

Amateur High-Definition Digital Television

- **Jim Andrews**
- **Boulder, Colorado**
- **www.kh6htv.com**



Your own Broadcast TV Station



Bill - AB0MY 70cm & 23cm DVB-T & 70cm VUSB-TV



Joe - AD0I 70cm VUSB-TV



Roger - K0IHX & Naomi - KD0PDZ
70cm & 23cm DVB-T & 70cm VUSB-TV



Pete - WB2DVS & Debbie - WB2DVT
70cm DVB-T

Modern Digital TV

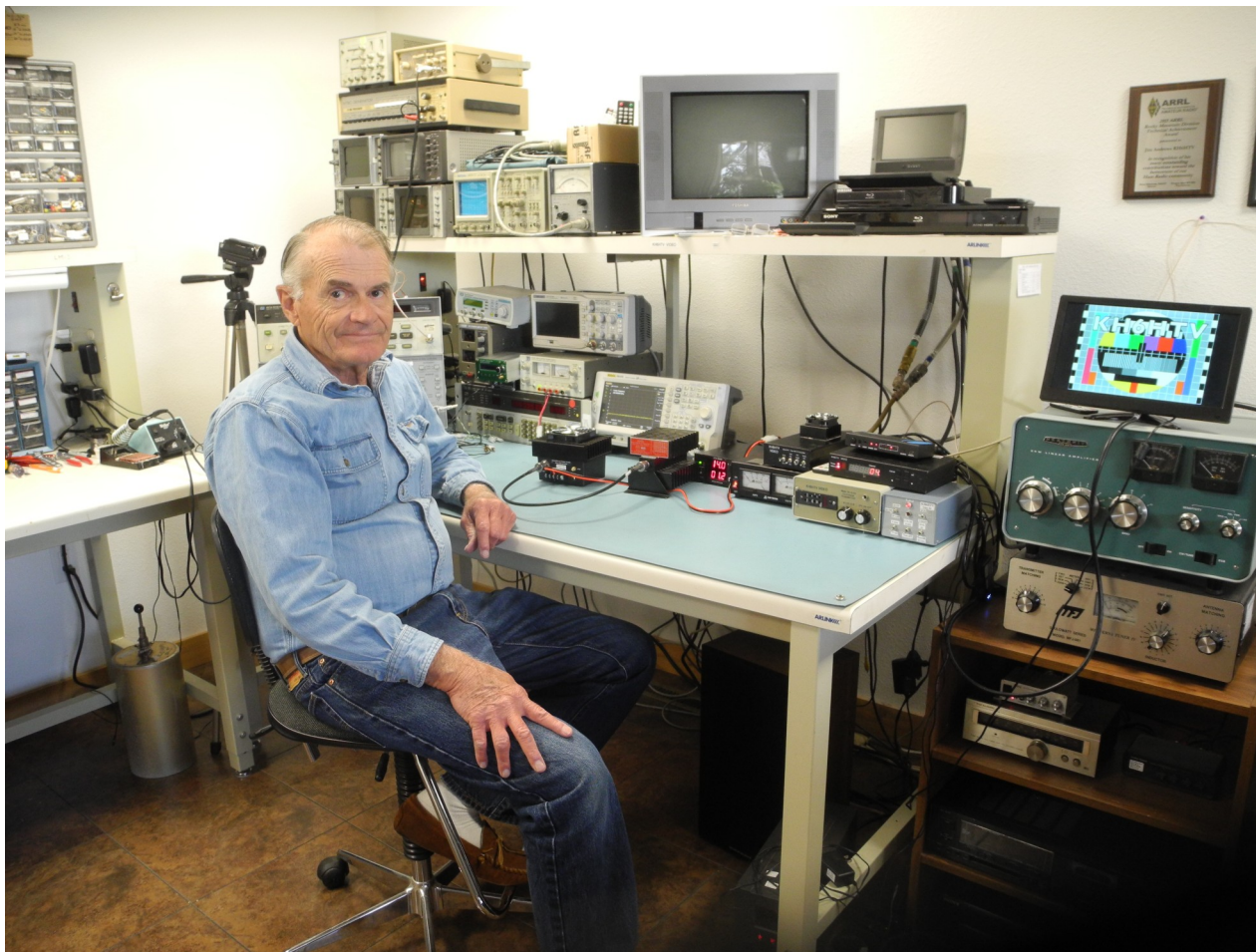
High - Resolution, 1080P

CD Quality, Stereo Audio

Jim, KH6HTV



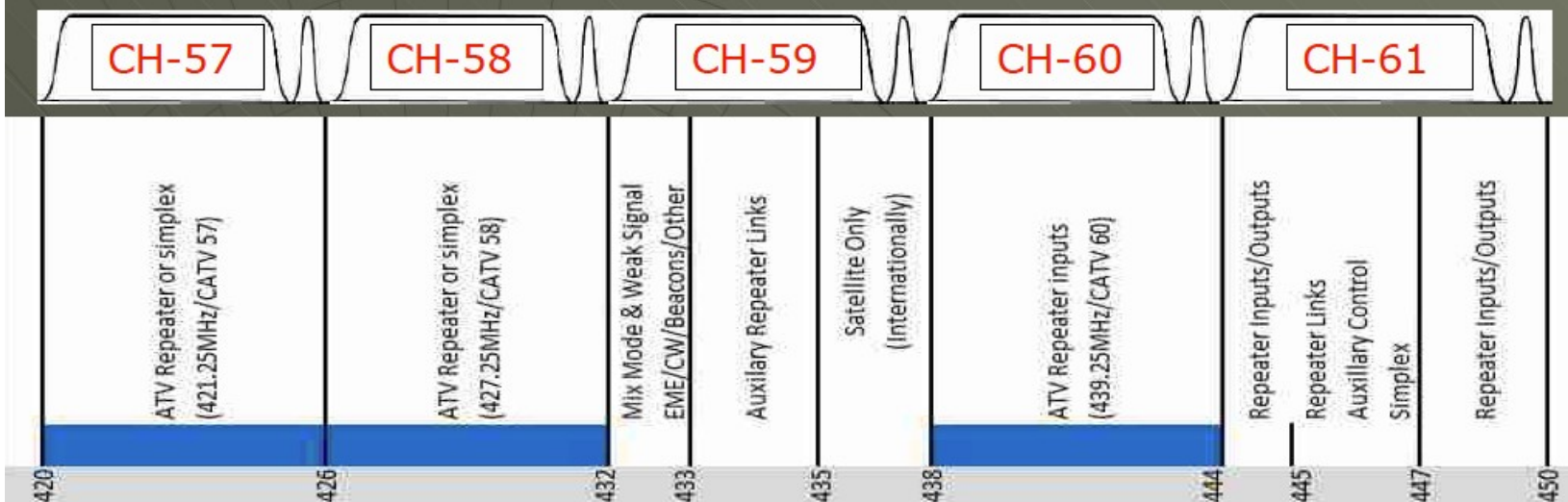
Boulder, Colorado



**The FCC allows hams to transmit
"fast scan" broadcast quality TV
on the 70cm band & all higher
microwave frequencies**



70cm Band (420-450MHz)



Each ATV Channel has a 6MHz Bandwidth.

