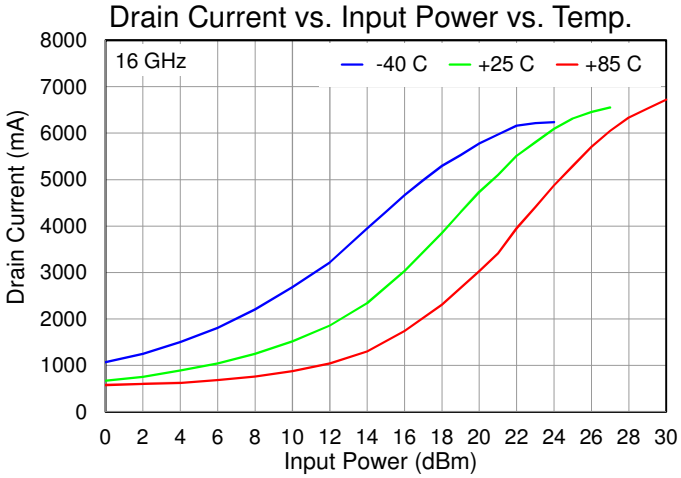


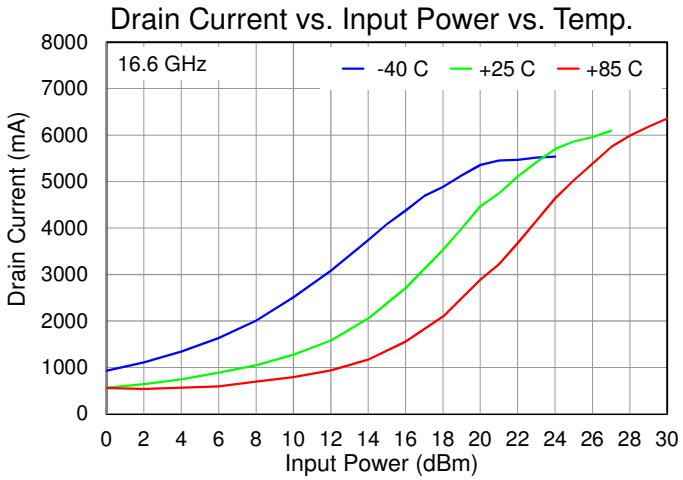


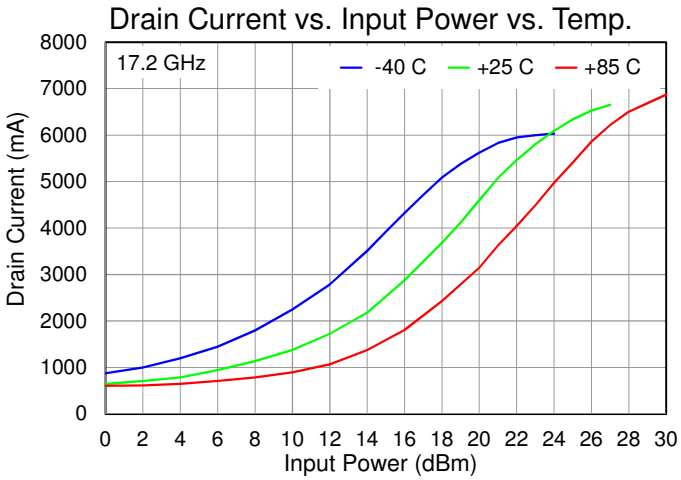


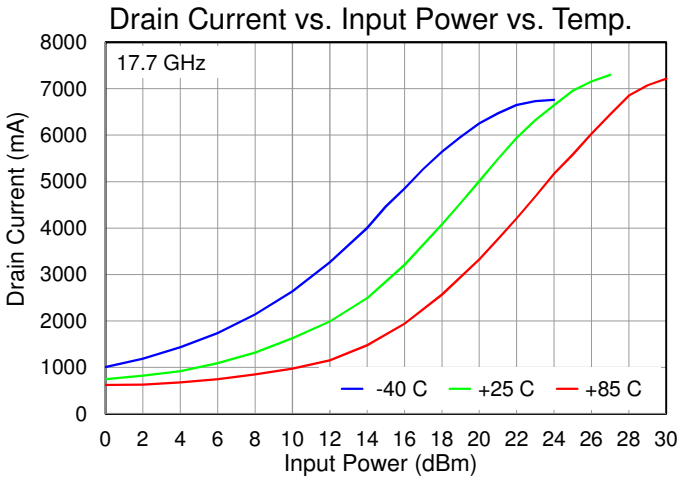

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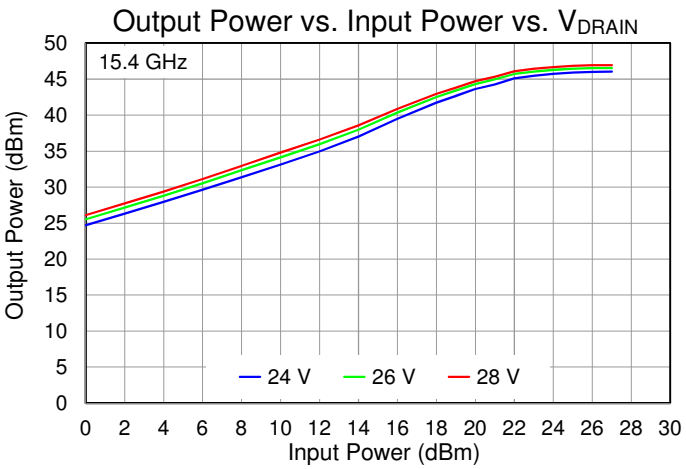


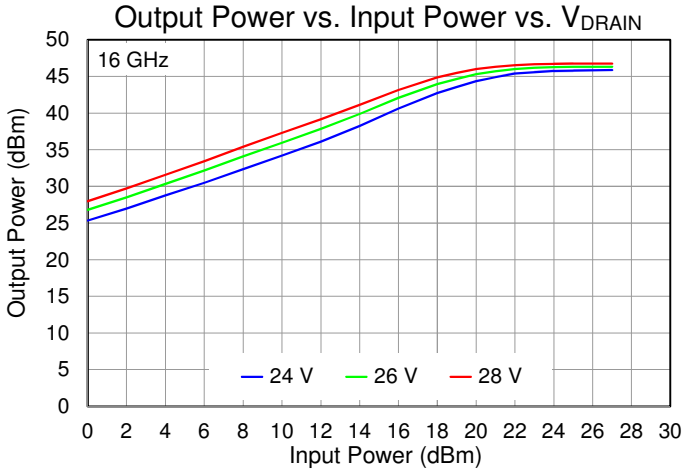


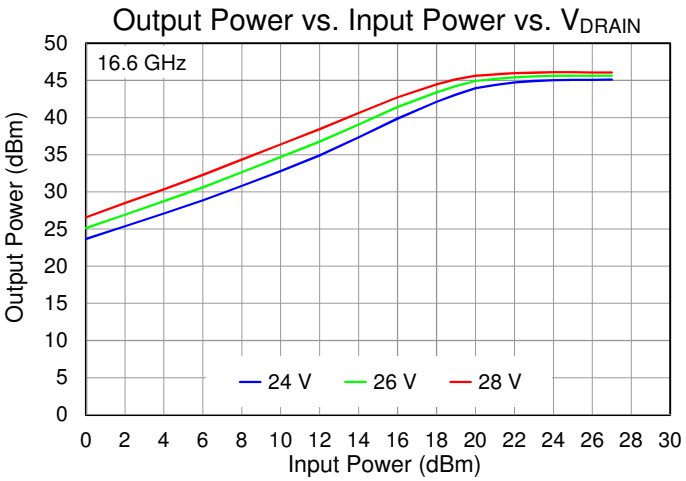


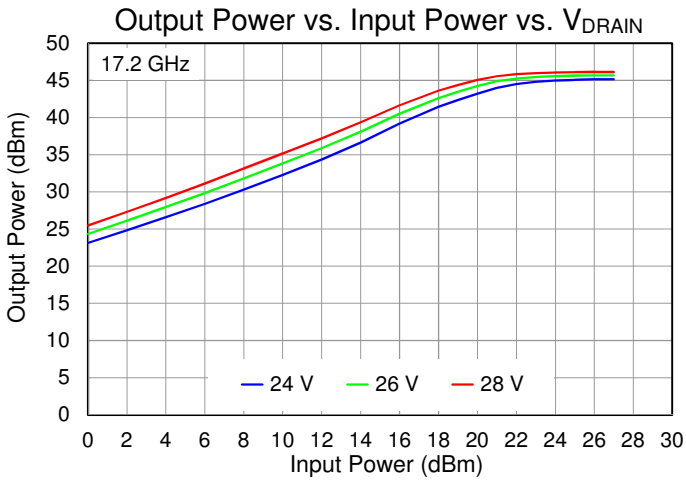


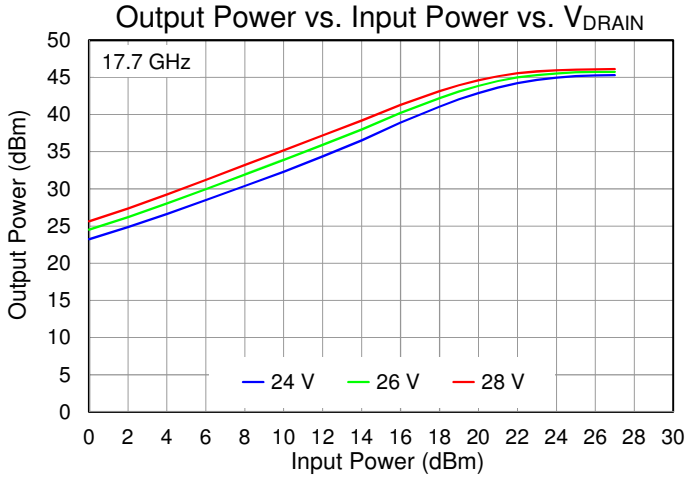

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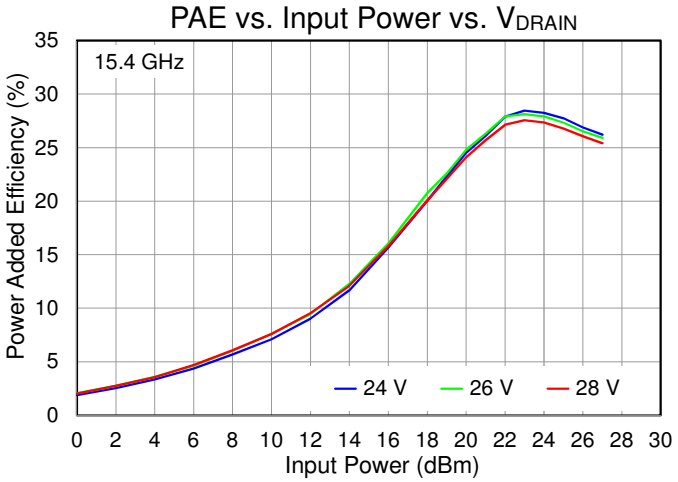


