# Amateur High-Definition Digital Television

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

# Modern Digital TV

# High - Resolution, 1080P

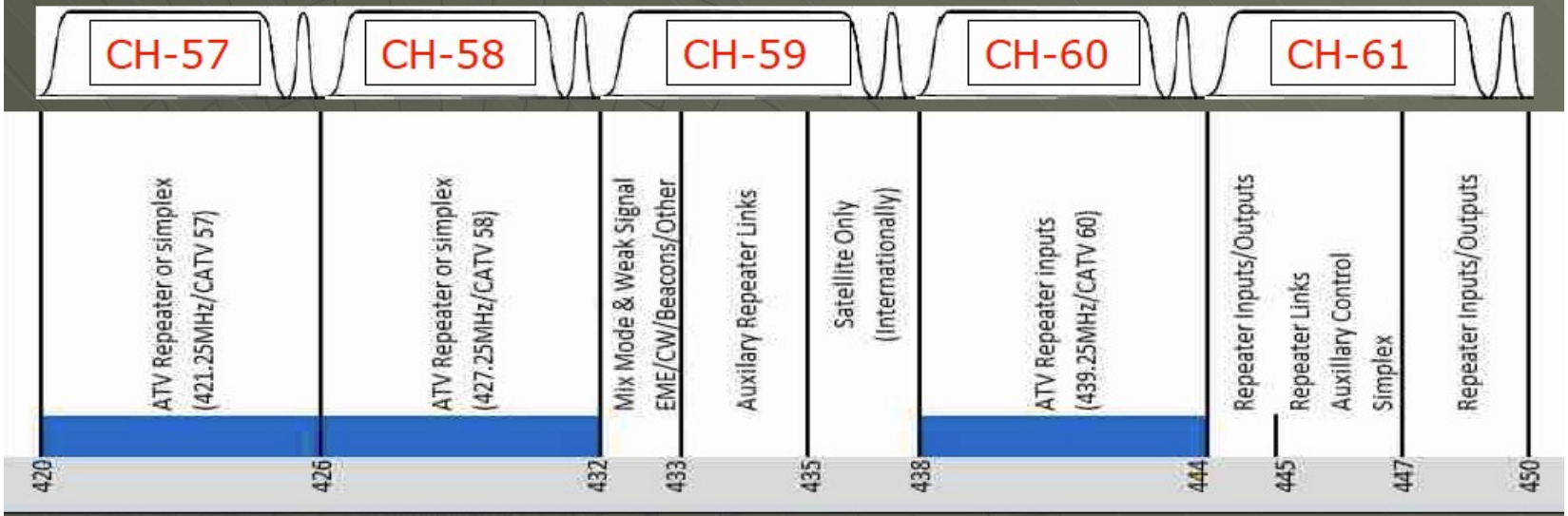
# CD Quality, Stereo Audio

# 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

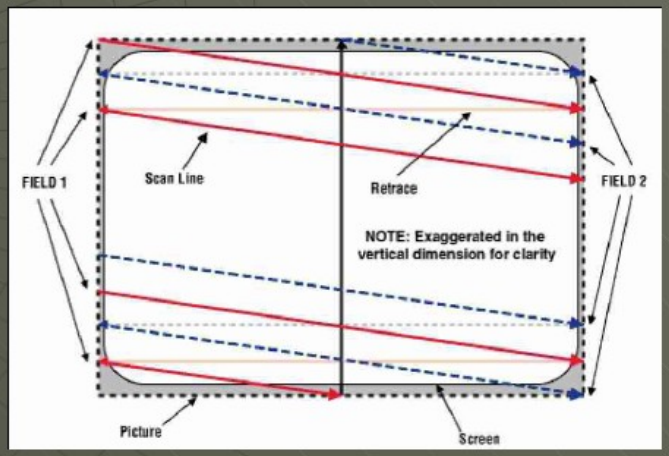
# The Origin of Television

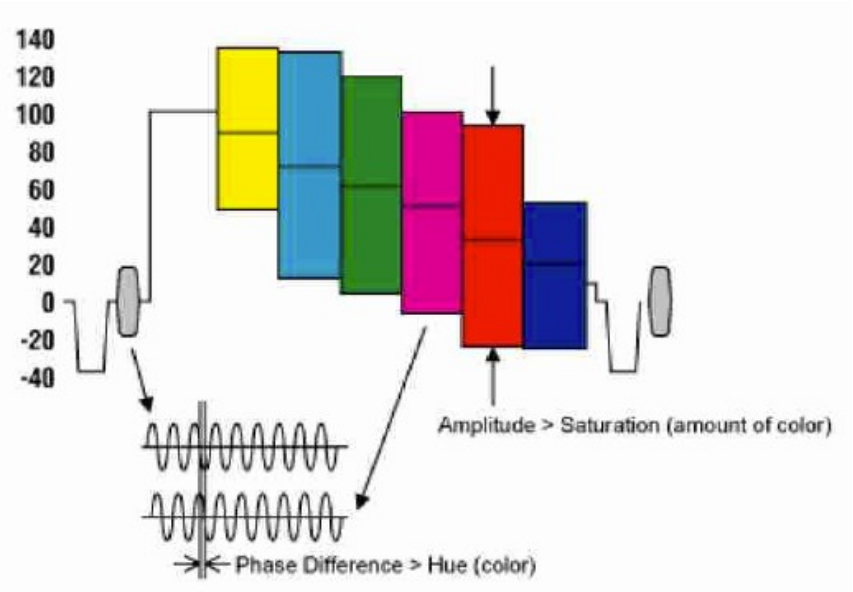
- Initial development of TV in mid-20s (100 years ago !)
- 1st Broadcasts by BBC, 1929 & NBS, 1939
- Used technology available then, i.e. AM
- 1941 – FCC etches “in stone” the TV standards – remain unchanged for 60 years !
- Only update, color added - 1953

# Analog Composite Video

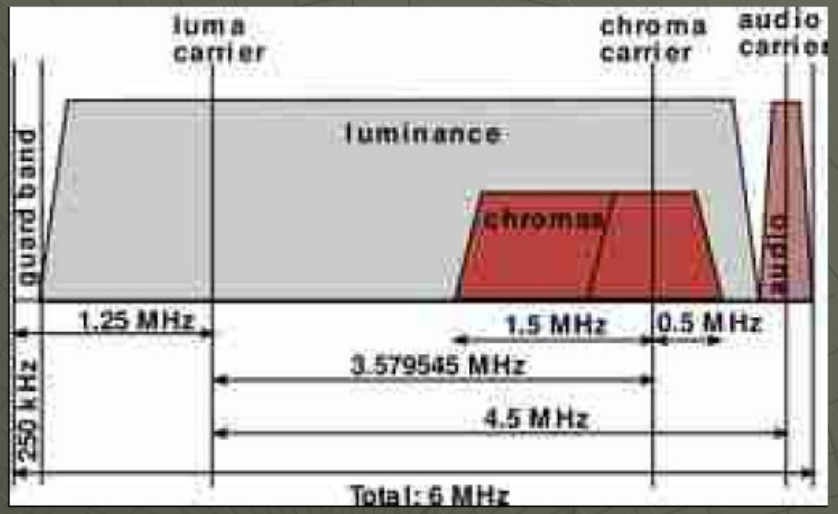
Each Analog television signal consists of:

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



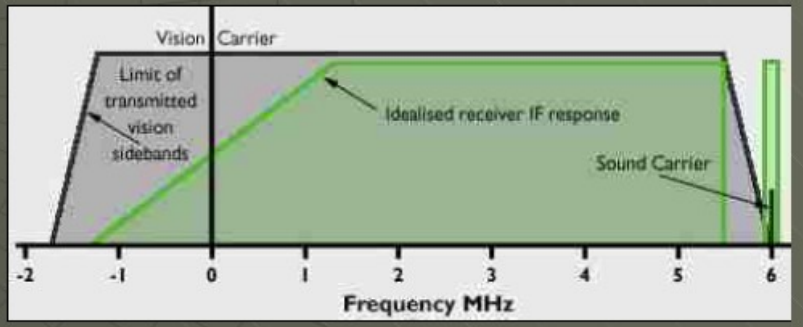




# What's in a VUSB-TV Channel?




Video Signal is AM

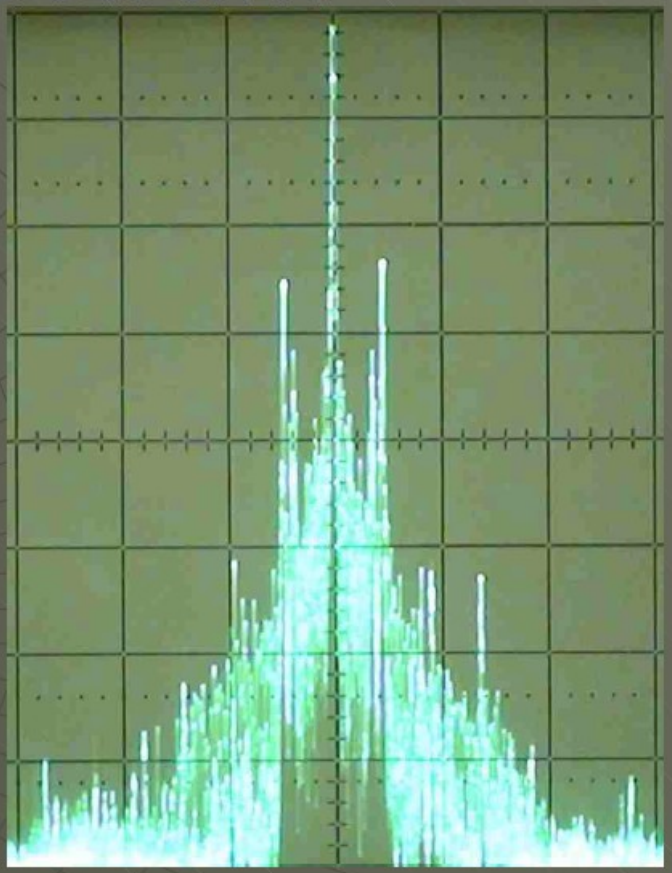
Audio Signal is FM




Effect of Vestigial Sideband Filtering

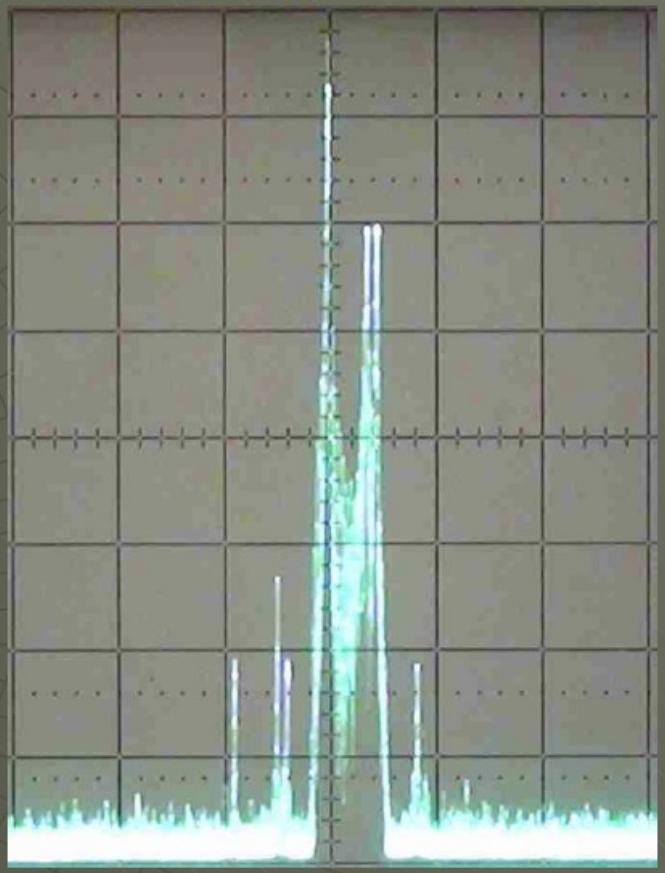
# Typical Ham AM-TV Transmitter Spectrum

