Boulder Amateur Television Club
TV Repeater's REPEATER

February, 2020
2ed Edition

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ATV REPEATER STATUS

Good News ! The W0BTV, Boulder ATV repeater is back in it's home on the mesa. Don, N0YE, & Jim, KH6HTV, returned it on Thursday morning, 6 Feb. Preliminary tests showed it to be working well. It had been removed recently to install a new 23cm Band-Pass Filter in the hopes that this would eliminate the RFI from the 23cm FAA Radar. This filter was designed for us by Dan, WB9AIA, and built by Mark, N0IO. It was discussed in detail in the previous newsletter, January, issue # 32. Other modifications performed on the repeater were:

1. Removal of the old 23cm BPFs and the 23cm FM-TV receiver.

2. Removal and replacement of the Astron model SS-30m switching power supply. It had gotten flaky and would jump in and out of voltage regulation with serious voltage spikes on the output. It was replaced with a Samlex model 1235.

3. Repair of the damaged final amplifier in the 70cm transmitter (damaged by the faulty power supply)

4. Installation of NEW, 5.9 GHz, FM-TV Transmitter (not activated yet)

5. Installed new W0BTV repeater ID slide show video (more slides, 1 1/2 minutes)

6. Realignment and calibration.

While at the repeater site, Jim, KH6HTV, took along the test equipment to perform 5ns Impulse TDR measurements on both the receive and transmit coaxial cables. This was done to measure their lengths to provide data for system calculations. The transmit coax is 7/8" Heliax and was found to be 84 ft. in length. The receive coax is LMR-400 and was found to be 62 ft. in length.

The NEW FM-TV transmitter was not yet installed. It and it's antenna will be mounted on the roof of the south tower. Once the snow melts (or blows off) the roof, we will

then be allowed access to install it. After this transmitter is installed and found to be functioning properly, then new Application Notes, AN-51 & AN-53 will be issued documenting all of the above changes.

REPEATER ON-AIR TEST RESULTS: The first acid test of the repeater was our weekly, Thursday afternoon net on 6 Feb. Unfortunately we still had some issues. The most difficult was for Ed, K0JOY, from his Old Stage Road QTH, shooting his 23cm signal along the ridge line of the Front Range to the repeater site. We still had issues with audio breakup and freeze framing on Ed. Royal Bummer ! We were really hoping our latest repeater modifications would have solved Ed's issues.
(note: We really do however have good news to report -- see the follow on report) Colin & Jack were monitoring other signal activity, especially on 70cm and Colin reported seeing an extremely strong carrier for quite awhile on 445.05 MHz. Could have been causing some problems. Plus the 146.70 repeater at our ATV repeater site was up occasionally.

We did try to record some data on the various transmissions today for comparisons. Most all Boulder ATV hams are now transmitting digital ATV. The transmitter power levels reported of Low, Medium and High were from those hams using KH6HTV Video power amplifiers. These amps had three front panel adjustable power levels with nominal -5dB & -10dB settings for medium and low. The repeater's digital receivers' on screen displays of power level in dBm and S/N in dB were observed directly on the repeated output. The dBm levels reported here are corrected for the receivers' offsets. (see above)

