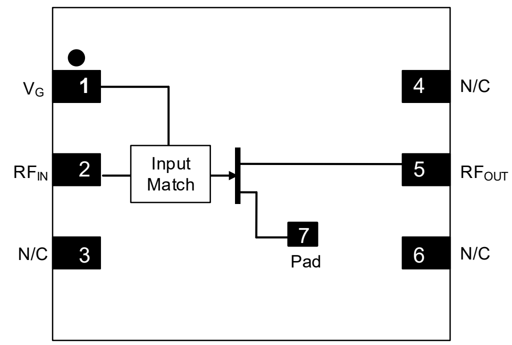
GaN Amplifier 50 V, 25 W 30 - 2700 MHz

Features

- *MACOM PURE CARBIDE*™ Amplifier Series
- Suitable for Linear & Saturated Applications
- CW & Pulsed Operation: 25 W Output Power
- 50 Ω Input Matched
- 260°C Reflow Compatible
- 28 V & 50 V
- 100% RF Tested
- RoHS* Compliant

6.5 x 7.0 mm DFN

Functional Schematic



Description

The MAPC-A1000 is a GaN on Silicon Carbide HEMT D-mode amplifier suitable for 30 - 3000 MHz frequency operation. The device supports both CW and pulsed operation with minimum output power levels of 25 W (44 dBm) in a 6.5 x 7.0 mm plastic package.

The MAPC-A1000 has a wide range of applications, including military radio communications, RADAR, avionics, digital cellular infrastructure, RF energy, and test instrumentation.

Typical Performance:

- Measured under load-pull at 2.5 dB Compression, 100 µs pulse width, 10% duty cycle.

- V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C

Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D[2] (%)
0.9	45.8	13.1	77.2
1.4	45.8	12.6	76.4
2.0	45.9	12.5	74.3
2.7	45.9	11.6	72.0
3.0	45.9	10.8	69.6

- V_{DS} = 28 V, I_{DQ} = 40 mA, T_C = 25°C

Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D[2] (%)
0.9	43.1	11.0	74.0
1.4	43.0	10.8	73.0
2.0	43.2	10.7	71.5
2.7	43.3	9.6	70.7
3.0	43.2	8.8	68.2

1. Load impedance tuned for maximum output power.
2. Load impedance tuned for maximum drain efficiency.

Pin Configuration

Pin #	Pin Name	Function
1	V_G	Gate
2	RF_{IN}	RF Input
3, 4, 6	N/C	No Connection
5	RF_{OUT} / V_D	RF Output / Drain
7	Pad[3]	Ground / Source

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

Ordering Information

Part Number	Package
MAPC-A1000-AD000	Bulk Quantity
MAPC-A1000-ADTR1	Tape and Reel
MAPC-A1000-ADSB1	Sample Board

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

RF Electrical Characteristics: T_C = 25°C, V_{DS} = 50 V, I_{DQ} = 40 mA
Note: Performance in MACOM Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	Pulsed[4], 2.7 GHz	G_{SS}	-	12.8	-	dB
Power Gain	Pulsed[4], 2.7 GHz, 2.5 dB Gain Compression	G_{SAT}	-	10.3	-	dB
Saturated Drain Efficiency	Pulsed[4], 2.7 GHz, 2.5 dB Gain Compression	η_{SAT}	-	60	-	%
Saturated Output Power	Pulsed[4], 2.7 GHz, 2.5 dB Gain Compression	P_{SAT}	-	44.8	-	dBm
Gain Variation (-40°C to +85°C)	Pulsed[4], 2.7 GHz	ΔG	-	0.017	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[4], 2.7 GHz	ΔP2.5dB	-	0.003	-	dBm/°C
Power Gain	Pulsed[4], 2.7 GHz, P_{IN} = 32.7 dBm	G_P	-	11.3	-	dB
Drain Efficiency	Pulsed[4], 2.7 GHz, P_{IN} = 32.7 dBm	η	-	56.4	-	%
Input Return Loss	Pulsed[4], 2.7 GHz, P_{IN} = 32.7 dBm	IRL	-	-8.7	-	dB
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 10:1, No Damage			

RF Electrical Specifications: T_A = 25°C, V_{DS} = 50 V, I_{DQ} = 40 mA
Note: Performance in MACOM Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	Pulsed[4], 2.7 GHz, 2.5 dB Gain Compression	G_{SAT}	9.0	10.0	-	dB
Saturated Drain Efficiency	Pulsed[4], 2.7 GHz, 2.5 dB Gain Compression	η_{SAT}	48	52.7	-	%
Saturated Output Power	Pulsed[4], 2.7 GHz, 2.5 dB Gain Compression	P_{SAT}	43	44.4	-	dBm
Power Gain	Pulsed[4], 2.7 GHz, P_{IN} = 33.6 dBm	G_P	10	10.5	-	dB
Drain Efficiency	Pulsed[4], 2.7 GHz, P_{IN} = 33.6 dBm	η	48	52.6	-	%
Input Return Loss	Pulsed[4], 2.7 GHz, P_{IN} = 33.6 dBm	IRL	-7.5	-9	-	dB

