Boulder Amateur Television Club
TV Repeater's REPEATER

September, 2021
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BATVC web site: www.kh6htv.com

ATN web site: www.atn-tv.com

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Microwavelengths

Microwave Amateur Television

Amateur microwave bands have a lot of bandwidth, and we only use a small fraction for weak-signal communications. This leaves room for experimentation with wider-bandwidth modes, such as amateur television (ATV). Digital TV requires much less transmitted power for quality pictures, therefore, digital ATV (DATV) has become more popular. For this month's column, I've asked Jim Andrews, KH6HTV, (kh6htv@gmail.com), Editor of the Boulder Amateur Television Club Newsletter, to explain ATV.

When discussing ATV, most hams think of slow-scan television (SSTV). They're unaware that amateur radio bands can be used for more than voice, CW, digital text modes, or SSTV. However, the FCC allows hams to also operate live broadcast-quality TV on the 70-centimeter band and the higher microwave frequencies. In the US, TV channels are 6 MHz wide. Thus, the 70-centimeter band at 430 MHz is our first higher band with sufficient spectrum available to support TV. It's also close to the UHF TV broadcast band (470 – 698 MHz) with similar propagation characteristics.

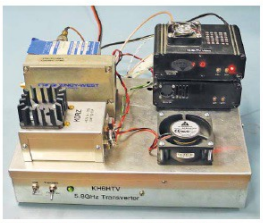
Digital ATV

The first ham radio TV two-way contact was made in 1940. Today, broadcast TV has transitioned from the old analog NTSC (National Television Standards Committee) to digital. Many ATV hams now transmit high-definition (1080p) digital video and CD-quality stereo audio, resulting in great pictures and sound. A few US hams are experimenting with the American digital broadcast system called ATSC (Advanced Television Systems Committee), but most are exploring digital TV using the European-based system, DVB-T (Digital Video Broadcasting — Terrestrial). DVB-T uses COFDM modulation with QPSK, 16QAM, or 64QAM and is highly tolerant of severe multipath propagation. In Europe, most ATV hams are using DVB-S (Digital Video Broadcasting — Satellite) and have the QO-100 geostationary satellite to experiment with. This satellite is a transponder for amateur digital TV, with microwave uplink in the 2.4 GHz band and downlink in the 10 GHz band.

We've found that digital TV outperforms the old analog NTSC TV. Experiments have shown that with identical transmitter powers, antennas, and so on, digital TV provides a perfect image and sound, while a P2-quality analog TV signal provides images that are barely distinguishable.

Due to bandwidth, there's a big difference in TV receiver sensitivity versus SSB or FM voice. It's set by the law of physics and the thermal noise baseline: Pn = kTB. Boltzmann's constant is k, the Kelvin temperature is T, and bandwidth in Hertz is B. Using this equation for a 6 MHz DATV signal, the noise floor for a receiver will be –106 dBm. For an FM voice radio with 15 kHz bandwidth, it's –132 dBm. For an SSB voice radio with 2.4 kHz bandwidth it's –140 dBm, so a received signal level greater than –130 dBm is needed for a 10 dB signal-to-noise ratio. With DVB-T, using a good low-noise preamplifier on the receiver and 6 MHz bandwidth, QPSK, 1080p resolution, and normal forward error correction (FEC) of ¾, the minimum detectable signal requires an 8 dB signal-to-noise ratio, or about –98 dBm (2.8 µV). If we use really aggressive FEC of ½, we get another 3 dB in sensitivity. Therefore, a signal of about 30 dB more is needed for DATV compared to SSB.

There's also a difference in how we rate digital transmitter power versus analog. Analog TV is rated the same as an SSB transmitter — by peak envelope power (PEP). The peak is the sync pulse on an analog TV signal. For digital, the waveform has no distinguishing features, but looks like random noise with power peaks 8 – 10 dB above the average root mean square (RMS) power. Therefore, a digital transmitter is rated by its RMS power, which is typically 8 – 10 dB below its maximum power rating. For example, a 10 W RMS DVB-T transmitter amplifier is capable of putting out 50 W PEP in SSB service, and 70 W in FM/CW service.



