

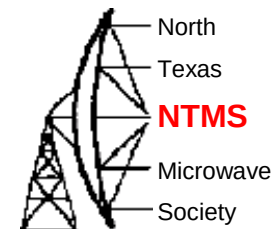
Wavelab 24 GHz Systems

Microwave Update

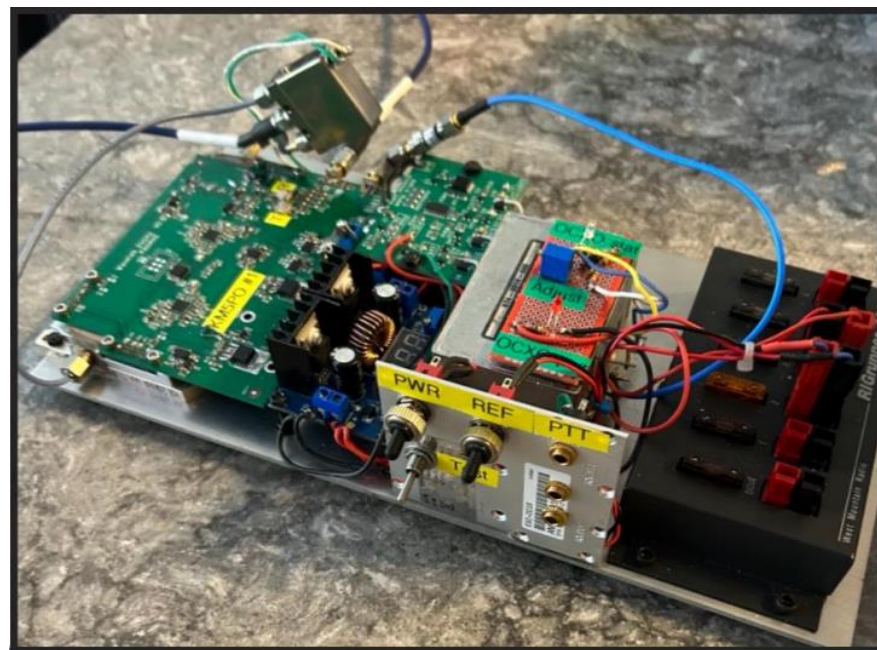
Oct 5, 2024

Vancouver, B.C.

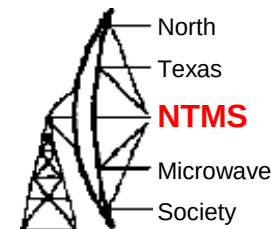
Low cost 24 GHz



- Wavelab 23 GHz module and PA0MHE control board [1.5-2.0 w out]
- Wavelab units are salvage from ODU. XP model or XN model w/mod
- Add 10 MHz ref
- Add power/SMA relay/Ant

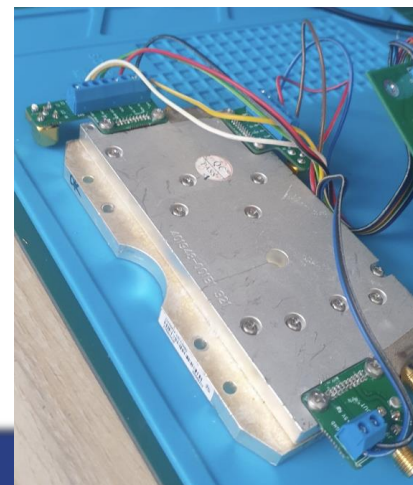


Original discovery/analysis

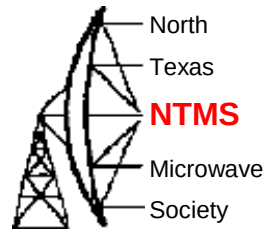


- Ryszard SP2JYR pulled modules from ODUs and put on ebay
- SQ1GQC Powell designed snap on connectors for module 3/21
- Stanisław Ziemczonek SP6GWB performed the initial breakdown and analysis and built power supply board 4/21
- YO4HFU provided reverse engineering and module schematic 1/22
- Maarten PA0MHE designed board and put on github 6/22
 - Integrated 2 synthesizers and PTT switching plus all CV

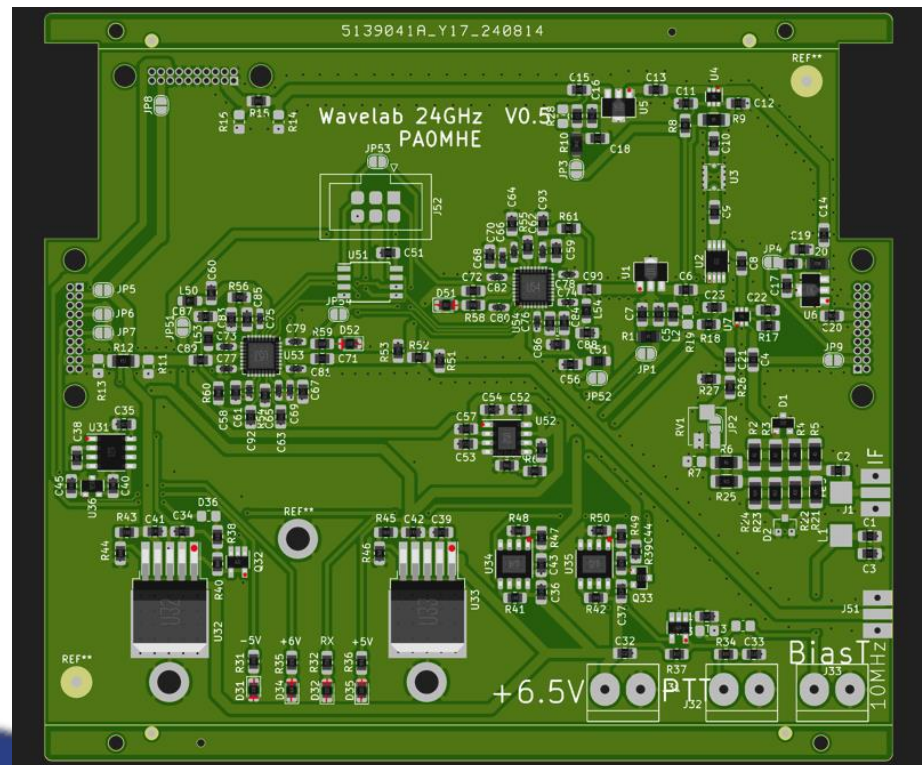
[VHF & Up - TRV \(mikrofaale.cafe\)](http://mikrofaale.cafe)



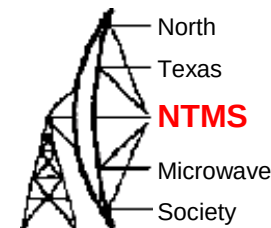
Board variants



- U1, U5, U6 original parts became not available, subbed Qorvo TQP369182, then ADL5545 and ADL5611. Ed Marciniak NB0M has the Qorvo parts with him at the conference.

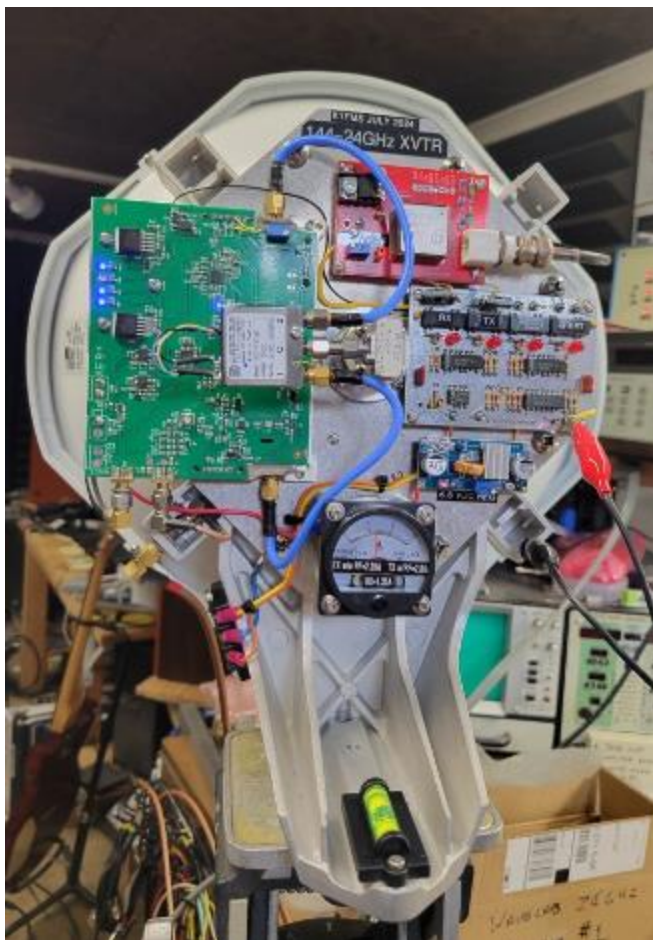
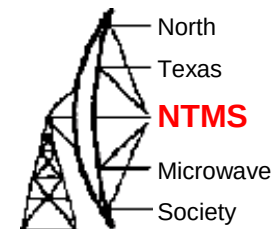


Wavelab popularity



- NTMS has delivered 190 control boards in 9 distinct JLCPCB orders
 - Europe – 66 units
 - Canada – 15 units
 - Australia – 6 units
 - U.S.A – 103 units
- Activity “centers” have appeared worldwide as one or more ops will produce several working systems
- Effort has moved into modifying XN modules for
 - Beacon use
 - Receive only use
 - Power Amplifier use
 - Building even more systems to engage more locals (K1FMS)

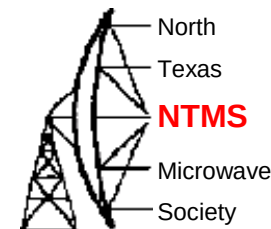
K1FMS implementation



- Prime focus Radiowaves 12" dish large lot on auction site.

