Using Ku band PLL LNB's

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In years past Ku band LNB's were used on 10GHz as amplifiers. The LNB's were designed as superhetrodyne front ends for satellite receivers. They had several stages of RF amplification at a good noise figure but had dielectric resonator oscillators (DRO) for their LO's. DRO's are excellent oscillators but are relatively unstable. The latter made them unusable as 10GHz front ends for us, although plenty were converted to RF amplifiers.

In more recent times there have been two improvements in LNB's. The first is the advent of "Universal" LNB's that cover the upper half of 10GHz. The second is that chips have been developed that include the mixer, PLL and IF amplifier. A 25MHz crystal locks the PLL and provides usable stability. The modification to use a TCXO makes the modern LNB's an excellent front end, both as a receiver and for a spectrum analyzer.

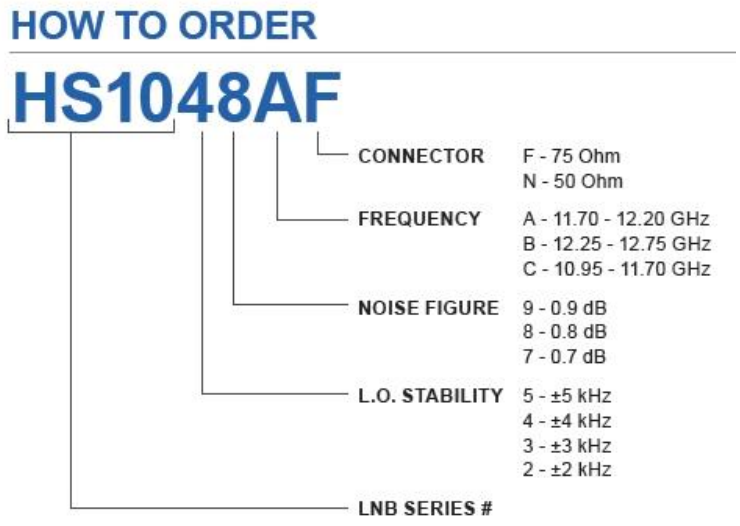
As I was working on the latter idea, it occurred to me that the LNB's would make an inexpensive 10GHz front end for a lower frequency spectrum analyzer. That arrangement might allow microwavers to spend more money on a quality "back end" and use an LNB for the front end, instead of buying a second fairly poor microwave spectrum analyzer. Along the way several other ideas crept in such as a GPS source locking module, modifications for an external input and changing the IF frequency to 432 MHz

The use and modification of several LNB's

A universal LNB is the easiest to use and translates 10.368GHz to 618MHz as an IF. The LNB usually comes with a 25 or 27MHz crystal for its PLL. By changing to a

crystal of a different frequency an IF of 432MHz can be obtained. Straight out of the box with a 618MHz IF the LNB can easily receive local beacons, etc. With the addition of a dish, some have even copied the DL0SHF beacon.

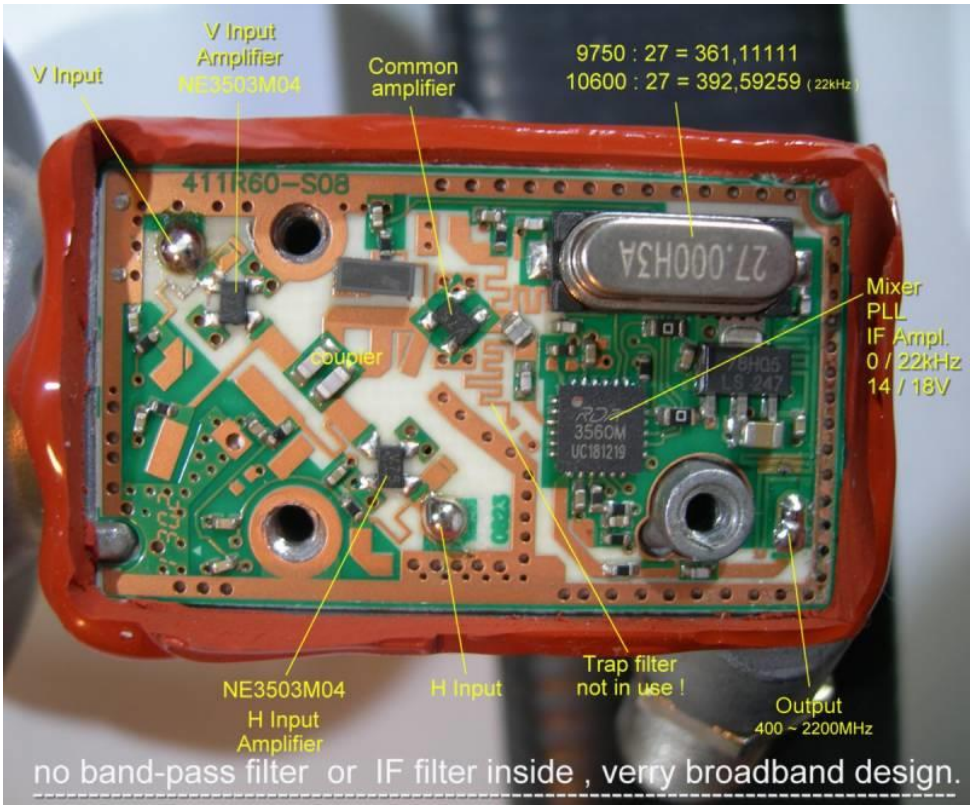
The first LNB is the **Norsat HS1057HCN** . The model number says the story. It is stable to 5 kHz, has a .7db noise figure, is tuned for the C, or lowest band, and has an N connector on the output. There are lots of different types and the buyer should be careful. This particular model has a WR75 input. It is designed in the 1990's style of circuit and engineered quite well. The stability and repeatability are excellent with almost no drift observed. However at the low IF of 368 MHz, the sensitivity is down about 10db from the other LNB's. I have been using it as a front end for a low frequency spectrum analyzer and it works very well.

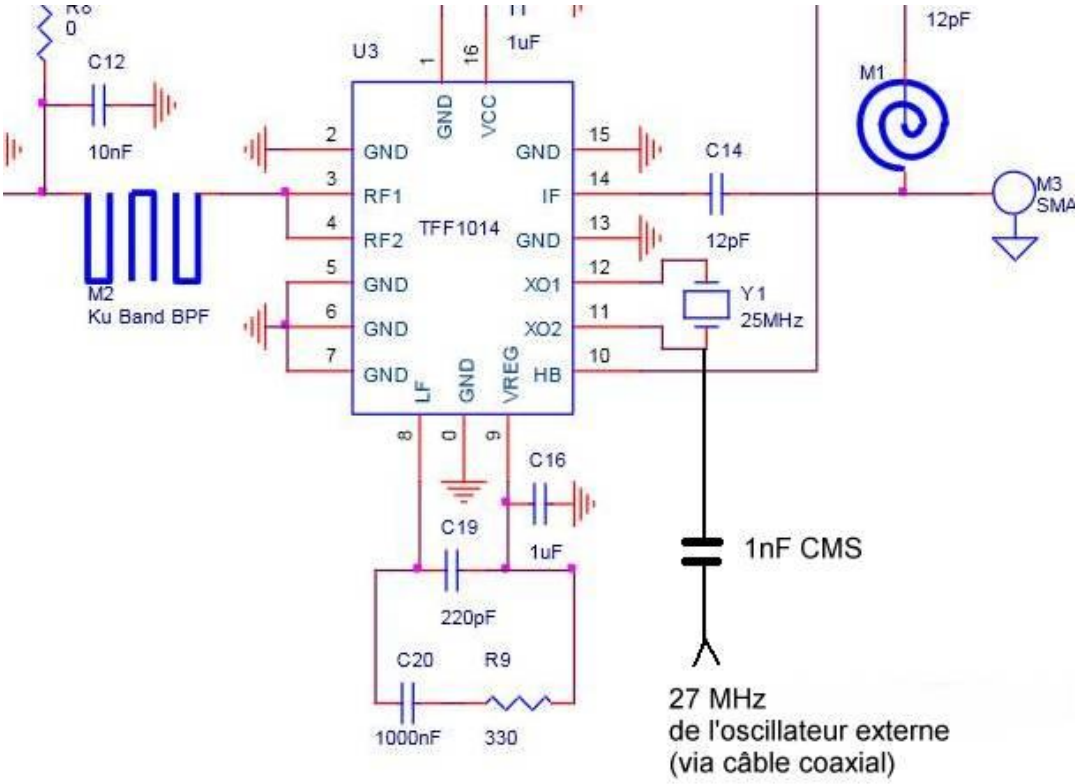


Amiko L-104

The L104 is a better candidate. You can see from both of the pictures that these are very simple- RF amplifiers for each polarization are combined into a second RF stage. An interdigital filter follows and goes into the PLL/mixer chip. There is no output filtering. As can be seen from the pictures, modification is pretty straightforward. However, soldering is a different story. I ended up using a digital microscope soldering station and the finest wire I could find. It saved me making a mess of the LNB. With the modification the LNB drifts at 50Hz/minute –