4. Pulse details: 100 µs pulse width, 10% Duty Cycle.

DC Electrical Characteristics: T_A = 25°C

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Drain-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 130 V	I_{DLK}	-	-	3.3	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	3.3	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 3.3 mA	V_T	-3.3	-2.9	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 40 mA	V_{GSQ}	-	-2.75	-	V
On Resistance	V_{GS} = 2 V, I_D = 24.8 mA	R_{ON}	-	1.45	-	Ω
Maximum Drain Current	V_{DS} = 7 V, pulse width 300 µs	$I_{D, MAX}$	-	3.94	-	A

Absolute Maximum Ratings[5,6,7,8,9]

Parameter	Absolute Maximum
Drain Source Voltage, V_{DS}	130 V
Gate Source Voltage, V_{GS}	-10 to 3 V
Gate Current, I_G	6.62 mA
Storage Temperature Range	-65°C to +150°C
Case Operating Temperature Range	-40°C to +85°C
Channel Operating Temperature Range, T_{CH}	-40°C to +225°C
Absolute Maximum Channel Temperature	+250°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} < 55 V will ensure MTTF > 2 x 10^6 hours.
8. Operating at nominal conditions with $T_{CH} \leq 225°C$ will ensure MTTF > 2 x 10^6 hours.
9. MTTF may be estimated by the expression MTTF (hours) = A $e^{[B + C/(T+273)]}$ where *T* is the channel temperature in degrees Celsius, *A* = 1, *B* = -38.215, and *C* = 26,343.

Thermal Characteristics[10]

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance using Finite Element Analysis	V_{DS} = 50 V T_C = 85°C, T_{CH} = 225°C	R_θ(FEA)	6.9	°C/W
Thermal Resistance using Infrared Measurement of Die Surface Temperature	V_{DS} = 50 V T_C = 85°C, T_{CH} = 225°C	R_θ(IR)	5.5	°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

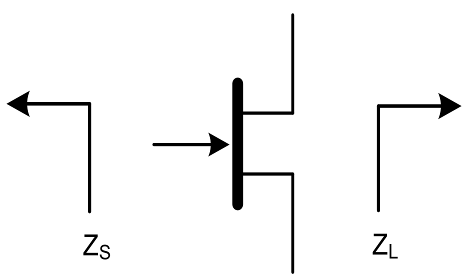
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

Pulsed[4] Load-Pull Performance at 50 V
Reference Plane at Device Leads

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	23.1 + j2.7	18.2 - j14.5	11.7	45.8	38.0	65.5	112.0
1.4	27.9 + j6.4	19.9 + j7.1	11.5	45.8	38.0	63.4	96.6
2.0	25.8 - j1.2	14.8 + j6.2	11.5	45.9	38.9	61.5	45.0
2.7	25.2 - j20	14.8 + j0.3	11.0	45.9	38.9	62.6	-10.0
3.0	36.1 - j31.4	12.6 - j2.3	10.2	45.9	38.9	59.3	-29.3

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	21.2 + j 2.9	33.1 + j8.3	13.1	42.9	19.5	77.2	100.9
1.4	25.8 + j6.4	22.9 + j27	12.6	43.7	23.4	76.4	84.2
2.0	23.8 - j1.9	9.8 + j15.2	12.5	44.1	25.7	74.3	31.0
2.7	28.7 - j21.5	10.2 + j7.1	11.6	44.7	29.5	72.2	-20.7
3.0	39.8 - j31.6	8.4 + j3.3	10.8	44.8	30.2	69.6	-42.2

