# 2009 ARRL TAPR Digital Comm Conference

## Planning a DATV Station on DVB-S

by

- Ken Konechy W6HHC
  W6HHC@ARRL.net

- Robbie Robinson KB6CJZ
  KB6CJZ@ARRL.net

# Planning a DVB-S DATV Station

## So What Started our DATV Project?

Over several years both of us have been involved in interesting conversations like:

"...we hams should change analog ATV over to Digital-ATV (aka DATV) to keep up with technology..."

# Planning a DVB-S DATV Station

## Why Go Digital ATV?

- Picture quality can be nearly perfect much of time
- Digital allows error correction from noise, multipath
- Digital techniques allow advanced modulation
  - compression
  - less bandwidth
- Digital TV components for hams will become more common
- Analog TV components for hams will start to disappear

# Planning a DVB-S DATV Station

## Introduction to Commercial DTV Standards

- DVB-C (cable) – Europe/Asia/Pacific
- DVB-S (satellite) – Europe/Asia/Pacific
- DVB-T (terrestrial) – Europe/Asia/Pacific
- ATSC (terrestrial) – United States/Canada

# Planning a DVB-S DATV Station

## DVB-C (cable) – Europe/Asia/Pacific

- The cable environment is very low loss
- The cable environment is noise-free
- The cable environment is free of multi-path
- Uses higher order modulation schemes starting from QPSK up to 256QAM
- Does not represent a good choice of technology for hams to consider for DATV

# Planning a DVB-S DATV Station

## DVB-S (satellite) – Europe/Asia/Pacific

- Uses simple QPSK modulation
- Was NOT designed to deal with multi-path envir't
- Uses different layers of Forward Error Correction (FEC) for very robust protection against any kind of errors
- RF bandwidth can be as small as 2 MHz
- Chosen by many European and United States DATV groups for digitizing ATV.

# Planning a DVB-S DATV Station

## DVB-T (terrestrial) – Europe/Asia/Pacific

- Designed to overcome the destructive effects of multipath reflections
- Uses 16QAM modulation for a low effective bitrate per carrier
- 1,705 closely spaced carriers (using COFDM ...aka Coded Orthogonal Frequency Division Multiplexing) to create a 6 or 8 MHz bandwidth.

# Planning a DVB-S DATV Station

## ATSC (terrestrial) – United States / Canada

- 8-VSB is 8-level Vestigial Sideband Modulation
- Like DVB-S, uses MPEG-2 for video compression
- Uses AC3 (Dolby) algorithm for audio compression
- Uses multiple layers of Forward Error Correction (FEC) for very robust protection against any kind of errors
- ATSC SetTopBoxes are very cheap in U.S.

# Planning a DVB-S DATV Station

## Drawbacks for DATV

- Weak Signal Reception

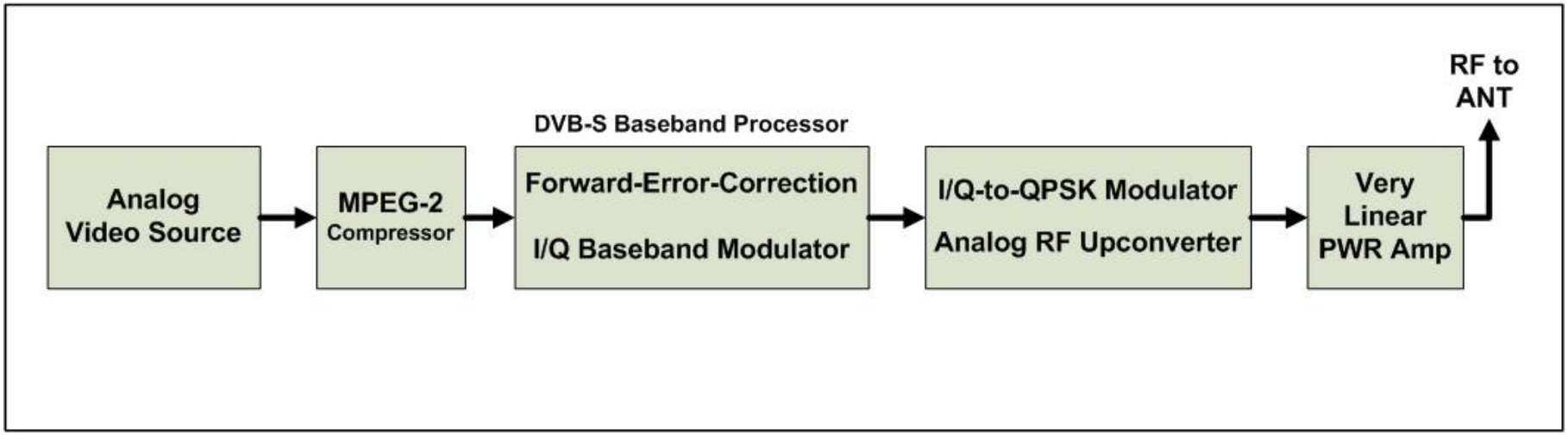
  As Henry AA9XW explained in the Amateur Television of Central Ohio News (ATCO):

