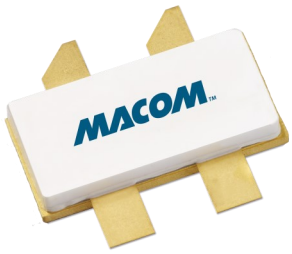
GaN Amplifier 50 V, 500 W
896 - 928 MHz

MAGE-100809-500G00
Rev. V1

Features

- Suitable for Linear and Saturated Applications
- Pair of Isolated, Symmetric Amplifiers
- CW and Pulsed Operation: 500 W Output Power
- Internally Pre-Matched
- 260°C Reflow Compatible
- 50 V Operation
- 100% RF Tested
- RoHS* Compliant



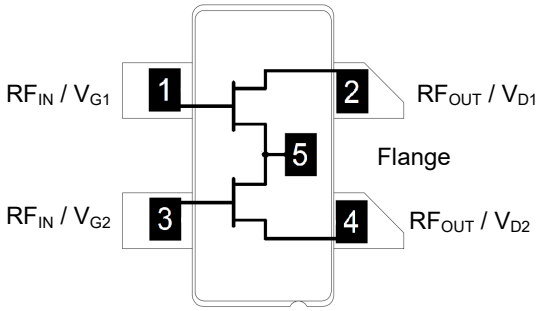
AC-780S-4

Description

The MAGE-100809-500G00 is a high power GaN on Si HEMT D-mode amplifier designed for 500 W peak power and optimized for 896 - 928 MHz frequency operation. This device supports both CW and pulsed operation with output power levels of at least 500 W (57 dBm) in an air cavity ceramic package.

The MAGE-100809-500G00 is ideally suited for CW applications as a highly efficient, precise heat and power source. The wide range of applications includes solid state cooking, RF plasma generation, material drying, industrial heating, automotive ignition, lighting and medical.

Functional Schematic



Typical Performance:

- V_{DS} = 50 V, I_{DQ} = 150 mA, T_C = 25°C.
  One side measured under load-pull at 2.5 dB Compression, 100 µs pulse width, 10% duty cycle.

Frequency (MHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D[2] (%)
896	56.8	18.9	78
915	56.6	18.7	76.8
928	56.7	18.7	78

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$_{G1}$	RF Input / Gate
2	RF$_{OUT}$ / V$_{D1}$	RF Output / Drain
3	RF$_{IN}$ / V$_{G2}$	RF Input / Gate
4	RF$_{OUT}$ / V$_{D2}$	RF Output / Drain
5	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
MAGE-100809-500G00	Bulk Quantity
MAGE-100809-500GT0	Tape and Reel
MAGE-1C0809-500G00	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} = 150 mA
Note: Performance in MACOM Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	Pulsed[4], 928 MHz	G_{SS}	-	20.6	-	dB
Power Gain	Pulsed[4], 928 MHz, 2.5 dB Gain Compression	G_{SAT}	-	18	-	dB
Saturated Drain Efficiency	Pulsed[4], 928 MHz, 2.5 dB Gain Compression	η_{SAT}	-	76.3	-	%
Saturated Output Power	Pulsed[4], 928 MHz, 2.5 dB Gain Compression	P_{SAT}	-	58	-	dBm
Gain Variation (-40°C to +85°C)	Pulsed[4], 928 MHz	ΔG	-	0.01	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[4], 928 MHz	$\Delta P2.5dB$	-	0.01	-	dBm/°C
Power Gain	Pulsed[4], 928 MHz, P_{IN} = 39.2 dBm	G_P	-	18.5	-	dB
Drain Efficiency	Pulsed[4], 928 MHz, P_{IN} = 39.2 dBm	η	-	73.6	-	%
Input Return Loss	Pulsed[4], 928 MHz, P_{IM} = 39.2 dBm	IRL	-	-11.6	-	dB
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 10:1, No Device Damage			

RF Electrical Specifications: T_A = 25°C, V_{DS} = 50 V, I_{DQ} = 150 mA
Note: Performance in MACOM Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	Pulsed[4], 928 MHz, 2.5 dB Gain Compression	G_{SAT}	16.0	17.2	-	dB
Saturated Drain Efficiency	Pulsed[4], 928 MHz, 2.5 dB Gain Compression	η_{SAT}	69.8	75.2	-	%
Saturated Output Power	Pulsed[4], 928 MHz, 2.5 dB Gain Compression	P_{SAT}	57.4	58.1	-	dBm
Gain	Pulsed[4], 928 MHz, P_{IN} = 39.2 dBm	G_P	17.1	18.4	-	dB
Drain Efficiency	Pulsed[4], 928 MHz, P_{IN} = 39.2 dBm	η	65.6	71.0	-	%
Input Return Loss	Pulsed[4], 928 MHz, P_{IN} = 39.2 dBm	IRL	-	-9.6	-5	dB

