GaN Amplifier 65 V, 1300 W
960 - 1215 MHz

MACOM PURE CARBIDE™

MAPC-A1501
Rev. V4

Features

- *MACOM PURE CARBIDE™* Amplifier Series
- Suitable for Linear & Saturated Applications
- Pulsed Operation: 1300 W Output Power @ 65 V
- 1000 W Output Power @ 50 V
- Internally Pre-Matched
- 260°C Reflow Compatible
- 65 V Operation
- 100% RF Tested
- RoHS* Compliant
- Compatible with MACOM Power Management Bias Controller/Sequencer MABC-11040

AC-780B-2

AC-780S-2

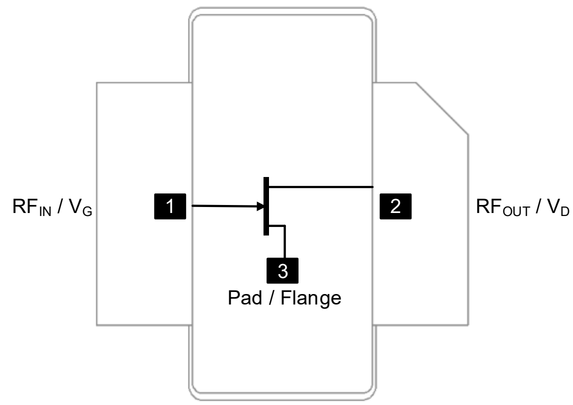
Applications

- Avionics, IFF Transponders.

Description

The MAPC-A1501 is a high power GaN on Silicon Carbide HEMT D-mode amplifier suitable for 960 - 1215 MHz frequency operation. The device supports pulsed operation with output power levels of 1300 W (61.1 dBm) at 65V and 1000 W (60.0 dBm) at 50V and in an air cavity ceramic package.

Functional Schematic



Typical Performance:

Measured under load-pull at 2.5 dB Compression, 100 µs pulse width, 1% duty cycle.

- V_{DS} = 65 V, I_{DQ} = 650 mA, T_C = 25°C.

Frequency (MHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D [2] (%)
960	62.4	20.8	76.1
1030	62.2	20.4	73.1
1090	62.1	20.4	73.1
1215	61.9	18.8	71.0

- V_{DS} = 50 V, I_{DQ} = 650 mA, T_C = 25°C.

Frequency (MHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D [2] (%)
960	61.1	19.9	71.2
1030	60.8	19.6	70.4
1090	60.7	19.1	70.7
1215	60.7	18.4	71.3

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

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-A1501-AS000	Bulk Quantity Earless
MAPC-A1501-ASTR1	Tape and Reel Earless
MAPC-A1501-ASSB1	Sample Board Earless
MAPC-A1501-AB000	Bulk Quantity Boltdown
MAPC-A1501-ABTR1	Tape and Reel Boltdown
MAPC-A1501-ABSB1	Sample Board Boltdown

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

RF Electrical Characteristics: T_C = 25°C, V_{DS} = 65 V, I_{DQ} = 650 mA
Note: Performance in MACOM 1030 - 1090 MHz Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	Pulsed[4], 1.06 GHz	G_{SS}	-	18.0	-	dB
Saturated Output Power	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	P_{SAT}	-	61.8	-	dBm
Power Gain	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	G_{SAT}	-	18.2	-	dB
Saturated Drain Efficiency	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	η_{SAT}	-	69.5	-	%
Gain Variation (-40°C to +85°C)	Pulsed[4], 1.06 GHz	ΔG	-	0.012	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[4], 1.06 GHz	ΔP2.5dB	-	0.003	-	dB/°C
Power Gain	Pulsed[4], 1.06 GHz, P_{OUT} = 61 dBm	G_P	-	20	-	dB
Drain Efficiency	Pulsed[4], 1.06 GHz, P_{OUT} = 61 dBm	η	-	64.5	-	%
Input Return Loss	Pulsed[4], 1.06 GHz, P_{OUT} = 61 dBm	IRL	-	-15	-	dB
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 7:1, No Damage			

RF Electrical Characteristics: T_C = 25°C, V_{DS} = 50 V, I_{DQ} = 650 mA
Note: Performance in MACOM 1030 - 1090 MHz Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	Pulsed[4], 1.06 GHz	G_{SS}	-	17.2	-	dB
Saturated Output Power	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	P_{SAT}	-	60.3	-	dBm
Power Gain	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	G_{SAT}	-	17.2	-	dB
Saturated Drain Efficiency	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	η_{SAT}	-	64.5	-	%
Gain Variation (-40°C to +85°C)	Pulsed[4], 1.06 GHz	ΔG	-	0.021	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[4], 1.06 GHz	ΔP2.5dB	-	0.005	-	dB/°C
Power Gain	Pulsed[4], 1.06 GHz, P_{OUT} = 61 dBm	G_P	-	18.2	-	dB
Drain Efficiency	Pulsed[4], 1.06 GHz, P_{OUT} = 61 dBm	η	-	62.5	-	%
Input Return Loss	Pulsed[4], 1.06 GHz, P_{OUT} = 61 dBm	IRL	-	-15	-	dB
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 7:1, No Damage			

RF Electrical Specifications: T_A = 25°C, V_{DS} = 65 V, I_{DQ} = 650 mA
Note: Performance in MACOM 1030 - 1090 MHz Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	G_{SAT}	17	18.1	-	dB
Saturated Drain Efficiency	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	η_{SAT}	62	69.5	-	%
Saturated Output Power	Pulsed[4], 1.06 GHz, 2.5 dB Gain Compression	P_{SAT}	60.4	61.8	-	dBm

4. Pulse details: 100 µs pulse width, 1% 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}	-	-	133	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	133	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 133 mA	V_T	-3.6	-3.1	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 650 mA	V_{GSQ}	-	-2.71	-	V
On Resistance	V_{GS} = 2 V, I_D = 1000 mA	R_{ON}	-	0.026	-	Ω
Maximum Drain Current	V_{DS} = 7 V pulsed, pulse width 300 µs	$I_{D, MAX}$	-	126	-	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	133 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 $T_{CH} \leq 200°C$ 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 (Pulsed: 100µs, 10%)	V_{DS} = 65 V, T_C = 85°C, T_{CH} = 225°C	R_θ(FEA)	0.16	°C/W
Thermal Resistance using Infrared Measurement of Die Surface Temperature	V_{DS} = 65 V, T_C = 85°C, T_{CH} = 225°C	R_θ(IR)	0.15	°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

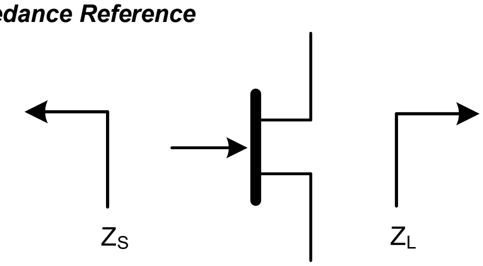
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