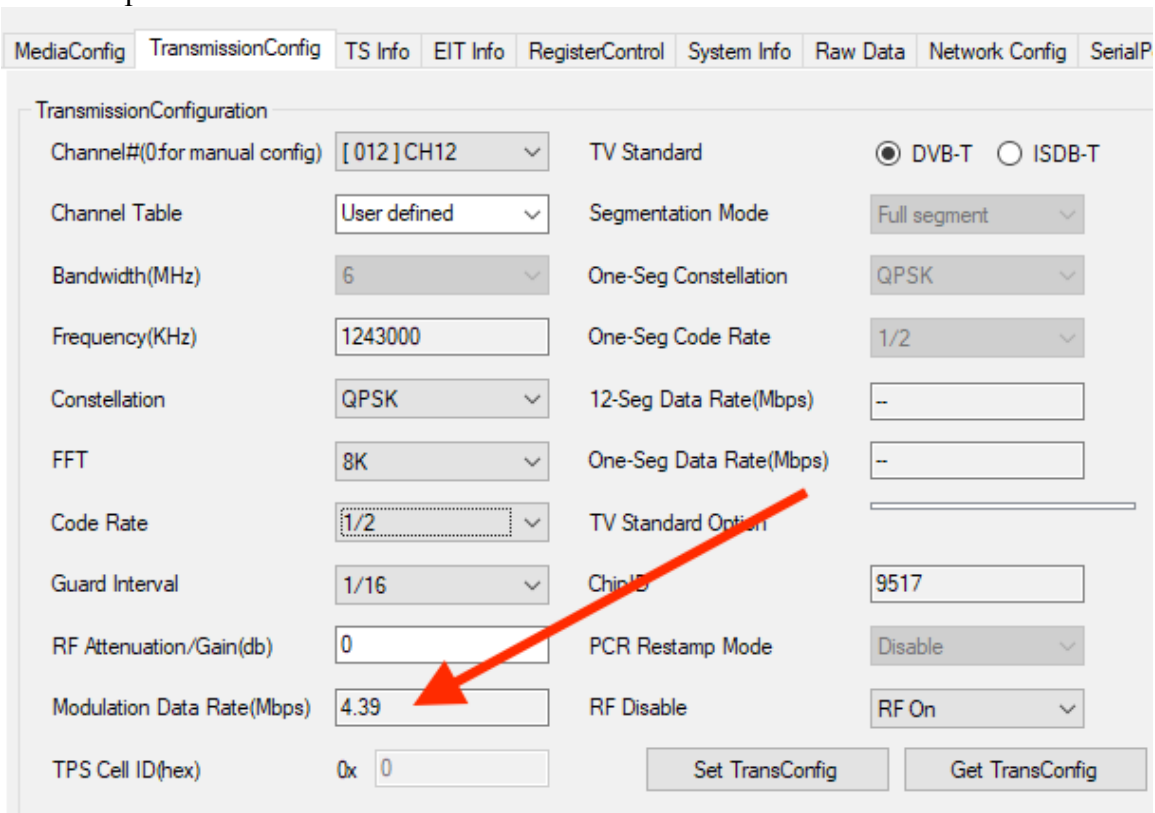
Call Sign	Band	Xmit Power	P (dBm)	S/N (dB)
no input	23cm	-- na --	-105	0
	70cm	-- na --	-99	0
KH6HTV	23cm	Hi	-63	22
		Med	-67	21
	70cm	Hi	-59	22
		Med	-65	21
N0YE	70cm	?	-51	18
	23cm	?	-83	21
K0JOY	23cm	hi	-83	19
		med	-89	14
AB0MY	23cm	med	-82	23
K0IHX	70cm	hi	-63	17
WA2YUN	23cm	hi	-75	21
		med	-81	17
K0HEH	23cm	hi	-81	17
		med	-86	15
WB2DVS	70cm	hi	-58	21
		med	-65	21

GOOD NEWS ! -- K0JOY's Issues Resolved

So, now as of Saturday, 8 Feb. -- we can happily report that Ed's issues have been resolved. Dr. Ed & Dr. Jim, put Ed's transmitter up on the surgical operating table in Jim's ham shack and dissected it. We discovered a Major issue and a Minor issue. The major issue was the video encoding max. bit rate was set too high. It had been set at the theoretical max. limit. Hi-Des recommends it never be set higher than 80% of the theoretical limit. The other more minor issue was the amplifier was being overdriven and thus compressing the rf output peaks, causing higher bit error rates. We reset the encoding rate to 80% and backed off the drive by -2dB and -- VOILA ! It worked perfectly. His 23cm signal now into the repeater is -84dBm with s/n = 23dB on high power (4.7 W), -90dBm and 15dB s/n on med. power (1.4W), and -92dBm and 11dB s/n on low power (600mW)

