HITACHI
Inspire the Next
Broadcast and Professional Cameras
Hitachi Kokusai Electric America
...and now a word from our sponsor...
Hitachi Limited

- Hitachi was founded in 1910
- Hitachi America started in 1959
- Over $90 Billion Annual Gross Revenue
- 335,000 employees World-wide

- Hitachi spends about $4 billion per year for R&D
- We receive the largest number of world patents per year.
Hitachi Divisions

Technology and Engineering EMMY® award for development of the single-chip MOS camera in 1982.
Hitachi Kokusai Divisions

- Broadcast and Professional: HD, 4K and 8K TV cameras
- IVS: Medical, Machine Vision & Surveillance cams
- Crucial Imaging: OEM custom imaging devices and software
- Comark: TV Transmitters, encoders
SK-UHD4000

World’s first 4K camera with 2/3” imagers allowing a standard B4 lens mount.
SK-UHD8060

5th Generation Super Hi-Vision System

Single 35mm imager.

7680×4320 pixels

4K OLED VF
EC710MP-BB

High-Efficiency, Low Power Solid State UHF Transmitter
New Camera Developments
Broadcast and Professional Cameras
Hitachi Kokusai Electric America, Ltd.

May, 2019

Atlanta Section
Once upon a time…
In a land not so far away…

• NTSC was the signal format
• …and all the signals were the same...
• …and if it was coax with a BNC connector...
• …everybody knew what the signal was...
• …and everyone was happy!
Now, it’s a Hybrid world

Rolling Shutter and Global Shutter Imagers

Multiple HDR profiles and SDR

Resolution at 2K, 4K & 8K

SDI vs. ST 2110
HDTV Television cameras at NAB

- 2/3” Global Shutter
- 1080 progressive
- Motorized filters
- SDR & HDR adjust
- 4K 12G upconverter
- ST 2100 VoIP
- Triax & SMPTE Fiber
- V Control w/Dashboard
Trends at NAB 2019

• 2/3” Global Shutter CMOS imagers
• High performance HDR displays. 8K displays are emerging.
• HDR is accepted, but how do we use it?
• 1080 60p is emerging de-facto standard for live events
• ST 2110 Media over IP Networks (VoIP)
• 4K cameras are mostly used in 1080p
• Cameras & lenses?
Agenda

1. Rolling Shutter vs. Global Shutter
2. High Performance Pro and Consumer Displays
3. High Dynamic Range
4. 8K Super High Vision
5. ST 2110 media networks
A sip of water from a fire hose.
Rolling Shutter & Global Shutter
Charge Coupled Device

• The CCD imager can hold a charge and shift it to an adjacent cell.
• The individual cells also respond to light while retaining the ability to shift charges.
Differences between CCD and CMOS

CCDs are analog and were (effectively) global shutter.

MOS & CMOS sensors are digital and have been rolling shutter.
With Rolling Shutter, the image is scanned sequentially, from the top to bottom, line by line.
Why do we have CMOS Rolling Shutter?

• Rolling shutter sensors provide good performance metrics while keeping costs down.

• Global-shutter sensor costs are dramatically higher.
Why do we need Global Shutter?

LED Walls and lights are controlled by Pulse Width Modulation. Our Persistence of Vision allows this to appear normal.

But it is visible by a camera with Rolling Shutter.

The relative frequency of the refresh rate, PWM vs. the camera shutter frequency can cause banding or other artifacts.
Rolling Shutter artifacts – LED Banding
Rolling Shutter artifacts – LED Banding
Rolling Shutter artifacts – LED Lighting
Direct View LED Video Wall - Moiré

Ways to control Moiré: Reduce sharpness:

• Diffusion filter in front of the lens - reduces camera resolution.
• Diffusion filter in front of the LED display - affects sharpness

• Lower the gain of the camera and open the iris to reduce the depth of field, putting the LED screen slightly out of focus.
Rolling Shutter – Image Skew

Straight lines appear as curved with Rolling Shutter. Straight lines appear as a blur on a Global Shutter camera.
Professional Displays & Consumer TVs
High Rez LED Displays .9mm pixel pitch
Professional Displays – Flanders Scientific

31” True 4K
Near 2020 WCG
3,000 nits HDR

PRODUCT of the YEAR
NABSHOW
Where Content Connects Life
Consumer TV Displays

• Price erosion causes fabs to increase panel size and pixel count.
  • They constantly need the “next big thing”.
• Consumer marketing purposely confuses buyers.
  • QLED vs OLED
    • Quantum dot is more about color, not contrast range.
• Consumer terminology purposely confuses buyers.
  • LED TVs are not LED, they are LCD with LED backlight
  • Big Screens and Micro LED Displays are really LED.
Size Matters – Consumer TV Displays

• The market for 75-inch and bigger TVs is expected to grow by 43 percent in 2019.
New 8K Consumer TV Displays

