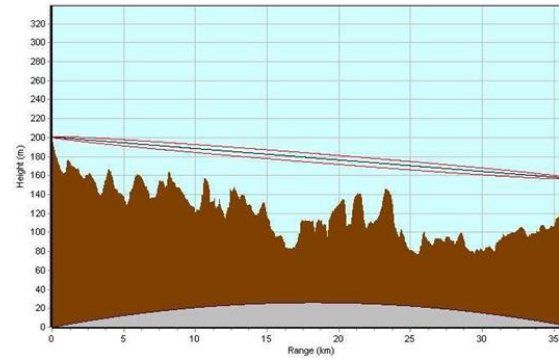


Adventures on 122GHz

Noel Matthews G8GTZ

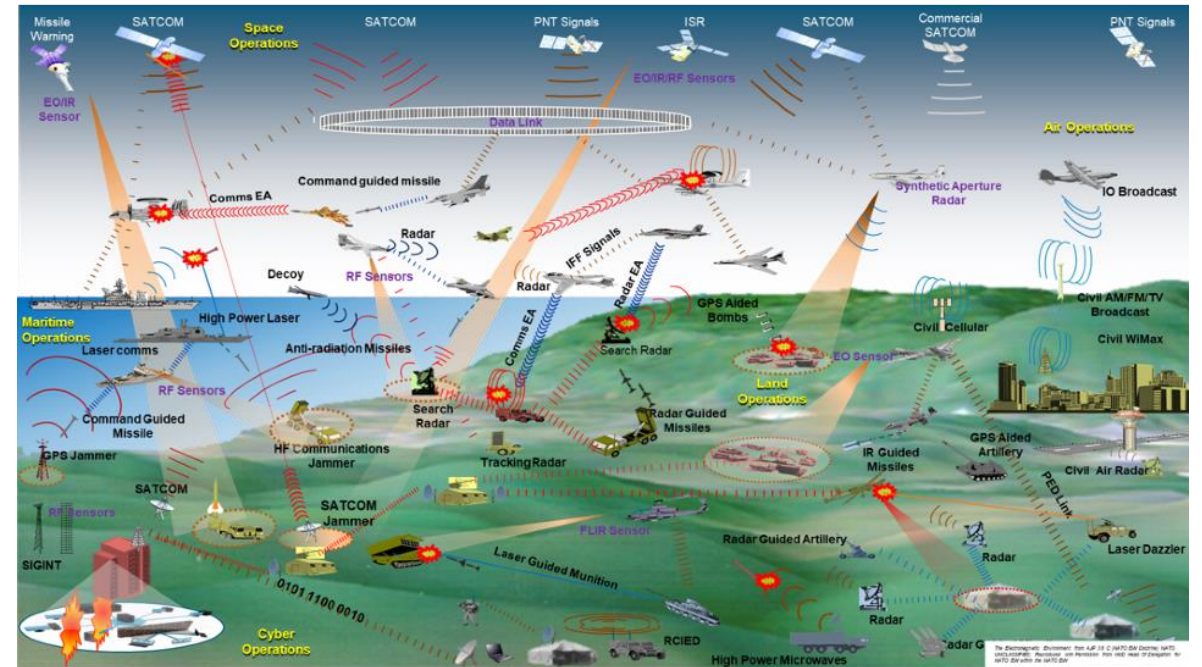


With thanks and acknowledgement to
G1EHF, G8ACE, G8AGN, G0FDZ , K6ML
and the 122 project iogroup



Where is 122GHz!

- VHF
 - 50, 70 and 144MHz
- UHF
 - 432MHz
- Low microwave bands up to 10GHz
 - 1.3, 2.3, 3.4 and 5.6GHz
- Higher Microwave bands up to 100GHz
 - 10, 24, 47 and 76GHz
- **Millimeter bands above 100GHz**
 - **122, 134, 241GHz and above**



The Electromagnetic Environment from AJP 3.6 C
(NATO EW Doctrine) NATO UNCLASSIFIED

Some bands are easier than others!

- **23cms** has always been a stepping stone
 - Lot of activity and designs
- 13cms not so easy, until QO100 and UMTS
- 3.4GHz some surplus Ionica
- 5.7GHz no surplus
- **10GHz** the next step after 23cms
 - Lots of designs and surplus
- 24GHz – too difficult until recently!
- 47GHz and 76GHz – definitely harder
- Above 100GHz – top bands!
 - Just too difficult until.....

