GaAs MMIC Double Balanced Mixer

1. Device Overview

1.1 General Description
The MM1-1850HSM is a GaAs MMIC double balanced mixer that operates at high frequency in a proprietary surface mount package. MM1-1850HSM is a K/Ka band mixer that works well as both an up and down converter. This mixer offers exceptionally high frequency RF bandwidth for a surface mount mixer and high spurious suppression. The sister MM1-1850SSM is recommended for high linearity applications. The MM1-1850HSM is available in a proprietary 4x4 mm package. Evaluation boards are available.

1.2 Features
▪ High Frequency Operation
▪ High LO to RF isolation
▪ RoHS Compliant

1.3 Applications
▪ Electronic Warfare Scanners
▪ 5G Test Receivers
▪ Recommended Surface Mount Amplifier: AMM-6702SM

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>MM1-1850HSM-2</td>
<td>KFN</td>
<td>SM</td>
<td>RoHS</td>
<td>Active</td>
<td>EAR99</td>
</tr>
<tr>
<td>EVAL-MM1-1850H</td>
<td>Connectorized Evaluation Fixture</td>
<td>Eval</td>
<td></td>
<td>Active</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

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>May 2019</td>
<td>Datasheet Release</td>
</tr>
<tr>
<td>A</td>
<td>July 2019</td>
<td>Corrected SM Package Dimension Callout</td>
</tr>
</tbody>
</table>
2. Port Configurations and Functions

2.1 Port Diagram
A bottom-up view of the MM1-1850HSM’s SM package outline drawing is shown below. The MM1-1850HSM has the input and output ports given in Port Functions. The MM1-1850HSM can be used in either an up or down conversion. For configuration A, input the LO into pin 1, use pin 3 for the RF, and pin 2 for the IF. For configuration B, input the LO into pin 3, use pin 1 for the RF, and pin 2 for the IF.

2.2 Port Functions

<table>
<thead>
<tr>
<th>Port</th>
<th>Function</th>
<th>Description</th>
<th>DC Interface Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 1</td>
<td>LO (Configuration A) RF (Configuration B)</td>
<td>Pin 1 is DC open and AC matched to 50 Ohms from 18 to 50 GHz.</td>
<td><img src="image1" alt="Schematic" /></td>
</tr>
<tr>
<td>Pin 2</td>
<td>IF</td>
<td>Port 2 is DC coupled to the diodes. Blocking capacitor is optional.</td>
<td><img src="image2" alt="Schematic" /></td>
</tr>
<tr>
<td>Pin 3</td>
<td>RF (Configuration A) LO (Configuration B)</td>
<td>Pin 3 is DC open and AC matched to 50 Ohms from 18 to 50 GHz.</td>
<td><img src="image3" alt="Schematic" /></td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>SM package ground path is provided through the ground paddle.</td>
<td><img src="image4" alt="Schematic" /></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>Power Handling, at any Port</td>
<td>+30</td>
<td>dBm</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>TBD</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>TBD</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</td>
</tr>
<tr>
<td>MSL</td>
<td>J-STD-020</td>
<td>TBD</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></td>
<td>+25</td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>LO Input Power</td>
<td>+12</td>
<td></td>
<td>+22</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 a down conversion application with a $+18\text{dBm}$ sine wave LO input. Specifications shown for configuration A. Configuration B may be suitable for conversions below 45 GHz.

