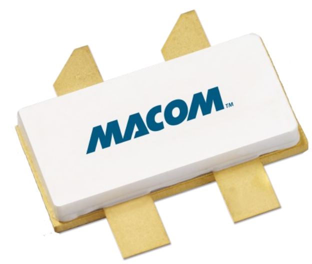
GaN Amplifier 50 V, 450 W
0.7 - 2.7 GHz

MACOM PURE CARBIDE

MAPC-A1559
Rev. V1

Features
- *MACOM PURE CARBIDE®* Amplifier Series
- Suitable for Linear & Saturated Applications
- CW Operation: 450 W Output Power
- Internally Pre-Matched
- 50 V Operation
- Utilizes enhanced thermal conductivity flange material to support CW and extreme pulse width and duty cycle conditions
- Compatible with MACOM Power Management Bias Controller/Sequencer MABC-11040B

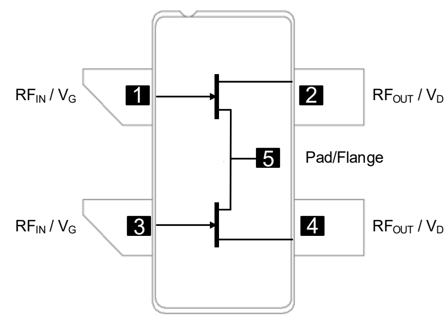


AC-780S-4

Applications
- RADAR, Datalink and Satellite Communications

Description
The MAPC-A1559 is a high power GaN on Silicon Carbide HEMT D-mode amplifier suitable for 0.7 - 2.7 GHz frequency operation. The device supports CW operation with output power levels of 450 W (56.5 dBm) and in an air cavity ceramic package.

Functional Schematic



Typical Performance:
Measured under evaluation board at 3 dB Compression,
CW, V_{DS} = 50 V, I_{DQ} = 800 mA, T_C = 25°C

- Efficiency Tuned Board (2.5 - 2.7 GHz)

Frequency (GHz)	Output Power (dBm)	Power Gain (dB)	Efficiency (%)
2.5	56.9	18.1	62.1
2.6	56.3	19.1	66.8
2.7	55.3	19.5	63.5

- Wideband Tuned Board (1.0 - 2.5 GHz)

Frequency (GHz)	Output Power (dBm)	Power Gain (dB)	Efficiency (%)
1.0	55.6	14.9	49.8
1.3	55.3	13.6	56.4
1.7	54.7	13.9	44.5
2.1	54.1	13.6	38.7
2.5	55.3	13.5	48.0

Pin Configuration

Pin #	Pin Name	Function
1, 3	RF_{IN} / V_G	RF Input / Gate
2, 4	RF_{OUT} / V_D	RF Output / Drain
5	Flange[1]	Ground / Source

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

Ordering Information

Part Number	Package
MAPC-A1559-AS000	Bulk Quantity
MAPC-A1559-ASTR1	Tape and Reel
MAPC-A1559-ASSB1	Sample Board

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

DC-0037390

RF Electrical Characteristics: T_C = 25°C, V_{DS} = 50 V, I_{DQ} = 800 mA
Note: Performance in MACOM Efficiency Tuned Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Output Power	CW, 2.6 GHz, 3 dB Gain Compression	P_{SAT}	-	56.3	-	dBm
Power Gain	CW, 2.6 GHz, 3 dB Gain Compression	G_{SAT}	-	19.1	-	dB
Drain Efficiency	CW, 2.6 GHz, 3 dB Gain Compression	η_{SAT}	-	66.8	-	%
Input Return Loss	CW, 2.6 GHz, 3 dB Gain Compression	IRL	-	-22	-	dB
Gain Variation (-40°C to +85°C)	CW, 2.6 GHz, 3 dB Gain Compression	ΔG	-	-0.014	-	dB/°C
Power Variation (-40°C to +85°C)	CW, 2.6 GHz, 3 dB Gain Compression	ΔP3.0dB	-	-0.005	-	dB/°C
Ruggedness: Output Mismatch	Pulsed[2], All phase angles	Ψ	VSWR = 10:1, No Damage, Stable			

2. Pulse details:500 µs pulse width, 20% Duty Cycle

RF Electrical Specifications: T_A = 25°C, V_{DS} = 50 V, I_{DQ} = 900 mA
Note: Performance in MACOM Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Output Power	Pulsed[3], 2.6 GHz, 3 dB Gain Compression	P_{SAT}	55.8	56.6	-	dBm
Power Gain	Pulsed[3], 2.6 GHz, 3 dB Gain Compression	G_{SAT}	18.1	18.7	-	dB
Drain Efficiency	Pulsed[3], 2.6 GHz, 3 dB Gain Compression	η_{SAT}	59.3	65.6	-	%
Input Return Loss	Pulsed[3], 2.6 GHz, 3 dB Gain Compression	IRL	-	-22	-	dB

3. 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} = 150 V	I_{DLK}	-	-	57.6	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	57.6	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 57.6 mA	V_T	-3.8	-3.0	-2.3	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 450 mA	V_{GSQ}	-	-2.7	-	V
Maximum Drain Current	V_{DS} = 7 V pulsed, pulse width 300 µs	$I_{D, MAX}$	-	55.0	-	A

Absolute Maximum Ratings [4,5,6,7]

Parameter	Absolute Maximum
Drain Source Voltage, V_{DS}	150 V
Gate Source Voltage, V_{GS}	-8 to 2 V
Gate Current, I_G	57.6 mA
Storage Temperature Range	-65°C to +150°C
Case Operating Temperature Range	-40°C to +85°C
Absolute Maximum Channel Temperature	+275°C

4. Exceeding any one or combination of these limits may cause permanent damage to this device.
5. MACOM does not recommend sustained operation above maximum operating conditions.
6. Operating at drain source voltage $V_{DS} \leq 50$ V and $T_{CH} \leq 275$°C will ensure MTTF > 2 x 10^6 hours.
7. 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 = 1.537, B = -24.81, and C = 21,330.

