# GaN Amplifier 28 V, 15 W
# 728 - 960 MHz



## Features

- *MACOM PURE CARBIDE*™ Amplifier Series
- Optimized for 728 - 960 MHz Applications
- High Terminal Impedances for Broadband Performance
- 26 - 36 V Operation
- Low Thermal Resistance
- 100% RF Tested
- RoHS* Compliant


**6 mm QFN**

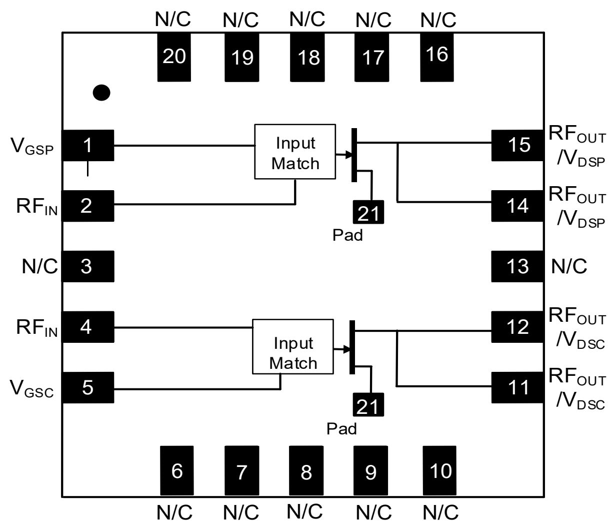
## Applications

- 5G Cellular Networks
- Tri-band Small Cells

## Description

The MAPC-A1533 is a GaN on Silicon Carbide HEMT D-mode amplifier suitable for applications 3W average power and optimized for 728 - 960 MHz modulated signal operation. The device supports pulsed, and linear operation with peak output power levels to 15 W (42 dBm) in an 6 mm surface mount QFN package.

## Functional Schematic




## Typical Doherty Performance:

- WCDMA 3GPP TM1, 9.9 dB PAR @ 0.01% CCDF. $V_{DS}$ = 28 V, $I_{DQCAR}$ = 60 mA, $V_{GSP}$ = -4.5 V, $T_C$ = 25°C, $P_{OUT}$ = 35.3 dBm

| Frequency (MHz) | GP (dB) | $\eta_D$ (%) | Output PAR (dB) | ACPR (dBc) |
|---|---|---|---|---|
| 728 | 15.2 | 53 | 7.3 | -35 |
| 844 | 17.5 | 59 | 7.1 | -35 |
| 960 | 15.1 | 49 | 6.6 | -31 |

## Pin Configuration

| Pin # | Pin Name | Function |
|---|---|---|
| 1 | $V_{GSP}$ | Gate Voltage (Peaking) |
| 2 | $RF_{IN}$ | RF Input (Peaking) |
| 3,6-10,13, 16-20 | N/C | Not Connected |
| 4 | $RF_{IN}$ | RF Input (Carrier) |
| 5 | $V_{GSC}$ | Gate Voltage (Carrier) |
| 11-12 | $RF_{OUT}$ / $V_D$ | RF Output / Drain Voltage (Carrier) |
| 14-15 | $RF_{OUT}$ / $V_D$ | RF Output / Drain Voltage (Peak) |
| 21 | Pad[1] | Ground / Source |

1. The pad on the package bottom must be connected to RF, DC and thermal ground.

## Ordering Information

| Part Number | Package |
|---|---|
| MAPC-A1533-AQ000 | Bulk Quantity |
| MAPC-A1533-AQTR1 | Tape and Reel |
| MAPC-A1533-AQSB1 | Sample Board |

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

## RF Electrical Characteristics: $T_C$ = 25°C, $V_{DS}$ = 28 V, $I_{DQCAR}$ = 60 mA, $V_{DSP}$ = -4.5 V
**Note: Performance in MACOM Doherty Evaluation Circuit, 50 Ω system.**

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Small Signal Gain | Pulsed[2], 844 MHz | $G_{SS}$ | - | 19.4 | - | dB |
| Saturated Output Power | Pulsed[2], 844 MHz | $P_{SAT}$ | - | 42 | - | dBm |
| Drain Efficiency at Saturation | Pulsed[2], 844 MHz | $\eta_{SAT}$ | - | 84 | - | % |
| Modulated Peak Power | WCDMA[3], 844 MHz | P3dB[4] | - | 42.4 | - | dBm |
| Gain Flatness in 60MHz | WCDMA[3], $P_{OUT}$ = 35.3 dBm | $G_F$ | - | 1.7 | - | dB |
| Gain Variation (-25°C to +105°C) | WCDMA[3], 844 MHz, $P_{OUT}$ = 35.3 dBm | ΔG | - | -0.01 | - | dB/°C |
| Power Variation (-25°C to +105°C) | Pulsed[2], 844 MHz | Δ P3dB | - | -0.002 | - | dBm/°C |
| Power Gain | WCDMA[3], 844 MHz, $P_{OUT}$ = 35.3 dBm | $G_P$ | - | 17.5 | - | dB |
| Drain Efficiency | WCDMA[3], 844 MHz, $P_{OUT}$ = 35.3 dBm | η | - | 60 | - | % |
| Output CCDF @ 0.01% | WCDMA[3], 844 MHz, $P_{OUT}$ = 35.3 dBm | PAR | - | 7.1 | - | dB |
| Adjacent Channel Power | WCDMA[3], 844 MHz, $P_{OUT}$ = 35.3 dBm | ACP | - | -35 | - | dBc |
| Input Return Loss | WCDMA[3], 844 MHz, $P_{OUT}$ = 35.3 dBm | IRL | - | -14 | - | dB |
| Ruggedness: Output Mismatch | All phase angles | Ψ | VSWR = 10:1, No Device Damage | | | |

2. Pulse details: 100 µs pulse width, 1 ms period, 10% Duty Cycle
3. Modulated Signal: 3.84MHz, WCDMA 3GPP TM1 64 DPCH, 9.9 dB PAR @ 0.01% CCDF
4. P3dB = $P_{OUT}$ + 7.0 dB where $P_{OUT}$ is the average output power measured using a modulated signal[5] where the output PAR is compressed to 7.0 dB @ 0.01% probability CCDF.

