

## Low Noise Amplifier DC - 28 GHz

Rev. V3

### Features

- Ultra Wideband Performance
- Noise Figure: 1.4 dB @ 8 GHz
- High Gain: 17 dB @ 8 GHz
- Output IP3: 28 dBm @ 8 GHz
- Bias Voltage:  $V_{DD} = 5 - 6$  V
- Bias Current:  $I_{DSQ} = 60 - 100$  mA
- 50  $\Omega$  Matched Input / Output
- Positive Voltage Only
- Die Size: 2.99 x 1.5 x 0.1 mm
- RoHS\* Compliant

### Description

The MAAL-011141-DIE is an easy to use, wideband low noise distributed amplifier die. It operates from DC to 28 GHz and provides 17 dB of linear gain, 16 dBm of P1dB and 1.4 dB of noise figure at 8 GHz. The input and output are fully matched to 50  $\Omega$  with typical return loss >15 dB.

This amplifier employs an active termination circuit to achieve a lower noise figure at the lower end of the frequency range than is possible using traditional resistive termination techniques.

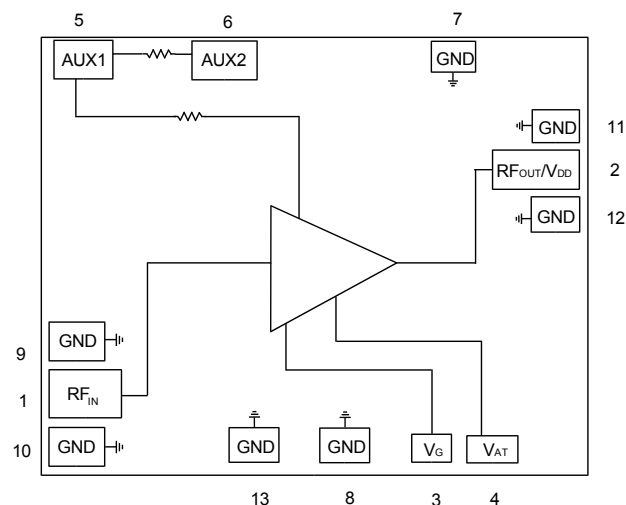
This product is fabricated using a GaAs pHEMT process which features full passivation for enhanced reliability.

The MAAL-011141-DIE can be used as a low noise amplifier stage or as a driver stage in higher power applications. This device is ideally suited for Test and Measurement, EW, ECM, and Radar applications.

### Ordering Information

| Part Number        | Package                 |
|--------------------|-------------------------|
| MAAL-011141-DIE    | gel pack                |
| MAAL-011141-DIESMB | wafer evaluation module |

### Functional Schematic<sup>1</sup>



1. Image not to scale.

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

| Pin # | Pin Name                            | Description                    |
|-------|-------------------------------------|--------------------------------|
| 1     | RF <sub>IN</sub>                    | RF Input                       |
| 2     | RF <sub>OUT</sub> / V <sub>DD</sub> | RF Output / Drain Voltage      |
| 3     | V <sub>G</sub>                      | Gate Voltage                   |
| 4     | V <sub>AT</sub>                     | Active Termination Voltage     |
| 5     | AUX1                                | Auxiliary Drain Voltage 1      |
| 6     | AUX2                                | Auxiliary Drain Voltage 2      |
| 7-13  | GND                                 | DC + RF Ground to Backside Via |

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

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

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**Electrical Specifications:  $T_A = +25^\circ\text{C}$ ,  $V_{DD} = 6\text{ V}$ ,  $I_{DSQ} = 75\text{ mA}$ ,  $V_{AT} = 5\text{ V}$ ,  $Z_0 = 50\ \Omega$**

