IP Video Contribution for Broadcasters

Bojan Nedelcev
Systems Engineer SPVTG – Emerging Markets
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Presentation Outline

- Video Contribution Landscape
- Video Compression Technologies
- JPEG 2000 Compression Format
- DCM IP Video Gateway
- D9093/D9094 AVC Contribution Codec
Contribution and Distribution Network
High-Level Diagram

Production

Contribution

Core IP Network

Post Production

Video Data Center

Distribution

Primary

Secondary

Direction Home

Headend

Over the Air

Headend

Telco

Headend

Cable

Headend

Broadband

CDN

IP

Home IP Network

Consumption

News Gathering

Studio-to-Studio

Sport Events

IP Network

Home Gateway

IP
Compression technology
Choosing the Right Horse

Bitrate

Very Low Bit-Rate
HD: <20Mbit/s
SD: <8Mbit/s
AVC
MPEG-2

Traditional Compressed
HD: <100Mbit/s
SD: <50Mbit/s
AVC
MPEG-2

Very High Quality
HD: <500Mbit/s
SD: <100Mbit/s
JPEG2000

Uncompressed
HD: 1.5 / 3Gbit/s
SD: 270Mbit/s

PQ

Latency

Trade-off

Technology
IP Contribution landscape – HD example

Terrestrial:
- Post production
- Inter-studio contribution
- Sports contribution
- Regional News

Uncompressed
- • 4:2:2 10 bit resolution
- • I mode only
- • Error Correction: Standardization
- • Transport: Standardization RTP/UDP

JPEG2k
- • 4:2:2 10 bit resolution
- • I mode only
- • Error Correction: Standardization
- • Transport: MXF/ MPEG-2 over RTP/UDP

MPEG-2
- • 4:2:2 8-bit resolution
- • I/P/B mode
- • Error Correction: SMPTE 2022
- • Transport: MPEG-2 TS over RTP/UDP

MPEG-4 AVC
- • 4:2:2 8-bit or 10-bit resolutions
- • I/P/B mode
- • Error Correction: SMPTE 2022
- • Transport: MPEG-2 TS over RTP/UDP

MPEG-4 AVC
- • 4:2:0 8-bit resolution
- • I/P mode only
- • Error Correction SMPTE 2022
- • Transport: MPEG-2 TS over RTP/UDP

Satellite:
- Special events
- Inter-studio contribution
- Sports contribution

Ultra low latency
<150msec

Very low latency
<300msec

Low latency
<800msec

DSNG, DTNG:
- Field news coverage

Bit rates
- 1.5G/3G
- <500Mbps
- <100Mbps
- <20Mbps

Latency

Uncompressed

Very low latency
<300msec

Low latency
<800msec
Latency (E2E Delay) using an IP Network

### Uncompressed:
- <<1 msec

### JPEG2000 encoding*
- 55 msec @ 25Hz
- 50 msec @ 30Hz

### Dejittering buffer:
- 10-200ms

### JPEG2000 decoding*
- 20 msec @ 25Hz
- 18 msec @ 30Hz

### Gen-lock delay:
- Up to 40 msec @ 25Hz (optional)

---

**FEC will of course also add delay to the end-to-end, very dependent on FEC configuration.**

With Pro-MPEG FEC CoP4 the maximum matrix size can be as large as 1500 RTP packets, which equals 1375 bytes x 1500 packets (max):
- 61 ms at SDTV 270Mbit/s
- 12 ms at HDTV 1.485Gbps.

Realistic FEC delays are in the range of 5 ms – even with JPEG2K compressed HD.

---

<table>
<thead>
<tr>
<th>Condition</th>
<th>Network delay</th>
<th>Dejittering buffer</th>
<th>Compression/Packetization</th>
<th>FEC</th>
<th>Gen-lock</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncompressed</td>
<td>Typical</td>
<td>&lt; 5ms</td>
<td>&lt;&lt; 1ms</td>
<td>5 ms</td>
<td>&lt;33 ms</td>
<td>&lt;63 ms</td>
</tr>
<tr>
<td>Uncompressed</td>
<td>Best case</td>
<td>&lt; 1ms</td>
<td>&lt;&lt; 1ms</td>
<td>None</td>
<td>0 ms</td>
<td>5-10 ms</td>
</tr>
<tr>
<td>JPEG2K @30Hz</td>
<td>Typical</td>
<td>&lt; 5ms</td>
<td>&lt;&lt; 1ms</td>
<td>5 ms</td>
<td>&lt;33 ms</td>
<td>&lt;140 ms</td>
</tr>
<tr>
<td>JPEG2K @30Hz</td>
<td>Best case</td>
<td>&lt; 1ms</td>
<td>68ms</td>
<td>None</td>
<td>0 ms</td>
<td>80 ms</td>
</tr>
</tbody>
</table>