- 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

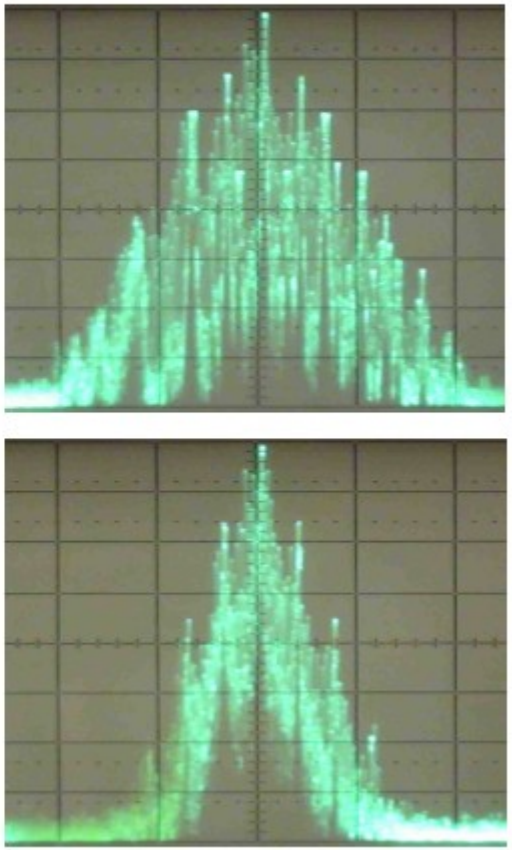


# Analog TV Limitations

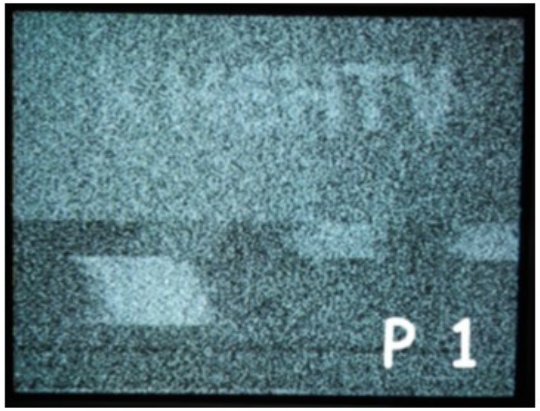
- Basically uses AM modulation
- 4.2 MHz video BW required for std. def. with SSC at 4.5 MHz.  Required AM BW >9 MHz. Use VUSB to reduce BW to 6 MHz
- Standards set in 1941 by FCC
- “Snow” with weak signals, need 40 dB s/n & -60dBm at receiver for P5 picture
- “Ghosts” with multi-path
- FM-TV added later for microwave links, works better with weaker signals, but much wider spectrum required.  Thus not used on 70cm

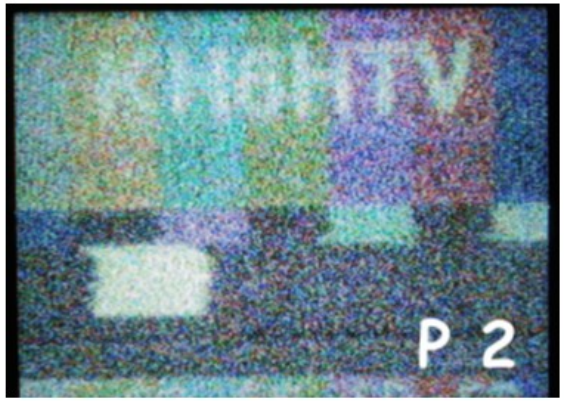
# Why not FM-TV on 70cm ?

- 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



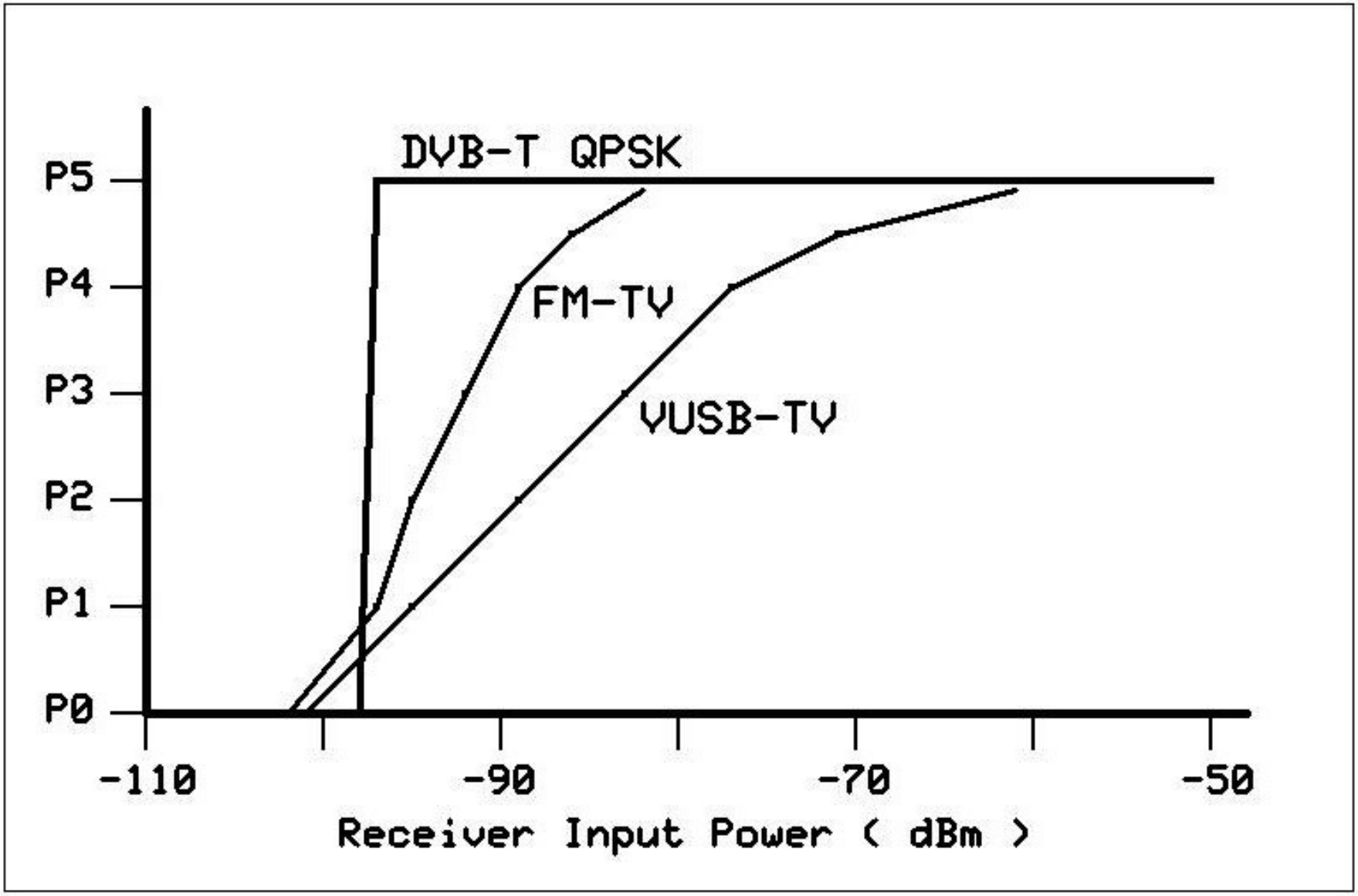
# ATV Picture Ratings – P units




# DTV vs Analog TV



# ATV no longer “Amateur”

## Perfect Pictures & CD quality Audio

(photos from off the air DVB-T)




