

# Power Amplifier, 11.5 W 27 - 31 GHz



MAPC-MP0003-DIE

Rev. V1P

## Features

- Ka-band Power Amplifier
- Gain: 25 dB
- Output Power: 11.5 W
- Supply Voltage: 22 V
- PAE: 27%
- Bare Die
- Die Size: 4.5 x 4.1 x 0.1 mm

## Applications

- Ka-band Satellite Communications

## Description

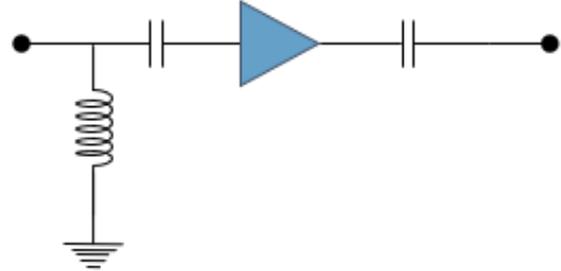
The MAPC-MP0003-DIE is a 11.5 W, Ka-band power amplifier. This GaN on SiC power amplifier operates at 22 V and has typical power added efficiencies of 25%. Typical applications include Ka-band satellite communications.

Each device is 100% RF tested to ensure performance compliance.

## Ordering Information

| Part Number         | Package      |
|---------------------|--------------|
| MAPC-MP0003-DIE-PPR | Bulk         |
| MAPC-MP0003-SB1PPR  | Sample Board |

## Functional Schematic



## Pin Configuration<sup>1</sup>

| Pin #  | Label             |
|--|-------------------|
| 1  | RF <sub>IN</sub>  |
| 2, 8, 11, 12, 14, 15, 17, 18, 20, 21, 24, 30, 31 | GND               |
| 3, 29  | VG1               |
| 4, 28  | VG2               |
| 5, 27  | VG3               |
| 6, 26  | VG4               |
| 7, 25  | VD1               |
| 9, 23  | VD2               |
| 10, 22   | VD3               |
| 13, 19   | VD4               |
| 16   | RF <sub>OUT</sub> |

1. The backside of the die must be connected to RF, DC and thermal ground.

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

## Pin Description

| Pin #  | Name   | Description                               |
|--|--------|---|
| 1  | RF_IN  | RF Input has DC ground for ESD robustness |
| 2, 8, 11, 12, 14, 15, 17, 18, 20, 21, 24, 30, 31 | GND    | RF and DC Ground                          |
| 3, 29  | VG1    | Gate voltage, stage 1                     |
| 4, 28  | VG2    | Gate voltage, stage 2                     |
| 5, 27  | VG3    | Gate voltage, stage 3                     |
| 6, 26  | VG4    | Gate voltage, stage 4                     |
| 7, 25  | VD1    | Drain voltage, stage 1                    |
| 9, 23  | VD2    | Drain voltage, stage 2                    |
| 10, 22   | VD3    | Drain voltage, stage 3                    |
| 13, 19   | VD4    | Drain voltage, stage 4                    |
| 16   | RF_OUT | RF Output is DC de-coupled                |

**Electrical Specifications:**

**Freq. = 27 - 31 GHz, T<sub>C</sub> = 25°C, V<sub>D</sub> = +22 V, I<sub>DQ</sub> = 300 mA, CW Operation, Z<sub>0</sub> = 50 Ω**

| Parameter                    | Test Conditions  | Units | Min. | Typ.         | Max. |
|------------------------------|--|-------|------|--------------|------|
| Gain                         | Small Signal, P <sub>IN</sub> = -10 dBm<br>Large Signal, P <sub>IN</sub> = +21 dBm | dB    | —    | 25.0<br>19.5 | —    |
| Gain Flatness (Peak-to-Peak) | P <sub>IN</sub> = -10 dBm  | dB    | —    | 2            | —    |
| IM3                          | P <sub>OUT</sub> = 33 dBm per tone,<br>spacing 100 kHz to 1 GHz                    | dBc   | —    | 25           | —    |
| Output Power                 | P <sub>IN</sub> = +21 dBm  | dBm   | —    | 40.6         | —    |
| Output Power Flatness        | P <sub>IN</sub> = +21 dBm  | dB    | —    | 1            | —    |
| Input Return Loss            | P <sub>IN</sub> = -10 dBm  | dB    | —    | 12           | —    |
| Output Return Loss           | P <sub>IN</sub> = -10 dBm  | dB    | —    | 10           | —    |
| Power Added Efficiency       | P <sub>IN</sub> = +21 dBm  | %     | —    | 27           | —    |

**Recommended Operating Conditions**

| Parameter                           | Unit            |
|-------------------------------------|-----------------|
| RF Input Power (max.)               | 25 dBm          |
| Drain Supply Voltage (max.)         | 24 V            |
| Gate Supply Voltage (min.)          | -5 V            |
| CW Duty Cycle                       | 10 % to 100%    |
| Junction Temperature <sup>4,5</sup> | +200°C          |
| Operating Temperature <sup>6</sup>  | -40°C to +85°C  |
| Storage Temperature                 | -55°C to +150°C |