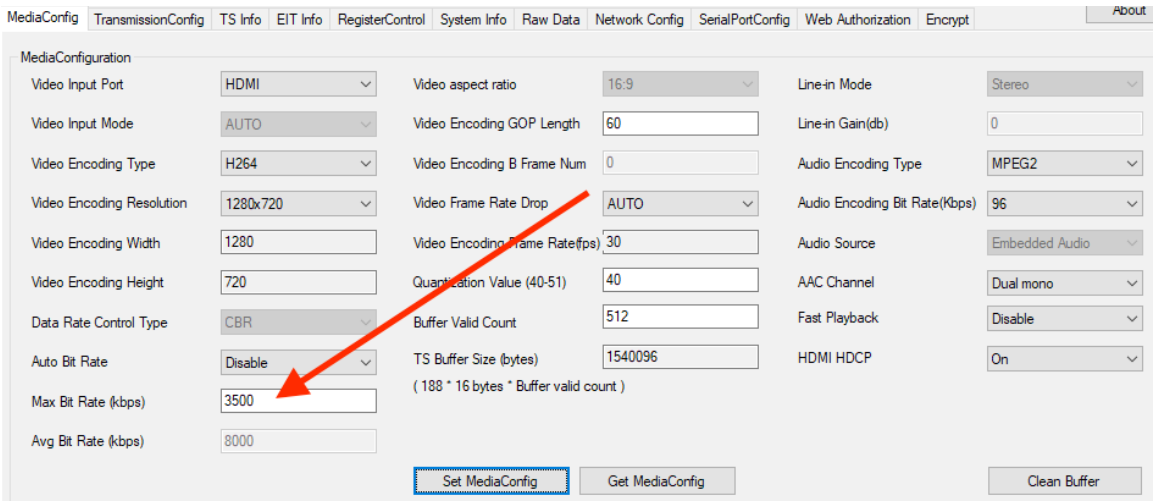
LESSON LEARNED (or Re-Learned)

So for anyone having issues with freeze framing and / or loss of audio in their digital ATV transmissions, it would be well to revisit your digital parameter settings in your Hi-Des modulator. Also go back and re-read the Application Note AN-39, *"DVB-T Recommended Parameters"*. Fire up again the *AV-Sender* program and look at the Media Config and Transmission Config pages. The example shown below contains the settings for a "Poor Channel" with the most aggressive Forward Error Correction (FEC). The code rate parameter sets the FEC.



Transmission Configuration page for most aggressive FEC for a Poor Channel.

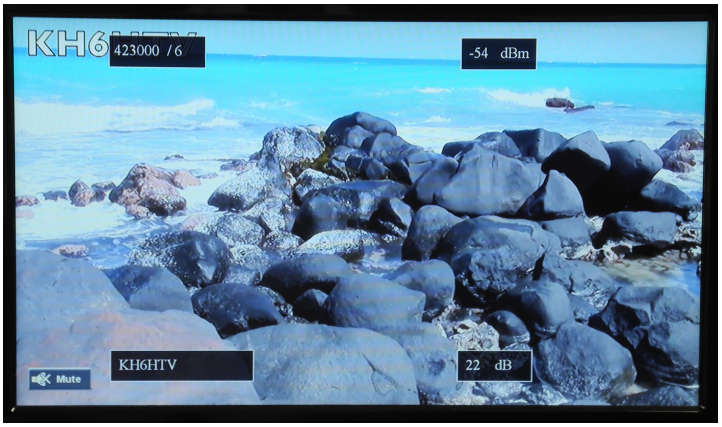
Note in particular the line labeled "Modulation Data Rate (Mbps). You can not adjust this line. It is a calculated value based upon the above settings for bandwidth, constellation, FFT, code rate and guard interval. It is the theoretical, absolute maximum data rate permitted for those settings. Now look at the Media Config page.



Media Configuration page for most aggressive FEC for a Poor Channel.

The key parameter to be set on the Media page now is the Max Bit Rate (kbps). This is the maximum video encoding bit rate to be used. Note the above grayed out line CBR. This means Constant Bit Rate encoding. This max. bit rate must never exceed the theoretical modulation data rate shown on the Trans Config page. It actually needs to be less than that to also allow for the encoded data for the audio channel. In the Hi-Des instruction manual, they recommend that it never be set higher than 80% of the theoretical modulation data rate. Thus for the example shown above we find

Max. Bit Rate = 80% * 4.39 Mbps = 3.512 Mbps = 3512 kbps



W0BTV-TVR On Screen Display of signal parameters

HOW STRONG IS MY SIGNAL INTO THE REPEATER ?

