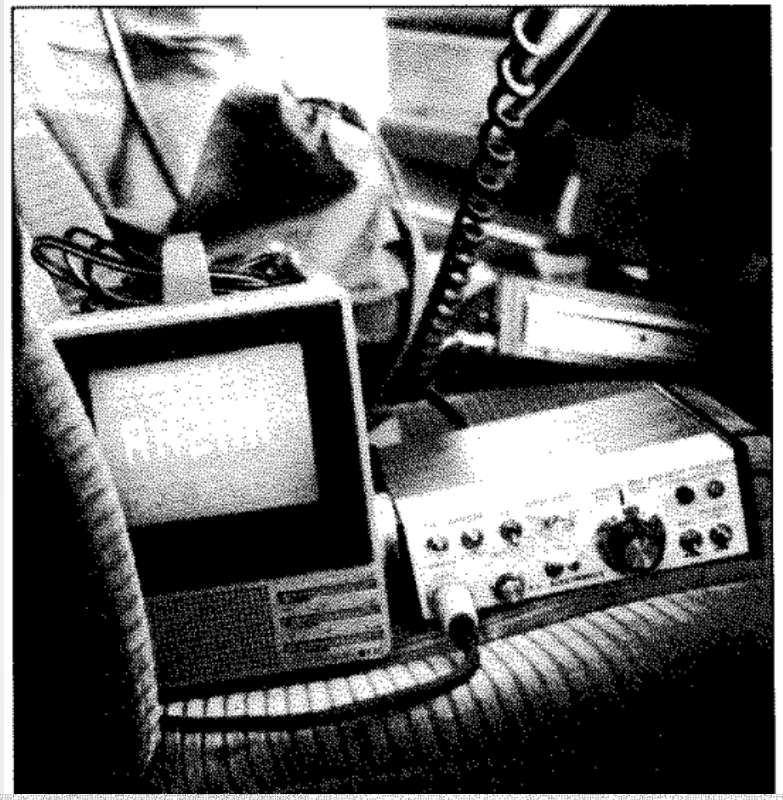
# Digital Amateur Television

**How to get Started**

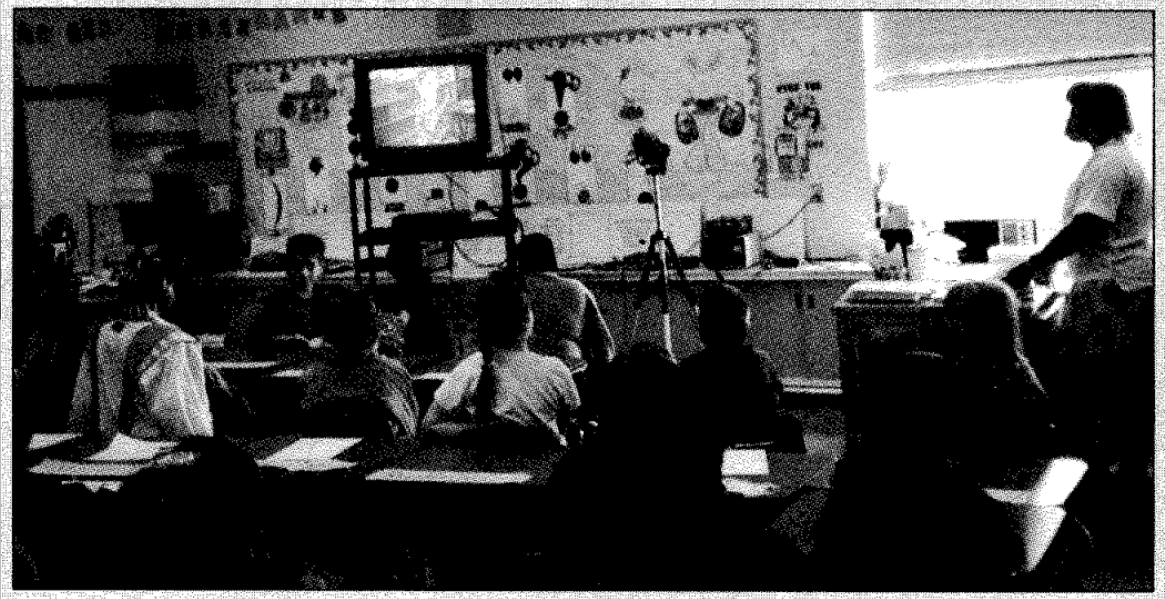
Joel Wilhite – KD6W

# Why do TV at all?

Source: ARRL Handbook



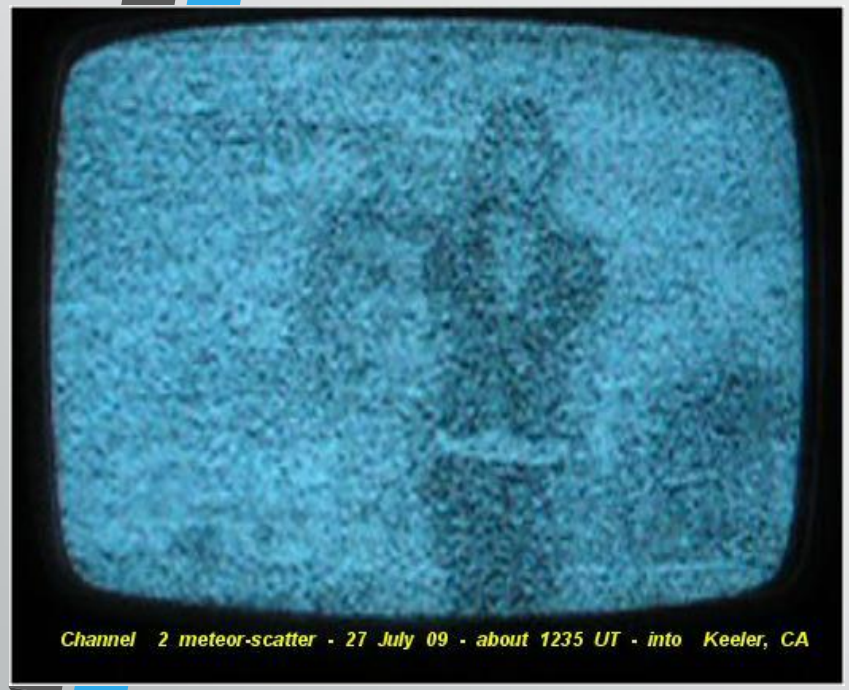
From this lofty perch, a remote camera and link antenna, part of the Baton Rouge, Louisiana, ATV repeater, allow area ATVers to watch the weather on the Mississippi River and downtown Baton Rouge. The man on the scene is Kenny, WB5JLZ, the repeater trustee and club president. *(photo courtesy of WB5JLZ)*

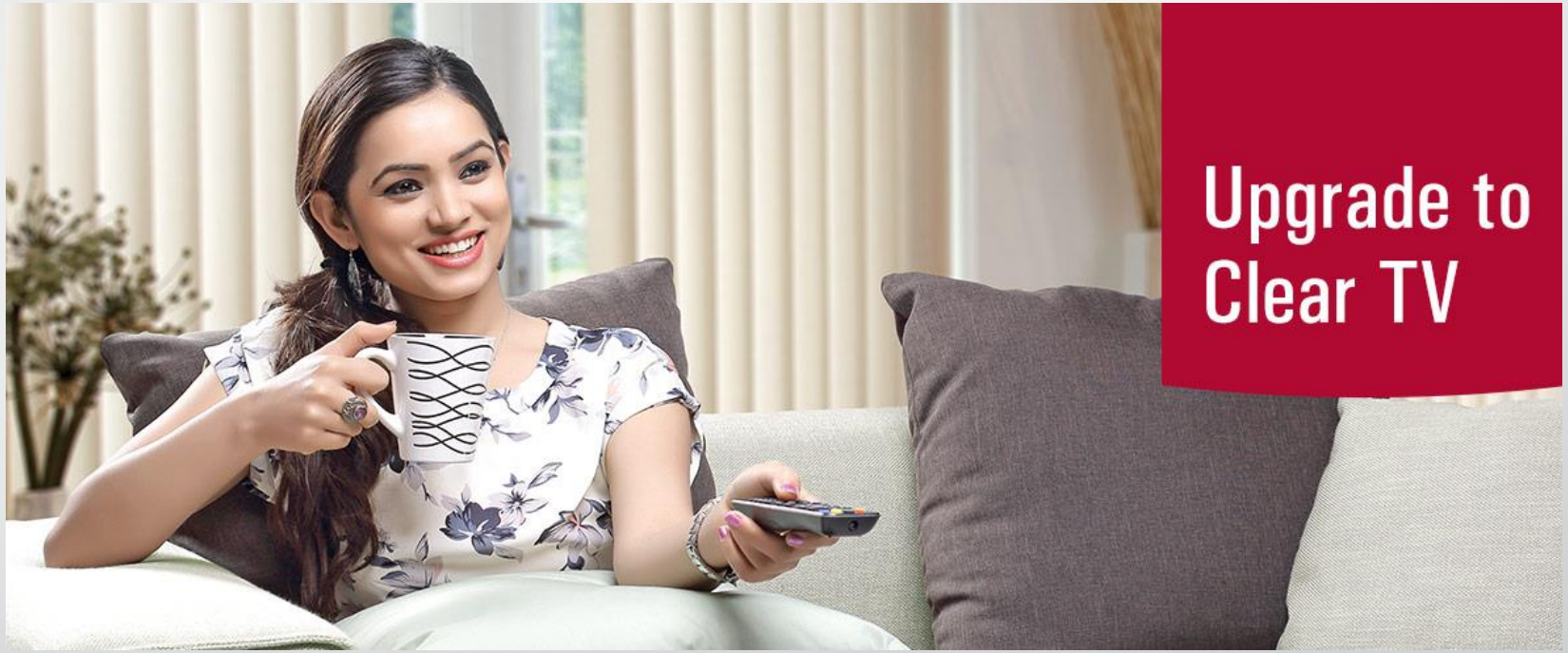


These pictures of Mrs Plater's 5th-grade classroom at Harley Franks Elementary school in Lansing, Michigan, were taken by Jim Hein, WD8BDL. At the time, Jim was in ATV communication with Mark Lynch, KB8LKC, located in Mrs Drake's 5th-grade classroom at North Elementary school, also in Lansing. The two classrooms were linked on May 14, 1992, during the school district's Science Week.

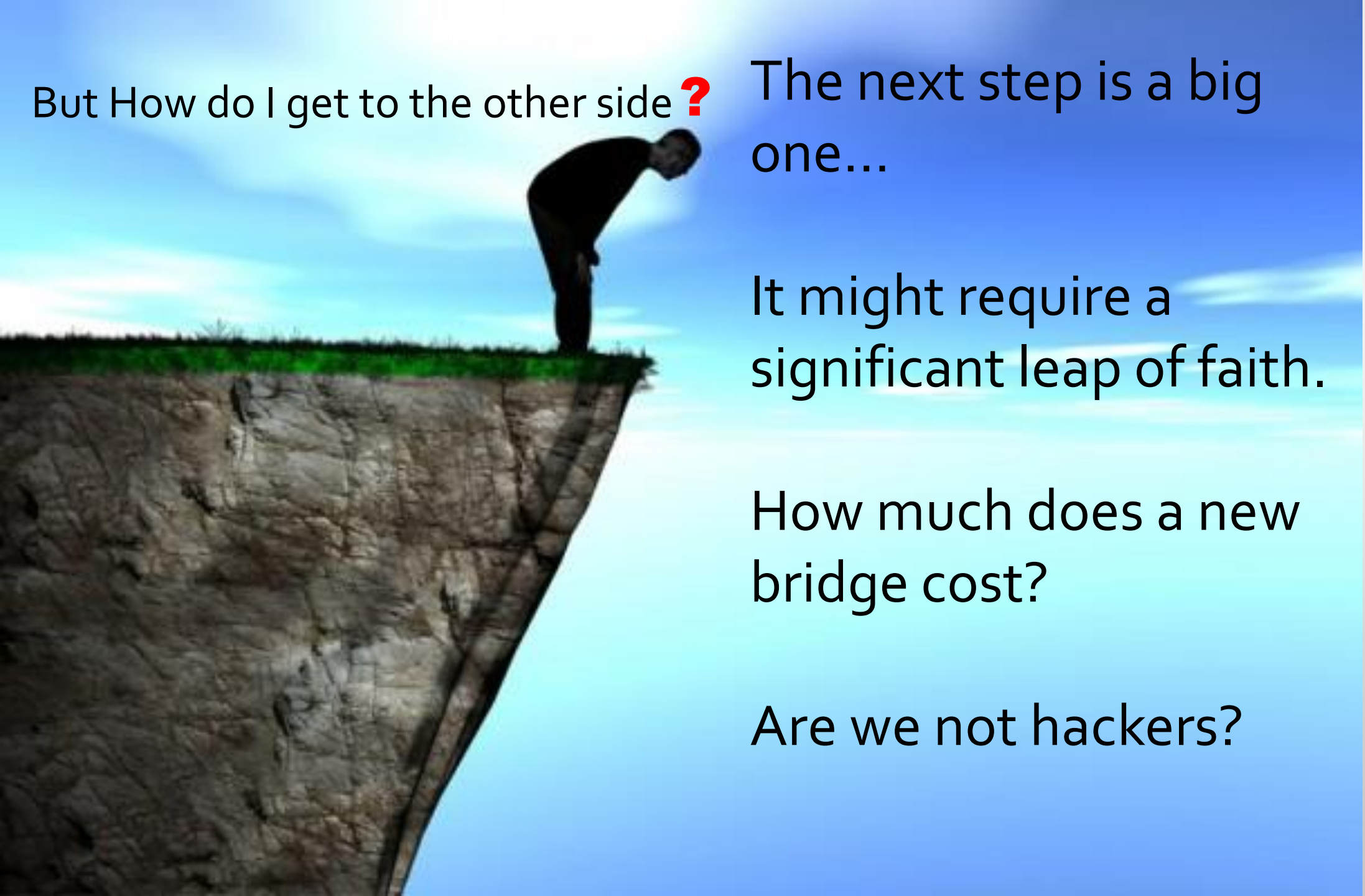
# Analog is fine, why Digital?

NTSC, PAL, SECAM




ATSC, DVB – X, ISDBT/b, QAM Cable etc.