  **"Yes, digital [ATV] is 'noise free' until you hit the blue wall. There is 1 dB between perfect and nothing. So don't expect a lot of DX, since you can't find the signal in the noise without a spectrum analyzer and BPF [band pass filter]."**

- High Cost of DATV Equipment
  - Analog ATV benefited from cheap Closed-Circuit surplus
  - DATV XMTRs do not benefit from surplus commercial, yet

# Planning a DVB-S DATV Station

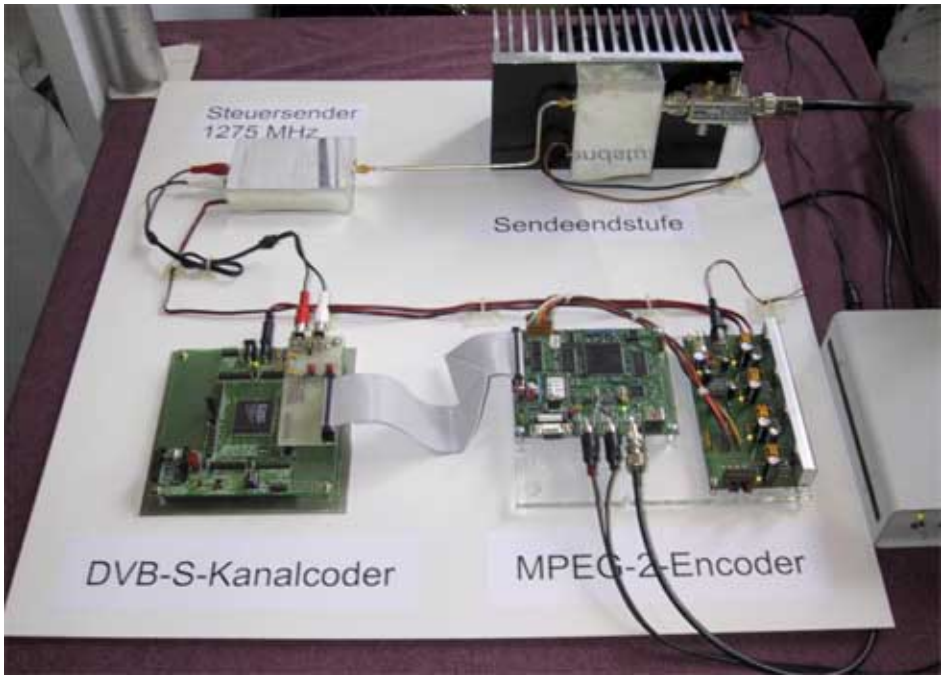
## Status of DATV Today




Block diagram of typical ham DATV transmitter

# Planning a DVB-S DATV Station

## Status of DATV Today – cont'd

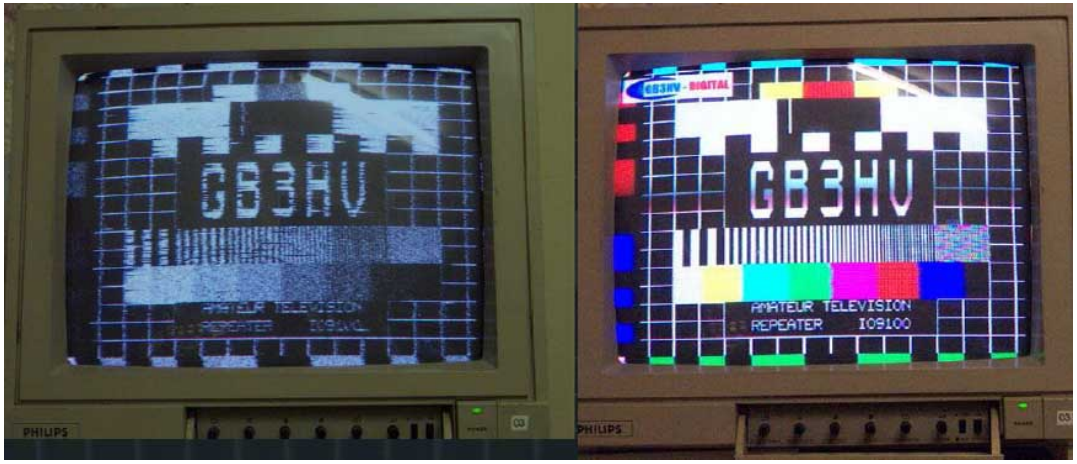



Prototype DVB-S DATV transmitter similar to the earlier Block Diagram

(courtesy of Thomas Sailer-HB9JNX/AE4WA, et al.)

