New Technology

Apr, 2015
Panasonic Technical Approach for UHD/Network

1. 4K/8K Broadcast Situation

2. UHD TV Standard
   - BT.2020
   - HDR (High Dynamic Range)

3. 4K Signal Cabling
   - 6G, 12G SDI
   - Optical
   - IP Transmission

4. Single Sensor 4K Camera

5. Network Workflow
   - Dynamic Adaptive QoS Streaming
   - P2cast Service
1. 4K/8K Broadcast Situation
Channel Plan after 2018 will be decided at summer 2015.
Trial Broadcast may start by June 2016. TV Manufacturers will launch 4K TV with receiver in 2016.
The early launch of 8K TV receiver is under consideration.
Next Generation CAS system will be decided soon.
4K Broadcasting

- Korea: Start Trail broadcast by KBS and 3 Commercial stations
  - It is announced that 4K Broadcast will start from December, 2015.
  - KCTA (Cable TV Association): April 2014, KT Skylife (satellite): December 2014
- Europe: 4K Satellite Broadcast: December 2014 (NTV plus/SES Astra/Eutelsat)
  - SES Astra 4K Multi Ch on 2016, Eutelsat plan 4K broadcasting
- North America: Comcast plan 4K on Cable, DirecTV/HISPA SAT consider 4K Satellite

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<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>2nd 4K Trial Broadcast</td>
</tr>
<tr>
<td>2014</td>
<td>FIFA WC 4K Broadcast</td>
</tr>
<tr>
<td>2015</td>
<td>3rd 4K Trial Broadcast, Olympic Games, Asian Games, 4K Broadcast</td>
</tr>
<tr>
<td>2016</td>
<td>Olympic Winter, 8K Trial Broadcast</td>
</tr>
<tr>
<td>2017</td>
<td>FIFA WC 4K Broadcast</td>
</tr>
<tr>
<td>2018</td>
<td>Tokyo Olympic 4K Satellite Broadcast</td>
</tr>
<tr>
<td>2019</td>
<td>4K Broadcast</td>
</tr>
<tr>
<td>2020</td>
<td>8K Trial Broadcast</td>
</tr>
</tbody>
</table>

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- Korea (KBS, MBC, SBS, EBS)
  - Terrestrial (KCTA), Cable, (KT Skylife) Satellite
- Europe
  - Terrestrial
  - Satellite
- North America
  - Cable
  - Satellite

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- 4K Live Trial (BSkyB..)
- 4K Trial Broadcast (Terrestrial, Satellite) (France Television/French)
- French Open Tennis
- 4K Trial Broadcast (Abertis/Spain)
- Sochi W Olympic
- 4K Live Trial (NTV plus/Russia)
- 4K Trial Broadcast (NTV plus/Russia) (SESAstra/Czech/Eutelsat/French)
- 4K Broadcast (Comcast)
- 4K VOD Broadcast (DirecTV/HISPA SAT)
- 4K Broadcast (DirecTV/HISPA SAT)
- 4K Broadcast (DirecTV/HISPA SAT)
Super Hi-Vision (8K) Recorder

- Player and Recorder of 8K Dual Green signal
- Using four express P2 cards and micro P2 card
- AVC Intra 4K codec for 8K signal encoding
- 4U compact size

### Specification

<table>
<thead>
<tr>
<th></th>
<th>Video</th>
<th>Audio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td>Dual Green (59.94Hz)</td>
<td>SDI embedded or MADI max 32ch</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>Dual Green (59.94Hz)</td>
<td>SDI embedded, MADI</td>
</tr>
<tr>
<td><strong>8K Compression</strong></td>
<td>AVC Intra 4K (High 4:2:2 Intra @L5.2) x 2</td>
<td></td>
</tr>
<tr>
<td><strong>HD Proxy Compression</strong></td>
<td>AVC Intra 100 (High 4:2:2 Intra @L4.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Slot</strong></td>
<td>expressP2 card slot x 8 (4 cards per 1 group)</td>
<td>microP2 card slot x 2 (1 card per 1 group)</td>
</tr>
</tbody>
</table>
2. UHD TV Standard

