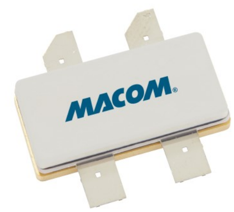
GaN Amplifier 52 V, 450 W
2.0 - 2.4 GHz

MACOM PURE CARBIDE

MAPC-A1506
Rev. V1

Features

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

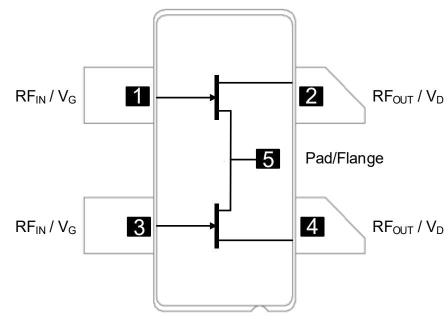


AP-780S-4

Applications

RADAR, Datalink and Satellite Communications

Functional Schematic



Description

The MAPC-A1506 is a high power GaN on Silicon Carbide HEMT D-mode amplifier suitable for 2.0 - 2.4 GHz frequency operation. The device supports pulsed operation with output power levels of 450 W (56.6 dBm) and in an air cavity thermally enhanced package.

Typical Performance:

Measured under evaluation board at 3 dB Compression, 100 µs pulse width, 10% duty cycle.

Frequency (GHz)	Output Power[1] (dBm)	Gain[2] (dB)	η_D[2] (%)
2.0	57.5	16.1	64.6
2.2	56.6	16.9	68.2
2.4	55.8	16.3	63.9

Pin Configuration

Pin #	Pin Name	Function
1	RF_{IN} / V_G	RF Input / Gate (Carrier)
2	RF_{OUT} / V_D	RF Output / Drain (Carrier)
3	RF_{IN} / V_G	RF Input / Gate (Peaking)
4	RF_{OUT} / V_D	RF Output / Drain (Peaking)
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-A1506-AS000	Bulk Quantity
MAPC-A1506-ASTR1	Tape and Reel
MAPC-A1506-ASSB1	Sample Board

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

RF Electrical Characteristics: T_C = 25°C, V_{DS} = 52 V, I_{DQ} = 500 mA
Note: Performance in MACOM Evaluation Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Saturated Output Power	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	P_{SAT}	-	56.6	-	dBm
Power Gain	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	G_{SAT}	-	16.9	-	dB
Saturated Drain Efficiency	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	η_{SAT}	-	68.2	-	%
Gain Variation (-40°C to +85°C)	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	ΔG	-	-0.019	-	dB/°C
Power Variation (-40°C to +85°C)	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	ΔP2.5dB	-	-0.004	-	dB/°C
Ruggedness: Output Mismatch	All phase angles	Ψ	VSWR = 10:1, No Damage			

RF Electrical Specifications: T_A = 25°C, V_{DS} = 52 V, I_{DQ} = 500 mA
Note: Performance in MACOM Production Test Fixture, 50 Ω system

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Power Gain	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	G_{SAT}	15.7	16.5	-	dB
Saturated Drain Efficiency	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	η_{SAT}	56	60	-	%
Saturated Output Power	Pulsed[2], 2.2 GHz, 3 dB Gain Compression	P_{SAT}	55.8	56.4	-	dBm

2. 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}	-	-	62.4	mA
Gate-Source Leakage Current	V_{GS} = -8 V, V_{DS} = 0 V	I_{GLK}	-	-	62.4	mA
Gate Threshold Voltage	V_{DS} = 50 V, I_D = 62.4 mA	V_T	-	-3.0	-	V
Gate Quiescent Voltage	V_{DS} = 50 V, I_D = 450 mA	V_{GSQ}	-	-2.6	-	V
Maximum Drain Current	V_{DS} = 7 V pulsed, pulse width 300 μs	$I_{D, MAX}$	-	53.0	-	A

Absolute Maximum Ratings [3,4,5,6,7]

Parameter	Absolute Maximum
Drain Source Voltage, V_{DS}	130 V
Gate Source Voltage, V_{GS}	-10 to 3 V
Gate Current, I_G	62.4 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

3. Exceeding any one or combination of these limits may cause permanent damage to this device.
4. MACOM does not recommend sustained operation above maximum operating conditions.
5. Operating at drain source voltage V_{DS} < 55 V will ensure MTTF > 2 x 10^6 hours.
6. Operating at nominal conditions with T_{CH} ≤ 225°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* = 1.93, B = -45.31, and C = 29,585.