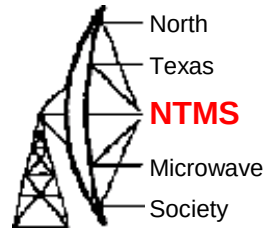


Wavelab XN model mods

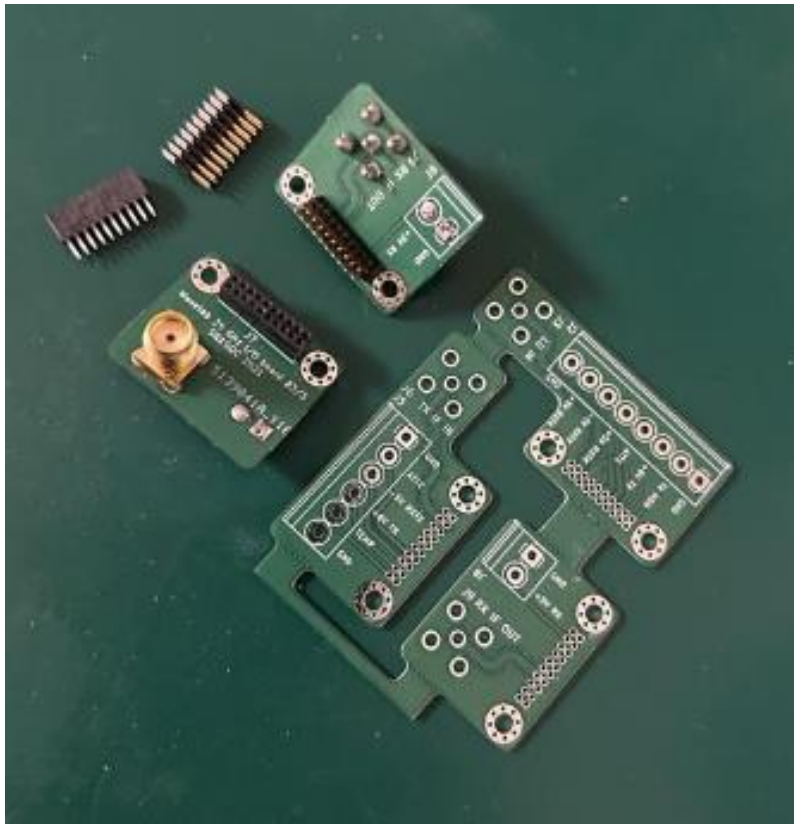


- Model XN operates at higher frequency on LO chain
- The XN receive front end selects Lower Side Band
- The XN transmit band pass filter rejects unwanted image
- SP and JA ops have experimented with modifying XN modules
 - Objective of optimizing the module to arrive at 24.020 and 24.048 GHz
- For North America terrestrial operation, we want 24.192 GHz
- For the ultimate in testing the XN board I wanted control over all frequency inputs (and power levels) to the module
- 1st and 2nd LO (2nd LO mixes with TX IF and TX RX)
- Build a test harness that allows separation of the PA0HME control board from the module

Test Harness

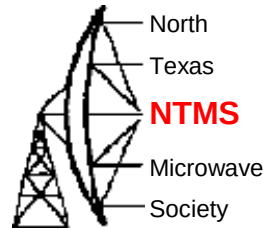


- Use SQ1SQC PCB break-out boards

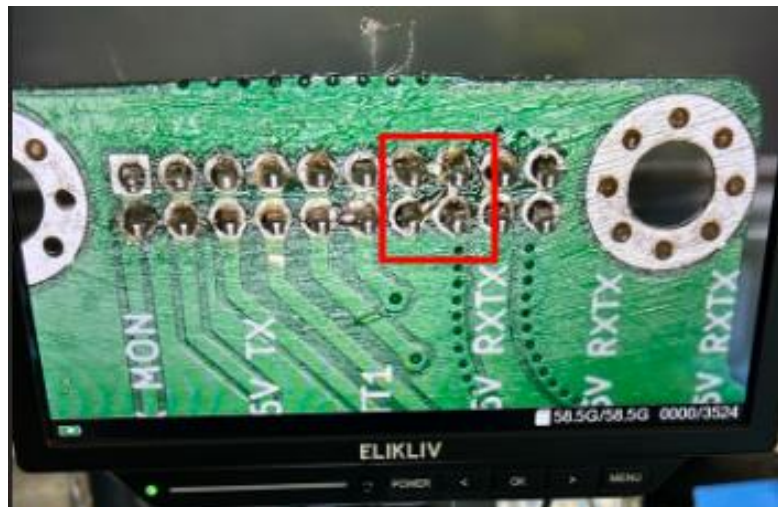


- Receptacle 2 x 10 rows, has pins on one side:
Mouser 649-221311-00020T4LF
- Pins on both sides 2 x 10 rows, one set gold:
Mouser 649-221111-00020T4LF (same header pins used to complete the PA0MHE control board

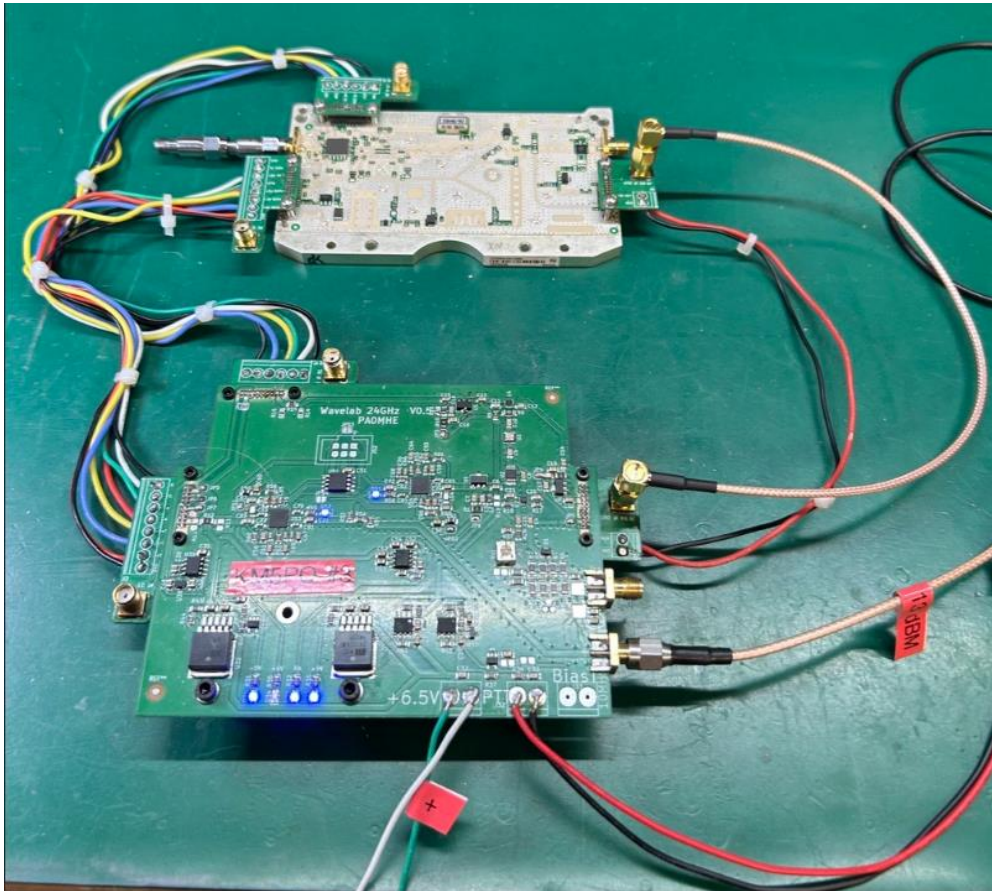
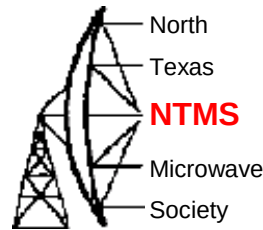
Test Harness



- Since there are 6 connection points between pcb and module and the pin headers are 2 x 10 rows you have exactly 120 solder joints on the pin headers in which to fail.. Then you have another 26 wire connections to solder.
- Ohm out the wiring harness to identify shorts before you attach board or apply power!

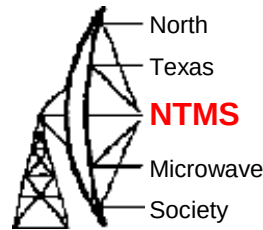


Remoted XP test



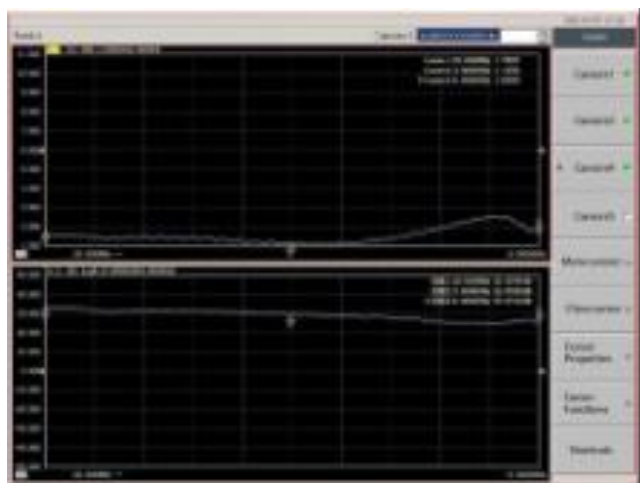
- Test PTT control and test all voltages and current are nominal.
- Cover the open module when not testing to protect open wire bonded assemblies.

