GaN Amplifier 50 V, 15 W
30 MHz - 3.5 GHz

MACOM PURE CARBIDE™

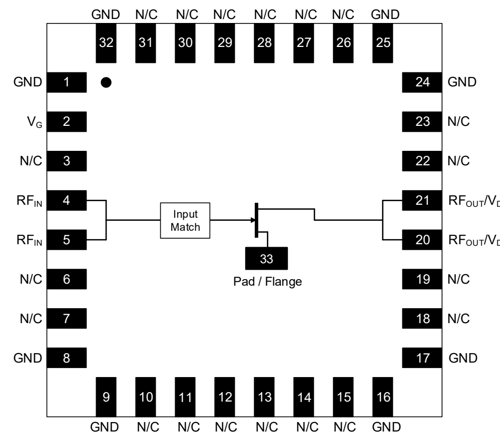
MAPC-S1000
Rev. V2

Features

- *MACOM PURE CARBIDE™* Amplifier Series
- Suitable for Linear & Saturated Applications
- Pulsed Operation: 15 W Output Power
- 50 Ω Input Matched
- 260°C Reflow Compatible
- 50 V & 28 V Operation
- 100% RF Tested
- RoHS* Compliant
- End-Use Statement Required

5 mm AQFN

Functional Schematic



Description

The MAPC-S1000 is a high power GaN on Silicon Carbide HEMT D-mode amplifier suitable for DC - 3.5 GHz frequency operation. The device supports pulsed operation with peak output power levels of at least 15 W (41.8 dBm) in an air cavity plastic package.

Typical RF 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	42.3	13.1	77.2
1.4	42.3	13.4	76.5
2.0	42.4	14.6	67.5
2.5	42.6	14.2	67.5
3.0	42.6	13.4	71.1
3.5	42.2	11.1	64.6

- 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	39.5	12.3	76
1.4	39.8	12.1	76.5
2.0	40.3	13.3	69.8
2.5	40.2	13.3	69.4
3.0	40.1	12	71.4
3.5	39.7	10.3	65.3

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

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

Pin Configuration

Pin #	Pin Name	Function
1, 8, 9, 16, 17, 24, 25, 32	GND	Ground
2	V_G	Gate
3, 6, 7, 10 - 15, 18, 19, 22, 23, 26 - 31	NC[3]	No Connection
4 - 5	RF_{IN}	RF Input
20 - 21	RF_{OUT} / V_D	RF Output / Drain
33	Pad[4]	Ground / Source

3. MACOM recommends connecting unused package pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

Ordering Information

Part Number	Package
MAPC-S1000-AD000	Bulk Quantity
MAPC-S1000-ADTR1	Tape and Reel
MAPC-S1000-ADSB1	Sample Board

DC-0025939

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[5], 3.5 GHz	G_{SS}	-	13.0	-	dB
Power Gain	Pulsed[5], 3.5 GHz, 2.5 dB Gain Compression	G_{SAT}	-	10.5	-	dB
Saturated Drain Efficiency	Pulsed[5], 3.5 GHz, 2.5 dB Gain Compression	η_{SAT}	-	52.2	-	%
Saturated Output Power	Pulsed[5], 3.5 GHz, 2.5 dB Gain Compression	P_{SAT}	-	41.8	-	dBm
Gain Variation (-40°C to +85°C)	Pulsed[5], 3.5 GHz	ΔG	-	0.020	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[5], 3.5 GHz	ΔP2.5dB	-	0.003	-	dB/°C
Power Gain	Pulsed[5], 3.5 GHz, P_{IN} = 31.2 dBm	G_P	-	10.6	-	dB
Drain Efficiency	Pulsed[5], 3.5 GHz, P_{IN} = 31.2 dBm	η	-	52.0	-	%
Input Return Loss	Pulsed[5], 3.5 GHz, P_{IN} = 31.2 dBm	IRL	-	-14.3	-	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[5], 3.5 GHz, 2.5 dB Gain Compression	G_{SAT}	-	11.1	-	dB
Saturated Drain Efficiency	Pulsed[5], 3.5 GHz, 2.5 dB Gain Compression	η_{SAT}	-	51.4	-	%
Saturated Output Power	Pulsed[5], 3.5 GHz, 2.5 dB Gain Compression	P_{SAT}	-	42.1	-	dBm
Power Gain	Pulsed[5], 3.5 GHz, P_{IN} = 29.8 dBm	G_P	-	11.9	-	dB
Drain Efficiency	Pulsed[5], 3.5 GHz, P_{IN} = 29.8 dBm	η	-	50.4	-	%
Input Return Loss	Pulsed[5], 3.5 GHz, P_{IN} = 29.8 dBm	IRL	-	-20	-	dB

5. 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}	-	-	2.8	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	2.8	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 2.8 mA	V_T	-	-3.1	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 40 mA	V_{GSQ}	-	-2.9	-	V
On Resistance	V_{GS} = 2 V, I_D = 21 mA	R_{ON}	-	1.71	-	Ω
Maximum Drain Current	V_{DS} = 7 V, pulse width 300 μs	$I_{D, MAX}$	-	3.33	-	A

Absolute Maximum Ratings[6,7,8,9,10]

Parameter	Absolute Maximum
Drain Source Voltage, V_{DS}	150 V
Gate Source Voltage, V_{GS}	-15 to 2 V
Gate Current, I_G	2.8 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

6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.
8. Operating at drain source voltage V_{DS} < 55 V will ensure MTTF > 2 x 10^6 hours.
9. Operating at nominal conditions with $T_{CH} \leq 225°C$ will ensure MTTF > 2 x 10^6 hours.
10. 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* = 1.03, *B* = -33.74, and *C* = 24.137.