Jim Andrews', KH6HTV, homebrew 5.8 GHz DVB-T transverter. [Jim Andrews, KH6HTV, photo]

DATV Operation

As with 2-meter and 70-centimeter FM voice, ATV hams also use repeaters to enhance their coverage areas. In the US, I know of at least 40 active ATV repeaters (analog, digital, and mixed mode). Most are on the 70- and 23-centimeter bands, but some also include inputs and/or outputs on the higher microwave bands up to 10 GHz. For example, our Boulder, Colorado, W0BTV repeater has inputs on 70 and 23 centimeters, and outputs on the 70- and 5-centimeter bands. Many ATV repeaters also stream their video and audio over the internet. The best place to find many of them is on the British Amateur Television Club's (BATC) website (**https://batc.org.uk/live**). There you'll find almost 60 ATV repeater streams from around the world. The most complex ATV repeater system is that of the Amateur Television Network (ATN), a system of linked ATV repeaters covering southern California, southern Nevada, and Arizona (Phoenix and Tucson). ATN uses microwave links on the 9- and 5-centimeter bands to tie the various sites together.

Like other microwavers, ATVers like to get out in the field on microwave DXpeditions to see how far they can exchange signals. Boulder ATV hams have worked all bands (70, 33, 23, 13, 9, 5, and 3 centimeters) with digital ATV up to 10 GHz, and have used ATV to send pictures of our club's 2021 Field Day operation around the world. This required an intermediate point-to-point relay hop to get from our mountaintop site to our W0BTV TV repeater, and from there to the internet. We've also participated in the ARRL 10 GHz and Up Contest, but with fewer ATV participants we haven't scored very high. Locally, our current best distances on microwaves are 51 kilometers (5.7 GHz) and 36 kilometers (10 GHz). With our W0BTV DVB-T repeater, we've successfully made two-way contacts with the 70- and 23-centimeter inputs and 70-centimeter output, to 123 kilometers on the Colorado/Wyoming border. The repeater also has an analog FM-TV transmitter on 5.905 GHz, and we've been able to receive that microwave signal out to 112 kilometers.


Debbie Goldman, WB2DVT, operating 10 GHz digital ATV during the 2020 ARRL 10 GHz and Up Contest. [Pete Goldman, WB2DVS, photo]


Don Nelson's, N0YE, DATV picture received from 9.4 miles away, recorded by Jim Andrews, KH6HTV. [Jim Andrews, KH6HTV, photo]

Equipment

A mixture of commercial and homebrew equipment can be used for digital ATV. HiDes Technologies modulators are popular and cost about $370. For receivers, we use inexpensive set-top box receivers from Amazon, which only cost $50. Cheap USB TV tuner dongles for a PC can also be used as receivers. The BATC sells transmitter and receiver kits to its members (they require a computer such as a PC or Raspberry Pi).

Commercial DVB-T modulators and receivers are available for bands up to 13 centimeters (2.4 GHz). Above that, we need to use transverters for digital TV signals. Microwave transverters from Down East Microwave (US) and Kuhne Electronic (Germany) can be easily modified from SSB service to work with digital ATV by using a 70-centimeter DVB-T modulator and receiver for the IF, rather than an SSB transceiver. If you homebrew your digital ATV transverter, the key element is a good local oscillator (LO). For digital TV, absolute frequency accuracy isn't as important as it is for SSB, but low phase noise is crucial in the LO.

More Information

If you want to learn more about analog and digital ATV, download *Introduction to Amateur Digital Television*, by Jim Andrews, KH6HTV, at **www.arrl.org/atv-fast-scan-amateur-television**.

ATV in QST: ATV made news with a two page article in the October, 2021 issue of QST. Paul Wade, W1GHZ, the editor of the Microwavelengths column invited us to write an article about doing ATV on the microwave bands. ARRL members can read it on-line at the ARRL web site. It is also posted as a .pdf file on our web site of www.kh6htv.com Local Boulder ATVers, Debbie, WB2DVT, and Don, N0YE, are now world famous with their smiling photos appearing in the article.

FEEDBACK from Down-East Microwave:

I have gotten a response back from Down-East Microwave on the issue of supplying microwave absorber material with their 10GHz LNA kits to prevent the amplifiers from oscillating.

I obviously screwed up by not contacting them and discussing the issue first with them before writing my review article in the previous issue (#87) of this newsletter. For that I sincerely apologize to Down-East Microwave.

