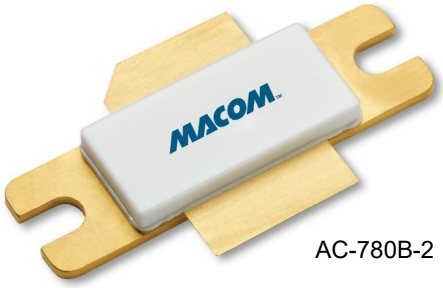
GaN Amplifier 50 V, 500 W
1.2 - 1.4 GHz

MACOM PURE CARBIDE™

MAPC-A1504
Rev. V2

Features

- *MACOM PURE CARBIDE™* Amplifier Series
- Suitable for Linear & Saturated Applications
- CW & Pulsed Operation: 500 W Output Power
- 260°C Reflow Compatible
- 50 V Operation
- 100% RF Tested
- RoHS* Compliant



AC-780B-2

Applications

- ISM
- Multi Market

Description

The MAPC-A1504 is a GaN on Silicon Carbide HEMT D-mode amplifier suitable for 1.2 - 1.4 GHz frequency operation. The device supports both CW and pulsed operation with minimum output power levels of 500 W (57 dBm) in an air cavity ceramic 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} = 380 mA, T_C = 25°C

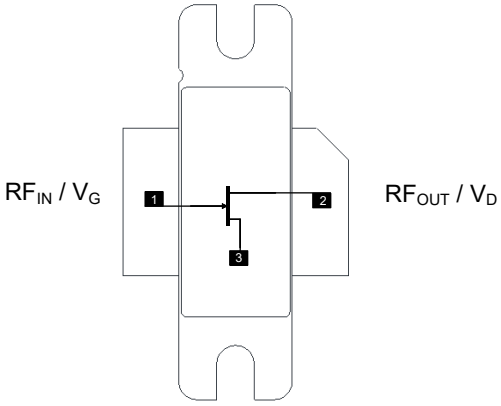
Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D[2] (%)
1.2	58.3	17.9	74.6
1.3	58.3	18	73.5
1.4	58.2	18.1	73.1

- V_{DS} = 28 V, I_{DQ} = 380 mA, T_C = 25°C

Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D[2] (%)
1.2	55.3	16.4	71.3
1.3	55.2	16.7	71.1
1.4	55.1	16.2	70

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

Functional Schematic



Pad / Flange

Pin Configuration

Pin #	Pin Name	Function
1	RF_{IN} / V_G	RF Input / Gate
2	RF_{OUT} / V_D	RF Output / Drain
3	Flange[3]	Ground / Source

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

Ordering Information

Part Number	Package
MAPC-A1504-AB000	Bulk Quantity
MAPC-A1504-ABTR1	Tape and Reel
MAPC-A1504-ABSB1	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} = 380 mA
Note: Performance in MACOM Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	CW, 1.3 GHz	G_{SS}	-	18.3	-	dB
Power Gain	CW, 1.3 GHz, 2.5 dB Gain Compression	G_{SAT}	-	15.8	-	dB
Saturated Drain Efficiency	CW, 1.3 GHz, 2.5 dB Gain Compression	η_{SAT}	-	70	-	%
Saturated Output Power	CW, 1.3 GHz, 2.5 dB Gain Compression	P_{SAT}	-	57.4	-	dBm
Gain Variation (-40°C to +85°C)	Pulsed[4], 1.3 GHz	ΔG	-	0.2	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[4], 1.3 GHz	$\Delta P2.5dB$	-	0.005	-	dB/°C
Power Gain	CW, 1.3 GHz, P_{IN} = 40.3 dBm	G_P	-	16.8	-	dB
Drain Efficiency	CW, 1.3 GHz, P_{IN} = 40.3 dBm	η	-	67	-	%
Input Return Loss	CW, 1.3 GHz, P_{IN} = 40.3 dBm	IRL	-	-18	-	dB
Ruggedness: Output Mismatch	Pulsed[4], All phase angles	Ψ	VSWR = 10:1, No Damage			
Ruggedness: Output Mismatch	CW , All phase angles	Ψ	VSWR = 7:1, No Damage			

RF Electrical Specifications: T_A = 25°C, V_{DS} = 50 V, I_{DQ} = 380 mA
Note: Performance in MACOM Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	Pulsed[4], 1.4 GHz, 2.5 dB Gain Compression	G_{SAT}	15.8	16.6	-	dB
Saturated Drain Efficiency	Pulsed[4], 1.4 GHz, 2.5 dB Gain Compression	η_{SAT}	59.8	64.1	-	%
Saturated Output Power	Pulsed[4], 1.4 GHz, 2.5 dB Gain Compression	P_{SAT}	56.8	57.4	-	dBm

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}	-	-	71.6	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	71.6	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 71.6 mA	V_T	-	-3.1	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 380 mA	V_{GSQ}	-	-2.5	-	V
Maximum Drain Current	V_{DS} = 7 V, pulse width 300 µs	$I_{D, MAX}$	-	85.2	-	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	71.6 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)	0.420	°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)	0.378	°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

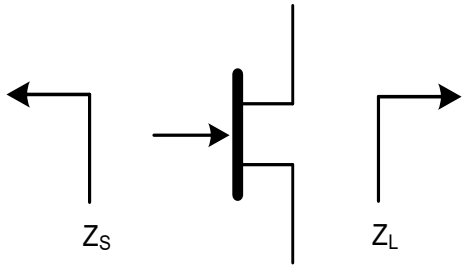
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling.