# Planning a DVB-S DATV Station

## Status of DATV Today – cont'd




Comparison of analog picture and an DATV picture using the same antennas with weak sigs

# Planning a DVB-S DATV Station

## What Band Should We Plan for DATV?

- **440 MHz** – very crowded band
  - Looks like a difficult band for DATV
  - RF amps are cheaper
- **920 MHz** – presents a tight fit for DATV,
  - Lots of noise from “ISM Part 15” devices.
- **1,200 MHz** – more room for simplex DATV,
  - Probably no room for a DATV repeater-pair.
  - This is a clear ham band.

# Planning a DVB-S DATV Station

## What Band Should We Plan for DATV?-contd

- **2,400 MHz** – probably has room for a DATV repeater
  - 2.4 GHz region is shared with lots of others commercial services.
  - Some “ISM Part 15” devices share the frequencies with the hams.

- **3,400 MHz** – probably has room for a DATV repeater-pair
  - 3.4 GHz is shared only with U.S. Air Force

- **5,800 MHz** – Narrow band, may not have room for DATV repeater-pair.
  - 5.8 GHz region is shared with commercial services & “ISM Part 15”

- **10,000 MHz** - RF Amplifiers get still more expensive.
  - This band is clear Ham band and only sharing with the government.

# Planning a DVB-S DATV Station

## What Band Should We Plan for DATV?-contd

- Initial home / portable transmitters on 1.2 GHz
- Later may add a DATV repeater – with output on 2.4 GHz or 3.4 GHz

