Boulder Amateur Television Club
TV Repeater's REPEATER
October, 2019

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

The 10 GHz, 6 km path as seen from N0YE, qth to 30th & Walnut parking garage in Boulder

BOULDER DATV Reaches 10 GHz !

A Video DVB-T, 10 GHz transmission was done today (9/3/2019) over a 6.0 km distance from the N0YE QTH to the garage next to Macys in Boulder Colorado. The distance was

6.0 km. The received video was P5 quality. The video content, a slide show with motion, was received without interruption. According to the receiver the received signal was strong as shown on one of the attached pictures. The path is line of sight. The position of the receiver dish was critical. Moving the dish off the peak signal by only a few degrees lost the signal.

The 10 Ghz equipment is re-purposed subsystems and systems that I have used in the ARRL 10 GHz and Up, SSB contests over the years.

The transmitter is a 10 GHz transverter with a 1 foot dish attached via wave guide. The input to the transverter was a 441 MHz DVB-T video signal out of the HV100 modulator. The HV100 output was 1 dBm. The output of the transverter was 15 dBm at 10.359 GHz. The LO in the transverter is high side operating at 10.800 GHz. The transverter was not modified and used only as a transmitter. The receiver capability was not used in this exercise. Modifications to the transmitter may be done later for more power when needed. The gain of the dish is about 27 dB.

The receiver is a 10 GHz down converter with an LO feeding a balanced mixer capable of rejecting the upper sideband and passing only the lower side band. The LO is high side operating at 10.800 GHz. The front end of the receiver has a preamp with a NF of 1.8 dB and gain of about 15 dB. The receiver dish was an 18 inch off-center fed dish. The gain of the dish is about 32 dB.

73 de Don, N0YE


N0YE, 10GHz Transmitter

N0YE, 10GHz Receiver

The view back towards the transmitter

The received 10GHz, DVB-T signal

The logical question is: "What is next?" I do not know. I have had this on the *"to-do"* list to get DVB-T on 10 GHz for quite some time now. I have now put DVB-T on the bands from 70 cm thru 10 GHz. (70, 33, 23, 13, 9, 5 & 3cm) And I have done so transmitting each time a modest distance of 6 km as a demo that the effort was more than across the work bench. So it may be appropriate to ask the question back at you - "What is next?" (*editor's note -- OK Don, keep going up, 24, 47GHz, etc.*)

This 10 GHz effort was one way. Maybe a two way 10 GHz contact would be appropriate. I have more 10 GHz hardware and I might make two rigs operate with transmit and receive using DVB-T. And of course, make contacts at distances greater than 6 km. Knowing Jim, he would say go to DN71NB (Wyoming border). Jim? There would not be enough chasers to make a valid activation of a summit, four or more are needed.

I do have a 10 GHz 10w TWT. My impression is that TWTs are pretty linear and should give me some power before going too nonlinear for DVB-T. Do we need that much power? Do I have the parts to make a third 10 GHz DVB-T rig?? I do have some dishes that are 30 inches and bigger.

So WHATs NEXT? 73 de Don

Arapahoe County ARES -- DATV:

On Thursday evening, Sept. 12th, Jim, KH6HTV, presented a talk to the Arapahoe County ARES group on DATV. His talk was entitled "Amateur High Definition Digital Television". The talk covered: the history and time line of the development of TV; amateur DTV timeline; TV in ARES, in particular it's use in Boulder county (BCARES); limitations of analog TV; DVB-T; basics of assembling an amateur DVB-T system; characteristics of various UHF & microwave bands for TV; and DTV repeaters. A .pdf copy of Jim's power-point slides is available from: https://kh6htv.com/application-notes/

NEWS from other ATV Groups:

ATV NEWS from San Diego: To all, greetings on this Labor Day weekend. Since like many whom are employed or busy with other matters of importance as Amateur Radio TV users and operators we do not always have time to participate or watch programs or events being transmitted on our systems. As one of three(3) SysOp's and program manger for our repeater system we like to share programs, events and technical nets with our group. Especially when we miss a great net with awesome participation. We do up-link other ATV networks from the U.S.A and from abroad, one of our favorites is the weekend technical net on GB3SQ, with host Colin [G4KLB]. We did link up and had a full-duplex participation with most of the BATC membership on the net, we were lucky as the audio and video link up was working in our favor this past Saturday. W8BI ATV repeater club had a great program hosted my David, AH2AR with Reuben, W8GUC. In the past I'd also link up by audio via "Echolink" using my simplex node on 2m [KD6ILO-L] Used also with WW7ATS and W6CX. Since our digital repeater matrix controller has a built in DVR we re-transmitted Davids presentation program on our system in 1080p HD on 23cm test frequency {DVB-S2} and what a great video from W8BI via IP to repeater. We had a great time with our group today at our homes watching TV on Amateur TV. We are also bringing in K6BEN in San Jose. Ben has been told of our plans and he said.quote; "Ok Mario thanks a lot that'ill be nice so others can watch". As technology improves in this mode of operations, our systems can be upgraded and continue to support DATV. I've attach a short video and picture from our monitor on site. 73 to all have a very safe and pleasant week ahead. I'm going on a small break.

73 For the OCS_DV Repeater Group - Mario KD6ILO (e-mail 9/2/19)

S. Calif - ATN: Jim, Thank you for the last two newsletters. Well done and lots of good news! I just finished reading your article in QST. Thank you for getting ATV front and center in the Amateur Radio Community! I am glad you are getting some response.

73, Mike WA6SVT (e-mail 9/3/19)

Aloha Jim! Thank YOU again for another FABULOUS newsletter. Wonderful job. I am very excited to see our ATV community responding to both your QST article and your newsletters. It is so exciting to see our ATV group "re-igniting" the ATV interest, especially towards DATV.

Mike Collis - WA6SVT and I are planning to transition another ATN repeater (Mt. Wilson) to DATV (DVB-T) Once we acquire the needed gear, we will install the system and begin testing.

The ATN is now streaming our repeater systems on our YouTube channel on 720p HD. Immediate plans are to link our ATV chapters throughout the country on our network, especially during their weekly nets.

Take care Jim and THANK YOU so much for all your hard work and dedication to our ATV community. You are a ROCKSTAR.

73, ~Roland - KC6JPG (e-mail 9/3/19)

Norris Nahman, W6ETK, Silent Key

I am sad to report the passing of Norris Nahman on the 6th of September. Bill McCaa, K0RZ, and I had a very special relationship with Norris. He was our graduate school professor at the University of Kansas in the 1960s, our boss at the National Bureau of Standards here in Boulder, and our life long friend. Norris is the reason why Bill and I now live in Boulder. In 1966, Norris was offered a job at NBS to start a whole new program in the field of very fast (nanosecond and faster), electrical pulse measurements. As the nucleus of his new program, he brought along three of his KU grad students, Charlie Manney, Bill and myself. We all three earned our Ph.D. degrees under Norris while working at NBS. In addition, after Norris retired from NBS in 1985, I then hired him to be the vice-president of my company, Picosecond Pulse Labs. Norris worked for me until 1991, when he took his second retirement. Afterwards, he continued serving PSPL as a member of the board of directors, along with Bill. Also, three of Norris' four children, Scott, Vicki and Vance, also worked at various times for PSPL. Vance eventually became the CEO of PSPL prior to it being sold to Tektronix in 2014. The Nahman and Andrews families were very close. Norris always was considered as my second father and the surrogate grandfather for Janet's and my children.