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

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 50 V, I_{DQ} = 380 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
1.2	1.7 - j2.2	0.8 - j0.2	16.9	58.3	676	63.7	16.6
1.3	2.5 - j0.9	0.8 - j0.3	17	58.3	676	63.3	-26.6
1.4	1.3 - j0.1	0.8 - j0.4	17	58.2	660.7	62.3	-73

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 50 V, I_{DQ} = 380 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
1.2	2.6 - j1.9	0.9 + j0.7	17.9	55.7	371.5	74.6	-21.8
1.3	1.9 - j0.1	0.9 + j0.5	18	56.3	426.5	73.5	-70.7
1.4	0.8 - j0.1	0.8 + j0.3	18.1	56.3	426.5	73.1	-107.3

Impedance Reference

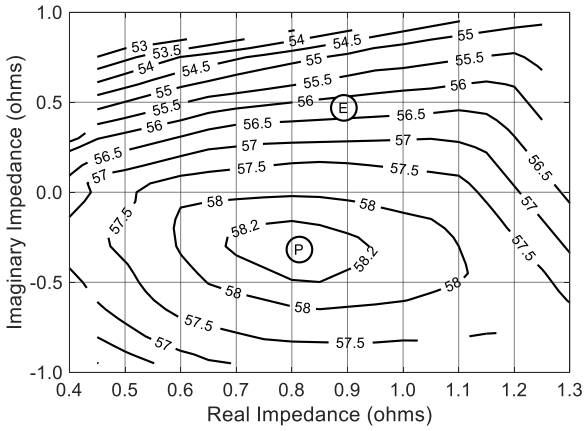


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

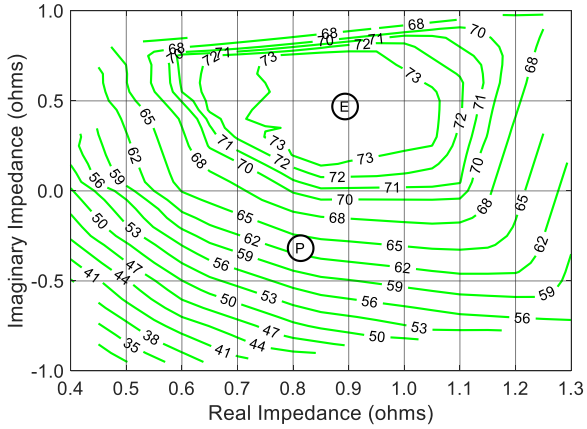
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

Pulsed[4] 50 V Load-Pull Performance @ 1.3 GHz

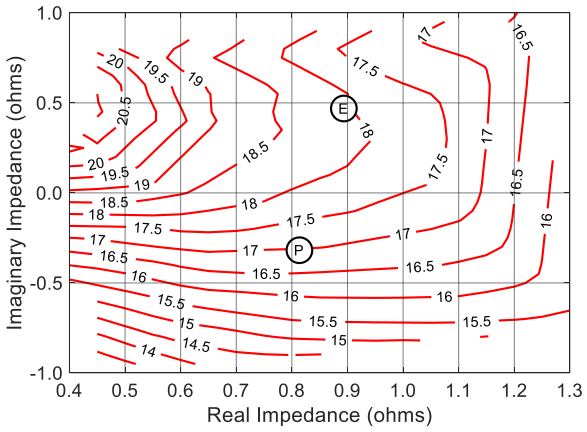
P2.5dB Loadpull Output Power Contours (dBm)



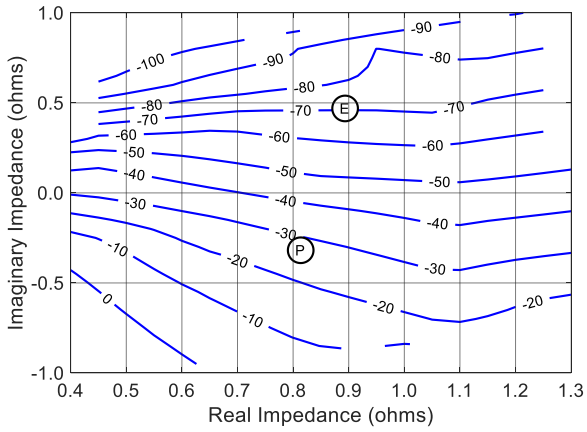
P2.5dB Loadpull Drain Efficiency Contours (%)



