EXPERIMENTS ON 241 GHZ

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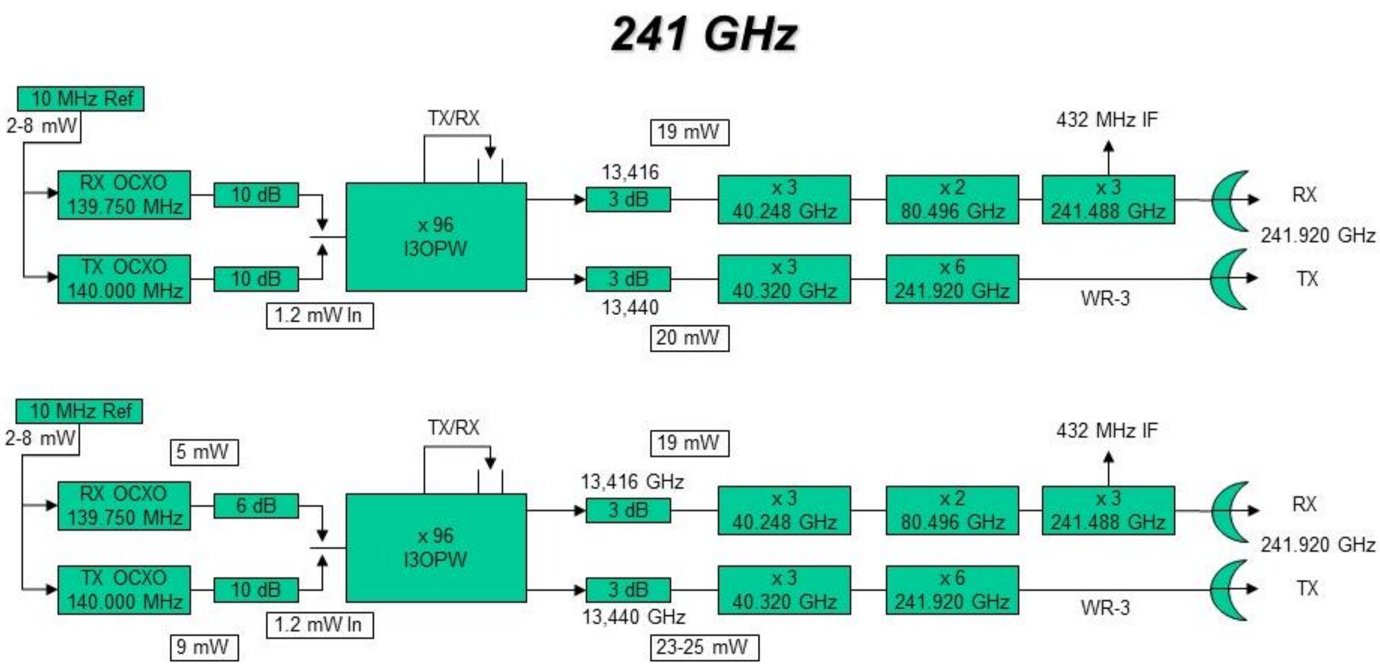
HISTORY

In early 2011, Henry, KT1J acquired the first 241 GHz system. Later that year, we were able to make a 100 foot contact across his front lawn. This was only one way as we only had one transmitter and one receiver. For the next 4 years, Henry and I have slowly built up the systems in hopes of eventually making a 2 way contact on this band. With two complete systems now running, we are working towards that goal.

First we'll look at the equipment and then share some results we've had so far.

EQUIPMENT

Here is the block diagram of the complete systems.



The systems consist of a separate optimized receive mixer and transmit multiplier. Each system has its own LO chain. The OCXOs are all from Axtal. For transmit, they are 140.000 MHz. This is multiplied up to 241.920 GHz. For receive, they are 139.750 MHz. After multiplication, this yields a receive IF of 432.000 MHz.

The LO's are all GPS locked using VE1ALQ Reflock boards. The 10 MHz GPSDO systems used in the field are the "Simple GPS" units. These have excellent accuracy, but stability is limited to about 2 Hz/GHz. This yields a frequency drift of under 500 Hz at 241 GHz. These units were chosen because of their minimum lock time and we had several units on hand. From a cold start, they are usable in well under 5 minutes.

