Amateur High Definition Digital Television

Jim Andrews, KH6HTV

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.

- **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 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 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, BBC, 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 --- 525 interlaced scan lines (480i active), 30 Hz frame rate, AM video modulation, but part of lower sideband suppressed to conserve bandwidth (VUSB), 6 MHz channel, FM audio modulation on 4.5 MHz sound sub-carrier.
- **1941-45** WWII, TV development suspended
- **1946-50** Major deployment of broadcast TV stations in all major metro areas

TV Timeline contd.

- **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

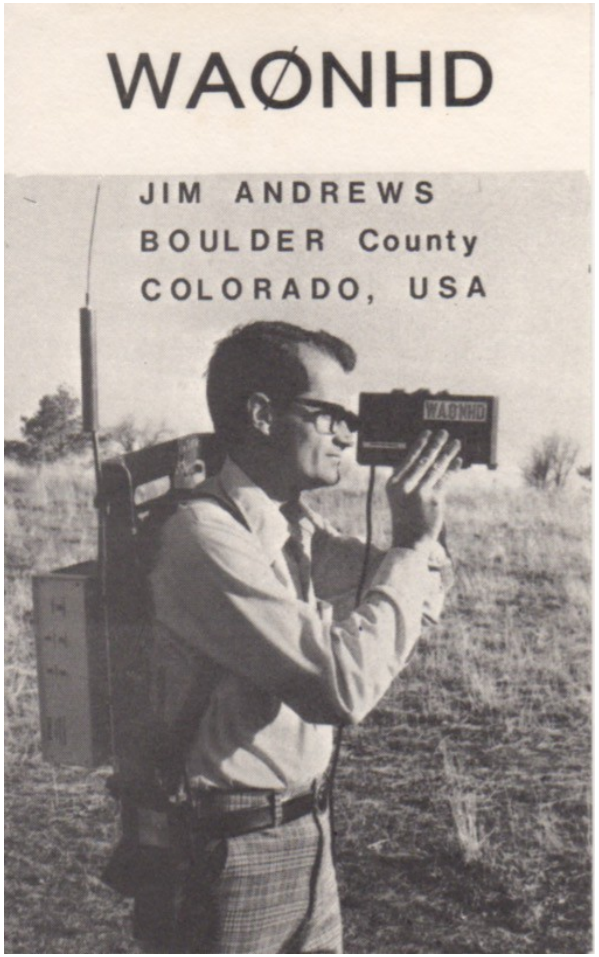
- **1996** FCC selects ATSC's 8-VSB system for broadcast DTV in USA with 10 year transition period from analog to digital
- **1999** Sinclair Broadcasting challenges selection of 8-VSB over DVB-T. Field tests show superiority of DVB-T for indoor reception with simple antennas. FCC turns down petition.
- **2009** USA switches completely from analog TV to DTV (8-VSB)
- **2017** FCC approves voluntary, ATSC 3.0 – an enhanced version of DVB-T. Not backwardly compatible. Will not support ATSC 1.0

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. Ham ATV 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
- **2019** – Now are 25 DATV repeaters in the USA, most using DVB-T. Also many in Europe, especially U.K., using DVB-S.

Boulder ATV Time Line

- Mid 70s, RMVHFS hams experimenting with B&W AM-TV
- Late 70s - 1st TV Repeater operational on Lee Hill
- 1990 – BCARES adds TV capability



TV in ARES

Jim Andrews, KH6HTV

This is an ATV success story for ARRL, ARES & RACES

The #1 most requested service from BCARES is

TV !

BCARES

- Provides ATV coverage for Sheriff, Police & Fire in Boulder County
- Forest Fires, Floods, Riots, SWAT, Political demonstrations
- Provides ATV for all CU home football games (4 cameras)
- Bolder Boulder, Memorial Day, 10K race (50,000 runners) (8 cameras)

Police Chief's Comments

- “Having BCARES video allowed me to have an actual visual picture of distant events vs. my EOC team having to paint a mental picture based on radio comms”
- “The amount of radio traffic was down considerably due to having video”
- “I watched the quad video much more than the tactical messages on the computer”
- *Republican State Convention - 2008, Broomfield*

2010 - Four Mile Canyon Fire

BCARES mobilized for a week

7,000 acres of forest burned, 170 homes lost

BCARES had ATV fire spotters on several mountain tops

(credited with saving half dozen homes)

EOC Command Center

note: night time fire video on main monitor

BCARES-ATV Operations

We typically operate four DTV transmitters simultaneously on 70cm channels 57, 58, 59 & 60.

We use commerical quality, DTV receivers plus low-noise preamplifiers.

