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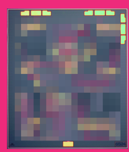
MMIQ-1865LCH-2

Passive GaAs MMIC IQ Mixer

DEVICE OVERVIEW

General Description

The MMIQ-1865L is a low LO drive, passive MMIC IQ mixer. This is an ultra-broadband mixer spanning 18 to 65 GHz on the RF and LO ports with an IF from DC to 23 GHz. Up to 35 dB of image rejection is available due to the excellent phase and amplitude balance of its on-chip LO quadrature hybrid. Both wire bondable die and connectorized modules are available.



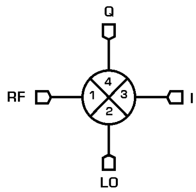
Features

N/A

Applications

- Single Sideband and Image Rejection Mixing
- IQ Modulation / Demodulation
- Vector Amplitude Modulation
- Band Shifting

Functional Block Diagram



Part Ordering Options

Part Number	Description	Package	Packing Size	Green Status	Product Lifecycle	Export Classification
MMIQ-1865LCH-2	Passive GaAs MMIC IQ Mixer	CH	-	RoHS	Released	EAR99
MMIQ-1865LUB	Passive GaAs MMIC IQ Mixer	UB	-	RoHS	Released	EAR99

Table Of Contents

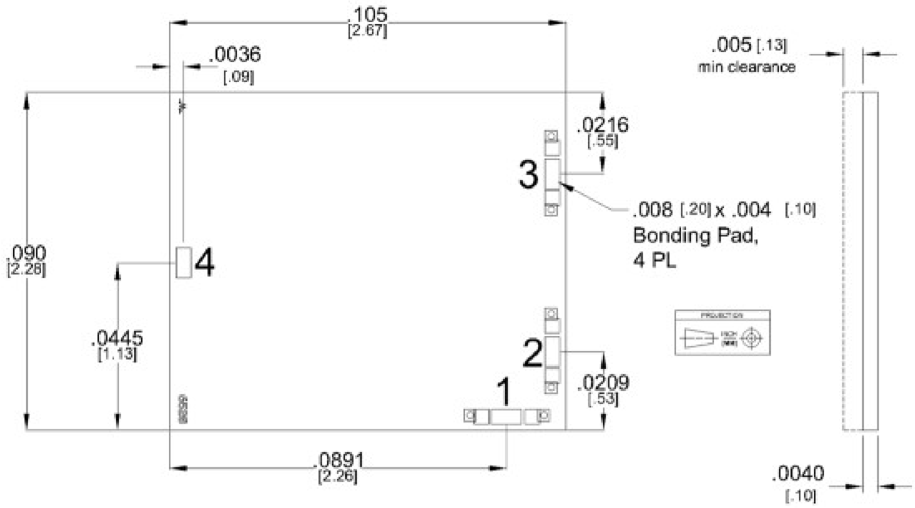
Revision History

Revision Code	Revision Date	Comment
-	2019-03-01	Datasheet Initial Release
A	2019-05-01	Added P1dB Data to Electrical Specifications
B	2019-08-01	Changed I/Q Max Current Rating
C	2019-10-01	Updated Max Power Handling
D	2019-10-01	Corrected Port Designations

Port Configuration and Functions

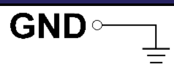
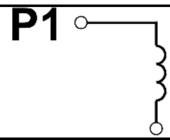
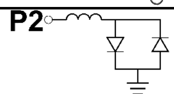
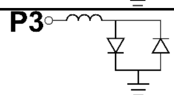
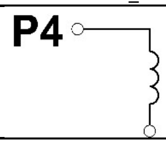
Port Diagram

The mixer may be operated as either a downconverter or an upconverter. Use of the RF or IF as the input or output port will depend on the application.



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

Port Functions

Port	Function	Description	Equivalent Circuit for Package
GND	Ground	CH package ground path is provided through the substrate and ground bond pads.	
Port 1	LO Input	Port 1 is DC open and AC matched to 50Ω over the specified LO frequency range.	
Port 2	Q Input / Output	Port 2 is diode coupled and AC matched to 50Ω over the specified Q port frequency range.	
Port 3	I Input / Output	Port 3 is diode coupled and AC matched to 50Ω over the specified I port frequency range.	
Port 4	RF Input / Output	Port 4 is DC open and AC matched to 50Ω over the specified RF frequency range.	

Specifications

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	Unit
Maximum Operating Temperature	100	°C
Maximum Storage Temperature	125	°C
Minimum Operating Temperature	-55	°C
Minimum Storage Temperature	-65	°C
Port 2 DC Current	30	mA
Port 3 DC Current	30	mA
Power Handling, at any Port	26	dBm

Package Information

Parameter	Details	Rating
Dimensions	-	2.67x2.28mm

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.

Parameter	Min	Nominal	Max	Unit
LO Input Power	8	13	17	dBm
Ambient Temperature	-55	25	100	°C
RF/IF Input Power	-	-	4	dBm

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.

Electrical Specifications

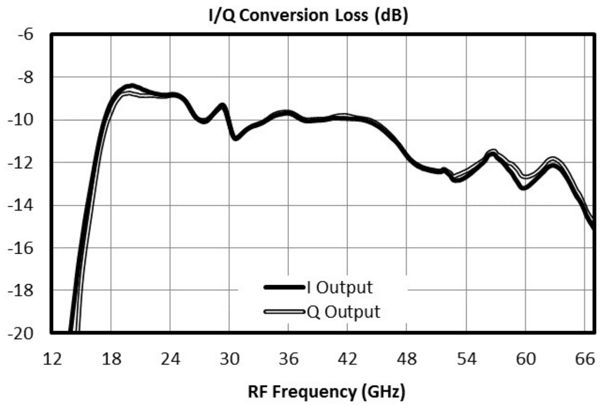
The electrical specifications apply at TA=+25°C in a 50Ω system. Typical data shown is for a down conversion application with a +13dBm sine wave LO input. Min and Max limits apply only to our connectorized units and are guaranteed at TA=+25°C. All bare die are 100% DC tested and visually inspected.

