Broadcast Monitors

Colour Balance Alignment

Solutions in Audio & Video

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Illusion
or
Reality

It appears, as if intense morning sunlight was projected

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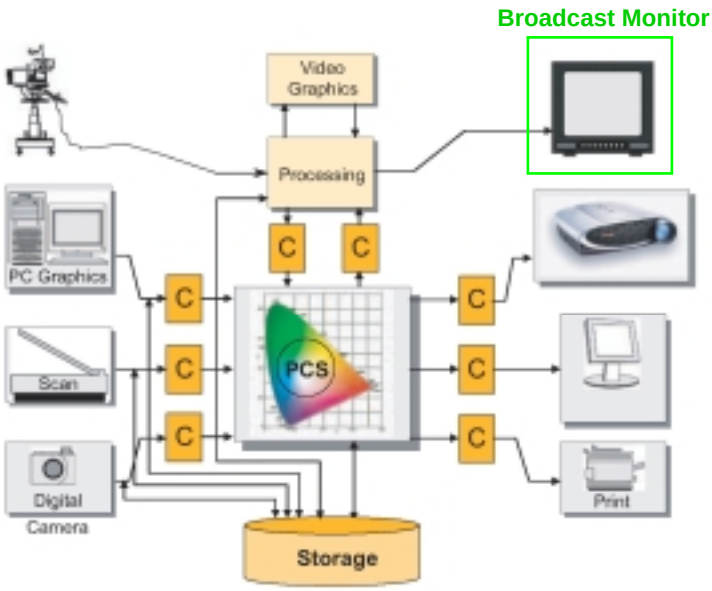


SD Video - Europe

Chromaticity Coordinates	x	y
Red	0.64	0.33
Green	0.29	0.60
Blue	0.15	0.06

White Reference	x	y
D_{65}	0.313	0.329

Luminance Signal

Y'= 0.299R'+ 0.587G'+ 0.114B'

HD Video - World

Chromaticity Coordinates	x	y
Red	0.640	0.330
Green	0.300	0.600
Blue	0.150	0.060

White Reference	x	y
D_{65}	0.3127	0.3290

Luminance Signal

Y'= 0.2126R'+ 0.7152G'+ 0.0722B'

Luminance (photometric)

Luminance is the amount of visible light that comes to the eye from a surface.
The SI unit for luminance is candela per square meter: cd/m^2

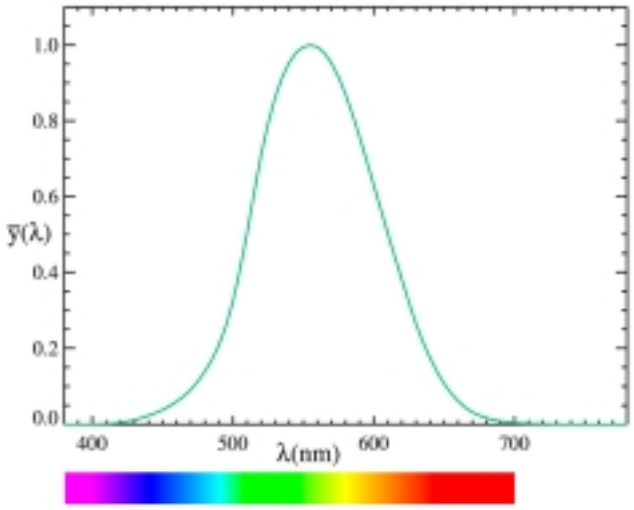
Luminance (video)

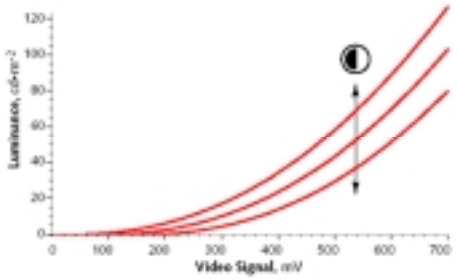
The luminance signal is the weighted sum of the gamma corrected R'G'B' components. Y' or simply Y is used as the symbol.
The luminance level is measured as a voltage or digital code.