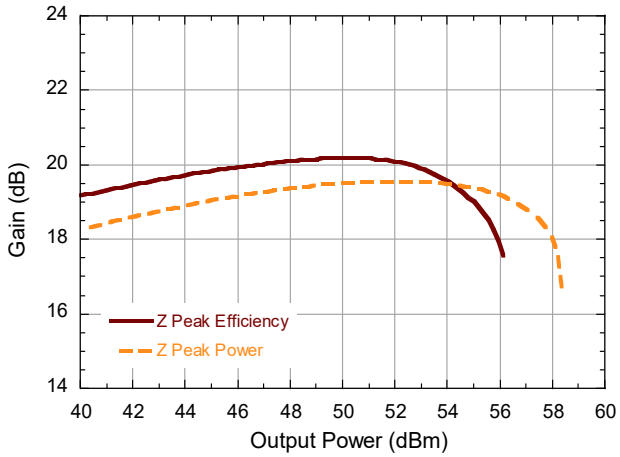
P2.5dB Loadpull Gain Contours (dB)



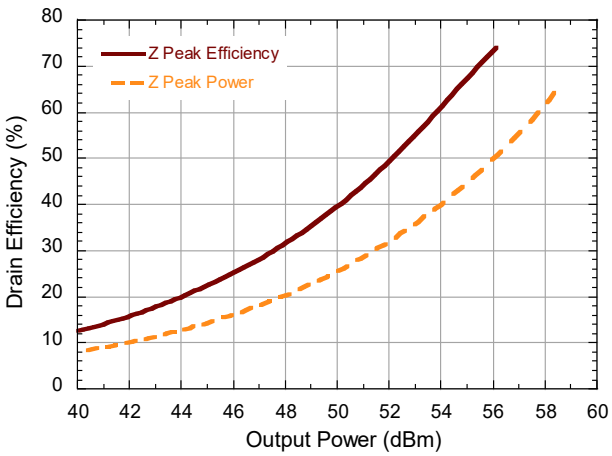
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

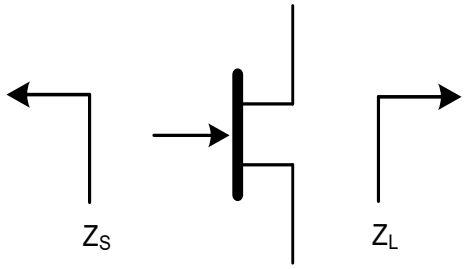


Pulsed[4] Load-Pull Performance at 28 V: Reference Plane at Device Leads

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 28 V, I_{DQ} = 380 mA, T_C = 25°C, P2.5dB Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
1.2	1.6 - j2.3	0.5 - j0.4	15.6	55.3	338.8	62.2	26.1
1.3	2.9 - j1.0	0.5 - j0.6	15.6	55.2	331.1	58.8	-13.4
1.4	1.5 + j0	0.5 - j0.7	15.6	55.1	323.6	58.4	-65.1

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 28 V, I_{DQ} = 380 mA, T_C = 25°C, P2.5dB Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
1.2	2.5 - j1.7	0.8_ j0.3	16.4	52.2	166	71.3	-29.1
1.3	2.1 + j0.2	0.8 + j0.1	16.7	52.2	166	71.1	-77.3
1.4	0.8 - j0.2	0.8 - j0	16.2	52.4	173.8	70	-104.7

Impedance Reference

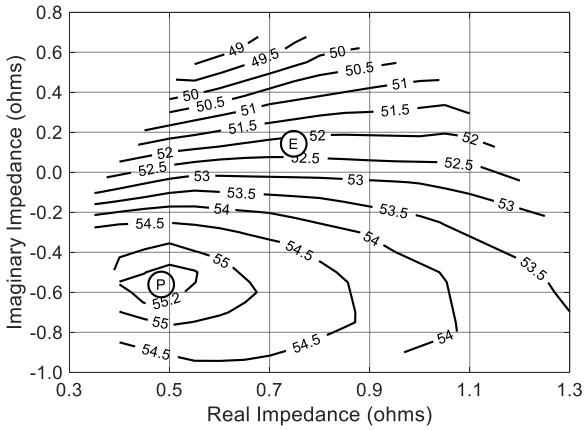


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

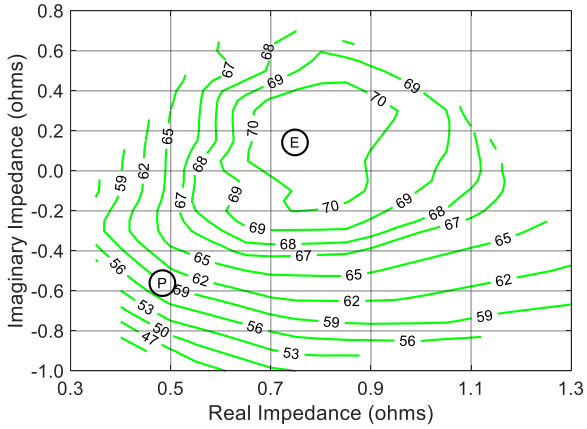
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

Pulsed[4] 28 V Load-Pull Performance @ 1.3 GHz

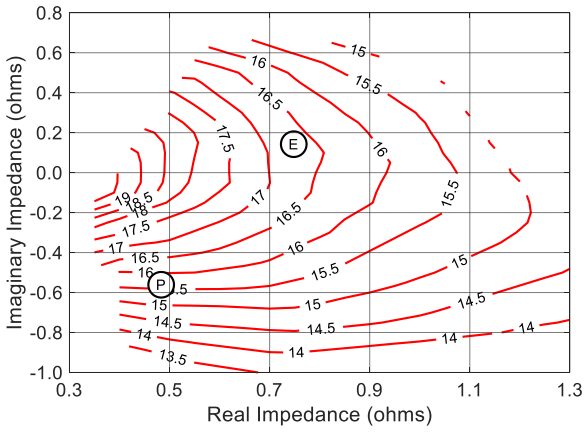
P2.5dB Loadpull Output Power Contours (dBm)



