



Application Note

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How to Receive Amateur Digital, DVB-T Television Signals

Jim Andrews, KH6HTV

The fundamental question is "How can I receive amateur DTV signals ?"

The commercial TV broadcast industry began a transition from analog TV to Digital TeleVision (DTV) starting in the mid 90s. Several different, DTV systems were developed for different applications, such as over the air terrestrial broadcast, satellite broadcast and cable distribution. Each system had it's unique propagation characteristics and as a result, it's coding implementation. For amateur DTV, the system adopted should be optimized for terrestrial propagation where "multi-path" is always a major issue. DTV systems for TV signals received from satellites are optimized for weak signals, but relatively free from multi-path., DTV signals on a CATV network are relatively strong and in a perfect (low VSWR) environment and are not subject to multi-path. Thus such satellite or CATV systems are less suitable for amateur DTV.

The DTV system adopted by Boulder, Colorado radio amateurs is called DVB-T, or Digital Video Broadcast - Terrestrial. It is NOT the ATSC (8-VSB) system used in the USA for commercial TV broadcast over the air, nor for transmission in cable TV (CATV). It is the system developed in Europe and used by most of the rest of the world for broadcast DTV. Thus, in the USA, you can NOT use directly your home TV receiver to receive DVB-T. The reasons, we have adopted a European standard rather than an American standard are primarily based upon cost and availability of transmitting equipment and also on the superior multi-path performance of DVB-T over ATSC [1].

DVB-T includes special digital algorithms to characterize the time varying channel and eliminate the delayed multi-path signal [2]. The result is perfect, digital quality, ghost free, pictures even under extremely strong multi-path conditions. DVB-T also offers a choice of modulation methods of QPSK, 16-QAM and 64-QAM. 64-QAM supports the highest data bit rate, especially important mainly for video with a lot of extremely fast moving events, such as sports. We have found that the simplest QPSK adequately supports high-definition, 1080P video with ordinary video scenes with some motion. Using QPSK gave an almost 20dB (3 S units) improvement in receiver sensitivity over 64-QAM [4]. Broadcast DVB-T stations use bandwidths of either 6, 7 or 8 MHz depending upon the various country's historical channel allocations. Here in the USA,

the FCC fixed TV channel bandwidths at 6 MHz. Therefore, all of our DTV activity has been done using 6 MHz. The FCC allows radio amateurs to transmit 6 MHz TV signals on the 70cm band and all higher frequency bands. Amateurs are also experimenting with lower DTV bandwidths down as low as 1 MHz. These lower bandwidths do not support high definition (1080P), but seem to work ok for lower resolution, standard definition TV.

In the USA, DTV is called ATSC, (Advanced Television Systems Committee). All TV receivers sold in the USA will only receive ATSC signals or CATV DTV signals. To receive amateur DVB-T transmissions will thus require using some auxiliary receiving equipment, such as a set-top box, similar to those supplied by the cable company. The A/V output from the receiver then goes to your TV's rear panel monitor inputs. No different than plugging in a cable box, or a DVD player.

Digital TV Receiver Universal "Gotcha" There is a "Gotcha" for almost all digital TV receivers, whether it is a new SONY that you buy at Best-Buy, a set-top box receiver, or whatever. Unlike the old analog TV receivers, we can not simply enter on the remote control any arbitrary channel number and the receiver will automatically tune to that frequency and start working. Due to unfortunate, poor human interface design by DTV engineers, they require that DTV receivers must be "taught" each and every new channel by exposing it to the actual rf signal. This is typically done once when unpacking your TV, connecting it to the cable system or outside antenna and doing an "Auto-Scan". The TV receiver scans all frequencies and memorizes only those on which it found a valid signal. Thus no matter what DTV receiver you are using -- you will have to teach it first to find and memorize a specific frequency (channel). This means you need to either (1) own your own DVB-T modulator, (2) carry your receiver to another ham's house and train it on his modulator, or (3) if you have a really good RF path, have the other ham point his antenna at you and transmit a DTV signal on each frequency of interest. You have the same issues when trying to receive over the air broadcast tv signals. Bummer !!

