# QPA2225D

## 28 – 38 GHz 0.4 Watt GaN Driver Amplifier

## Product Overview

Qorvo's QPA2225D is a wide band MMIC driver amplifier fabricated on Qorvo's production 0.15 um GaN on SiC process (QGaN15). Covering 28 – 38 GHz, the QPA2225D provides > 0.4 W of saturated output power with >23 dB of small-signal gain.

The QPA2225D MMIC dimensions are 1.65 x 0.67 x 0.05 mm. It can support a variety of operating conditions to best support system requirements. With good thermal properties, it can support a range of bias voltages.

The QPA2225D has DC blocking capacitors on both RF ports, which are matched to 50 ohms.

The QPA2225D is ideal for supporting communications and radar applications in both commercial and military markets.

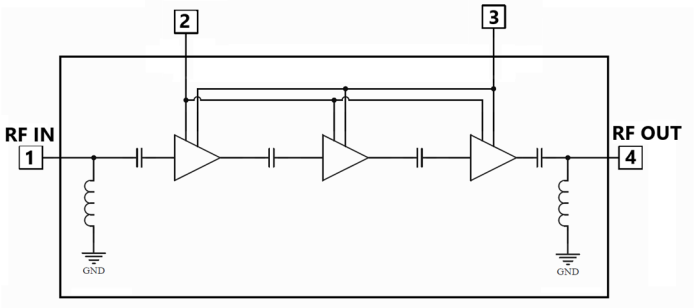
Lead-free and RoHS compliant.


### Key Features

- Frequency Range: 28 – 38 GHz
- $P_{SAT}$ ($P_{IN}$ = 13 dBm): > 26 dBm
- Small Signal Gain: > 23 dB
- IM3 ($P_{OUT}$/Tone = 20 dBm): -20 dBc
- Bias: CW, $V_D$ = +20 V, $I_{DQ}$ = 64 mA, $V_G$ = -2.5 V typ.
- Die Dimensions: 1.65 x 0.67 x 0.05 mm

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

## Functional Block Diagram




### Applications

- Communications
- Radar
- Satellite Communications
- Electronic Warfare

## Ordering Information

| Part No. | Description |
|---|---|
| QPA2225D | 28 – 38 GHz 0.4 Watt GaN Amplifier (100 pcs.) |
| QPA2225DEVBA | Evaluation Board for QPA2225D |

## 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 ($I_D$) | 456 mA |
| Gate Current ($I_G$) | See plot page 18 |
| Power Dissipation ($P_{DISS}$), 85 °C | 5 W |
| Input Power ($P_{IN}$), CW, 50 Ω, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, $T_{BASE}$ = 85 °C | 18 dBm |
| Input Power ($P_{IN}$), CW, 3:1 VSWR, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, $T_{BASE}$ = 85 °C | 18 dBm |
| Mounting Temperature (30 seconds) | 320 ºC |
| 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 ($V_D$) | | +20 | | V |
| Drain Current, ($I_{DQ}$) | | 64 | | mA |
| Drain Current, RF ($I_{D\_Drive}$) | See chart page 6 | | | mA |
| Gate Voltage Range ($V_G$) | –2 to -2.9 | | | V |
| Gate Current, RF ($I_{G\_Drive}$) | See chart page 6 | | | mA |
| $T_{BASE}$ Range | –40 | | +85 | ºC |

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

## Electrical Specifications

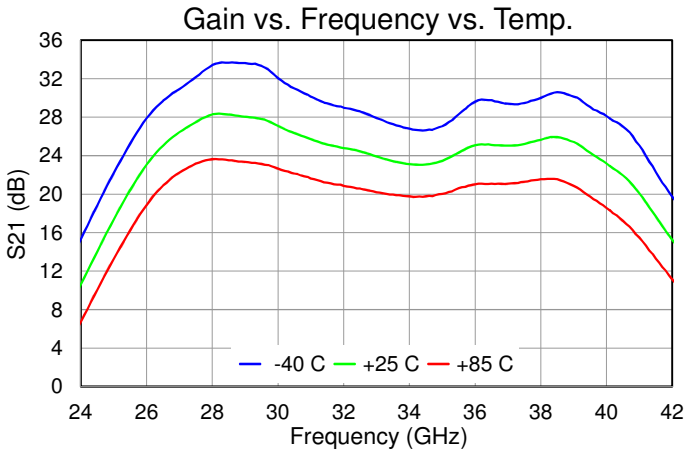
| Parameter | Conditions (1) (2) | Min | Typ. | Max | Units |
|---|---|---|---|---|---|
| Operational Frequency Range | | 28 | | 38 | GHz |
| Output Power at Saturation, $P_{SAT}$ | $P_{IN}$ = +13 dBm | | > 26 | | dBm |
| Large Signal Gain | $P_{IN}$ = +13 dBm | | > 13 | | dB |
| Small Signal Gain, S21 | | | > 23 | | dB |
| Input Return Loss, IRL | | | 5 | | dB |
| Output Return Loss, ORL | | | 5 | | dB |
| 3RD Intermodulation Products, IM3 | $P_{OUT}$/Tone = 20 dBm; Freq. = 35 GHz; Δf = 100 MHz | | -20 | | dBc |
| 5TH Intermodulation Products, IM5 | $P_{OUT}$/Tone = 20 dBm; Freq. = 35 GHz; Δf = 100 MHz | | -30 | | dBc |
| $P_{SAT}$ Temperature Coefficient | $T_{DIFF}$ = –40 ºC to +85 ºC; $P_{IN}$ = +13 dBm | | -0.02 | | dBm/ºC |
| S21 Temperature Coefficient | $T_{DIFF}$ = –40 ºC to +85 ºC | | -0.07 | | dB/ºC |

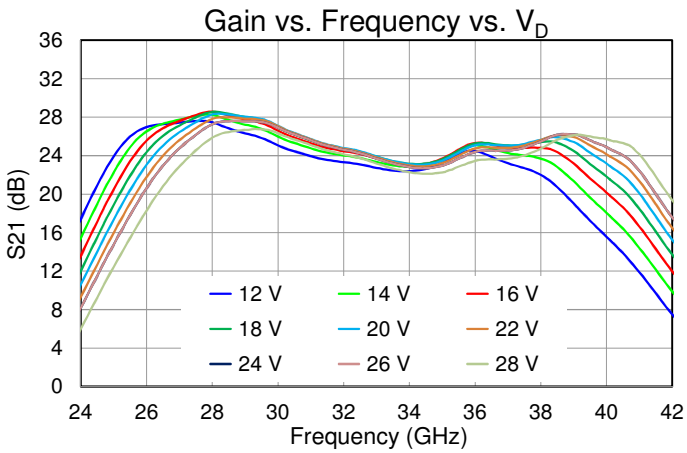
Notes:

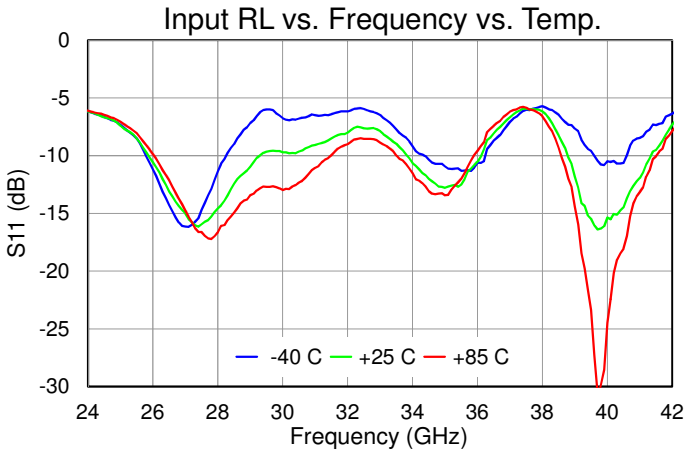
1. Test conditions unless otherwise noted: CW, $V_D$ = + 20 V, $I_{DQ}$ = 64 mA, $V_G$ = -2.5V +/- typical, $T_{BASE}$ = +25 ºC, $Z_0$ = 50 Ω
2. $T_{BASE}$ is back side of 20 mil CuMo carrier plate with AuSn solder

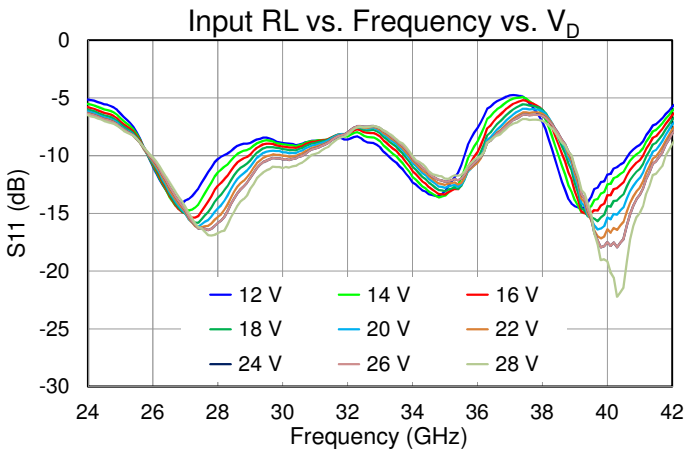
## Performance Plots – Small Signal

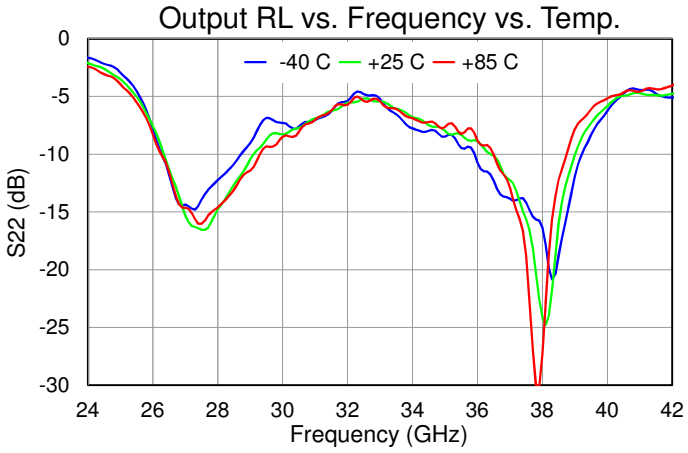
Test conditions, unless otherwise noted: CW, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, $T_{BASE}$ = +25 ºC

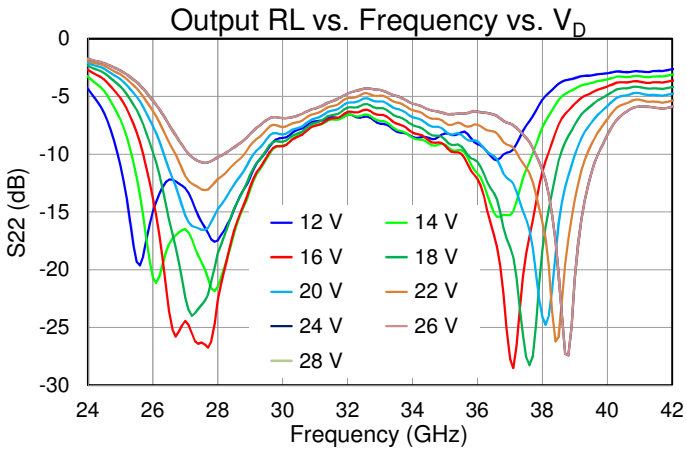


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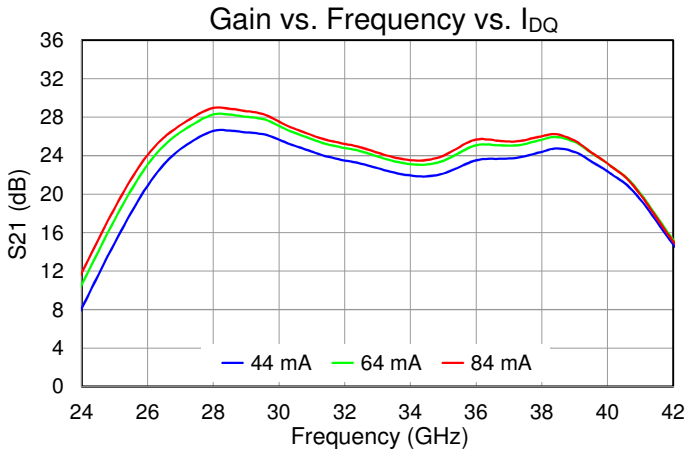
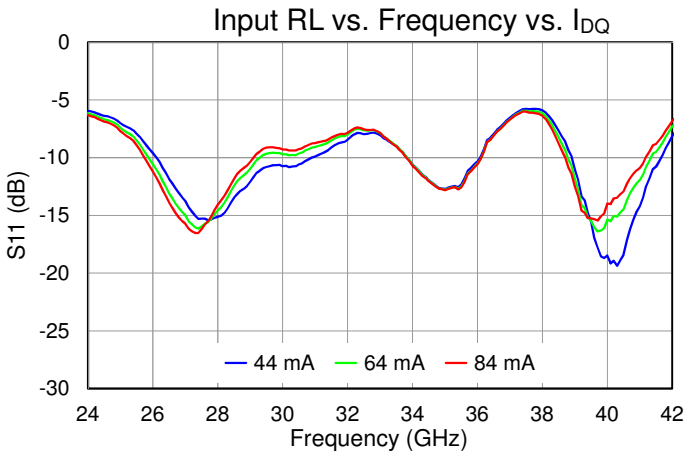
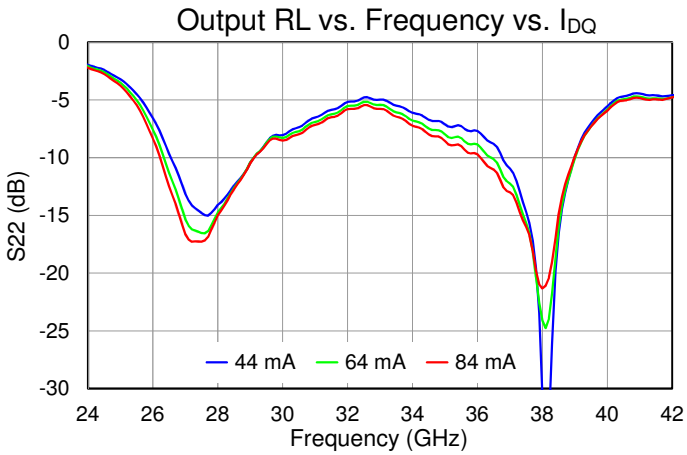
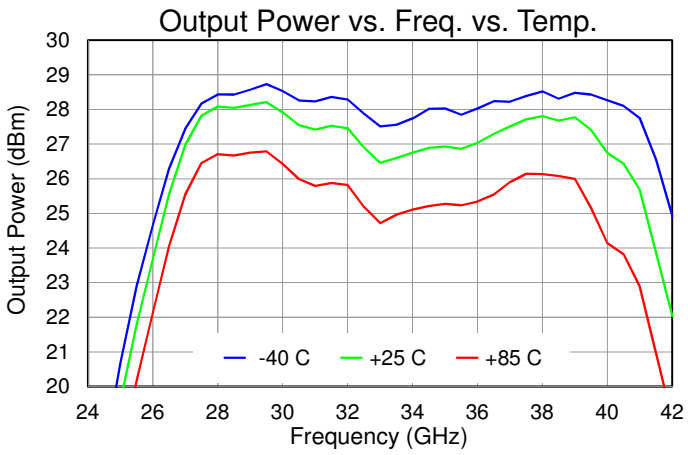