A new feature added to our ATV repeater in 2019 was the addition of permanent, On Screen Display (OSD) for the digital receivers. The parameters displayed are Frequency/Bandwidth (upper left), received station Call Sign (lower left), S meter Power in dBm (upper right) and Signal/Noise ratio in dB (lower right). It should be noted that the S meter reading is not true. It has significant offsets (they read too high). However, it is accurate for relative changes, i.e. 1 dB change in input power causes a 1 dB change in the S meter reading. The S meter and S/N can be used as tuning aids for antenna alignment. The Hi-Des HV-120 receivers have significant offset errors of 12 dB (70 cm) and 27 dB (23 cm). The total offset correction factor reported below also includes the insertion loss of the antenna triplexer and the band-pass filters, plus the gain of the preamps.

S-Meter Calibration:
23cm DVB-T Receiver: The offset correction is ≈ +42dB. i.e. if the S meter reads -40dBm, then the actual signal strength into the repeater is -40dBm - 42dB = -82dBm. With no signal input, and 50Ω termination on antenna input, the S meter reads ≈ -62dBm (i.e. -104dBm true)
70cm DVB-T Receiver: The offset correction is ≈ +24dB. i.e. if the S meter reads -50dBm, then the actual signal strength into the repeater is -50dBm -24dB = -74dBm. With no signal input, and 50Ω termination on antenna input, the S meter reads ≈ -78dBm (i.e. -

Receiver Sensitivity: The sensitivity was measured at the Receive Antenna, type N, input connector on the front panel of the repeater's receiver assembly. The DVB-T receivers were calibrated using amateur TV, "Normal"(*) DVB-T parameters. They are the same as used for the TV repeater's output DVB-T signal. Digital threshold is defined as the lowest signal with perfect P5 video and Q5 audio and no freeze framing. For *"Normal QPSK"* parameters, this occurs with a S/N = 8 dB. This is also the level required to key up the repeater.

23cm DVB-T Receiver = -96 dBm & 70cm DVB-T Receiver = -9 4dBm

If one uses the "Poor Channel" (*), very aggressive FEC coding, then one buys an additional 4 dB improvement in sensitivity. For the 23 cm receiver, the sensitivity improves from -96 dBm to -100 dBm with a S/N of 5 dB.

For the **70cm, NTSC, VUSB-TV receiver**, the sensitivity is defined as the signal level required to open the video squelch. At squelch threshold, the video picture quality is rated at P2+ **70cm Analog Receiver = - 86 dBm** The required input power for P3 is ≈ -80dBm, for P4 -70dBm and for P5 -60dBm.

(*) "Normal" ATV DVB-T parameters are: encoding = 1080P, H.264, CBR, 6 Mbps transmission = 6 MHz BW, QPSK, 8K FFT, 5/6 FEC, 1/16 Guard (sync) For "Poor Channel", aggressive coding, use 720P, 3.5 Mbps & 1/2 FEC. For details see AN-39.

OTHER SIGNIFICANT REPEATER DATA:

For those hams inclined to do more calculations on the repeater's coverage, etc. -- the following relevant data is provided. For the receiver, the key items are the sensitivities (listed above), the coax cable loss and the antenna characteristics. For the transmitter, the key items are the transmitter's output powers, the BARC/BATVC repeaters combiner loss, the coax cable loss, and the antenna characteristics.

70cm TRANSMITTER OUTPUT POWER:

RF output from 19" rack - after N0YE, Ch 57 Band-Pass Filter (-2dB IL)
70 cm Digital = 6.3 Watts (rms, avg), (+38 dBm) (423 MHz, 6 MHz, DVB-T)
70 cm Analog = 14 Watts (PEP), (+41.4dBm) (421.25 MHz, NTSC, VUSB-TV)

70cm Transmit Antenna is an Andrew model DB-411. 11dBi gain, cardiod pattern, oriented to 30° from true north. Polarization is vertical. The antenna height is about 120 ft. above ground level. The coax feedline is 7/8" heliax. The length is 84 ft. Coax loss is 0.65 dB. This antenna is shared with the Boulder Amateur Radio Club (BARC), 70 cm, FM voice repeater. The W0DK repeater transmits on 448.90 MHz. A duplexing antenna combiner network was designed and built by Don, NOYE. The insertion loss of the BARC/BATVC transmitter combiner for the 423 MHz DTV signal is -1.8 dB.