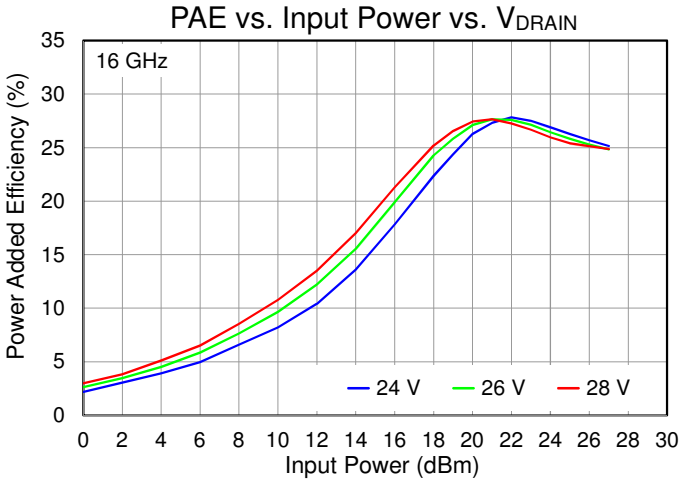


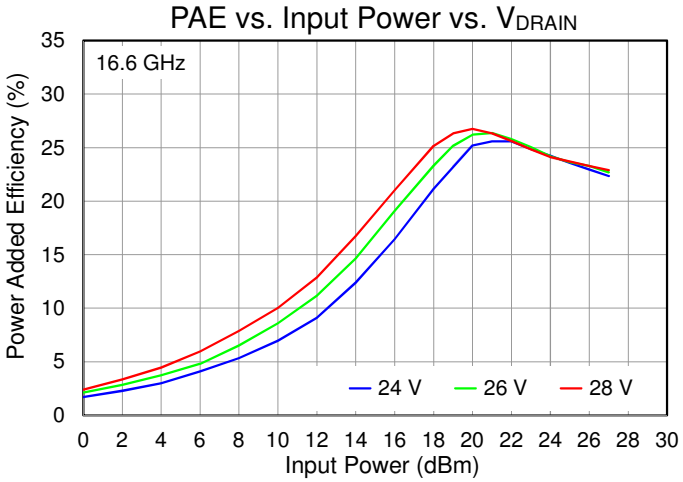


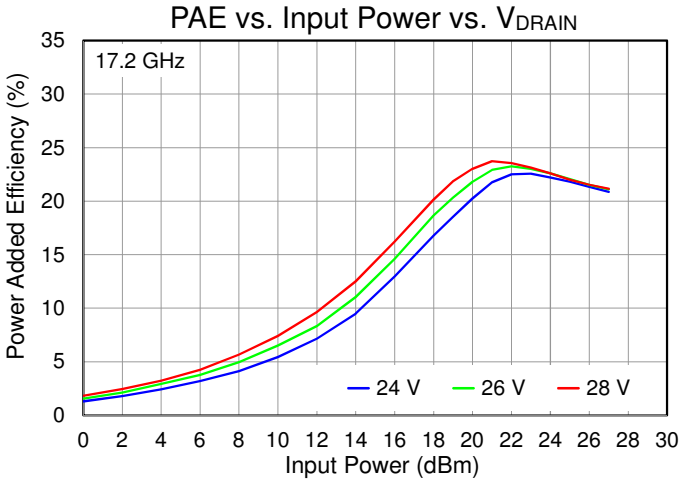


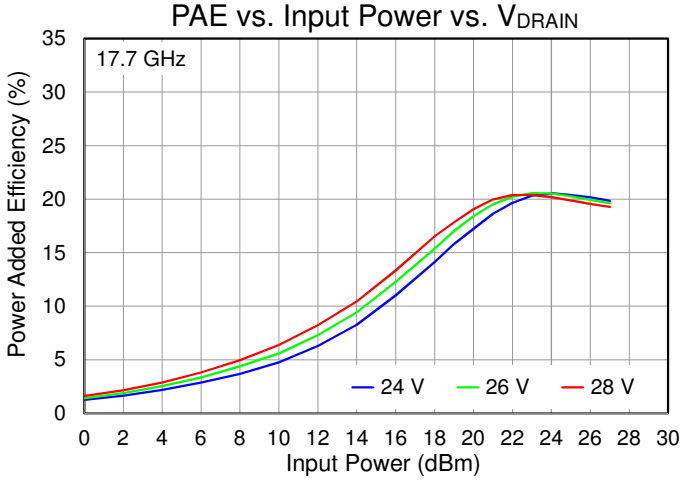

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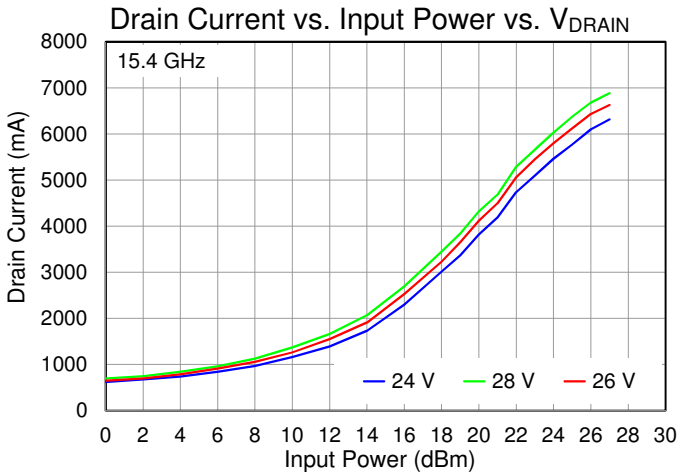
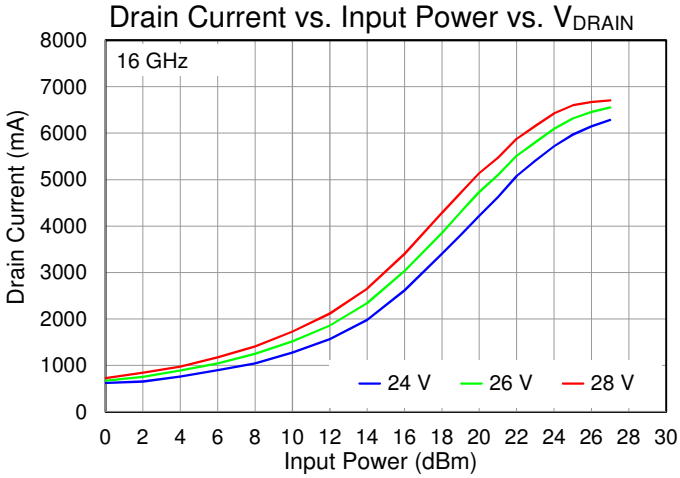
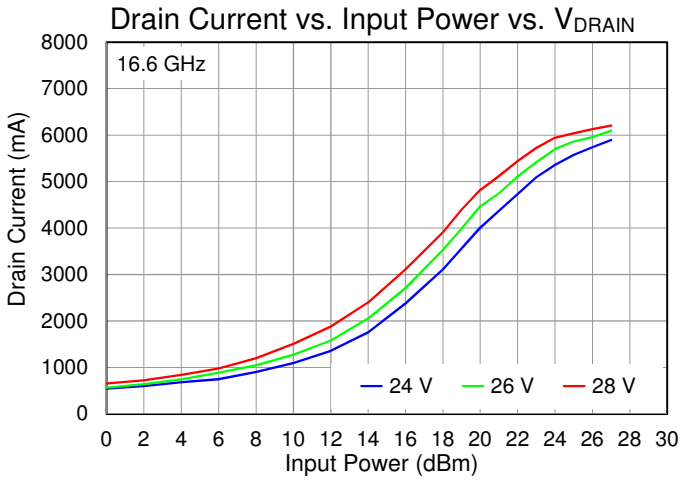
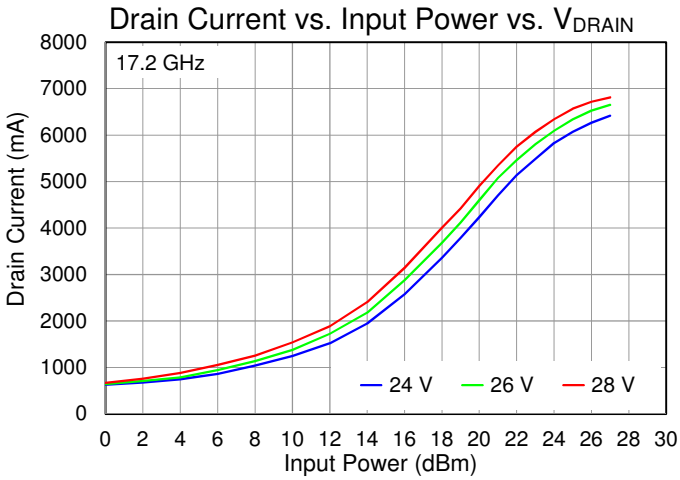
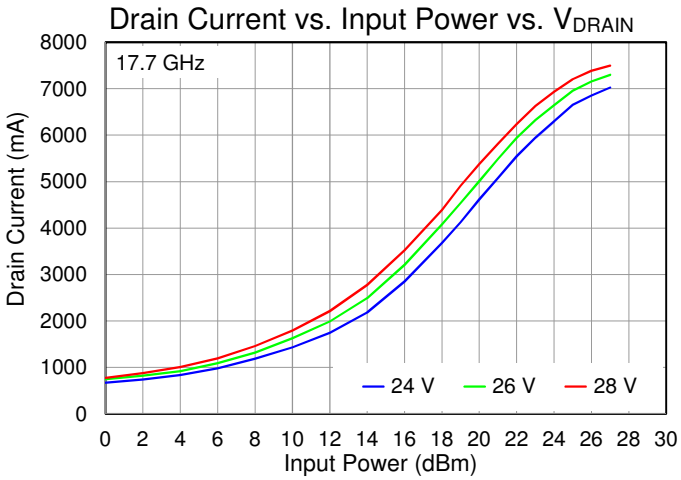


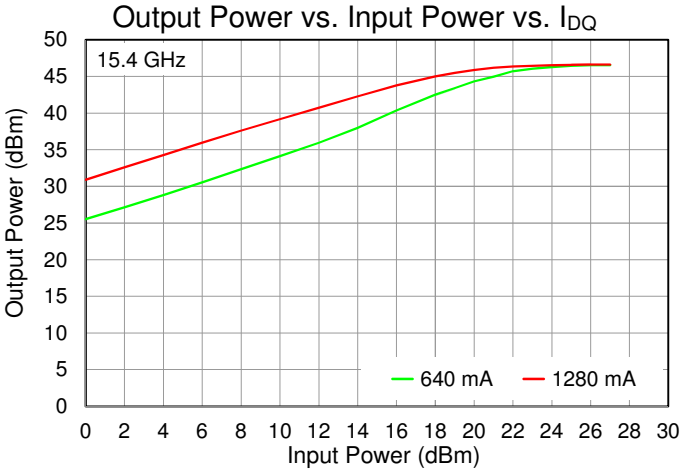



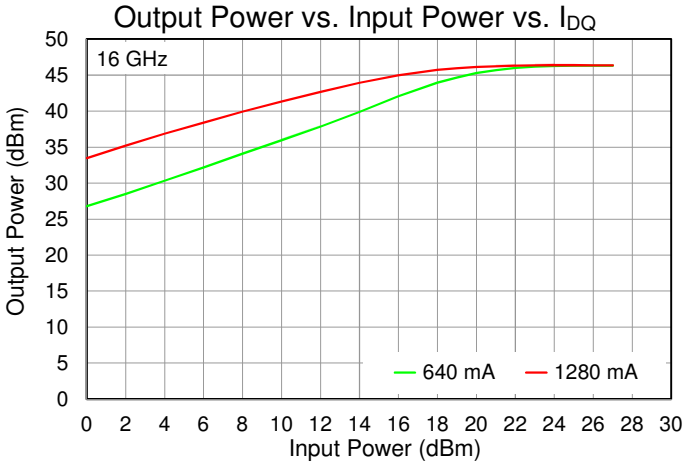



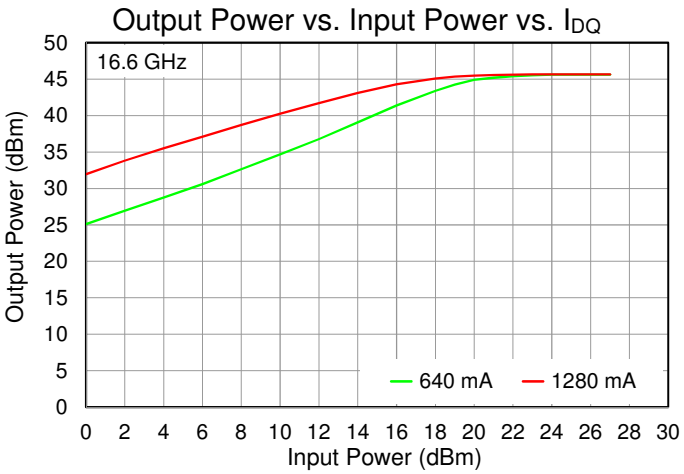



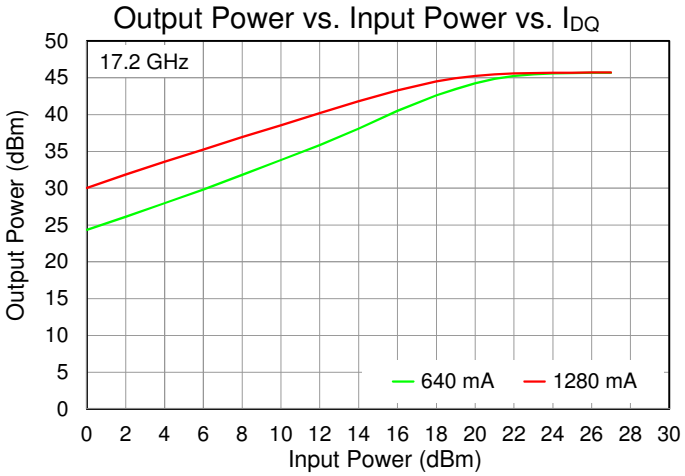
## Performance Plots – Large Signal (Pulsed)

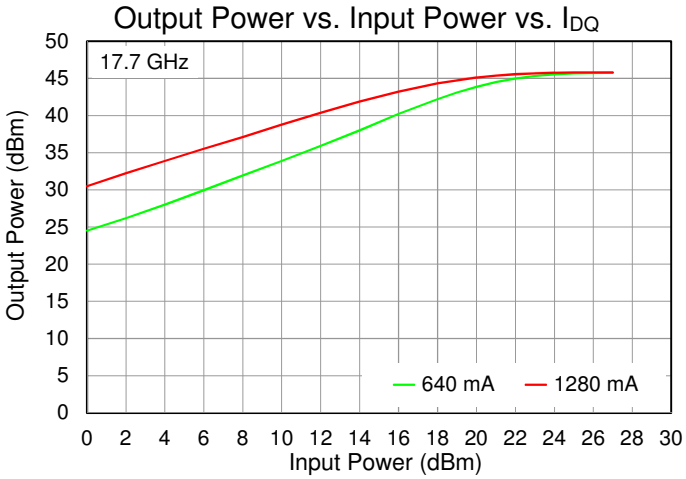
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



