

GaN Amplifier 50 V, 65 W

DC - 3.5 GHz



MACOM PURE CARBIDE™

MAPC-A1100

Rev. V5

Features

- MACOM PURE CARBIDE™ Amplifier Series
- Suitable for Linear & Saturated Applications
- CW & Pulsed Operation: 65 W Output Power
- Internally Pre-Matched
- 28 V and 50 V Operation
- Compatible with MACOM Power Management Bias Controller/Sequencer MABC-11040

Applications

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

Description

The MAPC-A1100 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 65 W (48.1 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.

- $V_{DS} = 50 \text{ V}$, $I_{DQ} = 110 \text{ mA}$, $T_C = 25^\circ\text{C}$

| Frequency (GHz) | Output Power ¹ (dBm) | Gain ² (dB) | η_D^2 (%) |
|-----------------|---------------------------------|------------------------|----------------|
| 0.9 | 48.7 | 24.2 | 73.4 |
| 1.4 | 48.6 | 20.7 | 72.4 |
| 2.0 | 48.9 | 18.4 | 65.0 |
| 2.5 | 49.3 | 17.4 | 68.2 |
| 3.0 | 48.9 | 16.4 | 69.7 |
| 3.5 | 48.7 | 15.8 | 74.0 |

- $V_{DS} = 28 \text{ V}$, $I_{DQ} = 110 \text{ mA}$, $T_C = 25^\circ\text{C}$

| Frequency (GHz) | Output Power ¹ (dBm) | Gain ² (dB) | η_D^2 (%) |
|-----------------|---------------------------------|------------------------|----------------|
| 0.9 | 46.0 | 20.9 | 72.7 |
| 1.4 | 45.8 | 18.6 | 71.2 |
| 2.0 | 46.6 | 16.5 | 67.9 |
| 2.5 | 46.7 | 15.4 | 70.7 |
| 3.0 | 46.2 | 14.2 | 70.5 |
| 3.5 | 46.0 | 13.8 | 74.1 |

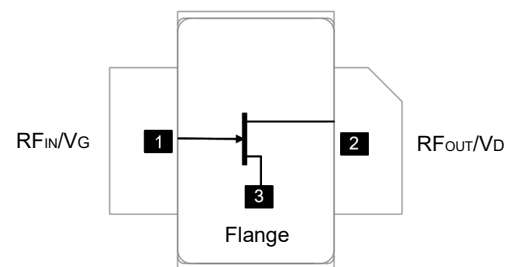
1. Load impedance tuned for maximum output power.
2. Load impedance tuned for maximum drain efficiency.

¹ * Restrictions on Hazardous Substances, compliant to current RoHS EU directive.



AC-360S-2

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-A1100-AS000 | Bulk Quantity |
| MAPC-A1100-ASTR1 | Tape and Reel |
| MAPC-A1100-ASSB1 | Sample Board |

RF Electrical Characteristics: $T_C = 25^\circ\text{C}$, $V_{DS} = 50\text{ V}$, $I_{DQ} = 110\text{ mA}$

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} | - | 17.7 | - | dB |
| Power Gain | Pulsed ⁴ , 3.5 GHz, 2.5 dB Gain Compression | G_{SAT} | - | 15.1 | - | dB |
| Saturated Drain Efficiency | Pulsed ⁴ , 3.5 GHz, 2.5 dB Gain Compression | η_{SAT} | - | 70.5 | - | % |
| Saturated Output Power | Pulsed ⁴ , 3.5 GHz, 2.5 dB Gain Compression | P_{SAT} | - | 46.2 | - | dBm |
| Gain Variation (-40°C to +85°C) | Pulsed ⁴ , 3.5 GHz | ΔG | - | 0.012 | - | dB/°C |
| Power Variation (-40°C to +85°C) | Pulsed ⁴ , 3.5 GHz | $\Delta P_{2.5dB}$ | - | 0.005 | - | dB/°C |
| Power Gain | Pulsed ⁴ , 3.5 GHz, $P_{IN} = 30.5\text{ dBm}$ | G_P | - | 15.5 | - | dB |
| Drain Efficiency | Pulsed ⁴ , 3.5 GHz, $P_{IN} = 30.5\text{ dBm}$ | η | - | 69.5 | - | % |
| Ruggedness: Output Mismatch | All phase angles | Ψ | VSWR = 10:1, No Damage | | | |

RF Electrical Specifications: $T_A = 25^\circ\text{C}$, $V_{DS} = 50\text{ V}$, $I_{DQ} = 110\text{ mA}$

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} | 14.7 | 15.6 | - | dB |
| Saturated Drain Efficiency | Pulsed ⁴ , 3.5 GHz, 2.5 dB Gain Compression | η_{SAT} | 60 | 65.1 | - | % |
| Saturated Output Power | Pulsed ⁴ , 3.5 GHz, 2.5 dB Gain Compression | P_{SAT} | 45.8 | 47.2 | - | dBm |
| Power Gain | Pulsed ⁴ , 3.5 GHz, $P_{IN} = 30.5\text{ dBm}$ | G_P | 15.4 | 16.3 | - | dB |
| Drain Efficiency | Pulsed ⁴ , 3.5 GHz, $P_{IN} = 30.5\text{ dBm}$ | η | 58 | 63.3 | - | % |