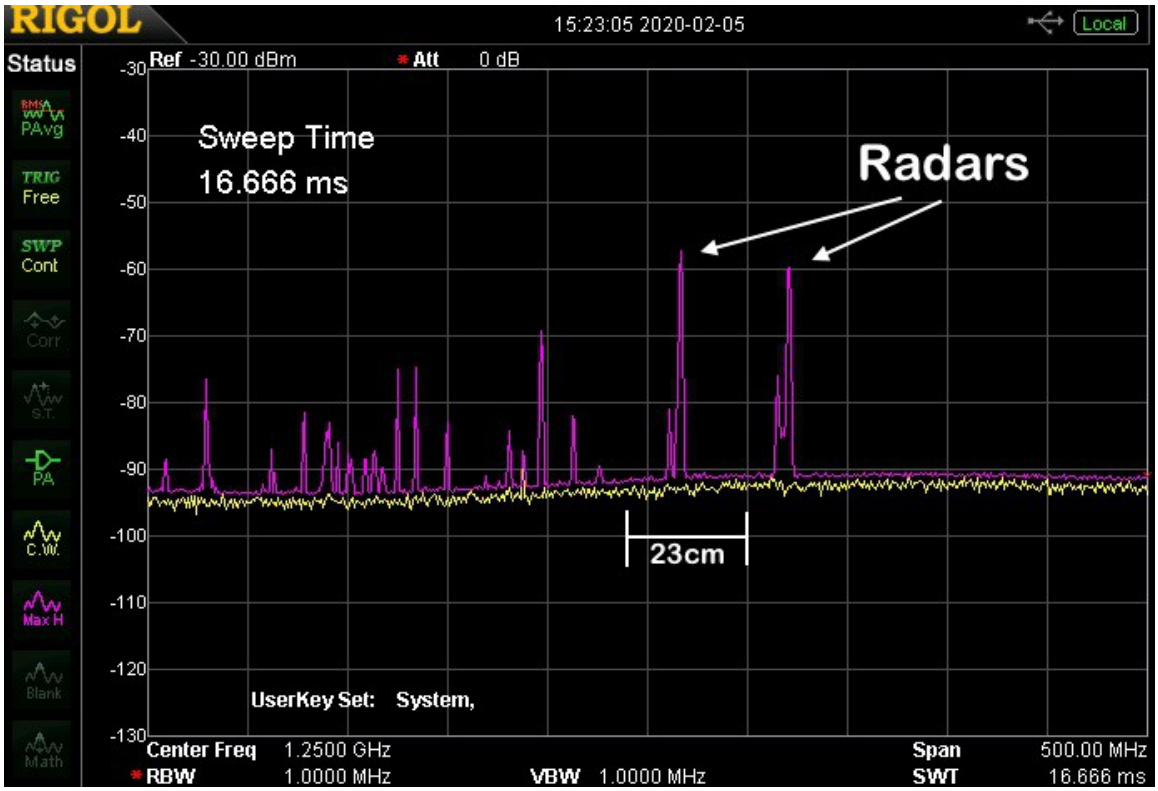
Receive Antenna is a Diamond model X-6000. This is a tri-band antenna for 2 m, 70 cm & 23 cm amateur bands. The mfgr's spec. is 6.5 dBi (2m), 9 dBi (70cm) and 10 dBi (23 cm) with an omni-directional pattern. Polarization is vertical. The antenna height is approximately 100 ft. above ground level. The coax feedline is LMR-400. The length is 62 ft. Coax loss is 1.65 dB, at 441 MHz and 2.9 dB, at 1243 MHz. Add an additional 0.3dB for loss in the on-roof, 5.9GHz, FM-TV transmitter box.

A Not So Simple Combiner

When we received permission to install our ATV repeater in it's new home on the mesa, it was with the restriction that we add no more coaxial cables from the radio room. There was only one spare, LMR-400 coax available for us to use. Also there was no more space available on the tower to add our DB-411, 4 element, co-linear, 70cm transmit antenna. If we wanted to move in, we would have to share BARC's 70cm FM voice repeater, DB-411 antenna. How to do that without screwing up each other's transmitter ? The solution we came up with used what looks like a very simple, type N tee adapter to join each transmitter to the antenna. But wouldn't that send an awful lot of RF power not just into the antenna, but also the other antenna ? Yes, but No.