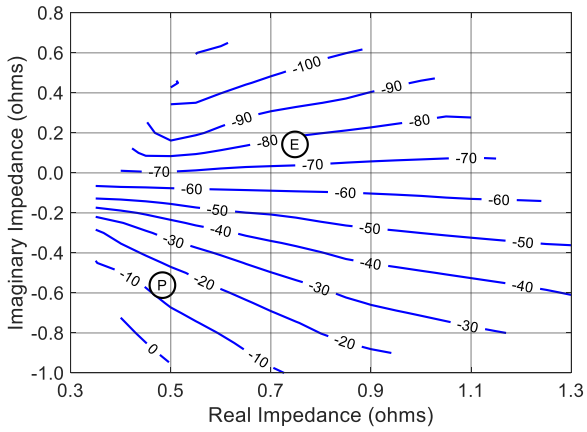
P2.5dB Loadpull Drain Efficiency Contours (%)



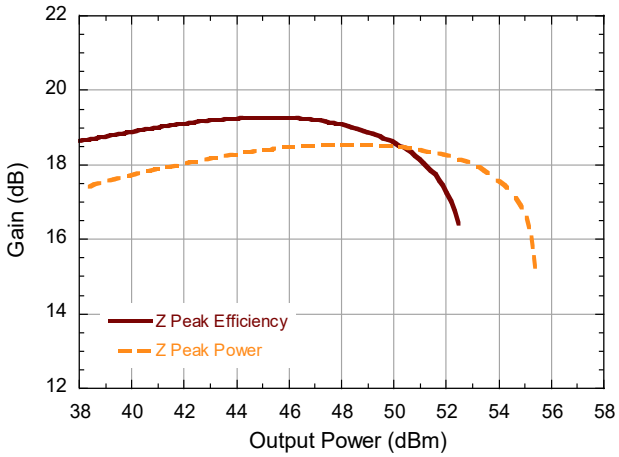
P2.5dB Loadpull Gain Contours (dB)



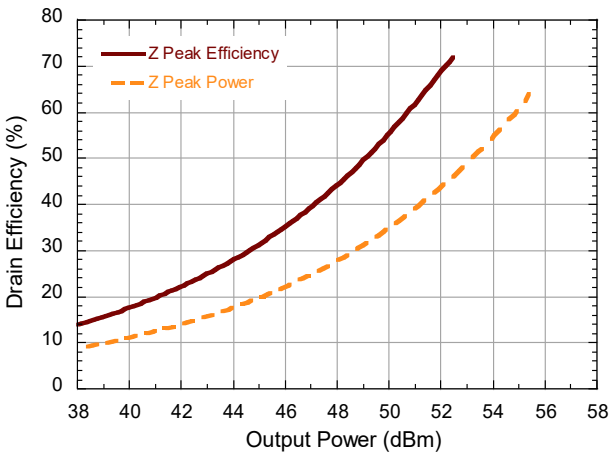
P2.5dB Loadpull AM/PM Contours (°)