65V Pulsed[13] Load-Pull Performance
Reference Plane at Device Leads

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 65 V, I_{DQ} = 650 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
960	1.1 - j2.0	0.73 - j0.55	19.6	62.4	1740	65.8	32
1030	2.3 - j1.8	0.68 - j0.61	19.0	62.2	1660	62.5	-3
1090	2.6 - j0.8	0.64 - j0.62	18.7	62.1	1620	62.2	-32
1215	1.3 + j0.1	0.62 - j0.73	18.2	61.9	1550	63.7	-81

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 65 V, I_{DQ} = 650 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
960	1.1 - j2.2	0.85 + j0.24	20.8	60.0	1000	76.1	14
1030	2.6 - j1.5	0.87 + j0.08	20.4	60.0	1000	73.1	-30
1090	2.5 - j0.1	0.86 + j0.0	20.4	59.5	890	73.1	-69
1215	1.0 + j0.0	0.77 - j0.12	18.8	59.5	890	71.0	-106

Impedance Reference



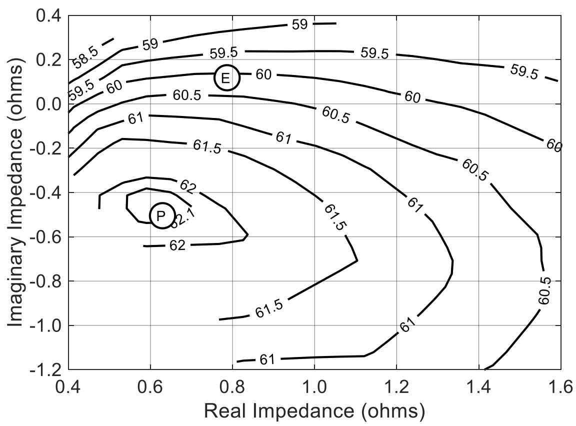
Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.
13. Pulse Details: 15µs pulse width, 1% duty cycle

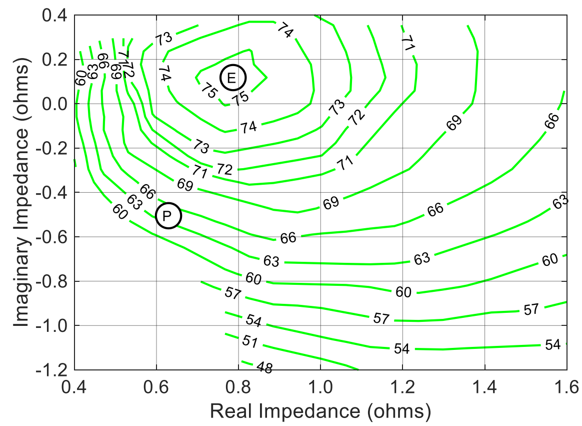
65V Pulsed[13] Load-Pull Performance

1090 MHz

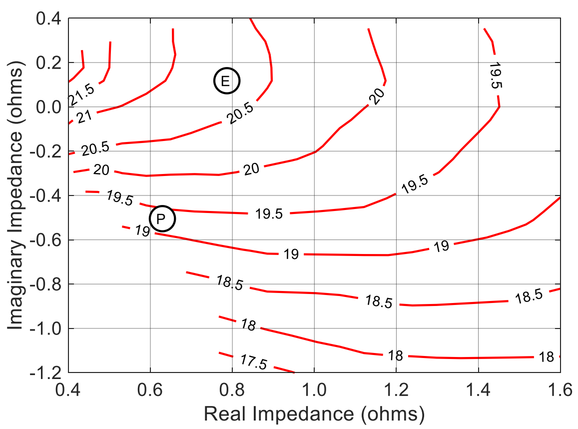
P2.5dB Loadpull Output Power Contours (dBm)



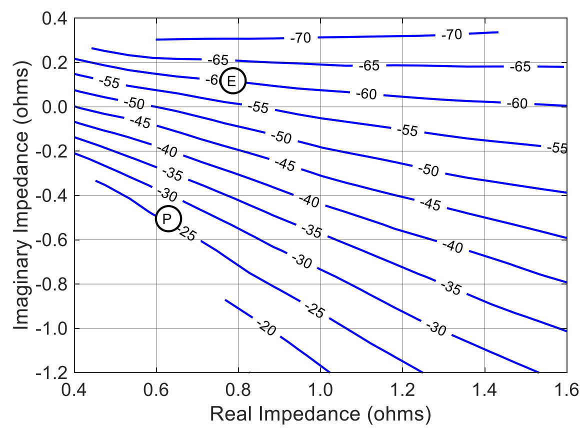
P2.5dB Loadpull Drain Efficiency Contours (%)



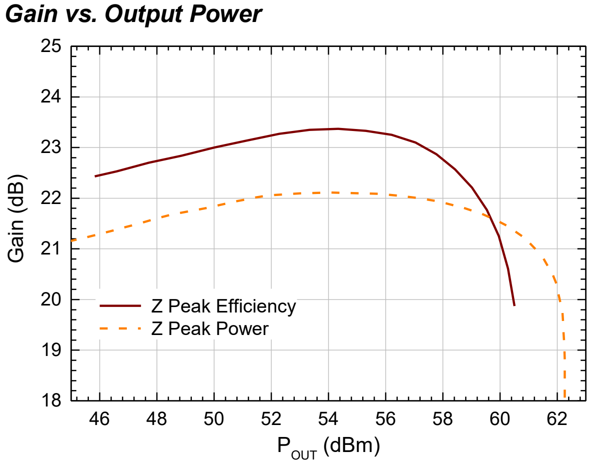
P2.5dB Loadpull Gain Contours (dB)



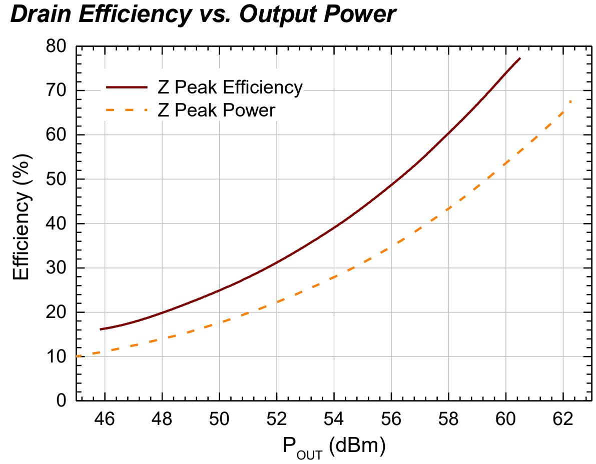
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

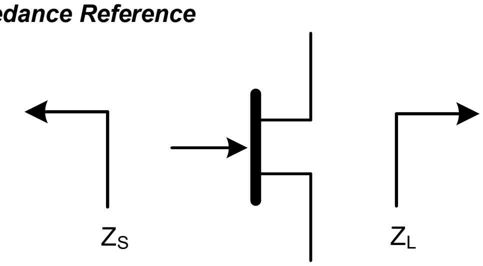


50V Pulsed[13] Load-Pull Performance
Reference Plane at Device Leads

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 50 V, I_{DQ} = 650 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
960	1.2 - j2.2	0.55 - j0.54	19.1	61.1	1290	62.6	35
1030	2.6 - j1.2	0.54 - j0.81	18.4	60.8	1200	60.8	0
1090	2.5 + j0.3	0.49 - j0.80	18.4	60.7	1175	60.8	-32
1215	1.1 - j0.1	0.47 - j0.93	17.7	60.7	1175	59.7	-78

