Down Converter
37 - 40 GHz

Features
- Integrates Image Reject (Balanced) Mixer, LO Buffer, LO Quadrupler and RF Buffer
- 13 dB Conversion Gain
- 3.8 dB Noise Figure
- 2 dBm Input Third Order Intercept (IIP3)
- 30 dBm Average Two-Tones Input Second Order Intercept (IIP2)
- 25 dBm Input Second Order Intercept (IIP2 IF/2)
- 25 dBc Image Rejection
- 12 dB RF and 15 dB LO Return Loss
- Lead-Free 4 mm, 24 Lead QFN Package
- RoHS^ Compliant

Description
The MADC-011010 is an integrated LSB/USB receiver that has a noise figure of 3.8 dB and a typical conversion gain of 13 dB. The device integrates a four stage LNA followed by an image rejection mixer, and includes an integrated LO quadrupler and buffer amplifier within a 4 mm QFN package. The I/Q and complementary I*/Q* mixer outputs are provided, and two external 180° hybrids and one external 90° hybrid are required to complete the image rejection function.

The MADC-011010 is ideally suited for 38 GHz band point to point radios.

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

Ordering Information^1,2

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MADC-011010-TR0500</td>
<td>500 Piece Reel</td>
</tr>
<tr>
<td>MADC-011010-001SMB</td>
<td>Sample Evaluation board</td>
</tr>
</tbody>
</table>

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


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## Electrical Specifications

**LO = 4 dBm, \( T_A = +25^\circ C \)**

\[ V_{D1} = V_{D2} = V_{D3} = 3 \, V, \quad I_{D1} = 30 \, mA, \quad I_{D2} = 100 \, mA, \quad I_{D3} = 150 \, mA \]

<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>4</td>
<td>—</td>
</tr>
<tr>
<td>USB Conversion Gain (IF = 2 GHz)</td>
<td>dB</td>
<td>10</td>
<td>13</td>
<td>—</td>
</tr>
<tr>
<td>USB Noise Figure (IF = 2 GHz)</td>
<td>dB</td>
<td>—</td>
<td>3.8</td>
<td>5</td>
</tr>
<tr>
<td>Image Rejection</td>
<td>dBC</td>
<td>—</td>
<td>25</td>
<td>—</td>
</tr>
<tr>
<td>Input IP3</td>
<td>dBm</td>
<td>—</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Input IP2 (IF/2)</td>
<td>dBm</td>
<td>—</td>
<td>25</td>
<td>—</td>
</tr>
<tr>
<td>Average Two-Tones Input IP2 (ZIF)</td>
<td>dBm</td>
<td>—</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>RF Return Loss</td>
<td>dB</td>
<td>—</td>
<td>12</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(D)1)</td>
<td>mA</td>
<td>—</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>Current, Drain 2 (I(D)2)</td>
<td>mA</td>
<td>—</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>Current, Drain 3 (I(D)3)</td>
<td>mA</td>
<td>—</td>
<td>150</td>
<td>—</td>
</tr>
<tr>
<td>Gate Voltage (V(G)4)</td>
<td>V</td>
<td>—</td>
<td>-2.5</td>
<td>—</td>
</tr>
<tr>
<td>Drain Voltage on each IF port</td>
<td>V</td>
<td>—</td>
<td>0.3</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 280 mA = 30 (\(I_{D1}\)) + 100 (\(I_{D2}\)) + 150 (\(I_{D3}\)) mA. Refer to App Note [1] for biasing details.
Absolute Maximum Ratings\(^6,7\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Absolute Maximum</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(^8,9)</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. Operating at nominal conditions with \(T_J \leq +150°C\) will ensure \(MTTF > 1 \times 10^6\) hours.
9. Junction Temperature \(T_J = T_C + \Theta_{jc} \times (V \times I)\)

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 = 4 dBm, RF = -20 dBm @ 50 MHz IF, $P_{DC} = 0.84$ W

**Conversion Gain**

![Conversion Gain graph](image)

**Conversion Gain, LO Power swept**

![Conversion Gain, LO Power swept graph](image)

**Conversion Gain @ 37 GHz**

![Conversion Gain @ 37 GHz graph](image)

**Conversion Gain @ 40 GHz**

![Conversion Gain @ 40 GHz graph](image)

**Conversion Gain, IF = 2 GHz**

![Conversion Gain, IF = 2 GHz graph](image)

**Conversion Gain, IF = 3.5 GHz**

![Conversion Gain, IF = 3.5 GHz graph](image)
Typical Performance Curves: LO = 4 dBm, RF = -20 dBm @ 50 MHz IF, P_{DC} = 0.84 W
Typical Performance Curves: LO = 4 dBm, RF = -20 dBm @ 50 MHz IF, P_{DC} = 0.84 W

**Output IP3**

**Output IP3 @ 37 GHz**

**Output IP3, IF = 2 GHz**

**Output IP3, IF = 3.5 GHz**

**Output IP3 @ 40 GHz**

**Output IP3, LO Power swept**
Typical Performance Curves: LO = 4 dBm, IF = 150 MHz, P_{DC} = 0.84 W

**Noise Figure, LO Power swept**

![Graph showing noise figure vs. frequency for different LO powers.]

