TGF2023-2-10

50 Watt Discrete Power GaN on SiC HEMT

Applications

- Defense & Aerospace
- Broadband Wireless

Product Features

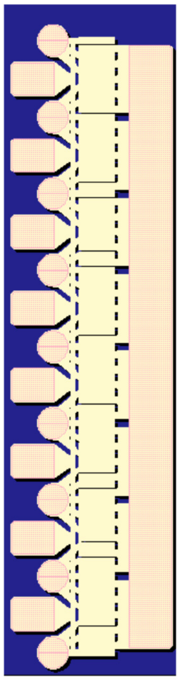
- Frequency Range: DC - 14 GHz
- 47.3 dBm Nominal P_{3dB} at 6 GHz
- 65.6% Maximum PAE at 6 GHz
- 17.4 dB Linear Gain at 6 GHz
- Bias: V_D = 28 V, I_{DQ} = 500 mA
- Technology: QGaN25 on SiC
- Chip Dimensions: 0.82 x 2.48 x 0.10 mm

General Description

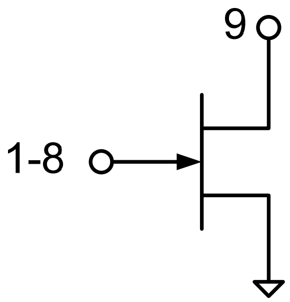
The Qorvo TGF2023-2-10 is a discrete 10 mm GaN on SiC HEMT which operates from DC-18 GHz. The TGF2023-2-10 is designed using Qorvo's proven QGaN25 production process. This process features advanced field plate techniques to optimize microwave power and efficiency at high drain bias operating conditions.

The TGF2023-2-10 typically provides 47.3 dBm of saturated output power with power gain of 14.4 dB at 6 GHz. The maximum power added efficiency is 65.6 % which makes the TGF2023-2-10 appropriate for high efficiency applications.

Lead-free and RoHS compliant



Functional Block Diagram



Pad Configuration

Pad No.	Symbol
1-8	V_G / RF IN
9	V_D / RF OUT
Backside	Source / Ground

Ordering Information

Part	ECCN	Description
TGF2023-2-10	3A001b.3.b	50 Watt GaN HEMT

Absolute Maximum Ratings

Parameter	Value
Drain to Gate Voltage (V_{DG})	100 V
Gate Voltage Range (V_G)	–10 to 0 V
Drain Current (I_D)	10 A
Gate Current (I_G)	–10 to 28 mA
Power Dissipation, CW (P_D)	35 W
CW Input Power (P_{IN})	+40 dBm
Channel Temperature (T_{CH})	275 °C
Mounting Temperature (30 Seconds)	320 °C
Storage Temperature	–65 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(1)

Parameter	Value
Drain Voltage Range (V_D)	12 - 40 V
Drain Quiescent Current (I_{DQ})	0.5 A (Typ.)
Drain Current Under RF Drive (I_D)^2	1 A (Typ.)
Gate Voltage (V_G)	–3.0 V (Typ.)
Channel Temperature (T_{CH})	225°C (Max.)
Dissipation Power. CW (P_D)^3	28 W
Dissipation Power, Pulsed (P_D)^{2,3}	35 W

1. Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.
2. 1.46 mS Pulse Width, 10% Duty Cycle
3. Carrier Plate Temperature is at 85 °C.

RF Characterization – Model Optimum Power Tune

Simulated conditions: T = 25°C, Signal Duty Cycle = 10%.

Parameter	Typical Value								Units
Frequency (F)	3		6		8		10		GHz
Drain Voltage (V_D)	28	28	28	28	28	28	28	28	V
Bias Current (I_{DQ})	200	500	200	500	200	500	200	500	mA
Output P3dB (P_{3dB})	47.3	47.2	47.3	47.3	47.3	47.3	47.3	47.2	dBm
PAE @ P_{3dB} (PAE_{3dB})	62	61	60	60	57	56.9	54.5	54.6	%
Gain @ P3dB (G_{3dB})	19	19.9	13.6	14.4	11.1	11.8	9.3	9.9	dB
Parallel Resistance (1) (R_p)	64.8	64.2	61.3	61.2	56.5	56.5	51.3	50.9	Ω·mm
Parallel Capacitance (1) (C_p)	0.233	0.249	0.292	0.297	0.300	0.296	0.327	0.329	pF/mm
Load Reflection Coefficient (2) (Γ_L)	0.18∠51°	0.41∠170°	0.18∠53°	0.31∠89°	0.38∠103°	0.37∠103°	0.46∠116°	0.46∠117°	--

Notes:
1. Large signal equivalent output network (normalized).
2. Characteristic Impedance (Zo) = 5 Ω.

RF Characterization – Model Optimum Efficiency Tune

Simulated conditions: T = 25°C, Signal Duty Cycle = 10%.

Parameter	Typical Value								Units
Frequency (F)	3		6		8		10		GHz
Drain Voltage (V_D)	28	28	28	28	28	28	28	28	V
Bias Current (I_{DQ})	200	500	200	500	200	500	200	500	mA
Output P3dB (P_{3dB})	45.9	45.7	45.9	46	46.1	46.1	46.2	46.2	dBm
PAE @ P_{3dB} (PAE_{3dB})	68.5	67.2	66.5	65.6	63.4	63	59.6	59.5	%
Gain @ P3dB (G_{3dB})	21	21.6	15.1	15.8	12.3	13	10.5	11.1	dB
Parallel Resistance (1) (R_p)	117	117	108	105	98.9	96	83	82	Ω·mm
Parallel Capacitance (1) (C_p)	0.375	0.359	0.378	0.375	0.376	0.375	0.373	0.375	pF/mm
Load Reflection Coefficient (2) (Γ_L)	0.46∠46°	0.45∠44°	0.55∠79°	0.54∠79°	0.60∠94°	0.59∠95°	0.62∠107°	0.62∠108°	--

Notes:
1. Large signal equivalent output network (normalized).
2. Characteristic Impedance (Zo) = 5 Ω.

Thermal and Reliability - CW (1)

Parameter	Test Conditions	Value	Units
Thermal Resistance, θ_{JC}	P_D = 10 W, Tbaseplate = 85℃	4.1	℃/W
Channel Temperature, T_{CH}		126	℃
Median Lifetime, T_M		4.3E10	Hrs
Thermal Resistance, θ_{JC}	P_D = 20 W, Tbaseplate = 70℃	4.5	℃/W
Channel Temperature, T_{CH}		174	℃
Median Lifetime, T_M		1.9E8	Hrs
Thermal Resistance, θ_{JC}	P_D = 30 W, Tbaseplate = 85℃	5.0	℃/W
Channel Temperature, T_{CH}		236	℃
Median Lifetime, T_M		7.6E5	Hrs
Thermal Resistance, θ_{JC}	P_D = 40 W, Tbaseplate = 85℃	5.6	℃/W
Channel Temperature, T_{CH}		310	℃
Median Lifetime, T_M		4.6E3	Hrs

Notes:

1. Assumes eutectic attach using 1.5 mil thick 80/20 AuSn mounted to a 10 mm x 10 mm x 40 mil CuMo Carrier Plate.

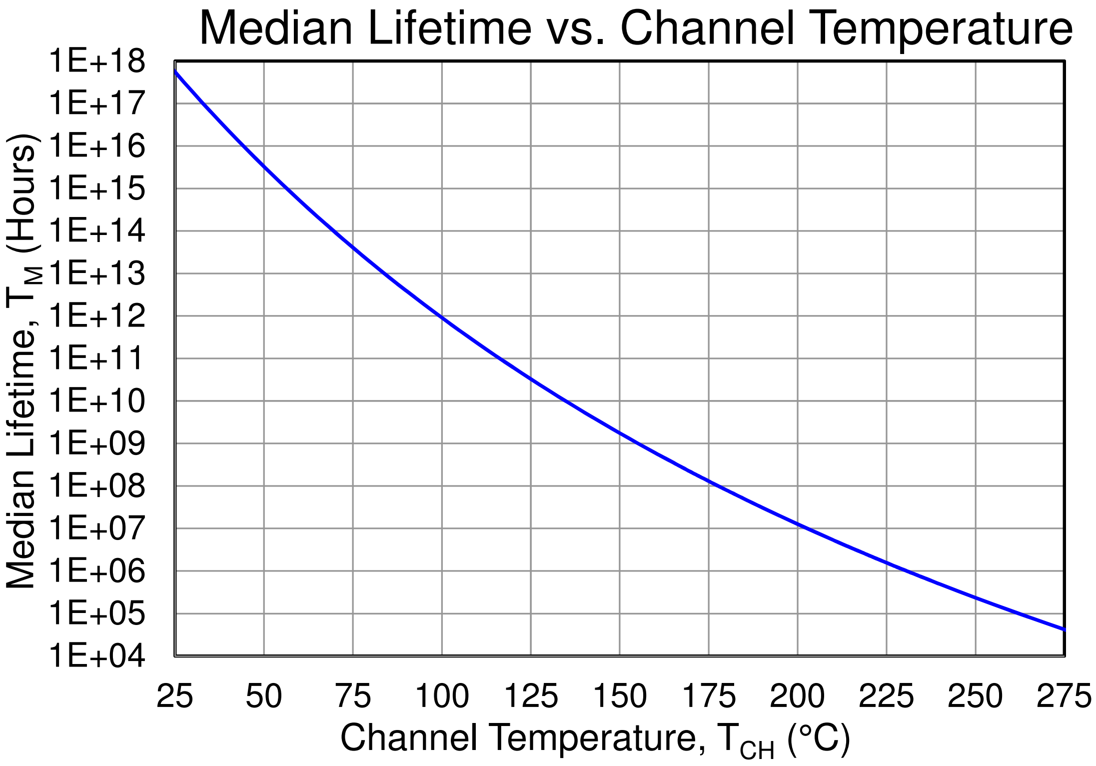
Thermal and Reliability - Pulsed (1)