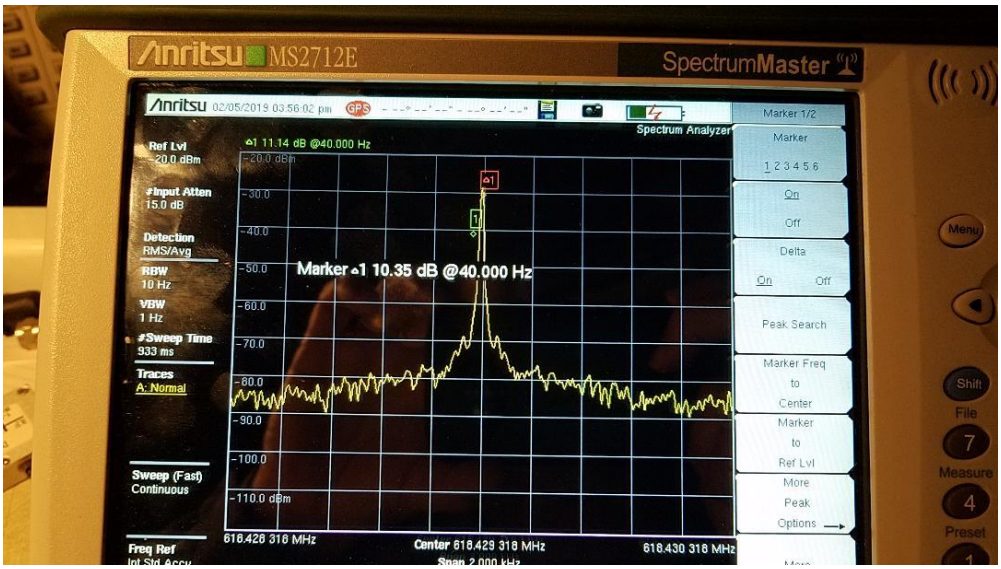
excellent stability.



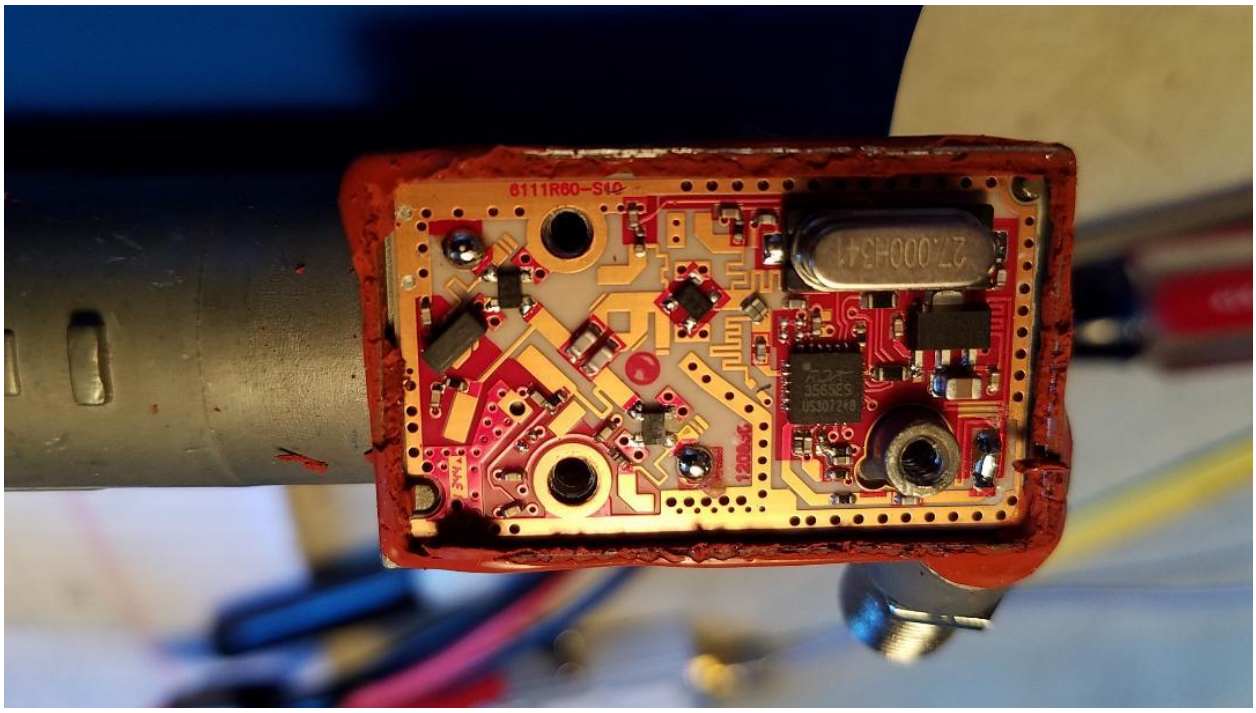


The TCXO is a good choice to stabilize the LNB as it is compact and does a great job. However, you are left with a 618MHz IF. By using the GPS disciplined oscillator by SDR Kits for $100 you can generate any frequency between 400Hz and 800MHz. A frequency of 27.515MHz yields an IF of 432MHz (factor 361.11) for the L104 LNB. That should make the LNB a lot more useful. 1296 and 144MHz IF's are out of lock or sensitivity range. (From G4INT- Using an external LO Source with the Octagon PLL Low Noise Block 2016)

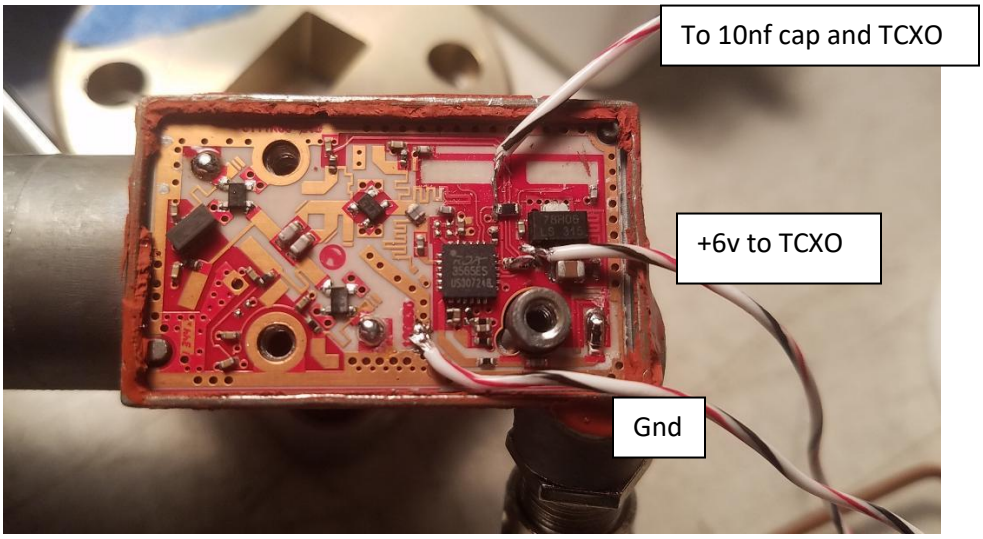
With a standard crystal the L104 LNB will drift 500cy per minute after a 15minute warm up. With a TCXO the drift is 50cy per minute after a 5minute warm up.



Anritsu analyzer at 618MHz IF showing a 40Hz drift during one minute.



