GaN Amplifier 50 V, 85 W
DC - 3.5 GHz

MACOM PURE CARBIDE™

MAPC-A1101
Rev. V7

Features

- *MACOM PURE CARBIDE*™ Amplifier Series
- Suitable for Linear & Saturated Applications
- CW & Pulsed Operation: 85 W Output Power
- Internally Pre-Matched
- 50 V Operation
- Compatible with MACOM Power Management Bias Controller/Sequencer MABC-11040

AC-360S-2

AC-360B-2

Applications

Military Radio Communications, RADAR, Avionics, Digital Cellular Infrastructure, RF Energy, and Test Instrumentation.

Description

The MAPC-A1101 is a high power GaN on Silicon Carbide HEMT D-mode amplifier suitable for DC - 3.5 GHz frequency operation. The device supports both CW and pulsed operation with output power levels of at least 85 W (49.3 dBm) in an air cavity ceramic package.

Typical Performance:

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

- V_{DS} = 50 V, I_{DQ} = 130 mA, T_C = 25°C

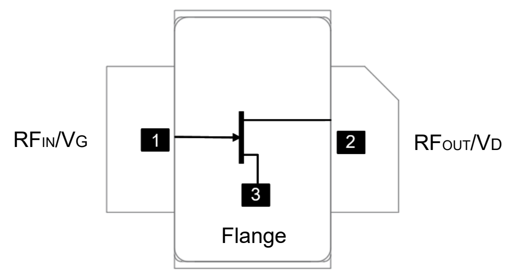
Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D [2]
0.9	49.9	25.0	72.5
1.4	50.0	21.7	72.6
2.0	49.8	16.5	66.1
2.5	50.6	17.2	64.8
3.0	50.1	16.5	67.6
3.5	49.7	15.7	70.5

- V_{DS} = 28 V, I_{DQ} = 130 mA, T_C = 25°C

Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D [2] (%)
0.9	47.0	22.0	71.2
1.4	47.0	20.0	72.0
2.0	47.2	14.7	68.1
2.5	47.8	14.6	69.0
3.0	47.4	14.2	70.0
3.5	47.0	13.4	72.5

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

Functional Schematic



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-A1101-AS000	Bulk Quantity: Earless
MAPC-A1101-ASTR1	Tape and Reel: Earless
MAPC-A1101-ASSB1	Sample Board: Earless
MAPC-A1101-AB000	Bulk Quantity: Boltdown
MAPC-A1101-ABTR1	Tape and Reel: Boltdown
MAPC-A1101-ABSB1	Sample Board: Boltdown

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

RF Electrical Characteristics: T_C = 25°C, V_{DS} = 50 V, I_{DQ} = 130 mA
Note: Performance in MACOM Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	Pulsed[4], 3.5 GHz	G_{SS}	-	17.0	-	dB
Power Gain	Pulsed[4], 3.5 GHz, 2.5 dB Gain Compression	G_{SAT}	-	14.8	-	dB
Saturated Drain Efficiency	Pulsed[4], 3.5 GHz, 2.5 dB Gain Compression	η_{SAT}	-	68.0	-	%
Saturated Output Power	Pulsed[4], 3.5 GHz, 2.5 dB Gain Compression	P_{SAT}	-	49.0	-	dBm
Gain Variation (-25°C to +85°C)	Pulsed[4], 3.5 GHz	ΔG	-	0.019	-	dB/°C
Power Variation (-25°C to +85°C)	Pulsed[4], 3.5 GHz	ΔP2.5dB	-	0.008	-	dB/°C
Power Gain	Pulsed[4], 3.5 GHz, P_{OUT} = 49.3 dBm	G_P	-	12.7	-	dB
Drain Efficiency	Pulsed[4], 3.5 GHz, P_{OUT} = 49.3 dBm	η	-	70.2	-	%
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} = 130 mA
Note: Performance in MACOM Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	Pulsed[4], 3.5 GHz, 2.5 dB Gain Compression	G_{SAT}	14.0	15.1	-	dB
Saturated Drain Efficiency	Pulsed[4], 3.5 GHz, 2.5 dB Gain Compression	η_{SAT}	55.0	60.0	-	%
Saturated Output Power	Pulsed[4], 3.5 GHz, 2.5 dB Gain Compression	P_{SAT}	47.5	48.9	-	dBm
Power Gain	Pulsed[4], 3.5 GHz, P_{IN} = 33 dBm	G_P	14.8	15.7	-	dB
Drain Efficiency	Pulsed[4], 3.5 GHz, P_{IN} = 33 dBm	η	54.0	59.1	-	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}	-	-	8.9	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	8.9	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 8.88 mA	V_T	-3.6	-2.8	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 130 mA	V_{GSQ}	-3.2	-2.6	-2.2	V
Maximum Drain Current	V_{DS} = 7 V pulsed, pulse width 300 μs	$I_{D, MAX}$	-	7.6	-	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	8.9 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} ≤ 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)	3.28	°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)	2.56	°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

