

BOULDER TV Repeater's REPEATER

November, 2018



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REPEATER STATUS: The repeater is once again alive and well and functioning normally. Thanks Don, N0YE, for nursing it back to health. Details about the repeater are available on our web site: www.kh6htv.com AN-43 gives all the technical details.

SICK REPEATER: The weekly TV Net on Thursday, Oct. 11th, was a difficult experience for all. The 70cm input didn't work at all. 23cm input was difficult. Plus the 2 meter control seemed "deaf". Where a simple HT could be used in the past to send control codes to the repeater, even a 50 watt base station with a yagi antenna sometimes couldn't get into the control receiver. Because we are using a single, tri-band antenna for all receive functions, it seemed obvious that we were experiencing an antenna failure.

Thursday morning, Oct. 18th, Don, N0YE, and I made a trip to the repeater site equipped to do major trouble shooting. Note: our repeater is in a quasi-govt. facility and we do not have easy access, at will. We have to reserve ahead of time a date and time to visit the site and be escorted onto the facility. Our time on site is thus limited. We took along a Rigol spectrum analyzer / tracking generator to do swept frequency return loss measurements on the antennas from inside the radio room. We also took along a Fluke signal generator to test the 2 m, FM control receiver and a Hi-Des, DVB-T modulator plus step attenuator to test the digital TV receivers' sensitivities.

For the antenna issue, we concluded that the coax feedline, lightning arrestor and the Diamond X-6000 antenna were all OK. The issue seemed to be a replacement bias tee that Don had installed on the roof the previous week. Don's 2.4 GHz mesh node at the site is sharing the use of our coax feedline. He is sending dc power up the coax from the radio room to the rooftop using a pair of bias tees in the radio room and also on the roof. Replacing the rooftop bias tee improved the return loss seen in the radio room. Thus Don left his new bias tee in place. Return Loss plots were recorded of the transmit and receive antennas for future reference.

The various receiver sensitivity tests showed both "the good, the bad & the ugly". On 2 meters, with the existing squelch control setting, the ICOM IC-228H receiver measured 0.28 μ V. With the DCI, 2m band-pass filter, it measured 0.32 μ V and then at the actual

repeater's receiver input port of the Diamond triplexer, it measured $0.38\mu\text{V}$. Thus the 2m control receiver was deemed in good health.

It was a different story for the DVB-T receivers. I used QPSK, 6MHz BW, 5/6 FEC. For 23cm, the digital threshold was measured to be about -93dBm. This was OK. For 70cm, the digital threshold measured to be about -75dBm. UGLY ! Totally unacceptable. So what had changed since the repeater had left my ham shack ? ? What had changed, was we had installed later a couple of notch, band-reject filters in the 70cm receive path. One was to notch out a couple of other ham repeaters at the site. One was for the 70cm, D-Star on 446,8625 MHz and the other was for the 2m, BARC on 146.70 MHz. Access time at the site is limited and I didn't have a lot of time to spend with exhaustive testing, so I made the decision to do an immediate appendectomy, i.e. cut out all of these newly installed filters. I thus returned the 70cm receive circuit to it's original condition. The only front end protection for the 70cm preamp is thus the original, 6 MHz BW, inter-digital, band-pass filter (438-444 MHz). After rerouting the various coax cables, I then remeasured the 70cm, DVB-T receiver sensitivity. It was now much improved at -89dBm. A whopping 14dB improvement. I would have liked to have seen it a bit better in the low 90s, but we can live with -89dBm.

Later that afternoon, we held our weekly ATV net and found everything back to normal. Whew ! We still have RFI issues on the 70cm input.

Weak Signals into Repeater -- After the recent repair of the repeater, I have again run a few tests putting very weak signals into the repeater from my QTH. I have an excellent, line-of-sight path from my house to the repeater. The path distance is 5 miles. For 23cm, I used a Directive Energy, 3ft. loop yagi antenna at 20 ft. with 1/2" hardline coax. For 70cm, I used a KLM, 6 element, yagi antenna at 25 ft. with 3/8" hardline coax.