4. Pulse details: 100 µs pulse width, 10% Duty Cycle.

DC Electrical Characteristics: (Per Each Side of Symmetric Device) 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}	-	-	58	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	58	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 58 mA	V_T	-2.6	-2.2	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 150 mA	V_{GSQ}	-2.4	-2.13	-1.4	V
On Resistance	V_{GS} = 2 V, I_D = 435 mA	R_{ON}	-	0.08	-	Ω
Maximum Drain Current	V_{DS} = 7 V, pulse width 300 µs	$I_{D, MAX}$	-	33.8	-	A

Absolute Maximum Ratings (Per Each Side of Symmetric Device)[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	58 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 > 1 x 10^7 hours.
8. Operating at nominal conditions with $T_{CH} \leq 225°C$ will ensure MTTF > 1 x 10^7 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 = 3.686, B = -35.00, and C = 25,416.

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)	0.41	°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)	0.33	°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

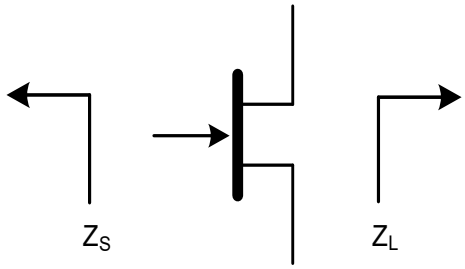
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1C, CDM Class C3 devices.

Pulsed[4] 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} = 150 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[11] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
896	2.3 - j3.0	1.3 + j0.0	17.3	56.8	478.6	66	22.3
915	2.6 - j3.1	1.3 + j0.0	17.5	56.6	457.1	66	15.2
928	2.8 - j2.8	1.3 + j0.1	17.1	56.7	467.7	64.6	10.3

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency					
		V_{DS} = 50 V, I_{DQ} = 150 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[12] (Ω)	Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
896	2.9 - j3.1	1.7 + j1.3	18.9	54.8	302	78	-2.9
915	3.3 - j3.0	1.9 + j1.4	18.7	54.6	288.4	76.8	-16.7
928	3.6 - j2.6	1.8 + j1.4	18.7	54.4	275.4	78	-22.1

Impedance Reference

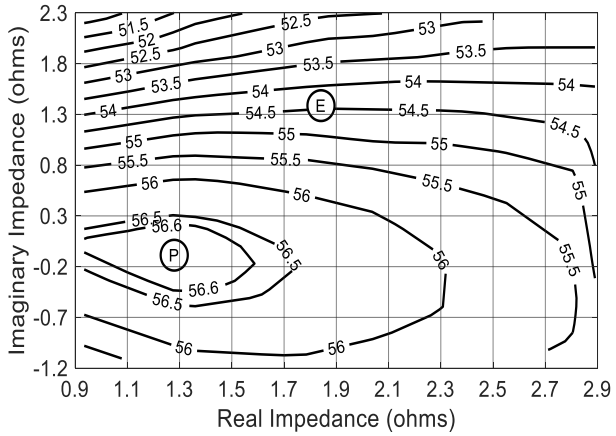


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

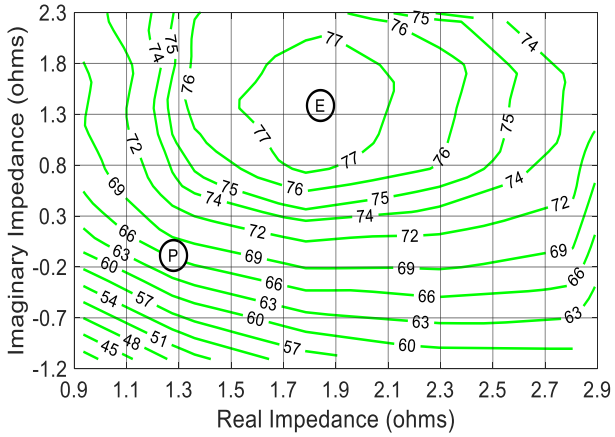
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

