Digital Video for BICSI Folks

Karl Rosenberg
Regional Applications Specialist
Extron Electronics

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Agenda

• Digital Video Signal Characteristics
  • EDID and HDCP
• Digital Signal Types
  • USB and HDMI
• Resolution and Color
• Transmission Methods
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:
  - Cable attenuation
    - Cable capacitance
    - Cable resistance
    - Impedance mismatch
  - Noise coupling
  - Crosstalk
  - Jitter
- All factors that affect the receiver’s ability to distinguish high and low transitions
Digital Video Characteristics – Loss

• Difficult to anticipate
  • Image quality does not degrade like analog

• Cliff effect
  • Occurs when the receiver can no longer distinguish high and low values
    • Too many bit errors have occurred
EDID
Extended Display Identification Data
EDID – Data

• EDID contains the following information:
  • Sink identity – device type, model number, etc.
  • Sink capability – video/audio
    • Video timing parameters, color space, audio formats, etc.
• EDID also defines the data structure
  • Block 0 – 128 byte of hexadecimal data
  • Block 1 – additional 128 byte of hexadecimal data
    • Block 1 was added in version 1.3
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

1080p native
HDCP-Compliant Video Scalar

EDID to 720p
Output to 1080p

- Reformats signal for system requirements
- Delivers consistent resolution to endpoints
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
- Can be difficult to troubleshoot
HDCP Handshakes

- **I/O authentication**

![Diagram of HDCP Handshakes]

**Matrix Input**
- **HDCP Source**
- **Non-HDCP Source**

**Matrix Output**
- **HDCP Sink**
- **Non-HDCP Sink**

**Devices**
- **PC with DVI output**
- **4K Blu-ray with HDMI**
- **4K Display HDCP compliant**
- **Display Non-HDCP compliant**
- **4K Display HDCP compliant**

**Connections**
- **Authenticated**

**Flow**
- PC with DVI output → Digital Matrix Switcher → 4K Blu-ray with HDMI → 4K Display HDCP compliant
- PC with DVI output → Digital Matrix Switcher → 4K Display HDCP compliant
HCDP Handshakes With Products That Are Not HDCP Compliant

- **Visual confirmation**

![Diagram of HCDP Handshakes with Products That Are Not HDCP Compliant](image)
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
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 – Connectors, Distance, Communication**

- **HDMI**
  - Standard
  - Mini
  - Micro

**Mini**
- Added in HDMI version 1.3

**Micro**
- Max resolution 1080p

**HDMI specification does not define transmission distance**
- Cable performance has a direct bearing on distance

**EDID information is sent from the display to the source**
- Required by HDMI specifications
HDMI 2.0

• **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
  • Up to 32 audio channels with up to 1536 kHz audio sample frequency
    • 32 channels @ 48kHz each
  • Dual video streams on same screen, 4 audio streams
  • Support widescreen 21:9 format
  • Dynamic sync of audio/video
  • CEC extensions with expanded control via single point

• **Backwards compatible**
Resolution
4K / UHD and 1080p Video Signals
Resolutions

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

Standard Dynamic Range  High Dynamic Range
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>Digital Signage</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>30Hz</td>
<td>8-bit</td>
<td>4:4:4</td>
<td>BT.709</td>
<td>1.4</td>
<td>Single Cable</td>
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<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>
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<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>
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</table>
Transmission Methods
CAT Cable
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>
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</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>
</tr>
<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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<tr>
<td>CAT 6 (STP)</td>
<td>24-23</td>
<td>Solid</td>
<td>Foil</td>
<td>None</td>
<td>250 MHz</td>
<td>~37dB</td>
</tr>
<tr>
<td>CAT 6a (U/UTP)</td>
<td>24-23</td>
<td>Solid</td>
<td>None</td>
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<td>CAT 6a (F/UTP)</td>
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</tr>
<tr>
<td>CAT 6a (SF/UTP)</td>
<td>24</td>
<td>Solid</td>
<td>Braid and Foil</td>
<td>None</td>
<td>500 MHz</td>
<td>~37dB</td>
</tr>
<tr>
<td>CAT 7 (S/FTP)</td>
<td>24</td>
<td>Solid</td>
<td>Braid and Foil</td>
<td>Foil</td>
<td>600 MHz</td>
<td>~60dB</td>
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<tr>
<td>CAT 7a (S/FTP)</td>
<td>24</td>
<td>Solid</td>
<td>Braid and Foil</td>
<td>Foil</td>
<td>1 GHz</td>
<td>~60dB</td>
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</tbody>
</table>
Twisted Pair Installation

- Cable infrastructure and patch points
  - Up to 2 patch points recommended

Typical scenario for AV connectivity
Fiber
Benefits of Fiber in AV Systems

• Secure transmission
• Resistant to ground loops
• Low attenuation
• EMI/RFI immunity
• Lightweight
• Connector install speed
• Future-proof system
Fiber Optics Fundamentals

- A basic fiber optic system contains three parts
  - Transmitter (electrical to optical conversion)
  - Fiber optic cabling (light transmission)
  - Receiver (optical to electrical conversion)
Fiber Optic Cable Performance

- Fiber is categorized by performance and function
- Multimode fiber has four classifications
  - OM1 and OM2 fiber were built for LED systems
    - Typically supports up to 100 Mb networks
    - Low bandwidth performance
  - OM3 and OM4 are designed to work with LASERS
    - Supports 10 Gb networks
    - Can carry high bandwidth signals long distances
- Singlemode fiber has two classifications
  - OS1 and OS2
Fiber Optic Cable Performance

- Fiber Transmitter
- Fiber Receiver
- Multimode
- Singlemode
- Engineering
- Mathematics
- Physics
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

**Signal Extension**
- 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

**Collaboration**
- 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

**Moderator mode:** Controls content being displayed
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