- ◆ CH-59 & CH-61 are NOT recommended due to their likely interference to Repeaters and other active frequencies.
- ◆ Vestigial Sideband (VSB) is recommended for ATV

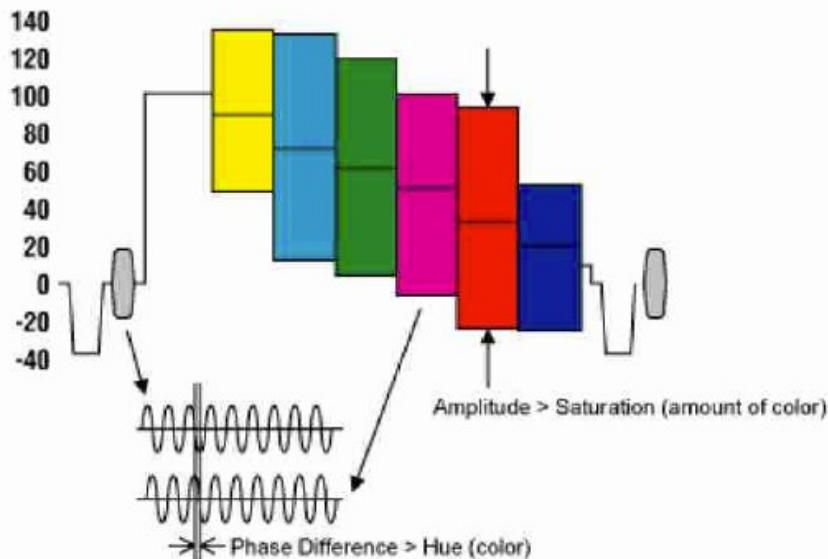
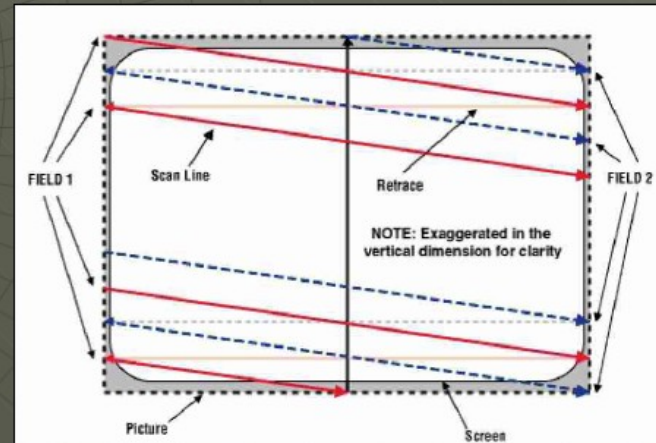
The Origin of Television

- Initial development of TV in mid-20s (100 years ago !)
- 1st Broadcasts by BBC, 1929 & NBS, 1939
- Used technology available then, i.e. AM
- 1941 – FCC etches “in stone” the TV standards – remain unchanged for 60 years !
- Only update, color added - 1953

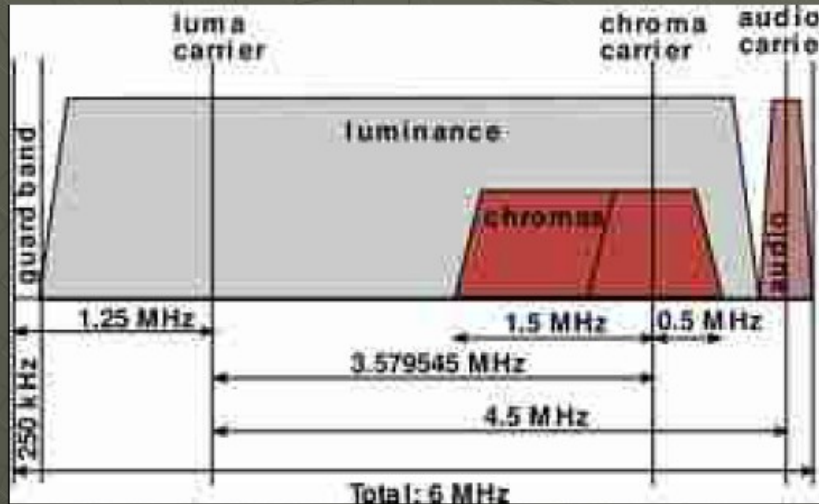
Analog Composite Video

Each Analog television signal consists of:

- ◆ 29.97 Interlaced frames of video per second.
- ◆ 525 Lines per frame.
- ◆ 262.5 lines per field Odd/Even
- ◆ 640x480 (WxH) Pixels



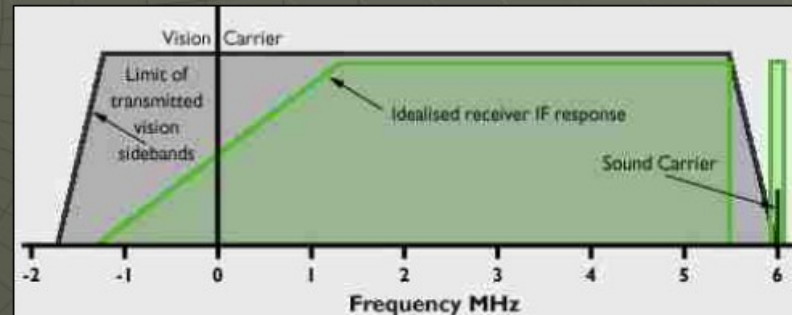
What's in a VUSB-TV Channel?



Video Signal is AM

Audio Signal is FM

Effect of Vestigial Sideband Filtering



Ham ATV in the Past

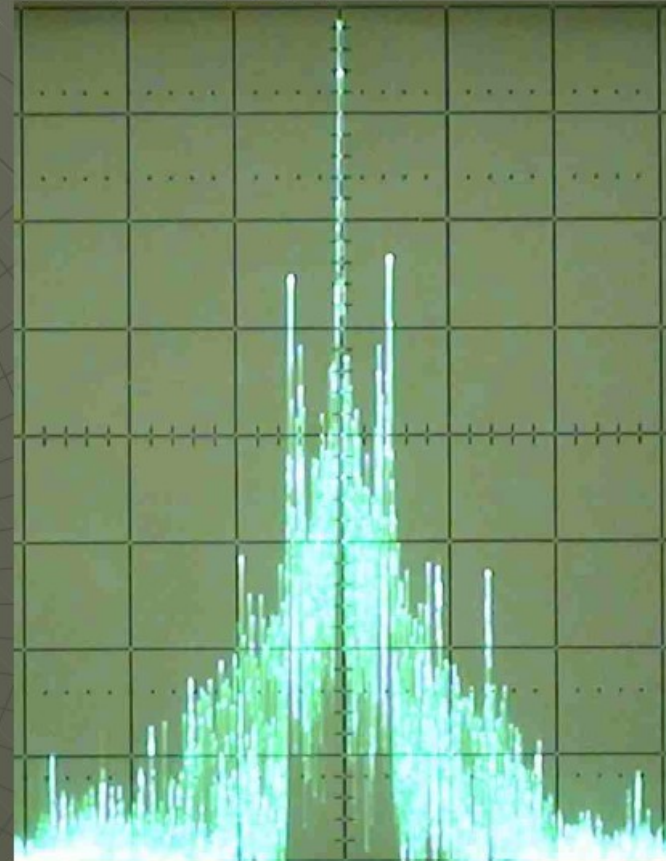
In the past, most ATV activity was on 70cm band using AM-TV