* These are depending on implementation and not set by the standard (can be higher)
## Cisco Full Range of Contribution Products

### Typical Latency & Bit-Rate Criteria

<table>
<thead>
<tr>
<th>Product</th>
<th>Bitrate</th>
<th>Latency</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPEG-4 AVC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D9054 AVC Encoder</td>
<td>B/W: 4 to 20 Mbps</td>
<td>Lat: &gt; 1 sec</td>
</tr>
<tr>
<td>D9094 AVC Contribution Codec</td>
<td>B/W: 4 to 38 Mbps</td>
<td>Lat: 270 to 500 msec</td>
</tr>
<tr>
<td>JPEG 2000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCM Gateway</td>
<td>B/W: 40 to 500 Mbps</td>
<td>Lat: 80 to 140 msec</td>
</tr>
<tr>
<td>Uncompressed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCM Gateway</td>
<td>B/W: 1.5 to 3 Gbps</td>
<td>Lat: 5 to 70 msec</td>
</tr>
</tbody>
</table>

[Image of Cisco Full Range of Contribution Products diagram]
Video Compression Technologies
# Uncompressed Video

SDI Video - Related Standards

<table>
<thead>
<tr>
<th>Terminology</th>
<th>Standard</th>
<th>Bit Rates</th>
<th>Video Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD-SDI</td>
<td>SMPTE 259M</td>
<td>270Mbps</td>
<td>480i 29.97, 576i 25</td>
</tr>
<tr>
<td>HD-SDI</td>
<td>SMPTE 292M</td>
<td>1.5Gbps</td>
<td>720P 50/59.95, 1080i 25/29.97</td>
</tr>
<tr>
<td>Dual Link HD-SDI</td>
<td>SMPTE 372M</td>
<td>2 x 1.5Gbps</td>
<td>1080P 50/60</td>
</tr>
<tr>
<td>3G-SDI</td>
<td>SMPTE 424M</td>
<td>3Gbps</td>
<td>1080P 50/60</td>
</tr>
</tbody>
</table>
SDI Video
Uncompressed vs JPEG2K compressed

**Uncompressed:**
- **All samples** from the SDI signal is RTP encapsulated.
- This also means that by default we support SDTI, as the transport and encapsulation cannot see the difference between an 270Mbit/s SD-SDI signal or an 270Mbit/s SDTI signal.

**JPEG2K Compressed:**
- Video samples are JPEG2K compressed
- Embedded Audio channels are user selected and not compressed.
- Ancillary data are user selected and not compressed or slightly compressed (TXT).
- All elements from one frame are MXF wrapped and RTP encapsulated.
**MXF**

*Material eXchange Format*

- **What is MXF?**
  - Wrapper for video, audio, ancillary data and metadata
  - An interchange file format
  - Primarily designed for storage and file transfer
  - Used in Camcorders like Panasonic P2, SONY XDCAM HD, Grass Valley Infinity
  - Used in various digital workflow systems like Avid, in the Adobe Premiere Pro video editing suite, as well as in Apple Final Cut Studio
  - Standardized within SMPTE

- **What is MXF over RTP?**
  - Adaptation of MXF for RTP video streaming
  - Collect all data for one frame (compressed video (eventually JPEG2K), audio, ancillary data, etc.) in one MXF Content Package
RTP Encapsulation
MPEG-2 TS & MXF

- This is currently being standardized!