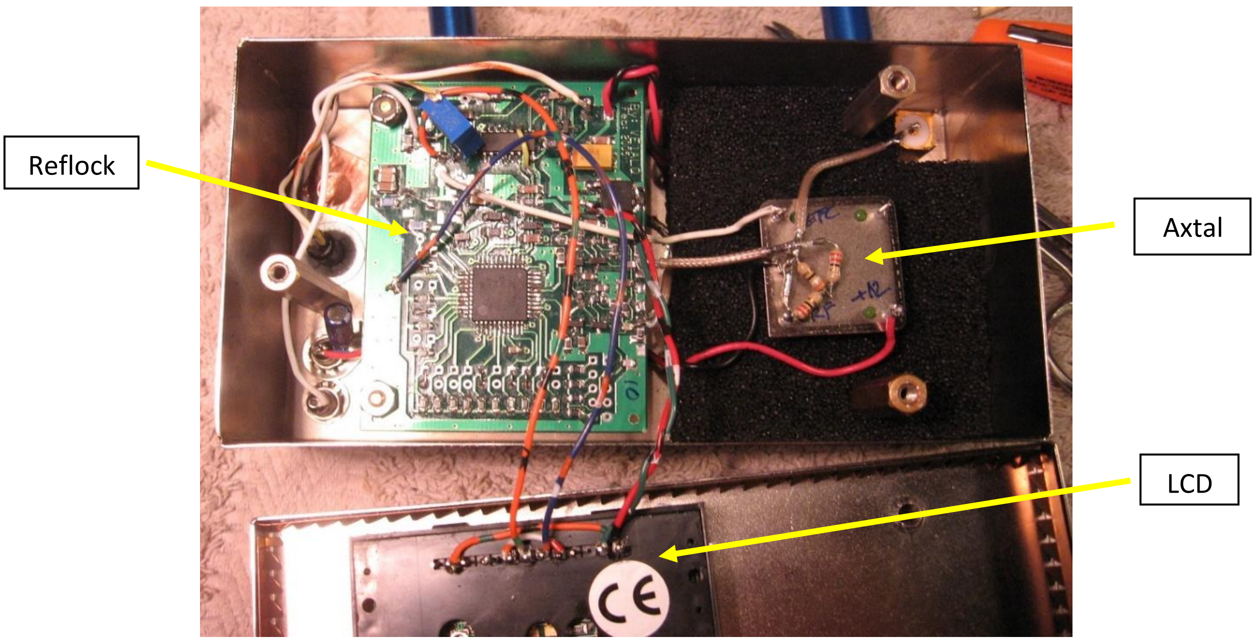
For greater stability, we would need to use one of better GPSDO's such as a Thunderbolt. The issue that arises is increased lock time because the units need to do a rather lengthy "survey" for position.

We are experimenting with a new GPSDO from Jackson Labs. This “LTE-Lite” unit trades some stability for reduced survey time. It should be capable of stability in the 30 Hz range at 241 GHz. Survey time is 20 minutes. http://www.jackson-labs.com/index.php/products/lte_lite

It is also possible to use a good standalone 10 MHz reference.

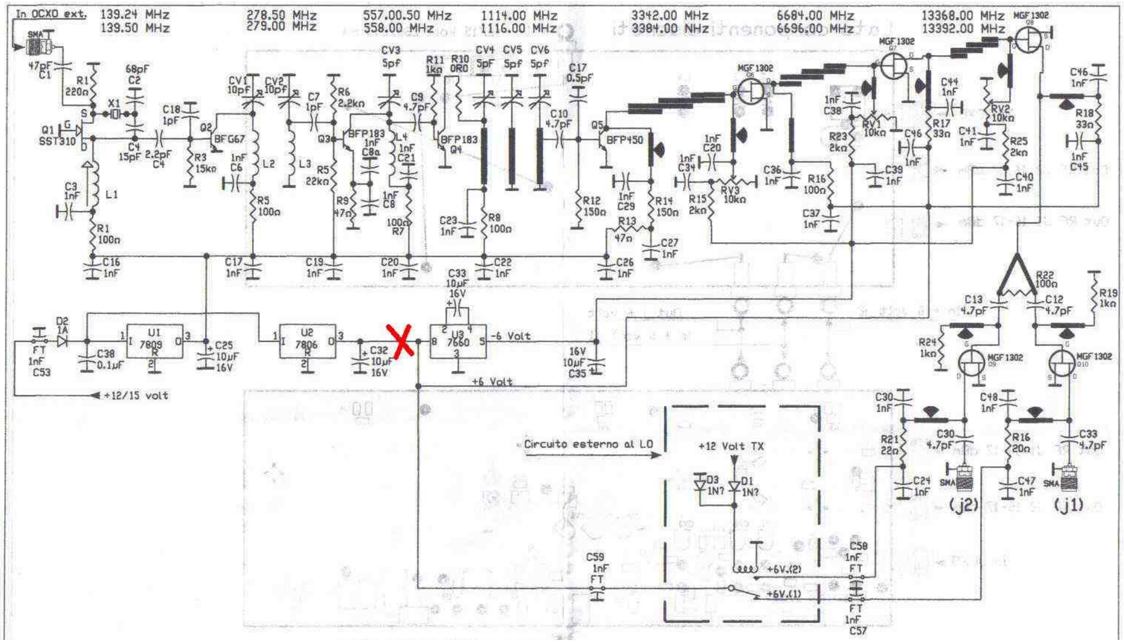
LO

We standardized on Axtal Axiom 75 OCXO's for all our LO's. http://www.axtal.com/cms/docs/doc86235.pdf
Below is a picture of one of the Axtal GPS locked units. You can see the Reflock board on the left and OXCO on the right. In the bottom of the picture, you can just see the back of an LCD voltmeter (CE sticker on the back) that measures the EFC voltage applied to the OCXO. This gives a positive indication of lock. The Reflock correction output can swing from 0-5 volts, with nominal being 2.5 volts.

