Do These Factories Calibrate?

Sharp Sakai City - $11 Billion
Panasonic Amagasaki $2.11 Billion
Introductions…

Name -
Experience –
Personal Reference Quality Disc?
Have you ever calibrated an UHDTV?
Quality in Taking Pictures?

Canon G10 had 14.7 MP – The next models G11 and G12 had 10 MP? Which created better quality pictures??

[Images of Canon G10 and G12 cameras]
What is the Most Important Part of a Camera?

What Will You See on Your Screen With A Higher Quality Lens?

Canon 50mm 1.4 - $399  Leica 50mm 1.4 - $3999
Quality In Printing pictures

Which of these magazines deliver superior image quality?

Why?
21st Century HDTV Quality?

The Perception获.....
The Reality.............
The Old HD Number everyone knew?...
The Marketing.........LED TV?
The Blacks?.............
1080p? – Did it make it to the HDTV?

1080p To Be?

Or

1080p Not To Be?

Vast majority of HDTVs – “Not To Be”

Overscan, aspect ratios and keystone

WHY IS THE FACTORY PRESET WRONG?

What has changed in UHD 4K?
Overscan / Resolution Tools

BBC Test Card

ISF 4K 2011
1080p Bit Mapped Right Looks Better
UHD Can Have Bit Mapping Errors Too

What else can we make look better?

What is “better”?

Where did “better” come from?
STANDARDS
Why must we all know about Standards?
Who Here Owns an AVR?

Who here has set audio levels on their AVR?
Who used the built in set up process and mikes?
Who used a superior equipment for their set up?
What percent of buyers have their AVRs set up to MEET STANDARDS?
What percent of clients have UHDTVs set up for them?
What is the ISF?

We are a Standards Organization, We:
Represent Standards
Deploy Standards
Train Professionals to Understand Standards
Help develop UHDTVs that calibrate to Standards
Help Write Standards for CTA, InfoComm and CEDIA
What are C.T.A. *R10 Standards*?

C.T.A = **Consumer Technology Association**

www.cta.tech

Represents over 2000 major Electronics companies

Produces the yearly CES!

R10 is CTA’s Standards and Technology group

ISF Chairs *Home Theater Video Design*

CEDIA Awards Require Compliance!
This standard dictates a state of the art performance design that requires the best projectors and screens and room designs – it followed the two top tiers of the Digital Cinema specs!
CEB 23 Uses Dual Methodology for Calculating Contrast

“Intraframe”
4 x 4 Checkerboard
150 : 1 (100:1 Tier One)
(This is very difficult)

“Sequential”
White and Then Black Test Patterns
2000 : 1 (1200:1 Tier One)
(This is not difficult with a quality projector)
What is the SMPTE?

The Society of Motion Picture and Television Engineers (SMPTE) was founded in 1916

http://www.smpte.org/home
What is the NTSC?

National Television System Committee
U.S. standardization body that adopted the broadcast standard in 1941
In 1953 a second standard was issued, for color broadcasting compatibility with black-and-white receivers
PAL and SECAM were later TV systems that resolved some problems in NTSC
What is the ATSC?

The Advanced Television Systems Committee (ATSC)

Formed in 1982 to develop Standards for DTV

1998 Recommendations are still being deployed now!
What is the BBC?

The British Broadcasting Corporation, abbreviation "BBC" is the world's largest broadcaster.

The BBC plays an active part in development of all open standards for UK broadcasting, Europe & world-wide where appropriate.

BBC and NHK - HLG HDR!
Early BBC “Cards”
What is the DCI?

