Application Note
AN-52

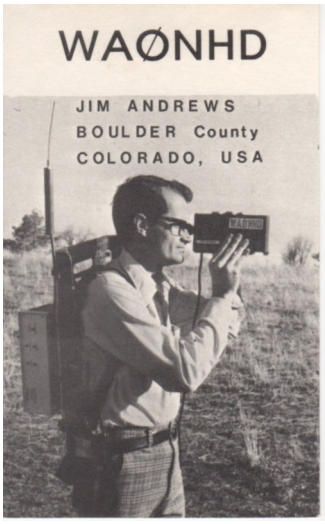
October, 2019
Rev. b, Nov. 2024

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

Boulder, Colorado ATV Repeater - History

Jim Andrews, KH6HTV

1979 Boulder Vintage ATV Station



Boulder, Colorado has had an amateur Television repeater since the late 70s. Boulder hams, including myself, became interested in amateur TV starting in 1974 when an in-expensive, small, partially solid-state, B&W TV camera became available from a bankrupt company in Austria that had come out with an early consumer grade video tape recorder. Most of the active TV hams then were also members of the Rocky Mtn. VHF Society. The RMVHFS had a 2 meter FM repeater (146.76MHz) then on Lee Hill, north-west of Boulder. Under the sponsorship of RMVHFS, I, Joe Woods AD0I, John Shafer, W0KWR, and Bob O'Connell, WA0BAF, designed and built our first TV repeater and installed it at the repeater site on Lee Hill. It was a 70 cm repeater with the input on 439.25 MHz and

the output on 421.25MHz. It used a single DB Products, DB-411, antenna with a circulator (25dB isolation) and separate 6 MHz, interdigital, band-pass filters on the receiver and transmitter. I designed and built the 10 watt transmitter and controller. Joe built the receiver, John built the band-pass filters. Bob did the wiring of the controller. This repeater was operational from about 1978 till 1981. It operated under the RMVHFS club call sign, W0IA. During this era all ham TV was in black & white (B&W), as no one could afford a color TV camera. In 1981, a new, powerful (10kW), FM broadcast transmitter was installed at the Lee Hill site. The resultant RFI was so strong that we were unable to keep it out of our controller, etc. Thus, we removed our TV repeater from Lee Hill.

In 1980, I started my business, Picosecond Pulse Labs, and began working on it full time in 1981. For the next ten years, I was too occupied with PSPL to devote any time to ham radio or TV. The TV repeater sat in storage in my basement for the next ten years. TV activity in Boulder died during this interval.

In the fall of 1989, Captains Bill McCaa, K0RZ, and Chuck Pringle, K0DGP, of the Boulder County Sheriff's Department approached BCARES (Boulder County Amateur Radio Emergency Services) and asked that BCARES provide TV services to the Boulder Sheriff's department for major emergencies. They promised to provide financial and other support for the project. At this time, I was the chairman of BCARES. Also at this time, several camera companies, like Canon, etc. had come on the consumer market with the new idea of camcorders. These combined in one relatively inexpensive, small, hand-held package, both a color TV camera with a zoom lens and also an 8mm video cassette recorder. Thus, with the new color camcorders and the support of the Boulder Sheriff, BCARES accepted the TV challenge. We pulled out of storage our old 1970s vintage TV repeater. The Sheriff arranged for us to install it in the City of Boulder's radio site in Chautauqua Park. The Sheriff also purchased antennas, and hard line, coaxial cable and provided their radio technician to install the antennas using a city cherry-picker truck. We no longer had a circulator, so when the repeater was installed at Chautauqua Park, we now used a pair of DB-411 antennas, one for receive and the other for transmit. We had the repeater back on the air by the summer of 1990.