Remoted XP test

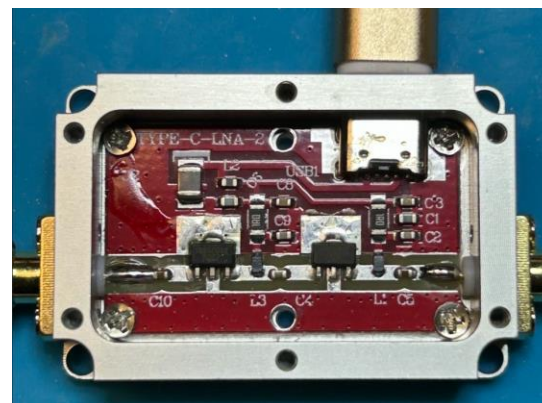


- Note the gain blocks and SMA attenuators to supply precise level of LO and TX IF from the control board
- Best results from:
 - LO1 1819 Mhz -5dBm
 - LO2 2364 Mhz +3dBm
 - Yields 32 dBm output

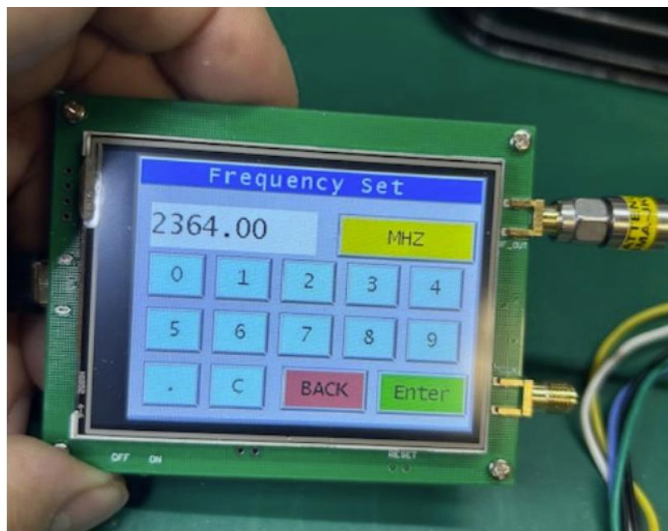
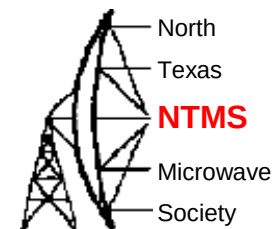
Cheap gain blocks



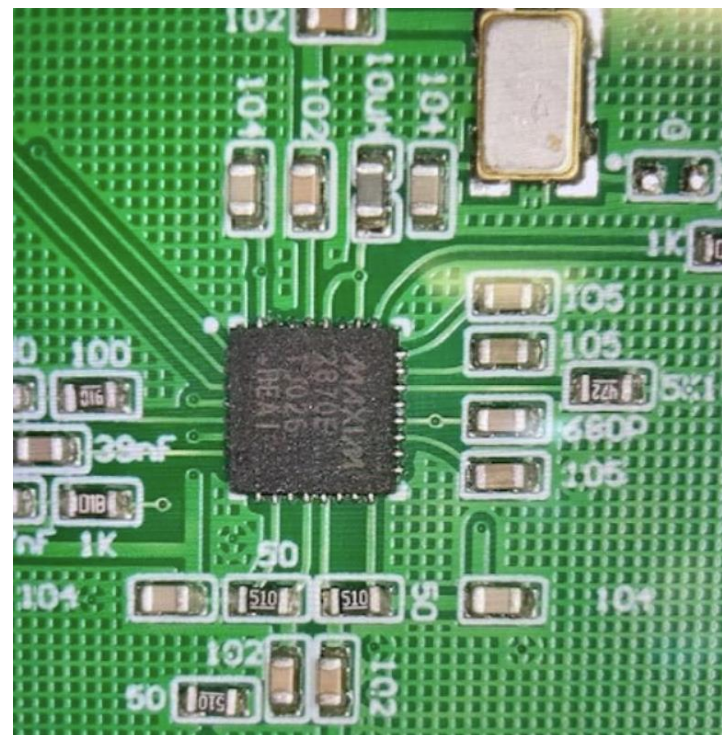
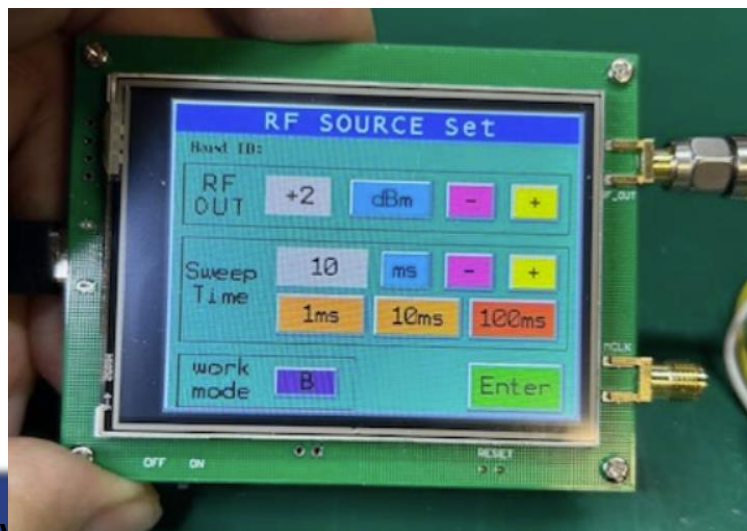
- 10 MHz to 6 GHz
- 20 dB gain stated
- Best results from:
Inputs of -10 to -20 dBm
Yield gains of +18 to +20 dBm
- Pair of Qorvo SBB5089Z



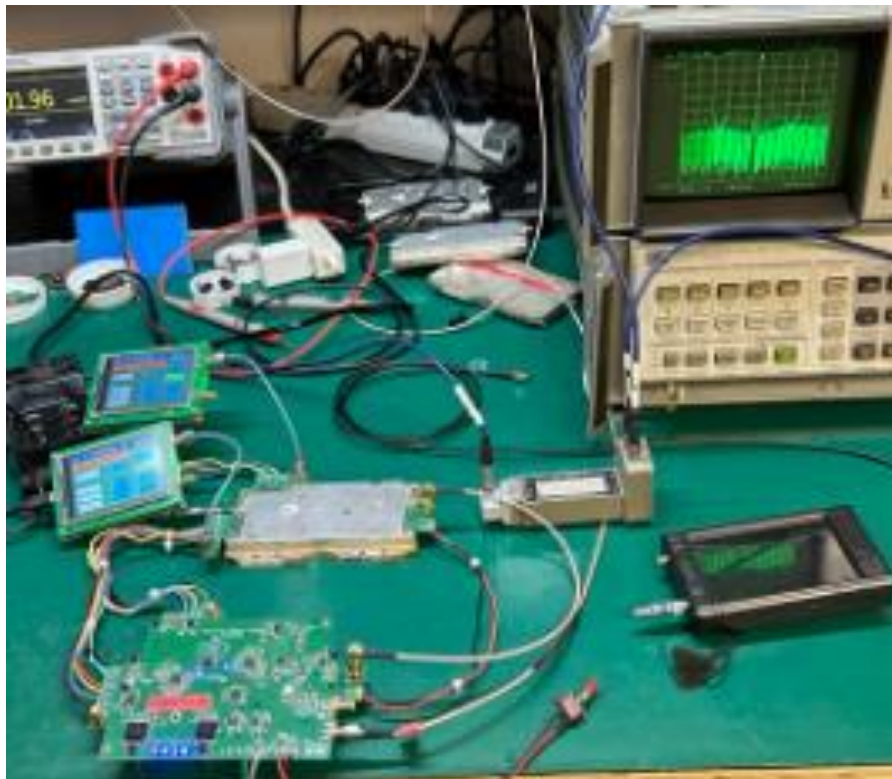
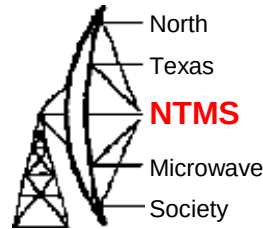
Low cost sig gen