BT.2020

HDR (High Dynamic Range)
**Rec.BT.2020** is standardized by ITU-R at 2012.
Frame Rate 120Hz
Wide Color Space (Rec.2020 Wide-gamut) is standardized.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Resolution</th>
<th>Sample Structure</th>
<th>Signal Format</th>
<th>Color Space</th>
<th>Bit Depth</th>
<th>Frame Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMPTE 428-1 4K-Cinema</td>
<td>4096x2160</td>
<td>4:4:4</td>
<td>XYZ</td>
<td>DCI-P3</td>
<td>12</td>
<td>24p</td>
</tr>
<tr>
<td>SMPTE 2048-1 4K-Digital</td>
<td>4096x2160</td>
<td>4:2:2, 4:4:4</td>
<td>YC&lt;sub&gt;B&lt;/sub&gt;C&lt;sub&gt;R&lt;/sub&gt;, YC&lt;sub&gt;B&lt;/sub&gt;C&lt;sub&gt;R&lt;/sub&gt;, RGB</td>
<td>Rec.709</td>
<td>10,12</td>
<td>24p/25p/30p/48p/50p/60p</td>
</tr>
<tr>
<td>ITU-R BT.2020 UHDTV</td>
<td>UHDTV1: 3840x2160</td>
<td>4:2:0, 4:2:2</td>
<td>YC&lt;sub&gt;B&lt;/sub&gt;C&lt;sub&gt;R&lt;/sub&gt;, YC&lt;sub&gt;B&lt;/sub&gt;C&lt;sub&gt;R&lt;/sub&gt;, RGB</td>
<td>Rec.2020 Wide-gamut</td>
<td>10,12</td>
<td>24p/25p/30p/50p/60p/120p</td>
</tr>
<tr>
<td></td>
<td>UHDTV2: 7680x4320</td>
<td>4:4:4</td>
<td>YC&lt;sub&gt;B&lt;/sub&gt;C&lt;sub&gt;R&lt;/sub&gt;, RGB</td>
<td>Rec.2020 Wide-gamut</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) 24p, 30p, 48p and 60p frame rates include 1/1.001
Cover 75.8% of the actual existing color

Reference White is D65.
HDR: High Dynamic Range

- The current Display Device can perform 1000nit (CRT has 100nit).
- Current 4K/UHD standard only cover 100nit.
- HDR is technology which will display the high brightness area by using the extending the peak level of the display device.
Rec.709

\[ V = \begin{cases} 
4.5L & \text{for } 0 \leq L < 0.018 \\
1.09L^{0.45} - 0.099 & \text{for } 0.018 \leq L \leq 1
\end{cases} \]

HDR

\[ V = \begin{cases} 
4.5L & \text{for } 0 \leq L < \beta \\
\alpha L^{0.45} - (\alpha - 1) & \text{for } \beta \leq L \leq \mu \\
\eta \ln(L) + \rho & \text{for } L > \mu
\end{cases} \]

Opto Electronic Transfer Functions

- Rec 709
- Knee (400%)
- Proposed (400%)
- Perceptual Quantiser

Luminance (relative to reference white)
Production flow for HDR
Based on High Dynamic range recording with V-Log shooting and grading process at Post production.

LIVE Broadcast flow for HDR
Camera will have OETF inside.
The sensor need the wide latitude as base performance.
### BDA HDR Standard (Mandatory part)

<table>
<thead>
<tr>
<th>HDR master spec</th>
<th>Color space</th>
<th>YCbCr BT.2020 (non constant luminance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits</td>
<td>10 bits</td>
<td></td>
</tr>
<tr>
<td>EOTF</td>
<td>SMPTE 2084 EOTF (10bits) and ITU (e.g. BBC EOTF)</td>
<td></td>
</tr>
</tbody>
</table>

**Peak luminance**
- “Maximum Average Luminance” not to exceed 400 nits.
- Over 1000 nits should be limited to specular highlights which are expected to be a small percentage of the picture area.

