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TechTalk111
DATV Testing Report
- Part 6 (Bench Test DATV-Express)

by Ken W6HHC and Robbie KB6CJZ

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The earlier TechTalk109 presented an overview of the DATV-Express Project efforts and progress to create a lower-cost version of a DigitalATV transmitter exciter board and software. In this TechTalk article we will perform some basic bench tests for the board. W6HHC is again pleased to be joined by fellow OCARC club member Robbie Robinson KB6CJZ for the creation of this TechTalk article on Digital-ATV. Robbie is the club guru on analog ATV and commercial satellite receivers and ham microwave communications in general.

The Testing Set-up

Fig 1 shows the configuration of the set-up used for testing the DATV-Express hardware board as a full-blown DVB-S DATV transmitting station on the 1.2 GHz ham band. Two RF amplifiers were used: a 1 Watt (FM rating) unit by Kuhne and a 30 W (FM rating) by Down East. An old Pentium P4 computer running at 1.8 GHz had the disk drive partitioned to install Ubuntu V12.0.4 32-bit operating system. Qt V5.0.2 with the Qt Creator application was downloaded off the internet to build the software program and graphic user interface (GUI) used by Charles G4GUO to design the software for the DATV-Express project. Although the hardware board and software are designed to generate several DATV protocols (like DVB-S2 and DVB-T) this report only used DVB-S

(with QPSK modulation) as the primary protocol for our testing.

A USB video capture dongle is needed to encode the camera NTSC (or PAL) analog video and audio as highly compressed MPEG-2 data stream for the DATV-Express processing. The video-capture unit used in these tests is the Hauppauge model HVR-1950. Note that Hauppauge uses the designation HVR to mean "hybrid"; indicating that the model includes the capability to capture on-the-air digital-TV (ATSC), as well as analog-TV, as well as analog-camera input.

Barefoot Exciter Board Tests

Fig 2 shows the exciter board. The modulator chip runs very warm (even in non-transmit mode), so Ken added a 1/4-inch aluminum plate to act as a heat-spreader though the four standoffs on the board.

Figure 2 – The DATV-Express exciter hardware board is fitted with an aluminum plate as a heat-spreader
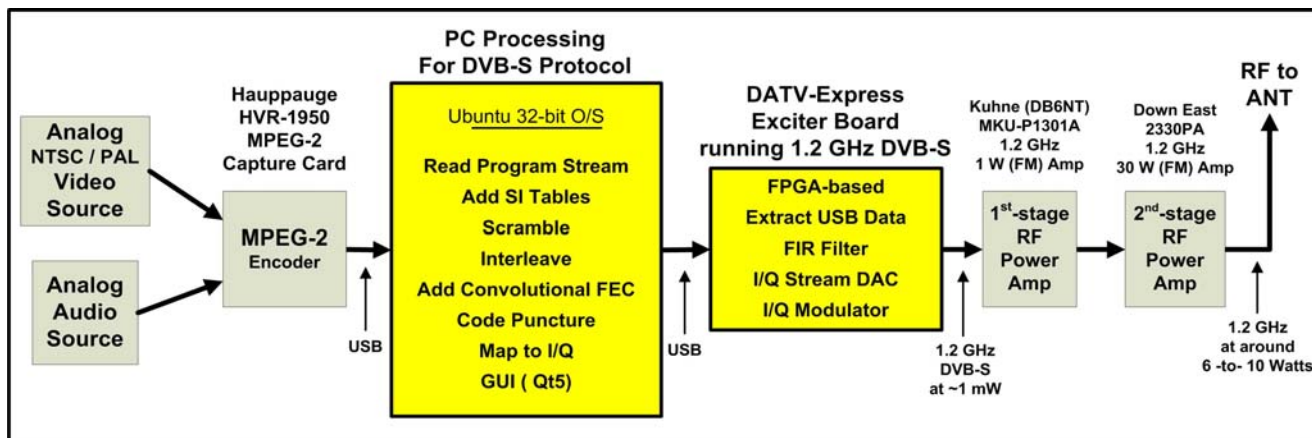

Figure 1 – Test Set-up for Bench Testing of DATV-Express DVB-S Transmitter

Ken had an initial problem in that he did not have the firmware for this Hauppauge model on his computer. Charles easily found the correct Hauppauge firmware file on the internet, Ken put the file on his computer....and the Hauppauge unit now loaded the firmware on start up in a Ubuntu environment.

