# TGA2963

## *6 – 18GHz 20W GaN Power Amplifier*

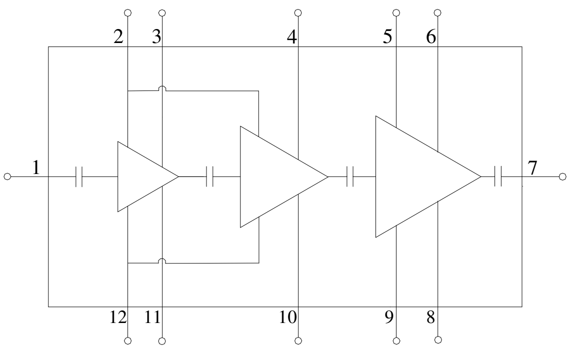
## Applications

- Test Instrumentation
- Electronic Warfare (EW)
- Radar
- Communications

## Product Features

- Frequency Range: 6 – 18GHz
- $P_{OUT}$: >43dBm @ $P_{IN}$ = 23dBm
- PAE: >20% @ $P_{IN}$ = 23dBm
- Large Signal Gain: >20dB @ $P_{IN}$ = 23dBm
- Small Signal Gain: >26dB
- Return Loss: >6.5dB
- Bias: $V_D$ = 20V, $I_{DQ}$ = 2500mA, $V_G$ = -2.3V Typical
- Chip Dimensions: 5.4 x 6.85 x 0.10 mm

## Functional Block Diagram




## General Description

Qorvo's TGA2963 is a broadband high power MMIC amplifier fabricated on Qorvo's production 0.15um GaN on SiC process (QGAN15). The TGA2963 operates from 6 – 18GHz and provides more than 20W saturated output power with power-added efficiency >20% and large-signal gain >20 dB. This combination of wideband performance provides the flexibility designers are looking for to improve system performance while reducing size and cost.

The TGA2963 is matched to 50Ω with integrated DC blocking capacitors on both RF I/O ports simplifying system integration. The broadband performance makes it ideally suited in support of test instrumentation and electronic warefare, as well as, supporting multiple radar and communication bands.

The TGA2963 is 100% DC and RF tested on-wafer to ensure compliance to electrical specifications.

Lead-free and RoHS compliant.
Evaluation boards are available upon request.

## Pad Configuration

| Pad No. | Symbol |
|---|---|
| 1 | RF In |
| 2, 12 | $V_{G12}$ |
| 3, 11 | $V_{D1}$ |
| 4, 10 | $V_{D2}$ |
| 5, 9 | $V_{G3}$ |
| 6, 8 | $V_{D3}$ |
| 7 | RF Out |

## Ordering Information

| Part | ECCN | Description |
|---|---|---|
| TGA2963 | 3A001.b.2.c | 6 – 18GHz 20W GaN Power Amplifier |

## Absolute Maximum Ratings

| Parameter | Value |
|---|---|
| Drain Voltage ($V_D$) | 29.5V |
| Gate Voltage Range ($V_G$) | -8 to 0V |
| Drain Current ($I_{D1}$) | 960mA |
| Drain Current ($I_{D2}$) | 1440mA |
| Drain Current ($I_{D3}$) | 5760mA |
| Gate Currents ($I_{G1}$/$I_{G2}$/$I_{G3}$) | See plot on page 3 |
| Power Dissipation ($P_{DISS}$), 85°C, CW | 150W |
| Input Power ($P_{IN}$), 50Ω, $V_D$ = 20V, $I_{DQ}$ = 2500 mA, 85°C, CW | 30dBm |
| Input Power ($P_{IN}$), VSWR 3:1, $V_D$ = 20V, $I_{DQ}$ = 2500 mA, 85°C, CW | 30dBm |
| Channel Temperature ($T_{CH}$) | 275°C |
| Mounting Temperature (30 seconds) | 320°C |
| Storage Temperature | -55 to 150°C |

Operation of this device outside the parameter ranges given above may cause permanent damage. These are stress ratings only, and functional operation of the device at these conditions is not implied.

## Recommended Operating Conditions

| Parameter | Value |
|---|---|
| Drain Voltage ($V_D$) | 20V |
| Drain Current ($I_{DQ}$) | 2500mA (Total) |
| Gate Voltage ($V_G$) | -2.3V (Typ.) |

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

## Electrical Specifications

Test conditions unless otherwise noted: 25°C , $V_D$ = 20V, $I_{DQ}$ = 2500mA, $V_G$ = -2.3V Typical

| Parameter | Min | Typical | Max | Units |
|---|---|---|---|---|
| Operational Frequency Range | 6 | | 18 | GHz |
| Small Signal Gain | | >26 | | dB |
| Input Return Loss | | >8 | | dB |
| Output Return Loss | | >6.5 | | dB |
| Power Gain (Pin = 23dBm) | | >20 | | dB |
| Output Power (Pin = 23dBm) | | >43 | | dBm |
| Power Added Efficiency (Pin = 23dBm) | | >20 | | % |
| Small Signal Gain Temperature Coefficient | | -0.062 | | dB/°C |
| Output Power Temperature Coefficient | | -0.017 | | dBm/°C |

## Thermal and Reliability Information

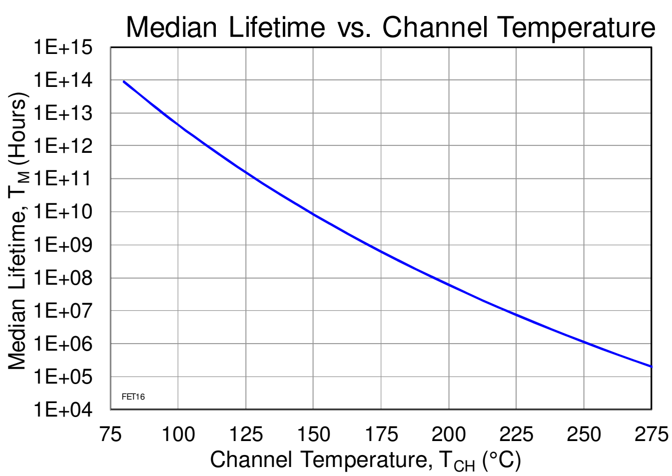
| Parameter | Test Conditions | Value | Units |
|---|---|---|---|
| Thermal Resistance ($\theta_{JC}$) [(1)] | $T_{base}$ = 85°C, CW<br>$V_D$ = 20V, $I_{DQ}$ = 2500mA<br>$P_{DISS}$ = 50W | 1.26 | ºC/W |
| Channel Temperature ($T_{CH}$) (No RF drive) | | 148 | °C |
| Median Lifetime ($T_M$) | | 1.1 x 10^10 | Hrs |

