



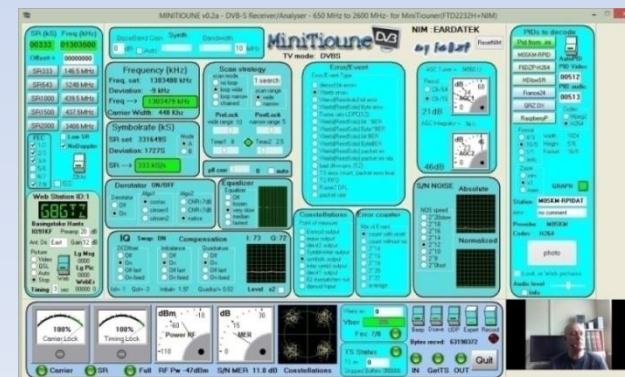
ATV on the microwave bands

Noel Matthews – G8GTZ







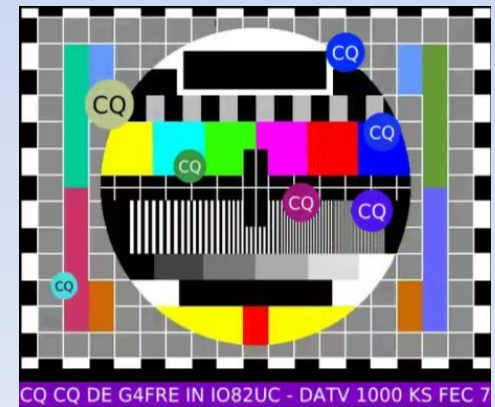
Topics

- BATC What is ATV?
- BATC Transmission Modes
- BATC Current Trends
- BATC FM ATV on 5.6 GHz
- BATC Digital ATV
- BATC ATV on 10 GHz, 24 & 76GHz
- BATC Satellite ATV








What is Amateur Television?

-  Includes video production, editing and transmission
-  Covers classic camera restoration right through to transmitting live pictures from a Raspberry Pi on a tethered drone.
-  Real freedom to experiment
-  ATV generally refers to fast-scan TV



Transmission Modes

-  **Amplitude modulation (DSB/VSB)**
 - Now rarely used due to bandwidth
-  **Frequency Modulation**
 - Lower Deviation still used on 23cms and 3cms
 - Higher Deviation used on 6cms
-  **Digital DVB-S and DVB-S2**
 - All bands, various bandwidths
-  **Digital DVB-T and GMSK**
 - Rarely used in UK
-  **Internet Streaming**



Band-by-Band

71 & 146 MHz

- The “new” ATV bands
- RB-TV

70cms

- Digital only on 437MHz

23cms

- Analogue and digital
- Activity on repeaters and simplex

13cms

- Still room after PSSR!
- Repeaters and simplex
- Oscar 100 uplink

3.4 GHz

- Digital only
- Repeater outputs

5.6 GHz

- FM ATV for under £20
- Repeater inputs

10 GHz

- Repeaters and simplex
- FM and DATV
- Oscar 100 downlink

24 / 47 / 76GHz

- DATV
- 120 kms is the goal



Low cost 5.6 GHz FM ATV

 Using tx and Rx made for drone FPV use

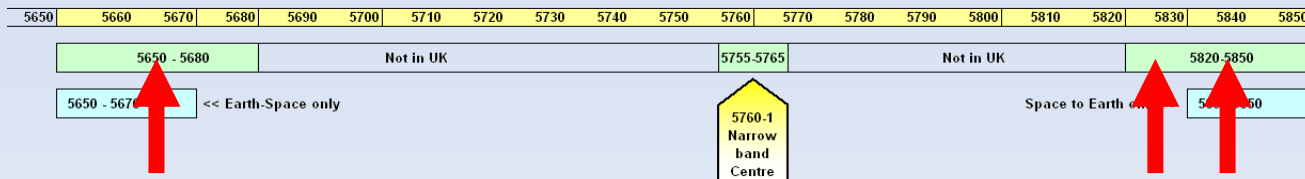
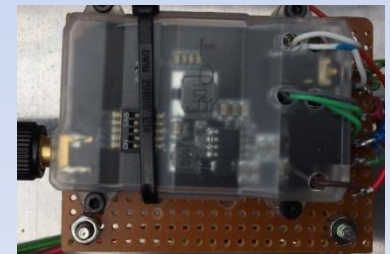
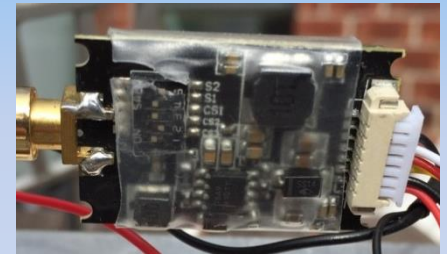
- Tx = 600 Milliwatts out
- Rx = -85 dBm
- 27MHz wide

 Available on ebay!

 Cover UK amateur Band

- 5665 MHz

 They just work out of the box!



The system

- ⓑ Wire up power, video and audio
 - Beware blue screen and Reverse SMA!
- ⓑ Connect antennae
 - 5.8 Ghz wi fi or Sky dish (available from the local tip!)
 - SMA relay is the most expensive bit!
 - Single or 2 ant working

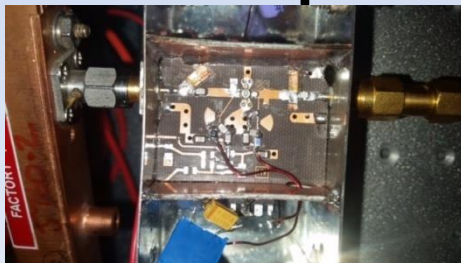


5.6Ghz on the air

- BATC** Clear line of site paths
 - 50Km is easy
 - Best DX so far = >153 Km
 - 350Km with tropo!

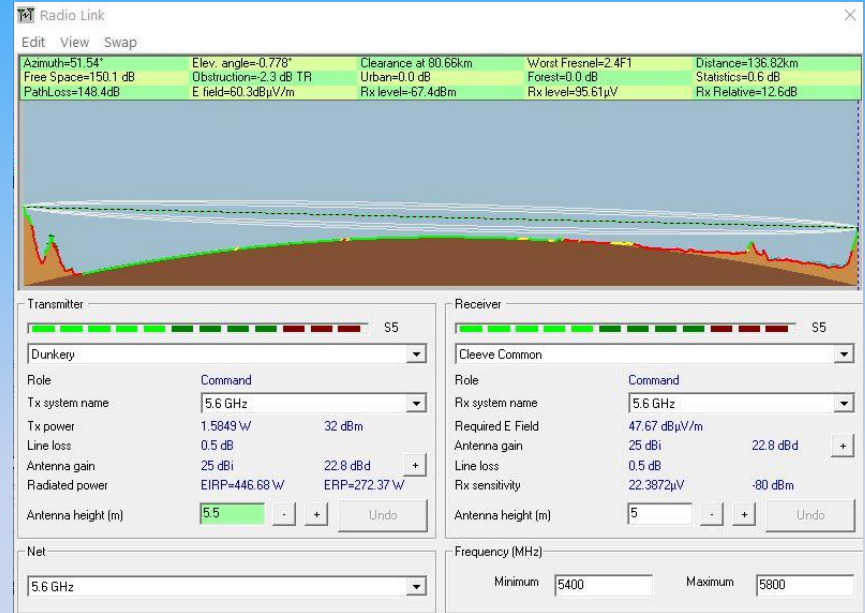
- BATC** Also used for WB voice
 - PW Siren project

- BATC** Great club project
 - Backpack /p!



Paths

Blorunge to
Win Green
111 km
obstructed



Dunkery to
Cleeve
Common
136 km LoS

ATV is going Digital

- **The move to digital is happening**
 - First tests in ~ 2000
 - Pressure on spectrum eg 13cms
 - A new challenge
- **Broadcast standards are being adopted and adapted**
- **DVB-S at 66KS > 4 MS**
 - 100 KHz > 6 MHz Bandwidth
- **Significant bandwidth gains and better pictures**
- **DVB-S2 and H265 give even more gain**



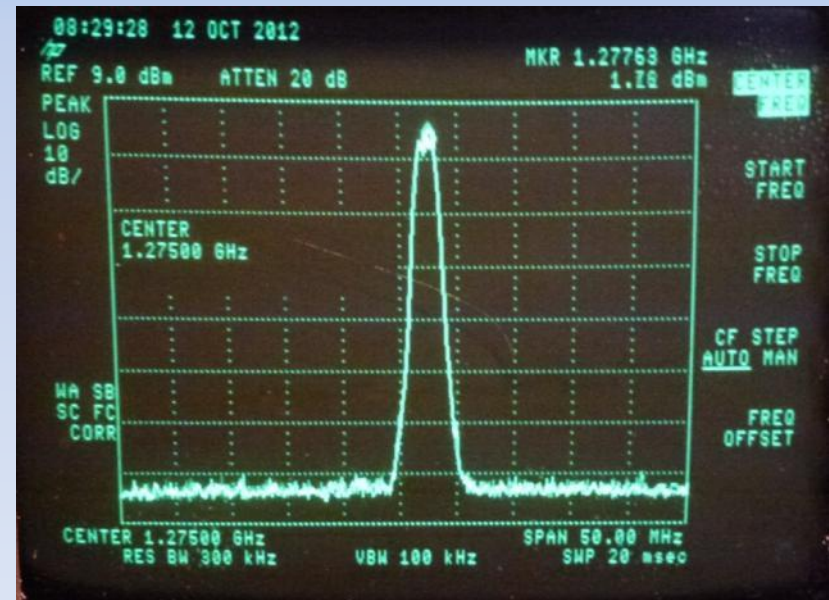
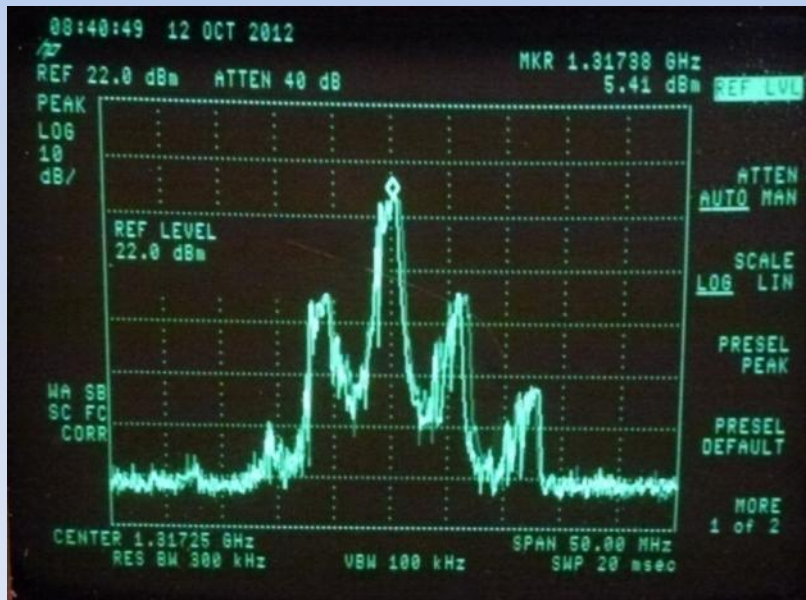
Analogue vs Digital ATV

