Video And Cameras
Presented by John Bradford
Additive Color System
Television Signal Formats--- Tektronix

Analog Composite Video (PAL/NTSC/SECAM)

Color Difference Component Analog Video (Y, B-Y, R-Y)
4,2,2 sampling

Y is Created from RGB
The Approx. mix is
60% is Green
30% is Red
10% is Blue

Component Analog Video (RGB)
What could go wrong?

- **Color Not Correct**
  - Company logo/brand incorrect color in commercial or graphic.
  - Format conversion caused clip of color in change from one color space to another

- **Color Balance**
  - Overall image appears washed out
  - Image appears to dark
  - Cameras incorrectly balanced produced different look from scene to scene
What’s Your Reference

Computer Display

Consumer Displays
What's Your Reference

Test Equipment

Calibrated Monitors
Calibrate Your Eyes

6500K light panels are used in many Color Correction Suites
HDMI Color Accuracy
Measuring HDMI Performance

Android Tablet
75% Colorbars 1080i@29.97

Converted to 1080P @60
Measuring HDMI Performance

Apple iPad Lightning to HDMI Adapter
75% Colorbars 1080i@29.97

Converted to 1080P @60
Measuring Set Top Box Performance

Roku3
75% Colorbars 1080i@29.97

Converted to 720P @60
Measuring Set Top Box Performance

Amazon fireTVstick
75% Colorbars 1080i@29.97

Converted to 1080P @60
Gamut and Color Space
Color Model – developing color spaces

- CIE 1931 XYZ color space is still foundation of most color models
- Trichromatic stimulus (color value)
- Lightness decreases towards not shown third dimension
- Saturation increases towards edges
Colourimetry change between HD and SD

- HD YPbPr Waveform display 709
- SD YPbPr Waveform display 601

Notice difference in Green-Magenta transition
When things are not correct…

- Input format was signaled as 1080P
- But received data was 601 color space

Color is washed out
<table>
<thead>
<tr>
<th></th>
<th>CIE x</th>
<th>CIE y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>0.630</td>
<td>0.340</td>
</tr>
<tr>
<td>Green</td>
<td>0.310</td>
<td>0.595</td>
</tr>
<tr>
<td>Blue</td>
<td>0.155</td>
<td>0.070</td>
</tr>
<tr>
<td>White</td>
<td>0.3127</td>
<td>0.3290</td>
</tr>
</tbody>
</table>

**ITU 601 Gamut**

<table>
<thead>
<tr>
<th></th>
<th>CIE x</th>
<th>CIE y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>0.640</td>
<td>0.330</td>
</tr>
<tr>
<td>Green</td>
<td>0.300</td>
<td>0.600</td>
</tr>
<tr>
<td>Blue</td>
<td>0.150</td>
<td>0.060</td>
</tr>
<tr>
<td>White</td>
<td>0.3127</td>
<td>0.3290</td>
</tr>
</tbody>
</table>

**ITU 709-5 & sRGB Gamut**

<table>
<thead>
<tr>
<th></th>
<th>CIE x</th>
<th>CIE y</th>
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</thead>
<tbody>
<tr>
<td>Red</td>
<td>0.708</td>
<td>0.292</td>
</tr>
<tr>
<td>Green</td>
<td>0.170</td>
<td>0.797</td>
</tr>
<tr>
<td>Blue</td>
<td>0.131</td>
<td>0.046</td>
</tr>
<tr>
<td>White</td>
<td>0.3127</td>
<td>0.3290</td>
</tr>
</tbody>
</table>

**ITU-R BT.2020**
### Academy Color Encoding System (ACES) Color Space

<table>
<thead>
<tr>
<th></th>
<th>CIE x</th>
<th>CIE y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>0.73470</td>
<td>0.26530</td>
</tr>
<tr>
<td>Green</td>
<td>0.00000</td>
<td>1.00000</td>
</tr>
<tr>
<td>Blue</td>
<td>0.00010</td>
<td>-0.07700</td>
</tr>
</tbody>
</table>

- File based System
- Method for conversion between range of color spaces
Waveform View

YPbPr View

RGB View

YRGB View

Composite View
Gamut monitoring - The traditional way RGB domain

Maximum Gamut

Minimum Gamut
RGB and YPbPr Color space.

- YPbPr color cube shows Parallel-Piped of RGB colors
- Certain YPbPr values when converted to RGB will fall outside the allowed range and will be out of Gamut
Impact of Distortions on Different Color Spaces

A signal can be legal in one color space but not valid when converted to another.
Cameras
Camera Balancing

- Use calibrated test charts of reference patterns such as step-scales
- Compare measurements with theoretical targets on waveform, vector, and gamut displays
- Test charts complement electronic pattern generators by including the camera’s “taking characteristics”
  - Lens and adapters
  - Filters
  - Characteristics of the CCD
White Balance – Camera Shading

- Even brightness white source
  - Ambi-Illuminator
- Often the center can be brighter than the edges
- Measure light output with a luminance spot meter
- Set camera gain to 0dB & camera controls to zero
- Set camera F-stop between f4 to f5.6
  - Adjust distance of camera to source
- Defocus Camera
White Balance