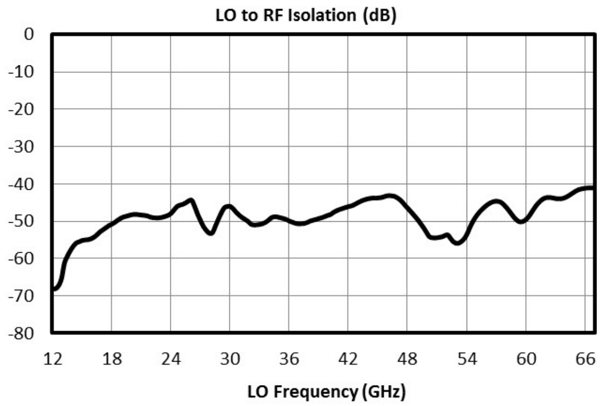
Parameter	Test Conditions	Minimum Frequency (GHz)	Maximum Frequency (GHz)	Min	Typ	Max	Unit
RF Frequency Range	-	-	-	18	-	65	GHz
LO Frequency Range	-	-	-	18	-	65	GHz
Conversion Loss [1]	RF/LO = 18 - 65 GHz I = 0.2 - 23 GHz	18	65	-	12	-	dB
Conversion Loss [2]	RF/LO = 18 - 65 GHz I = DC – 0.2 GHz	18	65	-	11	-	dB
Conversion Loss [3]	RF/LO = 18 - 65 GHz Q = 0.2 - 23 GHz	18	65	-	12	-	dB
Conversion Loss [4]	RF/LO = 18 - 65 GHz Q = DC -0.2 GHz	18	65	-	11	-	dB
Noise Figure [5]	RF/LO = 18 - 65 GHz I = DC – 0.2 GHz	18	65	-	11	-	dB
Noise Figure [6]	RF/LO = 18 - 65 GHz Q = DC – 0.2 GHz	18	65	-	12	-	dB
Image Rejection [7]	RF/LO = 18 - 65 GHz I+Q = DC – 0.2 GHz	18	65	-	35	-	dBc
Input IP3 [8]	RF/LO = 18 - 65 GHz I = DC – 0.2 GHz	18	65	-	15	-	dBm
IF Frequency Range	-	-	-	0	-	23	GHz
Input 1 dB Gain Compression Point (P1dB), I	-	-	-	-	3.8	-	dBm
Input 1 dB Gain Compression Point (P1dB), Q	-	-	-	-	4	-	dBm
Q (Port 2) Frequency Range	-	-	-	0	-	23	GHz
Isolation, LO to I	IF/LO = 18-65 GHz	18	65	-	44	-	dB
Isolation, LO to Q	IF/LO = 18-65 GHz	18	65	-	28	-	dB
Isolation, LO to RF	RF/LO = 18-65 GHz	18	65	-	49	-	dB
Isolation, RF to I	RF/IF = 18-65 GHz	18	65	-	50	-	dB
Isolation, RF to Q	RF/IF = 18-65 GHz	18	65	-	50	-	dB

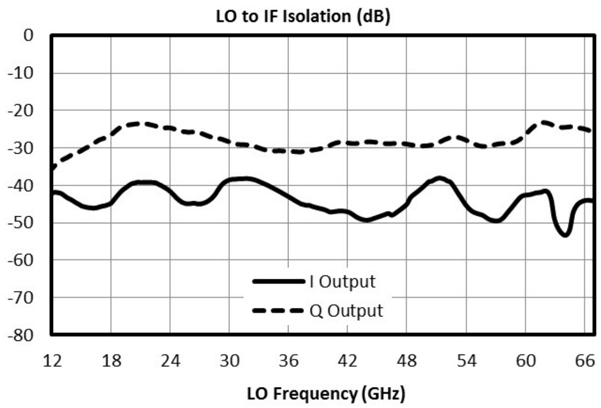
[1][2][3][4] Measured as an I/Q down converter. (i.e., I and Q powers are not combined)
[5][6] Mixer Noise Figure typically measures within 0.5 dB of conversion loss for IF frequencies greater than 5 MHz.
[7] Image Rejection and Single sideband performance plots are defined by the upper sideband (USB) or lower sideband (LSB) with respect to the LO signal. Plots are defined by which sideband is selected by the external IF quadrature hybrid.
[8] Typical IIP3 measured with I and Q ports combined with an external quadrature hybrid coupler.

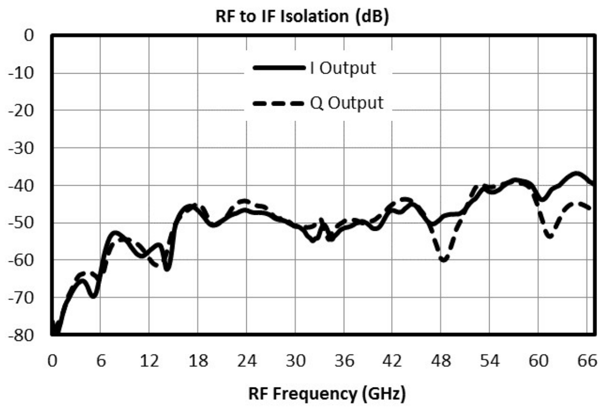
Typical Performance Plots

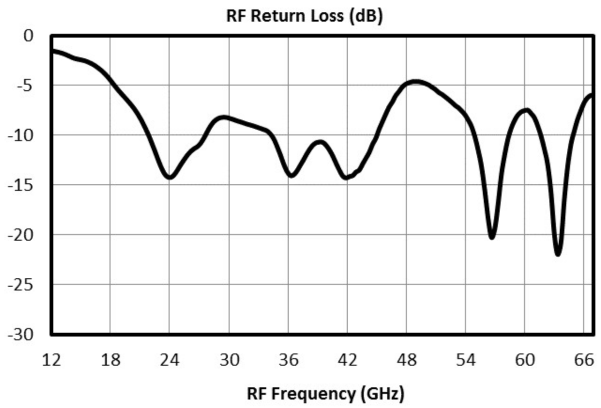
I output means that the IF output signal is measured at the I port of the mixer and the Q port is loaded. Q output means the IF output signal is measured at the Q port of the mixer while the I port is loaded.