Fig 3 shows the clean spectrum view of the barefoot DATV-Express exciter board. The output of the Hauppauge MEG-2 encoder is a data-bit-rate of about 2 Mbits/sec for the normal D1 resolution that is shown on a normal Standard-Definition Digital Television (DVD quality D1 = 720 x 480 Pixel for NTSC). So with the FEC (Forward Error Correction) set to a robust value of 1/2, we used a Symbol-Rate of 2.2 MSymb/sec to provide a compact RF bandwidth of $BW_{allocated}$ = 3.0 MHz.
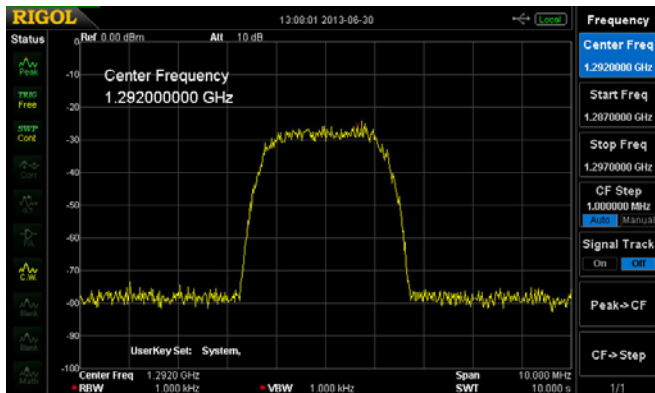

Figure 3 – A clean DVB-S spectrum of Prototype #4 board running 2.2 MSymb/sec on 1.292 GHz

Ken was able to look at his new RIGOL Spectrum Analyzer and screen-capture the DVB-S spectrum on 1.292 GHz. This RIGOL is really economical (compared to Agilent and used HP units) and works up to 1.5 GHz.

Ken also had a bit of difficulty with unexpected video-drop-outs on the SetTopBox. Charles G4GUO suspected a buffering problem inside the PC. So Charles prepared a design change to replace the synchronous software buffering design with asynchronous buffering code. Ken re-built the DATV-Express software application with the new source code using Qt Creator and the video-drop-out problem disappeared. The slow Pentium P4 1.8 GHz probably made Ken's testing more susceptible to display the problem than at QTH of G4GUO with his faster PC.

With the video drop-out issue resolved, Ken was able to reliably send DVB-S signals barefoot inside his software lab. **Fig 4** is one of the first DVB-S signals received (using screen-capture on his notebook computer) from across the lab using less than 0 dBm.
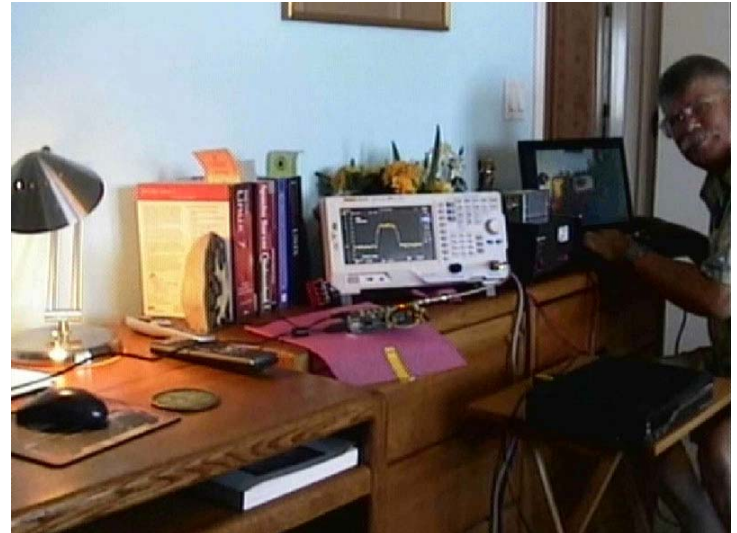