# Planning a DVB-S DATV Station

## Use ATSC or DVB-S Modulation??

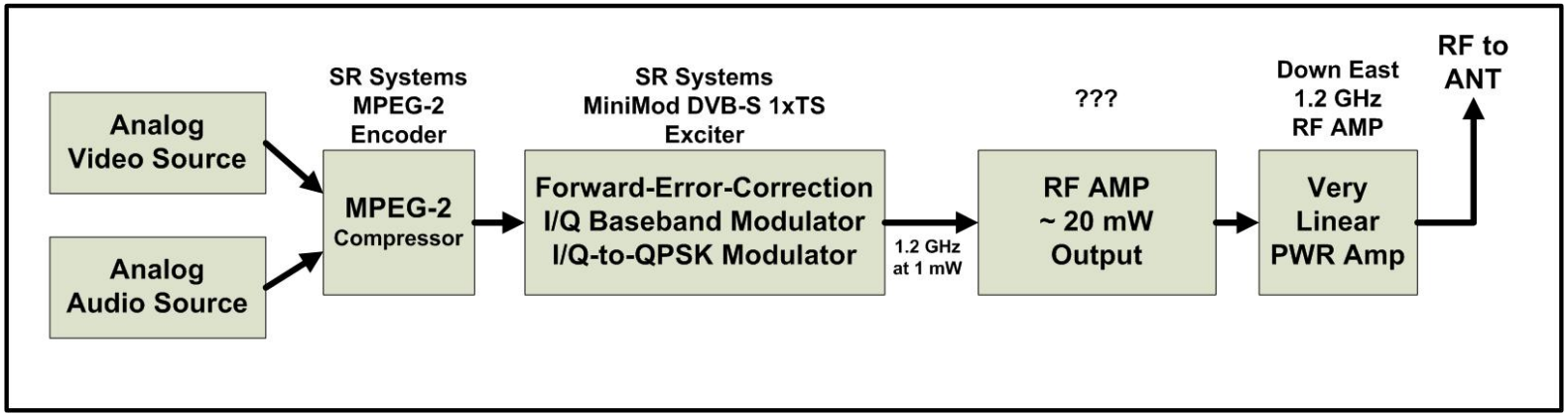
**DVB-S**

- QPSK Modulation
- Video compression is MPEG-2
- Audio compression is MPEG-2

# Planning a DVB-S DATV Station

## Use ATSC or DVB-S Modulation??

### DVB-S – contd




**Block Diagram of DVB-S Transmitter for DATV**

# Planning a DVB-S DATV Station

## Use ATSC or DVB-S Modulation??

## DVB-S Transmitter Cost Estimate

| Item | Description | Manufacturer | Model | Cost Estimate Low end | Cost Estimate High end |
|---|---|---|---|---|---|
| 1 | MPEG Encoder Board | SR-Systems | MPEG Encoder | $290 | $360 |
| 2 | 1.2 GHz FEC & IQ Modulator for DVB-S | SR-Systems | DVB-S 1xTS MiniMOD | $470 | $540 |
| 3 | First RF amplifier | ?? | (about 50 mW) | $25 | $50 |
| 4 | RF Power Amplifier 30W (very linear) | Down East Microwave | Part Number 2330PA | $240 | $240 |
| | **TOTAL** | | | **$1,025** | **$1,190** |

# Planning a DVB-S DATV Station

## Use ATSC or DVB-S Modulation??

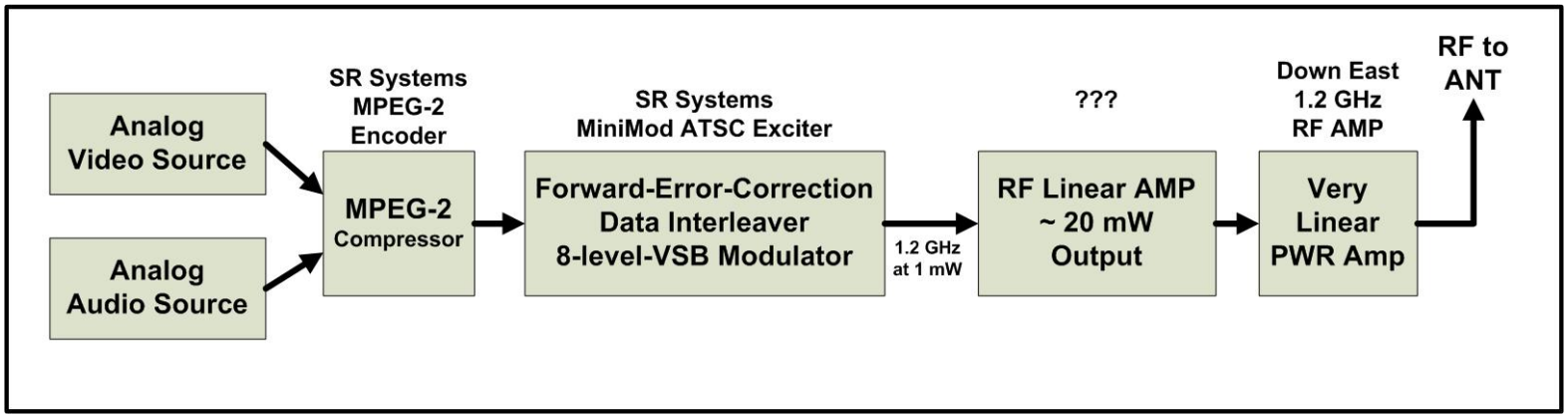
### ATSC

- 8-VSB modulation
- Video compression is MPEG-2
- Audio compression is AC3 (Dolby)
- SR-Sys ATSC board does not use AC3 (Dolby) audio because of license costs