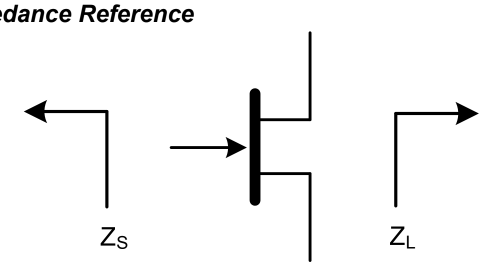
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

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

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 50 V, I_{DQ} = 130 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	0.76 + j1.85	9.76 + j1.80	22.6	49.9	96.8	61.5	0.1
1.4	0.93 - j1.98	7.71 + j2.28	19.4	50.0	99.8	62.0	0.4
2.0	1.77 - j4.86	5.43 + j1.16	14.9	49.8	94.6	55.1	-3.6
2.5	1.79 - j8.49	5.30 - j0.02	15.3	50.6	116.0	55.6	-0.3
2.7	2.29 - j10.5	5.34 - j0.27	15.2	50.1	101.4	56.0	0.8
3.0	4.02 - j13.7	4.39 - j0.74	14.9	50.1	102.3	59.4	1.5
3.5	14.6 - j15.5	3.74 - j2.47	13.8	49.7	94.2	57.9	-1.6

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 50 V, I_{DQ} = 130 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	0.56 + j1.13	13.3 + j13.5	25.2	47.4	54.8	72.5	-0.8
1.4	0.76 - j2.30	7.58 + j9.68	21.7	47.8	59.8	72.6	0.2
2.0	1.55 - j4.95	3.90 + j5.30	16.5	47.7	59.4	66.1	-8.0
2.5	1.49 - j8.55	4.00 + j3.21	17.2	49.3	84.3	64.8	-0.1
2.7	1.90 - j10.3	3.60 + j2.83	17.2	48.6	72.8	64.7	-1.4
3.0	3.30 - j13.6	2.92 + j1.45	16.5	48.6	73.1	67.6	-0.2
3.5	13.1 - j17.3	2.07 - j0.28	15.8	47.7	58.7	70.5	-13.2

Impedance Reference

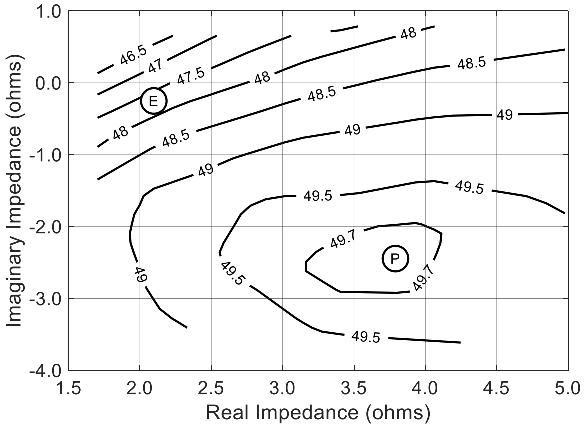


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

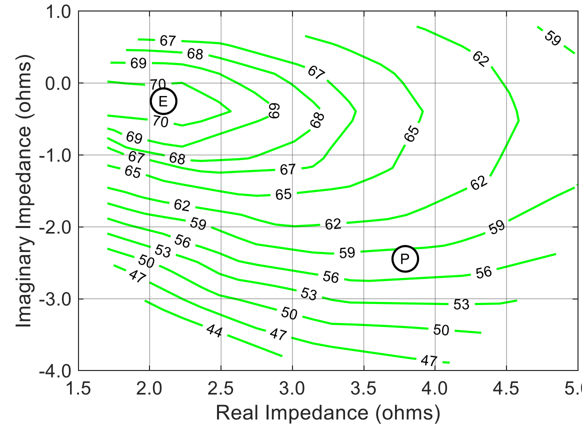
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

50 V Pulsed[4] Load-Pull Performance @ 3.5 GHz

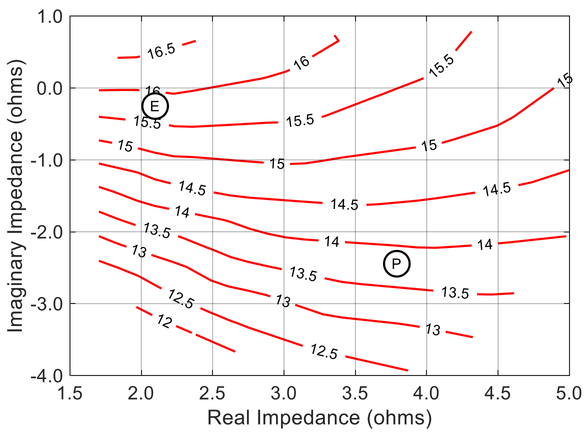
P2.5dB Loadpull Output Power Contours (dBm)