Parameter	Test Conditions	Value	Units
Thermal Resistance, θ_{JC}	P_D = 35 W, Tbaseplate = 85℃ Pulse Width = 100 uS Duty Cycle = 5%	2.4	℃/W
Channel Temperature, T_{CH}		168	℃
Median Lifetime, T_M		7.1E9	Hrs
Thermal Resistance, θ_{JC}	P_D = 35 W, Tbaseplate = 85℃ Pulse Width = 100 uS Duty Cycle = 10%	2.5	℃/W
Channel Temperature, T_{CH}		173	℃
Median Lifetime, T_M		2.1E9	Hrs
Thermal Resistance, θ_{JC}	P_D = 35 W, Tbaseplate = 85℃ Pulse Width = 100 uS Duty Cycle = 20%	2.7	℃/W
Channel Temperature, T_{CH}		181	℃
Median Lifetime, T_M		4.7E8	Hrs
Thermal Resistance, θ_{JC}	P_D = 35 W, Tbaseplate = 85℃ Pulse Width = 100 uS Duty Cycle = 50%	3.6	℃/W
Channel Temperature, T_{CH}		210	℃
Median Lifetime, T_M		1.3E7	Hrs

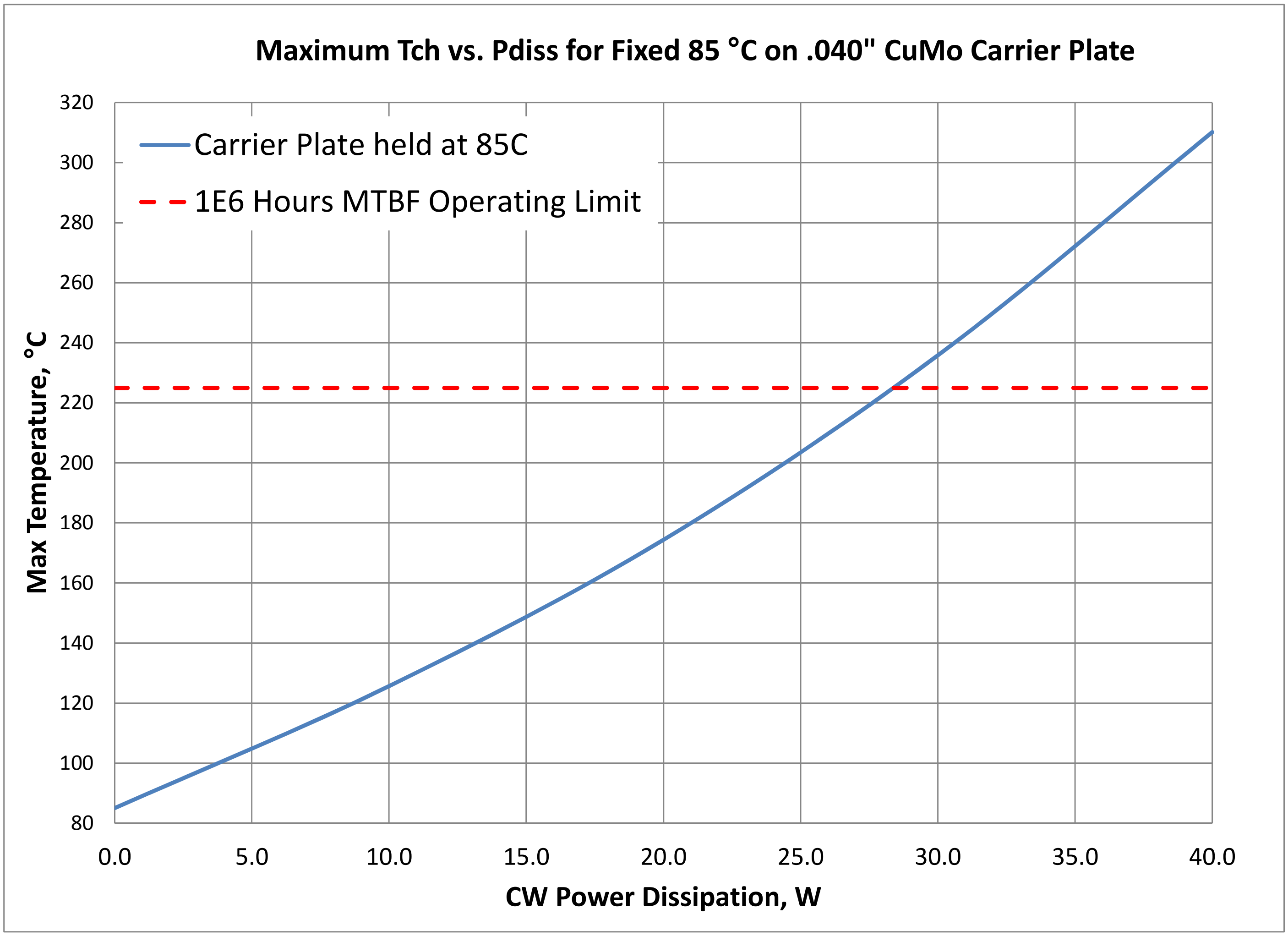
Notes:

1. Assumes eutectic attach using 1.5 mil thick 80/20 AuSn mounted to a 10 mm x 10 mm x 40 mil CuMo Carrier Plate.

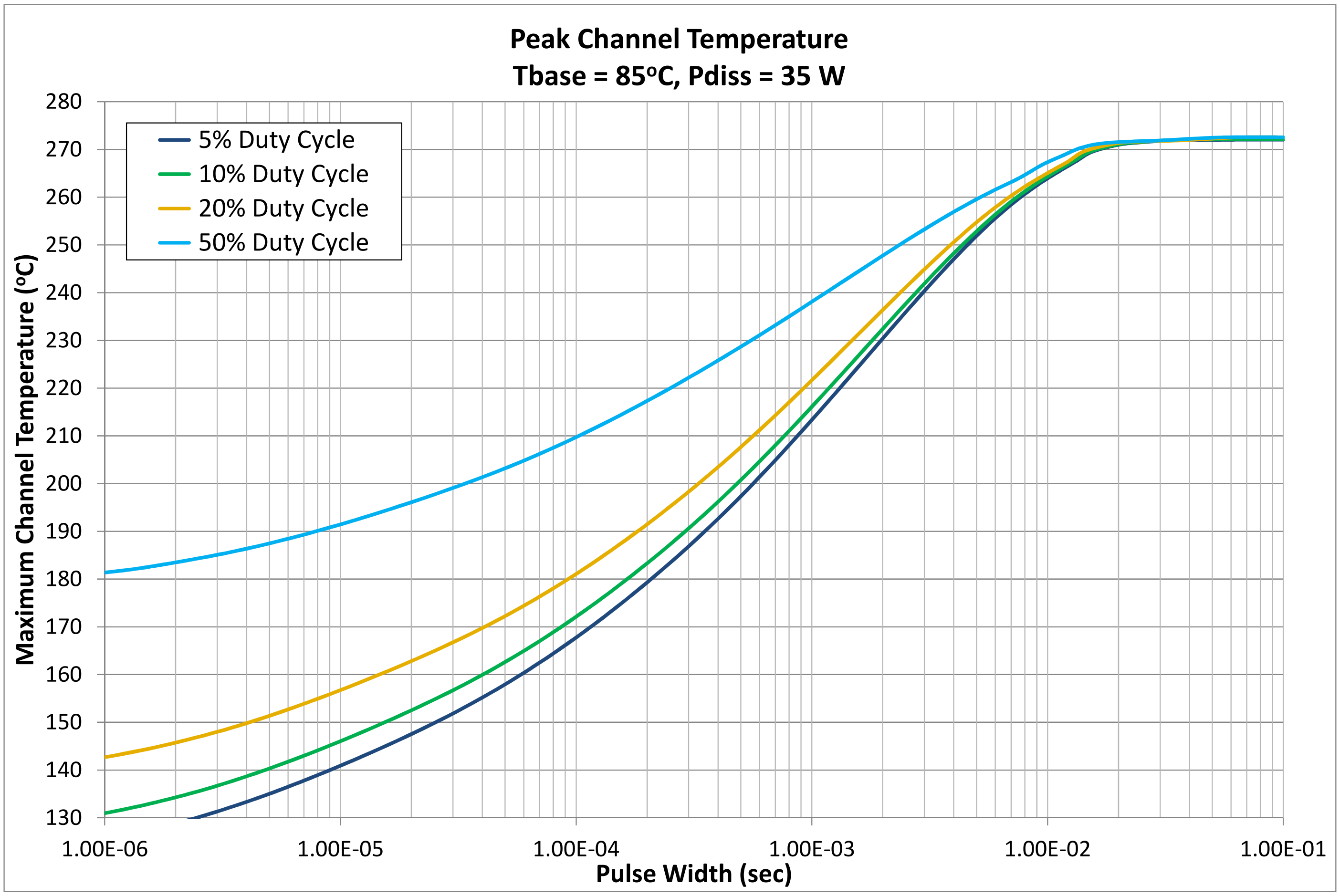
Median Lifetime



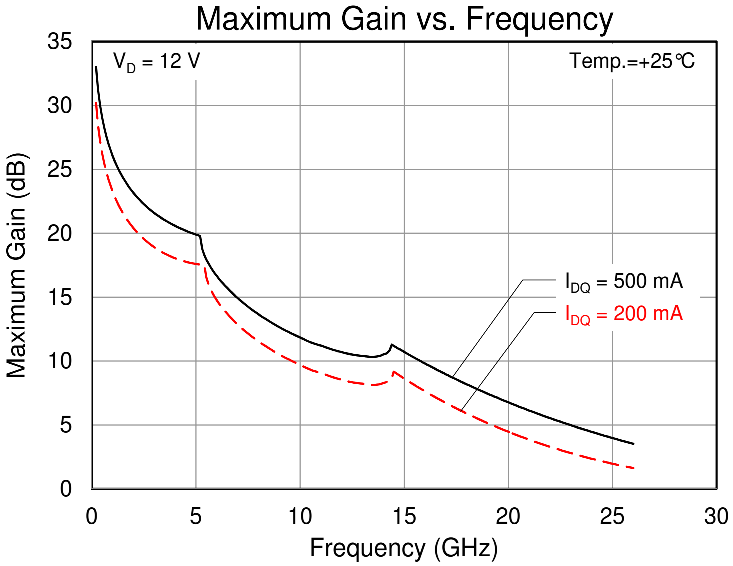
Maximum Channel Temperature - CW

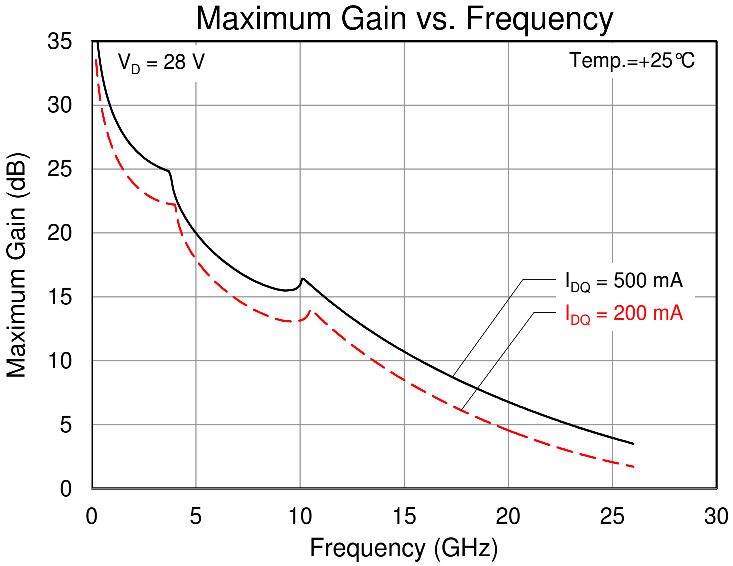


Peak Channel Temperature - Pulsed



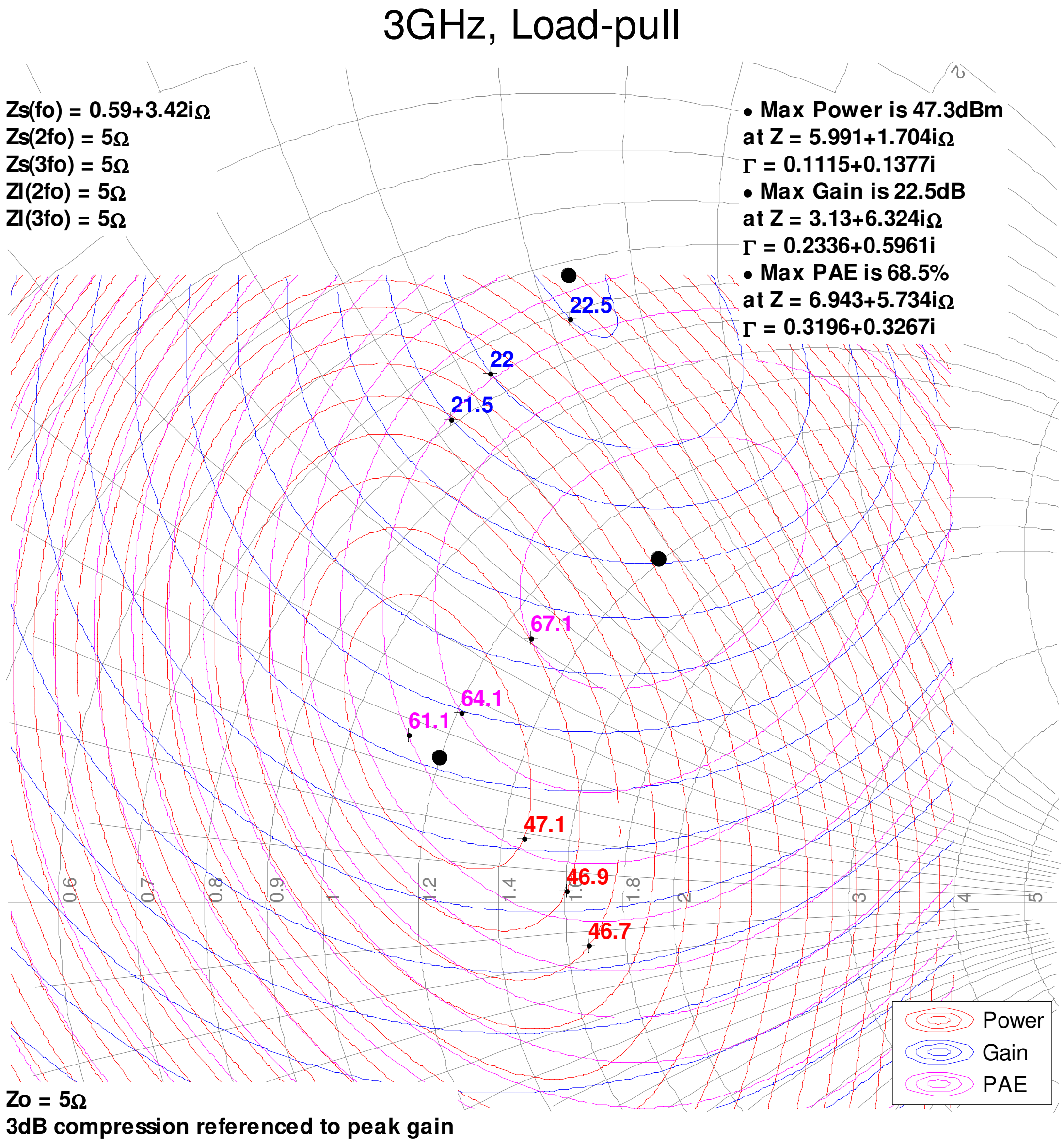
Model Maximum Gain





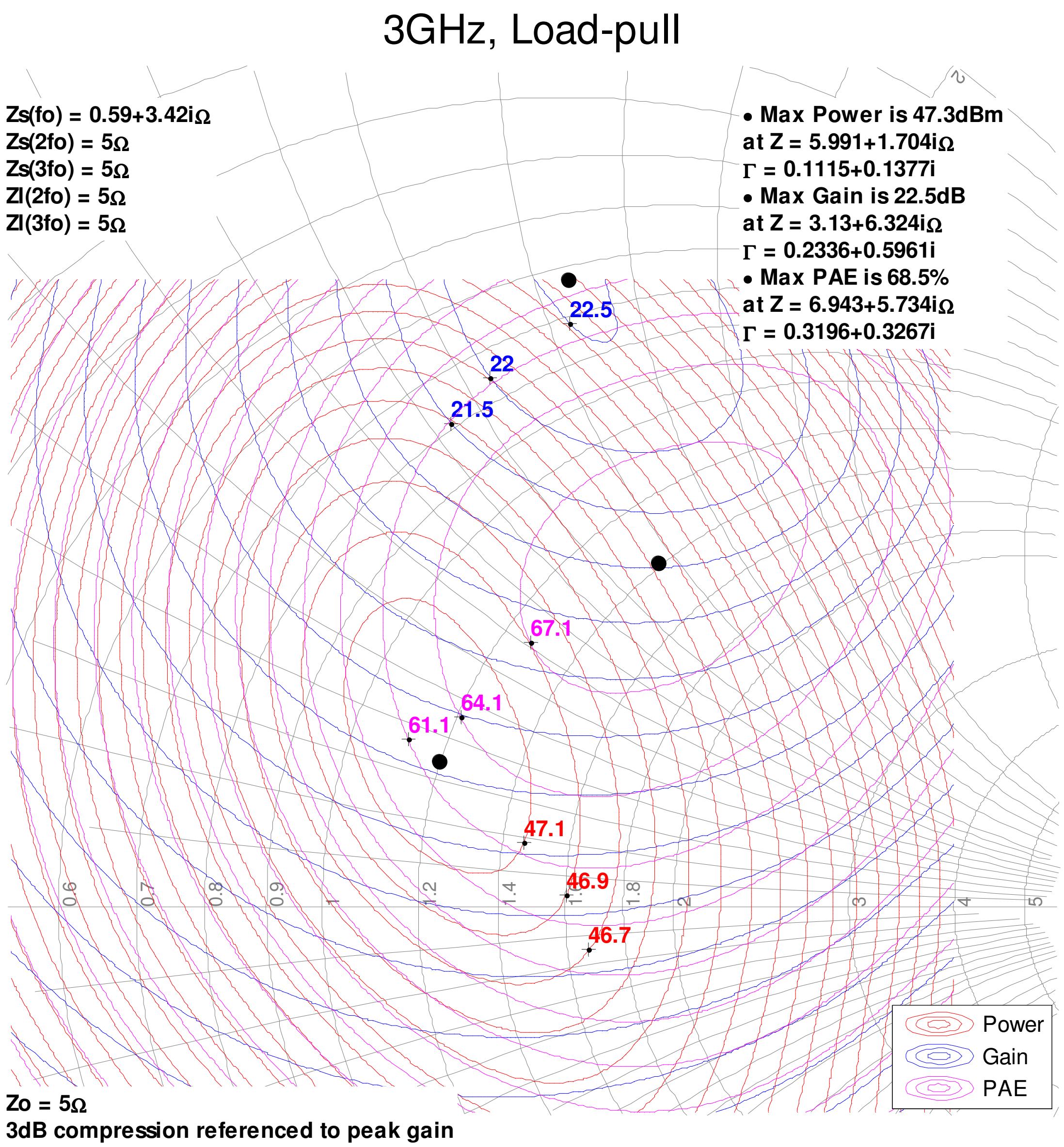
Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 200 mA