Norris was born in 1925 and raised in San Francisco, California. While in high school, Norris worked part-time in an electrical shop repairing and rewinding motors. He served in the merchant marine as an electrician in the Pacific during WWII. Sailing all over the Pacific during the war delivering vital war supplies, he was present at many invasions. This included being strafed by Japanese war planes and kamikaze attacks at Okinawa. After the war, Norris attended California Polytechnic State University in San Luis Obispo where he received his B.S. in electrical engineering degree. He then was a student at Stanford obtaining his masters degree in EE. He then took a job in San Francisco with the Robert Dollar - Heintz & Kaufman radio company. Norris designed some radio circuits for H&K and also worked in the Navy shipyard installing radios. A good history of Dollar - H&K radio is found at:

http://www.radiomarine.org/gallery/show?keyword=RDS&panel=pab1_7

When the Korean war broke out, Norris was drafted into the Army. Fortunately, the Army recognized his scientific abilities and instead of sending him as a rifleman to Korea, they assigned him to work at the Army Security Agency, which later became NSA. At ASA, Norris worked on developing very high speed computers. For the early 50s, vacuum tube computers, 10 MHz was high speed. While there, he became involved in how to measure high speed, nanosecond pulses. Thus Norris' nick-name from his initials, NSN, became "Nano Second" Nahman. This research lead he and co-worker Robert Wigington to publish in 1957 in the very prestigious Proceedings of the IRE, his most important technical paper, "Transient Analysis of Coaxial Cables Considering Skin Effect". Over succeeding years, Norris and his graduate students published many more significant technical papers, primarily in the field of high speed pulse electronics and measurements. Norris was recognized by the IEEE as a Fellow, honoring his leadership in the field of nanosecond and picosecond pulse metrology.

After the Army, Norris left NSA and moved to Lawrence, Kansas, where he joined the faculty of the University of Kansas in the Electrical Engineering dept. Norris obtained his Ph.D. degree from KU. He brought to KU from NSA a large research grant which enabled him to set up the Electronics Research Lab, ERL, with project Jayhawk. ERL specialized in high speed electrical pulse research. It was at KU and ERL, where both Bill and I became graduate students of Norris. He was our advisor for both our Masters and Ph.D. degrees. After moving to Boulder and NBS in 1966, Norris became an adjunct professor on the University of Colorado, EE dept. faculty. In the mid-70s, for a couple of years, he was the EE dept. chairman for the University of Toledo. He mentored a lot of graduate students over the years.

Since his early days in San Francisco, Norris was always an amateur radio enthusiast. It was his encouragement which got me into ham radio. He even set me up with my first novice rig. A 40 meter transmittter and receiver he had built from surplus WWII parts. Norris held the Extra class license. Norris' call sign was W6ETK. His primary love was HF radio and using CW, Morse Code. The ham radio way of saying he has passed on, is to say he is a "Silent Key". For Norris, this is especially true. Bill, K0RZ, is keeping his old Morse code key as a memento.

73 & 88s Norris-SK - de - Jim, KH6HTV & Bill, K0RZ

BARCfest - 2019: The Boulder Amateur Radio Club (BARC) will again be holding it's annual swapfest on Sunday, October 6th. The location is the same as year's past, i.e. the Boulder County Fairgrounds in Longmont, Hover Rd. & Nelson Rd. Doors open at 8 am. Admission is $5 and table rentals are $10. BATVC will have a display table there. This time, we hope to put up a yagi antenna outside the west doors and receive a picture from the TV repeater as part of our demo. We will again use the nice banner, Roger and Naomi provided last year.

Application Note AN-49

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70 cm, DVB-T, Television Repeater with a Duplexer

