Boulder Amateur Television Club
TV Repeater's REPEATER
August, 2019

Jim Andrews, KH6HTV, editor - kh6htv@arrl.net

Call Sign / Number	Grant Date	Expiration Date	File Number	Print Date	Effective Date
W0BTV	07-12-2019	07-12-2029	0008703181	07-12-2019	07-12-2019

Operator Privileges — **Station Privileges:** CLUB

THIS LICENSE IS NOT TRANSFERABLE

Special Conditions / Endorsements: NONE

ATTN: JAMES R ANDREWS
BOULDER AMATEUR TELEVISION CLUB
1025 PARAGON DRIVE
BOULDER, CO 80303

AMATEUR RADIO LICENSE

FCC Registration Number (FRN): 0028587012

FCC 660 - May 2007

Fold Here

(Licensee's Signature)
FEDERAL COMMUNICATIONS COMMISSION

NEW FCC LICENSE for our New Club, BATVC

REPEATER STATUS: The TV repeater is again functioning normally. However, due to the rebuilding of the repeater currently in process, a temporary repeater is in service. Thanks to Jack, K0HEH & Don, N0YE. It is a portable unit, 70cm in-band only. Ch 60 in / Ch 57 out. DVB-T only.

Don is streaming the TV repeater's weekly, Thursday afternoon, ATV nets over the BATC server (https://batc.org.uk/live/) under his own call sign N0YE. If you have any questions about the current operations or status of the repeater, contact either Jim, KH6HTV or the assistant. trustee, Don, N0YE.

ATV Net: The Boulder ATV group meets every week on Thursday afternoons for an informal A/V net. The net starts at 3 pm local time and usually runs for 1 to 1 1/2 hours. There is usually a DVD playing a travel video both preceding and following the net for about 1/2 to 1 hour. The net is called initially and uses as our audio intercom the

BCARES, Gunbarrel Hill, 2 meter, FM voice repeater. (146.76MHz, - offset, 100 Hz PL tone required).

Future Newsletters: If you have contributions for future newsletters, please send them to me. Jim Andrews, KH6HTV, email = kh6htv@arrl.net

SAN DIEGO ATV: We finally got both our DATV repeaters on and linked covering pretty much all of San Diego, we have linked the W6CX, W8BI and ATCO DATV repeaters as they get on air with their nets. The matrix controllers automatically are programmed to put them over our port two transmit output on DVB-S2 23cm. all local transmissions are on port 1 DVB-T. Full-duplex works well for our small 12 man group. 73 and hope to get your system programmed also to be seen here in San Diego.
73 de Mario, KD6ILO (e-mail 7/6/19)

61 YEARS & GOING STRONG ! Congratulations of our fellow ATVers, Naomi, KD0PDZ, & Roger, K0IHX on 61 years of marriage. They recently celebrated their anniversary on the 5th of July. Bet there were a lot of fireworks 61 years ago and it wasn't because of the 4th ! They have lived most of their married life in the home they built, and still live in, on the top of Davidson Mesa.

SILENT KEY -- N0AES: The Longmont Amateur Radio Club, LARC, just lost their president. Starr Aldrich, N0AES, had a fatal heart attach, Sunday, July 7th. Starr formerly worked for many years at IBM, then Wells Fargo and was a retired fire fighter. Starr was quite active in amateur radio, being a member of LARC and BCARES.

OUR OWN HAM FILTER EXPERT IS FAMOUS

Dan, WB9AIA, is giving an on-line lecture, sponsored by the IEEE Microwave Theory & Techniques Society. Dan has given Don, N0YE, assistance in improving his inter-digital, band-pass filters. He also recently gave a great talk at the Boulder ham club.

Featured Webinar

An Enhanced Design Flow for Cavity Combline Filters

Tuesday, July 23rd, 2019 - 12pm EST

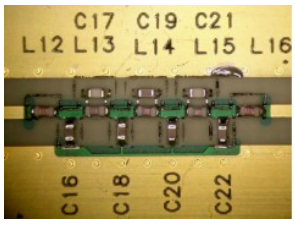
Cavity combline filters and multiplexers are widely used in commercial and military communications systems. Many combline filters use finite transmission zeros to increase selectivity in the stopband by introducing cross couplings into the topology. This webinar presents an enhanced flow for the design of cavity combline filters that uses optimization

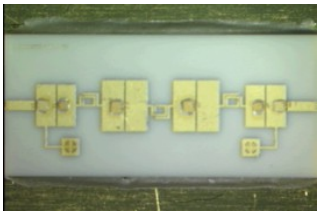
rather than synthesis technology. A cross-coupled filter with calibrated port tuning design example is presented. While synthesis is excellent for developing the initial design phase and generating mathematical filter solutions as lumped or ideal distributed networks, its abilities are limited for developing an accurate physically-realizable filter. The method discussed in this webinar is based on a technique introduced by Dishal and adapted by the presenter for use with modern circuit and electromagnetic (EM) , simulation.

