

Two Projects in Amateur Television

Dylon Mutz, N6MX
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Intro

This presentation will introduce two ways to build an amateur television (ATV) system:

- Digital ATV with Portsdown

- Analog ATV using drone components

Who am I?

- Dylon Mutz, N6MX

- Living in San Pedro, CA

- 2015 - B.S. Computer Engineering CSU, Fullerton

- 2015 - Obtained Tech license (KK60TK)

- 2015 - Became W6TRW club member

- 2022 - Obtained Extra license & N6MX callsign

- 2023 - W6TRW Club President

- Career: Digital ASIC/FPGA design and verification engineer

- Credits RF knowledge to W6TRW club members and their encouragement and inspiration

- Interests: Span digital hardware, software, and RF

Background

- Digital standards used by hams
 - DVB-T (Terrestrial)
 - Digital choice for most hams in U.S.
 - Good for multipath and DX
 - Local W6ATN amateur network uses it (2MHz BW)
 - DVB-S/S2 (Satellite)
 - Good for line-of-sight
 - Popular in Europe for QO-100 satellite work

The logo for DVB-T, featuring the letters 'DVB' in a bold, black, sans-serif font, followed by a blue square containing a white letter 'T'.The logos for DVB-S and DVB-S2. The top logo shows 'DVB' in black followed by a blue square with a white 'S'. The bottom logo shows 'DVB' in black followed by a blue square with a white 'S2'.

Background

- Been curious to experiment with sending video
- Already checked the box on SSTV
- Also heard of W6ATN network from club members

- Buying ready-to-go equipment isn't as much fun for me. I like hands-on projects I can learn from.
 - Ex: HiDes Company HV-100EH Modulator & HV-110 Receiver are ready-to-go
- Research brought me to the **Portsdawn...**

Portsdown

Portsdown

What is a Portsdown?

- Digital amateur television (DATV) transceiver system
 - Capable of DVB-S, DVB-S2, DVB-T standards
- *Relatively* low-cost
- Based around
 - Raspberry Pi 4
 - Hobby SDR (Adalm Pluto or LimeSDR)
 - A few RPi peripherals (touchscreen, camera)
- Fun for experimenters with lots of potential
 - With PlutoSDR, can become a “Langstone” microwave transceiver
 - More on this later

Portdown

Current Functionality w/Pluto SDR

- H264 video encoding only (RPi determines the encoding)
- 4:3 SD, 16:9 or 720p. No 1080p
- Power range approx 0 to -70dBm
- Maximum DVB frequency 4.1GHz
 - However, Pluto can actually go to 6GHz
- DVB-S, DVB-S2 modulation: 125kS to 1MS selectable symbol rate
- DVB-T: 150 kHz to 1 MHz bandwidth
- Pluto and RPi GPIO PTT switching capable for amplifiers with external board

Portsdown

- Raspberry Pi connects everything together
- Touchscreen shows controls
- Several options for A/V Input
 - Logitech C920 A/V Webcam
 - Pi Cam + Mic Dongle
 - EasyCap A/V Capture
- Several options for transmit
 - LimeSDR
 - Pluto SDR
 - DATV Express (BATC custom board)
- One supported option for receive at this time
 - MiniTiouner (BATC custom board)
(Note: DVB-S/S2 only)

