Features
- Integrates Image Reject (Balanced) Mixer, LO Buffer, LO Quadrupler and RF Buffer
- 13 dB Conversion Gain
- +20 dBm Input Third Order Intercept (IIP3)
- -30 dBm (4x) LO Leakage (@ RF Port)
- 18 dBc Image Rejection
- Variable Gain with Adjustable Bias
- Lead-Free 4 mm, 24 Lead QFN Package
- RoHS^ Compliant

Description
The MAUC-011009 is an integrated up-converter that has a typical conversion gain of 13 dB, and an image rejection of 18 dBc. The device includes a LO quadrupler, LO buffer amplifier, and RF buffer amplifier. Variable gain can be achieved by adjusting the bias, with turn-down trajectories optimized to maintain linearity and 4×LO leakage over the gain control range. The output IP3 is 32 dBm at maximum gain.

The MAUC-011009 is ideally suited for 38 GHz band point-to-point radios under both LSB and USB operation.

Each device is 100% RF tested to ensure performance compliance.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAUC-011009-TR0500</td>
<td>500 Piece Reel</td>
</tr>
<tr>
<td>MAUC-011009-000SMB</td>
<td>Sample Board</td>
</tr>
</tbody>
</table>

1. Reference Application Note M513 for reel size information.
2. All sample boards include 3 loose parts.

MAUC-011009-TR0500

Pin Configuration

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Function</th>
<th>Pin No.</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/C</td>
<td>13</td>
<td>VD3</td>
</tr>
<tr>
<td>2</td>
<td>I*</td>
<td>14</td>
<td>VG4</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>15</td>
<td>VG1</td>
</tr>
<tr>
<td>4</td>
<td>Q*</td>
<td>16</td>
<td>VG1</td>
</tr>
<tr>
<td>5</td>
<td>Q</td>
<td>17</td>
<td>VG2</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
<td>18</td>
<td>VD2</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>19</td>
<td>GND</td>
</tr>
<tr>
<td>8</td>
<td>LO</td>
<td>20</td>
<td>RF</td>
</tr>
<tr>
<td>9</td>
<td>GND</td>
<td>21</td>
<td>GND</td>
</tr>
<tr>
<td>10</td>
<td>GND</td>
<td>22</td>
<td>GND</td>
</tr>
<tr>
<td>11</td>
<td>VG3</td>
<td>23</td>
<td>N/C</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>24</td>
<td>GND</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>Paddle4</td>
</tr>
</tbody>
</table>

3. MACOM recommends connecting all N/C (no connection) package pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

Electrical Specifications:
LO = 0 dBm, IF = -10 dBm, $T_A = +25^\circ C$
$V_{D1} = V_{D2} = V_{D3} = 4 \, V$, $I_{D1} = 45 \, mA$, $I_{D2} = 135 \, mA$, $I_{D3} = 200 \, mA$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range (RF)</td>
<td>GHz</td>
<td>37</td>
<td>—</td>
<td>40</td>
</tr>
<tr>
<td>Frequency Range (LO)</td>
<td>GHz</td>
<td>8.375</td>
<td>—</td>
<td>10.875</td>
</tr>
<tr>
<td>Frequency Range (IF)</td>
<td>GHz</td>
<td>DC</td>
<td>—</td>
<td>3.5</td>
</tr>
<tr>
<td>LO Input Power (PLO)</td>
<td>dBm</td>
<td>—</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>USB Conversion Gain (IF = 3.5 GHz)</td>
<td>dB</td>
<td>9.5</td>
<td>13</td>
<td>—</td>
</tr>
<tr>
<td>Image Rejection</td>
<td>dBc</td>
<td>—</td>
<td>18</td>
<td>—</td>
</tr>
<tr>
<td>Input IP3 (P_{IN} = -10 dBm/tone, IF = 3.5 GHz, $\Delta$IF = 10 MHz)</td>
<td>dBm</td>
<td>—</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td>USB Output IP3 (P_{IN} = -10 dBm/tone, IF = 3.5 GHz, $\Delta$IF = 10 MHz)</td>
<td>dBm</td>
<td>28</td>
<td>32</td>
<td>—</td>
</tr>
<tr>
<td>Spurious (4xLO) [tuned - IF voltages ~ 0.2 V]</td>
<td>dBm</td>
<td>—</td>
<td>-30</td>
<td>—</td>
</tr>
<tr>
<td>RF Return Loss</td>
<td>dB</td>
<td>—</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>LO Return Loss</td>
<td>dB</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>IF Return Loss</td>
<td>dB</td>
<td>—</td>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>Current, Drain 1 ($I_{D1}$)</td>
<td>mA</td>
<td>—</td>
<td>45</td>
<td>—</td>
</tr>
<tr>
<td>Current, Drain 2 ($I_{D2}$)</td>
<td>mA</td>
<td>—</td>
<td>135</td>
<td>—</td>
</tr>
<tr>
<td>Current, Drain 3 ($I_{D3}$)</td>
<td>mA</td>
<td>—</td>
<td>200</td>
<td>—</td>
</tr>
<tr>
<td>Gate Voltage ($V_{G4}$)</td>
<td>V</td>
<td>—</td>
<td>-3.25</td>
<td>—</td>
</tr>
<tr>
<td>Gate Current ($I_{G4}$)</td>
<td>mA</td>
<td>—</td>
<td>-1</td>
<td>—</td>
</tr>
</tbody>
</table>