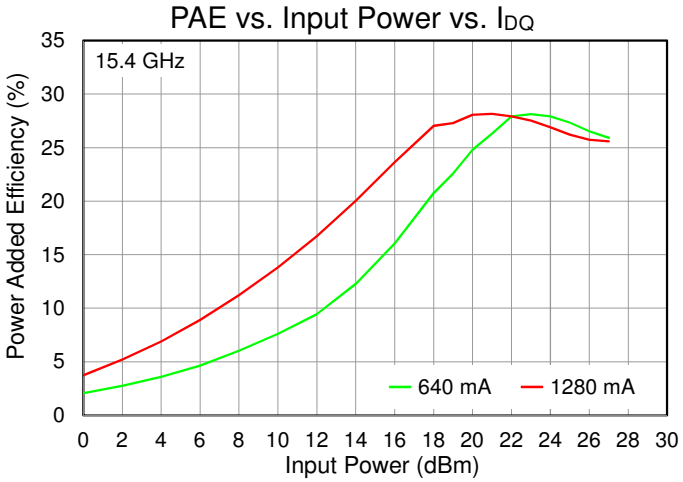



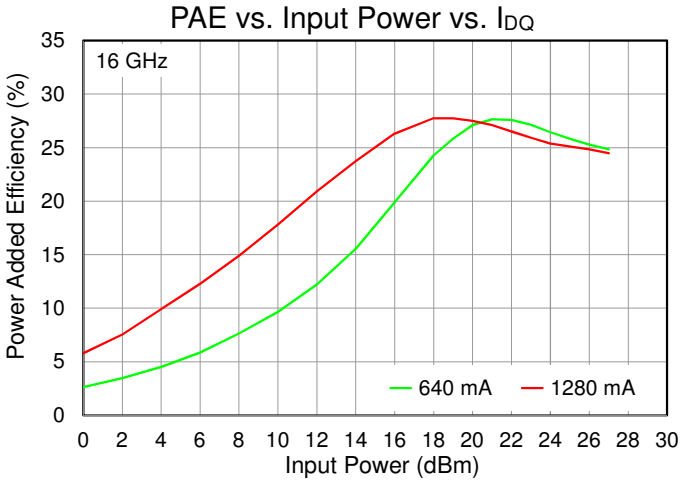



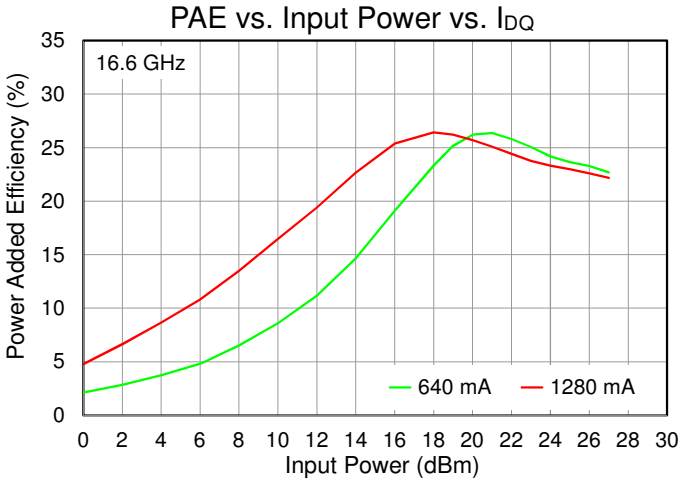



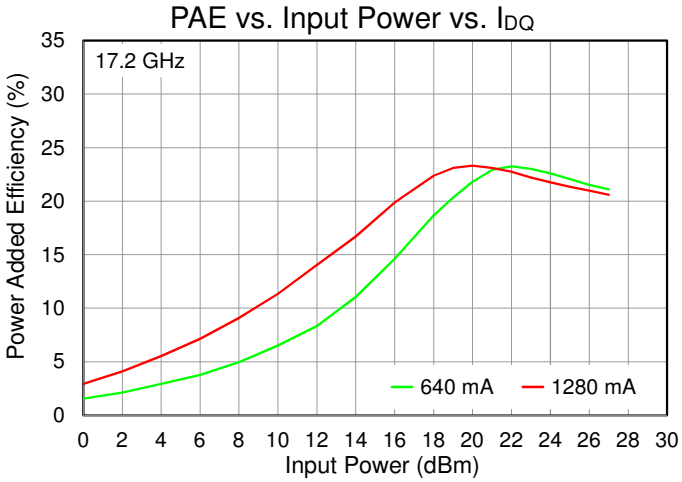
## Performance Plots – Large Signal (Pulsed)

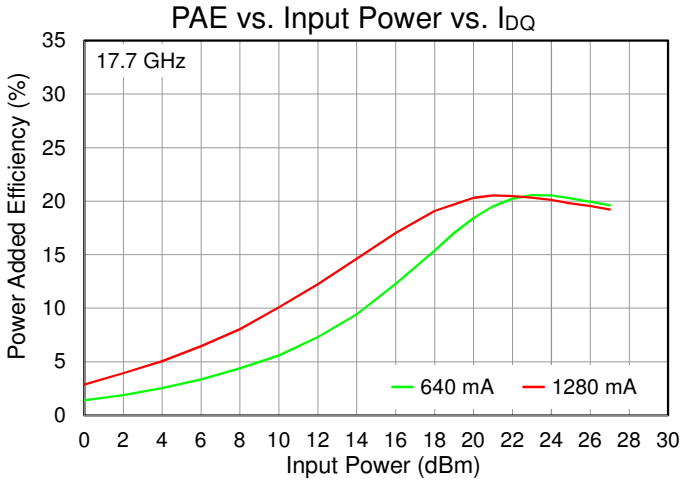
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



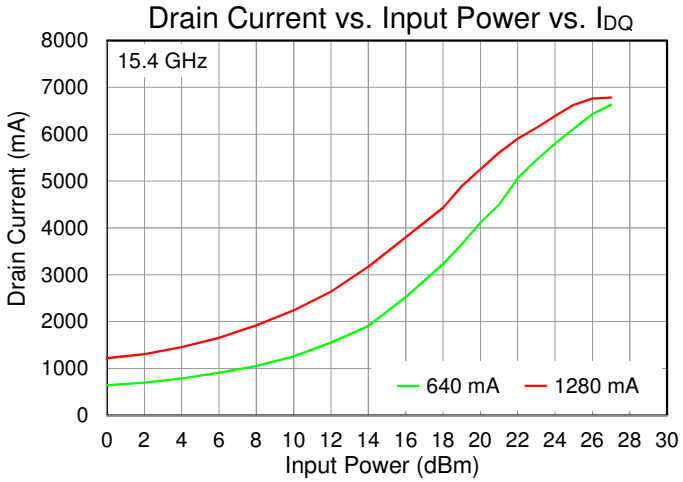



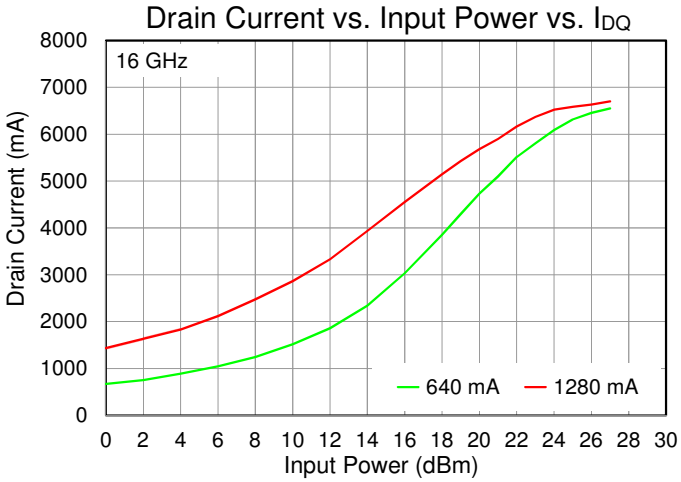



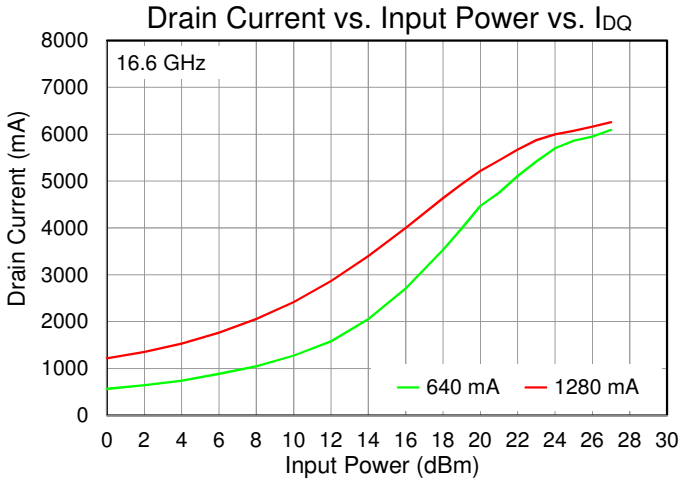



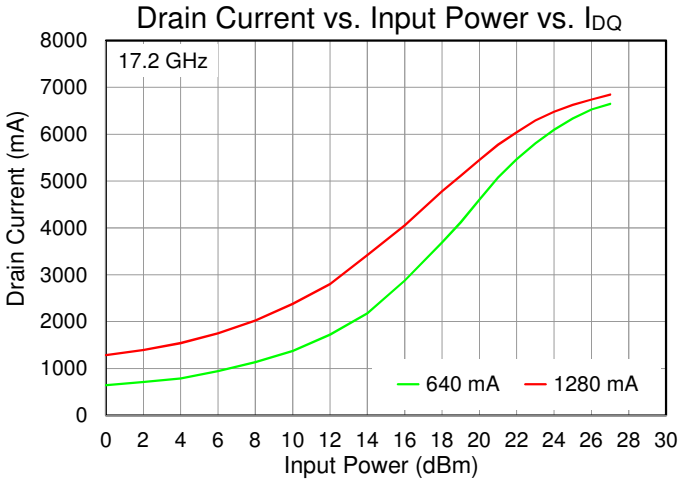
## Performance Plots – Large Signal (Pulsed)

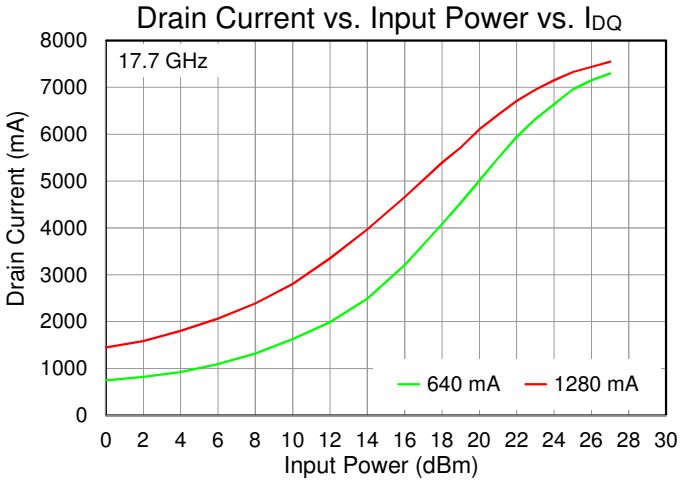
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



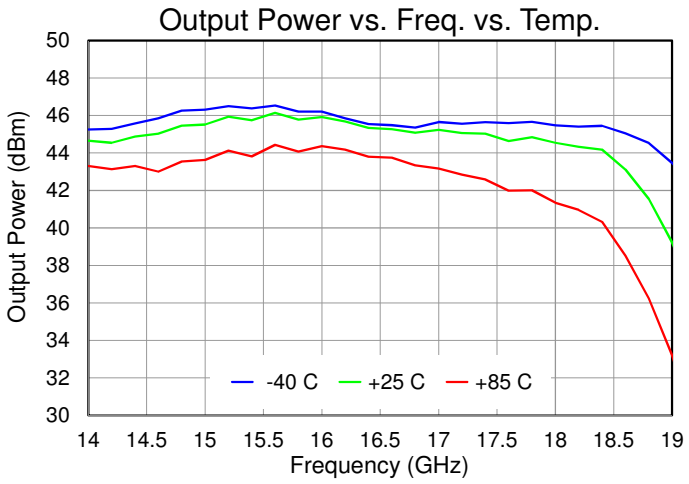



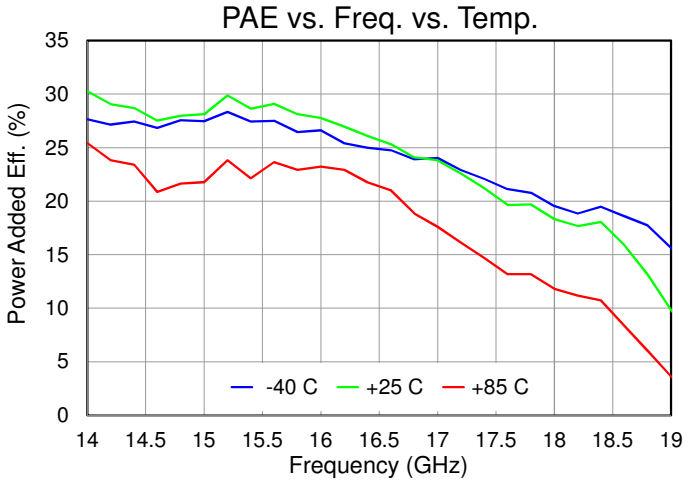



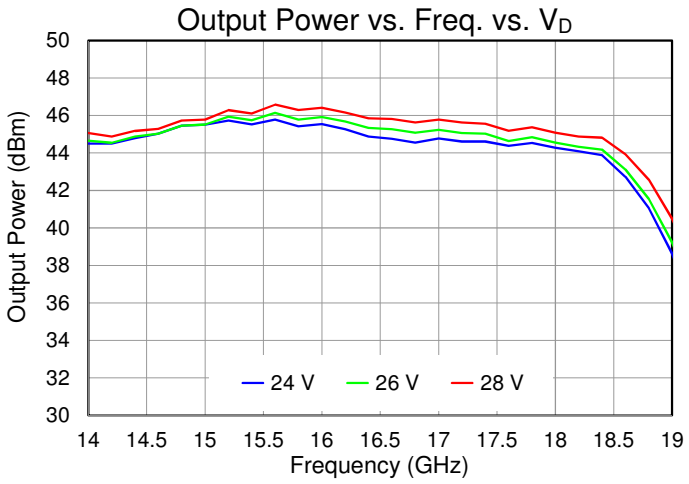



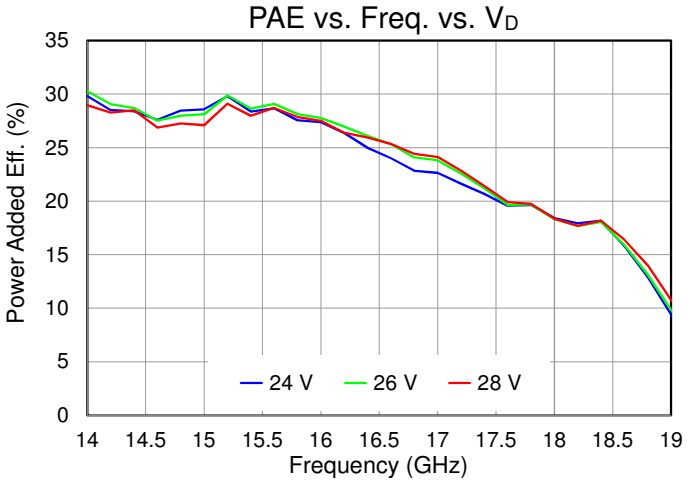
## Performance Plots – Large Signal (Pulsed)

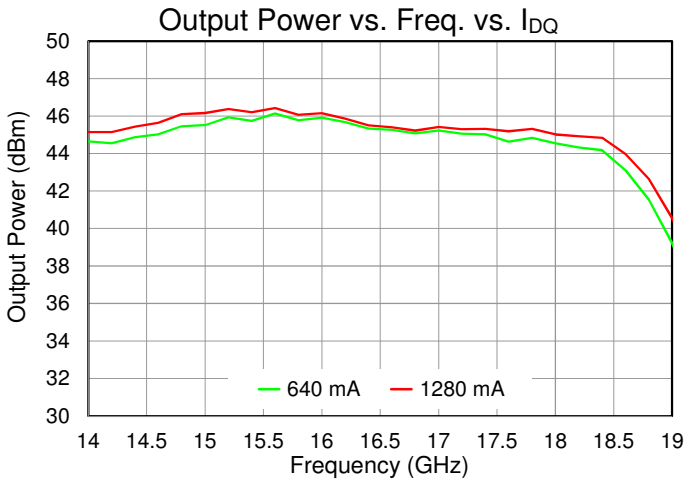
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 300 us, DC = 30%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).

