Application Note
AN-48

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Building a Basic, 70 cm, DVB-T, Television Repeater

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Fig. 1 A basic, 70cm, 10 Watt, DVB-T, Television Repeater

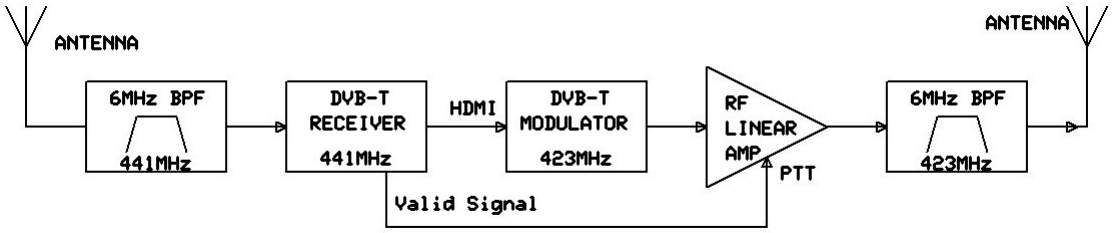

Fig. 2 Basic, 70 cm, Digital TV Repeater, block diagram.

Application Note, AN-23, has previously discussed the basics of what is required to build a Digital TV (DTV) repeater. Fig. 1 in AN-23, and Fig. 2 above, shows the typical method of constructing a basic 70 cm DTV repeater. It consists of using two, separate antennas, one for receive and one for transmitting. The isolation between the antennas, plus the sharp skirts of the band-pass filters (BPF) allow the receiver to hear (see) a weak incoming TV signal on one TV channel while transmitting a high power TV signal on a nearby TV channel.

Fig. 1 is a photo of an actual 70cm, DVB-T repeater built in the summer of 2019 by KH6HTV for the Pueblo, Colorado Amateur Radio Club (W0PHC). It is a basic TV repeater using the block diagram of Fig. 1. Fig. 3 below is the actual block diagram of the W0PHC-TV repeater. The only added items were a low noise, preamplifier and a pair of HDMI components to provide an A/V output from the receiver to be viewed on an external video monitor. It does not have any added fancy "bells & whistles".

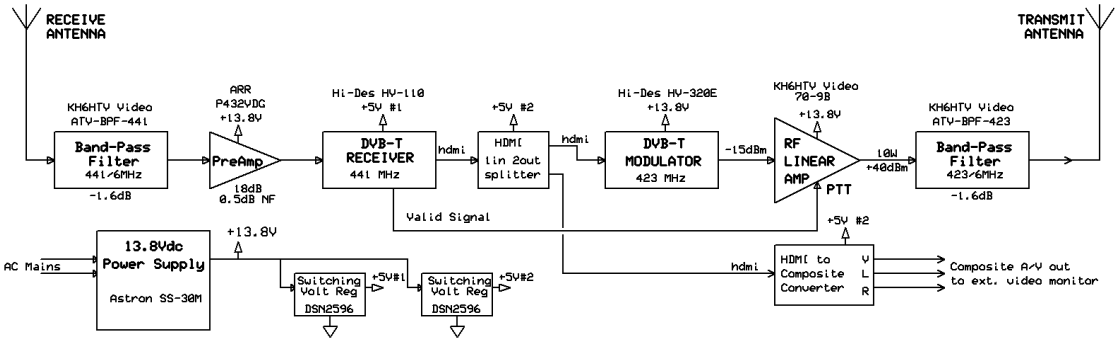

Fig. 3 Block Diagram of the Pueblo, W0PHC-TV repeater

The major components used in the repeater were: Hi-Des model HV-110 Receiver, Hi-Des model HV-320E Modulator, Advanced Receiver Research, model P432VDG Pre-Amplifier. KH6HTV Video supplied the pair of band-pass filters, models ATV-BPF-423 & ATV-BPF-441, plus the RF Linear Power Amplifier, model 70-9B. +13.8Vdc power was supplied by an Astron model SS-30M. The complete TV repeater was assembled on a 19" rack mount, 2U, open shelf (14 1/2" deep).