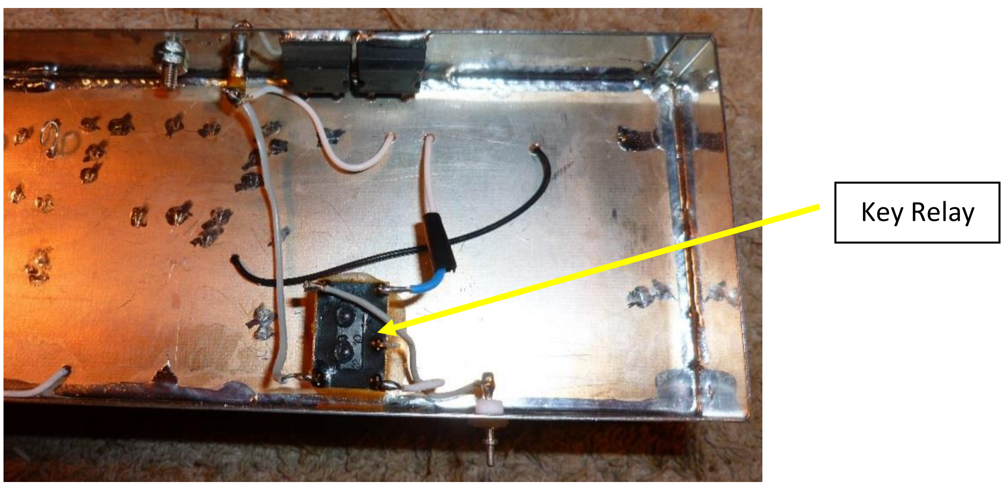


x 96 Multiplier

We use a single x 96 multiplier per system. These multipliers are from I3OPW. They are the classic DB6NT style. Armando built them up with 2 separate switchable outputs that we use to drive both signal chains. This allows us to optimize the output drive level to each LO chain. In the schematic below, the frequencies listed are not what we are using, but the multiplication shown is correct.



There is an external SMA relay that switches either 140 or 139.75 MHz in to the unit. Since we are using a straight transmit multiplier, we use CW only. To send CW, we key a section of the x 96 multiplier. If you study the schematic, you will see a 6 volt regulator that drives the output sections. We use a small DIP relay to toggle that 6 volt line at the point marked with a red X. A picture of the relay mounted in the multiplier is below.

