

**DTV ATSC 8-VSB
Standard Review**



April 20, 2001

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Sarnoff Corporation*

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Outline

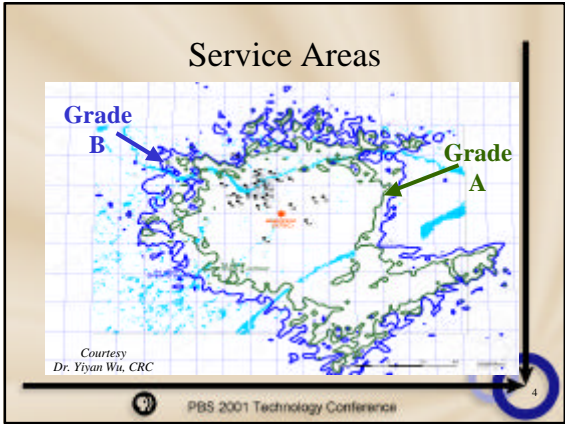
- Original Requirements
- What the RF channel can support
- ATSC Channel Coding
- 8-VSB Scorecard
- New Requirements
- The future

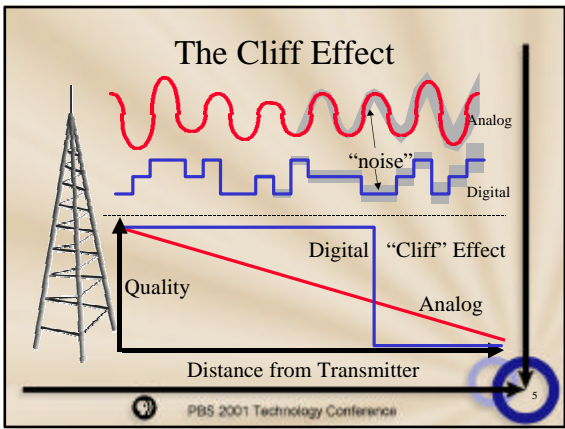
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Original Requirements

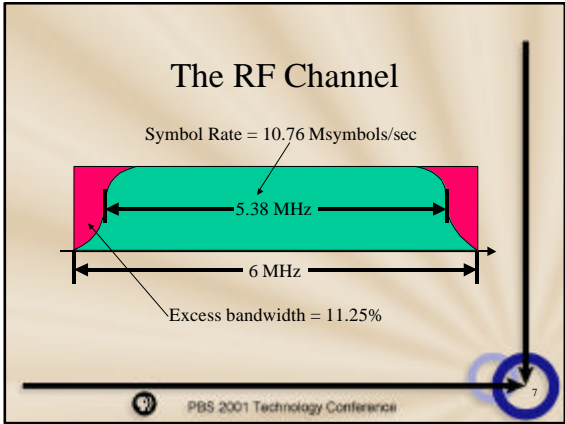
- Must replicate NTSC Grade B service area
- Must support HDTV programming
- Must work in the presence of
 - thermal (white) and impulse noise
 - co-channel and adjacent channel interference
- Reception must be highly reliable for fixed receivers using suitable antennas

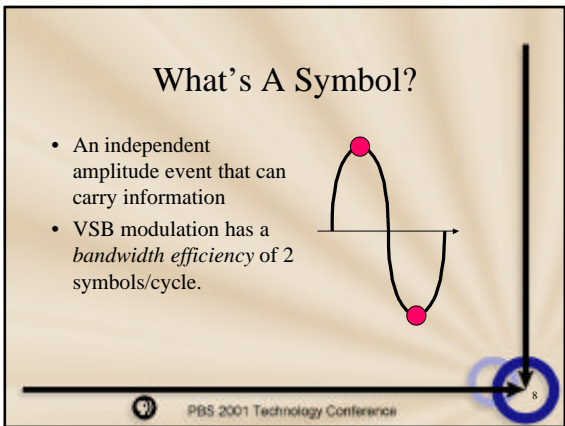
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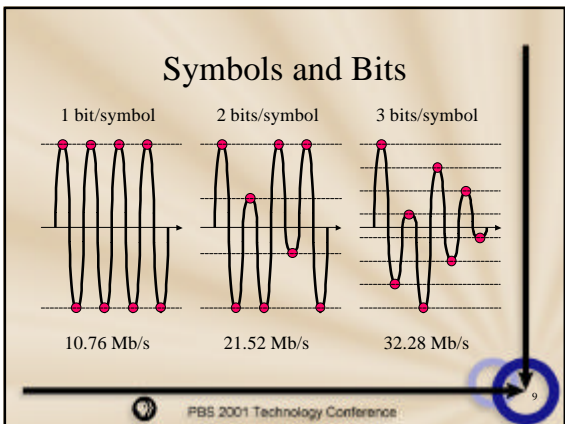