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 50 V, I_{DQ} = 650 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
960	1.2 - j2.2	0.91 + j0.07	19.9	58.5	710	71.2	7
1030	2.6 - j1.2	0.78 - j0.16	19.6	58.5	710	70.4	-36
1090	2.5 + j0.3	0.77 - j0.23	19.1	58.4	690	70.7	-69
1215	1.1 - j0.1	0.68 - j0.38	18.4	58.4	690	71.3	-106

Impedance Reference

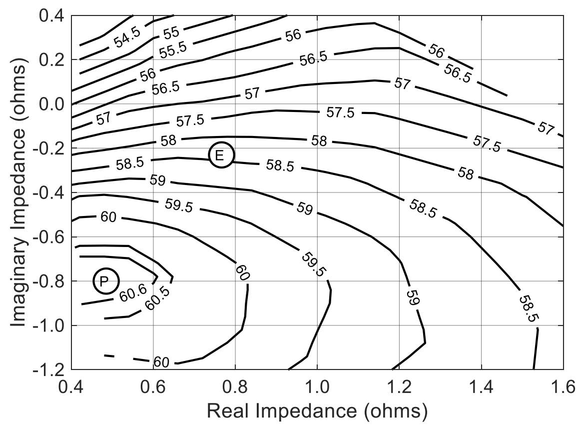


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

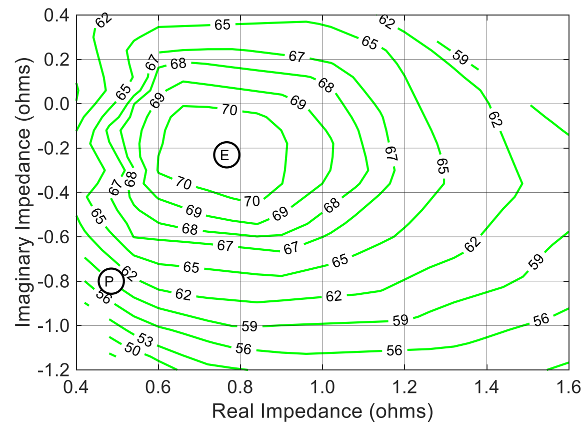
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

50V Pulsed[13] Load-Pull Performance
1090 MHz

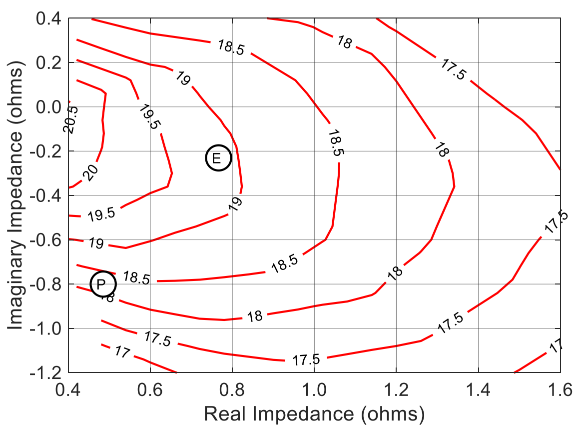
P2.5dB Loadpull Output Power Contours (dBm)



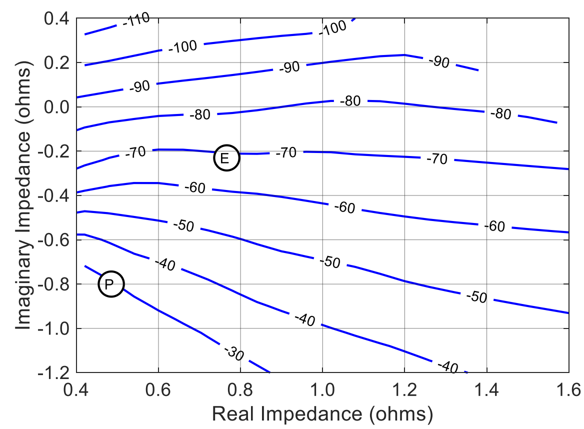
P2.5dB Loadpull Drain Efficiency Contours (%)



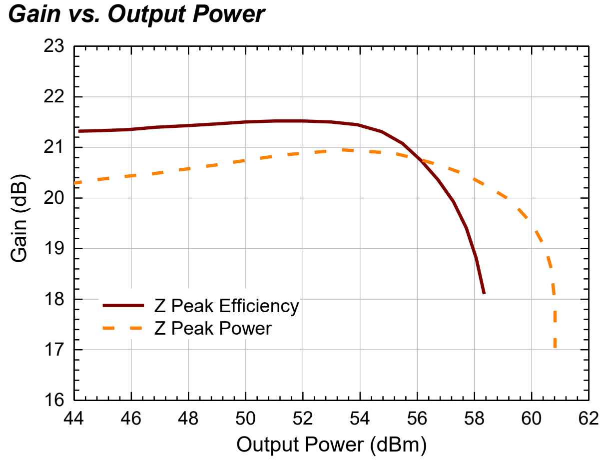
P2.5dB Loadpull Gain Contours (dB)



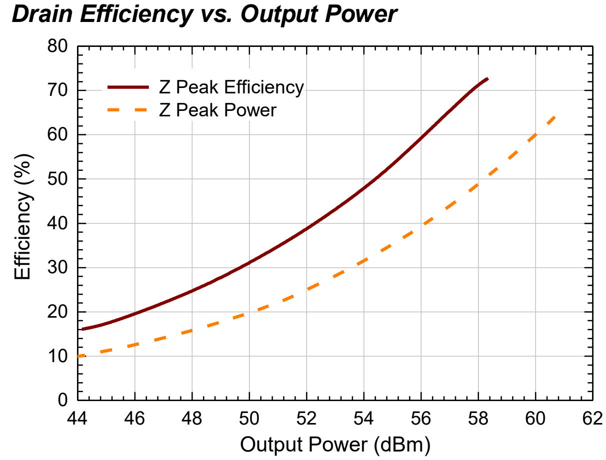
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

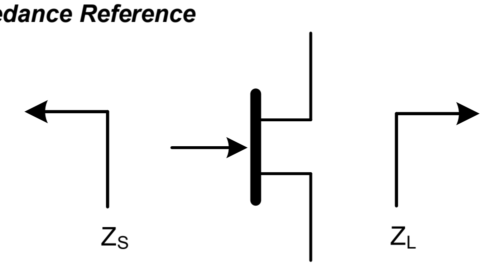


28V Pulsed[14] Load-Pull Performance
Reference Plane at Device Leads

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 28 V, I_{DQ} = 650 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
960	0.50 - j1.5	0.33 - j0.55	16.1	57.4	554	57.8	-0.2
1030	1.1 - j1.8	0.28 - j0.61	16.4	57.8	607	58.6	-2.6
1090	1.6 + j1.9	0.27 - j0.65	16.0	57.5	567	57.3	-5.0
1215	2.0 - j0.5	0.28 - j0.75	15.6	57.4	550	60.6	-7.8