## RF Electrical Characteristics: $T_A$ = 25°C, $V_{DS}$ = 28 V, $I_{DQCAR}$ = 60 mA, $V_{DSP}$ = -4.8 V
**Note: Performance in MACOM Doherty Production Test Fixture, 50 Ω system.**

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Power Gain | WCDMA[3], 844 MHz, $P_{OUT}$ = 35 dBm | $G_P$ | 15.5 | 16.3 | - | dB |
| Drain Efficiency | WCDMA[3], 844 MHz, $P_{OUT}$ = 35 dBm | η | 36.6 | 40 | - | % |
| Output CCDF @ 0.01% | WCDMA[3], 844 MHz, $P_{OUT}$ = 35 dBm | PAR | 6.7 | 7.1 | - | dB |
| Input Return Loss | WCDMA[3], 844 MHz, $P_{OUT}$ = 35 dBm | IRL | - | -16 | - | dB |

## DC Electrical Characteristics: $T_C$ = 25°C

| Parameter | Test Conditions | Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Carrier/Peaking Amplifier | | | | | | |
| Drain-Source Breakdown Voltage | $V_{GS}$ = -8 V, $I_D$ = 2.4 mA | $V_{BDS}$ | 100 | - | - | V |
| Gate-Source Leakage Current | $V_{GS}$ = -8 V, $V_{DS}$ = 0 V | $I_{GLK}$ | - | 0.01 | - | mA |
| Gate Threshold Voltage | $V_{DS}$ = 28 V , $I_D$ = 2.4 mA | $V_T$ | - | -3.1 | - | V |
| Gate Quiescent Voltage | $V_{DS}$ = 28V , $I_D$ = 60 mA | $V_{GSQ}$ | - | -2.7 | - | V |
| Maximum Drain Current | $V_{DS}$ = 7 V pulsed, pulse width 300 µs | $I_{D,MAX}$ | - | 2.0 | - | A |

## Absolute Maximum Ratings[5,6,7,8,9]

| Parameter | Absolute Maximum |
|---|---|
| Drain Source Voltage, $V_{DS}$ | 100 V |
| Gate Source Voltage, $V_{GS}$ | -10 to 3 V |
| Gate Current (Carrier), $I_G$ | 2.4 mA |
| Gate Current (Peaking), $I_G$ | 2.4 mA |
| Storage Temperature Range | -65°C to +150°C |
| Case Operating Temperature Range | -40°C to +120°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 $V_{DS}$ < 36 V will ensure MTTF > 1 x $10^6$ hours.
8. Operating at nominal conditions with $T_{CH}$ ≤ 220°C will ensure MTTF > 1 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* = 1.34, *B* = -31.81, and *C* = 22,397.

## Thermal Characteristics[10]

| Parameter | Test Conditions | Symbol | Typical | Units |
|---|---|---|---|---|
| Thermal Resistance using Finite Element Analysis | $V_{DS}$ = 28 V<br>$T_C$ = 85°C, $T_{CH}$ = 225°C | $R_\theta$(FEA) | 7.6 | °C/W |
| Thermal Resistance using Infrared Measurement of Die Surface Temperature | $V_{DS}$ = 28 V<br>$T_C$ = 85°C, $T_{CH}$ = 225°C | $R_\theta$(IR) | 5.5 | °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

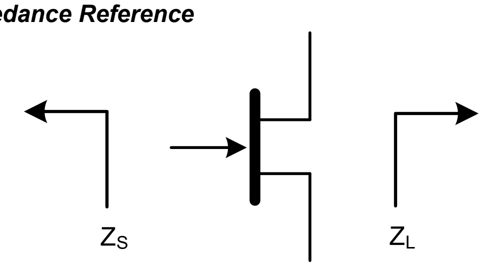
Gallium Nitride Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

## Pulsed[2] Load-Pull Performance
### Reference Plane at Device Leads

| Frequency (MHz) | $Z_{SOURCE}$ (Ω) | Single Channel: Maximum Output Power $V_{DS}$ = 28 V, $I_{DQ}$ = 48 mA, $T_C$ = 25°C, P2.5dB | | | | | |
|---|---|---|---|---|---|---|---|
| | | $Z_{LOAD}$[11] (Ω) | Gain (dB) | $P_{OUT}$ (dBm) | $P_{OUT}$ (W) | $\eta_D$ (%) | AM/PM (°) |
| 700 | 15.4 - j1.3 | 21.1 + j3.5 | 11.7 | 39.7 | 9.3 | 44.6 | 113.3 |
| 850 | 17.7 - j6.3 | 28.0 + j0.7 | 12.7 | 40.2 | 10.5 | 58.0 | 112.3 |
| 1000 | 20.7 - j10.2 | 25.4 + j2.6 | 12.2 | 40.1 | 10.2 | 52.8 | 108.9 |
| 1500 | 22.5 - j9.8 | 20.5 + j1.2 | 13.6 | 40.3 | 10.7 | 53.7 | 85.3 |

