GaAs MMIC mmWave Tuner Mixer

1. Device Overview

1.1 General Description
MM1-1467H is a GaAs MMIC double balanced mixer with a broad IF bandwidth and low conversion loss. This mixer is ideal for applications which require broad IF bandwidths with operation at mmWave frequencies. The MM1-1467H is available as both wire bondable die and as connectorized modules. The -1 option for die is available for this mixer. Both the -1 and -2 mixers are electrically identically but with mirrored footprints. 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 IF bands covering critical Ku & K band
- Flat IF response through K band
- High linearity

1.3 Applications
- Test and measurement equipment
- Fixed RF up converters
- Electronic warfare equipment

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>MM1-1467HCH-2</td>
<td>Wire bondable die</td>
<td>CH (option -2)</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
<tr>
<td>MM1-1467HCH-1</td>
<td>Wire bondable die</td>
<td>CH (option -1)</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
<tr>
<td>MM1-1467HUB</td>
<td>Connectorized module</td>
<td>UB</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 .. 8
      3.6.2 Typical Performance Plots: LO Harmonic Isolation .. 9
      3.6.3 Typical Performance Plots: Tuner Mixer .......... 10
      3.6.4 Typical Spurious Performance: Down-Conversion ...... 11
      3.6.5 Typical Spurious Performance: Up-Conversion .......... 11
4. Die Mounting Recommendations ...... 12
   4.1 Mounting and Bonding Recommendations .............. 12
   4.2 Handling Precautions ....................................... 12
   4.3 Bonding Diagram ............................................. 13
5. Mechanical Data ............................................. 14
   5.1 CH Package Outline Drawing (Option - 2) .................. 14
   5.2 CH Package Outline Drawing (Option - 1) ............... 14
   5.3 UB Package Outline Drawing ....................... 15

Revision History

<table>
<thead>
<tr>
<th>Revision Code</th>
<th>Revision Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>May 2019</td>
<td>Datasheet Initial Release</td>
</tr>
</tbody>
</table>
2. Port Configurations and Functions

2.1 Port Diagram
A top-down view of the MM1-1467HCH-2 outline drawing is shown below to the left. The MM1-1467HCH-1 is shown below to the right. Both mixers are electrically identical and have mirrored footprints. The MM1-1467H has the input and output ports given in Port Functions. The MM1-1467H can be used in either an up or down conversion.

![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>Port 1</td>
<td>LO (Configuration A) RF (Configuration B)</td>
<td>Port 1 is DC open for the CH and UB packages.</td>
<td><img src="circuit" alt="P1" /></td>
</tr>
<tr>
<td>Port 2</td>
<td>IF</td>
<td>Port 2 is diode connected for the CH and UB package.</td>
<td><img src="circuit" alt="P2" /></td>
</tr>
<tr>
<td>Port 3</td>
<td>RF (Configuration A) LO (Configuration B)</td>
<td>Port 3 is DC open for the CH and UB packages.</td>
<td><img src="circuit" alt="P3" /></td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>CH package ground path is provided through the substrate and ground bond pads. UB package ground provided through metal housing and outer coax conductor.</td>
<td><img src="circuit" alt="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>N/A</td>
<td>mA</td>
</tr>
<tr>
<td>Port 2 DC Current</td>
<td>TBD</td>
<td>mA</td>
</tr>
<tr>
<td>Power Handling, at any Port</td>
<td>+27</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>Details</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>UB Package</td>
<td>16 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&lt;sub&gt;A&lt;/sub&gt;, Ambient Temperature</td>
<td>-55</td>
<td>+25</td>
<td>+100</td>
<td>°C</td>
</tr>
<tr>
<td>LO Input Power</td>
<td>+11</td>
<td></td>
<td>+20</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 $T_A=+25^\circ$C in a 50$\Omega$ system. Typical data shown is for the connectorized UB package mixer used with a +15 dBm sine wave LO. Specifications shown for configuration A (B).

Min and Max limits apply only to our connectorized units and are guaranteed at $T_A=+25^\circ$C. All bare die are 100% DC tested and visually inspected.