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

DC Electrical Characteristics $T_A = 25^\circ\text{C}$

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|------------------------------|---|--------------|------|------|------|----------|
| Drain-Source Leakage Current | $V_{GS} = -8\text{ V}$, $V_{DS} = 130\text{ V}$ | I_{DLK} | - | - | 6.72 | mA |
| Gate-Source Leakage Current | $V_{GS} = -8\text{ V}$, $V_{DS} = 0\text{ V}$ | I_{GLK} | - | - | 6.72 | mA |
| Gate Threshold Voltage | $V_{DS} = 50\text{ V}$, $I_D = 6.72\text{ mA}$ | V_T | -3.6 | -3.1 | - | V |
| Gate Quiescent Voltage | $V_{DS} = 50\text{ V}$, $I_D = 110\text{ mA}$ | V_{GSQ} | - | -2.6 | - | V |
| On Resistance | $V_{GS} = 2\text{ V}$, $I_D = 50.4\text{ mA}$ | R_{ON} | - | 0.49 | - | Ω |
| Maximum Drain Current | $V_{DS} = 7\text{ V}$ pulsed, pulse width 300 μs | $I_{D, MAX}$ | - | 8.0 | - | 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 | 6.7 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 $MTTF > 2 \times 10^6$ hours.
8. Operating at nominal conditions with $T_{CH} \leq 225^\circ\text{C}$ will ensure $MTTF > 2 \times 10^6$ hours.
9. MTTF may be estimated by the expression $MTTF \text{ (hours)} = A e^{[B + C/(T+273)]}$ 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, $T_C = 85^\circ\text{C}$, $T_{CH} = 225^\circ\text{C}$ | $R_{\theta}(\text{FEA})$ | 4.63 | °C/W |
| Thermal Resistance using Infrared Measurement of Die Surface Temperature | $V_{DS} = 50$ V, $T_C = 85^\circ\text{C}$, $T_{CH} = 225^\circ\text{C}$ | $R_{\theta}(\text{IR})$ | 3.70 | °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

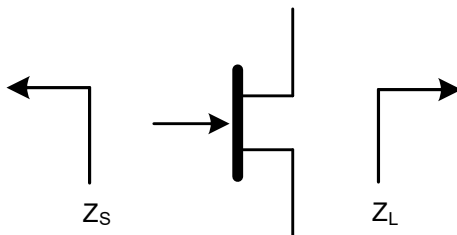
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

**50 V Pulsed⁴ Load-Pull Performance
Reference Plane at Device Leads**

| Frequency (GHz) | Z _{SOURCE} (Ω) | Maximum Output Power | | | | | |
|-----------------|-------------------------|---|-----------|------------------------|----------------------|--------------------|-----------|
| | | V _{DS} = 50 V, I _{DQ} = 110 mA, T _C = 25°C, P _{2.5dB} | | | | | |
| | | Z _{LOAD} ¹¹ (Ω) | Gain (dB) | P _{OUT} (dBm) | P _{OUT} (W) | η _D (%) | AM/PM (°) |
| 0.9 | 1.3 + j2.0 | 12.6 + j3.1 | 22.5 | 48.7 | 74.6 | 65.0 | 64.9 |
| 1.4 | 1.3 - j2.4 | 10.3 + j2.7 | 19.6 | 48.6 | 72.9 | 67.1 | 45.7 |
| 2.0 | 1.9 - j6.7 | 8.0 + j1.9 | 16.7 | 48.9 | 77.3 | 56.0 | 28.2 |
| 2.5 | 2.9 - j12.7 | 7.9 + j0.5 | 15.8 | 49.3 | 84.1 | 60.2 | 10.5 |
| 2.7 | 4.2 - j15.6 | 7.7 - j0.2 | 15.6 | 48.8 | 76.3 | 62.6 | 0.4 |
| 3.0 | 9.8 - j20.6 | 6.6 - j1.2 | 14.3 | 48.9 | 77.5 | 61.3 | -18.5 |
| 3.5 | 28.3 - j0.5 | 5.5 - j3.0 | 14.2 | 48.7 | 73.9 | 63.8 | -75.7 |

| Frequency (GHz) | Z _{SOURCE} (Ω) | Maximum Drain Efficiency | | | | | |
|-----------------|-------------------------|---|-----------|------------------------|----------------------|--------------------|-----------|
| | | V _{DS} = 50 V, I _{DQ} = 110 mA, T _C = 25°C, P _{2.5dB} | | | | | |
| | | Z _{LOAD} ¹² (Ω) | Gain (dB) | P _{OUT} (dBm) | P _{OUT} (W) | η _D (%) | AM/PM (°) |
| 0.9 | 0.7 + j1.2 | 17.6 + j12.6 | 24.2 | 47.3 | 54.2 | 73.4 | 54.1 |
| 1.4 | 1.1 - j2.8 | 10.1 + j10.0 | 20.7 | 47.5 | 56.6 | 72.4 | 33.4 |
| 2.0 | 1.7 - j7.4 | 6.9 + j7.3 | 18.4 | 47.8 | 60.9 | 65.0 | 16.5 |
| 2.5 | 2.8 - j13.5 | 6.1 + j4.5 | 17.4 | 47.9 | 61.0 | 68.2 | -0.8 |
| 2.7 | 3.9 - j16.4 | 5.4 + j3.5 | 17.1 | 47.5 | 56.3 | 67.9 | -8.8 |
| 3.0 | 10.4 - j25.4 | 4.3 + j2.2 | 16.4 | 47.8 | 59.9 | 69.7 | -30.4 |
| 3.5 | 28.9 + j10.4 | 3.1 - j0.4 | 15.8 | 46.7 | 46.7 | 74.0 | -81.4 |