Pulsed[4] Load-Pull Performance (Per Each Side of Symmetric Device)
928 MHz

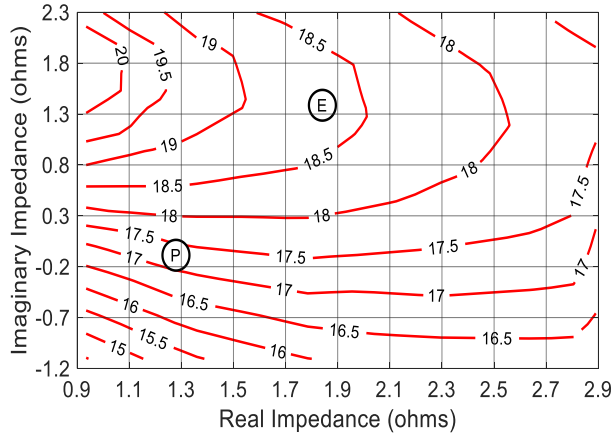
P2.5dB Loadpull Output Power Contours (dBm)



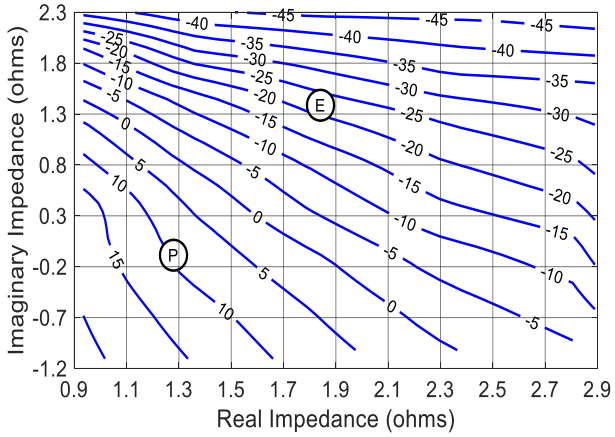
P2.5dB Loadpull Drain Efficiency Contours (%)



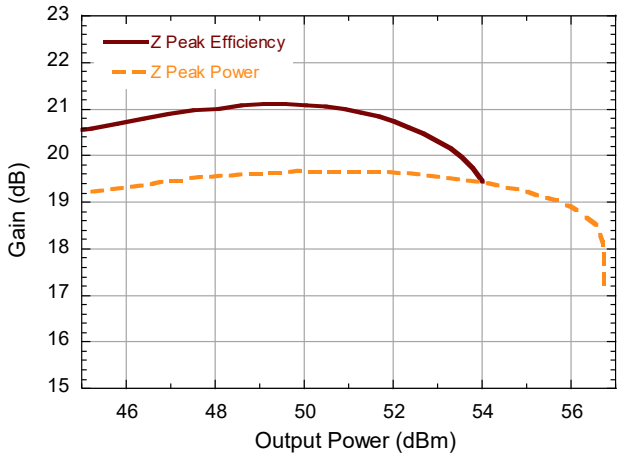
P2.5dB Loadpull Gain Contours (dB)



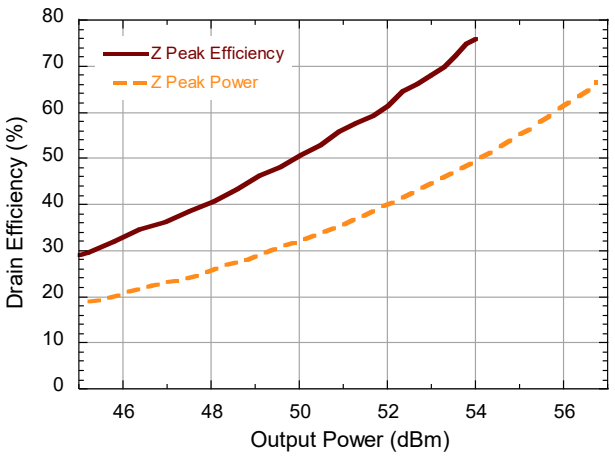
P2.5dB Loadpull AM/PM Contours (°)



