

GaN Amplifier 28 V, 8 W 1.8 - 2.7 GHz



MACOM PURE CARBIDE®

MAPC-A1109

Rev. V2

Features

- MACOM PURE CARBIDE® Amplifier Series
- Optimized for 1.8 to 2.7 GHz Applications
- High Terminal Impedances for Broadband Performance
- 20 V to 28 V Operation
- Low thermal resistance
- 100% RF Tested
- RoHS* Compliant



4 x 4 mm QFN

Applications

- Aerospace & Defense

Description

The MAPC-A1109 is a GaN on Silicon Carbide HEMT D-mode amplifier suitable for applications 1 W average power and optimized for 1.8 - 2.7 GHz modulated signal operation. The device supports pulsed, and linear operation with peak output power levels to 8 W (39 dBm) in an 4 mm surface mount QFN package.

Typical Driver Performance:

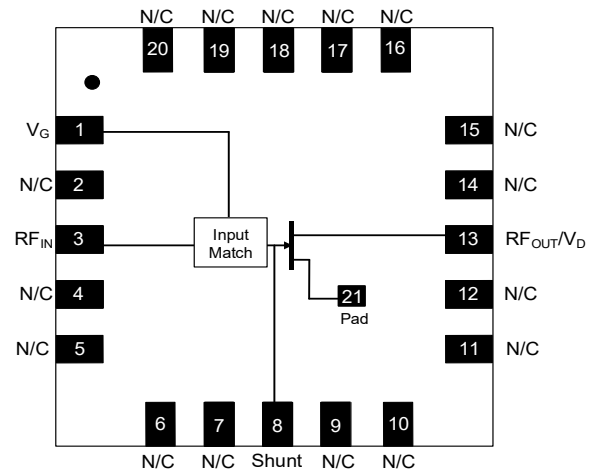
- WCDMA 3GPP TM1, 10 dB PAR @ 0.01% CCDF. $V_{DS} = 24$ V, $I_{DQ} = 48$ mA, $T_C = 25^\circ\text{C}$, $P_{OUT} = 32$ dBm

Frequency (GHz)	GP (dB)	η_D	Output PAR (dB)	ACPR (dBc)
1.8	17.2	40	7.8	-32.3
2.3	16.9	38	7.7	-34.1
2.7	16.8	40	7.8	-35.5

Ordering Information

Part Number	Package
MAPC-A1109-AQ	Bulk Quantity
MAPC-A1109-SB	Sample Board

Functional Schematic



Pin Configuration

Pin #	Pin Name	Function
1	V_G	Gate Voltage
2, 4-7, 9-12, 14-20	N/C	Not Connected
3	RF_{IN}	RF Input
8	SHUNT	Gate Shunt Capacitor
13	RF_{OUT} / V_D	RF Output / Drain Voltage
21	Pad ¹	Ground / Source

1. The pad on the package bottom must be connected to RF, DC and thermal ground.

1 * Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

RF Electrical Characteristics: $T_C = 25^\circ\text{C}$, $V_{DS} = 24\text{V}$, $I_{DQ} = 48\text{ mA}$

Note: Performance in MACOM Single-ended Class-AB Evaluation Circuit, 50 Ω system.

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	Pulsed ² , 2.7 GHz	G_{SS}	-	17.2	-	dB
Saturated Output Power	Pulsed ² , 2.7 GHz	P_{SAT}	-	38.9	-	dBm
Drain Efficiency at Saturation	Pulsed ² , 2.7 GHz	η_{SAT}	-	73.5	-	%
Modulated Peak Power	WCDMA ³ , 2.7 GHz	$P_{2.5dB}^4$	-	40.1	-	dBm
Gain Flatness in 60MHz	WCDMA ³ , $P_{OUT} = 32\text{ dBm}$	G_F	-	0.1	-	dB
Gain Variation (-25°C to $+105^\circ\text{C}$)	WCDMA ³ , 2.7 GHz, $P_{OUT} = 32\text{ dBm}$	ΔG	-	0.016	-	dB/ $^\circ\text{C}$
Power Variation (-25°C to $+105^\circ\text{C}$)	Pulsed ² , 2.7 GHz	$\Delta P_{2.5dB}$	-	0.007	-	dBm/ $^\circ\text{C}$
Power Gain	WCDMA ³ , 2.7 GHz, $P_{OUT} = 32\text{ dBm}$	G_P	-	16.8	-	dB
Drain Efficiency	WCDMA ³ , 2.7 GHz, $P_{OUT} = 32\text{ dBm}$	η	-	40	-	%
Output CCDF @ 0.01%	WCDMA ³ , 2.7 GHz, $P_{OUT} = 32\text{ dBm}$	PAR	-	7.8	-	dB
Adjacent Channel Power	WCDMA ³ , 2.7 GHz, $P_{OUT} = 32\text{ dBm}$	ACP	-	-35.5	-	dBc
Input Return Loss	WCDMA ³ , 2.7 GHz, $P_{OUT} = 32\text{ dBm}$	IRL	-	-14	-	dB
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 10:1, No Device Damage			

RF Electrical Characteristics: $T_A = 25^\circ\text{C}$, $V_{DS} = 28\text{V}$, $I_{DQ} = 48\text{ mA}$

Note: Performance in MACOM Single-ended Class-AB Production Test Fixture, 50 Ω system.

