

Video Engineering 101



What are we covering?

- Digital Video Standards
- Digital Video Interfaces
- Computer Video Standards
- VE Equipment and Concepts
 - Switchers, Genlock, Frame Sync, Routers, DAs, Scalers, Converters



Digital Video Standards

- Video Resolution

- The resolution of a digital image represents how many pixels are displayed in accordance to width x height. This can be described as horizontal lines (left to right) and vertical lines (top to bottom). As video consists of many rapidly displayed digital images, video resolution follows the same format.
- 1920 x 1080 = 1920 pixels wide x 1080 pixels high

- Aspect Ratio

- The aspect ratio of a digital image represents the proportional relationship between width x height size, described as a ratio.
- 720 x 480 = 4:3 1920 x 1080 = 16:9



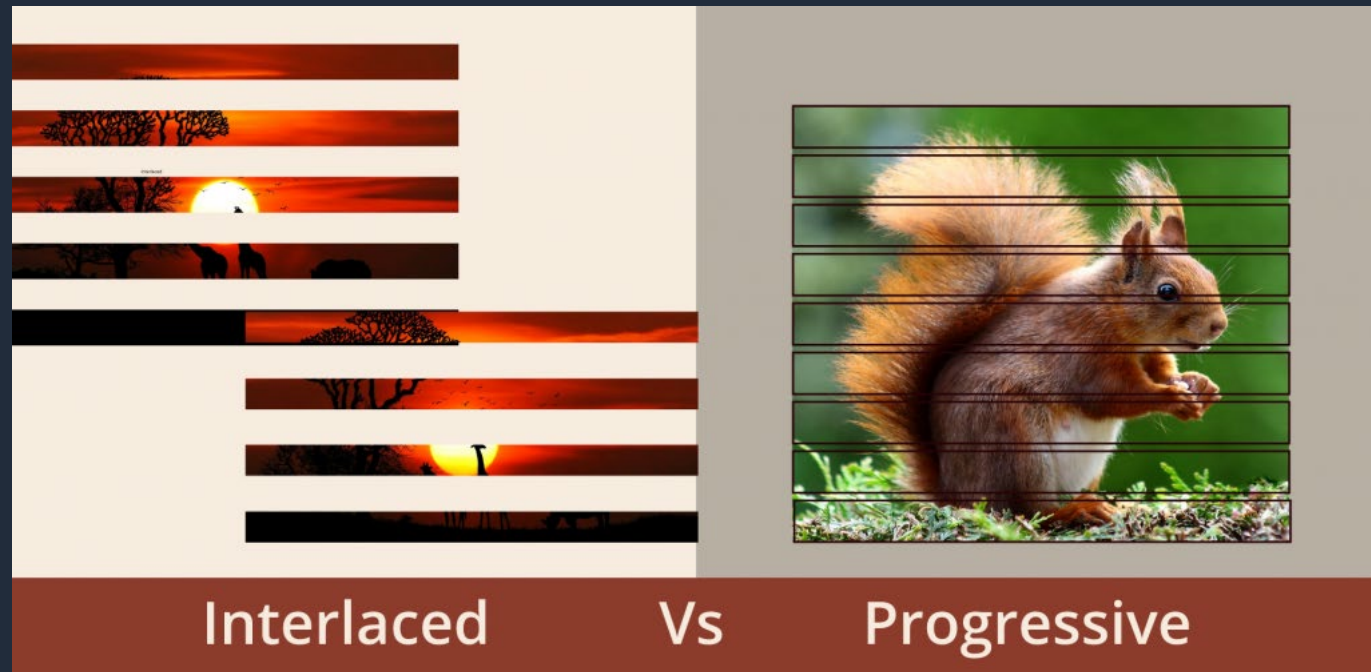
Digital Video Standards

- Frame Rates = Frames per Second

- A video 'frame' is one single digital image, built up of pixels. A video's frame rate is determined by how many frames are displayed within a one second period. Frames per second (FPS) is the measurement of a frame rate.
- 10 - 12 - perception of motion
- 24 - film
- 29.97 - Color Broadcast Video (dropframe timecode)
- 30 - B&W Broadcast video (historical) based on 60hz AC
- 59.94 - HD Broadcast Video (dropframe timecode)
- 60 - HD Broadcast Video (non-drop frame timecode)

Digital Video Standards

- SD Video 480i or 480p (720 x 480)
 - Interlaced Scan
 - 2 fields = 1 frame (odd + even fields)
 - Progressive Scan
 - 1 frame
- HD 720 P (1280 x 720)
- HD 1080i / 1080P (1920 x 1080)
- 2K (3840 x 2160) 30p
- 4K (3840 x 2160) 60p





Digital Video Standards

- Codecs – Compression/Decompression
 - A **video codec** is software or hardware that compresses and decompresses digital video. In the context of video compression, codec is a portmanteau of *encoder* and *decoder*, while a device that only compresses is typically called an encoder, and one that only decompresses is a *decoder*.
 - Apple ProRes and AVID DNxHD are available for use on video studio record decks.
- Software Container or Wrapper (.AVI, .MOV, .WMV)
 - Codec: HEVC / H.265, H.264, ProRes, DNxHD,
- Streaming Protocols: RTMP, RTSP, SRT (codec wrapper for network transport)
 - RTMP: Most common, used by Youtube, FaceBook, Vimeo, DaCast, Wowza, OBS Studio, Wirecast
 - RTSP: Less common today, used on streaming servers
 - SRT: Secure Reliable Transport, open-source low latency and supports encryption

