Amateur Television Journal

June, 2026
issue # 210
BATVC web site: www.kh6htv.com
ATN web site: www.atn-tv.com

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Application Note AN-76

May, 2026

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RFI Potential of Digital TV

Jim Andrews, KH6HTV

For frequency coordination of amateur band repeaters, frequency coordinators ask the question
"What is the possibility of RFI from Digital TV signals to FM users ?"

I claim that due to the wide band-widths and noise like characteristics of DTV, the RFI potential is quite low.

So, let's compare what the rf spectrums look like for typical FM voice and DTV transmissions. Fig. 1 shows a typical 5 kHz deviation FM signal. When fully deviated, it occupies about 15 kHz of band-width. Fig. 2 shows a typical DVB-T TV transmitter's signal. It occupies a 6 MHz wide TV channel with a uniform, flat noise-like spectrum. If a DTV signal is listened to on a conventional SSB receiver, it sounds simply like white noise. It has no distinguishing features.

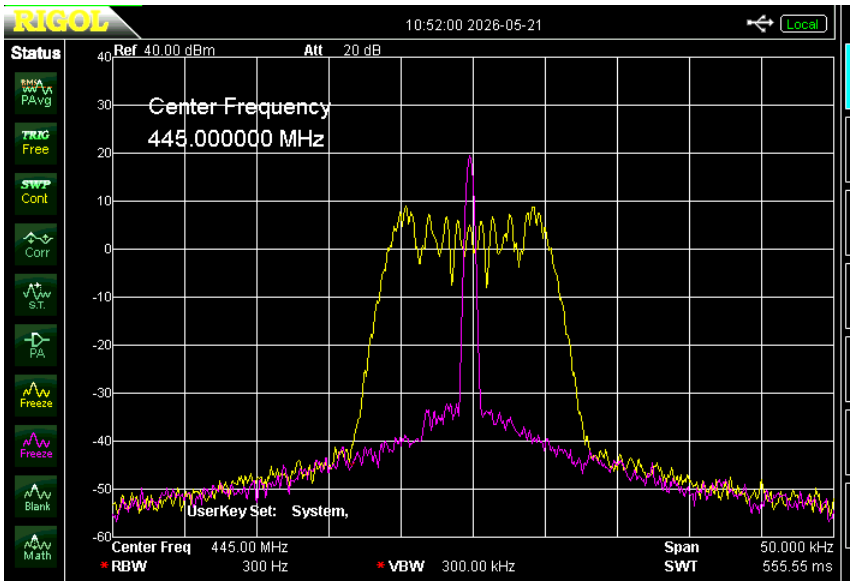

Fig. 1 Typical FM voice transmitter spectrum. Signal from HP-8640B Signal Generator. Set to 445 MHz, -10dBm. Display is 445 MHz center frequency, span of 50 kHz, 10dB/div & 5kHz/div. Resolution band-width was set to 300 Hz. Magenta trace is generator in CW mode. Yellow trace is generator set for FM modulation. 400 Hz tone at 5 kHz deviation.

