

## Power Amplifier, 4 W 28.5 - 31 GHz

Rev. V1

### Features

- High Gain: 22 dB @ 30 GHz
- P1dB: 34.5 dBm
- P<sub>SAT</sub>: 36 dBm
- IM3 Level: -27 dBc @ P<sub>OUT</sub> 29 dBm/tone
- Power Added Efficiency: 23% @ P<sub>SAT</sub>
- Lead-Free 5 mm 32-lead AQFN Plastic Package
- RoHS\* Compliant

### Description

The MAAP-011139 is a 4-stage, 4 W power amplifier assembled in a lead-free 5 mm 32-lead AQFN plastic package. This power amplifier operates from 28.5 to 31 GHz and provides 22 dB of linear gain, 4 W saturated output power, and 23% efficiency while biased at 6 V.

The MAAP-011139 is a power amplifier ideally suited for VSAT communications.

This product is fabricated using a GaAs pHEMT process which features full passivation for enhanced reliability.

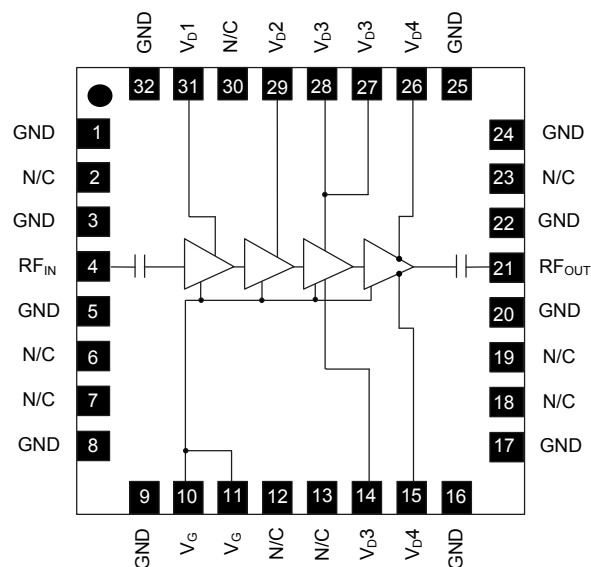
### Ordering Information<sup>1,2</sup>

| Part Number        | Package        |
|--------------------|----------------|
| MAAP-011139-TR0500 | 500 piece reel |
| MAAP-011139-SMB    | Sample Board   |

1. Reference Application Note M513 for reel size information.
2. All sample boards include 3 loose parts.

\*Restrictions on Hazardous Substances,  
European Union Directive 2011/65/EU.

### Functional Schematic



### Pin Configuration<sup>3</sup>

| Pin No. | Function        | Pin No.             | Function        |
|---------|-----------------|---------------------|-----------------|
| 1       | Ground          | 18, 19              | No Connection   |
| 2       | No Connection   | 20                  | Ground          |
| 3       | Ground          | 21                  | RF Output       |
| 4       | RF Input        | 22                  | Ground          |
| 5       | Ground          | 23                  | No Connection   |
| 6, 7    | No Connection   | 24, 25              | Ground          |
| 8, 9    | Ground          | 26                  | Drain Voltage 4 |
| 10      | Gate Voltage    | 27                  | Drain Voltage 3 |
| 11      | Gate Voltage    | 28                  | Drain Voltage 3 |
| 12, 13  | No Connection   | 29                  | Drain Voltage 2 |
| 14      | Drain Voltage 3 | 30                  | No Connection   |
| 15      | Drain Voltage 4 | 31                  | Drain Voltage 1 |
| 16, 17  | Ground          | 32                  | Ground          |
|         |                 | Paddle <sup>4</sup> | Ground          |

3. MACOM recommends connecting unused package pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

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**Electrical Specifications: Freq. = 30 GHz,  $T_A = +25^\circ\text{C}$ ,  $V_D = 6\text{ V}$ ,  $Z_0 = 50\ \Omega$**

| Parameter              | Test Conditions                          | Units | Min. | Typ. | Max. |
|------------------------|------------------------------------------|-------|------|------|------|
| Gain                   | $P_{IN} = 0\text{ dBm}$                  | dB    | 19   | 22   | —    |
| $P_{OUT}$              | $P_{IN} = +17\text{ dBm}$                | dBm   | 34.5 | 36.0 | —    |
| IM3 Level              | $P_{OUT} = +29\text{ dBm} / \text{tone}$ | dBc   | —    | -27  | —    |
| Power Added Efficiency | $P_{SAT} (P_{IN} = +17\text{ dBm})$      | %     | —    | 23   | —    |
| Input Return Loss      | $P_{IN} = -20\text{ dBm}$                | dB    | —    | 10   | —    |
| Output Return Loss     | $P_{IN} = -20\text{ dBm}$                | dB    | —    | 10   | —    |
| Quiescent Current      | $I_{DQ}$ (see bias conditions, page 5 )  | mA    | —    | 2000 | —    |
| Current                | $P_{SAT} (P_{IN} = +17\text{ dBm})$      | mA    | —    | 2700 | —    |

### Maximum Operating Conditions

| Parameter                           | Maximum        |
|-------------------------------------|----------------|
| Input Power                         | +17 dBm        |
| Junction Temperature <sup>5,6</sup> | +160°C         |
| Operating Temperature               | -40°C to +85°C |