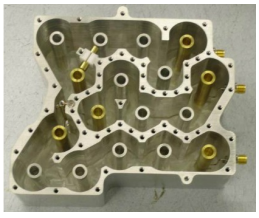
Daniel G. Swanson, Jr.,
DGS Associates, WB9AIA
www.dgsboulder.com

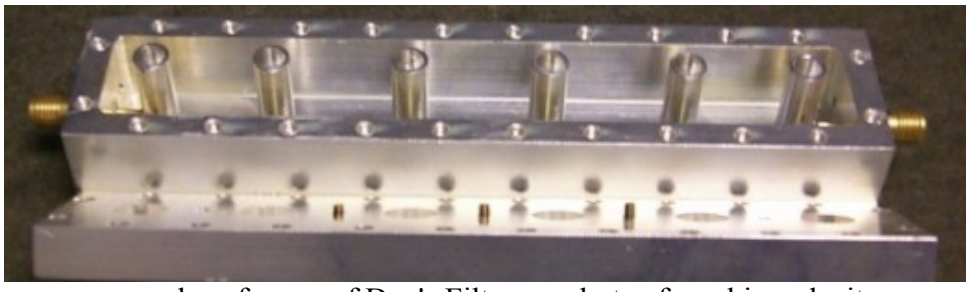
Dan Swanson received his BSEE from University of Illinois in 1976 and his MSEE from the University of Michigan in 1978. He was elected a Fellow of the IEEE in 2000 and recently achieved Life Fellow status. Dan has served for many years on the editorial board of the IEEE Transactions on Microwave Theory and Techniques and the IEEE Microwave and Wireless Components Letters. He has published numerous technical papers, presented many workshops and short courses, and holds two patents. He has been teaching courses on EM simulation and filter design in the U.S. and Europe since 1995 and is the principal author of Microwave Circuit Modeling Using Electromagnetic Field Simulation, published by Artech House. Dan established DGS Associates in 2015 after more than four decades as a design engineer, with expertise in high-Q filters and multiplexers for commercial applications, broadband thin film filters for electronic warfare (EW) systems, and printed circuit board (PCB) filters using standard surface mount components for the microwave industry.

DGS Associates
Filter Design / Antenna Design / EM Simulation

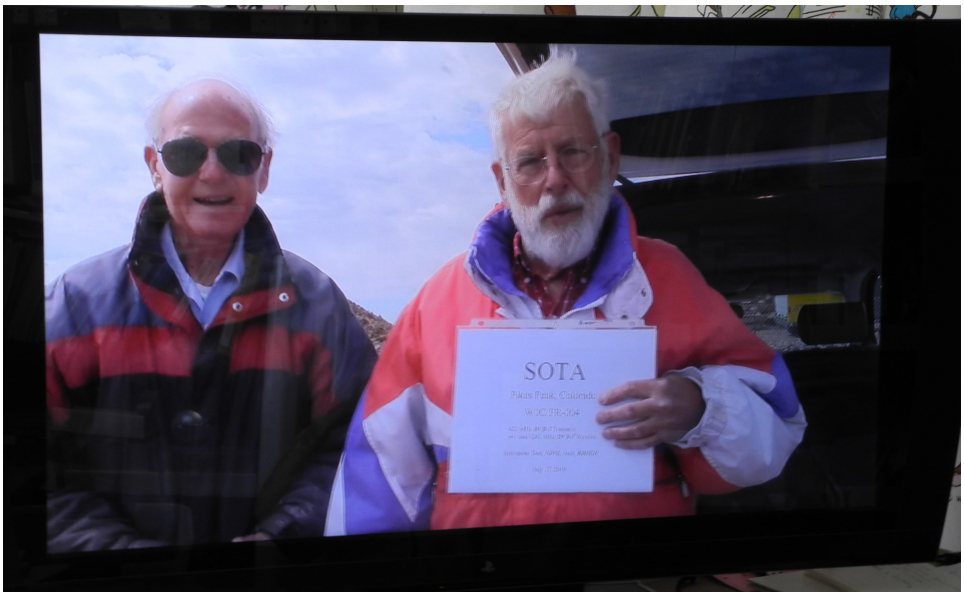








examples of some of Dan's Filters -- photos from his web site



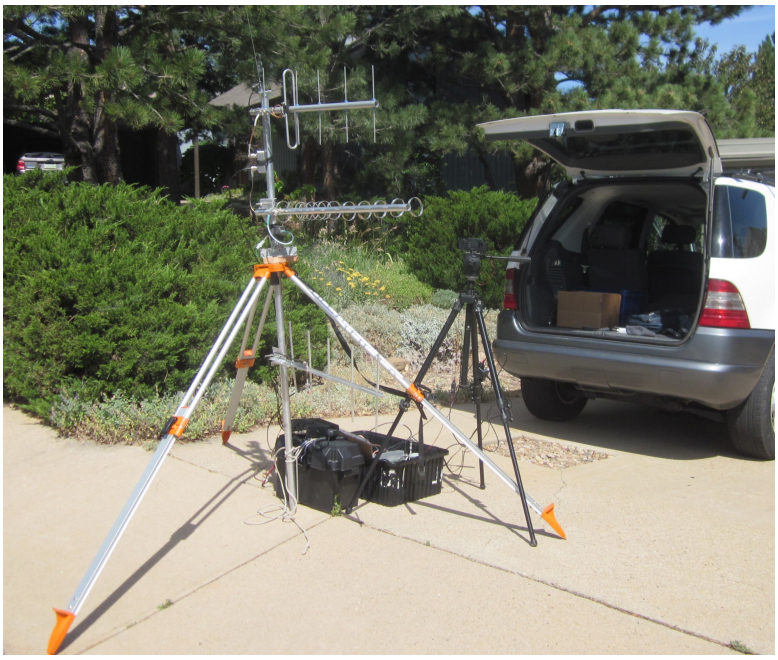
Jack, K0HEH, & Don, N0YE, on top of Pike's Peak --- TV picture received 79 miles away by Roger, K0IHX. Lew, K0ANS, got the same at 91 miles !

