MAAL-011151-DIE

Ultra Low Phase Noise Amplifier
2 - 18 GHz

Features
- Wideband Performance
- Noise Figure: 4 dB @ 8 GHz
- Phase Noise: -154 dBc/Hz @ 1 kHz
- Bias Voltage: 5 V
- Bias Current: 60 mA
- 50 Ω Matched Input / Output
- Positive Voltage Only
- Die Size: 2.8 x 1.73 x 0.1 mm
- RoHS* Compliant

Description
The MAAL-011151-DIE is an easy to use, wideband low noise distributed amplifier die. It operates from 2 to 18 GHz and provides 17 dB of linear gain, 16 dBm of P1dB and 4 dB of noise figure at 8 GHz. The input and output are fully matched to 50 Ω with typical return loss >15 dB.

The RF input and RF output ports are DC blocked. Amplifier control is available through the use of a control circuit or by direct bias injection.

This product is fabricated using a low phase noise HBT process which features full passivation for enhanced reliability.

The MAAL-011151-DIE can be used as a low noise amplifier stage for signal generation applications. This device is ideally suited for Test and Measurement, EW, ECM, and Radar applications where ultra low phase noise and drive power is required.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAL-011151-DIE</td>
<td>gel pack</td>
</tr>
</tbody>
</table>

Functional Schematic

1. Image not to scale.

Pin Configuration

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RFIN</td>
<td>RF Input</td>
</tr>
<tr>
<td>2</td>
<td>RFOUT</td>
<td>RF Output</td>
</tr>
<tr>
<td>3</td>
<td>VCC</td>
<td>Collector Voltage</td>
</tr>
<tr>
<td>4</td>
<td>VB4</td>
<td>Bias Voltage 4</td>
</tr>
<tr>
<td>5</td>
<td>VB3</td>
<td>Bias Voltage 3</td>
</tr>
<tr>
<td>6</td>
<td>VB2</td>
<td>Bias Voltage 2</td>
</tr>
<tr>
<td>7</td>
<td>VB1</td>
<td>Bias Voltage 1</td>
</tr>
<tr>
<td>8</td>
<td>VB5</td>
<td>Bias Voltage 5</td>
</tr>
</tbody>
</table>

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: \( T_A = +25^\circ C, \ \text{VC} = \text{VCT}^3 = 5 \text{ V}, \ Z_0 = 50 \ \Omega \)

<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**           | \( P_{\text{IN}} = -15 \text{ dBm} \)  
2 GHz
10 GHz
18 GHz            | dB     | 15.0  | 16.5  | —    |
| **Output P3dB\(^4\)** | 2 GHz
10 GHz
18 GHz            | dBm    | —     | 23    | 19   | 14   |
| **Output Power**   | \( P_{\text{IN}} = +4.5 \text{ dBm, 2 GHz} \)  
\( P_{\text{IN}} = +2.8 \text{ dBm, 10 GHz} \)  
\( P_{\text{IN}} = -3.0 \text{ dBm, 18 GHz} \) | dBm | 18.0  | 20.0  | —    |
| **Input Return Loss** | \( P_{\text{IN}} = -15 \text{ dBm} \) | dB | —     | 10   | —    |
| **Output Return Loss** | \( P_{\text{IN}} = -15 \text{ dBm} \) | dB | —     | 10   | —    |
| **Noise Figure**   | 2 GHz
10 GHz
18 GHz            | dB     | —     | 8     | 5    | 8    |
| **Isolation**      | \( P_{\text{IN}} = -15 \text{ dBm} \)  
2 GHz
10 GHz
18 GHz            | dB     | —     | 50    | 42   | 30   |
| **Phase Noise**    | \( P_{\text{IN}} = +3 \text{ dBm, 12 GHz} \)  
100 Hz
1 kHz
10 kHz
1 MHz            | dBC/Hz | —     | -144  | -150 | -156 | -162 | — |
| **ICQ**            | -15 dBm \( P_{\text{IN}}, \ \text{VC} = 5 \text{ V} \) | mA    | —     | 60   | —    |
| **ICT\(^3\)**      | Total current into R1, R2       | mA    | —     | 2    | —    |

3. Reference detailed bias conditions on pages 3-4.
4. MACOM does not recommend sustained operation at power levels above 3 dB compression.
Ultra Low Phase Noise Amplifier
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Maximum Operating Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power^4</td>
<td>( P_{IN} \leq 3 \text{ dB compression level} )</td>
</tr>
<tr>
<td>ICQ</td>
<td>90 mA</td>
</tr>
<tr>
<td>Junction Temperature(^5,6)</td>
<td>+130°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