# Major DTV Objection

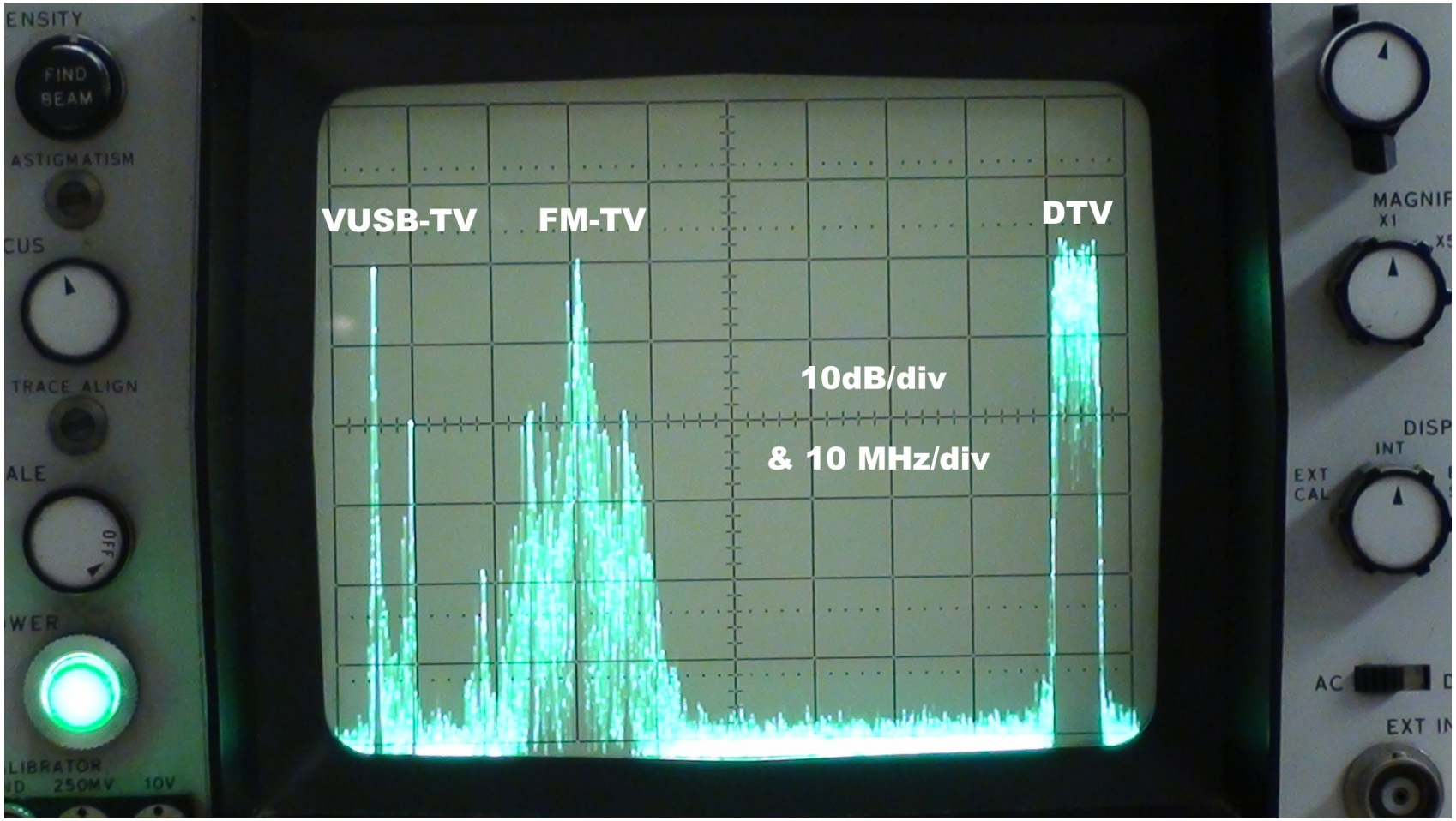
- Latency ( i.e. delay )
- Tremendous amount of computer processing involved, both at transmitter and also in receiver
- Noticeable delay of at least ½ second
- Delays build up through multiple repeaters
- NOT Recommended for flying drones – i.e. a Safety issue

# Technical Discussion of Digital Television

# 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

# Comparison of Analog & Digital TV Spectrums



# DTV Broadcast Standards

- **8-VSB or ATSC** - Eight Vestigal 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**

