Boulder Amateur Television Club
TV Repeater's REPEATER

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BATVC web site: www.kh6htv.com

ATN web site: www.atn-tv.com

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

W0BTV - DATV Repeater Antenna Project Success - at Last !

On Thursday, June 13th, we think we finally found a workable solution to our receive antenna problem.

We do not have unrestricted access to our repeater site. So each trip needs to be coordinated well in advance with our host. Don & Jim completed the new antenna installation on the 13th.

We have suspected for quite some time now that our receivers were not as sensitive as bench tests said they should be. We suspected the issue lay with our choice of the Diamond X-6000, tri-band (2m/70cm/23cm), omni-directional, base station antenna. Especially suspect was the 23 cm band. Due to limited tower space, we were not able to

Jim, KH6HTV, pointing to the new antennas

mount it in the ideal location at the top, free and clear of other metal. We had to mount it at the base of the tower with a horizontal metal bracket putting it about 2 ft. away from the tower.

This past spring, we did an exhaustive set of field strength measurements. We compared the measured results with predictions made by the radio propagation modeling program Radio Mobile. See the April issue #159 for details. This comparison showed that we were losing between 10 to 20 dB on the 23cm receiver sensitivity. Obviously, something needed to be done.

As seen in the above photograph on page 1, our repeater site has a very high mountain immediately behind it to the west. Thus our service area only covers a 180 degree arc (from North, to East, to South) over the prairie of eastern Boulder County, Colorado. It does not penetrate into the Rocky mountains which cover the western half of the county.

Panoramic view of the eastern prairie of Boulder County as seen from the W0BTV antennas.
pan scan from true north (left side) to south (right side).

The collective wisdom of the BATVC members felt that part of our issue was due to multi-path reflections from the tall Flatiron mountains behind the repeater. They felt that we needed to replace the omni-directional antenna with a broad beam-width, directional antenna looking out to the east with a null on the west side. OK, where do we find such an antenna with suitable gain, but a 180 deg. beam-width ?

NEW 23cm Antenna: The potential solution we came up with was a stacked array of two, 23cm patch antennas. After a long search, we did find what appeared to be an attractive, rugged patch antenna from China. We have previously reported on it in this ATV newsletter in the April issue #159. The article included our modeling with EZNEC of a pair of these antennas with a 60 deg. offset between them to give us a broader azimuth beam-width. We didn't end up with 180 degrees. The predicted performance of the two patch staggered array was for a gain of about +9 dBi with ± 2 dB ripple over a 116 deg. beam-width. The photo on the first page shows these antennas. They are the two, white rectangles mounted to the tower.

NEW 70cm Antenna: We took this opportunity to replace the X-6000. We no longer needed it's 23cm coverage. Plus, we were also suspecting it to be part of our receive problems (besides the severe RFI) on 70cm. We had noted that it being a tall, slender, 10 ft. pole, that it waved around a lot during strong winds and caused many dB variation in S meter readings. We all have had very good luck using the Diamond X-50 (2m/70cm) antenna for our home base stations. Plus our antenna testing has shown it to be a very good, broad-band, performer for 70cm ATV. We thus elected to install a new X-50 in place of the X-6000. It is the tall, 5 ft, white stick in the foreground of the photo on page 1.

Only One Coax Cable Available: This had been a major driving factor when we first moved the repeater to it's new site, determining what antenna we would use for receiving. There was only one, unused coax cable available coming from the radio room to the roof top. We were not allowed to install any new cables. (note: For transmit, we ended up sharing BARC's DB-411, 70cm antenna and it's coax. It had been installed in the 1960s) We needed to receive 2 meters for control, plus both 70cm and 23cm bands for ATV receive. Not many choices. Hence the X-6000. Now that we have two receive antennas rather than one, how do we cram those three frequencies into one single coax cable ? The solution we hit upon was to use a 2m/70cm duplexer to first split the rf output from the X-50 into two cables. Then to use a 2m / 70cm / 23cm triplexer to then combine these two (2m & 70cm) cables, along with the 23cm patch antenna array cable into one single coax cable which then went through the roof and down into the building to the radio room. We used a Diamond MX72A and MX3000N.