| Parameter          | Test Conditions                                                                                                 | Units | Min.                        | Typ.                                 | Max.                      |
|--------------------|-----------------------------------------------------------------------------------------------------------------|-------|-----------------------------|--------------------------------------|---------------------------|
| Gain               | $P_{IN} = -20\text{ dBm}$<br>2.0 GHz<br>8.0 GHz<br>12.0 GHz<br>18.0 GHz<br>26.5 GHz                             | dB    | 16.5<br>—<br>15.0<br>—<br>— | 18.5<br>17.0<br>17.0<br>17.0<br>17.0 | —                         |
| Output P1dB        | 2.0 GHz<br>8.0 GHz<br>12.0 GHz<br>18.0 GHz<br>26.5 GHz                                                          | dBm   | —                           | 17.0<br>16.0<br>16.0<br>15.0<br>12.5 | —                         |
| OIP3               | $P_{IN} = -20\text{ dBm}$ / tone, 10 MHz Tone Spacing<br>2.0 GHz<br>8.0 GHz<br>12.0 GHz<br>18.0 GHz<br>26.5 GHz | dBm   | —                           | 29.5<br>28.0<br>26.5<br>26.0<br>22.5 | —                         |
| Input Return Loss  | $P_{IN} = -20\text{ dBm}$                                                                                       | dB    | —                           | 15                                   | —                         |
| Output Return Loss | $P_{IN} = -20\text{ dBm}$                                                                                       | dB    | —                           | 15                                   | —                         |
| Noise Figure       | 2.0 GHz<br>8.0 GHz<br>12.0 GHz<br>18.0 GHz<br>26.5 GHz                                                          | dB    | —                           | 2.5<br>1.4<br>1.6<br>2.4<br>4.0      | 3.0<br>—<br>2.2<br>—<br>— |
| Isolation          | $P_{IN} = -20\text{ dBm}$<br>2.0 GHz<br>8.0 GHz<br>12.0 GHz<br>18.0 GHz<br>26.5 GHz                             | dB    | —                           | 60<br>40<br>37<br>33<br>32           | —                         |
| $V_G$              | Adjusted to set $I_{DSQ} = 75\text{ mA}$                                                                        | V     | —                           | 0.7                                  | —                         |
| $I_{AT}$           | $V_{AT} = 5\text{ V}$                                                                                           | mA    | —                           | 10                                   | —                         |

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### Operating Conditions

Recommended biasing conditions are  $V_{DD} = 6\text{ V}$ ,  $I_{DSQ} = 75\text{ mA}$ . Bias of 5 V must be applied to  $V_{AT}$  pin.  $I_{DSQ}$  is set by adjusting  $V_G$  after setting  $V_{DD}$  and  $V_{AT}$ . The drain bias voltage range,  $V_{DD}$ , is 5 to 6 V, and the quiescent drain current biasing is 60 to 100 mA. To maintain the best performance MACOM recommends using an active bias circuit for constant  $I_{DD}$ .

There are three possible bias methods:

1. The use of an external bias tee where the required  $V_{DD}$  is applied at  $RF_{OUT}/V_{DD}$  and  $V_G$  is set to provide a current bias ( $I_{DSQ}$ ) of 60 to 100 mA. This provides wide band performance of DC - 28 GHz (depending on the bandwidth of the bias tee).
2. The direct application of  $V_{DD}$  to AUX1. Using this method provides for an operational frequency of 2 - 28 GHz. However, a voltage drop across an internal 17  $\Omega$  resistance must be accounted for. For example, with  $I_{DSQ} = 75\text{ mA}$ , 7.3 V must be applied at AUX1 for a  $V_{DD}$  of 6 V.
3. The direct application of  $V_{DD}$  to AUX2. Using this method provides for an operational frequency of DC - 28 GHz. However, a voltage drop across series 17  $\Omega$  and 32  $\Omega$  resistors must be accounted for. For example, with  $I_{DSQ} = 75\text{ mA}$ , 9.67 V must be applied at AUX2 for a  $V_{DD}$  of 6 V.

In all cases DC blocking is required on the RF input. Additionally options 2 or 3 require DC blocking on the RF output line. It should also be noted that when using the internal bias circuit (option 2 or 3)  $I_{DSQ}$  is limited to a maximum of 80 mA.

Regardless of bias method used, 2 bypass capacitors of 100 pF and 0.1  $\mu\text{F}$  should be connected to AUX2. This provides for increased device stability margins and improved gain flatness below 2 GHz when required. The 100 pF cap is a single layer chip capacitor and should be positioned as close to the device as possible. The 0.1  $\mu\text{F}$  SMT cap can be placed further away on the PCB.

The available evaluation board is configured for bias option 3 using AUX2 for the supply of  $V_{DD}$ .

