

## Features

- Frequency Range: 32 to 38 GHz
- Small Signal Gain: 18 dB
- Saturated Power: 37 dBm
- Power Added Efficiency: 23%
- 100% On-Wafer RF and DC Testing
- 100% Visual Inspection to MIL-STD-883 Method 2010
- Bias  $V_D = 6\text{ V}$ ,  $I_D = 2.5\text{ A}$ ,  $V_G = -0.9\text{ V}$
- Dimensions: 3.09 x 5.67 x 0.05 mm

## Description

The MAAP-015016-DIE is a wideband power amplifier operating from 32 to 38 GHz, with a saturated output power of 37 dBm, 23% PAE and small signal gain of 18 dB.

The design is fully matched to 50 Ohms and includes on-chip ESD protection and integrated DC blocking caps on both I/O ports. The device is manufactured in 0.15  $\mu\text{m}$  GaAs pHEMT device technology with BCB wafer coating to enhance ruggedness and repeatability of performance.

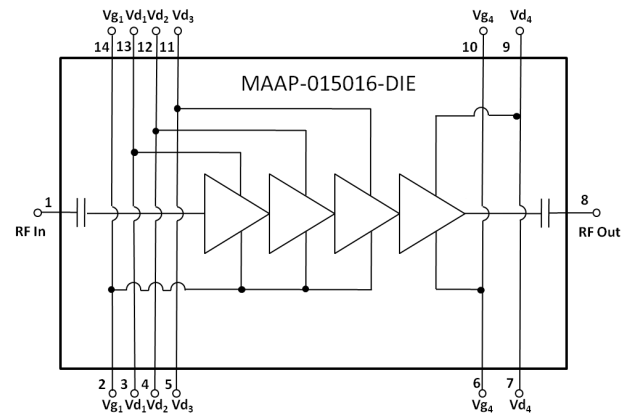
The part is well suited for Radar and Communications applications.

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

| Part Number        | Package                      |
|--------------------|------------------------------|
| MAAP-015016-DIE    | Die in Gel Pack <sup>1</sup> |
| MAAP-015016-DIEEV1 | Evaluation Module            |

1. Die quantity varies.

## Functional Diagram



## Pin Configuration<sup>2</sup>

| Pad  | Function            | Description                    |
|------|---------------------|--------------------------------|
| 1    | RF <sub>IN</sub>    | Input, matched to 50 $\Omega$  |
| 2,14 | V <sub>G1,2,3</sub> | Gate Voltage Stage 1 - 3       |
| 3,13 | V <sub>D1</sub>     | Drain Voltage Stage 1          |
| 4,12 | V <sub>D2</sub>     | Drain Voltage Stage 2          |
| 5,11 | V <sub>D3</sub>     | Drain Voltage Stage 3          |
| 6,10 | V <sub>G4</sub>     | Gate Voltage Stage 4           |
| 7,9  | V <sub>D4</sub>     | Drain Voltage Stage 4          |
| 8    | RF <sub>OUT</sub>   | Output, matched to 50 $\Omega$ |

2. Backside metal is RF, DC and thermal ground.

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

**Electrical Specifications- Pulsed Operation:**

Freq. = 32 - 38 GHz,  $T_A = +25^\circ\text{C}$ ,  $Z_0 = 50 \Omega$ , Duty Cycle = 5%, Pulse = 5  $\mu\text{s}$ ,  $P_{IN} = 20 \text{ dBm}$

| Parameter                  | Test Conditions                    | Units | Min.     | Typ. | Max. |
|----------------------------|------------------------------------|-------|----------|------|------|
| Gain                       | —                                  | dB    | —        | 18   | —    |
| Input Return Loss          | —                                  | dB    | —        | 10   | —    |
| Gain Flatness              | —                                  | dB    | —        | 1.5  | —    |
| Output Return Loss         | —                                  | dB    | —        | 14   | —    |
| Output Power at Saturation | 33.0 - 36.0 GHz<br>36.0 - 36.5 GHz | dBm   | 35<br>34 | 37   | —    |
| PAE at Saturation          | —                                  | %     | —        | 23   | —    |
| Drain Voltage              | —                                  | V     | —        | 6    | —    |
| Gate Voltage               | —                                  | V     | -1.1     | -0.9 | -0.8 |
| Drain Current              | —                                  | A     | -        | 2.5  | -    |
| Drain Current              | Under RF Drive (33.0 - 36.5 GHz)   | A     | 2        | 3.7  | 4.5  |

