

Quality Control and Measurement in HD



EBU / IRT HDTV Briefing

Geneva, 22. November 2005

Tektronix

Werner Kluetsch and Winfried Schultz

Tektronix Today

- ▶ One of the largest test, measurement and monitoring companies
- ▶ Strong brand
- ▶ Customer relationships
- ▶ Innovative technology
- ▶ Global operations
- ▶ Financial discipline
- ▶ Focused on long term growth



Tektronix Focus



Communications Test & Monitoring

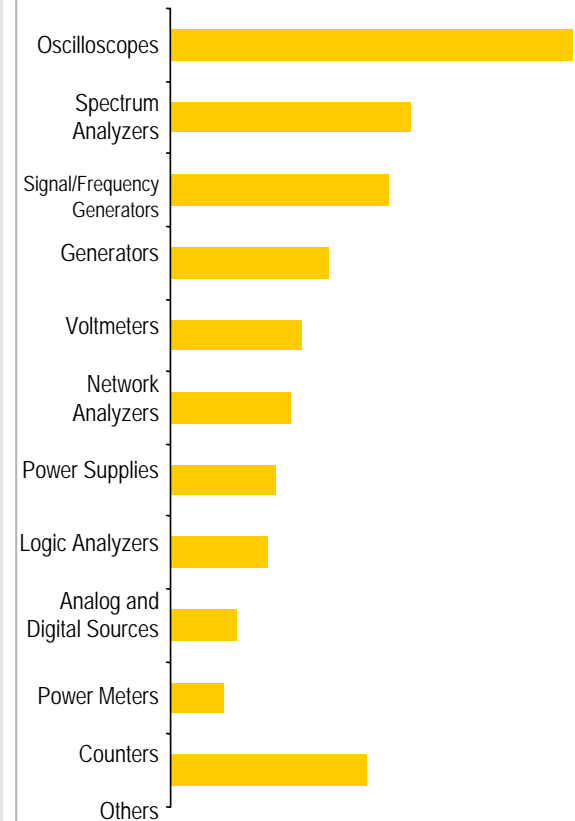
- ▶ Communications equipment manufacturers and operators
- ▶ Products and systems designed for specific applications
- ▶ Tektronix makes protocol, wireless and network management products and systems



General Purpose Test Equipment

- ▶ Products used for all electrical and electronic markets and applications
- ▶ Generally price and/or performance driven
- ▶ Tektronix oscilloscopes, logic analyzers, signal sources, RTSAs

General Purpose T&M Calendar Year 2004 \$3.8 Billion

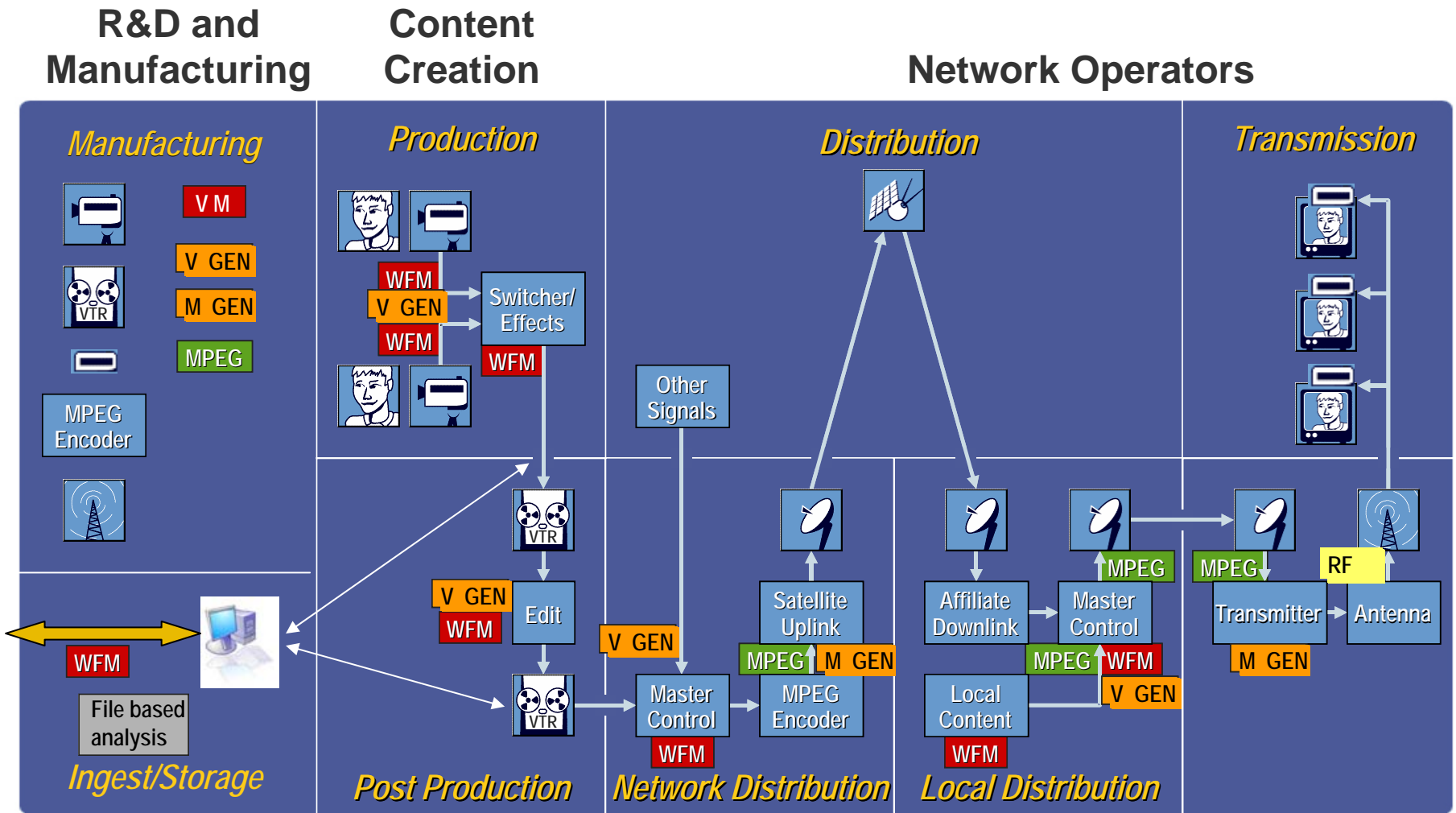


Source: Prime Data and company research

HD Video Test: Challenges for quality control and measurement

- ▶ Digital Video: a changing environment
- ▶ Picture and Sound: Multichannel and multiformat audio
- ▶ Test, measurement and quality control in digital facilities:
 - Physical Layer: SDI, IP, RF
 - Protocol Layer: MPEG-2 TS, new encoding schemes, new formats
- ▶ Impact of IT based infrastructure on T&M
- ▶ Signal flow and work flow: T&M must complement changes
 - Acquisition
 - (Post) Production
 - Ingest and storage
 - Distribution
 - Service and maintenance
 - A networked environment
- ▶ Managing skill levels, changing investment cycles

Signal Path typical test points



Test to HDTV Standards

- ▶ SMPTE 240M 1125 Line High Definition System
 - 1920x1035 @ 60i & 59.94i Colourimetry CIE (1931)
- ▶ ITU-R.BT 1120-5 Digital Interfaces for HDTV studio signals
 - Supports 1125 and 1250 formats
- ▶ ITU-R.BT 1543 1280 × 720, 16×9 progressively-captured image format for production and international programme exchange in the 60 Hz environment
- ▶ SMPTE 274M 1920x1080 Scanning and Analogue and Parallel Digital Interfaces for Multiple Picture Rates
 - 1125 - 1920x1080 @ 60p, 59.94p, 50p, 60i, 59.94i, 50i, 30p, 29.97p, 25p, 24p, 23.98p, 30sF, 29.97sF, 25sF, 24sF, 23.98sF Colourimetry ITU-R BT.709
- ▶ SMPTE 296M 1280x720 Progressive Image Sample Structure - Analogue and Digital
 - 750 - 1280x720 @ 60p, 59.94p, 50p, 30p, 29.97p, 25p, 24p 23.98p Colourimetry ITU-R BT.709
- ▶ SMPTE 292M Bit Serial Digital Interface for High Definition Television Systems

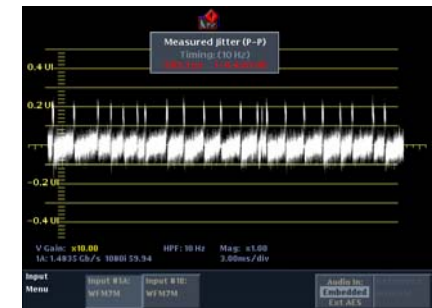
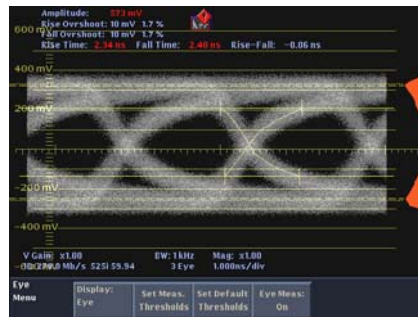
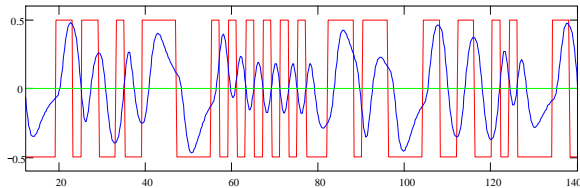
Ensuring the Health of a HD system

- ▶ Starts during installation ensure correct type of cable used
- ▶ Ensure system has correct termination between links
- ▶ Verified each link with drum of cable and pathological test signal
- ▶ Use re-clocking D/A in long signal paths.

- ▶ Use Eye and Jitter modes to determine problems
- ▶ Monitor using CRC/EDH checks

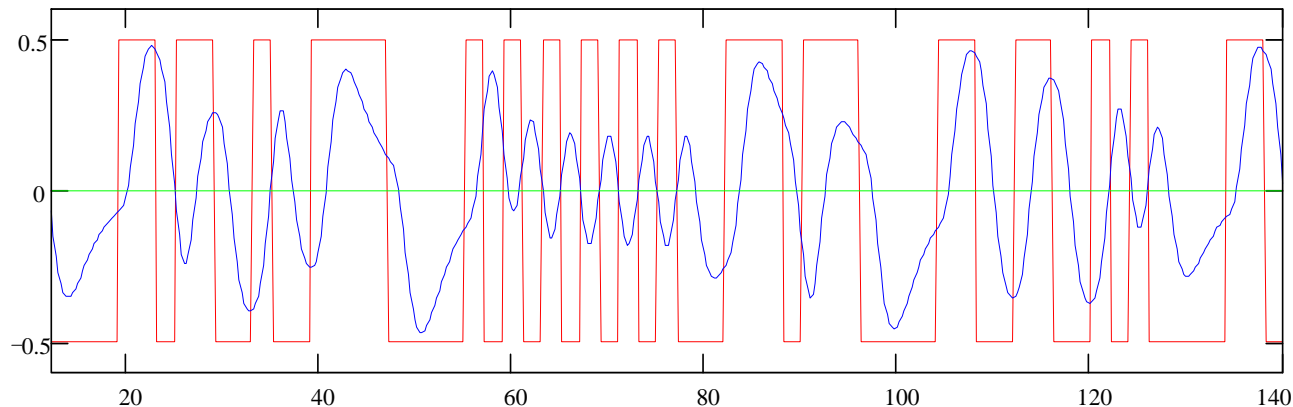
Facility surveys: will HD work and how far?

- ▶ Physical layer analysis
 - Attenuation and jitter accumulation = limits of regeneration
 - Standards recommend sinewave based assessment – reality?
- ▶ Repeatability and reliability of testing
- ▶ Pathological test signals
- ▶ Timing distribution

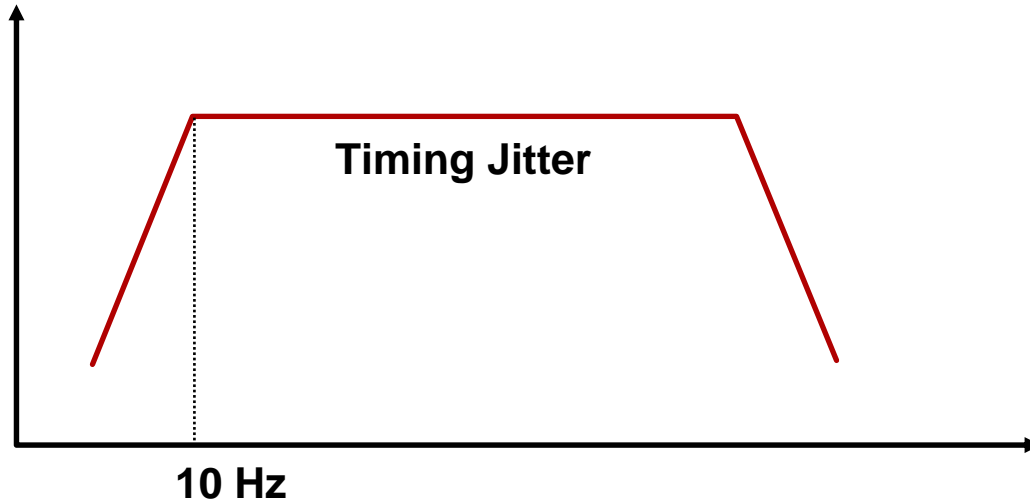


Physical Layer: Sources of Jitter

- ▶ Clock variation
- ▶ Noise
 - Intrinsic in the generator/sender device
 - Environmentally produced
 - ▶ Random
 - ▶ Deterministic
- ▶ Group delay performance of cabling and connectors
 - 1.485 GHz/s
 - 3 GHz/s ?