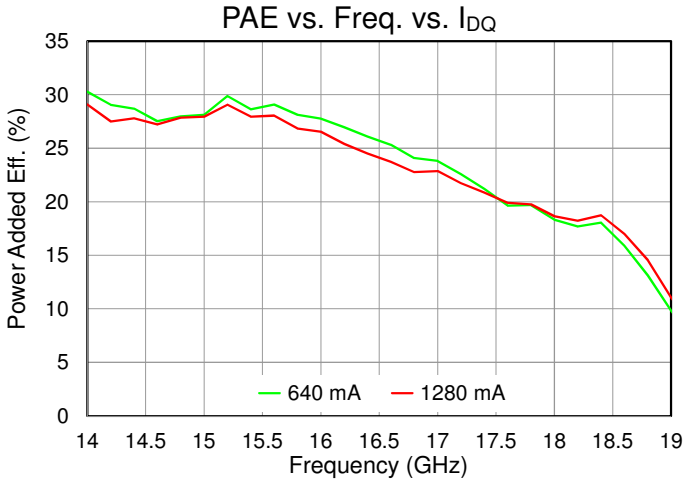


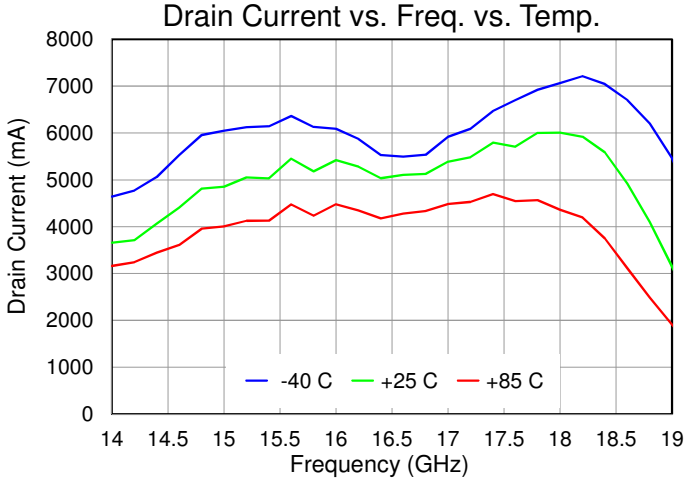



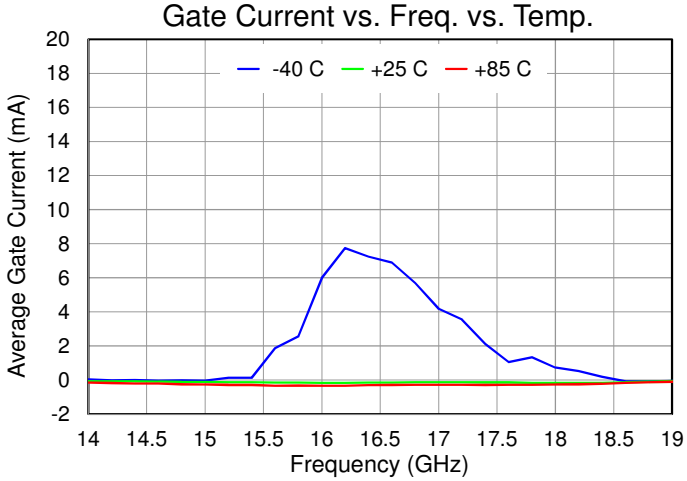
## Performance Plots – Large Signal (Pulsed)

Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 300 us, DC = 30%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).

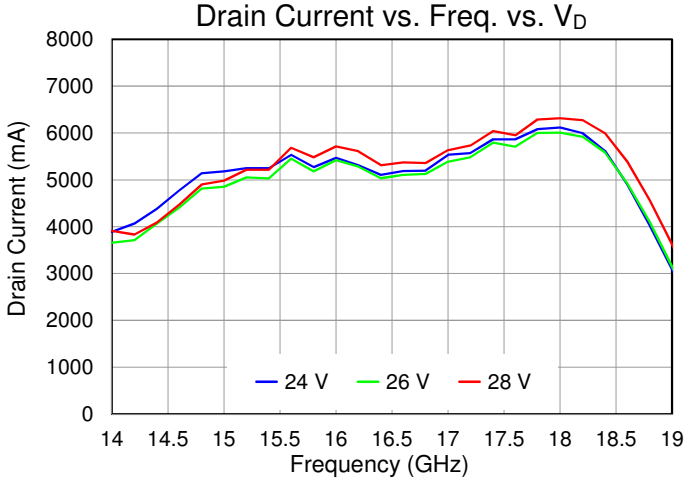
Drain Current vs. Freq. vs. Temp.



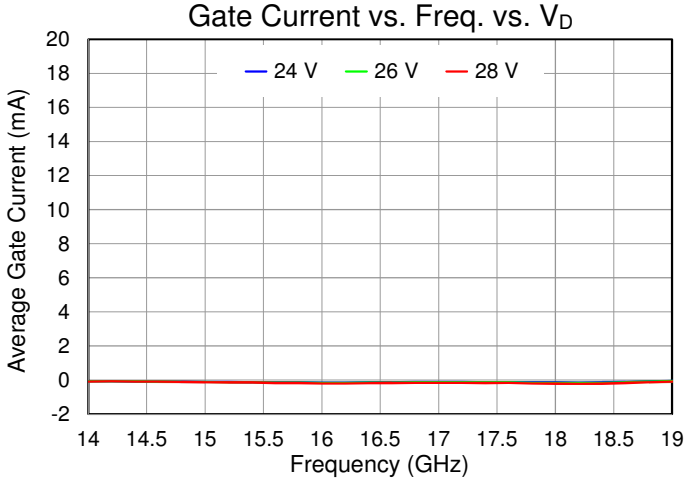

Gate Current vs. Freq. vs. Temp.



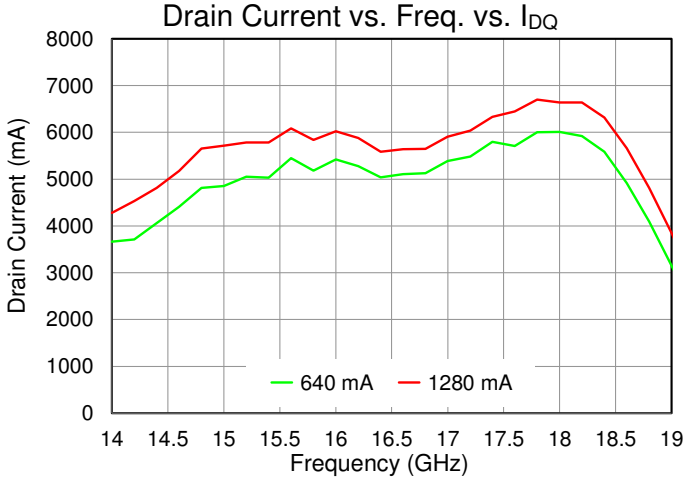

Drain Current vs. Freq. vs. $V_D$



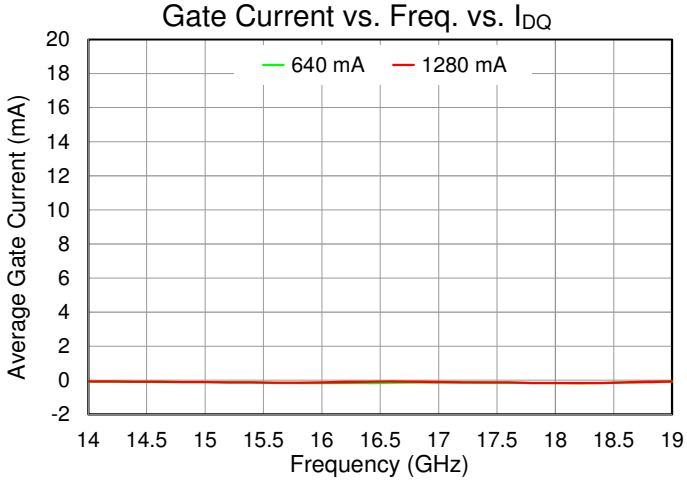

Gate Current vs. Freq. vs. $V_D$




Drain Current vs. Freq. vs. $I_{DQ}$

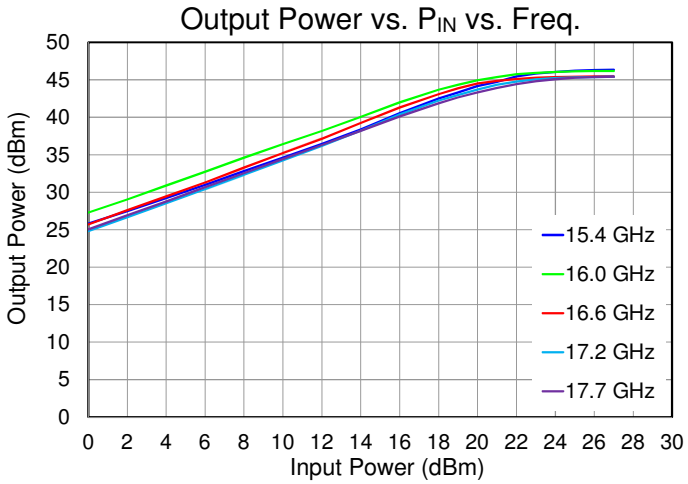


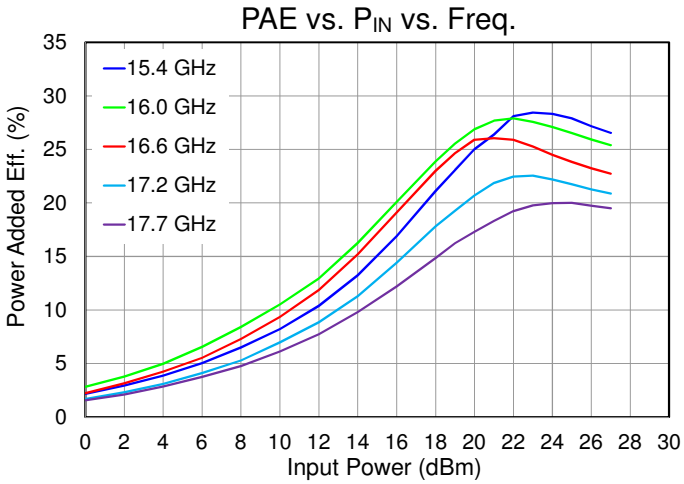

Gate Current vs. Freq. vs. $I_{DQ}$

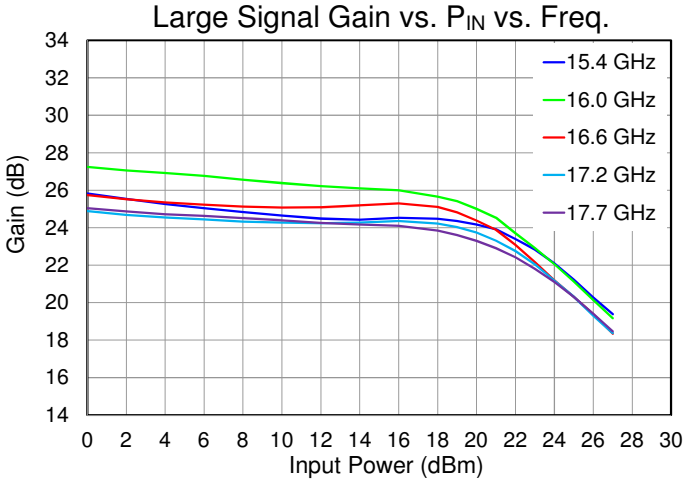


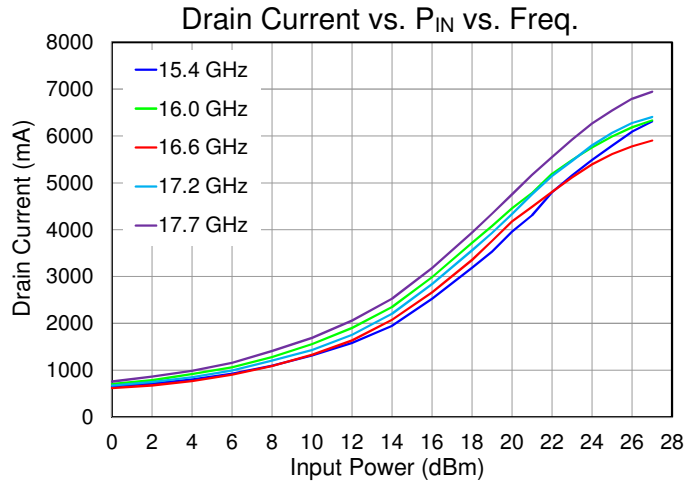
## Performance Plots – Large Signal (Pulsed)

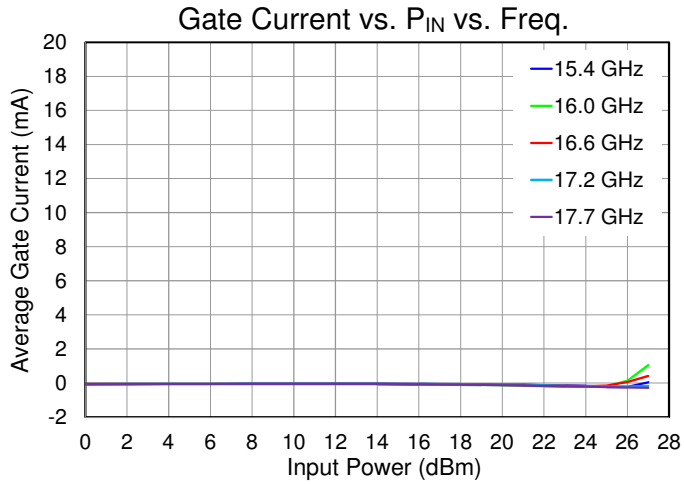
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 300 us, DC = 30%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