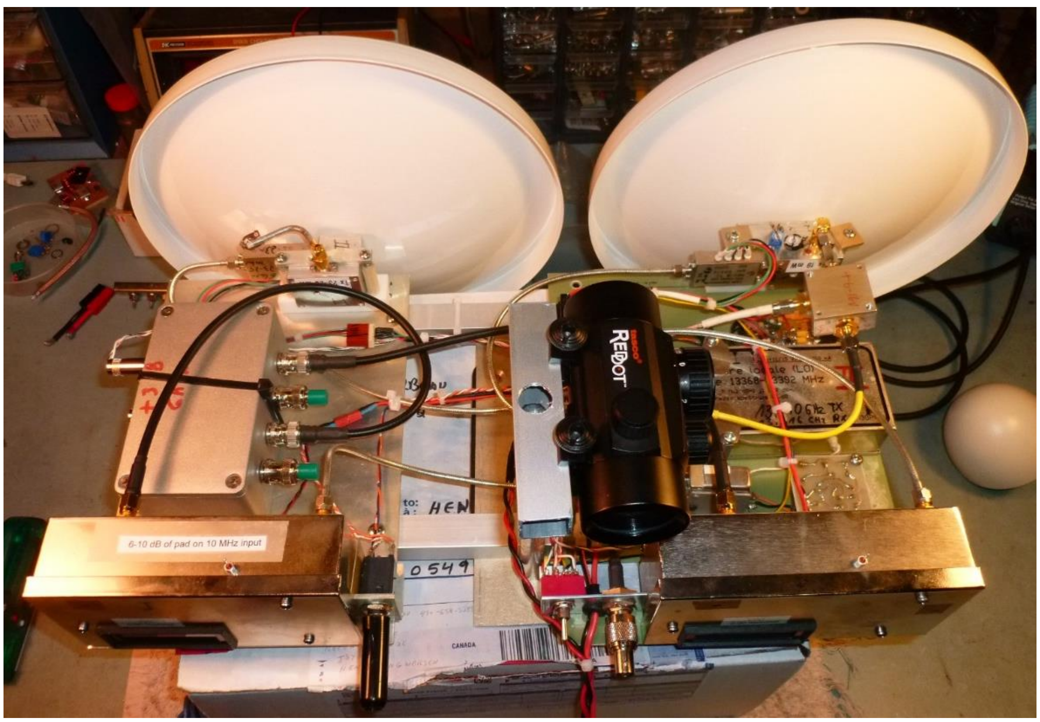


RECEIVE MIXER AND TRANSMIT MULTIPLIER

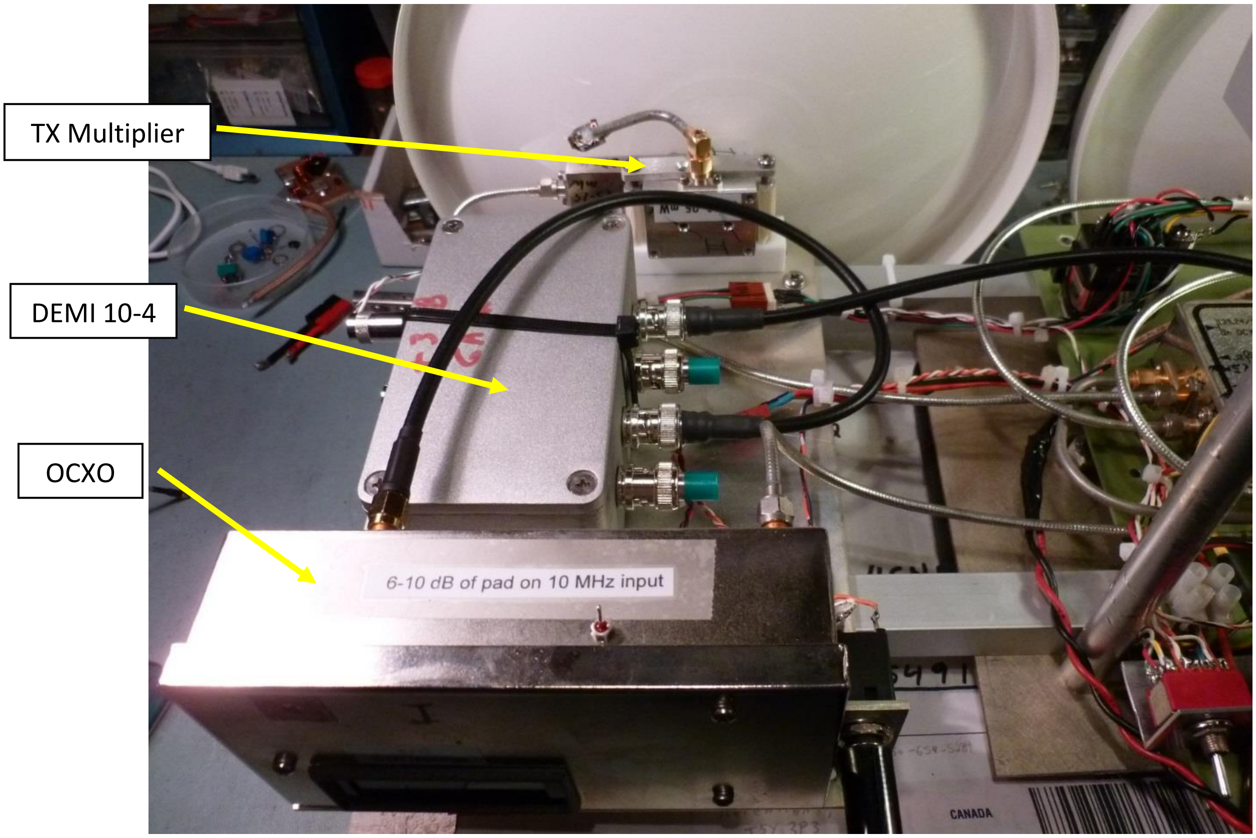
Below is one complete system. On the left is the transmit multiplier and on the right is the receive mixer. There are also a pair of splasher feeds for our Procom dishes. Also pictured are the x 96 multipliers and the small power supplies for the 40 GHz x 3 multipliers.