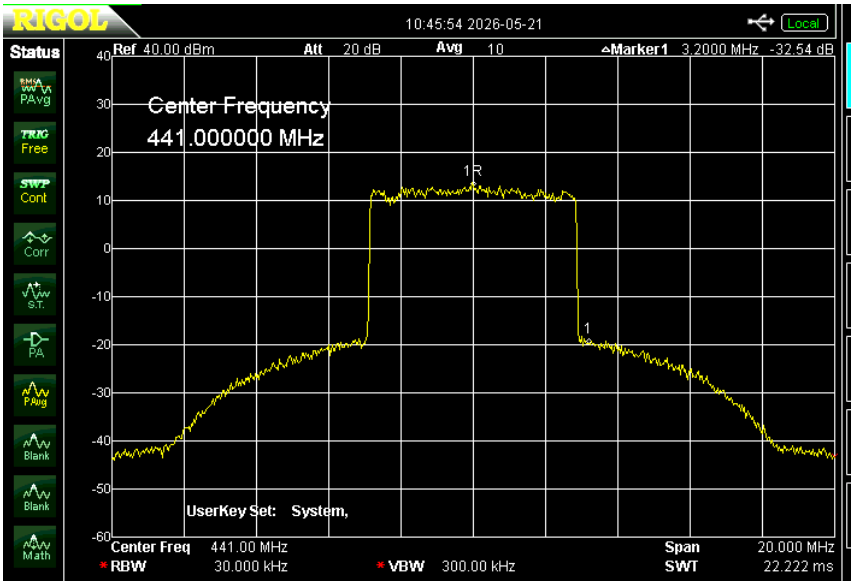

Fig. 2 Typical amateur band, digital Television transmitter's spectrum. The transmitter's average power output was 3 Watts (+35 dBm). Center frequency is 441 MHz, span of 20 MHz, 10dB/div & 2 MHz/div. 30kHz resolution band-width.

A pure DTV signal (such as from a DTV modulator), only occupies the center 6 MHz TV channel. The extra skirts seen on either side in adjacent TV channels are due to inherent non-linearities in the

final RF power amplifier of the transmitter. They are internally generated inter-mod products. A properly driven final amplifier has the shoulder break-point set no higher than -30 dB below the in channel power level. For DTV repeaters, we then also add additional 6 MHz wide TV channel band-pass filters to remove these shoulders. See Fig. 3 for an example.

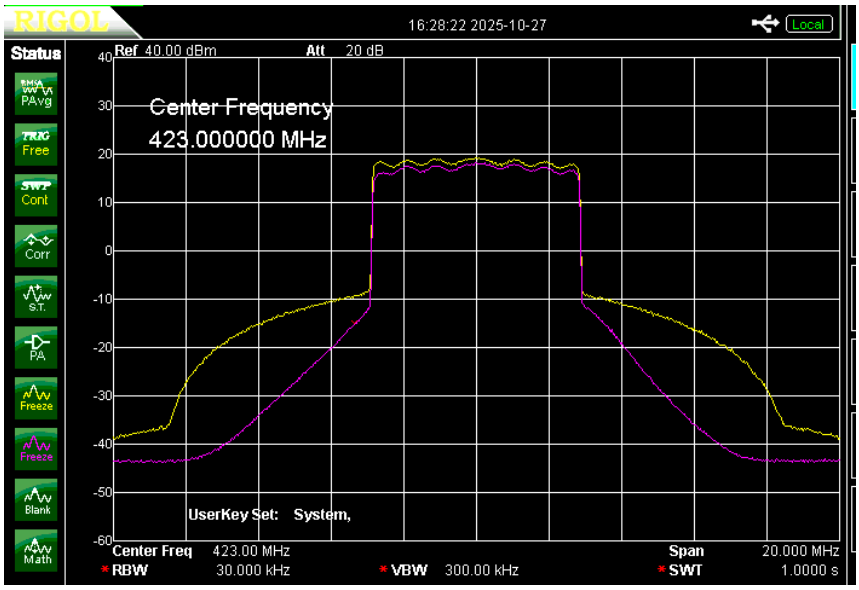

Fig. 3 RF spectrum from a typical DVB-T TV repeater with a 10 Watt transmitter. Yellow trace is the rf output from the final amplifier at 10 Watts. Magenta trace is after passing this through an inter-digital TV channel band-pass filter. 8 Watts output. center frequency is 423 MHz, span of 20 MHz, 10dB/div & 2 MHz/div. 30kHz resolution band-width.

For DTV, the max. average power of the transmitters in use today by Colorado ATV hams is 10 Watts. It should be noted that for DTV transmitters, for linearity and bit-error-rate considerations, the amplifiers can NOT be driven to max. saturation. The average rf power output must be kept at least -8 dB or more below the max. saturated power output. Thus, most Colorado DTV hams and repeaters are using rf power amplifiers capable of at most 70 Watts max. saturated power. The max. average powers from these amplifiers are about 10 Watts (+40 dBm). When conditions permit, many DTV hams even throttle back the power. Many times, we get perfect digital pictures with much lower power levels of even 300 mW.