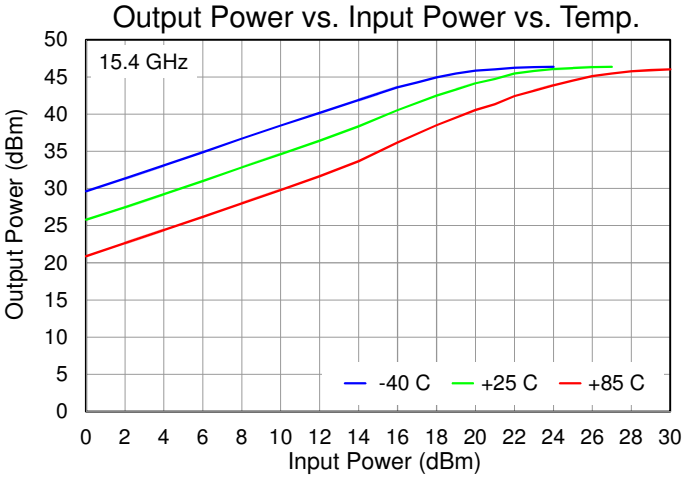



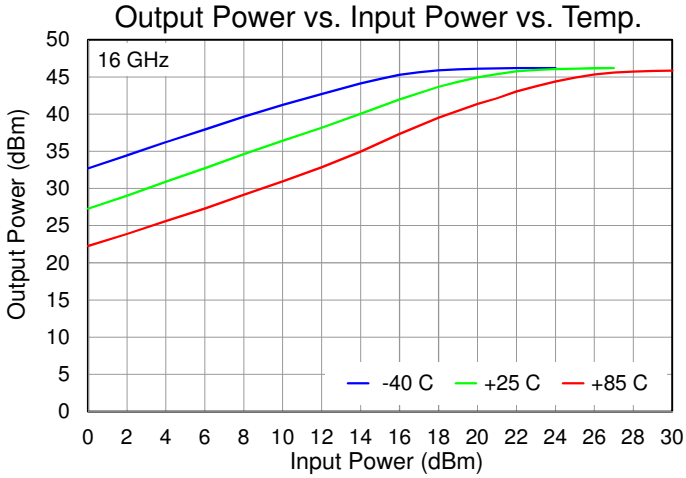



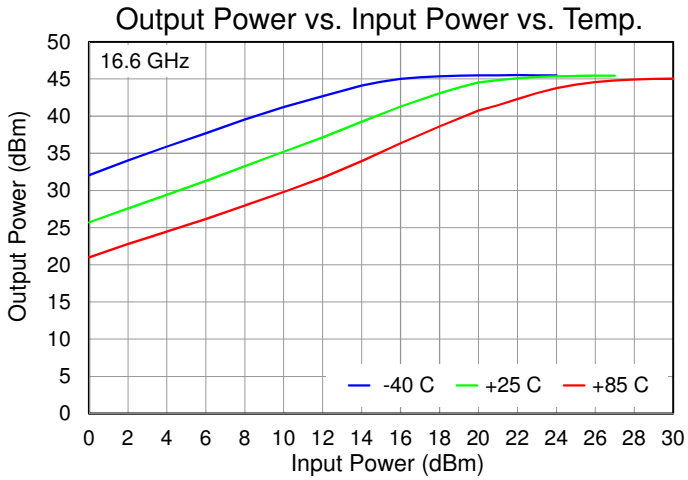



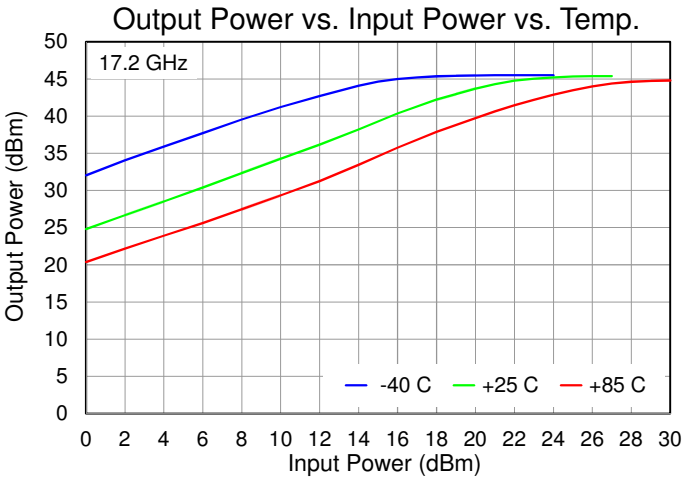
## Performance Plots – Large Signal (Pulsed)

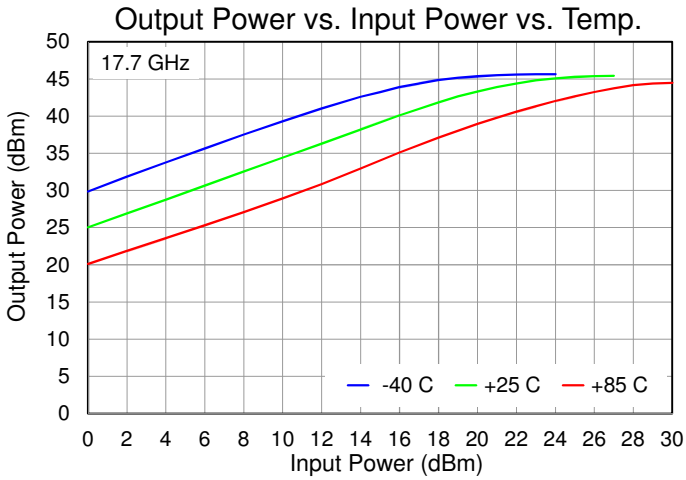
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 300 us, DC = 30%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



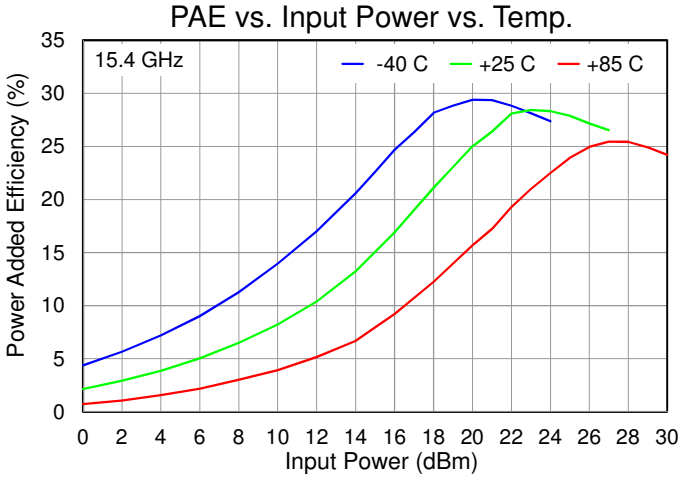



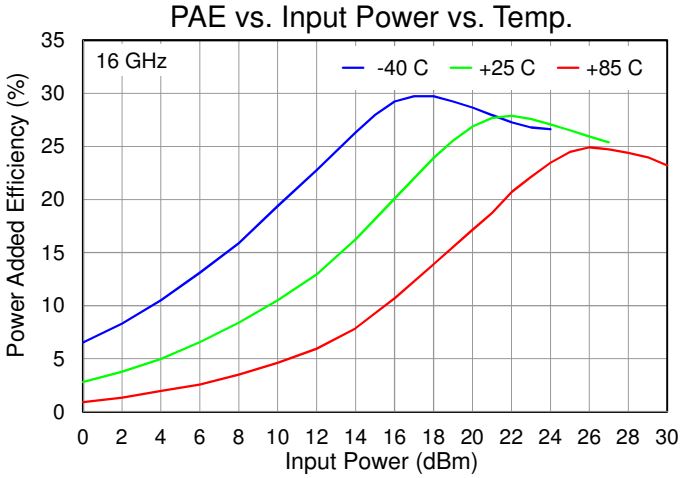



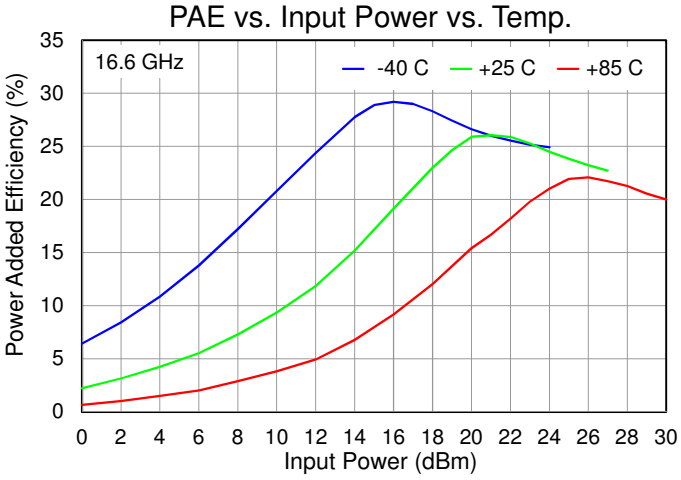



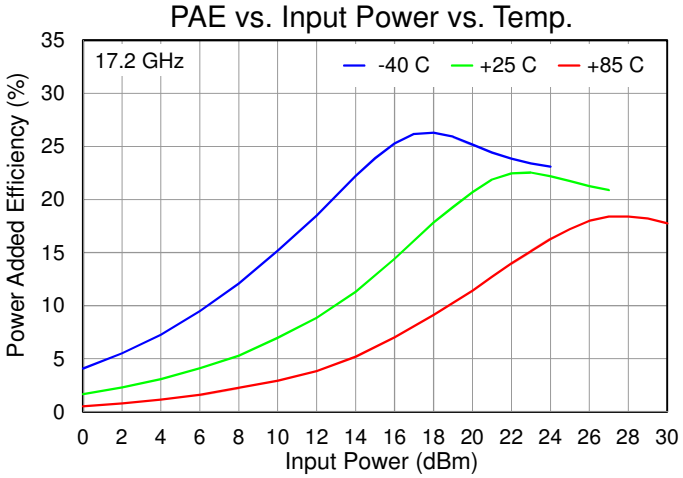
## Performance Plots – Large Signal (Pulsed)

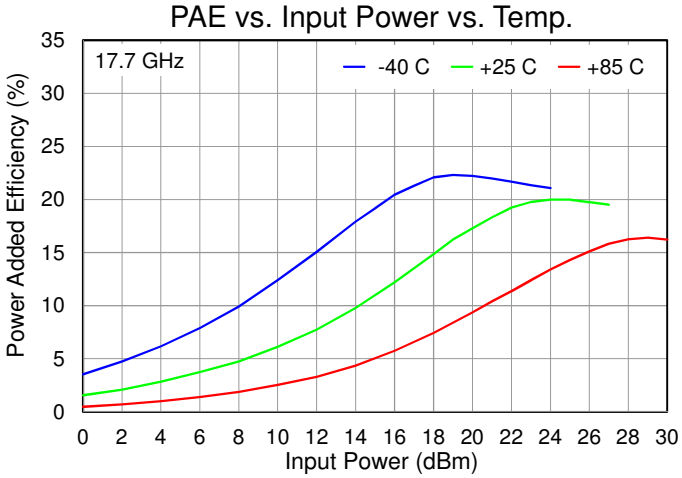
Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 300 us, DC = 30%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



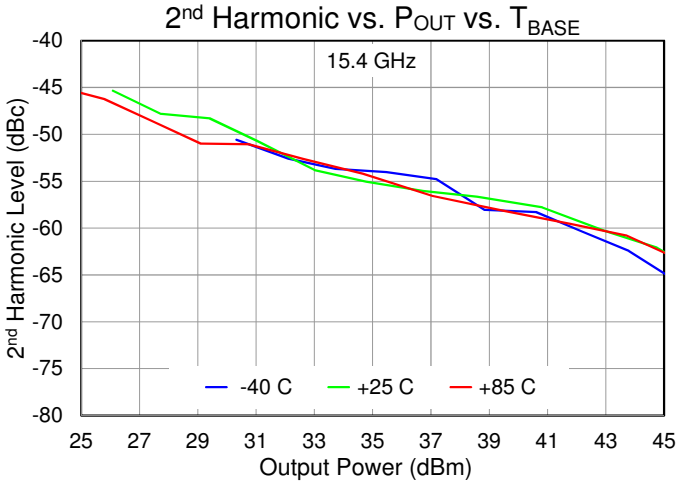



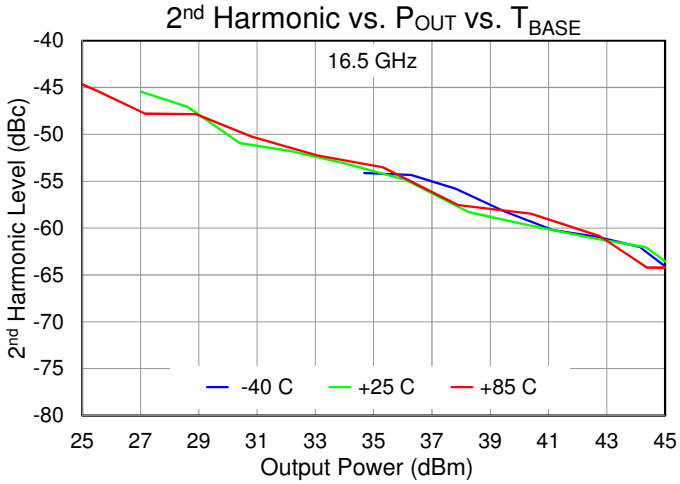



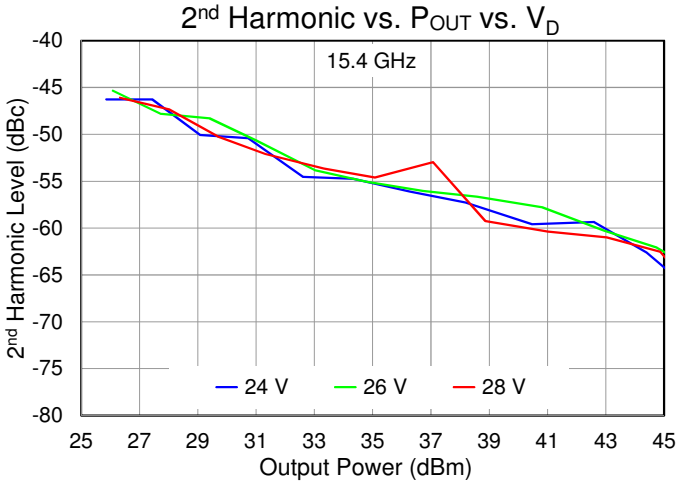



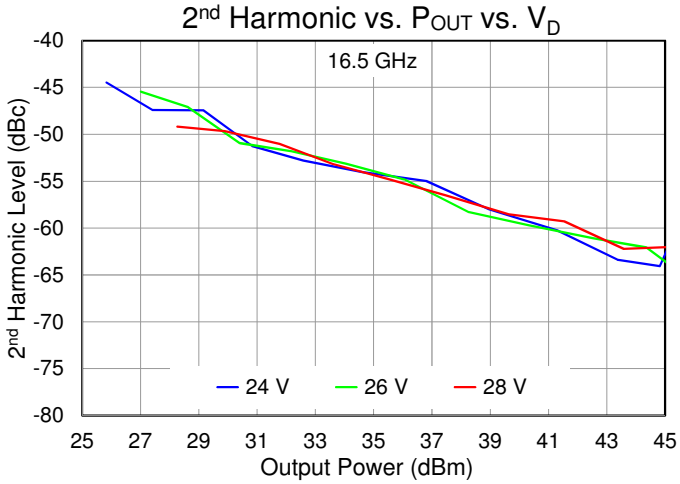
## Performance Plots – Harmonics (Pulsed)