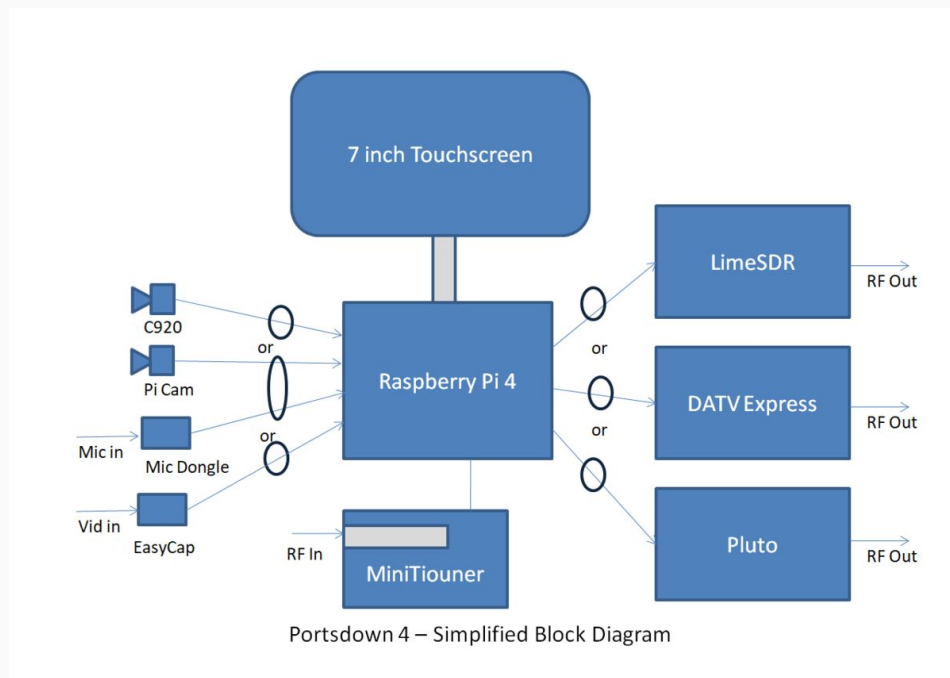
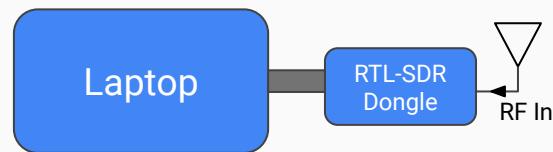
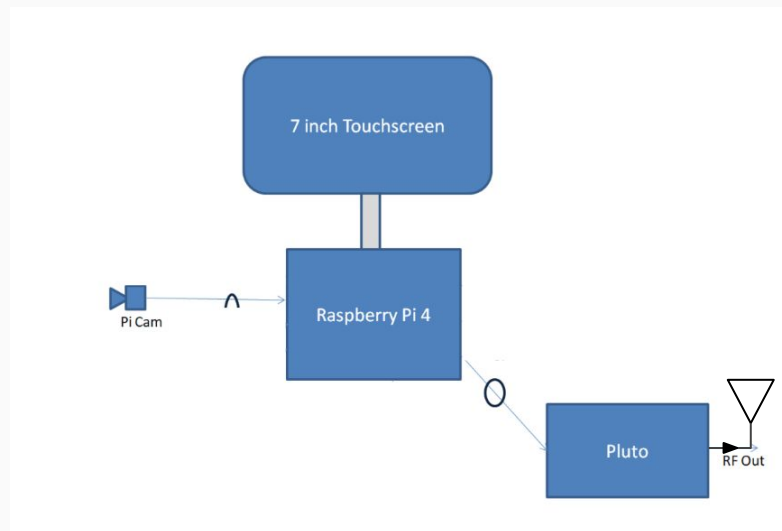


Image Source: <https://wiki.batc.org.uk/>

Portdown

- Here's what I did:
 - Raspberry Pi 4 Model B
 - NORSMIC 10" RPi Touchscreen
 - Arducam Raspberry Pi Camera Module
 - Adalm Pluto SDR
 - 70cm Bandpass Filter (not pictured)

- RTL-SDR Dongle



Portsdown

Assembly

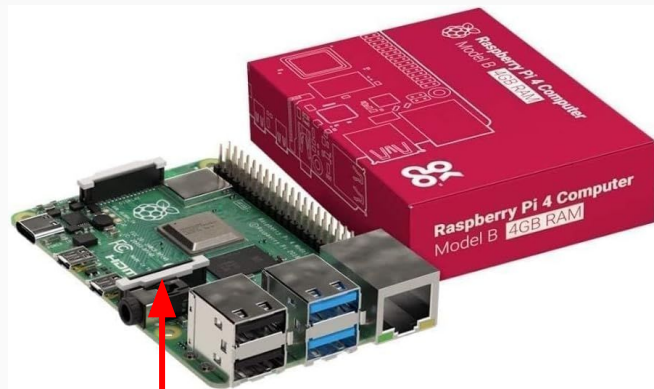
- RTL-SDR dongle receiver
- Broadcast DVB-T tuner
- Chip actually a lot more capable
- Use alternate driver
- 100kHz - 1.5GHz receive only
- Use PC and SDR software to demodulate many modes



Portsdown

Raspberry Pi 4 Model B

- Low-cost single-board computer
- USB 3.0 port preferred for connecting to the Pluto
- Previous models may work, but are no longer officially supported



Arducam Camera Module

- Already had one extra from old project
- 5 megapixel camera
- Ribbon cable plugs into dedicated port on RPi



Portsdown

- NORSMIC 10" RPi Touchscreen
 - HDMI ribbon cable plugs into RPi for video
 - Touchscreen plugs in through USB port
 - PlutoSDR plugs in through USB 3.0 port
 - Note: The Portsdown project currently only supports 7" screens, but I was able to get this 10" screen to work

Suitable for DIY Projects
Specifically Designed Touchscreen for [Raspberry Pi](#)