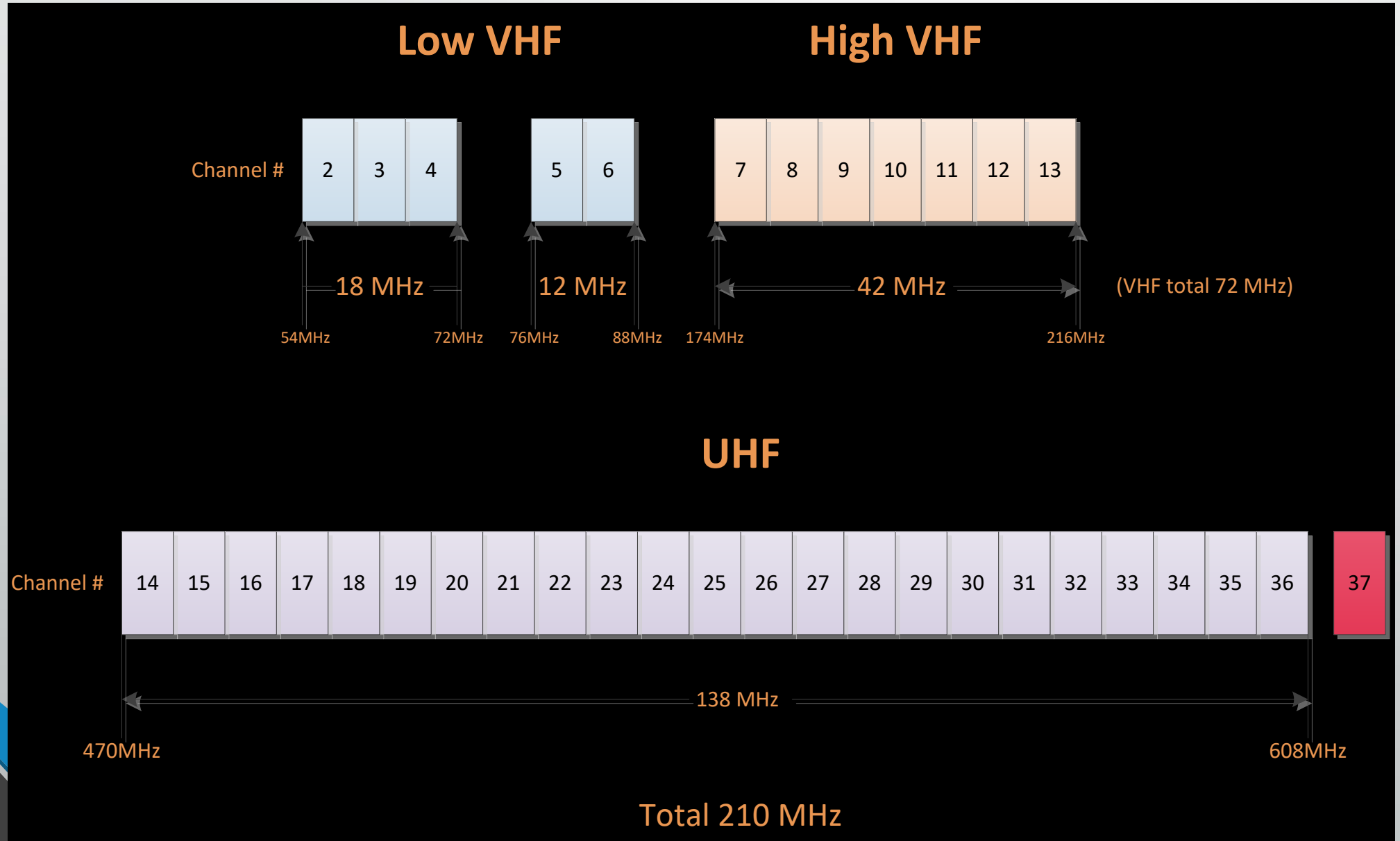

The next step is a big one…

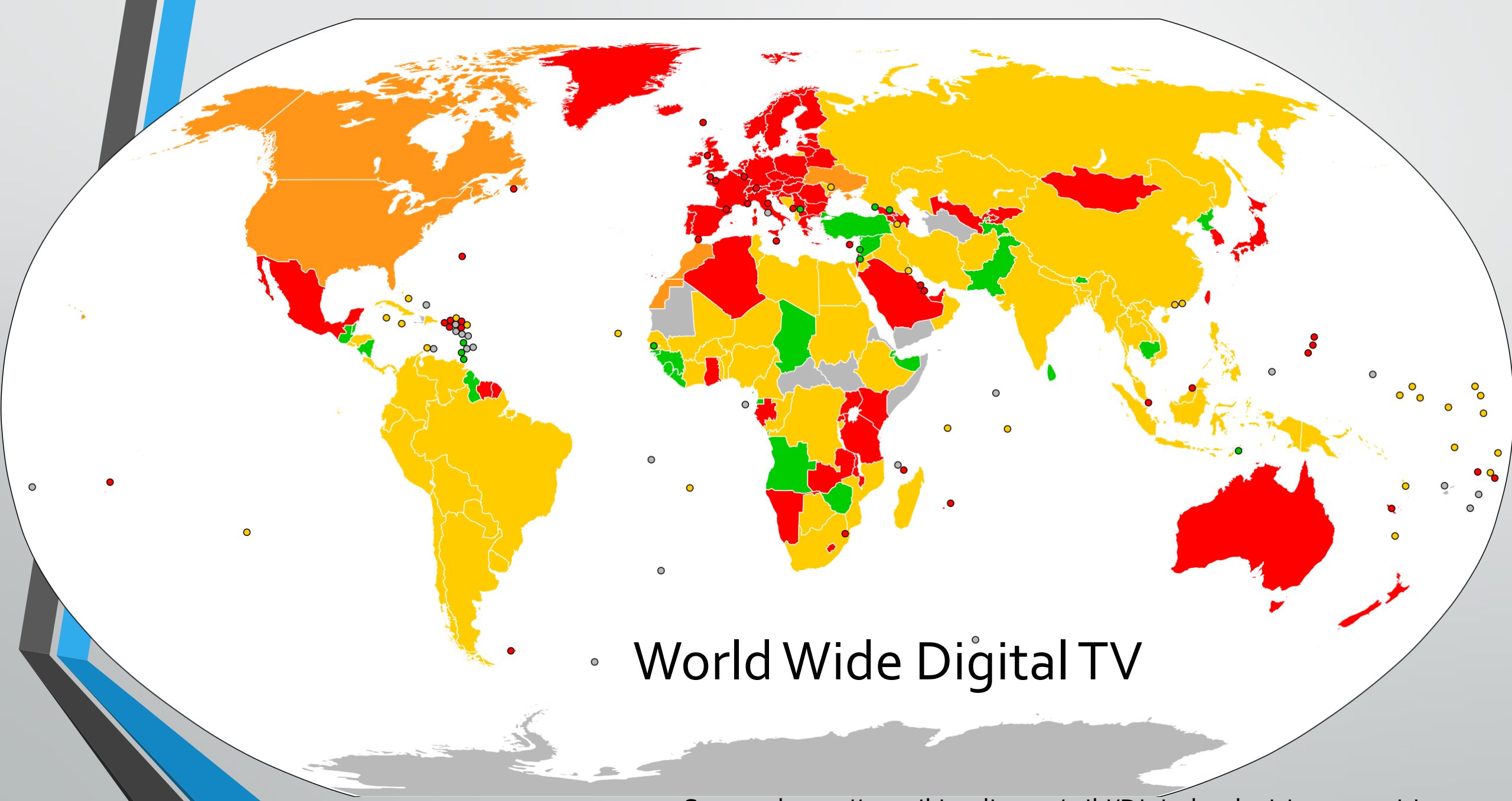
It might require a significant leap of faith.

How much does a new bridge cost?

Are we not hackers?

# 1 broadcast frequency = 1 analog channel





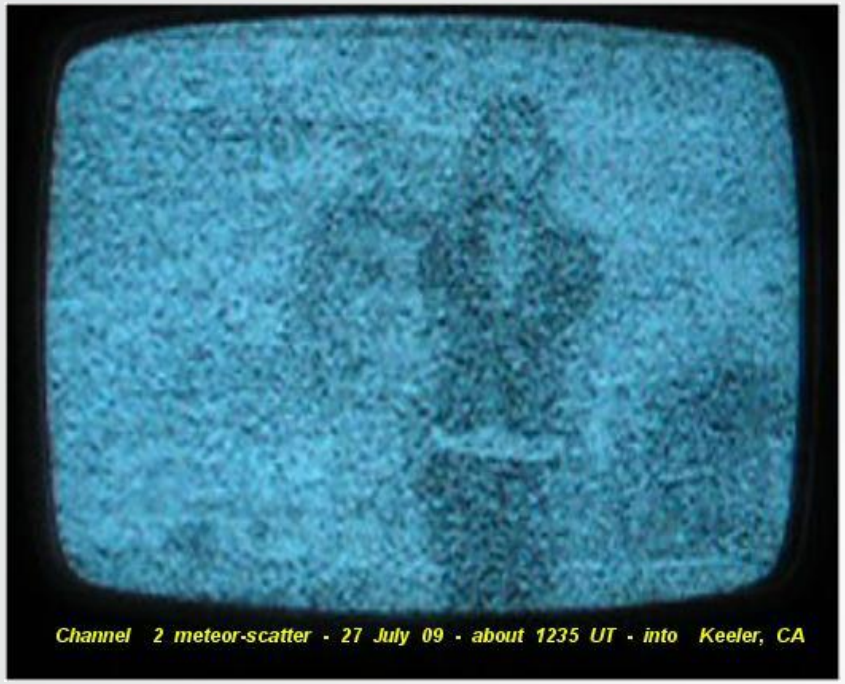

Source: https://en.wikipedia.org/wiki/Digital_television_transition

# DATV Beginnings

BATC

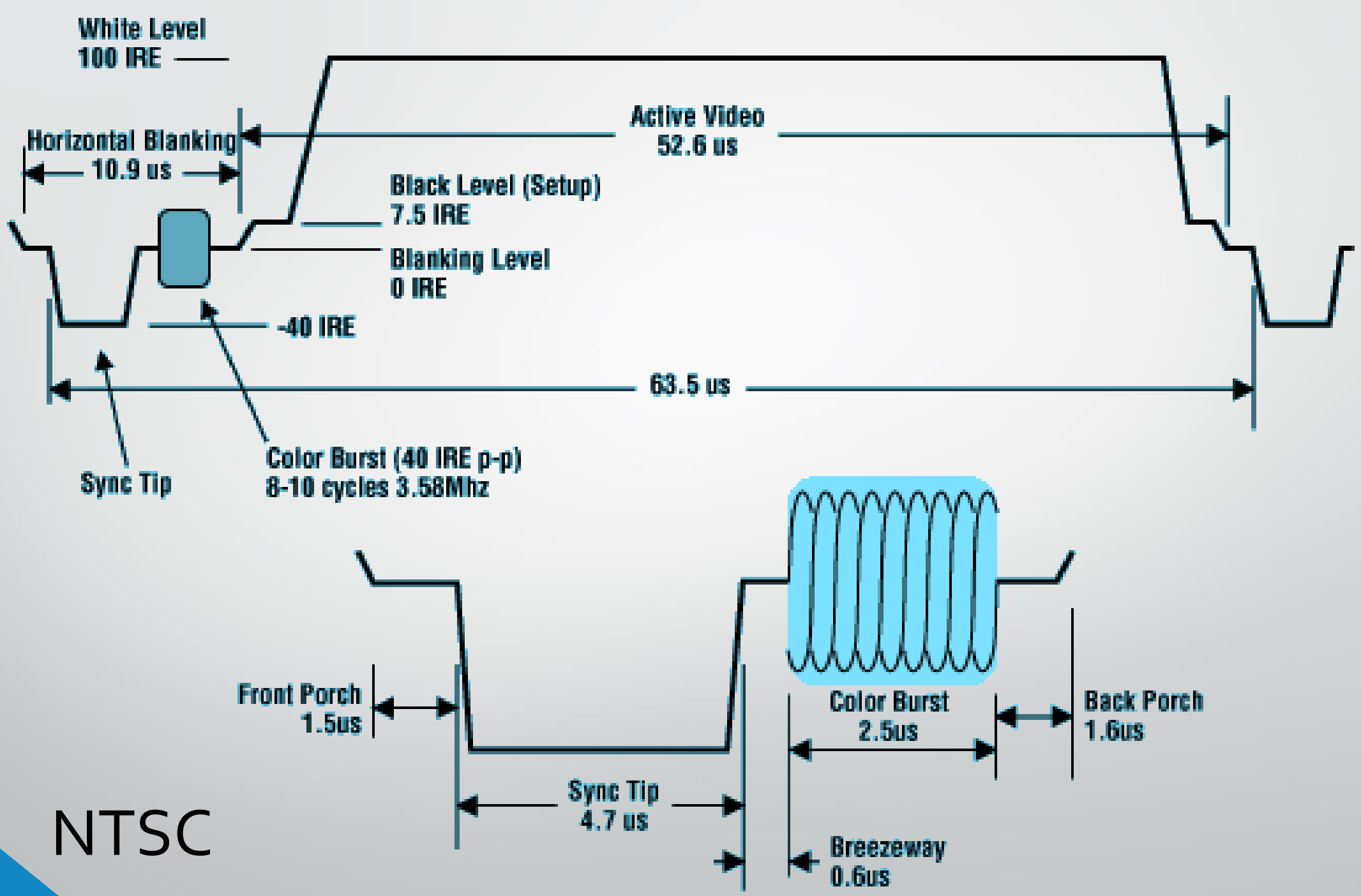
EST. 1949

1946
MOUNT DIABLO
W6CX
AMATEUR RADIO CLUB
WWW.MDARC.ORG



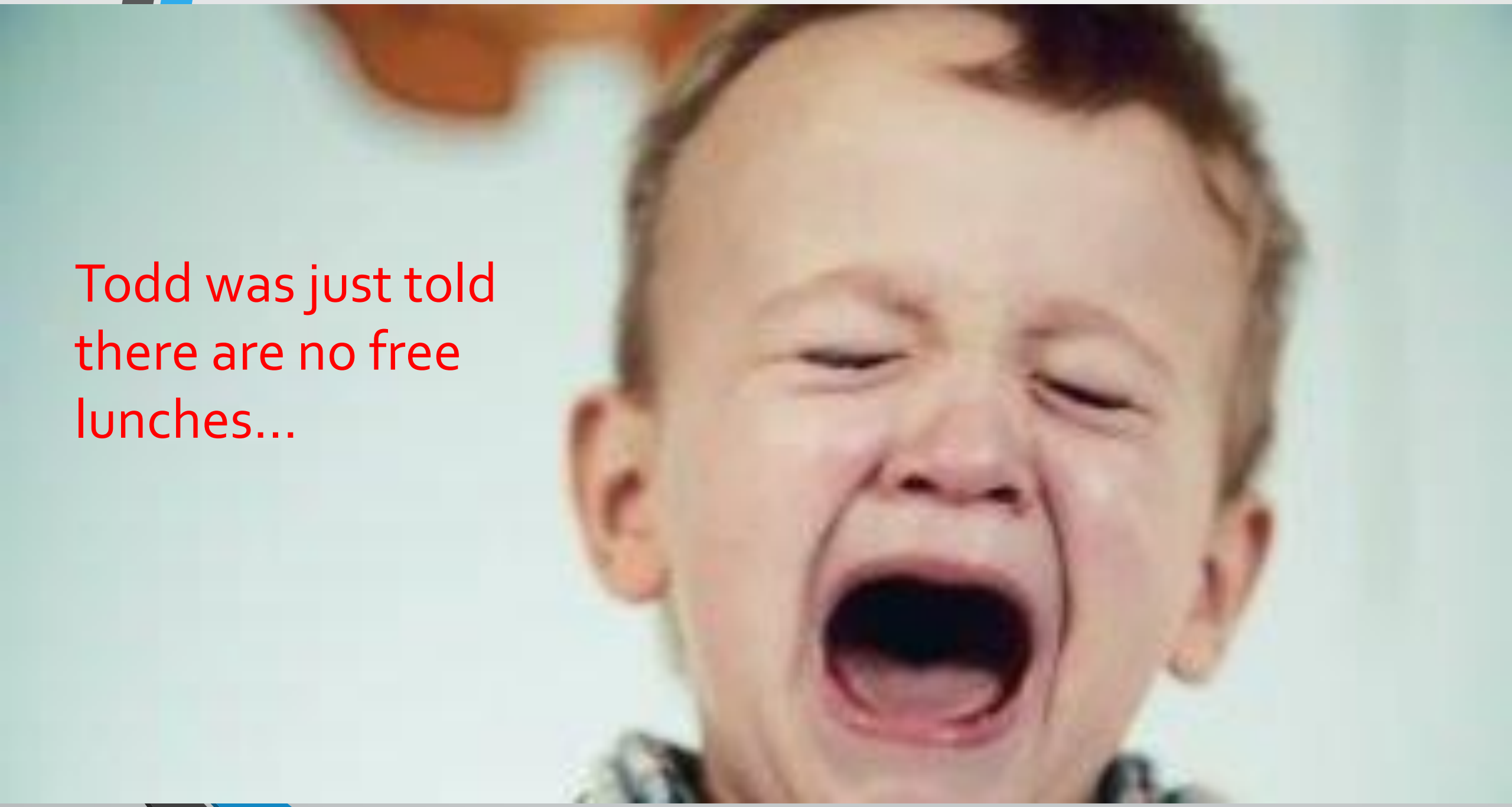

# Increasing system gain…

# NTSC


White Level
100 IRE
Horizontal Blanking
10.9 us
Active Video
52.6 us
Black Level (Setup)
7.5 IRE
Blanking Level
0 IRE
-40 IRE
63.5 us
Sync Tip
Color Burst (40 IRE p-p)
8-10 cycles 3.58Mhz
Front Porch
1.5us
Sync Tip
4.7 us
Color Burst
2.5us
Back Porch
1.6us
Breezeway
0.6us