Thermal Characteristics[8]

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance using Finite Element Analysis	CW, V_{DS} = 50 V, T_C = 85°C, T_{CH} = 223°C	R_θ(FEA)	0.48	°C/W
Thermal Resistance using Infrared Measurement of Die Surface Temperature	CW, V_{DS} = 50 V, T_C = 85°C, T_{CH} = 225°C	R_θ(IR)	0.38	°C/W

8. 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

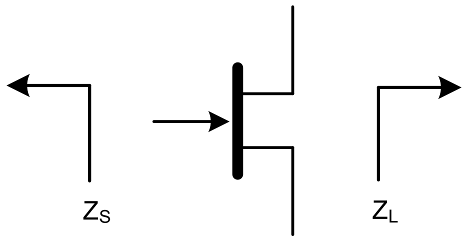
These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

50 V Pulsed[3] Load-Pull Performance (Per Each Side of Symmetric Device)
Reference Plane at Device Leads

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 50 V, I_{DQ} = 450 mA, T_C = 25°C, P3.0dB					
		Z_{LOAD}[9] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
800	2.0 - j1.2	3.9 - j0.9	24.5	54.4	276	63.9	68.5
1400	2.5 - j4.5	2.8 - j2.0	19.8	54.7	295	61.3	41.4
1800	3.0 - j6.0	3.1 - j3.2	18.5	55.6	363	63.1	29.0
2100	3.8 - j7.5	2.8 - j4.0	17.5	55.6	363	64.0	24.6
2500	5.0 - j10.0	2.8 - j5.3	17.2	55.3	339	63.4	-8.6
2700	6.0- j10.5	2.6 - j6.0	17.2	55.2	331	64.1	-43.7

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 50V, I_{DQ} = 450 mA, T_C = 25°C, P3.0dB					
		Z_{LOAD}[10] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
800	2.0 - j1.2	5.9 + j2.6	27.2	52.4	174	74.2	40.0
1400	2.5 - j4.5	3.3 + j0.6	22.1	52.9	195	72.5	24.7
1800	3.0 - j6.0	3.1 - j1.2	20.0	54.3	269	72.5	15.7
2100	3.8 - j7.5	2.5 - j1.8	19.6	54.0	251	75.7	9.0
2500	5.0 - j10.0	2.2 - j3.1	19.5	53.4	219	75.1	-28.2
2700	6.0- j10.5	2.1 - j4.0	19.4	53.3	214	75.8	-59.7

Impedance Reference

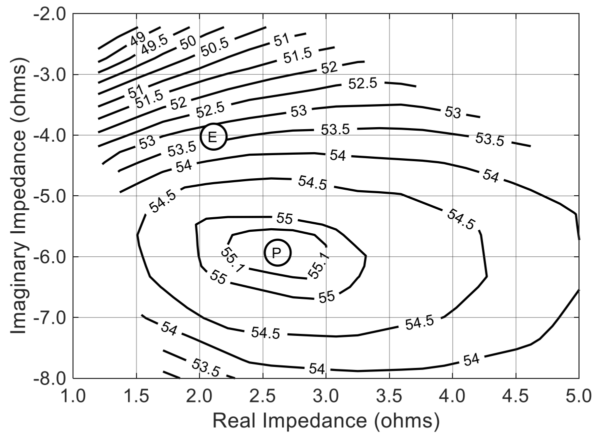


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

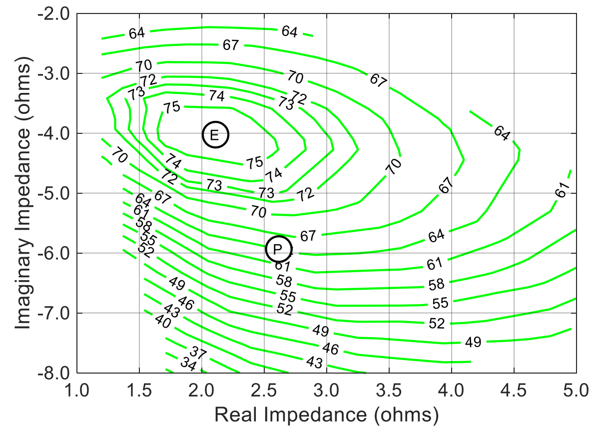
9. Load Impedance for optimum output power.
10. Load Impedance for optimum efficiency.

Pulsed[3] Load-Pull Performance (Per Each Side of Symmetric Device) @ 2.7 GHz

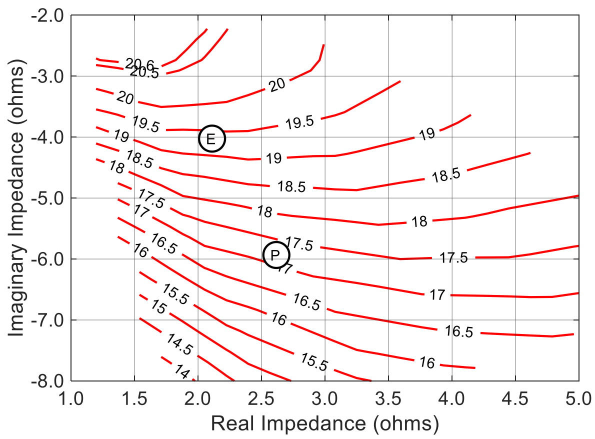
P3.0dB Loadpull Output Power Contours (dBm)



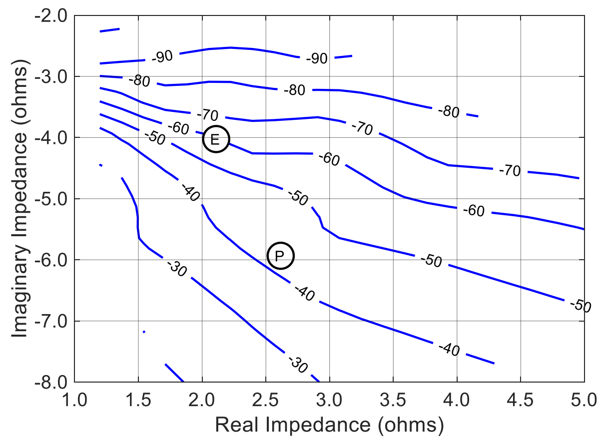
P3.0dB Loadpull Drain Efficiency Contours (%)



