









# Microwave Digital ATV Made Easy

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# Topics

-  What is ATV?
-  Band and Modes
-  Current Trends
-  FM ATV on 5.6 GHz
-  Digital ATV
-  Transverting to 3.4 GHz and above
-  Phase Noise
-  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





# Band-by-Band



## 71 & 146 MHz

- The “new” ATV bands
- RB-TV



## 70cms

- Digital only on 437MHz



## 23cms

- Analogue (FM) and digital
- Activity on repeaters and simplex



## 13cms

- Still room after PSSR!
- Repeaters and simplex



## 3.4 GHz

- Digital only
- Excellent results



## 5.6 GHz

- FM ATV for under £20
- Repeater inputs



## 10 GHz

- Repeaters and simplex



## 24 GHz

- Digital and Analogue
- 120 kms is the goal



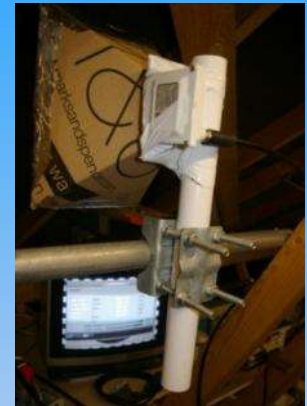
## 47 GHz

- DATV
- 30 km achieved








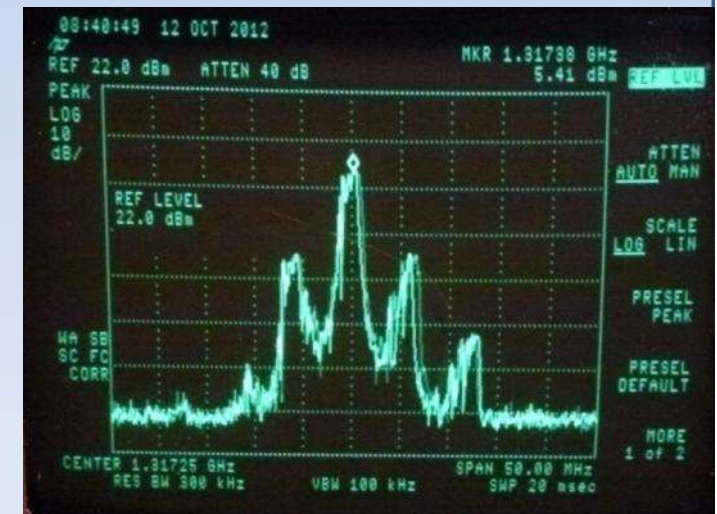
## 76 GHz

- DATV
- 14 kms achieved



# 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









# 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 less than 1 MS
- Live TV in ~450Khz bandwidth (333 KS = 537 Kbit/s video)
- Based on DVB-S standard BUT...
  - Benefits from MPEG-4 (or H265) encoding for transmit
  - "Normal" satellite RX won't work below 1 MS
- So the ATV community has developed TX and RX products
  - MiniTiouner RX
  - Portsdown DATV TX
  - SDR-based Transmitters
- RB-TV will go when FM signals are S9







# Current Trends

-  More home-built Digital Equipment
-  Use of Digital to “add” path gain
-  Use of drone FPV FM TV equipment
-  High Definition digital  
(Pi Cam or Webcams)
-  Existing Analogue and Digital Repeaters
-  Repeater and personal streaming







# 5.6 GHz FM ATV

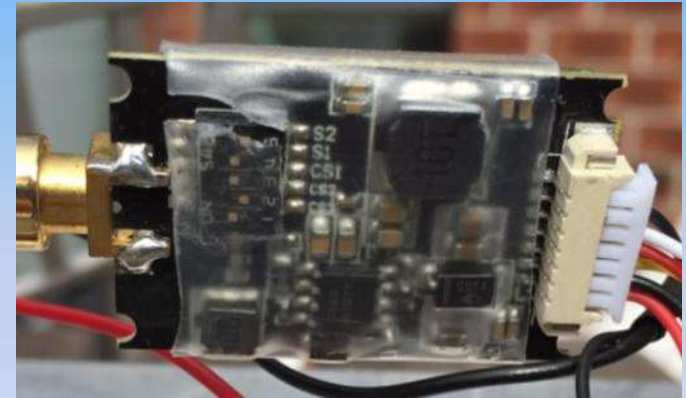
-  Cheap kit available for drone FPV use
-  New technical challenge
-  Easily accessible
-  Very simple






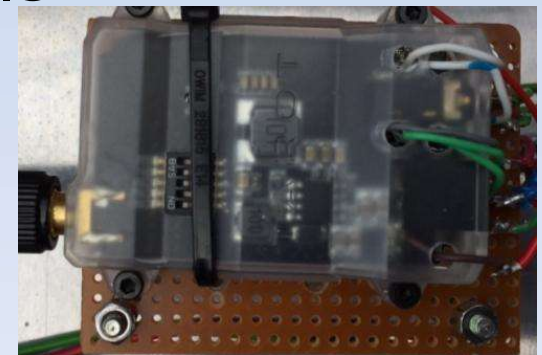


# What Kit

-  Transmitters typically 600mw output
-  Video + Audio in, RF out
-  Preset Channels
-  Spurii?