# If only I had more system gain…

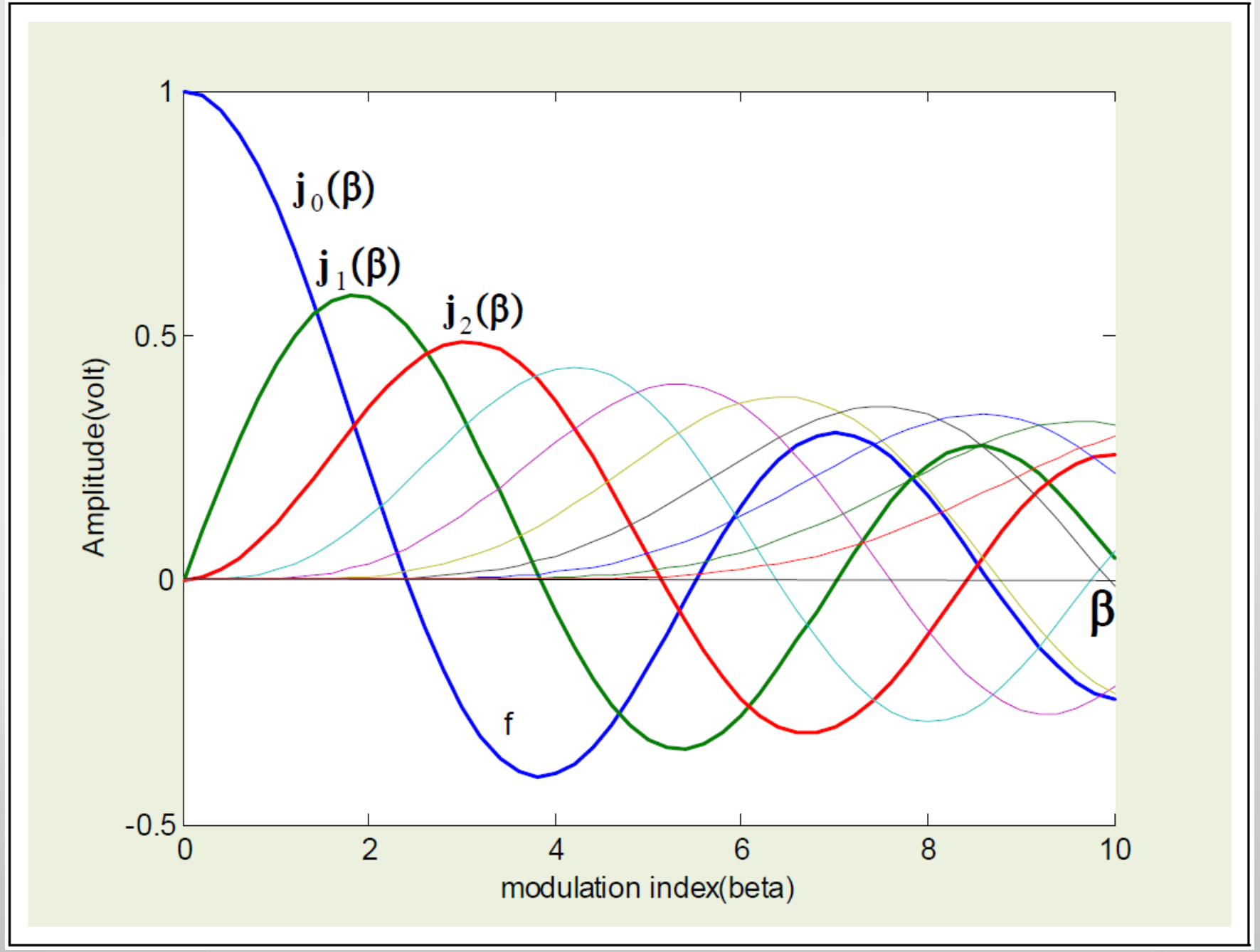
Todd was just told there are no free lunches…

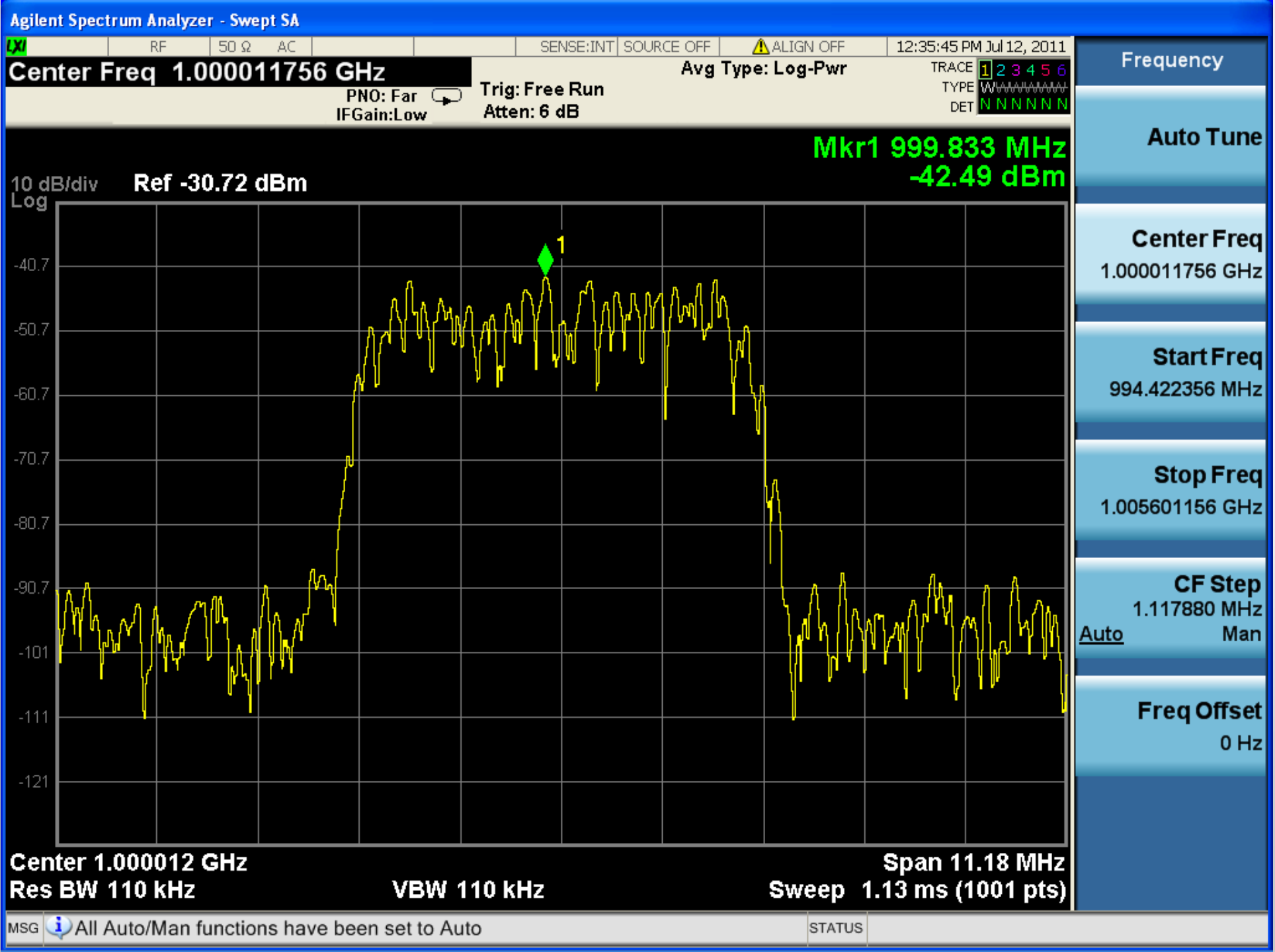



We Need More
POWER Scotty

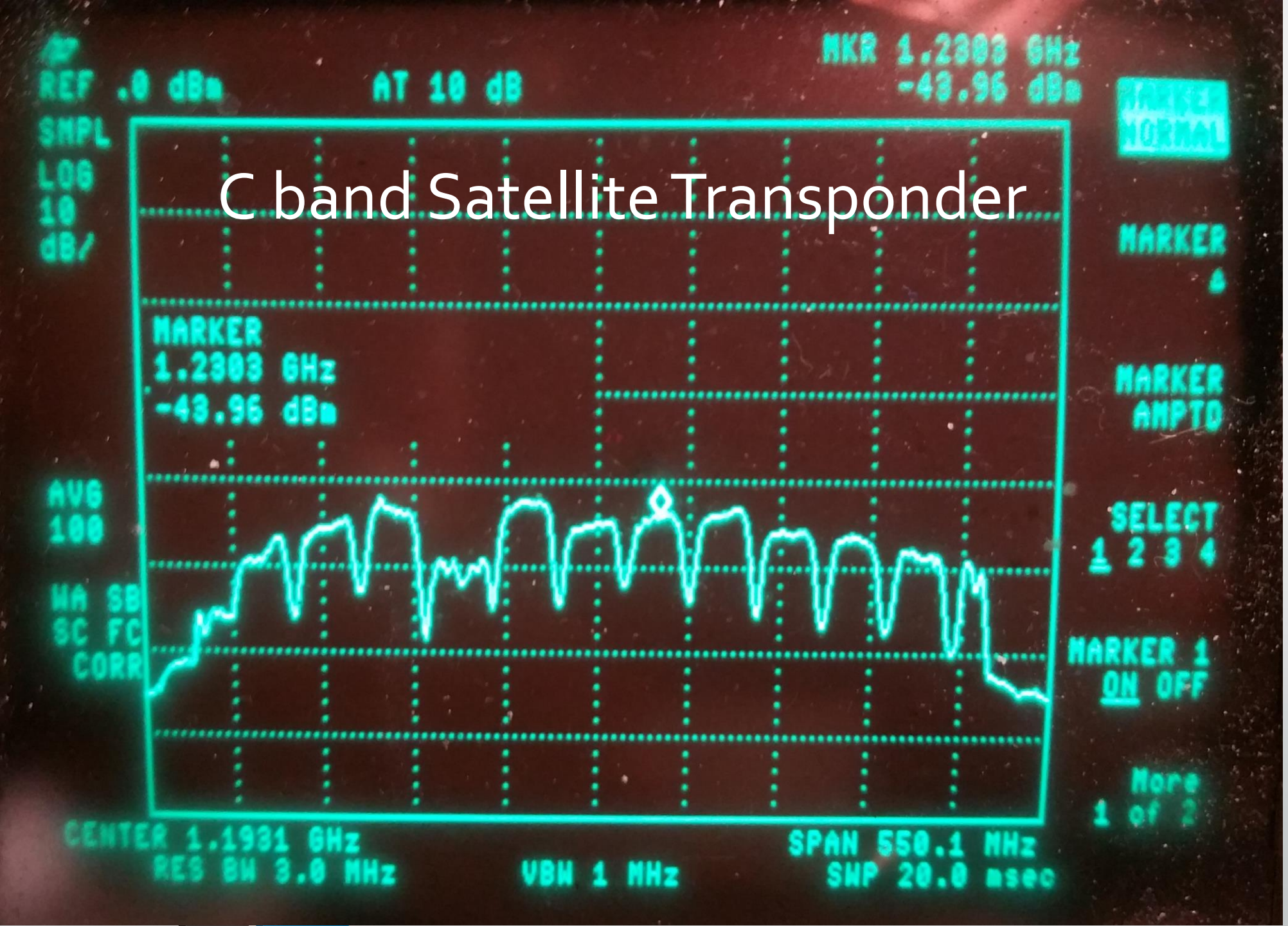

# How did the satellite TV industry fix their bandwidth problem?

# FM TV


1
0.5
0
-0.5
0
2
4
6
8
10
Amplitude(volt)
modulation index(beta)
j0(β)
j1(β)
j2(β)
β
f




