Application Note
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DVB-T RECEIVER SENSITIVITY MEASUREMENTS

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The purpose of this application note is to document the results of testing the sensitivity of an assortment of DVB-T television receivers. They include two receivers from the major amateur DTV supplier, Hi-Des in Taiwan (www.hides.com.tw), a commercial set-top box receiver and USB TV Tuner dongles. Previous KH6HTV Video Application Notes have discussed these various receivers [1-4]. Measurements were made on the 70cm, 33cm and 23cm bands, where applicable, at frequencies of 435MHz, 915MHz and 1243MHz.

TEST SETUP: Extreme care must be taken when performing extremely weak signal sensitivity measurements. There must be adequate isolation between the test signal generator and the receiver under test. Inadvertent leakage from the signal source can contaminate and invalidate the test results. The test setup used at KH6HTV consisted of a Hi-Des model HV-100EH DVB-T modulator as the signal source and calibrated coaxial attenuators to attenuate the test signal to the receiver under test. A Blu-Ray, 1080P, DVD player with a continuously playing disc was used to provide "live" HDMI video and audio for testing. To avoid "leakage", the modulator was placed in another room from the receiver under test and a long 75ft., lossy, RG-58 coax cable was run from the modulator to the receiver test bench. This allowed one to have weak signals far below -100dBm without contamination from leakage.

The HV-100EH internal attenuator was set to +3dB for all tests. At this setting, the carrier leakage was minimal and the shoulder attenuation of the spectrum was excellent. The HV-100EH rms output power into 50Ω was measured using an HP-432A power meter with an 18GHz, HP-8478B Thermistor Power Sensor head. The HV-100EH output power was: +0.4dBm (70cm), -2.2dBm (33cm) and -8.5dBm (23cm).

The isolating coaxial cable was a 75 foot length of RG-58 with BNC connectors. The HP-432A power meter was used to measure the power reaching the test bench thru the lossy coax cable. The max. power available at the test bench was: -8dBm (70cm), -15dBm (33cm) and -24dBm (23cm).

Both fixed and adjustable coaxial attenuators were used to reduce the signal into the receiver under test. The adjustable attenuator was a DC-18GHz, Weinschel model AD9003-69-31-01 with 0 to 60dB, 10dB steps and 0-9dB, 1dB steps. Three additional fixed value, calibrated DC-3GHz, Narda, model 771, type N attenuators of 10dB, 20dB and 30dB were used as needed. The signal level was reduced until the digital threshold was reached. In most cases, the difference between no picture and a perfect picture was typically < 1dB. In some cases, an intermediate state of picture breakup or pixelization was noted with a threshold digital cliff of < 2dB. The sensitivity recorded was the minimum signal level required for a perfect picture with audio.

Additional sensitivity tests were performed on receivers using low noise pre-amplifiers. For the 70cm band, an Advanced Receiver Research model P432VDG (0.5dB NF, 18dB gain) was used. For the 33cm band, a KH6HTV Video model 23-3 (0.7dB NF, 24dB gain) was used. For the 23cm band, a KH6HTV Video model 23-4LNA (0.9dB NF, 34dB gain) was used.

All of the receivers were tested using 6 MHz bandwidth DVB-T signals. In addition, the Hi-Des receivers were capable of lower bandwidth reception. They were also tested using a 2 MHz bandwidth, standard definition (480i), DVB-T signal.

DVB-T Transmission Parameters:

Tests were performed to evaluate the sensitivity under different DVB-T parameters. Unless noted otherwise, all results are reported for the 1080P/6MHz BW parameters.

1080P/6MHz -- For true 1080P high definition under good signal propagation conditions, the HV-100EH modulator was set as follows:
Trans = QPSK, 16QAM or 64QAM, 6 MHz Bandwidth, 8K FFT, 5/6 Code Rate, 1/16 Guard Interval
Media = Video encoding H.264, resolution 1920 x 1080, CBR
Audio encoding MPEG2, 96Kbps
Modulation Date Rate (theoretical max.) = 7.32Mbps (QPSK), 14.74Mbps (16QAM), & 21.96Mbps (64QAM)
actual code rate used 6.0Mbps (QPSK), 11.7Mbps (16QAM), 17.5Mbps (64QAM)

720P/6MHz -- for extremely poor, multi-path conditions, K0DVB, [2], recommends lowering the resolution to 720P and using these more aggressive coding parameters:
Trans = QPSK only, 6 MHz Bandwidth, 8K FFT, 1/2 Code Rate, 1/32 Guard Interval
Media = Video encoding H.264, resolution 1280 x 720, CBR
Audio encoding MPEG2, 96Kbps
Modulation Date Rate = 4.52 Mbps max. theoretical limit, actually used 3.6Mbps