**Absolute Maximum Ratings<sup>2,3</sup>**

| Parameter                  | Unit            |
|----------------------------|-----------------|
| RF Input Power             | 28 dBm          |
| Drain Supply Voltage       | 28V             |
| Gate Supply Voltage (min.) | -6 V            |
| Junction Temperature       | +225°C          |
| Storage Temperature        | -55°C to +150°C |

2. Exceeding any one or combination of these limits may cause permanent damage to this device.
3. MACOM does not recommend sustained operation near these survivability limits.
4. Operating at nominal conditions with T<sub>J</sub> ≤ +200 °C will ensure MTTF > 1 x 10<sup>6</sup> hours.
5. Junction Temperature (T<sub>J</sub>) = T<sub>C</sub> + Θ<sub>JC</sub> \* (V \* I - (P<sub>OUT</sub> - P<sub>IN</sub>))  
Typical thermal resistance (Θ<sub>JC</sub>) = TBD °C/W.
  - a) For T<sub>C</sub> = +25°C, quiescent conditions:  
T<sub>J</sub> = TBD °C @ 22 V, 300 mA
  - b) For T<sub>C</sub> = +85°C, quiescent conditions:  
T<sub>J</sub> = TBD °C @ 22 V, 300 mA
6. T<sub>C</sub> is defined as backside of die

**Handling Procedures**

Please observe the following precautions to avoid damage:

**Static Sensitivity**

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

### Application Notes

MAPC-MP0003-DIE is designed to be easy to use yet high performance. The ultra small size and simple bias allows easy placement on system board. RF output ports are DC de-coupled internally. RF input port has DC connection to the ground for the ESD protection purpose.

### Supply Sequencing

#### Turn-on

1. Apply  $V_G$  (-5 V).
2. Apply  $V_D$  (22 V typical).
3. Set  $I_{DQ}$  by adjusting  $V_G$  more positive (typically  $V_G \sim -3.9$  V for  $I_{DQ} = 300$  mA).
4. Apply  $RF_{IN}$  signal.

#### Turn-off

1. Remove  $RF_{IN}$  signal.
2. Decrease  $V_G$  to -5 V.
3. Decrease  $V_D$  to 0 V.

### Die Attachment

This product is manufactured from 0.1 mm (0.004") thick SiC substrate and has vias through to the backside to enable grounding to the circuit.

Recommended conductive epoxy is Namics Unimec XH9890-6. Epoxy should be applied and cured in accordance with the manufacturer's specifications and should avoid contact with the top of the die.

### Biasing Conditions

Recommended biasing conditions are:

$V_D = 22$  V,  $I_{DQ} = 300$  mA (controlled with  $V_G$ ).

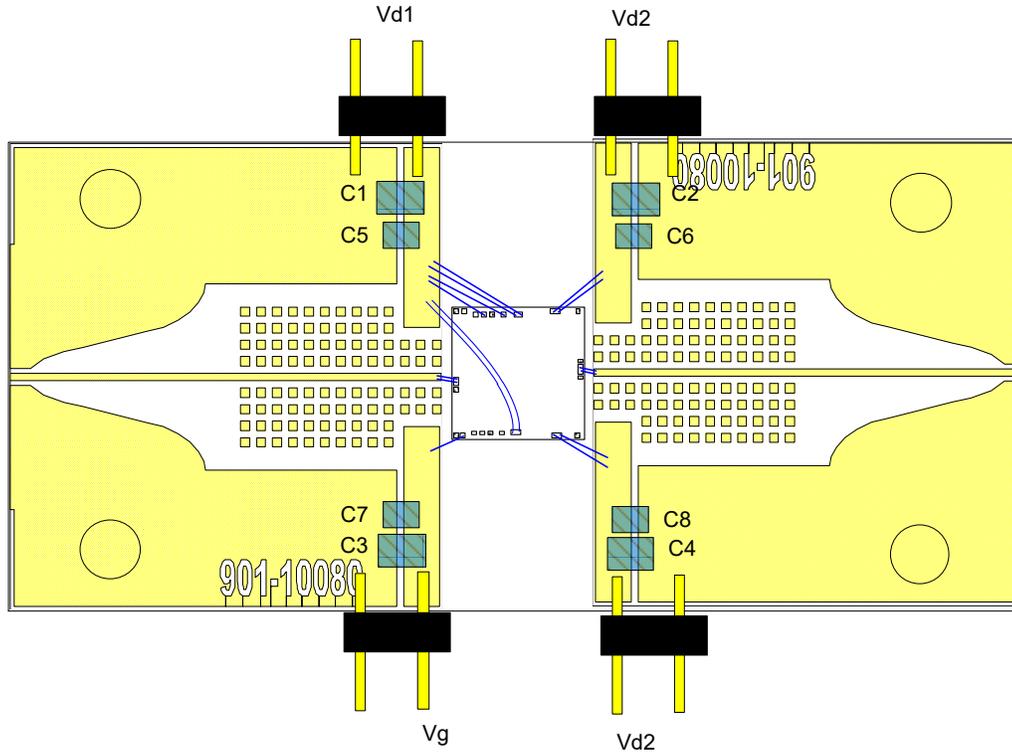
$V_D$  bias must be applied to  $V_{D1}$ ,  $V_{D2}$ ,  $V_{D3}$ , and  $V_{D4}$  pads.