FM analogue

- 16 MHz deviation
- ~ 16 MHz

DVB-S QPSK,

- 1.6 MS, $\frac{1}{2}$ FEC
- ~ 2 MHz



Analogue vs Digital ATV



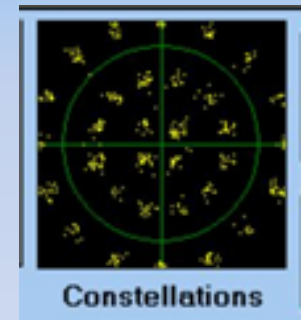
Reduced Bandwidth (RB-TV)

- Not enough space for “normal” DVB-S on the lower bands so we invented RB-TV
- RB-TV is “normal” fast scan DATV at <1 MS
- Live TV in ~450Khz bandwidth (333 Kbit/s video)
- Based on DVB-S standard BUT...
 - Benefits from MPEG-4 / H265 encoding for transmit
 - “Normal” satellite RX won’t work below 1 MS
- So the ATV community has developed TX and RX products
 - Portsdown DATV TX
 - MiniTiouner RX
- Significant power/bandwidth gains
 - DVB-S2 in 500KHz decodable <5 dB above noise
 - RB-TV will go when FM signals are S9



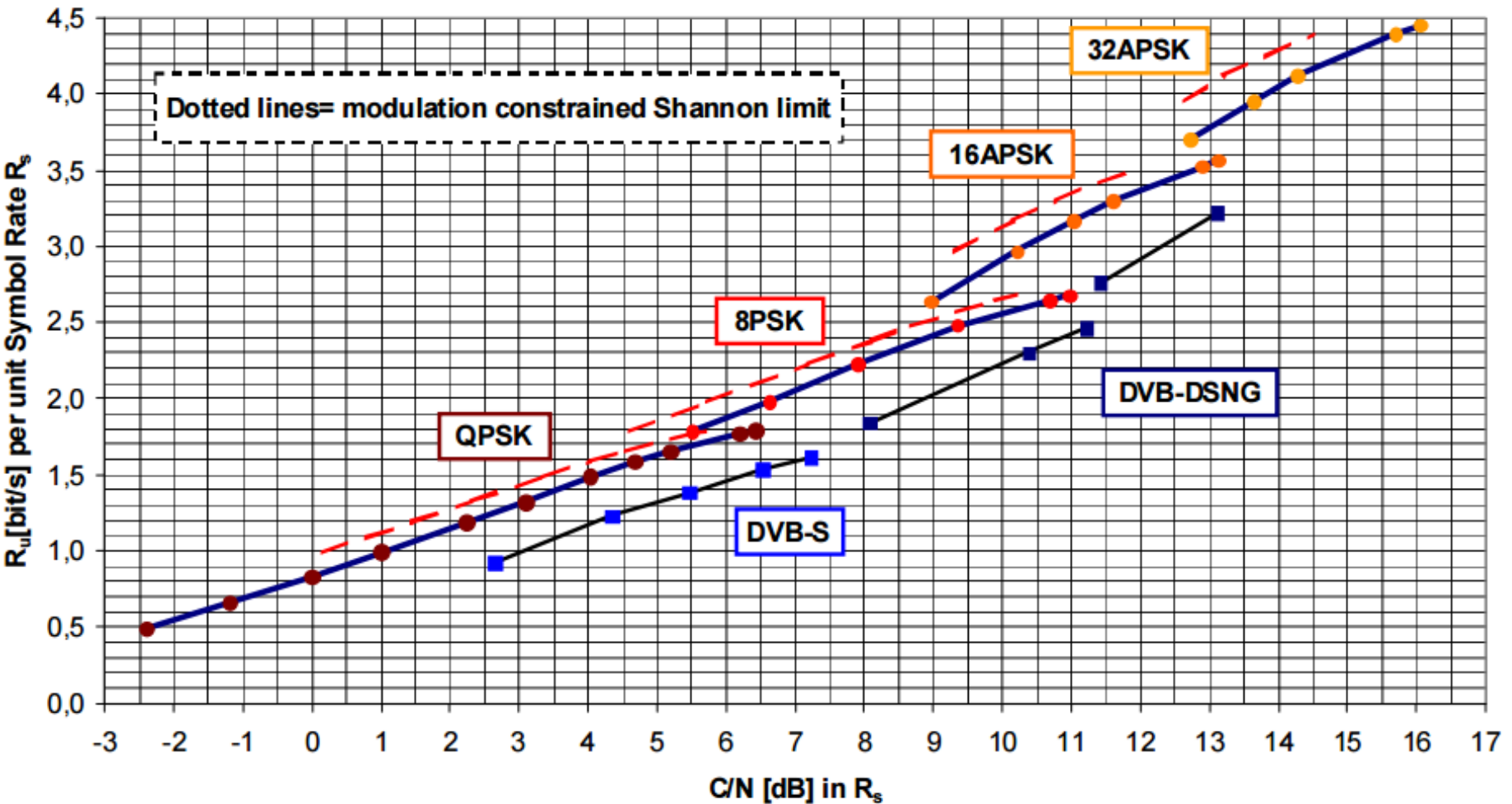
DVB-S2

- **DATV has used DVB-S for last 10 years but equipment is now available to tx and rx DVB-S2**
- **Originally deployed on satellites as it is capable of carrying more bits/hz**
 - HD in the same bandwidth as SD
- **Operates closer to the Shannon Limit**
 - 2 -3 dB gain over DVB-S
 - Proven in on-air tests
 - Significant when limited to 50 watts erp
 - Helps achieve 50+ dB spectral re-growth!
- **Enables higher bit rates in reduced bandwidth**



DVB-S2 vs DVB-S

Spectrum efficiency versus required C/N on AWGN channel



DVB-S2 results

BATC Tests on Oscar 100 show S2 does give some valuable gains

BATC At 1/2 FEC 2 MS

- DVB-S2 needs 3 dB less power than DVB-S
- going from 1/2 to 1/4 FEC needs 4 dB less power

BATC Or can be used to provide higher payload

- DVB-S2 with 32APSK, 7/8 FEC gives 1.4 Mbit/s in 500Khz
- Enough bit for 1920 * 1080 High Definition video on 146 MHz!

BATC Also experimenting with H265 codecs

- 50% bit rate saving!

The screenshot displays the MiniTouner v0.6d software interface. The main window shows a video feed of a person holding a MiniTouner device. The interface includes several control panels:

- SR (kS) Freq (kHz):** 00333, 00146500
- Offset:** 00000000
- SR List:**
 - SR333: 146.5 MHz
 - SR125: 437 MHz
 - SR250: 1249 MHz
 - SR1000: 2395 MHz
 - SR4167: 71 MHz
- DVB mode:** DVB-S2 (selected)
- FEC:** 1/2 (selected)
- Format:** 4/3 (selected)
- Width:** 1920
- Height:** 1080
- Format:** ?
- Station:** Station1
- Provider:** DVB-S
- Codec:** H264
- Audio level:** 0
- TS Status:** TS err 0, TS Buffer: 7896 bytes
- Bytes recvd:** 65073192

Generating DATV

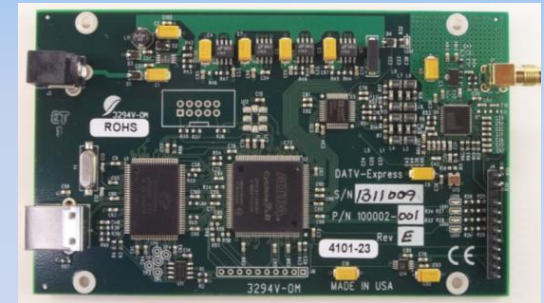
 Ex-commercial encoders

 Amateur Market:

- SR Systems Equipment
- BATC DTX-1
- DATV Express

 “Homebrew”

- DigiLite – PC-based, external modulator
- DigiThin – RPi-based RB-TV only
- Portsdown – RPi-based, full bandwidth