The major supplier from 1960s to 2014 was Tom, W6ORG, P.C. Electronics
www.hamtv.com



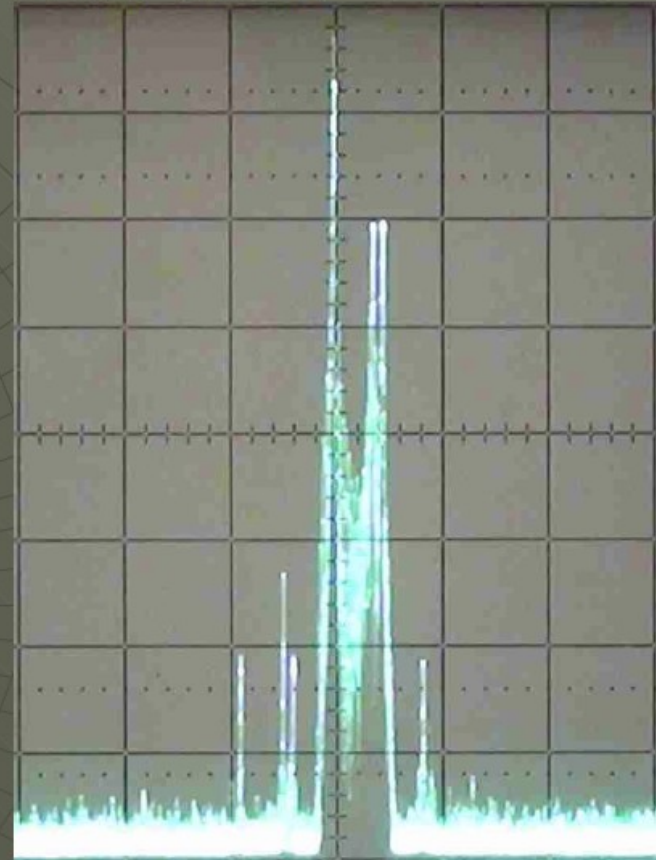
Typical Ham AM-TV Transmitter Spectrum

- Note: Broad, double sidebands
- Excessive bandwidth consumed
- 10dB/div & 10MHz/div



Ham 70cm, VUSB-TV Transmitter Spectrum

- Much cleaner spectrum
- Less co-channel interference
- Near Broadcast Quality
- 10dB/div & 10MHz/div



ATV Picture Ratings – P units

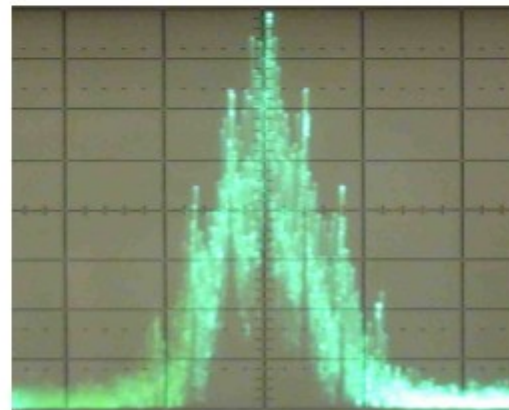
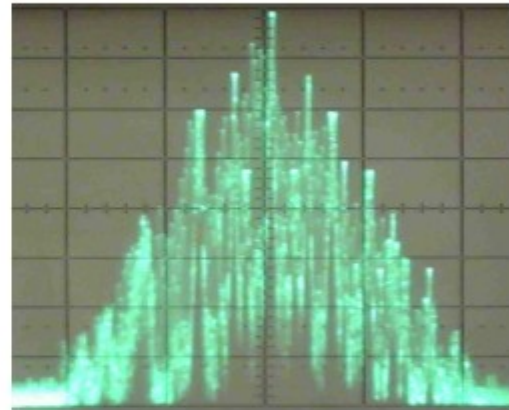


Analog TV Limitations

- 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 in 1941 by FCC
- “Snow” with weak signals, need 40 dB s/n & -60dBm at receiver for P5 picture
- “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

Why not FM-TV on 70cm ?

- The FM spectrum is too broad. 20+MHz vs. 6 MHz
- FM-TV spectrum plots 10dB/div & 10MHz/div
Bottom is 4 MHz deviation “live” video modulation. Top is with stereo sound subcarriers (SSC) added



Analog ATV Today

Almost impossible to find
any 70cm AM-TV gear
now

Best option today, and
low cost – is 5.8GHz,
FM-TV. Used for
drones

Available for about \$30
from Amazon & E-Bay



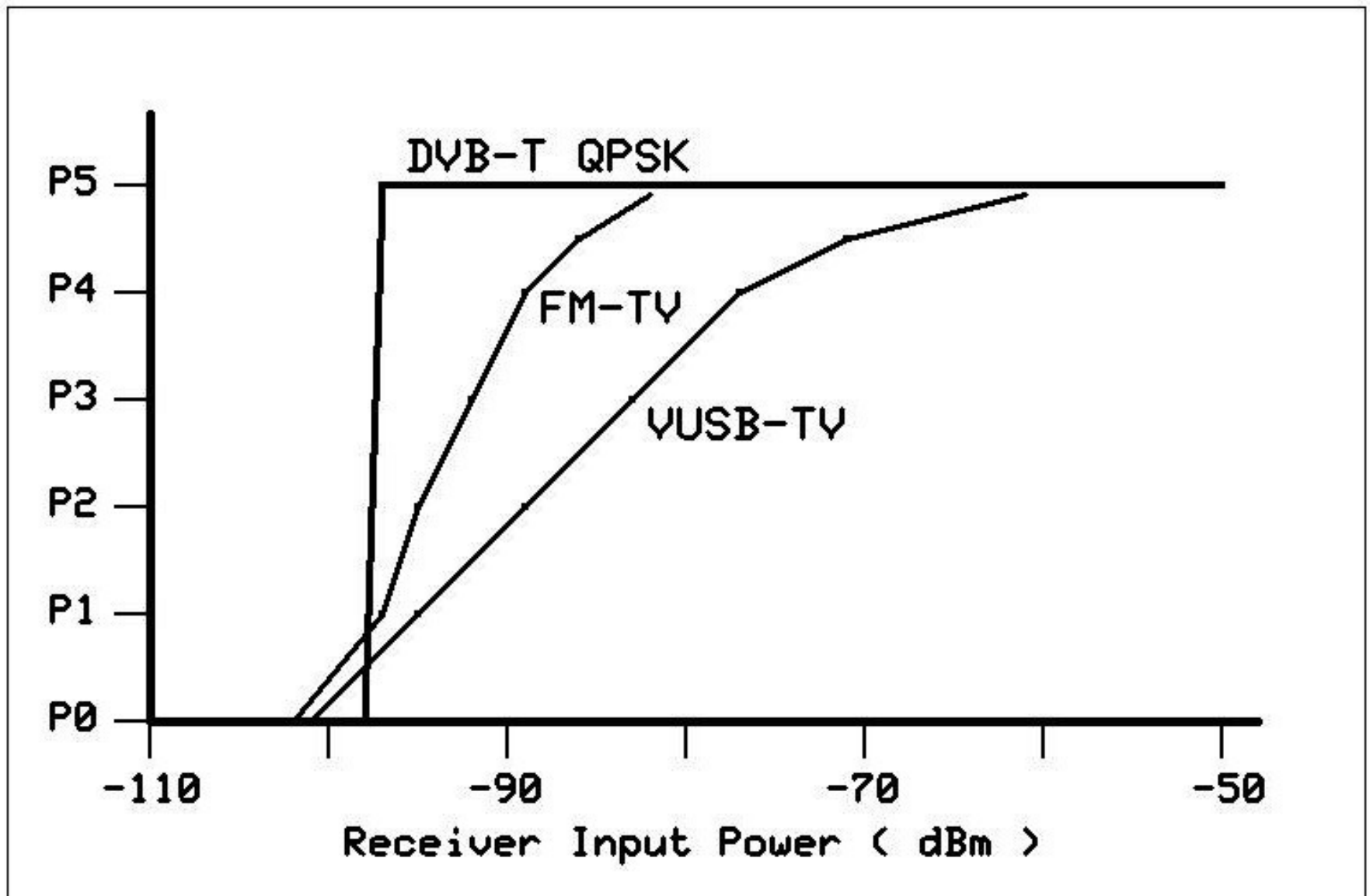
Digital ATV no longer “Amateur”

