North Texas NTMS Microwave Society

# 122 GHz Progress

## using VK3CV Transceiver

KM5PO Jim McMasters

December 4, 2021

# What is it?

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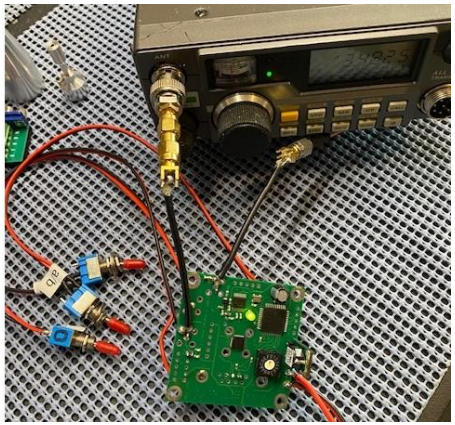
- Not your usual transverter
  - Complete 122 GHz transmitter on PCB
  - Receive down converter & IF amp on PCB
- Minimum configuration
  - Power (12 v battery)
  - Control switches, morse key
  - IF receiver (144 MHz) or SDR



# 122 GHz VK3CV board & antennas

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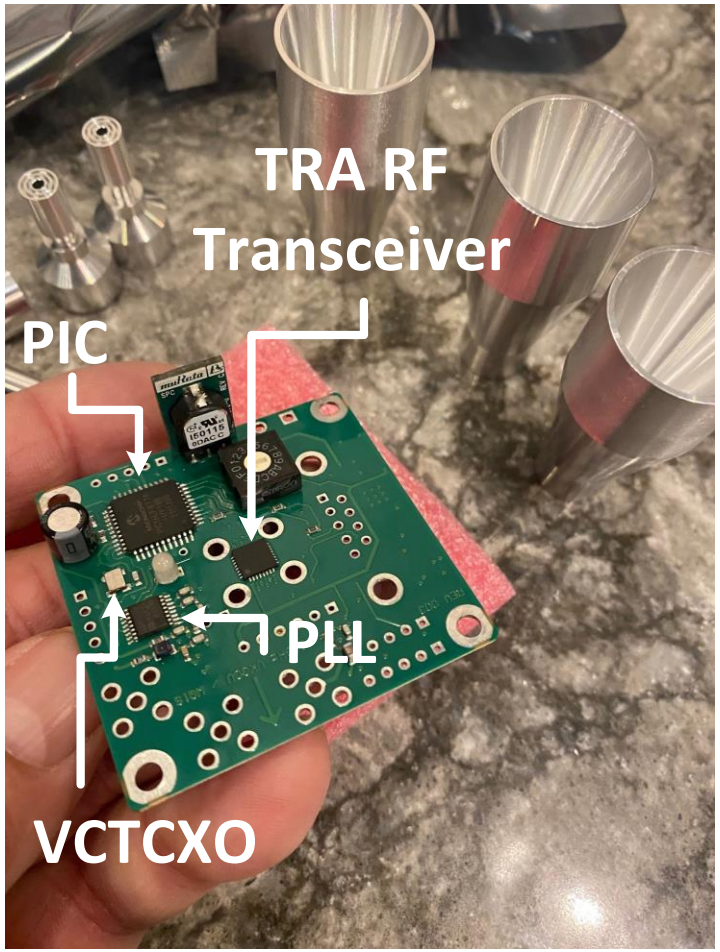
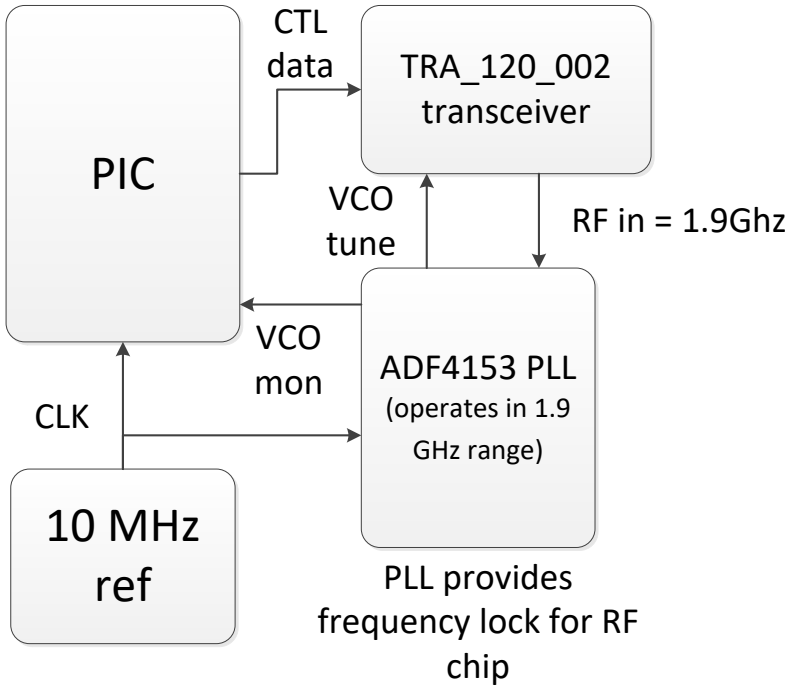
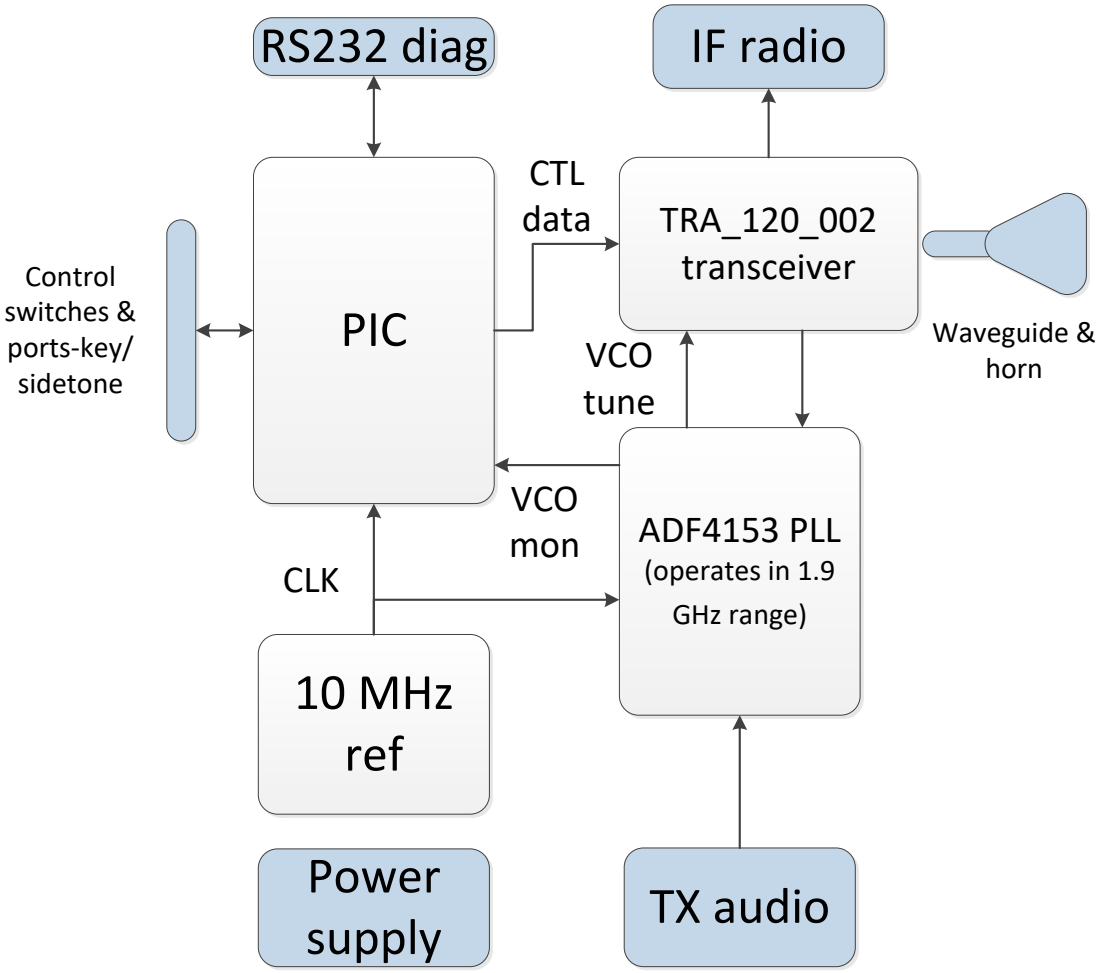