Thermal Characteristics[11]

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)	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)	7.2	°C/W

11. 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

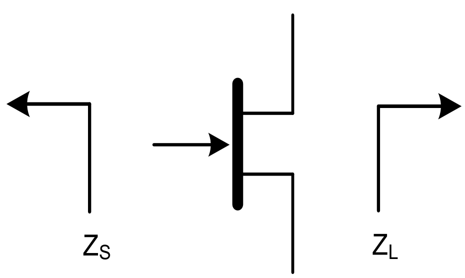
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

Pulsed[5] 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}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	31.9 - j1.2	45.6 + j14.7	12.1	42.3	17.0	60.1	140.0
1.4	41.0 + j6.4	37.9 + j23.1	12.7	42.3	17.0	58.8	108.7
2.0	14.7 + j14.7	36.4 + j20.5	14.1	42.4	17.4	51.9	63.3
2.5	14.0 - j5.6	36.3 + j21.2	14.2	42.6	18.2	53.5	30.5
3.0	36.2 - j20.9	32.3 + j20.8	13.1	42.6	18.2	54.8	-10.3
3.5	43.6 + j14.9	29.5 + j20.1	11.2	42.2	16.6	51.5	-53.4

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[13] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	30.0 + j0.3	77.6 + j80.2	13.1	39.5	8.9	77.2	131.2
1.4	33.2 + j4.3	35.5 + j83.5	13.4	38.2	6.6	76.5	96.9
2.0	15.5 + j9.5	30.4 + j60.1	14.6	40.1	10.2	67.5	53.9
2.5	17.9 - j8.6	27.6 + j54.5	14.2	40.5	11.2	67.5	16.5
3.0	58.3 - j23.7	14.5 + j46.4	13.4	39.2	8.3	71.1	-27.3
3.5	35.5 + j19.6	16.0 + j40.1	11.1	40.1	10.2	64.6	-66.4

Impedance Reference

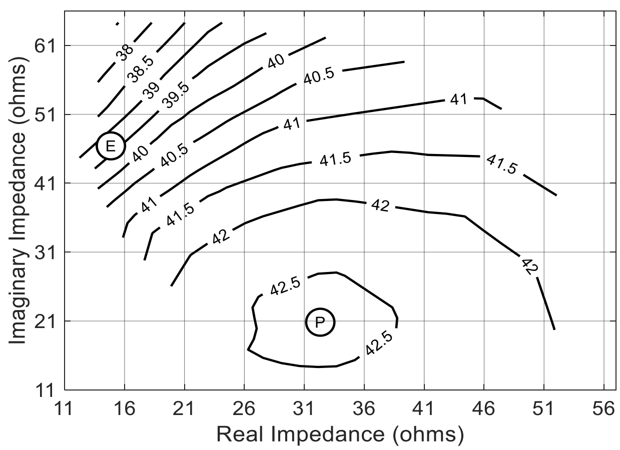


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

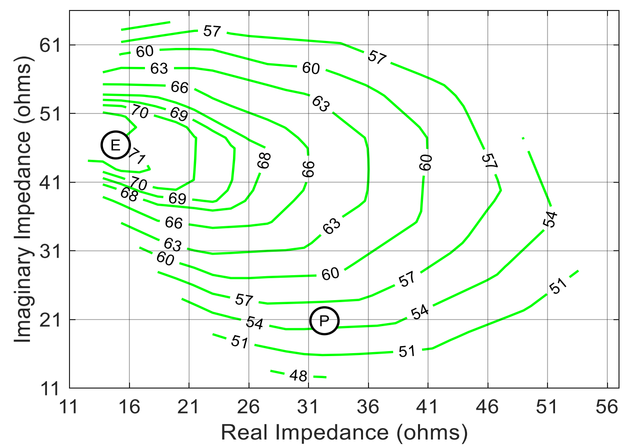
12. Load Impedance for optimum output power.
13. Load Impedance for optimum efficiency.

Pulsed[5] Load-Pull Performance @ 3.0 GHz

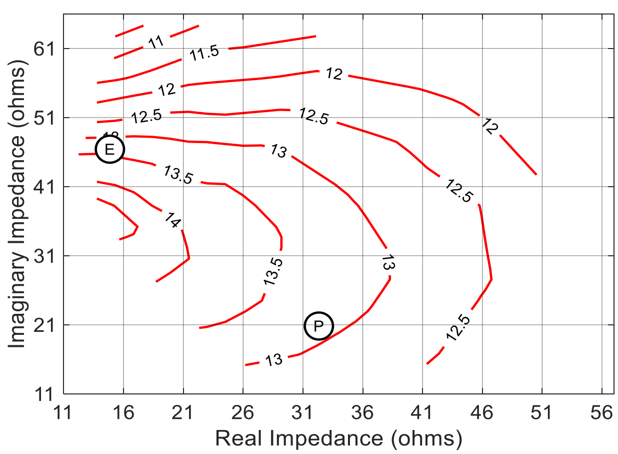
P2.5dB Loadpull Output Power Contours (dBm)