Brightness

Brightness is the intensity of light coming from the image as seen by the eyes. Brightness is purely subjective
Brightness is also defined as perceived luminance.

Sensitivity of the Human Eye as Function of Wavelength of Light



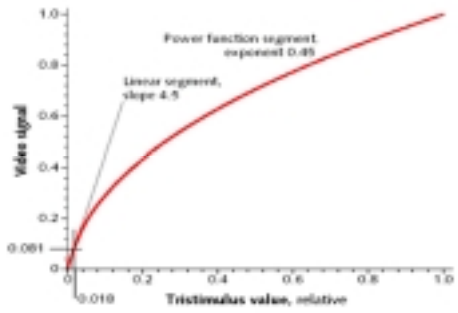


CRT's transfer function at 3 different contrast settings

$L = V^{\gamma}$

L: Luminance appearing on CRT screen
V: Video signal input to CRT
γ: Display gamma value

Assumed Gamma	
SD	2.8
HD	2.2



The Rec. ITU-R BT.709-5 transfer function for television cameras

$V = 1.099 * L^{0.45} - 0.099$ for $0.018 \leq L \leq 1.0$

$V = 4.500 * L$ for $0.0 \leq L \leq 0.018$

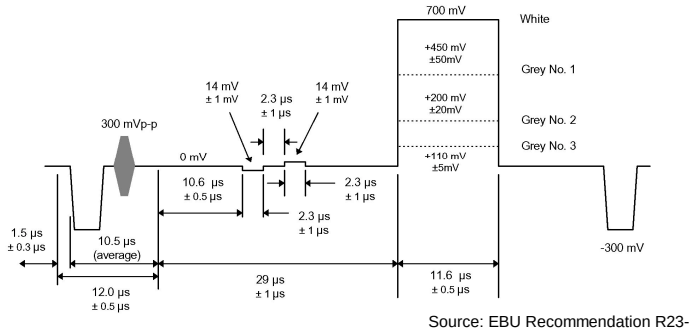
L: luminance of the image $0 \leq L \leq 1$
V: corresponding electrical signal

Overall gamma from scene to monitor screen is 1.0 to 1.25

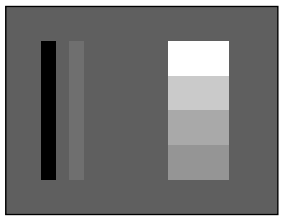
Why use gamma?

- **Was the compensation for the CRT non-linearity**
- **Perceptual uniformity (noise is more visible in dark grey)**
- **Huge amount of archive material with gamma pre-correction**

PLUGE – Picture Line-Up Generating Equipment



Source: EBU Recommendation R23-1997

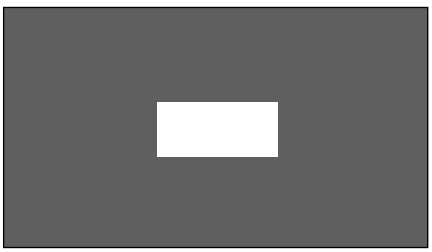


Step 1: Adjust Black Level with the Brightness control

- **Test signal: PLUGE signal**
- **Ambient light: As under normal operation**
- **Procedure: Adjust brightness control so that the blacker than black bar disappears and the lighter than black bar is visible**