Digital Cinema Initiatives, LLC (DCI) is a joint venture of Disney, Fox, Paramount, Sony Pictures Entertainment, Universal and Warner Bros. Studios. DCI's primary purpose is to establish and document voluntary specifications for open architecture for digital cinema that ensures uniform, high level of technical performance, reliability and quality control.

www.dcmovies.com
**DCI Specs Categories For Contrast**

CEB23 includes Two Specs - “Theatrical” and “Nominal”

<table>
<thead>
<tr>
<th>Image Parameters</th>
<th>Nominal (Projected Image)</th>
<th>Tolerances (Review Rooms)</th>
<th>Tolerances (Theatrical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel Count</td>
<td>2048x1080 or 4096x2160</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Luminance Uniformity, corners and sides</td>
<td>85% of center</td>
<td>80% to 90% of center</td>
<td>70% to 90% of center</td>
</tr>
<tr>
<td>Calibrated White Luminance, center</td>
<td>48 cd/m² (14 ft)</td>
<td>±2.4 cd/m² (± 0.7 ft)</td>
<td>±10.2 cd/m² (± 3.0 ft)</td>
</tr>
<tr>
<td>Calibrated White Chromaticity, center from code values [3794 3980 3890]</td>
<td>x=3.140, y=3.510</td>
<td>±0.002 x, y</td>
<td>±0.006 x, y</td>
</tr>
<tr>
<td>Color Uniformity of White Field, corners</td>
<td>Matches center</td>
<td>±0.008 x, y Relative to center</td>
<td>±0.010 x, y Relative to center</td>
</tr>
<tr>
<td>Sequential Contrast</td>
<td>2000:1 minimum</td>
<td>1500:1 minimum</td>
<td>1200:1 minimum</td>
</tr>
<tr>
<td>Intra-frame Contrast</td>
<td>150:1 minimum</td>
<td>100:1 minimum</td>
<td>100:1 minimum</td>
</tr>
<tr>
<td>Grayscale Tracking</td>
<td>No visible color shading</td>
<td>No visible color shading</td>
<td>No visible color shading</td>
</tr>
<tr>
<td>Contouring</td>
<td>Continuous, smooth ramp, with no visible steps</td>
<td>(same)</td>
<td>(same)</td>
</tr>
<tr>
<td>Transfer Function</td>
<td>Gamma 2.6</td>
<td>±2%¹¹ Per component</td>
<td>±5%¹² Per component</td>
</tr>
<tr>
<td>Color Gamut</td>
<td>Minimum Color Gamut enclosed by white point, black point¹¹ and Red: 0.693 x, 0.320 y, 10.1 Y Green: 0.265 x, 0.368 y, 34.6 Y Blue: 0.150 x, 0.060 y, 3.31 Y</td>
<td>(same)</td>
<td>(same)</td>
</tr>
<tr>
<td>Color Accuracy</td>
<td>Colorimetric Match</td>
<td>+/- 4 delta E¹³</td>
<td>+/- 4 delta E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2000:1 minimum</th>
<th>1500:1 minimum</th>
<th>1200:1 minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequential Contrast</td>
<td>2000:1 minimum</td>
<td>1500:1 minimum</td>
<td>1200:1 minimum</td>
</tr>
<tr>
<td>Intra-frame Contrast</td>
<td>150:1 minimum</td>
<td>100:1 minimum</td>
<td>100:1 minimum</td>
</tr>
</tbody>
</table>
What is the ITU?

International Telecommunication Union

ITU is a United Nations standards agency for information and communication technology

TEST PATTERNS VERIFY ITU COMPLIANCE
Report ITU-R BT.2246-1
(08/2012)

The present state of ultra high definition television

BT Series
Broadcasting service
(television)

Phase 3

4320p100/120*

Phase 2

2160p100/120*
1080p100/120* (base layer)

Phase 1

2160p50/60*
1080p100/120*

344 depth: 10 bit, 12 bit preferred
Color Space: Rec. 709
Dynamic Range: HDR preferred
Subsampling: 4:2:2, 4:4:4 mandatory & 4:4:4:4
Audio: 5.1
Coding: HEVC Main 10

Production
Distribution
Presentation

Bit depth: 10 bit, 12 bit, 14 bit?
Color Space: Rec. 709
Audio: surround 5.1 or object based

* it was suggested that the standard should also include 120/100 fps, 80/100 fps, and 30/100 fps. Further decisions on 100 and 150 fps will be taken.

Quelle: © 2013 DVB-EBU UHDTV Task Force Meeting Summary Report. p. 3
Color Compression – Sins of the Past
Video Processing Creates What’s Missing

4:1:1  4:2:0  4:2:2  4:4:4
Next Generations Charted:

**The Roadmap to next-gen TV**

Technology improvements will not come all at once with a big bang but gradually, making backward compatibility and graceful degradation essential for consumer confidence.