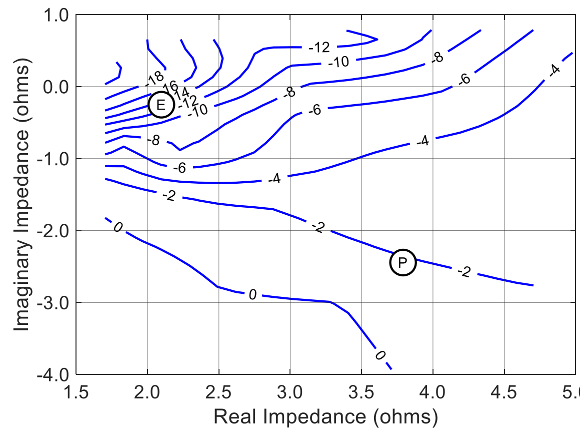
P2.5dB Loadpull Drain Efficiency Contours (%)



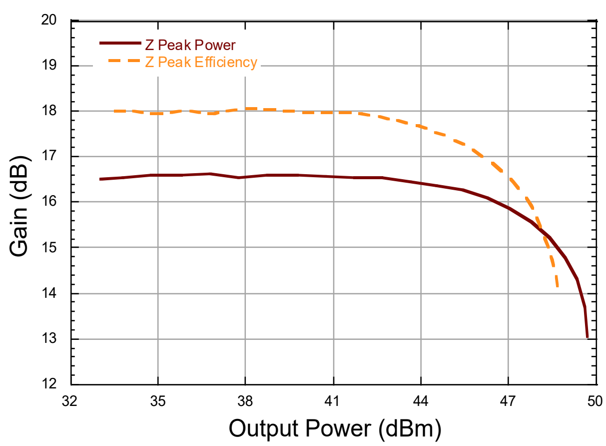
P2.5dB Loadpull Gain Contours (dB)



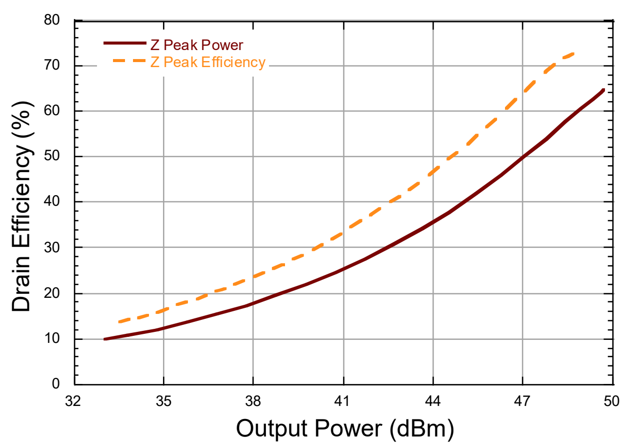
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

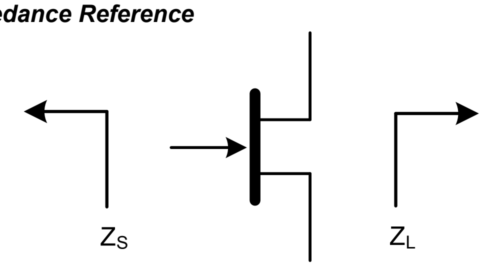


28 V Pulsed[4] Load-Pull Performance
Reference Plane at Device Leads

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 28 V, I_{DQ} = 130 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	0.80 + j1.38	6.36 - j0.32	20.5	47.0	49.8	60.2	-0.3
1.4	0.97 - j2.15	5.45 - j0.76	17.2	46.9	49.2	58.0	0.7
2.0	1.83 - j5.07	3.95 - j1.18	12.8	47.3	53.6	54.8	-3.0
2.5	2.01 - j8.91	4.33 - j2.30	13.2	48.0	63.1	56.5	-1.3
2.7	2.64 - j11.0	4.33 - j2.88	13.0	47.4	54.3	54.1	0.1
3.0	4.93 - j14.4	3.96 - j3.50	12.4	47.4	55.2	55.6	0.7
3.5	17.4 - j13.9	3.28 - j4.55	11.6	47.0	50.5	56.4	-4.6

Frequency (GHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 28 V, I_{DQ} = 130 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	0.72 + j0.58	12.35 +j8.87	22.7	43.9	24.6	70.2	-2.1
1.4	0.71 - j2.61	7.30 + j5.46	19.9	44.5	28.4	70.5	0.1
2.0	1.58 - j5.46	3.47 + j3.02	14.7	44.5	28.2	66.2	-9.5
2.5	1.74 - j9.26	4.13 + j0.52	14.8	46.5	45.1	65.4	-5.3
2.7	2.20 - j11.4	3.20 + j0.64	15.0	45.3	34.2	64.2	-6.0
3.0	4.73 - j15.5	2.96 - j0.48	14.3	45.6	36.6	67.0	-3.4
3.5	22.5 - j14.1	1.93 - j1.70	13.6	43.9	24.8	69.3	-20.1