**Electrical Specifications - CW Operation:**

Freq. = 32 - 38 GHz,  $T_A = +25^\circ\text{C}$ ,  $Z_0 = 50 \Omega$ ,  $P_{IN} = 20 \text{ dBm}$

| Parameter                  | Test Conditions | Units | Min. | Typ. | Max. |
|----------------------------|-----------------|-------|------|------|------|
| Gain                       | —               | dB    | —    | 18   | —    |
| Gain Flatness              | —               | dB    | —    | 1.5  | —    |
| Input Return Loss          | —               | dB    | —    | 10   | —    |
| Output Return Loss         | —               | dB    | —    | 14   | —    |
| Output Power at Saturation | —               | dBm   | —    | 36.5 | —    |
| PAE at Saturation          | —               | %     | —    | 21   | —    |
| Drain Voltage              | —               | V     | —    | 6    | —    |
| Gate Voltage               | —               | V     | -1.1 | -0.9 | -0.8 |

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

| Parameter                          | Rating          |
|------------------------------------|-----------------|
| Input Power, CW, 50 Ω              | +23 dBm         |
| Drain Voltage                      | +6.5 V          |
| Gate Voltage                       | -2 to 0 V       |
| Drain Current                      | 4.5 A           |
| Gate Current                       | -20 mA to 5 mA  |
| Power Dissipation                  | 20 W            |
| Storage Temperature                | -65°C to +165°C |
| Operating Temperature              | -40°C to +85°C  |
| Channel Temperature <sup>4,5</sup> | +175°C          |

- Exceeding any one or combination of these limits may cause permanent damage to this device.
- MACOM does not recommend sustained operation near these survivability limits.
- Operating at nominal conditions with  $T_C \leq +175^\circ\text{C}$  will ensure  $\text{MTTF} > 1 \times 10^6$  hours.
- Channel Temperature ( $T_C$ ) =  $T_A + \Theta_{jc} * ((V * I) - P_{out})$   
 Typical thermal resistance ( $\Theta_{jc}$ ) = 4.3°C/W.
  - For  $T_A = 25^\circ\text{C}$ ,  
 $T_C = 90^\circ\text{C}$  @ 6 V, 2.5 A (Quiescent bias only)
  - For  $T_A = 85^\circ\text{C}$ ,  
 $T_C = 150^\circ\text{C}$  @ 6 V, 2.5 A (Quiescent bias only)

## Recommended Operating Conditions

| Parameter                      | Rating |
|--------------------------------|--------|
| Drain Voltage                  | +6 V   |
| Gate Voltage                   | -0.9 V |
| Drain Current                  | 2.5 A  |
| Drain Current (Under RF Drive) | 3.7 A  |

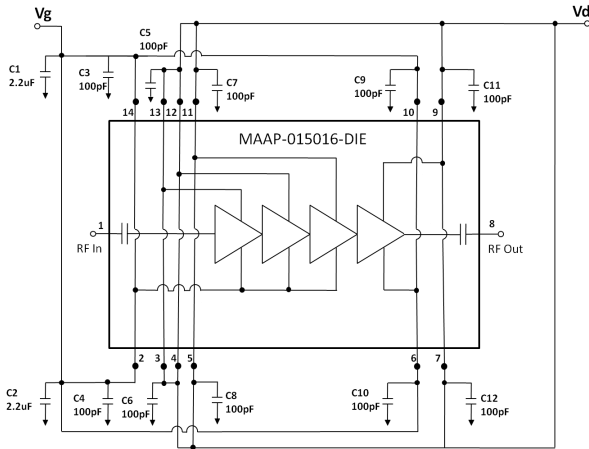
## Handling Procedures

Please observe the following precautions to avoid damage:

## Static Sensitivity

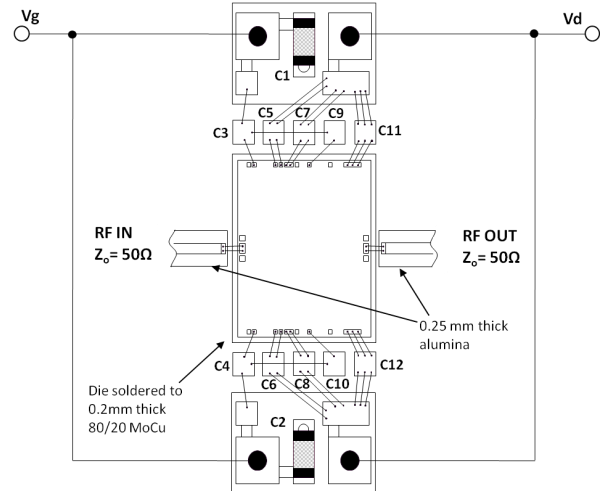
Gallium Arsenide Integrated Circuits are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM class 1B devices.

### Application Circuit<sup>4,5,6,7</sup>



4.  $V_G$  must be biased from both sides (pins 2,6,10,14).
5.  $V_D$  must be biased from both sides (pins 3,4,5,7,9,11,12,13).
6. It is recommended that bias control circuits are used at  $V_G$  and  $V_D$ . Additional bypass capacitors may also be required depending on the application, 1 to 47  $\mu\text{F}$  tantalum capacitors are commonly used here.
7. Each bias pad,  $V_G$  or  $V_D$  must have a decoupling capacitor as close to the device as possible, as is shown in the Assembly Drawing.

### Assembly Drawing



### Parts List

| Component | Value             |
|-----------|-------------------|
| C1, C2    | 2.2 $\mu\text{F}$ |
| C3 - C12  | 100 pF            |

### Operating the MAAP-015016

The MAAP-015016 is static sensitive. Please handle with care. To operate the device, follow these steps.

#### Using Up-Bias Procedure:

1. Set  $V_G$  to -1.5 V
2. Set  $V_D$  to +6 V
3. Adjust  $V_G$  positive until quiescent  $I_D$  is 2.5 A ( $\sim V_G = -0.9$ )
4. Apply RF signal to RF Input

#### Using Down-Bias Procedure:

1. Turn off RF supply
2. Reduce  $V_G$  to -1.5 V
3. Turn  $V_D$  to 0 V
4. Turn  $V_G$  to 0 V

### Biasing -

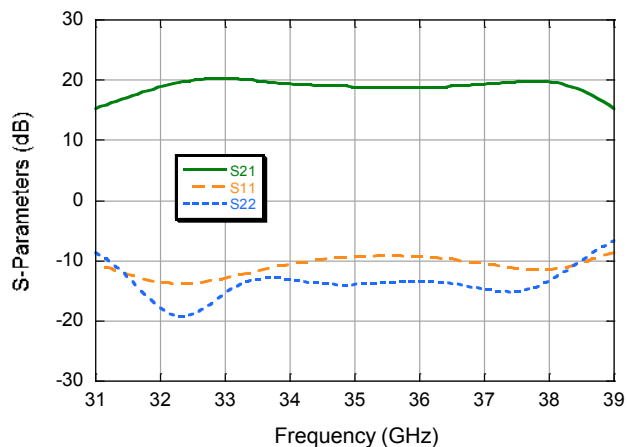
It is recommended to use active biasing to keep the currents constant as the RF power and temperature vary; this gives the most reproducible results.

### Pulse Operation -

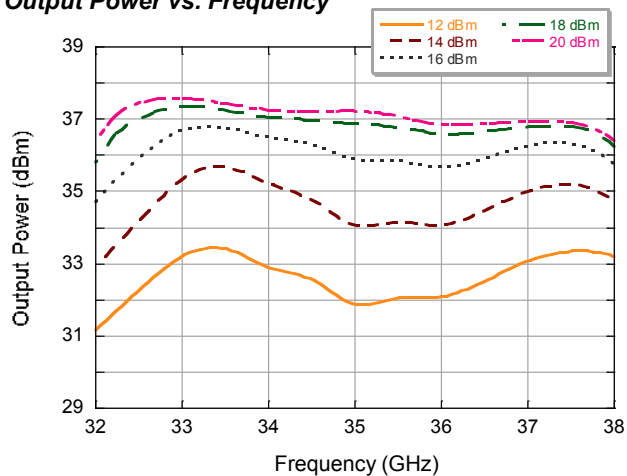
The performance of the MAAP-015016-DIE is characterized under pulsed conditions with a duty cycle of 5% consisting of a pulse width of 5  $\mu\text{s}$  applied to the drain. Under pulsed conditions the gate is constantly biased using a gate voltage directly applied to the PA. It is recommended that the die is mounted with an adequate thermal solution.