**Meta**
- Max/Min Luminance (static)
- Mastering display color volume SEI, Content peak luminance and Maximum Average Luminance
- Color Volume Mapping (dynamic) - No Mandatory (HDMI2.0), TBD (HDMI2.1)

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**Next Gen. Blu-ray disc**
- HDR Video Stream (HEVC 10bit)
- SDR Video Stream (HEVC 10bit)

**Next Gen. Blu-ray Device**
- HDR(SDR) Video Decoder
- HEVC 10bit Decoder (UHD/HD video)
- HDR => SDR Color mapping

**Next Gen. 4K/UHDTV (HDR Ready TV)**
- HDR color Mapping
- Display Panel unit
- 4K/UHD TV

*Note: decided by October (at the latest)*
3. 4K Signal Cabling

6G, 12G SDI
Optical
Video Over IP Transmission
4K/UHD electrical interface has been standardized in SMPTE
Multi-link 3G-SDI standards (ST 425-x) have been completed
Multi-link 6G/12G-SDI standards (ST 2081-x/ST2082-x) are under development
Standardization of Multi-link 24G-SDI (ST 2083-x) is planned

<table>
<thead>
<tr>
<th>4K/UHDTV1</th>
<th>Sampling Bit depth</th>
<th>Frame rate</th>
<th>3G-SDI ST 425-x</th>
<th>6G-SDI ST 2081-x</th>
<th>12G-SDI ST 2082-x</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:2:2 10 bit</td>
<td>24p, 25p, 30p</td>
<td>Dual-link</td>
<td>Single-link</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:2:2 10 bit</td>
<td>48p, 50p, 60p</td>
<td>Quad-link</td>
<td>Dual-link</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:2:2 10 bit</td>
<td>100p, 120p</td>
<td>Quad-link</td>
<td>Quad-link</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:4:4 12 bit</td>
<td>24p, 25p, 30p</td>
<td>Quad-link</td>
<td>Dual-link</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:4:4 12 bit</td>
<td>48p, 50p, 60p</td>
<td>Quad-link</td>
<td>Dual-link</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:4:4 12 bit</td>
<td>100p, 120p</td>
<td>Quad-link</td>
<td>Quad-link</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*1) 4K: 4096x2160, UHDTV1: 3840x2160
*2) 24p, 30p, 48p, 60p and 120p frame rates include 1/1.001.
UHD optical interfaces have been standardized in SMPTE ST 2036. Multi-link 10G optical interface employs the 10 bit payload compatible with the exiting SDI ST 2036. Multi-link 10G optical interface employs new 12 bit payload. Actual bit rate of 10G interface is 10.692 Gbps.

<table>
<thead>
<tr>
<th>Sampling Bit depth</th>
<th>Frame rate</th>
<th>Number of links</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 bit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHDTV1 4:2:2</td>
<td>24p, 25p, 30p</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>50p, 60p</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>100p, 120p</td>
<td>4</td>
</tr>
<tr>
<td>12 bit</td>
<td>24p, 25p, 30p</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>50p, 60p</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>100p, 120p</td>
<td></td>
</tr>
</tbody>
</table>

*1) UHDTV1: 3840x2160
*2) 24p, 30p, 60p and 120p frame rates include 1/1.001.
## Video Over IP

### Target
- Replace from SDI to IP
- Achieve with IP what we can not make with SDI

### Function
- High Quality Video over IP network
- Time Synchronization
- Clear Frame Remote Switching
- Remote control & Proxy Monitoring via the internet
- Easy-Cooperation with image recognition, analysis and tracking

![Diagram of Video Over IP](image-url)
Panasonic Strategy for VoIP

- Interoperable with other equipment
- Use open standard technologies
  SMPTE 2022, H.264, PTP etc…
- The right codec in the right use-case
  Uncompressed for time-critical case
  Light compression for lower delay
  H.264 (Intra / LongGOP)
- Simultaneous proxy monitoring
## Video Over IP Implementation

### The right codec in the right use-case

<table>
<thead>
<tr>
<th>Codec</th>
<th>HD</th>
<th>4K</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non Compression</strong></td>
<td>Manageable</td>
<td>—</td>
</tr>
<tr>
<td><strong>Light Compression</strong></td>
<td>—</td>
<td>1/4~1/6</td>
</tr>
<tr>
<td><strong>Intra</strong></td>
<td>H,264</td>
<td>H,264</td>
</tr>
<tr>
<td><strong>GOP</strong></td>
<td>H,264</td>
<td>HEVC</td>
</tr>
</tbody>
</table>

### Application

- **Broadcast Station**
  - High End Production
- **Live Event, Pro Video**
- **Transmission, Emission, Live Production**

### Protocol

- **Audio**: Embedded, AES67(TBD)
- **Redundancy**: SMPTE ST 2022-7
- **Sync**: SMPTE ST 2059-2
- **RTP Protocol**: SMPTE 2022-6

- **Common Basic Protocol**

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**Compatible Protocol**
4. Single Sensor 4K Camera
New Concept of 2/3” 4K Camera

- Combination of Large MOS sensor and embedded lens enable compact 4K camera with affordable pixel size.
- Capable to expand Dynamic range, HFR and High resolution with advanced DSC / Cinema camera technology.
- Capable to build high performance 1080p camera system with low budget.