<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 (Port 3) Frequency Range</td>
<td></td>
<td>14</td>
<td>67</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>LO (Port 1) Frequency Range</td>
<td></td>
<td>14</td>
<td>67</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>I (Port 2) Frequency Range</td>
<td></td>
<td>0</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversion Loss (CL)$^2$</td>
<td>RF/LO = 14 - 67 GHz, I = 0.091 GHz</td>
<td>7</td>
<td>12</td>
<td>(8)</td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>RF/LO = 14 - 67 GHz, I = 0.091 - 21 GHz</td>
<td>9</td>
<td>(10.5)</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Noise Figure (NF)$^3$</td>
<td>RF/LO = 14 - 67 GHz, I = 0.091 - 21 GHz</td>
<td>8.5</td>
<td></td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>Isolation</td>
<td>LO to RF</td>
<td>RF/LO = 14 - 67 GHz</td>
<td>53</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>LO to IF</td>
<td>IF/LO = 14 - 67 GHz</td>
<td>33</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>RF to IF</td>
<td>RF/IF = 14 - 67 GHz</td>
<td>48</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Input IP3 (IIP3)</td>
<td>RF/LO = 14 - 67 GHz, I = 0.091 GHz</td>
<td>+17.5</td>
<td>(+19.5)</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Input 1 dB Gain Compression Point (P1dB)</td>
<td></td>
<td>+9</td>
<td>(+9)</td>
<td>dBm</td>
<td></td>
</tr>
</tbody>
</table>

$^2$ 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.
3.6 Typical Performance Plots

Conversion Loss (dB)

Configuration A
- Configuration B

RF Frequency (GHz)

Configuration A Conversion Loss vs. LO Power (dB)

RF Frequency (GHz)

Configuration B Conversion Loss vs. LO Power (dB)

RF Frequency (GHz)

Relative IF Response (dB)

IF Frequency (GHz)

18 GHz RF - Configuration A
- 18 GHz RF - Configuration B

Relative IF Response (dB)

IF Frequency (GHz)

60 GHz RF - Configuration A
- 60 GHz RF - Configuration B

IF Return Loss (dB)

IF Frequency (GHz)

IF RL HSLO 18 GHz - Configuration A
- IF RL HSLO 18 GHz - Configuration B

IF Return Loss (dB)

IF Frequency (GHz)

IF RL LSLO 60 GHz - Configuration B
- IF RL LSLO 60 GHz - Configuration B
3.6.1 Typical Performance Plots: IP3

- **Input IP3 (dBm)**
  - Configuration A
  - Configuration B
  - RF Frequency (GHz)

- **Output IP3 (dBm)**
  - Configuration A
  - Configuration B
  - RF Frequency (GHz)

- **Configuration A Input IP3 vs LO Power (dBm)**
  - +18 dBm
  - +16 dBm
  - +14 dBm
  - RF Frequency (GHz)

- **Configuration A Output IP3 vs LO Power (dBm)**
  - +18 dBm
  - +16 dBm
  - +14 dBm
  - RF Frequency (GHz)

- **Configuration B Input IP3 vs LO Power (dBm)**
  - +18 dBm
  - +16 dBm
  - +14 dBm
  - RF Frequency (GHz)

- **Configuration B Output IP3 vs LO Power (dBm)**
  - +18 dBm
  - +16 dBm
  - +14 dBm
  - RF Frequency (GHz)
3.6.2 Typical Performance Plots: LO Harmonic Isolation

- **Even LO Harmonic to RF Isolation (dB)**
  - LO Output Frequency (GHz)
  - Graphs show the isolation at different LO frequencies for 2xLO and 4xLO configurations.

- **Odd LO Harmonic to RF Isolation (dB)**
  - LO Output Frequency (GHz)
  - Graphs show the isolation at different LO frequencies for 3xLO configurations.

- **2xRF x 2LO Spurious Suppression (dBc) -10 dBm RF Input**
  - RF Input Frequency (GHz)
  - Graph shows the spurious suppression for different configurations.

- **2xRF x 1LO Spurious Suppression (dBc) -10 dBm IF Input**
  - RF Output Frequency (GHz)
  - Graph shows the spurious suppression for different configurations.
3.6.3 Typical Performance Plots: Tuner Mixer

Tuner mixer performance plots are taken with the following test conditions and frequency plan:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Start</th>
<th>Nominal</th>
<th>Stop</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF Input Frequency</td>
<td>0</td>
<td>24</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>IF Input Power</td>
<td>-10</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>LO Input Frequency</td>
<td>24</td>
<td>48</td>
<td></td>
<td>GHz</td>
</tr>
<tr>
<td>LO Input Power</td>
<td>+15</td>
<td></td>
<td></td>
<td>dBm</td>
</tr>
<tr>
<td>RF Output Frequency</td>
<td>24</td>
<td></td>
<td></td>
<td>GHz</td>
</tr>
</tbody>
</table>

![Typical Performance Plot](image)

- Tuner Operation
- MM1-1467
- Tuned Output at 24 GHz
- 24-48 GHz LO Source
- Tuner Conversion Loss (dB)
- Tuner IIP3 (dBm)
- Tuner OIP3 (dBm)
3.6.4 Typical Spurious Performance: Down-Conversion

Typical spurious data is provided by selecting RF and LO frequencies ($\pm m^{\text{LO}} \pm n^{\text{RF}}$) within the RF/LO bands, to create a spurious output within the IF band. The mixer is swept across the full spurious band and the mean is calculated. The numbers shown in the table below are for a -10 dBm RF input. Spurious suppression is scaled for different RF power levels by $(n-1)$, where “n” is the RF spur order. For example, the 2RF x 2LO spur is 67 dBc for a -10 dBm input, so a -20 dBm RF input creates a spur that is $(2-1) \times (-10 \text{ dB})$ lower, or 77 dBc.