Jim Andrews, KH6HTV

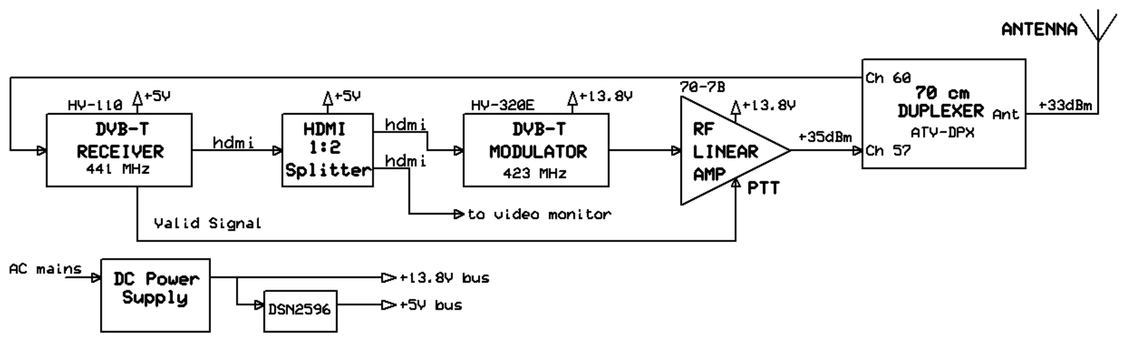

Fig. 1 70 cm, Digital TV Repeater with Duplexer, block diagram.

Application Note, AN-23, in 2015, has previously discussed the basics of what is required to build a Digital TV (DTV) repeater. More recently, AN-23e (2019) added a section on using a Duplexer to permit using a single, common antenna for both receive and transmit. Most TV repeaters are built using separate antennas for receive and transmit along with very sharp cut-off band-pass filters on both the receiver and transmitter. Duplexers for TV service are more difficult to build, and are more costly. They serve the same function as the Rx/Tx band-pass filters but include internal cross coupling between the two filters. A TV duplexer will not give as much isolation as the separate Rx/Tx BPFs & two antenna arrangement. Thus a duplexer will typically work only with lower powered transmitters. This application note gives the details on a low power, 70cm TV repeater built using a TV Duplexer.

Fig. 1 above is the basic block diagram of 2 watt, 70cm, TV repeater built with a duplexer. The major components used in this repeater were: Hi-Des model HV-110 Receiver, Hi-Des model HV-320E Modulator. KH6HTV Video model 70-7B RF Linear Power Amplifier and KH6HTV Video model ATV-DPX Duplexer.

The key element in this repeater is the Duplexer, Fig. 2. All of the isolation between the receiver and transmitter is provided by the duplexer. Fig. 3 shows the measured S