Now let's put a little math to compare RFI potentials.

What is the RF power density therefore of a DTV signal ? Assume a 10 Watt transmitter.

$$Pd(DTV) = \text{Avg. Power} / \text{Channel BW} = 10\ W / 6\ MHz = 1.67 \times 10^{-6}\ \text{Watts / Hz}$$

What is the RF power density of a typical FM voice signal ? Also assume a 10 Watt transmitter.

$$Pd(FM) = \text{Avg. Power} / BW = 10\ W / 15\ kHz = 6.67 \times 10^{-4}\ \text{Watts / Hz}$$

Now what would be the equivalent rf power in a 15 kHz FM channel from a 10 W DTV transmitter ?

$$P(15kHz) = Pd(DTV) \times BW(FM) = 1.67 \times 10^{-6}\ W/Hz \times 15\ kHz = 25\ milli\text{-}Watts$$

Thus, we see that due to the extremely low rf power density of a DTV signal, even our most powerful 10 Watt transmitters create the equivalent RFI of a very low power, 25 mW, hand-held HT FM radio !

Due to the complex design of a DVB-T signal, it was originally designed to be very tolerant and resist in-band interference from narrow-band, CW/FM signals. The DVB-T signal uses about 8,000 sub-carriers with COFDM. If an RFI CW signal knocks out a few of these sub-carriers, the digital TV receiver is still able to decode the DTV signal. We have conducted RFI tests on a lab bench. We found that an interfering CW/FM signal in the TV channel pass-band had to be at least > 20 dB stronger than the desired DTV signal to cause the DTV receiver to stop decoding the picture.

Conclusion: As a result, both wide-band DTV and narrow-band FM voice signals should be able to normally co-exist in the 70 cm amateur band.

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Aligning Dish Antennas - Feed-Back:

Hi Jim -- In response to the piece on peaking dish antennas by K0CJG, here is the solution that we have adopted in the UK. Please feel free to publish in your next issue.

73, Dave Crump, G8GKQ, BATC Treasurer, Salisbury, England

BandViewer

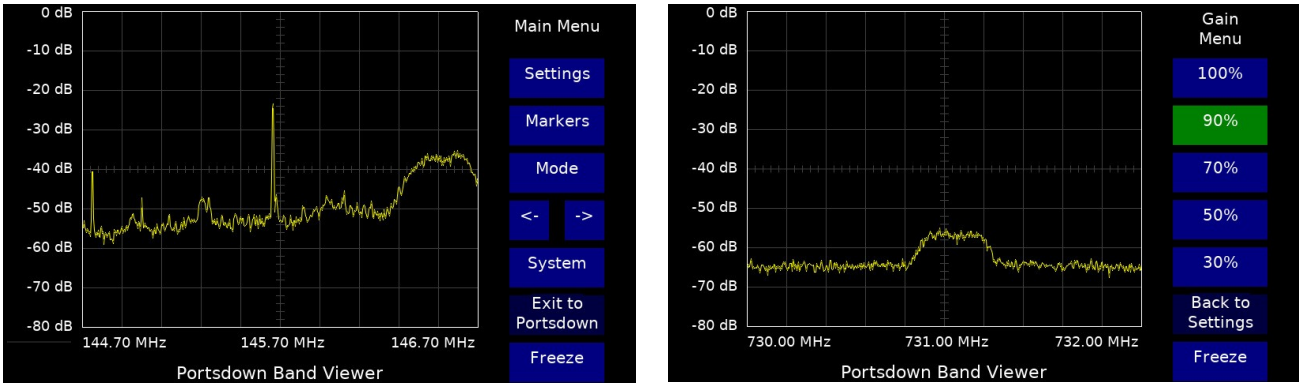
To solve the problem of peaking in digital signals, BandViewer was designed and built into the Portsdown DATV transceiver. It works well for peaking DVB-T and DVB-S signals, as well as for showing shoulders to check for PA linearity.