On 23cm, using DVB-T, QPSK, I am able to access the TV repeater with only +3dBm of rf power to the antenna feedline. With my 23cm FM-TV transmitter, I can key up the repeater with only -1dBm of power. It is not a useable picture. It is only P2. With +7dBm, I get a P4 picture with some noise in the audio. A bit stronger signal results in absolutely perfect P5 video and Q5 audio.

On 70cm, the presence of RFI from other in-band, ham signals makes meaningful measurements difficult. The amount of RFI depends upon the day of the week and the time of day. I made my tests at many different times. The quietest time I found was a Saturday evening after 9 pm. Sometimes I had to use as much as +30dBm (1 watt) to key up the repeater. With DVB-T on 441 MHz, under the best conditions, I could key up the repeater with +10dBm, but with horrible freeze framing. I then needed at least +22dBm to reliably get into the repeater with a perfect picture and no freeze framing. For VUSB-TV on 439.25 MHz, it was even worse. I seem to need my full 10 watts (pep) (+40dBm) to bring up the repeater. When it does come up I get a P5, snow free, picture, but torn up with RFI herringbones. RFI or defective analog receiver or both ?

So how does this all compare with what the computer program, *Radio Mobile*, predicts ? Putting in all of the various system parameters (frequency, transmit power, antenna gains, coax losses, etc.), Radio Mobile says I should be able to access the repeater on 23cm with only +3dBm of rf power. Guess What ?? That is exactly what I measured !!! Fantastic correlation !!

However, the results on 70cm were far different. *Radio Mobile* predicted I should only need again +3dBm of power on 70cm to access the repeater. What I measured was I needed at least +10dBm (+23dBm for a perfect picture), a 7dB (or 20dB) difference. Why ? It has to be the severe RFI encountered on 70cm.

Something has deteriorated in the repeater's 70cm performance. I have gone back into my notes and found that I performed the same tests last spring in April and got much better results on 70cm. I got essentially the same, good results on 23cm, both with DVB-T and FM-TV. Last spring, on 70cm with analog VUSB-TV, I was then able to key up the repeater with only +4dBm of transmitter power (P1 pix), +20dBm (P4) & +30dBm (P5). Now I need +40dBm to even key it up.

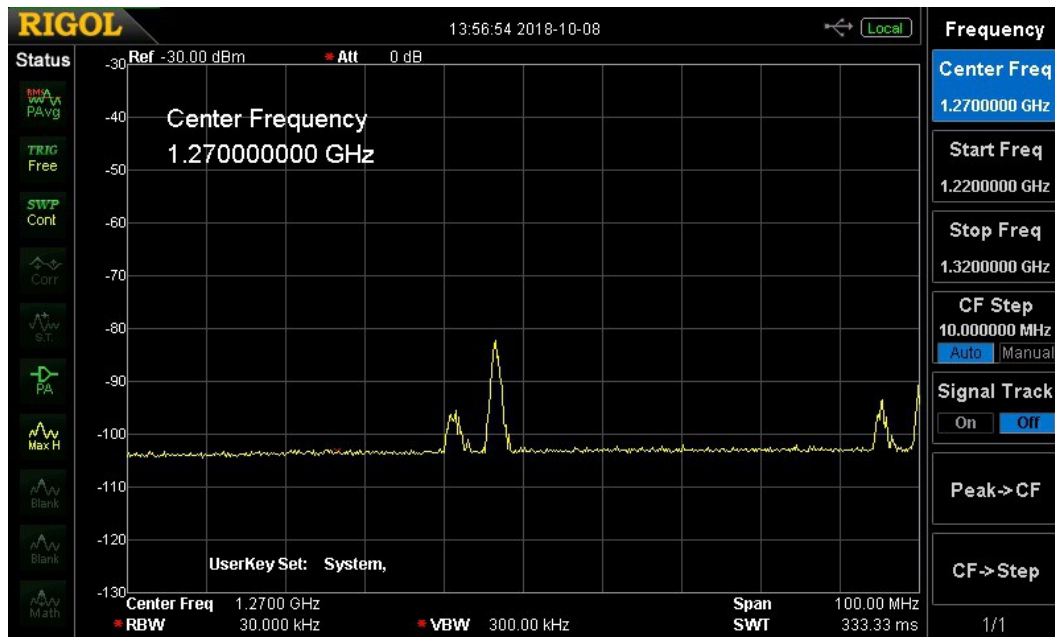
Recommended DVB-T Parameters for 70cm: While doing the above weak signal tests, I then asked myself, "What improvement can be gained if I use very aggressive encoding to overcome the RFI on 70cm ?" The above measurements were all done with good channel parameters of: QPSK, 1080P, 5/6 FEC, 1/16 guard, & 6 Mbps.