Digital Video Interfaces - HDMI

- HDMI 1.4 - Support for increased resolutions – up to 3840 x 2160p at 25/30Hz and 4096 x 2160p at 24Hz (bandwidth up to 10.2 Gbps)
 - Support for the audio return channel (ARC). Allows the TV to send audio from an HDMI connection to an AV receiver or soundbar. Therefore, allowing an easy way to send this audio to a home theater sound system
 - Allowed for an Ethernet connection over HDMI – therefore allowing an internet or home network connection through the cables
 - Support for 3D TV signals
- HDMI 2.0 - Supported bandwidth increased to 18Gb per second
 - Added support for 4K Ultra HD resolutions at 60 frames per second
 - Support for the BT.2020 standard for UHD TVs
 - Support for up to 32 audio channels
 - Support for up to 1536 kHz audio resolution
 - Support for dual video streams to the same screen
 - Added support for 21:9 aspect ratios



Digital Video Interfaces - HDMI

- HDMI 2.1

- Added support for Dynamic HDR
- Support for 4K/120 and 8K/120 video resolutions
- Support for Display Stream Compression (DSC). This allows for Type A (uncompressed) and Type B (compressed) video
- Specified a new cable type – 48G. This supports a bandwidth of 46 Gb/s and uses HDMI type A (standard), C (mini) and D (micro) connectors
- Specified a new Enhanced Audio Return Channel (eARC). Allows the transfer of uncompressed and object-based audio from the TV to a home theater system via an existing HDMI connection. eARC also supports a new Auto Lip Sync feature.



Digital Video Interfaces - HDMI

| VIDEO FORMAT | | HDMI VERSION | | | | |
|--------------|-------------------|--------------|---------------|---------------|---------------|----------|
| RESOLUTION | REFRESH RATE (HZ) | HDMI 1.0-1.1 | HDMI 1.2-1.2a | HDMI 1.3-1.4b | HDMI 2.0-2.0b | HDMI 2.1 |
| 720p | 25/30 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 50/60 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 100/120 | ✗ | ✓ | ✓ | ✓ | ✓ |
| 1080p | 25/30 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 50/60 | ✓ | ✓ | ✓ | ✓ | ✓ |
| | 100/120 | ✗ | ✗ | ✓ | ✓ | ✓ |
| | 240 | ✗ | ✗ | ✗ | ✓ | ✓ |
| 1440p | 25/30 | ✗ | ✓ | ✓ | ✓ | ✓ |
| | 50/60 | ✗ | ✗ | ✓ | ✓ | ✓ |
| | 100/120 | ✗ | ✗ | ✗ | ✓ | ✓ |
| | 240 | ✗ | ✗ | ✗ | ✗ | ✓ |
| 4K | 25/30 | ✗ | ✗ | ✓ | ✓ | ✓ |
| | 50/60 | ✗ | ✗ | ✗ | ✓ | ✓ |
| | 100/120 | ✗ | ✗ | ✗ | ✗ | ✓ |
| 8K | 25/30 | ✗ | ✗ | ✗ | ✗ | ✓ |
| | 50/60 | ✗ | ✗ | ✗ | ✗ | ✓ |
| | 100/120 | ✗ | ✗ | ✗ | ✗ | ✓ |



Digital Video Interfaces

- HDBaseT

- HDBaseT is a standard for the transmission of ultra-high-definition video & audio, Ethernet, controls, USB and up to 100W of power over a single Cat6 cable.

- NDI

- Compressed Video over IP Protocol developed by NewTek
- 1 x stream SD video = 20 Mbps
- 1 x stream 1080p50/59.94 video = 125Mbps
- 1 x stream 720p50/59.94 video = 90Mbps
- 1 x stream UHDp30 video = 200Mbps
- 1 x stream 1080i50/59.94 video = 100Mbps
- 1 x stream UHDp60 video = 250Mbps

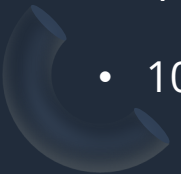




Digital Video Interfaces (SDI)

- SDI –
 - Serial Digital Interface (SDI) is a family of digital video interfaces first standardized by SMPTE (Society of Motion Picture and Television Engineers) in 1989. For example, ITU-R BT.656 and SMPTE 259M are defined for broadcast-grade video.