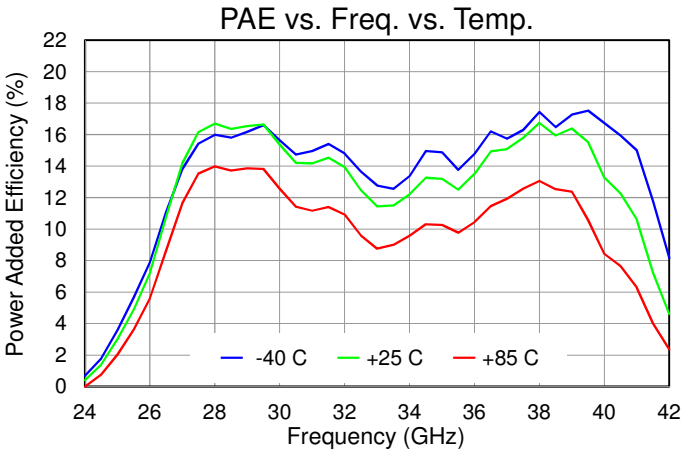



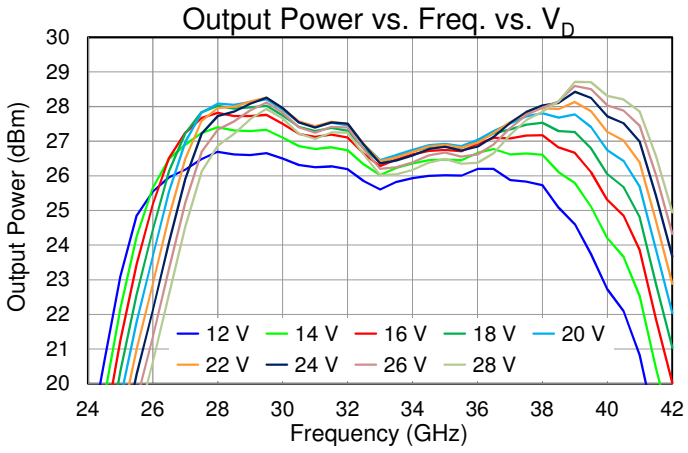



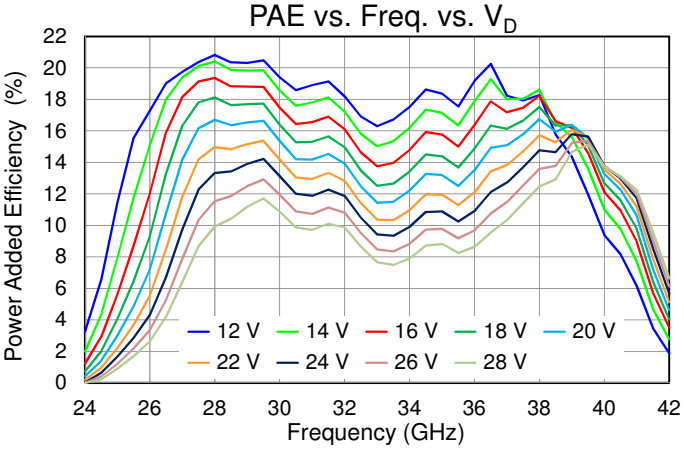
## Performance Plots – Large Signal (CW)

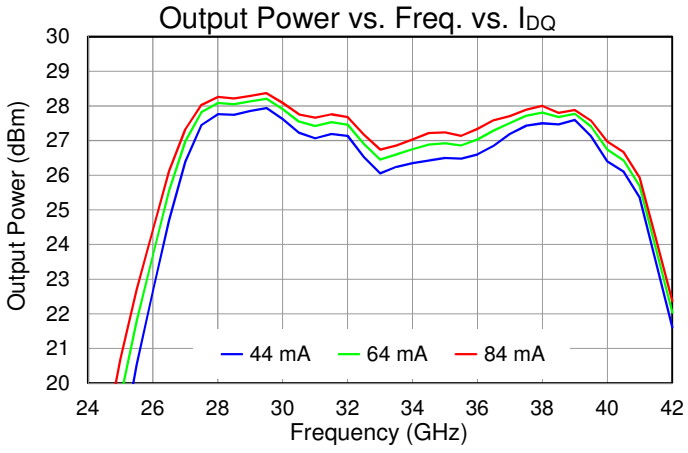
Test conditions, unless otherwise noted: **CW**, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, $P_{IN}$ = +13dBm, $T_{BASE}$ = +25 ºC

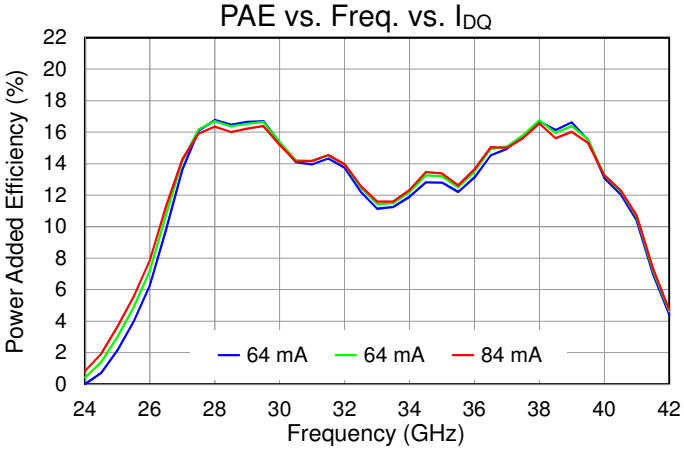


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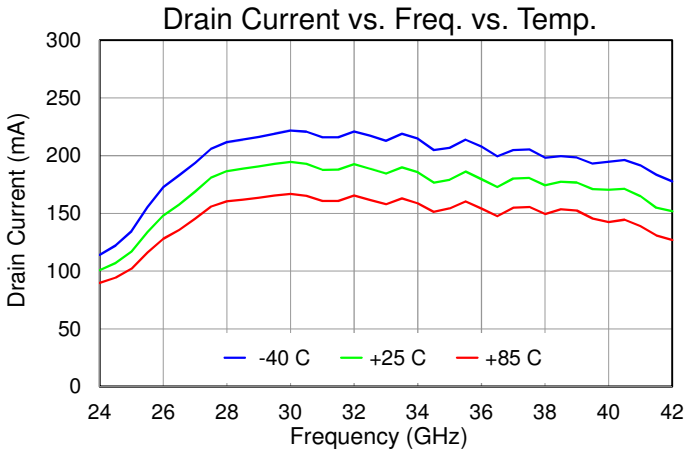


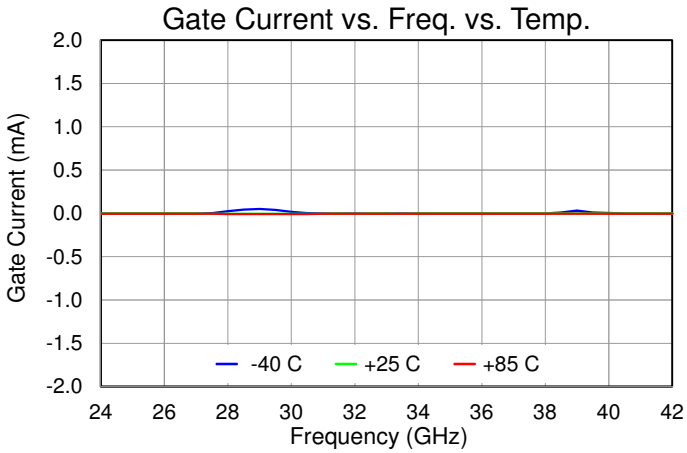


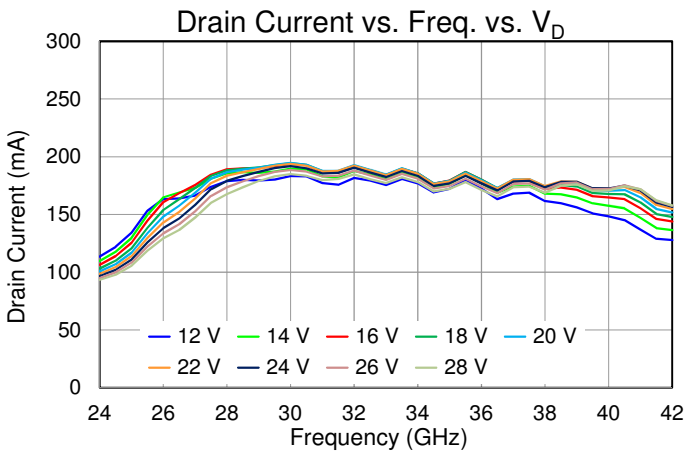


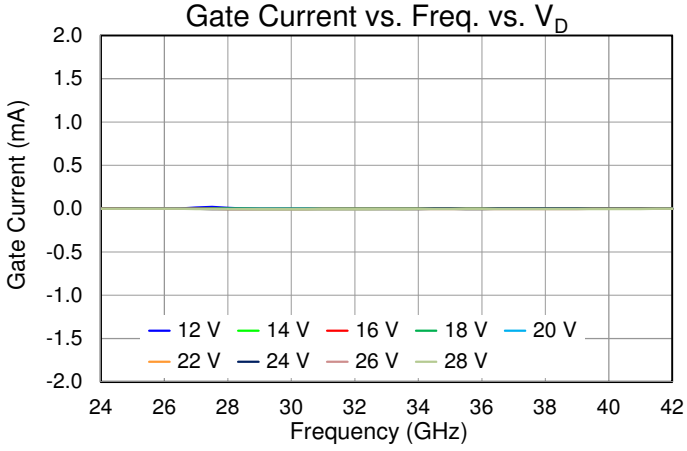


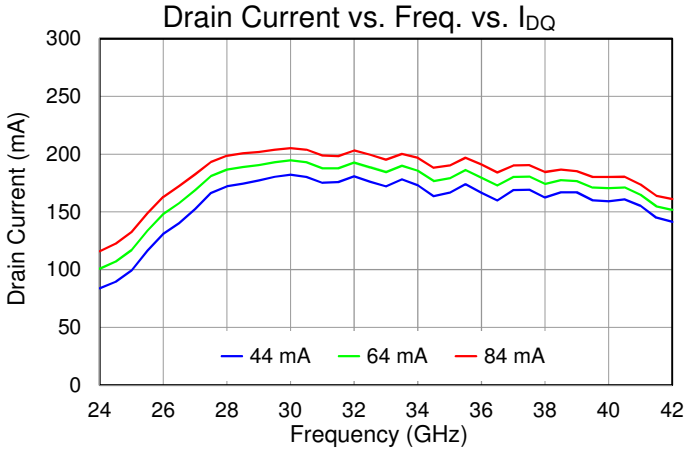


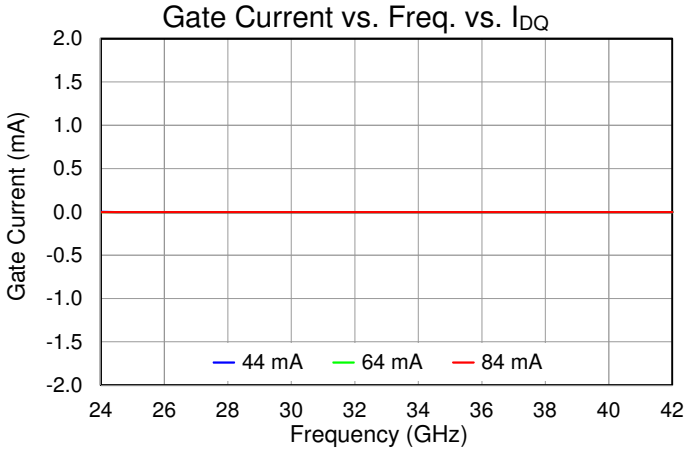

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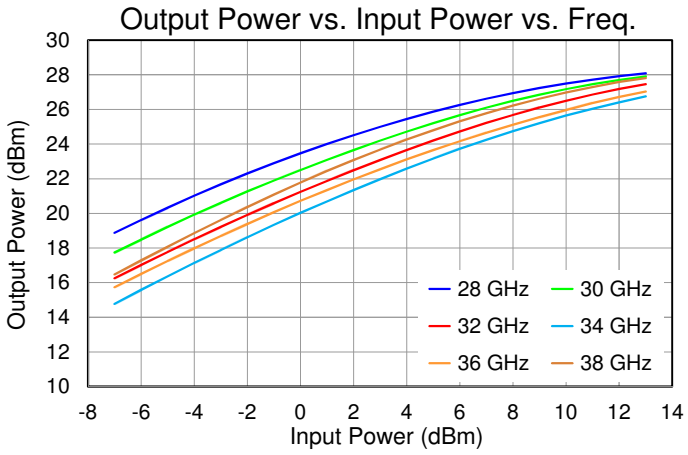


