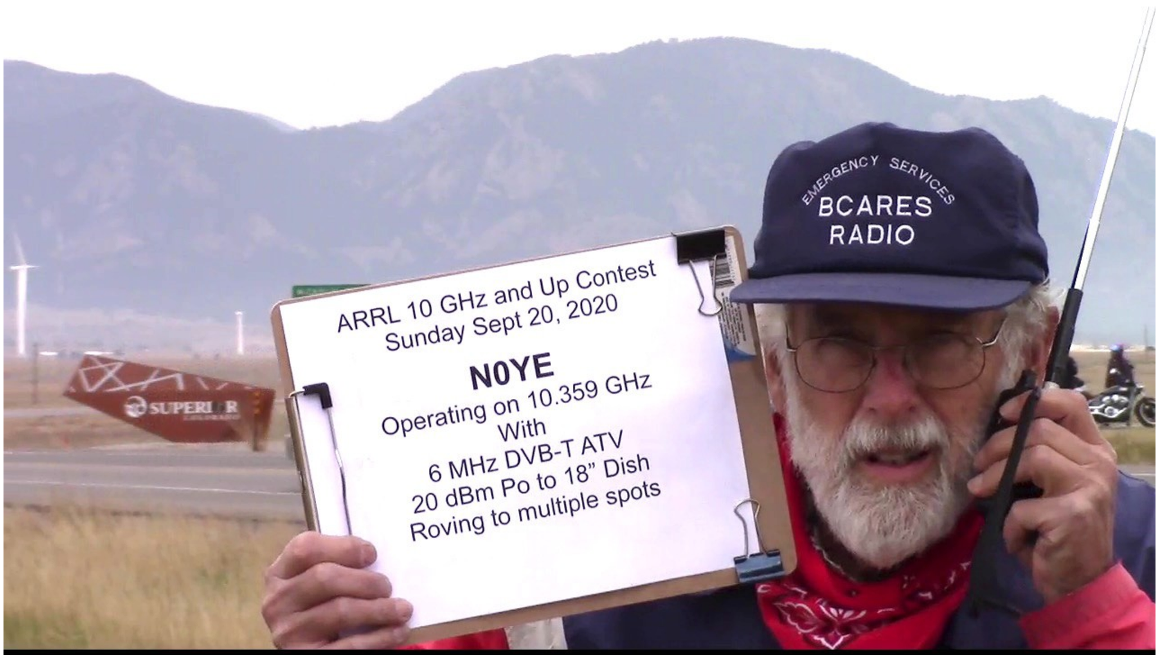
Boulder Amateur Television Club
TV Repeater's REPEATER
October, 2020

BATVC web site: www.kh6htv.com

ATN web site: www.atn-tv.com

ATN The Amateur Television Network

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



NOYE's DVB-T signal as received by KH6HTV - distance was 9.4 miles

ARRL 10 GHz & Up Contest:

The second weekend of this annual ARRL contest was held on Sept. 19th & 20th. Don, N0YE, organized several of the BATVC members to participate with him doing DATV on Sunday the 20th. The contest has historically been one just for SSB & CW contacts. Don wanted to make an impression on the ARRL that ATV has a place also in the contest. So we have submitted to the ARRL, not just the contact logs, but also photos and a write-up about what we accomplished. While we didn't rack up huge totals of contacts, nor distances worked compared to the SSB participants, we demonstrated that DATV is a viable and useful mode on 10 GHz.

The following ATV hams participated: Don, N0YE; Debbie, WB2DVT; Pete, WB2DVS; Bill, AB0MY; Jim, KH6HTV; and Jack, K0HEH. There were a total of four, 10 GHz, DATV rigs deployed. Don and Bill were planning on being rovers setting up at several, widely dispersed locations across the eastern Colorado prairie. The other rigs of WB2DVS/DVT and KH6HTV were at fixed locations. We coordinated our operations using 2 meter FM on the Boulder Amateur Radio Club's 146.70 MHz repeater.