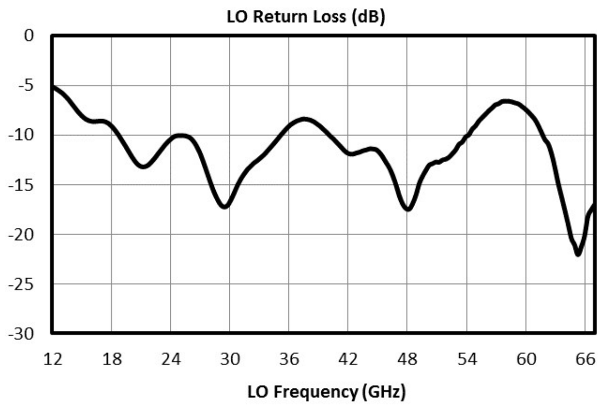


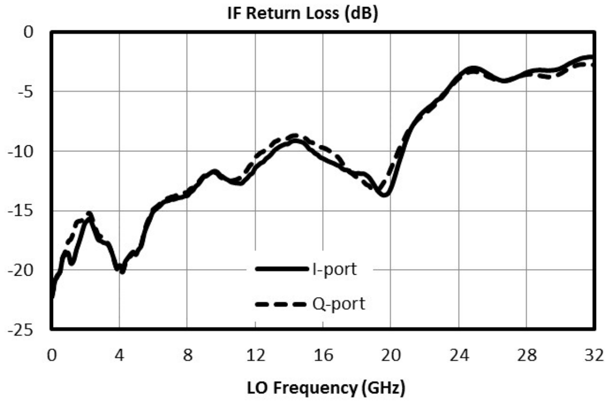


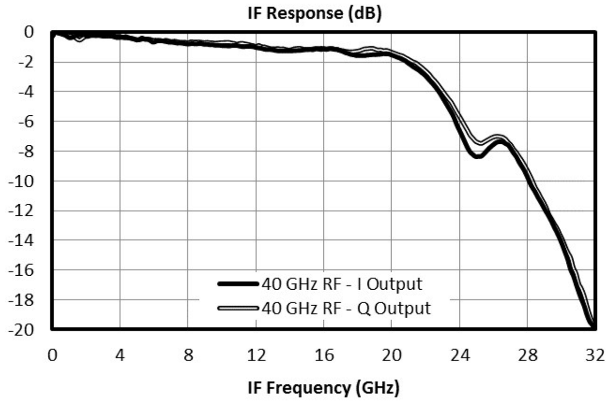


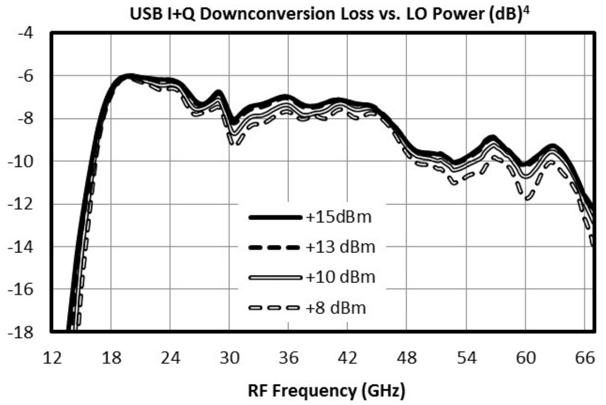


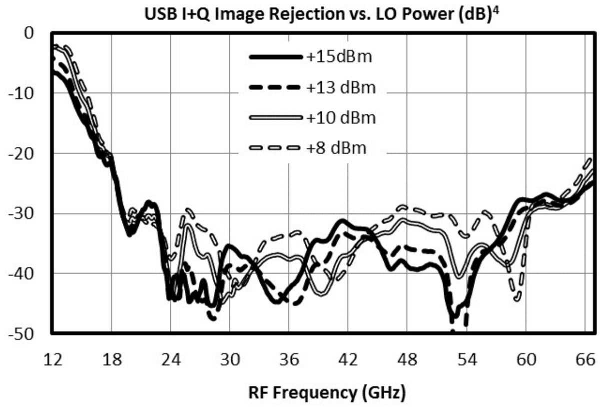


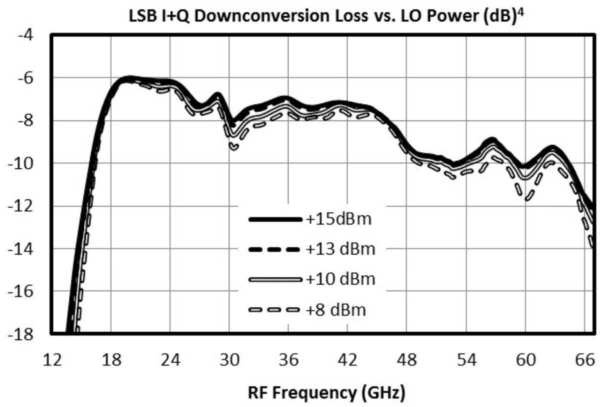


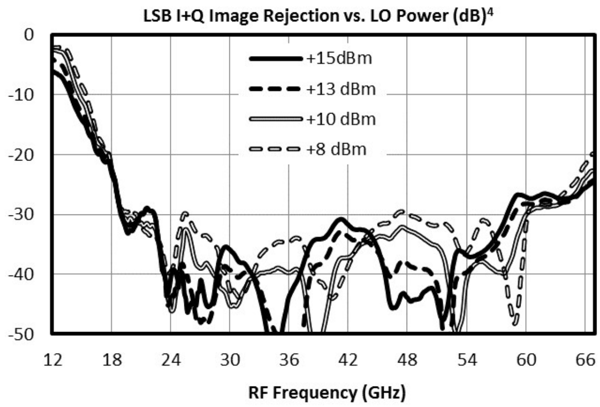

IF Return Loss (dB)
0
-5
-10
-15
-20
-25
0
4
8
12
16
20
24
28
32
LO Frequency (GHz)
I-port
Q-port


IF Response (dB)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
0
4
8
12
16
20
24
28
32
IF Frequency (GHz)
40 GHz RF - I Output
40 GHz RF - Q Output

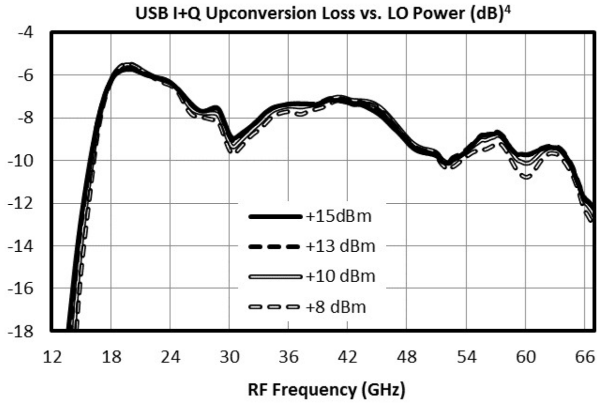

USB I+Q Downconversion Loss vs. LO Power (dB)4
-4
-6
-8
-10
-12
-14
-16
-18
12
18
24
30
36
42
48
54
60
66
RF Frequency (GHz)
+15dBm
+13 dBm
+10 dBm
+8 dBm


