# GaN Amplifier 50 V, 270 W
# DC - 2.7 GHz

MACOM PURE CARBIDE™

**MAPC-A1103**
**Rev. V3**

## Features

- *MACOM PURE CARBIDE*™ Amplifier Series
- Suitable for Linear & Saturated Applications
- CW & Pulsed Operation: 270 W Output Power
- Internally Pre-Matched
- 28 V and 50 V Operation
- Compatible with MACOM Power Management Bias Controller/Sequencer MABC-11040

**AC-650S-4**

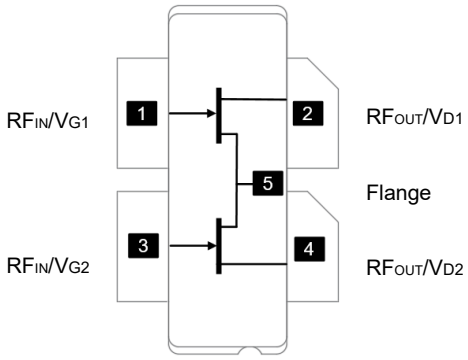
## Applications

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

## Description

The MAPC-A1103 is a high power GaN on Silicon Carbide HEMT D-mode amplifier suitable for DC - 2.7 GHz frequency operation. The device supports both CW and pulsed operation with output power levels of at least 270 W (54.3 dBm) in an air cavity ceramic package.

## Functional Schematic




## Typical Performance:

One side measured under load-pull at 2.5 dB compression, 100 µs pulse width, 10% duty cycle.

- $V_{DS}$ = 50 V, $I_{DQ}$ = 220 mA, $T_C$ = 25°C

| Frequency (GHz) | Output Power[1] (dBm) | Gain[2] (dB) | $\eta_D$[2] (%) |
|---|---|---|---|
| 0.9 | 51.7 | 23.4 | 71.5 |
| 1.4 | 51.7 | 20.0 | 74.5 |
| 2.0 | 52.5 | 17.9 | 67.9 |
| 2.5 | 52.0 | 16.8 | 69.1 |
| 2.7 | 51.9 | 16.3 | 70.2 |

- $V_{DS}$ = 28 V, $I_{DQ}$ = 220 mA, $T_C$ = 25°C

| Frequency (GHz) | Output Power[1] (dBm) | Gain[2] (dB) | $\eta_D$[2] (%) |
|---|---|---|---|
| 0.9 | 48.9 | 21.4 | 70.3 |
| 1.4 | 48.8 | 18.0 | 71.9 |
| 2.0 | 50.0 | 16.3 | 72.2 |
| 2.5 | 49.3 | 15.0 | 69.8 |
| 2.7 | 49.3 | 14.8 | 71.7 |

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 |
|---|---|
| MAPC-A1103-AS000 | Bulk Quantity |
| MAPC-A1103-ASTR1 | Tape and Reel |
| MAPC-A1103-ASSB1 | Sample Board |

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

## RF Electrical Characteristics: $T_C$ = 25°C, $V_{DS}$ = 50 V, $I_{DQ}$ = 430 mA
**Note: Performance in MACOM Evaluation Test Fixture, 50 Ω system**

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Small Signal Gain | Pulsed[4], 2.6 GHz | $G_{SS}$ | - | 18.4 | - | dB |
| Power Gain | Pulsed[4], 2.6 GHz, 2.5 dB Gain Compression | $G_{SAT}$ | - | 16.1 | - | dB |
| Saturated Drain Efficiency | Pulsed[4], 2.6 GHz, 2.5 dB Gain Compression | $\eta_{SAT}$ | - | 68.2 | - | % |
| Saturated Output Power | Pulsed[4], 2.6 GHz, 2.5 dB Gain Compression | $P_{SAT}$ | - | 53.5 | - | dBm |
| Gain Variation (-40°C to +85°C) | Pulsed[4], 2.6 GHz | $\Delta G$ | - | 0.013 | - | dB/°C |
| Power Variation (-40°C to +85°C) | Pulsed[4], 2.6 GHz | $\Delta P2.5dB$ | - | 0.005 | - | dB/°C |
| Power Gain | Pulsed[4], 2.6 GHz, $P_{IN}$ = 36.5 dBm | $G_P$ | - | 16.7 | - | dB |
| Drain Efficiency | Pulsed[4], 2.6 GHz, $P_{IN}$ = 36.5 dBm | $\eta$ | - | 67.6 | - | % |
| Ruggedness: Output Mismatch | All phase angles | $\Psi$ | VSWR = 10:1, No Damage | | | |

## RF Electrical Specifications: $T_A$ = 25°C, $V_{DS}$ = 50 V, $I_{DQ}$ = 430 mA
**Note: Performance in MACOM Production Test Fixture, 50 Ω system**