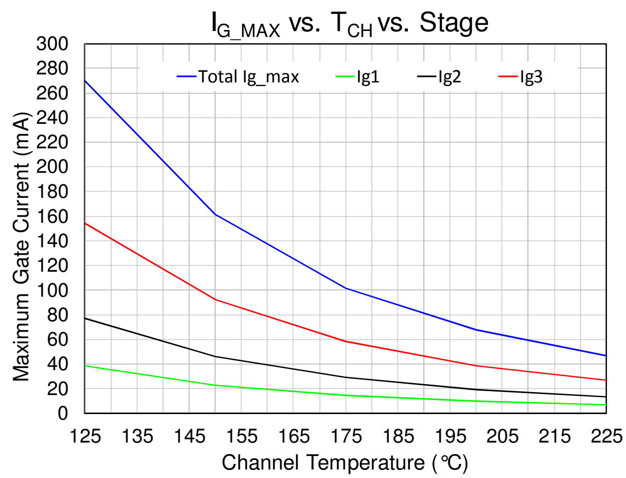
| Parameter | Test Conditions | Value | Units |
|---|---|---|---|
| Thermal Resistance ($\theta_{JC}$) [(1)] | $T_{base}$ = 85°C, $V_D$ = 20V, $I_{DQ}$ = 2500mA, CW<br>$I_{D\_Drive}$ = 6.6A, Freq = 12GHz<br>$P_{IN}$ = 25dBm, $P_{OUT}$ = 45dBm, $P_{DISS}$ = 106W | 1.56 | ºC/W |
| Channel Temperature ($T_{CH}$) (Under RF drive) | | 250 | °C |
| Median Lifetime ($T_M$) | | 1.1 x 10^6 | Hrs |

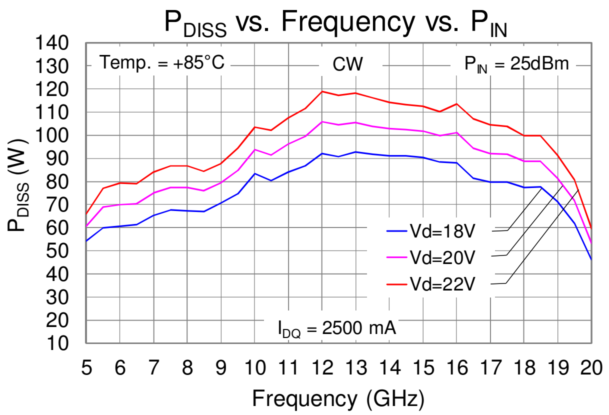
Notes:

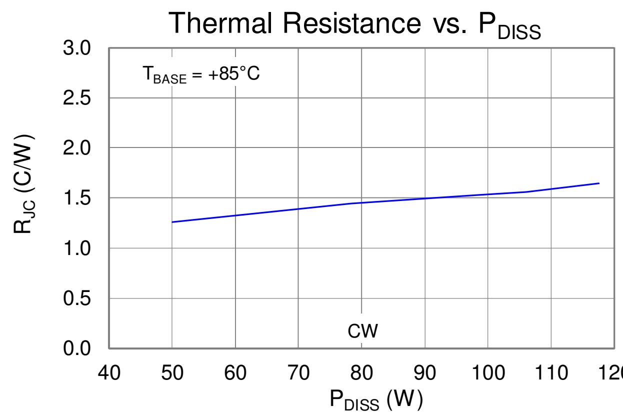
1. Thermal resistance measured to back of carrier plate. MMIC mounted on 40 mils CuMo (CM15) carrier using 1.5 mil AuSn.

Test Conditions: $V_D$ = 28 V; Failure Criteria = 10% reduction in $I_{D\_MAX}$

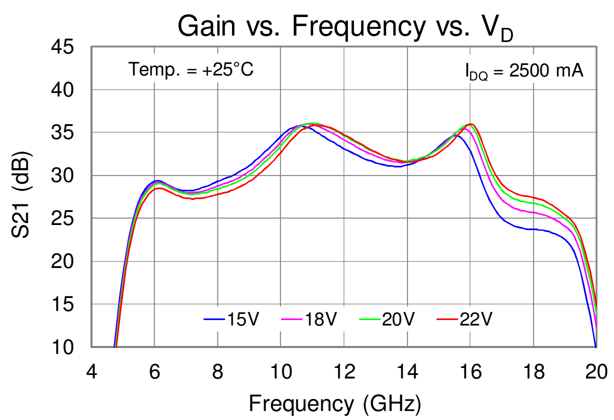


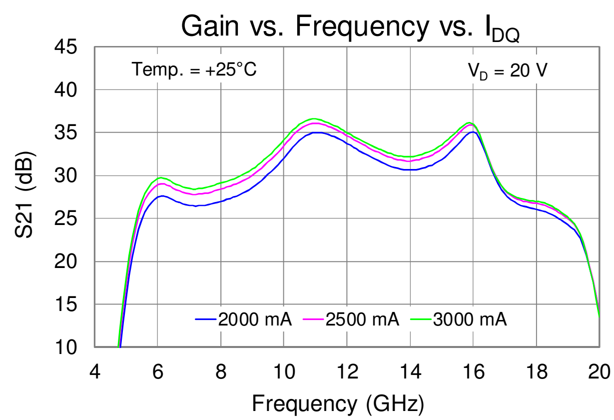



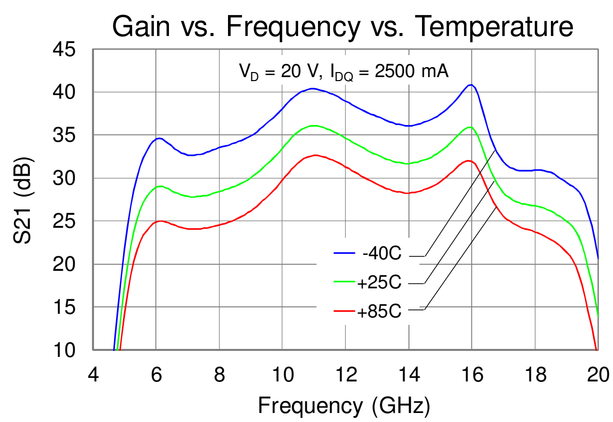



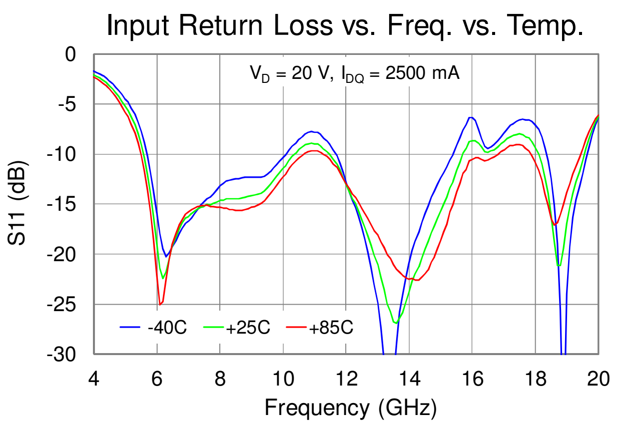



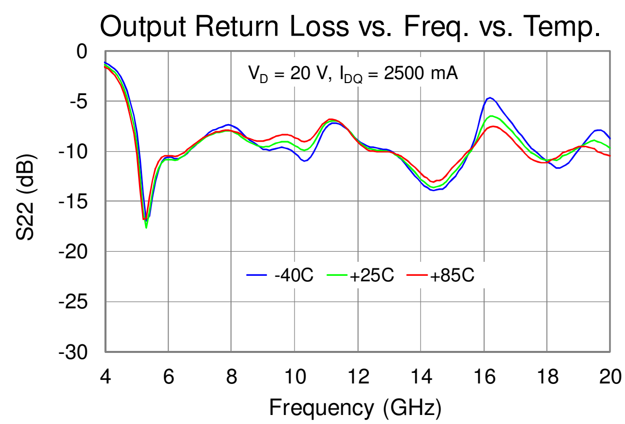
## Typical Performance (Small Signal)