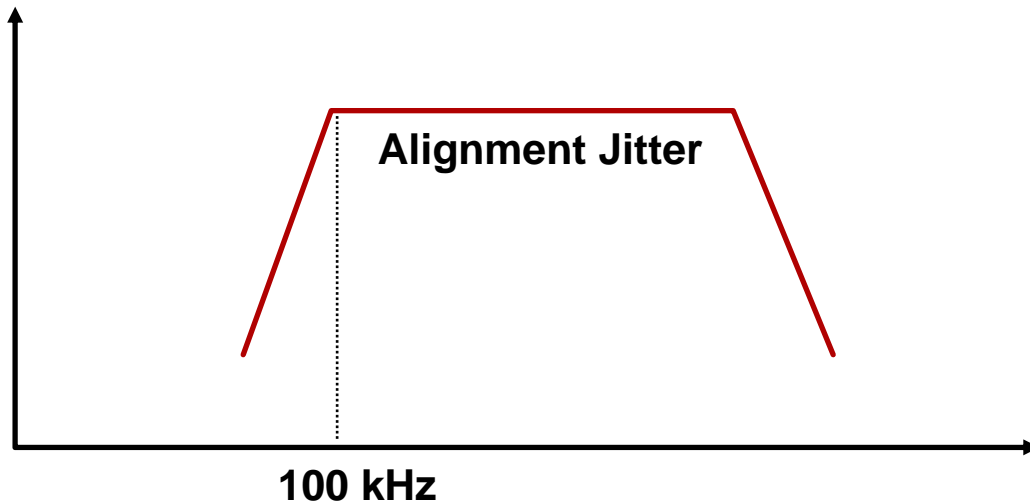
Jitter Measurement Bands HD



Timing Jitter : (Threshold: 1.0UI)

The variation in time of the significant instants of a digital signal relative to a clock with no jitter above some low frequency (about 10Hz)

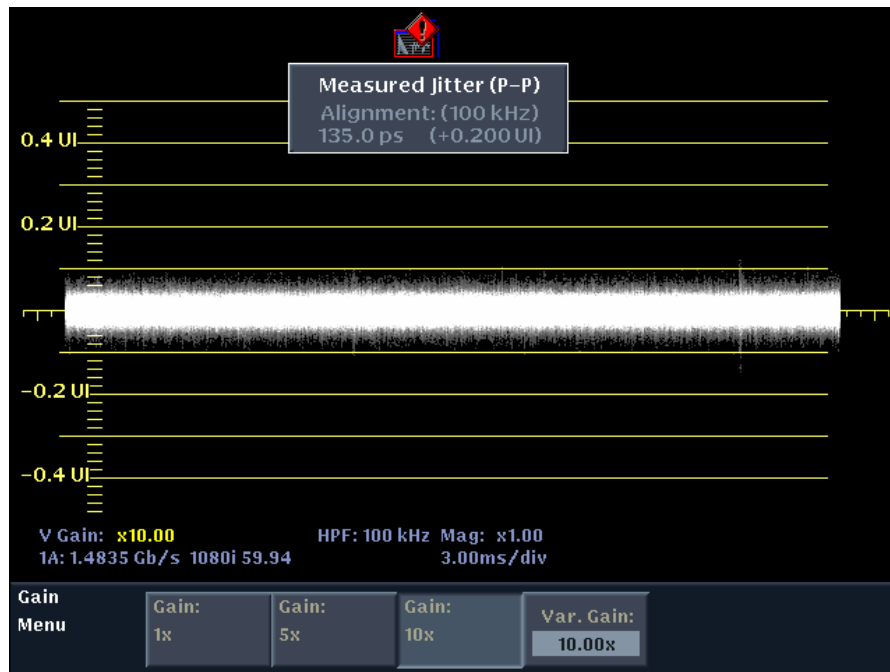
Jitter Measurement Bands HD



Alignment Jitter : (Threshold: 0.2UI)

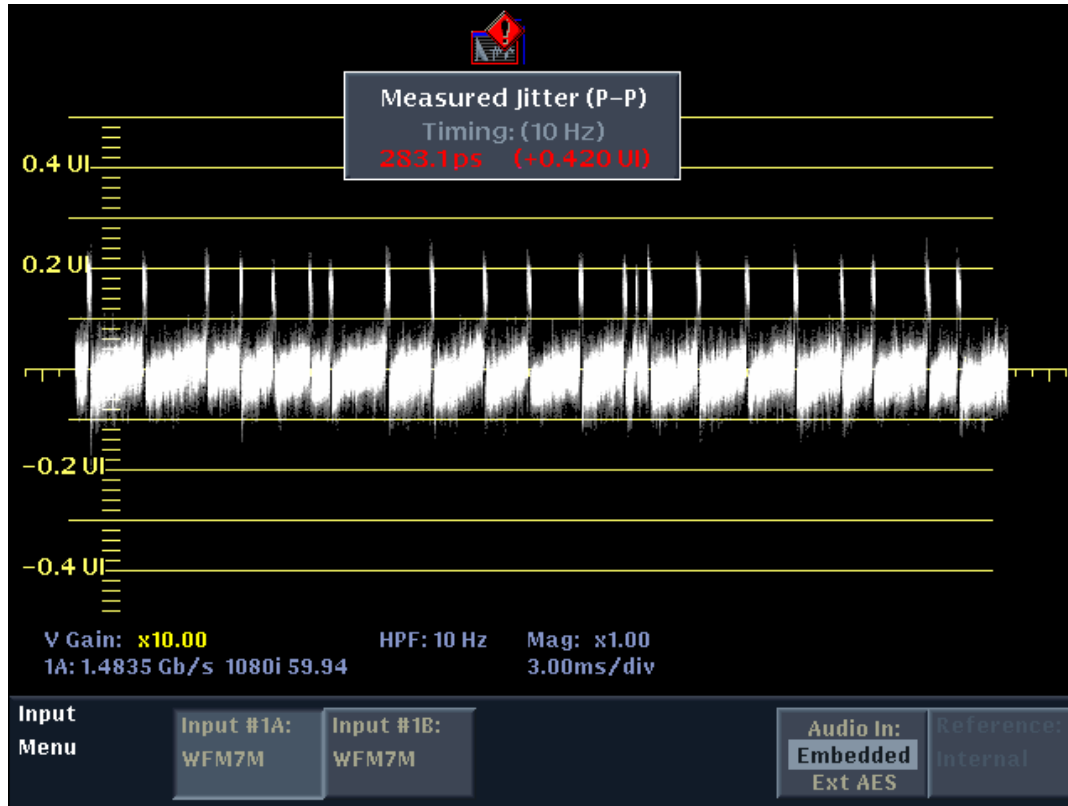
The variation in time of the significant instants of a digital signal relative to a clock recovered from the signal itself

Jitter Display and Measurement



- ▶ Eye based measurements (?)
- ▶ Demodulation methods
 - Analog PLL
 - A/D conversion and digital PLL filtering
- ▶ Line jitter and field jitter
- ▶ Launch amplitude of device should be less than 0.2UI

Jitter Display and Measurement



- ▶ Direct readout of either timing or alignment jitter
- ▶ Custom limits allow warning values to be shown in red
- ▶ Jitter display shows interfering pulse present within signal
- ▶ Demodulated jitter output for further analysis using oscilloscope

Pathological Signals - Stress Testing

SDI Checkfield

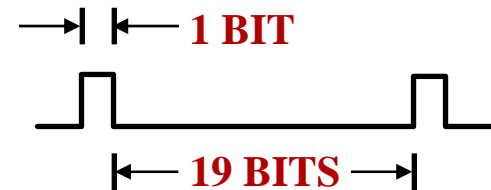
- ▶ Condition occurs once per field for a complete line