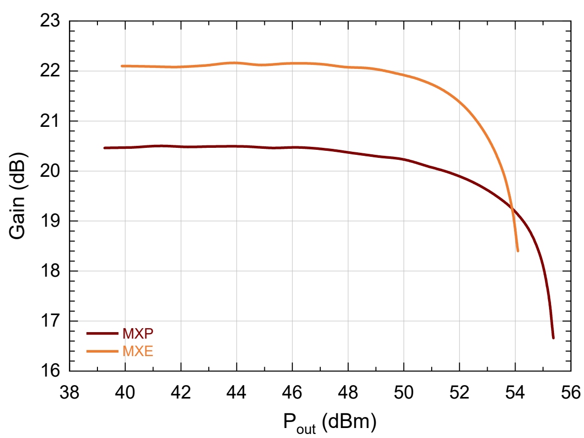
P3.0dB Loadpull Gain Contours (dB)



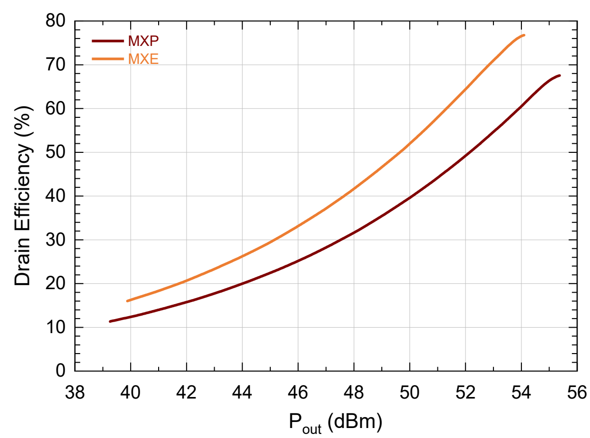
P3.0dB Loadpull AM/PM Contours (°)



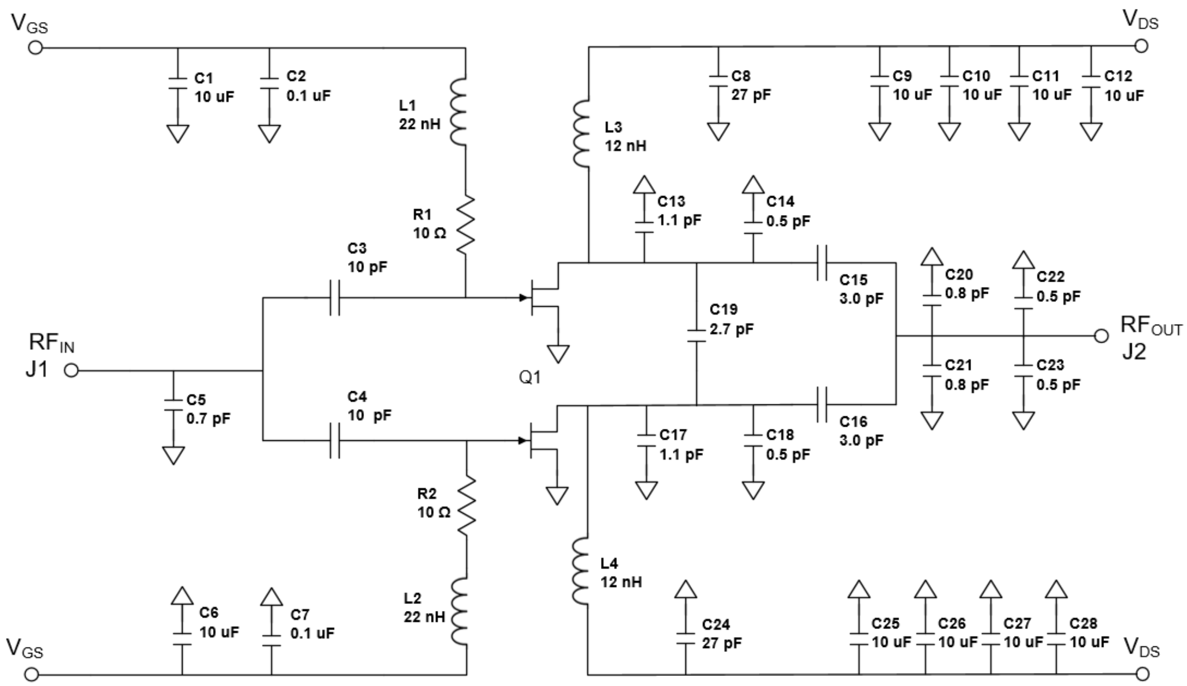
Transducer Gain vs. Output Power



Drain Efficiency vs. Output Power



Efficiency Tuned Test Fixture and Recommended Tuning Solution 2.5 - 2.7 GHz



Description

Parts measured on evaluation board (20 mil thick RO4350B). 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