Model Load Pull Contours

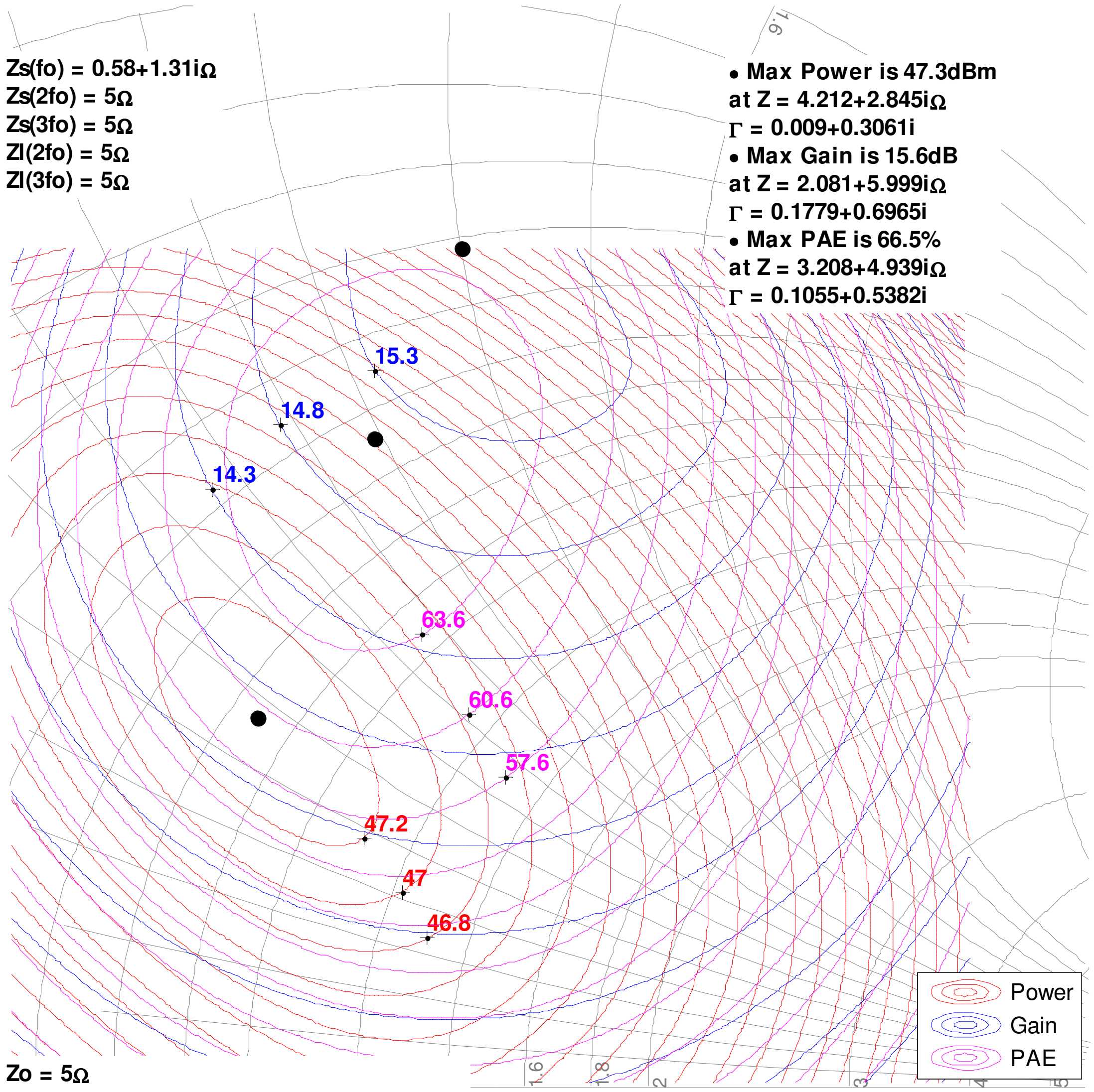
Simulated signal: 10% pulses.
Vd = 28 V, Idq = 200 mA



Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 200 mA

6GHz, Load-pull



Zs(fo) = 0.58+1.31iΩ
Zs(2fo) = 5Ω
Zs(3fo) = 5Ω
Zl(2fo) = 5Ω
Zl(3fo) = 5Ω

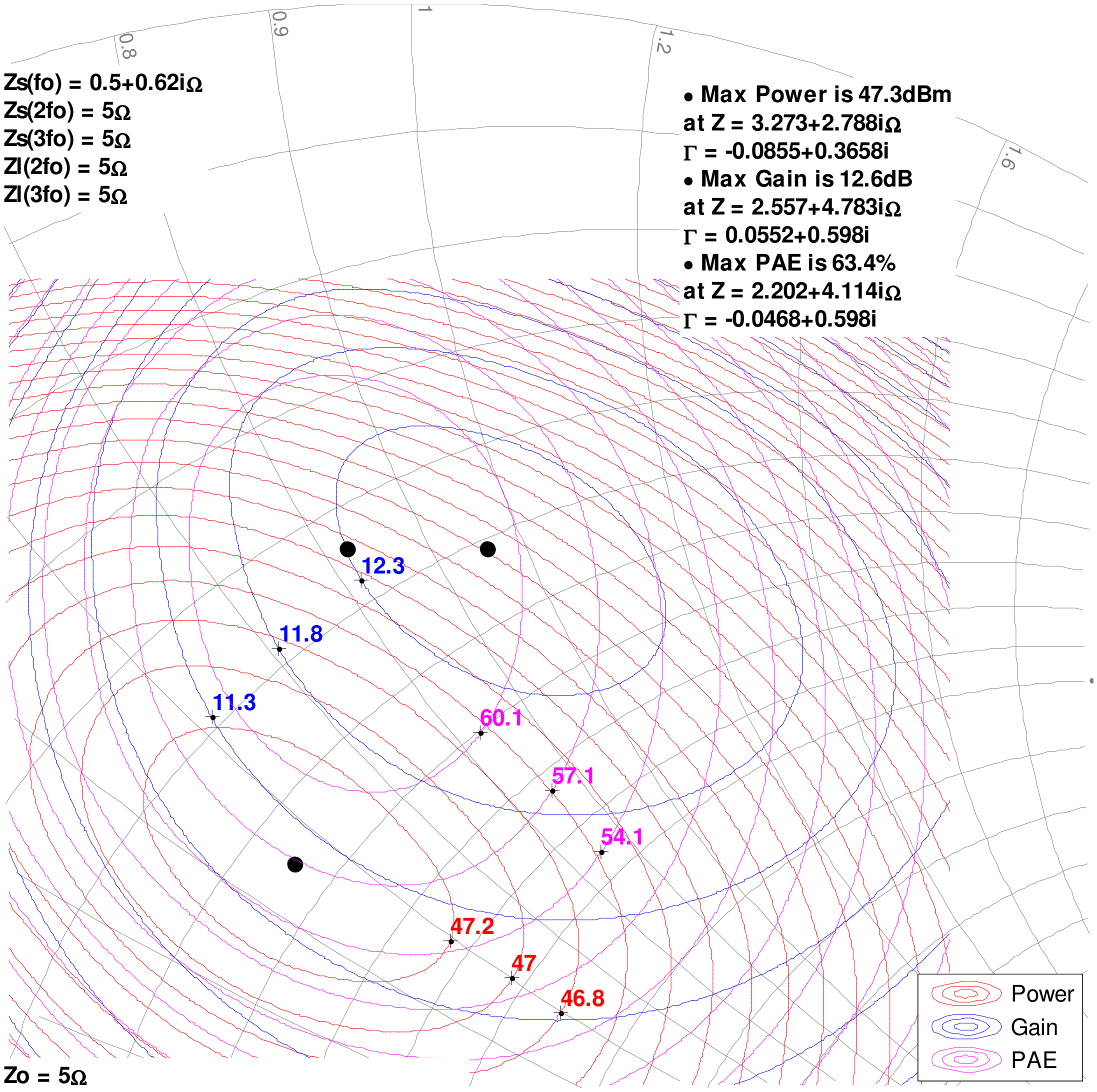
- **Max Power is 47.3dBm**
at Z = 4.212+2.845iΩ
Γ = 0.009+0.3061i
- **Max Gain is 15.6dB**
at Z = 2.081+5.999iΩ
Γ = 0.1779+0.6965i
- **Max PAE is 66.5%**
at Z = 3.208+4.939iΩ
Γ = 0.1055+0.5382i

