Sales: 408-778-9952 | General: 408-778-4200 | Fax: 408-778-4300
Sales & Customer Support: sales@markimicrowave.com
Tech Support: support@markimicrowave.com
General Support: info@markimicrowave.com

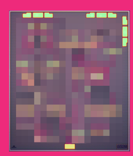
MMIQ-1865SCH-2

Passive GaAs MMIC IQ Mixer

DEVICE OVERVIEW

General Description

The MMIQ-1865S is a high linearity, 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.



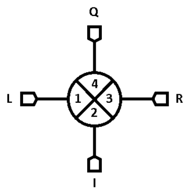
Features

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-1865SUB	Passive GaAs MMIC IQ Mixer	UB	-	RoHS	Released	EAR99
MMIQ-1865SCH-2	Passive GaAs MMIC IQ Mixer	CH	-	RoHS	Released	EAR99

Table Of Contents

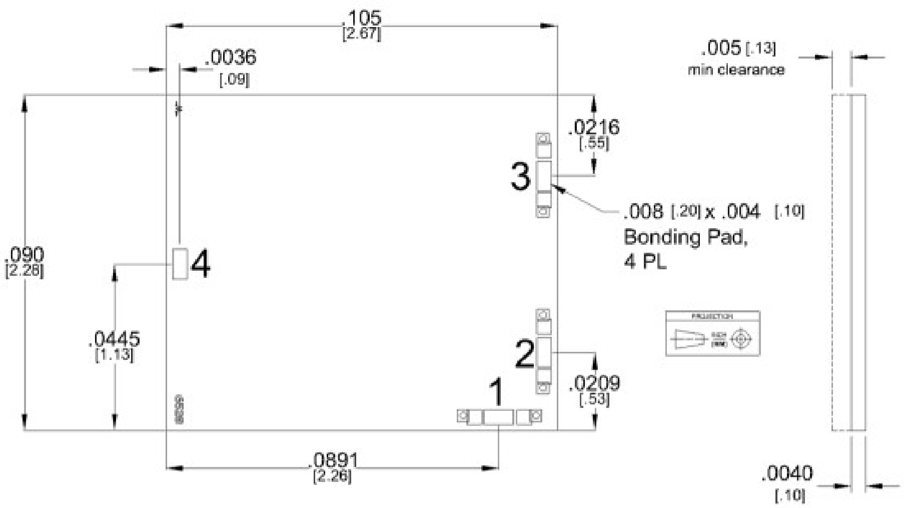
Revision History

Revision Code	Revision Date	Comment
-	2019-10-01	Datasheet Initial Release

Port Configuration and Functions

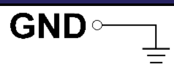
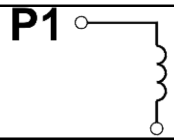
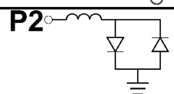
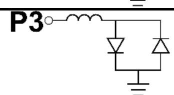
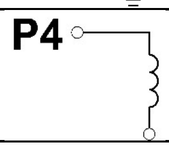
Port Diagram

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	23	mA
Port 3 DC Current	23	mA
Power Handling, at any Port	30	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
Ambient Temperature	-55	25	100	°C
LO Input Power	23	25	27	dBm
RF/IF Input Power	-	-	19	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 +21dBm 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.

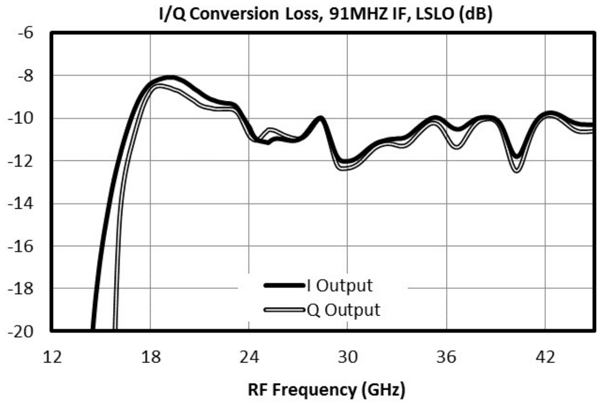
Parameter	Test Conditions	Minimum Frequency (GHz)	Maximum Frequency (GHz)	Min	Typ	Max	Unit
RF Frequency Range	-	-	-	18	-	65	GHz
LO Frequency Range	-	-	-	18	-	65	GHz
Conversion Loss [1]	RF/LO = 18 - 65 GHz I = 0.2 - 23 GHz	18	65	-	13	-	dB
Conversion Loss [2]	RF/LO = 18 - 65 GHz I = DC – 0.2 GHz	18	65	-	12	-	dB
Conversion Loss [3]	RF/LO = 18 - 65 GHz Q = 0.2 - 23 GHz	18	65	-	13	-	dB
Conversion Loss [4]	RF/LO = 18 - 65 GHz Q = DC -0.2 GHz	18	65	-	12	-	dB
Noise Figure [5]	RF/LO = 18 - 65 GHz I = DC – 0.2 GHz	18	65	-	12	-	dB
Noise Figure [6]	RF/LO = 18 - 65 GHz Q = DC – 0.2 GHz	18	65	-	13	-	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	-	27	-	dBm
IF Frequency Range	-	-	-	0	-	23	GHz
Input 1 dB Gain Compression Point (P1dB), I	-	-	-	-	19	-	dBm
Input 1 dB Gain Compression Point (P1dB), Q	-	-	-	-	19	-	dBm
Q (Port 2) Frequency Range	-	-	-	0	-	23	GHz
Isolation, LO to I	IF/LO = 18-65 GHz	18	65	-	45	-	dB
Isolation, LO to Q	IF/LO = 18-65 GHz	18	65	-	33	-	dB
Isolation, LO to RF	RF/LO = 18-65 GHz	18	65	-	50	-	dB
Isolation, RF to I	RF/IF = 18-65 GHz	18	65	-	53	-	dB
Isolation, RF to Q	RF/IF = 18-65 GHz	18	65	-	53	-	dB

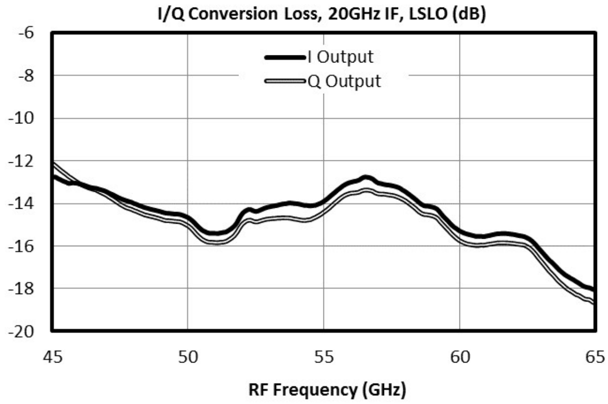
[1][2][3][4] Measured as an I/Q down converter. (i.e., I and Q powers are not combined)
[5][6] Mixer Noise Figure typically measures within 0.5 dB of conversion loss for IF frequencies greater than 5 MHz.
[7] Image Rejection and Single sideband performance plots are defined by the upper sideband (USB) 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.