* Mount Pi on the Back,
Better for Wiring

* **Please Note:**
Raspberry Pi and case
are not included



Portsdown

Adalm Pluto

- Rx/Tx SDR
- Analog Devices AD9363 RF Chip
- Xilinx Zynq Z-7010 FPGA
 - Running ARM Cortex A9 soft processor
- Covers 325MHz - 3.8GHz; 20MHz BW
- Easy SW mod gets you 70MHz - 6GHz; 56MHz BW

- Supports MATLAB/Simulink, GNU Radio, and more
- Marketed as a learning tool
- Product page: [Analog Devices Product Page](#)



Portsdown

Filtering

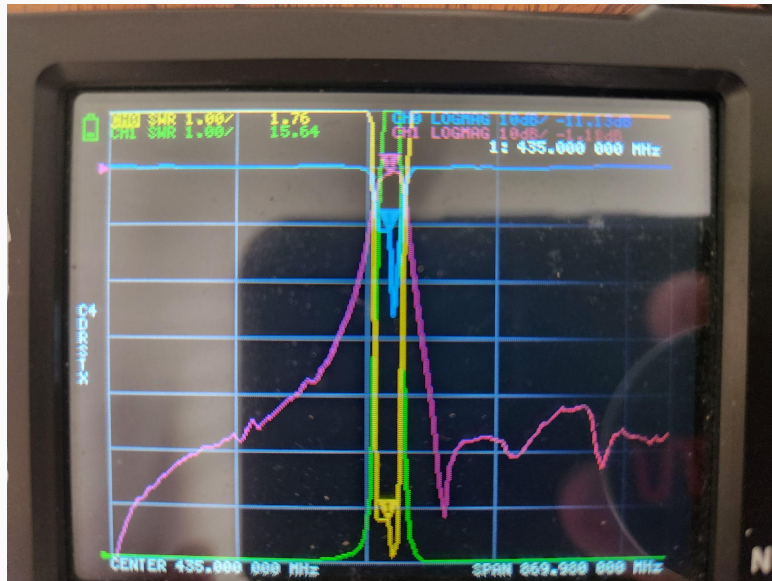
- Important: the Pluto is wideband and contains no filters
- Must add your own filter to reduce harmonics, interference, and stay legal
- To right: 70cm combline filter made with scrap semi-rigid coax, 2 SMA connectors, and housed in an Altoids tin
- Based on W1GHZ design
http://www.w1ghz.org/filter/Altoids_Tin_Filters.pdf



Portsdown

Filtering

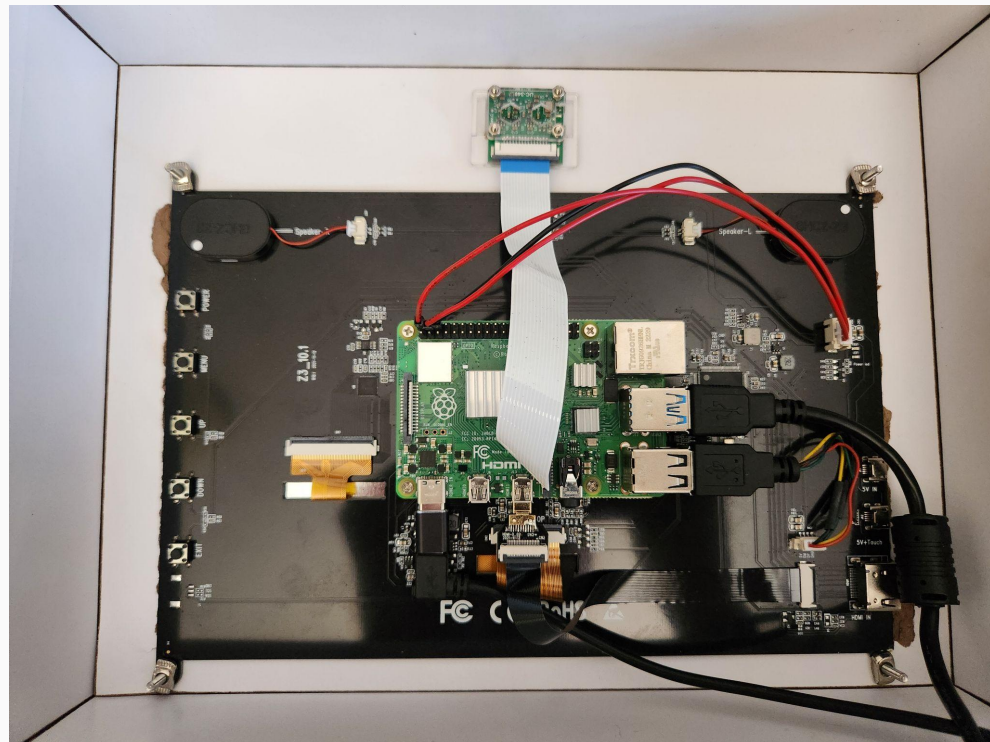
- W1GHZ filter on nanoVNA
- ~1dB loss in passband
- ~50MHz bandwidth centered at 434MHz
- Good enough for this application