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Power Gain | Pulsed[4], 2.6 GHz, 2.5 dB Gain Compression | $G_{SAT}$ | 15.3 | 16.1 | - | dB |
| Saturated Drain Efficiency | Pulsed[4], 2.6 GHz, 2.5 dB Gain Compression | $\eta_{SAT}$ | 63.4 | 68.2 | - | % |
| Saturated Output Power | Pulsed[4], 2.6 GHz, 2.5 dB Gain Compression | $P_{SAT}$ | 52.6 | 53.5 | - | dBm |
| Power Gain | Pulsed[4], 2.6 GHz, $P_{IN}$ = 36.5 dBm | $G_P$ | 15.9 | 16.7 | - | dB |
| Drain Efficiency | Pulsed[4], 2.6 GHz, $P_{IN}$ = 36.5 dBm | $\eta$ | 63.2 | 67.6 | - | % |

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 | $I_{DLK}$ | - | - | 13.5 | mA |
| Gate-Source Leakage Current | $V_{GS}$ = -8 V, $V_{DS}$ = 0 V | $I_{GLK}$ | - | - | 13.5 | mA |
| Gate Threshold Voltage | $V_{DS}$ = 50 V, $I_D$ = 13.5 mA | $V_T$ | -3.6 | -3.1 | - | V |
| Gate Quiescent Voltage | $V_{DS}$ = 50 V, $I_D$ = 220 mA | $V_{GSQ}$ | - | -2.6 | - | V |
| On Resistance | $V_{GS}$ = 2 V, $I_D$ = 101 mA | $R_{ON}$ | - | 0.15 | - | Ω |
| Maximum Drain Current | $V_{DS}$ = 7 V pulsed, pulse width 300 µs | $I_{D, MAX}$ | - | 16.1 | - | 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, $I_G$ | 13.5 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 $T_{CH} \leq 225°C$ 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 | $R_\theta$(FEA) | 1.16 | °C/W |
| Thermal Resistance using Infrared Measurement of Die Surface Temperature | $V_{DS}$ = 50 V, $T_C$ = 85°C, $T_{CH}$ = 225°C | $R_\theta$(IR) | 0.93 | °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

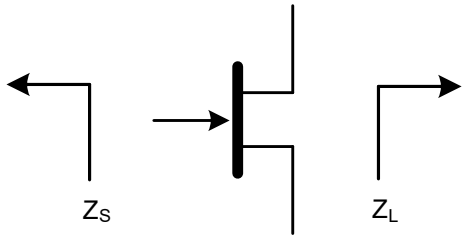
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

## 50 V Pulsed[4] Load-Pull Performance (Per Each Side of Symmetric Device)
### Reference Plane at Device Leads

| Frequency (GHz) | $Z_{SOURCE}$ (Ω) | Maximum Output Power | | | | | |
|---|---|---|---|---|---|---|---|
| | | $V_{DS}$ = 50 V, $I_{DQ}$ = 220 mA, $T_C$ = 25°C, P2.5dB | | | | | |
| | | $Z_{LOAD}$[11] (Ω) | Gain (dB) | $P_{OUT}$ (dBm) | $P_{OUT}$ (W) | $\eta_D$ (%) | AM/PM (°) |
| 0.9 | 0.9 + j0.0 | 5.9 + j1.7 | 22.3 | 51.7 | 147.9 | 66.0 | 64.0 |
| 1.4 | 1.0 - j2.8 | 4.4 + j1.2 | 18.3 | 51.7 | 147.9 | 66.3 | 48.6 |
| 2.0 | 1.1 - j5.8 | 4.0 + j0.3 | 16.2 | 52.5 | 177.6 | 58.3 | 33.3 |
| 2.5 | 2.3 - j10.2 | 3.6 - j0.6 | 15.2 | 52.0 | 158.7 | 60.8 | 18.6 |
| 2.7 | 3.6 - j12.1 | 3.4 - j1.0 | 15.2 | 51.9 | 156.0 | 63.0 | 8.1 |

| Frequency (GHz) | $Z_{SOURCE}$ (Ω) | Maximum Drain Efficiency | | | | | |
|---|---|---|---|---|---|---|---|
| | | $V_{DS}$ = 50 V, $I_{DQ}$ = 220 mA, $T_C$ = 25°C, P2.5dB | | | | | |
| | | $Z_{LOAD}$[12] (Ω) | Gain (dB) | $P_{OUT}$ (dBm) | $P_{OUT}$ (W) | $\eta_D$ (%) | AM/PM (°) |
| 0.9 | 0.8 - j0.2 | 8.8 + j7.2 | 23.4 | 49.7 | 93.1 | 71.5 | 48.4 |
| 1.4 | 0.6 - j3.1 | 4.3 + j4.8 | 20.0 | 50.3 | 108.3 | 74.5 | 31.9 |
| 2.0 | 0.9 - j6.3 | 3.6 + j2.6 | 17.9 | 51.6 | 144.6 | 67.9 | 21.9 |
| 2.5 | 1.9 - j10.9 | 2.9 + j1.4 | 16.8 | 51.2 | 132.8 | 69.1 | 7.4 |
| 2.7 | 3.0 - j13.2 | 2.5 + j1.0 | 16.3 | 51.2 | 132.8 | 70.2 | -2.7 |

***Impedance Reference***

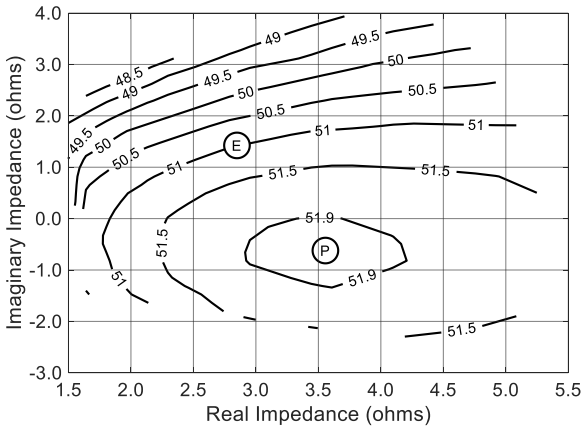



$Z_{SOURCE}$ = Measured impedance presented to the input of the device at package reference plane.
$Z_{LOAD}$ = Measured impedance presented to the output of the device at package reference plane.