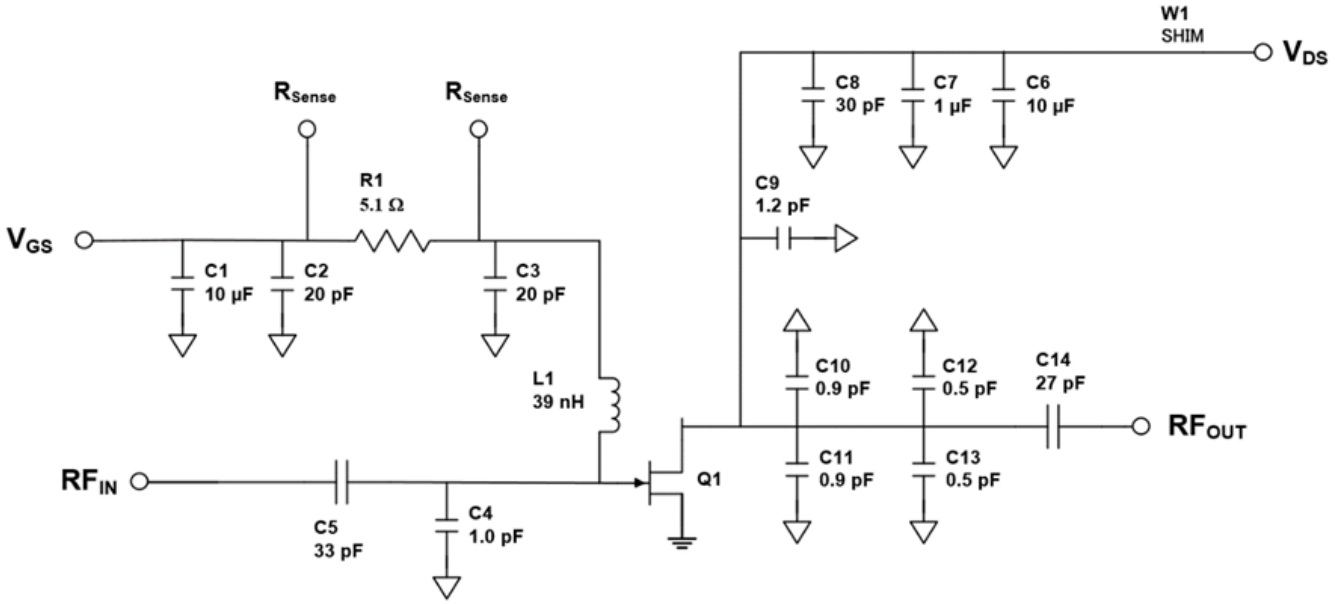
Gain vs. Output Power



Drain Efficiency vs. Output Power



Evaluation Test Fixture and Recommended Tuning Solution 1.2 - 1.4 GHz



Description

Parts measured on evaluation board (25-mil thick RO6010). 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

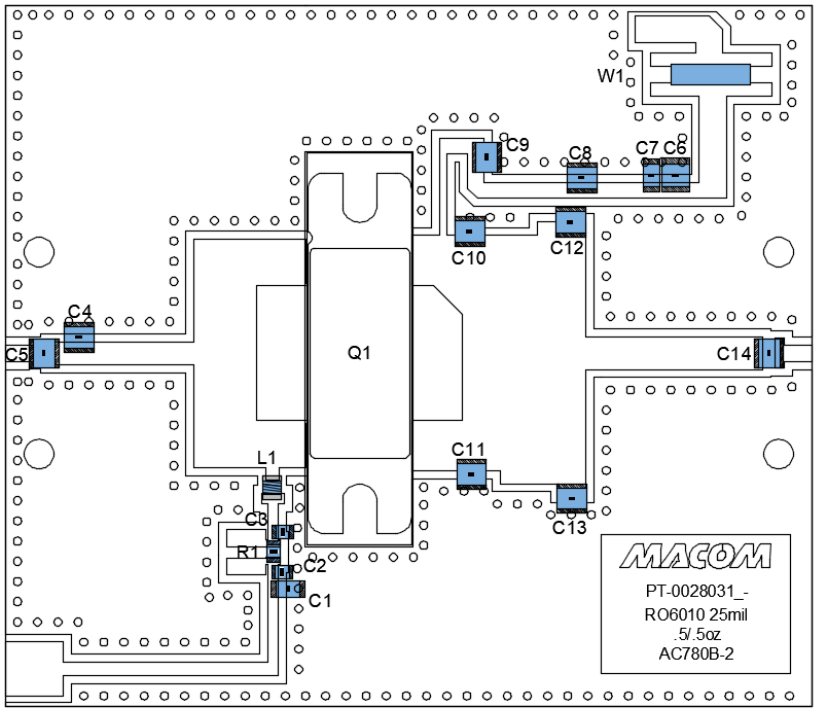
Turning the device ON

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}.

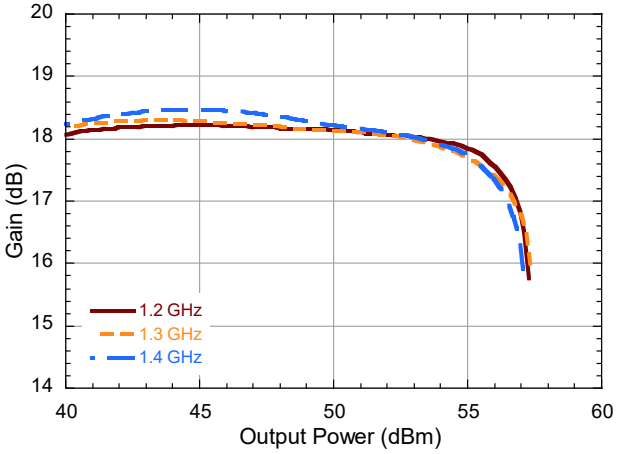
Evaluation Test Fixture and Recommended Tuning Solution 1.2 - 1.4 GHz