Impedance Reference

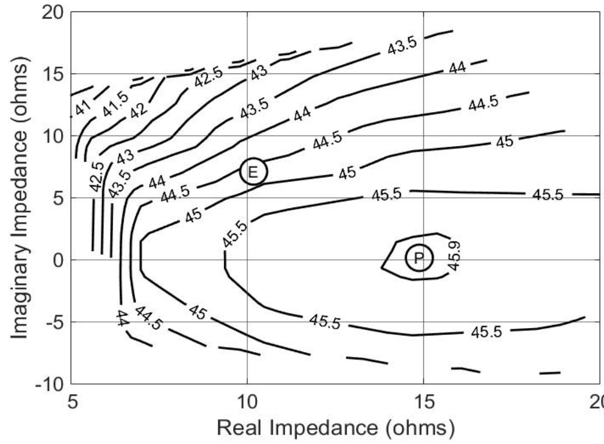


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

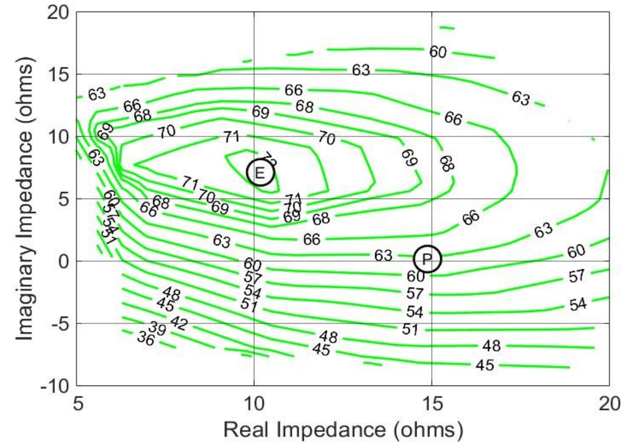
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

Pulsed[4] Load-Pull Performance @ 2.7 GHz

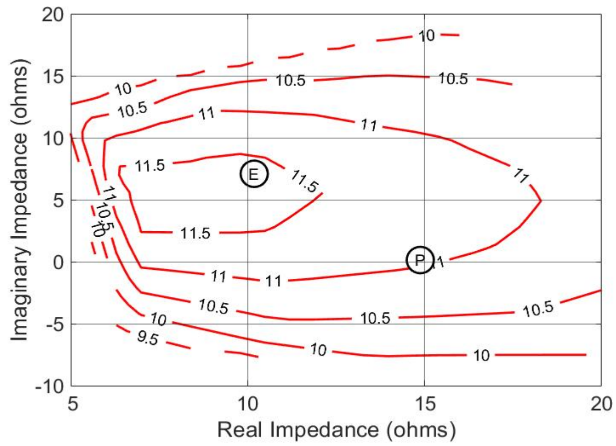
P2.5dB Loadpull Output Power Contours (dBm)



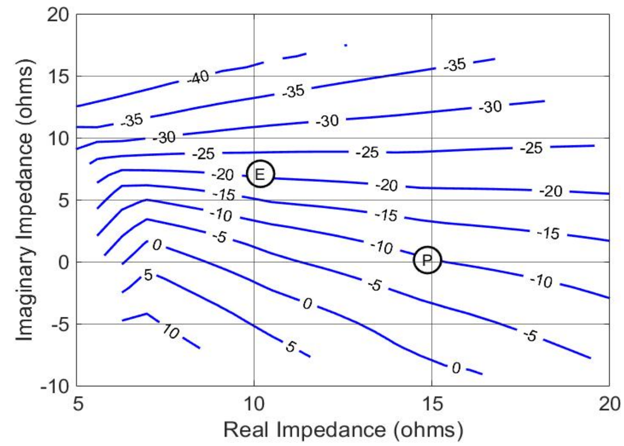
P2.5dB Loadpull Drain Efficiency Contours (%)



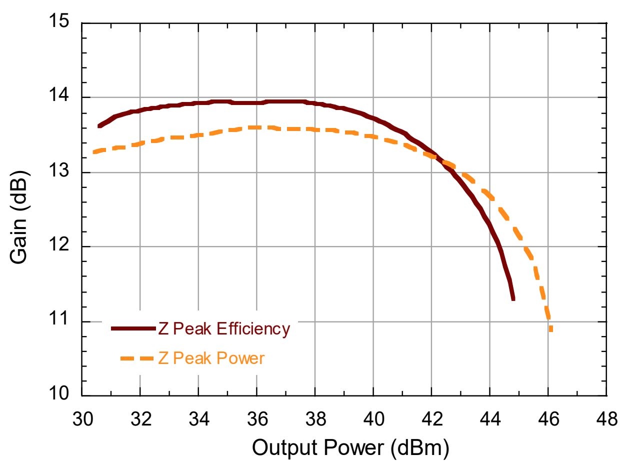
P2.5dB Loadpull Gain Contours (dB)