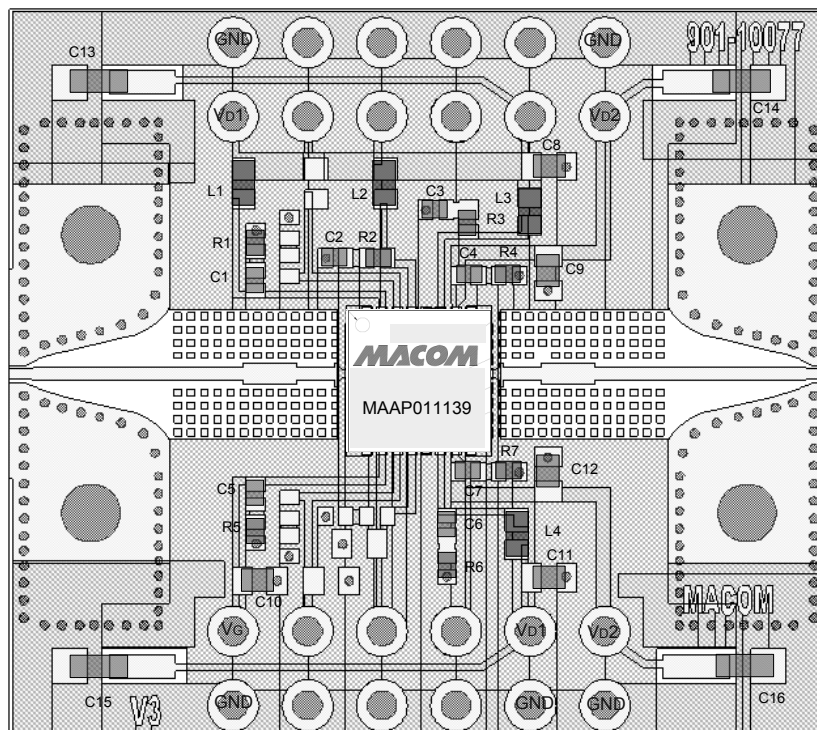
5. Operating at nominal conditions with junction temperature  $\leq +160^\circ\text{C}$  will ensure MTTF  $> 1 \times 10^6$  hours.
6. Junction Temperature ( $T_J$ ) =  $T_C + \Theta_{JC} * [(V * I) - (P_{OUT} - P_{IN})]$ .  
Typical thermal resistance ( $\Theta_{JC}$ ) = 4.4 °C/W.
- a) For  $T_C = +25^\circ\text{C}$ ,  
 $T_J = +79^\circ\text{C}$  @ 6 V, 2.7 A,  $P_{OUT} = 36\text{ dBm}$ ,  $P_{IN} = 17\text{ dBm}$
- b) For  $T_C = +85^\circ\text{C}$ ,  
 $T_J = +143^\circ\text{C}$  @ 6 V, 2.7 A,  $P_{OUT} = 35.1\text{ dBm}$ ,  $P_{IN} = 17\text{ dBm}$

### Absolute Maximum Ratings<sup>7,8</sup>

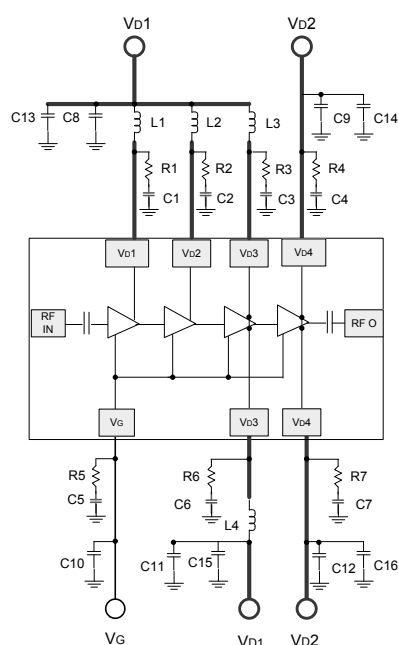
| Parameter                         | Absolute Maximum |
|-----------------------------------|------------------|
| Input Power                       | +23 dBm          |
| Drain Voltage                     | +6.5 V           |
| Gate Voltage                      | -3 to 0 V        |
| Junction Temperature <sup>9</sup> | +175°C           |
| Storage Temperature               | -65°C to +125°C  |

7. Exceeding any one or combination of these limits may cause permanent damage to this device.
8. MACOM does not recommend sustained operation near these survivability limits.
9. Junction Temperature directly effects device MTTF. Junction temperature should be kept as low as possible to maximize lifetime.

