Digital Video for BICSI Folks

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Agenda

• Digital Video Signal Characteristics
  • EDID and HDCP
• Digital Signal Types
  • USB and HDMI
• Resolution and Color
• Transmission Methods
• Designs and Real World Applications
Digital Video Signal Characteristics
Introduction

• Technology is constantly evolving
  • Video formats
  • Communication
  • Collaboration
  • Mobile/wireless

• This evolution creates AV system design challenges
Signal Integrity

- Distance and quality – how far is too far?
- Cable quality – are all cables the same?
- Cables or electronics?
- Connections – how many connection points?
Signal Integrity

- Digital video signal loss – cliff effect
Digital Video Characteristics – Eye Diagram

- An Eye Diagram is formed by repeated sampling of a digital signal
  - The eye pattern is a useful tool in measuring overall signal quality
Digital Video Characteristics – Bit Errors

- The mask allows you to identify when bit errors occur
- The signal touching the mask is an indication of a bit error
Digital Video Characteristics – Loss

- Digital video signals consist of high speed transitions
- Very susceptible to degradation from:
  
  ![Diagram showing video signal transitions before and after degradation]

Cabling / System
Digital Video Characteristics – Loss
Digital Video Characteristics – Variables

- What is the quality of the signal from the source?
  - This information is not listed in the product’s specifications
Digital Video Characteristics – Variables

- Cables can vary widely in performance
  - Adapters are useful but may affect signal quality
Digital Video Characteristics – Variables

- What is the sensitivity of the receiving device?
  - This information is not listed in the product’s specifications
Product Interoperability

• The emphasis going forward is to build products that establish the best in interoperability
  • Working with equipment that might not meet the specifications
EDID
Extended Display Identification Data
EDID – Data

• EDID contains the following information:
  • Sink identity – device type, model number, etc.
  • Sink capability – video/audio
EDID – Sequence

1. Power on PC or activate external graphics card
2. Computer requests EDID data from display
3. Display sends EDID data to computer
4. Computer attempts to match display parameters
EDID Minder

- Provides communication to the connected source to ensure it boots up using the correct video/audio output parameters

Display’s EDID stored in the input switcher is provided to the PC during boot up
Scaler Solution

- BYOD equipment with Scaler/EDID Minder
  - Resolution management

- Reformats signal for system requirements
- Delivers consistent resolution to endpoints

EDID to 720p

HDCP-Compliant Video Scalar

Output to 1080p
EDID Management and Switching
Edid Minder

- Displays have different native resolutions
  - Most ideal Edid configuration depends on requirements
  - Advisable to select Edid from pre-stored settings for each source
# EDID Strategy

## System Description

<table>
<thead>
<tr>
<th>Sources</th>
<th>Format</th>
<th>Resolution</th>
<th>Refresh</th>
<th>ColorSpace</th>
<th>Audio</th>
<th>HDCP</th>
<th>Location</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>1 Lectern Laptop</td>
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## Destinations

<table>
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<tr>
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<th>ColorSpace</th>
<th>Audio</th>
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<td>3 Projector</td>
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</table>
HDCP
High-bandwidth Digital Content Protection
HDCP – Protocol

• HDCP protocol is a 3-phase process
  • Authentication
  • Content encryption
  • Renewability

• This can take a few moments depending on the number of downstream devices
Challenges: HDCP

- Many sources encrypt playback of high value content
- Content encrypted with HDCP
- Typical sources are:
  - Blu-ray players
  - Cable/satellite receivers
  - PC, Mac and iOS devices
- HDCP can negatively affect switching performance
- Some devices unnecessarily encrypt output
What If You Get It Wrong?