## Typical Performance Curves - Pulsed Operation

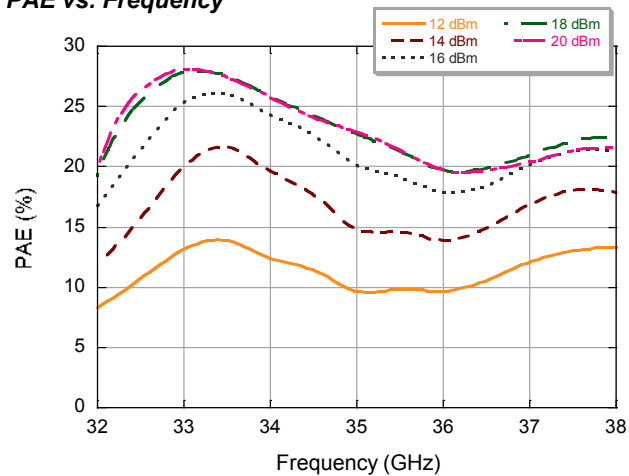
**S-Parameters vs. Frequency**



**Output Power vs. Frequency**

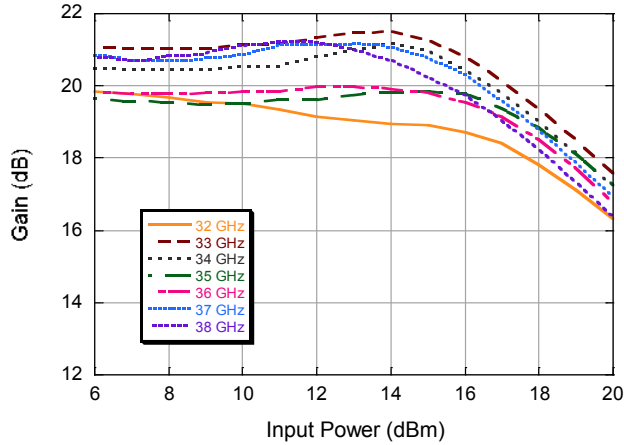


**PAE vs. Frequency**

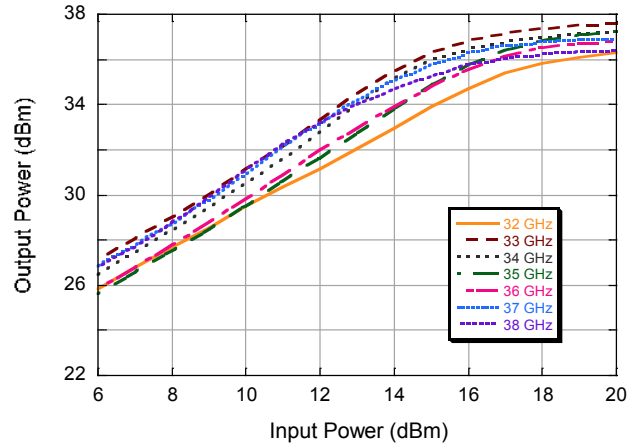


## Typical Performance Curves - Pulsed Operation

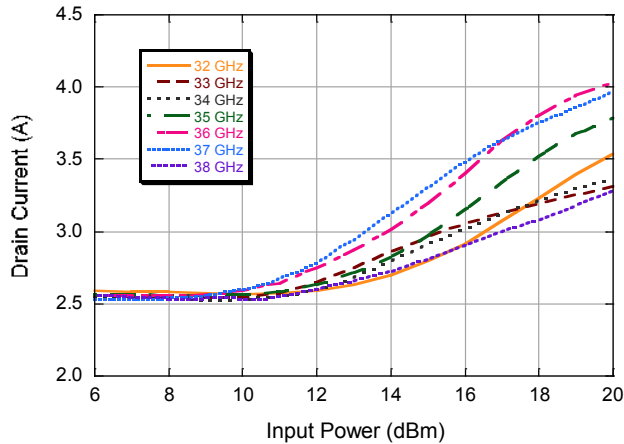
**Gain vs. Input Power**



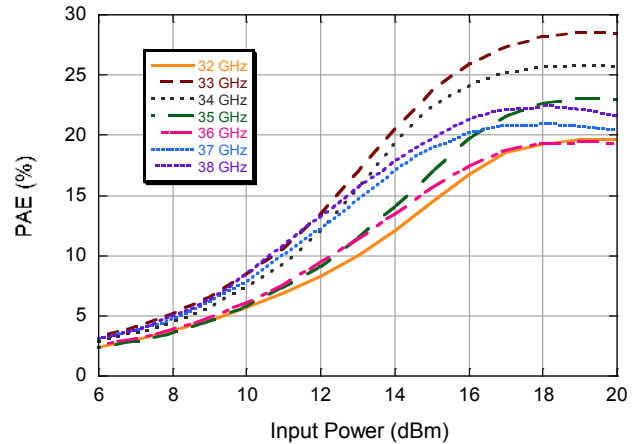
**Output Power vs. Input Power**



**Drain Current vs. Input Power**

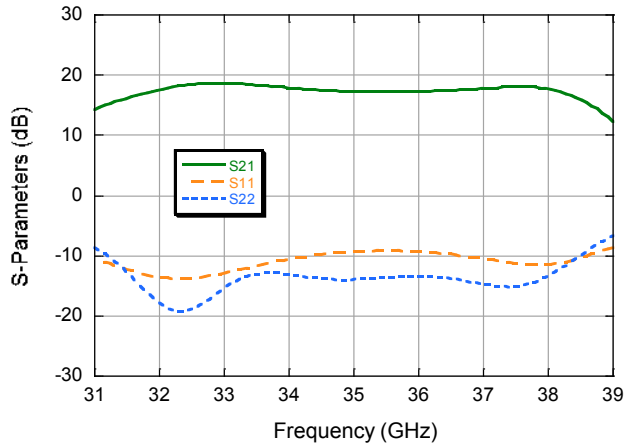


**PAE vs. Input Power**

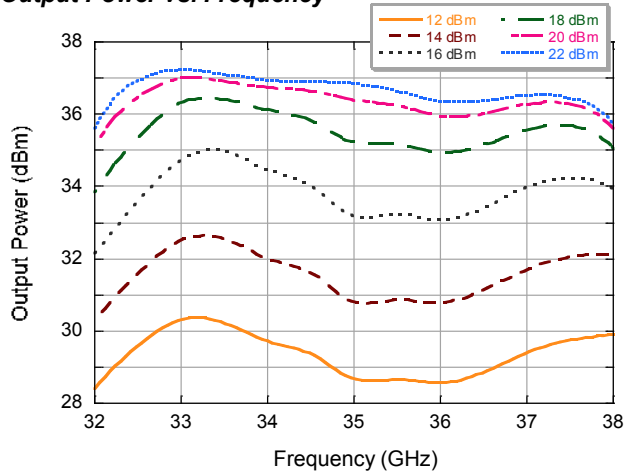


## Typical Performance Curves- CW Operation

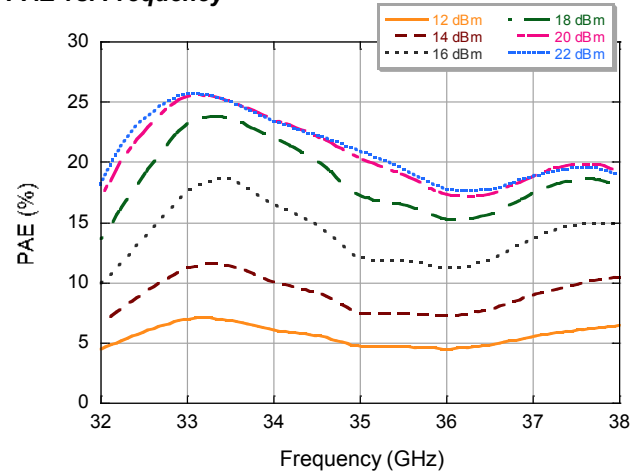
### S-Parameters vs. Frequency



### Output Power vs. Frequency

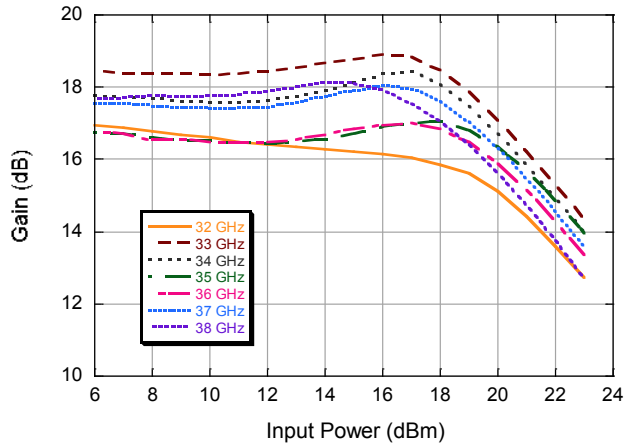


### PAE vs. Frequency

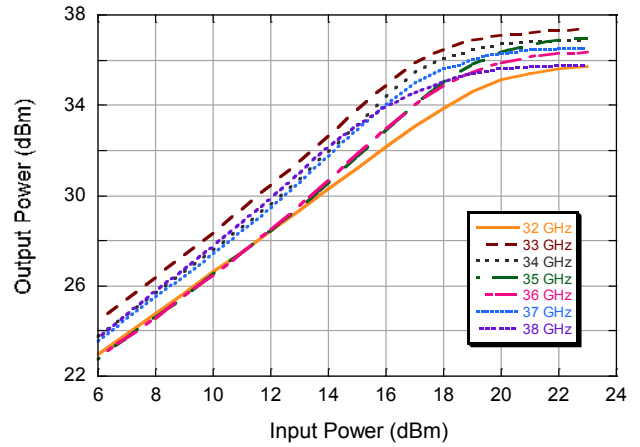


## Typical Performance Curves- CW Operation

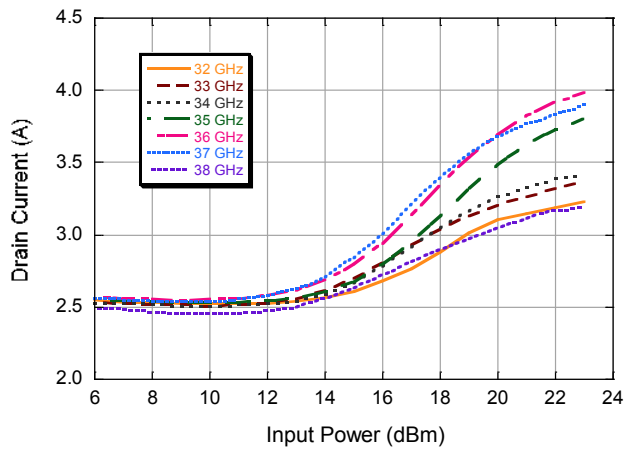
**Gain vs. Input Power**



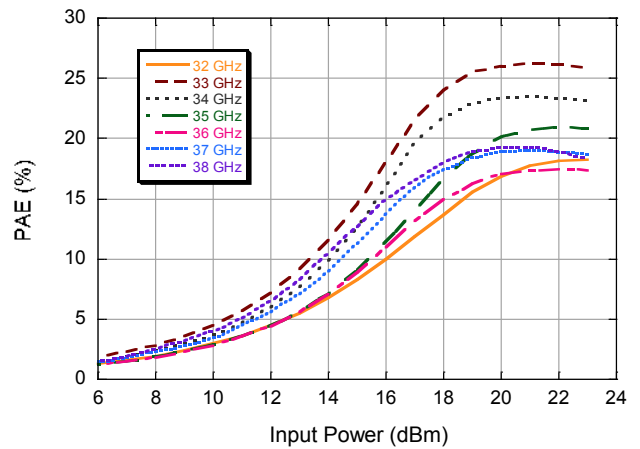