Portsdown

Assembly

- View inside of my temporary cardboard Portsdown box.
- RPi mounts to touchscreen
- Camera module mounted above screen and connects to RPi
- Touchscreen control connects to USB port
- PlutoSDR connects to USB 3.0 port
- HDMI ribbon cable between RPi and screen
- 5V power supplied to RPi and also powers peripherals



Portdown

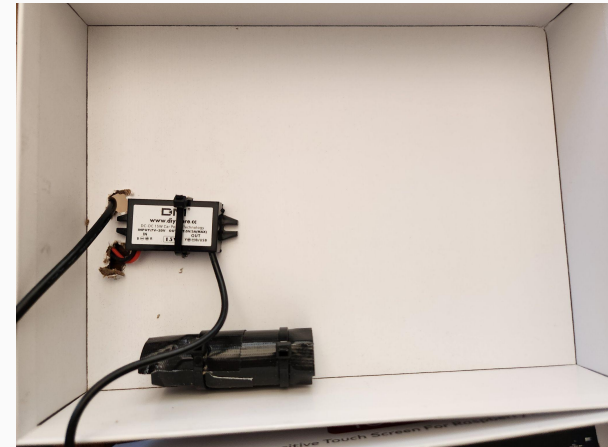
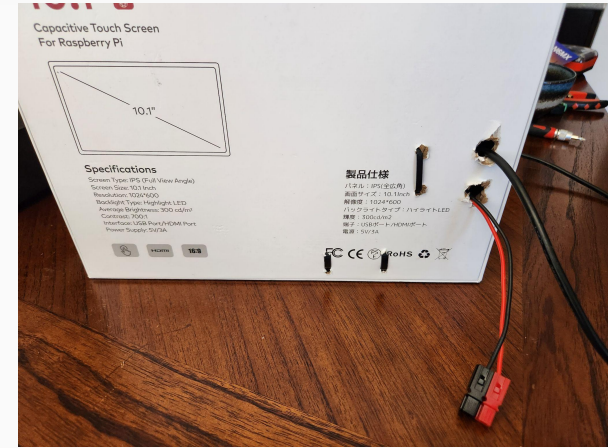
Assembled system



Left: Assembled Portdown. Altoid tin is a 70cm filter and blue dongle is the RTL-SDR for receive.

Top right: 12V power supplied through PowerPole connectors. Black USB cable to Pluto

Bottom right: 12V power through DC converter to 5V for RPi and peripherals. Zip tied a heavy bolt to container to help weigh it down.



Portsdown

Raspberry Pi Setup

- Install fresh Raspberry Pi OS to SD card
- Install Portsdown SW
 - <https://github.com/BritishAmateurTelevisionClub/portsdown4>

PlutoSDR Setup

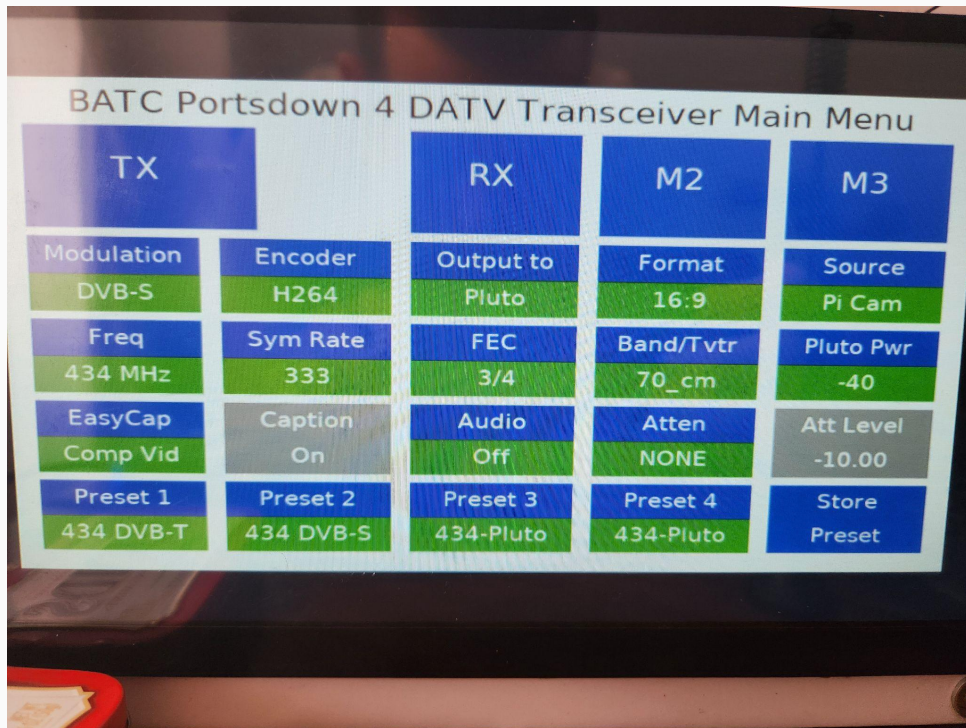
- SW mods
 - Expand frequency
 - <https://wiki.analog.com/university/tools/pluto/users/customizing>
 - Enable 2nd CPU
 - https://wiki.batc.org.uk/Portsdown_4_Pluto
- F50EO Firmware (support DATV modes)
 - https://wiki.batc.org.uk/Custom_DATV_Firmware_for_the_Pluto