Zo = 5Ω
3dB compression referenced to peak gain

Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 200 mA

8GHz, Load-pull



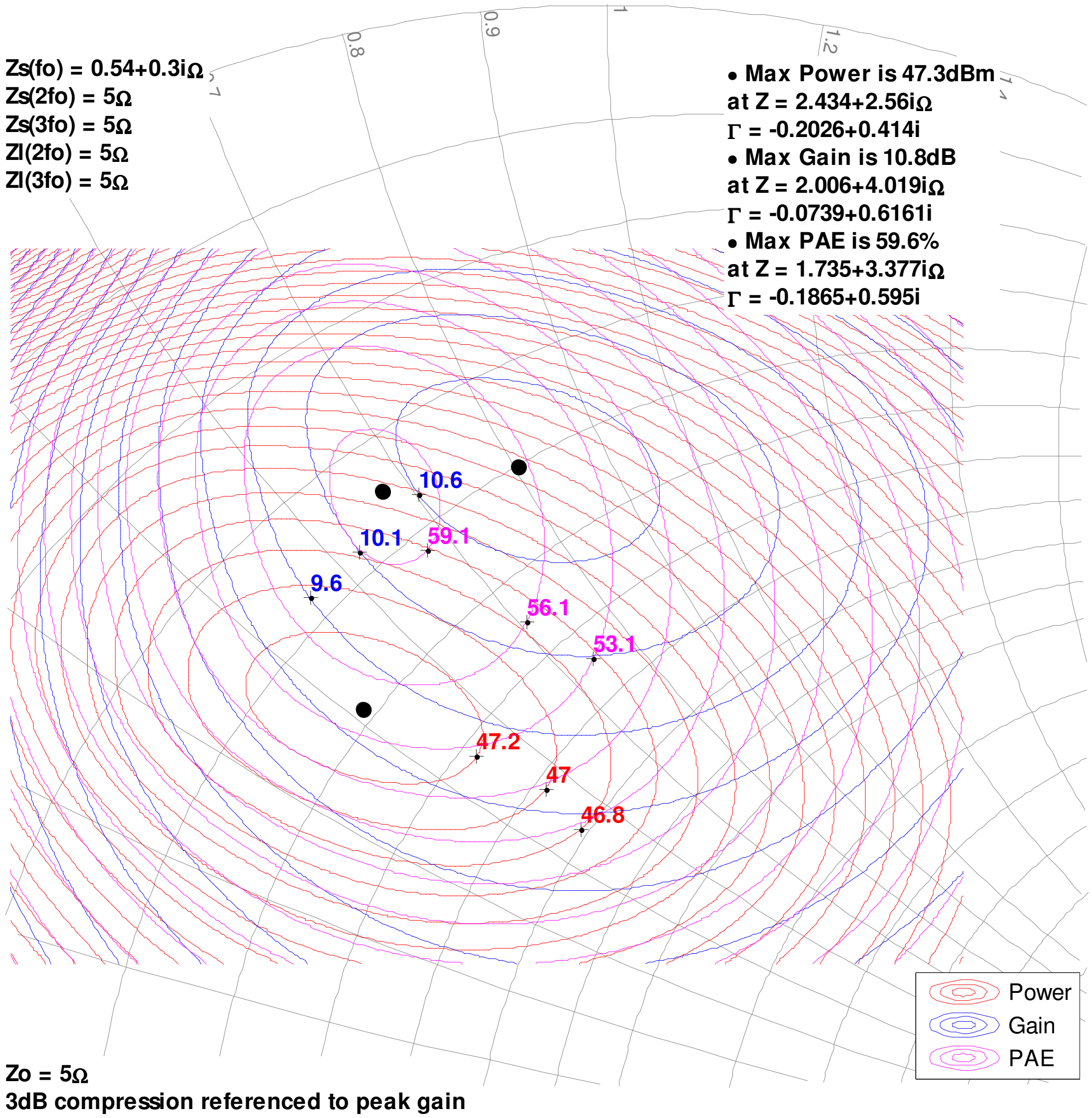
Zs(fo) = 0.5+0.62iΩ
Zs(2fo) = 5Ω
Zs(3fo) = 5Ω
Zl(2fo) = 5Ω
Zl(3fo) = 5Ω

- **Max Power is 47.3dBm**
  at Z = 3.273+2.788iΩ
  Γ = -0.0855+0.3658i
- **Max Gain is 12.6dB**
  at Z = 2.557+4.783iΩ
  Γ = 0.0552+0.598i
- **Max PAE is 63.4%**
  at Z = 2.202+4.114iΩ
  Γ = -0.0468+0.598i

Zo = 5Ω
3dB compression referenced to peak gain

Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 200 mA



10GHz, Load-pull

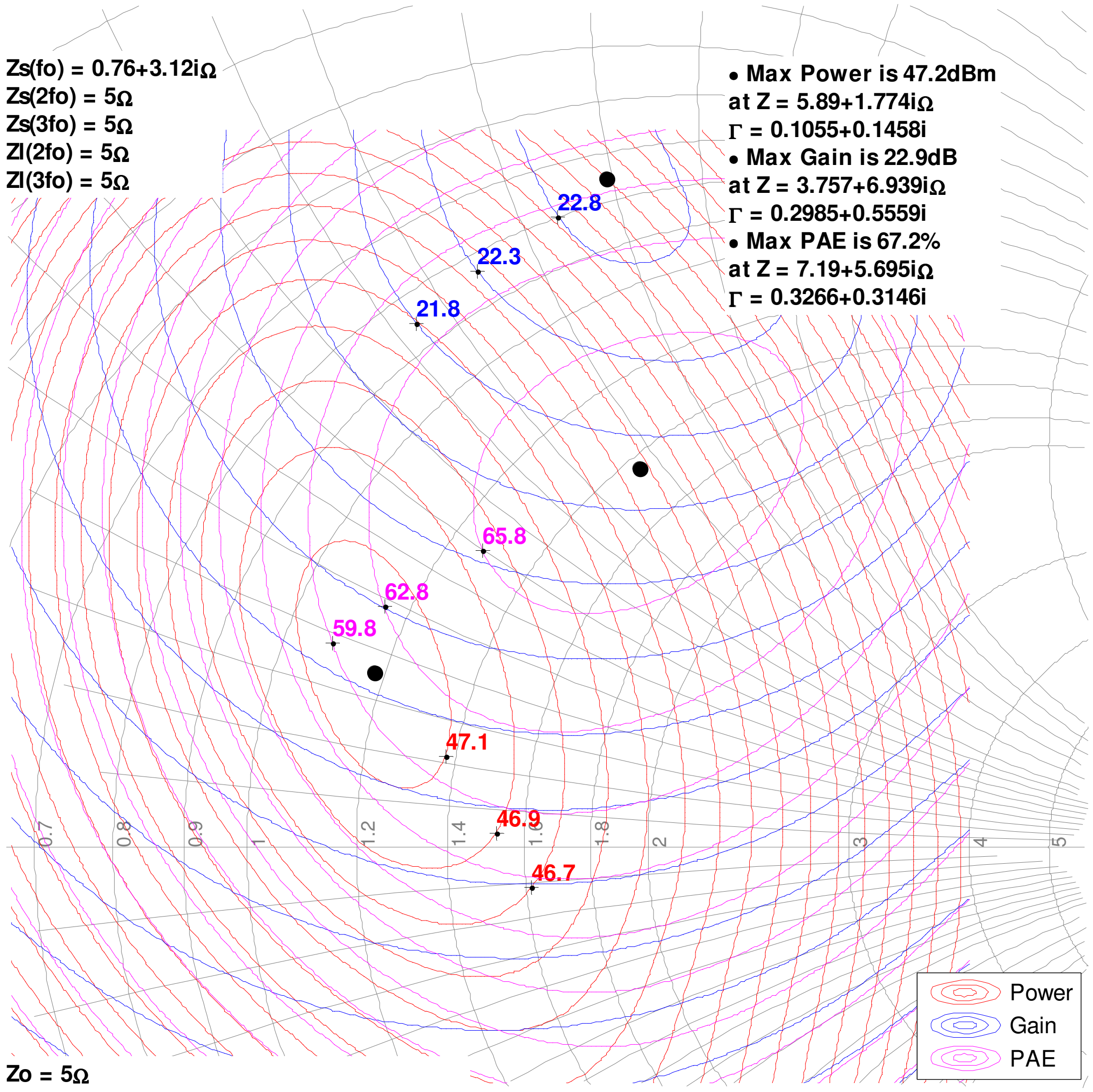
Zs(fo) = 0.54+0.3iΩ
Zs(2fo) = 5Ω
Zs(3fo) = 5Ω
Zl(2fo) = 5Ω
Zl(3fo) = 5Ω

• Max Power is 47.3dBm
at Z = 2.434+2.56iΩ
Γ = -0.2026+0.414i
• Max Gain is 10.8dB
at Z = 2.006+4.019iΩ
Γ = -0.0739+0.6161i
• Max PAE is 59.6%
at Z = 1.735+3.377iΩ
Γ = -0.1865+0.595i

Zo = 5Ω
3dB compression referenced to peak gain

Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 500 mA



3GHz, Load-pull

Zs(fo) = 0.76+3.12iΩ
Zs(2fo) = 5Ω
Zs(3fo) = 5Ω
Zl(2fo) = 5Ω
Zl(3fo) = 5Ω

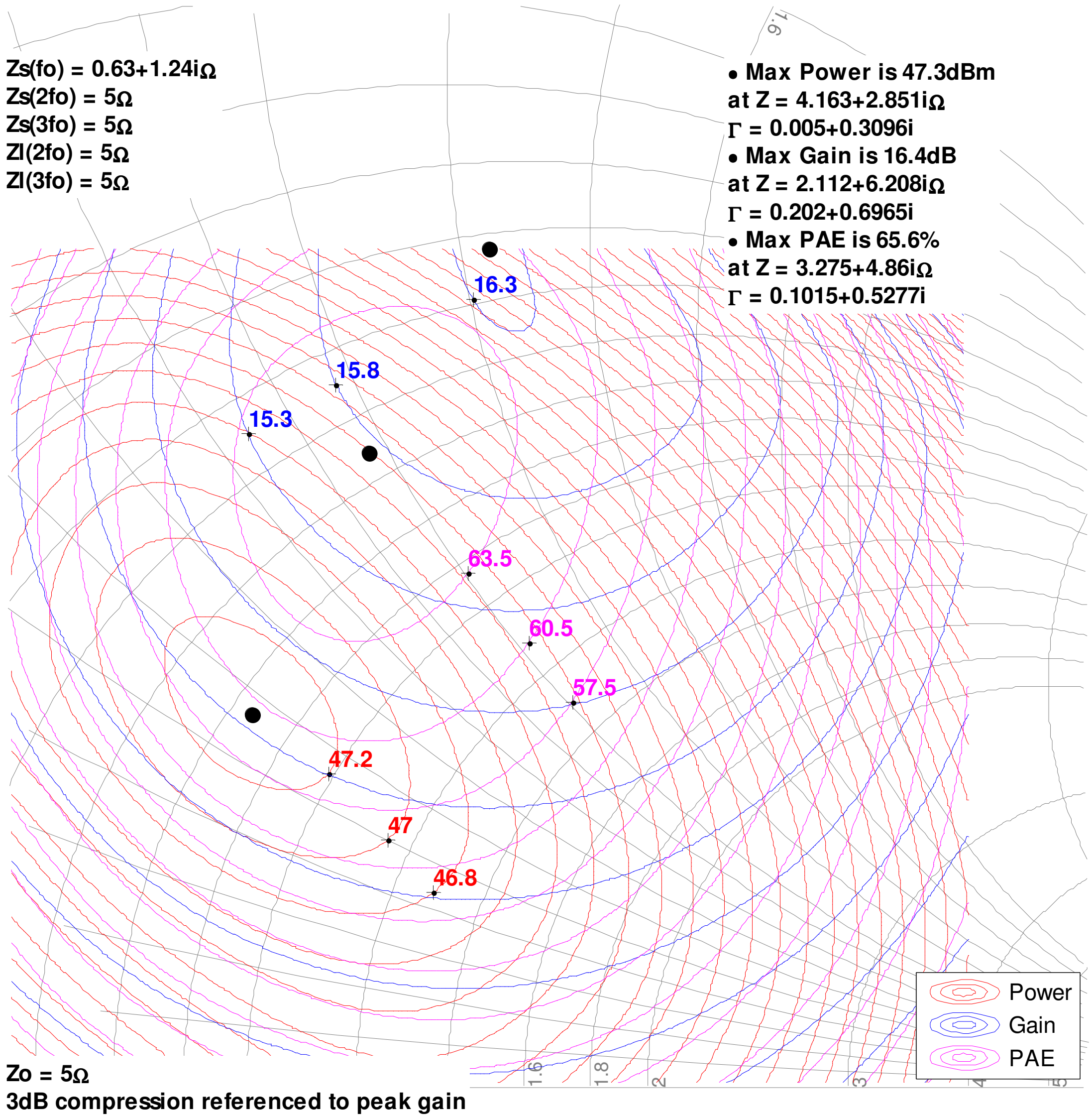
● Max Power is 47.2dBm
at Z = 5.89+1.774iΩ
Γ = 0.1055+0.1458i
● Max Gain is 22.9dB
at Z = 3.757+6.939iΩ
Γ = 0.2985+0.5559i
● Max PAE is 67.2%
at Z = 7.19+5.695iΩ
Γ = 0.3266+0.3146i