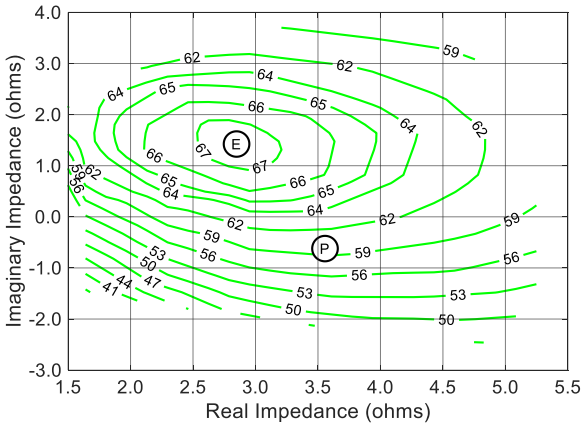
11. Load Impedance for optimum output power.
12. Load Impedance for optimum efficiency.

## Pulsed[4] Load-Pull Performance (Per Each Side of Symmetric Device) @ 2.5 GHz

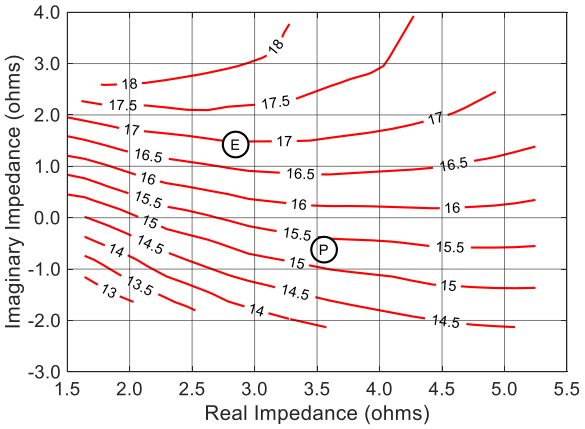
***P2.5dB Loadpull Output Power Contours (dBm)***