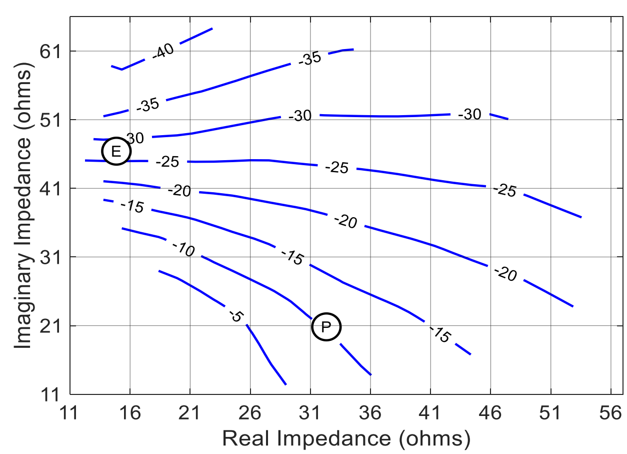
P2.5dB Loadpull Drain Efficiency Contours (%)



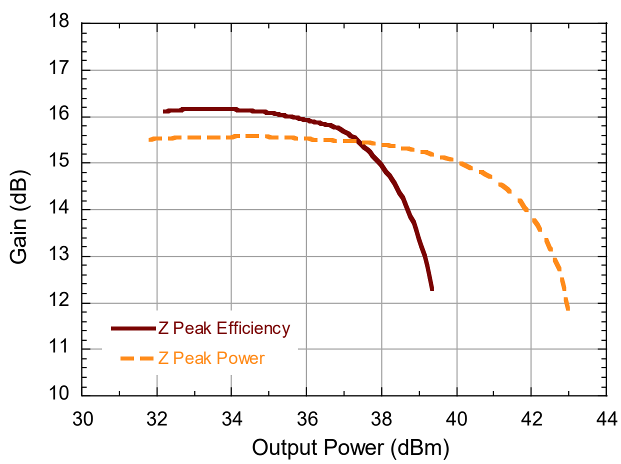
P2.5dB Loadpull Gain Contours (dB)



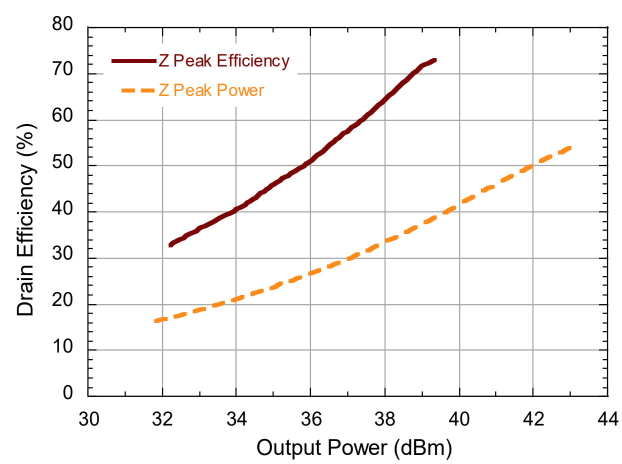
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power