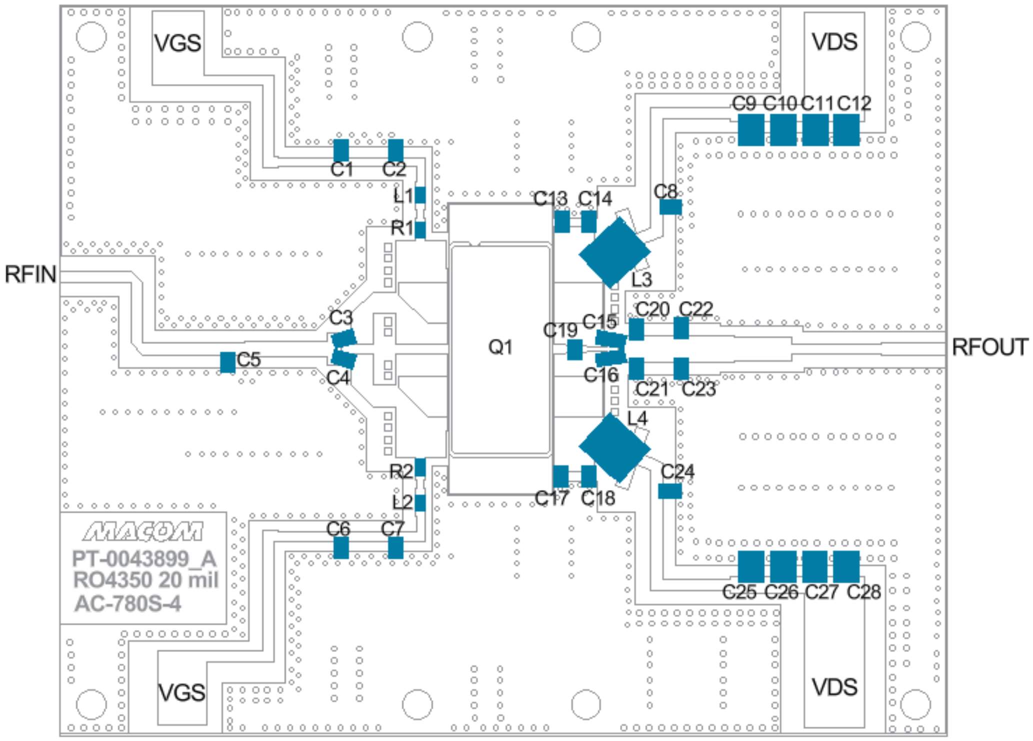
1. Set V_{GS} to pinch-off (V_P).
2. Turn on V_{DS} to nominal voltage (50 V).
3. Increase V_{GS} until I_{DS} current is reached.
4. Apply RF power to desired level.

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-11040B.

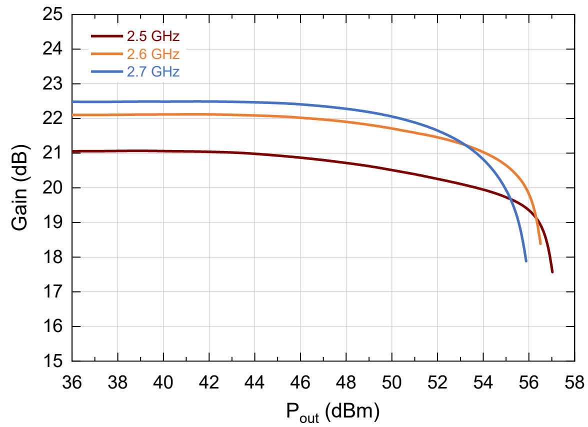
Efficiency Tuned Test Fixture and Recommended Tuning Solution 2.5 - 2.7 GHz



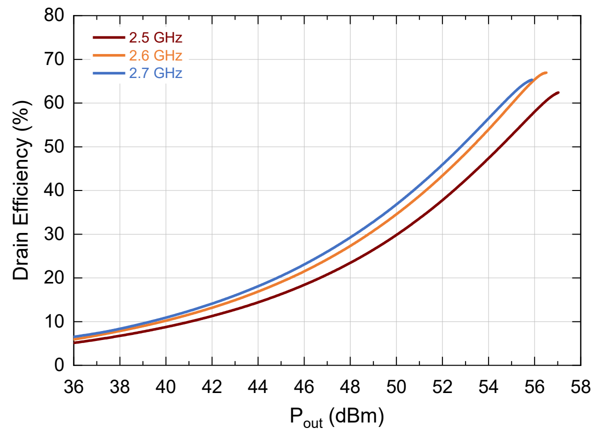
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1,C6	10 µF	+/- 10%	Venkel	C1210X7R101-106KNE
C2,C7	0.1 µF	+/- 10%	Murata	GRM219R71C104KA01D
C3,C4	10 pF	+/- 5%	Kyocera AVX	600F100JT250XT
C5	0.7 pF	+/- 0.05 pF	Kyocera AVX	600F0R7AT250XT
C8,C24	27 pF	+/- 1%	Kyocera AVX	600F270FT250XT
C9,C10,C11,C12,C25,C26,C27,C28	10 µF	+/- 10%	Murata	GRM32EC72A106KE05L
C13,C17	1.1 pF	+/- 0.1 pF	Kyocera AVX	600F1R1BT250XT
C14,C18,C22,C23	0.5 pF	+/- 0.1 pF	Kyocera AVX	600F0R5BT250XT
C15,C16	3.0 pF	+/- 0.1 pF	Kyocera AVX	800B3R0BT500XT
C19	2.7 pF	+/- 0.1 pF	Kyocera AVX	600F2R7BT250XT
C20,C21	0.8 pF	+/- 0.1 pF	Kyocera AVX	600F0R8BT250XT
L1,L2	22 nH	+/- 5%	Kyocera AVX	LCMC0603J22NGTAR
L3,L4	12 nH	+/- 5%	Coilcraft	GA3094-ALC
R1,R2	10 Ω	+/- 1%	Vishay	RCC060310R0FKEA
Q1	MACOM GaN Power Amplifier			MAPC-A1559-AS
PCB	RO4350B, 20 mil, 1 oz. Cu, Au Finish			

Typical Performance Curves as Measured in the 2.5 - 2.7 GHz Efficiency Tuned Test Fixture: CW, 2.6 GHz, V_{DS} = 50 V, I_{DQ} = 800 mA, T_C = 25°C (Unless Otherwise Noted)

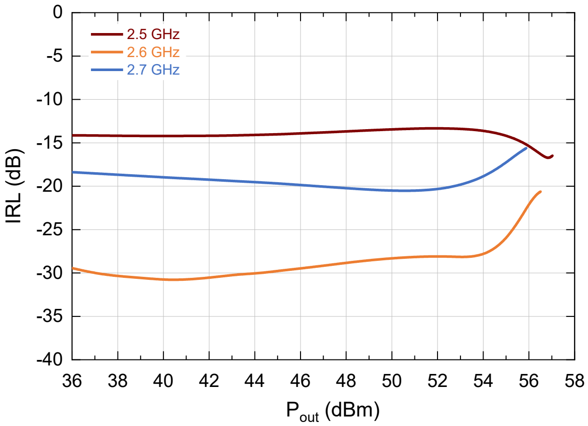
Gain vs. Output Power and Frequency



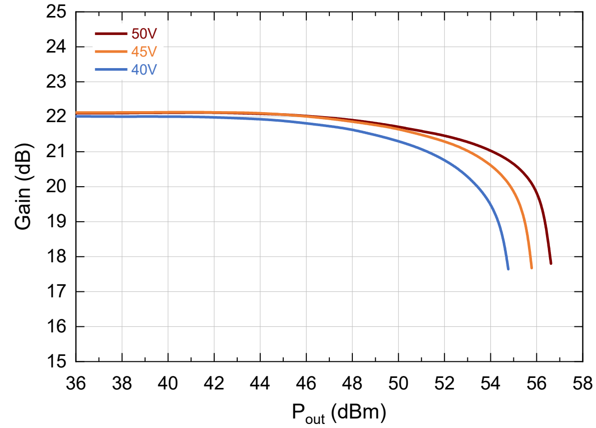
Drain Efficiency vs. Output Power and Frequency