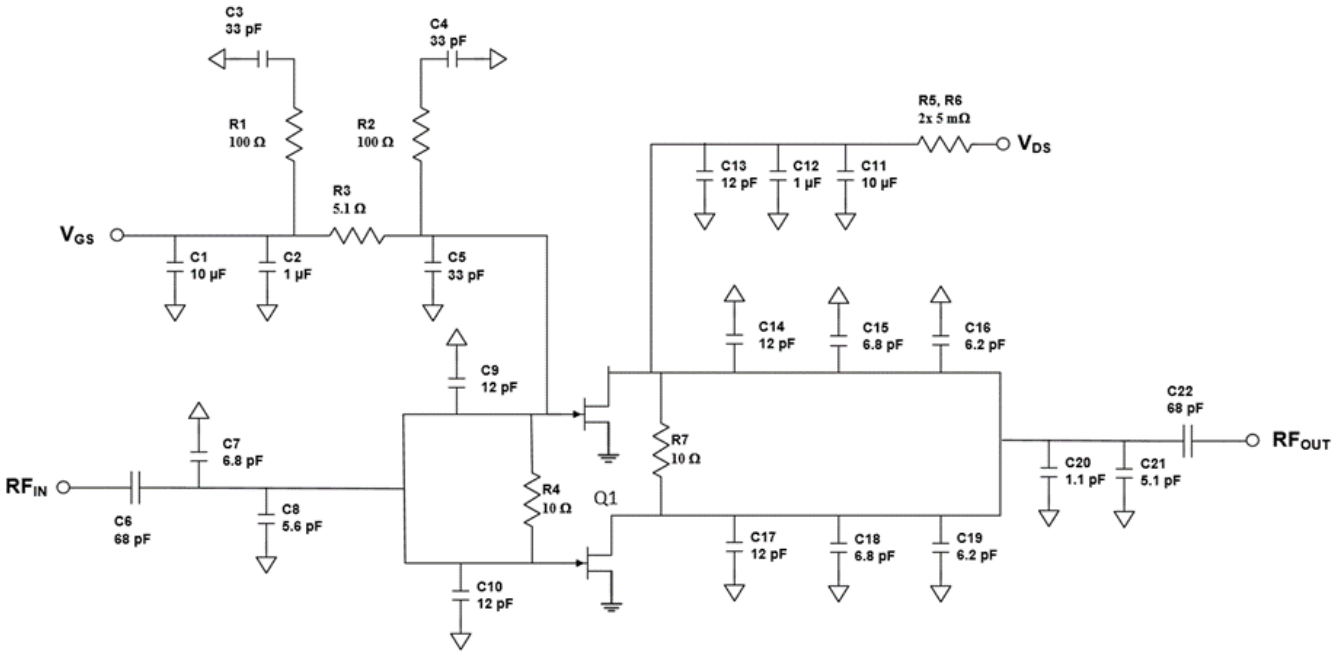
Gain vs. Output Power



Drain Efficiency vs. Output Power



Evaluation Test Fixture and Recommended Tuning Solution 896 - 928 MHz



Description

Parts measured on evaluation board (30-mil thick RO6035HTC). 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

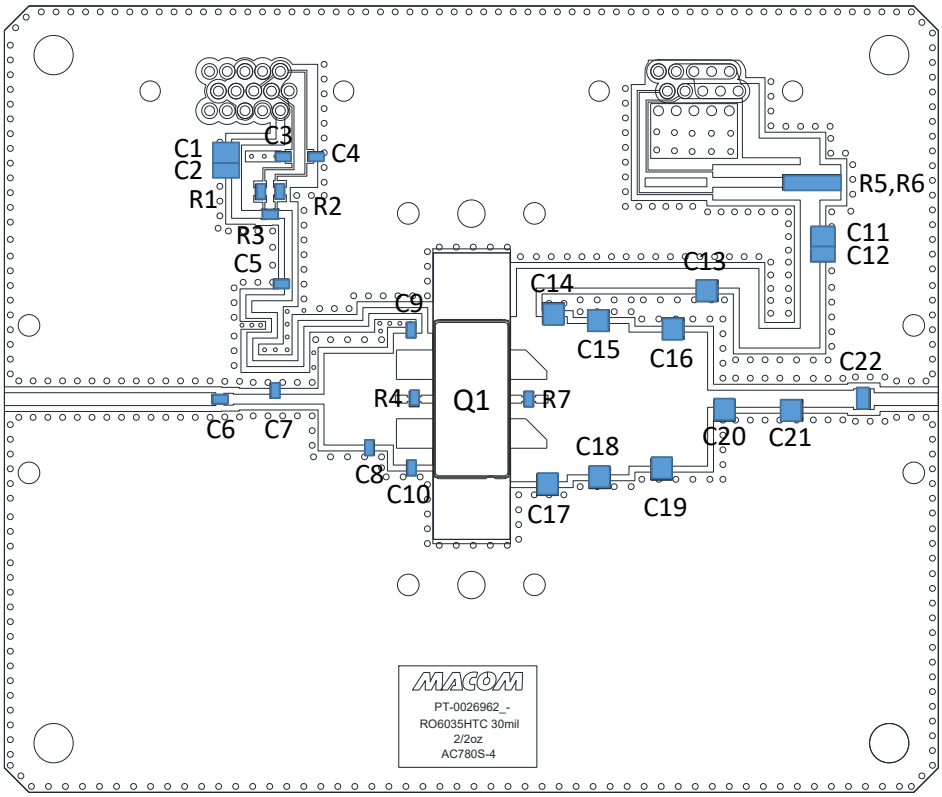
Turning the device ON

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.
3. Decrease V_{DS} down to 0 V.
4. Turn off V_{GS}.