Step 2: Adjust White Level with the Contrast control

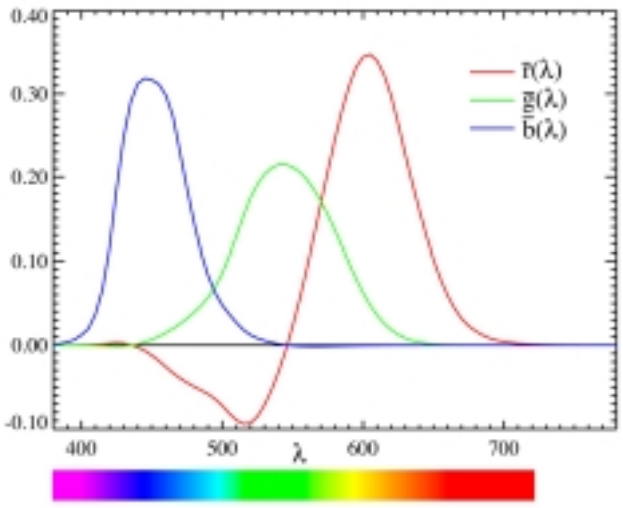
- **Test signal: Window Signal 100% White**
- **Measure luminance with PM5639 Colour Analyser**
- **Adjust contrast to desired level**.
  Recommendations for CRT: EBU: 80 Cd/m2 and SMPTE: 35 ftL



Why is Colour Calibration so important:

- The monitor is probably the most unstable element in the production chain
- The monitor is the sole instrument used to evaluate the colour truth in the pictures
- Achieve uniform quality of material from different sources
- Production of commercials demand fidelity to company colour schemes
- Signal properties like contrast and average picture level can be evaluated with a WFM

CIE 1931 RGB Colour Matching Function



CIE RGB space requires negative colour weights

Strictly positive system is computationally more convenient.

Colour perception linear ⇒ can choose arbitrary primaries

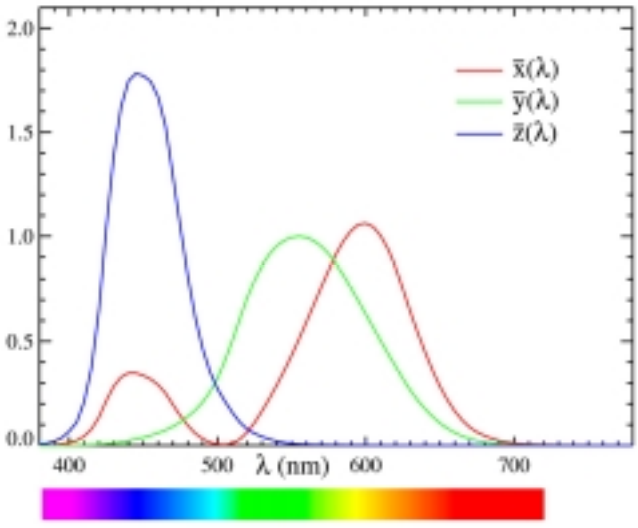
Colour spaces related by a linear transformation:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad \text{or} \quad C_{XYZ} = M_{RGB \to XYZ} C_{RGB}$$

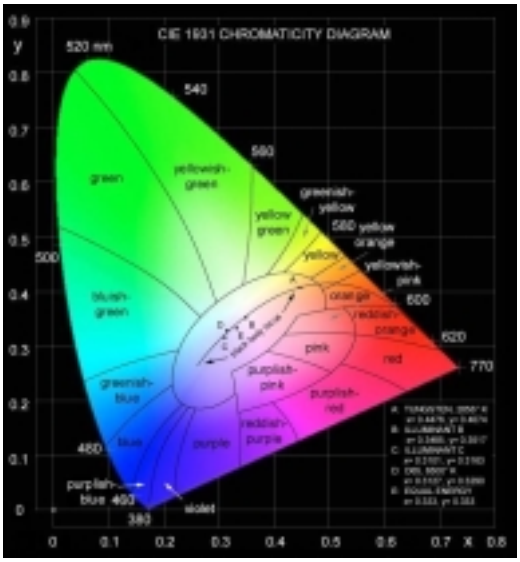
Choose appropriate XYZ primaries to eliminate negative values in tri-stimulus curves:

$$\bar{x}(\lambda) \quad \bar{y}(\lambda) \quad \bar{z}(\lambda)$$

CIE 1931 Standard Colorimetric Observer XYZ Function



CIE 1931 xy Chromaticity Diagram



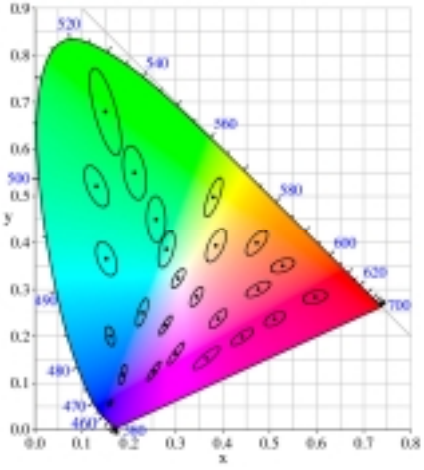
$x = X / (X + Y + Z)$
$y = Y / (X + Y + Z)$
$z = Z / (X + Y + Z)$

$x + y + z = 1$

Y - Luminance

MacAdam Ellipses Plotted on the CIE 1931 xy Chromaticity Diagram

(Ellipses are 10 times their actual size)

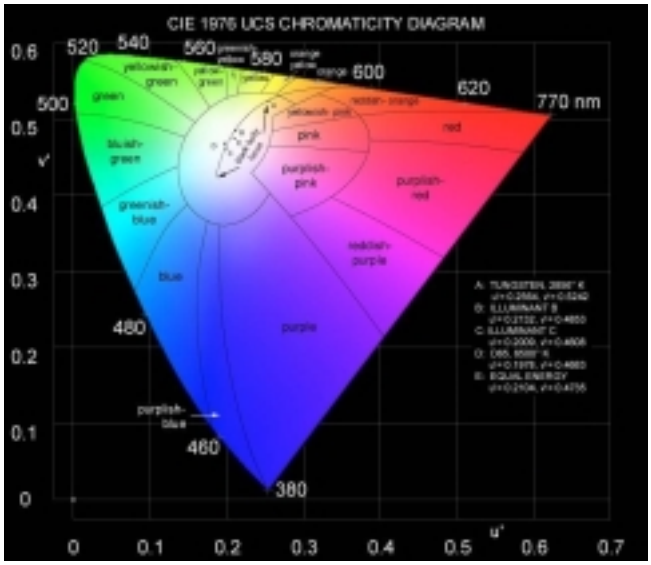


Colour Differences:

JND –
Just Noticeable Difference

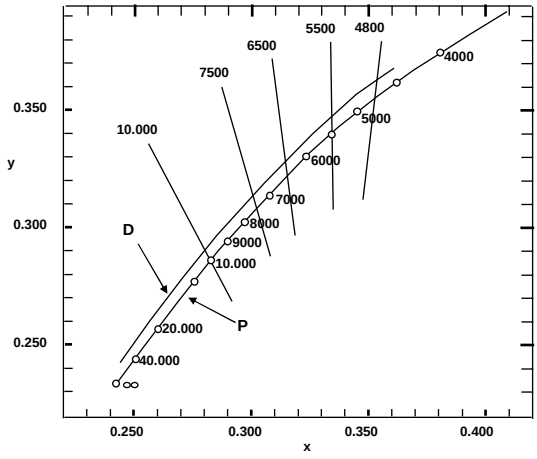
CIELUV – ΔE
The psychometric size of the CIELUV unit closely equals, what the eye can perceive as a colour difference.