# Functional process



# Add peripherals



# Initial check out

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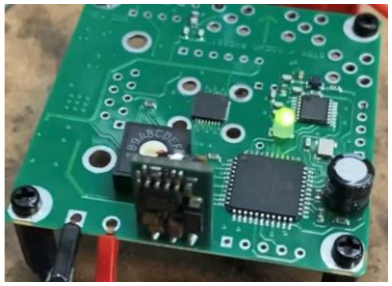
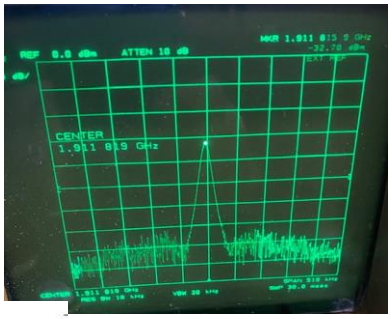
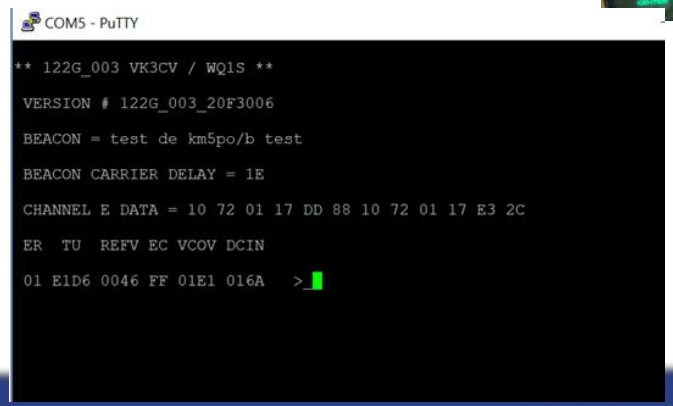
- Power up and check for
  - Proper LED operation
    - Start RED then GREEN in RX mode Red in TX
    - Flashing RED=no PLL lock
    - Alt RED/GREEN=low DC voltage






  - Proper VCO test point frequency
    - 1.911 815 = pretty darn close
  - Add RS-232
    - Diag output
    - Change /B string



