Application Note
AN-3a

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Field Trials Comparing VUSB, FM, DVB-S & 64-QAM Television

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Note: The original AN-3 was written in 2011 and the cable TV modulation method of 64-QAM was used. Since then, the author has discovered the European Digital Video Broadcast - Terrestrial, DVB-T, modulation scheme. It has been found to be far superior for over-the-air transmissions than CATV 64-QAM, particularly in terms of receiver sensitivity and tolerance of multi-path. The reader of this app. note is also encouraged to read about DVB-T in application note, AN-17.

In Sept. 2011, four Boulder - Denver, Colorado hams got together to run field trials comparing analog and digital ham television in real world situations. This summarizes the results. A copy of the complete, lengthy report is available upon request to the author at kh6htv@arrl.net

The TV systems compared were VUSB and FM for analog TV and DVB-S and 64-QAM for digital TV. VUSB was used for commercial TV broadcast since the 1940s and only recently was discontinued in the USA in favor of ATSC, 8-VSB digital TV. FM has historically been used for TV transmission in the microwave bands for remote news gathering and studio to transmitter links. DVB-S is the QPSK digital modulation scheme used for satellite broadcast TV, such as Direct TV and the Dish Network. QAM is the system used by cable TV operators (CATV). 64 or 256 level QAM are the most common. 256-QAM is not recommended for ham TV, because it has an 8 dB higher threshold for reception. All of the systems tested, except 64-QAM, transmitted only standard definition, 480i, 4:3 video. The CATV 64-QAM system transmitted full high-definition, 1080i, 16:9, video complete with digital stereo audio. The KH6HTV-VIDEO logo above shows the respective spectrums of the various systems tested. (10dB/div & 10 MHz/div).

It should be noted that in my internet www. searches, I have discovered that around the world, there seems to be only small pockets of hams experimenting with DTV. They are in western Europe, Australia, San Diego, Orange County and the Bay area of California and in Ohio. They all are using DVB-S, mostly on the 23cm band. I have not found mention of any ham using 64-QAM. What I do find is they mention it as one of the techniques for DTV, but then immediately dismiss it as being unsuitable for ham TV

because it was intended for use within the closed, controlled environment of CATV. I also have found no mention of hams using DTV for High Definition TV. They all seem to be running standard definition, 480i DTV. I seem to be the first ham to actually use 64-QAM, the first to transmit High Definition, and the first to actually conduct field trials to prove that Hi-Def, 1080i, 64-QAM will work for ham TV.

The hams participating in the field trial were: Ed, WA6RZW, who furnished the DVB-S transmitter and receiver. http://wa6rzw.homelinux.net/addon/adtv/ Jim, KH6HTV, who furnished the other transmitters and receivers, plus some antennas. Bill, K0RZ, who furnished some antennas and the excellent transmitter location on Davidson Mesa, overlooking the Boulder valley. Jack, K0HEH, who furnished the automobile, mobile receive station, to drive around the Boulder valley and up into the mountains beyond.,

The VUSB and QAM transmitters operated on the 70cm band and had output powers of 1 watt (+30 dBm). The DVB-S and FM transmitters operated on the 23cm band and had output powers of 10 watts (+40 dBm). By deliberately selecting these power levels, we were able to balance out the additional 10 dB path loss between 70cm and 23cm.which made comparing various systems much easier.

For reception of 23cm, DVB-S, a SonicView model SV4000 was used. It's threshold sensitivity was -95 dBm. For reception of 70cm, VUSB and 64-QAM, a Haier 7", LCD, analog/digital TV receiver was used. An ARR model P432VDG preamp with a 0.5dB noise figure was used ahead of the Haier receiver. The Haier receiver had a built-in video squelch. Thus sensitivities are reported at squelch threshold. With the preamp, it's sensitivity for VUSB was -96dBm and -85dBm for 64-QAM. For 23cm FM, an old, discontinued High Frequency Technology receiver was used along with another Haier receiver serving as a base band video monitor. The FM sensitivity was -89dBm. A precision, step attenuator (1dB steps) was used on the input to each receiver to determine the dB margin above threshold at each receive site. Having the step attenuator plus the precisely calibrated video squelch thresholds allowed us to make absolute receive signal strength measurements.

At the transmit site, we used both omni-directional antennas and directional yaggis, all with vertical polarization. For mobile reception, we used mag. mount, whip antennas. At various fixed receive site locations, we would set up yaggi antennas on a tripod mount. We would then make precise field strength measurements using both the mobile omni antennas and slosh the yaggis.

