The World’s First 8K/4K “Regular” Broadcasting

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• Introduction
• System overview
• Production/Post-production equipment
• Playout control/Transmission system
• Receiver
• Standards/Guidelines for HDR
• Future prospect
Introduction

History and Roadmap
Test broadcasting scheme
History and Roadmap

- 1995 NHK started R&D on UHDTV.
- 2002 8K first public demo at NHK STRL
- 2005 Public viewing at Expo 2015 Aichi
- 2006 First appearance at NAB show
- 2012 Rec. ITU-R BT.2020
- 2012 Showcasing at London Olympics
- 2013 National roadmap
- 2016 Test broadcasting via satellite
- 2016 Showcasing at Rio de Janeiro Olympics
Test broadcasting scheme

- Broadcasters
  NHK Aug. 1, 2016
  A-PAB* Dec. 1, 2016

- BSAT-3

- BS channel/transponder 17
  12.03426 GHz BW: 34.5 MHz

- Service channel: 8K/60p**
  1ch, or 4K/60p** 2ch

- Commercial receivers are under development.

* The association for Promotion of advanced broadcasting services
** with WCG, HDR, future extension for HFR

Report ITU-R BD.2397-0 Satellite transmissions for UHDTV satellite broadcasting
Regular broadcasting

- 7 hours daily operation
  NHK: 6 hours, A-PAB: 1 hour

- A number of programs in diversified genre are to be provided.

- Sets of program production equipment are required.

- A play-out control system is required.

An example of monthly program table
System overview

Core technologies
Format
Encoding
Transmission
# Core technologies

<table>
<thead>
<tr>
<th>Layer</th>
<th>Current HD service</th>
<th>8K/4K test broadcasting</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Format</strong></td>
<td>Video</td>
<td>2K/60i, 8bit</td>
<td>8K/60p*, 4K/60p*, 10bit</td>
</tr>
<tr>
<td></td>
<td>Audio</td>
<td>5.1, stereo, mono</td>
<td>22.2, 7.1, 5.1, stereo</td>
</tr>
<tr>
<td></td>
<td>Video</td>
<td>MPEG-2 Video</td>
<td>HEVC</td>
</tr>
<tr>
<td></td>
<td>Audio</td>
<td>MPEG-2 AAC</td>
<td>MPEG-4 AAC (LC profile)</td>
</tr>
<tr>
<td></td>
<td>MUX</td>
<td>MPEG-2 TS</td>
<td>MMT TLV</td>
</tr>
<tr>
<td><strong>Coding</strong></td>
<td>Modulation</td>
<td>TC8PSK</td>
<td>16APSK</td>
</tr>
<tr>
<td></td>
<td>FEC</td>
<td>CC+RS (2/3)</td>
<td>LDPC+BCH (7/9)</td>
</tr>
<tr>
<td></td>
<td>Rolloff</td>
<td>0.35</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Transmission</strong></td>
<td>Capacity</td>
<td>52 Mbps typ.</td>
<td>100 Mbps typ.</td>
</tr>
</tbody>
</table>

* with WCG, HDR, future extension for HFR
Format layer

- An ultimate form of two-dimensional television
- ITU-R Rec. BT.2020
  - UHD image: 7680 x 4320 (8K)
  - High frame rate: 120 Hz ready
  - Wide color gamut
  - Bit depth: 10
- ITU-R Rec. BT.2100
  - High dynamic range: Hybrid Log-Gamma
- ITU-R Rec. BS.2051
  - 22.2 multi-channel audio
Encoding layer

- HEVC
  - High compression efficiency
  - 72 Gbps -> 85 Mbps
- MPEG-4 AAC
  - 22.2 ch -> 1.4 Mbps
- MMT
  - Synchronization
    - multiple transmission paths
    - multiple display devices
  - Multiplexing
  - Reliability

http://www.rhk.or.jp/stf/conepoint/8kmmt_e.html
Transmission layer

- **ISDB-S3**: The state-of-the-art satellite transmission system specified in ITU-R Rec. BO.2098