Pike's Peak, SOTA, DVB-T, DX-pedition is Successful

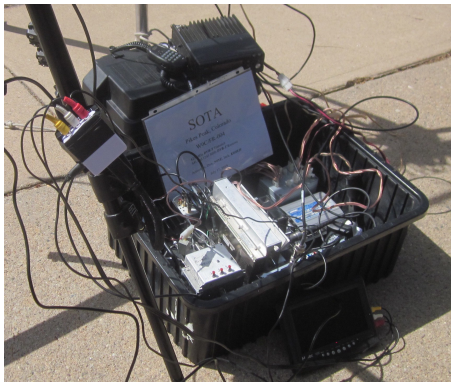
Jim Andrews, KH6HTV

Don, N0YE, recently announced on the Boulder ATV Net that he was planning to do a SOTA (Summits On The Air), https://www.sota.org.uk/ ATV operation from Pike's Peak. Pike's Peak is the highest mountain in the southern part of the front range of the Rocky mountains. It is 14,115 ft. high and towers over the city of Colorado Springs at 6,000 ft. It can be seen visually from extremely long distances from many locations in the eastern, prairie part of the state of Colorado. There is a road going all the way to the summit which is very popular with tourists in the summer. Closed in the winter.

View from the summit of Pike's Peak looking north towards Boulder, 80+ miles in the distance Photo of live DTV transmission taken from TV receiver at K0IHX / KD0PDZ's QTH on Davidson Mesa, Boulder



The SOTA-DTV setup. Don forgot to take a photo while on the mountain. So he took this photo the next day in his home driveway.



close-up of all the ATV gear plus battery

Don and Jack, K0HEH, drove to the summit of Pike's Peak on Wednesday morning, July 17th. They adhered to the SOTA rules and did not use their car for either physical or electrical support for their TV operation. It was however their "mule" to hump all their ATV gear up the very tall mountain ! Their equipment was all set up outside the car and they used a separate, large storage battery provided by Colin, WA2YUN. They set up one, rugged, tri-pod antenna mast with three yagi antennas. For 70cm, they had two, 6 element yagis (1 transmit & 1 receive). For 23cm, they had a 15 element, loop yagi for receive only. They transmitted, live, high-definition, pictures using digital, DVB-T modulation. Their output power on 70cm was 5 watts, rms. They transmitted on Ch 57 (423MHz / 6MHz BW) and received on Ch 60 (441MHz / 6MHz BW). They received incoming DVB-T on 441MHz (70cm) and also 1243 MHz (23cm). They did voice coordination with the various other ATV stations participating using 2m FM on simplex 144.33MHz.

Don had prearranged with several of the active Boulder ATV hams to be rovers and go to good rf locations and set up their own portable, DVB-T stations. The following hams participated:

Pete, WB2DVS, & Debbie, WB2DVT, were the closest at 47 miles and were setup in Highlands Ranch, CO. with a 70cm rig running 3 W to a 6 element yagi antenna. From the photo, it looks like they were "sitting down on the job! "

Bill, AB0MY, was next at 74 miles at the Broomfield jail. He was on 70cm with 1 watt to a 6 element yagi.

Doshia, KB0NAS, & George, N0RUX, were also 74 miles from Pike's Peak at the high spot on 120th Ave. west of Indiana, Arvada, CO. They had a 70cm rig running 3 watts to a 10 element M2 yagi antenna at 8 ft.

Roger, K0IHX, Naomi, KD0PDZ, & Jim, KH6HTV were 79 miles from Pike's Peak operating from Roger & Naomi's QTH on Davidson Mesa with their assortment of 2m, 70cm & 23cm antennas. They transmitted on both 70cm & 23cm with 3 watts. It only took 300mW on 70cm to get to Pike's Peak. For 70cm receive they used a Diamond X50 omni. For 70cm transmit they used a 10 element yagi. For 23cm transmit they used a Diamond X6000, omni.

Ed, K0JOY, was in the most unlikely location to get signals. He was at his own QTH on a ridgeline in the foothills north-west of Boulder, near Olde Stage Road & Left Hand Creek. He was 89 miles north of Pike's Peak. Ed received on 70cm and transmitted on 23cm (3W). His 70cm antenna was an 8-bay Dipole array with flat reflector. His 23cm antenna was a home-brew, 6 element yagi.

Lew, K0ANS, was the farthest away at 91.4 miles and operating from his home QTH in Longmont, CO. Lew was 70cm receive only. His antenna was a homebrew, 8 element yagi.

The SOTA, DTV DX-pedition was a TOTAL Success ! Everyone participating was able to receive the 70cm, DTV signals from Pike's Peak, plus Don & Jack were able to receive DTV signals on 70cm and 23cm from everyone that transmitted. All pictures were reported to be very solid P5 with no breakups nor freeze framing.

In addition to doing simplex ATV with the above hams, at the end of the session, Don & Jack then swapped 70cm frequencies to see if they could also hit the Boulder ATV repeater, W0BTV, on Table Mesa. (Ch 60 in & Ch 57 out). They were successful. Note: contacts via repeaters do not count for SOTA scores.

The following is Don, N0YE's, after action report

THANK YOU all for the successful activation of Pike's Peak using DVB-T TV. Jack and I were able to work everyone wanting to participate on 70cm and 23cm. All signals were P5. You all were ready and made our task of getting all of the exchanges done efficiently.

Several of you demonstrated different signal strength thresholds for working/not working by lowering your power levels below our receiver's thresholds. This reinforced that we were not doing a "slam dunk" undertaking. Our antenna pointing on 70cm was not critical. We were far enough away from everyone and the antenna beam width wide enough so that your diversity of location was not an issue on 70cm. We did not have to adjust the 70cm antenna to work everyone. The antenna pointing on 23cm was important, understandably, because the 23cm antenna was higher gain and the signal strengths may have been less. Plus the strong winds keep us busy keeping it pointed properly.