OVERALL SYSTEM

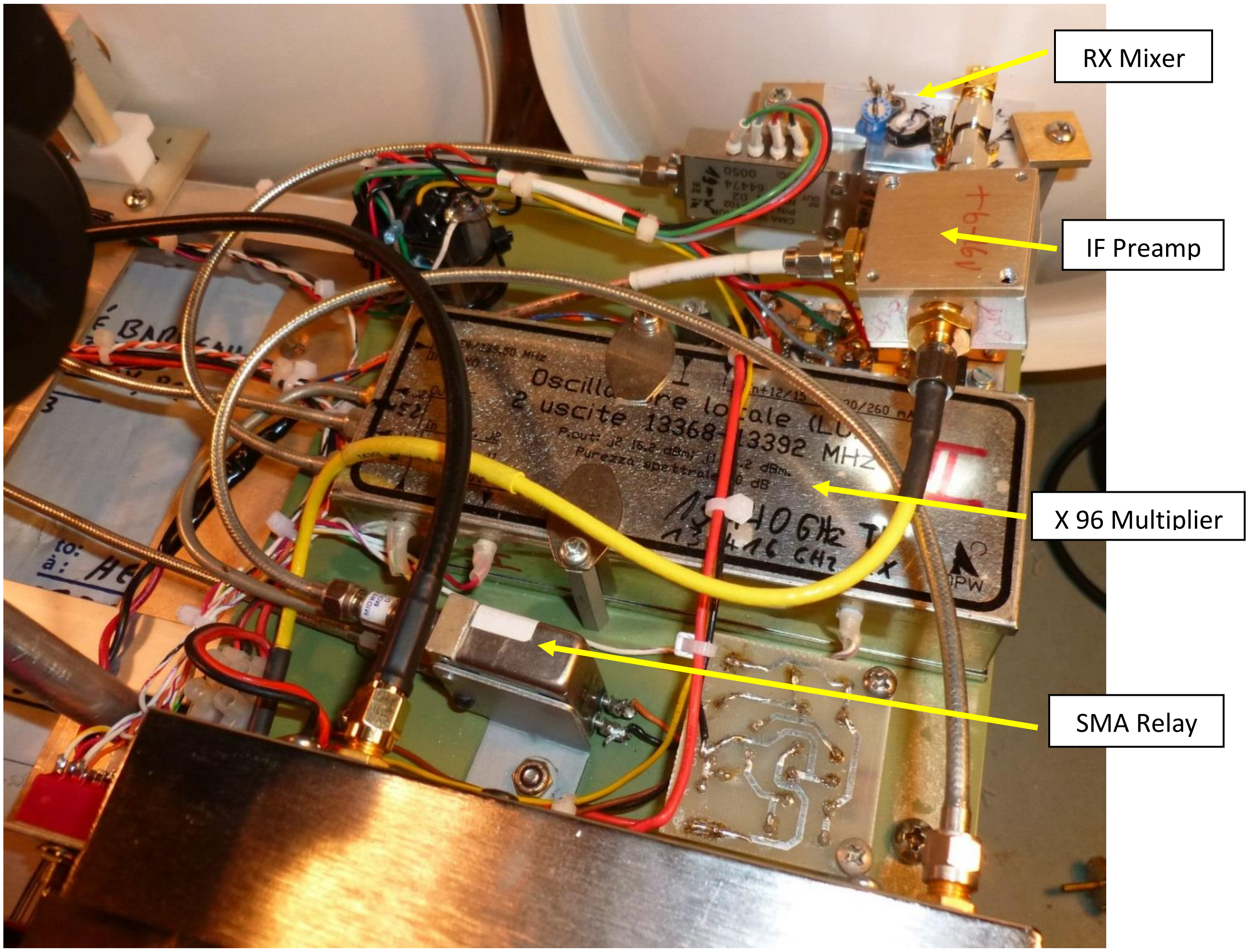
Here is what one complete system looks like. Transmit on the left and receive on the right.



Looking closer at the receive side below, you can see the Axtal OCXO in front. Behind that is a DEMI 10-4. This is used to split/amplify/filter the 10 MHz GPSDO and feed it to both OCXOs. In front of that is the transmit multiplier attached to the dish.