- SMPTE ST 2110 –
 - Designed to replace SDI.
 - Professional Media Over Managed IP Networks suite of standards
 - 10G network required



Digital Video Interfaces (SDI)

| Standard | Name | Introduced | Bitrates | Example video formats |
|---------------|------------------|------------|---|-----------------------|
| SMPTE 259M | SD-SDI | 1989 | 270 Mbit/s, 360 Mbit/s, 143 Mbit/s, and 177 Mbit/s | 480i, 576i |
| SMPTE 344M | ED-SDI | | 540 Mbit/s | 480p, 576p |
| SMPTE 292M | HD-SDI | 1998 | 1.485 Gbit/s, and 1.485/1.001 Gbit/s | 720p, 1080i |
| SMPTE 372M | Dual Link HD-SDI | 2002 | 2.970 Gbit/s, and 2.970/1.001 Gbit/s | 1080p60 |
| SMPTE 424M | 3G-SDI | 2006 | 2.970 Gbit/s, and 2.970/1.001 Gbit/s | 1080p60 |
| SMPTE ST-2081 | 6G-SDI | 2015 | 6 Gbit/s | 2160p30 |
| SMPTE ST-2082 | 12G-SDI | 2015 | 12 Gbit/s | 2160p60 |
| SMPTE ST-2083 | 24G-SDI | | 24 Gbit/s | 2160p/4k@120,8k@60 |

Video Cabling

- Length restrictions
 - Category Cable - 100M (330 ft.) - HDBaseT, NDI
 - Fiber Cable - Multimode 400M (1300 ft.) / Single Mode 10km
 - HDMI - passive up to 50 ft. / active 100M (330 ft.) or even longer
 - SDI - dependent on cable rating and signal type
 - 12G rated SDI cable can send 12G-SDI signal (4K) up to 100M (330 ft.) or 3G-SDI signal (1080p) up to 161M (528 ft.)
 - Check the manufacturers cable specs. (Belden, Canare, etc)



Computer Video Standards

- VGA – 640 x 480 – Video Graphics Array (4:3)
- SVGA – 800 x 600 – Super Video Graphics Array (4:3)
- XGA – 1024 x 768 – Extended Graphics Array (4:3)
- HD – 1280 x 720 – High Definition (16:9)
- WXGA – 1280 x 800 – Widescreen Extended Graphics Array (16:10)
- SXGA – 1280 x 1024 – Super Extended Graphics Array (5:4)
- UXGA – 1600 x 1200 – Ultra Extended Graphics Array (4:3)
- FHD – 1920 x 1080 – Full High Definition (16:9)
- WUXGA – 1920 x 1200 – Widescreen Ultra Extended Graphics Array (16:10)

Video Equipment

- Video Switcher

- device used to select between several different live video sources and, in some cases, compositing live video sources together to create visual effects, such as picture in picture and keying effects.



Video Switcher Compositing Effects



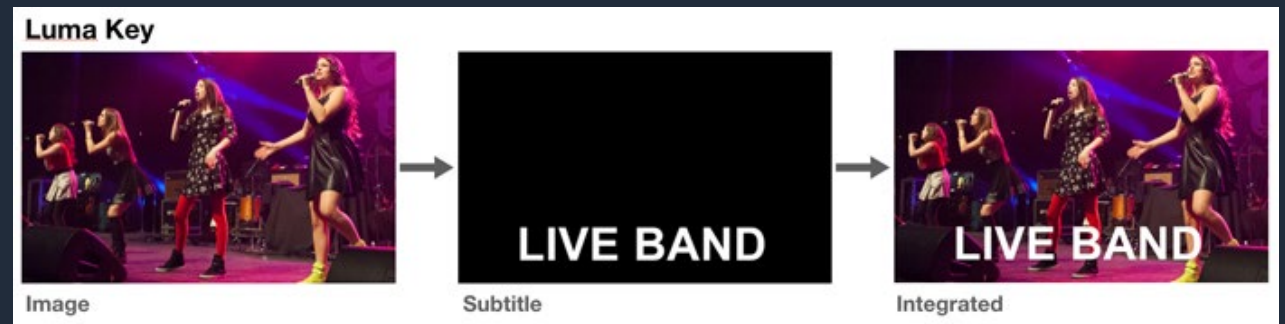
Picture in Picture



Chroma Keying



Alpha Keying (lower third)



Luma or Luminance Keying

Video Concept

- Upstream Key

- A key applied in a mix/effects bus. This is upstream of the video and any downstream keys. It is used for elements that appear as “part of the shot,” such as virtual sets.