VERTICAL BLANKING INTERVAL

FIRST HALF OF ACTIVE FIELD

$300_h, 198_h$

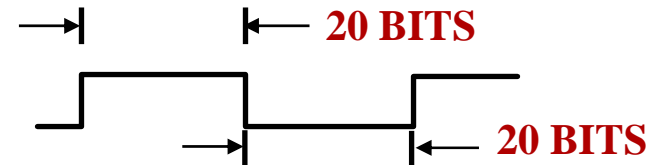
FOR CABLE EQUALIZER TESTING



SECOND HALF OF ACTIVE FIELD

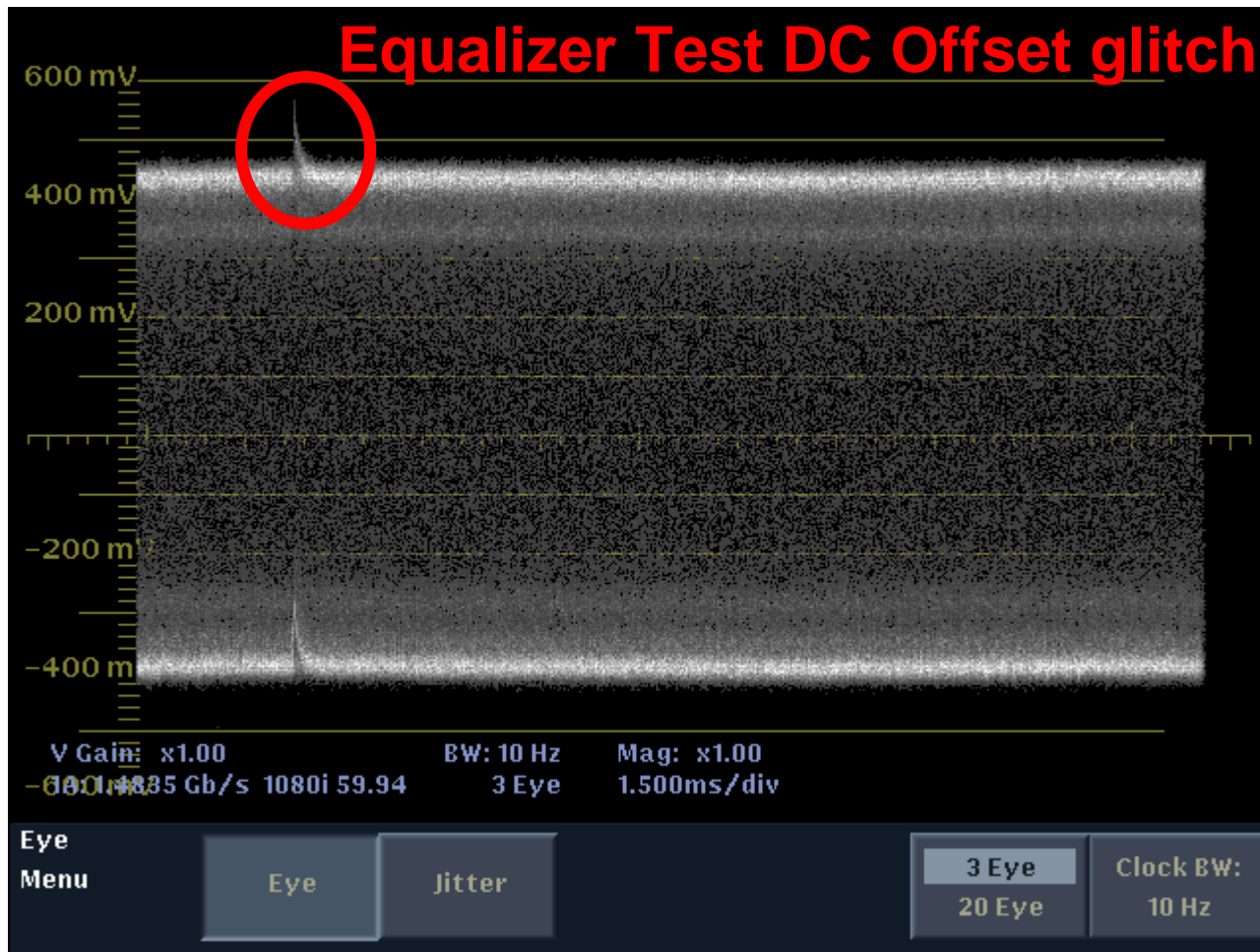
$200_h, 110_h$

FOR PHASE LOCKED LOOP TESTING



← **HORIZONTAL ACTIVE LINE ONLY** →

EYE Display



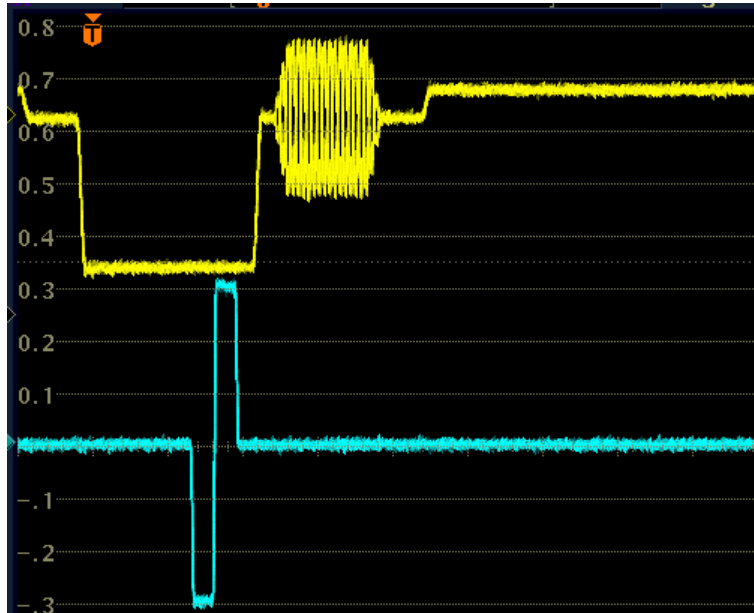
Cable Length Distances for HD & SD

Maximum Transmission Distance at Serial Digital Data Rates

Data Rate:		143 Mb/s		177 Mb/s		270 Mb/s		360 Mb/s		540 Mb/s		1.5 Gb/s	
Spec:		SMPTE 259M		ITU-R BT. 601		SMPTE 259M		SMPTE 259M		SMPTE 344M*		SMPTE 252M	
Application:		Composite NTSC		Composite PAL		Component Video		Component Widescreen		Component Widescreen		HDTV	
Part No.	Ft.	m	Ft.	m	Ft.	m	Ft.	m	Ft.	m	Ft.	m	
1865A	810	247	760	232	600	183	520	158	420	128	170	52	
8279	910	277	810	247	640	195	550	168	440	134	170	52	
1855A-7787A	1000	305	910	277	750	229	650	198	530	162	210	64	
9209	1030	314	930	283	750	229	650	198	540	165	200	61	
9209A	1030	314	930	283	750	229	650	198	540	165	200	61	
1505A-7794A	1430	436	1320	402	1110	338	960	293	790	241	300	91	
1505F	1200	366	1071	326	857	261	732	223	588	179	225	69	
1506A	1360	415	1200	366	940	286	810	247	670	204	270	82	
9231	1430	436	1270	387	1000	305	850	259	680	207	260	79	
9141	1430	436	1270	387	1000	305	850	259	680	207	260	79	
8281	1430	436	1270	387	1000	305	860	262	700	213	260	79	
8281B	1430	436	1270	387	1000	305	850	259	680	207	250	76	
8281F	1250	381	1100	335	860	262	730	222	590	180	240	73	
88281	1300	396	1150	351	910	277	770	235	600	183	200	61	
1694A-7710A	1760	536	1620	494	1360	415	1180	360	970	296	370	113	
1695A	1670	509	1520	463	1250	381	1080	329	880	268	310	94	
7855A	2220	677	2000	610	1670	509	1460	445	1210	369	470	143	
7731A	2730	832	2460	750	2000	610	1740	530	1430	436	540	165	
7732A	2420	738	2140	652	1690	515	1440	439	1150	351	430	131	