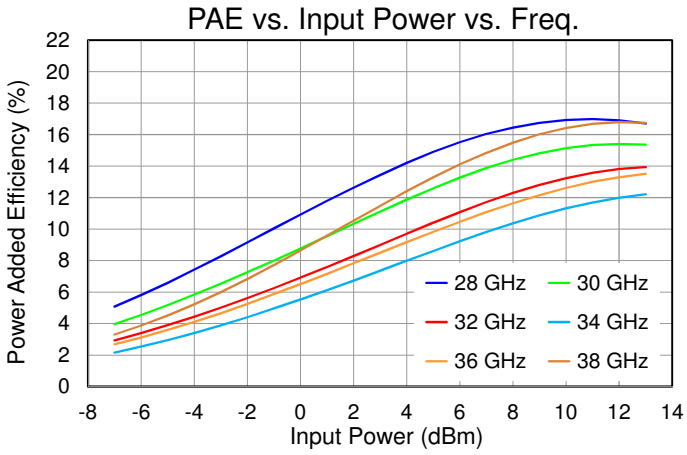


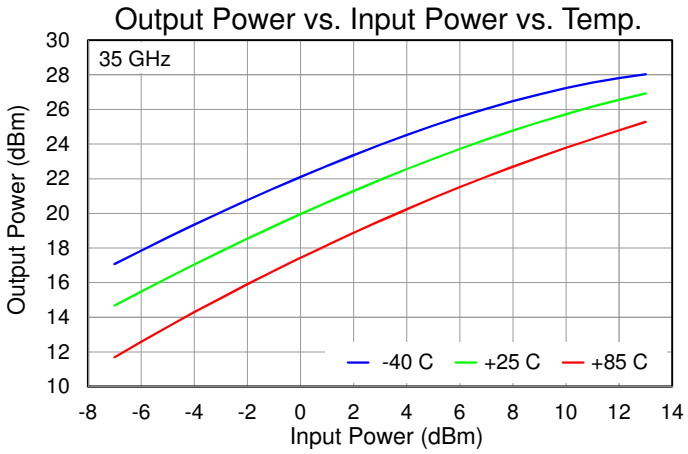


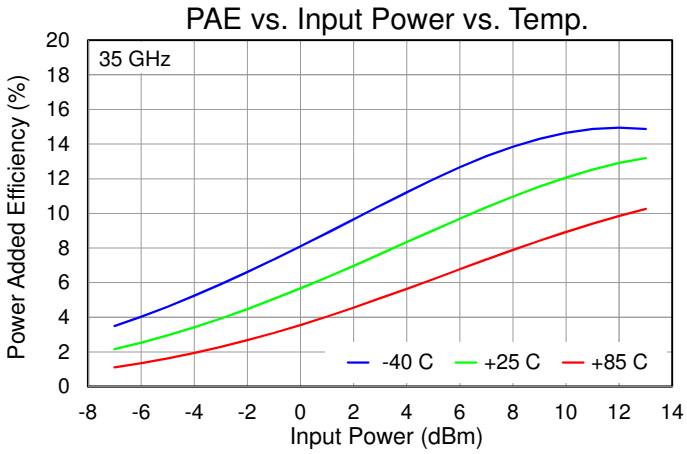


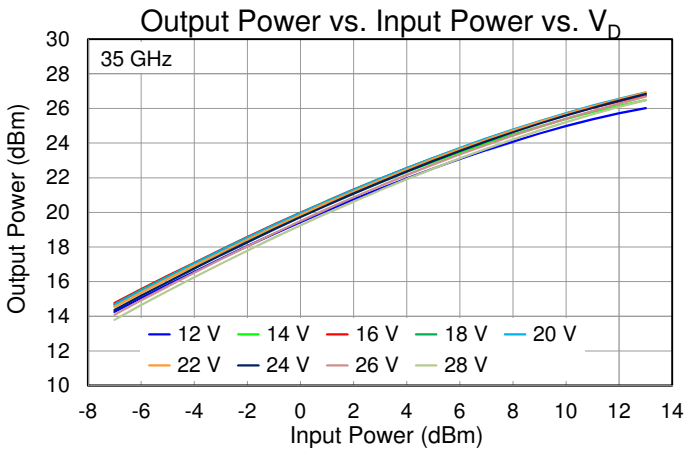


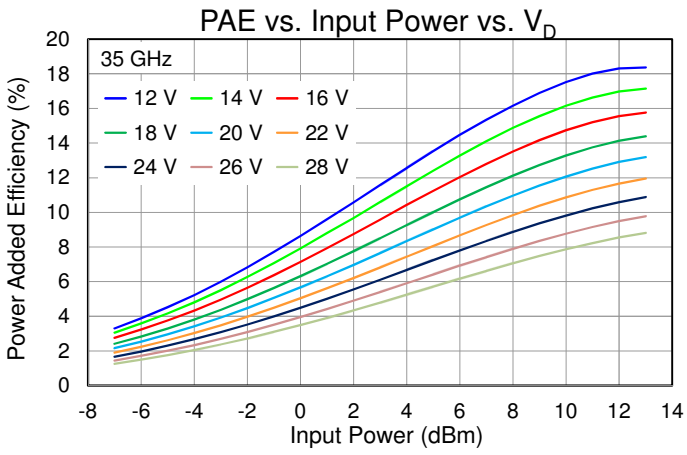

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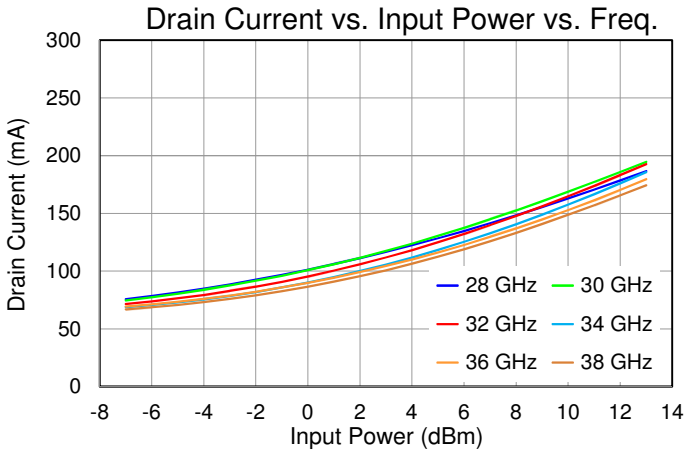