Figure 4 – Early 1.2 GHz DVB-S received video using barefoot DATV-Express to STB to Notebook

Tests with First-Stage RF Amp

Robbie provided the needed RF attenuators to protect the input of the Spectrum Analyzer's front end (rated at 30 dBm to create "front end" damage) from the first stage RF amplifier. An external attenuator of 20 dB was used in addition to the spectrum analyzer internal setting of 10 dB of attenuation. No "distortion-shoulders" (also known as "spectral regrowth") ever appeared on the spectrum output of the Kuhne RF amplifier, with the DATV-Express RF output set to a very high value of 40 (out of 47 levels). The photo in
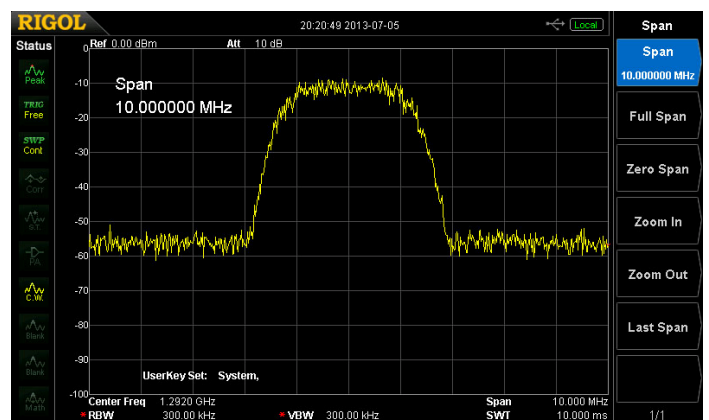

Figure 5 – Clean DVB-S spectrum on 1.2 GHZ using DATV-Express with Kuhne P1301A RF Amp

Fig 6 shows Robbie KB6CJZ inspecting the test set-up for measuring the spectrum output of the first-stage Kuhne RF amplifier.

Figure 06 – KB6CJZ is shown after connecting an external 20 dB attenuator from Kuhne RF amp

Tests with Second-Stage RF Amp

Fig 7 shows the Down East model 2330PA RF amplifier that is rated at 30W on FM and can develop about 6-to-10 Watts of output using QPSK digital modulation on 1.2 GHz band.
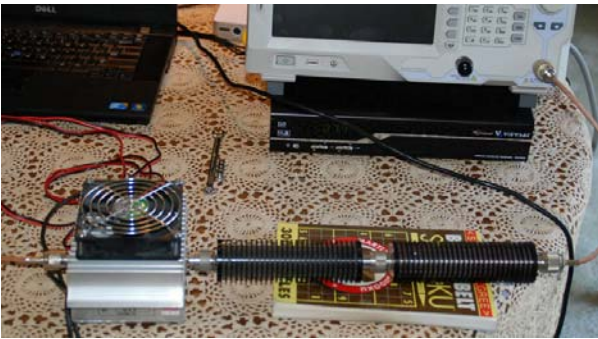

Figure 7 – The Down East RF Power Amp is connected to the Spectrum Analyzer through an external 40 dB of attenuation

For the testing with the Down East amplifier, external attenuators totaling 40 dB were used in addition to the spectrum analyzer internal setting of 10 dB of attenuation. **Fig 8** shows the spectrum for the second-stage RF amp output when the DATV-Express RF output drive setting was equal to a value of 30.

A table of measurements is provided as **Table 1** that lists the outputs obtained at different levels of power drive settings.