I found that by changing the encoding parameters to be more aggressive, I was able to achieve a 4 to 5dB improvement in the ability of the TV repeater's receiver to decode successfully my signal in the presence of strong RFI. I could then get a perfect picture with no freezing with +18dBm vs. +23dBm. Thus, I recommend all Boulder ATV hams wanting to transmit DVB-T signals on 70cm, use the following parameters:

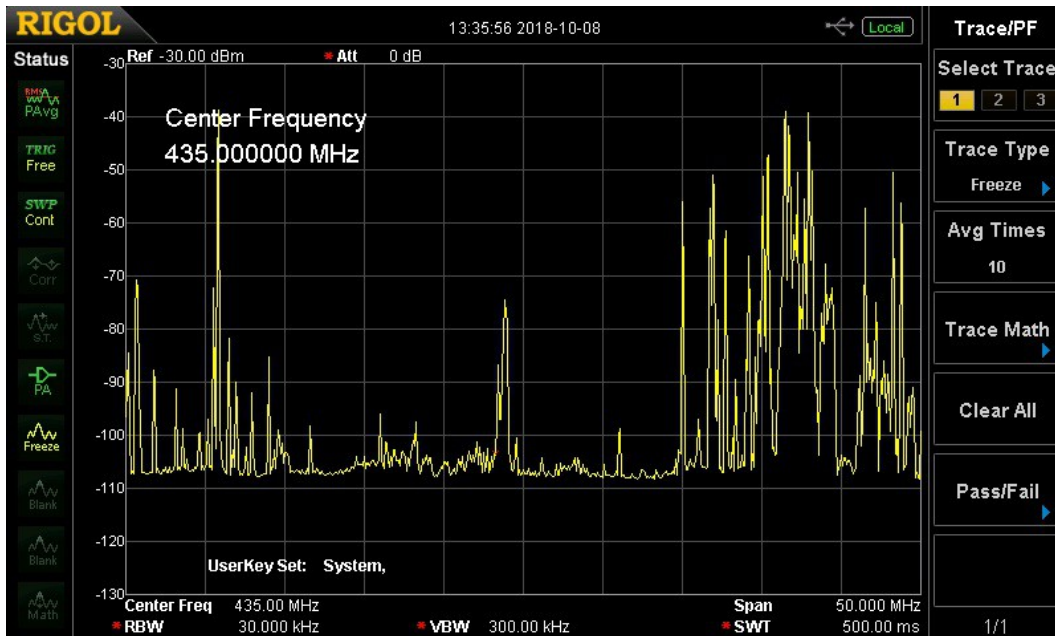
Modulation = QPSK
Video Resolution = 720P (1280 x 720)
Forward Error Correction (Code Rate) = 1/2
Guard Interval = 1/8
Data Rate Control Type = CBR
Data Rate = 3300 kpbs = 3.3 Mbps