But Did It Work ? The answer is "**YES !**" We immediately saw improvements. Prior to going on the roof, Don, N0YE, and Jim, KH6HTV, asked for BATVC hams to be on stand-by to provide us with test signals for before and after comparisons. Bill, ABOMY, Chris, K0CJG, and Ed, K0JOY provided our test signals for 23cms. Bill is located 4.5 miles north of the repeater. He noted a +4 dB improvement with the new patch antenna array. Chris is located 2.9 miles to the ENE. He observed an outstanding +11dB improvement. Ed lives on the first ridge of the mountains 8.9 miles away and WNW of the repeater. Ed saw no improvement, nor loss. Signal strength was the same. This was to be expected because of our orientation of the new patch antenna array's pattern. We had deliberately placed it's CCW edge on Ed's QTH.

We also asked for test signals on the 70cm band. Bill was the only one available to provide them. With the new X-50 2m/70cm antenna, Bill also noted a +4dB improvement in signal strength on 441 MHz into the repeater.

Mobile Tests: Jim, KH6HTV, on the day of the test, had outfitted his automobile to run mobile 23cm transmit and simultaneous 70cm receive. So after leaving the repeater site, we put the repeater in the Quad Viewer, Beacon mode. This turned on the repeater's 70cm transmitter and displayed simultaneously the video outputs from the three receivers (444/2 MHz, 441/6 MHz & 1243/6MHz). Jim then transmitted a 2 watt, 23cm DVB-T signal and monitored the repeater's 423/6 MHz output. The Hi-Des receivers give us a continuous display of received signal strength in dBm and S/N in dB. On the way home, he then drove by a few of the locations where we had previously made mobile field tests earlier this spring. At each location he noted a significant improvement varying from +5 to +9 dB in signal strength. There was also always significant improvements in the S/N.

Also significant was a brief test at the QTH of Colin, WA2YUN. Unfortunately, Colin was unavailable to provide us test signals on the day of the antenna installation and testing. Colin lives the closest to the repeater, but he is significantly shadowed by a dramatic change in elevation of 525 ft. The repeater is on the top of a mesa, while Colin lives on the east flank of the same mesa. He has had a horrible time trying to get a signal into the repeater. Always lots of freeze-framing. Jim parked on the street in front of Colin's driveway and with his simple mobile setup was able to get a good s/n = 12 dB DVB-T signal into the repeater with absolutely no freeze-framing. It should be noted that we put a 5 degree

down-tilt in the positioning of the patch antennas in an attempt to maximize the coverage to Colin. He really required a 10 deg. tilt. 5 deg. was our compromise to still give proper coverage to others much farther removed from the repeater.

Subsequent testing by BATVC members is allowing us to get a further appreciation of the improved performance of our new receive antennas. The below tables lists the reported results.

Before & After Performance of W0BTV's 23 cm Receive Antennas

ATV Station	Distance	Bearing	S meter (old antenna)	S meter (new antenna)	Difference
K0JOY	14.4 km	347 deg	-88 dBm	-88 dBm	- 0 -
AB0MY	7.2 km	358 deg	-74 dBm	-70 dBm	+4 dB
K0HEH	3.7 km	27 deg	-83 dBm (?)	-65 dBm	+18 dB (?)
WB2DVS	4.9 km	40 deg	-81 dBm	-73 dBm	+8 dB
WA2YUN	0.9 km	50 deg	-90 dBm	-85 dBm	+5 dB
K0CJG	4.7 km	54 deg	-82 dBm	-71 dBm	+11 dB
K0RZ	9.0 km	87 deg	-96 dBm	-92 dBm (-79 dBm)	+4 dB
KH6HTV	19.0 km	88 deg	-85 dBm	-80 dBm	+5 dB
N0YE	2.2 km	119 deg	-82 dBm	-86 dBm	- 4 dB