Fig. 4 Close up view of the TV repeater's front panel

Fig. 4 shows the front panel operating controls. The repeater is very simple to operate. First connect the antennas. The DC power supply is turned on. The RF Power Amplifier's RF Power Level rotary knob is set to HIGH and it's toggle switch is set to Ext. PTT. The HV-110 receiver is set to Ch 04 (i.e. 441 MHz). The HV-320E modulator is set to Ch 57 (i.e. 423 MHz). From this point on, the repeater is ready to function automatically.

When a valid, DVB-T signal is received, the receiver's LED turns from red to green. This keys the PTT logic line and turns on the RF Power Amplifier. The amplifier's LED turns from stand-by (yellow) to transmitter on (red). The cooling fan starts running and the power supply's amp meter jumps up to 10 Amps. Approx. 1.5 amps, stand-by.

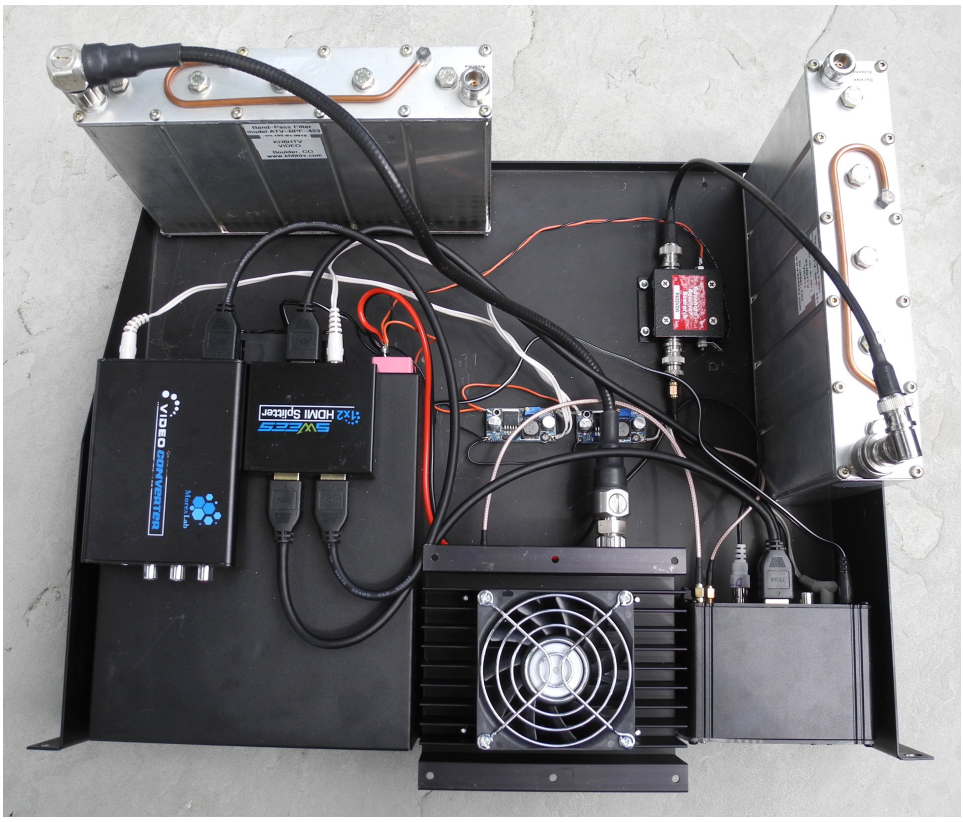

Fig. 5 Top view of the W0PHC-TV repeater