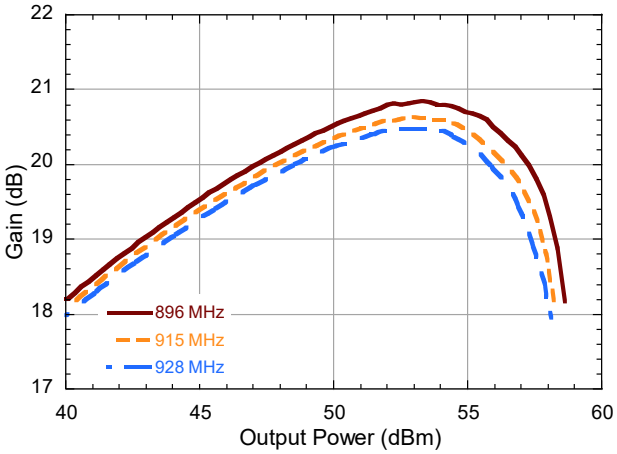
Evaluation Test Fixture and Recommended Tuning Solution 896 - 928 MHz



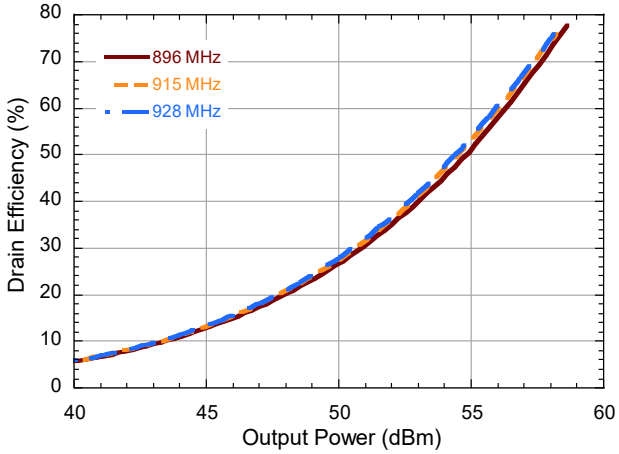
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1, C11	10 µF	+/- 10 %	Murata	GRM32EC72A106KE05L
C2, C12	1 µF	+/- 10 %	Murata	GRM31CR72105KA01L
C3, C4, C5	33 pF	+/- 5 %	PPI	0805N330JW251X
C6	68 pF	+/- 5 %	PPI	0805N680JW251X
C7	6.8 pF	+/- 0.1 pF	PPI	0805N6R8BW251X
C8	5.6 pF	+/- 0.1 pF	PPI	0805N5R6BW251X
C9,C10	12 pF	+/- 5 %	PPI	0805N120JW251X
C13, C14, C17	12 pF	+/- 5 %	PPI	1111N120FW501XT
C15, C18	6.8 pF	+/- 0.1 pF	PPI	1111N6R8FW501XT
C16, C19	6.2 pF	+/- 0.1 pF	PPI	1111N6R2FW501XT
C20	1.1 pF	+/- 0.1 pF	PPI	1111N1R1FW501XT
C21	5.1 pF	+/- 0.1 pF	PPI	1111N5R1FW501XT
C22	68 pF	+/- 5 %	PPI	0708N680JW501T
R1, R2	100 Ω	+/- 1 %	Vishay	CRCW0805100RFKEAC
R3	5.1 Ω	+/- 1 %	Vishay	CRCW08055R10FKEA
R4, R7	10 Ω	+/- 1 %	Viking	CR-05FL7-10R
R5, R6	5 mΩ	+/- 1 %	Susumu	RL7520WT-R005-F
Q1	MACOM GaN Power Amplifier			MAGE-100809-500G00
PCB	RO6035HTC, 30 mil, 2 oz. Cu, Au Finish			

Typical Performance Curves as Measured in the 896 - 928 MHz Evaluation Test Fixture:
Pulsed[4] 928 MHz, V_{DS} = 50 V, I_{DQ} = 150 mA, T_C = 25°C
Unless Otherwise Noted