DUBUS

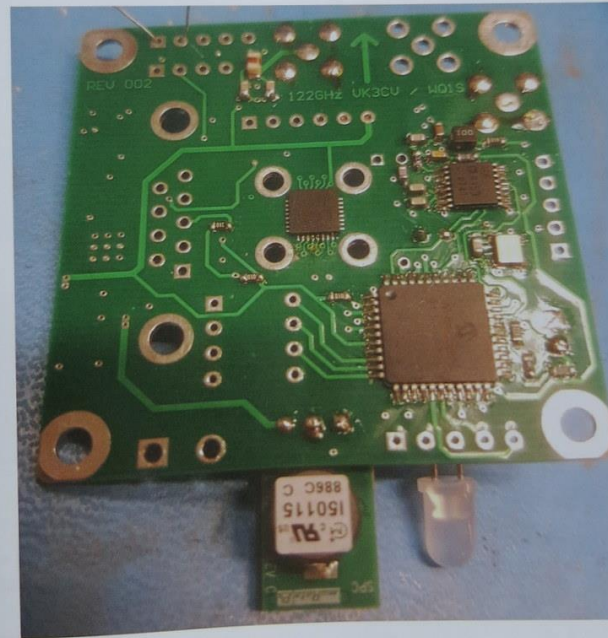
3/2019

Vol.48

3. Quarter

www.DUBUS.org

122 GHz for all!



by VK3CV

Magazine for Amateur Radio on VHF/UHF and Microwaves

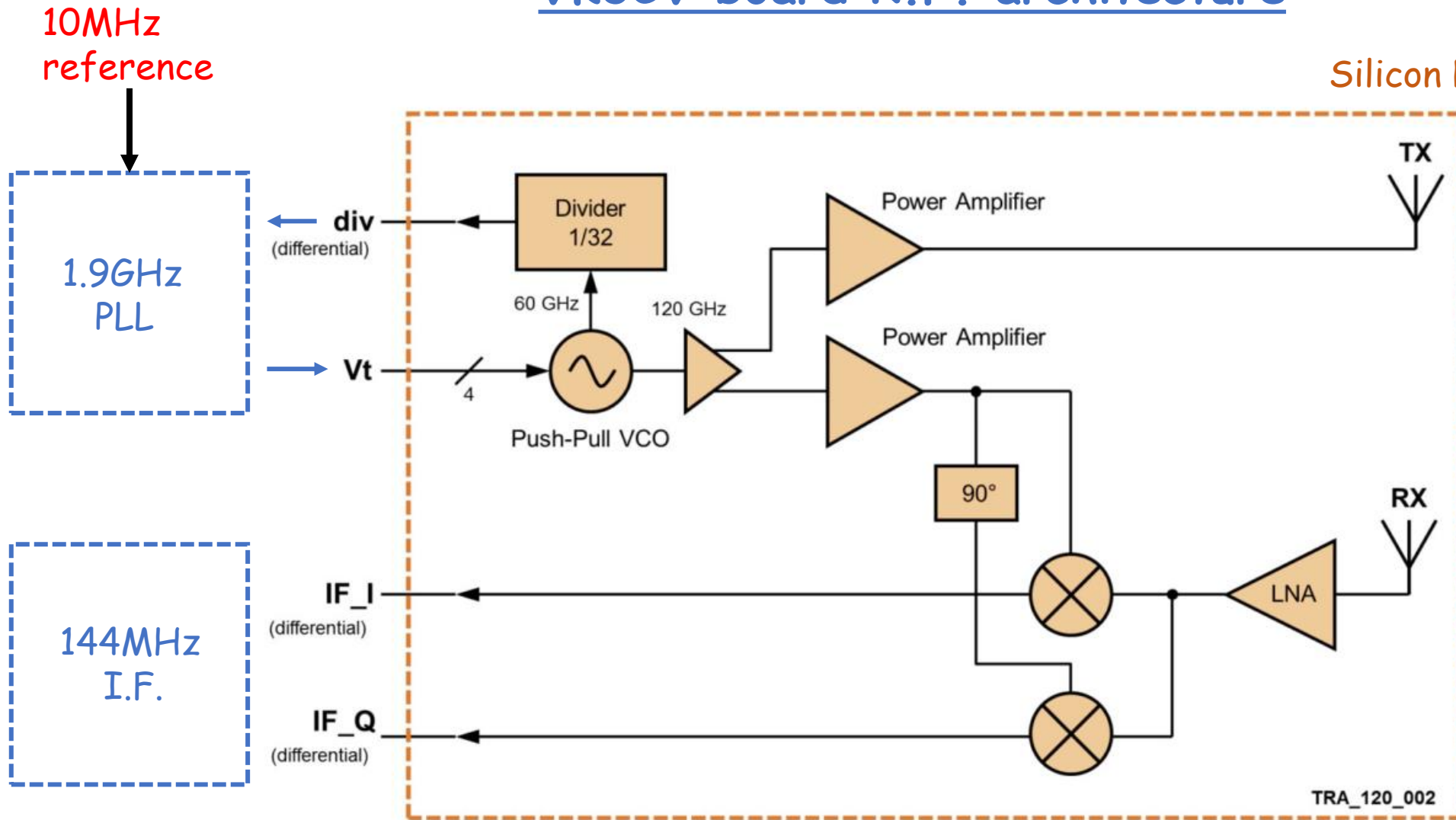
VK3CV 122GHz transceiver

- A single PCB based around the Silicon Radar TRA-120-002
- Designed for use in car collision radar systems
- I+Q receiver output
- FM only transmit by modulating the 1.9GHz reference
 - FSK CW and Hellscriber (and WSJT)
- Very simple to get on the air
- Outperforms simple mixer systems
 - But no SSB