Thermal Characteristics[8]

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance using Finite Element Analysis (Pulsed 10%, 100 µs)	V_{DS} = 52 V, T_C = 85°C, T_{CH} = 225°C	R_θ(FEA)	0.12	°C/W
Thermal Resistance using Infrared Measurement of Die Surface Temperature (Pulsed 10%, 100 µs)	V_{DS} = 52 V, T_C = 85°C, T_{CH} = 225°C	R_θ(IR)	0.096	°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

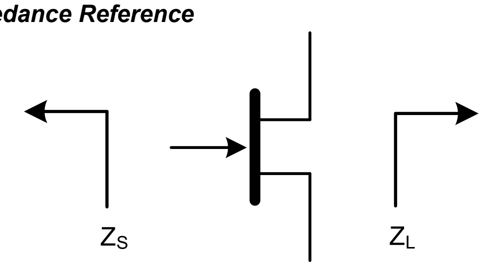
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

52V Pulsed[2] Load-Pull Performance (Per Each Side of Symmetric Device)
Reference Plane at Device Leads

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Output Power V_{DS} = 52 V, I_{DQ} = 460 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[9] (Ω)	Operating Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
2000	4 - j9	5.2 - j4.4	18.5	55.0	316	60.5	-28.2
2200	15 - j5	6.6 - j3.2	18.5	54.9	309	59.9	-94.1
2400	4 + j0	6.1 - j0.6	17.8	54.7	295	59.4	163.5

Frequency (MHz)	Z_{SOURCE} (Ω)	Maximum Drain Efficiency V_{DS} = 52 V, I_{DQ} = 460 mA, T_C = 25°C, P2.5dB					
		Z_{LOAD}[10] (Ω)	Operating Gain (dB)	P_{OUT} (dBm)	P_{OUT} (W)	η_D (%)	AM/PM (°)
2000	4 - j9	2.1 - j4.5	19.9	53.3	214	70.2	-31.4
2200	15 - j5	3.5 - j5.4	19.8	53.5	224	69.4	-83.6
2400	4 + j0	5.3 - j5.2	19.0	53.1	204	68.5	179.0

Impedance Reference

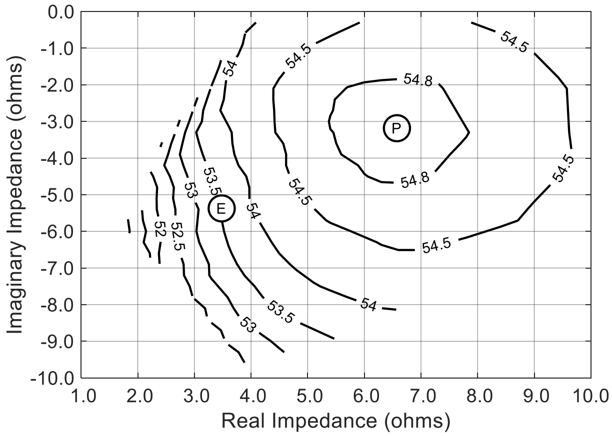


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.
Z_{LOAD} = Measured impedance presented to the output of the device at package reference plane.

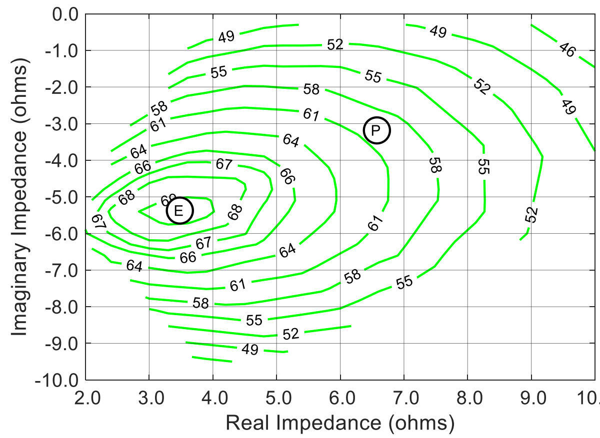
9. Load Impedance for optimum output power.
10. Load Impedance for optimum efficiency.

