Multiband Receive Converter

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PREFACE:

The Florida Weak Signal Society maintains beacons from 6M through 24 GHz. They are located on top of an complex in the Orlando Florida area. It is a shared site with some local repeaters and commercial systems. One of the issues with this site is that our maintenance crew requires special permission to enter the keyed access roof top location. Once the permission is granted, the crew heads to the site and then is required to locate the individual to allow them access. This becomes a problem if multiple trips are required to make an equipment repair or change. An issue that arose after the crew finishes their work was to verify that the beacons were working properly before they left the site. Making a phone call to someone in the area to check them on the air resulted in no answers or that someone didn't have the ability to check all of the bands at the same time resulting in uncertainty of correct operation before they left the roof. A portable spectrum analyzer verified that the beacons were in operation on the correct frequency but did not verify the matter of the keyer working correctly with the ID and to check on possible Key Clicks and chirp. A SDR dongle type receiver was considered but would need some sort of frequency converter for the higher frequencies. And Of course, with an SDR, a laptop computer would be required at the minimum to be carried to the roof top adding to the equipment count and set up before testing. Since the Beacon Crew already had a portable Handheld receiver through 23 cm (less the 900 MHz band) I was asked if I had any ideas about of how to possible make their job easier. The final result is pictured above and the details require further reading.

THE PROJECT:

So, not so pure, but simple was the approach. Correctly down converting microwave signals to a 28 MHz hand held receiver requires extensive filtering to prevent image and out of band signals from mixing producing spurious or unwanted signals in a high performance receive system. But, we don't require a high performance receiver. We just want to copy the beacon's signals on the roof top. Since we know what frequency the beacon is on or "Near", and actual testing will be done only a few feet away from the TX antenna, we can assure that any type of frequency conversion , such as a single wide band Mixer, will produce the results that will only require the frequency selectivity of the IF receiver. This means, no RF filters will be utilized and the absolute meaning of not so pure, but simple!

Since the development of quality economical multi-frequency synthesizers, the concept of a multiband converter has been floating around my design bench since 2009. Recently, development of economical synthesizer technology has extended the frequency range through the 10 GHz region. This eliminates the need for additional frequency multipliers and filters on the LO side of the mixer to convert 10 GHz signals and simplifies any project such as this! The real technical requirement becomes the performance of a wide band Mixer. ----- Or does it?

WIDE BAND FREQUENCY MIXERS:

Any type of a diode if injected with two separate frequencies will produce products at different frequencies. The effort of frequency mixing devices is controlling the levels of the undesirable mixing products, while producing the desired frequency at efficient levels. This requires multiple diodes or a ring type mixer. This type of “Ring Diode mixing” is very easy to do until you need to impedance match the ports into the next gain stage or from the desired input signal without causing reflections. Then to produce these matching circuits (LO, IF, and RF) in a Broadband fashion with limited insertion loss and maximum port to port isolation becomes the “Art” of the design. Now, to miniaturize it into a small surface mount package and sell it to a bunch of experimenters for a couple of Bucks, well that’s another story!

But lucky for us, many component manufactures now offer such products. Octaves of bandwidth on both LO and RF, great port to port isolation, low insertion loss and produced in many different packages at different LO drive levels. The most complicated part of picking a mixer that operates between 1 and 10 GHz is deciding what size of package you want in your final product and how you want to utilize it in your circuit. The mixer I chose for this project did blow the budget because I elected to utilize coaxial version vs creating a PC board design. Granted, a simple board could have been done with LO, RF and IF gain stages making a complete RX converter less the Local Oscillator to simplify this project, but it became more of a proof of concept than a production manufactured design. The part number and specifications are listed below.

ZX05-14+

CASE STYLE: FL905

Connectors	Model
SMA	ZX05-14-S+

Features

- wide bandwidth, 3700 to 10000 MHz
- low conversion loss, 6.7 dB typ.
- high L-R isolation, 38 dB typ.
- excellent IF BW, DC to 4000 MHz
- rugged construction
- small size
- useable as up and down converter