70cm vs. 23cm BAND ACTIVITY: From my QTH with my Rigol spectrum analyzer, I have monitored the relative activity on both the 70cm and 23cm bands. Dramatic differences ! The screen shots shown below were taken under the same analyzer settings on both bands. The analyzer was set to the Peak Hold mode to capture everything which occurred in the 10 minute acquisition interval. The measurements were made on a weekday in the middle of the day. On 70cm, the span of 50 MHz includes the government band 410-420MHz (bottom 2 divisions) and the commercial / FRS band 450-460MHz (top 2 divisions). A lot of amateur, 70cm, FM repeater outputs are noted in the 445-450 MHz portion. Also a lot of unlicensed activity is seen in the 434 MHz region. On 23cm, the span of 100 MHz includes government

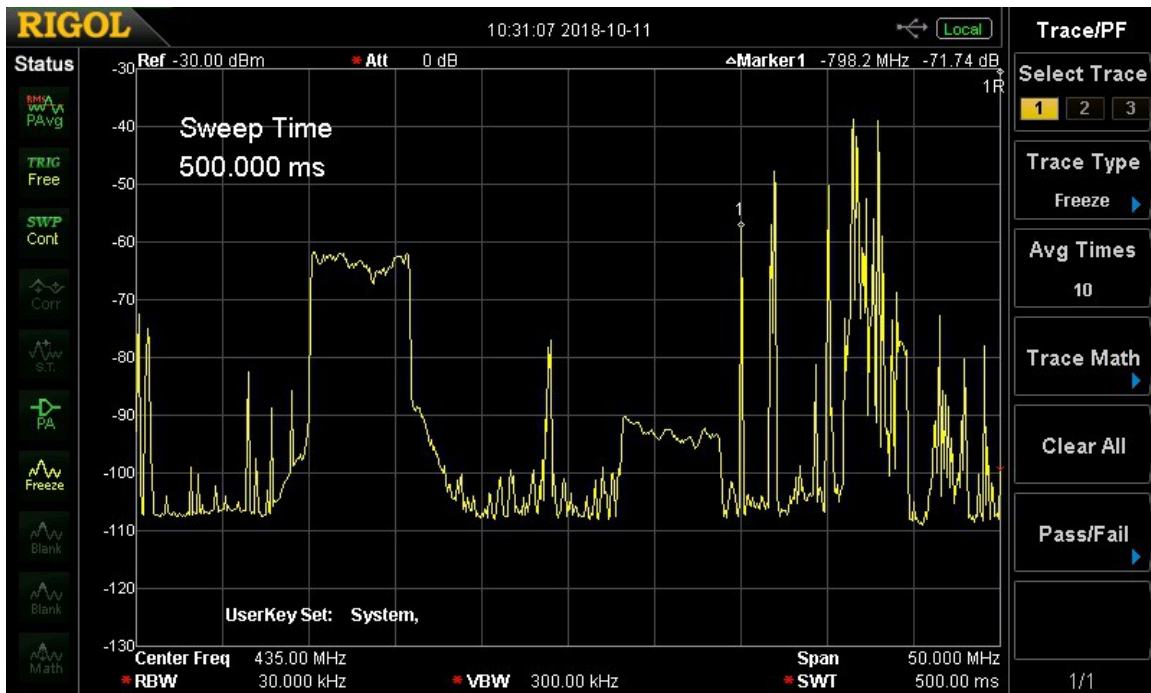
bands below 1240 and above 1300MHz. Absolutely the only activity detected were the govt. radars in the vicinity of 1265MHz and 1318MHz. 23cm monitoring over extended 1/2 day periods also showed essentially an empty, quiet band, except for the radar signals.



23cm Normal Band Activity -- 1270MHz center frequency, 100 MHz span, 10MHz/div data acquired in max. hold for 10 minutes. The only signals seen are government radars.