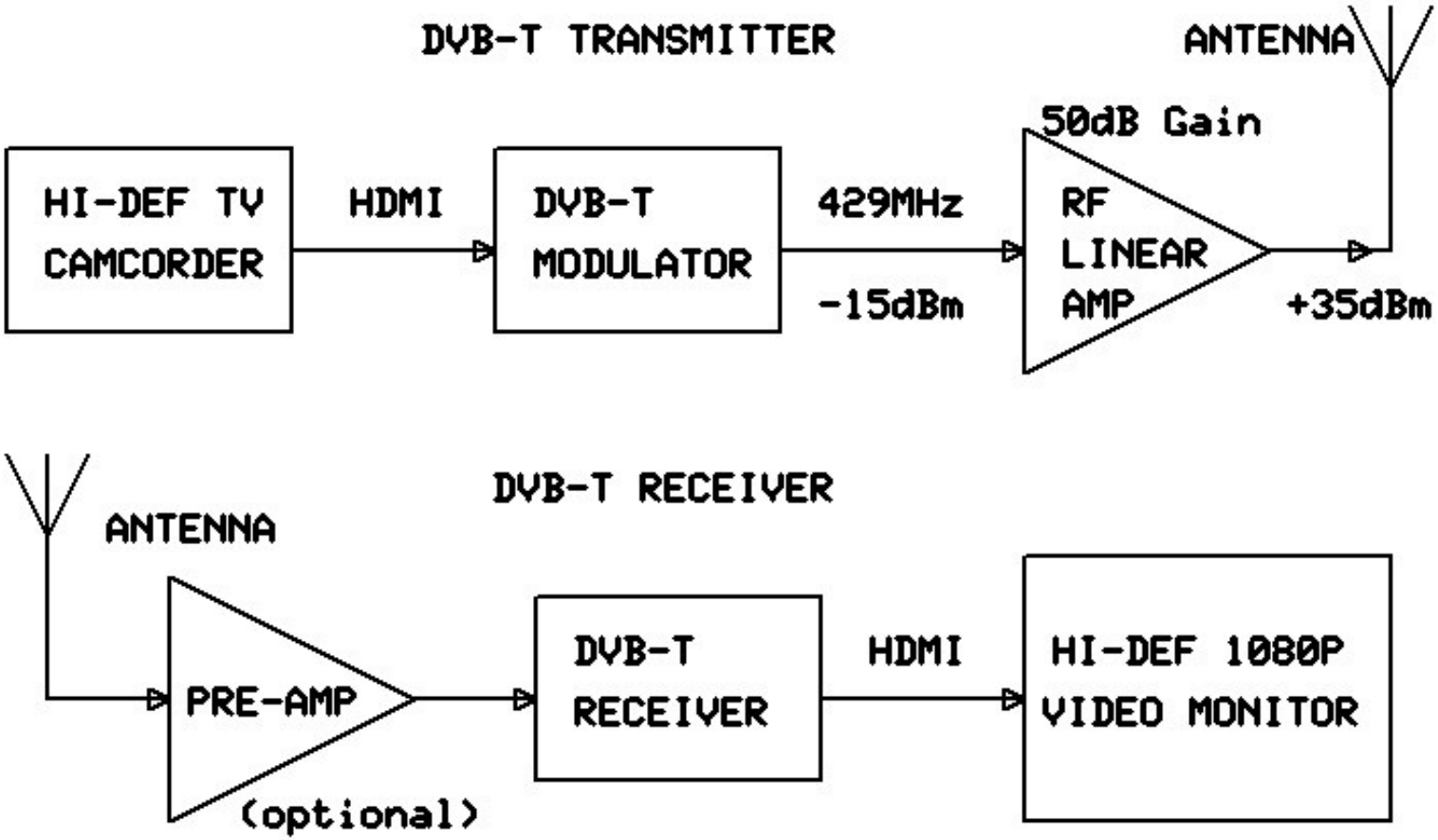
**64QAM = -82 dBm**

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

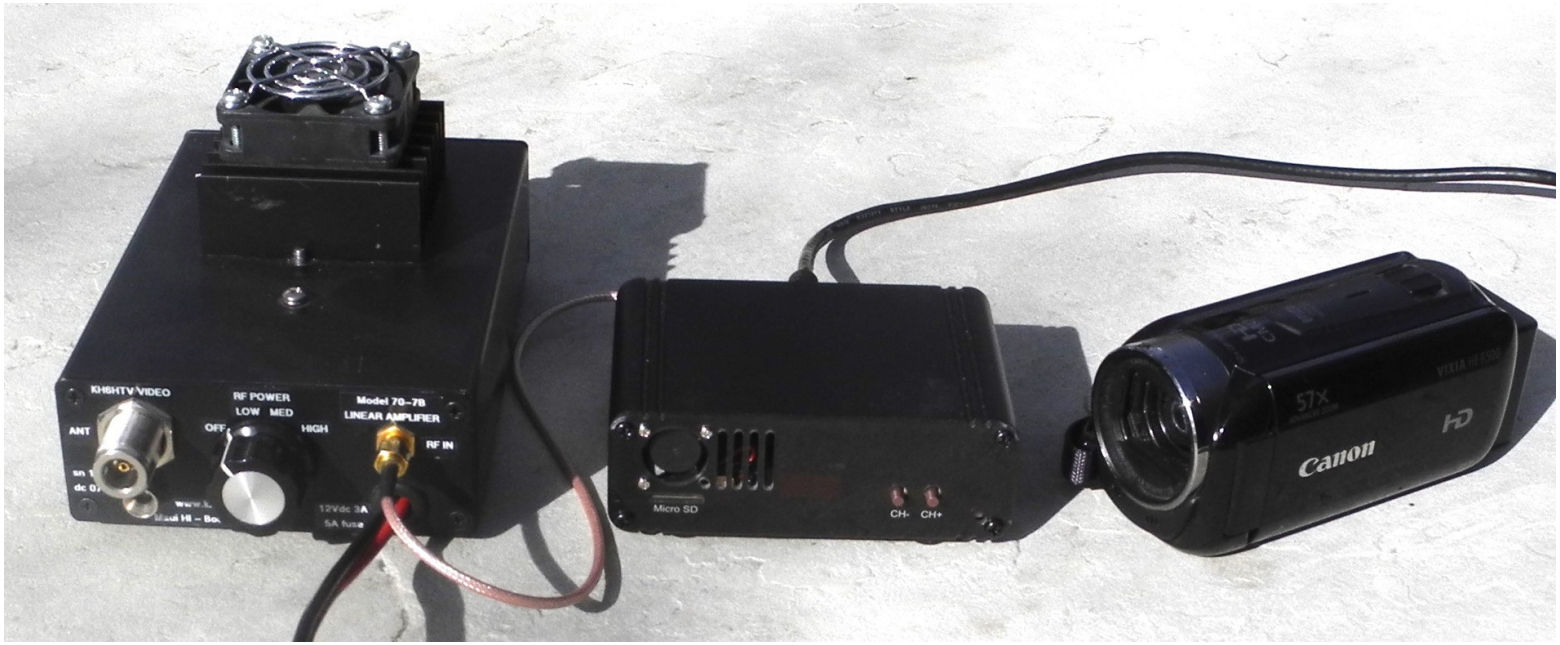
- Max Video Encoding data rates for various modulations with 6 MHz BW: QPSK = 7.3 Mbps, 16-QAM = 14.6 Mbps & 64-QAM = 21.9 Mbps
- Higher bit rates needed to follow really fast action, such as sports, thus prefer QAM
- For typical ham TV, low power, marginal antenna situations, the 15 dB QPSK margin often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


- *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

# ATV  Antennas

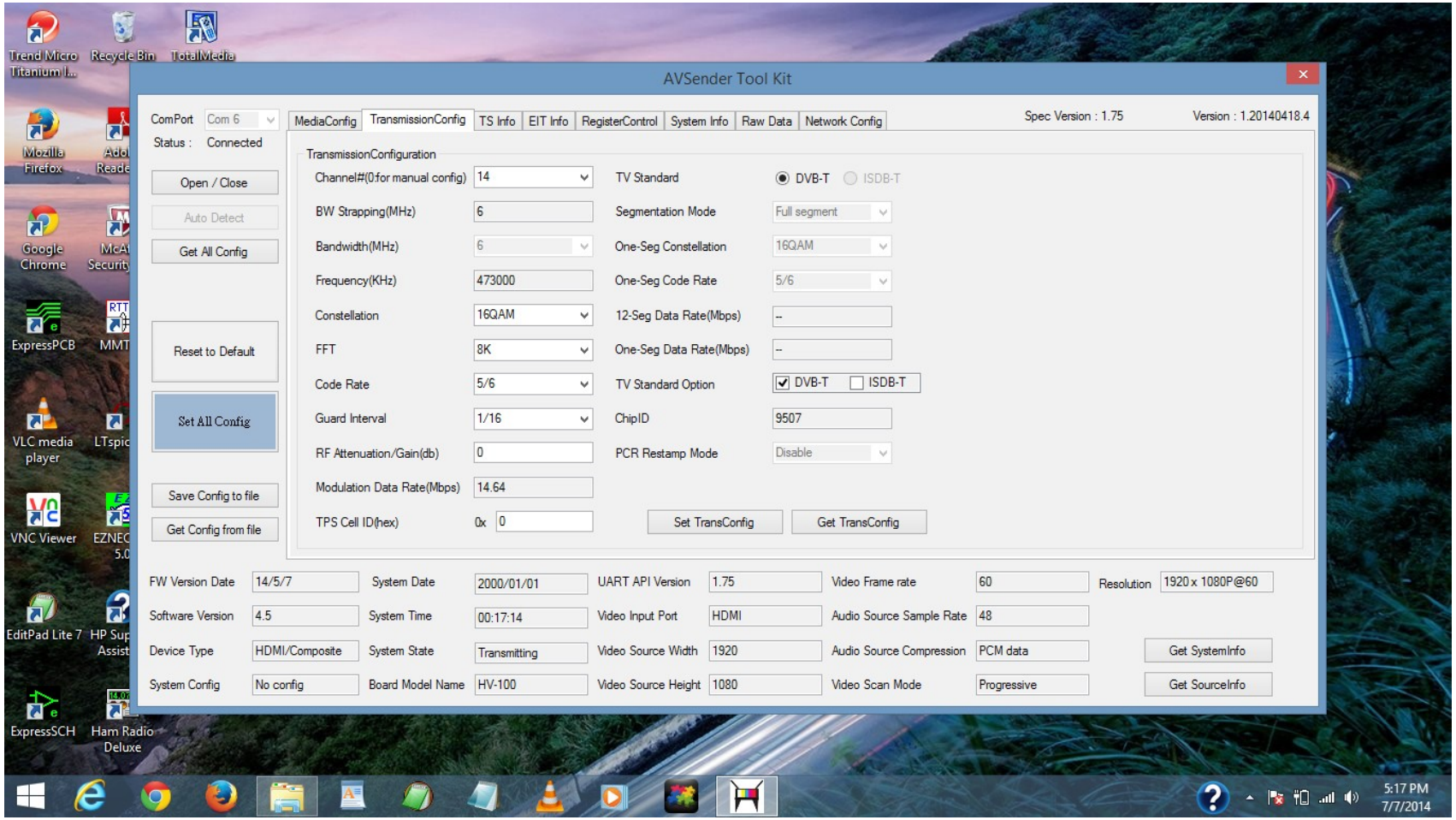
# TV Antennas must be Broad-Band !