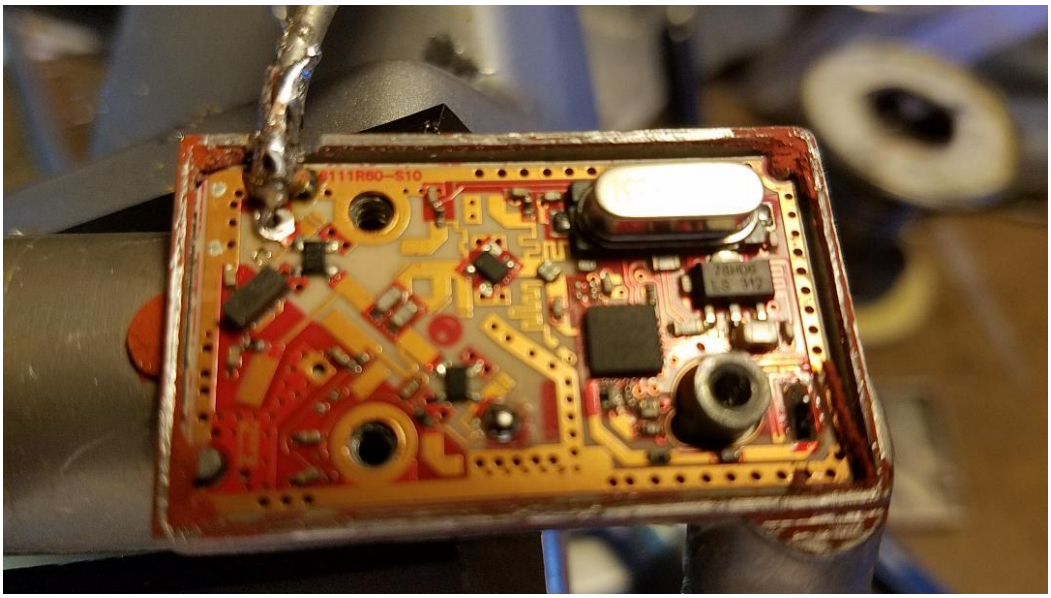
You can clearly see the modification. TCXO input, 6v from the regulator and a ground contact. Just use very small wire and RTV them down so they don't move.



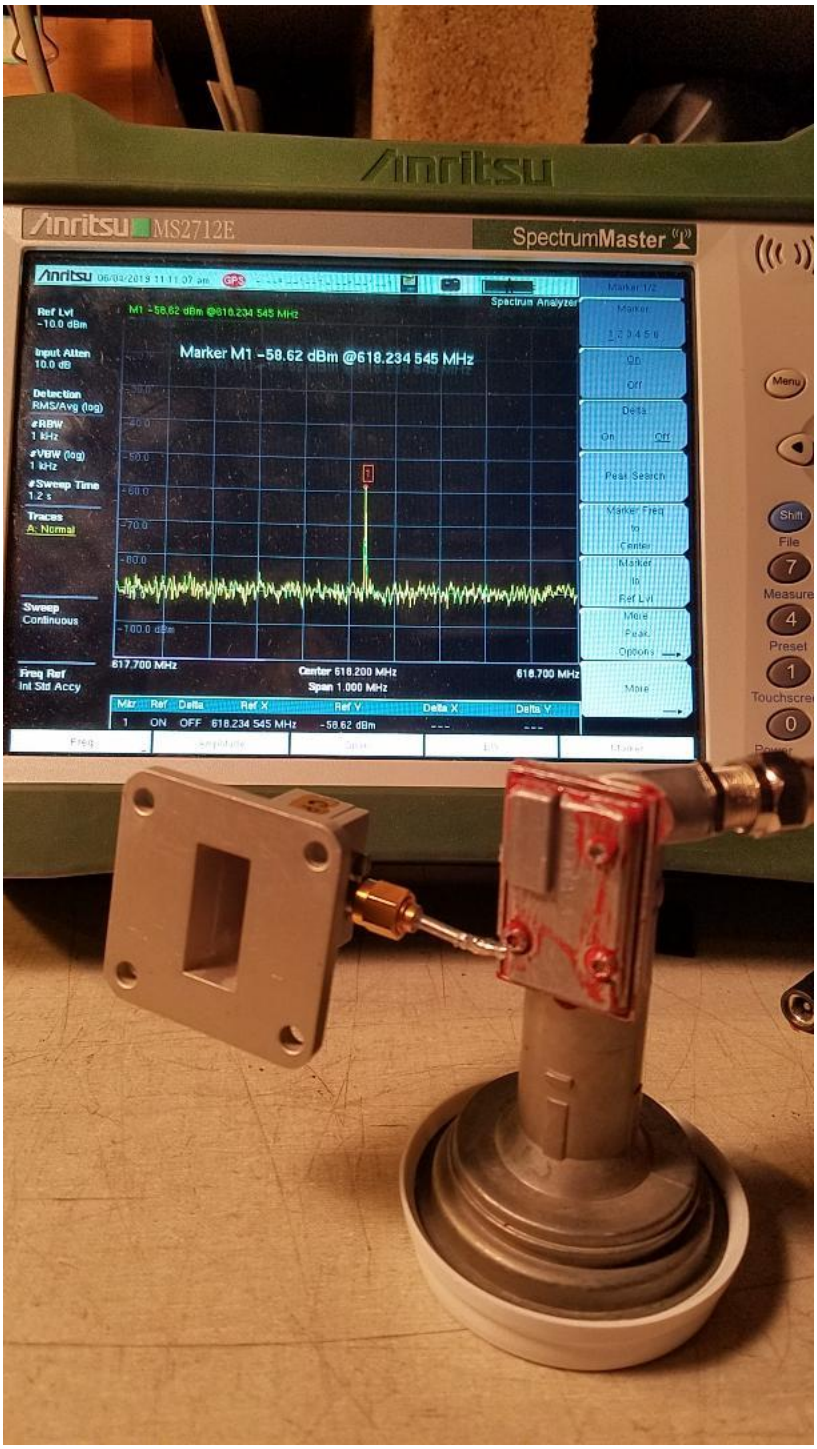
External Input Modifications

One of the frustrations with working on the LNB's is that the input is a horn. For many applications, a waveguide or SMA connector would be more desirable.

Here are a couple of examples of what can be done.



- Use the vertical input as the horiz. input is disabled by default
- Push through Vertical probe element
- File a hole in the seam of the case to pass the coax.
- Connect small dia. semi-rigid coax to V side
- For external connection
    - Use coupling cap from the gate to the coax
    - Use an external DC block. (0.6 db loss)
    - Use an SMA to WR90 adapter.


Anritsu
Anritsu MS2712E
SpectrumMaster
Spectrum Analyzer
Ref Lvl
-10.0 dBm
Input Atten
10.0 dB
Detection
RMS/Avg (log)
#RBW
1 kHz
#VBW (log)
1 kHz
#Sweep Time
1.2 s
Traces
A: Normal
Sweep
Continuous
Freq Ref
Int Std Accy
M1 -58.62 dBm @618.234 545 MHz
Marker M1 -58.62 dBm @618.234 545 MHz
617.700 MHz
Center 618.200 MHz
Span 1.000 MHz
618.700 MHz
Mkr Ref Delta Ref X Ref Y Delta X Delta Y
1 ON OFF 618.234 545 MHz -58.62 dBm
Freq
Marker
Menu
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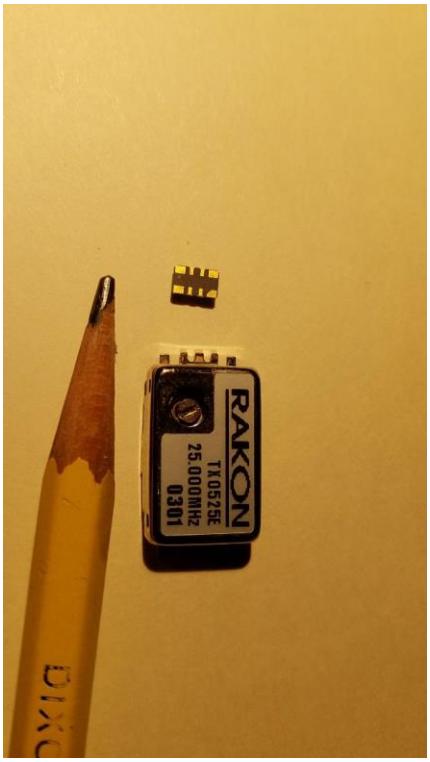
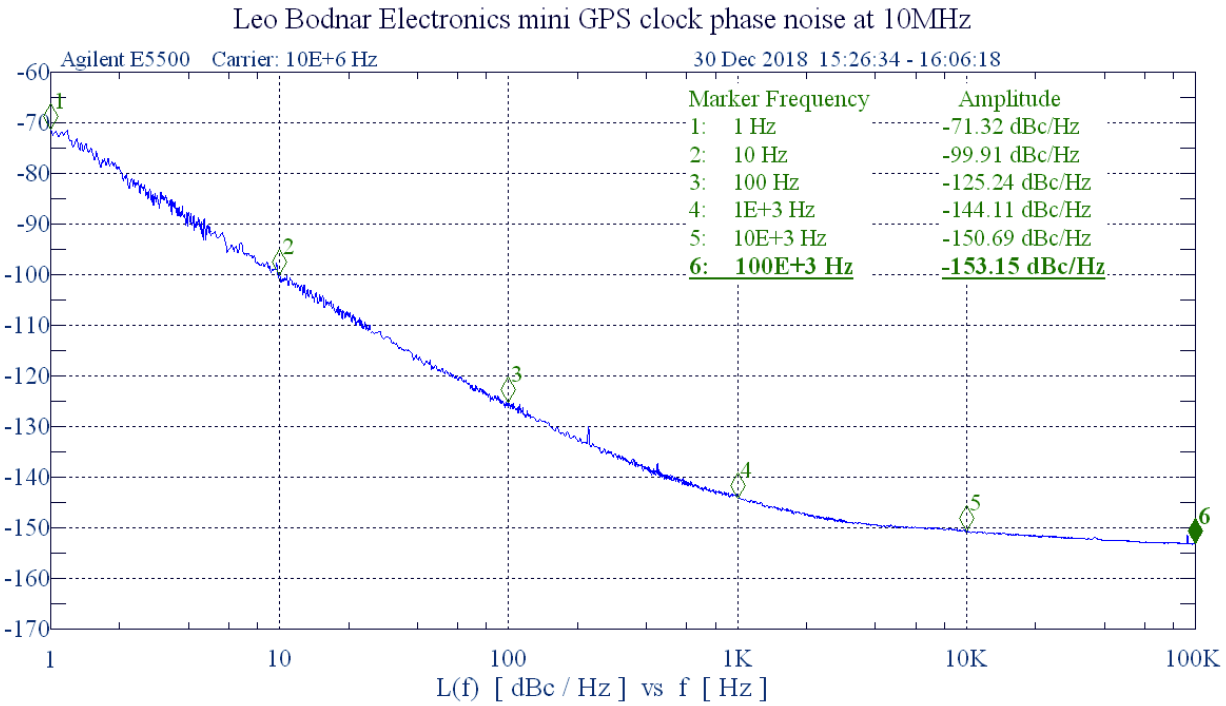
File
Measure
Preset
Touchscre
Power