Pulsed[2] Load-Pull Performance (Per Each Side of Symmetric Device)
2.2 GHz

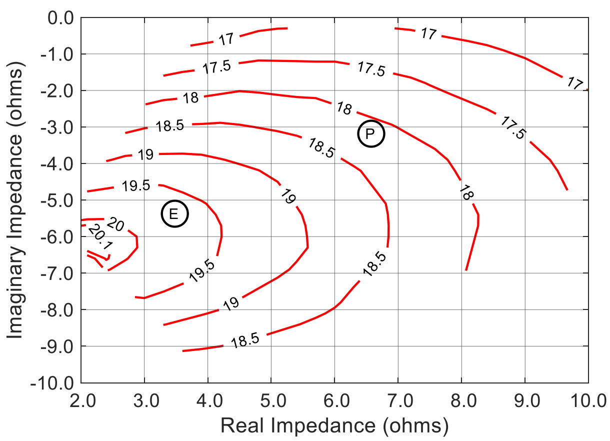
P2.5dB Loadpull Output Power Contours (dBm)



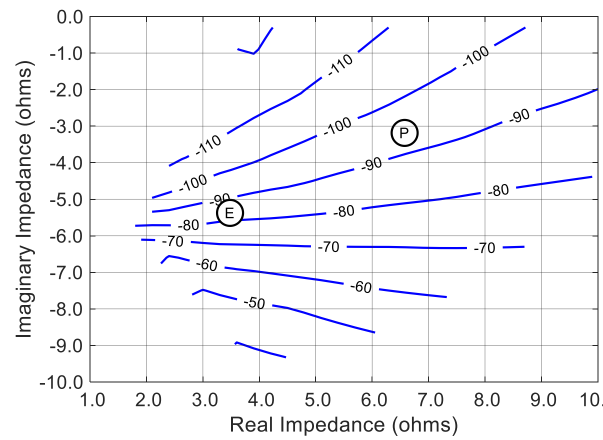
P2.5dB Loadpull Drain Efficiency Contours (%)



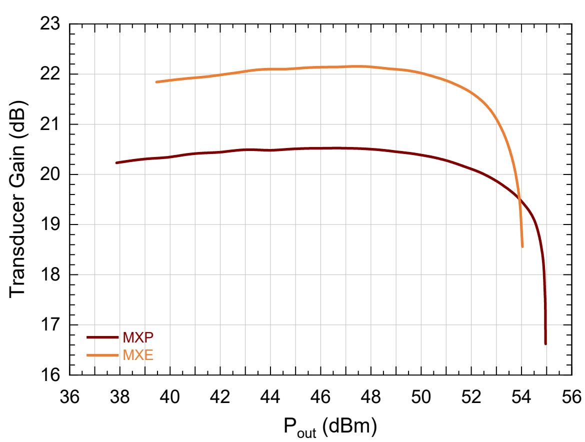
P2.5dB Loadpull Gain Contours (dB)



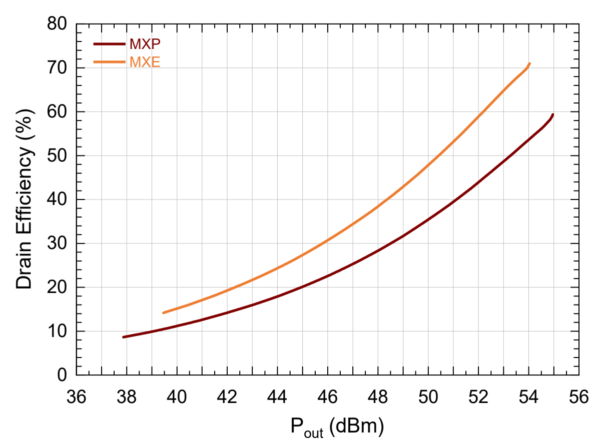
P2.5dB Loadpull AM/PM Contours (°)



