DATV-Express Users Guide

For running on Windows OS

(based on Express_DVB-S/-S2/-T_Transmitter software v1.23-beta)

Draft 010

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1.0 – Introduction

The DATV-Express board is a Digital-ATV transmitting exciter that can output around 10 mW of RF using DVB-S protocol and DVB-S2 protocol and DVB-T protocol. Previous implementations of DATV-Express software were mainly focused on LINUX Operating System distributions like Ubuntu. Now, with the DATV-Express companion software called Express_DVB-S/-S2_Transmitter, the board can currently be used with the Windows7, 8, or 10 OS. This software can be used to transmit Standard Definition TeleVision (SDTV) format video and even H.264 (HDTV) payload using the DVB-S protocol. The hardware board PLL design is capable of transmitting in any ham radio band between about 70 MHz and 2450 MHz. The software is based on a Software Designed Radio (SDR) design and is capable of many forms of modulation and protocols, although the Express_DVB-S/-S2_Transmitter software is no longer restricted to the DVB-S protocol but can also transmit DVB-S2 protocol with its more robust FEC. The current release (v1.23) of the software has been reasonably alpha-tested with DVB-S2 DATV protocol and has now "production released for DVB-S protocol" on Windows operating system. The DATV-Express Project Team would appreciate any feedback good or bad. If possible please use the BATC forum or DATV-Express yahoo support group (see Section 7.3 for the URL) so your testing information can be shared with others.

This User Guide covers using the Express_DVB-S_Transmitter software to drive the DATV-Express Board transmitter in both 32-bit or 64-bit Windows environment on Intel-based desktop and notebook computers, as shown in **Figure 1** and **Figure 2.** For preparing the DVB-S protocol, the Windows PC captures the video/audio input stream, uses software-based CODECs for encoding, prepares the Transport Stream (TS) and handles the GUI interface. The hardware board FPGA does most of the hard work for processing the DVB-S protocol, adding the Forward Error Correction (FEC) calculations (as shown in **Figure 1**). The DATV-Express hardware board also shapes the IQ data streams and modulates using an Analog Devices model ADRF6755 IQ-modulator chip.

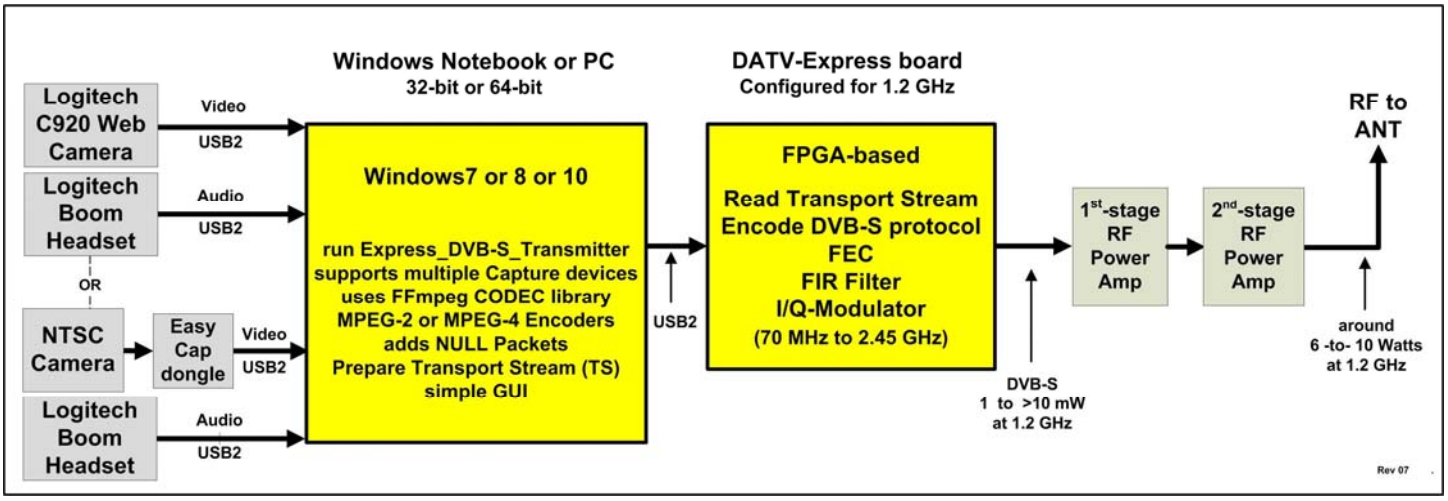


Figure 1 – Block Diagram of typical DATV-Express board set-up with v1.23 software for DVB-S protocol

When running the DVB-S2 protocol, the FPGA is too small to encode the DVB-S2 protocol. The same FPGA restriction is true for the DVB-T protocol. Therefore both the DVB-S2 and DVB-T protocols need to be encoded on the Windows computer (as shown in **Figure 2**)

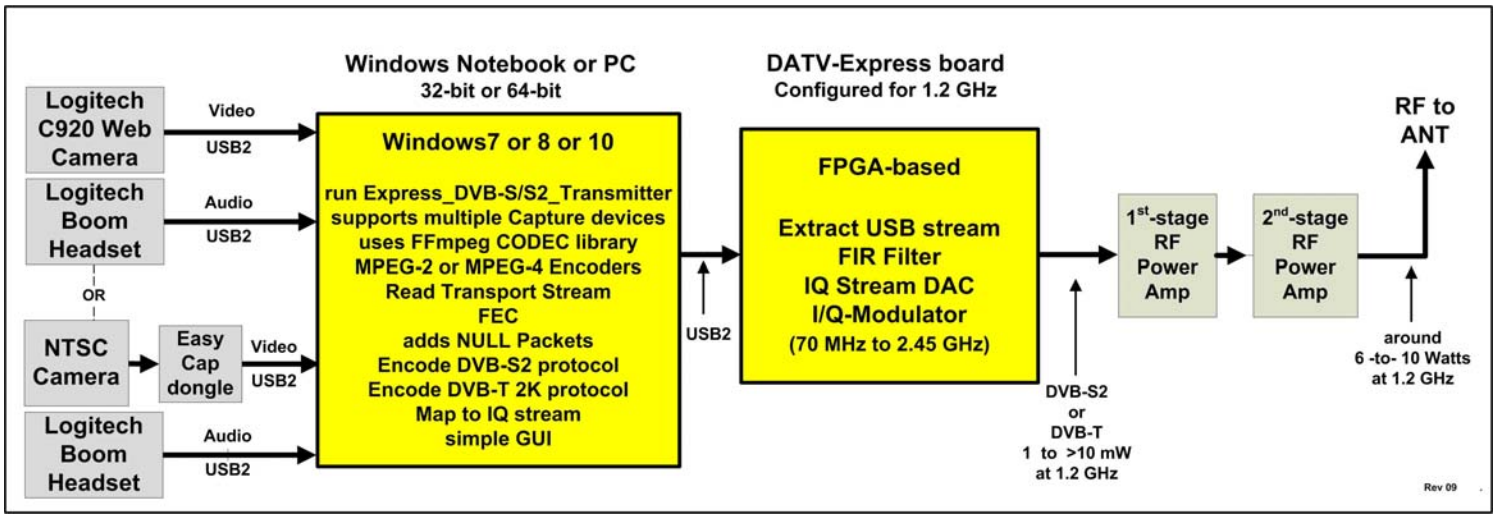


Figure 2 – Block Diagram of typical DATV-Express board set-up with v1.23 software for DVB-S2 protocol or DVB-T protocol

Sections 2.0 of this User Guide provide assistance to install the Express_DVB-S/-S2_Transmitter application software using Windows Operating System. Section 3.0 guides you to conduct some basic tests to confirm that your set-up is running correctly. Section 4.0 is a reference guide for the different settings inside the Express_DVB-S/-S2_Transmitter software that can be changed by the user via the software's User's Interface.

2.0 – Install Express_DVB-S/-S2_Transmitter software package

The Express_DVB-S/-S2_Transmitter software requires a Windows desktop/notebook and the DATV-Express hardware board to perform all of the DVB-S processing. The Windows PC will capture the video and audio and then send the processed Transport Stream (TS) datastream to the DATV-Express hardware board via USB2 connection. The FPGA on the hardware board does all the DVB-S protocol encoding. See Figure 1 (earlier page) for a block diagram of a typical DATV-Express transmitter set-up for the DVB-S protocol (shown configured to transmit on 1.2 GHz).

Currently the Express_DVB-S/-S2_Transmitter software runs only the Vista, Win7, Win8 or Win10 Operating System (OS). (NOTE – sorry, but WinXP does NOT contain the functionality required by Express_DVB-S/-S2_Transmitter software.) First, you will need to install the Windows driver for the DATV-Express hardware board. Second, you will need to install the actual Express_DVB-S/-S2_Transmitter software package.

2.1 Install the Windows Driver for DATV-Express hardware board

There is a program called **Zadig** http://zadig.akeo.ie/ which makes loading Windows drivers easy.
(CAUTION: When downloading Zadig tool from the web site, be careful to use the correct DOWNLOAD button. An incorrect selection will cause many undesirable programs to be installed!)
NOTE - If you already have the software called **DatvExpressServerApp** installed on your machine, then the Windows DATV-Express hardware driver needed for Express_DVB-S/-S2_Transmitter has already been installed and there will be nothing further to do for the windows HW driver.

2.1.1 You need to have ADMIN privileges on your PC to change drivers.

2.1.2 Have the DATV-Express hardware board installed as Unknown Device in the Windows-CONTROL-PANEL

- open the DEVICE MANAGER mode of the Windows Control Panel.
- Attach the DATV-Express board powered-up into USB2 port of Windows machine
- **DO NOT RUN** the inf wizard exe for libusb0
  ****(does **NOT** show correct the usb device, yet...**JUST ABORT**)
- When you insert the USB cable to the Board from Windows...you will see "unknown hardware do you want to find driver" say **NO**

*****IF you are not allowed to abort out of Windows searching the internet, see Section 2.1.3**

- If you are allowed to say NO…. then go to
  CONTROL PANEL -> DEVICE DRIVER -> OTHER DEVICES -> UNKNOWN DEVICE

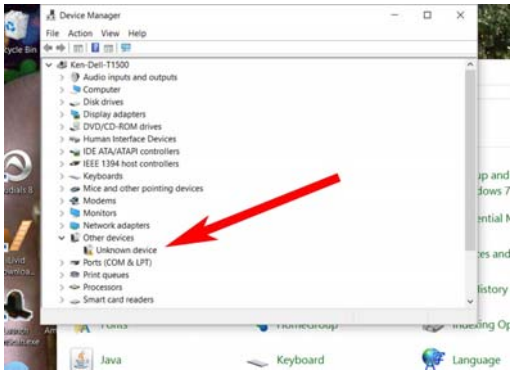


Figure 3 – Before using ZADIG, connecting Hardware Board will result in "Unknown device" driver appearing in DEVICE MANAGER

2.1.3 Change Windows to NOT “download drivers automatically”

If you had trouble with Windows OS insisting on automatically looking for a driver on the internet without giving you an opportunity to ABORT out of that action (perhaps an artifact of old Win7), then follow steps below.

- On the Windows PC, go to Devices and Printers from START.
- Right-Click on the Icon that represents the computer in the next pane.
- Left-Click device installation settings from the menu.
- A window opens “Do you want Windows to download driver software and realistic Icons for your devices?” The default is “**Yes, do this automatically**”, click on the button next to “**No, Let me choose what to do**”.
- Click on the button: “**Never install driver software from Windows Update**”.
- Click on “**save changes**” and it will exit. Then go back and repeat Section 2.1.2 again

2.1.4 Start up ZADIG in libusb-win32 mode

Then start-up Zadig and it will then fill in USB ID automatically and install the drivers as “Unknown Device #1”

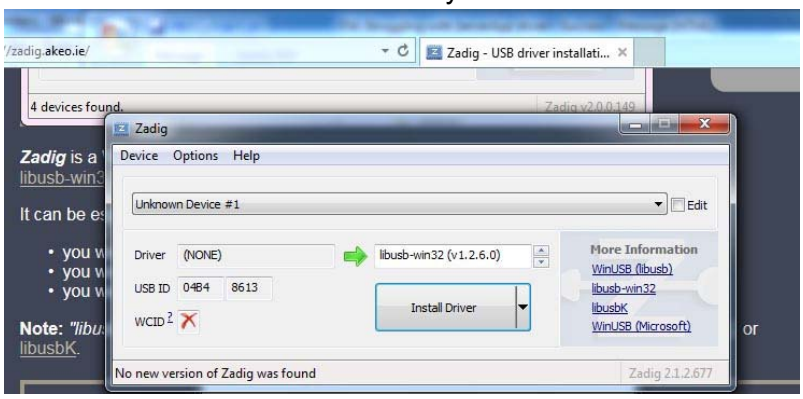


Figure 4 – ZADIG tool will install a new driver named “Unknown Device #1”

2.1.5 Recommend editing ZADIG device driver name to "DATV-Express”

- after completing the steps in Section 2.2.4, stay in ZADIG
- double click on UNKNOWN DEVICE
- use the EDIT button in ZADIG screen (next to current name of the Device driver) and change the driver name to “Datv-Express”
- click on UPDATE DRIVER

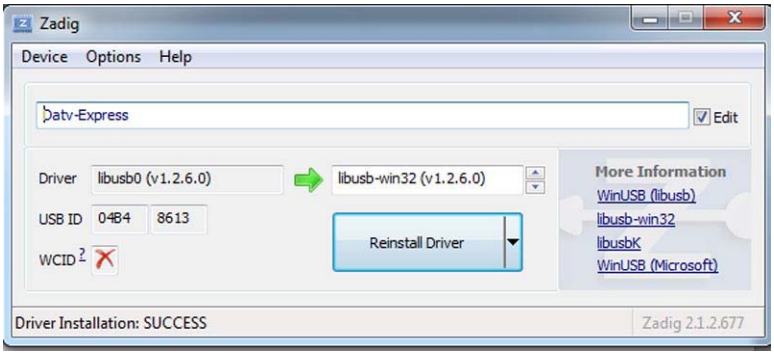


Figure 5 – Use ZADIG EDIT feature to rename the Device driver name

Go back to the Control Panel tab for DEVICE DRIVER and confirm that the renamed driver is now called **Datv-Express** as shown in Figure 6.

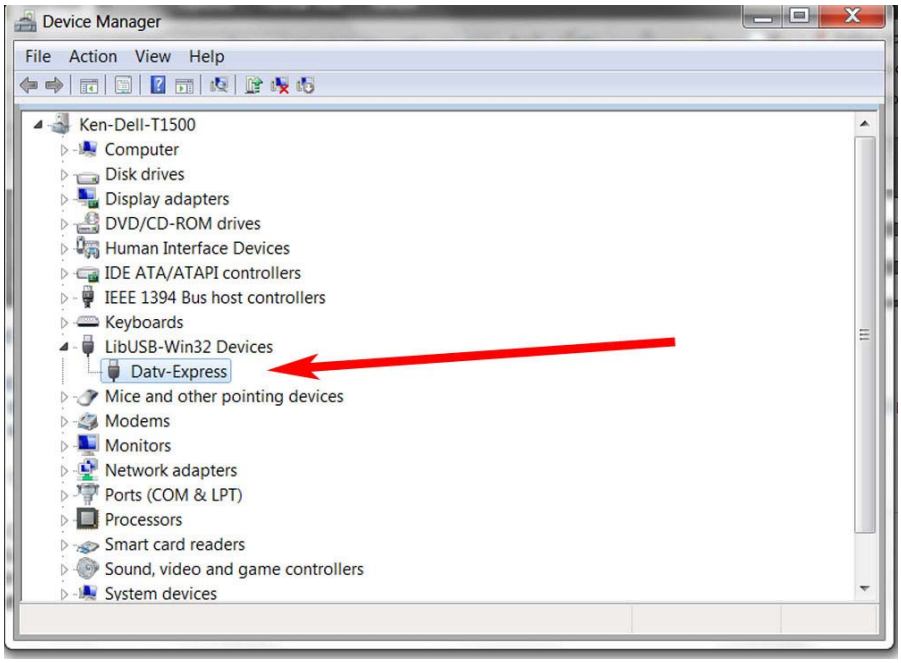


Figure 6 – DEVICE MANAGER shows successful installation of driver.

- For further information consult the Zadig webpage and instructions.

2.2 Install the Express_DVB-S/-S2_Transmitter software package on Windows

The software needed to install the Express_DVB-S/-S2_Transmitter app on Windows is found in an easy-to-use package installer file that was prepared by the **Inno Set-up** utility.

2.2.1 Download Express_DVB-S/-S2_Transmitter Installer package from DATV-Express.com

"Inno Setup" is the name of a utility that helps to install the Express_DVB-S/-S2_Transmitter software application package onto Windows OS. The Express_DVB-S/-S2_Transmitter installer package has already used Inno Set-up to hide much of the tedious complexity for installing software on the Windows OS.

- Download the **Windows_setup_datv_express_dvb-s_transmitter_v1.23.zip** zip file from the **www.DATV-Express.com** website on the **DOWNLOADS** page.
- Be sure to read the **NOTES .TXT** file for this software, also on the **DOWNLOADS** page.
- SAVE the zip file to whatever directory you like on your Windows PC.
- OPEN the ZIP file and if given a choice…save the contents to a folder called Express-DVB-S_Transmitter

  NOTE 1 – you will **NOT** need to run this setup as ADMIN
  NOTE 2 – you will **NOT** need internet access during the install

- RUN the SETUP.EXE installer file and allow it to install at the default location…in the ROOT DIRECTORY.

  NOTE 3 – I find it convenient to let SETUP create a "shortcut" icon on the DESKTOP

- When SETUP.EXE has finished, the Windows root directory should look like Figure 06 with a ROOT-directory folder called **DatvExpress** containing the folder for the software that is named **Express-DVB-S_Transmitter**.

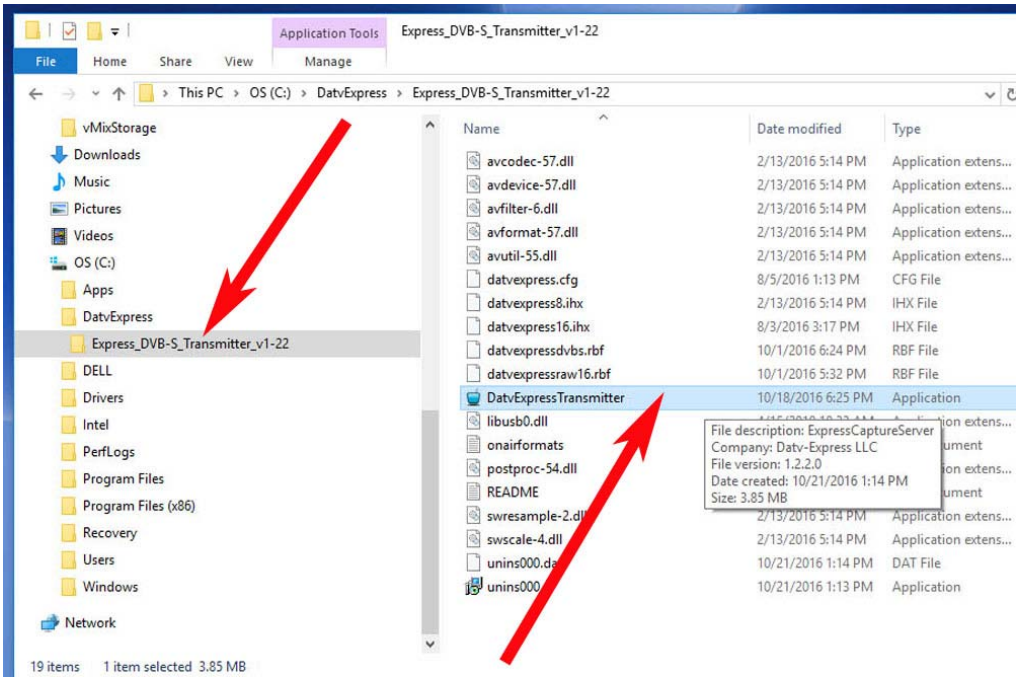


Figure 7 – The SET-UP.exe should be allowed to default to installing software inside a Directory called DatvExpress (see left arrow)

- The new EXE file for the Express_DVB-S/-S2_Transmitter software is the file named "DatvExpressTransmitter.exe" (see right arrow in **Figure 7**).