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 28 V, I_{DQ} = 650 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
960	0.50 - j1.5	0.62 - j0.20	17.2	54.8	301	68.3	-7.3
1030	1.1 - j1.8	0.60 - j0.17	16.9	54.5	280	70.8	-12.8
1090	1.6 + j1.9	0.54 - j0.29	16.7	54.3	268	69.3	-21.3
1215	2.0 - j0.5	0.50 - j0.36	16.0	54.5	282	71.6	-10.7

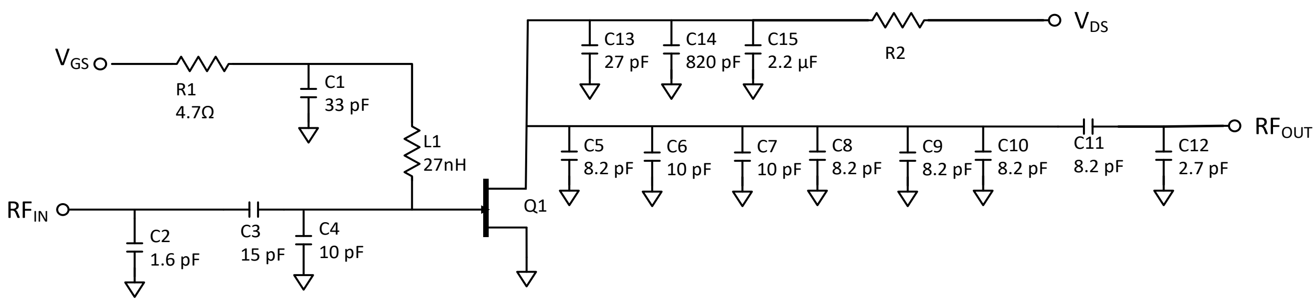
Impedance Reference



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.
14. Pulse Details: 50µs pulse width, 1% duty cycle

Evaluation Test Fixture and Recommended Tuning Solution 1.03-1.09 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

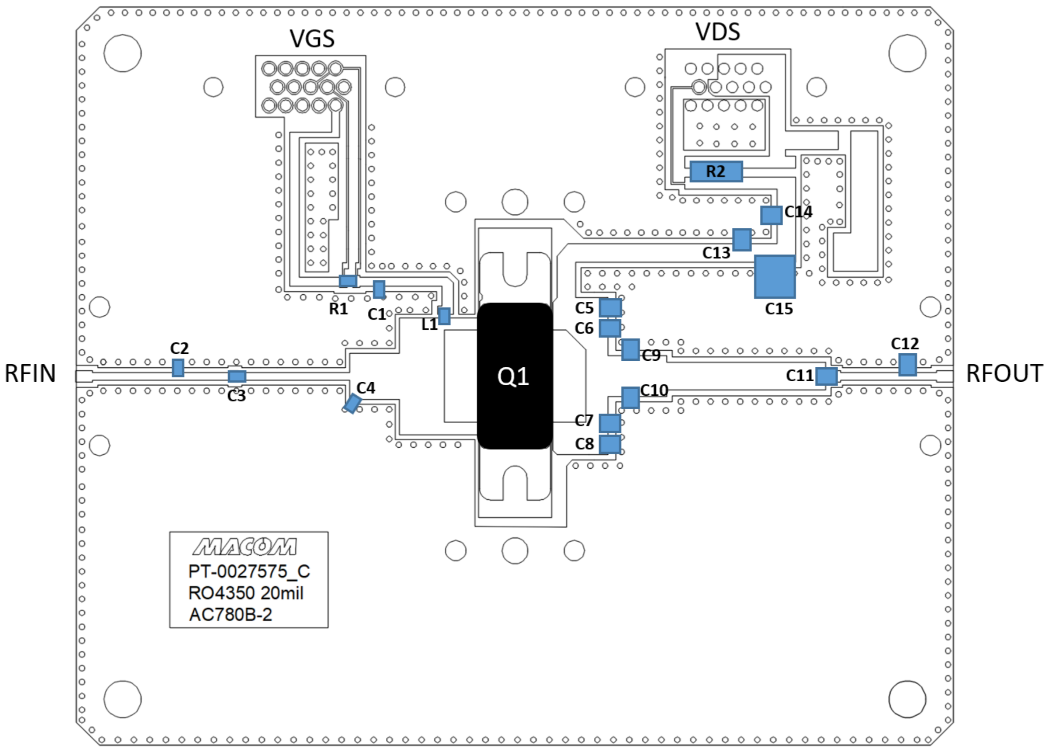
1. Set V_{GS} to pinch-off (V_P).
2. Turn on V_{DS} to nominal voltage (50 V).
3. Increase V_{GS} until I_{DS} current is reached.
4. Apply RF power to desired level.

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}.

* For an integrated power management solution please contact MACOM support regarding the MABC-11040.

Evaluation Test Fixture and Recommended Tuning Solution 1.03 - 1.09 GHz

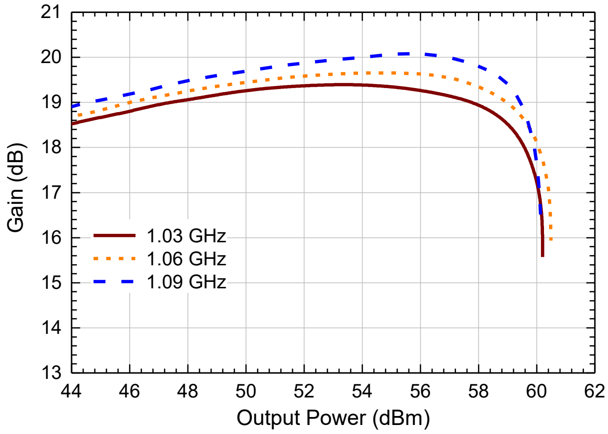


Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1	33 pF	± 5 %	Murata	GQM2195C2E330JB02
C2	1.6 pF	± 0.1 pF	Murata	GQM2195C2E1P6BB12
C3	15 pF	± 5 %	Murata	GQM2195C2E150JB02
C4	10 pF	± 5 %	Murata	GQM2195C2E100JB02
C5, C8, C9, C10, C11	8.2 pF	± 0.1 pF	Murata	GQM22M5C2H8P2JBB01
C6, C7	10 pF	± 5 %	Murata	GQM22M5C2H100JB01
C12	2.7 pF	± 0.1 pF	Murata	GQM22M5C2H2P7BB12
C13	27 pF	± 5 %	Murata	GQM22M5C2H270JB01
C14	820 pF	± 5 %	ATC	800B821JT500XT
C15	2.2 µF	± 10 %	Murata	KRM55TR72E225MH01L
L1	27 nH	± 5 %	CoilCraft	1008CS-270XJL
R1	4.7 Ω	± 1 %	Yageo	RT0805FRE074R7L
R2	0.00 Ω	-	-	Copper jumper
Q1	MACOM GaN Power Amplifier			MAPC-A1501
PCB	RO4350, 20 mil, 1 oz. Cu, Au Finish			