USB I+Q Image Rejection vs. LO Power (dB)4
0
-10
-20
-30
-40
-50
12
18
24
30
36
42
48
54
60
66
RF Frequency (GHz)
+15dBm
+13 dBm
+10 dBm
+8 dBm

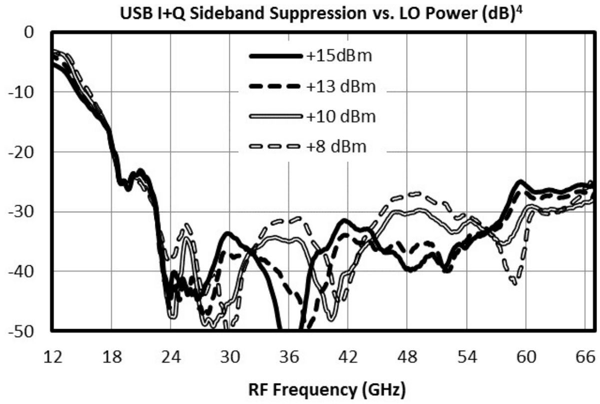

LSB I+Q Downconversion Loss vs. LO Power (dB)4
-4
-6
-8
-10
-12
-14
-16
-18
12
18
24
30
36
42
48
54
60
66
RF Frequency (GHz)
+15dBm
+13 dBm
+10 dBm
+8 dBm


LSB I+Q Image Rejection vs. LO Power (dB)4
0
-10
-20
-30
-40
-50
12
18
24
30
36
42
48
54
60
66
RF Frequency (GHz)
+15dBm
+13 dBm
+10 dBm
+8 dBm

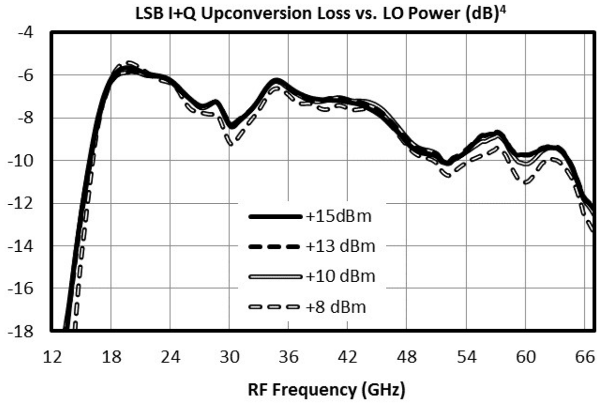
USB I+Q Upconversion Loss vs. LO Power (dB)[4]



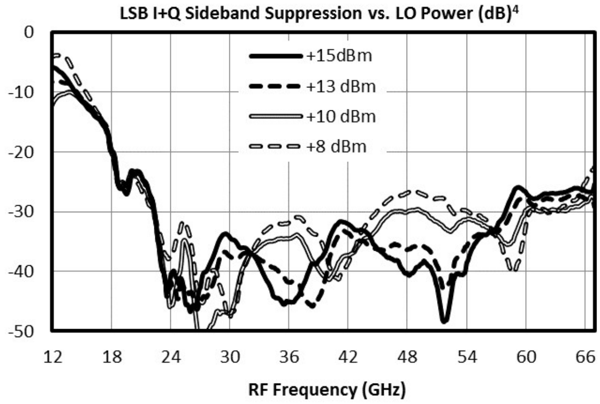
USB I+Q Sideband Suppression vs. LO Power (dB)[4]



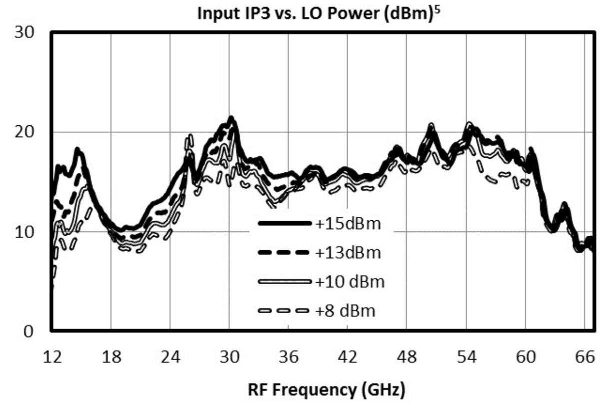
LSB I+Q Upconversion Loss vs. LO Power (dB)[4]



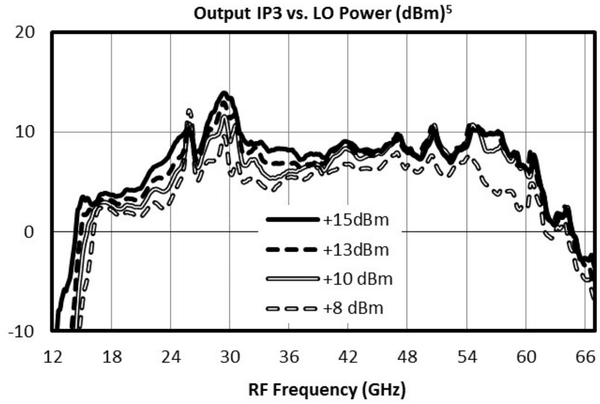
LSB I+Q Sideband Suppression vs. LO Power (dB)[4]



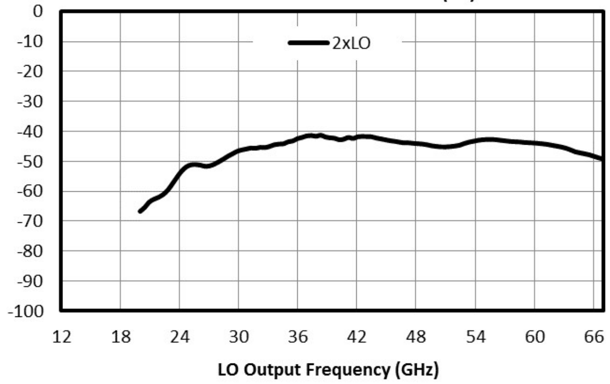
Input IP3 vs. LO Power (dBm)[5]