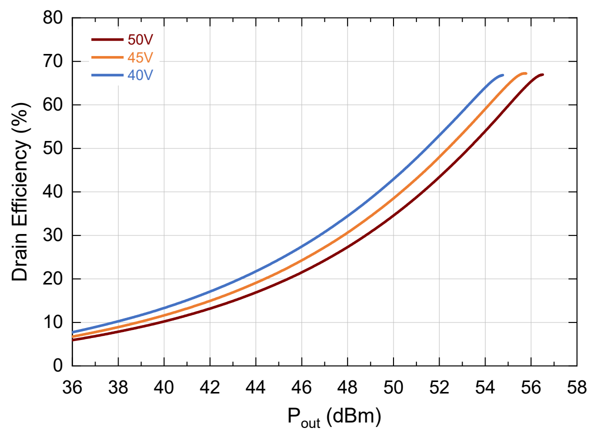
Input Return Loss vs. Output Power and Frequency



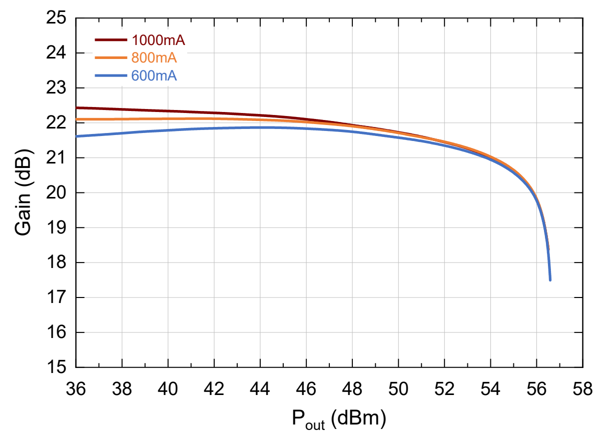
Gain vs. Output Power and V_{DS}



Drain Efficiency vs. Output Power and V_{DS}

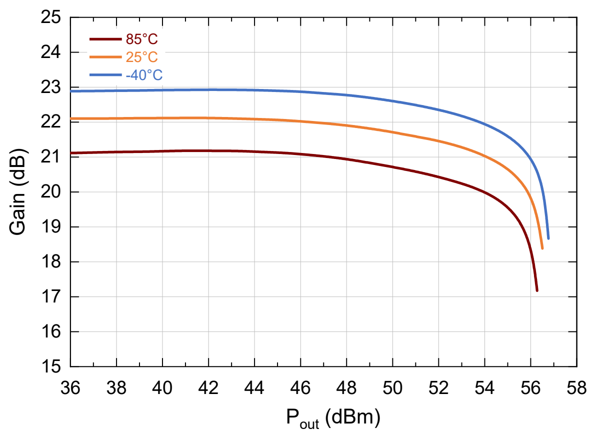


Gain vs. Output Power and I_{DQ}

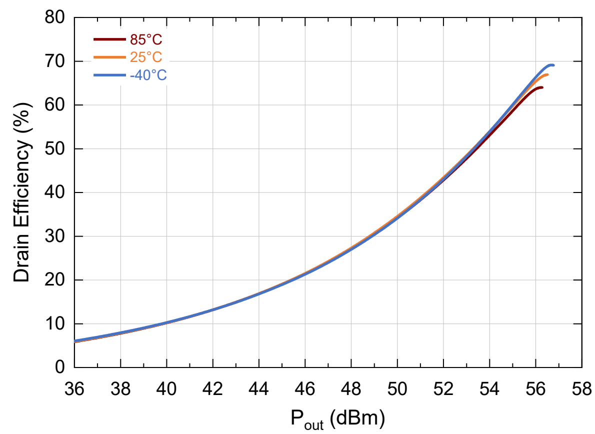


Typical Performance Curves as Measured in the 2.5 - 2.7 GHz Efficiency Tuned Test Fixture: CW, 2.6 GHz, V_{DS} = 50 V, I_{DQ} = 800 mA, T_C = 25°C (Unless Otherwise Noted)

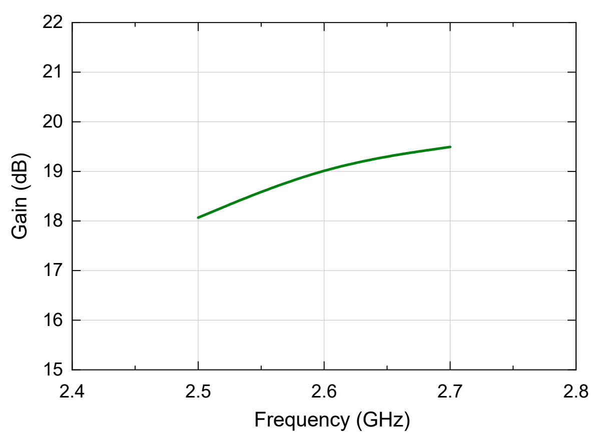
Gain vs. Output Power and T_C



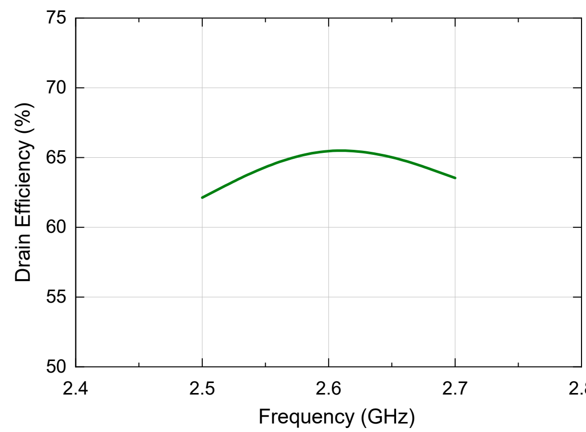
Drain Efficiency vs. Output Power and T_C