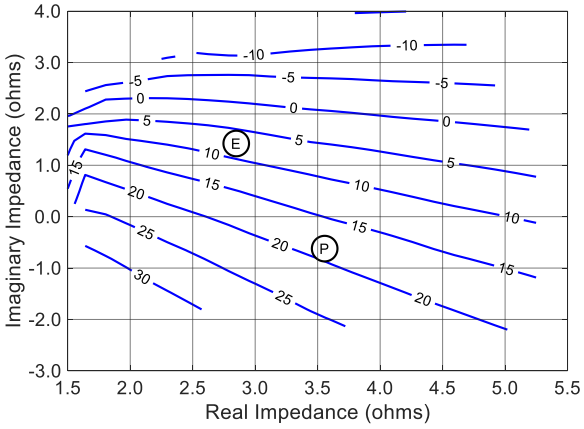

***P2.5dB Loadpull Drain Efficiency Contours (%)***



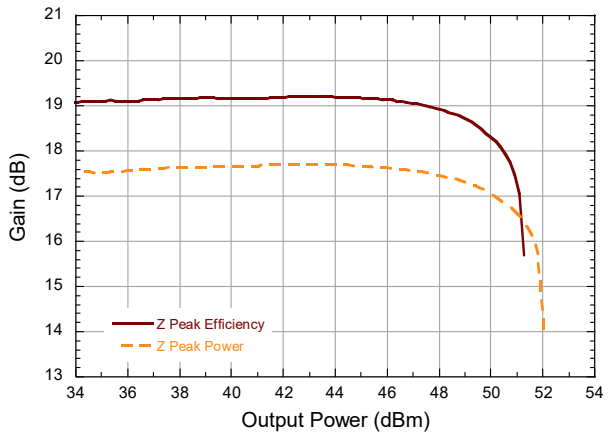

***P2.5dB Loadpull Gain Contours (dB)***



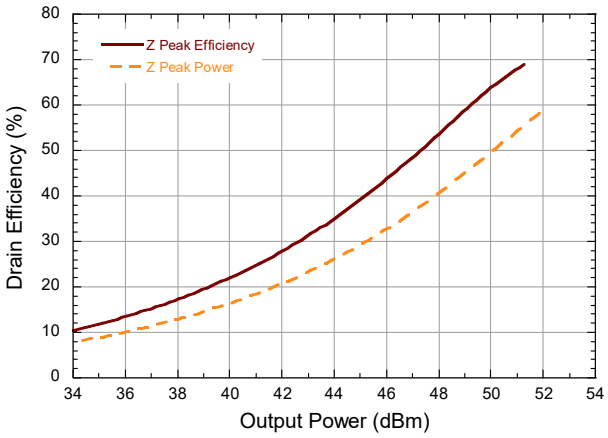

***P2.5dB Loadpull AM/PM Contours (°)***




***Gain vs. Output Power***




***Drain Efficiency vs. Output Power***

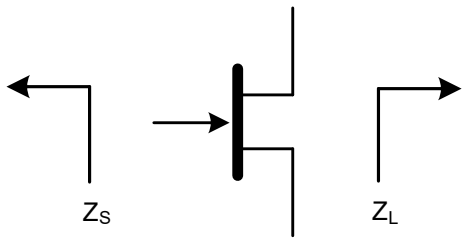


## 28 V Pulsed[4] Load-Pull Performance (Per Each Side of Symmetric Device)
### Reference Plane at Device Leads

| Frequency (GHz) | $Z_{SOURCE}$ (Ω) | Maximum Output Power | | | | | |
|---|---|---|---|---|---|---|---|
| | | $V_{DS}$ = 28 V, $I_{DQ}$ = 220 mA, $T_C$ = 25°C, P2.5dB | | | | | |
| | | $Z_{LOAD}$[11] (Ω) | Gain (dB) | $P_{OUT}$ (dBm) | $P_{OUT}$ (W) | $\eta_D$ (%) | AM/PM (°) |
| 0.9 | 1.0 + j0.0 | 3.6 - j0.1 | 19.5 | 48.9 | 77.2 | 58.0 | 70.0 |
| 1.4 | 0.9 - j3.0 | 3.0 - j0.5 | 16.6 | 48.8 | 75.7 | 64.6 | 55.7 |
| 2.0 | 1.2 - j6.2 | 3.1 - j1.5 | 14.0 | 50.0 | 99.8 | 58.1 | 40.1 |
| 2.5 | 2.3 - j10.3 | 2.9 - j2.2 | 13.3 | 49.3 | 85.7 | 61.0 | 26.7 |
| 2.7 | 3.8 - j12.8 | 2.8 - j2.6 | 13.4 | 49.3 | 84.6 | 65.4 | 15.4 |

| Frequency (GHz) | $Z_{SOURCE}$ (Ω) | Maximum Drain Efficiency | | | | | |
|---|---|---|---|---|---|---|---|
| | | $V_{DS}$ = 28 V, $I_{DQ}$ = 220 mA, $T_C$ = 25°C, P2.5dB | | | | | |
| | | $Z_{LOAD}$[12] (Ω) | Gain (dB) | $P_{OUT}$ (dBm) | $P_{OUT}$ (W) | $\eta_D$ (%) | AM/PM (°) |
| 0.9 | 0.5 - j0.6 | 5.9 + j2.8 | 21.4 | 47.6 | 57.0 | 70.3 | 56.5 |
| 1.4 | 0.7 - j3.3 | 4.0 + j2.4 | 18.0 | 47.5 | 55.7 | 71.9 | 38.0 |
| 2.0 | 0.9 - j6.4 | 3.0 + j0.9 | 16.3 | 48.4 | 69.5 | 72.2 | 21.8 |
| 2.5 | 2.1 - j11.7 | 2.6 - j0.2 | 15.0 | 48.0 | 63.0 | 69.8 | 12.8 |
| 2.7 | 3.4 - j13.8 | 2.3 - j0.6 | 14.8 | 47.7 | 58.6 | 71.7 | 0.9 |