We operated on the 3 cm band on the frequency of 10.359 GHz. We were all using transverter rigs that were originally built to operate on 10 GHz SSB on the calling frequency of 10.368.1 GHz. The transverters consisted of a Frequency West local oscillator (LO), mixers and amplifiers. The rigs had either 2 meter or 70cm IFs. Our center frequency was chosen to be close, but removed by 9 MHz from the SSB calling frequency. This allowed us to still be reasonably close to the rigs' designed IF center frequencies. We were running 6 MHz bandwidth. This then put our DATV signal at least 6 MHz away from the SSB contestants in the contest. All of the rigs were built by Don, N0YE, over the span of many years. For SSB service, they used typically a Yaesu FT-817 as the IF transceiver. Don modified all of them slightly to be able to work with our Hi-Des, DVB-T modulators and receivers. They still were usable as SSB transverters.

We were running Hi-Definition video using the European digital video broadcast standard called DVB-T. We use the USA standard TV channel bandwidth of 6 MHz. Normally for our routine DVB-T transmissions through our 23cm / 70cm DATV repeater, W0BTV, we run 1080P resolution video with QPSK modulation, 7/8 FEC, and 6 Mbps data rate. However, to optimize our chances for success in the 10 GHz contest, we used what we call "aggressive" digital parameters. These were 720P video resolution, 3.5 Mpbs, QPSK, 8K FFT, 1/2 Forward Error Correction (also called code rate) and 1/16 guard interval. Doing so, buys us an additional 3 to 4 dB in sensitivity. The threshold for a perfect P5 digital picture with no freeze frames or drop-outs is a signal to noise ratio of 8 dB for our normal parameters. The minimum S/N drops to 5 dB for the aggressive parameters.

The typical transmitter power levels were about +17 to +23dBm (50-200 mW). We all were using dish antennas of either 12" or 18" diameter. Dish antenna gains ranged from +25dBi to +28dBi. Typical receiver sensitivities were of the order of -96dBm (normal parameters) and -100dBm (aggressive parameters).

Three of the four stations operated on the flat, rolling prairie of eastern Colorado. One station was set up on the side of Flagstaff mountain on the west side of Boulder, Colorado. Don, N0YE, set up on CO-128 & Indiana. Pete, WB2DVS & Debbie, WB2DVT set up on CO-128 near the NREL labs. Jim, KH6HTV & Jack, K0HEH set up at Panorama Point on Flagstaff mountain. Bill, ABOMY, started out first at the CO-128 - NREL site with Pete & Debbie. Bill then later relocated as a rover north first to Gunbarrel Hill & Lookout Road. He finished the morning even farther north at the far north end of 75th St. at the Rabbit mountain open space park.

Debbie, WB2DVT, with her and Pete's 10 GHz rig at the CO-128 & NREL site

Two way DATV QSOs were exchanged between all of the sites. Photos of monitor screens were taken to document the contacts. Also using the DVR capability in the Hi-Des receivers, several of the contacts were recorded as live videos. The photos shown here were taken from these DVR recordings. The greatest distance we achieved in the contest was 22.1 miles (35.5 km). This was between AB0MY at Rabbit mtn. and WB2DVS/WB2DVT at NREL.

Bill, ABOMY, aiming his antenna on Gunbarrel Hill towards Jim, KH6HTV, on Flagstaff mtn. Photo from video received by Jim & Jack. Distance = 8.6 miles

Dr. Murphy, of Murphy's Law fame, made an un-invited appearance again. Don after his first contacts, started blowing fuses with his rig and was never able to go roving as planned. Jim forgot early on to attach his modulator to the 20dB pre-driver amplifier for his transmitter. Thus as a result he was running ultra-QRP of only -3dBm (0.5 mW) for his early contacts. After realizing his error, he made the proper connections and boosted his rf power up to +17dBm (50mW). But even with the measly -3dBm he still managed to make two P5 contacts.