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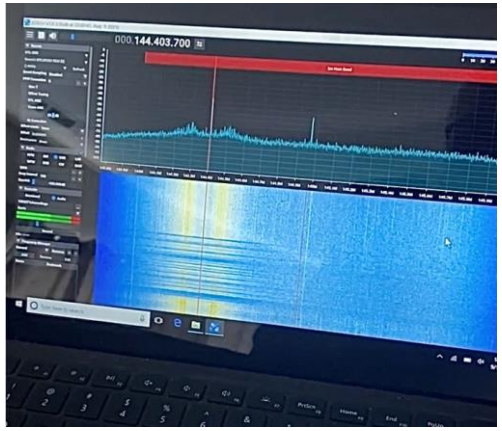
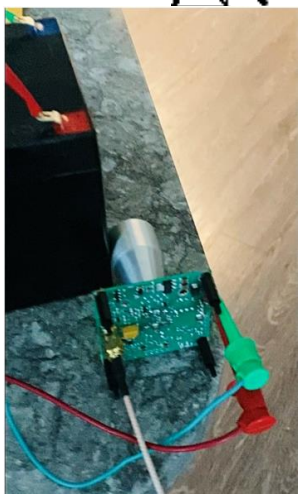
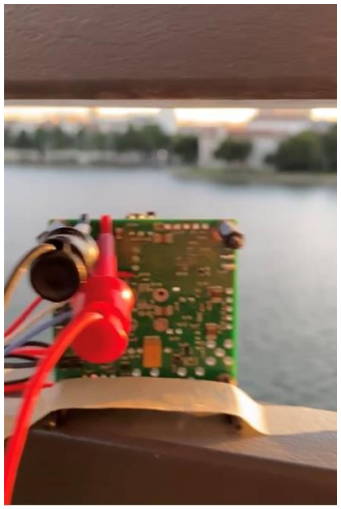
# Transmit-receive test

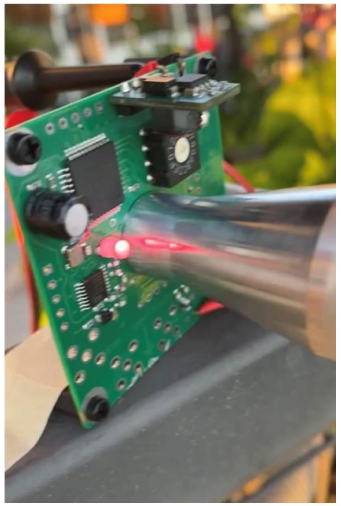
- 10 meters DX
  - Hallway
  - RTL-SDR IF
  - CW
  - ~30dB s/n
  - +/- 300 hz drift

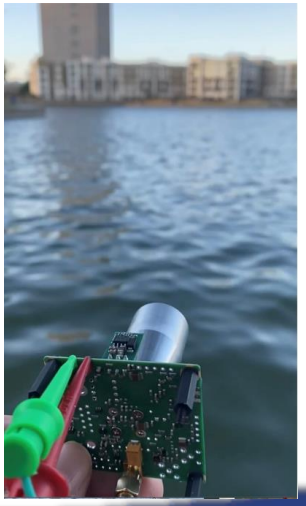




- 300 meters DX
  - Across Lake Carolyn
  - IF=FT290 in a bag..
  - FM beacon
  - S8 full quieting







# SDR ++ (www.sdrpp.org)

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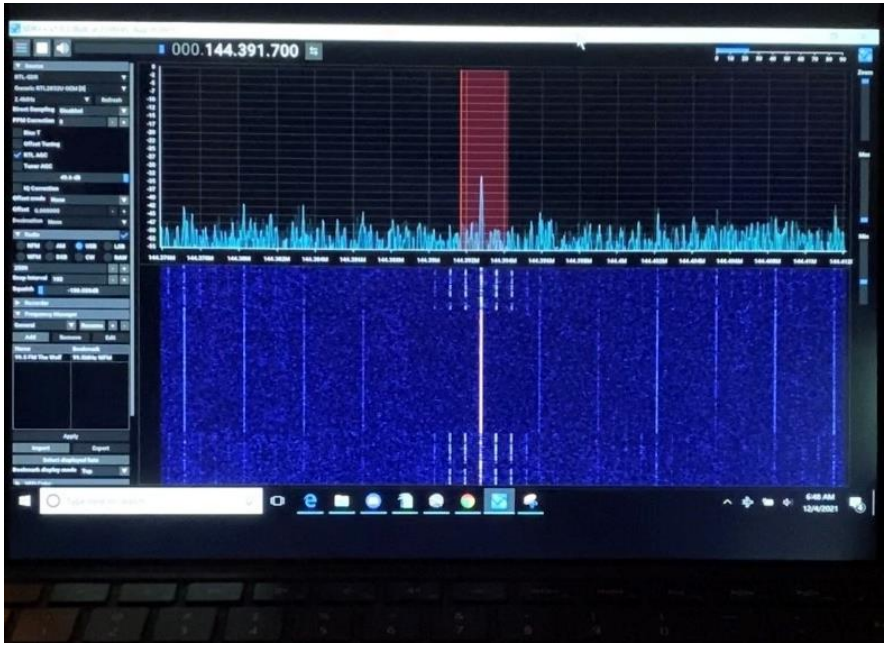
- RTL-SDR receiver and SDR ++ software

- Multi VFO
- Wide hardware support (both through SoapySDR and dedicated modules)
- SIMD accelerated DSP
- Cross-platform (Windows, Linux, OSX and BSD)
- Full waterfall update when possible.
- Modular design (write your own plugins)

- Seems not as sensitive for what we need in weak signal work but convenient in the shop versus dedicating a regular IF rig.



# Implementing the board

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- Determine configurations
  - Modify all units for external 10 MHz ref.
    - Internal VCTXCO would probably work although CW signals drift
    - Using GPS reference can present some issues
  - Build a Beacon unit
    - Power by internal LIPO 8 AH – no batt charge circuit
    - Aluminum bar stock to support PCB
      - Permits access to both sides of PCB but also exposes PCB to possible hazards
    - Add all switching/mic/key/sidetone items
    - Use as a pattern for remaining units
  - Build remote controlled units #1 & #2
    - Use beacon as pattern for control unit – add batt charge circuit
    - Use DB15 and cable for signaling with remote head unit

