

Rev. V2

#### **Features**

High Gain: 22 dB
P1dB: 24 dBm
P<sub>SAT</sub>: 24.5 dBm
Output IP3: 33 dBm
Bias Voltage: V<sub>DD</sub> = 5 V
Bias Current: I<sub>DSQ</sub> = 375 mA
50 Ω Matched Input / Output

 Temperature Compensated Output Power Detector

Die Size: 2500 x 851 x 100 μm

RoHS\* Compliant

## **Applications**

- Test & Measurement
- 5G FR2, EW, ECM
- Radar

## **Description**

The MAAP-011377-DIE is a 0.25 W distributed power amplifier offered in die form. The power amplifier operates from 20 to 55 GHz and provides 22 dB of linear gain and 24.5 dBm of saturated output power. The device is fully matched across the band and includes a temperature compensated output power detector.

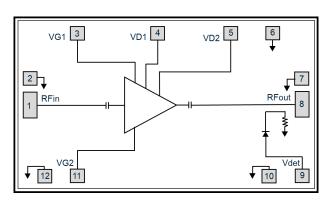
The MAAP-011377-DIE can be used as a power amplifier stage or as a driver stage in higher power applications. This device is ideally suited for test and measurement, 5G FR2, EW, ECM, and radar applications.

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

# **Ordering Information**

Part Number	Package
MAAP-011377-DIE	Bare Die

## **Functional Schematic**



# Bond Pad Configuration<sup>1</sup>

Pad #	Pad Name	Description
1	RFIN	RF Input
2,6,7,10,12	GND	Ground
3	VG1	Gate Voltage 1
4	VD1	Drain Voltage 1
5	VD2	Drain Voltage 2
8	RFOUT	RF Output
9	$V_{DET}$	Power Detector
11	VG2	Gate Voltage 2

Backside of die must be connected to RF, DC and thermal ground.

<sup>\*</sup> Restrictions on Hazardous Substances, compliant to current RoHS EU directive.



Rev. V2

# Electrical Specifications: $T_A = +25$ °C, $V_D = 5$ V, $I_{DSQ} = 375$ mA, $Z_0 = 50$ $\Omega$

Parameter	Test Conditions	Units	Min.	Тур.	Max.
Gain	P <sub>IN</sub> = -10 dBm 20.0 GHz 30.0 GHz 40.0 GHz 48.5 GHz 55.0 GHz	dB	18.5 — 19.5 19.5 —	21.0 20.0 23.0 23.0 21.0	_
Input Return loss	_	dB	_	10	_
Output Return Loss	_	dB	_	10	_
P1dB	20.0 GHz 30.0 GHz 40.0 GHz 48.5 GHz 55.0 GHz	dBm	22.5 — 23.75 22.0 —	23.5 24.0 25.0 24.0 19.0	_
P <sub>SAT</sub>	20.0 GHz 30.0 GHz 40.0 GHz 48.5 GHz 55.0 GHz	dBm	_	24.5 24.5 24.5 25.0 21.0	_
OIP3	P <sub>OUT</sub> /Tone = 14 dBm, Δf = 2 MHz	dBm	_	33	_
Drain Current	P <sub>SAT</sub> , 40 GHz	mA	_	450	_
Power Added Efficiency	P <sub>SAT</sub> , 40 GHz	%	_	10	_

# **Maximum Operating Ratings**

Parameter	Rating
Input Power	10 dBm
Drain Voltage	5.5 V
Junction Temperature <sup>2,3</sup>	+160°C
Operating Temperature	-40°C to +85°C

- 2. Operating at nominal conditions with junction temperature
- ≤ +160°C will ensure MTTF > 1 x 10<sup>6</sup> hours.
   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>) = 13°C/W
  - a) For T<sub>C</sub> = +25°C at the backside of the die T<sub>J</sub> = 49°C @ 5 V, 425 mA,  $P_{OUT} = 24.5 \text{ dBm}, P_{IN} = 5 \text{ dBm}$
  - b) For  $T_C = +85^{\circ}C$  at the backside of the die  $T_J = 110^{\circ}C @ 5 V, 425 mA,$  $P_{OUT} = 23 \text{ dBm}, P_{IN} = 5 \text{ dBm}$

