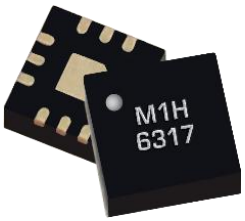
**GaAs MMIC Double Balanced Mixer** **MM1-1040HPSM**

# 1. Device Overview




3x3 mm
plastic QFN

## 1.1 General Description

The MM1-1040HPSM is a GaAs MMIC double balanced mixer suitable for both up and down-conversion applications. As with all Marki Microwave mixers, it features excellent conversion loss, isolation and spurious performance across a broad bandwidth and in a small form factor. The MM1-1040HPSM is available in a lead-free, RoHS compliant 3x3 mm QFN package and is compatible with standard leaded and lead-free PCB reflow soldering processes. Evaluation boards are also available. For a list of recommended LO driver amps for all mixers and IQ mixers, see here.

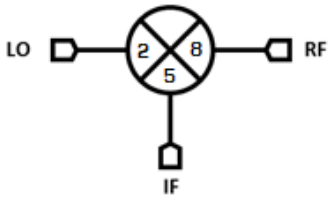
## 1.2 Features

| Parameter | Typical |
|---|---|
| RF/LO response | 10GHz – 40 GHz |
| IF response | DC – 12 GHz |
| Conversion Loss | 7 dB |
| LO to RF Isolation | 45 dB |

## 1.3 Applications

- Test and measurement equipment
- Electronic Warfare
- 5G
- SATCOM

## 1.4 Functional Block Diagram




## 1.5 Part Ordering Options[1]

| Part Number | Description | Package | Green Status | Product Lifecycle | Export Classification |
|---|---|---|---|---|---|
| **MM1-1040HPSM-2** | 3x3 mm QFN | PSM | **RoHS** | Active | EAR99 |
| **EVAL-MM1-1040HP** | Connectorized Evaluation Fixture | Eval | **Non-RoHS** | Active | EAR99 |

[1] Refer to our website for a list of definitions for terminology presented in this table.

## Table of Contents



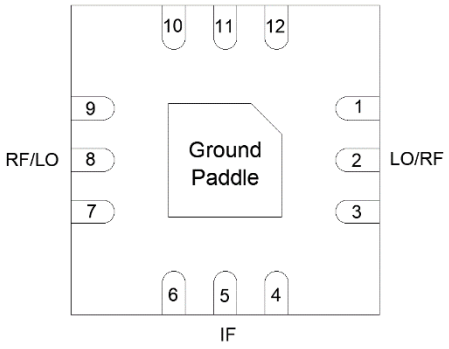
**Revision History**

| Revision Code | Revision Date | Comment |
|---|---|---|
| - | June 2021 | Datasheet Initial Release |

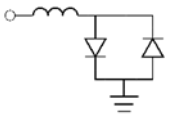
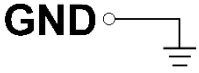
# 2. Port Configurations and Functions

## 2.1 Port Diagram

A bottom-up view of the MM1-1040HPSM's PSM package outline drawing is shown below. The MM1-1040HPSM has the input and output ports given in Port Functions. The MM1-1040HPSM can be used in either an up or down conversion application. For configuration A, input the LO into pin 2, use pin 8 for the RF, and pin 5 for the IF. For configuration B, input the LO into pin 8, use pin 2 for the RF, and pin 5 for the IF.




## 2.2 Port Functions

| Port | Function | Description | Equivalent Circuit for Package |
|---|---|---|---|
| Pin 2 | LO (Configuration A)<br>RF (Configuration B) | Pin 2 is DC short and AC matched to 50 Ohms from 10 to 40 GHz. |  |
| Pin 5 | IF | Pin 5 is DC coupled to the diodes. Blocking capacitor is optional. |  |
| Pin 8 | RF (Configuration A)<br>LO (Configuration B) | Pin 8 is DC open and AC matched to 50 Ohms from 10 to 40 GHz. |  |
| GND | Ground | PSM package ground path is provided through the ground paddle. |  |

