Amateur
High Definition
Digital Television

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Amateur Television

- FCC allows, wide bandwidth, fast scan TV on 70cm (420-450MHz) band and all higher, amateur, microwave bands
- Most ham TV operations are on 70cm with 6MHz channels. Second popular band is 23cm.
- We use CATV channels 57 (420-426), 58 (426-432), 59 (432-438) & 60 (438-444)
- The ARRL band plan calls for Ch 60 = TV Repeater Input, Ch 57 = TV Repeater Output & Ch 58 = TV Simplex. Use of channels 59 & 61 discouraged
TV Acronyms

- **ATV** – Amateur Television – also Analog TV
- **DTV** – Digital Television
- **NTSC** – National Television Subcommittee, the original Analog TV system with 525 (480i) lines, standard definition, VUSB
- **VUSB** – Vestigal Upper Side Band – analog TV modulation method, a form of AM with carrier, full upper side-band and small portion of lower side-band
- **ATSC** – Advanced Television Subcommittee – developed current USA broadcast DTV
TV Acronyms contd.

- **8-VSB** - Eight Vestigal Side Bands, *USA std. for broadcast DTV*
- **DVB-C** - Digital Video Broadcast – for Cable, uses QAM
- **DVB-S** – Digital Video Broadcast – for Satellite, uses BPSK, QPSK, 8PSK or 16-QAM
- **DVB-T** – Digital Video Broadcast – Terrestrial, uses QPSK, 16-QAM or 64-QAM *European std. for broadcast TV*
TV Acronyms contd.

- **BPSK** – Binary Phase Shift Keying 0 & 180 degrees
- **QPSK** – Quadrature Phase Shift Keying 0, 90, 180, 270 degrees
- **QAM** – Quadrature Amplitude Modulation, combination of both QPSK & discrete digital level amplitude modulation. $2^n$ states, such as 16, 64, 256, etc.
- **COFDM** – Coded Orthogonal Frequency Division Multiplexing
TV Historical Timeline

- **1925** – QST reports on TV experiments using mechanical scanning
- **1926** – John Blair in Scotland, demos 1st working TV using mechanical scanning
- **1927** – Philo Farnsworth, 1st patent for all electronic scanned TV system
- **1929** – 1st TV broadcast, London
- **1939** – NBS 1st live TV broadcast, NYC
- **1940** – 1st ham TV 2 way QSO, W2USA & W2DKJ in New York City, 56 & 112MHz
TV Timeline contd.

- 1941 - FCC issues NTSC standard, VUSB
- 1941-45 WWII, TV development suspended
- 1946-50 Major deployment of broadcast TV stations in all major metro areas
- 1948 – San Francsico bay area hams are transmitting NTSC TV on 70cm band
- 1950 – Ed Tilton, QST June issue reports on major ham TV activity in USA, UK, and Holland
- 1953 – Color added to TV, compatible with B&W
- 1957 – Cop McDonald, VY2CM, develops slow-scan TV for use on HF
TV Timeline contd. - HDTV

- **1968** – Japan starts analog HDTV development
- **1986** – USA & Europe turn down Japan’s proposal for their analog HDTV system
- **1987** FCC creates ATSC to develop DTV
- **1991** DVB development starts in Europe
- **1991-92** FCC holds field trials for competing digital and analog HDTV systems
- **1993** MPEG-2 video encoding standard adopted
- **1993** Europe selects DVB as their DTV system
TV Timeline contd. - HDTV

• **1996** FCC selects ATSC’s 8-VSB system for broadcast DTV in USA with 10 year transition period from analog to digital

• **1999** Sinclair Broadcasting challenges selection of 8-VSB over DVB-T. Field tests show superiority of DVB-T for indoor reception with simple antennas. FCC turns down petition.