So -- now back to the original question *"How can I see the local amateur DVB-T pictures?"* There are a few possible solutions, some simple and some not so simple, plus some expensive and some very cheap. They include: 1. buy a TV receiver from overseas 2. KISS solution - buy a Hi-Des receiver, 3. buy a DVB-T set-top tuner - or - 4. buy a cheap (\$10) USB TV tuner dongle for your PC computer.



Off-Shore TV Receiver: This might seem to be the most direct approach for USA amateurs. Namely to actually purchase a TV receiver intended for use in another country where DVB-T is used. However, there are several gotchas. First will be the cost of purchase plus shipping it to the USA. The most important is the fact that it probably will NOT tune to the amateur 70cm band (420-450MHz). They are already pre-programmed to only tune the standard VHF and/or UHF channels in use in that particular country. Thus to use a standard TV receiver will require you to build/buy a frequency up/down converter. The cost for the down converter could easily be more than for the TV receiver. You would have this same issue of needing a down converter, even if you were to buy a USA, ATSC-8VSB, DTV receiver. This is not as simple as it sounds. It turns out that there are very stringent requirements on low phase noise for the local oscillator to function properly with DVB-T signals. The least amount of either FM or phase noise on the LO and the DVB-T receiver will not decode the signal. Also one needs to take care and only purchase a TV set that is capable of receiving 6 MHz bandwidth signals. Most countries use 7 and/or 8 MHz bandwidths. Thus, this is not a very attractive alternative, and a potentially very expensive way to go.



KISS SOLUTION: The real KISS (Keep It Simple Stupid !), and guaranteed to work, solution to receiving amateur DVB-T on both the 70cm and 33cm bands is to purchase the Model HV-110, set-top box, DVB-T receiver directly from the Hi-Des company in Taiwan (www.hides.com.tw). This is the receiver being used by most radio amateurs experimenting with DVB-T because it allows them to experiment with both conventional wide bandwidths (6-8MHz) and also narrow bandwidths (down to 2MHz). It costs \$169 which includes shipping. It is extremely easy to setup and operate. It can be trained to receive any arbitrary frequency from 170 to 950 MHz, including the amateur 70cm and 33cm bands. More recently, Hi-Des introduced another similar receiver, their model HV-120A, which features enhanced frequency coverage from 100-950MHz and also 1150-2650MHz, thus adding the 23 and 13cm bands. It costs \$209. [3].

The HV-110 has an SMA antenna input connector. Video output is either via digital HDMI or analog, composite (480 NTSC or 576 PAL only). It has selectable video resolution up to 1080P. The HDMI or composite video can then be connected directly to your home TV receiver/monitor via the rear panel video input connectors. It requires +5Vdc power. An AC power supply is included. It is programmed and controlled via a supplied IR remote control. The receiver is frequency synthesized to any frequency with

1 kHz resolution between 170 and 950 MHz. The receiver is quite sensitive. The DTV threshold has been measured at -94dBm for a QPSK, 6 MHz signal [4].

The Hi-Des HV-110 supports commercial broadcast bandwidths of 6, 7 and 8 MHz and also supports using lower bandwidths of 2, 3, 4 & 5 MHz. Some DTV amateurs elsewhere have been experimenting using narrower bandwidths down to 2 MHz. High-Definition TV (720p or 1080p) will not work at 2 MHz. However, standard-definition, 480i video will work with a low, 2 MHz bandwidth.



Another nice feature of the Hi-Des HV-110 receiver is the available On Screen Diagnostics (OSD) as seen in the above live photo. In the lower left corner is the call sign of the transmitting station. In the upper left corner is the center frequency and the bandwidth. In the lower right corner is the signal to noise ratio of the received signal. In the upper right corner is the actual signal strength in dBm of the signal at the antenna input. This rf power meter has been found to be extremely accurate (within ± 1 dB from -10 to -90dBm)

It should be noted that Hi-Des also supplies other DTV receivers, including USB dongles. I have not evaluated any of them. The prices of their dongles were not inexpensive, but were comparable to the HV-110. It was felt by the author that the true KISS solution would avoid the necessity of including a PC computer in the setup with all of its inherent driver, software bug, etc. issues.