# 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.

| Parameter | Maximum Rating | Units |
|---|---|---|
| Pin 2 DC Current | 15 | mA |
| Pin 5 DC Current | 24 | mA |
| Pin 8 DC Current | N/A | mA |
| Power Handling, at any Port | +25 at +25°C, derated linearly to +21 dBm at +100°C | dBm |
| Operating Temperature | -55 to +100 | °C |
| Storage Temperature | -65 to +125 | °C |

## 3.2 Package Information

| Parameter | Details | Rating |
|---|---|---|
| ESD | Human Body Model (HBM), per MIL-STD-750, Method 1020 | 1A |
| Weight | EVAL package | 11.4 g |

## 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.

| | Min | Nominal | Max | Units |
|---|---|---|---|---|
| $T_A$, Ambient Temperature | -55 | +25 | +100 | °C |
| LO Input Power | +12 | +17 | +20 | dBm |

## 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.

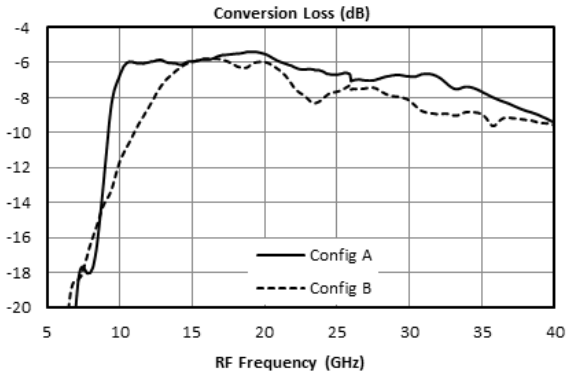
## 3.5 Electrical Specifications

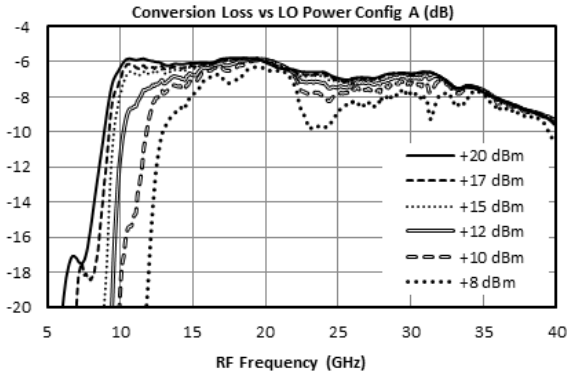
The electrical specifications apply at TA=+25°C in a 50Ω system. Typical data shown is for a down conversion application with a +17 dBm sine wave LO input. Specifications shown for configuration A (B).

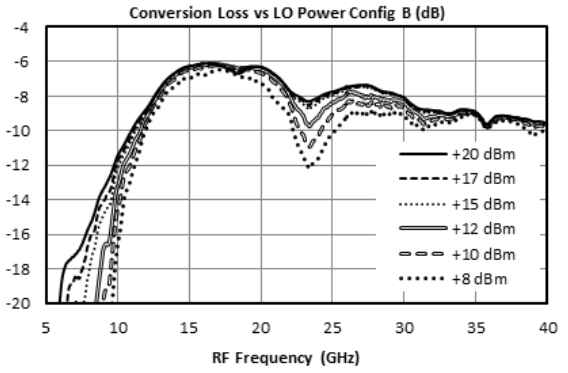
| Parameter | | Test Conditions | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| RF (Pin 8) Frequency Range | | | 10 | | 40 | GHz |
| LO (Pin 2) Frequency Range | | | 10 | | 40 | |
| I (Pin 5) Frequency Range | | | 0 | | 12 | |
| Conversion Loss (CL)[2] | | RF/LO = 10 - 40 GHz<br>I = DC - 0.2 GHz | | 7<br>(8) | 12<br>(14) | dB |
| | | RF/LO = 10 - 40 GHz<br>I = 0.2 - 12 GHz | | 9<br>(9) | | |
| Noise Figure (NF)[3] | | RF/LO = 10 - 40 GHz<br>I = DC - 0.2 GHz | | 7<br>(8) | | dB |
| Isolation | LO to RF | RF/LO = 10 - 40 GHz | | 45<br>(46) | | dB |
| | LO to IF | IF/LO = 10 - 40 GHz | | 24<br>(45) | | |
| | RF to IF | RF/IF = 10 - 40 GHz | | 45<br>(23) | | |
| Input IP3 (IIP3) | | RF/LO = 10 - 40 GHz<br>I = DC - 0.2 GHz | | +20<br>(+24) | | dBm |
| Input 1 dB Gain Compression Point (P1dB) | | | | +11<br>(+10) | | dBm |