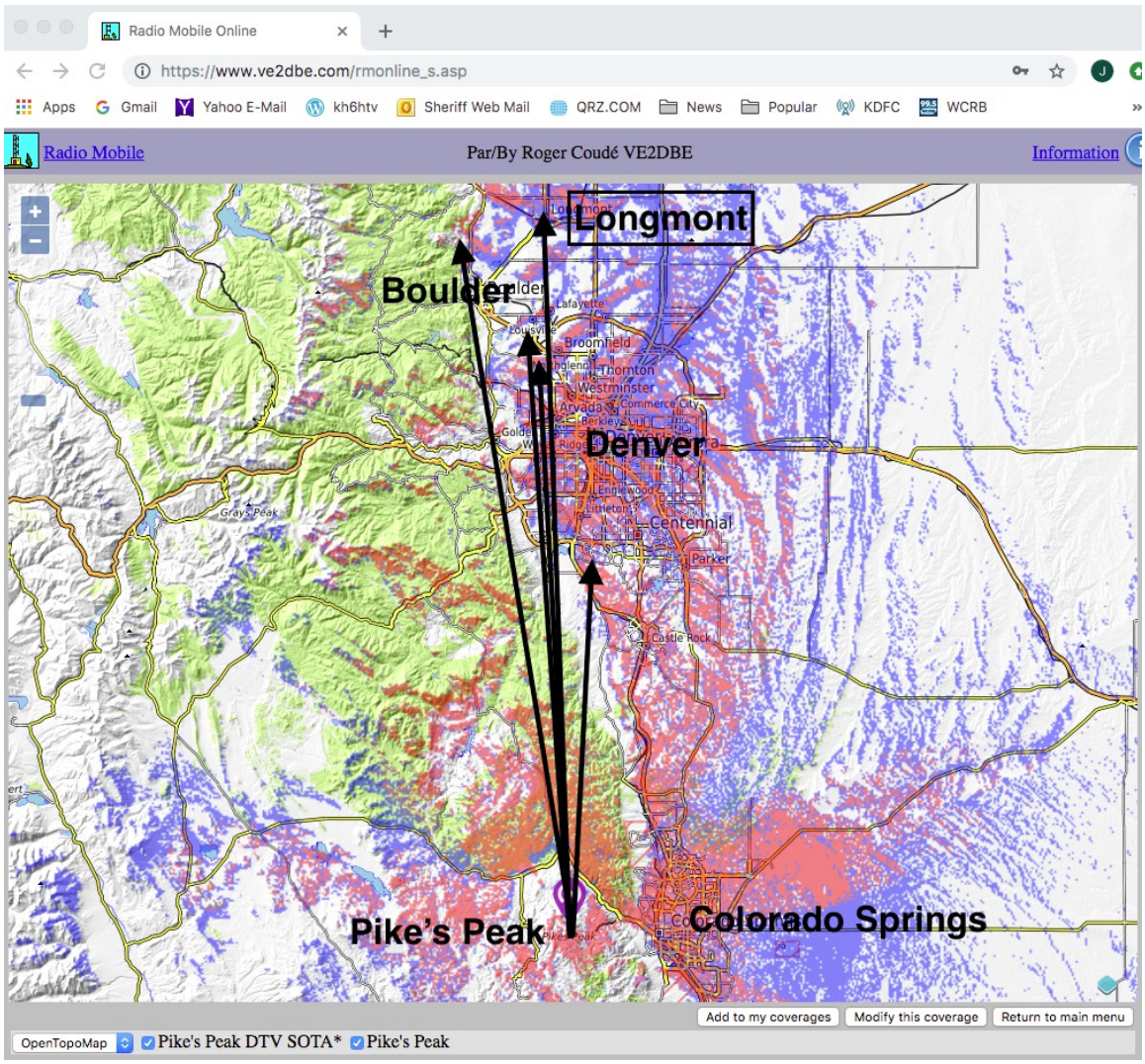
Being at 14,000 feet diminishes ones proficiency, clarity of action, etc. I demonstrated that again to myself yesterday. Fortunately I had done much of the setup ahead of time. For example, the antenna system including preamps and cabling was done at home minimizing the setup details and time. When we moved to 23cm, we were not getting any video. Well when the output of the 23cm receiver is not connected, it does not work!

We needed a special pass to get the top. Everyone else was stopped at a parking lot part way up the mountain. In fact there were two parking lots at two different elevations depending on activity. Yes it is summer and there were lots of people. The drive up and down was slow because of the volume of cars. On the top we were able to choose our parking location for good operation to the north. Had we wanted to work pointing in other directions, the construction equipment and materials would have been in the way. It is clear that the construction up there is going to be a multi year activity.