Portsdown 2019

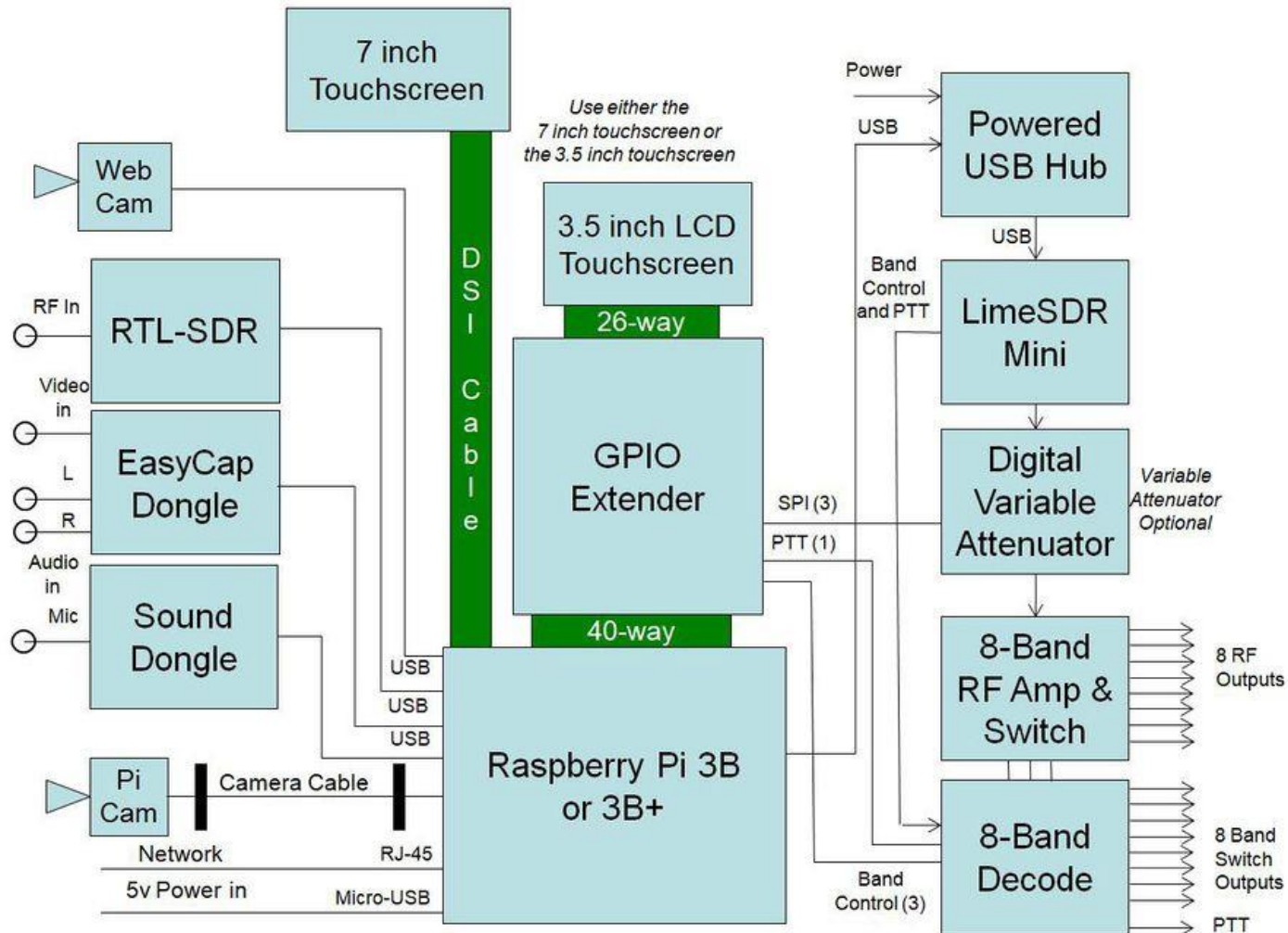
- BATC** BATC project to bring DATV to everyone
 - All the common modes and bandwidths
 - 28MHz to 3.4GHz
- BATC** Based around RPi3 and Lime SDR Mini
 - MPEG 2 / 4 encoding
 - Touch screen control
- BATC** Requires some hands on construction
 - “I made that!”
- BATC** Easy way to get on air at low cost



BATC Portsdown Transmitter Main Menu




| TX | | RX | | M2 |
|------------|----------|-----------|-----------|-----------|
| Modulation | Encoder | Output to | Format | Source |
| DVB-S | MPEG-2 | UGLY | 4:3 | Pi Cam |
| Freq | Sym Rate | FEC | Band/Tvtr | Att Level |
| 1255 MHz | 4000 | 7/8 | 23_cm | -10.00 |
| EasyCap | Caption | Audio | Atten | |
| Comp Vid | On | Auto | NONE | |
| Preset 1 | Preset 2 | Preset 3 | Preset 4 | Store |
| 146.5_333 | 437_1MS | 1255_HD | 437-Ugly | Preset |

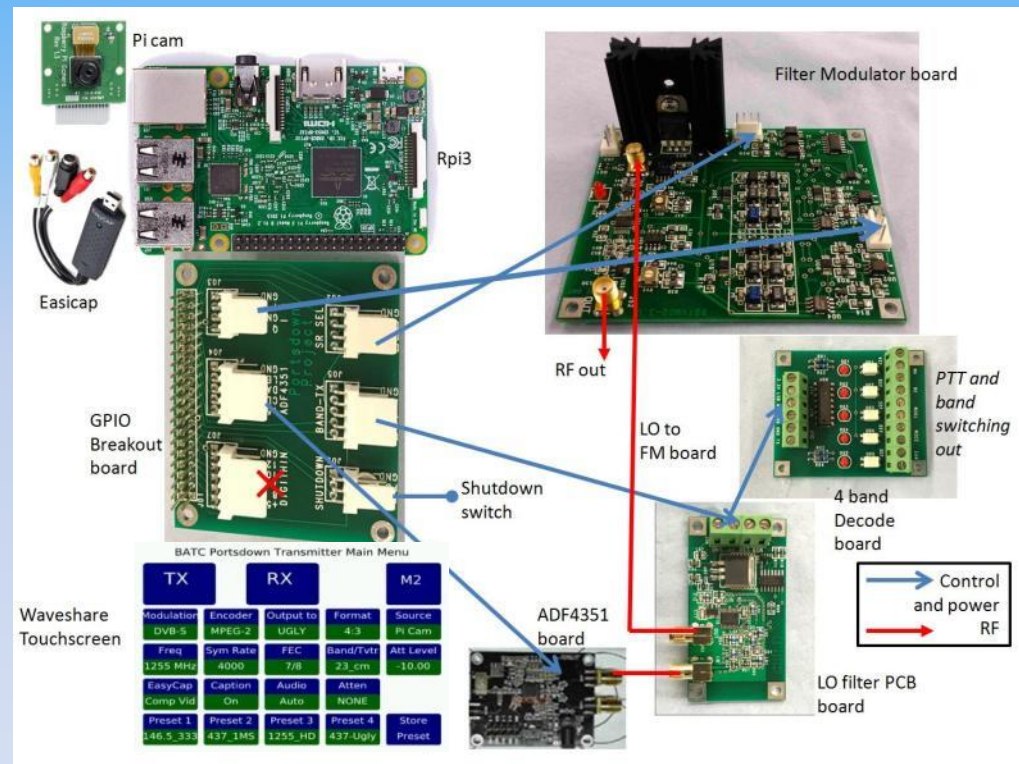
Portsdown 2019 system



The Portsdown 2019 ATV Transmitter

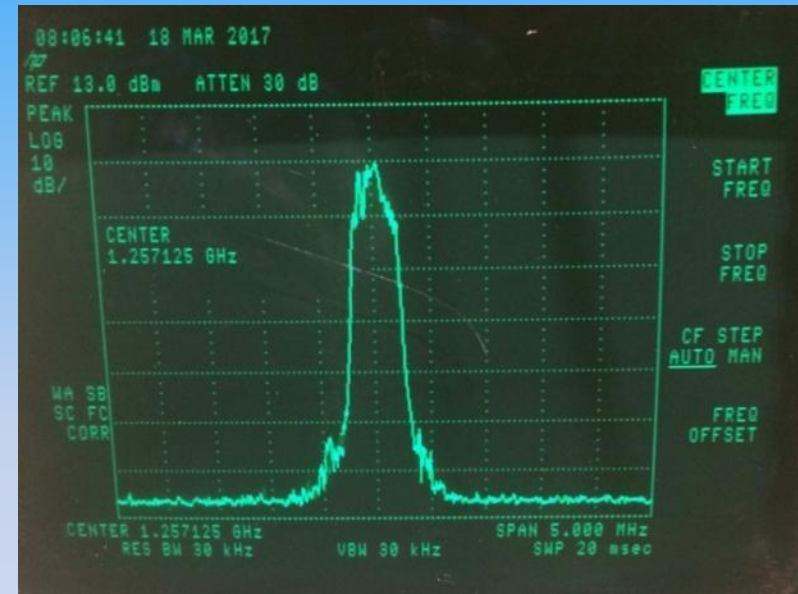
Portsdown made easy

-  All hard to get or critical components in BATC shop
-  Full set of PCBs and LimeMini from BATC shop
-  Pre-programmed SD Card from BATC shop or self-build







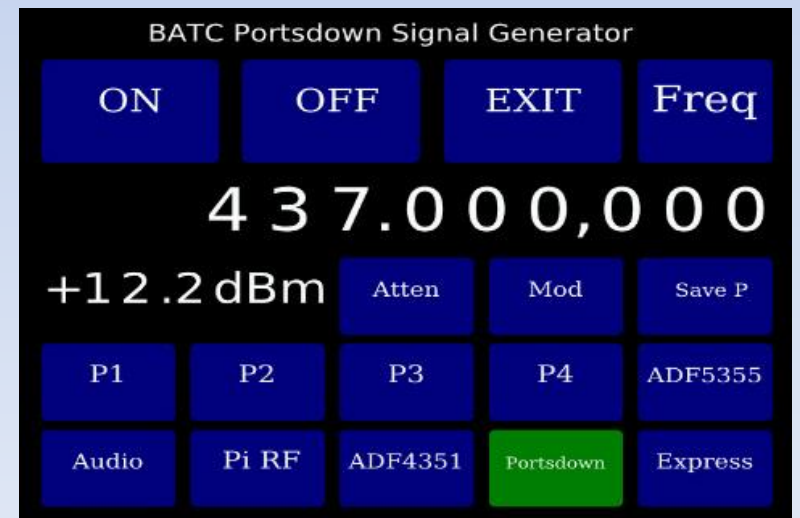
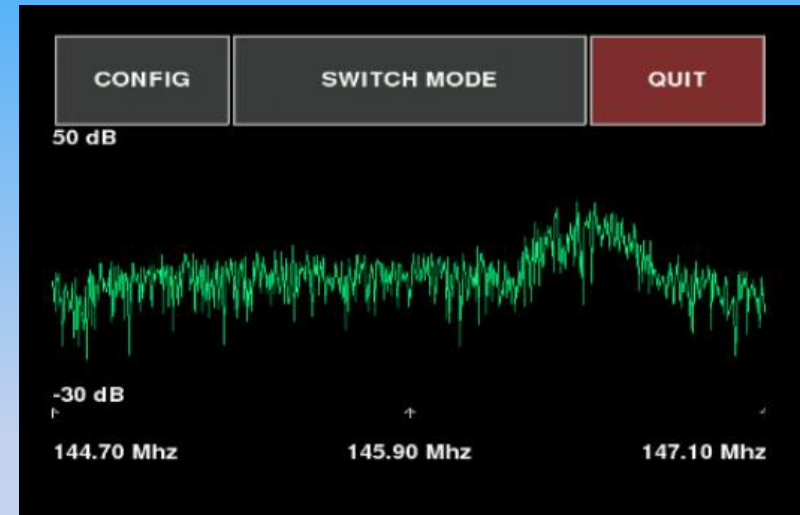
Portsdown Specs

- 30MHz to 3.5GHz
- 88KS to 1 MS
- MPEG-2 and MPEG-4 encoding
- Touch screen or PC control
- PTT and band switching control
- Analogue Video out with test patterns








Portsdown 2019

-  Not just a DATV system!
-  Portsdown is being developed by the ATV community
 - Code is on Git Hub
-  Latest developments include:
 - Microwave transverter switching
 - Spectrum monitor
 - FM receiver
-  All from the standard software!