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	WCDMA ³ , 2.7 GHz, $P_{OUT} = 33\text{ dBm}$	G_P	14.0	16.1	-	dB
Drain Efficiency	WCDMA ³ , 2.7 GHz, $P_{OUT} = 33\text{ dBm}$	η	34	42	-	%
Output CCDF @ 0.01%	WCDMA ³ , 2.7 GHz, $P_{OUT} = 33\text{ dBm}$	PAR	6.2	6.9	-	dB
Adjacent Channel Power	WCDMA ³ , 2.7 GHz, $P_{OUT} = 33\text{ dBm}$	ACP	-	-35	-30	dBc
Input Return Loss	WCDMA ³ , 2.7 GHz, $P_{OUT} = 33\text{ dBm}$	IRL	-	-5	-4	dB

DC Electrical Characteristics: $T_C = 25^\circ\text{C}$

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Drain-Source Leakage Current	$V_{GS} = -8\text{ V}$, $V_{DS} = 84\text{ V}$	I_{DLK}	-	-	2.16	mA
Gate-Source Leakage Current	$V_{GS} = -8\text{ V}$, $V_{DS} = 0\text{ V}$	I_{GLK}	-	-	-2.16	mA
Gate Threshold Voltage	$V_{DS} = 28\text{ V}$, $I_D = 2.16\text{ mA}$	V_T	-2.6	-2.0	-1.6	V
Gate Quiescent Voltage	$V_{DS} = 28\text{ V}$, $I_D = 48\text{ mA}$	V_{GSQ}	-	-1.8	-	V
On Resistance	$V_{GS} = 2\text{ V}$, $I_D = 24\text{ mA}$	R_{ON}	-	0.8	-	Ω
Maximum Drain Current	$V_{DS} = 7\text{ V}$, pulse width 300 μs	$I_{D, MAX}$	-	2.6	-	A

2. Pulse details: 100 μs pulse width, 1 ms period, 10% Duty Cycle

3. Modulated Signal: 3.84MHz, WCDMA 3GPP TM1 64 DPCH, 9.9dB PAR @ 0.01% CCDF

4. $P_{2.5dB} = P_{OUT} + 7.5\text{ dB}$ where P_{OUT} is the average output power measured using a modulated signal⁵ where the output PAR is compressed to 7.5 dB @ 0.01% probability CCDF.

Absolute Maximum Ratings^{5,6,7,8,9}

Parameter	Absolute Maximum
Drain Source Voltage, V_{DS}	84V
Gate Source Voltage, V_{GS}	-10 to 3 V
Gate Current, I_G	2.2 mA
Storage Temperature Range	-65°C to +150°C
Case Operating Temperature Range	-40°C to +120°C
Channel Operating Temperature Range, T_{CH}	-40°C to +225°C
Absolute Maximum Channel Temperature	+225°C

5. Exceeding any one or combination of these limits may cause permanent damage to this device.
6. MACOM does not recommend sustained operation above maximum operating conditions.
7. Operating at drain source voltage $V_{DS} < 28$ V will ensure $MTTF > 1 \times 10^6$ hours.
8. Operating at nominal conditions with $T_{CH} \leq 225^\circ\text{C}$ will ensure $MTTF > 1 \times 10^6$ hours.
9. $MTTF$ may be estimated by the expression $MTTF \text{ (hours)} = A e^{\left[\frac{B}{T} + C/(T+273)\right]}$ where T is the channel temperature in degrees Celsius., $A = \text{TBD}$, $B = \text{TBD}$, and $C = \text{TBD}$.

Thermal Characteristics¹⁰

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance using Finite Element Analysis	$V_{DS} = 28$ V $T_C = 85^\circ\text{C}$, $T_{CH} = 150^\circ\text{C}$	$R_{\theta}(\text{FEA})$	10.1	°C/W

10. Case temperature measured using thermocouple embedded in heat-sink. Contact local applications support team for more details on this measurement.

Handling Procedures

Please observe the following precautions to avoid damage:

Static Sensitivity

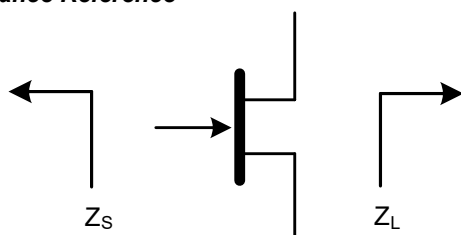
These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

Pulsed² Load-Pull Performance: Reference Plane at Device Leads

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power					
		$V_{\text{DS}} = 28 \text{ V}$, $I_{\text{DQ}} = 48 \text{ mA}$, $T_{\text{C}} = 25^{\circ}\text{C}$, P2.5dB					
		Z_{LOAD}^{11} (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_{D} (%)	AM/PM ($^{\circ}$)
1.8	41.1 - j7.4	24.0 + j3.0	15.5	40.7	11.7	57.3	100.3
2.3	29.4 - j15.7	22.8 + j0.0	15.1	40.6	11.5	54.2	62.6
2.7	30.1 - j37.4	23.1 + j6.8	15.9	40.0	10.0	60.8	35.4

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency					
		$V_{\text{DS}} = 28 \text{ V}$, $I_{\text{DQ}} = 48 \text{ mA}$, $T_{\text{C}} = 25^{\circ}\text{C}$, P2.5dB					
		Z_{LOAD}^{12} (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_{D} (%)	AM/PM ($^{\circ}$)
1.8	32.2 - j9.0	35.7 + j25.3	17.0	39.2	8.3	69.7	87.7
2.3	25.7 - j21.2	33.6 + j29.0	16.6	38.8	7.6	69.5	49.9
2.7	28.4 - j44.2	22.1 + j30.5	16.7	37.8	6.0	73.5	21.3

Impedance Reference



Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.