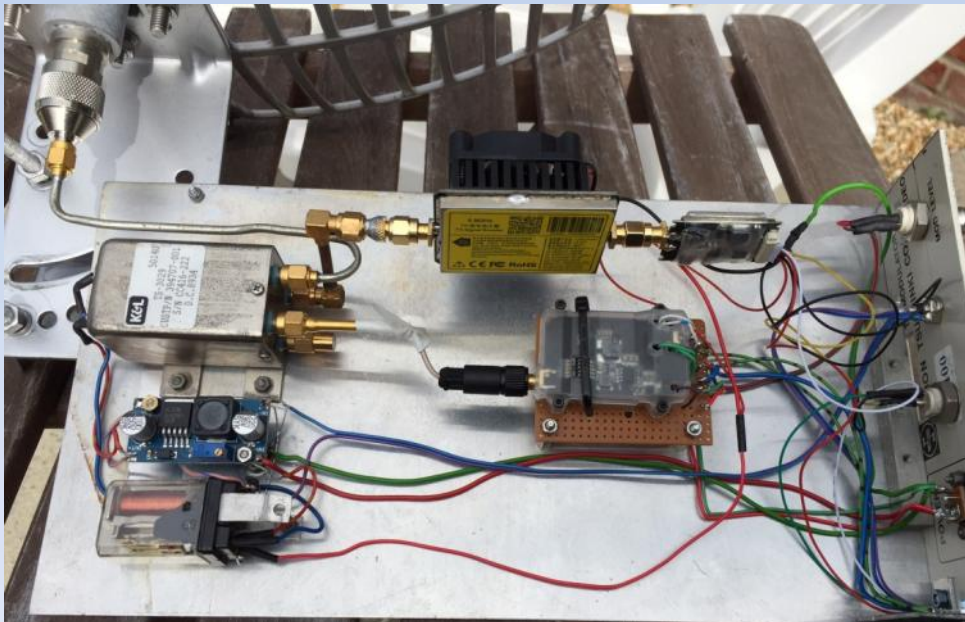


-  Receivers have preset channels
-  RF in, video and audio out
-  All runs from 12v






# Simple

- Wire up power, video and audio
- Connect aerial
- Changeover relay?







# Operating

-  Horizontal Polarity
-  Dishes typically 4 – 8 degrees beamwidth
-  Peak on sound subcarrier quieting?



# Digital ATV

-  The move to digital has happened
  - Experiments for over 16 years
  - Pressure on spectrum eg 13cms
  - More modern image and new challenge
-  Broadcast standards have been adopted and adapted
-  DVB-S at 66KS to 4 MS  
= 100 KHz to 6 MHz Bandwidth
-  Significant bandwidth gains and better pictures – when it's there!