2.2.2 A quick "test launch" of Download Express_DVB-S/-S2_Transmitter software

You should now have a "short-cut" icon called Express showing up on the Windows OS Desktop. We will now step though a quick launch of the Express_DVB-S/-S2_Transmitter software to make sure that everything seems to be working….before you do more set-up and Testing in Section 3.0

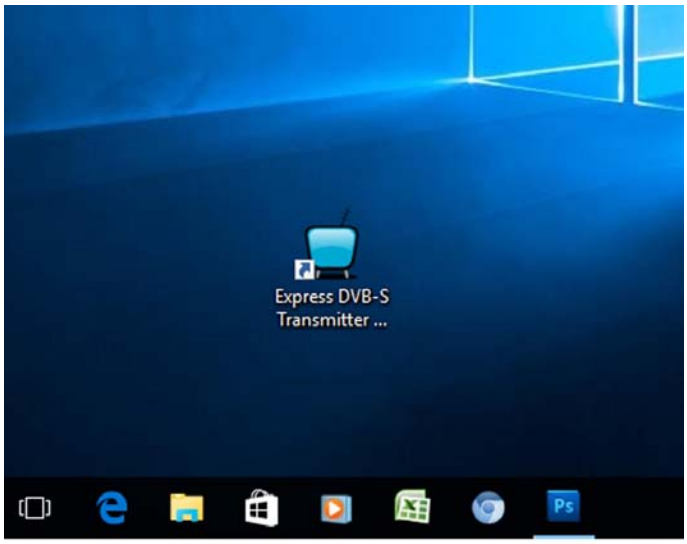


Figure 8 – The Express DVB-S Transmitter app icon should appear on the Desktop

- Attach the camera you plan to use to the Windows computer USB port.
- Also attach the audio input (if different than camera) to the computer USB port.
- Attach the DATV-Express hardware board to a computer USB port.
- Now power up the DATV-Express hardware board. (no RF amplifiers are needed at this point.)
- Double-click on the desk-top icon. The main screen of Express_DVB-S/-S2_Transmitter software should open as shown in Figure 9. The PTT button will remain grayed out until valid video / audio selections are made and saved (see selections steps below).

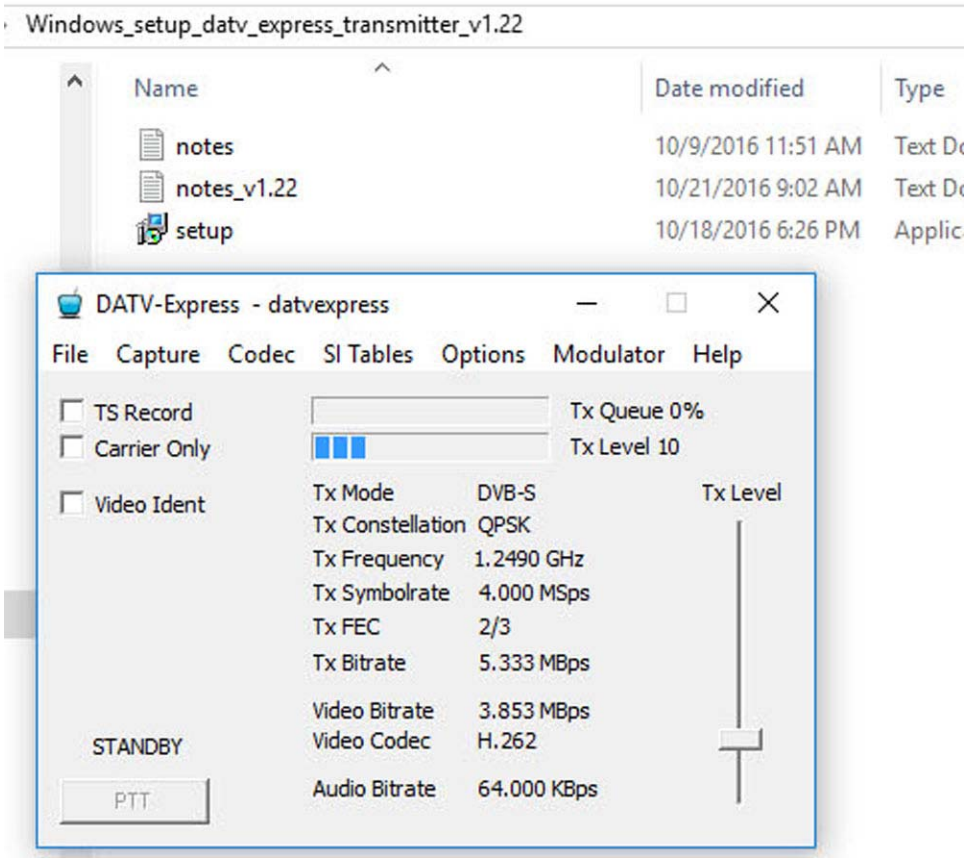


Figure 9 – The initial MAIN screen you should see after set-up is run

- LED lights 3, 4, 5 on the hardware board should be lit….with the second from bottom blinking, LED2.
- First we need to configure a valid video input and a valid audio input…before the software will really run.
- Select the CAPTURE TAB on the Main screen shown in Figure 9
- Now select VIDEO
- The VIDEO CAPTURE Settings screen as shown in Figure 10 should appear.

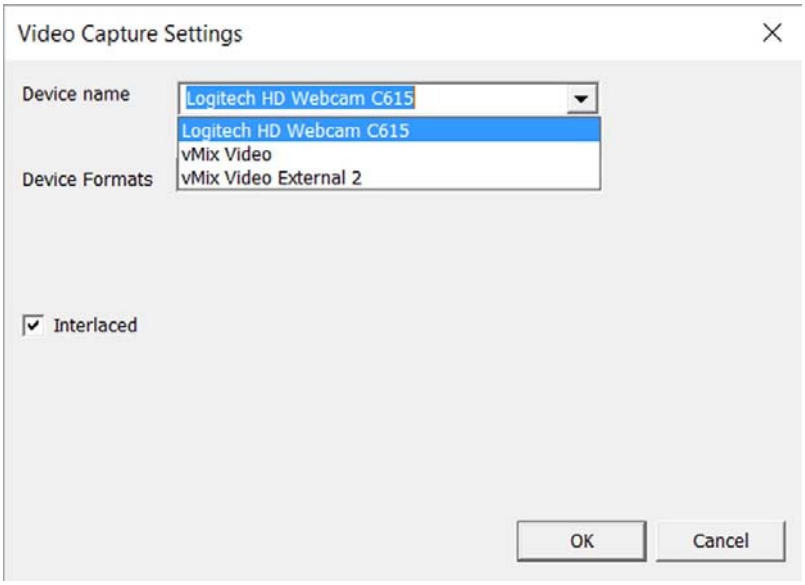


Figure 10 – The Video Capture screen allows you to select your camera if plugged in.

- Select the desired Camera from the DEVICE NAME field's pull-down menu.
- Click OK
- Now pull down the menu from the DEVICE FORMATS field as shown in Figure 11. Note that not all formats shown will be supported by a specific camera.

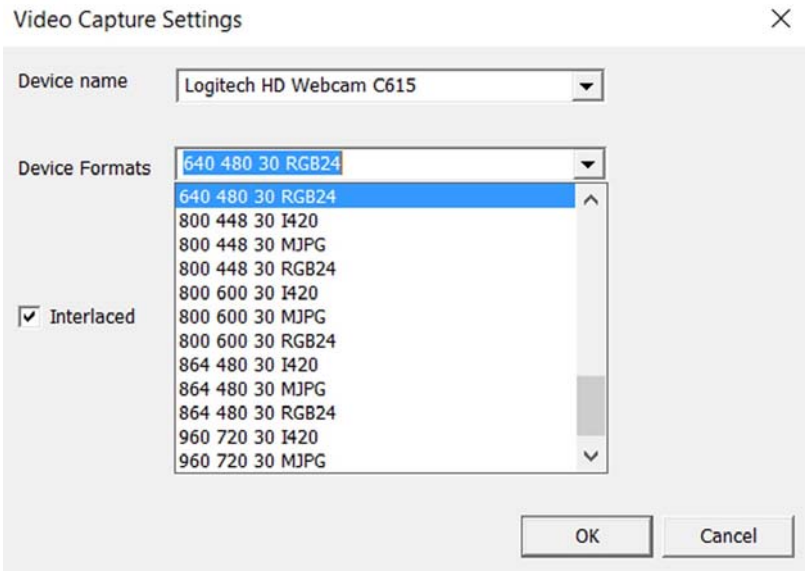


Figure 11 – The DEVICE FORMATS menu allows a number of possible values

- Select a Device Format setting
- Click OK
- Then click the INTERLACED box and again say OK
- Go to the FILE TAB on the MAIN MENU and select SAVE
- Go back to the FILE TAB on the MAIN MENU and select RESTART
- Select the CAPTURE TAB on the Main screen
- Now select AUDIO
- The AUDIO CAPTURE Settings screen shown in Figure 12 should appear.

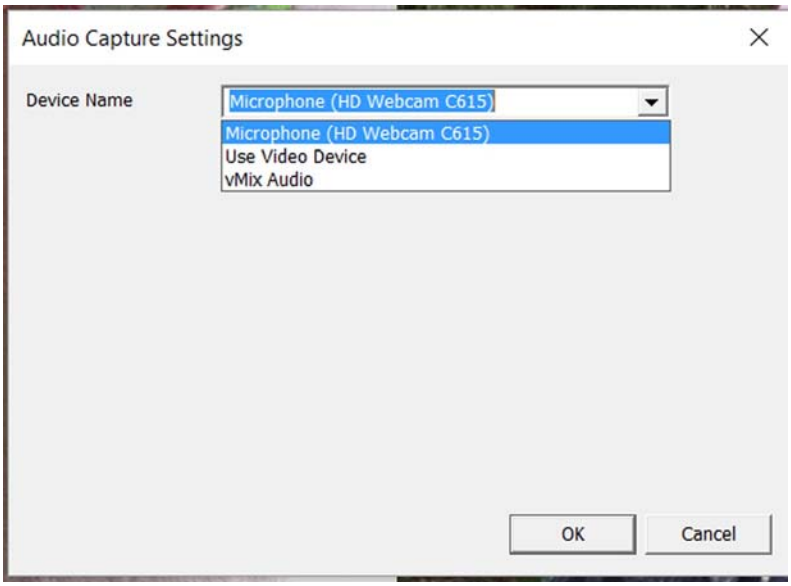


Figure 12 – The AUDIO Capture screen allows you to select the Audio device.

- Select the desired source of AUDIO from the DEVICE NAME field's pull-down menu.
- Click OK
- Go to the FILE TAB on the MAIN MENU and select SAVE
- Go back to the FILE TAB on the MAIN MENU and select RESTART
- You are going to power-OFF the computer at this point.
- Go to the FILE TAB on the MAIN MENU and select EXIT.
- Turn the Power-OFF to the DATV-Express hardware board.

2.2.3 Test the PTT Button

If everything in Section 2.2.2 worked correctly, then the PTT button will be allowed to work properly, (and PTT will NO LONGER be "grayed out").

- Now power up the hardware board. (no RF amplifiers are needed at this point.)
- Double-click on the desk-top icon. The main screen of Express_DVB-S/-S2_Transmitter software should open.
- First check to see if your VIDEO and AUDIO selections were correctly saved using the CAPTURE TAB
- If everything is correct…select the CANCEL button to escape back to the MAIN screen
- Finally press PTT. If everything is working the MAIN screen should display that you are in the TRANSMIT mode in RED.

2.3 Upgrading your installed DATV-Express Software

Occasionally you may want to upgrade your Express_DVB-S/-S2_Transmitter software file to begin using a newly released feature or bug-fix. When newer installation upgrade files are available, these upgrades can be downloaded from the **DOWNLOADS** area on the DATV-Express web site (See **Section 7.2**)

- It is NOT required FOR the Windows PC provides Wi-Fi or Ethernet access to the internet during the upgrade installation after the upgrade .ZIP file has been downloaded to the target computer.
- Simple - run the installation script file (setup.exe) again. It will replace the old files.

3.0 - Hook-up the DATV hardware and Test

3.1 Here is what you need

A list of minimum items you need to have your first test of the DATV-Express software and board

- A version E (or later) DATV-Express exciter hardware board
- A PC with appropriate Windows Operating System installed (as used in Section 2.2).
- A 12V DC power supply to run the DATV-Express. By itself, the DATV-Express board will run about 2 Watts (mostly quiescent power in the modulator chip U4).
- A 12V power cable with a 2.54 mm center contact connector at one end to attached to J3 on the hardware board.
- Invest in purchasing a brand-new USB2 cable with a “Type A” connector for PC-end, and a “Type B” connector for the J1 connector on the hardware board.
- A web-camera with USB interface (Logitech units work well).
- Or a PAL or NTSC video camera with an appropriate video-capture dongle like (EZ-cap)
- RCA-type cable to connect the camera to the Hauppauge or other video-capture unit.
- A Set-Top-Box (STB) connected to some form of display (a TV set or computer) or receiver/analyzer for the DVB-S protocol like TuTioune.
- Optionally, you can use a spectrum analyzer, if you have access to one.
- [NOTE – optionally I use a microwave “directional coupler” unit (cheap on e-Bay) to split the exciter output RF signal to both the spectrum analyzer (the forward signal sample) and to the transmitter antenna.
- A small bent piece of wire to act as a one-quarter-wave vertical antenna for both the DATV-Express exciter board and a second antenna for the DATV STB or stand-alone DATV receiver.
- RF Amplifiers are optional, but are not needed for checkout at this point if the board and software are working as expected.

3.2 First Test – power up the DATV-Express board by itself

- IMPORTANT NOTE – please take adequate precautions against ESD discharges to the board. A minimum precaution should be to first touch the 12V DC power supply chassis....or the top of the SMA connector, J2, before you handle the board. Components on an exposed DATV-Express board are susceptible to ESD damage if not handled correctly.
- NOTE – do not connect the USB2 cable to the DATV-Express board at this point of testing.
- Connect the 12V power cable to J3 on the DATV-Express board
- Power up the power supply
- If the LED 4 lights (5.5 V on-board DC-to-DC power supply) near the upper-right mounting hole, then the test is successful
- No other LEDs on the hardware board should activate during this test (see Section 4.13 for locations).
- Note that LED 1, 2, 3, and 5 normally glow very dimly. They are **OFF** if they are not as bright as LED 4.
- Power off the power supply.

3.3 Second Test – connect hardware board & start Express_DVB-S/S2_Trans SW

- Disconnect THE USB cable from the hardware board at this point
- Power OFF the 12V power supply for the hardware board..
- Connect the USB2 cable between the PC and J1 on the hardware board
- Power ON the Windows computer
- After PC boots up, power ON the 12V power supply for the DATV-Express board
- Only LED 4 should light (5.5 V on-board DC-to-DC power supply)
- Start up the Express_DVB-S/-S2_Transmitter software by double-clicking on Express_DVB-S/-S2_Transmitter desktop icon
- An error message indicating an “Invalid Video Capture Device” as shown in Figure 13 should appear.

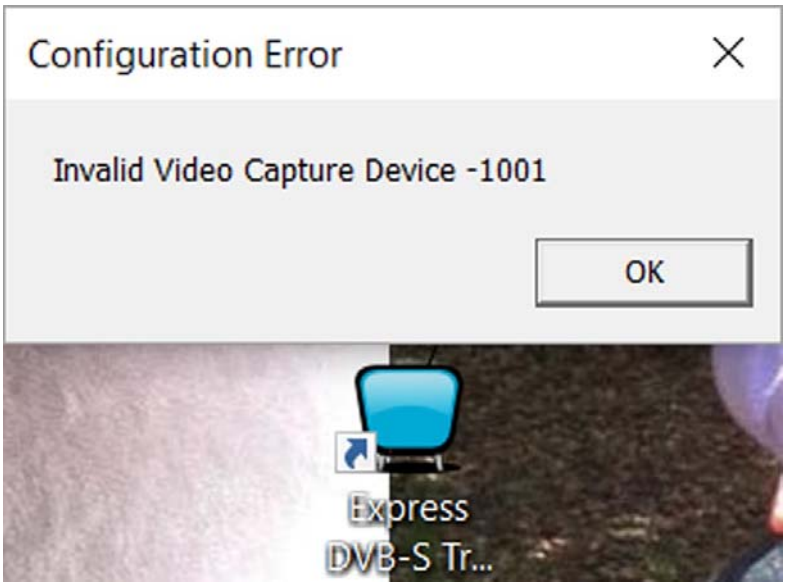


Figure 13 – An error message appears because the camera (video-source) is not connected

- Say OK to the error message.
- Now, the MAIN user display window on the Windows PC should appear in a DEMO mode as in photo below.

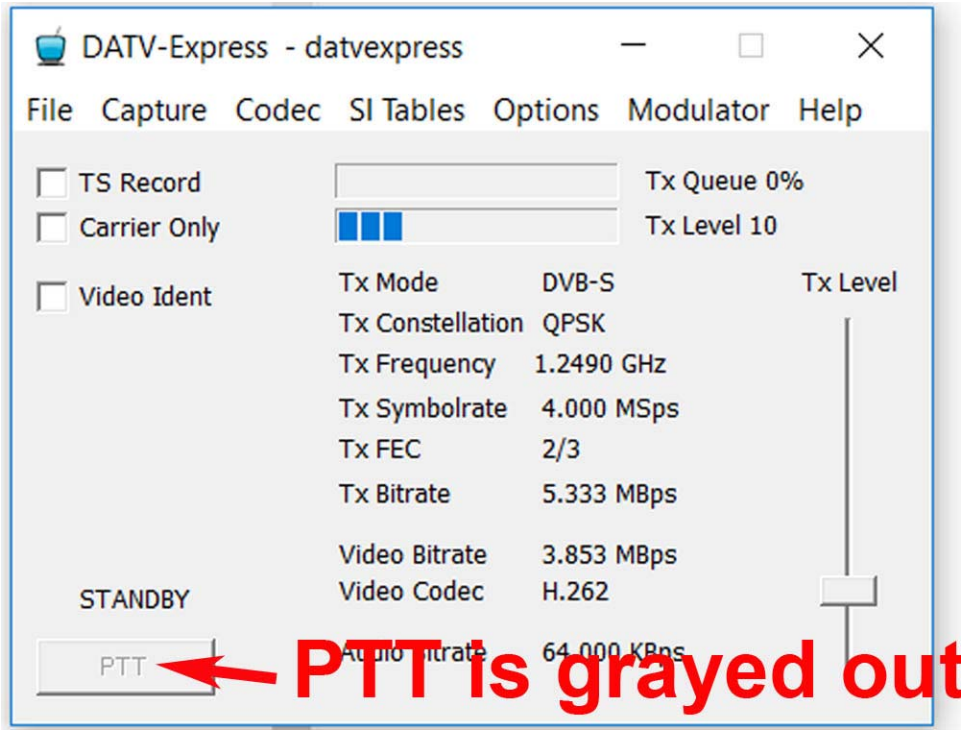


Figure 14 – The MAIN window confirms that the software is running in the DEMO Mode with PTT button "grayed out"

- TWO additional LEDs should be ON (LED 2 and LED 3). NOTE Note that an LED is ON if it glows as brightly as LED 4.
- LED 5 should still be OFF for now.

3.4 Third Test – now connect video-capture to the PC

- Start by exiting the Express_DVB-S/-S2_Transmitter software, then powering OFF the board 12V power
- Connect the video-capture camera to the PC by an unused USB connector
- Also attach the audio input (if different than camera) to the computer USB port.
- Attach the DATV-Express hardware board to a computer USB port.
- Now power up the hardware board. (no RF amplifiers are needed at this point.)
- Start the Express_DVB-S/-S2_Transmitter software application file by double-clicking the desktop icon.
- If you have already successfully completed the earlier steps in Sections 2.2.2 and 2.2.3, then the MAIN GUI screen in Figure 15 should be displayed with PTT button no longer "grayed out".
- By the time that the GUI window opens up on the PC display, LED 5 should now be ON and LED 3 should light up and LED 2 should blink if the PC has loaded the FPGA on the hardware board. [See section 6.13 for LED details.]