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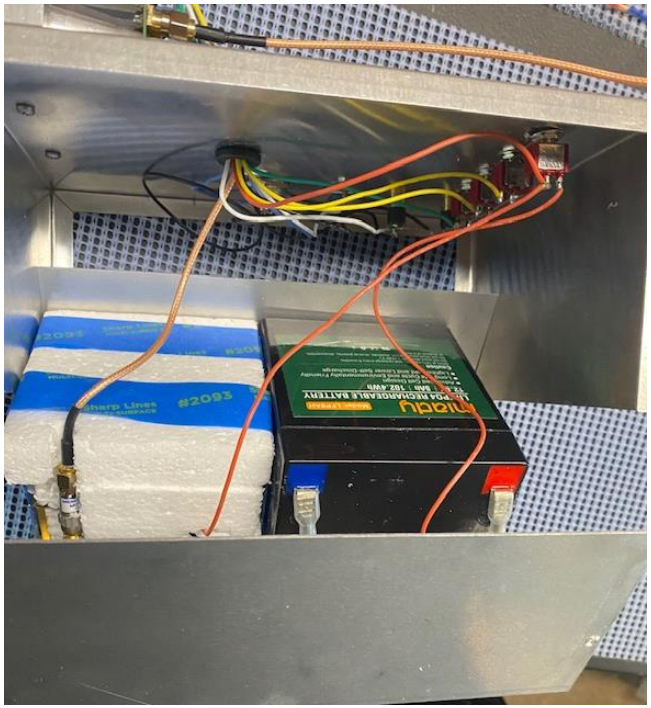
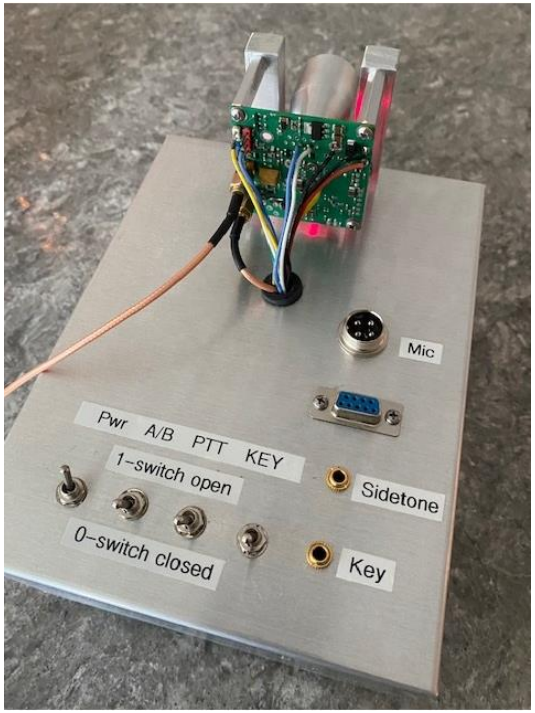
# Beacon “build”



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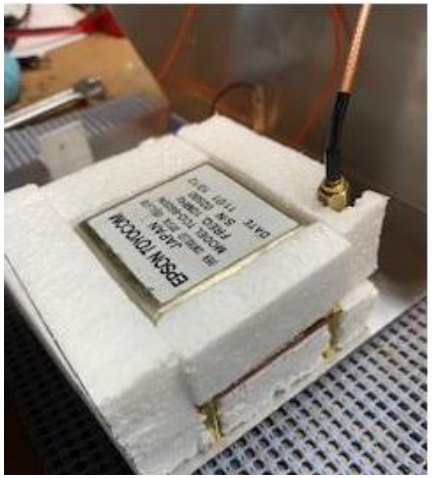