Portsdwn

Controls

- DVB-S
 - Sub menu for QPSK modulation
- Freq: 434MHz
- Symbol Rate: 333
- PlutoSDR
- FEC: 3/4

- Select between Testcard/Camera
- Power: > -20dBm Pluto starts to get overdriven on this mode



Portsdown

Set up and ready

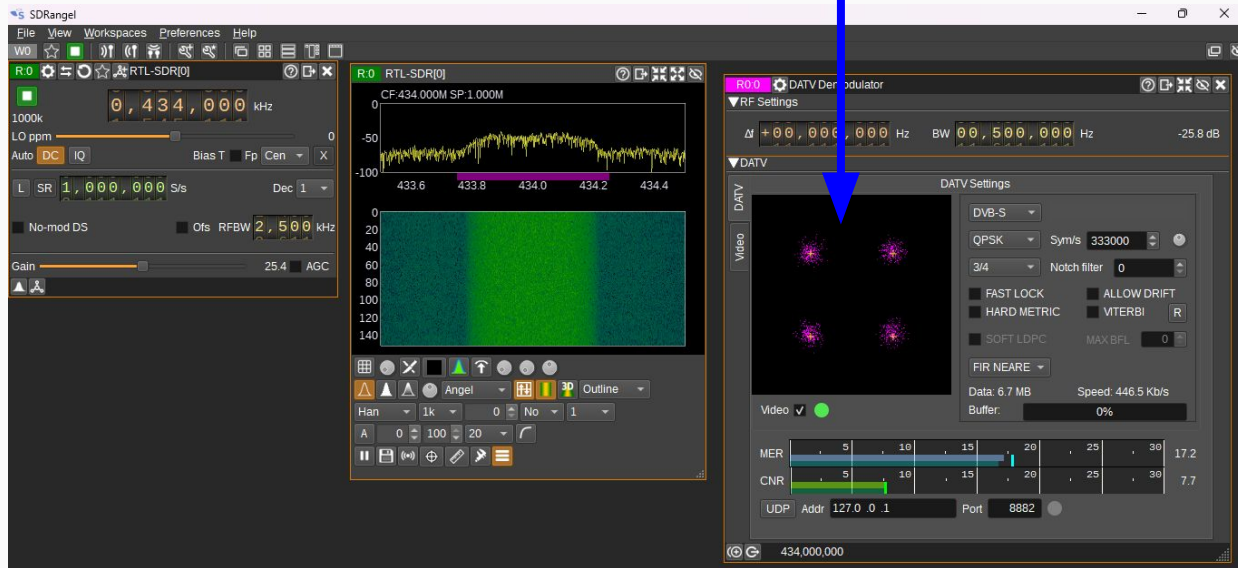
- Tx: RPi -> Pluto -> Filter -> telescopic antenna (tuned for resonance)
- Rx: non-resonant antenna (ok, just on hand) -> RTL-SDR -> Laptop with SDRangel software



Portsdown

SDRangel software

- Receive signal from RTL-SDR
- Select DVB plugin
- Adjust settings to match Tx
 - Frequency
 - Sample rate
 - Bandwidth
 - Standard (DVB-S)
 - Modulation (QPSK)
 - Symbol Rate
 - FEC
- Set some gain



Good
QPSK
signal

Portsdown

SDRangel software

- Receiving video!
- Embedded metadata contains callsign. I still visually show for fun

The screenshot displays the SDRangel software interface, which is used for software-defined radio (SDR) operations. The interface is divided into several panels:

- Left Panel (RTL-SDR[0]):** Shows the main SDR controls, including the frequency (0,434,000 kHz), LO ppm (1000k), Auto (DC, IQ), Bias T, Fp, Cen, X, L SR (1,000,000 S/s), Dec (1), No-mod DS, Ofs RFBW (2,500 kHz), Gain (25.4), and AGC.
- Center Panel (RTL-SDR[0]):** Displays a spectrum plot (CF:434.000M SP:1.000M) and a waterfall plot. The spectrum plot shows a signal at 434.0 MHz. The waterfall plot shows a signal at 434.0 MHz with a bandwidth of 2,500 kHz.
- Right Panel (DATV Demodulator):** Shows the demodulator settings, including RF Settings (Frequency: +00,000,000 Hz, Bandwidth: 00,500,000 Hz, Gain: -27.3 dB) and DATV settings. The video stream is displayed as a still image of a bridge at sunset with the callsign "N6MX" and "San Pedro California" overlaid.
- Bottom Panel (VIDEO Stream):** Shows the video stream metadata, including PID (256), Width (1024), Height (576), service_name (N6MX), service_provider (FIRM2101RC), and Codec (H.264 / AVC / MPEG-4 AVC / MPEG-4 part 10). The video stream is currently muted.

Portsdown

SDRangel software

- Portsdown also has its own testcard w/callsign

The screenshot displays the SDRangel software interface. The main window is titled "SDRangel" and contains several panels:

- Left Panel (RTL-SDR[0]):** Shows the frequency of the received signal as 0,434,000 kHz. It includes controls for LO ppm, Auto (DC, IQ), Bias T, Fp, Cen, X, L, SR (1,000,000 S/s), Dec (1), No-mod DS, Ofs, RFBW (2,500 kHz), Gain (25.4), and AGC.
- Top Center Panel (R:0 RTL-SDR[0]):** Displays a spectrum plot with a center frequency of CF:434.000M and SP:1.000M. The plot shows a signal centered at 434.0 MHz. Below the spectrum plot is a video frame showing a testcard with a woman and a mascot, and the callsign "N6MX".
- Right Panel (R:0 DATV Demodulator):** Shows RF Settings with a frequency offset of +00,000,000 Hz, a bandwidth of 00,500,000 Hz, and a gain of -26.2 dB. Below this is the DATV section, which includes a video stream display with a testcard and the callsign "N6MX".
- Bottom Right Panel (VIDEO Stream):** Provides technical details for the video stream: PID: 256 - Width: 1024 - Height: 576, service_name: N6MX, service_provider: FIRM2101RC, Codec: H.264 / AVC / MPEG-4 AVC / MPEG-4 part 10. It also includes checkboxes for Data, Transport, Video, and Decoding, and a volume control slider.

The status bar at the bottom of the window shows the current frequency: 434,000,000.

Portsdown

Other Notes

- RPi Software developer is Dave Crump G8GKQ
- Pluto Firmware developer is Evariste Courjaud F50EO
- Local SoCal W6ATN network has an input for 70cm DVB-T at 2MHz BW, but the Portsdown currently only goes to 1MHz BW, so not possible to use Portsdown on W6ATN at this time

Portdown

- Bill of Materials

Item	Cost
Raspberry Pi 4 Model B 4GB	\$68
NORSMIC 10" RPi Touchscreen	\$100
Arducam RPi Camera Module	\$13
Adalm Pluto SDR	\$230
5V DC Converter (x2 pieces)	\$12
RTL-SDR	\$30
Misc (Altoid tin, coax, etc)	--
Total	\$453

Portsdown

Langstone Microwave Transceiver Project

- Expands the Portsdown 4's capabilities*
- CW/SSB/FM/AM, 70MHz-6GHz
- Experimental support for 10GHz, 24GHz using harmonic mixing
- * Only with PlutoSDR



G8GKQ's Lanstone Transceiver

Image Source: https://wiki.microwavers.org.uk/Langstone_Project

Portsdown

Only loosely related to this project...

HamTV on the ISS!

- Original HamTV active 2016-2018
 - Primarily for ARISS school contacts
- March 21, 2024: Upgraded DATV transmitter delivered to ISS
 - Pending recommission Spring/Summer 2024
- 2395MHz main frequency
- DVB-S modulation
- Could use RTL-SDR to receive



HamTV getting installed on the ISS. March 2024
Image Source: https://wiki.batc.org.uk/HAMTV_from_the_ISS