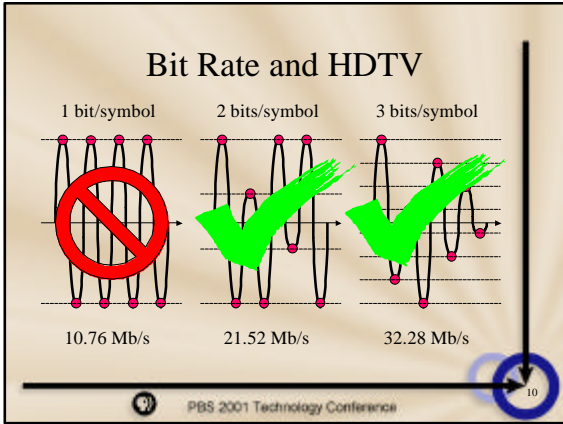


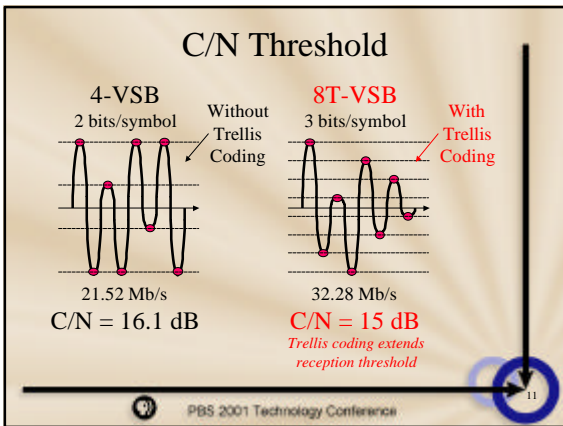


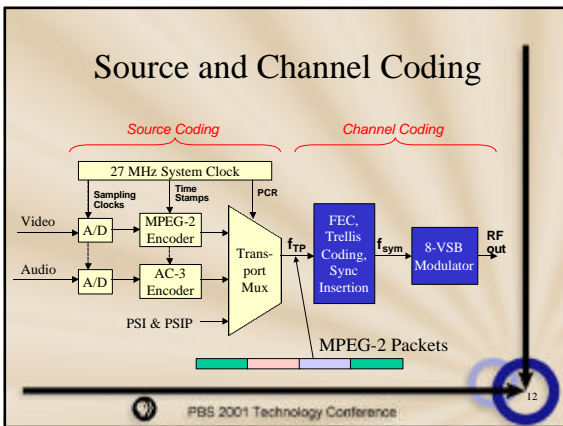












Related Rates

684 ATSC Symbols

One NTSC Line

- Eases the ability to reject NTSC interference

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ATSC Channel Coding

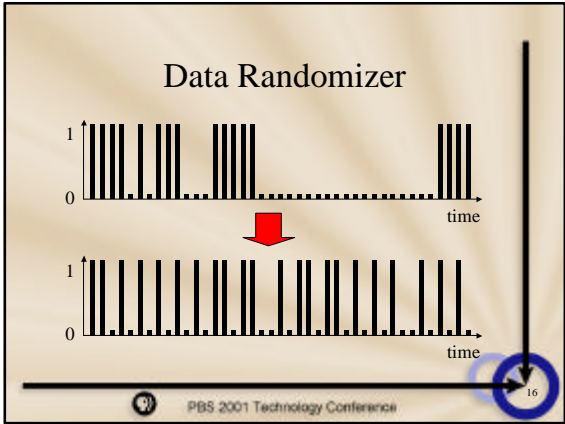
- Two Vestigial Sideband (VSB) Modulation Modes
 - 8-VSB (Terrestrial)
 - 16-VSB (Cable - not used in practice)
- 8-VSB is focus of this talk

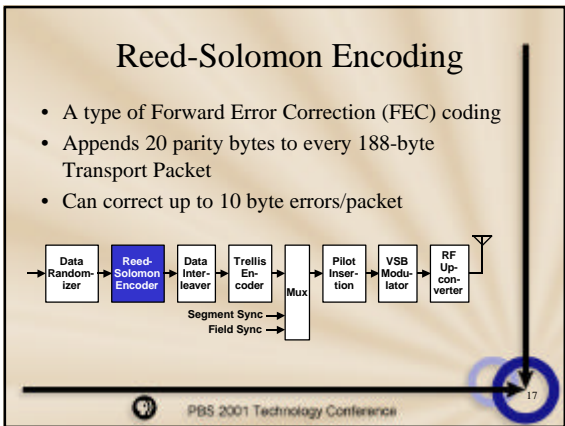
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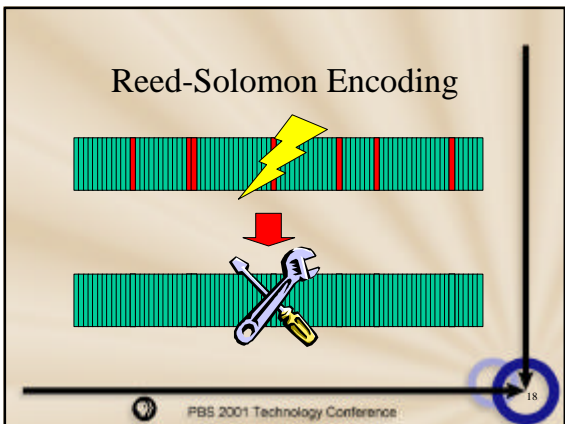
Data Randomizer

- Randomizes data payload within a Transport Packet
- Flattens RF spectrum, even when no signal is present

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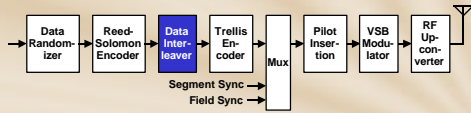






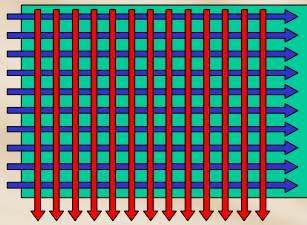
Data Interleaver

- Shuffles bytes among 52 data segments (data segment = transport packet + FEC)
- Spreads burst errors out over time
- Increases efficiency of FEC



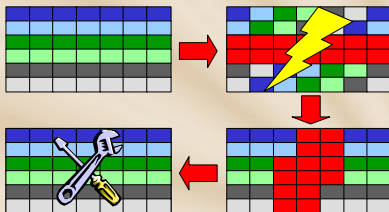
Data Interleaver

Read in by rows.



Write out by columns.