| Frequency (MHz) | $Z_{SOURCE}$ (Ω) | Single Channel: Maximum Drain Efficiency $V_{DS}$ = 28 V, $I_{DQ}$ = 48 mA, $T_C$ = 25°C, P2.5dB | | | | | |
|---|---|---|---|---|---|---|---|
| | | $Z_{LOAD}$[12] (Ω) | Gain (dB) | $P_{OUT}$ (dBm) | $P_{OUT}$ (W) | $\eta_D$ (%) | AM/PM (°) |
| 700 | 12.3 - j2.1 | 80.6 + j52.9 | 16.9 | 35.9 | 3.9 | 66.2 | 101.6 |
| 850 | 14.9 - j5.7 | 55.4 + j38.3 | 15.9 | 37.2 | 5.2 | 69.4 | 102.2 |
| 1000 | 17.3 - j10.1 | 50.7 + j29.5 | 15.5 | 37.5 | 5.6 | 64.4 | 99.3 |
| 1500 | 17.7 - j12.2 | 33.1 + j18.1 | 16.3 | 38.5 | 7.1 | 64.8 | 72.2 |

***Impedance Reference***



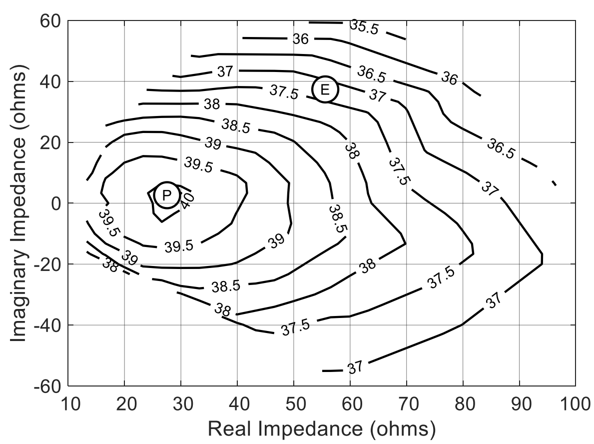

$Z_{SOURCE}$ = Measured impedance presented to the input of the device at package reference plane.
$Z_{LOAD}$ = Measured impedance presented to the output of the device at package reference plane.

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

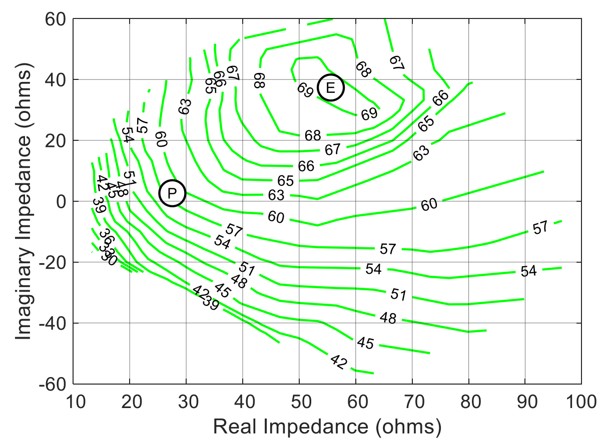
## Pulsed[2] Load-Pull Performance

**850MHz**

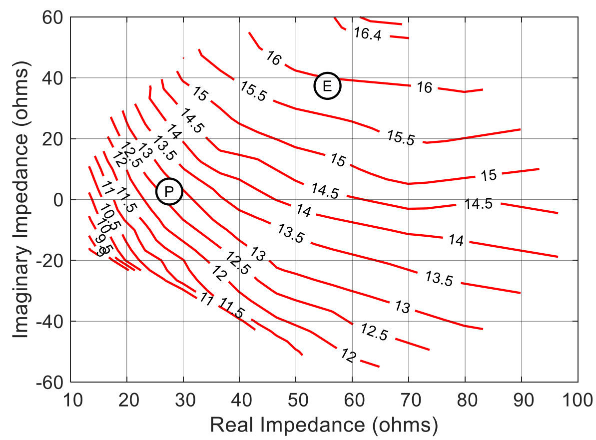
***P2.5dB Loadpull Output Power Contours (dBm)***