Both  $V_{D3}$  pads (11, 23) are required for current symmetry.

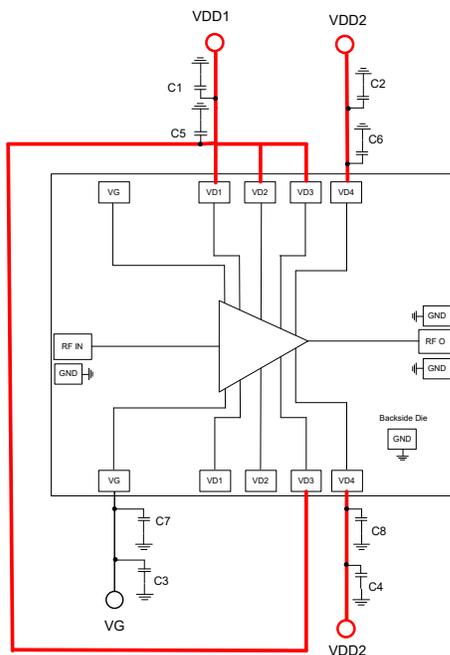
Both  $V_{D4}$  pads (14, 20) are required for current symmetry.

A single DC voltage ( $V_G$ ) will bias all amplifier stages. Muting can be accomplished by setting the  $V_G$  to the pinched off voltage ( $V_G = -5$  V).

Sample Board Layout



Application Schematic



Parts List

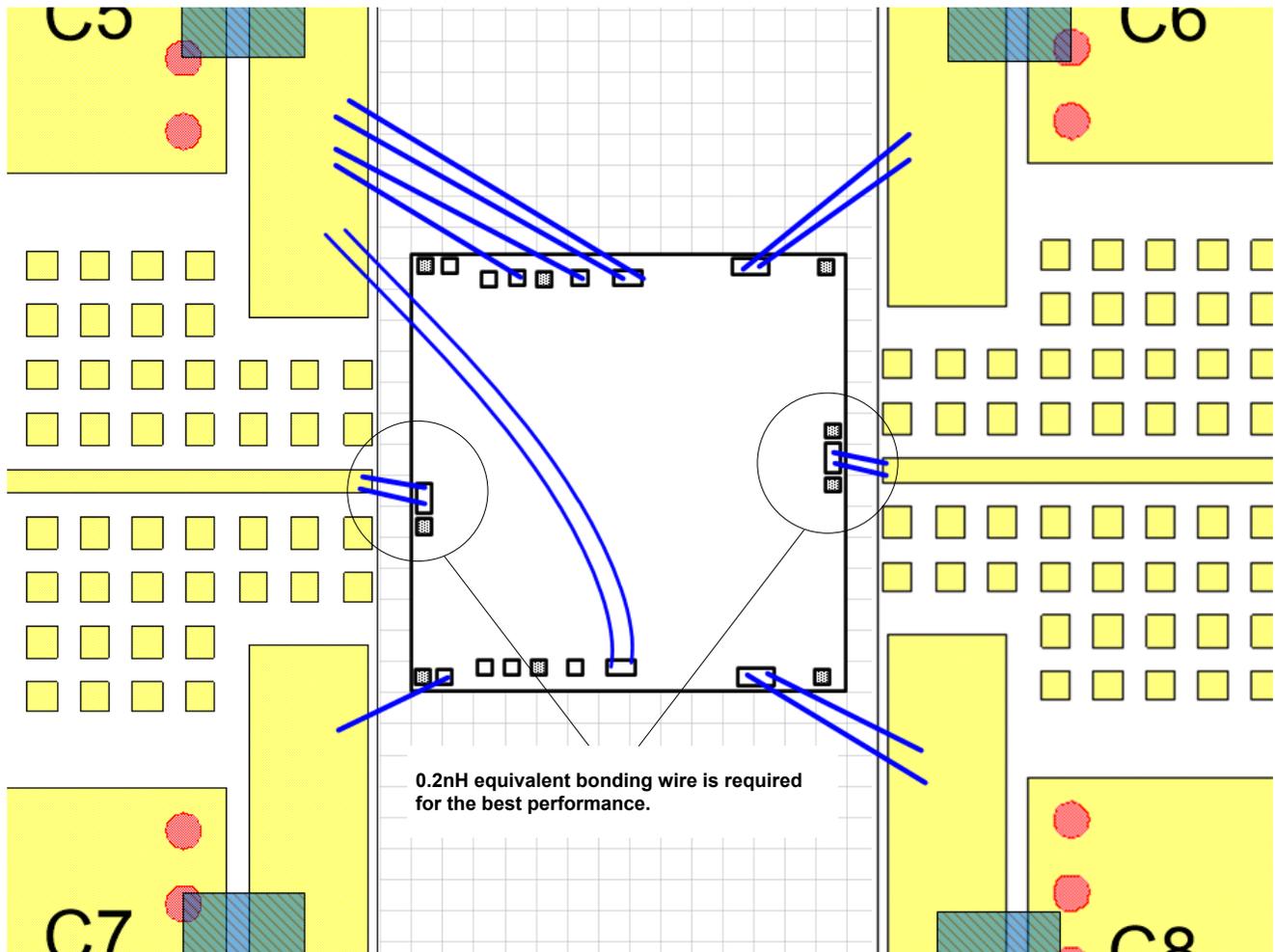
| Part    | Value        | Case Style |
|---------|--------------|------------|
| C5 - C8 | 0.01 $\mu$ F | 0402       |
| C1 - C4 | 22 $\mu$ F   | 0603       |