KH6HTV on Flagstaff mtn. to WB2DVS at NREL. Distance = 7.8 miles

We all were using the Hi-Des model HV-110, DVB-T receivers for the IF receiver. This receiver has the very nice feature of an accurate, built-in, rf power meter. Activating the on-screen-display (OSD) shows the transmitting station call sign, frequency/bandwidth, received signal strength in dBm and signal/noise ratio in dB. The S meter reading in dBm is accurate to within 1dB in the HV-110. Thus knowing the transverter RF in to IF out receiver gain, one can accurately determine the true received signal strength. Thus, instead of simply reporting you have an S9, or P5, we are able to give true dBm reports, plus a S/N report.

We have found the free, on-line computer program, ***Radio Mobile***, to be very accurate for predicting rf coverage maps and point-to-point rf paths for 70cm and 23cm. We were interested to know how well it might work at the higher microwave frequencies. Having accurate S meter readings allowed us to do such a comparison between measured and predicted received signal strengths. The table on the next page lists all of the pertinent data for all of the contest QSOs. The final results are in the two columns on the right reporting the Radio Mobile predictions and the measured results in dBm. There was very good agreement in some cases.

Tabulation of Results from ARRL 10GHz & Up Contest for BATVC, DVB-T Contacts

Prepared by Jim, KH6HTV, 20 Sept 2020

Receive Station	Receive Site	Transmit Station	Transmit Site	Distance	Time MDT	Received OSD Pwr	Rec S/N	Xmit Pwr	Xmit Ant	Xmit Coax	Rcv Ant	Rcv Coax	Tran Rcvr Gain	**Radio Mobile Received Power**	**Measured Received Power**
KH6HTV	Flagstaff	WB2DVS	NREL	12.5km	9:20	-71dBm	18dB	24dBm	25dBi	0.1dB	28dBi	1.5dB	11dB	**-69dBm**	**-81dBm**
KH6HTV	Flagstaff	AB0MY	NREL	12.5km	9:35	-65dBm	23dB	17dBm	25dBi	0.1dB	28dBi	1.5dB	11dB	**-76dBm**	**-76dBm**
KH6HTV	Flagstaff	N0YE	Indiana	15.1km	10:01	-64dBm	21dB	18dBm	28dBi	2dB	28dBi	1.5dB	11dB	**-74dBm**	**-75dBm**
KH6HTV	Flagstaff	N0YE	Indiana	15.1km	10:05	-76dBm	14dB	18dBm	28dBi	2dB	17dBi	1.5dB	11dB	**-85dBm**	**-87dBm**
KH6HTV	Flagstaff	AB0MY	Gunbarrel	13.8km	10:27	-58dBm	17dB	17dBm	25dBi	0.1dB	28dBi	1.5dB	11dB	**-73dBm**	**-69dBm**
KH6HTV	Flagstaff	AB0MY	75 st	27km	11:30	-74dBm	16dB	17dBm	25dBi	0.1dB	28dBi	1.5dB	11dB	**-77dBm**	**-85dBm**
N0YE	Indiana	KH6HTV	Flagstaff	15.1km	10:00	-67dBm	20dB	-3dBm	28dBi	1.5dB	28dBi	2dB	22dB	**-95dBm**	**-89dBm**
N0YE	Indiana	WB2DVS	NREL	3.6km	10:14	-71dBm	10dB	24dBm	25dBi	0.1dB	28dBi	2dB	22dB	**-70dBm**	**-93dBm**
N0YE	Indiana	AB0MY	NREL	3.6km	09:40	-61dBm	23dB	17dBm	25dBi	0.1dB	28dBi	2dB	22dB	**-77dBm**	**-83dBm**
WB2DVS	NREL	N0YE	Indiana	3.6km	9:09	-59dBm	12dB	18dBm	28dBi	2dB	25dBi	0.1db	8.5dB	**-75.5dBm**	**-67.5dBm**
WB2DVS	NREL	AB0MY	Gunbarrel	18.2km	10:44	-77dBm	19dB	17dBm	25dBi	0.1dB	25dBi	0.1dB	8.5dB	**-83.6dBm**	**-85.5dBm**
WB2DVS	NREL	KH6HTV	Flagstaff	12.5km	11:13	-62dBm	21dB	17dBm	28dBi	1.5dB	25dBi	0.1dB	8.5dB	**-75.8dBm**	**-70.5dBm**
WB2DVS	NREL	AB0MY	75 st	35.5km	11:37	-85dBm	12dB	17dBm	25dBm	0.1dB	25dBi	0.1dB	8.5dB	**-85.2dBm**	**-93.5dBm**
AB0MY	NREL	N0YE	Indiana	3.6km	0909	-41dBm	+13	18dBm	28dBi	2dB	25dBi	0.1dB	25dB	**-76dBm**	**-66dBm**
AB0MY	NREL	KH6HTV	Flagstaff	12.5km	0930	-66dBm	+15	-3dBm	28dBi	1.5dB	25dBi	0.1dB	25dB	**-96dBm**	**-91dBm**
AB0MY	Gunbarrel	KH6HTV	Flagstaff	13.8km	1040	-60dBm	+22	-3dBm	28dBi	1.5dB	25dBi	0.1dB	25dB	**-93dBm**	**-85dBm**
AB0MY	Gunbarrel	WB2DVS	NREL	18.2km	1051	-38dBm	+23	24dBm	25dBi	0.1dB	25dBi	0.1dB	25dB	**-77dBm**	**-63dBm**
AB0MY	75 St.	WB2DVS	NREL	35.5km	1144	-54dBm	+23	24dBm	25dBi	0.1dB	25dBi	0.1dB	25dB	**-78dBm**	**-79dBm**
AB0MY	75 St	KH6HTV	Flagstaff	27km	1202	-58dBm	+22	17dBm	28dBi	1.5dB	25dBi	0.1dB	25dB	**-76dBm**	**-83dBm**