Hi-Des, Taiwan, is a very reputable firm. They are obviously trying to support the amateur DTV market. They advertise in Amateur Television Quarterly (www.atvq.com) They stand behind their products with excellent warranty service. They provide excellent technical support via e-mail. Good luck trying to get such support from almost any other, unknown, E-bay or Amazon supplier in China !!!



DVB-T Set-Top Receiver: This is a good, potentially low cost, solution. Doing a Google search on the internet for "DVB-T Receivers" will bring up a lot of "hits". Some with very attractive prices in the less than \$100 range. You need to find one that is advertised to cover the 70cm band (420-450MHz) with bandwidth of 6 MHz. However, **BUYER BEWARE !**. There are many receivers on the internet advertising to cover from 48 to 862MHz with bandwidths of 6, 7 & 8 MHz, but many of them omit the amateur 70cm band and actually only cover the commercial broadcast TV frequencies. I have purchased some, only to find that they didn't work on 70cm. Be advised that these receivers will have European antenna connectors and AC power plugs and some might only work on 220Vac. It is also questionable, if you do find a suitable receiver on the internet as to how long it really will be available for purchase over the internet. Some items appear and then disappear within weeks, or even hours.



Model 70-14 DVB-T, Set-Top Box, Receiver - front & rear views

KH6HTV Video has found a supplier in China that does make a suitable DVB-T Set-Top Box Receiver for receiving 6 MHz BW, DVB-T on the amateur 70cm band. KH6HTV Video has imported a quantity of these receivers and is selling them as it's model 70-14 for \$90 each. KH6HTV Video supplies them pre-programmed to receive the five standard, 70cm, TV channels. The sensitivity for 6 MHz, QPSK, was measured at -94dBm[4], comparable to the Hi-Des HV-110. Detailed specs. are available on www.kh6htv.com



LOW COST (\$10) SOLUTION: The really low cost approach is to buy a DVB-T, TV Tuner, USB dongle for your PC computer. Most of the "hits" from a Google search for DVB-T receivers will in fact be these dongles. They are found from many sources on www.ebay.com and www.amazon.com among others. Most of these seem to use the same basic design with an R820T DTV tuner IC (www.rafaelmicro.com) and an RTL2832U DVB-T COFDM demodulator IC with a USB interface (www.realtek.com) The tuner's frequency range is specified to be 42 to 1002 MHz with a 3.5 dB noise figure. These same dongles have been used by amateurs as generic software defined radio (SDR) receivers for many other RF applications, such as a spectrum analyzer, with appropriate software. These dongles typically come with a small mag. mount whip antenna, remote control and a mini-CD disc with TV tuner software. The RF connectors vary and sometimes are not actually what are shown in the internet advertisement photos. The antenna connector is usually a small MCX or the larger European TV antenna connector, called the Belling-Lee (IEC 61169-2) or PAL connector. Most USA amateurs are not using MCX or Belling-Lee/PAL connectors. We have made our own adapters by simply cutting off a connector pigtail from the supplied mini antenna and installing another connector of our own choice on the other end of the pig-tail. Suitable coax adapters are also available on the internet.