www.belden.com

SD versus HD

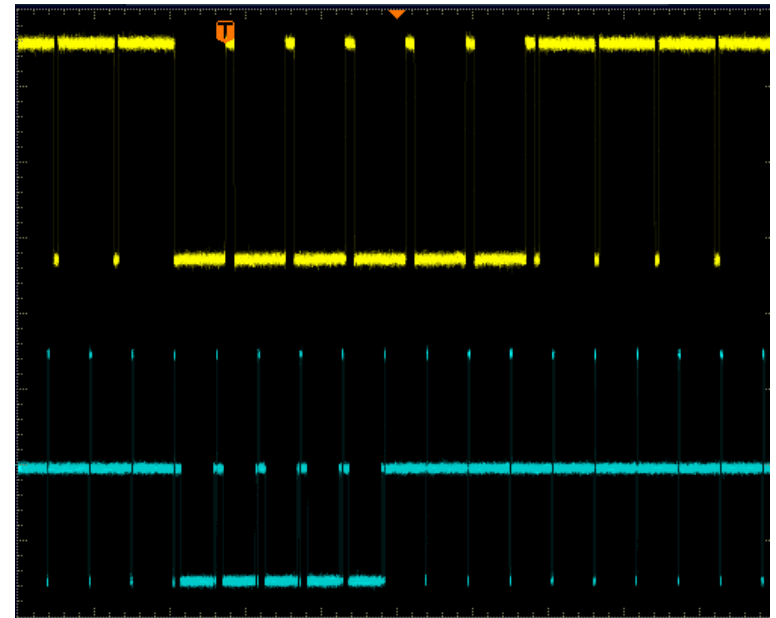


SD Line

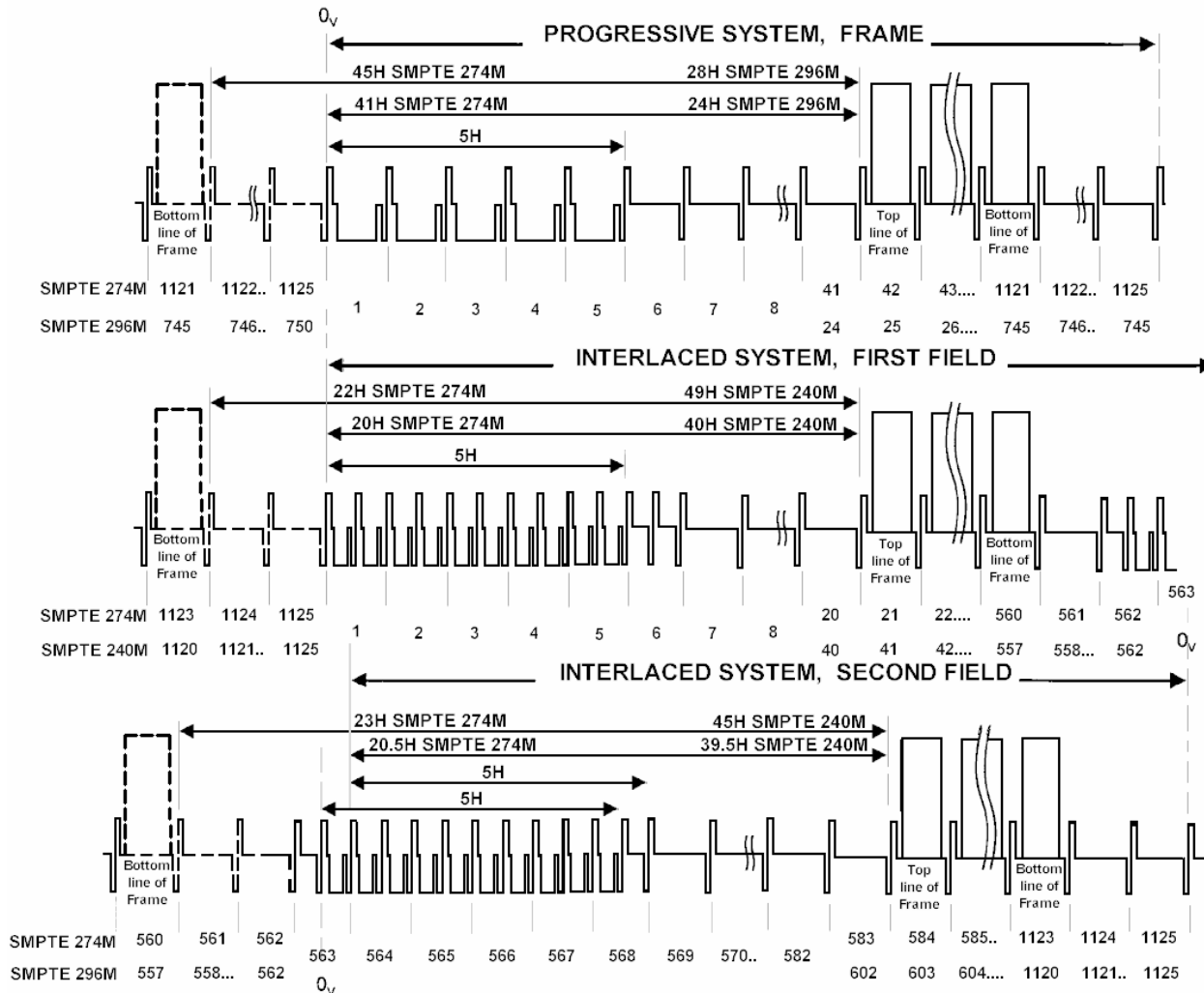
HD Line

SD Field

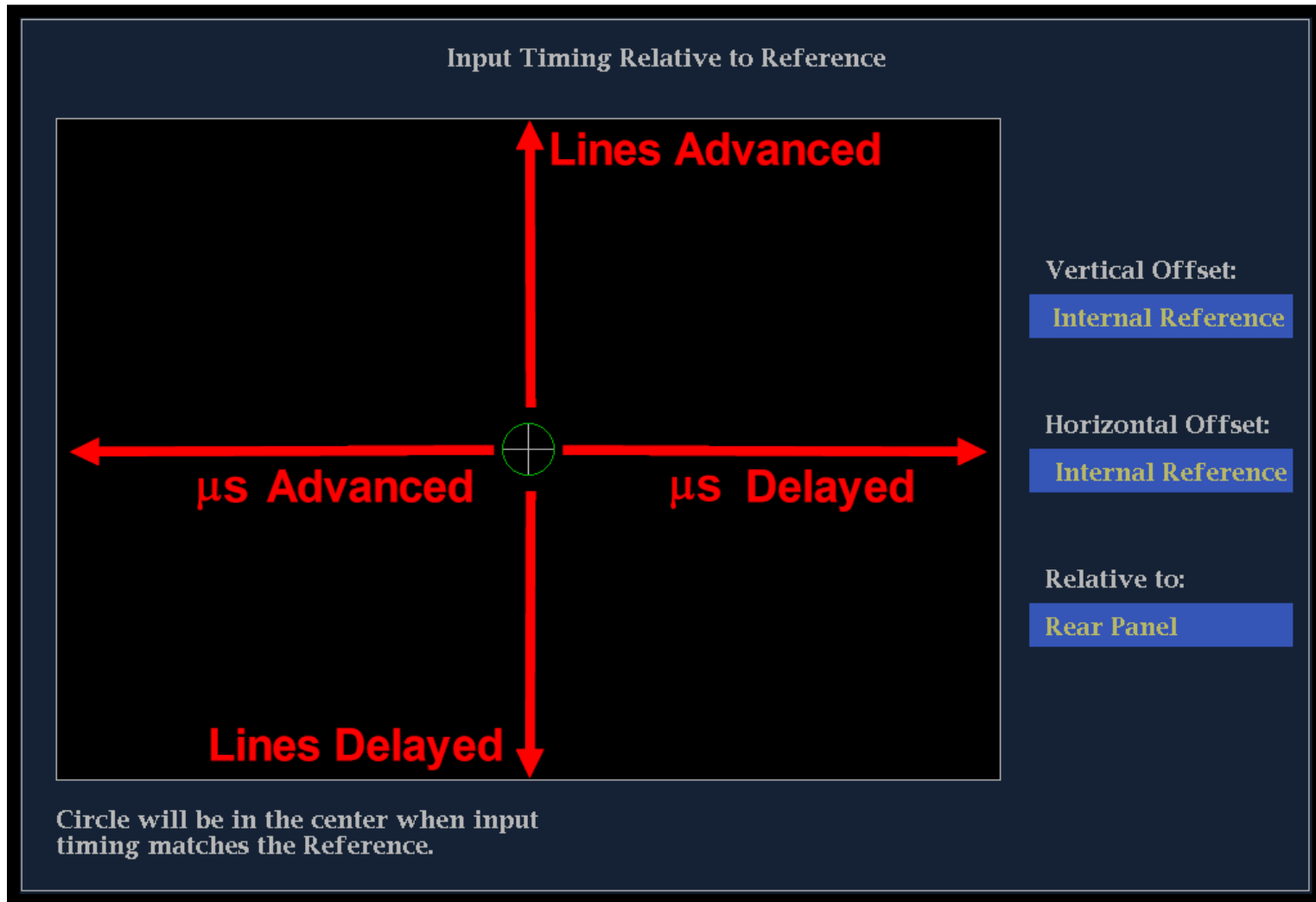
HD Field



HD Vertical Timing



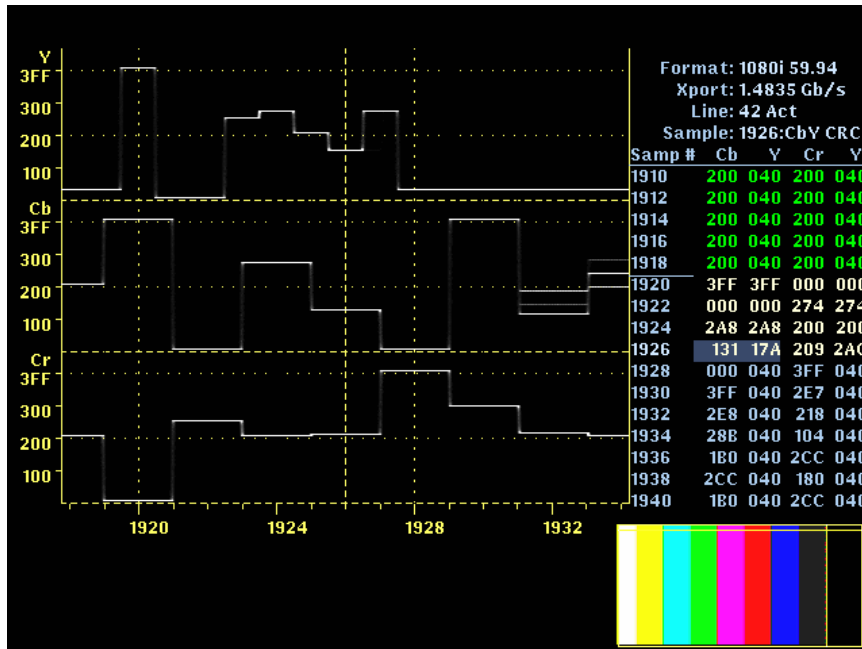
Tektronix patented *Timing* display



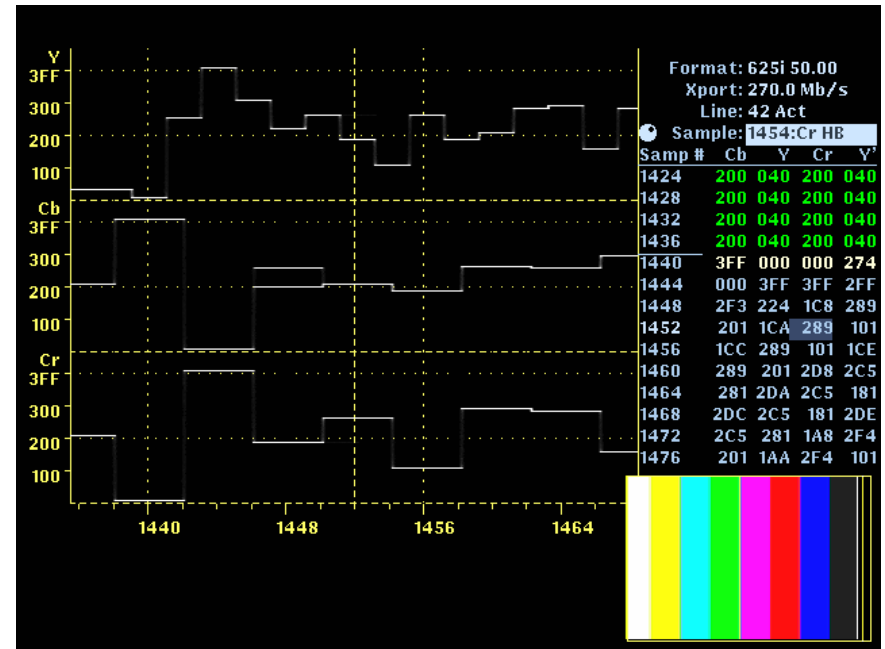
HD Embedded Audio

- ▶ Defined by ITU.BT-R 1365 and SMPTE299M
- ▶ Up to 16 audio channels
 - Packaged as 4 audio groups with 4 audio channels.
- ▶ Full 24 bits of audio sample carried with ANC data
- ▶ Data is carried only in Cb and Cr samples
- ▶ Additional CLK data words used for synchronization
- ▶ Additional ECC words for error correction

HD versus SD Embedded Audio

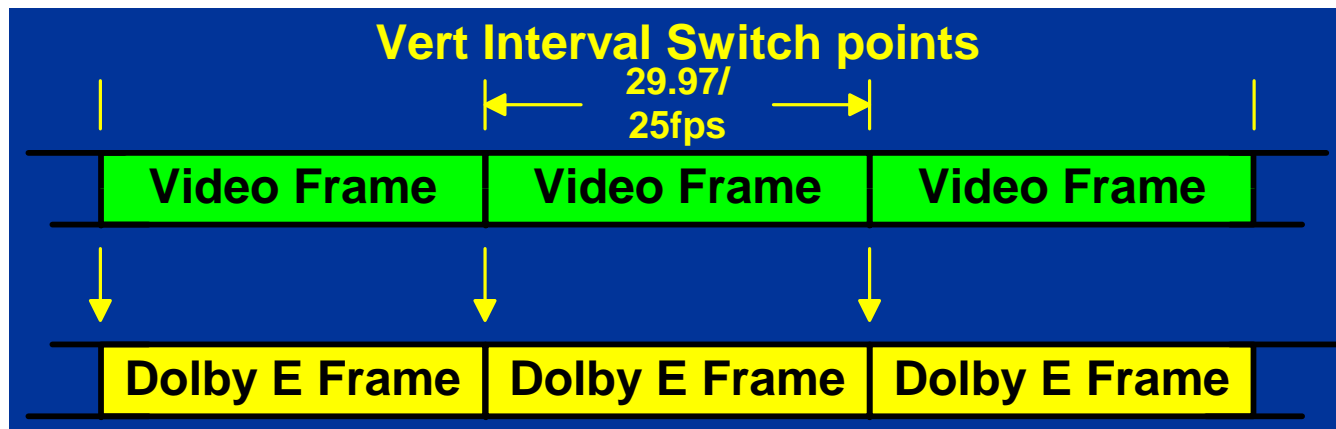
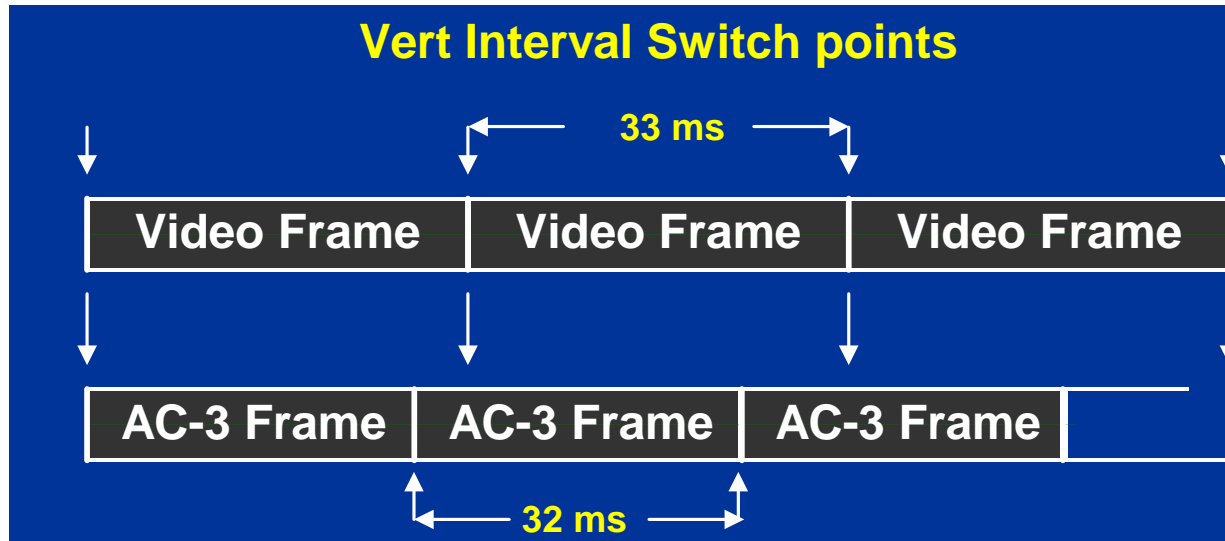


HD embedded audio
Only Present in Cb/Cr



SD embedded audio
Present in Y/Cb/Cr

Video with Dolby Digital Audio: Editing and Switching Points



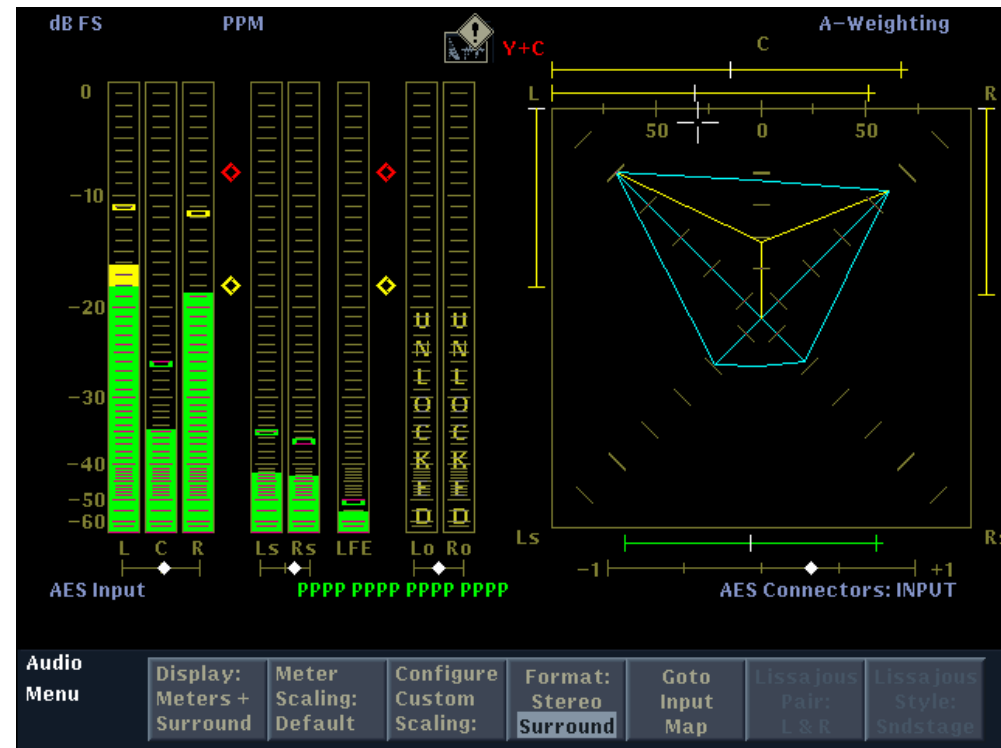
SMPTE RP168 - Line 10

SMPTE Standards

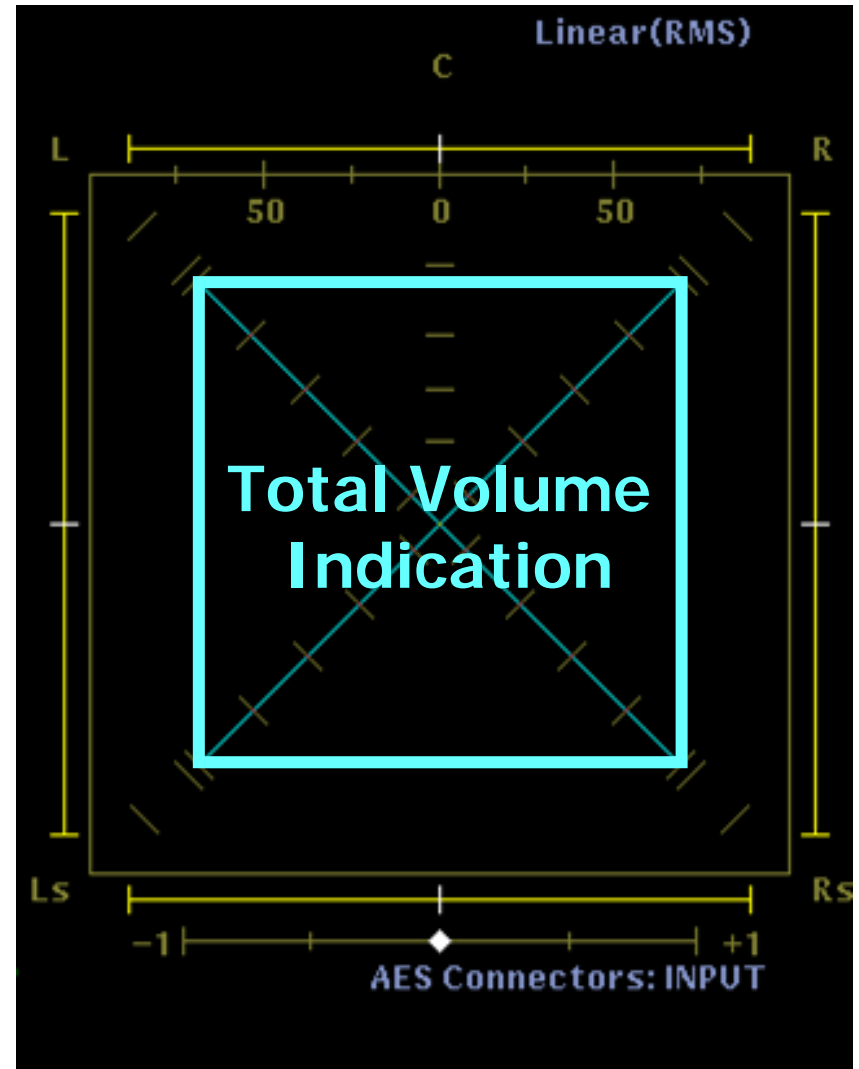
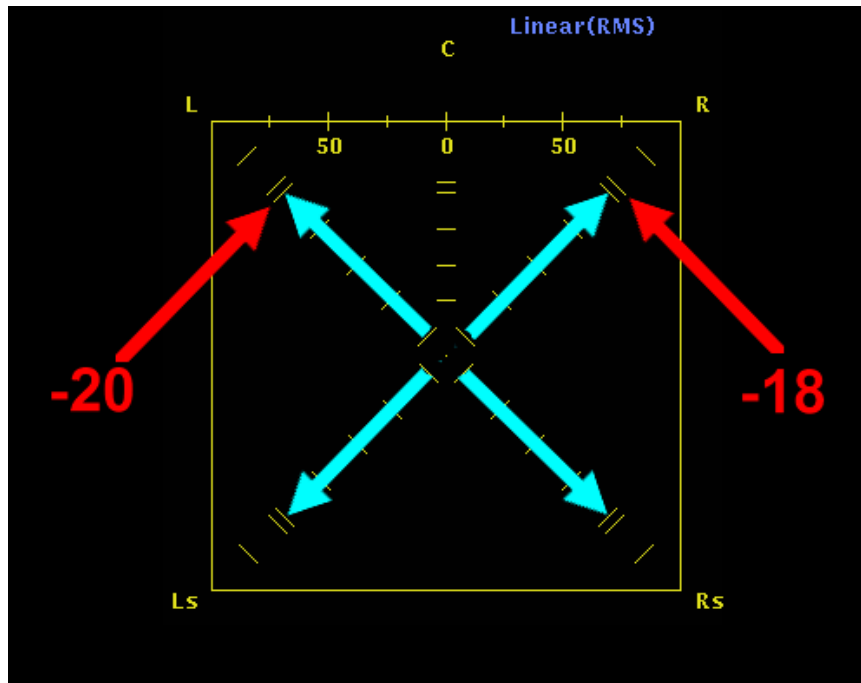
- ▶ SMPTE 337M Format for Non_PCM Audio and Data in an AES Serial Digital Audio Interface
- ▶ SMPTE 338M Format for Non_PCM Audio and Data in an AES3 – Data Types
- ▶ SMPTE 339M Format for Non_PCM Audio and Data in an AES3 – Generic Data Types
- ▶ SMPTE 340M Format for Non_PCM Audio and Data in an AES3 – ATSC A/52 (AC-3) Data Type