<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 Frequency Range</td>
<td></td>
<td>18</td>
<td></td>
<td>50</td>
<td>GHz</td>
</tr>
<tr>
<td>LO Frequency Range</td>
<td></td>
<td>18</td>
<td></td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>IF Frequency Range</td>
<td></td>
<td>0</td>
<td></td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>
| Conversion Loss (CL)$^2$         | $\text{RF} = 18 - 50\text{GHz}$  
$\text{LO} = 18-45\text{GHz}$  
$\text{IF} = \text{DC} - 0.2\text{GHz}$ | 8.7 | 11.5    |     | dB   |
|                                 | $\text{RF} = 18 - 50\text{GHz}$  
$\text{LO} = 18-45\text{GHz}$  
$\text{IF} = 0.2 - 21\text{GHz}$ | 11.5 |         |     |      |
| Noise Figure (NF)$^3$            | $\text{RF} = 18 - 50\text{GHz}$  
$\text{LO} = 18-45\text{GHz}$  
$\text{IF} = \text{DC} - 0.2\text{GHz}$ |     | 10      |     | dB   |
| Isolation                        | $\text{LO to RF}$  
$\text{RF/LO} = 18 - 50\text{GHz}$ | 39  |         |     |      |
|                                 | $\text{LO to IF}$  
$\text{IF/LO} = 18 - 50\text{GHz}$ | 35  |         |     |      |
|                                 | $\text{RF to IF}$  
$\text{RF/IF} = 18 - 50\text{GHz}$ | 28  |         |     |      |
| Input IP3 (IIP3)                 | $\text{RF/LO} = 18 - 50\text{GHz}$  
$\text{IF} = \text{DC} - 0.2\text{GHz}$ | +17 |         |     | dBm  |
| Output IP3 (OIP3)                | $\text{RF/LO} = 18 - 50\text{GHz}$  
$\text{IF} = \text{DC} - 0.2\text{GHz}$ | +6  |         |     | dBm  |
| Input 1 dB Gain Compression Point (P1dB) |                               | +9  |         |     | dBm  |

$^2$ Measured as a down converter to a fixed 91MHz IF.

$^3$ 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: 91 MHz IF, LSLO (dB)]

- RF Frequency (GHz)
- Configuration A

![Conversion Loss: 8 GHz IF, LSLO (dB)]

- RF Frequency (GHz)
- Configuration A

![Configuration A Conversion Loss vs. LO Power: 91 MHz IF (dB)]

- RF Frequency (GHz)
- LO Power: +20 dBm, +18 dBm, +16 dBm, +14 dBm

![Configuration A Conversion Loss vs. LO Power: 8 GHz IF (dB)]

- RF Frequency (GHz)
- LO Power: +20 dBm, +18 dBm, +16 dBm, +14 dBm

![Relative IF Response (dB)]

- IF Frequency (GHz)
- 21 GHz RF - Configuration A

![LO to RF Isolation (dB)]

- LO Frequency (GHz)
- Configuration A

![LO to IF Isolation (dB)]

- LO Frequency (GHz)
- Configuration A

![RF to IF Isolation (dB)]

- RF Frequency (GHz)
- Configuration A
3.6.1 Typical Performance Plots: IP3

3.6.2 Typical Performance Plots: LO Harmonic Isolation
RF Input Frequency (GHz)

2RF x 2LO Spurious Suppression (dBc) -10 dBm RF Input

Configuration A

RF Output Frequency (GHz)

2IF x 1LO Spurious Suppression (dBc) -10 dBm IF Input

Configuration A

RF Output Frequency (GHz)

2IF x 0LO Spurious Suppression (dBc) -10 dBm IF Input

Configuration A

RF Output Frequency (GHz)

3IF x 0LO Spurious Suppression (dBc) -10 dBm IF Input

Configuration A
3.6.3 Typical Spurious Performance: Down-Conversion

Typical spurious data is provided by selecting RF and LO frequencies ($\pm m^{\circ}\text{LO} \pm n^{\circ}\text{RF}$) 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 $2\text{RF} \times 2\text{LO}$ spur is 57 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 67 dBc. Data is shown for the frequency plan in Typical Performance. mLOx0RF plots can be found in section 3.6.2 Typical Performance Plots: LO Harmonic Isolation. OLOx1RF plot is identical to the plot of LO-RF isolation.