Zo = 5Ω
3dB compression referenced to peak gain

Model Load Pull Contours

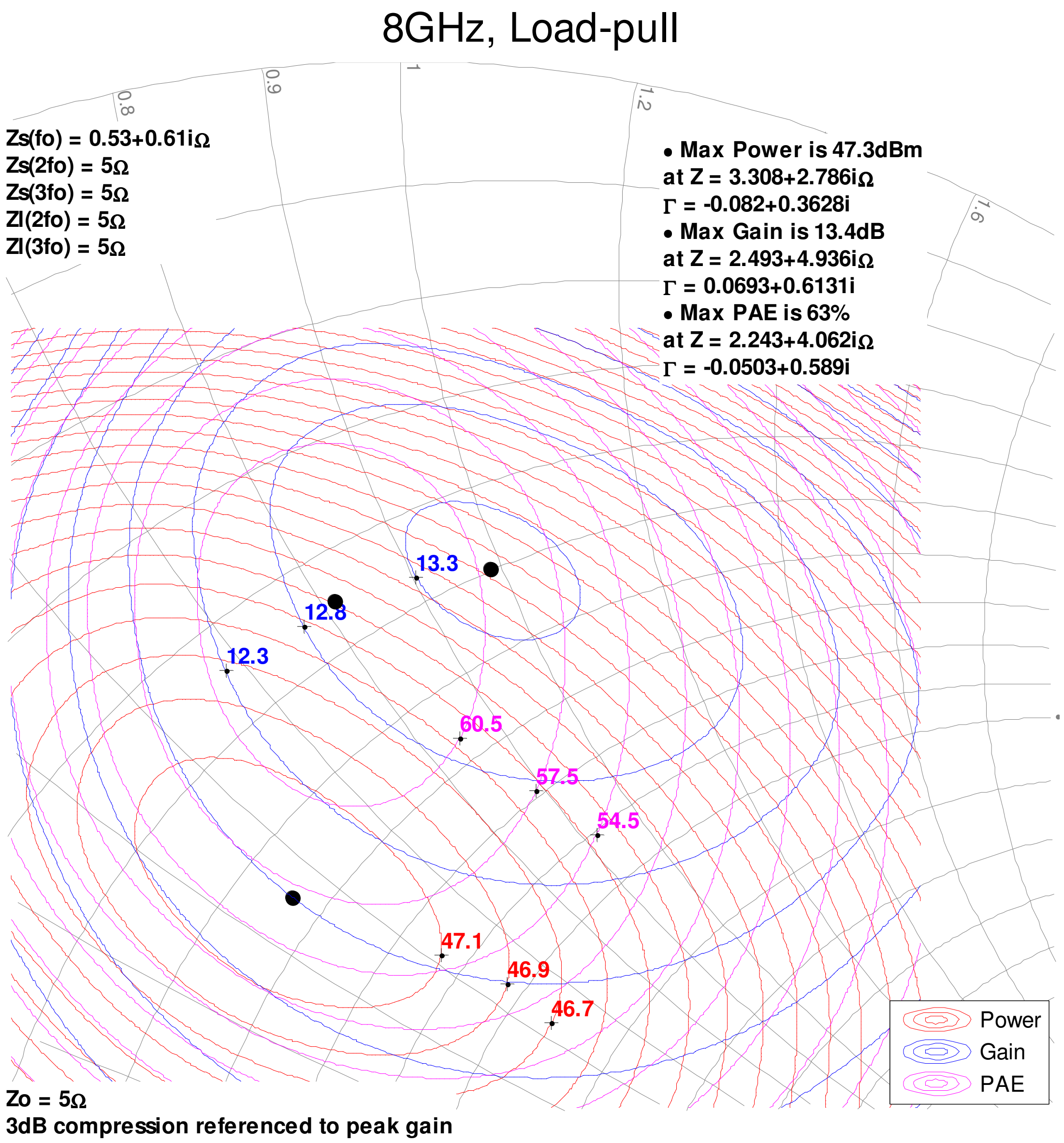
Simulated signal: 10% pulses.
Vd = 28 V, Idq = 500 mA

6GHz, Load-pull



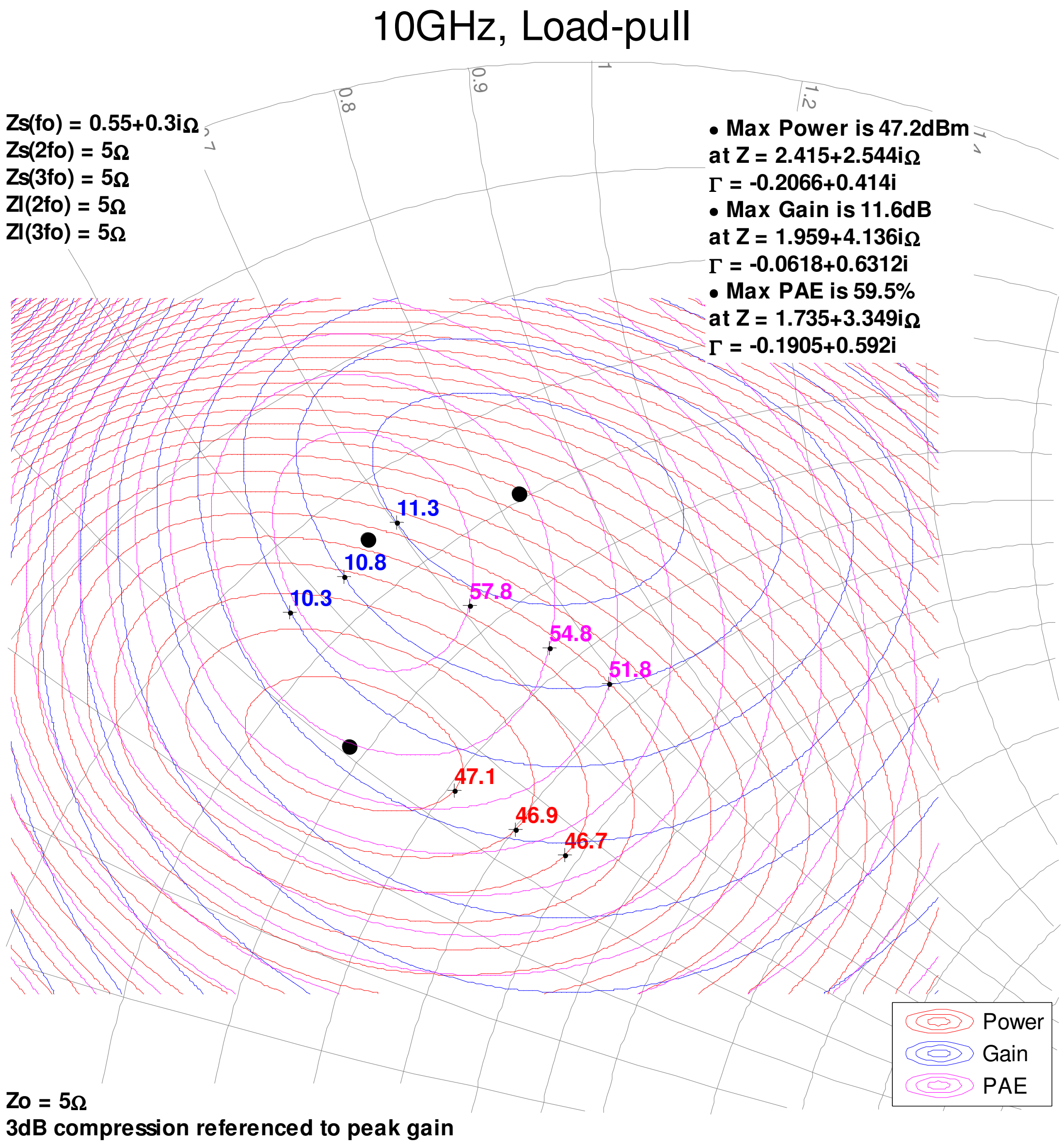
Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 500 mA