- The standardization work is done within VSF (Video Service Forum) and EBU

- There are two paths under consideration
  - MPEG-2 TS
  - MXF

- Within VSF there is working to finalize the MPEG-2 TS first, and the MXF secondly

- Within EBU the priority is the opposite. EBU, with the broadcasting community behind them is a strong speaker for MXF, especially because it can carry other existing formats and have metadata embedded in the stream
JPEG 2000 Compression Format
# JPEG2000

## Today’s Compression Formats Comparisons

<table>
<thead>
<tr>
<th></th>
<th>MPEG-2 / AVC</th>
<th>AVC I-only</th>
<th>JPEG-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Ratio</td>
<td>Highest</td>
<td>Medium / High</td>
<td>Medium / Low</td>
</tr>
<tr>
<td>Compression Latency</td>
<td>Large</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Resolution</td>
<td>8-bit</td>
<td>8-bit (10 bit in 4:2:2 profile)</td>
<td>10-bit</td>
</tr>
<tr>
<td>Compression Basis</td>
<td>Block &amp; Entropy (AVC)</td>
<td>Block &amp; Entropy</td>
<td>smoother</td>
</tr>
<tr>
<td>Picture Quality</td>
<td>Affects multiple frames</td>
<td>Single Frame only</td>
<td>Single Frame only</td>
</tr>
<tr>
<td>Dependency</td>
<td>Quality Loss</td>
<td>Quality Loss</td>
<td>Quality Loss - Possible w/o quality loss</td>
</tr>
<tr>
<td>Cascading (multiple encode/decode chains)</td>
<td>Quality Loss</td>
<td>Quality Loss</td>
<td>Quality Loss - Possible w/o quality loss</td>
</tr>
<tr>
<td>Error Correction</td>
<td>SMPTE-2022</td>
<td>SMPTE-2022</td>
<td>Under standardization</td>
</tr>
<tr>
<td>Transport Layer</td>
<td>MPEG-2 TS over UDP/RTP</td>
<td>MPEG-2 TS over UDP/RTP</td>
<td>MPEG-2 TS or MXF over UDP/RTP</td>
</tr>
<tr>
<td>License Scheme</td>
<td>Yes</td>
<td>Yes</td>
<td>Free</td>
</tr>
<tr>
<td>Open Technology</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
JPEG2000 versus MPEG-4 AVC (INTRA & IP)
Study conducted by Ali Jerbi, Ph.D

- **Purpose of study:**
  - Evaluate performance of these two compression technologies for HD sequences at a range of bitrates of ~50-250Mbps

- **Results:**
  - Recommendations for deployment of JPEG2k versus MPEG-4 AVC compression technologies for specific bitrate ranges
JPEG-2000 vs MPEG-4 I/IP

Conclusion

- **AVC Intra**
  - JPEG-2000 and MPEG-4 Intra performs *similarly* at high bitrates (100Mbps and higher)
  - MPEG-4 Intra generally *outperforms* JPEG-2k slightly at lower rates (50Mbps and lower)
  - When visual frequency weighing is enabled, JPEG-2k produces, in some cases, better visual quality than MPEG-4 Intra. Need to use QP scaling for MPEG-4 AVC for a more fair comparison

- **AVC IP-frames**
  - MPEG-4 AVC IP significantly outperforms JPEG-2k especially at low and medium rates (~80Mbps and lower).
  - May add one frame of latency.

- **JPEG 2000**
  - Very LOW latency at high bitrates
  - Robust, scalable quality, lossless compression
  - Inexpensive
JPEG2000 Compression Theory

Compression process

- Wavelet filtering
- Quantization
- Bitplane encoding
- Codestream building
JPEG2000 Compression Process

- **Tiling**
  - The image YCbCr can be split into tiles, rectangular regions of the image that are transformed and encoded separately. Typically one single tile is used. (full frame – best quality)

- **Wavelet based image compression standard**
  - A wavelet is a mathematical function used to divide the picture into different frequency components (sub-bands). Then wavelet coefficients are generated for all frequency sub-bands.
  - By itself the Wavelet Transform does not compress image data; it restructures the image information so that it is easier to compress

- **Quantization and Entropy encoding**
  - A study of each component with a resolution that matches the compression bitrate.
  - The quantized sub-bands are split into rectangular regions. Each of these rectangular regions are then further broken down into code blocks and then entropy coded. This is context modelling and arithmetic coding on a code block.
JPEG2000 Compression Theory

Wavelet Filters

- The filters are one-dimensional and are applied in the horizontal and vertical directions.