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

# 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

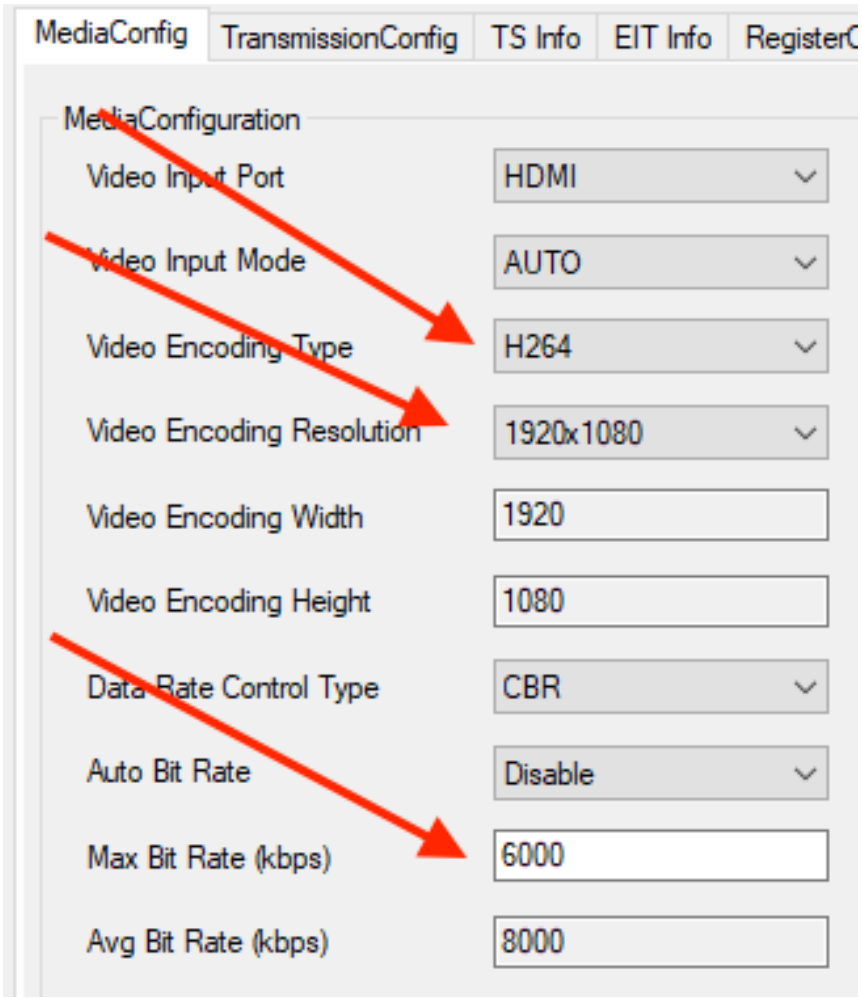
# Program Modulator with external PC computer via USB

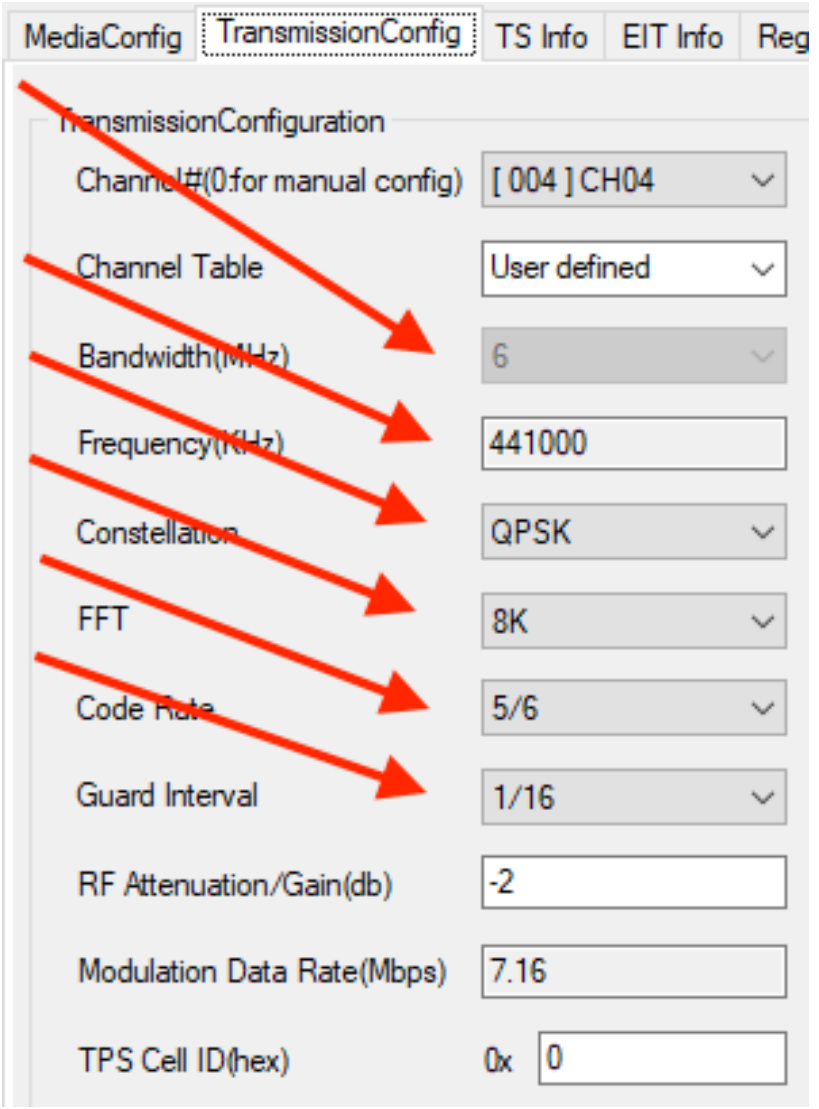


# Key Modulator Parameters to be Set-Up

- Video Encoding: H264 or MPEG2
- Encoding Resolution: up to 1080P
- Bit Rate:
- Audio Encoding
- Frequency
- Bandwidth
- Modulation: i.e. QPSK or 16QAM or 64QAM
- Subcarriers: 2K or 8K
- Forward Error Correction: 7/8 to 1/2
- Guard Interval (i.e. sync)

