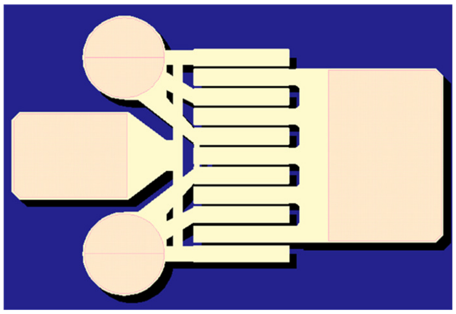
TGF2023-2-01

6 Watt Discrete Power GaN on SiC HEMT

Applications

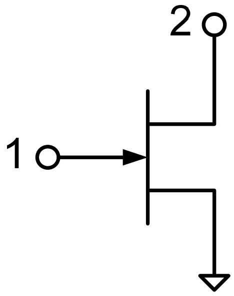
- Defense & Aerospace
- Broadband Wireless



Product Features

- Frequency Range: DC - 18 GHz
- 38 dBm Nominal P_{3dB} at 6 GHz
- 62.5% Maximum PAE
- 18.4 dB Linear Gain at 6 GHz
- Bias: V_D = 12 - 32 V, I_{DQ} = 25 – 125 mA
- Technology: QGaN25 on SiC
- Chip Dimensions: 0.82 x 0.66 x 0.10 mm

Functional Block Diagram



General Description

The Qorvo TGF2023-2-01 is a discrete 1.25 mm GaN on SiC HEMT which operates from DC-18 GHz. The TGF2023-2-01 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 TGF2023-2-01 typically provides 38 dBm of saturated output power with power gain of 15.4 dB at 6 GHz. The maximum power added efficiency is 62.5 % which makes the TGF2023-2-01 appropriate for high efficiency applications.

Lead-free and RoHS compliant

Pad Configuration

Pad No.	Symbol
1	V_G / RF IN
2	V_D / RF OUT
Backside	Source / Ground

Ordering Information

Part	ECCN	Description
TGF2023-2-01	EAR99	6 Watt GaN HEMT

Absolute Maximum Ratings

Parameter	Value
Breakdown Voltage (BV_{DG})	100 V
Gate Voltage Range (V_G)	–10 to 0 V
Drain Current (I_D)	1.25 A
Gate Current (I_G)	–1.25 to 3.5 mA
Power Dissipation (P_D)	See graph on pg.5.
CW Input Power (P_{IN})	+31 dBm
Channel Temperature (T_{CH})	275 °C
Mounting Temperature (30 Sec.)	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})	62.5 mA
Drain Current Under RF Drive (I_D)	400 mA (Typ.)
Gate Voltage (V_G)	–3.0 V (Typ.)
Channel Temperature (T_{CH})	225 °C (Max.)
Dissipation Power. CW (P_D)^3	5.75 W
Dissipation Power, Pulsed (P_D)^{2,3}	6.25 W

1. Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions.
2. Pulse Width = 1.26 mS, Duty Cycle = 10%
3. Carrier Plate Temperature is at 85°C.

Model RF Characterization – Optimum Power Tune

Test conditions unless otherwise noted: T = 25°C.

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})	25	62.5	25	62.5	25	62.5	25	62.5	mA
Output P3dB (P_{3dB})	38	37.8	38.1	38.0	38.1	38.0	38.1	38.0	dBm
PAE @ P_{3dB} (PAE_{3dB})	60.2	59.1	57.7	57.3	55.4	55.6	53	53.3	%
Gain @ P3dB (G_{3dB})	20	20.8	14.6	15.4	12.2	13	10.4	11.2	dB
Parallel Resistance (1) (R_p)	65.2	65.1	63.1	62.7	59.3	59.7	56.1	55.8	Ω·mm
Parallel Capacitance (1) (C_p)	0.318	0.312	0.324	0.321	0.341	0.343	0.328	0.330	pF/mm
Load Reflection Coefficient (2) (Γ_L)	0.19∠94°	0.19∠95°	0.36∠110°	0.35∠110°	0.46∠120°	0.47∠120°	0.52∠126°	0.52∠127°	--

Notes:
1. Large signal equivalent output network (normalized).
2. Characteristic Impedance (Zo) = 50 Ω.

Model RF Characterization – Optimum Efficiency Tune

Test conditions unless otherwise noted: T = 25°C.

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})	25	62.5	25	62.5	25	62.5	25	62.5	mA
Output P3dB (P_{3dB})	36.8	36.7	37.0	37.0	37	37.1	37.1	37.1	dBm
PAE @ P_{3dB} (PAE_{3dB})	65.6	64.3	63.3	62.5	60.5	60.1	57.3	57.4	%
Gain @ P3dB (G_{3dB})	21.6	22.4	15.9	16.6	13.3	14.1	11.4	12.2	dB
Parallel Resistance (1) (R_p)	110	112	104	100	99.8	94.4	88.9	85.9	Ω·mm
Parallel Capacitance (1) (C_p)	0.398	0.384	0.394	0.390	0.394	0.390	0.384	0.386	pF/mm
Load Reflection Coefficient (2) (Γ_L)	0.39∠64°	0.39∠62°	0.55∠97°	0.53∠97°	0.63∠110°	0.62∠111°	0.68∠120°	0.67∠121°	--

Notes:
1. Large signal equivalent output network (normalized).
2. Characteristic Impedance (Zo) = 50 Ω.

Thermal and Reliability - CW (1)

Parameter	Test Conditions	Value	Units
Thermal Resistance, θ_{JC}	P_D = 1.25 W, Tbaseplate = 85°C	19.2	°C/W
Channel Temperature, T_{CH}		109	°C
Median Lifetime, T_M		4.2E11	Hrs
Thermal Resistance, θ_{JC}	P_D = 2.50 W, Tbaseplate = 85°C	20.4	°C/W
Channel Temperature, T_{CH}		136	°C
Median Lifetime, T_M		1.3E10	Hrs
Thermal Resistance, θ_{JC}	P_D = 3.75 W, Tbaseplate = 85°C	21.6	°C/W
Channel Temperature, T_{CH}		166	°C
Median Lifetime, T_M		4.4E8	Hrs
Thermal Resistance, θ_{JC}	P_D = 5.0 W, Tbaseplate = 85°C	23.2	°C/W
Channel Temperature, T_{CH}		201	°C
Median Lifetime, T_M		1.4E7	Hrs
Thermal Resistance, θ_{JC}	P_D = 6.25 W, Tbaseplate = 85°C	25.0	°C/W
Channel Temperature, T_{CH}		241	°C
Median Lifetime, T_M		5.2E5	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.

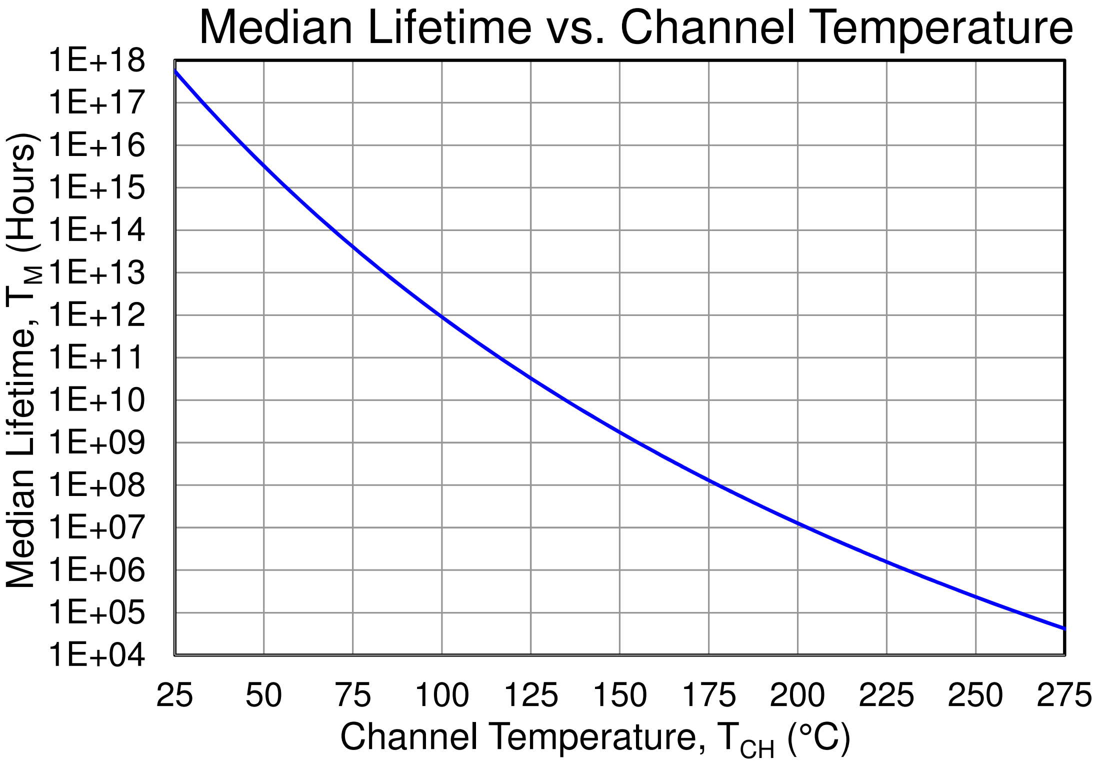
Thermal and Reliability - Pulsed (1)