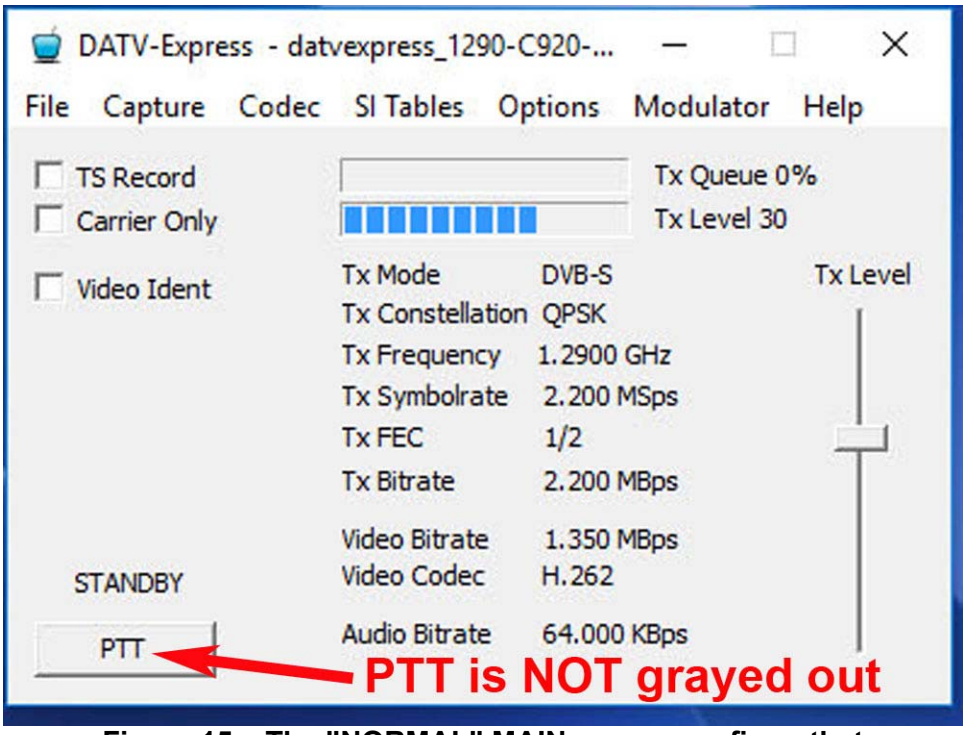


Figure 15 – The "NORMAL" MAIN screen confirms that Software is no longer running in DEMO Mode

- If the MAIN screen you see still has the PTT button "grayed out", then perhaps you did not yet successfully complete the steps in Sections 2.2.2 and 2.2.3? Go back and complete those steps again?
- **If the FPGA does NOT light the new LEDs (LED 5, LED3, and LED2) on the board,** that probably means that the code did not download to the board FPGA for some reason.
- If everything is OK...then close the DATV-Express software application, then turn OFF power on the 12V power supply , and finally turn OFF power on the computer.

3.5 Fourth Test – Transmitting DATV video

- Get ready to plan for the ham band you want to use, the exact frequency, DVB-S Symbol-Rate, and the FEC setting you want to use.

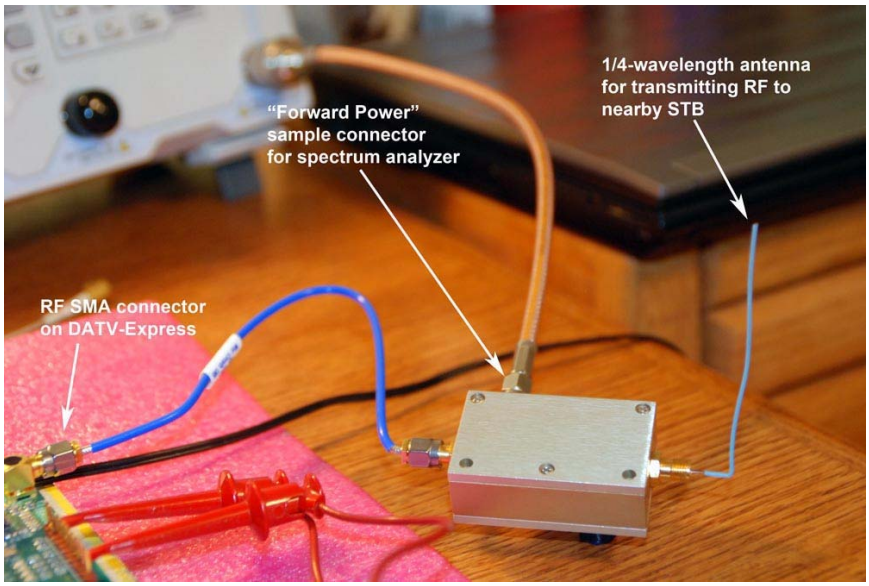


Figure 16 - a microwave "directional-coupler" is used to sample some RF energy for the Spectrum Analyzer (shown antenna is for 1.2 GHz band)

- Set–up (A) a nearby SetTopBox (STB) as a receiver for the protocol, and all the DVB settings that the receiver needs to know. Alternatively you could just look on a (B) spectrum analyzer or (C) using an RF "splitter" or microwave directional-coupler, sample the exciter RF output to the spectrum analyzer and connect the RF output to an antenna to be received by a nearby STB.
- I suggest you will have the best results if you can preprogram the receiver to the channel you plan to transmit on. "Blind scans" can work to allow the STB to find transmitted DATV signals, but many things can go wrong to cause the STB to not lock on the signal during scanning. The PAT/PMT table sequence is sometimes transmitted in DATV applications NOT often enough. If the STB does NOT pick up that PAT/PMT table information in it's "scan dwell period", then the STB will skip to the next channel in the search scan.
- Place a small bent piece of wire to act as a one-quarter-wave vertical antenna in the SMA connector of the DATV-Express exciter board for the planned transmission band/frequency.
- If you will be using a nearby-STB or receiver to display the video, then connect another small bent piece of wire to act as a one-quarter-wave vertical antenna for the receiver (see **Figure 16**).
- Power ON the STB receiver and/or the spectrum analyzer and set it to the desired pre-programmed channel.
- Power ON the DATV-Express board. Just LED 4 will be light at this point.
- Double-click on the Express-DVB-S_Transmitter software application icon on the desk top
- By the time that the GUI window opens up on the PC display, LED 5 and LED 3 should light up and LED 2 should blink if the PC has loaded the FPGA on the hardware board. [See section 6.13 for LED details.]
- You will need to set-up the Express-DVB-S_Transmitter software to the exact protocol that you are using. This manual will walk you through setting up for a DVB-S test.
- Go to the **MODULATOR** Tab in the Express-DVB-S_Transmitter program window. (See section 4.6)
    - Edit the TRANSMITTER FREQUENCY field in the MODULATOR Tab window to the exact center frequency you plan to transmit….for example 1292000000 in the 1.2 GHz/23 cm band
    - Edit the Symbol-Rate field in the same Tab to the value you desire…for example 4000000
    - Edit the FEC setting to the value you desire…for example 7/8
    - Edit the TRANSMITTER LEVEL field to the RF output level you want to try…for example **20**
    - Click on the OK button to send these values to the software
    - Go to the FILE TAB and select SAVE.
    - Go to the FILE TAB and select RESTART.

- Go to the **CODEC** Tab in the Express-DVB-S_Transmitter program window. (See section 4.3)
    - Select the Video encoding technology that your STB is set to receive…the simplest is H.262 (aka MPEG-2)?
- Click on the OK button to send these values to the software
- Go to the FILE TAB and select SAVE.
- Go to the FILE TAB and select RESTART.
- If you are trying to view video on an STB, then the configure video on the DATV-Express software. It is then necessary to go to the HW Tab and set up your video-capture device (see section 5.10).
- At this point, click on the large PTT button…and the STANDBY mode next to PTT, should change to TRANSMIT.
- Hopefully you will see an RF signal appear on the receiver or the spectrum analyzer. If you are using a DVB-S STB receiver or if you have a MiniTiouner analyzer, you will see video…if everything has been set up for your STB correctly.

4.0 - Express_DVB-S/-S2_Transmitter GUI Reference Guide

Section 4 walks the reader through the function of the controls of each of the TABS shown in the user interface window.

4.1 FILE Tab

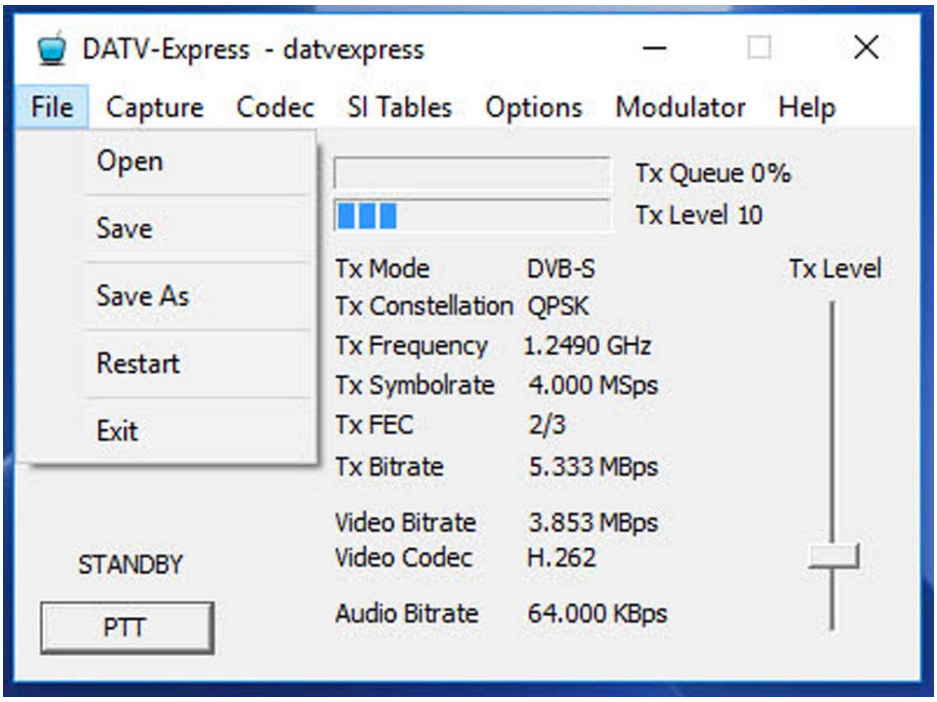


Figure 17 – Window for the FILE Tab
displaying various configuration file actions that can be selected

4.1.1 Open

This selection allows the user to select from previously stored preset values for Frequency and CODECs, etc., in the files ending in **.CFG .** For example, a file named datvexpress_23cm_H.262.CFG could store the users normal settings for the 23 CM band for H.262 operations.

4.1.2 Save

This selection allows the user to SAVE any recently changed values back to the currently used **.CFG** file.

4.1.3 Save As

This selection allows the user to SAVE any recently changed values back to a new .CFG file for a different band. For example, a file named datvexpress_70cm_H.262.CFG could save settings to be used on the 70 CM band.

4.1.4 Restart

After saving the latest changes to configuration settings, use the RESTART selection to assure that the software is using these latest changes.

4.1.5 Exit

This selection will immediately shut down the Express software program..

4.2 CAPTURE Tab

The CAPTURE TAB allows you to select either Video-capture devices-and-settings or Audio-capture devices-and-settings.

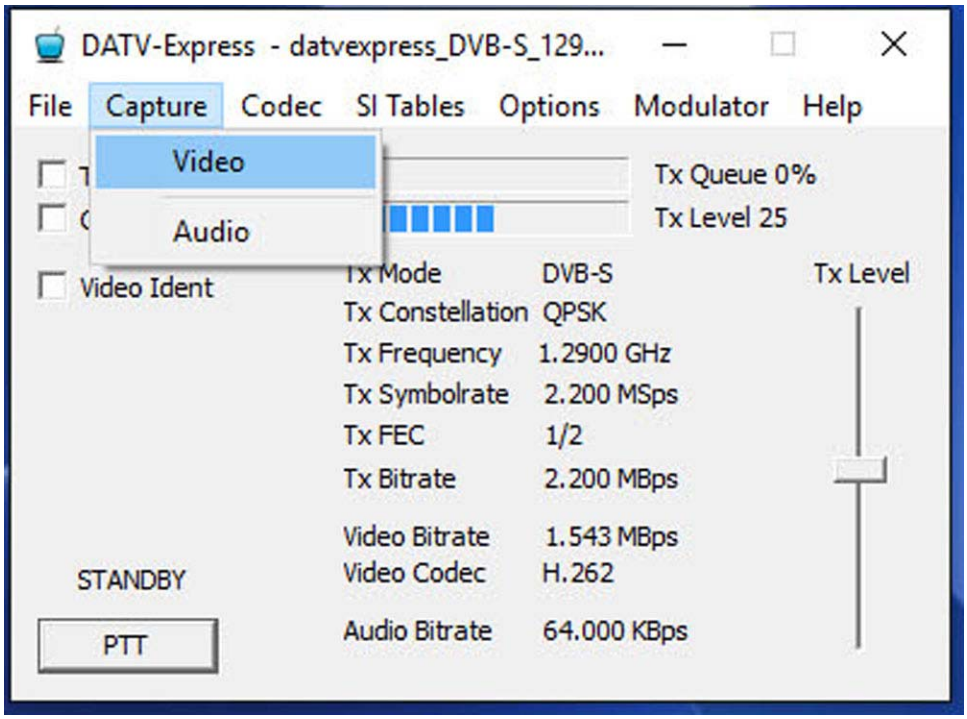


Figure 18 – Window for the CAPTURE Tab selecting Video

4.2.1 VIDEO Capture

The Video Capture Settings screen in Figure 19 allows you to select the desired video-capture device and choose the Device Format for that device and to choose if you want to interlace the video display lines.

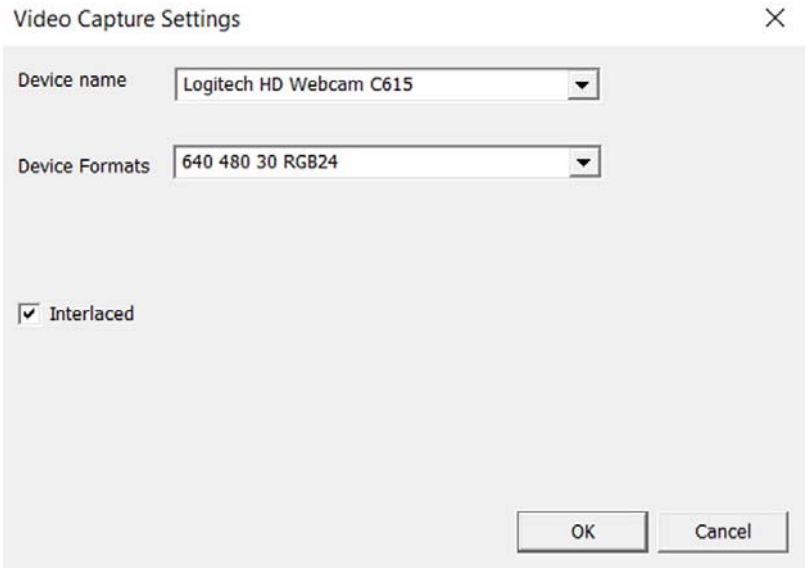


Figure 19 – Window for the VIDEO CAPTURE selection

4.2.2 VIDEO – Device Name field

The pull-down menu on the DEVICE NAME field shows the valid devices that are installed on your Windows computer (see Figure 20). Just select the one you plan to use. Then press OK

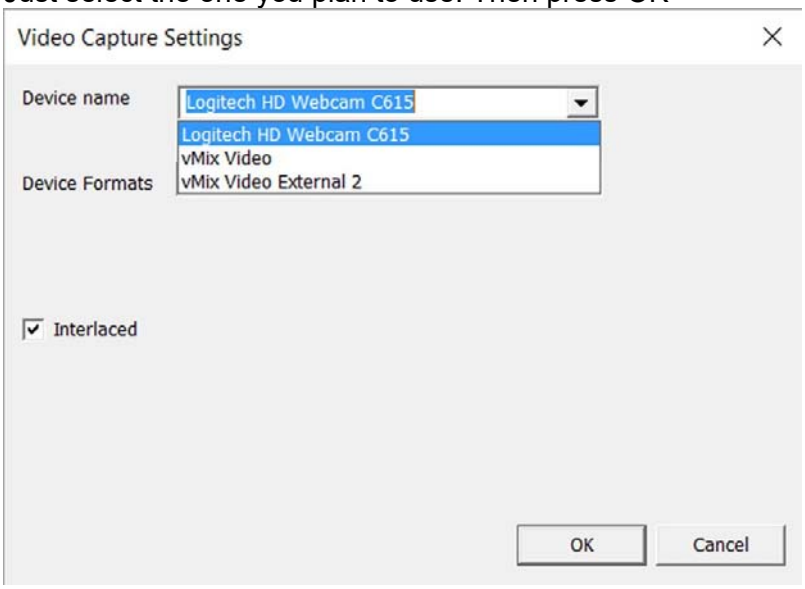


Figure 20 – Window for selecting the Video-source device

4.2.3 VIDEO – Device Formats field

The pull-down menu on the DEVICE FORMATS field shows many “possible” choices. When selecting a Video capture device, make sure you select a format. Only analogue formats can be used such as YUV, RGB, etc. Not all shown format values are allowed. The software includes all the “possible” formats for debugging. A good selection for a Logitech C920 camera is **640 480 30 RGB24**. Some frame rates will not be supported by your video capture device. Also, some older cameras can not output 30 frames-per-sec,

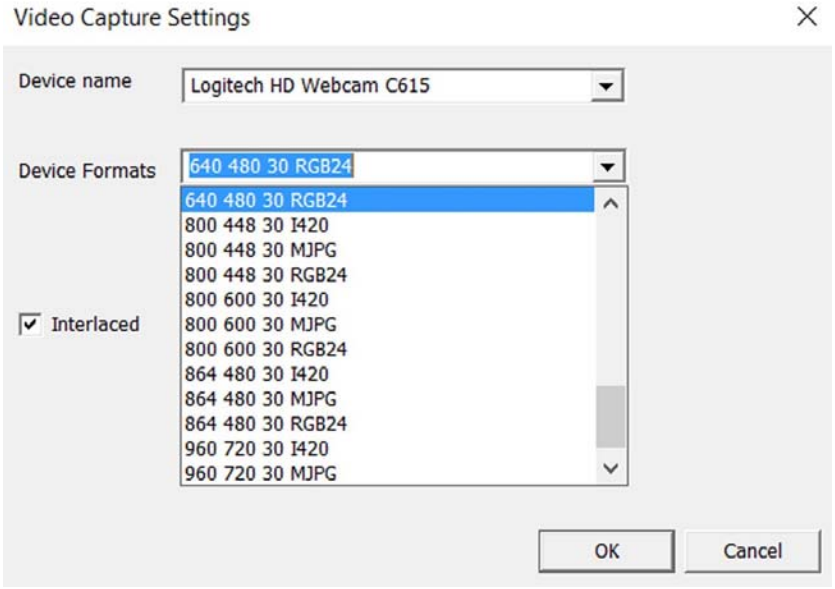


Figure 21 – Window for selecting the Video input format from camera

In Windows, it is a good idea to use Logitech install program when you install a camera. G4GUO has noticed that Windows default drivers and manufacturers own drivers support different formats. The Express application only supports a limited number of formats. Those formats it does not support are not displayed. That may explain why in some cases - vMix can see the camera…but Express software can not see that camera.

4.2.4 VIDEO – Interlaced (checkbox)

The “interlaced” function was brought over straight from the FFmpeg library and is associated with the capabilities of the video-capture device. Always monitor your own transmissions and see what effect occurs with and without the Interlaced (check box) enabled.

4.2.5 VIDEO – OK button

Click on the OK button when all of the settings have been correctly configured.

4.2.6 VIDEO – CANCEL button

Click on the CANCEL button if you want to escape from any selections you may have changed,

4.2.7 AUDIO

The CAPTURE Tab allows you to select the source for AUDIO that you plan to use.

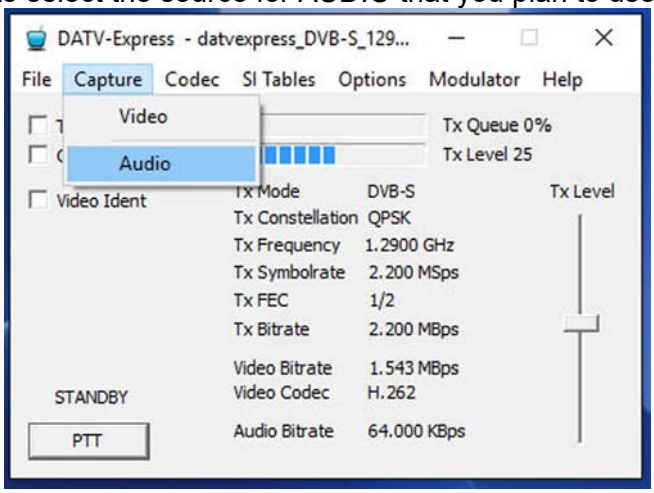


Figure 22 – Window for the CAPTURE Tab selecting Audio

4.2.8 AUDIO – Device Name field

The pull-down menu on the DEVICE NAME field shows the valid audio devices that are installed on your Windows computer (see Figure 23).

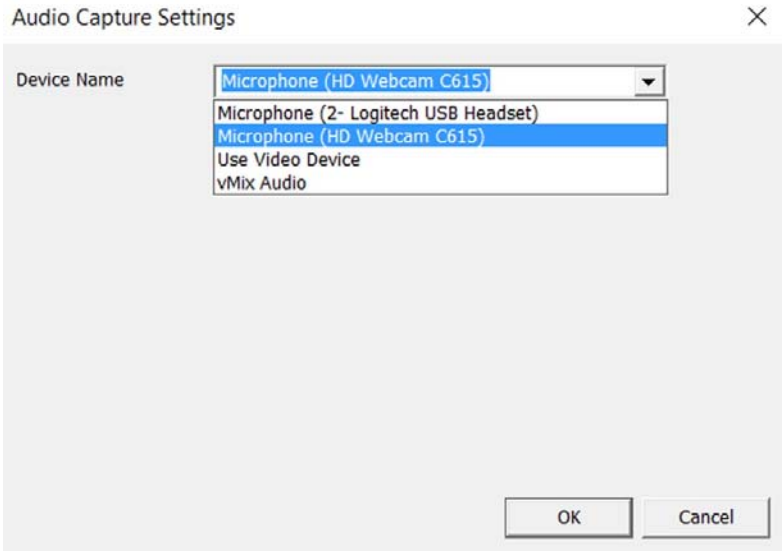


Figure 23 – Window for selecting the Audio-source device

4.2.9 AUDIO – OK button

Click on the OK button when all of the settings have been correctly configured.