# A typical Digital carrier waveform



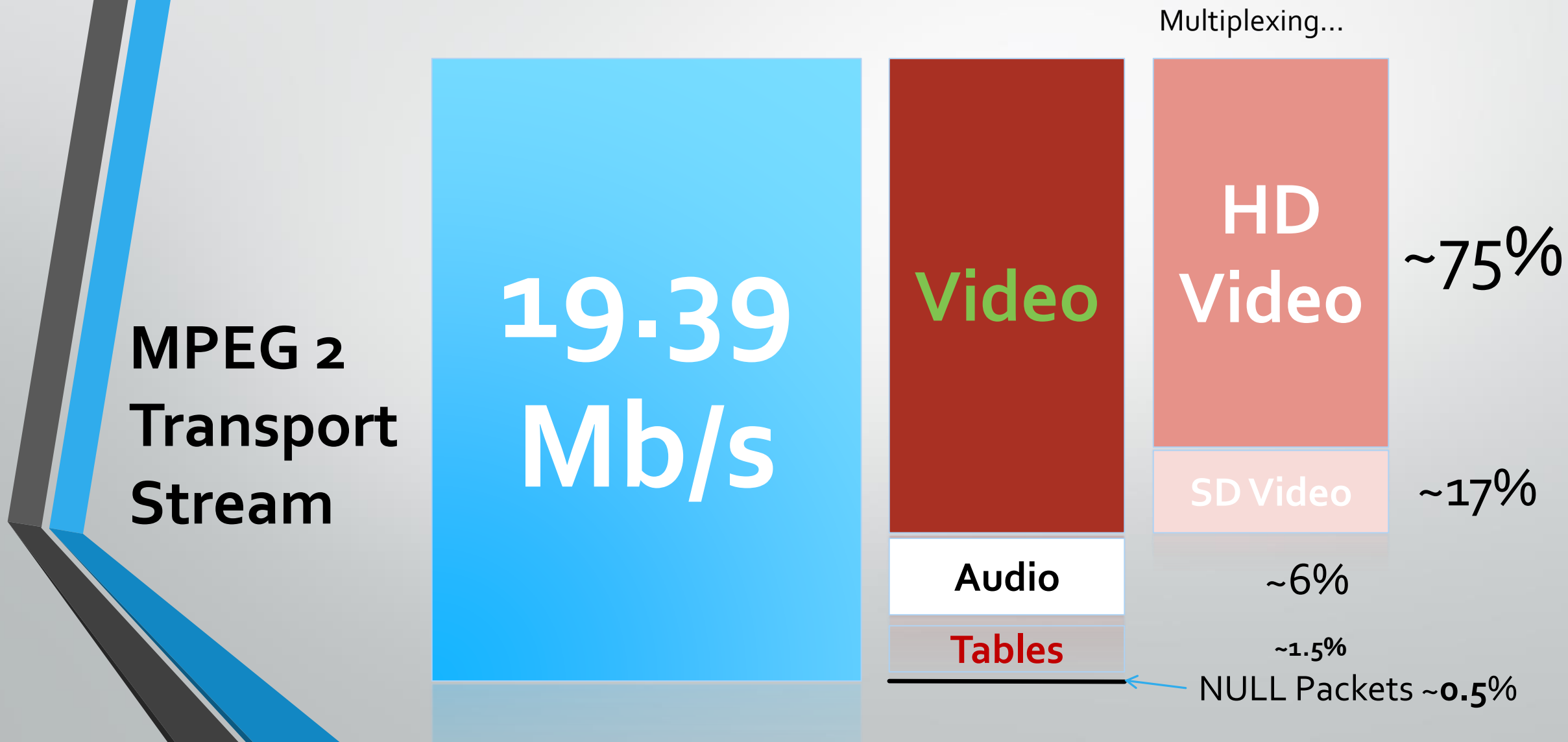

# C band Satellite Transponder

Modulation

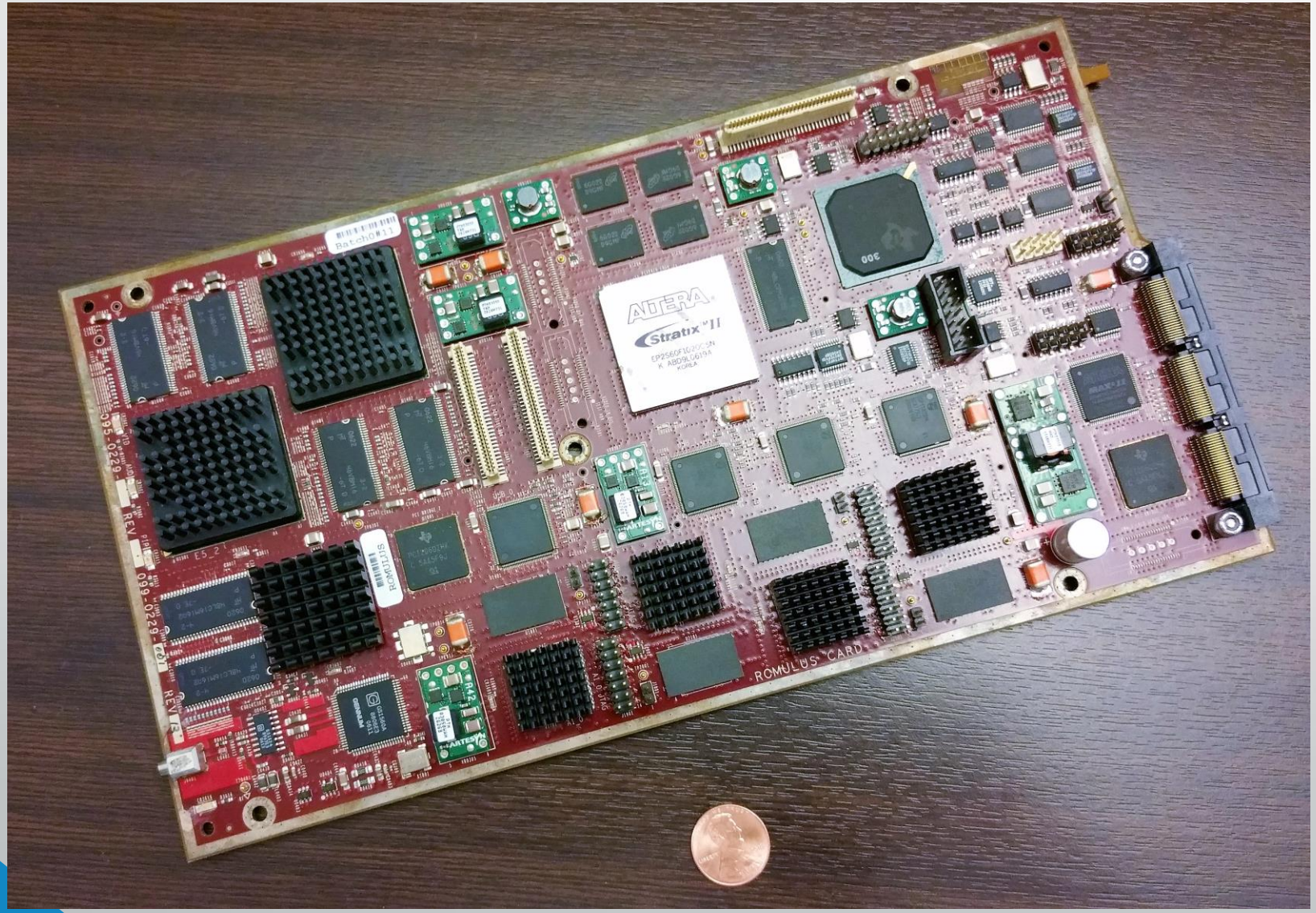
# So switching to digital is hard…

# SD MPEG 2 ENCODER  (CIRCA 2001)

# The capacity of ATSC 1.0



# HD H.264 encoder (circa 2006)



# Where to begin

NTSC…. ATSC…. KIT…. HOMEBREW?

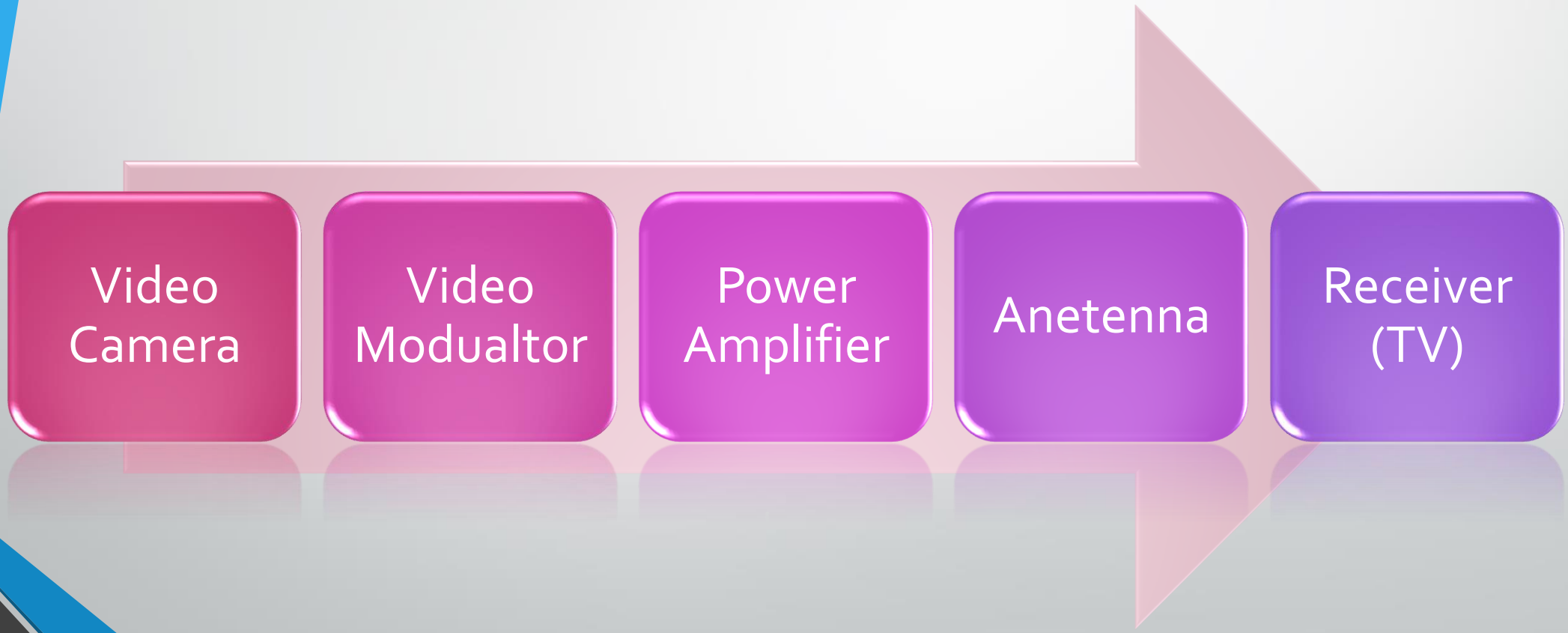

WHICH
parts are
available?

# Analog TV Modulator

# **Cable** TV frequencies

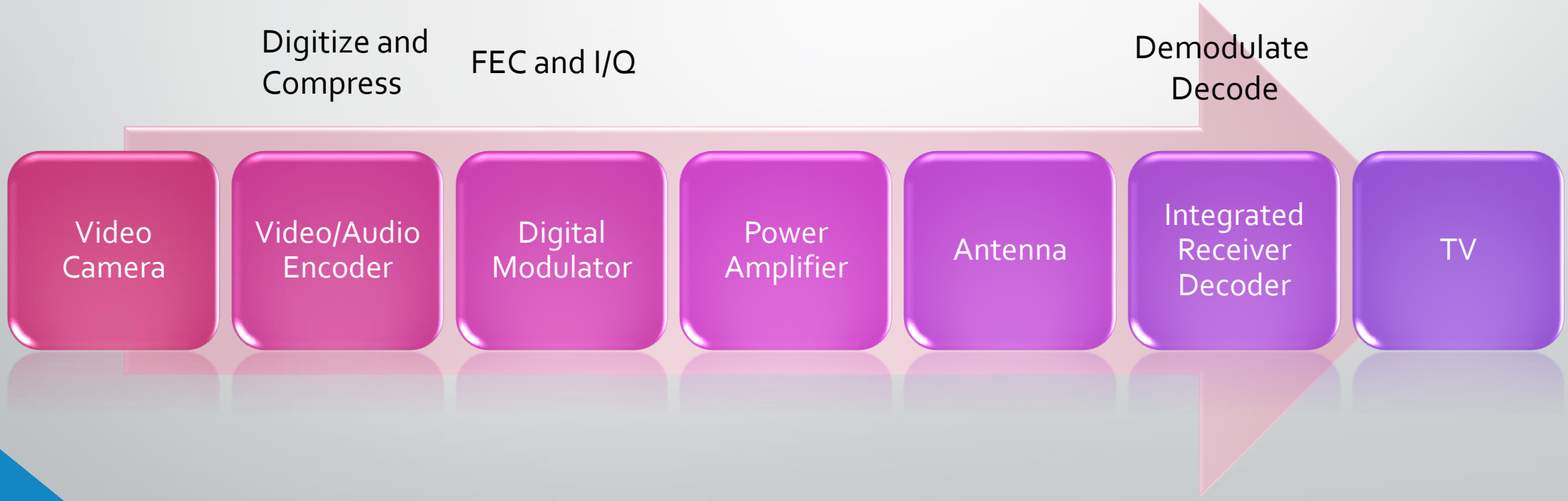
| | | |
|---|---|---|
| 57 | UU or W+21 | 421.25 |
| 58 | VV or W+22 | 427.25 |
| 59 | WW or W+23 | 433.25 |
| 60 | XX or W+24 | 439.25 |

# Analog TV Flow



But we want more power…

# Converting from Analog TV to Digital TV

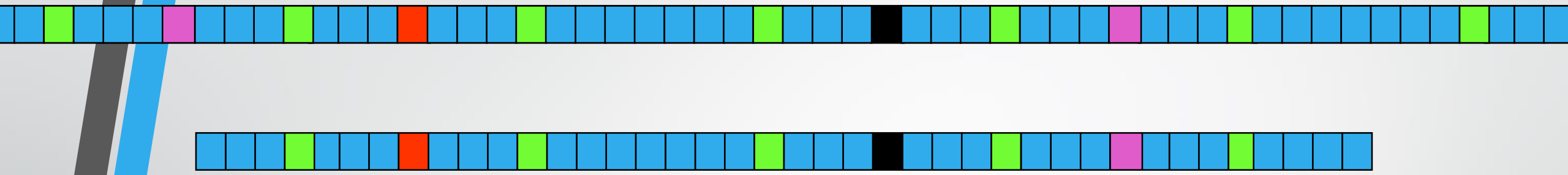


# Let’s examine the system in more detail…

# The MPEG 2 Transport Stream

MOVING PICTURES EXPERT GROUP

# 10,000 foot view of MPEG 2 Transport Stream





Video

Tables

Audio

nulls

## Electrical View

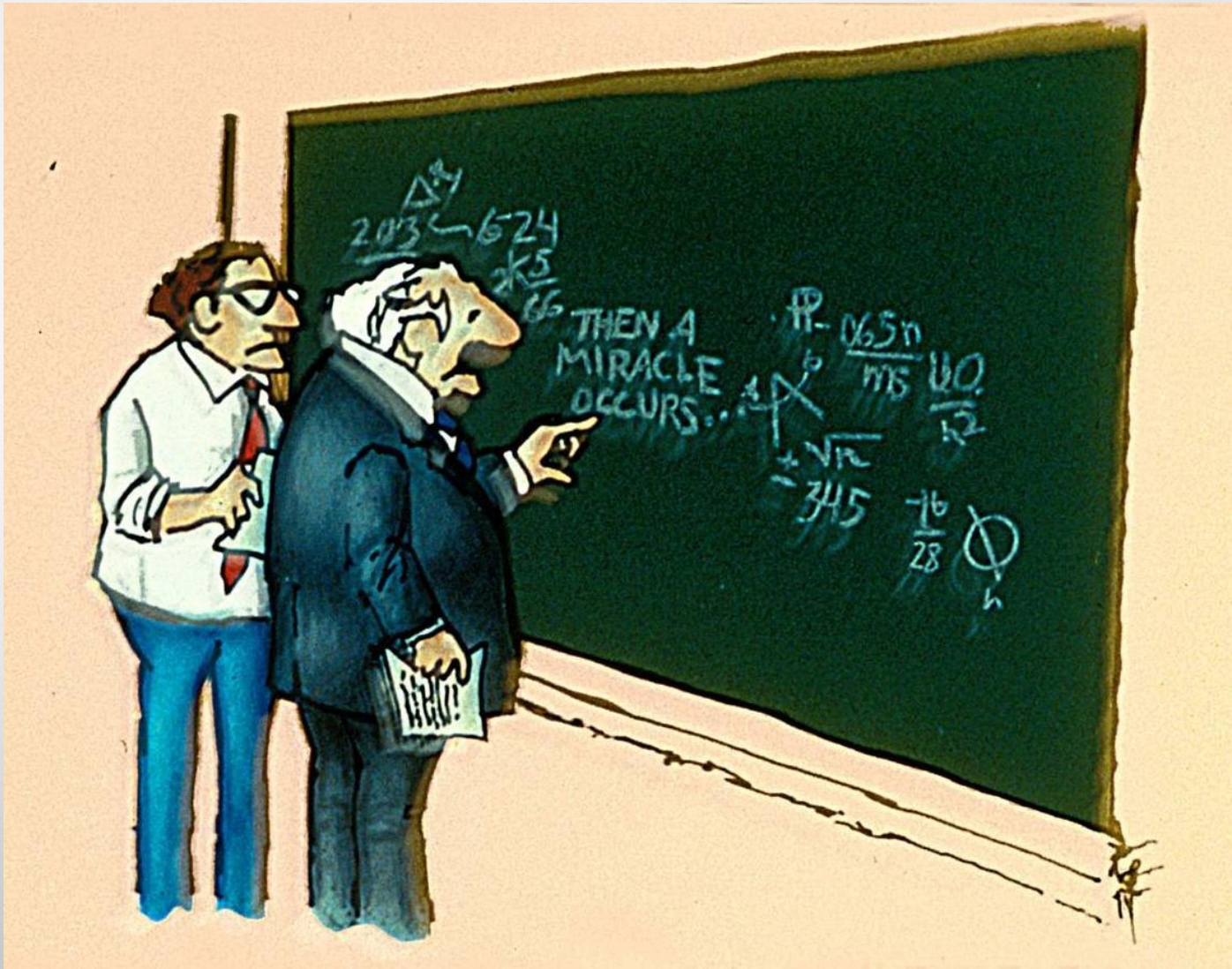
- **Tables** are packets with metadata carried on defined PIDs to indicate to a decoder how to "tune in" the channel element(s) inside the transport stream multiplex.