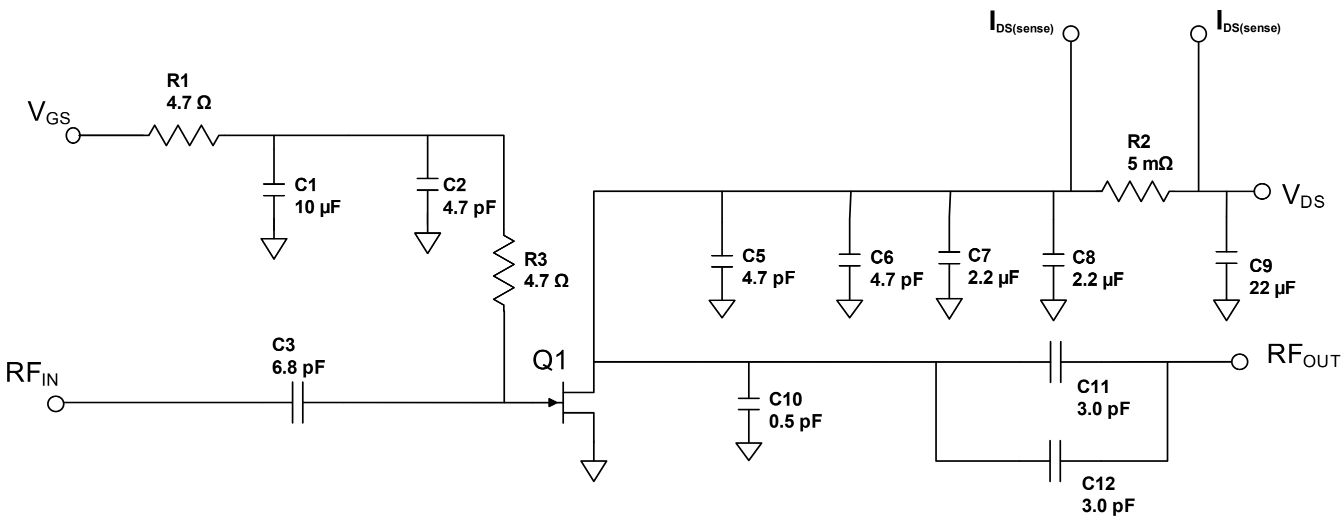
Impedance Reference



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: 3.45 - 3.55 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

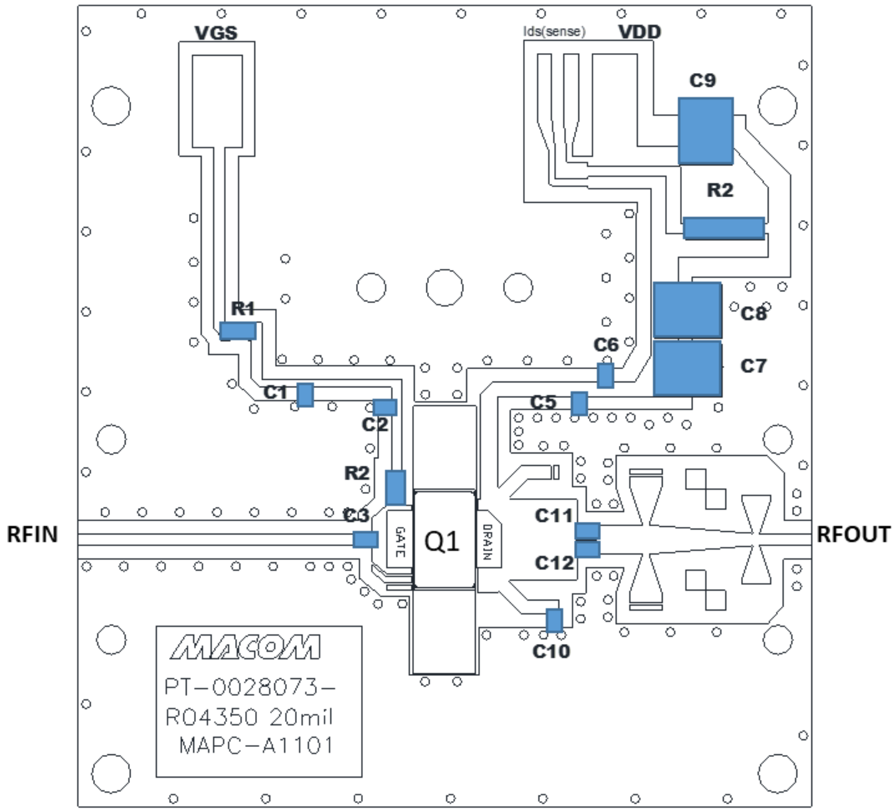
Turning the device ON

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}.