At this time, Bill McCaa, also encouraged us to get the TV repeater frequency coordinated with the CCARC (www.ccarc.net) to nail down the 421.25 MHz frequency for our exclusive use. The CCARC was unwilling to give us frequency coordination for an in-band 70cm repeater. They gave us the 421.25 MHz output frequency, but insisted that we must be a cross-band repeater with our input on the 23cm band. They assigned us 1277.25 MHz as our input frequency. This was a very unfortunate assignment as the third harmonic of the 70cm transmitter's sound sub-carrier at 425.75 MHz was also exactly 1277.25 MHz ! ! ! I was thus faced with the difficult task of adding a 23cm receiver to the repeater and also suppressing dramatically the third harmonic from the transmitter. I accomplished it, but not without a lot of effort. At this time, we also made the decision to still retain the 70cm input capability at 439.25 MHz to support 70cm ATV transmitters. Granted this was against the CCARC ruling, but we felt it was needed to adequately support the Sheriff's dept. Thus our 70cm input was un-coordinated with

the state frequency coordinator. For remote control of the TV repeater, we used a simplex 2 meter channel with DTMF (touch-tones).

In 1991, we also saw the need to have a portable TV repeater to be able to adequately cover forest fires in the mountains of Boulder County. The Chautauqua Park TV repeater gave good coverage of the city of Boulder and the eastern plains portion of Boulder County. It didn't give any coverage of the western mountains in the county, except for the first ridge of foothills to the north. I thus, started a project to design and build a portable, 70 cm in/out, 10 watt TV repeater. I enlisted Rip Van Winkle, NV0M, to assist me with the packaging of the repeater. We managed to cram all of the necessary electronics into a small (12"w x 8"h x 12" d) enclosure. This portable ATV repeater has performed flawlessly and is still in service to this day.

The 1970s vintage repeater and transmitters used were my own design using a Motorola, 70cm brick amplifier. In the 1990s, all of the BCARES TV transmitters, including the repeater transmitter, were made by PC Electronics (www.hamtv.com). We had both 1 watt and 10 watt transmitters. One watt for portable, back-pack service and ten watts for mobile service. By the late 90s, we had added the capability to receive 23cm FM-TV in addition to VUSB-TV. Over the succeeding years, I continued to make improvements in the various components of the repeater, with several major rebuilds.

During most of this time, the repeater operated under my own personal call sign which then was WA0NHD. In Dec. 2006, I changed my call sign to KH6HTV. This was done because now in retirement I was living for half the year in Hawaii and half in Colorado. BCARES felt that a KH6 call was not appropriate for the TV repeater. We thus applied for the vanity call sign, W0BCR, for BCARES, with myself as the trustee. From that time on, the TV repeater operated under the call, W0BCR.

In 2012, we encountered a major problem with RFI on the repeater's 23cm input. It was from a new FAA radar at the Denver airport operating on 1265-67MHz. I applied to the CCARC for permission to move our input frequency from 1277.25MHz to the bottom end of the 23cm band at 1240-1246MHz. The request was approved. With Don's, N0YE, help we were able to come up with a suitable band-pass / notch filter for the 23cm receiver which rejected the extremely powerful radar pulses which were clobbering our receiver.

In 2014, I discovered DVB-T, digital TV and Hi-Des in Taiwan (www.hides.com.tw) as a supplier. This made a major transformation in amateur TV in Boulder, Colorado. BCARES adopted it for use in support of public safety. The Univ. of Colorado Police dept. funded the purchase of four complete DVB-T, portable, transmitters with all necessary other equipment. Today (2018), almost all of the active ATV hams in Boulder are now on high-definition (1080P), digital, DVB-T, television. In the summer of 2016, I spent the whole summer designing and rebuilding the TV repeater to make it a dual mode, analog & digital, TV repeater. It went back into service in the fall of 2016.