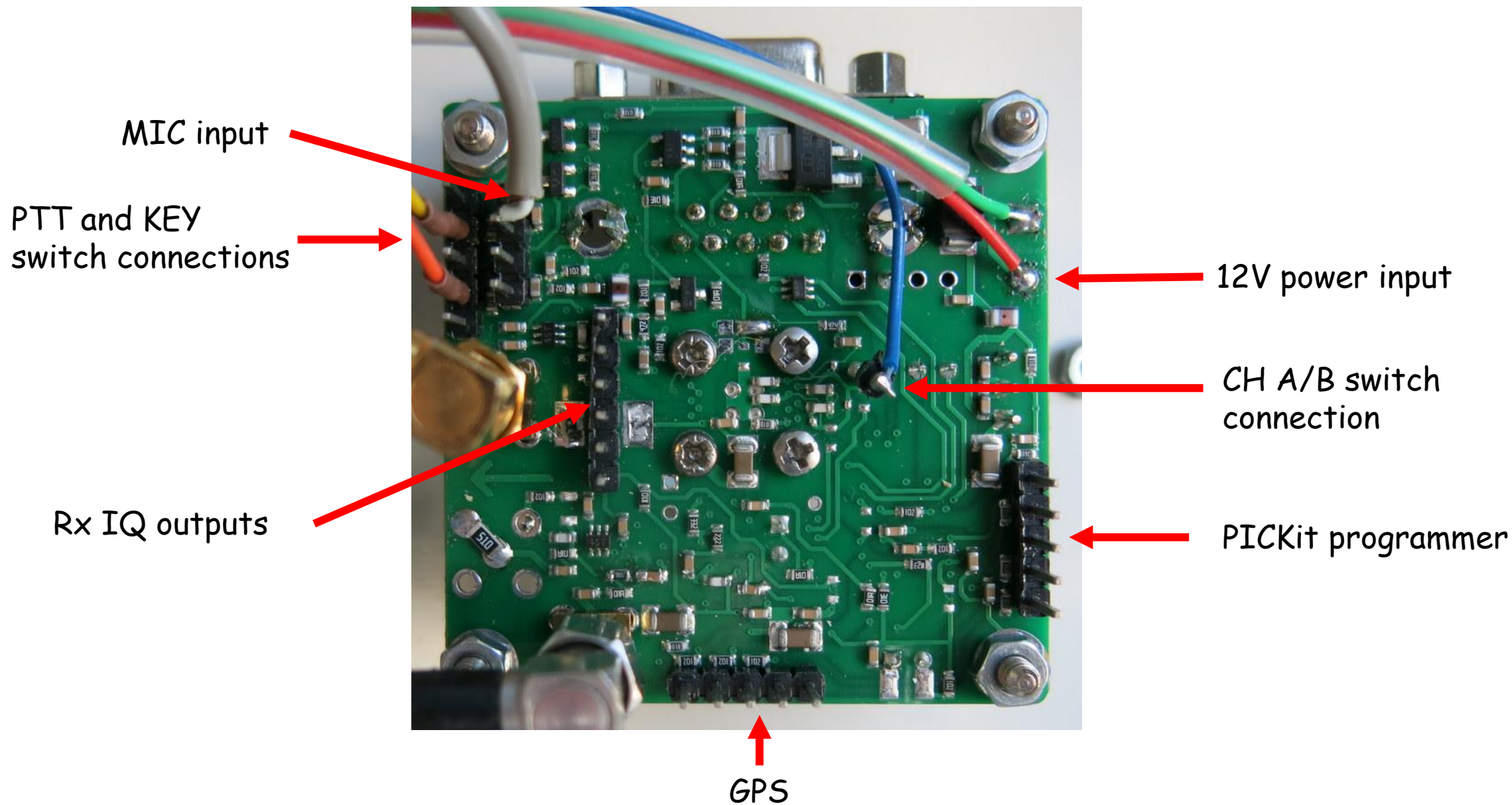
VK3CV board R.F. architecture

Silicon Radar TRA-120-002



Tx power: 0.5mW, Rx NF: 12dB (DSB), I.F.: 0 - 200MHz

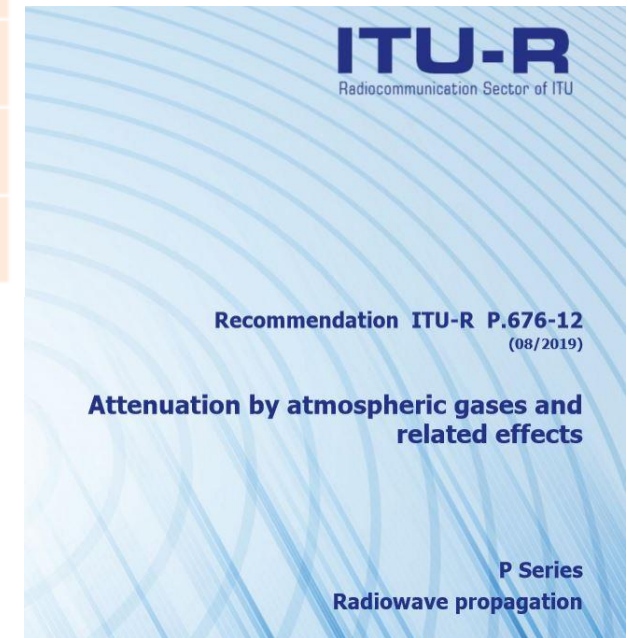
Getting the VK3CV board ready for use



Operating on 122GHz

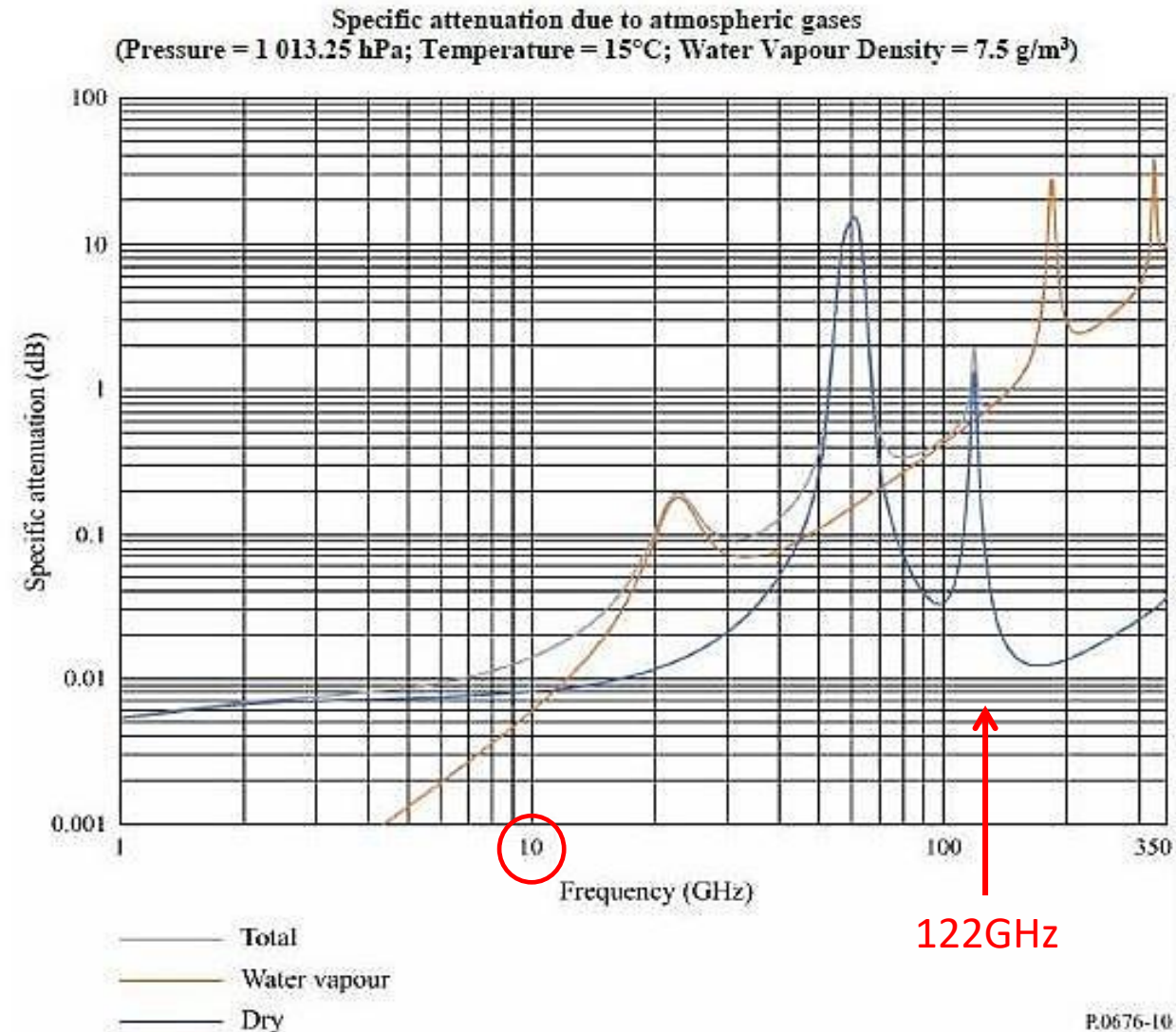
- At 122GHz all paths are LoS
 - Trees and buildings cause significant losses
 - K factor = 1 (optical)
- Dish beam widths ~ .25 degrees
 - Initial alignment and mechanical stability
- Frequency stability
 - Hi Stab or GPS locked
- Free space loss is “only” 22dB / 100km worse than 10GHz
- But atmospheric loss is a major issue at 122GHz

GHz	100km
10	-152
24	-160
47	-166
80	-171
123	-174
134	-175
241	-180



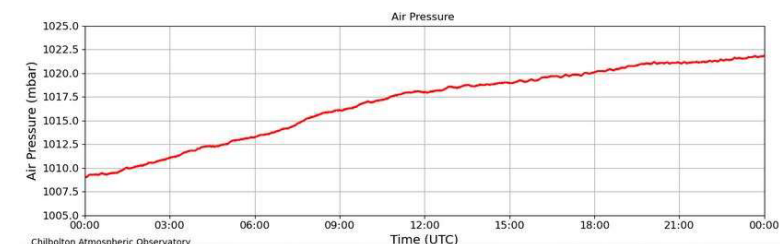
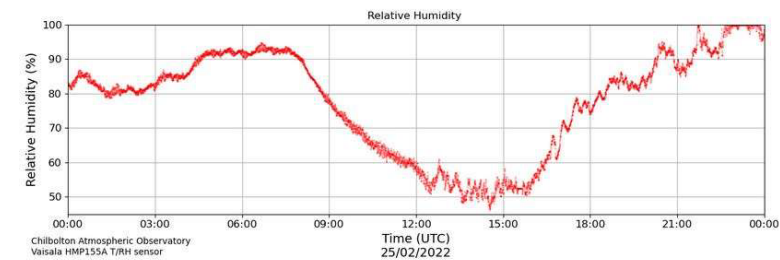
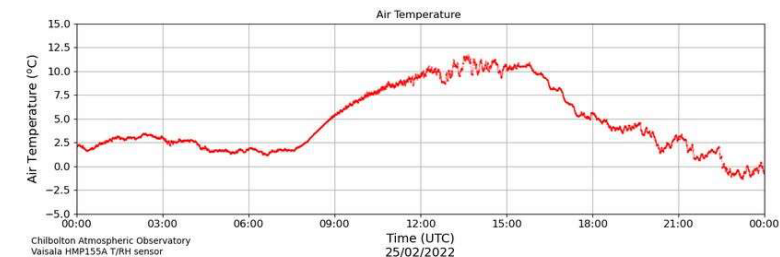
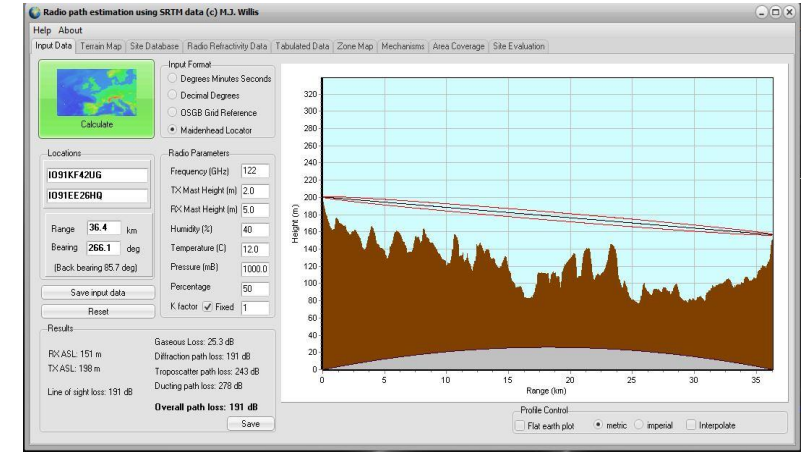
Atmospheric loss at 122GHz