# Planning a DVB-S DATV Station

## Use ATSC or DVB-S Modulation??

### ATSC – contd




**Block Diagram of ATSC Transmitter for DATV**

# Planning a DVB-S DATV Station

## Use ATSC or DVB-S Modulation??

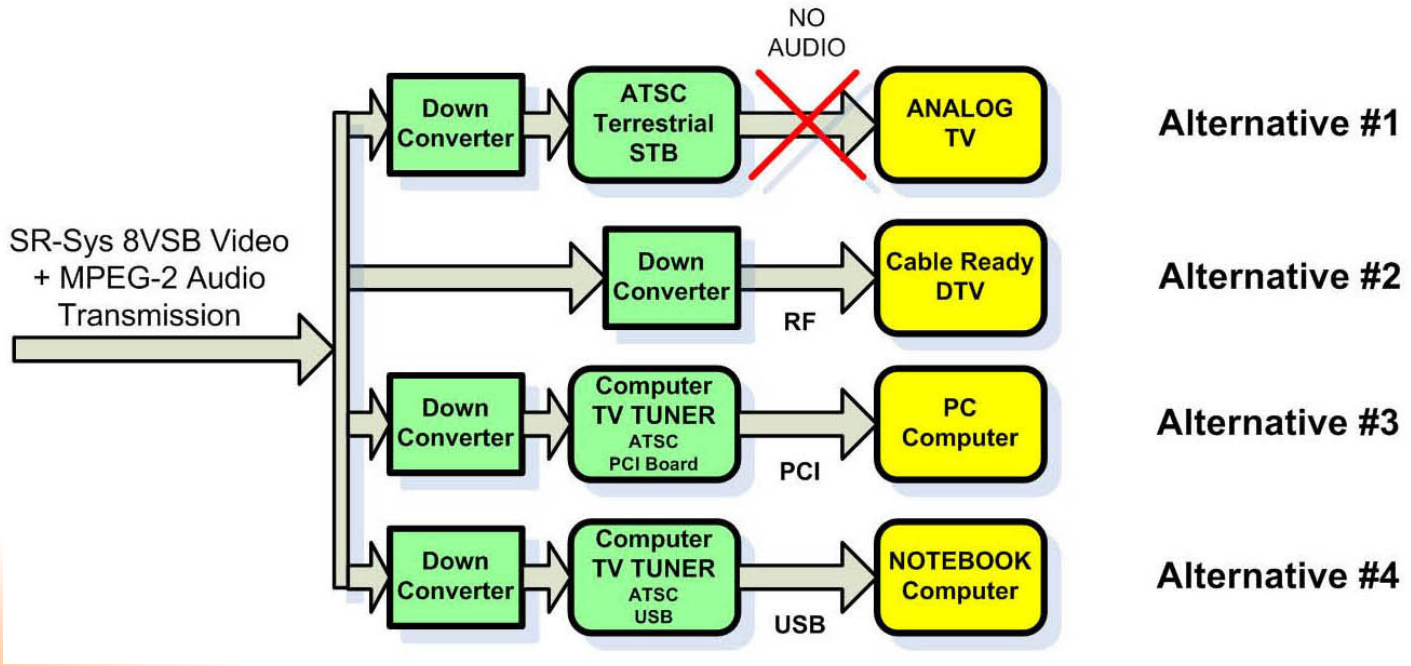
### ATSC – cont'd

- SR-Sys ATSC board does not use AC3 (Dolby) audio because of license costs
- No U.S. ham has succeeded using MPEG-2 audio into terrestrial ATSC STB
- N6QQQ reports success with cable-ready DTV
- N6QQQ reports success with USB or PCI ATSC tuners