◆ Large single sensor with expansion lens

Proto Type
Advantage of Large single sensor

- Large single sensor system capable of achieving high saturation (Dynamic range) under equal sensitivity condition compared to 3MOS system, VERY important factor for HDR system in UHD.
- Need to open IRIS in 2/3” 3 MOS system to avoid blur due to diffraction, since VERY high saturation characteristics is required.

◆ Specification

Sensitivity

- 2/3” 3MOS
- Large 1MOS

- Sensitivity becomes equal.
  (independent of sensor size)

Saturation (Dynamic range)

- 2/3” 3MOS
- Large 1MOS

- Large sensor has a high saturation

MTF specification

- MTF=50%
  HD: 5 Stop (F2~F11)
  4K: 2.5 Stop (F2~F4.8)
**Imbalance of Color Reproduction with Single Sensor**

**Spectra Characteristics**

- **3 Image Sensor**
- **Conventional Single Sensor**
- **New Developed Single Sensor**

Color Reproduction is deteriorated because of the energy leaking to the other channel on conventional system.

- **Color Filter**
- **New Pigment Material**
- **Optimize Thickness**

Color Spectra Characteristics is drastically improved.
Thank you
### 2/3” 4K Camera Comparison

<table>
<thead>
<tr>
<th>technology</th>
<th>Pix number</th>
<th>Pix size</th>
<th>Comparison</th>
<th>Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>3MOS</td>
<td>3840×2160</td>
<td>2.5μm</td>
<td></td>
<td>SONY</td>
</tr>
<tr>
<td></td>
<td>C 2000TVL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single MOS (w/Ex lens)</td>
<td>3840×2160</td>
<td>3.4–4.4μm</td>
<td></td>
<td>Panasonic</td>
</tr>
<tr>
<td></td>
<td>~4608×2592</td>
<td></td>
<td>1800TVL ~2000TVL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 1000TVL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single MOS With adapter</td>
<td>4096×2160</td>
<td>6μm</td>
<td></td>
<td>SONY F55 RED EPIC, etc</td>
</tr>
<tr>
<td></td>
<td>~4608×2592</td>
<td></td>
<td>1800TVL ~2000TVL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 1000TVL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 MOS with pixel shift</td>
<td>1920×1080</td>
<td>5μm</td>
<td></td>
<td>Hitachi System camera</td>
</tr>
<tr>
<td></td>
<td>C 1000TVL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3MOS system capable of achieving high resolution, however lower saturation cause of small pixel size.

3MOS system difficult to realize affordable system cause of cost and power consumption.

4 MOS with pixel shift incapable of achieving high resolution since RGGB pixel isolation is NOT enough, and system cost is high.
ITU-R HDR標準化動向

| Dolby提案 | ・最大輝度レベル: 10000 cd/m²  
|           | ・ガンマ特性: 視覚特性に基づいた独自のガンマ特性(PQ(*) Log カーブ)を規定し、Rec.709との互換性無し。(*)PQ: Perceptual Quantizer  
|           | ・ビット幅: 10,12ビット  
|           | ・HDR用メタデータ: 輝度レベルの最大値と最小値を規定  
| BBC提案  | ・最大輝度レベル: 6400 cd/m²  
|           | ・ガンマ特性: 輝度レベルが低い部分には、Rec.709ガンマを使用し、輝度レベルの高い部分にLog特性を追加。Rec.709のシステムでも使用可能。  
|           | ・ビット幅: 10,12ビット（12bitの1ビットはダイナミックレンジ拡大に使用）  
|           | ・HDR用メタデータ: 必要なし  
| NHK提案  | ・最大輝度レベル: 未定  
|           | ・基準ホワイトレベルを50%と規定し、50%以上のレンジをHDRとして使用  
|           | ・ガンマ特性: 50%のレベル(SDR)まではRec.709と同じガンマ特性を使用し、50%以上のレベル(HDR)は任意  
|           | ・ビット幅: 10,12ビット  
|           | ・HDR用メタデータ: 必要なし  