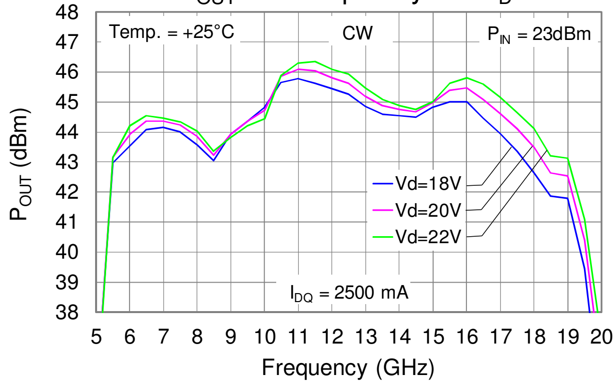



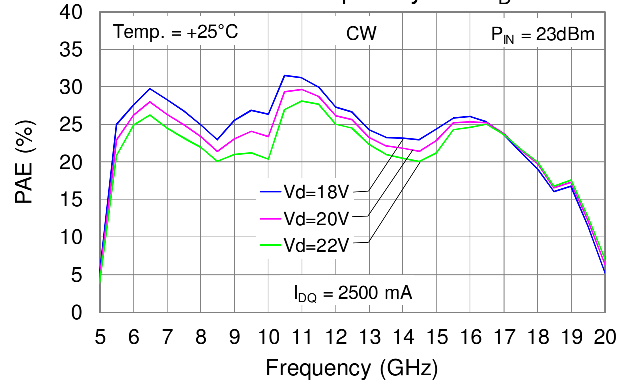



## Typical Performance (Large Signal CW)

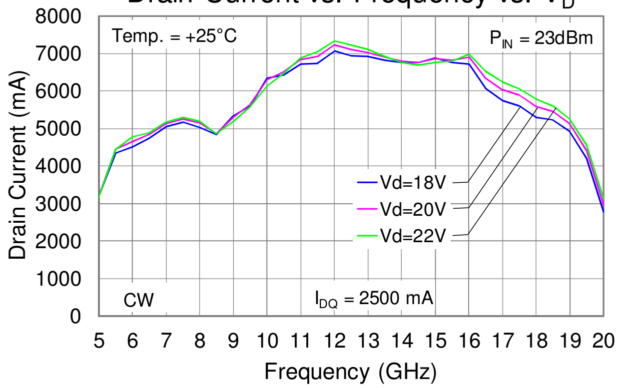
$P_{OUT}$ vs. Frequency vs. $V_D$



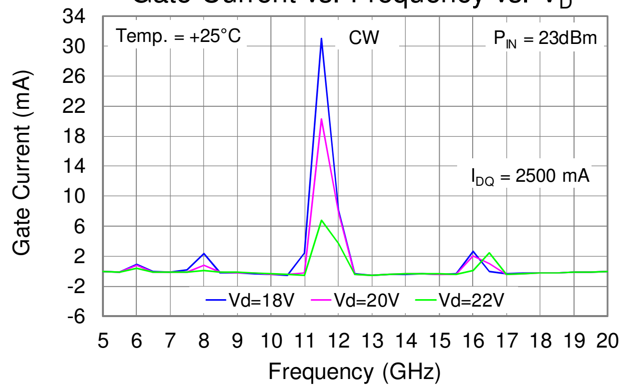

PAE vs. Frequency vs. $V_D$



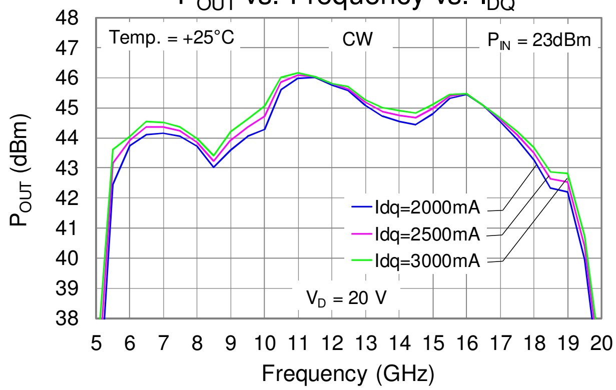

Drain Current vs. Frequency vs. $V_D$



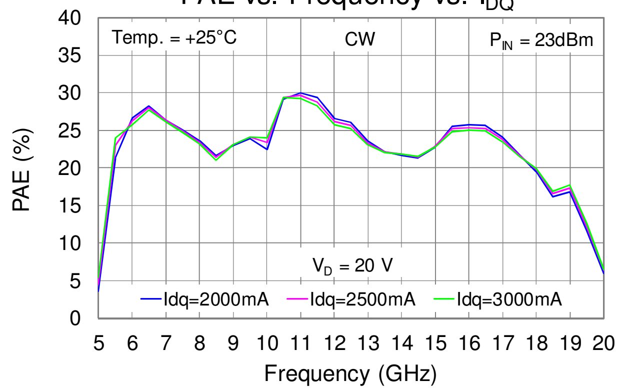

Gate Current vs. Frequency vs. $V_D$




$P_{OUT}$ vs. Frequency vs. $I_{DQ}$

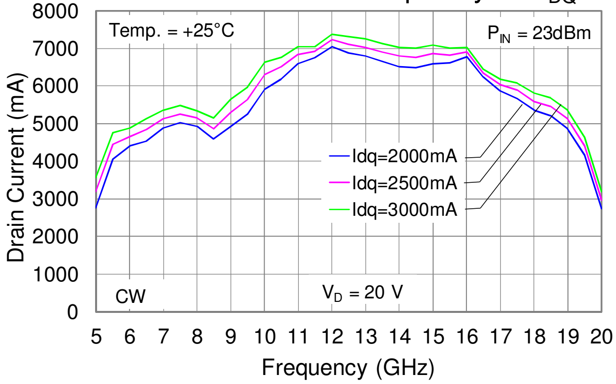



PAE vs. Frequency vs. $I_{DQ}$

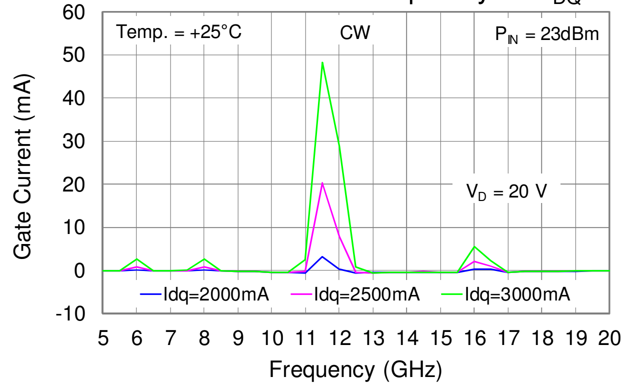


## Typical Performance (Large Signal CW)

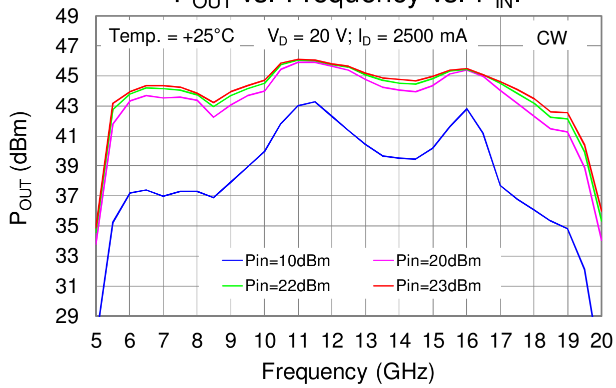
Drain Current vs. Frequency vs. $I_{DQ}$