Model Load Pull Contours

Simulated signal: 10% pulses.
Vd = 28 V, Idq = 500 mA



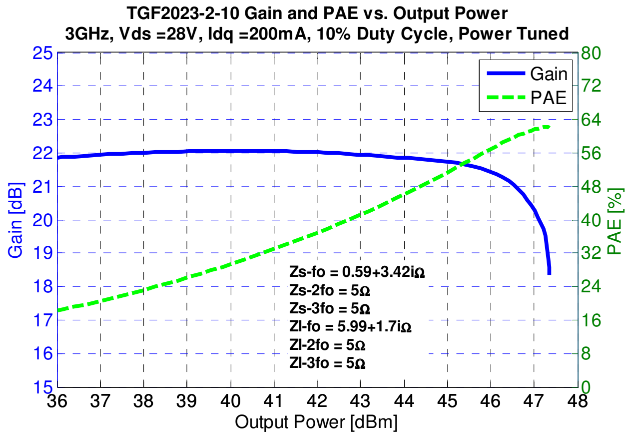
10GHz, Load-pull

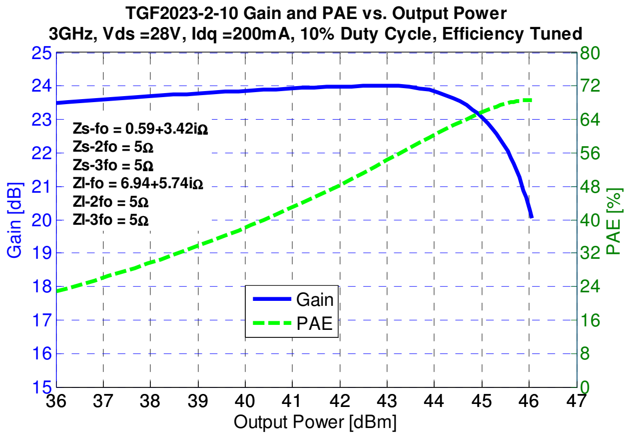
Zs(fo) = 0.55+0.3iΩ
Zs(2fo) = 5Ω
Zs(3fo) = 5Ω
Zl(2fo) = 5Ω
Zl(3fo) = 5Ω

- **Max Power is 47.2dBm**
at Z = 2.415+2.544iΩ
Γ = -0.2066+0.414i
- **Max Gain is 11.6dB**
at Z = 1.959+4.136iΩ
Γ = -0.0618+0.6312i
- **Max PAE is 59.5%**
at Z = 1.735+3.349iΩ
Γ = -0.1905+0.592i

Zo = 5Ω
3dB compression referenced to peak gain

Model Drive-up Data – 3 GHz


TGF2023-2-10 Gain and PAE vs. Output Power
3GHz, Vds =28V, Idq =200mA, 10% Duty Cycle, Power Tuned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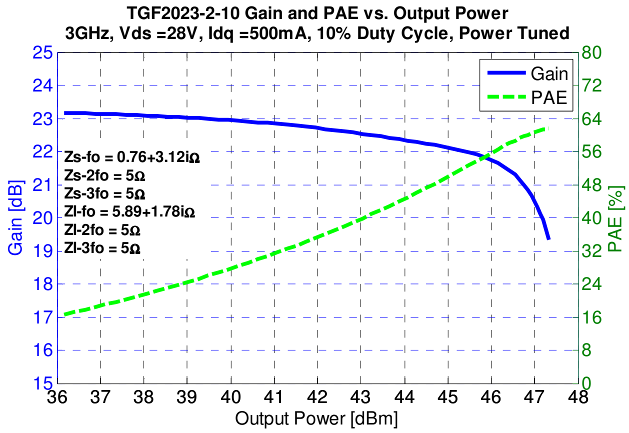
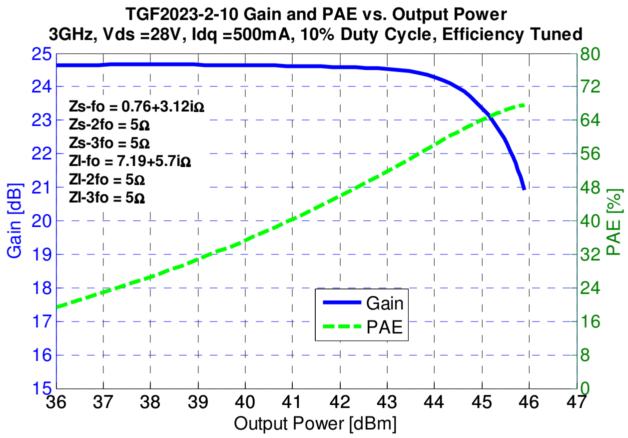
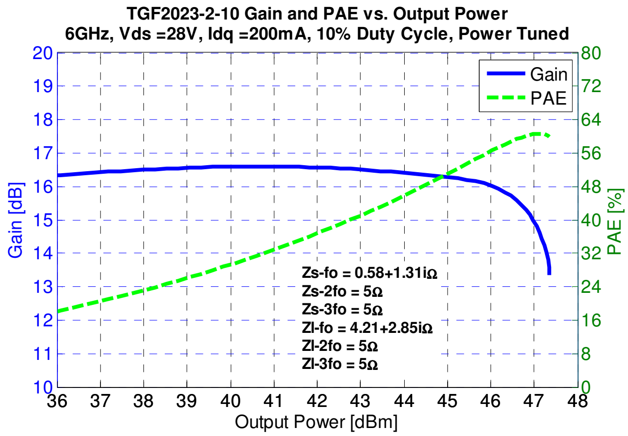
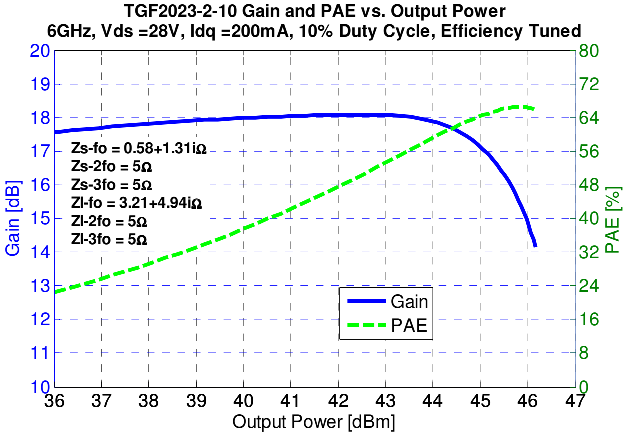
3GHz, Vds =28V, Idq =200mA, 10% Duty Cycle, Efficiency Tuned

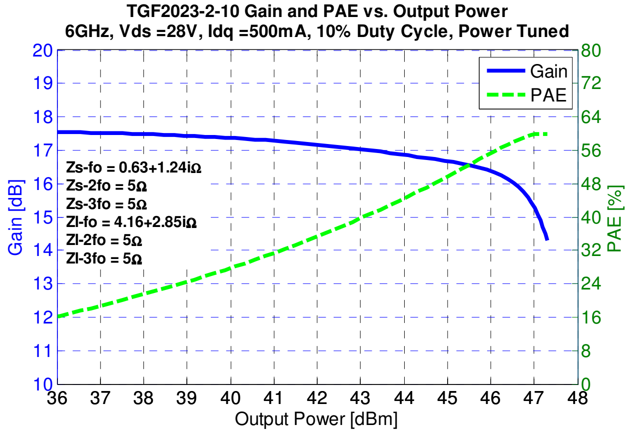

TGF2023-2-10 Gain and PAE vs. Output Power
3GHz, Vds =28V, Idq =500mA, 10% Duty Cycle, Power Tuned

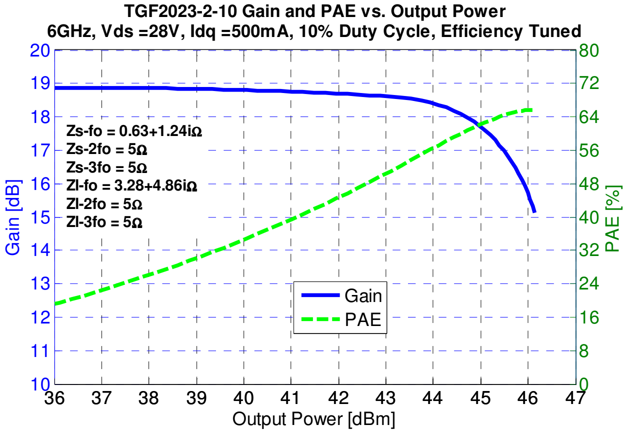

TGF2023-2-10 Gain and PAE vs. Output Power
3GHz, Vds =28V, Idq =500mA, 10% Duty Cycle, Efficiency Tuned