- Above 20GHz atmospheric losses become an issue
 - Water vapour loss can be more than 1dB / km
 - Bit of a problem in the UK!
 - Must be added to the free space loss
- 40km path
 - Free space loss = 166 dB
 - Atmospheric loss = ~ 30dB!
- Oxygen resonances at 60 and 119GHz
 - Just clear at 122GHz – use higher part of the band
 - Less loss at higher elevations!
- Low Relative Humidity (RH) is not by itself a measure of low losses
 - Low RH on a hot day can still mean high water content and loss.
- Dewpoint is the critical measure
 - Air temperature at which saturation occurs



122GHz operation in the UK

- Path must be Line of Sight (LoS)
 - High ground is good
 - Cliff edge not plateau
 - But no oxygen loss reduction in the UK!
- Choose day carefully to minimise atmospheric losses
- Go for minimum dewpoint
 - Aim for 0 degrees or below
 - Average UK grey day is +9°
 - Texas winter day = -6° Dewpoint at 19°C
- Watch weather and pressure forecasts
- Or use the G8AGN weather box



G8AGN WeatherBox

- Stand-alone (Arduino Mega 2560)
- Real-time measurement of location and date-time
- Real-time measurement of pressure, temperature and relative humidity
- Real-time path propagation loss using ITU-676 model
- Real-time mm-wave radio system performance indicator
- Logging to SD card of weather and radio system performance data
- Help screen for key functions



Antennas?

- External antenna coupled in to by placing on top of the chip secured by 4 * M2 holes
- VK3CV project designed a 20dB horn and a Chapperal feed
- Using the VK3CV horn paths of 5km can be worked in the UK...
 - Or it can be used as a dish feed
- Lens antennas
- Dish antennas



Experimenting with antennas

- 122GHz antennas not readily available on ebay!
 - Clearly time for experimentation
- Significant gains from dishes
 - If the reflector is true
 - Mesh dishes do NOT work!
 - 122GHz wave guide is 1/16"
- Optical reflectors should work
- Good quality satellite dishes do work well
 - 60cms = 50dB+ gain at 122GHz
 - ~ same as 32mt Goonhilly 6 at 2.3GHz!



Dish gain is significant at 122GHz

Band	D = 60 cm (2')		D = 120 cm (4')	
GHz	Gain (dBi)	Beam (deg)	Gain (dBi)	Beam (deg)
10	34	3	40	1.5
24	41	1.3	47	0.65
47	47	0.66	51	0.33
80	52	0.38	58	0.19
123	56	0.25	62	0.13
134	56	0.24	56	0.12
241	61	0.13	67	0.06

Chart by K4ML

Antenna Testing

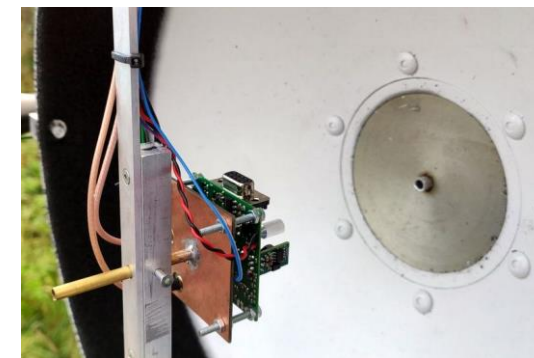
- Simple near field test range
 - 11,126.66 MHz source driving an HSM8101 diode generates a low level signal on 122GHz
 - Diode mounted at focus of WD40 can base!
 - Rxr placed ~10 metres away
- Used the VK3CV 21dB horn as a reference
- SDR# with AGC turned off
- Good for comparative tests which seemed to model real live results



Dishes



0.3 f/D dish (G4APV)

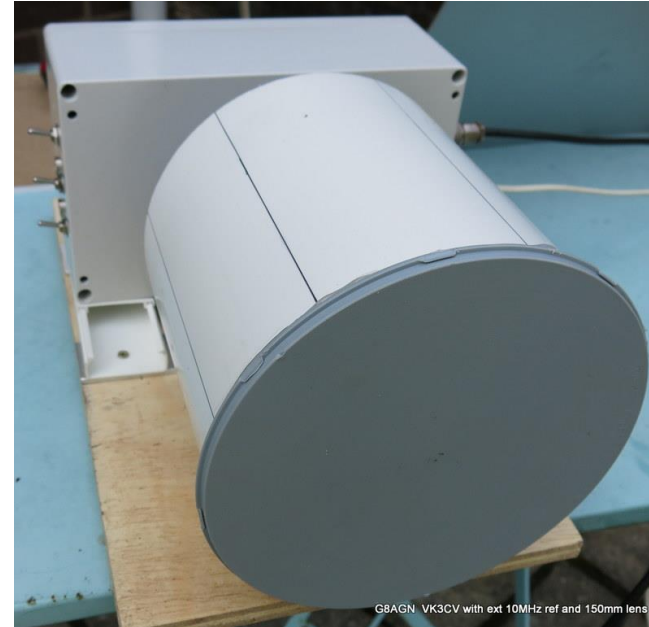


Optical dishes

- Experimented with Edmunds optical dish
- Good mirror surface but too deep
- Cassegrain worked best
- Too much blockage with direct PCB feed