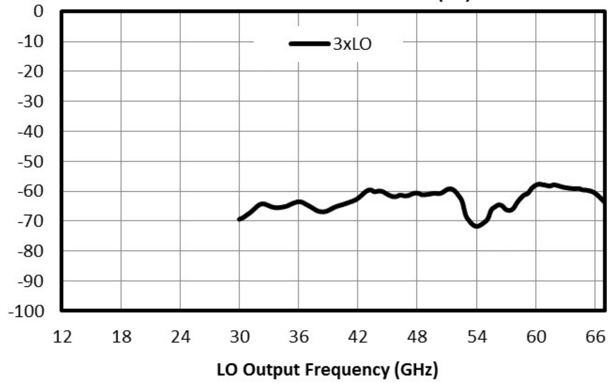
Output IP3 vs. LO Power (dBm)[5]



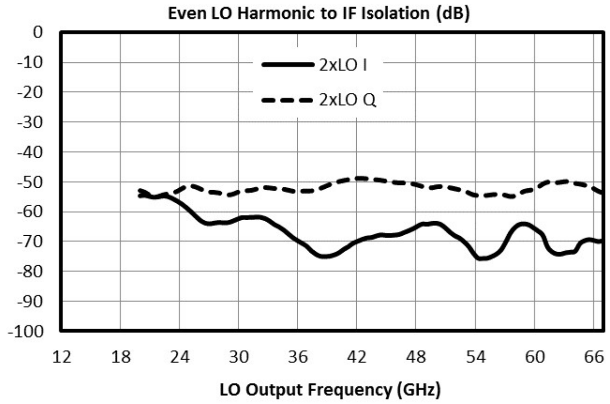
Even LO Harmonic to RF Isolation (dB)



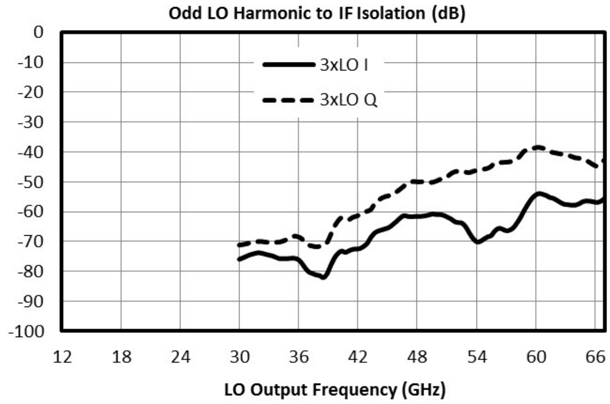
Odd LO Harmonic to RF Isolation (dB)



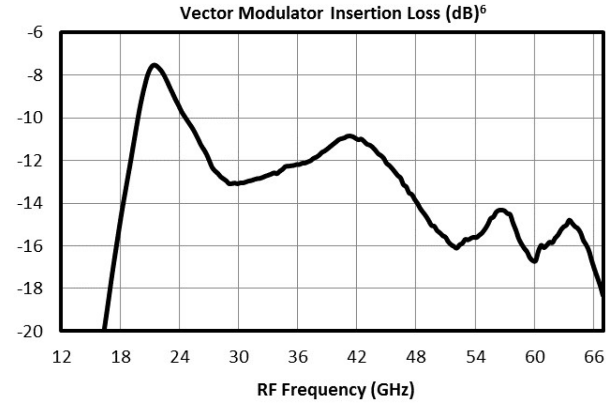
Even LO Harmonic to IF Isolation (dB)



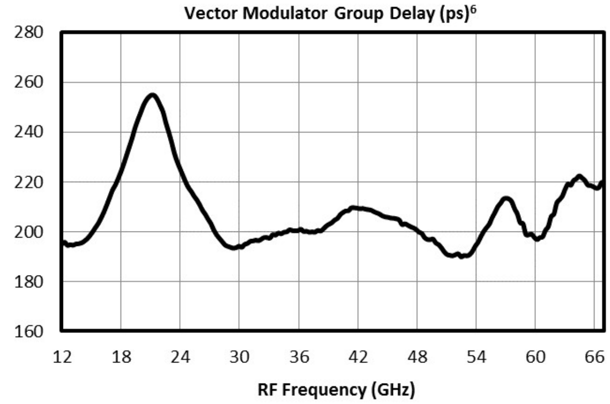
Odd LO Harmonic to IF Isolation (dB)



Vector Modulator Insertion Loss (dB)[6]



Vector Modulator Group Delay (ps)[6]



Spur Table

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 64 dBc for a -10 dBm input, so a -20 dBm RF input creates a spur that is (2-1) x (-10 dB) lower, or 74 dBc. Data is shown for the frequency plan in Typical Performance.

Measured as I/Q mixer (not IR/SSB mixer). SSB/IR mixers experience additional spurious suppressions.

Typical Down-conversion spurious suppression (dBc): I Port (Q Port)

-10 dBm RF Input	0xLO	1xLO	2xLO	3xLO	4xLO	5xLO
1xRF	39 (40)	Reference	29 (22)	12 (16)	19 (20)	N/A
2xRF	82 (75)	51 (47)	64 (64)	61 (64)	67 (61)	68 (60)
3xRF	71 (74)	59 (59)	90 (91)	72 (71)	87 (84)	80 (80)
4xRF	N/A	90 (87)	101 (104)	104 (106)	112 (114)	111 (114)
5xRF	N/A	N/A	125 (126)	115 (115)	130 (134)	117 (116)

Typical Spurious Performance: Up-Conversion

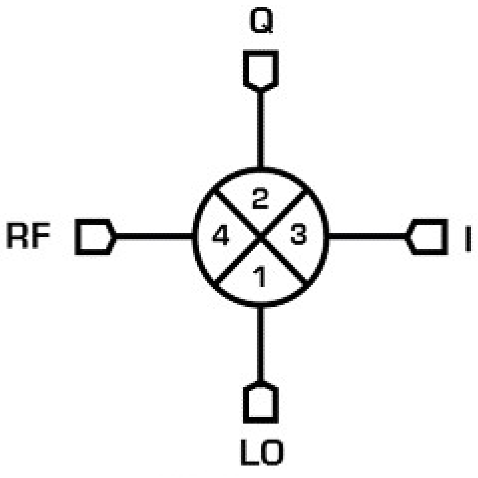
Typical spurious data is taken by mixing an input within the IF band, with LO frequencies (± m*LO ± n*IF), to create a spurious output within the RF output band. The mixer is swept across the full spurious output band and the mean is calculated. The numbers shown in the table below are for a -10 dBm 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 Typical Performance.

Measured as I/Q mixer (not IR/SSB mixer). SSB/IR mixers experience additional spurious suppressions.