Notes:
1. Results highlighted in yellow are for close agreement, within 2dB, of Radio Mobile computer calculations and actual measued received power.
2. If the measured receive power is less than that predicted by Radio Mobile, it is no doubt due to antenna mis-alignment, or additional vegetation in path

Table II -- List of Sites visited for Contest

Site Name	Latitude	Longitude	Elevation	Grid Square
CO-128 - NREL	39º 54' 50" N	105º 12' 33"W	5,965 ft.	DM79JV
CO-128, Indiana St.	39º 54' 36" N	105º 10' 02" W	5,853 ft.	DM79JV
Flagstaff Mtn. - Panorama Pt.	40º 00' 22" N	105º 17' 33" W	5,968 ft.	DN70IA
Gunbarrel Hill - Lookout Rd.	40º 04' 22" N	105º 09' 20" W	5,410 ft.	DN70KB
Rabbit Mtn. - 75th St.	40º 13' 57" N	105º 10' 40" W	5,282 ft.	DN70JF

To read more about ***Radio Mobile***, we refer you to the KH6HTV Video application note, AN-33a, "TV Propagation". It is available as a free, .pdf download from www.kh6htv.com

Comparisons of Microwave SSB vs. DATV

Jim Andrews, KH6HTV

Recent experiences in the ARRL 10 GHz & Up contest have shown significant differences in propagation characteristics between 10GHz, single side-band (SSB) voice and digital amateur television (DATV) and in particular DVB-T. So what are the major differences and how do these impact our ability to make contacts ?

Bandwidth: This is the biggest difference. SSB uses only 3 kHz of bandwidth. Conventional, live, TV uses 6 MHz of bandwidth. Even the more recent experiments with compressed video, etc. have pushed down the bandwidth requirements but they still require several 100s of kHz or 1 or 2 MHz of bandwidth.

Bandwidth mainly impacts the weakest signal that can be detected. There is a fundamental noise floor set by the equation.