Fresnel lens



Ex Philips 49GHz 150mm MVDS lens

Fresnel "page magnifiers" not effective

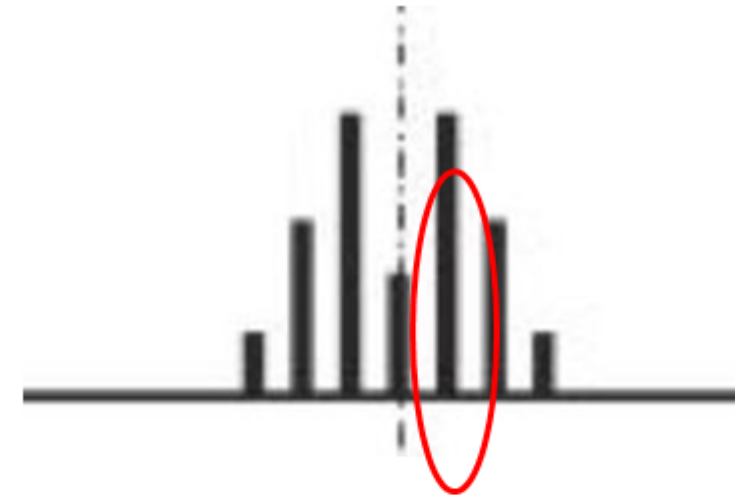
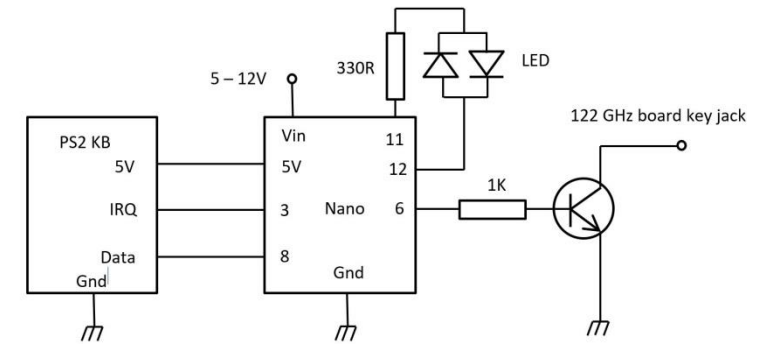
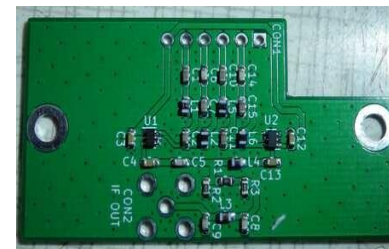
Using lower frequency dishes

- Successfully used 50GHz dishes
- G8GTZ – Nera,
 - Coupled in to circular w/g
- G1EHF – NEC Pasolink
 - Fed subreflector with VK3CV horn through back on dish
- Currently experimenting with a 76GHz dish
- Coupling in to w/g does not seem critical



Improvements to VK3CV

- Frequency stability ~~can~~ must be improved by replacing the on-board 10MHz TCXO
 - GPS 1 pps
 - 10MHz double ovened TCXO
 - Reference level can be critical
- I+Q filtering
 - Theoretical 3 – 4dB improvement from I+Q combiner
- Data modes
 - CW and Hellscriber
 - WSJT using over modulated FM (reduced carrier AM)
 - SSTV
 - Opera....



FM signal with modulation index adjusted to produce AM-RC signal

JT modes only use 1st USB component (base frequency + tone)

Methodology suggested by K6ML

First QSO 1.1km – 19/7/2020

- G1EHF/P to G8GTZ/P
- Walbury Hill to Coombe Gibbet
- LoS path
- During 24/47/76 contest weekend
- VK3CV horn to horn



2.0km – 27/8/2020

- First real QSO
- G1EHF to G8GTZ



8 & 12km paths - Aug 2020

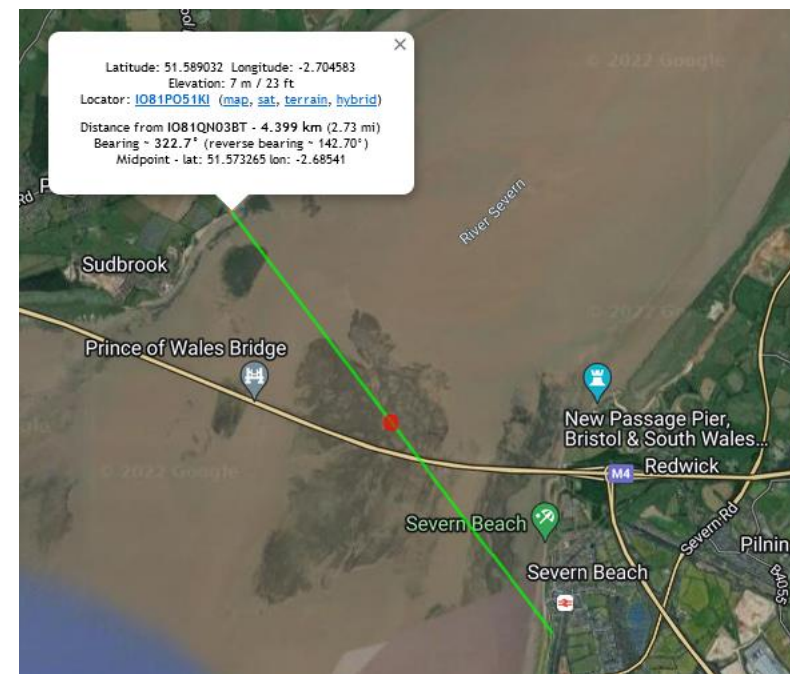
- G8GTZ
 - 30cm offset dish fed with VK3CV horn
 - SDR# on rxr at 144MHz
- G1EHF
 - NEC Pasolink 50GHz sub reflector dish
 - Fed by VK3CV chapperal at rear of dish



video

First G to GW QSO - 4/8/2020

- G8GTZ/P to GW1EHF & GW4LDR/P
- 30cms dish > 40cms dish
- 4km sea/river path through the 12th arch from the left!
- Conditions:
 - 18 deg C
 - 61%r/h
 - 1015mb
- Dewpoint = 10.4 degrees
 - But only a short path



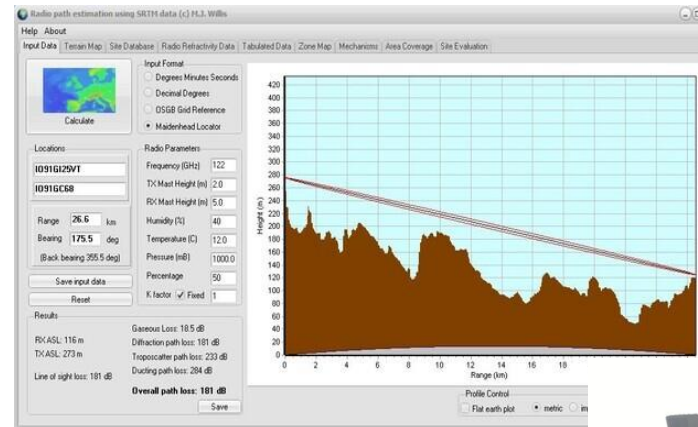
17km path – Oct 2020

- LoS but very misty / humid!
- G8GTZ
 - 47GHz dish
 - Removed w/g adapter
 - Fed VK Chaperral in to circular waveguide