Parameter	Test Conditions	Value	Units
Thermal Resistance, θ_{JC}	P_D = 6.25 W, Tbaseplate = 85°C Pulse Width = 100 uS Duty Cycle = 5%	17.4	°C/W
Channel Temperature, T_{CH}		194	°C
Median Lifetime, T_M		5.5E8	Hrs
Thermal Resistance, θ_{JC}	P_D = 6.25 W, Tbaseplate = 85°C Pulse Width = 100 uS Duty Cycle = 10%	17.8	°C/W
Channel Temperature, T_{CH}		196	°C
Median Lifetime, T_M		2.3E8	Hrs
Thermal Resistance, θ_{JC}	P_D = 6.25 W, Tbaseplate = 85°C Pulse Width = 100 uS Duty Cycle = 20%	18.4	°C/W
Channel Temperature, T_{CH}		200	°C
Median Lifetime, T_M		7.7E7	Hrs
Thermal Resistance, θ_{JC}	P_D = 6.25 W, Tbaseplate = 85°C Pulse Width = 100 uS Duty Cycle = 50%	21.3	°C/W
Channel Temperature, T_{CH}		218	°C
Median Lifetime, T_M		6.6E6	Hrs

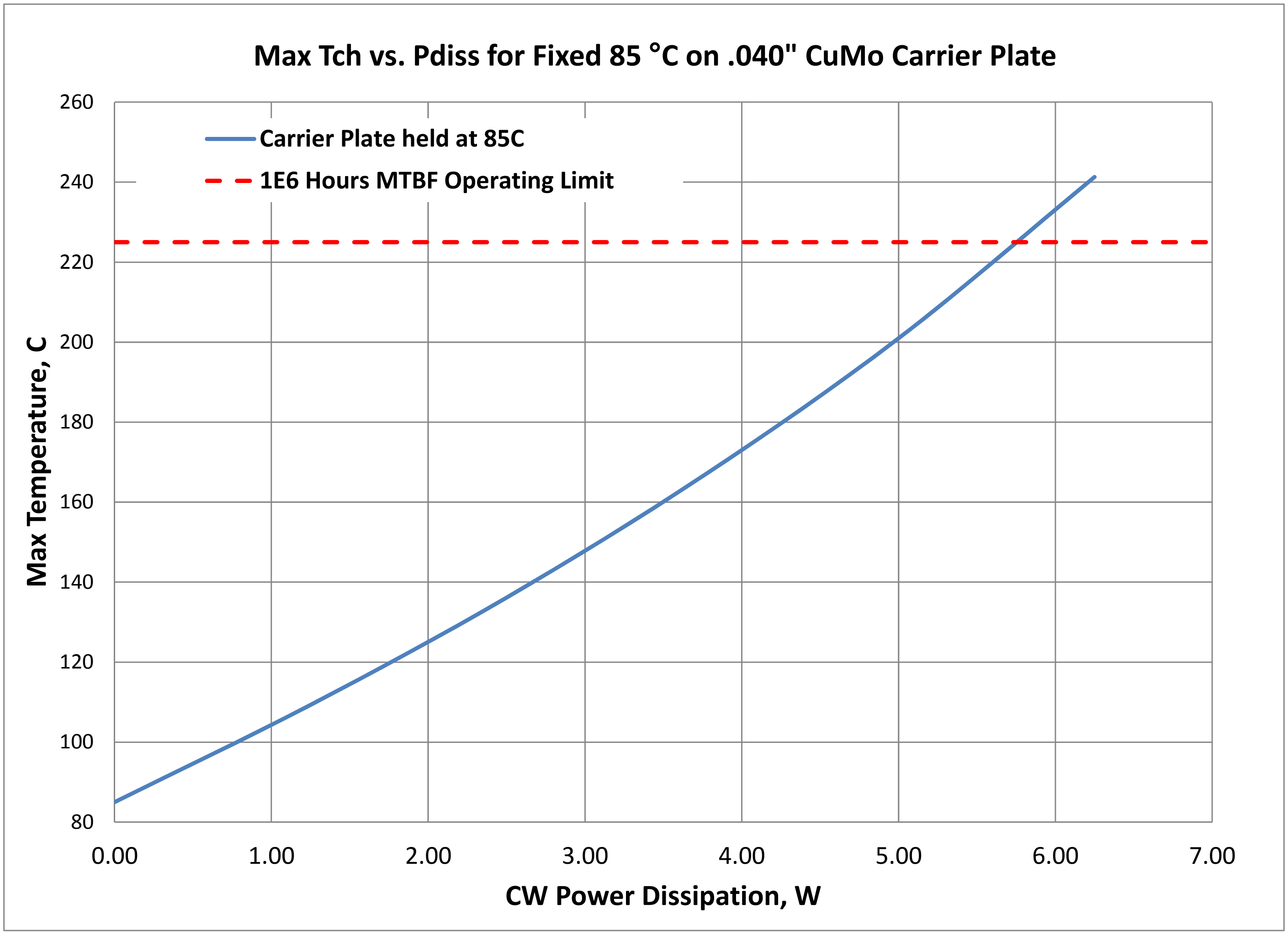
Notes:

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.