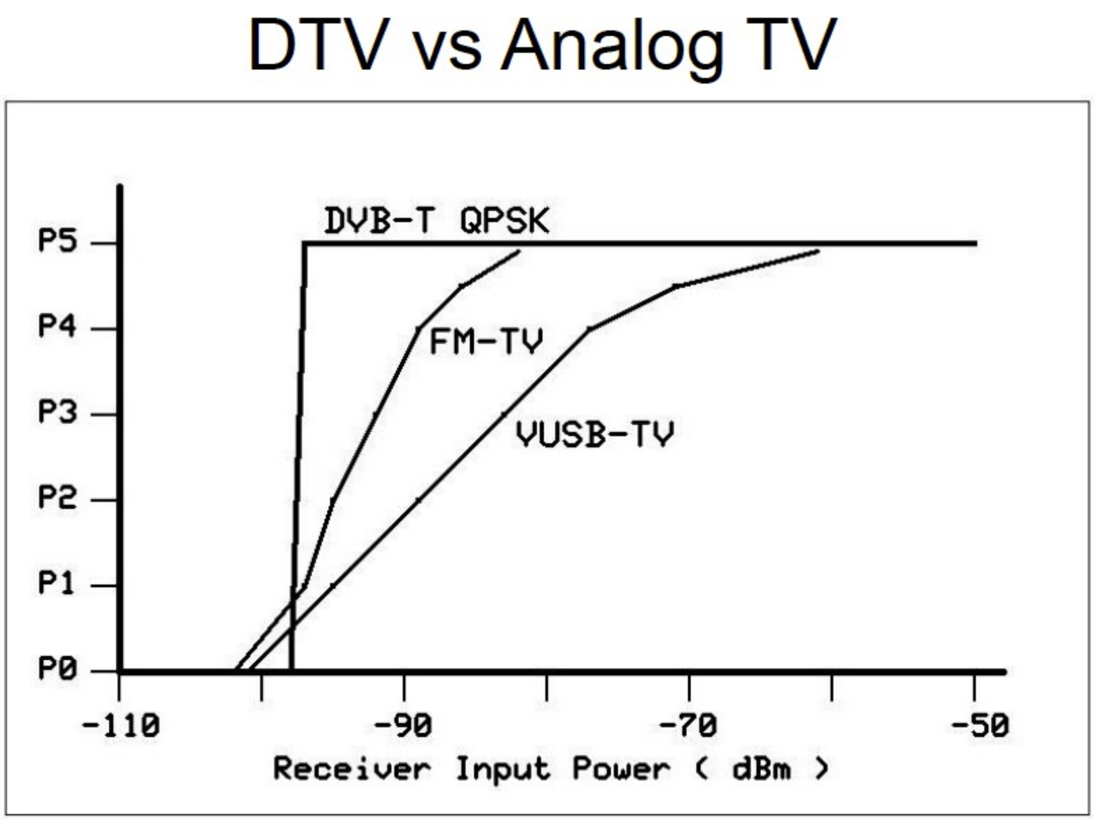
$$P(noise) = k_B * T * B$$

where k_B is the Boltzmann constant, T is the absolute temperature (^{o} K), and B is the bandwidth. T = 290^o K (20^o C) is normal room temperature.

Thus for a 3 kHz, SSB bandwidth, the thermal noise floor is -139.2 dBm. For our typical 6 MHz, TV bandwidth, it is -106.1 dBm. This is a really big difference of 33 dB ! Everything else being similar in transmitters, receivers and antennas, we should never expect TV to match SSB in distance, etc.

Required Signal to Noise Ratio: Most hams would agree that they need a minimum of 10 dB s/n for SSB signals to achieve reasonably accurate copy. Thus for a perfect receiver, this would mean the required SSB signal level needs to be at least -129dBm or stronger.