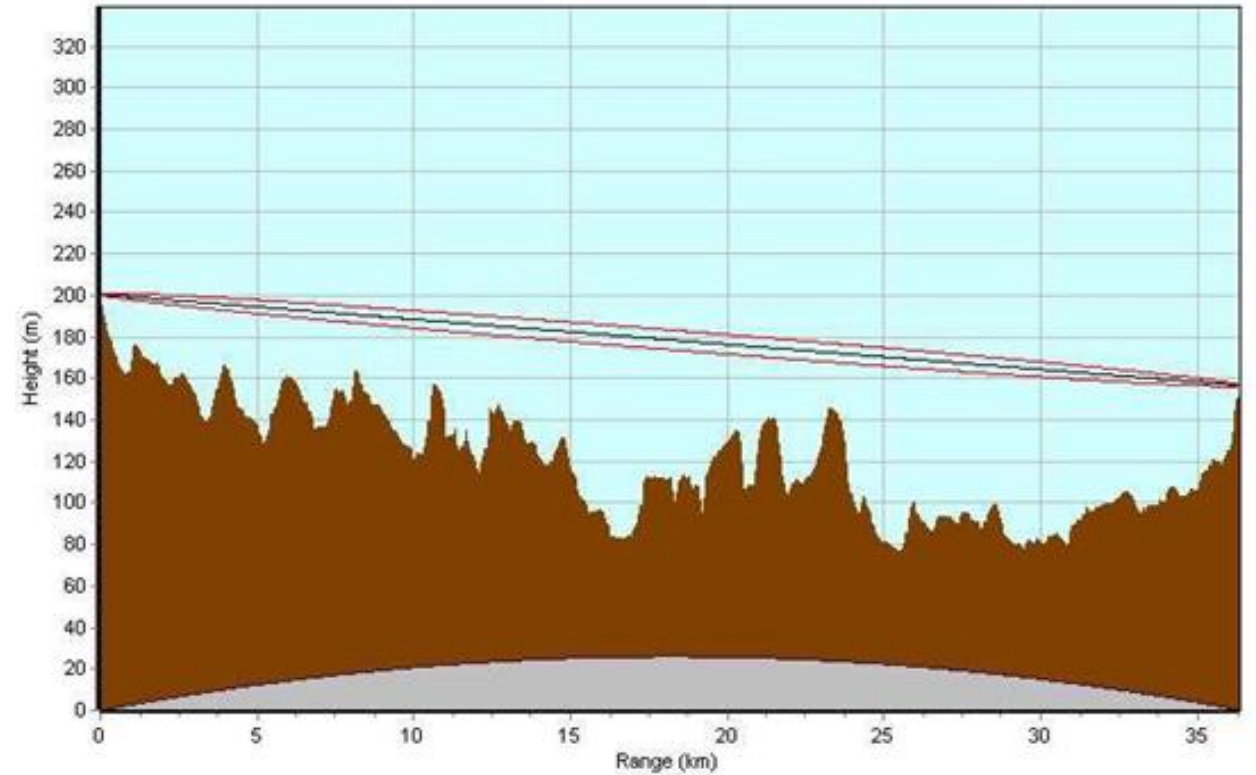
27km – 28/11/2021

- Cold and frosty morning
 - Air temp = 1 degree (felt much colder)
 - Ice on the ground!
 - Dew point -3 degrees 😊
- 26.km LoS path
 - IO91GI25 Coombe Gibbet
 - IO91GC68 Stockbridge
- Dish alignment is an issue as IO91GC is not on the horizon
 - Used LED Phlatlights
- Signals were about 14dB SNR in 220hz b/w
 - just readable on FM
 - CW is an issue for both operators 😞
- BTW - Remember the signal levels



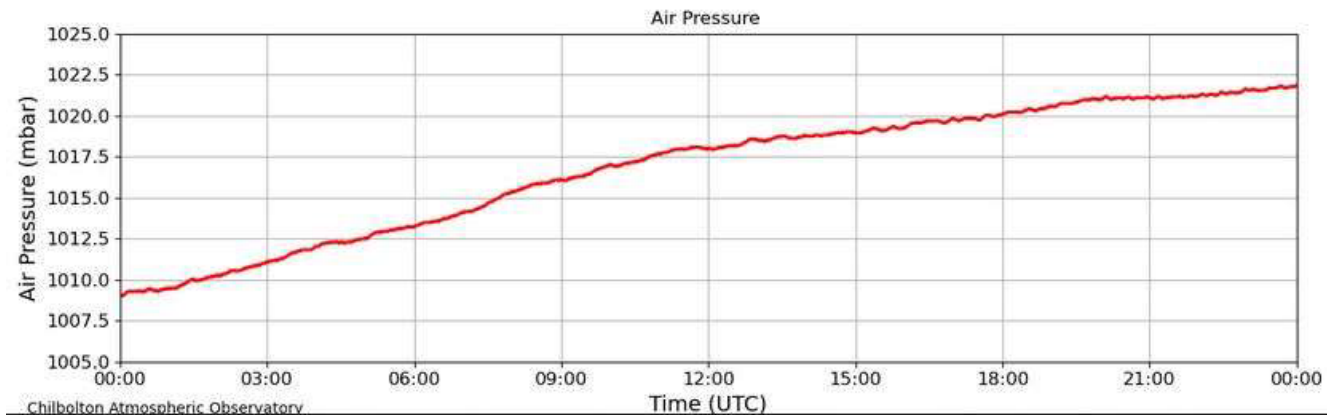
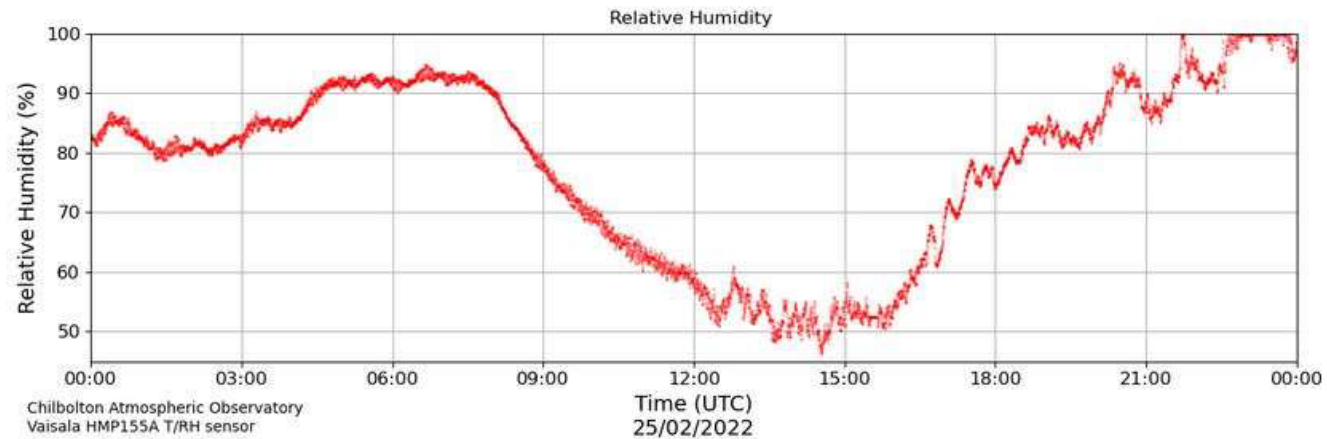
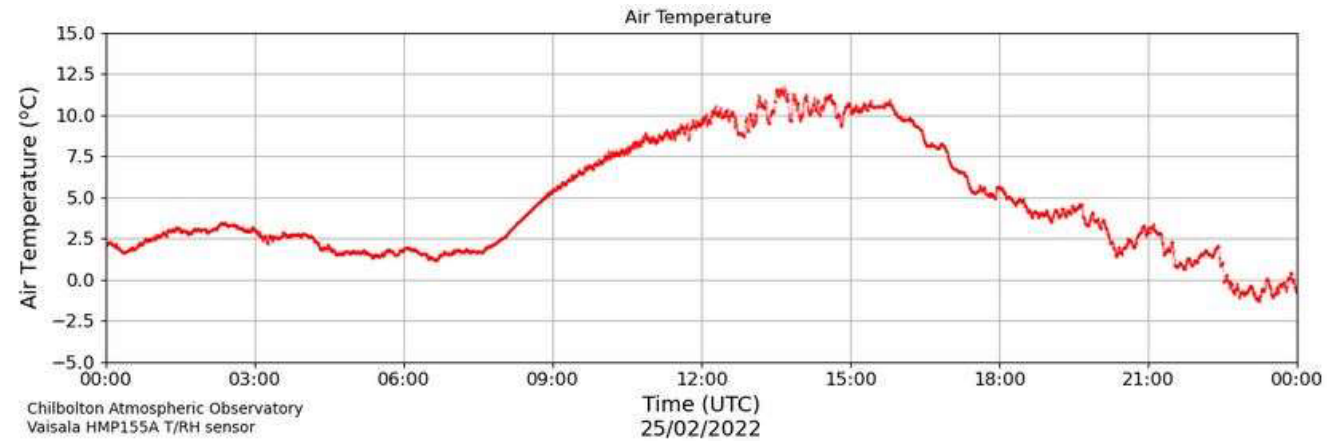
25/2/2022 – 36km and UK record 😊