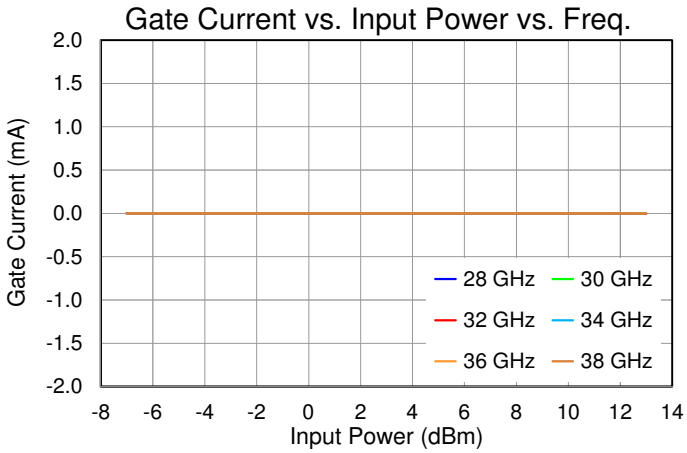


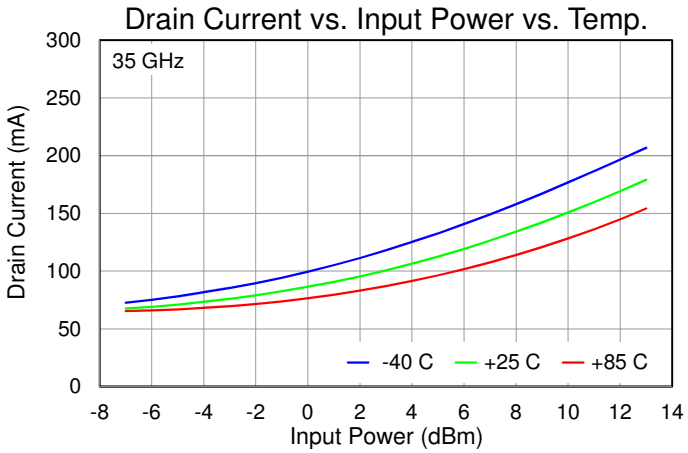


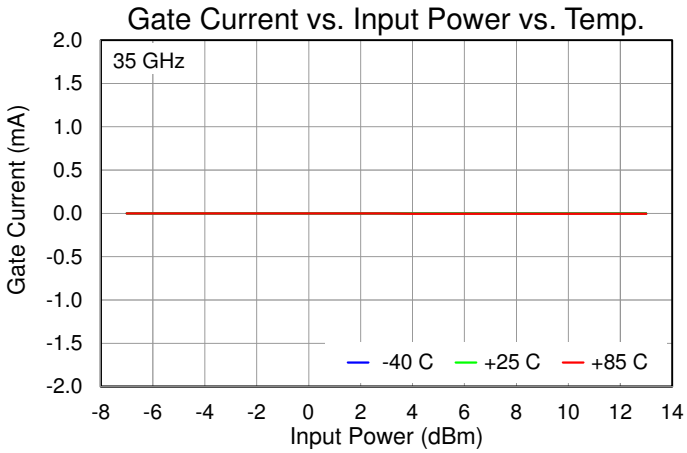


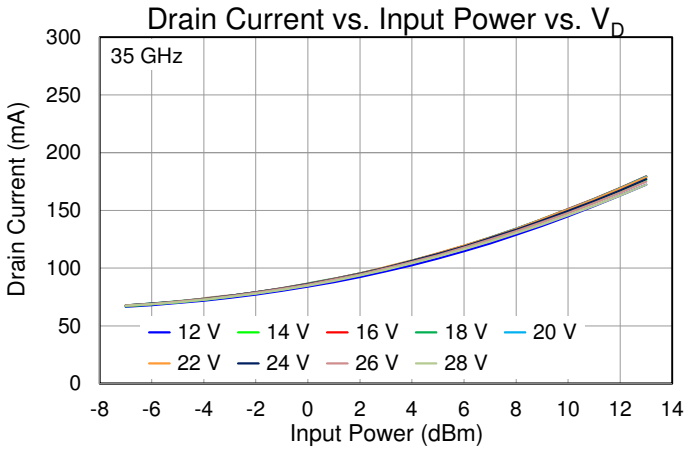


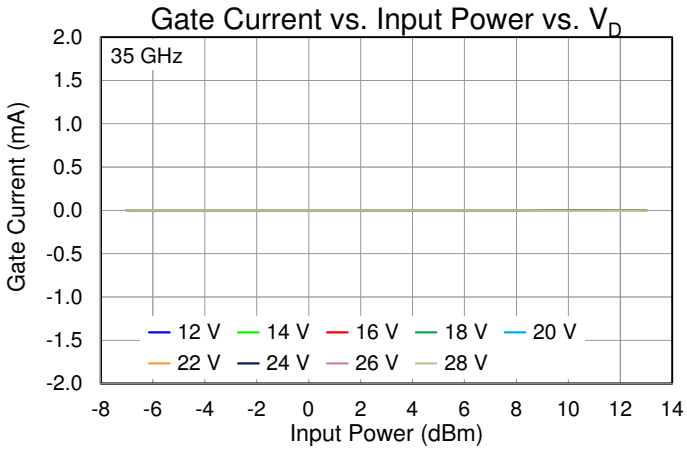

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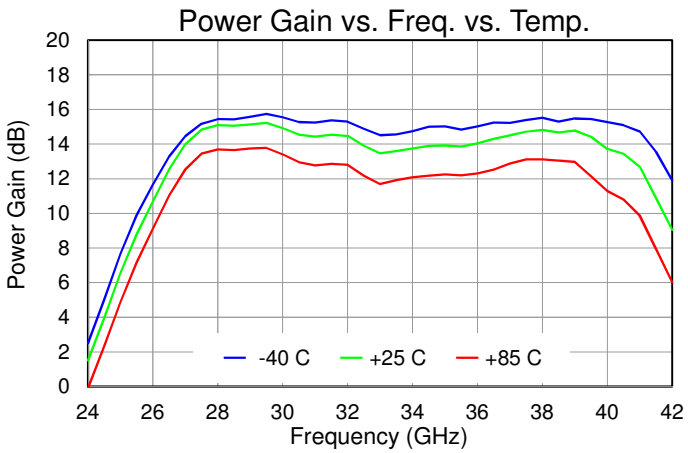
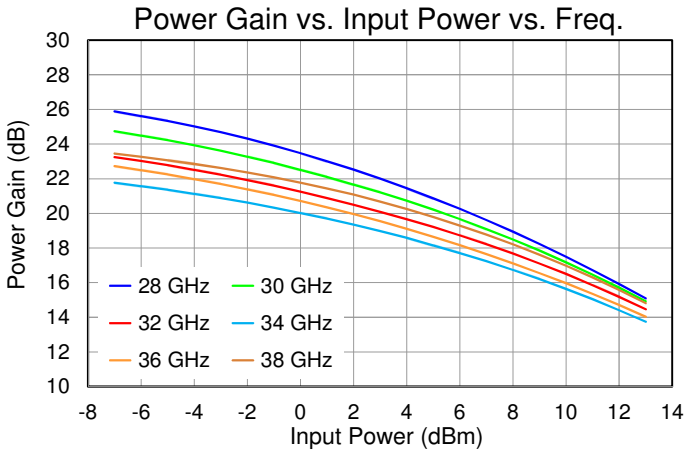
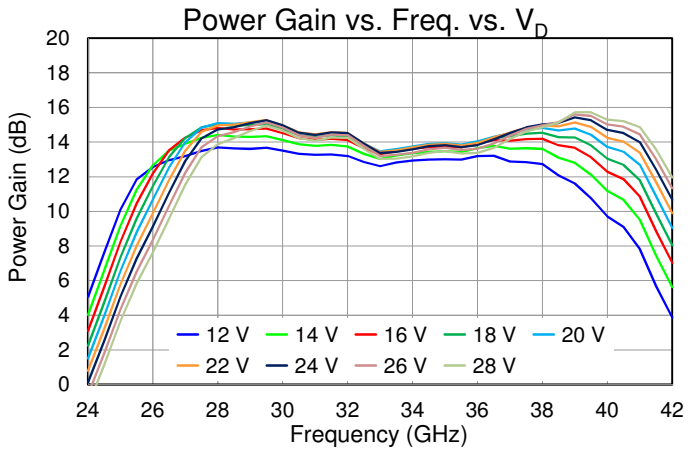
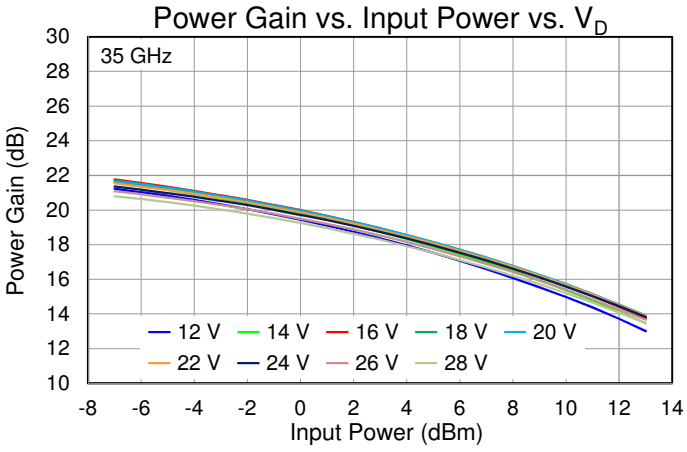
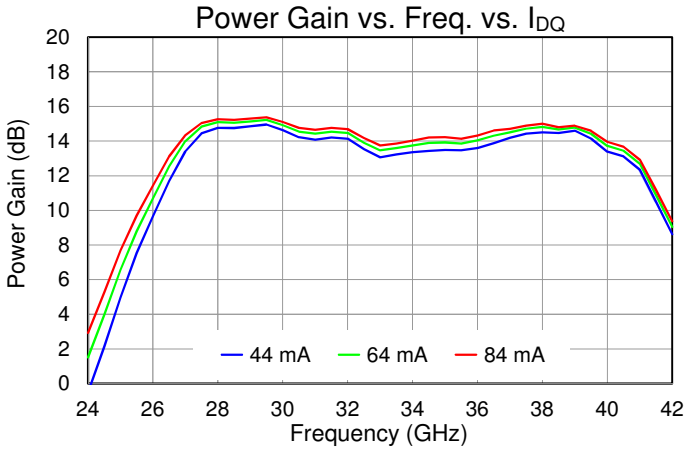
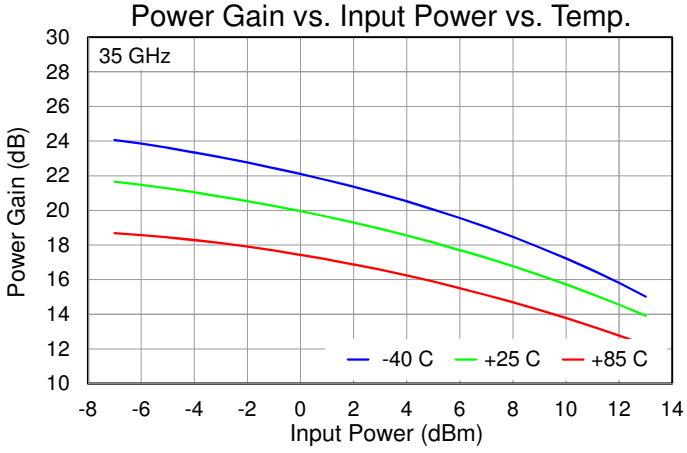


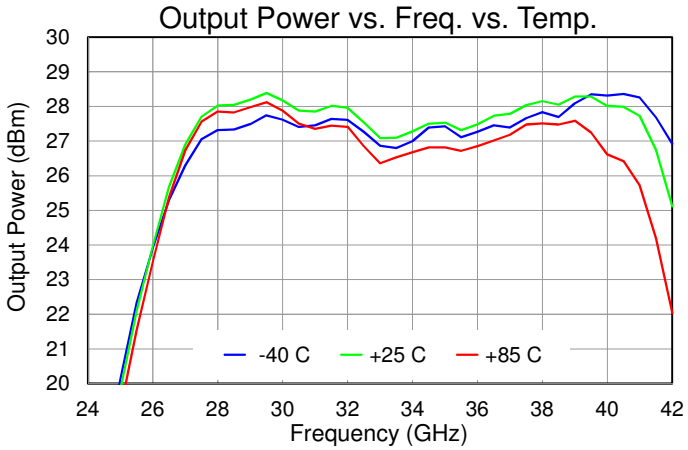



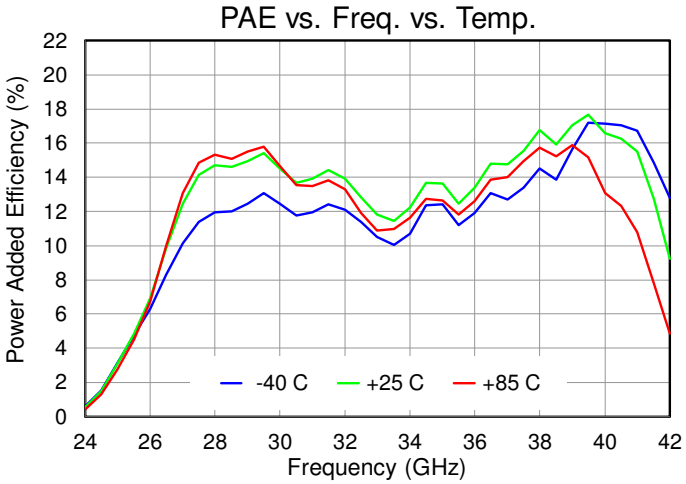



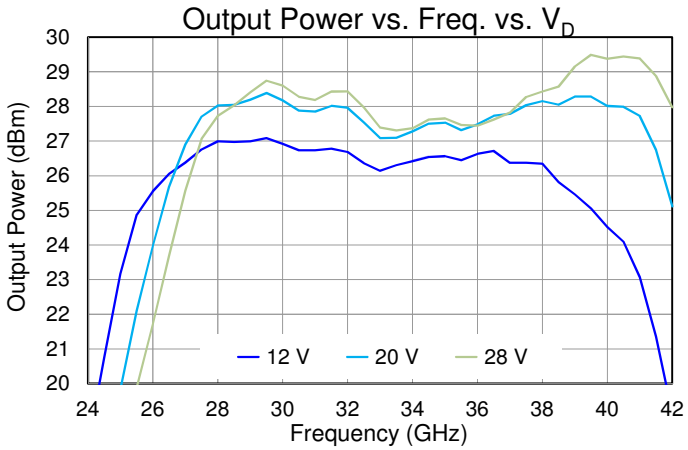



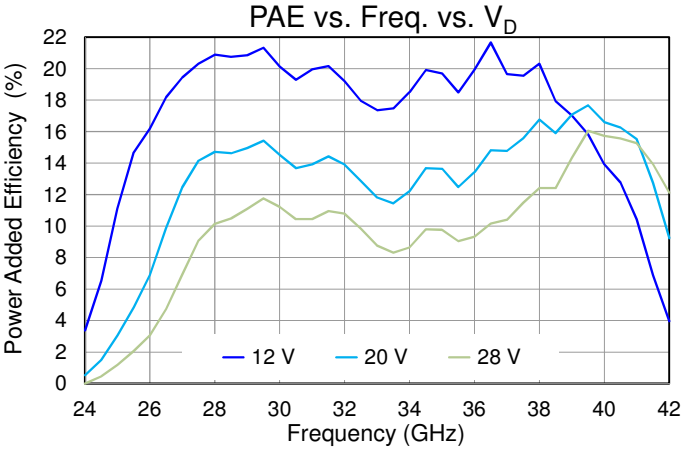
## Performance Plots – Large Signal (Pulsed)

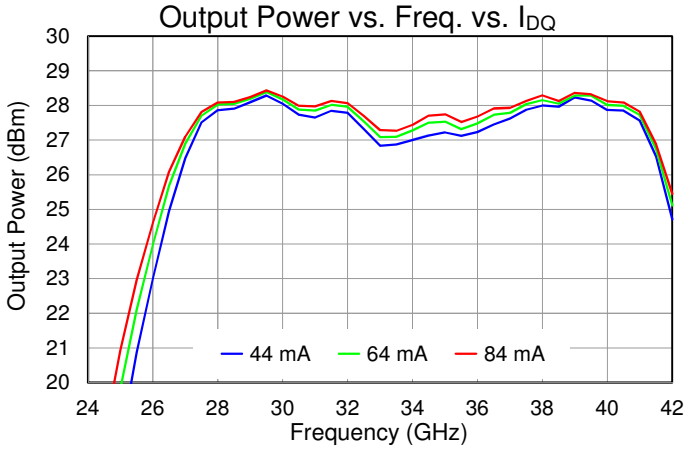
Test conditions, unless otherwise noted: **Pulsed** $V_D$ = 20 V, $I_{DQ}$ = 64 mA, PW = 100 µs, DC = 10%, $P_{IN}$ = +13dBm, $T_{BASE}$ = +25 ºC

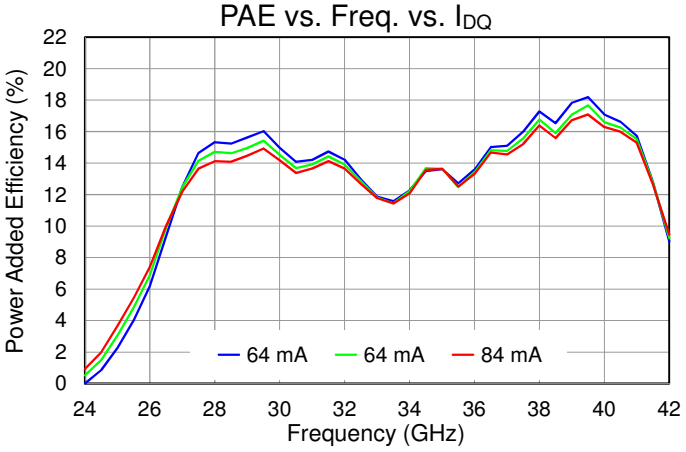


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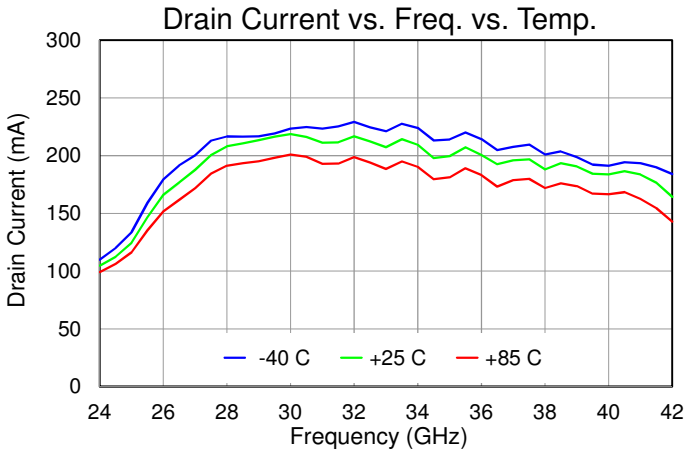
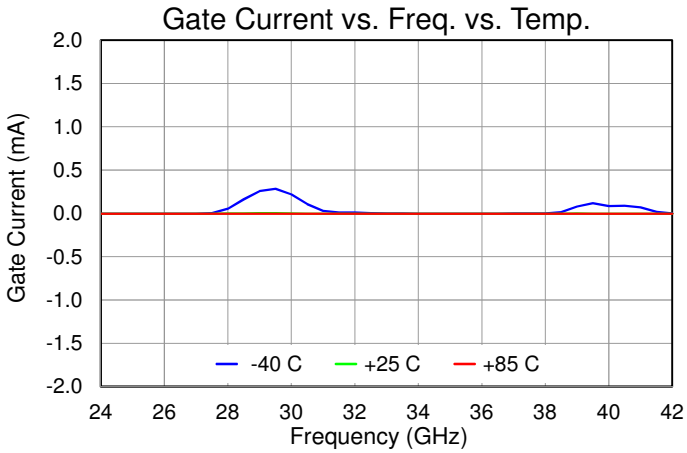
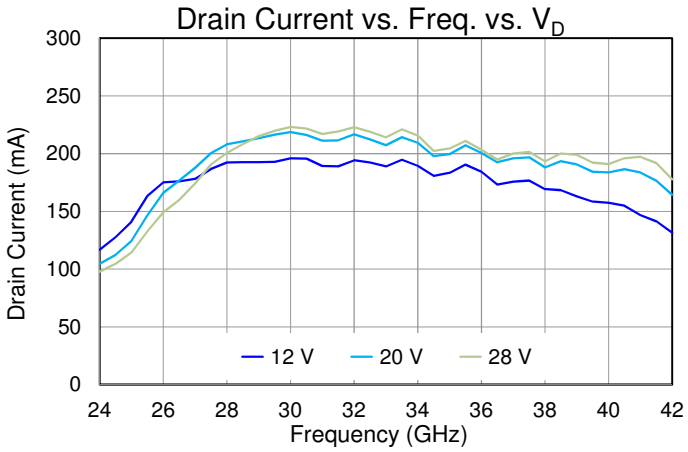
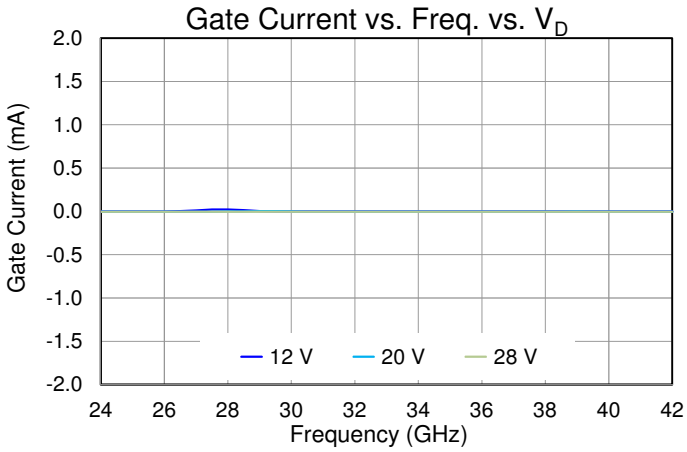
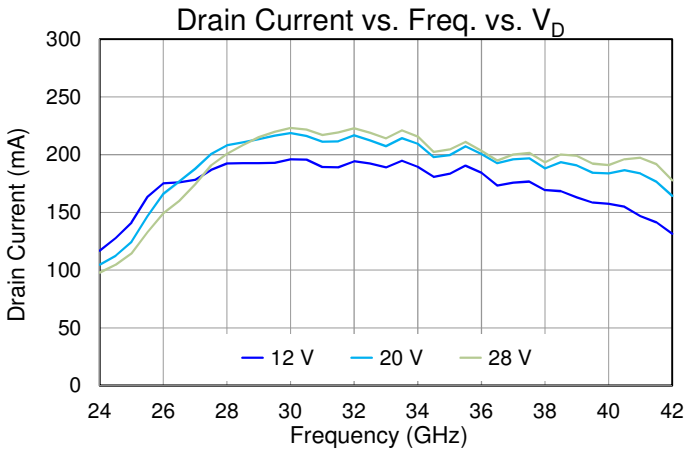
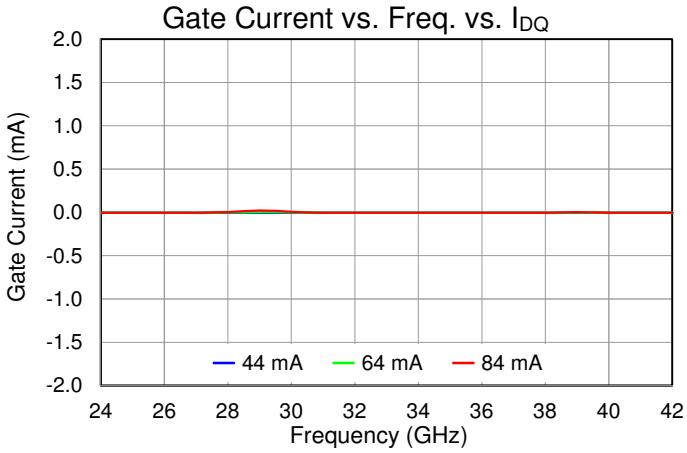