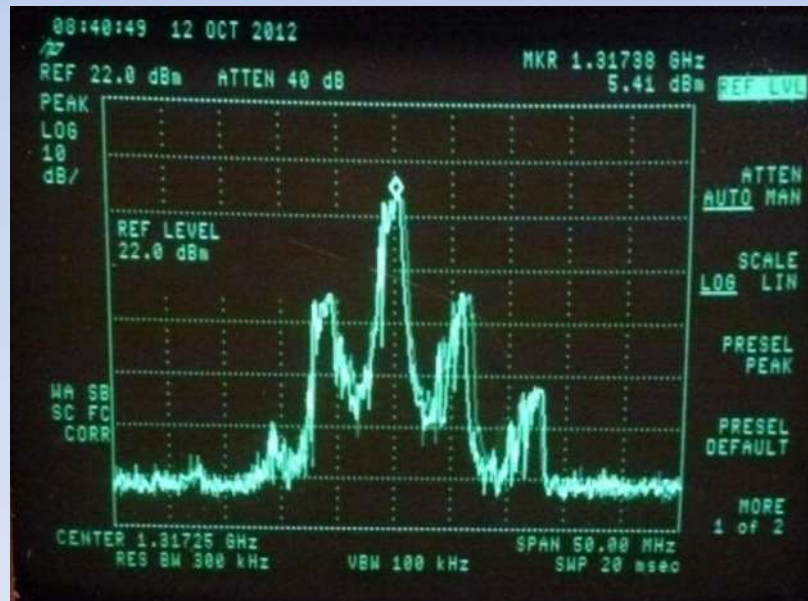




# Analogue vs Digital ATV

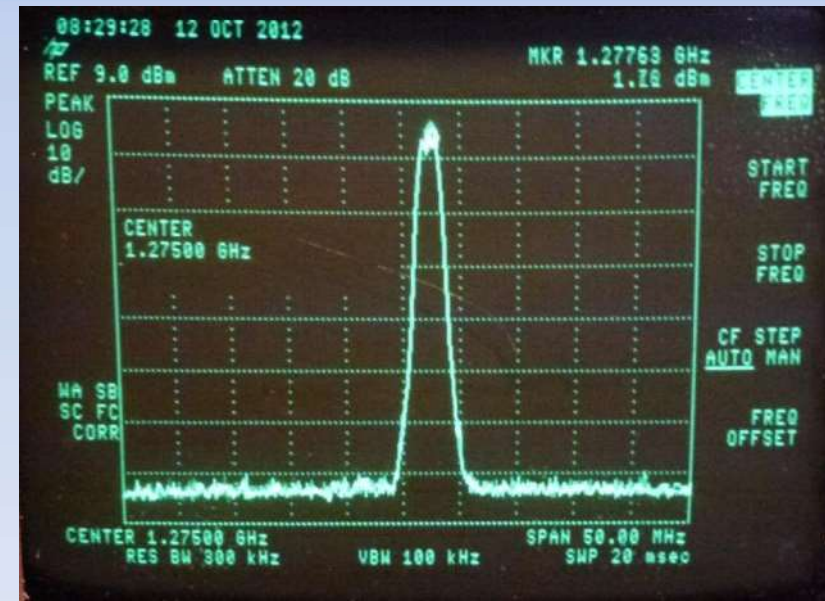
## FM analogue

- 16 MHz deviation
- ~ 16 MHz












## DVB-S QPSK,

- 2 MS, 1/2 FEC
- ~ 2.6 MHz



# Digital ATV – How?

-  Digitise Video
-  Compress the Video
-  Add headers and error correction
-  Sort into I and Q bitstreams
-  QPSK modulate carrier
-  Get the signal to the other end
-  Demodulate into I and Q
-  Use error correction to recover video bitstream
-  Uncompress and display the Video

# Generating DATV



Ex-commercial encoders



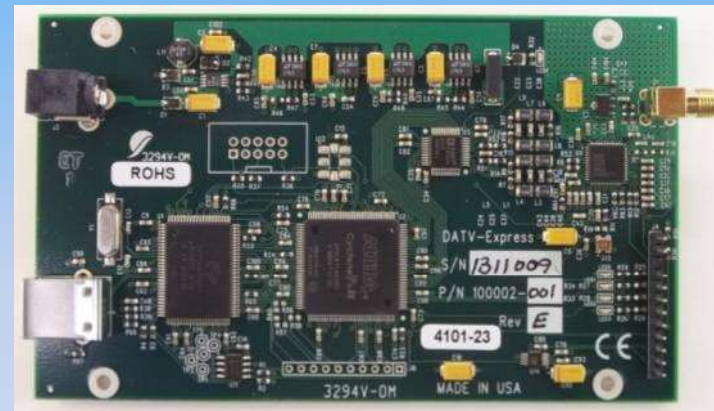
Amateur Market:

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



“Homebrew”

- DigiLite – PC-based, external modulator
- DigiThin – RPi-based, RB-TV only
- Portsdown – RPi-based, full bandwidth
- SDRs – with a PC, RPi or FPGA



# Portsdown DATV project

-  The BATC project to bring DATV to everyone
  - All the common modes and bandwidths
-  Based around a RPi3
  - MPEG2 or H264 encoding
  - Touch screen control
-  Requires some hands on construction
  - “I made that!”
-  Easy way to get on air at low cost