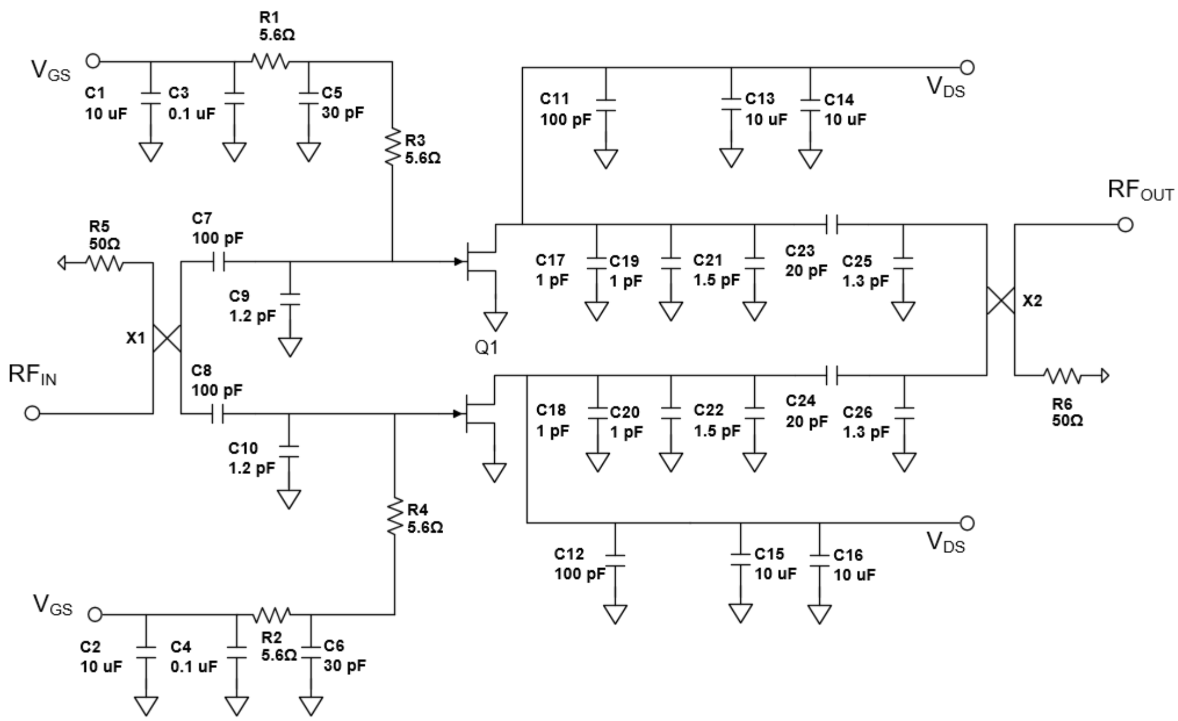
Transducer Gain vs. Output Power



Drain Efficiency vs. Output Power



Evaluation Test Fixture and Recommended Tuning Solution 2.0 - 2.4 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

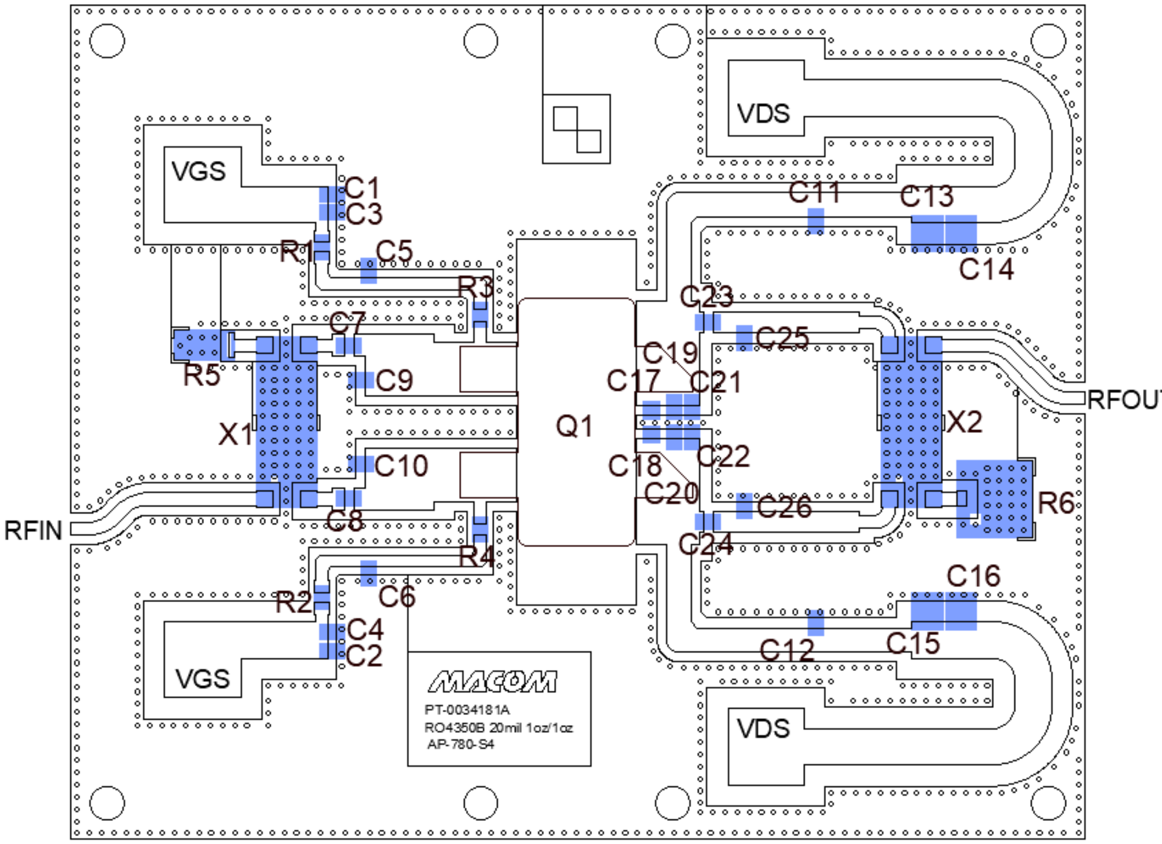
1. Set V_{GS} to pinch-off (V_P).
2. Turn on V_{DS} to nominal voltage (52 V).
3. Increase V_{GS} until I_{DS} current is reached.
4. Apply RF power to desired level.