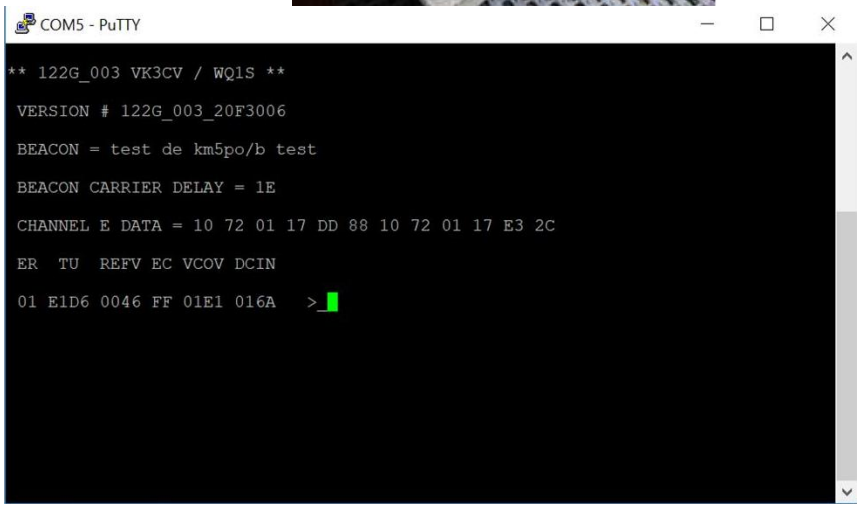


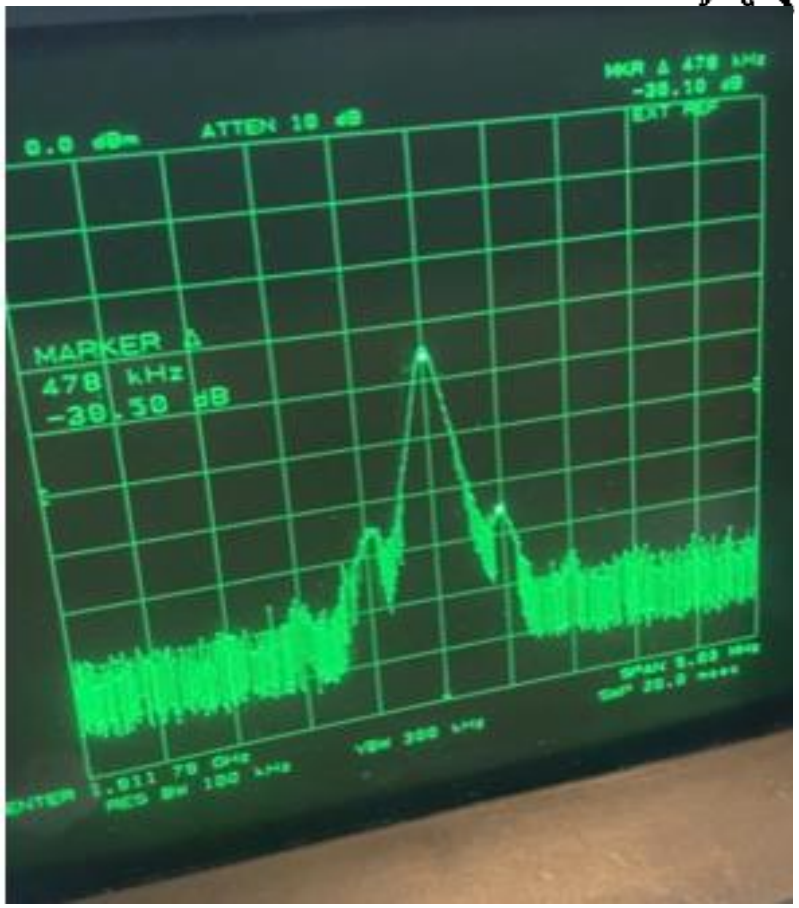


ER = GPS lock error result
TU = Current 10 MHz VCTCXO ref error TU value
REFV = Current 10 MHz VCTCXO ref tune voltage
EC = VCTCXO error count since last correction (lock quality)
VCOV = Current VCO error voltage
DCIN = Current DC input voltage

# Build remote controlled unit

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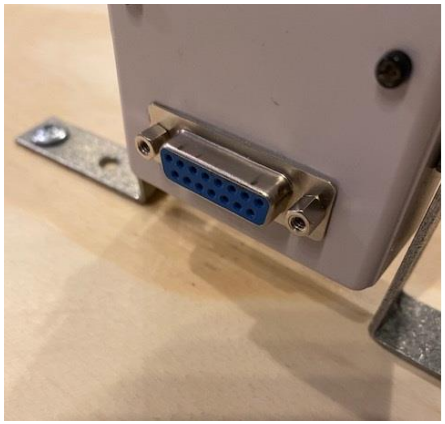
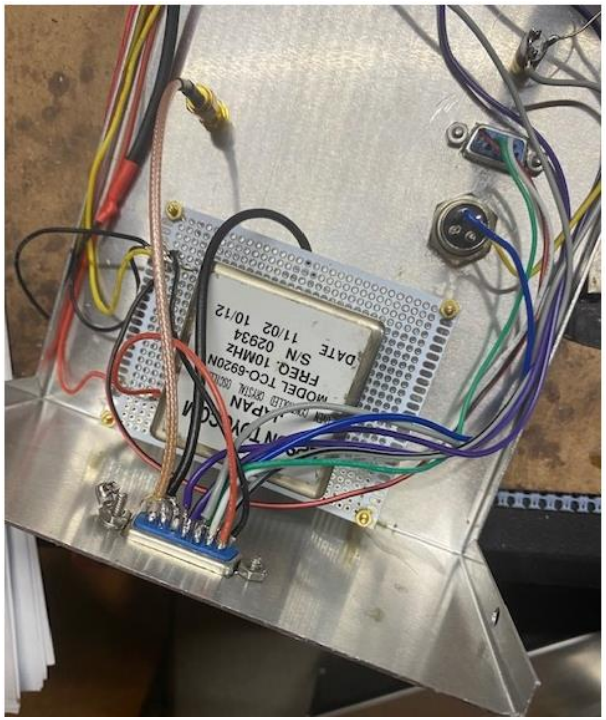
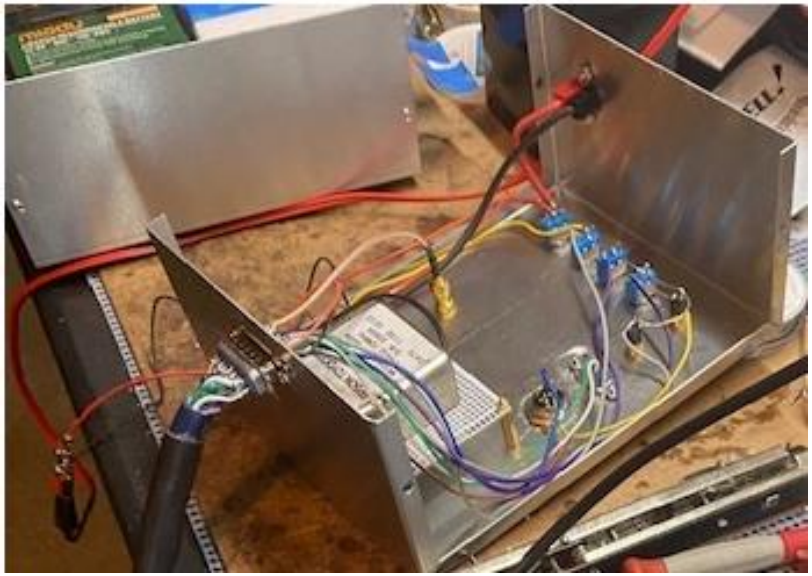
- DB15 connectors, 9 conductor cable, two RG-174 coax cables.