Typical Down-conversion spurious suppression (dBc): Config A (B)

<table>
<thead>
<tr>
<th>-10 dBm RF Input</th>
<th>0xLO</th>
<th>1xLO</th>
<th>2xLO</th>
<th>3xLO</th>
<th>4xLO</th>
<th>5xLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1xRF</td>
<td>40 (25)</td>
<td>Reference</td>
<td>40 (35)</td>
<td>21 (16)</td>
<td>45 (35)</td>
<td>N/A</td>
</tr>
<tr>
<td>2xRF</td>
<td>86 (93)</td>
<td>50 (66)</td>
<td>67 (74)</td>
<td>61 (69)</td>
<td>68 (72)</td>
<td>64 (73)</td>
</tr>
<tr>
<td>3xRF</td>
<td>98 (90)</td>
<td>58 (61)</td>
<td>84 (84)</td>
<td>66 (74)</td>
<td>86 (85)</td>
<td>63 (69)</td>
</tr>
<tr>
<td>4xRF</td>
<td>124 (122)</td>
<td>89 (111)</td>
<td>102 (110)</td>
<td>98 (115)</td>
<td>111 (119)</td>
<td>101 (114)</td>
</tr>
<tr>
<td>5xRF</td>
<td>N/A</td>
<td>117 (130)</td>
<td>124 (118)</td>
<td>107 (120)</td>
<td>124 (127)</td>
<td>109 (121)</td>
</tr>
</tbody>
</table>

3.6.5 Typical Spurious Performance: Up-Conversion

Typical spurious data is taken by mixing an input within the IF band, with LO frequencies ($\pm m^{\text{LO}} \pm n^{\text{IF}}$), to create a spurious output within the RF output band. The mixer is swept across the full spurious output band and the mean is calculated. The numbers shown in the table below are for a -10 dBm IF input. Spurious suppression is scaled for different IF input power levels by $(n-1)$, where “n” is the IF spur order. For example, the 2IFx1LO spur is typically 79 dBc for a -10 dBm input with a sine-wave LO, so a -20 dBm IF input creates a spur that is $(2-1) \times (-10 \text{ dB})$ lower, or 89 dBc.

Typical Up-conversion spurious suppression (dBc): Config A (B)

<table>
<thead>
<tr>
<th>-10 dBm RF Input</th>
<th>0xLO</th>
<th>1xLO</th>
<th>2xLO</th>
<th>3xLO</th>
<th>4xLO</th>
<th>5xLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1xIF</td>
<td>40 (25)</td>
<td>Reference</td>
<td>40 (34)</td>
<td>17 (14)</td>
<td>42 (34)</td>
<td>N/A</td>
</tr>
<tr>
<td>2xIF</td>
<td>70 (70)</td>
<td>79 (79)</td>
<td>68 (71)</td>
<td>74 (76)</td>
<td>57 (67)</td>
<td>77 (74)</td>
</tr>
<tr>
<td>3xIF</td>
<td>89 (80)</td>
<td>61 (69)</td>
<td>82 (79)</td>
<td>65 (64)</td>
<td>77 (72)</td>
<td>54 (58)</td>
</tr>
<tr>
<td>4xIF</td>
<td>109 (111)</td>
<td>106 (109)</td>
<td>106 (108)</td>
<td>105 (104)</td>
<td>89 (99)</td>
<td>102 (105)</td>
</tr>
<tr>
<td>5xIF</td>
<td>121 (119)</td>
<td>105 (110)</td>
<td>120 (121)</td>
<td>103 (107)</td>
<td>114 (112)</td>
<td>98 (104)</td>
</tr>
</tbody>
</table>
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
5. Mechanical Data

5.1 CH Package Outline Drawing (Option -2)

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.

5.2 CH Package Outline Drawing (Option -1)

3. CH Substrate material is 0.004 in thick GaAs.
4. I/O trace finish is 4.2 microns Au. Ground plane finish is 5 microns Au.
5.3 UB Package Outline Drawing

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