480I/2MHz -- for ultimate performance with weak signals and narrow bandwidth, we used these parameters:
Trans = QPSK only, 2 MHz Bandwidth, 8K FFT, 1/2 Code Rate, 1/8 Guard Interval
Media = Video encoding H.264, resolution 720 x 480, CBR
Audio encoding MPEG2, 96Kbps
Modulation Date Rate = 1.38 Mbps max. theoretical limit, actually used 1.0Mbps

SUMMARY of MEASUREMENTS

Comparison of QPSK, 16QAM & 64QAM Modulation

Measured with Hi-Des HV-120 Receiver at 70cm
(6MHz BW, 8K FFT, 5/6 Code, 1/16 Guard, H.264, 1080P, CBR, 6Mbps)

	QPSK	**16QAM**	**64QAM**
Sensitivity	-95 dBm	-90 dBm	-82 dBm
min. S/N	8 dB	15 dB	22 dB
max. S/N	23 dB	26 dB	32 dB

Conclusion: There is a 13 dB (2 S units) difference between QPSK and 64QAM with QPSK being more sensitive. Acceptable video is obtained using QPSK. For weak signal, amateur DTV with low power transmitters, QPSK should be used.

Comparison of Different DVB-T Parameters

Measured with Hi-Des HV-120 Receiver at 70cm - all QPSK

Video Resolution	**1080P**	**720P**	**480I**
Band-Width	6 MHz	6 MHz	2 MHz
Code Rate	5/6	1/2	1/2
Guard Interval	1/16	1/32	1/8
Sensitivity	-95 dBm	-100 dBm	-104 dBm
min. S/N	8 dB	5 dB	5 dB

Conclusions:
1. Lowering the resolution to 720P and using more aggressive coding gives a 5 dB improvement in sensitivity.
2. Using a narrower bandwidth of 2 MHz, 480i resolution and aggressive coding gives a 9 dB improvement.
3. Adding a low noise, pre-amp when using 2 MHz BW improves sensitivity further from -104 to -107 dBm.

Comparison of 70cm Sensitivity of Various Receivers

(6MHz BW, 8K FFT, 5/6 Code, 1/16 Guard, H.264, 1080P, CBR, 6Mbps)

Manufacturer	Model	Receiver Only	with Pre-Amp
Hi-Des	HV-110	-94 dBm	-99 dBm
Hi-Des	HV-120	-95 dBm	-99 dBm
?? China (set-top box)	HD DVB-T2 & S2 COMBO	-94 dBm	-99 dBm
USB TV Tuner Dongles below			
?? China (TRL2832U+R820T)	DVB-T+DAB+FM	-93 dBm	-97 dBm
NooElec	R820T SDR & DVB-T NESDR Mini	-92 dBm	-98 dBm
RTL-SDR.COM	DVB-T+DAB+FM+SDR RTL2832U R820T2 TCXO	-87 dBm marginal !	-99 dBm
WandTV	DVB-T digital terrestrial TV stick	-72 dBm very poor !	-90 dBm

Conclusions: Good receivers have a senstivity of about -94dBm. Adding a low noise, pre-amp typically enhances the sensitivity by several dB to approx. -99dBm.

Comparison of 33cm Sensitivity of Various Receivers

(6MHz BW, 8K FFT, 5/6 Code, 1/16 Guard, H.264, 1080P, CBR, 6Mbps)

Manufacturer	Model	Receiver Only	with Pre-Amp
Hi-Des	HV-110	-93 dBm	-98 dBm
Hi-Des	HV-120	-96 dBm	-98 dBm

Conclusions: improved design HV-120 has 3dB better sensitivity over HV-110

23cm Receiver Sensitivity

(6MHz BW, 8K FFT, 5/6 Code, 1/16 Guard, H.264, 1080P, CBR, 6Mbps)

Manufacturer	Model	Receiver Only	with Pre-Amp
Hi-Des	HV-120	-87 dBm poor !	-97 dBm

Conclusions: The use of a pre-amp is mandatory on 23cm.due to the poor HV-120 sensitivity

REFERENCES:

1. "DVB-T the Solution for Ham Digital Television", KH6HTV Video Application Note, AN-17, July, 2014

2. "Notes of Using Hi-Des DVB-T Products with KH6HTV Video -- RF Linear Power Amplifiers", KH6HTV Video Application Note, AN-18a, Dec. 2015

3. "How to Receive Amateur Digital, DVB-T Television Signals", KH6HTV Video Application Note, AN-21a, Dec. 2015

4. "Evaluation of New Hi-Des Model HV-120A, DVB-T, Receiver", KH6HTV Video Application Note, AN-27a, March 2016

note: All of the above app. notes are available from www.kh6htv.com