Sample Board Material Specifications

Top Layer: 1/2 oz Copper Cladding, 0.017 mm thickness  
Dielectric Layer: Rogers RO4350B 0.101 mm thickness  
Bottom Layer: 1/2 oz Copper Cladding, 0.017 mm thickness  
Finished overall thickness: 0.135 mm

**Recommended Bonding Diagram and PCB Layout Detail:**

Optimum bonding wire inductance for the RF I/O connection is 0.2 nH, and physical length for the gold bond wire (.001" dia.) is approximately 350  $\mu$ m each for the two wire connection.



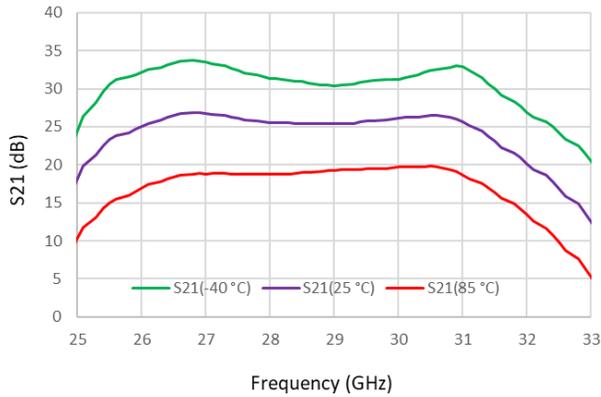
# Power Amplifier, 11.5 W 27 - 31 GHz



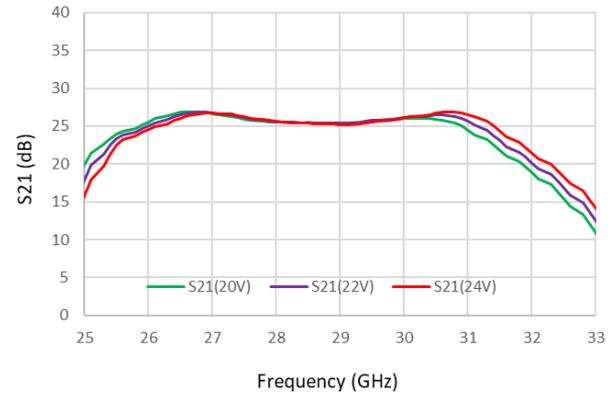
MAPC-MP0003-DIE  
Rev. V1P

Typical Performance Curves:  $V_D = 22\text{ V}$ ,  $I_{DSQ} = 300\text{ mA}$ ,  $V_G = -3.9\text{ V}$  typical

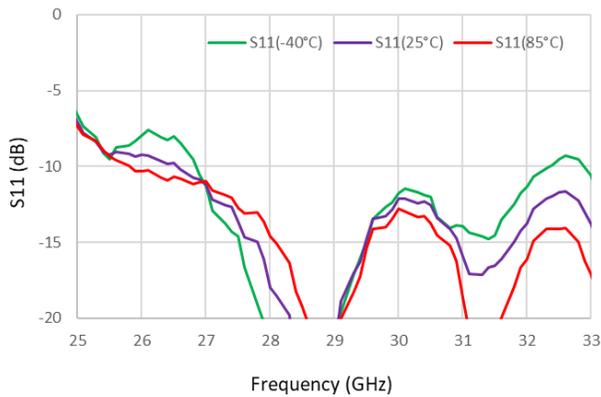
Small Signal Gain vs. Frequency over Temperature



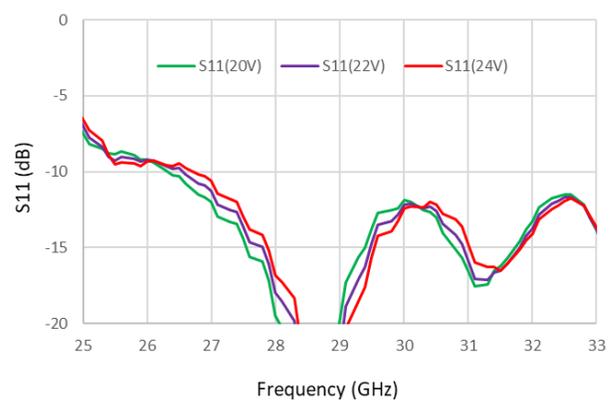
Small Signal Gain vs. Frequency over Bias Voltage