# Key Modulator Parameters



# 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**



**rev "A" - Dec. 2015**
**rev "B" - Mar. 2017**
**rev "C" - Oct 2019**

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

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# FCC IDing

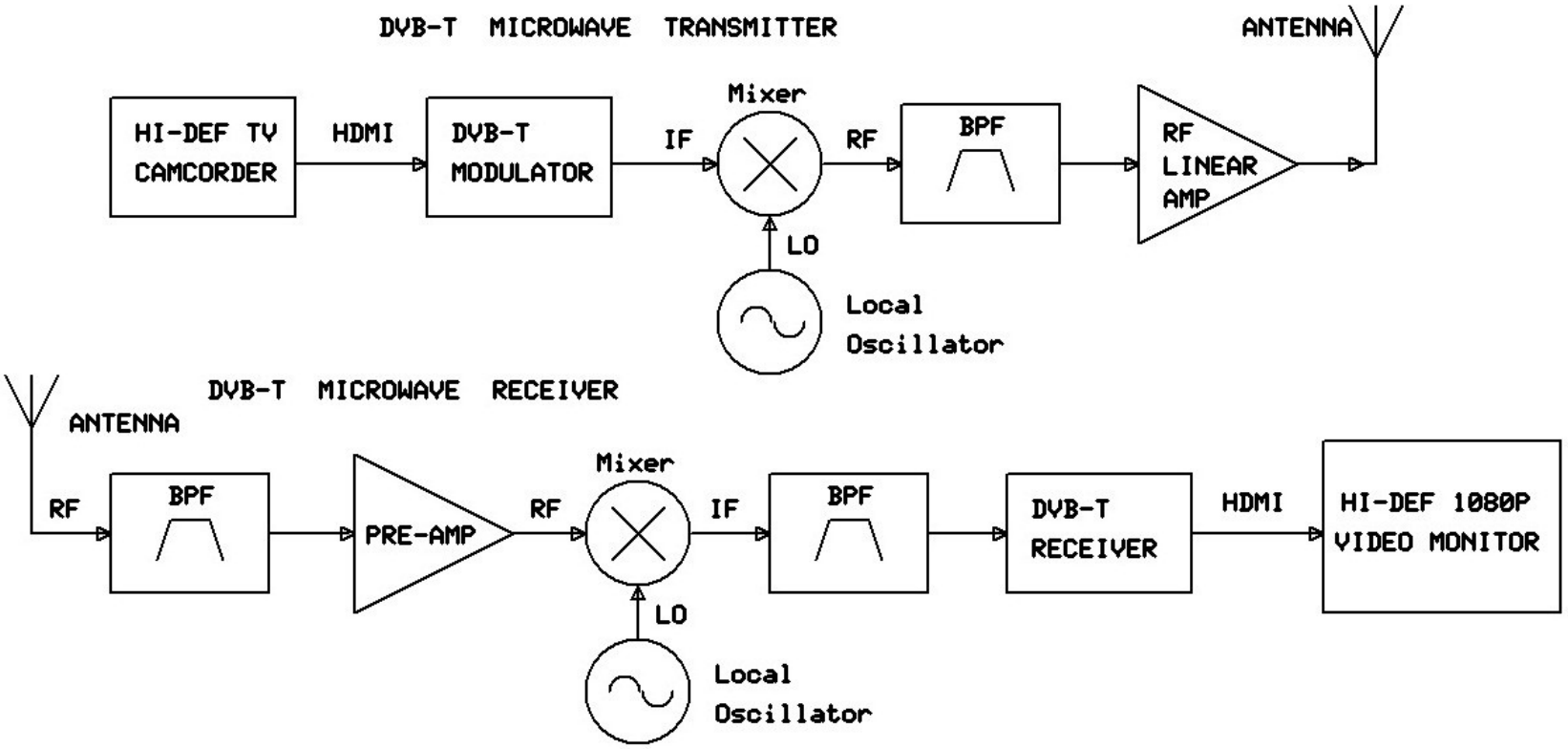
- SIMPLE ! With DTV done automatically
- Program your call sign into modulator
- Call Sign transmitted not every 10 minutes, but with every video frame as part of meta-data header
- To see call sign, simply push “Info” button on receiver’s remote control
- Some controversy about legality however