### Maximum Operating Conditions

| Parameter                         | Operating Maximum                           |
|-----------------------------------|---------------------------------------------|
| Input Power <sup>3</sup>          | $P_{IN} \leq 1\text{ dB compression level}$ |
| Junction Temperature <sup>4</sup> | +150°C                                      |
| Operating Temperature             | -40°C to +85°C                              |

3. MACOM does not recommend sustained operation at power levels above 1 dB gain compression.
4. Operating at nominal conditions with junction temperature  $\leq +150^\circ\text{C}$  will ensure MTTF >  $1 \times 10^6$  hours.

### Absolute Maximum Ratings<sup>5,6</sup>

| Parameter                         | Absolute Maximum |
|-----------------------------------|------------------|
| Input Power                       | 18 dBm           |
| Drain Voltage                     | 7 V              |
| Gate Voltage                      | 0.9 V            |
| Active Termination Voltage        | 6 V              |
| AUX1 Current                      | 80 mA            |
| AUX2 Current                      | 80 mA            |
| Junction Temperature <sup>7</sup> | +175°C           |
| Storage Temperature               | -65°C to +125°C  |

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

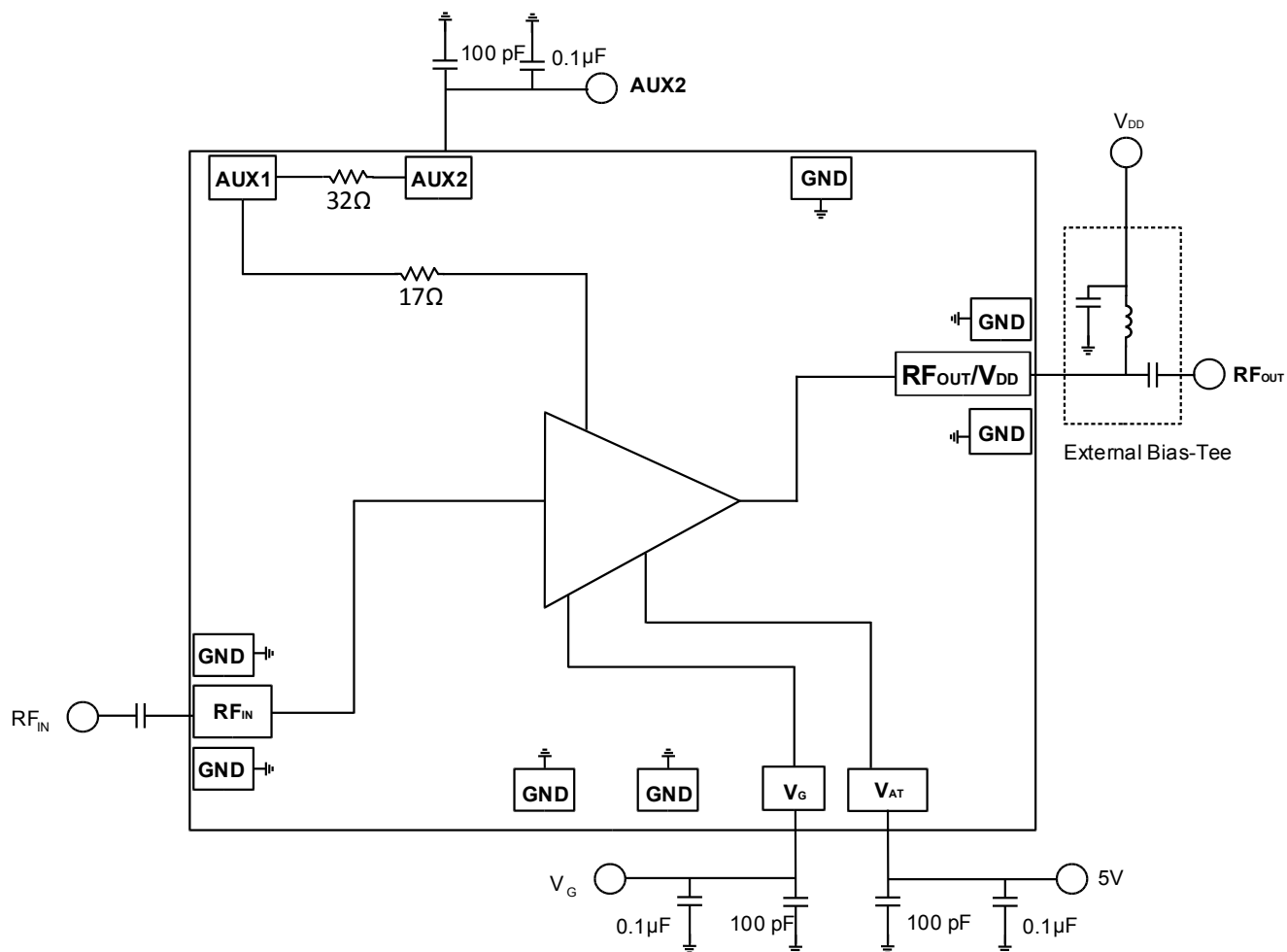
### Handling Procedures

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.