# Planning a DVB-S DATV Station

## Comparison of Possible DATV Receivers

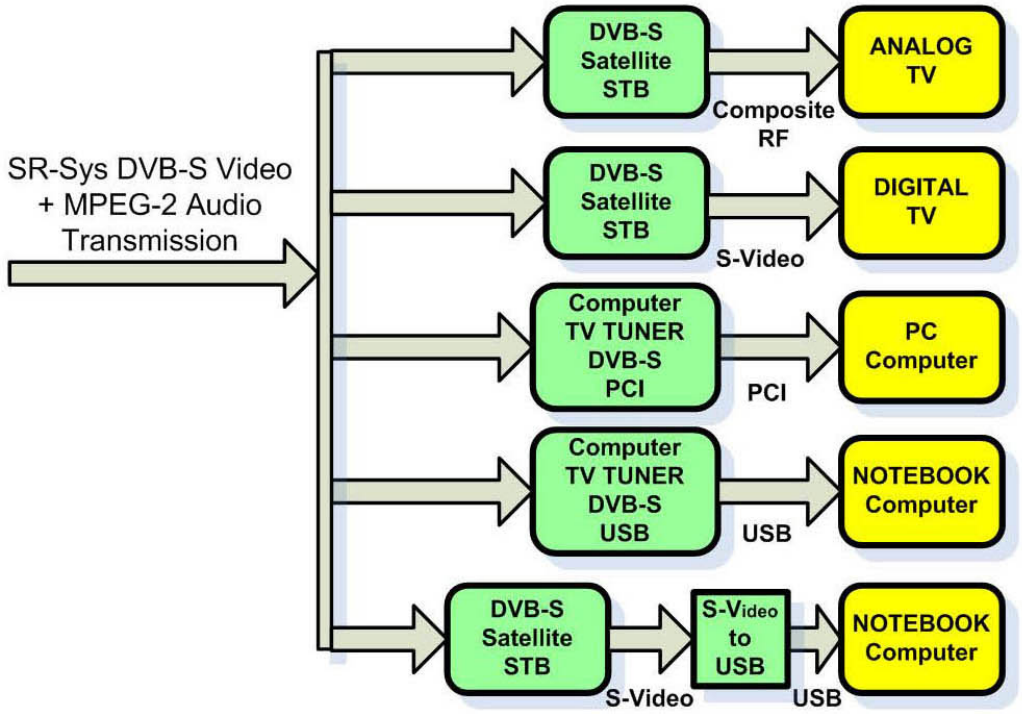
### ATSC



# Planning a DVB-S DATV Station

## Comparison of Possible DATV Receivers

### DVB-S



# Planning a DVB-S DATV Station

## Selecting Our DATV Station

- We chose DVB-S Transmitter technology
- ATSC would mean trial-and-error because of the MPEG-2 “audio quirk”
- DVB-S selection benefits from wide-spread experience and knowledge by European hams
- Robbie receiver choice is Alternative-5 (TV)
- Ken receiver choice is Alternative 9 (notebook)

# Planning a DVB-S DATV Station

## Understanding Symbol-rates, FEC, & BW

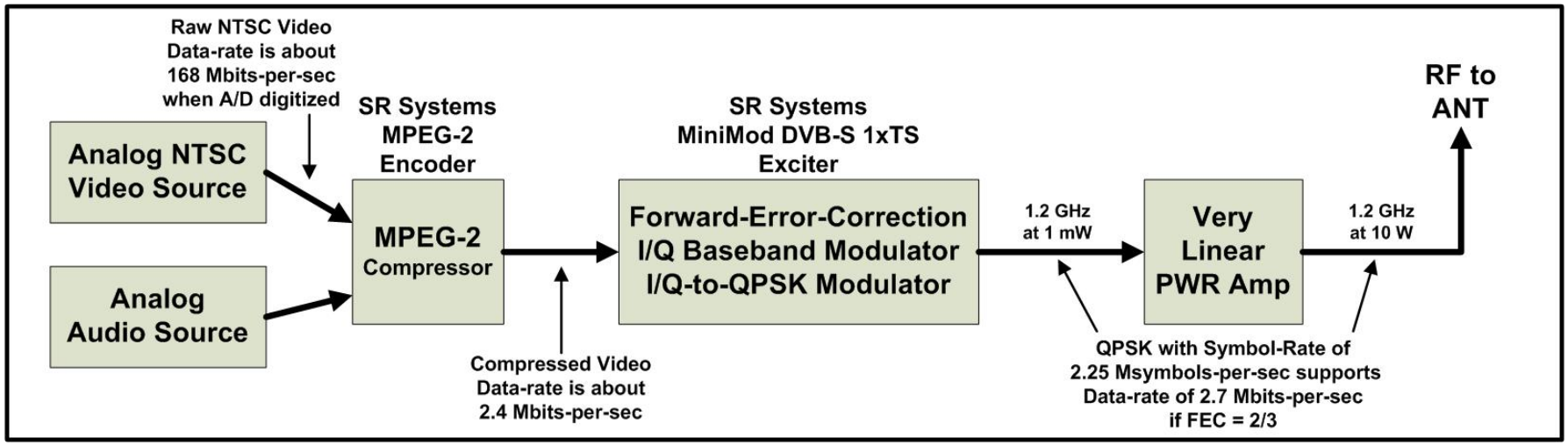
For DVB-S QPSK Modulation:

- Video-stream data-bit-rate
- Symbol-rates
- Forward-Error-Correction “inflation” of data rate

All impact RF Bandwidth

# Planning a DVB-S DATV Station

## Video Data-Rate and Compression




**DATV Block Diagram Showing Various Data-Rates and Symbol-Rates for DVB-S QPSK Modulation (for 2.25 Msymbols-per-sec, the Bandwidth is 3 MHz)**

# Planning a DVB-S DATV Station

## Video Data-Rate and Compression – cont'd

| Video Data Stream | Data-Rate | Notes |
|---|---|---|
| Analog NTSC camera | 168 Mbits/sec | A/D digitized, uncompressed |
| NTSC MPEG-2 | 2-3 Mbits/sec | compressed |
| VHS MPEG-2 | 1-2 Mbits/sec | compressed |
| | | |
| Analog PAL camera | 216 Mbits/sec | A/D digitized, uncompressed |
| PAL MPEG-2 | 2.5-6 Mbits/sec | compressed |
| | | |
| HDTV camera | 1-1.5 Gbits/sec | uncompressed |
| HDTV MPEG-2 | 12-20 Mbits/sec | compressed |