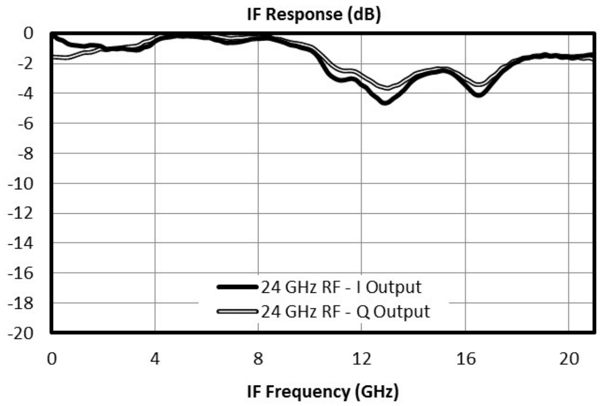
Typical Performance Plots

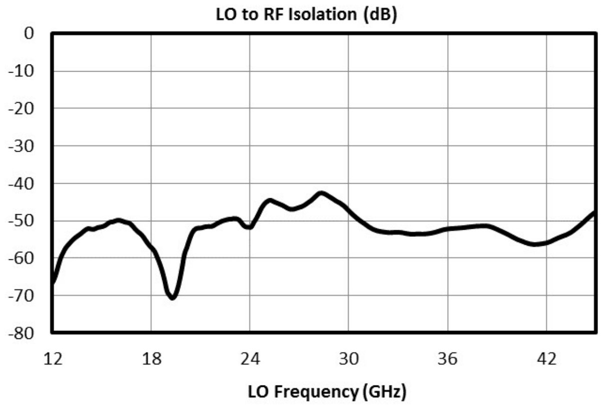
Due to limited available LO power, all performance plots are measured with a +21dBm LO drive and in most cases bandlimited to 45 GHz. Data is not representative of the performance of a properly operated unit. Linear performance at high frequency and high LO power is similar to MMIQ-1865H. See MMIQ-1865H datasheet for expected linear performance.

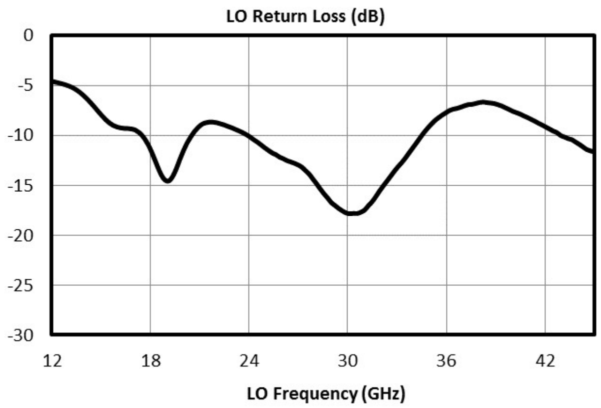
I output means that the IF output signal is measured at the I port of the mixer and the Q port is loaded. Q output means the IF output signal is measured at the Q port of the mixer while the I port is loaded.