Impedance Reference



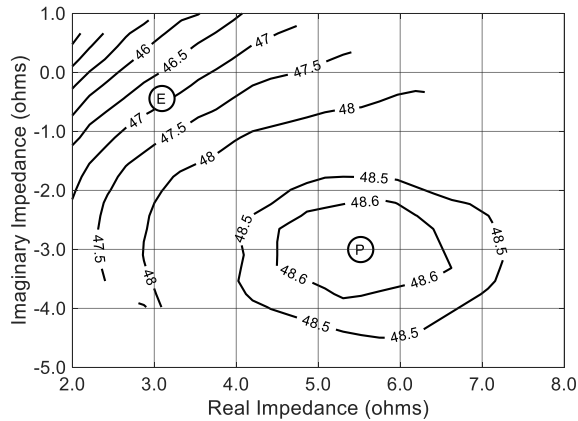
Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.

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

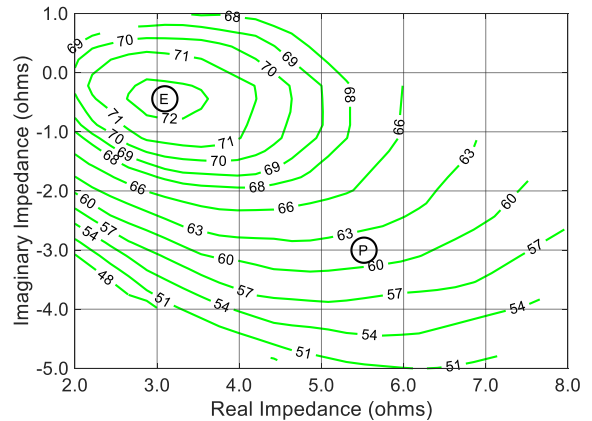
- 11. Load Impedance for optimum output power.
- 12. Load Impedance for optimum efficiency.

Pulsed⁴ Load-Pull Performance @ 3.5 GHz

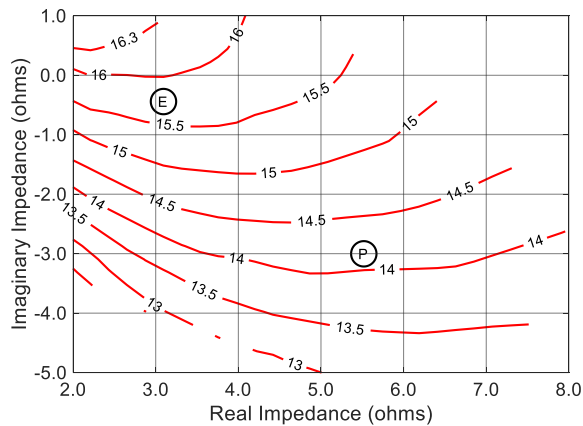
P2.5dB Loadpull Output Power Contours (dBm)



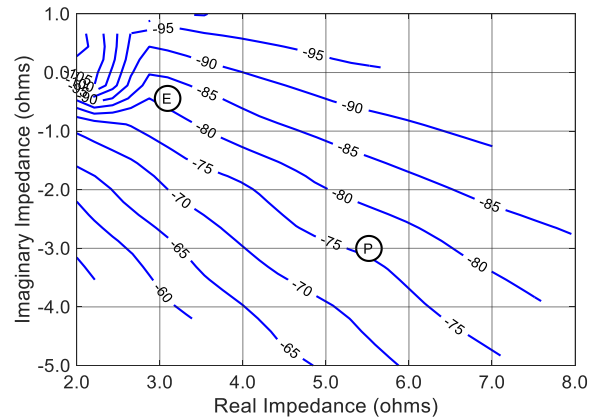
P2.5dB Loadpull Drain Efficiency Contours (%)



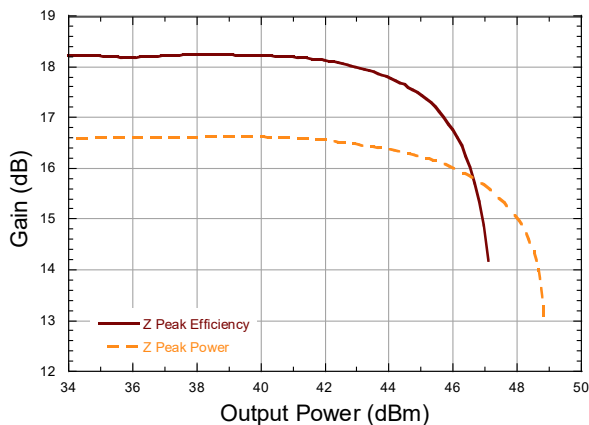
P2.5dB Loadpull Gain Contours (dB)