- Same synth as in DigiLO

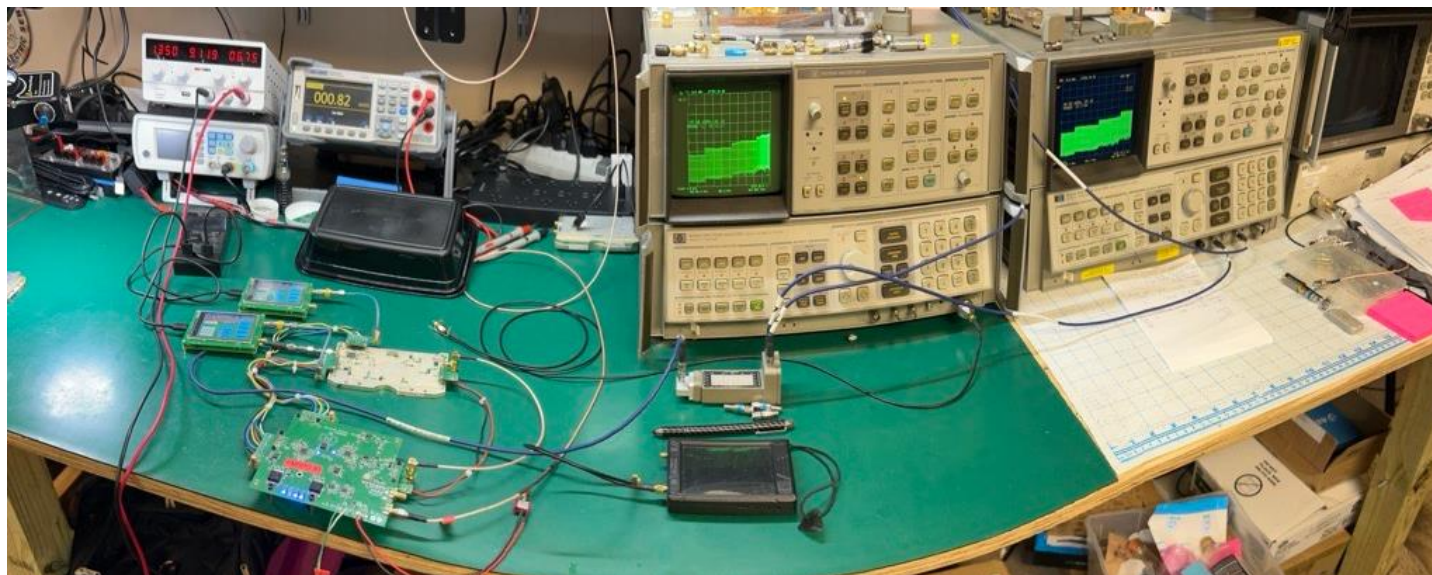


Test Harness



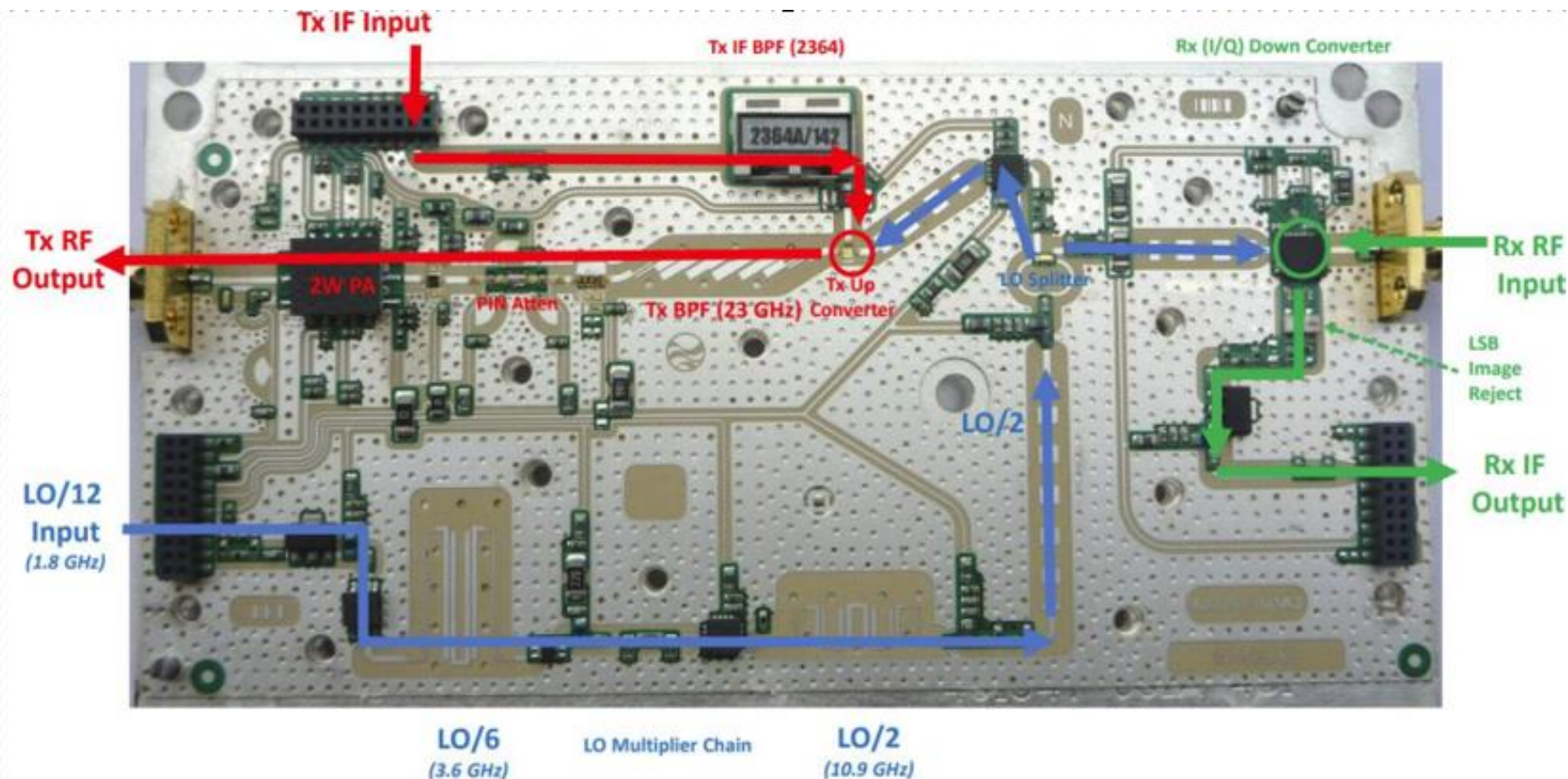
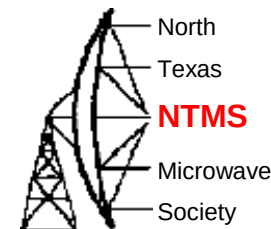
- Finally, supply LO1/LO2 direct from sig gens and reconfirm spectrum of output.
- If all good, ready to sub in the XN module.

Tools

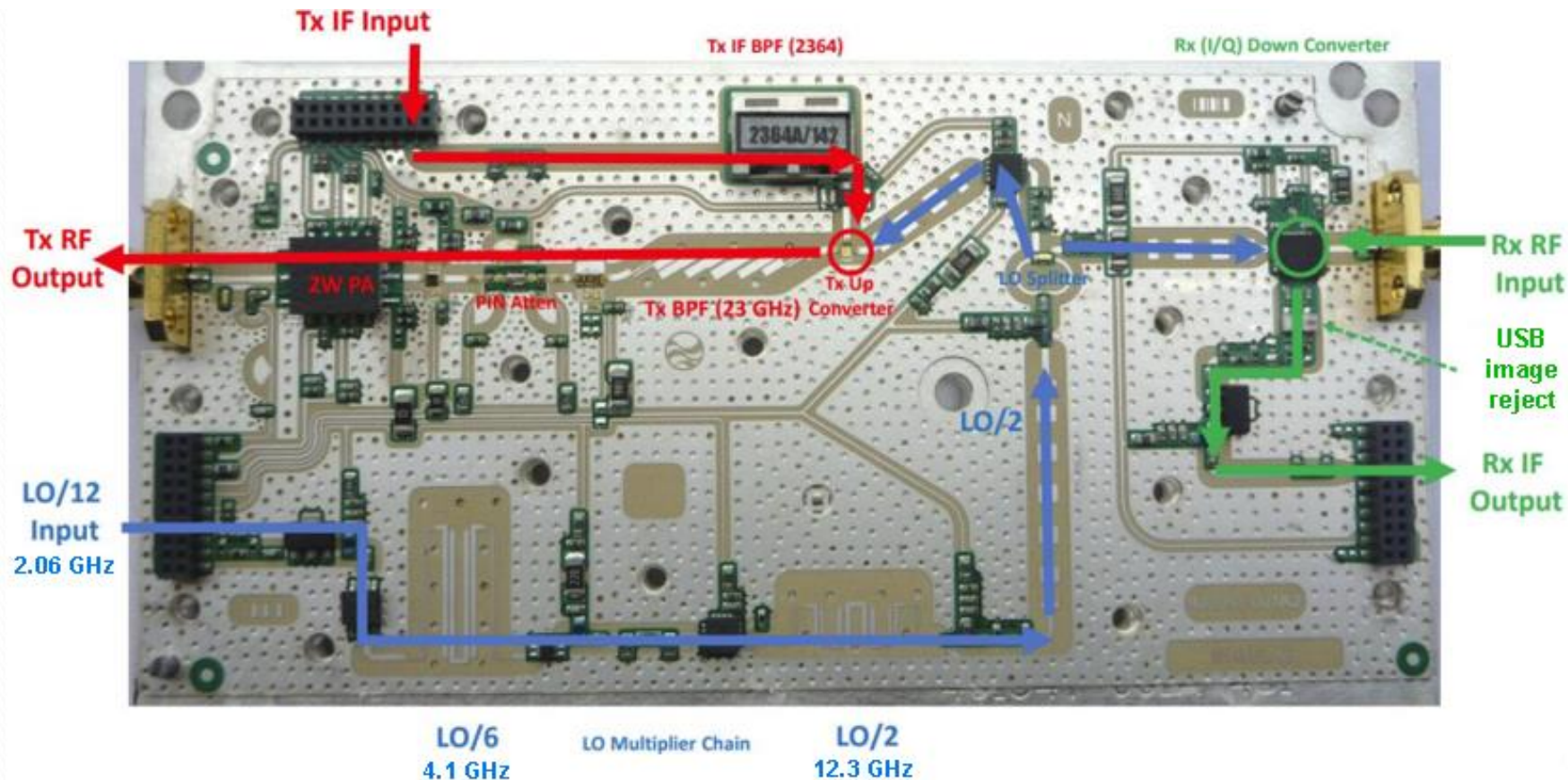
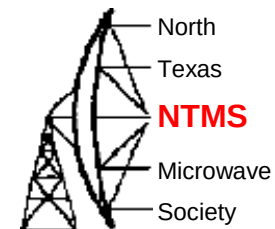


- Pair of HP 8566B with K-Band external harmonic mixer
- Independent sig gens for LO1/LO2
- The usual means for attenuation, etc

Module signal flow - XP



Module signal flow - XN

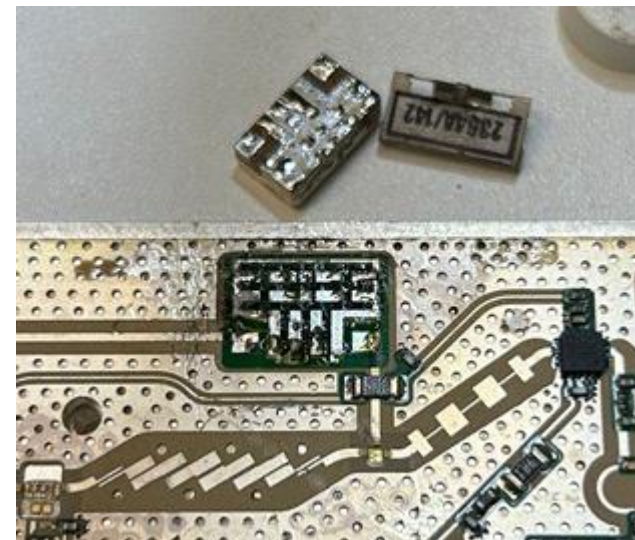


Frequency selection

	LO/12	LO/6	LO/2	LO/1	LO2	IF	LO2+IF	LO1+LO2+IF
XN N.A.opt1	1870	3740	11220	22440	1608	144	1752	24192

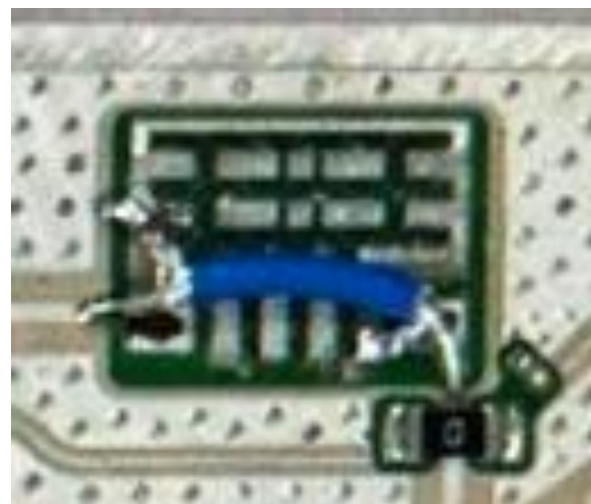
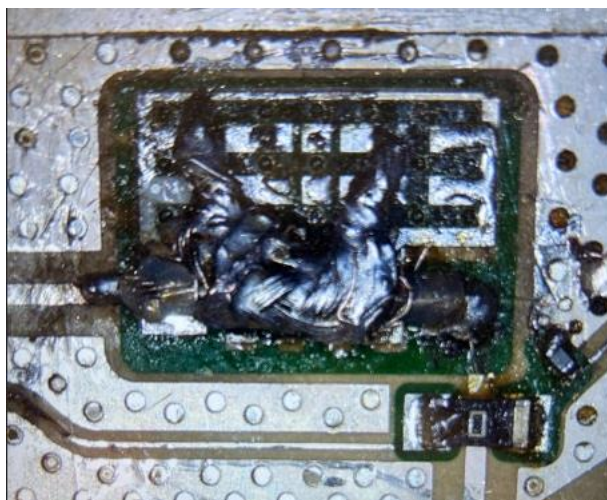
- LO chain is operating ~ 10 % lower than design frequency – not great
- LO2 & IF freq is within mixer capability on board
- LO2 + IF (1752 MHz) require removal of U3 on board and 2364 ceramic filter in module. Replace U3 with Digikey 1748LP18A0075001E and replace ceramic filter with short length of 50 ohm coax.
- TX BPF in module needs trimming by 8.5%, approx. .255 mm
- Flip resistors on RX front end