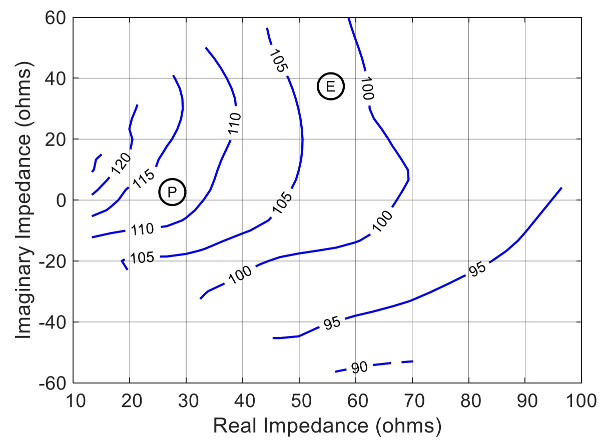

***P2.5dB Loadpull Drain Efficiency Contours (%)***



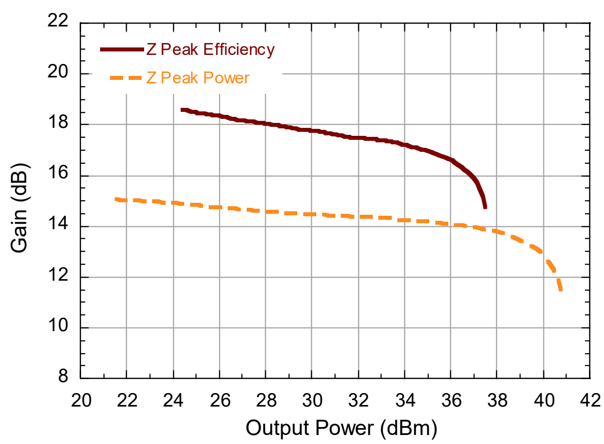

***P2.5dB Loadpull Gain Contours (dB)***



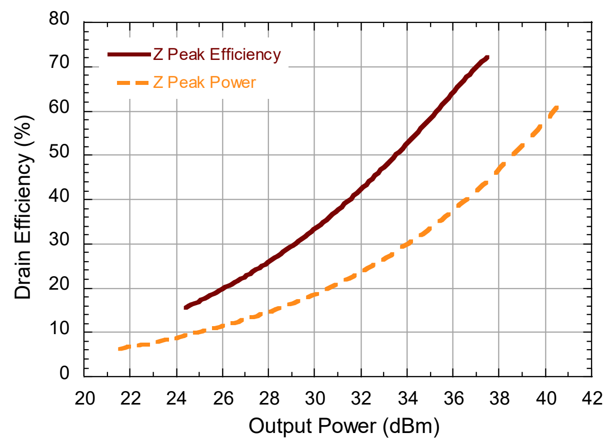

***P2.5dB Loadpull AM/PM Contours (°)***



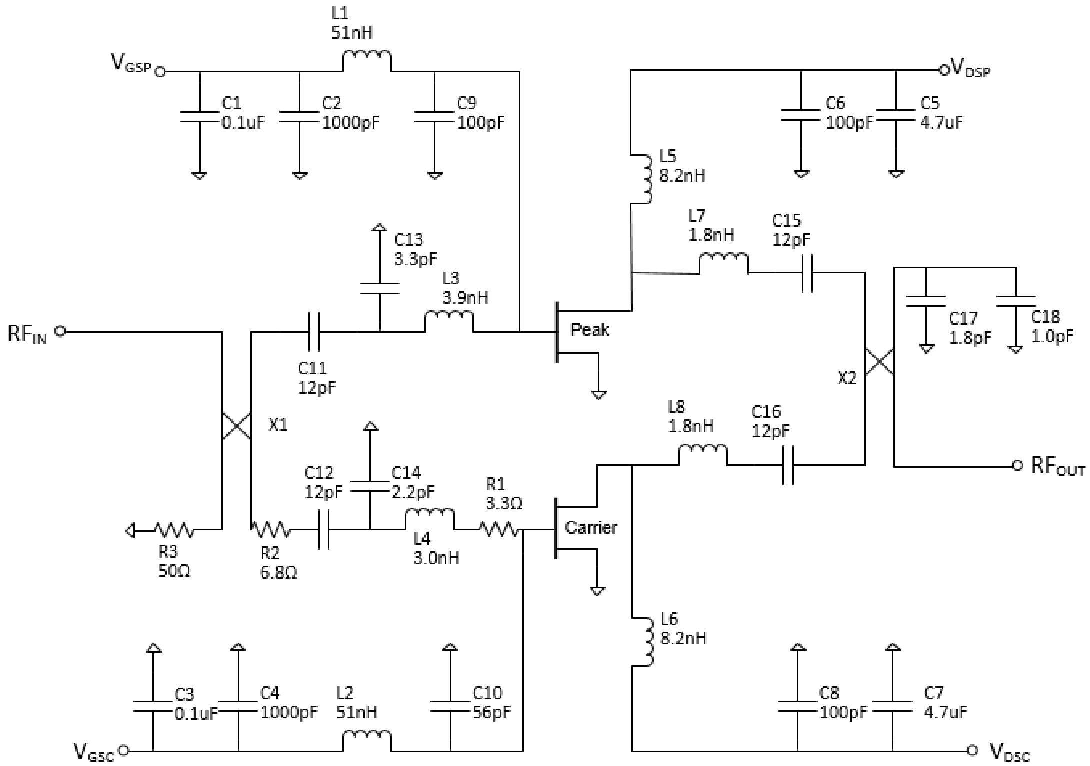

***Gain vs. Output Power***




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



## Evaluation Test Fixture and Recommended Tuning Solution 728 - 960 MHz




## 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

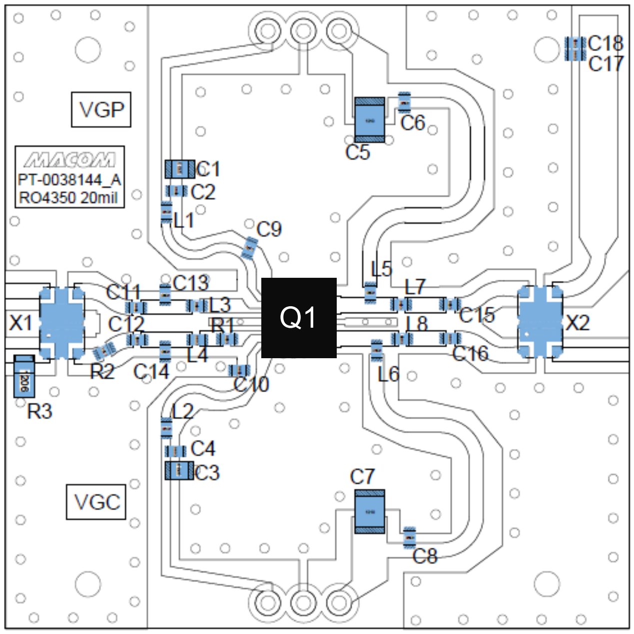
### Turning the device ON

1. Set $V_{GSC}$ to pinch-off voltage ($V_P$), typically -4 V.
2. Set $V_{GSP}$ to nominal voltage, typically -4.5 V.
3. Turn on $V_{DSC}$ and $V_{DSP}$ to nominal voltage (28 V).
4. Increase $V_{GSC}$ until $I_{DSC}$ current is reached.
5. Apply RF power to desired level.

### Turning the device OFF

1. Turn the RF power off.
2. Decrease $V_{GSC}$ down to $V_P$.
3. Decrease $V_{DSC}$ and $V_{DSP}$ down to 0 V.
4. Turn off $V_{GSC}$ and $V_{GSP}$.

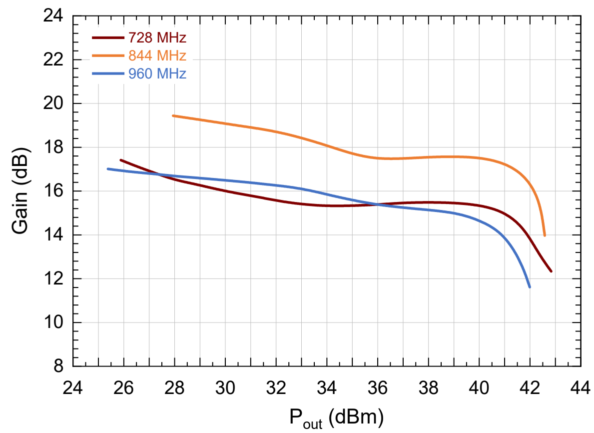
## Evaluation Board and Recommended Tuning Solution 728 - 960 MHz



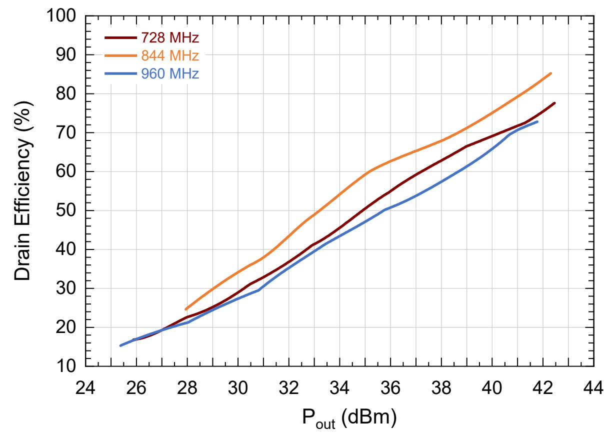

| Reference Designator | Value | Tolerance | Manufacturer | Part Number |
|---|---|---|---|---|
| C1, C3 | 0.1µF | +/- 10% | Vishay | GA0805Y104KBBBT31G |
