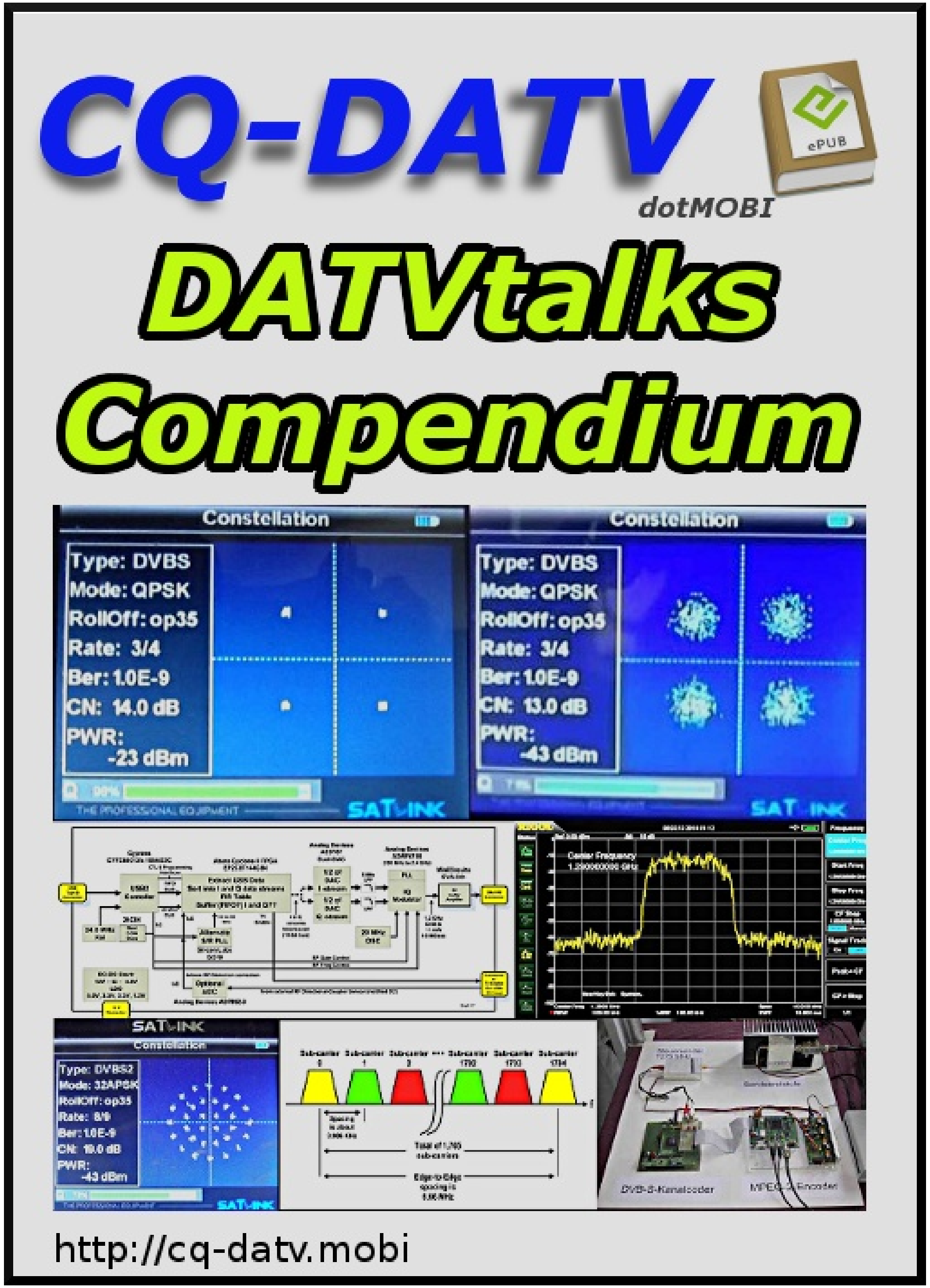


In this issue

Introduction

New readers to CQ-DATV may not know of the wide assortment of DATVtalk articles that have been published over the history of CQ-DATV. These articles contain an introduction to Digital-ATV as well focusing in on various aspects and areas of DATV.

I want to recognise two pioneers of ham radio Digital-ATV who have had a great impact on me and my ability to see and understand "how to do DATV". These two influential pioneers are Thomas Sailer, HB9JNX/AE4WA and Stefan Reimann, DG8FAC. Their early digital-ATV article published from DCC 2001 is available on TAPR website for download at www.tapr.org/pub_dcc20.html. You may recognise Stefan DG8FAC as the owner behind SR-Systems that went onto become one of the earliest suppliers of "ham radio grade DATV" equipment.

Please note that the DATVtalks 1 to 4 were NOT published in pdf format and so they are included in this version of the compendium as conversions from the ePub edition. This means that there is a lot of 'white space' on many of the pages.

This is a list of the DATVtalks published to date

DATVtalk#1 - Looking at the DATV-Express Digital-ATV XMTR Project

by Ken Konechy, W6HHC

This article is reprinted, with kind permission, from the newsletter of the Orange County Amateur Radio Club series of newsletter articles on DATV, www.W6ZE.org

Most people involved with Amateur TV (ATV), now recognise the advantages of digital-ATV technology over analog-ATV. The digital modulation and Forward-Error-Correction of D-ATV provides superior video quality and robustness against ghosting.

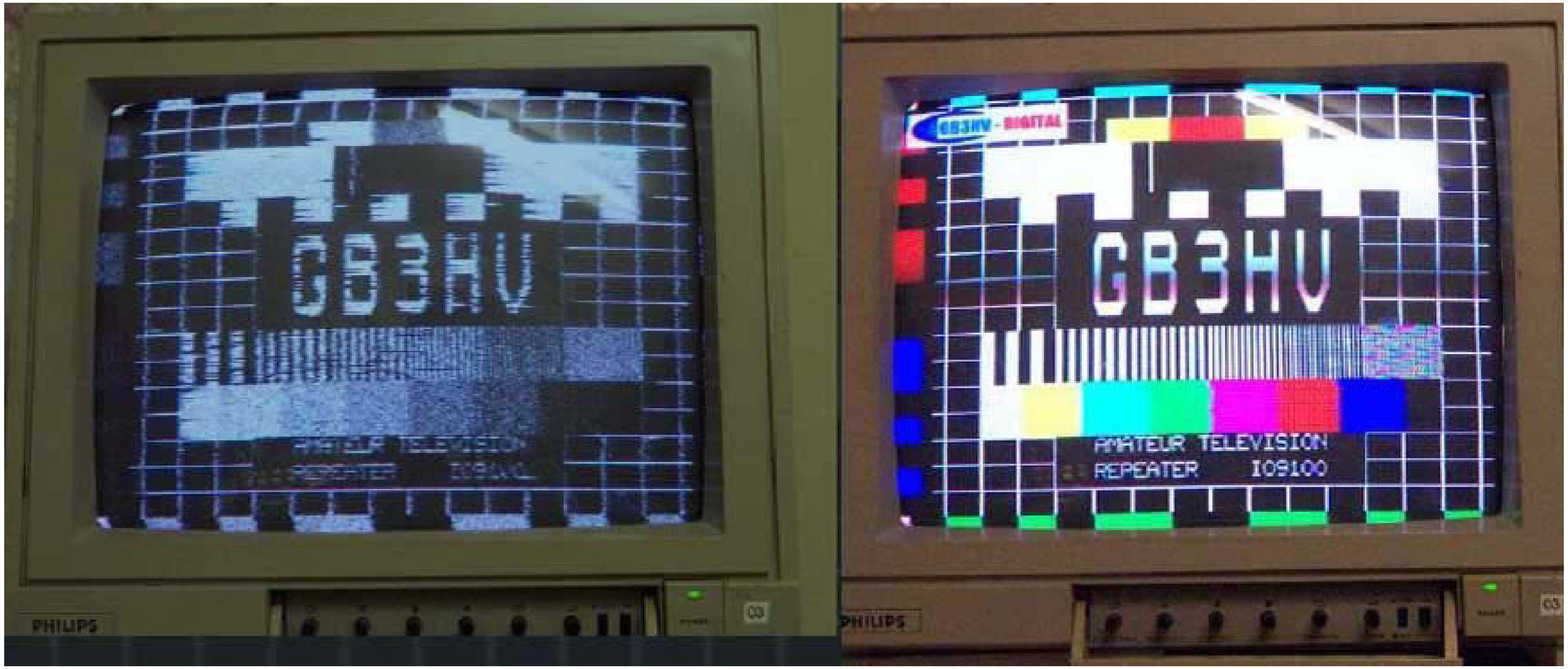


Fig 01 - Comparison of analog-ATV video and D-ATV video using the same antennas with weak sigs (courtesy of G7LWT & GB3HV)

For several years, hams have also recognized that the cost to buy ham-grade MPEG2 encoders boards and Digital-ATV exciter boards is too expensive. A ham-grade set of MPEG-2-and-DVB-S boards from SR-Sys in Germany cost about US$875. The cost of commercial-grade digital-TV boards is even higher. This high cost is known to prevent many hams from "trying Digital-ATV". A group of hams in US and England got together at the end of 2010 to start a project that will lower the cost of DATV considerably.

The open-source project is known as DATV- Express. The team members are:

- *Art Towslee WA8RMC – electronics design*
- *Charles Brain G4GUO – software design*
- *Tom Gould WB6P – PCB layout design*
- *Ken Konechy W6HHC – project mgmt & pubs*

System Block Diagram for DATV-Express

The most important concept about the DATV- Express board is that it is software-based SDR radio. While the system block diagram for a typical Digital- ATV DVB-S transmitter using the DATV-Express board is shown in Fig 2, the modulator chip and software can also produce several other types of modulations and protocols, such as COFDM for DVB-T and 32APSK for DVB-S2. The analog output of a video camera is sent to an MPEG2 encoder unit (made by Hauppauge) to compress the video stream. The video file is stored on a PC and a Windows-based or Linux-based PC does much of the "heavy lifting" to provide real time processing of the Program Stream from the MPEG2 Encoder into a Transport Stream to be used with DVB-S protocol.

The PC processes most of the protocol streams down to the IQ symbol bit-stream that is output via USB2 to the DATV-Express board. Then an FPGA manipulates the data and sends an I-stream and a Q-stream to a modulator. The operating frequency for the DATV transmitter is determined by the PLL within the IQ modulator chip and can be selected by the PC GUI for 70 cm, 23 cm, or 13 cm bands.

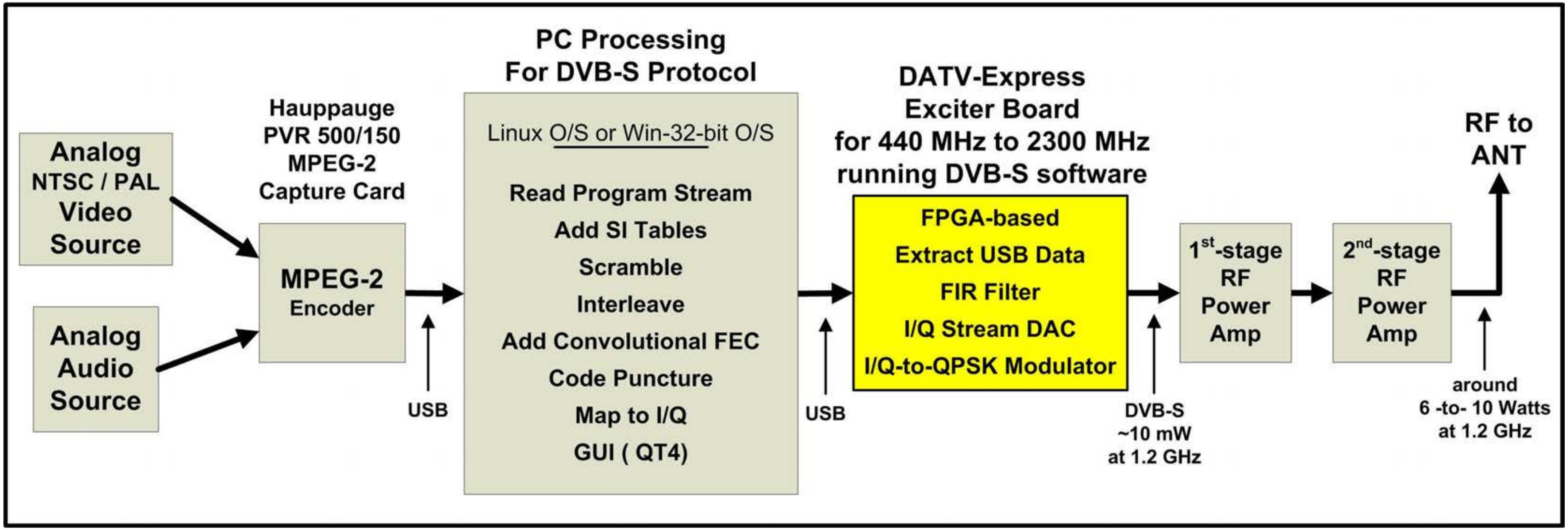


Fig 02 – System Block Diagram of Typical DATV-Express Project DVB-S Digital-ATV Transmitter PC can also run software for DVB-T and DVB-S2 DATV protocols

The RF output level from the DATV-Express board is fairly low, usually around 0-to10 dBm. So the typical DATV station will probably follow the DATV-Express RF output with about two stages of RF amplifiers to get up to a normal transmitter power level. The DATV-Express project team also recommends using an external band-pass filter to get rid of harmonics.

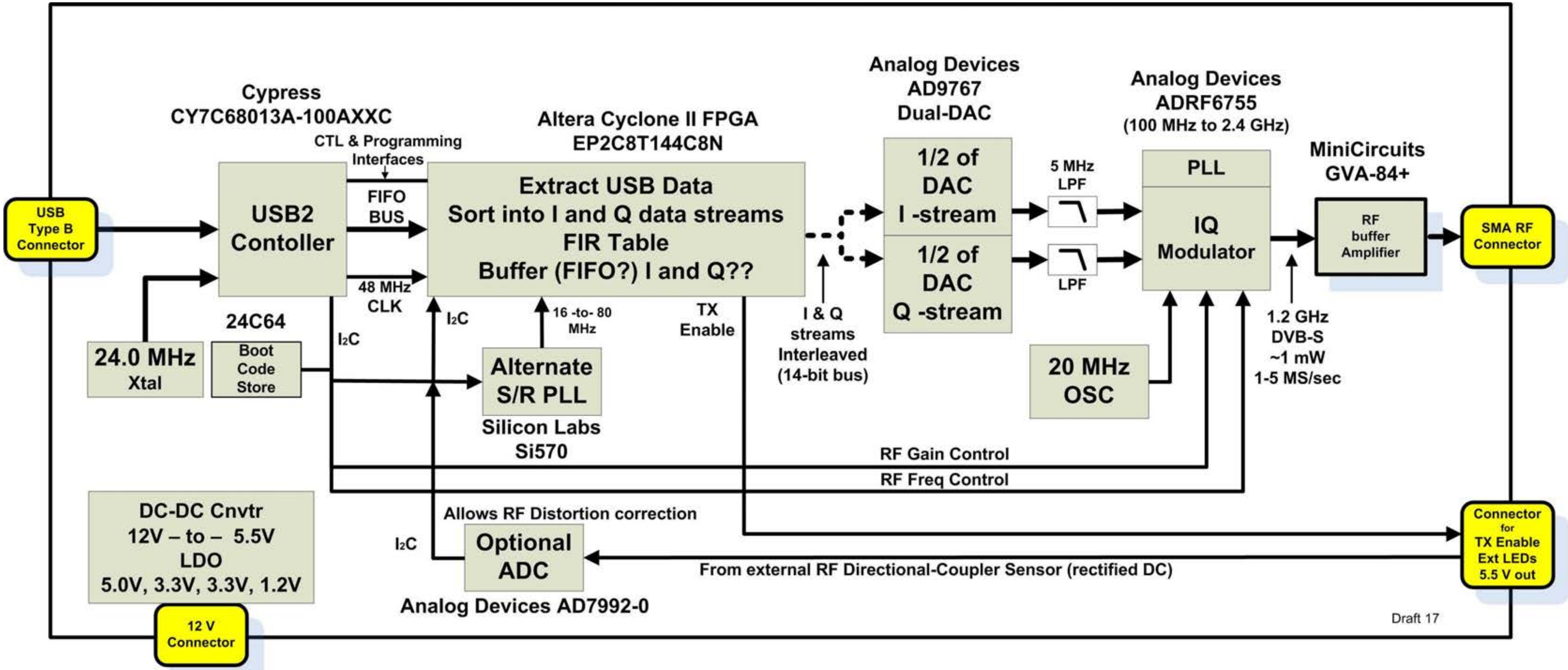


Fig 03 – Block Diagram of DATV-Express Project Digital-ATV Exciter Board

The DATV-Express Board

The DATV-Express exciter is a single printed circuit board shown in Figure 4. Hand-soldering fine-pitch SMT components requires extraordinary skills in my opinion. I complement Art WA8RMC on his ability to hand-solder the "first-article" prototype board you see in Figure 04. The 4-layer board dimensions are 5.3 x 3.18 inches. Tom WB6P used a schematic-capture tool called DX- Designer and layout tool called PADS to create PCB.

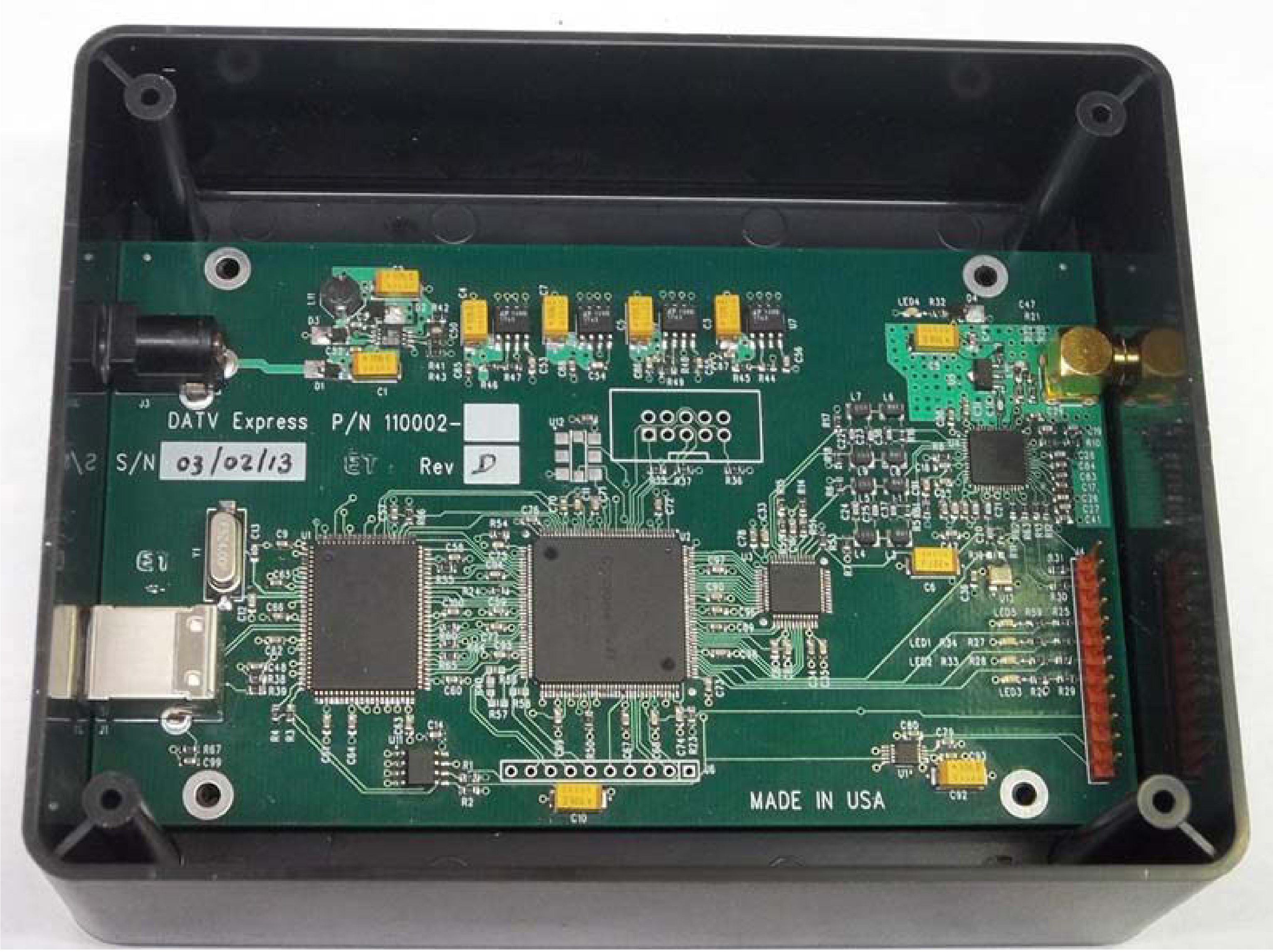


Fig 04 – the DATV-Express exciter board is a single printed circuit board.

The connector for USB2 is on the left side. The RF SMA connector is on the right side of the board. Fig 3 shows a more detailed block diagram for the DATV- Express board design. The PLL on the Analog Devices ADRF6755 IQ modulator allows defining an RF frequency between 72.5 MHz and 2480 MHz. The board contains a total of five DC regulators providing DC outputs between 5.5 VDC to 1.2 VDC for the various chips.

Fig 05 - On the left is the clean QPSK modulation Constellation from new second board etch layout. On the right is the noisy QPSK Constellation from the original board etch layout.

A small MiniCircuits GVA-84+ RF buffer amplifier follows the IQ-modulator chip. Initial bench tests on the first prototype board measured output of 18 dBm on 1.3 GHz. The initial RF etch layout was not done well and resulted in a noisy output and tended to self- oscillate. These RF problems were cleaned up in an etch-update called Version 2. Figure 5 shows the cleaned-up RF modulation (QPSK constellation) output, compared to the original etch layout. Figure 6 shows the fairly clean 1.3 GHz RF spectrum. The spurs are down about 55 dB from the CW carrier.

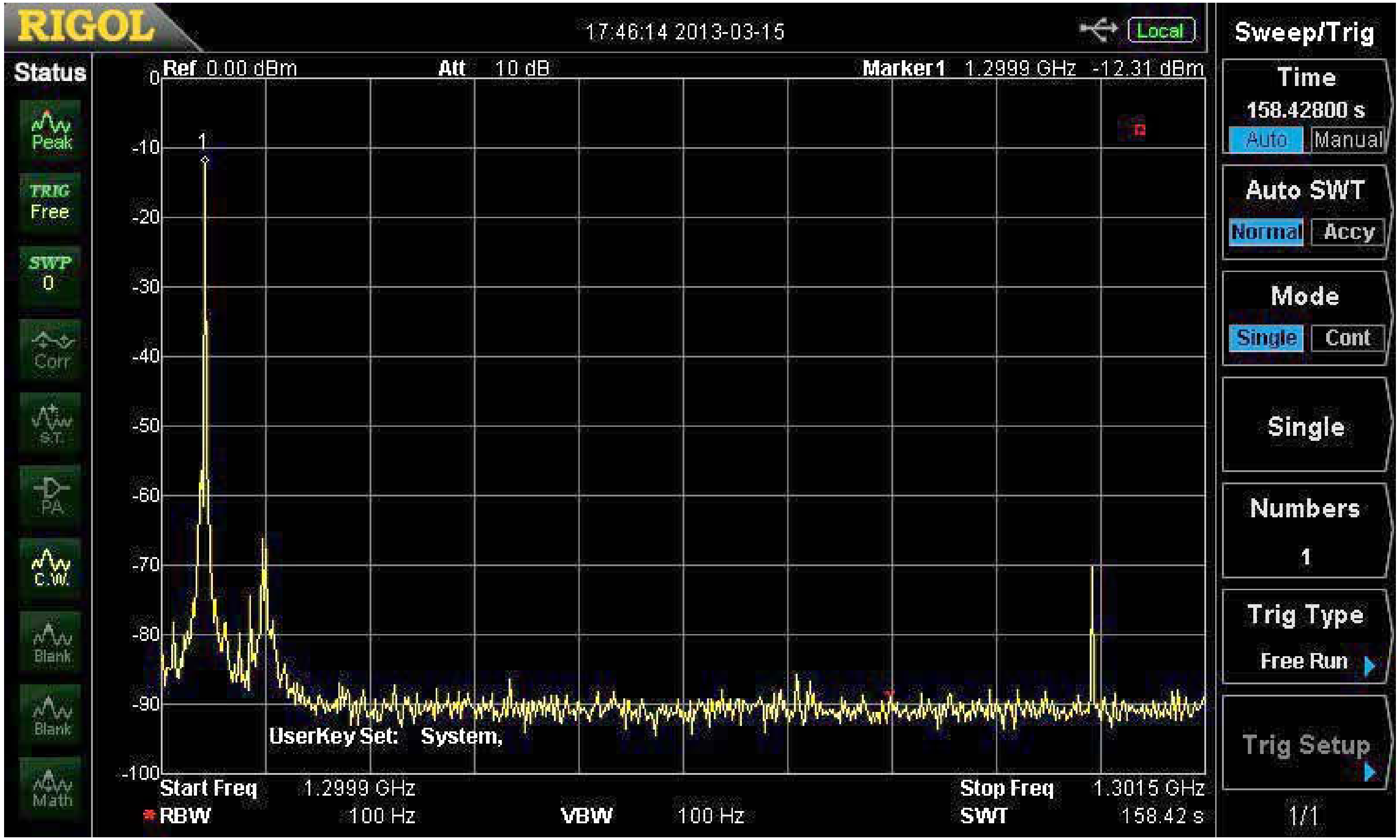


Fig 06 - Spectrum of new board with 1.299 GHz unmodulated carrier signal

Software for DATV-Express

The DATV-Express project uses three sets of software:

- *Software that runs on the external PC or Raspberry-Pi, etc.*
- *Software that runs on the 8051 (inside FX2 USB controller)>*
- *Verilog code that defines the FPGA functions*

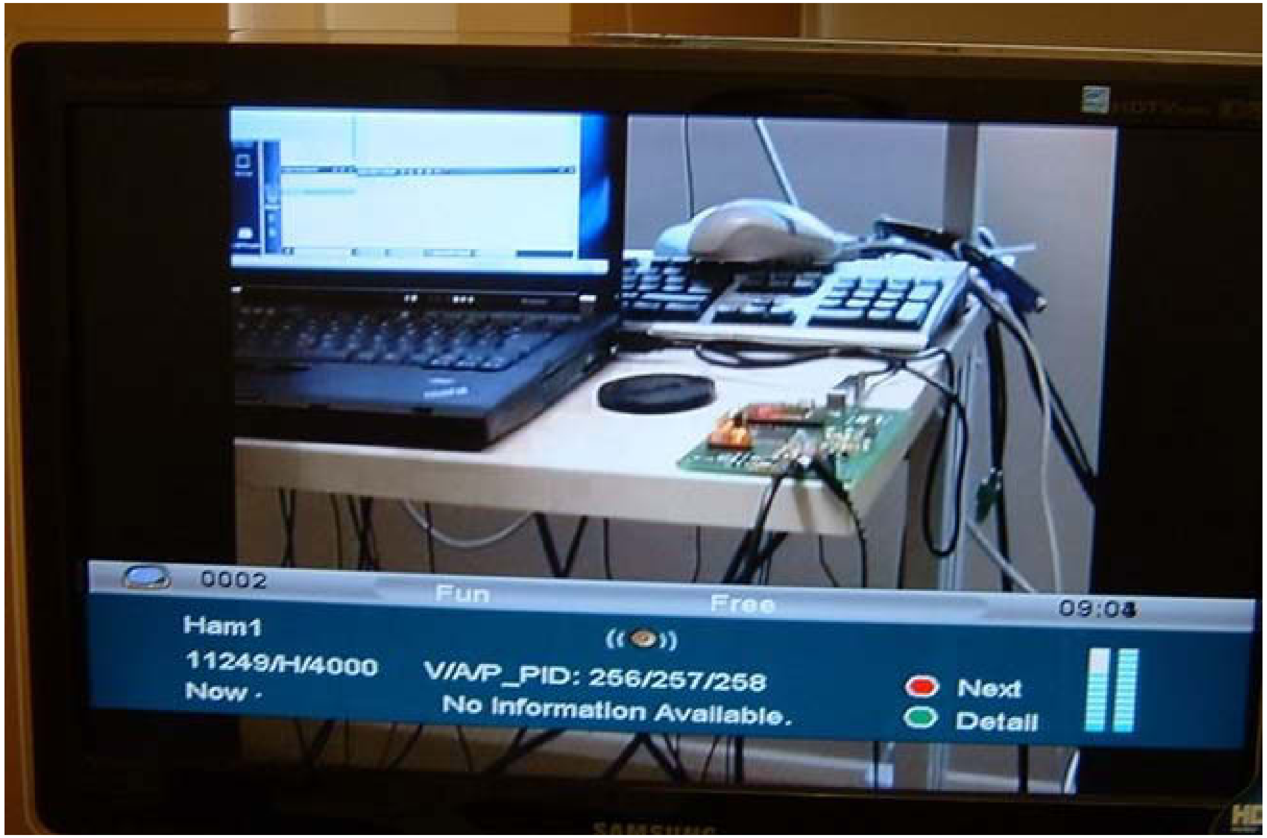


Fig 07 – The first DVB-S video ever transmitted by the DATV-Express board

The main focus of the project currently is getting to release the PC software using 32-bit Linux (Ubuntu Ver12.04.02 distribution). Currently the PC software does most of the protocol processing. An important function of the PC is to keep symbol rate constant, no overruns or under runs by adding Null transport packets as needed. The PC software also can download the firmware for the 8051 microcontroller. There is an on-board boot-ROM chip for storing firmware, but the project has not utilized it, yet. Finally, the PC downloads the code that goes into the FPGA.

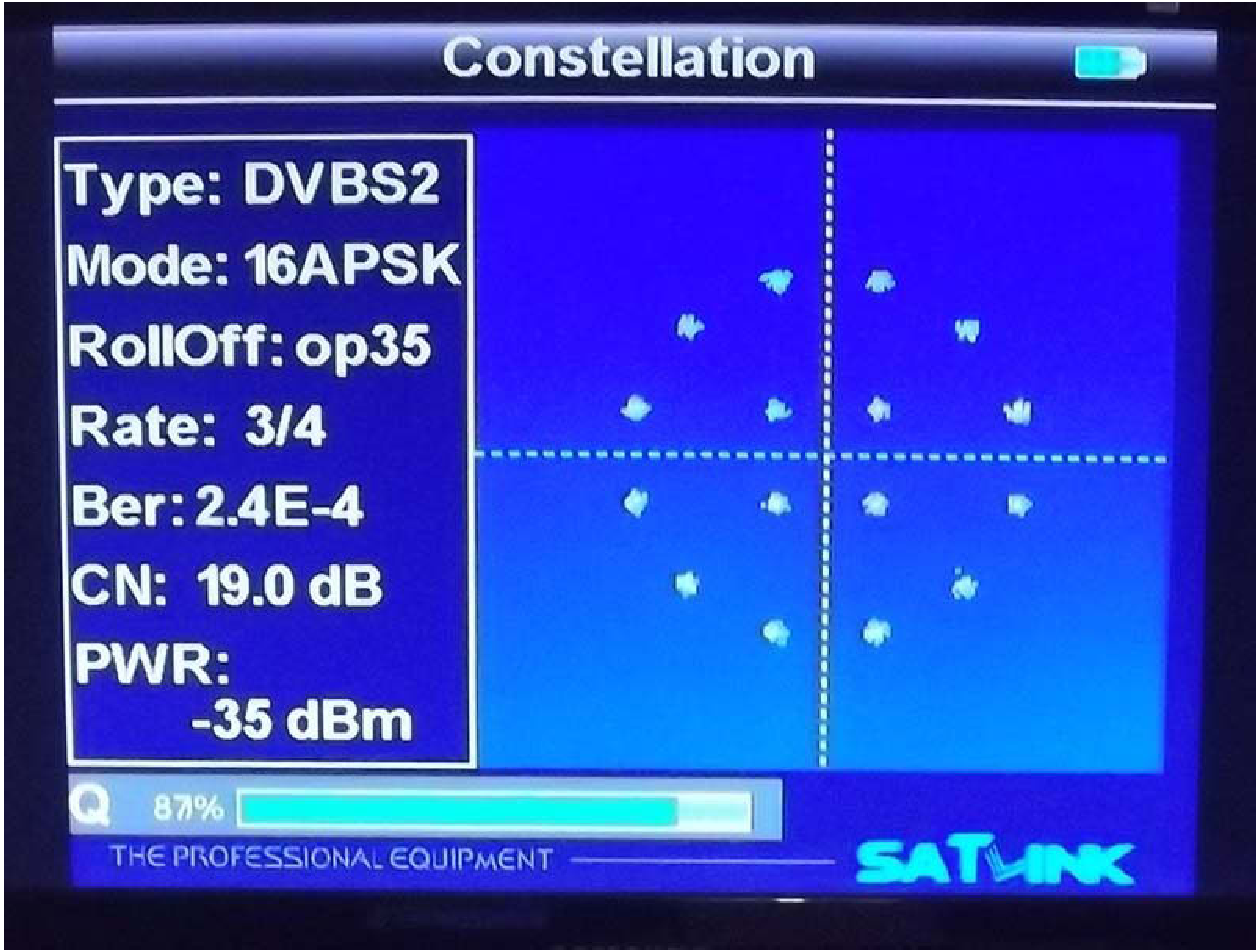


Fig 08 – This constellation of 16APSK digital modulation is being used on a DVB-S2 protocol transmission

The USB controller delivers the IQ symbol stream to the FPGA using a 16-bit FIFO on the EP1 bus. The FPGA firmware does a number of shaping functions of the IQ streams as well as calibrating for any IQ modulator offset mismatches in gain.

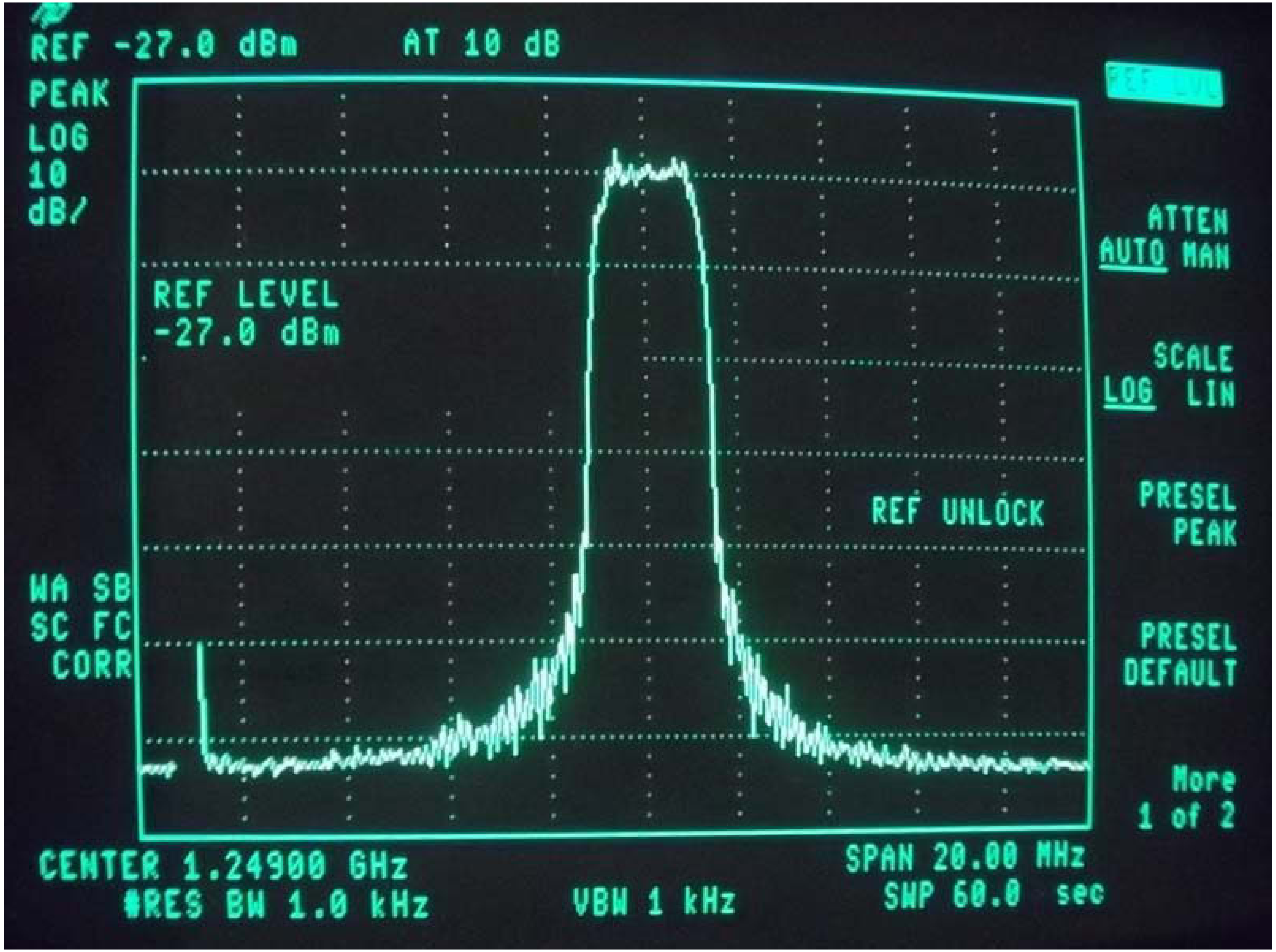


Fig 09 – 2 MSymbols/sec symbol-rate spectrum achieved using DVB-S2 protocol on 1.249 GHz

Figure 9 shows a DVB-S2 signal using 32APSK modulation being filtered by a 95 tap x8 interpolating filter with a rolloff of 0.35 and a compensated root raised cosine response. The filter takes the DVB-S2 symbols and interpolates them by a factor of 8 to put the aliases outside the LC Nyquist filter response. It is difficult to believe that 6 Mbits/s of video is crammed into that piece of spectrum approximately 2.5 MHz wide. The blip on the left hand side at 1.24 GHz is probably a multiple of 20 MHz reference clock signal on the board. The blip remains stationary when the operating frequency changes.

Fig 10 – Test pattern received using DVB-T protocol with 7 MHz bandwidth on 1.3 GHz

The QT4-based GUI on the PC (see Fig 11) controls which protocol to download, the PLL frequency, Symbol-Rate, the FEC configuration settings, and the RF power output level.

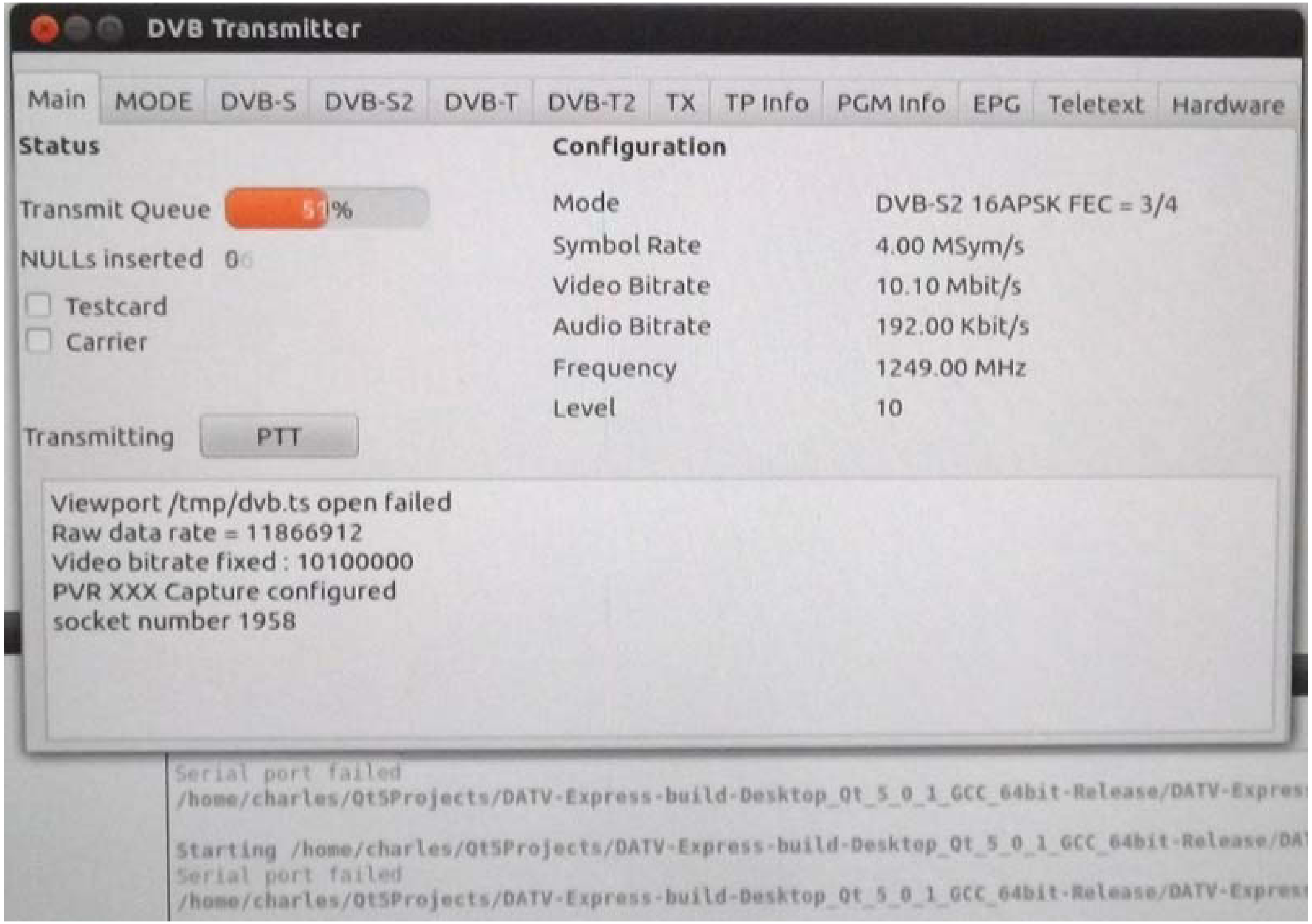


Fig 11 – The simple GUI being used by the DATV-Express software

Project Plans

The primary goal right now is to get the board and software ready to distribute into the hands of hams. The team is working towards a "final" etch-update for pre-production to resolve some inner-layers etch clearance issues and make some silk screen changes like adding the CE Mark symbol. The pre- production run will also confirm the correctness of the solder-paste stencil file and the pick-and-place file. The first release of software will run on 32-bit Linux. A little later, further releases of software will run on 32-bit Windows OS. Right now the team hopes to have a few boards ready towards the end of this year, probably in October.

Another plan is to make the design files of this open source project available to anyone. This includes hardware design (like schematic capture and gerber files) as well as software source code for PC and Verilog. In this way, other hams can experiment and extend SDR and even manufacture the boards if that is their commercial goal.

Finally, Charles G4GUO has also been looking at what might be done using the Raspberry-Pi (ARM based) single-board-computer and/or the MK808 media player (also ARM based) to interface with the DATV-Express board as an alternative to using a normal PC. With the help of Rob MØDTS, Charles has played with a modularised version of his DATV host software. It turns out that the Reed-Solomon FEC encoder software consumes a large portion of the ARM resources. Charles has tried porting the Reed-Solomon code to run inside the FPGA. This seems to work well. Also, the project is lucky that Brian G4EWJ has written an optimised version of this module in ARM assembly language. Brian's module uses about 1/4 of the processing cycles that the G4GUO C module does. So we have managed to get the whole thing down from 60% to about 20% of cycles. Further improvements can be made.

The Author may be contacted at *W6HHC@ARRL.net*

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 newsletter entire series of 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*
- *SR-Systems D-ATV components (Boards and complete XMTR) – see www.SR-systems.de*
- *CQ-DATV online (free bi-monthly) e-magazine – see www.CQ-DATV.mobi*

DATVtalk02
ATV and the
Digital Fork in the Road

by Ken Konechy, W6HHC

Reproduced from the newsletter of the Orange County Amateur Radio Club www.W6ZE.org by kind permission.

[Please Note – This is the first article in series of articles to introduce Digital-ATV to hams for this new area of ham radio. The article was originally written in 2009. Since, 2009, there have been changes and improvements in technology…but there is still a basic problem (most severe in US) that too few hams are using digital-ATV. This article has been now updated to reflect the changes since 2009.]

By now, everyone is using commercial Digital Television. Old commercial analog TV transmitters essentially went off the air in the US in June of 2009 and have been replaced by commercial digital TV transmitters.

For several years before 2009 I had listened to some interesting ham conversations about "we hams should change analog ATV over to Digital-ATV (aka DATV or D-ATV) to keep up with technology". This article is the result of my attempt to get "my arms around digital ATV" and be able to explain it to other hams. In this series, I plan to stay away from complex math equations (like used in Fast Fourier Transforms) and details of tedious algorithms used in the DVB protocols.

Why Go Digital ATV?

The main benefits of digital ATV are:

1. *The picture quality can be nearly perfect much of the time*
2. *Digital techniques allow error correction from noise, multipath*

3. *Digital techniques allow advanced modulation (less bandwidth) and compression*
4. *Digital TV components will become more common on the marketplace.*
5. *Analog TV components will start to disappear from the marketplace.*

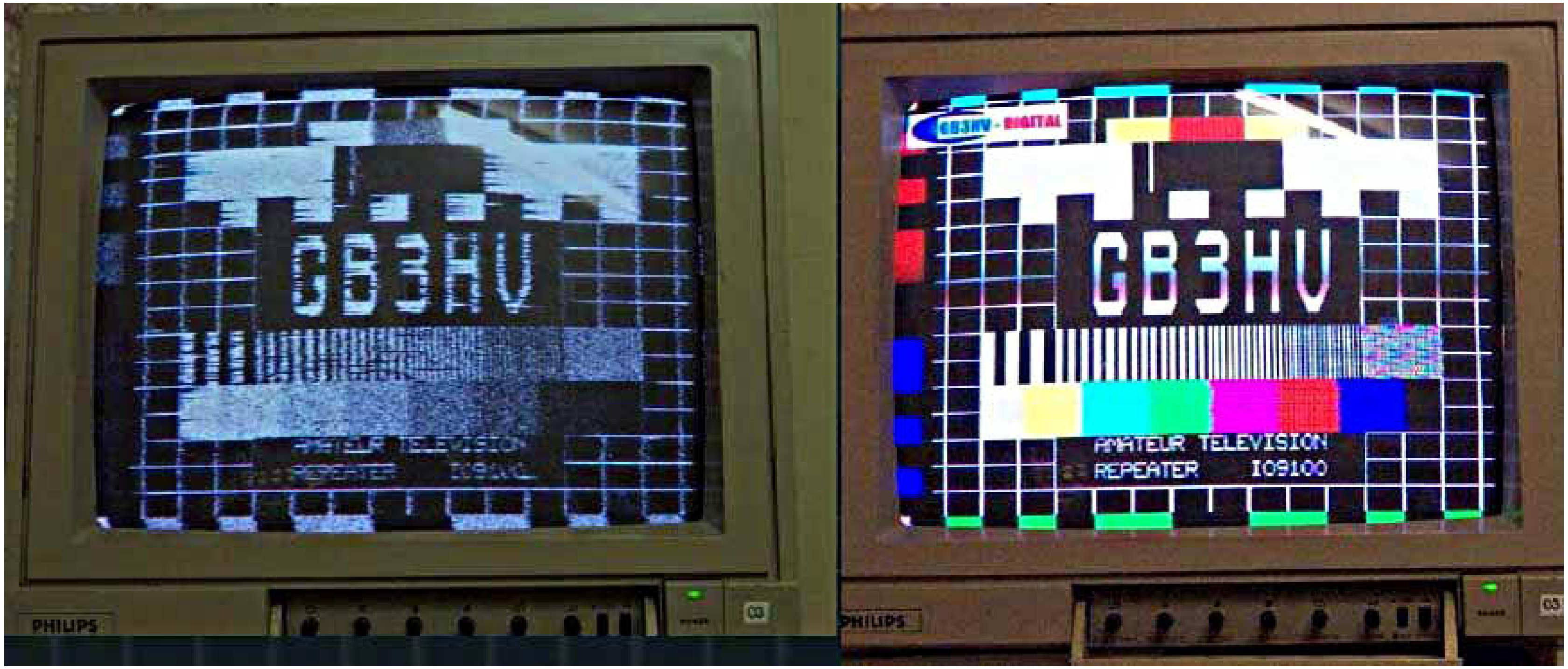


Figure 1 - Comparison of analog ATV video and D-ATV video using the same antenna with weak sigs (courtesy of G7LWT & GB3HV)

Different Types of Digital Video Broadcasting Specs

To start with, there are three fundamental broadcasting environments for Digital Video broadcasting:

- *Cable*
- *Satellite*
- *Terrestrial*

Each of these three different environments requires a different specification as described below.

DVB-C (cable)

The DVB-C standard for cable broadcasting was established by the Digital Video Broadcasting organisation (*www.DVB.org*). The environment of cable is very low noise and very low loss. So resistance-to-noise is not needed for cable digital TV. The nice cable environment allows implementing higher order modulation schemes starting from QPSK up to 256QAM. Because of the need for a guaranteed low signal path loss in cable, this does not represent a good choice of technology for hams to consider. The more complex modulation technologies end up with less robustness to noise than the simple DVB-S standard (discussed latter).

ITU-T_J.83-Annex B (cable)

In the US, there is a variation of the DVB-T standard that is used by the US (and Canada) cable industry. The US standard for digital cable is called ITU-T_J.83-Annex B. However, ITU-T _J.83-Annex B still essentially reflects all of the strengths and weakness of the DVB-T standard. One advantage in the North America is that a ITU-T_J.83-Annex B transmitter can transmit directly on one of the frequencies used by a US cable-ready TV sets, without the use of a Set-Top-Box (STB). However, while these two cable protocols are similar to each other, their details make them incompatible with each other.

DVB-S (satellite)

The DVB-S standard for satellite broadcasting is designed to work in an environment that contains lots of signal path attenuation and line-of-sight communication. To compensate for the weak signals, the DVB-S standard uses different layers of Forward Error Correction (FEC) for a very robust protection against any kind of errors. One drawback for hams is that DVB-S was NOT designed to deal with multipath environment situations. Typically, the DVB-S uses MPEG-2 for video data compression and QPSK for modulation that can be run in a 2 MHz bandwidth mode. This is the standard chosen by many European and United States D-ATV groups for digitising ATV.

DVB-T (terrestrial)

The DVB-T standard for terrestrial broad-casting by the Digital Video Broadcasting organisation is designed to work in the classic situation where a transmitter is broadcasting RF signals to home antennas coupled to a digital TV receiver.

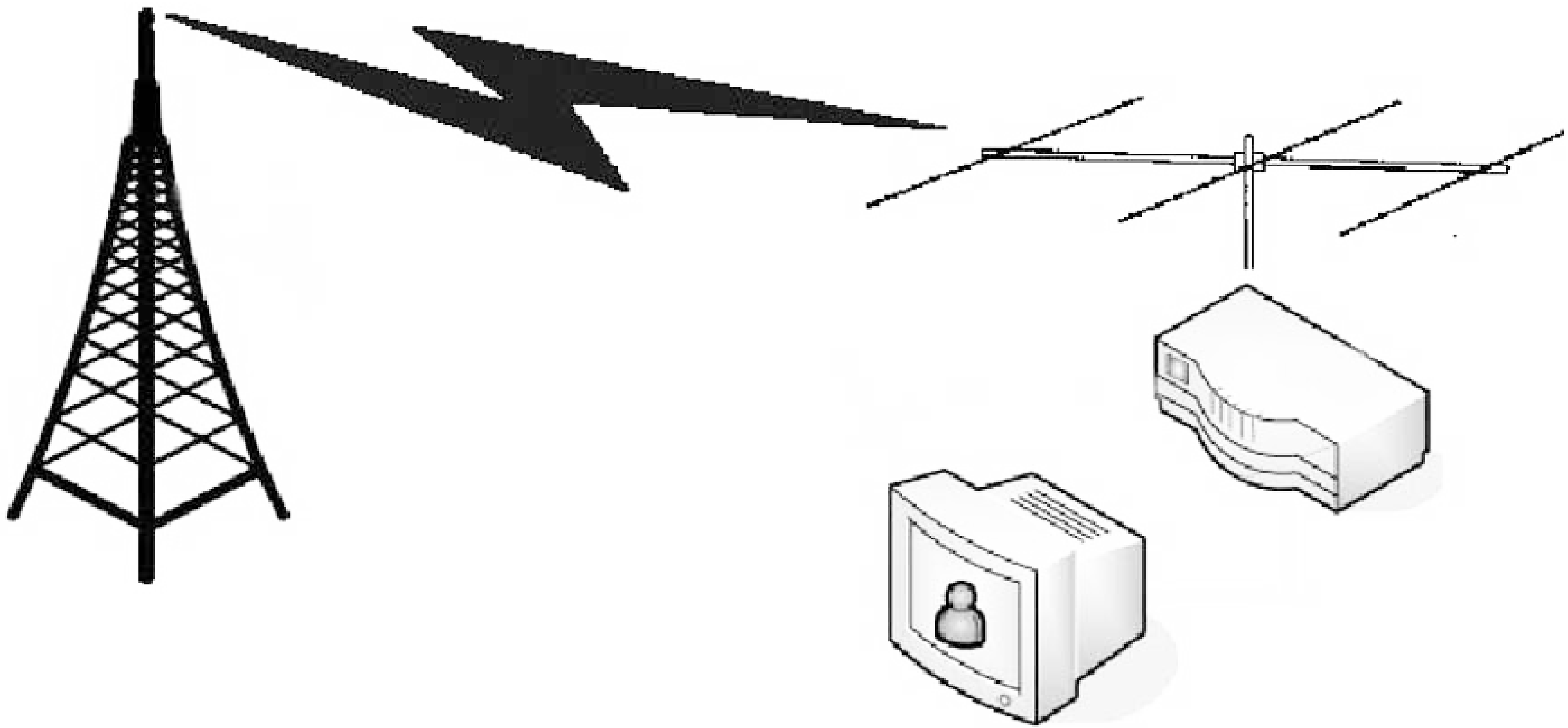


Figure 2 Terrestrial reception using commercial set-top box

In over-the-air broadcasts, the terrestrial technology needs to overcome the destructive effects of multipath reflections. Also, the terrestrial signal path attenuation's can be frequency dependent and can result in a partly distorted received signal. The negative effects of multipath reflections can be reduced, by using 16QAM modulation for a low effective bitrate per carrier. To reduce the effective bitrate per carrier, DVB-T spreads out the bitrate over a large amount of carriers. This spreading out will result in 1,705 closely spaced carriers (using COFDM…aka Coded Orthogonal Frequency Division Multiplexing) to create typically a 6 MHz bandwidth. If we look at the possibilities for D-ATV then hams will come to the conclusion that DVB-T can provide the ultimate approach if it comes to robustness. While the DVB-T standard provides for bandwidth's of 6 MHz, 7 MHz and 8 MHz, this wide bandwidth (compared to analog-ATV) can transmit two video streams (2 video channels) on 6 MHZ…so it is used by several DATV Repeaters to allow two separate up link channels that go out on a single DATV-T transmitter down link.

Clever hams have "bent the standard" a little and redesigned the SDR software code to produce DVB-T signals for DATV that now occupy only 2 MHz of RF bandwidth.

ATSC 8-VSB (terrestrial)

What I have not mentioned, so far, is that the Digital Video Broadcasting organisation standards are only used for commercial TV in Europe and Asia….NOT in the United States. In the United States (and Canada) the commercial TV industry uses standards from the Advanced Television Systems Committee (ATSC) a spin-off from the old NTSC TV standards organisation. So again things are a little different in the US commercial digital television world for terrestrial broadcasts.

8-VSB is the 8-level Vestigial Sideband Modulation method adopted for terrestrial broadcast of the ATSC digital television standard. Like DVB-S, it usually uses MPEG-2 for video compression and multiple layers of Forward Error Correction (FEC) for a very robust protection against any kind of errors. Interestingly, the 8-VSB modulation does not use phase-shift techniques, but uses 8 levels of amplitude for modulation and demodulation. This modulation approach produces a gross bit rate of 32 Mbit/s, and a net bit rate of 19.39 Mbit/s of usable data in a 6 MHz bandwidth. The net bit rate is lower due to the addition of forward error correction (FEC) codes. While, the set-top DTV boxes are very common, the current lack of low cost 8-VSB transmitting circuitry has prevented US hams from using this ATCS 8-VSB approach for ham radio D-ATV.

Drawbacks for D-ATV

There are two main drawbacks to D-ATV for ham radio ATV enthusiasts:

1) Weak Signal Reception

Digital TV technology tends to have “ALL or NOTHING” video performance. The picture is GREAT thru noise and weakening signals….then POOF, it’s gone. The transition phase between ALL or NOTHING tends to be very narrow. As Henry AA9XW explained in the Amateur Television of Central Ohio News (ATCO), “Yes digital [ATV] is “noise free” until you hit the blue wall. There is 1 dB between perfect and nothing. So don’t expect a lot of DX since you can’t find the signal in the noise without a spectrum analyser and BPF [band pass filter].”

2) High Cost of Equipment

One advantage of analog ATV was the cost of equipment, especially transmitting equipment was relatively cheap. You could buy commercial analog CCTV equipment and easily modify it for ham radio ATV use. The receiving circuits can be obtained from old home satellite dishes (DVB-S) that are surplus on e-Bay and can be converted to D-ATV. But, obtaining transmitters…with image processing and the modulators…is the main problem. There is no flood of cheap surplus satellite digital-transmitting equipment around. So you either buy boards from European D-ATV companies or you buy the Integrated Circuits used by transmitters and build your own equipment. In my opinion, this last approach takes a lot of engineering/software technical skill that most hams do not possess and requires an investment of a lot of time. SR-Systems in Germany offers a wide selection of printed circuit boards for D-ATV. Robbie KB6CJZ of OCARC estimates it costs about US$1,200 or more to buy a D-ATV transmitter exciter, digital band-pass filter, and very-linear power amp. A camera and a wide-bandwidth antenna would also be needed. D-ATV repeaters are more expensive.

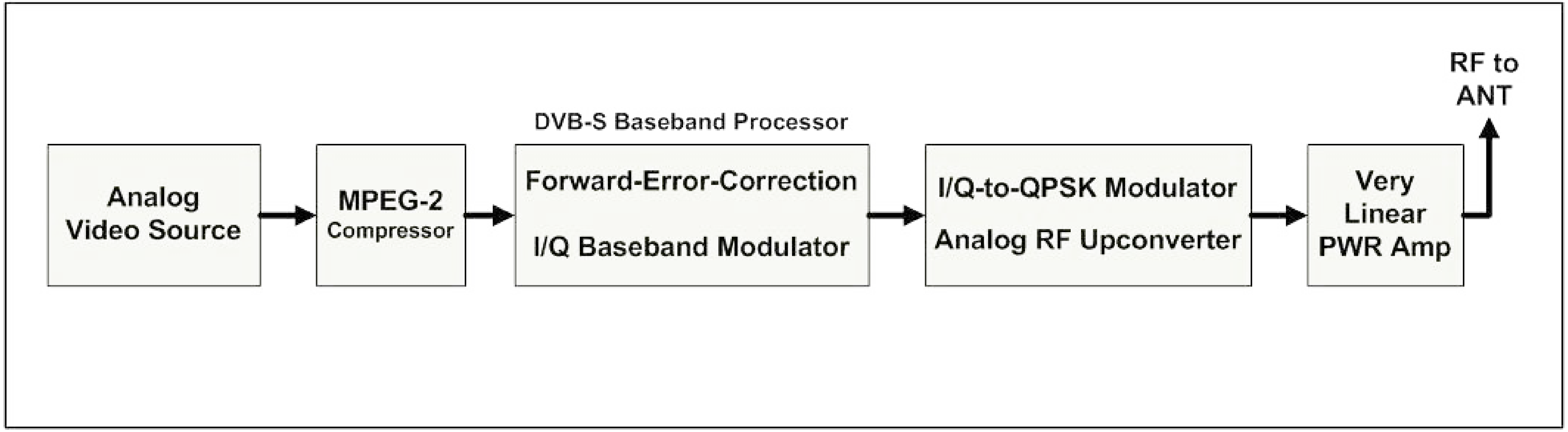


Figure 3 – Basic Block Diagram of DVB-S Transmitter for Digital-ATV

Status of D-ATV Today.