Sony 98” 8K TV. $70,000. ...With floor stand
Samsung has a 98” 8K TV. No price.
Unilumin UTVII 165”LED TV. $158K (discontinued)
Sony 8K Micro LED panels. 25’ diagonal.
High Dynamic Range

HD and HLG
HDR Misconceptions

*HDR is more about the display’s capability*

- HDR video is not the same as still image HDR.
- HDR is independent of resolution and color gamut.
- HDR is not more brightness, it’s detail in the tonal RANGE.
- HDR is not a format war. They all accomplish similar things.
- HDR can be compatible with today’s SDR displays.
SDR - HDR Comparison (Simulated images)
Why HDR is better than 4K alone

World-wide average TV viewing distance is about 9 feet.

• That’s too far away to see the full resolution of 4K.
  • 4K/UHD maximum viewing distance is about 6 feet for 65” TV
  • At average distance of 9’ the optimum size is 4K/UHD TV is 105”
Bandwidth For Picture Improvement

Bandwidth Increase

- 4K UHDTV
- High Frame Rate - 120FPS
- High Frame Rate - 60FPS
- Color Gamut
- 10-Bit Bit Depth

HDR 25%
History of Dynamic Range

The CRT characteristics are standardized as BT.1886. This limits the display’s peak white to 100 nits.

**BT.709 was established in 1934.**

Modern displays are capable of higher luminance, contrast ratio and wider color gamut than is employed in today’s program production.
Display Luminance

Luminance: 1 candela per square meter = 1 nit

- Black: 0 nits
- Cinema: 50 nits
- BT.709: 100 nits
- (HLG & PQ): 1,000 - 2,000 nits
- Pulsar: 4,000 nits
- Future: 10,000 nits

Luminance range: 0 - 10,000 nits

- 10 stops for Black to Cinema
- 16 stops for Cinema to Future

Luminance: 1 candela per square meter = 1 nit
HDR Quantization

A minimum of 10 bit quantization is required for HDR. It offers a wider range of tones and colors needed for HDR & WCG.
Wide Color Gamut

In 1931, CIE established the 2D Chromaticity Diagram.

CIE was first to describe the perception of colors in a quantifiable manner.

Rec.601 & Rec.709 are similar.

No current monitor or TV can display the full BT.2020 color gamut. (DCI-P3)
Visual Difference between HDRs (simulated)

- SDR: BT.709
- Static HDR-WCG: PQ (HLG)
- Dynamic HDR-WCG: DolbyVision
HDR / SDR Compatibility

HDR adoption requires how legacy SDR sets will display HDR.

**HLG – no metadata.** A more compatible “hybrid” curve for traditional TVs.
PQ curve is less compatible usually post produced. **Static (or no metadata).**
Dolby Vision is the least compatible. **Dynamic metadata and 12 bits.**

*It is unlikely that a single HDR will be best for all situations.*
Modern Flat Panels

Hybrid Log-Gamma is more similar to the BT.709 gamma curve up to 65%
The HLG curve follows BT.709 and is more compatible with SDR TV

Modern displays are capable of higher luminance, contrast ratio and wider color gamut than is allowed in production.
HLG & SDR Compatibility

4K HDR monitor (HLG)  HD SDR monitor (HLG)

HLG “Hybrid” Log-Gamma Curve is more compatible with SDR displays.
Using PQ on a SDR display would make the picture brighter at A and darker at B, creating a low contrast image.
PQ & SDR Compatibility

4K HDR monitor (PQ)  HD SDR monitor (PQ)

The PQ curve will appear grey, muddy & washed out on a SDR display.
Consumer support of HDR Profiles (2018)
HDR Workflow Considerations

Mixing various SDR sources in HDR Workflow?
HDR conversion to accurate SDR
Simultaneous HDR and SDR CCU output?
Live Workflow – Compatible HDR/SDR Shading?
Delivery of SDR and HDR?
Multiple format signal feeds?
Broadcast Delivery of Simultaneous HDR and SDR?
Mixed Sources in HDR Production

Live production must handle many different sources and intermix HDR & SDR material.
HDR/SDR Conversion

Required conversions for Broadcast HDR to SDR formats

- Dynamic Range: BT.2100 ➔ BT.709/BT.1886 (display)
- Color Space: BT.2020 ➔ BT.709
- Bit Depth: 10 bit ➔ 8 bit (Broadcast)
- Spatial Resolution: 2160 (4K) ➔ 1080/720 (HD)
- Temporal Resolution: 60 Hz Progressive ➔ Interlace
- Video coding: HEVC ➔ MPEG-2 (Broadcast)
Camera HDR & SDR Outputs

Hitachi 4K and 2K Cameras have two simultaneous outputs. Each CCU output is individually adjustable from Remote.
The camera exposure is adjusted for the HDR output. The SDR signal is derived by using an inverse gamma curve. Gain is lowered about -9 dB, followed by a conventional BT.709 OETF.
HDR and SDR shading...