Measuring Power

There are three basic approaches to measuring power for DATV output:

1. Power meter – the most straight forward approach is to use a dedicated power meter that uses a thermal head. All hams seem to agree that the old faithful HP Model 432 is a good choice for DATV.
2. Power-capable Spectrum Analyzer – expensive industrial grade come with a special mode to measure and display channel power directly for digital modulations (such as Tektronix RSA5000).
3. Normal Spectrum Analyzer – Mike WA6SVT explained to Ken to set the RBW and VBW on the
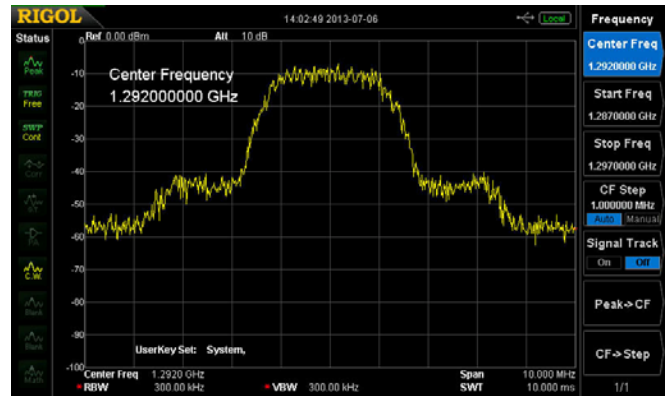

Figure 08 – Spectrum using Down East amplifier shows "shoulders" are developed but down about 32 dB. (DATV-Express power setting is 30)

Figure 09 – Stray RF from Bench Test set-up provided easy DATV Signal Reception on the STB. (Notebook screen-capture of W6HHC)

Spectrum analyzer to same width as the RF "occupied bandwith". The power is the top-of-the haystack. Ron W6RZ and Rob MØDTS have pointed out to us that you can use a little math to calculate the power level from the value at the top-of-the-haystack if the spectrum analyzer does not have a wide-enough bandwidth setting.. The correction factor in dB to add to the haystack value is:

10*log10 (channel bandwidth/resolution bandwidth).

One aspect of power amplifiers that always surprises newcomers to Digital-ATV is that DATV can NOT achieve the same average power out of an RF amplifier as FM modulation can. This is because most digital modulation technologies (except GMSK) have a very high "peak-to-average ratio". In order to prevent DATV distortion, you need to reduce the drive so that the peaks do not go into compression or flat-topping. On the web site from Alberto (DGØVE) you can read (in German): "All amplifiers can also be used for DVB-S and DVB-T with reduced power. You will notice that in the DVB-S mode only about 20% to 25% of the maximal power (P-1dB) can be used. Working in the DVB-T mode you will get only approximately 8% to 10% of the P–1dB power level."

Table 1 - Measurements taken during DATV-Express DVB-S Transmitter Bench Testing

DATV-Express exciter Menu Power-setting	Kuhne first-amp spectrum level	Spectrum Analyzer RBW setting	"distortion shoulder" below main carrier	Down East 2nd-amp spectrum level	Spectrum Analyzer RBW setting	"distortion shoulder" below main carrier	Down East Power Measurement (HP 432A) Output dBm	Down East Power Measurement (HP 432A) Output W
20	- 2 dBm	300 KHz	NONE				N/A	
30	+ 7 dBm	300 KHz	NONE				N/A	
40	+ 18 dBm	300 KHz	NONE				N/A	
46	+ 25 dBm	300 KHz	- 34 dB				N/A	
The above spectrum reading values account for 30 dB attenuation								
20	N/A			+ 32 dBm	300 KHz	NONE	N/A	
25	N/A			+ 38 dBm	300 KHz	- 35 dB	N/A	
30	N/A			+ 41 dBm	300 KHz	- 32 dB	36.3 dBm	4.3 W
33	N/A			+ 42 dBm	300 KHz	- 30 dB	38.8 dBm	7.6 W
35	N/A			+ 45 dBm	300 KHz	- 28 dB	40.3 dBm	10.7 W
				The above spectrum readings account for 50 dB attenuation				