Fig. 2 KH6HTV Video model ATV-DPX, 70cm, TV Duplexer

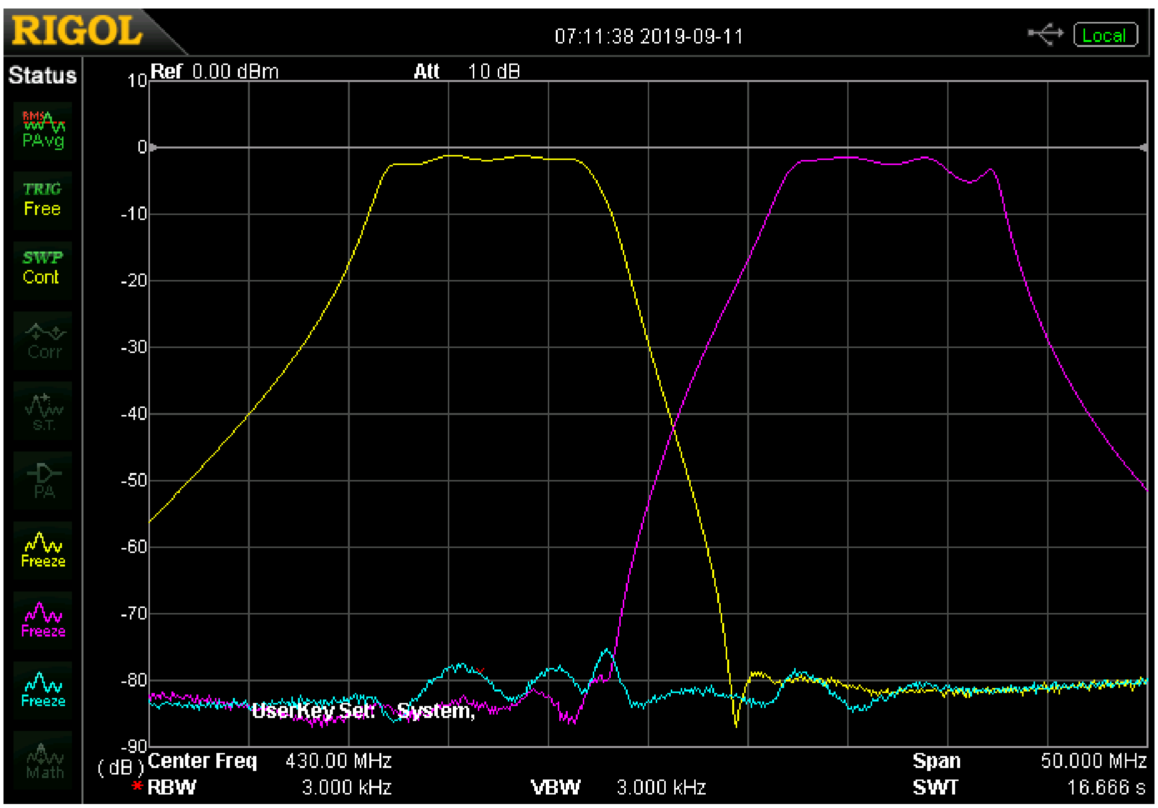

Fig. 3 Insertion Loss of Ch 57 / Ch 60 ATV Duplexer, S21 = yellow, S31 = magenta, S32 = cyan Center freq = 430 MHz, span = 50 MHz (5 MHz/div), Vert = 10 dB/div. Noise floor is -83dB

parameters of the duplexer used in the repeater. The duplexer's bandwidth at 10MHz is wider than the 6 MHz required for a standard USA TV channel. The duplexer was tuned to place the Ch 57 BPF upper corner at 426MHz and the Ch 60 BPF lower corner at 438MHz. It was also tuned to minimze the S_{32} coupling from the Ch 57 transmitter to the Ch 60 receiver.

Sensitivity tests were run on the repeater to determine the maximum transmitter output power possible without desensing the receiver. To do this, a 20dB directional coupler was inserted in the antenna coaxial line to inject controlled levels of a weak, 441MHz, DVB-T signal. Rather than using an antenna, the duplexer antenna output was terminated in a high power, 50Ω dummy load. An HDMI monitor was connected to the second port of the HDMI splitter to watch the received video. The highest transmitter power which worked reliably was approximately +35dBm (3 Watts). With the transmitter turned on, the measured receiver sensitivity was -94dBm with no desensing apparent. The input test signal was a "normal" DVB-T signal with the following parameters: 441 MHz center frequency, 6 MHz bandwidth, 1080P resolution, 6 Mbps, QPSK modulation, 8K FFT, 5/6 FEC, & 1/16 guard.