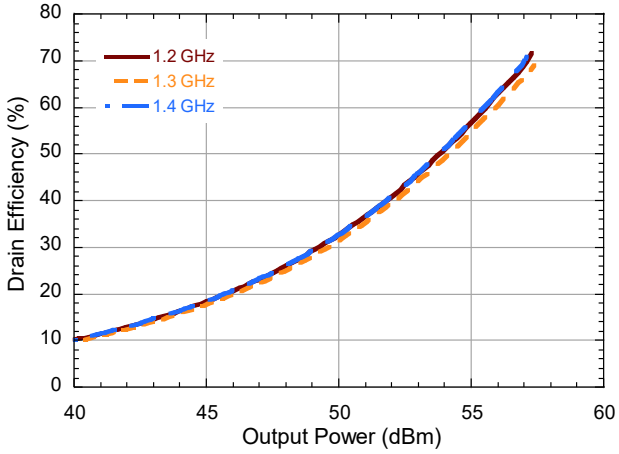
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1	10 µF	+/- 10 %	Murata	GRM32EC72A106KE05L
C2, C3	20 pF	+/- 5 %	PPI	0805N200JW251X
C4	1.0 pF	+/- 0.1 pF	PPI	1111N1R0BW501XT
C5	33 pF	+/- 5 %	PPI	1111N330JW501XT
C6	10 µF	+/- 10 %	Murata	GRM32EC72A106KE05L
C7	1 µF	+/- 10 %	Murata	GRM31CR72A105KA01L
C8	30 pF	+/- 10 %	PPI	1111N300JW501XT
C9	1.2 pF	+/- 0.1 pF	PPI	1111N1R2BW501XT
C10, C11	0.9 pF	+/- 0.1 pF	PPI	1111N0R9BW501XT
C12, C13	0.5 pF	+/- 0.1 pF	PPI	1111N0R5BW501XT
C14	27 pF	+/- 0.1 pF	PPI	1111N270JW501XT
R1	5.1 Ω	+/- 1 %	Vishay	CRCW08055R10FKEA
L1	39 nH	+/- 5 %	Coilcraft	0805CS-390XJE
W1	-	-	-	Copper Shim
Q1	MACOM GaN Power Amplifier			MAPC-A1504
PCB	RO6010, 25 mil, 0.5 oz. Cu, SnPb Finish			

Typical Performance Curves as Measured in the 1.2 - 1.4 GHz Evaluation Test Fixture:
CW 1.3 GHz, V_{DS} = 50 V, I_{DQ} = 380 mA, T_C = 25°C (Unless Otherwise Noted)

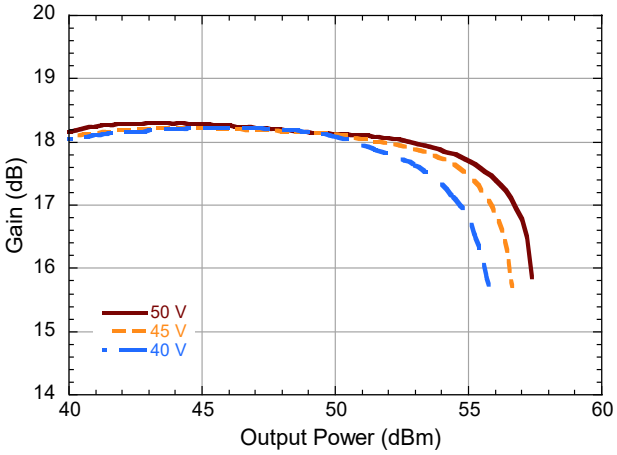
Gain vs. Output Power and Frequency



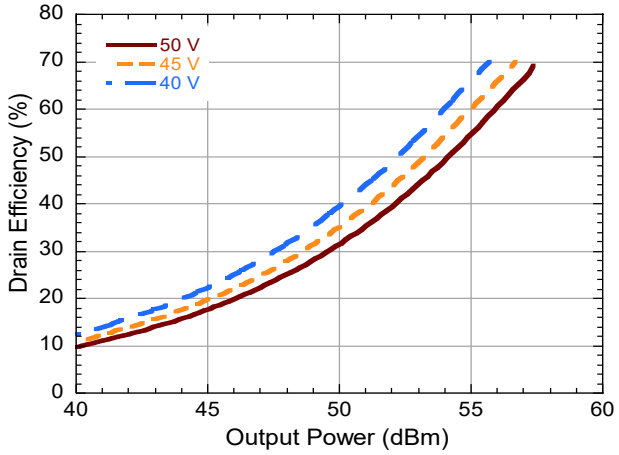
Drain Efficiency vs. Output Power and Frequency



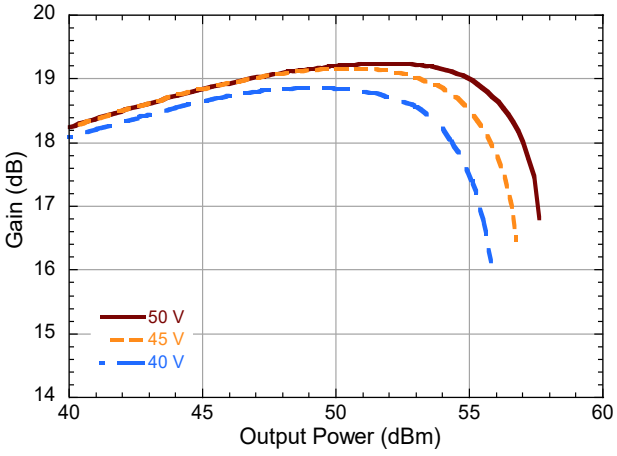
Gain vs. Output Power and V_{DS}



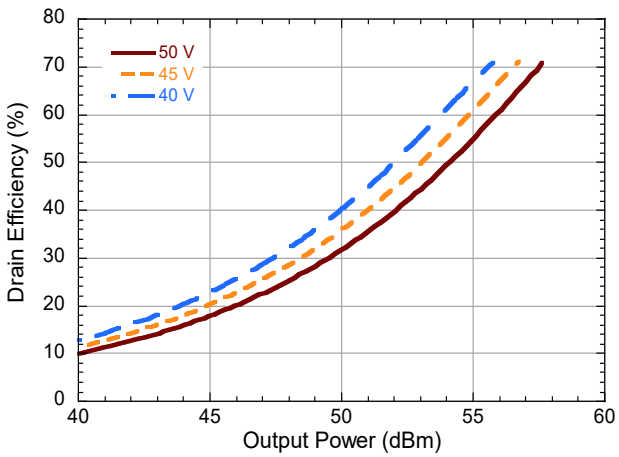
Drain Efficiency vs. Output Power and V_{DS}