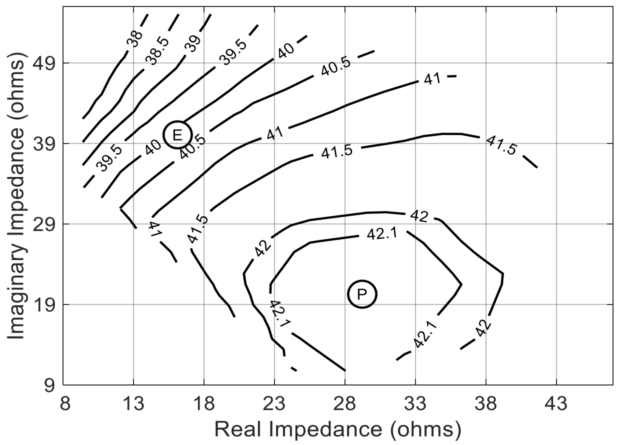


Drain Efficiency vs. Output Power

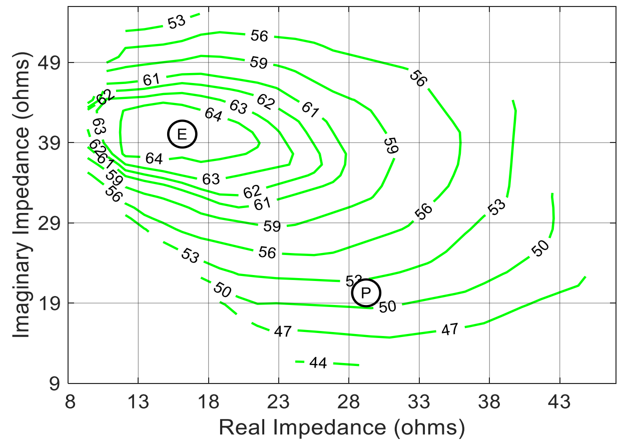


Pulsed[5] Load-Pull Performance @ 3.5 GHz

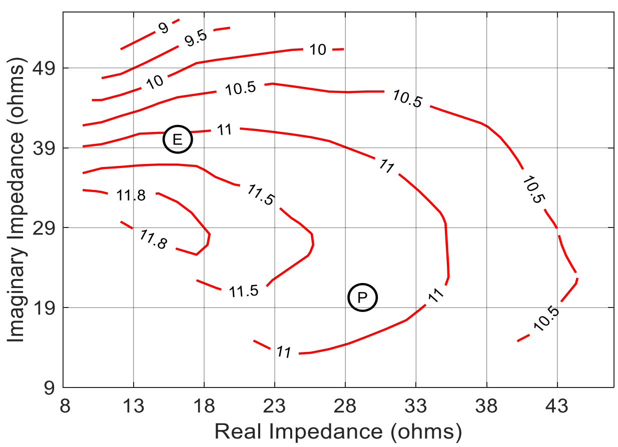
P2.5dB Loadpull Output Power Contours (dBm)



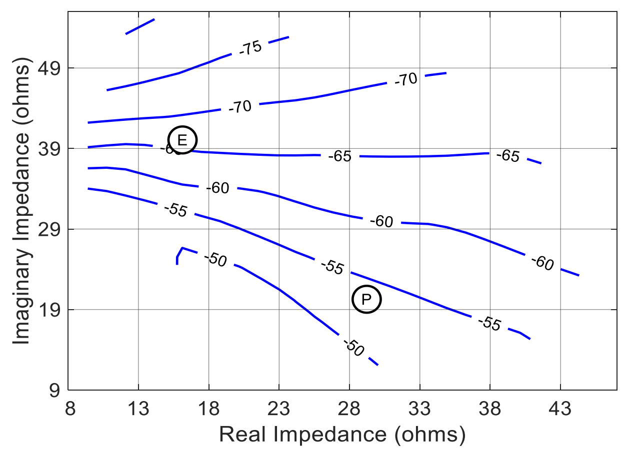
P2.5dB Loadpull Drain Efficiency Contours (%)



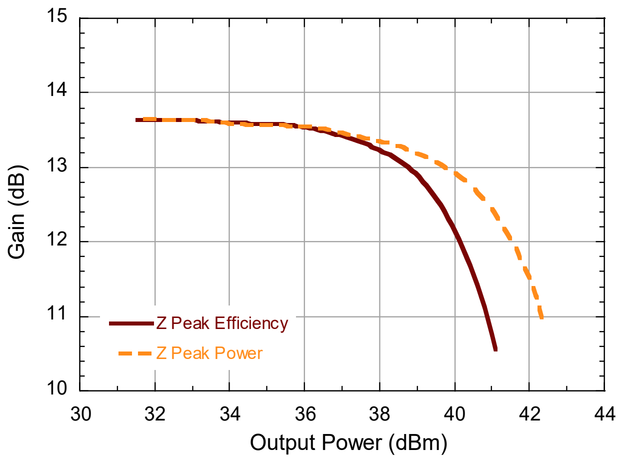
P2.5dB Loadpull Gain Contours (dB)



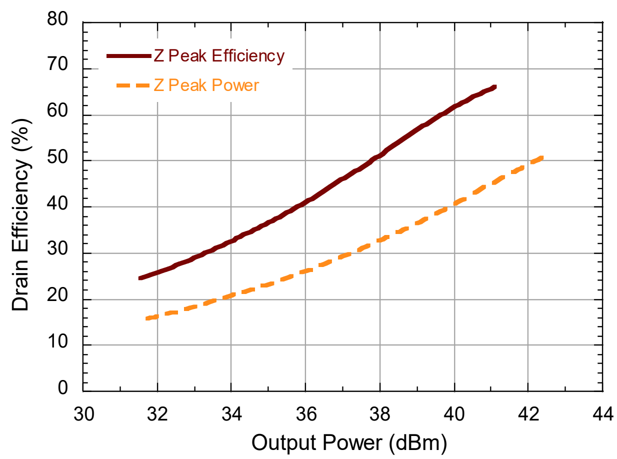
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

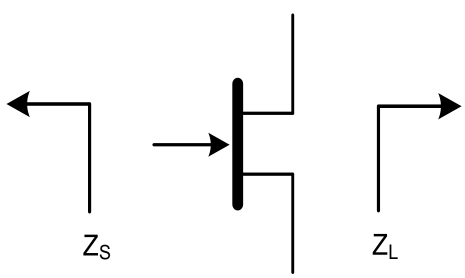


Pulsed[6] Load-Pull Performance at 28 V
Reference Plane at Device Leads

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 28 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	31.7 - j0.4	28.2 + j9.3	11.3	39.5	8.9	61.1	141.3
1.4	40.3 + j7.6	20.1 + j16.1	10.5	39.8	9.5	58.4	115.9
2.0	12.7 + j15.2	21.0 + j9.9	12.5	40.3	10.7	53.7	72.1
2.5	12.8 - j6.7	21.4 + j8.5	13.3	40.2	10.5	54.5	37.0
3.0	38.8 - j20.0	22.9 + j7.3	11.9	40.1	10.2	55.8	-6.7
3.5	42.3 + j16.5	22.1 + j6.7	10.2	39.7	9.3	53.2	-50.4