Groups and clubs of D-ATV enthusiasts have shown that digital technology is possible for hams and works as expected. Fig 4 is a display of an early European DVB-S prototype transmitter demonstrated at the 2001 Friedrichshafen Ham Fair in Germany by Howard Sailer HB9JNX/AE4WA, Stefan Reimann DG8FAC, et al. The display is based on the block diagram shown in Fig 3. The compete article can be found in the TAPR Digital Communications Conference for DCC Proceedings 2001

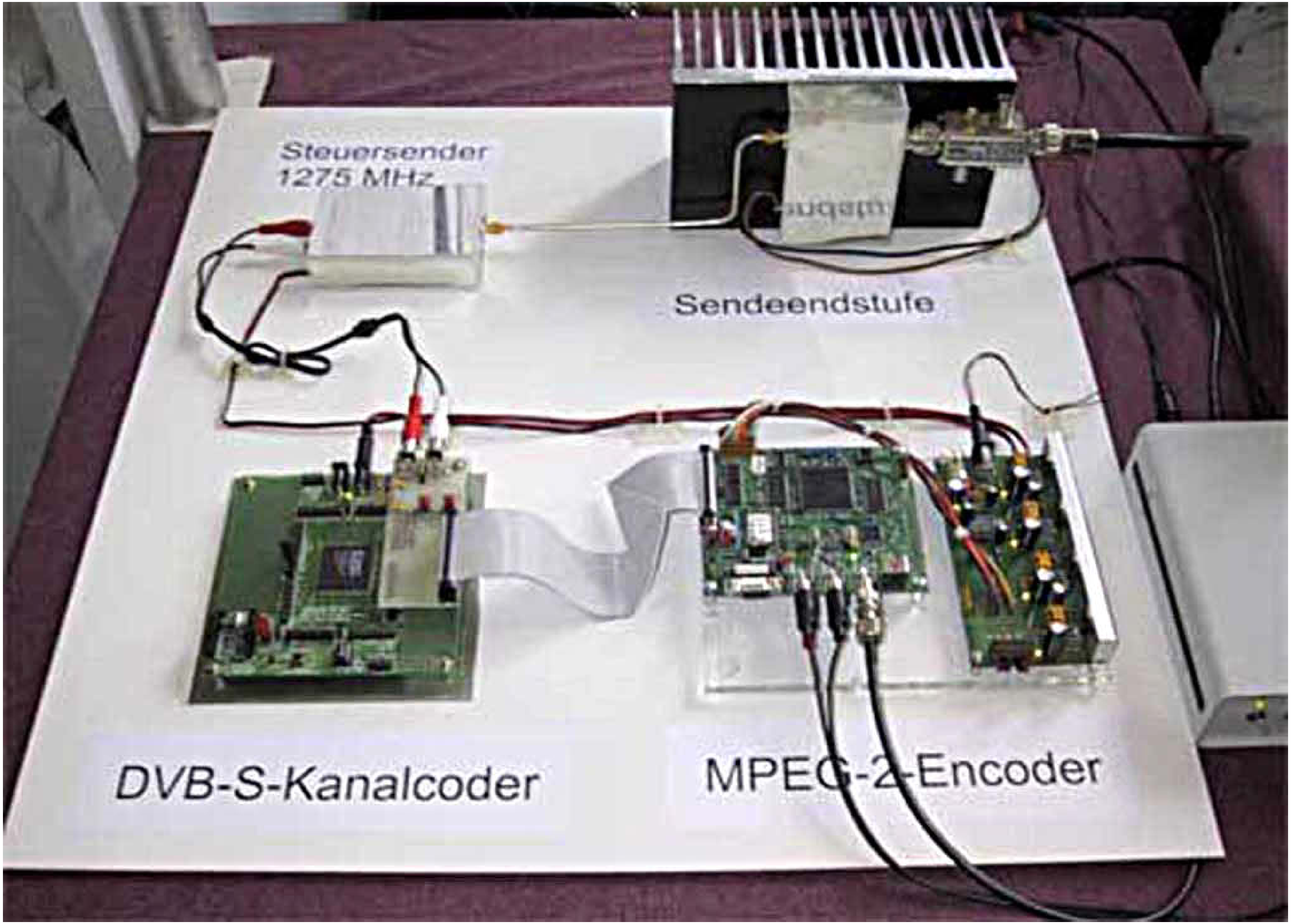


Figure 4 – Very early Prototype DVB-S D-ATV transmitter (courtesy of Thomas Sailer HB9JNX/AE4WA, et al.)

In my googling the Internet, participating in ATV/DATV forums and through having local conversations, I found that there was a very large burst of D-ATV efforts by hams (mainly in Europe) that lasted from about 2000 to about 2004. SR-Systems of Germany began producing what I called ham-grade boards (as compared to very very expense commercial Digital TV components) to allow hams to buy DATV components. At the same time AGAF, the ATV organisation in Germany, began sponsoring a project under the leadership of Professor Dr Uwe Kraus DJ8DW to also design and produce ham-grade DATV board components. The early activity level increases then went flat for a bit, and then a new project called DigiLite became finished in 2011. The BATC organisation offers a DVB-S kit for a transmitting exciter called DigiLite at a low total cost of less than US250. But, DigiLite is a kit. You have to order the individual components by yourself, and you need to solder the board, including the some surface-mount-devices (SMD aka SMT). About 250 of DigiLite transmitters have been sold as of 2013.

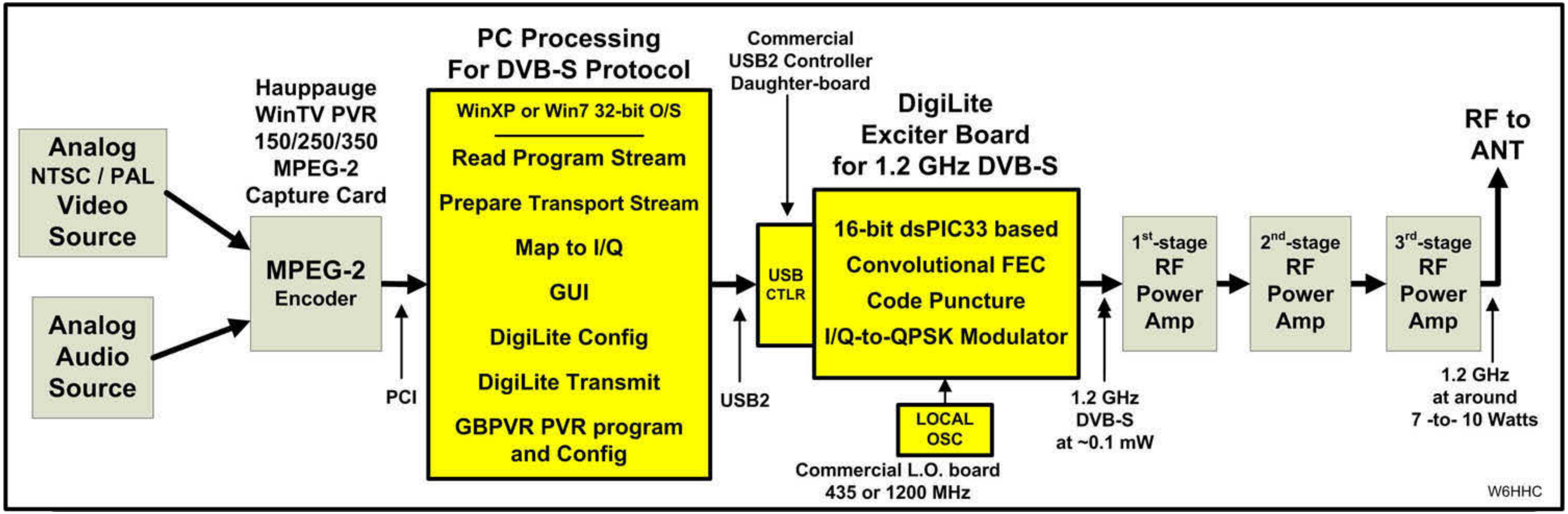


Figure 5 – System Block Diagram of DigiLite Project DVB-S Digital-ATV Transmitter

From what I have learned, there are only four or five areas in the US that have D-ATV repeaters or are even testing D-ATV.

- *ATCO began the WR8ATV/R using digital DVB-S repeater output on 1268 MHz in central Ohio in 2004.*

- *The COAR RACES group switched from analog-ATV to DVB-S DATV for emergency video communications from the field back to the Emergency Operations Center (EOC) in the city of Orange, beginning in 2010.*
- *The San Diego / Del Mar ATV group (SDDM ATVG) completed a portable DVB-S DATV repeater in 2011 to be used for ARES and CERT activities.*
- *Jim KH6HTV (of KH6HTV Video) has been testing the robustness of the DATV ITU-T_J.83-Annex B protocol beginning in Colorado in 2011.*
- *The ATN Repeater group has begun testing an ITU-T_J.83-Annex B DATV repeater on 1243 MHz using QAM-64 modulation in the Los Angeles basin in early 2013.*

What is the Future for D-ATV?

Based on what I have learned while first preparing this article on D-ATV, I am surprised by the small amount of current D-ATV activities in the United States. I expected a lot more activity in US in 2009 and I had hoped for a lot more activity in 2013. There is a great picture-quality-performance attraction for Digital TV. But, it seems to me that the weak signal picture loss associated with D-ATV may be taking some of the adventure of DX out of the equation.

If I examine the needs of emergency communications groups (like RACES and ARES) to provide ATV video pictures back to an EOC….it was extremely difficult to get a little analog ATV (point-to-point) through the hills of Orange County. The testing of COAR RACES proved that D-ATV could overcome path loss difficulties and multipath reflections to deliver crystal clear picture video to the EOC.

Finally, I personally find D-ATV technology quite complex. Since transmitters for D-ATV are expensive or you can design your own…I find the complexity of designing my own D-ATV much much more complex than designing my own SSB transmitter or FM transmitter. I have also had a number of analog ATVers tell me that the technical complexities of DATV seem overwhelming…they will “stick with analog-ATV”. In addition, commercial standards continue to evolve. For example: The DVB-S spec is being commercially replaced by the newer DVB-S2 standard to accommodate the higher data bandwidth needed by High Definition DTV (HDTV). While DVB-S2 provides for faster data rates and provides better noise robustness (and even more complex - using new FEC scheme like Bose-Chaudhuri-Hocquengham), it also poses a possible threat to obsolete D-ATV equipment built with DVB-S designs?

In conclusion, it appears that the mainline analog ATV-ers in US are still passing up the “the Digital Fork in the Road” for D-ATV and continuing to use analog ATV. But, I am hopeful that I will see a big increase in D-ATV usage over the next five years. Only the cheap availability of cheap set-top boxes in US and more inexpensive D-ATV transmitters/components are probably able to improve the current situation. There is a ham radio project going on called the DATV-Express that plans to lower the cost a DATV exciter board using SDR approach. If this open-source project can successfully get their design manufactured…this can help DATV move forward and become wider-spread among hams.

I continue to be very much interested in D-ATV technology. If readers have other knowledge of D-ATV information and activities, and have other insights on the viability of D-ATV…I would be delighted to hear from you.

The author may be contacted at: *W6HHC@ARRL.net*

D-ATV References and Links:

- *Digital Video Broadcasting organisation (DVB) – see www.DVB.org*
- *Advanced Television Systems Committee (ATSC) – see www.ATSC.org*
- *WHAT EXACTLY IS 8-VSB ANYWAY? – see http://www.broadcast.net/~sbe1/8vsb/8vsb.htm*
- *Digital Amateur TeleVision (D-ATV), by HB9JNX/AE4WA, et al – see www.baycom.org/~tom/ham/dcc2001/datv.pdf*
- *DigiLite Project for DATV (derivative of the “Poor Man’s DATV”) - see www.G8AJN.tv/dlindex.html*
- *Charles-G4GUO blog on DATV-Express project development – see www.g4guo.blogspot.com/*
- *Amateur Television of Central Ohio - see www.ATCO.TV*
- *British ATV Club - Digital Forum - see www.BATC.org.UK/forum/*
- *OCARC library of newsletter DATV articles - see www.W6ZE.org/DATV/*
- *TAPR Digital Communications Conference proceedings (free downloads)- see www.TAPR.org/pub_dcc.html*
- *Yahoo Group for Digital ATV - see http://groups.yahoo.com/group/DigitalATV/*
- *CQ-TV magazine from BATC (mostly analog) – see www.BATC.org.uk/cq-tv/*
- *CQ-DATV online (free bi-monthly) e-magazine (ePub format) –see www.CQ-DATV.mobi*
- *SR-Systems D-ATV components (Boards) – see www.SR-systems.de*

Planning a Digital-ATV Station

by Ken Konechy W6HHC and Robbie Robinson KB6CJZ

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the second article in a series of DATVtalk articles to introduce Digital-ATV to hams for this new area of ham radio. The article was originally written in 2009. Since, 2009, there have been changes and improvements in technology…but there is still a basic problem (most severe in US) that too few hams are using digital-ATV. This article has been now updated to reflect the most significant changes since 2009.]

In the May 2009 OCARC newsletter, the TechTalk presented an introduction to D-ATV called: "ATV – the Digital Fork in the Road". In this article, DATVtalk03 will cover planning to create our own D-ATV station. But to a certain extent (especially in the US), Digital-ATV seems like a maze. There are plenty of decisions that need to be made to plan for a D-ATV station:

- *Some decisions could be very expensive*
- *Some decisions may lead to an obsolete design*
- *Some decisions could have major technical issues*

I am pleased to be joined by fellow OCARC club member Robbie-KB6CJZ for the creation of this month's TechTalk article. Robbie is the club guru on analog ATV and commercial satellite receivers and ham microwave communications in general.

What Band Should I plan for D-ATV?

Robbie explained that the view of ham radio bands for ATV and D-ATV in Southern California looks like this:

- *440 MHz – very crowded - looks like a difficult band for D-ATV, but RF amps are cheaper*
- *920 MHz – presents a tight fit for D-ATV, plus lots of noise from "part 15" devices (Industrial, Medical, and Scientific).*

- *1,200 MHz – more room for simplex D-ATV, probably no room for a D-ATV repeater pair-of-frequencies. RF amplifiers get more expensive.*
- *2,400 MHz – RF amplifiers get even more expensive. Very noisy because band is shared with IEEE802.11 Wi-Fi. But, probably has room for a D-ATV repeater.*
- *3,400 MHz - RF amplifiers continue to get even more expensive. Has room for a D-ATV repeater.*

The decision we made is to plan for ham home/portable transmitters on the 1.2 GHz band as a good compromise. Later, if we can put up a D-ATV repeater…the repeater will output on 3.4 GHz

ATSC or DVB-S Modulation Protocol??

TechTalk #74 explained that a predominance of Europe/Asia/Pacific was using the DVB-S commercial standard for ham radio D-ATV, using QPSK modulation for video and MPEG-2 for audio. But, in the US (and Canada), the terrestrial commercial HDTV standard is called ATSC and uses a modulation scheme called 8-level-VSB for video and AC3 (Dolby) for audio. Because of band-plan limitations in US, we have selected 1.2 GHz band for doing the planning for D-ATV. What D-ATV modulation standard should we choose for our station?

Possible DVB-S and ATSC Transmitters

- First let's look at DVB-S

So far in the previous article, we have seen that while there are several ham designs in Europe for DVB-S D-ATV boards, especially AGAF and SR-Systems (both in Germany), D-ATV boards, especially AGAF and SR-Systems (both in Germany), and the DigiLite kit via BATC, and the DATV-Express Project, and the newly announced BATC DTX-1 exciter. Soldering a DigiLite kit together does not appeal to us…and the DATV-Express design is not for sale, yet…and the DTX-1 is too new to become our selection. The lion's share of Ham radio transmitter units appear to be made by Stefan-DG8FAC of SR-Systems (see the link/URL at the end). The block diagram in Fig 1 uses a SR-Systems MiniMod-DVB-S board and a MPEG-2 board as the heart of a D-ATV transmitter.

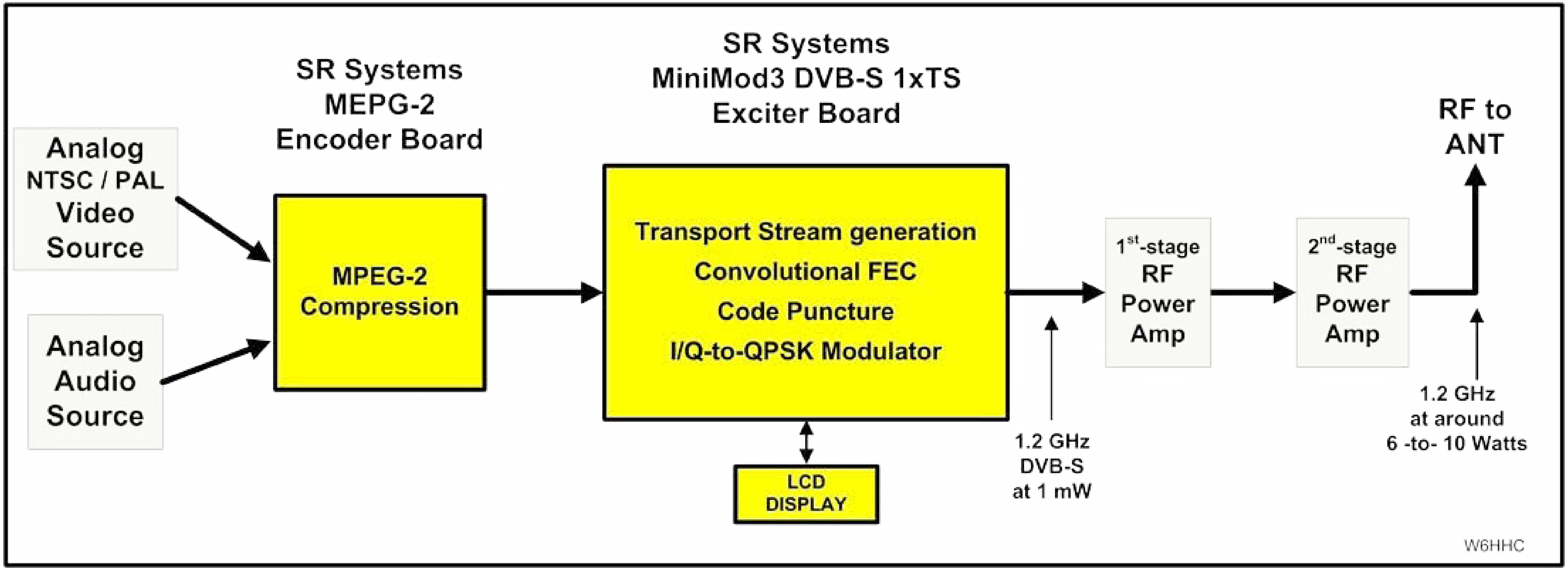


Figure 1 - Block Diagram of SR-Systems DVB-S Transmitter for D-ATV

FIG 2 shows a block diagram for DigiLite transmitter, FIG 3 shows a block diagram for DATV-Express transmitter, and FIG 4 shows a block diagram for the new BATC DTX1 transmitter.

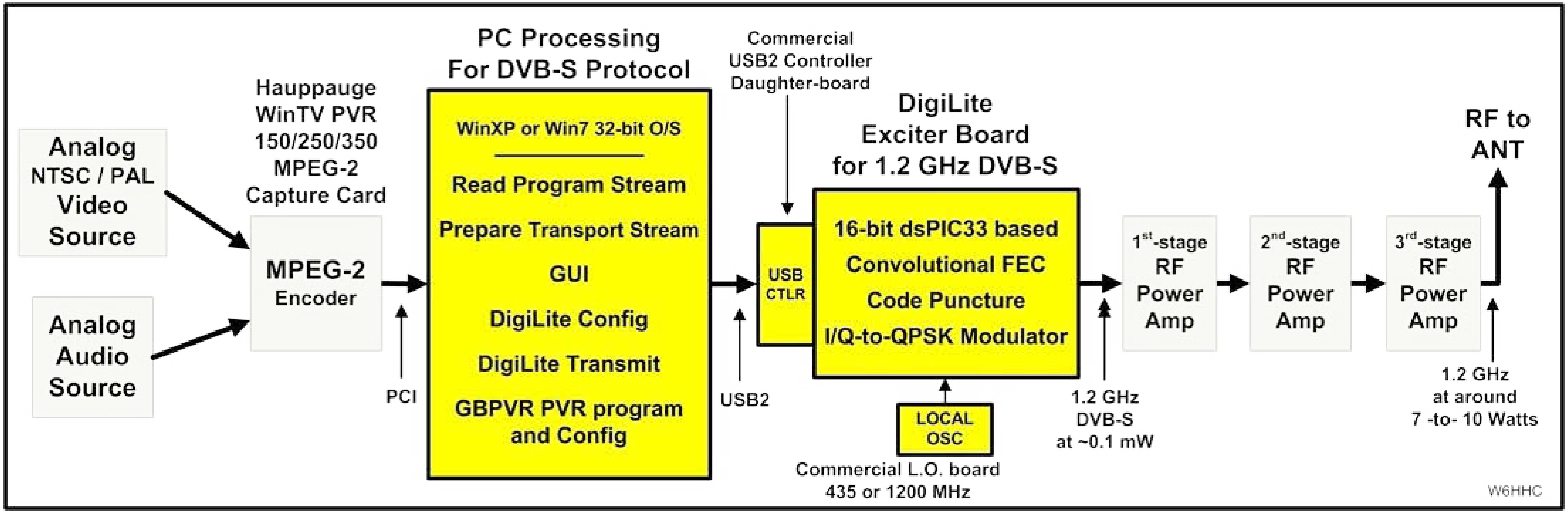


Figure 2 - Block Diagram of DigiLite DVB-S Transmitter for D-ATV

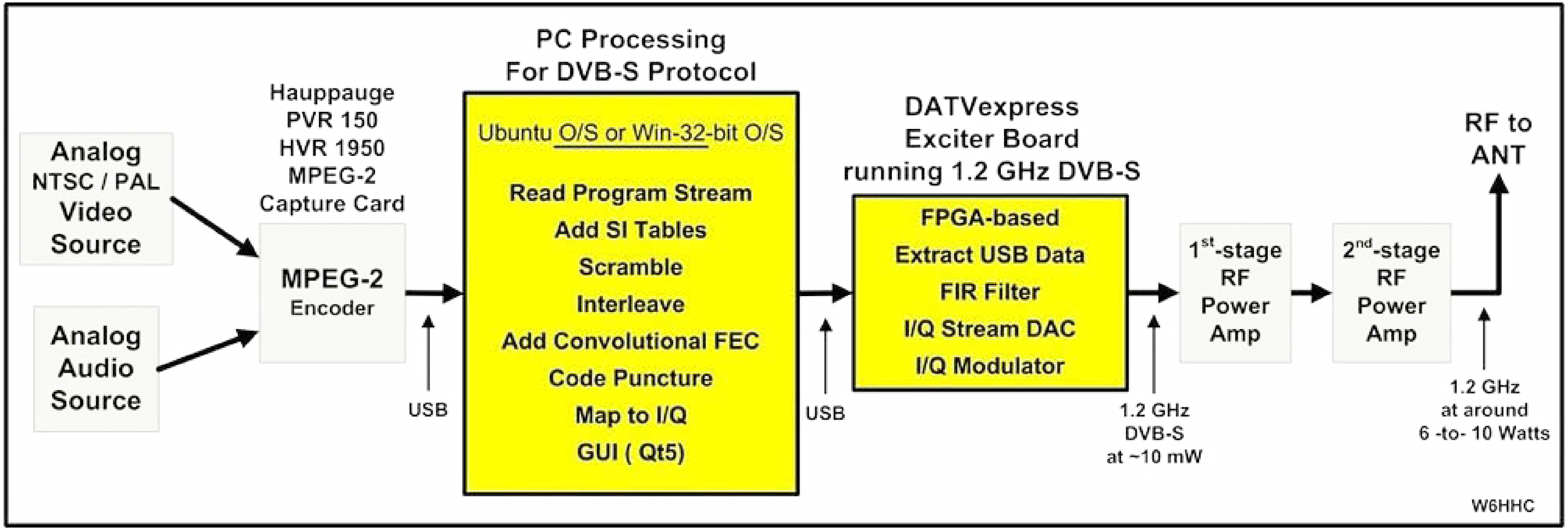


Figure 3 - Block Diagram of DATV-Express DVB-S Transmitter for D-ATV

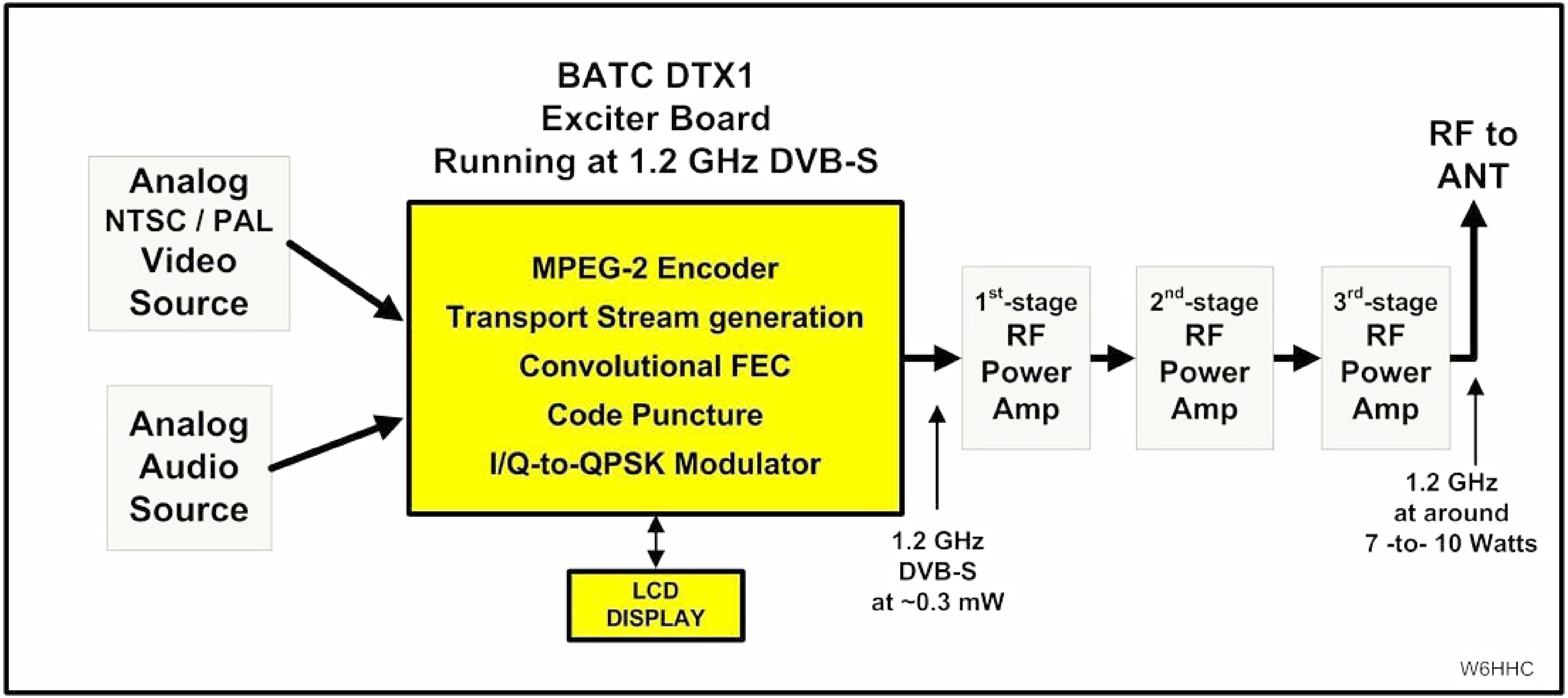


Figure 4 - Block Diagram of DTX1 DVB-S Transmitter for D-ATV

The SR-Systems MiniMod board is shown in Fig 1 and will produce about 1 mWatt RF output. I will need a small RF amplifier to get that power up to about 25 mWatts to drive the 10 Watt RF. All Digital RF modulations require very linear Class A power amplifiers. We plan to run a 30W 1.2 GHz linear amp at about 10 watts or so. Note that the SR-Systems datasheets caution that the RF output of the MiniMod board is UNFILTERED. Stefan-DG8FAC of SR-Sys explained this note means that we need to suppress the second harmonic and the third-harmonic a little (using a band-pass filter). Following the RF output of the MiniMod with two 1.2 GHz amps provides the required harmonic suppression. Amplifiers for DVB-S need to be be-rated from their FM power rating, but less de-rating than required for ATSC. The DVB-S 1xTS D-ATV signal can be configured for variable wide bandwidth if from about 2 MHz to 6 MHz wide. Finally, DVB-S protocol using QPSK modulation is not-well suited for HD (High Definition) transmissions, it creates a much larger RF bandwidth than other modulation technologies. But HD DATV is not one of our goals. Table 1 below looks at an estimate of costs for a DVB-S transmitting station based on the SR-Systems HamSet-3 pricing (NOTE: no VAT is required for USA sales and "low" and "high" columns estimate Euro-to-US$ fluctuations.).

Table 1 – Cost Estimate of DVB-S Transmitter

Item	Description	Manufacturer	Model	Cost Estimate Low end	Cost Estimate High end
1	MPEG Encoder Board (HamSet-3)	SR-Systems	MPEG-2 Encoder V5	~US$229	US$286
2	1.2 GHz FEC & IQ Modulator for DVB-S	SR-Systems	DVB-S 1xTS MiniMOD3	~US$372	US$464
3	Shipping and Handling	SR-Systems	100 Euro	$120	$150
4	First RF amp	??	(about 50 mW to about 1 Watt)	$25	$200
5	RF Power Amplifier 30W (very linear)	Down East Microwave	Part Number 2330PA	$240	$240
	TOTAL			**$986**	**$1,340**

- Next let's look at ATSC Protocol

While there are several ham designs in Europe for DVB-S D-ATV boards…there is only one ham design that we can find for an ATSC D-ATV transmitter. Again Stefan-DG8FAC of SR-Systems in Germany produces a board for the US 8VSB terrestrial video standard. Block diagram in Fig 2 uses the SR-Systems MiniMod-ATSC board and MPEG-2 board as the heart of a D-ATV transmitter. There is one “quirk” with MiniMod-ATSC design. The US ATSC standard calls for transmitting audio in AC3 format (Dolby), but the Dolby licensing fees for AC3 are very expensive. SR-Systems elected to pair up the 8-VSB video with MPEG-2 audio to avoid the AC3 licensing fees. This 8-VSB/MPEG-2 combo works in many receivers in US as we will see later in this article, but is not compatible with the plentiful and really cheap ATSC Terrestrial SetTopBoxes.

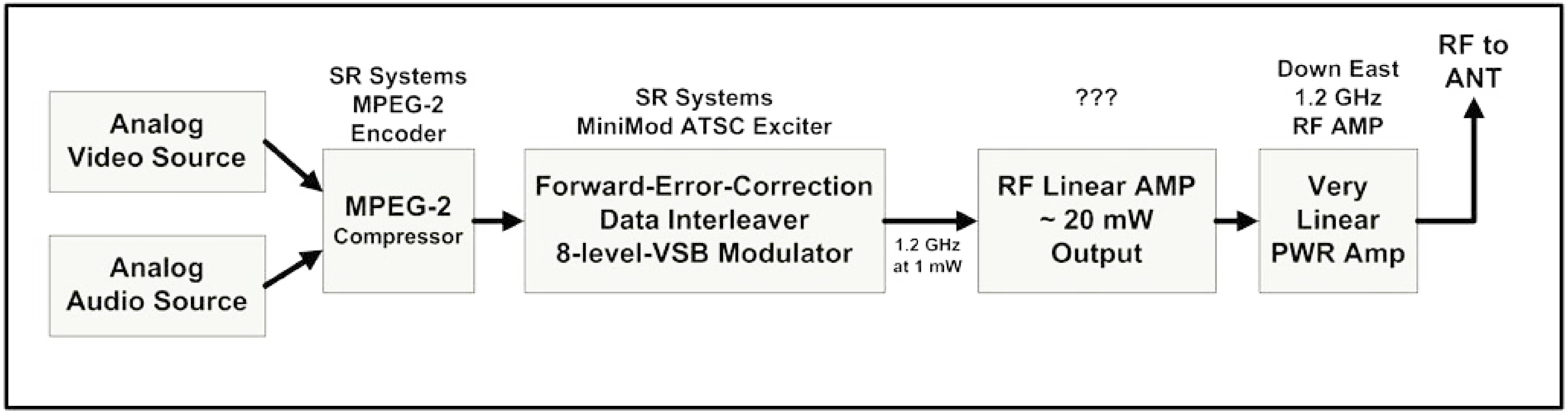


Figure 5 - Block Diagram of ATSC Transmitter for D-ATV

The ATSC transmitter block diagram looks almost the same as the DVB-S. The MiniMod ATSC board will also produce about 1 mWatt RF output. I will need a small RF amplifier to get that power up to about 25 mWatts to drive the final 10 Watt RF amplifier. All Digital RF modulations require very linear Class A power amplifiers. We plan to run a 30W (FM-rated) 1.2 GHz amp at about 10 watts or so. Note again that the SR-Systems datasheets caution that the RF output of the MiniMod board is UNFILTERED requires that we need to suppress the second harmonic and the third-harmonic a little. Following the MiniMod output with two 1.2 GHz amps provides the required harmonic suppression. RF amplifiers for ATSC protocol need to be be-rated from their FM power rating even more than required for DVB-S. The 8VSB signal will have an RF bandwidth of about 5.5 MHz wide. Table 2 looks at an estimate of costs for an ATSC transmitting station.

Table 2 – Cost Estimate of ATSC Transmitter

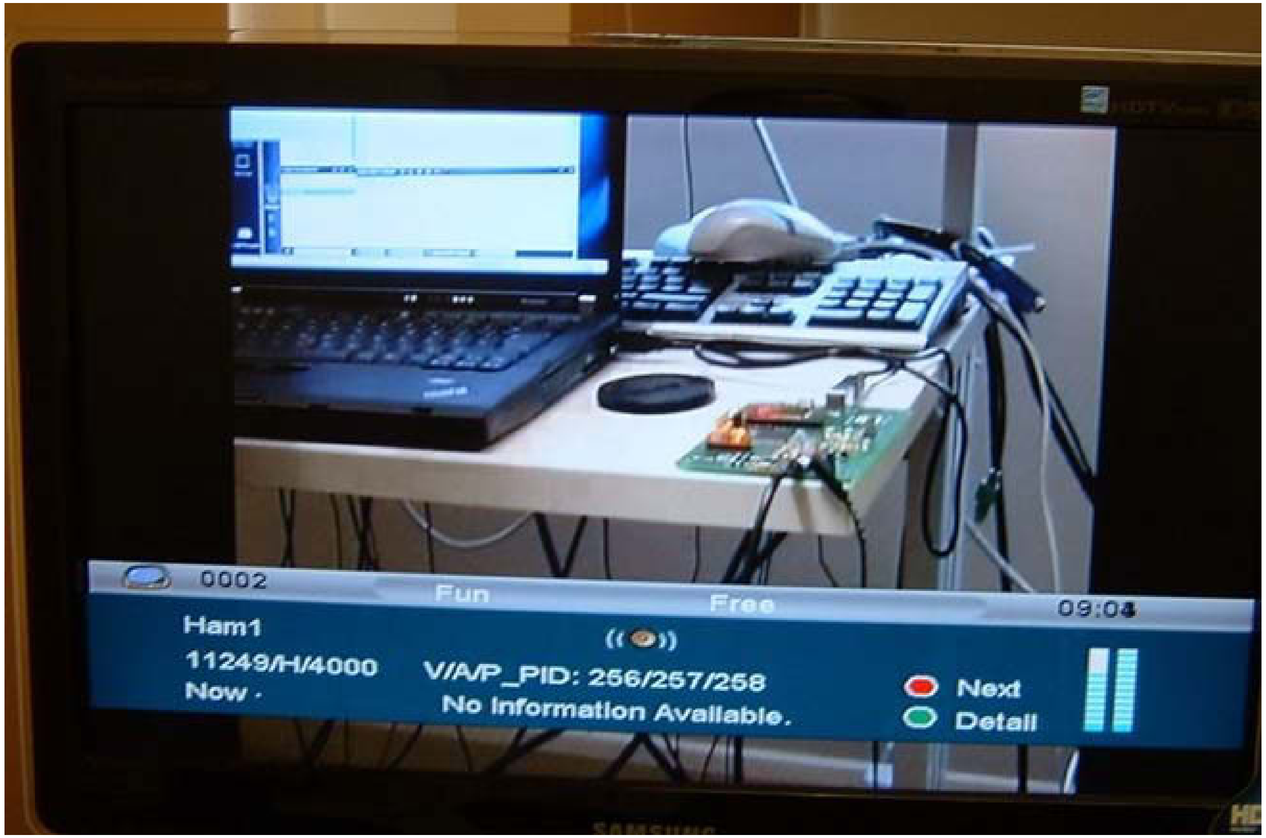


Fig 07 – The first DVB-S video ever transmitted by the DATV-Express board

The main focus of the project currently is getting to release the PC software using 32-bit Linux (Ubuntu Ver12.04.02 distribution). Currently the PC software does most of the protocol processing. An important function of the PC is to keep symbol rate constant, no overruns or under runs by adding Null transport packets as needed. The PC software also can download the firmware for the 8051 microcontroller. There is an on-board boot-ROM chip for storing firmware, but the project has not utilized it, yet. Finally, the PC downloads the code that goes into the FPGA.

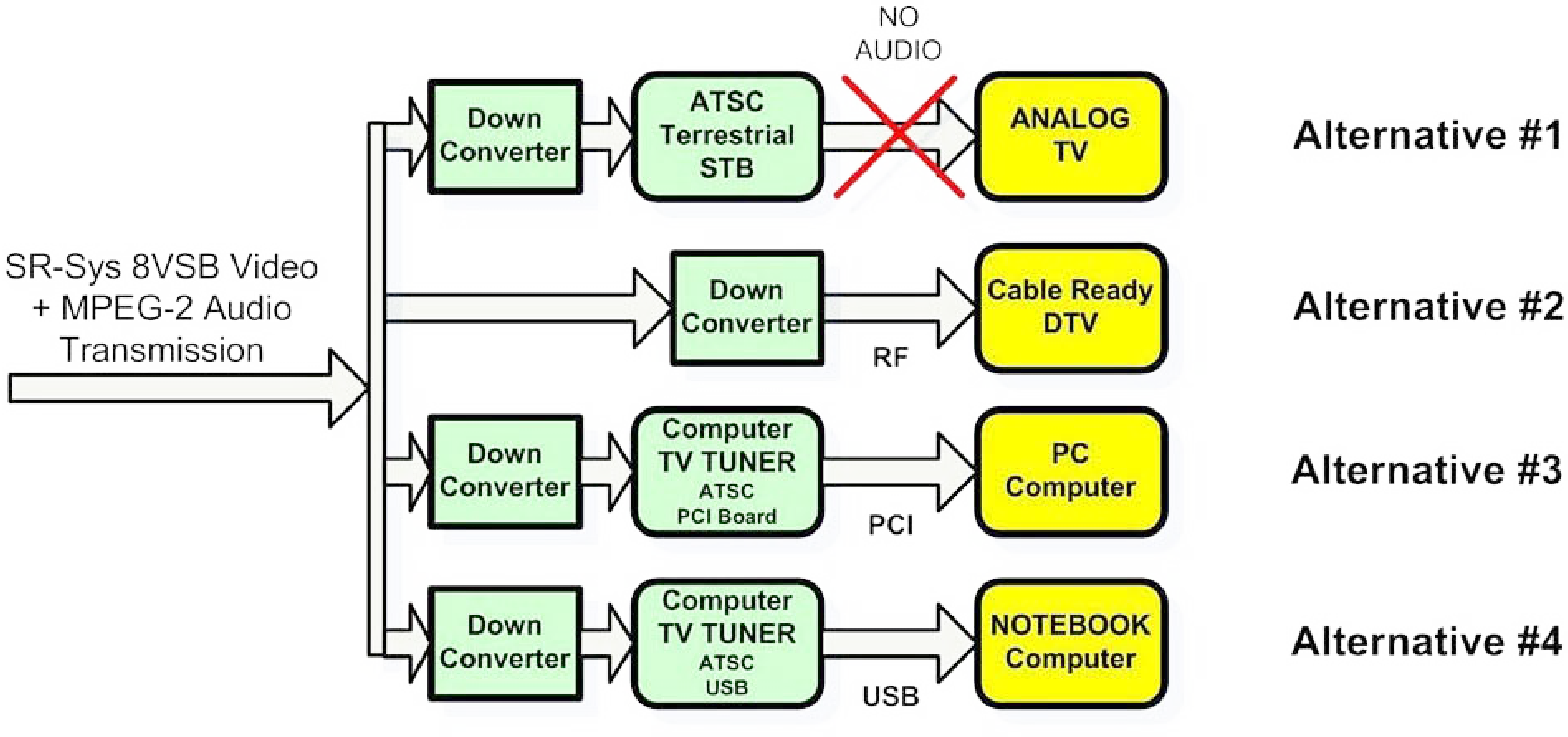


Figure 6 – Possible DATV ATSC Receiver Choices

Now we will walk through each of the receiving station alternatives that are shown in Fig 6…starting with receiving ATSC ham signals.

Alternative 1 – Using a Terrestrial ATSC STB

The first approach for receiving ATSC is to use the cheap ($50 new) ATSC terrestrial SetTopBoxes that have been made common by the US government preparations for eliminating commercial analog TV broadcasts. The MPEG-2 audio compression from the Fig 5 transmitter appears to create a real problem for this approach. The STB is expecting the AC3 format (not MPEG-2) for audio. We have found no US hams who have succeeded in receiving the intended ATSC D-ATV transmission from SR-Systems MiniMod on these ATSC terrestrial SetTopBoxes.

Alternative 2 – Using Cable-Ready DTV

In the second approach, some models of “cable-ready” digital TVs can receive QAM (for cable) as well as ATSC (for terrestrial) and will correctly handle the MPEG-2 audio OK. Nick-N6QQQ in Santa Clara has reported he tested this approach with the MiniMod ATSC board and it does work well. This approach needs a front-end down-converter to take the received 1.2 GHz signal and bring it down to perhaps the 480-to-700 MHz range of US ATSC DTV tuners. Perhaps some cable-ready DTVs may not work?

Alternative 3 – Using Computer PCI ATSC Tuner

In the next approach, we use a PCI board designed to add an ATSC TV tuner to a PC. Nick-N6QQQ has reported MiniMod success with using computer peripheral tuners, simply because all they do is take the 8VSB and put out the MPEG-2 transport stream. The computer winds up doing the rest of the work by decoding the MPEG-2 video and the MPEG-2 audio. The Hauppauge WinTV-HVR-1600 PCI TV Tuner Card – 1101 covers analog (NTSC) and DTV (ATSC) for under $100. Another interesting approach for a computer is the Silicon Dust HD HomeRun box that networks to the computer. Again, we need a down-converter to take the incoming 1.2 GHz signal and bring it down to the range of US ATSC DTV tuners.

Alternative 4 – USB ATSC Tuner for Notebook

In this approach, we use an ATSC tuner with a USB output that can deliver to a Notebook computer (no room for PCI card). The notebook will again accept the MPEG-2 transport stream output and provide for the presenting the video and audio. The Hauppauge WinTV-HVR-950Q TV Tuner Stick can be purchased on the internet for around $70 new. Again, we need a down-converter to take the incoming 1.2 GHz signal and bring it down to the range of US ATSC DTV tuners.

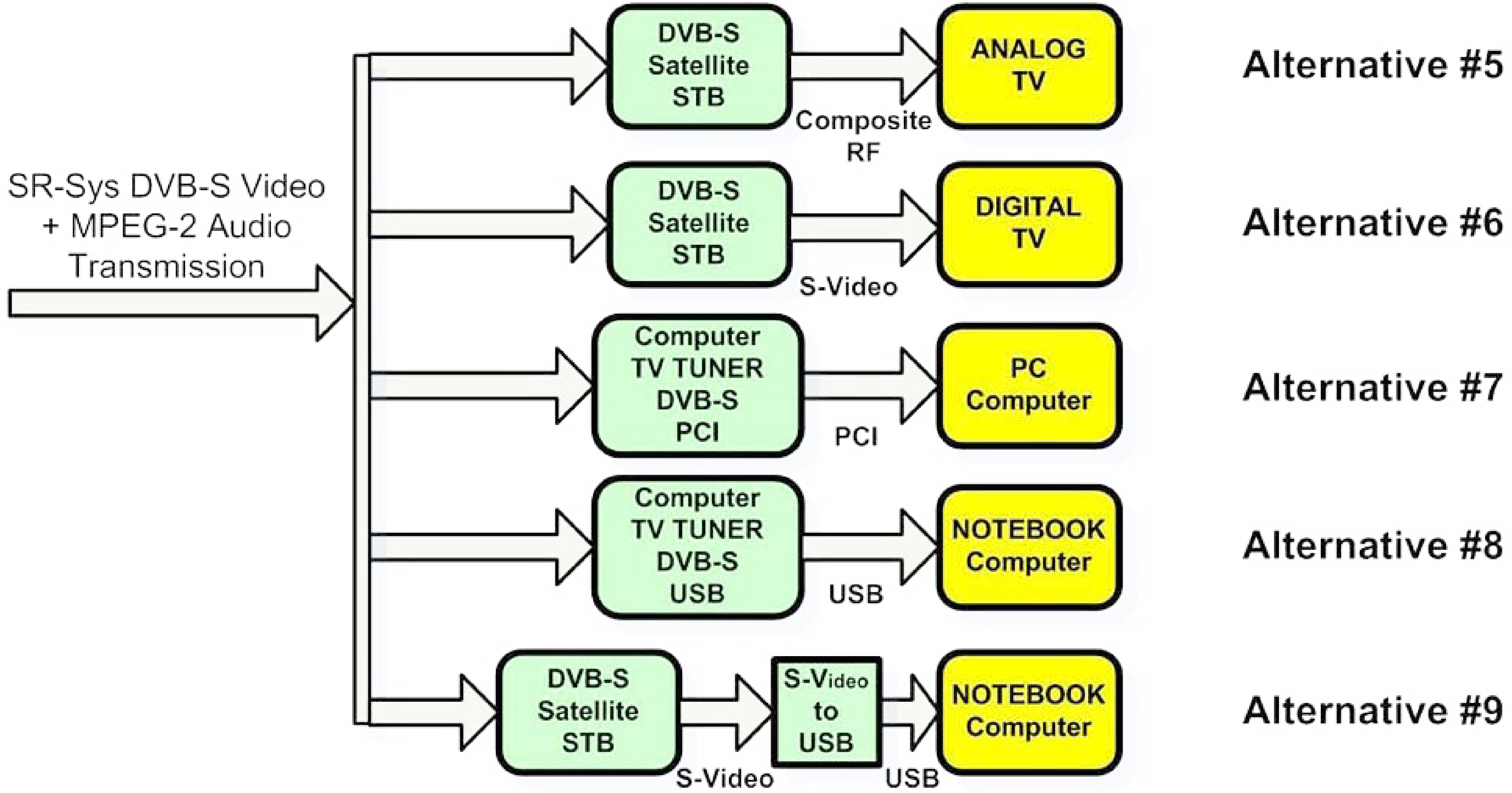


Figure 7 – Possible DATV DVB-S Receiver Choices

Now we will walk through each of the receiving station alternatives that are shown in Fig 7…for receiving DVB-S ham DATV signals.

Alternative 5 – Using a Satellite DVB-S STB

Our first approach to receiving DVB-S transmissions uses a DVB-S satellite box (commonly called Free-To-Air or FTA). A “composite RF” output from the STB can go straight into an old analog TV set. The frequency range of the DVB-S STB tuner range for satellites will include the 1.2 GHz ham band, so no down-converter is needed. The Viewsat VS2000 Xtreme is an example of a DVB-S FTA STB that can be purchased new for about $100 or bought used on eBay for about $50.

Alternative 6 – Using DVB-S STB with DTV

This approach is the same as #5 above, except it takes the S-Video output of the Free-to-Air DVB-S SetTopBox to provide the input to a HDV set.

Alternative 7 – Computer PCI DVB-S Tuner

In this approach, a PCI DVB-S tuner board is installed in the PC computer. The Hauppauge WinTV Nova-s PLUS DVB-S PCI Card costs less than $100.

Alternative 8 – USB DVB-S Tuner for Notebook

This approach uses a DVB-S USB tuner box (for example: the SkyStar USB2 model costs about $100) to output directly to the USB port on the notebook computer.

Alternative 9 – Using DVB-S STB with Notebook

This approach is very similar to #6 above except we add an S-Video to USB converter to take the STB output to the USB input on the notebook computer. A typical S-Video-to-USB converter is the Startech.com USB 2.0 and costs about $50 through Radio Shack (in addition to the STB cost).

Selecting Our D-ATV Station

Robbie and I had both hoped for an ATSC approach for D-ATV because of the easy availability of low-cost terrestrial STBs in the US. But, neither of us wanted to deal on a trial-and-error basis to see if equipment we purchased for receivers would really work with the current “MPEG-2 audio quirk” of ATSC D-ATV transmissions. So our decision is to plan for a DVB-S D-ATV station here in Southern California. Also, by comparing the cost estimates in Table 1 and Table 2, you can see we will save almost $500 by choosing a DVB-S transmitting station instead of an ATSC station. As a note…if it was possible, both of us would had gladly paid an extra US$50 or 50EUR for an AC3 Dolby license charge to avoid the "MPEG-2 audio quirk" situation that would allow us to go to the ATSC route with full compliance.

Now that we have chosen our D-ATV transmitting station, any of the D-ATV receiving station approaches ALTERNATIVE #5 through ALTERNATIVE #9 in Fig 7 will work well for DVB-S. The costs of each of these five receiving approaches are reasonable. So the reader can choose the approach that appeals to him. I will probably choose ALTERNATIVE #8 because I want to use my notebook computer (instead of a TV set) for my home D-ATV station. Robbie-KB6CZJ prefers to go with ALTERNATIVE #5, because he prefers the wide-availability and feature-rich-capability of a DVB-S FTA SetTopBox.

There are still a few details to sort out for our station, but hopefully you can see that this top-down approach to planning a D-ATV station provides a "big picture" of alternatives…allows us to understand the trade-offs….and allows a direction to be chosen.

Contact Info

The authors may be contacted at *KB6CJZ@ARRL.net* and *W6HHC@ARRL.net*

More D-ATV Links

- *AGAF D-ATV components (Boards) – see www.datv-agaf.de and www.AGAF.de*
- *BATC Store – purchase PCBs and parts for DigiLite – see www.BATC.org.uk/shop/*
- *BATC info site for DTX1 exciter – see www.DTX1.info*
- *SR-Systems D-ATV components (Boards and transmitters) – see www.SR-systems.de*
- *British ATV Club – DigiLite Project Forum – see www.BATC.org.UK/forum/*
- *TAPR 2012 DCC Proceedings – "DATV-Express Recent Project Progress" – see www.TAPR.org/pub_dcc.html*
- *Typical Internet store for FTA DVB-S Receivers – see www.GoSatellite.com*

- *DigiLite Project for DATV (derivative of the "Poor Man's DATV") - see www.G8AJN.tv/dlindex.html*
- *"WHAT EXACTLY IS 8-VSB ANYWAY?" – see www.broadcast.net/~sbe1/8vsb/8vsb.htm*
- *Nick-N6QQQ blog on putting together an ATSC D-ATV station – see http://nsayer.blogspot.com/search/label/ham*
- *Series article "ATV – the Digital Fork in the Road" – see CQ-DATV Issue 5 CQ-DATV.mobi*
- *Orange County ARC entire series of newsletter DATV articles – see www.W6ZE.org/DATV/*
- *Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/*
- *British ATV Club – Digital/DigiLite/DTX1 forums – see www.BATC.org.UK/forum/*
- *CQ-DATV online (free) magazine – see CQ-DATV.mobi*

DATV talk 04
Bench-Testing a DVB-S Transmitter – Part 1

by Ken Konechy W6HHC and Robbie Robinson KB6CJZ

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the third article in a series of DATVtalk articles to introduce Digital-ATV to hams for this new area of ham radio. The article was originally written in 2009 for the OCARC newsletter. Since, 2009, there have been changes and improvements in technology…but there is still a basic problem (most severe in US) that too few hams are using digital-ATV. This article has been now updated to reflect new knowledge about DATV that we have learned and reflect the most significant changes since 2009.]

In the CQ-DATV5 issue, the DATVtalk02 article presented an introduction to Digital-ATV. In the CQ-DATV6 issue, Robbie-KB6CJZ and I teamed-up in the DATVtalk03 article to present a top-down approach for planning a DATV Station that resulted in selecting the DVB-S protocol standard. In this DATVtalk04 article, Robbie and I team up to test and share the initial test results of the DATV station we had planned.

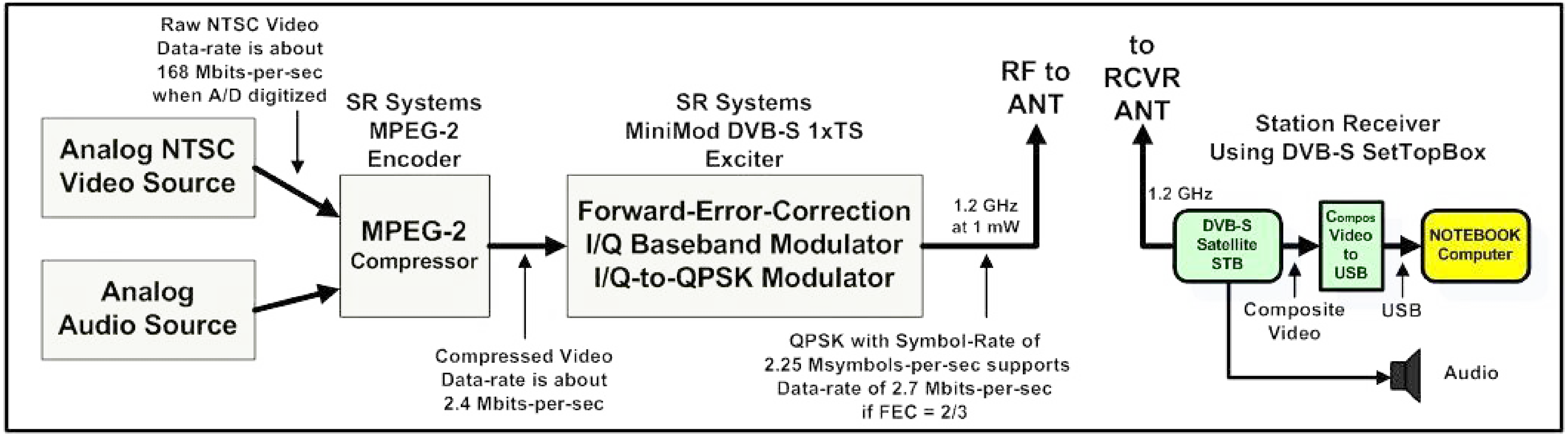


Figure 01 Test Set-up for DVB-S exciter bench tests

Configuring the DATV Transmitter

A block diagram for the set-up for testing the DATV transmitter "exciter" for the DVB-S protocol is shown in Fig 1. The two critical boards for the DVB-S station are the MEP-2 encoder board and the MiniMod DVB-S exciter board for 1200 MHz band. These boards were purchased from SR-Systems located in Germany (…see links at the end). Fig 2 shows a "breadboard" for the two-board DATV exciter station. Note (at this point) that we have not yet added an RF power amplifier to the test set up, so we tested with only 1 mW output on 1.290 GHz. The RF power amplifiers will be discussed in detail in the next in-the-series-article called DATVtalk05.

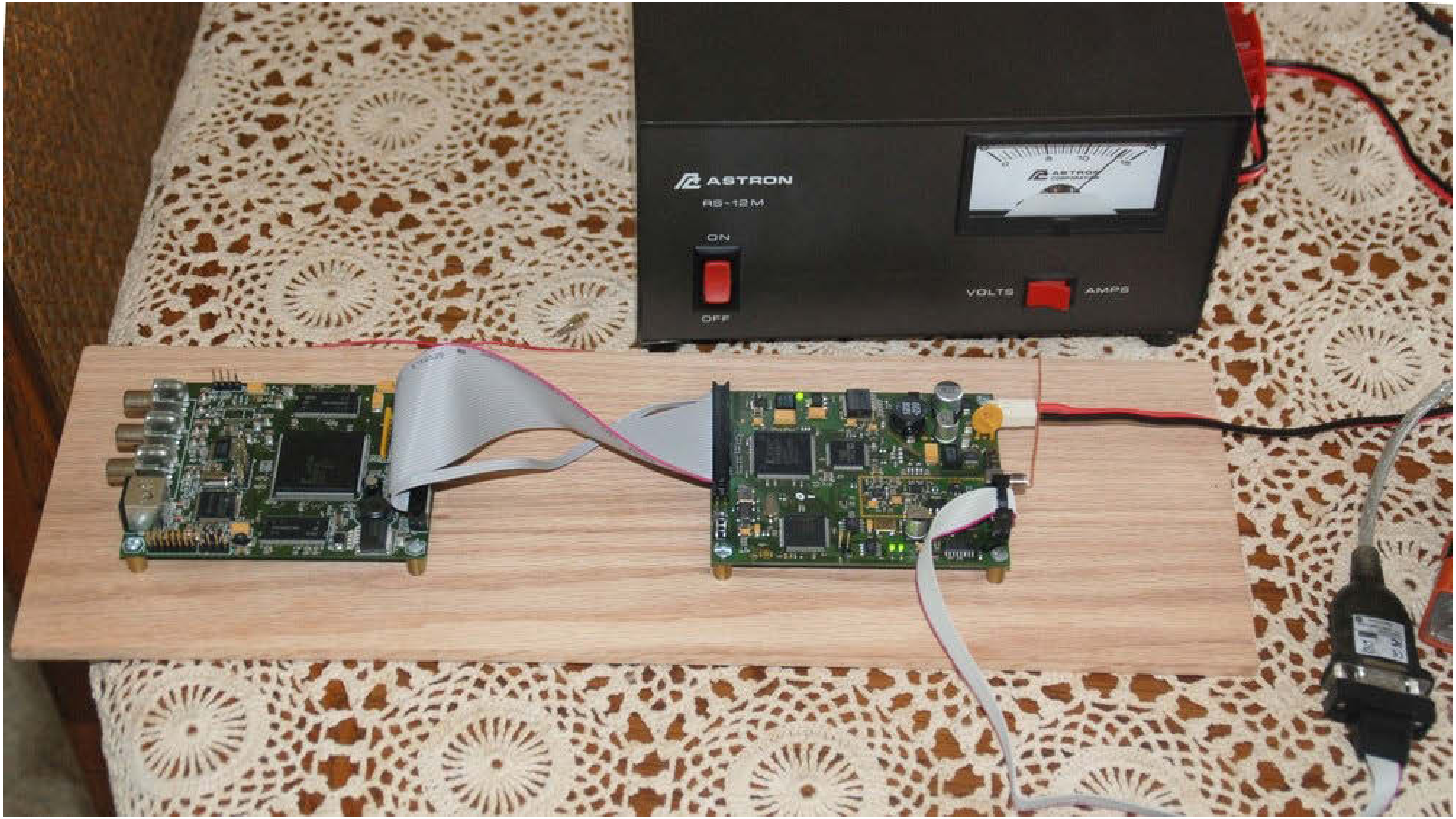


Figure 02 "breadboard" set-up for the two-board DVB-S Exciter

Choosing the transmitter frequency and all other setups and adjustments with the DVB-S exciter board and the MPEG2 encoder board are made through an RS232 interface connected on the DVB-S Exciter board. I used a RS232-to-USB adaptor to plug the RS232 cable into the notebook computer. By running a Windows XP application called "Hyper-Terminal", I can read out the settings on the boards and make changes to the settings on my computer screen. [NOTE: in Windows7 and Windows8, the "Hyper-Terminal" application is no longer supplied by Microsoft. For Windows7, I now use a terminal program called uCon terminal emulator (www.umonFW.com/ucon/) to communicate with the SR-Systems board.] Shown in Fig 3 is a typical display *of the settings menu as seen on the notebook computer.*

```
DVB MiniMod Firmware V54.34 LOWDVBT
(c) 2009 maintech GmbH

OnBoard VCO: ADF4360-0
Real HF output range from 575000 to 1425000 kHz.
FPGA firmware v042.
Encoder firmware upload done (tvp5146,
0x01600425).

MiniMod Mainmenu
1) show status
2) Input Settings
3) Modulation Settings
4) Video Settings
5) Audio Settings
6) PSI Settings
7) PID Settings
> 3

Modulation Settings
1) TX Enable (ON AIR)
2) Output Frequency (1290000 kHz)
3) Spectrum (normal)
4) Carrier Only (no)
5) Output Gain (12)
6) Symbolrate (2500 ksym/s)
7) Coderate (FEC) (3/4)
0) exit menu
>
```

Figure 03 – Computer display of SR-Systems menu

For the test set-up, a very simple ¼ wavelength wire was inserted into the RF SMA connector and used to provide a 1.2 GHz vertical antenna on the XMTR, as shown in Fig 4.