4.2.10 AUDIO – CANCEL button

Click on the CANCEL button if you want to escape from any selections you may have changed,

4.3 CODEC Tab

A CODEC is a compression algorithm that can ENCODE or DECODE the video and audio data streams. The CODEC Tab will allow you to choose a VIDEO encoder and an AUDIO encoder.

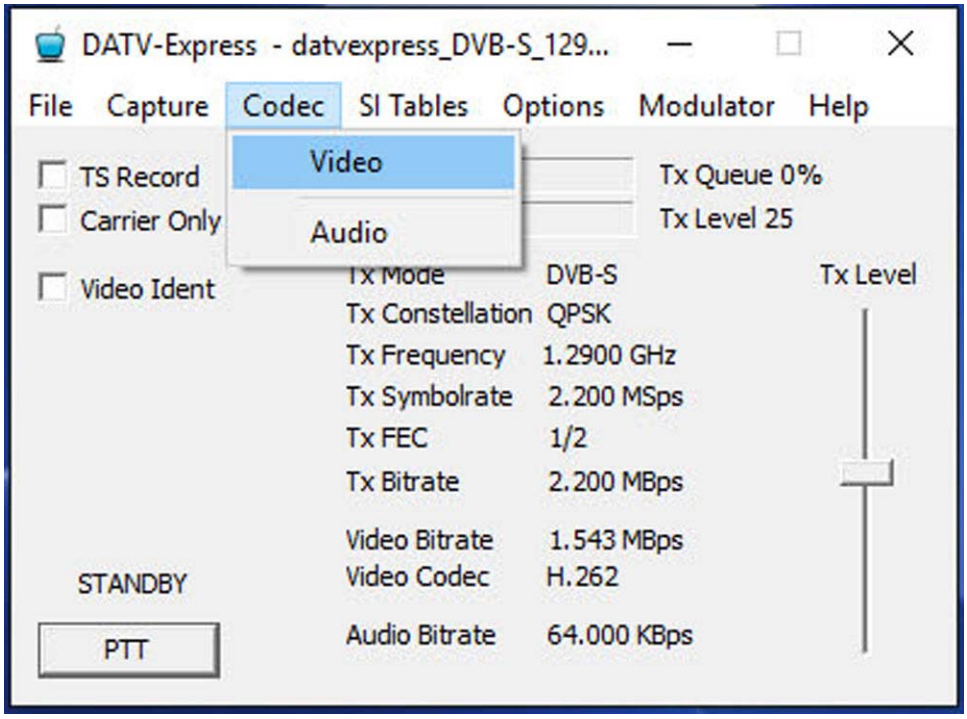


Figure 24 – Window for selecting VIDEO or Audio encoders

4.3.1 CODEC – VIDEO Settings

The Video Codec Settings windows are shown in Figure 25 and in Figure 26. It allows choosing the CODEC technology, adjusting some compression parameters, controlling how much CPU is to be used when using H.264 and H.265, and tweaking the Video Bitrate if needed,

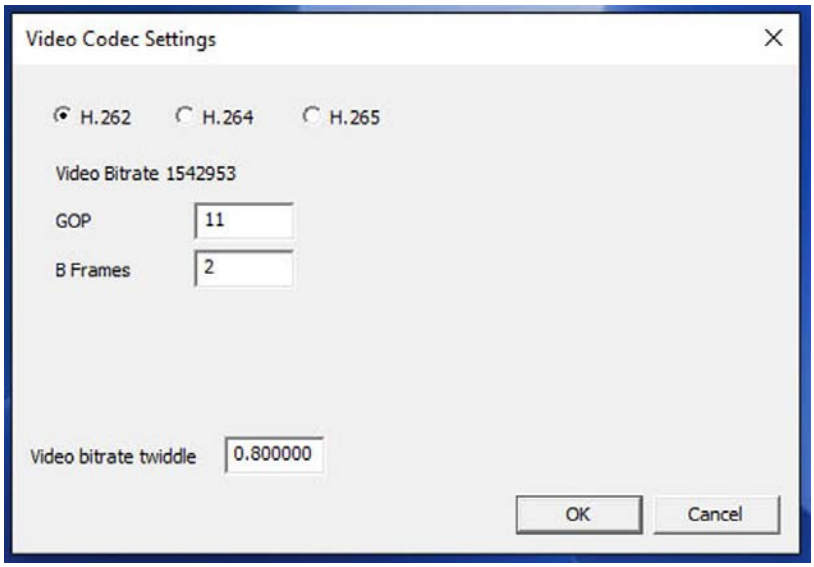


Figure 25 – Window for selecting Video Codec Settings (for H.262)

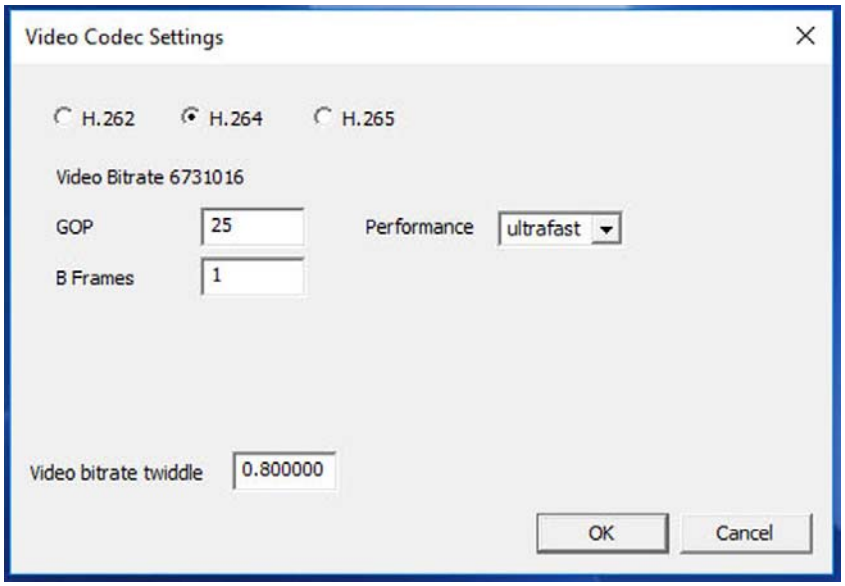


Figure 26 – Window for selecting Video Codec Settings (for H.264 and H.265)

4.3.2 VIDEO CODEC – Radio Button Selection

The radio buttons along the top of the Figure 25 and Figure 26 windows allow you to select one of three different CODEC VIDEO encoding technologies for your transmission.

- **H.262** is the standard MPEG-2 video encoding that is used by commercial DVB-S DTV transmissions. It works well but does not compress as efficiently as H.264 or H.265. H.262 is more compatible on older SetTopBox receivers (such as FTA before MPEG-4 was introduced).
- **H.264** is the newer MPEG-4 video compression that is used by commercial DVB-S2 and DVB-T2 HDTV transmissions. H.264 encoding provides higher bit stream compression efficiency than H.262, but may have a little longer latency (video delay) than H.262. The good news is that H.264 CODEC can be used as the "payload" video stream inside the DVB-S protocol…as long as the receiver is capable of receiving both DVB-S and H.264…such as a DVB-S2 STB. Another advantage of the H.264 CODEC is that it works better (than H.262) in low Symbol-Rate (less than 1.0 MSymb/sec) environments for RB-DATV (Reduced Bandwidth – DATV). The smoother (less broken) video seen on the receiver is due to H.264 design using a more suitable macro block size.
  One caution is that if you insist on using HDTV quality video as an input, then the video bitrate will be very large and may require a 6 MHz Bandwidth on the spectrum to receive that quality. Hams can tweak the video capture format and SR and frame-rate (FPS) to achieve acceptable BW and video quality as the RB-

DATV hams do on 2 Meters where reduced bandwidth is required. RB-DATV is also very useful to reduce DATV bandwidth spectrum requirements on other ham bands like 70 CM and even 10 GHz.

- **H.265** is a more recent video compression encoder that is also known as High Efficiency Video Coding (HEVC) can encode 4Kp60/10-bit video in real-time (with hardware encoder). H.265 can compress 480-line video with 50% more reduction and 1080-line video is reduced by 60% (both compared to H.264 CODEC). H.265 is very computer intensive - typically results in latencies nearly 10 seconds on slow CPUs.

4.3.3 VIDEO Bitrate – display

The Video Bitrate displayed below the radio buttons is the calculated bitrate from the software that is left over for the video data stream after all the other overheads are subtracted. The software calculated value can then adjusted by the twiddle factor in Section 4.3.6.

4.3.4 GOP (Group Of Pictures)

The GOP (Group Of Pictures setting) is one of the compression parameters that affects the compression efficiency and also affects the video delay (latency). GOP value is equal to 16 (length between two I frames) in this example **IBBBPBBBPBBBPBBB**IBBBPB... GOP value is equal to 7 in Figure26. The GOP length is also known as the N parameter. GOP is an advanced topic, outside the scope of this guide but is provided to those advanced hams who need to adjust it. I suggest you use the default value of 10. If you insist on tweaking this parameter, or want to learn more…try Googling for it as "GOP (Group Of Pictures) ". One recommended resource for MPEG-2 video encoding concepts is an article called TechTalk85 , available at **www.W6ZE.org/DATV/** under the "DATV Articles" link. Google has wealth of detailed info including:

https://ffmpeg.org/doxygen/2.8/structAVCodecContext.html#a3e5334a611a3e2a6a653805bb9e2d4d4

4.3.5 B-Frames Count

A B-Frame is a type of compressed video frame that contains only information to describe the changes from the I-Frame and the P-Frame. The number of B-frames between I and P frames or length between two consecutive P Frames is also known as the M parameter. The B setting (B-Frames count) is another one of the compression parameters that affects the compression efficiency and also affects the video delay (latency). The number of B-frames used obtain determines how much compression will be obtained by comparing differences to I-frames and P-frames. This parameter sets the maximum number of B-frames between non-B-frames Note: The video output will be delayed by max_b_frames+1 relative to the input. Figure 27 shows the concept.

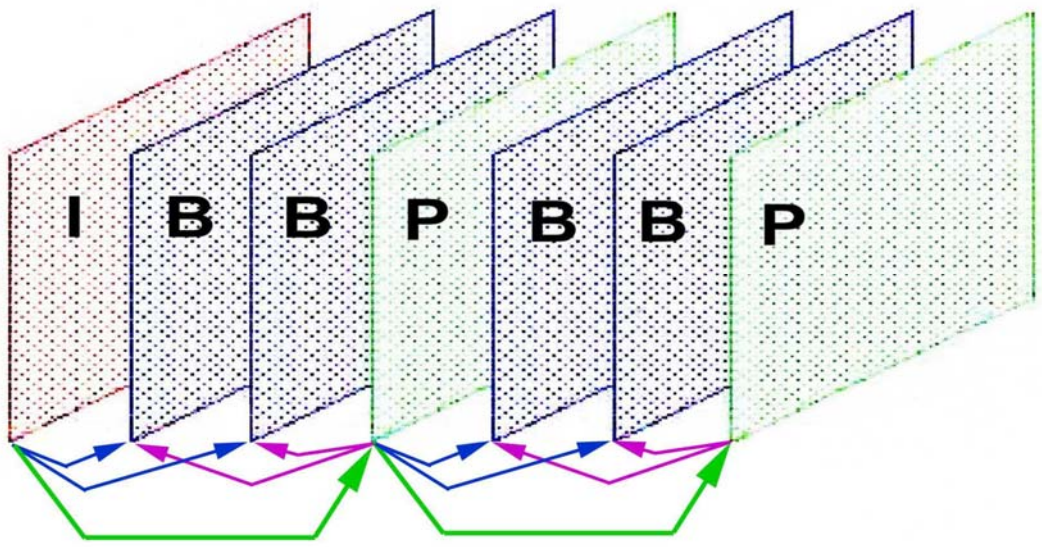


Figure 27 - A diagram of a Sequence of Compressed Frames (using the GOP mode called IBBP) that is: the B-Frames count is 2 (with GOP set to 7) (courtesy of TechTalk85)

- **I-Frame** This type of video frame contains ALL the necessary information to display a whole picture frame (low JPEG-like compression). That is: I-frames are coded without reference to other pictures (frames).
- **B-Frame** This type of compressed video frame contains only information to describe the changes from the I-Frame and the P-Frame.
- **P-Frame** This frame is a resulting Predicted Picture that can use the previous I-frame or P-frame for motion compensation and may be used as a reference for further prediction.

B-Frames settings is an advanced topic, outside the scope of this manual….but is provided to those advanced hams who need to adjust it. I currently suggest you use the value of 2 (with GOP set to 10) for low latency to start with. Using GOP=10 and B-Frames=2 will result in the frame pattern **IBBPBBPBBP**IBBP**…** Also, experiment trying to receive different settings from your transmitter.

Another beta tester using an i5 laptop with USB composite capture card and Vmix - uses

H.262 between 1.5 to 4+ MSymbols/sec – GOP (N) = 15 and B-frames (M) = 5
H.264 below 1.5 MSymbols/sec – GOP (N) = 20 and B-frames (M) = 3

4.3.6 Performance

The **PERFORMANCE** setting (the field pull-down menu is shown in Figure 26 and 28) determines how much CPU performance will be allocated to perform the H.264 and H.265 video encoding. NOTE that this setting is only active when using the H.264 CODEC. This field allows you to tell the Codec how much effort to make when analyzing the video frame. The faster the option the less CPU required. (for example: **Ultrafast** means “do **NOT** use much of CPU resources in video encoding”.) These commands are sent directly to the Codecs themselves. If you set the CPU resource allocation too high (for example: perhaps by using the setting called SLOW) some software running on this PC may crash, because you have maxed-out of available CPU cycles (all were consumed at some point….CRASH). One beta tester reported that his fairly fast i5 machine seems happy with the "**very fast**" setting, but a slower machines should apparently be set to "**ultrafast**".

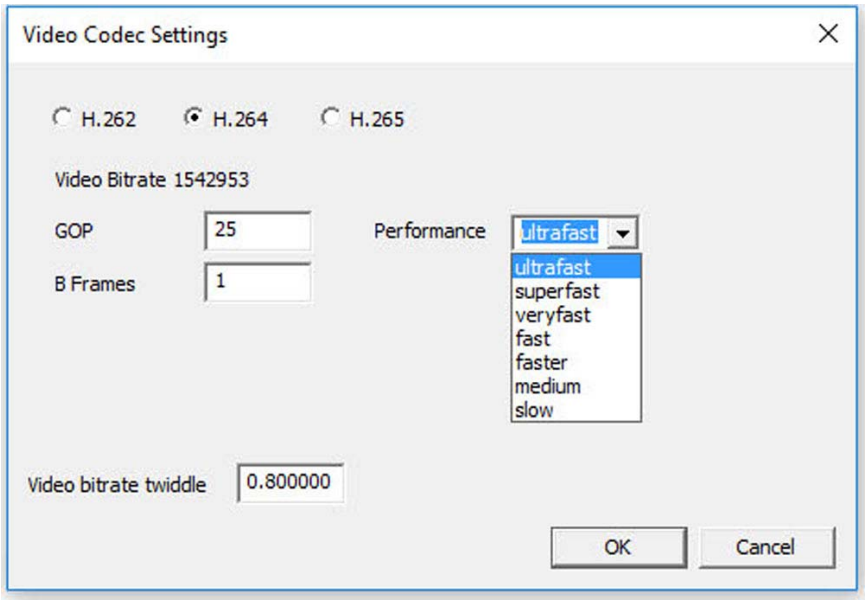


Figure 28 – Pull-Down Menu for selecting Codec Performance for H.264

4.3.7 VIDEO Bitrate twiddle – adjustable field

At both high and low symbol rates the program does not correctly estimate the available bit rate well (displayed as **VIDEO Bitrate** value in Section 4.3.3 and also on the Main screen, It may be necessary to adjust the VBITRATE twiddle factor. It simply multiplies it's estimate by the twiddle factor in this field.

The **VIDEO BITRATE** twiddle factor adjustment has significant effect - this allows fine tuning of the encoder buffer and is dependent on video bit rate and content. One beta tester has found that this should be adjusted on each symbol rate to give an indication of around 1 - 5% on the Tx queue bar graph on the Main Tab (see section 4.8.1) - No indication on the Tx Queue graph means the buffer is under running and the TS will be stuffed with null packets. Higher than 5% on the graph means the buffer seems to eventually fill up with waiting packets and will crash the receiver. As you make changes, you can see the video bit rate display change.

4.3.8 Video Codec – OK button

Click on the OK button when all of the settings have been correctly configured.

4.3.9 Video Codec – CANCEL button

Click on the CANCEL button if you want escape from any selections you may have changed,

4.3.10 CODEC – AUDIO Settings

The Audio Codec Settings page allows you to select the CODEC and the audio bitrate to be used.

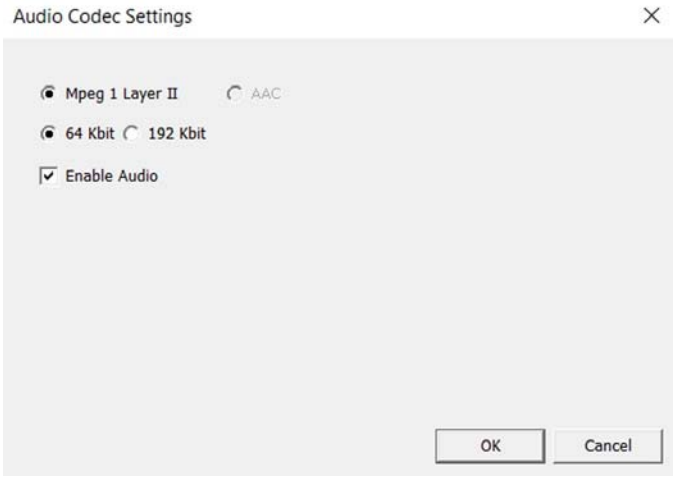


Figure 29 – Window for selecting Audio Codec Settings

4.3.11 AUDIO CODEC – Radio Button Selection

The radio buttons along the top currently only allow choosing the Mpeg-1 Layer II audio Codec. The AAC (aka Dolby audio Codec) is reserved to be implemented in the future.

4.3.12 AUDIO Bitrate – Radio Button Selection

The second row of radio buttons allows choosing between data bitrates for audio:

- **64 Kbit** – a low bitrate stream for audio capture that has good quality, but is non-standard in the DVB-S protocol. It is very useful to trim down the bitrate budget for audio in low Symbol Rate applications, such as 2 Meter RB-DATV where bandwidth is critical. But, some receivers are not expecting 64 Kbps audio and produce audio distortion.
- **192 Kbit** - this bitrate selection for audio is the default setting used by the commercial television world DVB-S protocol with MPEG-2.

4.3.13 Enable AUDIO – checkbox

This checkbox will remove audio from the Transport Stream and transmission if not selected (“checked”). Some RB-DATV hams prefer to use all possible bandwidth for the video stream in low Symbol-Rate transmissions, by relying on separate FM transmissions for the audio.

4.3.14 Audio Codec – OK button

Click on the OK button when all of the settings have been correctly configured.

4.3.15 Audio Codec – CANCEL button

Click on the CANCEL button if you want escape from any selections you may have changed,

4.4 SI TABLES Tab

Packet ID's (PIDs) play an important role in the DATV Transport Stream (TS). Each table or elementary stream in a transport stream is identified by a 13-bit packet ID (PID). A Transport Stream specifies a container format encapsulating Packetized Elementary streams, with error correction and stream synchronization features for maintaining transmission integrity when the signal is degraded during DATV terrestrial transmissions. Program streams are created by combining one or more Packetized Elementary Streams (PES), which have a common time base, into a single stream. A Transport Stream may carry multiple programs. Service Information describes the delivery system, content and scheduling/timing of broadcast data streams etc. The Service Information Table is a container for organizing the many DVB-S Packet ID's and is then inserted into the Transport Stream.