5. Operating at nominal conditions with junction temperature ≤ 130°C will ensure MTTF > 1 x 10^6 hours.

6. Junction Temperature \((T_J) = T_C + \Theta_{JC} * \left( (V * I) - (P_{OUT} - P_{IN}) \right)\).

   Typical thermal resistance \((\Theta_{JC}) = 120°C/W.\)

   a) For \(T_C = +25°C\)

   \(T_J = +72°C @ 5 \text{ V}, 98 \text{ mA}, P_{OUT} = 20 \text{ dBm}, P_{IN} = 4.5 \text{ dBm}\)

   b) For \(T_C = +85°C\)

   \(T_J = 129°C @ 5 \text{ V}, 88 \text{ mA}, P_{OUT} = 19 \text{ dBm}, P_{IN} = 4.5 \text{ dBm}\)

Absolute Maximum Ratings\(^7,8\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>12 dBm</td>
</tr>
<tr>
<td>ICQ</td>
<td>120 mA</td>
</tr>
<tr>
<td>VCC</td>
<td>6 V</td>
</tr>
<tr>
<td>VB1, VB2, VB3, VB4, VB5</td>
<td>6 V</td>
</tr>
<tr>
<td>VB1, VB2, VB3, VB4, VB5 Current</td>
<td>5 mA</td>
</tr>
<tr>
<td>Junction Temperature(^9)</td>
<td>+150°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +125°C</td>
</tr>
</tbody>
</table>

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.

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.
Operating Conditions
Recommended biasing conditions are VC = 5 V applied to the VB4 and VCC pads. Apply 5 V to the amplifier control VCT node through the offset resistors to VB2 and VB3 pads according to the application schematic as shown. Applying VCT = 5 V will turn the LNA on, which should draw 60 mA from VC. Applying VCT = 0 V will turn off the LNA. The VCT will draw <2 mA at 5 V. All DC supplies need to be low noise to prevent degradation of the amplifier phase noise.
Recommended Bonding Diagram & PCB Layout
RF input and output port matching circuit patterns are designed to compensate for bonding wires. Input and output bonding configuration are identical.

Parts List

<table>
<thead>
<tr>
<th>Part #</th>
<th>Value</th>
<th>Case Style</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - C4</td>
<td>330 pF</td>
<td>Single Layer</td>
</tr>
<tr>
<td>C5, C6</td>
<td>1 µF</td>
<td>0402</td>
</tr>
<tr>
<td>R1</td>
<td>1.56 kΩ</td>
<td>Thin film</td>
</tr>
<tr>
<td>R2</td>
<td>3.2 kΩ</td>
<td>Thin film</td>
</tr>
</tbody>
</table>
Typical Performance Curves: 5 V, ICQ = 60 mA

**Gain**

- **S21 (dB)**
  - Frequency (GHz): 0, 6, 12, 18, 24
  - Temperature: +25°C, -40°C, +85°C

**Noise Figure**

- **Noise Figure (dB)**
  - Frequency (GHz): 0, 5, 10, 15, 20
  - Temperature: +25°C, -40°C, +85°C

**Input Return Loss**

- **S11 (dB)**
  - Frequency (GHz): 0, 6, 12, 18, 24
  - Temperature: +25°C, -40°C, +85°C

**Output Return Loss**

- **S22 (dB)**
  - Frequency (GHz): 0, 6, 12, 18, 24
  - Temperature: +25°C, -40°C, +85°C

**Phase Noise @ +25°C**

- **Phase Noise (dBc/Hz)**
  - Frequency Offset (Hz): 10, 100, 1000, 10000, 100000
  - Temperature: +25°C
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Typical Performance Curves: $P_{1\text{dB}}$ @ ICQ = 60 mA

![Graph showing $P_{1\text{dB}}$ vs. Frequency for different temperatures: +25°C, -40°C, +85°C](image)

Gain vs. Frequency for different temperatures: +25°C, -40°C, +85°C

Typical Performance Curves: $P_{3\text{dB}}$ @ ICQ = 60 mA

![Graph showing $P_{3\text{dB}}$ vs. Frequency for different temperatures: +25°C, -40°C, +85°C](image)

Gain vs. Frequency for different temperatures: +25°C, -40°C, +85°C
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**MMIC Die Outline**

**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>100</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>4 - 8</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

10. All dimensions shown as microns (µm) with a tolerance of +/-5 µm, unless otherwise noted.
11. Die thickness is 100 µm +/-10 µm.

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