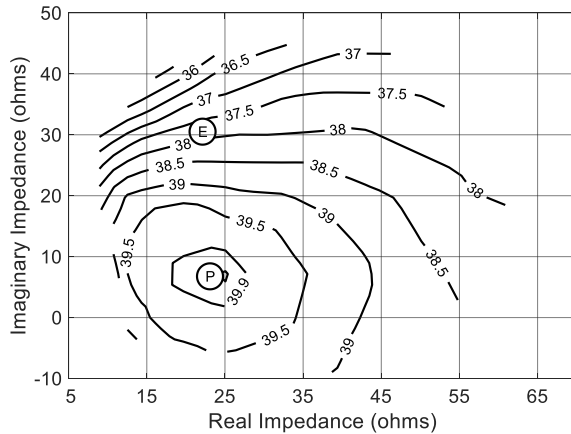
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

11. Load Impedance for optimum output power.

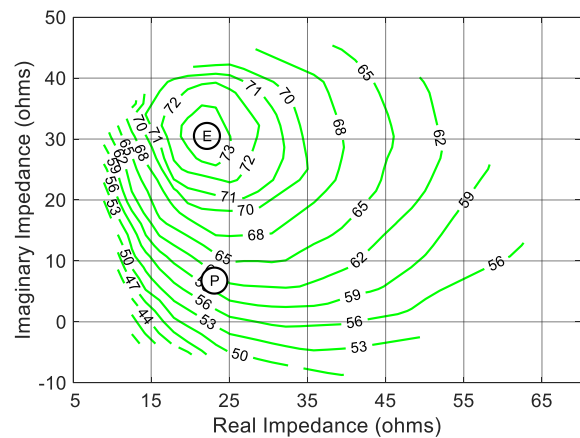
12. Load Impedance for optimum efficiency.

Pulsed² Load-Pull Performance @ 2.7 GHz

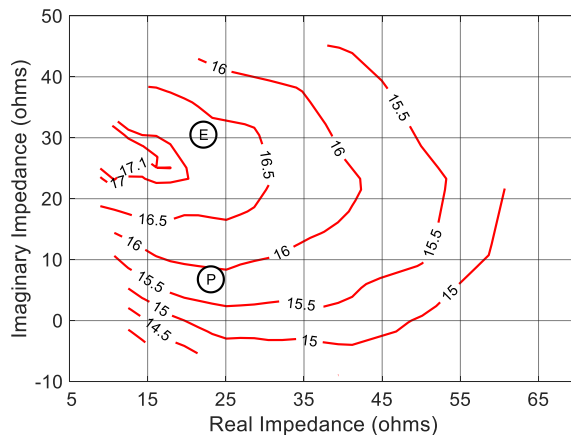
P2.5dB Loadpull Output Power Contours (dBm)



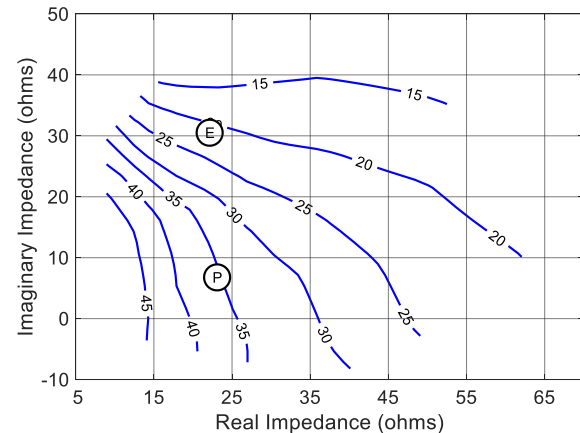
P2.5dB Loadpull Drain Efficiency Contours (%)



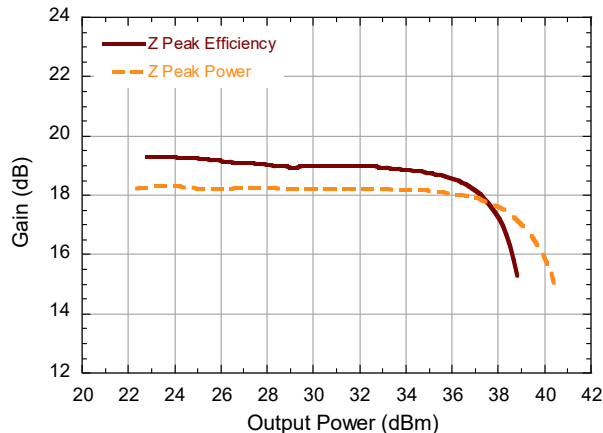
P2.5dB Loadpull Gain Contours (dB)