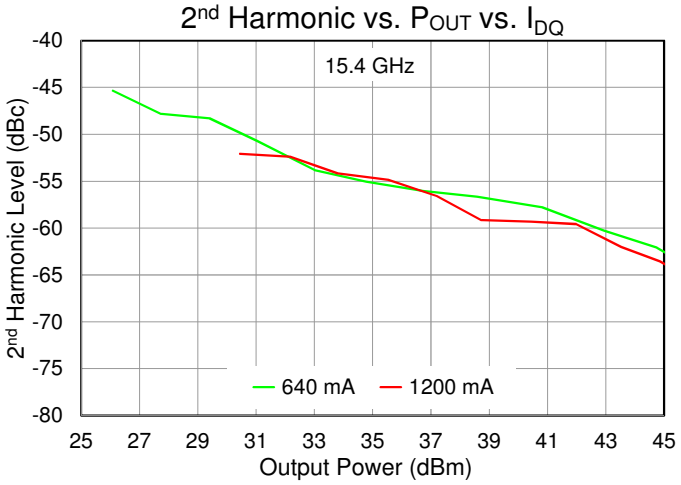
Test conditions, unless otherwise noted: CW, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, PW = 100 us, DC = 10%, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).

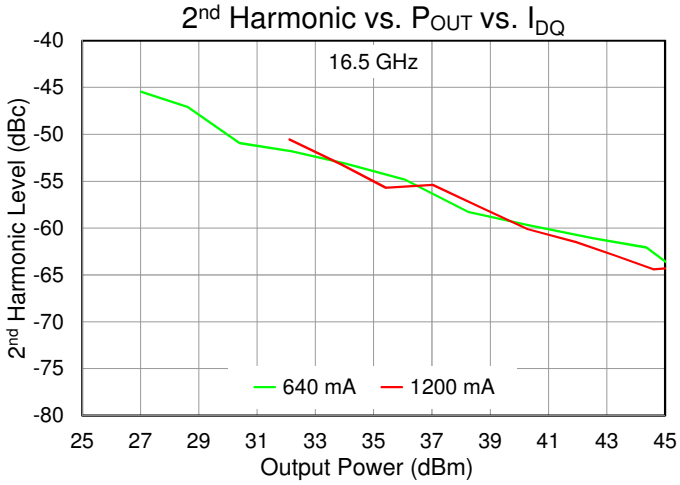


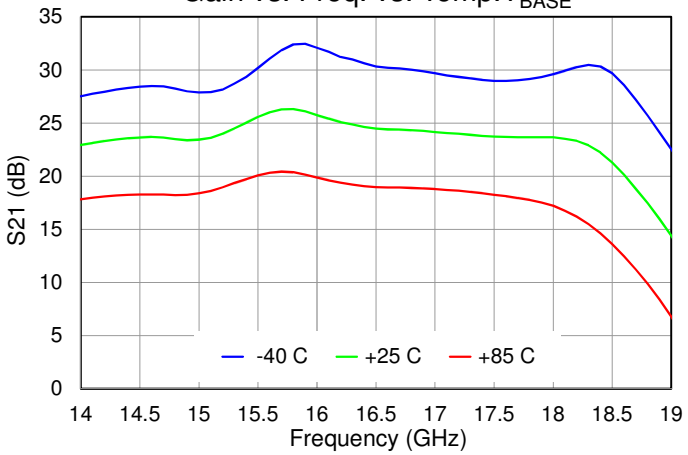



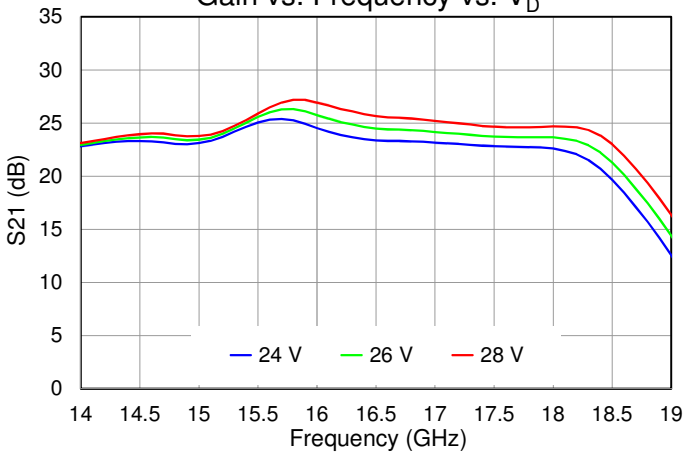
## Performance Plots – Small Signal (CW)

Test conditions, unless otherwise noted: CW, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).

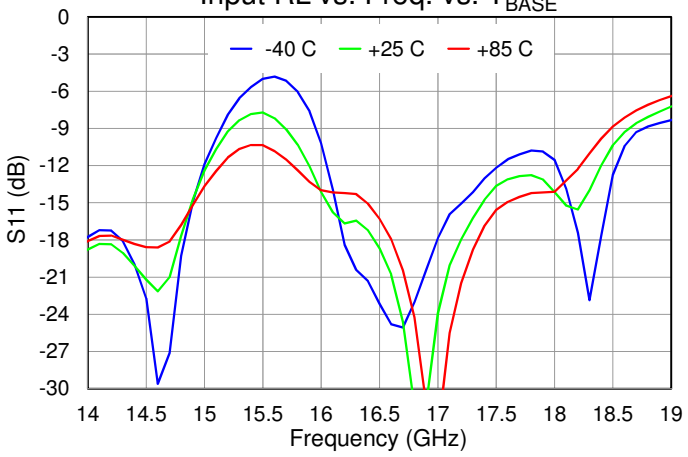
Gain vs. Freq. vs. Temp.$T_{BASE}$



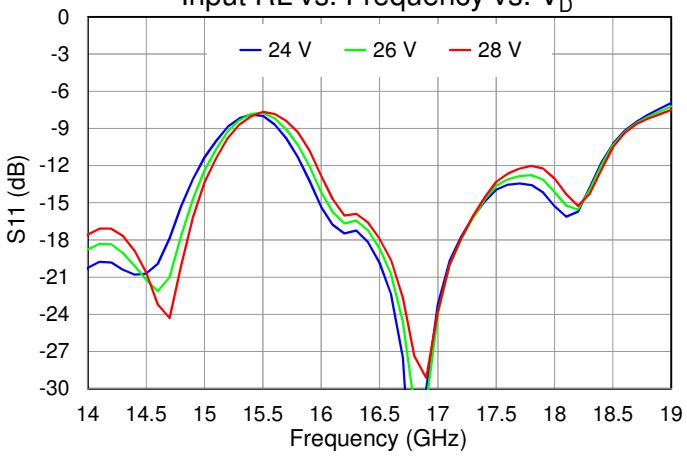

Gain vs. Frequency vs. $V_D$



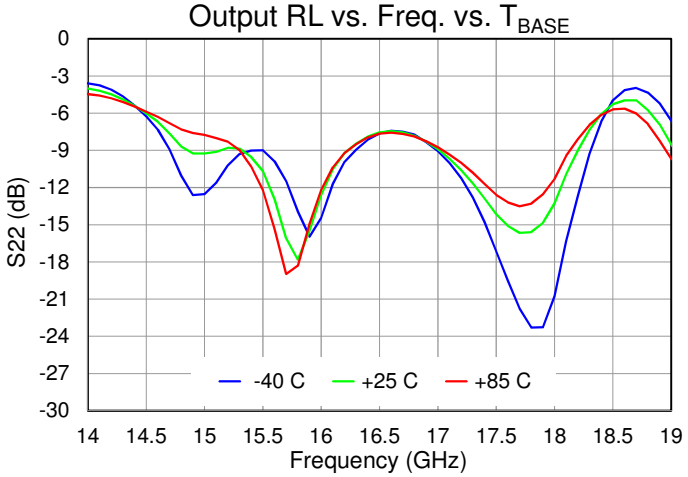

Input RL vs. Freq. vs. $T_{BASE}$



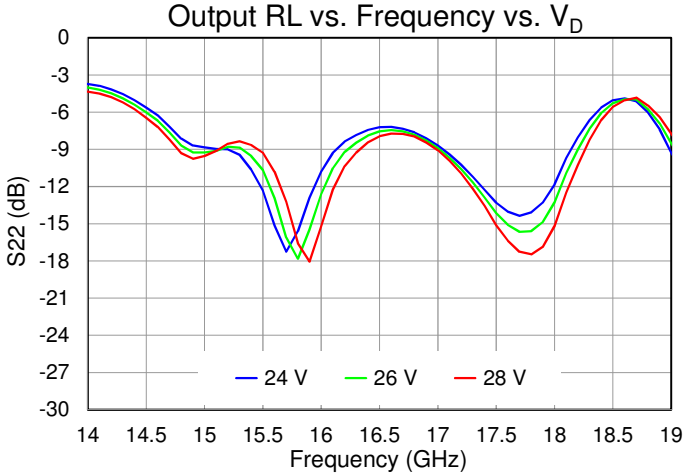

Input RL vs. Frequency vs. $V_D$




Output RL vs. Freq. vs. $T_{BASE}$

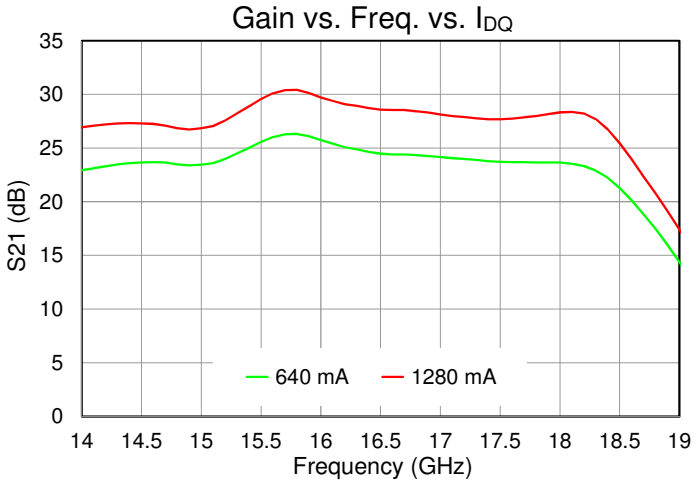


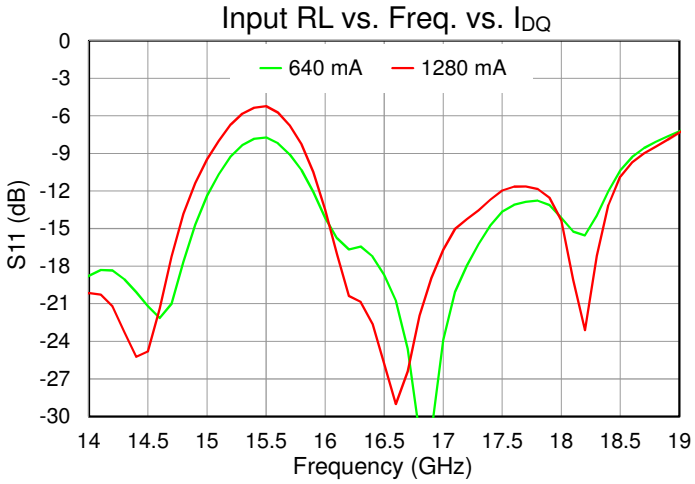

Output RL vs. Frequency vs. $V_D$

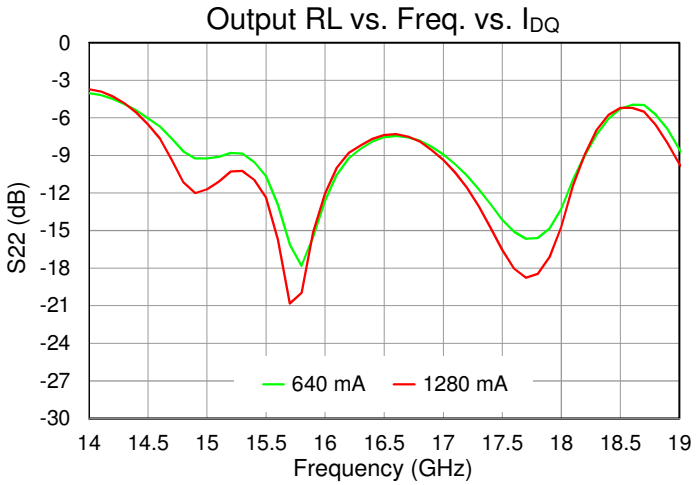


## Performance Plots – Small Signal (CW)

Test conditions, unless otherwise noted: CW, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, $T_{BASE}$ = +25 ºC ($T_{BASE}$ is backside of QPA1315).