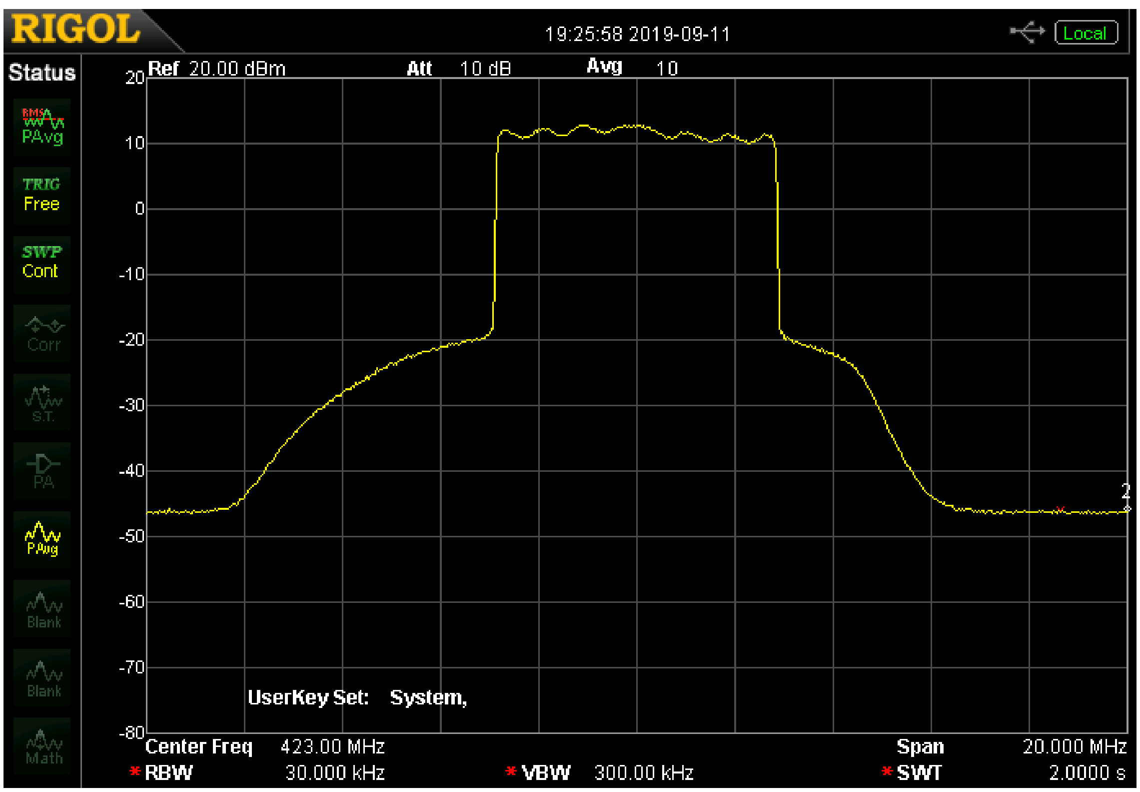

Fig. 4 TV repeater, Ch 57, output spectrum. center freq. = 423MHz, 20 MHz span. 10dB/div & 2 MHz/div. Power out to the antenna, Pout = +33.7dBm = 2.3 Watts rms

A +35dBm output level is the typical high power output from a KH6HTV Video model 70-7B amplifier. Thus it is the ideal choice for use in such a repeater. For the particular 70-7B amplifier used, it's output power was +35.4dBm (3.5 W rms). The output power from the repeater to the antenna is diminished by the -1.7dB insertion loss, S_{13}, of the duplexer. Thus the output to the antenna was +33.7dBm, i.e. 2.3 Watts rms. Fig 4 shows the output spectrum of the repeater. The out of channel, sideband skirts are seen to be asymmetrical. This is due to the duplexer's bandwidth of 10 MHz being wider than the 6 MHz TV channel and the fact that the upper channel edge at 426MHz was placed on the upper corner of the duplexer's passband. The drive power to the amplifier was set to maximize the output power while still keeping the skirt shoulder at least -30dB below the in channel power. For Fig. 4, the shoulder attenuation is -32dB measured at ±3.2 MHz from the center. For comparison, see Fig. 8 in AN-48. It shows a cleaner spectrum with greatly reduced spectrum skirts for a repeater built using two antennas and seperate band-pass filters.

The cost to build this TV repeater, including antenna, is approximately $2,000. The below table lists the major items required and their estimated cost. This does not include an enclosure to house all of the components.

Item	**Mfgr**	**Model #**	**Cost**
DVB-T Receiver	Hi-Des	HV-110	$125
DVB-T Modulator	Hi-Des	HV-320E	$369
RF Power Amplifier	KH6HTV Video	70-7B	$350
Duplexer	KH6HTV Video	ATV-DPX	$800
HDMI 1in/2out Splitter	Amazon or E-Bay	many available	$15
DC Power Supply 13.8Vdc, 10 Amp		many available	$100
70cm Antenna	Diamond	X-50NA	$100
Antenna Coax	LMR-400, 50ft, N		$80
Amp->DPX Coax	LMR-400, 3ft, N		$25
SMA cables (2)			$30
N/SMA adapter			$10
HDMI cables (2)			$10

KH6HTV VIDEO

Application Note AN-50

Sept, 2019

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Is DVB-T Sideband Sensitive ?