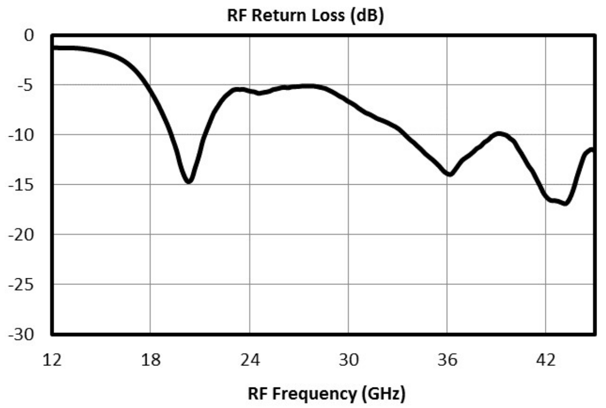


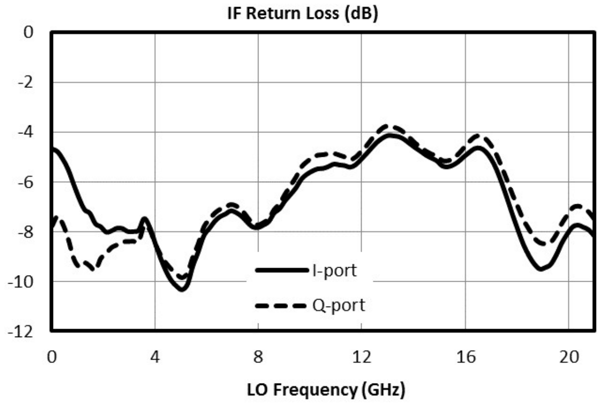


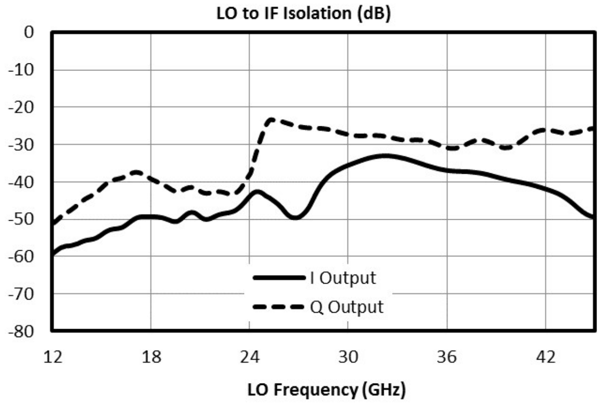


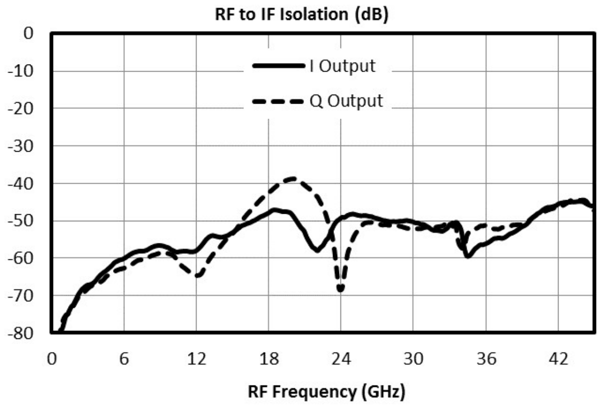


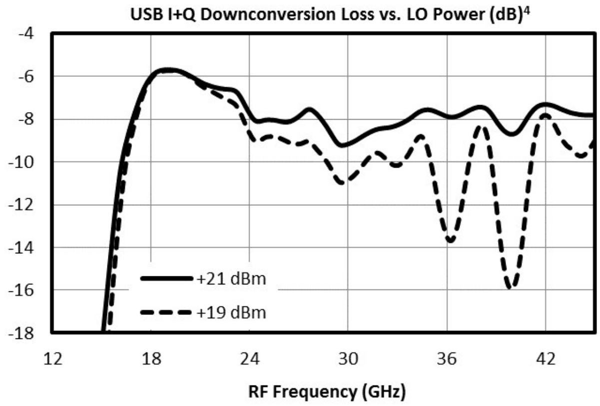


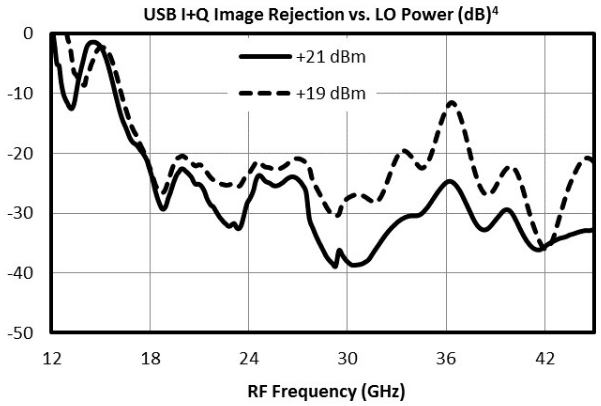


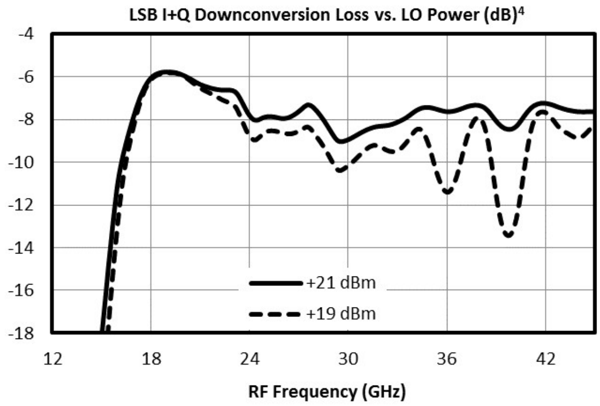

IF Return Loss (dB)
0
-2
-4
-6
-8
-10
-12
0
4
8
12
16
20
LO Frequency (GHz)
I-port
Q-port

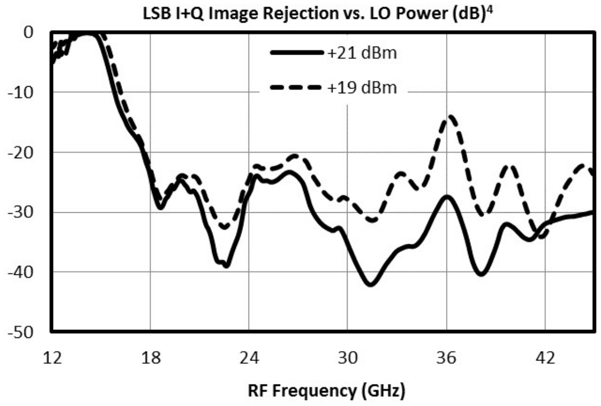

LO to IF Isolation (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
12
18
24
30
36
42
LO Frequency (GHz)
I Output
Q Output

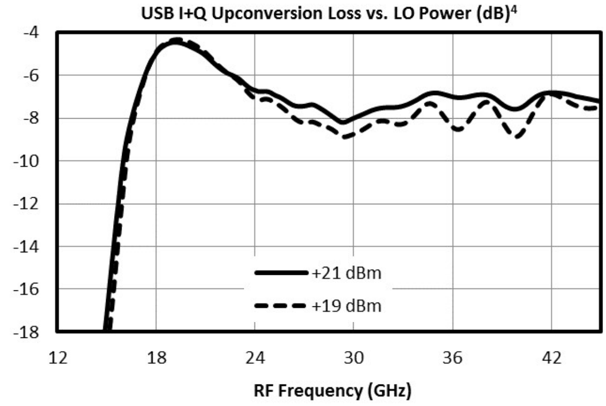

RF to IF Isolation (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
0
6
12
18
24
30
36
42
RF Frequency (GHz)
I Output
Q Output

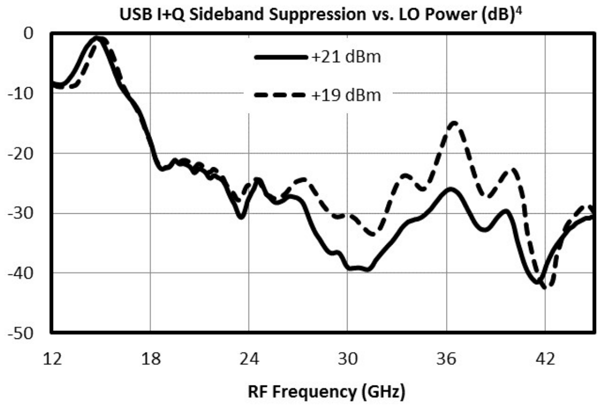

USB I+Q Downconversion Loss vs. LO Power (dB)4
-4
-6
-8
-10
-12
-14
-16
-18
12
18
24
30
36
42
RF Frequency (GHz)
+21 dBm
+19 dBm

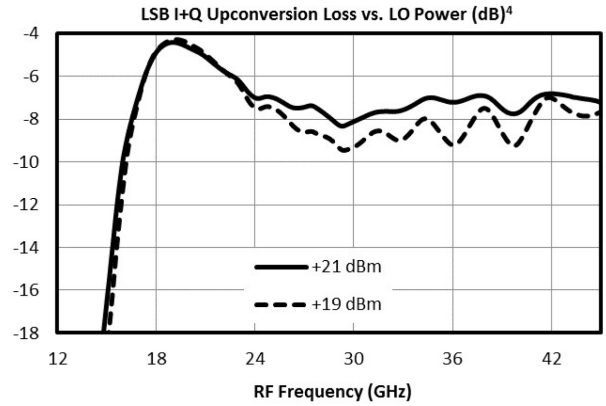

USB I+Q Image Rejection vs. LO Power (dB)4
0
-10
-20
-30
-40
-50
12
18
24
30
36
42
RF Frequency (GHz)
+21 dBm
+19 dBm

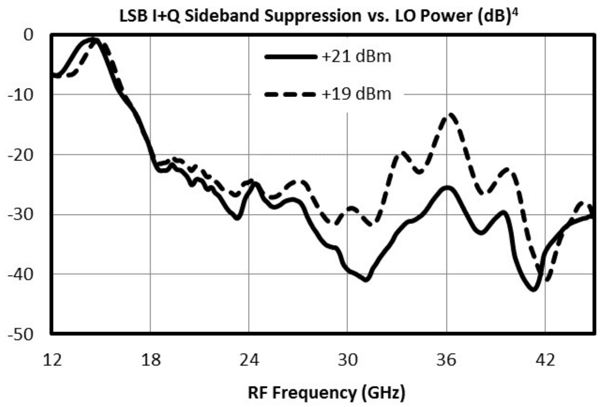

LSB I+Q Downconversion Loss vs. LO Power (dB)4
-4
-6
-8
-10
-12
-14
-16
-18
12
18
24
30
36
42
RF Frequency (GHz)
+21 dBm
+19 dBm