Let's put some transmission line theory to work. What happens to an impedance when it is separated from the point of connection by a 1/4 λ piece of coax cable ? The Z takes a trip 180 degrees around the Smith Chart. So if I have a short circuit on one end of this 1/4 λ coax, on the other end -- I see an open circuit, or in other words an infinitely high impedance (∞ Ω). Now this same phenomena repeats for all odd values of 1/4 λ, i.e. 3/4 λ, 5/4 λ, etc.

So, fortunately, our two transmitters are at opposite ends of the 70cm band. The BARC FM transmitter is at 448.9 MHz. Our BATVC transmitter is at 423 MHz. Now if we carefully (*emphasis on VERY CAREFULLY ! !)* prepare two coaxial cables of exactly the correct lengths we can have two very nice n * 1/4 λ, Z transformers. The antenna connectors on both transmitters are actually dc short circuits. The inputs to the BARC duplexer and our BPF are DC short coupling loops. By cutting each coax going to the type N tee correctly, we can transform each of these shorts to ∞ Ω. The coax connecting the BARC transmitter to the tee needs to do this for our frequency of 423 MHz. The coax connecting our transmitter to the tee needs to do this for the BARC frequency of 448.9 MHz. A complicating factor was the fact where the tee attached to the 7/8" Heliax was near the ceiling in the radio, thus each cable to the transmitters had to be quite long at 7 to 8 feet in length. Don, N0YE, was able to accomplish this heroic feat with the help of Colin, WA2YUN. The resultant combiner worked and we measured -1.8dB of insertion loss for our 423 MHz DTV signal.



Boulder ATV Repeater Site Spectrum: On the 5th of Feb. in the mid-afternoon, Don, N0YE, Colin, WA2YUN, & Jim, KH6HTV set up a couple of spectrum

analyzers in the parking lot of our ATV repeater's site on the mesa south-west of the city of Boulder. We were interested to see what, if anything we found in the 23cm band. In general, the amateur band is very quiet, except for the FAA radar. The above plot shows what we found sweeping from 1 to 1.5 GHz.. The yellow trace is a "live" single sweep. The magenta trace was with the spectrum analyzer in "peak hold" mode for several minutes. The analyzer's bandwidth was set to 1 MHz.

PARKER FAA RADAR:

On Saturday, Feb. 1st, I visited the FAA Denver ARSR site in Parker. There were 2 pulse groupings. One centered at 1262MHz and the other at 1268MHz. I refer to these as groupings because both have pulses approximately 3MHz above and below the middle of each channel. In other words there is a lot going on all across that slice of spectrum. Attached is a photo of the BATVC technical scout car at the ARSR site. Before leaving I left a note on the gate requesting that they move the radar above 1300MHz.

73 de Colin, WA2YUN

(Good Luck Colin - Do you really think the FAA will even read the note, let alone change frequencies ?)

ATSC 3.0 Update: The new standard for over-the-air digital television in the U.S. continues to advance. Sixty television stations in forty markets are expected to be on the air with the new standard by the end of 2020. Twenty television sets with ATSC 3.0 tuners were shown at the recent 2020 Consumer Electronics Show. Several stand-alone tuners (set top boxes) were also shown. Stand by for more updates and announcements after the National Association of Broadcasters convention in Las Vegas coming up in April.

If you haven't been thinking about the ATSC 3.0 digital television format, you may want to give it some consideration. This is going to be the new digital broadcast standard in the U.S. It utilizes COFDM and it is FAR superior to ATSC 1.0 in terms of signal coverage and capabilities, including I.P. protocol, 4K video and enhanced emergency broadcast features. Further, if you operate an ATV repeater you would be wise to retain your 6 MHz channel allotments. Although European DVB can be operated at less than 6 MHz channel widths, I am not aware of any provision in the ATSC 3.0 standard to do so.

73, Dan Rapak - WA3ATV

Future Newsletters: If you have contributions for future newsletters, please send them to me. We also encourage you to forward this newsletter on to other ham friends in your clubs.

Jim Andrews, KH6HTV, email = kh6htv@arrl.net

ATV HAM ADs: ATV hams may place ads at no charge in this newsletter to sell or buy ham gear.