In the next summer of 2017, BCARES was given notice by the City of Boulder that the TV repeater had to be removed from the Chautauqua Park site. This was because the city wanted to expand their own radio system and needed the rack space in the radio shack and also the space on the tower for more of their own antennas. Since then the repeater has been in a couple of temporary locations. It was first at my QTH and then more recently on Davidson Mesa at Roger & Naomi's QTH (K0IHX & KD0PDZ). Neither site gave as good coverage as the Chautauqua site. A search was on for a better site. A proposal was made to the Boulder Amateur Radio Club (BARC) to use their site and share their 70cm antenna. Their repeaters were located on a high mesa, south-west of the city of Boulder, on the top of the south tower of the NCAR labs building. BARC agreed subject to approval from the CCARC for the move. Approval was obtained from the CCARC in Jan. 2018. The TV repeater was thus moved from Davidson Mesa to the new NCAR site. At this same time, BCARES informed us that they no longer wanted to be associated with the TV repeater. It thus no longer has any ARES affiliation. Thus, the repeater began operating under my own personal call sign, KH6HTV.

In 2017, Don, N0YE, started streaming the weekly ATV nets. His streams used VLC and were essentially private requiring a special log-in and his computer would only support a few users. In 2018, we started using the streaming service of the British Amateur Television Club (BATC). This gave us a world-wide, unlimited audience. The link to BATC is: https://batc.org.uk/live/

In the summer of 2018, we started a monthly newsletter for the ATV repeater. The newsletter was called the *TV Repeater's Repeater*. Past issues are available on: https://kh6htv.com/newsletter/ The newsletter has grown by 2023 to become the "de-facto" USA national ATV newsletter and goes out to over 500 ATV hams.

In the spring of 2019, a new HDMI switch was discovered that was both low cost and allowed computer control over an RS-232 line. The decision was made to again redesign and rebuild the repeater incorporating this new HDMI switch. The new switch allowed a more seamless switching between sources and the incorporation of a 10 minute timer for ID on the digital transmissions. Now the repeater can also

transmit a quad view showing simultaneously images from all of the receiver, plus the video IDer. The new Arduino program was again written by Don Nelson, N0YE. Jim, KH6HTV, did the rebuild.

For details: www.qrz.com & www.kh6htv.com

In 2019, we formed a club solely for the purposes of obtaining a unique call sign for the repeater. We called the club the Boulder Amateur Television Club or BATVC for short. The "club" was to be a very informal organization. The members were automatically all of the current active ATV hams in Boulder. The officers were the repeater's trustees. No dues were charged to be a member. The "club" was to be affiliated with both BARC and BCARES. The FCC issued the vanity call sign, W0BTV (for **B**oulder **T**ele**V**ision) to BATVC in July, 2019, with Jim Andrews, KH6HTV, as the trustee.

In 2020, we were encountering serious RFI issues with our 23cm input. The RFI was coming from an FAA radar. Dan Swanson, K0DGS, designed for us a very good, custom, band-pass, band-notch filter to eliminate the radar RFI.

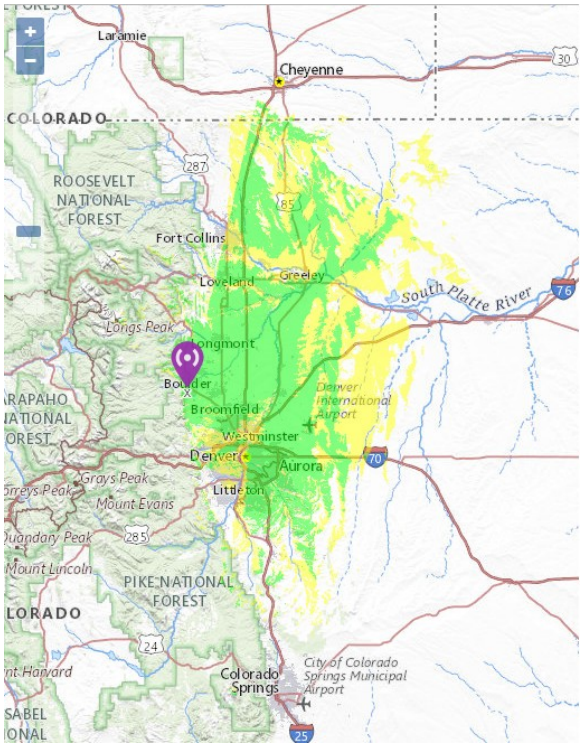
Also in 2020, we added a second transmitter to the ATV repeater. It was a microwave, analog FM-TV transmitter on the 5 cm band. The frequency was 5.905GHz. The transmitter put out 2 Watts into a 10dBi gain, omni-directional, horizontally polarized antenna. We operate this transmitter in a continuous 24/7 mode to serve as an ATV microwave beacon. When the repeater is not currently keyed up, this transmitter broadcasts our continuously looping ID movie.