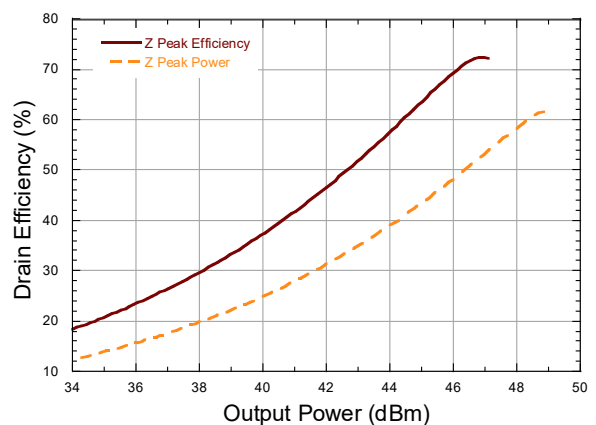
P2.5dB Loadpull AM/PM Contours (°)



Gain vs. Output Power



Drain Efficiency vs. Output Power

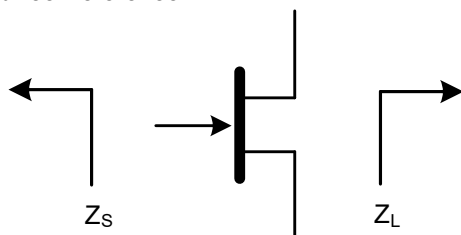


28 V Pulsed⁴ Load-Pull Performance
Reference Plane at Device Leads

| Frequency (GHz) | Z _{SOURCE} (Ω) | Maximum Output Power | | | | | |
|-----------------|-------------------------|---|-----------|------------------------|----------------------|--------------------|-----------|
| | | V _{DS} = 28 V, I _{DQ} = 110 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 | 1.4 + j2.0 | 8.1 - j0.7 | 19.8 | 46.0 | 39.4 | 58.0 | 71.0 |
| 1.4 | 1.6 - j2.5 | 7.2 - j1.3 | 17.0 | 45.8 | 37.6 | 61.5 | 54.4 |
| 2.0 | 2.0 - j7.0 | 7.0 - j1.7 | 15.1 | 46.6 | 45.9 | 64.1 | 35.2 |
| 2.5 | 3.4 - j13.4 | 6.9 - j3.4 | 13.6 | 46.7 | 46.5 | 60.1 | 15.4 |
| 2.7 | 4.4 - j15.9 | 6.3 - j4.3 | 13.1 | 46.0 | 40.0 | 57.3 | 8.8 |
| 3.0 | 11.3 - j22.6 | 6.1 - j4.9 | 13.1 | 46.2 | 41.8 | 63.5 | -13.9 |
| 3.5 | 28.3 + j4.4 | 5.3 - j6.5 | 12.1 | 46.0 | 39.7 | 62.6 | -75.3 |

| Frequency (GHz) | Z _{SOURCE} (Ω) | Maximum Drain Efficiency | | | | | |
|-----------------|-------------------------|---|-----------|------------------------|----------------------|--------------------|-----------|
| | | V _{DS} = 28 V, I _{DQ} = 110 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 | 0.8 + j1.2 | 13.3 + j9.4 | 20.9 | 43.0 | 20.8 | 72.7 | 55.1 |
| 1.4 | 1.1 - j3.3 | 9.4 + j6.8 | 18.6 | 43.6 | 22.7 | 71.2 | 36.5 |
| 2.0 | 1.8 - j7.6 | 6.5 + j2.9 | 16.5 | 45.1 | 32.5 | 67.9 | 22.2 |
| 2.5 | 3.2 - j14.1 | 5.7 + j1.4 | 15.4 | 45.1 | 32.0 | 70.7 | -2.8 |
| 2.7 | 4.3 - j17.6 | 5.3 + j0.1 | 14.8 | 44.7 | 29.3 | 66.7 | -6.4 |
| 3.0 | 13.0 - j26.4 | 4.8 - j0.9 | 14.2 | 44.7 | 29.7 | 70.5 | -30.7 |
| 3.5 | 24.7 + j12.6 | 3.3 - j3.1 | 13.8 | 44.0 | 25.1 | 74.1 | -98.5 |