• Slow source switching
• Streamed content may not work as expected
• System may fail to display an image
HDCP Handshakes

- I/O authentication
HCDP Handshakes With Products That Are Not HDCP Compliant

- Visual confirmation
Backward Compatibility With HDCP 1.x

- HDCP 1.x source to HDCP 2.2 displays
  - Most HDCP 2.2 displays accept HDCP 1.x encrypted content
Backward Compatibility With HDCP 1.x

- HDCP 2.2 source to HDCP 1.x displays – content marked “High Value”
  - An HDCP 2.2 compliant source will not transmit high value protected content to HDCP 1.x displays
Backward Compatibility With HDCP 1.x

- HDCP 2.2 source to HDCP 1.x displays – content not marked “High Value”
Digital Signal Types
USB and HDMI
Digital Signals – USB

• A standard for communication protocols that includes cables and connectors
• Historically used for attaching peripheral devices to computers
Digital Signals – USB

• Over the years speeds have increased and USB supports video and audio transfer
  • USB 2.0 - 480 Mbps
  • USB 3.0 - 5 Gbps
• Providing additional options for transporting video and audio
USB Type-C

- Latest, high speed, reversible USB
- 10Gbps data rate (V3.1), V3.0 = 5Gbps
- Deliver up to 100 watts! Devices negotiate...
- Supports “alternate modes”... like DisplayPort
- “...beyond 20 Gbps in the future.”
  – Pres. USB-IF
USB 3.1 Types-C hub

- MacBook
- Chromebook
- Type-C Supply Power to Laptop
- Projector
- Display Monitor
- HD TV
- Keyboard/Mouse
- USB Drive
- Phone
- HDMI
- USB 3.1
Digital Video Signals – HDMI

• HDMI is an uncompressed digital video signal
  • Designed for the consumer market
• Adds support for:
  • Audio – stereo and surround formats (PCM, Dolby, DTS)
  • YCbCr color space – optional
  • HDCP – optional but recommended
  • CEC – Consumer Electronic Control – optional
  • InfoFrames
HDMI 2.0 and HDCP 2.2

• New functionality includes
  • Enables transmission of HDR – High Dynamic Range video
  • Signaling speed to 18 Gbps
  • 4K@50Hz/60Hz, (2160p)
    • 4 times the clarity of 1080p/60 video resolution
Resolution
4K / UHD and 1080p Video Signals
Resolutions

- Old Resolutions
- New standard 1080p
- Headed to 4K/UHD

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Pixels</th>
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<tbody>
<tr>
<td>SD</td>
<td>720x480</td>
</tr>
<tr>
<td>HD</td>
<td>1280x720</td>
</tr>
<tr>
<td>Full HD</td>
<td>1920x1080</td>
</tr>
<tr>
<td>2K</td>
<td>2048x1080</td>
</tr>
<tr>
<td>UHD</td>
<td>3840x2160</td>
</tr>
<tr>
<td>4K</td>
<td>4096x2160</td>
</tr>
</tbody>
</table>
4K Video Signal – What You Need to Know

• Data rate requirements determined by
  • Resolution
  • Refresh rate
  • Chroma sampling
  • Color bit depth
  • Maximum supported data rate
4K Signal Parameters

- **4K DCI is 4096x2160**
  - Four times the resolution of 2K DCI
  - Targeted towards digital cinema
- **4K refresh rates**
  - Varies – 24 Hz up to 60 Hz
- **Color bit depth**
  - 8-Bit, 10-bit, and 12-bit
- **Aspect Ratio**
  - 17:9 – same as 2K
Ultra HD Video Signal Parameters

- Ultra HD is 3840x2160
  - Four times the resolution of 1080p
  - Targeted towards consumer and broadcast markets
- Ultra HD refresh rates
  - Varies – 24 Hz up to 60 Hz
- Color bit depth
  - 8-Bit, 10-bit, and 12-bit
- Aspect Ratio
  - 16:9 – same as 1080p
4K and Ultra HD Resolution Comparison

- **SD**: (720 x 480)
- **HD**: (1280 x 720)
- **Full HD**: (1920 x 1080)
- **2K**: (2048 x 1080)
- **Ultra HD (UHD)**: (3840 x 2160)
- **4K**: (4096 x 2160)
Wide Color Gamut

- UHD proposes a significantly broader color space standard
  - Rec. 2020 supports a very wide color gamut