I did receive a very lengthy letter from DEM after they got the newsletter. They were quite upset because I did not contract them first and rightly so. I am reprinting here portions of their letter to explain their position and how they deal with the issue.

Why didn't DEM include some Q damping material in their kit ?
We don't for a couple of reasons. First it is not required by most of the ULNA's. Second, a true microwave equipment builder (much like your self) has their favorite RF absorber on hand and most likely can detect if it is required or not. Third, just placing some absorber for the purpose of using it because it may be required, if not located correctly may degrade the ULNA's performance. So-- we do not provide it!

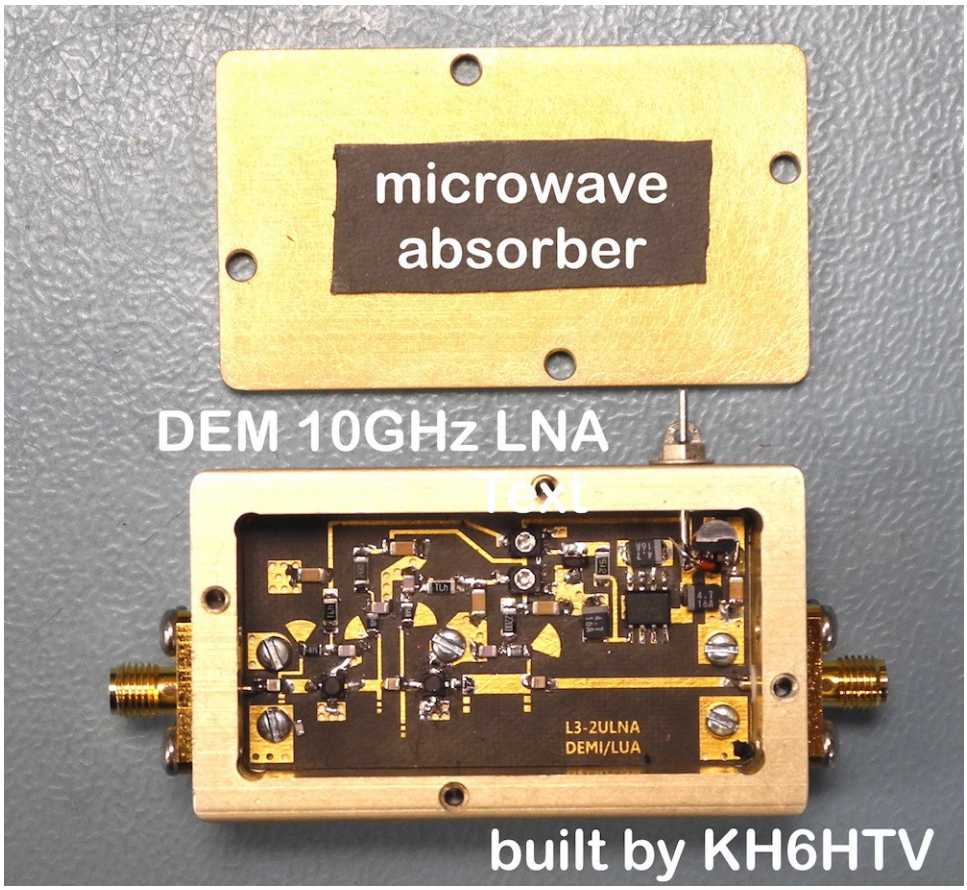
How many hams out there building these kits have built oscillators rather than amplifiers ?
Is their any LNA kit builder out there that thinks a amplifier can't oscillate? And especially any microwave enthusiasts that has the experience in microwave circuit building?
As I explained previously, if we don't know you, we will question you to verify that you have the skill and the equipment before we make the sale. AND-- we provide the help and service for any issues that may pop up of which you decided to neglect but have no issue in generating the bad press about.

If they don't have the proper instrumentation, they probably don't realize they have an oscillating amplifier on their hands.
As explained above, if we felt the soon to be kit builder did not have what was required to complete the kit, they would be cautioned and the pitfalls would be explained. Then we would suggest and assembled unit unless the client just wanted the experience. And even then, we would bail them out of any problems one way or the other with them starting with a question to our technical dept.

Also, what about buying an assembled amplifier from DEM. Did they simply test the amplifier with the cover lid off and then put the cover on and ship it ? Or do they put an rf absorber in their assembled units ?"

