GaAs MMIC T3 Mixer with Differential IF

1. Device Overview

1.1 General Description
MT3D-0113LSM is a GaAs MMIC triple balanced mixer with high dynamic range and low conversion loss. This mixer belongs to the T3 family which offers high IP3, \( P_{1dB} \), and broad operating bandwidths for applications in the S, C and X bands. The MT3D-0113LSM has on-chip baluns for the LO and RF ports, while offering differential ports on the IF for flexible operation with an external balun or differential interface. The MT3D-0113LSM is available in a 4x4 mm\(^2\) QFN package. For a list of recommended LO driver amps for all mixers and IQ mixers, see here.

1.2 Features
- High LO to RF isolation
- Broad, overlapping RF/LO & IF bands
- Differential IF ports

1.3 Applications
- Test and measurement equipment
- S/C/X band radar

1.4 Functional Block Diagram

1.5 Part Ordering Options

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Package</th>
<th>Green Status</th>
<th>Product Lifecycle</th>
<th>Export Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT3D-0113LSM-2</td>
<td>4x4 mm(^2) QFN</td>
<td>SM</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

\(^1\) Refer to our [website](#) for a list of definitions for terminology presented in this table.
Table of Contents

1. Device Overview .................................. 1
   1.1 General Description ......................... 1
   1.2 Features ..................................... 1
   1.3 Applications ................................ 1
   1.4 Functional Block Diagram ................. 1
   1.5 Part Ordering Options...................... 1
2. Port Configurations and Functions ...... 3
   2.1 Port Diagram ................................ 3
   2.2 Port Functions .............................. 3
3. Specifications ................................. 4
   3.1 Absolute Maximum Ratings ............... 4
   3.2 Package Information ....................... 4
   3.3 Recommended Operating Conditions 4
   3.4 Sequencing Requirements ............... 4
   3.5 Electrical Specifications ................. 5
   3.6 Typical Performance Plots ............... 6
       3.6.1 Typical Performance Plots: IP3, Sine Wave LO ...................... 8
       3.6.1 Typical Performance Plots: IP3, Square Wave LO ................. 9
4. Application Information .................... 10
   4.1 Configuration A/B ......................... 10
   4.2 Example Application Circuit ............. 10
5. Mechanical Data .............................. 11
   5.1 SM Package Outline Drawing ............ 11
   5.2 SM Package Footprint .................... 11

Revision History

<table>
<thead>
<tr>
<th>Revision Code</th>
<th>Revision Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>August 2021</td>
<td>Datasheet Initial Release</td>
</tr>
</tbody>
</table>
2. Port Configurations and Functions

2.1 Port Diagram
A bottom-up view of the MT3D-0113LSM’s SM package outline drawing is shown below. The MT3D-0113LSM has the input and output ports given in Port Functions. The MT3D-0113LSM can be used in either an up or down conversion. Configuration A/B refer to the same part number (MT3D-0113LSM) used in one of two different ways for optimal spurious performance. For configuration A, input the LO into pin 4, use pin 15 for the RF. For configuration B, input the LO into pin 4, use pin 15 for the RF. Refer to section 4.1 for explanation of Configuration A and B operation.

![Port Diagram](image)

2.2 Port Functions

<table>
<thead>
<tr>
<th>Port</th>
<th>Function</th>
<th>Description</th>
<th>Equivalent Circuit for Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 15</td>
<td>RF (Configuration A)</td>
<td>Pin 15 is DC short for the SM package.</td>
<td>Pin 15</td>
</tr>
<tr>
<td></td>
<td>LO (Configuration B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pin 8</td>
<td>IF P1 and P2</td>
<td>Pins 8 and 9 are DC coupled to the diodes. Blocking capacitors are required.</td>
<td>Pin 8, 9</td>
</tr>
<tr>
<td>Pin 9</td>
<td></td>
<td>Pins 8 and 9 should be DC blocked and connected prior to balun.</td>
<td></td>
</tr>
<tr>
<td>Pin 10</td>
<td>IF N1 and N2</td>
<td>Pins 10 and 11 are DC coupled to the diodes. Blocking capacitors are required.</td>
<td>Pin 10, 11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pins 8 and 9 should be DC blocked and connected prior to balun.</td>
<td></td>
</tr>
<tr>
<td>Pin 4</td>
<td>LO (Configuration A)</td>
<td>Pin 4 is DC short for the SM package.</td>
<td>Pin 4</td>
</tr>
<tr>
<td></td>
<td>RF (Configuration B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>SM package ground path is provided through the ground paddle.</td>
<td>GND</td>
</tr>
</tbody>
</table>
3. Specifications