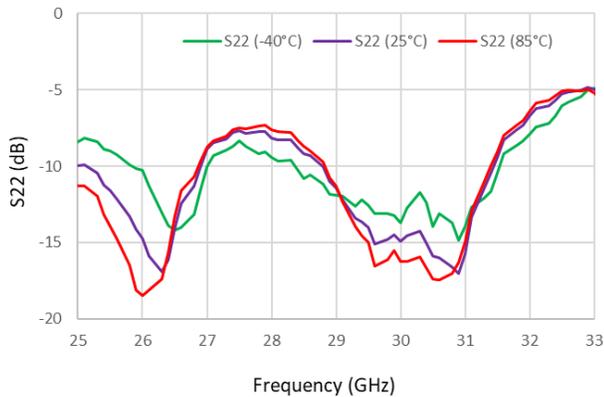
Input Return Loss vs. Frequency over Temperature



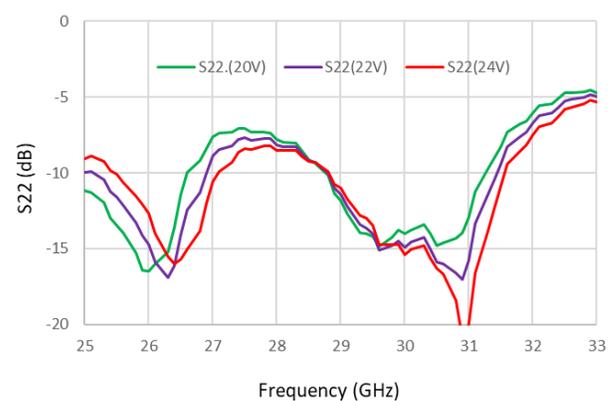
Input Return Loss vs. Frequency over Bias Voltage



Output Return Loss vs. Frequency over Temperature



Output Return Loss vs. Frequency over Bias Voltage



# Power Amplifier, 11.5 W 27 - 31 GHz

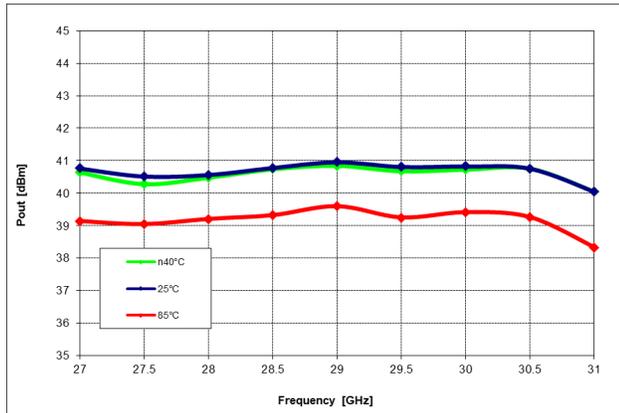


MAPC-MP0003-DIE

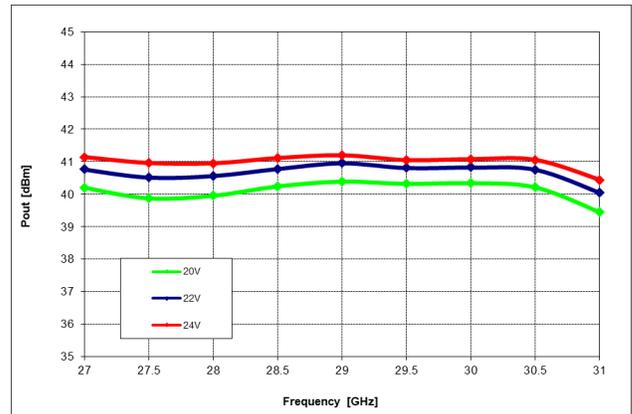
Rev. V1P

Typical Performance Curves:  $V_D = 22\text{ V}$ ,  $I_{DSQ} = 300\text{ mA}$ ,  $V_G = -3.9\text{ V}$  typical,  $P_{in} = 21\text{ dBm}$

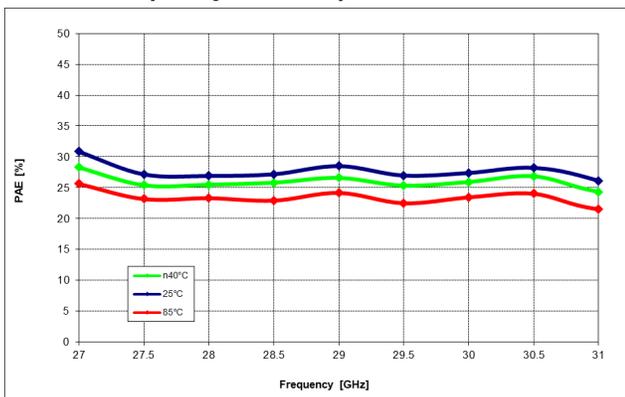
***P<sub>out</sub> vs. Frequency over Temperature***



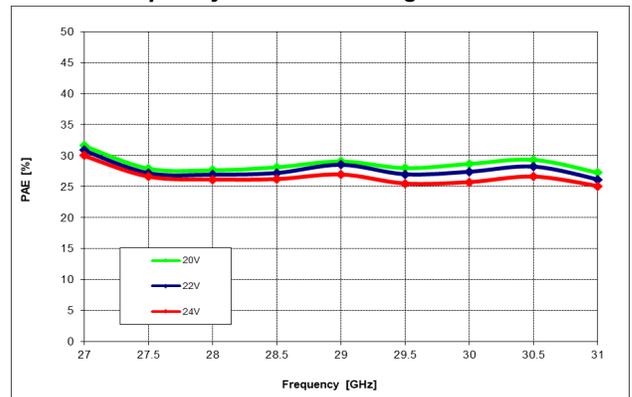
***P<sub>out</sub> vs. Frequency over Bias Voltage***