Surround Sound Display

- ▶ Allows visualization of interaction between multiple channels
 - Left (L), Right (R), Center (C), Left Surround (Ls), Right Surround (Rs)
 - Show Dominant Sound
 - Correlation between channels
 - Phantom Phase Indicators
 - Linear or A Weighting Filters

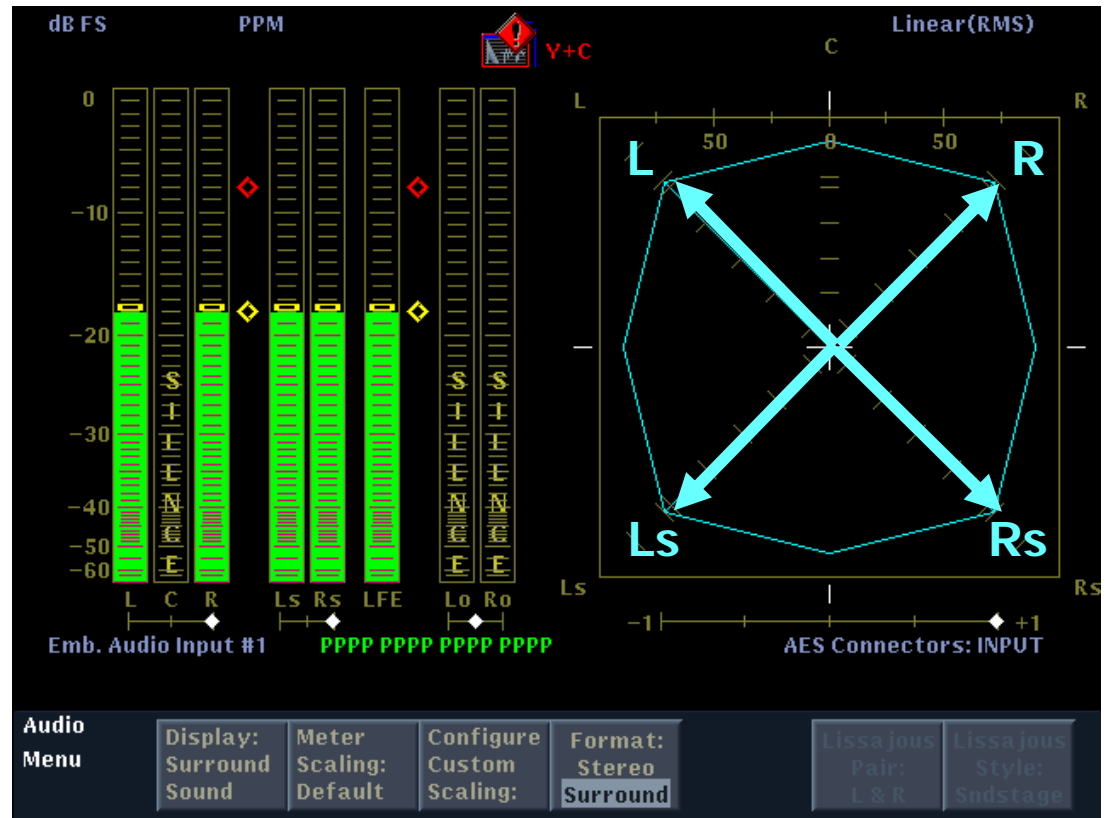


Basics of Display



Basics of Display

- ▶ Linear (RMS) Filter
 - Linear relationship between amplitude of sound and display
- ▶ A Weighting Filter
 - Amplitude modulated by frequency of sound related to human auditory response
- ▶ Correlation
 - Bend outwards In-Phase
 - Straight Line 0 Correlation
 - Bend inwards Out-Phase



Why The New CODEC Technologies?

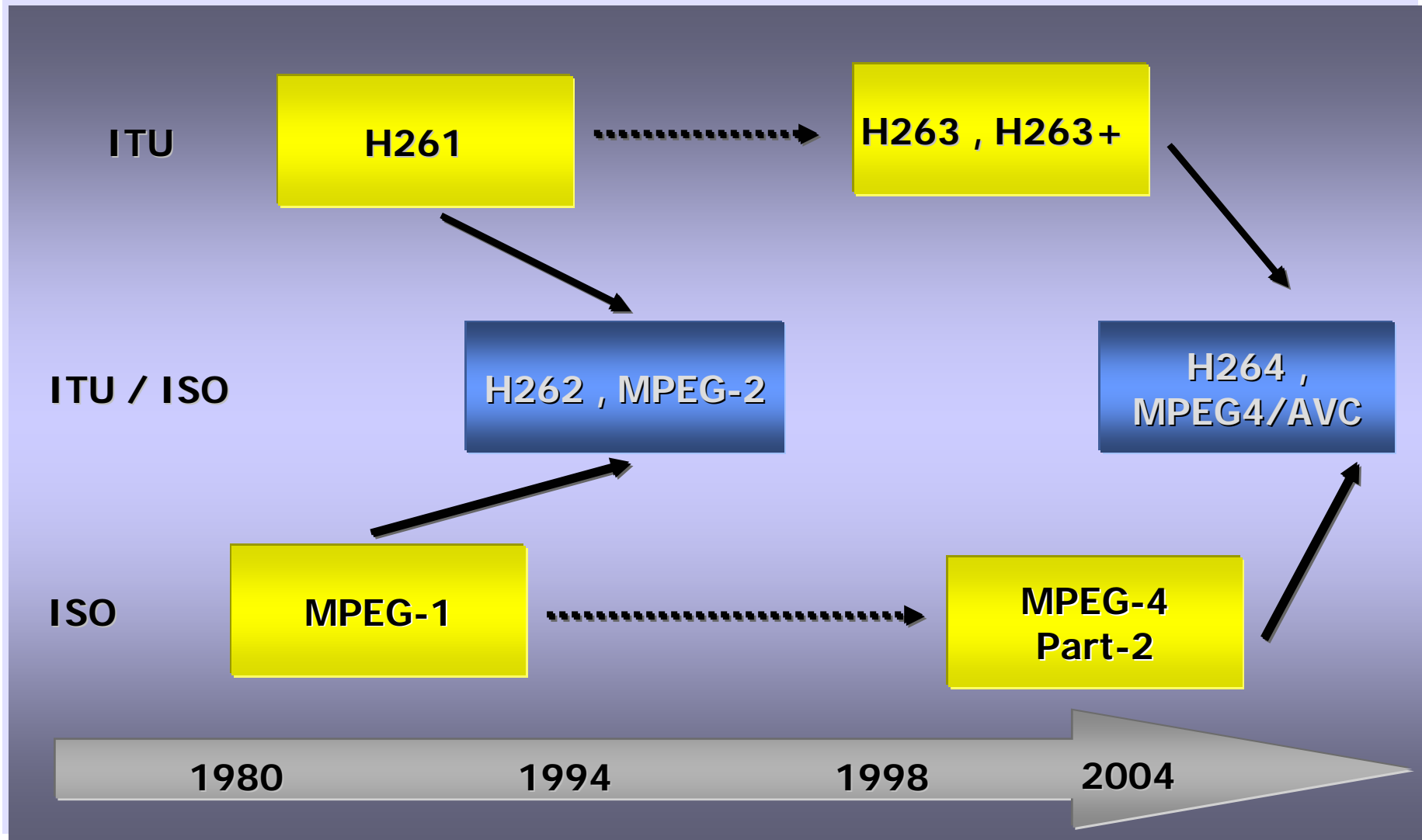
▶ Bit Rate Reduction

- More Services per Transport Stream
 - ▶ Cost reduction
 - ▶ HD Support
- New Consumer Devices adopting video
- New transmission technologies
 - ▶ IP Transmission to the home
 - ▶ Mobile Video (DVB-H, T-DMB)

▶ HD

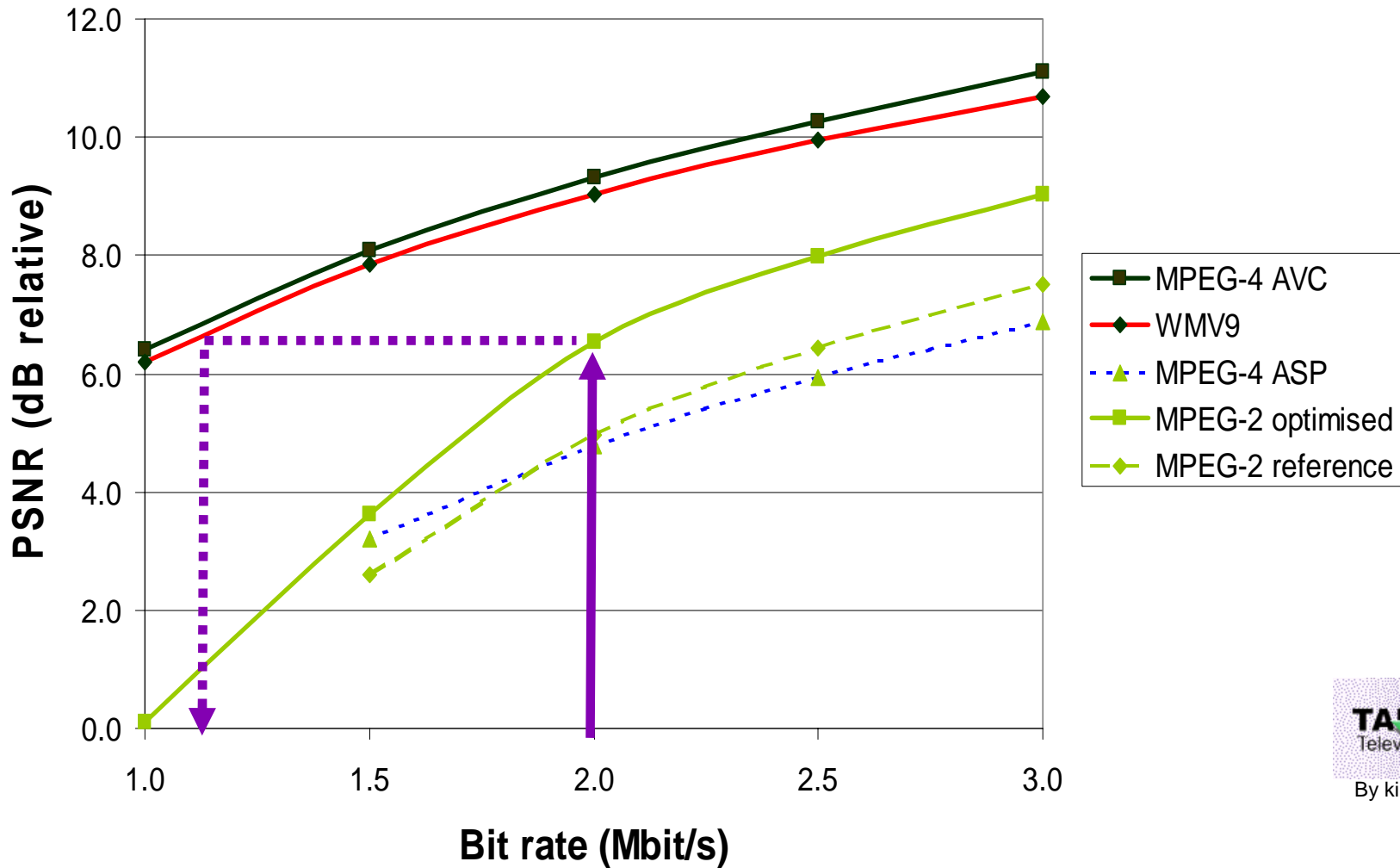
- Conventional Satellite, Cable or Terrestrial Delivery
- HD DVD