For Sale -- 23cm FM-TV Receiver: $300

KH6HTV Video model 23-7 Down-Converter & model 23-5 70MHz IF Amplifier & De-Modulator. These units were recently pulled from the W0BTV ATV Repeater when the FM-TV feature was removed. Perfect working condition. The only cosmetic defects are extra mounting holes which have been drilled in the cabinets. The down-converter can be reprogrammed to any desired 23cm frequency. The de-modulator can be easily modified to meet any local FM-TV standards, such as SSC frequencies, polarity, de-emphasis, etc. Detailed spec. sheets available on the web site: https://kh6htv.com/products/ Instruction manuals included. If interested, contact Jim, KH6HTV at kh6htv@arrl.net

Quality Products & Application Notes for the Amateur Radio/TV market www.kh6htv.com

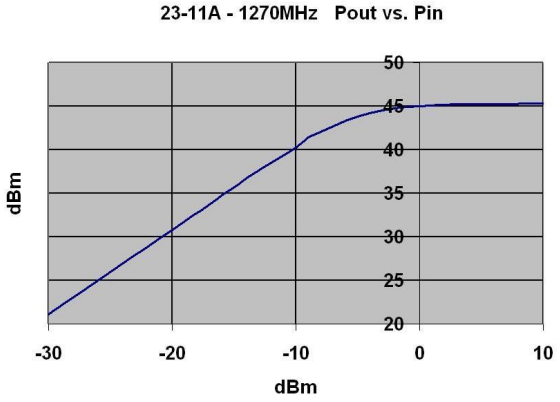
Featured Product of the Month

Model 23-11A, 23 cm RF Linear Power Amplifier

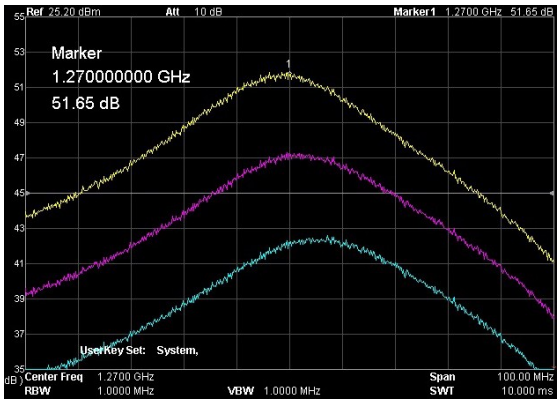
Model 23-11A
23 cm, 50 dB, 25/15/3 W
RF LINEAR
POWER AMPLIFIER

The KH6HTV-VIDEO Model 23-11A, RF Linear Power Amplifier is for use in the amateur radio 23 cm band (1240-1300 MHz). It can produce a 3 Watt (avg), high-definition (1080p), digital TV signal. It can also be used to produce a 25W, FM/CW signal or 15 Watt (pep), analog, TV signal. The rf power output can be lowered -5dB or -10dB for reduced DC current draw with the front panel rotary switch. Provision is included for external PTT control, useful for repeaters.

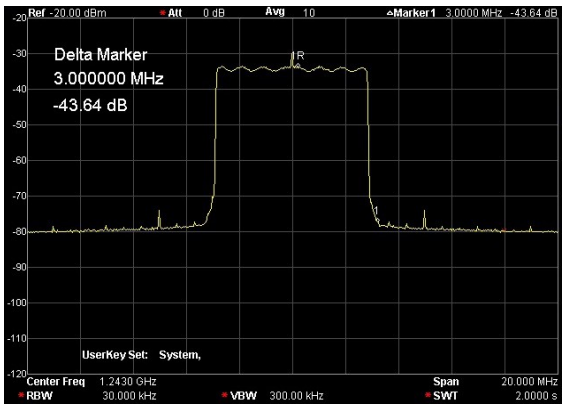
PARAMETER	Typical Performance	Notes
Output Power (analog TV) (VUSB-TV, NTSC)	15 Watts PEP (+42 dBm) also 5 Watt or 1.5 Watt	peak power on sync tips adjustable in 5dB steps
Output Power (Digital TV)	3 Watts (+35dBm), 1W & 0.3W	rms, avg. power,DVB-T service
Output Power (FM, CW)	25-30 Watts	saturated output
Output Power (SSB)	20 Watts PEP	
Output Power (AM)	5 Watts	
Output Power, P(-1dB)	20 Watts	-1dB gain compression
Output Power vs. Supply Voltage	+35 dBm @ 12 - 13.8 Vdc +34 dBm @ 10 Vdc	DTV
RF Power Amplifier Gain	50 dB, nominal	
Amplifier Gain Flatness	± 2.5 dB	1240 - 1300 MHz
Amplifier Max Input Power	50 mW, +17 dBm	
LSB Rejection (analog VUSB)	-20dB	LSB/USB ratio
Spectrum Regrowth (Digital TV)	-30 dB at +35dBm avg.	shoulder break-point
Duty Cycle	100 %	heat sink & cooling fan included
DC Supply Voltage	13.8 Vdc	10 to 15 Vdc
DC Current @ 13.8 Vdc	6.5, 4, or 2.5Amps (DTV) 10 Amps (FM/CW)	HI / MED / LO power
Controls - Rotary Switch	OFF - HI - MED - LOW	rf power adjustable in 5 dB steps
Control - Mini Toggle Switch	Xmit ON - Stand-By - Ext PTT	
RF Connectors	SMA input & N output	
Rear Panel Terminal Strip	GND,+12Vdc,PTT IN, PTT OUT	PTT provided for repeater control
Dimensions & Weight	5.5" x 4.5" x 5.0", 2 lbs	
Accessories Included	instruction manual & test report	