70cm Normal Band Activity -- 435MHz center frequency, 50 MHz span, 5MHz/div data acquired in max. hold for 10 minutes



70cm Band Activity with ham DTV signals. TV repeater at 423 MHz & another ham's signal at 441 MHz -- 435 MHz center frequency, 50 MHz span data acquired in max. hold for 1 minute

BCARES Provides TV Coverage for CU Police at Football Games



Dave, KI0HG & David, W0DRR with a 70cm, DVB-T transmitter at CU stadium



Mark, KB0LRS, TV net control in CU-PD command post

BCARES can use some help from experienced ATV operators. BCARES has been supplying TV coverage of the crowds in the football stadium since 1995 for the CU police dept. There are two more home games this season. We play Oregon State this Saturday (10/27) with kickoff at 1pm. If you can help out, please contact Matt, K0DVB, at matt4etc@mac.com



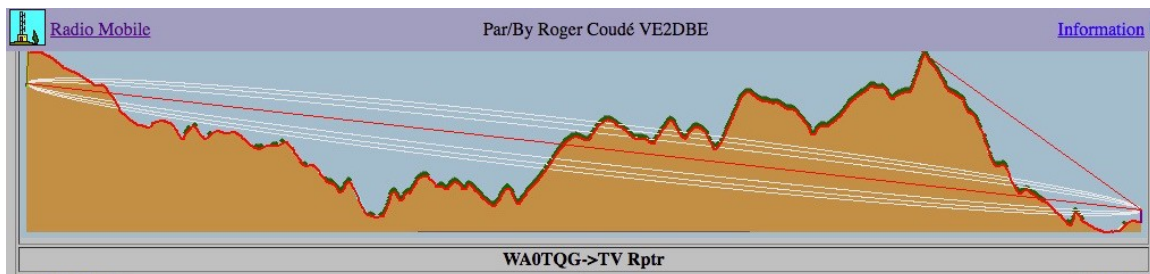
Steve, WA0TQG finally makes it thru the TV repeater !!!

MISSION IMPOSSIBLE !! -- We were actually able to see Steve, WA0TQG's smiling face on the TV repeater on the Thursday net, Oct. 4th. Steve lives on the flank of Sugarloaf mountain in the western part of the county. He has a great view from his QTH out onto the plains of eastern Colorado. However, he is shielded from the TV repeater by the Flatiron mountains. *Radio Mobile* computer rf path predictions say the path from Steve to the repeater is impossible with a -77dB margin. Steve however is just barely able to receive a picture from the TV repeater. So some kind of funky path exists. Steve is transmitting DVB-T with QPSK on 70cm with 6 watts of power. He is however unable to get into the repeater directly. Using KH6HTV's remote 70cm/23cm receive site, on Thursday, Oct. 4th, Steve was finally able to get into the repeater. Jim's QTH is further east out on the prairie and has a good view back into the mountains in the western part of the county. *Radio Mobile* predicted that the path from Steve would actually be worse at -95dB margin. But it worked ! So much for computer predictions ! They usually work, but for really weird paths with many possible reflections from other mountains, etc. all bets are off. The moral of the story is, even if everyone says it is impossible, try it anyway.