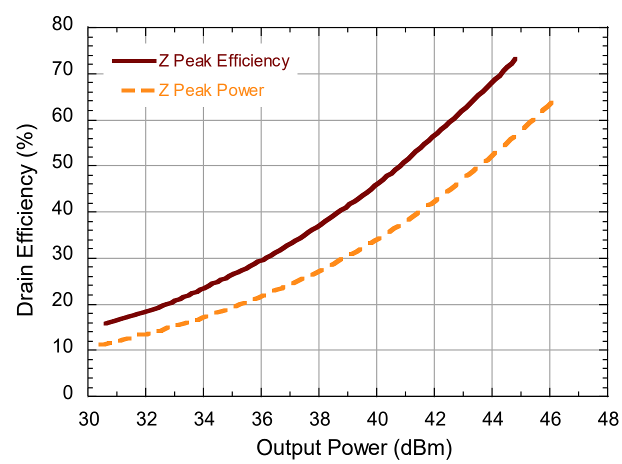
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

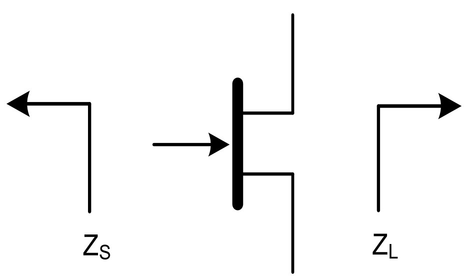


Pulsed[4] Load-Pull Performance at 28 V
Reference Plane at Device Leads

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 28 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	22.3 + j3.4	7.7 + j10.3	9.3	43.1	20.4	60.0	128.0
1.4	27.9 + j8.7	13.6 + j1.9	9.4	43.0	20.0	57.7	93.0
2.0	25.1 - j0.5	13.1 - j1.8	9.4	43.2	20.9	57.6	50.6
2.7	28.5 - j20.8	12.5 - j5.2	8.9	43.3	21.4	61.2	-1.8
3.0	43 - j30.3	12 - j7.5	8.3	43.2	20.9	59.7	-26.7

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 28 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	18.9 + j3.0	13.5 + j25	11.0	38.4	6.9	74.0	111
1.4	24.7 + j5.6	14.9 + j16.8	10.8	40.8	12.0	73.0	72.1
2.0	24.5 - j4.7	12 + j10.1	10.7	41.6	14.5	71.5	32.2
2.7	32.6 - j22.9	9.9 + j4.5	9.6	41.7	14.8	70.7	-20.5
3.0	47.1 - j30.6	9.6 + j0.2	8.8	41.9	15.5	68.2	-40.5

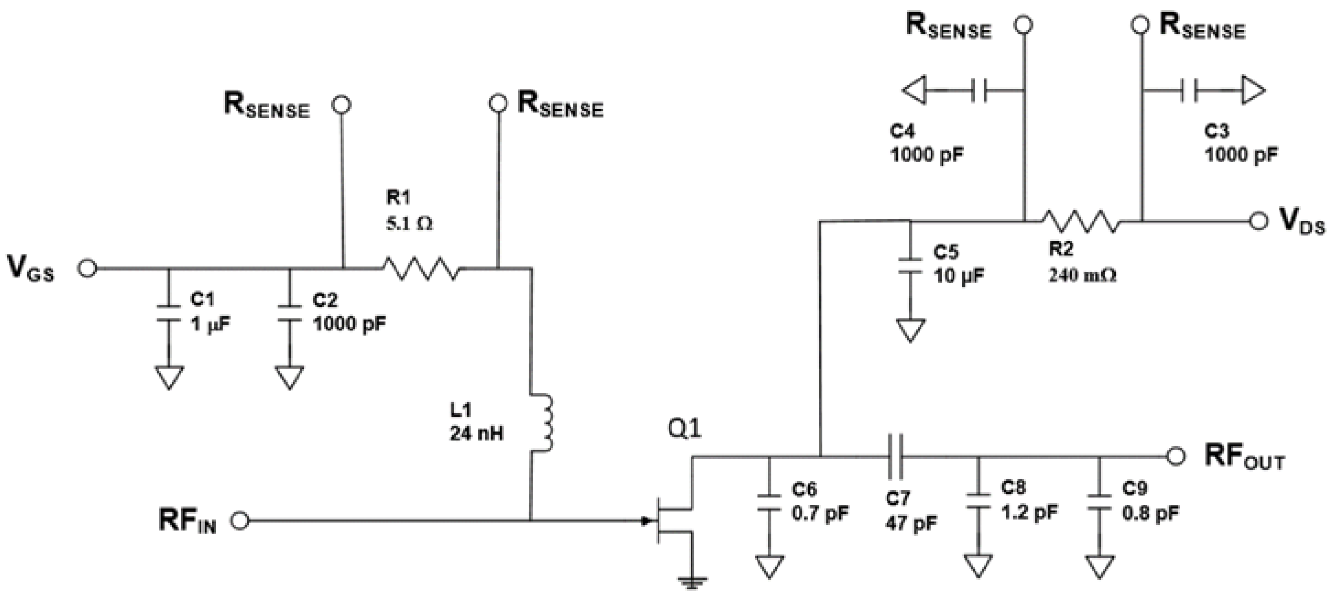
Impedance Reference



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.

