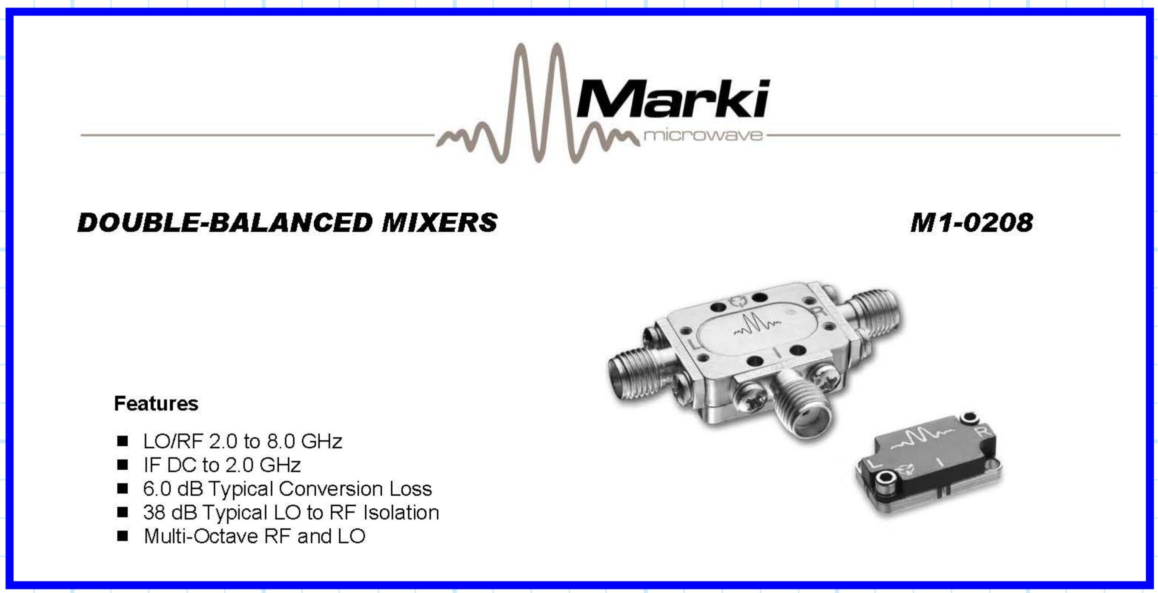
Mixer Bandwidth

Q: *Signals that come out at* ***different frequencies*** *than they go in—how are we supposed to describe the* ***bandwidth*** *of such a device as a mixer?*

A: We find that **each** port of a microwave mixer will have its **very own** bandwidth specification!

Because we typically use a mixer for **down-conversion**, we will find that the signal bandwidth for the LO and RF ports to be much **higher** and **broader** than the bandwidth spec for the IF port.

For **example**, consider this high-quality **microwave mixer** manufactured by Marki Microwave.



To each port, their own bandwidth

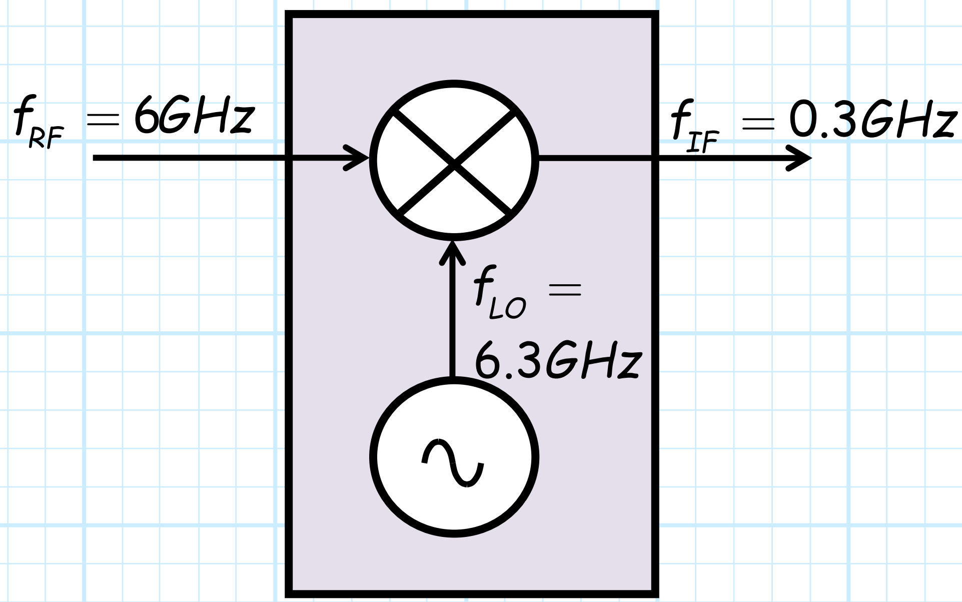
Mixer model M1-0208 has the following **bandwidth** spec:

LO bandwidth: 2.0 GHz to 8.0 GHz

RF bandwidth: 2.0 GHz to 8.0 GHz

IF bandwidth: 0 to 2.0 GHz

Thus, we **could** use this mixer to convert a 6.0 GHz signal to a much lower frequency of 300 MHz.



Note the LO, RF, and IF signals are all within the specified bandwidth of the device!

Bandwidth is based on a key parameter

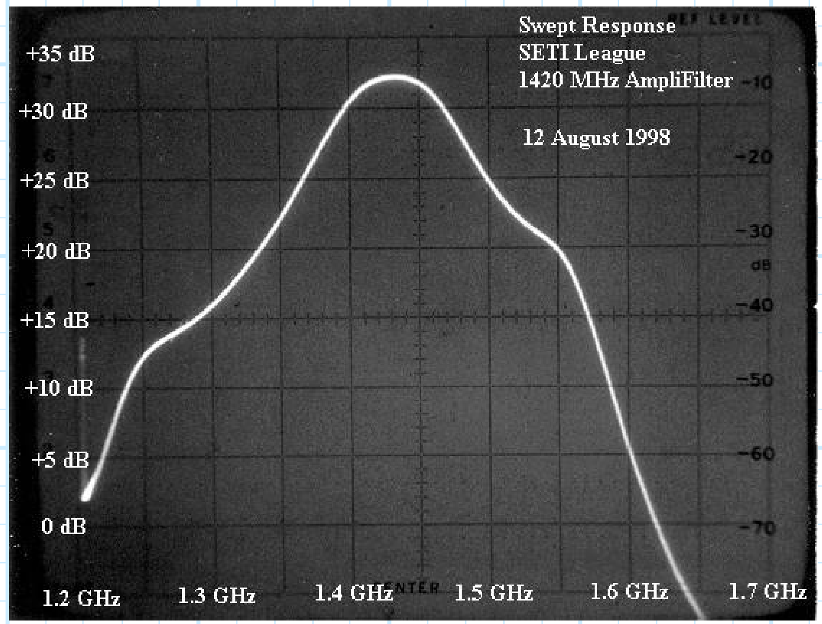
Q: *But what if one (or more) of these signal frequencies resides **outside** their respective bandwidths?*

*What **then** would happen?*

A: Remember, every bandwidth spec is defined with respect to a **key** component **parameter**.

For **example**, the bandwidth of microwave **amplifiers** is almost always defined in terms of **gain** ***G***.

The **bandwidth** of the amplifier is defined as those frequencies that exhibit a **gain** within 3 *dB* of the "nominal" gain value.



http://www.setileague.org/hardware/afilresp.jpg

Key parameter for mixers: conversion loss

But for mixers, bandwidth is generally defined in terms of the **key** parameter of **conversion loss**.

For the Marki mixer model M1-0208, the "nominal" conversion loss is specified as **6.0 *dB***.

Electrical Specifications - Specifications guaranteed from -55 to +100°C, measured in a 50-Ohm system.