Remove ceramic filter



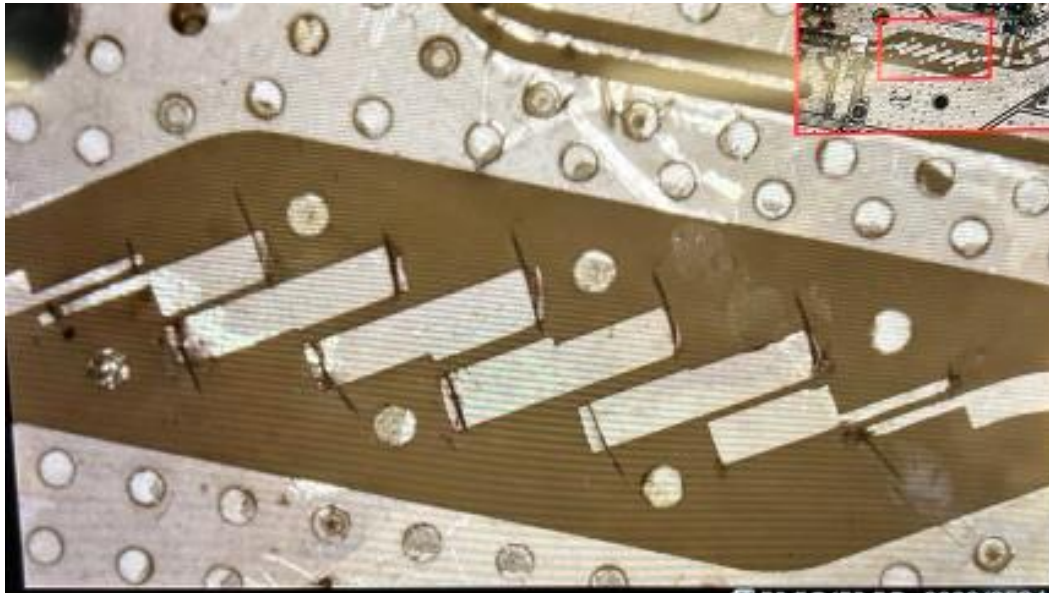
- Heat module to ~ 400 F
- Apply focused hot air ~ 700 F

Replace filter



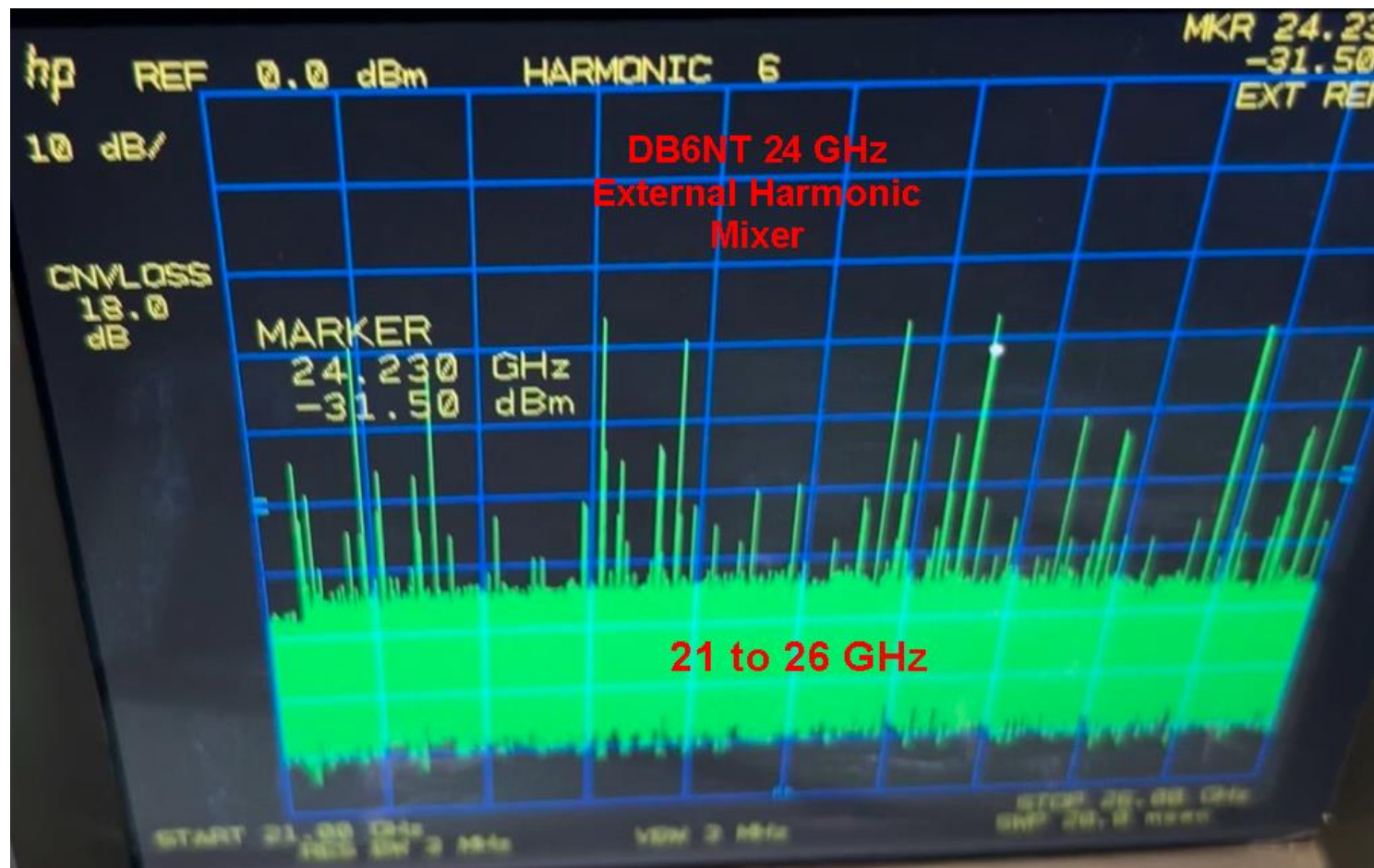
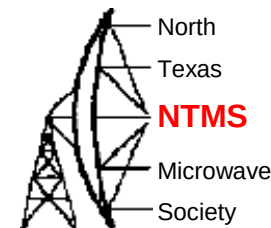
Dead dog works (left example) but right example looks better. Clamshell cover is recessed for filter so keep the coax short and contained in the perimeter of removed ceramic filter.

Trim the TX BPF .25 mm

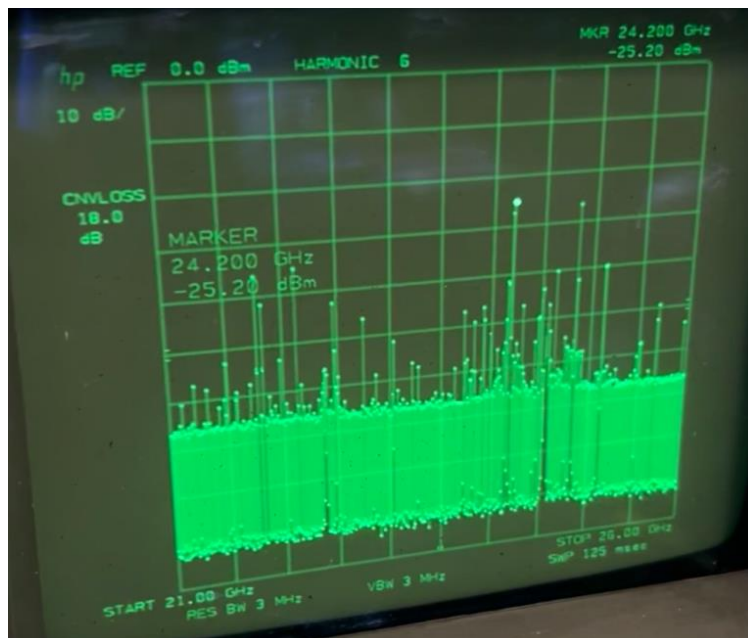
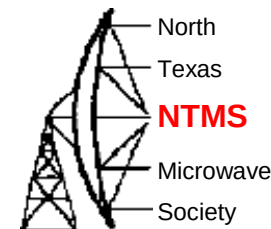


- Carefully remove the cut foil pieces
- Hardly science here, more like a trembling guess