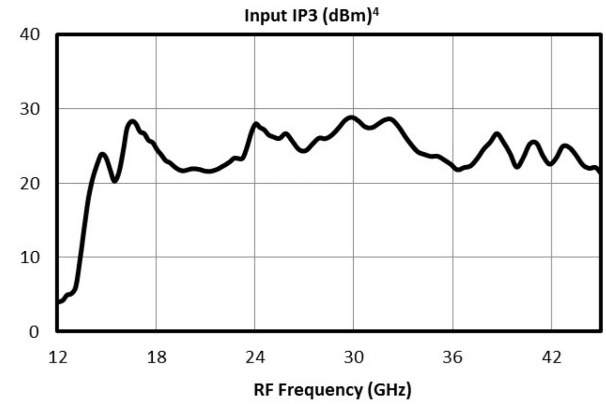

LSB I+Q Image Rejection vs. LO Power (dB)4
+21 dBm
+19 dBm
0
-10
-20
-30
-40
-50
12
18
24
30
36
42
RF Frequency (GHz)

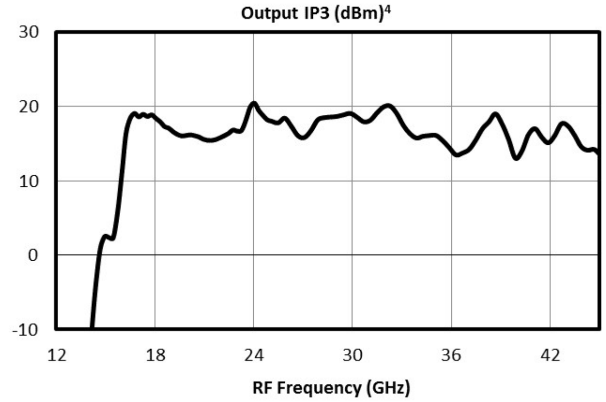

USB I+Q Upconversion Loss vs. LO Power (dB)4
+21 dBm
+19 dBm
-4
-6
-8
-10
-12
-14
-16
-18
12
18
24
30
36
42
RF Frequency (GHz)

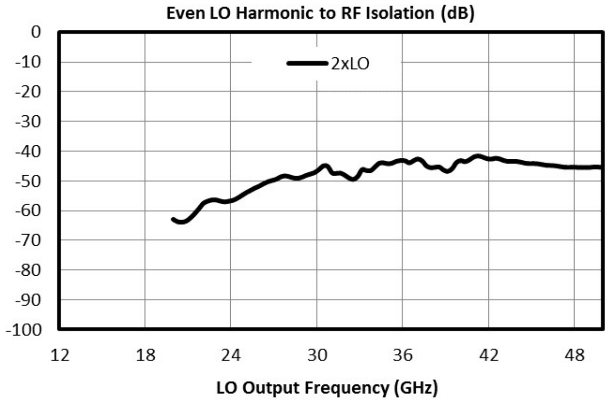

USB I+Q Sideband Suppression vs. LO Power (dB)4
+21 dBm
+19 dBm
0
-10
-20
-30
-40
-50
12
18
24
30
36
42
RF Frequency (GHz)

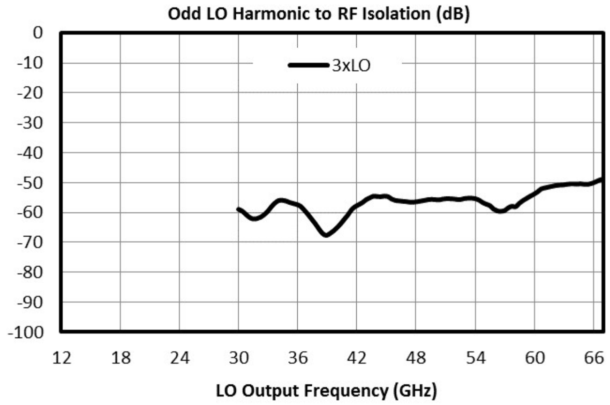

LSB I+Q Upconversion Loss vs. LO Power (dB)4
+21 dBm
+19 dBm
-4
-6
-8
-10
-12
-14
-16
-18
12
18
24
30
36
42
RF Frequency (GHz)

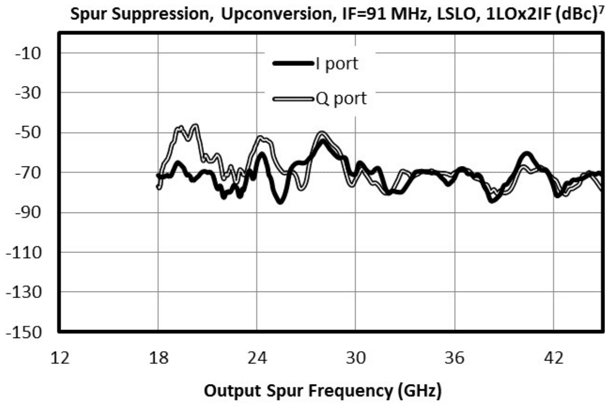

LSB I+Q Sideband Suppression vs. LO Power (dB)4
+21 dBm
+19 dBm
0
-10
-20
-30
-40
-50
12
18
24
30
36
42
RF Frequency (GHz)

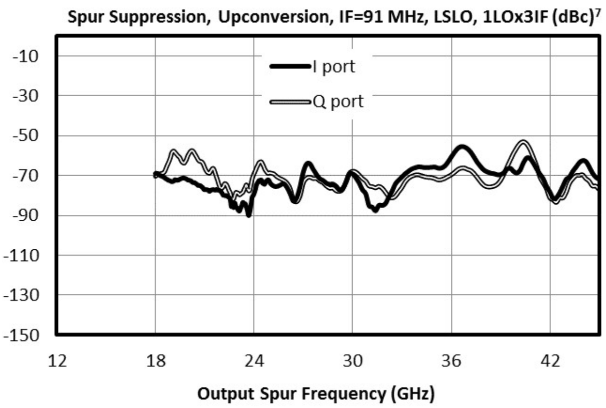

Input IP3 (dBm)4
40
30
20
10
0
12
18
24
30
36
42
RF Frequency (GHz)

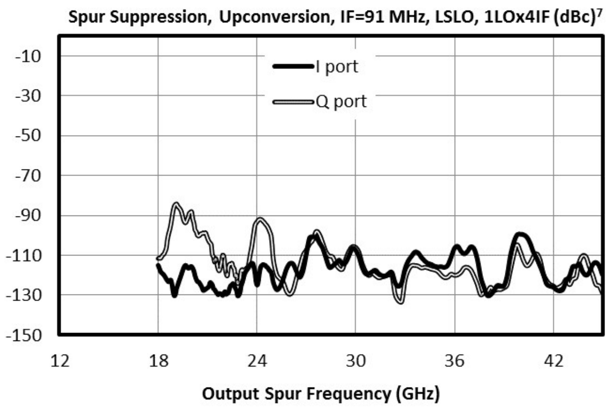

Output IP3 (dBm)4
30
20
10
0
-10
12
18
24
30
36
42
RF Frequency (GHz)