CIE 1931 chromaticity diagram
Ultra HD Color Bit Depth

- For UHD to achieve the full color spectrum of REC-2020, greater color bit depth is required

- 8-bit
  - 256 shades for each color
  - $256^3 = 16$ million colors

- 10-bit
  - 1024 shades for each color
  - $1024^3 = 1$ billion colors

- 12-bit
  - 4096 shades for each color
  - $4096^3 = 68$ billion colors
HDR – High Dynamic Range

- Produces video with a greater contrast range closer to what the human eye perceives
  - Color gamut is technically not part of HDR but goes hand in hand since greater contrast and brightness will display more colors
UHD Alliance Premium Certified

• Rating applied to displays that meet or exceed certain performance minimums for Ultra High Definition displays
  • Specs include High Dynamic Range and Wide Color Gamut, brightness and more
    • Resolution: 3840x2160 pixels
    • Color depth: 10-bit
    • Color gamut: Wide, including the ability to show at least 90% of the P3 color gamut
4K Applications with HDMI

- Optimal 4K parameters depend on the application

<table>
<thead>
<tr>
<th>Application</th>
<th>Refresh Rate</th>
<th>Color Bit Depth</th>
<th>Sub-sampling</th>
<th>Color Space Version</th>
<th>HDMI Version</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer/Residential</td>
<td>60Hz</td>
<td>8-bit</td>
<td>4:2:0</td>
<td>BT.709</td>
<td>1.4</td>
<td>Single Cable</td>
</tr>
<tr>
<td>Digital Signage</td>
<td>60Hz</td>
<td>8-bit</td>
<td>4:2:0</td>
<td>BT.709</td>
<td>1.4</td>
<td>Dynamic Content – Single Cable</td>
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<tr>
<td></td>
<td>30Hz</td>
<td>10-bit</td>
<td>4:4:4</td>
<td>BT.2020</td>
<td>2.0</td>
<td>Static Content – Single Cable</td>
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<tr>
<td>Corporate Presentation</td>
<td>30 Hz</td>
<td>8-bit</td>
<td>4:4:4</td>
<td>BT.709</td>
<td>1.4</td>
<td>Single Cable</td>
</tr>
<tr>
<td>Graphic Workstations</td>
<td>30Hz</td>
<td>8/10/12bit</td>
<td>4:4:4</td>
<td>BT.709/ BT.2020</td>
<td>1.4/2.0</td>
<td>Single Cable</td>
</tr>
<tr>
<td>Special Applications (Medical/VR/Military)</td>
<td>High Frame Rate (&gt;60Hz)</td>
<td>12/16bit</td>
<td>4:4:4</td>
<td>BT.2020</td>
<td>2.0</td>
<td>Multi-Lane signal paths</td>
</tr>
</tbody>
</table>
Transmission Methods
CAT Cable and HDBaseT
HDBaseT

- A Valens technology that enables the transport of multiple signals over a single twisted pair cable
- HDBaseT 5Play
  - Signal support – Video, Audio, Control, Power, Ethernet
  - Distance capabilities – 100m (328 feet)
  - Cable type – Shielded Twisted Pair
- Different implementations using HDBaseT (Valens)
  - 2-3-4Play – something less than all five signals
Why Use Twisted Pair?

• One twisted pair cable can carry multiple signals
  • Video
  • Audio
  • Bidirectional RS-232 control and IR
  • Ethernet
  • Remote Power
Twisted Pair Transmission

- Distance
  - 328 feet (100 meters) between endpoints
XTP Twisted Pair Transmission

- **Distance**
  - 328 feet (100 meters) between devices
Twisted Pair Transmission

- **Cable**
  - Supports CATx cable
  - Solid conductor, shielded twisted pair cable with shielded connectors should always be used
  - Skew-free cable **should not** be used with XTP Systems
Twisted Pair Signal Transmission

- Shielded cable protects against outside interference from:
  - Air conditioning units
  - Power from adjacent cabling
  - Crosstalk from other cables or within the same cable
  - Radio interference from walkie-talkies

- Symptoms of noisy environments
  - Image drop-out or flashing
  - No image at all
Twisted Pair Shielding