**Camera Video Data Streams and MPEG-2 Data Streams**

# Planning a DVB-S DATV Station

## Symbol Bit-Packing for Various Digital Modulation Technologies

| Modulation Scheme | Data Bits per Symbol (Me) |
|---|---|
| BPSK | 1 |
| QPSK | 2 |
| 8-VSB | 3 |
| QAM16 | 4 |
| QAM256 | 8 |

# Planning a DVB-S DATV Station

## Symbol-rate required for Net Data Bit-Rate

**Symbol-Rate Needed =** $\dfrac{\text{NDBR}}{\text{Me} \times \text{CRv} \times \text{CRrs}}$

Where:

**NDBR** = Net Data Bit Rate (aka the information rate)
Same as MPEG-2 output data rate listed in Table 2

**Me** = Modulation Efficiency (value is 2 for QPSK listed in Table 3)

**CRv** = Correction Rate setting for Viterbi algorithm (1/2, 3/4, etc)

**CRrs** = Correction Rate value for Reed-Solomon algorithm is 188/204

# Planning a DVB-S DATV Station

## Symbol-Rates and RF Bandwidth

For QPSK, where output of MPEG-2 is 2 Mbits/sec and $FEC_{viterbi}$ is 1/2:

$$\text{Symbol-Rate Needed} = \frac{2.0\ \text{Mbit/sec}}{2\ \text{bit/symbol} \times (1/2) \times (188/204)}$$

Symbol-Rate Needed = 2.17 Msymbols/sec

RF Bandwidth = 1.33 x Symbol-Rate

RF Bandwidth = 1.33 x 2.17 Msymbols/sec = 2.9 MHz

# Planning a DVB-S DATV Station

## Net data bit-rate supported by DVB-S at:

- a specific FEC setting
- a specific Symbol-Rate
- resulting RF Bandwidth

| Modulation | FEC Coderate | DVB-S RF BANDWIDTH for DATV (RF BW = SymbolRate x 1.33) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2.0 MHz (SR = 1.5 MS/sec) | 2.5 MHz (SR = 1.88 MS/sec) | 3.0 MHz (SR = 2.25 MS/sec) | 4.0 MHz (SR = 3.0 MS/sec) | 5.0 MHz (SR = 3.75 MS/sec) | 6.0 MHz (SR = 4.50 MS/sec) |
| QPSK | 1/2 | ~~1.38~~ | ~~1.73~~ | ~~2.07~~ | 2.76 | 3.46 | 4.15 |
| | 2/3 | ~~1.84~~ | ~~2.30~~ | 2.76 | 3.69 | 4.61 | 5.53 |
| | 3/4 | ~~2.07~~ | 2.59 | 3.11 | 4.15 | 5.18 | 6.22 |
| | 5/6 | ~~2.30~~ | 2.88 | 3.46 | 4.61 | 5.76 | 6.91 |
| | 7/8 | 2.42 | 3.02 | 3.63 | 4.84 | 6.05 | 7.26 |

(NOTE-1: NTSC Analog Camera produces about 2.4 to 2.5 Mbits-per-sec of MPEG-2 output for Ham Radio type broadcasts)

(NOTE-2: The Net Data Bit-Rate values inside the Table need to be at 2.4 Mbps or larger to support the expected camera data rate coming from MPEG-2 encoder)

(NOTE-3: The Net Data Bit-Rate values inside the Table shown in RED (with strikethrough) are Net Data Bit-Rates that will not support the video data stream.)

# Planning a DVB-S DATV Station

## Conclusion and Plans

- This paper has tried to explain many DATV concepts to provide an understanding to hams about what is involved.

- Our hope is to make transition from analog-ATV to Digital-ATV a little more straightforward.

- Our plans are to first order a first set of DVB-S boards from SR-Systems
  - Do some testing at home and some measurements.
  - Do some field tests for picture quality sent to EOC (Emergency Operation Center)