| C2, C4 | 1000pF | +/- 10% | KYOCERA AVX | KAM15AR72A102KT |
| C5, C7 | 4.7µF | +/- 10% | KYOCERA AVX | KAF32LR72A475KU |
| C6, C8, C9 | 100pF | +/- 5% | Passive Plus | 0603N10JW251X |
| C10 | 56pF | +/- 5% | Passive Plus | 0603N560JW251X |
| C11, C12, C15, C16 | 12pF | +/- 5% | Passive Plus | 0603N120JW251X |
| C13, C14 | 3.3pF | +/- 0.1pF | Passive Plus | 0603N3R3BW251X |
| C14 | 2.2pF | +/- 0.1pF | Passive Plus | 0603N2R2BW251X |
| C17 | 1.8pF | +/- 0.1pF | Passive Plus | 0603N1R8BW251X |
| C18 | 1.5pF | +/- 0.1pF | Passive Plus | 0603N1R5BW251X |
| L1, L2 | 51nH | +/- 5% | Coilcraft | 0603HP-51NXJRW |
| L3 | 3.9nH | +/- 2% | Coilcraft | 0603HP-3N9XGRW |
| L4 | 3.0nH | +/- 2% | Coilcraft | 0603HP-3N0XGRW |
| L5, L6 | 8.2nH | +/- 2% | Coilcraft | 0603HP-8N2XGRW |
| L7, L8 | 1.8nH | +/- 5% | Coilcraft | 0603HP-1N8XJRW |
| R1 | 3.3Ω | +/- 0.1% | Stackpole | RMCF0603FT3R30 |
| R2 | 6.8Ω | +/- 0.1% | Stackpole | RMCF0603FT6R80 |
| R3 | 49.9Ω | +/- 0.1% | Stackpole | RMCF1206FT49R9 |
| X1, X2 | 3dB | | TTM Tech | X3C07F1-03S |
| Q1 | | | MACOM | MAPC-A1533 |
| PCB | RO4350, 20mil, 1oz Cu, Tin Lead Finish | | | |

## Typical Performance Curves as Measured in the 728 - 960 MHz Evaluation Board: Pulsed[2] 844 MHz, $V_{DS}$ = 28 V, $I_{DQCAR}$ = 60 mA, $V_{DSP}$ = -4.5 V, $T_C$ = 25°C Unless Otherwise Noted