Before & After Performance of W0BTV's 70 cm Receive Antennas

Station	Distance	Bearing	S meter (old antenna)	S meter (new antenna)	Difference
AB0MY	7.2 km	358 deg	-64 dBm	-61 dBm	+3 dB
K0HEH	3.7 km	27 deg		-61 dBm	
WA0TQG-R	3.7 km	27 deg	-59 dBm	-56 dBm	+3 dB
WB2DVS	4.9 km	40 deg		-64 dBm	
WA2YUN	0.9 km	50 deg		-79 dBm	
KH6HTV	19.0 km	88 deg		-59 dBm	
N0YE	2.2 km	119 deg	-63 dBm	-64 dBm	- 1 dB

Before & After Performance of W0BTV's 23 cm Receive Antennas (field tests from various remote sites)

Remote Site	Distance	Bearing	S meter (old antenna)	S meter (new antenna)	Difference
Boulder EOC-911 Center	7.2 km	32 deg	-87 dBm	-78 dBm	+9 dB
Lookout Road east of 79th	14.1 km	42 deg	-88 dBm	-83 dBm	+5 dB
Baseline Lake Cherryvale Rd	5.6 km	71 deg	-86 dBm	-77 dBm	+9 dB
Spanish Hills Paragon Dr.	7.9 km	90 deg	-88 dBm	-82 dBm	+6 dB
Anthem Ranch Deer Mtn. Cir.	19.0 km	88 deg	-95 dBm	-88 dBm	+7 dB

CONCLUSION: We didn't expect to see much change at all on the 70cm antenna, but we realized about +3dB improvement. We were hoping for significant improvement on the 23cm antenna and we did get that with up to 11dB in one instance.

Letters from BATVC members describing their experiences with the new antennas.

Hello Don, Jim --- Using my 1296 Horizontal Yagi on 1243, and before your antenna change I was able to just break the video squelch but not hold it open such that the repeater started the beacon cycle.

With your latest 1243 antenna, and again using the 1296 antenna, my 23cm signal was -92 dBm and 11 s/n. Yesterday I got the nerve and gumption to climb the tower and install the vertically polarized 1243 KLM Yagi at the 28 foot level. Feed line is ½" hard line. Latest reading with the KLM Yagi is now -79 dBm and 23 s/n. I don't ever recall seeing a signal at that high level when I was on previously in 2019. 23cm Tx power is +32 dBm.

Thanks for the effort and obvious improvement. I'm not setup to try the 70cm repeater inputs.

73, Bill, K0RZ, Boulder, Colorado

Signal / Noise vs. Code Rates

I found this table in a recent article in the May issue of the Microwave Journal. It is relevant to our Digital ATV. The S/N values compare favorably to my experiences of doing bench-top testing of my Hi-Des DVB-T receivers using their on-screen-displays of signal strength (dBm) and S/N (dB).

73 de Jim, KH6HTV

TABLE 1

SNR REQUIREMENTS FOR DIFFERENT MODULATION SCHEMES AND CODING RATES

REQUIRED BASEBAND SNR
SNR REQUIREMENTS VS. CODING RATE AND MODULATION SCHEME

Modulation	Code Rate	SNR (dB)
QPSK	1/8	-5.1
	1/5	-2.9
	1/4	-1.7
	1/3	-1.0
	1/2	2.0
	2/3	4.3
	3/4	5.5
	4/5	6.2
16-QAM	1/2	7.9
	2/3	11.3
	3/4	12.2
	4/5	12.8
64-QAM	2/3	15.3
	3/4	17.5
	4/5	18.6

What Frequencies Should We Use for 5 cm, FM-TV ?