# Video Compression Standards

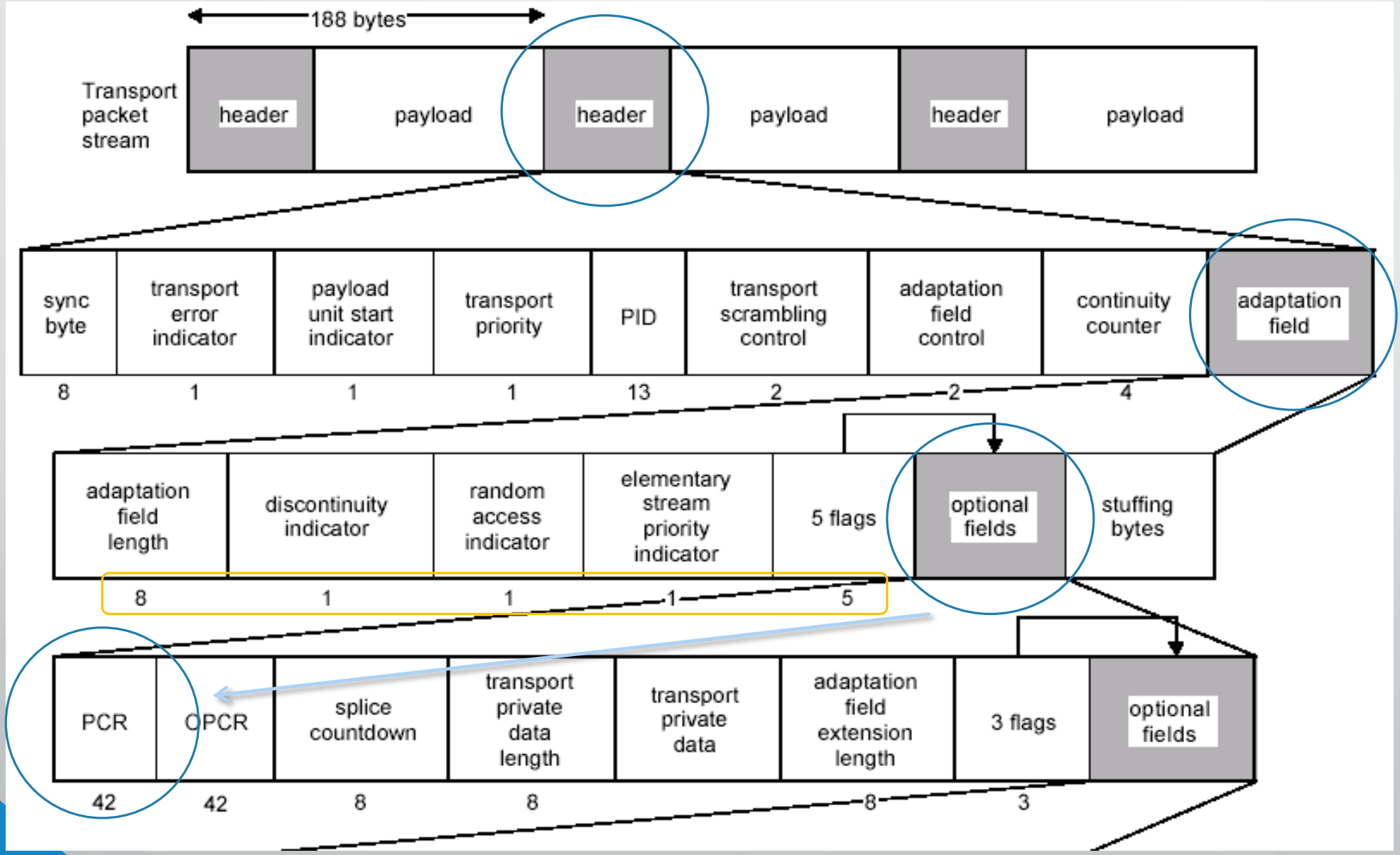
# Video Compression

Every frame of video is digitized to convert pixels along the scan lines into quantized levels and formed into data blocks.

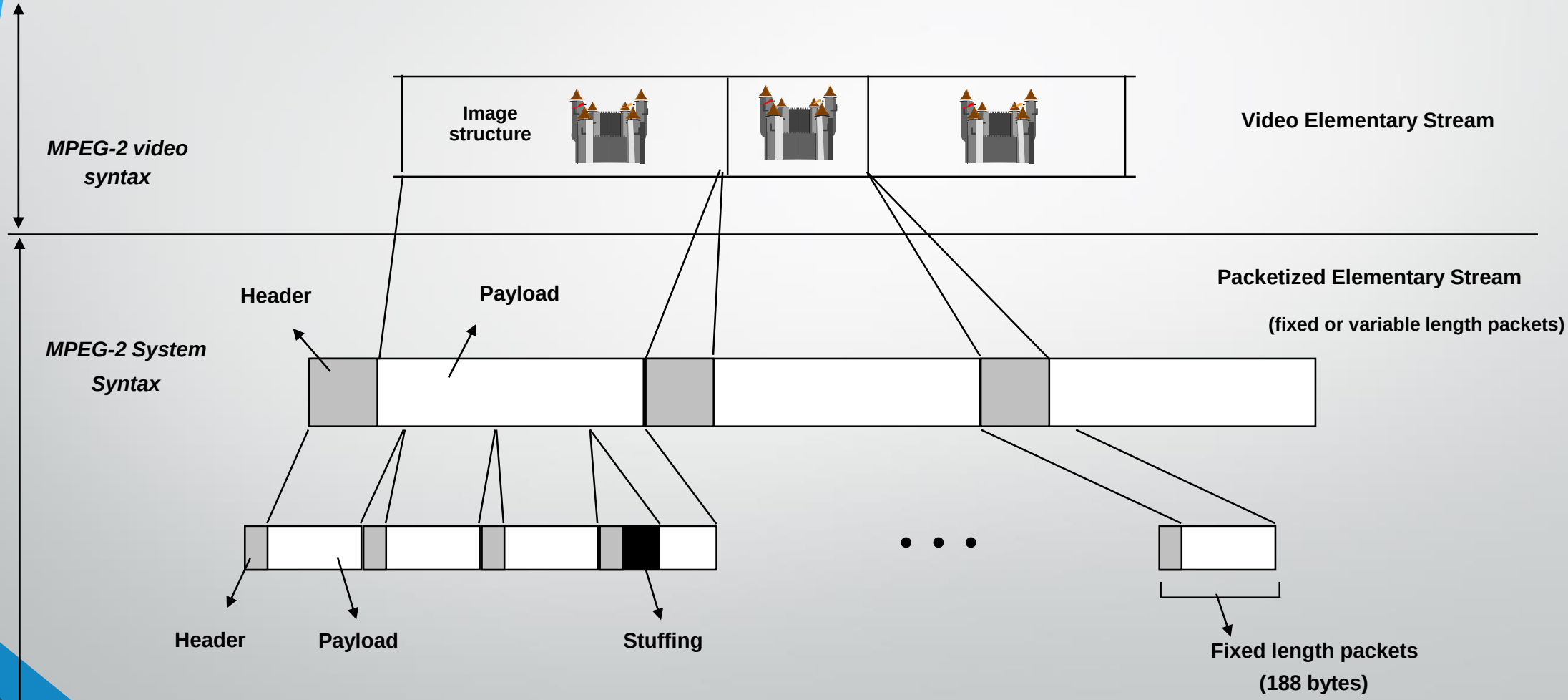
Using DCT on the blocks allows the encoder to detect changes in luminosity, color, shape* or direction so that only the blocks of the image which change are coded. The coded frames are packetized and stuffed with meta data. Then data compression is applied to form payload packets where the packets are lined up serially to make a bit stream …