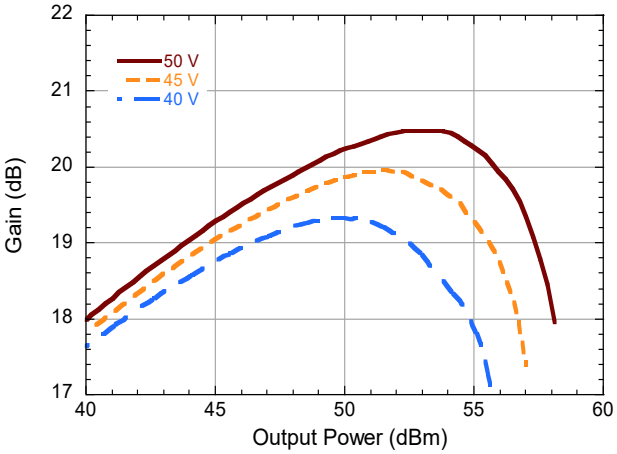
Gain vs. Output Power and Frequency



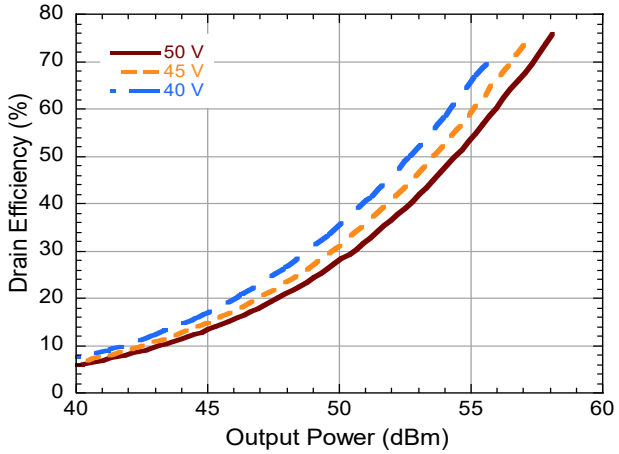
Drain Efficiency vs. Output Power and Frequency



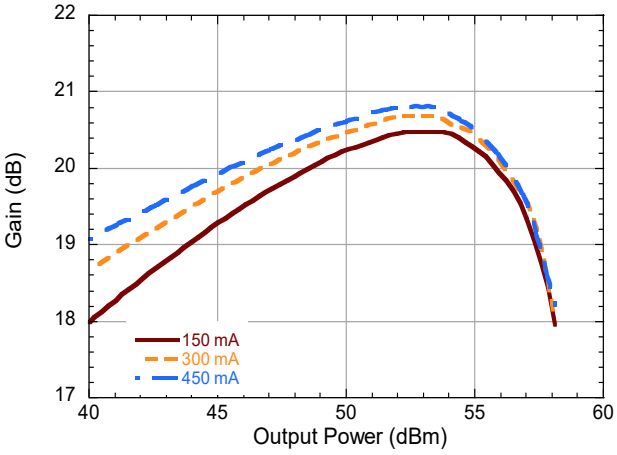
Gain vs. Output Power and V_{DS}



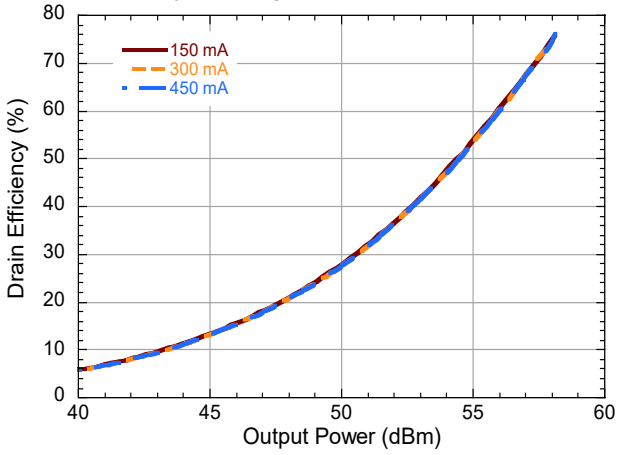
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}