Perfect Pictures & CD quality Audio

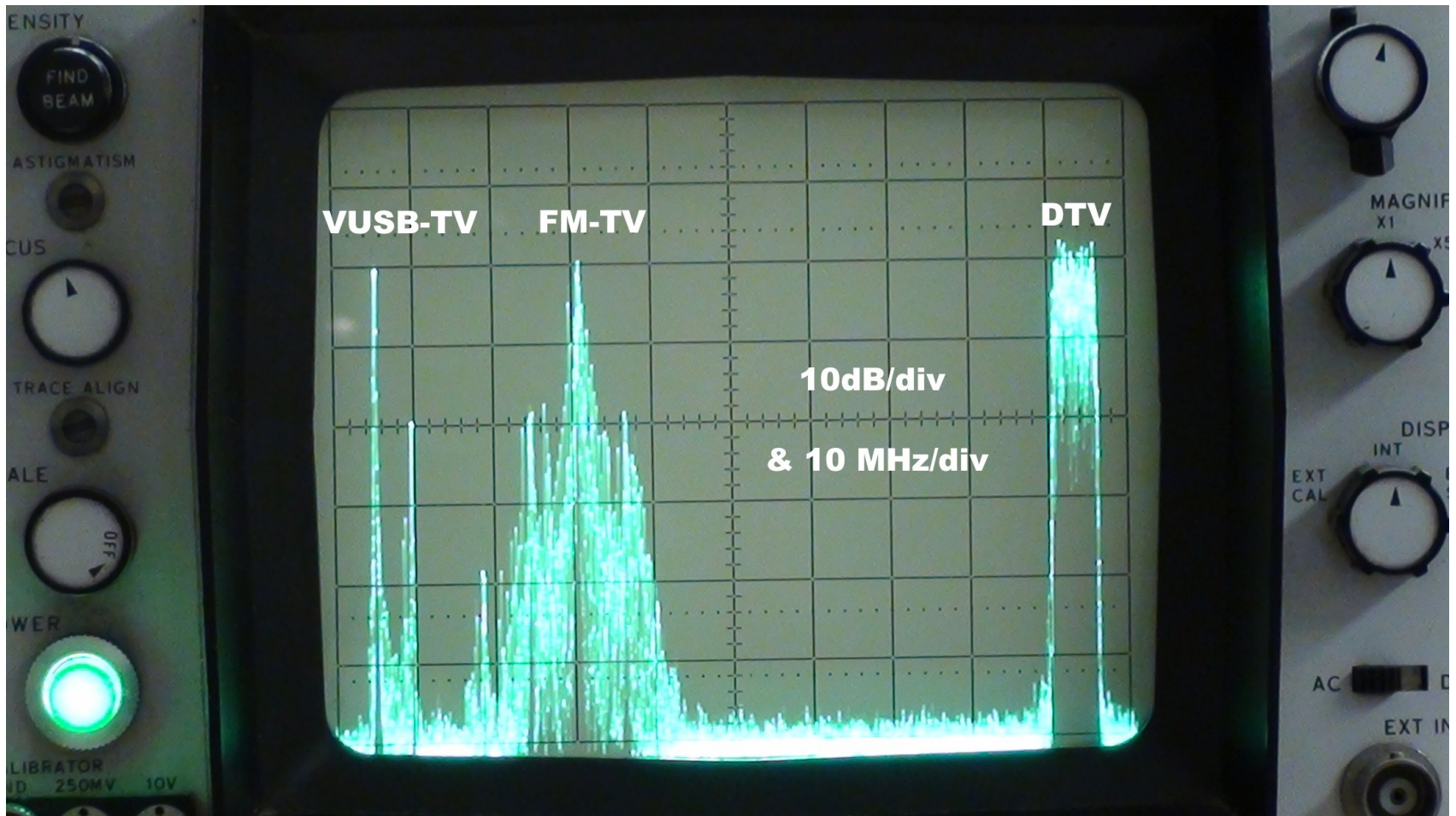
(photos from off the air DVB-T)



DTV vs Analog TV



Comparison of Analog & Digital TV Spectrums



Major DTV Objection

- Latency (i.e. delay)
- Tremendous amount of computer processing involved, both at transmitter and also in receiver
- Noticeable delay of at least $\frac{1}{2}$ second
- Delays build up through multiple repeaters
- NOT Recommended for flying drones – i.e. a Safety issue

DTV vs. Mesh Network

- Mesh is Point-to-Point – 2 way
- DTV is wide-area Broadcast – one way
- Mesh requires transmit/receive boxes
- DTV can be 1 transmitter & unlimited receivers
- Mesh requires “hand-shaking” for data transfer
- DTV is “broadcast” and anyone can receive

DTV Broadcast Standards

- **8-VSB or ATSC** - Eight Vestigial Side Bands, *USA standard 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, choice of most USA ADTV*
- **ATSC 3.0** - **NEW !** A variation of DVB-T. USA broadcasters are now transitioning to this. NOT backwardly compatible with ATSC 1.0 (8-VSB)

Why Not Use USA Commercial Broadcast TV's **ATSC, 8-VSB** ?