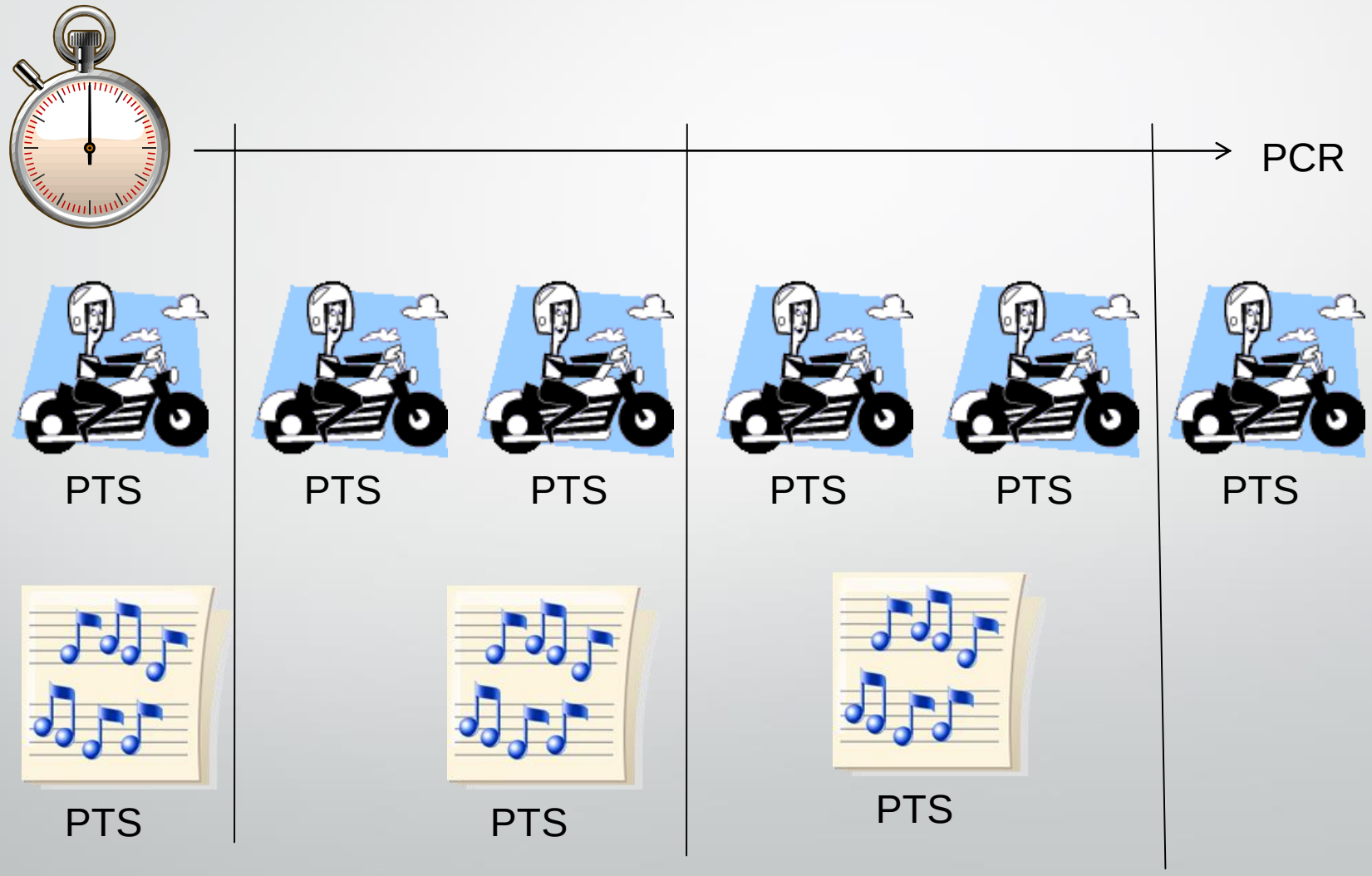
# MPEG-2 Syntax



# MPEG Transport, Video, Audio, Data



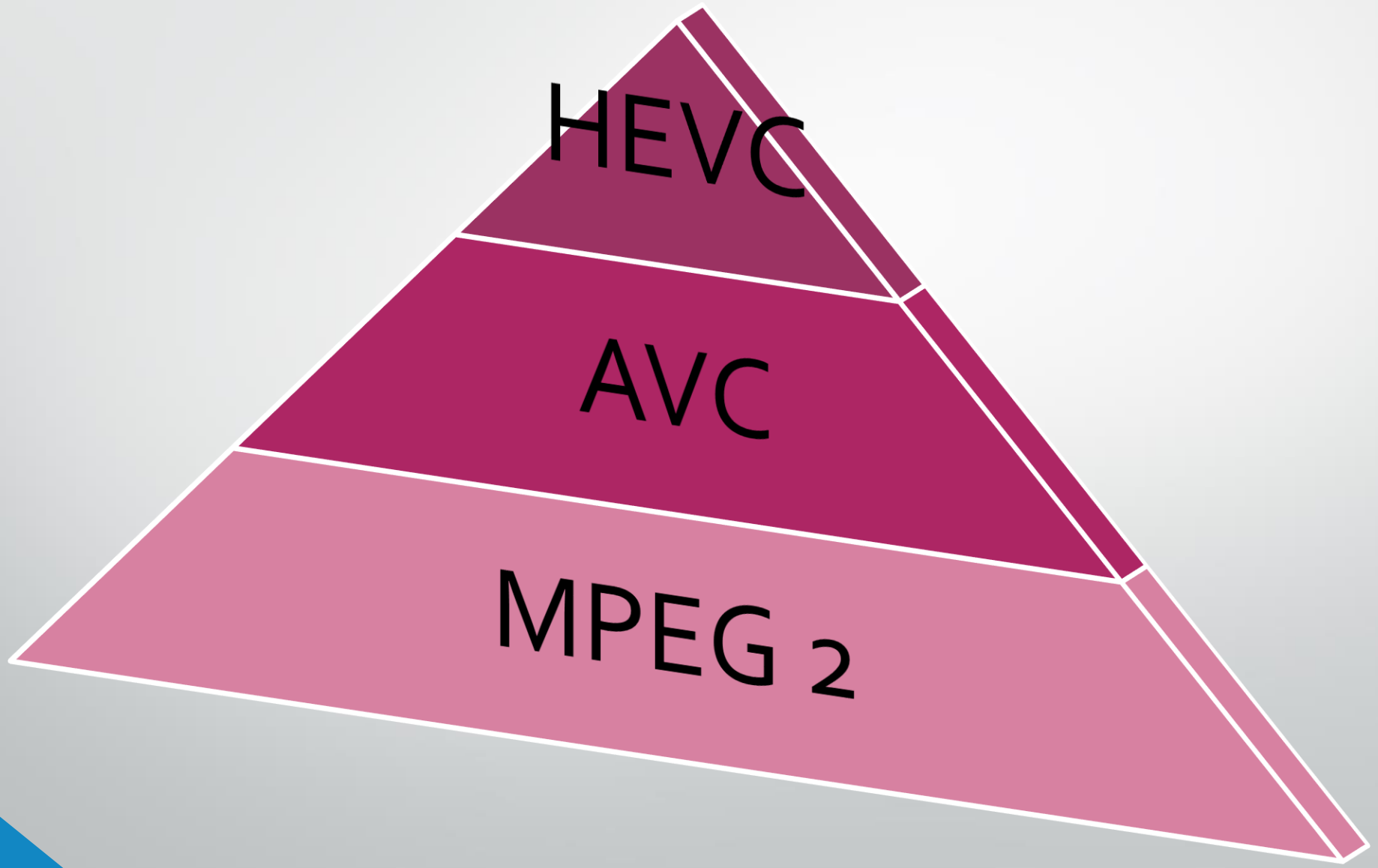
# MPEG-2 Synchronization



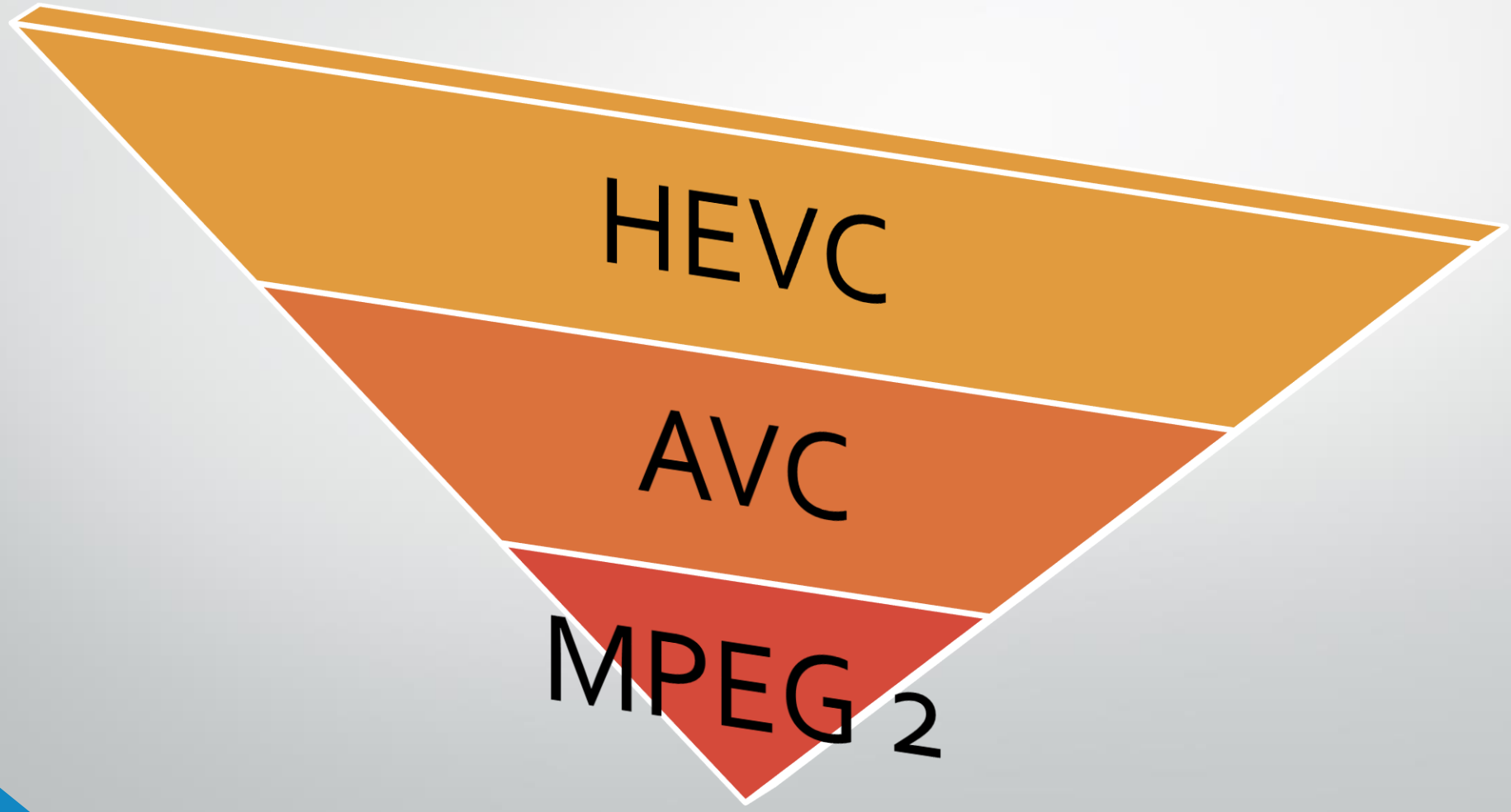
# Which video compression codec?

# Even Batman is good with MPEG 2

# Bit Rate or Compression Efficiency



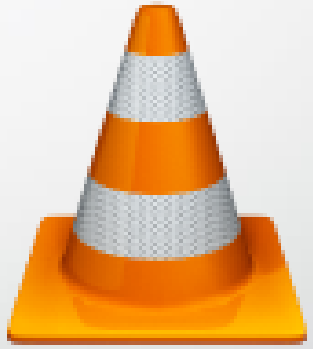
# Processing Power and Resources



# Software tools
# Free for **non-commercial** use

FFMPEG

TSReader



VLC

# Audio Compression

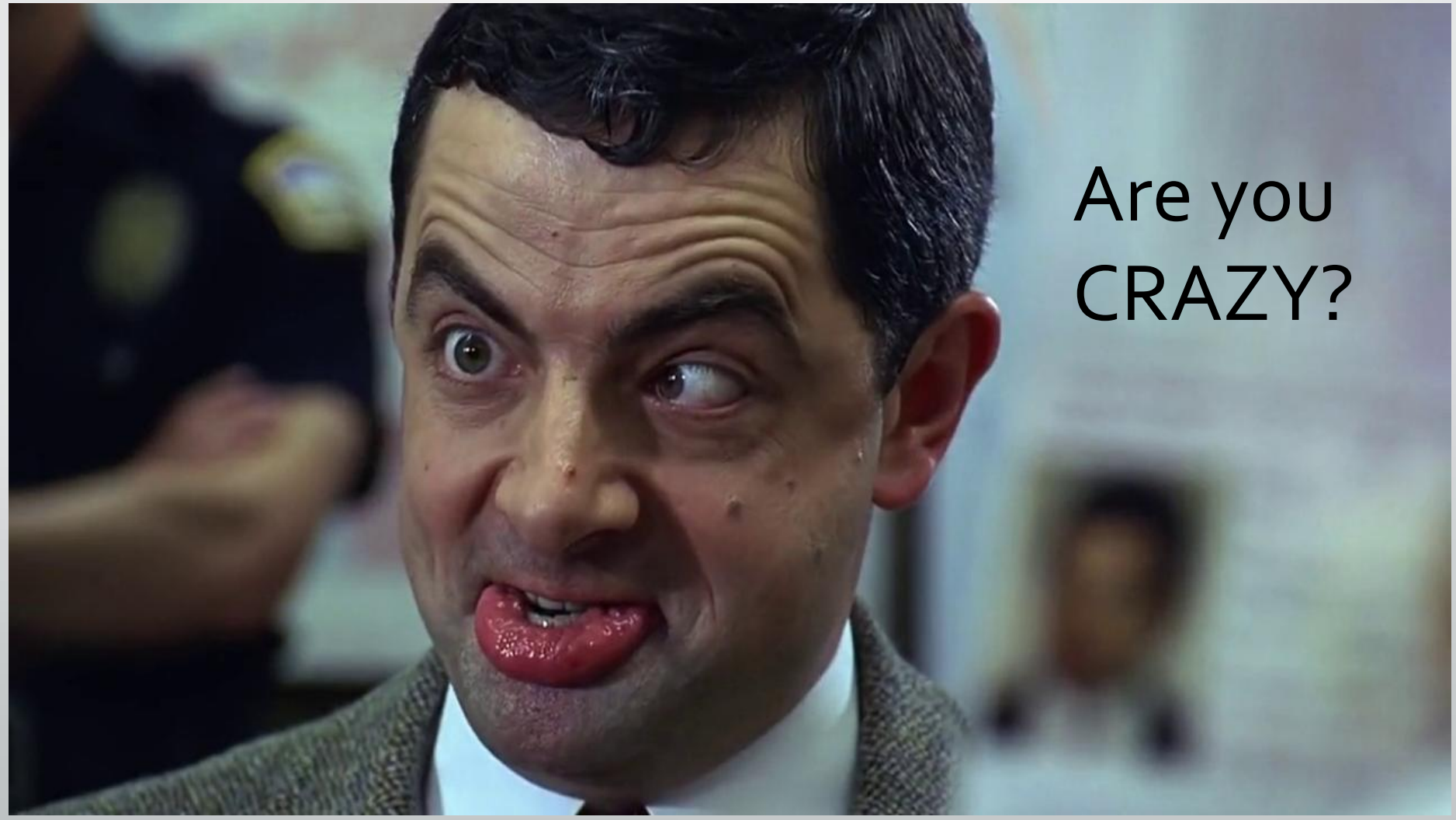
# MPEG 1 layer II audio is good enough, ok?

# Modulation Systems

# Modulation Standards

- ATSC 6 MHz (terrestrial)
- DTMB 8 MHz (terrestrial)
- DVB-C 6 / 8 MHz (cable)
- DVB-S variable (satellite)
- DVB-T 6 / 7 / 8 MHz* (terrestrial)
- ISDB-T 8 MHz (terrestrial)