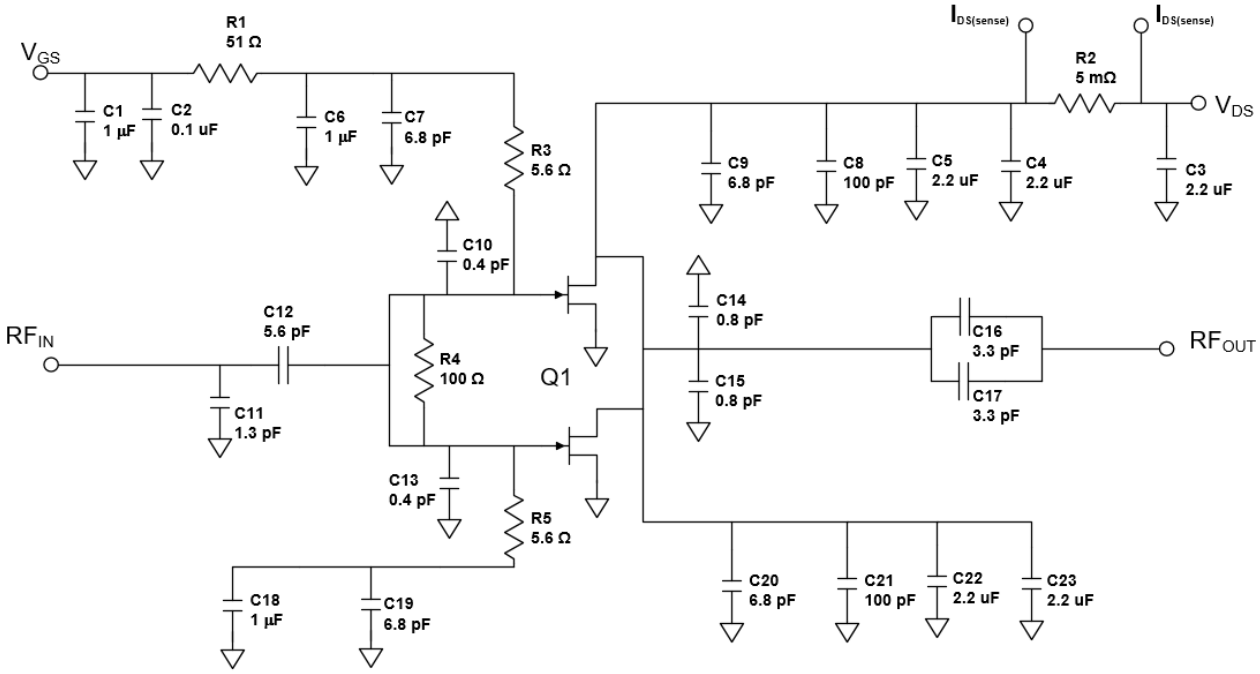
***Impedance Reference***




$Z_{SOURCE}$ = 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 2.55 - 2.65 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

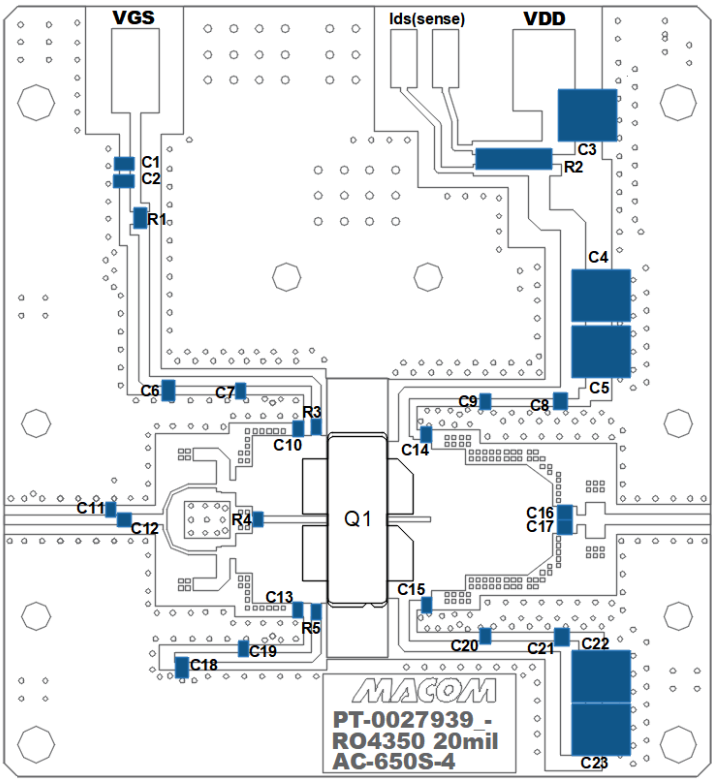
### Turning the device ON

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 $V_{GS}$.

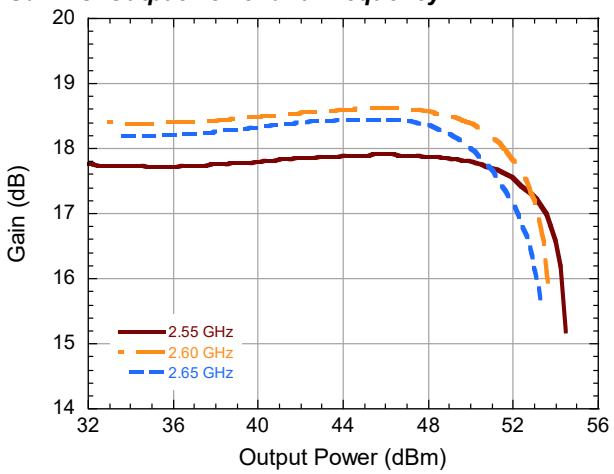
## Evaluation Test Fixture and Recommended Tuning Solution 2.55 - 2.65 GHz