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.

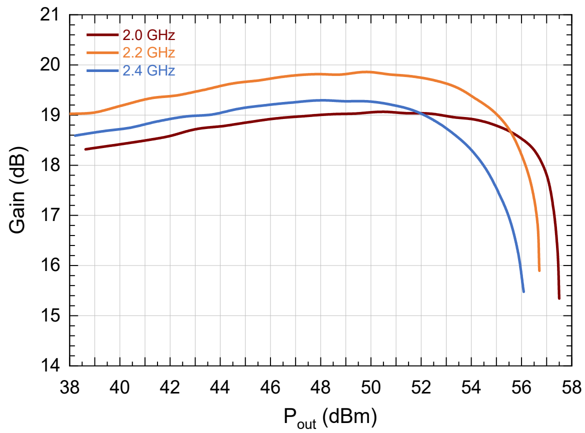
Evaluation Test Fixture and Recommended Tuning Solution 2.0 - 2.4 GHz



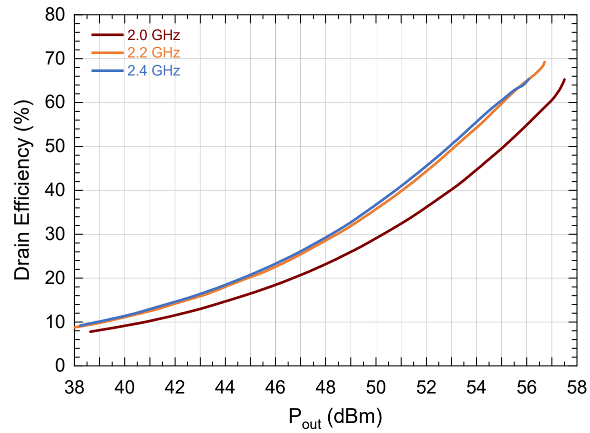
Reference Designator	Value	Tolerance	Manufacturer	Part Number
C1, C2	10 µF	+/- 10 %	Murata	GRM21BR6YA106KE43L
C3, C4	0.1 µF	+/- 10 %	Murata	GRM21BR72A104KAC4L
C5, C6	30 pF	+/- 5 %	Kyocera/AVX	600F300JT250X
C7, C8, C11, C12	100 pF	+/- 5 %	Kyocera/AVX	600F101JT250X
C9, C10	1.2 pF	+/- 0.1 pF	Kyocera/AVX	600F1R2BT250X
C13, C14, C15, C16	10 µF	+/- 10 %	Murata	GRM32EC72A106KE05L
C17, C18	1 pF	+/- 0.1 pF	Kyocera/AVX	800A1R0BT250X
C19, C20	1 pF	+/- 0.1 pF	Kyocera/AVX	600F1R0BT250X
C21, C22	1.5 pF	+/- 0.1 pF	Kyocera/AVX	600F1R5BT250X
C23, C24	20 pF	+/- 5 %	Kyocera/AVX	600F200JT250X
C25, C26	1.3 pF	+/- 0.1 pF	Kyocera/AVX	600F1R3BT250X
C13, C14, C15, C16	10 µF	+/- 10 %	Murata	GRM32EC72A106KE05L
R1, R2, R3, R4	5.6 Ω	+/- 0.5 %	Yageo	RT0805DRE075R6L
R5	50 Ω	+/- 2 %	RN2	S1020N
R6	50 Ω	+/- 2 %	RN2	S2525N150
X1, X2	RN2 Quadrature Hybrid Coupler			CMX25S03
Q1	MACOM GaN Power Amplifier			MAPC-A1506
PCB	RO4350B, 20 mil, 1 oz. Cu, ENIG Finish			