MiniTioner

-  Satellite TV tuner with USB interface
-  Receiver / analyser software by F6DZP
-  Tunes 144 – 2600 MHz
-  Symbol Rates 66 KS – 30 MS
-  Kit or ready-built



A screenshot of the MiniTioner software interface, showing a receiver/analyser window. The interface displays various parameters and controls for DVB-S/S2 reception. The main window shows a video feed of the hardware being held by a person. The interface includes a list of symbol rates (SR) and their corresponding frequencies, a 'Web Station ID-1' section, and a 'PIDs' section. The bottom status bar shows carrier lock, timing lock, power, MER, and constellation data.

| SR (KS) | Freq (kHz) |
|---------|------------|
| 00333 | 80146500 |
| SR333 | 146.5 MHz |
| SR125 | 437 MHz |
| SR250 | 1249 MHz |
| SR1000 | 2395 MHz |
| SR4167 | 71 MHz |

Web Station ID-1
Harwell 109110 Preamp 20 dB
Ant. Dir. East Gain 12 dB
Picture: Video DVB-S DVB-S2 AUTO
Lg Msg 1000
Lg Pic 1000
Web 1000
WebEz 0

PIDs
Pid from: any
Station1
GDMW/H264 00256
HDlowSR
France24 00257
QRZ DK
RaspberP
Format: 4/3 Width: 1320
 16/9 Height: 1080
 1/1 Format: ?
Zone: auto
 adjust
 H4 ESC to change 5 display format
Station: Station1
Info: DVB-S
Codec: H264
photo
Audio level:

Carrier 100%
Timing Lock 98%
Power RF -60 dBm
MER 15 dB
Constellations
Viterbi on 0
Fec 3/4 32APSX
Bytes recvd: 65073192
TS Status
TS on 0
TS Buffer: 7896 bytes
IN GetTS OUT

Minitioune s/w

MINITIOUNE v0.8s - Receiver/Analyser DVB-S/S2 144 MHz to 2450 MHz - SRmini=65 kS/s - for MiniTiouner/MiniTiouner-Pro

SR (kS) Freq (kHz)
01000 10496200

Offset-> - **09749924**

| | |
|--------|-------------|
| SR1000 | 10495MHz |
| SR500 | 10496MHz |
| SR250 | 10497MHz |
| SR333 | 10498MHz |
| SR125 | 146.5 Serit |

Low SR DVB mode
 FEC DVB-S
 1/2 3/5 DVB-S2
 2/3 3/4 AUTO
 4/5 5/6 1/4
 6/7 7/8 1/3
 8/9 9/10 2/5

Web Station ID:2
68677

Hampshire UK
1091KF Preamp 20 dB
Ant. Dir. All Gain 30 dB
Picture
 Video Lg Msg 1009
 QSL Lg Pic 23811
 Auto Web
 Stop WebEr

Timing 3 sec 0

PIDs

Pid from .ini

| | |
|------------|------------------|
| G4KLB | AutoPID |
| F6DZP-H264 | PID Video |
| HDlowSR | 00256 |
| France24 | PID audio |
| QRZ DX | 00257 |
| RaspberryP | Codec |

Mpeg2
 H264
 H265

Format
 4/3 Width: 704
 16/9 Height: 576
 1/1
 auto Audio
 adapt MPA
 x1 AAC
 maxi AC3

GRAPH

Station **G4KLB**
infos: DVB-S2
Provider: G4KLB
Codec: VH264 + AAC

photo

Audio level

Info ISS

Carrier Lock 43% Timing Lock 46%

Carrier SR Full

Power RF -34dBm S/N MER 2 dB

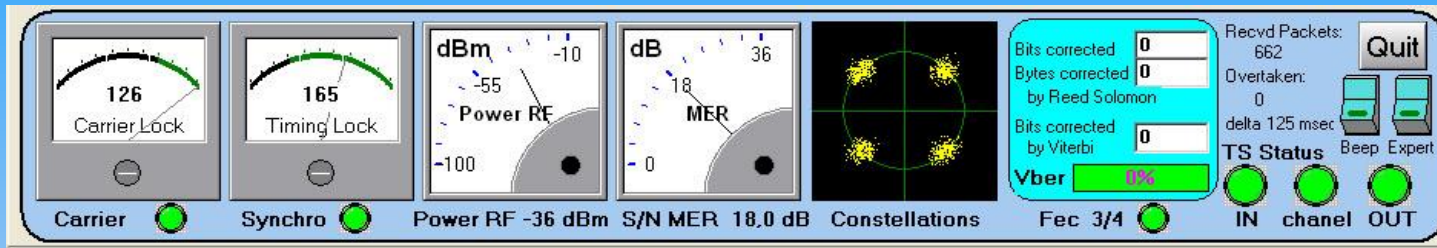
Constellations

Viterbi err 0
Vber 0%
FEC 1/2 QPSK
TS TS err 0
Bytes recvd: 32900

Beep Dsave UDP Record

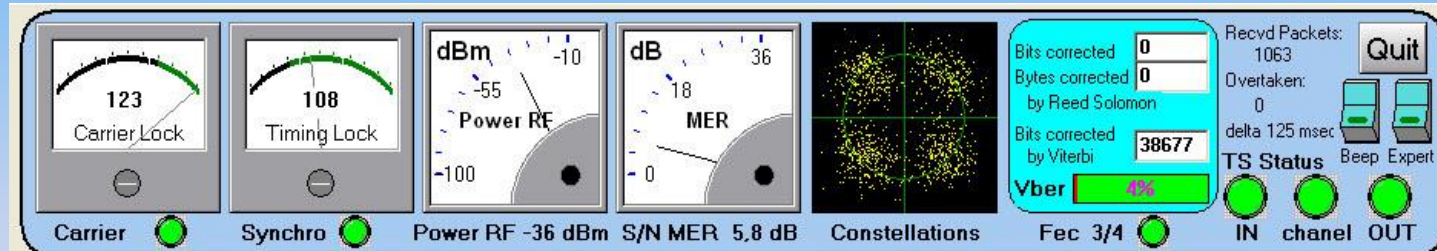
Expert Quit

Forget the S meter!



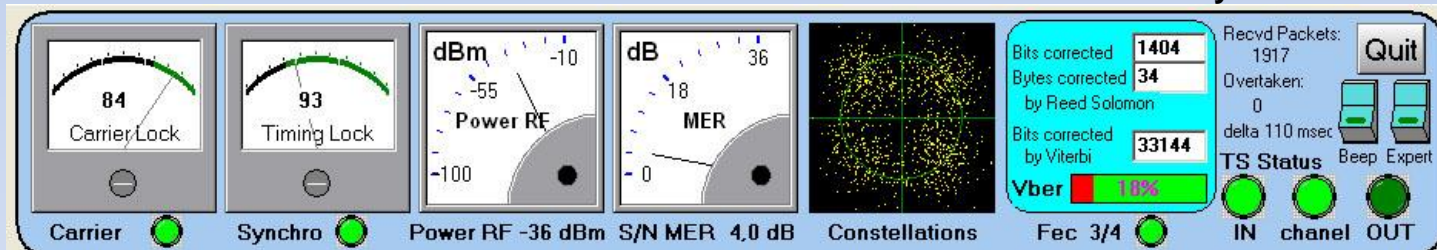
MER 18dB ----RF level -36dBm ----VBER 0% not bit corrected

→TS OK



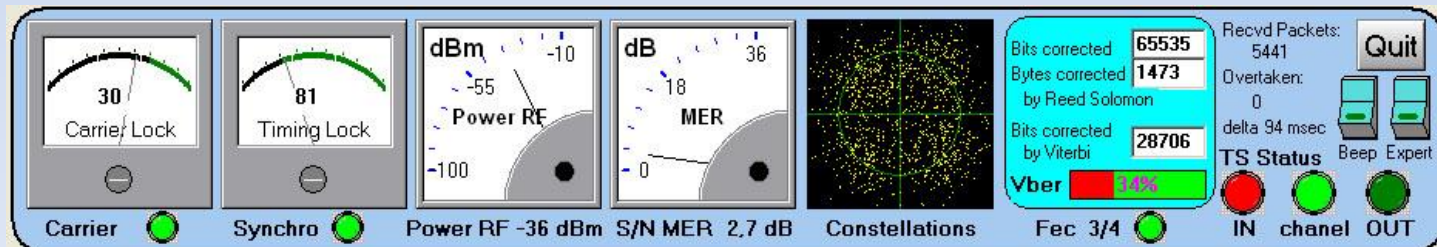
MER 5.8dB ----RF level -36dBm ----VBER 4% bits corrected by Viterbi

→TS OK



MER 4dB ----RF level -36dBm ----VBER 18% bits corrected by Viterbi and Reed Solomon