I recommend the RAKON TCXO as the other one is too small to be installed (by me).

SDR Kits GPS Ref. Source

One can use a GPS source from SDR Kits. It is truly a game changer. The box is small and can be run off of a phone battery. After it locks up its TCXO to GPS the antenna can be removed and the unit will go into holdover mode. The unit then becomes a standalone, very accurate source for any frequency between 400Hz and 810MHz. The phase noise is superb at -140db at 1 KHz. It should eliminate any drift problems in an LNB. Just couple it into the LNB through a 10nf capacitor.

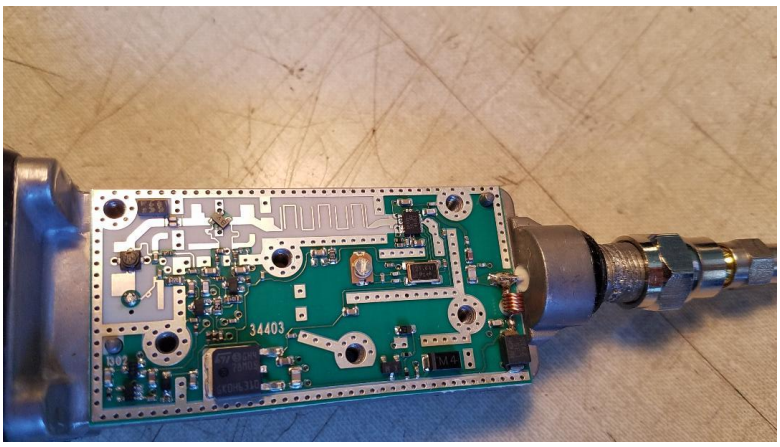


Other LNB's

Jan, OK2ZAW offers a complete package with an LNB, TCXO and outboard Bias tee. The Tee has an attenuator, fuse and pilot light. All for $55. http://ok2zaw.blogspot.com/search/label/10GHz The output is on 432MHz. In general most LNB's can be changed to this Band and get good results. The 2meter and 23cm bands seem to be outside the range of the LNB's and don't do well.

N1320

This is about a $20 purchase off of the internet. It has an internal filter which reduces the gain at the 368MHz IF and an uncompensated crystal at an odd frequency internally. At first glance it seemed a poor choice. However when paired with the RF Explorer Spectrum analyzer, it gains a new life. The analyzer has a minimum selectivity of 2.5 KHz and the 1320's crystal doesn't seem to wander off more than that. What it does is provide a compact and hand held 10GHz spectrum analyzer with a WR75 input. Probably the best deal in the presentation.


34403


RF Explorer
Handheld Spectrum Analyzer
RETURN
MENU
ENTER
HELP
SET

Applications- Receiver

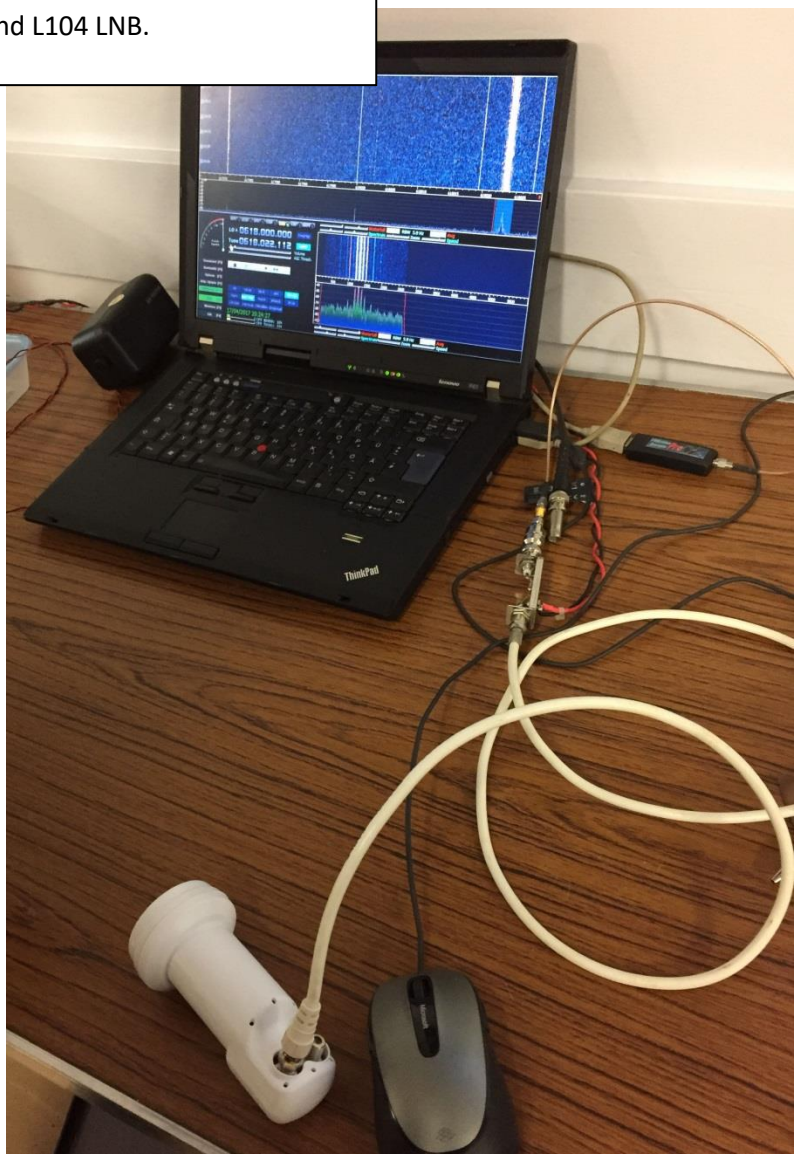
Alinco DJ-X11

The first application is with a broadband receiver. I had an Alinco DJX11 hand held receiver which tuned 618MHz easily. In comparison it was much more stable and received better than the Kenwood TH F6 handy talkie. With a bias tee for the LNB it is still my favorite set up. I'm listening to the local beacon 50mi away.