• **2009** USA switches completely from analog TV to DTV (8-VSB)
Amateur DTV Timeline

- **Early 2000s** - Earliest work was in Germany, France & UK, using DVB-S, standard definition only. USA TV hams slow to get on DTV bandwagon. (except in Ohio)
- **2011** – Drake introduces, low-cost ($1.2K), CATV, QAM modulator. Experiments show it works over the air, but only when little or no multi-path present.
- **2014** – Hi-Des company in Taiwan introduces, low-cost, DVB-T modulator and receivers. Field trials show DVB-T to be far superior than analog TV or CATV-QAM
- **Fall 2014** – 77 mile DVB-T, 70cm, DX record, Cheyenne, WY to Boulder, CO, 10 watts + conventional yaggi antennas. KH6HTV to N0YE
DVB-T DX Record
Cheyenne to Boulder, 77 miles

KH6HTV
DVB-T
High-Definition (1080P)
70cm, 429 MHz, 6 MHz BW
from DN71NB
Cheyenne, Wyoming
Analog TV Limitations

- Basically uses AM modulation
- 4.2MHz video BW required for std. def. with SSC at 4.5MHz. Required AM BW >9MHz. Use VUSB to reduce BW to 6MHz
- Standards set 75 years ago by FCC
- “Snow” with weak signals, need 40dB s/n
- “Ghosts” with multi-path
- FM-TV added later for microwave links, works with weaker signals, but much wider spectrum required
Comparison of Analog & Digital TV Spectrums

VUSB-TV  FM-TV  DTV

10dB/div
& 10 MHz/div
DTV vs Analog TV
Why Not Use 8-VSB?

- Cost & Technical Performance
- From FCC 1999 report “…the COFDM (DVB-T) system has better performance in dynamic and high level static multi-path situations, and offers advantages in mobile reception.”
- $$$ - Big Bucks necessary to buy modulators.
- No modulators found available in small units for 12Vdc, portable service
DVB-T

• Broadcast standard for terrestrial DTV broadcasting for Europe and most of the rest of the world. Only USA, Canada, Mexico & S. Korea use 8-VSB
• Uses COFDM with 2K or 8K close spaced sub-carriers with packetized, digital data
• Uses QPSK, 16-QAM or 64-QAM
• Includes dynamic channel characterization and correction and forward error correction (FEC)
• Highly tolerant of extreme multi-path
• Works in mobile situations with doppler shift
DVB-T Receiver Sensitivity

- QPSK = -97 dBm
- 16-QAM = -92 dBm
- 64-QAM = -82 dBm
- Adding a low noise pre-amp buys another 3dB in sensitivity
QPSK vs QAM

• Max Video Encoding data rates for various modulations with 6MHz BW: QPSK = 7.3Mbps, 16-QAM = 14.6Mbps & 64-QAM = 21.9Mbps

• Higher bit rates needed to follow really fast action, such as sports, thus prefer QAM

• For typical ham TV, low power, marginal antenna situations, the 15dB QPSK margin often means the difference between no signal vs. a perfect signal.

• For most normal video scenes, perfectly acceptable, hi-def., 1080P images are possible with QPSK
Amateur DVB-T System
70cm, 3 Watt, DVB-T Transmitter
(total system cost $1,250)
Hi-Des model HV-100EH
DVB-T Modulator

- Extremely simple to operate – only control is channel selector. Up to 100 channels.
- Frequency Synthesized – 50 to 950MHz plus 1200 to 1350MHz, 1kHz resolution, covers amateur 70cm, 33cm & 23cm bands
- Adjustable Bandwidth – 2 to 8 MHz, 1MHz steps
Hi-Des DVB-T Modulator

- -3dBm RF output, with programmable attenuator to -20dB, 1dB steps
- HDMI (up to 1080p) & Composite (480i) video & audio inputs
- USB & Ethernet
- +12Vdc @ 700mA     cost = $570
Program with external PC computer via USB
Recommended Modulator Parameters