# 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

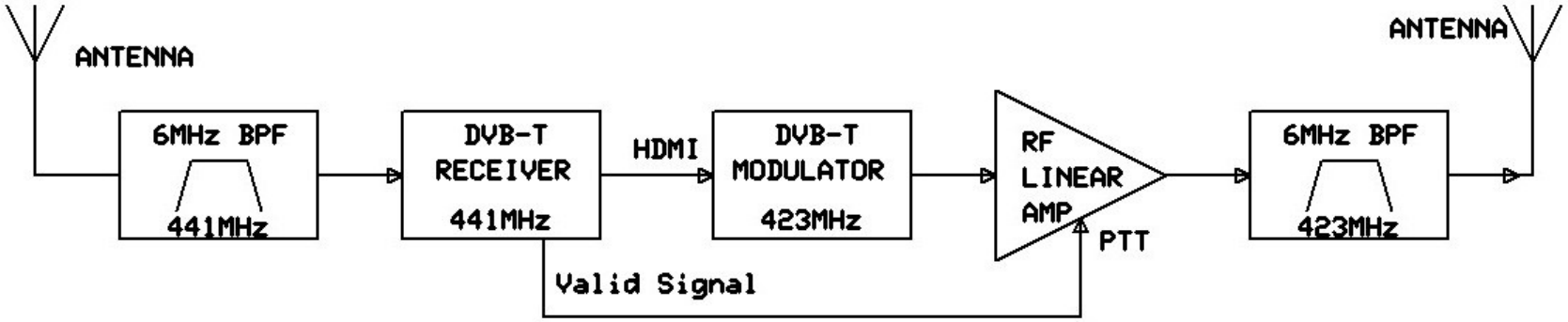
note: LO must have very low phase noise



# 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

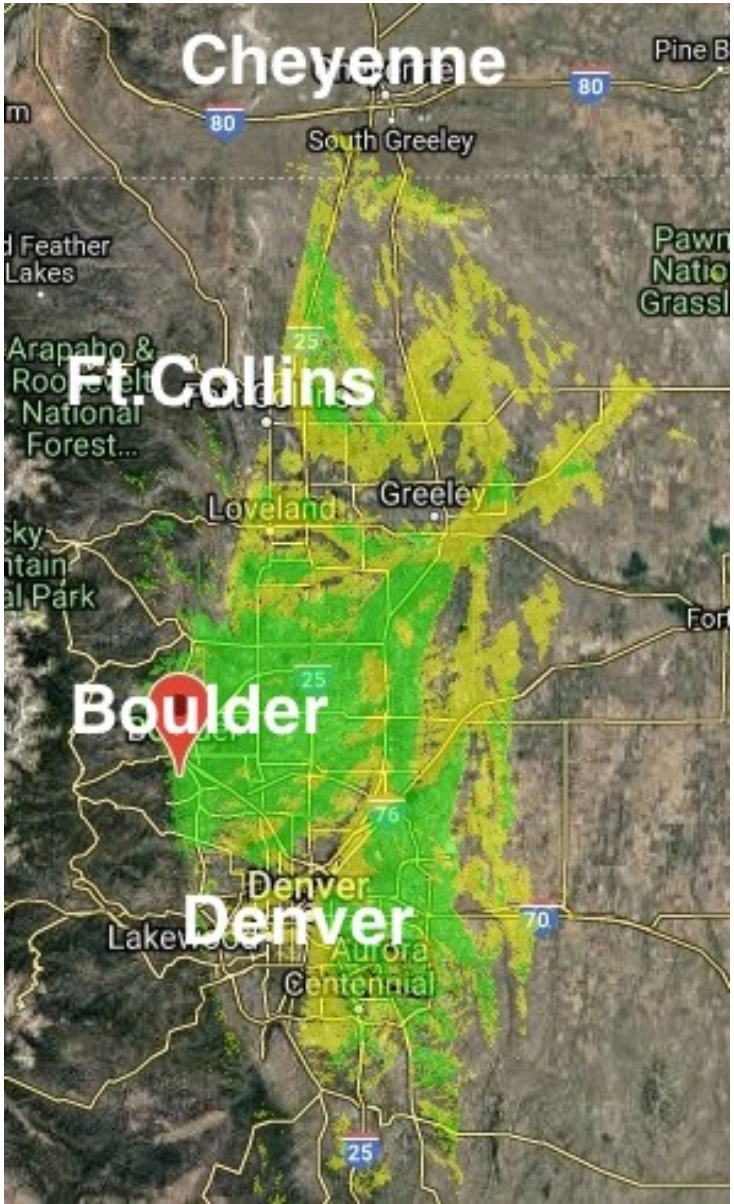
# Boulder ATV Repeater

dual band – 23 cm & 70 cm inputs

70 cm & 5 cm outputs

dual mode - analog & digital


# Boulder DATV Repeater

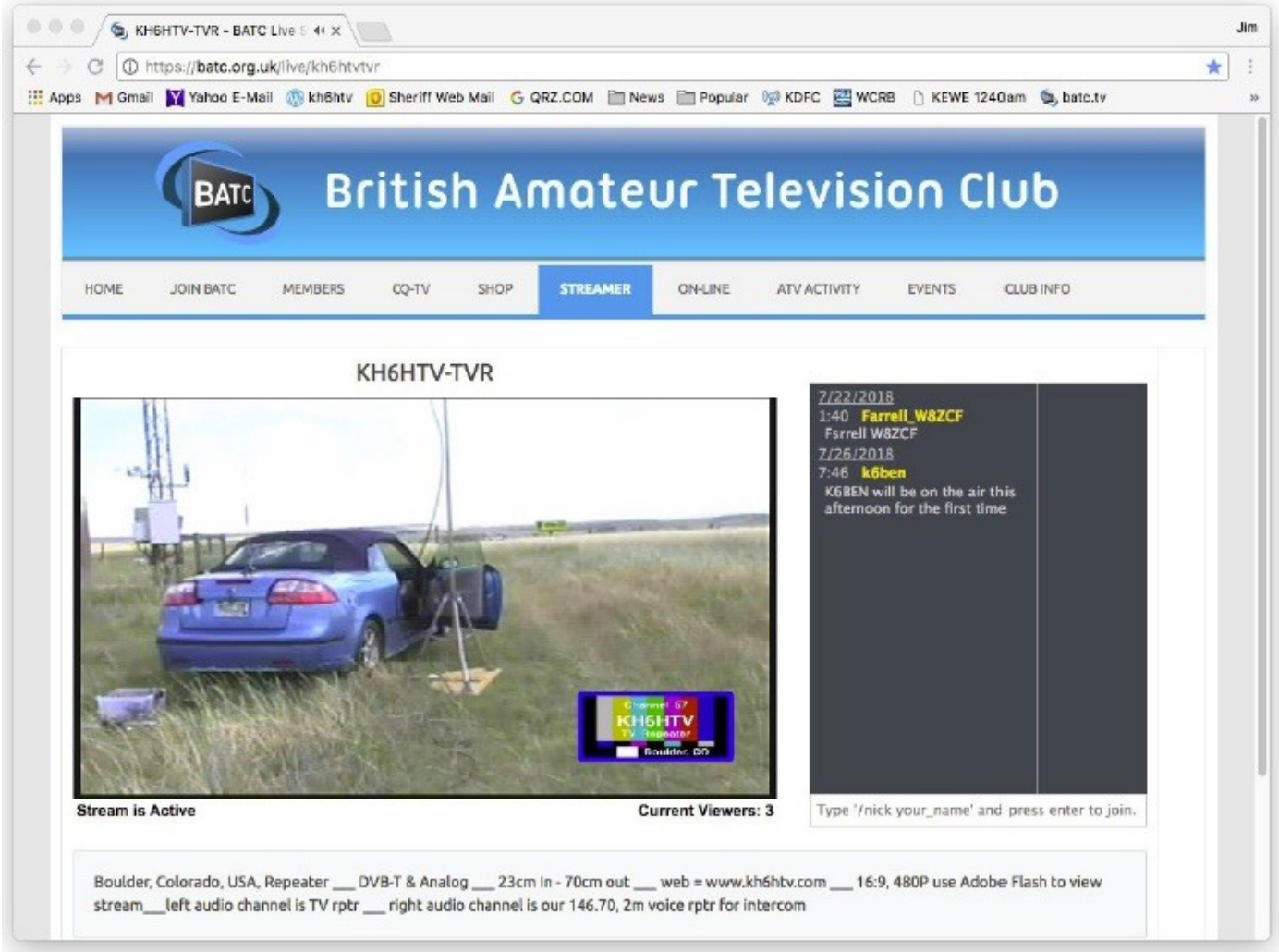



# USA ATV Repeaters

- 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/



# 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

# 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 500+ ATV hams

# Amateur High-Definition Digital Television

- This power-point presentation is available in .pdf from my web site
- **www. kh6htv.com**
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# Questions ? ? ?