→TS OK



MER 2.7dB ----RF level -36dBm ----34% bits corrected by Viterbi and Reed Solomon

→TS NOT OK

Microwave DATV

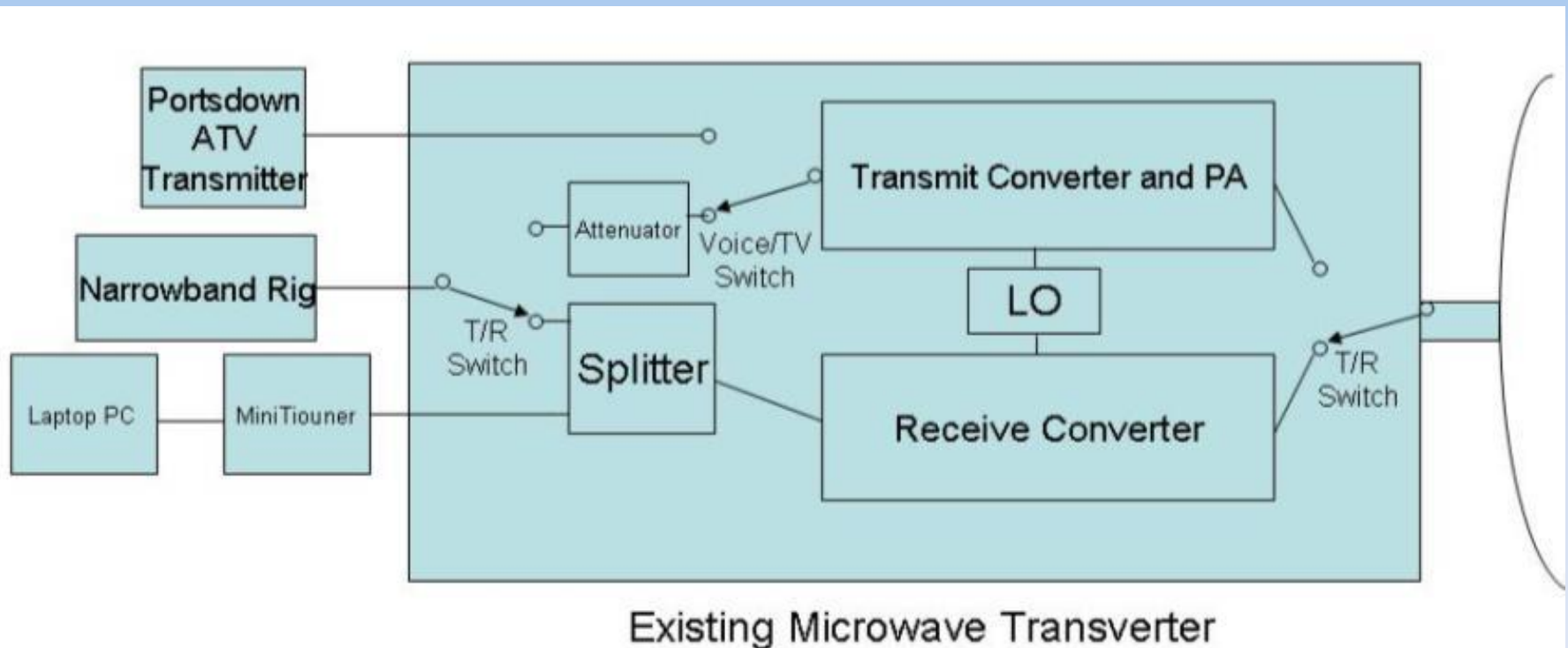


- **DATV needs linear transverter Tx**
 - FM ATV can be multiplied up
- **Microwave transverters use 144 or 432 as an IF**
 - 2.3, 3.4, 5.6, 10GHz, 24 GHz
- **Portdown covers 144 and 432MHz**
- **MiniTiouner covers 144 and 432MHz for receive**
- **So what happens if we drive the transverter with DATV?**
 - It just works on Tx and Rx 😊
- **Just a few system issues**
 - Switching issues (DC on Tx and Rx!)
 - Drive levels

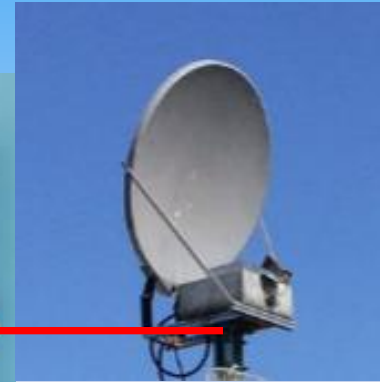
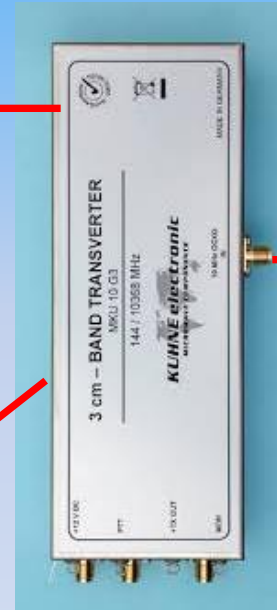


DATV on Microwaves

- Lime SDR covers up to 3.4GHz
- Higher bands via NB transverter
- Used successfully on 10, 24, 47 and 76 GHz



10GHz DATV system



Phase Noise

- ❸ DVB-S is vulnerable to phase noise
- ❸ Initial assumption was SSB was more critical proved to be incorrect
 - Readable SSB, but no-go on DVB-S
- ❸ ADF5355 (x2) as a 24 GHz LO works but..
 - Internal supply smoothing with 2000uF +
 - High Reference frequency
 - High charge pump current
- ❸ Problem is worse on higher bands
 - Multiplied LO multiplies the phase noise

Phase noise on 3.4GHz

MINITIOUNE v0.8s - Receiver/Analyser DVB-S/S2 650 MHz to 2600 MHz - SRmini=65 kS/s - for MiniTioner

SR (kS) Freq (kHz)
01000 01744000
Offset - 00000000
SR2000 1255 MHz
SR1000 2395 MHz
SR500 437 Serit
SR333 437 Sup
SR125 146.5 Serit

Low SR DVB mode
FEC DVB-S
 1/2 3/5 DVB-S2
 2/3 3/4 AUTO
 4/5 5/6 1/4
 6/7 7/8 1/3
 8/8 9/10 2/5

Tuner
LNA gain: 16 dB
BaseBand Gain 0 dB
 Auto
Bandwidth 10 MHz
Offset -500kHz
Fplug LNB
 A 0 V
 B 13 V
 18 V
 22kHz
 OFF
 ON
 TS_OK

MiniTioner DV3
NIM : SHARP/Samsung
TV mode: DVB-S

Frequency (kHz)
Freq asked: 1744000kHz Freq. set: 1743500 kHz
Freq → 1743950 kHz
Target dev. 450kHz Deviation: 450 kHz

Scan strategy
mode: no loop loop wide loop narrow chained
range: wide narrow
1 search
PreLock wide range 12
PostLock narrow range 10
Timer1 8 Timer2 3.0
pll corr 0 auto

PIDs
Pid from .ini
G8GKQ/P AutoPID
F6DZPH264 PID Video 00256
HDlowSR PID audio 00257
France24 Codec
QRZ DX Mpeg2
RaspberryP H264
 H265

Format: 4/3 Width: 704
 16/9 Height: 576
 1/1
 auto
Audio: MPA
 AAC
 AC3
Zoom: adapt x1 maxi
GRAPH

Station G8GKQ/P
infos: DVB-S
Provider: G8GKQ/P
Codec: VH264 + AAC
photo
Audio level
 Info ISS

Web Station ID: 3
68677
MY-CITY
ID80LX Preamp 20 dB
Ant. Dir. East Gain 12 dB
Picture Video Lg Msg
 QSL Auto Lg Pic
 Stop Web 0000
Timing 3 sec 00000 0

Scan Width
 +/- 8000 kHz
 +/- 4000 kHz
 +/- 2000 kHz
 +/- 1000 kHz
 +/- 500 kHz
 +/- 250 kHz
 +/- 125 kHz

Symbolrate (kS) Mode
SR set: 993906S A
Deviation: 6212S B
SR → 1000 kS/s
Carrier Width: 1342 KHz

IQ
Swap: OFF
x2
I: 77 Q: 77
Equa Noise

Station G8GKQ/P
infos: DVB-S
Provider: G8GKQ/P
Codec: VH264 + AAC
photo
Audio level
 Info ISS