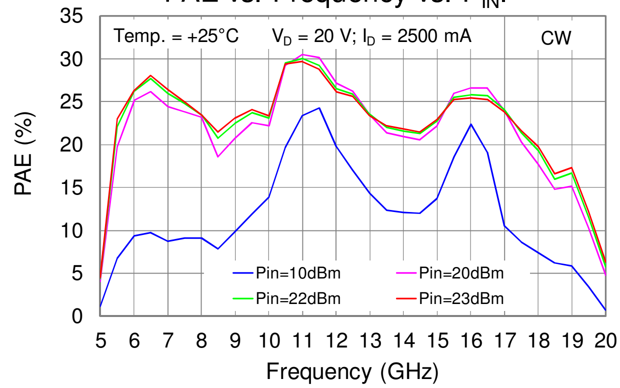

Gate Current vs. Frequency vs. $I_{DQ}$



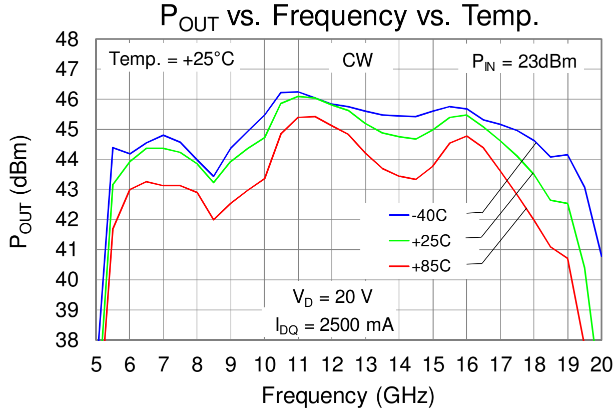

$P_{OUT}$ vs. Frequency vs. $P_{IN}$.



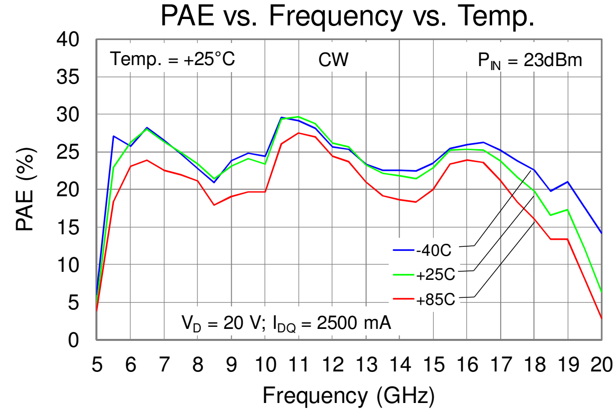

PAE vs. Frequency vs. $P_{IN}$.



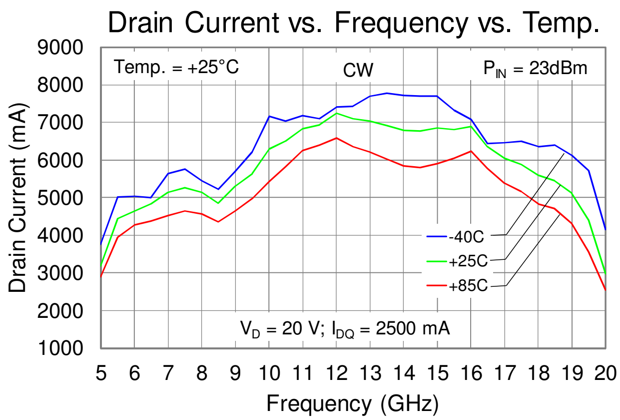

$P_{OUT}$ vs. Frequency vs. Temp.

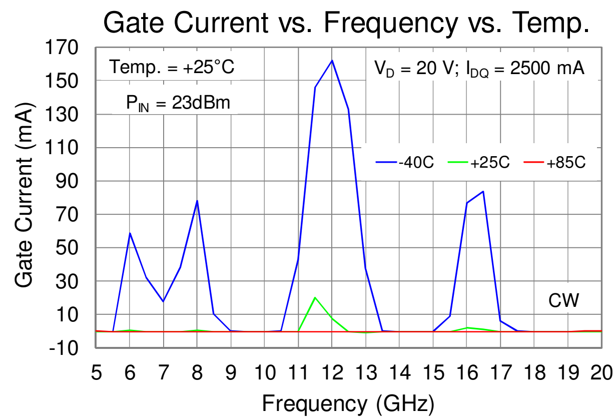


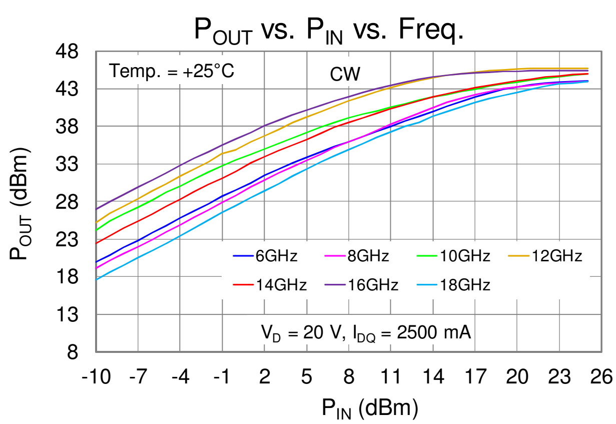

PAE vs. Frequency vs. Temp.

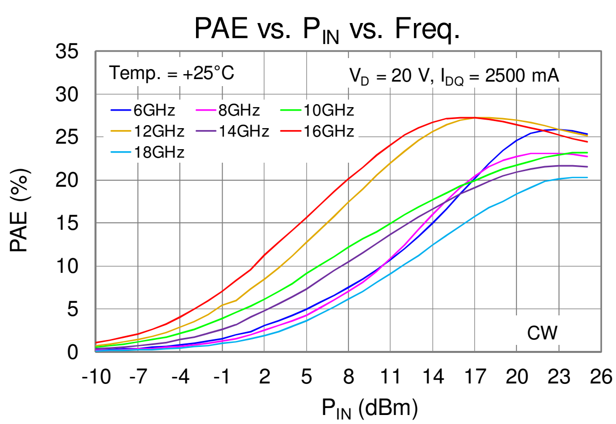


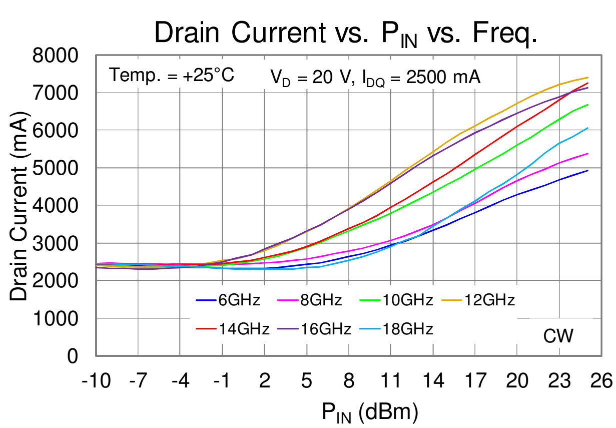
## Typical Performance (Large Signal CW)