・テレビジョンの映像ダイナミックレンジの拡大（EIDR: Extended Image Dynamic Range）を審議中  
・EIDRの要求条件、枠組みが規定され、システムパラメータとして、「空間特性（解像度）」、「時間特性（フレームレート）」、「測色パラメータ」、「信号形式（ガンマ特性、最大輝度、基準白レベル等）」、「デジタル映像信号表現（ビット長等）」の検討中。

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  - ガンマ特性: 視覚特性に基づいた独自のガンマ特性(PQ*) Log カーブを規定し、Rec.709との互換性無し。（*）PQ: Perceptual Quantizer
  - ビット幅: 10,12ビット
  - HDR用メタデータ: 輝度レベルの最大値と最小値を規定

- BBC提案
  - 最大輝度レベル: 6400 cd/m²
  - ガンマ特性: 輝度レベルが低い部分には、Rec.709ガンマを使用し、輝度レベルの高い部分にLog特性を追加。Rec.709のシステムでも使用可能。
  - ビット幅: 10,12ビット（12bitの1ビットはダイナミックレンジ拡大に使用）
  - HDR用メタデータ: 必要なし

- NHK提案
  - 最大輝度レベル: 未定
  - 基準ホワイトレベルを50%と規定し、50%以上のレンジをHDRとして使用
  - ガンマ特性: 50%のレベル(SDR)まではRec.709と同じガンマ特性を使用し、50%以上のレベル(HDR)は任意
  - ビット幅: 10,12ビット
  - HDR用メタデータ: 必要なし
H.265/HEVC is proposed by JCT-VC as successor of H.264/MPEG-4 AVC. It is covered 4K/8K horizontal resolution and up to 120p frame rate.

It is aimed to obtain higher efficiency based on H.264 technology such as CABAC and Intra prediction.

While decode processing load is around 1 ~ 1.5 times compared to H.264, encode processing load is several times than H.264 and it varies which encoding tools are used.
H.264 vs HEVC comparison

-24% GOP 25M
-17% Intra 100M
-50% GOP 7M
Reducing the bitrate with keeping picture quality

Code Name  “DYNA”
AVC-ULTRA codec Chip

AVC-ULTRA

Quality & Resolution

4K

Class 4K4:4:4
12bit 24~30p

Class 4K4:2:2
4:2:2 10bit 24~60p

Class 4:4:4, 2K4:4:4
12bit 24~30p

Class 200, 2K4:2:2
4:2:2/10bit 24~60p

Class 100
4:2:2/10bit

HD

Class 50
4:2:0/10bit

Class G25, G50
4:2:2 10bit

Class G12
4:2:0 8bit

Mobile casting

Cable

News

Sports

TV episodic

Documentaries

Cinema

Efficiency

Twice as efficient as current MPEG2-GOP
H.265/HEVC positioning

• In the area of backhaul transmission or content delivery at relatively lower bit-rate usage, H.265 is coming into practical use as it enables bit-rate half compared to H.264.

• In the area of video production which requires higher quality, H.265 is limited benefit around 17% to 25%, while processing load for encoding is several times higher than H.264. Considering power consumption of mobile gear and editing process time by PC, it needs further progress of semiconductor and processor technology in order to reach in practical use, which will take substantial time frame.

For these reasons, we believe AVC-Ultra (H.264 base ) products will not obsolete in a short period.
Divide 4K/UHD image into four Sub images using 2-sample interleave
(Square division are also used in legacy products)
Each Sub image can be carried in a single-link 1.5G-SDI
Quad-link 1.5G-SDI is integrated into Dual-link 3G/Single-link 6G-SDI
<table>
<thead>
<tr>
<th>Codec</th>
<th>Class</th>
<th>Color sample</th>
<th>Bit depth</th>
<th>Full Resolution</th>
<th>Intra/Long</th>
<th>CBR/ VBR</th>
<th>File format</th>
<th>4K</th>
<th>2K</th>
<th>1080</th>
<th>720</th>
</tr>
</thead>
<tbody>
<tr>
<td>4K4:4:4</td>
<td>4:4:4</td>
<td>12bit</td>
<td>Yes</td>
<td>Intra</td>
<td>VBR</td>
<td>MXF</td>
<td>640M</td>
<td>800M</td>
<td></td>
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