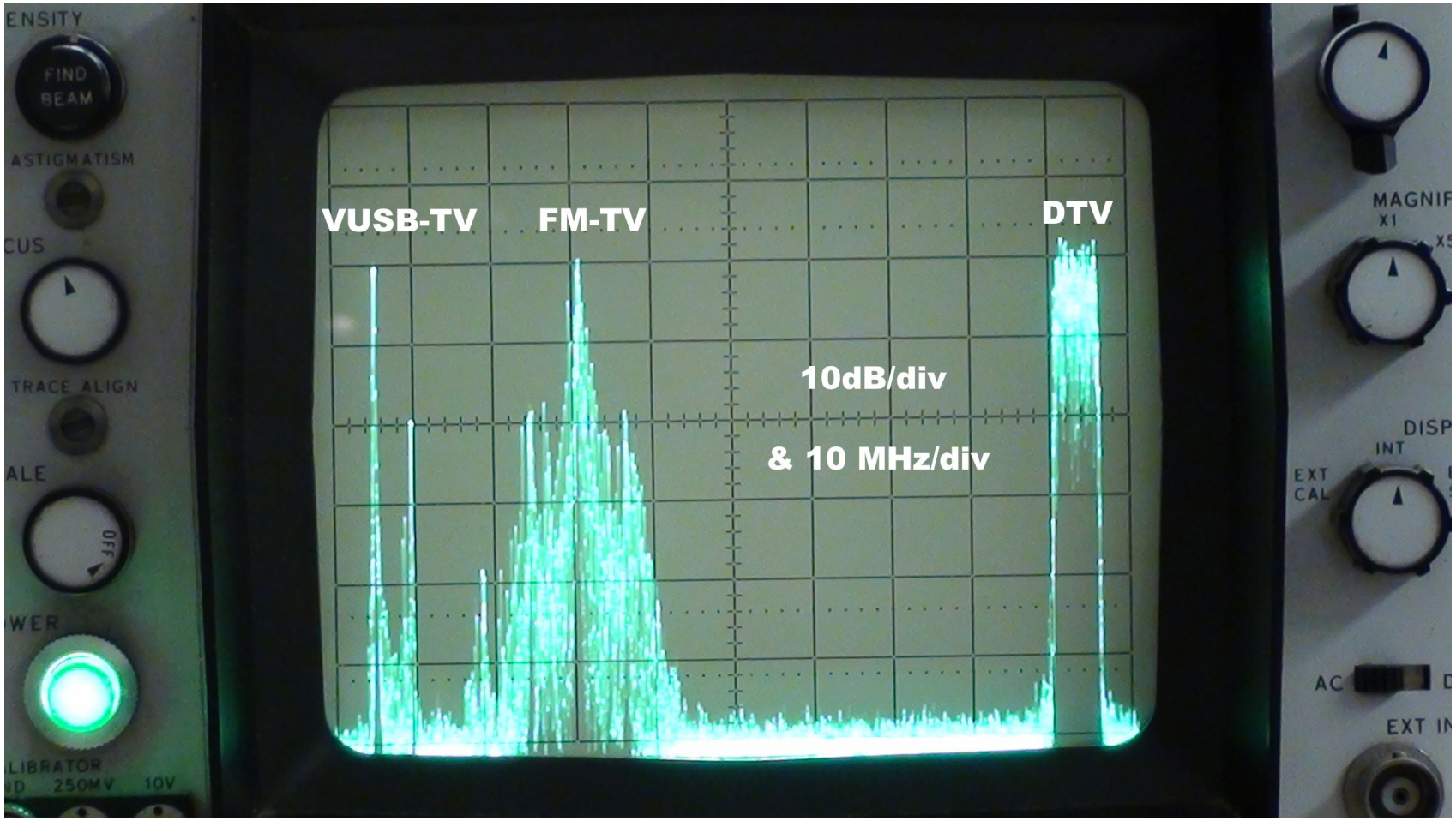
We use a Quad Processor to display all four pictures on a large, flat screen monitor for the police/sheriff/fire commander.