Portsdown

Helpful resources

- British Amateur Television Club (BATC)
 - BATC is very active, continuously experiments, and has a quarterly newsletter
 - Website: <https://batc.org.uk/>
 - Wiki: https://wiki.batc.org.uk/BATC_Wiki
 - Portsdown: https://wiki.batc.org.uk/images/d/d2/Getting_Started_With_Portsdown_4.pdf
- KH6HTV
 - Lots of good information on website
 - Has a “ATV Handbook” PDF for download
 - <https://kh6htv.com/>
- HiDes
 - DVB-T equipment for amateur radio
 - Receiver: http://www.hides.com.tw/product_HV110_eng.html
 - Modulator: http://www.hides.com.tw/product_HV100eh_eng.html

Easy 5.8GHz ATV using drone
components

5.8GHz ATV

5.8GHz Analog ATV Project

- Analog is still relevant and easy to put together a working system
- Today's drone hardware makes it easy and cheap!
- Many ATV hams already doing variations of this project

5.8GHz ATV

Wavelength band	ITU Region 1	ITU Region 2	ITU Region 3	Sharing requirements see § 97.303 (paragraph)
SHF	GHz	GHz	GHz	
5 cm	5.650-5.850	5.650-5.925	5.650-5.850	(a), (b), (e), (r).

- Amateurs have secondary privileges on the 5cm band
- Note the “sharing requirements”
 - Be ok with receiving interference
 - Don't cause harmful interference
 - ISM band: 5.725 - 5.875 GHz

5.8GHz ATV

- Eachine TX526
 - 5cm band audio/video transmitter
 - FM modulation, NTSC/PAL video formats
 - 40 selectable channels
 - Selectable power: 25/200/600mW
 - Works on nominal 12V
 - Power, ground, video in, audio in
 - Other models also exist, but may have limited power and frequency selection

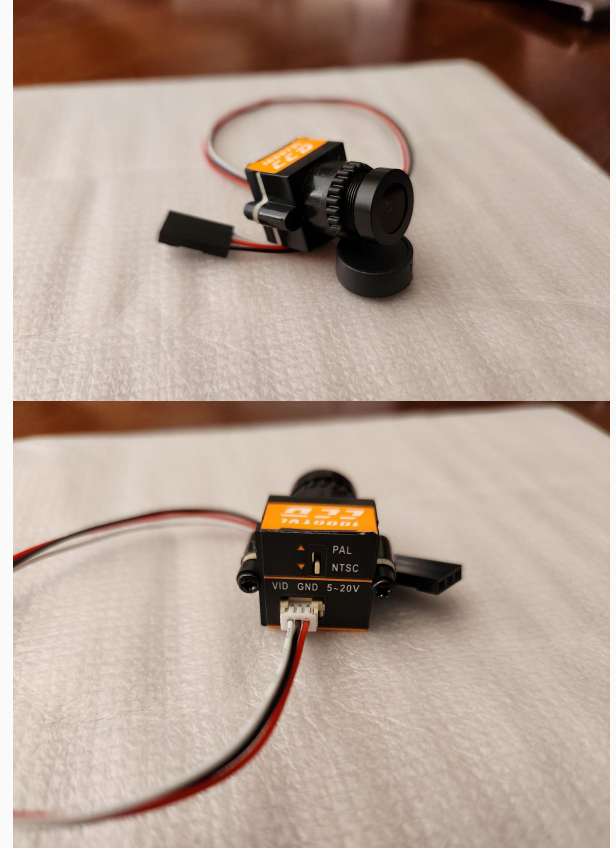
Frequency and channel frequency table:

	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
FR1/Band A	5865M	5845M	5825M	5805M	5785M	5765M	5745M	5725M
FR2/Band b	5733M	5752M	5771M	5790M	5809M	5828M	5847M	5866M
FR3/Band E	5705M	5685M	5665M	5645M	5885M	5905M	5925M	5945M
FR4/Band F	5740M	5760M	5780M	5800M	5820M	5840M	5860M	5880M
FR5/Band r	5658M	5695M	5732M	5769M	5806M	5843M	5880M	5917M



5.8GHz ATV

- Readytosky Mini 1000TVL FPV Camera
 - Selectable NTSC/PAL video formats
 - Works on nominal 12V
 - May also do infrared? Need to try with IR LED
 - Power, ground, video out



5.8GHz ATV

- Eachine RC832
 - 5cm band audio/video receiver
 - Complements the TX526 transmitter
 - 48 selectable channels
 - Works on nominal 12V
 - Power, ground, video out, audio out
 - Comes with power cable and component A/V cable

E. Frequency and Channel Frequency table:

FR	CH	CH							
	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	
FR	FR1(A)	5865M	5845M	5825M	5805M	5785M	5765M	5745M	5725M
	FR2(B)	5733M	5752M	5771M	5790M	5809M	5828M	5847M	5866M
	FR3(C)	5705M	5685M	5665M	5645M	5885M	5905M	5925M	5945M
	FR4(D)	5740M	5760M	5780M	5800M	5820M	5840M	5860M	5880M
	FR5(H)	5658M	5695M	5732M	5769M	5806M	5843M	5880M	5917M
	FR6(L)	5474M	5492M	5510M	5528M	5546M	5564M	5582M	5600M