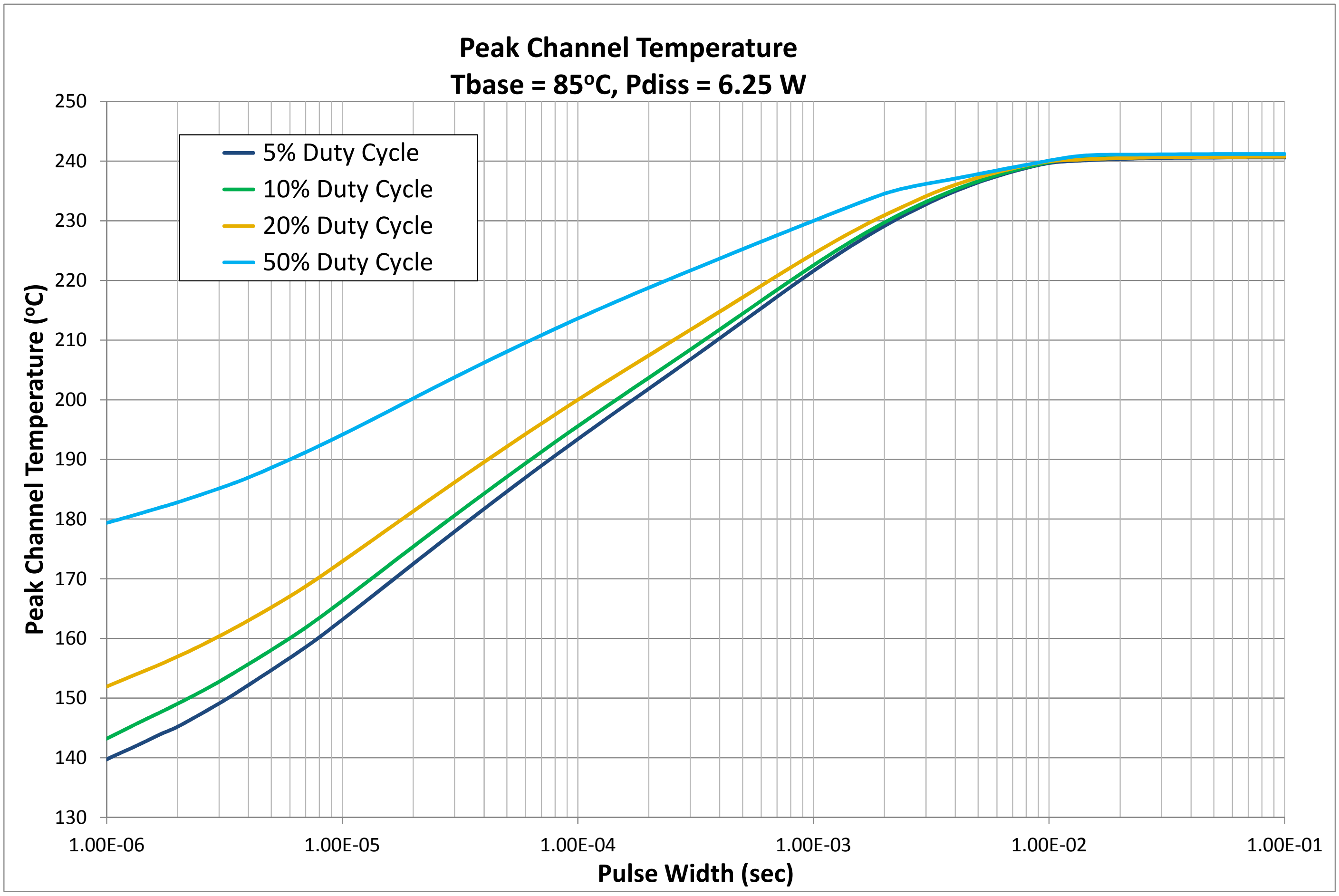
Median Lifetime



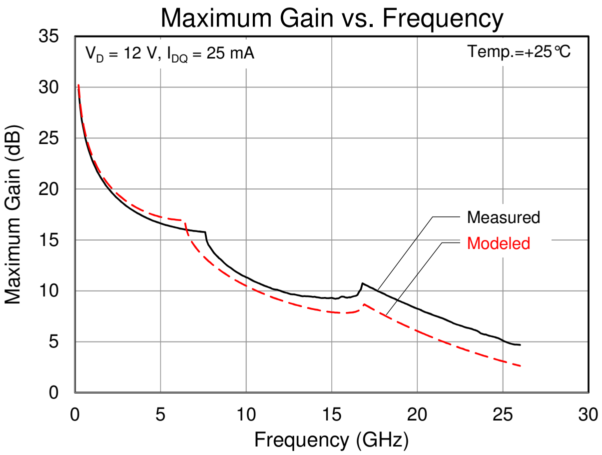
Maximum Channel Temperature - CW

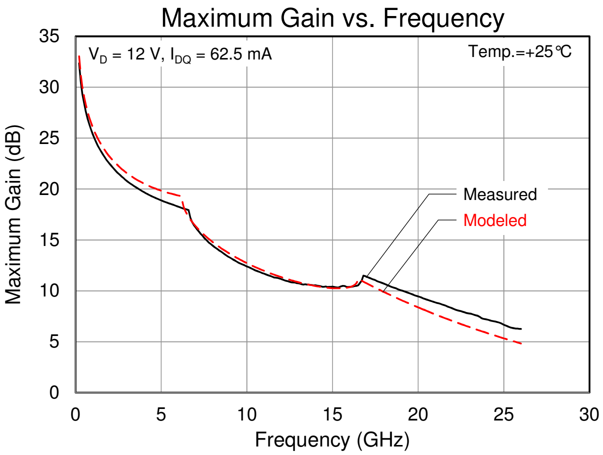


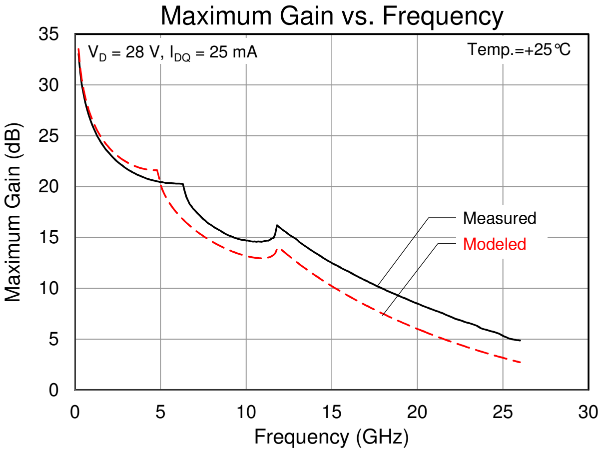
Peak Channel Temperature - Pulsed

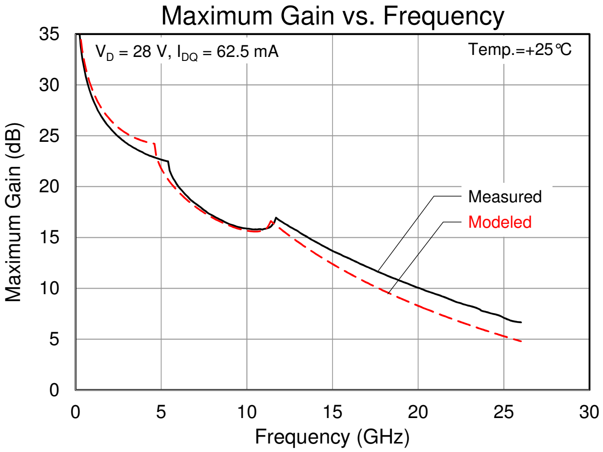


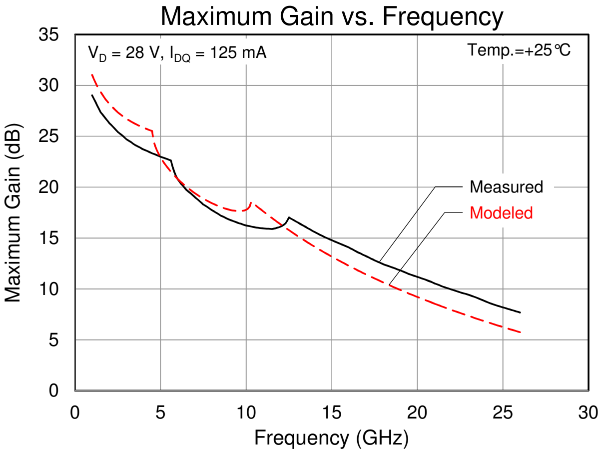
Maximum Gain Performance





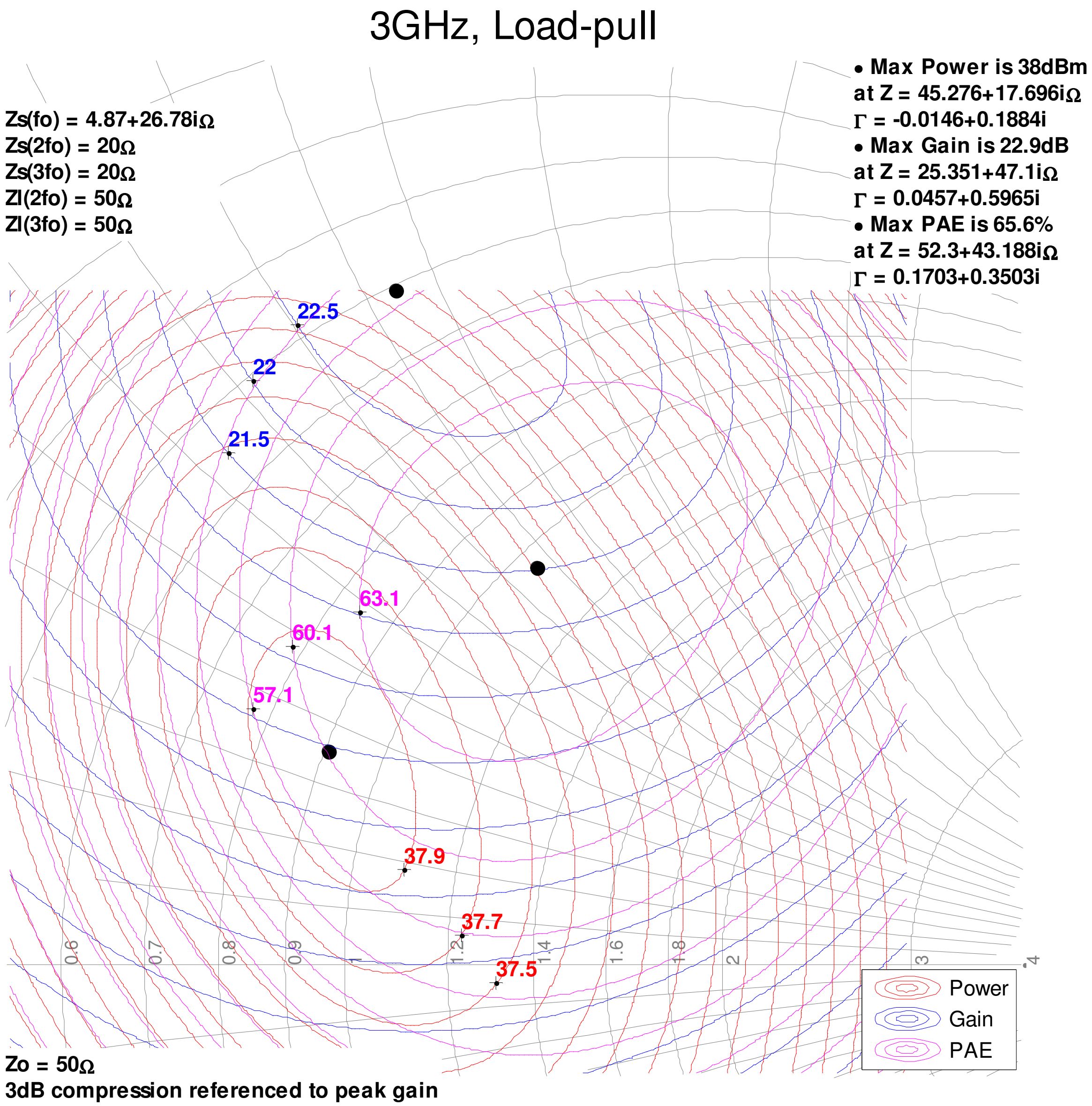






Model Load Pull Contours – 3 GHz

Simulated signal: 10% pulses
Vd = 28 V, Idq = 25 mA



3GHz, Load-pull

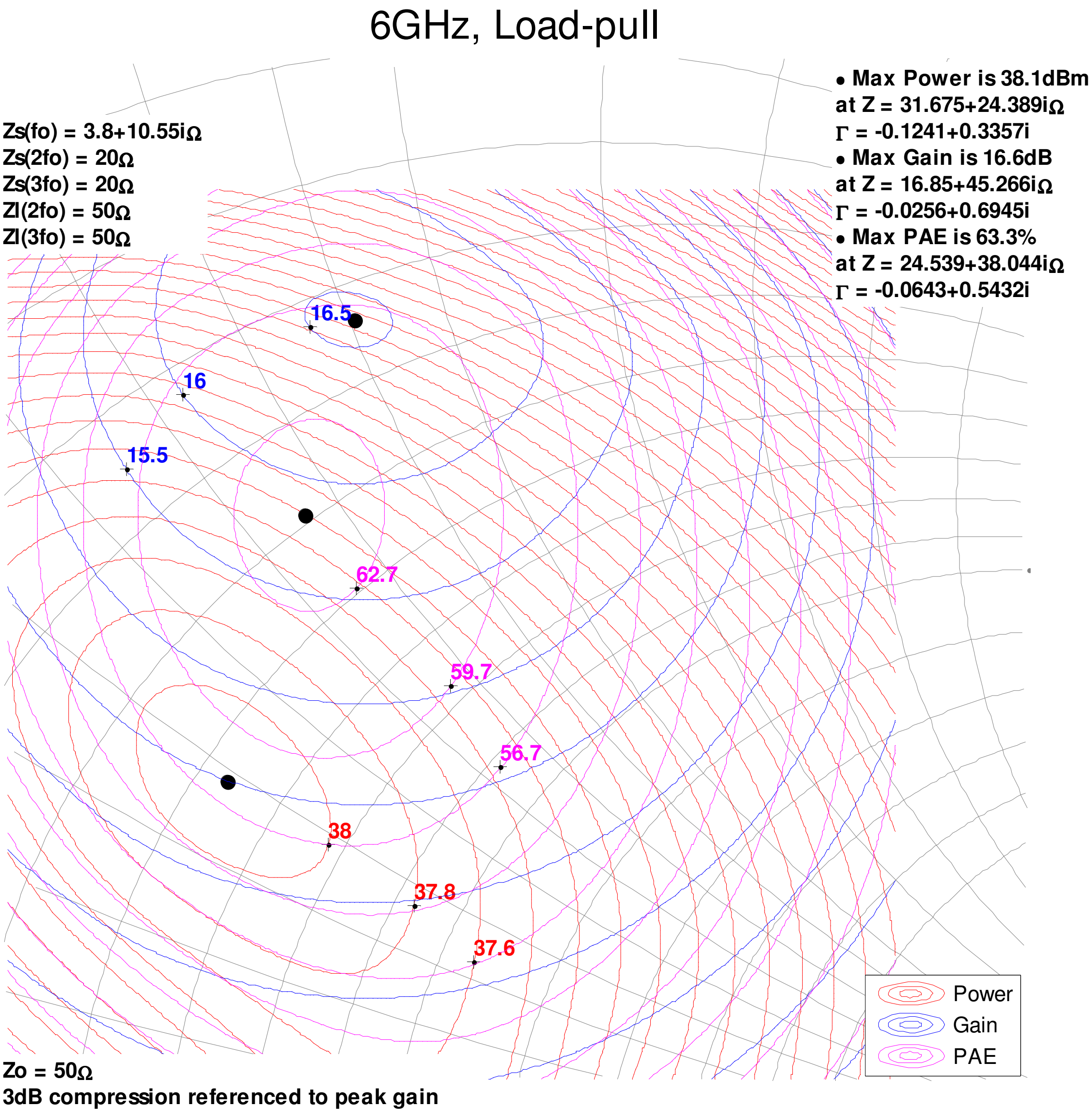
Zs(fo) = 4.87+26.78iΩ
Zs(2fo) = 20Ω
Zs(3fo) = 20Ω
Zl(2fo) = 50Ω
Zl(3fo) = 50Ω

- **Max Power is 38dBm**
at Z = 45.276+17.696iΩ
Γ = -0.0146+0.1884i
- **Max Gain is 22.9dB**