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 28 V, I_{DQ} = 40 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[13] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
0.9	29.1 + j0.5	59.2 - j57.4	12.3	35.9	3.9	75.8	128.5
1.4	33.3 + j3.6	28.7 + j53.8	12.1	35.5	3.5	76.5	105.3
2.0	18.9 + j9.9	29.0 - j46.0	13.4	37.0	5.0	69.8	51.6
2.5	19.8 - j10.7	23.0 + j39.8	13.3	37.1	5.1	69.4	13.0
3.0	50.8 - j11.3	18.8 +j33.2	12.0	37.4	5.5	71.4	-30.8
3.5	34.8 + j20.0	15.5 + j26.1	10.3	37.4	5.5	65.3	-68.9

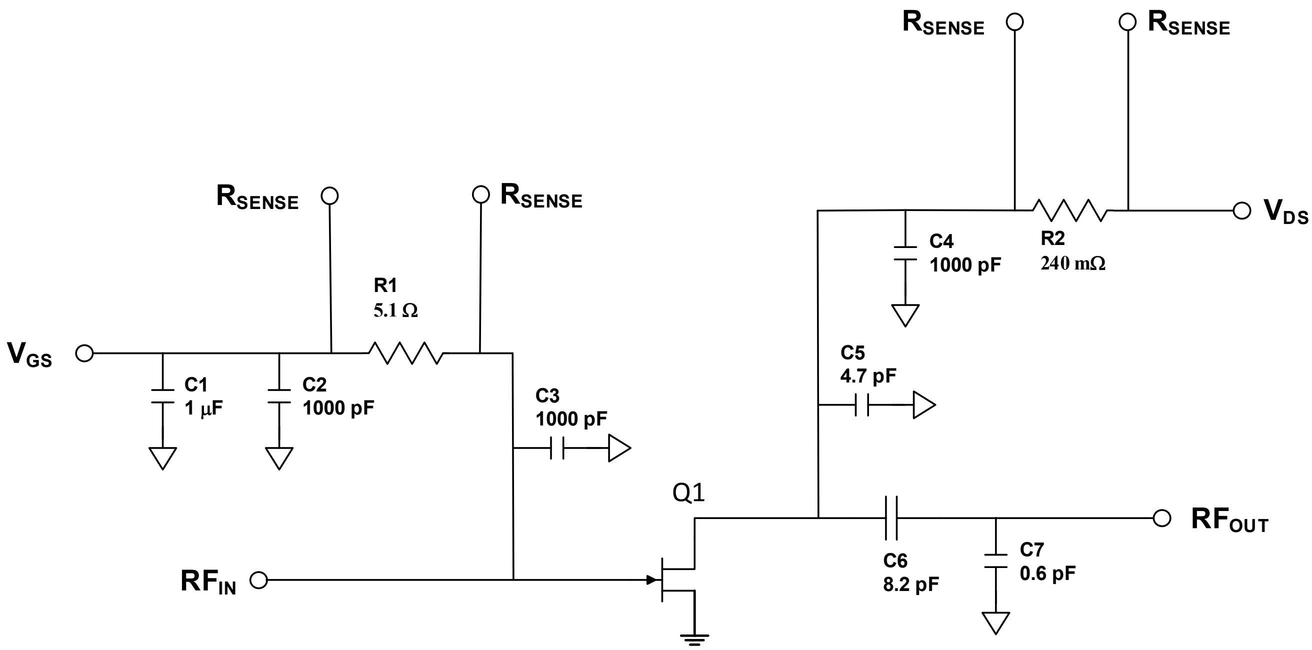
Impedance Reference



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.

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

Evaluation Test Fixture and Recommended Tuning Solution 2.0 - 3.5 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