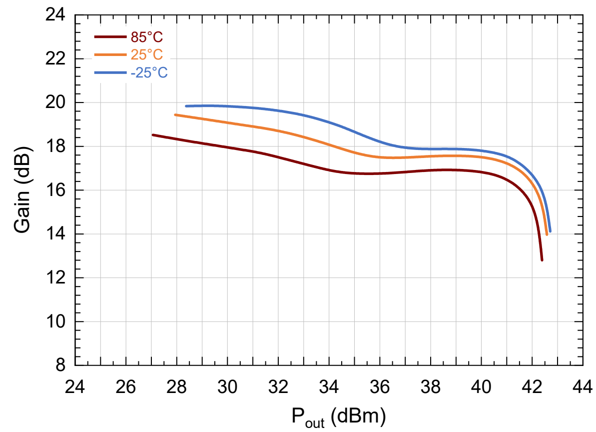
***Gain vs. Output Power and Frequency***



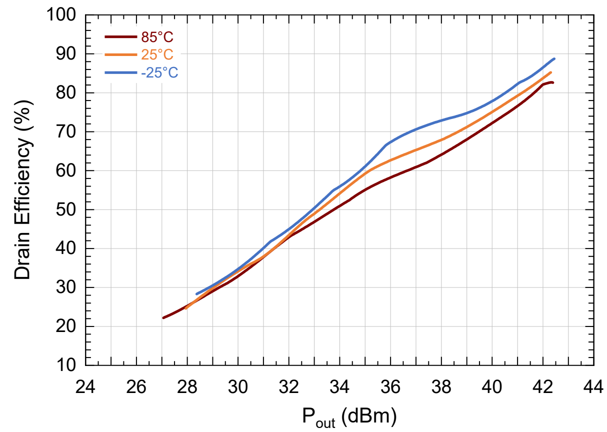

***Drain Efficiency vs. Output Power and Frequency***



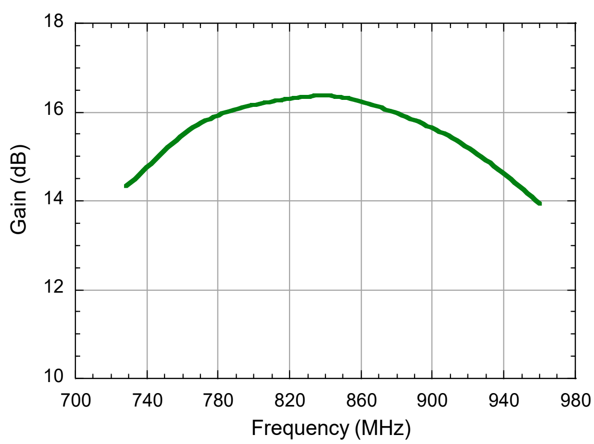

***Gain vs. Output Power and $T_C$***



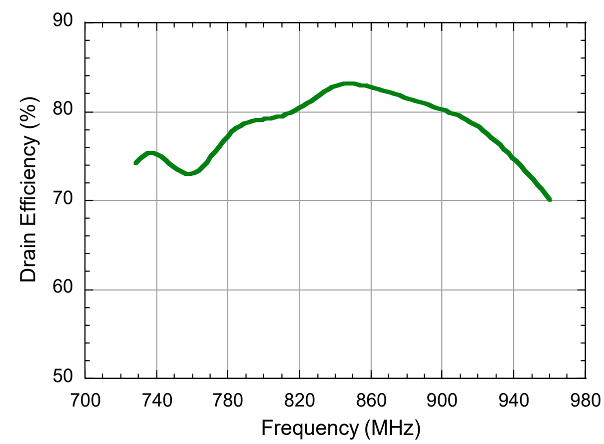

***Drain Efficiency vs. Output Power and $T_C$***




***Gain vs. Frequency, 3dB Gain Compression***

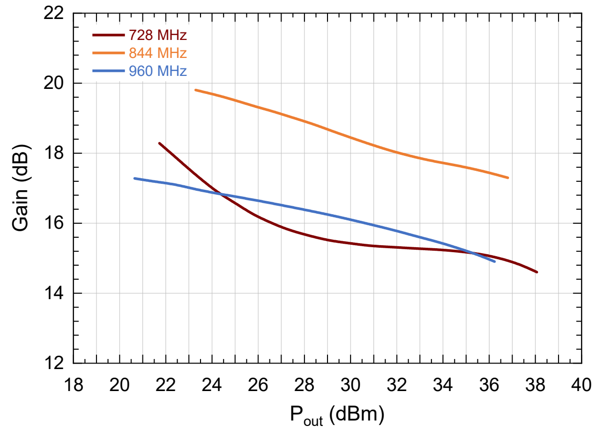



***Drain Efficiency vs. Frequency, 3dB Gain Compression***

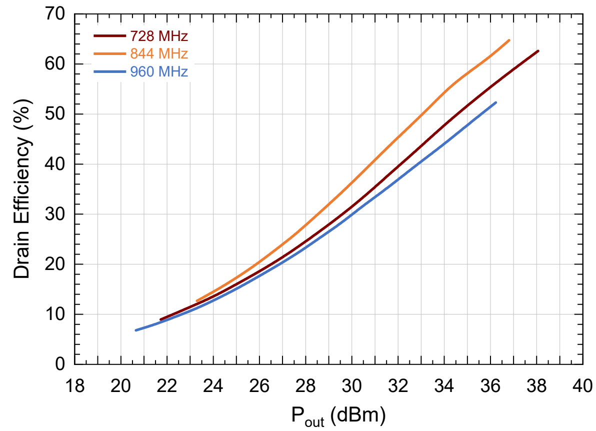


## Typical Performance as Measured in the 728 - 960 MHz Evaluation Board: WCDMA 3GPP TM1 64 DPCH 9.9 dB PAR @ 0.01% CCDF $V_{DS}$ = 28 V, $I_{DQCAR}$ = 60 mA, $V_{DSP}$ = -4.5 V, $T_{CASE}$ = 25 °C