Carrier Lock 97%
Timing Lock 100%

Power RF dBm -60 to -110
-110

MER dB 18 to 36
-0

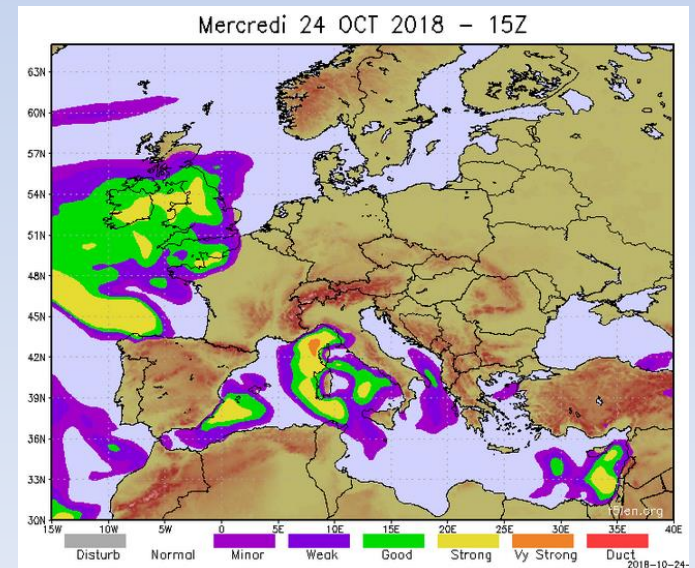
Constellations

Viterbi err 302
Vber 0%
FEC 7/8
TS TS err 0
Bytes recvd: 25004

Beep Dsave UDP Record
Quit
Expert

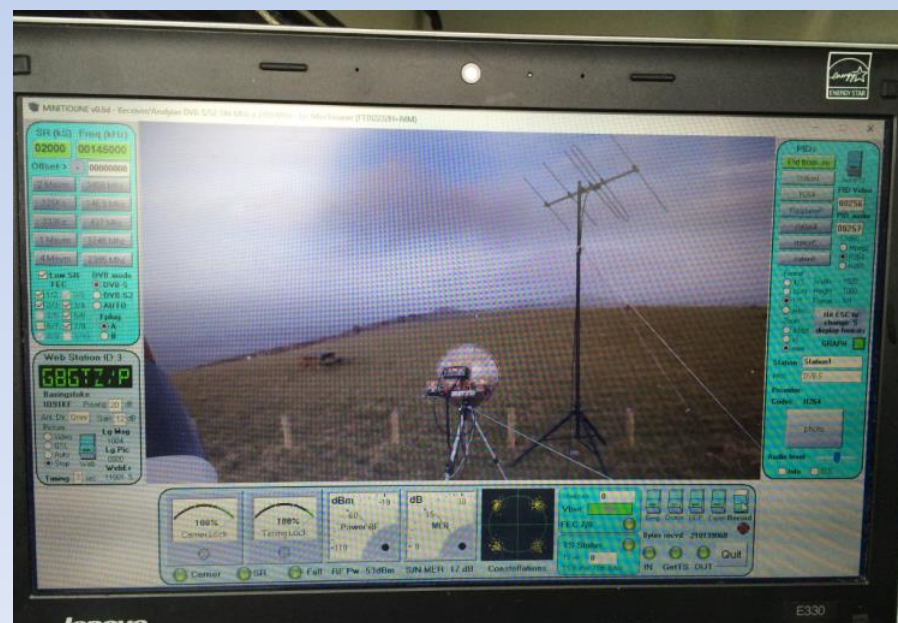
10 GHz DATV

- BATC** First tests in 2016
 - 92KM
- BATC** RB-TV and DATV
 - Best DX was 138KM
 - Dunkery to Cleeve
 - 2Ms (~2 MHz) with 23dB MER!
- BATC** Lot of margin in hand
 - 200+Km should be easy!
 - Under flat band condx
- BATC** October 2018 tropo
 - MODTS/P > G4UVZ
 - 407Kms!!



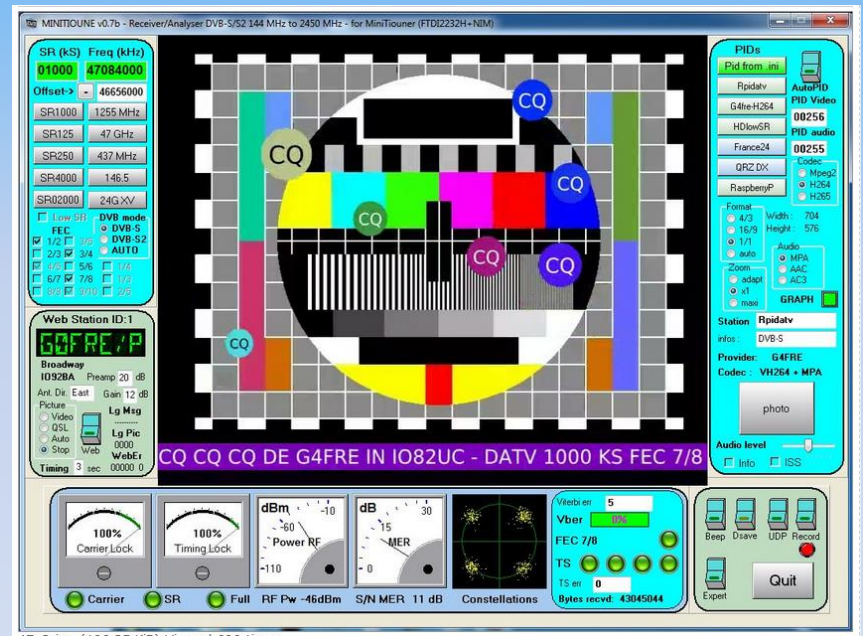
24GHz

- Same architecture as 10GHz
- Power levels < 1 watt
- Current UK Dx record = 85Kms
 - 1090LX > 1080WP
- World record only 120Kms
 - Can be beaten!



47GHz

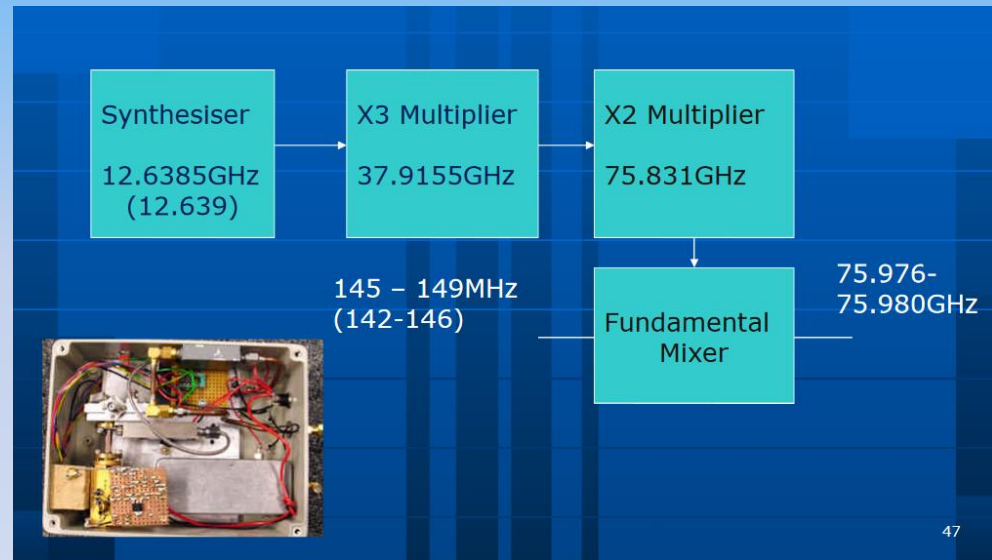
- Only one station active!
- G4FRE has had a one way QSO from /p back to home
- Broadway > Malvern = 34.9Km
- .2mw > Paso link rx



4703.jpg (196.25 KiB) Viewed 606 times

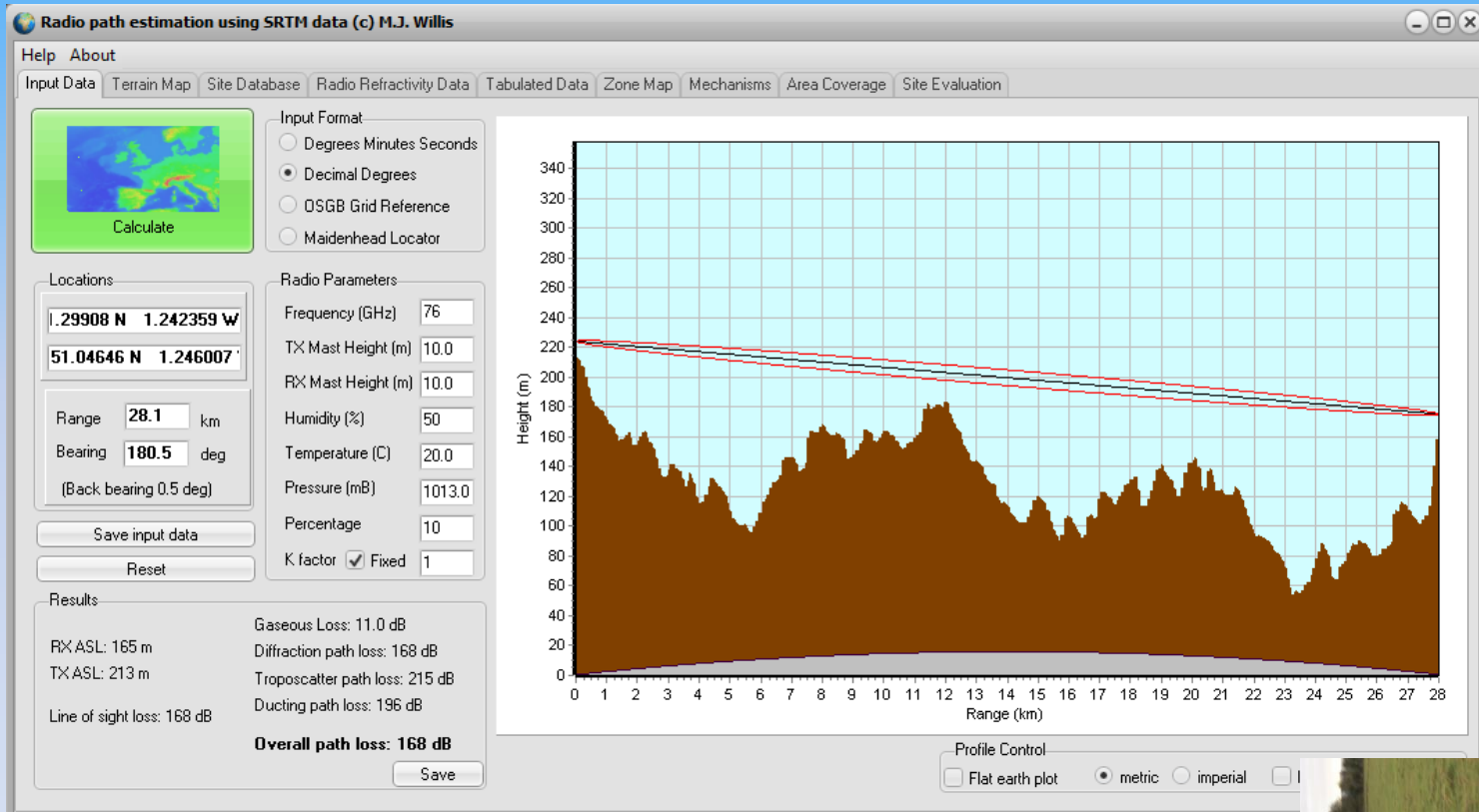
76GHz

- BATC G4LDR and G8GTZ have been experimenting with 76GHz DATV for 18 months
- BATC Ukmicrowave loan kit
- BATC ~ 5 milliwatts – NF ??
- BATC Very critical on atmospheric phase distortion and equipment phase noise
- BATC Current (world / UK) record is 35Kms
- BATC A 38Km LoS path would not go