Even LO Harmonic to RF Isolation (dB)
2xLO
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
12
18
24
30
36
42
48
LO Output Frequency (GHz)

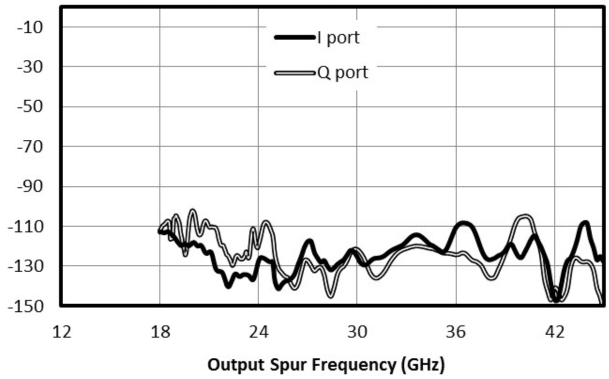

Odd LO Harmonic to RF Isolation (dB)
3xLO
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
12
18
24
30
36
42
48
54
60
66
LO Output Frequency (GHz)


Spur Suppression, Upconversion, IF=91 MHz, LSLO, 1LOx2IF (dBc)7
I port
Q port
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
Output Spur Frequency (GHz)

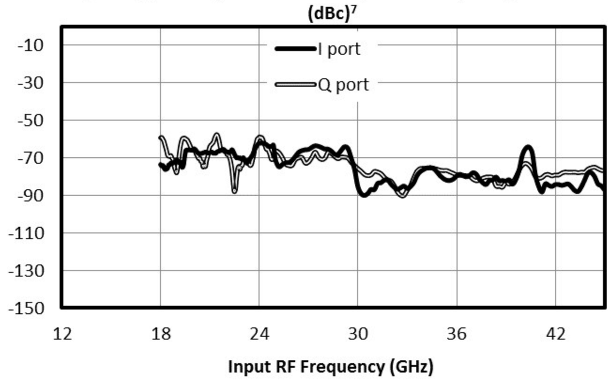

Spur Suppression, Upconversion, IF=91 MHz, LSLO, 1LOx3IF (dBc)7
I port
Q port
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
Output Spur Frequency (GHz)


Spur Suppression, Upconversion, IF=91 MHz, LSLO, 1LOx4IF (dBc)7
I port
Q port
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
Output Spur Frequency (GHz)

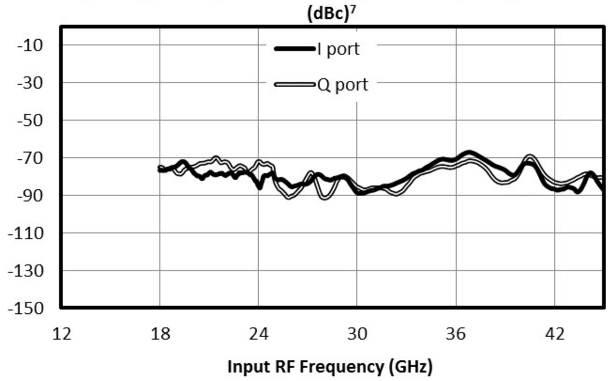
Spur Suppression, Upconversion, IF=91 MHz, LSLO, 1LOx5IF (dBc)[7]



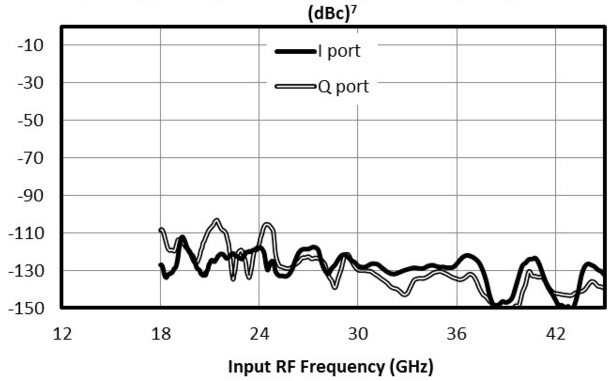
Spur Suppression, Downconversion, IF=91 MHz, LSLO, 2LOx2RF (dBc)[7]



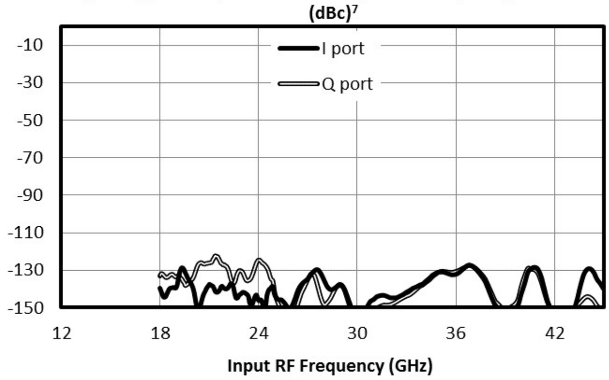
Spur Suppression, Downconversion, IF=91 MHz, LSLO, 3LOx3RF (dBc)[7]



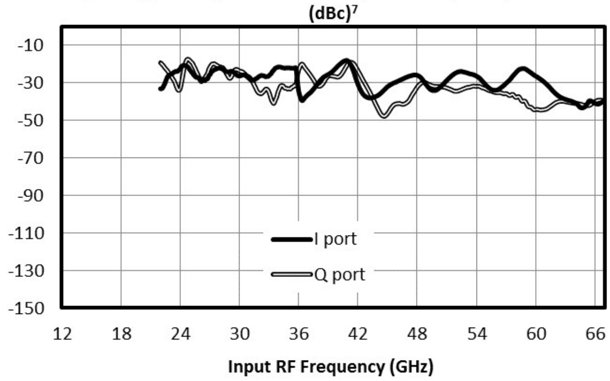
Spur Suppression, Downconversion, IF=91 MHz, LSLO, 4LOx4RF (dBc)[7]

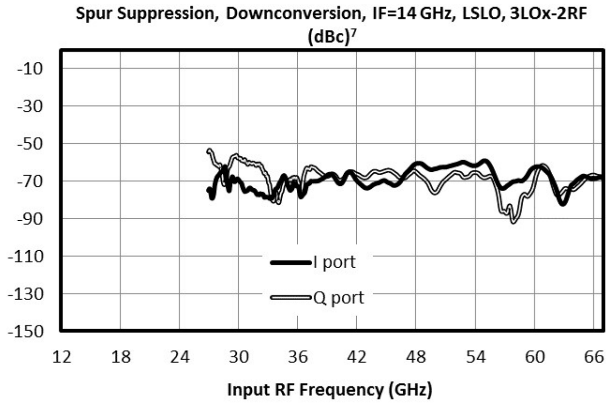


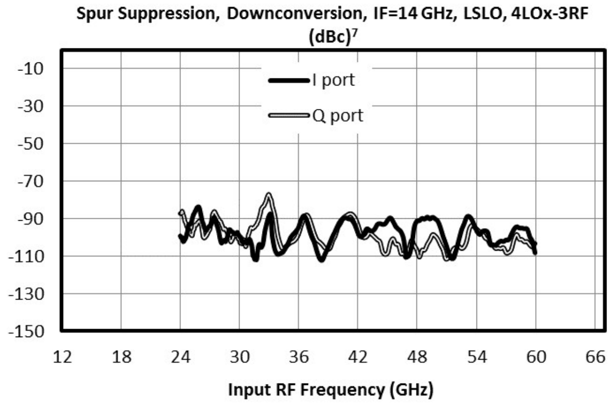
Spur Suppression, Downconversion, IF=91 MHz, LSLO, 5LOx5RF (dBc)[7]