Evaluation Test Fixture and Recommended Tuning Solution 0.5 - 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

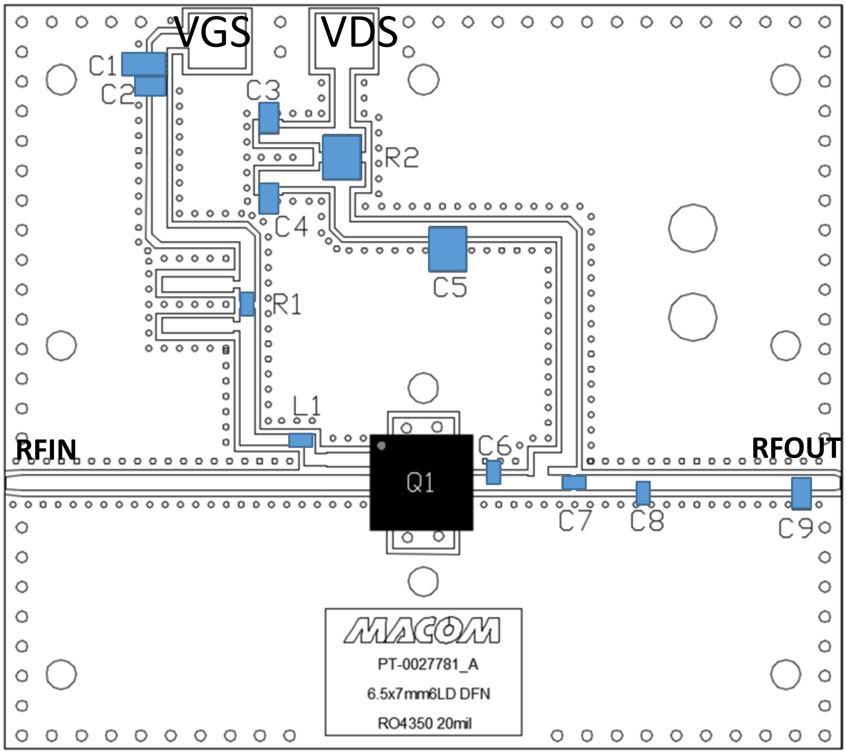
Turning the device ON

1. Set V_{GS} to pinch-off (V_P).
2. Turn on V_{DS} to nominal voltage (50 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}.

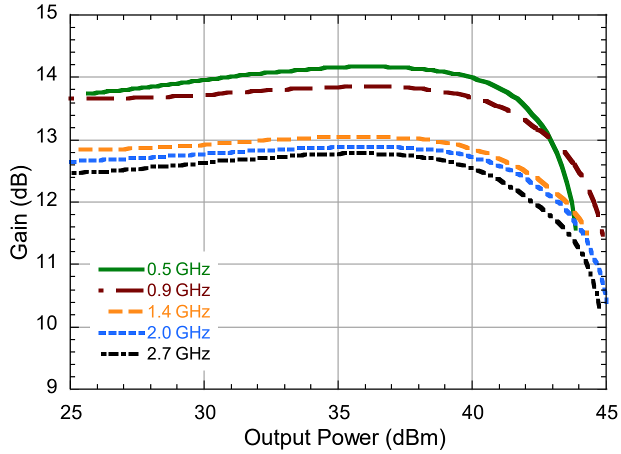
Evaluation Test Fixture and Recommended Tuning Solution 0.5 - 2.7 GHz