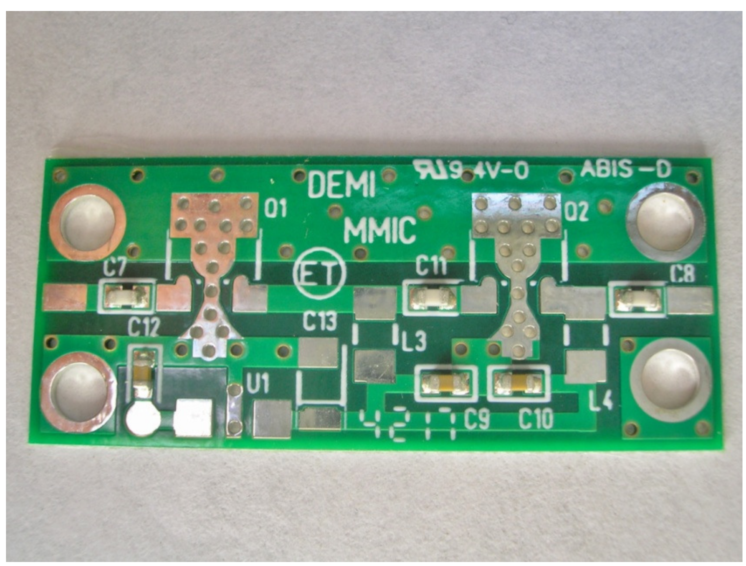
As you can see, the frequency of operation is not quite low enough for our application but it was useful down to 900 MHz. Yes, of course, the insertion loss increased as the frequency decreased, but it provided a mix that was more than adequate for our application and proved to be a hidden attribute at the time.

WIDE BAND MMIC AMPLIFIERS:

There are many MMIC's (monolithic microwave integrated circuits) amplifiers that could have been utilized for the project. I chose the NLB-310. It was selected because it provided relative flat gain between 1 and 10 GHz.

Parameter	Specification			Unit	Condition
	Min	Typ	Max		
General Performance					**V_D = +4.6V, I**
Small Signal Power Gain, S21	12.0	12.7		dB	f = 0.1GHz to 1.0GHz
		10.7		dB	f = 1.0GHz to 4.0GHz
		10.0		dB	f = 4.0GHz to 6.0GHz
	8.5	9.7		dB	f = 6.0GHz to 10.0GHz
		9.6		dB	f = 10.0GHz to 12.0GHz

The same MMIC was utilized for both RF and LO signal amplification on a simple one or two stage MMIC circuit board. The reason for the LO gain stage is because the output power of the Synthesizer is low compared to the LO drive required for proper mixing. The output power drops above 2 GHz so the gain requirement to maintain the proper LO drive level increases when utilizing the DigiLO synthesizer. Now using the LO gain stage causes the LO drive level to be excessive at the lower frequencies but with the Port mis-match of the mixer below 3 GHz, it became a benefit. Again, the proper way would be to design a board with the correct parts for the application but we just required a Mix of LO and RF anyway we could get it. Excess LO drive will produce excessive harmonics! This is yet another benefit we will discuss later.



The MMIC boards are biased directly from a 5 VDC regulator controlled by the ON/OFF switch of the converter. Some gain management was required but, the Noise figure of the RF amplifiers was not considered at all. We are not going for DX! We just want to check the quality of a signal from a transmitter that is a few feet away! So, we expected to see a “Big” signal at the desired frequency therefore no need to worry about front end gain and noise figure, we just wanted at the time , to overcome the Mixer loss .

FREQUENCY SYNTHESIZERS:

Without a frequency agile synthesizer in accuracy, range, and constant output power level, this project would become very complicated. In fact, because of the ability of the synthesizers available today, this project became possible and remained simple. If I was to do this project again, I would have chosen a synthesizer with higher frequency capability but an understanding of the circuitry and utilizing the chosen components beyond their specified regions of operation proved successful!