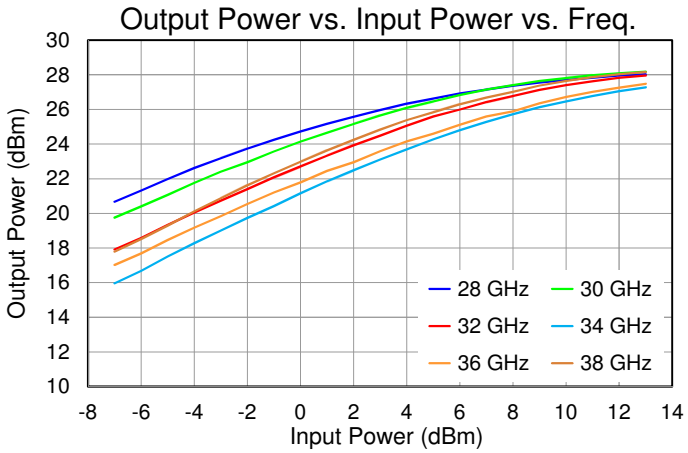



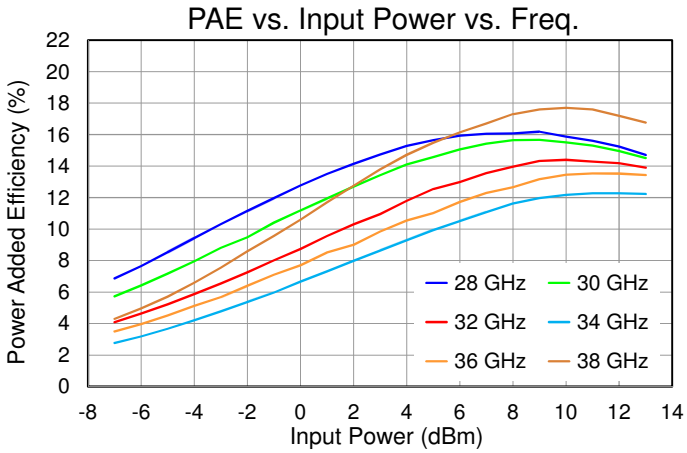



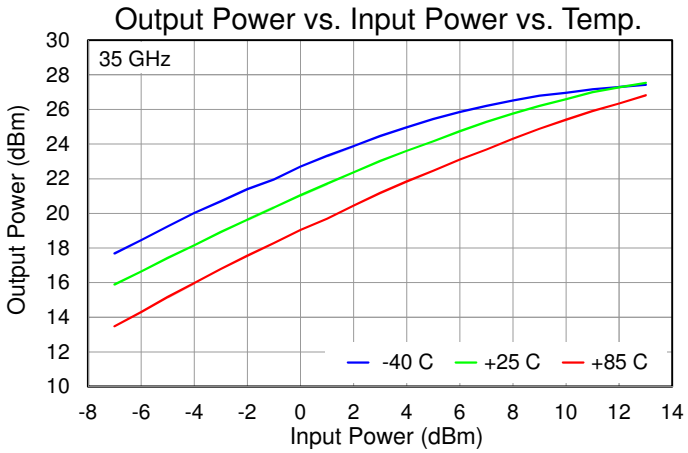



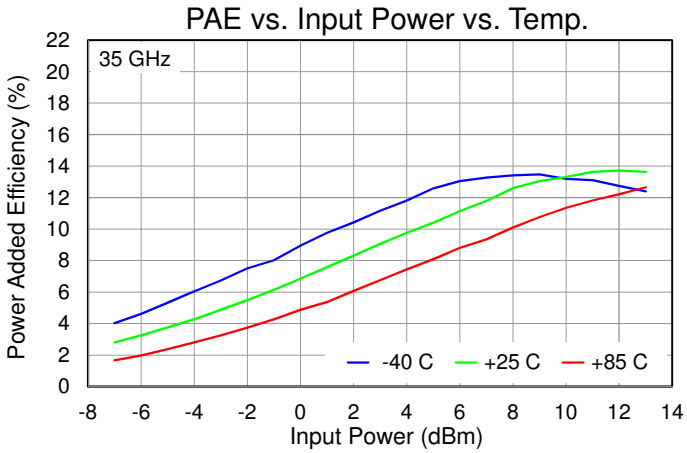
## Performance Plots – Large Signal (Pulsed)

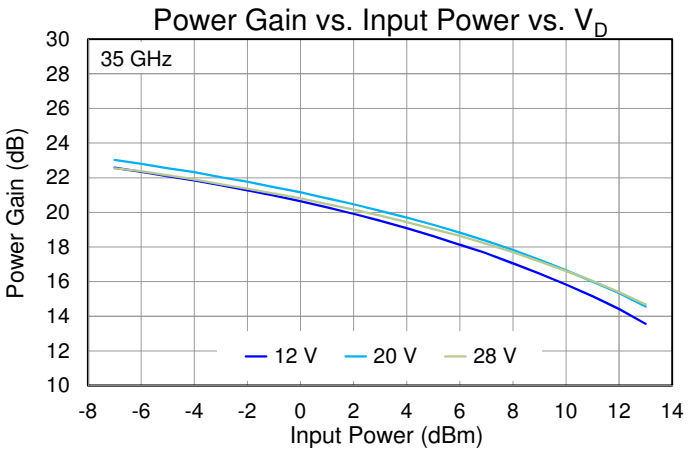
Test conditions, unless otherwise noted: **Pulsed** $V_D$ = 20 V, $I_{DQ}$ = 64 mA, PW = 100 µs, DC = 10%, $P_{IN}$ = +13dBm, $T_{BASE}$ = +25 ºC

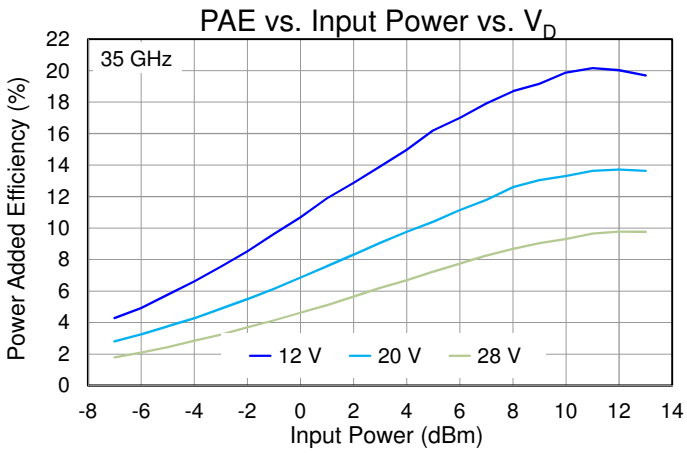


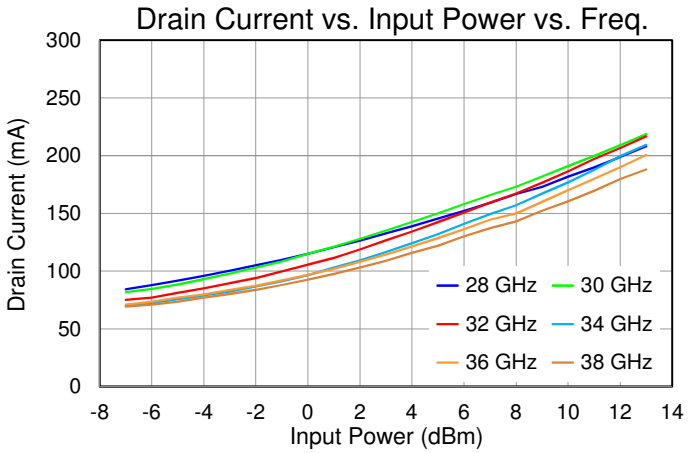



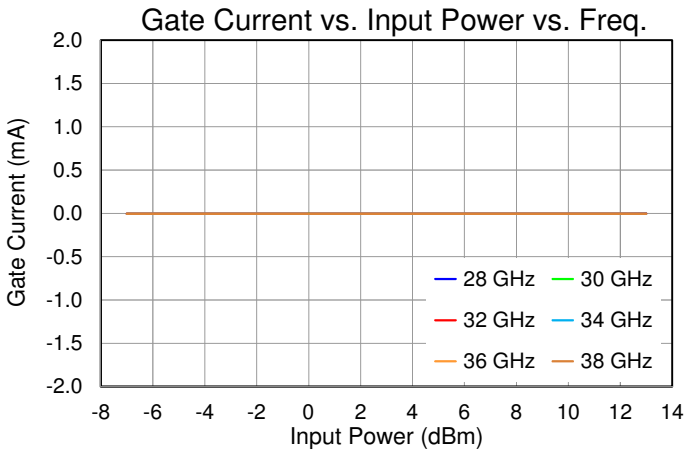



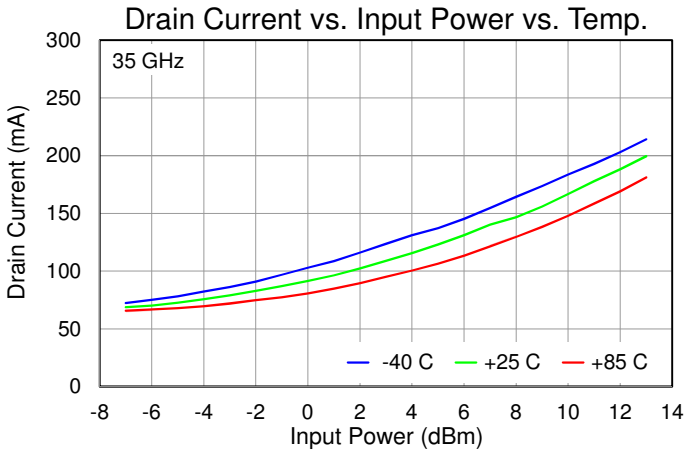



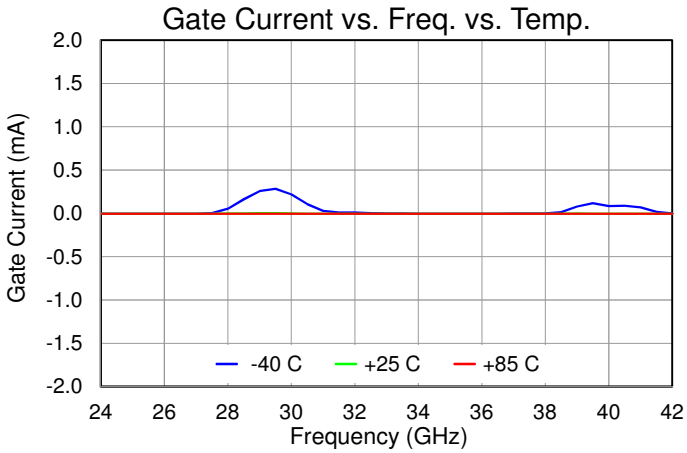
## Performance Plots – Large Signal (Pulsed)