BandViewer is one of the pieces of test equipment within the Portsdown DATV transceiver standard build, needing only an SDR, Raspberry Pi 4 and touchscreen to operate, so is ideal for portable operation.

Using the receive side of an SDR such as a LimeSDR, Pluto, Airspy, RSPdx or RTL-SDR, the BandViewer provides a spectrum analyser style view of any frequency covered by the SDR.

SDR	Frequency Coverage		Max Span Width
	Lower limit	Upper limit	
LimeSDR	30 MHz	3.5 GHz	20 MHz
Pluto	70 MHz	6.0 GHz	50 MHz
Airspsy	30 MHz	1.7 GHz	10 MHz
RSPdx	1 MHz	2.0 GHz	10 MHz
RTL-SDR	30 MHz	1.7 GHz	2 MHz

The BandViewer is selected from Portsdown Menu 2, or from the Portsdown Receiver page (for terrestrial reception). The Portsdown system can also be configured to boot directly to the BandViewer (Menu 3, System Config, Start-up App).



(left) A typical off-air BandViewer display is shown above with a 144.75 MHz FM signal at the left, a 146.5 MHz DATV signal on the right, and an FM repeater in the middle. (right) Shows a signal from the IF of a 2.4 GHz downconverter, after the signal had been peaked by aerial adjustment.

The BandViewer settings may need some adjustment to achieve the optimum display. Any overload of the SDR input can wipe out the display or cause a massive spike at the centre frequency. From the settings menu, it is possible to adjust the Lime Gain to minimise this problem, although extremely strong signals might need external attenuators. Sometimes the Lime may need to be recalibrated (System menu, Re-cal LimeSDR) to minimise spurious responses, but some spurs do remain.

Although it is not possible to provide an absolute calibration for the vertical scale, the relative calibration between levels is accurate, as is the frequency calibration. An expanded (20 dB total range) vertical display is available from the Mode menu. Markers can be used to measure both frequencies and levels. The detection of short-duration signals can be made easier by using the Peak Hold function on the marker menu.

Direct entry of the centre frequency is available on the Settings menu, as are 5 configurable presets. These can be configured from the Mode, Set Config menu. Arrows on the Main menu move the centre frequency higher or lower by a tenth of the scan width. When selected from the Portsdown receive menu, the centre frequency is initially set to the DATV receive frequency.

The display can be frozen for closer examination, or captured as a “snap” which will be stored in the /home/pi/snaps folder on the Raspberry Pi SD Card.

The BandViewer is particularly useful for peaking up weak signals, or for tracking down sources of noise or interference. The screenshot above shows a signal from the IF of a 2.4 GHz downconverter, after the signal had been peaked by aerial adjustment.

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CIRCULATOR Feed-Back:

Hi Jim, Thanks for the nice newsletter! Using a circulator to separate TX from RX is standard practice in waveguide microwave work. We use it between each RX filter and TX filter when we tie more than one TX in a group and more than one in the RX group. The circulator closest to the waveguide is the one used to separate TX from RX. We call the circulator(s) and filter(s) a branching network.

The reason you do not see this done much in coax bases feedline systems is the issue of circulator generating a 2nd harmonic. In waveguide, the 2nd harmonic is outside the waveguide propagation and not an issue of the 2nd harmonic making it to the antenna. Usually circulators are connected between a transmitter and a filter (can be a low pass filter, series 2nd harmonic trap from center pin to shield or a bandpass cavity. Then to the antenna to remove the 2nd harmonic. You can get away using a circulator to separate TX and RX in coax systems if you add a low pass filter between the antenna and circulator or a 2nd harmonic trap on the antenna side. The other issue to note is if you have an antenna or feedline fault resulting in high VSWR, your tx power will be forwarded directly toward your receiver filter. If that filter on its own does not have adequate filtering to reject the transmitter energy, the receiver will be damaged.