- JPEG2000 provides both lossy and lossless compression based on the filters applied.

- The Daubechies (9,7) floating point filter gives best compression performance.
  Called the irreversible transform

- The Le Gall (5,3) integer filter provides lossless compression
  Called the reversible transform

- Result of convolution process
  - The low pass filter removes all but the low frequency content.
  - The high pass filter can be considered as local Fourier transform.

Only lossy compression is currently foreseen to be used for IP contribution
JPEG2000 Compression Theory

The Wavelet filtering process

- The output contains a low pass copy of the input + 3 high pass subbands in the frequency domain.
- The result contains the same number of elements as the source image.
- The inverse process will rebuild the input picture provided the lossless filter pair is used.
- Compression is gained by an effective representation of the content in the low frequency sub band and the 3 HF frequency sub-bands.

Low pass filter
High pass filter
Downsampling
JPEG2000 Compression Theory

Wavelet filtering result

- High pass and low pass filters are applied to rows and columns, producing four sub-bands.
- Process is repeated on the “low low”, or LL sub-band.
The filtering is repeated multiple times in order to create a more bit effective representation of the LL subband.
JPEG2000 Theory
Wavelet Transform Example - Two Levels (Three Resolutions)

- The LL sub-band is the most important for recreating the image.
- Other sub-bands provide detail and resolution.
- Sub-bands are further divided into quality layers.
JPEG2000 Theory

Entropy Encoding

- For the bit rate selected, the optimal quality codestream is produced
- Possible because subbands are divisible into “quality layers”
- Entropy encoding determines how much of each quality layer is included

<table>
<thead>
<tr>
<th>Bit Rate</th>
<th>Quality Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>100Mbps</td>
<td>![100Mbps Quality Layers]</td>
</tr>
<tr>
<td>75Mbps</td>
<td>![75Mbps Quality Layers]</td>
</tr>
<tr>
<td>50Mbps</td>
<td>![50Mbps Quality Layers]</td>
</tr>
<tr>
<td>25Mbps</td>
<td>![25Mbps Quality Layers]</td>
</tr>
</tbody>
</table>
The combination of JPEG2000 compression and IP networks is a very good solution for high bitrate contribution of content.

Main advantages of JPEG2000 include:

- low latency
- high video quality (4:2:2 &10 bit video resolution)
- high error resiliency
DCM IP Video Gateway
DCM Gateway
Video over IP

- 1RU DCM with up to two gateway blades
  - Each blade has dual IP-ports equipped either with 1GbE SFP’s or 10GbE SFP+’s.
  - Up to 6 ports SD, HD 720p/1080i per blade
  - Optional J2K module
  - Up to 3 3G-HD 1080p per blade
  - Video ports can be electrical or optical
  - ASI transparent transport

- S/W licenses enable
  - More video channel processing
  - HD on top of SD, 3G on top of HD
  - 10Gig on top of 1Gig
    (+ exchange SFP to SFP+)
  - FEC (CoP4)

- Transport of video, embedded audio and VBI
- Advanced adaptive clock recovery & Gen-lock

- Very compact SDI gateway
  - 12 Video stream / 1RU
- Best in class IP connectivity and redundancy features
  - Hitless switchover (@1GbE) 100ms delay
- Unique upgrade path
  - S/W as well as H/W
  - Future proof investment
- Flexible & scalable architecture
  - Allows video quality improvements through software downloads
  - Allows adaptation to evolution of transport protocols through software downloads
  - Future proof investment
DCM Gateway
Front & Rear

DCM 1RU

- Mgmt IP1 (1GbE)
- Mgmt IP2 (10/100BT)
- PSU Slot1 (AC or DC)
- PSU Slot2 (AC or DC)
- GbE Port1 (GbE Port2 = BU Port)
- 6 Video Ports
- Loop through of any the of 6 video ports
- Alarm & PSU LEDs
- GPI I/O
- SFP cage will support SFP’s for 1GbE as well as SFP+ for 10GbE

Reference input for Gen-locking, B&B or Tri-level sync
DCM Gateway
Product Description – H/W modularity