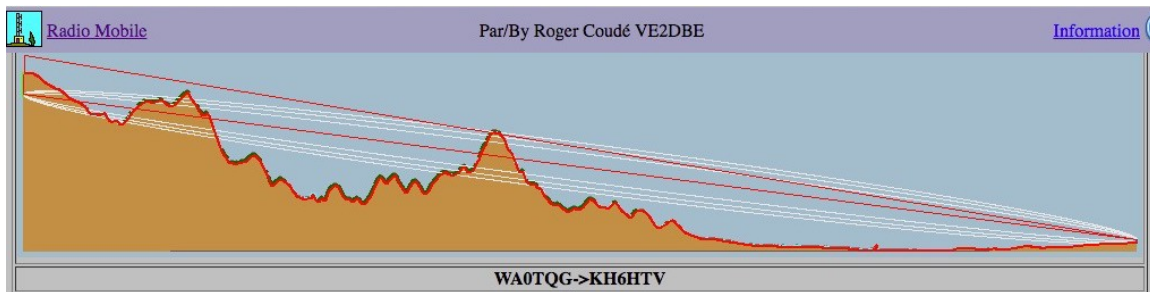
The two photos here were taken from the TV repeater's output. Steve's signal first went on 441 MHz to Jim's QTH where it was received and then relayed on 1243 MHz up to the TV repeater where it was then broadcast all over the Front Range on 423 MHz. The on-screen-display (OSD) seen was superimposed by Jim's Hi-Des HV-110 receiver showing the received signal strength (upper right corner) and signal/noise ratio (lower right corner). The received power needs to be corrected by 11dB for Jim's preamp (18dB gain) and a 1:4 signal splitter (-7dB). Thus -78dBm was actually -89dBm coming in from the antenna. The S/N was seen to vary from 7 to 11dB.



TV camera view from the top of Steve's tower looking to the SE towards the repeater.
The repeater is hidden behind the tall peak in the center.



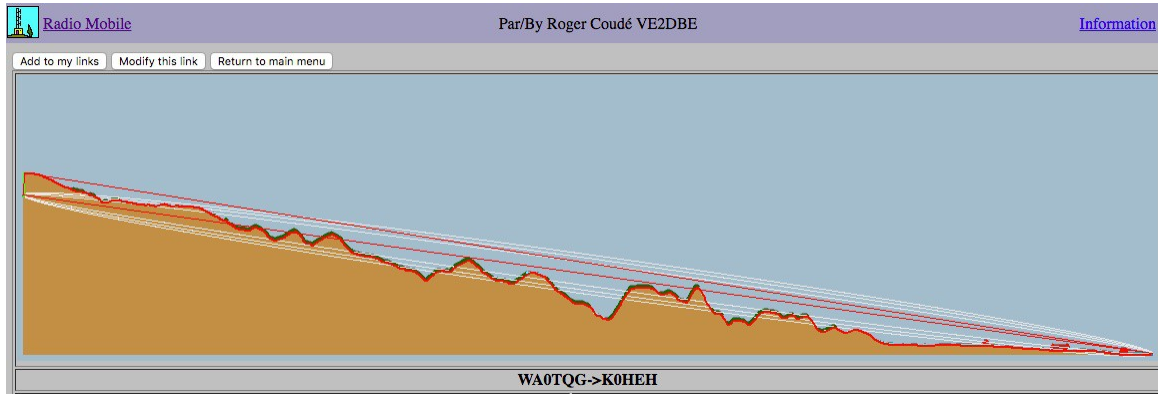
Radio Mobile predicted path from Steve to the TV repeater -77dB margin



Radio Mobile predicted path from Steve to Jim's QTH - 95dB margin

On a more recent ATV Net on Oct. 18th, Steve was unable to get a signal thru to KH6HTV. However, Jack, K0HEH, reported that he was receiving Steve's 70cm DVB-T signal fine at his QTH in central Boulder. Thus Jack quickly patched the HDMI cable from his DVB-T receiver over to his 23cm DVB-T transmitter and was immediately

relaying Steve's picture on to the repeater. The plot below shows the path from Steve to Jack. Radio Mobile predicts the signal strength, receive margin at Jack's QTH to be better, but still horrible at -84 dB. Hopefully, Jack will continue to be Steve's relay repeater in the future.