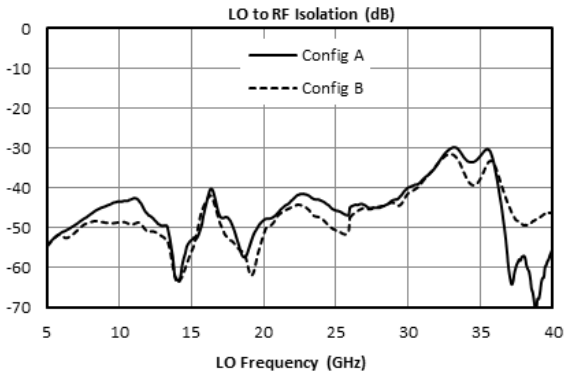
[2] Measured as a down converter to a fixed 91MHz IF.
[3] Mixer Noise Figure typically measures within 0.5 dB of conversion loss for IF frequencies greater than 5 MHz.

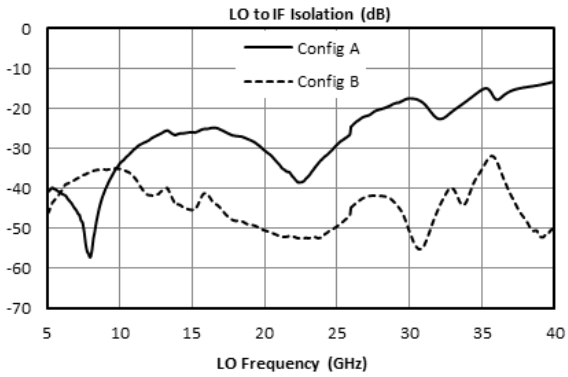
## 3.6 Typical Performance Plots

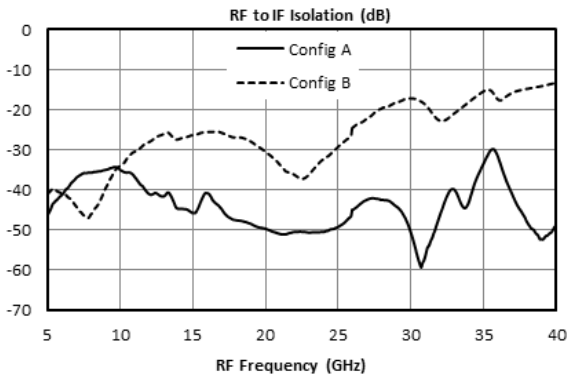


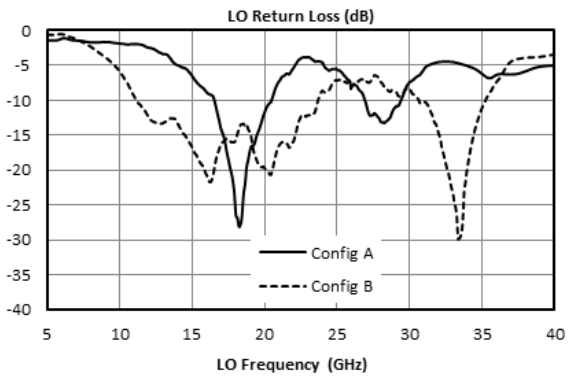