Typical 4 Camera Operation

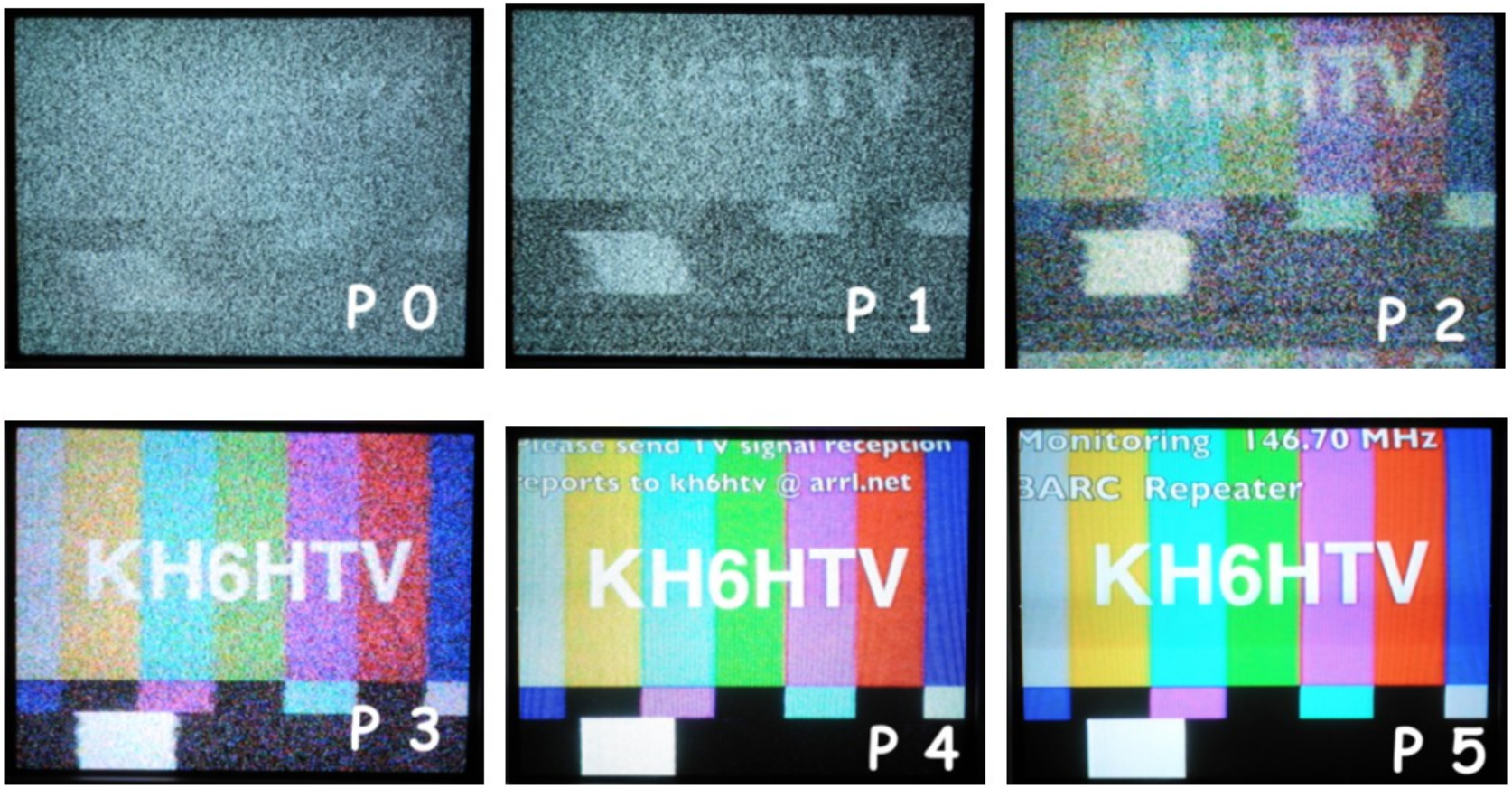
Analog TV Limitations

- Basically uses AM modulation
- 4.2 MHz video BW required for std. def. with SSC at 4.5 MHz. Required AM BW >9 MHz. Use VUSB to reduce BW to 6 MHz
- Standards set 78 years ago by FCC
- “Snow” with weak signals, need 40 dB s/n
- “Ghosts” with multi-path
- FM-TV added later for microwave links, works better with weaker signals, but much wider spectrum required. Thus not used on 70cm

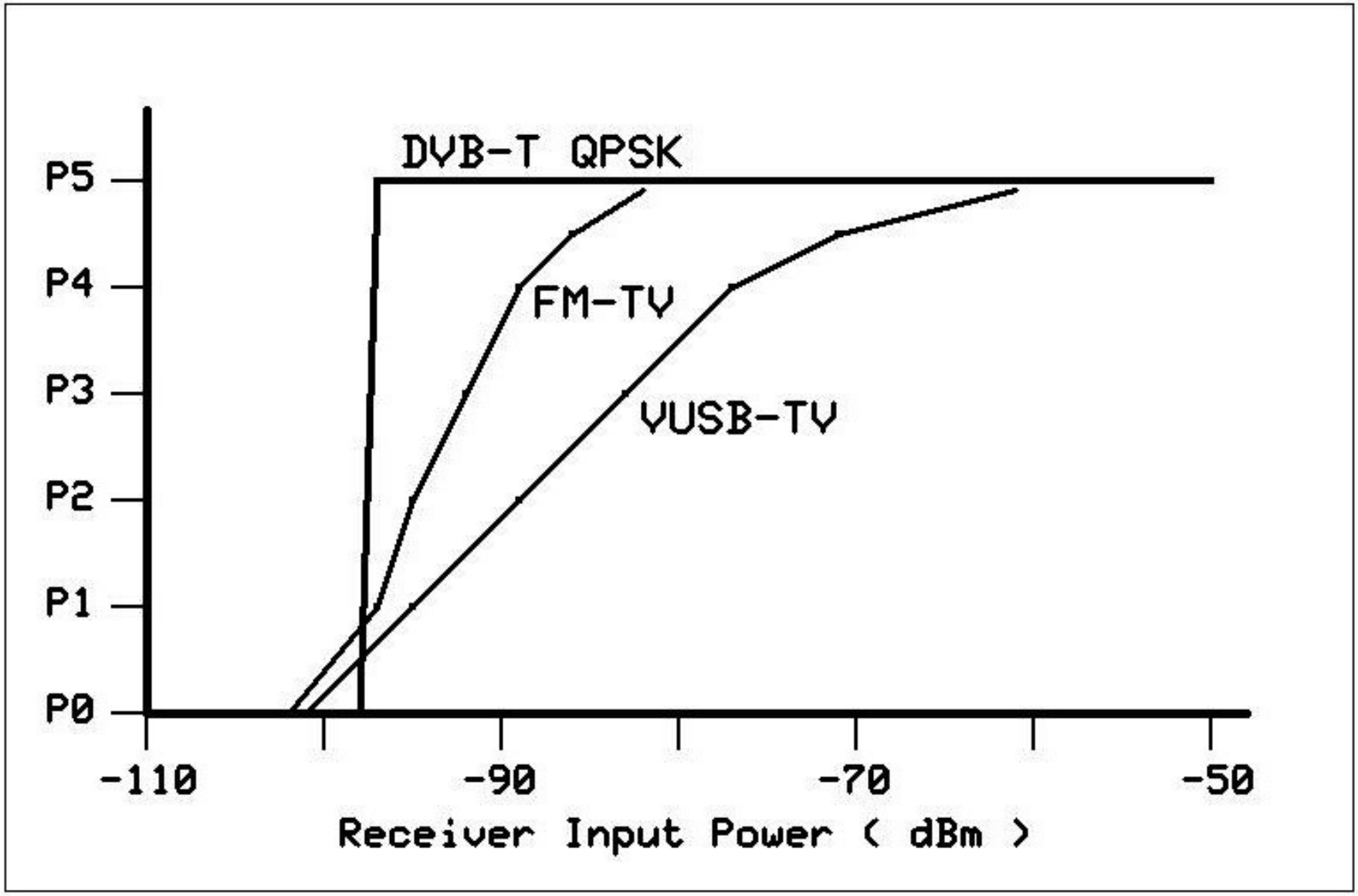
Comparison of Analog & Digital TV Spectrums