- 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.”
- 8 - 10 years ago when USA ATV hams became serious about DTV, the major factor was cost of the modulator. A DVB-T modulator cost \$600 while an ATSC modulator cost \$6,000 +.
- ATSC modulators are now available at same low cost as DVB-T

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

16QAM = -92 dBm

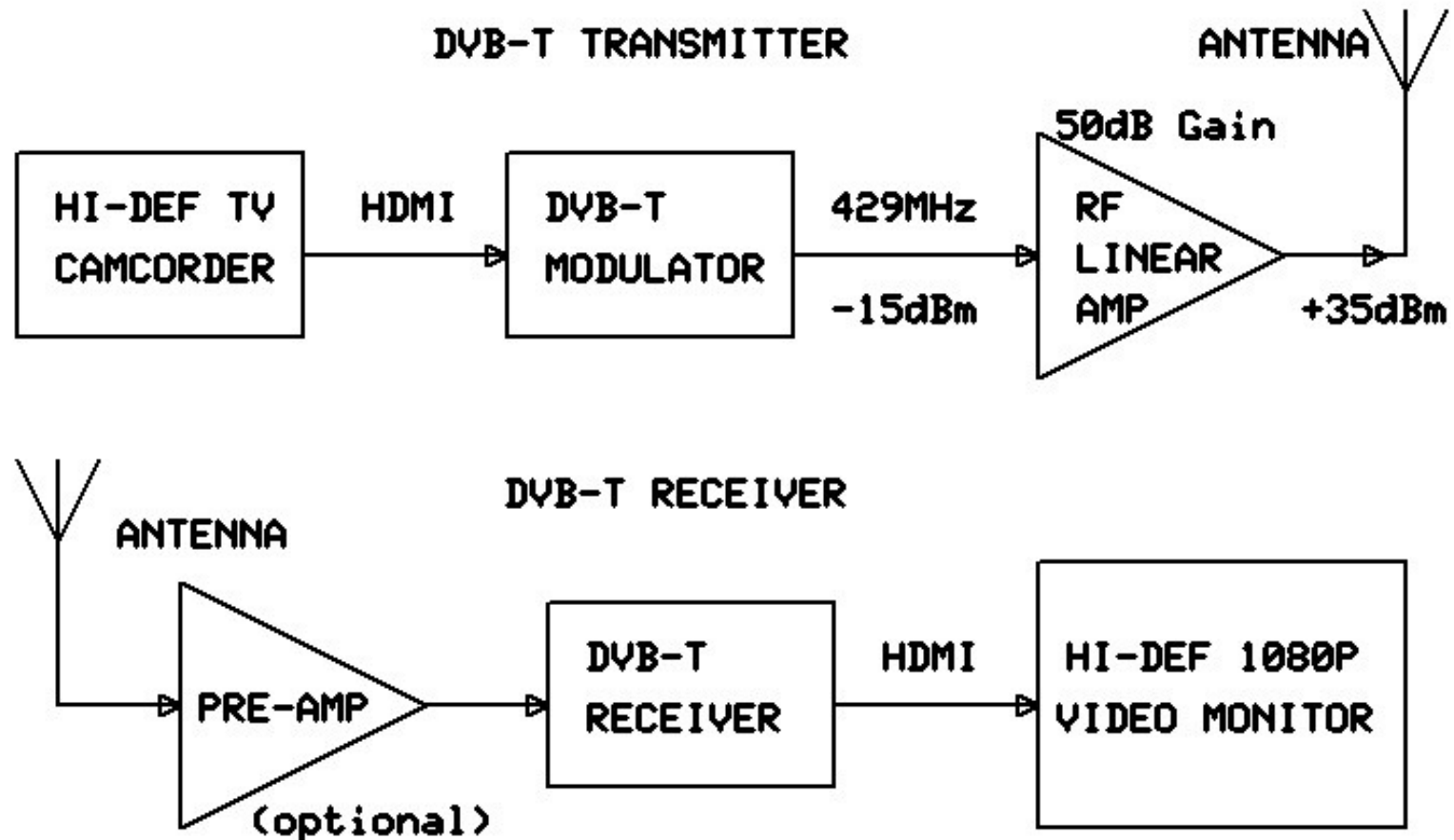
64QAM = -82 dBm

1. Adding a low-noise preamp typically buys another 3dB in sensitivity
2. Using very aggressive FEC also buys another 3dB in sensitivity

QPSK vs. QAM

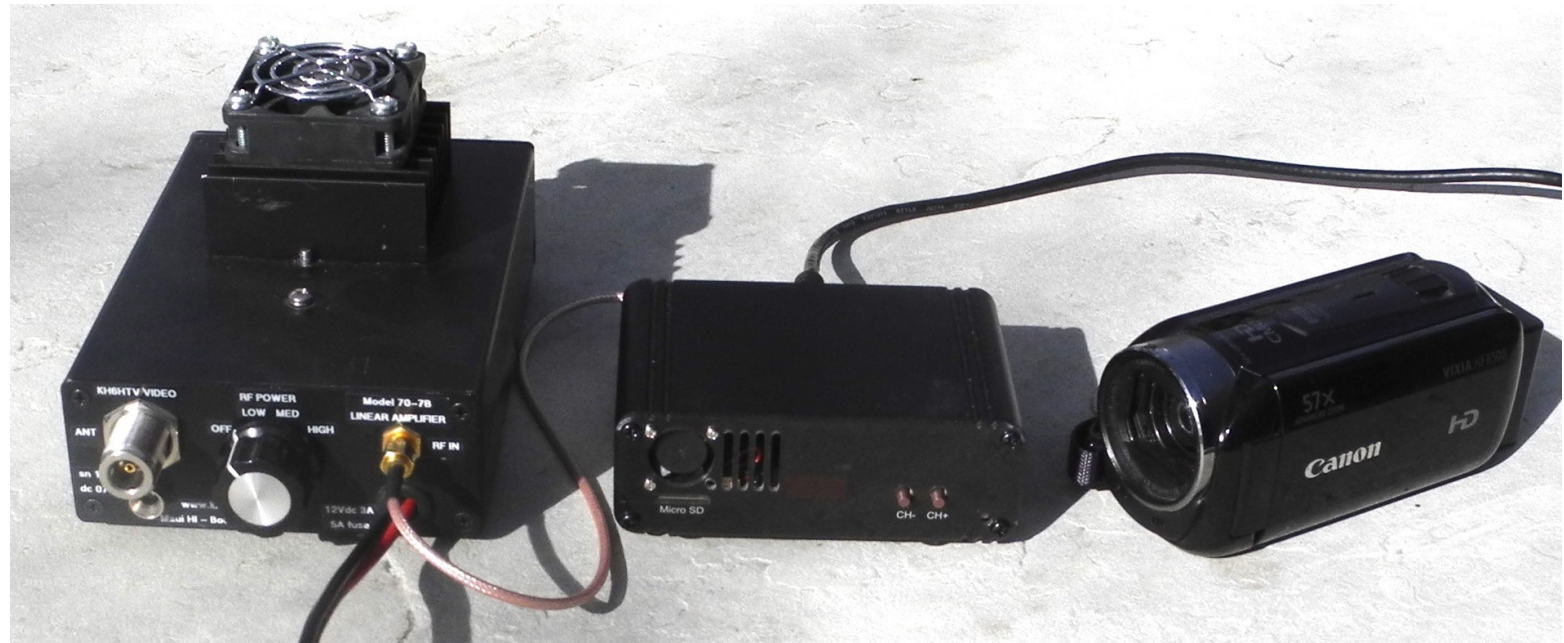
- Max Video Encoding data rates for various modulations with 6 MHz BW: QPSK = 7.3 Mbps, 16-QAM = 14.6 Mbps & 64-QAM = 21.9 Mbps
- Higher bit rates needed to follow really fast action, such as sports, thus prefer QAM
- For typical ham TV, low power, marginal antenna situations, the 15 dB QPSK margin often 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 cost = \$1,100)