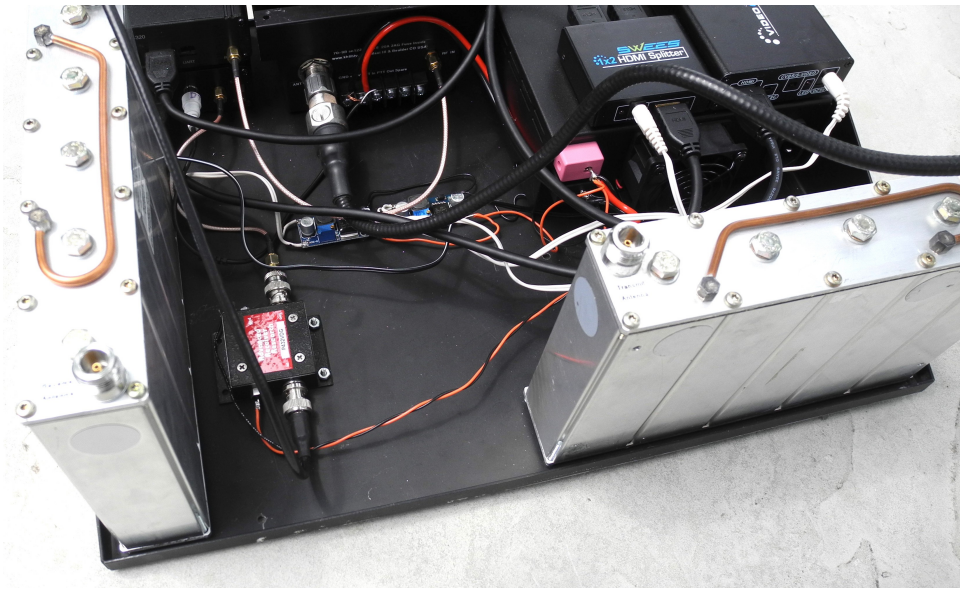

Fig. 6 Rear view of the W0PHC-TV repeater

Basic performance tests were performed on the finished repeater.

TRANSMITTER TESTS:

The transmitter was set up to transmit QPSK, DVB-T signals on a center frequency of 423 MHz with 6 MHz bandwidth.

The rf output power was measured using an HP-432A Power Meter with an HP-8478B Thermistor power head. This allowed the rf power to be measured in true RMS. The repeater's rf output was attenuated using a high power (150W), 30dB attenuator. It was a Narda model 769-30. This was followed by precision 10.0dB, 2 W, N attenuator.

The repeater's RF output power was: 9.3 Watts (rms) (+39.7dBm)

The repeater's rf spectrum was measured using the 150W, 30dB power attenuator and a Rigol model DSA-815 Spectrum Analyzer. Figs. 7 & 8 show the rf output from the rf power amplifier and also the repeater's output from the transmit BPF.