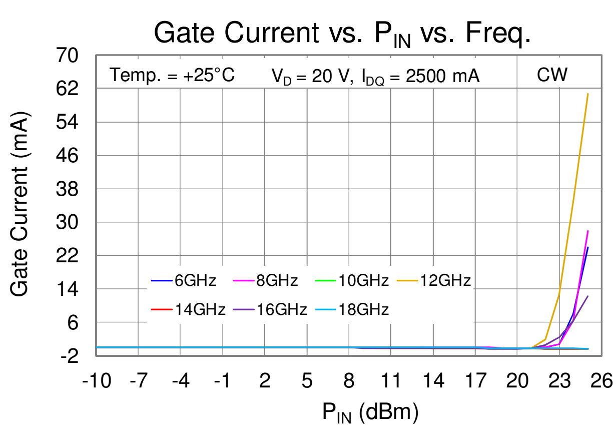


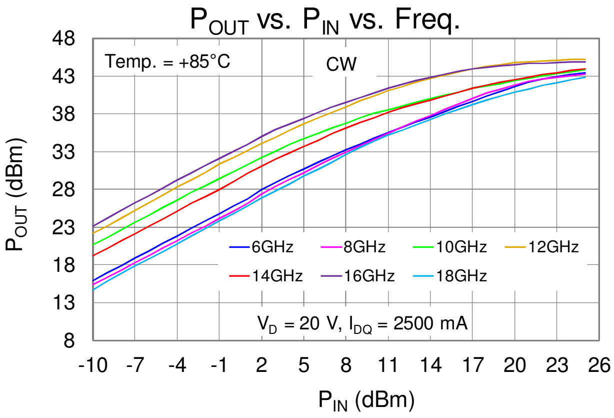



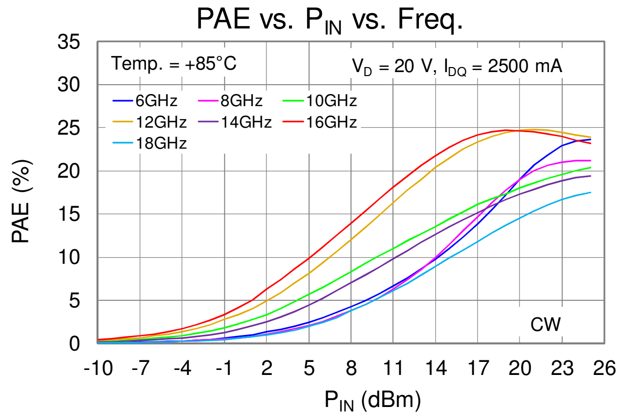



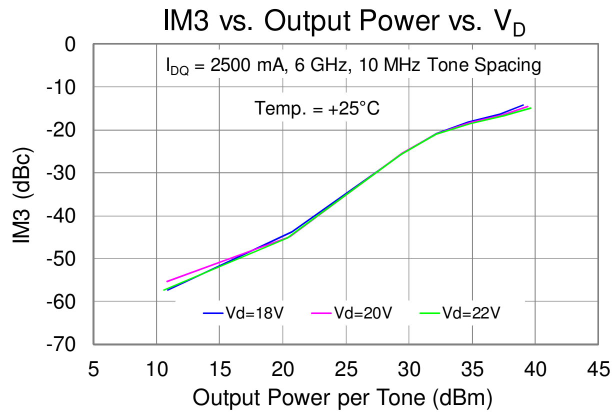



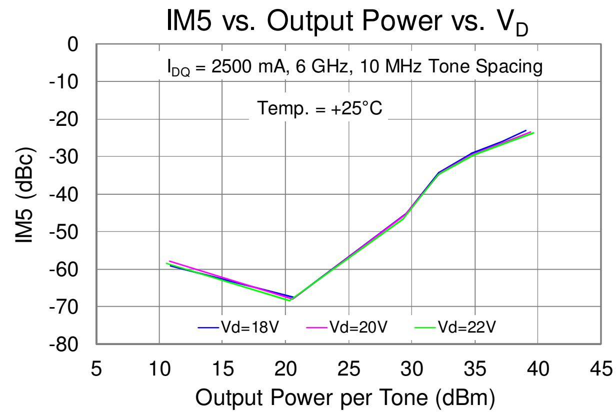



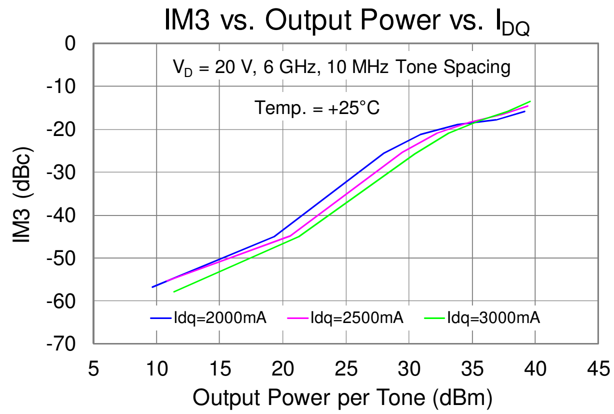
## Typical Performance (Large Signal & Linearity)