As a delivered assembled product, we build L3-2ULNA's in 10-20 unit batches and they receive extreme testing sometimes requiring component replacement to meet specification. Then, circuit optimization is performed and finally a stability test that sometimes requires microwave absorber placed not only strategically

but as a specific size to prevent a degradation of gain and noise figure. There is only a small percentage of ULNA's that the bias is set and they meet the specifications but even then, we optimize every unit to ensure that the client receives the best performing product possible. Our specifications are minimum specifications.



CONCLUSIONS:

1. Yes, I screwed up in writing the first article in the previous newsletter. I should have contacted DEM first.

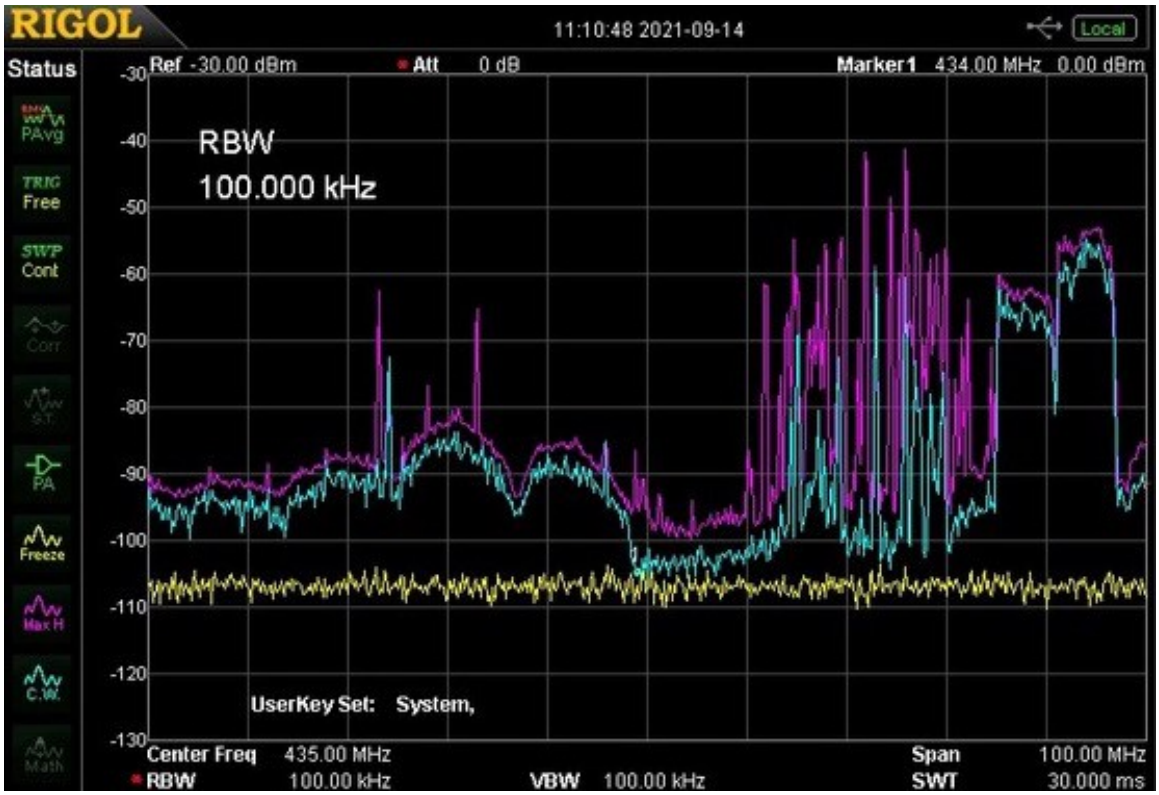
2. But, I still am convinced that DEM should have included a piece of microwave absorber material in their kit along with specific instructions on where to place it in the finished amplifier. This would assure that none of the amplifier kits, if built according to instructions would oscillate. A simple fix which would prevent a lot of grief and hand-holding by DEM later.

3. In light of DEM's comments on how they build and test these LNAs, I would thus recommend to our readers that they always forgo purchasing the kits and instead spend a few more bucks and instead purchase the fully assembled and tested LNAs from Down East Microwave. It will be money well spent. As I said in my original article, I was impressed with the final product. It did meet my expectations.