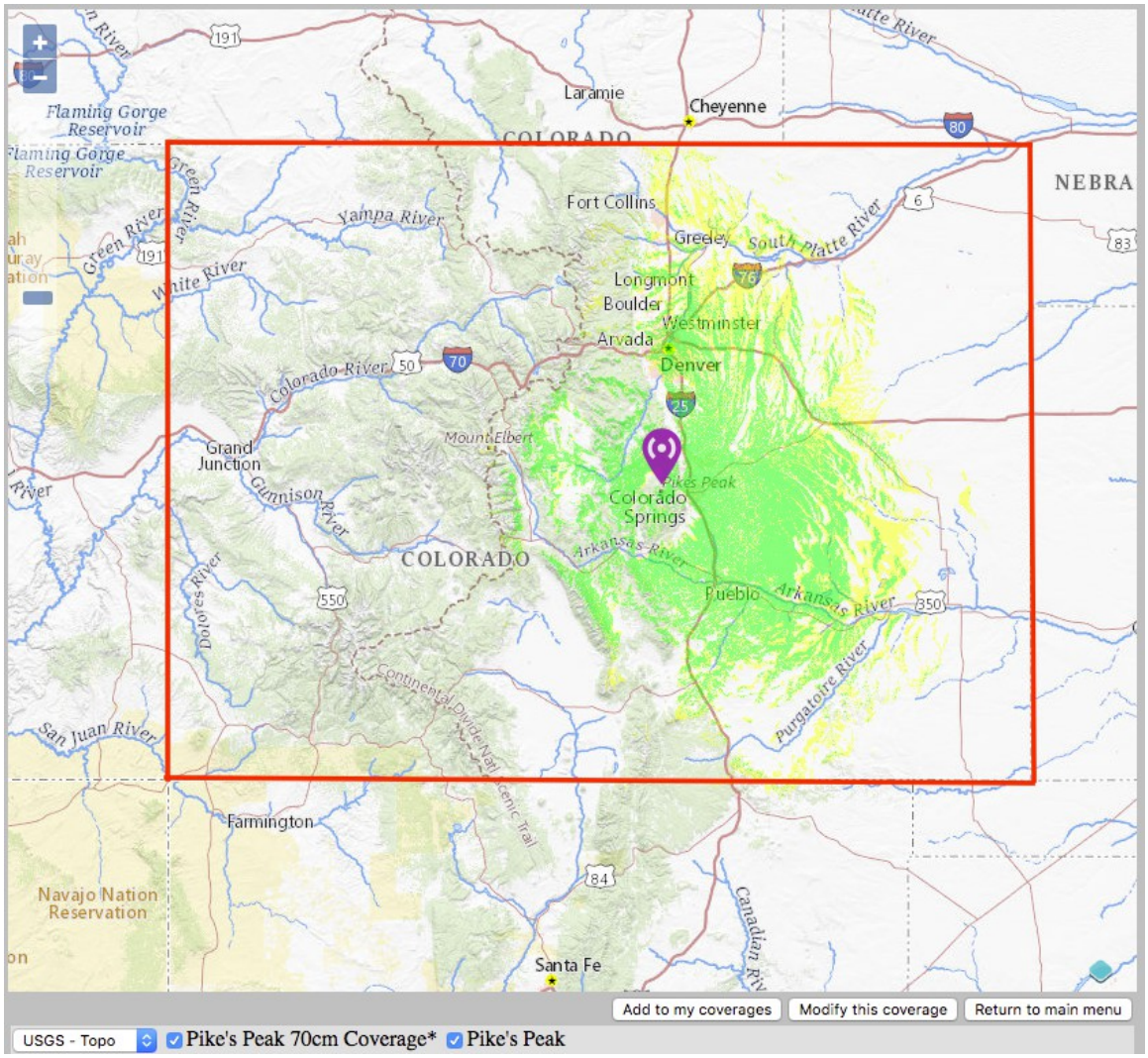
The weather was about as good as it gets up there. Yes it was 42 degrees when we arrived, and the wind was a reasonable 10-15 MPH maybe. Where we were given the summit pass, the attendant said the winds were mild and no ROCKS were being made airborne yet ! A "ranger" commented, up there, that the afternoon winds would be much worse. It was a relief to be able to setup and do a legitimate SOTA instead of having to work out of the car. 73 de Don, N0YE

The map on the following page shows a lot of details about the DTV, DX-pedition. The arrows show the paths to the various receive sites. The color shading is the predicted rf signal strength using the on-line, rf propagation program, *Radio Mobile*. Red = strong signals. Blue = weak signals.

So, these great results, beg the question, what could we do if the hams in Colorado Springs were to install a 70cm, DVB-T, television repeater on the top of Pike's Peak ? The next map shows the coverage area that would result from a 5 watt, 70cm, DVB-T transmitter with a 7dBi, omni directional antenna at the summit. It would be great ! The strong signal (>-80dBm) area would include Pueblo on the south, to Colorado Springs, to Denver, up to Longmont on the north. The weak signal area would extend all the way from the New Mexico border on the south to the Wyoming border on the north. It would also extend out east on the prairie as far as Limon.



Radio Mobile RF propagation predicted coverage area for the N0YE/K0HEH Pike's Peak DTV operation. Using a 70cm, 5 W transmitter with a 6 element yagi pointing north towards Boulder. The receiving stations were assumed to have 6 element yagis at 10 ft. The blue shaded areas are for weak signals (-90 to -80dBm). The red shaded areas are for strong signals (> -80dBm). The green areas show the locations of national forests. This is a topo enhanced map. The flat, rolling prairie of eastern Colorado is on the right side of the map. The Rocky mountains of Colorado are on the left side of the map. The rf signals from Pike's Peak were shooting due north right along the front range of the Rockies.



Predicted rf coverage area map for a 70cm, 5 W, DVB-T transmitter on the top of Pike's Peak using a 7dBi omni antenna. Assumed receiving stations are using an 11dBi yagi at 30ft. Red lines are the borders of the state of Colorado, 380 miles x 280 miles. note: max. radius for the calculation was the largest possible at 300km (186 miles).