In microwave systems we get away with it as most microwave waveguide bandpass filters have very good rejection due to the multiple poles. The microwave transmitters are also low power 1 to 2 watts typical. This results in the RX filter being able to dissipate the heat. In coax based systems like 70cm, we rune medium to high power so you may have many watts or 10s of watts needing a place to dissipate if the antenna system develops high VSWR. If I had to use a circulator to separate TX-RX at UHF, I would have two circulators, one at the TX prior to the bandpass filter with a reject load so at least the TX will be happy during a high VSWR event. The 2nd one to do the TX-RX separation. A harmonic filter after that then the antenna. I would likely not run more than 10 to 15 watts to protect the RX bandpass filter inside elements and any arcing effects.

In the case of duplexers, you have the 1/4 wave lines between the coax tee and each filter, this allows the high VSWR of a RX filter to the TX frequency to look like an open circuit and keeping the TX energy aimed to the TX filter.

73, Mike WA6SVT / VP6MC, Crestline, California & Pitcairn Island

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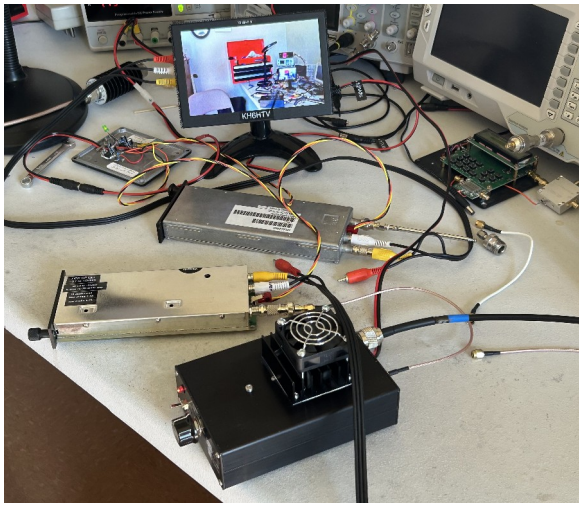


Revisiting Antique Television

Jim, KH6HTV, Don, N0YE, & Bill, AB0MY

Earlier this spring here in our ATV Journal, we discussed "Antique TV", i.e. AM-TV (see the April, 2026 issue # 206, pp. 2-6). Also we published a much longer, 27 page, application note, AN-75. These most recent articles discussed what gear is presently available commercially for hams still wishing to get on the air on 70 cm band with AM-TV.

Fast forward now to the end of May. Weather is now much nicer. The three of us decided it was time to dust off the old AM-TV gear and actually make some ATV contacts with it. Just for fun. No other reason. Maybe we have gotten too spoiled with the perfect P5 pictures and Q5 audio with our modern day, digital TV.

The above photo on the left is Jim's lashed up rig. It consists of a CATV, VUSB-TV modulator driving a model 70-7B rf linear power amplifier. It put out 10 Watts (peak sync, i.e. PEP) with vestigal upper-sideband modulation. A companion CATV, VUSB-TV demodulator was used as the receiver. The new $65 Amazon receiver also was used successfully. The above photo on the right was the live AM-TV picture received from N0YE's QTH. Don was also running 10 Watts. He used the Chinese model HDM65, AM-TV modulator (see issue #206. p.4 for details) to drive a 70-7B amplifier.

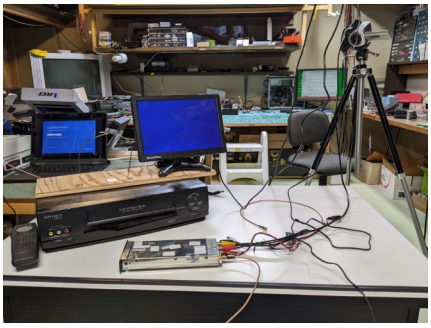
KH6HTV as received by N0YE

Obviously NOT digital quality video, but typical of the "Good Old Days" with lots of colorful confetti snow, plus lots of multi-path ghosting. Granted, we could also get excellent pictures under better propagation conditions and stronger signals.