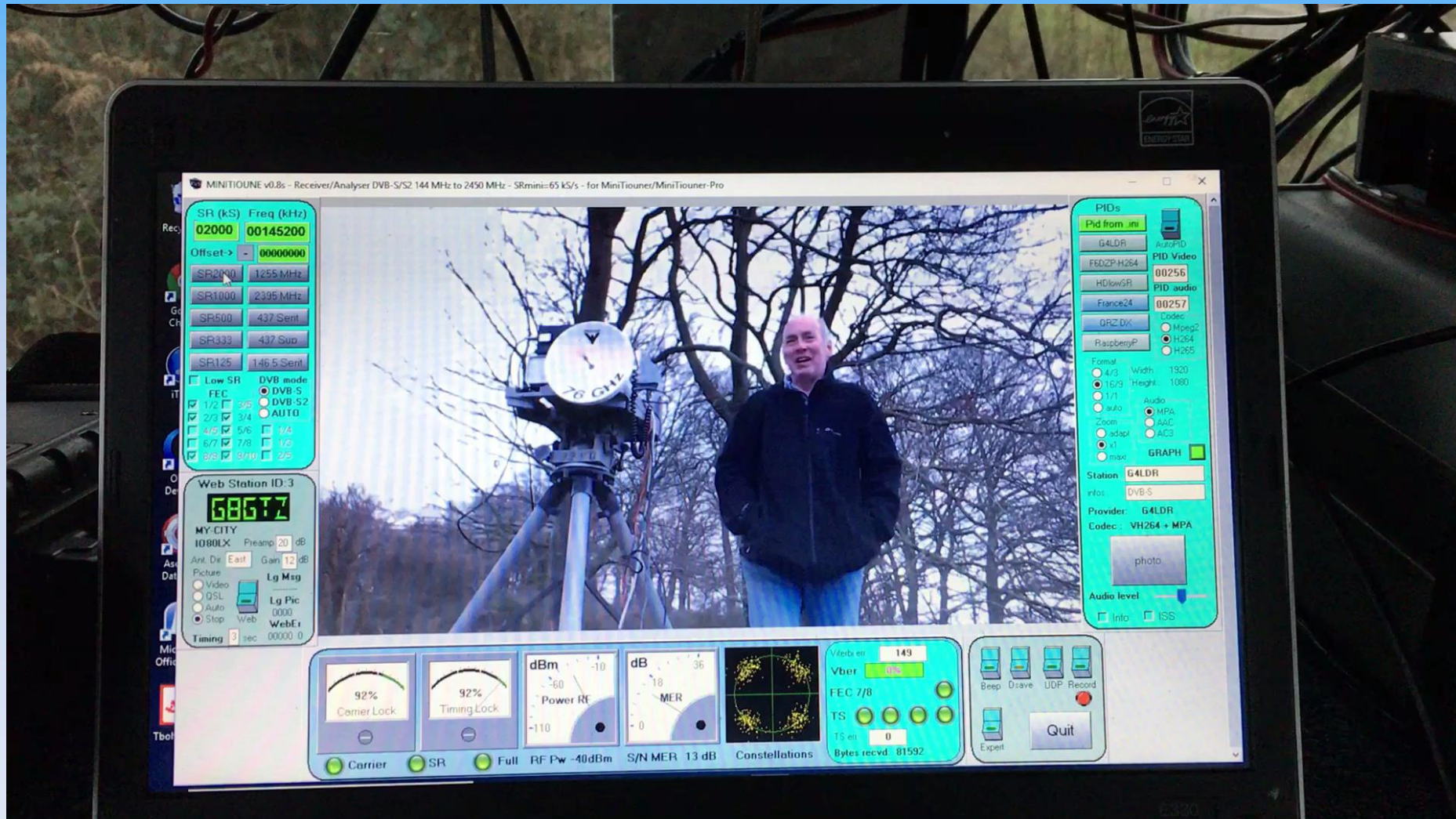


Hannington > Cheesefoot

28.1Km



Video - 76GHz @ 28.1Km

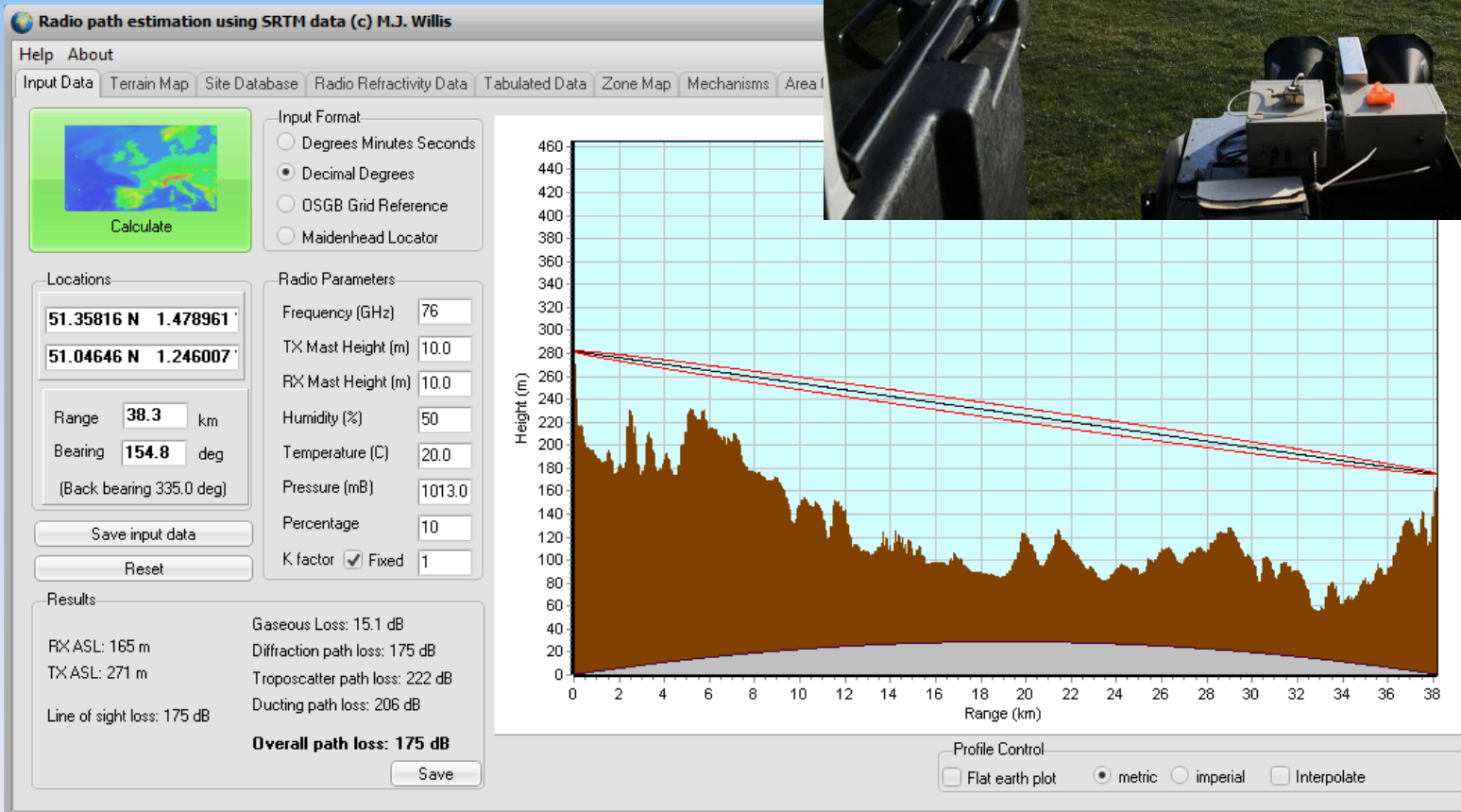


Coombe Gibbet > Cheesefoot

38.3Km LoS

175dB

Did not go on TV!

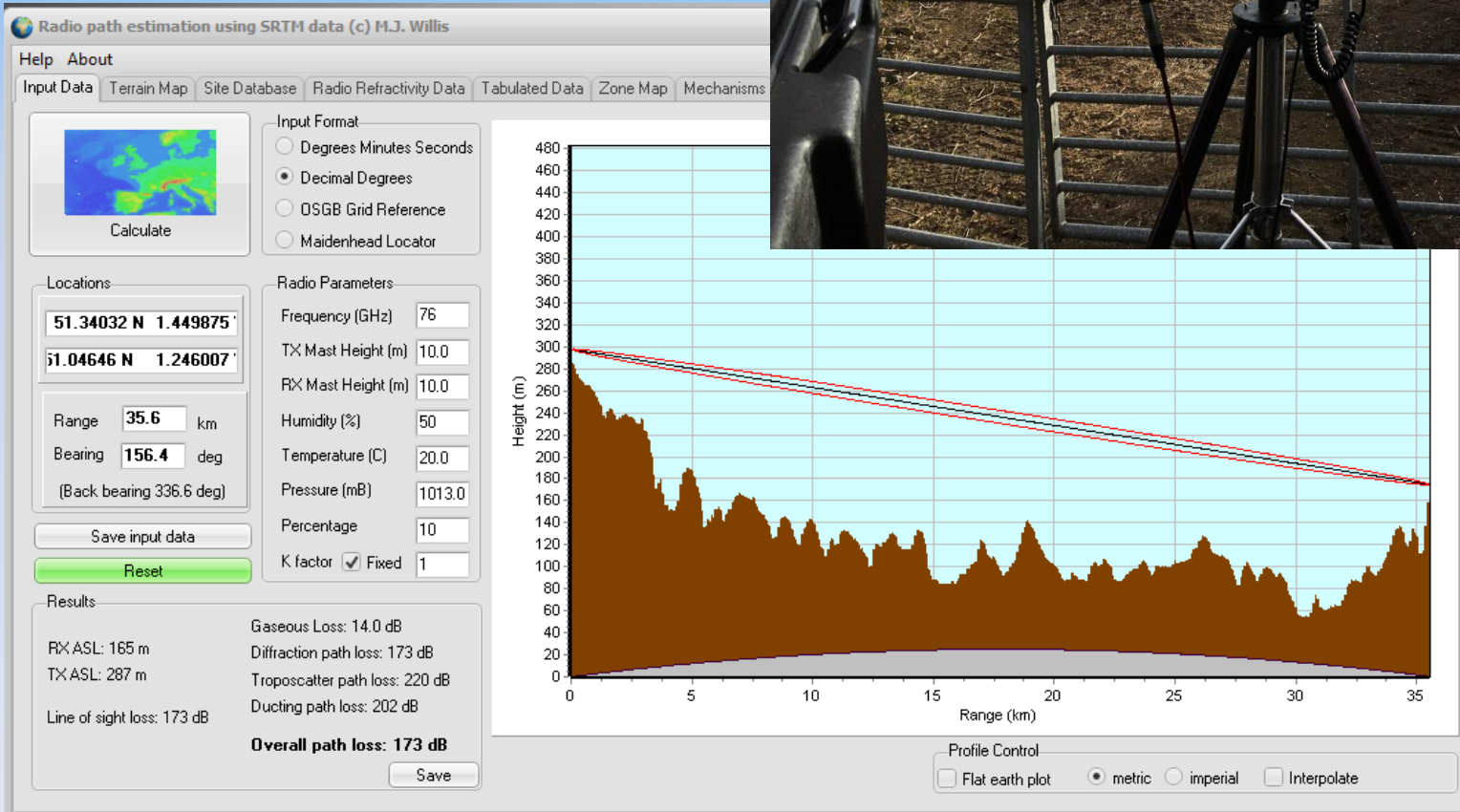


Coombe PMR > Cheesefoot

35.6Km LoS

173dB





Did go on TV!