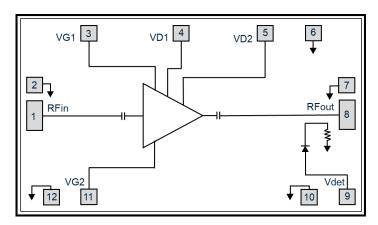
# **Absolute Maximum Ratings**<sup>4,5</sup>

Parameter	Absolute Maximum	
Input Power	17 dBm	
Drain Voltage	6.5 V	
Gate Voltage	-3 to 0 V	
Junction Temperature <sup>6</sup>	+175°C	
Storage Temperature	-65°C to +125°C	

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

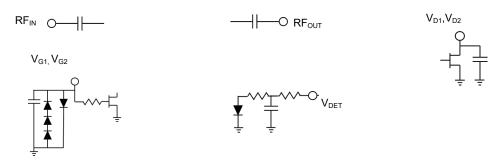


# **Pin Configuration and Functional Descriptions**



Pin#	Pin Name	Description
1	RF <sub>IN</sub>	RF Signal Input. This pad is matched to 50 $\Omega$ and is AC coupled.
2,6,7,10,12	GND	These pads are grounded on the MMIC.
3,11	$V_{G1}, V_{G2}$	Power amplifier gate controls. Adjust $V_{\rm G}$ from $-2$ V to 0 V to achieve the desired quiescent current. External bypass capacitors are required as described in the applications schematic. There is an internal connection between pads 3 & 11 and so only one pin needs to be externally connected to the gate voltage.
4	$V_{D1}$	Drain bias 1 for the amplifier. External bypass capacitors are required as described in the applications schematic. There is no internal connection between pads 4 and 5 and so both of the pins need to be externally connected to the drain supply.
5	$V_{D2}$	Drain bias 2 for the amplifier. External bypass capacitors are required as described in the applications schematic. There is no internal connection between pads 4 and 5 and so both of the pins need to be externally connected to the drain supply.
8	RF <sub>OUT</sub>	RF Signal Output. This pad is matched to 50 $\Omega$ and is AC coupled
9	$V_{DET}$	Power detector output voltage. There is an internal $5k\Omega$ resistor on this pin.

# **Interface Schematics**





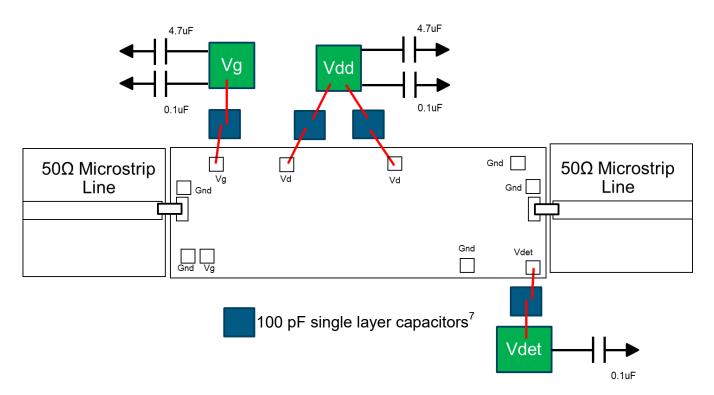
Rev. V2

## **Recommended Bonding Diagram and Application Details:**

For optimum performance, RF input and output transmission lines require either 3 mil gold ribbon (wedge bond) or 3 x 1 mil diameter gold wire bonds. The gap between the MMIC and the RF input and output lines should be a nominal 3mil.

In the configuration shown below 100 pF chip capacitors are used as part of the drain supply bypassing network. These chip capacitors are to be placed as close to the die as practically possible. The larger 0.1  $\mu$ F capacitor could be implemented using an SMT component on a PCB instead of a chip cap: in this case, proximity to the MMIC die is less important. The circuit is not sensitive to the positioning of the 4.7  $\mu$ F capacitors however these should be on the same PCB as the rest of the biasing components.