- Select WFM display and configure for RGB parade.
- No color hue should be present
  - Red, green, blue channels must be balanced
  - Ideally RGB should be at same level and flat
White Balance with the Vector Display

- Monochrome image should be centered tightly on the vector graticule
- Off-center ovular shape indicates shading error
- Use gain controls on the vector display to confirm correct white balance
Tools for Camera Alignment & Matching
Camera Matching

- No two cameras are identical
  - Physical Differences
    - Lens
    - Sensor
    - Electronics
- Cannot load preset from one camera to another
- Scene to scene cameras need to match
- Comparison of video levels between camera is required
RGB Parade

- View video levels of each component

- Need to look and compare each component RGB
RGB Waveform Display - Traditional Method

- RGB Overlay
- Adjust for minimum difference
Camera Alignment with Luma Qualified Vector Display
Camera Setup with Vector Display
Saturation

- The purest (most saturated) color is achieved by using just one wavelength at a high intensity, such as in laser light. If the intensity drops, then as a result the saturation drops. To desaturate a color of given intensity in a subtractive system (such as watercolor), one can add white, black, gray, or the hue's complement.

In this case the picture on the right I have added some white to And the Vector still shows the same as the one on the left
Vector Waveform Display - Method

- Vector
- Turn on Gain (X5)
- Adjust for smallest centered dot
Luma Qualified Vector Display

- Allows User to define luma slice of vector display
- Selectable upper and lower limits
- Allows user to select low, medium and high ranges to isolate certain luma regions.
Luma Qualified Vector Display

- Focus on White region to remove color offset
  - Upper limit 766mv
  - Low limit 600mv

- Focus on Black region to remove color offset
  - Upper limit 50mv
  - Low limit -51mv
Camera Alignment
Diamond Display
Gamut monitoring — *Diamond* display

Configuration Menu
Selectable Gamut Thresholds

- **Diamond High**: 735 mV
- **Diamond Low**: -35 mV
- **Diamond Area**: 1%
- **Reset Diamond Defaults**: Press SEL
How the *Diamond* Display is constructed

![Diagram of Diamond Display construction](image-url)
Diamond Display for Grayscale Luma signal

- Luma produces vertical straight line on Diamond Display
- Black at center of double Diamond
- White at Apex of double Diamond
Understanding Lightning display

Pb (B' - Y') signal

Clamp Point

White

+ Luma (Y')

Y' Signal

0 V

- Luma (Y')

Pr (R' - Y') signal
Lightning display for Black Level Adjustment

- Black at center of Lightning display
- Magnified view allows user to easily make black adjustments
- Ensures no color cast in the blacks of the signal
Diamond Display – Chip Chart

High: 735 mV
Low: -35 mV
Area: 1 %%
Lens Flare Adjustment
Flare

Flare manifests itself as swift in black levels with a change light level.

Lens flare is the light scattered in lens systems.
Gamma monitoring — *Diamond* display

- Blacks Lifted
- Slightly Cool
- Green-Blue White Points slightly Blue
- Green Red White Points slightly Green
Flare Adjustment

- Iris down the camera
- Set black level to 0mv
- Adjust Iris so white chip is 1 to 2 f-stop above 700mv
- Adjust the flares for black chip to 0mv
Setting Gamma
Gamma

Camera Gamma

Monitor Gamma
Gamma Curve

- Black gamma (aka black stretch) to change the lower end of your contrast curve.
- Adjust knee point and slope to change the upper end of your contrast curve.
Normal Gamma
Low Gamma
High Gamma

Camera Alignment & Matching
Gamma Curve

- Black gamma (aka black stretch) to change the lower end of your contrast curve.

- Adjust knee point and slope to change the upper end of your contrast curve.

- Some camera have Gamma preset
  - Some Cine gammas or Hyper gammas preset take whites up to 109%
  - 709 or broadcast safe whites no higher than 100%
Gamma Curve

- Black gamma (aka black stretch) to change the lower end of your contrast curve.

- Adjust knee point and slope to change the upper end of your contrast curve.
The Matrix Adjustment
The Matrix

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- DSC Labs Test Chart
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  - Lens and adapters
  - Filters
  - Characteristics of the CCD
Color adjustment using the Vectorscope

- Select Vector Display
- Configure 2.0X Var Gain
  - DSC Charts represent saturation level found in real life
- Original Camera Output
- Camera adjustment controls interact
  - May need to go back and forth to various controls
- Final Corrected Image
Color adjustment using the Vectorscope

- Many cameras give you six matrix adjustment options: R-G, R-B, B-R, B-G, G-R and G-B

- The matrix adjustments allow us to adjust how red, green and blue images mix together.

- The R-G adjustment will change the Red saturation and but Green will change both in hue and in saturation.
Image matching with Capture
Freeze mode

- Freeze saves an image of the display.
- Allows comparison to other cameras or scenes.
- To Enable Freeze press Capture button.
CaptureVu™ on WFM

- CaptureVu saves a buffer capture of the SDI signal.
- Frame of data can be reconstituted to different displays.
- Frame buffers can be saved to USB for later recall.