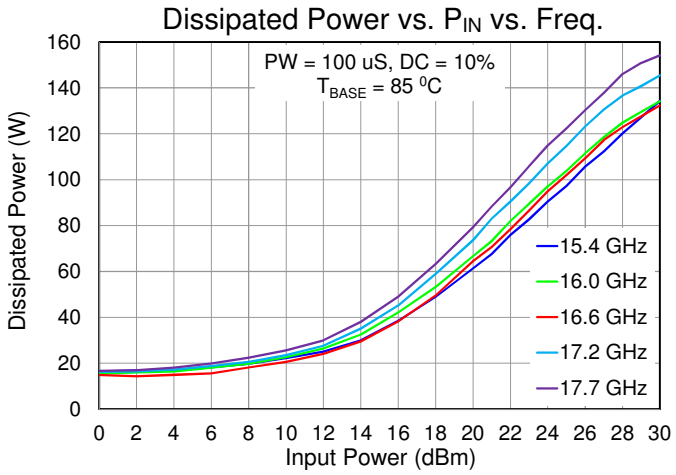
## Thermal and Reliability Information

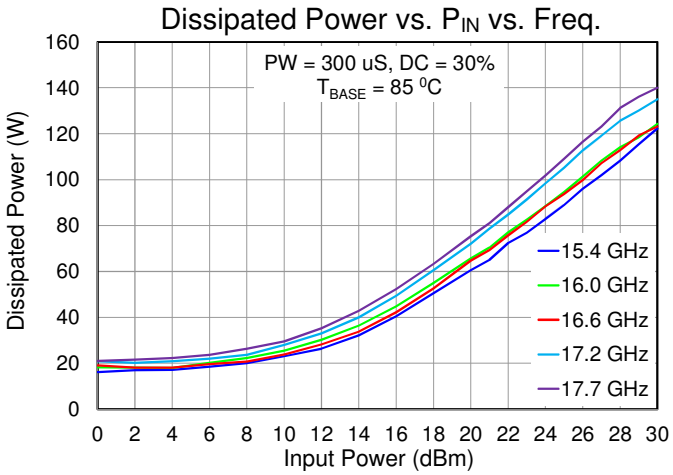
| Parameter | Test Conditions | Value | Units |
|---|---|---|---|
| Thermal Resistance, $\theta_{JC}$ | Quiescent, no RF, CW<br>$T_{BASE}$ = 85 °C, $V_D$ = 26 V, $I_{DQ}$ = 640 mA,<br>$P_{DISS}$ = 16.6 W | 0.75 | ºC/W |
| Channel Temperature, $T_{CH}$ | | 98 | °C |
| Thermal Resistance, $\theta_{JC}$ | Pulsed PW = 100 us, DC = 10%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = 85 °C, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, Freq = 17.7 GHz, $I_{D\_DRIVE, PEAK}$ = 5.16 A, $P_{OUT, PEAK}$ = 42.5 dBm,<br>$P_{DISS, PEAK}$ = 115.5 W | 0.51 | ºC/W |
| Channel Temperature, $T_{CH}$ | | 144 | °C |
| Thermal Resistance, $\theta_{JC}$ | Pulsed PW = 100 us, DC = 10%, $P_{IN}$ = 28 dBm, $T_{BASE}$ = 85 °C, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, Freq = 17.7 GHz, $I_{D\_DRIVE, PEAK}$ = 6.85 A, $P_{OUT, PEAK}$ = 45 dBm,<br>$P_{DISS, PEAK}$ = 146 W | 0.52 | ºC/W |
| Channel Temperature, $T_{CH}$ | | 161 | °C |
| Thermal Resistance, $\theta_{JC}$ | Pulsed PW = 300 us, DC = 30%, $P_{IN}$ = 24 dBm, $T_{BASE}$ = 85 °C, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, Freq = 17.4 GHz, $I_{D\_DRIVE, PEAK}$ = 4.7 A, $P_{OUT, PEAK}$ = 43 dBm,<br>$P_{DISS, PEAK}$ = 104 W | 0.57 | ºC/W |
| Channel Temperature, $T_{CH}$ | | 144 | °C |
| Thermal Resistance, $\theta_{JC}$ | Pulsed PW = 300 us, DC = 30%, $P_{IN}$ = 28 dBm, $T_{BASE}$ = 85 °C, $V_D$ = 26 V, $I_{DQ}$ = 640 mA, Freq = 17.4 GHz, $I_{D\_DRIVE, PEAK}$ = 6.13 A, $P_{OUT, PEAK}$ = 44 dBm,<br>$P_{DISS, PEAK}$ = 131 W | 0.58 | ºC/W |
| Channel Temperature, $T_{CH}$ | | 161 | °C |

Notes:

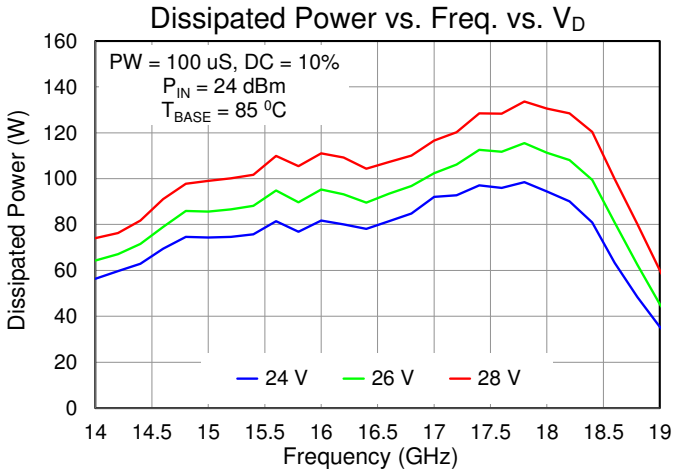
1. Thermal resistance determined to $T_{BASE}$ ($T_{BASE}$ is backside of package QPA1315)
2. Channel temperature indicated is an IR scan equivalent temperature. Thermal resistance is calculated using this value. Additional information can be found in the Qorvo Applications Note “GaN Device TCHMAX Theta-JC and Reliability Estimates,” located here https://www.qorvo.com/products/d/da006480

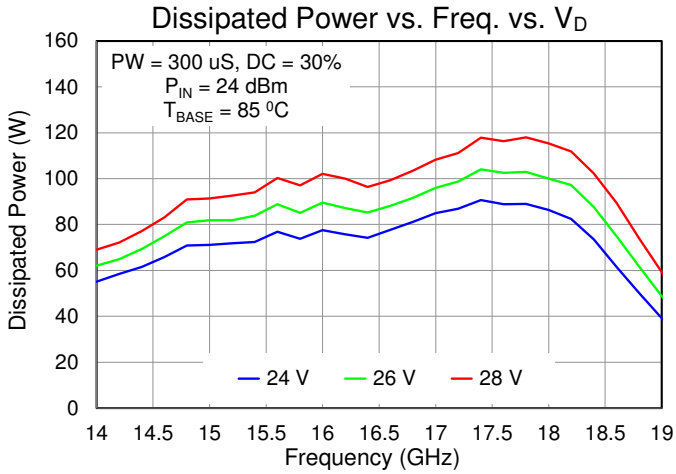
## Dissipated Power



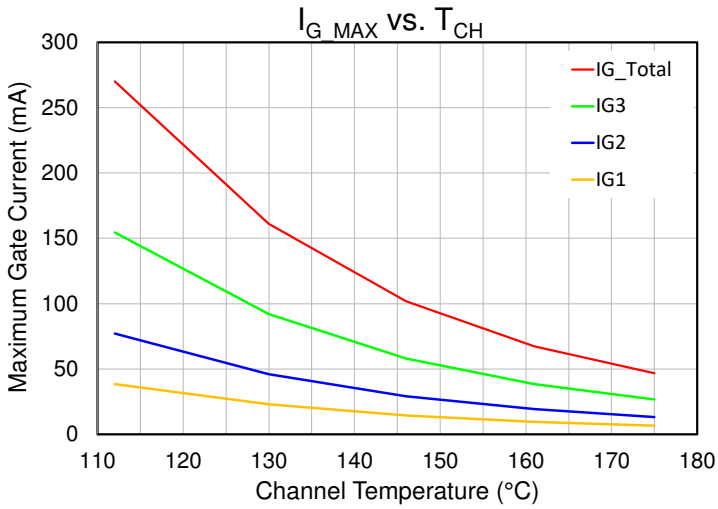
## Dissipated Power (cont.)



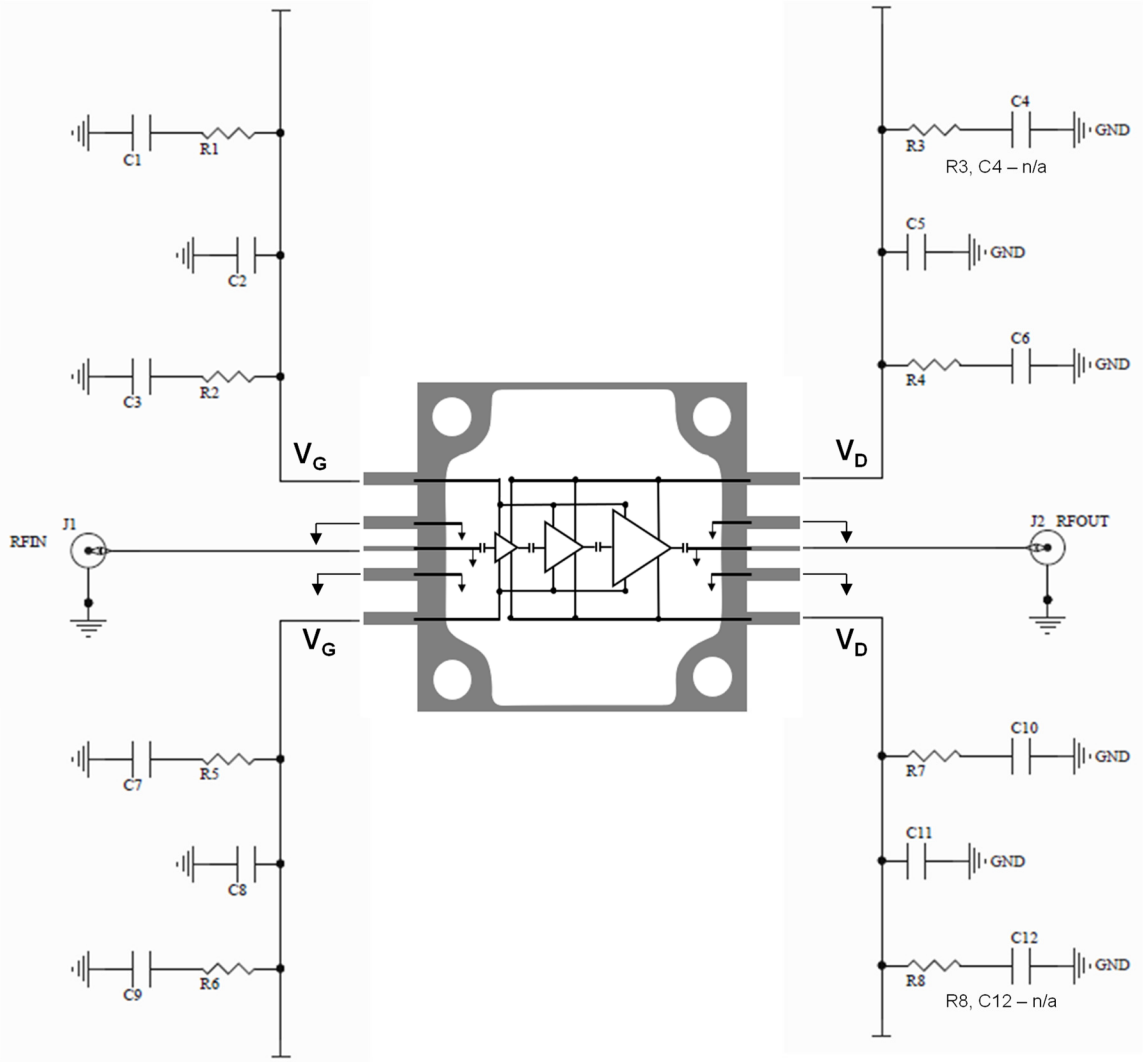

Test conditions, unless otherwise noted: Pulsed $V_D$ = 26 V, $I_{DQ}$ = 640 mA, $T_{BASE}$ = 85 ºC
$T_{BASE}$ is back side of QPA1315