The capacitors on the detector output are optional: values will depend on the required response time of the detector output. There is an internal series  $5 \text{ k}\Omega$  resistor on this pin.



7. For the 100 pF single layer capacitors use MACOM MKVC-050100-1453.

# Power Amplifier, 0.25 W 20 - 55 GHz



MAAP-011377-DIE

Rev. V2

## **Biasing Conditions**

Recommended biasing conditions are  $V_D = 5$  V,  $I_{DQ} = 375$  mA (controlled with  $V_G$ ). The drain bias voltage range is 4 to 5.5 V, and the quiescent drain current biasing range is 325 to 425 mA.

## **Operating the MAAP-011377-DIE**

#### Turn-on

- 1. Apply V<sub>G</sub> (-2 V).
- 2. Apply V<sub>D</sub> (5 V typical).
- 3. Set  $I_{DQ}$  by adjusting  $V_G$  more positive (typically -0.9 to -1.0 V for  $I_{DQ}$  = 375 mA).
- 4. Apply RF<sub>IN</sub> signal.

#### Turn-off

- 1. Remove RF<sub>IN</sub> signal.
- 2. Decrease V<sub>G</sub> to -2 V.
- 3. Decrease V<sub>D</sub> 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.

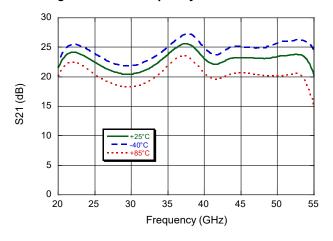
## Handling the Die

This MMIC has fragile exposed airbridges on its surface and must be handled on the edges only using a vacuum collet or suitable tweezers. Do not touch the surface of the chip with a vacuum collet, tweezers, or fingers.

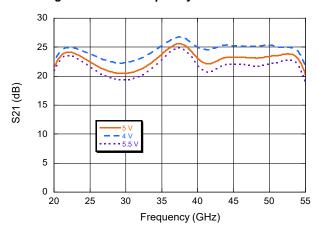


# Typical Performance Curves: $V_D = 5 V$ , $I_{DSQ} = 375 mA$

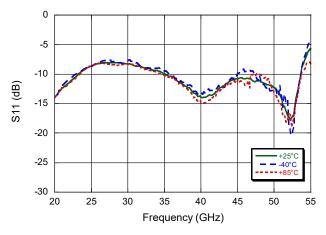
## Small Signal Gain vs. Frequency



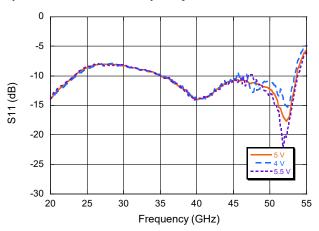
## Small Signal Gain vs. Frequency



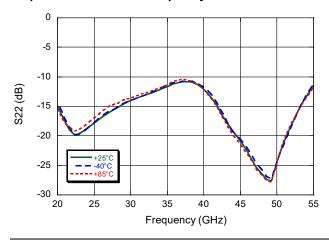
## Input Return Loss vs. Frequency



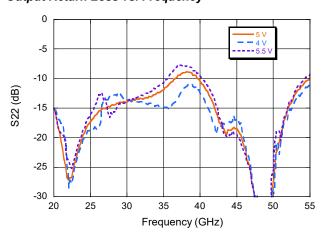
#### Input Return Loss vs. Frequency



#### Output Return Loss vs. Frequency



#### Output Return Loss vs. Frequency



6

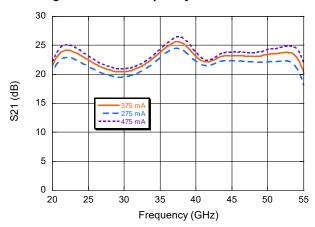
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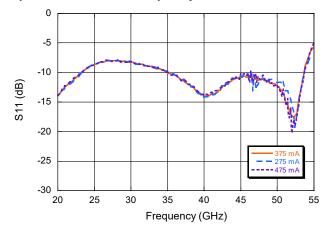