ATV Picture Ratings – P units



DTV vs Analog TV



Why Not Use USA Commercial Broadcast TV's ATSC, 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 --- the choice of most USA Digital ATV Hams

- 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

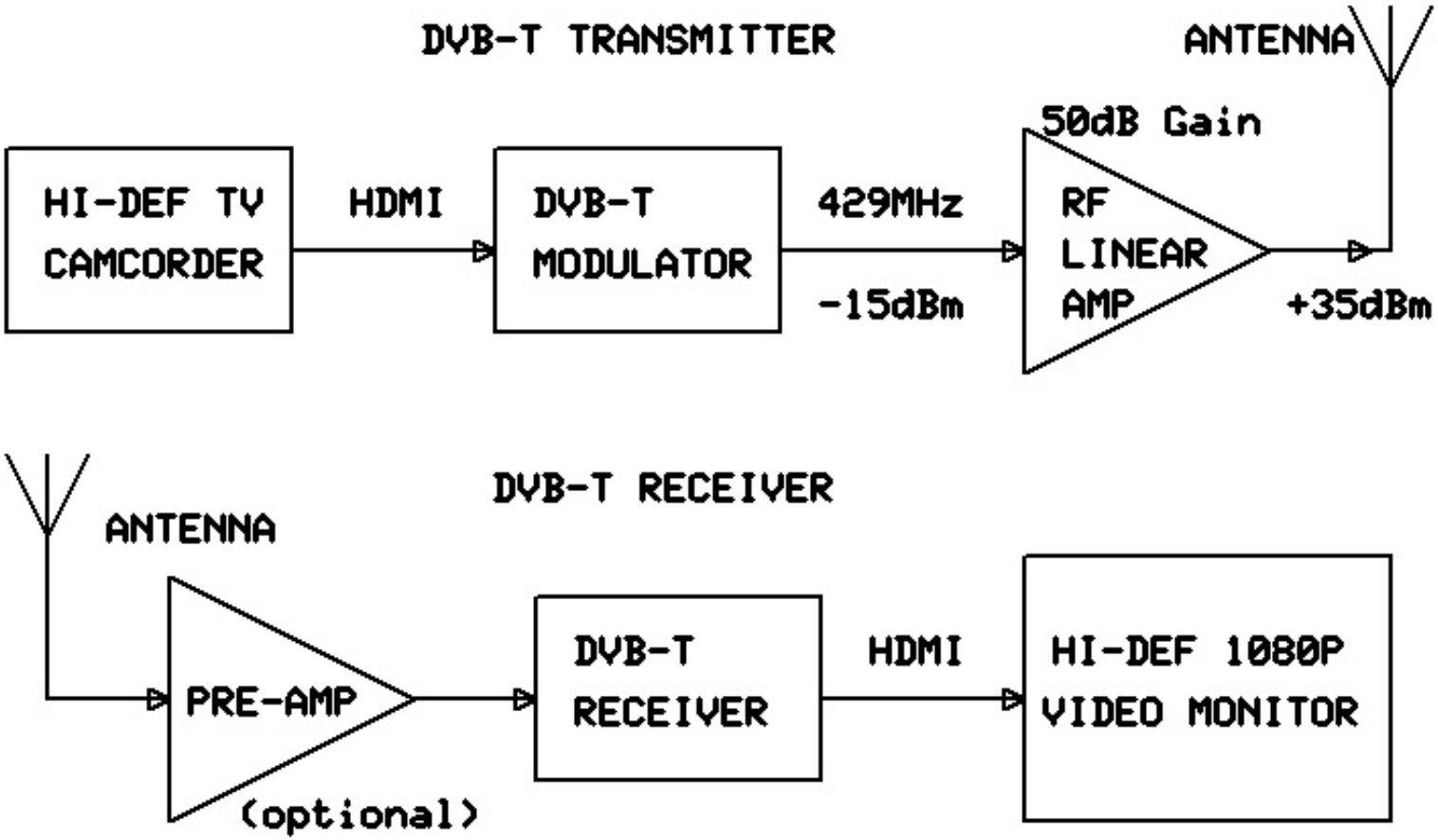
64 QAM = -82 dBm

Adding a low noise pre-amp typically buys another 3 dB in sensitivity

QPSK vs. QAM

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



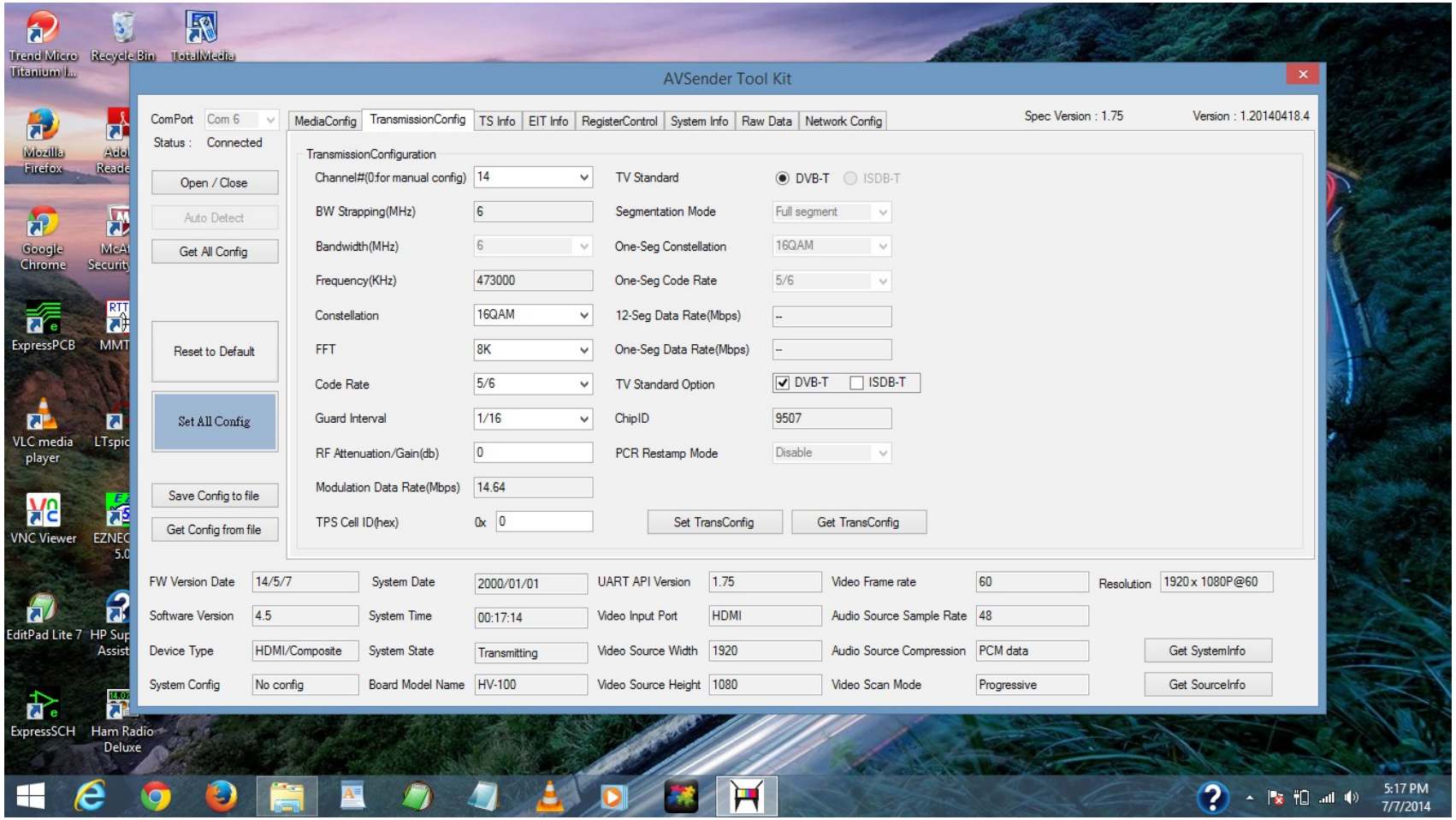
70cm, 3 Watt, DVB-T Transmitter

(total system cost ≈ $1,000)

Hi-Des HV-320E Modulator

- 100MHz – 2.5GHz, covers 70cm,33cm, 23cm & 13cm bands, synthesized
- DVB-T, up to 1080P resolution
- Programmable Bandwidths from 1 to 8 MHz, 1 MHz steps
- HDMI & composite video inputs
- ½ amp @ 12Vdc
- $369

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 – sent with every frame as part of metadata**

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, $350
- Other amps available up to 10 Watts & for 33 & 23cm bands

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 = $125
- HV-320E, 100MHz to 2.65GHz, 12Vdc, $209

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 amateur 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: not all hams have been able to get them to work.