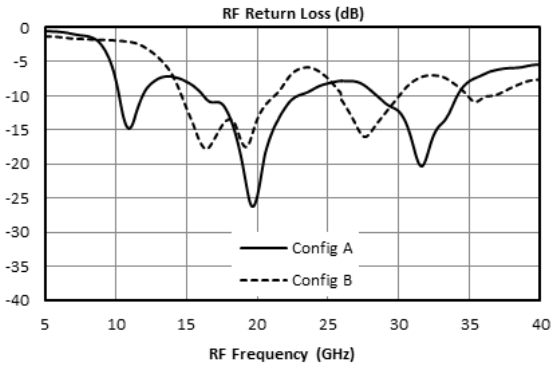



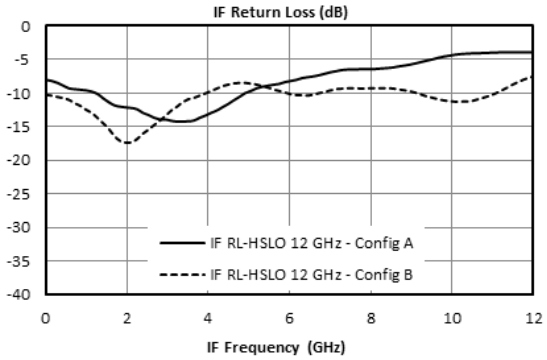



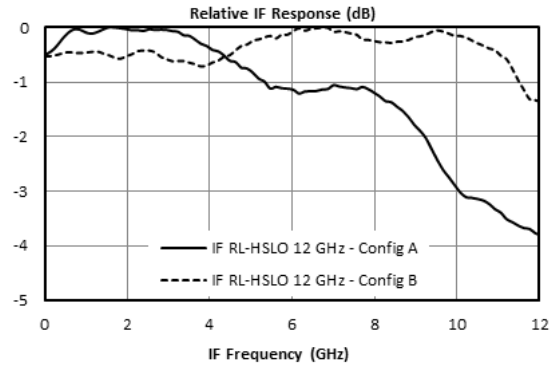



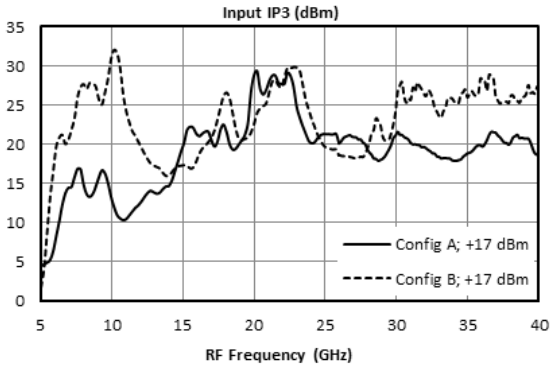



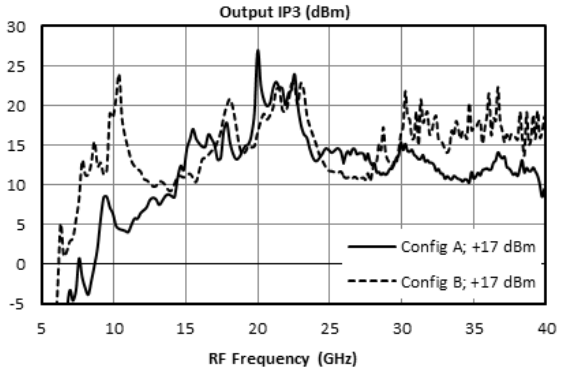


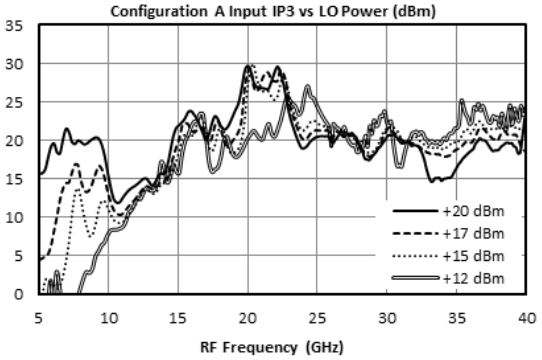



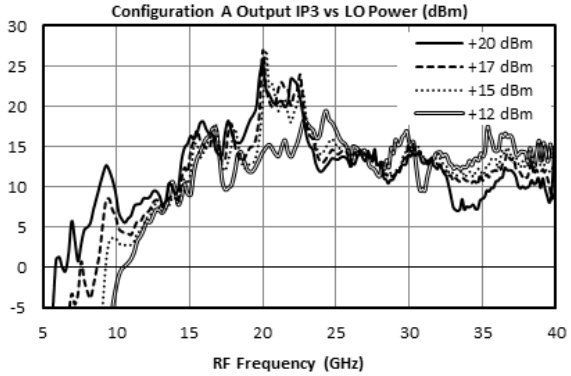



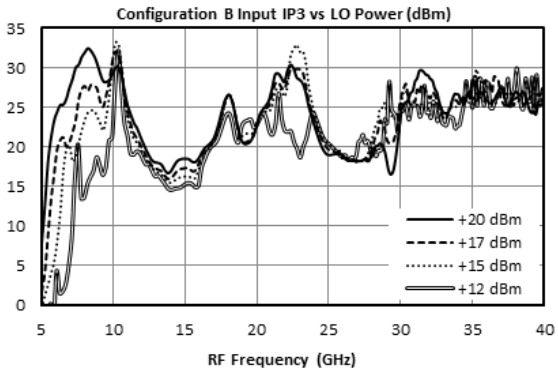
### 3.6.1 Typical Performance Plots: IP3