## Application Schematic





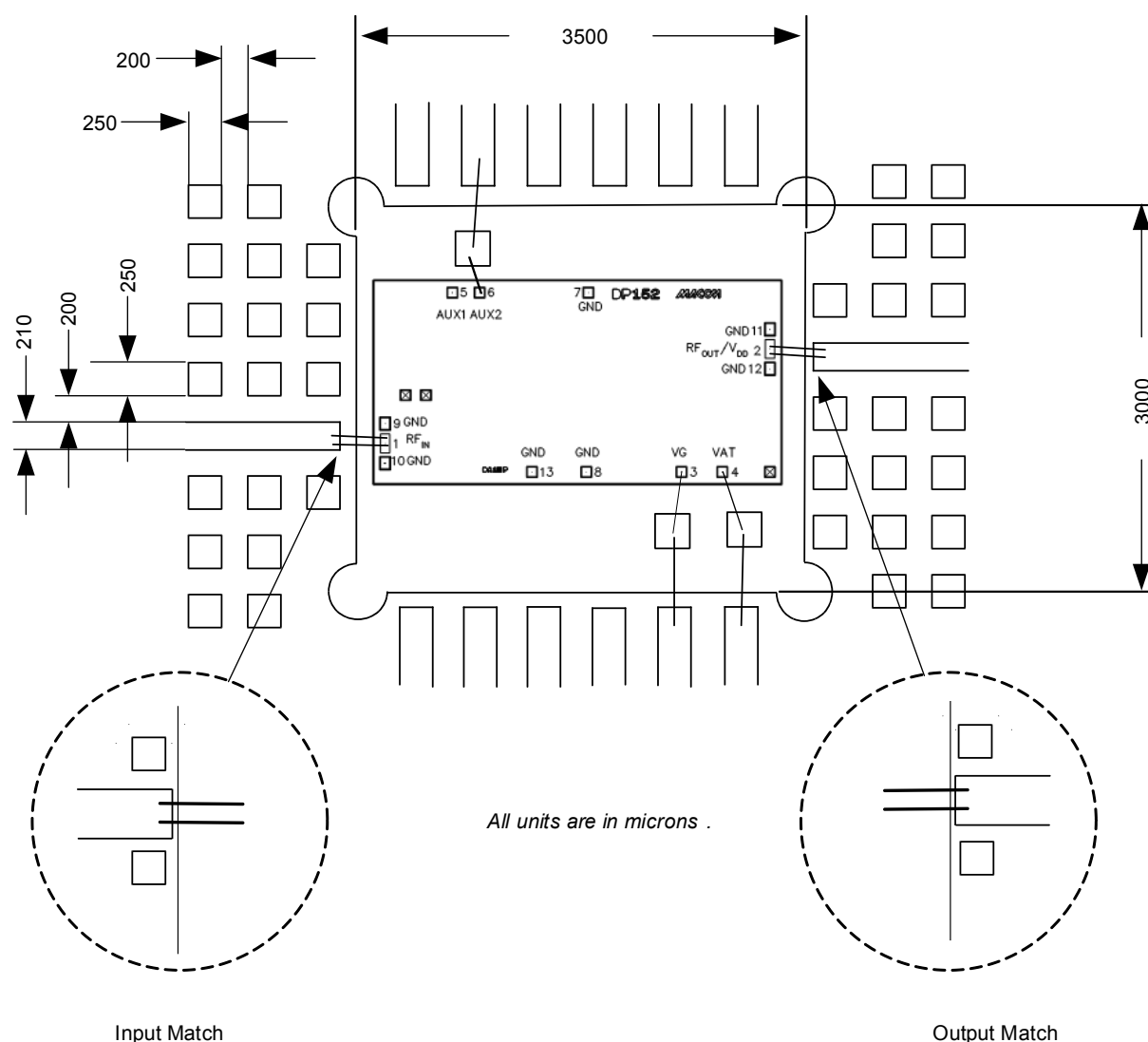
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| Part    | Value       | Case Style   |
|---------|-------------|--------------|
| C1 - C3 | 0.1 $\mu$ F | 0402         |
| C4 - C6 | 100 pF      | Single Layer |

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 & PCB Layout

RF input and output port matching circuit patterns are designed to compensate for bonding wires. Input and output matching are identical.