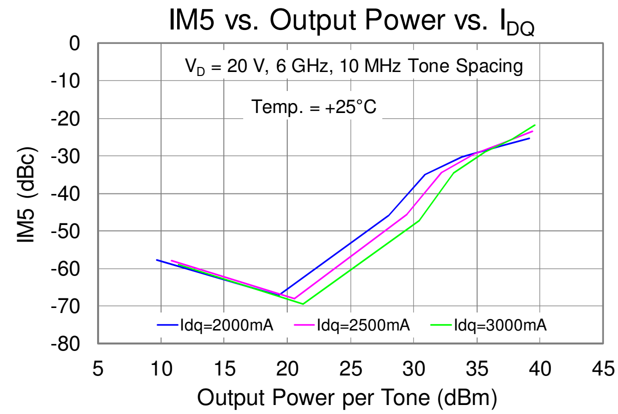


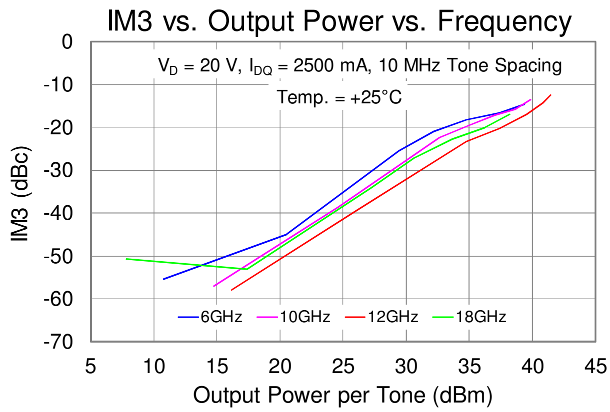



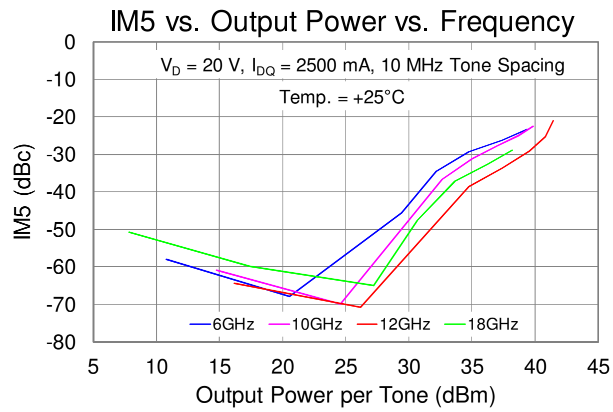



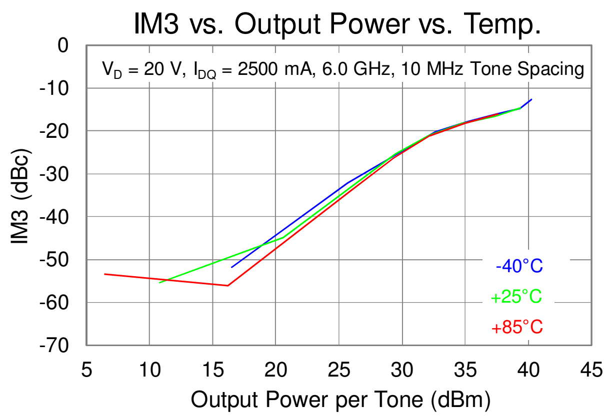



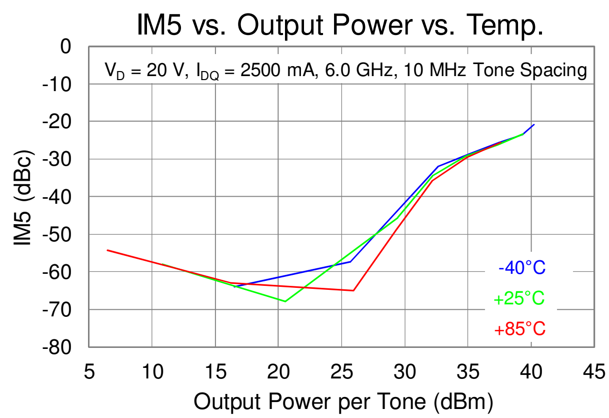



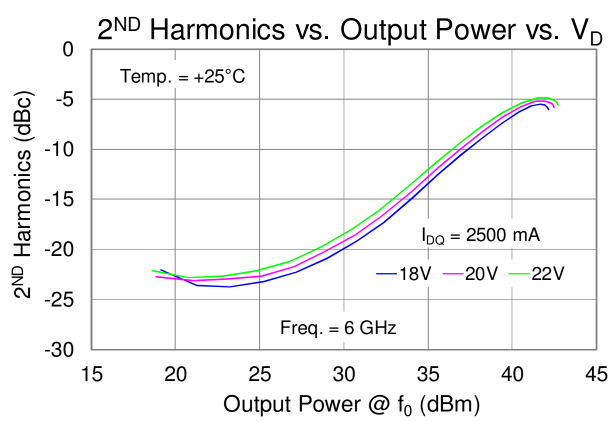
## Typical Performance (Linearity)