SDR Dongle

The second application is with an SRD dongle. You can use whichever dongle works at 618mzh and it will work fine. Mind the input level or overload, though. The disadvantage is that you need a laptop to make it work. An Android or tablet application may make it more portable. With $10 spent for the LNB and $20 or so on the dongle setup ends up being inexpensive. The RSP 2 is an excellent full featured dongle and so is the Fun Cube Pro+.

From Graham G8HAJ, using a dongle, bias t, and L104 LNB.



Receiver considerations-

Recently I did a comparison between the Alinco receiver and my old FT 817 transceiver as a back end receiver for the LNB's I used OK2ZAW's unit on 432MHz and compared the Alinco and Yaesu receivers. The Alinco worked OK but the FT817 was much better- stronger, more sensitive and tunes easily. The 817 sounds like an obvious choice, but I think it depends on your application. I suggest that if you want to do monitoring, use the dongle approach, or a Flex 1500. IF you want an extra receiver to take to the mountaintop or for testing in the garage, the Alinco is very handy and the battery lasts for days. The 817 is better, but may be

better employed elsewhere. In addition, transmitting into the back end of an LNB is destructive for both the LNB and the 817.

Applications- Spectrum Analyzer

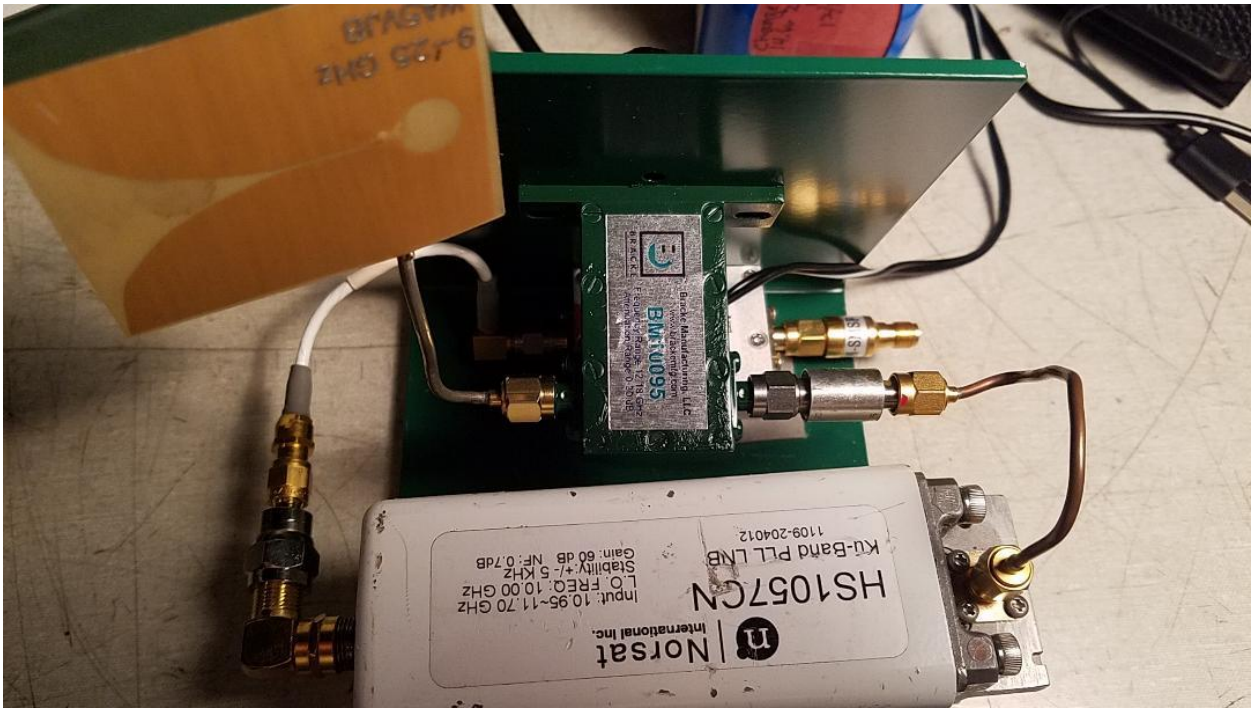
A 10GHz spectrum analyzer can be very expensive or very old, or both or big and heavy. Of course you may luck into something wonderful. Great, I hope you do. I have fond memories of my years with an HP 8551, Polarad SA 84W (just kidding on that one), various Systron Donner products, several AIL's, Tek 494AP, Anritsu and others. One could get one of those because of nostalgia or limited funds, or spend a bundle for a nice nearly new one, and I can't really say much against any of those choices (except for the SA84W). However, the LNB offers the use of a highly portable and more useful analyzer like the ones described below on 10GHz.

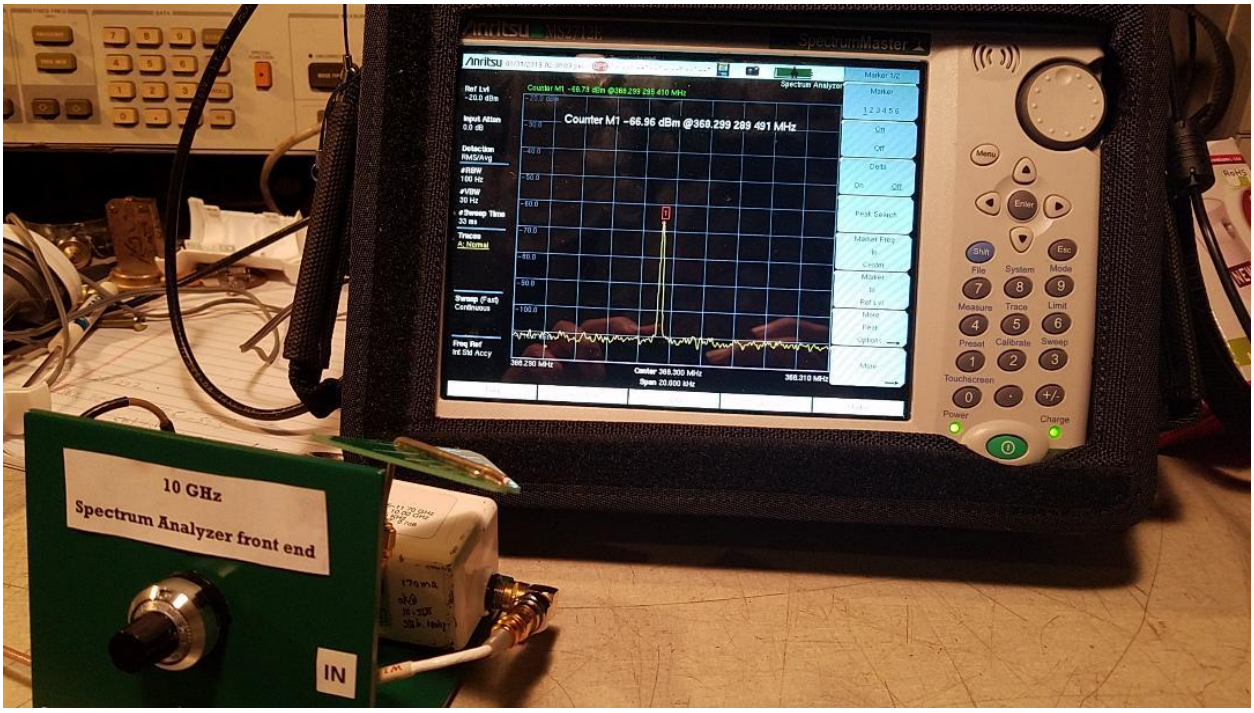
It seems to be productive to invest in a very good lower frequency analyzer and add a microwave front end to it. In this case I chose an Anritsu MS2712E. It is a current model that is available surplus for around $1500. It includes GPSDO frequency setting, USB and Ethernet output/input, and a very large screen. It is also battery operated and portable I also recommend the Anritsu MT8212B. They often come with excellent accessories. Don't get the A model. There are there models and manufactures that are cheaper and can also work.

The Norsat Front 10GHz front end

The first application uses the Norsat in an open chassis with a variable attenuator. The bias tee is hidden next to the Norsat. The rig works well and gives about a 200MHz wide spectrum. I used two fixed attenuators and a variable attenuator to equalize the gain between the input and output. I put a chart on the front to note settings for reducing the input by 0-40db.