at Z = 25.351+47.1iΩ
Γ = 0.0457+0.5965i
- **Max PAE is 65.6%**
at Z = 52.3+43.188iΩ
Γ = 0.1703+0.3503i

Zo = 50Ω
3dB compression referenced to peak gain

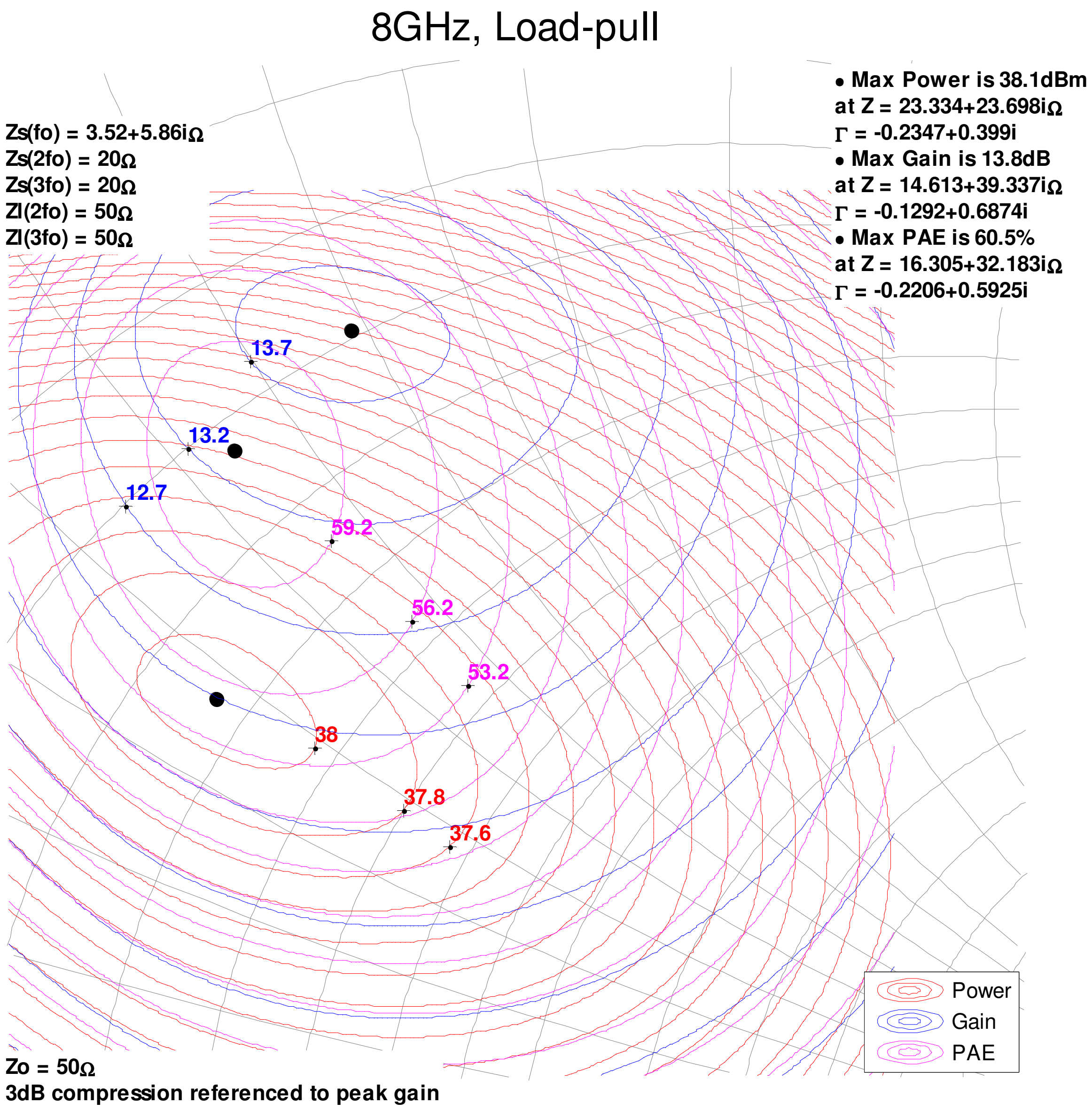
Model Load Pull Contours – 6 GHz

Simulated signal: 10% pulses
Vd = 28 V, Idq = 25 mA



Model Load Pull Contours – 8 GHz

Simulated signal: 10% pulses
Vd = 28 V, Idq = 25 mA


8GHz, Load-pull

Zs(fo) = 3.52+5.86iΩ
Zs(2fo) = 20Ω
Zs(3fo) = 20Ω
Zl(2fo) = 50Ω
Zl(3fo) = 50Ω

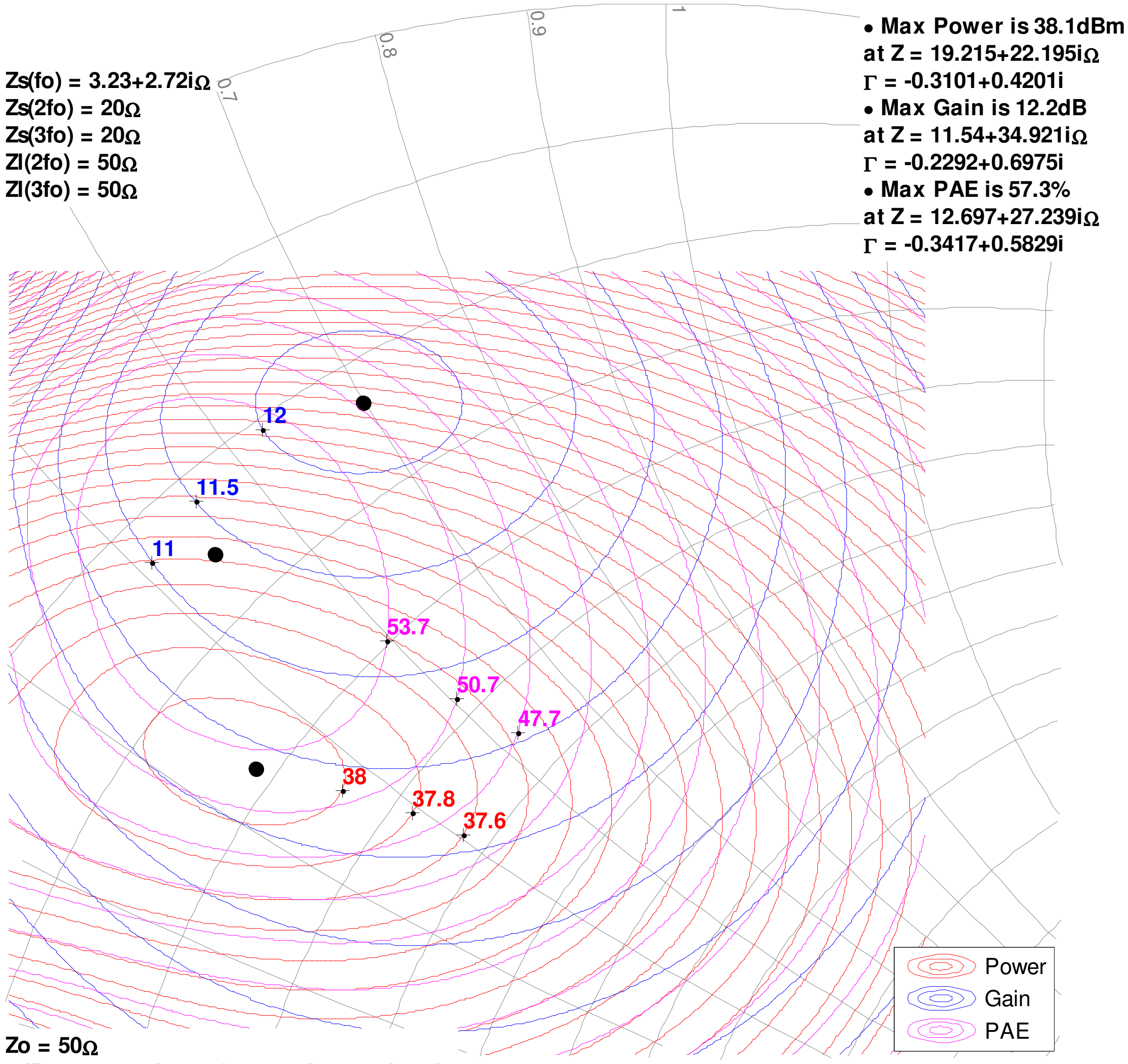
- **Max Power is 38.1dBm**
at Z = 23.334+23.698iΩ
Γ = -0.2347+0.399i
- **Max Gain is 13.8dB**
at Z = 14.613+39.337iΩ
Γ = -0.1292+0.6874i
- **Max PAE is 60.5%**
at Z = 16.305+32.183iΩ
Γ = -0.2206+0.5925i