CODEC Standards Evolution



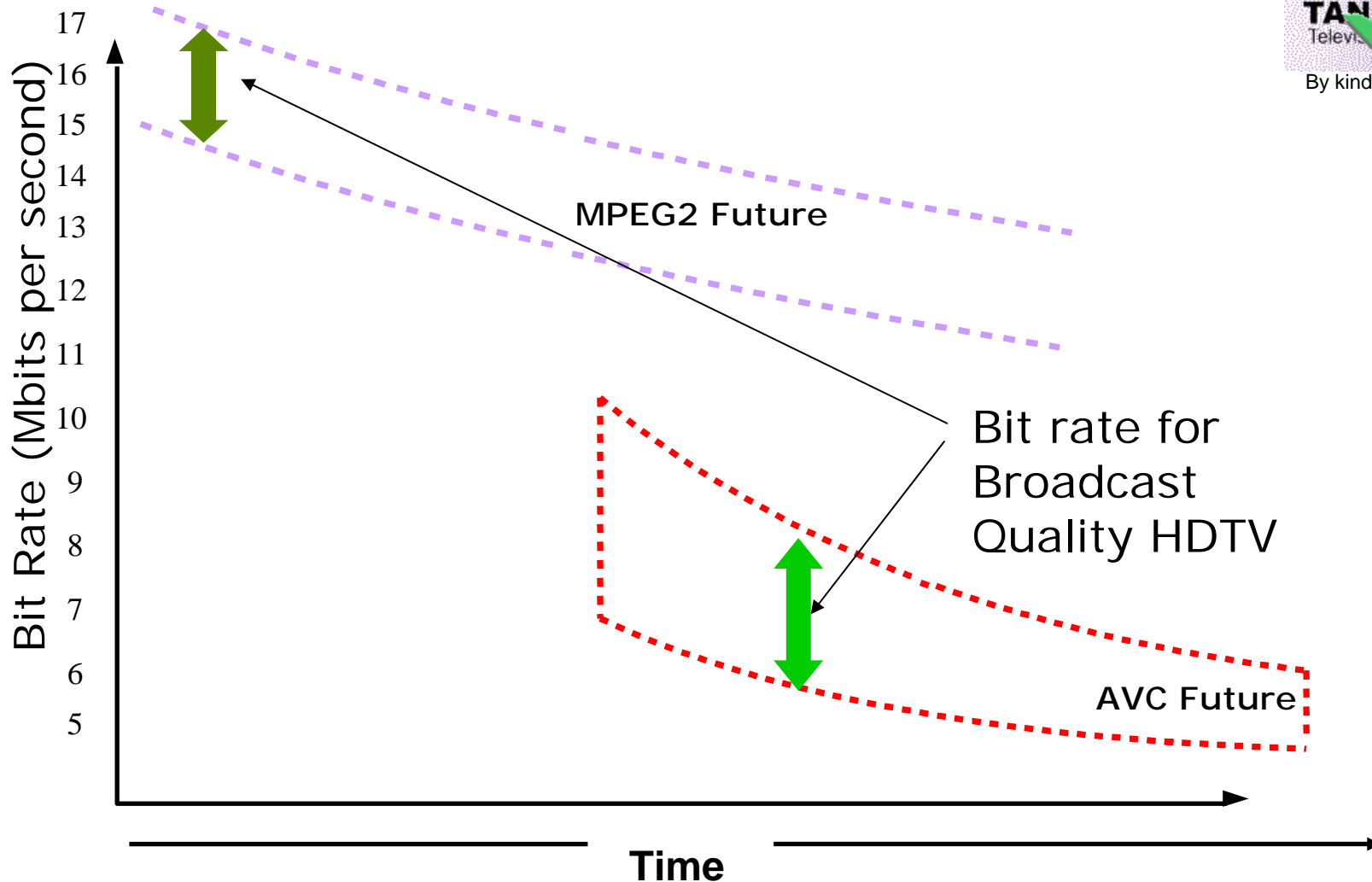
Performance Comparison

Soccer example at full D1 resolution



TANBERG
Televis
By kind permission

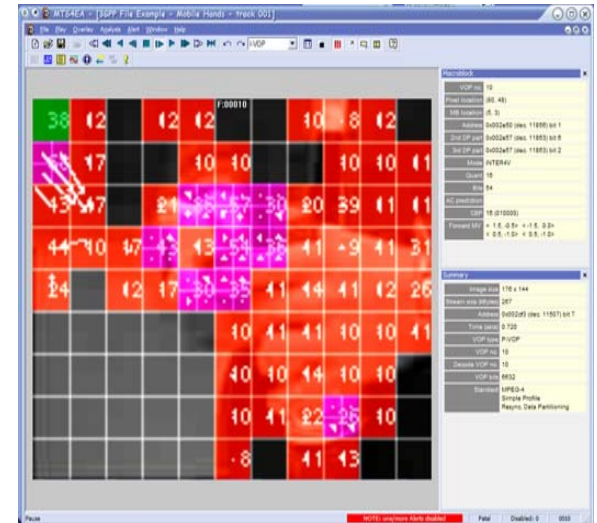
The HD Scenario



By kind permission

CODEC Testing Issues

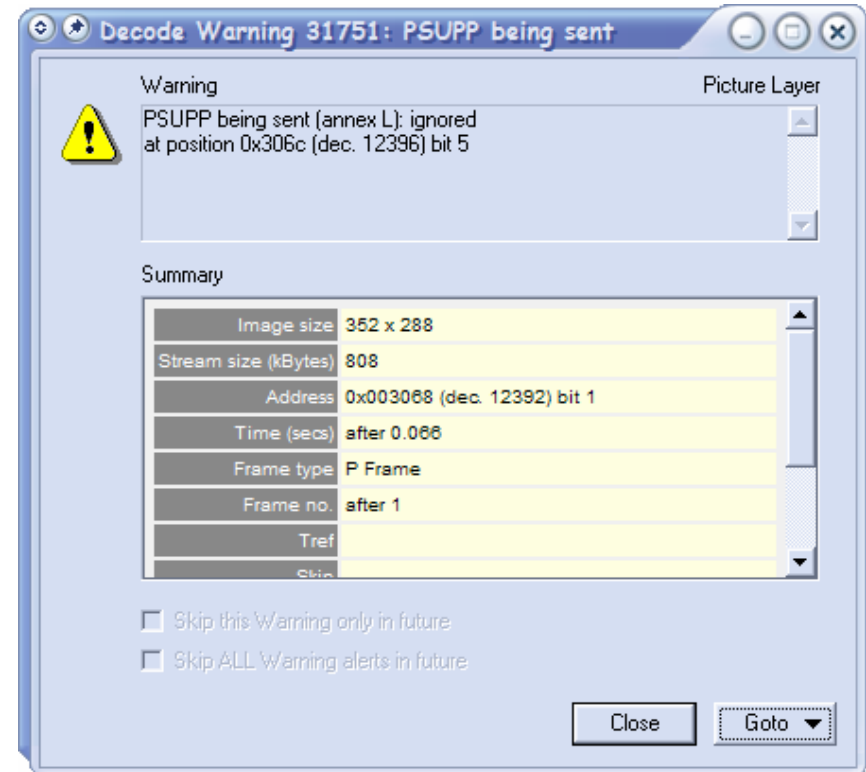
- ▶ Testing CODEC coding and standards compliance
 - MPEG-2, MPEG-4, H.264/AVC, VC-1, 3GPP
 - Alerts and Trace log file outputs
- ▶ Testing CODEC efficiency
 - Bits wasted on inefficient coding
 - Statistical tests - Bits per coded MacroBlock, Intra-coding frequency, quantiser averages etc
- ▶ Visual identification of CODEC errors
 - Macroblocks
 - Motion vectors
- ▶ Detecting Video Artefacts
 - Can be assessed by PSNR, Root Mean Square Error, Mean Square Error Mean Absolute Difference analysis etc.
- ▶ Identifying Video Buffer issues
 - Video buffer verifier
 - Video complexity verifier
 - Hypothetical reference decoder (HRD)



Tektronix MTS4EA

Testing - CODEC Standards Compliance

- ▶ Syntax and other error alerts
- ▶ Error location
 - bitstream address
 - frame number
- ▶ Error description



Testing - CODEC Standards Compliance

- ▶ Parse bitstream
- ▶ Interpret
- ▶ Frame summary
- ▶ GOB/MB row summary
- ▶ MB summary
- ▶ DCT
- ▶ Pixel-level

```
0001 0000 ---- ---- ---- ---- ---- (0x00000091,4) : INTER_QUANT_MAT
1---- ---- ---- ---- ---- ---- (0x00000092,4) : COMPLEXITY_ESTIMATION_DISABLE
0----- ---- ---- ---- ---- ---- (0x00000092,3) : RESYNC_MARKER_DISABLE
0----- ---- ---- ---- ---- ---- (0x00000092,2) : DATA_PARTITIONED

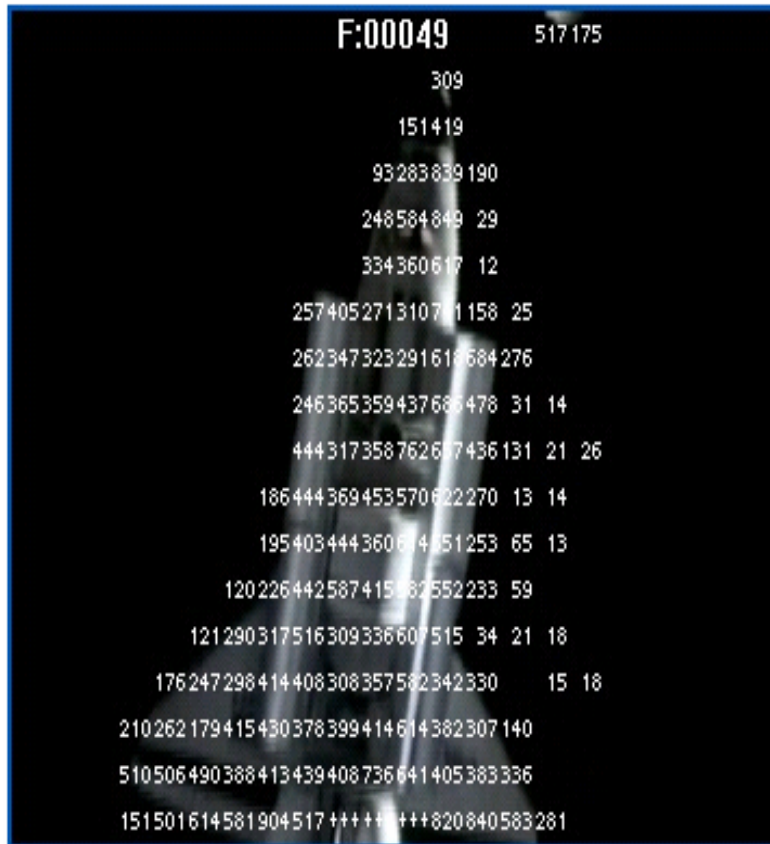
=====
0000 0000 0000 0000 0000 0001 1011 0110 (0x00000093,7) : VOP_START_CODE
00-- ---- ---- ---- ---- ---- (0x00000097,7) : VOP_CODING_TYPE
1--- ---- ---- ---- ---- ---- (0x00000097,5) : MODULO_TIME_BASE
1--- ---- ---- ---- ---- ---- (0x00000097,4) : MARKER_BIT
0001 0--- ---- ---- ---- ---- (0x00000097,3) : VOP_TIME_INCR
1--- ---- ---- ---- ---- ---- (0x00000098,6) : MARKER_BIT
1--- ---- ---- ---- ---- ---- (0x00000098,5) : VOP_CODED
010- ---- ---- ---- ---- ---- (0x00000098,4) : INTRA_DC_VLC_THR
0010 0--- ---- ---- ---- ---- (0x00000098,1) : PQUANT
011- ---- ---- ---- ---- ---- (0x00000099,4) : MCBPC_I
0----- ---- ---- ---- ---- ---- (0x00000099,1) : AC_PRED
11-- ---- ---- ---- ---- ---- (0x00000099,0) : CBPY
```

```
(0x00000091,4) [VOL] (MP4) nonintra_quant_mat = 16
(0x00000092,3) [VOL] (MP4) resync_marker_disable = 0
(0x00000092,2) [VOL] (MP4) data partitioned = 0

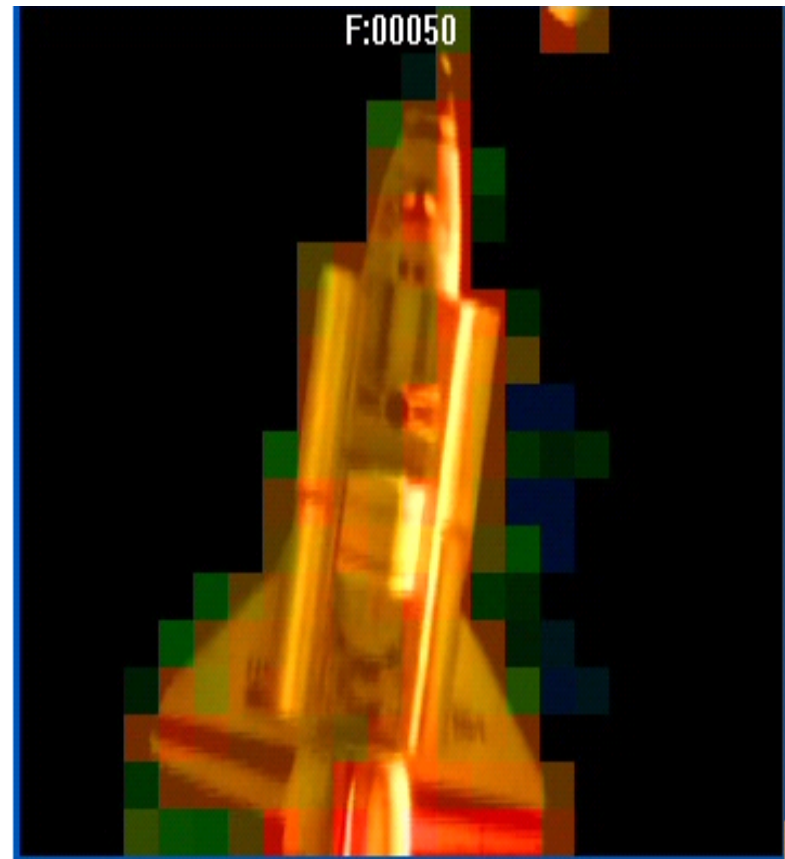
=====
(0x00000093,7) [SC ] (MP4) vop_start_code found (should be 0xB6) = 0xb6
(0x00000097,7) [VOP] (MP4) vop_coding_type = 0
(0x00000097,5) [VOP] (MP4) modulo_time_base
(0x00000097,3) [VOP] (MP4) vop_time_increment = 2
(0x00000098,4) [VOL] (MP4) intra_dc_vlc_thr = 15
(0x00000099,3) [GOB] Start of GOB no. 0; no. MBs = 22
(0x00000098,2) [MB ] MB =0; GOB no.= 0
(0x00000099,4) [MB ] mcbpc_i = 3
```