3.1 Absolute Maximum Ratings
The Absolute Maximum Ratings indicate limits beyond which damage may occur to the device. If these limits are exceeded, the device may be inoperable or have a reduced lifetime.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Rating</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 15 DC Current</td>
<td>TBD</td>
<td>mA</td>
</tr>
<tr>
<td>Pin 4 DC Current</td>
<td>TBD</td>
<td>mA</td>
</tr>
<tr>
<td>Pin 8, 9, 10, 11 DC Current</td>
<td>0</td>
<td>mA</td>
</tr>
<tr>
<td>Power Handling, at any Port</td>
<td>+30</td>
<td>dBm</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40 to +100</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
</tbody>
</table>

3.2 Package Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD</td>
<td>Human Body Model (HBM), per MIL-STD-750, Method 1020</td>
<td>1A</td>
</tr>
<tr>
<td>Weight</td>
<td>EVAL Package</td>
<td>TBD g</td>
</tr>
</tbody>
</table>

3.3 Recommended Operating Conditions
The Recommended Operating Conditions indicate the limits, inside which the device should be operated, to guarantee the performance given in Electrical Specifications. Operating outside these limits may not necessarily cause damage to the device, but the performance may degrade outside the limits of the electrical specifications. For limits, above which damage may occur, see Absolute Maximum Ratings.

<table>
<thead>
<tr>
<th>T&lt;sub&gt;A&lt;/sub&gt;, Ambient Temperature</th>
<th>Min</th>
<th>Nominal</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-40</td>
<td>+25</td>
<td>+100</td>
<td>°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LO Input Power</th>
<th>Min</th>
<th>Nominal</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+11</td>
<td>+17</td>
<td>+25</td>
<td>dBm</td>
</tr>
</tbody>
</table>

3.4 Sequencing Requirements
There is no requirement to apply power to the ports in a specific order. However, it is recommended to provide a 50Ω termination to each port before applying power. This is a passive diode mixer that requires no DC bias.
3.5 Electrical Specifications
The electrical specifications apply at TA=+25°C in a 50Ω system. Typical data shown is for the connectorized EVAL package mixer† used with a +17 dBm sine wave LO. Typical IP3 data shown for a +19 dBm square wave LO. Specifications shown for configuration A (B).

Min and Max limits apply only to our connectorized units and are guaranteed at TA=+25°C.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF (Pin 15) Frequency Range</td>
<td></td>
<td>1.5</td>
<td></td>
<td>13</td>
<td>GHz</td>
</tr>
<tr>
<td>LO (Pin 4) Frequency Range</td>
<td></td>
<td>1.5</td>
<td></td>
<td>13</td>
<td>GHz</td>
</tr>
<tr>
<td>IF (Pins 8, 9, 10, 11) Frequency Range</td>
<td></td>
<td>0.01</td>
<td>See note (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversion Loss (CL)²</td>
<td>RF/LO = 1.5 - 13 GHz\nI = 91 MHz</td>
<td>7.5</td>
<td>(7.5)</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Noise Figure (NF)³</td>
<td>RF/LO = 1.5 - 13 GHz\nI = 91 MHz</td>
<td>7.5</td>
<td>(7.5)</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Isolation</td>
<td>LO to RF</td>
<td>43</td>
<td>(37)</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LO to IF</td>
<td>43</td>
<td>(42)</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>RF to IF</td>
<td>42</td>
<td>(43)</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Input IP3 (IIP3)⁴</td>
<td>RF/LO = 1.5 - 13 GHz\nI = 91 MHz</td>
<td>27</td>
<td>(27)</td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>Input 1 dB Gain Compression Point (P1dB)</td>
<td></td>
<td></td>
<td>See Plots</td>
<td></td>
<td>dBm</td>
</tr>
</tbody>
</table>

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† All data measured using a proprietary off-chip balun. EVAL package follows the example application circuit shown in section 4.2. Contact support@markimicrowave.com for details.

* IF range max value is determined by off-chip balun. Contact support@markimicrowave.com for details.

² Measured as a down converter to a fixed 91 MHz IF. Unless otherwise stated, frequency conversion done using a highside LO.