Zo = 50Ω
3dB compression referenced to peak gain

Model Load Pull Contours

Simulated signal: 10% pulses
Vd = 28 V, Idq = 25 mA

10GHz, Load-pull



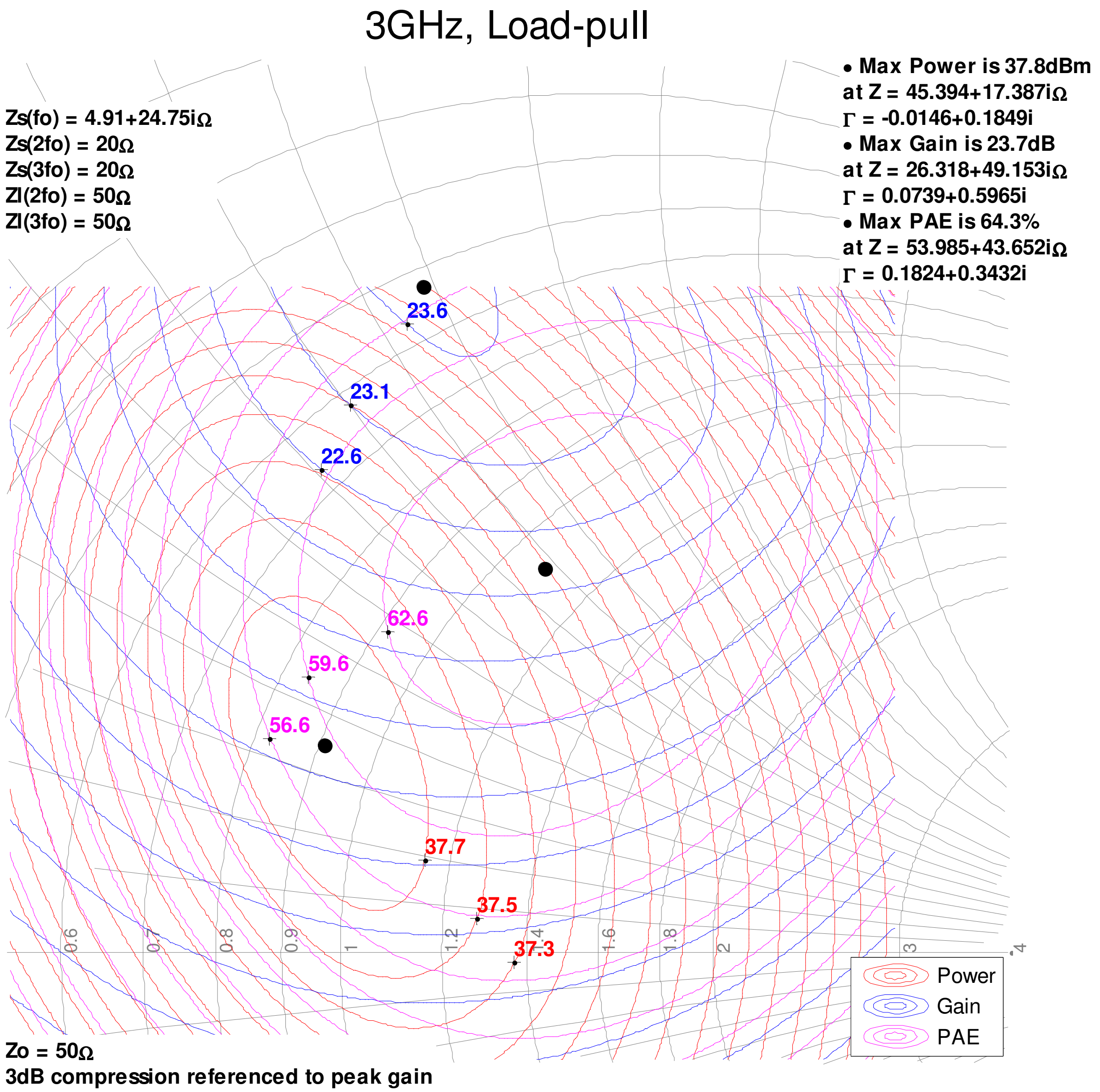
Zs(fo) = 3.23+2.72iΩ
Zs(2fo) = 20Ω
Zs(3fo) = 20Ω
Zl(2fo) = 50Ω
Zl(3fo) = 50Ω

- Max Power is 38.1dBm
at Z = 19.215+22.195iΩ
Γ = -0.3101+0.4201i
- Max Gain is 12.2dB
at Z = 11.54+34.921iΩ
Γ = -0.2292+0.6975i
- Max PAE is 57.3%
at Z = 12.697+27.239iΩ
Γ = -0.3417+0.5829i

Zo = 50Ω
3dB compression referenced to peak gain

Model Load Pull Contours

Simulated signal: 10% pulses
Vd = 28 V, Idq = 62.5 mA



Zs(fo) = 4.91+24.75iΩ
Zs(2fo) = 20Ω
Zs(3fo) = 20Ω
Zl(2fo) = 50Ω
Zl(3fo) = 50Ω

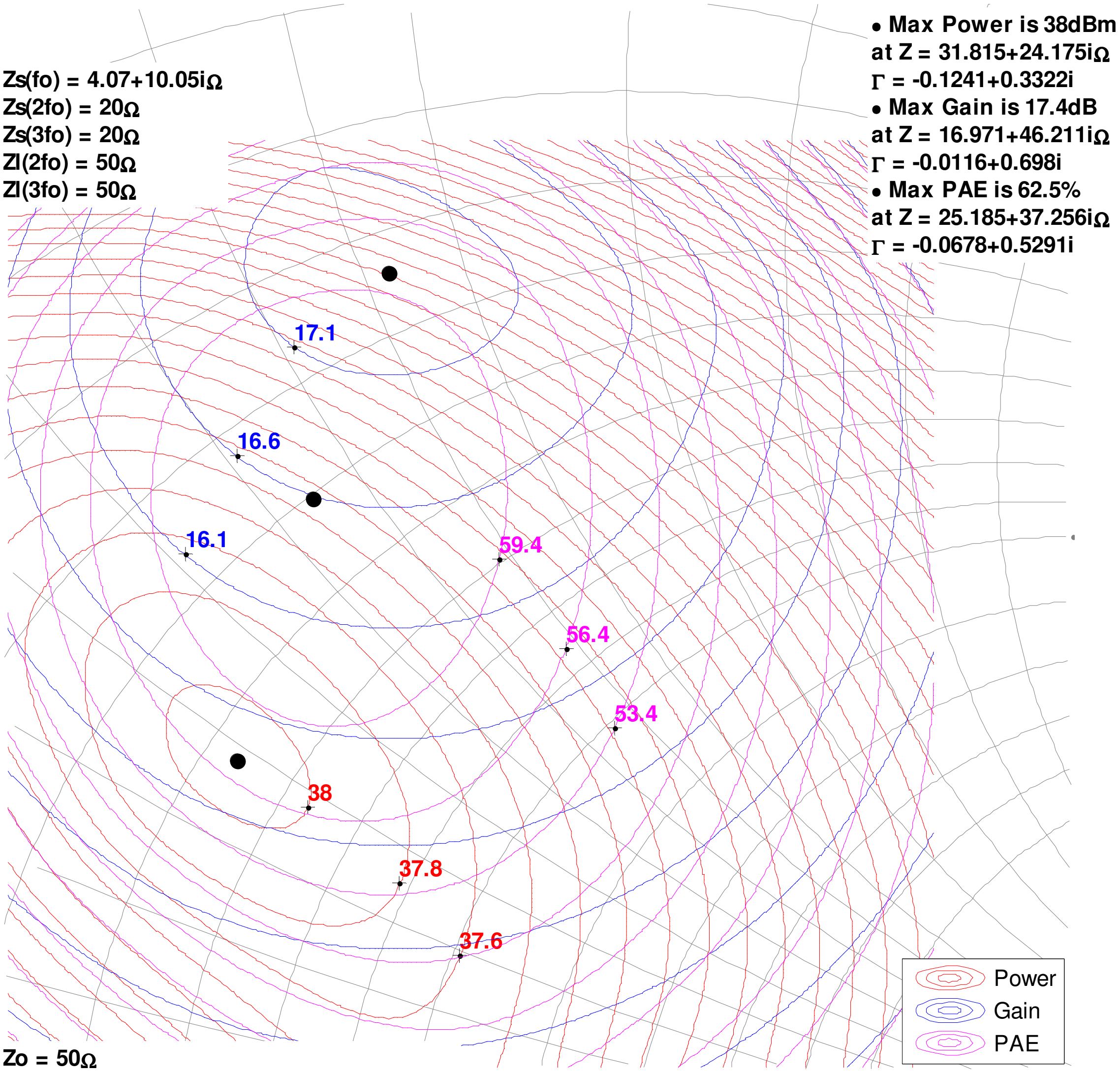
- **Max Power is 37.8dBm**
at Z = 45.394+17.387iΩ
Γ = -0.0146+0.1849i
- **Max Gain is 23.7dB**
at Z = 26.318+49.153iΩ
Γ = 0.0739+0.5965i
- **Max PAE is 64.3%**
at Z = 53.985+43.652iΩ
Γ = 0.1824+0.3432i