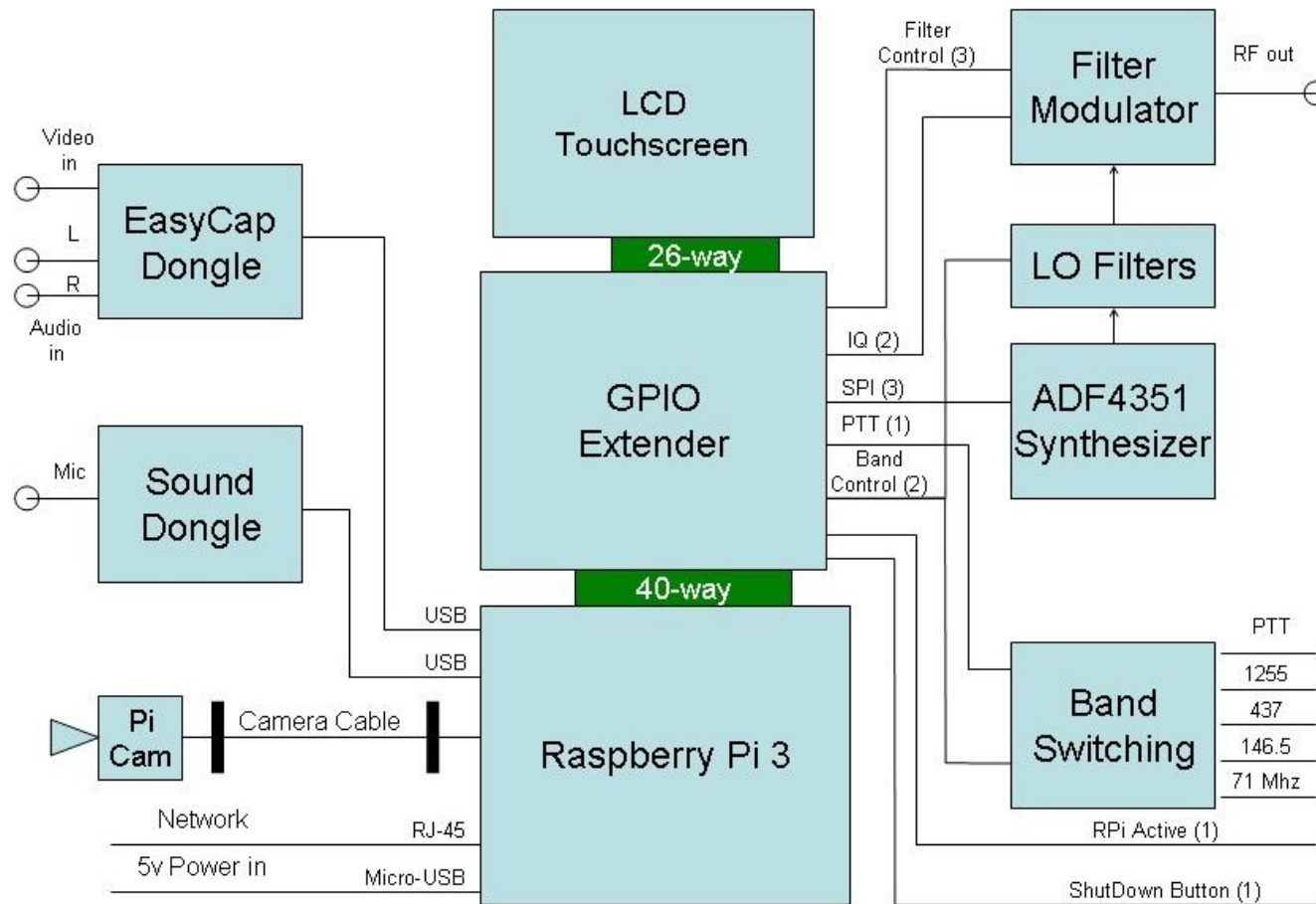


BATC Portsdown Transmitter Main Menu

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 Preset
146.5_333	437_1MS	1255_HD	437-Ugly	