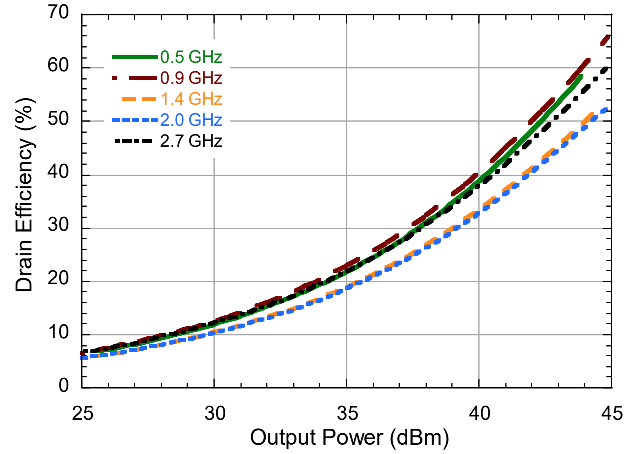
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1	1 µF	+/- 10 %	Murata	GRM31CR72A105KA01L
C2, C3, C4	1000 pF	+/- 5 %	Murata	GRM219R72A102JA01D
C5	10 µF	+/- 10 %	Murata	GRM32EC72A106KE05L
C6	0.7 pF	+/- 0.1 pF	PPI	0603N0R7BL250
C7	47 pF	+/- 5 %	PPI	0603N470JL250
C8	1.2 pF	+/- 0.1 pF	PPI	0603N1R2BL250
C9	0.8 pF	+/- 0.1 pF	PPI	0805N0R8BW251X
R1	5.1 Ω	+/- 1 %	Vishay Dale	CRCW06035R10FKEA
R2	240 mΩ	+/- 1%	Vishay Dale	RCWE1210R240FKEA
L1	24 nH	+/- 2 %	CoilCraft	0603HP-24NXGLW
Q1	MACOM GaN Power Amplifier			MAPC-A1000
PCB	RO4350, 20 mil, 0.5 oz. Cu, Au Finish			

Typical Performance Curves as Measured in the 0.5 - 2.7 GHz Evaluation Test Fixture:
Pulsed[4] 2.7 GHz, V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C (Unless Otherwise Noted)

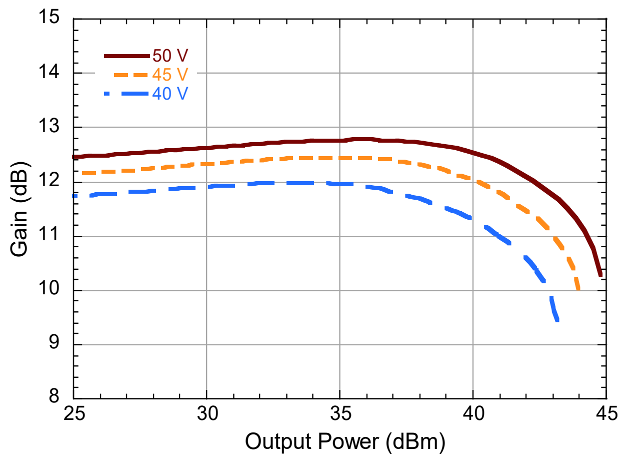
Gain vs. Output Power and Frequency



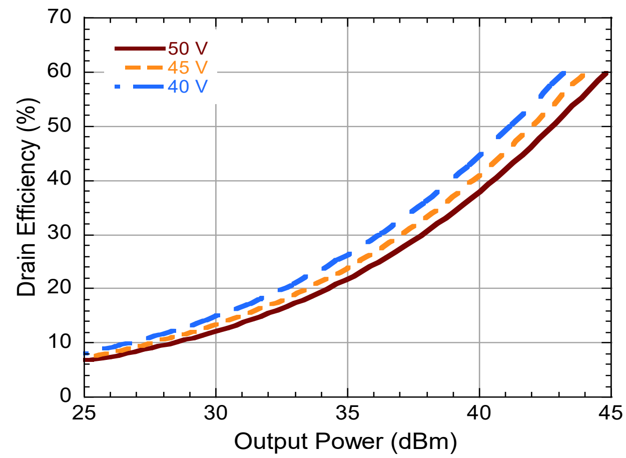
Drain Efficiency vs. Output Power and Frequency



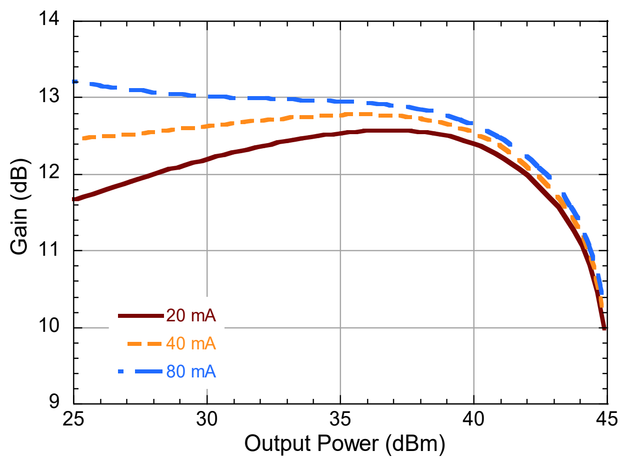
Gain vs. Output Power and V_{DS}



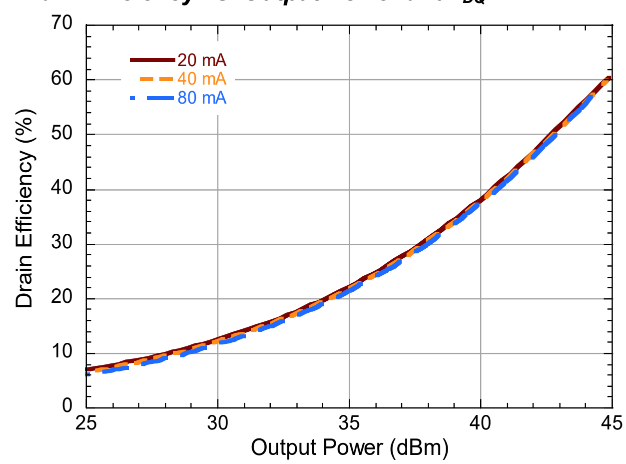
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}