EGG on My Face: Recently Colin, WA2YUN, put me onto a source of 70cm duplexers. They looked like they would work well for a TV repeater and allow us to only use a single antenna rather than the normal two antenna arrangement. I got some of them and tested them. I thought they would work out ok. My initial lash-up of a repeater on the bench said it would work. About this same time, Pueblo asked me to build a 70cm DTV repeater for them using a duplexer. I took their order. However, after completely assembling their repeater, I was dismayed to find the transmitter was desensing the receiver. I tried many different arrangements of various filters, etc. -- to no avail. I finally gave up and discarded the idea and rebuilt their repeater in the classical manner requiring two separate antennas. It worked fine, no desense. Needless to say, Pueblo was disappointed. The following new app. note describes the Pueblo TV repeater, W0PHC-TVR, in detail. --- Jim, KH6HTV

Application Note
AN-48

July, 2019

web = www.kh6htv.com email = kh6htv@arrl.net

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

Jim Andrews, KH6HTV

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

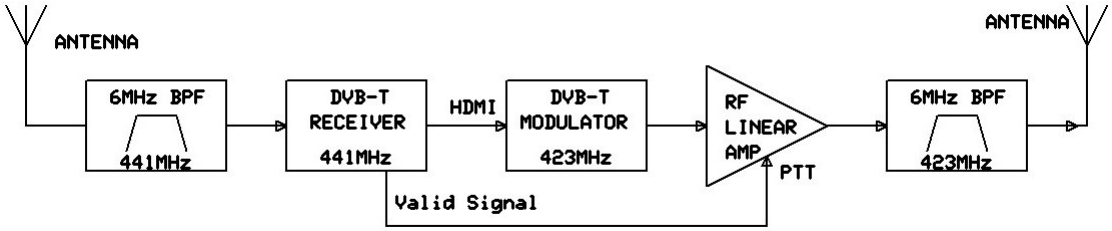


Fig. 2 Basic, 70 cm, Digital TV Repeater, block diagram.

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".

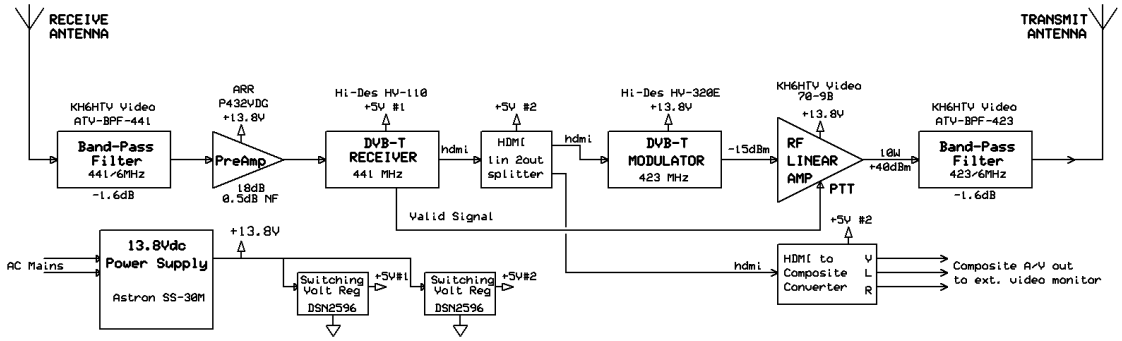


Fig. 3 Block Diagram of the Pueblo, W0PHC-TV repeater

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.