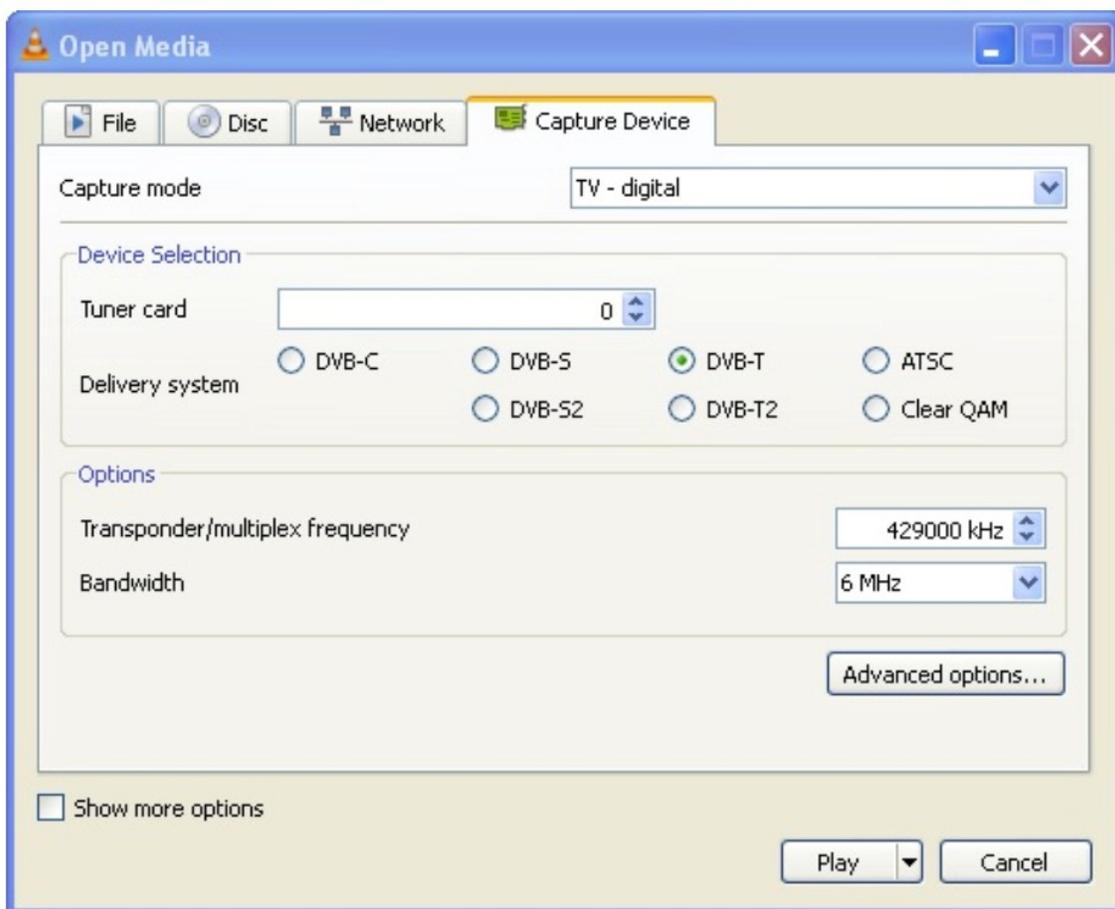
While this is a very inexpensive approach, it is not a simple KISS, turn-key, solution such as found with the purchase of a set-top box receiver. A PC computer, and attendant computer skills are required to use this approach.

Not all USB TV tuner dongles are equal. Receiver sensitivity tests [4] were performed on several different brands and the results varied widely with the best at -93dBm and the worst at -72dBm (tested at 6 MHz BW, QPSK).

All of the cheap, USB TV tuner dongles seem to come with free TV tuner software by Blaze Video (www.blazevideo.com) It only runs on Windows PC computers. It seems to be supplied as a "teaser" and they really want you to purchase their \$50 upgrade software. I have heard very mixed reviews from other hams about Blaze. I myself have had all sorts of issues trying to get it to work on several computers and with several dongles. It seems to work or not work depending upon which version of Windows one is using. Some hams have had it work for a couple of weeks and then lock up and never