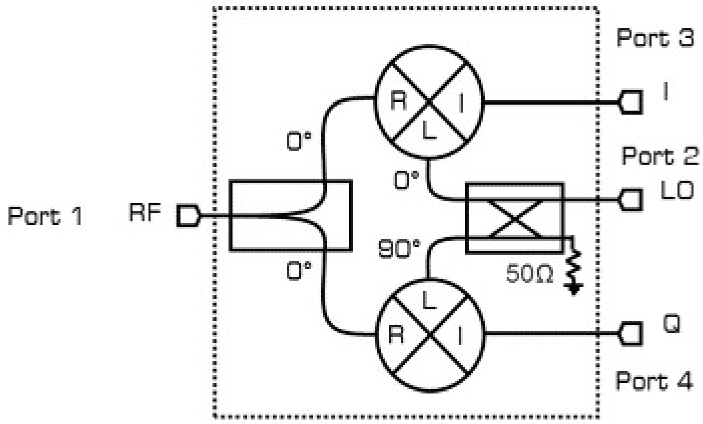
Typical Up-conversion spurious suppression (dBc): I Port (Q Port)

-10 dBm RF Input	0xLO	1xLO	2xLO	3xLO	4xLO	5xLO
1xIF	39 (40)	Reference	27 (21)	12 (13)	31 (28)	N/A
2xIF	68 (71)	66 (65)	54 (52)	65 (53)	65 (58)	68 (58)
3xIF	79 (79)	63 (62)	64 (65)	61 (54)	66 (65)	58 (58)
4xIF	105 (106)	109 (108)	65 (58)	108 (105)	102 (90)	107 (106)
5xIF	114 (110)	100 (100)	111 (117)	96 (96)	110 (107)	105 (102)

Application Circuit



IQ Mixer



Internal Structure

Application Circuit Description

Detailed Description

MMIQ-1865 belongs to Marki Microwave's MMIQ family of mixers. The MMIQ product line consists of passive GaAs MMIC mixers designed and fabricated with GaAs Schottky diodes. MMIQ mixers offer excellent amplitude and phase balance from the due to its on-chip LO quadrature hybrid. Up to 35dB of image rejection (i.e., single sideband suppression) can be obtained by using the MMIQ-1865 as an image rejection or single sideband mixer. The MMIQ-1865H and MMIQ-1865S are the sister mixers of the MMIQ-1865L. The MMIQ-1865H and MMIQ-1865S require a higher LO drive to operate the mixer. In exchange, the MMIQ-1865H and MMIQ-1865S display higher linearity (i.e., higher IIP3, P1dB, Spurious Suppression) than the MMIQ-1865L. Marki S, H, and L diodes correspond to different diode forward turn on voltages.

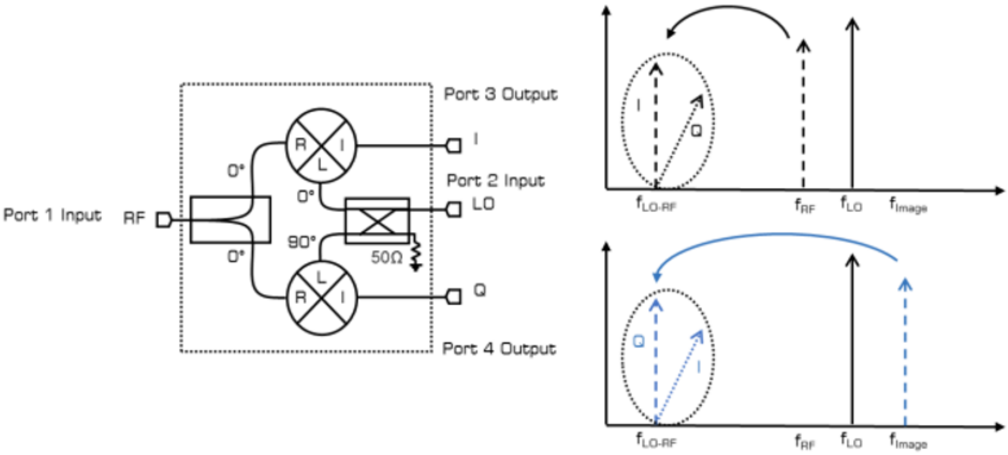
Support for the K, through V bands are offered by the ultra-broadband performance of the mixer's RF and LO ports (ports 1 and 2). Direct baseband to V band frequency conversions are available by using this mixer as an up-converter. Traditional use of this mixer to do image reject or single sideband mixing is available with an external IF quadrature hybrid. The MMIQ-1865 is also suitable for use as a Vector Modulator through DC bias of the I and Q ports (ports 3 and 4).

Port 1, the LO port, and port 4, the RF port, support an 18-65GHz signal. Ports 2 and 3, the I and Q ports, support a DC-23GHz signal. A signal may be input into any port of the mixer which supports that signal's frequency. This is the basis of using the mixer as a band shifter.

For a given LO power within the recommended operating range, the RF (in the case of a down conversion) or IF (in the case of an up conversion) input power should be below the input 1dB compression point to avoid signal distortion. The input 1dB compression point will vary across the mixer's operating bandwidth and with LO input power. Careful characterization is required for optimal performance for each application. There is no minimum small signal input power required for operation. Excessive RF/IF input power increases non-desired spurious output power and degrades the fundamental conversion loss. Excessive LO input power can also cause this effect. The table below describes how to use an IQ mixer and quad hybrid to select a single sideband.

Up Conversion		
Hybrid Port	Mixer Port	Sideband Selected
0	I	Lower Sideband
90	Q	
90	I	Upper Sideband
0	Q	
Down Conversion		
Hybrid Port	Mixer Port	Sideband Selected
0	I	Upper Sideband
90	Q	
90	I	Lower Sideband
0	Q	