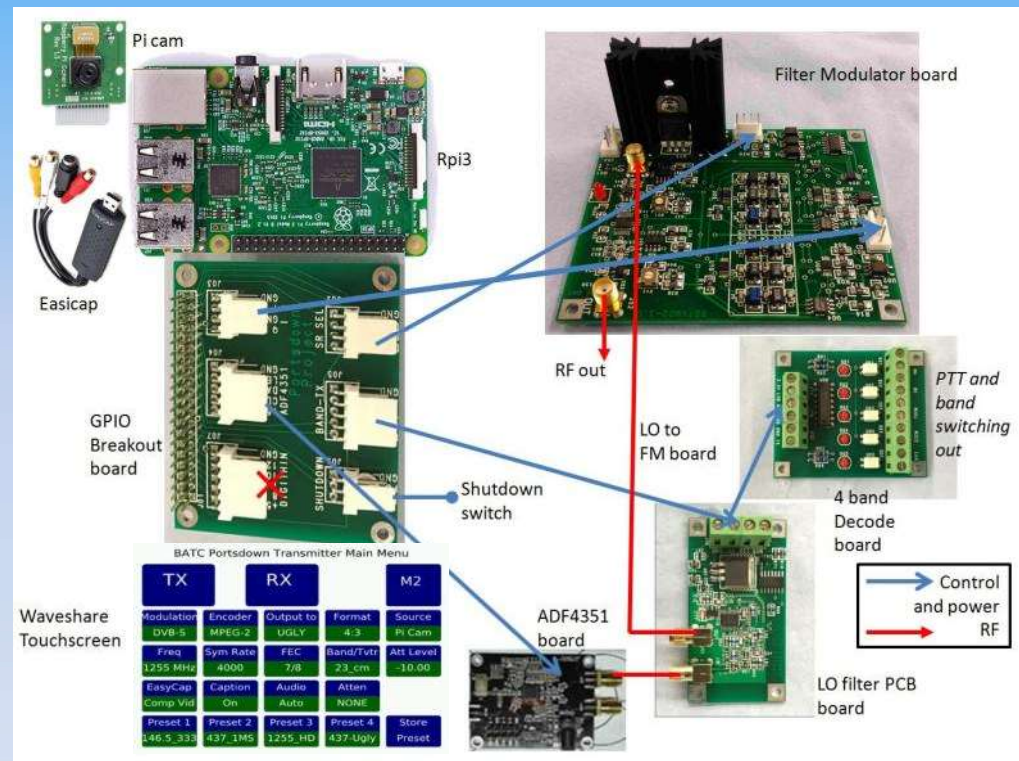
# Portsdown DATV system










The Portsdown ATV Transmitter

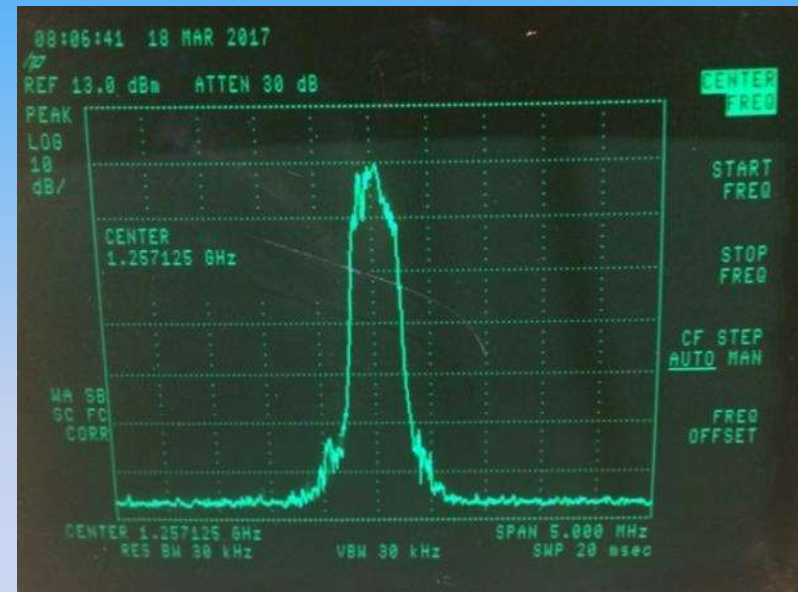
# Portsdown Makes DATV easy

-  All hard to get or critical components in BATC shop
-  Full set of PCBs from BATC shop
-  Main SMD board is available pre-built
-  Pre-programmed SD Card from BATC shop or self-build





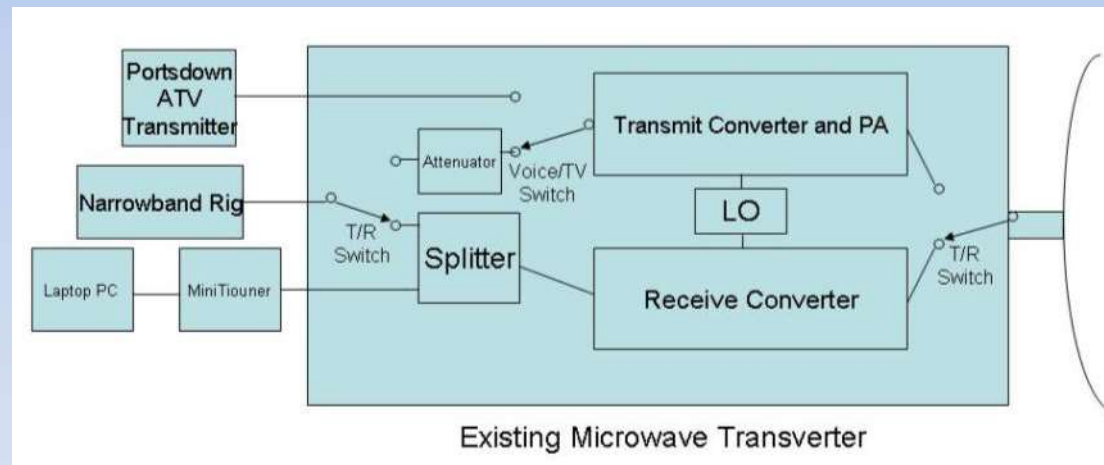
# Portsdown Specs


-  71 MHz to 2400 MHz
  - ~ 5dBm output
  - -7dBm at 2400MHz
-  DVB-S only
-  88KS to 5 MS
-  MPEG-2 and MPEG-4 encoding
-  Touch screen or PC control
-  PTT and band switching control
-  Analogue Video out with test patterns