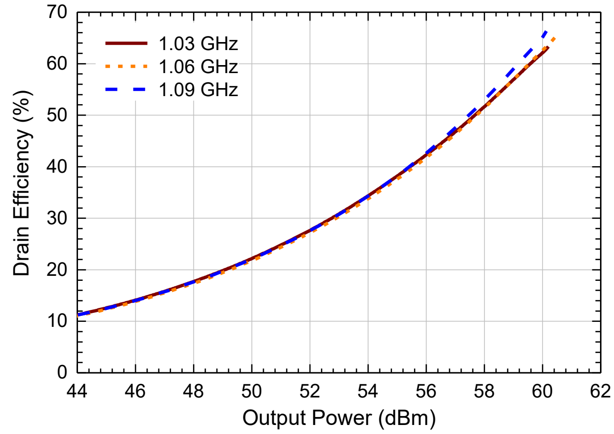
Typical Performance Curves as Measured in the 1.03 - 1.09 GHz Evaluation Test Fixture:

Pulsed[4] 1.06 GHz, V_{DS} = 50 V, I_{DQ} = 650 mA, T_C = 25°C
Unless Otherwise Noted

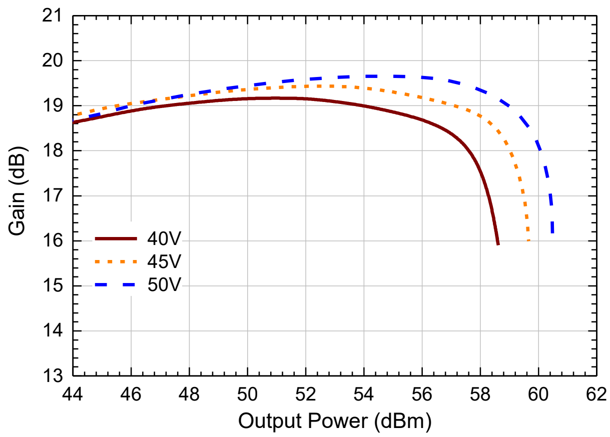
Gain vs. Output Power and Frequency



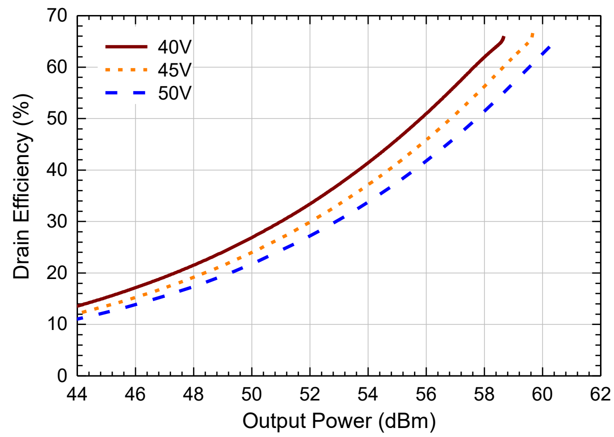
Drain Efficiency vs. Output Power and Frequency



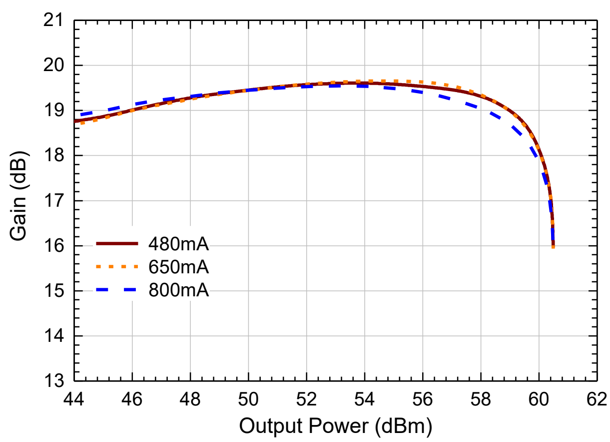
Gain vs. Output Power and V_{DS}



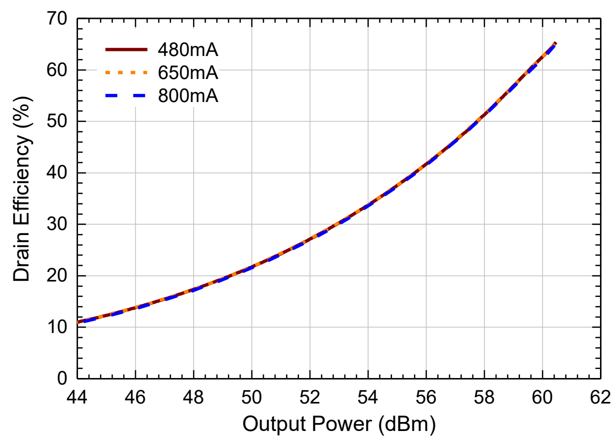
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}

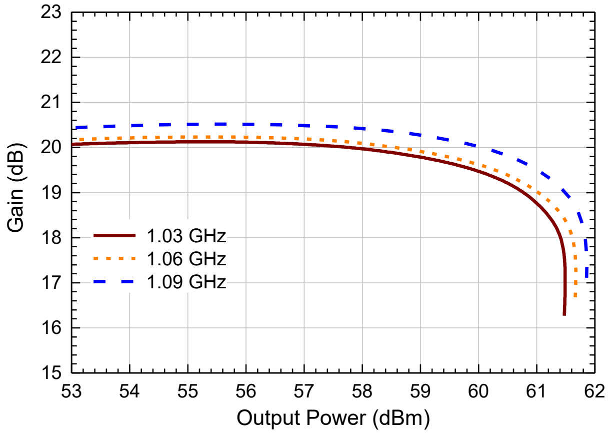


Drain Efficiency vs. Output Power and I_{DQ}

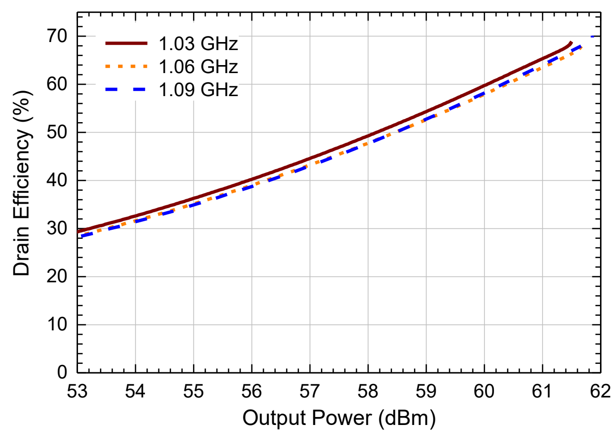


Typical Performance Curves as Measured in the 1.03 - 1.09 GHz Evaluation Test Fixture:
Pulsed[4] 1.06 GHz, V_{DS} = 65 V, I_{DQ} = 650 mA, T_C = 25°C
Unless Otherwise Noted