We have a really big band at 5 cm. We have 275 MHz extending from 5650 to 5925 MHz. BUT - we have to share a good portion of it with the unlicensed crowd of Wi-Fi users. Fortunately, we do have segments at the bottom and top which are for amateur use only. (sometimes as secondary, but not for Wi-Fi users). Our FM-TV signals are rather broad-band. As shown in the previous May issue #163, our FM-TV spectrum using the low cost FPV transmitters is of the order of 10 MHz band-width. These low cost FPV transmitters are frequency synthesized and come pre-programmed typically with at least 40 channels installed. The user can not re-program them. So we are constrained to using their channel standardization. The below plot and table shows these channel / frequencies for both the 40 and 48 channel units. Now considering where the Wi-Fi users are located, we really don't want their RFI clobbering our ATV signals. So, this means we need to avoid all of those suspect channels. Plus, if you examine carefully the channel tables, you will find that some of the frequencies actually land outside of the USA amateur radio 5 cm band. They are thus illegal for us to use. Also we need to avoid any channel which is on a frequency too close to the band edge such that our 10 MHz wide FM-TV signal's spectrum would spill over below or above the band edge.

This all really means there are only about four frequencies out of 40+ which we should consider using for our ATV. They are: **5665, 5685, 5705 and 5905 MHz.**

Here in Boulder, Colorado, we have chosen to use 5685 MHz as our simplex frequency and 5905 MHz as the microwave, 24/7 beacon output from our W0BTV-ATV repeater.

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5.8 GHz, FPV, FM-TV Standard Channels

BAND	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8
FR1-A	5865	5845	5825	5805	5785	5765	5745	5725
FR2-B	5733	5752	5771	5790	5809	5828	5847	5866
FR3-E	5705	5685	5665	5645	5885	5905	5925	5945
FR4-F	5740	5760	5780	5800	5820	5840	5860	5880
FR5-R	5658	5695	5732	5769	5806	5843	5880	5917
FR6-D	5362	5399	5436	5473	5510	5547	5484	5621

Frequency Notes:

1. The USA amateur radio 5 cm band is from 5650 to 5925 MHz.
2. The unlicensed part 15, ISM, (Wi-Fi) band is from 5725 to 5895 MHz.
3. The ITS radio service band is now from 5895 to 5925 MHz.
4. 40 channel units use the first 5 bands, A, B, E, F & R.
5. Channels 3-4, 3-7, 3-8 are outside of the amateur band. Do not use.
6. Best choices for amateur use avoiding Wi-Fi are channels 3-1, 3-2, 3-3, & 3-6
7. 48 channel units add band D. Totally illegal for amateur use.
8. There are also additional bands U, O, L & H found on more expensive units with frequencies spanning from 5325 to 5933 MHz. Most frequencies are illegal for amateur use.

10 meter ATV/DATV Update

(**Editor's Note:** *For quite some time now, Grant has been working on developing a new ATV process to be able to send live video over a very narrow bandwidth channel on HF radio. Here is his latest progress update which he recently posted.*)

Over the last few months I have reworked the video compression software to better process Key(K) and Motion(M) frames, to work as KMK or KMMK configuration. With analog video there a number limitations to overcame to get this all to well, such as the information from each K frame is all I have to

work with, to rebuild the missing M frames with. This places a limit on the maximin number of M frames possible between the K frames.

On the digital audio side the compression between the each simple is done in same way, one is more like what is done with M frame process, where the missing information recovered from the the samples on each side, the other is a digital form of audio companding.

Note: there is no error correction is been sent, only noise reduction within this transmission system, this done to maximize spectrum efficiency, along side Orthogonal Frequency-Division Multiplexing (OFDM) used for the modulation type.

As for the modulator and de-modulator sides, I have written a good part of this in VHDL code for Altera FPGA's, I was planing to use on this project. But it is looking like the cost to build this hardware is going to around $3000.00 US, so now I need to start all over again and now looking other options. Therefore I looking at the HackRF as possible replacement to do this job, however, I am looking for someone who has done coding for this device to help me out on this part of the project. As it taken me years to learn how work with DSP block and VHDL coding and I do not want to spend another to few years working out how code a HackRF hardware.

I also made a lot of progress with the signal processor to minimize phase errors from sky wave propagation effects, as the modulation is basically analog within a digital modulator, therefore, by removing most of the phase error before the de-modulator stage has a big advantage.

As this NBTV system can be transmitted and received without the need for a signal processor stage, even with poorer performance, it would cut down the development time. The other factor is I plan do a patent for technology and until this has been done, I am not able to make it all public at this stage.