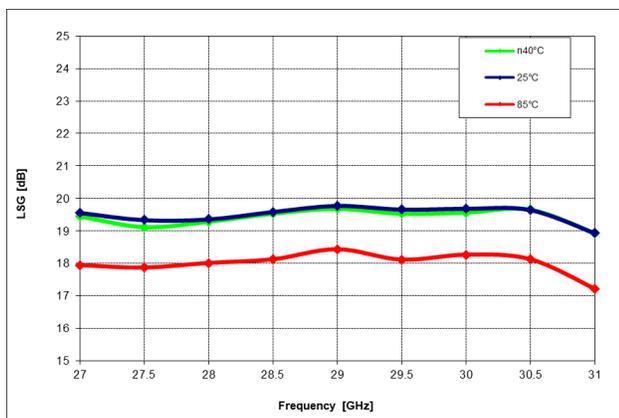
***PAE vs. Frequency over Temperature***



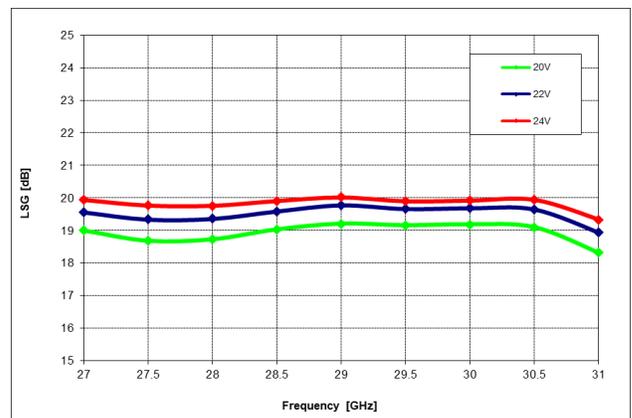
***PAE vs. Frequency over Bias Voltage***



***LSG vs. Frequency over Temperature***



***LSG vs. Frequency over Bias Voltage***



# Power Amplifier, 11.5 W 27 - 31 GHz

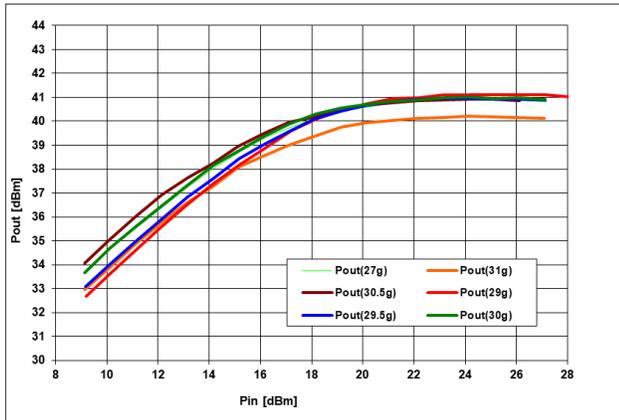


MAPC-MP0003-DIE

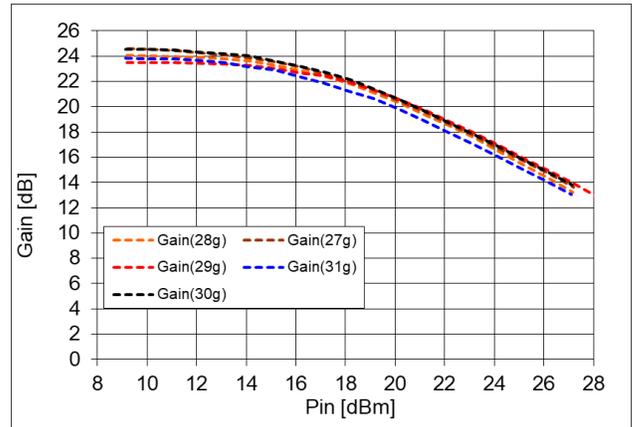
Rev. V1P

Typical Performance Curves:  $V_D = 22\text{ V}$ ,  $I_{DSQ} = 300\text{ mA}$ ,  $V_G = -3.9\text{ V}$  typical,  $25^\circ\text{C}$

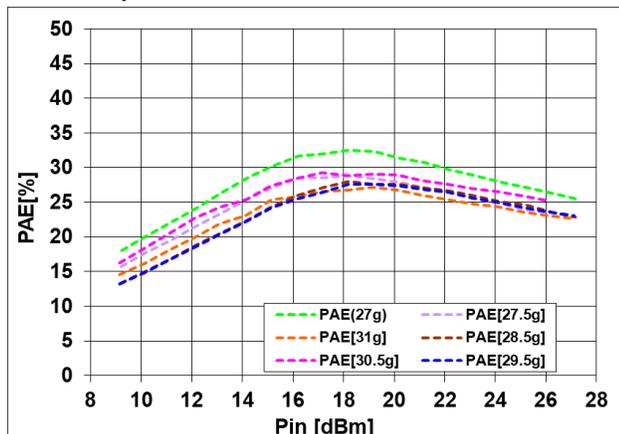
Output Power vs. Input Power at  $25^\circ\text{C}$