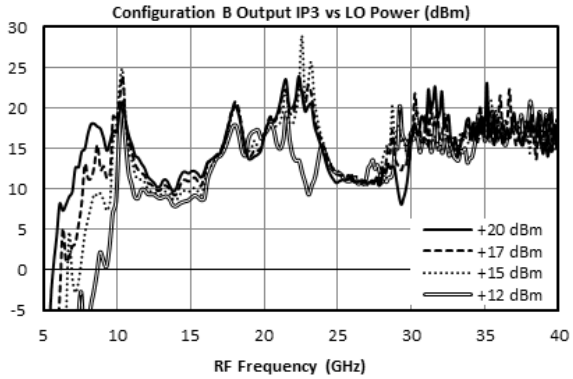


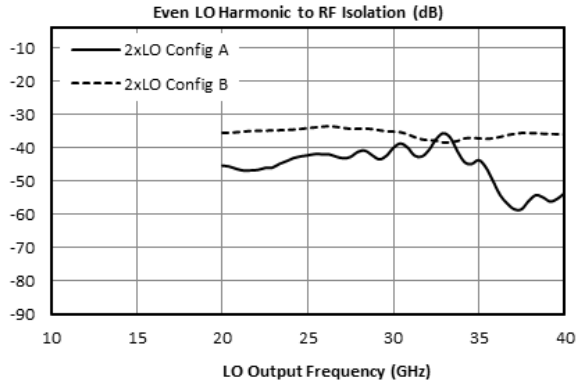



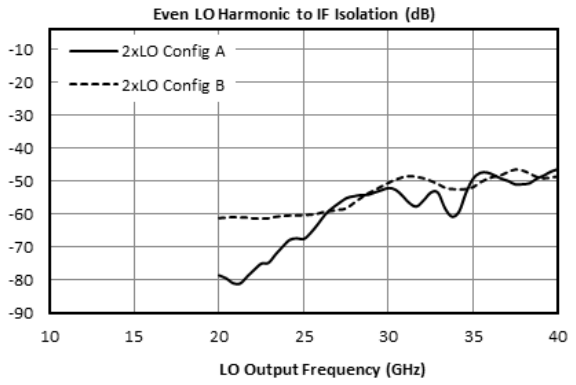



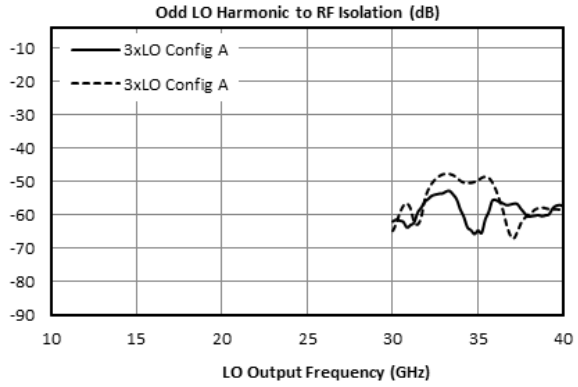



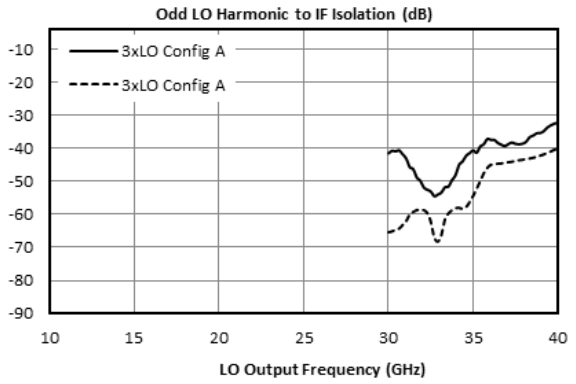



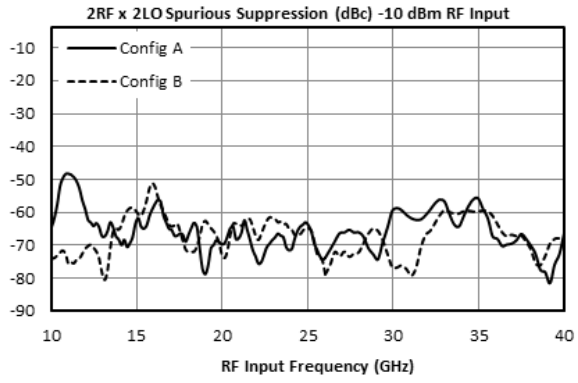
### 3.6.2 Typical Performance Plots: LO Harmonic Isolation

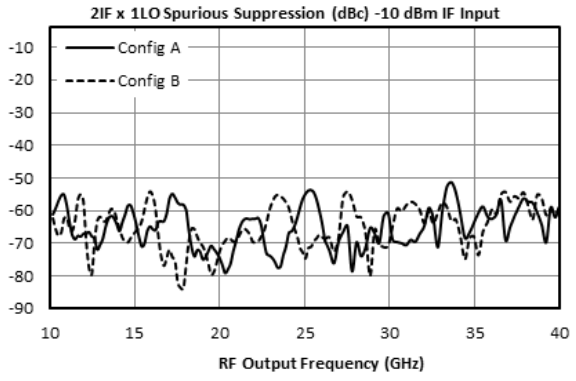


### 3.6.3 Typical Spurious Performance: Down-Conversion

Typical spurious data is provided by selecting RF and LO frequencies (± m*LO ± n*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 65 dBc for a -10 dBm input, so a -20 dBm RF input creates a spur that is (2-1) x (-10 dB) lower, or 75 dBc. Data is shown for the frequency plan in 3.6 Typical Performance. 0LOx1RF plot is identical to the plot of LO-RF isolation.

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

| -10 dBm RF Input | 0xLO | 1xLO | 2xLO | 3xLO | 4xLO | 5xLO |
|---|---|---|---|---|---|---|
| **1xRF** | 36 (15) | Reference | 33 (36) | 15 (15) | N/A | N/A |
| **2xRF** | 75 (75) | 64 (60) | 65 (67) | 63 (59) | 65 (68) | 59 (60) |
| **3xRF** | 95 (91) | 64 (76) | 81 (88) | 70 (74) | 83 (87) | 65 (69) |
| **4xRF** | N/A | N/A | 107 (109) | 107 (105) | 109 (112) | 114 (107) |
| **5xRF** | N/A | N/A | 106 (132) | 117 (125) | 120 (133) | 118 (127) |

### 3.6.4 Typical Spurious Performance: Up-Conversion

Typical spurious data is taken by mixing an input within the IF band, with LO frequencies (± m*LO ± n*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 66 dBc for a -10 dBm input with a sine-wave LO, so a -20 dBm IF input creates a spur that is (2-1) x (-10 dB) lower, or 76 dBc. Data is shown for the frequency plan in 3.6 Typical Performance.