- Large transmission capacity: 100 Mbps
  - Low Roll-off factor :0.03
  - Introduction of LDPC for FEC
  - 16 APSK

- Rain fade survivability
  - Stable reception for low C/N

- Transmission of variable length packets

- Robustness against satellite transponder nonlinearity
  - Worst-month service availability of 99.7% using a 45 cm receive antenna in Tokyo

<table>
<thead>
<tr>
<th>System</th>
<th>Rate</th>
<th>Roll-off Factor</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISDB-S</td>
<td>TC8PSK</td>
<td>2/3, $\alpha=0.35$</td>
<td>52.17 Mbps</td>
</tr>
<tr>
<td>ISDB-S3</td>
<td>16APSK</td>
<td>7/9, $\alpha=0.03$</td>
<td>100.49 Mbps</td>
</tr>
</tbody>
</table>

Report ITU-R BO.2397-0 Satellite transmissions for UHDTV satellite broadcasting
Production/Post-production equipment

- Camera
- Display
- Audio
- Recorder
- OB vans
- Post-production rooms
## Camera

### Image sensor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image size</td>
<td>Super 35 mm</td>
</tr>
<tr>
<td>Total pixels</td>
<td>7696 (H) x 4332 (V)</td>
</tr>
<tr>
<td>Active area</td>
<td>24.6 mm (H) x 13.9 mm (V)</td>
</tr>
<tr>
<td>Pixel size</td>
<td>3.2 μm x 3.2 μm</td>
</tr>
<tr>
<td>Bit depth</td>
<td>14 bit</td>
</tr>
<tr>
<td>Electronic shutter</td>
<td>Rolling</td>
</tr>
<tr>
<td>Signal output</td>
<td>SLVS 16 ch.</td>
</tr>
<tr>
<td>Package</td>
<td>816pin LGA</td>
</tr>
<tr>
<td>Power consumption</td>
<td>below 3 W</td>
</tr>
</tbody>
</table>

### Camera systems

- **Handy type**
- **Dockable type**

<table>
<thead>
<tr>
<th>Imaging</th>
<th>33Mpixel single-chip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>8K/59.94P, 4K/59.94P, HD/59.94i</td>
</tr>
<tr>
<td>Performance</td>
<td>F8@2000 Lux SNR 60dB</td>
</tr>
<tr>
<td>Functions</td>
<td>4K view finder</td>
</tr>
<tr>
<td></td>
<td>Focus assist</td>
</tr>
<tr>
<td></td>
<td>Auto chroma-aberration compensation</td>
</tr>
</tbody>
</table>

---


# Displays for monitoring

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Size/Type</th>
<th>Resolution/HDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main@Studio, Editing room, etc.</td>
<td>85” LCD</td>
<td>8K, HLG</td>
</tr>
<tr>
<td>Main@OB van</td>
<td>55” LCD</td>
<td>8K, HLG</td>
</tr>
<tr>
<td>Video Engineer, preview</td>
<td>17.3” LCD</td>
<td>8K, HLG</td>
</tr>
<tr>
<td>Video Engineer, Preview</td>
<td>30” OLED</td>
<td>4K, HLG</td>
</tr>
<tr>
<td>Camera VF</td>
<td>9.6, 12” LCD</td>
<td>4K, SDR</td>
</tr>
</tbody>
</table>
Audio

- 22.2 one-point microphone (upper left) to acquire sounds from 16 directions
- Live production mixer with 1000 tracks and 3D panning I/F
- Signal processor for headphone monitoring (upper right)

Recorder

- Second generation for more practical use
- Reduced in size and power consumption
- 4K compression technology applied
- Multi-format output