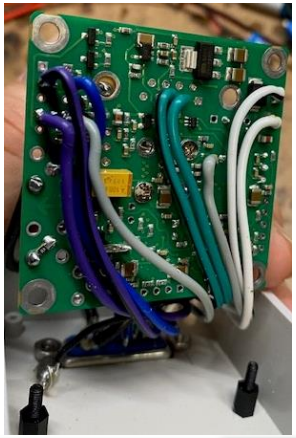


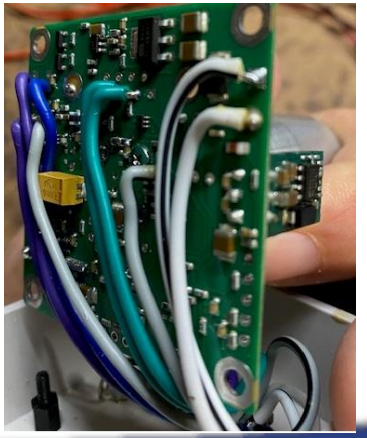
| Pin | Function | | Pin | Function |
|---|---|---|---|---|
| 1-Wht/Blk | Com GND | | 9-Wht | 12vDC |
| 2-Gry/Blk | A/B ch | | 10-Grn | RS232 rx |
| 3-Grn/Blk | RS232 tx | | 11-Grey | Sidetone |
| 4-Blu | Mic in | | 12-Vio/Blk | PTT in |
| 5-Vio | Key in | | 13-Braid | GND-10 MHz |
| 6-Braid | GND-IF sig | | 14- | N/C |
| 7- | N/C | | 15-RG174 | hot-10 MHz |
| 8-RG174 | hot-IF sig | | | |



# Control box and head







- RG-174U for RF signals
- Use color coding of connecting cable as reference to wiring control box/head.
- LED will be hidden when head is closed
- No provision for dynamic channel changing aside from A/B ie. 122500.400/122356.000

# Build remote controlled unit

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- Power applied and no LED action (at head) ARGGG!
- Test point measures -36 + 23 cor = -13 but 1.85 GHz
- 1.85 GHz not on the VCO tune curve but it is listed in specs
  - Rabbit hole (why parked at 1.85 GHz?):
    - Source code- why no init red LED
    - Did the initial freq set not occur?
    - After cleanup and fiddling with ref levels, now normal LED sequence but still on 1.85 GHz
  - Need a baseline of measurements from good rig!

120-GHz IQ Transceiver **TRA_120_002**
Preliminary Data Sheet
Revision 0.8 2018-11-05

SILICON radar

**4.4 Electrical Characteristics**

$T_A$ = -40 °C to +85 °C unless otherwise noted. Typical values measured at $T_A$ = 25 °C and $V_{CC}$ = 3.3 V.

Table 5 Electrical Characteristics

| Parameter | Symbol | Min | Typ | Max | Unit | Condition / Remark |
|---|---|---|---|---|---|---|
| **DC Parameters** | | | | | | |
| Supply current consumption | $I_{CC}$ | | 128 | 155 | | |
| DIVen input voltage, low level | $V_{DIVen\_L}$ | 0 | | 0.3 × $V_{CC}$ | | |
| DIVen input voltage, high level | $V_{DIVen\_H}$ | 0.7 × $V_{CC}$ | | $V_{CC}$ | | |
| RXen input voltage, low level | $V_{RXen\_L}$ | 0 | | 0.5 × $V_{CC}$ | | |
| RXen input voltage, high level | $V_{RXen\_H}$ | $V_{CC}$ -0.4 | | $V_{CC}$ | | |
| VCO tuning voltage | $V_{VT}$ | 0 | | $V_{CC}$ | | |
| **RF Parameters** | | | | | | |
| VCO start frequency | $f_{TX}$ | 117.8 | 119.3 | 120.8 | | |
| VCO stop frequency | $f_{TX}$ | 124.3 | 125.8 | 127.3 | | |
| VCO tuning full bandwidth | $\Delta f_{TX}$ | 5.5 | 6.5 | 7.5 | | |
| Number adjustable of frequency bands | | | 8 | | | switching |
| Pushing VCO | $\Delta f_{TX}/\Delta V_{CC}$ | | 27 | | MHz/V | |
| Phase noise | $P_N$ | | -90 | -88 | dBc/Hz | at 1 MHz offset |
| Transmitter output power | $P_{TX}$ | -7 | -3 | 1 | dBm | Measured without antennas |
| Divider ratio of TX signal | $N_{DIV}$ | | 64 | | | |
| Divider output power | $P_{DIV}$ | -10 | | -7 | dBm | Note 1 |
| Divider output frequency | $f_{DIV}$ | 1.85 | | 1.98 | GHz | |
| Receiver gain | | | 8 | 10 | dB | Measured without antennas |
| IF frequency range | $f_{IF}$ | 0 | | 200 | MHz | |
| IF output impedance | $Z_{OUT}$ | | 500 | | Ω | Differential outputs |
| IQ amplitude imbalance | | | tbd | | dB | |
| IQ phase imbalance | | -10 | | 10 | deg | |
| Noise figure (DSB) | | | 8.7 | | dB | Simulated, at $f_{IF}$ = 1 MHz) |
| Input compression point | 1dB ICP | | -20 | | dBm | Measured without antennas |

Note 1 Measured single-ended. Divider outputs are loaded with 50 Ω, external decoupling capacitors are required. No 50-Ω match is required in application.

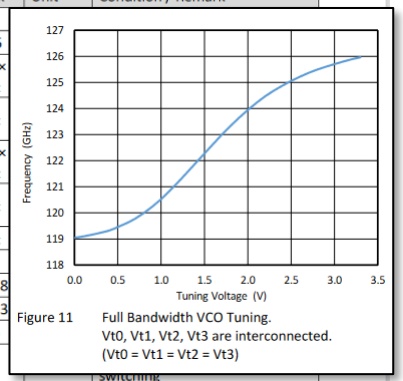


Figure 11 Full Bandwidth VCO Tuning.
Vt0, Vt1, Vt2, Vt3 are interconnected.
(Vt0 = Vt1 = Vt2 = Vt3)