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

| -10 dBm IF Input | 0xLO | 1xLO | 2xLO | 3xLO | 4xLO | 5xLO |
|---|---|---|---|---|---|---|
| **1xIF** | 40 (35) | Reference | 37 (37) | 16 (14) | 30 (36) | 20 (22) |
| **2xIF** | 62 (65) | 66 (65) | 58 (59) | 61 (68) | 53 (52) | 61 (69) |
| **3xIF** | 88 (90) | 72 (68) | 75 (78) | 58 (68) | 71 (77) | 57 (67) |
| **4xIF** | 110 (109) | 109 (106) | 100 (96) | 101 (101) | 101 (94) | 95 (108) |
| **5xIF** | 136 (134) | 120 (117) | 122 (125) | 106 (120) | 120 (122) | 105 (110) |

# 4. Operation

## 4.1 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.

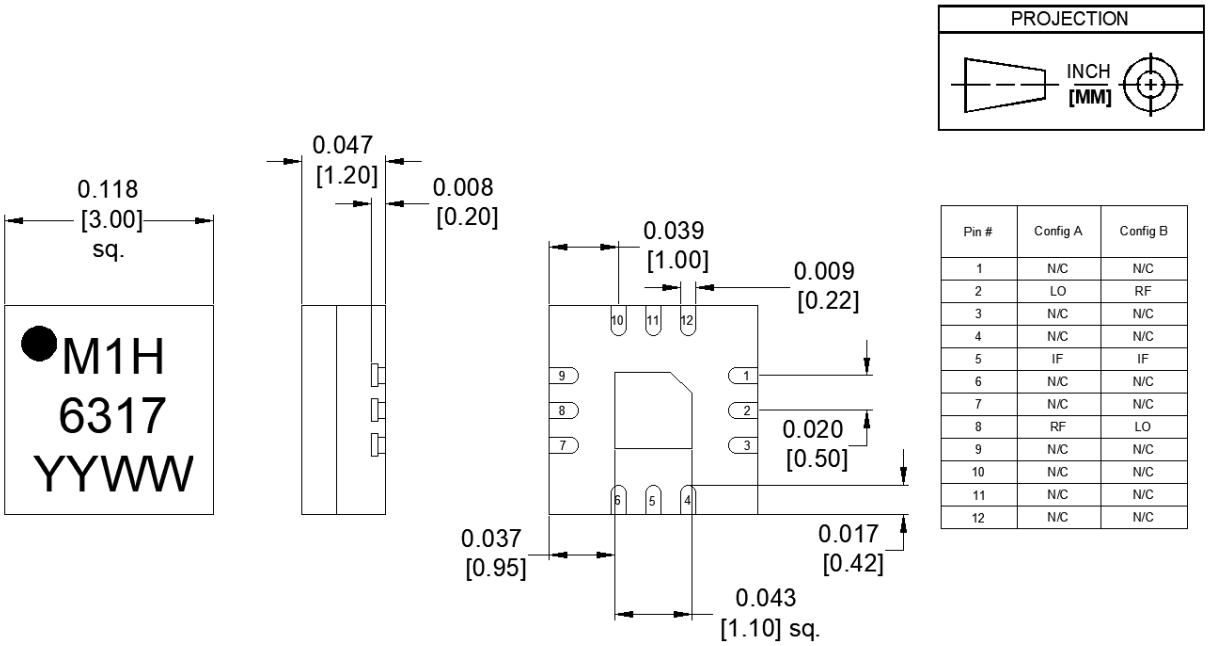
**Filtering and Matching**- Filtering is generally desired for spurious and image removal on the output port of the mixer. Reflective filters can cause out of band signals to reflect back into the mixer and cause conversion loss ripple, erroneous spurs, and other undesired behaviors. To eliminate these 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 PSM Package Outline Drawing