Impedance Reference

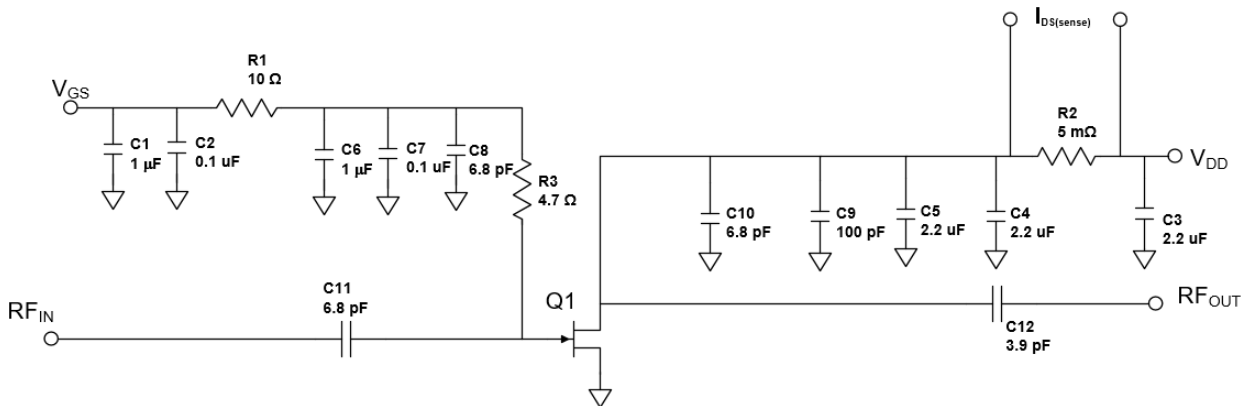


Z_{SOURCE} = Measured impedance presented to the input of the device at package reference plane.

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

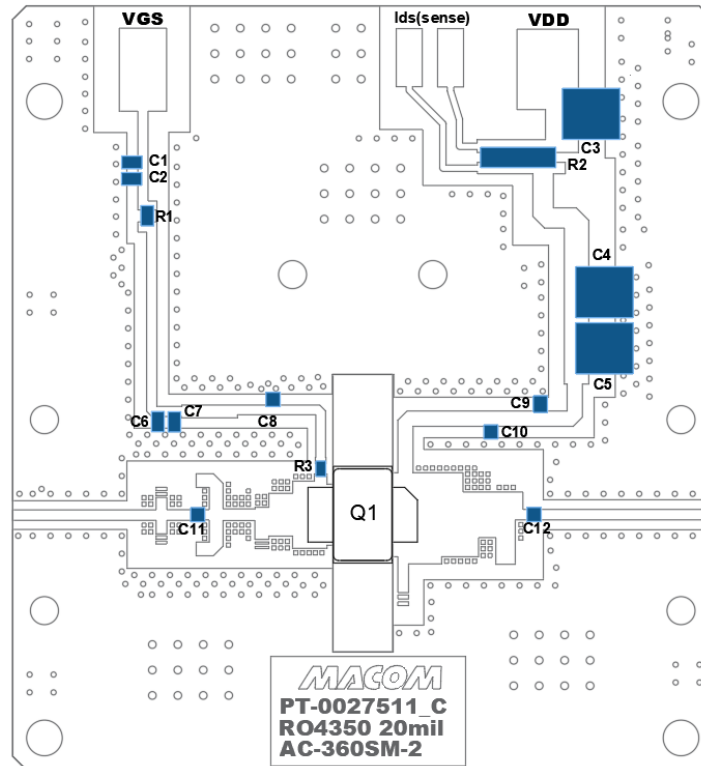
Turning the device ON

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} .

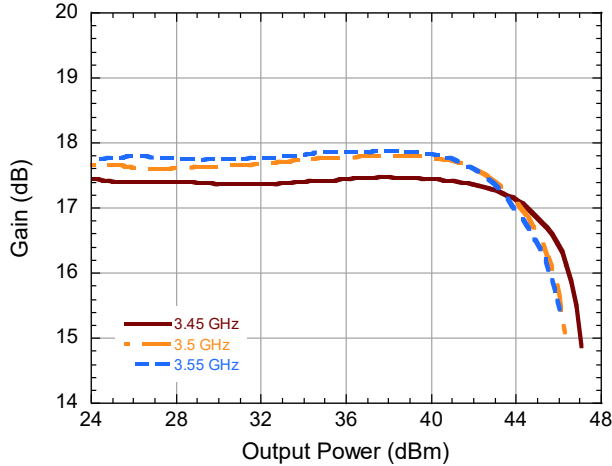
Evaluation Test Fixture and Recommended Tuning Solution 3.45 - 3.55 GHz