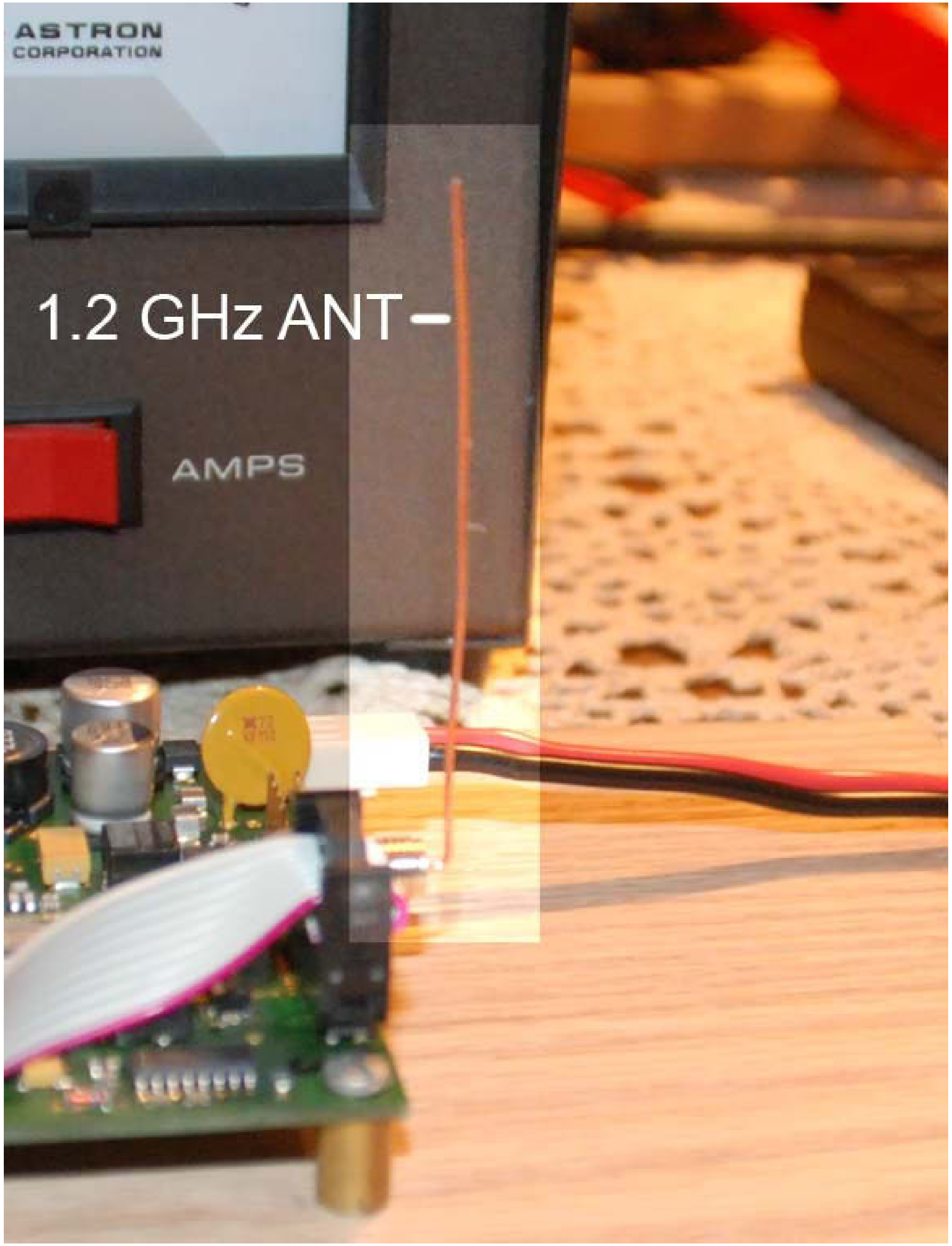


Figure 04 - Simple ¼-wave vertical antenna used for testing the DVB-S exciter

For the first step, we used W6HHC's trusty Kenwood TM-741A FM receiver to confirm that there was a nice strong RF signal centered around 1.290 GHz when the DVB-S exciter was turned on.

Configuring the DATV Receiver

The heart of the DATV receiving station is a ViewSat Model VS2000 Xtreme DVB-S SetTopBox (aka FTA or Free-to-Air) shown in Fig 5 (the STB unit is shown on the right-hand side). Ken and Robbie both bought this model used on e-Bay. The price was right; less than $75, including cost of shipping.

Figure 05 – The DVB-S testing set-up

As the block diagram in Fig 1 shows, the output of the STB sends Composite Video to the USB port on the

Dell notebook computer via Composite-Video-to-USB converter that costs about US$50 on the Internet. I bought a Startech.com USB 2.0 converter (new) via Amazon. Fig 6 shows a photo of the Startech.com USB 2.0 converter. Note that this model does not send the audio to the computer, only composite-video or S-video. The Startech.com product is primarily designed to capture video files to a disk on a computer and to take "snap shots" of video streams. It includes a software program called GrabBee that allows the USB data to be displayed on the computer screen.

Figure 06 – The Startech video-capture unit converts STB video to USB

The computer screens in Fig 7 and Fig 8 are being displayed by the GrabBee application software and device drivers for the video-capture dongle.

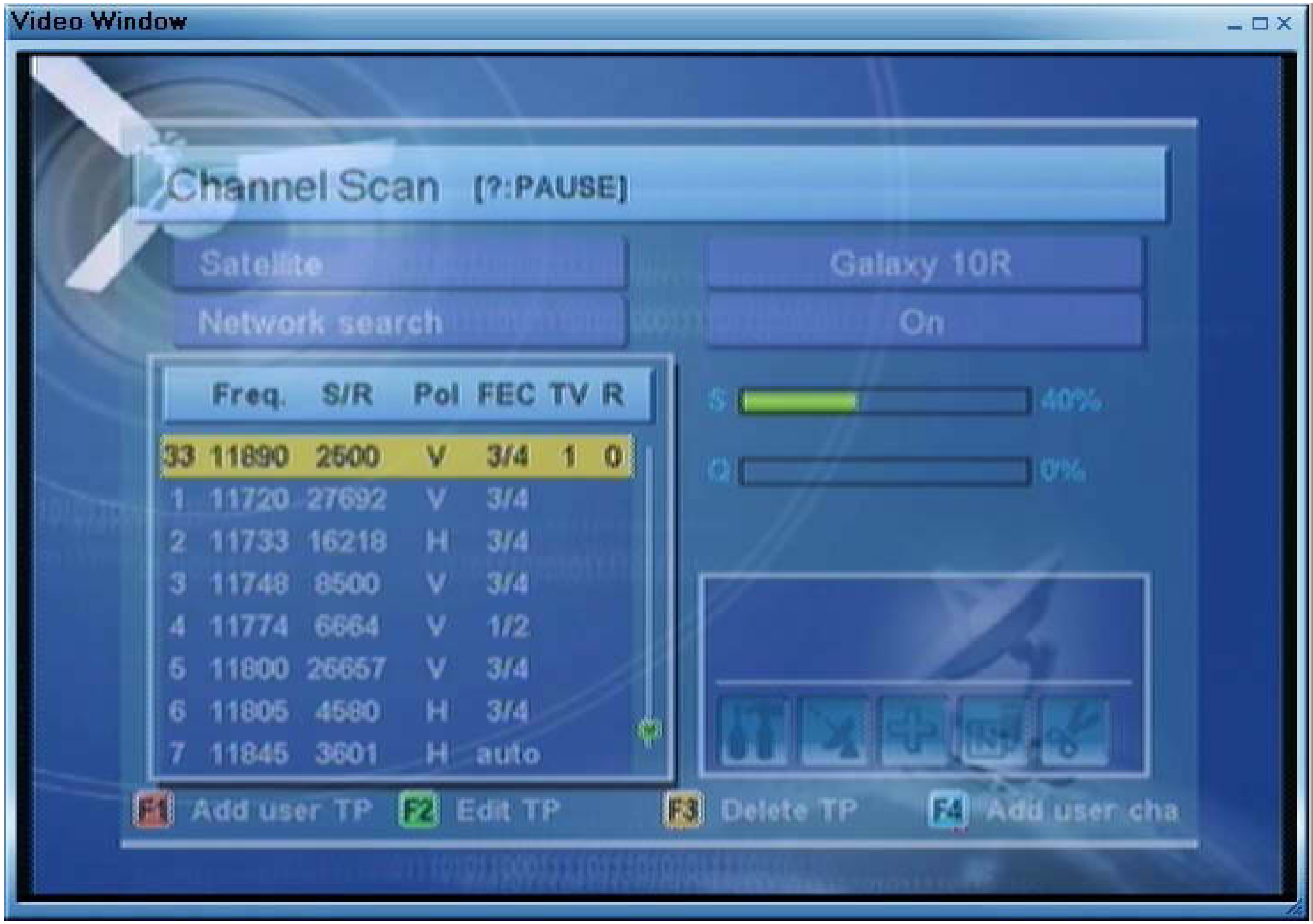


Figure 07 - The STB Configuration menu for editing received frequencies and other settings

The hardest part of our first testing session was to determine how to use the SetTopBox receiver to tune in the frequency we wanted, 1.290 GHz. This was not easy. Robbie determined from inspecting the STB menus that the STB local oscillator was 10,600 MHz. So, on this particular brand of STB:

- *STB Search Freq = XMIT Freq + 10,600 MHz*
- *STB Search Freq = 1290 MHz + 10,600 MHz*
- *STB Search Freq = 11890 MHz*

Because each brand of STB has a different user's interface…we could never determine how to command our

STB to search-and-find our signal on a frequency of 11,890 MHz. So we tried a different approach and added a "new transponder" to the GALAXY 10R Satellite settings already on the STB. Now we could edit the frequency for the new transponder to 11890 MHz. Fig 7 shows the settings for new 'transponder 33" is configured to 11890 with a Symbol-Rate (S/R) of 2500 (Ks/sec).

Robbie explained there are two cautions hams need to take on the antenna connector of satellite STB's:

1) The centre conductor of the STB antenna F-connector has a DC voltage present that is normally intended to power a remote LNB (low noise block) converter box near the satellite dish antenna. Do not short the centre conductor to ground. The fuse is normally soldered down to the PCBA inside the STB (not an easy task to replace). Robbie installed a "DC Block" adaptor to the antenna F-connector to prevent an accidental short circuit.

2) The STB receiver RF amplifier is quite sensitive and designed to receive tiny microWatt signals (typically -20 dBm to -70 dBm). We feared we could blow out the STB amp if the received signal is too strong. For initial testing, Robbie inserted some 50 dB of attenuators on the antenna…knowing we could always remove the attenuators once we knew the signal strength

First DATV Test Pictures Received

Once we determined how to correctly configure a "transponder" setting for our frequency on the STB, the picture magically appeared on the notebook screen….crystal clear!! A photo of our first test pictures is shown in Fig 8. To add a little professional touch to the received pictures, Robbie-KB6CJZ inserted his text generator in series with the video input to the MPEG2 encoder board. You can see the text "W6HHC ORANGE" show up in the upper-left corner of the DATV picture in Fig 8.

Figure 08 - First DATV test pictures (of Ken W6HHC) are displayed on the Dell notebook computer

The first thing that we noticed was that the audio had very little latency (delay) from real time. Probably about 1 second. For the first test trial, we had set the Symbol-Rate on the transmitter menu to 2.5 Msymb/sec and the MPEG2 databit-rate setting to "MANUAL" and 2.5 Mbits/sec, while FEC was set to 3/4. There was noticeable latency in the picture motion and also a noticeable "jerking" to the motion. We were confused to understand what was going on?? Why were we seeing so much video motion jerking??

The answer appeared with a little more testing at higher Symbol-Rates. When the GrabBee software was set for default 720 pixel wide picture, the jerking was gone. When the Grab-Bee was set for a 1024 pixel wide picture (full screen), the jerking was extreme. The settings on the transmitter were NOT incorrect, but the receiving notebook computer and its display lacked the processing speed to convert the NTSC video pixels into a full display screen at 1024 pixels wide at the frame rate. The notebook computer was probably dropping five frames (or more?) to process one frame at 1024!!

Inspecting RF Bandwidth

Robbie used his HP Model 8559A Spectrum Analyser 0.01-to-21 GHz plug-in (installed in a HP 182T display) to determine the quality of the transmitted QPSK RF signals. Ken used his Rigol Model DSA815-TG Spectrum Analyser (0.01-to-1500 MHz) and compared RF signals.

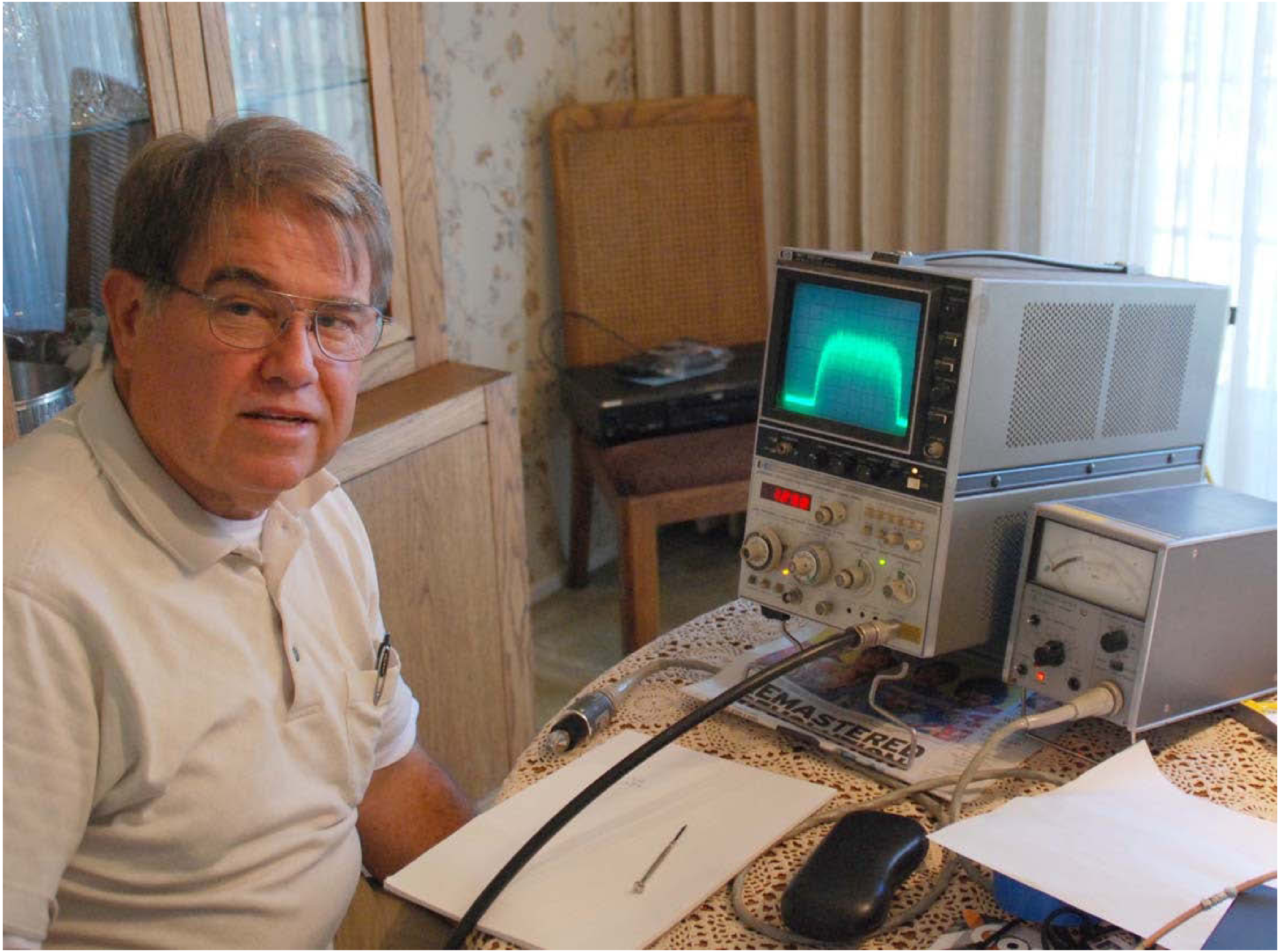


Figure 09 - Robbie-KB6CJZ inspects RF bandwidth with an HP spectrum analyser

Both spectrum analysers were set to 1.290 GHz, @500 KHz per /div (horizontal) and a bandwidth at 30 KHz. RF input was set at 0 dB with a two inch sniffer on the HP and a direct input was used on the Rigol. Robbie checked the signals bandwidth which was reading about 3.5 MHz. The DVB industry literature explains that "allocated" RF bandwidth for a QPSK (DVB-S) signal is predicted as:

- *RF Bandwidthallocated = 1.33 x Symbol-Rate*
- *RF Bandwidthallocated = 1.33 x 2.5 MSymbols/sec*
- *RF Bandwidthallocated = 3.33 MHz signal*

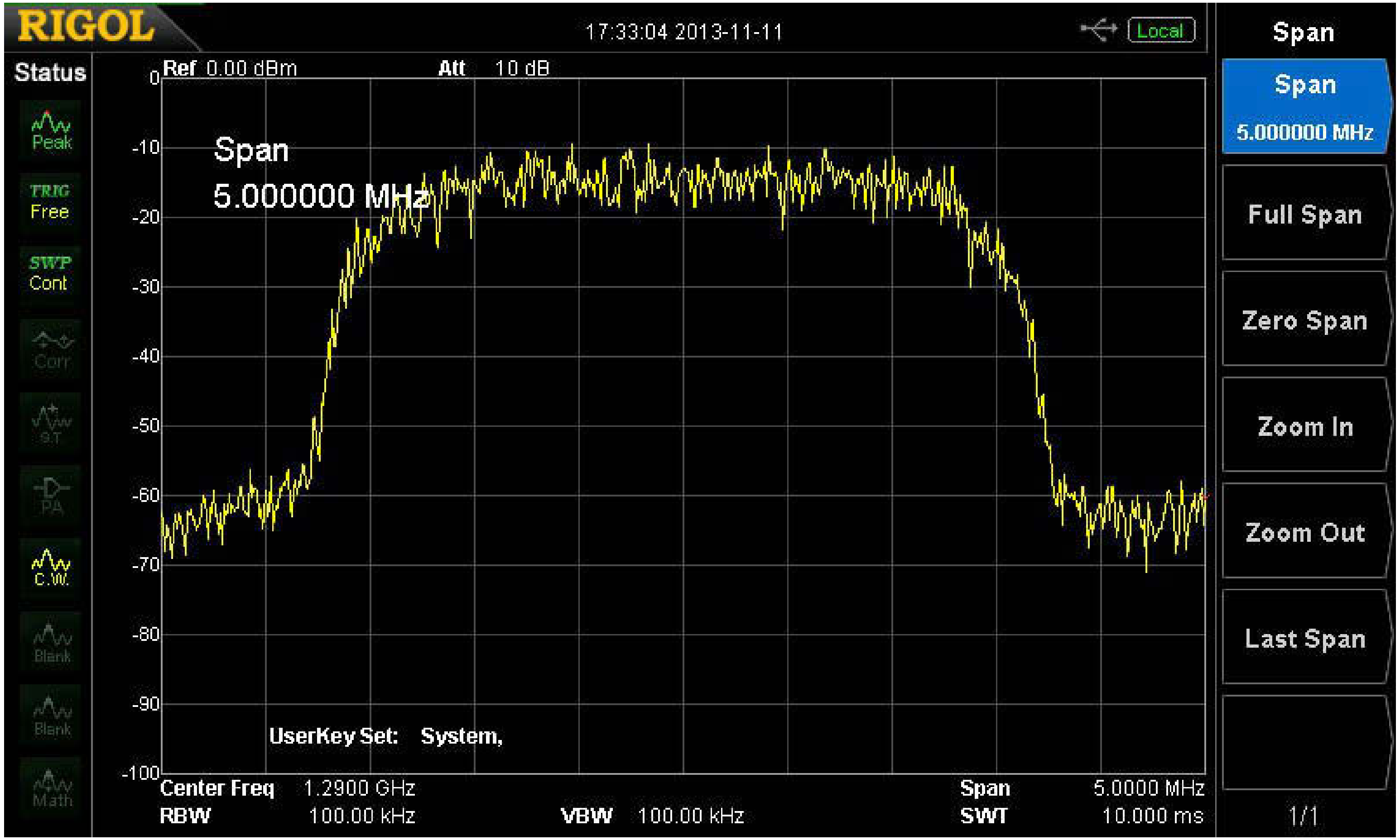


Figure 10 - A close-up of the 1.290 GHz signal RF bandwidth on the Rigol spectrum analyser

display

So our measured bandwidth looked as expected. The signal looked clean and did not drop out (or even change much) when the video was removed. No out-of-band testing or other testing was performed. More test reports will come in later DATVtalk articles.

Findings and Plans

The DATV station works like we had hoped it would work. The picture really is crystal clear. But, we need to still better understand computer display-density processing limitations when displaying DATV video. We will do more testing at various Symbol-rates and data-bit-rates. Then as a next step, we plan to amplify the RF output from 1 mW to around 10 W. Then we will do some cross-town distance testing.

Contact Info

The authors may be contacted at KB6CJZ@ARRL.net and W6HHC@ARRL.net

Useful D-ATV Links

AGAF D-ATV components (Boards) – see www.datv-agaf.de and www.AGAF.de

BATC info site for DTX1 exciter – see www.DTX1.info

British ATV Club – Digital/DigiLite/DTX1 forums – see www.BATC.org.UK/forum/

SR-Systems D-ATV components (Boards) – see www.SR-systems.de

Amateur Television of Central Ohio – see www.ATCO.TV

Orange County ARC entire series of newsletter DATV articles – see www.W6ZE.org/DATV/

Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/

By Ken Konechy W6HHC and Robbie Robinson KB6CJZ

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the fourth article in a series of DATVtalk articles to introduce Digital-ATV to hams for this new area of ham radio. The article was originally written in 2010 for the OCARC newsletter. Since, 2010, there have been changes and improvements in technology and products...but there is still a basic problem (most severe in US) that too few hams are using digital-ATV. This article has been now updated to reflect new knowledge about DATV that we have learned and reflect the most significant changes since 2010.]

In the CQ-DATV5 issue, the DATVtalk02 article presented an introduction to Digital-ATV. In the CQ-DATV7 issue, Robbie-KB6CJZ and I teamed-up in the DATVtalk04 article to present a test report for a DATV transmitter exciter, using the SR-Systems product from Germany. Now in DATVtalk05 article, Robbie and I team up again to continue our bench-testing of a DATV station with RF power amplifiers and share the test results.

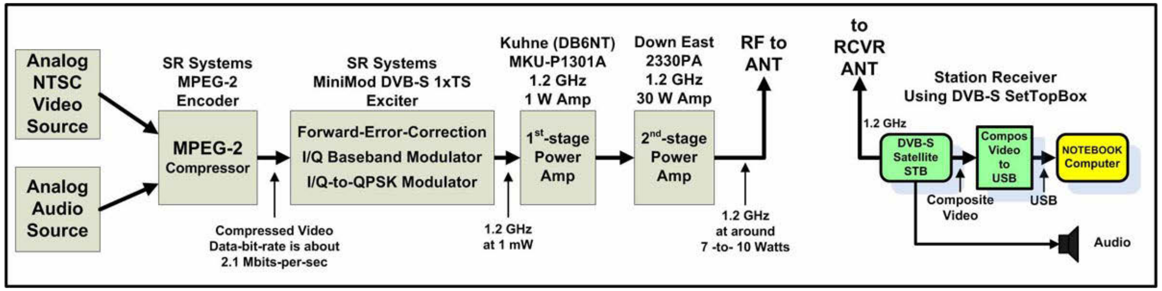


Figure 1 Test Set-up for DVB-S Exciter Bench Tests with RF PA's First-Stage Power Amp

If you look at the block diagram in Fig 1, you will see that the first-stage 1.2 GHz PA chosen was the Kuhne model MKU-P1301A unit. We knew we wanted to use the Down East unit for stage-two...and we knew that Down East specified that their PA needed no more than about 25 mW to drive to full linear output levels. But, the SR-Systems MiniMod-S exciter output was only around 1 mW. So the 1 W (FM rating) Kuhne MKU-P1301A PA turned out to be a good choice. A little expensive, this 1W PA costs more than the Down East 30W unit, but it is a well-engineered PA for our purposes.

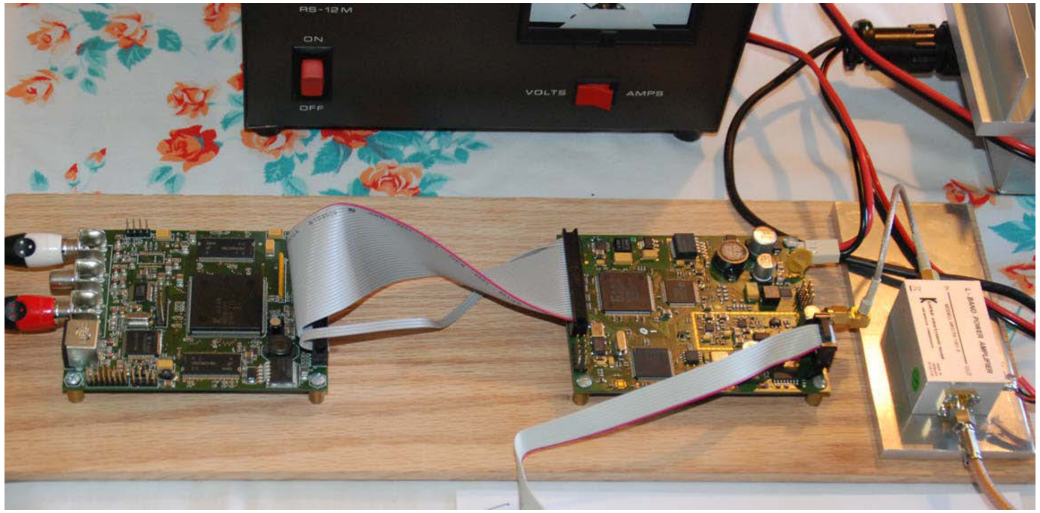


Figure 2 – Breadboard of MPEG-2 Board and MiniMod Exciter Board and Kuhne 1st-Stage PA

Fig 2 shows a photo of the exciter connected to the first-stage Power Amp on our "bread board" set-up. Notice that the Kuhne 1 W PA (on the far-right) is mounted on a thick aluminum plate that serves as a heat-spreader (aka "heatsink"). The Kuhne PA contains two internal voltage regulators to provide correct voltage to the power amp circuitry from the big 12V external power supply. These internal regulators draw a standby power of about 6 W.

When tested with an HP Model 432A microwave power meter, the Kuhne delivered plenty of power for our needs. Table 1 shows that we could get “measured average power” of over 300 mW output when driven hard by the exciter. Fig 3 shows that the output signal of the Kuhne Power Amp was very clean (without spectral regrowth “shoulders”) even when being driven to the maximum by the exciter RF output settings.

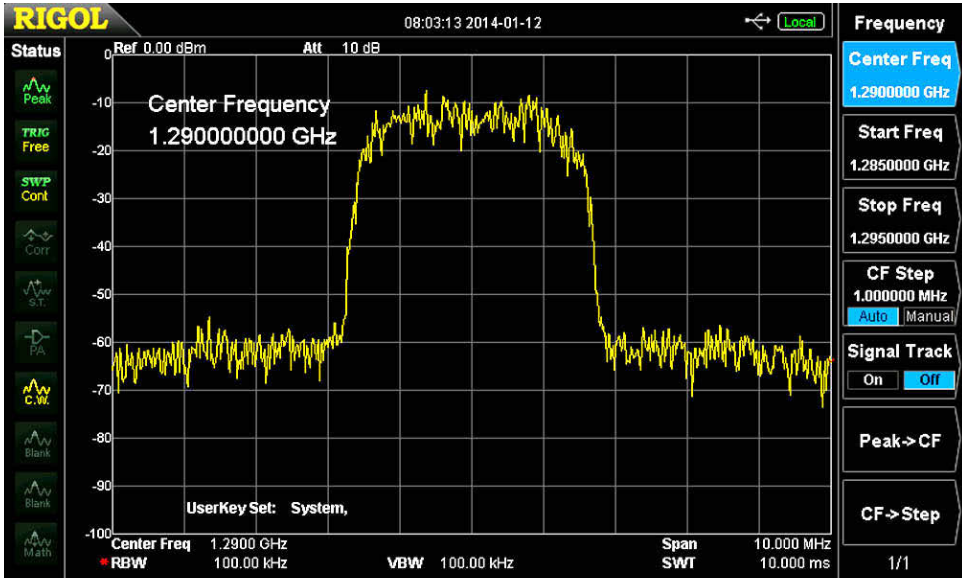


Figure 3 – Rigol Model DSA800-TG Spectrum Analyzer Inspects the Kuhne first-stage PA output

Second-Stage Power Amp

The block diagram in Fig 1 shows that the final-stage 1.2 GHz PA is a model 2330PA 30W (FM rating) unit from Down East Microwave (in Florida USA). Fig 4 shows the rugged well-cooled construction of the Down East Power Amp.

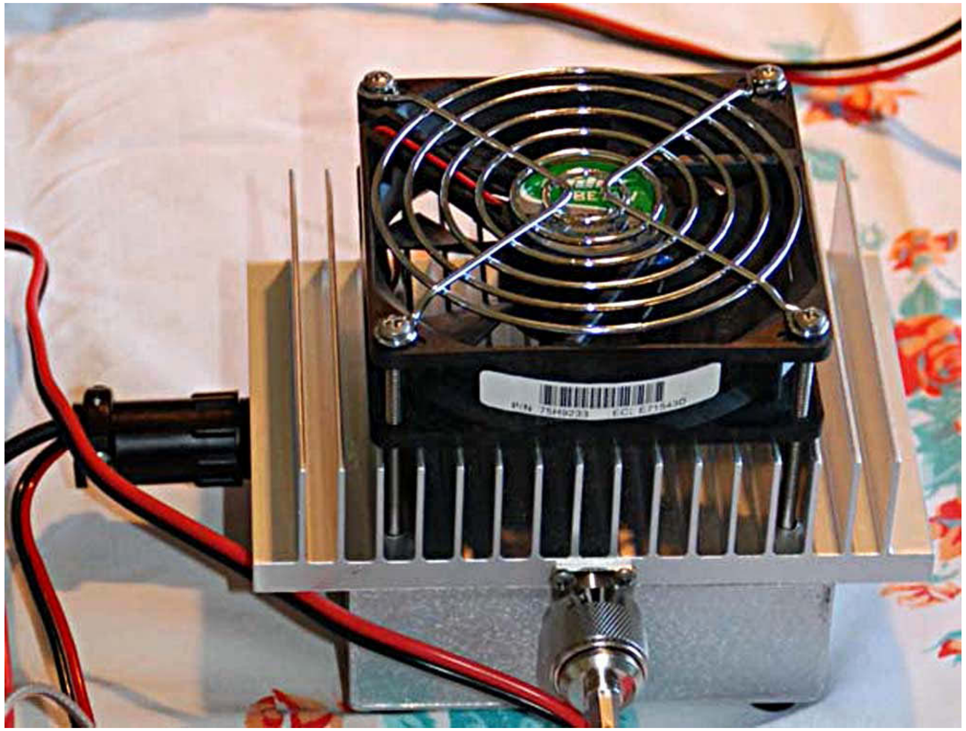


Figure 4 – Construction of Down East Model 2330PA Power Amplifier

Fig 5 shows the quality of the Down East PA output signal at about 13 W. The spectral regrowth shoulders are down about 28 dB from the main carrier signals. Fig 6 shows the HP Model 432A Power Meter (a bolometer type) that was used for power measurements. Note the stack of precision

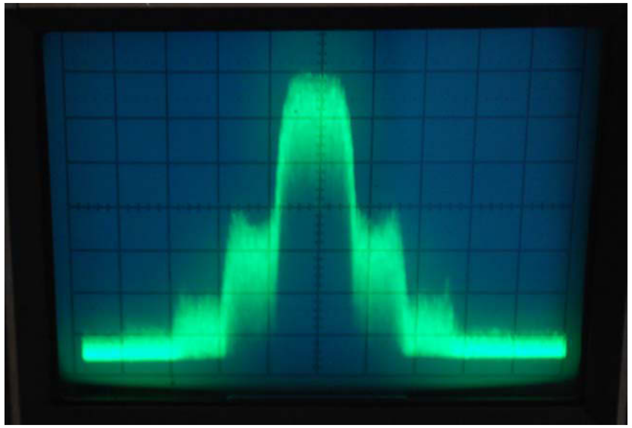


Figure 5 – HP Spectrum Model 8559A Analyzer looks at Down East output signal (the “shoulders” are about 28 dB down)

attenuators at the top of Fig 6 that are used to drop the power down close to 0 dBm for meter readings. Power measurements are shown in Table 1.

Figure 6 – HP Model 432A Power Meter Note attenuator-stack at the top of the photo

Table 1 – Power Measurements taken during the DVB-S Station Testing

MiniMod-S exciter menu power setting	Measured MiniMod Output mW	Measured Kuhne 1st-amp Output mW	Measured Down East 2nd-amp Output dBm	Measured Down East 2nd-amp Output W	"shoulder" below main carrier
1	0.0661 mw	N/A	N/A	N/A	N/A
2	0.158 mw	N/A	37.6 dBm	5.75 W	35 dB
3	0.302 mw	N/A	39.7 dBm	9.33 W	32 dB
4	0.490 mw	N/A	41.8 dBm	15.1 W	29 dB
(Note: the readings below are with 5 dB attenuator between the first-PA and the second-PA					
5	0.724 mw	N/A	38.0 dBm	6.31 W	34 dB
6	1.00 mw	N/A	39.3 dBm	8.51 W	32 dB
7	1.32 mw	N/A	40.3 dBm	10.7 W	31 dB
8	**1.74 mw**	**115 mW**	**41.1 dBm**	**12.9 W**	**28 dB**
9	2.24 mw	N/A	41.8 dBm	15.1 W	27 dB
10	2.63 mw	158 mW	42.3 dBm	17.0 W	25 dB

Choices of Video Resolution

The User Documentation manual (English) that we had found on the SR-Systems web site for the Mini-Mod-S exciter did not go into depth concerning the configurations for video resolution that can be selected. The manual clearly shows that there are three choices for the transmitted DATV video:.

- D1
- HD1
- SIF

But, what do these choices really mean? It took some Google searches to begin sorting out the puzzle and then finally found a very good article by DJ1CU (called “The DVB-S 70 cm sender” in German) is up on the www.DATV.de web site (under Projekte). Let’s look at each of these three resolutions.

D1 Resolution

D1 is the normal resolution that is shown on a normal Standard-Definition Digital television (DVD quality).

D1 = 720 x 576 Pixel for PAL
D1 = 720 x 480 Pixel for NTSC

HD1 Resolution

The HD1 resolution does NOT mean “High Definition”.

It turns out that HD1 really means “Half of D1”.

HD1 = 352 x 576 pixels for PAL
HD1 = 352 x 480 pixels for NTSC

Volker-DJ1CU states that in his opinion HD1 resolution is perfectly acceptable for DATV.

SIF Resolution

SIF stands for "Standard Input Format". It is related closely to CIF ("Common Interchange Format")

SIF = 352 x 288 pixels for PAL
SIF = 352 x 240 pixels for NTSC
CIF = 352 x 288 pixels for PAL and for NTSC

DJ1CU states that in his opinion SIF is unacceptable for ordinary video transmission. Ken and Robbie used SIF for many tests. The main problem is observed while displaying full screen video. Since you only have one-fourth of the video pixels...the display graphics needs to generate three more "phantom" pixels for every "real" pixel. What we could see in a full-screen video were...that some pixels in the background appeared to "flicker". The picture was clear...but the "phantom pixel flicker" was distracting.

Another impact of choosing the video resolution is that it determines the Net-Data-Bit-Rate (NDBR) coming out of the MPEG-2 encoder, and therefore affects the RF Bandwidth. A higher NDBR typically means a larger RF Bandwidth. DJ1CU reports:

Resolution	Video NDBR
D1	~2.0 Mbps
HD1	~1.1 Mbps
SIF	~0.5 Mbps

We are currently using the D1 video resolution for our DATV DATVtalk05 testing.

Digital-ATV "Latency"

During our first table-top tests in DATVtalk04, we described that we had seen a latency (delay) of about 1 sec and that the video motion really got "jerky" (lost frames) if we displayed at full-screen on the notebook display. We needed to dig onto what were the causes. We have determined that there are at least four primary potential-sources of latency involved with digital transmission/reception:

- MPEG-2 Encoder
- SetTopBox Receiver
- USB2 Video-Capture Board
- Graphics Processing in Notebook Display

After finishing the DATVtalk04 tests (in CQ-DATV7 issue), Ken W6HHC was concerned that he was display-processing-limited with his 6-year-old entry-level Dell notebook. There were also concerns that the low-end video-capture USB adapter could also be the source of delays. So, it seemed like a good time to buy a new Dell notebook computer (Precision model M4400) configured with a good graphics-processor for the notebook display.

At the same time, Ken had read an internet DATV article that introduced him to new Hauppauge WinTV-HVR-1950 USB-based ATSC/NTSC/video-capture adapter. It had an external AC power adapter, so it had plenty of power for fast-processing. A series of tests were conducted to measure the DVB-S real-time delays from camera-to-display. The latency results are shown in Table 2 on next page. Let's look at each of these four areas of potential delays.

MPEG-2 Encoder delays

There is a lot of processing that goes on during the MPEG-2 encoding (compressing data) processing. While discussing latency with Stefan-DG8FAC of SR-Systems, Stefan explained that typically 90% of the latency that I was seeing going to an analog TV (Test #1 in Table 2) was occurring inside the MPEG-2 board. Stefan stated "....The delays have nothing to do with the DVB-S Modulator/exciter, the delay is only generated by the MPEG-2 Chip on the Encoder board and the MPEG-2 Decoder that is in your SetTopBox...." We will see later when we discuss the SetTopBox, the SR-System MPEG-2 encoder board is generating about 1 second delay. Stefan explained that there is a "LowDelay Solution" for the encoder, but this encoder is very expensive, about 2500 Euro.

SetTopBox Receiver delays

Each frame of video requires 33 msec in NTSC. A quality STB will lag by about four frames (0.13 seconds) for the MPEG-2 decoding. A lot of inexpensive STBs have a delay of around 5-8 frames. The ViewSat VS2000 Xtreme STB is reported to be an excellent STB and we are inclined to believe it fits into the group of STBs with a four frame delay. That means that the MPEG-2 Encoder board in Test #1 (see Table 2) has about a delay of ~1 second.

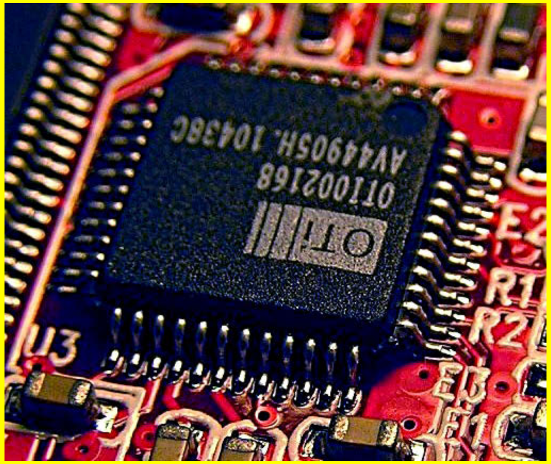
USB2 Video-Capture delays

The low-cost StarTech.com USB2 video-capture adapter steals its power from the USB port on the computer. So, we knew that StarTech does not have a lot of power for fast processing, a potential concern. But, Table 2 clearly shows a measureable delay of about only 0.1 second being introduced by the StarTech.com USB2 unit. On the other hand, the newer Hauppauge WinTV-HVR-1950, with its external power source, introduced a delay of 1.37 second using Ver 6 of WinTV display software. With the newer (Win7 certified) Ver 7 WinTV display software and device driver, an internal delay of 1.7 seconds was measured....for a total latency of 2.8 seconds.

Some Discussion on hand-soldering SMT Amplifier Kits

A funny thing happened while trying to select the first-stage PA for the W6HHC DATV station. The first choice was not the Kuhne. Our first-choice was a very low-cost kit for a 1 Watt 1.2 GHz model using an ATF50189 PHEMT from MiniKits in Australia. The kit was only about US$50, but offered a big challenge...it was a Surface Mount Technology (SMT) kit.

Now, Ken W6HHC has built more than his fair share of building the famous Heathkit ham gear. Including the really terrific SB-301/SB-401 SSB station. But, Ken was no match for hand-soldering SMT components.



The first trick learned for easy hand-soldering was to buy a tube of solder-paste (used by automated SMT soldering).

This works very well. It is very easy to control the amount of solder. Normal solder-wire tended to melt too much solder on the board for Ken. Solder-paste also nicely keeps the part in position on the board while you get ready to use solder iron.

The big SMT problem was losing parts while trying to get them onto the PCB. These SMT parts are small.

1) Tweezers could shoot an SMT part half-way across the lab. Sometimes Ken searched the lab floor on "all fours" for a half-hour without success.

2) Pressing an SMT part into the finger-tip and lifting it into position seemed to work better. But, parts still "disappeared" before they reached the magnifying glass view of the PCB.

3) Dipping a toothpick in solder rosin worked even better for picking up and placing SMT components.

Finally, purchasing an assembled-and-tested 1 Watt amplifier from Kuhne Electronics was the very best solution.

Table 2 – Measured DATV Latency Delays

Test	STB w/ NTSC Analog TV	STB w/ Dell Inspiron 1150 Notebook Intel 2.4 GHz CPU WinXP Pro	STB w/ Dell Precision M4400 Notebook Intel 3.1 GHz Core2 Win7 Pro	USB2 Video Capture board	NOTE
1	1.1 sec			(none used)	
2		1.2 sec	1.2 sec	Startech.com USB2	StarTech GrabBee lite display SW
3			2.47 sec	Hauppauge WinTV-HVR-1950	WinTV Ver 6 display software
4			2.8 sec	Hauppauge WinTV-HVR-1950	WinTV Ver 7 display software

To Ken, this Hauppauge HVR product was quite a disappointment for my DATV receiver application because of the extra delays it introduced, but OK for recording off-the-air commercial TV broadcasts.

Display Graphics Processing delays

The old entry-level Dell notebook had simple graphics processing....just a "vanilla" Intel 82852/82855 Graphics Controller. The new Dell M4400 notebook has a powerful NVIDIA Quadro FX 370M6 Graphics Controller. The video "jerking" I had described on the older Dell notebook computer, when displaying quarter-size SIF resolution to full-display-size, completely disappeared.

First Cross-Town Tests

Bench testing is important. But we get excited about seeing "proof of concept". So, we tried to send a 1.2 GHz test signal from Ken's home (using a 3-ft vertical) to the roof of the Orange PD where Robbie KB6CJZ set up a 24-element loop-Yagi.

The FEC was set to 1/2 and the RF bandwidth was 3 MHz

Figure 7 – Robbie KB6CJZ set up a 24-ele Loop-Yagi on the OPD roof and received perfect DATV pictures

(Symbol Rate = 2.2 MSymbol/sec). The distance is about 3 miles at roof-top heights, with plenty of tree-lined streets, two-story houses, back-yard trees, commercial buildings, and through one elevated-freeway. The DATV pictures were perfect!

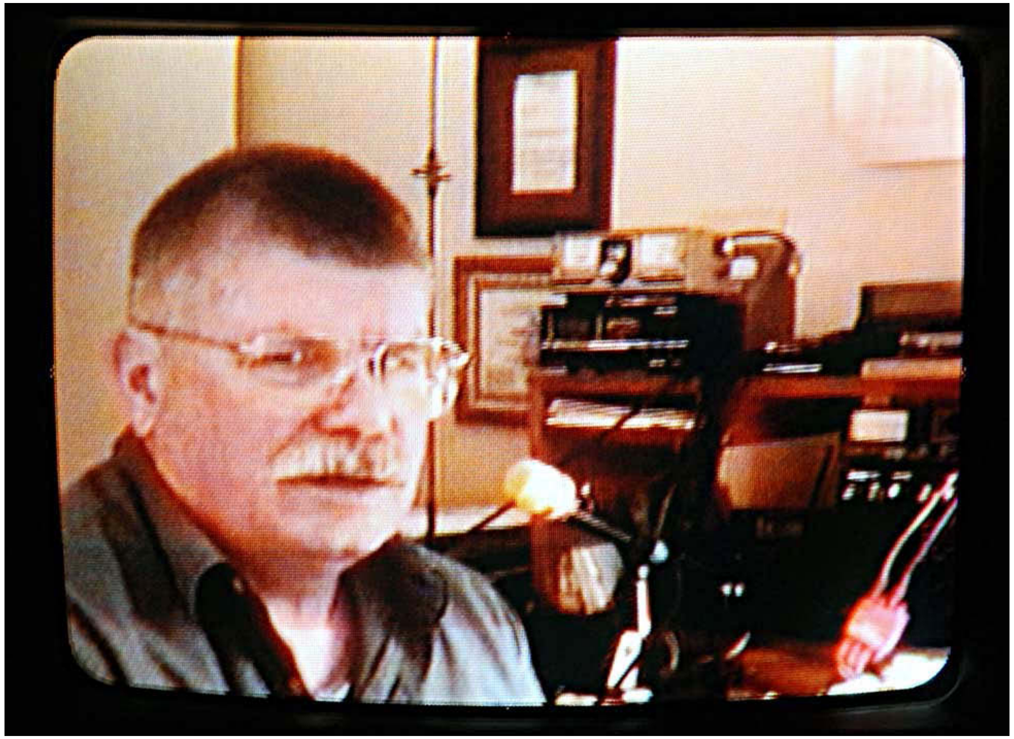


Figure 8 – First cross-town DATV Transmission received at Orange Police Department building (3 miles)

The use of a 24-element Yagi at the OPD was probably not required. The signal was clear D5 (P5?) whenever the antenna was pointed within about 30 degrees of Ken's QTH.

More field testing is planned.

Contact Info

The authors may be contacted at KB6CJZ@ARRL.net and W6HHC@ARRL.net

Useful D-ATV Links

BATC info site for DTX1 exciter – see www.DTX1.info
British ATV Club – Digital/DigiLite/DTX1 forums – see www.BATC.org.UK/forum/
DATV-Express Project web site (SDR-based exciter) – see www.DATV-Express.com
Down East Microwave RF amplifiers – see www.DownEastMicrowave.com
Kuhne Electronics (DB6NT) RF Amplifiers – see www.Kuhne-Electronic.de
MiniKits (SMT kits for RF amplifiers) – see www.MiniKits.com.au
SR-Systems D-ATV components (Boards) – see www.SR-systems.de
Amateur Television of Central Ohio – see www.ATCO.TV
British ATV Club - Digital Forum – see www.BATC.org.UK/forum/
British ATV Club – select from about 25 streaming repeaters – see www.BATC.TV/
Orange County ARC entire series of newsletter DATV articles – see www.W6ZE.org/DATV/
TAPR Digital Communications Conference free proceedings papers – see www.TAPR.org/pub_dcc.html
Volker Broszeit DJ1CU article for "The DVB-S 70 cm Sender" (in German) – see www.DATV.de/Projekte/projekte.html
Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/

by Ken Konechy W6HHC and Robbie Robinson KB6CJZ

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In the CQ-DATV5 issue, the DATVtalk02 article presented an introduction to Digital-ATV. In the CQ-DATV8 issue, Robbie-KB6CJZ and I teamed-up in the DATVtalk05 article to present a test report for bench-testing a DATV DVB-S transmitter exciter and Power Amplifiers, using the SR-Systems product from Germany. Now in DATVtalk06 article, Robbie and I team up again to continue our DATV testing of a DVB-S station in the field and we report on the results we obtained in field testing of a Digital-ATV portable unit in the City of Orange, here in Southern California.

Some Background

The authors are both members of the OCARC, but they are also members of the RACES emergency communications group for the City of Orange, called COAR (City of Orange Amateur Radio). For years, the COAR group had equipped itself with analog-ATV equipment intended to send field video to the city Emergency Operation Center (EOC) located inside the Orange Police Department building. But for years, COAR has been frustrated by the quality of the analog-ATV pictures being received by the EOC. The 440 MHz analog-ATV quality was degraded because the signal path typically included elevated-freeways, 2-story residential homes, 1-to-3-story commercial buildings and a “forest” of backyard trees and tree-lined streets. The only good transmissions for analog-ATV occurred if we parked the portable ATV transmitter on a hilltop with a clear signal path back to the Orange PD building.

Members of the COAR RACES team had speculated that perhaps Digital-ATV might provide the solution to improving the quality of our field video transmissions.

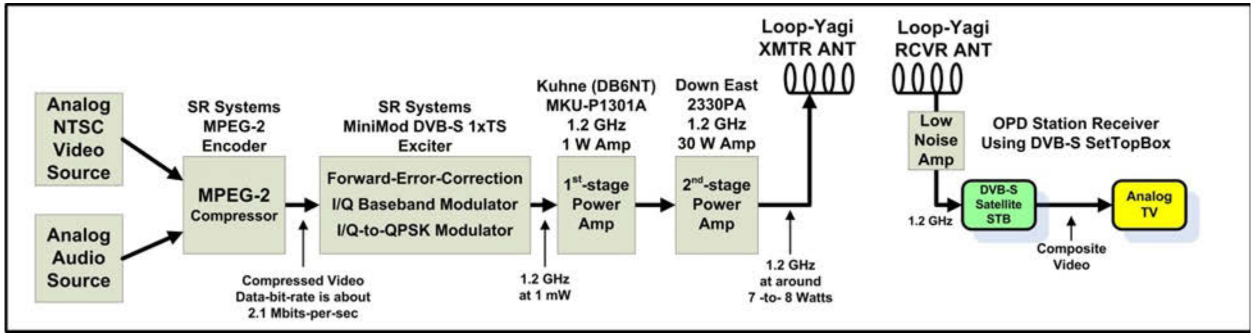

Figure 1 Block Diagram for DVB-S Initial Field Tests

The DATV Equipment

Fig 1 is a block diagram of the set-up used during the first set of field tests of DATV. The transmitter, and power amplifiers and SetTopBox (STB) receiver have all been described in more detail in an earlier DATVtalk05 testing report.

Another ViewSat VS2000 DVB-S STB was purchased on eBay for installation inside the EOC Radio Room for the purpose of conducting these DATV field Tests. The eBay cost of this FTA STB unit was less than US$60 including shipping. Fig 2 shows the new STB (bottom unit) being tested side-by-side with the personal STB receiver of Ken W6HHC before the field tests began.

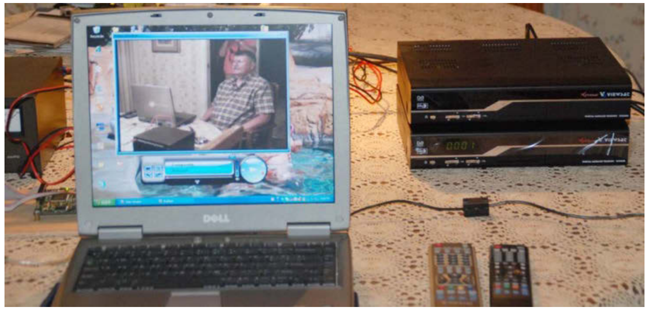
Figure 2 – Bench testing the new ViewSat STB to be used at OPD

The frequency used for the field tests was 1.292 GHz. Ken W6HHC had planned to set up the test frequency on 1.2915 GHz, but discovered that the STB menu would NOT allow him to enter 0.5 MHz digits. The Symbol-Rate was set to 2.2 MS/sec...producing an DVB-S RF BWallocated of 3 MHz. The Forward Error Correction (FEC) was configured to 1/2.

The receiving 1.2 GHz antenna (Fig 3) was a 24-element loop-Yagi antenna mounted 3-stories high on top of the Orange PD building. The loop-Yagi antenna is made by Directive Systems (in Maine US). A Down East Microwave LNA for 1.2 GHz was installed for the field tests to drive the received DATV signal down 250+ feet of coax to the EOC Radio Room receiver.

Figure 3 – a 1.2 GHz Loop-Yagi on roof of OPD

The SWR of the new DATV field antenna for COAR RACES was tested successfully in Fig 4. The SWR at 1.292 GHz was about 1.5:1 using a Bird Watt meter. The center-mounted loop yagi beam antenna is the Model 2325LY from Directive Systems, located in Maine USA, has somewhere between 23 and 25 elements The beam weighs only 3 pounds (1.4 KG)!! This is essentially the same antenna that is used at the Orange PD building for receiving DATV.


Figure 4 – COAR RACES Member KB6CJZ measures SWR on the new DATV 1.2 GHz “Elephant Gun” Loop-Yagi

First Field Test – El Modena High School

The first DATV test site we chose, the parking lot of the El Modena High School in the City of Orange, was picked because COAR RACES had tried analog-ATV tests on 440 MHz from this location two years earlier with extremely poor video quality...producing only P1 or P2 at best. But P1 or P2 was NOT the video quality that COAR RACES wanted to show to the Police or Fire Chiefs or to the Mayor of the city in the Emergency Operation Center (EOC) room. The test distance is only 3.2 miles, but includes one elevated freeway, three-story apartment buildings, homes, 2-and-3-story commercial buildings, and plenty of trees.

While Robbie KB6CJZ and Steve KI6DDE manned the OPD

Figure 5 – Bruce KC6DLA adjusts direction of the 1.2 GHz Loop-Yagi at the Field set-up site

Figure 6 – Mast-brace attaches to roof-rack

Figure 7 – The car tire secures the support base and prevents antenna mast from slipping

receiving station, Ken W6HHC and Bruce KC6DLA set up the DATV transmitting station in the back of his mini-van. Just to be prepared, Ken also set up a STB receiver with a “sniffer” antenna and a notebook computer display in the field to confirm that a video picture was actually being transmitted...in case there was a lack of picture at the OPD. Fig 5 shows Bruce KC8DLA adjusting direction after the field antenna has been set up.

The field antenna mast was constructed from Radio Shack 5-foot stacking mast sections and totaled 25-feet tall. Details for support the field antenna mast are shown in Fig 6 and Fig 7.

Steve KI6DDE reported seeing a picture at the Police station from El Modena High School, even before Ken could finish setting up his “sniffer” receiver. The received picture was perfect! Robbie KB6CJZ reported that the QUALITY monitor on the STB menu displayed 100%.

Second Field Test – City “Mock EOC Drill”

The Police Department conducted the planned “mock EOC” drill for the City of Orange in order to test the abilities and training of Police Department volunteers, including COAR RACES communications volunteers to provide support for city EOC

Fig 8 - Robbie KB6CJZ views received DATV Video Inside the EOC Radio Room officials and staff and to provide communications from the field in a simulated train wreck incident. As expected, COAR was directed to provide DATV video from the simulated medical triage area in the parking lot of the Amtrak train station. Ken led the field team and a perfect DATV picture was being received at the EOC with only 10 minutes of travel time and 10 minutes to set-up the portable DATV equipment.

Figure 9 – This close-up of a large-screen display in EOC Room show the clarity of received DATV.

The test distance is only 1.8 miles, but includes, 2-story commercial buildings, 3-story University buildings, homes, and plenty of trees. We had to aim the 1.2 GHz antenna right into a pair of large leafy trees, about 75 feet away. As with the earlier test site, this location in down town Orange had failed terribly earlier when analog-ATV was used because of “ghost” multipath reflections fr0m the commercial buildings and weak signals.

The received DATV signal was first displayed in the EOC Radio Room. The video was then distributed to many large screen LCD displays inside the EOC room itself, as shown in Fig 9. A picture was reported at the EOC Radio Room as soon as the transmitter switch was turned on. Again Robbie reported the DATV picture was perfect and the SetTopBox QUALITY meter read 100%.

Figure 10 – Members of COAR RACES and other OPD Volunteers gathered in the EOC room after the drill to begin a debrief session

Third Field Test – Up in the Hills

Figure 11 – View of KomplettSender DVB-S transmitter from SR-Systems with top cover removed

Based on the success and demonstration of the two previous DATV tests, the COAR RACES group in the city of Orange was very fortunate to obtain funding to purchase new Digital-ATV equipment to create a portable field station (instead of borrowing equipment from Ken W6HHC and Robbie KB6CJZ). This section

Figure 12 – Front panel of KomplettSender with LCD Display and Menu Controls

describes the testing of the new DATV equipment that includes a KomplettSender DVB-S transmitter (from SR-Systems in Germany) and then reports the results of field testing from a more difficult location with this new portable DATV equipment.

Fig13 shows the Block Diagram of how the new equipment was used in this third in a series of field tests. As we have said before, bench-testing is important …but results from the DATV field tests are exciting! The location chosen was a ridge up in the foot-hills of eastern part of the City of Orange that had been tried three years ago using 440 MHz analog-ATV.

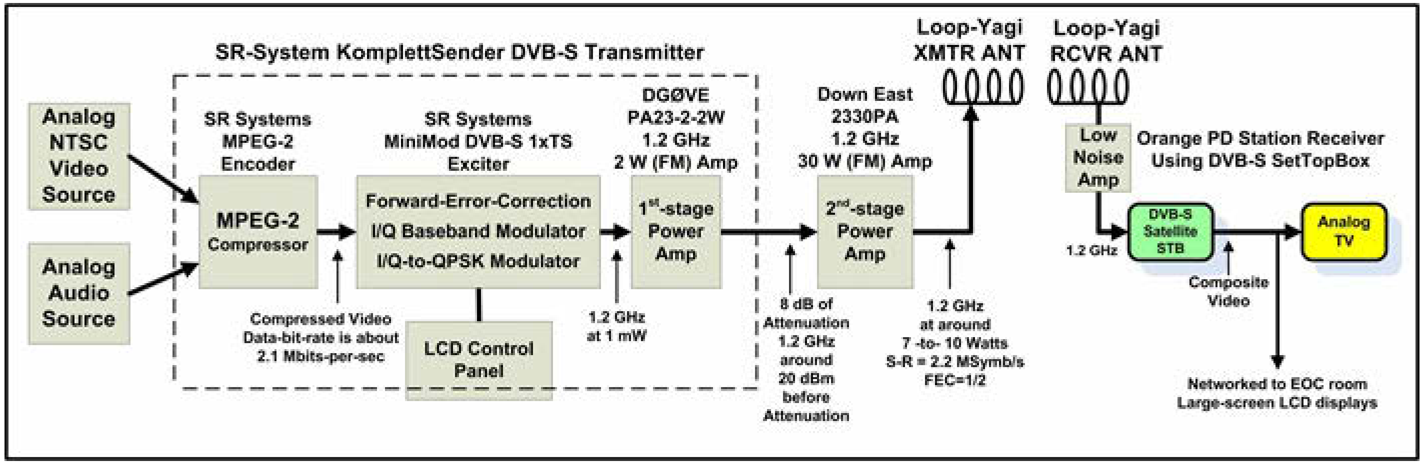

Figure 13 – Block Diagram Showing New W6OPD DATV Field Station being Tested

No video signals could be received from this ridge at the Orange PD building during the earlier analog-ATV field tests.

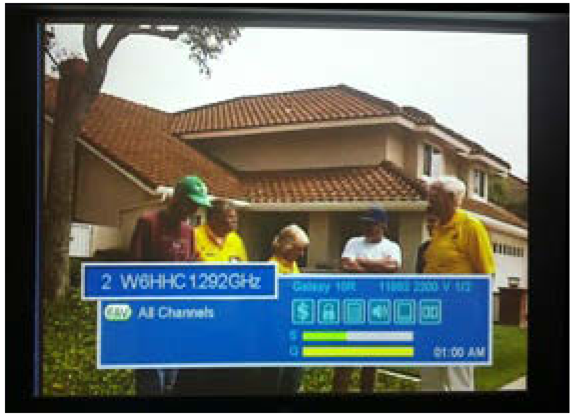

Figure 14 – The weak DVB-S DATV signals received at EOC produced perfect DATV pictures with 100% QUALITY

The tests were conducted from near the QTH of Kathleen K6IBH (up on a ridge across Jamboree Road to the West from Loma Ridge) and great pictures were sent back to the Orange PD EOC Room. This ridge allows camera video to the East of the ridge toward Sierra Peak, Irvine Park, Loma Ridge, and Saddleback Peak. East is the direction that wild grass fires normally approach our city. The DATV signals were fairly weak (see Fig14) because a hill was sloping down into and blocking the "line-of-sight" transmission path…and we probably had to "knife-edge" around the sloping hill side to reach the OPD EOC.

The critical DATV settings selected for DVB-S during these COAR field tests are listed below:

- Frequency - 1.292 GHz (center freq)
- FEC - 1/2
- Symbol-Rate - 2.2 MSymbols/sec
- RF BW(allocated) - 3.0 MHz
- Camera - NTSC
- Video Resolution - D1
- MPEG-2 GOP Mode - IBBP

Conclusion

The chosen DVB-S field equipment COAR worked very well. COAR's DATV field testing results have exceeded our expectations and has produced useful video from many difficult field locations. During the DATV planning efforts for COAR, we had many concerns whether DVB-S could handle the multi-path ghosts that had plagued earlier analog-ATV field tests. We were worried that DVB-T technology (with it very robust multi-path protection) might be the only useful DATV technology for COAR RACES.

The digital-ATV DVB-S video quality from the field is much improved over the older analog-ATV technology. This improvement is achieved because DATV technology uses Forward-Error-Correction (FEC) to overcome the "ghosts" and weak-signal conditions caused by elevated-freeways, buildings in the downtown area and the hills on the outskirts of our city.

Contact Info

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Useful D-ATV Links

BATC info site for DTX1 DVB-S exciter – see www.DTX1.info

British ATV Club – Digital/DigiLite/DTX1 forums – see www.BATC.org.UK/forum/

DATV-Express Project web site (SDR-based exciter) – see www.DATV-Express.com

Down East Microwave RF amplifiers – see www.DownEastMicrowave.com

DGØVE microwave RF amps, up-converters, down-converters – see www.DG0VE.de

Kuhne Electronics (DB6NT) RF Amplifiers – see www.Kuhne-Electronic.de

Directive Systems – loop YAGI antennas – see www.directivesystems.com

SR-Systems D-ATV components (Boards) – see www.SR-systems.de

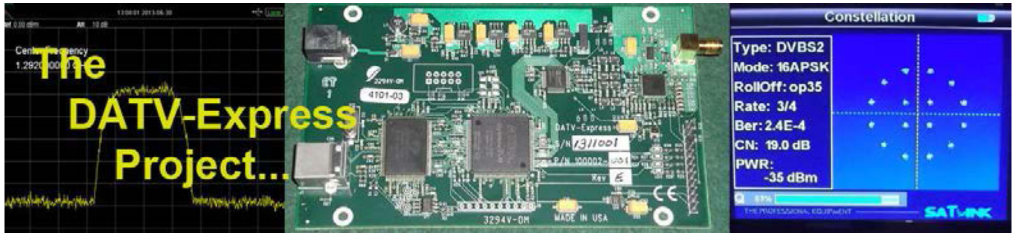
Amateur Television of Central Ohio – see www.ATCO.TV

British ATV Club - Digital Forum – see www.BATC.org.UK/forum/

Orange County ARC entire series of newsletter DATV articles – see www.W6ZE.org/DATV/

TAPR Digital Communications Conference free proceedings papers – see www.TAPR.org/pub_dcc.html

Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/



DATVtalk07 - DigitalATV - Using a Spectrum Analyzer

by Ken Konechy W6HHC

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note - This is the sixth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was the beginning of this series and presented an introduction article about Digital-ATV.]