- Downstream Key

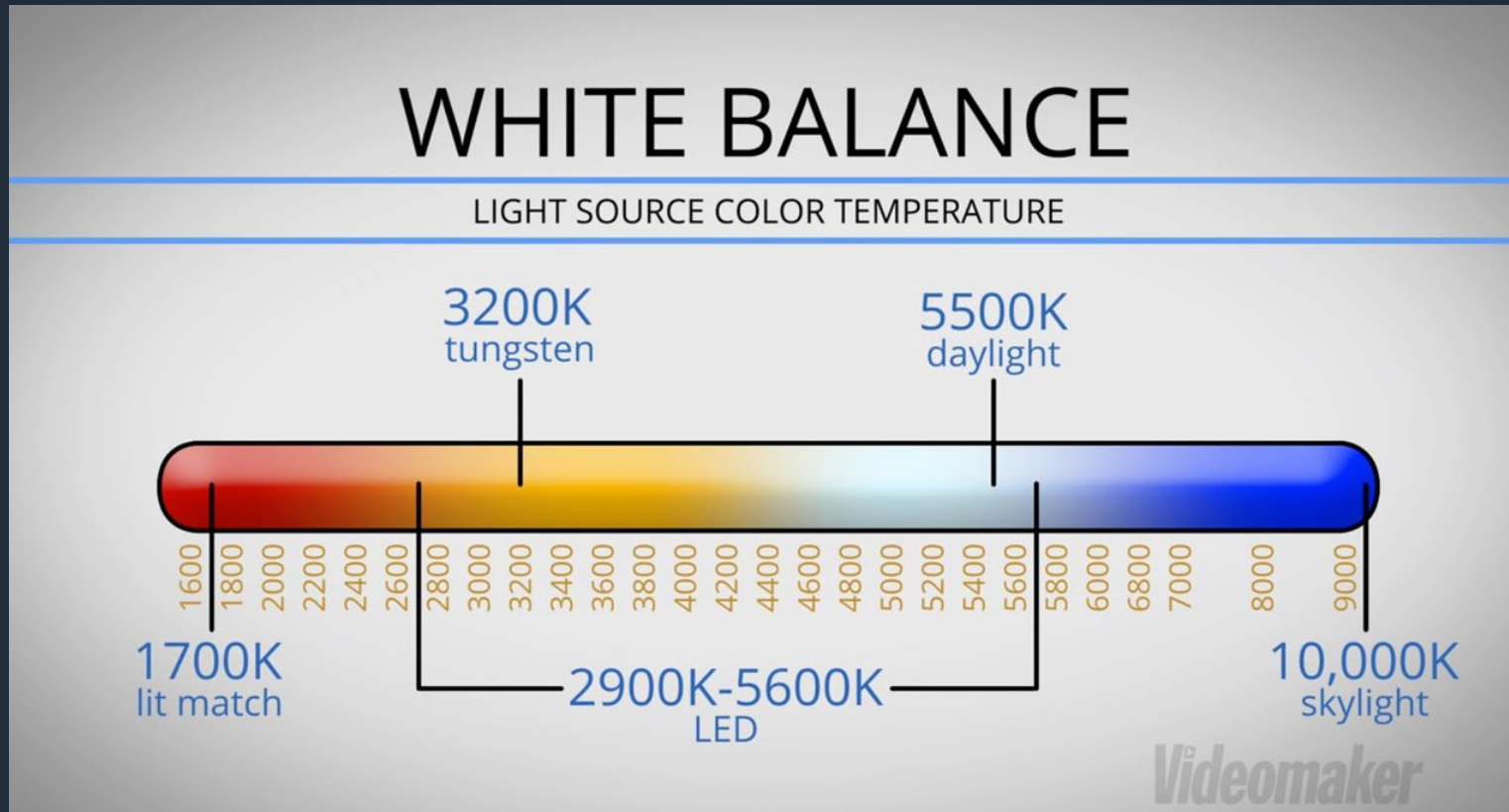
- This is a key applied after “everything else.” It is useful for adding static elements like log bugs and lower thirds, since the logo will remain superimposed “on top of” virtual sets or other composited elements.