Typical Performance Curves as Measured in the 2.0 - 2.4 GHz Evaluation Test Fixture: Pulsed[2] 2.2 GHz, V_{DS} = 52 V, I_{DQ} = 500 mA, T_C = 25°C (Unless Otherwise Noted)

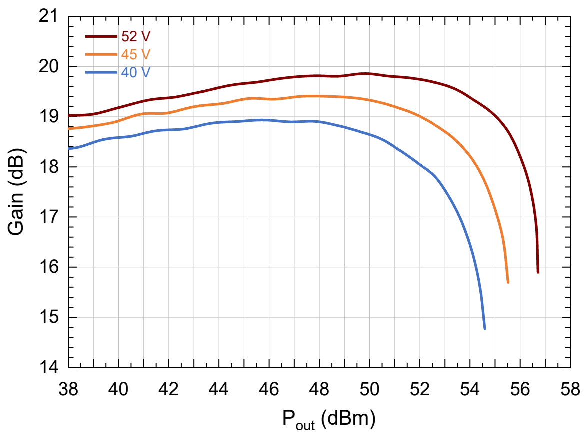
Gain vs. Output Power and Frequency



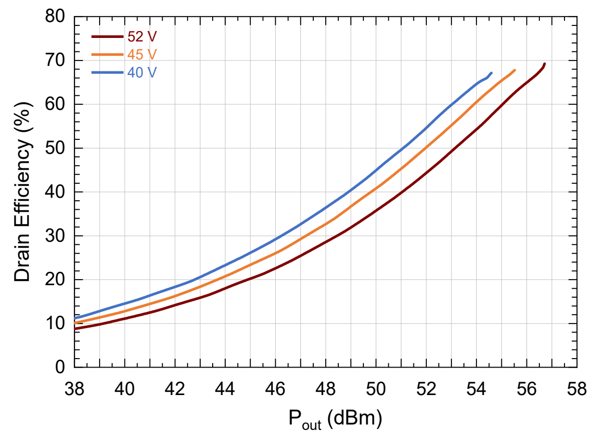
Drain Efficiency vs. Output Power and Frequency



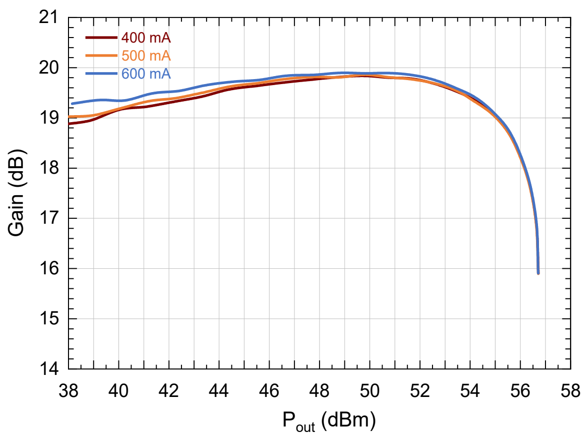
Gain vs. Output Power and V_{DS}



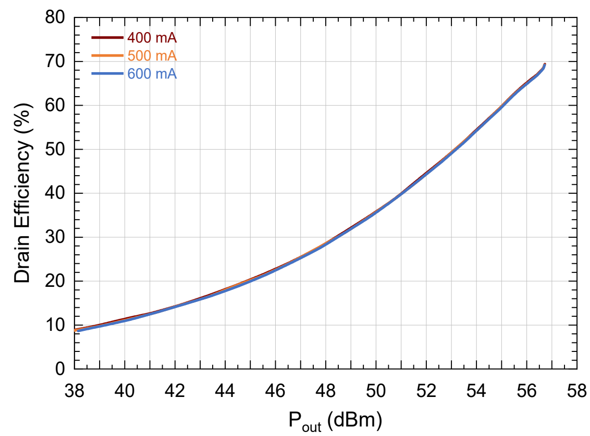
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}