- Different types of twisted pair shielding

<table>
<thead>
<tr>
<th>Cable Name</th>
<th>Outer Shielding</th>
<th>Individual Pair Shielding</th>
</tr>
</thead>
<tbody>
<tr>
<td>U/UTP</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>F/UTP</td>
<td>Foil</td>
<td>None</td>
</tr>
<tr>
<td>U/FTP</td>
<td>None</td>
<td>Foil</td>
</tr>
<tr>
<td>S/FTP</td>
<td>Braided</td>
<td>Foil</td>
</tr>
<tr>
<td>SF/UTP</td>
<td>Braided &amp; Foil</td>
<td>None</td>
</tr>
</tbody>
</table>
Twisted Pair Signal Transmission

- **Types of Category cable**

<table>
<thead>
<tr>
<th>Cable</th>
<th>Gauge</th>
<th>Conductor</th>
<th>Outer Shield</th>
<th>Pair Shielding</th>
<th>Required Bandwidth</th>
<th>Crosstalk Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT 5e (U/UTP)</td>
<td>24</td>
<td>Solid</td>
<td>None</td>
<td>None</td>
<td>100 MHz</td>
<td>~27dB</td>
</tr>
<tr>
<td>CAT 5e (F/UTP)</td>
<td>24</td>
<td>Solid</td>
<td>Foil</td>
<td>None</td>
<td>100 MHz</td>
<td>~27dB</td>
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<tr>
<td>CAT 6 (U/UTP)</td>
<td>24-23</td>
<td>Solid</td>
<td>None</td>
<td>None</td>
<td>250 MHz</td>
<td>~37dB</td>
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<td>CAT 6 (STP)</td>
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<td>None</td>
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<tr>
<td>CAT 6a (SF/UTP)</td>
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<tr>
<td>CAT 7a (S/FTP)</td>
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<td>Solid</td>
<td>Braid and Foil</td>
<td>Foil</td>
<td>1 GHz</td>
<td>~60dB</td>
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</table>
Twisted Pair Installation

• Cable infrastructure and patch points
  • Up to 2 patch points recommended
Wireless
Wireless Video Applications

• Point-to-point applications where source video signal is converted to a modulated RF signal for wireless transmission to a receiver connected to a display

• BYOD applications where computing device encodes and transmits video content over a Wi-Fi network to a receiver connected to a display
Wireless Video Applications

- No computing device required – simple signal extension
  - Real-time performance – extremely low latency
  - High video quality – maintains resolution, refresh rate, color depth
  - Works with more types of video sources
  - Entire bandwidth is dedicated to video

- Wide availability of networking and compression technologies
  - Receiver is the only hardware required
  - BYOD devices already have Wi-Fi built-in
  - Loaded software can perform video compression
  - Mobile device acts as transmitter
Mirroring iOS Devices

- Works for Apple iPads and iPhones
- Use Control Center on your iOS device
  - Swipe ‘up’ for Control Center
  - Select ShareLink from Airplay Device List
  - Disconnect when done
Wireless Collaboration

- Simultaneously share up to 4 different devices
Design Exercises
Small Meeting Room

**AV Requirements**
- **AV Sources**
  - Multiple Laptops
- **Output Devices**
  - 4K Display

**Technical Requirements**
- Users will have ability to connect to system with laptops using HDMI, DisplayPort, or VGA
- Auto-switching between inputs
- System will use internal speakers of display for Audio support
Small Meeting Room
Executive Meeting Room

Technical Requirements

• Elegant meeting room with two displays
• Diverse connectivity at the table that supports HDMI, DisplayPort, and VGA
• PC and Blu-ray player will be available in the room
Executive Meeting Room
Lecture Hall

AV Requirements

Sources
• (1) 4K Laptop
• (6) Gooseneck Table Microphones

Output Devices
• (1) 4K Projectors
• (4) SF 26

Technical Requirements
• Point-to-point communications with support for HD 4K video, mono audio, and RS-232 control
• Long range transmission with little or no interference from a wide variety of outside interference