Application Note
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web = www.kh6htv.com email = kh6htv@arrl.net

What Are the Differences in Receiver Sensitivity for 2, 4 & 6 MHz Band-Width DVB-T Signals ?

Jim Andrews, KH6HTV

Recently, in the BATVC TV Repeater's Repeater, ATV newsletter there has been discussions on the pros and cons of narrow vs. wide band-widths for DVB-T. It is obvious that we can get high-definition, 1080P resolution, high quality video and CD quality audio with 6 MHz band-width. DVB-T was originally designed to do just that for commercial broadcast TV with either 6, 7 or 8 MHz band-widths. But how well does it work for lower band-widths, such as 4 MHz as used by the ATV hams in St. Louis or 2 MHz as used in southern California and Ohio ? So, I decided to run an experiment to measure receiver sensitivity for 2, 4 and 6 MHz band-widths.

My experiment looked at many different settings. I used all three possible modulations of QPSK, 16QAM and 64QAM. I used two different digital encoding FEC settings for what I called "*normal*" and "*aggressive*". "*Normal*" used 8K FFT, 5/6 code rate and 1/16 guard interval. "*Aggressive*" used 8K FFT, 1/2 code rate and 1/4 guard interval. I also tested with and with-out a low noise pre-amplifier in front of the DVB-T receiver. The measurements were performed on the 70cm band (434 MHz).

Test Set-Up: I used a Hi-Des model HV-320E modulator as my DVB-T signal source. I programmed the various operating parameters in it using a Windows 10 PC running the program *AV-Sender*. The DVB-T receiver used was a Hi-Des model HV-110. It's HDMI output was displayed on an 11", 1080P flat screen monitor. I used a DVD player playing a pre-recorded video to provide a 1080P, HDMI source of "live", full motion video and audio for the modulator. I measured the rf power out of the modulator using an HP 432A rf power meter with an HP 478A thermistor rf power sensor head. The HV-320 signal source and the HV-110 receiver were located in different rooms and connected directly with a 45ft. coaxial cable. This was done to minimize the rf leakage coupling between the two units. I controlled the rf signal level into the receiver using fixed 10dB, 20dB and 30dB SMA attenuators plus a Midwest Microwave rotary step attenuator. (0 - 69dB in 1dB & 10dB steps). The 30dB attenuator was placed on the output of the HV-

320. The low noise pre-amplifier used for the tests was a KH6HTV Video model 70-LNA with 21dB gain and 0.7dB noise figure.

Different video data bit rates were required for each and every combination of band-width, modulation and encoding. *AV-Sender* calculates for each setting, the max. theoretical limit. Hi-Des recommends the video data rate not be set any higher than 80% of the max. limit. This is to allow for data overhead and the audio encoding data stream. For lower band-widths and more aggressive encoding, I found it necessary to use an even lower percentage than 80%. The following table lists the data rates I used for the experiment.

Bit Rate Setting Table:

Band-Width	**Modulation**	**Normal/ Aggressive**	**Max. Mod. Data Rate (Mbps)**	**scale factor %**	**Max. Bit Rate (Mbps)**
6 MHz	64QAM	Normal	21.96	80%	17
	64QAM	Aggressive	11.2	80%	9
	16QAM	Normal	15.83	80%	12.7
	16QAM	Aggressive	7.46	80%	5.9
	QPSK	Normal	7.16	80%	5.7
	QPSK	Aggressive	3.65	75%	2.7
4 MHz	64QAM	Normal	14.32	80%	11.5
	64QAM	Aggressive	7.46	80%	6.0
	16QAM	Normal	9.76	80%	7.8
	16QAM	Aggressive	4.98	80%	4.0
	QPSK	Normal	4.88	80%	3.9
	QPSK	Aggressive	2.49	70%	1.7
2 MHz	64QAM	Normal	7.32	80%	5.8
	64QAM	Aggressive	3.73	70%	2.6
	16QAM	Normal	4.88	80%	3.9
	16QAM	Aggressive	2.49	72%	1.8
	QPSK	Normal	2.44	70%	1.5
	QPSK	Aggressive*	1.95	66%	1.3

* Note: for 2 MHz BW, QPSK aggressive settings were 2/3 Code & 1/16 Guard. 1/2 code and 1/4 guard did not work.