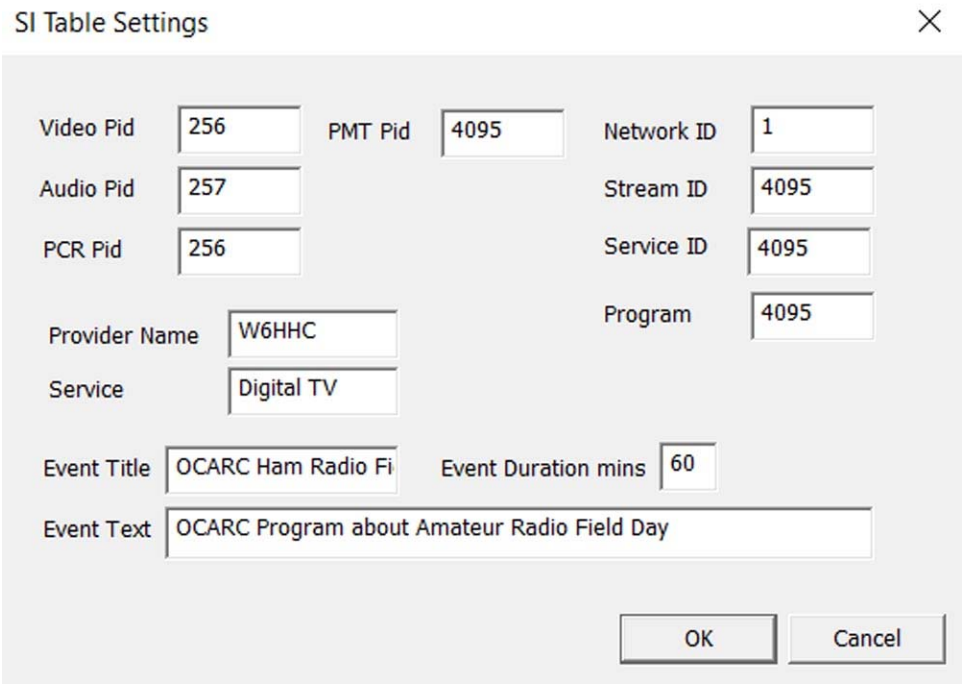


Figure 30 – Window for selecting settings for the SI TABLES

4.4.1 Video PID

The VIDEO PID is the Packet ID associated with the video Elementary Stream (ES). An ES contains only one kind of data, e.g. audio, video, or closed caption. An Elementary Stream is often referred to as "elementary", "data", "audio", or "video" bitstreams or streams. The default value is 256 (decimal). To edit the value, place the cursor inside the VIDEO PID field, edit the desired value, and press the OK button.

4.4.2 Audio PID

The AUDIO PID is the Packet ID associated with the audio Elementary Stream (ES). An ES contains only one kind of data, e.g. audio, video or closed/data caption. An Elementary Stream is often referred to as "elementary", "data", "audio", or "video" bitstreams or streams. The default value is 257 (decimal). To edit the value, place the cursor inside the AUDIO PID field, edit the desired value, and press the OK button.

4.4.3 PCR PID

The PCR PID is the Packet ID associated with the Program Clock Reference (PCR) field and is automatically set to the same value as the Video PID.

4.4.4 PMT PID

The PMT PID is the Packet ID associated with the Program Map Table (PMT). The PMT table contains PID numbers of elementary streams associated with the program and it has information about the type of these elementary streams (video, audio, etc.). The default value is 4095 (decimal). To edit the value, place the cursor inside the PMT PID field, edit the desired value, and press the OK button to save the new value.

4.4.5 NETWORK ID

A DVB network is defined as a "collection of MPEG 2 Transport Stream (TS) multiplexes transmitted on a single delivery system", e.g. a specific Network_ID is associated with each major transmission point. The NETWORK_ID field is the part of the DVB-SI (Service Information) table. The default value is 1.

4.4.6 STREAM ID

The STREAM_ID (Transport_stream_ID) field is used inside the NIT packet and the EIT packet. This field appears to be the same as the PROGRAM NUMBER field. These two field values (STREAM ID and PROGRAM NUMBER) must be both set to have the same value. The default value is 4095 (decimal).

4.4.7 SERVICE ID

The Service Info Table ID field contains the Packet ID for the Service Info Table??? The default value is 4095 (decimal).

4.4.8 PROGRAM Field

The PROGRAM NUMBER field and the STREAM ID…although having different names…appear to refer to the same thing. So these two field values must be both set to have the same value. The default value is 4095 (decimal).

4.4.9 Typical PID Values

There currently is no DATV standard for hams using PID values, yet.

4.4.9.1 DATV-Express Recommended PIDs

- **PMT PID 4095 (decimal).**
- **VIDEO PID 256**
- **AUDIO PID 257**
- **PCR PID 256 (Express_DVB-S/-S2_Transmitter automatically sets this PID to equal same as Vid)**
- **NETWORK_ID 1**
- **STREAM_ID 4095**
- **PROGRAM NR 4095**

4.4.9.2 BATC Forum DigiLite Suggested PIDs

- **PMT PID 4095**
- **VIDEO PID 256**
- **AUDIO PID 257**
- **PCR PID 256**

4.4.9.3 BATC DTX1 Manual Default PIDs

- **PMT PID 4095**
- **VIDEO PID 256**
- **AUDIO PID 257**

4.4.10 PROVIDER NAME

The Service Provider Name field is the name of the ham station or organization providing the content is entered in this field. Typically enter your call letters and the call letters will be overlaid on the video transmission if the Video IDENT field is checked on the MAIN SCREEN (see Section 4.8).

4.4.11 SERVICE NAME

Enter the name you want to apply to the SERVICE NAME that is displayed by the STB into this field.

4.4.12 EVENT TITLE

This field allows you to enter a title name of an event that will appear in the displayed EPG on the STB when your transmission is tuned in. You could enter TITLEs such as:

- CLUB NET
- W6HHC Test Pattern
- Field Day Video
- Etc.

4.4.13 EVENT DURATION Minutes

The EVENT DURATION field sets the times shown for an EVENT in the GUIDE (EPG) listing shown by the STB receiver. The starting time for the event will be when you started the DATV-Express software. The ending time shown for the EVENT listing will be (starting time + DURATION). The DURATION setting has no effect on the actual transmissions of the RF…just the information displayed in EPG by the STB.

4.4.14 EVENT TEXT

This field allows you to enter more detailed descriptive text in the displayed EPG on the STB when your transmission is tuned in. For example the text could say:

“2016 OCARC club FD was held in the city of Buena Park”

4.4.15 SI Tables – OK button

Click on the OK button when all of the settings have been correctly configured.

4.4.16 SI Tables – CANCEL button

Click on the CANCEL button if you want escape from any selections you may have changed,

4.5 OPTIONS Tab

The OPTIONS Tab allows three areas of selection:

- OUTPUT FORMAT
- IQ DC OFFSET CALIBRATION
- NOISE TOOL

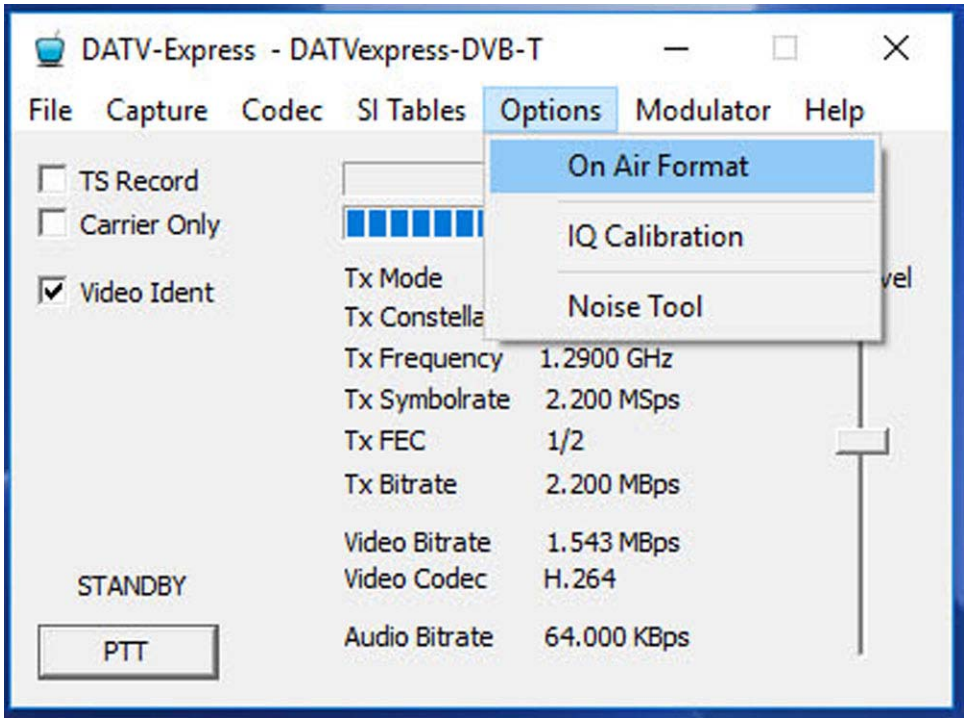


Figure 31 – Window for OPTIONS Tab menu

4.5.1 On Air Format

This OUTOUT FORMAT screen will appear and allow the user to select the format of the transmitted video.

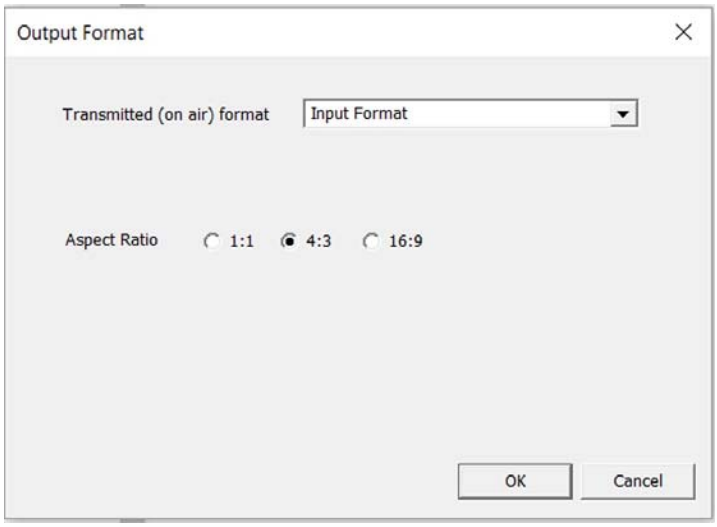


Figure 32 – Window for OPTIONS – On Air Output Format Tab

4.5.1.1 TRANSMITTED (on air) Format

The pull-down menu for the TRANSMITTED (on air) FORMAT field allows you to select either using the same format as you selected for the video-capture device input (See Section 4.2.3) or to select one of the formats shown in the pull-down list. NOTE: The Transmitted video frame rate MUST be <= to the video captured frame rate.

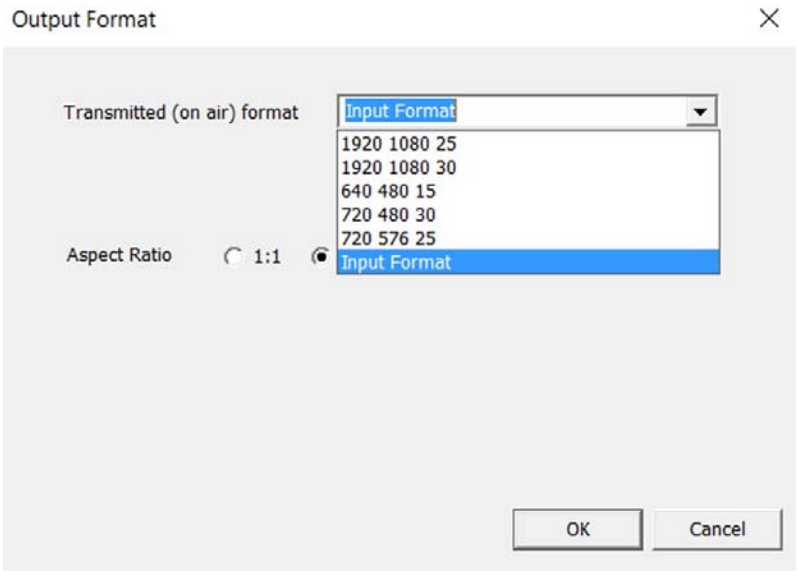


Figure 33 – Window for selecting Transmitted Format

4.5.1.2 ASPECT RATIO – Radio Buttons

The Aspect Ratio radio-buttons allow you to choose a transmitted video aspect ratio of 1:1 , 4:3 , or 16:9 as shown in Figure 33. As a note…16:9 aspect ratio is not restricted to MPEG-4/H.264 (as I had long suspected) and can be used with H.262 encoding.

4.5.1.3 Output Format – OK button

Click on the OK button when all of the settings have been correctly configured.

4.5.1.4 Output Format – CANCEL button

Click on the CANCEL button if you want escape from any selections you may have changed,

4.5.2 IQ DC OFFSET Calibration

Screen for adjusting DC-offset of the IQ signals.

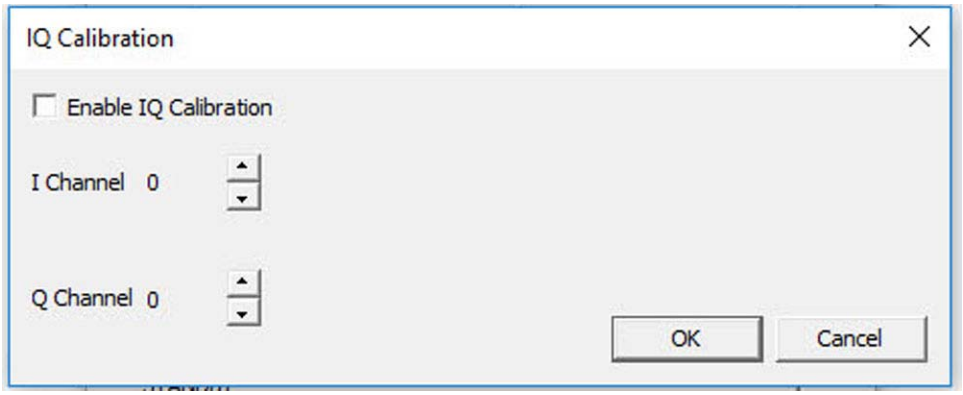


Figure 34 - Screen for adjusting DC Offset Calibration of the IQ signals

If a particular hardware board has a poor balance between the DC bias of the I signal and the Q signal, this condition can result in a “carrier-like” signal appearing at the middle of a “haystack” transmission waveform on a spectrum analyze.

While the software has put DATV-Express into the standby mode (no need to transmit a protocol during this test and adjustment), just tune a spectrum analyzer or FM receiver to the selected frequency and check the Enable IQ Calibrator box. You should be able to see a carrier (perhaps small) or see a S-Meter reading appear. Adjust the I Channel value and the Q Channel value until the carrier becomes smaller.

4.5.3 NOISE Tool

A DVB-S2 noise tool has been added. When the ENABLE NOISE box is checked, this tool will inject a set amount of gausian noise into your transmitted DVB-S2 (only) signal. This tool provides a good way to check the robustness of a signal being remotely received (at the other end), without changing the power level at the transmitter end.

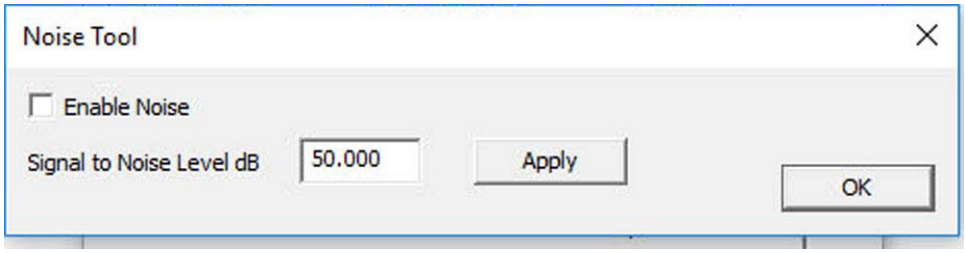


Figure 35 – The NOISE Tool feature allows injecting noise into your Transmitted Signal

4.6 MODULATOR Tab

The MODULATOR Tab allows you

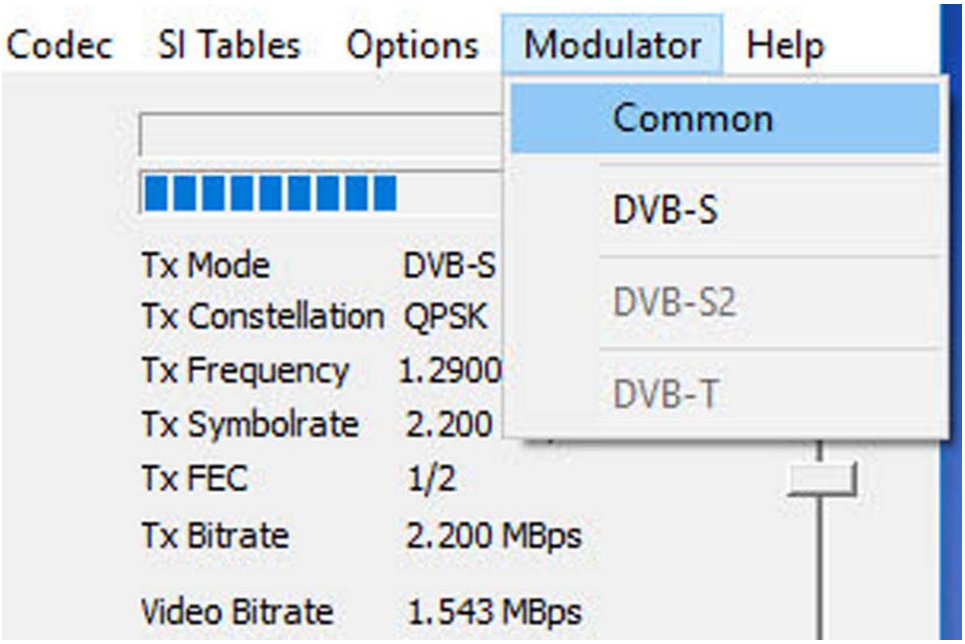


Figure 36 – MODULATOR Tab allows selecting COMMON or specific settings for three Protocols

4.6.1 MODULATOR – Common Settings Tab

The MODULATOR Tab allows you to set the frequency, Symbol-Rate, Forward-Error-Correction value, the RF output power level on the DATV-Express hardware board, and also activate a set of ports to work with different RF amplifiers.

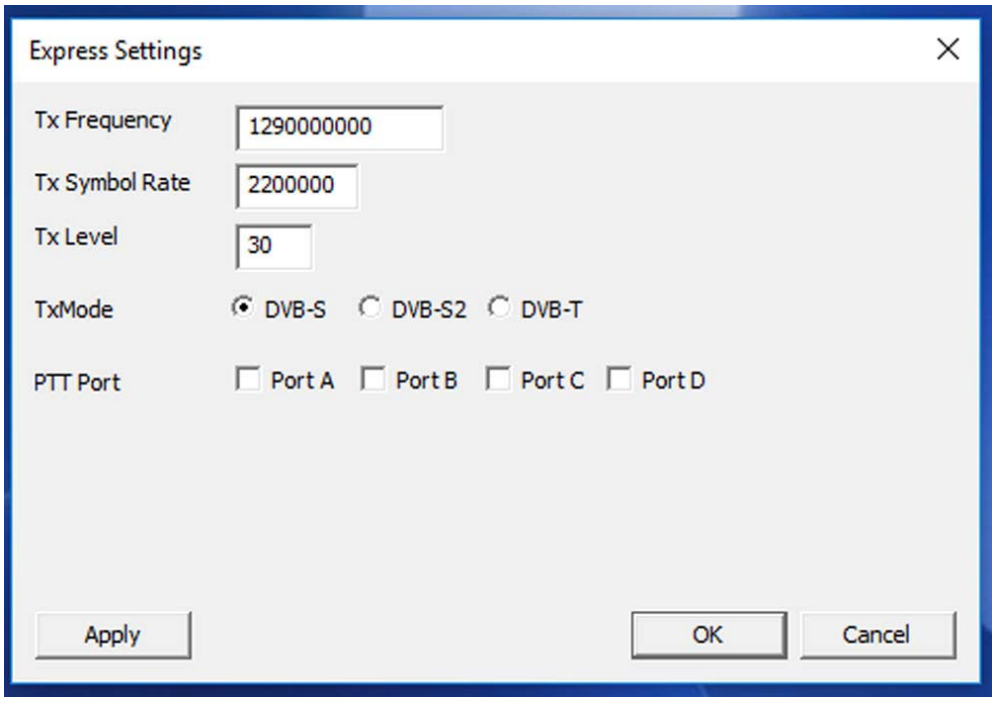


Figure 37 – Settings for the MODULATOR - COMMON Tab

4.6.1.1 TRANSMITTER FREQUENCY

This Tx Frequency field allows you to type in the frequency to transmit in Hertz. The setting in Figure 30 is 1.292 GHz (aka 1292 KHz). After you have typed in the desired frequency, click on the OK button.