5. Apply gate voltages prior to drain voltages. Adjust $V_{G1}$, $V_{G2}$ and $V_{G3}$ between -1.0 and -0.1 V to achieve specified drain current. Typical current 380 mA = $45 \times I_{D1} + 135 \times I_{D2} + 200 \times I_{D3}$ mA. Refer to App Note [1] for biasing details.
Up Converter
37 - 40 GHz

Absolute Maximum Ratings\(^6,7\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain Voltage</td>
<td>+4.3 V</td>
</tr>
<tr>
<td>Gate Bias Voltage ((V_{G1,2,3}))</td>
<td>-1.5 V &lt; (V_G) &lt; +0.3 V</td>
</tr>
<tr>
<td>Gate Bias Voltage ((V_{G4}))</td>
<td>-4.0 V &lt; (V_G) &lt; 0 V</td>
</tr>
<tr>
<td>Input Power</td>
<td>10 dBm</td>
</tr>
<tr>
<td>LO Input Power</td>
<td>13 dBm</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-55°C to +150°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>Junction Temperature(^8)</td>
<td>+150°C</td>
</tr>
</tbody>
</table>

6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.
8. Junction Temperature \((T_J) = T_C + \Theta_{JC} \times (V \times I)\)
   Typical thermal resistance \((\Theta_{JC}) = 36°C/W\).

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 devices.

Biasing Quickstart

**Turn ON:**

Step 1: Turn on the fixed voltage on VG4 first.
Step 2: Turn on VG1, VG2 and VG3 at approximately -1.0V.
Step 3: Turn on IF voltages at the fixed voltage.
Step 4: Turn on VD1, VD2 and VD3 at the fixed voltages, and adjust corresponding VG to get the required current levels.

**Turn OFF:**

Reverse steps indicated in **Turn ON** sequence

*For further details please see App Note [1]*
Typical Performance Curves: LO = 0 dBm, IF = -10 dBm @ 2 GHz, P_{DC} = 1.52 W

Conversion Gain

Conversion Gain, LO Power swept

Conversion Gain @ 37 GHz

Conversion Gain @ 40 GHz

Conversion Gain @ IF = 21.4 MHz

Conversion Gain @ IF = 3.5 GHz
Typical Performance Curves: LO = 0 dBm, IF = -10 dBm @ 2 GHz, P_{DC} = 1.52 W

**Input IP3**

![Graph showing Input IP3 vs Frequency at 37 GHz and 40 GHz](image)

**Input IP3, LO Power swept**

![Graph showing Input IP3, LO Power swept vs Frequency](image)

**Input IP3 @ 37 GHz**

![Graph showing Input IP3 @ 37 GHz vs ID1+ID2](image)

**Input IP3 @ 40 GHz**

![Graph showing Input IP3 @ 40 GHz vs ID1+ID2](image)

**Input IP3, IF = 21.4 MHz**

![Graph showing Input IP3, IF = 21.4 MHz vs Frequency](image)