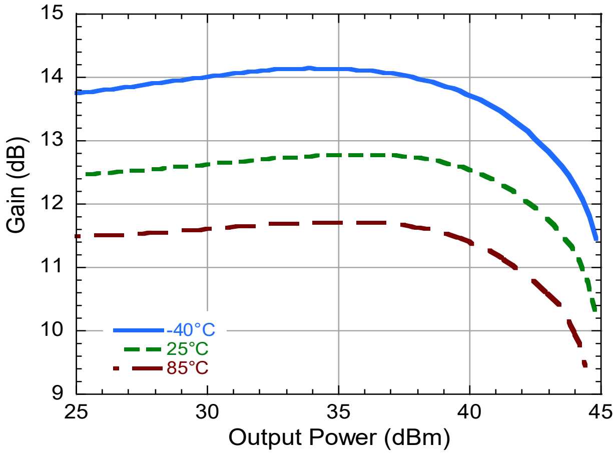
Drain Efficiency vs. Output Power and I_{DQ}



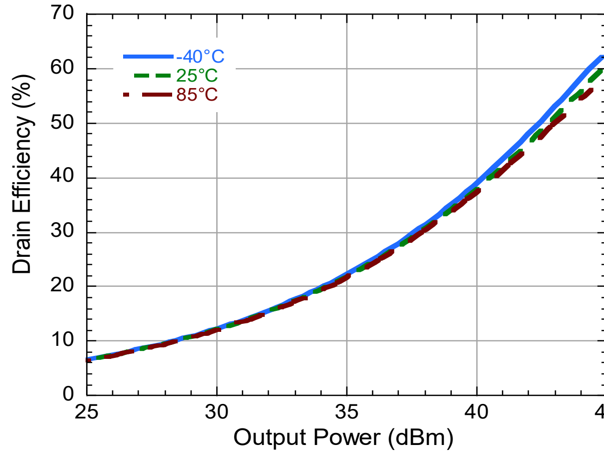
Typical Performance Curves as Measured in the 0.5 - 2.7 GHz Evaluation Test Fixture:

Pulsed[4] 2.7 GHz, V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C (Unless Otherwise Noted)

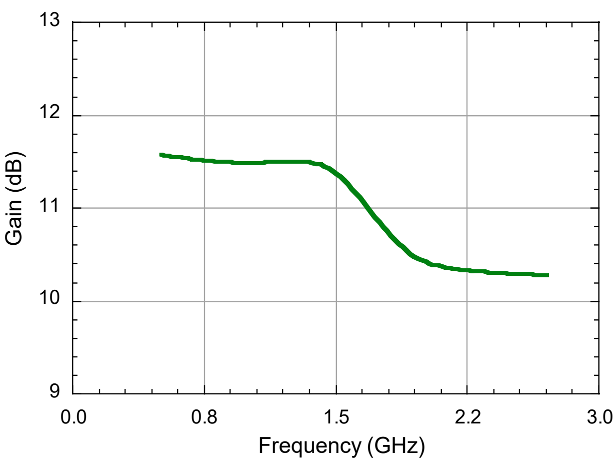
Gain vs. Output Power and T_C



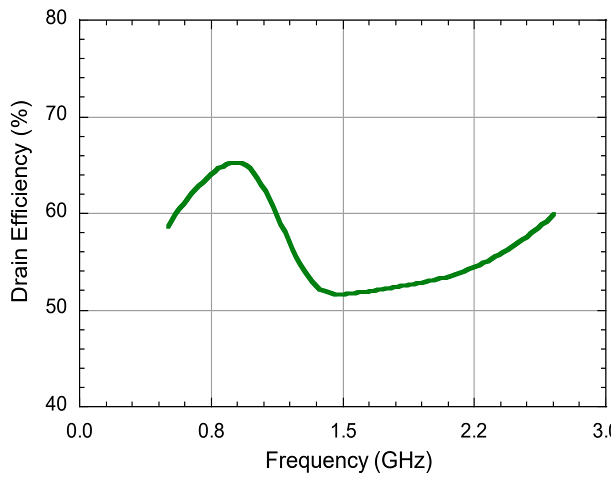
Drain Efficiency vs. Output Power and T_C