³ Mixer Noise Figure typically measures within 0.5 dB of conversion loss for IF frequencies greater than 5 MHz.

⁴ IP3 depends on LO drive condition. Reported table value is measured with a square wave LO formed using 2x ADM1-0026PA in series with +10 dBm input into the first stage. LO Power reported in plots is of the fundamental tone only. Square wave LO power in plots is stepped down using broadband DC-40 GHz attenuators.
3.6 Typical Performance Plots

**Conversion Loss: 91 MHz IF, Highside LO (dB)**

- **Configuration A:** +17 dBm sine-wave LO
- **Configuration B:** +17 dBm sine-wave LO

**Configuration A Conversion Loss vs LO Power: 91 MHz IF (dB)**

- +24 dBm sine-wave LO
- +21 dBm sine-wave LO
- +18 dBm sine-wave LO
- +15 dBm sine-wave LO
- +12 dBm sine-wave LO
- +9 dBm sine-wave LO

**Configuration B Conversion Loss vs LO Power: 91 MHz IF (dB)**

- +24 dBm sine-wave LO
- +21 dBm sine-wave LO
- +18 dBm sine-wave LO
- +15 dBm sine-wave LO
- +12 dBm sine-wave LO
- +9 dBm sine-wave LO

**LO to RF Isolation (dB)**

- **Configuration A**
- **Configuration B**
3.6.1 Typical Performance Plots: IP3, Sine Wave LO

**Input IP3: +18 dBm Sine Wave LO (dBm)**

**Output IP3: +18 dBm Sine Wave LO (dBm)**

**Configuration A Input IP3 vs LO Power: Sine Wave LO (dBm)**

**Configuration A Output IP3 vs LO Power: Sine Wave LO (dBm)**

**Configuration B Input IP3 vs LO Power: Sine Wave LO (dBm)**

**Configuration B Output IP3 vs LO Power: Sine Wave LO (dBm)**
3.6.1 Typical Performance Plots: IP3, Square Wave LO

Input IP3: +19 dBm Square Wave LO (dBm)

Configuration A
Configuration B

Output IP3: +19 dBm Square Wave LO (dBm)

Configuration A
Configuration B

Configuration A Input IP3: 91 MHz IF (dBm)

saturated square-wave LO
+22 dBm square-wave LO
+19 dBm square-wave LO
+16 dBm square-wave LO
+13 dBm square-wave LO
+10 dBm square-wave LO

Configuration A Output IP3: 91 MHz IF (dBm)

saturated square-wave LO
+22 dBm square-wave LO
+19 dBm square-wave LO
+16 dBm square-wave LO
+13 dBm square-wave LO
+10 dBm square-wave LO

Configuration B Input IP3: 91 MHz IF (dBm)

saturated square-wave LO
+22 dBm square-wave LO
+19 dBm square-wave LO
+16 dBm square-wave LO
+13 dBm square-wave LO
+10 dBm square-wave LO

Configuration B Output IP3: 91 MHz IF (dBm)

saturated square-wave LO
+22 dBm square-wave LO
+19 dBm square-wave LO
+16 dBm square-wave LO
+13 dBm square-wave LO
+10 dBm square-wave LO
4. Application Information

4.1 Configuration A/B
Configuration A and Configuration B refer to the same part number used in one of two different ways to optimize spurious performance while balancing other parameters such as conversion loss, LO drive, and isolation. Experimentation or simulation is required to determine which configuration results in optimal spurious suppression for a given application.

4.2 Example Application Circuit
A top-down view of the MT3D-0113LSM’s SM package outline drawing is shown below in Configuration A. Pins 8 and 9 should be DC blocked and connected prior to balun. Pins 10 and 11 should be DC blocked and connected prior to balun.
5. Mechanical Data

5.1 SM Package Outline Drawing

1. Substrate material is ceramic.
2. I/O Leads and Ground Paddle plating is (from base to finish):
   - Ni: 8.89um MAX 1.27um MIN
   - Pd: 0.17um MAX 0.07um MIN
   - Au 0.254um MAX 0.03um MIN
3. All unconnected pads should be connected to PCB RF ground.

5.2 SM Package Footprint

Footprint detailing IF traces with DC blocking capacitors prior to balun

Detailed view of landing pattern for QFN

QFN-Package Surface-Mount Landing Pattern
Click here for a DXF of the above layout.
Click here for leaded solder reflow. Click here for lead-free solder reflow.

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