TV Antennas must be Broad-Band !

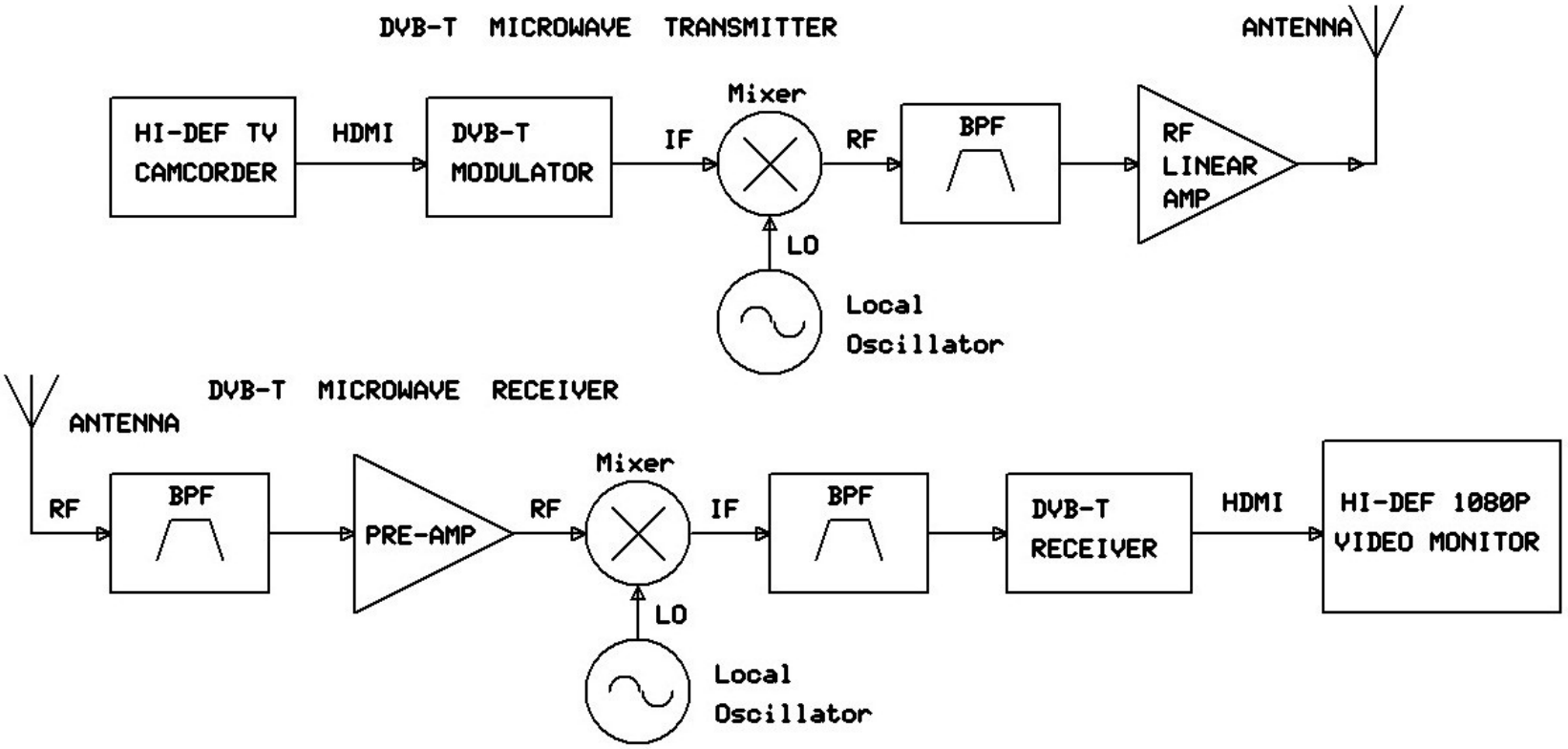
Boulder ARES has standardized on using Vertical Polarization for 70cm & 23cm TV – most suitable for back-pack portable, mobile & repeater operations

Propagation Characteristics of various bands

- 70 cm (430 MHz) - best all around for usefulness, reasonable size antennas, lower path loss and good penetration. 30 MHz supports up to five, 6 MHz, hi-def channels or fifteen, 2 MHz, std. def channels
- 33 cm (900 MHz) – Do have major RFI issues due to proliferation of unlicensed part 15 devices. Junk Band!
- 23 cm (1250 MHz) – 2ed choice, best used for point-to-point links. Main RFI issue is DIA radar at 1267 MHz
- 13 cm (2.4 GHz) – marginal results at 2.395 GHz - worthless due to Wi-Fi signals above 2.40 GHz
- 3.5, 5.8, 10 GHz & higher – point to point, high gain dish antennas. Very long distances, > 500 km, have been achieved.