- Fixed card connectors
  - SFP cages can house:
    - SFP for 1G
    - or
    - SFP+ for 10G
  - The Gateway card will support both types.
  - Add license to run 10G

- 3 types of front-ends
  - 3 x SDI OUTPUTS
    - or LoopThrough ports
  - 3 x SDI INPUTS
  - 3 SFP Cages (insertable)
    - Individually either OUTPUT or INPUT
  - Fixed Ref Input used as Clock Ref Input for SD & HD SDI Outputs.
  - B&B for SD, Tri-level sync for HD or mixed SD/HD
  - Fixed SDI Output Monitoring (LT) Output

ELECTRICAL

OPTICAL
DCM Gateway – JPEG 2K Plug-in
Codec Daughter Cards

“SDI Gateway”

- JPEG-2000 compression module
- Daughter board for “SDI gateway”
DCM Gateway
JPEG2000 Compression Engine

One common resource pool of 1.8Gbps – 6 inputs or 6 outputs

- **Examples:**
  - 6 video streams to a bit-rate of 300Mbps each, or
  - 5 video streams to a bit-rate of 360Mbps each, or
  - 4 video streams to a bit-rate of 450Mbps each, or
  - 3 video streams (HD/3G) to a bit-rate of 600Mbps each, or
  - 2 video streams (HD/3G) to a bit-rate of 900Mbps each, or
  - 1 video stream (3G) to a bit-rate of 1.8Gbps.
  - Or any combination that sums up to 1.8Gbps!

- **Notice,** that the uncompressed video processing can handle up to 6xHD/SD or 3x3G-HD.
**DCM Gateway**

**Video Quality Experience**

**Forward Error Correction (FEC)**
- Compute/send extra FEC bits, used to recover lost packets
- Some overhead and additional delay
- Use FC/FRR to bound protection period
- Most useful for recovering from intermittent packet loss, i.e., due to bit errors

**Spatial Redundancy (Live-Live)**
- Duplicate stream and send over disjoint paths
- Requires path diversity
- Most useful for recovering from burst losses, i.e., due to network failure events
- Multiple network technologies to support path diversity: MoFRR, MTR, MPLS TE
Due to network delay differences the two received streams are misaligned.

Misalignment is compensated for in the DCM Gateway receiver – up to 100ms, and a hitless switchover between the two feeds is performed in case of detected failures.
DCM Gateway
IP Port Redundancy

- **IP RX:** Based on link loss and UDP loss

- **IP TX:** Based on link loss
DCM Gateway
Service Redundancy

Principle Of Operation

- Monitoring at the ‘input service’ level: SDI
- Output takes services from source 1 (primary) and passes to output
- A problem with service 1 from source 1 (primary) – e.g. camera/cable failure
- Monitor detects “service loss” alarm (configurable) – e.g. SDI sync loss
- Service 1 output is replaced with Service 1 from Source 2 (backup)
D9093/D9094/D9894
AVC Contribution Codec
## Product overview Encoders