CIE 1976 UCS u'v' Chromaticity Diagram



- The colour temperature of light is defined by the physics as light from a black body at a given temperature
- Correlated colour temperature is the colour temperature which by a Standard Observer best approximates light from a given light source
- Two light sources with same correlated colour temperature may not look equal
- The different colour references do not equal the light from the black body so they should be named as light with a given correlated colour temperature

Portion of the CIE 1931 xy chromaticity diagram showing Daylight locus (D) and Plankian locus (P) with iso-temperature lines



EBU Primary Colours

	u’	v’	x	y
Red	0.451	0.524	0.64	0.33
Green	0.121	0.561	0.29	0.60
Blue	0.175	0.158	0.15	0.06

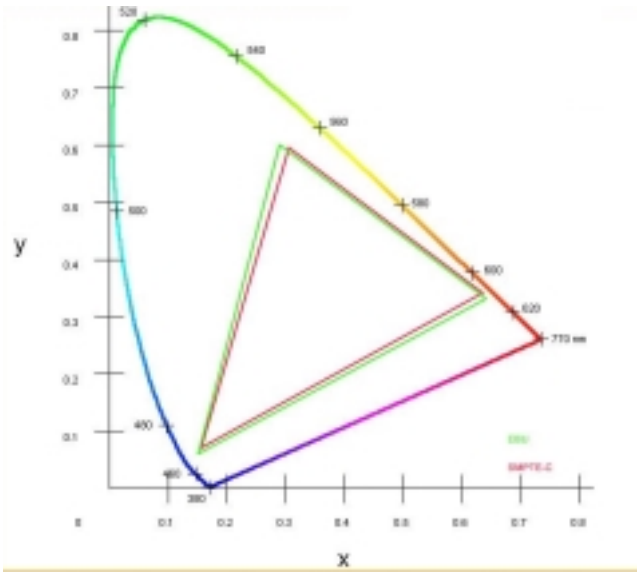
Reference White:

u’= 0.1978 **x=0.313**

v’=0.4683 **y=0.329**

Correlated Colour Temperature of white: D_{65} = 6504 K

EBU and SMPTE Primary Colours



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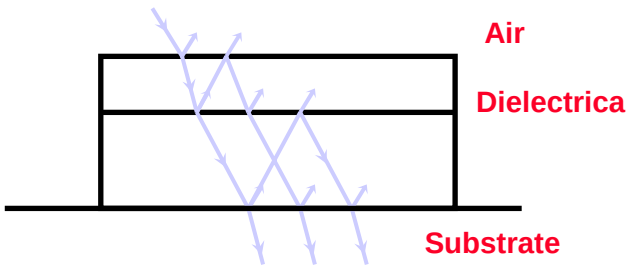
Dichroic Filters



- Sketch of light transmission through a two layer dichroic filter
- A stack of thin dielectric layers with high and low refractive index.
- Features:
  - No bleaching
  - High peak transmission
  - No self heating, low temperature dependency

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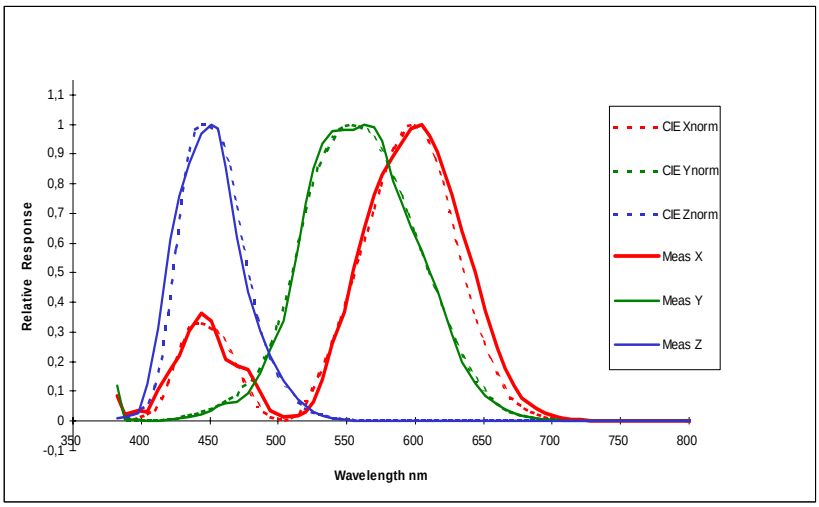
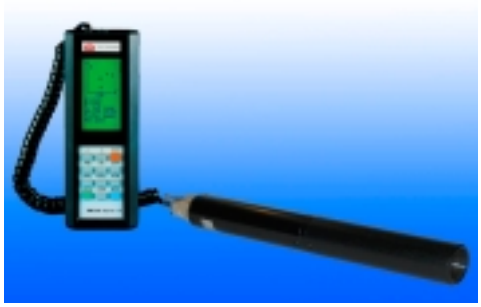