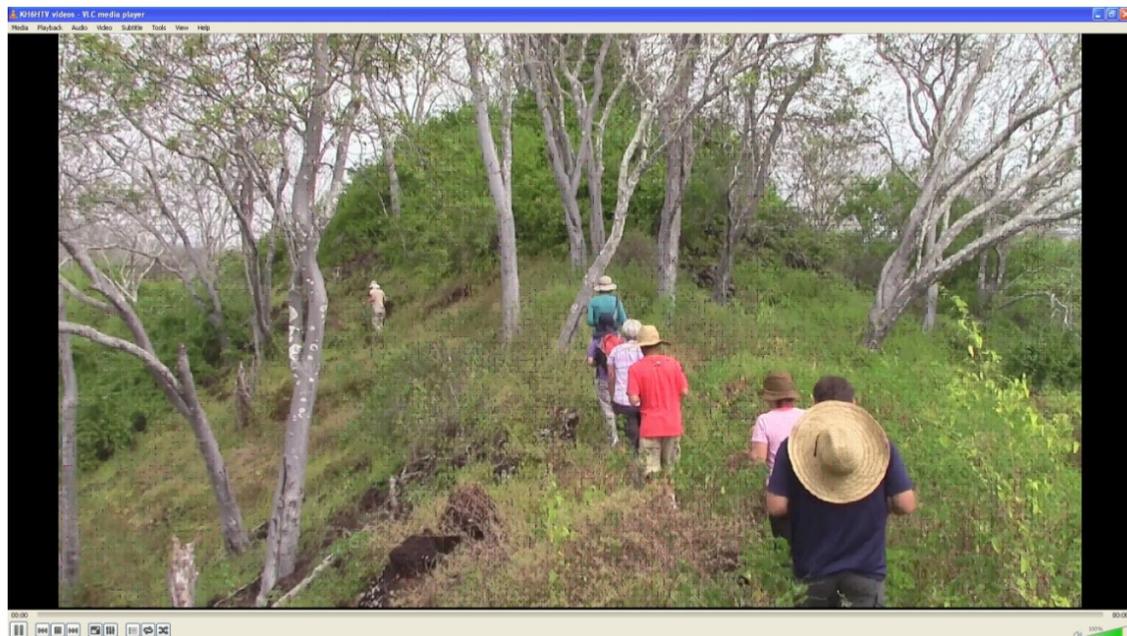
work again. Others have reported it to work fine for over a year or more. Some hams have reported that the software is extremely slow in responding to commands.

VLC Works for Dongles ! Steve, WB0NFQ, has discovered that the general purpose video processing software called *VLC* (www.videolan.org) works great with these USB TV Tuner dongles. *VLC* is a free and open source cross-platform multimedia player. *VLC* is available for Windows, Mac OS X, Linux and Unix. The Windows version does work with these dongles. The Mac version does not support these cheap, generic dongles. It only supports expensive Eye TV brand tuner dongles (<https://www.elgato.com/en/eyetv>). Several Boulder, CO amateurs are using *VLC* successfully on older Windows PCs. So far, none of us have had any success getting *VLC* and the dongles to work on Windows 10 computers.



To use *VLC* with a TV tuner dongle, first attach the dongle to a USB port. Attach an antenna to the dongle and make sure it is close to a strong DVB-T signal on the desired frequency. Next, launch the *VLC* program. On the upper task bar, click on "Media" and select "Open Capture Device". This will open the above page. For Capture Mode, select "TV - digital". For Tuner Card, select "0". For Delivery System, select "DVB-T". (note: VLC's menu also offers all other major DTV standards of DVB-S, DVB-C, ATSC and QAM). Under Options, enter the desired frequency and bandwidth.

Frequency is to be entered in kHz and must be the center frequency of the desired channel. For the example shown above, the channel was cable 58 (426-432MHz) with a center frequency of 429MHz (429000 kHz). Note: *VLC* is nice in that any arbitrary frequency within the tuning range of the R820T tuner IC is acceptable. This is an extremely nice feature of *VLC*. It is the equivalent of the old "random access" with analog TV. *VLC* does not have to be "trained" (auto scanned) like most DTV receivers. *VLC* offers a wide selection of bandwidths from 5 to 10MHz, plus an Auto search mode. It is best to not use Auto as it takes a lot longer to find a signal. Select "6 MHz" bandwidth. Do not use any of the Advanced Options. The final step is to click on the "Play" button at the bottom of the page. If a DVB-T signal is present at the antenna input on the desired frequency, you should now see a live video picture complete with audio. The following photo is an example of *VLC* receiving an amateur DVB-T signal on 429MHz.



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