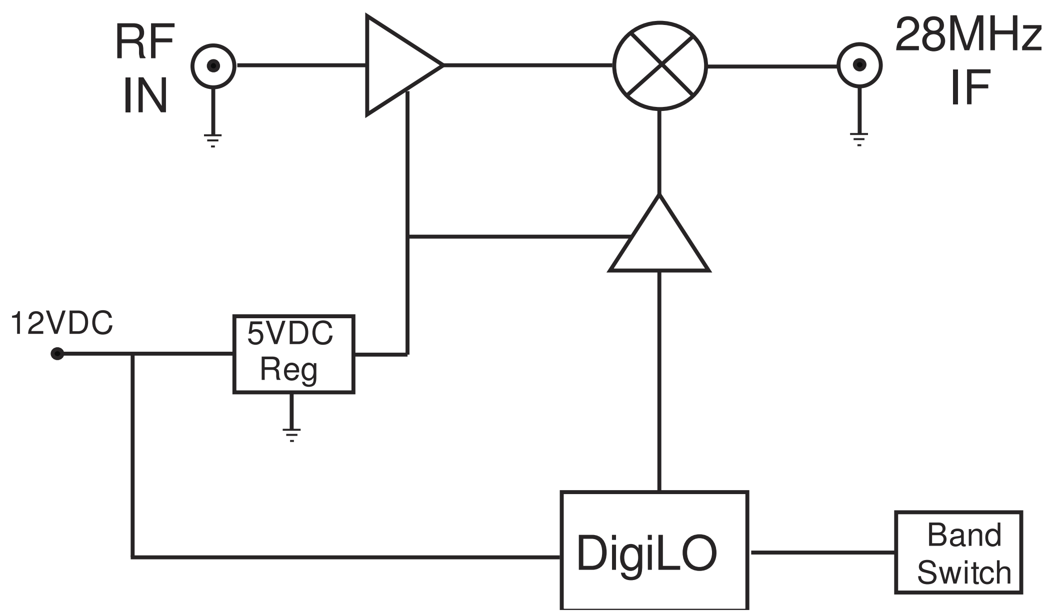
Normally, a Local Oscillator source for a microwave converter requires frequency multiplication to obtain the correct mixer injection frequency and it adds cost to the final design along with increasing the size of the circuit. If Separate frequency multipliers per band were required, it would make the final design cumbersome in size and costly with many components with only a single use. Band switching schemes then become complicated and tune up and adjustment would be time consuming. Then factor in the “More components, less reliable” aspect and you now have a finished product that may be a future problem.

With a frequency synthesizer such as the Q5 Signal DigiLO shown on the left, frequencies can be selected with a multi-position switch and diode matrix. The frequencies generated will normally support converters between 2 Meters and the 5 cm band without frequency multiplication. Frequency accuracy is maintained with an on board “clock” so no LOC detect indication is required but can be implemented. Then with the extra gain in the LO chain, we utilized the excessive harmonics to provide enough level to convert the 10 and 24 GHz. bands from the frequency injection in the 3- 4GHz region.

The mixer's LO port had enough drive to produce converted signals from the 10 and 24 GHz beacons and had enough circuit loss to prevent signal distortion at the lower out of range frequencies providing us with coverage from 900 MHz through 24 GHz.

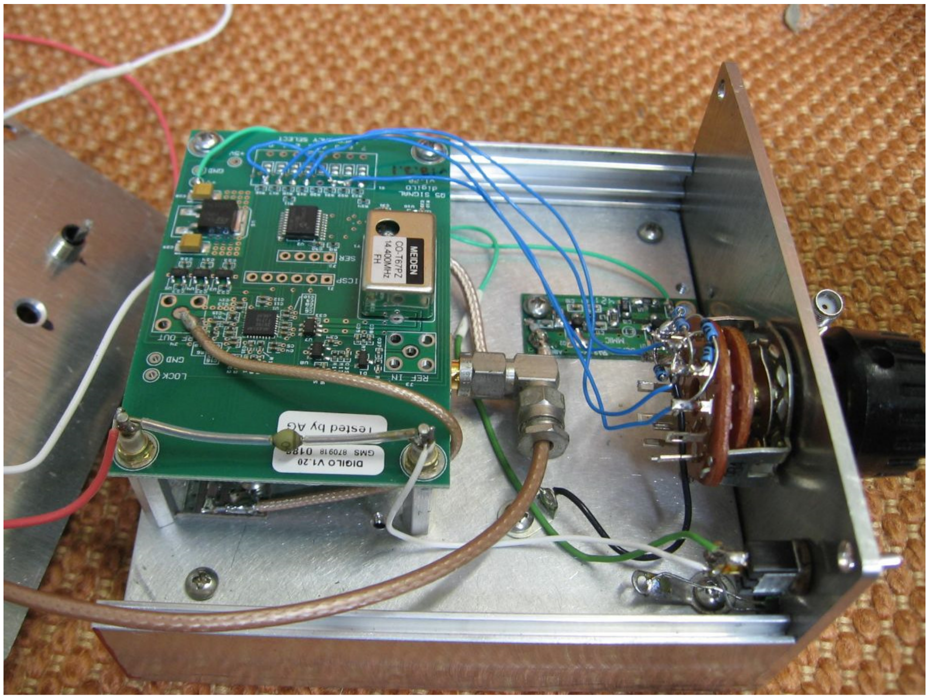
THE DESIGN:

The design is as simple as the following Block diagram. No filters, just a mixer, a frequency source and some gain stages with a regulator. The extras such as a switch and a POWER "on" LED make it all come together.