I will venture to guess that most hams do not use a "stand-alone" Spectrum Analyzer instrument. Quite a few hams have a Spectrum Analyzer built into their HF rig (like the Icom IC-7000, the Icom IC-7600, Yaesu FT DX 3000, or even a Yaesu FTM-4000M VHF/UHF rig, etc.) to look for signals on the band. In my situation, I was introduced to a built-in Spectrum Analyzer (SA) when I purchased an Icom IC-756-Pro3 in 2007. Later, I was introduced to a stand-alone Spectrum Analyzer instrument that I purchased in 2013 because my involvement in digital-ATV.

Historically, 'stand-alone' Spectrum Analyzer instruments were built by companies like HP and Agilent for use in industry and had huge price tags of $20,000 to $40,000 new! A ham could only hope to find a used Spectrum Analyzer for sale that still worked and had an affordable price tag. At least one instrumentation company based-in-China is now producing good-quality Spectrum Analyzers at a much more reasonable price.

Spectrum Analyzer Uses

Rigol Technologies produces many types of instruments, including several families of Spectrum Analyzers. Charles G4GUO pointed out to me that the Rigol Model DSA815 SA instrument is an en-try-level unit that can operate up to 1500

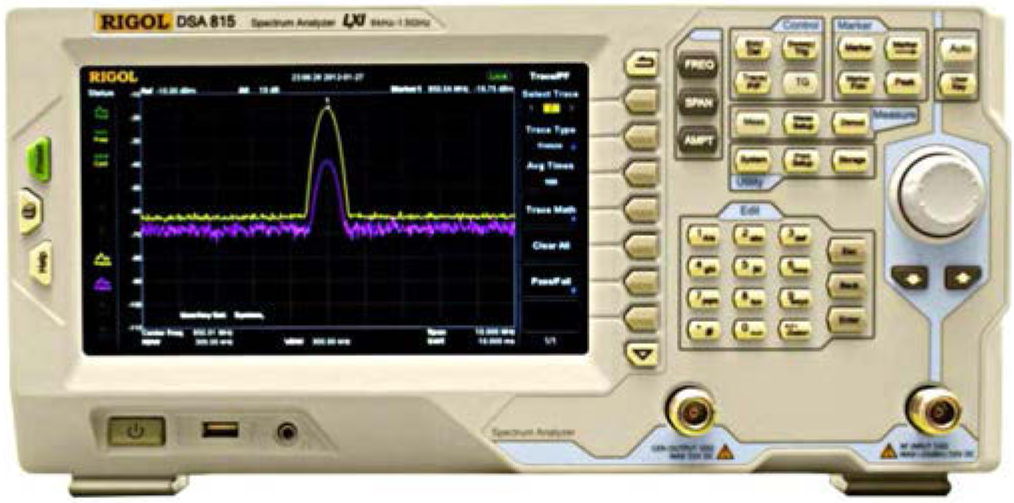


Figure 1 - Rigol Model DSA815 Spectrum Analyzer can operate from 9 KHz to 1500 MHz

MHz and has a base-price that is only US$1295.
The basic use of a Spectrum Analyzer is to analyze an RF signal over a range of frequencies. This is especially useful in DigitalATV (DATV) where you are interested in measuring band-width, looking for distortion, side-spurs and harmonics. These tasks of measuring band-width, looking for distortion, side-spurs and harmonics are very difficult to accomplish with only an oscilloscope.

Fig 2 (next page) shows a typical DVB-S/QPSK digital modulated signal on 1.290 GHz that is well-shaped and without distortion. The display is 10 MHz wide at 1 MHz per horizontal division.

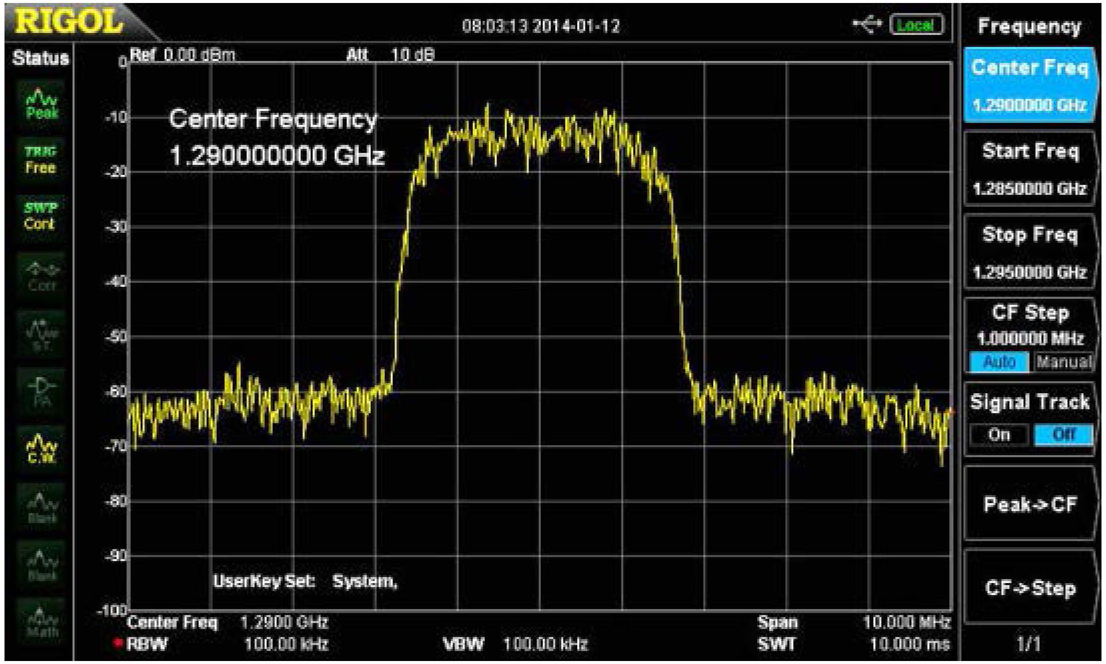


Figure 2 - Spectrum Analyzer display of QPSK digital modulation on 1290 MHz

There are quite few other functions that can be performed by a Spectrum Analyzer, such as:

- Signal generation
- SWR measurements
- Power measurements

Tracking Generator option

Rigol produces a variation of the base DSA815 SA unit that includes a "tracking generator" option. This model is called DSA815-TG. A tracking generator is a sweeping signal generator that tracks with the display span of the Spectrum Analyzer. Not only does the tracking generator help measure the performance of filters, but it makes a fine stand-alone RF signal generator that operates from 9 KHz up to 1500 MHz.

The design of a good quality spectrum analyzer that is useable up to 1500 MHz requires immense attention to details like shielding to prevent introducing cross-talk. Fig 3 shows that the Rigol unit utilized a complex shielding-box milled from a solid block of aluminum to contain the RF radiations of one part of the design from unintentionally interfering with another part of the circuit design.

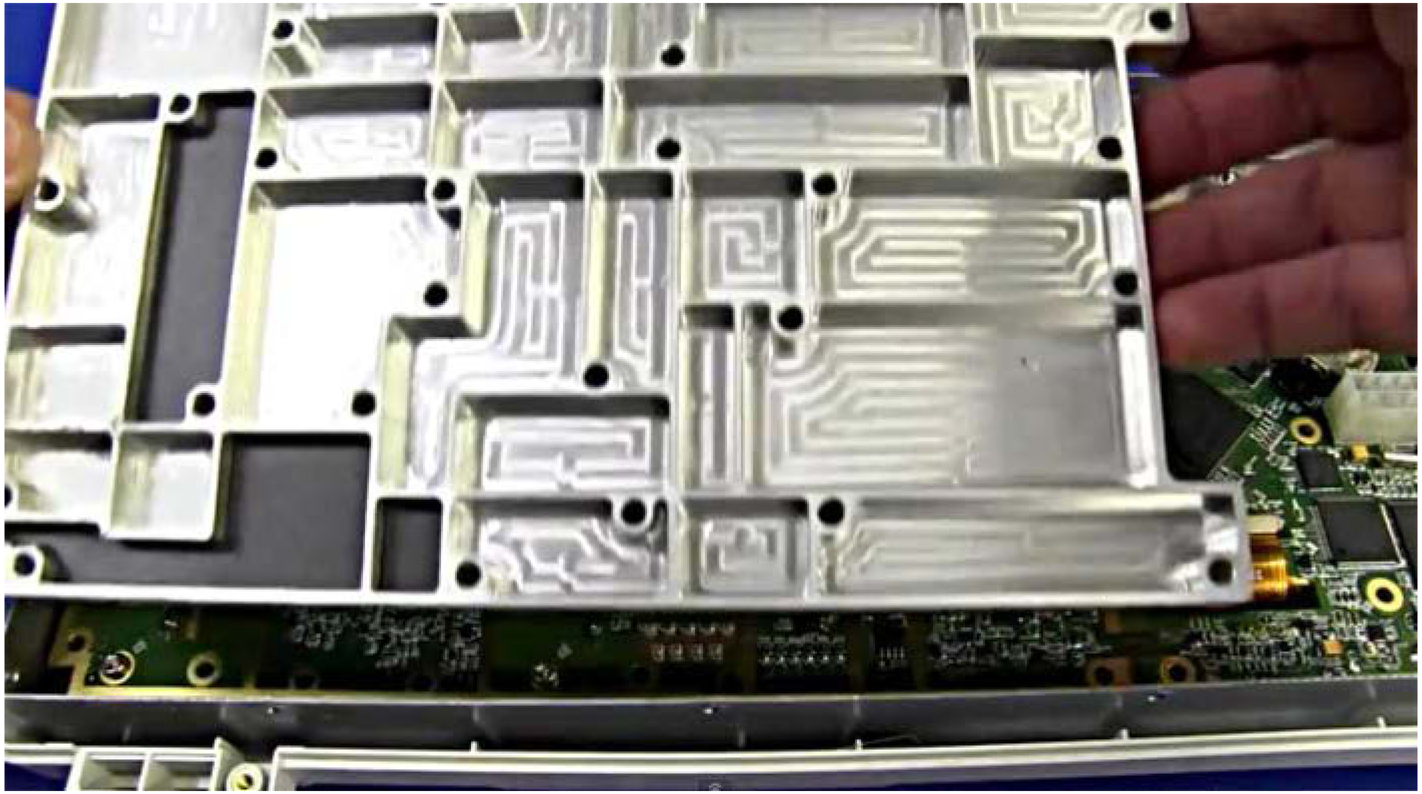


Figure 3 - Construction of the RF shielding-box milled from solid aluminum block (Courtesy of YouTube EEV #391)

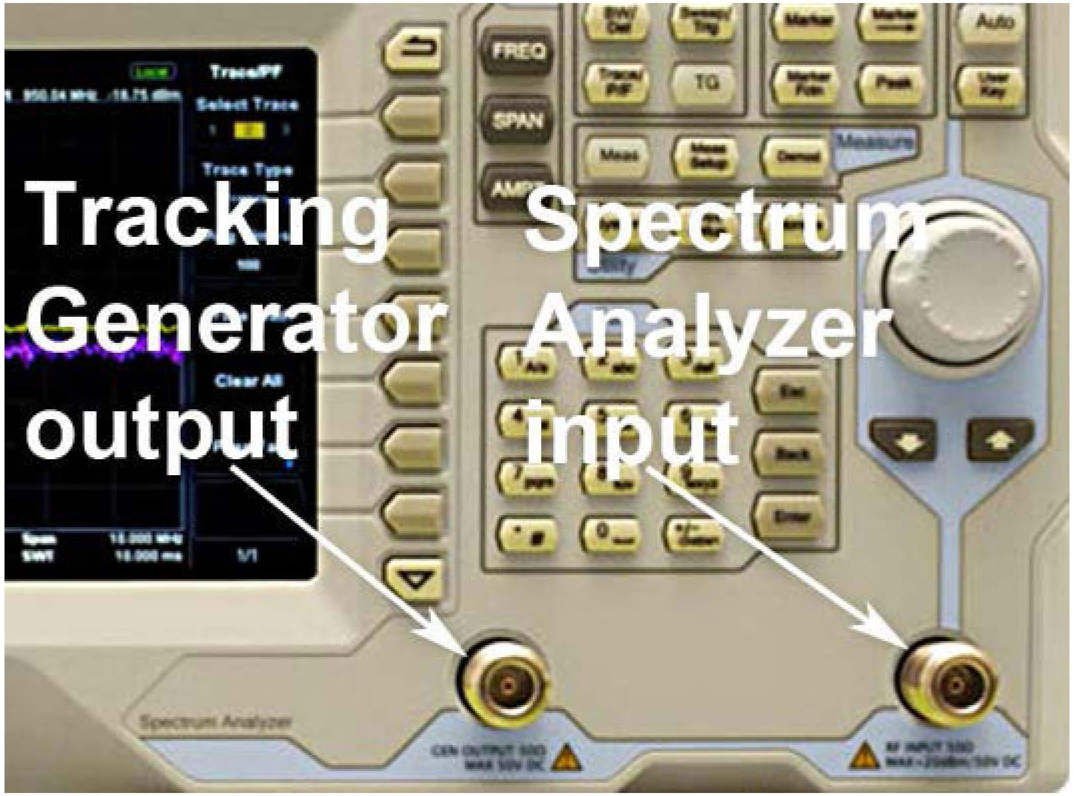


Figure 4 - Location of Tracking Generator output relative to the input connector of the SA

Do you want to calibrate a receiver....just place the tracking-generator output on the frequency of interest with a steady carrier and no sweeping.
As I mentioned earlier, one use of a tracking-generator option is to simplify the measurements of and displaying the performance of a filter. Fig 5 shows the measured performance a surplus tunable band-pass filter loaned to me for testing by Robbie KB6CJZ.

This tunable filter had the value of 1030 MHz hand-written on the unit. I think it is easy to envision using the Spectrum Analyzer to confirm re-tuning of this band-pass filter.

The Rigol Tracking-Generator option is priced at US$200, but must be ordered as a model DSA 815-TG Spectrum Analyzer, since it is not a plug-in option. The price of a DSA815-TG unit is US$1495, total.

SWR option

Another neat aspect of a tracking-generator is that it simplifies measurement and reports for documenting SWR of an antenna. The heart of making an SWR measurement with a Spectrum Analyzer is using a microwave directional-coupler to take a sample of the reflected RF and puts that sampled signal back into the input connector of the SA. Fig 6 shows a typical surplus microwave directional coupler.

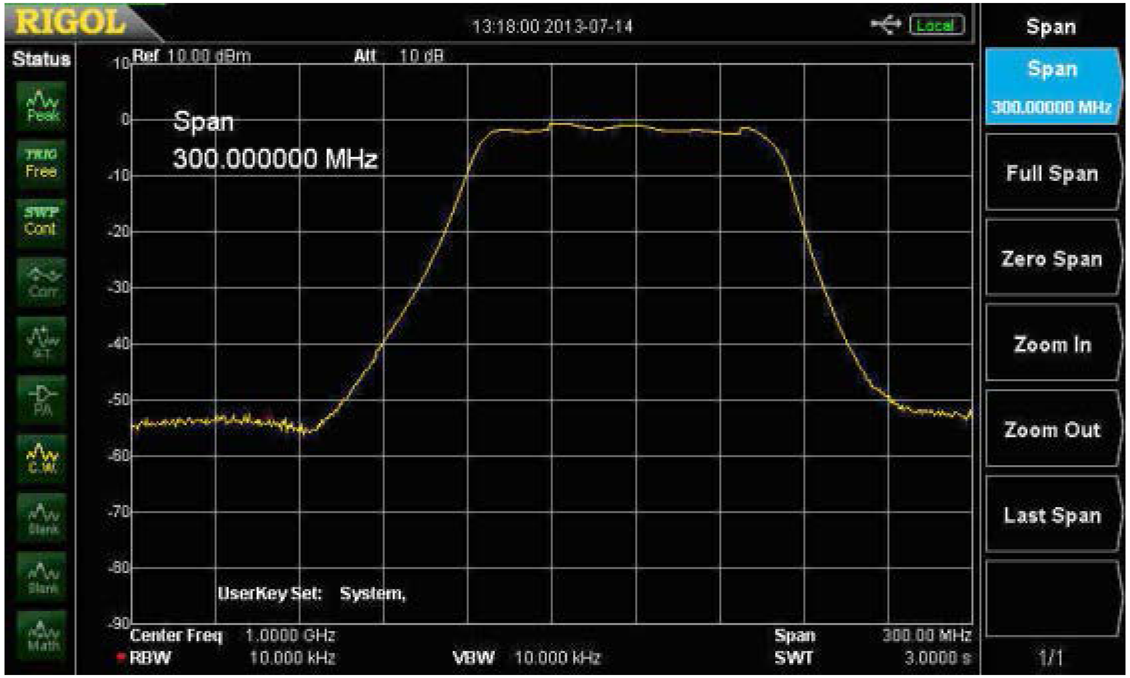


Figure 5 - Spectrum display (center frequency set to 1.0 GHz) of a surplus tunable band-pass filter

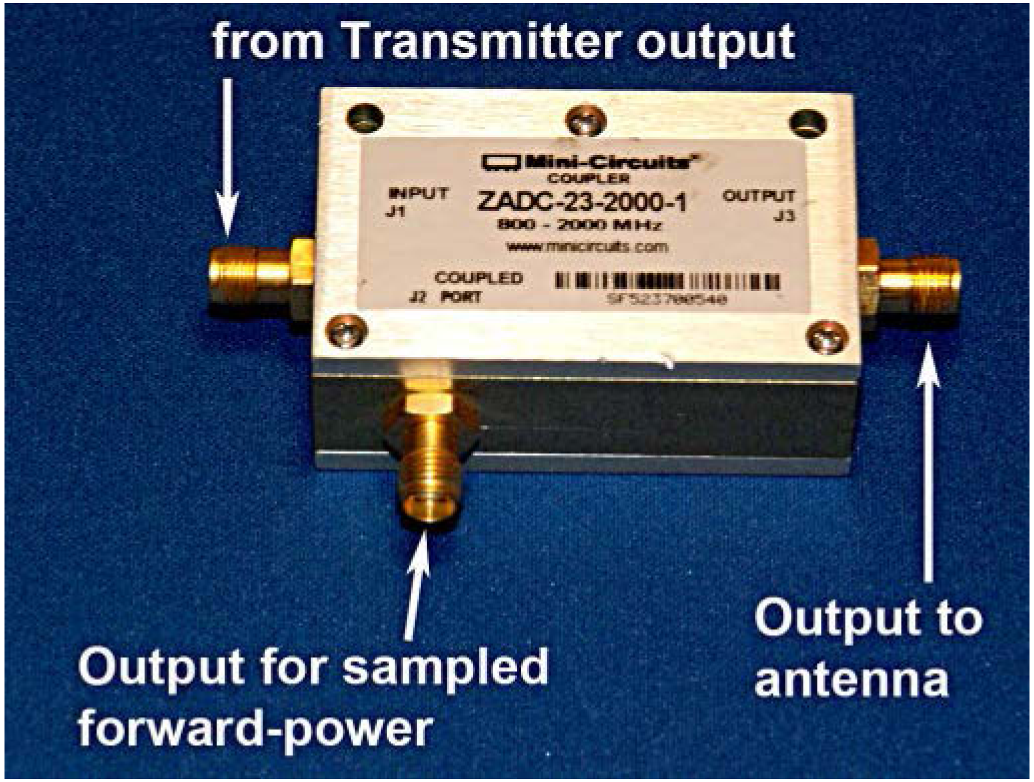


Figure 6 - Typical surplus directional-coupler with an output connector for sampled forward-power

Surplus directional-couplers are usually specified for a specific range of microwave frequencies. However for basic measurements of antenna SWR, you can use directional-couplers that are designed for a different frequency range. All that really changes is the gain of the sampled signal.
Art WA8RMC did point out to me that the "gain of the directivity" also changes when you operate in a different frequency range. Note - directional-couplers can be purchased with either SMA or N-connectors. Finally, these units are reversible...connect the transmitter to the J3 connector on the unit in Fig 6 and now the sampling connector delivers reflective-power as an output.

Fig 7 illustrates how a directional-coupler can be used with the Tracking-Generator output to find resonance on an antenna and help you tune it to the correct frequency. As a NOTE: No special Rigol optional-cost SWR software was used in Fig 7 to perform the test.

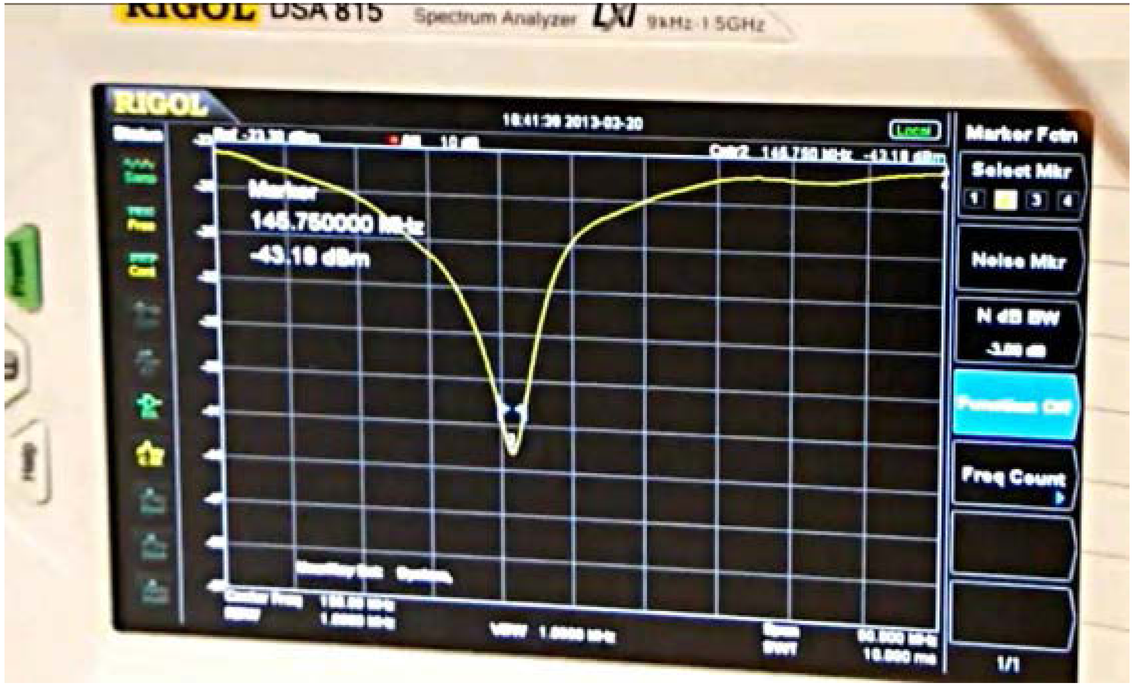


Figure 7 - Using a direction-coupler to tune an antenna (but, using no special SWR software)

Next, because modern Spectrum Analyzers contain microprocessors, a little software can be offered as an option to measure all the displayed SWR signal strength values...calculate a few values...and can provide you with a finished SWR report.

Rigol optionally sells two SWR accessories. The software-only measurements-calculations accessory Model DSA800-VSWR software kit sells for US$459 and provides professional reports

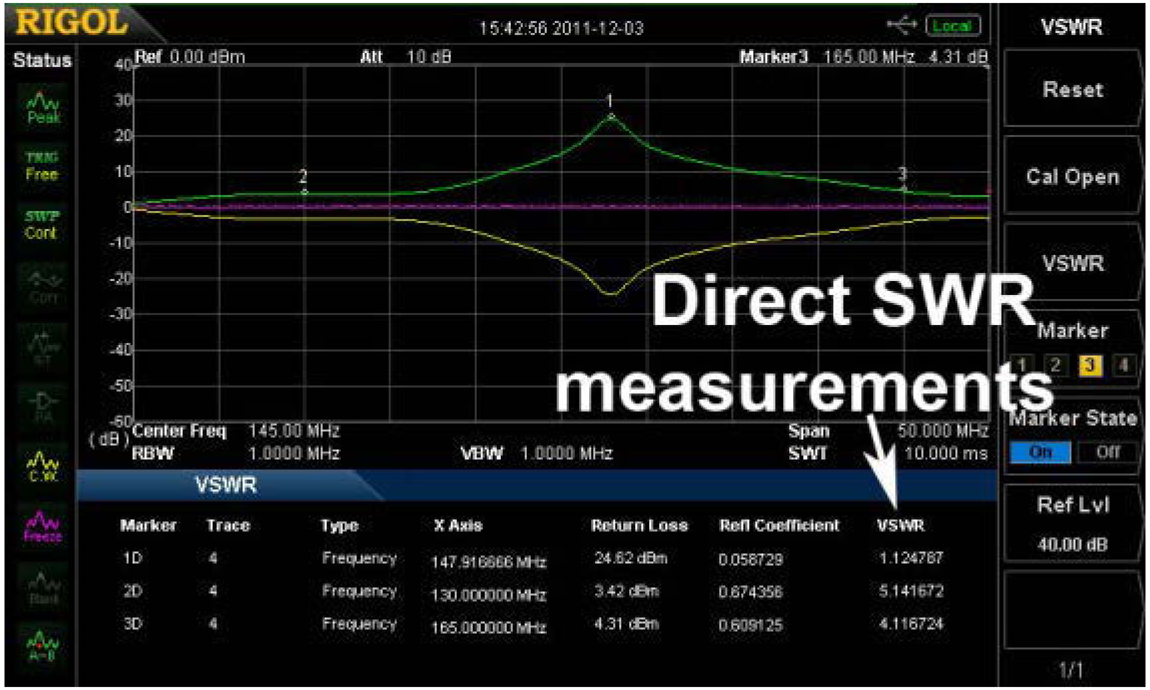


Figure 8 - The Rigol software DSA800-VSWR option measures values and displays SWR report

that perform all of the tedious calculations. Rigol also sells accessory Model VB1020 kit that includes:
(a) a specially designed directional-coupler hardware unit that has a frequency range from 1 MHz to 1500 MHz,
(b) the hardware unit screws directly onto the TG-output and the SA-input connectors, and
(c) the software measurements and SWR report code.
The cost of the optional Rigol Model VB1020 kit is US$599.

Power Measurement option

All Spectrum Analyzers can perform power measurements on simple carriers and even complex digital modulation without special software. Just put the SA into the dBm scale. However, for the complex digital-modulation signals, you need to compensate for the video-bandwidth setting of the SA, compared to the channel-bandwidth of the digital-modulation signal.

For a simple un-modulated carrier signals, because the bandwidth of the signal is so narrow (less than 1 KHz), the peak reading of the carrier is directly equal to the output power-level.

Mike WA6SVT (a commercial television station engineer) explained to me that for a more complicated RF signal such as a DVB-S/QPSK "hay-stack" (see Fig 2 as an example), the Video BandWidth (VBW) and Resolution BandWidth (RBW) setting on the Spectrum Analyzer has to be set to a value that is a little wider than the DATV signal you want to measure. If the RBW can be set correctly, then the DATV average power level is the value displayed at the top of the "hay stack".

On my entry-level Rigol DSA815, the largest VBW and RBW setting available is 300 KHz. This bandwidth is too small to directly measure power on a DATV signal that has 3 MHz or greater Occupied BandWidth. Fortunately there is a mathematical conversion that can compensate for a narrow VBW/RBW setting. Ron W6RZ and Rob M0DTS both suggested to me on the Yahoo DigitalATV Forum that the correction factor in dB for spectrum analyzers is:

10*log10 (channel bandwidth/resolution bandwidth)

Rigol optionally sells a software-add-on accessory to measure power directly called DSA800-AMK (Advanced Measurements Kit). The Channel Power mode of this kit uses the built SA microprocessor to integrate the power level measurements over an "integration BW" that you can select.

Fig 9 is a display of the optional Channel Power mode measuring the RF output of a bare-foot DATV-Express board signal running SR=2.2 MSymb/sec at 1292 MHz. The integration BW was set to 4 MHz for this measurement of 13.81 dBm power output.

This Channel Power mode option certainly makes it simple to measure DATV power levels. No more worrying if the Bird power meter you are using is a bolometer/thermal type or not...and without digging out your scientific log calculator. The optional cost of the Rigol Model DSA800-AMK kit is US$499.

"Secret" Demo-Mode for Options

One complaint that I have is that NONE of the Rigol (or Rigol distributor) literature or web site materials explains that most of the extra-cost software options are available as a free demo

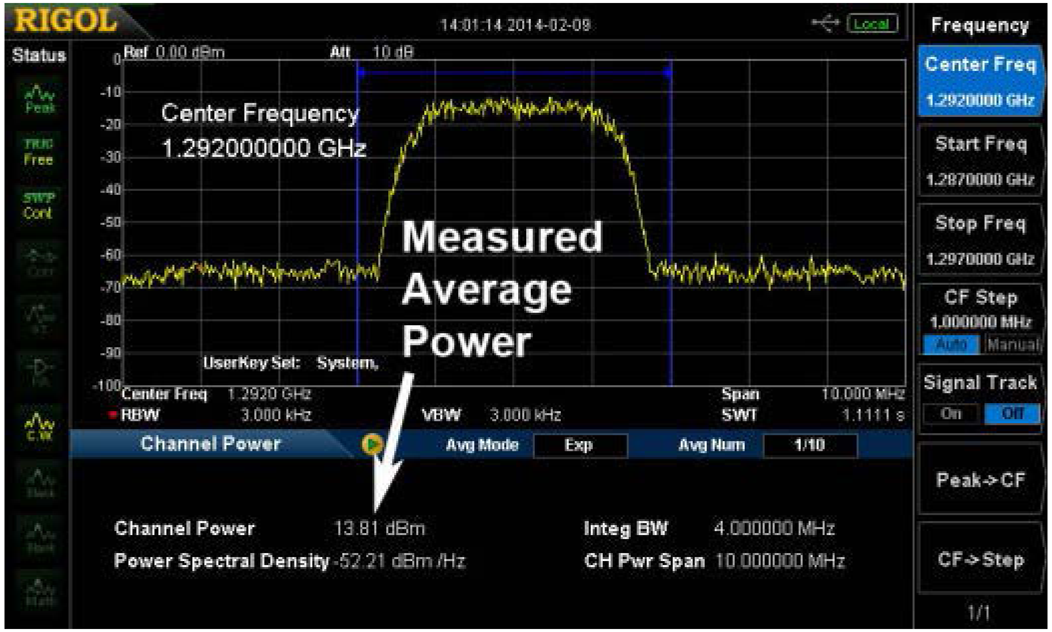


Figure 9 - Display of Channel Power option measuring 13.81 dBm average power (DVB-S at 2.2 MSymbols/sec)

mode to try out. The time-out period on the demo-modes is 200 hours of Rigol Spectrum Analyzer power-on. A phone conversation with technical support of Rigol (quite good at helping me use the instrument) hinted about the unpublicized demo-mode...but he did not have any real details of trial-period, etc. I finally discovered the "secret" demo-mode when I only had about 11 hours of use left to try them out.

Easy Screen-Capture Feature

A small feature on the Rigol SA that I really enjoy using is the one-button screen capture directly to an inserted USB-memory-stick. Just plug the USB-memory into the front-panel USB port...make sure the screen displays what you want to record...and press the PRINT button on the SA. Capturing the screen (just as displayed) could not be easier. I wish Windows would think about providing a setting for printing the screen directly to a USB-memory-stick.

Conclusion

While not essential, a Spectrum Analyzer is a very useful instrument to have available for looking at DATV signals. For normal DATV usage, viewing the SA is perfect for adjusting the drive into RF power amplifiers. An over-driven PA starts to exhibit spectral-regrowth distortion where the distortion creates a signal that grows wider and wider as the drive level is increased. The problem with spectral-regrowth is that the received video still looks good, but more and more RF interference is occurring on the sides of your intended signal. DATV uses include:

- Adjusting RF power amplifier drive
- Inspecting quality of transmitted signal
- Confirming any spurs are low-level

- Checking for undesired harmonics
- Tuning band-pass filters
- Adjusting SWR on antennas
- Measuring power of digital-modulation
- Pointing antenna to weak DX signal (Spectrum Analyzer will see weak signal faster than STB can lock onto to the signal)

Contact Info

The author may be contacted at W6HHC@ARRL.net

Useful URLs

Rigol Technologies (North America) - see www.Rigolna.com/

Rigol (United Kingdom) - see www.Rigol-UK.co.uk/

TEquipment USA Distributor for Rigol - see www.TEquipment.net/

YouTube "Tear-down" of Rigol DSA815-TG unit (EEVblog #391) - see www.youtube.com/watch?v=EY0acWrCYjw

BATC info site for DTX1 DVB-S exciter - see www.DTX1.info

British ATV Club - Digital/DigiLite/DTX1 forums - see www.BATC.org.UK/forum/

DATV-Express Project web site (SDR-based exciter) - see www.DATV-Express.com

British ATV Club - Digital Forum - see www.BATC.org.UK/forum/

Orange County ARC entire series of newsletter DATV articles - see www.W6ZE.org/DATV/

Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/

dBm to Watt power convertor - see www.rapidtables.com/convert/power/dBm_to_mW.htm

DATVtalk08 Digital ATV - Understanding DVB-S Protocol

by Ken Konechy W6HHC
and Bandwidth Updates by Hans Hass DC8UE

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the seventh article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was the beginning of this series and presented an introduction article about Digital-ATV.]

There are about four protocols being tried by hams for Digital-ATV (DATV) today. The four protocols were described in DATVtalk02. These DATV protocols are:

- DATV-S (originally used for commercial Standard Definition [SD] satellite transmissions)
- DATV-T (originally used for commercial SD terrestrial transmissions…over-the-air to your TV)
- DATV-S2 (originally used for commercial HDTV satellite transmissions)
- ITU-T_J.83-B (originally used for US/Canada cable-TV-industry transmissions)

Ken plans to cover each of these protocols in future articles. But, today we start with the DVB-S protocol.

This month, DATVtalk will explain a few Digital-ATV concepts that are typically not understood by most hams and even analog ATVers. Using the DVB-S standard to transmit a digital ATV signal involves:

- MPEG-2 compression data rates for video
- Video bit-rate needed
- Net Data bit-rate available
- Symbol-Rates
- FEC (Forward Error Correction) algorithms
- QPSK (Quadrature Phase Shift Keying) digital modulation
- RF Bandwidth

This article will now walk through these various DATV factors and arrive at determining the resulting RF bandwidth for DVB-S.

Video Data-Rate and Compression

DATV needs to compress the video data rate from a camera to a manageable value using video compression technology such as MPEG-2 or MPEG-4. Today, most hams use Standard Definition digital TV (SDTV) using MPEG-2. For DATV, the analog camera output (NTSC or PAL) is first digitized by the MPEG-2 Encoder board shown in Fig 1, and then compressed by the MPEG-2 algorithm. The reason the compressed video data rate varies in Table 1 is that the low value means little motion (a “talking head” QSO) in the video scene and the higher value means a lot of motion (like a soccer game). In the near future, digital cameras will find their way into mainstream ham DATV.

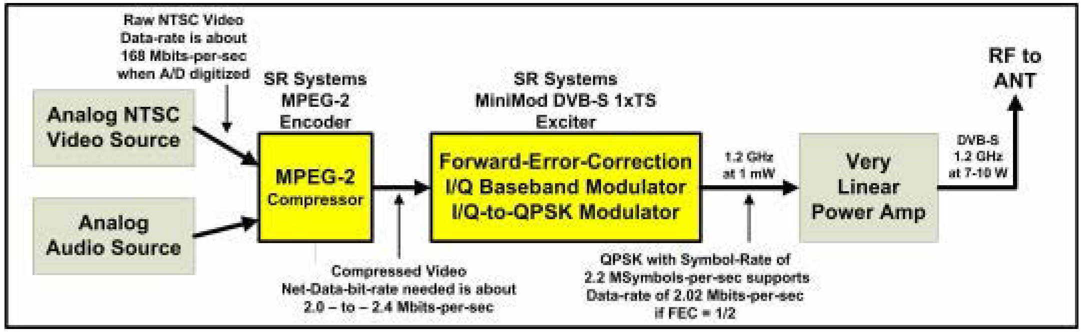


Figure 1 DATV Block Diagram Showing Various Data-Rates and Symbol-Rates for DVB-S QPSK(for 2.2 MSymbols-per-sec, the Bandwidth is 3 MHz)

Table 1 – Camera Video Data Streamsand MPEG-2 Data Streams

Video Data Stream	Data-Rate	Notes
Analog NTSC camera	168 Mbits/sec	A/D digitized, uncompressed
NTSC MPEG-2	2-3 Mbits/sec	compressed
VHS MPEG-2	1-2 Mbits/sec	compressed
Analog PAL camera	216 Mbits/sec	A/D digitized, uncompressed
PAL MPEG-2	2.5-6 Mbits/sec	compressed
HDTV camera	1-1.5 Gbits/sec	uncompressed
HDTV MPEG-2	15-60 Mbits/sec	compressed
HDTV MPEG-4	12-20 Mbits/sec	compressed

Stefan-DG8FAC of SR-Systems (located in Germany...see links at the end) has explained to me that in Europe many hams set the MPEG-2 output data-rate to be 2.5 Mbits/sec for PAL. Stephan further suggests that the MPEG-2 output data-rate for NTSC would be about the same. I suspect that for NTSC there should be about a 22% reduction in MPEG-2 output data-rate from PAL, to about 2.0 Mbits/sec. I originally planned for a 2.5 Mbits/sec video stream. But when I finally tested my station DVB-S transmitters, I measured that the NTSC MPEG-2 output (including audio) displayed reasonable quality all the way down to a data-bit-rate reduced to about 1.9 Mbits/sec stream. For comparison, I also added a row to show MPEG-4 compression with HDTV.

FEC Inflation of Video Stream Data-Rate

Forward Error Correction (FEC) is a technology that not only can detect an error on the received signal, but adds enough redundancy of the data so that it can correct the wrong bit. It can even correct two wrong bits. Since redundancy increases the data-rate of the video stream, there is a trade-off between more redundancy and the required video data-rate becoming too large. As we will see a little later in this article, the larger the video stream data-bit-rate, the higher the required RF bandwidth. So at some point the FEC algorithm will not have enough redundancy to correct too many errors, and the DATV screen will go blank.

The DVB-S commercial television standard uses two different Forward-Error-Correction (FEC) algorithms together in order to provide protection against noise errors and multi-path errors. The first FEC algorithm is called Viterbi. The second FEC algorithm is called Reed-Solomon.

The Viterbi FEC algorithm can be configured for different levels of error correction. These different Viterbi configuration/redundancy settings are usually called: 1/2, 2/3, 3/4, 5/6 and 7/8. The first number (“1” in the case of configuration 1/2) is the number of input bits. The second number (“2” in the case of configuration 1/2) is the number of output bits from the FECviterbi algorithm. So the MPEG-2 output data stream is “inflated” 100% by this FEC algorithm configured for 1/2. That is...for every bit going into the FEC engine, two bits come out. A FECviterbi algorithm configured for 3/4, for example, would inflate the MPEG-2 output data stream by 33%. So FEC levels can really inflate the data-bit-rate going to the RF modulator; the MPEG-2 algorithm compresses the video stream, but the FEC algorithms start to expand the required data-bit-rates again.

The Reed-Solomon FEC algorithm has a fixed configuration. Its data stream “inflation rate” is 188/204. So for every 188 bits going into the FECreed-solomon algorithm, 204 bits come out...an additional FEC inflation of 8.5%.

Digital Modulation Symbols and Symbol-Rates

Digital modulation technology like BPSK (for example PSK-31), QPSK (Quad Phase Shift Keying – like DVB-S) and QAM256 (Quadrature Amplitude Modulation with 256 “constellation points”) have the ability to put more information into a narrow frequency spectrum than analog modulation. The complexity of the digital modulation scheme, allows us to pack more "data bits" into each SYMBOL. Table 2 lists out how many data bits can be packed into a symbol for several well-known digital modulation technologies.

Table 2 – Symbol Bit-Packing for
Various Digital Modulation Technologies

Modulation Scheme	Data Bits per Symbol (Me)
BPSK	1
QPSK	2
8-VSB	3
QAM16	4
QAM256	8

Table 2 means that QPSK will pack two data bits into each symbol being modulated. If we know the final output data-bit-rate (I will call this inflated data rate the "Gross Data-Bit-Rate") we need for the television signal, then the "symbol-rate" we need is exactly one-half of that data-bit-rate. For example:

Gross Data-Bit-Rate = 4.5 Mbits/sec
Symbol-Rate Needed = 2.25 MSymbols/sec

The formula to calculate the Symbol-Rate setting that I need for my DVB-S transmitter is:
Symbol-Rate Needed = NDBR / (Me x CRv x CRrs)
Where:
NDBR = Net Data Bit Rate (aka the information rate)
Same as MPEG-2 output stream data rate in Table 1
Me = Modulation Efficiency (2 for QPSK in Table 2)
CRv = Correction Rate setting for Viterbi (1/2, 3/4, etc)
CRrs = Correction Rate value for Reed-Solomon is
188/204

I will now calculate an example for QPSK where the output of MPEG-2 is 2.4 Mbits/sec and FECviterbi is configured to a value of 1/2.

$$\text{Symbol-Rate Needed} = \frac{2.4\ \text{Mbit/sec}}{2\ \text{bits/symb} * (1/2) * (188/204)}$$

$$\text{Symbol-Rate Needed} = \frac{2.4\ \text{Mbit/sec}}{0.921\ \text{bits/symbol}}$$

Symbol-Rate Needed = 2.65 MSymbols/sec

If I change the FECviterbi setting to 3/4, then the CRv value becomes 3/4 and the results are:

Symbol-Rate Needed = 1.73 MSymbols/sec

The Symbol-Rate that is needed was reduced because the "inflated data-rate" caused by a lot of FEC redundancy was reduced. The values inside Table 3, shows the Net Data Bit Rate that can be supported by a particular Symbol-Rate using several FEC settings. The FEC setting needs to result in a number of Net Data Bit Rate that is at least 2.4 Mbits/sec. The red values in the table show FEC settings or Symbol-Rates that result in a Net Data Rate of less than 2.4 Mbits/sec that I set as my goal for MPEG-2 video stream output.

Confusion about the word "Bandwidth"

Note – Hans DC8UE, who has many years of experience as a satellite communications engineer for commercial television, was very kind to spend a lot of time to help me understand RF bandwidth for DATV. While talking to hams in Europe about DVB-S DATV repeater designs, Ken noticed that sometimes he was given unexpected values of RF bandwidths being used by the European repeaters. The Symbol-Rates (S/R) being reported by the repeaters were always accurate

Table 3 – Symbol Bit-Packing forVarious Digital Modulation Technologies

Modulation	FEC Coderate	DVB-S RF BANDWIDTH for DATV (RF BWallocation = SymbolRate x 1.33)					
		2.0 MHz (SR = 1.5 MS/sec)	2.5 MHz (SR = 1.88 MS/sec)	3.0 MHz (SR = 2.25 MS/sec)	4.0 MHz (SR = 3.0 MS/sec)	5.0 MHz (SR = 3.75 MS/sec)	6.0 MHz (SR = 4.50 MS/sec)
QPSK	1/2	~~1.38~~	~~1.73~~	2.07	2.76	3.46	4.15
	2/3	~~1.84~~	2.30	2.76	3.69	4.61	5.53
	3/4	2.07	2.59	3.11	4.15	5.18	6.22
	5/6	2.30	2.88	3.46	4.61	5.76	6.91
	7/8	2.42	3.02	3.63	4.84	6.05	7.26

NOTE-1: NTSC Analog Camera produces about 2.0 Mbits-per-sec MPEG-2 output for Ham Radio type broadcasts. The encoded audio data rate is usually at least 64 Kbps.

NOTE-2: The Net Data Bit-Rate values inside the Table need to be at 2.07 Mbps or larger to support the expected camera and audio data rates coming from MPEG-2 encoder

Note-3: The Net Data Bit-Rate values inside the table shown in RED (with strikethrough) are Net Data BitRates that are too small to support the payload data stream.

(Symbol-Rate is always a setting in the transmitter, so it is well known), but the RF bandwidth reported by repeater owners sometimes had an unexpected relationship to Symbol-rate. A little searching on the internet (love the Google and Bing search engines) showed that there are at least three popular ways methods of defining RF Bandwidth for DVB-S.

- “minus 3 dB” bandwidth method
- "occupied" bandwidth method
- "allocation" bandwidth method

So if you were to ask three different hams “what DATV bandwidth are you using?”...you may get three different answers when talking about the same DATV DVB-S repeater!!

The authors agree that the most important purpose of describing bandwidth for DATV hams...is to provide a value that can be used for band-plan spacing and frequency coordination to avoid adjacent interference. Now we will look at these three methods of describing RF Bandwidth for DVB-S (QPSK modulation).

“minus 3 dB” bandwidth method

With this method, the bandwidth is measured at the points that are down 3 dB. This is a typical method for measuring an analog filter bandwidth and represents the “half-power point” if you are looking at voltage on a spectrum-analyzer.

Mathematically, BW-3dB ~S/R for this definition of bandwidth

While the BW-3dB method is very familiar to analog engineers and analog ATVers, it is not very useful for DATV to define the bandwidth of a digital signal transmission link for two reasons.

First, creating a digital-(pulse-)modulation signal produces a non-Gaussian signal-flank (shape).

Second, you would not want to space the frequencies of several DATV stations “shoulder-to-shoulder” on their 1/2–power points, since significant power would overlap neighboring frequencies. This approach to spacing of stations would create potential receiving interference. Especially, if several DATV repeaters are located together on the same hill-top or tower so that receiving antennas are pointing in the same direction toward adjacent DATV repeaters.

As a note: The bandwidth of the DVB-S carrier at the minus 3.8 dB points is approximately the same as the symbol rate (S/R).

"occupied" bandwidth method

As defined by the commercial satellite standard, 3GPP TS 34.121, section 5.8, the Occupied Band-Width (OBW) is the bandwidth containing 99% of the total integrated power of the transmitted spectrum, centered on the assigned channel frequency.

Mathematically for hams: BWoccupied = 1.19 x S/R

How is the occupied bandwidth measurement determined? During this measurement, a Gaussian filter with a bandwidth greater than 10MHz and a resolution bandwidth (RBW) of 30 kHz or less is used to measure the distribution of the power spectrum.

First, the total power found in the measured frequency range is calculated.

Then, starting at the lowest frequency in the range and moving upward, the power distributed in each frequency is summed until this sum is 0.5% of the total power. This gives the lower frequency value for measuring the bandwidth.

Next, starting at the highest frequency in the range and moving downward, the power distributed in each frequency is summed until 0.5% of the total power is reached. This gives the upper frequency value. The bandwidth between the 0.5% power frequency points is called the “occupied bandwidth”.

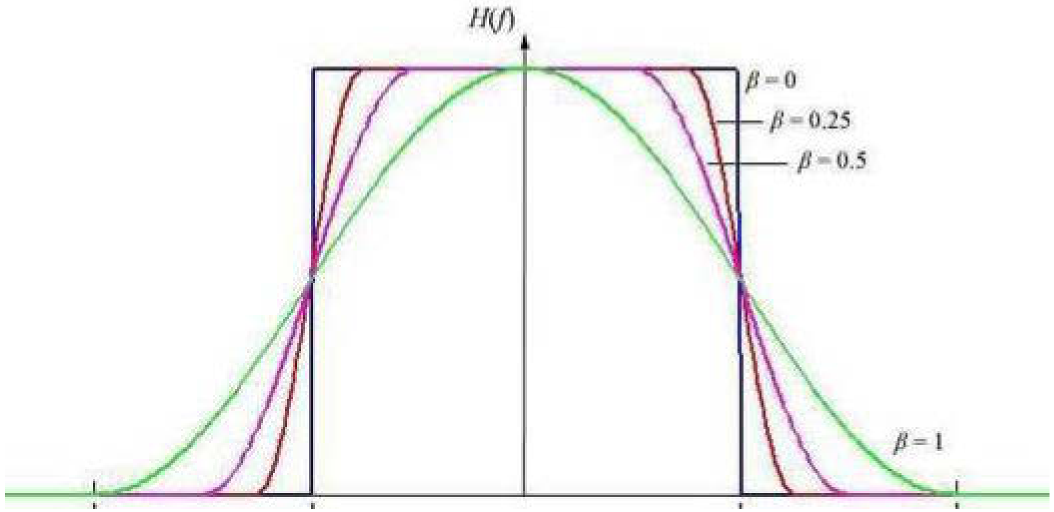
While the "occupied" bandwidth spacing of repeater frequencies is better at preventing adjacent interference than “minus 3 dB” bandwidth spacing, it still lacks one feature. The spacing should have a little guard-band to allow for unplanned obstacles ...like signal-path nonlinearity, etc.

"allocation" bandwidth method

This method for describing bandwidth provides a little guard-band between adjacent DATV signals. The allocation bandwidth for DVB-S is calculated as

BWallocation = (1 + Roll-off-Factor) x Symbol-rate
BWallocation = 1.35 x S/R

when using a 0.35 Roll-off-factor. The Roll-off-factor (as



shown in Fig 2) controls the grade of the slope of a DVB-S signal-edge.

Figure 2 – Different roll-off slopes for different Roll-off-factors

The “allocation bandwidth” is determined by the big commercial satellite-providers (like inside the Intelsat Earth Station Standard 420: (IESS420e.pdf) as an area, inside that the power-level will be not be lower than –26dB. There will be a filtering necessary on the signal borders (mostly performed by software), which takes care, that the borders rolls out weakly. The grade (slope) of this roll off will be described by the Rolloff-factor. It shows the relationship between half of the roll off area to half of the wanted channel-bandwidth.

The DVB-S standard specifies the Roll-off-factor at 0.35. A raised cosine filtering at the edge region for the transmission path is required. The used filter generates in a first step only a root raised cosine shape. Only in combination with the same filtering inside the receiver you will get the wanted raised cosine form of the filter shape.

Choosing an RF Bandwidth for DVB-S DATV

It turns out, one of the advantages of digital-ATV is it can be more bandwidth-efficient than analog-ATV. With DVB-S and QSPK modulation you actually have the ability to easily make the DATV RF bandwidth as narrow as 2 MHz or 3 MHz without giving up any noticeable quality. This is because the commercial DTV standards planned to transmit several Television streams inside one normal (old) RF TV bandwidth.

Fig 3 shows a D-ATV DVB-S QPSK signal using a 1.5 MSymbols/sec symbol-rate of (generated by a MiniMod). It shows clearly 2.025 MHz of used bandwidth.

Below 35dB you can see the additional shoulders, generated by distortion on the non-linear characteristic curves of the RF amplifiers being used. There is more on non-linearity, later in this article. The “allocation bandwidth” is in practice really very useful to describe the real used bandwidth for spacing DATV repeater frequencies. However, for ham radio, Ken

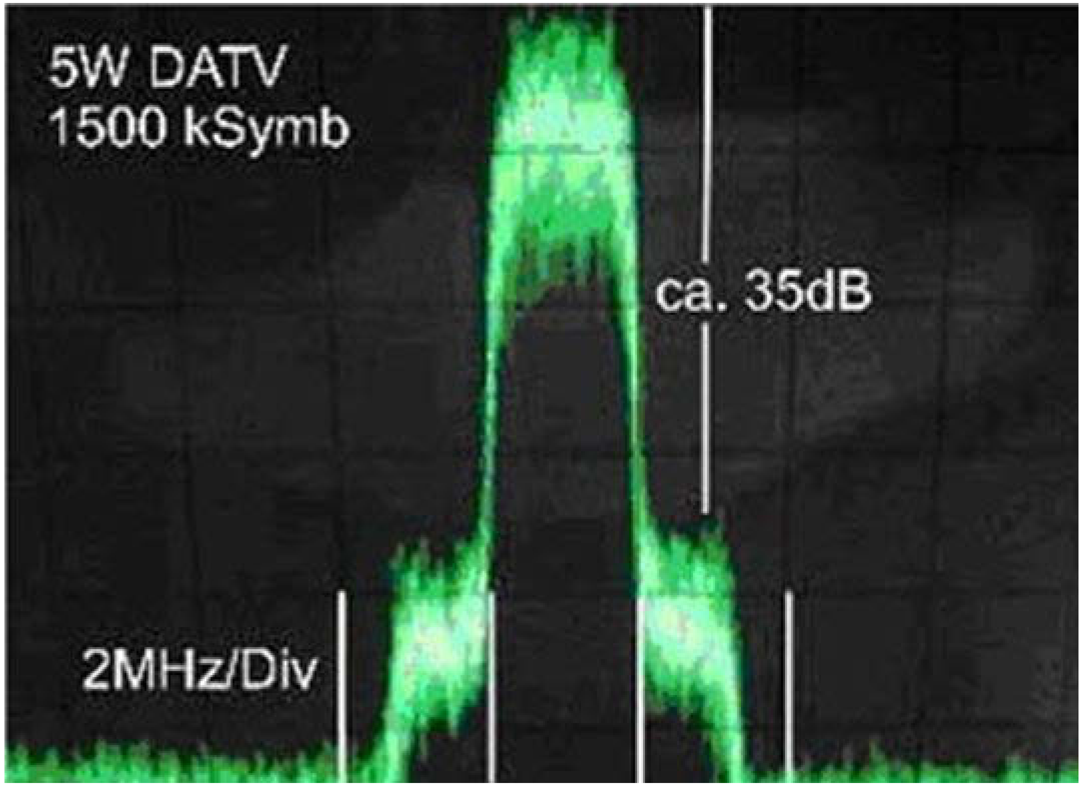
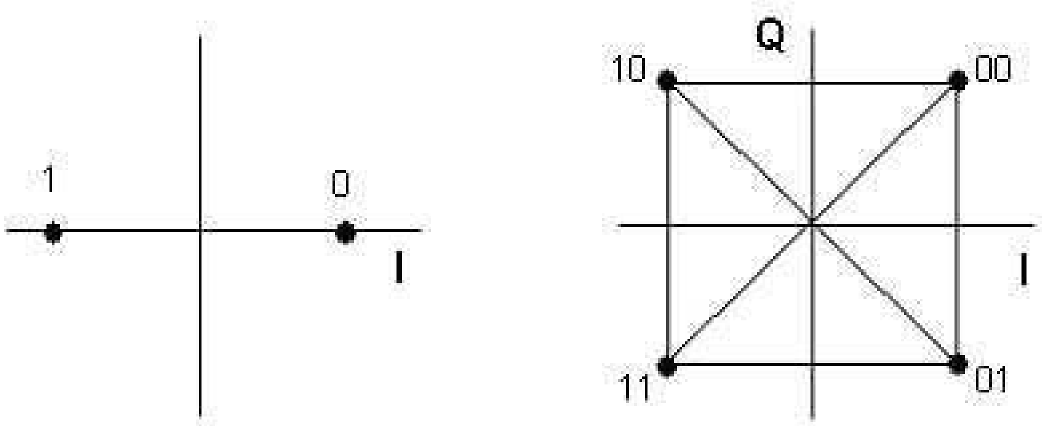


Figure 3 – DATV QPSK signal at 1.5 M Symbol/sec produces 2.025 MHz of bandwidth

W6HHC prefers to “adjust” the bandwidth allocation formula slightly to

BWallocation ~ = 1.33 x S/R

Ken explains that this “adjusted value” is less than a 2% error and is much easier to calculate in his head. The authors both agree that hams should only use the term BWallocation when they talk about DVB-S RF bandwidths for DVB-S. As Table 3 displays, a 3 MHz RF bandwidth can be achieved with plenty of error correction capacity (FEC = 1/2) by selecting a Symbol-Rate of 2.25 M Symbols/sec.



Non-Linearity effects on QPSK bandwidth

Digital modulation using phase shifting (PSK) like BPSK or QPSK transitions from one state to another state. For QPSK, you are always in one of four states...and your next transition can be to any of those four states, as shown in Fig 4.

Figure 4 – Theoretical transitions in the I-Q plane made by BPSK (on the left) with two states and by QPSK modulation with four states.

However, non-linearity in the RF amplifiers can cause the received values of I and Q to contain errors from the theoretical. It is extremely important, to avoid compression in the power amplifier and to operate the signal path and PA in a linear mode. Figures 5 and 6 show the effects of increasing non-linearity on the transition of states for QPSK modulation. You can see in Fig 7, that the power levels of the shoulders (aka spectral regrowth) have grown to 20 dB below the carrier. This will splatter power into adjacent frequencies outside of the allocated bandwidth.

See figures 5, 6 & 7 on the last page of this article.

So while the average power level may seem low, the peaks can be going into compression (or even flat-topping in saturation), hence nonlinearity and hence stronger shoulder power levels. Commercial satellite-uplink operators adjust their shoulders to be more than 26 dB below the main carrier. Likewise, it should be the duty of hams that operate DVB-S repeaters and transmitters to not allow the shoulders to get within 26 dB of their main carrier in order to avoid interference to nearby frequencies.

Conclusion

The authors are impressed that the DVB-S protocol brings ATV to a whole new level of performance for hams compared to the old analog technology. The Forward Error Correction and QPSK modulation are very robust...and it allows a savings in RF bandwidth for ATV. My own field tests show that DVB-S overcome snow (weak signals) and ghosts (multi-path propagation) that had plagued analog-ATV transmissions in the same locations. It is no wonder that today; DVB-S is the most widely-used protocol for DATV.

Contact Info

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Useful URLs

- British ATV Club – Digital/DigiLite/DTX1 forums – see www.BATC.org.UK/forum/
- BATC info site for DTX1 DVB-S exciter – see www.DTX1.info
- DATV-Express Project web site (SDR-based exciter) – see www.DATV-Express.com
- DigiLite Project for DATV (derivative of the “Poor Man's DATV”) – see www.G8AJN.tv/dlindex.html
- Orange County ARC entire series of newsletter DATV articles – see www.W6ZE.org/DATV/
- PE1JOK and PE1OBW on “The Ultimate Resource for Digital Amateur Television” – see www.D-ATV.com

- SR-Systems D-ATV components (Boards)
  – see www.SR-systems.de
- Yahoo Group for Digital ATV
  - see groups.yahoo.com/group/DigitalATV/

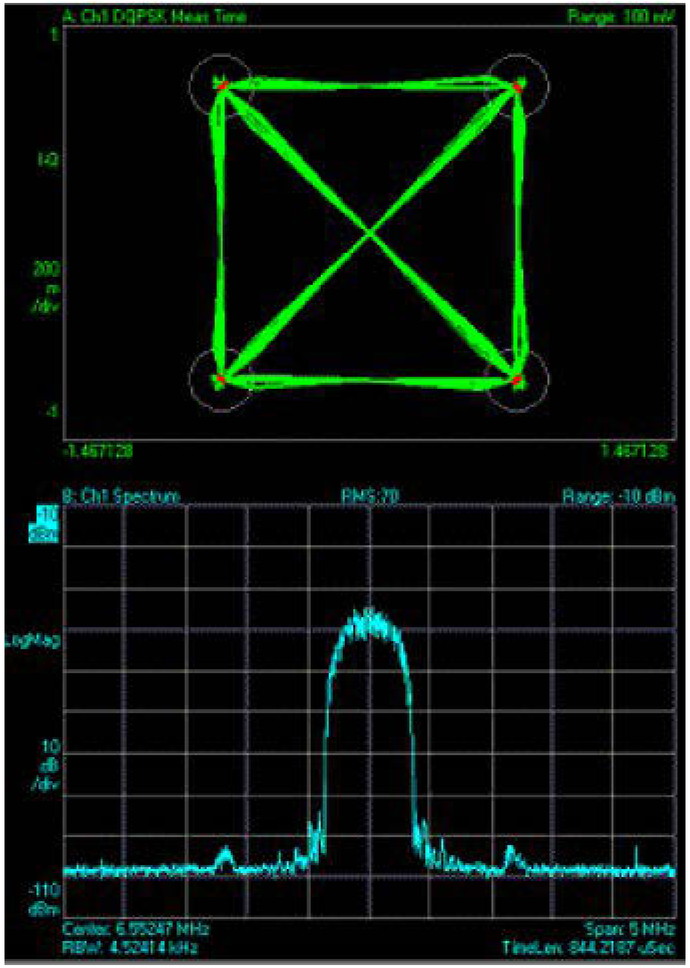

Figure 5 - Real-world QPSKstate transitions closely match theoretical with good linearity

Photo courtesy of PE1JOK and PE1O(BW)

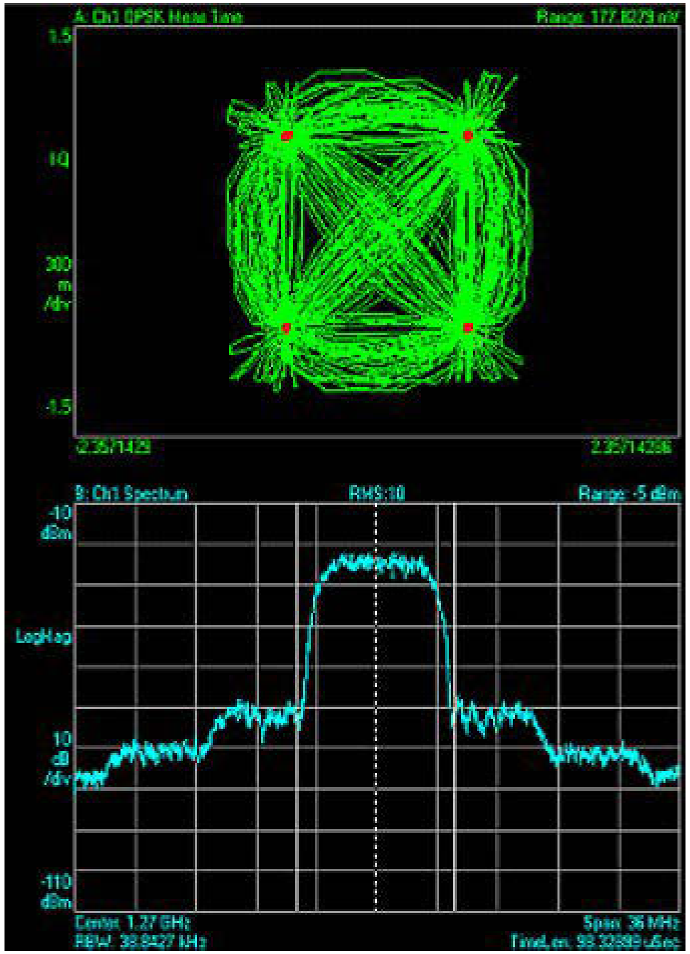

Figure 6 – More amplifier non-linearity increases errors as power increases

(Photo courtesy of PE1JOK and PE1OBW)

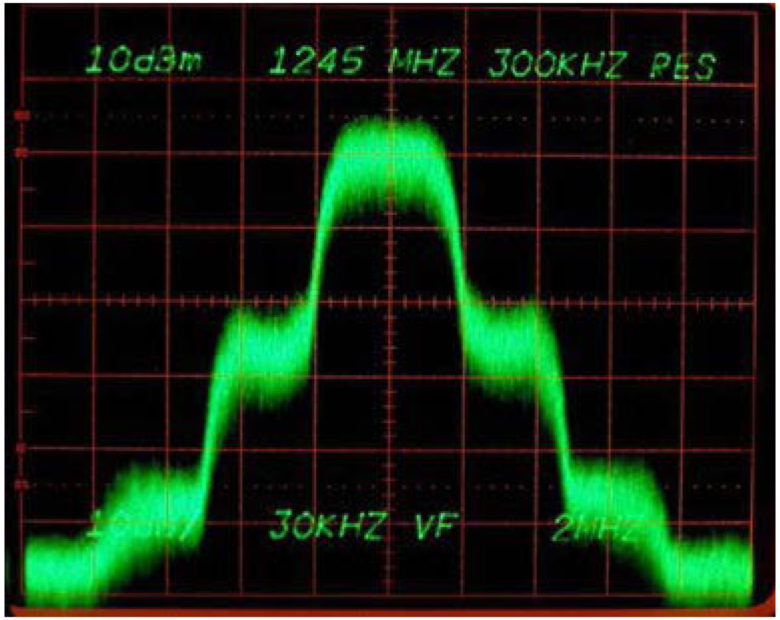

Figure 7 – Spectral regrowth after amplification with shoulders now only 20 dB below the carrier

(Photo courtesy of Art-WA8RMC)

DATVtalk09 DigitalATV - Understanding DVB-T Protocol

by Ken Konechy W6HHC

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the eighth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was the beginning of this series and presented an introduction article about Digital-ATV.]