## Sample Board Layout



## Application Schematic



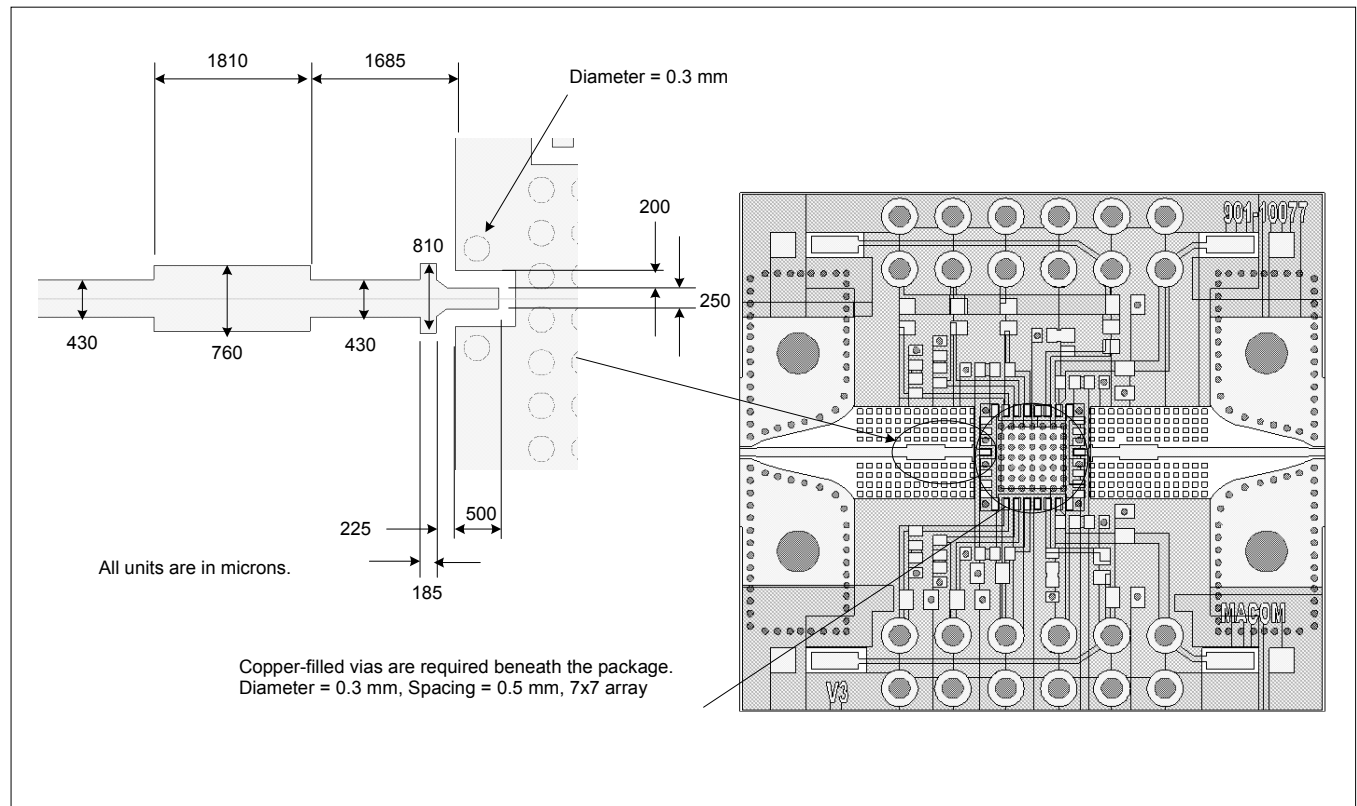
## Parts List

| Part                           | Value          | Case Style |
|--------------------------------|----------------|------------|
| C1 - C7                        | 0.01 $\mu$ F   | 0402       |
| C8 - C12                       | 1 $\mu$ F      | 0603       |
| C13 - C16                      | 10 $\mu$ F     | 0805       |
| R1 - R7                        | 10 $\Omega$    | 0402       |
| L1 - L4<br>(Chip Ferrite Bead) | BLM18HE601SN1D | 0603       |

## Sample Board Material Specifications

Top Layer: 1/2 oz Copper Cladding, 0.017 mm thickness  
Dielectric Layer: Rogers RO4003C 0.203 mm thickness  
Bottom Layer: 1/2 oz Copper Cladding, 0.017 mm thickness  
Finished overall thickness: 0.238 mm

**Sample Board Layout:** RF input and output port pre-matching circuit patterns are designed to compensate for packaging effects. Input and output match patterns are identical.



## Application Information

The MAAP-011139 is designed to be easy to use yet high performance. The ultra small size and simple bias allow easy placement on system board. RF input and output ports are DC de-coupled internally.

## Biasing conditions

Recommended biasing conditions are  $V_D = 6\text{ V}$ ,  $I_{DQ} = 2000\text{ mA}$  (controlled with  $V_G$ ). The drain bias voltage range is 3 to 6 V, and the quiescent drain current biasing range is 1500 to 2500 mA.

$V_G$  pins 10 and 11 are connected internally; choose either pin for layout convenience. Muting can be accomplished by setting the  $V_G$  to the pinched off voltage ( $V_G = -2\text{ V}$ ).

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

$V_{D3}$  pins 14 and either pin 27 or 28 are required for current symmetry. Pins 27 and 28 are connected internally; choose either pin for layout convenience.

Both  $V_{D4}$  pins 15 and 26 are required for current symmetry.

## Operating the MAAP-011139

### Turn-on

1. Apply  $V_G$  (-1.5 V).
2. Apply  $V_D$  (6.0 V typical).
3. Set  $I_{DQ}$  by adjusting  $V_G$  more positive (typically  $V_G \sim -0.9\text{ V}$  for  $I_{DQ} = 2000\text{ mA}$ ).
4. Apply  $RF_{IN}$  signal.