# Though convenient, why not 8VSB?



# **DVB-S** – has been used for many years

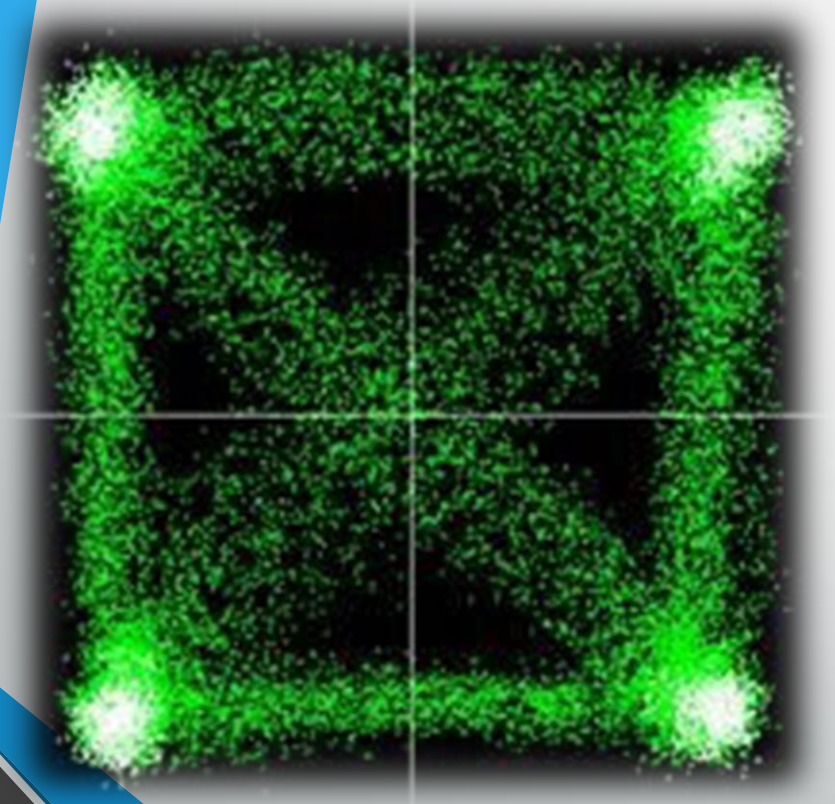
DVB S

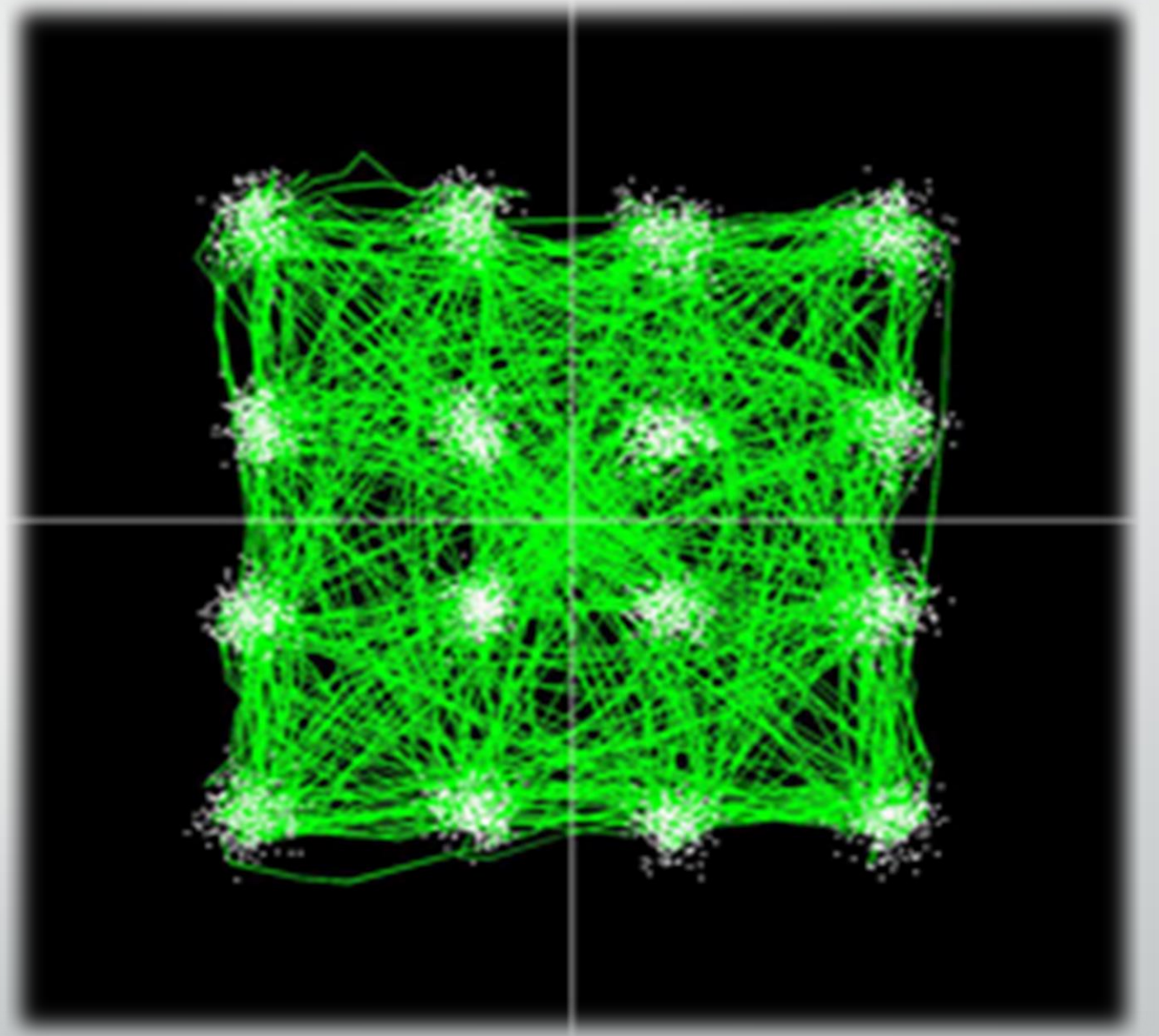
| Title | Standard |
| --- | --- |
| Framing structure, channel coding and modulation for 11/12 GHz satellite services | EN 300 421<br>V1.1.2<br>08/1997 |
| Implementation of Binary Phase Shift Keying (BPSK) modulation in DVB satellite transmission systems | TR 101 198<br>V1.1.1<br>09/1997 |

# And the winner is…

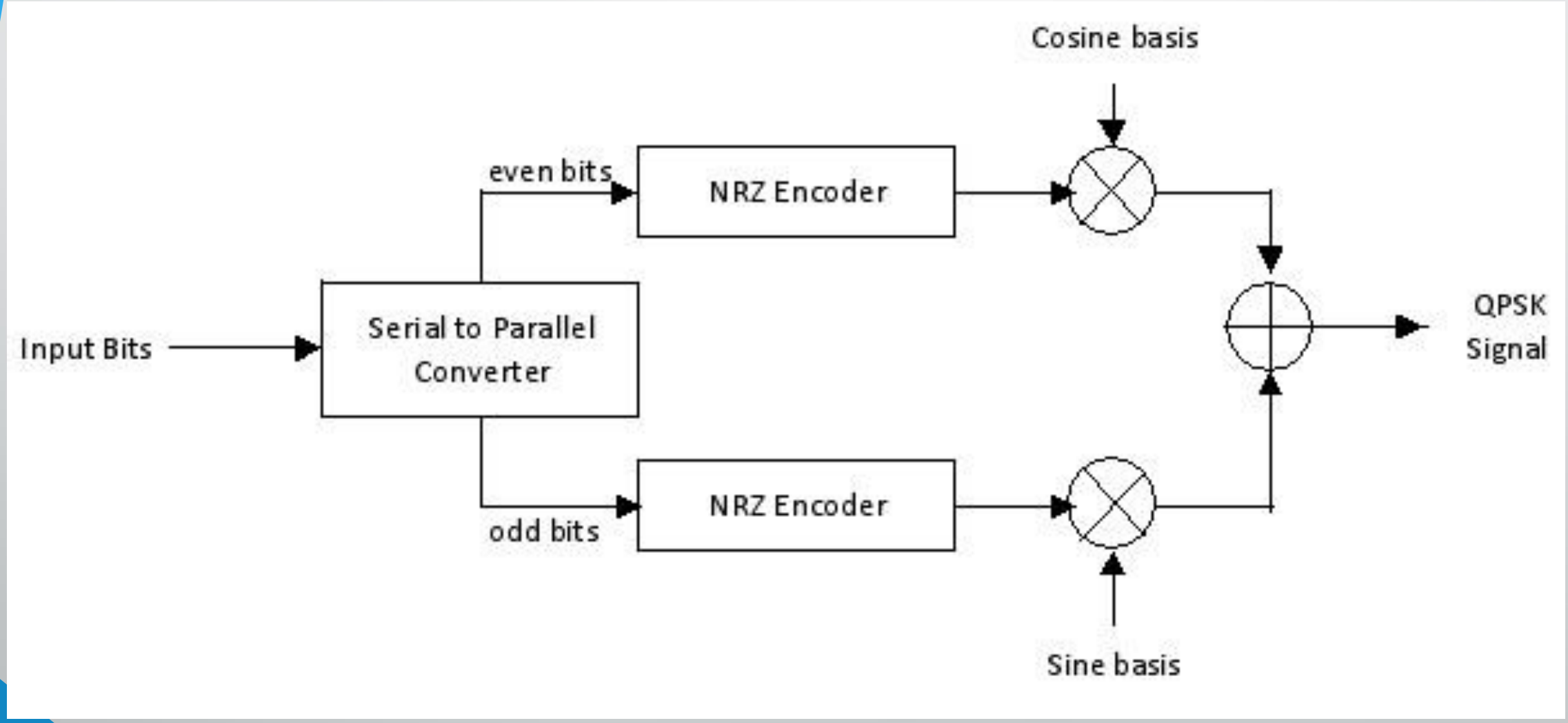
**QPSK**

# QPSK vs QAM





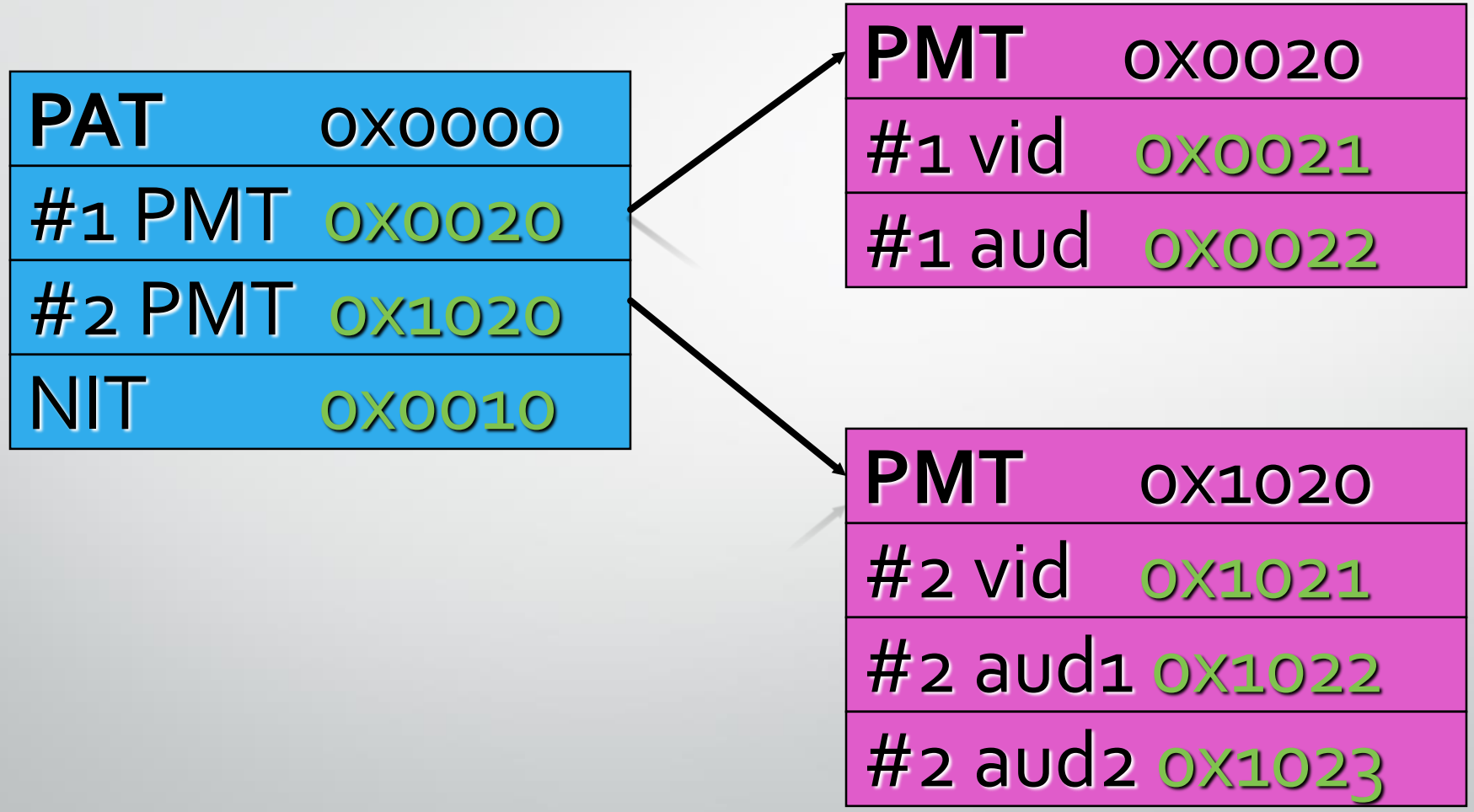
# QPSK Modulator



# MPEG Tables

and other regulatory stuff

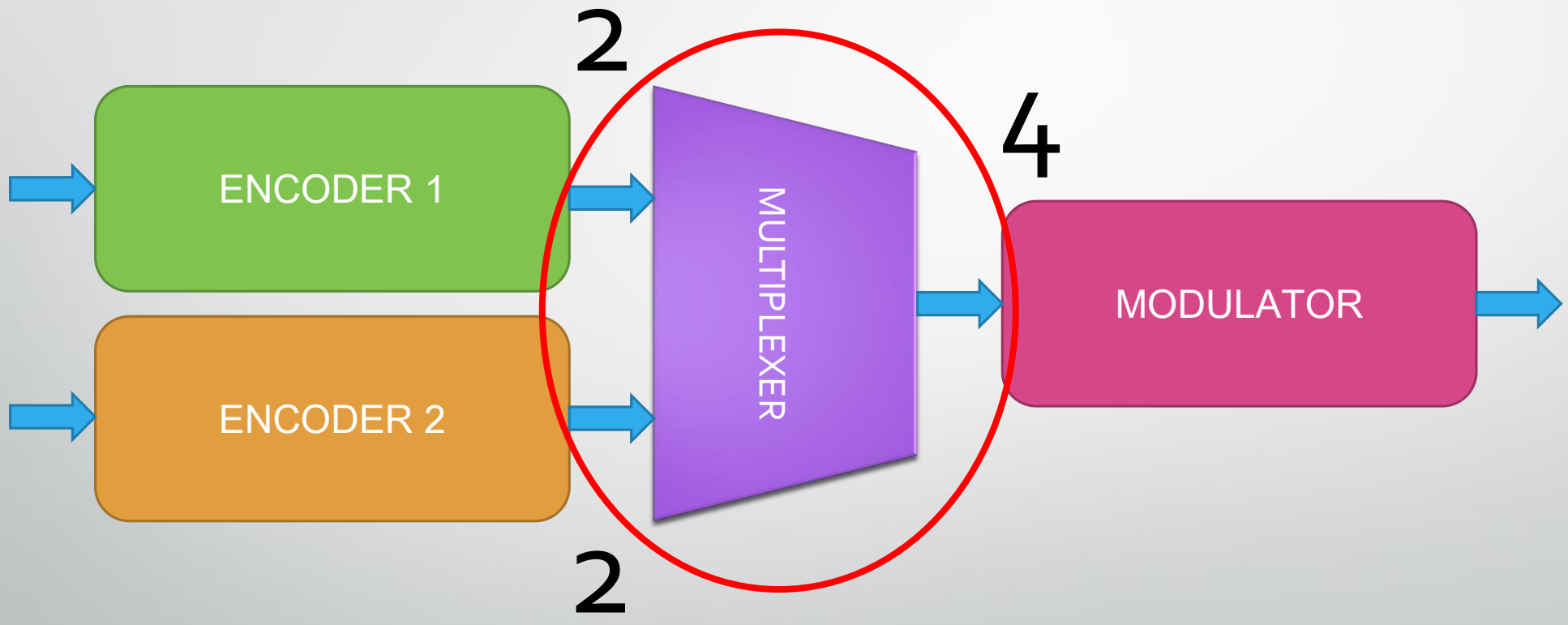
# Table Hierarchy - MPEG PAT and PMT




KD6W
was here

# Transport Streams and Multiplexing

# SIMPLE Multiplexing

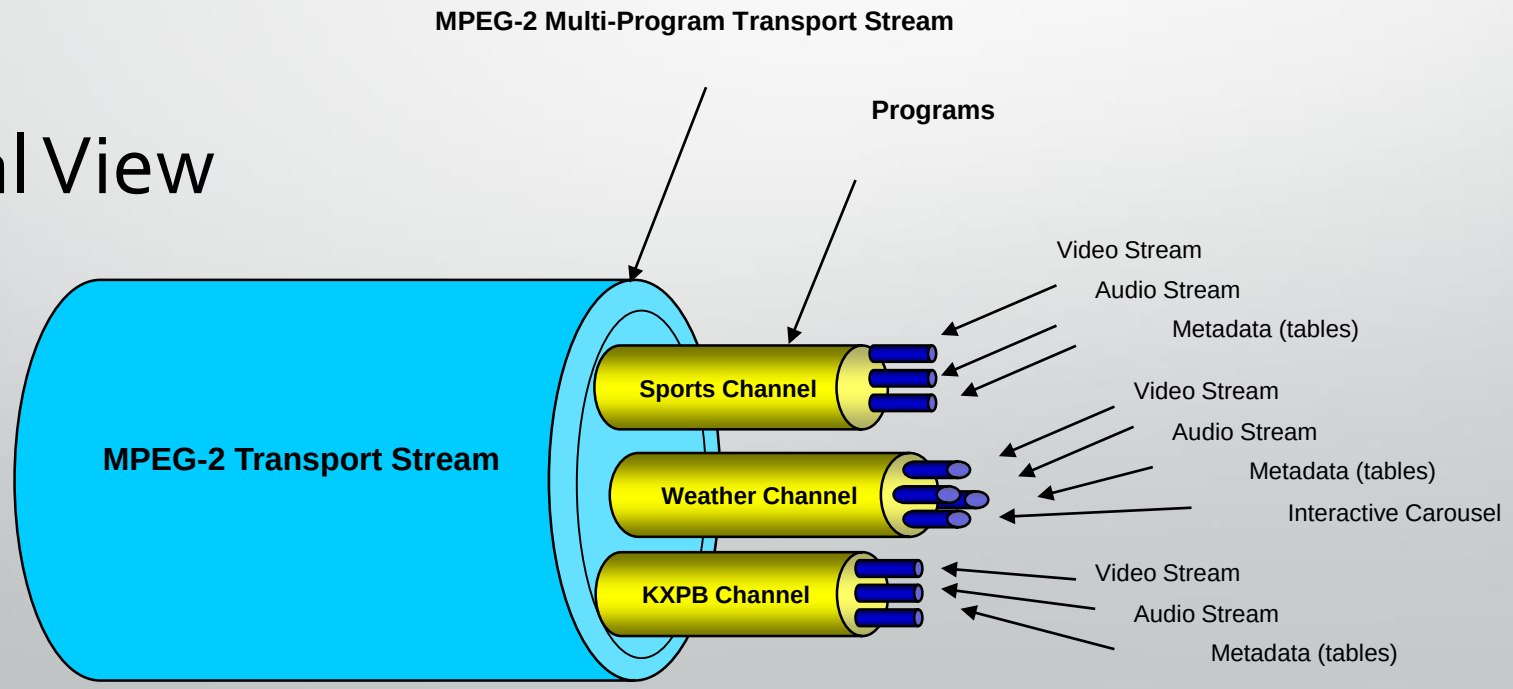



2+2 = 4

# MPEG-2 Transport Stream

- The MPEG transport stream is the data stream the decoder ultimately looks for.
- 188 byte packets
- PCR for each Program
- It contains the program elements and the metadata describing them