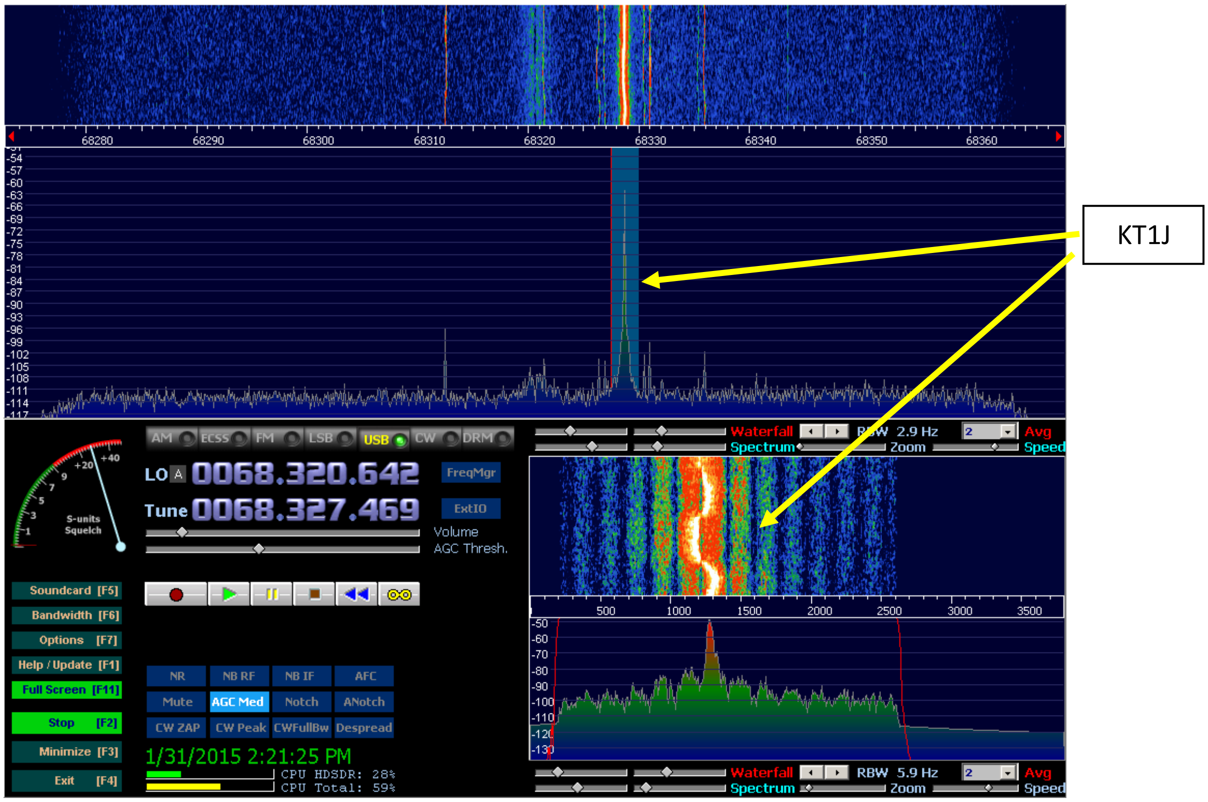
Looking closer at the transmit side below, you can see the SMA relay used to switch OCXOs in to the I3OPW x 96 multiplier. Since the SMA relay is a 28 volt unit, there is a small circuit board to the right which is a ‘kicker’ to operate the relay from our 13.8 volt supply. The SMA relay feeds the x 96 multiplier. You can see the dual x 96 multiplier 0.141 hand formable output cables running to the 40 GHz x 3 multipliers. The receive mixer is mounted to the rear of the dish. Off the top of the mixer is an AD6IW IF preamp (yellow cable attached to the output). Right under the preamp is the power supply for the 40 GHz x 3 multipliers. We use a single supply and switch it between transmit and receive via the relay to the left of the power supply.



TESTING AT 100 FEET

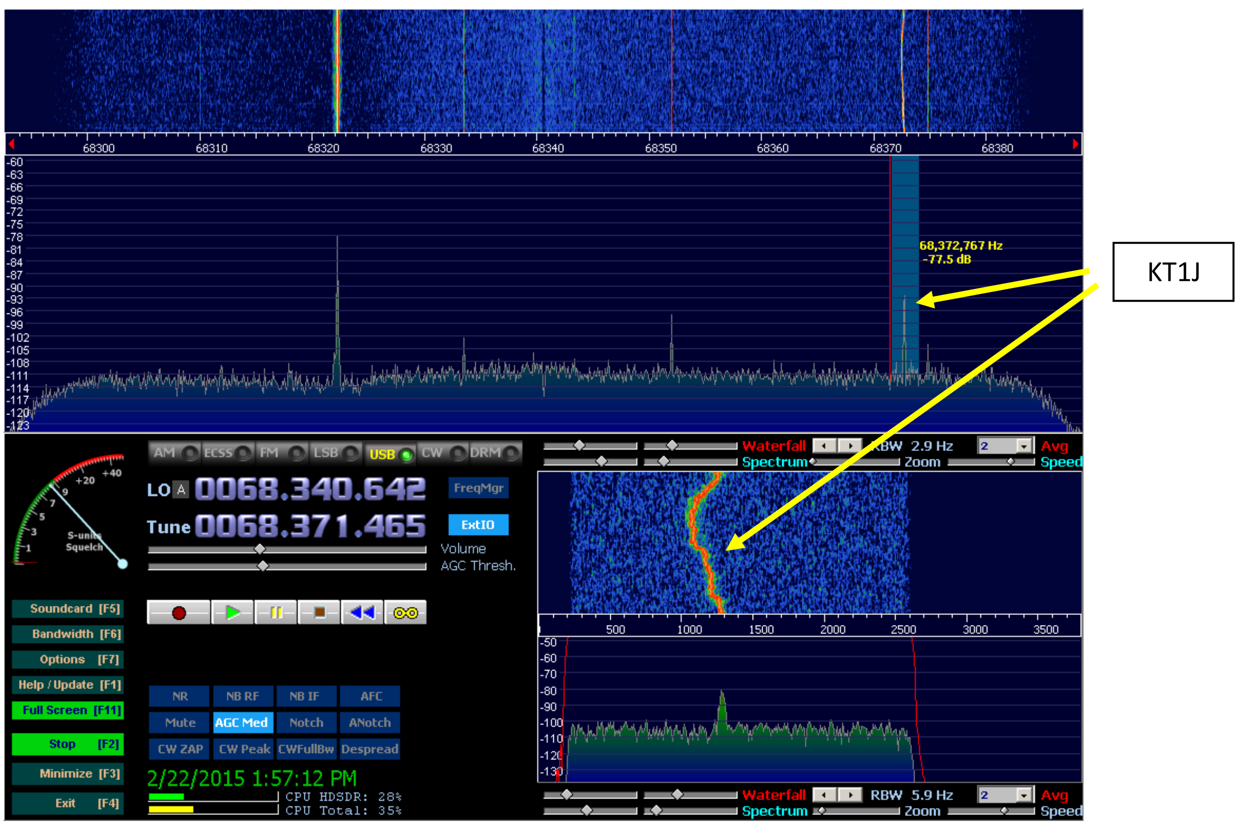
Here are all 4 dishes lined up on the bench as we get ready for outside testing. You will notice we are experimenting with different feeds. We have two DL2AM splasher feeds and two shepards crooks supplied by LX1DU. All the dishes are 0.25 M Procom. We use these on bands from 47 GHz up to 241 GHz.