<table>
<thead>
<tr>
<th>Input signal</th>
<th>8K: 3G-SDI x 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output signal</td>
<td>8K: 3G-SDI x 8</td>
</tr>
<tr>
<td></td>
<td>4K: 3G-SDI x 4</td>
</tr>
<tr>
<td></td>
<td>HD: HD-SDI</td>
</tr>
<tr>
<td>Compression</td>
<td>AVC-Intra 4K/10bit</td>
</tr>
<tr>
<td>Media</td>
<td>8K: Memory card x 4</td>
</tr>
<tr>
<td></td>
<td>HD: Memory card x 1</td>
</tr>
<tr>
<td>Audio</td>
<td>SDI embedded /MADI</td>
</tr>
<tr>
<td>Capacity</td>
<td>65 min. (256GB x 4)</td>
</tr>
<tr>
<td>Size (mm³)</td>
<td>W432 x H176x D500</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>18</td>
</tr>
<tr>
<td>Power consumption (W)</td>
<td>152</td>
</tr>
</tbody>
</table>

## OB vans

### 8K Super Hi-Vision OB vans

- **SHC-1**
- **SHC-2**

<table>
<thead>
<tr>
<th>Size (m³)</th>
<th>L11.93 x W2.49 (+1m extension) x H3.33</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switcher/router</td>
<td>SHC-1: SH-VS110 / NV-8280</td>
</tr>
<tr>
<td></td>
<td>SHC-2: XVS-N8K / NV-8280</td>
</tr>
<tr>
<td>Production room</td>
<td>Main + Sub</td>
</tr>
<tr>
<td>VE room</td>
<td>18 Rack + Operation space 10 cameras, 4 replay SSDs, 4 recorders</td>
</tr>
</tbody>
</table>

### Audio production vans

- **TA-1**
- **SA-1**

<table>
<thead>
<tr>
<th>Size (m³)</th>
<th>L12.0 x W2.49 (+1.3 m extension) x H3.68</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix room</td>
<td>2.7 m Hight 22.2 ch audio</td>
</tr>
<tr>
<td>Mix console</td>
<td>mc2 66 MK2</td>
</tr>
<tr>
<td>Size (m³)</td>
<td>L11.5 x W2.49 (+1.3 m extension) x H3.49</td>
</tr>
<tr>
<td>Mix room</td>
<td>2.2 m Hight 22.2 ch audio</td>
</tr>
<tr>
<td>Mix console</td>
<td>NT-900</td>
</tr>
</tbody>
</table>
Post-production rooms

- **8K Video**
  - Editing, image-synthesizing
  - Color grading (HDR capable)
  - Telop work
  - 85” Video monitor
  - Binaural audio monitor
  - 22.2 ch headphone

- **22.2ch Audio**
  - DAW
  - MADI I/F
  - 22.2, 5.1, stereo
  - Audio-transparent screen
  - 8K projector
  - Listening environment


Playout control/Transmission system

System configuration
HEVC codec
MMT multiplexer
Satellite transmission
System configuration
Playout

- **Video:** 8K x 1ch or 4K x 2ch
- **Audio:** 22.2ch, 5.1ch, and stereo
- **Simultaneous deliver**
- **Video encode:** HEVC/H.265
- **Audio encode:** AAC@LATM/LOAS
- **Transport:** MMT/TLV
- **Time ref.:** Network time protocol
- **Program info.:** MMT-SI
8K HEVC Encoder

- Input video/audio
  - 8K/4K: Opt. (ARIB STD-B58)
    - 8K (Dual green): 3G-SDI x 8
    - 4K: 3G-SDI x 4
  - 22.2 ch (32 ch max.)

- Encode video/audio
  - HEVC/H.265 Main10@Level6.1
    - 60M-200Mbps (8K) 15M-160Mbps (4K)
    - HDR capable
  - MPEG4 AAC

- Output
  - MMT or MPEG-2 TS
Multiplexer

- MMT Mux
  - Multiplex MMT packets
  - Video, audio
  - EPG, closed caption, etc.