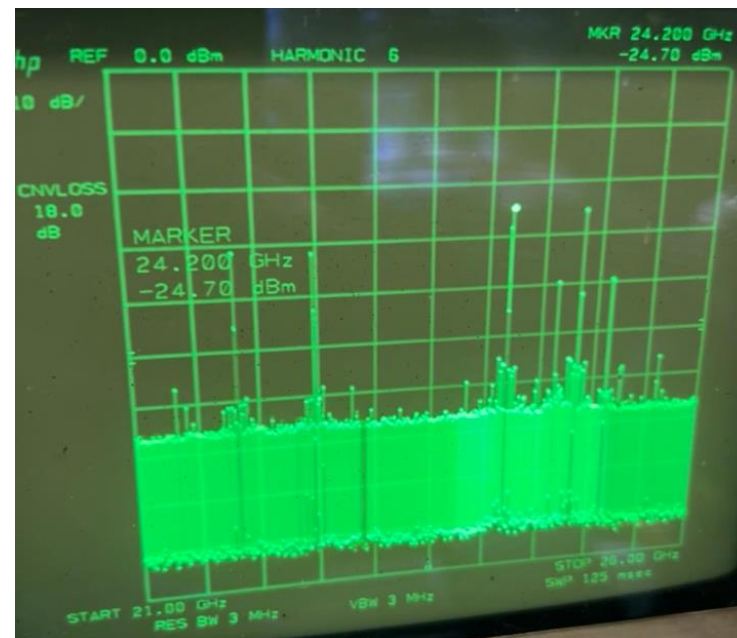
Clean up spectrum



Clean up spectrum 21 – 26 GHz view

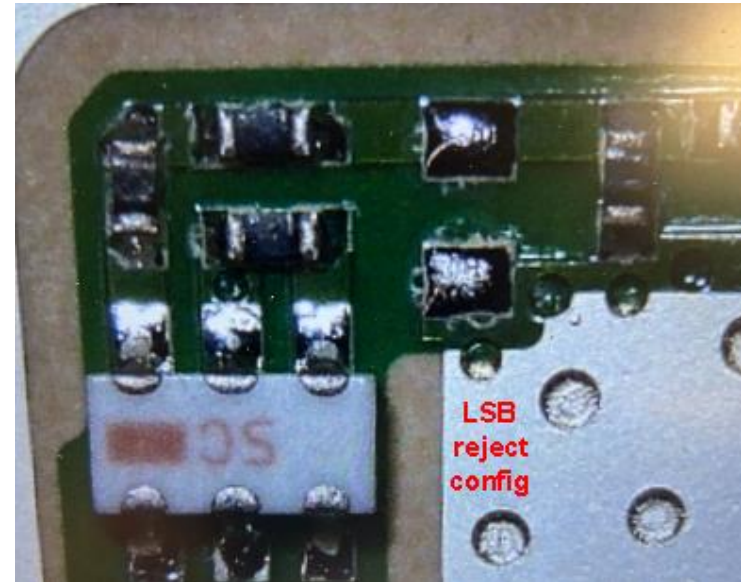
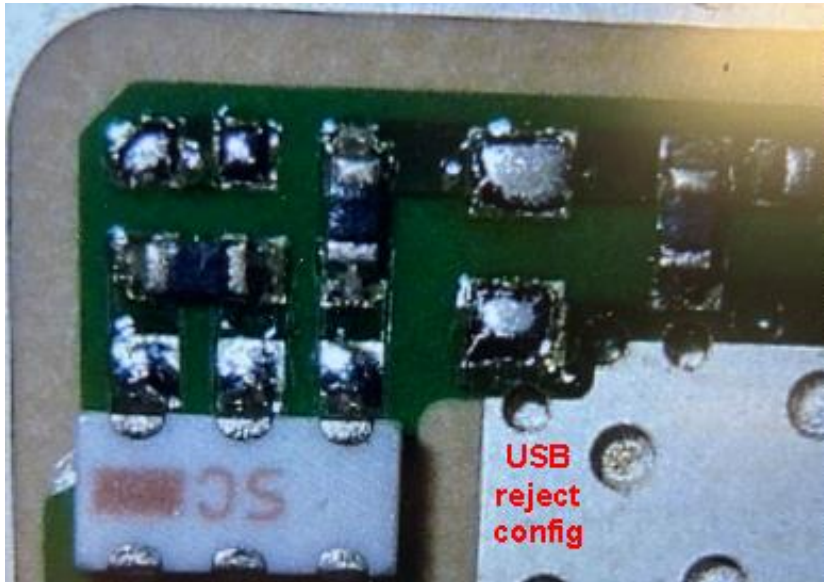
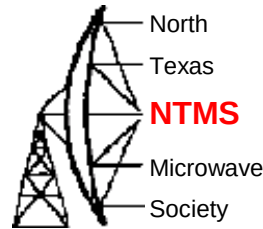


- XN before BPF trim



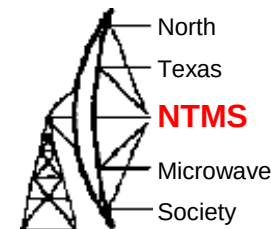
- XN after BPF trim

Flip resistors on RX front end



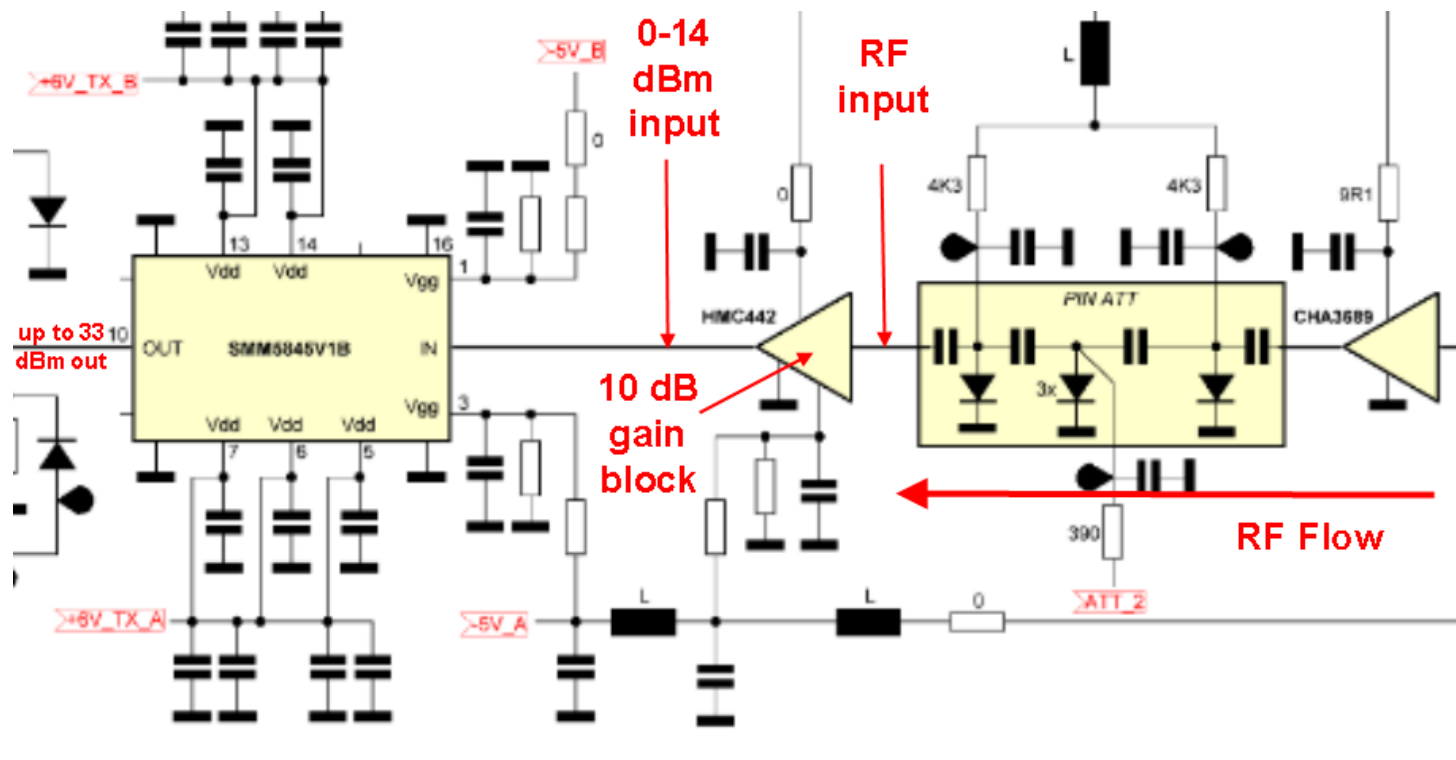
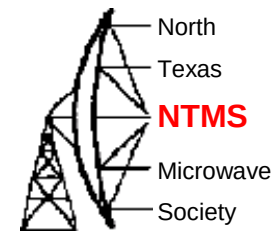
Resistor from port to center tab (ground) is 50 ohm, the others are 0 ohm

Other uses for XN

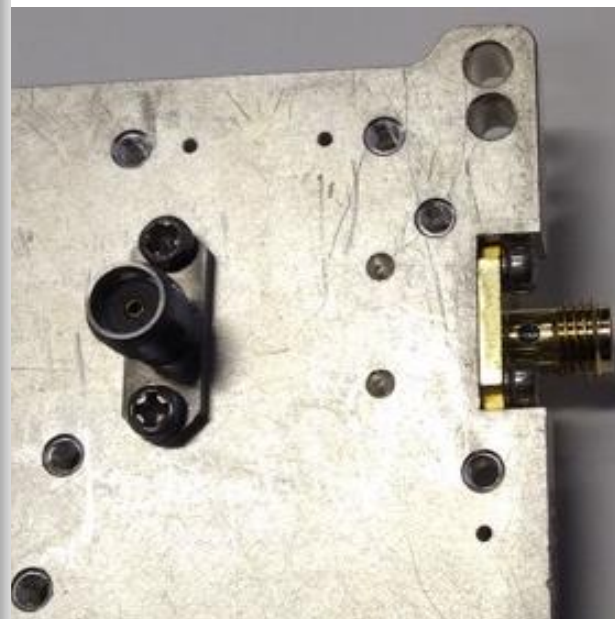
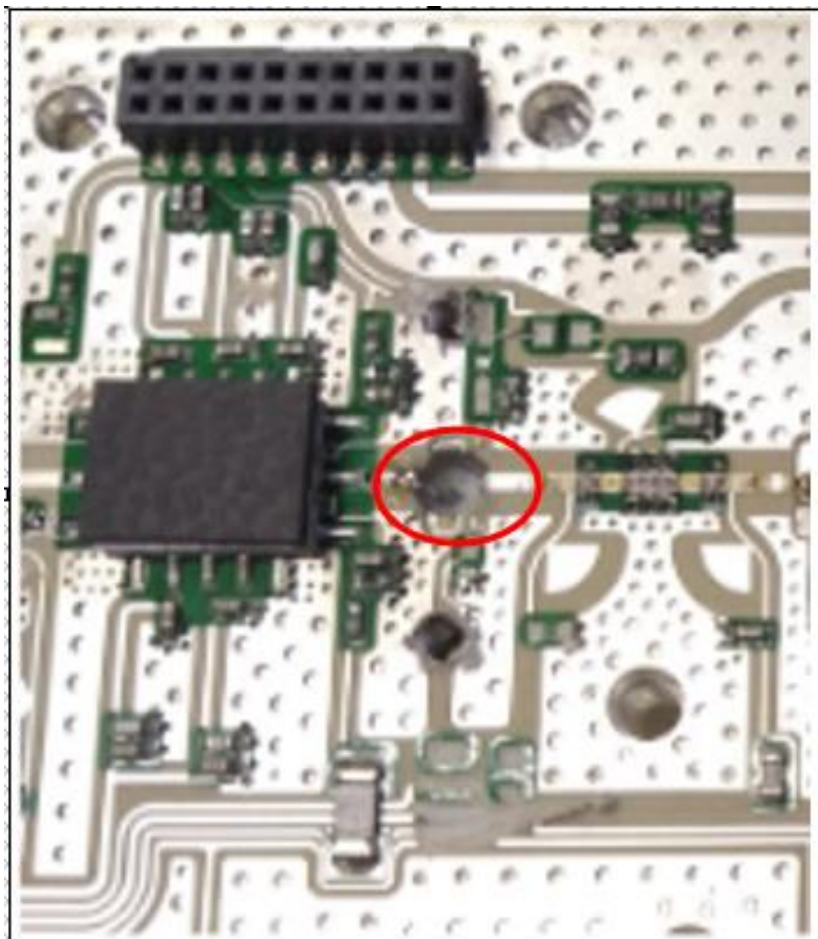
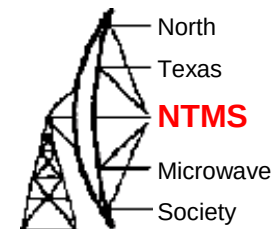