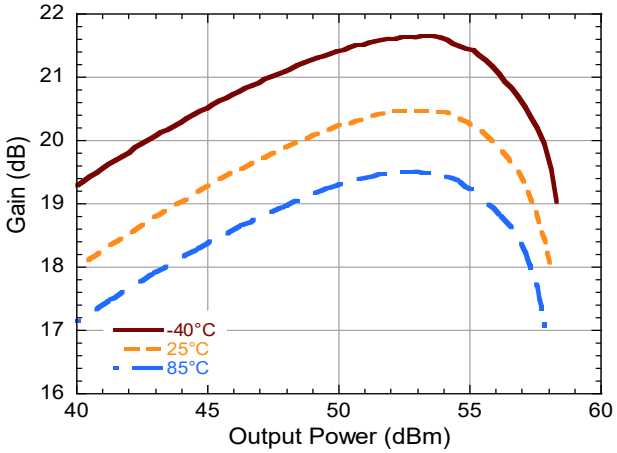


Drain Efficiency vs. Output Power and I_{DQ} ***Ef***

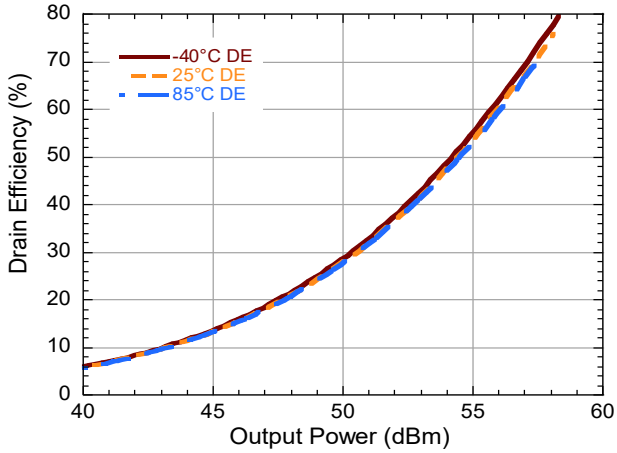


Typical Performance Curves as Measured in the 896 - 928 MHz Evaluation Test Fixture:
Pulsed[4] 928 MHz, V_{DS} = 50 V, I_{DQ} = 150 mA, T_C = 25°C
Unless Otherwise Noted

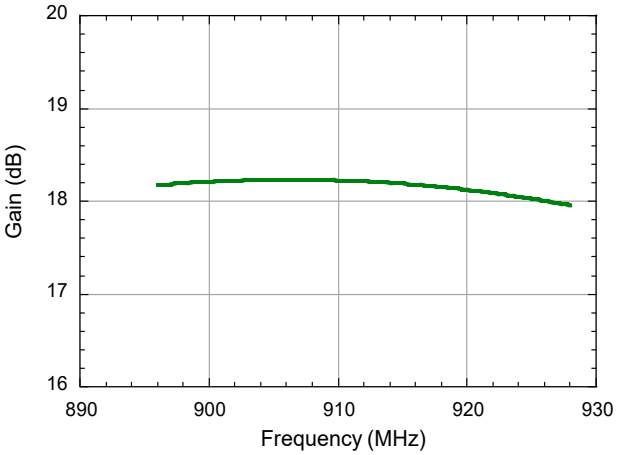
Gain vs. Output Power and T_C



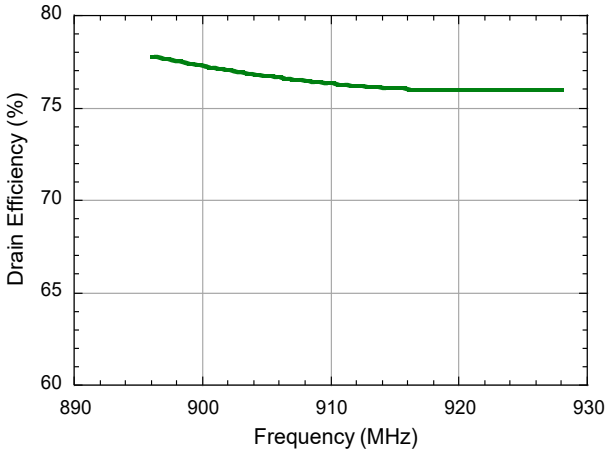
Drain Efficiency vs. Output Power and T_C