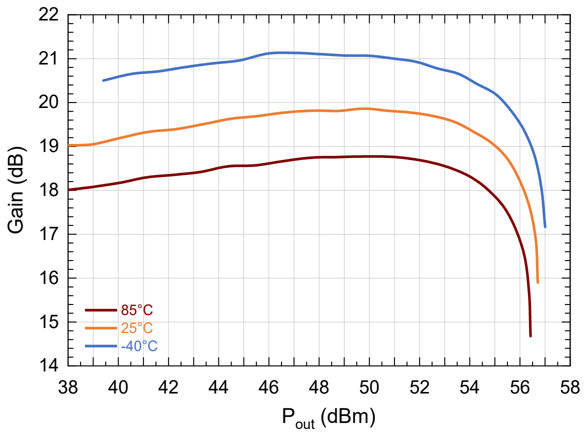


Drain Efficiency vs. Output Power and I_{DQ}

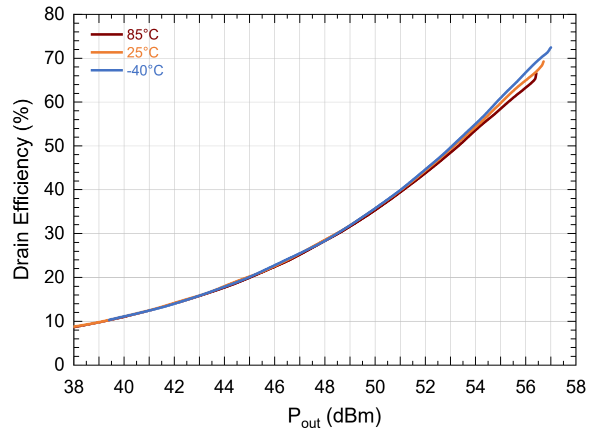


Typical Performance Curves as Measured in the 2.0 - 2.4 GHz Evaluation Test Fixture: Pulsed[2] 2.2 GHz, V_{DS} = 52 V, I_{DQ} = 500 mA, T_C = 25°C (Unless Otherwise Noted)

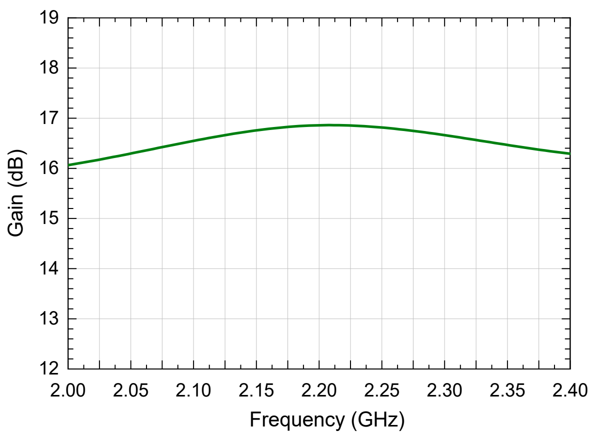
Gain vs. Output Power and T_C



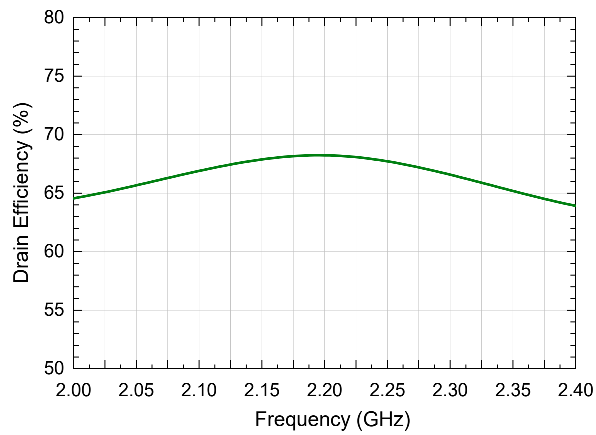
Drain Efficiency vs. Output Power and T_C



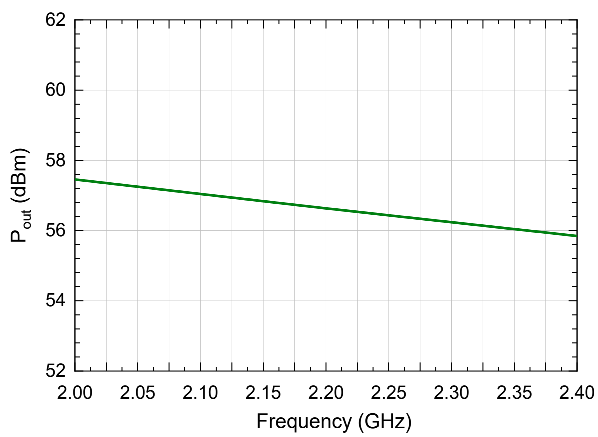
Gain vs. Frequency, 3dB Gain Compression