Many of the earlier DATVtalk articles about Digital-ATV have provided details about how DVB-S modulation works. DVB-S is currently the most popular modulation standard being used by hams for DATV. This month I will look at some of the technical details of DVB-T protocol/modulation.

The "T" in DVB-T protocol means that it is designed to work well for terrestrial transmissions to your commercial DTV set at home. Fig 1 shows a typical home terrestrial broadcast receiving station using a Set-Top-Box (STB).

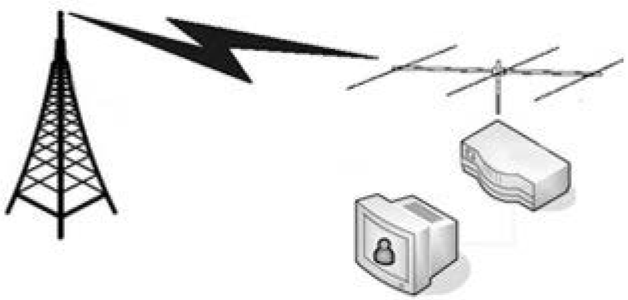

Figure 1 - Terrestrial Reception using a Commercial Set-Top-Box (STB)

DVB-T is used for home terrestrial reception of commercial television in much of the world (Europe, Asia, and Pacific). In the United States and Canada, the competing DTV broadcast standard for terrestrial reception is called ATSC. A comparison table for the PROs and CONs between DVB-T and ATSC and DVB-S technologies can be found near the end of this article.

Typical Transmitter Block Diagram

Groups and clubs of DATV enthusiasts have shown that DVB-T digital technology is possible for hams. Fig 2 is a block diagram of a basic DVB-T transmitter used by several groups in Europe and Australia for DATV. The analog camera and video is compressed by a MPEG-2 encoder board. The TransportStream (TS) digital data is fed to the exciter board that does a lot of complicated data processing and then converts the digital data directly to modulated RF at a desired frequency. The small RF output signal of the exciter board is typically amplified by two stages of very linear RF amplifiers.

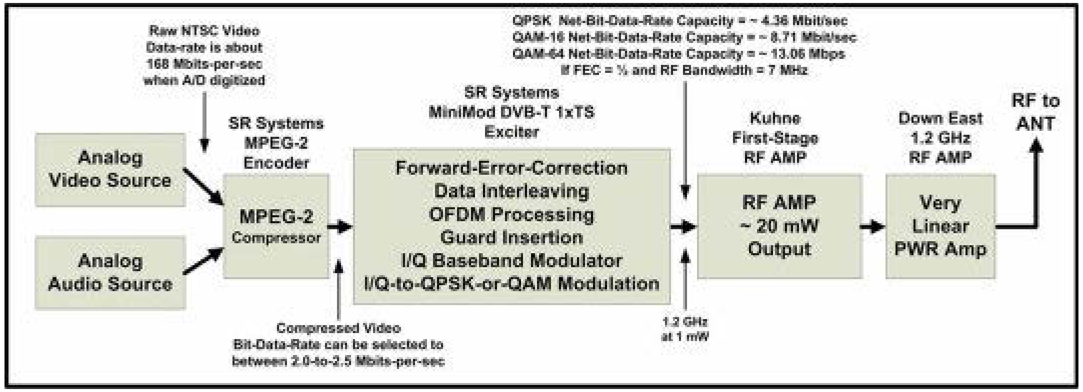

Figure 2 – Block Diagram of Typical DVB-T Transmitter for DATV)

Video Data-Rate and Compression

For DATV, the analog camera output is first digitized by the MPEG-2 Encoder board shown in Fig 2, and then compressed by the MPEG-2 algorithm. The reason the compressed video data rate varies in Table 1 is that the small value means little motion in the video scene and the larger value means a lot of motion. MPEG-2 encoding can be used in two modes: (a) constant output mode per frame with null packets inserted as needed and (b) variable data per frame. Below are two uses for these two modes of encoding:

a) Encoding for DVB-T uses constant data rate with null inserts as needed

b) Encoding for DVD burning uses variable data per frame

Table 1 – Camera Video Data Streams and MPEG-2 Data Streams

Video Data Stream	Data-Rate	Notes
Analog NTSC camera	168 Mbits/sec	A/D digitized, uncompressed
NTSC MPEG-2	2-3 Mbits/sec	compressed
VHS MPEG-2	1-2 Mbits/sec	compressed
Analog Pal Camera	216 Mbits/sec	A/D digitized, uncompressed
PAL MPEG-2	2.5 -6 Mbits/sec	compressed
HDTV camera	1-1.5 Gbits/sec	uncompressed
HDTV MPEG-2	15-60 Mbits/sec	compressed
HDTV MPEG-4	12-20 Mbits/sec	compressed

Notice in Table 1 that the digitized NTSC camera video data-bit-stream is 168 Mbits/sec before compression, and MPEG-2 encoding (compression) will reduce this to a Net-Bit-Data-Rate between 1 and 3 Mbps, which is quite a reduction.

The MPEG-2 encoder I use makes a direct measurement of the compressed video rate not practical. Discussions with many hams in Europe reveal that they plan for the MPEG-2 output payload data-rate to be set typically between 2.0 and 2.5 Mbits/sec for PAL with excellent results for D1 video resolution. My own DATV tests show that settings of either 2.0 or 2.1 Mbps provide excellent video quality for NTSC. [As a note: the TechTalk85 article in the OCARC DATV library (URL is listed at the end) provided a detailed look at how the MPEG-2 processing works.]

FEC Inflation of Payload Data Stream Data-Rate

Forward Error Correction (FEC) is a technology that not only can detect errors on the received signal, but adds enough redundancy of the data so that it can correct several wrong bits. But, there is a trade-off when choosing the amount of redundancy. Since redundancy inflates the data-rate of the output stream, the trade-off is between more redundancy or keeping the inflated data-rate smaller. As we will see a little later in this article, the larger the inflated output data-rate, the higher the required symbol rate. Higher symbol rates may force you to a wider-bandwidth or a more noise-sensitive modulation scheme. So at some point the FEC algorithm will not have enough redundancy to correct too many errors, and the DATV receiver screen will go blank or freeze.

The DVB-T commercial television standard uses a combination of two different Forward-Error-Correction (FEC) algorithms together in order to provide protection against noise errors and multipath errors. The first FEC algorithm is called the inner-Punctured-Convolutional-Code by the DVB-T specification (and typically called Viterbi in DVB-S articles). The second FEC algorithm is called Reed-Solomon. These two algorithms are the same as those used in DVB-S technology.

Convolutional encoding with Viterbi decoding is a FEC technique that is well suited to a channel in which the transmitted signal has been corrupted by Gaussian noise. The inner-Punctured-Convolutional-Code FEC algorithm can be configured for different levels of error correction. These different Puncture-Table redundancy settings are usually called: 1/2, 2/3, 3/4, 5/6 and 7/8....where the first number (“1” in the case of con-figuration 1/2) is the number of input bits. The second number ("2" in the case of configuration 1/2) is the number of output bits from this FEC algorithm.

So the MPEG2 output data stream is "inflated" 100% by this FECviterbi algorithm configured for 1/2. That is...for every bit going into the FEC engine, two bits come out. A FECviterbi algorithm configured for 3/4, for example, would inflate the MPEG-2 output data stream by 33%. So FEC levels can really inflate the data-bit-rate going to the RF modulator; the MPEG-2 algorithm compresses the video stream, but the FEC algorithms start to expand the required data-bit-rates again.

The second algorithm that is used, the Reed-Solomon FEC algorithm, has a fixed configuration. Its data stream "inflation rate" is 188/204. So for every 188 bits going into the FECreed-solomon algorithm, 204 bits come out...an additional FEC inflation of 8.5%.

Digital Modulation Symbols and Symbol-Rates

Digital modulation technology like BPSK (for example PSK-31), QPSK (Quad Phase Shift Keying – like DVB-S and DVB-T) and QAM-256 (Quadrature Amplitude Modulation with 256 "constellation points") have the ability to put more information into a more narrow frequency spectrum than analog modulation. The complexity of the digital modulation scheme, allows us to pack more "data bits" into each SYMBOL. Table 2 lists out how many data bits can be packed into a symbol for several well known digital modulation technologies.

DVB-T technology users can choose between QPSK, QAM-16, or QAM-64 modulation schemes (shown in BLUE) for the COFDM sub-carriers discussed latter.

The higher-order modulations schemes, like QAM-16 and QAM-64) can "pack" more bits into the symbol rate than QPSK. But, the complexities for QAM-16 and QAM-64 modulation make them more susceptible to noise and

Table 2 – Symbol Bit-Packing for Various Digital Modulation Technologies Modulations in BLUE can be selected for DVB-T

Modulation scheme	Data Bits per Symbol (Me)
BPSK	1
QPSK	2
8-VSB	3
QAM 16	4
QAM 64	6
QAM 256	8

interference. Fig 3, Fig 4, and Fig 5 are intended to give an appreciation of the increasing complexities for these three modulation schemes.

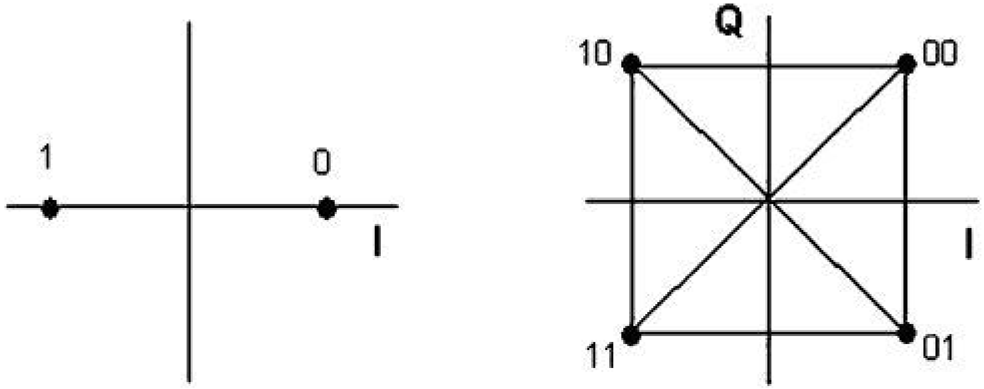

Figure 3 – The constellations of BPSK (on the left) with two states and by QPSK with four states.

Notice in Fig 4 that not only is the angle from the origin to the state important, but the amplitude from the origin is critical, also. The I-axis amplitude of the signal can have four different values. The Q-axis (shown as the R-axis in this drawing) can also have four amplitude values.

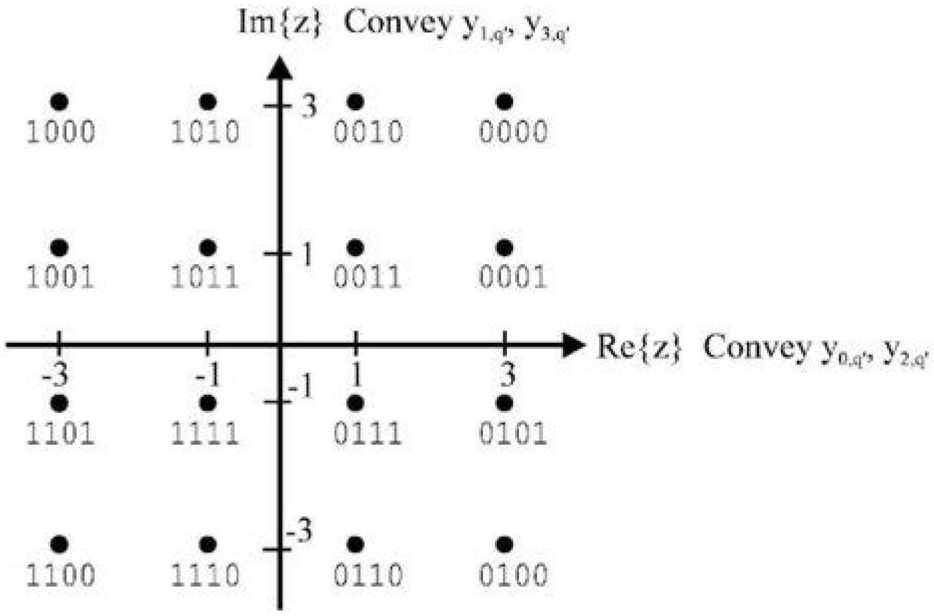

Figure 4 – The constellation for QAM-16 modulation contains 16 states. Each state defines four bits of data.

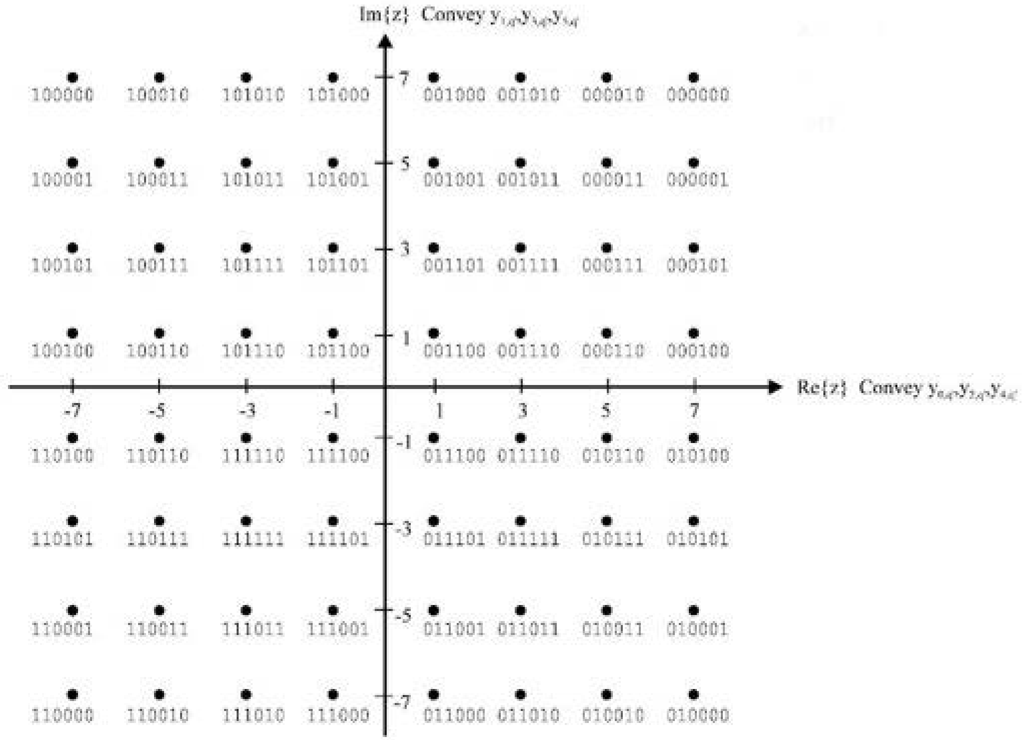

Figure 5 – The constellation for QAM-64 modulation contains 64 states. Each state defines six bits of data.

I use Fig 3 and 4 and 5 to help me to visualize the differences between the complexities of QPSK, QAM-16 and QAM-64 modulation technologies. There is a balance between the rate at which data can be transmitted and the signal-to-noise ratio that can be tolerated. The lower order modulation schemes like QPSK do not transmit data as fast as the higher modulation formats such as QAM-64, but they can be received better when signal strengths are weaker (that is QPSK is more robust).

COFDM

The DVB-T technology adds a process to the modulation of the RF signal that is very different from either DVB-S or ATSC modulations. The negative effects of multipath reflections can be reduced, by using 16QAM modulation with a low effective bitrate per carrier. To reduce the effective bitrate per carrier, DVB-T spreads out the bitrate over a large amount of carriers. This spreading out will result in 1,705 closely spaced sub-carriers (using COFDM.....aka Coded Orthogonal Frequency Division Multiplexing) to create a bandwidth that can be chosen to 6MHz or 7MHz or 8MHz wide. Fig 6 shows an example where there 1,705 sub-carriers spaced at about 3.906 KHz apart...to create a 7MHz bandwidth signal.

Normally these sub-carrier signals would be expected to interfere with each other, but by making the signals orthogonal to each another there is no mutual interference. This is achieved by having the carrier spacing equal to the reciprocal of the symbol period. This means that when the signals are demodulated they will have a whole number of cycles in the symbol period and their contribution will sum to zero - in other words there is no interference contribution.

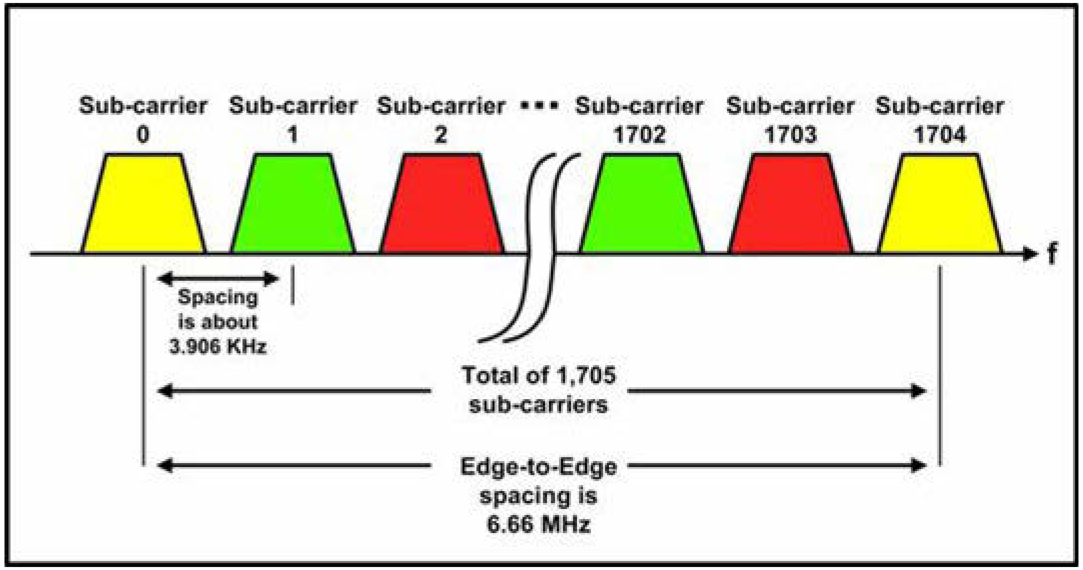

Figure 6 – COFDM spreads the DATV signal over 1705 sub-carriers (7 MHz bandwidth is shown)

When I read different articles on DVB-T technology, I observed that some articles use the term COFDM, and other articles use the term OFDM. What is the difference?? Wikipedia just says “they are the same” for DVB-T articles?? Hans Hass DC8UE was kind enough to dig up a better explanation for the difference between COFDM and OFDM. He found the following information

COFDM
Coded Orthogonal Frequency Division Multiplex
C=Coded – means it uses FEC
O=Orthogonal -means no cross talk between sub-carriers
FDM=Frequency Division Multiplex – means distribution of datastream over a lot of sub-carriers

So OFDM just is a similar communication protocol that does NOT use Forward-Error-Correction (FEC). In a way, Wikipedia is correct, the use of FEC does not affect the number of sub-carriers or the frequency bandwidth...FEC just changes the amount of data overhead added to the datastream. So many technical details stay the same between COFDM and OFDM.

Actually, COFDM can be chosen for 1,705 sub-carriers called the 2K mode, or for 6,816 sub-carriers, called the 8K mode. Stefan Reimann DG8FAC of SR-System explained that ham radio DATV only uses the 2K mode of DVB-T. Stefan DG8FAC detailed that the 8K mode is only used in commercial DTV broadcasts to create Single-Frequency-Networks (SFN) where two or more transmitters carrying the same data operate on the same frequency (to provided geographically overlap-ping coverage) without causing interference to each other. This SFN concept is too complex for ham radio applications and also the size of the FPGA needed for the 8K mode becomes larger and more expensive than the current SR-Systems MiniMod board design.

A final point about COFDM in DVB-T is that the sub-carriers, as shown in Fig 6, can all be modulated with either QPSK or with QAM-16 or with QAM-64.

The Role of the DVB-T Guard Insertion

Wikipedia explains that 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. With DVB-T, four guard intervals are available (given as fractions of a symbol period):

1/32 1/16 1/8 1/4

Therefore, choosing a guard interval of 1/32 gives lowest protection from long echoes and the highest data rate. A guard interval of 1/4 results in the best protection but the lowest data rate. Table 3 provides details of Guard Interval delay times for 6 MHz and 7 MHz configurations.

	6 MHz - 2K Mode				7 MHz - 2K Mode			
Guard Interval	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32
Duration of Symbol w/o padding	2048 x T 298.67 uSec				2048 x T 256 uSec			
Duration of Guard Interval	74.67 uSec	37.33 uSec	18.67 uSec	9.33 uSec	64 uSec	32 uSec	16 uSec	8 uSec
Guarded Symbol Duration	373.3 uSec	336.0 uSec	317.3 uSec	308.0 uSec	320 uSec	288 uSec	272 uSec	264 uSec

Table 3 – Details of Guard Interval timing for 6 MHz and 7 MHz Bandwidths

Modulation and RF Bandwidth with DVB-T

As discussed earlier, DVB-T transmissions can be chosen to use QPSK, QAM-16, or QAM-64 for modulation. In addition, the transmitter can be chosen for 6 MHz, 7 MHz or 8 MHz bandwidth. Recently, receivers (such as the HiDes Model UT-100B) have finally become available for hams to receive 2 MHz or 3 MHz DVB-T signals. The choice of the modulation does not affect the RF bandwidth because the carrier has been divided into so many evenly-spaced sub-carriers (1,705 sub-carriers for DATV). Fig 7 shows the typical spectrum analyzer view of a DVB-T transmission with 8 MHz bandwidth.

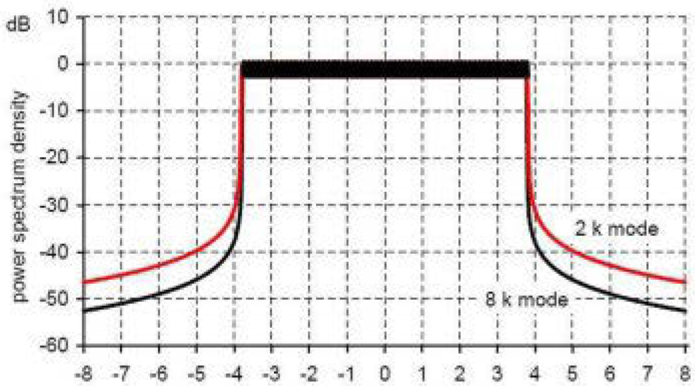

Figure 7 – Theoretical spectrum for an 8 MHz wide DVB-T signal (NOTE: bottom axis is labelled in MHz)

The only difference in the choice of modulation is the amount of payload for Net-Data-Bit-Rate that is available in the transmission, for a given bandwidth. The Net-Data-Rate that the transmission can provide is shown in Table 4. For a given bandwidth, the efficiency that is available is affected by the FEC setting and the Guard Interval setting. Notice that QAM-64 modulation in Table 4 provides approximately 50% more payload (NDBR) than the same settings for QAM-16 modulation. Also, QPSK modulation provides approximately 50% less payload than QAM-16 modulation.

Modulation	FEC Coderate	Channel bandwidth/Kanalbandbreite (MBit/sec)															
		8 MHz				7 MHz				6 MHz				5 MHz			
		Schutzintervall/Guard				Schutzintervall/Guard				Schutzintervall/Guard				Schutzintervall/Guard			
		1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32
QPSK	1/2	4,98	5,53	5,85	6,03	4,36	4,84	5,12	5,28	3,74	4,15	4,39	4,52	3,11	3,46	3,66	3,77
	2/3	6,64	7,37	7,81	8,04	5,81	6,45	6,83	7,04	4,98	5,53	5,86	6,03	4,15	4,61	4,88	5,03
	3/4	7,46	8,29	8,78	9,05	6,53	7,25	7,68	7,92	5,60	6,22	6,59	6,79	4,66	5,18	5,49	5,66
	5/6	8,29	9,22	9,76	10,05	7,25	8,07	8,54	8,79	6,22	6,92	7,32	7,54	5,18	5,76	6,10	6,28
	7/8	8,71	9,68	10,25	10,56	7,62	8,47	8,97	9,24	6,53	7,26	7,69	7,92	5,44	6,05	6,41	6,60
16-QAM	1/2	9,95	11,06	11,71	12,06	8,71	9,68	10,25	10,55	7,46	8,30	8,78	9,05	6,22	6,91	7,32	7,54
	2/3	13,27	14,75	15,61	16,09	11,61	12,91	13,66	14,08	9,95	11,06	11,71	12,07	8,29	9,22	9,76	10,06
	3/4	14,93	16,59	17,56	18,10	13,06	14,52	15,37	15,84	11,20	12,44	13,17	13,58	9,33	10,37	10,98	11,31
	5/6	16,59	18,43	19,52	20,11	14,52	16,13	17,08	17,60	12,44	13,82	14,64	15,08	10,37	11,52	12,20	12,57
	7/8	17,42	19,35	20,49	21,11	15,24	16,93	17,93	18,47	13,07	14,51	15,37	15,83	10,89	12,09	12,81	13,19
64-QAM	1/2	14,93	16,59	17,56	18,10	13,06	14,52	15,37	15,84	11,20	12,44	13,17	13,58	9,33	10,37	10,98	11,31
	2/3	19,91	22,12	23,42	24,13	17,42	19,36	20,49	21,11	14,93	16,59	17,57	18,10	12,44	13,83	14,64	15,08
	3/4	22,39	24,88	26,35	27,14	19,59	21,77	23,06	23,75	16,79	18,66	19,76	20,36	13,99	15,55	16,47	19,96
	5/6	24,88	27,65	29,27	30,16	21,77	24,19	25,61	26,39	18,66	20,74	21,95	22,62	15,55	17,28	18,29	18,85
	7/8	26,13	29,03	30,74	31,67	22,86	25,40	26,90	27,71	19,60	21,77	23,06	23,75	16,33	18,14	19,21	19,79

The specified data rates are valid for 8k, 4k and 2k modes and apply for 188 byte DVB packets

Table 4 – Net-Data-Rate for a Chosen RF Bandwidth and Modulation Scheme
(Table courtesy of SR-Systems)

Table 6 is a sample of "payloads" (NDBR) for different modulation schemes using same FEC setting and same Guard Intervals. If you remember that NTSC MPEG2 TS can be selected to be around 2.0 Mbps NDBR (see Table 1), then you can see that two video streams can be carried by a single QPSK 7 MHz carrier. Also, Table 6 illustrates that a QPSK 2 MHz BW signal does NOT provide enough NDBR "payload" to support a good quality NTSC or PAL video stream. QAM-16

Modulation	FEC Coderate	Channel bandwidth/Kanalbandbreite (MBit/sec)															
		4 MHz				3 MHz				2 MHz				1 MHz			
		Schutzintervall/Guard				Schutzintervall/Guard				Schutzintervall/Guard				Schutzintervall/Guard			
		1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32
QPSK	1/2	2,49	2,7	2,93	3,02	1,87	2,07	2,19	2,26	1,25	1,38	1,46	1,51	0,62	0,69	0,73	0,75
	2/3	3,32	3,69	3,91	4,02	2,49	2,76	2,93	3,02	1,66	1,84	1,95	2,01	0,83	0,92	0,98	1,01
	3/4	3,73	4,15	4,39	4,53	2,80	3,11	3,29	3,39	1,87	2,07	2,20	2,26	0,93	1,04	1,10	1,13
	5/6	4,15	4,61	4,88	5,03	3,11	3,46	3,66	3,77	2,07	2,31	2,44	2,51	1,04	1,15	1,22	1,26
	7/8	4,36	4,84	5,13	5,28	3,27	3,63	3,84	3,96	2,18	2,42	2,56	2,64	1,09	1,21	1,28	1,32
16-QAM	1/2	4,98	5,53	5,86	6,03	3,73	4,15	4,39	4,52	2,49	2,77	2,93	3,02	1,24	1,38	1,46	1,51
	2/3	6,64	7,38	7,81	8,05	4,98	5,53	5,85	6,03	3,32	3,69	3,90	4,02	1,66	1,84	1,95	2,01
	3/4	7,47	8,30	8,78	9,05	5,60	6,22	6,59	6,79	3,73	4,15	4,39	4,53	1,87	2,07	2,20	2,26
	5/6	8,30	9,22	9,76	10,06	6,22	6,91	7,32	7,54	4,15	4,61	4,88	5,03	2,07	2,30	2,44	2,51
	7/8	8,71	9,68	10,25	10,56	6,53	7,26	7,68	7,92	4,36	4,84	5,12	5,28	2,18	2,42	2,56	2,64
64-QAM	1/2	7,47	8,30	8,78	9,05	5,60	6,22	6,59	6,79	3,73	4,15	4,39	4,53	1,87	2,07	2,20	2,26
	2/3	9,96	11,06	11,71	12,07	7,47	8,30	8,78	9,05	4,98	5,53	5,86	6,03	2,49	2,77	2,93	3,02
	3/4	11,20	12,44	13,18	13,57	8,40	9,33	9,88	10,18	5,60	6,22	6,59	6,79	2,80	3,11	3,29	3,39
	5/6	12,44	13,83	14,64	15,08	9,33	10,37	10,98	11,31	6,22	6,91	7,32	7,54	3,11	3,46	3,66	3,77
	7/8	13,07	14,52	15,37	15,84	9,80	10,89	11,53	11,88	6,53	7,26	7,69	7,92	3,27	3,63	3,84	3,96

The specified data rates are valid for 8k, 4k and 2k modes and apply for 188 byte DVB packets

Table 5 – Net-Data-Rate for a RF Bandwidth of 2 MHz , 3 MHz (Table courtesy of SR-Systems)

	Net-Data-Bit-Rate for FEC=1/2 Guard = 1/4		
Modulation	**2 MHz BW**	**6 MHz BW**	**7 MHz BW**
QPSK	**1.25 Mbps**	**3.74 Mbps**	**4.36 Mbps**
QAM-16	**2.49 Mbps**	**7.46 Mbps**	**8.71 Mbps**
QAM-64	**3.73 Mbps**	**11.20 Mbps**	**13.06 Mbps**

Table 6 – Example of DVB-T Transmission “Payload” for different Modulation Schemes

and QAM-64 at 6 MHz , 7 MHz and 8 MHz bandwidths can carry even more than one TS videos at the same time. Essentially, this is how commercial DTV broadcast stations can carry six DTV “sub-channels” on the same transmitted signal.

I wondered why wider bandwidths provided a higher payload data-rate, if each bandwidth used exactly the same number of sub-carriers?? Then, I remembered that the Symbol-rate for each bandwidth is adjusted based on the spacing of the sub-carriers to provide the orthogonal interference protection. So, narrower bandwidths do require the use of slower Symbol-rates.

An interesting note about DVB-T RF Bandwidth is that SR-Systems has designed their MiniMOD exciter boards to allow for selection of DVB-T transmission bandwidths of 8, 7 ,6, 5, 4, 3 MHz and down to only 2 MHz BW. These narrow bandwidths of 5 –to– 2 MHz are not covered by the commercial DVB-T standard. But, as Stefan DG8FAC explains “...we transmit on 70cm with 2MHz in QAM-16, 1/2FEC and 1/4 Guard, and this works perfectly.” The NIM receiver boards that are available from SR-Systems, have modified firmware used with the DiBcom7000 chip used in the NIM DVB-T board to receive the 2 MHz BW. But, this “not-normal” bandwidth choice will not work with commercially available SetTopBoxes that were not intended to be used with a 2 MHz bandwidth.

Fig 8 shows a DVB-T transmission spectrum produced at the output of a MiniMOD exciter board. This picture shows the direct resemblance to the theoretical DVB-T spectrum shown in Fig 7. Fig 9 shows a similar output for the DATV-Express board.

The spectrum display in Fig 10 looks quite different than the theoretical shown in Fig 7. Peter Cossins VK3BFG who has contributed much to the VK3RTV repeater DATV progress explains “...The DVB-T spectrum from the final amp sampled via a directional coupler to a dummy load is quite rectangular. This spectrum [Fig 10] tapers off with increasing frequency ....it should be fairly flat on the top! The spectrum photo I have provided is live off a 49 element J beam ....I checked a local com-mercial UHF on the same antenna which

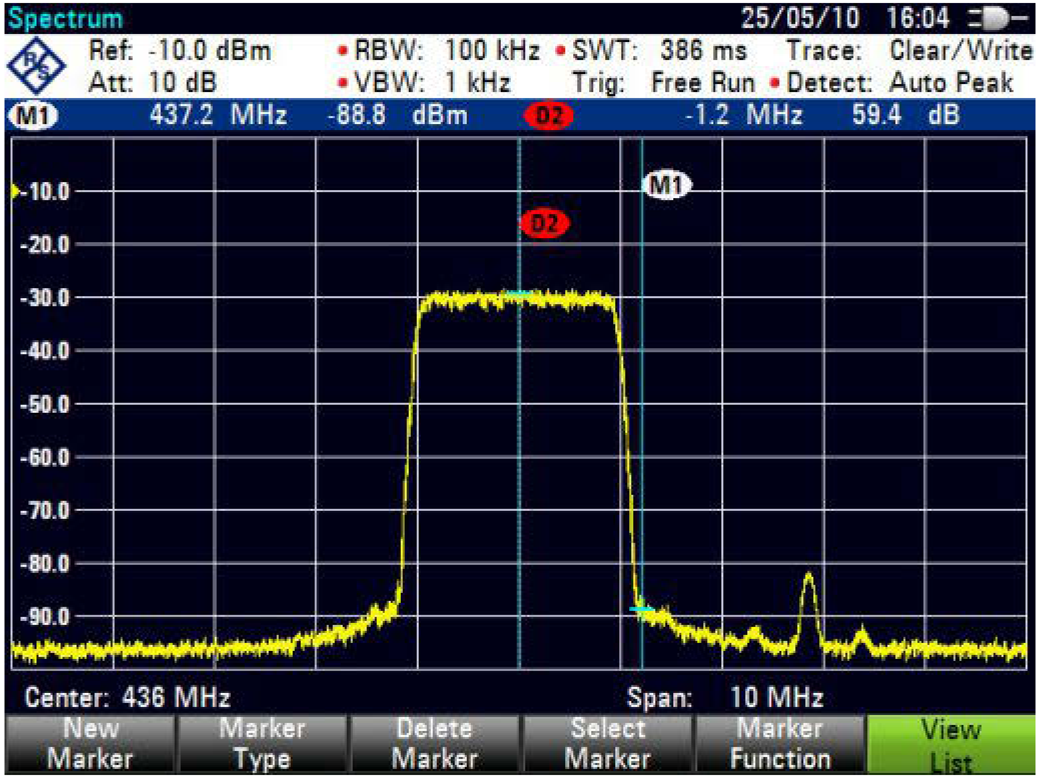

Figure 8 – A DVB-T MiniMOD exciter output transmission of 2 MHz BW is seen on a Spectrum Analyzer (Courtesy of Stefan DG8FAC)

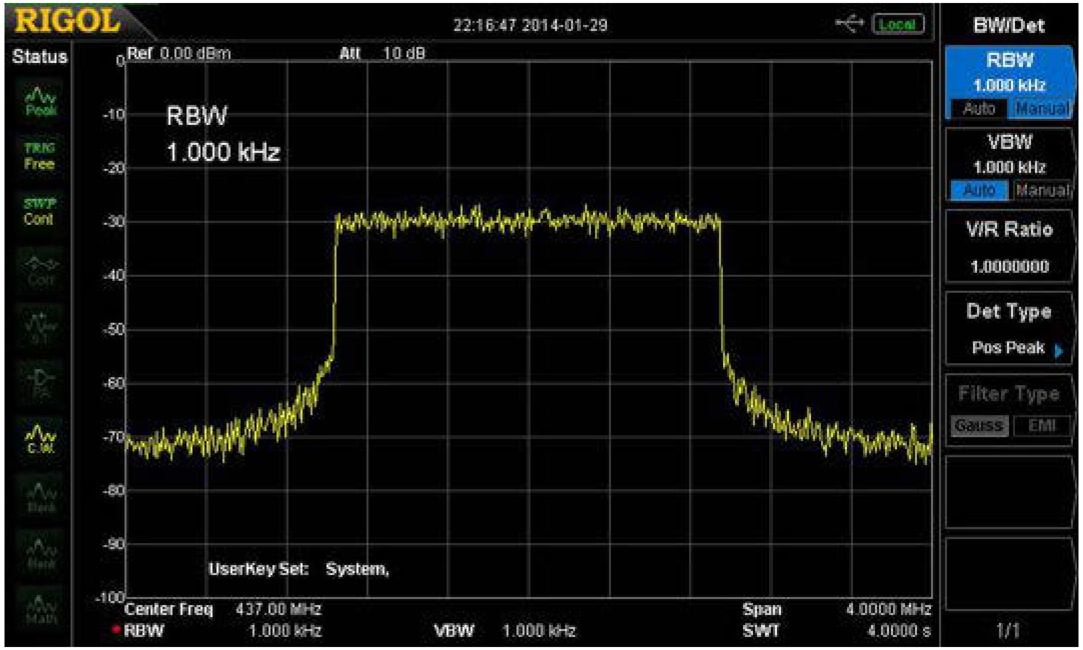

Figure 9 – A DVB-T DATV-Express exciter output transmission of 2 MHz BW is seen on a Spectrum Analyzer (Courtesy of Charles G4GUO)

is very close in freq and it looks somewhat similar, but a bit more rectangular as it should be. The repeater antenna up the hill is the original analogue one optimized for 444.25 MHz, not 446.5 Mhz. This seems to be confirmed as 'performance' is better at the bottom end rather than the top end. The repeater antenna is quite OK to about 4 MHz+ so it was satisfactory for the analogue system.

I think what you are seeing is the variations in gain performance of both antennas over the bandwidth... "

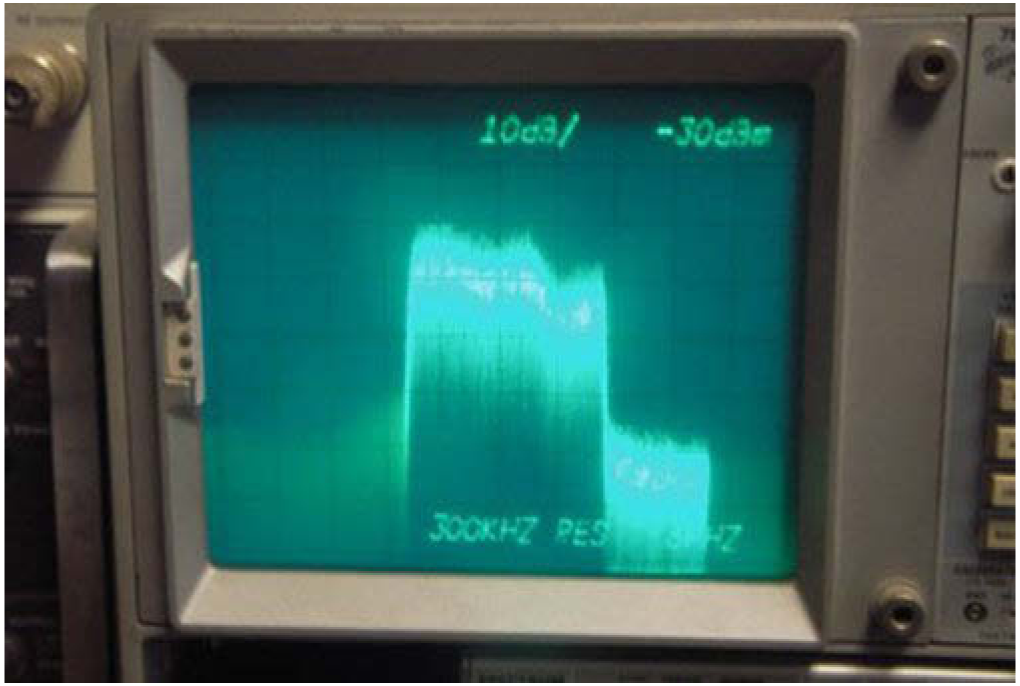

Figure 10 – DVB-T transmission as seen on a Receiving Station shows effects of VK3RTV Transmit Antenna tuned off-frequency (Courtesy of Peter VK3BFG)

De-rating the RF Power Amp Output

It is finally worth noting that DVB-T is more sensitive to non-linearity of a power amplifier than DVB-S technology. This is because the COFDM modulations have a very large "Peak-to-Average Ratio" called PAR. The graph in Fig 11 shows that OFDM/COFDM is very much worse than QPSK. This is because you can not allow "flat-topping" the power peaks to create distortion, therefore the average power out of the amplifier will be set lower.

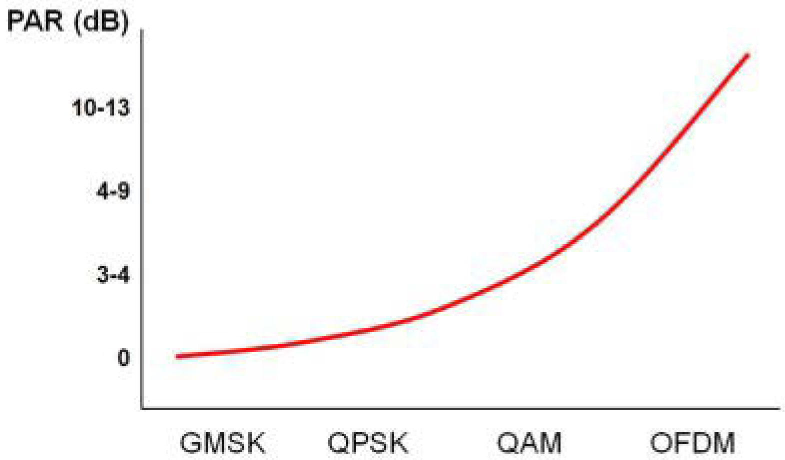

Fig 11 – PAR for amplifier output power when processing signals with various digital modulation technologies (Graph courtesy of Robert Green – Keithley Instruments, Inc.)

Peter VK3BFG confirms by explaining "...Digital television [DVB-T] requires extremely linear RF amplifiers and hence it was necessary to bias the module close to Class A. This is an extremely inefficient mode with a maximum efficiency of 50%. The actual efficiency obtained for DVB-T was about 14 % !!!.

Driving the amp is extremely non-linear and the spectrum growth occurs at an alarmingly fast rate after a certain point has been reached....".

Hans Hass DC8UE has experience as a satellite communications engineer at a commercial TV station and has access to good communications instrumentation. Hans explains that "...On measurements with my own DATV DVB-T transmitter, I can operate the linear 6 Watt PA (FM rating) only at 300mW (in QAM-16 mode). That is 13db below saturation or 5% from the possible FM-power (not DC-input power). If I increase the power, the MER [digital Modulation Error Ratio] will get poor values."

Stefan DG8FAC wrote: The exciter power output settings in DVB-T mode with a 6W (FM rating) Power Amplifier are made with ETL measuring equipment as follows:

- GAIN = 08 yields MER 40dB [good] at 100mW OUT
- GAIN = 10 yields MER 39dB [acceptable] at 250mW OUT
- GAIN = 13 yields MER 34dB [poor] at 500mW OUT

On the RF Amplifiers 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 achieved. Working in the DVB-T mode you will get only approximately 8% to 10% of the P–1dB power level.

Comparing DVB-T with DVB-S and ATSC

Table 7 goes through an exercise of PROs and CONs for each of the primary technologies considered for ham DATV. Many hams see the primary disadvantage of DVB-T for DATV as squeezing the fixed bandwidth of normally 6 MHz or wider into crowded band plans. However, recent new ham equipment now provides receivers capable down to 2 MHz bandwidth. But, on the opposite side of the coin is the DVB-T capability to easily carry more than one video picture simultaneously on the same carrier. Choosing a DATV technology really depends on your requirements.

Conclusion

DVB-T technology offers many interesting concepts and capabilities for ham DATV. There can be no doubt that its design to deal with multi-path noise is impressive. My main reason for selecting DVB-S for my home station was to take advantage of the narrow bandwidth offered for DATV. However, I made that decision before 2 MHz BW receivers were available for DVB-T. But still, I enjoy studying the competing DATV technologies and understanding how they work. My philosophy in this DATVtalk article is that it is good to know the strengths and weaknesses of each DATV technology.

	DVB-S	DVB-T	ATSC
PROs	Bandwidth can be as small as 2 or 3 MHz Cheap FTA Set Top Boxes (STB) on eBay Wide-spread experience and knowledge is provided by European hams on the Internet	Excellent multipath interference immunity Cheap Set Top Boxes (STB) on eBay 6 MHz bandwidth can support multiple video streams	Excellent multipath interference immunity Cheap Set Top Boxes (STB) in USA 6 MHz bandwidth can support multiple video streams
CONs	Multipath interference immunity not as strong as DVB-T or ATSC, but plenty of FEC correction is available	Standard 6, 7, or 8 MHz fixed bandwidth is no advantage over analog-ATV High Peak-to-Average of power for QAM modulation requires very linear power amps and large de-rating of average output power. Typically DVB-T exciter board is 100% more expensive than DVB-S	6 MHz fixed bandwidth is no advantage over analog-ATV Dolby audio AC3 encoder licensing issue unfeasible for hams Current ham transmitter boards for ATSC cannot provide AC3 audio (Dolby) Use of substitute MPEG-2 audio does not work with ATSC STBs, but can (may?) work with cable-ready DTV receivers

Table 7 – Comparing PROs and CONs between DVB-S, DVB-T and ATSC DATV Technologies

Contact Info

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Useful URLs

- British ATV Club – Digital/DigiLite/DTX1 forums – see www.BATC.org.UK/forum/
- BATC info site for DTX1 DVB-S exciter – see www.DTX1.info
- DATV-Express Project web site (SDR-based exciter) – see www.DATV-Express.com
- DigiLite Project for DATV (derivative of the "Poor Man's DATV") – see www.G8AJN.tv/dlindex.html
- Digital Video Broadcasting standard for DVB-T – see ETSI EN 300 744 V1.6.1 specification
- Melbourne DATV Repeater VK3RTV – see www.VK3RTV.com/latest.html
- Orange County ARC entire series of newsletter DATV articles – see www.W6ZE.org/DATV/
- HiDes DVB-T receivers and transmitters – see www.HiDes.com.tw/product_eng.html
- SR-Systems D-ATV components (Boards) – see www.SR-systems.de
- Yahoo Group for Digital ATV – see groups.yahoo.com/group/DigitalATV/

DATVtalk10 - DigitalATV Understanding DVB-S2 Protocol

by Ken Konechy W6HHC

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note - This is the ninth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was the beginning of this series and presented an introduction article about Digital-ATV.]

Many of the earlier DATVtalk articles about Digital-ATV have provided details about how DVB-S modulation works. DVB-S is currently the most popular modulation standard being used by hams for DATV. This month I will look at some of the technical details of DVB-S2 protocol/modulation.

While the majority of DATV hams use DVB-S modulation and some hams use DVB-T modulation (see DATVtalk09), I have had many conversations with hams who propose that ham radio should move on to DVB-S2 modulation for Digital-ATV. I am a big advocate of understanding all the competing DATV technologies and protocols, since each technology has its own set of strengths and weaknesses (aka: PROs and CONs). So let us see, if DVB-S2 can improve ham radio Digital-ATV?

Commercial World of Television

The Digital Video Broadcasting organization (DVB) created the DVB-S standard to carry Standard Definition digital satellite transmissions. The Digital Video Broadcasting organization (DVB) approved DVB-S2 to be the modulation technology for commercial High Definition TV (HDTV) broadcast satellite transmissions (uplinks and downlinks). The DVB organization succeeded in getting DVB-S2 approved as an ETSI standard in March 2005. The DVB organization states that "DVB-S2 will not replace DVB-S in the short or even the medium term, but makes possible the delivery of services that could never have been delivered using DVB-S".

Some of the commercial TV design goals for DVB-S2 are:

- Quasi-Error-Free operation at about 0.7dB to 1 dB from the Shannon limit
- Optimized for multi-stream HDTV
- Interactive Services (IS) Interactive data services including Internet access
- Digital TV Contribution and Satellite News Gathering (DTVC/DSNG)
- Data content distribution/trunking and other professional applications (PS)

I find it interesting to note that other than the first bullet above, none of the services and features in the other bullets are not of much interest to hams.

Typical Transmitter Block Diagram

DATV pioneer and enthusiast Stefan Reimann DG8FAC of SR-Systems in Germany has shown that DVB-S2 digital technology is possible for hams (see the SR-Sys model 2TS-MidiMOD2). Fig 1 is a block diagram of a basic DVB-S2 ham station for DATV. The analog camera and video is compressed by a MPEG-2 encoder board. The TransportStream (TS) digital data is fed to the DVB-S2 exciter board that does a lot of complicated data processing and then converts the digital data directly into modulated RF at a desired frequency. The small RF output signal of the exciter board is typically amplified by two stages of very linear RF amplifiers.

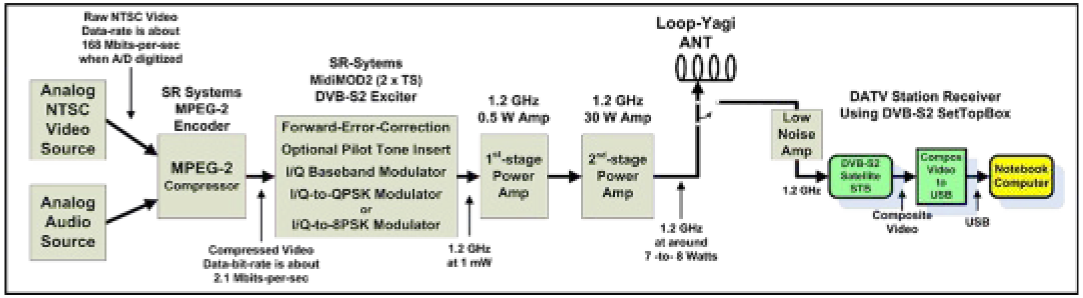


Figure 1
Block Diagram of Basic DVB-S2 Station for DATV

In Fig 1, the familiar DVB-S SetTopBox (STB) is replaced by the newer generation DVB-S2 STB in order to process newer FEC algorithms and additional modulation technologies.

Video Data-Rate and Compression

For DATV, the analog camera output is first digitized by the MPEG-2 Encoder board shown in Fig 1, and then compressed by the MPEG-2 algorithm. The reason the compressed video data rate varies in Table 1 is that the small value means little motion in the video scene and the larger value means a lot of motion.

Table 1 – Camera Video Data Streams and MPEG-2 Data Streams

Video Data Stream	Data-Rate	Notes
Analog NTSC camera	168 Mbits/sec	A/D digitized, uncompressed
NTSC MPEG-2	2-3 Mbits/sec	compressed
NTSC H.264/MPEG-4	~1.5 Mbits/sec	compressed
VHS MPEG-2	1-2 Mbits/sec	compressed
Analog PAL camera	216 Mbits/sec	A/D digitized, uncompressed
PAL MPEG-2	2.5-6 Mbits/sec	compressed
HDTV camera	1-1.5 Gbits/sec	uncompressed
HDTV MPEG-2	15-60 Mbits/sec	compressed
HDTV H.264/MPEG-4	12-20 Mbits/sec	compressed

Notice in Table 1 that the digitized NTSC camera video stream data-bit-rate is 168 Mbits/sec before compression, and MPEG-2 will reduce this to a Net-Bit-Data-Rate between 1 and 3 Mbps, which is quite a reduction in the data rate.

The newer video CODEC, H.264, can be also used with DVB-S2. This CODEC is sometime called H.264, sometimes called MPEG-4-Part-10, and sometimes called Advanced Video Coding (AVC). But, all of these terms mean the same standard, technically. H.264/MPEG-4 can reduce the bit rate by a factor of 50% over MPEG-2. Note that NTSC/PAL cameras can be used with the H.264 CODEC to reduce the video data-bit-rate needed and still obtain MPEG4 Standard Definition (SD) out (720x576 or 480). But, it is also important to realize that hams can transmit DVB-S2 using MPEG-2 encoding and the transmission will be received OK on DVB-S2 SetTopBoxes.

FEC Inflation of Payload Data Stream Data-Rate

Forward Error Correction (FEC) is a technology that not only can detect errors on the received signal, but adds enough redundancy of the data so that it can correct several wrong bits. But, there is a trade-off when choosing the amount of redundancy. Since redundancy inflates the data-rate of the output stream, the trade-off is between more redundancy or keeping the inflated data-rate smaller. As we will see a little later in this article, the larger the inflated output data-rate, the higher the required RF bandwidth. So at some point the FEC algorithm will not have enough redundancy to correct too many errors, and the DATV receiver screen will go blank or freeze.

The FEC algorithms used in the DVB-S2 protocol are different that those used in the older DVB-S and DVB-T protocols. The DVB-S commercial television standard uses a first FEC algorithm called the inner-Punctured-Convolutional-Code encoding specification and then decoded by Viterbi. The second FEC algorithm is called Reed-Solomon. Combining the Convolutional encoding with Viterbi decoding is an FEC technique that is well suited to a channel in which the transmitted signal has been corrupted by Gaussian noise.

The DVB-S2 FEC specification originated with the desire for improved efficiency. In DVB-S2, the DVB-S inner convolutional coding has been replaced with Low Density Parity Check (LDPC) coding and the DVB-S Reed-Solomon encoding is replaced with the Bose-Chaudhuri-Hocquenghem (BCH) algorithm for outer encoding.

The inner LDPC FEC algorithm can be configured for different levels of error correction. These different redundancy settings are usually called: 1/2, 3/5, 2/3, 3/4, 5/6, 8/9 and 9/10. (See Table 2) Where, the first number ("1" in the case of configuration 1/2) is the number of input bits. The second number ("2" in the case of configuration 1/2) is the number of output bits from this FEC algorithm. In the case of "1/2", the data "inflation rate" is 100%.

FEC	QPSK	8PSK	16APSK	32APSK
1/4	Optional	No	No	No
1/3	Optional	No	No	No
2/5	Optional	No	No	No
1/2	Yes	No	No	No
3/5	Yes	Yes	No	No
2/3	Yes	Yes	Optional	No
3/4	Yes	Yes	Optional	Optional
4/5	Yes	No	Optional	Optional
5/6	Yes	Yes	Optional	Optional
8/9	Yes	Yes	Optional	Optional
9/10	Yes	Yes	Optional	Optional

Table 2 FEC rates for DVB-S2 Broadcasts

The second algorithm that is used is the BCH FEC algorithm produces a variable length overhead. It adds an overhead of typically 192 bits to a long data body frame for the FECFRAME length of 64,000 bits. Its data stream "inflation rate" is very small, typically around 0.5% or less depending on the FEC Rate (see Table 3 for exact values).

FEC Rate	Frame lengths	CR_{BCH}
1/4	16,008 / 16,008 + 192	0.98815
1/3	21,408 / 21,408 + 192	0.99111
2/5	25,728 / 25,728 + 192	0.99256
1/2	32,208 / 32,208 + 192	0.99407
3/5	38,688 / 38,688 + 192	0.99506
2/3	43,040 / 43,040 + 160	0.99630
3/4	48,408 / 48,408 + 192	0.99810
4/5	51,648 / 51,648 + 192	0.99630
5/6	53,840 / 53,840 + 160	0.99704
8/9	57,472 / 57,472 + 128	0.99778
9/10	58,192 / 58,192 + 128	0.99780

Table 3 Value of BCH "inflation" for 64,800-bit Frame

Digital Modulation Symbols and Symbol-Rates

Digital modulation technologies like BPSK (an example is PSK-31), QPSK (Quad Phase Shift Keying), 8PSK and 32APSK (Amplitude and Phase Shift Modulation with 32 "constellation points") have the ability to put more information into a more narrow frequency spectrum than analog modulation. The complexity of the digital modulation scheme, allows us to pack more "data bits" into each SYMBOL. Table 4 lists out how many data bits can be packed into a symbol for several well known digital modulation technologies.

The higher-order modulations schemes, like 16APSK and 32APSK, can "pack" more bits into the symbol rate than

Modulation Scheme	Data Bits per Symbol (Me)
BPSK	1
GMSK	1
QPSK	2
8-VSB	3
8PSK	3
16APSK	4
QAM16	4
32APSK	5
QAM64	6
QAM256	8
256APSK	8

Table 4 Symbol Bit-Packing for Various Digital Modulation Technologies (Modulations in BLUE can be selected for DVB-S2) (Modulation in GREEN is an example of option added by recent DVB-S2X)

QPSK. But, the complexities for 16APSK and 32APSK modulation make them more susceptible to noise and interference than QPSK. The DVB-S2 protocol provides for QPSK, 8PSK, 16APSK, and 32APSK (marked in BLUE in Table 4). See later section on the newer DVB-S2X standard for additional modulations schemes that were added like 256APSK (marked in GREEN in Table 4). The drawings in Fig 2, Fig 3, Fig 4, and Fig 5 are intended to give an appreciation of the increasing complexities for these modulation schemes.

Notice in Fig 4 and Fig 5 that not only is the angle from the origin to the state important, but the amplitude from the origin is critical, also. Think of APSK as a digital modulation that is similar to QAM modulations...but providing a circular constellation.

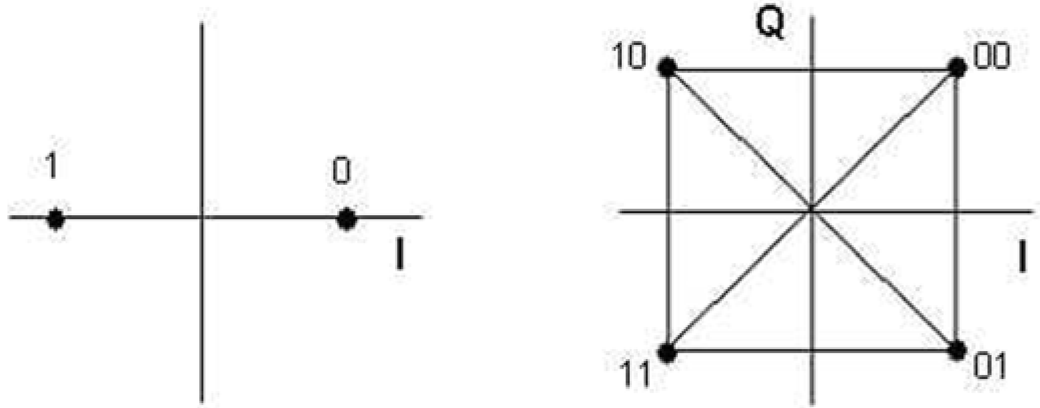


Figure 2 The constellations of BPSK (on the left, think PSK31) with two states and by QPSK with four states.