# Transverting to 10 GHz and 24 GHz

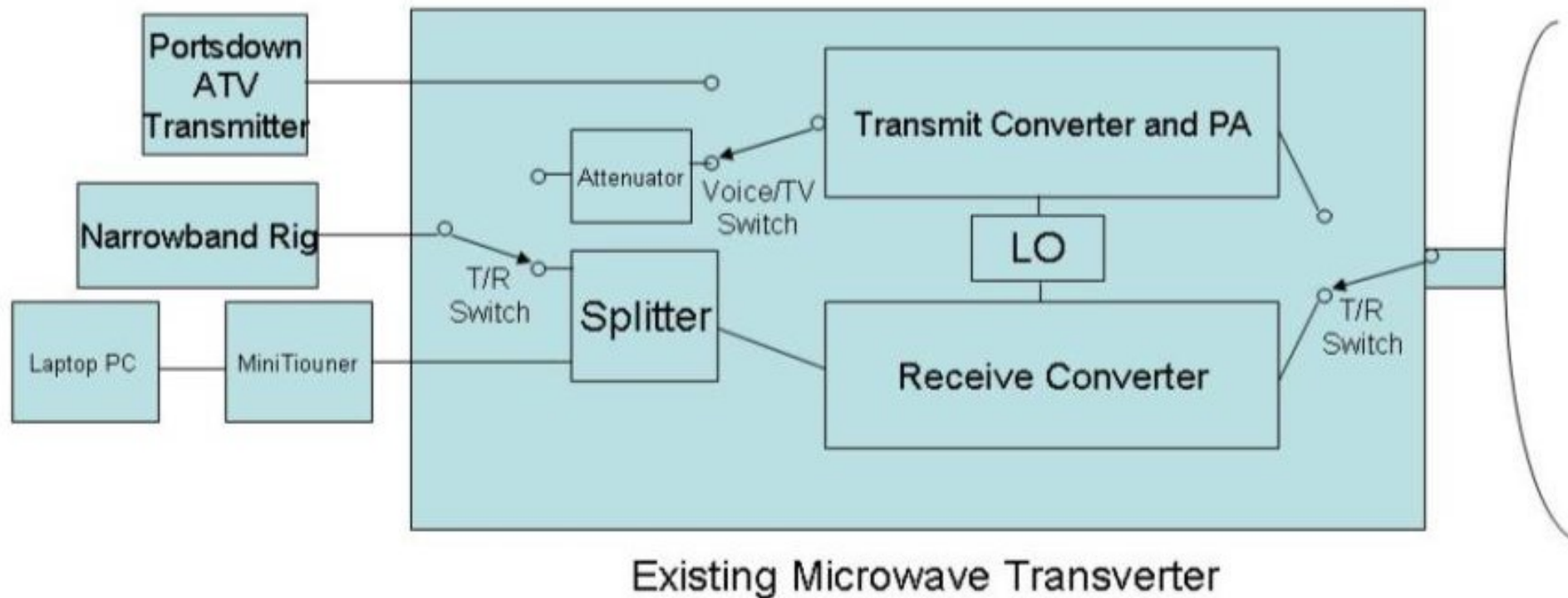
-  Encoders typically output 5 dBm at 146 MHz or 437 MHz
-  Easy to modify existing transverters to accept






-  MiniTioune Receiver will tune from 144 - 2600 MHz, so RX IF can be the same.




# Easy Modification



# Receiving DATV

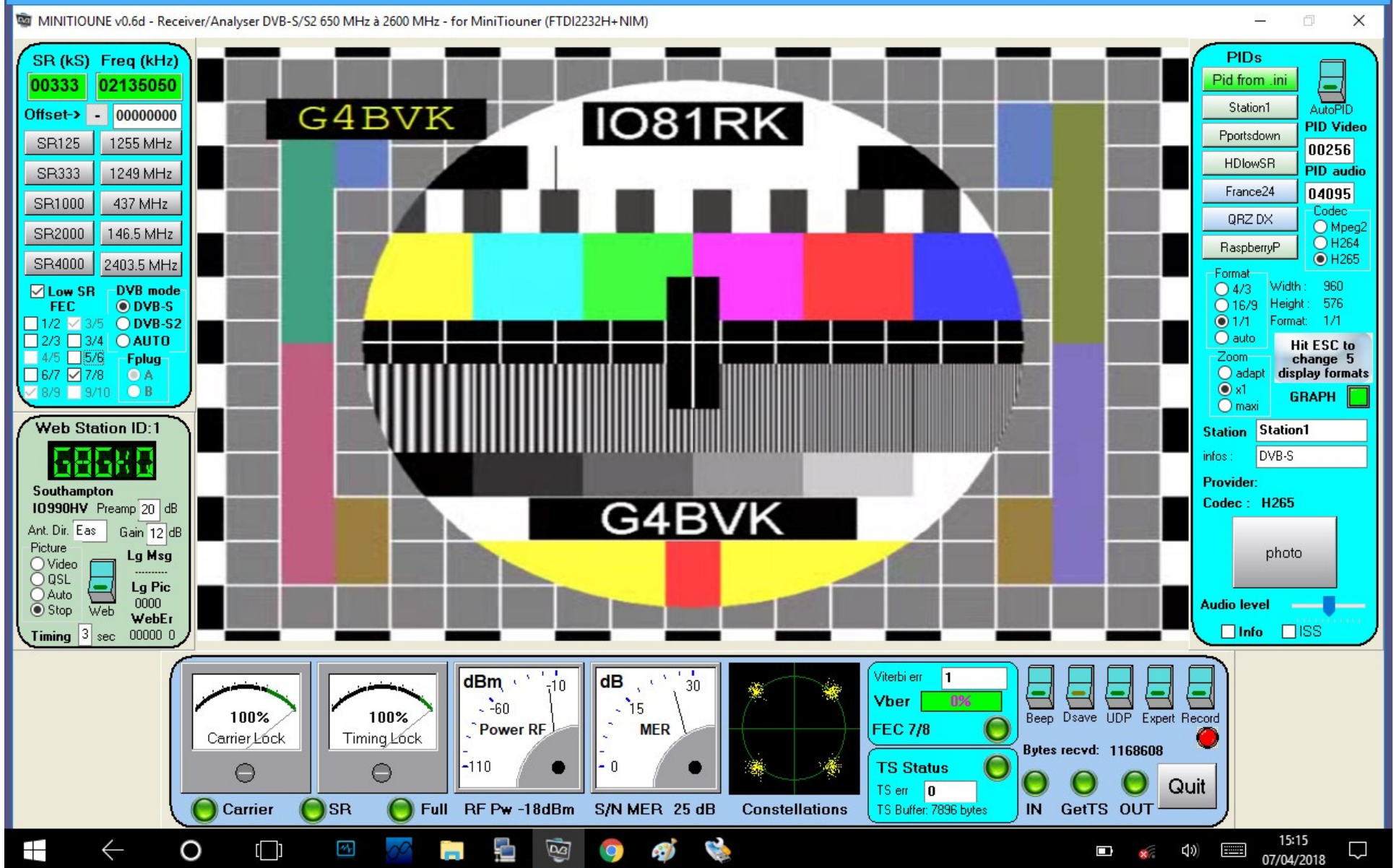
-  Normal free-to-air Satellite receiver can be used for non-RB-TV
  - Tunes 950 – 2150
-  Strong signals can be resolved using an RTL-SDR and a Linux PC or Rpi
-  Weak signals best received on a MiniTiouner