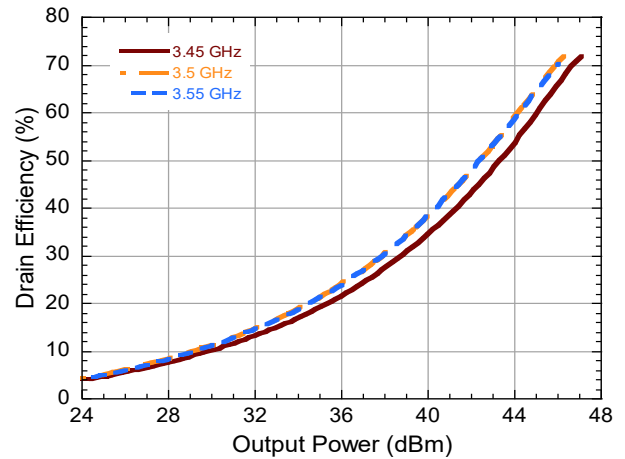
| Reference Designator | Value | Tolerance | Manufacturer | Part Number |
|----------------------|-------------------------------------|-------------|---------------------------|--------------------|
| C1,C6 | 1.0 μ F | +/- 10 % | Murata | GRM21BC72A105KE01L |
| C2,C7 | 0.1 μ F | +/- 10 % | Murata | GCD21BR72A104KA01L |
| C3,C4,C5 | 2.2 μ F | +/- 20 % | Murata | KRM55TR72E225MH01L |
| C8, C10, C11 | 6.8 pF | +/- 0.25pF | PPI | 0505C6R8CW151X |
| C9 | 100 pF | +/- 5 % | Murata | GQM2195C2E101JB12 |
| C12 | 3.9 pF | +/- 0.25 pF | PPI | 0505C3R9CW151X |
| R1 | 10 Ω | +/- 1% | Vishay Dale | CRCW080510R0FKTA |
| R2 | 5 m Ω | +/- 1% | Susumu | RL7520WT-R005-F |
| R3 | 4.7 Ω | +/- 0.1% | Stackpole Electronics Inc | RNCF0603BKE4R70 |
| Q1 | MACOM GaN Power Amplifier | | MAPC-A1100 | |
| PCB | RO4350, 20 mil, 1 oz. Cu, Au Finish | | | |

Typical Performance Curves as Measured in the 3.45 - 3.55 GHz Evaluation Test Fixture:
Pulsed⁴ 3.5 GHz, $V_{DS} = 50\text{ V}$, $I_{DQ} = 110\text{ mA}$, $T_C = 25^\circ\text{C}$ (Unless Otherwise Noted)

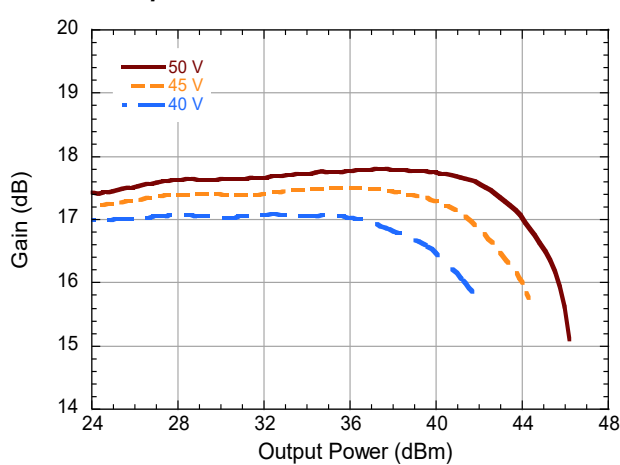
Gain vs. Output Power and Frequency



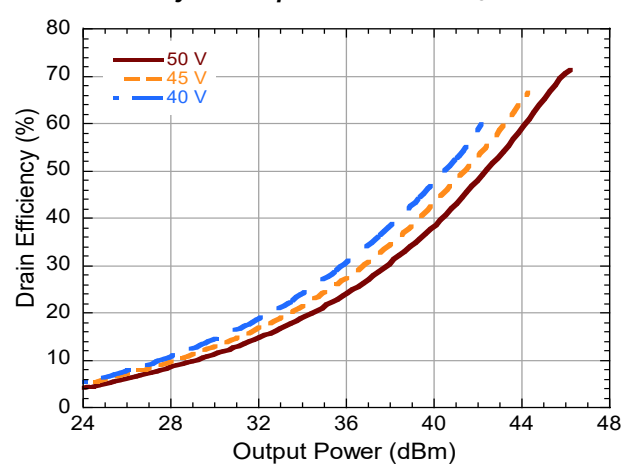
Drain Efficiency vs. Output Power and Frequency