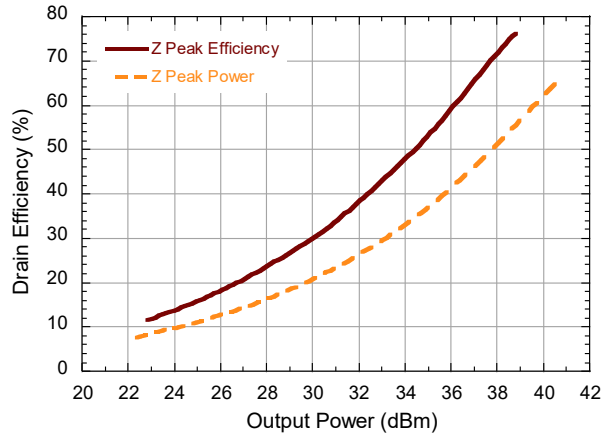
P2.5dB Loadpull AM/PM Contours (°)



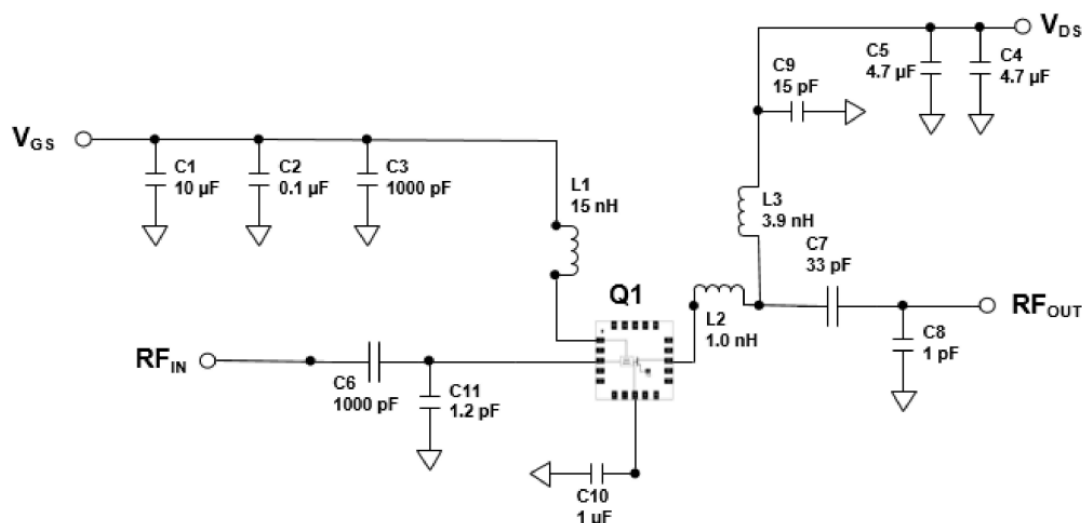
Gain vs. Output Power



Drain Efficiency vs. Output Power



Evaluation Test Fixture and Recommended Tuning Solution 1.8 - 2.7 GHz



Description

Parts measured on evaluation board (20-mil thick RO4350). Matching is provided using a combination of lumped elements and transmission lines as shown in the simplified schematic above. Recommended tuning solution component placement, transmission lines, and details are shown on the next page.

Bias Sequencing

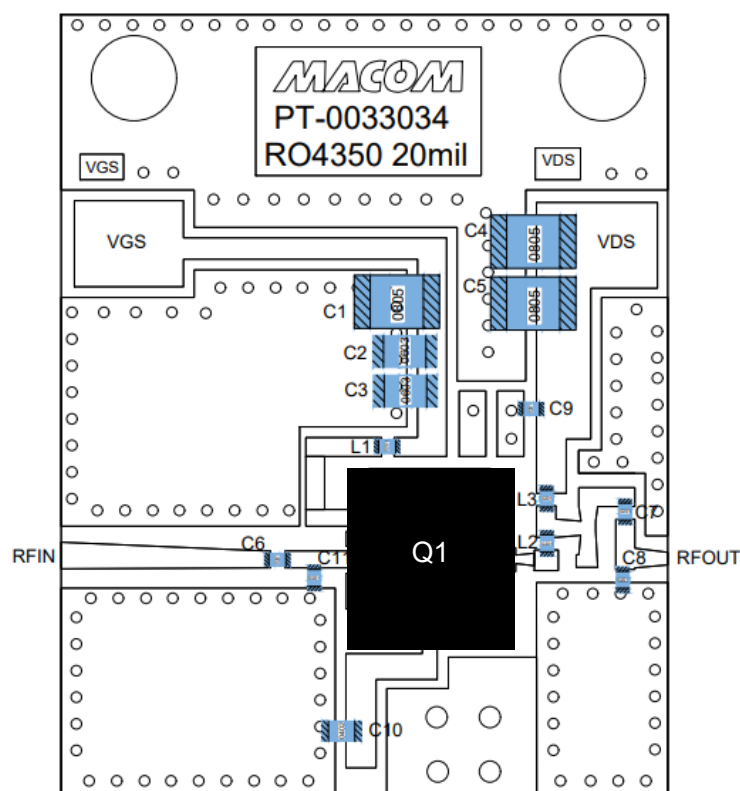
Turning the device ON

1. Set V_{GS} to pinch-off (V_P).
2. Turn on V_{DS} to nominal voltage (24 V).
3. Increase V_{GS} until I_{DS} current is reached.
4. Apply RF power to desired level.