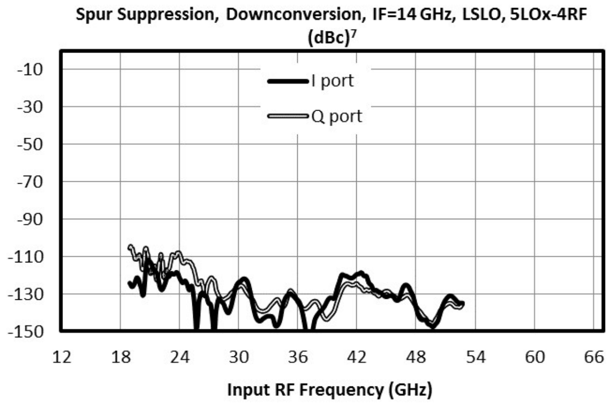


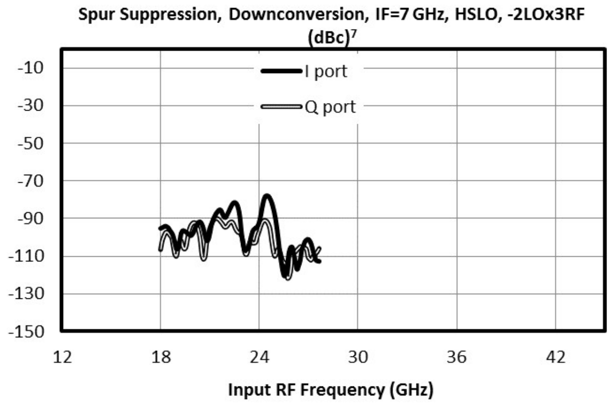
Spur Suppression, Downconversion, IF=14 GHz, LSLO, 2LOx-1RF (dBc)[7]

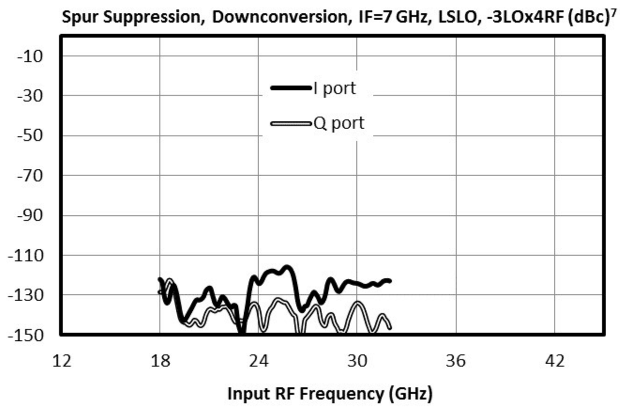


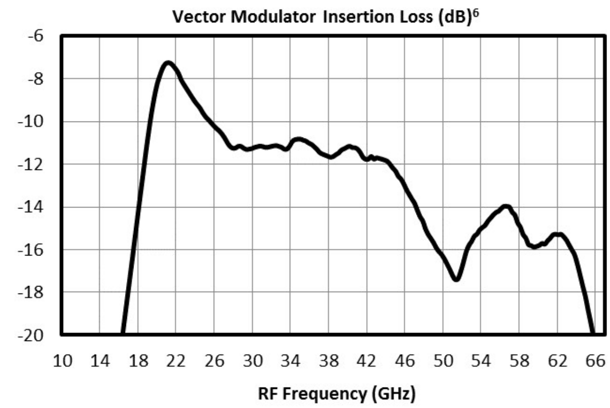

Spur Suppression, Downconversion, IF=14 GHz, LSLO, 3LOx-2RF (dBc)7
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
48
54
60
66
I port
Q port
Input RF Frequency (GHz)

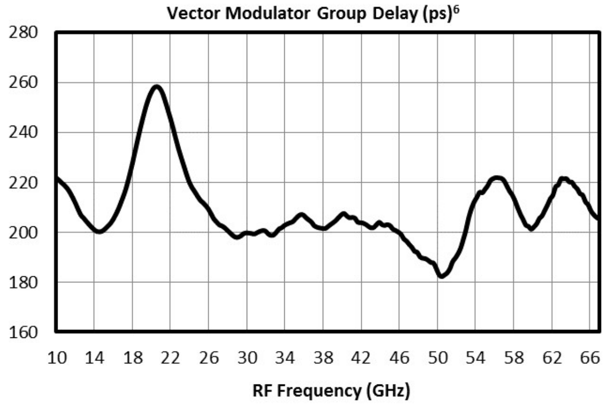

Spur Suppression, Downconversion, IF=14 GHz, LSLO, 4LOx-3RF (dBc)7
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
48
54
60
66
I port
Q port
Input RF Frequency (GHz)


Spur Suppression, Downconversion, IF=14 GHz, LSLO, 5LOx-4RF (dBc)7
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
48
54
60
66
I port
Q port
Input RF Frequency (GHz)

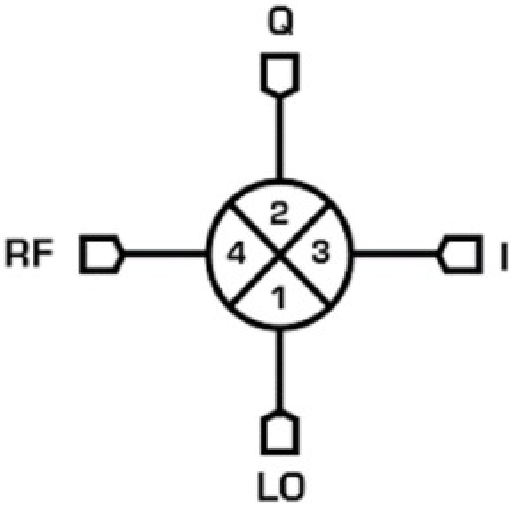

Spur Suppression, Downconversion, IF=7 GHz, HSLO, -2LOx3RF (dBc)7
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
I port
Q port
Input RF Frequency (GHz)


Spur Suppression, Downconversion, IF=7 GHz, LSLO, -3LOx4RF (dBc)7
-10
-30
-50
-70
-90
-110
-130
-150
12
18
24
30
36
42
I port
Q port
Input RF Frequency (GHz)