# Typical Performance Curves: $V_D = 5 V$

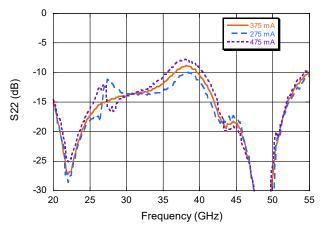
## Small Signal Gain vs. Frequency



## Input Return Loss vs. Frequency



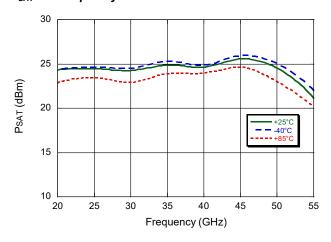
## Output Return Loss vs. Frequency



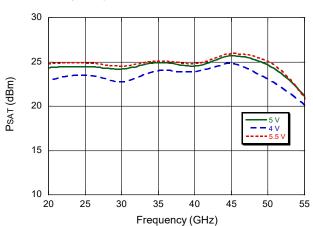


# Typical Performance Curves: $V_D = 5 V$ , $I_{DSQ} = 375 mA$

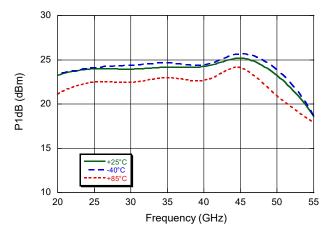
#### P<sub>SAT</sub> vs. Frequency



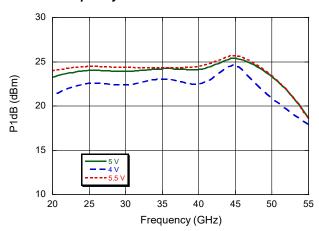
#### P<sub>SAT</sub> vs. Frequency



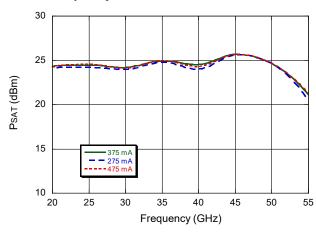
P1dB vs. Frequency



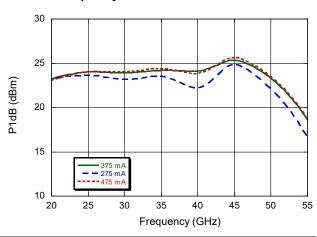
P1dB vs. Frequency



P<sub>SAT</sub> vs. Frequency



P1dB vs. Frequency



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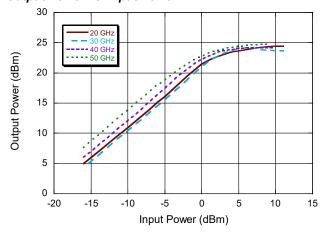
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8