Zo = 50Ω
3dB compression referenced to peak gain

Model Load Pull Contours

Simulated signal: 10% pulses
Vd = 28 V, Idq = 62.5 mA

6GHz, Load-pull



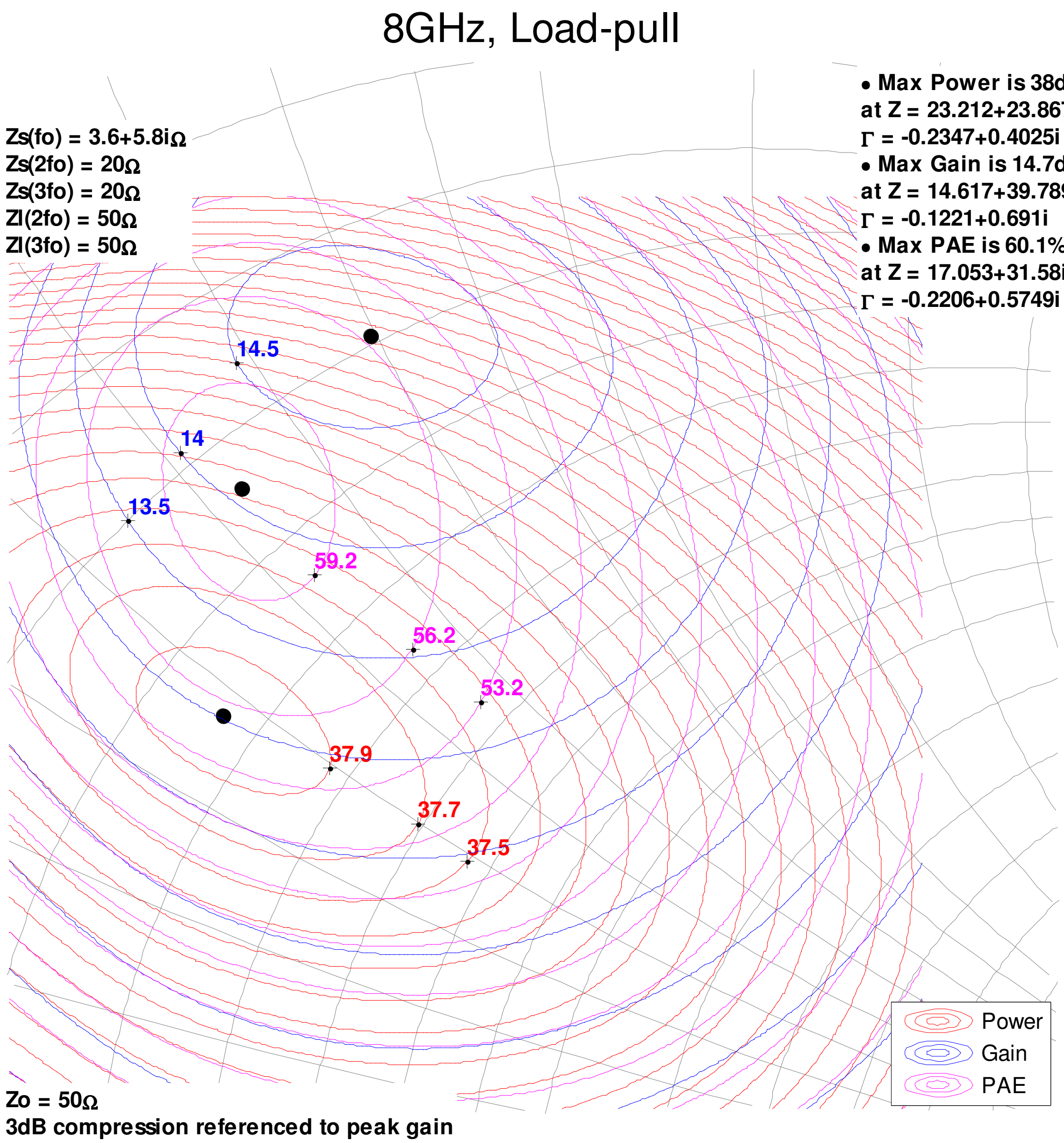
Zs(fo) = 4.07+10.05iΩ
Zs(2fo) = 20Ω
Zs(3fo) = 20Ω
Zl(2fo) = 50Ω
Zl(3fo) = 50Ω

- **Max Power is 38dBm**
at Z = 31.815+24.175iΩ
Γ = -0.1241+0.3322i
- **Max Gain is 17.4dB**
at Z = 16.971+46.211iΩ
Γ = -0.0116+0.698i
- **Max PAE is 62.5%**
at Z = 25.185+37.256iΩ
Γ = -0.0678+0.5291i

Zo = 50Ω
3dB compression referenced to peak gain

Model Load Pull Contours

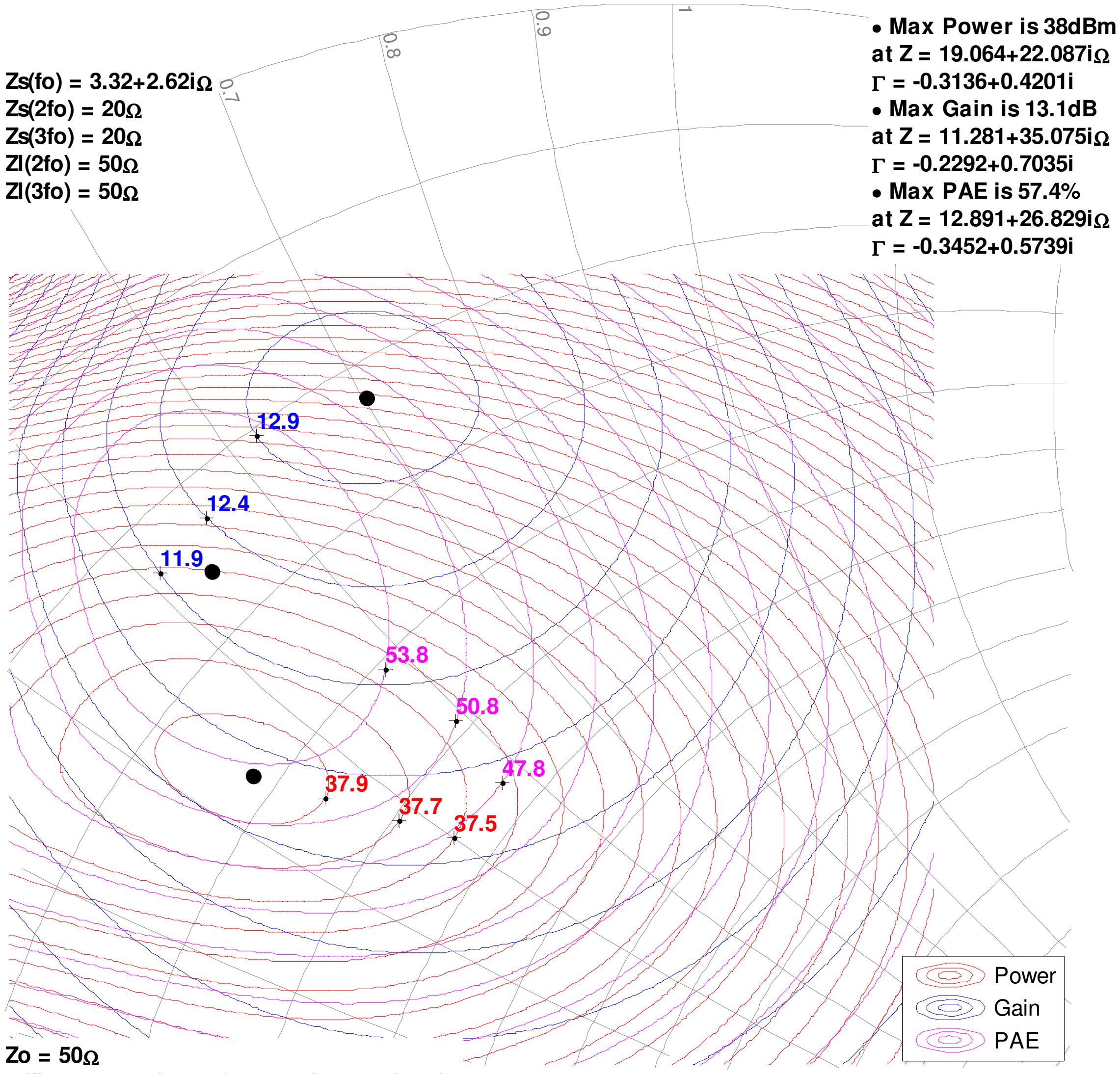
Simulated signal: 10% pulses
Vd = 28 V, Idq = 62.5 mA