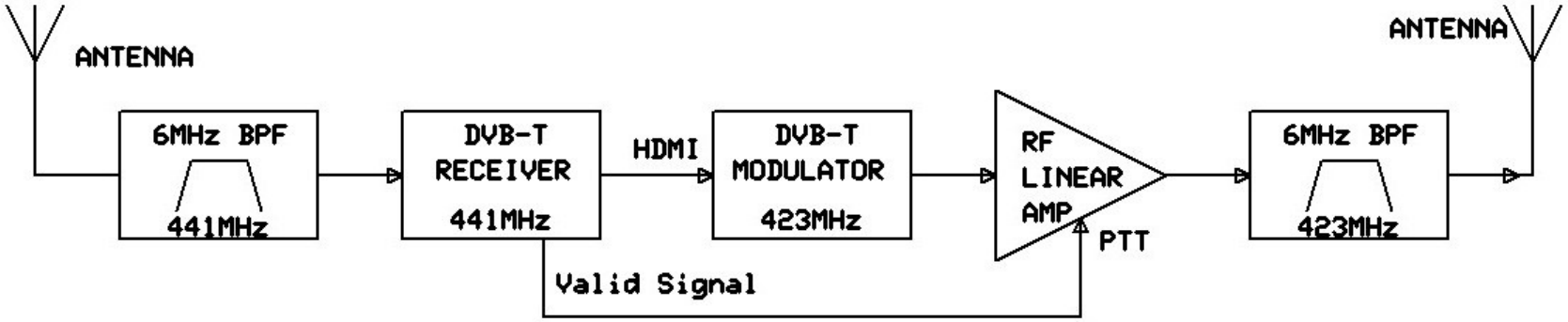
Higher Microwave Bands

note: LO must have very low phase noise



DVB-T TV REPEATER

(cost – approx. $2,500+)