Turning the device OFF

1. Turn the RF power OFF.
2. Decrease V_{GS} down to V_P pinch-off.
3. Decrease V_{DS} down to 0 V.
4. Turn off V_{GS} .

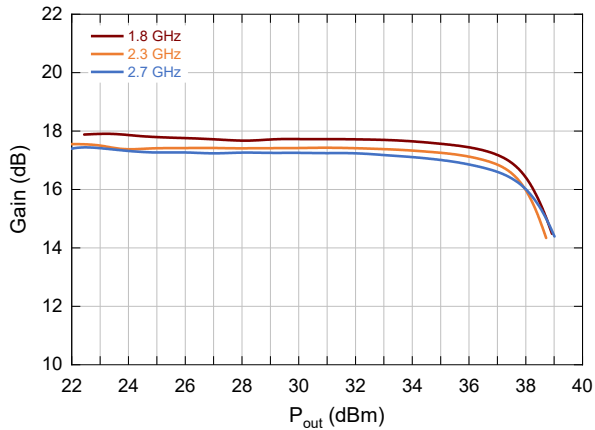
Evaluation Board and Recommended Tuning Solution 1.8 - 2.7 GHz



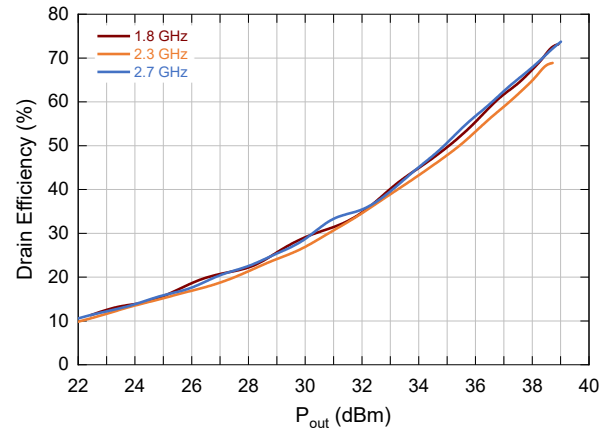
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1	10 μ F	+/- 20%	TDK Corporation	C2012X5R1C106M085AC
C2	0.1 μ F	+/- 10%	Murata	GCM21BR72A104KA37L
C3	1000 pF	+/- 5%	Murata	GRM1555C1H102JA01D
C4, C5	4.7 μ F	+/- 10%	Murata	GRM21BC81H475KE11L
C6	1000 pF	+/- 5%	Murata	GRM0335C1H102JE01D
C7	33 pF	+/- 5%	Murata	GRM0335C2A330JA01D
C8	1 pF	+/- 0.05pF	Murata	GJM0335C1H1R0WB01D
C9	15 pF	+/- 5%	Murata	GRM0335C2A150JA01D
C10	1 μ F	+/- 10%	Murata	GRM155Z71A105KE01D
C11	1.2 pF	+/- 0.05pF	Murata	GJM0335C1H1R20WB01D
L1	15 nH	+/- 3%	Murata	LQP03HQ15NH02
L2	1 nH	+/- 0.1nH	Murata	LQP03HQ1N0B02
L3	3.9 nH	+/- 0.1nH	Murata	LQP03HQ3N9B02
Q1			MACOM	MAPC-A1109
PCB	RO4350, 20mil, 1oz Cu, Tin Lead Finish			

Typical Performance Curves as Measured in the 1.8 - 2.7 GHz Evaluation Board:
Pulsed² 2.7 GHz, $V_{DS} = 24$ V, $I_{DQ} = 48$ mA, $T_C = 25^\circ\text{C}$
Unless Otherwise Noted

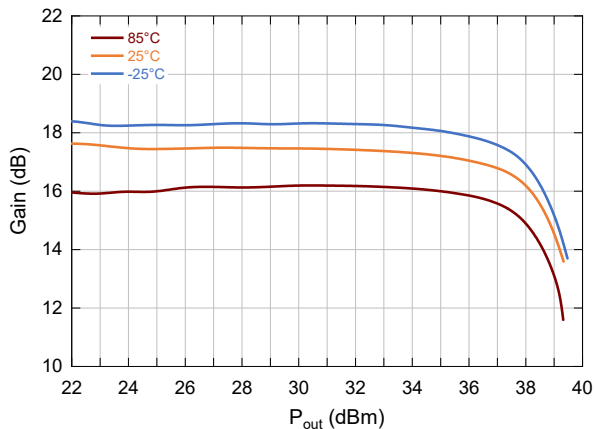
Gain vs. Output Power and Frequency



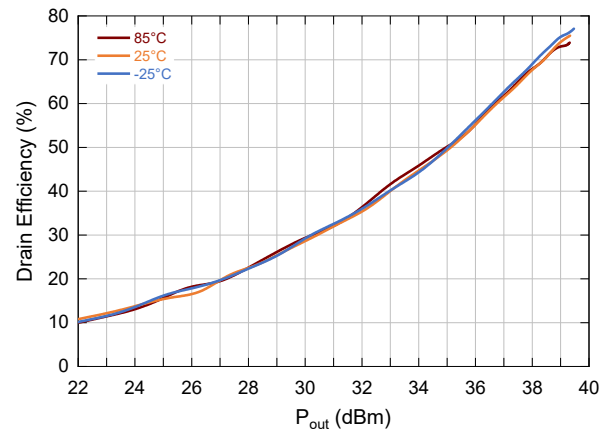
Drain Efficiency vs. Output Power and Frequency



