GaAs MMIC Millimeter Wave Doubler

1. Device Overview

1.1 General Description
The MMD-3580L is a MMIC millimeter wave doubler fabricated with GaAs Schottky diodes. This operates over a guaranteed 17.5 to 40 GHz input frequency range or a doubled output frequency range of 35 to 80 GHz. The die version, MMD-3580LCH, is capable of operating beyond 80GHz. Both the wire bondable die and connectorized units are available. The MMD-3567L is a bandlimited version of this doubler.

1.2 Features
▪ High fundamental rejection
▪ Millimeter wave output frequencies
▪ Low +7 dBm minimum input drive

1.3 Applications
▪ High frequency synthesis
▪ LO signal chain

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>MMD-3580LCH</td>
<td>Wire bondable die</td>
<td>CH</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
<tr>
<td>MMD-3580LU-KW</td>
<td>Connectorized module; 1.0 mm connector output</td>
<td>U</td>
<td></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.
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Revision History

<table>
<thead>
<tr>
<th>Revision Code</th>
<th>Revision Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>January 2018</td>
<td>Datasheet Initial Release</td>
</tr>
<tr>
<td>A</td>
<td>February 2019</td>
<td>Updated output return loss</td>
</tr>
</tbody>
</table>
2. Port Configurations and Functions

2.1 Port Diagram
A top-down view of the MMD-3580L’s CH package outline drawing is shown below. The MMD-3580L should only be used in the forward direction, with the input and output ports given in Port Functions.

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>Port 1</td>
<td>Input</td>
<td>Port 1 is DC open for the CH and U package.</td>
<td>P1</td>
</tr>
<tr>
<td>Port 2</td>
<td>Output</td>
<td>Port 2 is DC open for the CH and U package.</td>
<td>P2</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>CH package ground path is provided through the substrate and ground bond pads. U package ground provided through metal housing and outer coax conductor.</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>Port 1 DC Current</td>
<td>NA</td>
<td>mA</td>
</tr>
<tr>
<td>Port 2 DC Current</td>
<td>NA</td>
<td>mA</td>
</tr>
<tr>
<td>Power Handling, at any Port</td>
<td>+23</td>
<td>dBm</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-55 to +100</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65 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>U Package</td>
<td>10 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>Parameter</th>
<th>Min</th>
<th>Nominal</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_A, Ambient Temperature</td>
<td>-55</td>
<td>+25</td>
<td>+100</td>
<td>°C</td>
</tr>
<tr>
<td>Input Power</td>
<td>+7</td>
<td></td>
<td>+11</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 doubler that requires no DC bias.
3.5 Electrical Specifications

The electrical specifications apply at \( T_a = +25^\circ \text{C} \) in a 50\( \Omega \) system. Typical data shown is for the connectorized U package doubler used in the forward direction with a +8 dBm sine wave input.

Min and Max limits apply only to our connectorized units and are guaranteed at \( T_a = +25^\circ \text{C} \). RF testing of our die is performed on a sample basis to verify conformance to datasheet guaranteed specifications.

<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>Input (Port 1) Frequency Range</td>
<td></td>
<td>17.5</td>
<td></td>
<td>40</td>
<td>GHz</td>
</tr>
<tr>
<td>Output (Port 2) Frequency Range</td>
<td></td>
<td>35</td>
<td></td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Input Power</td>
<td></td>
<td>+7</td>
<td>+11</td>
<td></td>
<td>dBm</td>
</tr>
</tbody>
</table>
| 2F Conversion Loss (CL)                | Input = 17.5 - 33.5 GHz  
Output = 35 - 67 GHz | 11   |         | 15   | dB    |
|                                        | Input = 33.5 - 40 GHz  
Output = 67 - 80 GHz | 12   |         |      |       |
| Suppression\(^2,3\)                    | 1F  
Input = 17.5 - 40 GHz  
Output = 17.5 - 40 GHz | 38   |         |      | dBC   |
|                                        | 3F  
Input = 17.5 – 22.3 GHz  
Output = 52.5 - 67 GHz | 44   |         |      |       |
|                                        | 4F  
Input = 15 – 16.8 GHz  
Output = 60 - 67 GHz | 21   |         |      |       |
| Isolations\(^4\)                      | 1F  
Input = 17.5 - 40 GHz  
Output = 17.5 - 40 GHz | 47.7 |         |      | dB    |
|                                        | 3F  
Input = 17.5 – 22.3 GHz  
Output = 52.5 - 67 GHz | 54.4 |         |      |       |
|                                        | 4F  
Input = 15 – 16.8 GHz  
Output = 60 - 67 GHz | 31   |         |      |       |