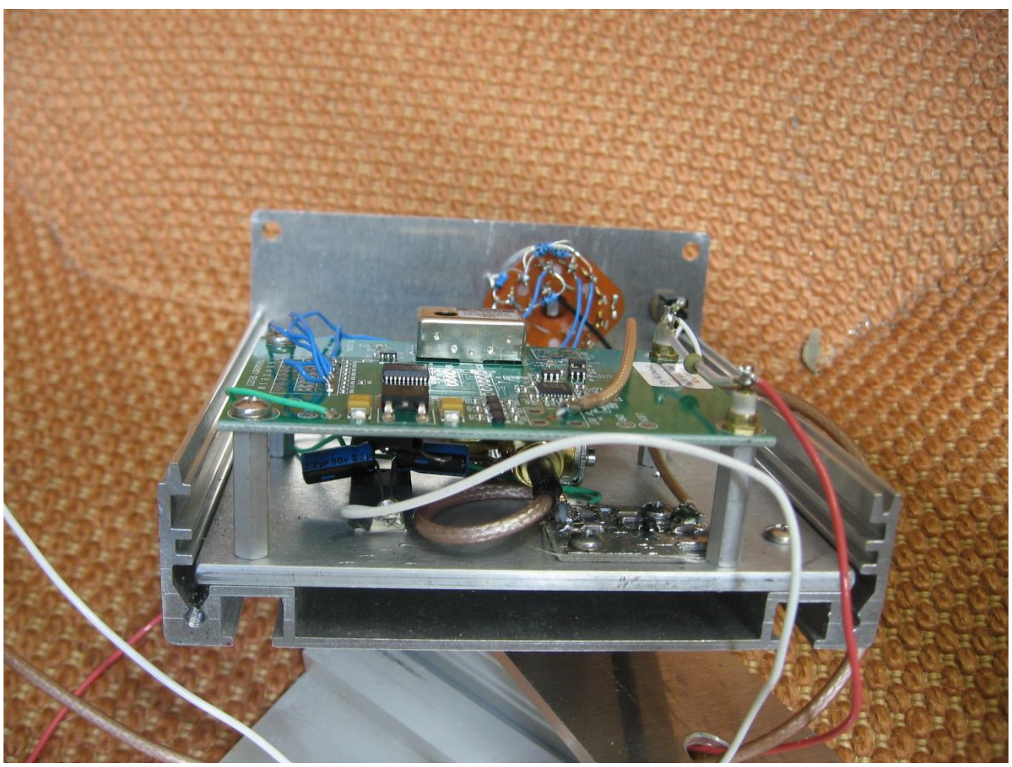


Receive Converter Block Diagram

It's all assembled in an enclosure that measures 3.5" x 4" x 2" with a SMA connector for the RF input or antenna port and a BNC for the IF out. A band select switch of any type may be utilized depending on the type of Synthesizer used. All circuits are mounted on a single plate with the clamshell enclosure. The voltage can be connected anyway desired. Please review the following pictures.



Complete assembly with RF gain stage in the Upper Right



End View with LO amplifier under DigiLO

Go Box with Battery shown

CONCLUSION:

The design was successful and all of the W4FWS beacons (50 MHz through 24 GHz) can be checked on the roof top for proper keying and signal quality with the combination of equipment in this simple “Go Box” type of set up. Further testing revealed that with a simple Log Periodic Antenna, our 900 MHz through 5 GHz can be copied up to 5 miles away. With a horn type antenna, the 10 and 24 GHz beacons can be copied away from the beacon location quantifying the result of utilizing components that are not specified for that frequency range.

The availability of economical state of the art components allows a multiband converter to be easily constructed to cover any frequency or frequency range. Yes, this was designed with the purpose of being test gear for our W4WFS beacon but a converter such as this is an economical piece of test gear that could be used as a portable receiver for rover to test their signals on all bands or on the test bench. This design was made for a 28 MHz IF, but with the synthesizer, IF frequencies can be chosen to suit your needs utilizing any simple transceiver in the 10m or 2 M bands with the standard frequency programming of the DigiLO.

This unit will be on display at the conference for your review and testing.

Thanks for reading and see you at the conference!