10 GHz
Spectrum Analyzer front end

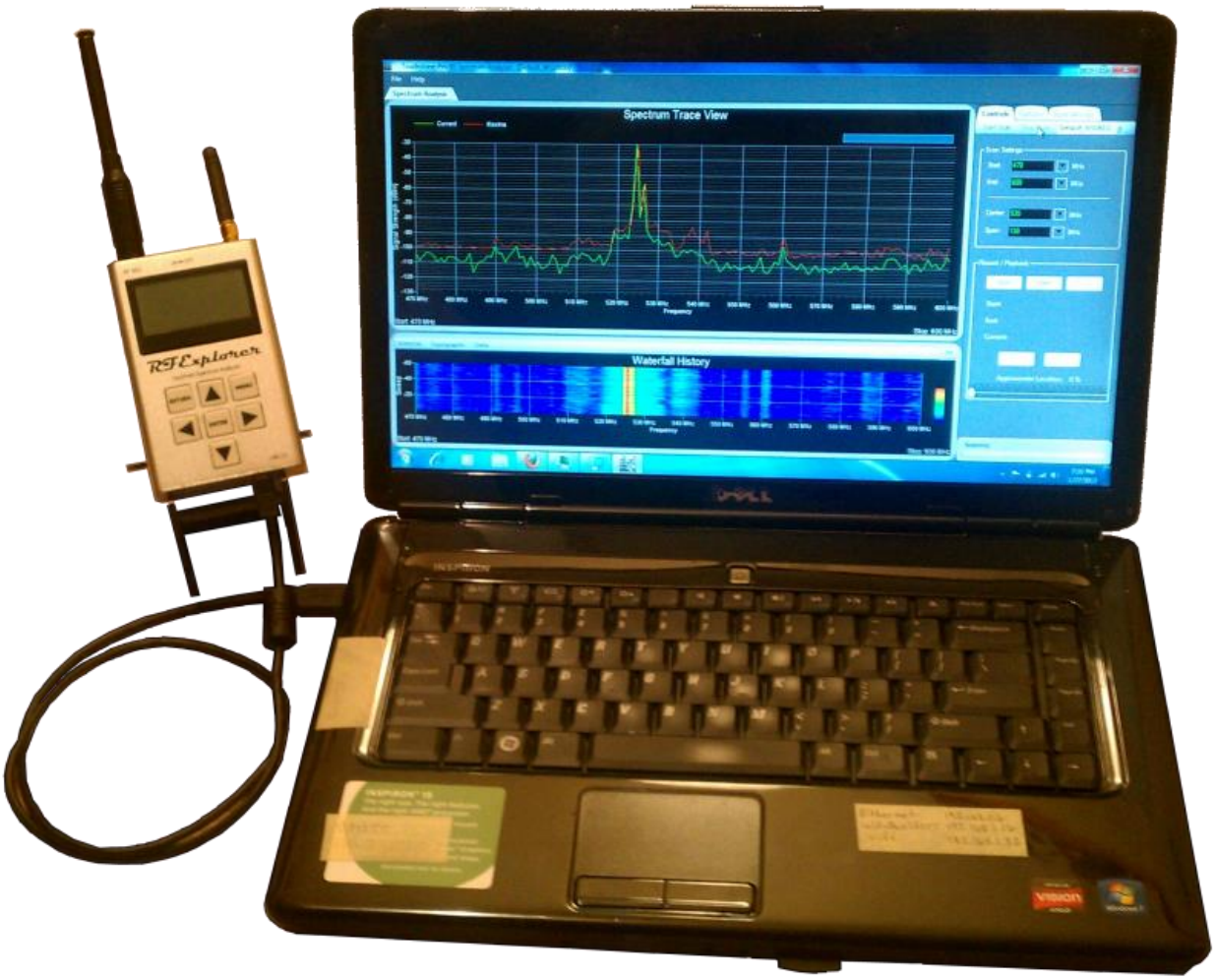

HS1057CN
Norsat International Inc.
Ku-Band PLL LNB
1109-204012
Input: 10.95~11.70 GHz
L.O. FREQ: 10.00 GHz
Stability: +/- 5 KHZ
Gain: 60 dB NF: 0.7dB
BMK1095



10GHz analyzer- $200+1,500= $1,700. How much for a stand-alone 10GHz analyzer that will do the same? Anritsu MS2723C- $4,000 plus.

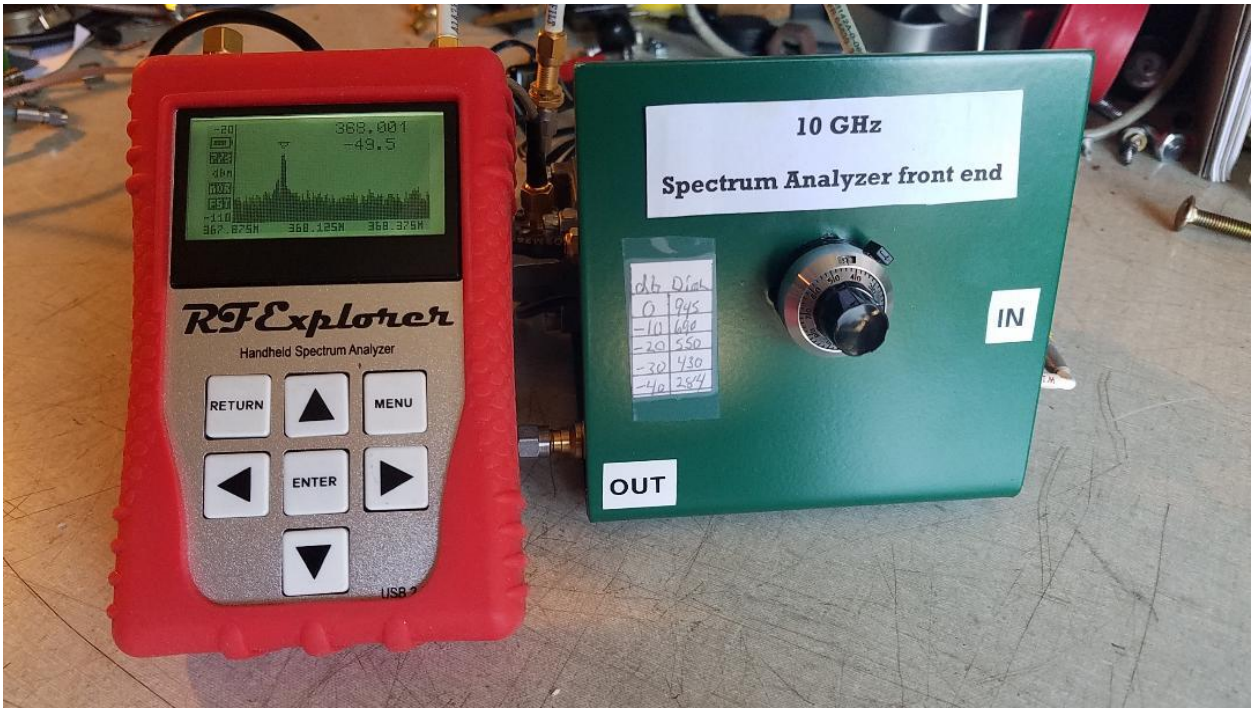
RF Explorer

The second analyzer is an RF Explorer. These are little hand held analyzer. The best model is WSUB1G+ and costs about $170 and tunes from 15 KHz to 960MHz. It gives good frequency and amplitude measurements and tracks the peak signal. There are several models and all are upgradable. Mine goes from 25 MHz to 2GHz. It makes a great 10GHz analyzer. If you attach a USB cable and download their application, the usefulness and accuracy/resolution of the analyzer becomes more like a desk top analyzer.

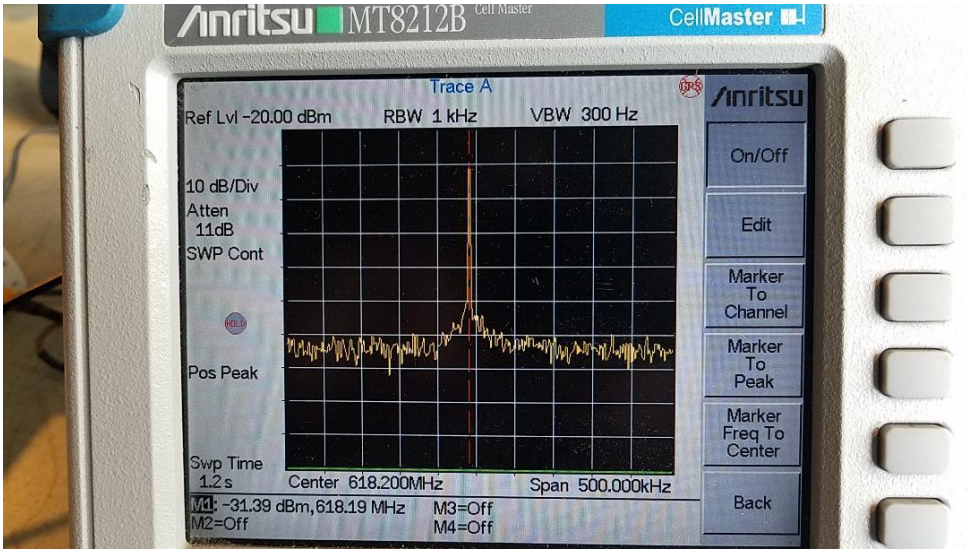


The Norsat and the RF Explorer

This begins to be a real hand held 10GHz analyzer.