## Evaluation PCB Specifications

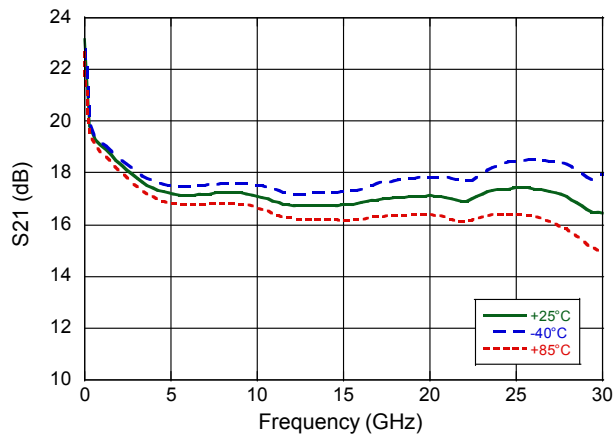
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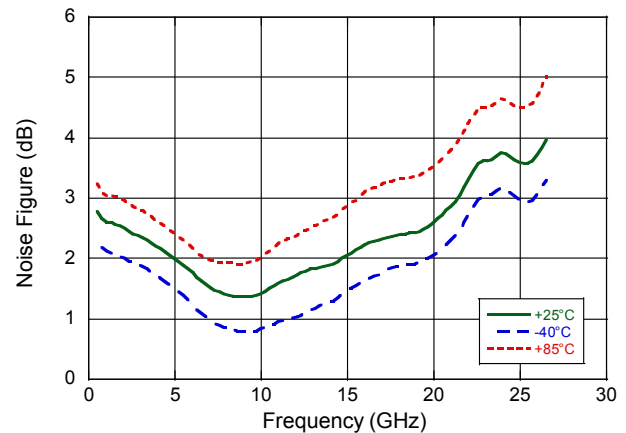
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Typical Performance Curves:  $V_{DD} = 6\text{ V}$ ,  $I_{DSQ} = 75\text{ mA}$ ,  $V_{AT} = 5\text{ V}$