- 3 Watt, RF Linear Power Amplifier - \$450
- DVB-T Modulator - \$400
- Hi-Def (1080P) Camcorder - \$250

Hi-Des - Major Supplier

- Taiwan company
- Reasonable prices & good reliability
- Support Amateur TV market
- Unique in providing lower bandwidths
- Excellent customer support
- Sells via E-Bay, accepts credit cards
- Very prompt shipping to USA
- www.hides.com.tw

Hi-Des Model 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**
- HDMI & composite video inputs
- \$400

DVB-T Receivers



Fig. 15 Set-Top box receivers for DATV & USB dongle TV tuner

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
- Cost = \$120

DVB-T Set Top Box Receivers



- Consumer grade
- Simple to operate
- Inexpensive, < \$50
- Available- internet
- Only for 6,7&8MHz
- **Caution: not all of them cover amateur 70cm band**



Cheap ! \$20 DVB-T Receiver



- USB TV Tuner Dongle
- Available amazon, ebay, etc.
- Uses RTL2832 software defined radio receiver IC
- Use free shareware VLC program
- Requires a different driver than used for other SDR apps

How to rate Transmitter RF Power

- FM: max. saturated power
- SSB: Peak Envelope Power (PEP)
- AM: Average carrier power (with 100% modulation $P_c = PEP / 4$)
- Analog Video (VUSB-TV): Peak Envelope Power, measured on sync tips
- Digital Video: average power, noise like signal with no distinguishing features

Typical Transmitter Power Ratings

(for the same amplifier)

- FM/CW: 70 Watts (max. saturated)
- P(-1dB): 50 Watts
- SSB: 50 Watts (PEP)
- VUSB-TV: 25 Watts (no sync compression)
- Digital TV: 10 Watts (avg) note: a min. of 8 dB head-room required for peaks in noise-like digital signal.

DATV Amplifier Supplier



**Quality Products & Application Notes for the
Amateur Radio/TV market www.kh6htv.com**

- *Full disclosure: I have a small, hobby business in my ham shack, building RF amplifiers and other products for the ATV market.*

Typical DATV Amplifiers

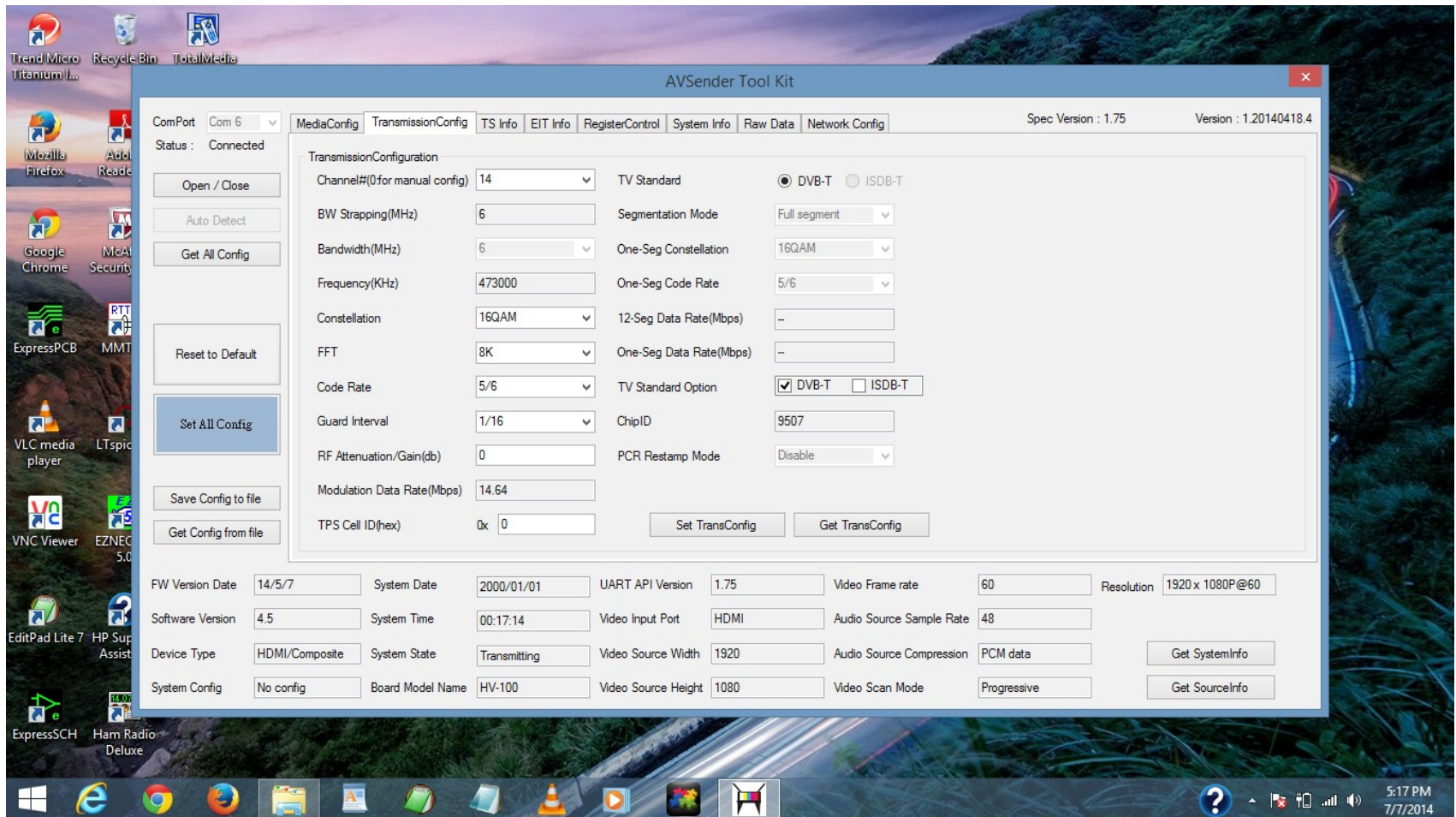


- High Power – 10 Watts, for base stations & repeaters
 - Medium Power – 3 Watts, for portable ARES use
 - Amplifiers for 70cm, 33cm & 23cm bands, 50dB gain
 - Adjustable power levels, 0 dB, -5 dB & -10 dB
 - Prices \$450
- 12Vdc operation

Some Set-Up Required for DTV

- Not as simple as Analog TV
- But simpler than DMR, D-Star, etc.
- Also simpler than many FM HTs !
- No registration required !
- Ph. D degree NOT required !
- Set-up required for both modulators and receivers