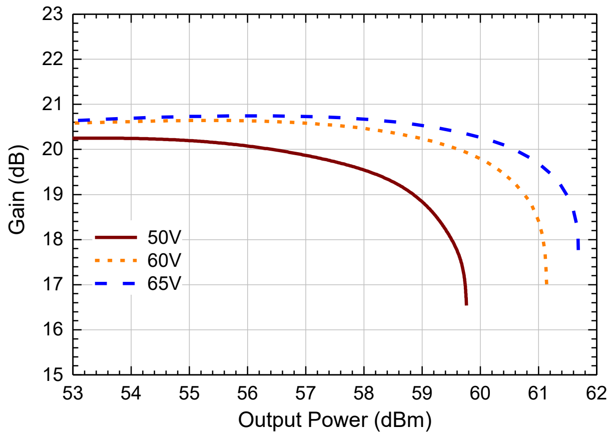
Gain vs. Output Power and Frequency



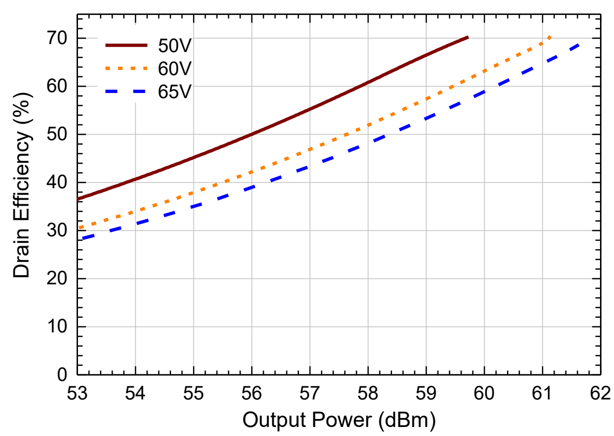
Drain Efficiency vs. Output Power and Frequency



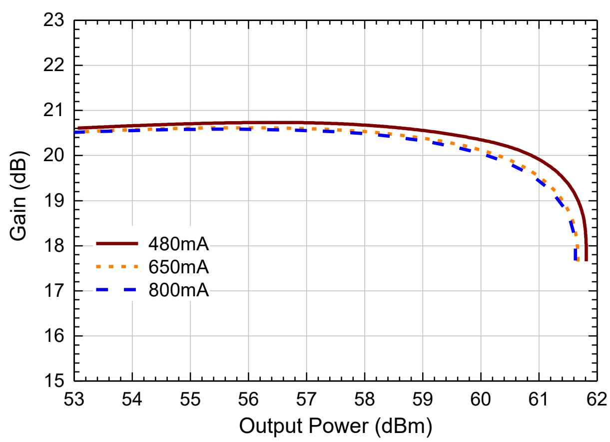
Gain vs. Output Power and V_{DS}



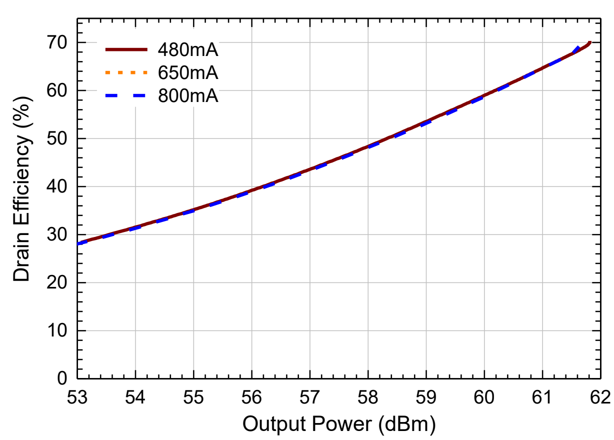
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}

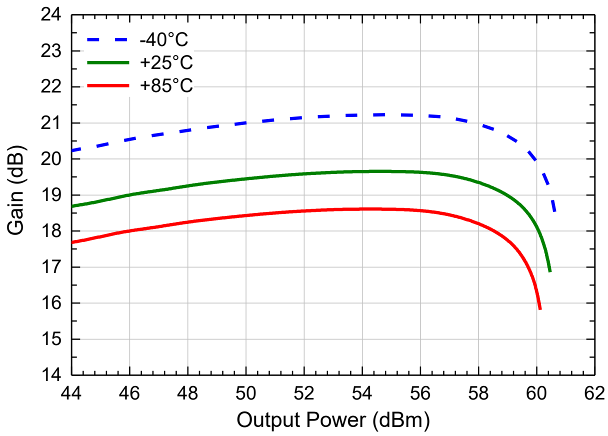


Drain Efficiency vs. Output Power and I_{DQ}

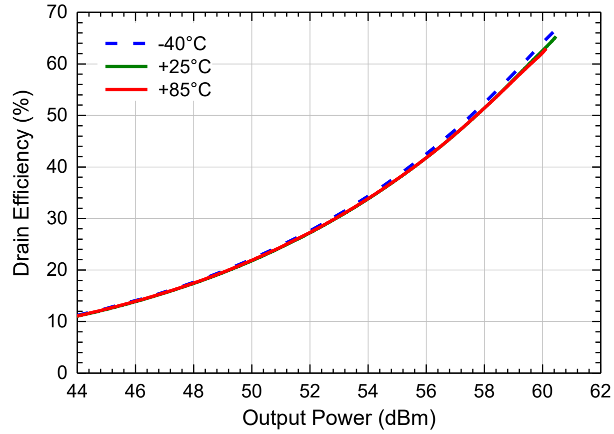


Typical Performance Curves as Measured in the 1.03 - 1.09 GHz Evaluation Test Fixture:
Pulsed[4] 1.06 GHz, V_{DS} = 50 V, I_{DQ} = 650 mA, T_C = 25°C
Unless Otherwise Noted

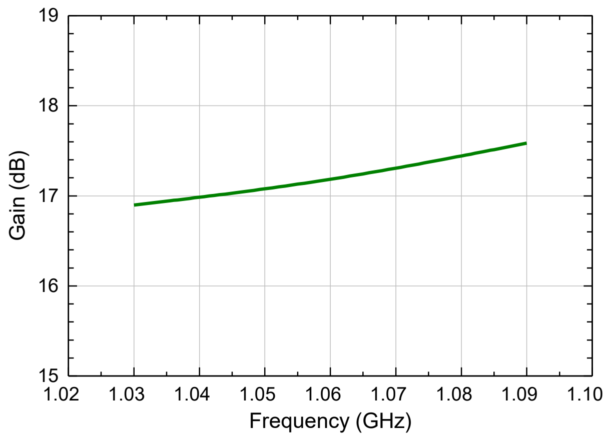
Gain vs. Output Power and T_C



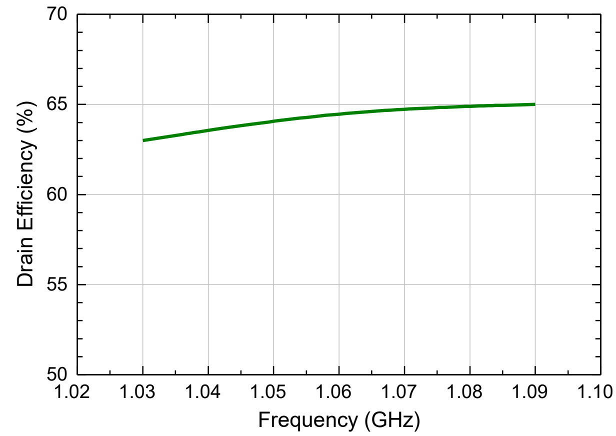
Drain Efficiency vs. Output Power and T_C