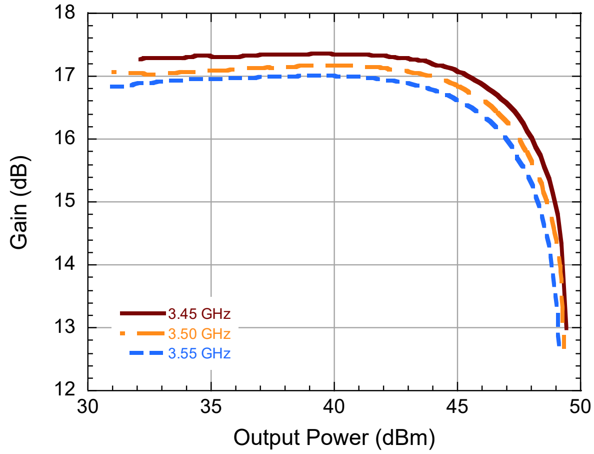
Evaluation Test Fixture and Recommended Tuning Solution: 3.45 - 3.55 GHz



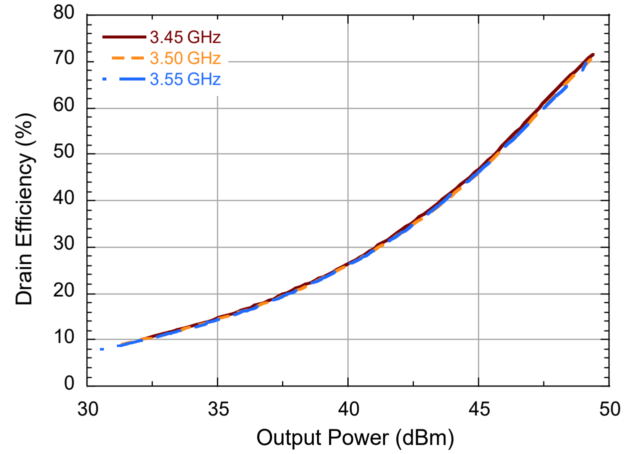
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1	10 µF	+/- 10 %	Murata	GRM21BZ71C106KE15L
C2, C5, C6	4.7 pF	+/- 0.1 pF	Murata	GQM2195C2E4R7BB12D
C3	6.8 pF	+/- 0.1 pF	Murata	GQM2195C2E6R8BB12D
C7, C8	2.2 µF	+/- 20%	Murata	KRM55TR72E225MH01L
C9	22 µF	+/- 20%	Murata	KRM55WR72A226MH01K
C10	0.5 pF	+/- 0.1 pF	Murata	GQM2195C2ER50BB12D
C11, C12	3.0 pF	+/- 0.1 pF	Murata	GQM2195C2E3R0BB12D
R2	5 mΩ	+/- 1%	Susumu	RL7520WT-R005-F
R1, R3	4.7 Ω	+/- 1%	Panasonic	ERJ-8RQF4R7V
Q1	MACOM GaN Power Amplifier			MAPC-A1101
PCB	RO4350, 20 mil, 1 oz. Cu, Au Finish			

Typical Performance Curves as Measured in the 3.45 - 3.55 GHz Evaluation Test Fixture: Pulsed[4] 3.5 GHz, V_{DS} = 50 V, I_{DQ} = 130 mA, T_C = 25°C (Unless Otherwise Noted)

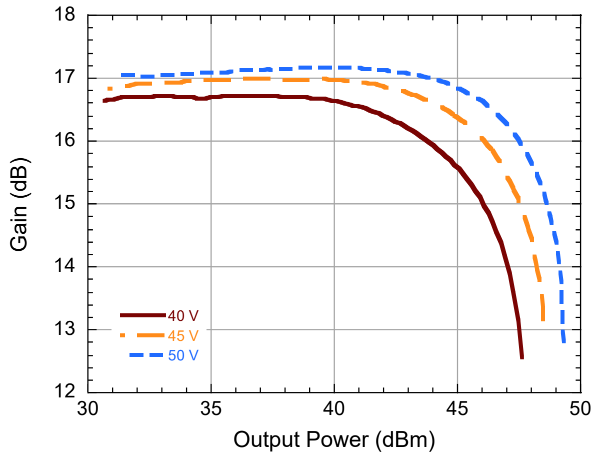
Gain vs. Output Power and Frequency



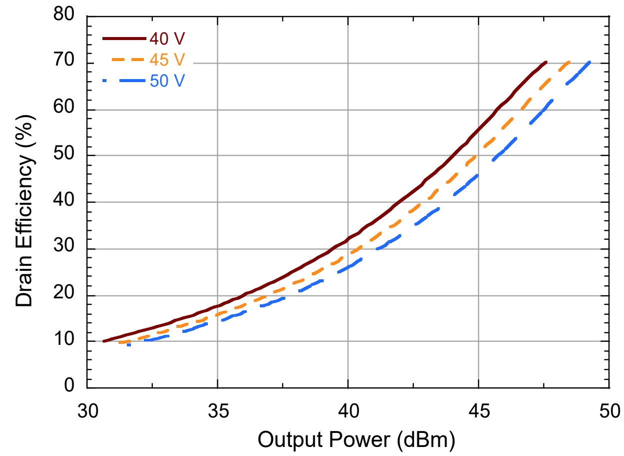
Drain Efficiency vs. Output Power and Frequency