Pulsed[4] Gain vs. Output Power and V_{DS}

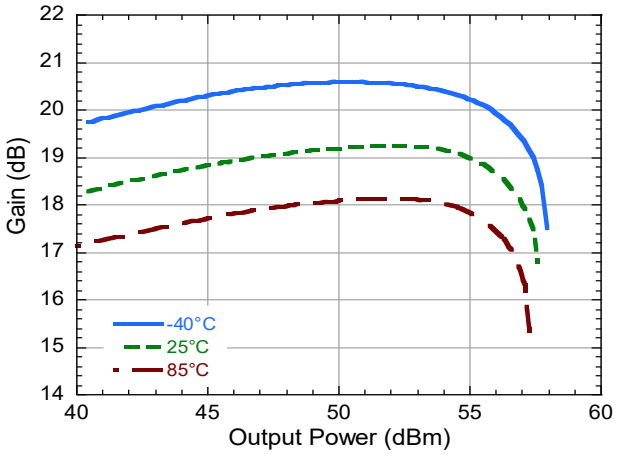


Pulsed[4] Drain Efficiency vs. Output Power and V_{DS}

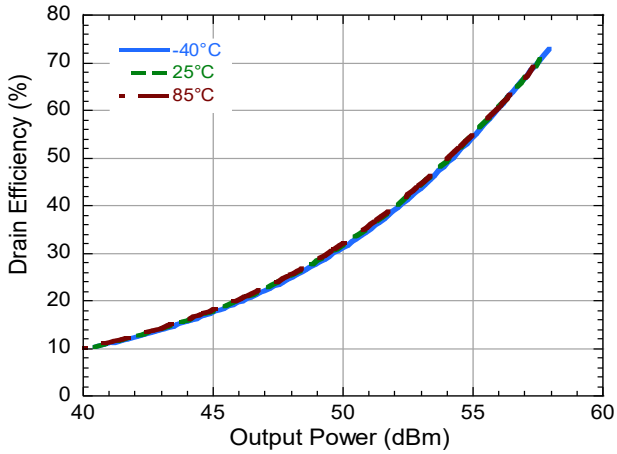


Typical Performance Curves as Measured in the 1.2 - 1.4 GHz Evaluation Test Fixture:
Pulsed[4] 1.3 GHz, V_{DS} = 50 V, I_{DQ} = 380 mA, T_C = 25°C (Unless Otherwise Noted)

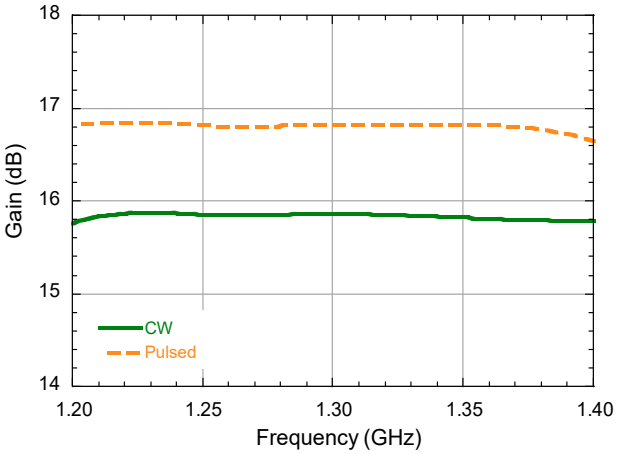
Gain vs. Output Power and T_C



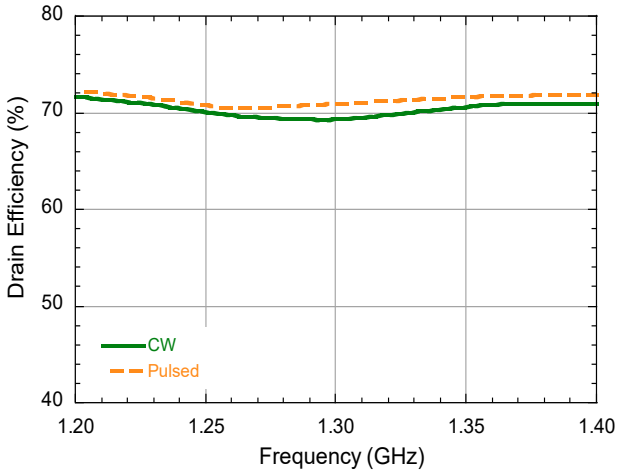
Drain Efficiency vs. Output Power and T_C