<table>
<thead>
<tr>
<th>Model</th>
<th>Input</th>
<th>Video</th>
<th>Audio</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D9054 HD AVC Encoder</strong></td>
<td>HD-SDI, Emb. Audio, 4 st. AES Audio</td>
<td>4:2:0 - MP4 CBR / VBR / Statmux 720p, 1080i</td>
<td>Up to 6 stereo, LII, AAC+, AC-3, Linear PT: Dolby-E, AC-3</td>
<td>ASI, IP (Dual 100BT)</td>
</tr>
<tr>
<td><strong>D9034 SD AVC Encoder</strong></td>
<td>SD-SDI, PAL/NTSC, Emb. Audio, 4 st. ana/AES audio</td>
<td>4:2:0 - MP4+PIP VBR / Statmux MP2 (s/w option)</td>
<td>Up to 4 stereo, LII, AAC+, AC-3, Linear PT: Dolby-E, AC-3</td>
<td>ASI, IP (Dual 100BT)</td>
</tr>
<tr>
<td><strong>D9032 SD MP2 Encoder</strong></td>
<td>SD-SDI, PAL/NTSC, Emb. Audio, 4 st. ana/AES audio</td>
<td>4:2:0 / 4:2:2 – MP2 CBR / VBR / Statmux Low delay, BISS-E</td>
<td>Up to 4 stereo, L II, AC-3, Linear PT: Dolby-E, AC-3</td>
<td>ASI, IP (Dual 100BT)</td>
</tr>
<tr>
<td><strong>D9040 SD MP2/AVC Encoder PowerVu</strong></td>
<td>SD-SDI, PAL/NTSC, Emb. Audio, 4 st. ana/AES audio</td>
<td>4:2:0 / 4:2:2 – MP2 MP4 (future) PNC Cntrl, Statmux</td>
<td>Up to 4 stereo, L II, AC-3, Linear PT: Dolby-E, AC-3</td>
<td>ASI</td>
</tr>
<tr>
<td><strong>D9050 HD MP2 Encoder</strong></td>
<td>HD-SDI Emb. Audio, 4 AES Audio</td>
<td>4:2:0 / 4:2:2 – MP2 CBR / Statmux 720p, 1080i</td>
<td>Up to 4 stereo, LII, AC-3, Linear PT: Dolby-E, AC-3</td>
<td>ASI</td>
</tr>
<tr>
<td><strong>D9022 SD MP2 Encoder CBR</strong></td>
<td>SD-SDI, PAL/NTSC, Emb. Audio, 2 st. ana/AES audio</td>
<td>4:2:0 – MP2 CBR Lowest cost</td>
<td>Up to 4 stereo, LII, AC-3, Linear PT: Dolby-E, AC-3</td>
<td>ASI, IP (Dual 100BT)</td>
</tr>
<tr>
<td><strong>D9093 D9094 D9894 Contribution encoder and decoder</strong></td>
<td>SD/HD-SDI, Emb. Audio, 1 st ana audio</td>
<td>MP4 4:2:0, 4:2:2 (fut), 525i/625i, 720p, 1080i, Latency &lt;500msec</td>
<td>Up to 4 stereo, LII and AAC, PT: D-E</td>
<td>IP (10/100/1000bT) + FEC Cop-3, ASI</td>
</tr>
</tbody>
</table>

Available now

Contact BU

Next Generation

SDI, HD-SDI, IP

MP2, MP4 SD, HD 4:2:0, 4:2:2

Up to 4 stereo, LII and AAC, PT: Dolby-E

IP (10/100/1000bT) + FEC Cop-3, ASI

(*) Shared resources in the platform
Low Delay Contribution
AVC Codec

D9094, D9093, D9894

- SD and HD support
  - HD AVC 4-27 Mbps (4:2:0)
  - HD AVC 12-38 Mbps (422csc)
  - SD AVC 1.3-10Mbps (4:2:0)

- Encode-Decode Latency as low as 280ms (ASI), 500ms (IP)

- 4 stereo channels
  - Layer II or AAC audio channels
  - DOLBY E & AC-3 pass-through

- DVB-S/S2, IF or L-band modulator

- ASI and IP transport w. FEC

- WEB based GUI and SNMP

- Low power

- Gen-lock in decoder

- **Market leading** audio/video MPEG-4 AVC codec that performs real-time transmission of HDTV at low bit rates and **low delays** over:
  - DVB-S/S2 or DVB-ASI
  - or broadband IP networks.

- **Powerful error correction** functions ensure high quality of service over IP networks by preventing the distortion of decoded images, even when network packet losses occur.

- **Flexible Codec architecture** allows user selection between encoder and decoder functionality
Low-delay AVC contribution codec
D9093, D9094, D9894

- D9093 SD Contribution AVC Codec
  - SD encoder & decoder
  - user switchable mode

- D9094 SD/HD Contribution AVC Codec
  - HD AND SD encoder & decoder - user switchable mode

- D9894 SD/HD Contribution AVC Decoder
  - Dedicated HD and SD AVC decoder

- Options
  - DVB-ASI card
  - DVB-S/S2 Modulator card (IF or L-band)
Hardware Description and Specifications