Data Interleaver



Trellis Encoder

- Another layer of error correction coding
- Extends reception threshold
- Adds an extra bit to each pair of bits (2/3 rate)
- Every 3 bits mapped to 8 distinct levels at output

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Trellis Encoder

Each pair of input bits mapped into one of eight levels

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Trellis Encoder

Forces dependency between symbols

Trellis decoder checks each symbol against past history to determine which values are allowed

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Data & Sync Mux

- Syncs are 2-level patterns that can be recovered at SNR's as low as 0 dB.
- 4-symbol Segment Sync replaces Transport Sync byte
- Field Sync contains training signals

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Segment Sync

828 Symbols (207 Bytes)
Data Segment
832 Symbols (208 Bytes)

3 bits/symbol

Data + FEC

Data Segment Sync

Data Segment Sync

4 Symbols

110
101
100
011

+7
+5
+3
+1
-1
-3
-5
-7

+7
+5
+3
+1
-1
-3
-5
-7

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Field Sync

832 Symbols

PN511 PN63 PN63 (+/-) PN63 2/4/8/16 Level ID Reserved

4 Symbols 511 Symbols 63 Symbols 63 Symbols 63 Symbols 24 Symbols 104 Symbols

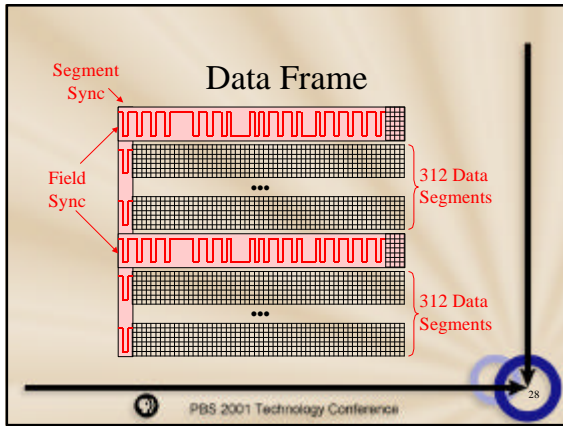
← 92 → 12

+7
+5
+3
+1
-1
-3
-5
-7

+7
+5
+3
+1
-1
-3
-5
-7

Can be used by receivers to adaptively equalize channel

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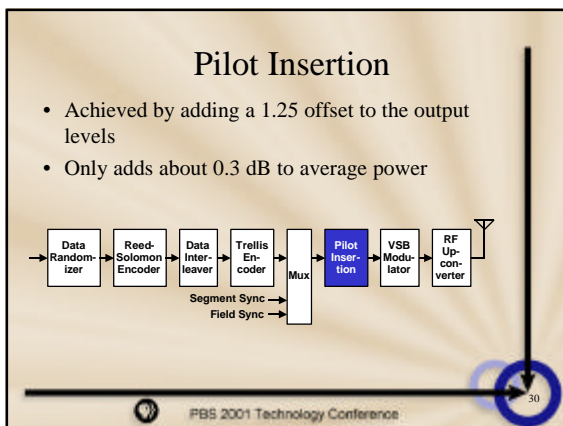


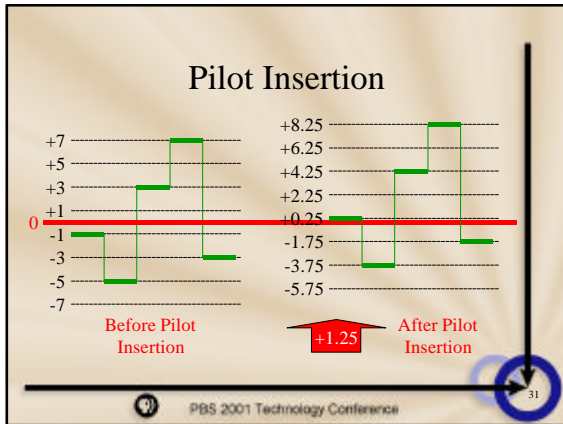
The Transport Rate

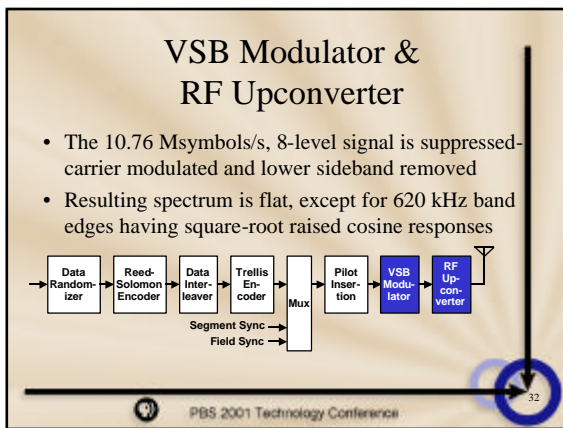
$$f_{transport} = 2 \cdot \left(\frac{188}{208}\right) \cdot \left(\frac{312}{313}\right) \cdot f_{symbol}$$