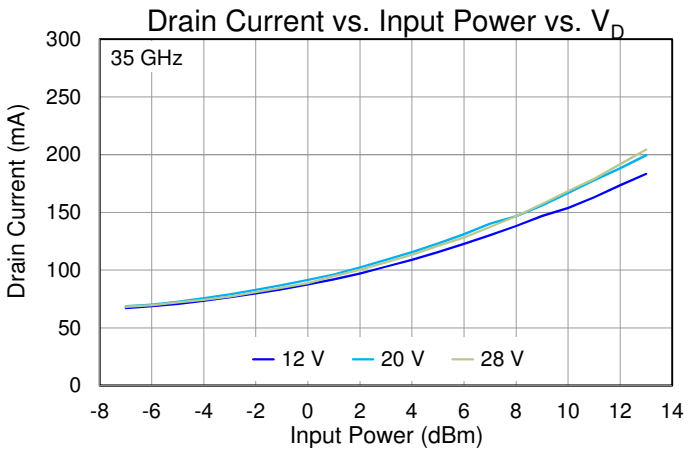
Test conditions, unless otherwise noted: **Pulsed** $V_D$ = 20 V, $I_{DQ}$ = 64 mA, PW = 100 µs, DC = 10%, $P_{IN}$ = +13dBm, $T_{BASE}$ = +25 ºC

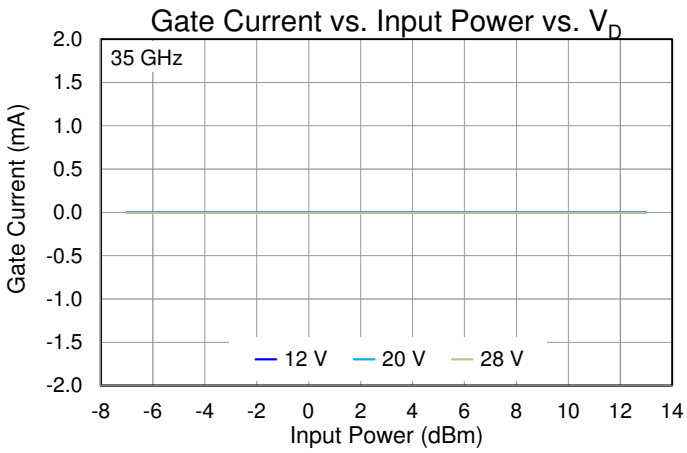


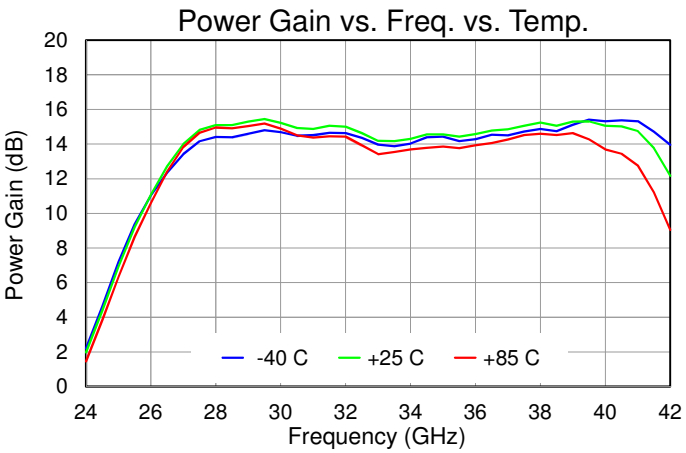



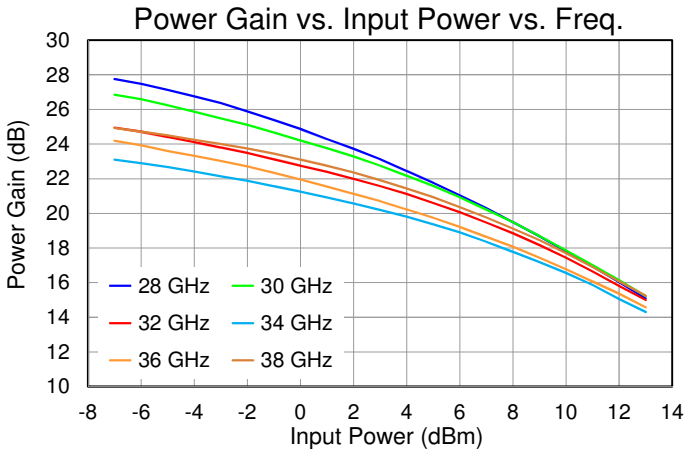



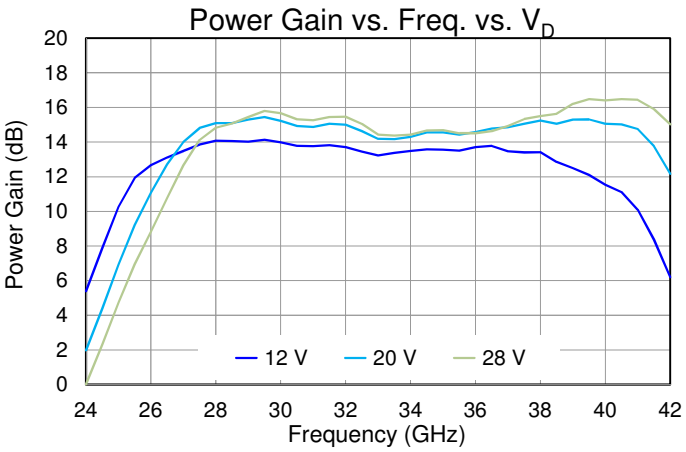



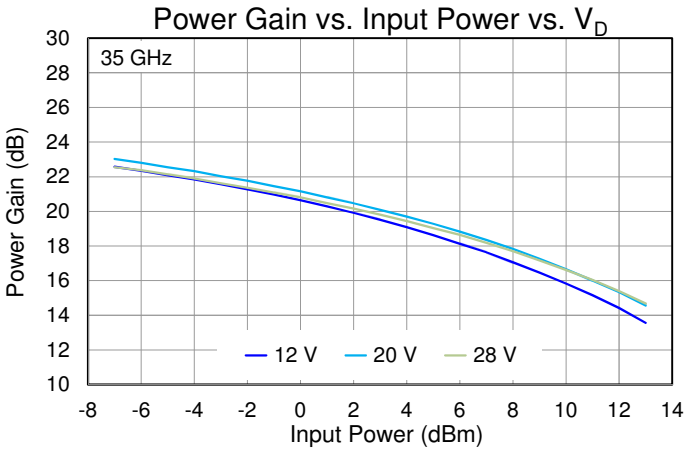
## Performance Plots – Large Signal (Pulsed)

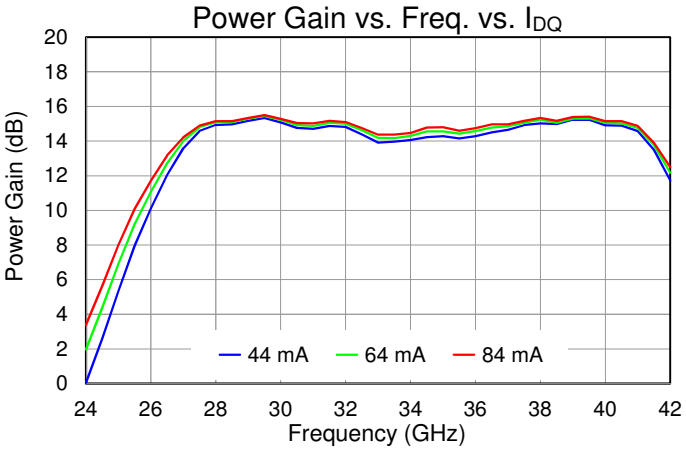
Test conditions, unless otherwise noted: **Pulsed** $V_D$ = 20 V, $I_{DQ}$ = 64 mA, PW = 100 µs, DC = 10%, $P_{IN}$ = +13dBm, $T_{BASE}$ = +25 ºC

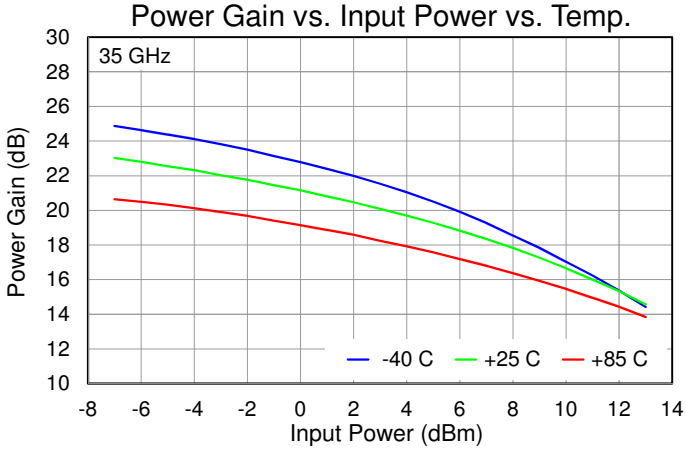


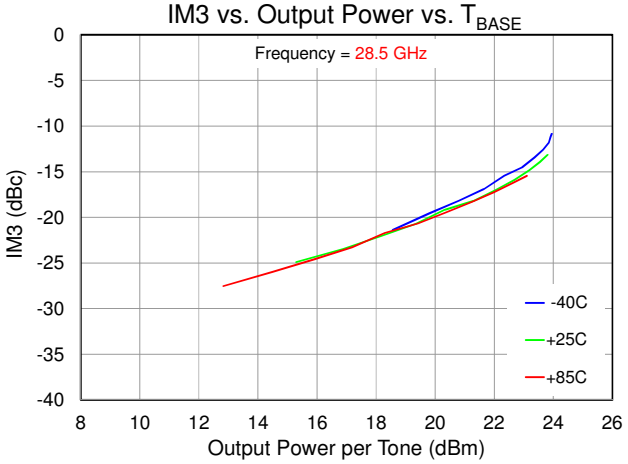



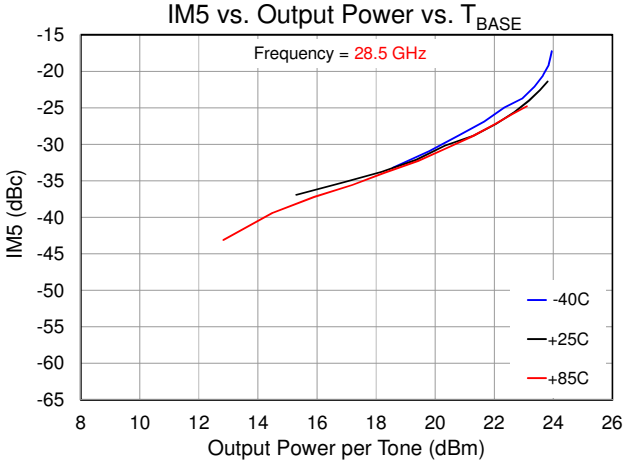
## Performance Plots – Linearity

Test conditions, unless otherwise noted: CW, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, **$F_C$ = 28.5 GHz**, Tone Spacing = 100 MHz, $T_{BASE}$ = +25 ºC