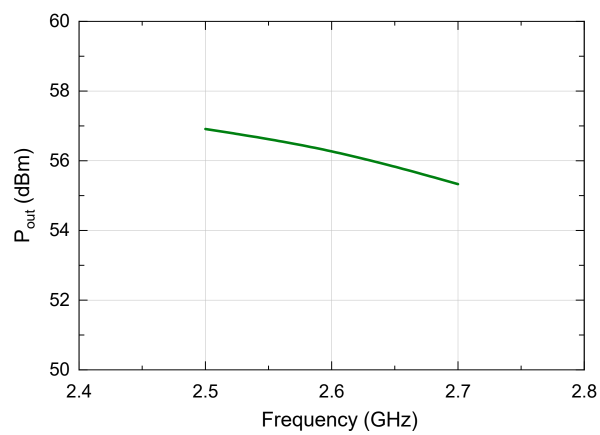
Gain vs. Frequency, 3dB Gain Compression



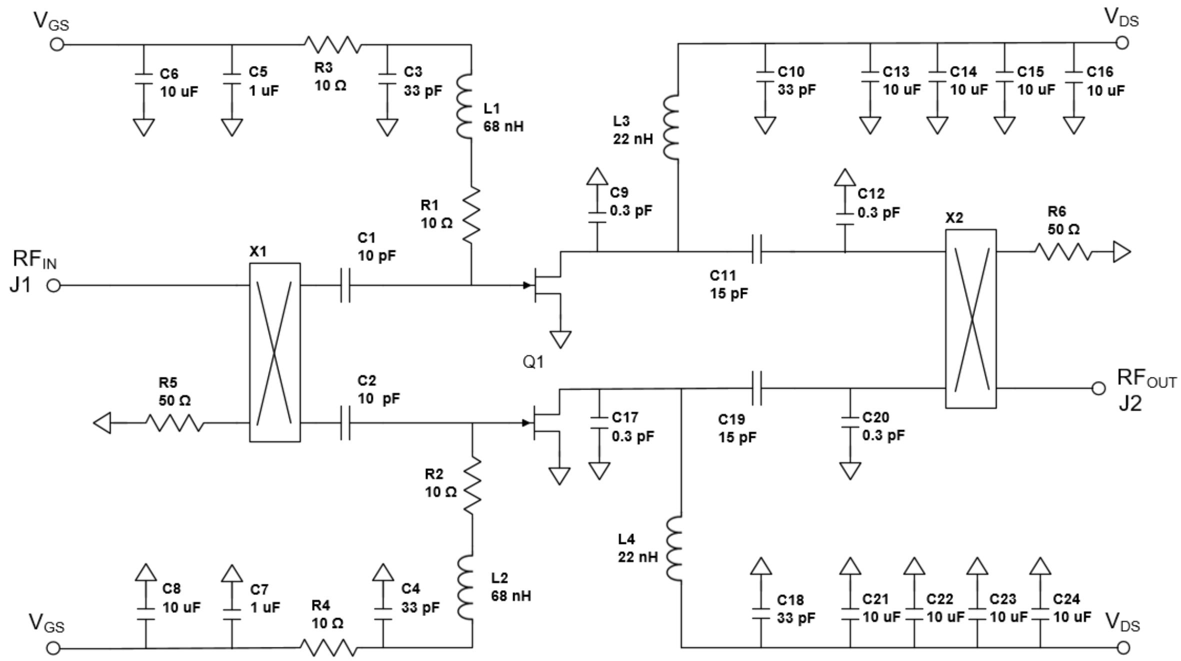
Drain Efficiency vs. Frequency, 3dB Gain Compression



Output Power vs. Frequency, 3dB Gain Compression



Wideband Tuned Test Fixture and Recommended Tuning Solution 1.0 - 2.5 GHz



Description

Parts measured on evaluation board (20 mil thick RO4350B). 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

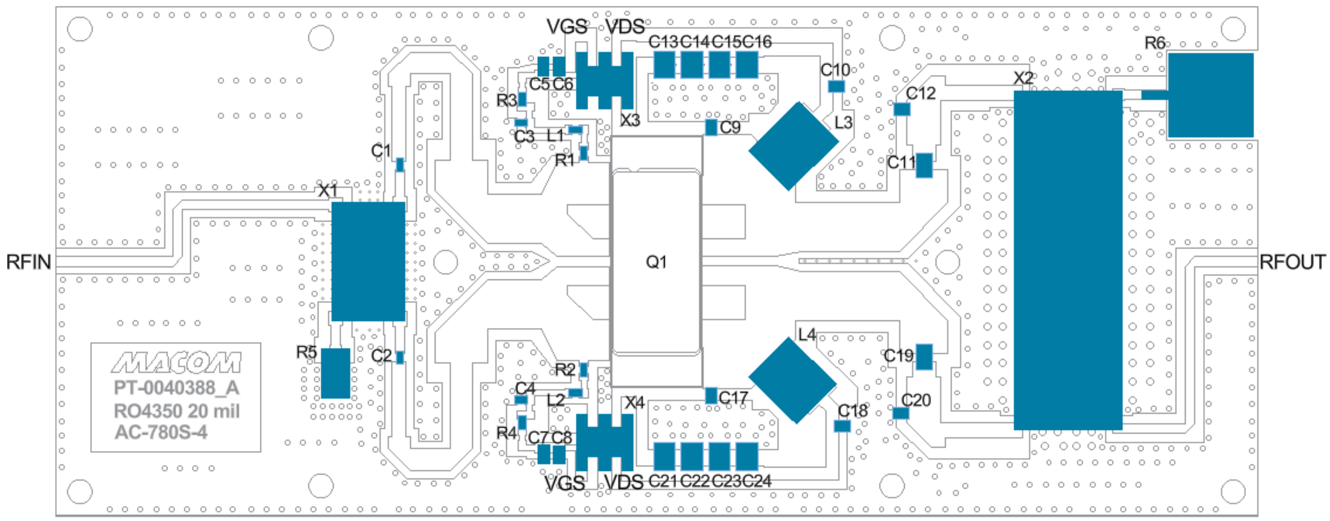
1. Set V_{GS} to pinch-off (V_P).
2. Turn on V_{DS} to nominal voltage (50 V).
3. Increase V_{GS} until I_{DS} current is reached.
4. Apply RF power to desired level.