### Turn-off

1. Remove  $RF_{IN}$  signal.
2. Decrease  $V_G$  to -1.5 V.
3. Decrease  $V_D$  to 0 V.

## Handling Procedures

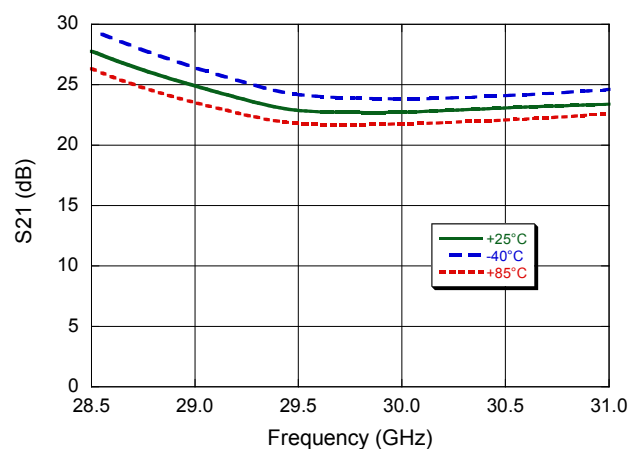
Please observe the following precautions to avoid damage:

### Static Sensitivity

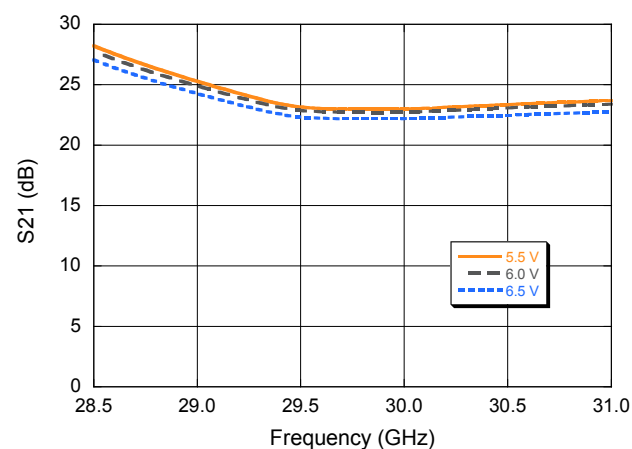
These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1A devices.

## Typical Performance Curves

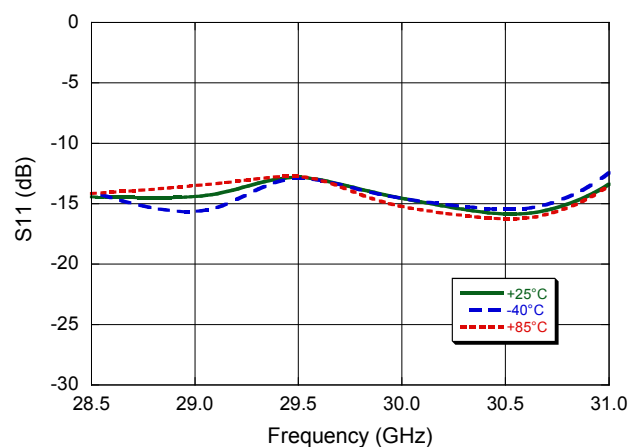
**Small Signal Gain vs. Frequency over Temperature**



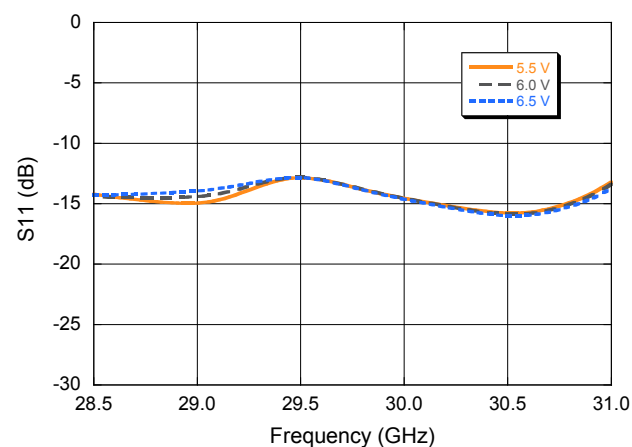
**Small Signal Gain vs. Frequency over Bias Voltage**



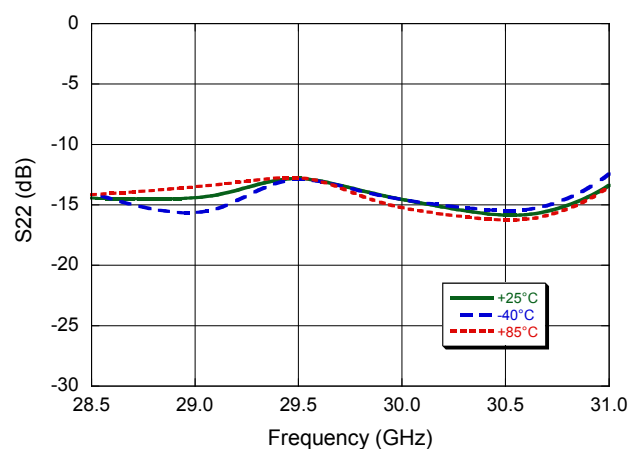
**Input Return Loss vs. Frequency over Temperature**