Down-Converter

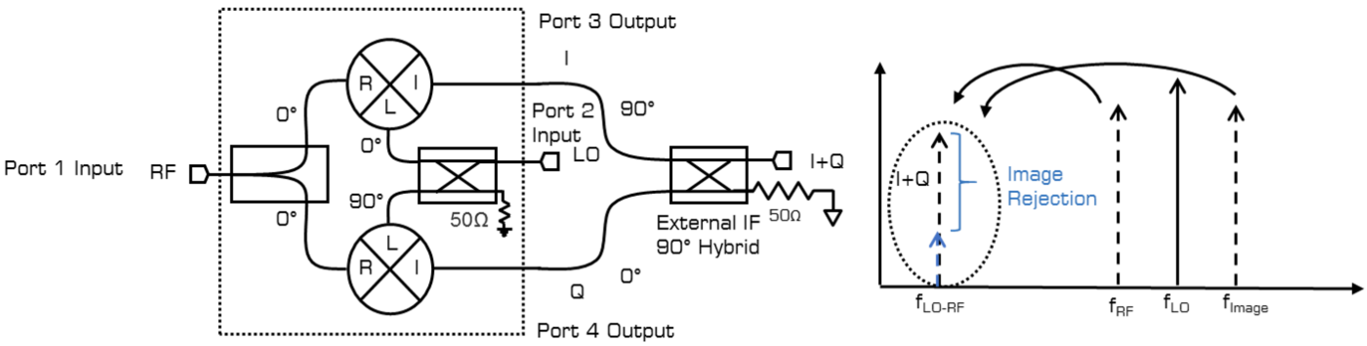


A down converter is a mixer application which takes a high frequency small signal RF input, and a high frequency large signal LO input and mixes the signals together to produce a low frequency IF output. The fundamental 1RFx1LO outputs present at the IF port are the f_{LO-RF} and f_{LO+RF} tones. The desired output in a down conversion is typically the f_{LO-RF} term. An image frequency at $f_{Image}=f_{2LO-RF}$ will also down convert to the f_{LO-RF} frequency. The above illustration shows the relative location of the image frequency for a highside LO, or the frequency plan for which $f_{LO} > f_{RF}$.

To use the IQ mixer as a down converter, input a high frequency small signal RF input into port 4, a high frequency large signal LO input into port 1, and pull the low frequency IF output from ports 2 and 3. Ports 2 and 3 will output the IF signals I and Q. I and Q IF outputs will be at the same frequency but 90° out of phase (i.e., I and Q are in quadrature). If only a single IF output is desired, terminate either the I or Q ports with a wideband 50Ω load.

This is the input scheme was used to take I/Q down-conversion data found in the Typical Performance Plots.

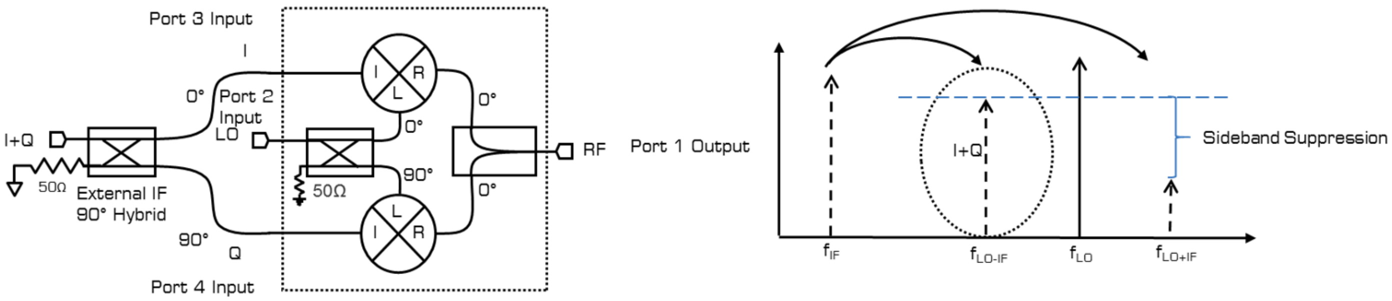
Image Reject Down-Converter



An image reject mixer is a mixer which rejects the down converted image frequency from the IF output. Image reject mixers are constructed using an external quadrature hybrid attached to the I and Q (i.e., IF) output ports. Using the external IF quadrature hybrid, one can select the whether the upper sideband or lower sideband signal is suppressed with respect to the LO signal.

To use the IQ mixer as an image reject mixer, input the high frequency small signal RF into port 1 and a high frequency large signal LO input into port 2. Take the combined I+Q down converted signal through the IF quadrature hybrid. Select the upper sideband (i.e., suppress the lower sideband) by connecting the I port to the 0° port of the IF quadrature hybrid

Single Sideband Up-Converter

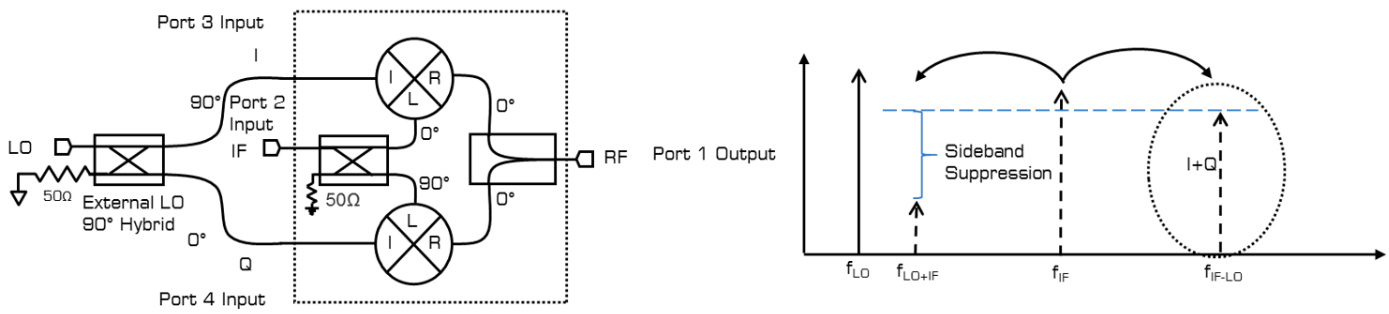


A single sideband mixer is a mixer which suppress the up converted image frequency from the RF output. Single sideband mixers are constructed using an external quadrature hybrid attached to the I and Q (i.e., IF) input ports. Using an external IF quadrature hybrid, one can select whether the upper sideband of the lower sideband signal is suppressed with respect to the LO signal.

To use the IQ mixer as a single sideband mixer, input the low frequency small signal I+Q IF signal into the IF quadrature hybrid. The IF quadrature hybrid is attached to the I and Q ports of the IQ mixer. Input the high frequency large signal LO input into port 1 and take the up converted high frequency RF signal from port 4. Select the upper sideband (i.e., suppress the lower sideband) by attaching the I port to the 90° port of the IF quadrature hybrid and attach the Q port to the 0° port of the IF quadrature hybrid. Select the lower sideband (i.e., suppress the upper sideband) by attaching the I port to the 0° port of the IF quadrature hybrid and attach the Q port to the 90° port of the IF quadrature hybrid.

This is the input scheme used to take single sideband up-conversion data found in Typical Performance.