Model Drive-up Data – 6 GHz

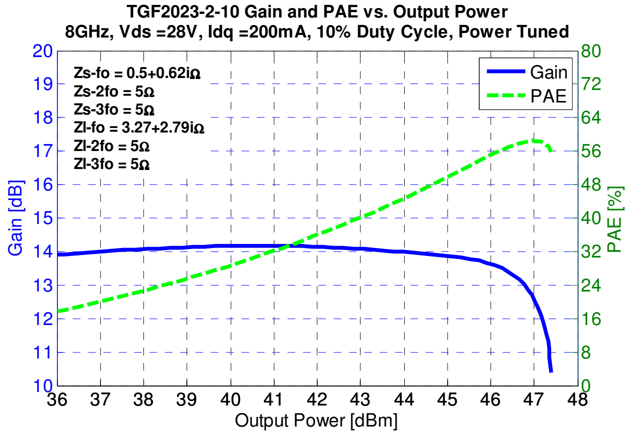


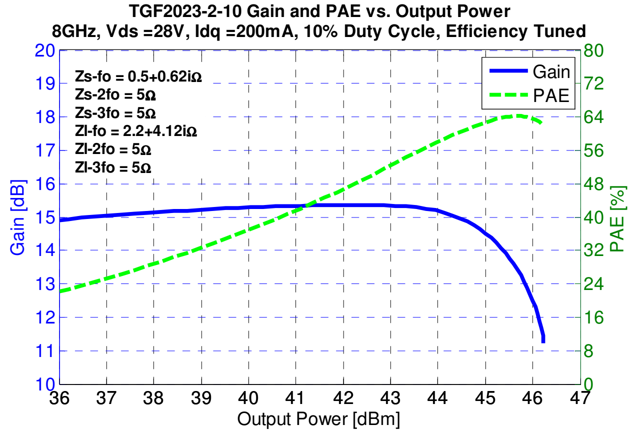


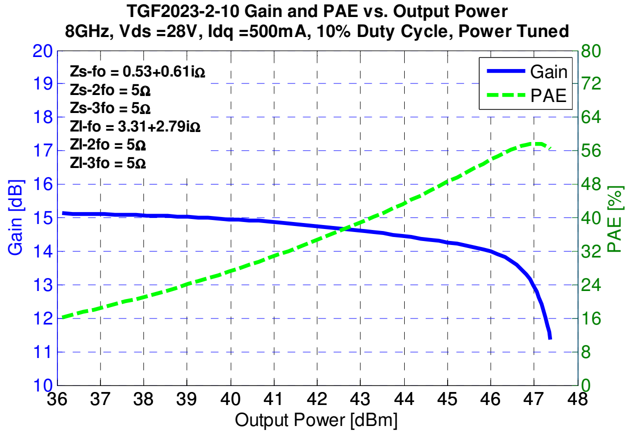


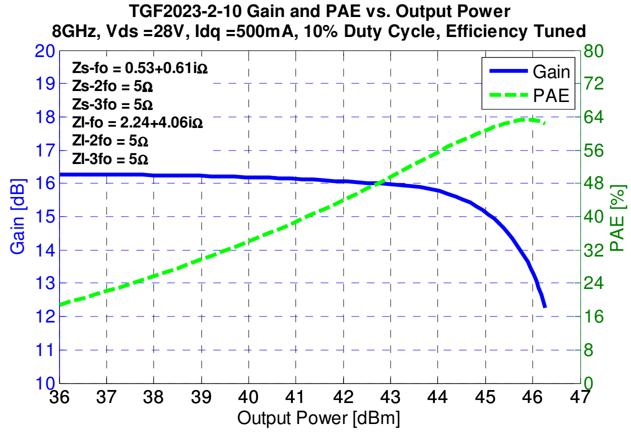


Model Drive-up Data – 8 GHz

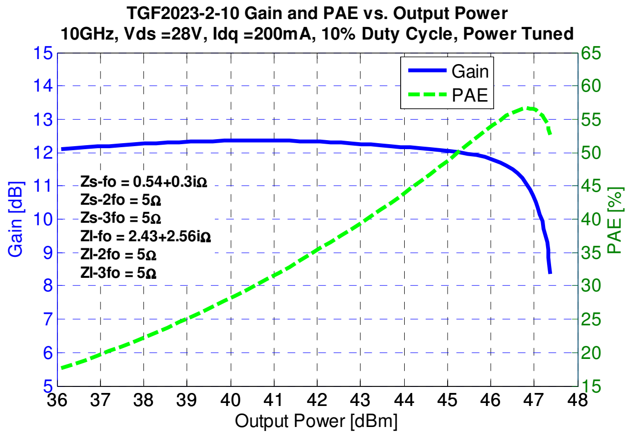


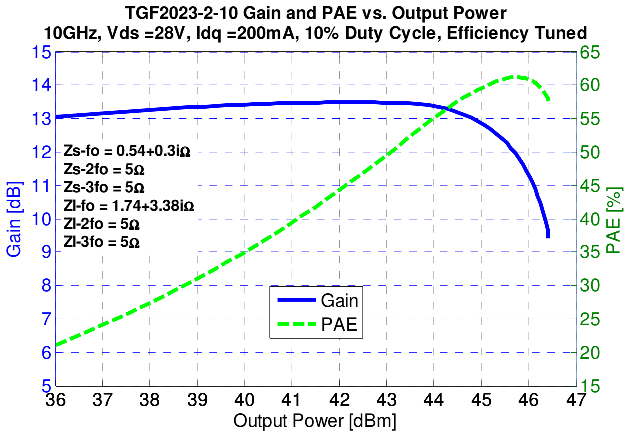


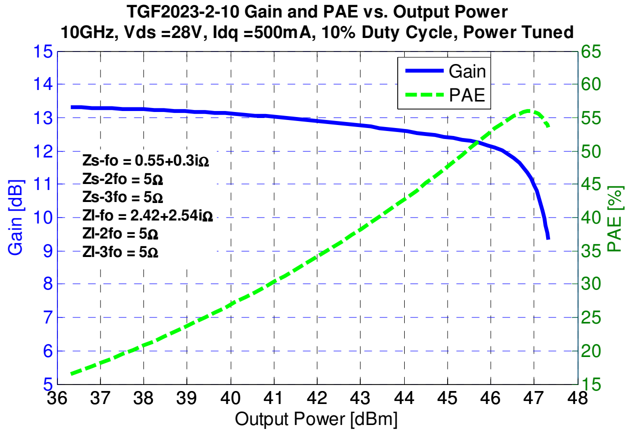


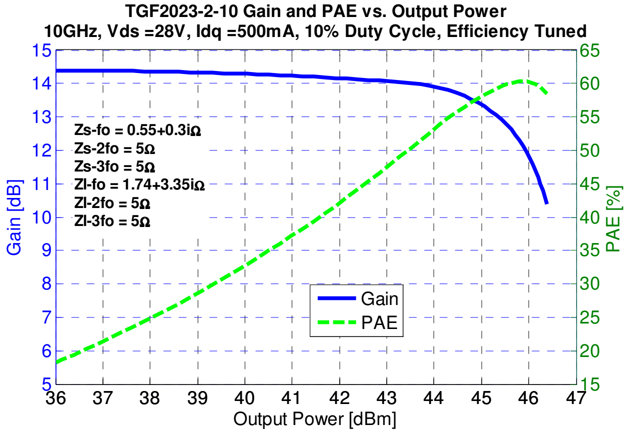


Model Drive-up Data – 10 GHz


TGF2023-2-10 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =200mA, 10% Duty Cycle, Power Tuned


TGF2023-2-10 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =200mA, 10% Duty Cycle, Efficiency Tuned

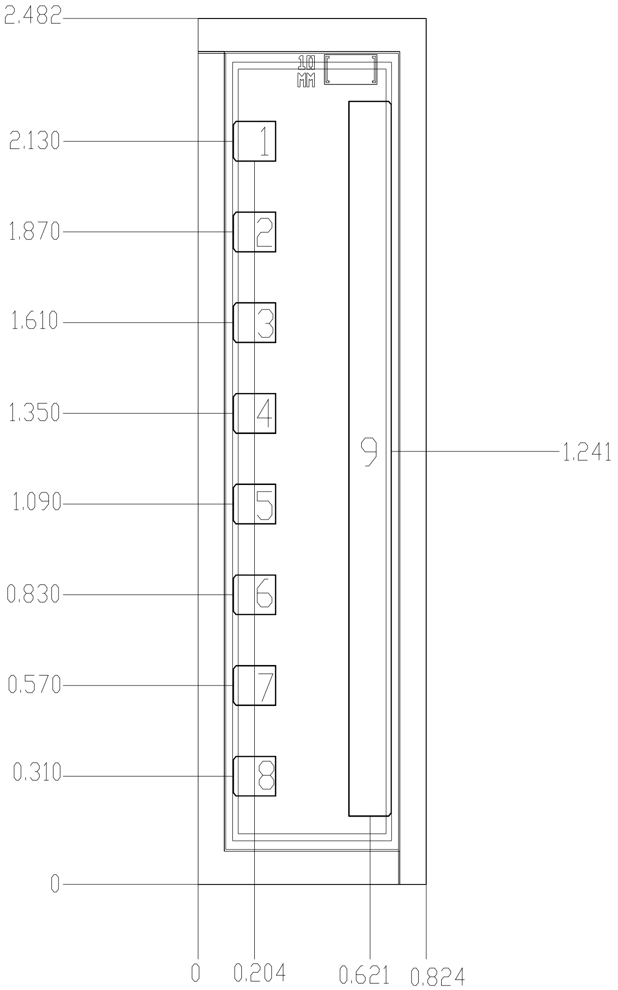

TGF2023-2-10 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =500mA, 10% Duty Cycle, Power Tuned


TGF2023-2-10 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =500mA, 10% Duty Cycle, Efficiency Tuned

Model

A model is available for download from Modelithics (at http://www.modelithics.com/mvp/Qorvo&tab=3) by approved Qorvo customers. The model is compatible with the industry's most popular design software including Agilent ADS and National Instruments/AWR applications. Once on the Modelithics web page, the user will need to register for a free license before being granted the download.

Mechanical Drawing



Notes:

1. Units: millimeters
2. Thickness: 0.100 mm
3. Die x,y size tolerance: ± 0.050 mm

Bond Pads

Pad No.	Description	Dimensions
1-8	Gate	0.154 x 0.115
9	Drain	0.154 x 2.05
Die Backside	Source / Ground	0.824 x 2.482

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) not recommended.

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:

- Ball bonding is the preferred interconnect technique, except where noted on the assembly diagram.
- Force, time, and ultrasonics are critical bonding parameters.
- Aluminum wire should not be used.
- Devices with small pad sizes should be bonded with 0.0007-inch wire.

Disclaimer

GaN/SiC devices are susceptible to damage from Electrostatic Discharge. Proper precautions should be observed during handling, assembly and test.

Bias-up Procedure

1. Set V_G to -5 V.
2. Set I_D limit to 0.55 A.
3. Set V_D to 28 V.
4. Adjust V_G more positive until quiescent I_D is 0.5 A.
5. Set I_D limit to 4 A.
6. Apply RF signal.

Bias-down Procedure

1. Turn off RF signal.
2. Turn off V_D and wait 1 second to allow drain capacitor dissipation.
3. Turn off V_G.