- IO91KF42UG to IO91EE26HQ
 - Doesn't look special
 - But is 36.4 LoS path



Wx condx

- Chilbolton weather station was exactly half way on the path
- Although it was warmer, the RH was low
 - The Dew Point ~ -1.6 degrees
 - RH 47.1%
 - Temp 9.1 degrees
 - Pressure 1005 mBar
 - Water 4.1 g/m³
 - Gas loss 23 dB for the path



Antenna alignment

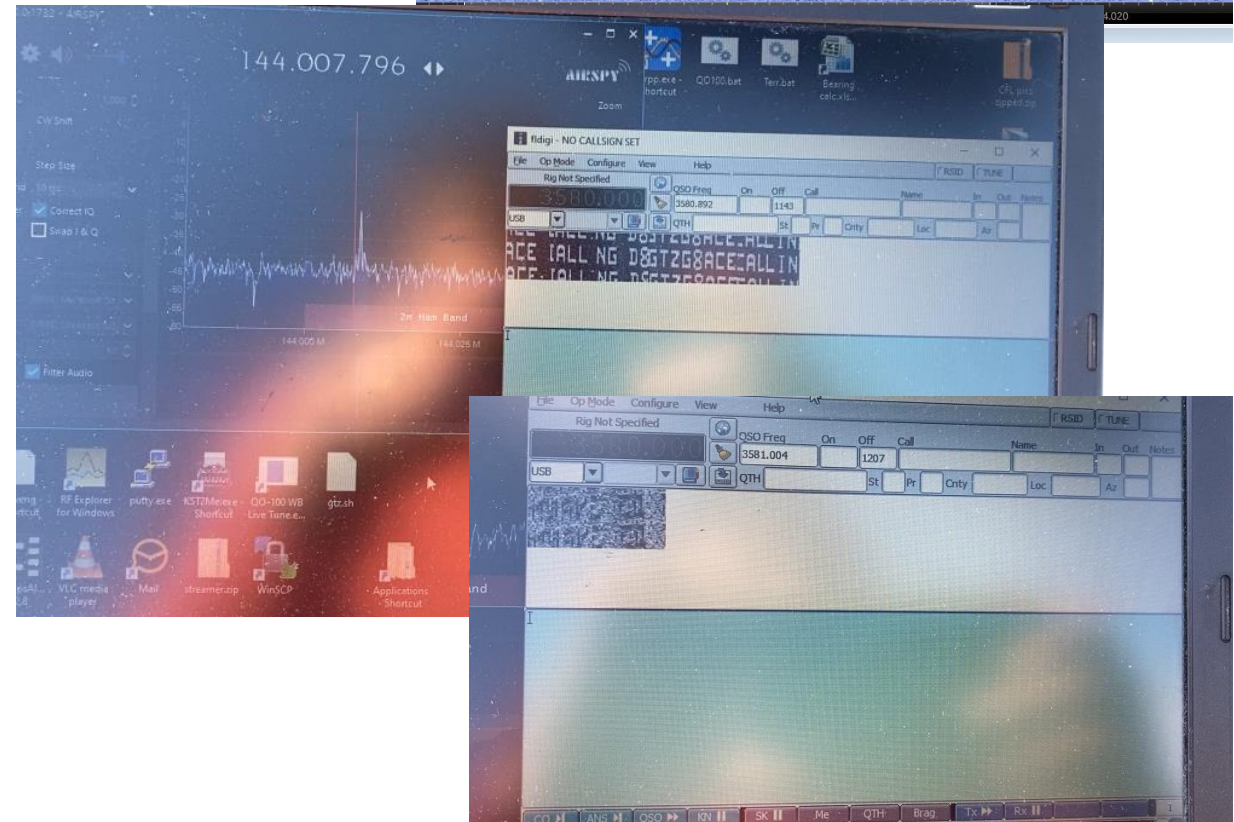
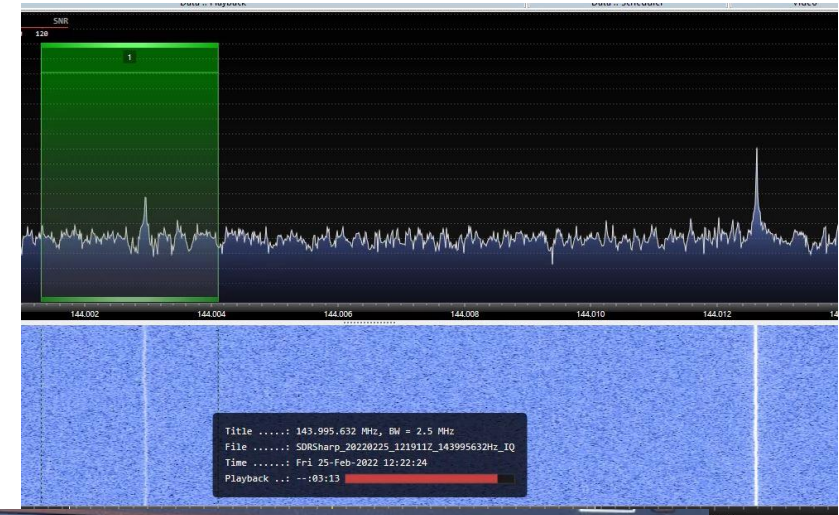
- G8GTZ was in bright sunshine
 - Flash from bathroom mirror was seen at 36km!
- G8ACE 20 watt Phlatlight was visible over the path
- Stable signals on optical and 122GHz over 3 hours