- TLV Mux
  - TLV packet generation from MMT packet
  - TMCC
Satellite Transmission

- Up-link
  - ISDB-S3 modulator
  - Linearizer
    - compensate TWT non-linearity
- BSAT-3
  - BS 17ch (12.03436 GHz)
  - 100% coverage in Japan
  - 45 cm receiving antenna
Receiver

STB
8K HEVC decoder LSI
Display panel
Audio
STB

- Channel: BS17ch, ISDB-S3
- Colorimetry: Rec. BT.2020
- HDR: Rec. BT.2100 (HLG)
- Closed captioning: Yes
- Multimedia: HTML5 Browser
- Input: RF, LAN, 3 USB
- Output: 8K (HDMI2.0 x 4) 22.2ch (HDMI x 3)
- Size(mm³): W435 x D617 x H170
- Weight(kg): Approx. 14
- Power consumption(W): 140

8K HEVC Decoder LSI

- Video format: 7680 x 4320/60P
- Input: PCI Express Gen2
- Output: HDMI 2.0 x 4ch
- On-board memory: DDR3 4GB x 4
- Size (mm²): 45 x 45

https://www.socionext.com/jp/pr/pr20160323_01.pdf
85” LCD panel

- Video: 7680 x 4320, 120Hz, 12bit
- Colorimetry: Rec.BT.2020
- Peak luminance: 1,000 nits
- Contrast ratio: 100,000:1 (local dimming)
- HDR: HLG, HDR conversion from SDR
- External input: 8K(HDMI 2.0 x 4), 4K

http://www.sharp.co.jp/business/8k-display/products/hv85001_feature.html
22.2 multi-channel audio reproduction

- Ideal speaker installation at home is not always possible.
- 22.2 ch reproduction with built-in loudspeakers
- Stereophonic method for front position channels
- Binaural signal processing for side and rear position channels
Standards/Guidelines for HDR

Requirements and Specifications
Operation
Requirements and Specifications

• Compatibility with existing SDR displays
  • A new service, but still a degree of compatibility is desirable.
  • It is recognized that HLG provides a good compatibility.

• Picture quality and bit rate increase
  • HEVC Main10 profile is used for high picture quality.
  • Objective test and experts’ observation indicate a similar range of bit rate to SDR can provide good HDR reproduction.

• HDR/SDR mixed programming
  • An identifier in multiplexed stream as well as VUI in video elementary stream was specified.
  • Recommended practices for smooth mode switching were specified.
Operation

- Video component descriptor in MMT is used as an identification of the transfer characteristics.

- HLG was selected as the HDR transfer characteristics, because of its compatibility with SDR.
Transfer functions switching

A display has to switch its transfer function during the interval.

Insert a video sequence such as black so that the switching causes no trouble.

- Encoder input
  - Program 1
    - Transfer function 1
  - Program 2
    - Transfer function 2

Switch timing

\[ \Delta t_1 \quad \Delta t_2 \]
Future prospect

Progresses between London and Lio
Next step in the roadmap
New satellite channel
Progress between London 2012 and Rio 2016


Toward commercial broadcasting in 2018

- **BS Right**-handed circularly polarized wave <In use> 4K
- **BS Left**-handed circularly polarized wave <New> 4K 8K
- **CS Left**-handed circularly polarized wave <New> 4K

New satellite channels

RF

Even channel transponders

Left-handed circularly polarized wave for even channels

Even

CS channel

Odd

Odd channel transponders

Right-handed circularly polarized wave for odd channels

BS channel

RF

IF

1032.23M

2070.25M

2224.21M

3223.25M

JEITA Label for 3224MHz capable equipment
Summary

• The World’s First 8K/4K “Regular” Broadcasting
• All parts of broadcast chain have been constructed.
• Many programs in various genre are being provided.
• Standards/Guidelines for practical HDR introduction
• Commercial launch is expected in 2018.

*Presentation materials: Courtesy of Ikegami, NHK, Sharp
Thank you.