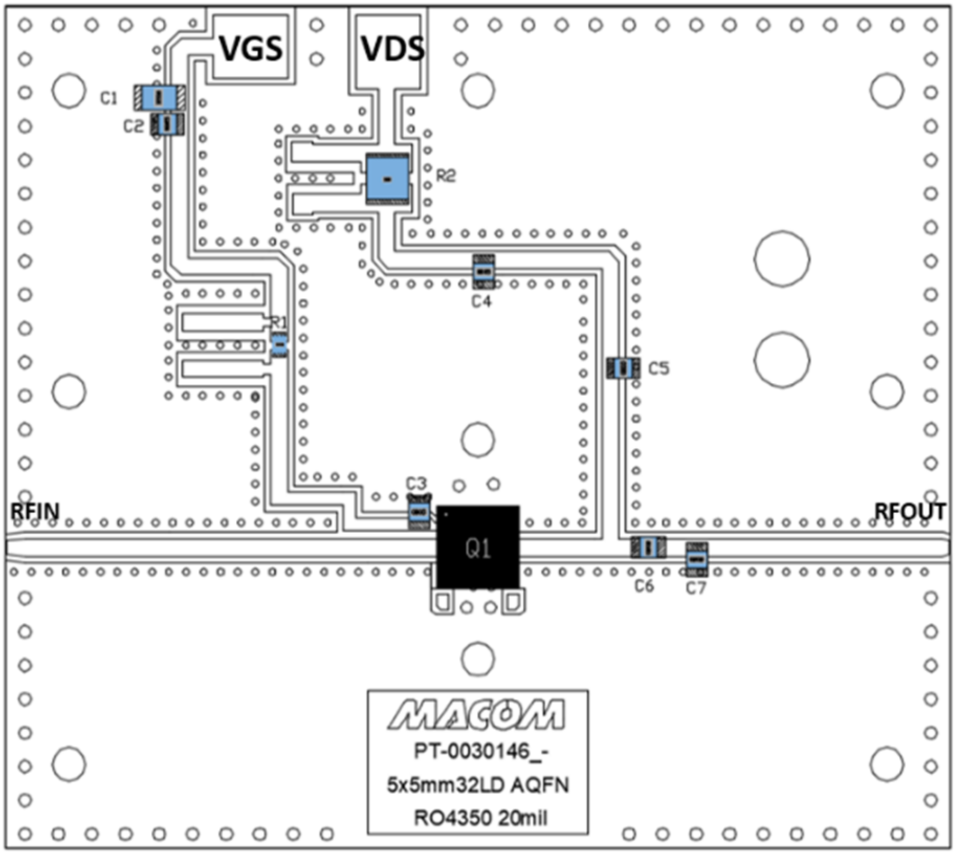
Turning the device ON

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}.

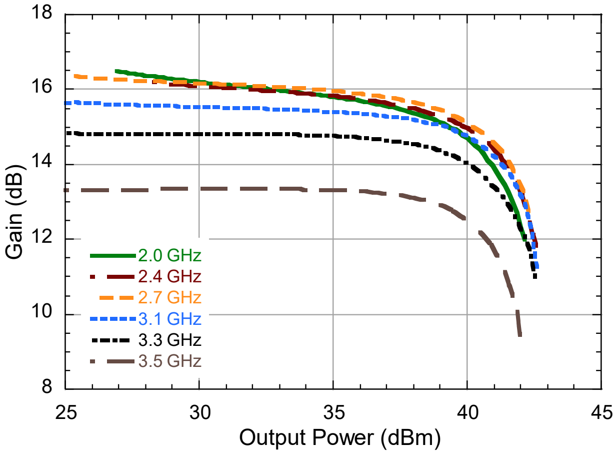
Evaluation Test Fixture and Recommended Tuning Solution 2.0 - 3.5 GHz



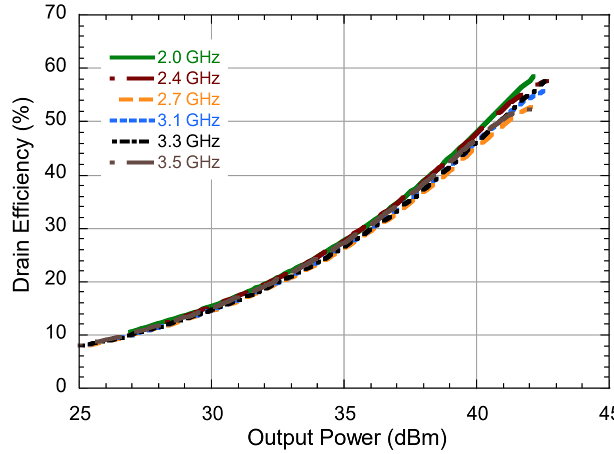
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1	1 µF	+/- 10 %	Murata	GRM31CR72A105KA01L
C2, C3, C4	1000 pF	+/- 5 %	Murata	GRM219R72A102JA01D
C5	4.7 pF	+/- 0.1 pF	PPI	0805N4R7BW251X
C6	8.2 pF	+/- 0.1 pF	PPI	0805N8R2BW251X
C7	0.6 pF	+/- 0.1 pF	PPI	0805N0R6BW251X
R1	5.1 Ω	+/- 1 %	Vishay Dale	CRCW06035R10FKEA
R2	240 mΩ	+/- 1%	Vishay Dale	RCWE1210R240FKEA
Q1	MACOM GaN Power Amplifier			MAPC-S1000
PCB	RO4350, 20 mil, 0.5 oz. Cu, Au Finish			

Typical Performance Curves as Measured in the 2.0 - 3.5 GHz Evaluation Test Fixture:
Pulsed[5] 3.5 GHz, V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C (Unless Otherwise Noted)

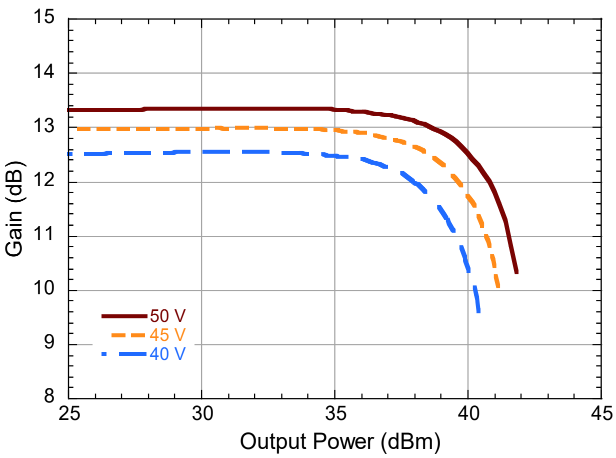
Gain vs. Output Power and Frequency



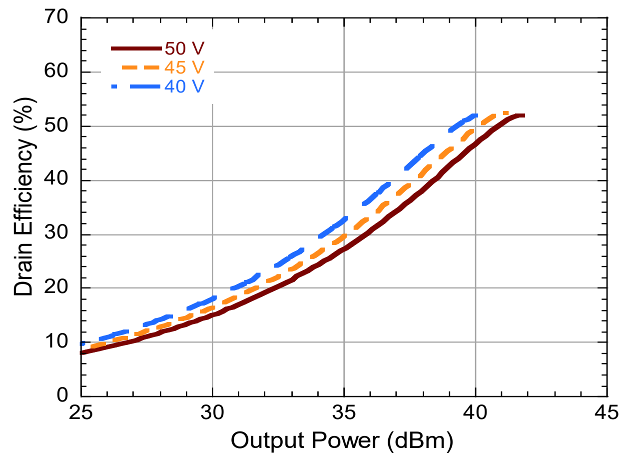
Drain Efficiency vs. Output Power and Frequency