Band Shifter



A band shifter is an unusual application for a mixer. Band shifters take an IF signal and shift it to a different band, generally to either avoid interference or for rebroadcast at a different frequency. For cases in which the desired band shift cannot be employed by using a standard up or down conversion scheme, an exotic input scheme is required.

A passive diode mixer is reciprocal on all ports. Port 4, the RF port, supports a 18-65GHz signal. Port 1, the LO port, supports a 18-65GHz signal. Ports 2 and 3, the IF ports, support a DC-23GHz signal. 2 signals input into any combination of the 3 ports, RF, LO, or IF, will result in an output signal at the 3rd port. In addition, an output signal will be present at both input ports. By using the IF port, as a large signal input port, low frequency LO applications can be supported.

The diagram above shows an IQ mixer being used as a band shifter. Using an IQ mixer as a band shifter allows for sideband suppression. This is identical to using the IQ mixer as a single sideband up converter. However, the large signal input port is now 2+3 versus port 1. Selection of the output tone is done through the orientation of the LO quadrature hybrid.

Die Mounting Recommendations

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.

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.

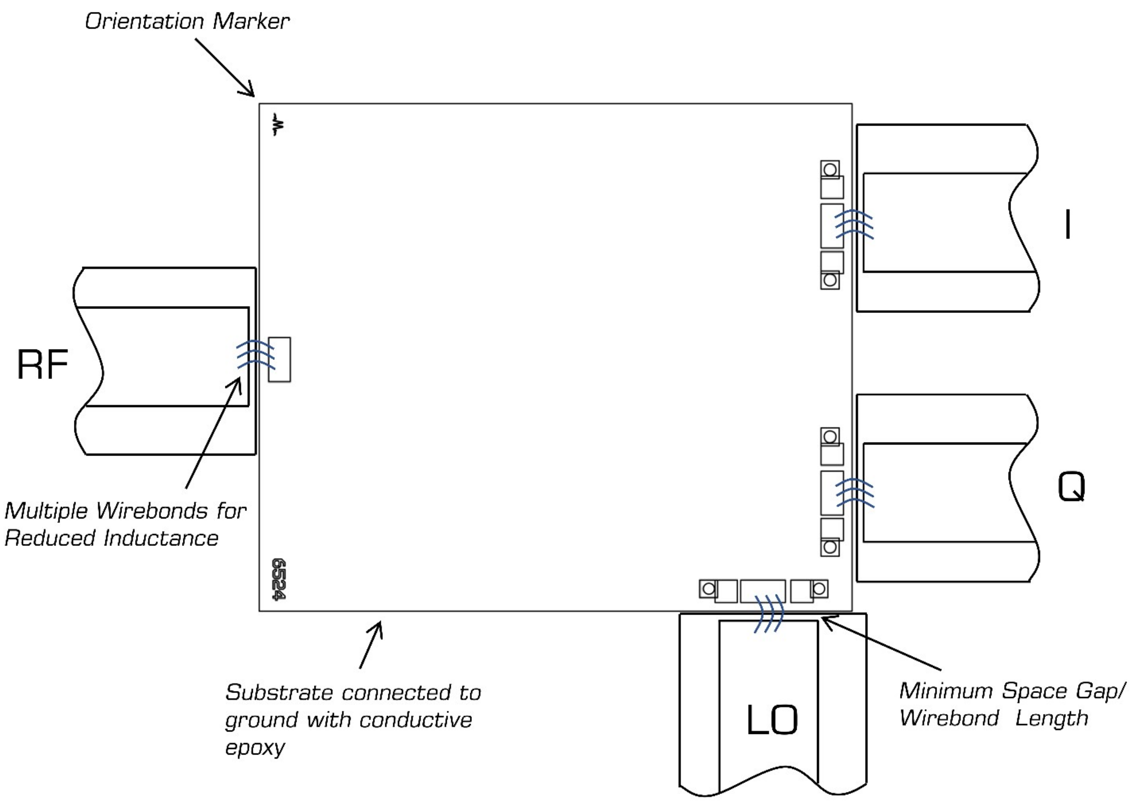
Static Sensitivity

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

Cleaning and Storage

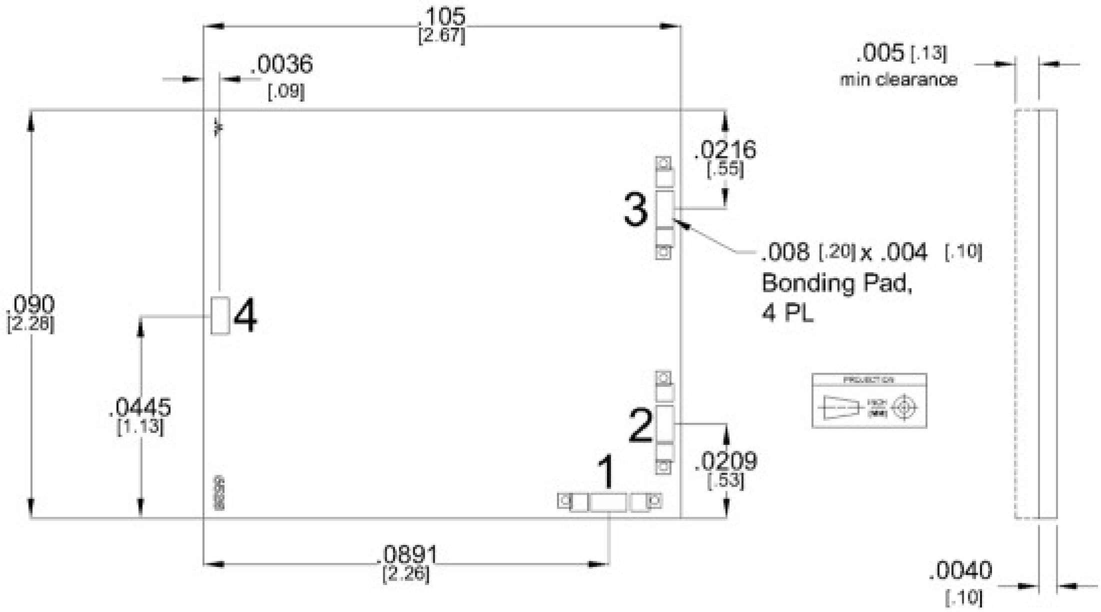
Do not attempt to clean the chip with a liquid cleaning system or expose the bare chips to liquid. Once the ESD sensitive bags the chips are stored in are opened, chips should be stored in a dry nitrogen atmosphere.

Bonding Diagram



Mechanical Data

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

Notes

DISCLAIMER