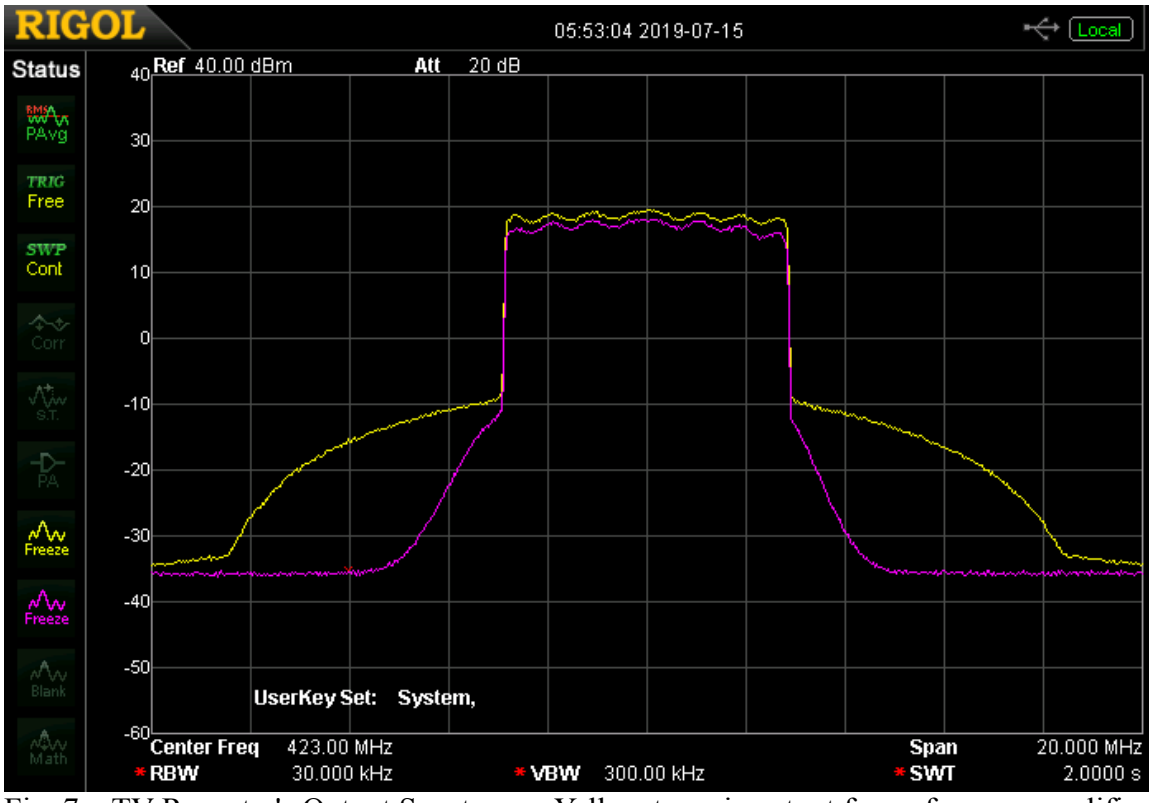

Fig. 7 TV Repeater's Output Spectrum: Yellow trace is output from rf power amplifier. (shoulder break-point is -29dB, Pout = 12.6 W, +41dBm) Magenta trace is the power amp output after passing through the 423 BPF (shoulder break-point is -34dB, Pout = 9.3 W, +39.7dBm). This is the output to the transmit antenna. 10dB/div & 2MHz/div. center freq. = 423MHz