Additional range, but outside ham band anyway

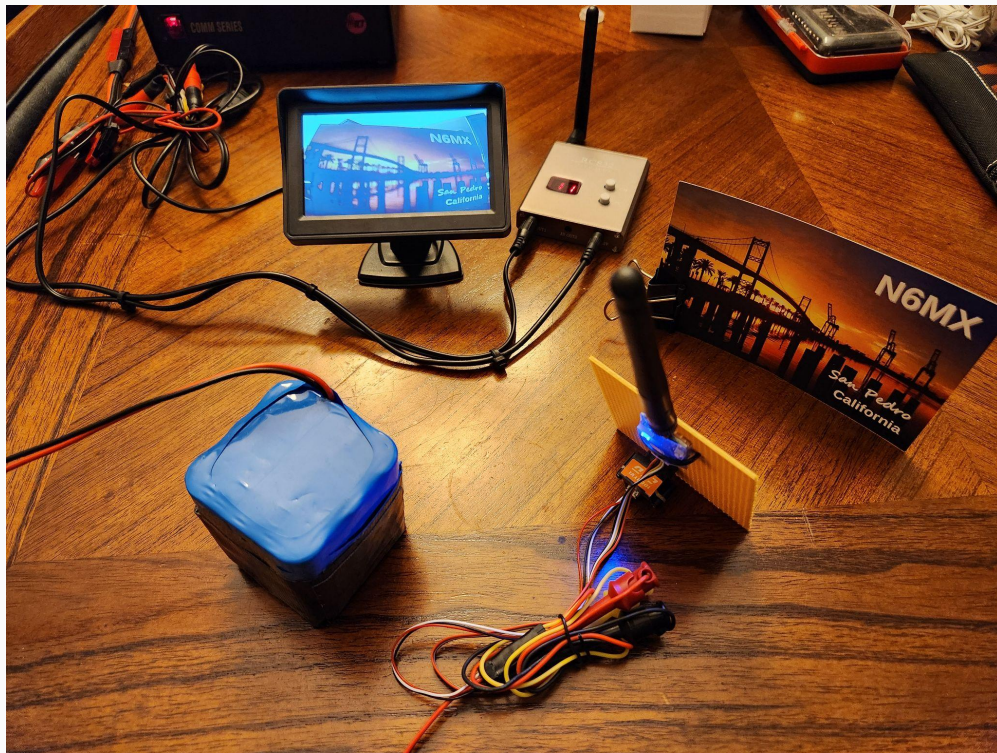
5.8GHz ATV

- B-Qtech 4.3 inch Color Display
 - Marketed as car backup cameras
 - Selectable NTSC/PAL video formats
 - Works on nominal 12V
 - Red connector is for power
 - White/Yellow connectors are video 1 and video 2
 - Video 2 has priority over video 1 if there is a signal
 - I keep forgetting this and plugging in the audio connector from the receiver
- This is a portable solution, but could go larger if you want! I always see used analog TVs at the thrift store



5.8GHz ATV

- Pinout is easy!
- Connect transmitter components, connect receiver components, and add 12V and you have a working system!
- Don't forget to ID w/callsign
 - Display visibly every 10 mins
 - Analog doesn't have metadata



5.8GHz ATV

Other notes

- Audio
 - I haven't done it yet, but...
 - TX526 has audio input
 - RC832 has audio output
 - Just need microphone and speaker
- Range
 - Claims with the stock antenna are several kilometers with line-of-sight
 - Should be more with a cheap directional PCB antenna
 - Could add a parabolic dish too, but would lose portability
- Full-duplex, just assemble a second system and pick 2 frequencies!

5.8GHz ATV

- Bill of Materials

Item	Cost	Source
Eachine TX526 transmitter	\$12	Banggood.com
Eachine RC832 receiver	\$13	Banggood.com
B-Qtech 4.3 inch Color Display	\$20	Amazon.com
Readytosky Mini 1000TVL FPV Camera	\$17	Amazon.com
Misc (batteries, wire, etc)	\$--	On hand
Total	\$62	

Final Points

The Portsdown digital ATV project is relatively low cost, works great on DVB-S, and has lot more potential.

The 5.8GHz analog ATV project is very low cost and fast and easy to assemble.

Both are fun to build and provides a great way to learn and get on ATV!

The 5.8GHz system is so easy and rewarding! You should build one!



Thank you for listening!

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