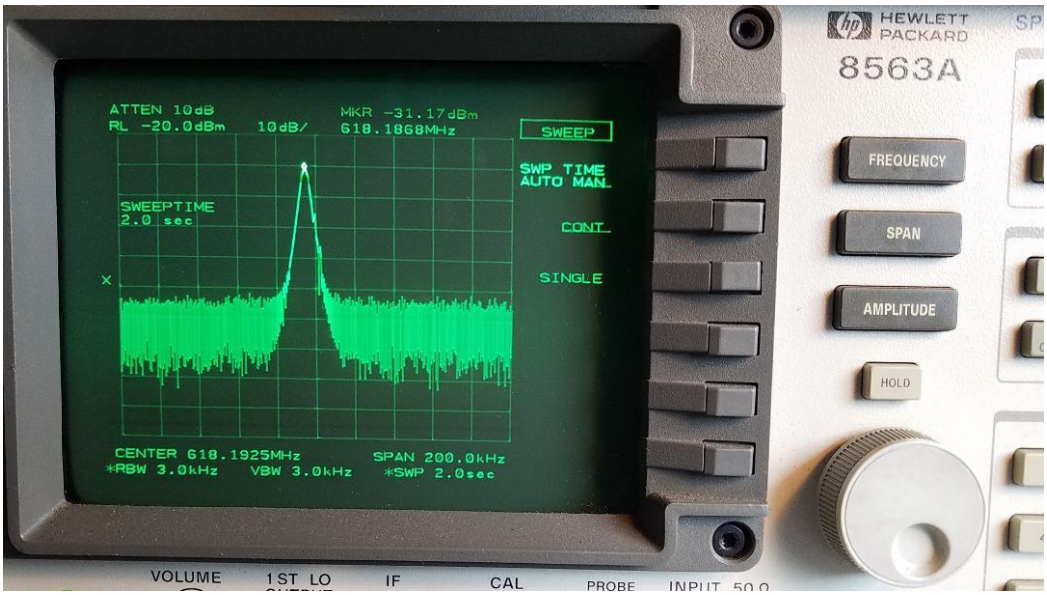


Here are several more pictures of analyzer applications.



Anritsu MT8212B

The above analyzer is probably the best deal in town. For less than $1000, you can get a great spectrum analyzer, vector network analyzer, power meter, gps, and more.

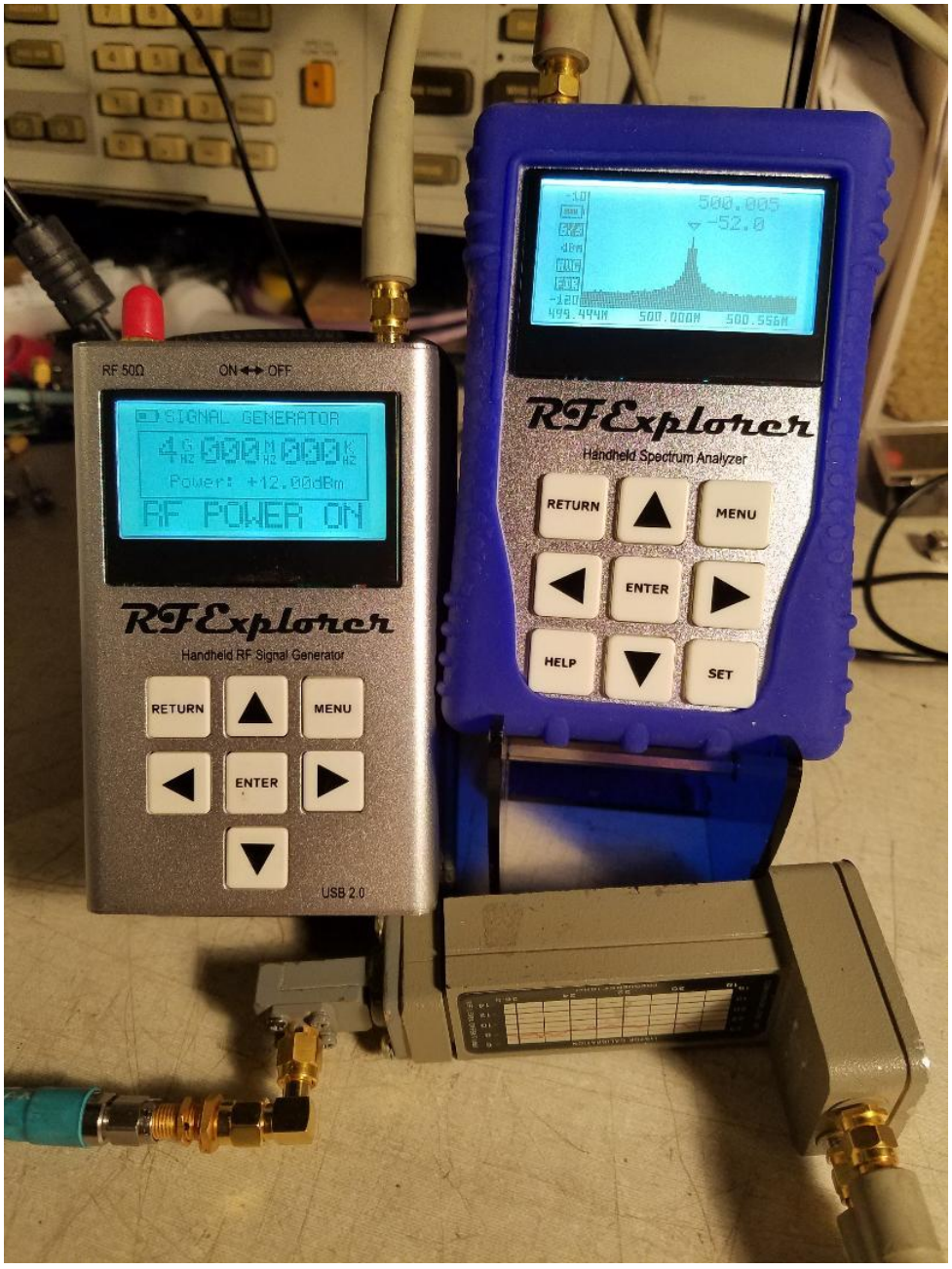


HP 8563A

Here is the analyzer adapter on an older HP 85 series analyzer.