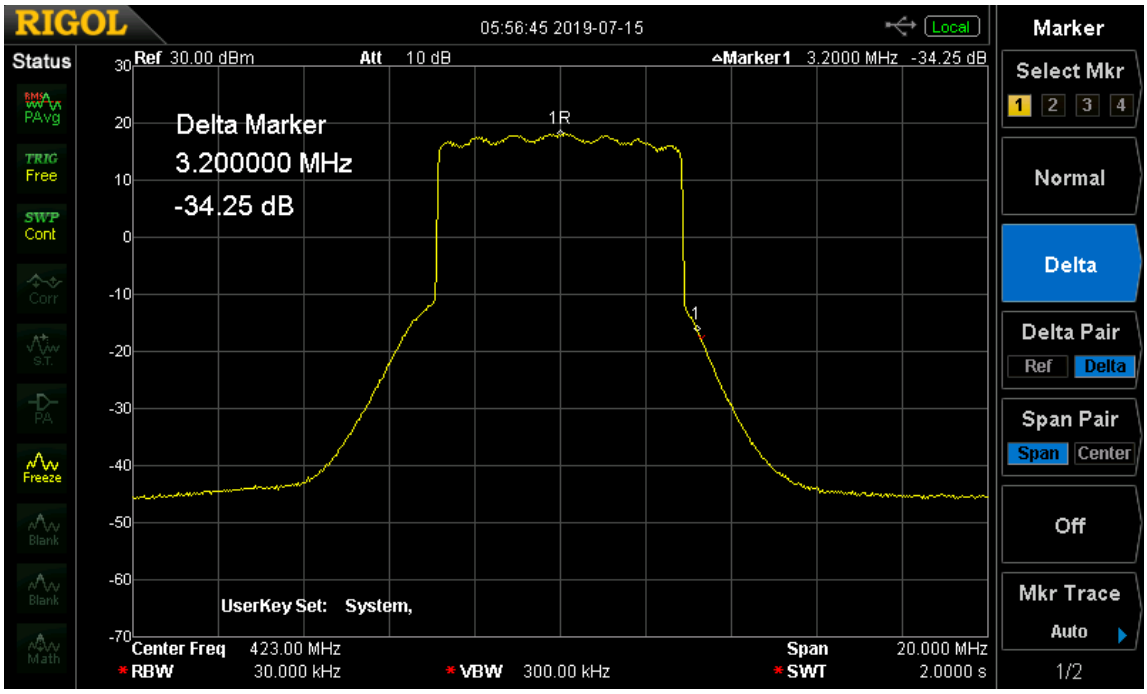

Fig. 8 Pueblo DVB-T Repeater's rf output spectrum. Center Freq = 423MHz, 10dB/div & 2MHz/div. Pout = 9.3 Watts (rms) = +39.7dBm. Shoulder break-point is -34dB down (+3.2MHz from center). Spectrum is attenuated by -40dB (-4MHz), -53dB (-5MHz), -47dB (+4Mz) & -58dB (+5MHz)

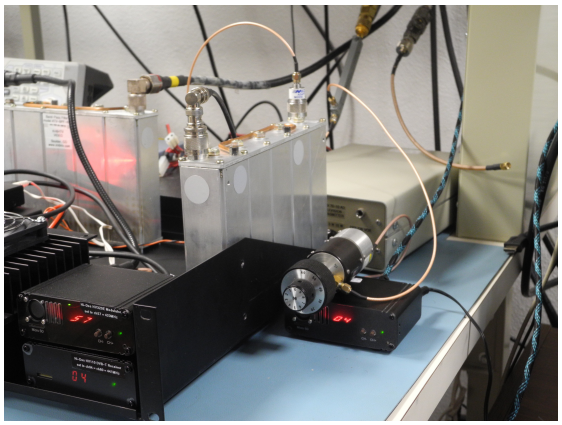

Fig. 9 Test setup for receiver

Fig. 10 Monitor showing OSD

RECEIVER SENSITIVITY TESTS:

The TV repeater's receiver was tested using normal, amateur, DVB-T, live video signals. The test signal's various parameters were: 441 MHz, 6 MHz bandwidth, QPSK modulation, 1080P resolution, H-264, 8K FFT, 1/2 FEC (code rate) & 1/16 Guard. The test signal was generated using a Hi-Des model HV-320E. Live video was furnished by a Blu-Ray DVD player playing a continuous looping Blu-Ray disc complete with constant motion and live audio. The +7dBm rf output from the HV-320E was attenuated using 20dB and 30dB SMA attenuators along with a Weinschel SMA rotary step attenuator (0-69dB, 1dB steps). See Fig. 9. The digital threshold was determined when the received

video was just above pixelization and the video was solid with no breakups. Also the receiver's LED glowed steadily green with no blinking. At this level, the receiver's on-screen-display (OSD) indicated a s/n of 8dB. See Fig. 10.

Initial Bench Tests of Receiver:

Test 1: Test signal directly into the HV-110 receiver. Sensitivity = -94dBm
no signal OSD = -98dBm, 0dB s/n -- with signal OSD = -92dB, 8dB s/n
i.e. for weak signals, the OSD power meter reads +2dB high.

Test 2: Test signal into Pre-Amp and then the receiver. Sensitivity = -98dBm
no signal OSD = -85dBm, 0dB s/n -- with signal OSD = -77dB, 8dB s/n

Test 3: Test signal into repeater's receive antenna connector. Sensitivity = -95dBm
(i.e. BPF -> PreAmp -> Rcvr)
no signal OSD = -85dBm, 0dB s/n -- with signal OSD = -75dB, 9dB s/n

Test 4: Strong signal into the receive antenna connector to calibrate the OSD.
Pin = -73dBm, OSD reads -55dBm, 23dB s/n. delta = +18dB
The OSD power meter has an offset of +18dB due to the preamp in the system.
For higher power levels the OSD power meter is accurate within ±1dB as long as this offset is accounted for.