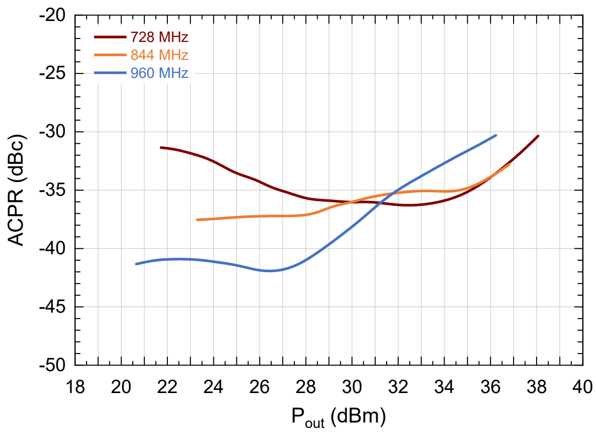
***Gain vs. Output Power and Frequency***



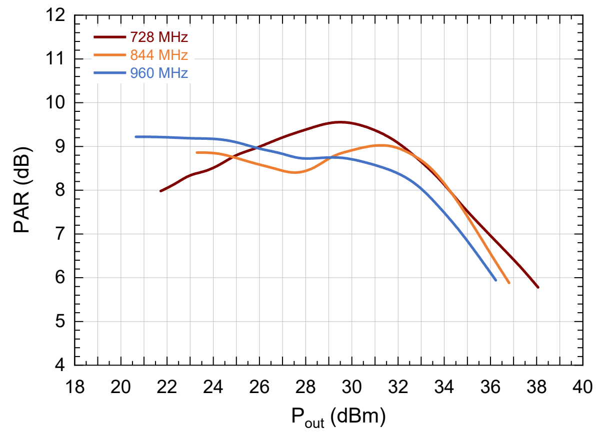

***Drain Efficiency vs. Output Power and Frequency***



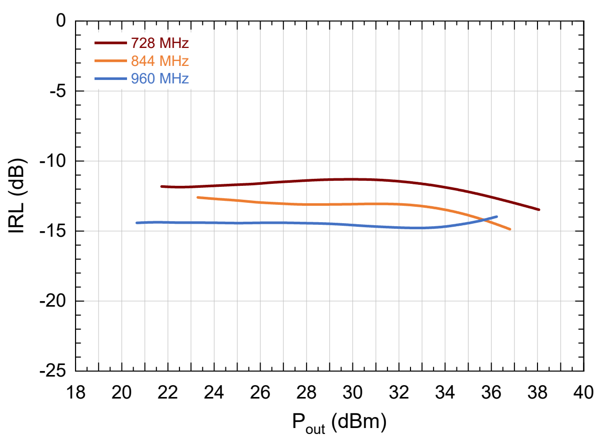

***ACPR (Max ±5 MHz) vs. Output Power and Frequency***




***PAR (CCDF @ 0.01%) vs. Output Power and Frequency***

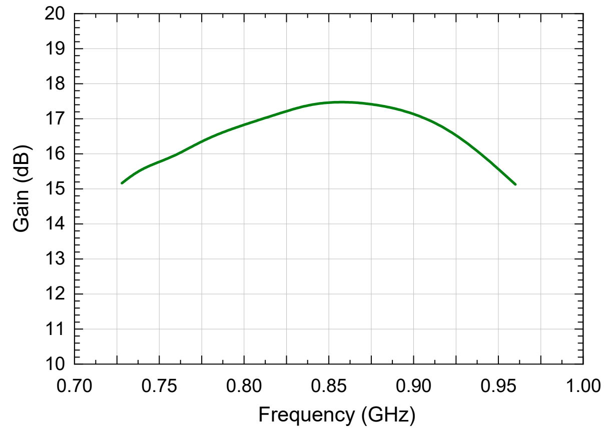



***Input Return Loss vs. Output Power and Frequency***

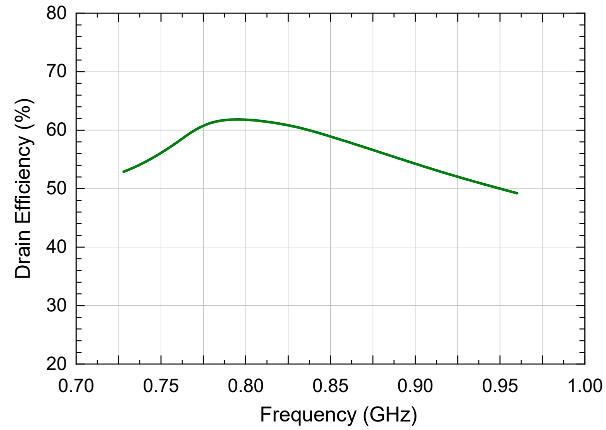


## Typical Performance as Measured in the 728 - 960 MHz Evaluation Board: WCDMA 3GPP TM1 64 DPCH 9.9 dB PAR @ 0.01% CCDF $V_{DS}$ = 28 V, $I_{DQCAR}$ = 60 mA, $V_{DSP}$ = -4.5 V, $T_{CASE}$ = 25 °C