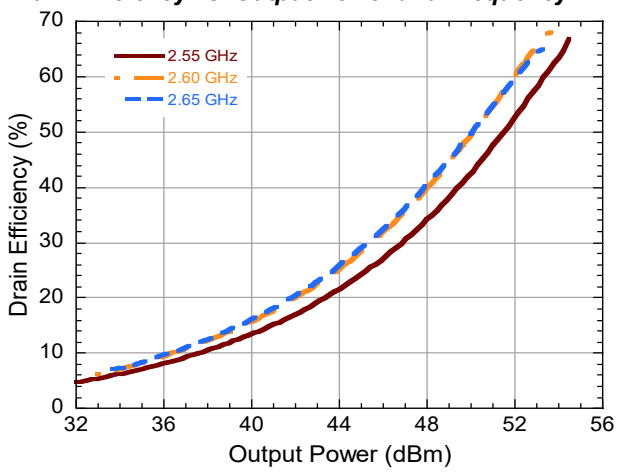

| Reference Designator | Value | Tolerance | Manufacturer | Part Number |
|---|---|---|---|---|
| C1,C6,C18 | 1.0 µF | +/- 10 % | Murata | GRM21BC72A105KE01L |
| C2 | 0.1 µF | +/- 10 % | Murata | GCD21BR72A104KA01L |
| C3,C4,C5,C22,C23 | 2.2 µF | +/- 20 % | Murata | KRM55TR72E225MH01L |
| C7,C9, C19,C20 | 6.8 pF | +/- 0.25pF | PPI | 0505C6R8CW151X |
| C8,C21 | 100 pF | +/- 5 % | Murata | GQM2195C2E101JB12 |
| C10,C13 | 0.4 pF | +/- 0.1 pF | PPI | 0505C0R4BW151X |
| C11 | 1.3 pF | +/- 0.1 pF | Murata | GQM1875C2E1R3BB12D |
| C12 | 5.6 pF | +/- 0.25 pF | PPI | 0505C5R6CW151X |
| C14,C15 | 0.8 pF | +/- 0.1 pF | Murata | GQM1875C2ER80BB12D |
| C16,C17 | 3.3 pF | +/- 0.25 pF | PPI | 0505C3R3CW151X |
| R1 | 51 Ω | +/- 1% | Yageo | RT0805FRE0751RL |
| R2 | 5 mΩ | +/- 1% | Susumu | RL7520WT-R005-F |
| R3,R5 | 5.6 Ω | +/- 1% | Vishay | MCT06030C5608FP500 |
| R4 | 100 Ω | +/- 1% | Vishay | MCT06030C1000FP500 |
| Q1 | MACOM GaN Power Amplifier | | | MAPC-A1103 |
| PCB | RO4350, 20 mil, 1 oz. Cu, Au Finish | | | |

## Typical Performance Curves as Measured in the 2.55 - 2.65 GHz Evaluation Test Fixture: Pulsed[4] 2.6 GHz, $V_{DS}$ = 50 V, $I_{DQ}$ = 430 mA, $T_C$ = 25°C (Unless Otherwise Noted)

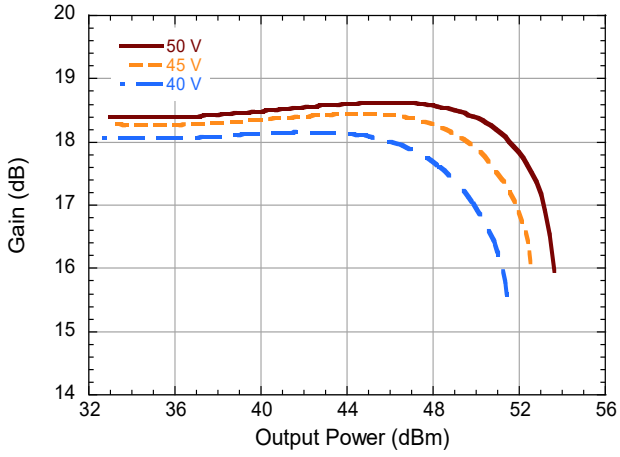
***Gain vs. Output Power and Frequency***