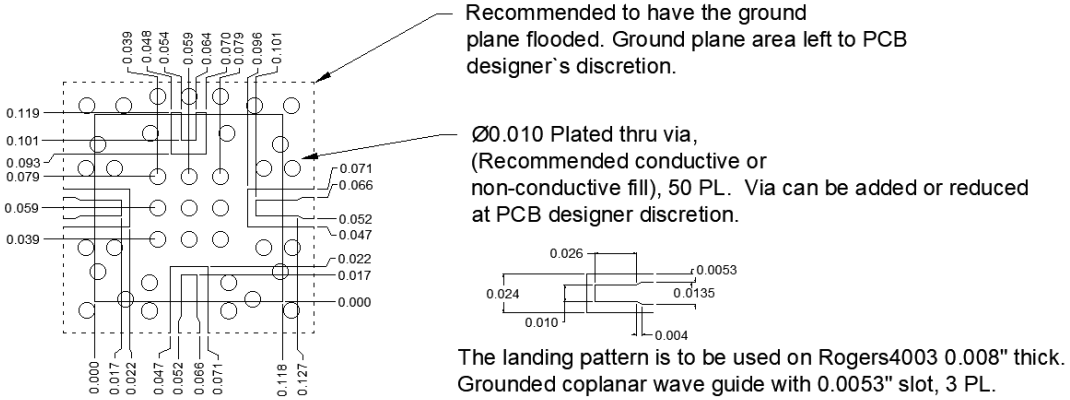

| Pin # | Config A | Config B |
|---|---|---|
| 1 | N/C | N/C |
| 2 | LO | RF |
| 3 | N/C | N/C |
| 4 | N/C | N/C |
| 5 | IF | IF |
| 6 | N/C | N/C |
| 7 | N/C | N/C |
| 8 | RF | LO |
| 9 | N/C | N/C |
| 10 | N/C | N/C |
| 11 | N/C | N/C |
| 12 | N/C | N/C |

1. Substrate material is LCP.
2. I/O Leads and Ground Paddle plating is (from base to finish):

| | |
|---|---|
| Ni: | 0.5 um MIN |
| Pd: | 0.02 um MIN |
| Au | 0.05 um MAX |

3. All unconnected pins should be connected to PCB RF ground.

## 5.2 PSM Package Footprint

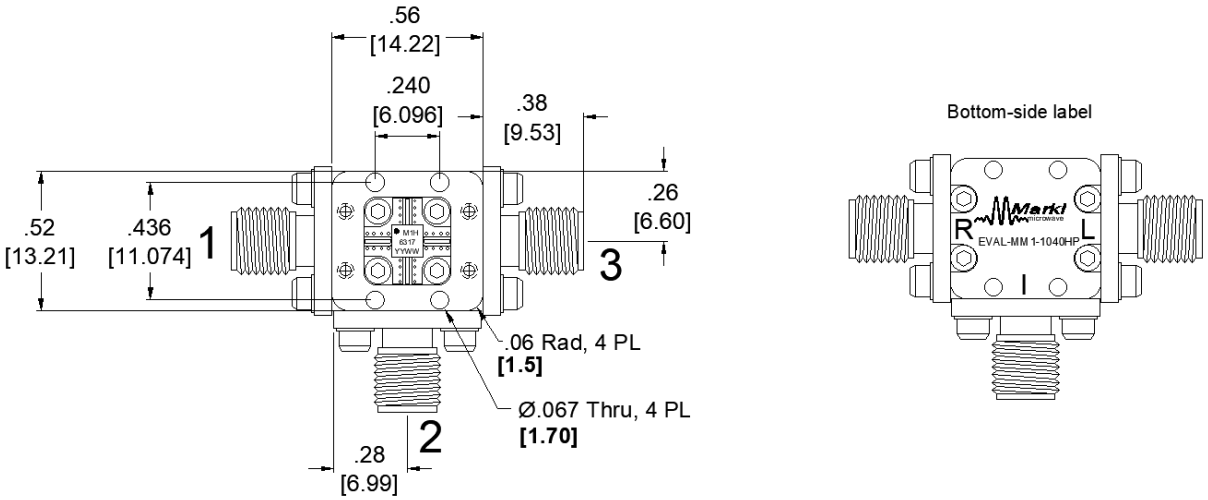



QFN-Package Surface-Mount Landing Pattern

Click here for a DXF of the above layout.

Click here for leaded solder reflow. Click here for lead-free solder reflow.

## 5.3 Evaluation Board Outline Drawing




| Function | Configuration A Port Number | Configuration B Port Number | Connector Type |
|---|---|---|---|
| LO | 1 | 3 | 2.92 mm Female |
| IF | 2 | 2 | SMA Female |
| RF | 3 | 1 | 2.92 mm Female |
| Note: Eval Connectors are not removeable | | | |