For analog ATV with either AM-TV or VUSB-TV modulation, a 40 dB s/n is required for a perfect, P5, picture. Lower s/n ratios result in increasing amounts of snow in the picture. An acceptable, P4 picture requires 24dB s/n. A very poor, P2, picture still requires 12dB s/n. For analog, FM-TV, the fm quieting effect improves things over AM. We know this from our experience with FM voice on 2 meters. FM requires 20dB s/n for perfect P5, 13dB for P4 and 7dB for P2. For digital TV, and in particular, for DVB-T, we have found that with normal digital parameters of QPSK modulation and 5/6 forward error correction, we can achieve perfect, P5 pictures down to an 8 dB s/n. With aggressive FEC encoding of 1/2, we can push this down to 5 dB s/n.



I have made some measurements on a Hi-Des model HV-110 receiver to demonstrate some typical numbers for 6 MHz bandwidth, DVB-T. These numbers are for "normal" parameters of 5/6 FEC, 1/16 guard interval, 8K FFT, 1080P resolution.
64QAM: The lower limit digital threshold is reached at -83dBm with 21dB s/n
16QAM: The digital threshold is reached at -88dBm with 15dB s/n
QPSK: The digital threshold is reached at -95dBm with 8dB s/n
Then adding a low noise (0.5dB NF) pre-amp in front of the HV-110 receiver, the digital threshold is pushed down further to -99dB, again with an 8dB s/n. If we are at 8 dB s/n, this then implies that the noise floor of this preamp enhanced receiver is about -107dBm. This is consistent within measurement accuracy of the calculated thermal noise floor of -106dBm

Transmitter Power: A SSB transmitter is rated in terms of it's Peak-Envelope-Power (PEP). With proper drive adjustment, the voice peaks just barely reach up to the max. output power rating of the transmitter. For an AM-TV, or VUSB-TV transmitter, it is again rated in terms of PEP, measured on the sync tips. Again the sync reaches up to the max. output power rating of the transmitter. For an FM-TV transmitter, the output power is constant and is pushed to the max. output power of the transmitter. Thus all of these transmitters will essentially have the same output power rating.

For digital TV, the situation is different. The modulating signal appears like random noise with peaks and valleys. It can only be characterized by it's RMS power. The transmitter must be able to handle peaks in the noise like waveform that are considerably stronger than the RMS value. We have found that for a QPSK, DVB-T transmitter, we need to provide at least 8 to 10dB of head-room to accommodate the peaks. If we clip off the peaks, we rapidly destroy the Bit Error Rate and the receiver can no longer decode the digital signal. Thus the power rating for a DVB-T transmitter will be at least -8dB below the max. output power rating of the transmitter.

35-40dB Difference: For identical transmitter peak output power ratings, 6 MHz DATV compared to SSB, the difference in expected propagation results will be about 35 to 40dB worse. 30dB for receiver bandwidth threshold limits (-129dBm vs. -99dBm) and another 8 to 10dB for head-room allowance in transmitter power ratings. The result is about the same between DATV and FM-TV. This is because to have a P5 picture requires about an 8-10dB stronger received FM signal, but this is offset by the FM transmitter being 8-10dB stronger. The differences become even worse for analog AM-TV which requires a much stronger -60dBm received signal for a P5 picture.

Frequency West LO (left) & ADF-5355 synthesizer (right)

LOs: The requirements on Local Oscillators (LOs) are quite different for SSB vs. ATV. For SSB with it's very narrow bandwidth of only 3 kHz at an exceeding high rf frequency of 10GHz -- frequency accuracy is the most stringent requirement. For ATV, be it either analog or digital, this is not the case. For example, DVB-T can tolerate several hundred kHz of frequency inaccuracy and still work. What causes LO problems for DVB-T is phase noise. Excessive phase noise and the receiver will not demodulate the signal at all, or for weak rf signals, even moderate phase noise will degrade the receiver's digital threshold sensitivity.

The photo shows two typical LOs used for radio amateur microwaves. The one on the left is the classical, Frequency West brick LO, that has been used for many years by microwave SSBers. The Freq. West brick consists of a free running, L band (1-2GHz), power oscillator phase locked to an oven controlled 100 MHz crystal oscillator. The L band oscillator then drives a step recovery diode (SRD) in a high Q, band-pass filter. The filter is tuned to the desired microwave output frequency. The Freq. West brick has very good phase noise, but it suffers from thermal drift. Thus for SSB service, they need to be turned on and warm up for at least 1/2 hour prior to use.