Video Concept

- Color temperature

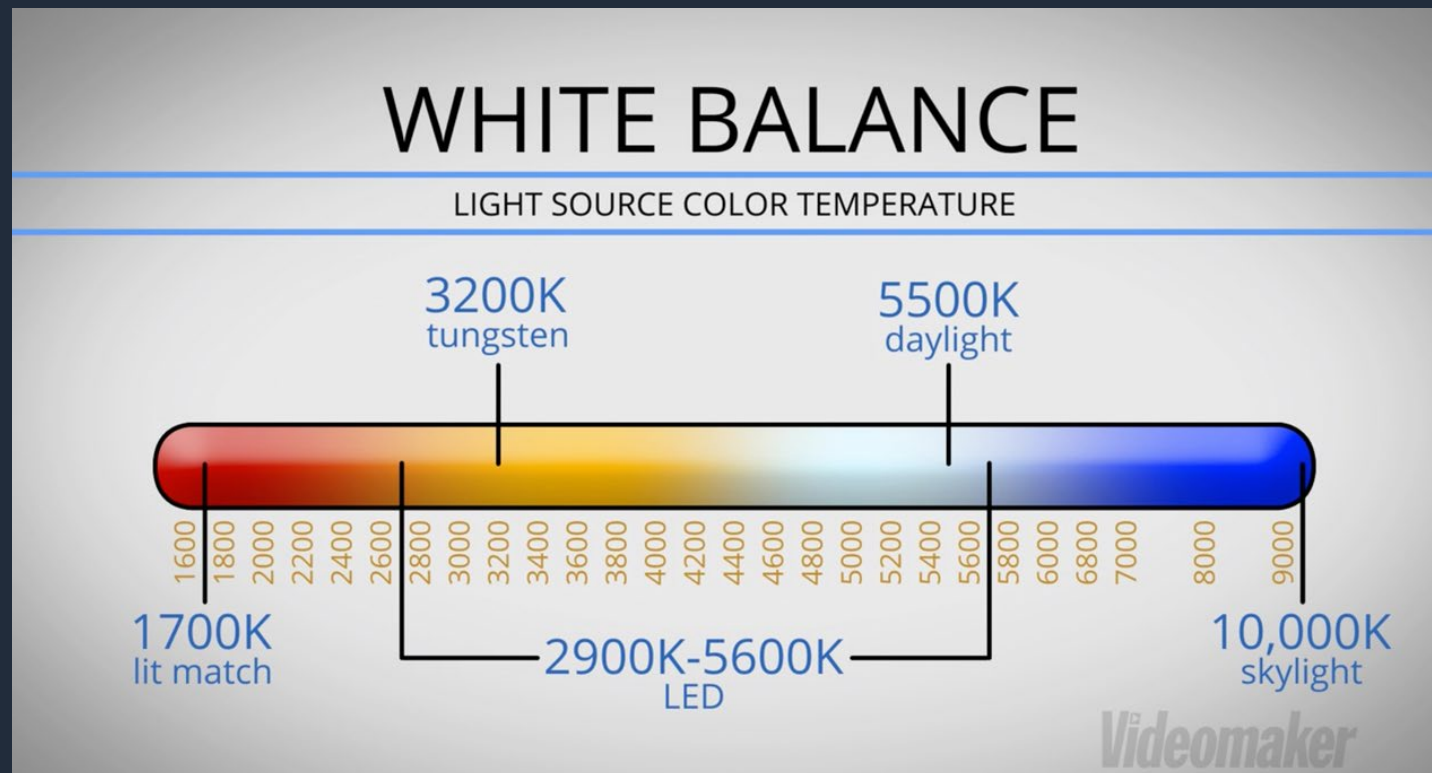
- The **color temperature** of a light source is the temperature of an ideal black-body radiator that radiates light of a color comparable to that of the light source.