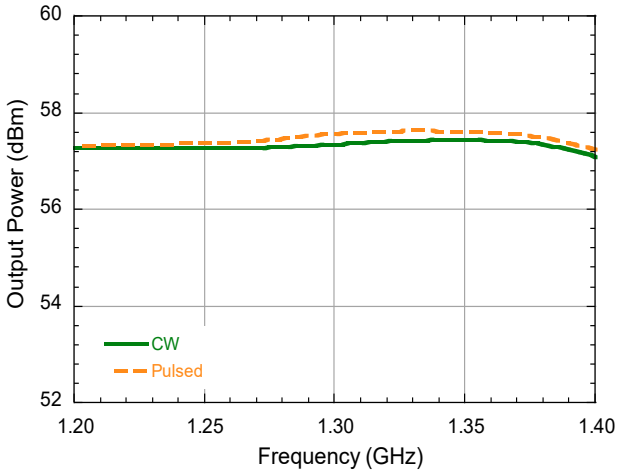
Gain vs. Frequency, 2.5dB Compression



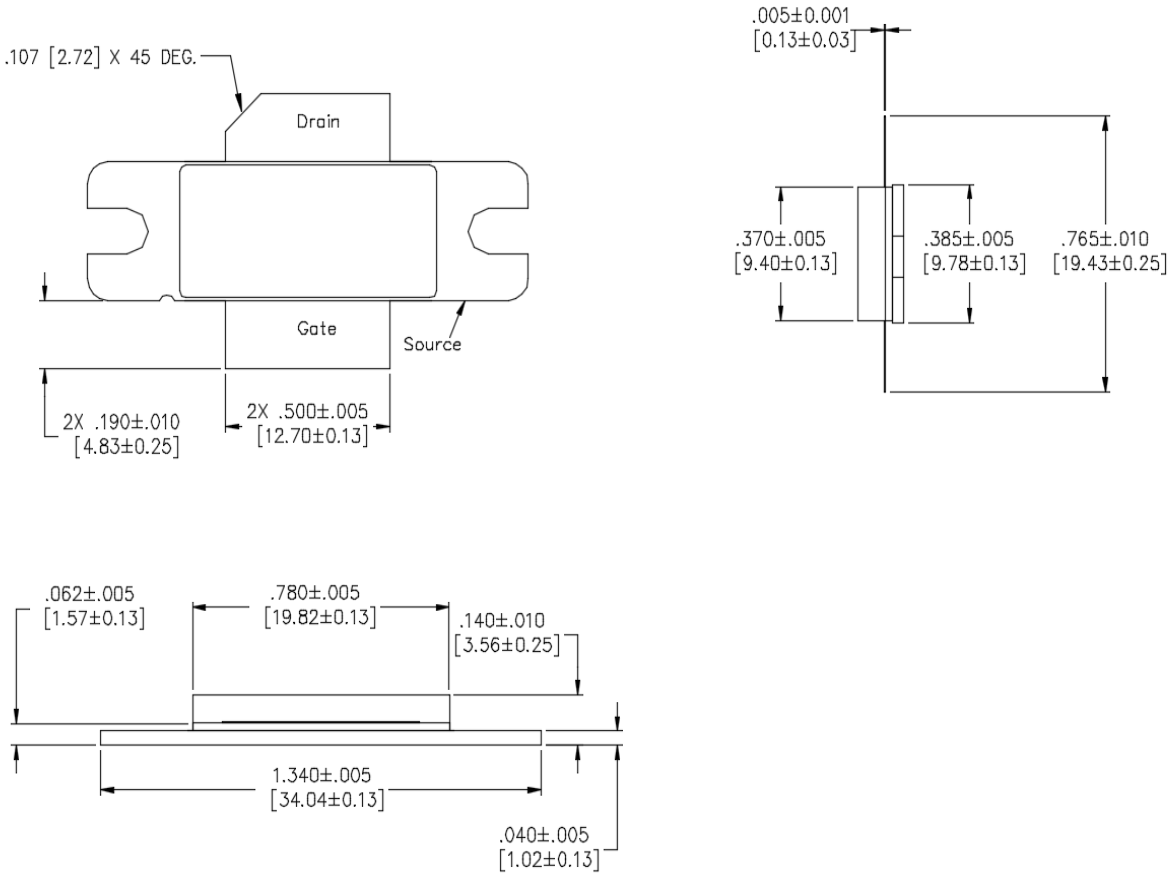
Drain Efficiency vs. Frequency, 2.5dB Compression



Output Power vs. Frequency, 2.5dB Compression



Lead-Free AC-780B-2 Package Dimensions†



NOTES:
1. ALL DIMENSIONS SHOWN AS in[mm]. CONTROLLING DIMENSIONS ARE IN in AND CONVERTED mm DIMENSIONS ARE NOT NECESSARILY EXACT.
2. LEAD FINISH: AU
   FLANGE FINISH: AU
3. LID SEAL EPOXY MAY FLOW OUT A MAXIMUM OF .018 [0.46] FROM EDGE OF LID
4. LID MAY BE MIS-ALIGNED UP TO .008 [0.20] FROM PACKAGE IN ANY DIRECTION

† Reference Application Note AN0004363 for mounting recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is Au.