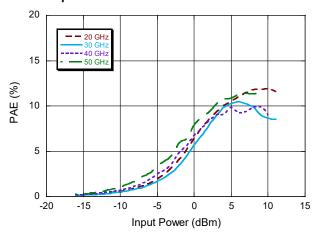


# Typical Performance Curves: V<sub>D</sub> = 5 V, I<sub>DSQ</sub> = 375 mA

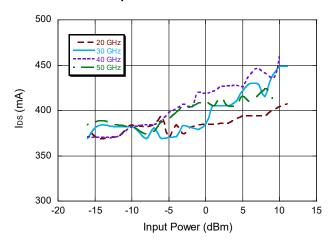
#### Output Power vs. Input Power



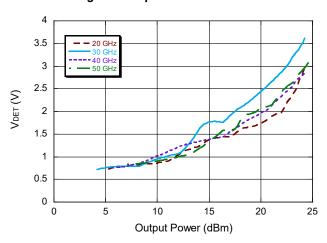
#### PAE vs. Input Power



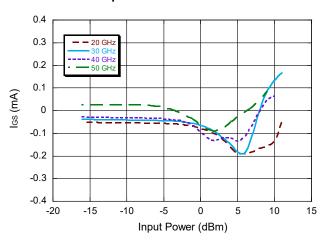
#### Drain Current vs. Input Power



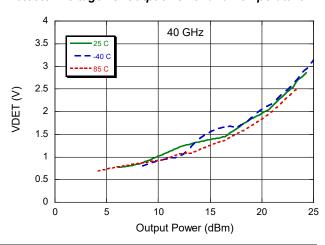
#### Detector Voltage vs. Output Power



#### Gate Current vs. Input Power



#### Detector Voltage vs. Output Power and Temperature



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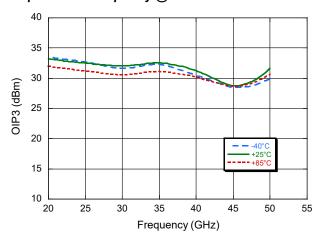
9



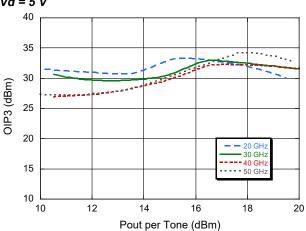
Rev. V2

# Typical Performance Curves: $V_D = 5 V$ , $I_{DSQ} = 375 mA$

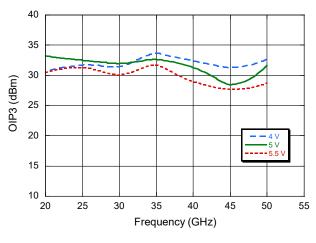
Output IP3 vs. Frequency @ Pout = 16 dBm / Tone



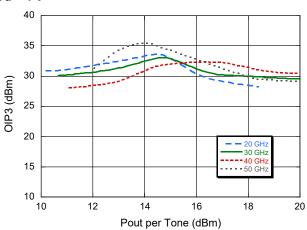
Output IP3 vs. Frequency and Pout per Tone Vd = 5 V



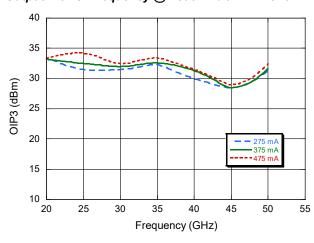
Output IP3 vs. Frequency @ Pout = 16 dBm / Tone



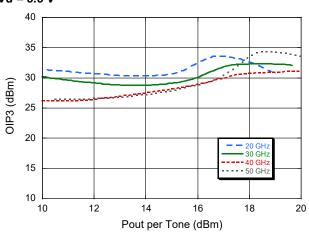
Output IP3 vs. Frequency and Pout per Tone Vd = 4 V



Output IP3 vs. Frequency @ Pout = 16 dBm / Tone



Output IP3 vs. Frequency and Pout per Tone Vd = 5.5 V



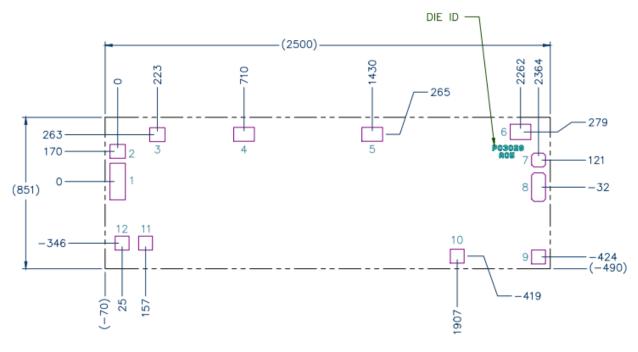
10

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## **Die Dimensions**



Units are in microns with a tolerance of  $\pm 5~\mu m$ , except for die exterior dimensions which are street-center-to-street-center – nominal saw or laser kerf ~  $25~\mu m$  tolerance each dimension. Pad and backside metal is gold. Die thickness is  $100~\pm~10~\mu m$ .

# Pad Dimensions (µm)

Pad#	X	Y
1	86	206
2,3	86	78
4,5,6	116	78
7	78	78
8	78	160
9,10,11,12	78	78

# Power Amplifier, 0.25 W 20 - 55 GHz



**MAAP-011377-DIE** 

Rev. V2

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