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

<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>0xRF</td>
<td>-</td>
<td>28</td>
<td>54</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1xRF</td>
<td>25</td>
<td>Reference</td>
<td>29</td>
<td>12</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2xRF</td>
<td>76</td>
<td>43</td>
<td>57</td>
<td>66</td>
<td>68</td>
<td>NA</td>
</tr>
<tr>
<td>3xRF</td>
<td>NA</td>
<td>51</td>
<td>73</td>
<td>73</td>
<td>83</td>
<td>79</td>
</tr>
<tr>
<td>4xRF</td>
<td>NA</td>
<td>NA</td>
<td>92</td>
<td>100</td>
<td>112</td>
<td>114</td>
</tr>
<tr>
<td>5xRF</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>109</td>
<td>123</td>
<td>121</td>
</tr>
</tbody>
</table>

3.6.4 Typical Spurious Performance: Up-Conversion

Typical spurious data is taken by mixing an input within the IF band, with LO frequencies ($\pm m^{\circ}\text{LO} \pm n^{\circ}\text{IF}$), 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 $2\text{IF} \times 1\text{LO}$ spur is typically 57 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 67 dBc. Data is shown for the frequency plan in Typical Performance.

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

<table>
<thead>
<tr>
<th>-10 dBm IF 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>0xIF</td>
<td>-</td>
<td>42</td>
<td>65</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1xIF</td>
<td>16</td>
<td>Reference</td>
<td>19</td>
<td>9</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2xIF</td>
<td>63</td>
<td>57</td>
<td>57</td>
<td>61</td>
<td>62</td>
<td>NA</td>
</tr>
<tr>
<td>3xIF</td>
<td>86</td>
<td>66</td>
<td>73</td>
<td>65</td>
<td>77</td>
<td>66</td>
</tr>
<tr>
<td>4xIF</td>
<td>108</td>
<td>102</td>
<td>59</td>
<td>105</td>
<td>98</td>
<td>106</td>
</tr>
<tr>
<td>5xIF</td>
<td>116</td>
<td>112</td>
<td>113</td>
<td>115</td>
<td>110</td>
<td>112</td>
</tr>
</tbody>
</table>
4. Operation

4.1 Application Circuit

![Diagram of application circuit]

**4.2 Ports Operation**

**IF Port** – Used as input on an upconversion, output on downconversion, or LO port in a band shifting application. Signals should be connected by 50 ohm microstrip or coplanar traces to well matched broadband 50 ohm sources and loads. Blocking capacitor is recommended if DC voltage is present on the line.

**RF Port** – Used as input on a downconversion, output on upconversion, or output in a band shifting application. Signals should be connected by 50 ohm microstrip or coplanar traces to well matched broadband 50 ohm sources and loads.

**Filtering and Matching** - Filtering is generally desired for spurious and image removal on the output port of the mixer. Reflective filters can cause out of band signals to reflect back into the mixer and cause conversion loss ripple, erroneous spurs, and other undesired behaviors. To eliminate these problems it is recommend that the filters be placed as close to the output port as possible. If undesired behavior is still observed, a diplexer with one port terminated or a 1-3 dB attenuator may reduce this problem.

**RF Ground** – The ground paddle of the QFN should be connected to a low noise RF ground with very low electrical resistance for high frequency operation.

**LO Port** – The noise floor of the LO input signal should be less than the value of the noise floor plus isolation of the mixer, or a filter is recommended to prevent reduction in dynamic range. An LO amplifier is required if the LO power is below the recommended drive level. It is important to use an amplifier with a broadband 50 ohm match such that it does not reflect spurious signals back into the mixer or other system circuitry.
5. Mechanical Data

5.1 SM Package Outline Drawing

1. Substrate material is ceramic.
2. I/O Leads and Ground Paddle plating is TiWNiAu, 0.51 μm max Au.
3. All unconnected pads should be connected to PCB RF ground.

5.2 SM Package Footprint

SM-Package Surface-Mount Landing Pattern

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