76GHz video @ 35Km



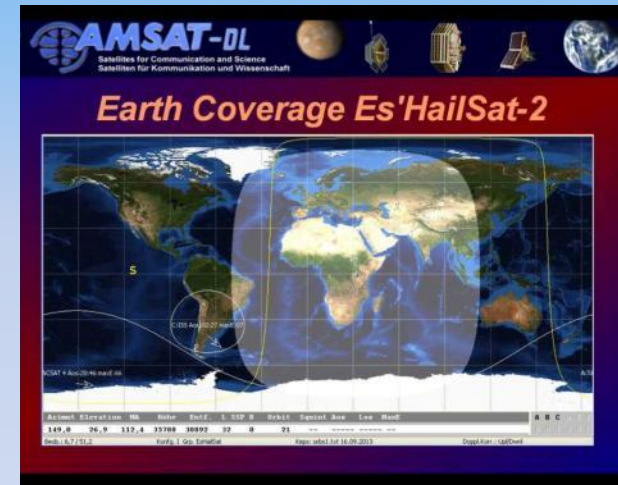
76GHz - what next?

-  Try a longer path
 - 45Km to Butser
-  Improve the gear
-  Neil is adding an image filter
 - 3dB more power / Rxr NF?
-  Improve phase noise on LO??





Oscar 100

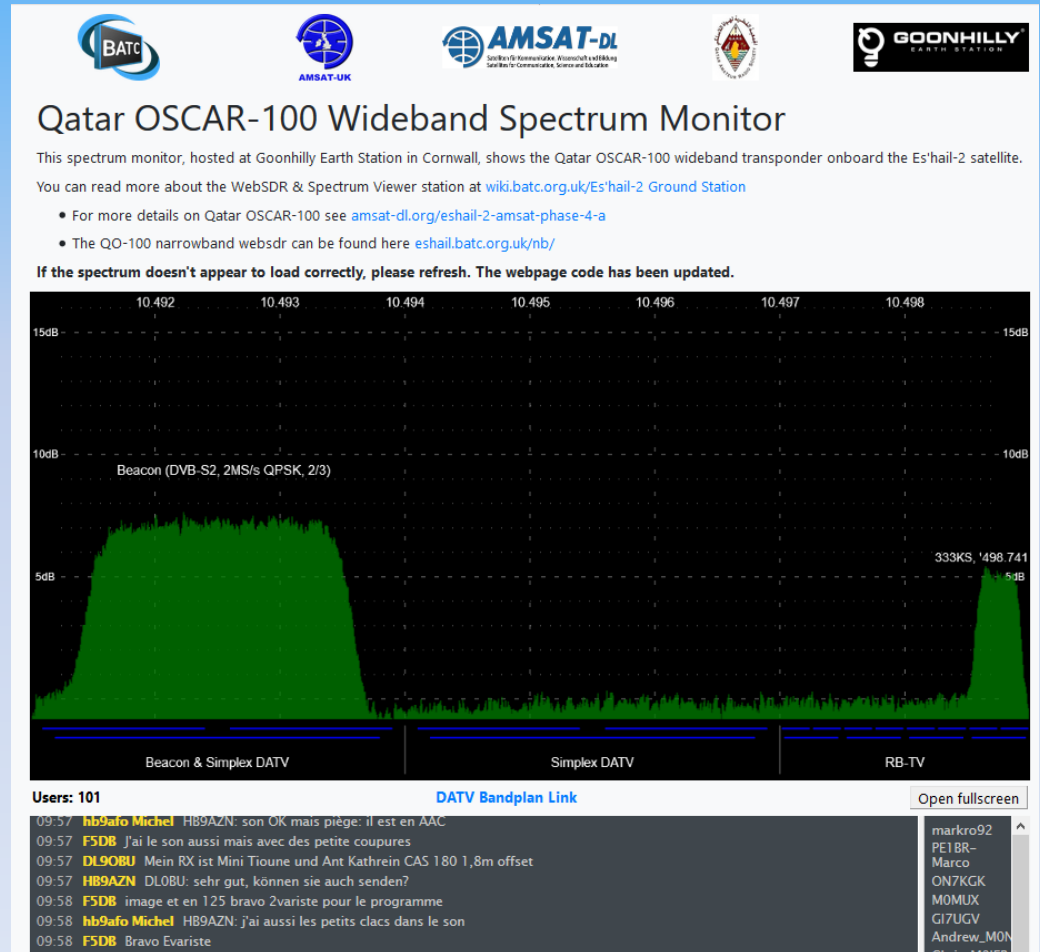
- A real game changer
- Es'Hail-2 wideband is an “8 MHz bent pipe” transponder
 - 2.4 GHz up, 10.49 GHz down
 - No spot beams – covers 1/3 of the earth!
 - Dedicated to DATV use
- DVB-S2 is preferred modulation
 - 88Ks > 2Ms
 - 100 KHz > 2.5MHz







Oscar 100 DATV

 Spectrum monitor and chat for coordination

 Beacon on 24/7
– Invaluable for dish alignment and dish checking in high winds!



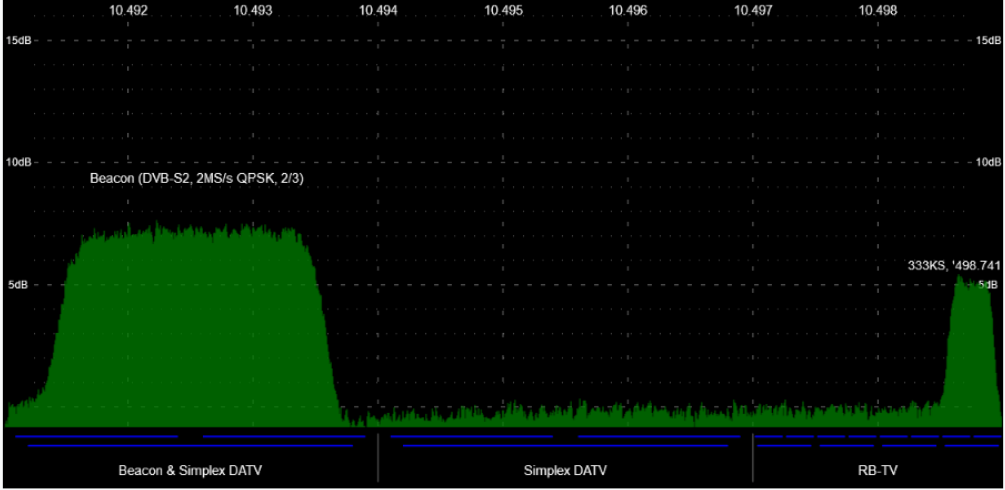
   

Qatar OSCAR-100 Wideband Spectrum Monitor

This spectrum monitor, hosted at Goonhilly Earth Station in Cornwall, shows the Qatar OSCAR-100 wideband transponder onboard the Es'hail-2 satellite. You can read more about the WebSDR & Spectrum Viewer station at [wiki.batc.org.uk/Es'hail-2 Ground Station](http://wiki.batc.org.uk/Es'hail-2_Ground_Station)

- For more details on Qatar OSCAR-100 see amsat-dl.org/eshail-2-amsat-phase-4-a
- The QO-100 narrowband websdr can be found here eshail.batc.org.uk/nb/

If the spectrum doesn't appear to load correctly, please refresh. The webpage code has been updated.



Users: 101 [DATV Bandplan Link](#) [Open fullscreen](#)

09:57 **hb9afo Michel** HB9AZN: son OK mais piège: il est en AAC
09:57 **F5DB** J'ai le son aussi mais avec des petite coupures
09:57 **DL90BU** Mein RX ist Mini Tioune und Ant Kathrein CAS 180 1,8m offset
09:57 **HB9AZN** DLOBU: sehr gut, können sie auch senden?
09:58 **F5DB** image et en 125 bravo 2variste pour le programme
09:58 **hb9afo Michel** HB9AZN: j'ai aussi les petits clacs dans le son
09:58 **F5DB** Bravo Evariste

markro92
PEI BR-
Marco
ON7KKG
MOMUX
G17UGV
Andrew_MON
Chris_MOIER

Oscar 100

Typical DATV rx station:

- 1mt dish
- PLL LNB
- MiniTiouner USB receiver

Typical DATV Tx station






- Portsdown2019 > Lime Mini
- DVB-S2 88Ks – 2Ms
- 30 watts on 2406MHz
- 1.2mt dish

MJW dual band patch feed

 Come to Bristol CAT on 31st March to learn more



The new golden age for ATV!

-  ATV is undergoing a real revival
-  Last area of real amateur radio
 - No commercial equipment
 - You have to build and experiment
 - Real open source
-  Covers all skill levels from beginner to seasoned professional
 - propagation, antennas, RF design, studio, video editing,
-  BATC is thriving
 - 25% increase in last 3 years
 - Growing a real ATV community
 - Sharing the knowledge and growing together
-  Do some real radio today – get involved in Amateur TV!



More information



 BATC wiki: https://wiki.batc.tv/BATC_Wiki

 5.6GHz: https://wiki.batc.tv/5.6_GHz

 Portsdown: https://wiki.batc.tv/The_Portsdown_Transmitter

 See you at CAT19 Bristol on 31st March