6 MHz BW, 70 cm, Inter-Digital Band-Pass Filter

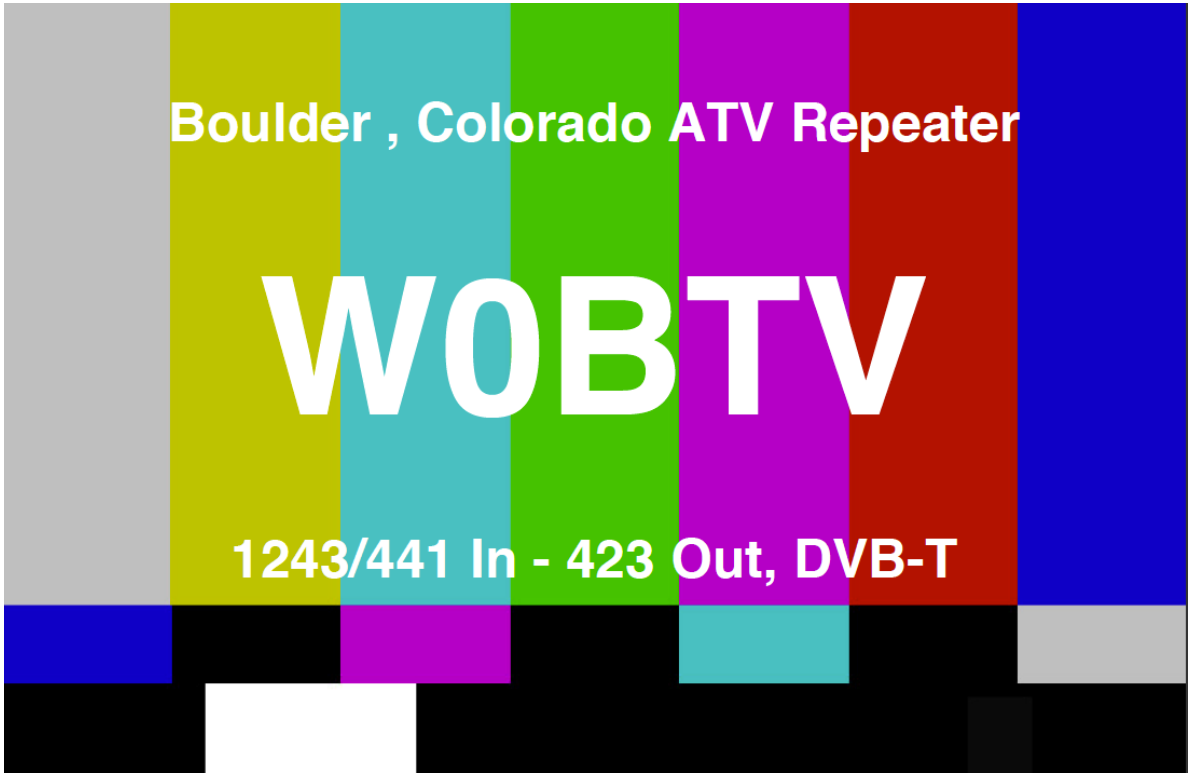
Basic 70 cm DVB-T Repeater

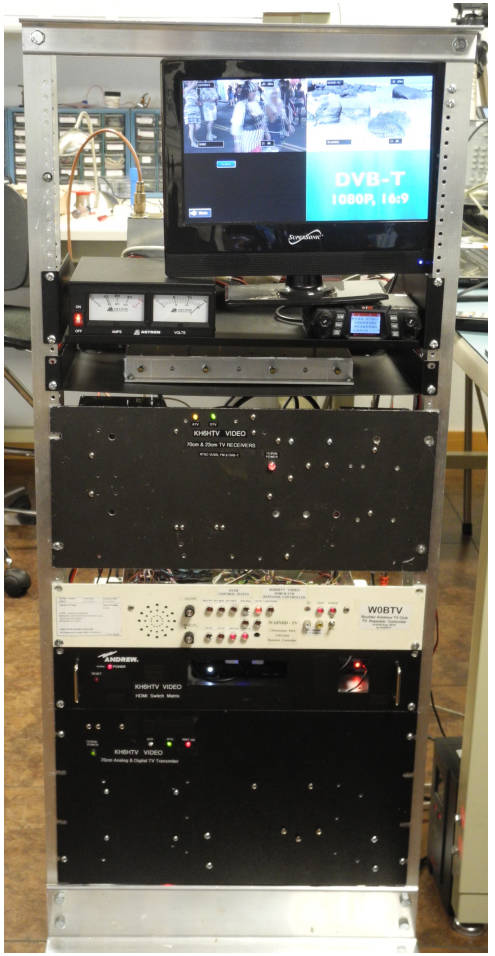
built for Pueblo, Colorado Ham Club

Boulder ATV Repeater

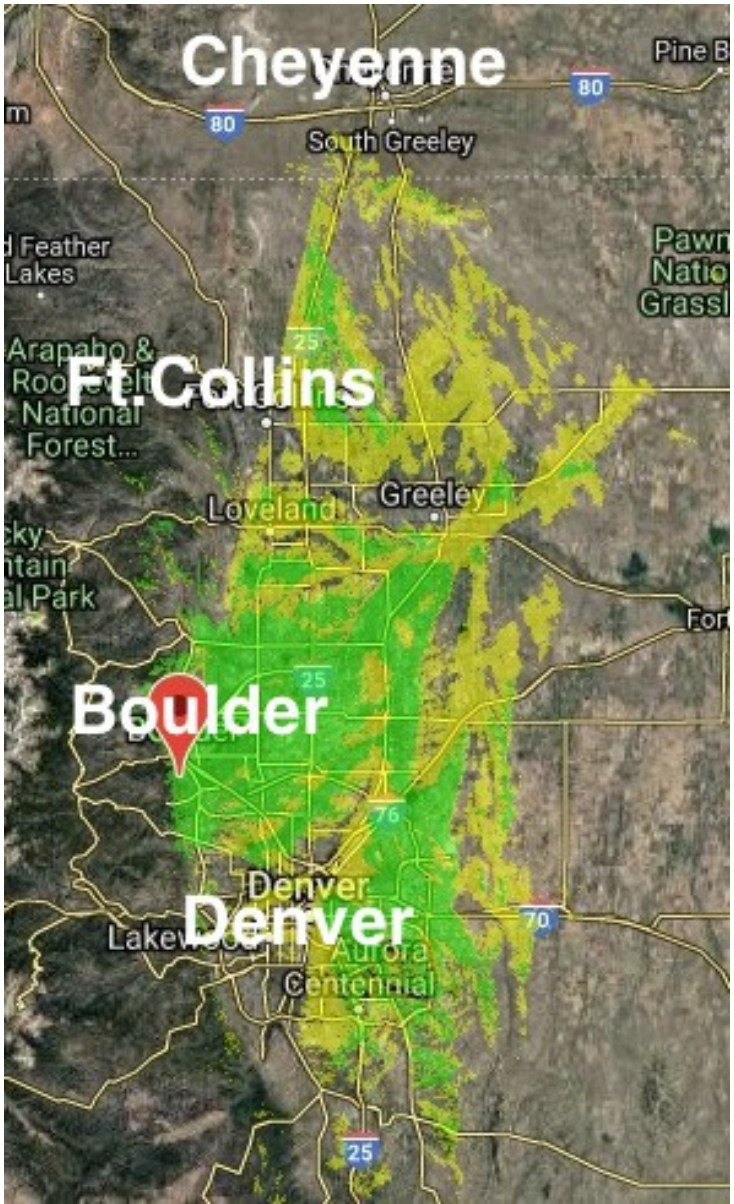
dual band – 23 cm & 70 cm inputs

dual mode - analog & digital





Boulder DATV Repeater



More Information

- **KH6HTV VIDEO** www. kh6htv.com over 45 ATV/DTV related application notes, plus RF linear power amplifiers and other amateur TV products
- AN-45 "Introduction to Amateur Digital Television", 30 page book

More Info contd.

- “DVB-T: A Solution for ARES Television Operations”, **QST**, June 2015, pp. 42-44, by KH6HTV
- “Digital ATV Repeaters”, **QST**, Sept. 2019, pp. 40-41, by KH6HTV
- Hi-Des Technologies --- supplier of low cost, quality, DVB-T modulators and receivers – www.hides.com.tw
- CQ-DATV, free, on-line magazine, www.cq-datv.mobi
- Live Streaming of TV repeaters – via British Amateur TV Club – https://batc.org.uk/live
- Yahoo DTV Users Group, https://groups.yahoo.com/neo/groups/DigitalATV/info

Questions ?

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This Power-Point slide show will be available in .pdf format on the web at:

www. kh6htv.com


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