## Logical View



# Which Bands are Most Useful for DATV?

# Popular Frequencies

- 427MHz 6 MHz
- 912 MHz 15 MHz

---

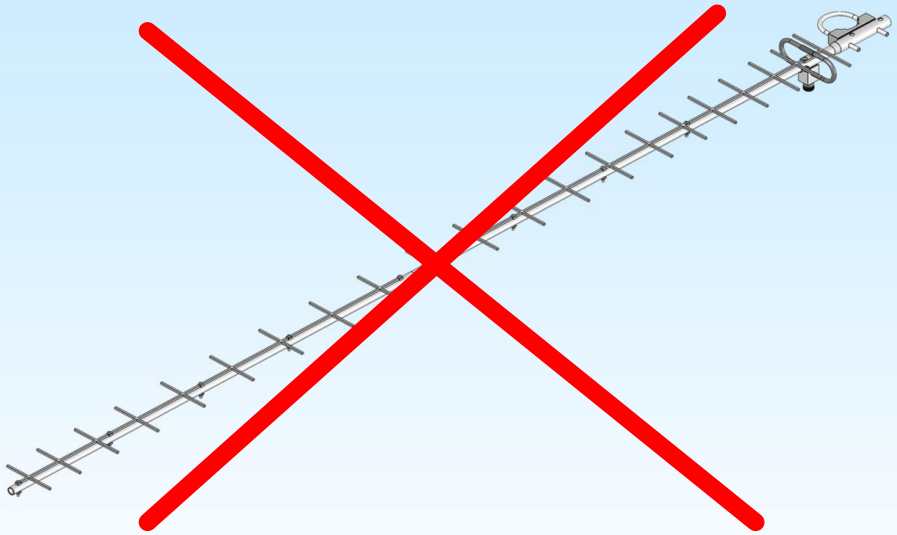
- 1240 - 1290 MHz 30 MHz
- 2400 - 2450 MHz 50 MHz
- 3440 – 3460 MHz 20 MHz
- 5600 – 5700 MHz 100 MHz
- 10100 – 10450 MHz ~350 MHz

# A quick word about 440 MHz

# 1.2 GHz Band

- The “L BAND” of an IRD is defined as a range 950 - 2200 MHz
- **IRD tuners can therefore tune the entire 1.2GHz band with no converters**

- The IRD has the ability to inject a bias 12-18VDC on the coax …
  - Turn off the DC in the IRD or
  - Add a DC block to the line or
  - Use the DC to run a LNA or
  - Use the DC and run a down converter



Designed for 1296 work

# A Ham friendly DATV RECEIVER for under $40

# THE DVB S/S2 IRD


GT MEDIA Freesat V7S FTA Satellite TV Receiver HD DVB-S/S2 SAT Finder TV Decoder, Supports PowerVu, DRE & Biss Key, YouTube, Newcam Set Top Converter Box

★★★½☆ 13

$33.99

prime FREE Delivery Sun, Feb 9

GT MEDIA V8 Satellite Finde Detector, HD 1080P Free to

★★★½☆ 26

$65.99

prime FREE Delivery Sun, Feb 9


Free to Air FTA HD Digital Sa Digital Tv Box DVB-S2/S Clea

★★★½☆ 21

$29.99

prime FREE Delivery Sun, Feb 9

# QPSK Calculations

A tiny bit of math…

# Scanning for settings…

# Forward Error Correction

FEC = 3/4


3 BITS are sent

Sum of 3 bits creates FEC

4 bits received, 1 is corrupt

Receiver corrects damage

# Forward Error Correction example

| FEC ratio | Bit Rate |
|---|---|
| 1/2 | 1.75509 Mb/s |
| 2/3 | 2.34013 Mb/s |
| 3/4 | 2.63359 Mb/s |
| 5/6 | 2.92706 Mb/s |
| 7/8 | 3.07380 Mb/s |

http://jaunty-electronics.com/blog/2012/05/bpsk-qpsk-8psk-and-qam-calculator/

# Calculating Occupied Bandwidth

**MPEG 2 TS packet = 188 bytes**

**Reed Solomon = 16 bytes**

**QPSK = 2 bits per symbol**

**Coding Rate = ½ 2/3 ¾ 5/6 7/8 etc.**

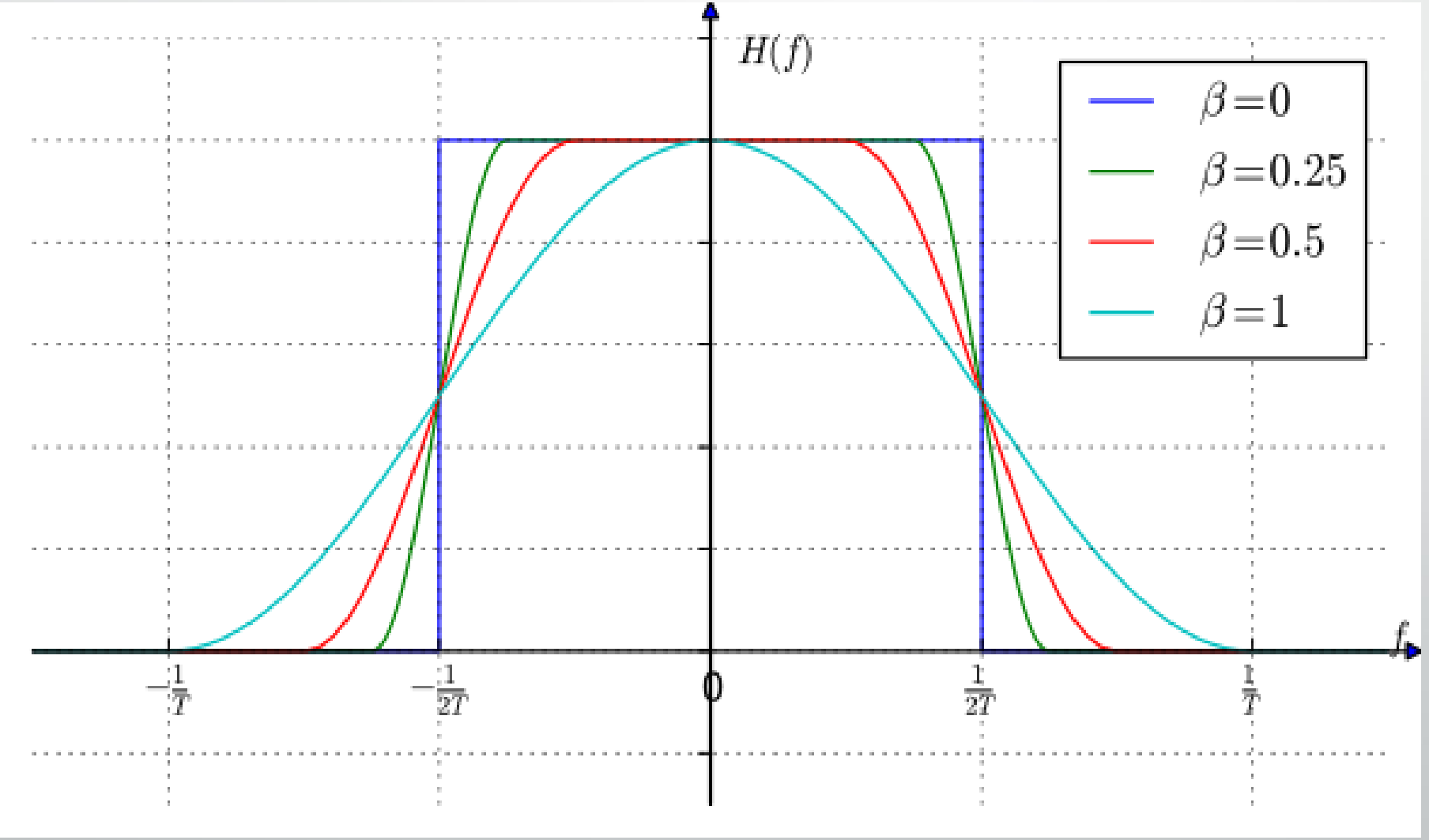
**Symbols/sec = (Bits/second × 204) / (188 × Bits/symbol(CR)**

## Example - 4 Mega bits/sec

**4000000 * 204 / 188 * 2(3/4) = 2894360**

**or 2.89436 Mega symbols/sec**

# NYQUIST Roll Off



# Calculating occupied bandwidth

**Nyquist Roll Off (factor)**

**2.89436 Mega symbols/sec  x  25% roll off =**

**2.89436 x 1.25 = 3.61795 MHz**

# System Setup

# POWER - AC or DC?

# Lights


# Cameras

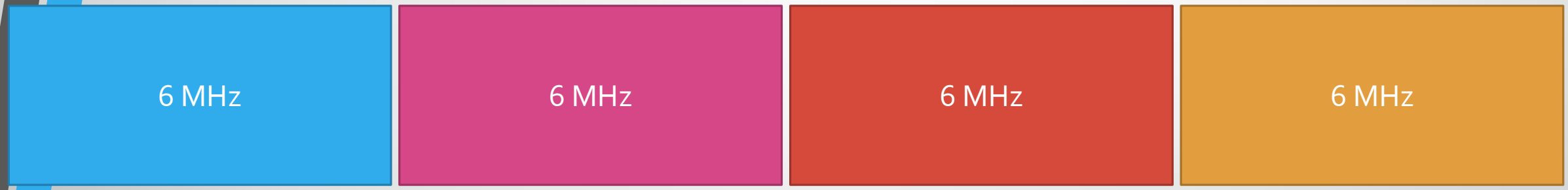

# Some Equipment Considerations

- Station Monitors
- Production Switcher
- Microphones
- Mixing board

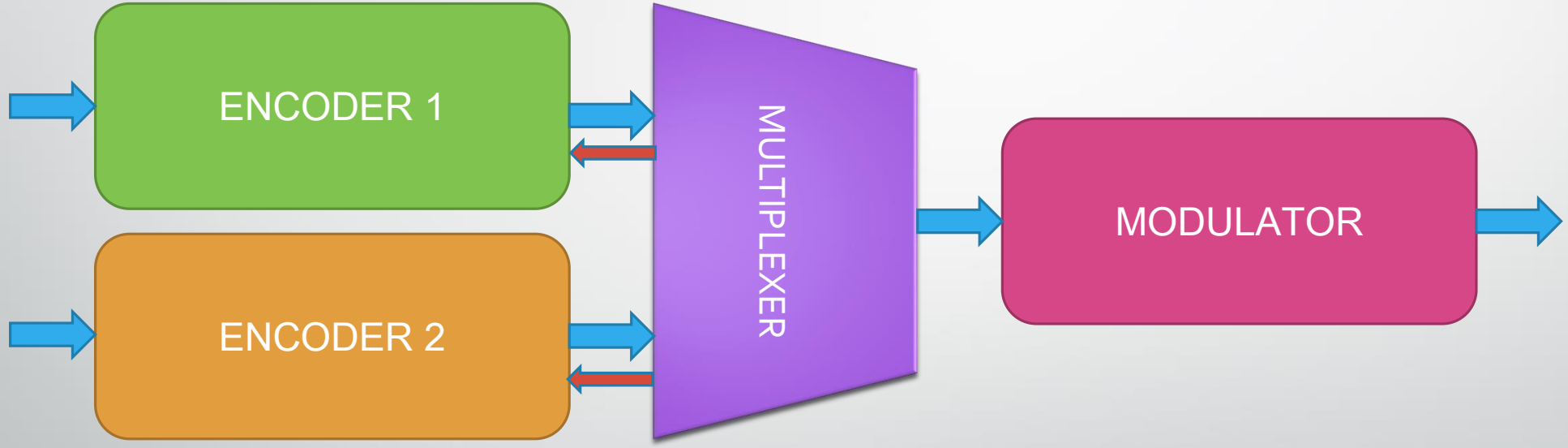
# Consider a DATV Multiplexed Repeater

# Spectrum Management

ANALOG = 4 Channels
(4 video + 4 audio)



# Building a MPEG 2 Multiplex




A statmux process is used to create Variable Bit Rate (VBR) encoding

# Spectrum management


DIGITAL =

15 Channels Video

and ~32 Ch. Audio

# Homebrew DATV station…

The bare minimum…

# ATV Receiver system

- Antenna – one for each band
- Frequency Converters - for the other band(s) of interest
- LNA – (optional)
- IRD – consumer QPSK tuner/decoder
- TV – usually includes an Analog "cable" receiver

# ATV Transmitter System

- Camera –
- Microphone –
- TV –
- Analog Modulator
- MPEG Encoder
- Digital Modulator –
- Frequency Up-converter
- Amplifier –
- **Mask Filter – be nice!**
- Antenna

Add a T/R relay and you are ready…

# Lets go for some DX!

# Summary

# Analog vs Digital

## Analog (AM)

- Only supports SD
- Only supports one channel
- Requires 6 MHz bandwidth
- Easily distorted but no cliff effect

## Digital

- Has buffer delay
- Introduces artifacts
- Adds more cost
- Steep learning curve
- Has cliff effect but pictures are always perfect

# EBay equipment search terms…

Blonder Tongue, DiviCom, Harmonic, Electra, ION, NDS, Ericsson, Motorola, Newtec, Scopus Scientific Atlanta, Tandberg, Tiernan, Sencore, DVB-S, MPEG2, IRD, encoder, decoder, modulator

# References - Web Links
# More information
# Get the word out…

www.arrl.org
www.atn-tv.org
www.atsc.org
www.batc.org.uk
www.darc.de
www.dvb.org
www.mdarc.org
www.mpeg.org
www.nor-cal-datv.org
www.hamtv.com *
www.tvhistory.tv
en.wikipedia.org/wiki/Program-specific_information

* I don't support or represent this site but they do offer some good information and other useful links for further research.

# Read on and prosper…

Thank you!

kd6w@arrl.net

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