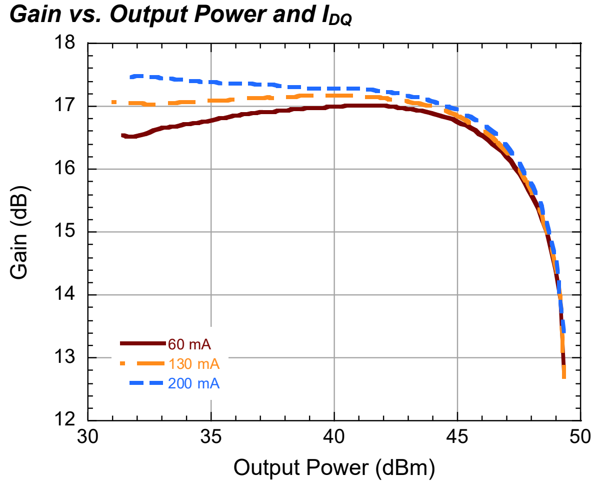
Gain vs. Output Power and V_{DS}



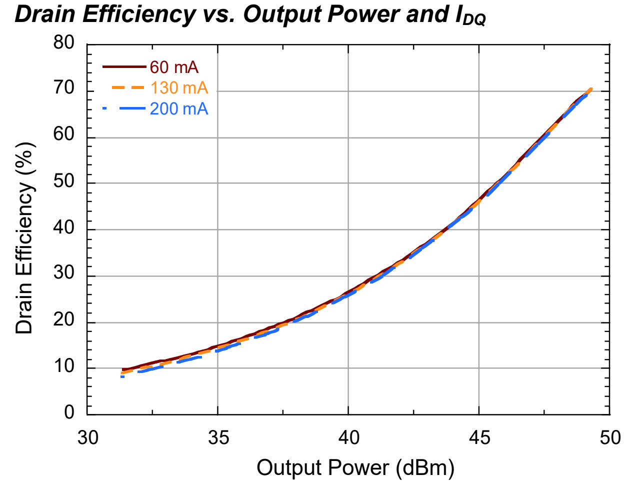
Dr



Gain vs. Output Power and I_{DQ}

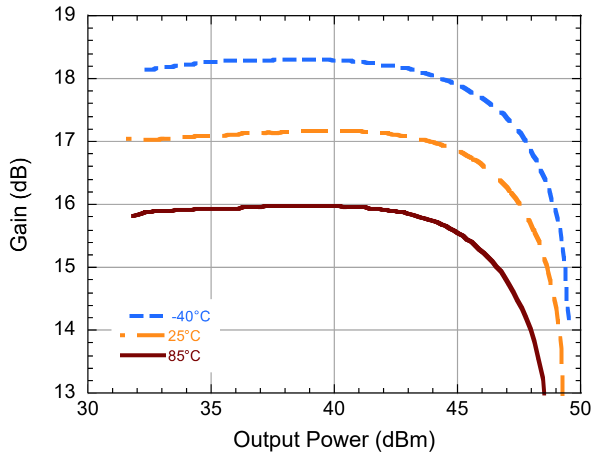


Drain Efficiency vs. Output Power and I_{DQ}

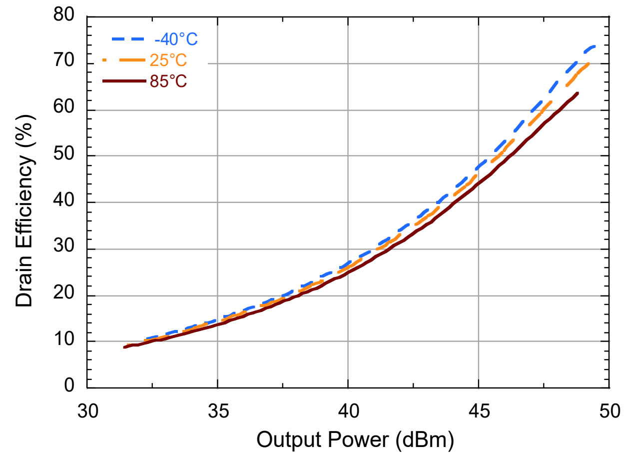


Typical Performance Curves as Measured in the 3.45 - 3.55 GHz Evaluation Test Fixture: Pulsed[4] 3.5 GHz, V_{DS} = 50 V, I_{DQ} = 130 mA, T_C = 25°C (Unless Otherwise Noted)