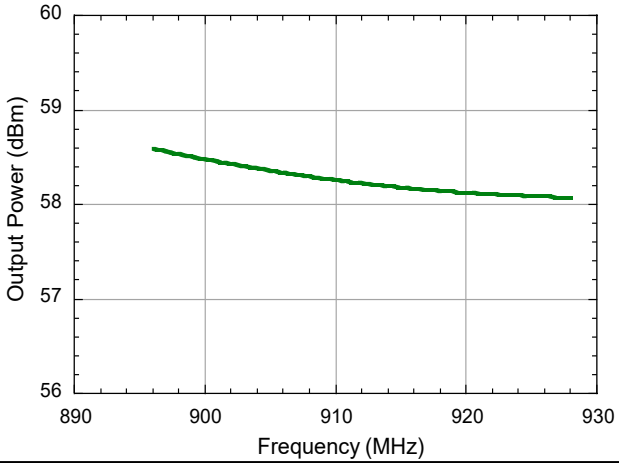
Gain vs. Frequency, 2.5dB Compression



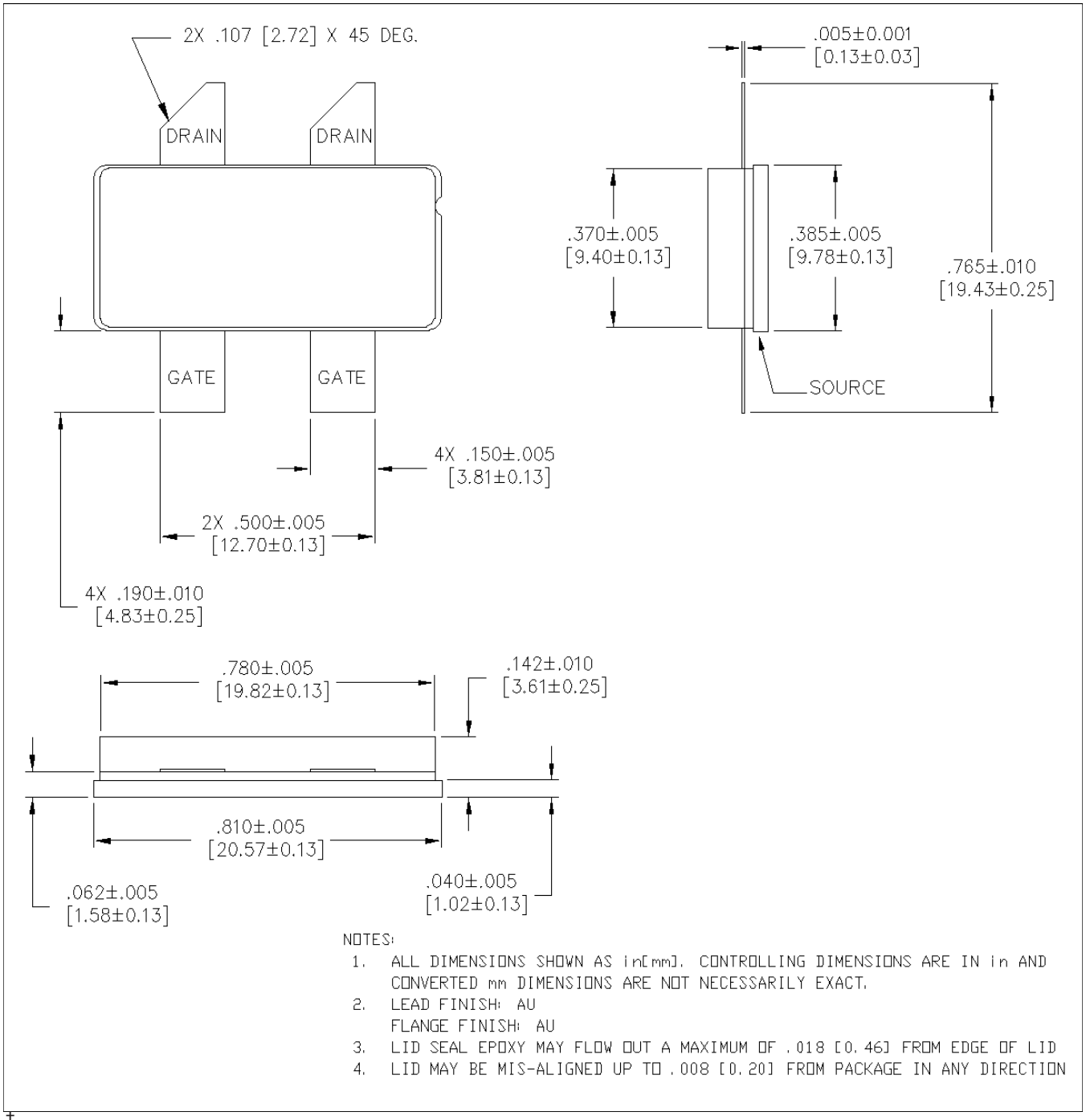
Drain Efficiency vs. Frequency, 2.5dB Compression



Output Power vs. Frequency, 2.5dB Compression



Lead-Free AC-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. 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.