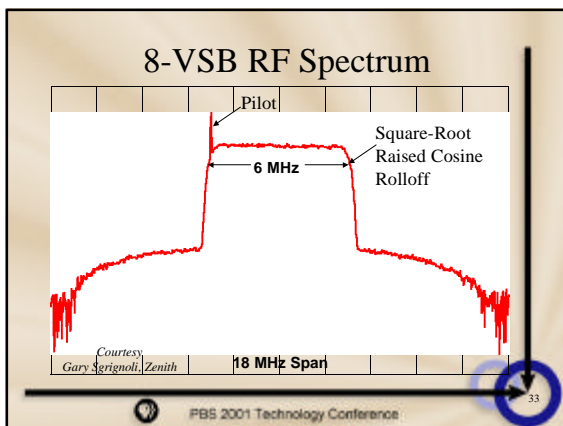
19.39 Mbits/sec 10.76 Msymbols/sec

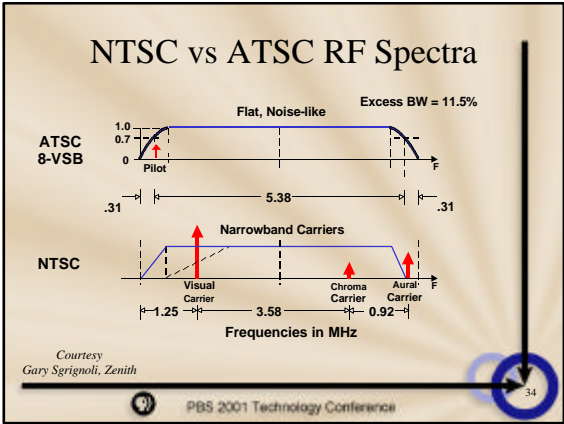
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- ### Transmitter Requirements
- High SNR
 - High Linearity
 - High Frequency Stability
 - Low Phase Noise
 - FCC Mask Compliance
 - Some manufacturers pre-correct for linear and nonlinear distortions
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- ### 8-VSB Analyzers
- ...a sampling based on Web search...*
- Agilent Technologies
 - Harris
 - Leader Instruments
 - Tektronix
 - Triveni Digital
 - Rohde & Schwarz
 - Videotek
-
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Reception Issues

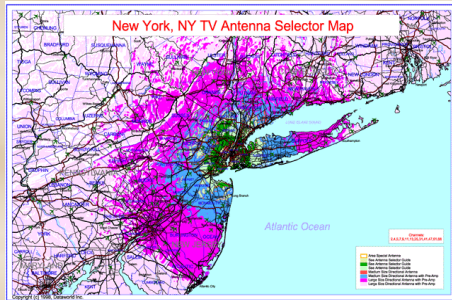
- Antenna gain and location
 - Directional antennas a must in certain areas
 - Indoor reception introduces 10-25 dB loss
- Noise figure
 - FCC planning uses 10 dB
- Adjacent and co-channel rejection
- Multipath requires adaptive equalization



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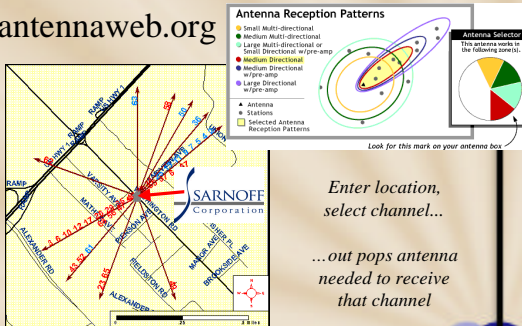
Antenna Maps