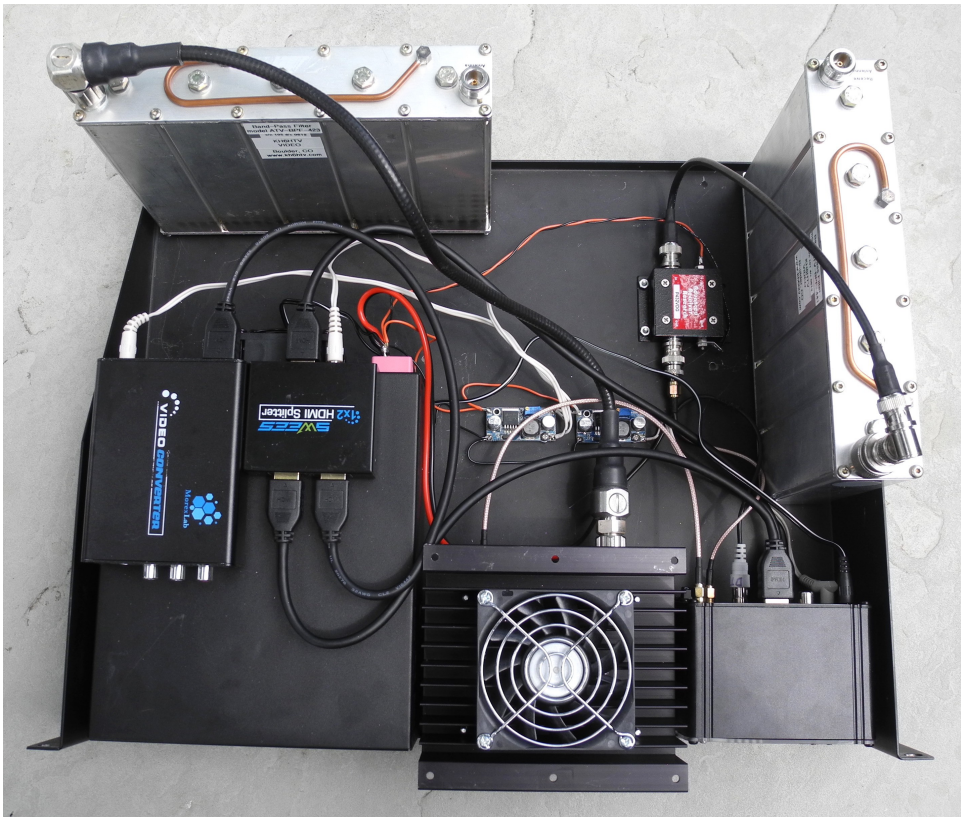


Fig. 5 Top view of the W0PHC-TV repeater

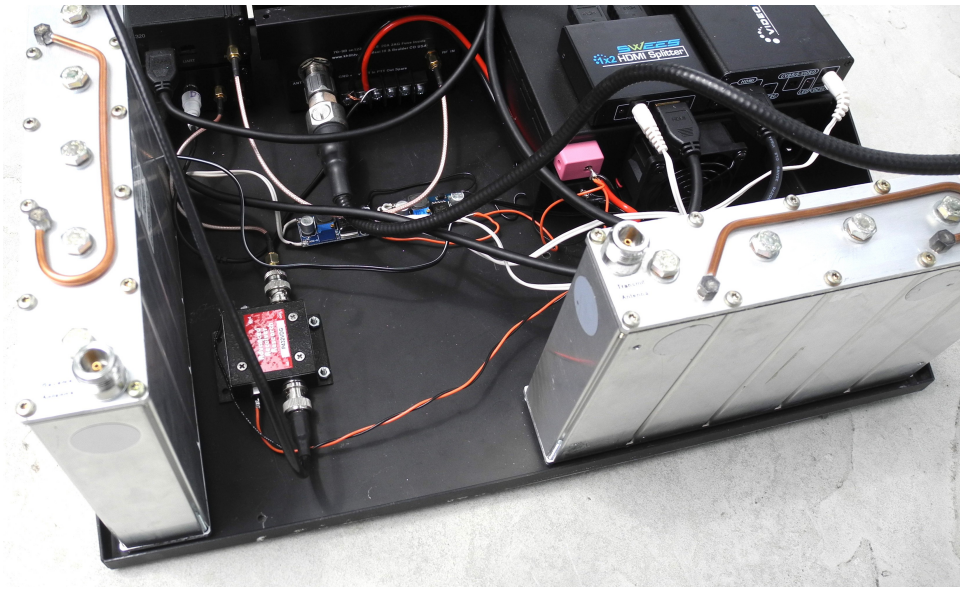


Fig. 6 Rear view of the W0PHC-TV repeater

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.

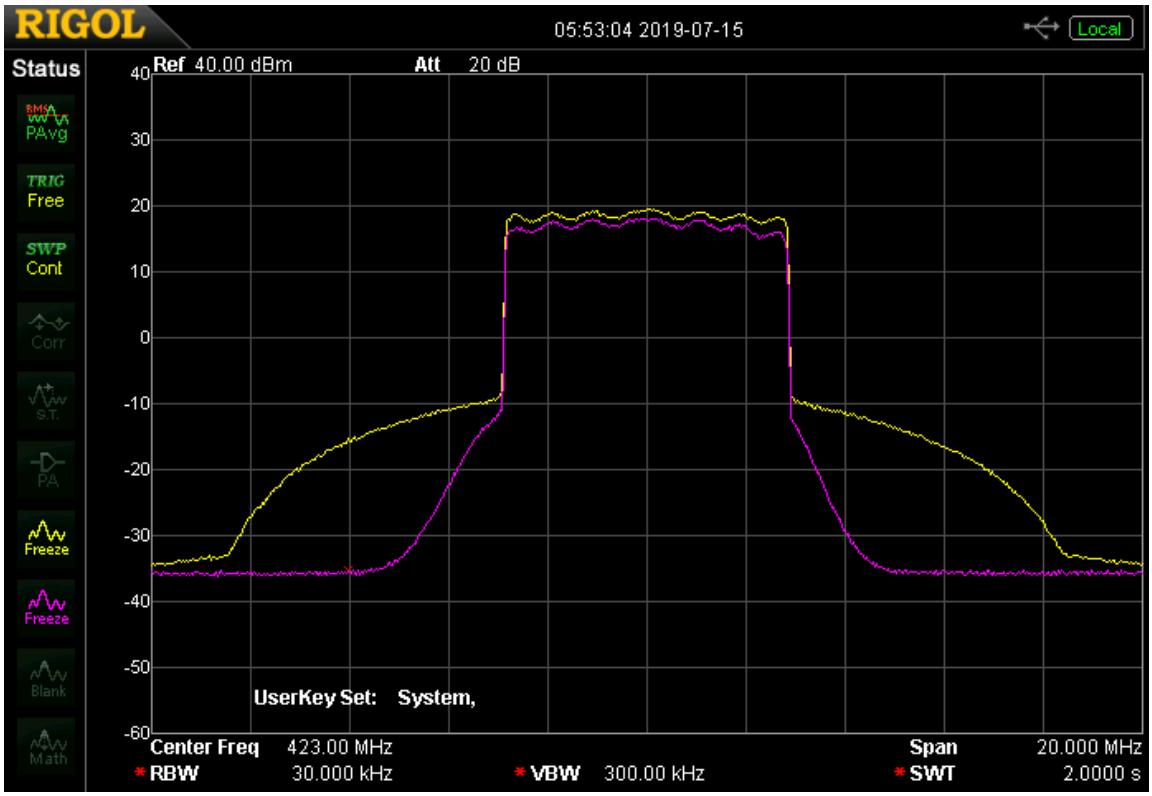


Fig. 7 TV Repeater's Output Spectrum: Yellow trace is output from rf power amplifier. (shoulder break-point is -29dB, Pout = 12.6 W, +41dBm) Magenta trace is the power amp output after passing through the 423 BPF (shoulder break-point is -34dB, Pout = 9.3 W, +39.7dBm). This is the output to the transmit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

