Low Noise Amplifier
DC - 28 GHz

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 Ω 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 Ω 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

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAL-011141-DIE</td>
<td>gel pack</td>
</tr>
<tr>
<td>MAAL-011141-DIESMB</td>
<td>wafer evaluation module</td>
</tr>
</tbody>
</table>

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

For further information and support please visit:
https://www.macom.com/support
### Electrical Specifications: $T_A = +25^\circ C$, $V_{DD} = 6$ V, $I_{DSQ} = 75$ mA, $V_{AT} = 5$ V, $Z_0 = 50$ Ω

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
</table>
| **Gain**           | $P_{IN} = -20$ dBm  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dB     | 16.5 | 18.5 | —    |
|                    | $P_{IN} = -20$ dBm  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dB     | 15.0 | 17.0 | 17.0 |
| **Output P1dB**    | 2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dBm    | —    | 17.0 | 16.0 |
|                    | $P_{IN} = -20$ dBm  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dBm    | —    | 16.0 | 15.0 |
| **OIP3**           | $P_{IN} = -20$ dBm / tone, 10 MHz Tone Spacing  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dBm    | 29.5 | 28.0 | —    |
|                    | $P_{IN} = -20$ dBm / tone, 10 MHz Tone Spacing  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dBm    | 28.0 | 26.5 | —    |
| **Input Return Loss** | $P_{IN} = -20$ dBm | dB     | —    | 15   | —    |
| **Output Return Loss** | $P_{IN} = -20$ dBm | dB     | —    | 15   | —    |
| **Noise Figure**   | 2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dB     | 2.5  | 1.6  | 2.2  |
|                    | $P_{IN} = -20$ dBm  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dB     | 1.4  | 2.4  | 4.0  |
| **Isolation**      | $P_{IN} = -20$ dBm  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dB     | 60   | 40   | —    |
|                    | $P_{IN} = -20$ dBm  
2.0 GHz  
8.0 GHz  
12.0 GHz  
18.0 GHz  
26.5 GHz | dB     | 40   | 37   | —    |
| **$V_G$**          | Adjusted to set $I_{DSQ} = 75$ mA | V      | —    | 0.7  | —    |
| **$I_{AT}$**       | $V_{AT} = 5$ V | mA     | —    | 10   | —    |
Operating Conditions
Recommended biasing conditions are V_{DD} = 6 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\textsubscript{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 Ω 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 Ω and 32 Ω 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 μF 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 μF 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Operating Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power(^3)</td>
<td>(P_{IN} \leq 1 \text{ dB compression level})</td>
</tr>
<tr>
<td>Junction Temperature(^4)</td>
<td>(+150^\circ\text{C})</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

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\(^5,6\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>18 dBm</td>
</tr>
<tr>
<td>Drain Voltage</td>
<td>7 V</td>
</tr>
<tr>
<td>Gate Voltage</td>
<td>0.9 V</td>
</tr>
<tr>
<td>Active Termination Voltage</td>
<td>6 V</td>
</tr>
<tr>
<td>AUX1 Current</td>
<td>80 mA</td>
</tr>
<tr>
<td>AUX2 Current</td>
<td>80 mA</td>
</tr>
<tr>
<td>Junction Temperature(^7)</td>
<td>+175°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +125°C</td>
</tr>
</tbody>
</table>

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.
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DC - 28 GHz

Application Schematic

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Applications Section: Sample Board Layout

**Parts List**

<table>
<thead>
<tr>
<th>Part</th>
<th>Value</th>
<th>Case Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - C3</td>
<td>0.1 µF</td>
<td>0402</td>
</tr>
<tr>
<td>C4 - C6</td>
<td>100 pF</td>
<td>Single Layer</td>
</tr>
</tbody>
</table>

**Evaluation PCB 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

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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.

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

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

Output \( P_{1dB} \)

Output IP3 (10 MHz tone spacing)

0 5 10 15 20 25 30

5 10 15 20 25 30

+25°C
-40°C
+85°C

P1dB (dBm)
Frequency (GHz)
OIP3 (dBm)
Frequency (GHz)
**MMIC Die Outline**

![Die Outline Diagram]

**Bond Pad Detail**

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Size (x)</th>
<th>Size (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>70</td>
<td>140</td>
</tr>
<tr>
<td>9 - 12</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>3 - 8, 13</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

8. All dimensions shown as microns ($\mu$m) with a tolerance of +/-5 $\mu$m, unless otherwise noted.
9. Die thickness is 100 $\mu$m +/- 10 $\mu$m.