Looking at even Higher Bands- 24 and 47GHz

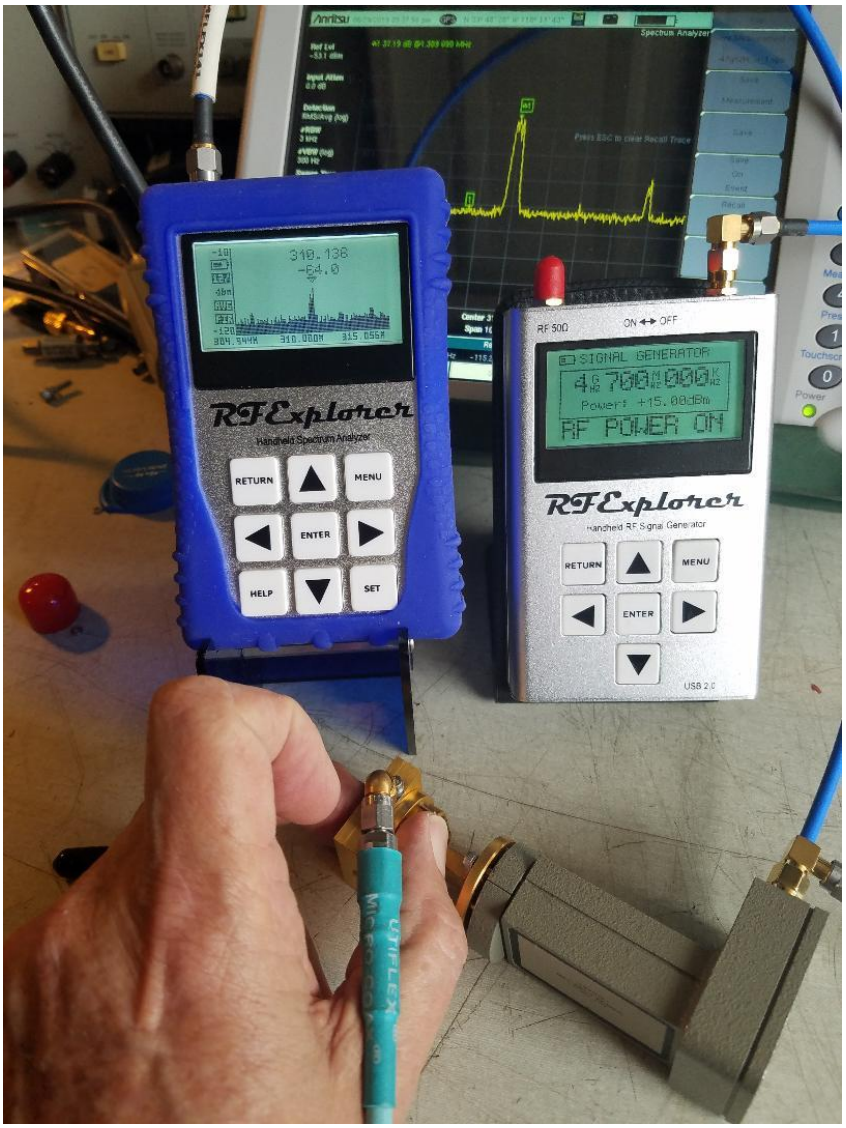
Having taken things this far, I wondered if I could make the idea work on the higher bands. I took an HP11870k external mixer (18-26GHz) and measured what the HP analyzer fed it. It turns out that on 24GHz, 8mw at 4GHz gets the mixer going and gives a good signal on both the RF Explorer and the Anritsu. I use an RF Explorer signal generator to supply the LO. Be advised that RF Explorer has a modification board that can be added to the generator that improves the output. Mine has the board in it. Here is a hand held 24GHz spectrum analyzer for about $500.



47GHz

The next step was to see if I could get 47GHz working. The HP puts out about 40mw at 4.731GHz. I was able to get 36mw out of the generator and tune the analyzer to 310MHz. I used an HP8673B signal generator with a Spacek RF doubler on the output. The Mixer is an HP11970Q for 33-50GHz. The picture also shows a

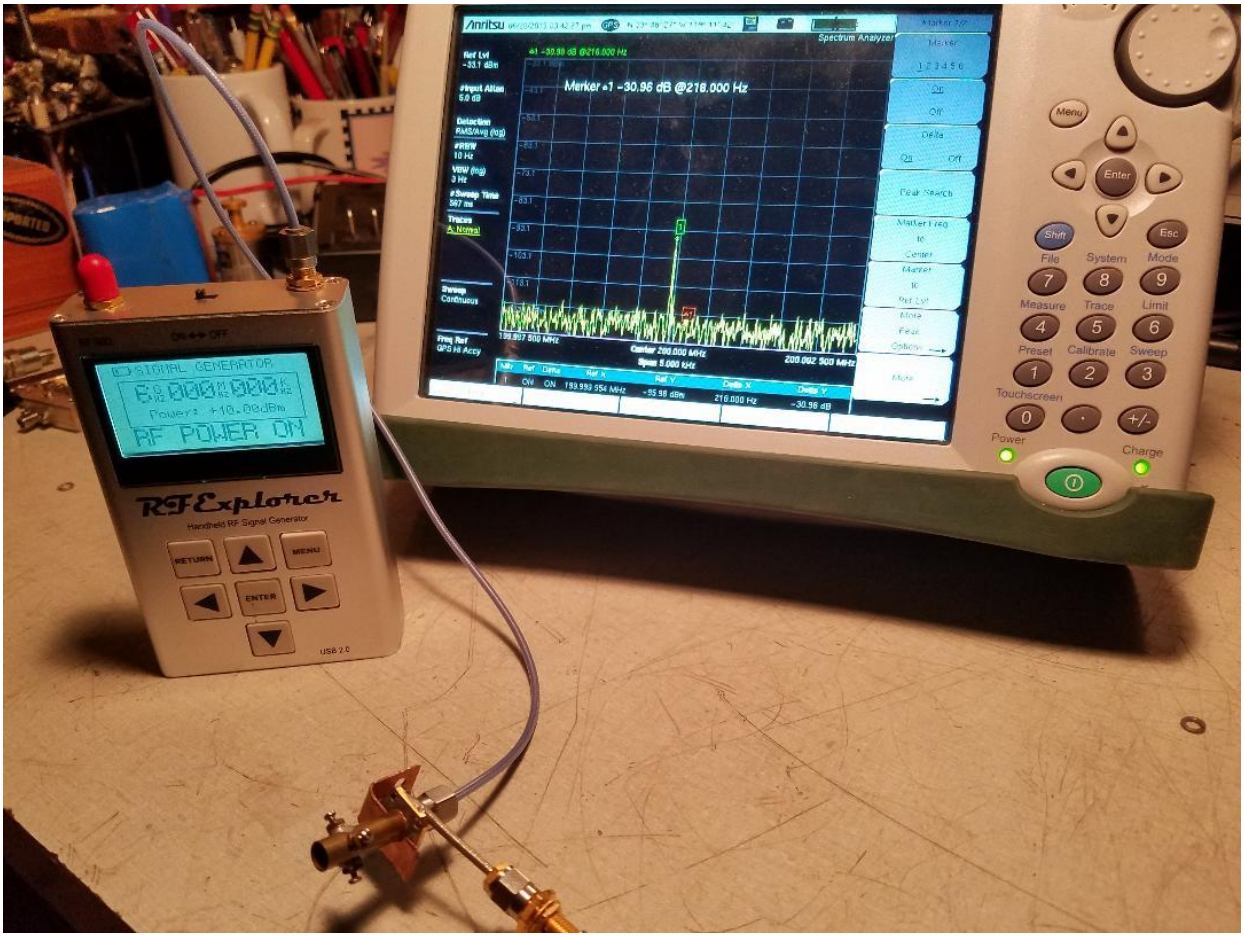
saved image of the setup on the Anritsu. A simple, hand held, battery operated spectrum analyzer for 47GHz.



Cheaper Mixer for 24-79GHz

If the cost of the mixers is a little steep for you there is an alternative. A discussion of mixer performance and the instructions for this mixer are in the reference page.

Kerry Banke K6IZW used some hobby brass and a Qualcomm mixer to fabricate a simple three port mixer for the upper bands including 79GHz. The cost is probably $10. The results speak for themselves. 24GHz RF input with a 6GHz LO input at 8mw. The mixer also works well at 47GHz, but not tested at 79GHz.



There are obviously some compromises involved in using the mixer scheme above. I think the limitations are outweighed by their economy, versatility and reliability. All of us do our building in individual ways. That is part of the beauty and challenge of microwaves. I present the above and wait to see what you can do with it.

Extras-

Bias tee- This is needed to feed power into the LNB. You can use almost anything, but the pictured bias tee is available on Ebay or $15 and contains an amazingly complex circuit. I would suggest that you find a source for 0.1uh RF chokes in case you short the B+ to the LNB. It is easy to do with F connectors. A resettable fuse is also good.

Portable Dish-As of this writing, this dish is available. It has 27db gain. Of course any other dish can be used. This will provide a big improvement in gain and distance, but takes some getting used to. For $15 it is worth it.

Conclusion-

For about $50 you can put together a respectable 10GHz receiver and enjoy activity on that band. You can also improve the frequency range of your low

frequency spectrum analyzer for a small investment. If you want to improve on the basics, options are reasonably priced and make a big difference.

Since beginning this project about a year ago with the above as a goal, the project has spread out into some interesting areas- external sources, external connectors, hand held analyzer ideas and options for the higher bands. I hope these are helpful, and I hope they inspire you to do some exploring. If you come up with more ideas or better engineering and soldering, I'd appreciate hearing about your progress.

Happy microwaving and enjoy, Doug K6JEY

References-

Homemade mixer from Kerry K6IZW

http://www.ham-radio.com/sbms/sd/47ghzmxr2.pdf

K6JEY Talk on Mixer evaluation.

http://www.nitehawk.com/k6jey/harmonic_mixationers.pptx