Video Concept

- White Balance

- White balance is used to adjust colors to match the color of the light source so that white objects appear white. Subjects may be lit by a number of different light sources with different color temperatures, including sunlight, incandescent bulbs, and fluorescent lighting.



Video Concept

- Color Spaces


- An RGB color space is any additive color space based on the RGB color model. An RGB color space is defined by chromaticity coordinates of the red, green, and blue additive primaries.
- YUV is a color model typically used as part of a color image pipeline. It encodes a color image or video taking human perception into account, allowing reduced bandwidth for chrominance components, compared to a "direct" RGB-representation. Historically, the terms YUV and Y'UV were used for a specific analog encoding of color information in television systems.[1] Today, the term YUV is commonly used in the computer industry to describe file-formats (pixel formats) that are encoded using YCbCr.



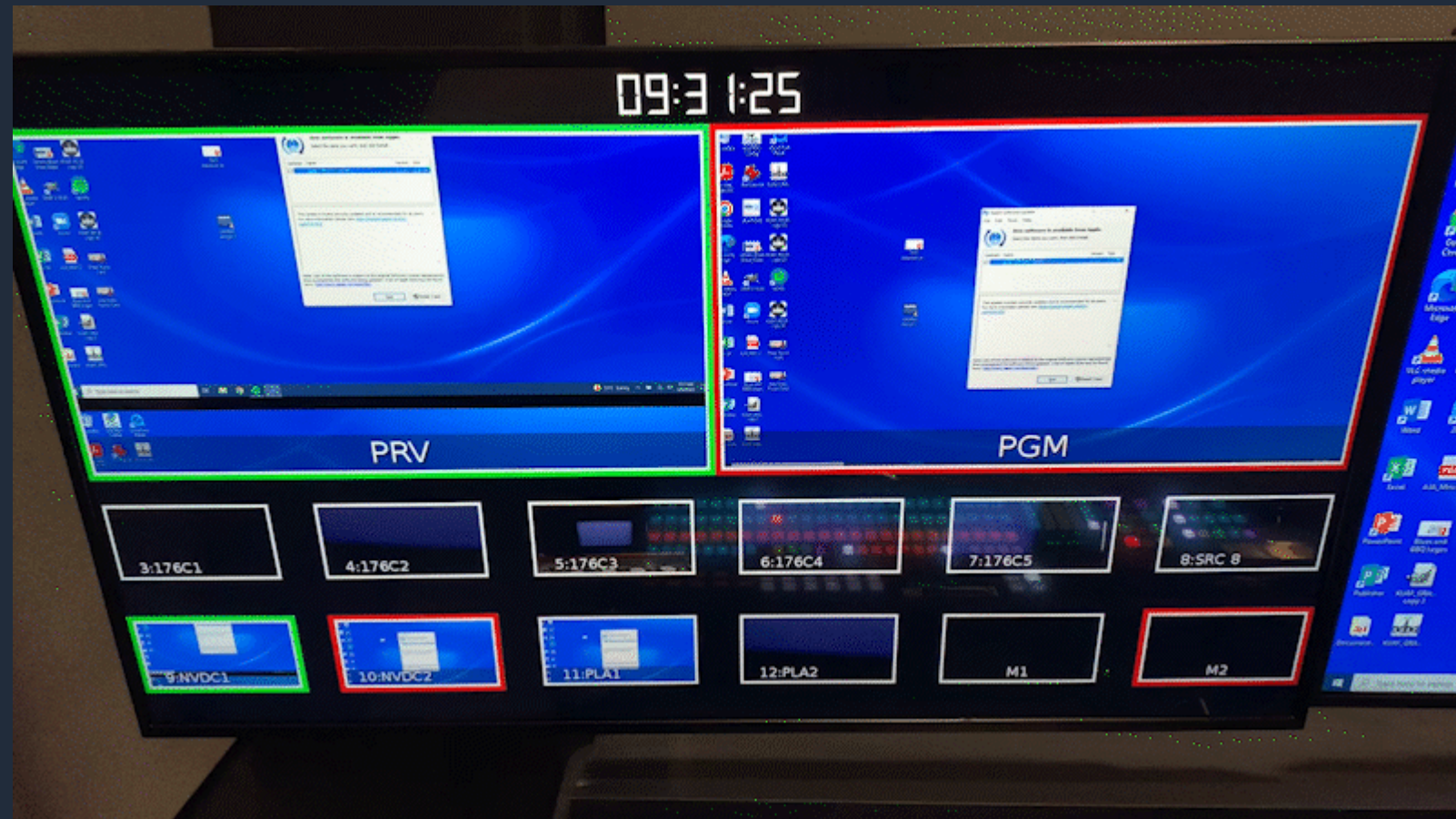


Video Concept

- Genlock & Tri-Level Sync

- **Tri-level sync** is an analogue video synchronization pulse primarily used for the locking of high-definition video signals (genlock)
 - **Genlock (generator locking)** is a common technique where the video output of one source (or a specific reference signal from a signal generator) is used to synchronize other picture sources together. The aim in video applications is to ensure the coincidence of signals in time at a combining or switching point. When video instruments are synchronized in this way, they are said to be *generator-locked*, or *genlocked*
- 

Non-Genlocked - Genlocked



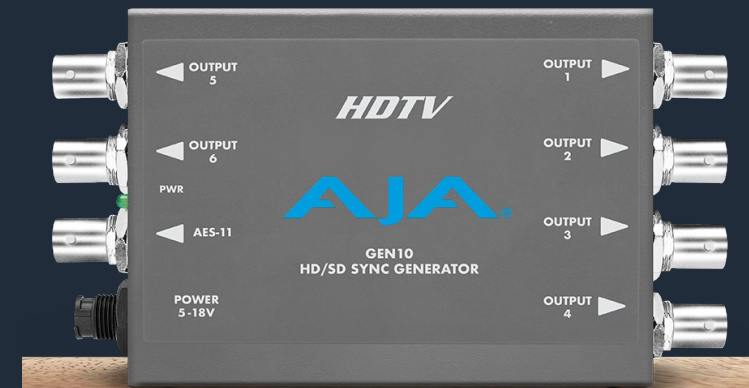
Video Engineer Tools

- Frame Synchronizers or Frame Syncs

- In video, **frame synchronization** is the process of synchronizing display pixel scanning to a synchronization source. When several systems are connected, a synchronization signal is fed from the synchronization source to the other systems in the network, and the video signals are synchronized with each other.

- Sync Generator

- A sync generator produces a central timing reference (Blackburst or Tri-Level) that is distributed throughout a facility. The central timing reference is used in video production to synchronize the timing of a video source signals. As a result, the timing or alignment of the video frame can be adjusted so that the start of the upper left corner scan line of the image occurs simultaneously on all video equipment in the network. This is an absolute requirement for both analog and digital systems in order to perform video effects or glitch-free source switching.



Video Concept

- Relationship between Sync Generators, Frame syncs and Genlock
 - All video systems need a synchronization source, typically provided by a sync generator. This sync source provides the timing signals to the video equipment to synchronize the start of each frame on each piece of equipment. If a piece of video equipment does not have a genlock input, (such as a laptop) then a frame synchronizer can be used to synchronize the timing of each frame of video.
 - Most video switchers will incorporate an optional frame sync for inputs.
 - The latest Blackmagic design switchers have frame syncs on each input as well as scalers, but require a frame's time to synchronize the inputs and outputs together. This can lead to a delay needed to be added (66.7 ms) to the incoming audio source (mixer) unless the audio is combined onto a video input (HDMI or SDI).