For these initial field trials, the maximum distance between transmitter and receiver was 7 miles. Successful transmission of P5 pictures was accomplished at this distance with all systems tested. Afterwards I made careful calculations of the actual field strengths measured and compared them to the theoretical best case predictions for a totally clear, line-of-sight path. After detailed analysis of our observations, I came to a set of conclusions. They are as follows:

CONCLUSIONS: ON DIGITAL TV (DVB-S vs. 64-QAM)

1. In general, DTV of either 64-QAM or DVB-S is not suitable for in-motion, mobile operations. It only works in the near vicinity of the transmitter where the RF fields are strong and less subject to multi-path. Note: The same has been found for commercial broadcast, ATSC, 8VSB, DTV.

2. Over very clear, line-of-sight paths, with directional antennas, where multi-path was not a major issue, the actual path loss was typically 5 to 15 dB worse than the calculated, theoretical path loss.

3. The better receiver sensitivity for DVB-S vs. 64-QAM was found to be a significant advantage. -95dBm vs. -85dBm Also to achieve -85dBm for 64-QAM required using a 0.5 dB noise figure pre-amp.

4. In multi-path situations, both 64-QAM and DVB-S can lock-up, even with clear line of sight paths to the transmitter. They seemed to be similarly susceptible in the same locations. The use of directional yaggi antennas to minimize multi-path usually helped, but not always.

5. In most cases where good 23cm DTV reception was possible, 70cm DTV also worked and vice-versa.

6. **Bottom Line --- NO SIGNIFICANT DIFFERENCES NOTED BETWEEN THE MODULATION SCHEMES OF 64-QAM (CATV) AND DVB-S (satellite).**

CONCLUSIONS ON ANALOG TV:(VUSB vs. FM)

1. In motion, mobile operation is possible with analog TV. Fading pictures with mobile flutter are more pleasing to watch with VUSB-TV, compared to FM-TV.

2. The FM-TV picture seemed to be more susceptible to multi-path interference.

3. The receiver margin required for a perfect, P5, picture is much less for FM-TV.

4. I was amazed to discover a few perfect rf paths that gave actual path losses within 1dB of the theoretical calculated path loss. Some of these were the same sites tested for DTV where higher path losses were encountered.. Whenever the actual path losses were higher, they were also accompanied by evidence of multi-path in the received picture.

5. For point-to-point, fixed links, FM-TV should almost always be chosen over VUSB-TV. The RF path loss margin required for a perfect P5 picture is much lower with FM. For point-to-point service, directional antennas should always be used to minimize multi-path interference.

OBSERVATIONS & OPINIONS OF ANALOG vs. DIGITAL TV:

1. For in-motion video, DTV doesn't work. The least objectionable mobile flutter is with VUSB-TV.

2. All systems were susceptible to multi-path interference. It's effect was least objectionable with VUSB-TV. For DTV, it could cause the system to fail completely.

3. Where possible, the use of directional antennas instead of omni-directional antennas usually helped to suppress multi-path effects. This was true for both analog and digital TV.

4. DTV always has the best picture quality. We either have a perfect P5 picture, or no picture. The "Cliff Effect" going from no picture to a perfect picture is typically 1 to 2 dB change in signal strength.

5. FM-TV ranks #2 relative to DTV in it's ability to provide a P5 picture with a weaker signal. With no multi-path present, a S/N > 13 to 15dB assures one of an almost perfect picture.

6. For general ham, wide-area coverage, where the user does not expect a perfect picture, VUSB-TV is best.

7. For the most reliable, fixed, point-to-point transmissions, FM-TV should be used.

8. The only distinct advantage DTV has over conventional analog TV is the ability to broadcast true, high-definition, 1080i, video and CD quality audio.

9. For transmission of standard definition, 480i, video, I would always chose FM-TV over DTV. One stands a much better chance of the picture being received almost anywhere in the coverage area.

10. The one advantage DVB-S DTV has over FM-TV for standard definition, 480i video is that it consumes a lot less spectrum.

11. In the 70cm ham band, I would not reccomend 64-QAM DTV be used on any channel except 57.1 (420-426 MHz) or 58.1 (426-432 MHz). When used on any higher 70cm channel, it's spectrum which consists of high powered white noise sitting upon a rectangular pedestal will significantly raise the noise floor for all other hams using cw, ssb, moon-bounce, satellites, FM, etc. Channels 57 and 58 sitting at the bottom of the 70cm band, today is almost exclusively used only for ham TV. Even on channel 58.1, the guard bands on the DTV signal keep the spectrum to >40dB down above 432 MHz to minimize interference with weak signal operators. (rev. 1/2/13)