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-11040B.

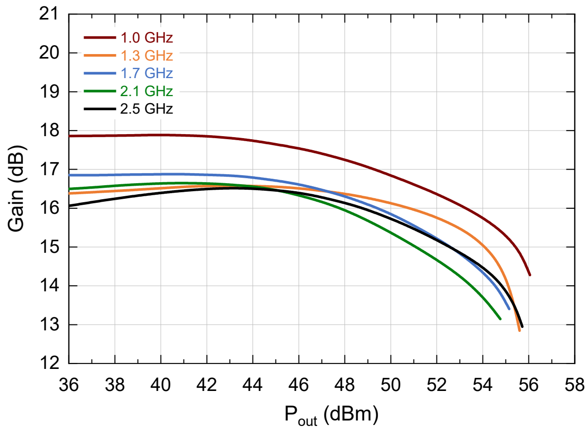
Wideband Tuned Test Fixture and Recommended Tuning Solution 1.0 - 2.5 GHz



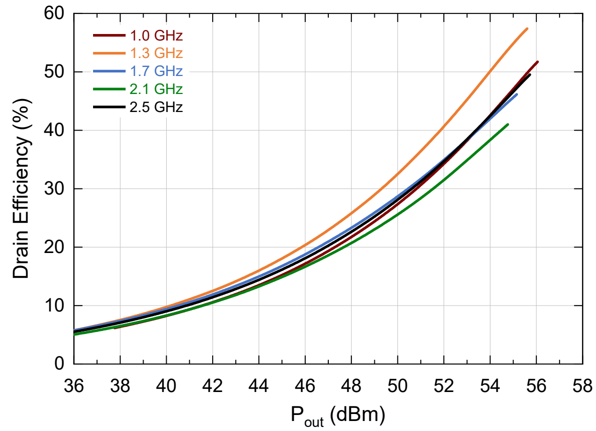
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1,C2	10 pF	+/- 1%	PPI	0603N100FW251
C3,C4	33 pF	+/- 2%	PPI	0603N330GW251
C5,C7	1 µF	+/- 10 %	TDK	CGA4J2X7R1C105K125AA
C6,C8	10 µF	+/- 10 %	TDK	C2012X6S1C106K085AC
C9,C12,C17,C20	0.3 pF	+/- 0.1 pF	Kyocera AVX	800A0R3BT250XT
C10,C18	33 pF	+/- 0.1 pF	Kyocera AVX	800A330BT250XT
C11,C19	15 pF	+/- 2%	Kyocera AVX	800B150GT500XT
C13,C14,C15,C16,C21,C22,C23,C24	10 µF	+/- 10%	Murata	GRM32EC72A106KE05L
L1,L2	68 nH	+/- 5%	Kyocera AVX	LCCI0603J68NGTAR
L3,L4	22 nH	+/- 5%	Coilcraft	WA3096-ALC
R1,R2,R3,R4	10 Ω	+/- 1%	Vishay	RCC060310R0FKEA
R5	50 Ω Termination		Anaren	C45N50Z4
R6	50 Ω Termination		Anaren	E250N50X4B
X1	50 Ω Hybrid Coupler		Anaren	X3C17A1-03WS
X2	25/50 Ω Hybrid Coupler		IPP	IPP-7105IT
X3,X4	Connector Header 6 Pins		Samtec	HW-03-09-F-D-450-SM
J1, J2	Radiall 9114-1113-000-SMA Connector			PT-0022540
Q1	MACOM GaN Power Amplifier			MAPC-A1559-AS
PCB	RO4350, 20 mil, 1 oz. Cu, Au Finish			

Typical Performance Curves as Measured in the 1.0 - 2.5 GHz Wideband Tuned Test Fixture: CW, V_{DS} = 50 V, I_{DQ} = 800 mA, T_C = 25°C (Unless Otherwise Noted)

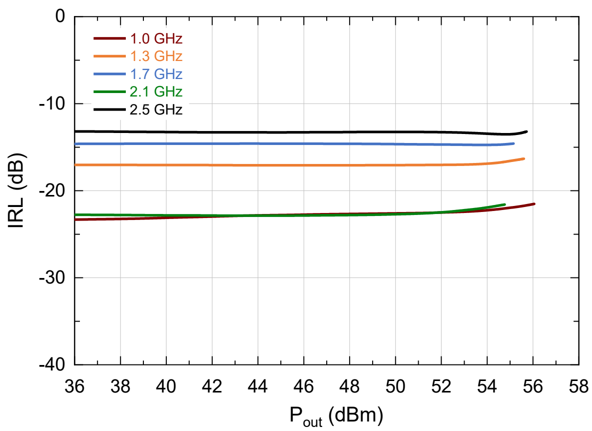
Gain vs. Output Power and T_C



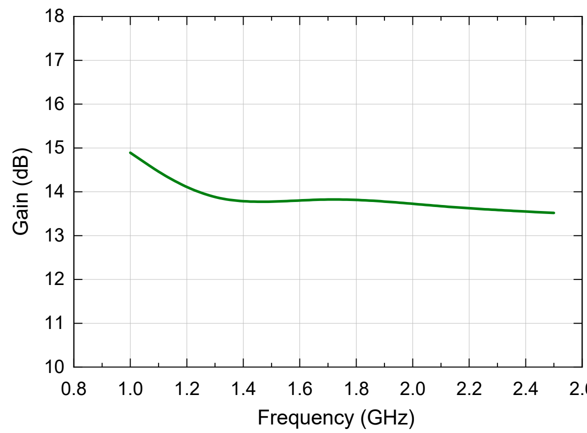
Drain Efficiency vs. Output Power and T_C