More recently frequency synthesizers from Analog Devices have now reached up to X band. The photo shows one such unit using the ADF-5355 device which covers from 54 MHz to 13.8GHz. It sells for about $160. I have found it to be extremely accurate and free from thermal drift. Mine is only off by 10 kHz at 10.3 GHz. I have found it very useful as a frequency marker to locate the SSB calling frequency of 10.368.1 GHz. However, it has a serious drawback of excessive phase noise which makes it unusable as an LO for DVB-T service. I thus was forced to use a Freq. West brick as my LO in my 5 & 10 GHz, DVB-T transverters. I suspect that the ADF-5355 would work ok as an LO in a SSB transverter.

Antenna Pointing: Experience has shown that for "Local" SSB contacts, antenna pointing is not a major issue. Many times, we can have round-table QSOs on 10 GHz SSB without exactly pointing our dish antennas at any one particular ham. Granted the S meter readings are all over the place from S0 to S9+40dB, but we still carry on good QSOs. Not so with ATV on 10 GHz. Even for "local" contacts, we do need to have our dishes accurately pointed. That 35-40dB difference between modes makes all the difference in the world to antenna pointing requirements.

39 Mile DX Report on new 5.9 GHz, FM-TV Beacon

Gary, WB5PJB, from way down south in Castle Rock has sent us this DX report on our new beacon transmitter. "I finally had time to stop by Daniel's Park here in Douglas

County this afternoon to see if I could receive the 5.905 GHz beacon from W0BTV. Sure enough, I was able to snag the signal with the 30 dBi, 5 GHz dish. I would say that's not bad for 2 Watts of broadband ATV at 5.9 GHz into an omni-directional antenna at the transmitter site. That is a 38.8 mile (62.4 km) path. And, just for grins, I thought I would see what the signal was like using vertical polarization on my receive end (the dish has dual feeds - vertical and horizontal) Still received a little something, but as you can see in the photo on the right, opposite polarization is bad. I will try some other locations as time permits. Thanks for getting the beacon running! "

OK BATVC guys & gals -- Gary has set the bar quite high. Can any of you beat Gary's distance record for receiving our new 5.9 GHz beacon signal ?

Gary's 30dBi, 5 GHz dish antenna and the FM-TV receiver connected to the horizontal polarization feed.

GPS Disciplined Oscillator

Over the summer I acquired a device called a GPS Disciplined Oscillator (GPSDO) for use in setting my shack's clocks and my rig's frequency references. A GPSDO uses the very accurate time signals available from GPS, GLONASS or other satellite-based time/position services to generate reference frequencies and timing signals which are accurate to a few parts per billion. Typically, a GPSDO locks onto the GPS constellation and uses the GPS signals to control its own internal oscillator. Once locked, the device outputs an extremely accurate sine wave at a chosen frequency, usually 10 MHz.

My new IC-9700, and most other new rigs, have a “Reference In” SMA jack on their rear panel that allows them to be connected to a time or frequency standard such as a GPSDO for more accurate generation of RF frequencies within the rig. The “REF IN” jack is circled in red. Usually, the 10 MHz signal from a GPSDO is used as reference, and the rig derives all its other frequencies and timing from this extremely accurate 10 MHz signal. This will ensure that the rig is right on frequency. The IC-9700 can achieve frequency accuracy within 1 Hz!

The reason I purchased a GPSDO is that I plan to do some EME operation on 1296 MHz in the 23 cm amateur band. EME on 23 cm uses the JT65 digital mode, and signals need to have very good accuracy. Hence my desire to use a GPSDO with my rig.