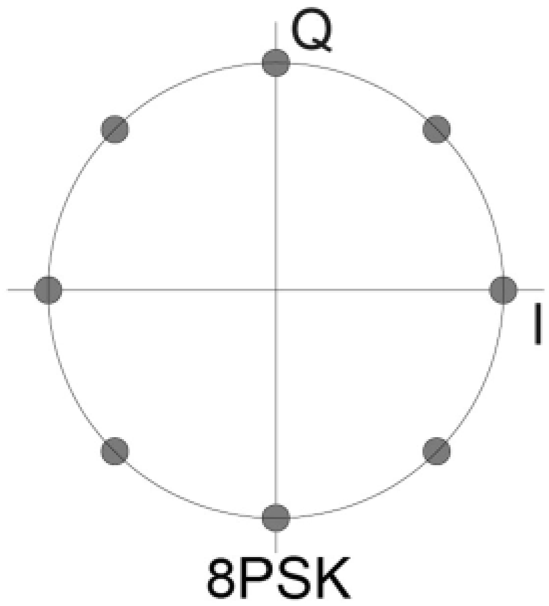


Figure 3 The constellation for 8PSK modulation contains 8 states. Each state defines three bits of data.

Hans DC8UE in Hamburg has conducted DATV testing that compares DVB-S2 to DVB-S. When he tests with DVB-S

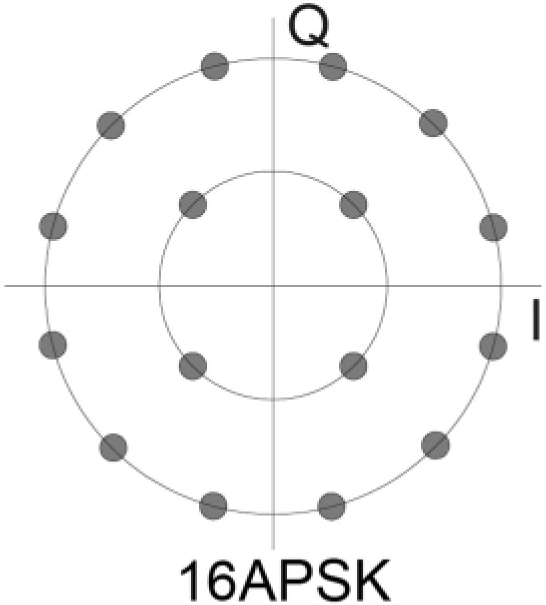
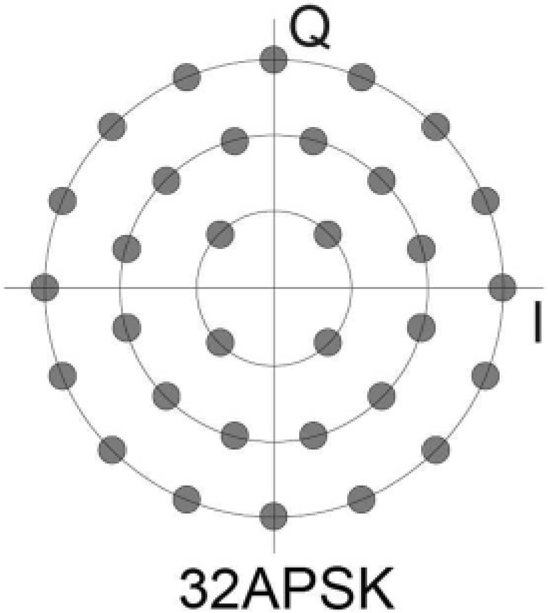


Figure 4 The constellation for 16APSK modulation contains 16 states. Each state defines four bits of data.



(QPSK with FEC equal 1/2) he needs the signal to be 5.5 dB above the noise (C/N). With DVB-S2 QPSK (FEC = 1/2) he needed C/N = 2.2 and with 8PSK (FEC = 3/5) he needed C/N = 6.5. Clearly the more complicated 8PSK modulation is more susceptible to noise.

For commercial DVB-S2 satellite broadcasting, only the QPSK and 8PSK modulations are currently being used. Stefan DG8FAC of SR-Systems explains that commercially, "16APSK and 32APSK modulations are only for Ground Links [and for portable Uplinks] at the moment". I do not know of any ham DATV installations that are currently using 16APSK or 32APSK modulation.

DVB-S2 Bandwidth

Table 4 shows for example that 8PSK modulation technology will pack three data bits into each symbol being modulated. If we know the final output data-bit-rate (I will call this inflated data rate the "Gross Data-Bit-Rate") that we need for the television signal, then the "symbol-rate" we need is exactly one-third of that gross data-bit-rate. That is: each symbol will produce three bits of data.
For example:

Gross Data-Bit-Rate = 4.5 Mbits/sec

Symbol-Rate Needed = 1.5 MSymbols/sec (for 8PSK)

The formula to calculate the Symbol-Rate setting that is needed for a DVB-S2 transmitter is:

Symbol-Rate Needed = NDBR / (Me x CRLDCP x CRBCH)

Figure 5 (Left) The constellation for 32APSK modulation contains 32 states. Each state defines five bits of data.

Where:

- NDBR= Net Data Bit Rate (aka the information rate - sometimes called the "payload" data rate)

  Same as MPEG-2 output data rate in Fig 1
- Me = Modulation Efficiency (3 for 8PSK in Table 4)
- CRLDPC = Correction Rate setting for LDPC (1/2, 3/4, etc)
- CRBCH = Correction Rate value for BCH found in Table 3

I will now calculate an example for 8PSK modulation where the output of MPEG-2 encoder is 2.4 Mbits/sec and the FEC rate is set to a value of 3/5.

- Symbol-Rate Needed =2.4 Mbit/sec 3 bits/symb * (3/5) * (0.99506)
- Symbol-Rate Needed =2.4 Mbit/sec 1.791 bits/symb
- Symbol-Rate Needed =1.34 Msymbols/sec

The final formula is for DATV Bandwidth (BW). The "roll-off" factor affecting BWallocation for DVB-S2 is 0.2; compared to DVB-S where roll-off is 0.35. For DVB-S2 modulations, the formula for (allocation) RF BW is:

RF BWallocation = 1.2 x Symbol-Rate

Fig6 shows a spectrum analyser capture of a 1.2 GHz DVB-S2 signal, using 8PSK modulation (13.5MSymb/sec, FEC=3/5, Pilots ON, RollOff = 20%). The Bandwidth shown is about 16.2 MHz.

Fig7 shows a constellation analyser screen capture of DVB-S2 transmission using the 16APSK modulation. Note that DATV-Express has tested, but not released DVB-S2 capabilities - mainly because of complex licensing issues.

The Net-Data-Bit-Rate (NDBR) is the "payload" bit rate

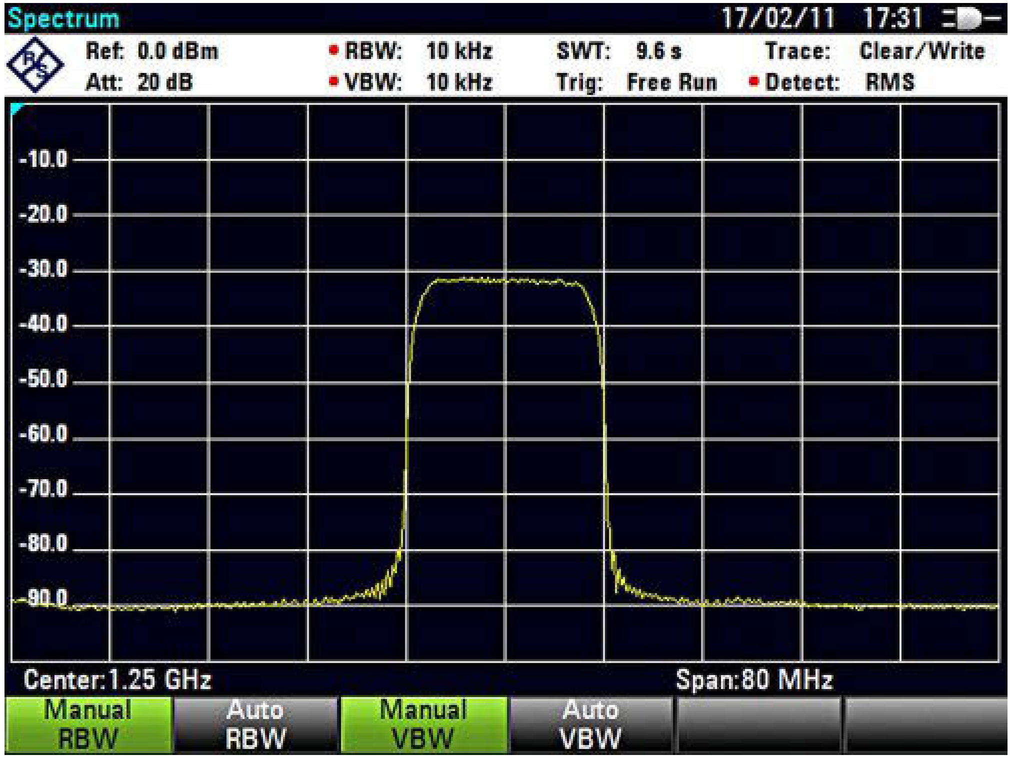


Figure 6 A DVB-S2 MidiMOD2 exciter 8PSK output transmission is seen on a Spectrum Analyzer with BW = 16.2 MHz
(Courtesy of Stefan DG8FAC)

needed for the video and audio streams. The Net-Data-Bit-Rate capacity that can be supported in a particular bandwidth is listed in Table 5. Note that these values do not include the overhead introduced by inserting Pilot Tones for improved receiving robustness.

Receiving DVB-S2

In Fig 1, the block diagram shows a typical DVB-2 receiving station used for DATV. The DVB-S2 SetTopBox (STB) can be purchased on e-bay and other online stores here in the USA. The output ports of many DVB-S2 STB's include: composite video, S-video, component video, and HDMI interfaces. It is

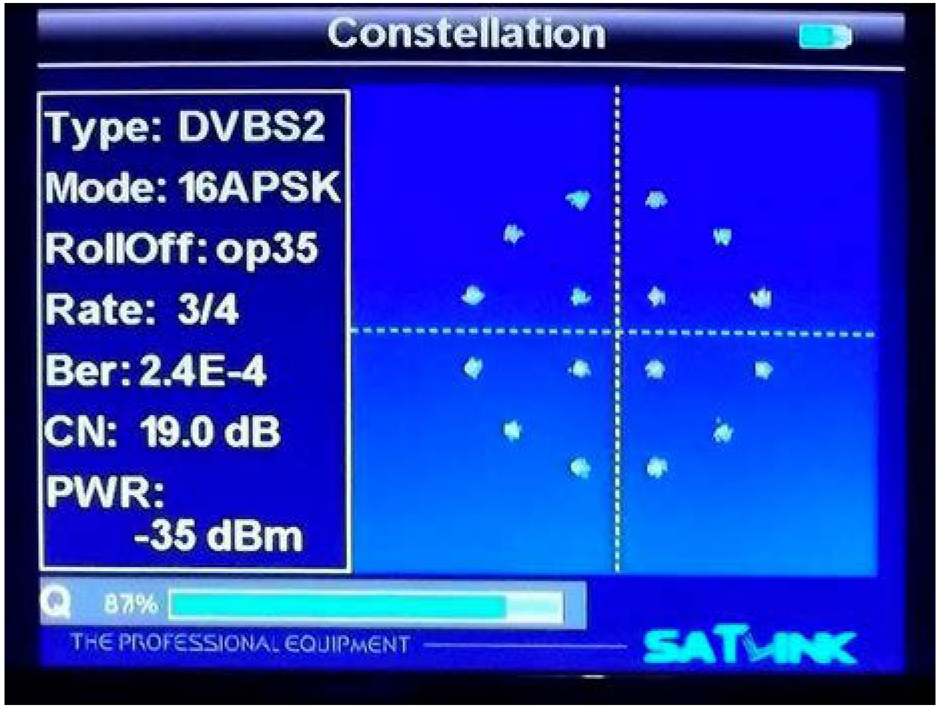


Figure 7 â€“ Constellation of a DATV-Express exciter testing DVB-S2 with 16APSK modulation (Courtesy of Charles G4GUO)

Modulation	FEC Coderate	DVB-S2 RF BANDWIDTH for DATV (RF BW = SymbolRate x 1.2)						
		1.5 MHz (SR = 1.25 MS/sec)	2.0 MHz (SR = 1.67 MS/sec)	2.5 MHz (SR = 2.08 MS/sec)	3.0 MHz (SR = 2.5 MS/sec)	4.0 MHz (SR = 3.33 MS/sec)	5.0 MHz (SR = 4.17 MS/sec)	6.0 MHz (SR = 5.0 MS/sec)
QPSK	1/4	0.62	0.83	1.03	1.24	1.65	2.06	2.47
	1/3	0.83	1.10	1.37	1.65	2.20	2.76	3.30
	2/5	0.99	1.33	1.65	1.99	2.64	3.31	3.97
	1/2	1.24	1.66	2.07	2.49	3.31	4.15	4.97
	3/5	1.49	1.99	2.48	2.99	3.98	4.98	5.97
	2/3	1.66	2.22	2.76	3.32	4.42	5.54	6.64
	3/4	1.87	2.50	3.11	3.74	4.99	6.24	7.49
	4/5	1.99	2.66	3.32	3.99	5.31	6.65	7.97
	5/6	2.08	2.78	3.46	4.15	5.53	6.93	8.31
	8/9	2.22	2.96	3.69	4.43	5.91	7.40	8.87
	9/10	2.25	3.00	3.74	4.49	5.98	7.49	8.98
8PSK	3/5	2.24	2.99	3.73	4.48	5.96	7.47	8.96
	2/3	2.49	3.33	4.14	4.98	6.64	8.31	9.96
	3/4	2.81	3.75	4.67	5.61	7.48	9.36	11.23
	5/6	3.12	4.16	5.18	6.23	8.30	10.39	12.46
	8/9	3.33	4.44	5.53	6.65	8.86	11.10	13.30
	9/10	3.37	4.50	5.60	6.74	8.97	11.23	13.47
16APSK	2/3	3.32	4.43	5.52	6.63	8.84	11.07	13.27
	3/4	3.74	4.99	6.22	7.47	9.95	12.46	14.94
	4/5	3.99	5.33	6.64	7.98	10.64	13.32	15.97
	5/6	4.15	5.55	6.91	8.31	11.07	13.86	16.62
	8/9	4.43	5.92	7.38	8.87	11.81	14.79	17.74
	9/10	4.49	6.00	7.47	8.98	11.96	14.98	17.96

Table 5 Net Data Bit Rates (NDBR) for DVB S2 at a given bandwith

interesting to note that the DVB-S2 STB usually will receive old DATV DVB-S transmissions using a "modified 8PSK mode" setting that is backward-compatible to DVB-S.

Newest Optional Standard - DVB-S2X

In March of 2014, the Digital Video Broadcasting standards group (DVB) released a new protocol standard called DVB-S2X, which is an optional extension to the DVB-S2 standard. The main goals of the DVB-S2X standard are:

Very Low SNR operation support down to -10 dB SNR

Add new Modulations schemes: 64APSK, 128APSK, and 256APSK

Add two smaller roll-off options of 5% and 10% (in addition to 20%, 25% and 35% in DVB-S2)

"Channel Bonding" to allow up to three transponders to become a logical TS for forth-coming UHDTV (Ultra High Definition) satellite transmissions

The new DVB-S2X extension standard goes a long way to make transmissions even more robust. This protocol "hugs" very close to the Shannon limit of spectral efficiency. This new DVB-S2X spec is called optional, and the DVB organization states that "Such DVB-S2X extensions are non-backwards-compatible with the S2 specification approved in 2004, and are optional for the implementation of new receivers under the S2 specification". My view of the world is

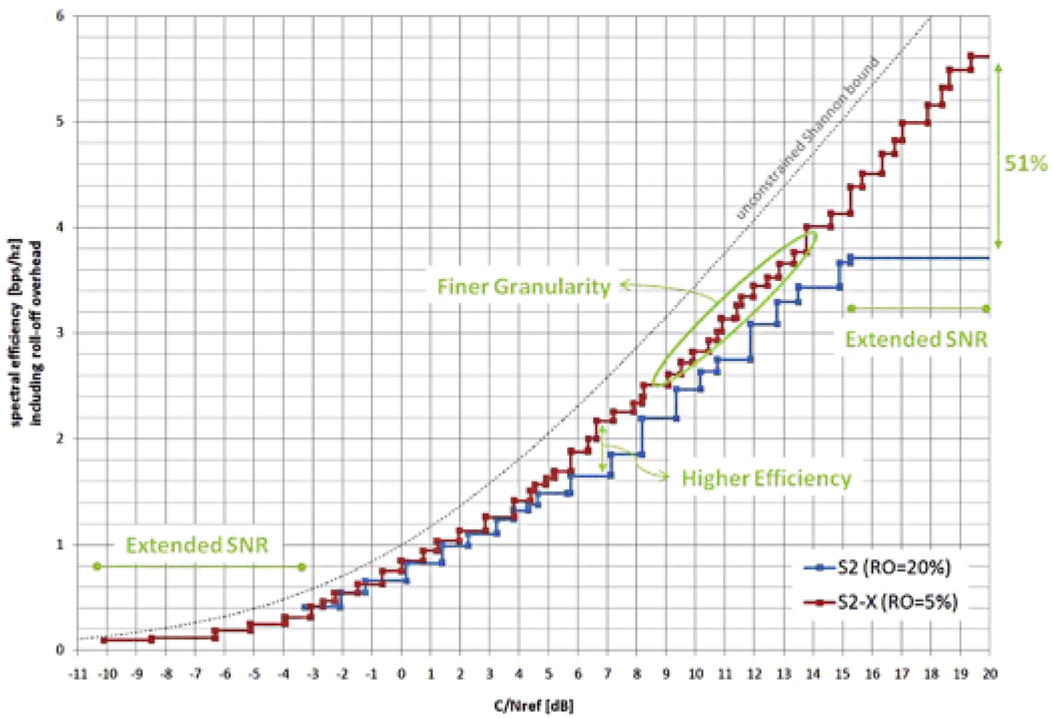


Figure 8 Graph comparing new DVB-S2X (RED) performance and older DVB-S2 (BLUE) against the "Shannon limit"

that "technologies keep on changing, usually getting better".

Comparing DVB-S2 with DVB-S

Table 6 attempts to compare the strengths and weaknesses (PROs and CONs) of DVB-S2 against DVB-S for Digital-ATV. There is no question that DVB-S2 provides a more robust signal and can pack multiple TS video streams into a small bandwidth. Earlier DVB-S2 STB's (around 2010) were reported to not be capable of receiving Symbol Rates less than 10 MSymbols/sec. But this Symbol Rate limitation is no longer true. Also G4GUO reports he uses PC-based DVB-S2 receivers and that most of them will operate at our low symbol rates.

	DVB-S2	DVB-S
PROs	Quasi-Error-Free operation at about 0.7dB to 1 dB from the Shannon limit 1xTS Bandwidth can be as small as 1 or 1.5 or 2 MHz with 8PSK The protocols allows use of MPEG-4 (H.264) comrpession standard that can reduce the payload data-stream by almost 50% Cheap Set Top Boxes (STB) on eBay and online 3 MHz bandwidth can support multiple video streams	1xTS Bandwidth can be as small as 2 or 3 MHz Cheap FTA Set Top Boxes (STB) on eBay Wide-spread experience and knowledge is provided by European hams on the Internet Newer DVB-S2 STB will receive DVB-S
CONs	Currently ham-grade DVB-S2 exciter board is 100% more expensive than DVB-S	QPSK modulation requires larger bandwidth than 8PSK modulation

Table 6 Comparing DVB-S2 with DVB-S

Conclusion

I am not yet convinced that DVB-S2 is the correct technology direction for most ham home D-ATV transmitters. Most new features provided by DVB-S2 technology (like "news gathering" and "data content trunking") are not of much interest to ham DATV. I also do not personally see most hams needing the pixels required by HDTV for DATV uses (think "more pixels equals more bandwidth"). But, the use of the new H.264 video CODEC is a powerful tool for reducing RF bandwidth. My main DATV interest is fitting narrow DATV 1xTS bandwidth into crowded ham band spectrum plans. I can envision placing three 2 MHz DATV repeater signals (or even four 1.5 MHz DATV repeater signals when using 8PSK) into the band space that used to be occupied by a single 6 MHz analog ATV signal. I am certainly impressed that DVB-S2 can provide a great technology for multiple video streams that can be used by DATV repeater operators, such as four

Transport Streams (TS) in a single 6 MHz repeater output transmission.

Contact Info

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Useful URLs

British ATV Club - Digital/DigiLite/DTX1 forums - see www.BATC.org.UK/forum/

BATC info site for DTX1 DVB-S exciter - see www.DTX1.info

DATV-Express Project web site (SDR-based exciter) - see www.DATV-Express.com

DigiLite Project for DATV (derivative of the "Poor Man's DATV") - see www.G8AJN.tv/dlindex.html

Digital Video Broadcasting standard for DVB-S2 - see ETSI EN302307-1 specification

Digital Video Broadcasting standard for DVB-S2X - see BlueBook A83-2 / EN302307-2

German portal for DATV streaming repeaters and downloads - see www.D-ATV.net (in German)

Swiss ARALD consortium of ATV repeaters (Amateur Radio ATV La Dôle) - see www.HB9TV.ch

Orange County ARC entire series of newsletter DATV articles - see www.W6ZE.org/DATV/

DG0VE microwave amps, up-converters, down-converters - see www.DG0VE.de

Down East Microwave RF amplifiers - see www.DownEastMicrowave.com

HiDes DVB-T receivers and transmitters - see www.HiDes.com.tw/product_eng.html

SR-Systems D-ATV components (Boards) - see www.SR-systems.de

Wikipedia on DVB-S2 - see http://en.wikipedia.org/wiki/DVB-S2

Wikipedia on H.264/MPEG-4 - see http://en.wikipedia.org/wiki/H.264

Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/

DATVtalk 11 - DigitalATV - Overview of ITU-T_J.83B Protocol

by Ken Konechy W6HHC

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note - This is the tenth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was the beginning of this series and presented an introduction article about Digital-ATV.]

Earlier DATVtalk articles about Digital-ATV have provided details about how DVB-S protocol works, and went on to cover DVB-T and DVB-S2 protocols. DVB-S is still currently the most popular modulation standard being used by hams for DATV. This month I will look at some of the technical details of the DATV protocol defined by the ITU-T_J.83-Annex B standard.

The complete list of commercial origins of the DATV protocols being used by hams are listed below:

- DVB-S (satellite based)
- DVB-S2 (satellite for HDTV)
- DVB-T (terrestrial reception)
- ATSC (commercial terrestrial reception in US)
- ITU-T_J.83-Annex B (US/Canada cableTV)

ITU-T_J.83B

The ITU-T_J.83-Annex B protocol (I've shortened to ITU-T_J.83B) is commercially used by the US/Canada cableTV industry. This standard is very closely related and similar to the DVB-C protocol used in Europe and most of the world for cable TV. One main attraction of ITU-T_J.83B for hams is that several cable channels can fall directly on the 430 MHz ham bands. Therefore a terrestrial transmission by hams can be received directly to a cable-ready TV without adding any special receiver cost (aka more money). Just connect an antenna and tune your TV to the right channel. This is the nice attraction of the old analog-ATV approach on 430 MHz band.

ITU-T_J.83B for the cable world is designed to work with strong signals and a low noise environment. The main issue with ITU-T_J.83B when used by hams in a terrestrial mode (over the air - OTA), is that the environment can change to weak signals and lots of noise. That is: the received S/N gets much worse when you leave the cable environment.

Typical Transmitter Block Diagram

Fig1 is a block diagram of an ITU-T_J.83B basic ham station for DATV using QAM64 modulation to transmit a full HD video. Hams typically use MPEG-4 encoding to achieve enough data compression to fit a full 1080i high definition signal into a 6 MHz bandwidth. Typical manufacturers of ITU-

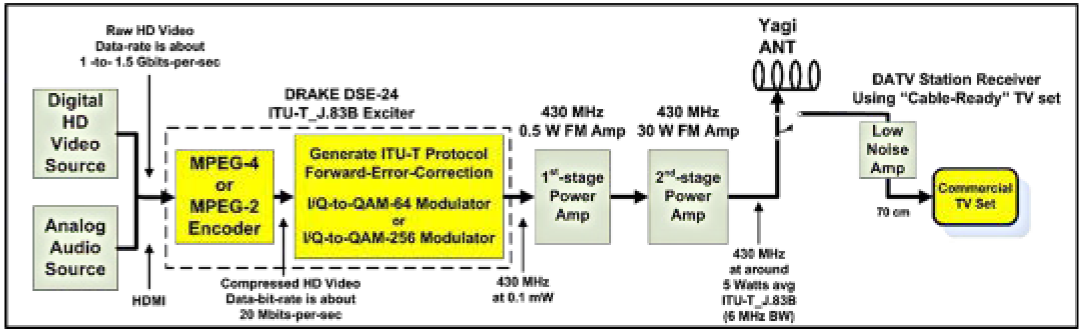

Figure 1 - Block Diagram of Basic ITU-T_J.83B Station for DATV

T_J.83B exciters used by hams (mainly here in USA) are the Drake (model DSE-24) and Thor (model H-VQAM-SD).

Typically a HDMI connector is available for HD cameras to be plugged in and composite video connectors (RCA jacks) are available for NTSC cameras and Standard Definition (SD) using MPEG-2 encoding. The DATV receiver is a commercial "cable-ready" TV set tuned to the 420-430 MHz USA cable TV channels 57-60 that overlaps the ham radio 70 cm band.

- 421.25 MHz CH-57
- 427.25 MHz CH-58
- 433.25 MHz CH-59
- 439.25 MHz CH-60

Video Data-Rate and Compression

For HD DATV, a digital camera output is compressed using MPEG-4 encoding (aka H.264 and even sometimes called Advanced Video Coding - AVC). This encoder CODEC provides more compression of the video than the older MPEG-2 CODEC. For SD DATV, the analog NTSC/PAL camera output is first digitized by the optional MPEG-2 encoder shown in Fig 1, and then compressed by the MPEG-2 algorithm. The reason the compressed video data rate varies in Table 1 is that the smaller value means little motion in the video scene and the larger value means a lot of motion. H.264/MPEG-4 can reduce the bit-rate by a factor of 50% over the older MPEG-2 CODEC.

FEC Inflation of Payload Data Stream Data-Rate

Forward Error Correction (FEC) is a technology that not only can detect errors on the received signal, but adds enough redundancy of the data so that it can correct several wrong bits. But, there is a trade-off when choosing the amount of

Video Data Stream	Data-Rate	Notes
Analog NTSC camera	168 Mbits/sec	A/D digitised uncompressed
NTSC MPEG-2	2-3 Mbits/sec	compressed
NTSC H.264/MPEG-4	~1.5 Mbits/sec	compressed
VHS MPEG-2	1-2 Mbits/sec	compressed
Analog PAL camera	216 Mbits/sec	A/D digitised uncompressed
PAL MPEG-2	2.5-6 Mbits/sec	compressed
HDTV camera	1-1.5 Gbits/sec	uncompressed
HDTV MPEG-2	15-60 Mbits/sec	compressed
HDTV H.264/MPEG-4	12-20 Mbits/sec	compressed

Table 1 - Camera Video Data Streams and MPEG-2/MPEG-4 Data Streams

redundancy. Since redundancy inflates the data-rate of the output stream, the trade-off is between more redundancy or keeping the inflated data-rate smaller. As we will see a little later in this article, the larger the inflated output data-rate, the higher the required RF band-width. So at some point the FEC algorithm will not have enough redundancy to correct too many errors, and the DATV receiver screen will go blank or freeze.

The FEC technology used by the ITU-T_J.83B protocol is that same as used by DVB-S protocol. That is: the two FEC algorithms are the Viterbi coding technology and Solomon-Reed. The puncture coding value used by ITU-T_J.83B DATV is not selectable and is difficult for me to pin down in the standard, but the redundancy is something close to 7/8. The total FEC overhead produced I estimate is approximately

20%. That translates into the MPEG-4 "payload" video data rate of about 20 Mbits/sec increasing to a "gross data rate" to a value of about 24 Mbits/sec that has to be encoded into the Symbol-Rate (SR).

Digital Modulation Symbols and Symbol-Rates

Digital modulation technologies like BPSK (an example is PSK-31), QPSK (Quad Phase Shift Keying), 8PSK, 32APSK (Amplitude and Phase Shift Modulation), and QAM-64 (Quadrature Amplitude Modulation) with 64 "constellation points" have the ability to put more information into a more narrow frequency spectrum than analog modulation. The complexity of the digital modulation scheme, allows us to pack more "data bits" into each SYMBOL. Table 2 lists out how many data bits can be packed into a symbol for several well-known digital modulation technologies.

Table 2 - Symbol Bit-Packing for Various Digital Modulation Technologies

Modulation Scheme	Data Bits per Symbol (Me)
BPSK	1
GMSK	1
QPSK	2
8PSK	3
8-VSB	3
QAM-16	4
32APSK	5
QAM-64	6
QAM-256	8

ITU-T_J.83B protocol allows the use of two digital modulations: QAM-64 that packs 6-bits of data into each symbol transition and QAM-256 packs 8 bits of data into each symbol transition.

Figures 2 and 3 (next page) shows a comparison between the more simple QPSK modulation constellation and the much more complex QAM-64 constellation.

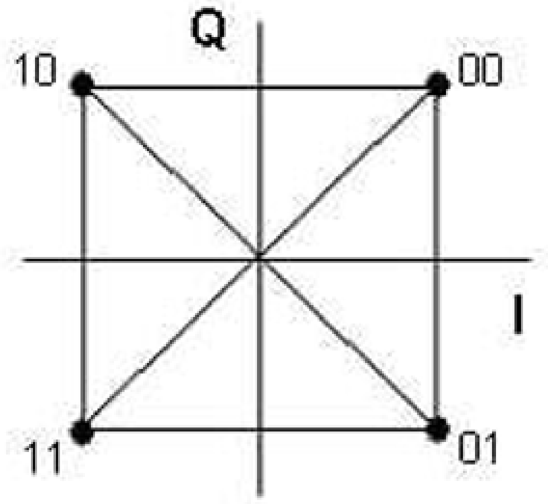

Figure 2 - The modulation constellation of QPSK used in DVB-S packs 2 bits of data in each symbol transition

The complexity of a digital modulation scheme like QAM-64 allows much more data to be carried in a defined RF bandwidth, but also carries a penalty in signal robustness. The greater the modulation complexity, the greater the signal to noise ratio (SNR and aka C/N) needs to be. Fig 4 compares the SNR needed to receive four different digital modulations, including QPSK and QAM-64. Even though this analysis is looking at COFDM world, it clearly shows that QAM-64 is less robust than QPSK. I think it is very easy to envision that the QAM-256 modulation would carry an even greater SNR robustness penalty (requires 8 dB more of SNR for a good signal than QAM-64).

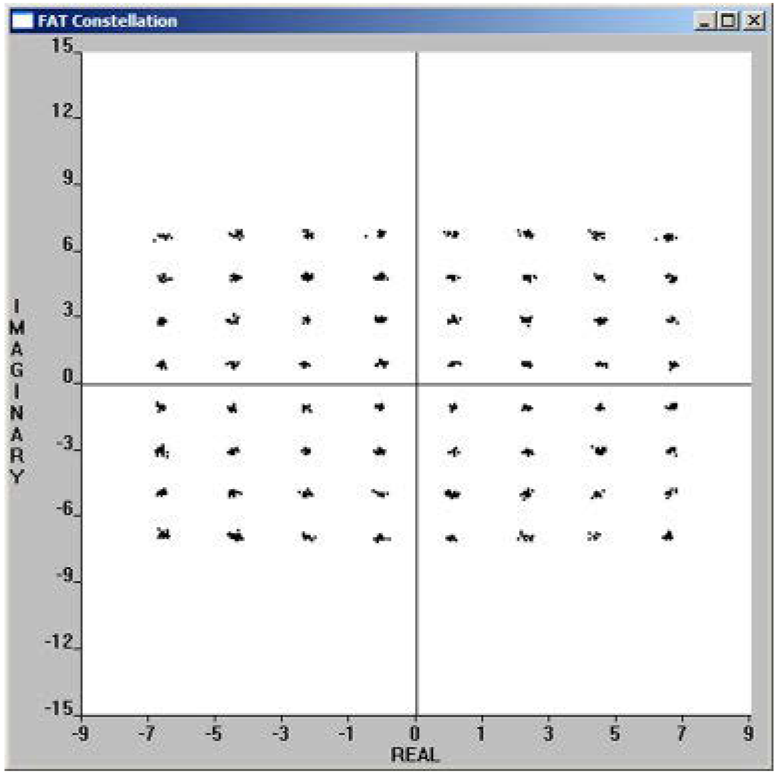

Figure 3 - The more complex modulation constellation of QAM-64 used in ITU-T_J.83B packs 6 bits of data into each symbol transition (courtesy of W6RZ)

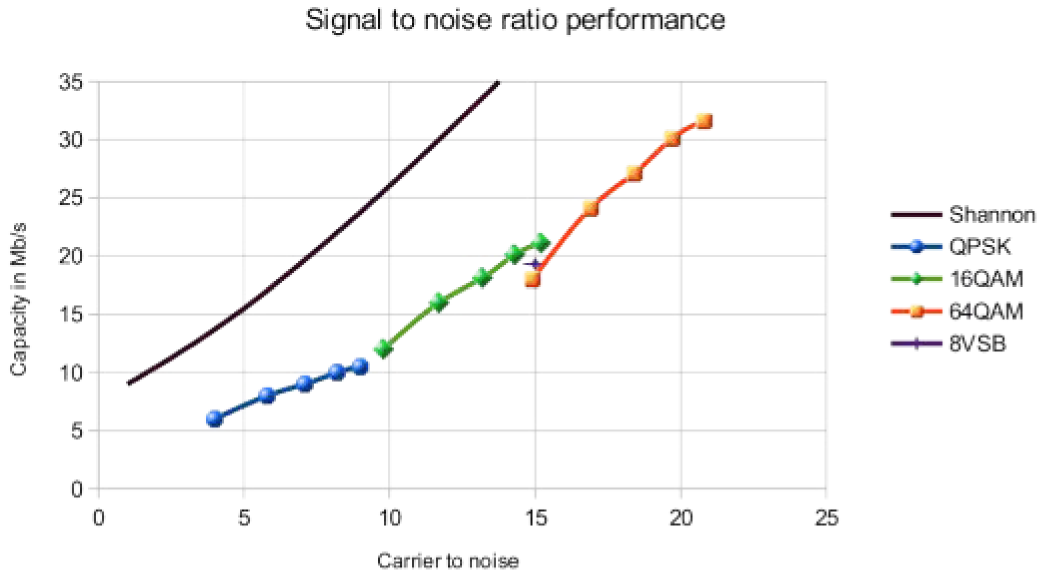

Figure 4 - A comparison of SNR of four different modulations including QAM-64 and QPSK shows the signal robustness penalty of complexity (courtesy of ZL1WTT)

ITU-T_J.83B Bandwidth

The ITU-T_J.83B standard defines the RF bandwidth as 6 MHz wide "channels". In a manner similar to DVB-S protocol, the RF bandwidth of an ITU-T_J.83B transmission is defined by its Symbol Rate (SR). That is:

RFbw = SR x 1.35 (roll-off factor)

So if we have a 6 MHz bandwidth, the Symbol Rate should be approximately:

SR = 6.0 MHz / 1.35 = 4.44 MSymb/s

The "gross data-rate" (that is: with protocol overhead) at this SR would then be ~26 Mbps. This is enough to carry a HD signal using MPEG-4 encoding with a "payload" data-rate of about 20 Mbits/sec.

The cable-ready TV receivers are set-up to receive transmissions on the pre-defined set frequencies. These channels are spaced 6 MHz apart. I have not heard of any hams being able to receive QAM-64 transmission bandwidths more narrow than 6 MHz on commercial TV sets.

Status of Ham ITU-T_J.83B DATV

One of the pioneers in US for DATV using the ITU-T_J.83B protocol is Jim KH6HTV. He participated in setting a DX record of 121 KM on the 70 cm band using QAM-64 modulation. Two ATV repeater groups in US have tested adding the ITU-T_J.83B protocol to their DATV repeaters.

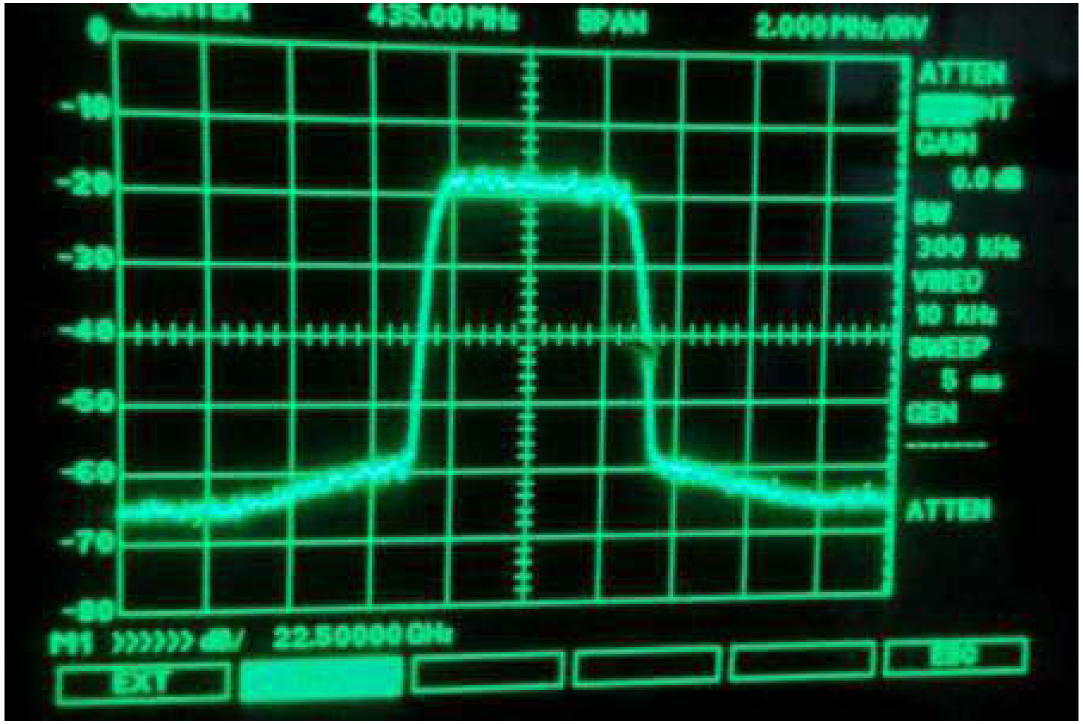

Figure 5 - A spectrum analyzer view of an ITU-T_J.83B QAM-64 transmission "haystack" on the 70 cm band (courtesy of WA6SVT)

The ATN group in Southern California tested a 70 cm DATV repeater on Mt Wilson, where uplinks were received via analog-ATV and downlinked using DATV as W6ATN. The ATCO group in Columbus Ohio (they installed the first DVB-S DATV repeater in USA in 2004) also installed ITU-T_J.83B DATV repeater in USA in 2004) also installed ITU-T_J.83B protocol to their WR8ATV DATV repeater downlink on 70 cm.

When I first started preparing for this article, I contacted Mike WA6SVT of the W6ATN repeaters and also contacted Art WA8RMC of the WR8ATV repeater to get feedback and obtain their insights on using ITU-T_J.83B for a DATV repeater.

To my surprise, I learned that both repeater groups had stopped using the ITU-T_J.83B protocol and were installing DATV-T down-links. The W6ATN tests had signal robustness difficulty being received across the large Los Angeles basin into Orange County.

Art WA8RMC explained that nobody was using the ATCO ITU-T_J.83B downlink. Art went on to report that: "I could see the CATV QAM signal but even though a vertically polarized signal was being sent, I could only receive it with my horizontally polarized antenna". After some additional testing and assumptions we concluded, "The QAM signal suffers from multipath cancellation issues which is minimally accommodated in the receiver. Also, minimal FEC is applied to the transmitted signal because it is not needed when in a cable". ATCO concluded that because of multipath issues, DATV using this mode is not practical.

Jim KH6HTV has also redirected his DATV interests and activities to DVB-T protocol because "it far outperforms the CATV DTV 64QAM. I only used the QPSK modulation because of its superior receiver sensitivity. I found I was still able to transmit very acceptable, HD 1080p pictures using simpler QPSK compared to QAM".

Conclusion

The ITU-T_J.83B approach to DATV offers "easy appliance-like installation" for DATV and also offers the glamor of being able to transmit full 1080 HD video. But, the penalty of the higher C/N requirements of the QAM-64 modulation is too large compared to other now-available alternatives. I do NOT see ITU-T_J.83B protocol becoming a significant factor for DATV in the future.

Contact Info

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Useful URL's - see Page 16

DATVtalk12 - Using ODROID with DATV-Express board

by Ken Konechy W6HHC

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note - This is the twelfth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was an introduction article about basic Digital-ATV.]

In DATVtalk01, I discussed how to use the DATV-Express exciter board with an Intel based Linux PC. In this follow-up article, I will discuss the next stage of the project, which is replacing the PC with a small, more portable, low powered ARM-based board. In particular, I will concentrate on the ODROID model U3 platform.

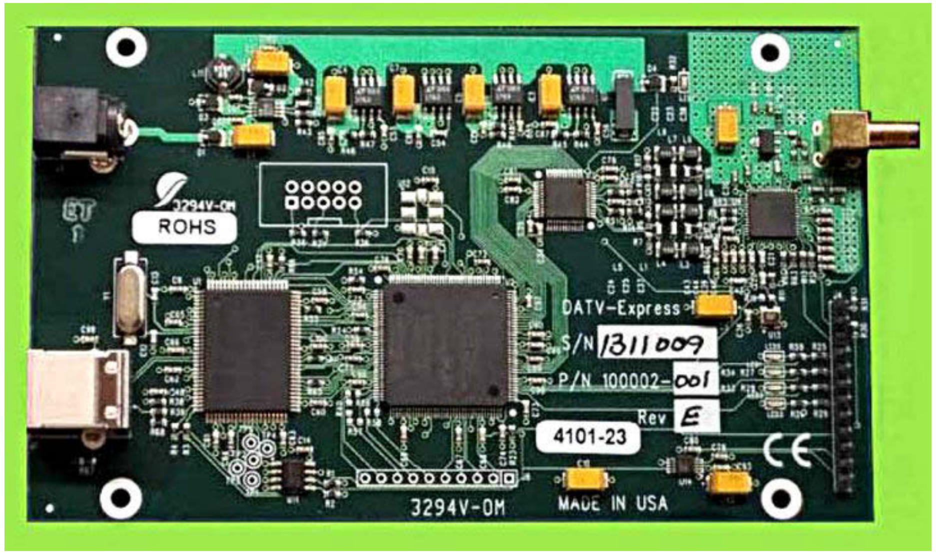


Figure 1 - Production DATV-Express hardware board for Digital-ATV

After the main Linux DATV-Express software was released earlier this year, the project team looked at the possibility using the following "micro-PC-s" to drive the DATV-Express hardware board:

- Raspberry Pi (single-core-ARM based)
- RikoMagic MK802iv (quad-core-ARM based)
- HardKernel ODROID U3 (quad-core-ARM)

ODROID Model U3

The Raspberry Pi and the MK802iv units that were tested with the DATV-Express hardware board and software - each had problems with our project. The single-core-ARM Raspberry Pi, running at 700 MHz, was underpowered for our particular use. Both the Raspberry Pi and the MK802iv had issues with the completeness of their software repositories' that prevented easily recompiling their linux kernel software. The small ODROID U3 (see Fig03), quad-core-ARM CPU running at 1.7 GHz, was tested and proven to be suitable for meeting our DVB-S goals.

Fig02 (next page) illustrates a typical transmitter set-up for using the ODROID U3 to drive the DATV-Express board in a typical DVB-S operation. This approach uses a USB2-based

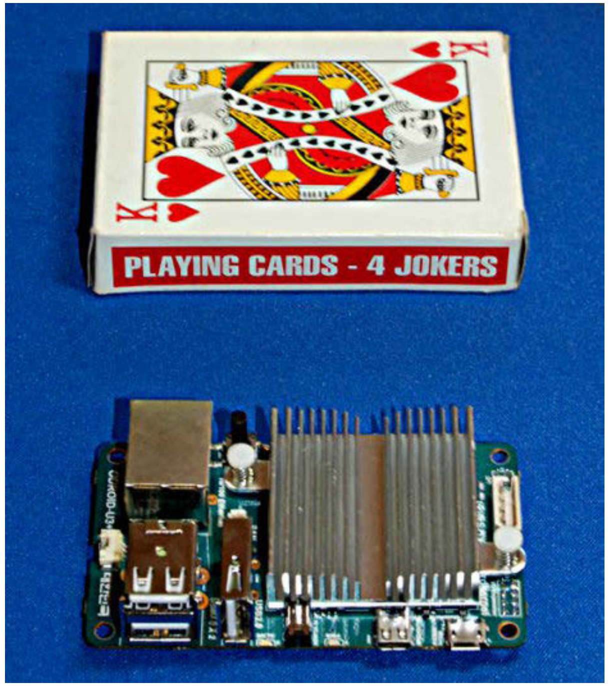


Figure 3 - Size of quadcore-ARM ODROID-U3 board is about the same size as Raspberry Pi

Hauppauge model HVR-1900 (PAL) or the HVR-1950 (NTSC) to perform video capture and MPEG-2 encoding. The MPEG-2 video and audio elementary streams are sent by a USB2 interface to the ODROID for processing into a Transport Stream (TS).

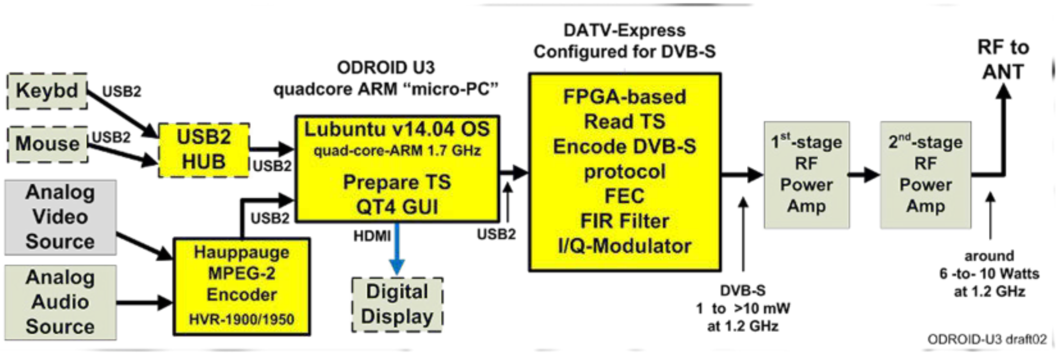


Figure 2 - Typical Block Diagram of ODROID DVB-S transmitter using DATV-Express

The first step that project-member Charles G4GUO took to get ready for allowing the software program to work with the "micro-PC" ARM computers was to move the DVB-S protocol processing into the FPGA coding, in order to off-load the processing on the ODROID. The quad-core-ARM is not as powerful as an equivalent Intel quad-core i5 or i7 CPU. The ODROID U3 runs with a light-weight version of Ubuntu 14.04 LTS operating system that is called Lubuntu 14.04 LTS. Lubuntu uses a small desk-top-environment called LXDE. It is recommended that the image of the Lubuntu 14.04 LTS OS be placed on a micro-SDI memory chip, not the available eMMc memory module.

You either need to: (a) purchase a micro-SD from HardKernel with the OS installed or (b) just purchase a "class 10 speed" 8 GB (or larger) micro-SD chip from your local computer store, down load the OS image from HardKernel (no cost) and burn the OS image onto the micro-SDI chip. Plug the micro-SD memory chip into the slot shown in Fig05.

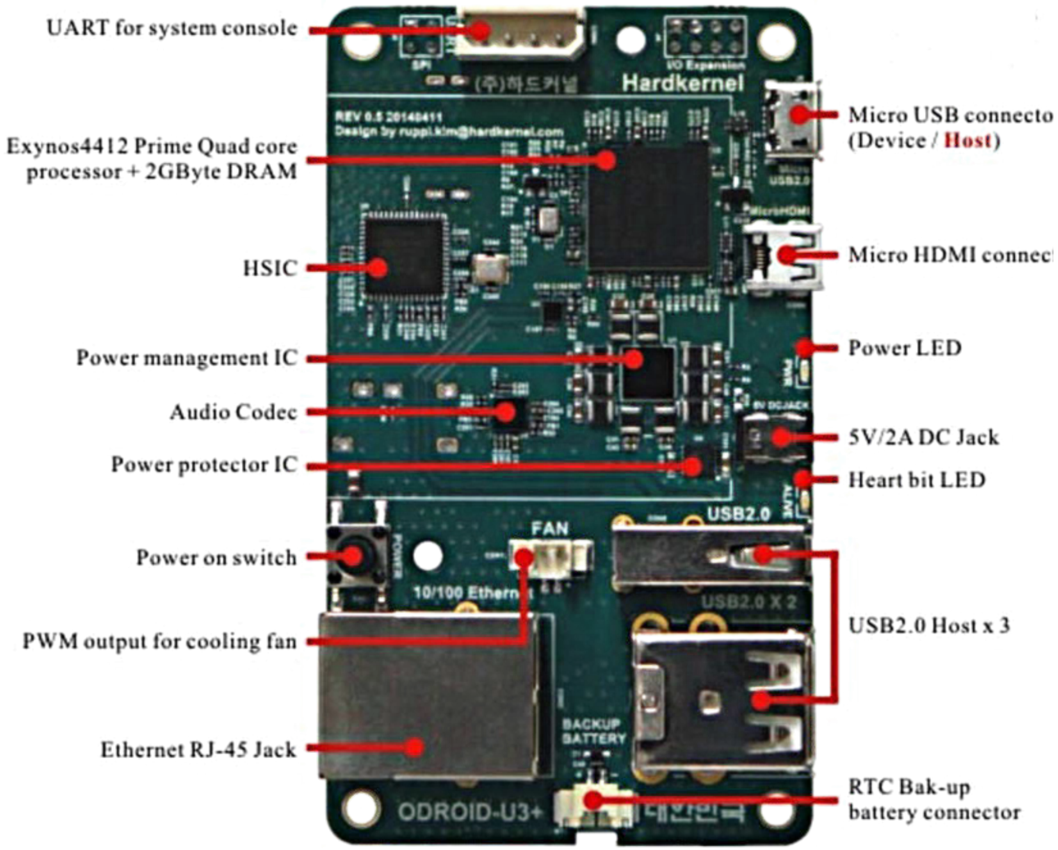


Figure 4 - The top side of the ODROID U3 board. The Heatsink on top of the Exynos Quad-Core CPU is not shown. Three USB2 connectors shown on right side, near bottom.

Running ODROID with DATV-Express

The first steps to operate the ODROID are to attach the WiFI or Ethernet connection for the ODROID, leave off the hardware board & Hauppauge cables, connect the micro-HDMI-adapter-cable to a display and connect the power-adapter (wall-wart) to the ODROID to power-up. You should see the ODROID boot-up on the display (with a blinking blue LED on the ODROID board). At this point it is necessary to enable the WiFi or Ethernet connection to internet.

More detailed instructions will be available in the DATV-Express User Guide for ODROID (coming soon to the www.DATV-Express web site).

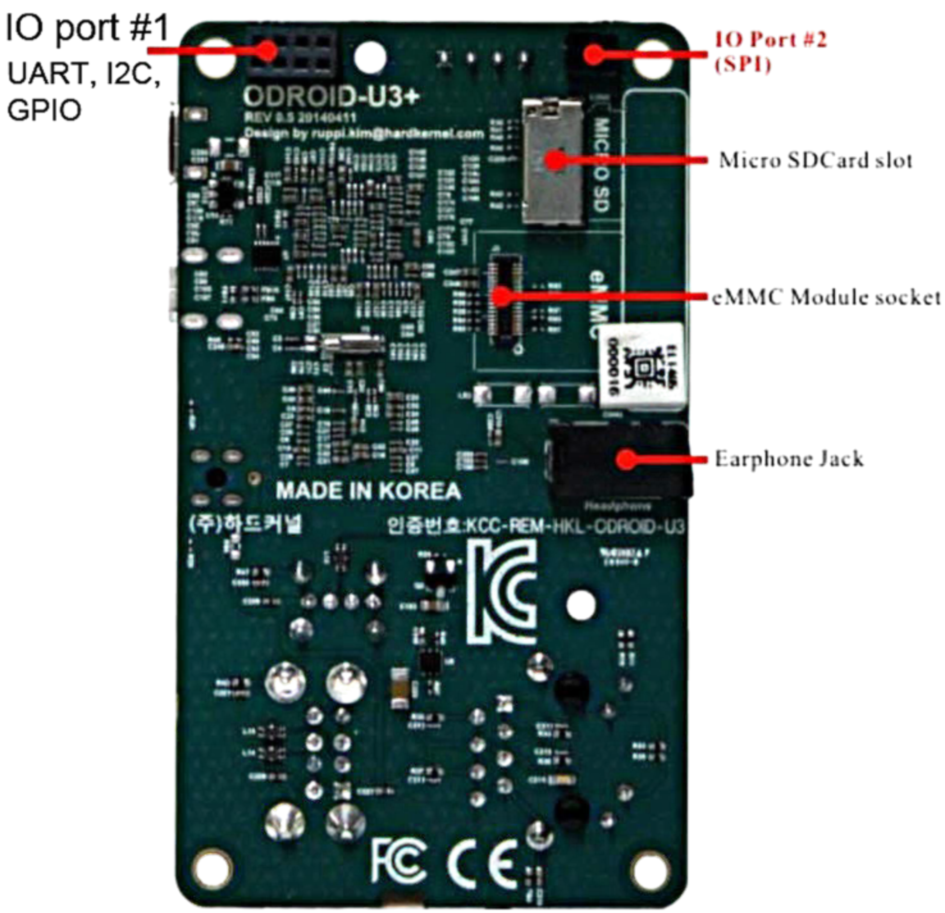


Figure 5 - The bottom side of ODROID U3. The micro-SD memory slot is shown on right side near the top

Place the correct DATV-Express .deb file (for ARMhf) on the ODROID desktop and double-click the file to install the DATV-Express software. You will need to modify one system file for access rights for USB (same as PC versions) and then you can remove the internet connection and attach the hardware board and Hauppauge video-capture unit.

Testing DATV-Express with ODROID

The DATV-Express software binary can be launched from the System Menu in the lower left-hand corner of the Lubuntu desktop. As shown in Fig06, the DATV-Express application is listed in the SOUND & VIDEO area in the system menu. Just click on it and it launches the app. The DATV-Express graphic user interface (GUI) looks essentially the same (see Fig07) as the GUI that displays on the Ubuntu PC installations. The set-up and configuration is also essentially the same - except most operating will use EXPRESS-AUTO mode (in HW Tab) to offload processing from the ODROID for DVB-S operations.

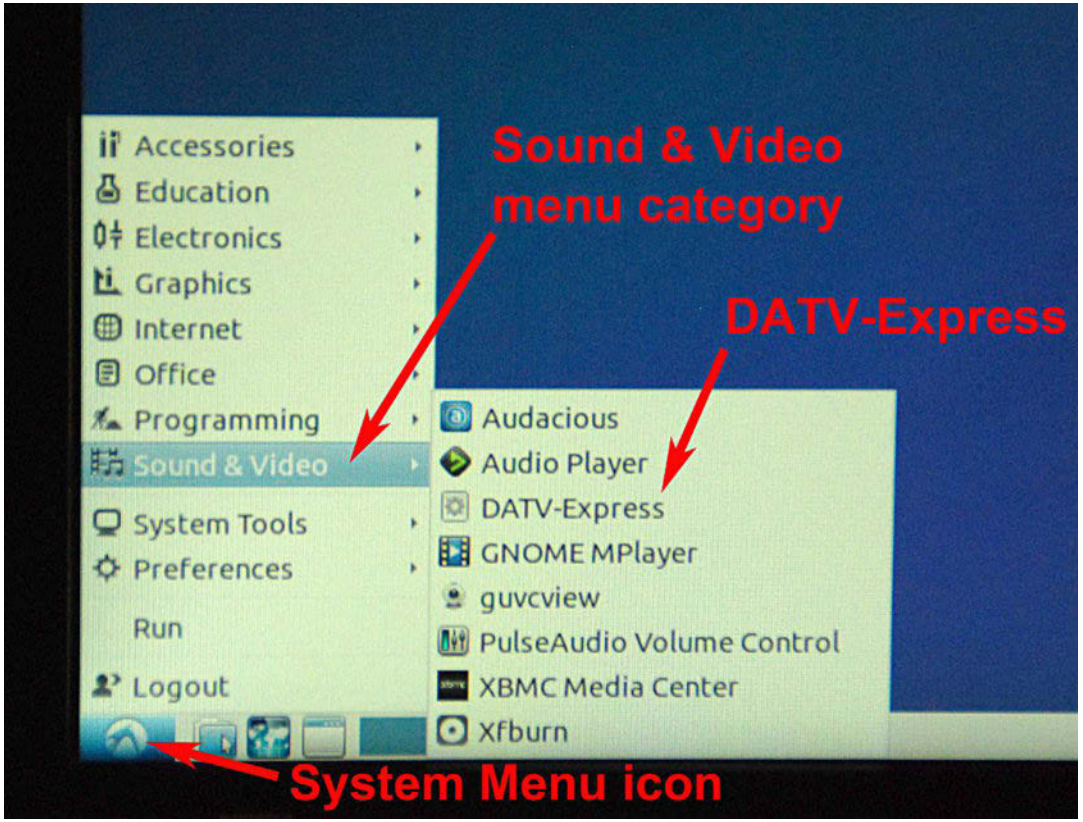


Figure 6 - The DATV-Express application can be launched from the System Menu of the Lubuntu Desktop

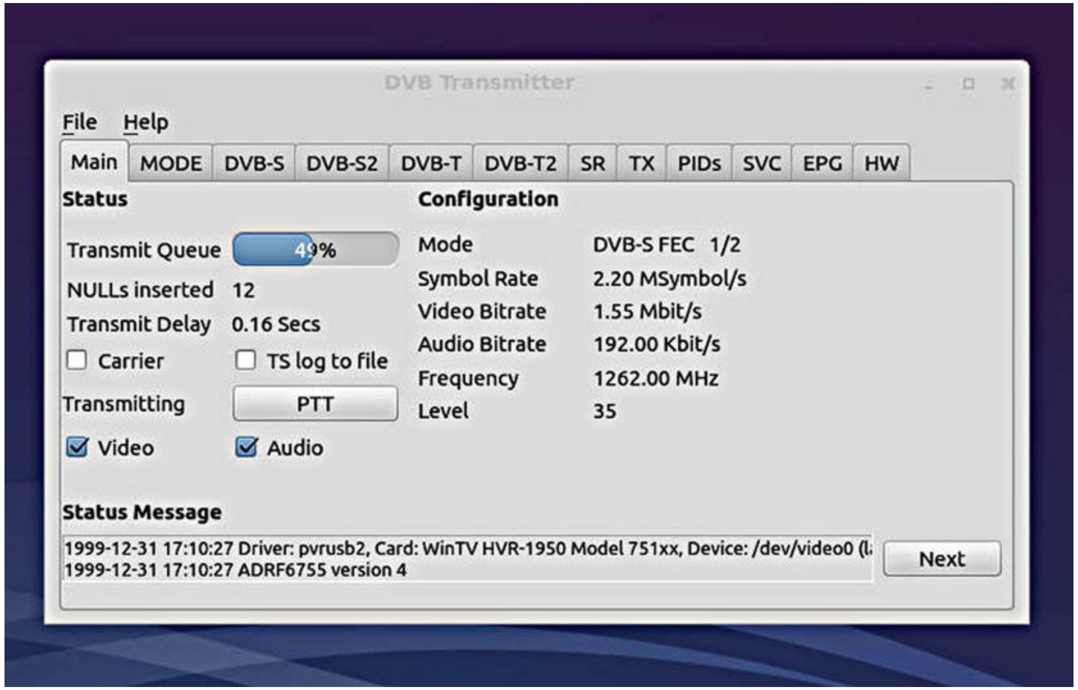


Figure 7 - The DATV-Express GUI for ODROID looks essentially the same as when installed on Ubuntu on a PC

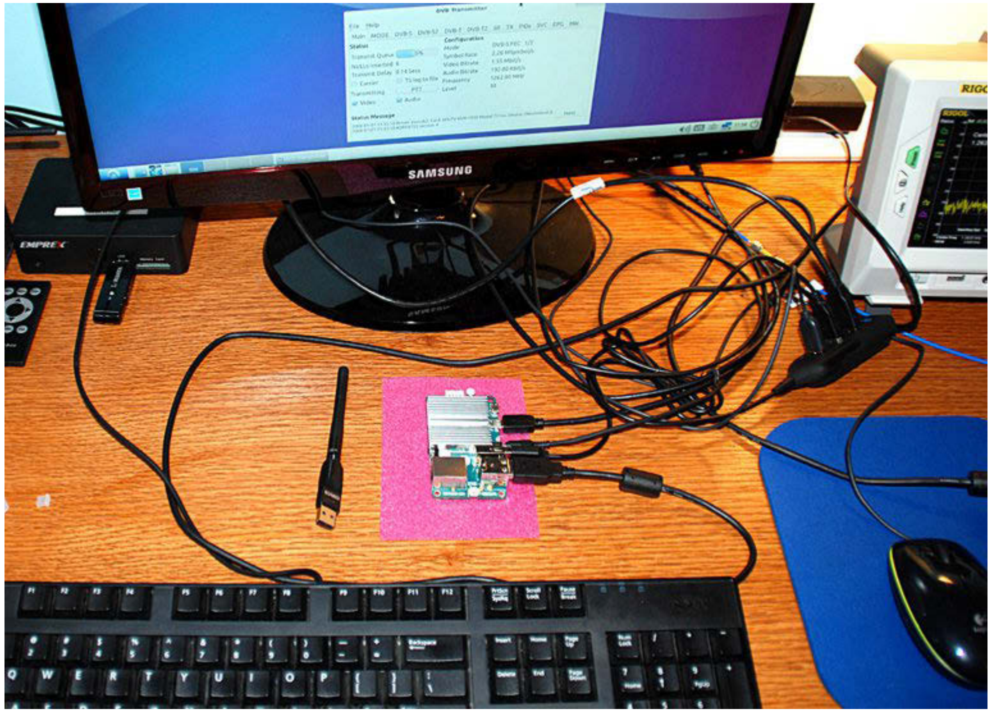


Figure 8 - Set-up to use ODROID U3 to test with DATV-Express board at QTH of W6HHC

Fig08 shows the ODROID set-up to operate and drive the DATV-Express board (not shown - off to the right). A non-powered USB-hub can be seen to the right of ODROID for connecting a mouse and keyboard. The Cisco USB WiFi unit, purchased from HardKernel, can be seen lying unconnected on the desk to the left of ODROID.