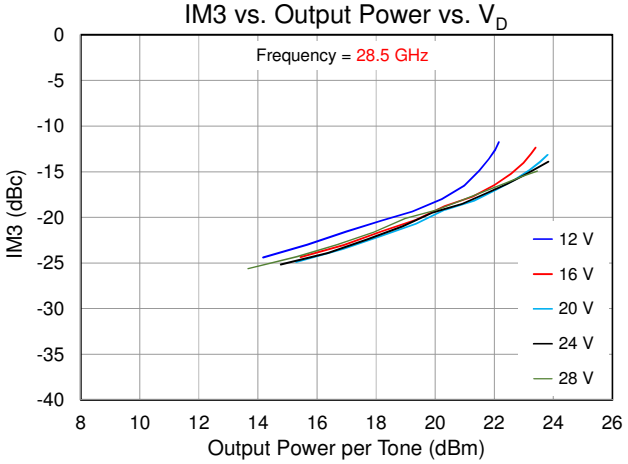
IM3 vs. Output Power vs. $T_{BASE}$



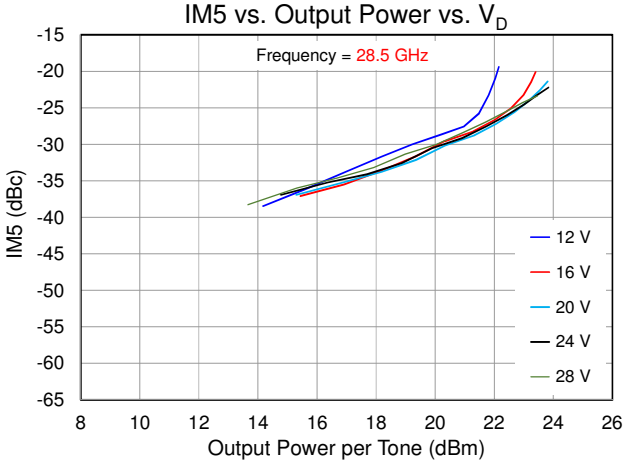

IM5 vs. Output Power vs. $T_{BASE}$



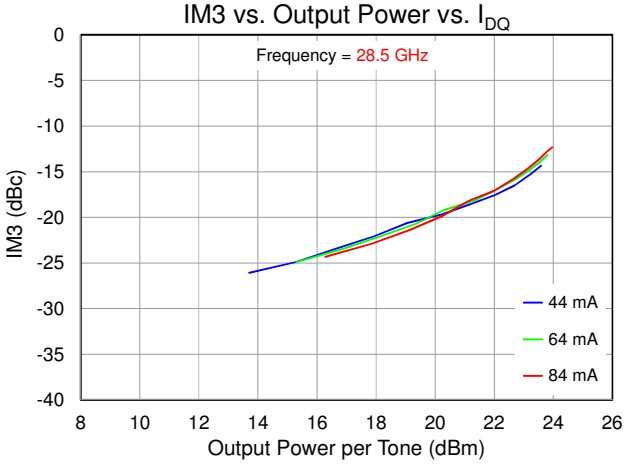

IM3 vs. Output Power vs. $V_D$



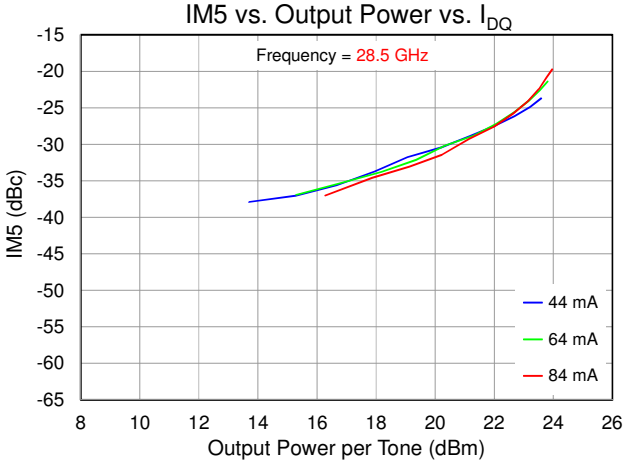

IM5 vs. Output Power vs. $V_D$




IM3 vs. Output Power vs. $I_{DQ}$



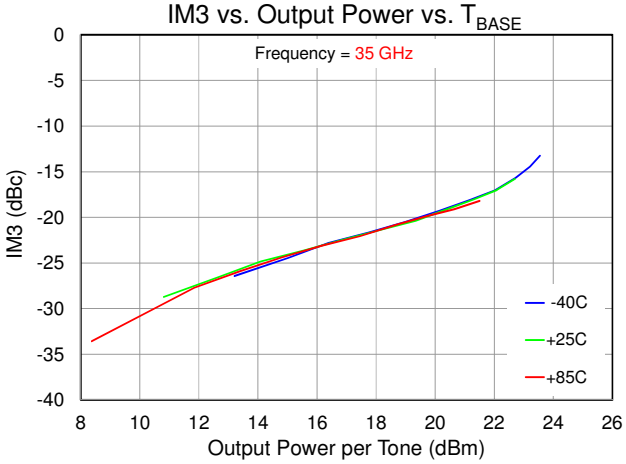

IM5 vs. Output Power vs. $I_{DQ}$



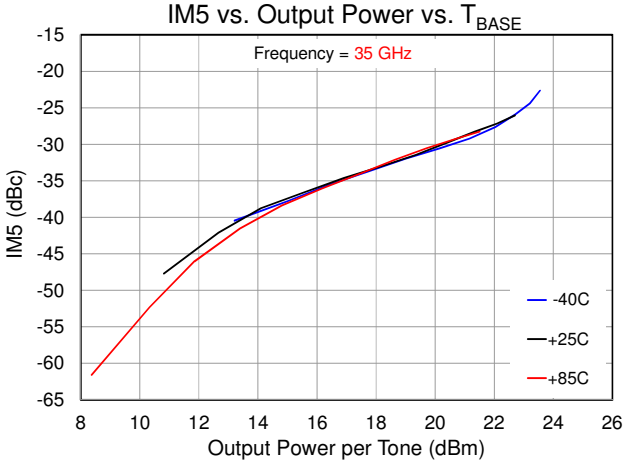
## Performance Plots – Linearity

Test conditions, unless otherwise noted: CW, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, **$F_C$ = 35 GHz**, Tone Spacing = 100 MHz, $T_{BASE}$ = +25 ºC

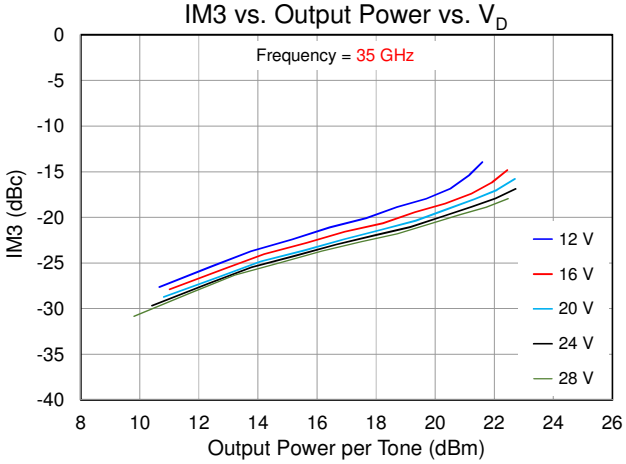
IM3 vs. Output Power vs. $T_{BASE}$



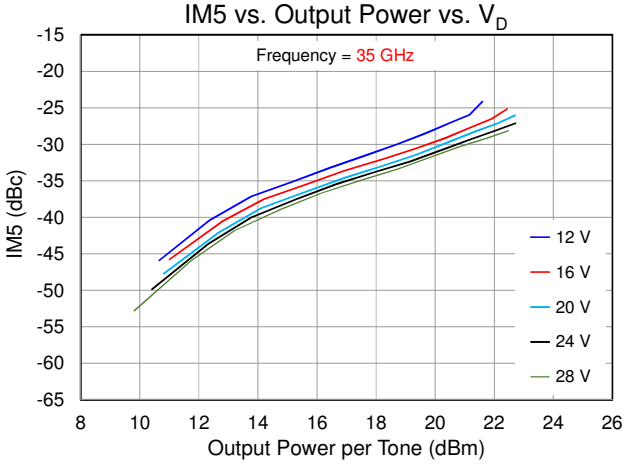

IM5 vs. Output Power vs. $T_{BASE}$



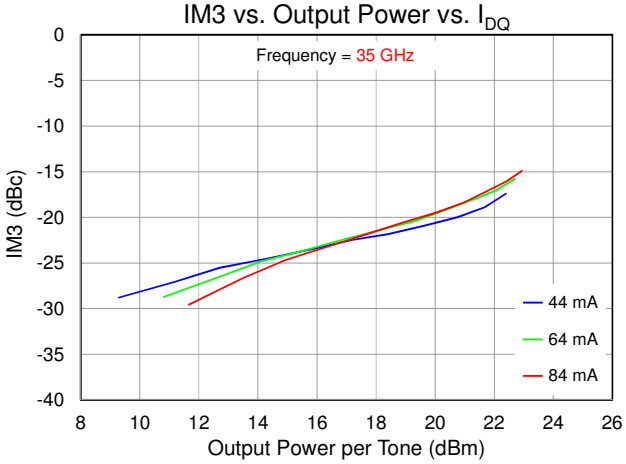

IM3 vs. Output Power vs. $V_D$



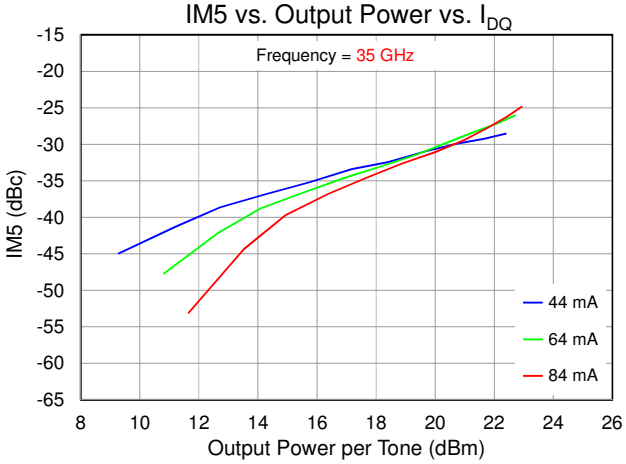

IM5 vs. Output Power vs. $V_D$




IM3 vs. Output Power vs. $I_{DQ}$



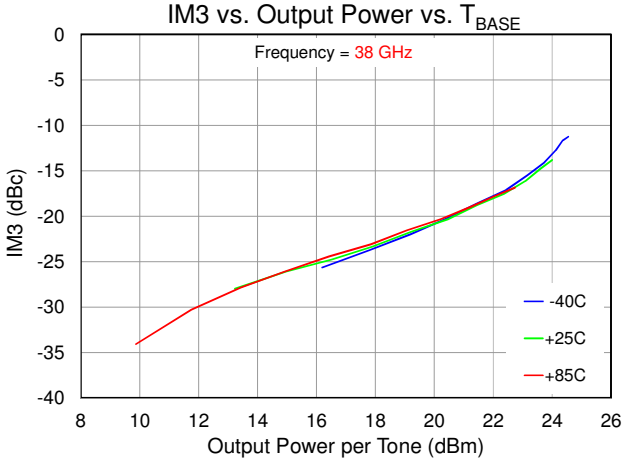

IM5 vs. Output Power vs. $I_{DQ}$



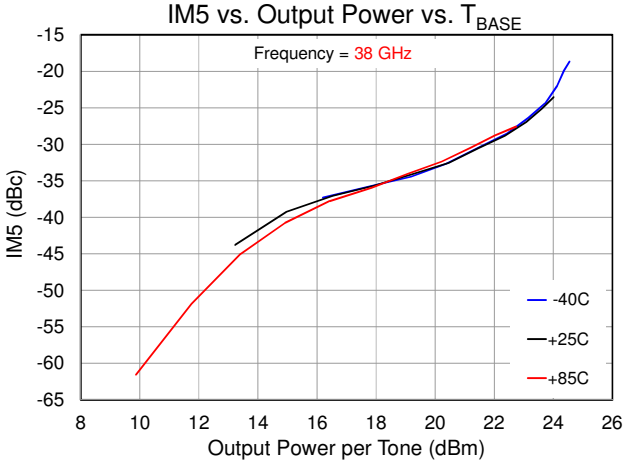
## Performance Plots – Linearity

Test conditions, unless otherwise noted: CW, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, **$F_C$ = 38 GHz**, Tone Spacing = 100 MHz, $T_{BASE}$ = +25 ºC