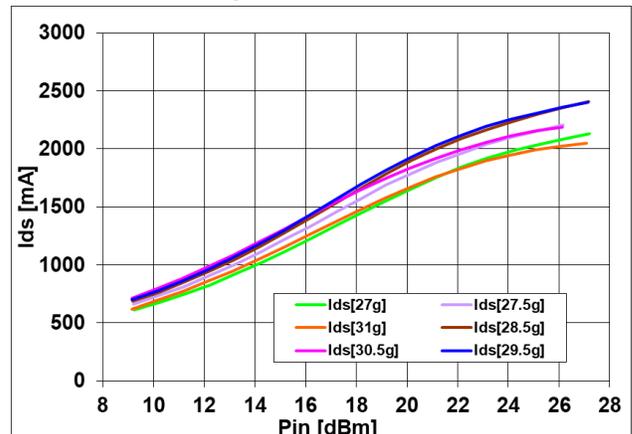
Gain vs. Input Power at  $25^\circ\text{C}$



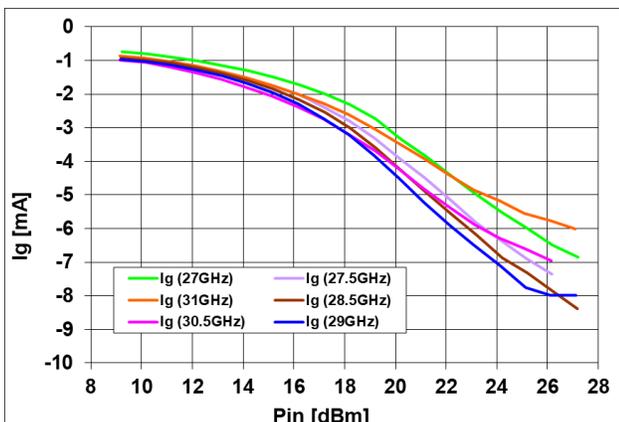
PAE vs. Input Power at  $25^\circ\text{C}$



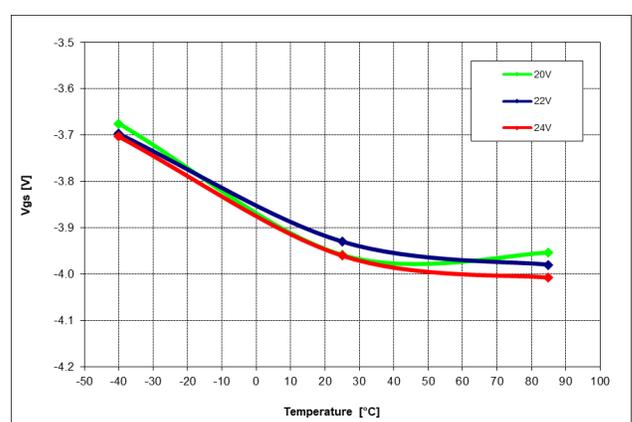
Drain Current vs. Input Power at  $25^\circ\text{C}$



Gate Current vs. Input Power at  $25^\circ\text{C}$



Gate Voltage vs. Temperature for constant  $I_{dsq}$



# Power Amplifier, 11.5 W 27 - 31 GHz

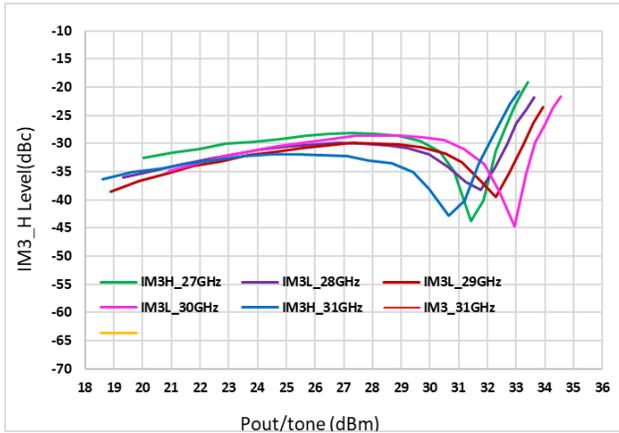


MAPC-MP0003-DIE

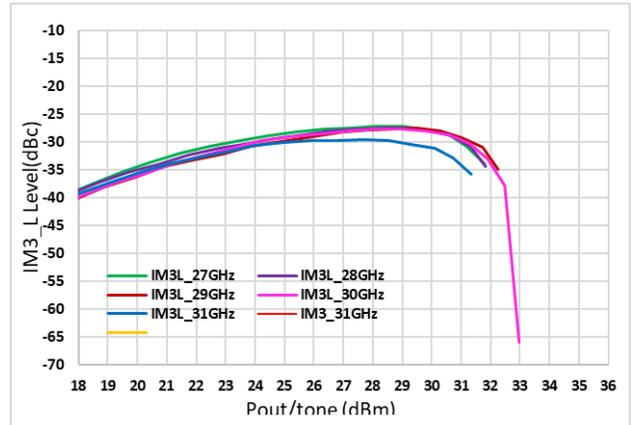
Rev. V1P

Typical Performance Curves:  $V_D = 22\text{ V}$ ,  $I_{DSQ} = 300\text{ mA}$ ,  $V_G = -3.9\text{ V}$  typical