Fig09 (next page) shows the normal DVB-S "haystack" during "barefoot" testing as displayed on a Spec-trum Analyzer. This test was operated on 1262 MHz with a 3 MHz bandwidth (BWallocation) using 2.2 MSymb/sec Symbol Rate (SR).

The RF coming from the DATV-Express hardware board driven by the ODROID should not be any different than when the board is being operated with a full-size PC. To confirm this, I hooked up a model MKU-P1301A first-stage RF Power Amp made by Kuhne (in Germany). This RF amp is rated at 1 W (FM) and is the same amplifier that I used to bench test the DATV-Express board driven by a PC. As expected, Fig10 shows that same reasonably shaped DVB-S "haystack" that was also produced when testing with Ubuntu on a PC.

The average output power measured in Fig10 was about 40 mW - enough to easily drive my DownEast second-stage RF PA (30 W FM) on the 1.2 GHz to about 6-to-8 W average power out.

The DATV-Express board was originally designed to just run DVB-S protocol. But, the project team is always curious if it can also run DVB-T. One of the first tests I ran on the ODROID U3 was to try the new 1 MHz bandwidth mode for DVB-T that was added in the v2.03 release of software.

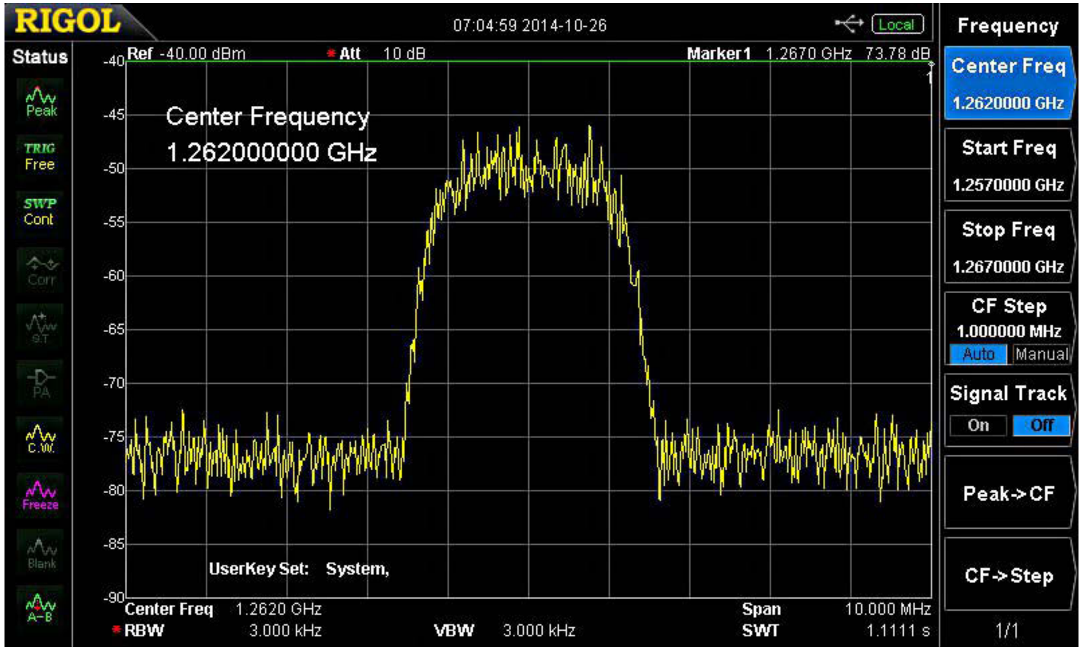


Figure 9 - Spectrum Analyzer display of "Barefoot" testing of DATV-Express exciter board using DVB-S on 1.2 GHz band.

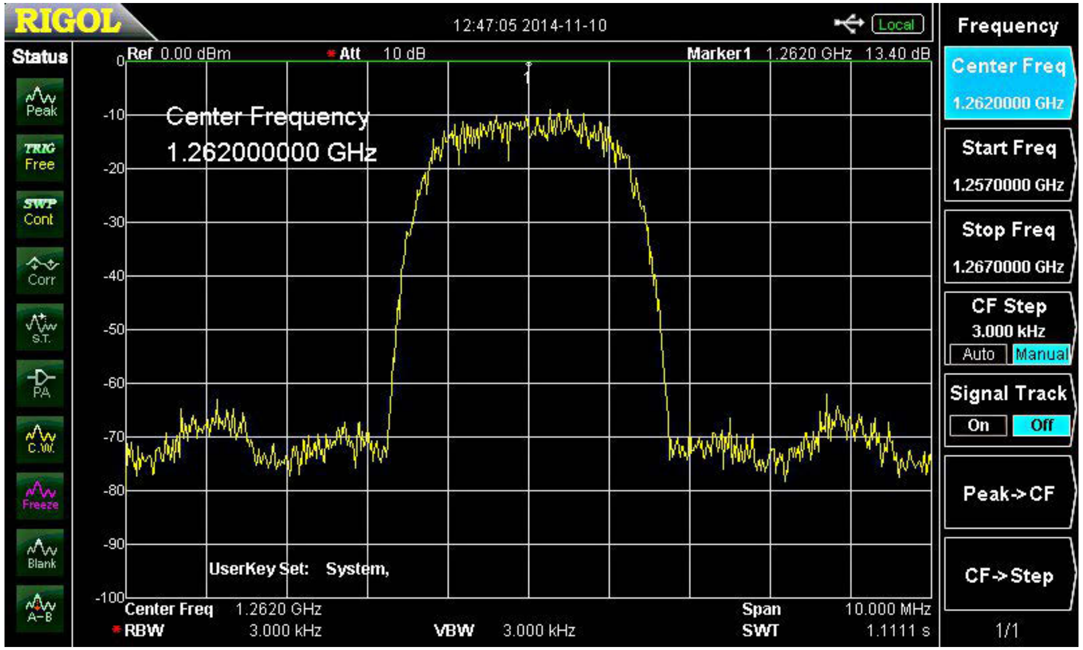
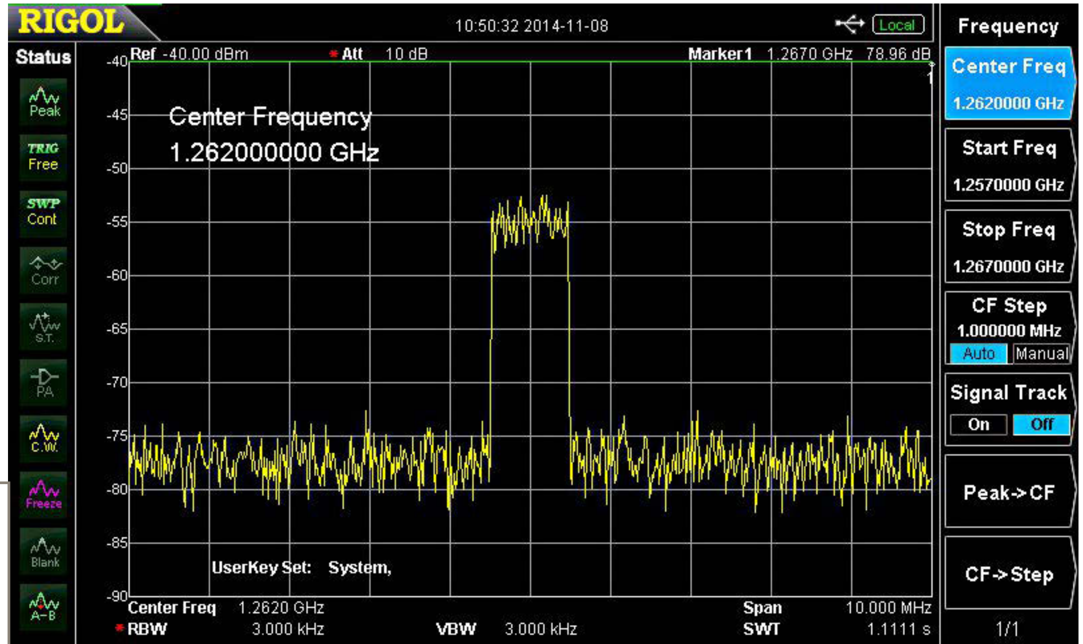


Figure 10 - Spectrum Analyzer display of DATV-Express driving a Kuhne 1.2 GHz RF Power Amp rated at 1W (FM)

Fig11 was taken using QPSK modulation and FEC=1/2. I do NOT have a DVB-T receiver, so I can not view the video quality. With that modulation and FEC setting, the GUI reported the video data rate at about 0.3 Mbps, which would only support a slow video display frame-rate. If I change the FEC setting to 7/8, then the GUI reports the video data-bit-rate increased to about 0.7 Mbps. Of course, the modulation for the 1 MHz bandwidth mode could be changed to use QAM-16 in order to support a higher video data-rate (although with some loss of signal robustness introduced by the increased-modulation-complexity). I also tested DVB-T with QPSK in the 2 MHz BW mode.

Figure 11 - right - Spectrum Analyzer of the ODROID driving the Hardware Board in the 1 MHz BW mode with DVB-T protocol. The SA display span is 10 MHz.



Using an alpha-test build of the software, one of the four ODROID CPUs was NOT able to keep up with the required processing load for the 2 MHz BW testing. Charles G4GUO suspects that further DVB-T load-reduction improvements could possibly be done by rewriting parts of the software in assembly language (but, will not occur soon).

Release of ODROID SW for DATV-Express

The project team plan for ODROID release is to:

1. need to complete the test of the resulting v2.03 in-stallation on ODROID-U3 to make sure that all fea-tures work well.
2. A stand-alone ODROID-version of the USER GUIDE needs to be prepared (many Lubuntu screens look different)

My current expectation is that these tasks will all be completed, released, and available on the DATV-Express web site by the end of November.

Possible Future Roadmap with ODROID

The DATV-Express project team recognizes that currently, the Hauppauge approach for video-capture creates two large problems for our project:

(1) The timing on the Hauppauge PCR with a linux driver seems to be very jittery. G4GUO has retimed the PCR and re-stamped the packets, but not perfectly.

(2) Hauppauge has come out with two new HVR models; HVR-1905 (PAL) and HVR-1955 (NTSC) but have not yet come out with the Linux drivers - creating a DATV-Express problem for buyers of those new models.

Alex OZ9AEC has been experimenting with a Logitech web camera, that outputs the video stream with H264 (aka MPEG-4) encoding. The Logitech model C920 web camera is small and even has mounting for a tripod.

The only issue with this nice and affordable web camera is that the audio has not been encoded by MPEG-4. My personal suspicion is that Logitech may be attempting to avoid paying a license fee for AC3 (a licensed CODEC by Dolby), the normal audio for H.264. So one approach could be to encode the C920 camera audio processing via a CPU CODEC for MPEG-4 or MPEG-2 on the ODROID.

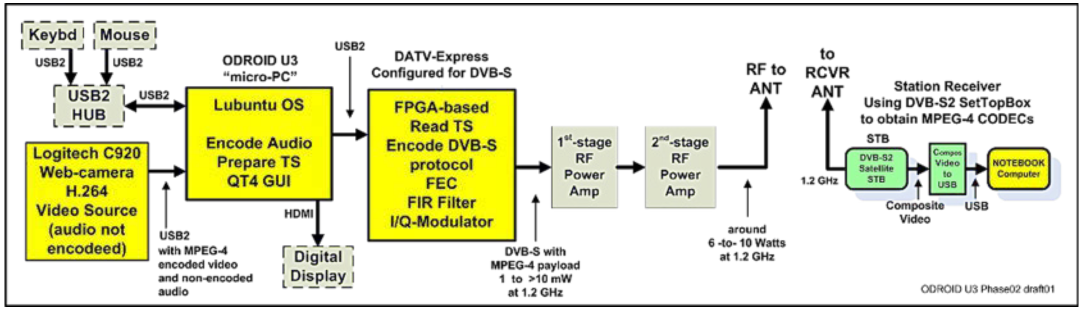


Figure 12 - Possible "concept" Block Diagram of ODROID DVB-S transmitter using C920 Web camera that outputs H.264 encoded video stream

Fig 12 is a concept block diagram of ODROID U3 using the Logitech C920 web camera to transmit H.264 video with DVB-S DATV protocol. The receiver is required to be a DVB-S2 STB receiver or DVB-S2 USB-dongle-receiver that is also capable of receiving legacy DVB-S protocols. Note that this is not a normal commercial protocol. Also note that Logitech does not supply linux drivers â€¦but do support the UVC standards supporting cameras in linux distributions. So there may be an issue with the Lubuntu distribution? But, the project team thinks this might work for DATV?? The team plans to take some time to investigate and sort out these potential C920 issues.

Conclusion

The ODROID U3 "micro-PC" works very well with the DATV-Express DATV exciter board, especially for the DVB-S protocol. It makes the use of a DATV-Express transmitting station more portable by eliminating a large PC or a bulky notebook computer. The ODROID U3 is fairly affordably priced at US$65 (70 Euro) plus plastic-case, 5V/2A power adapter (wall-wart) and shipping.

Contact Info

The author may be contacted at W6HHC@ARRL.net

Useful URLs

ATCO - Amateur Television of Central Ohio - see www.ATCO.tv

British ATV Club - Digital Forum - see www.BATC.org.UK/forum/

CQ-DATV online (free monthly) e-magazine - see www.CQ-DATV.mobi

DATV-Express Project for Digital-ATV (User Guide and downloads) - see www.DATV-Express.com

HardKernel web site for ODROID U3 - see www.hardkernel.com/

HardKernel USA Sales for faster shipping - see www.ameridroid.com

OZ9AEC discussions on using Logitech model C920 web camera - see www.OZ9AEC.net/index.php/gstreamer/473-using-the-logitech-c920-webcam-with-gstreamer

Orange County ARC entire series of newsletter DATV articles and DATV presentations - see www.W6ZE.org/DATV/

Yahoo Group for Digital ATV - see groups.yahoo.com/group/DigitalATV/

DATVtalk13 – Webcams and UDP and DatvExpressServerApp on Windows

by Ken W6HHC
Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the thirteenth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was an introduction article about basic Digital-ATV.]

Ever since December of 2014, I have been interested in using a web camera with DATV and the DATV-Express exciter board instead of my trusty-but-old NTSC video camera. And for a very long time, the entire DATV-Express project team has wanted to avoid using Hauppauge video-capture units to perform MPEG encoding. Another “wish list” item asked for by hams using DATV-Express board is to be able to send video stream to the board over ethernet or internet. Finally, many hams who want to use DATV do not want to learn how to use Linux…they like the Windows operating system.

This article describes progress that has been made in all four areas mentioned above.

Testing UDP feature without Express_Server

The current DATV-Express software has been implemented with the desire to choose an UDP IP address for the video source that is sending a stream to the CPU running DATV-Express. See Figure01 for the HW-Tab setting that is planned for this feature. The first set of tests that I tried sent UDP packets with video and audio stream over WiFi from a Windows PC to ODROID configured for UDP video source. I could NOT get this set-up to work.

Charles G4GUO encouraged me to abandon this configuration for now and start testing the Express_Server code installed on ODROID U3

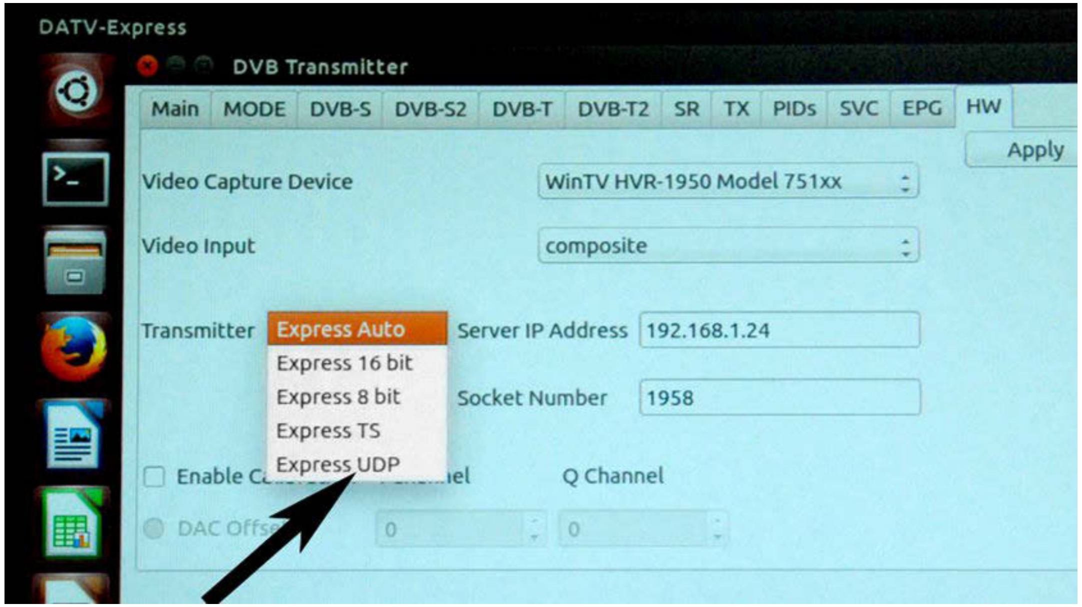


Figure 1 – HW Tab in DATV-Express software GUI has setting planned for UDP stream

Testing UDP feature using Express_Server

The Express_Server software was written by Charles G4GUO to better control the receiving of UDP packets by the computer connected to the DATV-Express transmitter board. In this test set-up shown in Figure02, A Windows computer has a LogiTech web camera attached and running software called GraphStudioNext to encode the webcam video and use a another piece of software called MajorUDP-Sender to aim the UDP packets to the IP address of the ODROID U3 computer.

The ODROID computer is running Lubuntu OS, has the Express_Server software installed and is connected to the DATV-Express transmitter board by USB.

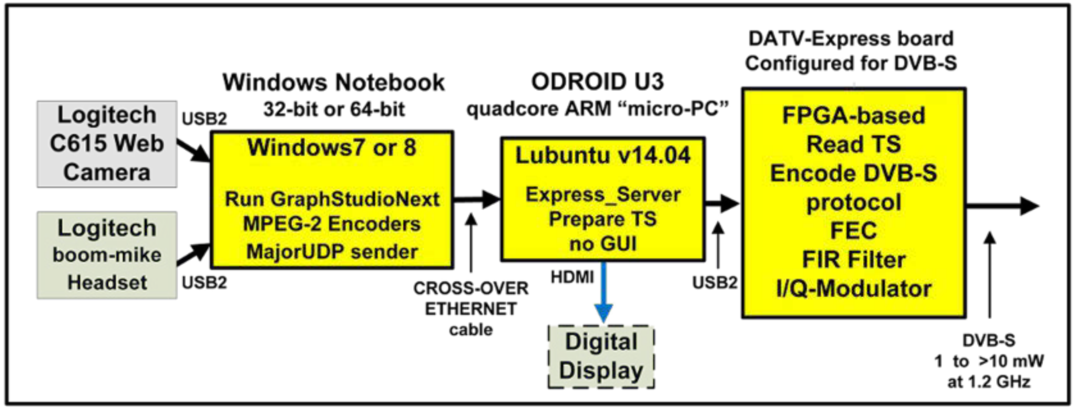
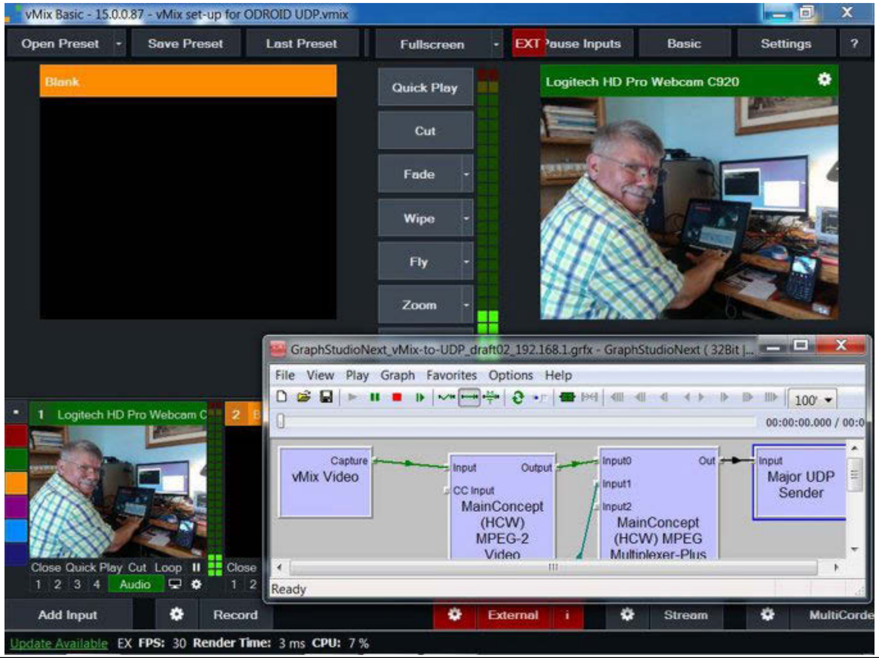


Figure 2 – Block Diagram for sending LogiTech web cam video by UDP to ODROID running Express_Server

The first testing configuration I tried with the Express_Server software used a LogiTech model C920 webcam, a video-editing software called vMix, encoders configured in a DirectShow Graph called GraphStudioNext installed on a Windows7 notebook computer (see Figure03). My initial tests tried to use my home WiFi between the Win7 notebook and the ODROID computer.



There were two areas of problems with this first testing configuration that I tried on the Win7 computer:

1. The LogiTech model C920 webcam outputs video that has already encoded using H.264 video compression (aka MPEG-4). Initial tests showed close to 12 seconds of latency delays to receive the video on my receiver. When I reported my C920 results on a DATV internet forum, Jean Pierre F6DZP reminded me that my test set-up was forcing the Win7 computer to first decode the H.264 video stream back to a non-encoded stream and then finally using GraphStudioNext to encode to the MPEG-2 standard. F6DZP recommended that I try using an earlier non-H.264 webcam.

2. The free video editor I was using, vMix BASIC SD (Standard Definition) model, was nice (even allows "green screen" magic) but added a level of complexity that I did not really need. It turns out that Charles had used it in one of his testing set-ups only because it was an easy tool to use to overlay his call letters on top of the video stream…to use during a DATV contest. But vMix added some operational complexity and also prevented me from controlling directly the source-filters settings for the LogiTech equipment.

The next Win7 testing configuration I tried with the Express_Server software was to change the webcam to an older LogiTech model C615 that I owned and to eliminate the vMix video editing software. Figure04 shows the configuration of "filters" that I now used in GraphStudioNext (I use the latest free version, V0.7.0.430).
(img,, alt: Fig04_W6HHC_C615_Win7-MPEG2-Graph src: ../Images/Fig04_W6HHC_C615_Win7-MPEG2-Graph.png)

The MajorUDP-Sender software block is aiming packets to ODROID IP address

Figure 3 Left - vMix manages the C920 video and GraphStudioNext allows MPEG2 encoding and aims the UDP packets to the Wi-Fi port on ODROID

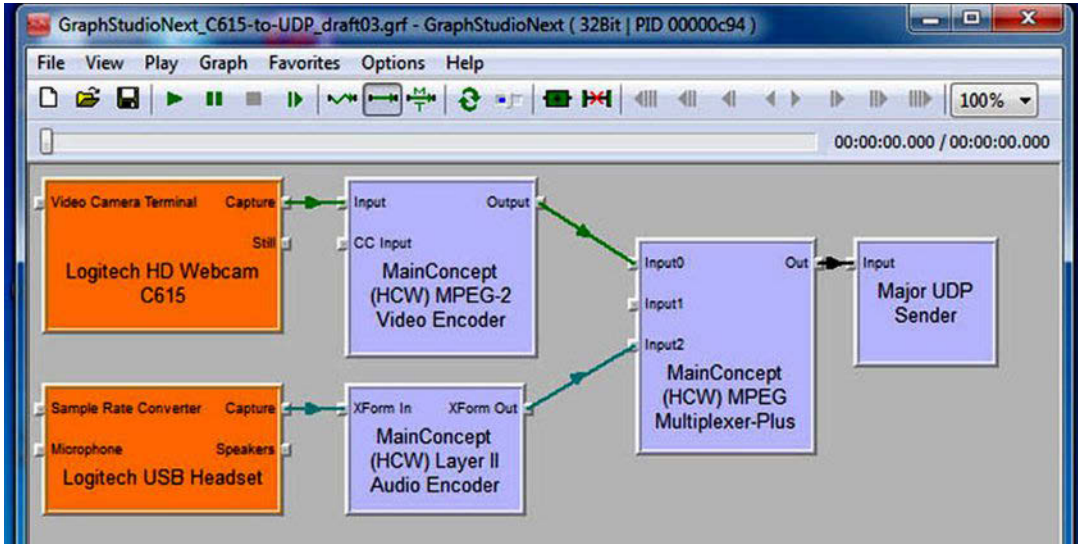


Figure 4 - Configuration of DirectShow filters using GraphStudioNext filter for using C615 webcam on Windows.

With the C615 camera, the latency was much improved (perhaps less than using Hauppauge video capture units), but the video would freeze after a minute or two while using a WiFi configuration between the two computers. I suspected perhaps buffer overflow somewhere? G4GUO encouraged me to switch to an ethernet “cable” connection...Charles pointed out he also had poor results with WiFi even though he had “line of sight”.

I chose to use a “cross-over ethernet” cable between the two computers. The only tricky part of the “cross-over ethernet” cable installation is that you have to configure both computers for static IP addresses. Setting Windows for a static IP adr was straight forward through the Win Control Panel.
But setting a static IP address on the ODROID was difficult to sort out...I had to “Google For It” and sort through adding the code below to the INTERFACES system file in the NETWORK folder.

auto eth0
iface eth0 inet static
address 192.168.1.10
netmask 255.255.0.0
gateway 192.168.1.20 (this is the static IP address of the Win7)

Confirm IP addresses are working by pinging from Win7 to ODROID at 192.168.1.10. The static IP addresses cable connection worked perfectly and video was stable in testing lasting more than 8 hours.

One significant difference when using the Ex-press_Server software is that there is NO Graphic User Interface (GUI). There is only a command line user interface to show you the server is running (see Figure05). The configuration settings that you configure for DATV-Express board DVB-S parame-ter settings are editable in a text file called, ex-press.txt

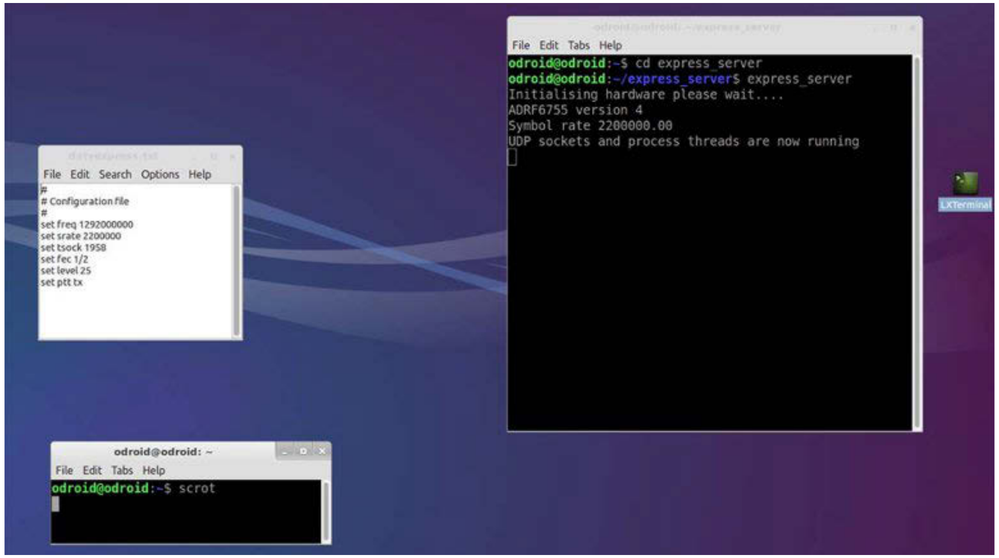


Figure 5 – The express_server software is installed and runs (terminal window is on right) on ODROID. It captures incoming internet UDP packets and sends Transport Stream to DATV-Express board. The configuration settings text file is shown on left.

There are two notes about express_server. First, I had to build the express_server software on the ODROID computer from source code that G4GUO makes available on his github (see URL at end of article). G4GUO points out that although I tested the express_server on an ODROID U3 (see Figure02), the Express_Server software will run on any linux system.

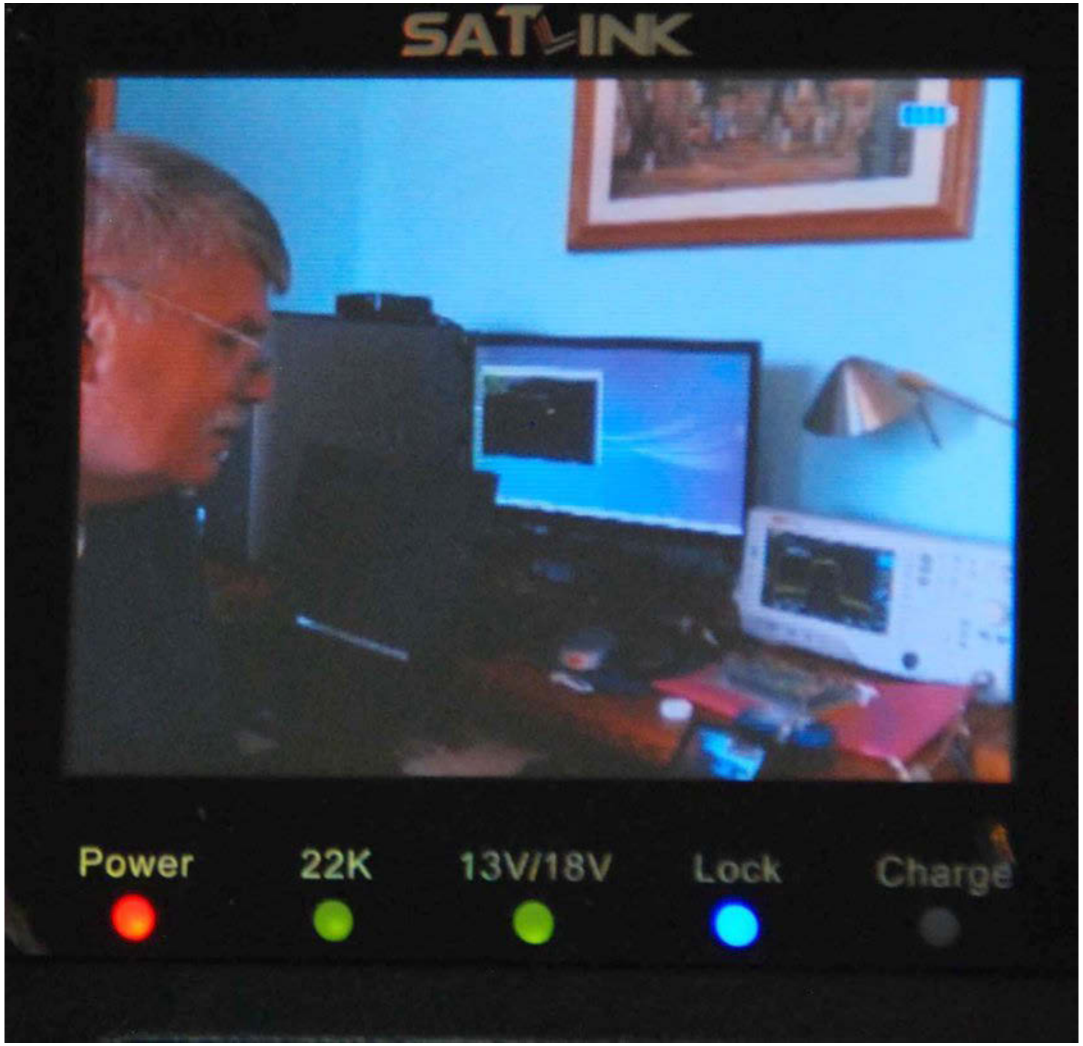


Figure 6 - First stable video received using the express_server and cross-over Ethernet cable for UDP packets

Testing DatvExpressServerApp on Windows (no linux used)

A constant request by hams wanting to use the DATV-Express transmitter board was "when will Windows be available?". I then tested the soft-ware that Charles G4GUO has written, called the DatvExpressServerApp, that allows the DATV-Express board to be connected directly to a Windows computer running Win7 or Win8. Figure 7 shows the block diagram for my testing set-up.

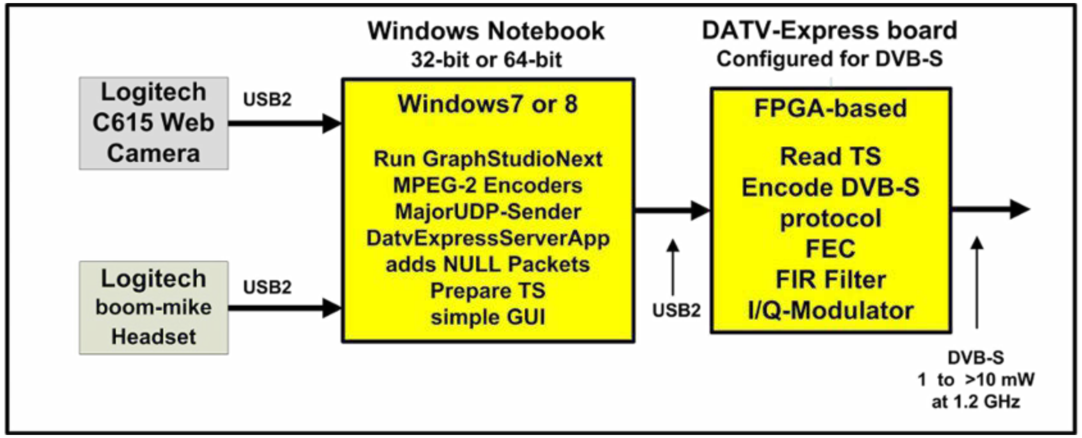


Figure 7 – Block Diagram showing the DatvExpressServerApp software runs completely on a Windows machine and connects to DATV-Express board

This testing configuration uses the same GraphStudioNext set of filters that had been used in Figure02 and Figure04. The only difference is that the Major-UDP-Sender software now aims UDP packets to the internal loopback IP address on the Windows PC, 127.0.0.1.

I did have to sort through installing libusb and driver for the DATV-Express board onto the Windows computer. Libusb(0).dll and the signed Windows driver are publicly available and comes from another Amateur Radio project (HPSDR).

Make sure that you use the readme file for DatvExprssServerApp called HELP.txt. Figure08 shows the simple GUI that DatvExpressServerApp provides on Windows.

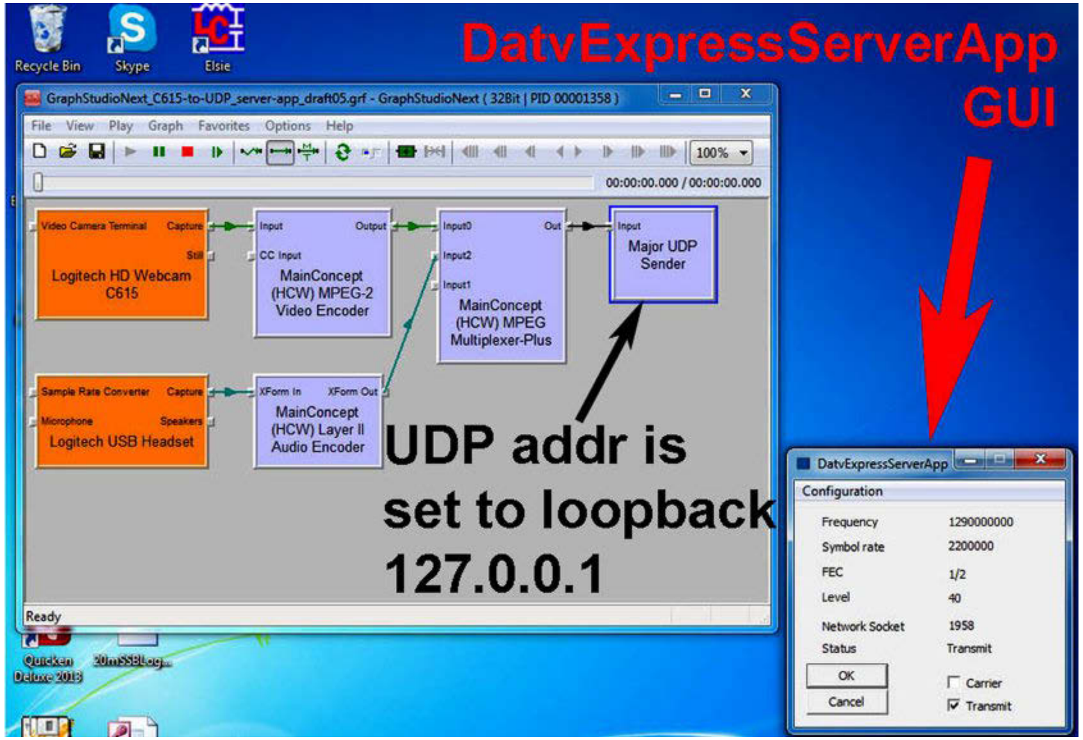


Figure 8 - Windows running GraphStudioNext graphs and simple GUI for DatvExpressServerApp

Again notice in Figure07 that the Hauppauge video-capture board/unit is not used by DatvExpressServerApp. The MPEG-2 audio and video encoder filters in Figure08 are from MainConcept (HCW). I obtained my copy of the three MainConcept filters from the Hauppauge installation CD-ROM that came with my Hauppauge usb-based video-capture unit.

The properties display of the MainConcept filter in Figure09 shows that I have currently set the CBR rate of the desired video bit-rate to 1500 Kbps to not overrun the SymbolRate of 2.20 MSymb/sec that I want to use.

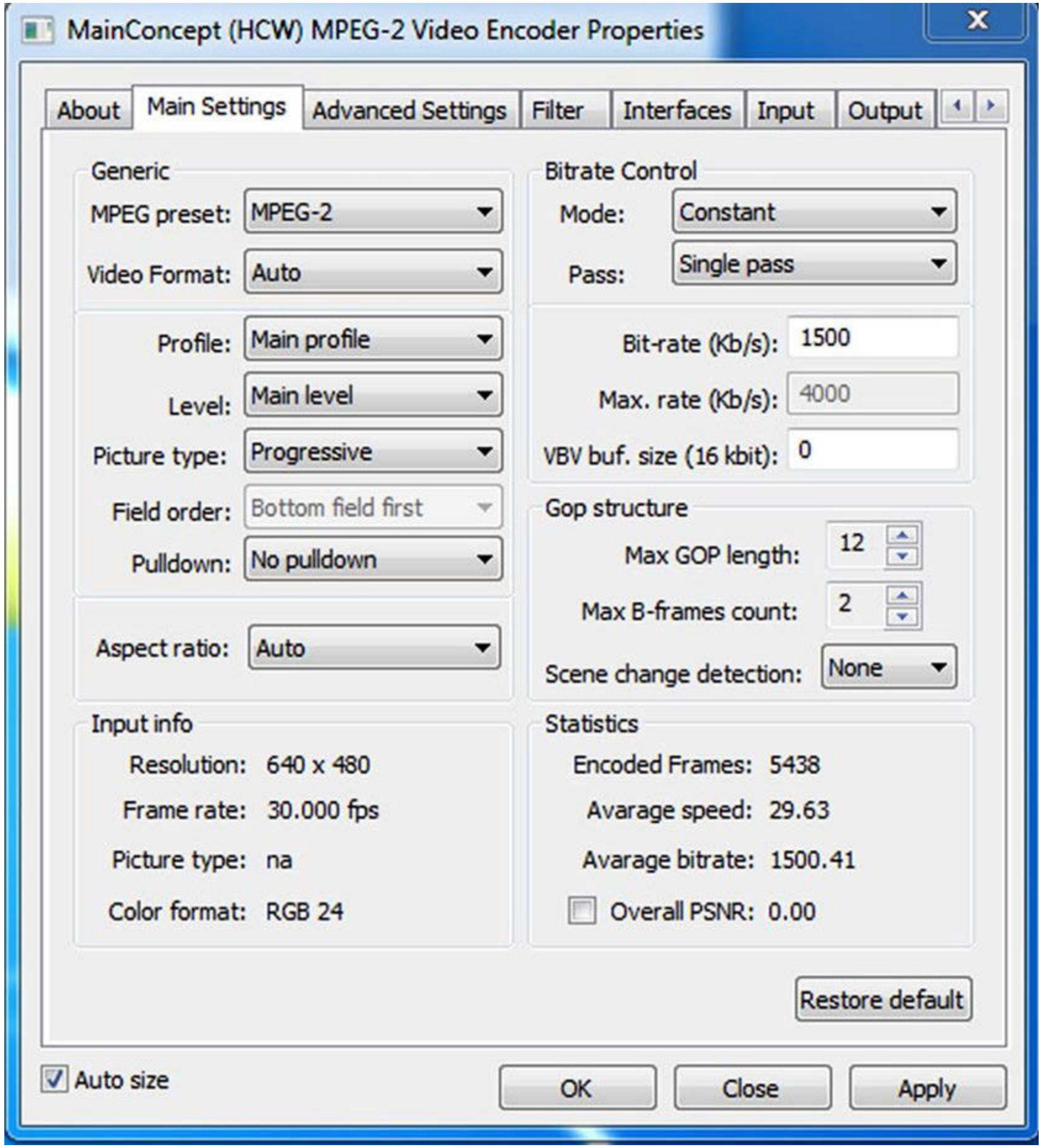


Figure 9 – Properties of MainConcept video encoder filter used in my current testing using ConstantBitRate (CBR)

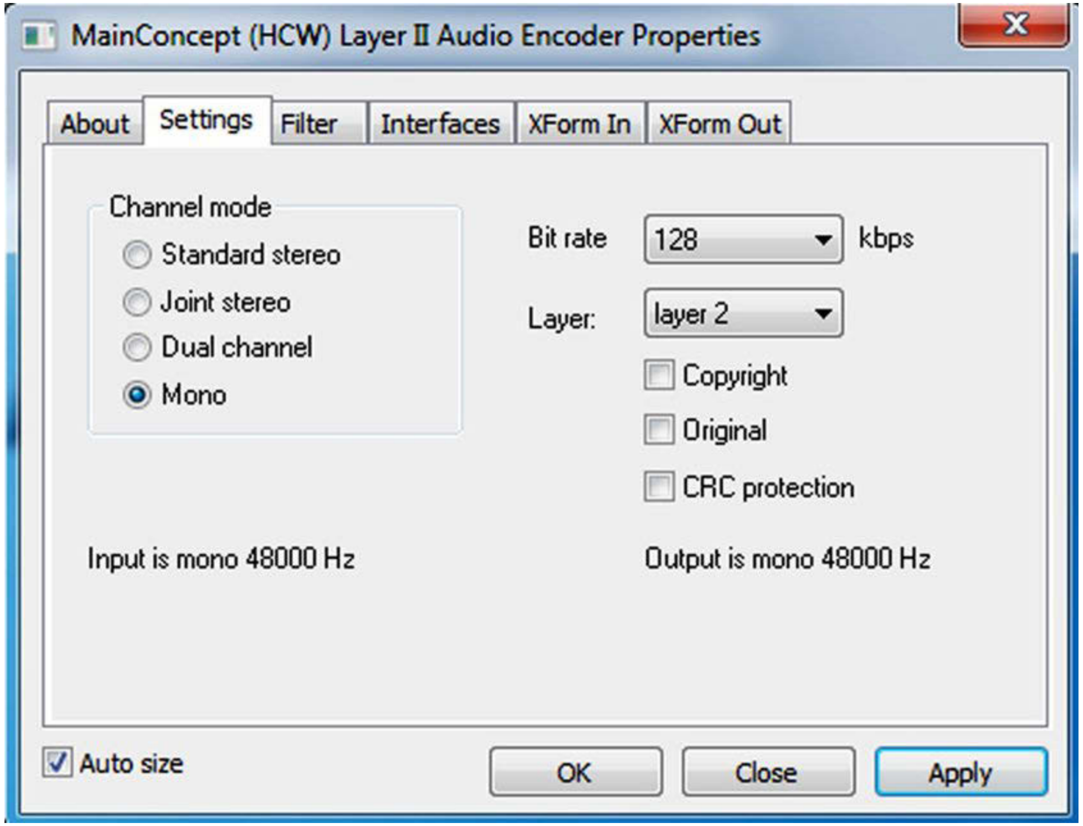


Figure 10 – Properties of MainConcept audio encoder filter used in my current testing

One small issue exists with the VideoPID and Audio-PID. The MainConcept MPEG MUX filter defaults to values of 1001 and 1002 (as compared to values of VidPID = 256 and AudPID = 257 used for most DVB-S installations). You can change the PIDs to another set of values, but I have not determined how to SAVE those new values as default values.

Conclusions

This report is the result of a lot fun trying to break out of the “handcuffs” created by the NTSC/PAL camera, Hauppauge encoder-boards, and Linux that have somewhat limited the appeal and limited possible applications of the DATV-Express project hardware board.

Using a USB-webcam from Logitech shows that endless cameras can be chosen with many possibilities for other camera interfaces rather than me being restricted to my hand-me-down old (becoming obsolete) home NTSC video camera. I can move to modern cameras now for DATV-Express.

This report also provides a roadmap for using DirectShow filters as software encoders, like the Main-Concept ones used

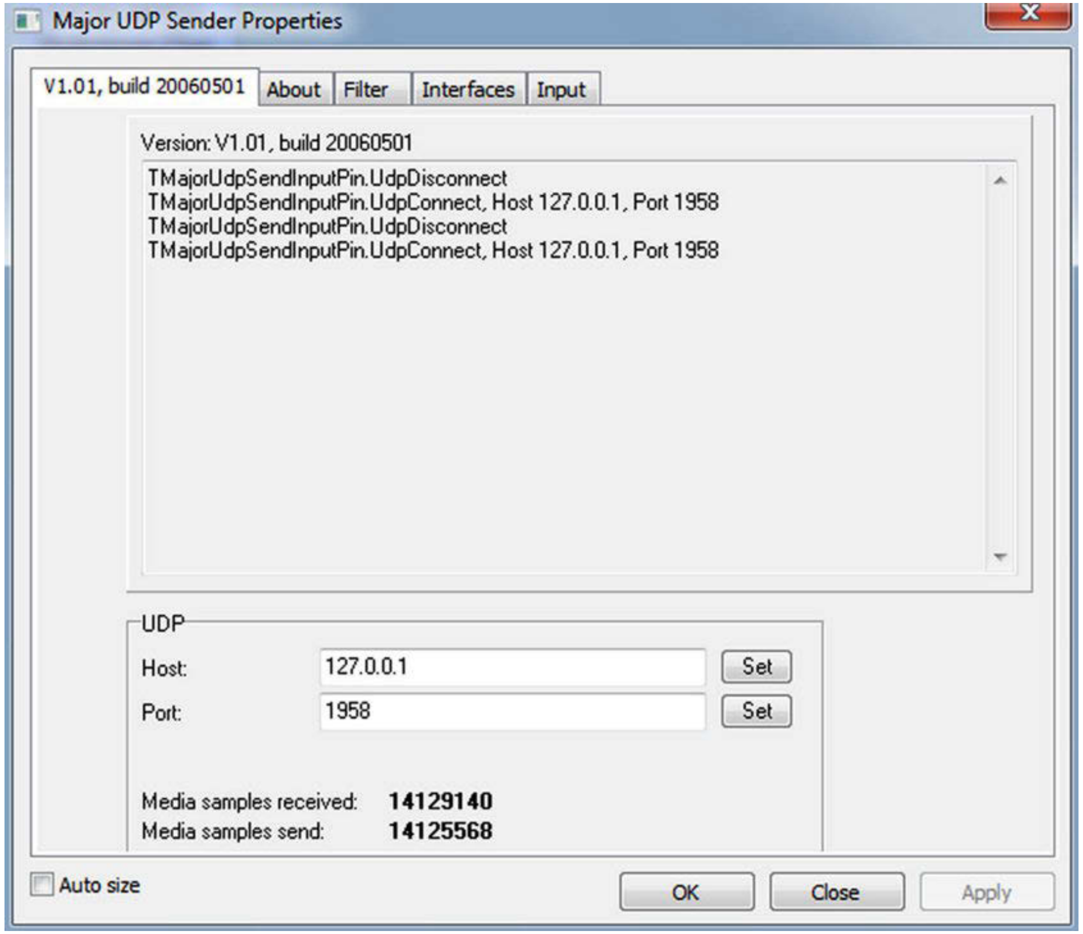


Figure 11 – Properties of MajorUDP-Sender software with IP destination address aimed at loopback 127.0.0.1 and socket chosen for an arbitrary 1958

in this report. The iron-clad hand-cuffs to Hauppauge video-encoders for many hams has been broken. It does not take too much imagination to see that other encoder filters for MPEG-4/H.264 can be found and substituted for the MPEG-2 encoders in this report to reduce the video-bit-stream-rate and allow smaller RF Bandwidths for DVB-S transmitters in SD (Standard Definition) mode.

Or transmit HD video if your application really needs true HD with the corresponding increase in RF Bandwidth over SD.

The ability to send video UDP packet streams over ethernet and even internet to the DATV-Express transmitter board (instead of being tied to the plugged-in-camera) opens up a thousand new possible applications that were not possible before.

Not being able to use Windows operating system and being forced to deal with Linux has been a learning challenge and a “barrier” for many hams.

The new DatvExpressServerApp software from Charles G4GUO will eventually allow Windows to be your choice if that is what you want. G4GUO is quick to point out that the DatvExpressServerApp software is still in a highly “experimental stage”. But it is a great start.

Other hams may be willing to volunteer to make improvements to the source code and add new features to DatvExpressServerApp in an open source spirit.

Finally, if any readers know how to change and save the default PID/PIS values for video and audio in the MainConcept MPEG MUX filter...please send me an e-mail.

Contact Info

The author may be contacted at W6HHC@ARRL.net

Useful URLs

- British ATV Club - Digital Forum – www.BATC.org.UK/forum/
- CQ-DATV online (free monthly) e-magazine – www.CQ-DATV.mobi
- DATV-Express Project for Digital-ATV (User Guide and downloads) – www.DATV-Express.com
- G4GUO github for DATV-Express source code – https://github.com/G4GUO/datvexpress_gui.git
- G4GUO github for express_server source code – https://github.com/G4GUO/express_server.git
- HardKernel web site for ODROID U3 – www.hardkernel.com/
- HardKernel USA Sales for faster shipping – www.ameridroid.com
- HardKernel web site for free ODROID Magazine – http://Magazine.Odroid.com
- Chris MWØLLK discussions on vMix and FFMPEG software on Windows to create transport stream – http://www.tannet.org.uk/using-ffmpeg-to-generate-a-transport-stream-more-details-and-how-to-add-text-overlays/
- Orange County ARC entire series of newsletter DATV articles and DATV presentations – www.W6ZE.org/DATV/
- Yahoo Group for Digital ATV - groups.yahoo.com/group/DigitalATV/

DATVtalk14

DATV-Express on Windows using Express DVB-S Transmitter Software

by Ken W6HHC

Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

Please Note – This is the Fourteenth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was an introduction article about basic Digital-ATV. This latest DATVtalk article describes progress on Express_DVB_S_Transmitter software for the DATV-Express exciter hardware board.

The old technology of analog-ATV suffers from susceptibility to snow and multi-path ghost images. Dig-ital-ATV (DATV) using new technologies like digital modulation, and Forward Error Correction (FEC) can result in robust video reception where analog-ATV fails, as well as providing more narrow band-widths on the ham bands.

Figure 01 shows the difference between receiving weak signals on analog-ATV and Digital-ATV using the same RF power amplifier and the same antennas.

The DATV-Express Digital-ATV exciter board was introduced in January 2014 to provide a more affordable product for hams to transmit DATV. The original DATV-Express software product ran on LINUX operating system...a very useful OS, but 95% of hams do NOT use LINUX...and most of those hams do NOT WANT to learn a new OS!!

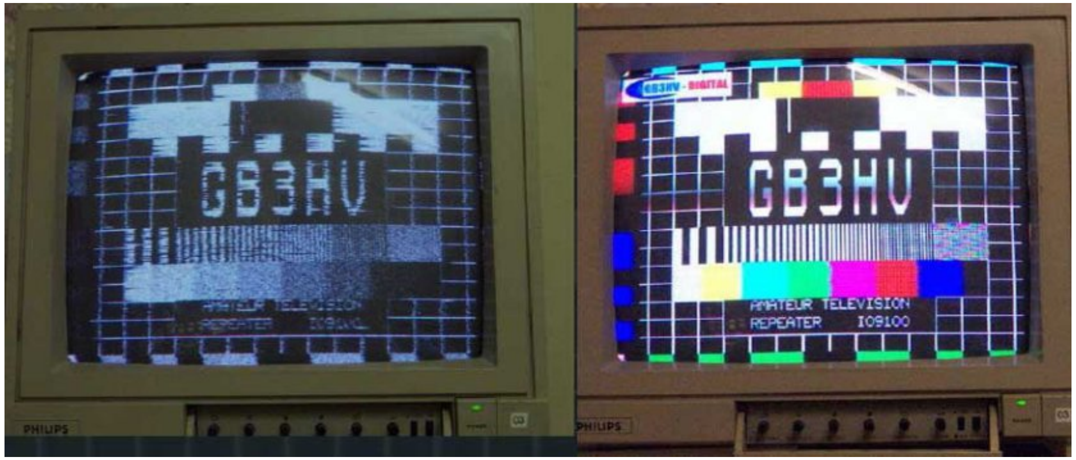


Figure 01 - Comparison of analog ATV video and DATV video using the same antennas with weak sigs (courtesy of G8GTZ & GB3HV)

Express_DVB-S_Transmitter software

The new Express_DVB-S_Transmitter software was written by Charles G4GUO to allow the DATV-Express transmitter board to operate in Windows (Win7, Win8, and Win10). A block diagram of a typical set-up is shown in Figure 02.

An important feature of this new software is that the video-capture-to-encoder function no longer needs to be performed on a Hauppauge video capture board. The Express_DVB-S_Transmitter software uses the FFMPEG CODEC library that is available in a Windows environment to perform the video encoding/compression (no more Hauppauge unit needed!).

The Main screen of the Express_DVB-S_Transmitter software displays all of the settings that the owner has made - as shown in Figure 03. There are seven tabs across the top of the Main screen that control the actual settings for the DATV transmission. For example: the CAPTURE Tab allows selecting the video and audio device and the MODULATOR Tab allows selection of frequency, Symbol Rate, FEC, etc.

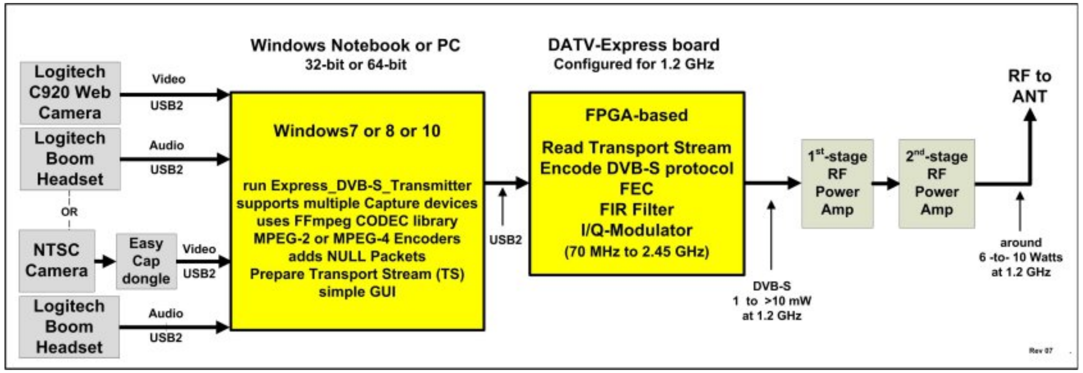


Figure 02 – Block Diagram for typical set-up running Express_DVB-S_Transmitter software on Windows

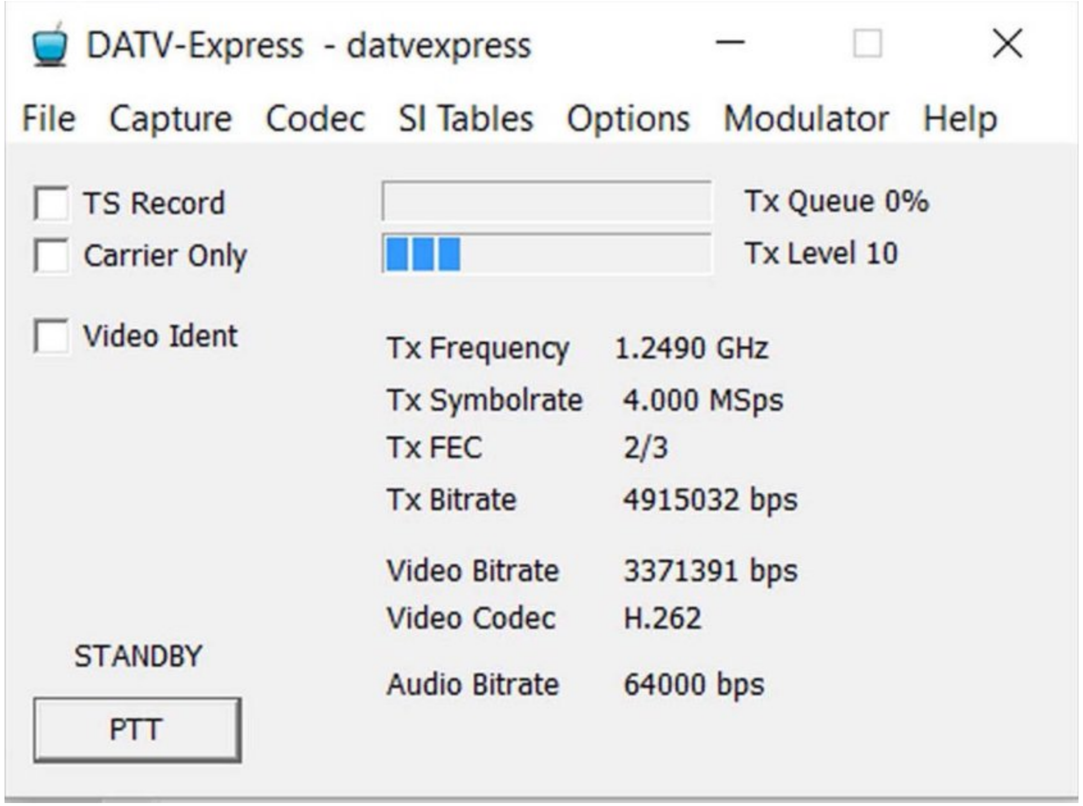


Figure 03 - The Main screen of Express_DVB-S_Transmitter software

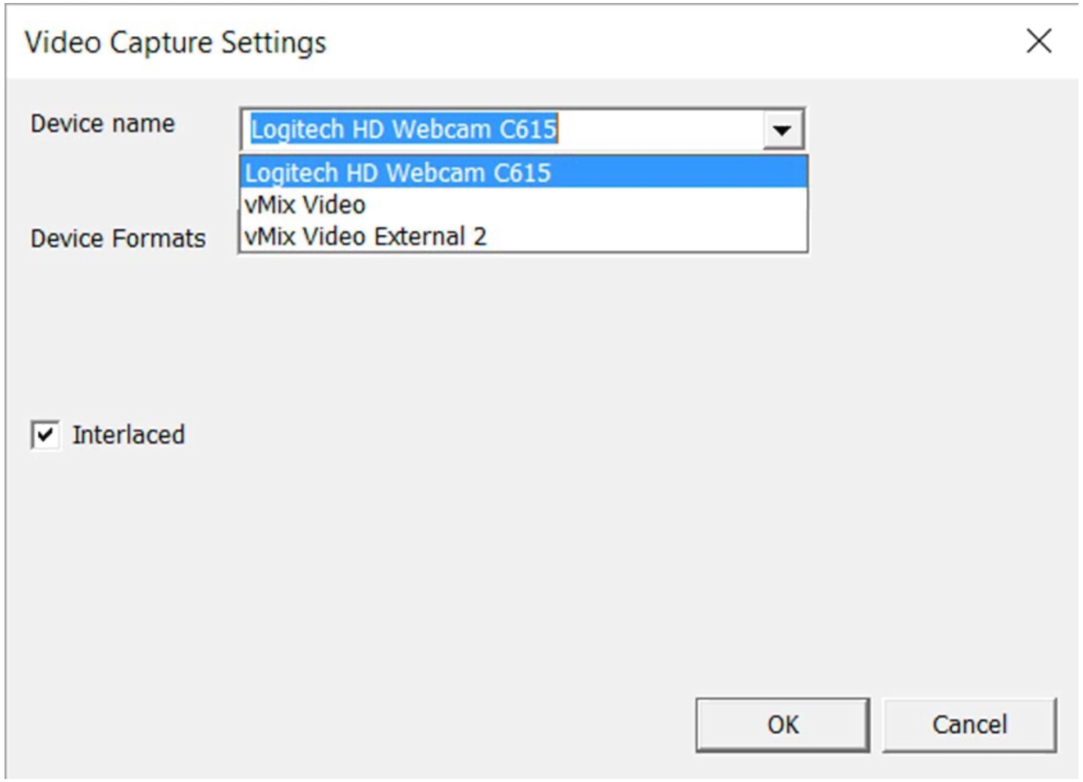


Figure 04 – CAPTURE Tab allows you to choose among cameras attached to the Windows PC

Choice of Cameras and Microphones

One big improvement made by this new Windows software for the DATV-Express hardware board is that there are many more camera models that can be used.