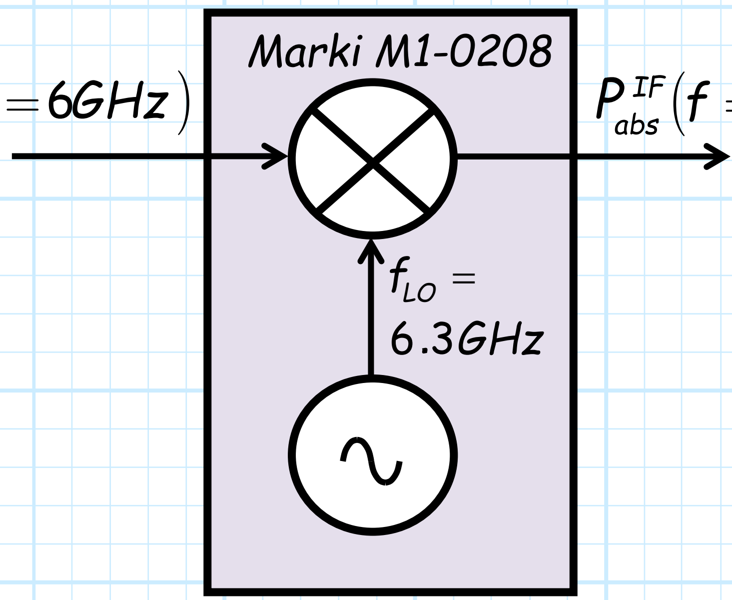
Parameter	LO (GHz)	RF (GHz)	IF (GHz)	Min	Typ	Max	Diode Option **LO drive level** (dBm)
Conversion Loss (dB)	2.0-8.0	2.0-8.0	DC-1.0		6.0	7.0	
	2.0-8.0	2.0-8.0	1.0-2.0		6.5	8.5	
Isolation (dB)							
LO-RF	2.0-8.0	2.0-8.0		25	38		
LO-IF	2.0-8.0	2.0-8.0			20		
RF-IF	2.0-8.0	2.0-8.0			25		
Input 1 dB Compression (dBm)	2.0-8.0	2.0-8.0			+2		L (+7 to +10)
					+5		M (+10 to +13)
					+8		N (+13 to +16)
					+11		H (+16 to +19)
					+14		S (+19 to +22)
Input Two-Tone Third Order Intercept Point (dBm)	2.0-8.0	2.0-8.0			+12		L (+7 to +10)
					+15		M (+10 to +13)
					+18		N (+13 to +16)
					+21		H (+16 to +19)
					+24		S (+19 to +22)

$$-10\log_{10}(1/4) = 6.0$$

This **6.0 *dB*** conversion loss value will be indeed be accurate **only if** all three signals (RF, LO and IF) reside in their respective bandwidths.

For **example,** if the RF, LO and IF signals lie entirely **within** their respective bandwidths:

$$P_{avl}^{RF}(f = 6GHz)$$

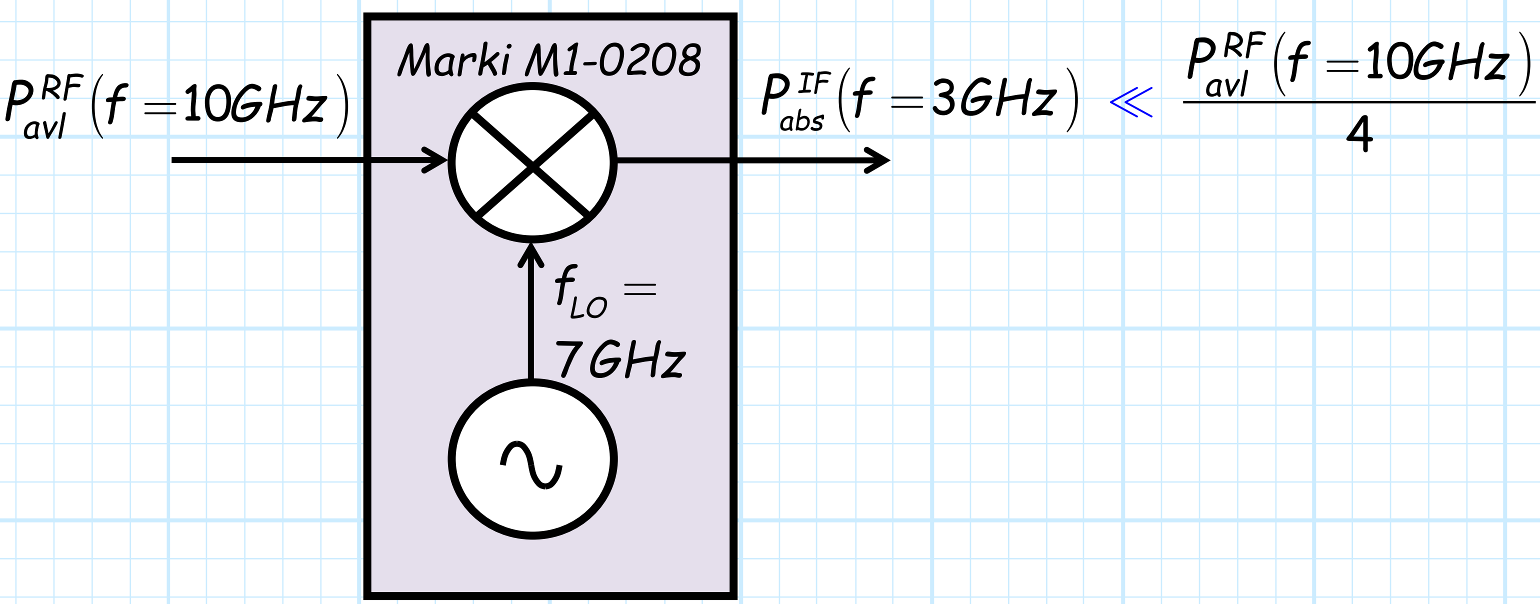


$$P_{abs}^{IF}(f = 0.3GHz) = \frac{1}{4} P_{avl}^{RF}(f = 6GHz)$$

It doesn't work nearly as well

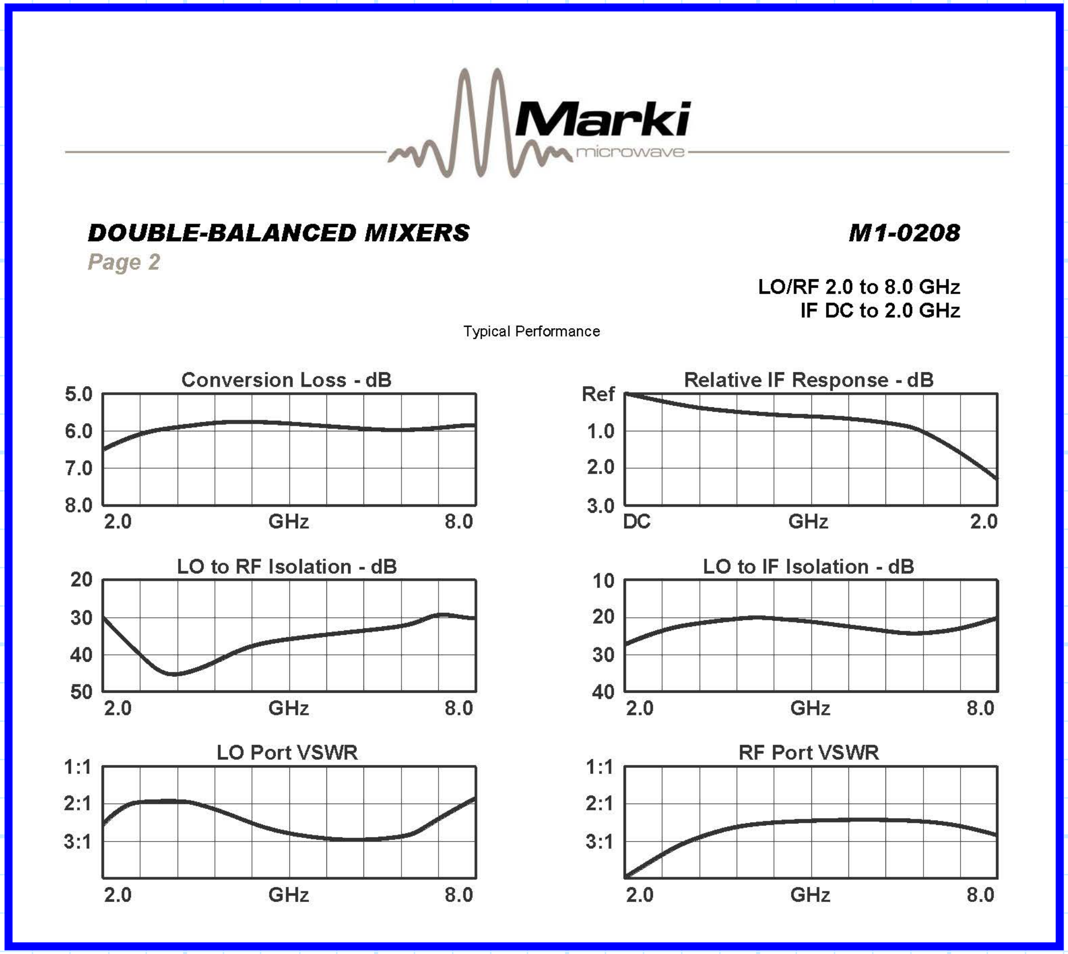
However, if one or more of these signal frequencies are **outside** of their bandwidth, then the conversion loss will be **greater** than 6.0 *dB*—perhaps **much** greater!