Media Configuration Settings: H.264 Video Encoding, 60 GOP length, Frame Rate 30 fps, ---- MPEG2 Audio Encoding at 96kbps

Video Resolution: I used 1920 x 1080 for both 6 MHz and 4 MHz band-widths successfully. I tried 1080 on 2 MHz but detected some artifacts in the transmitted video, so I used 1280 x 720 for 64QAM and 16QAM. For 2 MHz BW and QPSK, I found I needed to lower the resolution down to 640 x 480.

Receiver Measurements: For each test, the step attenuator was adjusted to determine the digital threshold. This is defined as the weakest signal for which a perfect, P5 picture and Q5 audio is obtained. Dropping another 1dB caused either total lockout or at least picture breakup with freeze frames. The on screen display (OSD) feature of the HV-110 receiver was used to measure the signal to noise ratio. The following table summarizes the results.

Comparison of Digital Thresholds with & with out low noise, pre-amp

Band-Width	Modulation	Normal/ Aggressive	HV-110	70-LNA HV-110	Improvement with pre-amp	S/N max / min
6 MHz	64QAM	Normal	-83dBm	-86dBm	3dB	32/22dB
	64QAM	Aggressive	-89dBm	-92dBm	3dB	32/15dB
	16QAM	Normal	-89dBm	-92dBm	3dB	26/15dB
	16QAM	Aggressive	-93dBm	-96dBm	3dB	26/10dB
	QPSK	Normal	-95dBm	-99dBm	4dB	23/8dB
	QPSK	Aggressive	-97dBm	-102dBm	5dB	23/5dB
4 MHz	64QAM	Normal	-85dBm	-89dBm	4dB	32/22dB
	64QAM	Aggressive	-90dBm	-94dBm	4dB	32/15dB
	16QAM	Normal	-91dBm	-94dBm	3dB	26/15dB
	16QAM	Aggressive	-94dBm	-98dBm	4dB	26/12dB
	QPSK	Normal	-97dBm	-100dBm	3dB	23/8dB
	QPSK	Aggressive	-99dBm	-104dBm	5dB	23/5dB
2 MHz	64QAM	Normal	-84dBm	-91dBm	7dB	32/22dB
	64QAM	Aggressive	-93dBm	-97dBm	4dB	32/15dB
	16QAM	Normal	-90dBm	-98dBm	8dB	26/15dB
	16QAM	Aggressive	-95dBm	-102dBm	7dB	26/12dB
	QPSK	Normal	-100dBm	-104dBm	4dB	23/8dB
	QPSK	Aggressive*	-101dBm	-106dBm	5dB	23/6dB

S/N: For QPSK, the max. possible s/n is 23dB. For 16QAM, it is 26dB. For 64QAM, it is 32dB. The lowest possible s/n at digital threshold depends upon the modulation and the aggressiveness of the FEC. For QPSK it was 8 and 5dB. For 16QAM, it was 15 and 12dB. For 64QAM, it was 22 and 15dB.

6 MHz BW Summary: For normal FEC encoding, the sensitivity measured was -95dB (QPSK), -89dBm (16QAM) and -83dBm (64QAM). Lowering the data rate and using very aggressive Forward Error Correction (FEC) of 1/2 was seen to buy several dB improvement. Also using a low noise pre-amp was seen to add 3 to 5 dB improvement.

4 MHz BW Summary: I found it possible to use 1080P for all settings on 4 MHz band-width. For normal FEC encoding, the sensitivity measured was -100dB (QPSK), -90dBm (16QAM) and -85dBm (64QAM). In other words, going from 6 to 4 MHz brought a 2 dB improvement in sensitivity. Lowering the data rate and using very aggressive Forward Error Correction (FEC) of 1/2 was seen to buy several dB improvement. Also using a low noise pre-amp was seen to add 3 to 5 dB improvement.

2 MHz BW Summary: As mentioned previously one needs to lower the video resolution for 2 MHz BW. 720P works well for QAM. QPSK requires even lower 480. For normal FEC encoding, the sensitivity measured was -99dB (QPSK), -92dBm (16QAM) and -84dBm (64QAM). Lowering the data rate and using very aggressive Forward Error Correction (FEC) of 1/2 was seen to buy considerable improvement for QAM, but little for QPSK. Also using a low noise pre-amp was seen to add from 4 to 8dB improvement. A significant difference. The lowest observed level was -106 dBm for 2 MHz BW, QPSK with 2/3 FEC (code rate), 1/16 Guard and 480 resolution.