Testing - CODEC Efficiency

Number overlay

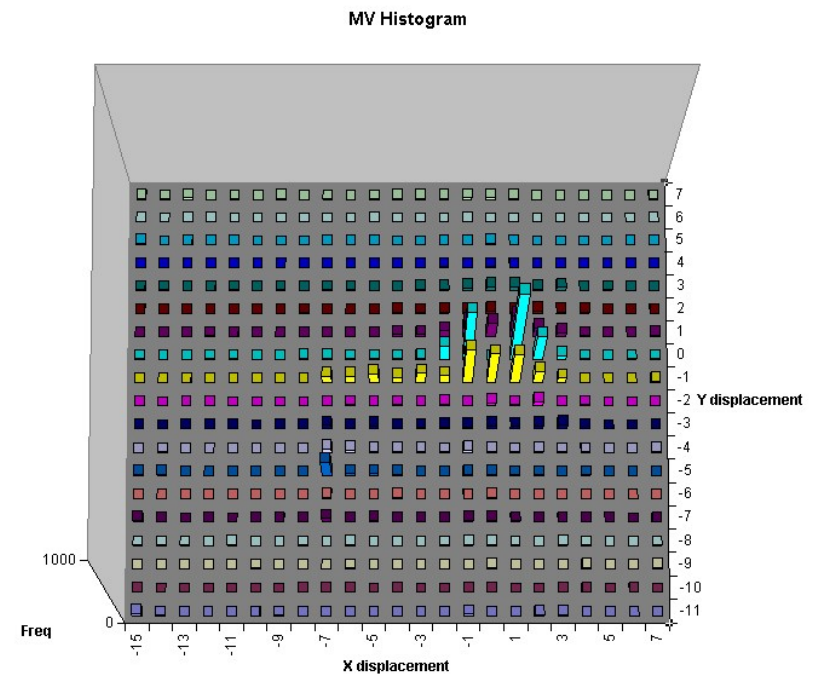
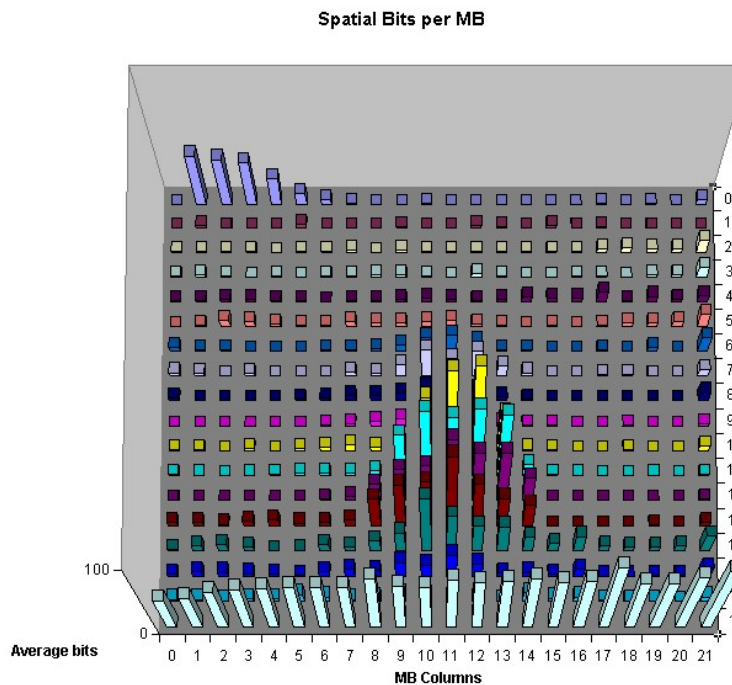


Bits – to – colour mapping



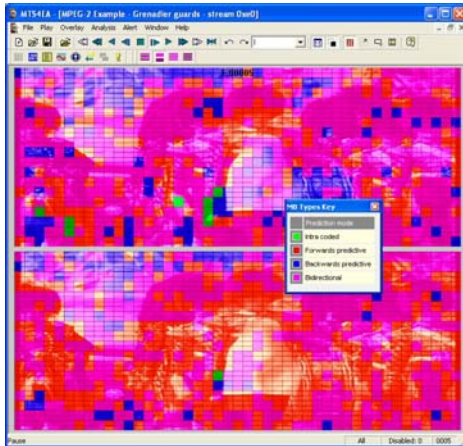
Testing - CODEC Efficiency

- ▶ Bits per MacroBlock
- ▶ Bits per coded MacroBlock
- ▶ Motion vector histogram
- ▶ DCT frequencies
- ▶ Average quantiser
- ▶ Coding frequency
- ▶ Intra-coding frequency



Visual identification of CODEC errors

- ▶ MacroBlock types



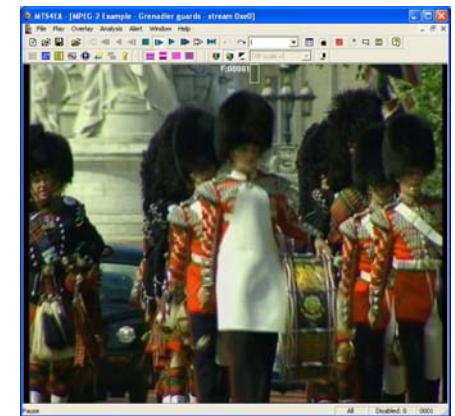
- ▶ Motion vectors



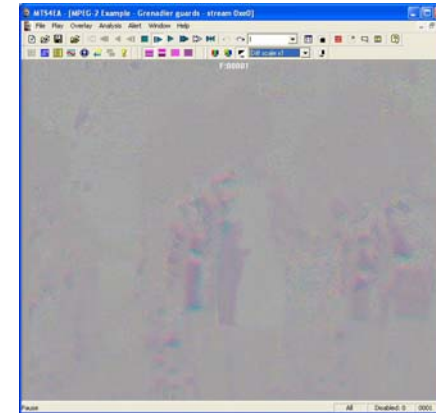
- ▶ Visual difference
Compressed



- Original



- Difference

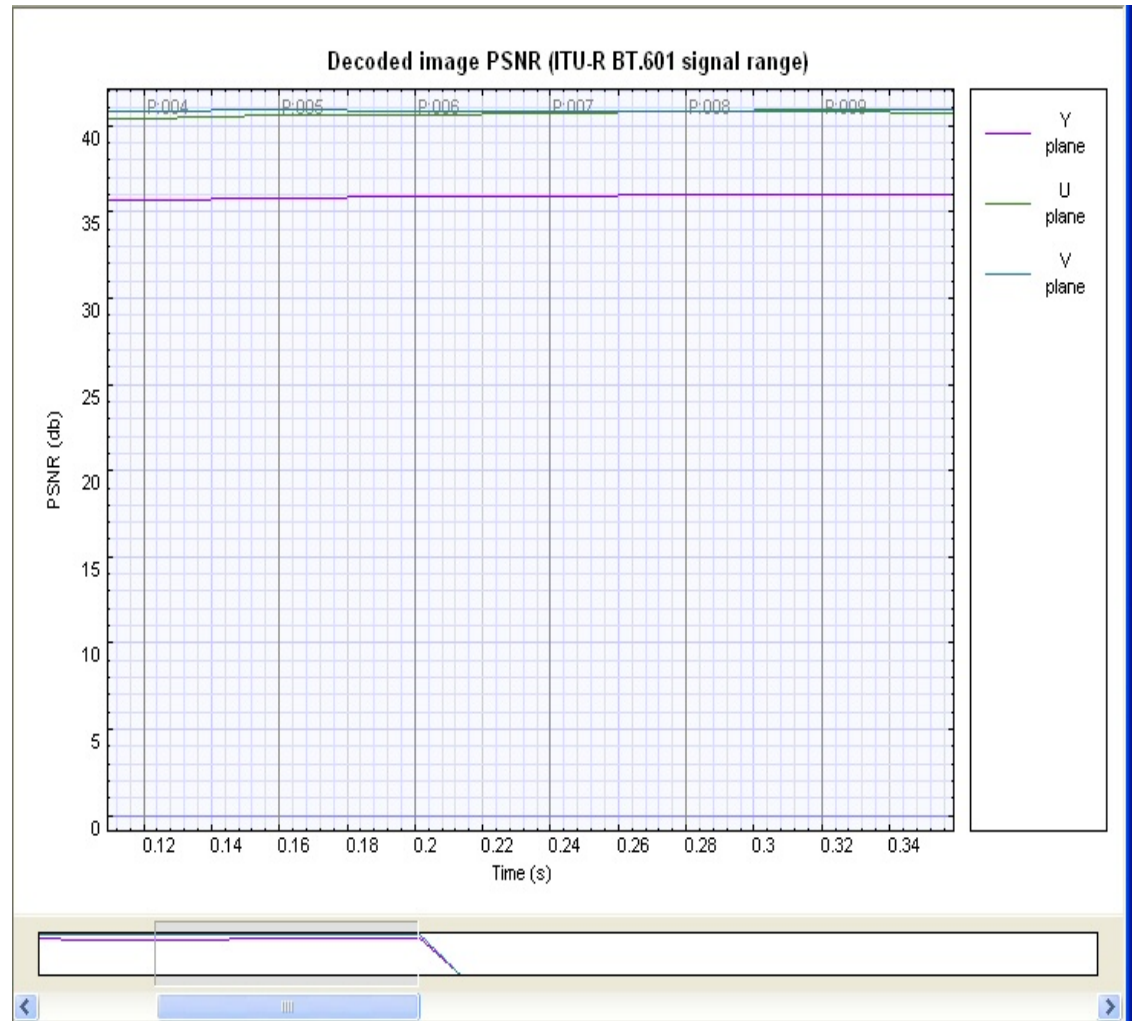


Detecting Video Artefacts – Fidelity Analysis

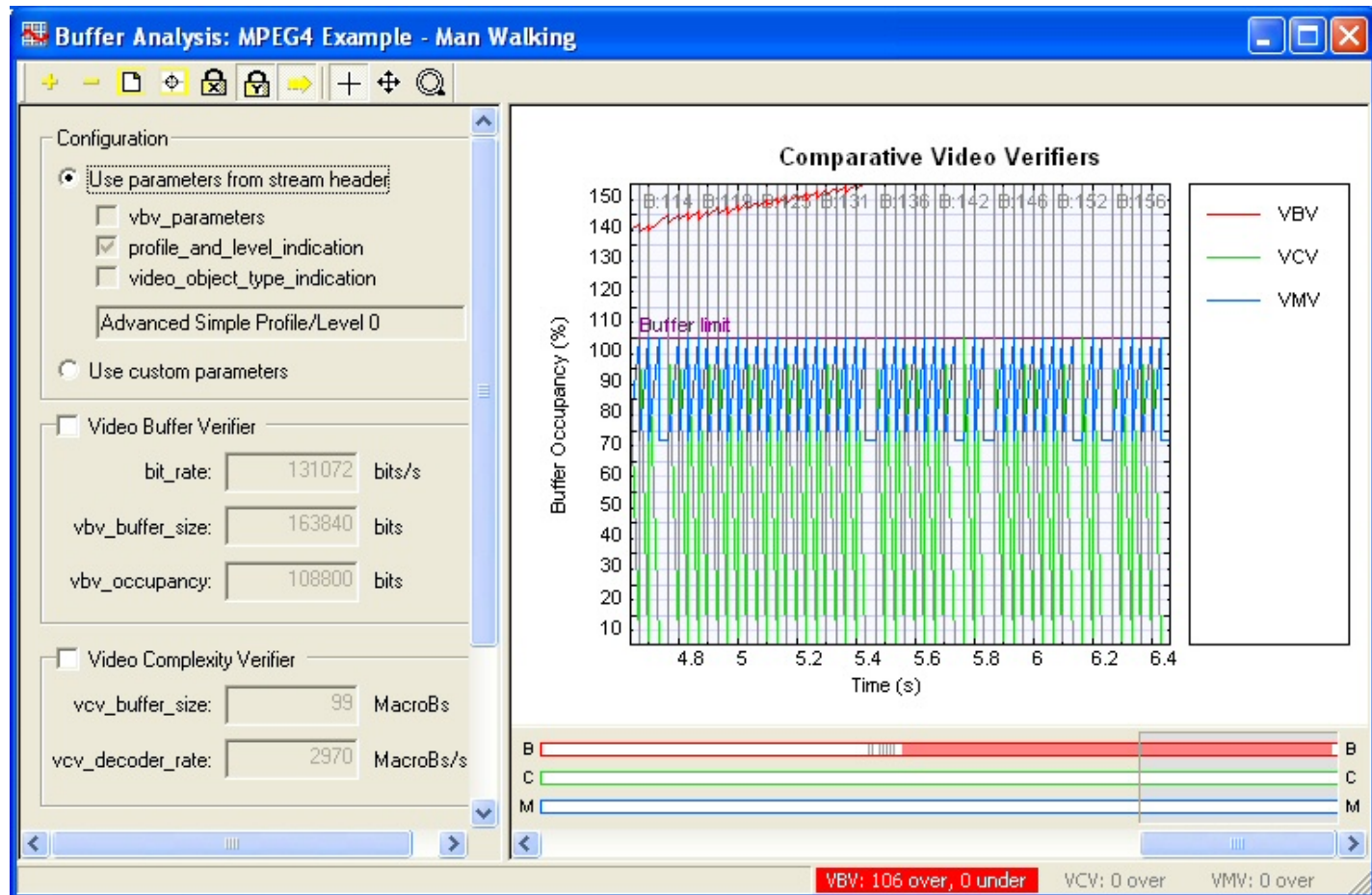
Fidelity Analysis

- ▶ Sharpness
- ▶ Blockiness
- ▶ Colour fidelity

- ▶ Correlate between reference and coded sequence
- ▶ PSNR (255 and ITU-R BT.601 signal ranges)
- ▶ Root Mean Square Error
- ▶ Mean Square Error
- ▶ Mean Absolute Difference
- ▶ Sum Absolute Difference