In the spring of 2023, we made some major changes to the ATV repeater, W0BTV. Due to total lack of use for previous several years of the 70cm analog capability, we elected to remove those features completely. Thus the 439.25 MHz, NTSC receiver was removed. Also the 421.25 MHz, NTSC modulator was removed. Removing the receiver freed up a slot on the Quad HDMI Switch. So in it's place, we installed a second 70cm DVB-T receiver. The first receiver was for the USA standard band-width of 6 MHz. This new receiver was narrow-band at 2 MHz. The center frequency for both receivers is 441 MHz.

By 2022-23, we began experiencing some really severe RFI issues on the 70cm input frequency (441 MHz) of our repeater. A great deal of effort was put into trying to resolve it. Spectrum studies showed it to be a very powerful, broad-band intermittant noise unique to the NCAR site. We considered moving the repeater to some other site, but were unable to negotiate access for the most promising site we found. So, by the fall of 2023, the decision was made to remain at NCAR. But to actively discourage ATV hams from using the 70 cm inputs. The 70 cm inputs will be retained to support

BCARES ATV operations. Historically dating back to 1990, all of BCARES ATV has been on 70 cm band. We will be encouraging active ATVers to set up their home stations to also function as a remote 70 cm receiving site, thus supporting BCARES. This is by having a second receiver monitor 24/7 the 441/6 MHz ATV channel and when a signal appears there to transmit it to the W0BTV repeater on 23cm.

2023 Version of W0BTV - DATV Repeater



70cm Coverage Map of W0BTV

In 2024, we made a major improvement in the performance of our 70 and 23 cm receive antennas. We had always been suspicious of the performance of the Diamond X6000 which we were using as our receive antenna for 2 m, 70 cm and 23 cm. We removed the X6000 and replaced it with a Diamond X-50, 2 m / 70 cm omni, vertical antenna. This immediately improved reception on 70 cm band. Then for the 23 cm band, we installed a totally different type of antenna. We used two 12 dBi, vertically polarized patch antennas. We arranged them on the antenna tower with 60 deg separation and phased their outputs in a 3dB combiner. This gave us a broader, cardiod type antenna pattern with about 10 dBi gain. Users immediately reported much better performance of the repeater on 23 cm.

Also in 2024, we added a new microwave band to the repeater. This time, we added a DVB-T receiver for the 3 cm (10 GHz) band. Our HDMI switch only has capability to handle three receivers plus the ID media player. Due to lack of use, except by one ham,

we opted to discontinue our 441 MHz / 2 MHz BW, DVB-T receiver. We repurposed it to be an IF receiver for 10 GHz instead. The receive frequency is 10.380 GHz. All of the 10 GHz equipment is mounted on the roof top of NCAR. The antenna is an Alford slot waveguide. The antenna has about 10 dBi gain and a wide cardiod pattern and uses horizontal polarization. A xtal controlled down-converter was purchased from Hi-Des. The IF frequency was 322 MHz. A separate coax cable was used for the IF run from the roof top down to the NCAR radio room. DC power for the down-converter was sent up the coax.

We are still plagued with severe RFI on our 70 cm input of 441 MHz. This has crippled our support for BCARES' 70 cm ATV operations. As a result, BCARES has applied for, and received a large grant from Boulder County to build and install at one or two other locations additional 70 cm only DVB-T repeaters.

(*latest up-date added 16 Nov, 2024, by KH6HTV*)