For **example**, **if** both the RF and IF signals lie **outside** their respective bandwidths:



Find quality in one place, and you'll likely find it everywhere

Note the fine people at Marki have provided a spec sheet with **measurement plots**, so **you** can see **specifically** how the mixer varies with frequency:



A general rule of thumb:

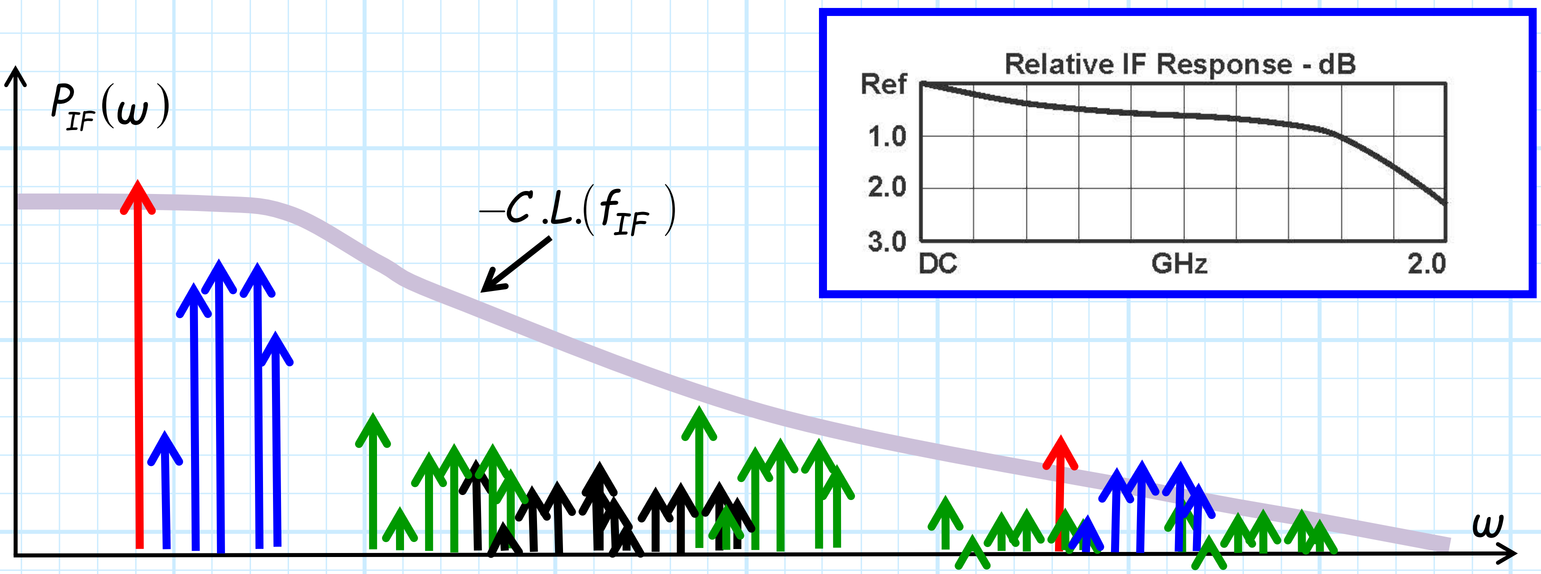
Manufacturers that produce a **professional**, detailed, organized, and unambiguous spec sheet almost always produce a **similarly excellent product**!

Spurious signals outside IF bandwidth are (somewhat) attenuated

Q: *What about **spurious** signals; won't **many** of them lie **outside** the IF port bandwidth?*

A: Indeed they will.

And, as a result, they will generally be **less** energetic than those that lie **inside** the IF bandwidth.



Remember that *other* ideal IF signal? It's not so ideal any more

Additionally, consider the **other** ideal term of a switching mixer.

Recall that **in addition** to a signal at the **difference** frequency $f_{LO} - f_{RF}$, there is a **second signal** generated at the **sum** frequency $f_{LO} + f_{RF}$.

For most mixers, this **higher** frequency signal at $f_{LO} + f_{RF}$ will lie well **outside** the mixer IF bandwidth, and so will be **significantly attenuated**.