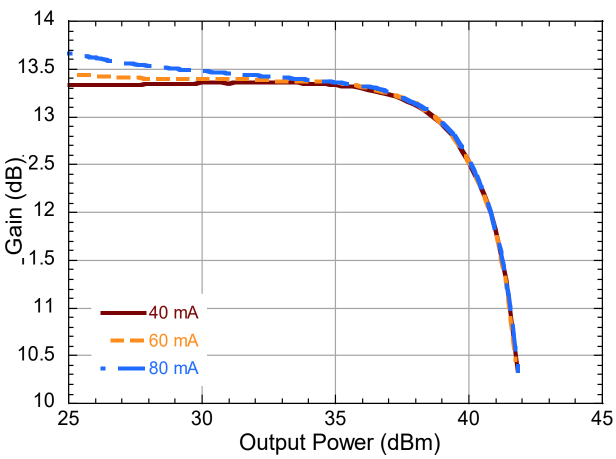
Gain vs. Output Power and V_{DS}



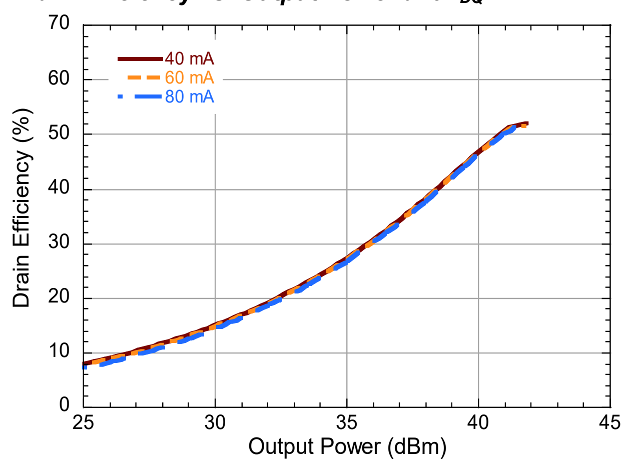
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}

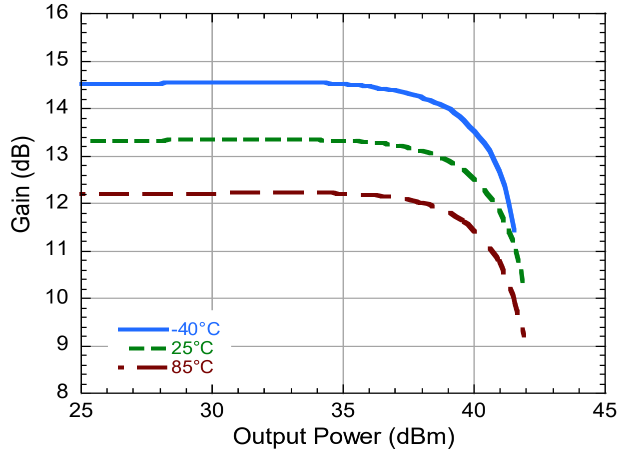


Drain Efficiency vs. Output Power and I_{DQ}

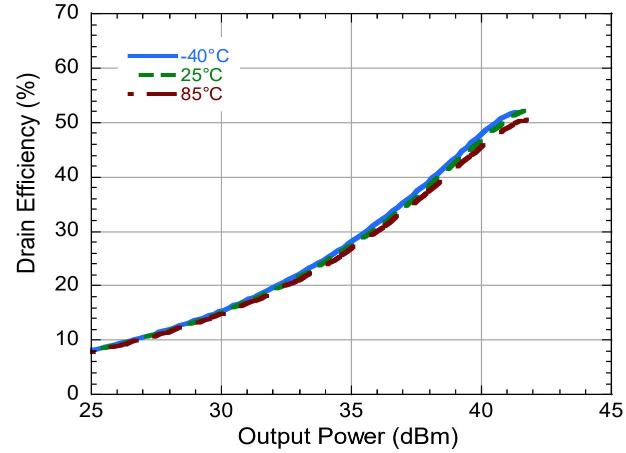


Typical Performance Curves as Measured in the 2.0 - 3.5 GHz Evaluation Test Fixture: Pulsed[5] 3.5 GHz, V_{DS} = 50 V, I_{DQ} = 40 mA, T_C = 25°C (Unless Otherwise Noted)