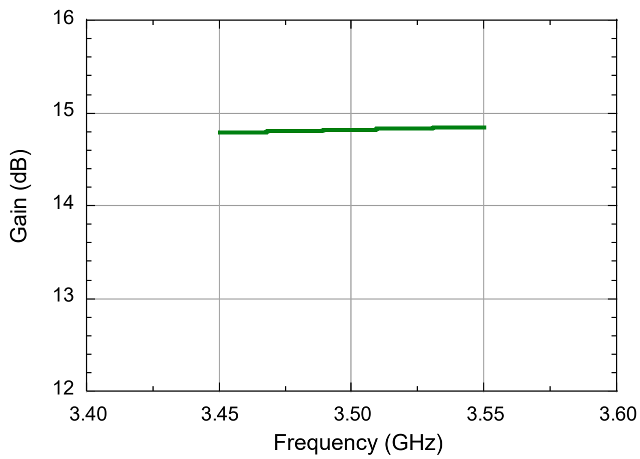
Gain vs. Output Power and T_C



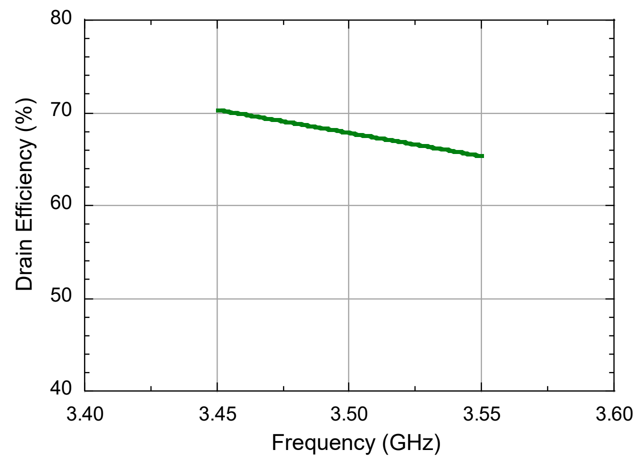
Drain Efficiency vs. Output Power and T_C



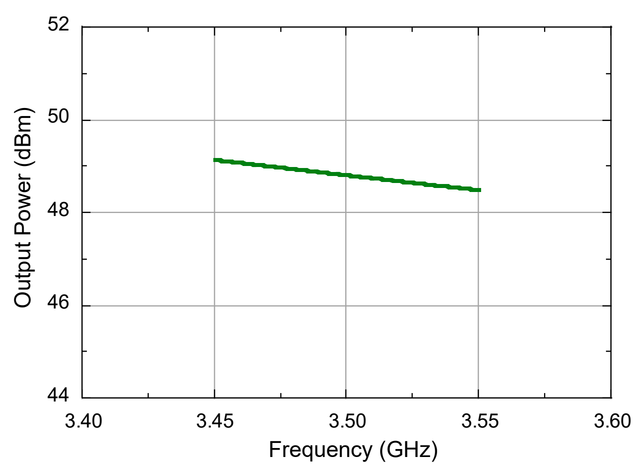
Gain vs. Frequency, 2.5dB Gain Compression



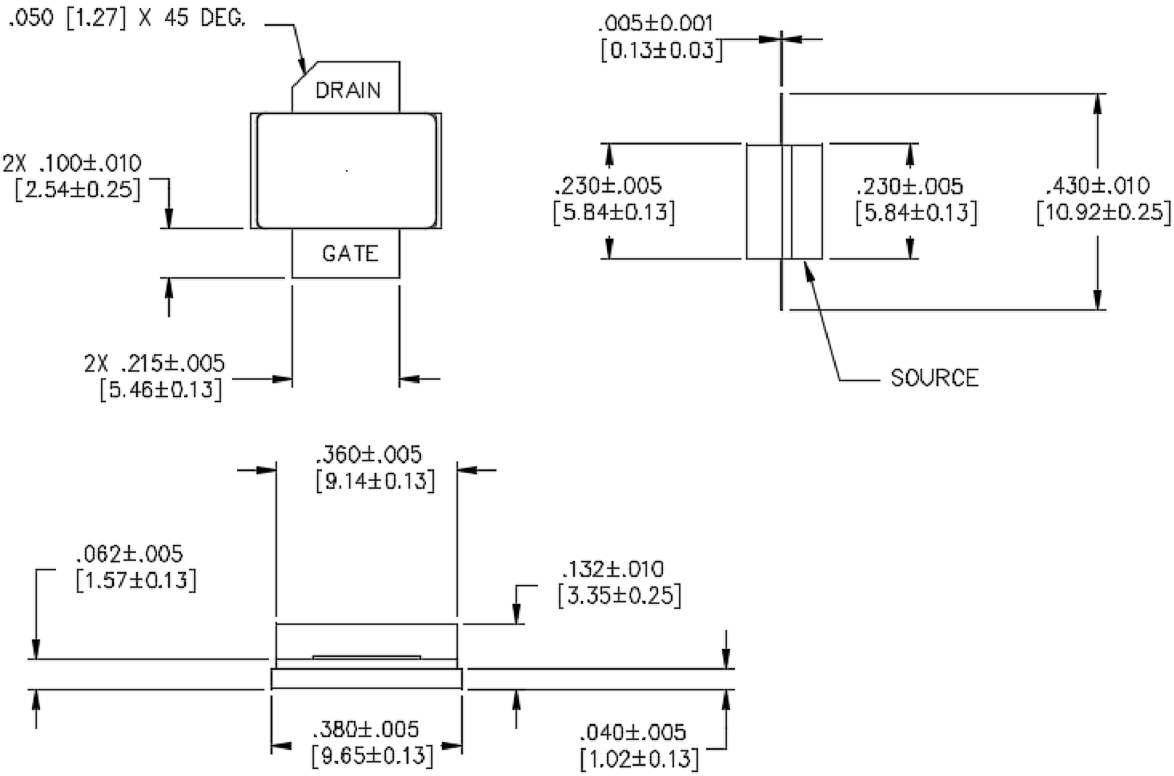
Drain Efficiency vs. Frequency, 2.5dB Gain Compression