- Lower powered transverter
- Beacon (key the IF)
- Use the final PA stage as an amplifier (2 options)
- Pointing augmentation for higher bands (RX only)
- Bench signal source
 - Filter test
 - Calibration for power meters

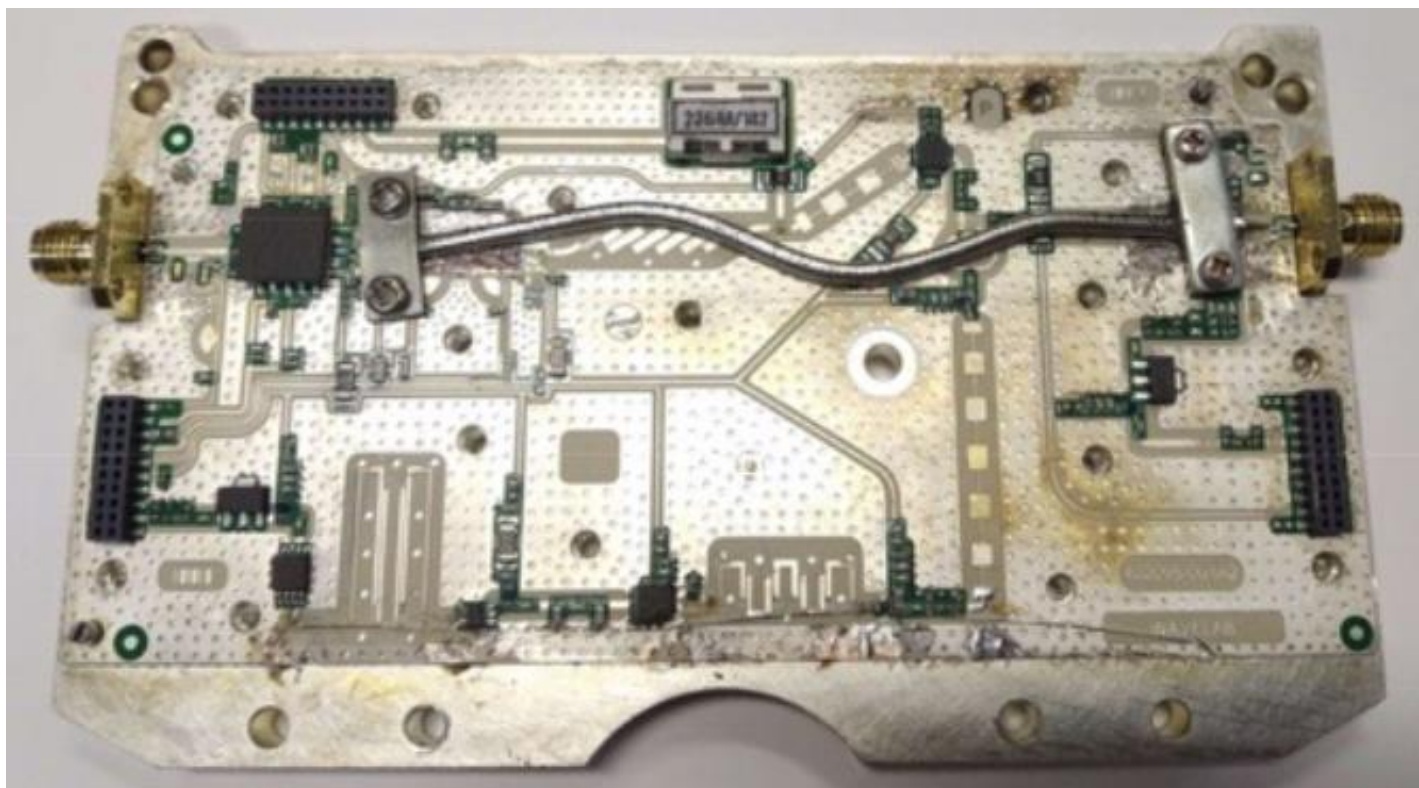
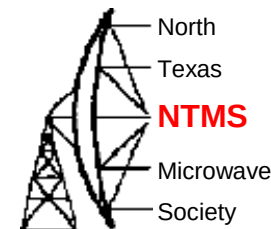
PA hack



Punch through case with SMA

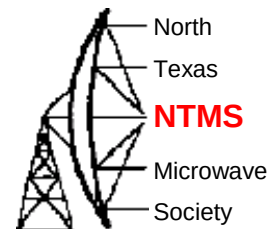


Hijack the RX port, tie to PA



- Requires routing a groove in cover

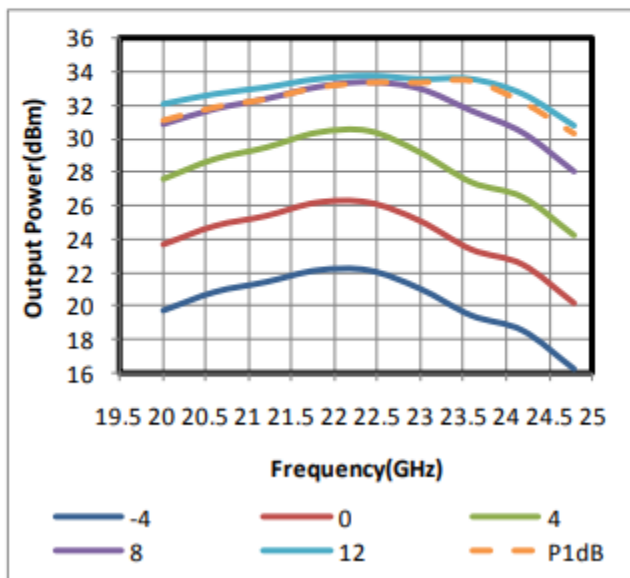
PA specs



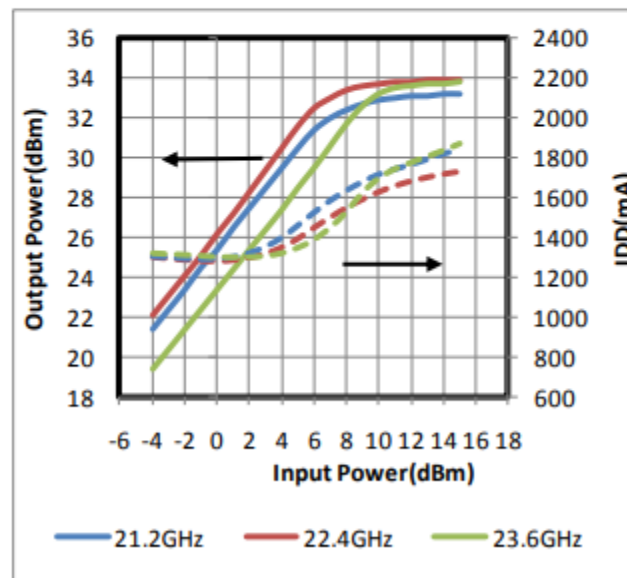
SMM5845V1B

K-Band Power Amplifier MMIC

Output Power vs. Frequency
VDD=6V, IDD(DC)=1400mA



Output Power, Drain Current vs. Input Power
VDD=6V, IDD(DC)=1400mA



Improving output

The modification



Turn the power off.

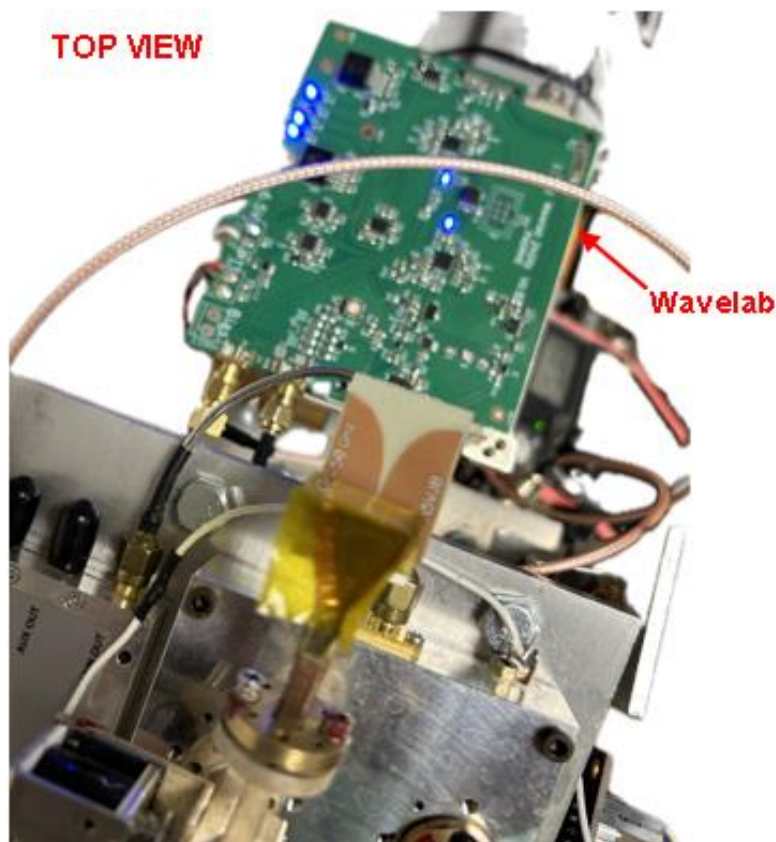
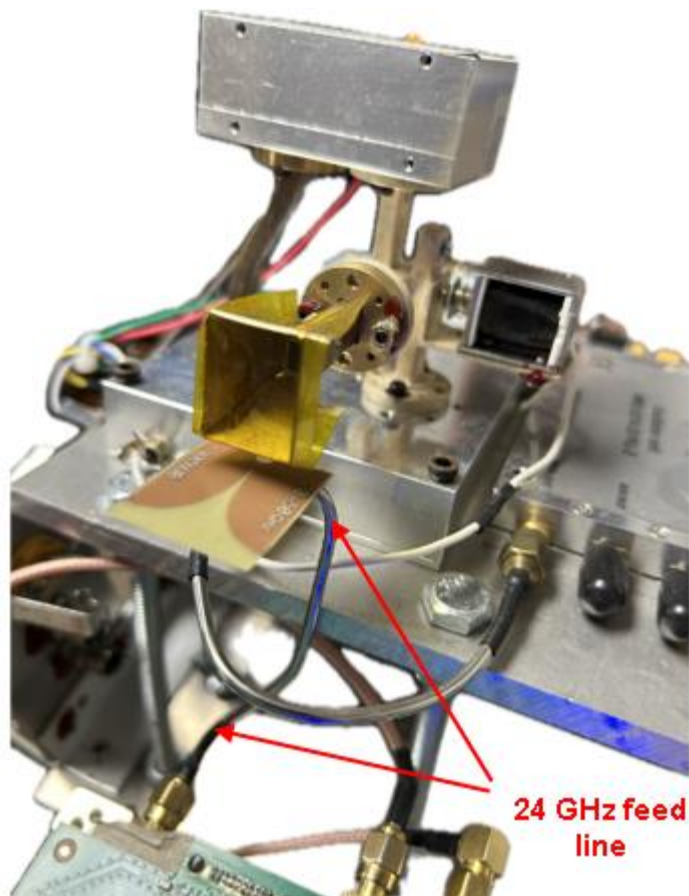
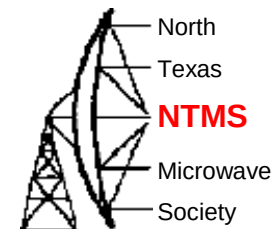
Make a vertical cut to the horizontal trace tied to the 3rd pair of pins on left side of board.