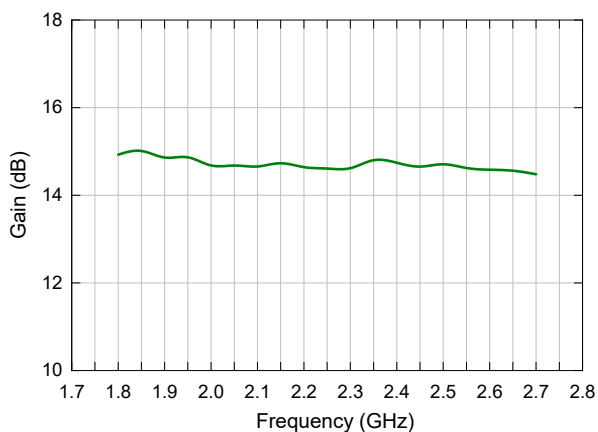
Gain vs. Output Power and T_C



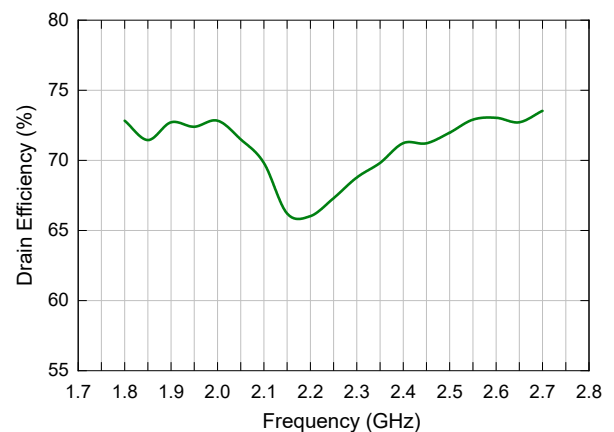
Drain Efficiency vs. Output Power and T_C



Gain vs. Frequency, 3dB Gain Compression



Drain Efficiency vs. Frequency, 3dB Gain Compression

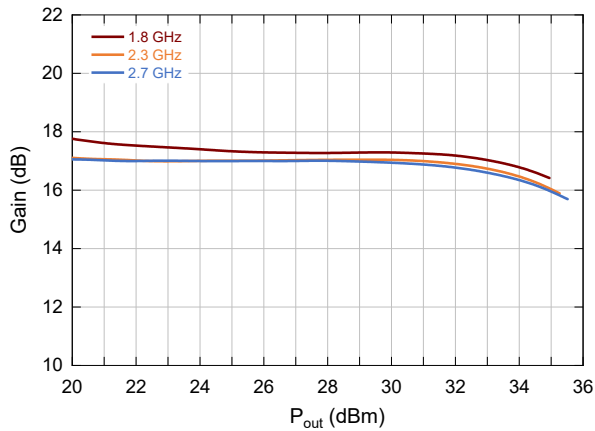


Typical Performance as Measured in the 1.8 - 2.7 GHz Evaluation Board:

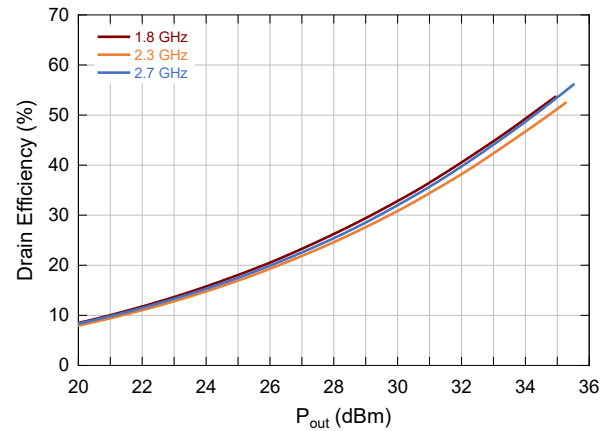
WCDMA 3GPP TM1 64 DPCH 9.9 dB PAR @ 0.01% CCDF

$V_{DS} = 24\text{ V}$, $I_{DQ} = 48\text{ mA}$, $T_{CASE} = 25\text{ }^{\circ}\text{C}$