The above results were the same with or without the transmitter being turned on.

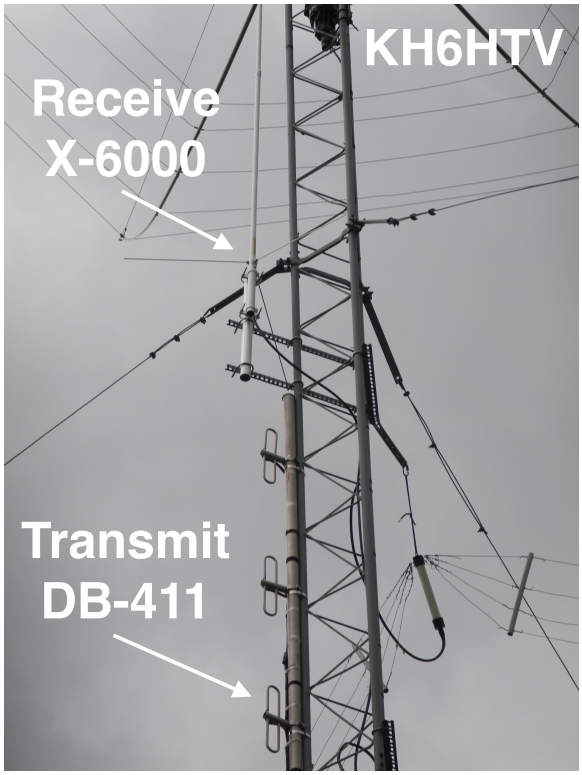

Fig. 11 TV Repeater's Antennas

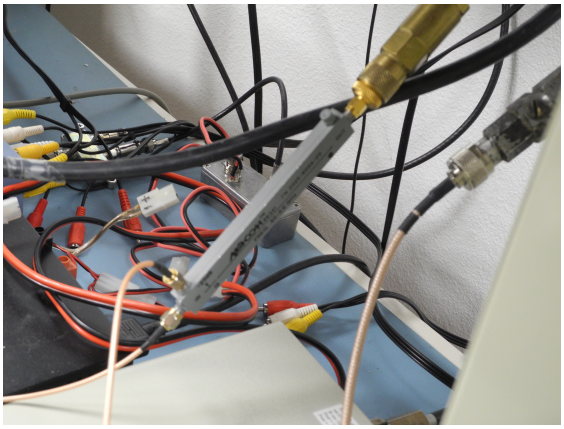
Fig. 12 20dB coupler in receive line

REAL WORLD FINAL TEST:

The final acid test was to connect the repeater to outside antennas and verify it still performed properly. It was connected to a pair of antennas on KH6HTV's 50 ft. antenna tower. See Fig. 11. These antennas have been used successfully in the past when the Boulder ATV repeater was temporarily at KH6HTV's QTH. The receive antenna was a Diamond X-6000 (2m/70cm/23cm) at 45 ft. The transmit antenna was a DB Products DB-411, four element, co-linear.

The Pueblo TV repeater performed flawlessly when using these antennas. The initial test was performed with Don, N0YE, transmitting through the repeater from his QTH about 5 miles away.

Sensitivity tests were again performed on the receiver while the repeater was operational and connected to the antennas. To perform this test an SMA, 20dB directional coupler (Macom 96341, 0.5-2GHz) was inserted into the receive antenna line at the repeater's input. See Fig. 12. The DVB-T test signal from the HV-320E and the step attenuator was injected into the receiver's antenna input via this 20dB directional coupler. Similar sensitivity tests were again run with this setup.

The conclusions were:

1. No desensing of the receiver when the transmitter was on.

2. Ambient background rf level on Ch 60 (438-444) raised the indicated OSD power level from -85dBm up to about -80dBm.

3. The receiver's threshold sensitivity when connected to an outside antenna was approximately -93dBm. Thus, the ambient, background rf degraded the effective threshold by about -2dB.