Testing – Buffer analysis



Cerify



***Know your content is correct
before you transmit it***

Cerify Overview

- ▶ Automated QC testing of file-based digital media
 - ❑ tests video - MPEG-2, MPEG-4, H.264, VC-1
 - ❑ tests audio - MPEG-2 audio, AAC, HE-AAC, AC3
- ▶ Server rack-mount system
 - ❑ comprises one or more 19" rack-mount servers
- ▶ It is for:
 - ❑ Broadcasters – terrestrial, satellite, cable, VoD, web/IP
 - ❑ Post Production – content providers
 - ❑ Analysis of archives



Cerify Tests all aspects of

➤ Video

- ❑ parameters (e.g. format, resolution, frame rate, bit-rate)
- ❑ black screen, colour bars, gamut
- ❑ quality, blockiness, breakup,
- ❑ encoding, compliance/correctness to coding standards

➤ Audio

- ❑ parameters (e.g. channels, format, resolution, bit-rate)
- ❑ quality, levels
- ❑ audio errors, silence
- ❑ compliance/correctness to standards

➤ System

- ❑ parameters (e.g. packet types, transmission rates)

Cerify Supports

▶ Video Standards

- ❑ systems level - MPEG-2 (TS, PS, PES), MP4, 3GPP, ASF
- ❑ elementary stream - MPEG-2, MPEG-4, H.264, VC-1

▶ Formats

- ❑ NTSC, PAL, SECAM
- ❑ interlaced or progressive
- ❑ frame size from 16x16 to HD (QCIF, CIF, D1, SD, 720p, 1080i)

▶ Audio

- ❑ MPEG-2 audio, MPEG-2 AAC, AAC-Plus HE-AAC, Dolby AC3

Cerify Templates

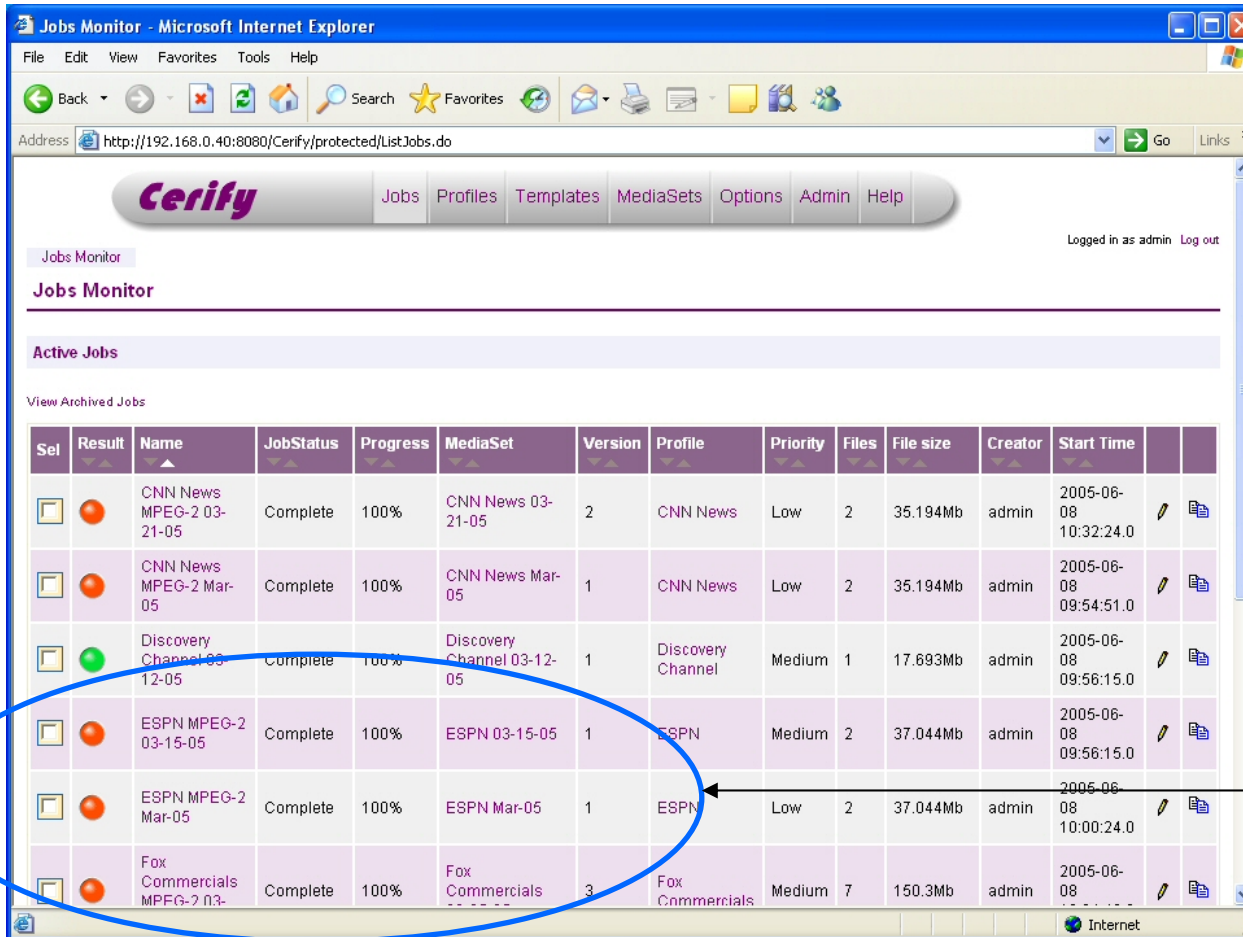
The screenshot displays the Cerify web application interface. At the top, there is a navigation menu with the Cerify logo and links for Jobs, Profiles, Templates, MediaSets, Reports, Options, Admin, and Help. The user is logged in as 'admin'. The main content area is titled 'Edit Video Template' and shows the following configuration details:

- Type:** MPEG-2
- TemplateName:** Video Tests
- Description:** (Empty text box)
- Version:** 13

The 'Configuration' section includes various settings, each with a checkbox and a dropdown menu:

- Standard:** MPEG-2
- Profile:** Main
- Level:** Main, Exactly
- Syntax checks:** Suppress alerts: None; Plus additional alert IDs: 22200 (comma separated list)
- Interface:** Required
- Play time:** At most, 1800 seconds
- Horizontal resolution:** Exactly, 704 pixels
- Vertical resolution:** Exactly, 480 pixels
- Colour depth:** 8 bits per sample, Only
- Frame rate:** 29.97, Only
- Bitrate:** Average bits per second between [] and [] bps
- Display aspect ratio:** 4:3
- Colour format:** 4:2:0

Browsing Results – Jobs List



The screenshot shows the Cerify Jobs Monitor interface. The main content area displays a table of active jobs. The 'Result' column contains status indicators: a green light for 'Discovery Channel 03-12-05' and a red light for 'ESPN MPEG-2 Mar-05'. A blue circle highlights the 'Result' column, and a red arrow points to the red light icon in the 'ESPN MPEG-2 Mar-05' row.

Sel	Result	Name	JobStatus	Progress	MediaSet	Version	Profile	Priority	Files	File size	Creator	Start Time		
<input type="checkbox"/>		CNN News MPEG-2 03-21-05	Complete	100%	CNN News 03-21-05	2	CNN News	Low	2	35.194Mb	admin	2005-06-08 10:32:24.0		
<input type="checkbox"/>		CNN News MPEG-2 Mar-05	Complete	100%	CNN News Mar-05	1	CNN News	Low	2	35.194Mb	admin	2005-06-08 09:54:51.0		
<input type="checkbox"/>		Discovery Channel 03-12-05	Complete	100%	Discovery Channel 03-12-05	1	Discovery Channel	Medium	1	17.693Mb	admin	2005-06-08 09:56:15.0		
<input type="checkbox"/>		ESPN MPEG-2 03-15-05	Complete	100%	ESPN 03-15-05	1	ESPN	Medium	2	37.044Mb	admin	2005-06-08 09:56:15.0		
<input type="checkbox"/>		ESPN MPEG-2 Mar-05	Complete	100%	ESPN Mar-05	1	ESPN	Low	2	37.044Mb	admin	2005-06-08 10:00:24.0		
<input type="checkbox"/>		Fox Commercials MPEG-2 03-	Complete	100%	Fox Commercials	3	Fox Commercials	Medium	7	150.3Mb	admin	2005-06-08		

Red light =
Jobs have alerts

Browsing Results – Media Files

The screenshot shows a Microsoft Internet Explorer window titled "Job Details". The address bar contains the URL: `http://192.168.0.40:8080/Cerify/protected/JobDetails.do?job=ESPN+MPEG-2+Mar-05&trail=Jobs+Monitor&trailindex=1`. The page content includes a "Job Details" section with the following information:

- Job Name: ESPN MPEG-2 Mar-05
- Version: 1
- Priority: Low
- Profile: ESPN
- MediaSet: ESPN Mar-05

Below this is a "Files" section containing a table with the following data:

Result	Filename	Size	Status	Progress	Start Time	Thumbnail
●	smb://vulcan/thesunwTemp/cerify_demo/sport/soccer.ts	26.815Mb	Complete	100%	2005-06-08 10:00:24.0	
●	smb://vulcan/thesunwTemp/cerify_demo/sport/world_sport.ts	10.229Mb	Complete	100%	2005-06-08 10:00:42.0	

Annotations on the screenshot include:

- An arrow pointing to the "Job Name" field with the text "Job details".
- An arrow pointing to the "Files" section header with the text "Media Files Processed".
- A blue oval around the second row of the table, with an arrow pointing to it from the text "Media File generated an alert".

Cerify Current Status

▶ Beta Test Sites

- Comcast (Denver) – 1st order achieved, production order expected in Dec
- MTV (New York) – budget expected in Jan
- Turner (Atlanta) – testing continues
- Corus (Edmonton) – HD movie channel, order expected in Nov
- BSkyB (London) – tests for new HD service
- Bloomberg (New York) – installation planned Dec

▶ Others who have had live demos

- UK – BBC, ITV, Disney, Boxer/Arqiva
- Italy – FastWeb, MediaSet, RAI, Telecom Italia

▶ OEMs who are interested

- Omneon, Miranda, Masstech, Harris,

Cerify Challenges

- ▶ An Integral Part of the Customers Broadcast Workflow
 - Not just an add-on test tool
- ▶ Requires site installation/test/sign-off (4 weeks)
 - Network integration, buffer storage, automation process integration, template set-up
- ▶ Every site is different
 - Different video servers (every supplier uses different wrappers/formats)
 - ▶ Pinnacle/Avid (3 different models encountered all with non standard ftp)
 - ▶ Omneon (has 5 different possible storage formats)
 - ▶ Grass Valley/Thomson (GXF support not yet available)
 - ▶ SeaChange (not yet tested with Cerify)
 - ▶ MXF (initial support for Cerify planned 1st Q 06)
 - ▶ Various Windows server based configurations
 - Different automation systems
 - Different formats, bitrates, content, processes
 - Different QC requirements (Note: automation may make people redundant)

Application Notes / Posters

- ▶ Monitoring Surround-Sound Audio
 - Literature no: 25W-17981-1
- ▶ Understanding Jitter Measurement for Serial Digital Video
 - Literature no: 2BW-18906-0
- ▶ A Guide to Standard and High-Definition Digital Video Measurements
 - Literature no: 25W-14700-0
- ▶ A Guide to MPEG Fundamentals and Protocol Analysis
 - Literature no: 25W-11418-4
- ▶ A Guide to Digital Televisions Systems and Measurements
 - Literature no: 25W-7203-3
- ▶ Posters:
 - Understanding High Definition Video, # 25W-15960-2
 - Understanding Colors and Gamut, # 25W-15618-0
 - MPEG-2 Transport Stream Poster, # 21W-14974-1

Thank you for your attention

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