Program Modulator with external PC computer via USB



Key Modulator Parameters

MediaConfig	TransmissionConfig	TS Info	EIT Info	RegisterC
MediaConfiguration				
Video Input Port	HDMI			
Video Input Mode	AUTO			
Video Encoding Type	H264			
Video Encoding Resolution	1920x1080			
Video Encoding Width	1920			
Video Encoding Height	1080			
Data Rate Control Type	CBR			
Auto Bit Rate	Disable			
Max Bit Rate (kbps)	6000			
Avg Bit Rate (kbps)	8000			

MediaConfig	TransmissionConfig	TS Info	EIT Info	Reg
TransmissionConfiguration				
Channel#(0 for manual config)	[004] CH04			
Channel Table	User defined			
Bandwidth(MHz)	6			
Frequency(KHz)	441000			
Constellation	QPSK			
FFT	8K			
Code Rate	5/6			
Guard Interval	1/16			
RF Attenuation/Gain(db)	-2			
Modulation Data Rate(Mbps)	7.16			
TPS Cell ID(hex)	0x 0			

DVB-T RECEIVER SETUP

- Not as simple to use as old analog TV
- But, no different than any other new digital TV receiver
- Scanning required to memorize each ATV channel
- Receiver is “SMART”. It will automatically track changes in most parameters such as modulation type, FEC, etc.



Application Note

AN-18c

copyright - Sept, 2014

rev "A" - Dec. 2015

rev "B" - Mar. 2017

rev "C" - Oct 2019

Notes on Setting Up Hi-Des DVB-T, Modulators & Receivers

Jim Andrews, KH6HTV

www.kh6htv.com e-mail **kh6htv@arri.net**

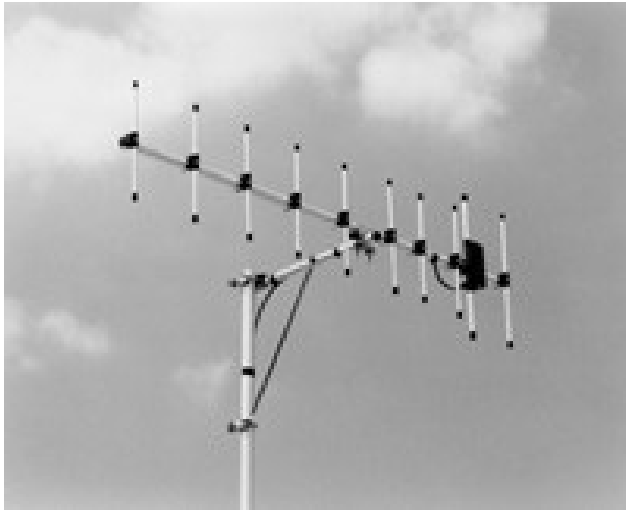
FCC IDing

- SIMPLE ! With DTV done automatically
- Program your call sign into modulator
- Call Sign transmitted not every 10 minutes, but with every video frame as part of meta-data header
- To see call sign, simply push “Info” button on receiver’s remote control
- Some controversy about legality however

ATV Antennas



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



ATV PROPAGATION

“Line-of-Sight” – practical limit

Why? We run low power, 10W typical, not kW like broadcast

Law of Physics – Thermal Noise Floor much higher for TV

2.4kHz (SSB) = -140dBm, 15kHz (FM) = -132dBm

2MHz (NBDTV) = -111dBm, 6MHz (DTV) = -106dBm

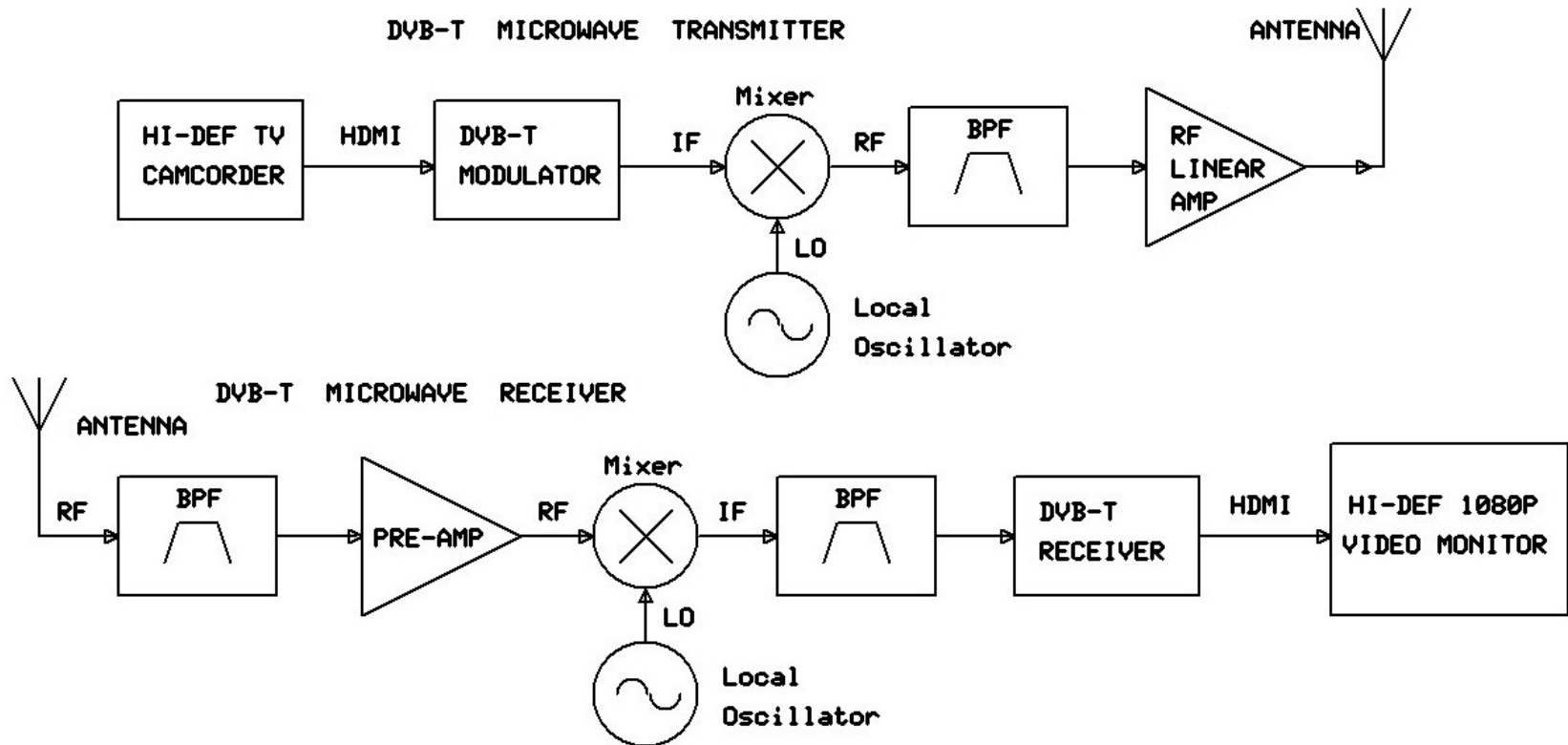
16MHz (FM-TV) = -102dBm

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 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. Used by many ATV repeaters. Main RFI issue is FAA radars
- **13 cm** (2.4 GHz) – marginal results at 2.393 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