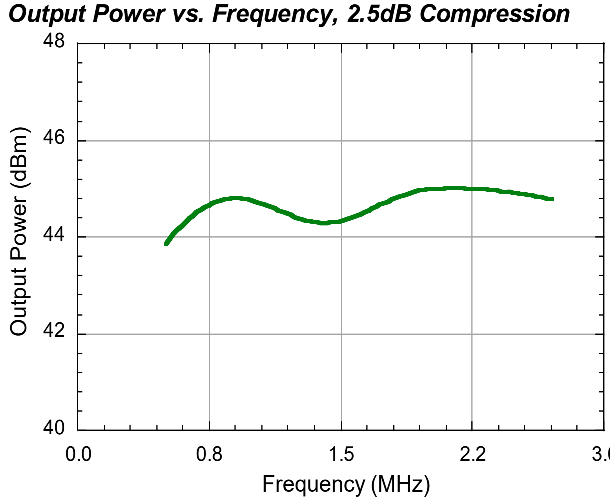
Gain vs. Frequency, 2.5dB Compression



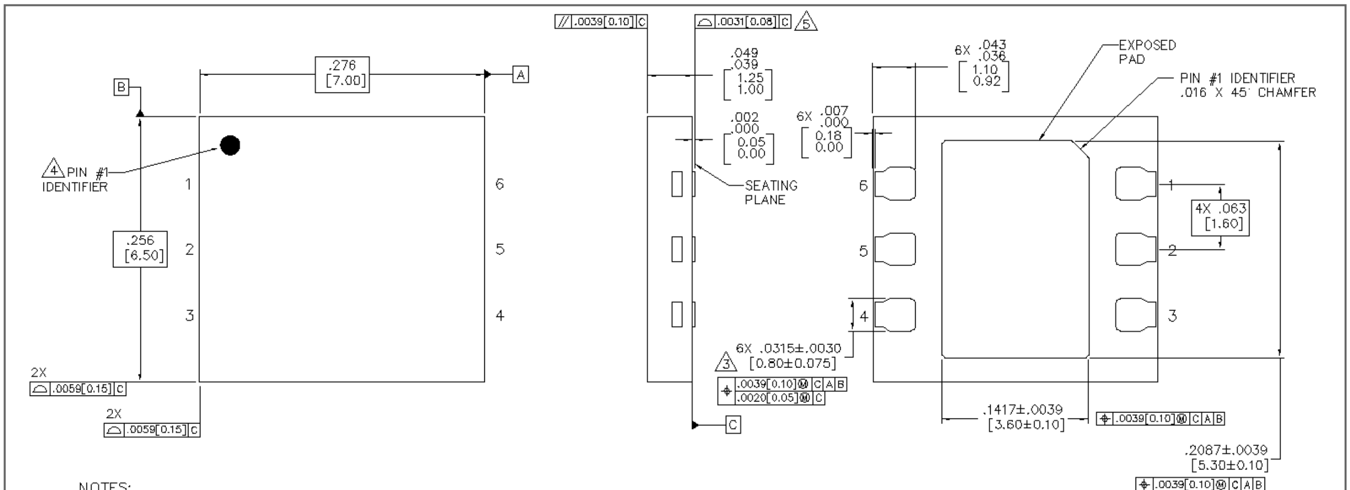
Drain Efficiency vs. Frequency, 2.5dB Compression



Output Power vs. Frequency, 2.5dB Compression



Lead-Free 6.5 x 7.0 mm 6-Lead Package Dimensions†



NOTES:

1. ALL DIMENSIONS AND TOLERANCES ARE BASED ON JEDEC MO–220, VAR WITH SAW SINGULATION. ALL DIMENSIONS SHOWN AS in[mm]. CONTROLLING DIMENSIONS ARE IN mm AND CONVERTED in DIMENSIONS ARE NOT NECESSARILY EXACT.
2. LEAD FINISH: NiPdAu PLATE
3. INDICATED DIMENSIONS/TOLERANCES APPLY TO THE PLATED LEAD AND IS MEASURED BETWEEN .0059[0.15] AND .0118[0.30] FROM THE LEAD END. LEAD NECK DOWN FEATURE IS OPTIONAL.
4. EXACT SIZE AND SHAPE OF THIS FEATURE IS OPTIONAL.
5. INDICATED DIMENSIONS/TOLERANCES APPLY TO LEADS AND EXPOSED PAD.

† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level (MSL) 3 requirements.
Plating is NiPdAu.