Camera video shaders should adjust the picture for the SDR image.

If SDR is correct, HDR will be OK. The SDR lies within HDR.

However, shading **only for HDR** may clip the SDR picture.
Simplified Live Delivery of SDR/HDR

CU-UHD4000

Inverse Gamma/Gamut Mapping

Mobile Production Truck

SDR Feed

Master Control distribution

3D LUT

SDR Feed

HDR Feed
Multiple Feed Signals

The 4K HDR signal has to be converted to HD SDR for wide distribution.

Camera shaders manage cameras primarily using SDR monitoring from the CCUs. The HDR signals will track the offset iris adjustments made for SDR.
Broadcast SDR/HDR Delivery

Stations will be able to deliver simulcast HDR/SDR with ATSC 3.0

**ATSC 3.0 A/341 Standard – SL-HDR1**

Technicolor’s Single Layer (HDR1)

Encodes a SDR signal with HDR metadata for transmission

Provides SDR & Reconstruction of HDR signal at the TV receiver.
8K Super High Vision  7,680 x 4,320
Panasonic 8K camera with ROI cutout ...and movement tracking.
Hitachi 8K = 7,680 x 4,320 High Speed

- One frame is 32-megapixel
- RGB, 10 bit, 59.94 = 60 Gb data rate
- 240 Gbps. Uses a new type of multi-strand fiber cable
True 8K box lens. 7.5:1 zoom. $500,000
Shown under glass
Managed, High Bit-Rate, Real-Time, Professional Media Networks
SMPTE ST 2110
Serial Digital Interface

SMPTE Standardized SDI in 1989
12G standardized in 2015

BNC connector was patented in 1951

SDI Drawback: send or receive a single signal
CU-HD1300 CCU - Today
CU-HD1300 CCU - Someday

Video 4K & HD, Sync, PIX/WFM, Prompter, VF Returns, Remote, Audio out, Intercom, Tally

ST 2110
The Beginning… ST 2022

Video is steady signals using full bandwidth. Not available previously

2022 Packetizes SDI data into 1 stream
Easy conversion from SDI
Typically MPEG-2 compressed
Requires SDI to be reconstructed/de-embedded

ST 2110 supported by Hitachi CU-HD1300
ST 2110 Media is packetized separately for transport across a standard IP network.
ST 2110 Benefits

✓ Separate Audio, Video & Metadata Flows. Bandwidth efficiency
✓ Uses COTS equipment  *(Possible future cost reduction)*
✓ Un-Compressed (currently)
✓ Accurate Synchronization (PTP)
✓ Uses Existing & Industry Standards
✓ Flexibility, Availability, Scalability, Infrastructure reduction
## ST 2110 Suite of Standards

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Delivery Terminology

*Media over IP is a very large amount of continuous data:*

**Multicast** SMPTE ST 2110 uses “one to many” connections

**RTP** (Real-time Transport Protocol)

**UDP** (User Datagram Protocol)

**TCP** (Transport Control Protocol) / **IP** (Internet Protocol)
Precision Time Protocol

No need for separate signal paths for sync

PTP will allow devices to be precision slaved to a common master clock
Hybrid SDI/IP System

Small Form Factor Pluggable (SFP)
Converts SDI inputs and/or outputs to ST 2110
Plugs into Switch SFP ports. 1Gb, 10Gb and 25Gb
Professional Groups

AIMS - Alliance for IP Media Solutions
VSF - Video Services Forum
AMWA - Networked Media. Working.
IABM - International Association of Broadcasting Media and Technology
EBU - European Broadcasting Union
AES - Audio Engineering Society
SMPTE - Society of Motion Picture and Television Engineers
Standards Groups

**SMPTE ST 2110**
**SMPTE ST 2022**
**AES67**

**IETF RFC 4566 (SDP)**
**IETF RFC 791 (IPv4), RFC 2460/8200 (IPv6)**
**IETF RFC 793 (TCP), RFC 768 (UDP), RFC 3550 (RTP), RFC 2236/3376 (IGMP Multicasting)**

**IEEE 802.3 (Ethernet), 802.11 (WiFi), IEEE 1588 (PTP)**
**Cat 5 ANSI/TIA, ISO/IEC 11801 (Copper/Fiber)**
**ITU-T G.651.1 (Fiber), IEEE 802.11 (WiFi)**
AMWA NMOS

SMPTE ST 2110 clearly defines those devices on the network that can send and receive packets.

However, it does not currently specify control or application layers of the network.

Significant work is still needed to achieve useful interoperability and automation in professional networked media environments.
Questions?

https://www.hitachikokusai.com/Products/BroadcastandProfessionalCameras/BroadcastandStudioProductionCameras/

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