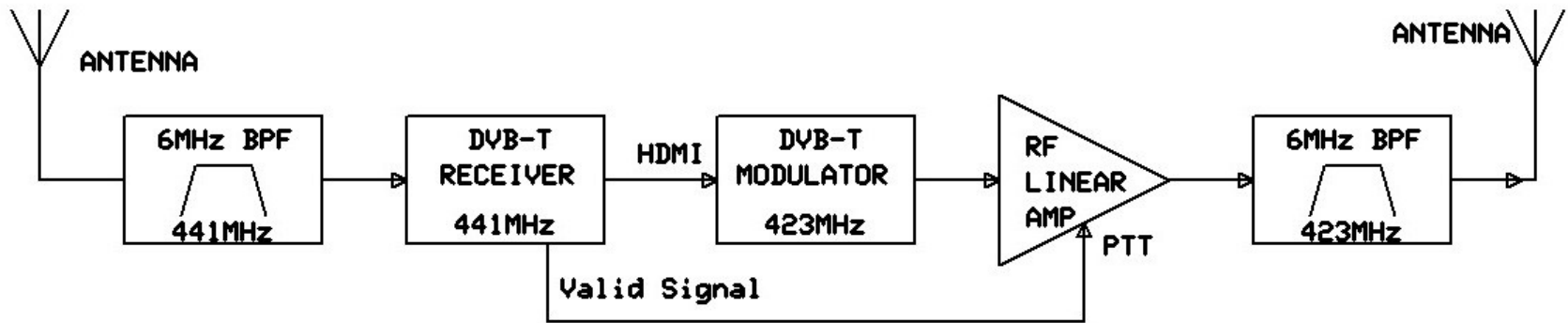
note: LO must have very low phase noise



DVB-T TV REPEATER

(cost – approx. \$2,500+)

far simpler to build than an FM voice repeater



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



Basic 70 cm DVB-T Repeater

built for Pueblo, Colorado Ham Club

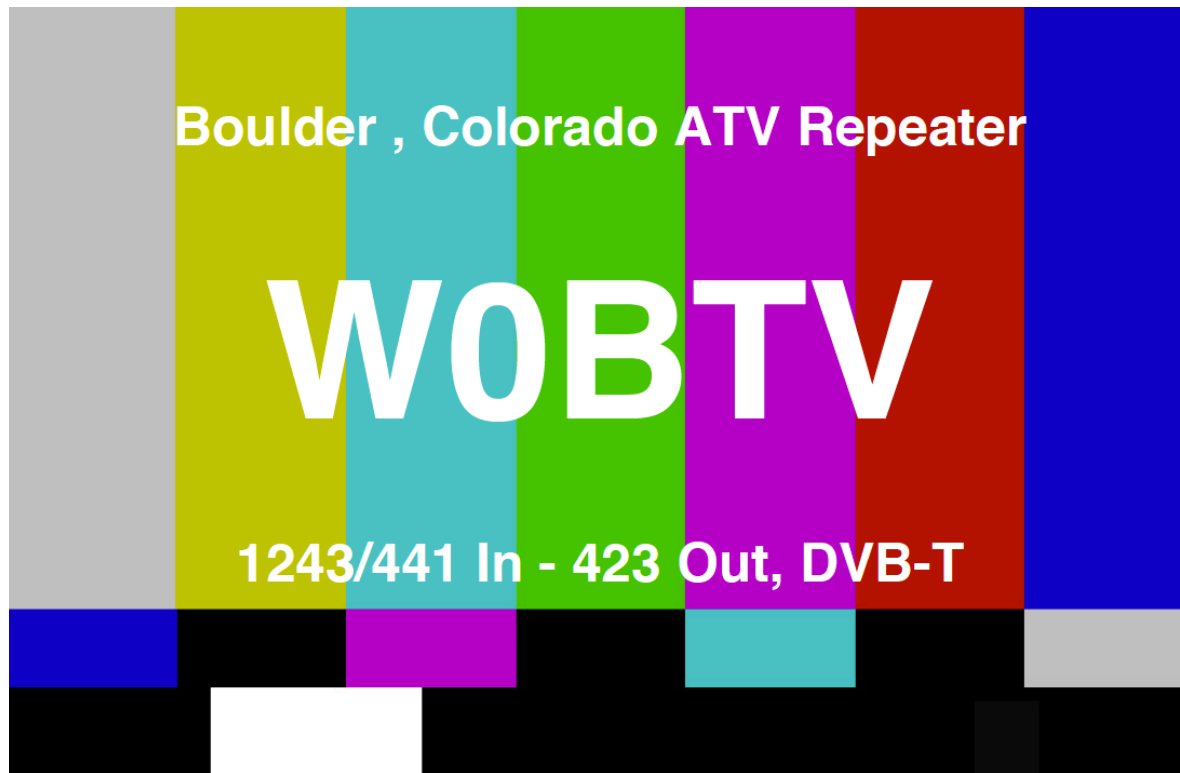


Boulder ATV Repeater

dual band – 23 cm & 70 cm inputs

70 cm & 5 cm outputs

dual mode - analog & digital



Boulder DATV Repeater



USA ATV Repeaters

- 41 active at present
- 23 analog only
- 18 digital or mixed mode
- 13 are narrow-band 2 or 4 MHz BW, DTV
- 21 have output on 70 cm band
- Amateur Television Network (ATN) is largest linked system connecting S. California, Nevada and Arizona

ATV Repeaters on Internet

<https://batc.org.uk/live/>


Browser window showing the BATC Live stream page for KH6HTV-TV.

Page Title: KH6HTV-TV - BATC Live

URL: <https://batc.org.uk/live/kh6htvtvr>

Navigation Menu: HOME, JOIN BATC, MEMBERS, CQ-TV, SHOP, **STREAMER**, ON-LINE, ATV ACTIVITY, EVENTS, CLUB INFO

KH6HTV-TV



Stream is Active

Current Viewers: 3

7/22/2018
1:40 **Farrell_W8ZCF**
Farrell W8ZCF
7/26/2018
7:46 **k6ben**
K6BEN will be on the air this afternoon for the first time

Type '/nick your_name' and press enter to join.

Boulder, Colorado, USA, Repeater __ DVB-T & Analog __ 23cm in - 70cm out __ web = www.kh6htv.com __ 16:9, 480P use Adobe Flash to view stream __ left audio channel is TV rptr __ right audio channel is our 146.70, 2m voice rptr for intercom

Also used for Public Safety ARES, Police, Fire, EOC





More Information

- **KH6HTV VIDEO** www.kh6htv.com over 60, free, ATV/DTV related application notes, plus RF linear power amplifiers and other amateur TV products
- AN-55 “ATV Handbook – an Introduction to Amateur TV”, 39 page book
- Free ATV Newsletter, “BATVC TV Repeater’s Repeater”, national newsletter goes out to 800+ ATV hams

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- This power-point presentation is available in .pdf from my web site
- www.kh6htv.com
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- April, 2024

Questions ? ? ?