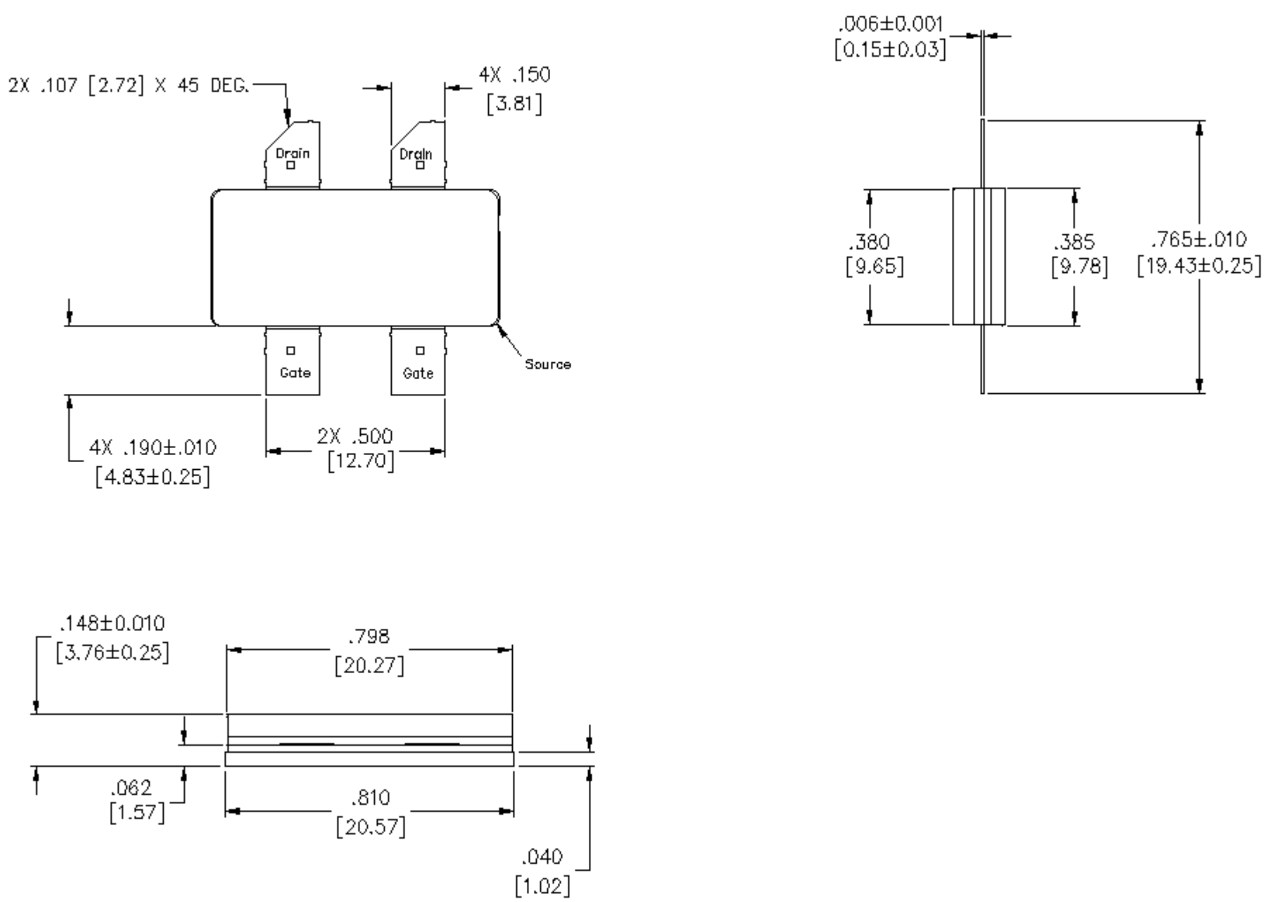
Drain Efficiency vs. Frequency, 3dB Gain Compression



Output Power vs. Frequency, 3dB Gain Compression



Lead-Free AP-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
5. LEAD DIMENSIONS DO NOT INCLUDE METAL PROTRUSIONS. ALLOWABLE PROTRUSION IS .010[0.25] PER SIDE

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