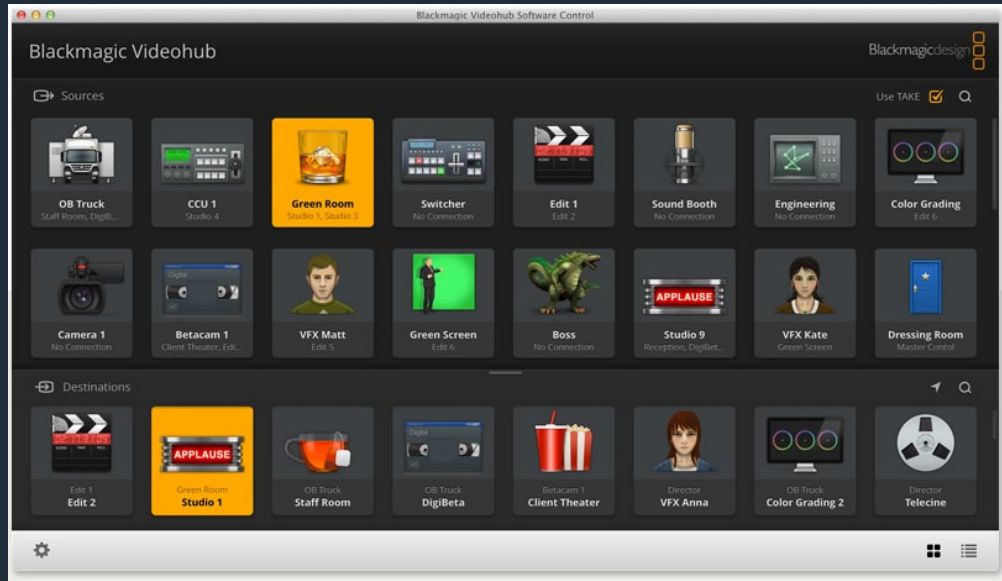
Video Engineer Tools

- Video Routers

- A **video router**, also known as a **video matrix switch** or **SDI router**, is an electronic switch designed to route video signals from multiple input sources such as cameras, VTRs, computers and DVD players, to one or more display devices, such as monitors, switchers, projectors, and TVs.
- Because any of the sources can be routed to any destination, the internal arrangement of the router is arranged as a number of crosspoints which can be activated to pass the corresponding source signal to the desired destination. Crosspoints can also be switched in the vertical interval to avoid losing picture information, for this the router would need to be genlocked to either blackburst or tri-level sync
- Any input (Source - SRC) to one or more outputs (Destinations - DST)



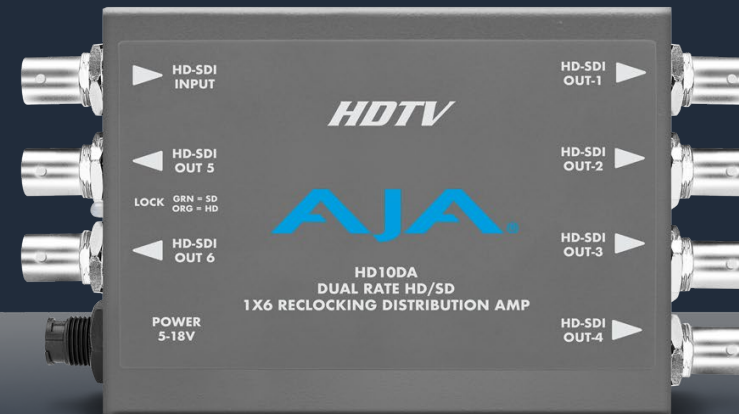
Video Routers



Video Engineer Tools

- Distribution Amps / Splitters

- A **Video Distribution Amplifier** (also known as a distribution amp, DA, or Splitter) takes a video signal as an input, amplifies it, and outputs the amplified video signal to two or more outputs. It is primarily used to supply a single video signal to multiple pieces of video equipment. It adjusts the amplitude of a video signal to compensate for loss of signal in a video distribution system.



Video Engineer Tools

- Scalers / Format Converters

- A **video scaler** is a system which converts video signals from one display resolution to another; typically, scalers are used to convert a signal from a lower resolution (such as 480p standard definition) to a higher resolution (such as 1080i high definition), a process known as "upconversion" or "upscaling" (by contrast, converting from high to low resolution is known as "downconversion" or "downscaling").



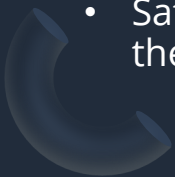
Video Engineering Tools

- Media Converters
 - Converts HDMI to SDI and vice versa
 - Some converters support SFP+ for video over fiber transmission
 - Note SDI version supported by converter (3G, 12G)