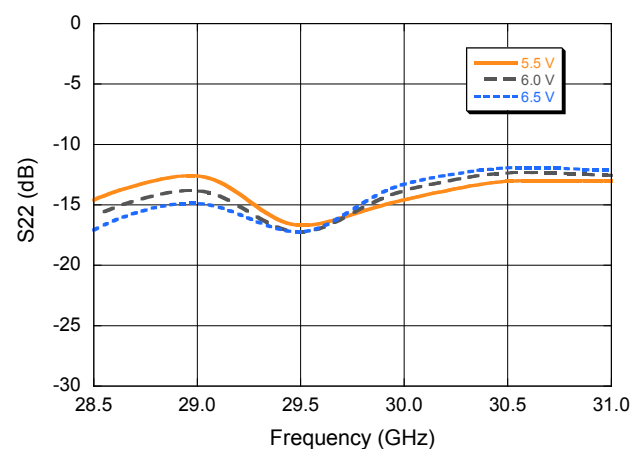
**Input Return Loss vs. Frequency over Bias Voltage**



**Output Return Loss vs. Frequency over Temperature**

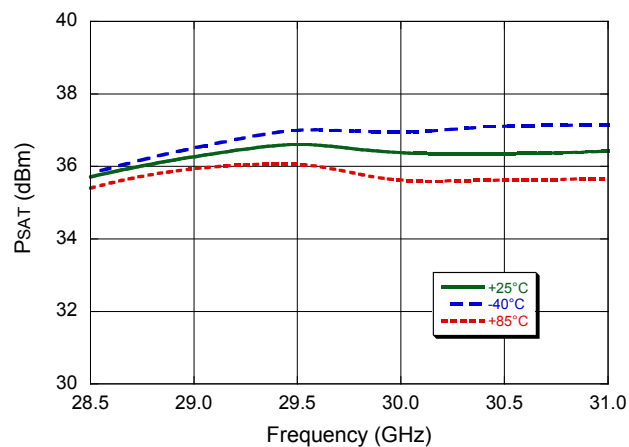


**Output Return Loss vs. Frequency over Bias Voltage**

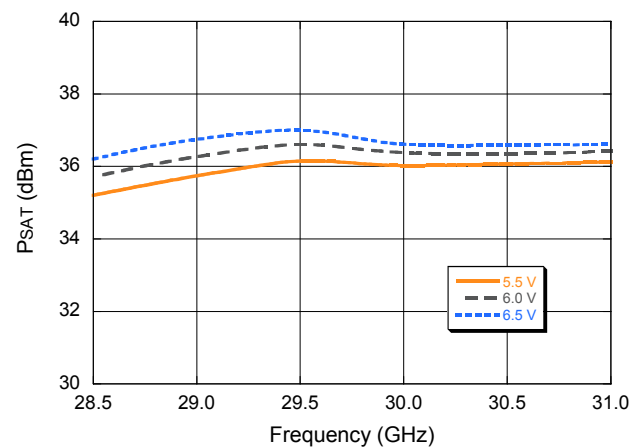


## Typical Performance Curves

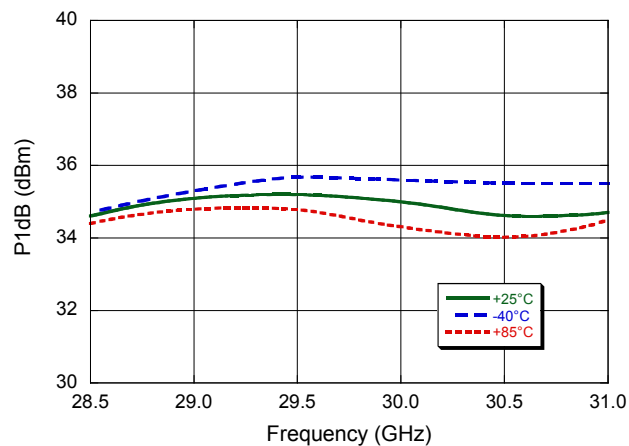
**$P_{SAT}$  vs. Frequency over Temperature**



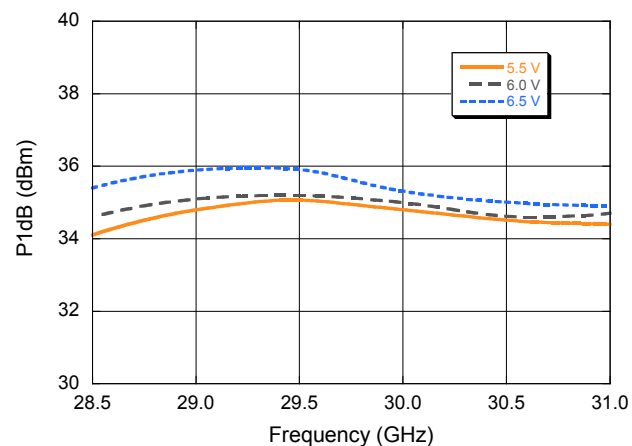
**$P_{SAT}$  vs. Frequency over Bias Voltage**