Our first test was over a 100 foot path to verify that everything was working. Our IF rigs are FT-817s. They are fitted with IF taps that drive a FUNcube dongle using HDSDR software for a Panadapter display. http://www.w1ghz.org/small_proj/FT817_Panadapter-N1JEZ.zip Below is a screen shot from HDSDR showing the signal at ~ 50 dB out of the noise. You can see some drift in the signal from the Simple GPSDO's used as a reference. This test was successful both ways.



Testing at 0.5 km

After successful testing at 100’, we then moved to 0.5 km. We worked on 78 GHz first to get a preliminary dish alignment and then switched to 241 GHz. Signal level is a bit over 20 dB out of the noise.



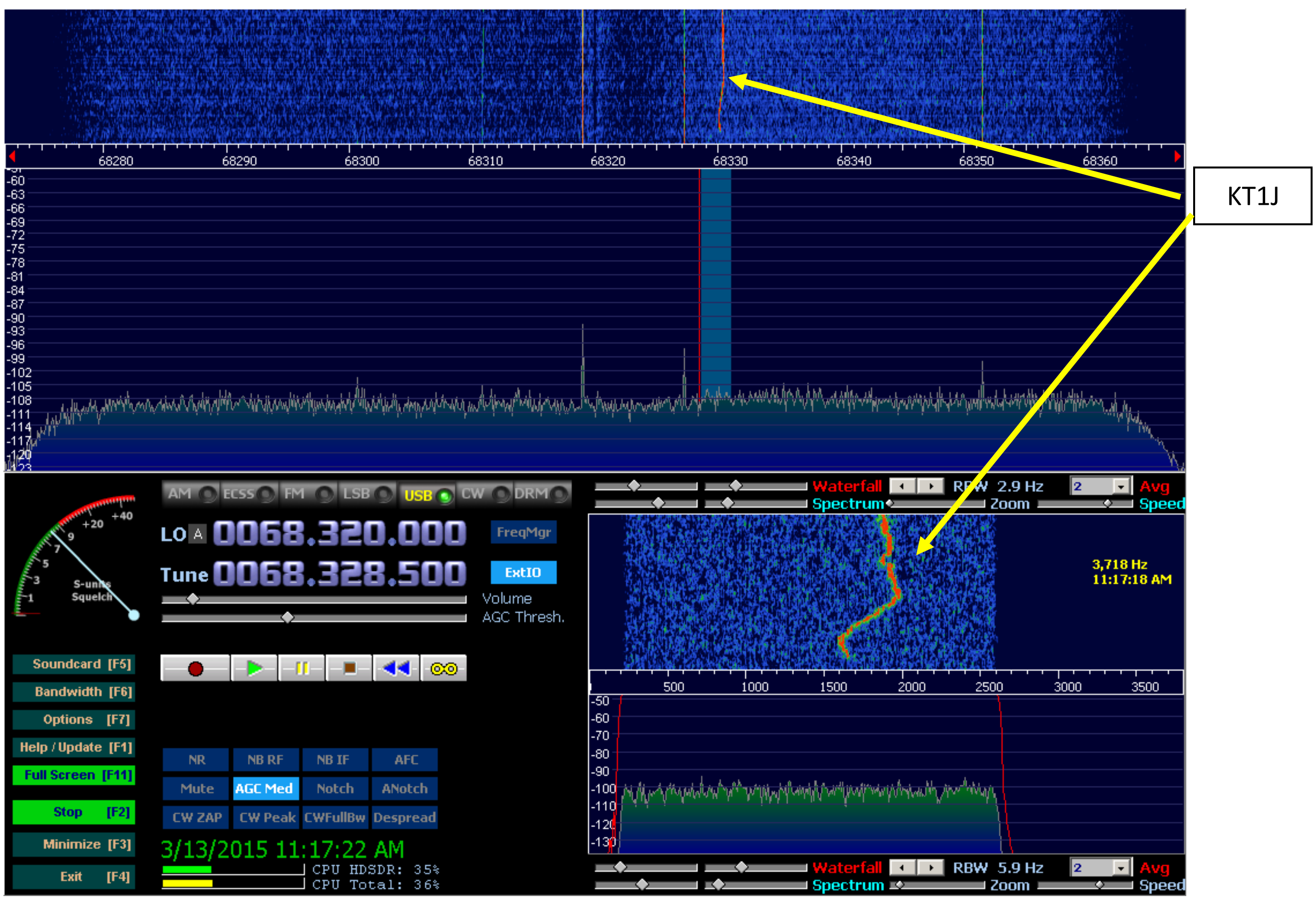
Unfortunately, this contact was only one way. Mike was able to acquire Henry's signal, but Henry couldn't find Mike. At this point, we were only using GPS lock on Mike's system. Henry's OXCOs were free running. So we decided to lock his OCXOs to take that variable out of the equation. We also started trying to refine our pointing method. We were finding that our 0.25 m Procom dish beam width was extremely tight! 1 degree in azimuth or elevation could make the difference in seeing a signal and seeing nothing! This surprised both of us. Our 122 GHz contact at 4 times the distance had proved to be quite a bit easier.