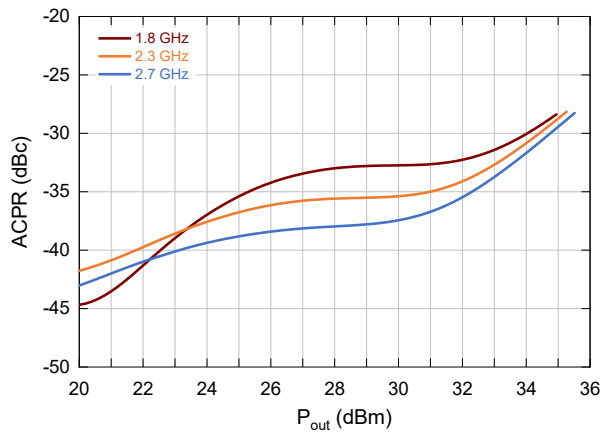
Gain vs. Output Power and Frequency



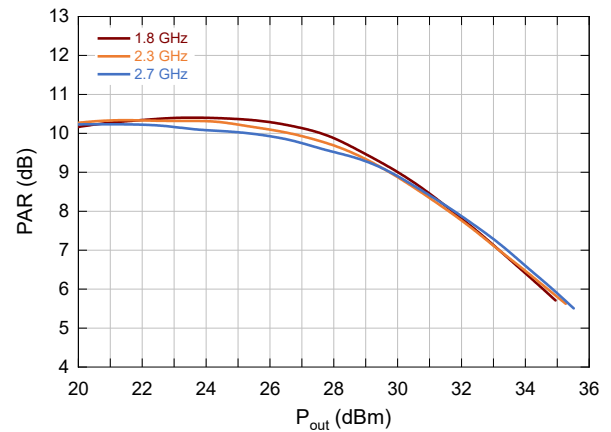
Drain Efficiency vs. Output Power and Frequency



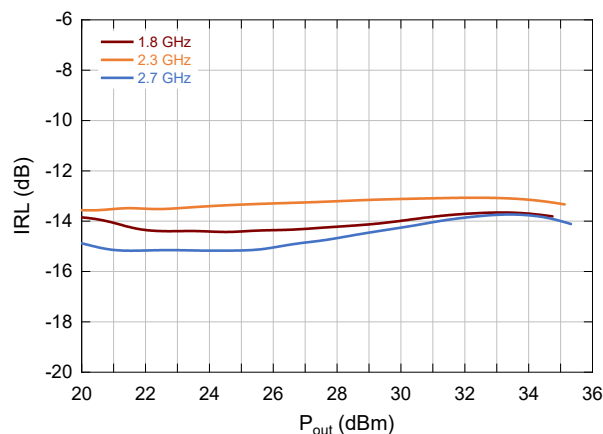
ACPR (Max $\pm 5\text{ MHz}$) vs. Output Power and Frequency



PAR (CCDF @ 0.01%) vs. Output Power and Frequency



Input Return Loss vs. Output Power and Frequency

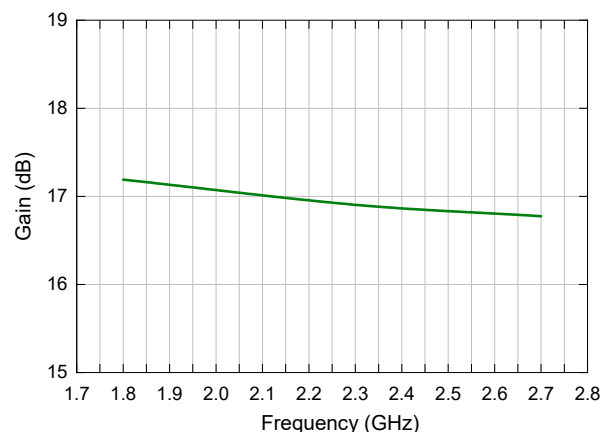


Typical Performance as Measured in the 1.8 - 2.7 GHz Evaluation Board:

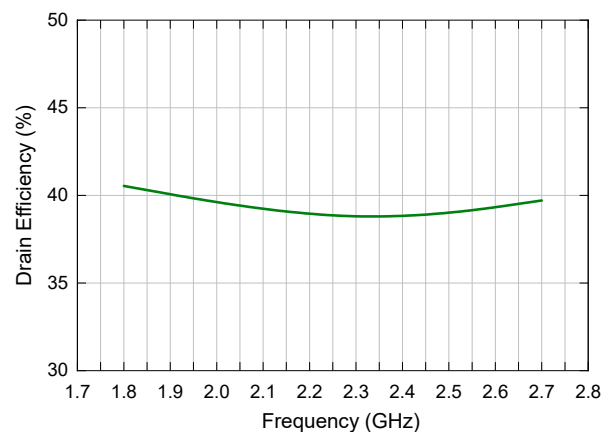
WCDMA 3GPP TM1 64 DPCH 9.9 dB PAR @ 0.01% CCDF

$V_{DS} = 24\text{ V}$, $I_{DQ} = 48\text{ mA}$, $T_{CASE} = 25\text{ }^{\circ}\text{C}$

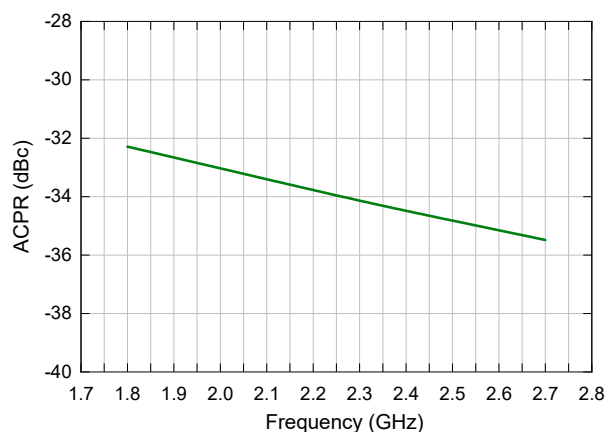
Gain vs. Frequency at $P_{OUT} = 32\text{ dBm}$