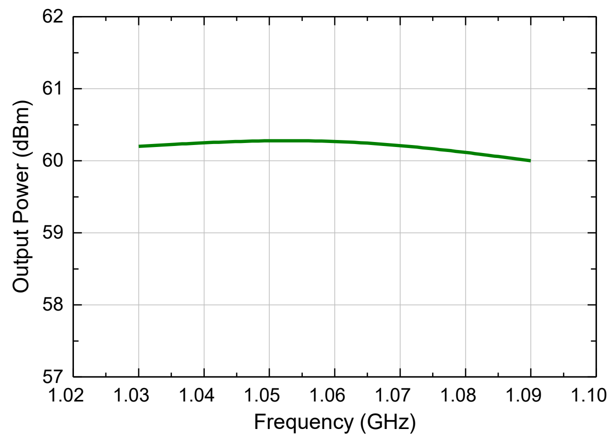
Gain vs. Frequency, 2.5dB Gain Compression



Drain Efficiency vs. Frequency, 2.5dB Gain Compression

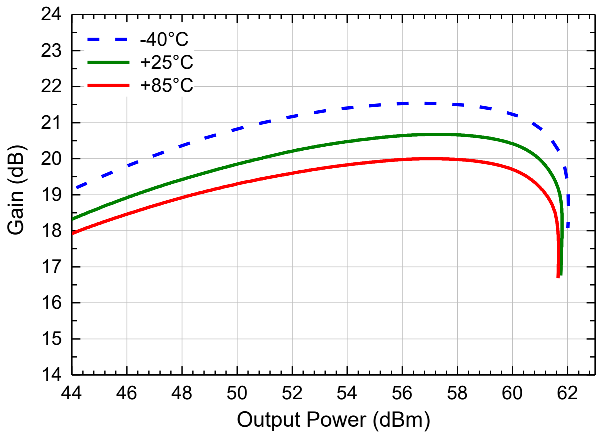


Output Power vs. Frequency, 2.5dB Gain Compression

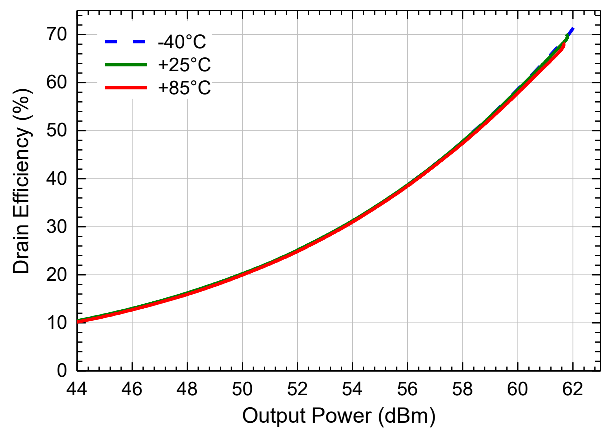


Typical Performance Curves as Measured in the 1.03 - 1.09 GHz Evaluation Test Fixture:
Pulsed[4] 1.06 GHz, V_{DS} = 65 V, I_{DQ} = 650 mA, T_C = 25°C
Unless Otherwise Noted

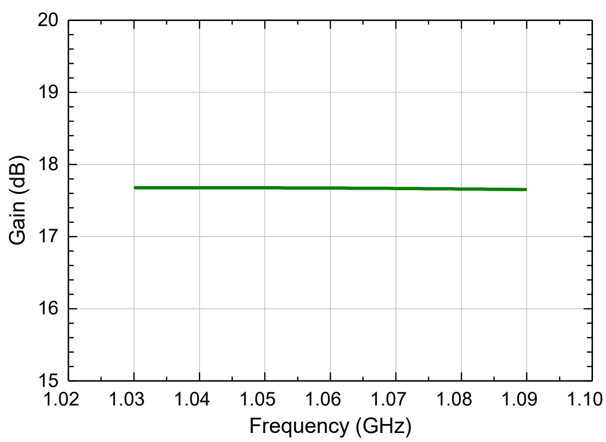
Gain vs. Output Power and T_C



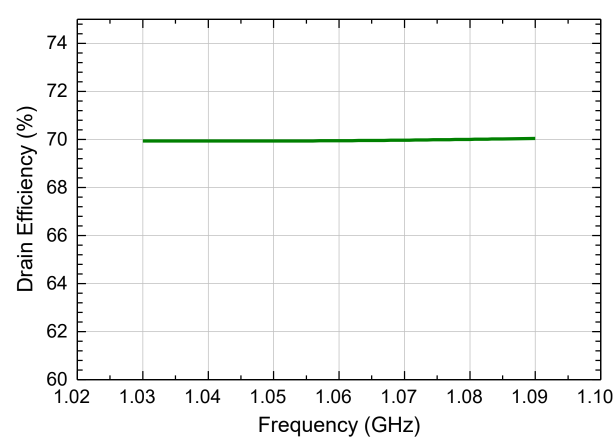
Drain Efficiency vs. Output Power and T_C



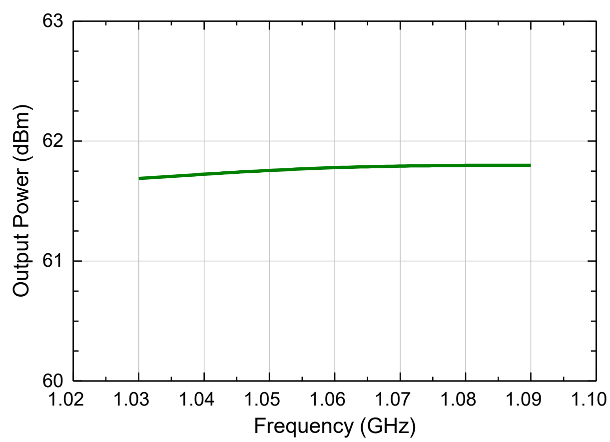
Gain vs. Frequency, 2.5dB Gain Compression