* = compromised conditions
** = extremely poor multi-path conditions

- Frequency = as desired, 423000kHz for ch 57
- Bandwidth = 6 MHz
- Modulation = QPSK
- Sub-Carriers = 8K
- Code Rate (i.e. FEC) = 5/6 (2/3 *, 1/2 **)
- Guard Interval (i.e. sync) = 1/16 (1/32 *, 1/32 **)
- RF Attenuation = as needed for particular linear amplifier

- Video Resolution = 1080P (720P **)
- Video Encoding = H.264
- Max Video Bit Rate = 6.0Mbps-CBR (5.4Mbps *, 4.2Mbps **)
- Audio Encoding = MPEG2
- Audio Encoding Bit Rate = 96kbps
- Service Name = your call sign, example KH6HTV, Note this satisfies FCC requirement for IDing
RF Linear Power Amplifier

- 70 cm (420-450MHz)
- 50 dB Gain
- 3 Watts avg (DTV)
- 10 Watts pep (VUSB)
- 20 Watts sat (FM)
- Adjustable power -5 dB & -10 dB (3W, 1W, 300mW)
- 12Vdc @ 3A, 1.1A & 600mA
- KH6HTV Video model 70-7B, $340
Hi-Des model HV-110
DVB-T Receiver
HV-110 Specs

• Frequency Synthesized – 170 to 950 MHz, 1kHz resolution, covers 70cm & 33cm bands
• Bandwidth – 2 to 8 MHz, 1 MHz steps
• HDMI(up to 1080p) & Composite (480i) video outputs
• Program & control via IR remote control
• +5Vdc @ 315mA   Cost = $170
DVB-T Set Top Box Receivers

- Consumer grade
- Simple to operate
- Inexpensive, <$100
- Available- internet
- Only for 6,7&8MHz
- Caution: not all of them cover 70cm band
Cheap ! $10 DVB-T Receiver

• USB TV Tuner Dongle
• Available amazon, ebay, etc.
• Uses RTL2832 software defined radio receiver IC
• Use free shareware VLC program
• Caution: doesn’t work on windows 10
TV Antennas must be Broad-Band!
Boulder ARES has standardized on using Vertical Polarization for 70cm & 23cm TV – most suitable for back-pack portable, mobile & repeater operations.
Higher Microwave Bands

note: LO must have very low phase noise
Propagation Characteristics of various bands

- **70cm (430MHz)** - best all around for usefulness, reasonable size antennas, lower path loss and good penetration. 30MHz supports up to five, 6MHz, hi-def channels or fifteen, 2MHz, std. def channels.
- **33cm (900MHz)** – Do have major RFI issues due to proliferation of unlicensed part 15 devices.
- **23cm (1250MHz)** – 2ed choice, best used for point-to-point links. Main RFI issue is DIA radar at 1267MHz.
- **13cm (2.4GHz)** – marginal results at 2.395GHz - worthless due to Wi-Fi signals above 2.40GHz.
- **9cm (3.5GHz)** – inconclusive results, some RFI found.
- **5cm (5.8GHz)** – successful results at 5.862GHz.
- **3cm (10GHz)** – unknown yet, will do future experiments.
DVB-T TV REPEATER
(cost – approx. $2,500+)
6MHz BW, 70cm, Inter-Digital Band-Pass Filter
DVB-T, 70cm, 6W, Repeater built by Matt, K0DVB
More Information

• **KH6HTV VIDEO**  [www.kh6htv.com](http://www.kh6htv.com) over 30 ATV/DTV related application notes, plus RF linear power amplifiers and other amateur TV products

• “DVB-T: A Solution for ARES Television Operations”, *QST*, June 2015, pp. 42-44, by KH6HTV

• Amateur Television Quarterly, national ATV magazine,  [www.atvquarterly.com](http://www.atvquarterly.com)
More Info contd.

• Hi-Des Technologies  www.hides.com.tw
  supplier of low cost, quality, DVB-T
  modulators and receivers

• Yahoo DTV Users Group,
  https://groups.yahoo.com/neo/groups/DigitalATV/info

• “Digital Video & Audio Broadcasting
  978-2-642-11611-7
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