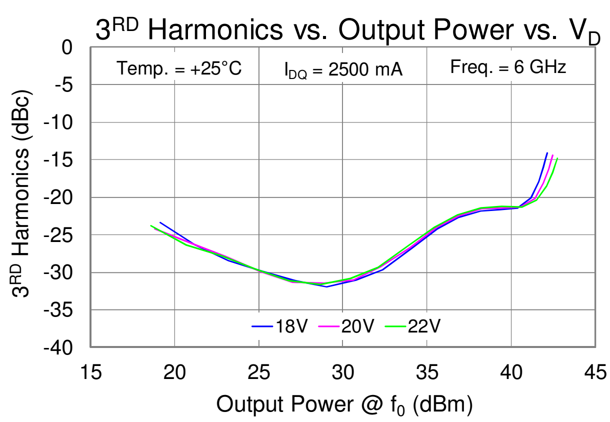


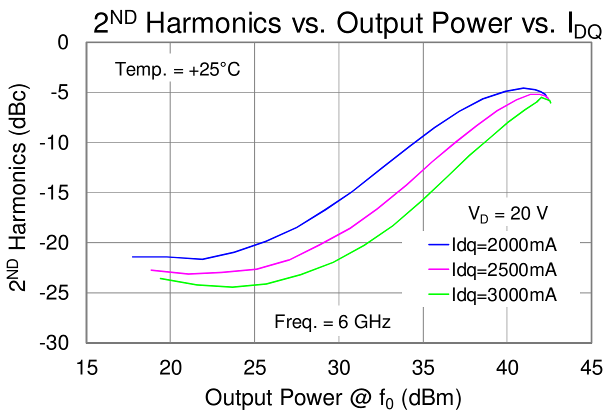



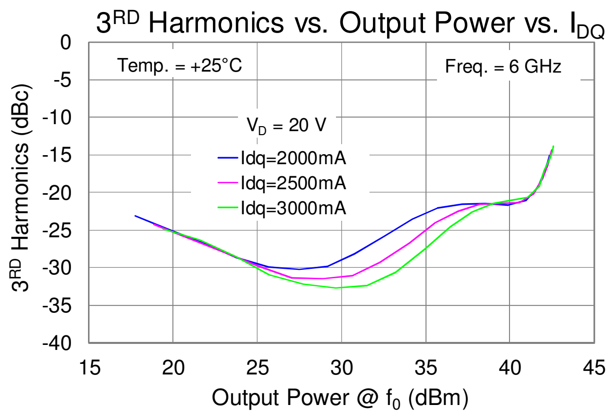



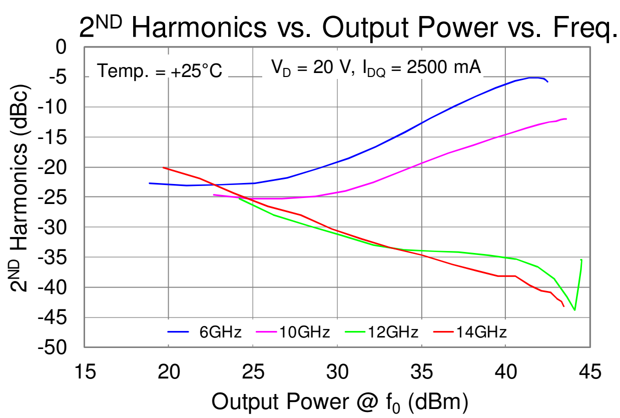



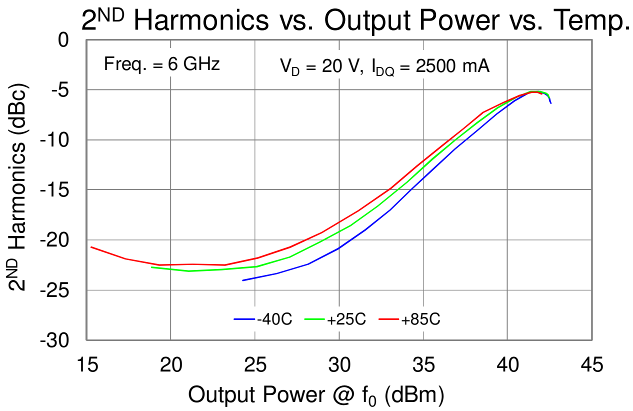



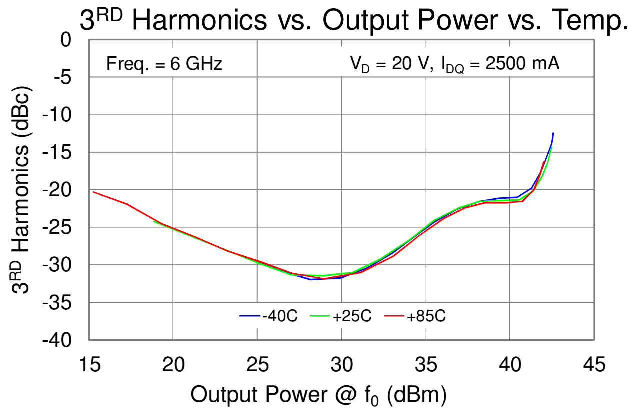
## Typical Performance (Linearity)