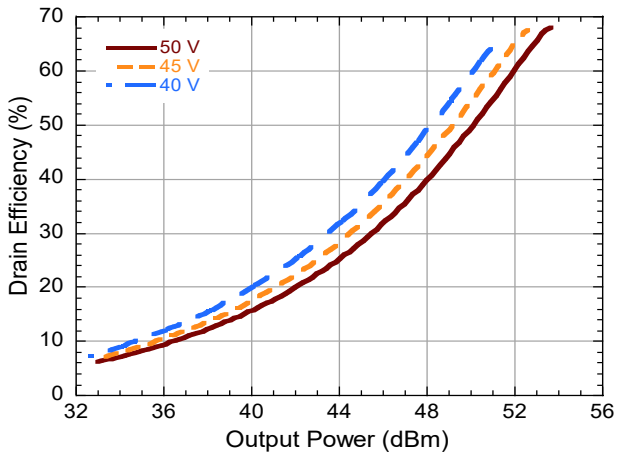

***Drain Efficiency vs. Output Power and Frequency***



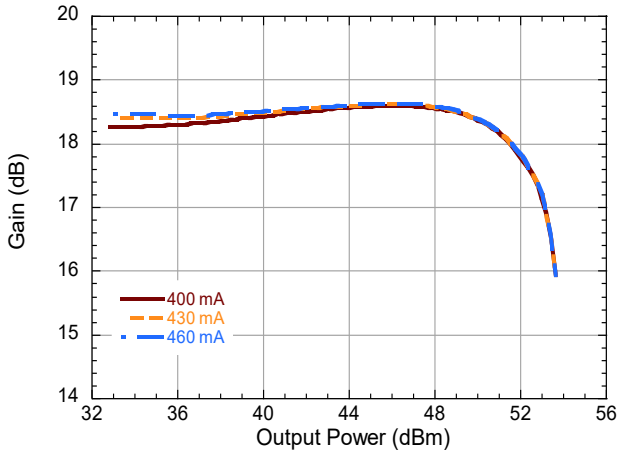

***Gain vs. Output Power and $V_{DS}$***



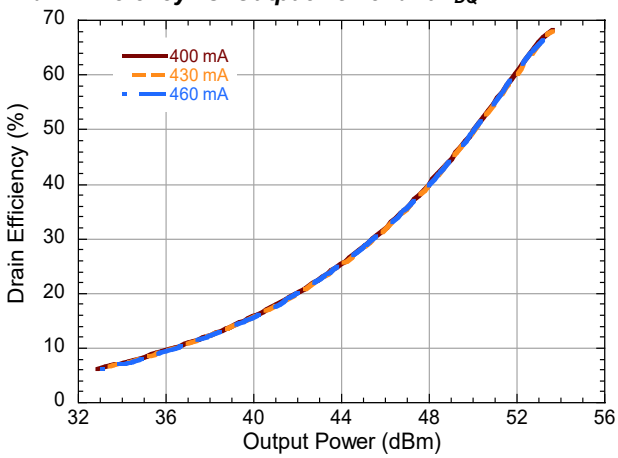

***Drain Efficiency vs. Output Power and $V_{DS}$***




***Gain vs. Output Power and $I_{DQ}$***

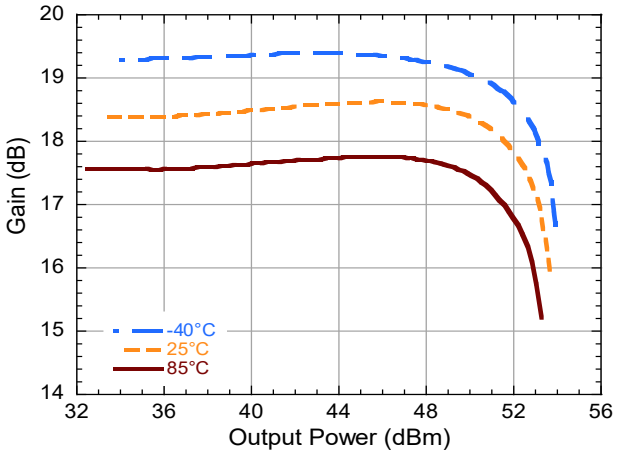



***Drain Efficiency vs. Output Power and $I_{DQ}$***

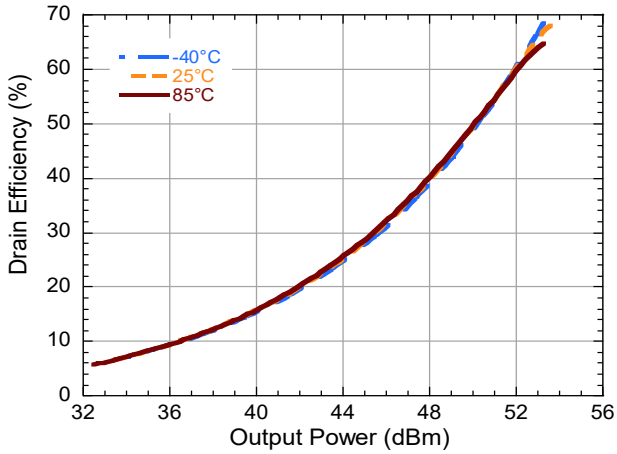


## Typical Performance Curves as Measured in the 2.55 - 2.65 GHz Evaluation Test Fixture: Pulsed[4] 2.6 GHz, $V_{DS}$ = 50 V, $I_{DQ}$ = 430 mA, $T_C$ = 25°C (Unless Otherwise Noted)