G8ACE / G1EHF equipment >



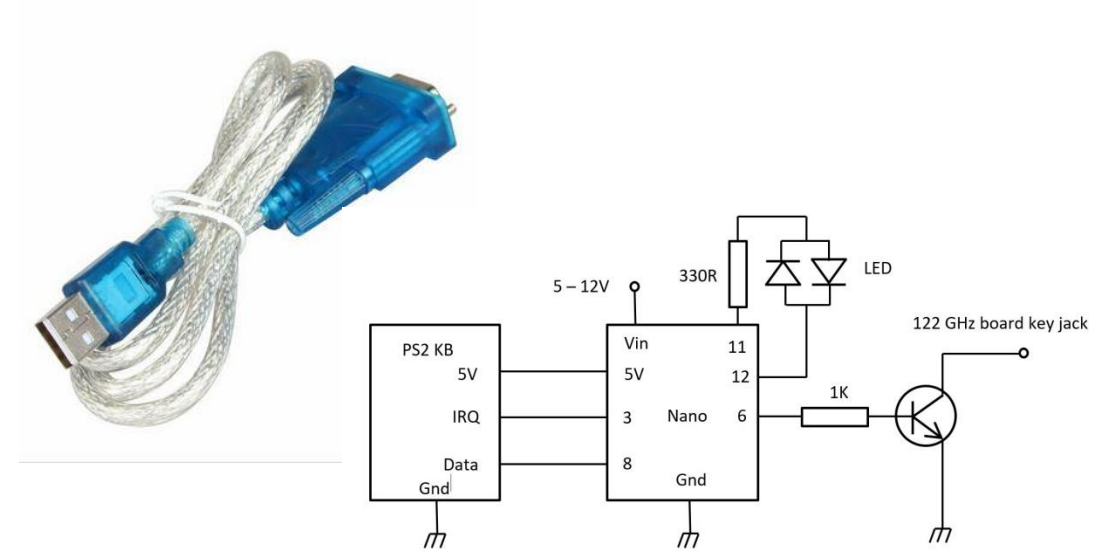
Results

- Multiple equipment at IO91KF
- G1EHF
 - VK3CV tx and Rx
 - Finningley optical tx / rx
- G8ACE
 - High power diode Tx – 5 mw
 - VK3CV rx
 - High power Phlatlight beacon
 - Optical Tx / Rx
- All stations had Helscriber on 122 and optical
- G8ACE significantly stronger than G1EHF on 122GHz
 - Completed one way FM QSO and easy Helscriber copy
- Two way QSO with G1EHF for the UK record
 - Helscriber and very, very slow CW
- Probably at the limit for VK to VK without real CW or data modes



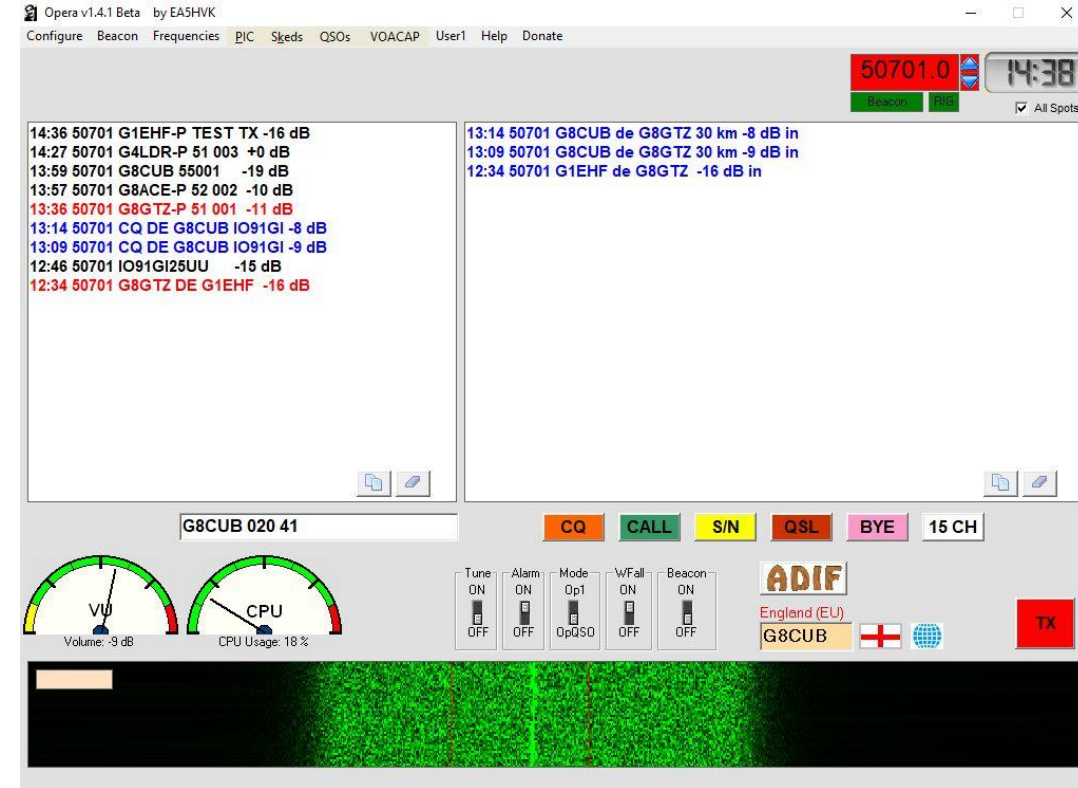
Opera data mode

- WSJT on FM is suboptimal
- GONBD suggested at the RSGB convention to try Opera
- Opera is a slow rate Manchester encoded “on / off” mode
 - Can decode down to -20dB s/n (?)
- [https://wiki.microwavers.org.uk/Digital modes using Opera](https://wiki.microwavers.org.uk/Digital%20modes%20using%20Opera)
- Software no longer supported
 - Version 1.4.1 only
 - User interface is interesting!
- PC com port fed in to the key input
 - 144Mhz shift FSK!
- Rx audio fed via sound card
 - USB dongle
 - IC705 etc



Opera tests Nov 20th 2022

- Tests over the 27km path Coombe Gibbet to Stockbridge
- Dew point as +5 degrees
 - Much higher than tests 1 year ago at -3 degrees
- Path did not go on VK to VK FM
 - Barely readable on CW!
 - Very interesting to compare with previous tests on this path
- Ideal test for Opera
 - Definitely got potential to break the 36km record



World records ☹️

- DB6NT & DK5NJ
 - Record of 157 km on 134 GHz
 - One way on 122GHz
 - 900 and 1,200mt ASL
 - -16 degree dewpoint!
- VK3CV record
 - 52km QSO by VK4GU and VK4CSD
 - 350mm offset dishes
 - -5 degree dewpoint



Summary

- Not able to beat the world records
 - No mountains
 - Dewpoint too high
- But we've had a lot of fun and learnt a lot and that's what this amazing hobby is all about!



Find out more.....

- 122GHz and the VK3CV – G8AGN, UK microwave Youtube channel



- K6ML Mmwave propagation April 2020



- K6ML building and operating 122GHz radios



- The 122GHz Project io.group