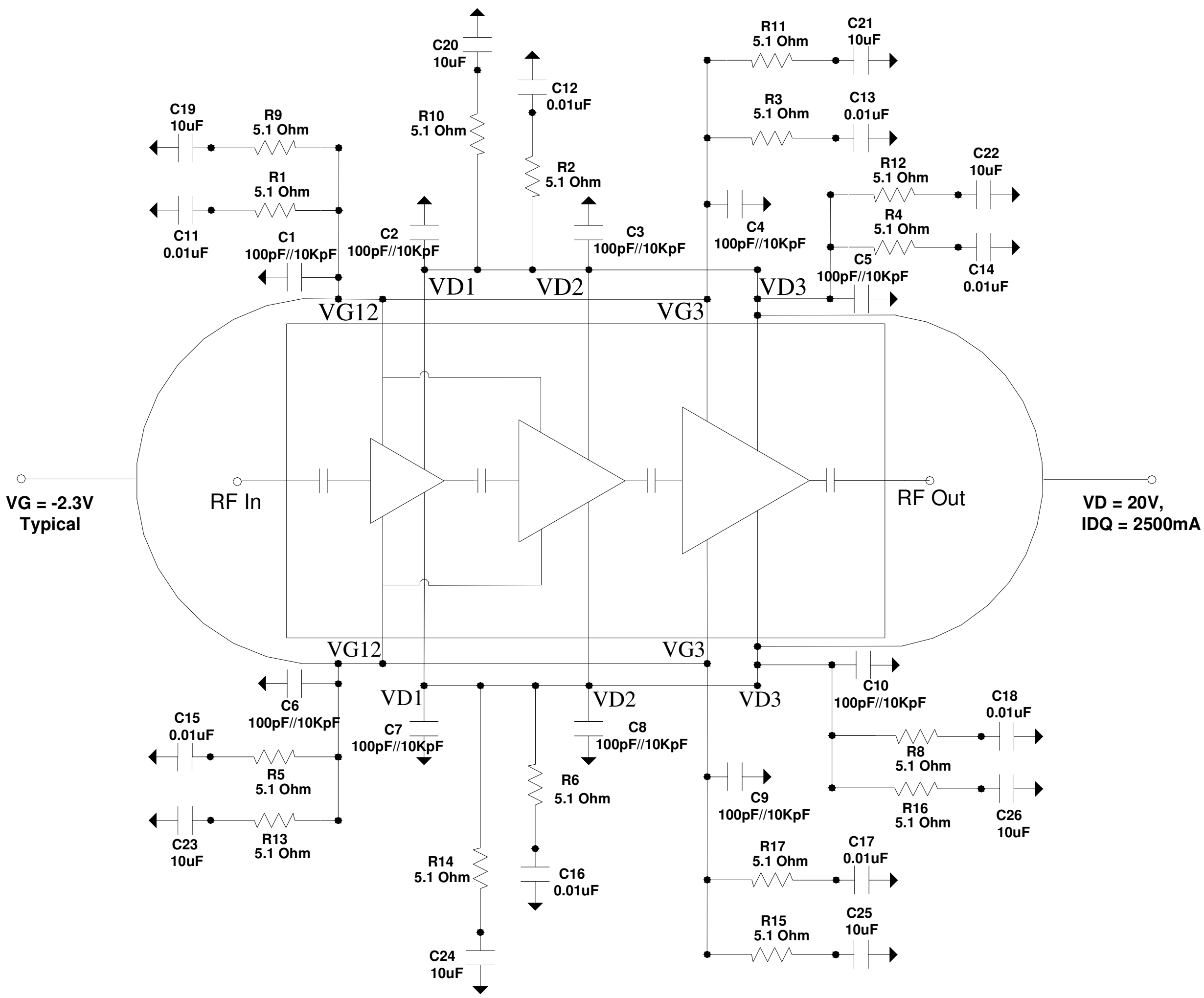



## Application Circuit



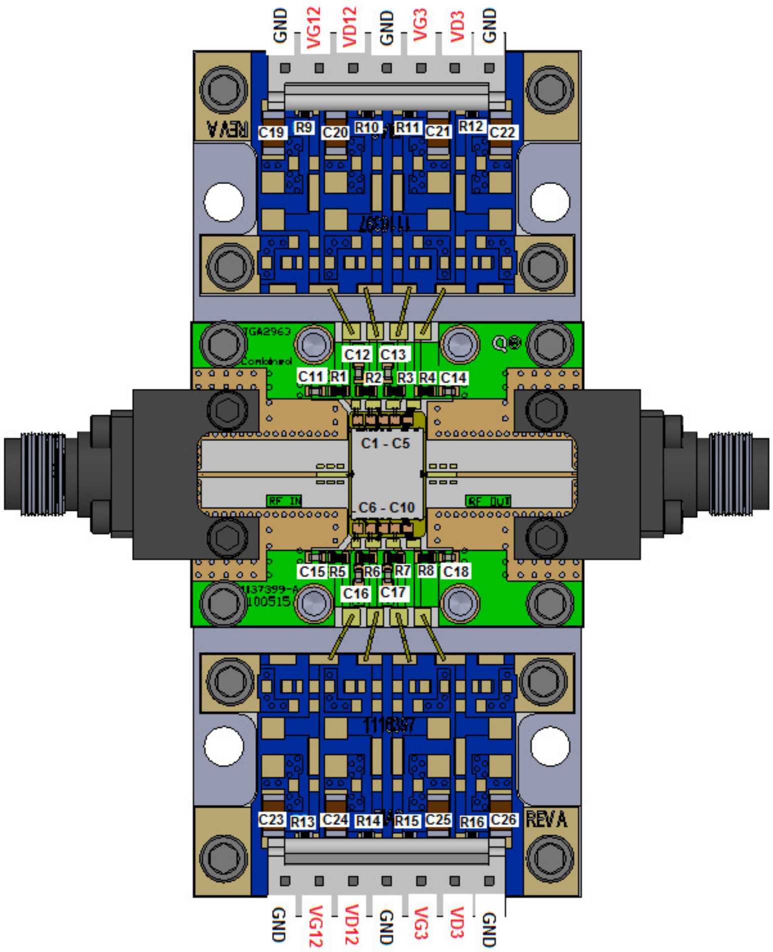

## Bias-up Procedure

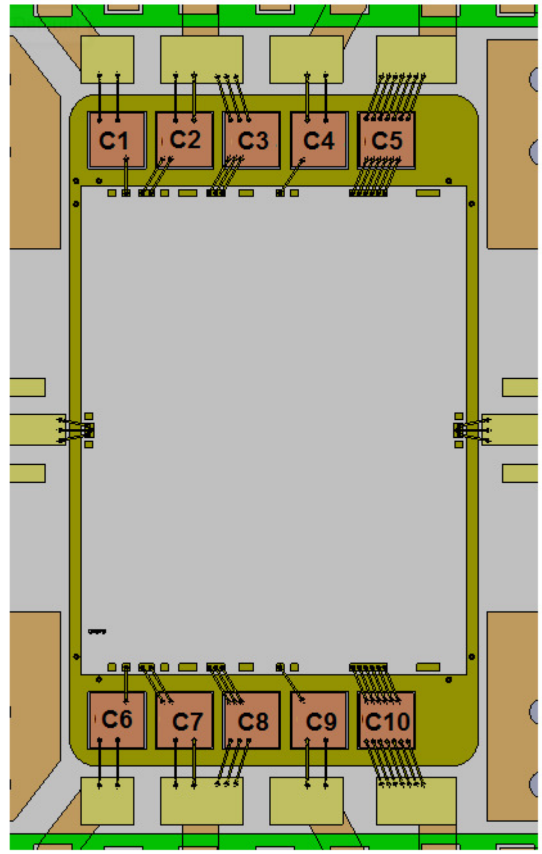
| |
|---|
| 1. Set $I_D$ limit to 8A, $I_G$ limit to 50mA |
| 2. Set $V_G$ to -5.0V |
| 3. Set $V_D$ +20V |
| 4. Adjust $V_G$ more positive until $I_{DQ}$ = 2500mA ($V_G$ ~ -2.3V Typical) |
| 5. Apply RF signal |

## Bias-down Procedure

| |
|---|
| 1. Turn off RF signal |
| 2. Reduce $V_G$ to -5.0V. Ensure $I_{DQ}$ ~ 0mA |
| 3. Set $V_D$ to 0V |
| 4. Turn off $V_D$ supply |
| 5. Turn off $V_G$ supply |

## Evaluation Board (EVB) Layout Assembly



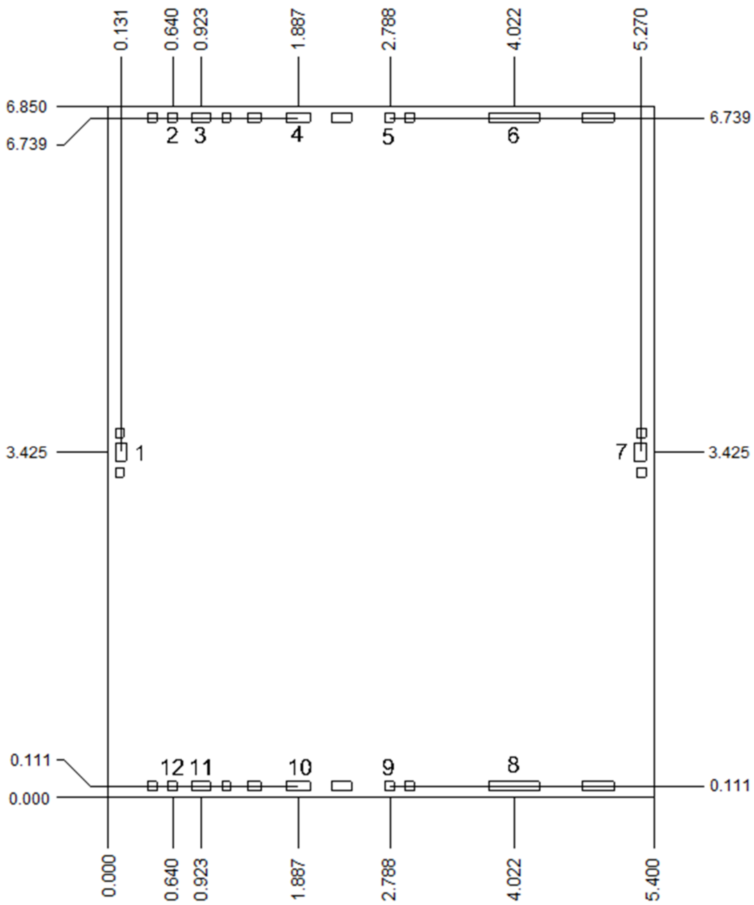

MMIC mounting/wire bonding detail

Notes: The MMIC must be biased from both sides top and bottom.

## Bill of Materials

| Reference Design | Value | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| C1 – C10 | 100pF//10KpF | Cap, 30x30, 50V, Single Layer | Various | |
| C11 – C18 | 0.01uF | Cap, 0402, 50V, 10%, X7R | Various | |
| C19 – C26 | 10uF | Cap, 1206, 50V, 20%, X5R | Various | |
| R1 – R16 | 5.1Ω | Res, 0402, 50V, 5%, SMT | Various | |

## Mechanical Drawing & Bond Pad Description




Unit: millimeters
Thickness: 0.10
Die x, y size tolerance: +/- 0.050
Chip edge to bond pad dimensions are shown to center of pad
Ground is backside of die

| Bond Pad | Symbol | Pad Size | Description |
|---|---|---|---|
| 1 | RF In | 0.115 x 0.190 | RF Input; matched to 50Ω; DC blocked |
| 2, 12 | $V_{G12}$ | 0.090 x 0.090 | Gate voltage 1-2, bias network is required; see Application Circuit on page 11 as an example. |
| 3, 11 | $V_{D1}$ | 0.190 x 0.090 | Drain voltage 1, bias network is required; see Application Circuit on page 11 as an example |
| 4, 10 | $V_{D2}$ | 0.235 x 0.090 | Drain voltage 2, bias network is required; see Application Circuit on page 11 as an example. |
| 5, 9 | $V_{G3}$ | 0.090 x 0.090 | Gate voltage 3, bias network is required; see Application Circuit on page 11 as an example. |
| 6, 8 | $V_{D3}$ | 0.508 x 0.090 | Drain voltage 3, bias network is required; see Application Circuit on page 11 as an example. |
| 7 | RF Out | 0.115 x 0.190 | RF Output; matched to 50Ω; 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.
- Organic attachment (i.e. epoxy) can be used in low-power applications.
- Curing should be done in a convection oven; proper exhaust is a safety concern.

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.