4. DEM also requested that I publish a photo of my completed 10GHz LNA as opposed to publishing the photo from their spec. sheet. So the above photo shows my finished LNA along with the microwave absorber attached to the top cover. I published their photo because it was a very high quality photo and showed very clearly the fine construction.

Jim, KH6HTV, Boulder, CO

DATV -- Boulder to Johnstown: Bob, WB0NRV, announced success finally on Sept. 16th ATV net being able to receive the Boulder, W0BTV, TV repeater's signal at his qth in Johnstown, Colorado. Johnstown is 47 km (29 miles) to the north-east of the repeater. Bob sent us the above confirmation photo. A vacation DVD happened to be playing over the repeater at the time the photo was taken. Bob has been trying for some time now to accomplish this feat. One hurdle he had to overcome was the issue of wrong firmware in his Hi-Des receiver. Bob reported that he finally made it happen using his 18 element yagi antenna, vertically oriented. He mounted it on a 24 ft. mast which allowed the antenna to just peek over the top of his roof line. Bob lives in an HOA controlled neighborhood and he didn't want the antenna visible from the street by neighbors. He then used 55 ft of LMR-400 coax to feed the signal into his ham shack. Bob is a recent transplant from Wichita, Kansas. He next hopes to be able to get an NTSC analog TV signal on 439.25 MHz into the repeater using the TV transmitter he used back in Wichita.



RF environment at KD0TLB's QTH 10dB/div vertical & 10MHz/div horizontal center frequency = 435 MHz, 100MHz span. 100kHz BW. Yellow trace is spectrum analyzer's baseline noise with no antenna connected. Cyan trace is live sweep. Magenta trace is peak hold

DENVER METRO RFI -- Jeff, KD0TLB, is another ham who has been struggling trying to receive the TV pictures from the Boulder, W0BTV, TV repeater. Jeff lives in north-central Denver just off of Federal Blvd and south of I-76. He has a good location on a hill top. His three story condo is in a good location. From his roof top deck he can look to the north-west and see the Flatiron mountains behind Boulder. The distance from the repeater to his qth is 30 km (18 miles). Radio Mobile rf path prediction says he has a good line of sight path to the repeater and he should receive a -83dBm digital TV signal. But he was only rarely ever able to catch and decode any signals. So on Sept. 14th, Dr. Jim (aka kh6htv) made a house call. He brought along his stethoscope (really his Rigol spectrum analyzer) to make his medical diagnosis. Dr. Don, N0YE, helped out back in Boulder by controlling the TV repeater.

The first test we ran was to check out Jeff's yagi antenna. We had Don put the TV repeater in the analog transmit mode. This gave us a strong, carrier on 421.25MHz to look for on the spectrum analyzer. We did see it and measured it's signal strength at -90dBm. Radio Mobile said it should have been -79dBm. Jim had brought along his old KLM, 6 element yagi antenna which has 10.3dBi gain on TV Ch 57. So swapping out antennas, we then did measure -80dBm of signal strength. Only 1dB off from Radio Mobile's prediction for the analog TV signal. Thus it was obvious, that problem number

one for Jeff was a yagi antenna with 0dB gain on Ch 57. Jeff was using a Cushcraft model A449-6, 6 element yagi. Later checking Cushcraft's specs., they say it has 10.5dBi gain, but only works over a narrow 10 MHz from 440 to 450 MHz. Jeff said "OK looks like I need to buy a new antenna."

The next test was for Don to put the TV repeater back into it's normal mode transmitting digital DVB-T. Don also put a live signal from his ham shack into the repeater to give us live video and audio to look for. Using the good KLM antenna and feeding it into a Hi-Des receiver set to 423 MHz, we hoped to then see a picture. NOTHING ! The Hi-Des receiver said we had a strong signal, but with 0 dB signal to noise ratio.

Connecting the antenna to the spectrum analyzer and looking with a wider span, the above photo shows what we observed as the rf environment at Jeff's qth. Some of this we expected, but some was a surprise. The center frequency on the photo is the center of the 70cm ham band at 435MHz. The region from 435 to 445 is very quiet. 445 to 450 we see some ham FM repeater activity. Then 450 to 470 is full of a lot of commercial business band FM activity with some signals peaking as high as -40dBm. Above 470, we saw several 6 MHz wide digital broadcast TV channels. Below 420 we saw a little bit of FM radio activity in the government band. What we did not expect to find was the high level of really broadband noise which raised the rf background baseline 10 to 20dB above the spectrum analyzer's noise baseline. This started just below 435 and extended down to 360 MHz. What was causing this ? We don't have a clue, but it was certainly clobbering our digital TV receivers.