# Test points

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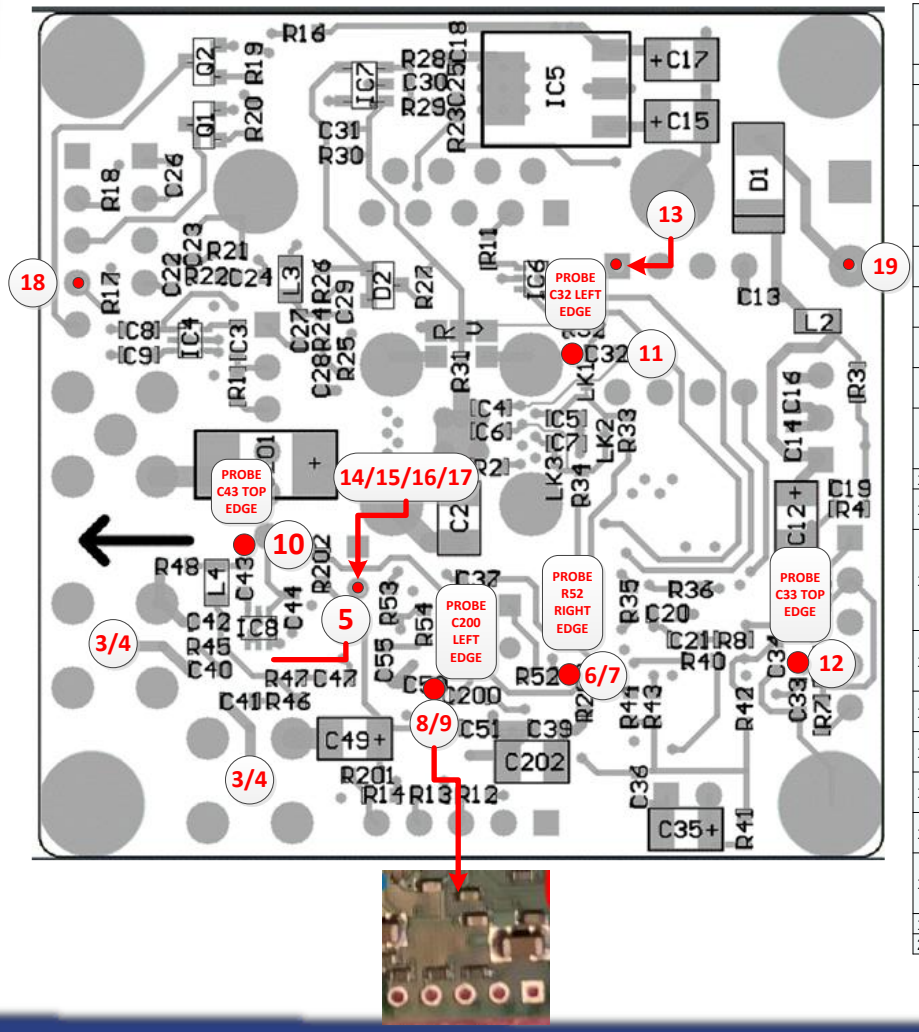


| | Test | Note | power- raw plus correction | Voltage or resistance | Frequency |
|---|---|---|---|---|---|
| | 122 GHz and 10 MHz ref DUTs | Beacon/Internal | | | |
| 1 | RF level of 10 MHz ref at end of hot cable | Follows intern. 7 db attn | -18 +27.5=5.5 | | |
| 2 | Voltage level of 10 MHz ref at end of hot cable | | | 800mv pp | 9.99996 MHz |
| 3 | RF level of 10 MHz ref at SMA input with pcb smd attenuation | | -23.8+27.5=3.7 | | |
| 4 | Voltage level of 10 MHz ref at SMA input with pcb smd attenuation | | | 440mv pp | 9.99996 MHz |
| 5 | RF level of 10 MHz ref at shorts over R47/C47 | | -25.2+27.5=2.3 | | |
| 6 | Voltage level at R52 (PIC pin 37 RC3/SCK/SCL & PLL pin 11 CLK) in TX | s/b 0.7 - 3.3 | | 2.63vDC | |
| 7 | Voltage level at R52 (PIC pin 37 RC3/SCK/SCL & PLL pin 11 CLK) in RX | | | 164mvDC and .86mvAC | |
| 8 | RF level of 10 MHz ref at C200 (PIC pin 30 OSC1/CLKIN) | | -25.2+27.5=2.3 | | |
| 9 | Voltage level of 10 MHz ref at C200 (PIC pin 30 OSC1/CLKIN) | s/b 1.4 - 3.3 (2v p-p ideal waveform) | | 1.45vDC and .86mvAC | ugly waveform? |
| 10 | RF level of 10 MHz ref at IC8 (probe C43) | | -19.8+27.5=7.7 | | |
| 11 | Voltage level at C32/R53 (PLL pin 2 - RF chip pin 18/VT0) | s/b 1.4 - 3.3 | | 1.58vDC | |
| 12 | Voltage level at R50/C33 (PLL pin 2/Cpout to PIC pin 22-RA3/AN3/VREF)[An VCOV] 1-2vDC indicates a lock | s/b 1 - 2v {1.3v} (this is DC component of VCO error voltage) | | 1.42vDC | |
| 13 | PIC pin 9 to ground (a/b switch line) resistance should change when hex switch moves from even to odd | | | 0 to 1.4k and .86vAC | |
| 14 | RF test point level and frequency channel A (switch open) | | -35+23= -12 | | 1.911 GHz |
| 15 | RF test point level and frequency channel B (switch closed) | | -35+23= -12 | | 1.914 GHz |
| 16 | RF test point level and frequency channel A Beacon CW | | -35+23= -12 | | 1.911 to 1.914 GHz |
| 17 | RF test point level and frequency channel B Beacon FM | | -35+23= -12 | | 1.914 GHz |
| 18 | DC v across the morse key port | Andrew measured 3.298vDC | | 3.23vDC | |
| 19 | DC power in | | | 12.96vDC | |
| 20 | Check spurs at test point and IF | | | | |