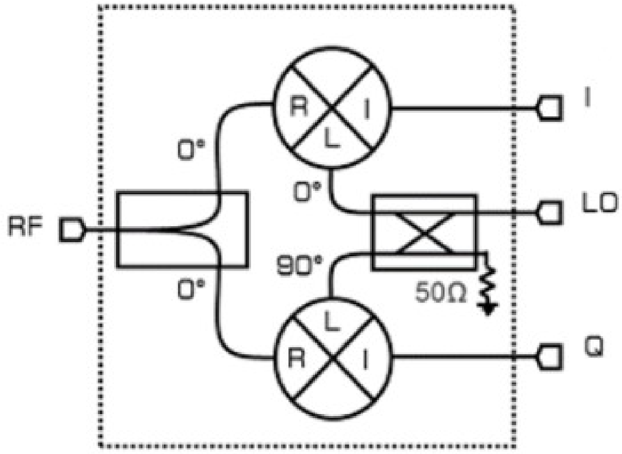

Vector Modulator Insertion Loss (dB)6
-6
-8
-10
-12
-14
-16
-18
-20
10
14
18
22
26
30
34
38
42
46
50
54
58
62
66
RF Frequency (GHz)


Vector Modulator Group Delay (ps)6
280
260
240
220
200
180
160
10
14
18
22
26
30
34
38
42
46
50
54
58
62
66
RF Frequency (GHz)

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-1865L and MMIQ-1865H are the sister mixers of the MMIQ-1865S. The MMIQ-1865L and MMIQ-1865H both require a lower LO drive to operate the mixer. In exchange, both display lower linearity (i.e., lower IIP3, P1dB, Spurious Suppression) than the MMIQ-1865S. Marki S, H, and L diodes correspond to different diode forward turn on voltages.

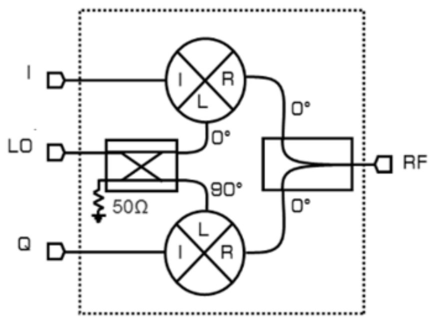
Support for the K, through V bands are offered by the ultra-broadband performance of the mixer's RF and LO ports (ports 1 and 4). Direct baseband to V band frequency conversions are available by using this mixer as an up-converter. Traditional use of this mixer to do image reject or single sideband mixing 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 2 and 3).

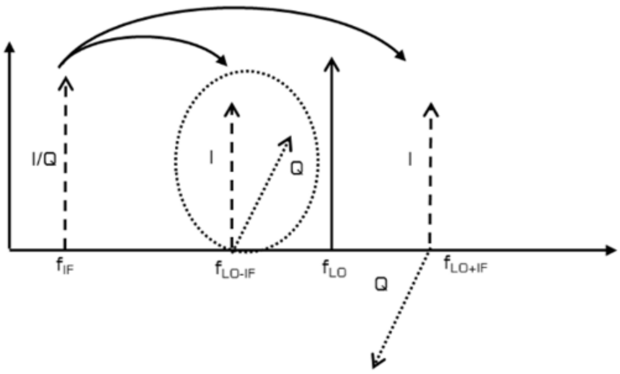
Port 1, the LO port, and port 4, the RF port, support an 18-65GHz signal. Ports 2 and 3, the I and Q ports, support a DC-23GHz signal. A signal may be input into any port of the mixer which supports that signal's frequency. This is the basis of using the mixer as a band shifter.

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.

<table>
<tr><th colspan="3">Up Conversion</th></tr>
<tr><th>Hybrid Port</th><th>Mixer Port</th><th>Sideband Selected</th></tr>
<tr><td>0</td><td>I</td><td rowspan="2">Lower Sideband</td></tr>
<tr><td>90</td><td>Q</td></tr>
<tr><td>90</td><td>I</td><td rowspan="2">Upper Sideband</td></tr>
<tr><td>0</td><td>Q</td></tr>
<tr><th colspan="3">Down Conversion</th></tr>
<tr><th>Hybrid Port</th><th>Mixer Port</th><th>Sideband Selected</th></tr>
<tr><td>0</td><td>I</td><td rowspan="2">Upper Sideband</td></tr>
<tr><td>90</td><td>Q</td></tr>
<tr><td>90</td><td>I</td><td rowspan="2">Lower Sideband</td></tr>
<tr><td>0</td><td>Q</td></tr>
</table>

Up-Converter



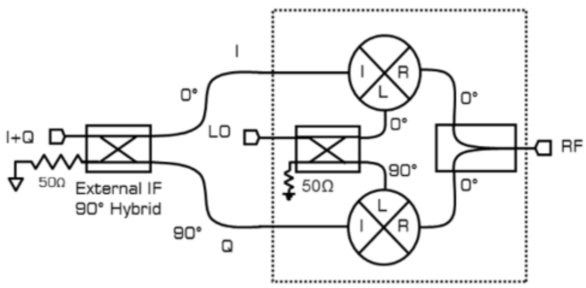


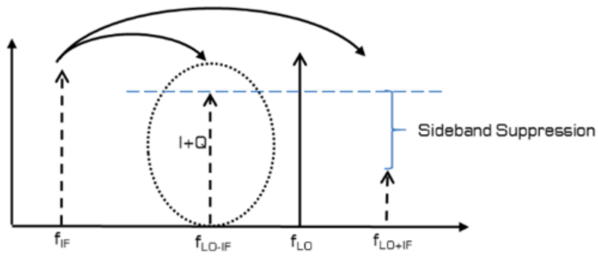
An up converter is a mixer application which takes a low frequency small signal IF input, and a high frequency large signal LO input and mixes the signal together to produce a high frequency RF output. The fundamental 1IFx1LO outputs present at the RF port are the f_{LO-IF} and f_{LO+RF} tones. An up conversion can select either the f_{LO-IF} or the f_{LO+IF} tones. The above illustration shows both up converted sidebands with either an I or Q port input signal.

To use the IQ mixer as an up converter, input a low frequency small signal IF input into port 2 or 3, a high frequency large signal LO input into port 1, and pull the high frequency RF output from port 4. Input into the Q port will result in a up converted signal that is 90° out of phase with the up converted I port input signal. If only a single IF input is desired, terminate either the I or Q ports with a wideband 50Ω load.

This is the input scheme used to take I/Q up-conversion data found inTypical Performance.