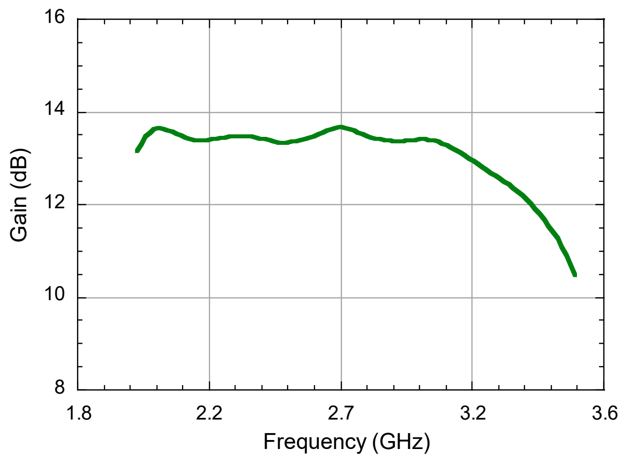
Gain vs. Output Power and T_C



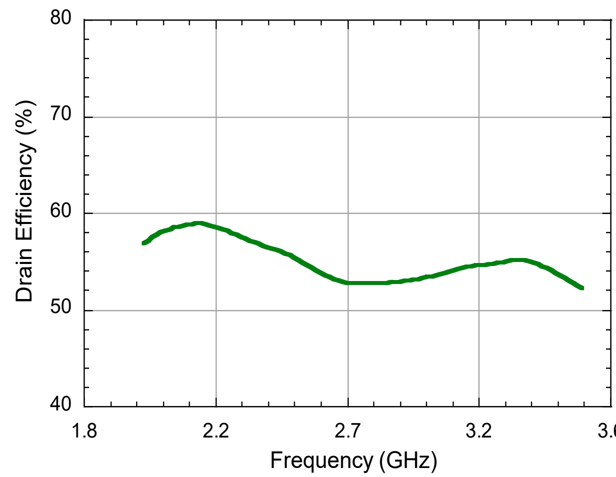
Drain Efficiency vs. Output Power and T_C



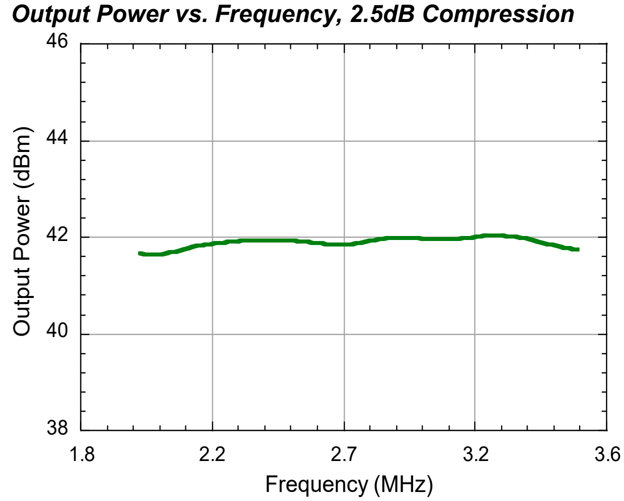
Gain vs. Frequency, 2.5dB Compression



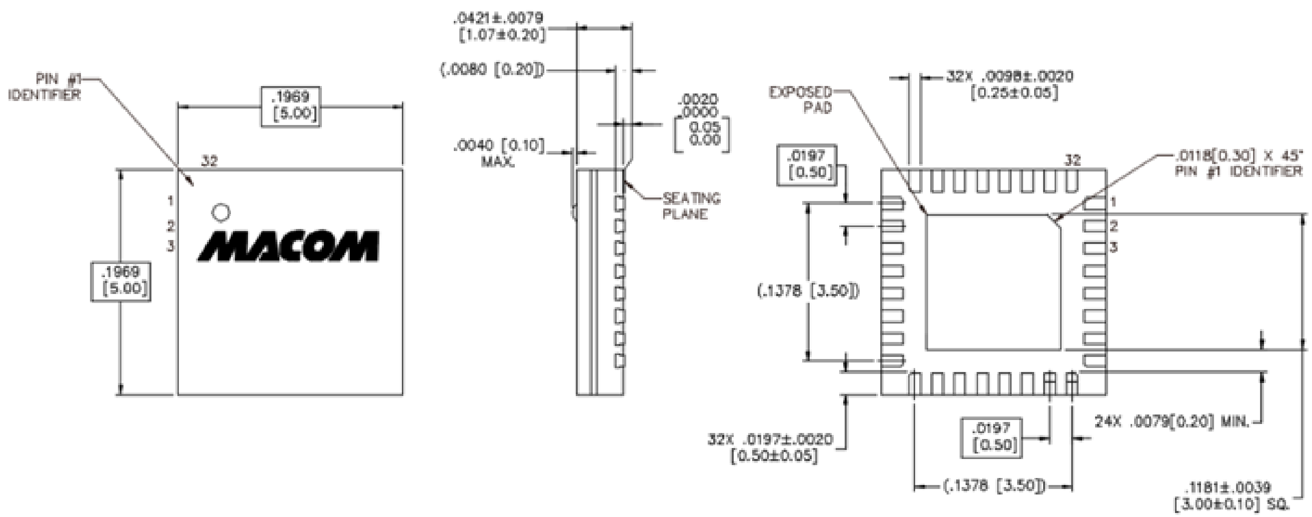
Drain Efficiency vs. Frequency, 2.5dB Compression



Output Power vs. Frequency, 2.5dB Compression



Lead-Free 5 x 5 mm AQFN Package Dimensions†



All dimensions shown as in [mm]

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