Output Power vs. Frequency, 2.5dB Gain Compression



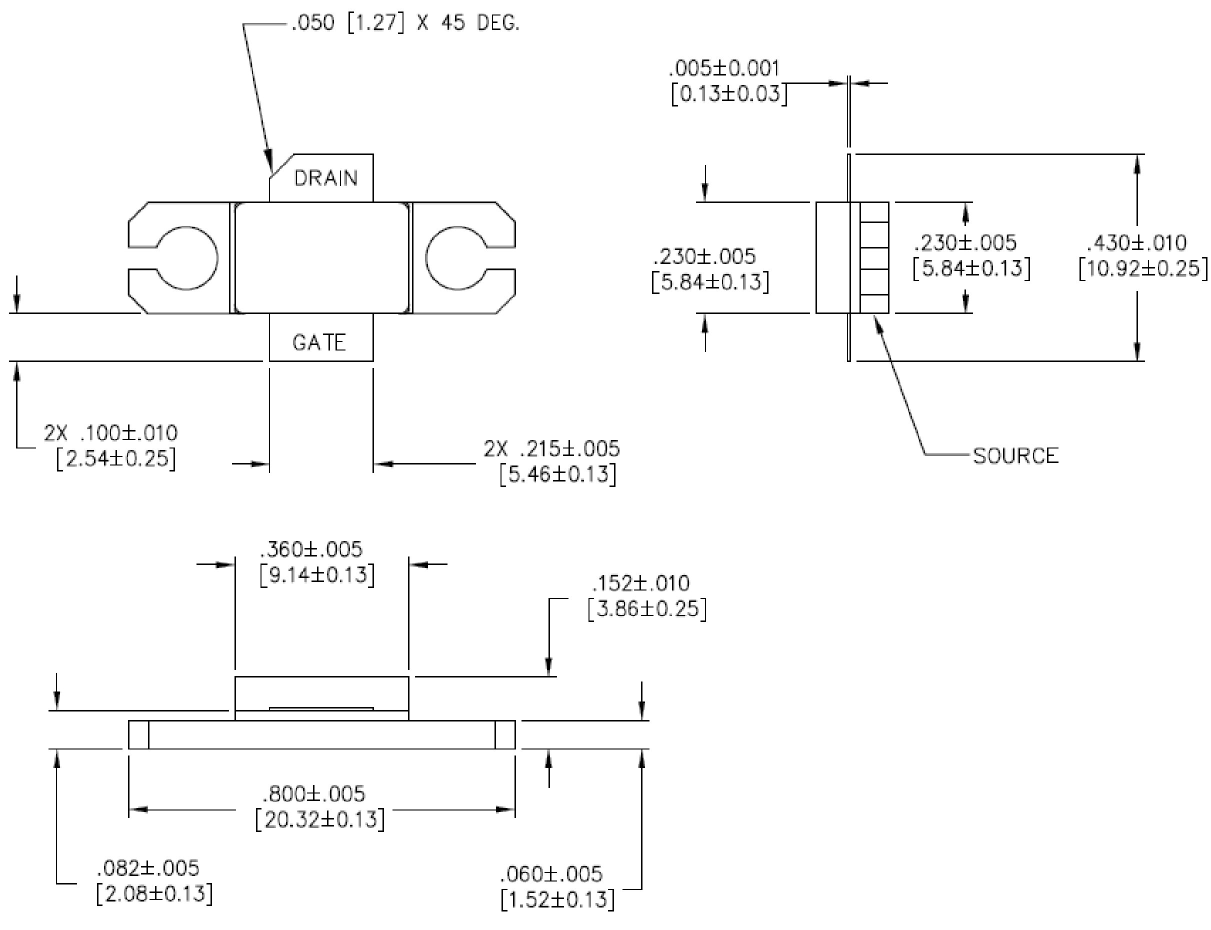
Lead-Free AC-360S-2 Package Dimensions†



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 lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is Au.

Lead-Free AC-360B-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 lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is Au.