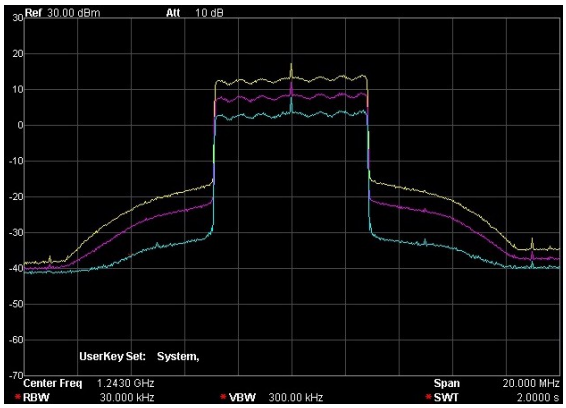


Note: slightly lower gain and power output at band edges

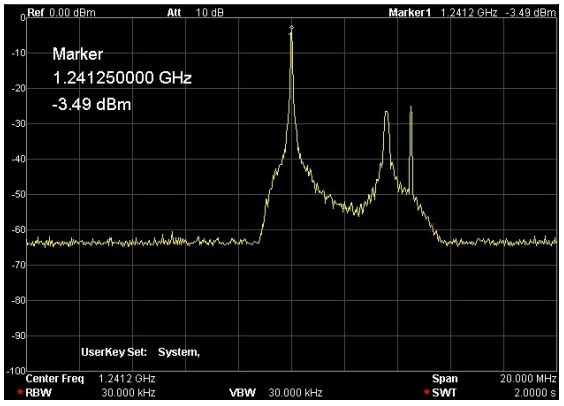


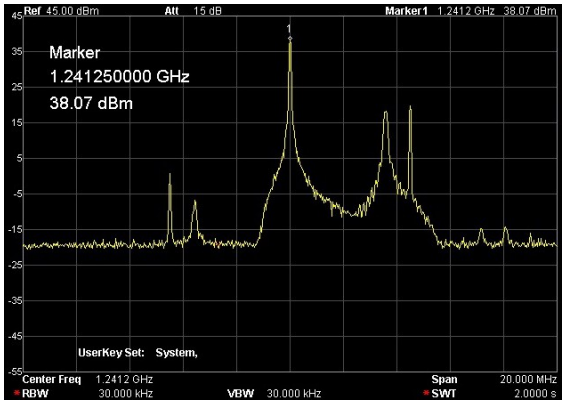
S21, 2dB/div & 10MHz/div, 1270MHz center Yellow=HIGH, Magenta=MED, Blue=LOW





RF Spectrum in DVB-T service. Modulator output (left) & Amplifier output (right) 10dB/div & 2MHz/div. Yellow = HIGH, Magenta = MED, Blue = LOW RF Power





RF Spectrum in NTSC, VUSB-TV service. Modulator output (left) & Amplifier output (right) 10dB/div & 2MHz/div.

NOTICE: This linear amplifier is not FCC type accepted. The use of this amplifier is only legal in the USA, amateur radio, 23cm band (1240-1300MHz). Owners and operators of this amplifier must be licensed amateur radio operators.

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