- Spread info about DATV – persuade more people to try DATV

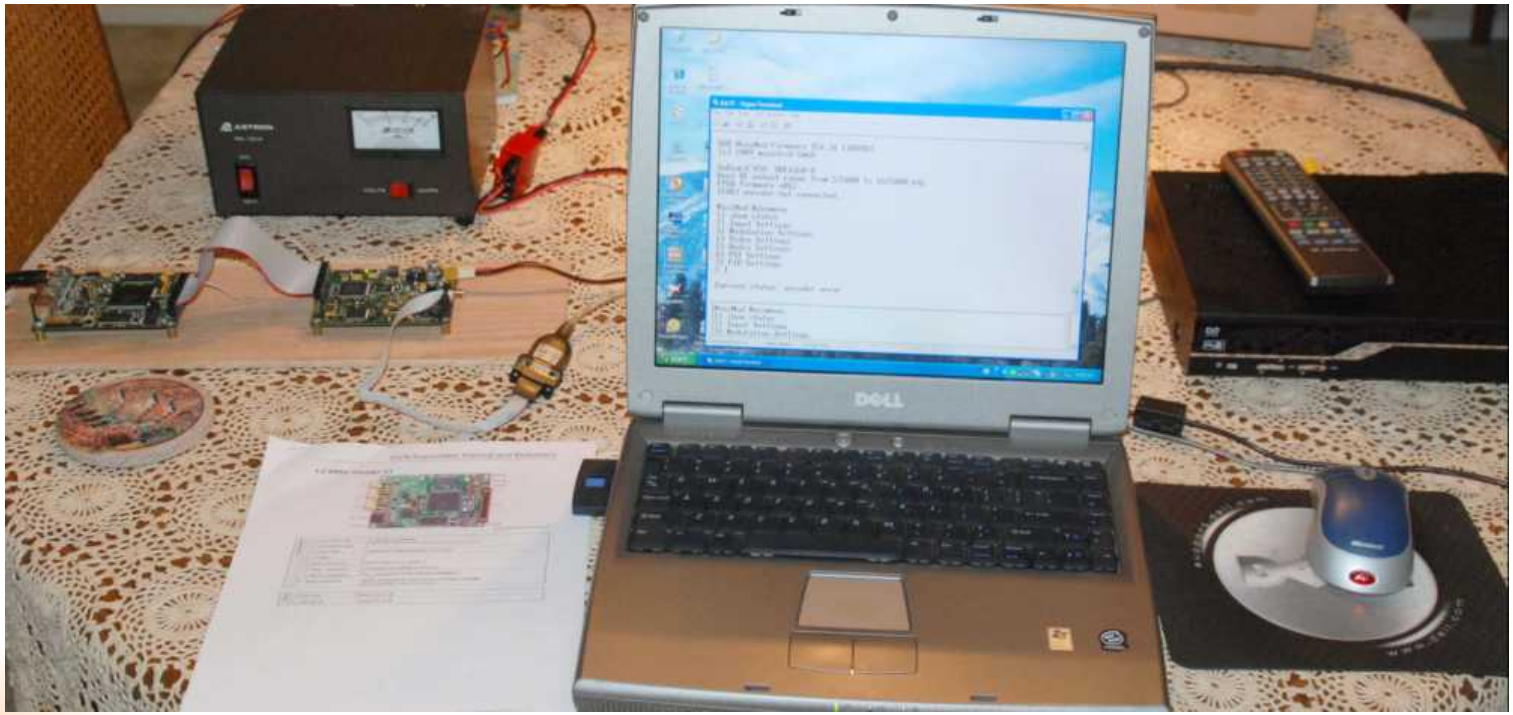
# Planning a DVB-S DATV Station

## Useful Links:

- Advanced Television Systems Committee (ATSC)
  www.ATSC.org
- Digital Video Broadcasting organization (DVB)
  www.DVB.org
- Amateur Television of Central Ohio
  www.ATCO.TV
- British ATV Club - Digital Forum
  www.BATC.org.UK/forum/
- Nick Sayer-N6QQQ blog on “putting together an ATSC DATV station” http://nsayer.blogspot.com/search/label/ham
- OCARC newsletter DATV Introduction article on “ATV – the Digital Fork in the Road” www.W6ZE.org/DATV/TechTalk74-DATV.pdf
- OCARC newsletter DATV article “Planning a Digital-ATV Station” www.W6ZE.org/DATV/TechTalk75-DATV.pdf
- OCARC newsletter DATV article “Understanding Symbol-rates, FEC, and RF Bandwidth for DVB-S” www.W6ZE.org/DATV/TechTalk76-DATV.pdf
- PE1JOK and PE1OBW on “The Ultimate Resource for Digital Amateur Television” www.D-ATV.com
- AGAF D-ATV components (Boards) www.datv-agaf.de and www.AGAF.de
- SR-Systems D-ATV components (Boards) www.SR-systems.de

# Planning a DVB-S DATV Station

**Initial Testing:** 1 mWatt DATV Station Test Set-up



# Planning a DVB-S DATV Station

**Initial Testing:** 1st Test Picture Showing Ken-W6HHC

# Planning a DVB-S DATV Station

**Initial Testing:** Robbie-KB6CJZ Inspecting Signal Quality