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>

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.
Electrical Specifications: $T_A = +25^\circ C$, $V_C = V_CT^3 = 5\,V$, $Z_0 = 50\,\Omega$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>$P_{IN} = -15,\text{dBm}$</td>
<td>dB</td>
<td>15.0</td>
<td>16.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>2 GHz</td>
<td></td>
<td>14.0</td>
<td>16.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>10 GHz</td>
<td></td>
<td>13.5</td>
<td>15.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>18 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output P3dB$^4$</td>
<td>2 GHz</td>
<td>dBm</td>
<td>23</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>10 GHz</td>
<td></td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 GHz</td>
<td></td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Power</td>
<td>$P_{IN} = +4.5,\text{dBm}$, 2 GHz</td>
<td>dBm</td>
<td>18.0</td>
<td>20.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>$P_{IN} = +2.8,\text{dBm}$, 10 GHz</td>
<td></td>
<td>15.0</td>
<td>17.5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>$P_{IN} = -3.0,\text{dBm}$, 18 GHz</td>
<td></td>
<td>9.0</td>
<td>11.5</td>
<td>—</td>
</tr>
<tr>
<td>Input Return Loss</td>
<td>$P_{IN} = -15,\text{dBm}$</td>
<td>dB</td>
<td>10</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>$P_{IN} = -15,\text{dBm}$</td>
<td>dB</td>
<td></td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Noise Figure</td>
<td>2 GHz</td>
<td>dB</td>
<td>8</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>10 GHz</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolation</td>
<td>$P_{IN} = -15,\text{dBm}$</td>
<td>dB</td>
<td>50</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>2 GHz</td>
<td></td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 GHz</td>
<td></td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Noise</td>
<td>$P_{IN} = +3,\text{dBm}$, 12 GHz</td>
<td>dBC/Hz</td>
<td>—</td>
<td>-144</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>100 Hz</td>
<td></td>
<td></td>
<td>-150</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 kHz</td>
<td></td>
<td></td>
<td>-156</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>10 kHz</td>
<td></td>
<td></td>
<td>-162</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICQ</td>
<td>-15 dBm $P_{IN}$, $V_C = 5,V$</td>
<td>mA</td>
<td>60</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>ICT$^3$</td>
<td>Total current into R1, R2</td>
<td>mA</td>
<td></td>
<td>2</td>
<td>—</td>
</tr>
</tbody>
</table>

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
2 - 18 GHz

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(^6,6)</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 \(\leq 130°C\) will ensure MTTF > 1 \(\times 10^6\) hours.
6. Junction Temperature \((T_J) = T_C + \Theta_{JC} \times ((V \times I) - (P_{OUT} - P_{IN}))\).
   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.
**Application Schematic**

**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>

All wirebonds are 1 mil gold. Separation between the die and 50 Ω RF transmission lines are 3 - 5 mil.
Ultra Low Phase Noise Amplifier
2 - 18 GHz

Typical Performance Curves: 5 V, ICQ = 60 mA

**Gain**

- Frequency (GHz) vs. S21 (dB)
- Temperature (°C)

**Noise Figure**

- Frequency (GHz) vs. Noise Figure (dB)
- Temperature (°C)

**Input Return loss**

- Frequency (GHz) vs. S11 (dB)
- Temperature (°C)

**Output Return Loss**

- Frequency (GHz) vs. S22 (dB)
- Temperature (°C)

**Phase Noise @ +25°C**

- Frequency Offset (Hz) vs. Phase Noise (dBc/Hz)
Ultra Low Phase Noise Amplifier
2 - 18 GHz

Typical Performance Curves: $P_{1\text{dB}} @ \text{ICQ} = 60 \text{ mA}$

Typical Performance Curves: $P_{3\text{dB}} @ \text{ICQ} = 60 \text{ mA}$
Ultra Low Phase Noise Amplifier
2 - 18 GHz

**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.

---

**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.

---

MACOM Technology Solutions Inc. (MACOM) and its affiliates reserve the right to make changes to the product(s) or information contained herein without notice.

Visit [www.macom.com](http://www.macom.com) for additional data sheets and product information.

For further information and support please visit: [https://www.macom.com/support](https://www.macom.com/support)
Ultra Low Phase Noise Amplifier
2 - 18 GHz

MACOM Technology Solutions Inc. All rights reserved.

Information in this document is provided in connection with MACOM Technology Solutions Inc ("MACOM") products. These materials are provided by MACOM as a service to its customers and may be used for informational purposes only. Except as provided in MACOM's Terms and Conditions of Sale for such products or in any separate agreement related to this document, MACOM assumes no liability whatsoever. MACOM assumes no responsibility for errors or omissions in these materials. MACOM may make changes to specifications and product descriptions at any time, without notice. MACOM makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppels or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MACOM FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MACOM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.