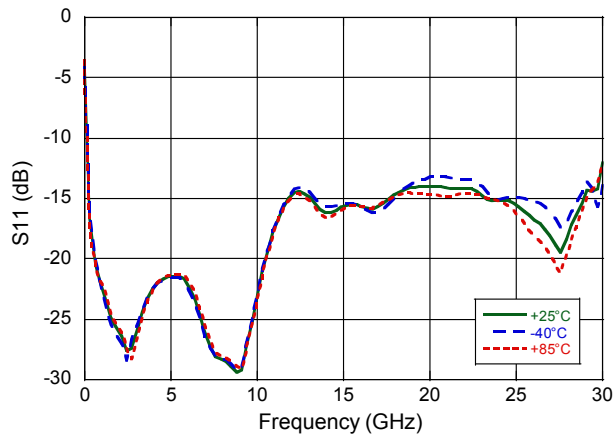
**Gain**



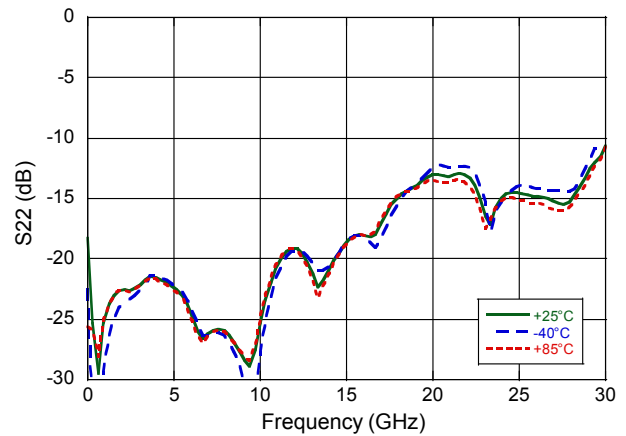
**Noise Figure**



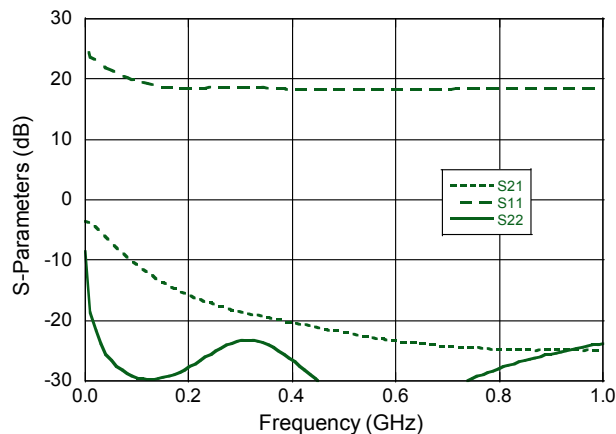
**Input Return loss**



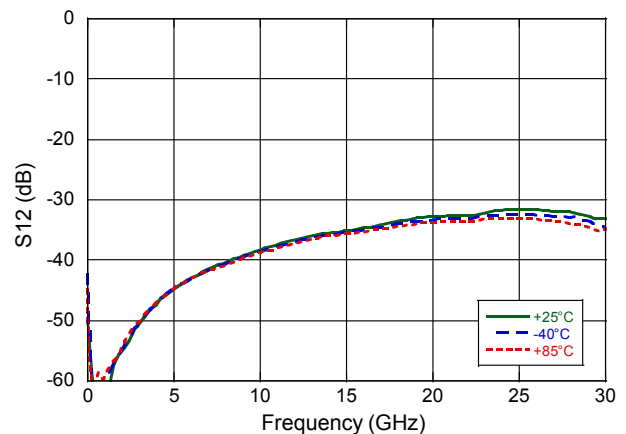
**Output Return Loss**



**Low Frequency S-Parameters**



**Reverse Isolation**

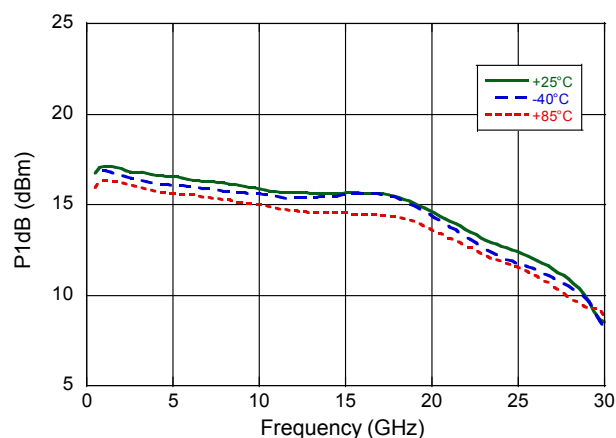


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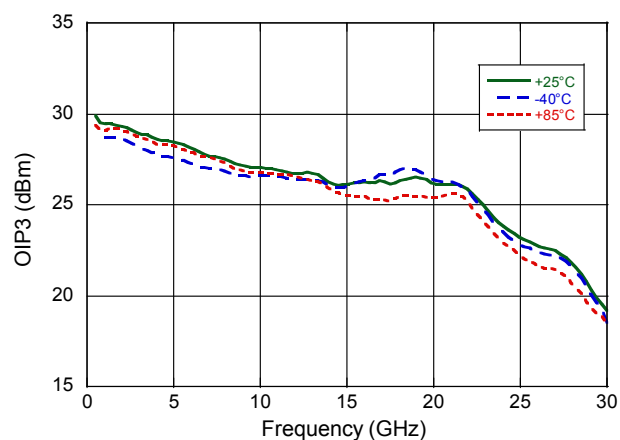
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Typical Performance Curves:  $V_{DD} = 6\text{ V}$ ,  $I_{DSQ} = 75\text{ mA}$ ,  $V_{AT} = 5\text{ V}$

Output P1dB



Output IP3 (10 MHz tone spacing)





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| Pin #     | Size (x) | Size (y) |
|-----------|----------|----------|
| 1 - 2     | 70       | 140      |
| 9 -12     | 70       | 90       |
| 3 - 8, 13 | 70       | 70       |

- DC-0012270

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