\(^2\) Suppressions and isolations measured with an input source with >70dBc (relative to fundamental input) harmonic suppression

\(^3\) Suppression is defined as the harmonic power relative to the 2F doubled output power

\(^4\) Isolation is defined as the harmonic power relative to the 1F fundamental input power.
3.6 Typical Performance Plots

- **2F Output Conversion Loss (dB)**
  - RF Frequency (GHz)
  - Values range from -20 to 0 dB

- **1F Output Suppression (dBc)**
  - RF Frequency (GHz)
  - Values range from -90 to 0 dBc

- **1F Harmonic Isolation (dB)**
  - RF Frequency (GHz)
  - Values range from -90 to 0 dB

- **3F Output Suppression (dBc)**
  - RF Frequency (GHz)
  - Values range from -90 to 0 dBc

- **3F Harmonic Isolation (dB)**
  - RF Frequency (GHz)
  - Values range from -90 to 0 dB

- **4F Output Suppression (dBc)**
  - RF Frequency (GHz)
  - Values range from -90 to 0 dBc

- **4F Harmonic Isolation (dB)**
  - RF Frequency (GHz)
  - Values range from -90 to 0 dB
4. Die Mounting Recommendations

4.1 Mounting and Bonding Recommendations
Marki MMICs should be attached directly to a ground plane with conductive epoxy. The ground plane electrical impedance should be as low as practically possible. This will prevent resonances and permit the best possible electrical performance. Datasheet performance is only guaranteed in an environment with a low electrical impedance ground.

**Mounting** - To epoxy the chip, apply a minimum amount of conductive epoxy to the mounting surface so that a thin epoxy fillet is observed around the perimeter of the chip. Cure epoxy according to manufacturer instructions.

**Wire Bonding** - Ball or wedge bond with 0.025 mm (1 mil) diameter pure gold wire. Thermosonic wirebonding with a nominal stage temperature of 150 °C and a ball bonding force of 40 to 50 grams or wedge bonding force of 18 to 22 grams is recommended. Use the minimum level of ultrasonic energy to achieve reliable wirebonds. Wirebonds should be started on the chip and terminated on the package or substrate. All bonds should be as short as possible <0.31 mm (12 mils).

**Circuit Considerations** – 50 Ω transmission lines should be used for all high frequency connections in and out of the chip. Wirebonds should be kept as short as possible, with multiple wirebonds recommended for higher frequency connections to reduce parasitic inductance. In circumstances where the chip more than .001” thinner than the substrate, a heat spreading spacer tab is optional to further reduce bondwire length and parasitic inductance.

4.2 Handling Precautions

**General Handling**
Chips should be handled with care using tweezers or a vacuum collet. Users should take precautions to protect chips from direct human contact that can deposit contaminants, like perspiration and skin oils on any of the chip's surfaces.

**Static Sensitivity**
GaAs MMIC devices are sensitive to ESD and should be handled, assembled, tested, and transported only in static protected environments.

**Cleaning and Storage:** Do not attempt to clean the chip with a liquid cleaning system or expose the bare chips to liquid. Once the ESD sensitive bags the chips are stored in are opened, chips should be stored in a dry nitrogen atmosphere.
4.3 Bonding Diagram

Orientation Marker

Multiple Wirebonds for Reduced Inductance

Minimum Space Gap/Wirebond Length

Input

Output
5. Mechanical Data

5.1 CH Package Outline Drawing

1. CH Substrate material is 0.004 in thick GaAs.
2. I/O trace finish is 4.2 microns Au. Ground plane finish is 5 microns Au.

5.3 U-KW Package Outline Drawing