Model Load Pull Contours

Simulated signal: 10% pulses
Vd = 28 V, Idq = 62.5 mA

10GHz, Load-pull

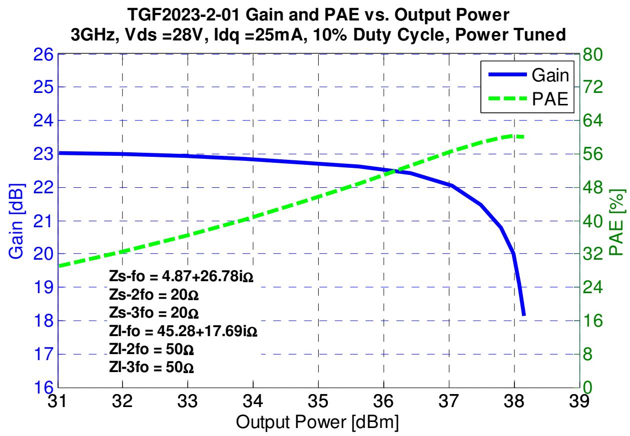


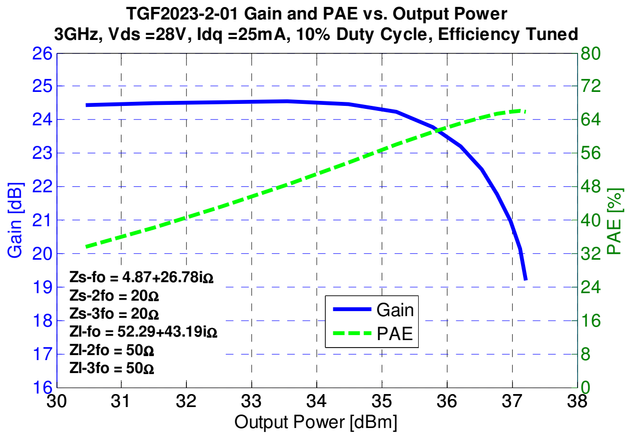
Zs(fo) = 3.32+2.62iΩ
Zs(2fo) = 20Ω
Zs(3fo) = 20Ω
Zl(2fo) = 50Ω
Zl(3fo) = 50Ω

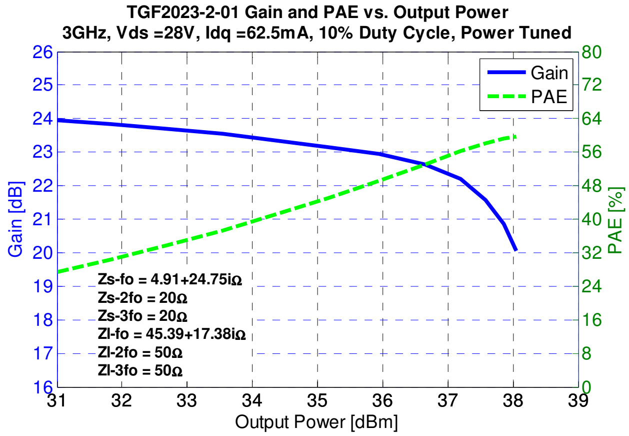
- **Max Power is 38dBm**
at Z = 19.064+22.087iΩ
Γ = -0.3136+0.4201i
- **Max Gain is 13.1dB**
at Z = 11.281+35.075iΩ
Γ = -0.2292+0.7035i
- **Max PAE is 57.4%**
at Z = 12.891+26.829iΩ
Γ = -0.3452+0.5739i

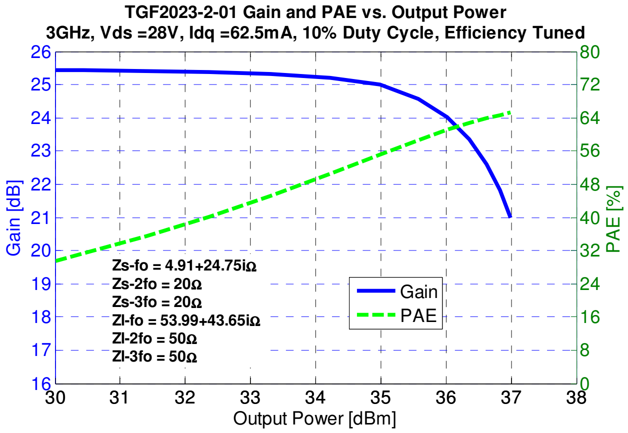
Zo = 50Ω
3dB compression referenced to peak gain

Model Drive-up Data – 3 GHz

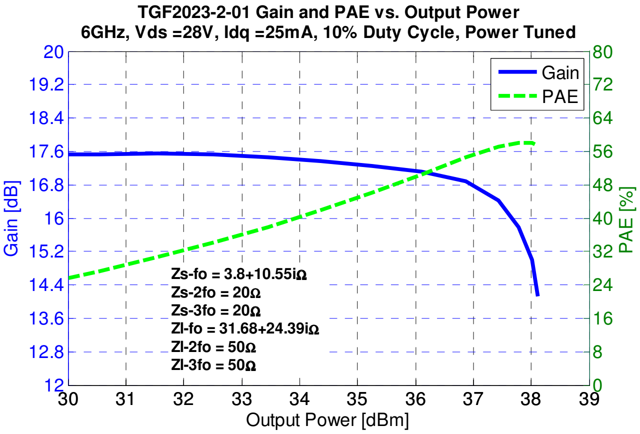




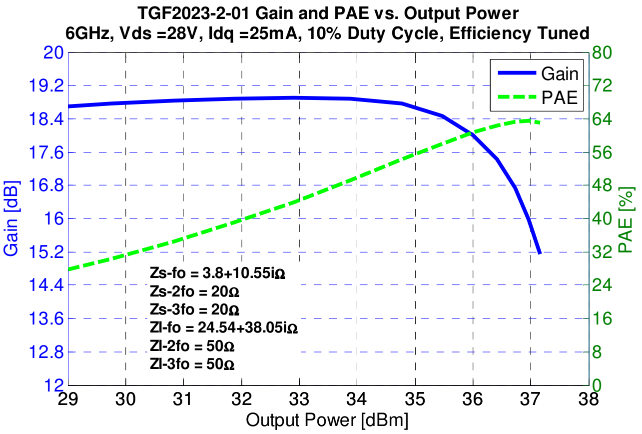




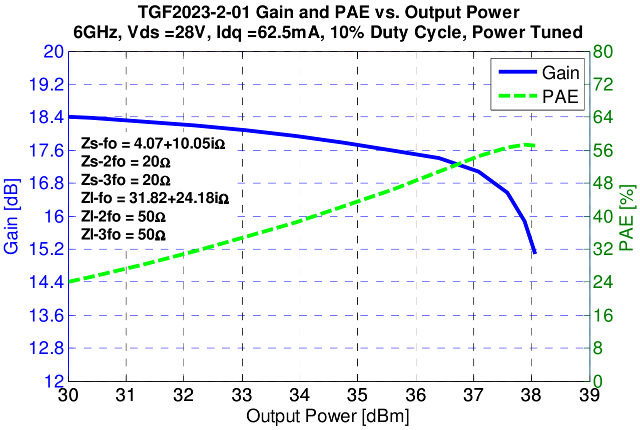
Model Drive-up Data – 6 GHz


TGF2023-2-01 Gain and PAE vs. Output Power
6GHz, Vds =28V, Idq =25mA, 10% Duty Cycle, Power Tuned

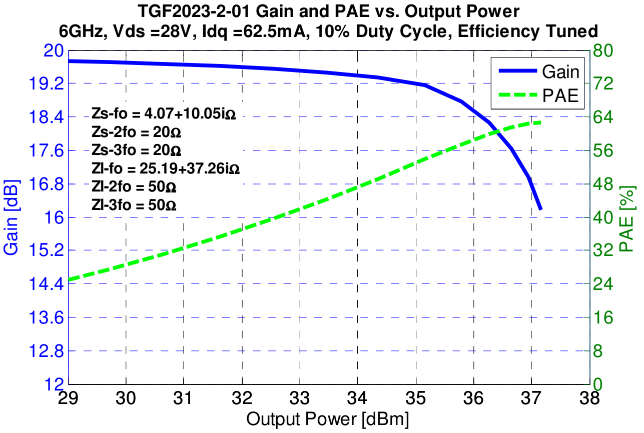
Zs-fo = 3.8+10.55iΩ
Zs-2fo = 20Ω
Zs-3fo = 20Ω
Zl-fo = 31.68+24.39iΩ
Zl-2fo = 50Ω
Zl-3fo = 50Ω


TGF2023-2-01 Gain and PAE vs. Output Power
6GHz, Vds =28V, Idq =25mA, 10% Duty Cycle, Efficiency Tuned

Zs-fo = 3.8+10.55iΩ
Zs-2fo = 20Ω
Zs-3fo = 20Ω
Zl-fo = 24.54+38.05iΩ
Zl-2fo = 50Ω
Zl-3fo = 50Ω

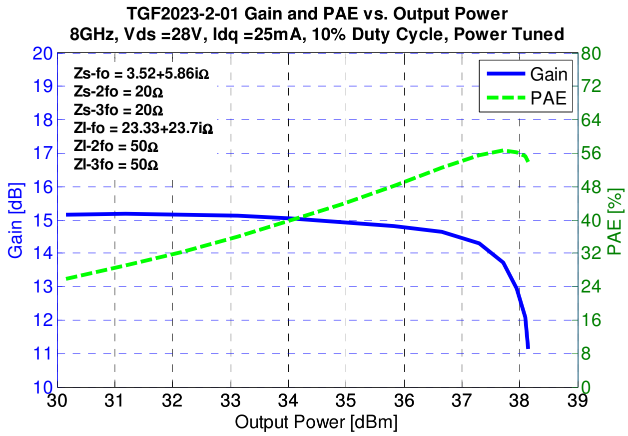

TGF2023-2-01 Gain and PAE vs. Output Power
6GHz, Vds =28V, Idq =62.5mA, 10% Duty Cycle, Power Tuned