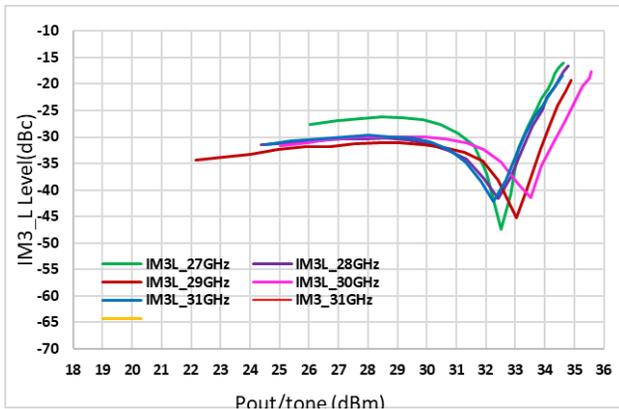
IM3 vs. Output Power (25 °C)



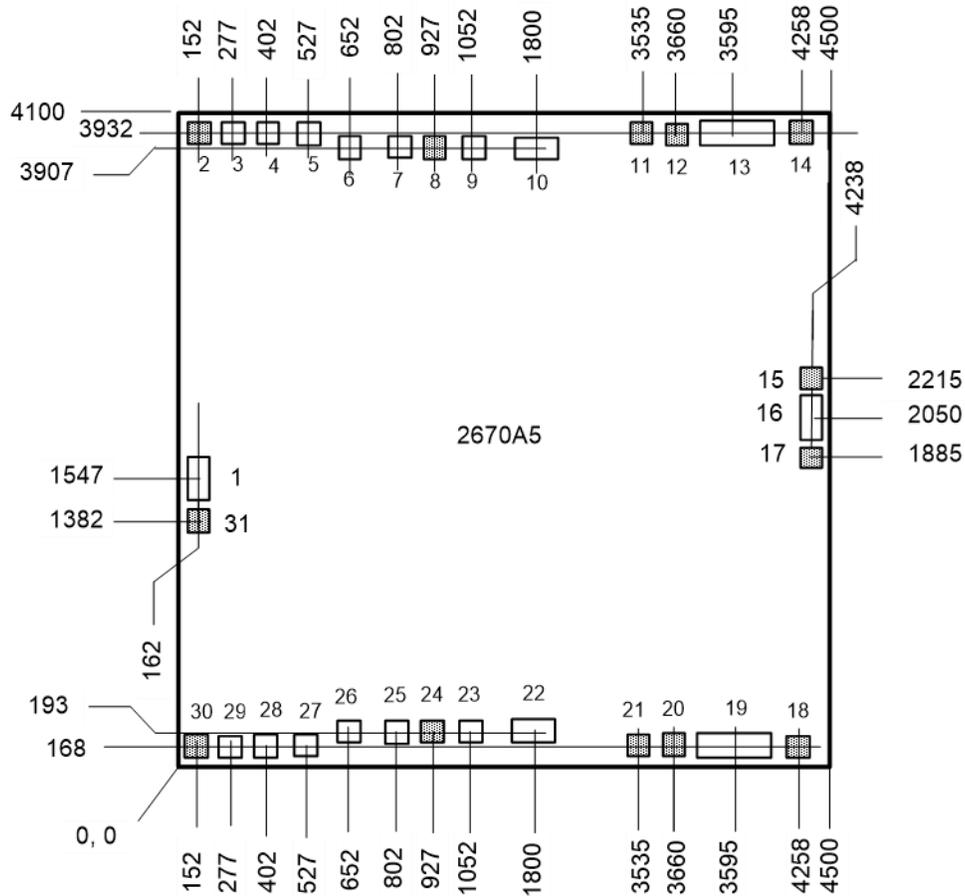
IM3 vs. Output Power @ 85 °C



IM3 vs. Output Power (-40 °C)



**Die Dimensions**



Die thickness is 100 +/- 10 µm.

**Revision history**

| Rev | Date    | Change description             |
|-----|---------|--------------------------------|
| V1P | 1/30/23 | Preliminary data sheet release |
|     |         |                                |
|     |         |                                |
|     |         |                                |
|     |         |                                |
|     |         |                                |

MACOM Technology Solutions Inc. ("MACOM"). All rights reserved.

These materials are provided in connection with MACOM's products as a service to its customers and may be used for informational purposes only. Except as provided in its Terms and Conditions of Sale or any separate agreement, MACOM assumes no liability or responsibility whatsoever, including for (i) errors or omissions in these materials; (ii) failure to update these materials; or (iii) conflicts or incompatibilities arising from future changes to specifications and product descriptions, which MACOM may make at any time, without notice. These materials grant no license, express or implied, to any intellectual property rights.

THESE MATERIALS ARE PROVIDED "AS IS" WITH NO WARRANTY OR LIABILITY, EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHT, ACCURACY OR COMPLETENESS, OR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES WHICH MAY RESULT FROM USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.