A couple of hours later, Bill, AB0MY, was able to come on the air. He used a CATV, VUSB-TV modulator driving a KH6HTV 70-9B amplifier with about 25 Watts. He used an old VCR for his receiver. From his location in north Boulder, his yagi antenna had clear line-of-sight rf paths to both Don & Jim and was able to send/receive P4 to P5 pictures. No multi-path seen on Bill's pictures.

N0YE as rcvd by AB0MY

KH6HTV as rcvd by AB0M6


AB0MY's 70cm rig

AB0MY rcvd by N0YE

AB0MY rcvd by KH6HTV

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Trip Down Nostaligia Lane - Part II

Jim, KH6HTV

In the previous issue #209 of this ATV Journal, I wrote about building (i.e. re-building) my 23cm FM-TV gear which I lost in the Dec. 2021 fire. Well it was all fine and good to build it and prove that it worked on the test bench. But for us hams, that is on 1/2 of the story. We really have to get out and radiate our signals to say we are truly hams.

So I convinced a ham friend, Don, N0YE, to help me out with this. I loaned Don the 23cm, FM-TV modulator, a 23cm, 15 Watt amplifier and a pair of antennas. Don then drove up to our TV repeater site and set it up in the parking lot and proceeded to transmit a "live video" FM-TV signal on 1255 MHz. At my home QTH in Spanish Hills, SE of Boulder, 8 km (5 miles) away, I was easily able to pick up immediately Don's transmission.

Don then told me he felt that the 15 watt amplifier was unnecessary. He was simply using the model 23-8 FM-TV modulator with the patch antenna. The modulator rf output was 50 mW (+17dBm). The patch antenna had 12dBi gain. This photo shows the received P5 picture of Don.

I also had my spectrum analyzer connected to monitor the 70 MHz IF from the 23-7 down-converter. Using it, we then performed several other experiments with various antennas and with/with out the 15 Watt power amplifier.

Thanks Don for making a 23cm FM-TV ham out of me once again !

W0BTV Details:

Inputs: 23 cm Primary (CCARC co-ordinated) + 70 cm & 3 cm secondary all digital using European Broadcast TV standard, DVB-T with standard 6 MHz wide TV channels. Frequencies listed are the center frequency of the TV channel.
23 cm = 1243 MHz (primary), 70 cm = 441 MHz & 3 cm = 10.380 GHz
Outputs: 70 cm Primary (CCARC co-ordinated), Channel 57 -- 423 MHz with 6 MHz BW, DVB-T
Also, secondary analog, NTSC, FM-TV output on 5.905 GHz (24/7 microwave beacon).
Operational details in AN-51d Technical details in AN-53d. Available at: *https://kh6htv.com/application-notes/*

W0BTV ATV Net:

We hold a social ATV net on Thursday afternoon at 3 pm local Mountain time (22:00 UTC). The net typically runs for 1 to 1 1/2 hours. ATV nets are streamed live using the British Amateur TV Club's server, via: ***https://batc.org.uk/live/*** Select ***ab0my or n0ye***. We use the Boulder ARES (BCARES) 2 meter FM voice repeater for intercom. 146.760 MHz *(-600 kHz, 100 Hz PL tone required to access*).

Newsletter Details:

This newsletter was started in 2018 and originally published under the title "*Boulder Amateur Television Club - TV Repeater's REPEATER*" Starting with issue #166, July, 2024, we have changed the title to "*Amateur Television Journal.*" This reflects the fact that it has grown from being simply a local club's newsletter to become the "de-facto" ATV newsletter for the USA and overseas hams. This is a free ATV newsletter distributed electronically via e-mail to ATV hams. The distribution list has now grown to over 800+, both in the USA and overseas. News and articles from other ATV groups are welcomed. Permission is granted to re-distribute it and also to re-print articles, as long as you acknowledge the source. All past issues are archived at: https://kh6htv.com/newsletter/

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Amateur Analog AM Television

Jim Andrews, KH6HTV

27 pages

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RFI Potential of Digital TV

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4 pages