Front Panel

1. CF CARD slot – Future Option
2. LAN port (LAN)
   - Ethernet 10BASE-T/100BASE-TX
   - 1000BASE-T
3. LAN Status LED (LINK/ACT)
4. LAN Speed LED (100/1000M)
5. CONSOLE port (CONSOLE)
   - Ethernet 10BASE-T/100BASE-TX
   - 1000BASE-T
6. CONSOLE Status LED (LINK/ACT)
7. Speed LED (100/1000M)
8. Digital HDMI input (HDMI IN)
   - 50Ω unbalanced.
9. Digital HDMI output (HDMI OUT)
   - 50Ω unbalanced.
10. Power LED (PWR)
    - Turns on when the device is powered on.
11. Status LED (RDY)
    - Turn on when D9094 power is on.
12. AV input status LED (INDWN)
    - Audio/Video input setting status
13. Alarm LED (ALM)
    - Turns on when D9094 operation is abnormal.
14. Voice input/output (VOICE)
    - Voice communication (Intercom) port between
      D9094/D9894’s.
15. LCD panel
    - Used to set D9094 up and displays status
    - 2 lines x 20 characters.
16. LCD brightness controller
17. Directional key
18. Enter key (Enter)
19. Cancel key (Cancel)
20. Power button
**Hardware Description and Specifications**

**Rear Panel**

21. Power inlet connector (INPUT 100-240VAC)
22. AC cord clamp hole
23. FG terminal (FG) - Use for an FG connection to the device.
24. FAN - Maintenance-free FAN that cools the inside of the device.
25. Audio input (ANALOG AUDIO IN) (L), (R) - Balanced audio input terminal.
26. Audio input (ANALOG AUDIO IN) (L), (R) - Balanced audio input terminal.
27. Audio output (ANALOG AUDIO OUT) (L), (R) - Balanced audio output terminal.
28. Audio output (ANALOG AUDIO OUT) (L), (R) - Balanced audio output terminal.
29. RS-232C port (232C) - RS-232C data communication port.
30. SDI video input (SDI IN) - Digital HD-SDI video input terminal. 75Ω unbalanced.
31. SDI video output (SDI OUT) - Digital HD-SDI video output terminal. 75Ω unbalanced.
32. Video output (ANALOG VIDEO OUT) - Analog video output terminal. 75Ω unbalanced.
33. Reference clock signal input (GENLOCK IN) - External clock signal input terminal. 75Ω unbalanced.
34. Optional card slot
35. Blank panel - Remove when the optional card is equipped.
36. Screws
## D9094 Functional Features

### Main Encoder

- **HD**
  - **Profile**
    - MP@L4
    - HP@L4
    - CSC422 (Proprietary)
  - **Rate**
    - 4 to 27 Mbps (38Mbps @4:2:2)
  - **Resolution (59.94/50 Hz)**
    - 1080i x [960, 1440, 1920]
    - 720p x [640, 960, 1280]
  - **Encoding Control**
    - Quality (IBBP) – 1.38s (ASI)
    - Motion (IBP) – 1.38s (ASI)
    - Low latency (IPPP) – 650ms* (ASI)
    - Low latency (PPPP) – 300ms (ASI)

### Sub Encoder

- **SD**
  - **Profile**
    - MP@L3
    - HP@L3
  - **Rate**
    - 1.3 to 10Mbps
  - **Resolution**
    - 480i (59.94 Hz)
    - 576i (50 Hz)
  - **Encoding Control**
    - Quality (IBBP) – 1.38s (ASI)
    - Motion (IBP) – 1.38s (ASI)
    - Low latency (IPPP) – 650ms* (ASI)
    - Low latency (PPPP) – 300ms (ASI)

* TBC (still being tested)
Main Encoder Audio

- Audio Encoding Formats
  - 4 stereo pairs selectable out of 8 embedded pairs input
  - MPEG-1 Layer-2
    - 128kbs, 256kbs, or 384kbs per pair
    - Stereo/Dual mono selectable
  - MPEG-2 AAC
    - 64kbs, 128kbs, 256kbs per pair
  - Uncompressed
    - 2,304kbs per pair

- Audio Pass-through
  - Pass thru (SMPTE302M)
    - 2,304kbs per pair
  - Pass thru AC-3
  - Sampling
    - 48kHz
  - Quantization
    - 16bit (Compressed)
    - 20bit (Uncompressed)
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