**Noise Figure, IF = 2 GHz**

![Graph showing noise figure vs. frequency for IF = 2 GHz.]

**Noise Figure, IF = 3.5 GHz**

![Graph showing noise figure vs. frequency for IF = 3.5 GHz.]

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Typical Performance Curves: LO = 4 dBm, IF = 150 MHz, $P_{DC} = 0.84$ W

**Noise Figure @ 37 GHz**

![Graph of Noise Figure @ 37 GHz](image1)

**Noise Figure @ 40 GHz**

![Graph of Noise Figure @ 40 GHz](image2)
Down Converter
37 - 40 GHz

Typical Performance Curves: LO = 4 dBm, RF = -20 dBm @ 50 MHz IF, P_{DC} = 0.84 W

Image Rejection

![Image Rejection Graph]

Image Rejection, LO Power swept

![Image Rejection LO Power swept Graph]

Image Rejection, IF = 2 GHz

![Image Rejection IF 2 GHz Graph]

Image Rejection, IF = 3.5 GHz

![Image Rejection IF 3.5 GHz Graph]
Typical Performance Curves: LO = 4 dBm, RF = -20 dBm @ 50 MHz IF, $P_{DC} = 0.84$ W

$P_{OUT}$ vs. $P_{IN}$

$P_{1dB}$, Input & Output

$P_{OUT}$ vs. $P_{IN}$, IF = 2 GHz

$P_{1dB}$, Input & Output, IF = 2 GHz

$P_{OUT}$ vs. $P_{IN}$, IF = 3.5 GHz

$P_{1dB}$, Input & Output, IF = 3.5 GHz

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Typical Performance Curves: LO = 4 dBm, IF1 = 41 MHz, IF2 = 53 MHz, \( P_{DC} = 0.84 \) W

**Two-Tones Input IP2 @ I - I* Ports or Q - Q* Ports**

**Average Two-Tones IIP2 @ I - I* Ports or Q - Q* Ports**

**Input IP2 (IF/2), IF = 2 GHz**

**Input IP2 (IF/2), IF = 3.5 GHz**
Typical Performance Curves: LO = 4 dBm, $P_{DC} = 0.84$ W

1xLO Leakage @ RF Port

2xLO Leakage @ RF Port

3xLO Leakage @ RF Port

1xLO Leakage @ RF Port, LO Power swept

2xLO Leakage @ RF Port, LO Power swept

3xLO Leakage @ RF Port, LO Power swept

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Typical Performance Curves: LO = 4 dBm, $P_{DC} = 0.84$ W

4xLO Leakage @ RF Port

5xLO Leakage @ RF Port
Typical Performance Curves:

**IF Return Loss**

![IF Return Loss Graph](image)

**RF Return Loss**

![RF Return Loss Graph](image)

**LO Return Loss**

![LO Return Loss Graph](image)
**App Note [1] Biasing**

MADC-011010 is operated by biasing $V_{D1}$, $V_{D2}$ and $V_{D3}$ at +3.0 V. The corresponding drain currents are set to 30 mA, 100 mA and 150 mA respectively. $V_{G4}$ requires a fixed voltage bias of nominally -2.5 V and all IF to be biased at +0.3 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.

**App Note [2] IF Outputs**

For highest gain, best image rejection and lowest noise figure all 4 IF ports should be used. $I/I^*$ and $Q/Q^*$ will be combined through two 180° hybrid couplers generating inphase and quadrature phase components. Inphase and quadrature signals then need to be combined through 90° hybrid combiner to create IF output. 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.

Recommended Board Layout

App Note [4] IF Bias
To obtain optimum OIP3 performance, it is required to apply DC bias of +0.3 V on each of the IF inputs (I, Q, I*, Q*). This can be 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. Before applying a
**Lead-Free 4 mm 24-Lead PQFN**

† Reference Application Note S2083 for lead-free solder reflow recommendations.

Meets JEDEC moisture sensitivity level 1 requirements.

Plating is NiPdAuAg over copper.