We did know that having a separate transmit and receive dish would be challenging. They never would be in perfect alignment. But we felt we could overcome that obstacle. We both added sighting scopes for visual alignment.

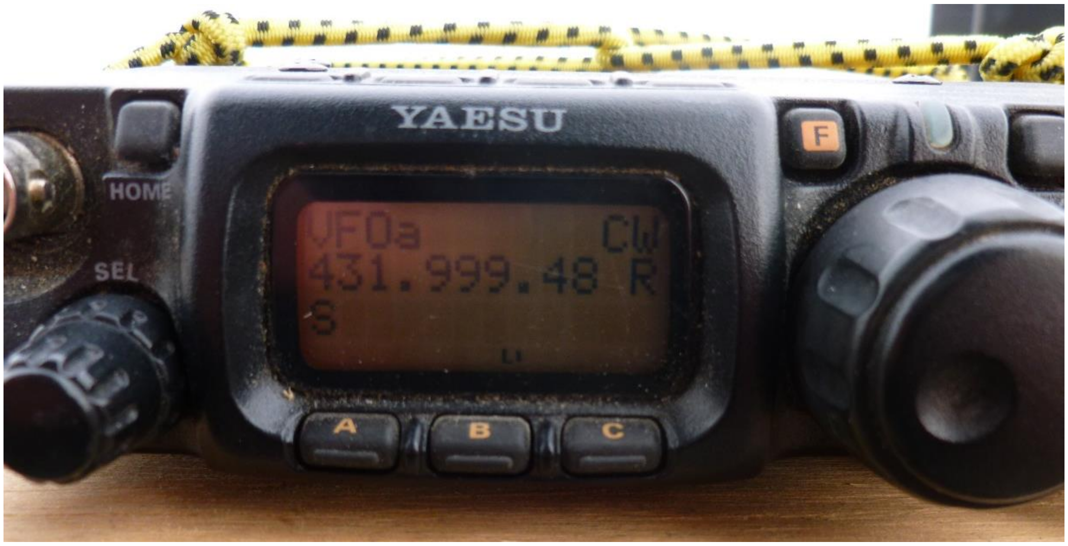
<u>TESTING AT 1.1 KM</u>

After our bench work, we headed out to try a contact over 1 km. As before, we used 78 GHz to get a preliminary alignment then switched to 241 GHz.

Henry's signal was about 15 dB out of the noise. Mike copied Henry's CW easily. Unfortunately Henry again was unable to acquire Mike's signal. We did switch back to Henry transmitting and Mike was able to reacquire his signal.



We did find that the GPS locking was working well. There was the anticipated signal drift due our less than perfect 10 MHz reference, but it fell easily within an SSB passband. Below is a shot of Mike's IF rig. As you can see, it's pretty close to 432.000 MHz! He never had to move it.



WHAT'S NEXT?

We plan to try a path of about 500 feet and line up our sighting scopes for the Mike to Henry path that we're having trouble completing. We also will verify just how much signal Henry receives from Mike's system to make sure there isn't a mixer or transmit multiplier issue.

Work continues on refining our tripod stability to aid in pointing. With the dish alignment being as critical as it is, we need to be able to set azimuth and elevation very accurately. Mike uses a Quickset Hercules tripod with a gear head which provides good accuracy and repeatability. Henry's tripod is a Quickset as well, but the Samson model with no gear head. Accuracy and repeatability can be challenging.

Operating on this high a frequency has been an exercise in eliminating variables. The signals are quite weak and the dish beam width is very small. When we started, we had three variables – dish azimuth, elevation and frequency. We have eliminated frequency and are working on taming azimuth and elevation.

We hope we will be able to report more progress at the upcoming 2015 Eastern VHF/UHF Conference.