4.6.1.2 TRANSMIT Symbol-Rate

This Transmit Symbol-Rate field allows you to select the Symbol-Rate you need for transmitting the DVB-S protocol. You can edit that SR field to the exact Symbol Rate that you plan to use on your STB or Receiver or DATV-Repeater. Express_DVB-S/-S2_Transmitter software will allow you to select between 125 KSymbols/sec and 8 MSymbols/sec. Be aware that many commercial receivers do not work below a SR of 1.5 MSymbols/sec.

4.6.1.3 TRANSMITTER RF LEVEL

This Tx RF Output Level field lets the software program set values from 0-through-47 to be entered for the RF output level on the DATV-Express hardware board. Each value represents a 1 dB difference in the RF output strength. The maximum output of the board's RF buffer amplifier design is somewhere between +10 dBm and +12 dBm. Some boards show a little distortion (spectral regrowth, aka "shoulders") occurring at output level values set higher than 35-to-40. For those who are curious, the reason for 0-to-47 steps is…that is how many levels of RF attenuation Analog Devices designed into the RF modulator chip being used.

4.6.1.4 TRANSMITTER Protocol (TxMode) – Radio Buttons

This TxMode field radio-buttons allows the user to select any of the standard DVB Protocols provided by the DATV-Express software: DVB-S, DVB-S2, or DVB-T. Note - that you can only select the individual protocol settings in Sections 4.6.2 (DVB-S), Section 4.6.3 (DVB-S2), or Section 4.6.4 (DVB-T) if you have clicked the corresponding Protocol in Figure 37 (common settings) and the pressed the OK button.

4.6.1.5 PTT PORTS

The PTT Port checkboxes enable the Port output signals selection in the MODULATOR menu to select/drive amplifiers or Relays. There tends to be some confusion in using the name "**PTT**" in PTT PORTS. When a port checkbox is enabled…the enabled port signal will be continuously asserted on the corresponding J6 pin for **BOTH** Tx and Rx. That is: the PORT pins are active high on both transmit and receive. Basically, it is better to think of these PTT PORTS as **FREQ** PORTS to change over the correct antennas and amplifiers when you change bands.
Port A = J6 pin 5, Port B = J6 pin 6, Port C = J6 pin 7, Port D = J6 pin 10
Pin 1 is the pin closest to the J6 label and is a ground pin (see J6 pin-out in Section 6.0).
IMPORTANT - These output pins are connected directly to the FPGA with no protection - you have been warned! The output must not exceed 20 mA and is at 3v3 logic levels. Optical isolation is recommended. (See the "DATV-Express Specifications" pages inside Section 6.0 for further information). J6 has no connector installed. If these optional connections are made, the user must provide a connector or solder directly to the connector pad holes.

There is a Chinese high-impedance opto-coupled relay-board available on eBay (actually loads of them). It's is a bit unclear who makes them. G8GTZ suggests he uses an opto-isolator / relay-board similar to ebay part number 291566724157 directly on to the DATVexpress I/O pins. G4GUO suggests that if you want to use the same 12v supply to drive the relay board as you use to drive Express you might consider one of the 12v opto-isolator boards. As far as wiring them up is concerned, that all depends on what the end-user wants to do with them. I think it is possible to get the schematic from one of the eBay sellers.

4.6.1.6 OPTIONS – OK button

Click on the OK button when all of the settings have been correctly configured.

4.6.2 MODULATOR – DVB-S Tab

When selecting the DVB-S menu item from the MODULATOR Tab, the following FEC (Forward Error Correction) configuration setting are available. Note - the DVB-S protocol only allows QPSK digital modulation technology to be used.

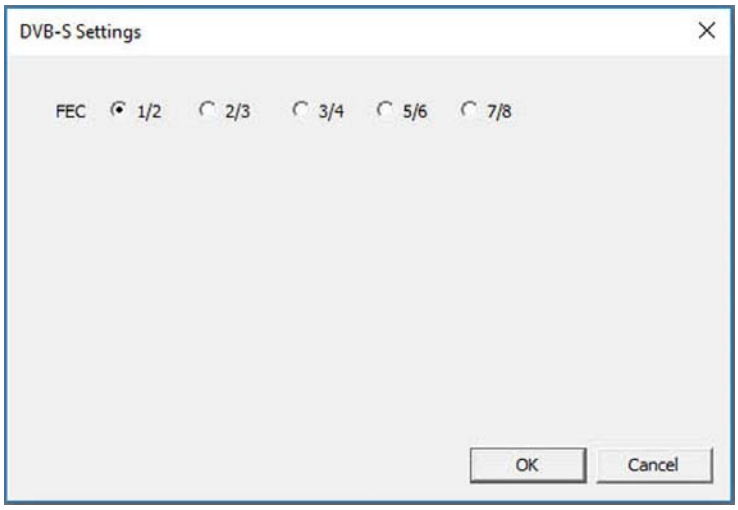


Figure 38 – Settings for the MODULATOR – DVB-S Tab

4.6.3 MODULATOR – DVB-S2 Tab

When selecting the DVB-S2 menu item from the MODULATOR Tab, the following configuration setting are available: Constellation (aka modulation technology), Roll-Off, FEC, and Pilot Symbols. One deviation from the commercial implementations for the Express_DVB_Transmitter beta DVB-S2 code is that only a Roll-Off factor of 0.35 is coded. The FPGA on the hardware board is not large enough to also implement the Roll-Off factors of 0.25 or 0.20.

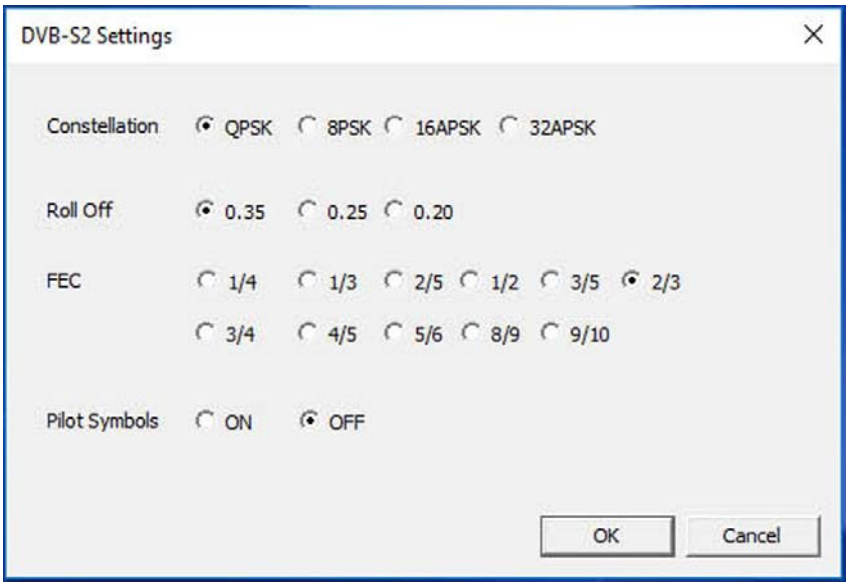


Figure 39 – Settings for the MODULATOR – DVB-S2 Tab

4.6.3.1 Constellations (Modulation Technology) – Radio-Button Selection

This implementation of the product supports all four modulation technologies offered for DVB-S2 protocol. As the modulation technology complexity increases from simple QPSK to the most complex 32APSK…the robustness of the received signal decreases. That is 32APSK requires the highest C/N ratio (signal to noise ratio). The complexity of the modulation technologies allow more data-bits to be included in each symbol-transition as listed below:

Modulation Technology	**data-bits per Symbol**
• QPSK	2
• 8PSK	3
• 16APSK	4
• 32APSK	5

4.6.3.2 Roll-Off Factor

As mentioned earlier, the Express_DVB_Transmitter beta DVB-S2 software code only implements a Roll-Off factor of 0.35. The FPGA on the hardware board is not large enough to also implement the Roll-Off factors of 0.25 or 0.20.

4.6.3.3 FEC – Radio-Button Selection

Select the FEC setting that you plan to use on the STB or Receiver from the radio-button menu. The radio-buttons for selecting FEC for QPSK modulation are shown in Figure 39. Other modulation technologies (aka constellations) will “grey out” FEC choices that are not available in a chosen modulation.

4.6.3.4 Pilot Symbols

The DVB-S2 protocol uses Pilot Symbols to end more info to a receiver and thereby help the receiver to more quickly train an adaptive equalizer. Without Pilot Symbols…the receiver needs to scan a blind scan to attempt to parse out settings or use trial and error…it will just take longer to capture the signal..

4.6.4 MODULATOR – DVB-T Tab

Note that not every feature of the DVB-T protocol implementation has been fully tested. This protocol release of DVB-T should be considered as **EXPERIMENTAL**. The DATV-Express board was designed to be a great DVB-S exciter. The DVB-T protocol is pushing the limits of what is possible with this hardware design. The testing has found 2K mode of DVB-T to give more consistent results than 8K DVB-T using the hardware. Individual results may vary. DVB-T 8K mode has been found to exceed the performance limits of the board design, and is NOT supported. The most significant feature of the PC CPU is the size of the on chip processor cache as most of the algorithms require continual accesses of the same memory locations, so fast processors with large caches are ideal for DVB-T. When selecting the DVB-T menu item from the MODULATOR Tab, the following configuration settings are available: confirming 2K mode, Channel Bandwidth desired (only 1 MHz and 2 MHz work well), Constellation (aka modulation technology), FEC , and Guard Period.

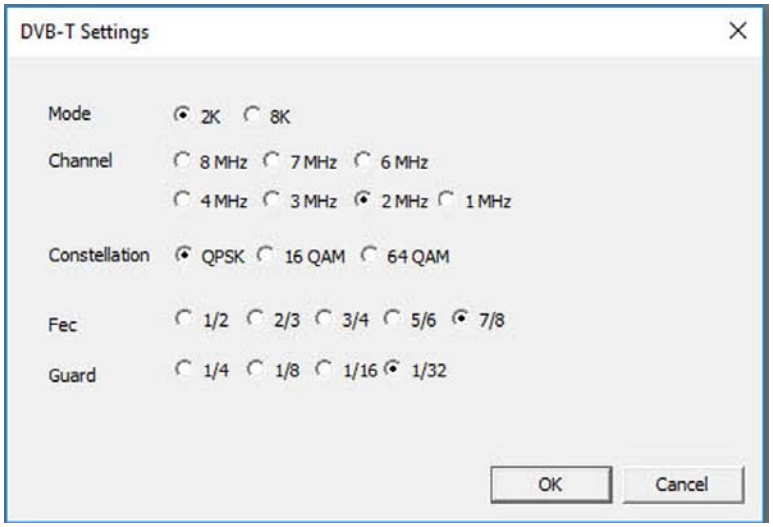


Figure 40 – Settings for the MODULATOR – DVB-T Tab

4.6.4.1 MODE

The COFDM modulation technology used by the DVB-T protocol can be chosen for 1,705 sub-carriers called the 2K packet length mode, or chosen for 6,816 sub-carriers, called the 8K packet length mode. Ham radio DATV only uses the 2K mode of DVB-T protocol. Select 2K or 8K length of packets from the pull-down menu. Again, be aware that the DVB-T 8K mode has been found to exceed the performance limits of the board design, and is NOT supported.

4.6.4.2 CHANNEL (RF Bandwidth)

Choose the RF bandwidth of the desired channel that you desire from the pull-down menu. Choose from 8 to 2, and 1 MHz bandwidths. Because of the high Windows CPU consumption and aliasing filtering-problems, DATV-Express V1.23 software is only able to support 2 MHz and lower channel-bandwidths. When trying to run more traditional DVB-T bandwidths like 7 MHz….large undesirable spikes from aliases appear nearby in the spectrum as illustrated in Figure 41. The current software is able to operate correctly for 2 MHz and 1 MHz channel-bandwidths to achieve an acceptable RF signal in the spectrum.

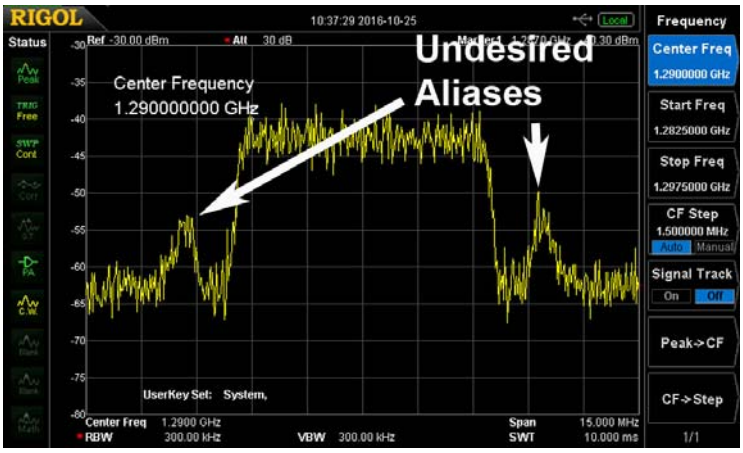


Figure 41 – With 7 MHz Channel selected, Spikes from improperly filtered aliases appear in the spectrum when DVB-T Channel-Bandwidth not operating at 2 MHz or 1 MHz.

4.6.4.3 Constellations (Modulation Technology) – Radio-Button Selection

This implementation of the product supports all three modulation technologies offered for DVB-T protocol. As the modulation technology complexity increases from simple QPSK to the most complex 64QAM…the robustness of the received signal decreases.

4.6.4.4 FEC RATE

Select the FEC setting that you plan to use on the STB or Receiver from the pull-down menu.

4.6.4.5 GUARD PERIOD

The purpose of the guard interval is to introduce immunity to propagation delays, echoes and reflections, to which digital data is normally very sensitive. In COFDM, the beginning of each symbol is preceded by a guard interval. As long as the echoes fall within this interval, they will not affect the receiver's ability to safely decode the actual data, as data is only interpreted outside the guard interval. Longer guard periods allow more distant echoes to be tolerated. However, longer guard intervals reduce the channel efficiency.

4.7 HELP Tab

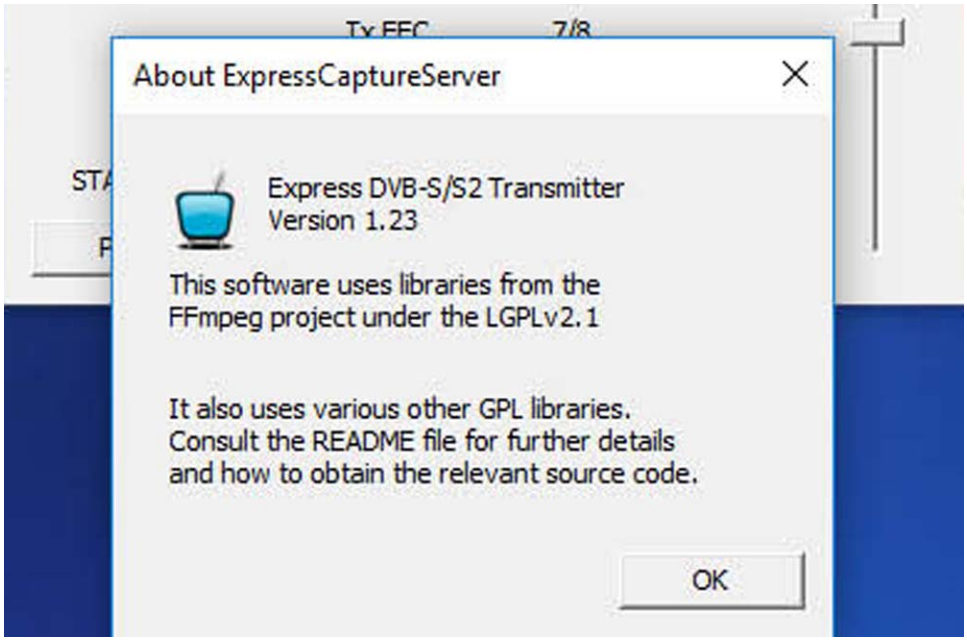


Figure 42 – Window for the HELP - ABOUT window

4.7.1 ABOUT

Selecting ABOUT on the HELP Tab allows you confirm what version of Express_DVB-S/-S2_Transmitter software you are running, as shown in Figure 42.

4.7.2 About – OK Button

Click on the OK button when you want to exit the ABOUT screen.

4.8 MAIN Screen

The MAIN window is where you will operate your transmitter once all of the capture-devices, protocol, CODECs and configurations have been set-up using the other GUI tab windows. The MAIN window displays the set-up values and provides a PTT button.

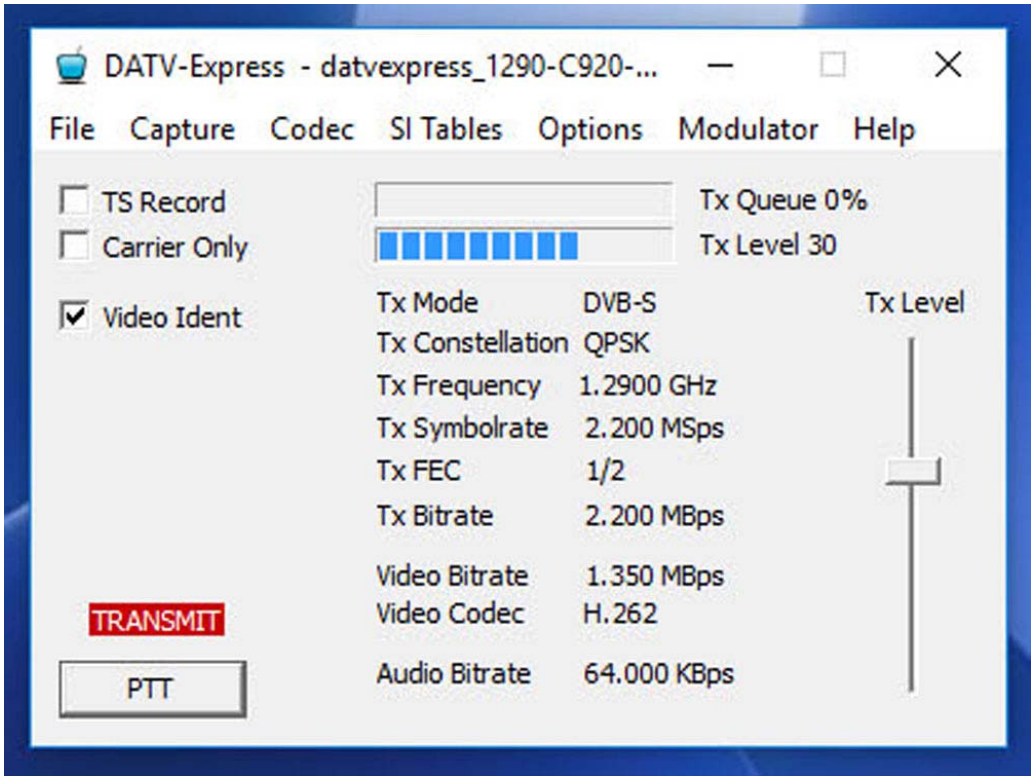


Figure 43 – The MAIN display showing normal running in TRANSMIT mode

4.8.1 TRANSMIT QUEUE - indicator

The TX Queue graphic indicator shows the number of video packets and NULL packets available in the Queue buffer waiting to be processed. The display may miss a few packets still in the queue buffer because it only gets updated every 100 msec. G4GUO explains that the most important aspect is whether the Tx Queue value is monotonically increasing or not. (see the graphs on the right side of the page at **https://en.wikipedia.org/wiki/Monotonic_function** for what Charles means). In testing by W6HHC, he found the Tx Queue is typically empty (0 %), with only an occasional packet going into the buffer and flickering the display. See Section 4.3.7 for some hints on how to fine tune the Tx Queue using the VIDEO BITRATE parameter.

4.8.2 TRANSMIT Level - indicator

This field displays the RF power out setting that was configured in the MODULATOR - Common Settings Tab (Section 4.6.1.3 TRANSMITTER RF LEVEL). In addition, you can control the value of TRANSMIT Level by moving the slider-control on the right-side of Figure 43.

4.8.3 TRANSMIT Level – Slide-Bar

You can also change the RF power out TRANSMIT value by grabbing the slider-control on the right-side of Figure 43 with your mouse. Finally, if you “mouse over” the slider-bar, you can use the mouse roll-wheel to increament or decrement the TRANSMIT level in 1 dB changes.

4.8.4 TS RECORD TO FILE (Checkbox)

Whenever the TS Record check box is clicked, the Express_DVB-S/-S2_Transmitter software immediately begins to capture the Transport Stream (TS) to a disk drive .ts file. However, the TS file ONLY works correctly with the CODEC running during the TRANSMIT function of the PTT button. The **.ts** file is called “datvexpress.ts” and will be found in your computer HOME Folder.

I suggest renaming the **.ts** file immediately to something like “datvexpress_G4xyz_4MSYM.ts”, so the file will not be overwritten the next time you use the TS RECORD. The file can then be moved or copied to your desktop.