**Input IP3, IF = 3.5 GHz**

![Graph showing Input IP3, IF = 3.5 MHz vs Frequency](image)
Typical Performance Curves: LO = 0 dBm, IF = -10 dBm @ 2 GHz, $P_{DC} = 1.52$ W

Output IP3

Output IP3, LO Power swept

Output IP3 @ 37 GHz

Output IP3 @ 40 GHz

Output IP3, IF = 21.4 MHz

Output IP3, IF = 3.5 GHz
Up Converter
37 - 40 GHz

Typical Performance Curves: LO = 0 dBm, IF = -10 dBm @ 2 GHz, P_{DC} = 1.52 W

**P\text{OUT} vs. P\text{IN}**

- **P\text{OUT} vs. P\text{IN} @ IF = 21.4 MHz**
  - Output Power (dBm)
  - Frequency (GHz)

- **P\text{OUT} vs. P\text{IN} @ IF = 3.5 GHz**
  - Output Power (dBm)
  - Frequency (GHz)

**P1dB, Input & Output**

- **P1dB, Input & Output, IF = 21.4 MHz**
  - P1dB (dBm)
  - Frequency (GHz)

- **P1dB, Input & Output, IF = 3.5 GHz**
  - P1dB (dBm)
  - Frequency (GHz)
Up Converter
37 - 40 GHz

Typical Performance Curves: LO = 0 dBm, IF = -10 dBm @ 2 GHz, $P_{DC} = 1.52$ W

Image Rejection

Image Rejection, LO Power swept

Image Rejection, IF = 21.4 MHz

Image Rejection, IF = 3.5 GHz
App Note [1] Biasing

MAUC-011009 is operated by biasing $V_D1$, $V_D2$ and $V_D3$ at 4.0 V. The corresponding drain currents are set to 45 mA, 135 mA and 200 mA respectively. $V_G4$ requires a fixed voltage bias of nominally -3.25 V. It is recommended to use active bias on $V_G1$, $V_G2$, $V_G3$ to keep the currents in $V_D1$, $V_D2$ and $V_D3$ constant, in order to maintain the best performance over temperature. Depending on the supply voltages available and the power dissipation constraints, the bias circuits may include a single transistor or a low power operational amplifier, with a low value resistor in series with the drain supply to sense the current. Make sure to sequence the applied voltage to ensure negative gate bias is available before applying the positive drain supply. If IF bias is to be used, it is important that $V_G4$ is applied first.

App Note [2] IF Inputs

The IF input to the typical configuration is through a 90° hybrid coupler. The hybrid splits the IF input into inphase and quadrature phase components which feed into two 180° hybrid couplers splitting into 4 signals. These four signals enter the MAUC-011009 on I/I*,Q/Q* IF inputs through bias tees. For highest gain, best image rejection and highest OIP3, all the 4 IF inputs should be used. See App Note [4] for IF bias.
App Note [3] Board Layout

As shown in the recommended board layout, it is recommended to provide 100 pF decoupling capacitors as close to the bias pins as possible. Additional 10 nF and 1 µF on each of the bias lines are recommended placed a distance further away.

App Note [4] IF Bias

To obtain optimum 4xLO leakage performance, tuning is achieved by adjusting the DC bias on each of the IF inputs (I, Q, I*, Q*). DC bias is implemented by adding simple bias tees to each of the four IF ports (see drawing from App Note [2] for the bias tees location). The diagram below shows a typical bias tee design used.

A typical tuning arrangement is to apply a fixed 0.2 V DC bias to I, Q. The remaining two IF ports can be tuned independently between - 0.5 and 1 V for minimum 4xLO leakage. Please note that $V_G4$ must be applied to the device before IF bias is applied.

For minimum 4xLO leakage in a system, it may be necessary to correct the IF DC bias for different frequency and temperature conditions. This can be implemented by calibration and offset tables stored in memory, and used to control IF bias over all practical conditions.
**Lead-Free 4 mm 24-Lead PQFN †**

† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meet JEDEC moisture sensitivity level 1 requirements.
Plating is NiPdAuAg over copper.
M/A-COM Technology Solutions Inc. All rights reserved.

Information in this document is provided in connection with M/A-COM 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 estoppel 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.