**$P1dB$  vs. Frequency over Temperature**

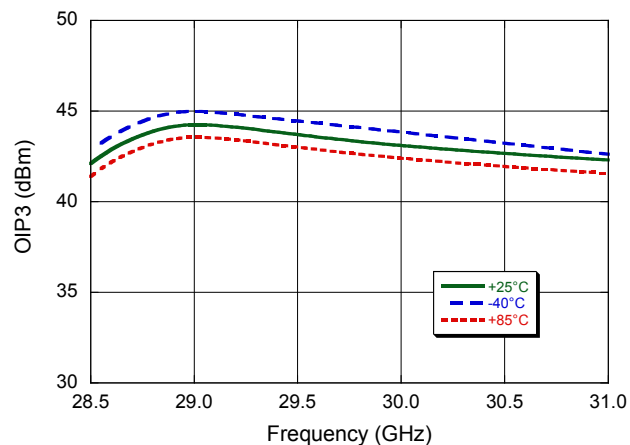


**$P1dB$  vs. Frequency over Bias Voltage**

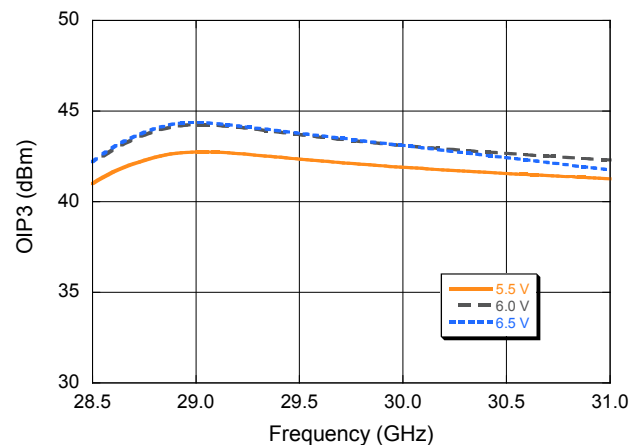


## Typical Performance Curves

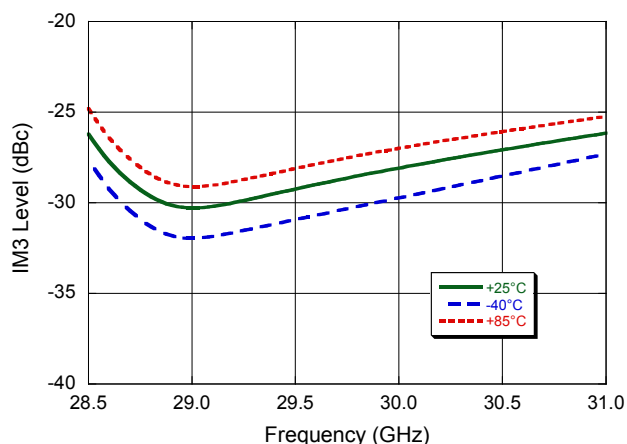
**Output IP3 over Temperature ( $P_{out}=29$  dBm/tone)**



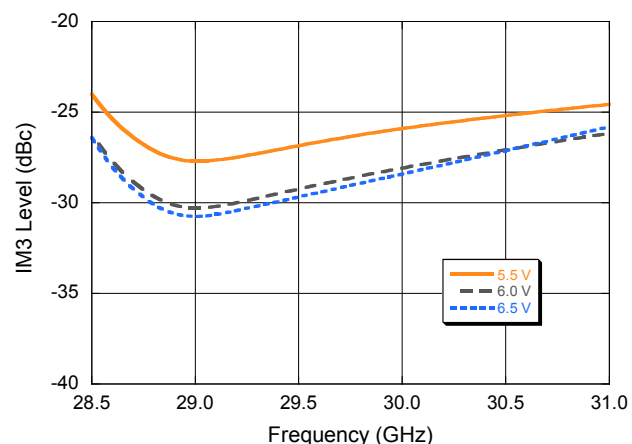
**Output IP3 over Bias Voltage ( $P_{out}=29$  dBm/Tone)**