You can watch the TS file played back using a program like Windows Media Player on Windows. The details of the TS file can be inspected using an analyzer like DVBinpector (free). It is important to understand that the format of the TS file video will be according to the video-capture input settings (CAPTURE Tab) and not the On-The-Air settings of OPTIONS Tab (like Aspect Ratio, etc.).

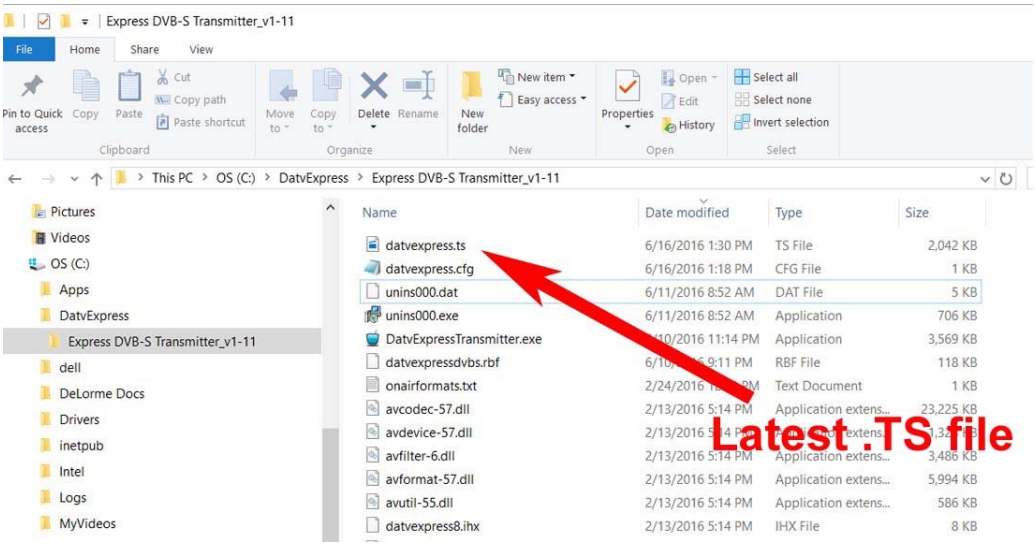


Figure 44 – The latest TS file will be stored in the Express_DVB-S_Transmitter (home) Directory as seen here using the Windows file manager

4.8.5 CARRIER ONLY (Checkbox)

The CARRIER ONLY check box can be enabled to transmit an unmodulated carrier signal instead of a DATV signal. If the CARRIER ONLY is checked, then the signal will be transmitted whenever the PTT button is in the TRANSMITTING mode.

NOTE – Currently the RF power level of the carrier is NOT the maximum output level that can be achieved by the design. It is NOT the “key down” output that would be produced by a CW transmitter at maximum gain. The output value is currently set mathematically (somewhat arbitrarily) to just provide a good beacon for antenna pointing, etc. Do NOT try to measure the power output level capability of the board or amplifiers using the CARRIER feature.

4.8.6 VIDEO IDENT (Checkbox)

The Video Ident check box enables the text (such as call letters) entered in SI TABLES Tab (Section 4.4.10 PROVIDER NAME) to be overlaid on the video transmission.

4.8.7 TX Mode - display

The TX Mode display field indicates what protocol mode was selected in Section 4.6.1 (MODULATOR – Common Settings Tab)

4.8.8 TX Constellation - display

The TX Constellation display field indicates what constellation (modulation technology) is associated with the DVB protocol you have selected (as displayed in Section 4.8.7).

4.8.9 TX FREQUENCY - display

The TX FREQUENCY display field value confirms the frequency setting entered in the MODULATOR Tab (Section 4.6.1 TRANSMITTER FREQUENCY).

4.8.10 TX SYMBOL RATE - display

The TX SYMBOL RATE display field value confirms the symbol-rate setting entered in the MODULATOR Tab (Section 4.6.2 TRANSMITTER Symbol-Rate).

4.8.11 TX FEC - display

The TX Forward-Error-Correction (FEC) display field value confirms the FEC setting entered in the MODULATOR Tab (Section 4.6.3 TRANSMITTER Forward Error Correction).

4.8.12 TX BITRATE - display

The TX Bitrate display field value is the calculation of the net payload data bit rate after the overhead of the selected FEC is removed.

4.8.13 VIDEO BITRATE - display

The Video Bitrate display field value is the calculation of how much of the Tx Bitrate is available for video bitrate after the audio bit rate is subtracted and the overhead of SI Tables is subtracted.

4.8.14 VIDEO CODEC - display

The Video CODEC display field value confirms the CODEC selected in the CODEC Tab (Section 4.3.2 VIDEO CODEC – Radio Button Selection).

4.8.15 AUDIO BITRATE - display

The Audio Bitrate display field value confirms the audio bit-rate setting selected in the CODEC Tab (Section 4.3.11 AUDIO CODEC – Radio Button Selection).

4.8.16 PTT (Button)

The PTT button can be clicked to alternate between STANDBY (receiving) and TRANSMIT modes.

4.9 Board LEDs

The main cluster of four LEDs is located in the lower right hand corner of the PCBA near the CE “mark”.

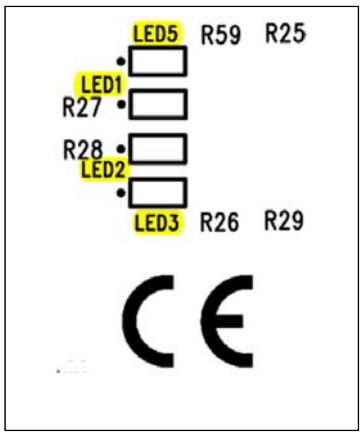


Figure 45 – identification of the four LEDs in lower-right hand corner of PCBA

LED 4 – +5.5V Power supply is operational (upper right-hand corner of board near mounting hole)

LED 5 – TS Flow Control is ON when the FPGA is successfully receiving TS from the host and performing flow control. If OFF, there is a setup or hardware malfunction.
LED 1 – does a short blink when there is activity with I2C interface on the board
LED 2 – Counter using Symbol-Rate clock – constantly blinks slowly to show that FPGA is running in RCV mode. The XMT blinking rate is three times as fast as RCV. The rate of blinking will increase as the SR setting is increased.
LED 3 – PLL Lock is ON when modulator reports lock status via I2C buss to FPGA.

4.10 Optional Si570 Symbol Rate chip

The PCBA has been designed with an etch “foot print” for an Si570 Symbol Rate PLL chip at position U12. If the Si570 is soldered onto the board, then the software will detect the chip and allow the Si570 to control the Symbol Rate setting with more precision. If U12 is not soldered in, then the FPGA will control the creation of the Symbol Rate flow.

Anyone adding one of these Si570 chips to their board will have to use the 570CAC000121DG part from the Digi-Key distributor. The reason being that the software needs to know the factory-default start up frequency of the chip before it can calculate the calibrated reference oscillator frequency which it needs when programming the chip to other frequencies. The 570CAC000121DG is a CMOS device with a default start up frequency of 100 MHz and an I2C address of 55 hex.

5.0 – Useful utilities

5.1 DVBinspector for TS files

DVBinspector is a free Windows software program that can analyze various aspects of Transport Stream (TS) files. DVBinspector offers five different views of a transport stream;

- tree view (for logical analyzes),
- EIT view (fast overview of EIT information),
- bitrate view (to see bitrate alter over time),
- bar view (summary of average/minimum and maximum bitrates) and
- grid view (to see how different PIDs are distributed over time).

Go to **www.digitalekabeltelevisie.nl/dvb_inspector/** to download the utility software.

Go to **www.digitalekabeltelevisie.nl/dvb_inspector/usermanual.shtml** for the manual.

5.2 Playing Back TS files.

The DATV-Express software can now create a Transport Stream (TS) file of your transmission (see the MAIN Tab in Section 5.12 for details on creating a TS file). If you want to play back and listen to the video on the TS files, there are listed below two utility programs that can play back TS file on your computer.

- Use Windows Media Player as the TS player on Windows OS
- Use the GNOME Mplayer as the TS player on Lubuntu. The GNOME Mplayer comes installed on Lubuntu 14.04 LTS. NOTE – the VLC player is not yet available for ARM-based computers like ODROID.

5.3 CPU performance monitor

It is easy to use the Windows TASK MONITOR for CPU performance monitoring. Perform the Windows "three finger salute" (CTL – ALT – DEL) and choose:

TASK MGR → PERFORMANCE Tab → CPU

5.4 Tutioune and MiniTiouner DVB-S analyzers

Tutioune is a software utility that has been specially developed to provide radio amateurs and DVB technicians with a tool that allows Digital ATV (DVB-S) to be measured precisely. With Tutioune you will no longer have the frustration of seeing only "level" and "quality" information from standard satellite receivers including STBs; basic quality guidance that fails to satisfy technical users.

Technical DVB-S users want to measure the received transmission characteristics exactly, so they can improve their systems and debug problems that may be encountered. Digital transmissions are not

really "all or nothing", in between there are many things that can happen; it's important to be able to observe and define the various stages.

Tutioune is a software solution for making these measurements. This free Windows software utility was developed by F6DZP Jean Pierre Courjaud. The software can be downloaded from **www.vivaDATV.org/viewtopic.php?f=60&t=214** Tutioune can be used with a number of DVB-S PCI-based satellite receiver cards such as the TechnoTrend TT-S2-3200 board (€80 new and possibly less on eBay) or the best: TT S2-1600 board. For these two families of card there are now two versions of software:

- Tutioune1600 for TT S2-1600 you can find it here : **www.vivadatv.org/viewtopic.php?f=60&t=352**
- Tutioune3200 for TT S2-3200 you can find it here : **www.vivaDATV.org/viewtopic.php?f=60&t=276**

MiniTiouner is a USB-based hardware DVB-S tuner that runs essentially the same analyzer software to make measurements. Details on the hardware product and the free version of software needed for MiniTiouner can found at:

- www.vivaDATV.org

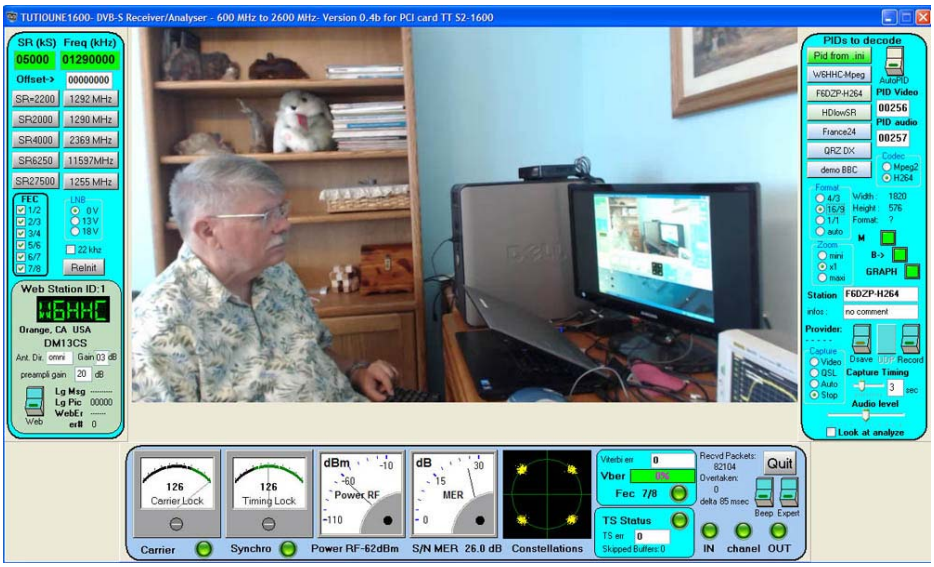


Figure 46 – Displaying H.264 video transmission in 16:9 Aspect Ratio using TuTioune Analyzer

5.5 vMix Basic Video Mixer

vMix is a great optional companion software tool to use with Windows DATV-Express. vMix Basic is an free video-mixer-editor software package for SDTV format video (Standard Definition) that is available from vMix.com. There are more-professional HDTV products that are available for sale, including the vMix Basic HD for US$60. See **Figure 47** for array of vMix products. The download you want is called **vMix 17** (for the version number).

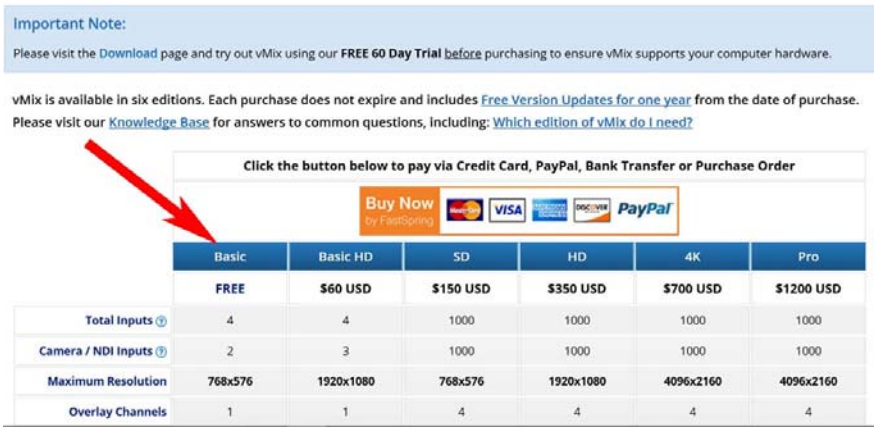


Figure 47 – The array of vMix products – including free vMix BASIC

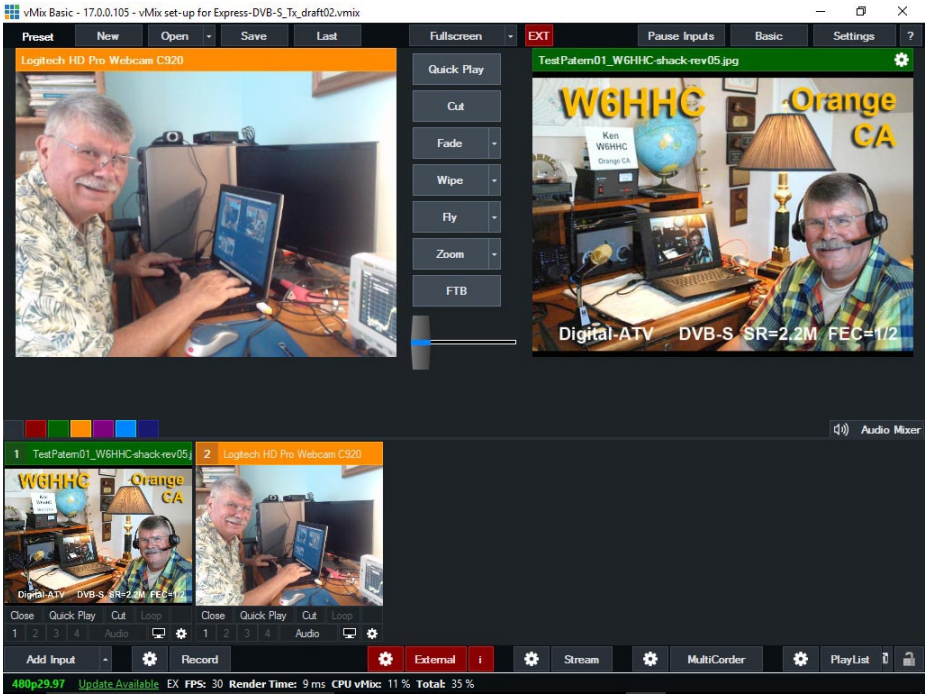


Figure 48 – An example of running vMix Basic video software with one camera and a "Test Pattern" JPEG

The free video-editing software allows you to:

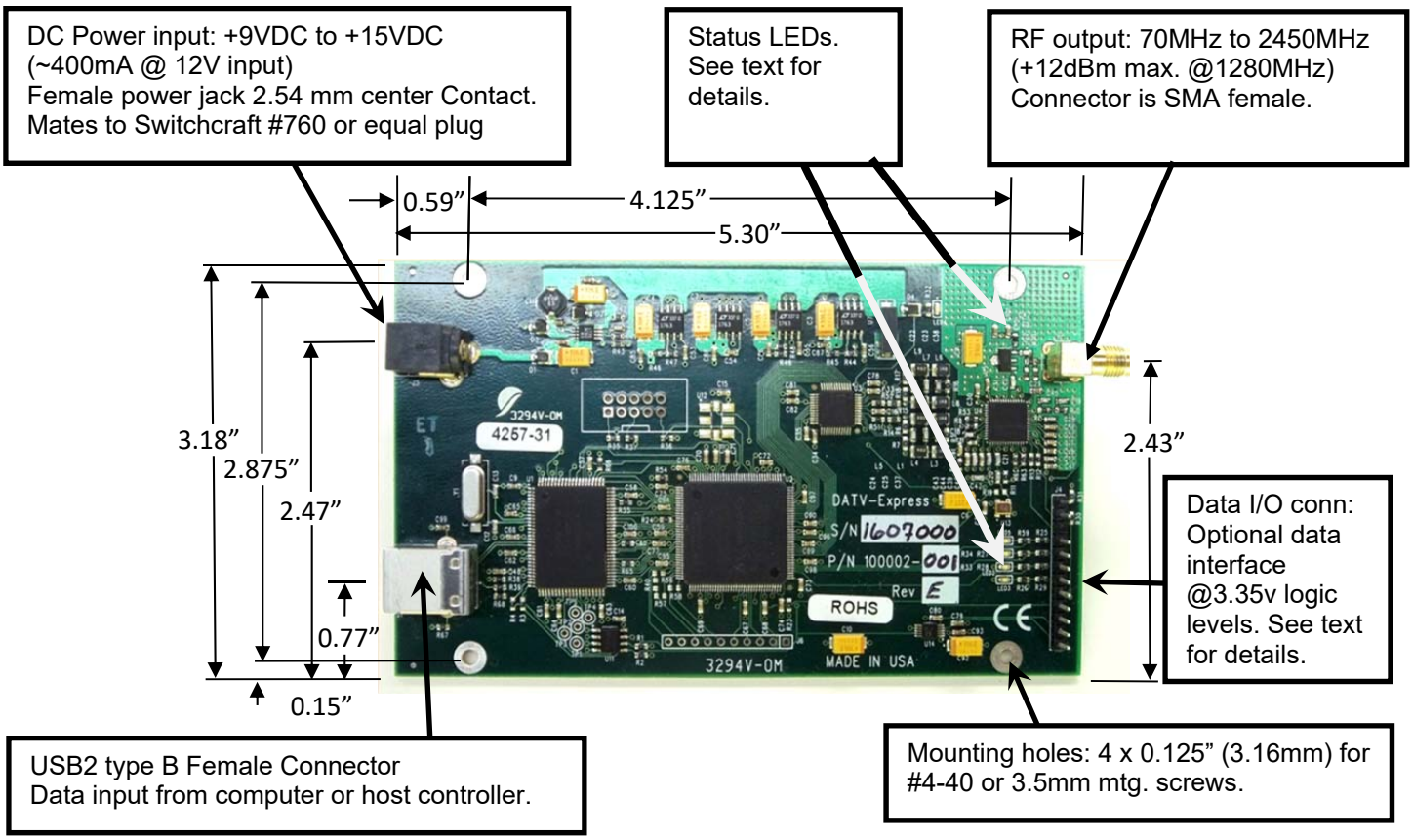
1) support one or two USB-cameras
2) use a JPEG file as a "Test Pattern" video source
3) switching between the two video sources (see **Figure 48**)
4) adding a better-looking call-letters-overlay
5) try "green-screen" video tricks.

You can capture any video that you can get to your Windows computer via USB, Firewire, ASI, or HDMI (while using an HDMI-USB capture card), and your old NTSC/PAL home camera (while using an EasyCAP USB video-capture dongle). vMix will be displayed as one of the available devices under CAPTURE – Video Devices and CAPTURE – Audio Devices.

This DATV-Express Users Guide does not cover set-up and running vMix in detail, since there are tons of YouTube tutorial videos describing how to set-up and use the vMix third-party product. That being said, the project team will offer one very non-intuitive step for those hams who just want to push buttons instead of follow a tutorial. In order to get the output video stream being sent to the Express_DVB-S_Transmitter software, you must configure and activate the EXTERNAL button at the very bottom of the vMix screen (see RED button in Figure 37).

6.0 – DATV-Express for Windows specifications:

Physical details:



It is recommended that the board be placed in an enclosure of some type, preferably of metal construction. The board mounting holes mate to a (5.6” x 4.3” x 1.8”) Bud Industries or DigiKey part number #CU-387 plastic enclosure and may be used from an economy standpoint. The input and output connector holes must be added by the user. If a metal enclosure is used, it is helpful for heat distribution purposes to use metal mounting standoffs. The modulator IC gets very warm during normal operation so using a metal standoff here will help sink heat away from it. Ventilation holes in either enclosure around the vicinity of the output connector is desired for elevated temperature environments.