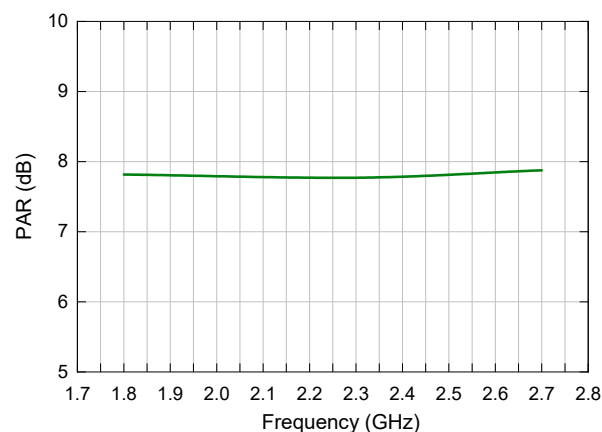
Drain Efficiency vs. Frequency at $P_{OUT} = 32\text{ dBm}$



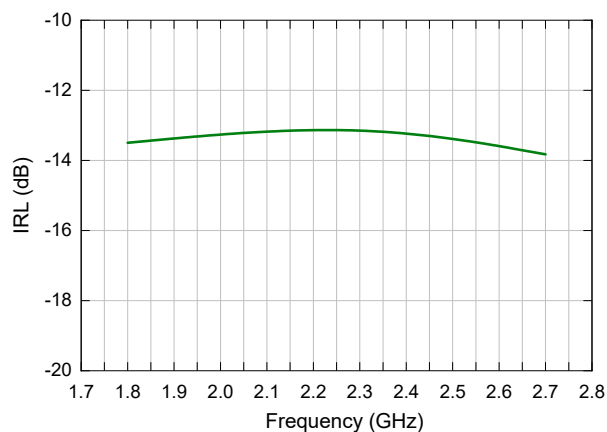
ACPR (Max $\pm 5\text{ MHz}$) vs. Frequency at $P_{OUT} = 32\text{ dBm}$



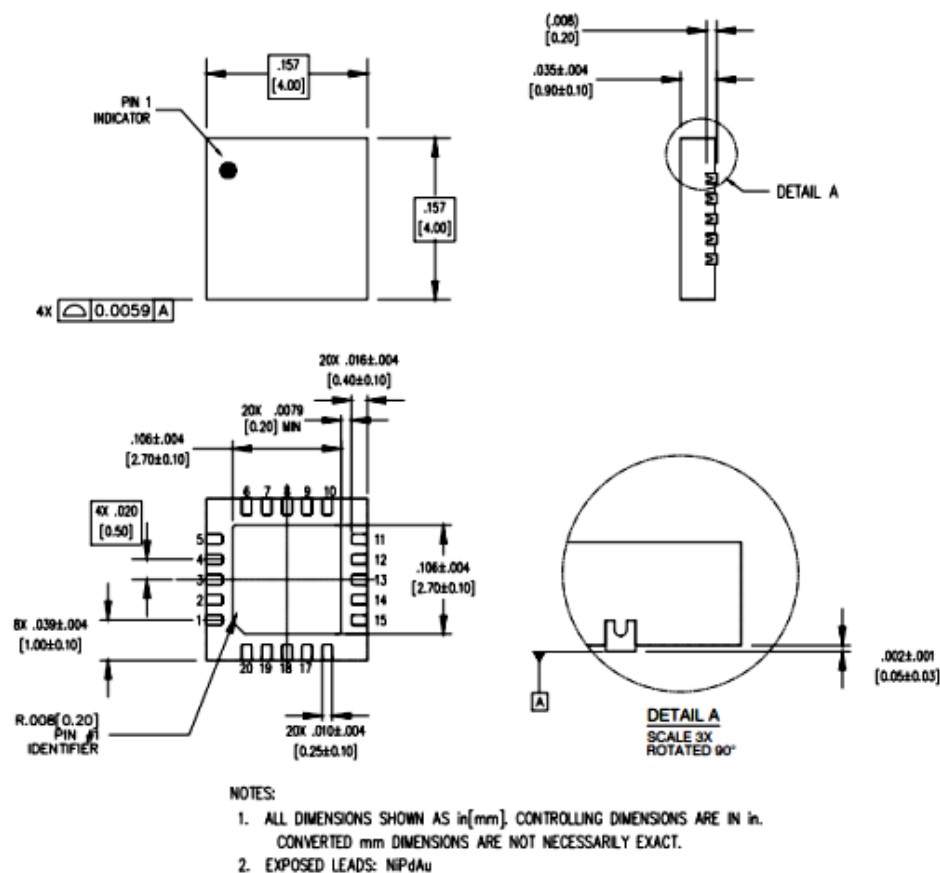
PAR (CCDF @ 0.01%) vs. Frequency at $P_{OUT} = 32\text{ dBm}$



Input Return Loss vs. Frequency at $P_{OUT} = 32\text{ dBm}$



Lead-Free 4 mm PQFN-20LD Package Dimensions[†]



PACKAGE OUTLINE

Figure 4: Outline included above for reference only (see DC-0037517 for latest information)

[†] Reference Application Note AN0004363 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is NiPdAu

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