Jim Andrews, KH6HTV

Application Note, AN-36, in 2017, has previously discussed the basics of what is required to operate at microwave frequencies with DVB-T. We can purchase from Hi-Des in Taiwan, both modulators and receivers that will work up to the 13cm (2.4 GHz) band. Above there in frequency, we need to then start using mixers and local oscillators to up/down convert. So, one question arises right away -- *"What happens when sidebands are inverted ?"*

When using a mixer and LO, the resultant output contains two mixing product signals, $f_{usb} = f_{lo} + f_{if}$ and also $f_{lsb} = f_{lo} - f_{if}$ The polarity of the RF sidebands remains the same as the IF for the plus (+) mixer product. But the polarity of the sidebands is reversed for the minus (-) mixer product. When running single sideband voice, this makes a big difference. Inverting the sidebands results in un-intelligible speech. What does it do to a DVB-T, digital TV signal ? ? ?

The quick answer is NOTHING ! It still works.

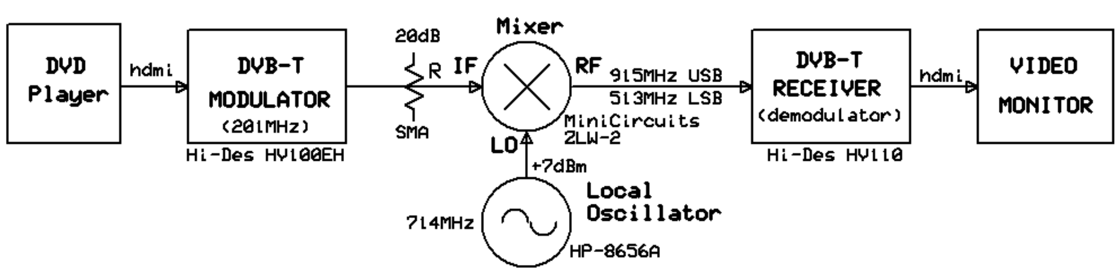

Fig. 1 Test set for mixer/LO tests of DVB-T

To experimentally determine this, I set up a controlled experiment. See above Fig. 1. I started with a DVB-T receiver which had already been trained to receive normally 915 MHz on 33 cm band. I also then trained the receiver to receive normally on 513 MHz. I then reprogrammed the HV-100 modulator to put out a normal DVB-T signal on Ch 11 (201 MHz). With a local oscillator set to 714 MHz, the USB product was 915 MHz, while the LSB product (with inverted DVB-T signal) was on 513 MHz. Connecting the HV-110 receiver to the mixer output, I was able to successfully receive both the 915 and 513 MHz signals. This thus proved that inverting the sideband polarity of the DVB-T signal had no effect.

Frequency Offset: With this LO/mixer test set, it was then a simple matter to determine the sensitivity of a DVB-T receiver to having a signal with the center frequency offset from the correct frequency. Adjusting the LO frequency of the HP signal generator, I found that I could move the LO up or down about ± 550 kHz and the receiver would retain lock. Thus, a DVB-T signal with Doppler shift up to this amount should still work.

Phase Noise: The next test was also simple to perform. What happens with phase noise? I was able to simulate this by turning on the FM modulation of the HP signal generator. What I found was the DVB-T receiver was very sensitive to small amounts of FM deviation of the center frequency. With a 1 kHz test tone, the receiver worked only up to about 600 Hz deviation. With a lower 400 Hz test tone, it was worse. 200 Hz deviation caused pixelization and anything higher, the receiver failed. The following table shows the degradation of a DVB-T signal's signal to noise ratio (S/N) with increasing FM deviation with a 1 kHz test tone. (the test DVB-T signal was QPSK, 1080P, 6Mbps, 1/2 FEC, 1/16 guard). Bottom Line -- DVB-T can not tolerate much FM or phase noise.

Deviation	S/N
none	23 dB
100 Hz	23 dB
200 Hz	20 dB
300 Hz	14 dB
400 Hz	11 dB
500 Hz	9 dB
600 Hz	8 dB
700 Hz	0 dB (i.e. no picture)