Environmental Details:

Temperature – 0 to +30°C (32-86°F)
Humidity - +10 to 95% non-condensing

Electrical Details:

Required Windows Computer components

Host computer with at least (2) USB2 I/O ports.
USB interface cable – USB type “A” connector at computer, USB type “B” connector at DATV-Express.
Software support requirements – Pentium 4 or better, 2GB available hard drive.
Operating system - 32 bit or 64 bit Windows Vista, 7, 8 or 10.
Hardware video-capture (Hauppauge) NOT required – Most Windows supported video capture devices are supported by the FFmpeg software CODEC library. Including a laptop webcam, Logitech C615 and C920 web cameras, EasyCap USB dongle with NTSC / PAL hand-cam, and optional Vmix video mixing software.

Input voltage requirements

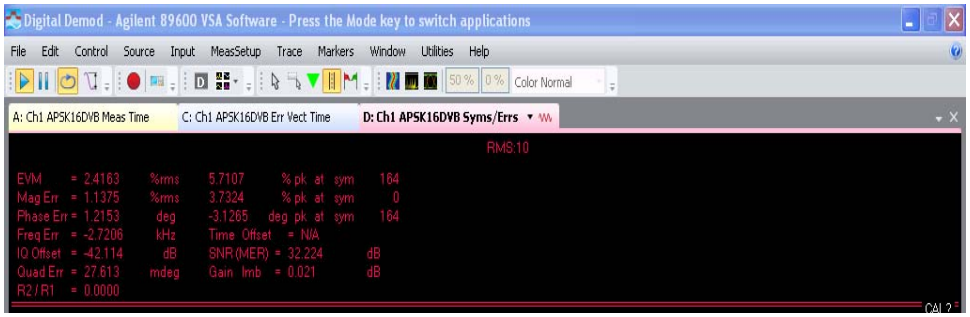
+9 to + 15VDC (400 ma@12vdc). Input is polarity protected but not fuse protected. External 1 amp slo-blo fuse is required by user for safe operation.

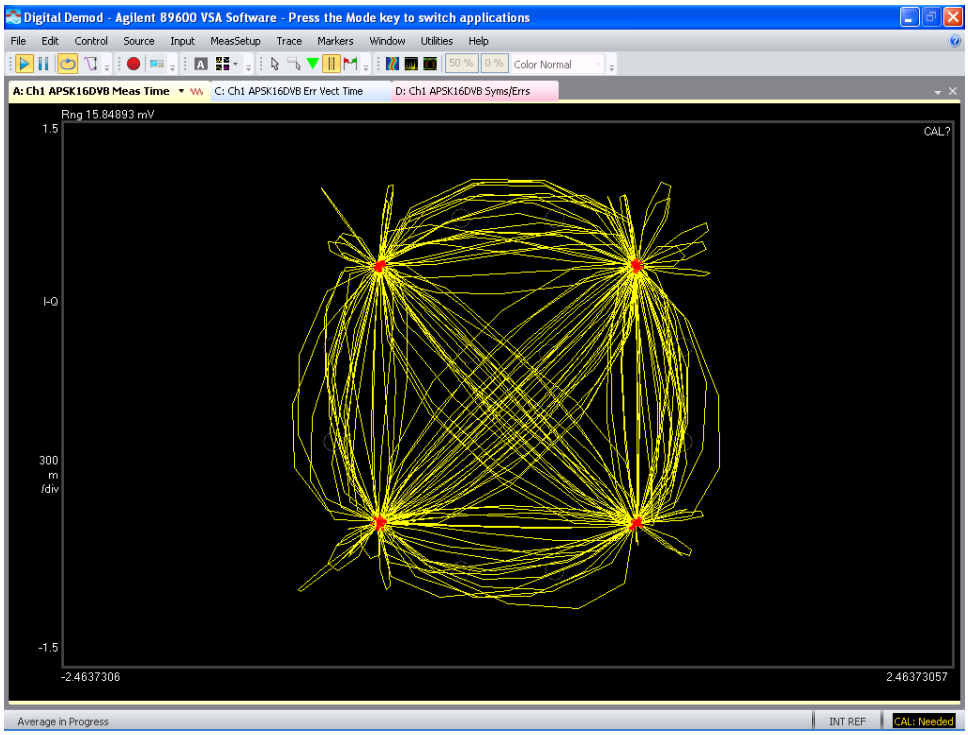
Frequency Range
70 MHz to 2450 MHz

Symbol Rate (Symbols/sec)
Select SR from 100000 to 8000000 in steps of one Symbol/second. (Design is optimized for 0.10-to-8 MS/sec). There are 12 preset and automatic configurable combinations to adjust for adequate aliasing adjustments.

FEC
Combinations: 1/2, 2/3, 3/4, 5/6, 7/8 for DVB-S protocol.

Signal quality data





EVM (Error Vector Magnitude) - 2.4%. (Measured with Agilent EXA N9010A Signal analyzer – software VSA 89600B). (≤3% is acceptable for commercial broadcast).

EVM is the percentage away from the ideal symbol landing spot in the signal constellation. This data is normally measured at the receiver and takes into account the combined effects of transmitter and receiver Carrier or Signal to Noise ratios (CNR or SNR).

MER (Modulation Error Ratio) - 32dB. Minimum recommended down-stream MER = 12-13dB for QPSK and 27dB for 64QAM including 3-4dB headroom for reliability. It's calculated as: 10LOG (average symbol power / average error power).

Video – Determined by capture card specs. Hauppauge model HVR1950 will accept 1V P-P 75 ohm NTSC or PAL video.

Audio – Determined by capture card selection. Compression: MPEG1

LED	Function	Description
LED1 –	I^2C activity - BLINK	Quick blink during I^2C communication. It's a very short blink and hard to see.
LED2 –	Symbol Rate Counter	Constant FLASH. Slow for RCV. X3 for XMT. Higher symbol rates = faster flashing.
LED3 –	PLL locked - ON	is ON if the USB controller is OK.
LED4 –	+5V power	is ON when +5.5VDC is present.
LED 5 –	TS Flow Control	is ON when the FPGA is successfully receiving TS from the host and performing flow control. If OFF, there is a setup or hardware malfunction.

(Note: LEDs glow very dimly when in OFF state)

Connector details

USB2 type "B" connector (J1) - Standard USB2 connections to/from host computer.

RF output connector (J2) – SMA female.

DC power connector (J3) - Female DC connector, 2.54mm center pin. Mates to Switchcraft #760 or equal plug

Data I/O connector (J4)

1	+5.2vdc thru 50Ω 1/4w resistor
2	PTT (non-delayed) output (+3.3V Tx & GND Rx. Limit sink current to 10mA.)
3	Key (no pin)
4	TS Flow Control (LED5)*
5	I^2C activity (LED1)*
6	Symbol Rate (LED2)*
7	PLL Locked output (LED3)*
8	I^2C buss SDA Reserved for future data communication/expansion and testing analysis.
9	I^2C buss SCL Reserved for future data communication/expansion and testing analysis.
10	Ground
11	Analog input 1
12	Analog input 2

*This data is + true to 3.3V for function indicated. The outputs are in parallel with LEDs thru a 100Ω resistor. Limit sink current to 10mA. (when LEDs are OFF)

These inputs are reserved for forward and reverse power output signals through a dual directional coupler. VSWR reporting and some linearization is possible with this data.

Expansion connector (J6)

1	Ground
2	Key (no pin)
3	Delayed-PTT output (goes + delayed 200 msec from C/O) Limit sink to 10mA FPGA output pin97
4	Change/Over (C/O) output (+ when PTT is TRANMIT for enabling amplifiers & relays FPGA pin96
5	PORT A output on Windows OS - FPGA I/O – output pin 95
6	PORT B output on Windows OS - FPGA differential - output pin 72
7	PORT C output on Windows OS - FPGA differential +output pin 71
8	FPGA differential – input pin 70
9	FPGA differential + input pin 69
10	PORT D output on Windows OS - FPGA I/O – output pin 67

NOTE: Port A-D outputs are +3V when respective Modulator Tab box is checked. They're active during Rx and Tx and intended to signal external circuitry of a given band selection. They're mutually inclusive so all or none may be selected allowing up to 16 combinations. Optical isolation recommended – max 10Ma sink current.

Transport Stream

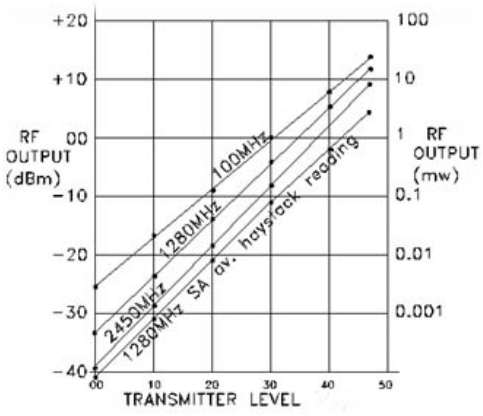
A "transport stream" feature is incorporated in the software to enable signal analysis. When the "**TS Record to file**" check-box is checked, the computer will collect the active signal in a continuous datvexpress.ts data stream in the default Home directory. The data will continue to collect as long as the "**TS Record to file**" button is checked at the rate of about 20-30 MB/minute. The file can then be played back with Windows Media Player or equal software to view the video. The transport stream captured is the same one sent to the DATV-Express board in normal operation. (It is NOT the actual transmitted RF signal).

Example: Your friend has a computer program with video analysis capability. You can Email the datvexpress.ts file to him so he can analyze your signal details as the video plays.

RF output

Frequency range: 70MHz to 2450MHz.
Resolution: 100 Hz Accuracy: ±2KHz
Frequency stability: ± 100 PPM
Output Impedance: 50 ohms

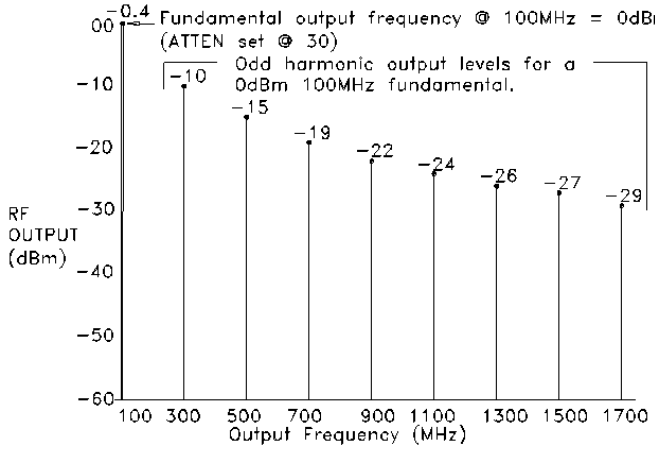
Level: -34dBm to +13dBm in 1dB steps (100MHz)
-35dBm to +12dBm in 1dB steps (1280MHz)
-39dBm to +8dBm in 1dB steps (2450MHz)
Spectral regrowth: -60dBc (RF output settings 00 to 35)
-50dBc (RF output settings 36 to 47)
Software controlled RF output: 00 to 47 in 1 dB steps
(00 is lowest level)



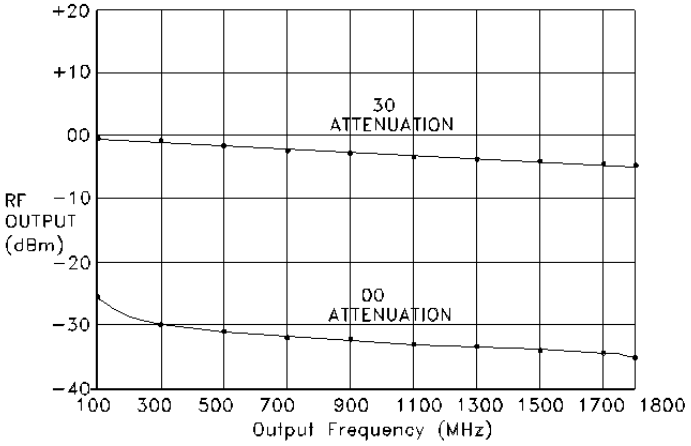
The table above illustrates the RF signal level at 100, 1280 and 2450MHz frequencies verses the internal software controlled RF output settings. An RF output setting of "00" produces the minimum level of RF output from the board and a setting of "35" is the maximum RF level out with no detectable signal distortion (spectral regrowth). Above a setting of 35, some sideband regrowth becomes noticeable on a spectrum analyzer as the power level increases due to slight compression in the RF MMIC amplifier. The 100MHz carrier is given to establish a reference point. It is below what a QPSK signal is allowed on the Amateur radio frequencies. !**CAUTION! DO NOT ATTEMPT TO TRANSMIT A SIGNAL OUTSIDE THE ALLOWED HAM FREQUENCIES?**

The 100MHz and 1280MHz graph lines represent the true average power output for either the single carrier or QPSK signal. The 1280 SA graph line is included to show how the signal amplitude at "top of haystack" on a standard scalar **S**pectrum **A**nalyzer compares to the true average power. The true power is actually close to 10dB greater than the SA reading! Note: A thermal milliwatt meter such as the Hewlett Packard model 432A, which has a bolometer probe does, in fact, indicate true average power for both "carrier only" and complex QPSK signals. Use that data to predict post amplifier maximum input requirements.

The graph at the right illustrates the harmonic content expected in the RF output signal. **It MUST pass through a filter of some type in order to suppress unwanted harmonics**. Since all unwanted frequencies are **above** the fundamental, a simple low pass filter may be all that is needed. The graph was created with a 100MHz signal to illustrate that the harmonic content extends many times beyond the fundamental. Only odd harmonics are produced. Even harmonics are below the SA measurable limit. If operation is planned for the 70cm band (420-450MHz), a third harmonic at ~1290MHz will be present about 26dB below the fundamental. **DO NOT use an interdigital filter here as that type of filter passes the third harmonic with almost no added loss!** Low pass filters are easy to construct and should be placed **between** the DATV-Express board and power amplifier, not after the PA. For low pass filter design examples go to **www.CalculatorEdge.com/** .

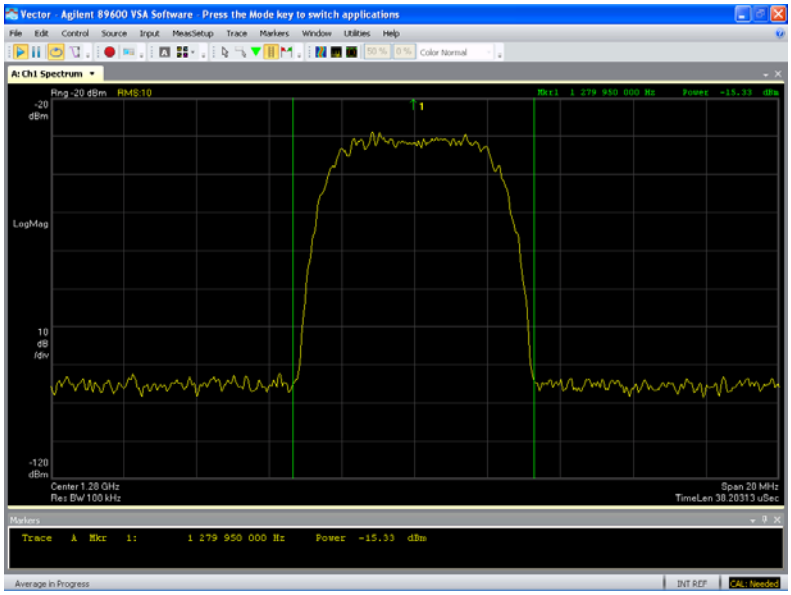


The graph at the right illustrates how the RF output decreases as the output frequency increases. At software-controlled RF output setting = 30, a 100MHz 0dBm signal reduces to about -5dBm at 1800MHz, everything else remaining the same.

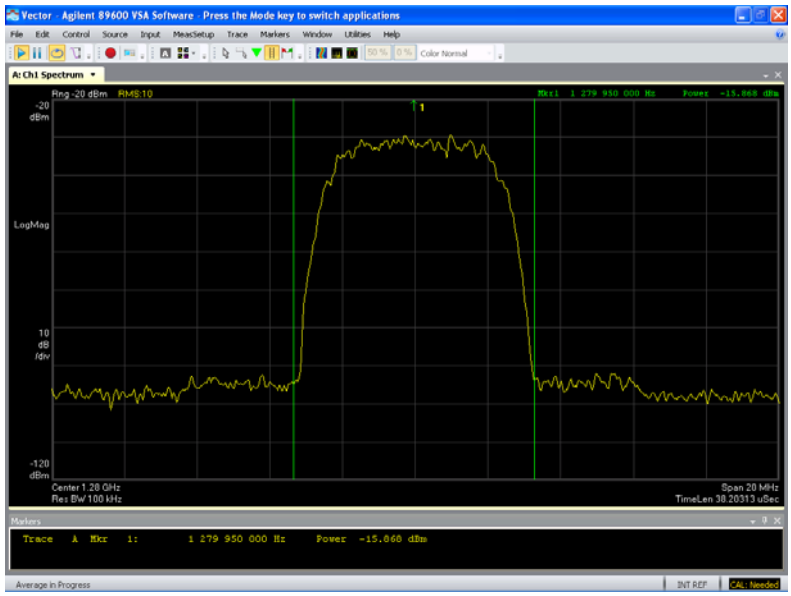


QPSK Analysis:

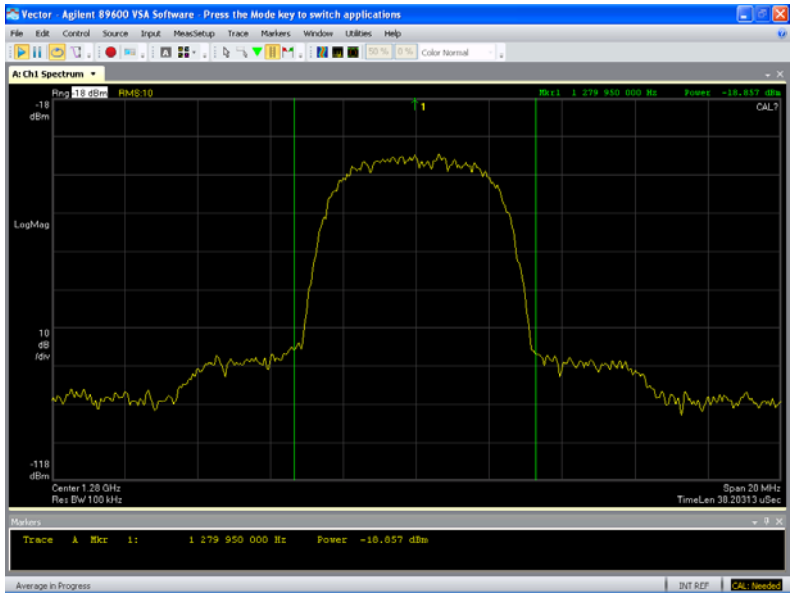
Since the spectral regrowth becomes noticeable when the attenuator output is greater than about 35, the graphs below show the RF output change as it passes thorough those points. From software-controlled RF output setting 00 to about 35, the regrowth is practically non-existent.



The graph at the right was taken with attenuator = 30 on an Agilent EXA analyzer and external 10dB attenuator in place between the DATV-Express board and analyzer. It shows a "top of the haystack" signal of about -30dBm which equates to true power = -15.3dBm between the 6MHz green markers. (Signal level is lower here than in earlier references due to added cable length and external attenuator). The noise floor is about -95dBm. This represents the noise being about a 65dB below the main signal.



The middle graph, taken with the software controlled output = 40 and external 20dB attenuator, shows slightly visible regrowth on each side of the main signal. It raises the noise floor up about 5dB resulting in distortion being down 60dB. This is still very good.



The bottom graph, taken with RF output setting = 47 (highest RF output) and external attenuator, shows higher regrowth sidebands. Regrowth is now about 10dB above the -95dB noise floor but still well within acceptable transmission limits. Here the spectral regrowth is down ~ 50dB.

The distortion and spurs on a QPSK DATV transmitter signal should be down at least 30 dB or more from the main signal on the "after amplifier" signal. Remember when looking at the DATV-Express RF output, any post signal amplification and (or) filters will tend to add distortion and decrease the overall signal quality.

7.0 – Contacts

7.1 E-Mail

- **Art Towslee – WA8RMC** Towslee1@EE.net
- **Charles Brain – G4GUO** G4GUO@ARRL.net
- **Ken Konechy – W6HHC** W6HHC@ARRL.net
- **Tom Gould – WB6P** Gould@Gekco.com
- **Project Team Support** SUPPORT@DATV-Express.com

7.2 Web Site

www.DATV-Express.com

WebMaster – Bob Tournoux – N8NT

7.3 Product Support

Yahoo Groups Support Forum for DATV-Express

https://groups.yahoo.com/neo/groups/DATV-Express/info

You can subscribe to the Support Forum by sending an email to:

datv-express-subscribe@yahoogroups.com