A decade ago, devices like GPSDOs cost on the order of US$20,000 to $30,000. In another miracle of modernization, miniaturization and digital signal processing, a low-end GPSDO can be purchased today for under US$100, by searching on e-bay for example. These low-end devices are not particularly accurate, although they perform like $20,000 devices of a decade ago. For about another US$100, one can purchase much more accurate GPSDOs from companies that specialize in this type of equipment. I decided to purchase a higher-quality unit. I avoided the cheap-looking US$91 eBay devices and instead bought a “Mini Precision GPS Reference Clock” from a UK firm called “Leo Bodnar Electronics” (www.leobodnar.com) for 99 ₤, or about C$172.

This unit measures 5.5 x 4 cm and is powered by 5 VDC via a USB cable. It generates an accurate output signal at any user-selectable frequency from 400 Hz to 810 MHz. Accuracy is a few parts per billion. I set the output to 10 MHz and use this signal with the “Reference In” SMA jack on my IC-9700.

The company is very well known within the VHF/UHF amateur community, and also supplies lots of government agencies and research labs. I thought it better to purchase a unit from a company with some validated technical expertise and recognition in the field.
I tested the unit I received with the calibrated test equipment in my basement lab and found that its output was extremely accurate. In fact, the tiny differences I observed in frequency were likely due to inaccuracies in my test equipment, rather than in the GPSDO unit itself!to consider adding a GPSDO device to your station.If you are looking for an extremely accurate frequency standard and have a newer rig with a “Reference In” jack, then you might want to consider adding a GPSDO device to your station.

73 - Kevin VE7ZD / KN7Q

From Surrey, B.C. Amateur Radio Club "Communicator", Sept-Oct. 2020, pp. 20-22. reprinted with permission from the author. To view the complete newsletter and all previous issues, go to --- https://ve7sar.blogspot.com/

FEEDBACK: Jim -- Pass this along to the sync detector guys. If you use a LM1881 sync seperator chip ahead of the LM357 you get a lower parts count and better sync detection. Been using this combo since 1983. 73 de Richard, WD0GIV

W0BTV Details: Inputs: 439.25MHz, analog NTSC, VUSB-TV; 441MHz/6MHz BW, DVB-T & 1243MHz/6MHz BW, DVB-T Output: 423MHz/6MHz BW, DVB-T, or optional 421.25MHz, analog VUSB-TV. Operational details in AN-51a Technical details in AN-53a. Available at: https://kh6htv.com/application-notes/ We hold an ATV net on Thursday afternoon at 3 pm local Mountain time. ATV nets are streamed live using the British Amateur TV Club's server, via: https://batc.org.uk/live/kh6htvtvr or n0ye.

Newsletter Details: This is a free newsletter distributed electronically via e-mail to ATV hams. The distribution list has now grown to over 400. 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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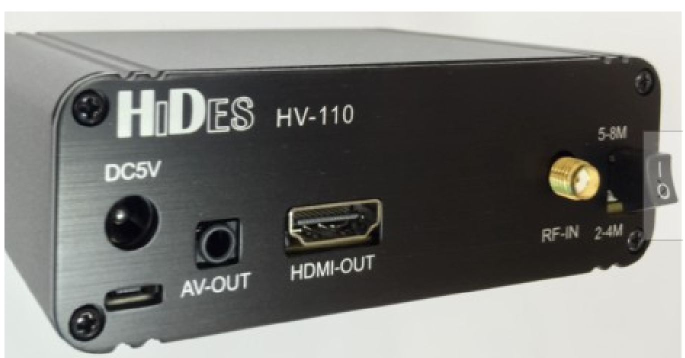

GOOD NEWS from Hi-Des !

We have just received this e-mail from Calvin at Hi-Des

"We have HV-110 available on eBay again. I am sorry it took us some time for the production process. The new HV-110 can support DC 12V now. We will ship it by air mail from now on to lower the price to $99. It may take 10~14 days.
Here is the eBay link; https://www.ebay.com/itm/324313346122
Best regards, Calvin Yang (calvin@hides.com.tw)

(note: The HV-110 is a DVB-T receiver and works from 170 to 950 MHz)