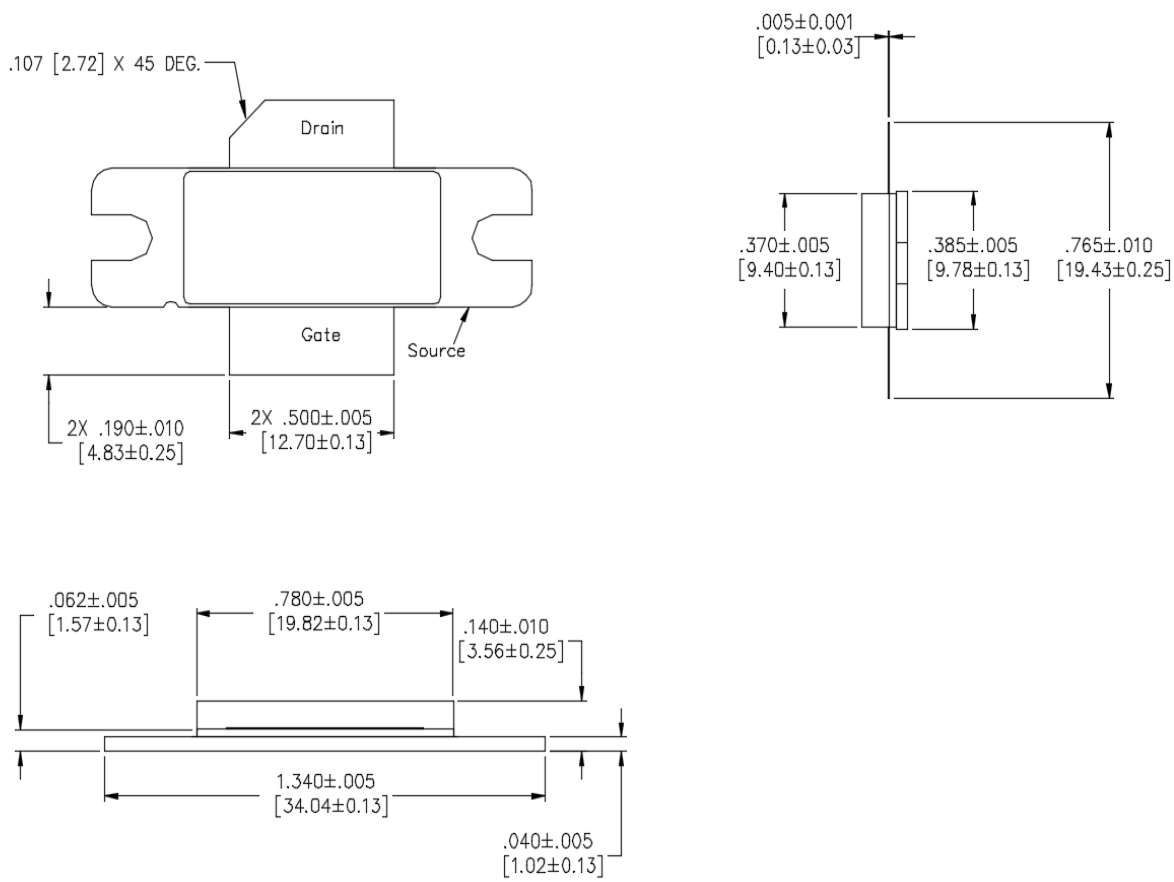
Drain Efficiency vs. Frequency, 2.5dB Gain Compression



Output Power vs. Frequency, 2.5dB Gain Compression



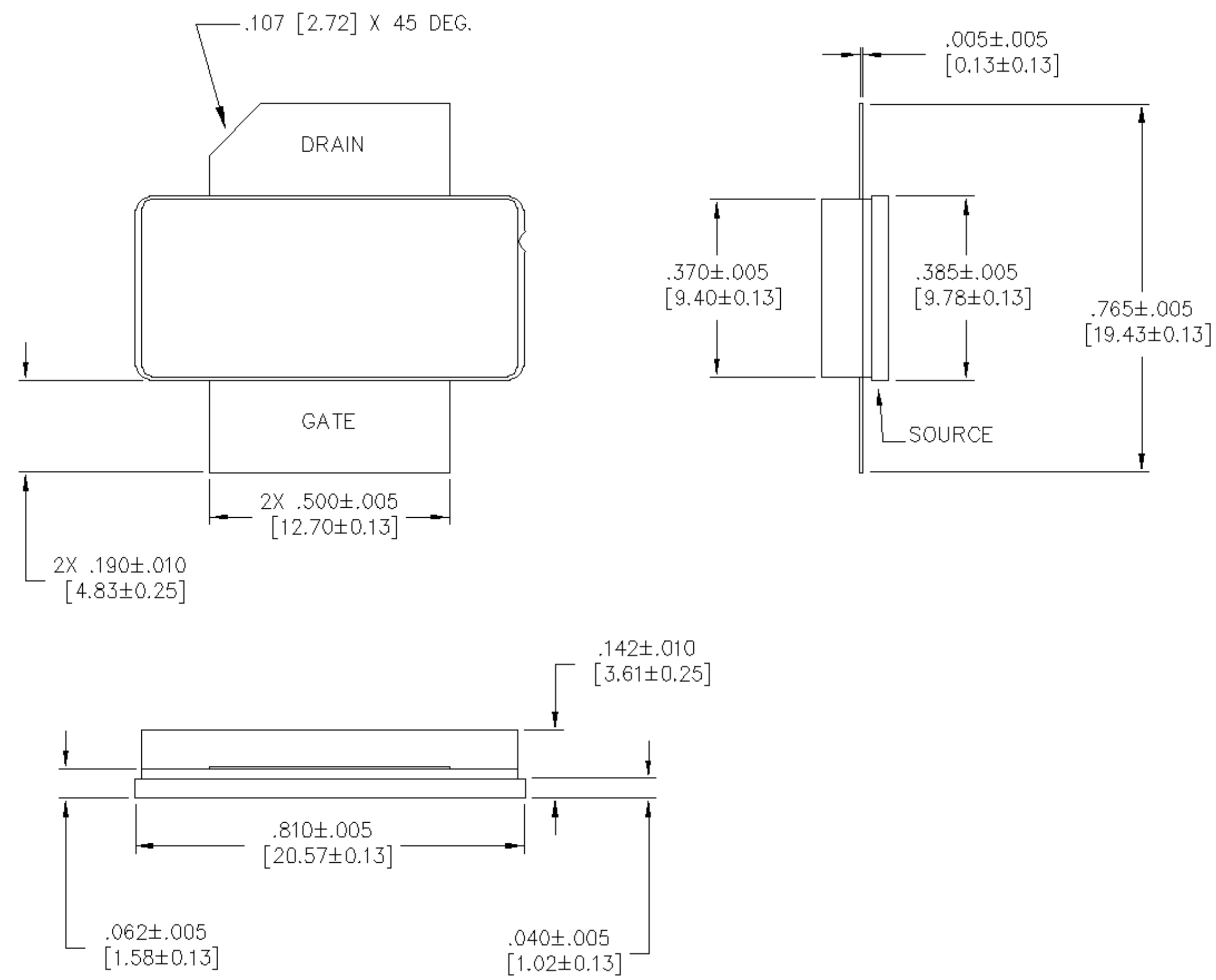
Lead-Free AC-780B-2 Ceramic Package Dimensions†



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.
Au plating on flange and leads.

Lead-Free AC-780S-2 Ceramic 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

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