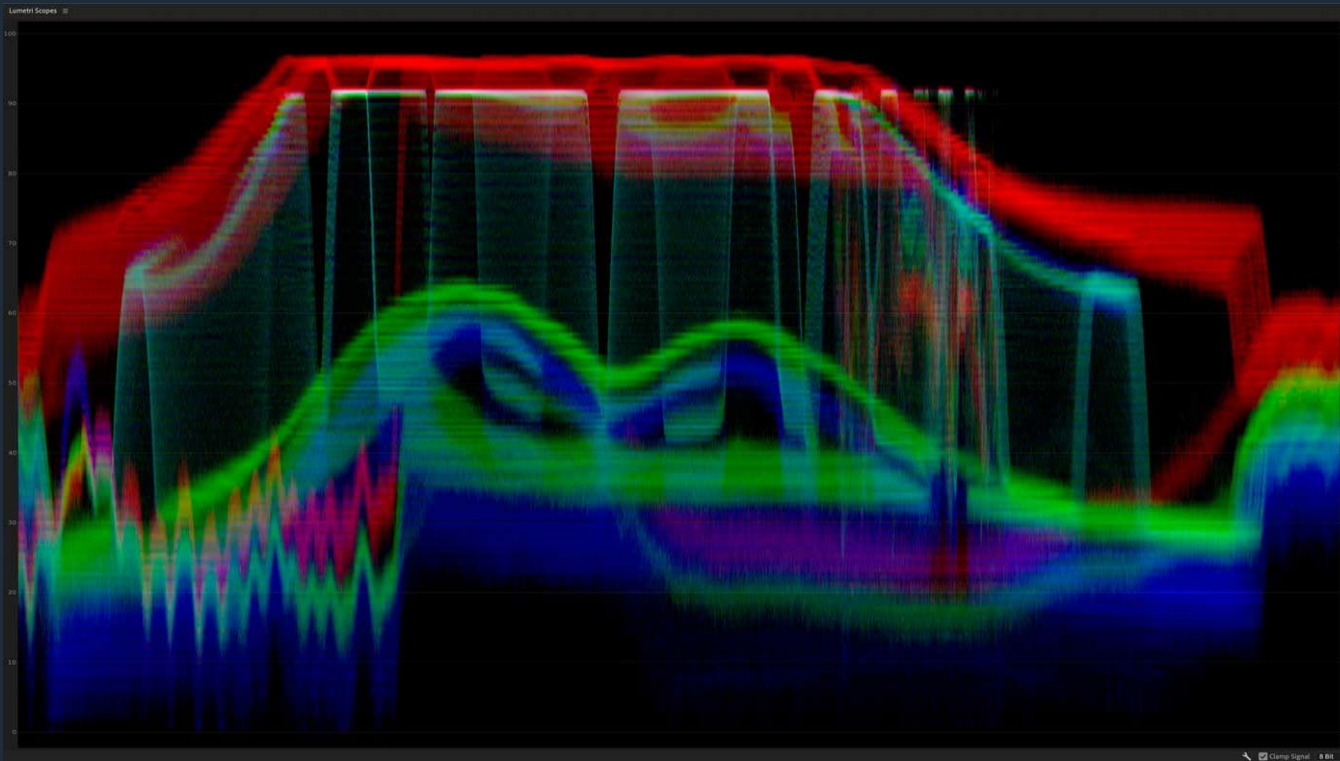
Video Engineer Tools

- Waveform Monitor / Vectorscope
 - **The waveform monitor measures the luminance of an image.**
 - **X-axis:** A typical waveform monitor represents the video image spatially across the horizontal x-axis of the monitor. Each point along the horizontal axis is in direct relation to a stack of the image's vertical pixels across the horizontal axis of the image.
 - **Y-axis:** The vertical y-axis of the waveform monitor is a scale of brightness. It goes from sub-black at the very bottom of the screen to brightness values that exceed white at the top of the screen. On most waveform monitors there are marks on the y-axis. These marks are representative of the luminance value, whether it's on a scale from 0 to 100, or 0 to 255.
 - **The vectorscope shows the hue and saturation of the image**
 - Vectorscopes use a polar coordinate system to display hue and saturation measurements. This is in contrast to the two linear axes, or a cartesian coordinate system, that waveforms use.
 - Hue, the color value, is mapped in radially around the center of the vectorscope.
 - Saturation, the intensity of the color, is measured in distance from the center of the vectorscope. The greater the saturation, the further away it is from the center.

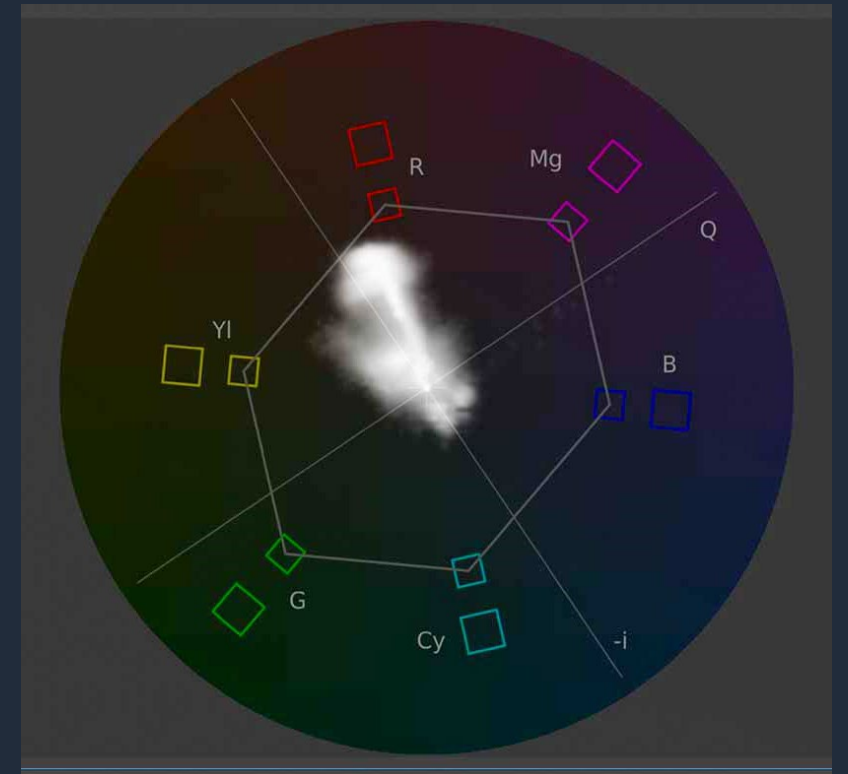


Video Engineering Tools

- Waveform Monitor



- Vectorscope



Helpful Links

- [YUV Color Space](#)
- [White Balance](#)
- [Production Buzzwords](#)
- [Chroma Key, Green screen guide](#)
- [Audio/Video Routers](#)
- [Basics of waveform monitors and vectorscopes](#)
- <https://www.haivision.com/products/srt-secure-reliable-transport/>
- <https://www.smpte.org/smpte-st-2110-faq>

Thanks for Joining Us!

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