# Test points

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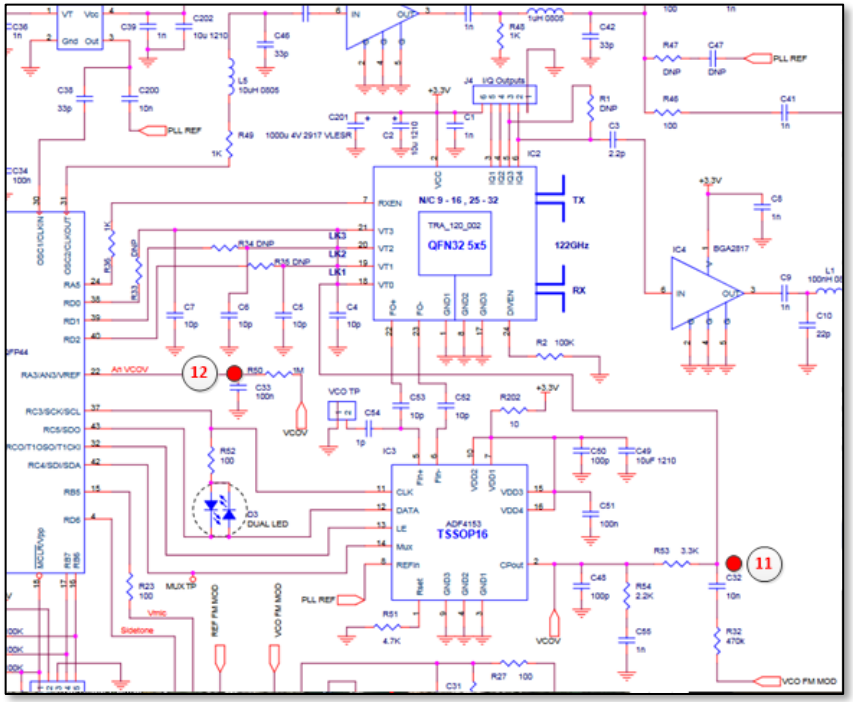


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| 15 | RF test point level and frequency channel B (switch closed) | | -35+23= -12 | | 1.914 GHz |
| 16 | RF test point level and frequency channel A Beacon CW | | -35+23= -12 | | 1.911 to 1.914 GHz |
| 17 | RF test point level and frequency channel B Beacon FM | | -35+23= -12 | | 1.914 GHz |
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| 19 | DC power in | | | 12.96vDC | |
| 20 | Check spurs at test point and IF | | | | |

# Next steps

- Make a real contact (Al & Scott, Paul Sarver-KI5EMN)
- Find max DX (horn to horn) – improve systems/operating methods
- Implement dish and feed and maybe lens on one or both remote rigs


# Finding LOS

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- During darkness hours
- Use binoculars from high operating position looking for cars and familiar landmarks and traffic signals
- Mark or remember your position
- Plot a path
- In darkness hours install flashing light at high op position
- Drive to estimated locations and identify the flashing light.
- Try to improve the dx position.
- Document the location.

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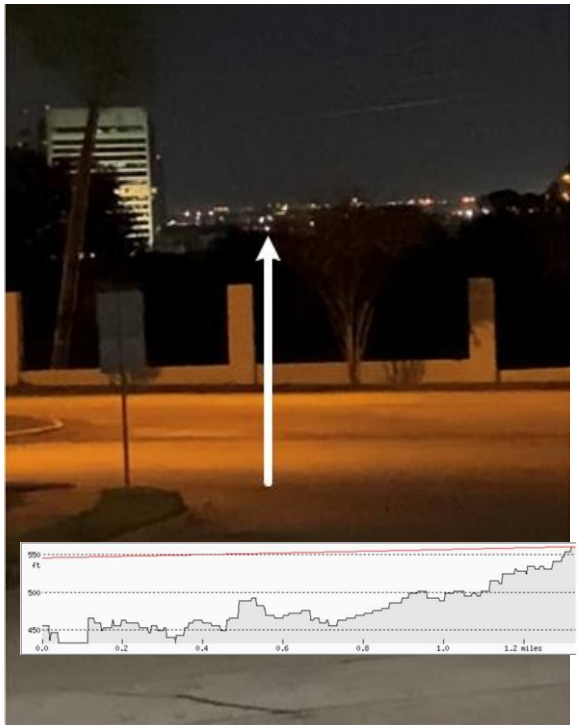
# LOS tool/tips

White flashing light at target 27.3 km DX

Lumina 1100 cycling light



White flashing light at apartment top floor parking lot -

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# More DX possibilities

Cedar Hill to Lone Star Rd (360) 10.5 km


Cedar Hill to Lillian/917 20.3 km


Cedar Hill to Windhaven 27.3 km

# Lots of resources

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- Home page of NTMS website
  - 7 presentations for 122 GHz
  - Dec. 7, 2019 - N5BRG - VK3CV 122 GHz Transverter review
  - Mar. 7, 2020 - W5LUA -122 GHz Update
  - May 2, 2020 – W5LUA – DB6NT 122 GHz Mixer
  - May 2, 2020 – W5LUA – 122 GHz Update
  - July 11, 2020 – W5LUA – 122 GHz Update – VK3CV Transceiver
  - Oct. 3, 2020 – W5LUA – Conquering Lake Lavon on 122 GHz

# More resources

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## The 122G03 Transverter Users Group

Active user group

https://groups.io/g/The122GProject

Gordon G0EWN

Noel – G8GTZ

Rene Barbeau VE2UG

K6ML – 122 GHz VK3CV Transceivers

http://www.50mhzandup.org/vk3cv_zoom_workshop_070720.pdf

K6ML – Building & Operating 122 GHz Radios

http://www.bay-net.org/uploads/1/2/2/7/122774721/122_ghz_radio_k6ml.pdf

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# Questions?