Fortunately, Jim had also brought along in the Dr's medicine bag, a channel 57, 6 MHz, inter-digital band-pass filter. Once we inserted it in front of the Hi-Des receiver -- BINGO ! -- we immediately saw Don's smiling face and heard him talking. At that point, the Hi-Des S/N meter jumped up to a very solid 15dB. Radio Mobile said the DTV signal strength would be -83dBm and we measured -85dBm. Good agreement.

So, to cure Jeff's problem, two additional items are needed. A good yagi which will work at the bottom end of the band and a Ch 57 band-pass filter. In the meantime, Jeff has already purchased a new M-Squared 440-6SS at HRO-Denver. He is also going to purchase from Don, one of his home-brew 423MHz / 6MHz inter-digital band-pass filters. The next step will be to get Jeff on the air with a DVB-T, 23cm transmitter.

NEW DTV Receiver Design Progress Report

I'm designing a new stand alone scanning DATV repeater receiver. I have the receiver designed but can't get a voltage regulator chip I need. The original backlog from Texas Instruments said production availability is November 2021. Now the revised forecast is August 2022. Some "China" markets say they have some stock but the $1.50 part is now $40 to $60 each. (I need 3 for each receiver). I really don't trust the China/Taiwan/Hong Kong market but now I may have to. I wish I had taken up the offer of regulator parts a couple of months ago when they were still in the 4-5 dollar range. Oh well, it's a huge supply and demand market now!! If I could get parts, I would have a new complete receiver to offer.

Also, my software designer is moving to Vermont and won't be able to continue software development for another month or so. So I am looking for DATV software developers with Java/Python experience that could chip in to help our effort?

Art WA8RMC, ATCO

FEEDBACK:

Great newsletter, Jim. Keep up the good work; it helps us defend our microwave spectrum and our public service conducted at that region.

73, Rick K1CE, QST ARES editor

Dear Jim --- Thank you for another great issue. You always do a fantastic job. Kindest regards, 73, Joan, HB9TYY and Ueli, HB9TTI, Wollerau, Switzerland

DEM 10GHz LNA FEEDBACK:

Hi Jim --- The problem is a cavity resonance with the housing. Absorber typically fixes the problem. I have experimented with narrowing up the cavity by bringing dividers from the lid but that only works with a brass lid where you can easily solder dividers to the lid. The narrower structure then causes the cavity resonance to occur way above the frequency of operation. It also helps to place an isolator on the output port. Hope these things helped. Those original preamps were designed over 10 years ago.

73 de Al, W5LUA, Allen, Texas

Hi-Des Firmware FEEDBACK:

Jim --- The HI-Des firmware issue is nothing new. It has always been an issue. That is why our group in San Diego / Oceanside, California stopped using their items years ago and went with THOR and using receivers from Europe {nothing from China or Taiwan} no issues on our systems network. We didn't want to invest in something that would have to be updated or replaced. You know the saying; do the job right the first time and never revisit the problem twice. Very sorry to hear about the issue that your team and others have experienced.

My work with other program systems engineers here at NASA/JPL has taught me and others how to modify our THOR modulators for the lower bandwidths, and we have it working, but we choose to use 6 MHz as the Colorado DATV repeater group does with great results, The Hi-Des items we acquired in the past have been donated and passed along to our STEAM students.

73 de Mario, KD6ILO, Oceanside, CA

NEWS from San Diego / Oceanside DATV Society:

We have lost five members this year, two relocated to Texas, one (SK) and two have family priorities that take priority over ham radio. but thirty five is not a bad membership count. I download your ATV news letters to our media file server so membership can access it from anywhere and also download. Your newsletter is read out on our weekly telecast on the network and on our cable CATV channel 1960 which is well received by all. (*editor's note: The folks in San Diego seem to have a unique relationship with the local cable TV company. One of the local access channels is dedicated to re-broadcasting their digital ATV repeater's signal. Are there any other ATV groups out there doing the same ? This is a great way to get publicity for ATV and ham radio in general.*)

Our technology programming today (9/19) featured my boss at JPL giving our viewers updates on current projects of interest with our nation's space program. Next week is our interview with SpaceX. This was transmitted on our DATV network as well as our local cable TV channel 1960.