**IM3 over Temperature ( $P_{out}=29$  dBm/tone)**



**IM3 over Bias Voltage ( $P_{out}=29$  dBm/tone)**

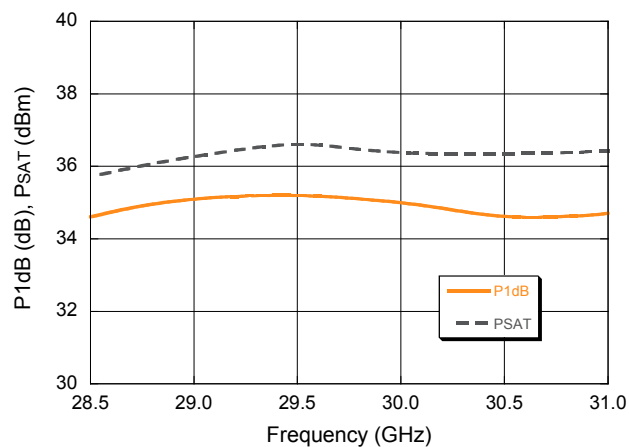


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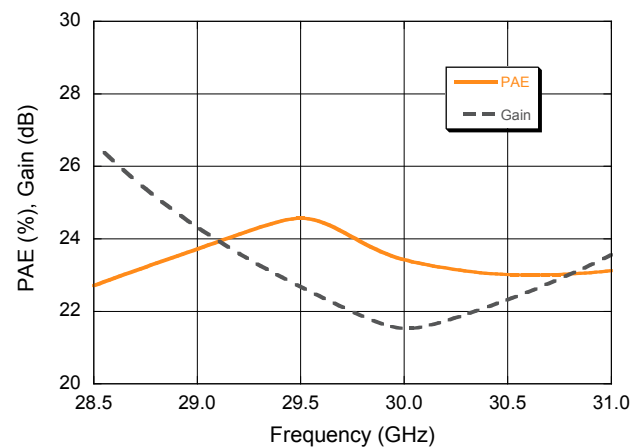
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### Typical Performance Curves

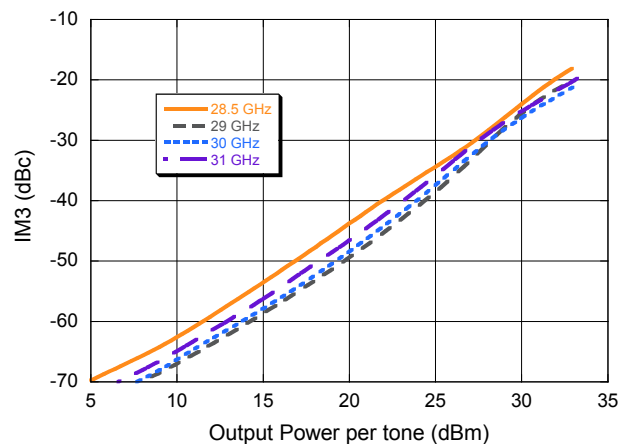
***P<sub>1dB</sub>, P<sub>SAT</sub> vs. Frequency***