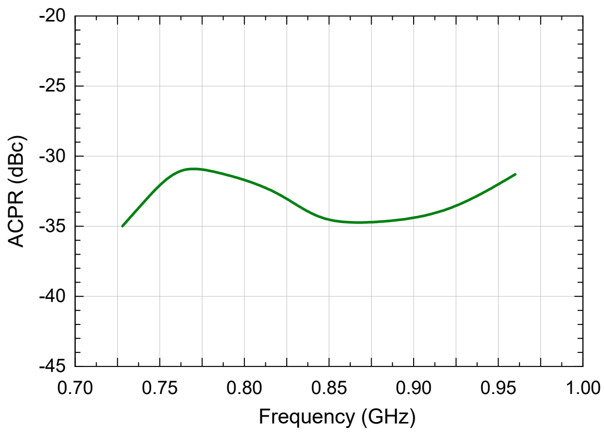
***Gain vs. Frequency at $P_{OUT}$ = 35.3 dBm***



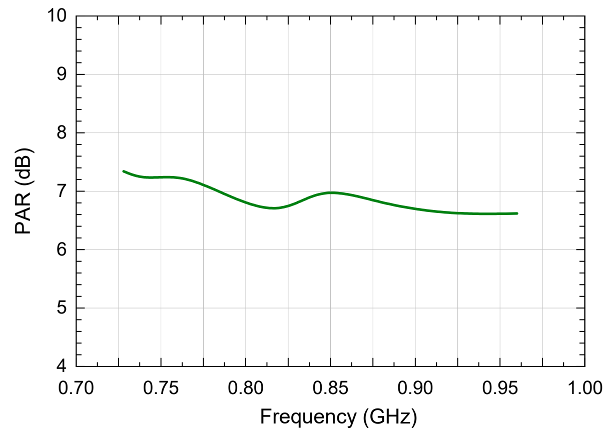

***Drain Efficiency vs. Frequency at $P_{OUT}$ = 35.3 dBm***



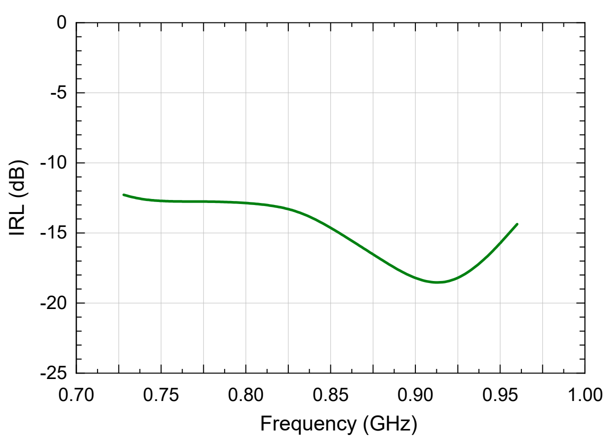

***ACPR (Max ±5 MHz) vs. Frequency at $P_{OUT}$ = 35.3 dBm***



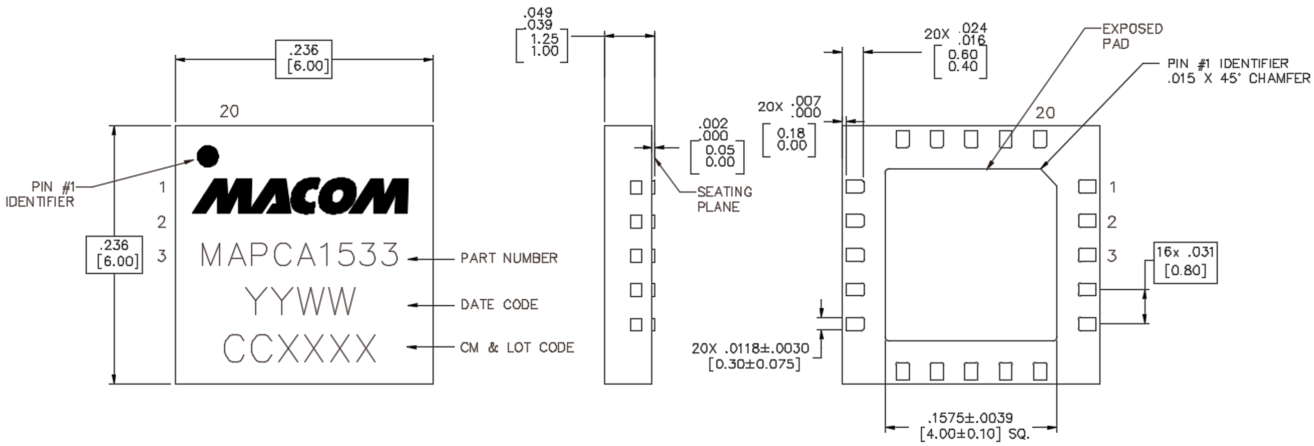

***PAR (CCDF @ 0.01%) vs. Frequency at $P_{OUT}$ = 35.3dBm***




***Input Return Loss vs. Frequency at $P_{OUT}$ = 35.3 dBm***



## Lead-Free 6 mm 20-Lead Package Dimensions†




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