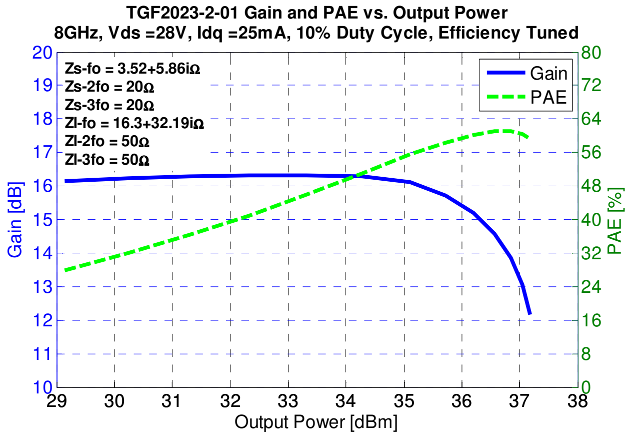
Zs-fo = 4.07+10.05iΩ
Zs-2fo = 20Ω
Zs-3fo = 20Ω
Zl-fo = 31.82+24.18iΩ
Zl-2fo = 50Ω
Zl-3fo = 50Ω

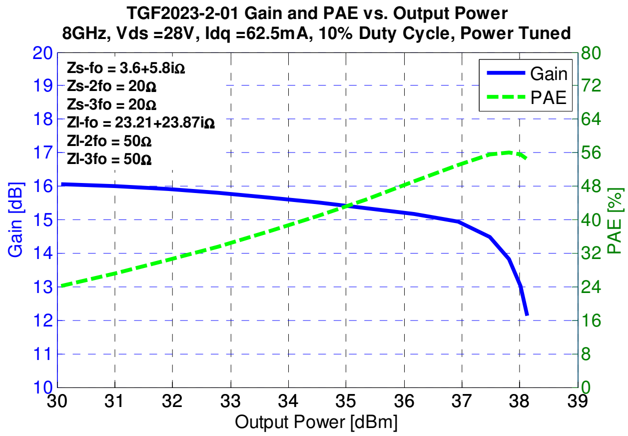

TGF2023-2-01 Gain and PAE vs. Output Power
6GHz, Vds =28V, Idq =62.5mA, 10% Duty Cycle, Efficiency Tuned

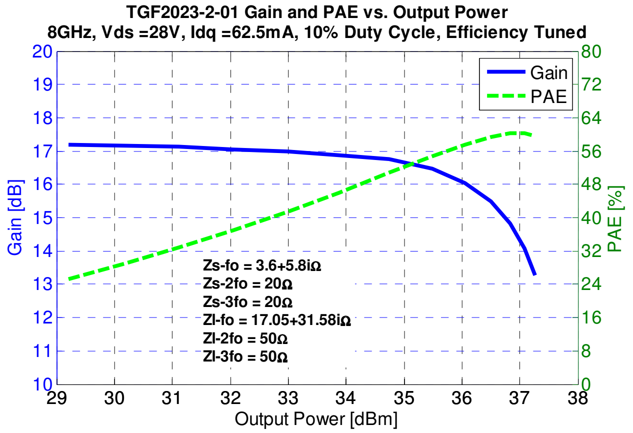
Zs-fo = 4.07+10.05iΩ
Zs-2fo = 20Ω
Zs-3fo = 20Ω
Zl-fo = 25.19+37.26iΩ
Zl-2fo = 50Ω
Zl-3fo = 50Ω

Model Drive-up Data – 8 GHz

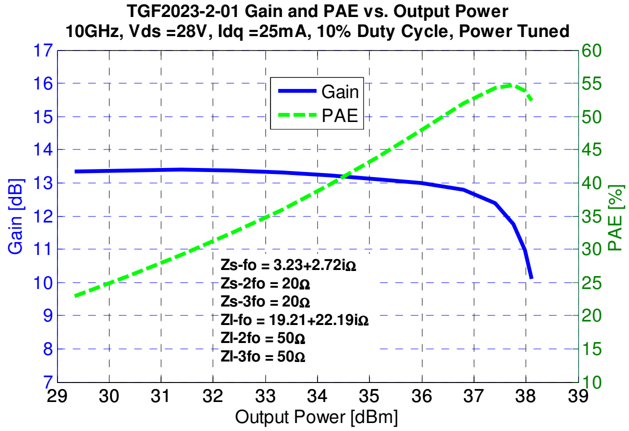

TGF2023-2-01 Gain and PAE vs. Output Power
8GHz, Vds =28V, Idq =25mA, 10% Duty Cycle, Power Tuned

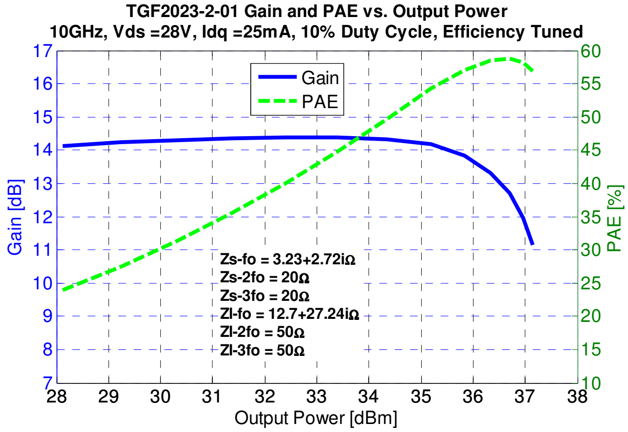

TGF2023-2-01 Gain and PAE vs. Output Power
8GHz, Vds =28V, Idq =25mA, 10% Duty Cycle, Efficiency Tuned

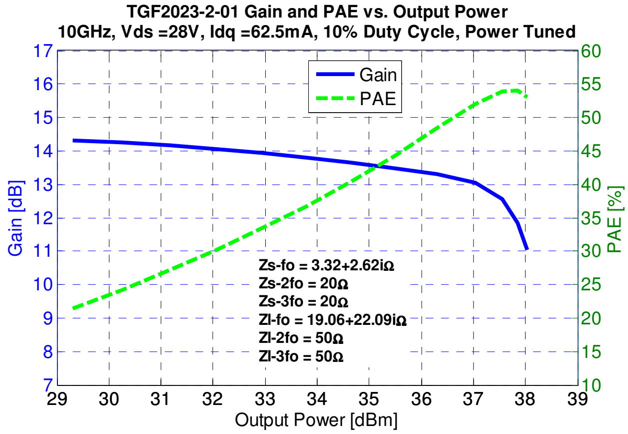

TGF2023-2-01 Gain and PAE vs. Output Power
8GHz, Vds =28V, Idq =62.5mA, 10% Duty Cycle, Power Tuned

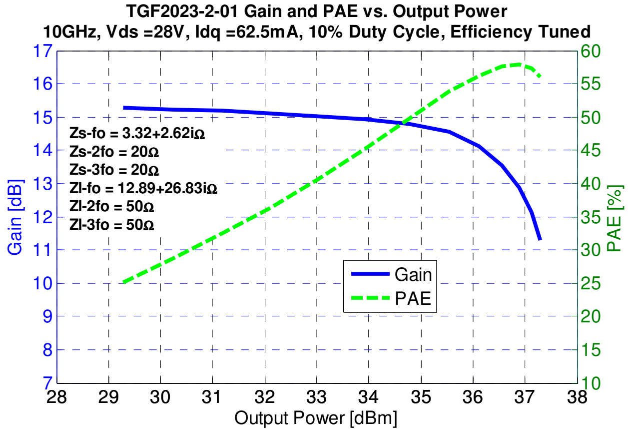

TGF2023-2-01 Gain and PAE vs. Output Power
8GHz, Vds =28V, Idq =62.5mA, 10% Duty Cycle, Efficiency Tuned

Model Drive-up Data – 10 GHz


TGF2023-2-01 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =25mA, 10% Duty Cycle, Power Tuned


TGF2023-2-01 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =25mA, 10% Duty Cycle, Efficiency Tuned

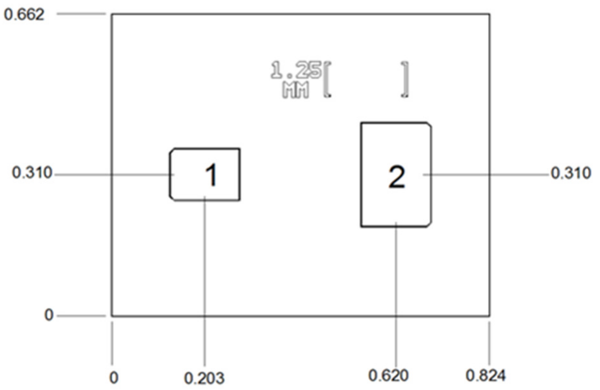

TGF2023-2-01 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =62.5mA, 10% Duty Cycle, Power Tuned


TGF2023-2-01 Gain and PAE vs. Output Power
10GHz, Vds =28V, Idq =62.5mA, 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	Gate	0.154 x 0.115
2	Drain	0.154 x 0.230
Die Backside	Source / Ground	0.662 x 0.824

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 70 mA.
3. Set V_D to 28 V.
4. Adjust V_G more positive until quiescent I_D is 62.5 mA.
5. Set I_D limit to 500 mA.
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.