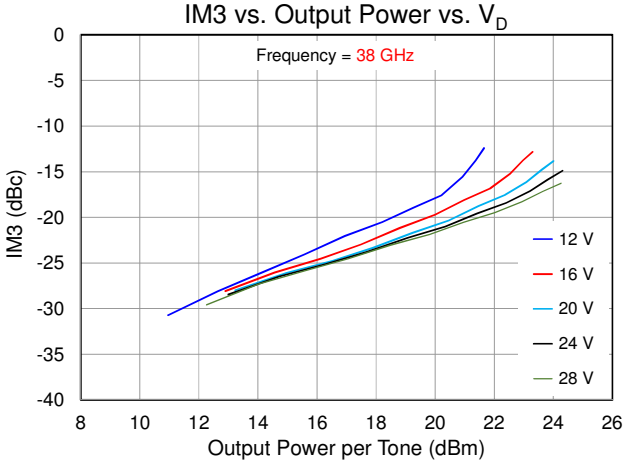
IM3 vs. Output Power vs. $T_{BASE}$



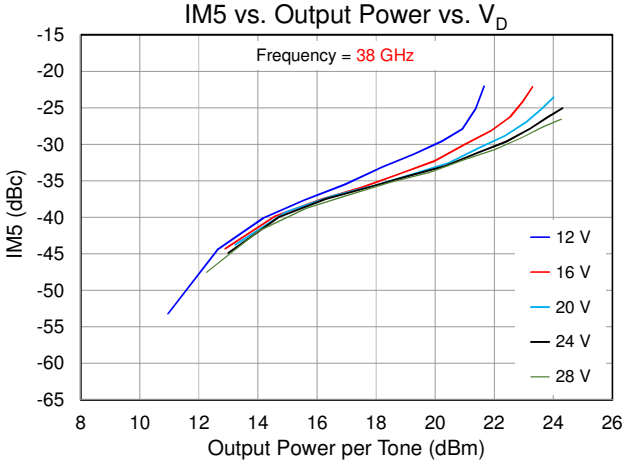

IM5 vs. Output Power vs. $T_{BASE}$



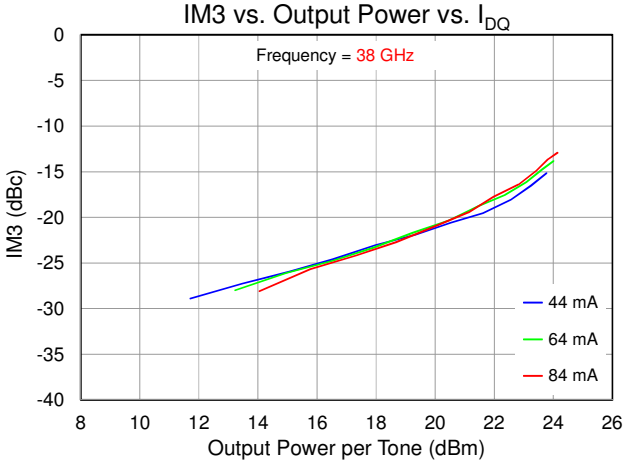

IM3 vs. Output Power vs. $V_D$



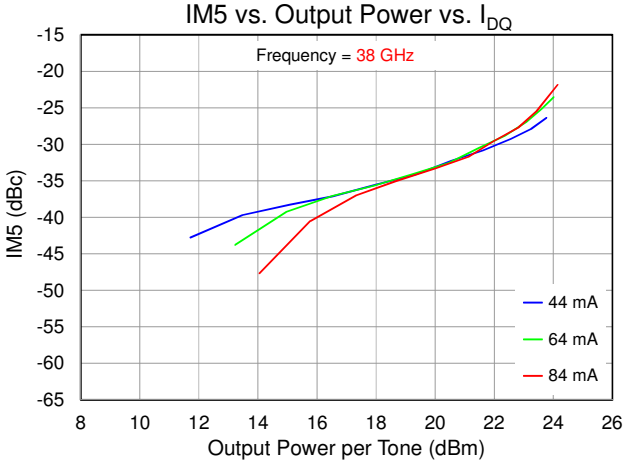

IM5 vs. Output Power vs. $V_D$




IM3 vs. Output Power vs. $I_{DQ}$




IM5 vs. Output Power vs. $I_{DQ}$

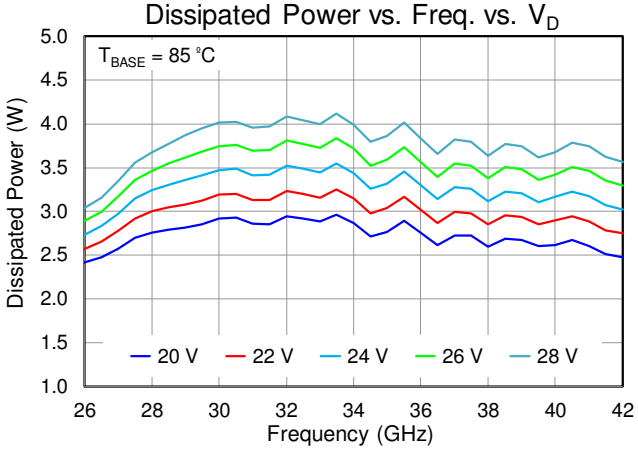


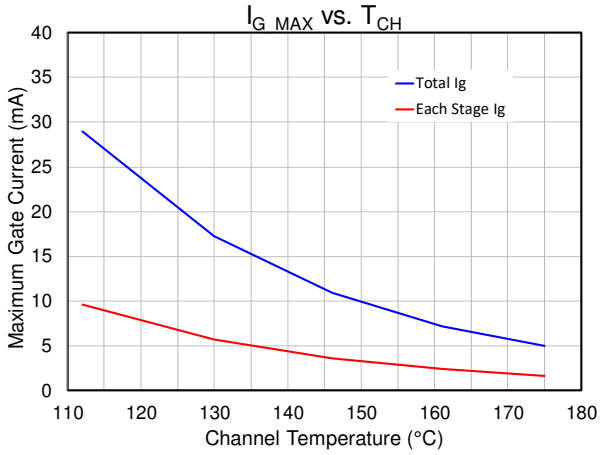
## Thermal and Reliability Information

| Parameter | Test Conditions | Value | Units |
|---|---|---|---|
| Thermal Resistance ($\theta_{JC}$) (1) | $T_{base}$ = 85 ºC, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, $P_{DISS}$ = 1.28 W, No RF (quiescent DC operation) | 16.4 | ºC/W |
| Channel Temperature, $T_{CH}$ (No RF) (2) | | 106 | °C |
| Thermal Resistance ($\theta_{JC}$) (1) | $T_{base}$ = 85 ºC, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, Freq = 32 GHz, $I_{D\_Drive}$ = 165 mA, $P_{IN}$ = 13 dBm, $P_{OUT}$ = 25.8 dBm, $P_{DISS}$ = 2.95 W | 17.3 | ºC/W |
| Channel Temperature, $T_{CH}$ (Under RF) (2) | | 136 | °C |
| Thermal Resistance ($\theta_{JC}$) (1) | $T_{base}$ = 85 ºC, $V_D$ = 28 V, $I_{DQ}$ = 64 mA, Freq = 32 GHz, $I_{D\_Drive}$ = 158 mA, $P_{IN}$ = 13 dBm, $P_{OUT}$ = 25.5 dBm, $P_{DISS}$ = 4.1 W | 18.1 | ºC/W |
| Channel Temperature, $T_{CH}$ (Under RF) (2) | | 159 | ºC |

Notes:
1. Thermal resistance determined to the back of a 20 mil Cu-Mo carrier plate with eutectic die attach (85 ºC)
2. Refer to the following document: GaN Device Channel Temperature, Thermal Resistance, and Reliability Estimates

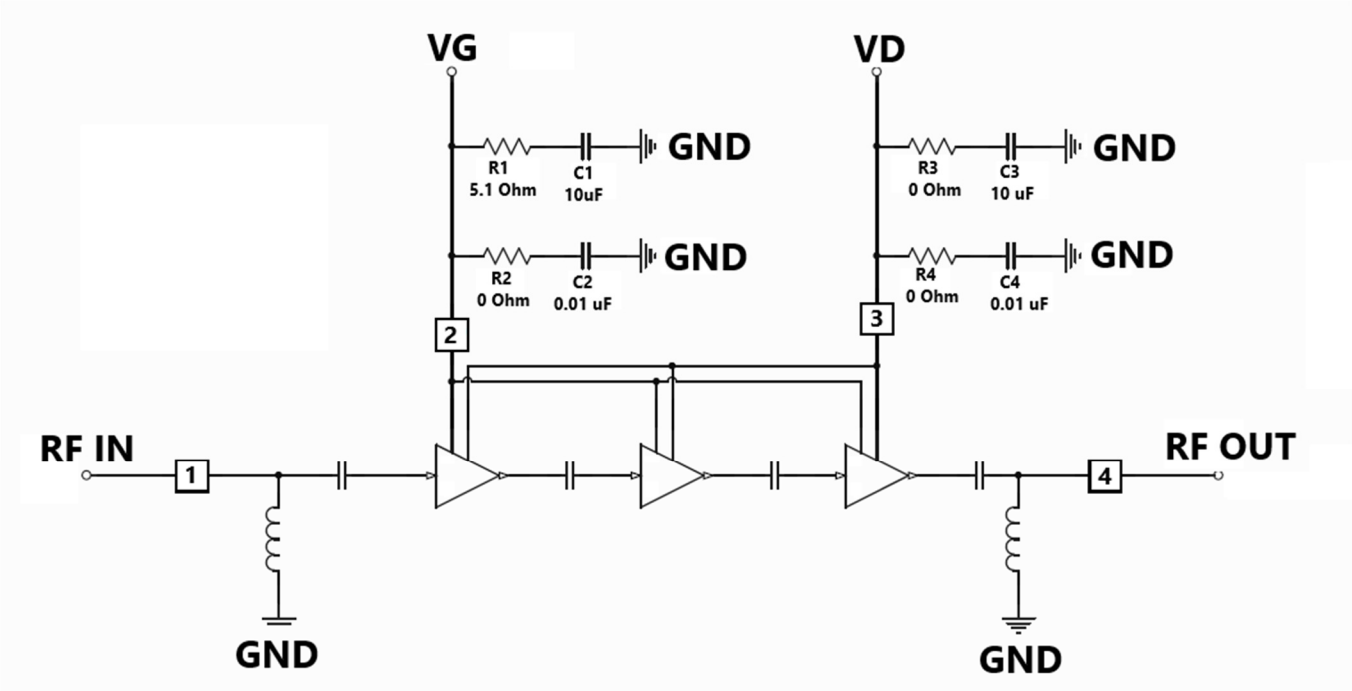
## Dissipated Power and Maximum Gate Current




Test conditions, unless otherwise noted: CW, $V_D$ = 20 V, $I_{DQ}$ = 64 mA, $P_{IN}$ = +13dBm, $T_{BASE}$ = +85 ºC

## Applications Information



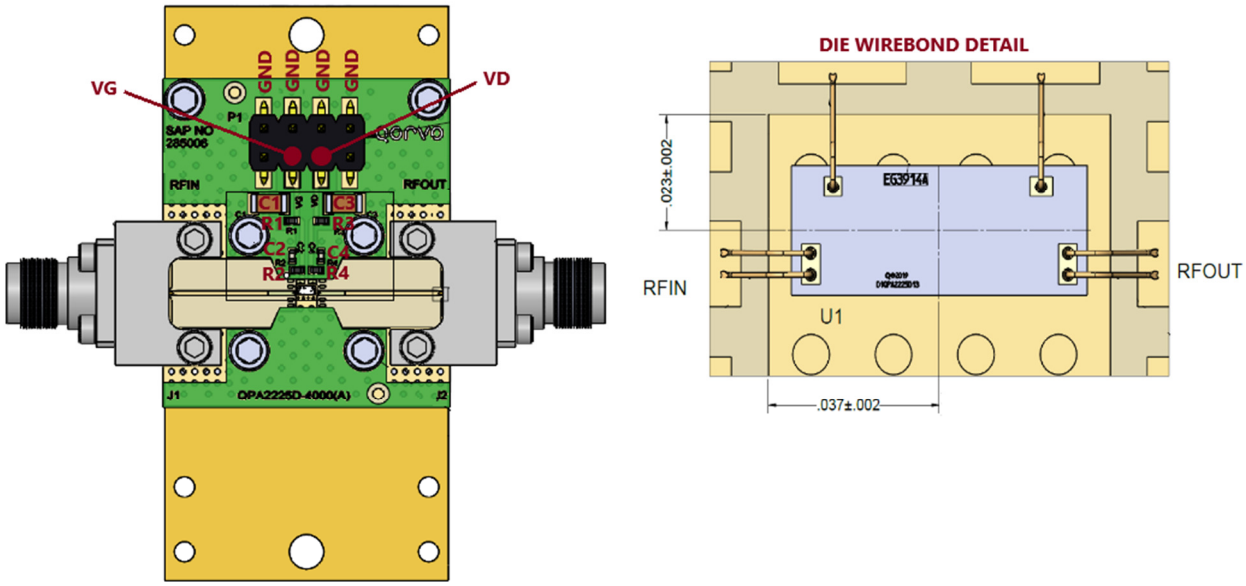

## Bias-Up Procedure

1. Set $I_D$ limit to 250 mA, $I_G$ limit to 10 mA
2. Set $V_G$ to –4.0 V
3. Set $V_D$ +20 V
4. Adjust $V_G$ more positive until $I_{DQ} \approx 64$ mA
5. Apply RF signal

## Bias-Down Procedure

1. Turn off RF signal
2. Reduce $V_G$ to –4.0 V. Ensure $I_{DQ}$ ~ 0 mA
4. Set $V_D$ to 0 V
5. Turn off $V_D$ supply
6. Turn off $V_G$ supply

## Evaluation Board (EVB) Layout Assembly

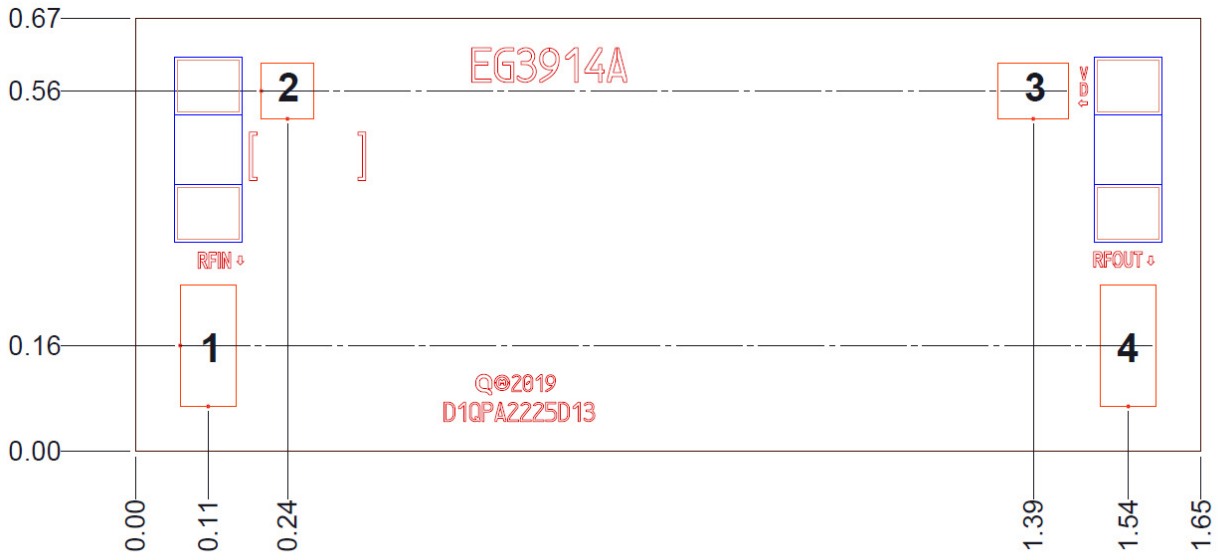



PCB is made from Rogers 4003C dielectric, 0.008 inch thick, 0.5 oz. copper both sides.

## Bill of Materials

| Reference Des. | Value | Description | Manuf. | Part Number |
|---|---|---|---|---|
| C1, C3 | 10 uF | CAP, 10 uF, 20%, 50 V, 20%, X5R, 1206 | Various | |
| C2, C4 | 0.01 uF | CAP, 0.01 uF, 10%, 50 V, X7R, 0402 | Various | |
| R1 | 5.1 Ω | RES, 5.1 OHM, 5%, 50 V, 0402 | Various | |
| R2, R3, R4 | 0 Ω | RES, 0 OHM, JMPR, 0402 | Various | |
| J1, J2 | 2.4 mm | CONNECTOR, FEMALE, ENDLAUNCH | Southwest Microwave | 1492-04A-5 |

## Mechanical Information




Dimensions are in mm
Thickness: 0.050
Die x, y size tolerance: ± 0.050
Ground is backside of die

## Bond Pad Description

| Pad No. | Symbol | Pad Size (mm) | Description |
|---|---|---|---|
| 1 | RF In | 0.087 x 0.188 | RF Input; matched to 50 Ω, DC blocked |
| 2 | VG | 0.081 x 0.086 | Gate voltage, bias network is required; see Application Circuit on page 19 as an example. |
| 3 | VD | 0.110 x 0.086 | Drain voltage, bias network is required; see Application Circuit on page 19 as an example. |
| 4 | RF Out | 0.087 x 0.188 | RF Output; matched to 50 Ω, DC blocked |

## Assembly Notes

Component placement and adhesive attachment assembly notes:

- Vacuum pencils and/or vacuum collets are the preferred method of pick up.
- Air bridges must be avoided during placement.
- The force impact is critical during auto placement.

Reflow process assembly notes:

- Use AuSn (80/20) solder and limit exposure to temperatures above 300 °C to 3 – 4 minutes, maximum.
- An alloy station or conveyor furnace with reducing atmosphere should be used.
- Do not use any kind of flux.
- Coefficient of thermal expansion matching is critical for long-term reliability.
- Devices must be stored in a dry nitrogen atmosphere.

Interconnect process assembly notes:

- Thermosonic ball bonding is the preferred interconnect technique.
- Force, time, and ultrasonic are critical parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

## Handling Precautions

| Parameter | Rating | Standard |
|---|---|---|
| ESD – Human Body Model (HBM) | 1B | ANSI/ESD/JEDEC JS-001 |

Caution!

ESD-Sensitive Device

## Solderability

Use only AuSn (80/20) solder, and limit exposure to temperatures above 300 °C to 3 – 4 minutes, maximum.

## 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 ($C_{15}H_{12}Br_40_2$) 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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