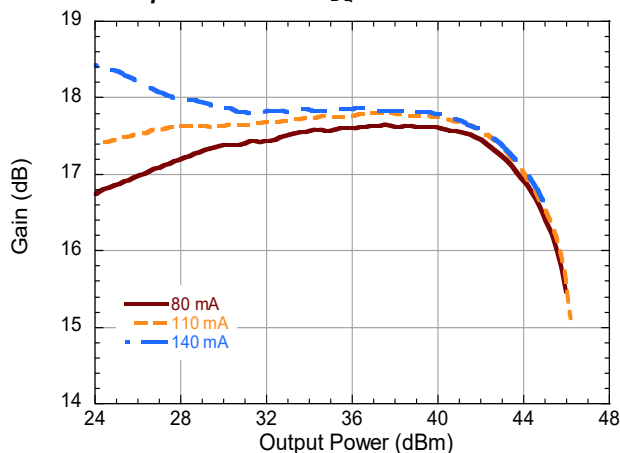
Gain vs. Output Power and V_{DS}



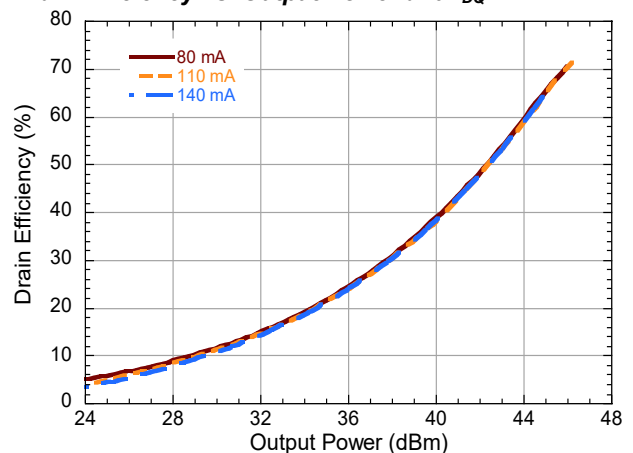
Drain Efficiency vs. Output Power and V_{DS}



Gain vs. Output Power and I_{DQ}

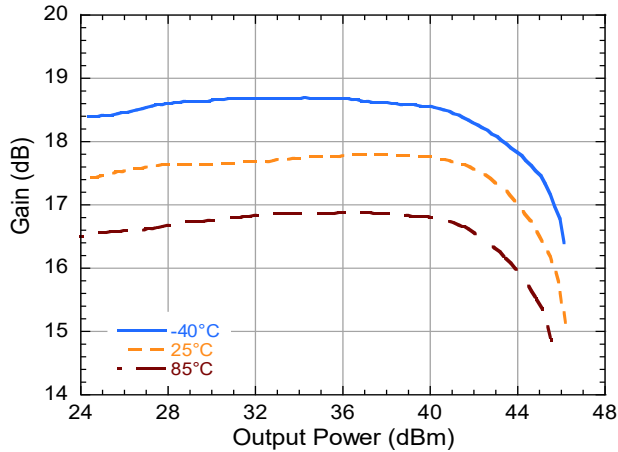


Drain Efficiency vs. Output Power and I_{DQ}

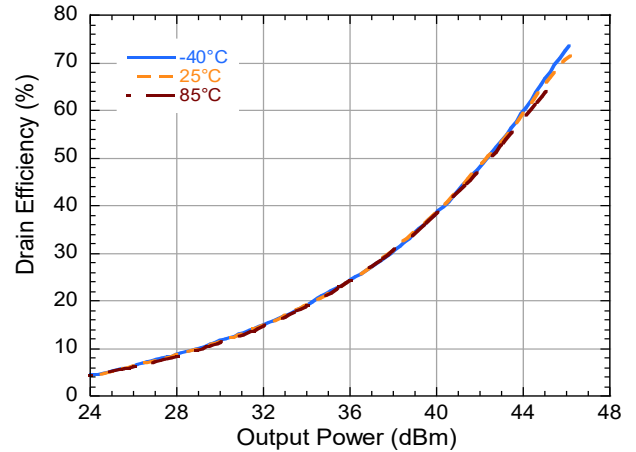


Typical Performance Curves as Measured in the 3.45 - 3.55 GHz Evaluation Test Fixture:
Pulsed⁴ 3.5 GHz, $V_{DS} = 50$ V, $I_{DQ} = 110$ mA, $T_C = 25^\circ\text{C}$ (Unless Otherwise Noted)

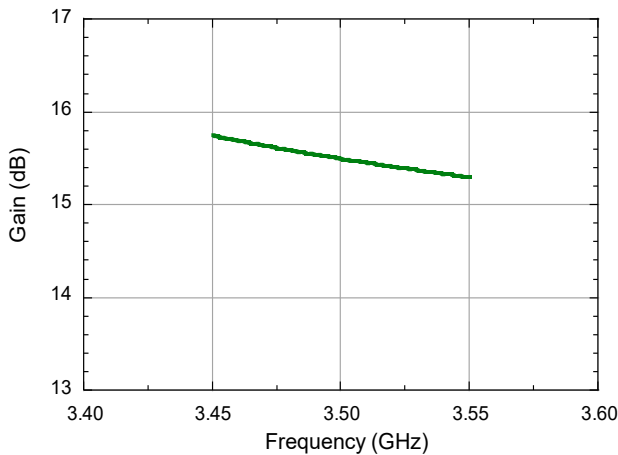
Gain vs. Output Power and T_C



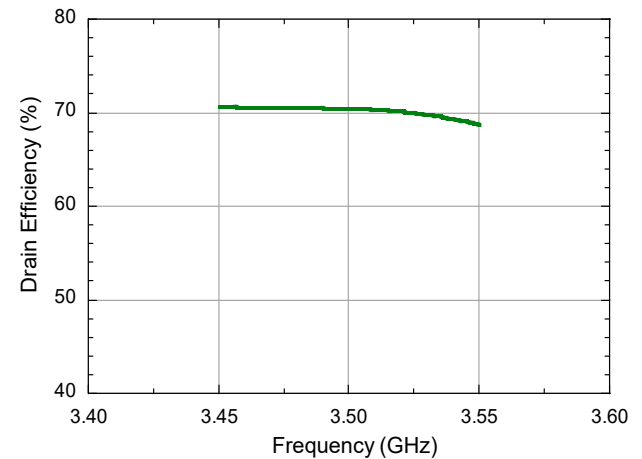
Drain Efficiency vs. Output Power and T_C