Use a USB-based web-camera such Logitech C920 and HD hand cameras as well as using your old NTSC hand-camera through a video-capture dongle like EasyCap (USB-based).

Even the camera and microphone on your note-book computer can be selected.

Choice of CODEC

A CODEC is a compression encoder. The CODECs Tab allows you to send H.264 (MPEG-4) video as the video-payload even though the soft-ware is using DVB-S protocol. In the commercial DTV world, the DVB-S protocol does NOT transmit H.264 CODEC, but DVB-S2 and DVB-T2 protocols do transmit H.264.

The radio buttons along the top of the Figure 05 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 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 environments under 1M Symb/sec. The significantly better low-SR video quality 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 and have shown to reduce DATV spectrum bandwidth requirements on other ham bands like 70 CM and 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 software encoding is very computer intensive and typically results in latencies nearly 10 seconds.

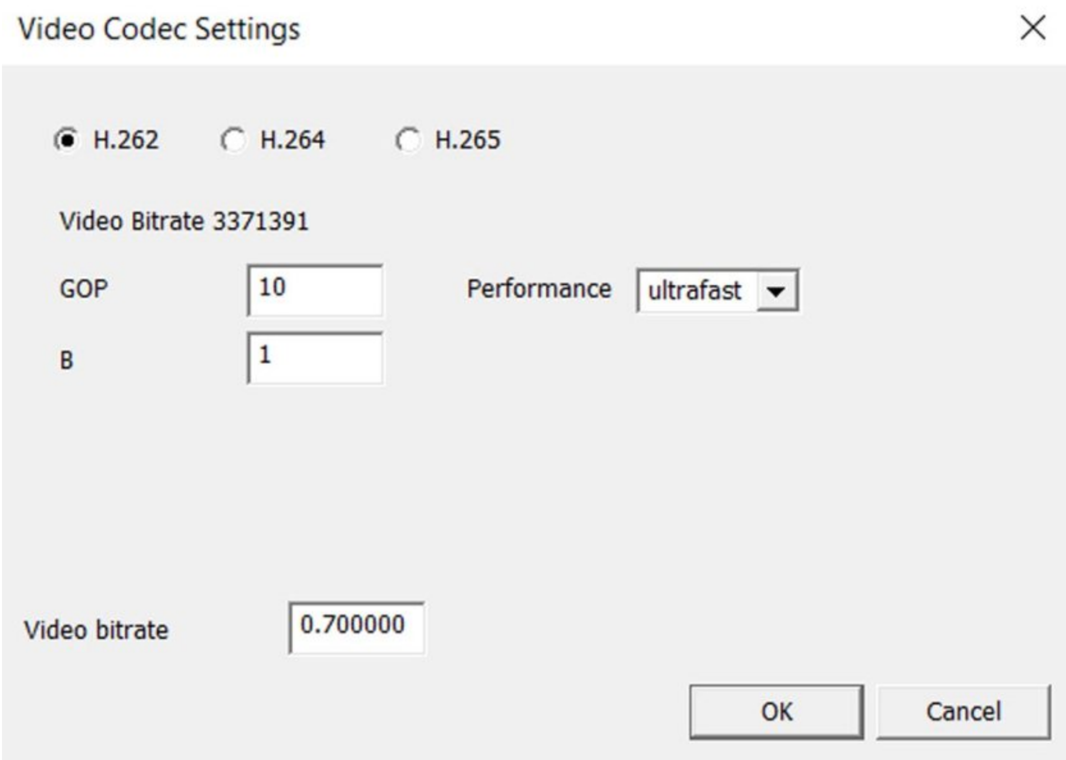


Figure 05 – The CODEC Tab allows selecting H.262 or H.264 or H.265 video encoding.

Figure 06 – The VIDEO IDENT feature can be enabled to display your call letters on the received transmission

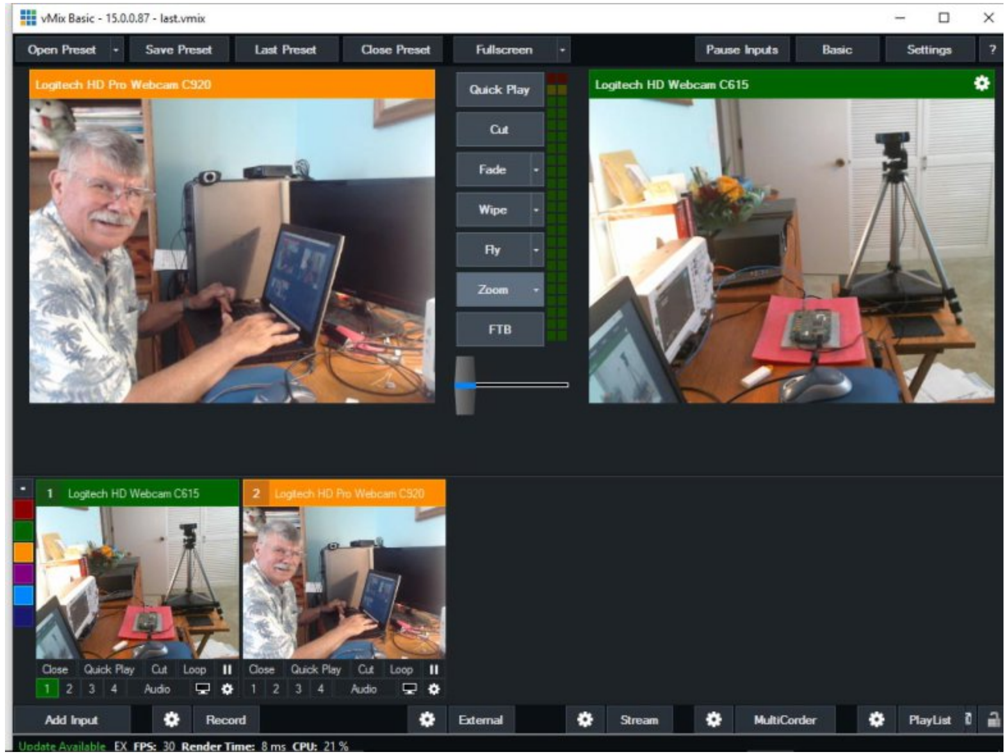


Figure 07 - Typical window for vMix Basic optional software can control multiple cameras and also create “green screen” video effects.

Simple Call Letters Overlay

Another new feature introduced in this Window software application is a simple video overlay for your call letters. This feature can be enabled by “checking” the VIDEO IDENT box on the Main window. Figure 06 shows how the video overlay field appears (shown as the call W6HHC) on the receiver’s screen.

Adding optional vMix Video software

vMix is a great optional companion software tool. vMix Basic is a free video-editor software package for SDTV format video (Standard Definition) is available from vMix.com.

There are more-professional HDTV products of vMix available for sale, including the vMix Basic HD for US$60.

The free video-managing software allows you to control multiple cameras and audio microphones, create call letter overlays, create blue-screen and green-screen tricks, and perform fades-between-cameras.

You can capture any video that you can get onto your Windows computer via USB, Firewire, ASI, or HDMI (using a HDMI-USB capture card). When running, vMix will display as one of the available devices under CAPTURE – Video Devices and CAPTURE – Audio Devices.

Downloading Software and Manual

The Express_DVB-S_Transmitter software is currently available (and free) as a “BETA release” of v1.11. This beta software does already have many successful users around the world and is expected to be “production released” by September.

The software install package, a beta-grade Users Guide for Windows and a readme file, called NOTES.txt can all be downloaded from the www.DATV-Express.com web site on the DOWNLOADS page.

Installation instructions are included in the Users Guide for Windows. The instructions also explain how to use the ZADIG free tool to easily install a Windows device driver for the DATV-Express hardware board.

Finally, a reminder that you can order the DATV-Express hardware board for US$300 + shipping on the PURCHASE page....but you have to be registered and logged-in to the web site in order to make the PayPal purchase.

Contact Info – the author may be contacted at W6HHC@ARRL.net

Useful URLs

British ATV Club - Digital Forum –
www.BATC.org.UK/forum/

CQ-DATV online (free monthly) e-magazine –
www.CQ-DATV.mobi

DATV-Express Project for Digital-ATV (User Guide and downloads) – www.DATV-Express.com

G4GUO github for DATV-Express source code –
https://github.com/G4GUO/datvexpress_gui.git

Chris MWØLLK discussions on vMix and FFMPEG software on Windows to create transport stream –
http://www.tannet.org.uk/using-ffmpeg-to-generate-a-transport-stream-more-details-and-how-to-add-text-overlays/

Orange County ARC entire series of newsletter DATV articles and DATV presentations –
www.W6ZE.org/DATV/

vMix Basic free optional video software tool download –
www.vMix.com

Yahoo Group for Digital ATV -
http://groups.yahoo.com/group/DigitalATV/

DATVtalk15 - vMix Video Mixer for DATV

by Ken W6HHC
Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the Fifteenth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was an introduction article about basic Digital-ATV. This latest DATVtalk article describes a very useful video editing program (and free) called vMix that can be used to control and mix multiple cameras and other video sources.]

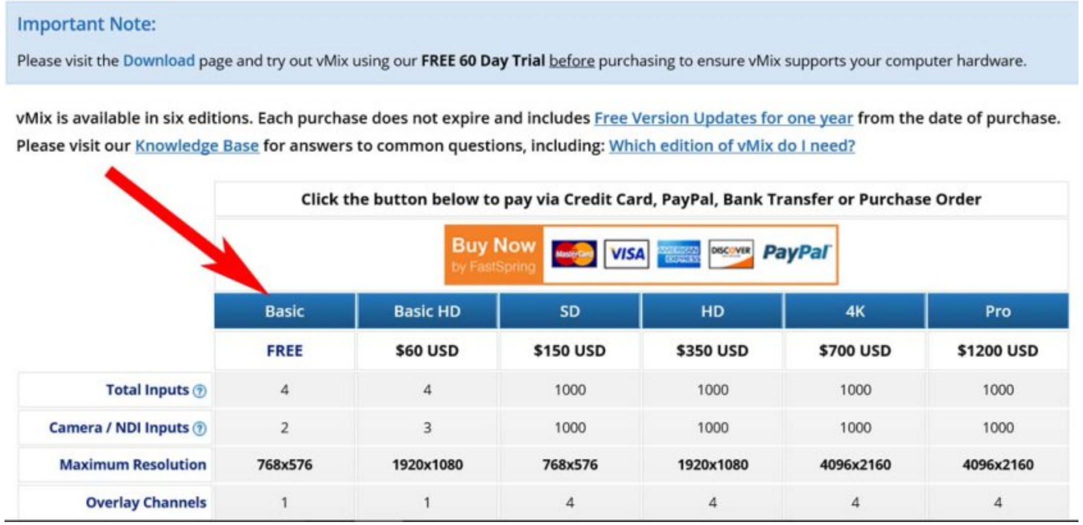
The vMix software is a good companion software application program that allows the user to switch and mix between different cameras/video-files and also do special video-effects, including “green screen”.

It works well with ham radio Digital-ATV (DATV) activities. Perhaps the best part is that the entry-level software package, called vMix Basic, is free to download for SDTV format video (Standard Definition) from vMix.com.

This DATVtalk article is NOT a tutorial on how to use vMix (there are tons of tutorial-videos on YouTube to walk you through the steps), but rather this article is an overview of the many concepts that vMix brings to the user. This article is written from my experience with the DATV-Express DATV transmitter product, but is also applicable to other ham radio DATV product lines that are compatible with vMix.

Which vMix Product to Get?

vMix Basic is a free video-mixer-editor software package for SDTV format video (Standard Definition) that is available from vMix.com.



Important Note:

Please visit the Download page and try out vMix using our **FREE 60 Day Trial** before purchasing to ensure vMix supports your computer hardware.

vMix is available in six editions. Each purchase does not expire and includes Free Version Updates for one year from the date of purchase.
Please visit our Knowledge Base for answers to common questions, including: Which edition of vMix do I need?

Click the button below to pay via Credit Card, PayPal, Bank Transfer or Purchase Order

	Basic	Basic HD	SD	HD	4K	Pro
	FREE	$60 USD	$150 USD	$350 USD	$700 USD	$1200 USD
Total Inputs	4	4	1000	1000	1000	1000
Camera / NDI Inputs	2	3	1000	1000	1000	1000
Maximum Resolution	768x576	1920x1080	768x576	1920x1080	4096x2160	4096x2160
Overlay Channels	1	1	4	4	4	4

Figue01 – The array of vMix products – including free vMix BASIC

There are more-professional HDTV products that are available for sale, including the vMix Basic HD for US$60. See Figure01 for array of vMix products. The download you want is currently called vMix 17

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 Figure02)
4. adding a better-looking call-letters-overlay
5. try “green-screen” video tricks

The vMix Main Screen

The screen-capture in Figure02 shows the normal screen to operate vMix.

The large window in the upper left is called the Preview Window. The large window in the upper right is called the Live Video Window.

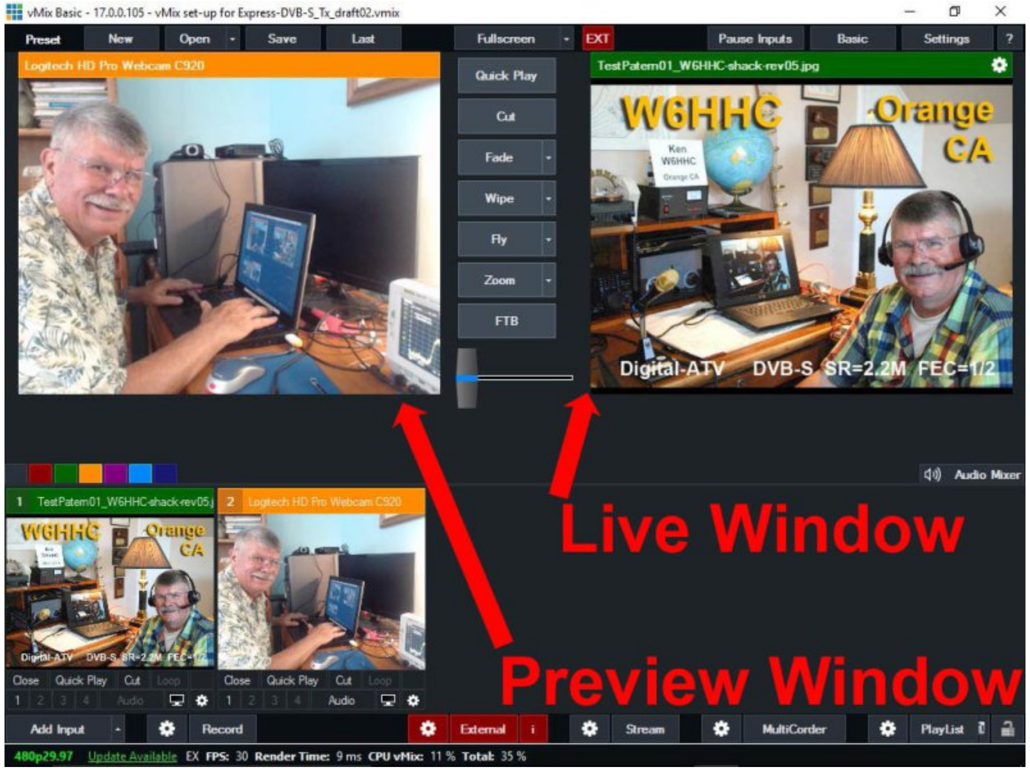
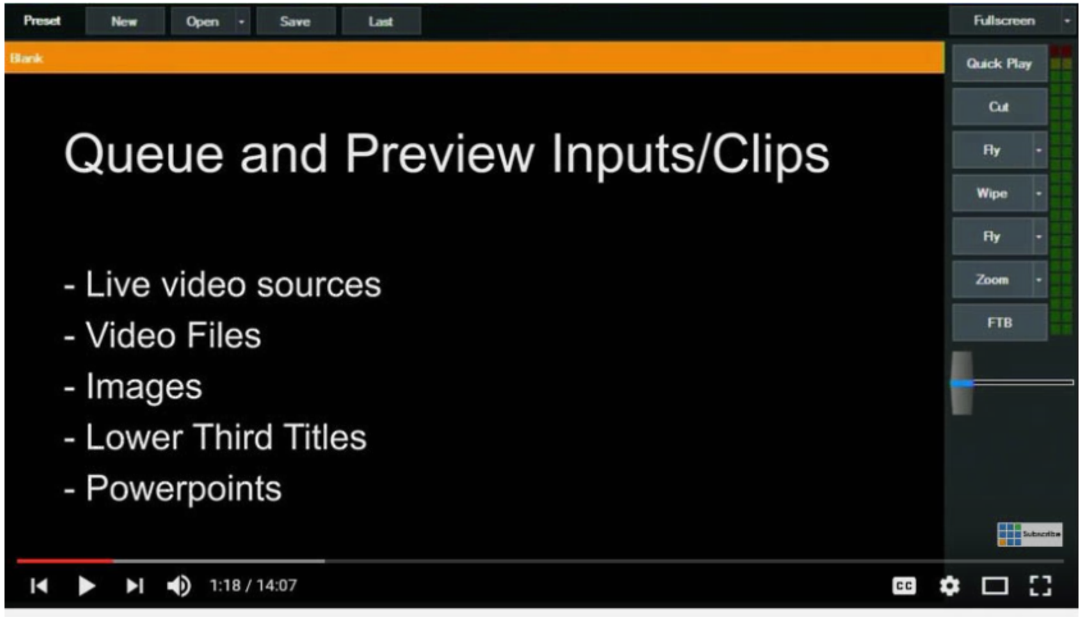


Figure02 – An example of vMix Basic video Main Screen with one camera (in Preview) and a "Test Pattern" JPEG (in Live Window)



vMix Live Production Software - General Overview & Demonstration Tutorial

Figure03 – Main capabilities of the Preview Window

The two smaller screens in the lower left are where you bring in new cameras and video to look at…and then select for Preview. The free vMix Basic only allows three video sources to be viewed in the lower-left. More-professional products available for sale can allow more video sources to be viewed here.

vMix Preview Window

The Preview Window allows you to queue up a number of video sources and have next selected video ready to become "Live" at the push of a button. What can be selected for display here can be cameras, video files, JPEGs, and PowerPoint slides for a slideshow video stream.

You will be able to switch from "Preview" to "Live" by clicking a single button.

vMix Live Program Video Window

The Live Video Window displays the actual video that you have chosen to transmit or stream out (Figure04).

vMix Input Selection List

When setting up a Preview Window for the correct camera and microphone, the user just presses the ADD INPUT button in the lower left corner of the Main Screen.

A long list of choices for video sources and audio sources will appear as shown in Figure05.

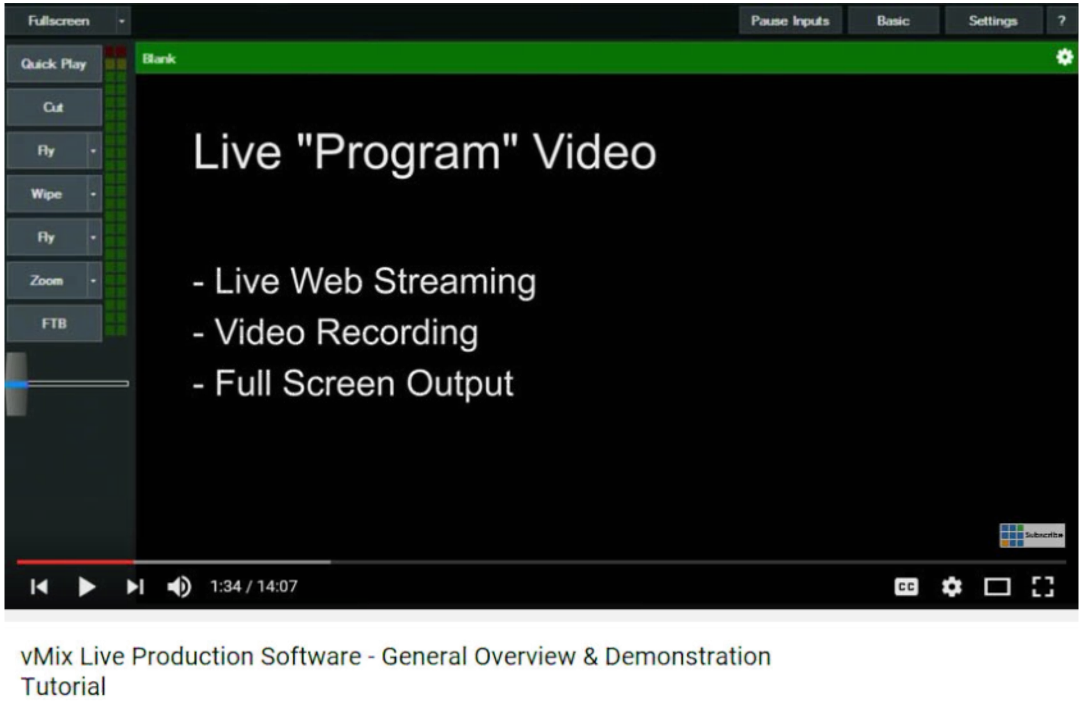


Figure04 – Main capabilities of the Live Program Video Window

Here is a partial list of inputs to vMix that can be selected:

- Video files
- DVD
- Cameras
- NDI allows Skype as input
- JPEG file (as Test Pattern, etc)
- A slideshow of JPEG files
- Audio files
- Microphones
- Adding Title overlays
- Your web browser

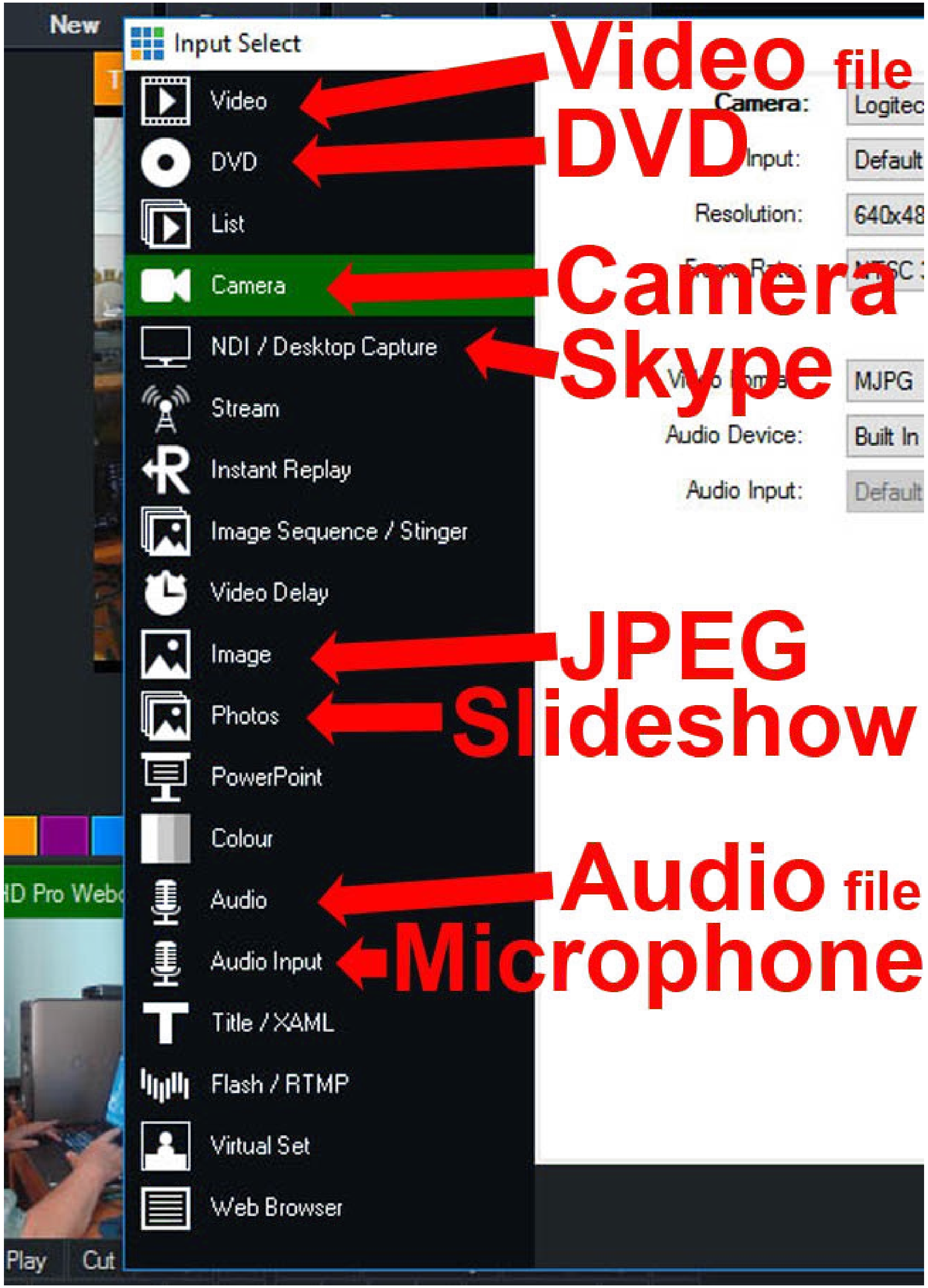


Figure05 (Right) – List of input sources available to be selected by DATV users.

One important concept about configuring your camera in vMix is selecting the correct frame rate. The selected framerate for vMix is ALWAYS set to equal the framerate being output from the camera, NOT the framerate that you want to transmit via DATV. The vMix tutorials on YouTube spend a lot of effort to explain that:

- PAL = 25p (progressive output fps)
- PAL = 50i (interlaced output fps)
- NTSC = 29.9p (progressive output fps)
- NTSC = 59.9i (interlaced output fps)

vMix Titles

vMix has the ability to allow you add a “title overlay” to your video. I personally do NOT like this feature very much, because it takes up too much room on the screen and is too fancy for my style.

Figure06 – Using the vMix Titles feature to overlay your transmitted video stream

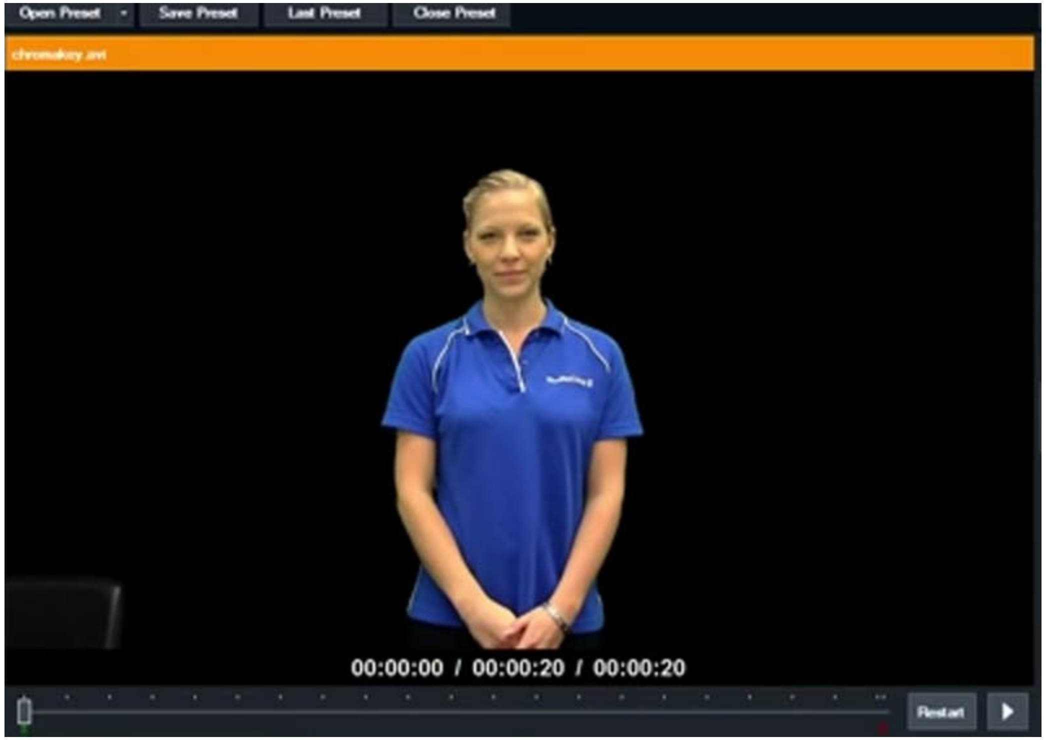
Green Screen Effects

A neat feature of vMix is to create “green screen” tricks to combine a live camera shot (perhaps a talking presenter in the studio) with a video clip of a faraway place. As shown in Figure07. There are three parts:

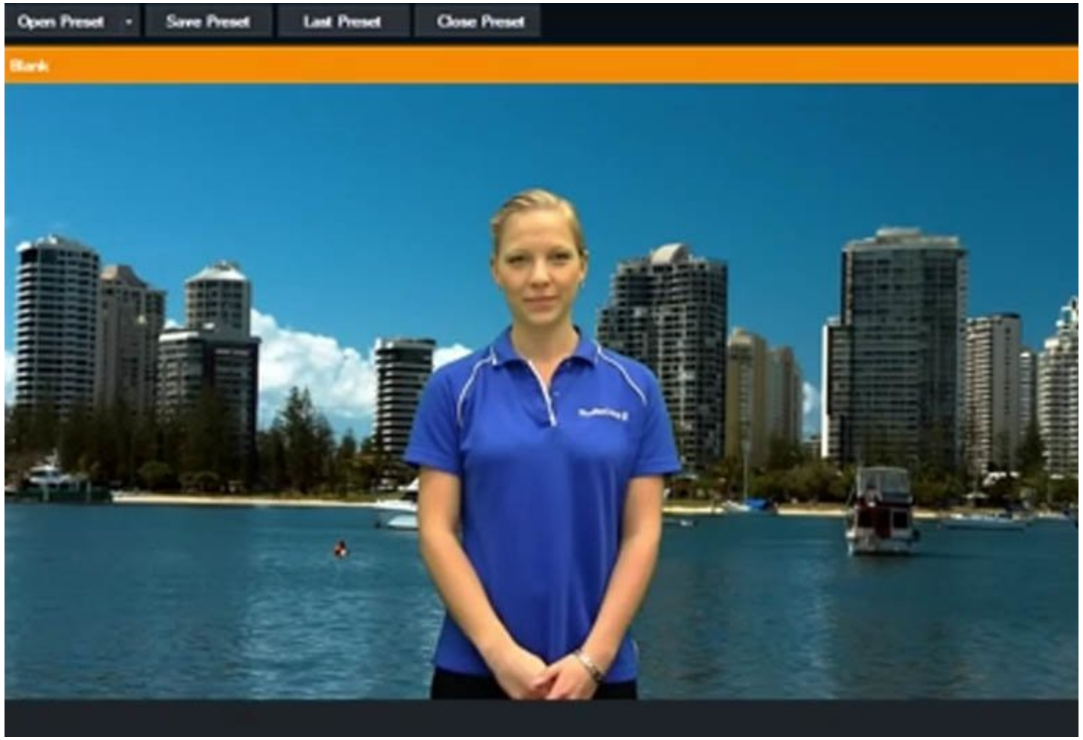
The studio camera video presenter stands in front of an actual green sheet

Figure07 (above) continued next page

Part 2 and 3 top left and right respectively



Using vMix to make the green sheet become transparent, leaving only the studio presenter remaining



Combining the transparent studio video and video file

Conclusion

The vMix function makes a good companion software package for Digital-ATV. The cost of the entry level vMix Basic product (SDTV) is free. The cost of the vMix Basic HD product (HDTV) is reasonable at US$60. vMix is very useful if you have more than one video camera being used for DATV transmissions. Or if you use one camera and want to switch to a Test Pattern sometimes or want to switch to a slideshow sometimes. vMix is a much better product than an old EMPREX model BMP-001 media box for producing DATV slideshows/test-patterns from JPEGs.

Contact Info

The author may be contacted at W6HHC@ARRL.net

Useful URLS

- vMix Product descriptions, prices and downloads: www.vMix.com
- vMix tutorials (including YouTube) on how to use features: https://www.youtube.com/watch?v=ESWTcbtWq7U&list=PLrm0RX9U0Mzxg-uJeE5Em3DAsgBHHaY8P and http://www.vmix.com/support/training-videos.aspx
- British ATV Club - Digital Forum: www.BATC.org.UK/forum/
- CQ-DATV online (free monthly) e-magazine: www.CQ-DATV.mobi
- Orange County ARC entire series of newsletter DATV articles and DATV presentations: www.W6ZE.org/DATV/

DATVtalk16 - The MiniTiouner Receiver/Analyzer for Digital-ATV

by Ken W6HHC
Reproduced from the Orange County Amateur Radio Club newsletter. www.W6ZE.org

[Please Note – This is the Sixteenth article in a series of DATVtalk articles to introduce Digital-ATV to hams and to explain various aspects of this new area of ham radio. In the CQ-DATV5 issue, the DATVtalk02 article was an introduction article about basic Digital-ATV. This latest DATVtalk article describes an extremely useful DATV receiver/analyzer called MiniTioune.]

Jean-Pierre F6DZP has been modifying Digital-ATV receivers for DVB-S protocol with software for years - in order to allow the tuner to provide information that hams need. The main problems with commercial DVB-S receivers are (a) that if the signal is not good enough - they show only the “blank screen of death” and (b) they do not work with smaller Symbol Rates that some hams want to use. The MiniTiouner receiver/analyzer solves these two problems.

The MiniTiouner Unit

The MiniTiouner is a second-generation DATV receiver/analyzer for hams and is USB2based. Figure 01 shows a block diagram of the MiniTiouner Receiver/Analyzer connected to a PC desktop or portable.

The MiniTiouner makes a great receiver for receiving and displaying ham DATV signals, including from the International Space Station (ISS) broadcasts from Ham-TV transmitter.

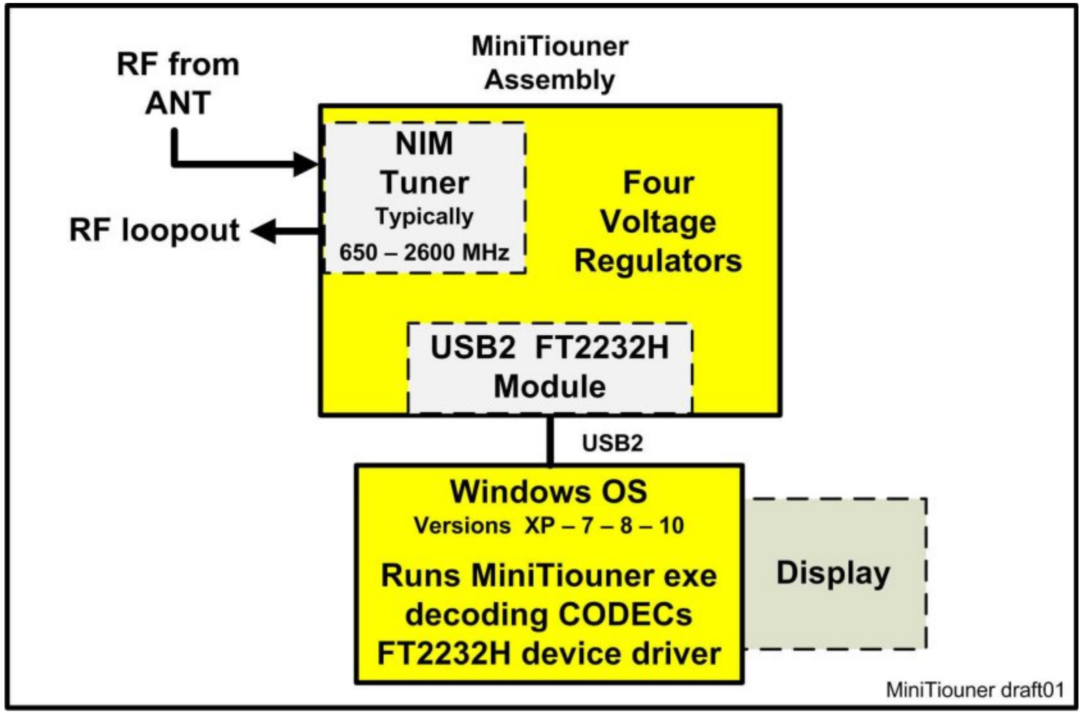


Fig01 – Block Diagram of MiniTiouner set-up for receiving DVB-S and DVB-S2 protocol

Figure 02 shows the construction and main components of the MiniTiouner assembly. The NIM-tuner, assembled FT2232H USB module, a hard-to-find 1.0 V regulator, and blank board can be purchased from the BATC online store. Other components can be ordered individually from an on-line electronic distributor like Digi-Key (some soldering is necessary).

The USB-2 controller module is a preassembled module and plugs onto the main PCBA by a pair of dual-inline connectors.

The MiniTiouner Receiver

The MiniTiouner makes a great receiver for DVB-S and DVB-S2 protocols. Figure 03 shows the uncluttered video display on your Windows PC.

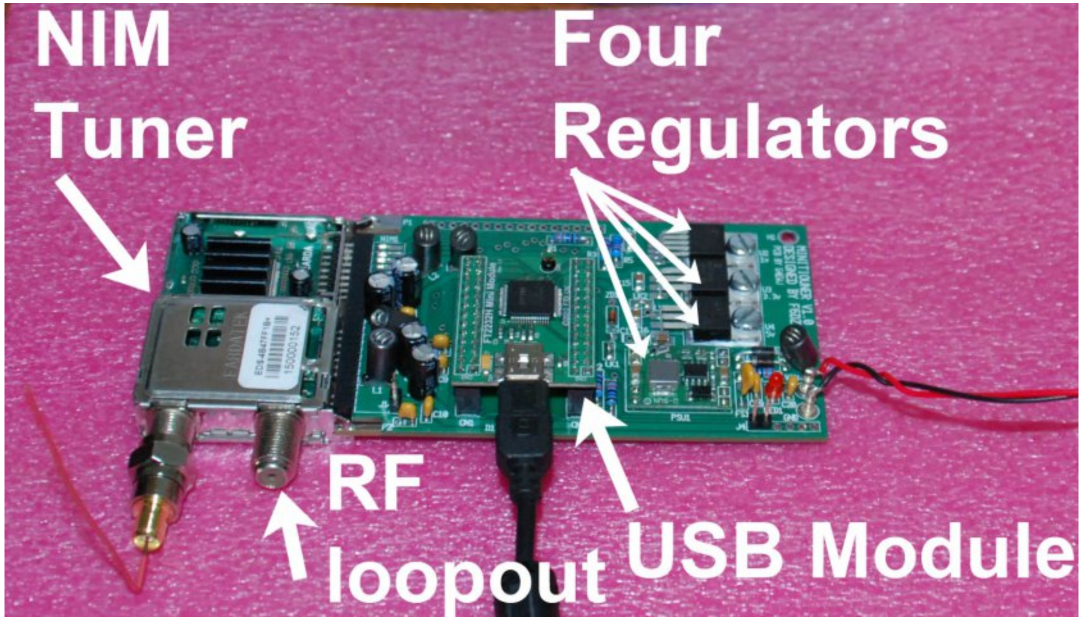


Fig02 – Main Components of the MiniTiouner Analyzer/Receiver

The MiniTiouner can accept NIM-tuners manufactured by different companies. Typically the “direct frequency range” of these TV tuners is from around 650 MHz to 2600 MHz. By adding the appropriate “up-converter” or “down-converter” in front of the receiver’s antenna connector, hams can receive DATV signals from 50 MHz to 10 GHz (and above). Video can be displayed in the video aspect ratio of 4:3 or 16:9 or even square (1:1).

The MiniTiouner Analyzer

The MiniTiouner is also a ham-radio analyzer tool for DVB-S protocol and DVB-S2 protocol. As Jean-Pierre F6DZP clearly explains: “On commercial receivers the DATV video is either good or missing…perhaps only with a signal strength reading to guide you. With MiniTiouner, 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.”

The MiniTiouner as an analyzer can be switched into the “expert-mode” to:

- measure signal strength directly in –dBm units
- look at encountered FEC error rates,
- measure MER (Modulation Error Rate)
- visualize noise on modulation “constellation”
- deviation of frequency received
- deviation of Symbol Rate received
- display PIDs for video and audio
- confirm selection of H.262 H.264 or H.265
- enable/disable “anti-rotation”
- …and the list goes on.

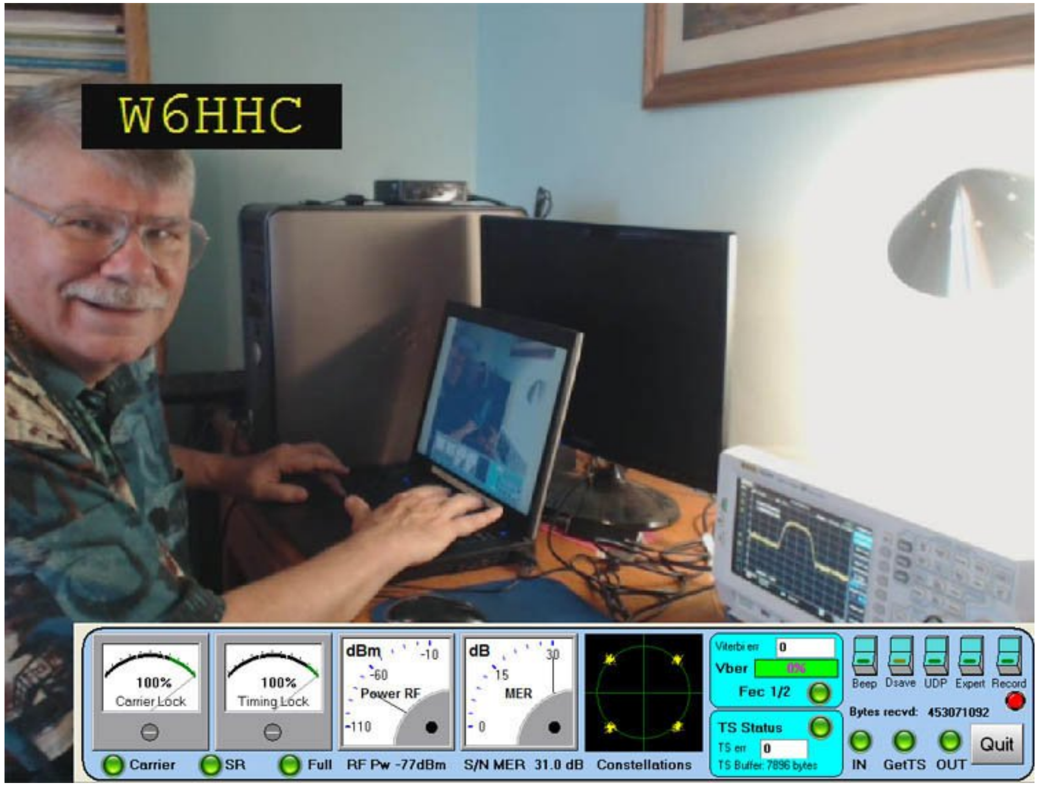


Fig03 - The MiniTiouner shown in receiver-mode for DVB-S. The Measurement-Panel at bottom can also be removed

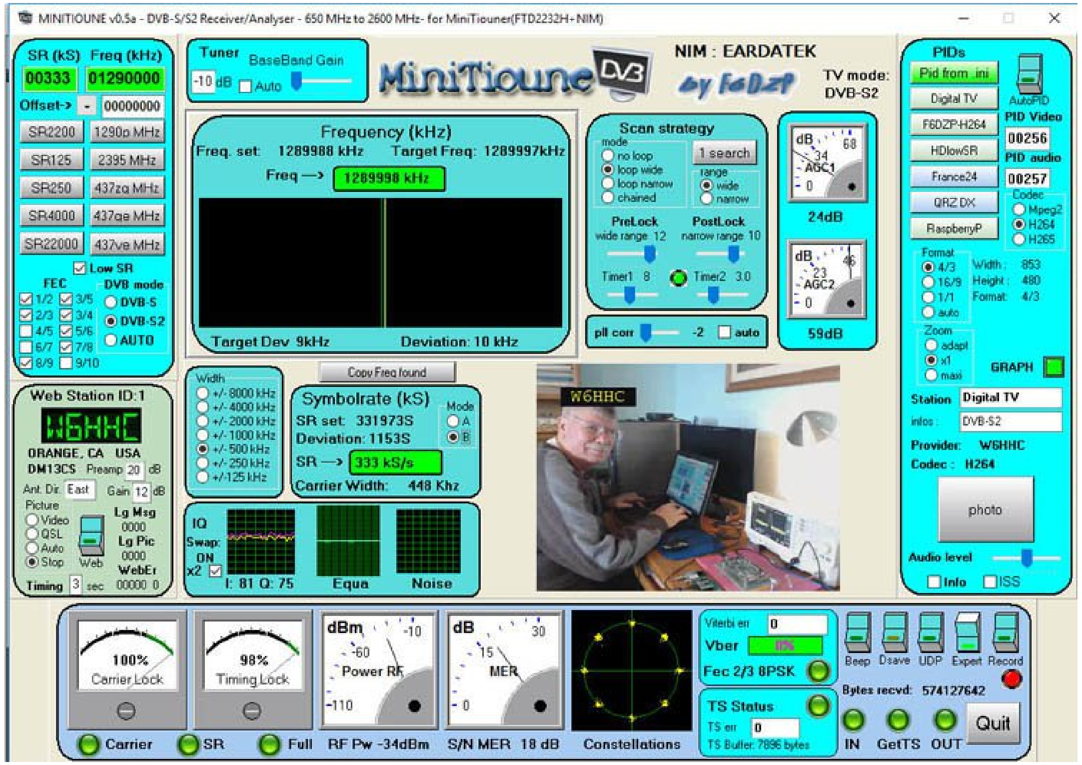


Fig04 - The MiniTiouner design by F6DZP is an excellent analyzer for DVB-S and DVB-S2. Shown in analyzer-mode (AKA “Expert” mode) looking at 8PSK modulation “constellation”.

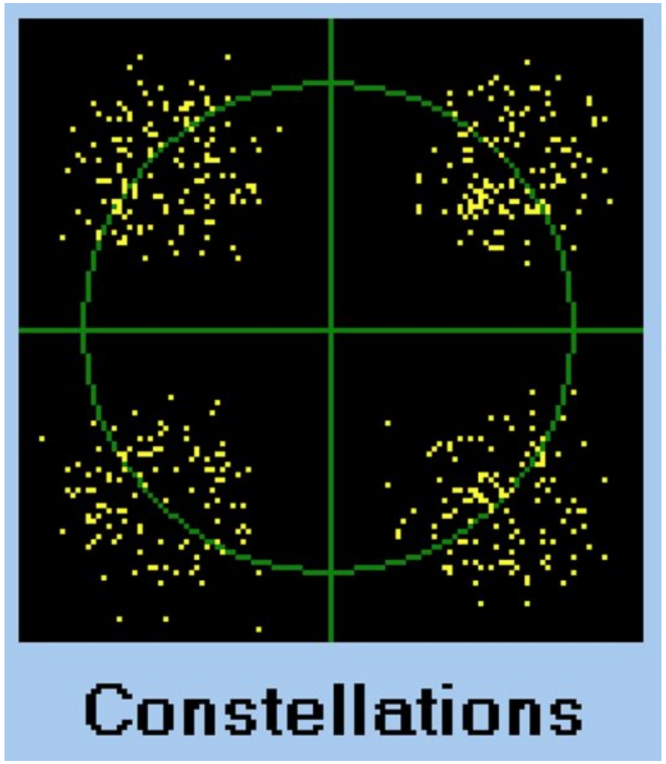


Fig05 – The MiniTiouner analyzer permits observing the “constellation” of the received DATV modulation (weak-signal QPSK in this case).

Figure 04 shows a typical the control panel display for the “expert mode analyzer” mode of the MiniTiouner for a DVB-S2 transmission.

Figure 05 displays a typical weak-signal modulation “constellation” for inspection (QPSK modulation in this screen-capture). There is a lot of noise being seen compared with the received DATV signal.

This “constellation” display also allows you to observe the quality of the modulation constellation being transmitted by your station (especially if your I and Q modulator gains have not been balanced).

Reduced-Bandwidth DATV

In 2015, hams in England were provided with a newly opened, but temporary, segment of 2 Meters (from 146.0 through 147.0 MHz.

The challenge made to the hams in England was to only use this new frequency segment for digital forms of communications (not just more FM repeaters) and to perhaps also invent a way to produce DATV in 0.5 MHz RF bandwidth...instead of just using the more typical 2 MHz RF bandwidth for DVB-S!! This new narrow band DATV mode is called RB-DATV.

Hams in England and France responded with enthusiasm and clever work to make this happen. The DATV-Express software was changed by Charles G4GUO to lower the Symbol Rates to 333 kSymb/sec (and lower) with changes to the anti-alias filters (all in software) to produce low-SR transmissions. Jean-Pierre F6DZP looked at the software of the older TuTioune design and the newer MniTioune design and with much perseverance was able to allow the MiniTioune RB-DATV reception to work down to less than 125 kSymb/sec (RF bandwidth around 170 KHz). Hams in England started setting distance records on the 2M band with DATV QSO's. These pioneering hams also observed that transmitting H.264 encoding with DVB-S protocol (instead of the normal MPEG2) provided a better (smoother) low SymbolRate video. Noel G8GTZ explained to me that the significantly better low-SR video quality seen on the receiver is due to the H.264 design using a more suitable macro block size.

Then even more benefits were confirmed (or better understood) from using RB-DATV than just reducing RF bandwidth to meet regulations. Reducing that bandwidth of the DATV transmission also increased the signal/noise (aka C/N) performance at the receiver. If you use the same transmitter power...but cut the signal bandwidth by one-half (perhaps going from 2 MHz to 1 MHz) then the receiver is looking at less noise (power) and therefore the signal/noise ratio is doubled (3 dB better)

Power required vs dish size vs bandwidth					
	8MHz	4MHz	2MHz	1MHz	0.5MHz
2.4m	100	50	25	12.5	6.25
1.7m	200	100	50	25	12.5
1.2m	400	200	100	50	25
0.85m	800	400	200	100	50

Fig06 – Comparing power required at transmitter as channel-bandwidth of Receiver gets smaller. (courtesy of Rob M0DTS)

Figure 06 shows that the power required at transmitter gets smaller as the channel-bandwidth of receiver is reduced: 25W for 2 MHz BW, 12.5W for 1 MHz BW and 6.25W for 0.5 MHz BW. Conversely, the same transmitter power will go further as the channel-bandwidth of the receiver gets smaller (and the signal S/N at receiver gets improved). [Note - this table was originally created by Rob M0DTS as he planned for ground stations transmitting on 2.4 GHz band to the future DATV satellite.]

Noel G8GTZ also pointed out to me that use of the RB-DATV approach is NOT limited to just the 2M band. Creating a more robust signal on 440 MHz, 1.2 GHz and even 10 GHz band by using RB-DATV communications theory also stretches the ability to work DX.

Receive DATV from ISS

Receiving DATV from the HamTV transmitter on the International Space Station (ISS) consists of dealing with three "hurdles" for hams:

- The ISS Is a moving target and you need a tracking antenna rotator.
- The ISS moving in orbit creates Doppler shifts in frequency.
- The DATV transmitter on ISS contains issues that prevent the video and audio PIDs from being inserted in the signal normally.

The MiniTioune can overcome the last two ISS challenges in software.

The MiniTioune software package also include a tool called Tioune Data Reader.

In Figure 07, the green bar at the top shows where a "solid DATV lock" occurred on this pass of ISS.

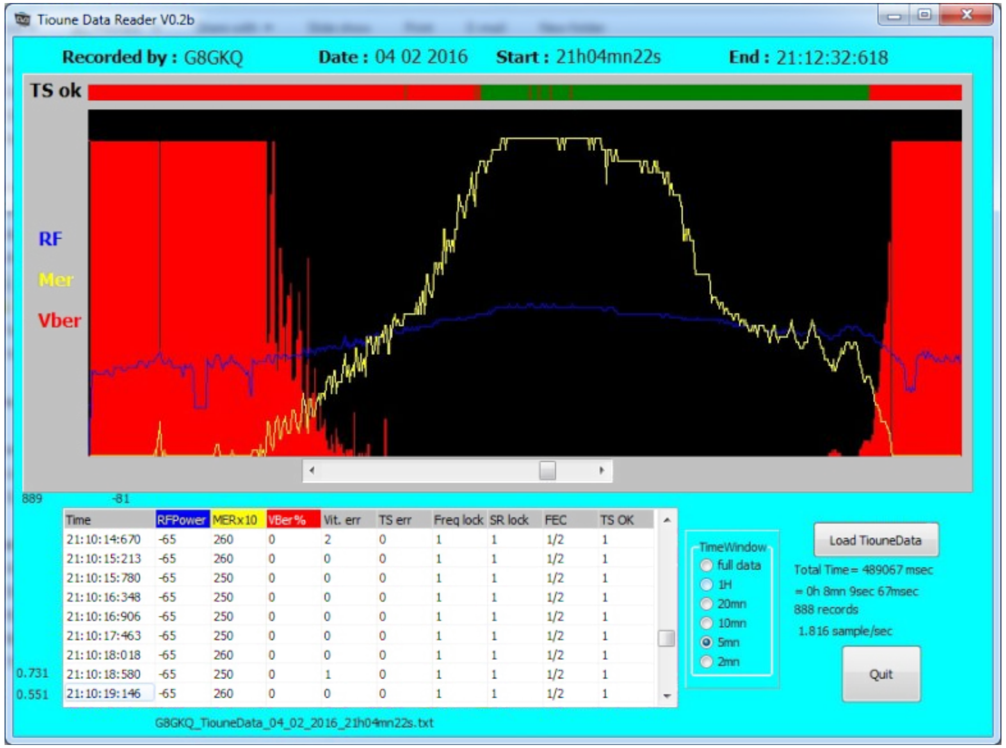


Fig07 – The Tioune Data Reader tool allows plotting the receiver DATV parameters during ISS pass. (Courtesy of Dave G8GKQ)

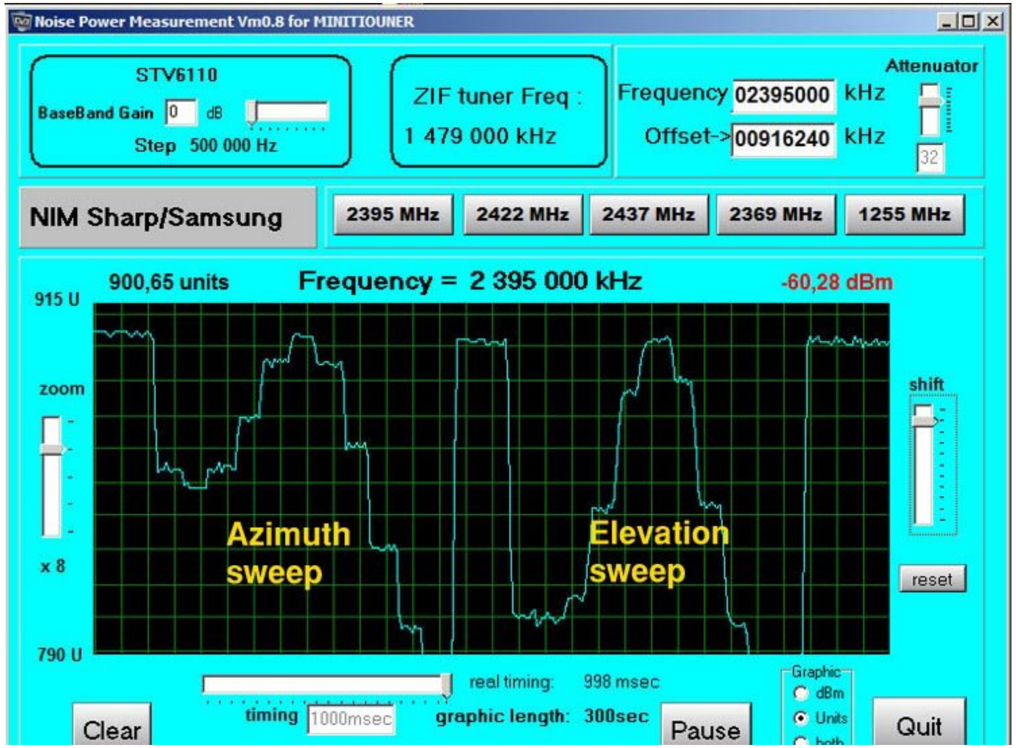


Fig08 - Display of Noise Power Measurement tool sweeping the Sun with antenna rotator (Courtesy of Jean-Pierre F6DZP)

Noise Power Measurement Tool

The VivaDATV website for MiniTioune software also contains another software package tool called NPM_USB.zip. The NPM tool can be used for (a) measuring the Sun noise, (b) sweeping their antenna dish around the good value, to be sure their antenna rotator tracking is set correctly (see Figure 08) or (c) for observing the noise/interferences.

In the example shown in Figure 08, we are tracking the Sun, sweeping the antenna at -10°, -8°, -6°, -4°, -2°, 0°, +2°, +4°, +6°, +8°, +10° in azimuth and in elevation. At 0° we must have the top of the pyramid.
If you obtain a symmetric pyramid, then your antenna is set well.

Software and Hardware

The BATC organization for ATV and DATV has created a terrific wiki site to place useful information in one (repository) web location. Included in the BATC wiki is a section devoted to the MiniTiouner details for hardware and software. (See the BATC wiki URL at the end of this article.) The wiki info on MiniTiouner is organized as five areas:

1. Hardware overview
2. Hardware parts-list and Assembly
3. Software Downloads
4. Software Installation
5. Receive up-converters and RF BP filters

Specifications (with MiniTioune v0.5a software)

- NIM-tuner frequency range – typically 650-2600 MHz
- DATV Protocols – DVB-S and DVB-S2
- Modulation constellations – QPSK, 8PSK
- Symbol Rate – 100 k –to– 22000 kSymb/sec
- Decoder CODECs - H.262 (MPEG2), H.264, H.265
- O/S – Windows XP, 7, 8, 10
- PC interface - USB-2
- Windows device driver – FT2232H from FTDi-chip
- Board power input voltage – 9–16 VDC.
- Assembled board size - approx 5.625 x 2.25 inches

Note that you must be registered on the VivaDATV.org website in order to download the MiniTioune software.

Plans

Jean-Pierre has discussed on DATV forums that he is interested in using a new NIM-tuner manufactured by Serit in Korea. The advantage of this Serit model FTS-4335 NIM-tuner is that the frequency range goes from 144 MHz up to 2450 MHz.

That means that the up-convertors would no longer be needed in order to receive on the 2M band and the 70cm band. Note that the pin assignments on the SERIT NIM-tuner are different than the first batch of NIM-tuners by SHARP and EARDATEK. So changes to the current MiniTiouner PCB board or an adapter cable may be necessary to use the SERIT NIM-tuner.

On the current v0.5a software for DVB-S2, only demodulators for QPSK and 8PSK are operational via the current SHARP and EARDATEK NIM-tuners.

In the future, the use of SERIT NIM-tuner can provide demodulation implementations for the other DVB-S2 modulation technologies of 16APSK and 32APSK.

Conclusions

Jean-Pierre F6DZP has provided hams with a very useful DATV analyzer. In addition, his design produces a DATV receiver that has capabilities that hams want...but are not provided by commercial DVB receivers. It is my favorite DVB-S/S2 receiver...so easy to use compared to commercial Set-Top-Box receivers!! I also want to give a very large “Thank You” to F6DZP for his help to me whenever I had difficulties or questions with my installing/testing of MiniTiouner.

Useful URLS

British ATV Club Digital Forum www.BATC.org.UK/forum/

BATC wiki site https://wiki.batc.tv/MiniTioune

CQ-DATV online free monthly e-magazine www.CQ-DATV.mobi

Orange County ARC newsletters DATV articles and DATV presentations www.W6ZE.org/DATV/

Yahoo Group Forum for Digital ATV
https://groups.yahoo.com/neo/groups/DigitalATV/info/

VivaDATV forum
http://www.vivadatv.org/viewforum.php?f=80 (English section)

Noise Power Measurement page
http://www.vivadatv.org/viewtopic.php?f=60&t=365

Contact Info – W6HHC@ARRL.net

External links

If you have an eBook reader that does not have WiFi then you will not be able to use the hyper-links in this publication.

If you have an eBook reader that has WiFi then you will be able too providing you are in a WiFi zone.

But if you have a Kindle 3G then yes, but only to Amazon, and there is not a lot of ATV material on their site.

Smart phone reading apps are ok providing that you have a 3G data connection.

Note: These links will fire up your devices browser and if you are using 3G/4G then you will incur data usages charges.

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