73 de Mario, KD6ILO, Oceanside, CA

THOR MODUALTORS

www.thorbroadcast.com Thor offers 15 different Modulators. The one recommended for amateur use by Mario, KD6ILO is this one. It is the one used by the San Diego / Oceanside ATV group for 6 MHz DVB-T.

Model H-HDMI-RF-PETIT, $470.

Key Features: Multiple Modulation Standards supported -- DVB-T, ISDB-T, ATSC, DTMB, DVB-C J.83A, & QAM J.83B
for DVB-T (Europe broadcast TV & USA ATV) supports 6, 7 & 8 MHz bandwidths, QPSK, 16QAM & 64QAM, code rates from 7/8 to 1/2, guard interval from 1/32 to 1/4, FFT of 2K or 8K
for ATSC (USA broadcast TV) supports 6 MHz bandwidth and 8VSB constellation
for QAM J.83B (USA cable TV) supports 6 MHz bandwidth with 64QAM & 256QAM
A/V Input: HDMI with loop-thru, 720@60p, 1080@50i, 1080@60p
Video Encoding: MPEG2 at 1080@30p max., bit rate from 2 Mbps to 24 Mbps
Audio Encoding: MPEG-1 layer 2, MPEG-2 AAC or AC3, 48kHz sample rate
RF Output: 50 to 950 MHz, programmable in 1 kHz steps.
Programming Control: via Ethernet from PC
Power Requirements: +12Vdc, at 1 Amp

W0BTV Details:

Inputs: 439.25MHz, analog NTSC, VUSB-TV; 441MHz/6MHz BW, DVB-T & 1243MHz/6MHz BW, DVB-T
Outputs: Channel 57 --- 423MHz/6MHz BW, DVB-T, or optional 421.25MHz, analog VUSB-TV. Also, secondary transmitter, FM-TV output on 5.905 GHz (24/7).
Operational details in AN-51a Technical details in AN-53a. 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. 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/kh6htvtvr* or *n0ye*. We use the Boulder ARES (BCARES) 2 meter FM voice repeater for intercom. 146.760 MHz (-600kHz, 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 450. 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/*

ATV HAM ADS

Free advertising space is offered here to ATV hams, ham clubs or ARES groups. List here amateur radio & TV gear **For Sale - or - Want to Buy.**

The following are companies supplying gear used by ATVers on 70cm and the higher microwave bands. These are not paid ads, but are listed for the convenience of our readers.

www.downeastmicrowave.com
USA supplier of LNAs, RF power Amplifiers and Transverters for 2 to 10 GHz.

www.q5signal.com
USA firm, Q5 now sells the 6m to 23cm RF power Amplifiers and Transverters formerly sold by Down East Microwave

www.shop.kuhne-electronic.com
German supplier of LNAs, RF power Amplifiers and Transverters

www.directivesystems.com
USA supplier of Antennas for 50MHz to 10 GHz

www.m2inc.com
USA supplier of Antennas for HF to 2.4 GHz

www.diamondantenna.net
Japan supplier of antennas for HF to 2.4GHz

www.hides.com.tw
Taiwan supplier of DVB-T Modulators and Receivers

www.thorbroadcast.com
USA supplier of Digital TV Modulators

www.gtmedia.cc
China supplier of DVB-S & DVB-T Receivers

www.datv-express.com
USA supplier of DVB-S Receiver and DATV exciter boards for ADAM-PLUTO SDR and Lime SDR web site includes many app. notes on DTV

www.batc.org.uk
U.K. supplier of Portsdown DTV Transmitter & MiniTiouner DTV Receiver

www.shop.usa.canon.com
Japan supplier of high-definition, camcorders

www.mfjenterprises.com
USA supplier of 70cm AM-TV Transmitter

www.atvresearch.com
USA distributor of NTSC VUSB-TV and DTV modulators and receivers

www.kh6htv.com
USA supplier of analog & digital ATV transmitters & receivers,
LNAs and RF power amplifiers