# MiniTiouner

-  Satellite TV tuner with USB interface
-  PC software by F6DZP
-  Latest version tunes 144 – 2600 MHz
-  Symbol Rates 66 KS – 20 MS
-  Kit or ready-built







# MiniTiouner Display






# Phase Noise from Transverter LOs

-  DVB-S is vulnerable to phase noise
-  Our initial assumption that SSB was more critical proved to be incorrect
  - Readable SSB, but no-go on DVB-S
  - Horrible SSB, but no problems for DVB-S
-  The Elcom LOs are good at both
-  Spectral distribution of the phase noise is also important

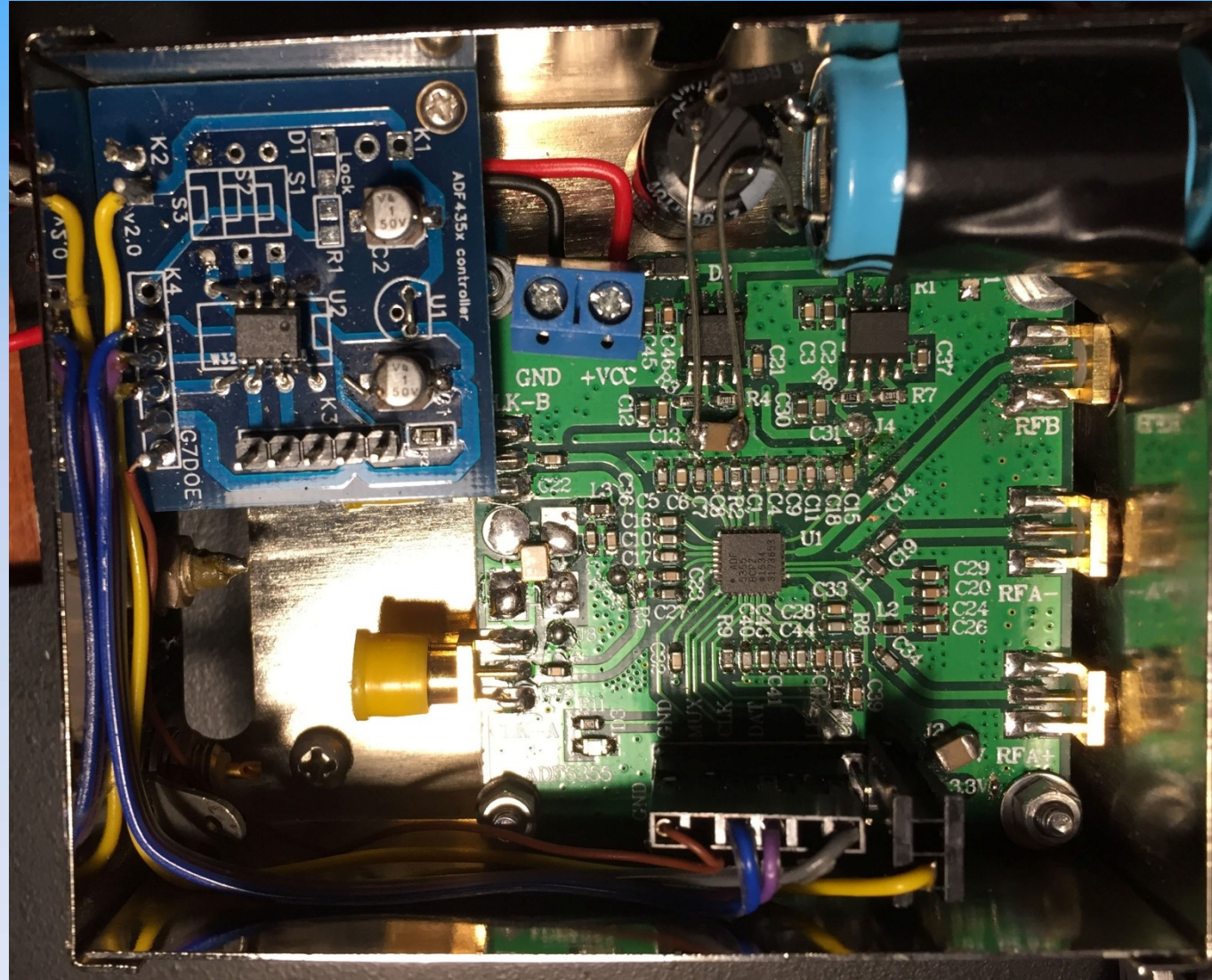
# ADF5355 Synthesizer

 Using an ADF5355 (x2) as a 24 GHz LO works, but it needs:





- Internal supply smoothing with 2000uF +
- High Reference frequency
- High charge pump current

 Does not sound nice on SSB

# ADF5355 Synthesizer



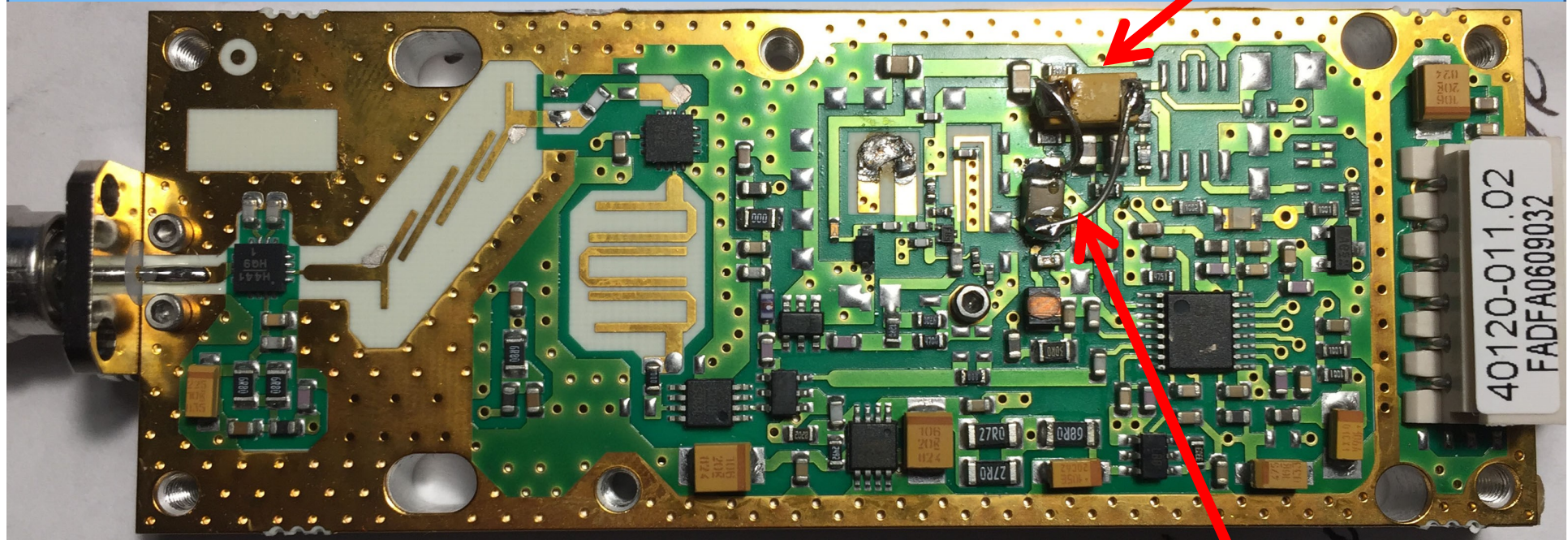
# Nortradio LOs

-  Good for SSB
-  Hopeless for DATV without modification
-  After modification, still not as good for DATV as an ADF5355
-  Needs the VCO supply capacitor replacing with a much higher value



# Nortradio LOs

Added 100  $\mu\text{F}$



Replaced 10  $\mu\text{F}$  with 22  $\mu\text{F}$

# ATV by Satellite

- Es'Hail-2 will be the first amateur geo-stationary satellite
- 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
  - Occupied bandwidths could be 500 KHz – 8 MHz
- Es'Hail-2 is a fantastic opportunity for amateur TV experimentation



# ATV – Your Next Challenge



## Real amateur radio

- Limited commercial equipment
- You have to build and experiment
- Open source



## Covers all skill levels from beginner to seasoned professional

- Propagation, antennas, RF design, studio, video editing, video encoding, software



## BATC is thriving

- 25% increase in last 3 years
- Growing a real ATV community
- Sharing the knowledge and growing together





# More Information



-  BATC wiki [https://wiki.batc.org.uk/BATC Wiki](https://wiki.batc.org.uk/BATC_Wiki)
-  5.6GHz [https://wiki.batc.org.uk/5.6 GHz](https://wiki.batc.org.uk/5.6_GHz)
-  Portsdown [https://wiki.batc.org.uk/The Portsdown Transmitter](https://wiki.batc.org.uk/The_Portsdown_Transmitter)



# Questions