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antennaweb.org



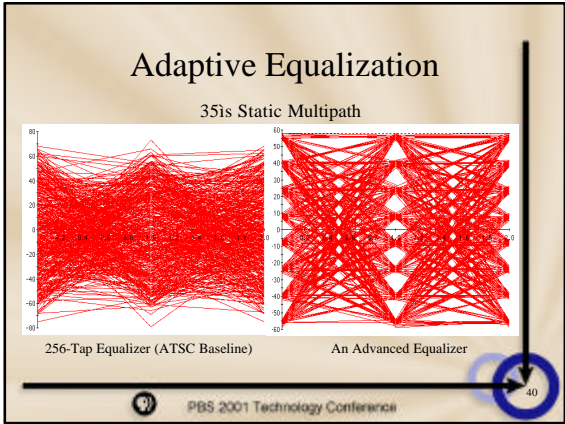
Enter location,
select channel...

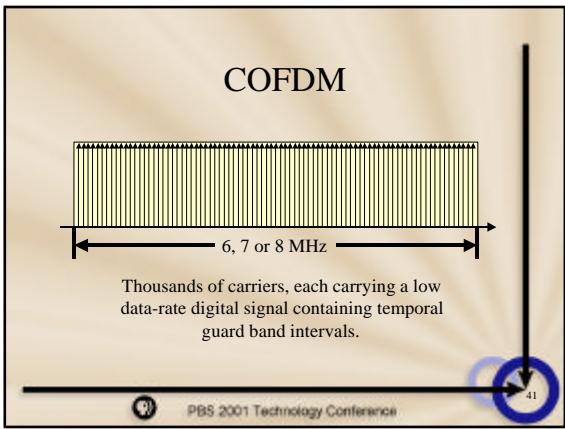
... out pops antenna
needed to receive
that channel



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8-VSB vs COFDM

Parameters	8-VSB	COFDM
Peak-to-Average ratio	+	
C/N	+	
Multipath distortion	+	
-Weak		+
-Strong		++
-Dynamic		
Spectrum Efficiency	MFN	SFN

Courtesy
Dr. Yiyun Wu, CRC

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8-VSB vs COFDM

Parameters	8-VSB	COFDM
HDTV	+	~+
Mobile	-	++
Phase Noise	+	
IntCo-Ch interference		
-DTV into NTSC	+	
-NTSC into DTV	~=	~=
-DTV into DTV	+	

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8-VSB: Ain't Broke

...but could be better...

- NAB/MSTV reaffirmed support for 8-VSB based on field tests
- FCC also reconfirmed 8-VSB for ATSC transmission
- ...but poor indoor reception and inability to meet new service requirements are forcing a second look



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Some New Requirements

- Portable Reception
- Pedestrian Reception
- Mobile Reception
- Multi-Mode Operation
- On-Channel Repeaters



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DTV Tradeoffs

Some new applications may require changes to 8-VSB modulation

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The Future

- Receiver technology will continue to improve, but some new services may require transmission enhancements
- ATSC has issued an RFP for potential revisions
 - Preference given to *compatible* 8-VSB enhancements

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T3/S9 Work Plan

- T3/S9 = ATSC Specialist Group on RF Transmission
- Milestones

– Responses to RFP due	April 2, 2001
– Selection of technology	September 14, 2001
– Field tests begin	November 14, 2001
– Review of field tests	January 15, 2002
– New standard or revision	January 31, 2002

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Conclusions

- 8-VSB has largely met original performance goals
- NAB/MSTV and FCC have all reaffirmed this
- New requirements may force a revision to the standard
- Work is in progress...stay tuned!

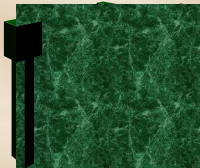


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Acknowledgements

- Gary Sgrignoli (Zenith)
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