As this transmission system is very much at the cutting edge of technology, it will highlight the importance of Ham radio in today's world. As technology has other applications not just in television, but also in advanced radar and navigation systems with LF, MF and HF bands. This is an area I am now doing development in as well alongside ATV work.

73 de Grant, VE3XTV, North York, Ontario, Canada

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DARA ATV News from Dayton, Ohio

A Scheduled 15 minute Reboot Cycle on the W8BI ATV DVB-T Transmitter Has Been Instituted

The W8BI Repeater's DVB-T transmitter runs continuously, and uses a "endless loop" video MPEG Identification file. A simple "re-boot" technique that we have used in the past has been revisited at the DARA, W8BI, ATV Repeater site. On occasion, the Hi-Des DVB-T transmitter on 428 MHz has had to be rebooted remotely to clear a glitch that had occasionally occurred where the transmitter would

lock-up, or would cease transmitting. We had called this reboot procedure "clearing the cache" as it allows the transmitter to reset and come back up on the air. We have noticed that recently, the condition has re-surfaced. We decided to put a mechanical on-off timer on the DVB-T transmitter's power supply, so at 02:00 local in the middle of the night, the transmitter reboots itself, so as not to have to be remotely re-booted. Re-booting by timer has allowed the transmitter to behave better, and its 15 minute "down time" has greatly helped with this particular issue. Meanwhile, we are suspecting the issue was directly related to its dedicated power supply. We swapped out the power supply, but inquiring minds want to know whether the supply was the issue. We will be checking the supply to see if we can get it to "sag" while under extended load on the bench... we shall see!

73 de Dave, AH8AR, AH2AR

(**Editor's Note:** *The condition Dave is talking about is not unique to the DARA repeater. We too, here in Boulder, Colorado have a similar issue with our Hi-Des equipment in our repeater. Our issues seem to be more with the receivers (both HV-110s and HV-120s) than the modulator (HV-100EH). Fortunately, when we were first designing the transition from analog to digital, we took the good advice from Art, WA8RMC, of ATCO. Art told us it was important to include a remote ability to do a complete system master Reset to Reboot all of the various digital modules in the repeater system. So we included a RESET command as part of the suite of control functions which we access via touch-tones on our radio control frequency. For our Reset, we remove the DC power from each and every digital device for 10 seconds and then reapply it. The 10 second power disconnect seems to be adequate to do a full Reboot. It then takes our repeater about an additional minute to again become fully functional. Unfortunately, we do find that we too need to do a Reset quite often.*)

Antenna Farm Keeps Growing: On our most recent weekly ATV net, Boulder ATVer Bill, AB0MY, told us about adding a 5 GHz dish on a rotator to the top of his ATV antenna mast. He plans to mount a 5.8 GHz, FM-TV transmitter & receiver to it. This is in addition to an existing 5 GHz dish with FM-TV receiver looking at the W0BTV beacon transmitter. Bill keeps adding more & more capabilities to his ATV station including multiple cameras, quad displays, etc. The above photo was taken live off the air via W0BTV repeater. It was from a fixed camera Bill has outdoors looking at his antennas.

Big Screen Mobile ATV ! - tnx to KV5Y

W0BTV Details:

Inputs: 23 cm Primary (CCARC co-ordinated) + 70 cm secondary all digital using European Broadcast TV standard, DVB-T 23cm, 1243 MHz/6 MHz BW (primary), plus 70cm (secondary) on 441 MHz with 2 receivers of 6 & 2 MHz BW
Outputs: 70 cm Primary (CCARC co-ordinated), Channel 57 -- 423 MHz/6 MHz BW, DVB-T
Also, secondary analog, NTSC, FM-TV output on 5.905 GHz (24/7 microwave beacon).
Operational details in AN-51c Technical details in AN-53c. 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. A DVD ham travelogue is usually played for about one hour before and 1/2 hour after the formal net. 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 is a free newsletter distributed electronically via e-mail to ATV hams. The distribution list has now grown to over 700+. 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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