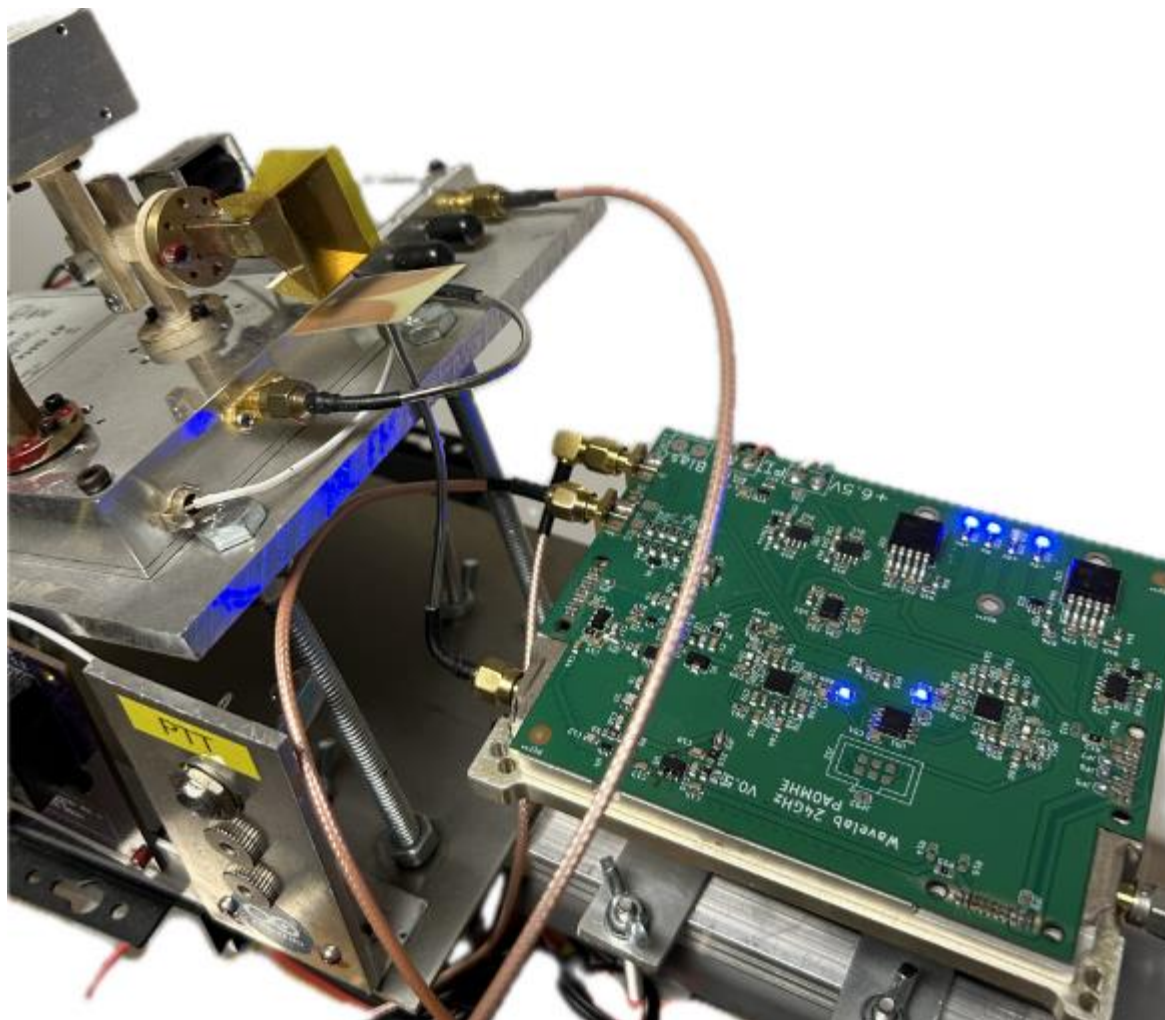
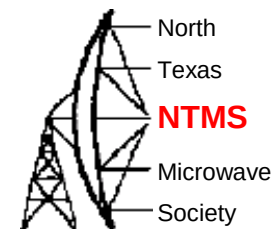
Check continuity from a +5v point like the +5v LED.

The 3rd pair of pins should now be open (not tied to +5v or grounded-although grounded will give the same results)

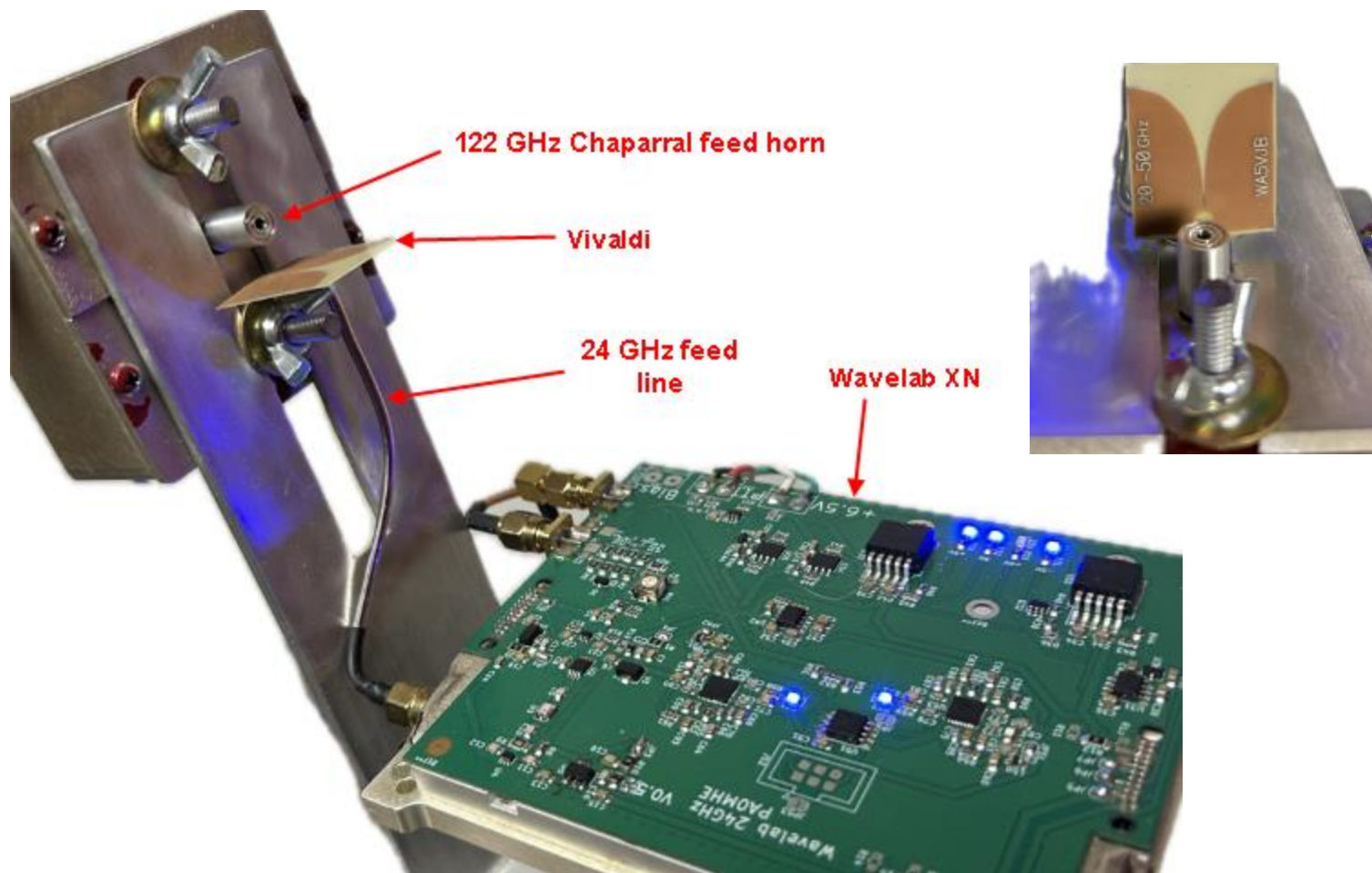
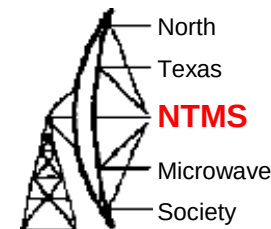
Lining up 47 GHz using XN on 24 GHz



Lining up 47 GHz using XN on 24 GHz



Lining up 122 GHz using XN on 24 GHz



Questions?