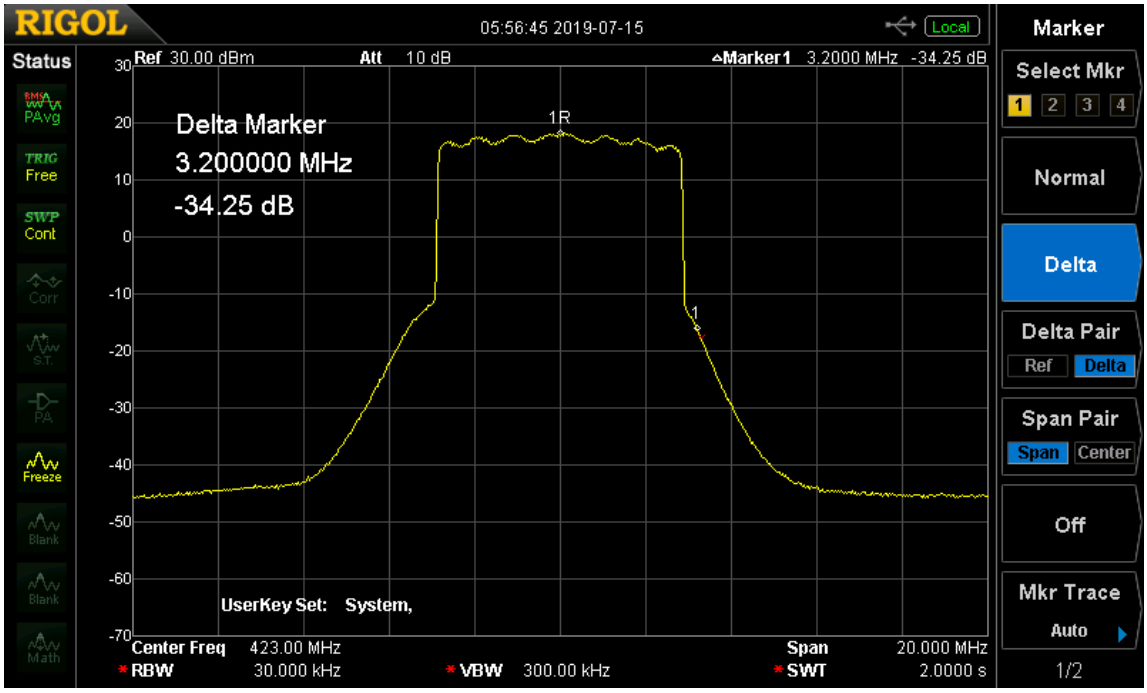


Fig. 8 Pueblo DVB-T Repeater's rf output spectrum. Center Freq = 423MHz, 10dB/div & 2MHz/div. Pout = 9.3 Watts (rms) = +39.7dBm. Shoulder break-point is -34dB down (+3.2MHz from center). Spectrum is attenuated by -40dB (-4MHz), -53dB (-5MHz), -47dB (+4Mz) & -58dB (+5MHz)

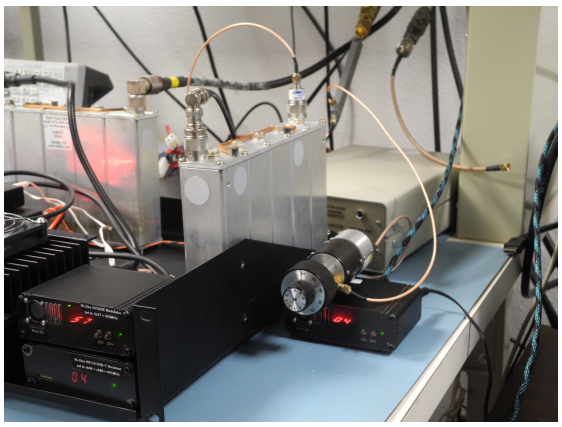


Fig. 9 Test setup for receiver

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.

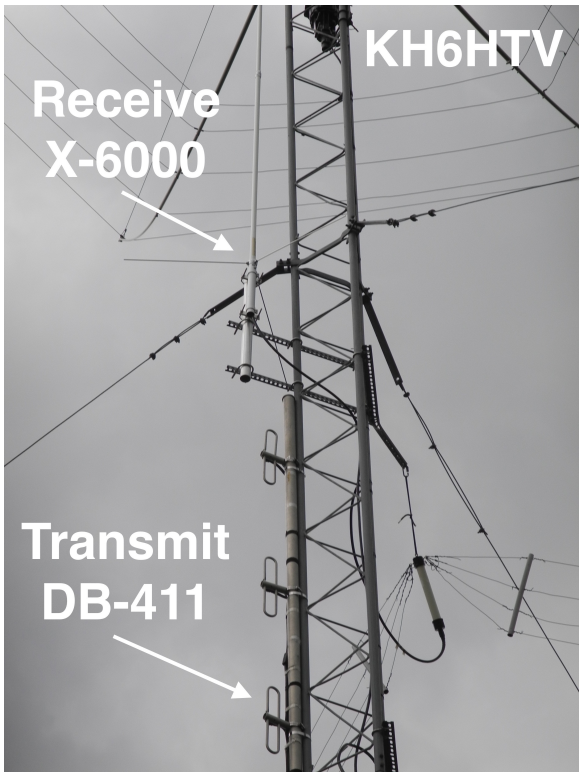


Fig. 11 TV Repeater's Antennas

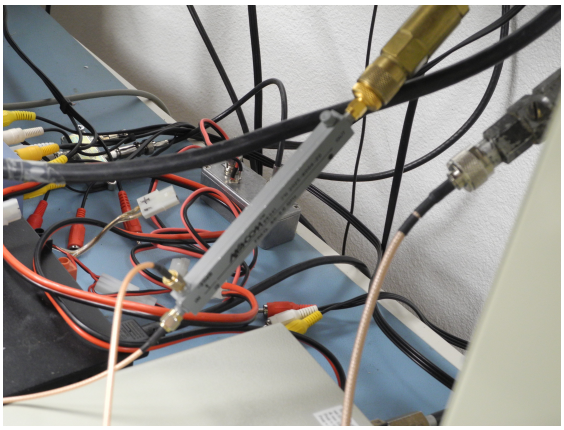


Fig. 12 20dB coupler in receive line

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.