Software GUI

The current DATV-Express software User Interface is very simple, but it allows the user to easily configure each of the supported protocols (aka modes) to the desired settings such as: frequency, modulation type, FEC, Symbol Rate, and power level. The TABs along the top of the screen shown in **Fig 10** are set up for DVB-S, DVB-S2, DVB-T, and DVB-T2 protocols. No code has currently been developed for DVB-T2, so the GUI TAB is just a "holding place". Since DATV-Express uses a Software Defined Radio approach, other interested hams could develop software for other protocols such as ITU-T_J.83-Annex-B or DVB-C, etc.
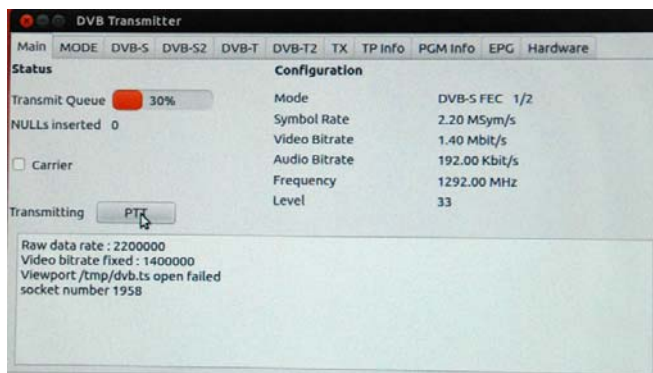

Figure 10 – DATV-Express software User Interface configured for DVB-S Protocol

Summary and Plans

The bench testing shows that the DATV-Express software and hardware board produce a very clean DVB-S signal. In our opinion, the signal quality appears to be as good as those we have measured with the MiniMod DVB-S boards produced by SR-Systems in Germany. As explained before, DATV-Express is capable of other DATV protocols used by ham radio. **Fig 11** shows the board generating a DVB-T protocol signal using 2 MHz BW with QPSK digital modulation.
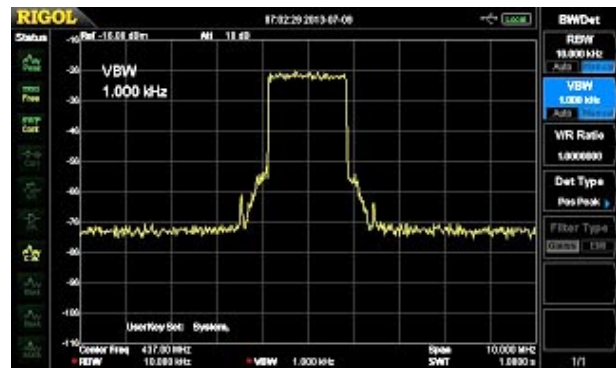

Figure 11 - Spectrum of DATV-Express board running 2 MHz wide DVB-T Protocol on 437 MHz
(Courtesy of G4GUO)

Ken and Robbie plan to do some DATV testing between our homes in the near future (flat and only 5 miles, but lots of buildings, elevated freeways, and tall trees.

Interesting DATV URLs

- YouTube Video on DATV-Express board – see **http://youtu.be/OXh-anABYaU**
- British ATV Club - Digital Forum – see **www.BATC.org.UK/forum/**
- Yahoo Group for Digital ATV - see **groups.yahoo.com/group/DigitalATV/**
- Orange County ARC entire series of newsletter DATV articles – see **www.W6ZE.org/DATV/**
- DigiLite Project for DATV (derivative of the "Poor Man's DATV" design)
  see **www.G8AJN.tv/dlindex.html**
- Rigol Model DSA815-TG Spectrum Analyzer – see **www.RIGOL.com**
- SR-Systems D-ATV components (Boards and complete XMTR) – see **www.SR-systems.de**
- TAPR 2012 Digital Comm Conf (DCC) Proceedings on "DATV-Express - a Project Update"
  see **www.TAPR.org/ pub_dcc31.html**
- CQ-DATV online (free bi-monthly) e-magazine – see **www.CQ-DATV.mobi**