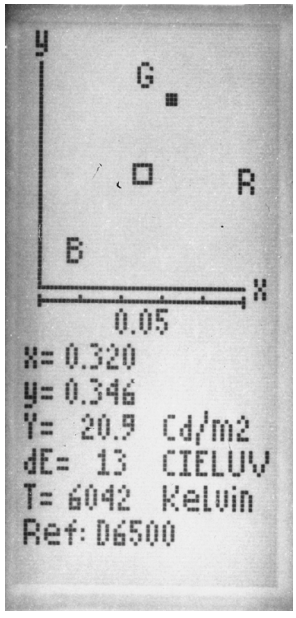
PM5639/00
CRT Colour Analyser with CRT colour probe and display unit

Auto alignment of class-1 broadcast monitor

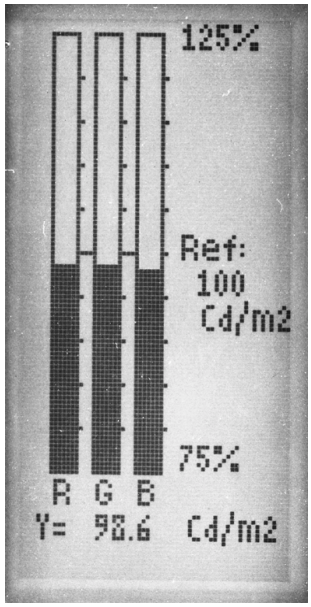
PM5639/06
LCD Colour Analyser with LCD colour probe and display unit



Alignment of high-end LCD broadcast monitor



- Displays the absolute CIE x and y chromaticity co-ordinates.
- The luminance value Y in either NIT, cd/m^2 or FtL.
- dE = the perceived colour difference between the measured value and the reference.
- T= Actual correlated colour temp in Kelvin.
- Ref is the White Reference selected.



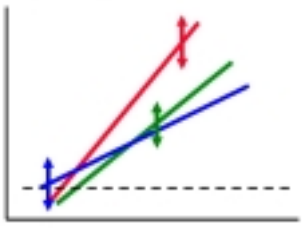
- Displays the RGB values relative to the selected White Reference.
- The RGB balance is relative to the selected display reference
- Select the right phosphor to minimize cross-talk between R, G, and B bars.
- Use a stored phosphor or perform a LEARN phosphor.
- Displays the luminance value Y in either NIT, cd/m^2 or FtL.

Step 3: Adjust Colour Balance at Low Level

• Test signal: Window Signal 10% - 20% White

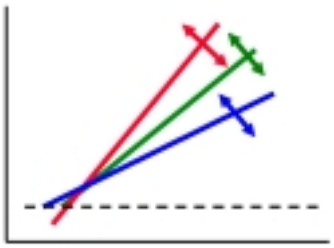
• Measure R, G, B with PM5639 Colour Analyser

• Adjust balance of R, G, B at low level.



Step 4: Adjust Colour Balance at High Level

- Test signal: Window Signal 100% White
- Measure R, G, B with PM5639 Colour Analyser
- Adjust balance of R, G, B at high level.



Step 1
Adjust brightness control to set black level on the screen

Step 2
Adjust contrast control to set white level on the screen

Step 3
Adjust colour balance at dark grey level

Step 4
Adjust colour balance at white level

Repeat steps 1 through 4 until there are no changes.