## Maximum Gate Current




Channel Temperature is an IR scan equivalent

## Applications Information



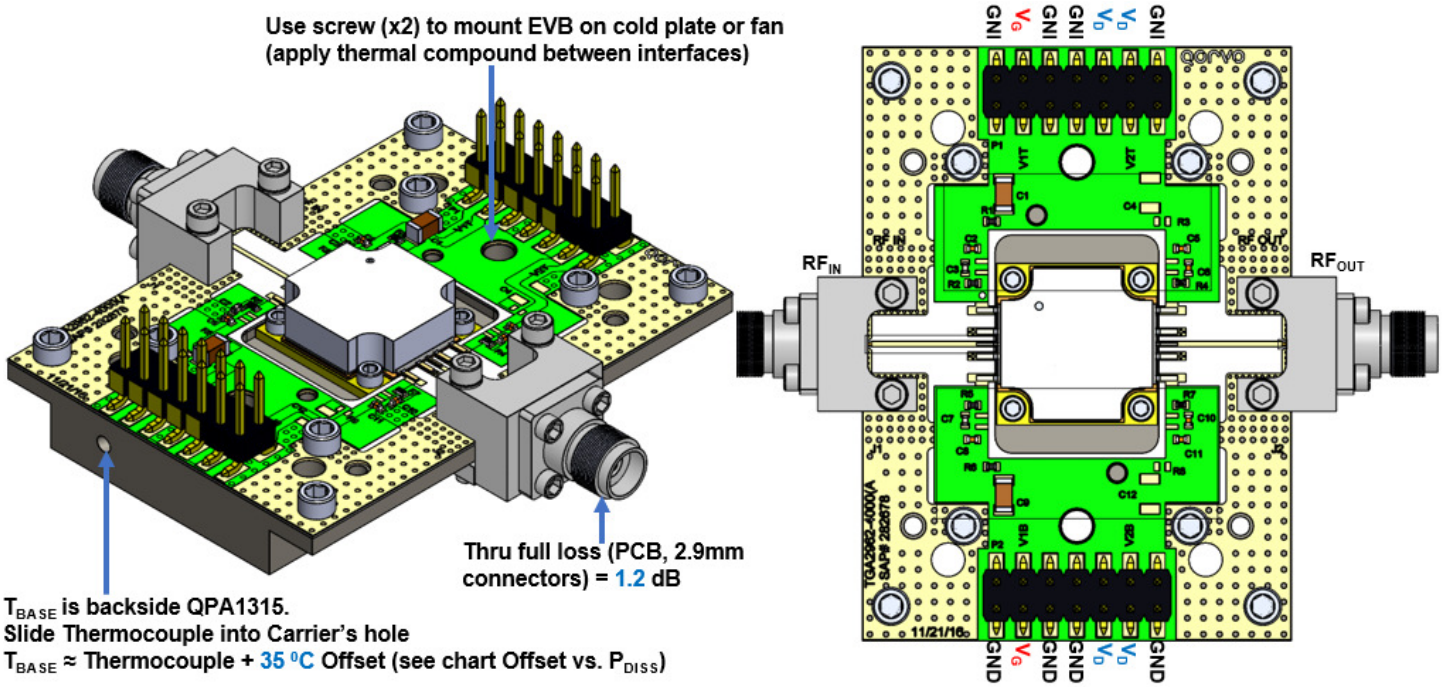

## Bias-Up Procedure

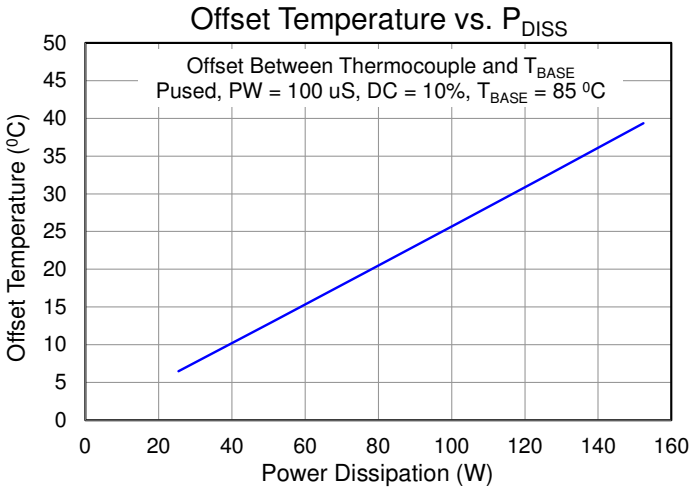
1. Set $I_D$ limit to 12 A, $I_G$ limit to 20 mA
2. Apply $V_G$ to –5 V
3. Apply $V_D$ to 26 V; ensure $I_{DQ}$ ~ 0 mA
4. Adjust $V_G$ more positive until $I_{DQ}$ = 640 mA; $V_G \approx$ -2.5 +/-0.6 V typical range
5. Turn on RF signal

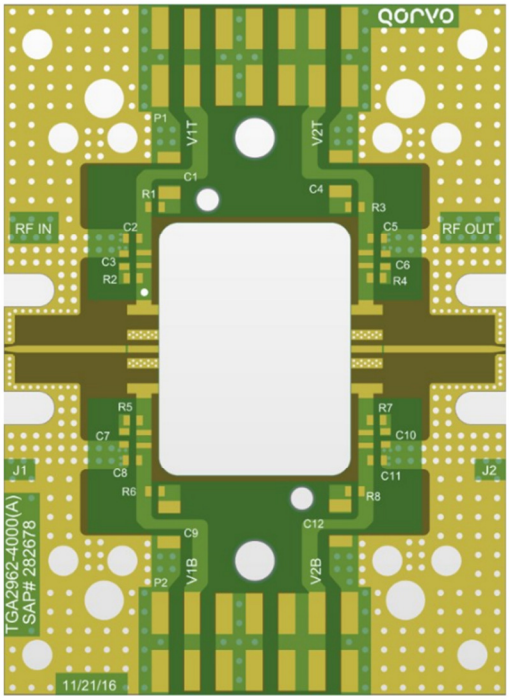
## Bias-Down Procedure

1. Turn off RF signal
2. Reduce $V_G$ to –5 V; ensure $I_{DQ}$ ~ 0 mA
3. Set $V_D$ to 0 V
4. Turn off $V_D$ supply
5. Turn off $V_G$ supply

## Evaluation Board (EVB) Layout



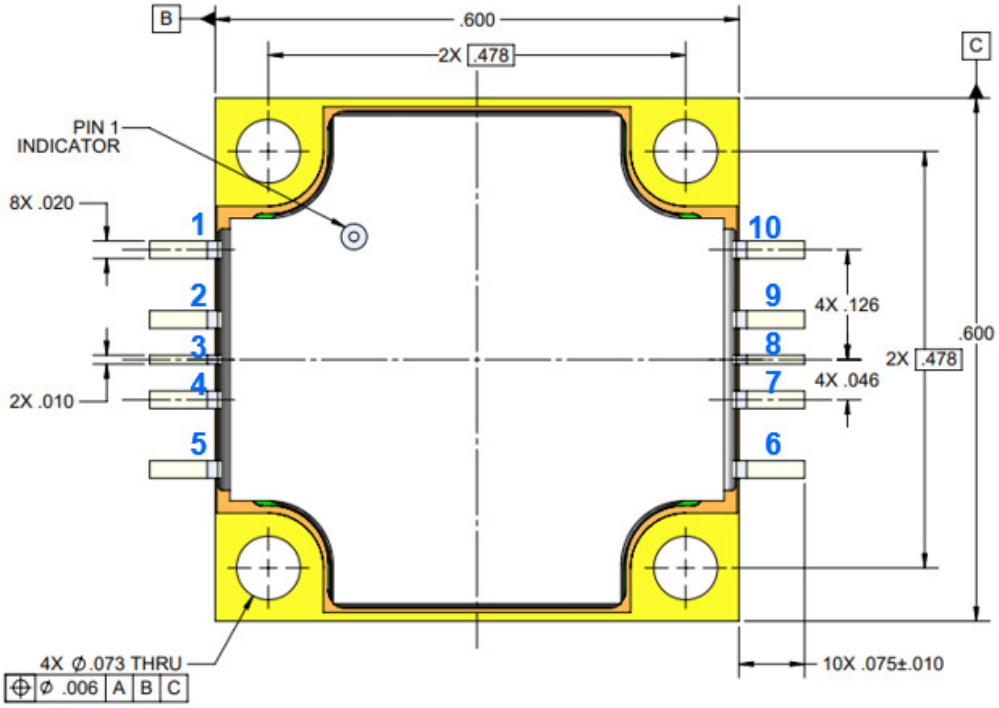




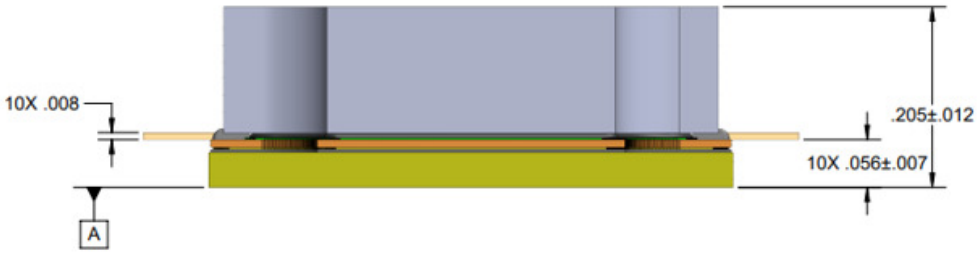
## Bill of Materials

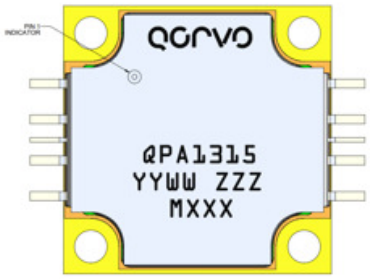
| Reference Des. | Qty | Value | Description | Part Number |
|---|---|---|---|---|
| C1, C9 | 2 | 10 uF | CAP, 10uF, ±20%, 50V, X5R, 1206 | |
| C2, C5, C6, C8, C10, C11 | 6 | 0.1 uF | CAP, 0.1uF, ±10%, 50V, X7R, 0402 | |
| C3, C7 | 2 | 0.01 uF | CAP, 0.01uF, ±10%, 50V, X7R, 0402 | |
| R1, R6 | 2 | 5.1 Ω | RES, 5.1 Ohm, ±5%, 50V, 0402 | |
| R2, R5 | 2 | 10 Ω | RES, 10 Ohm, ±5%, 1/10W, 0402 | |
| R4, R7 | 2 | 20 Ω | RES, 20 Ohm, ±5%, 1/10W, 0402 | |
| PCB | 1 | | PCB for QPA1315, see above | Qorvo, Custom |
| H1, H2 | 2 | | DC Header, 2x7, 14 POS, SMD | |
| J1, J2 | 2 | | RF Connector, 2.92mm, F, Pin 0.007, Diel. 0.048 | Southwest Microwave |
| H-Block | 1 | | H-Block, Copper C110, 1.594 x 2.200 x 0.275 in | Qorvo, Custom |
| S1 – S4 | 4 | | Screw, Cap, Socket Head,0-80X3/32” | |
| S5 – S12 | 8 | | Screw, Cap, Socket Head, 2-56X1/8” | |
| Epoxy | - | | Epoxy, Ablebond 84-1LMI | |
| Solder | - | | Paste, solder, Sn63/Pb37 | |

## Mechanical Information




NOTES:
1. MATERIALS
   LID: FR4
   BASE: COPPER; FINISH: GOLD
   LEADS: ALLOY 194; FINISH: GOLD
2. PART IS EPOXY SEALED
3. UNITS: INCHES
4. TOLERANCES (UNLESS NOTED):
   .XX = ± .01
   .XXX = ± .005
5. MARKINGS
   QPA1315: PART NUMBER
   YY: ASSEMBLY YEAR
   WW: ASSEMBLY WEEK
   ZZZ: SERIAL NUMBER
   MXXX: BATCH ID




## Pin Description

| Pin Number | Symbol | Description |
|---|---|---|
| 1, 5 | $V_G$ | Gate voltage (1). Must be biased on both pins |
| 2, 4, 7, 9 | Ground | Ground. Must be grounded on PCB |
| 3 | $RF_{IN}$ | RF Input. Matched to 50 Ω, DC blocked, DC shorted to ground |
| 6, 10 | $V_D$ | Drain voltage (1). Must be biased on both pins |
| 8 | $RF_{OUT}$ | RF Output. Matched to 50 Ω, DC blocked, DC shorted to ground |

1. External bypassing required; refer to page 25 for recommendation.

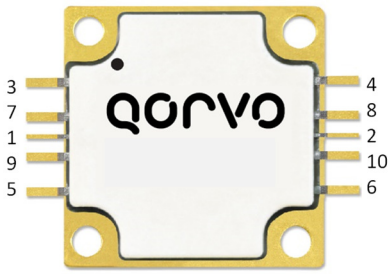
## Assembly Notes

1. Carefully clean the PC board, base plate, and package leads with alcohol. Allow it to dry fully.

2. To improve the thermal and RF performance, Qorvo recommends attaching a heat sink to the bottom of the package and apply either a thermal compound (Arctic Silver 5 recommended) or a .004 inch (maximum thickness) Indium shim between the heat sink and the package. Refer to the applications note Application of Arctic Silver 5 Thermal Compound and Indium Shims for Qorvo CP-style Packaged Components for more information.

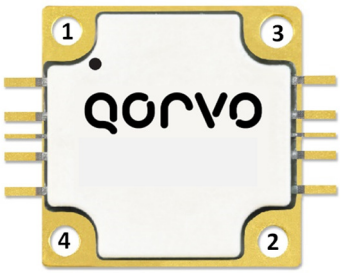
3. The component leads should be manually soldered. Apply a low residue solder alloy meeting J-STD-001 (ROL0, ROL1 or equivalent) with a liquidus temperature below 220 °C to each pin of the TGA/QPA/QPMxxxx. The use of low residue/no-clean flux (ROL0, ROL1) is recommended. The package lead temperature should not exceed 260 deg C. Each solder connection should be completed within 2 to 5 seconds. Adding flux during hand soldering of the component leads with localized spot cleaning is acceptable. Soldering irons meeting the requirements of J-STD-001, Appendix A are acceptable.

4. The leads should be soldered in a staggered or star pattern from side to side, and never solder two adjacent leads. This allows the heat to dissipate on each lead, and not cause the adjacent leads to become de-soldered and damaged or displaced.




5. The packaged part should not be subjected to conventional SMT automated solder reflow processes.

6. (The following is for information only. There are many variables in a second level assembly that Qorvo does not control, so Qorvo does not recommend an absolute torque value.) Use screws to attach the component to the heat sink. A suggested final torque value is 16 in-oz. for a 0-80 screw. Start with screws finger tight, then torque to 8 in-oz., then torque to final value. Use the following tightening pattern:



## Handling Precautions

| Parameter | Rating | Standard |
|---|---|---|
| ESD – Human Body Model (HBM) | 1A | ANSI/ESD/JEDEC JS-001 |
| ESD – Charged Device Model (CDM) | C2A | ANSI/ESD/JEDEC JS-002 |
| MSL – Moisture Sensitivity Level | N/A | Blank, null, no content |

Caution!

ESD-Sensitive Device

## 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
- Antimony Free
- TBBP-A ($C_{15}H_{12}Br_40_2$) Free
- PFOS Free
- SVHC Free

## Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

**Web: www.qorvo.com**

**Tel: 1-844-890-8163**

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

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