Single Sideband Up-Converter



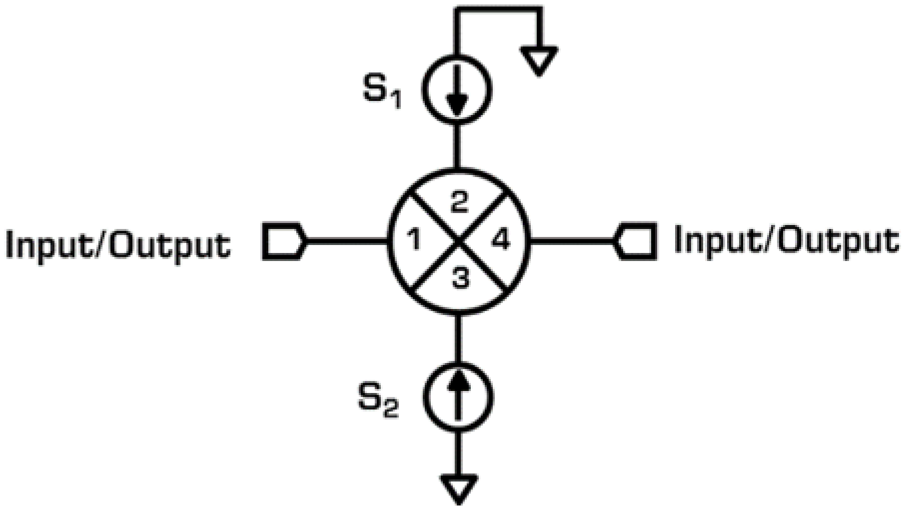


A single sideband mixer is a mixer which suppresses the up converted image frequency from the RF output. Single sideband mixers are constructed using an external quadrature hybrid attached to the I and Q (i.e., IF) input ports. Using an external IF quadrature hybrid, one can select whether the upper sideband or 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 inTypical Performance.

Vector Modulator



A vector modulator is a device that can modulate an input signal’s amplitude and phase. Similar to using a double balanced mixer as a phase modulator or phase shifter, an IQ mixer can be used as a vector modulator. An IQ mixer can be used as a vector modulator by inputting DC current into both the I and Q ports.

Injecting DC current into both the I and Q ports forward biases both mixer cores and causes them to be shorted. This connects the RF and LO baluns allowing the input signal to pass from balun to balun without a frequency conversion. Modulating the DC current into either or both I and Q mixers causes both the phase and amplitude to modulate based on the polarity of the input current and the magnitude of the input current. Modulating only the I or Q mixers causes the device to behave as a biphase modulator (i.e., the device can only swing the phase from +90° to -90°).

To use the IQ mixer as a vector modulator, supply a DC current sufficient to turn on the mixer through both the I and Q ports. Current limiting the DC source to the maximum DC current value found inAbsolute Maximum Ratings is recommended to prevent irreversible damage to the vector modulator. The typical DC current required to turn on the vector modulator is <30mA.

It is recommended to sequence the vector modulator by slowly increasing the DC bias until the vector modulator is operating at the user desired condition.

Near the band edges of the vector modulator, more current than is typical for mid-band operation may be necessary to achieve the same amplitude and phase shift. This is due to the on chip LO quadrature hybrid operating near its band edge.

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.

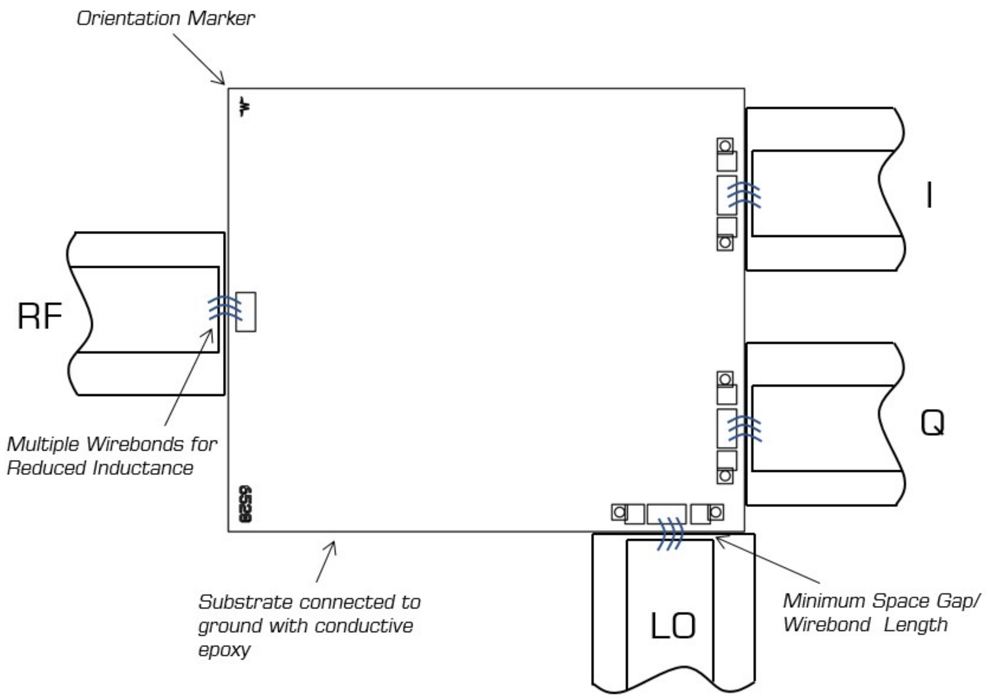
Static Sensitivity

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

Cleaning and Storage

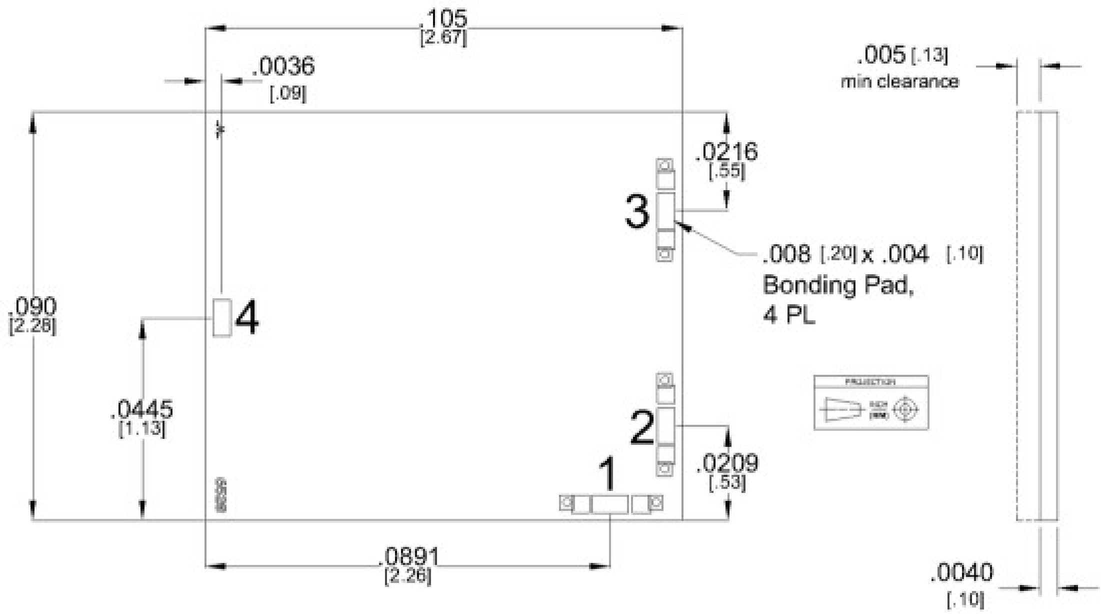
Do not attempt to clean the chip with a liquid cleaning system or expose the bare chips to liquid. Once the ESD sensitive bags the chips are stored in are opened, chips should be stored in a dry nitrogen atmosphere.

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

DISCLAIMER