**Output Power vs. Input Power**



**Drain Current vs. Input Power**

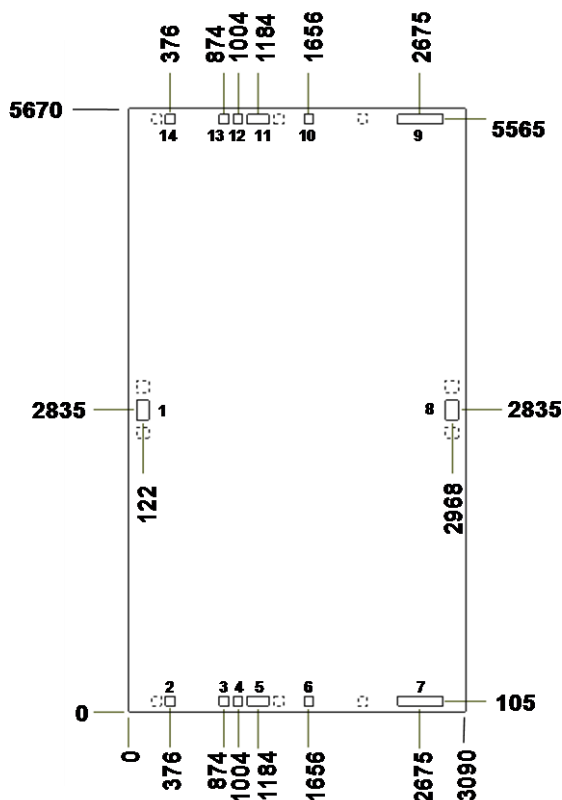


**PAE vs. Input Power**





## Die Outline



Thickness: 50 µm

Chip edge to bond pad dimensions are shown to center of pad

Ground is backside of die

| Pad  | Function             | Pad Size  | Description              |
|------|----------------------|-----------|--------------------------|
| 1    | RF <sub>IN</sub>     | 117 x 197 | Input, matched to 50 Ω   |
| 2,14 | V <sub>G</sub> 1,2,3 | 87 x 87   | Gate Voltage Stage 1 - 3 |
| 3,13 | V <sub>D</sub> 1     | 87 x 87   | Drain Voltage Stage 1    |
| 4,12 | V <sub>D</sub> 2     | 87 x 87   | Drain Voltage Stage 2    |
| 5,11 | V <sub>D</sub> 3     | 207 x 87  | Drain Voltage Stage 3    |
| 6,10 | V <sub>G</sub> 4     | 87 x 87   | Gate Voltage Stage 4     |
| 7,9  | V <sub>D</sub> 4     | 407 x 87  | Drain Voltage Stage 4    |
| 8    | RF <sub>OUT</sub>    | 117 x 197 | Output, matched to 50 Ω  |