Radio Mobile predicted path from Steve to Jack's QTH - 84dB margin

70cm ATV EDITORIAL: In the first part of this newsletter, we reported on the recent repairs to the repeater, then weak signal measurements into the repeater and 70cm & 23cm band activity monitoring. Moving the repeater to the new, much higher elevation location on the mesa south-west of Boulder now exposes our receive antenna to a multitude of 70cm signals from all up and down the Front Range from Cheyenne in the north to Castle Rock in the south and all of the Denver metro area. It's usefulness as a 70cm in / 70cm out repeater has been greatly diminished over what it previously was at it's Chautauqua Park location. My measurements showed that it's effective sensitivity has been degraded by about 20dB. RFI from other ham's signals on our Ch 60 (438-444 MHz) input is unavoidable. The ultimate solution for those ATV hams that can't put a really strong 70cm signal into the repeater is to QSY up to our 23cm input. That band is very quiet here in Colorado. In the meantime, a solution that does work is for us hams with dual-band capability to act as intermediate, remote 70cm receiver, and 23cm relay points for the 70cm ATV hams. I have been doing that all summer with success. Jack, K0HEH, recently proved he can do it by relaying Steve, WA0TQG's 70cm signal from Sugarloaf mountain into the repeater. I will be taking my station off the air shortly as I head off to my winter home in Maui, Hawaii. I would encourage others to take over as remote cross-band (70cm->23cm) relays. It is extremely simple to do. How to do it? Check out my app. notes, AN-23a & AN-44a, available on my web site: www.kh6htv.com Need help? Give me a shout.

TV REPEATER -- DTMF CONTROL CODES

Control Code	FUNCTION	(*)	(#)
1	BEACON - continuous playing slide show video with ID on each slide	ON	OFF
2	Receiver Band Switch	70cm	23cm
3	Receiver Mode	ATV	DTV
4	Transmitter Mode	ATV	DTV
5	Transmitter ON	ON	Stand-By
6	Not Used - Reserved future use	NA	NA
7	Transmitter Disable	OFF	Enabled
8	System Master Reset - also reboots the DTV modulator (note: 35 second time delay for re-booting)	Reset to # State	

The above control codes, along with the control frequency and password, are supplied to all active Boulder ATV hams that have their own TV transmitters. The actual control frequency and the password are to be kept confidential. This is a reminder to all active ATV hams that you are authorized to activate and use the various functions of the TV repeater. When you are using the TV repeater, please also monitor the BARC, 2 meter, FM repeater (146.70MHz) in case another ATV ham wants to communicate with you, or also use the TV repeater.

You will find the BEACON mode especially useful for checking out your own TV receiver and as an aid in antenna alignment. If you are making sensitivity, or other tests, you should use code 5 and turn on permanently the repeater's transmitter. The various digital modules in the repeater take a very long time to switch between modes and cycle on/off the repeater. If you see the repeater being used in an inappropriate or illegal manner, please use control code 7 to disable the repeater's transmitter. If you are having trouble getting something to work, first try control code 8. This does a master reset by removing dc power from all the various digital modules and then after about 10 seconds reapplying dc power to reboot them. It takes about 30-45 seconds for the rebooting process. When you are all done experimenting, please remember to turn off the transmitter (code 5#) and also reset the repeater to it's CCARC approved state, i.e. 23cm DTV input and 70cm DTV output. This is easiest done using the control code 8*.

FREE ANTENNA --

Diamond X-200A, 2 meter & 70cm, vertical, omni-directional. mfg. specs. 6dB(2m) & 8dB(70cm), 8.3 ft tall, 112 mph wind rating, fiber glass radome, 200 W(max), UHF connector.

Antenna was originally owned by Uleii, KB9TTI / HB9TTI before he and Joan, KB9TTY, moved back to Switzerland. It was in use at their mountain home in Allen's Park.

NOTE: *NOT useful for ham TV.* It does not cover the whole 70cm band (420-450). It does have good gain in FM portion (440-450).

You need to pick it up, I don't deliver.

Interested ? --- contact Jim, KH6HTV, kh6htv@arrl.net or 303-594-2547



NEWSLETTER ARCHIVES I have added a new section to the web site. for our newsletters. Past issues can be found there. <https://kh6htv.com/newsletter/>

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