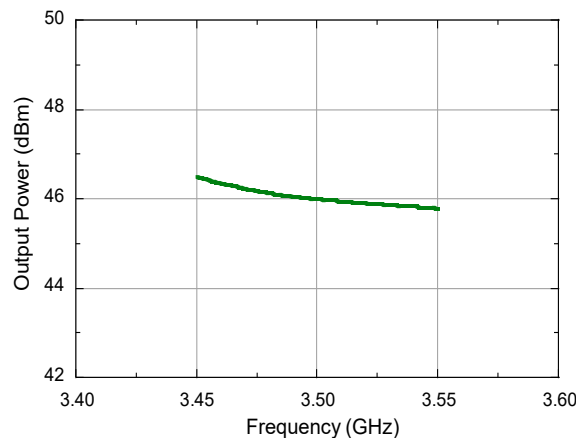
Gain vs. Frequency, 2.5dB Gain Compression



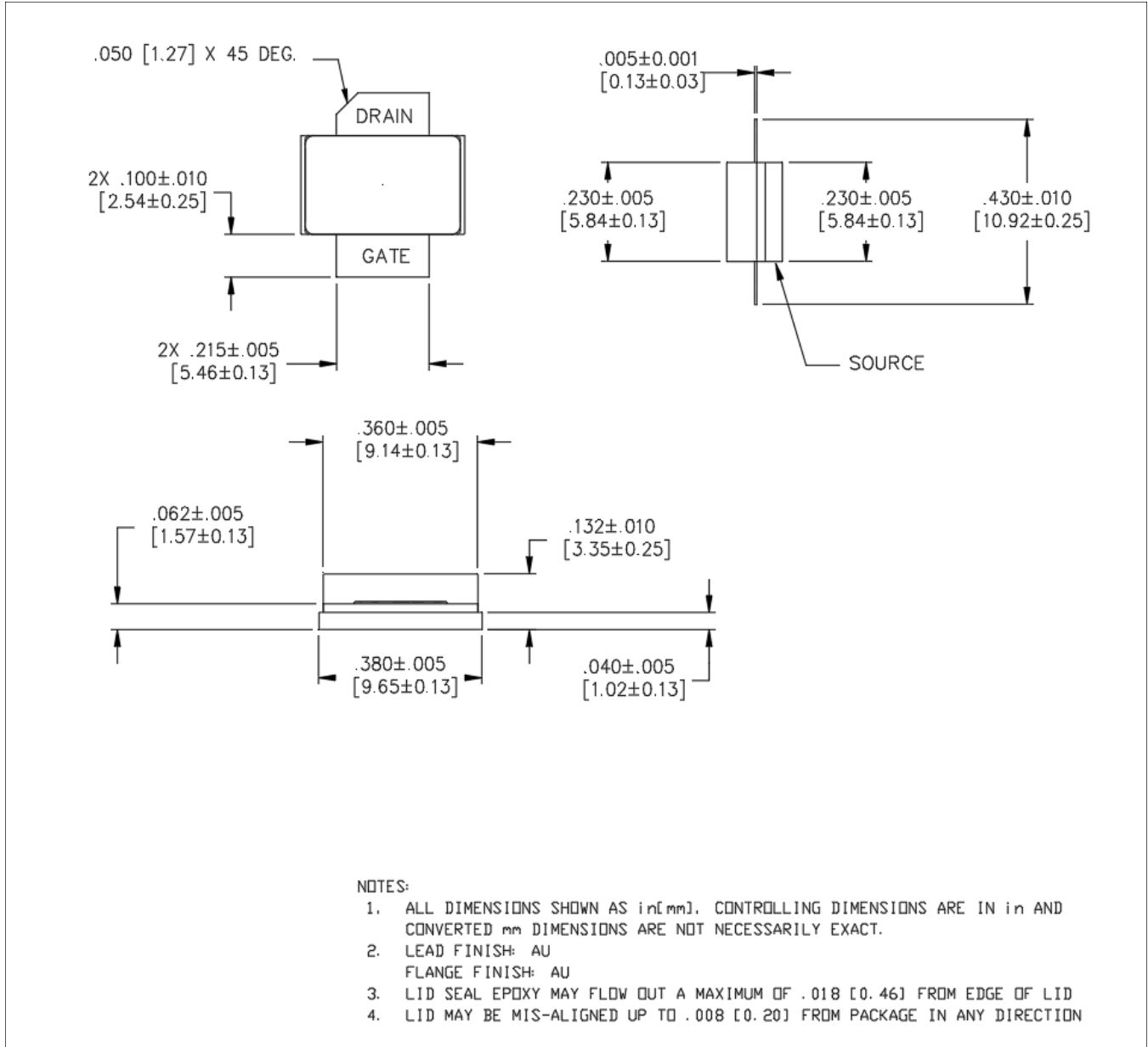
Drain Efficiency vs. Frequency, 2.5dB Gain Compression



Output Power vs. Frequency, 2.5dB Gain Compression



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



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

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