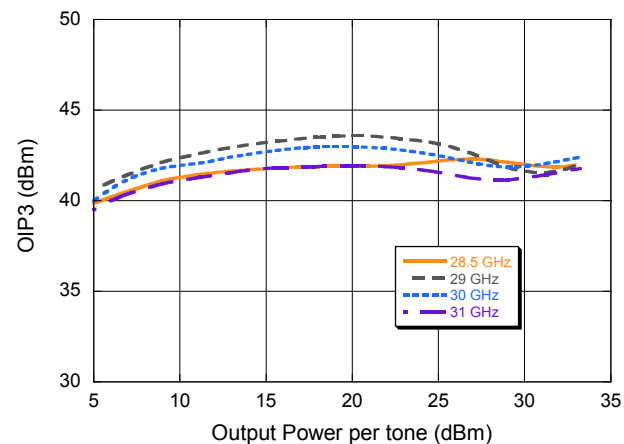
***PAE, Gain vs. Frequency***



***IM3 vs. Output Power (per tone)***

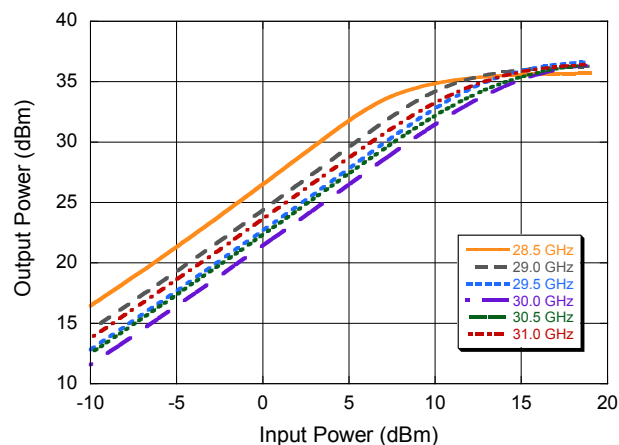


***Output IP3 vs. Output Power (per tone)***

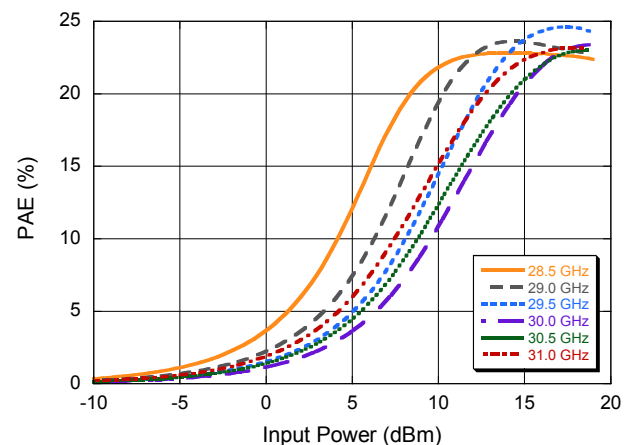


## Typical Performance Curves

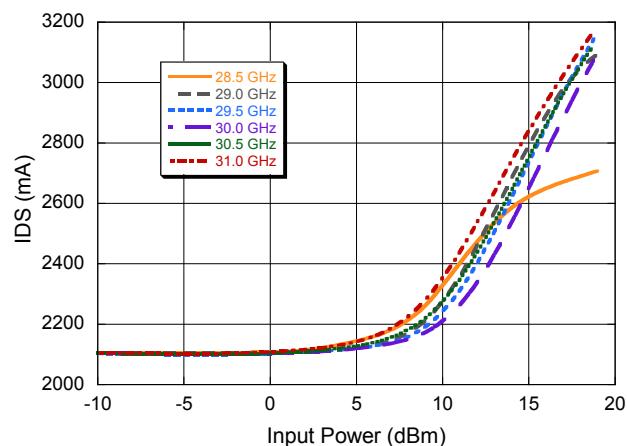
**Output Power vs. Input Power**



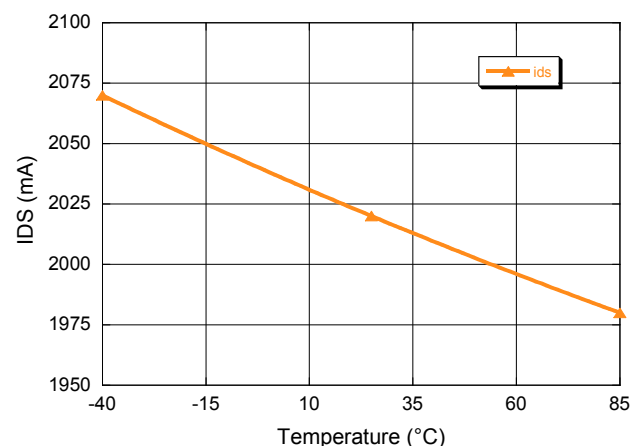
**PAE vs. Input Power**



**Bias Current vs. Input Power**



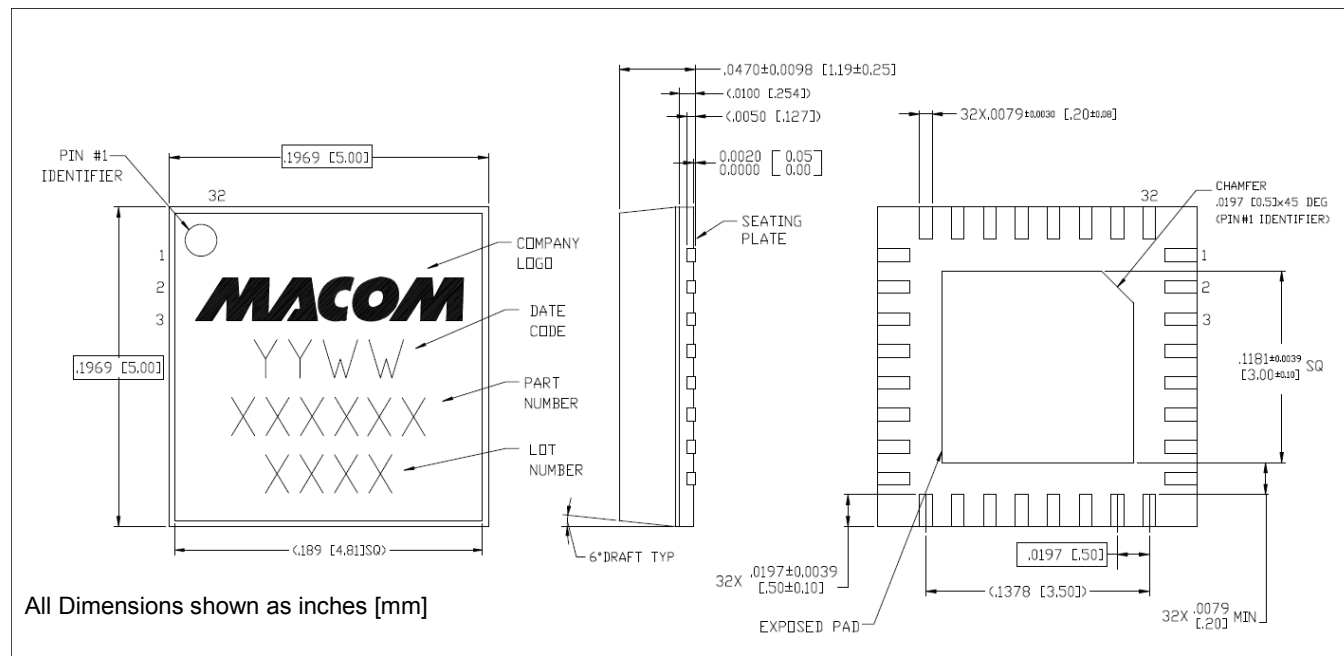
**Quiescent Drain Current vs. Temperature**



**Power Amplifier, 4 W**  
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## Lead-Free 5 mm QFN 32-Lead<sup>†</sup>



<sup>†</sup> Reference Application Note S2083 for lead-free solder reflow recommendations.  
Meets JEDEC moisture sensitivity level 3 requirements.  
Plating is NiPdAu.

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**Телефон:** +7 812 627 14 35

**Электронная почта:** [sales@st-electron.ru](mailto:sales@st-electron.ru)

**Адрес:** 198099, Санкт-Петербург,  
Промышленная ул, дом № 19, литера Н,  
помещение 100-Н Офис 331