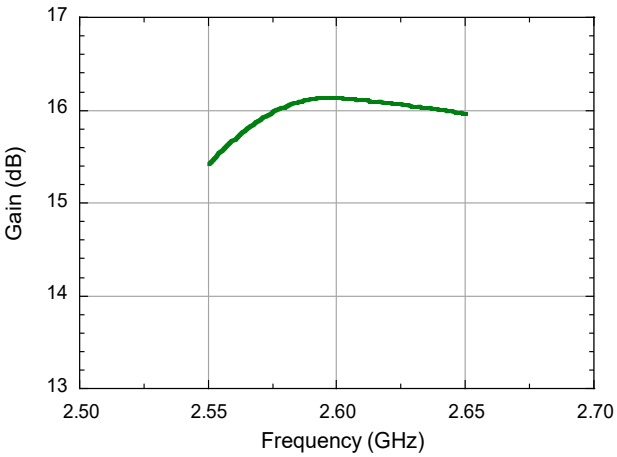
***Gain vs. Output Power and $T_C$***



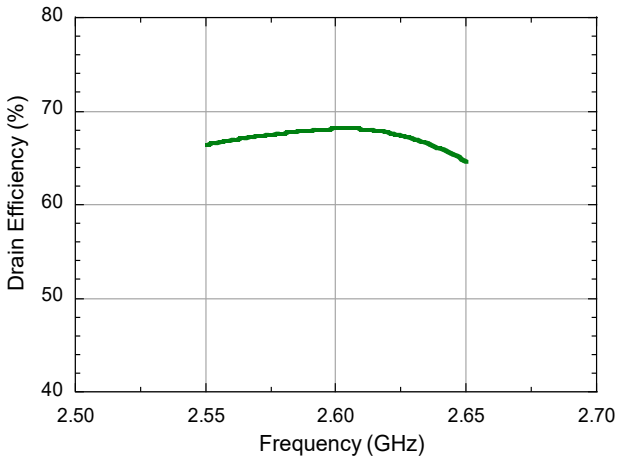

***Drain Efficiency vs. Output Power and $T_C$***



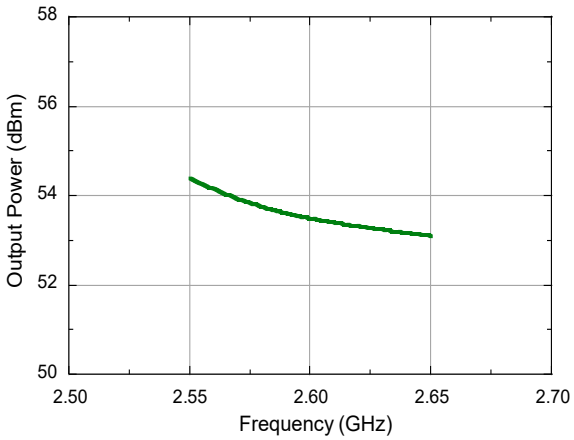

***Gain vs. Frequency, 2.5dB Gain Compression***



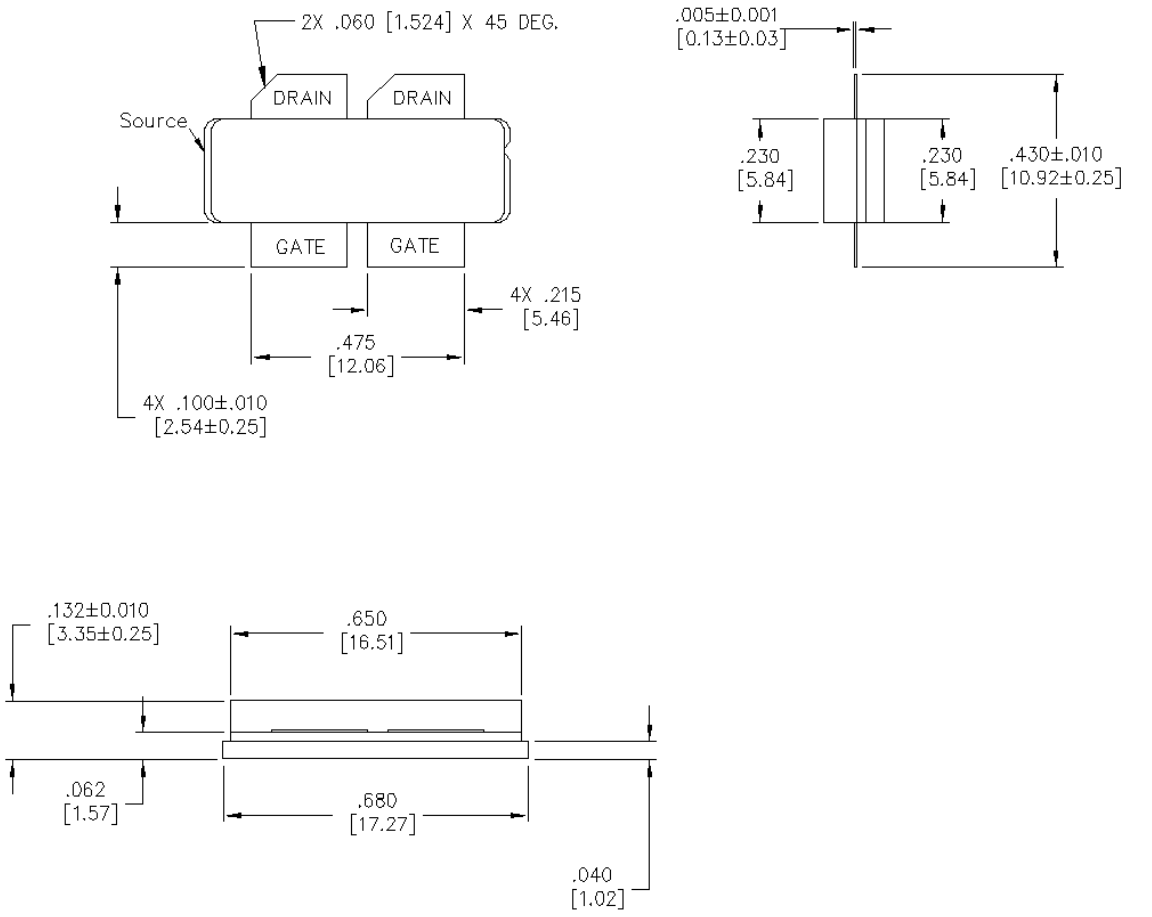

***Drain Efficiency vs. Frequency, 2.5dB Gain Compression***




***Output Power vs. Frequency, 2.5dB Gain Compression***



## Lead-Free AC-650S-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 lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 3 requirements.
Plating is Au.

# Mouser Electronics

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