## Applications Section

### Handling and Assembly

#### Die Attachment

This product is 0.050 mm (0.002") thick and has vias through to the backside to enable grounding to the circuit. Microstrip substrates should be brought as close to the die as possible. The mounting surface should be clean and flat. If using conductive epoxy, recommended epoxies are Abletherm 2600A, Tanaka TS3332LD, Die Mat DM6030HK or DM6030HK-Pt cured in a nitrogen atmosphere per manufacturer's cure schedule. Apply epoxy sparingly to avoid getting any on to the top surface of the die. An epoxy fillet should be visible around the total die periphery. For additional information please see the MACOM "Epoxy Specifications for Bare Die" application note.

If eutectic mounting is preferred, then a flux-less gold-tin (AuSn) preform, approximately 0.0012 thick, placed between the die and the attachment surface should be used. A die bonder that utilizes a heated collet and provides scrubbing action to ensure total wetting to prevent void formation in a nitrogen atmosphere is recommended. The gold-tin eutectic (80% Au 20% Sn) has a melting point of approximately 280°C (Note: Gold Germanium should be avoided). The work station temperature should be 310°C +/- 10°C. Exposure to these extreme temperatures should be kept to minimum. The collet should be heated, and the die pre-heated to avoid excessive thermal shock. Avoidance of air bridges and force impact are critical during placement.

#### Wire Bonding

Windows in the surface passivation above the bond pads are provided to allow wire bonding to the die's gold bond pads. The recommended wire bonding procedure uses 0.076 mm x 0.013 mm (0.003" x 0.0005") 99.99% pure gold ribbon with 0.5-2% elongation to minimize RF port bond inductance. Gold 0.025 mm (0.001") diameter wedge or ball bonds are acceptable for DC Bias connections. Aluminium wire should be avoided. Thermo-compression bonding is recommended though thermo-sonic bonding may be used providing the ultrasonic content of the bond is minimized. Bond force, time and ultrasonic's are all critical parameters. Bonds should be made from the bond pads on the die to the package or substrate. All bonds should be as short as possible.

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