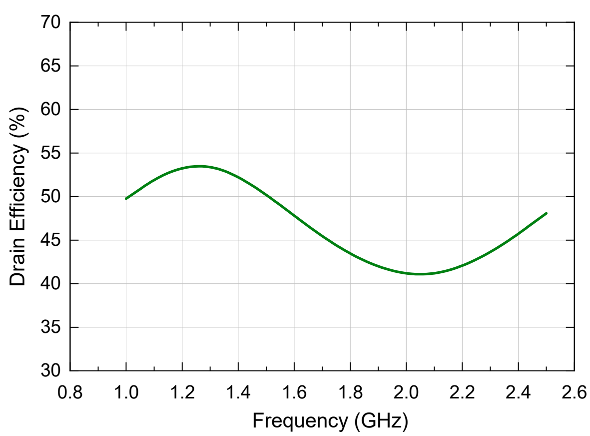
IRL vs. Frequency, 3dB Gain Compression



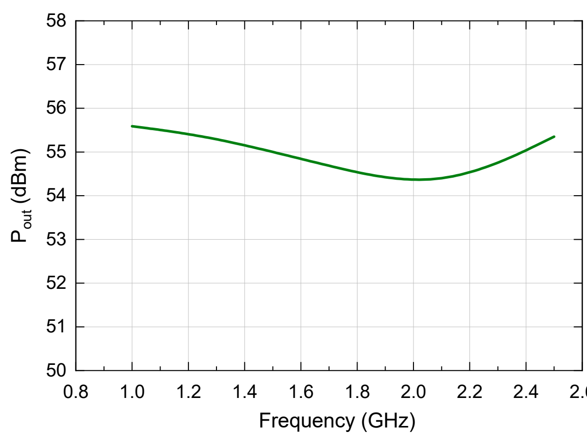
Gain vs. Frequency, 3dB Gain Compression



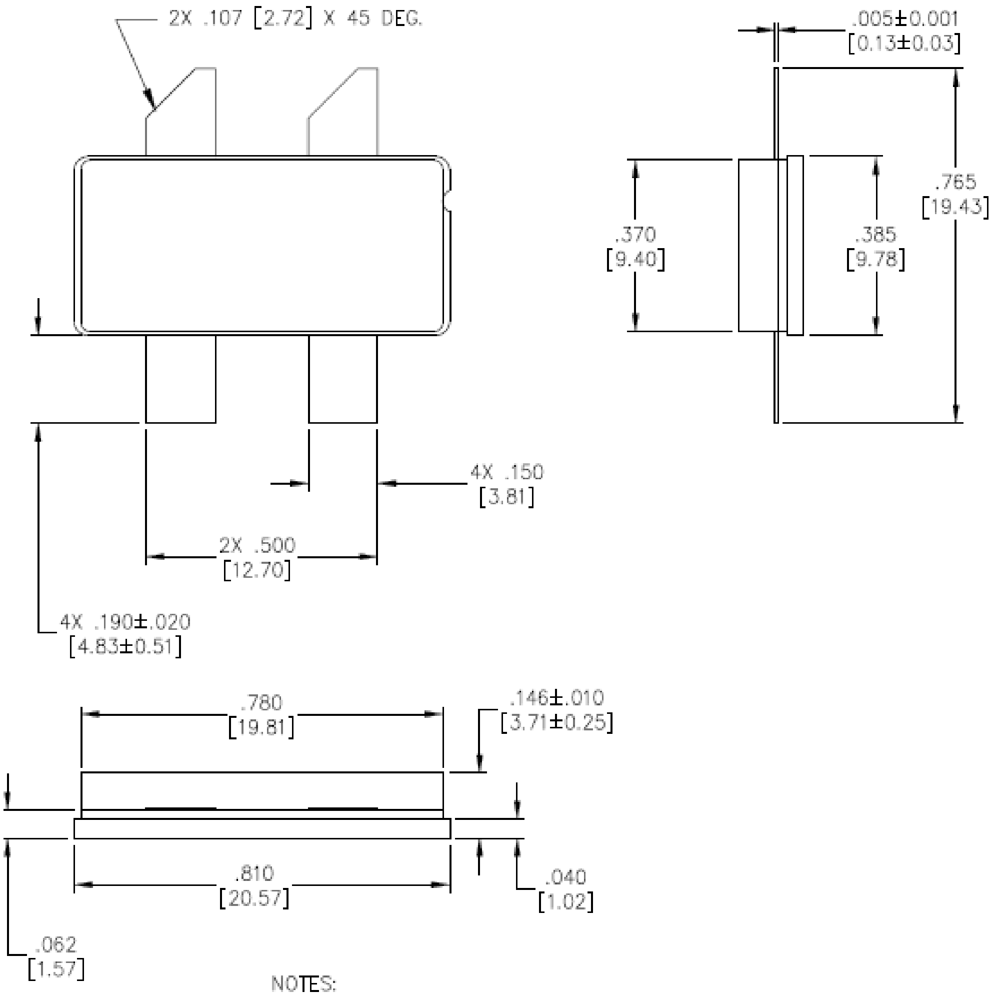
Drain Efficiency vs. Frequency, 3dB Gain Compression



Output Power vs. Frequency, 3dB Gain Compression



Lead-Free AC-780S-4 Package Dimensions†



NOTES:
1. ALL DIMENSIONS SHOWN AS in[mm]. CONTROLLING DIMENSIONS ARE IN in AND CONVERTED mm DIMENSIONS ARE NOT NECESSARILY EXACT.
2. ALL TOLERANCES ARE ±.005 [0.13] UNLESS OTHERWISE NOTED
3. LEAD FINISH: AU
   FLANGE FINISH: AU
4. LID SEAL EPOXY MAY FLOW OUT A MAXIMUM OF .020 [0.51] FROM EDGE OF LID
5. LID MAY BE MIS-ALIGNED UP TO .010 [0.25] FROM PACKAGE IN ANY DIRECTION

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