<table>
<thead>
<tr>
<th>CE Connectivity</th>
<th>HDMI 1.4a CEA 861-...</th>
<th>HDMI 2.0 CEA 861-E</th>
<th>HDMI 2.0a CEA 861.3</th>
<th>HDMI 2.0a CEA 861-G</th>
<th>Display Port USB 3.0 or MHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>1920x1080p</td>
<td>3840x2160p</td>
<td>7680x4320p</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frame Rate</td>
<td>30fps</td>
<td>60fps</td>
<td>120fps HFR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color Depth</td>
<td>8-bit</td>
<td>10-bit</td>
<td>12-bit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>100 nits SDR</td>
<td>&gt;500 nits HDR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color Gamut</td>
<td>Rec.709</td>
<td>Rec.2020 WCG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audio</td>
<td>Multi-Channel Audio (5.1-7.1)</td>
<td>Object-based Audio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Pre-UHD</td>
<td></td>
<td></td>
<td>UHD-I Phase 1</td>
<td>UHD-I Phase 2</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
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<tr>
<td>2016</td>
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<tr>
<td>2017</td>
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<tr>
<td>2018</td>
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<tr>
<td>2019</td>
<td></td>
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<tr>
<td>2020</td>
<td></td>
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<tr>
<td>2021</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2022</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
This “SYSTEM” Standard defines five contrast ratios based on content viewing applications:

A. Informational Viewing
B. Basic Decision Making
C. Critical Decision Making
D. Full Motion Video
E. Video Editing for Corporate Comm.
<table>
<thead>
<tr>
<th>Viewing Environment Category</th>
<th>Minimum System Contrast Ratio</th>
<th>Viewer's Requirements</th>
<th>Environment - Example Characteristics</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informational Viewing</td>
<td>7:1</td>
<td>• Able to distinguish important images and text from background&lt;br&gt;• Passive engagement with content&lt;br&gt;• Projected image informative but not critical</td>
<td>• Little control of ambient light&lt;br&gt;• Ambient light may be high&lt;br&gt;• Task lighting may not be ideal&lt;br&gt;• Windows may have insufficient blinds or curtains&lt;br&gt;• May be reflective surfaces (e.g., furniture)&lt;br&gt;• Projector light output may be inadequate</td>
<td>Retail stores, family (TV) rooms</td>
</tr>
<tr>
<td>Basic Decision Making</td>
<td>15:1</td>
<td>• Actively engaged with content&lt;br&gt;• Images and text are legible to the extent that basic decisions can be made&lt;br&gt;• Decisions based on content itself, not resolution or detail</td>
<td>Improvements relative to the above category are often in evidence</td>
<td>• Information displays&lt;br&gt;• Presentations containing detail images (e.g., classrooms, boardrooms multi-purpose rooms, product illustrations)</td>
</tr>
<tr>
<td>Critical Decision Making</td>
<td>50:1</td>
<td>• Fully engaged with the finest detail to support critical image assessment&lt;br&gt;• Mission-critical image displays</td>
<td>• Controlled ambient light&lt;br&gt;• Focused task lighting&lt;br&gt;• No ambient light directly affecting screen, back-out window treatments</td>
<td>Engineering and architectural drawings, electrical schematics, legal evidence, failure analysis, photographic evaluation (e.g., courtrooms, medical galleries)</td>
</tr>
<tr>
<td>Full Motion Video</td>
<td>80:1</td>
<td>• High level of engagement with content&lt;br&gt;• Films below movie theater distribution standard</td>
<td>Precisely controlled ambient light</td>
<td>Controlled viewing environment (e.g., home theater, business screening room)</td>
</tr>
</tbody>
</table>
I.S.C.A.R Methodology

Measure all White Squares
Average all measurements
Measure all Black Squares
(Keeping white squares out of meter)
Average all measurements
Divide White data by Black
What is the Contrast Ratio of This Room’s System?
ISCR Applies To Every Installation

These are real world - easily achievable Standards - that enable you to define **System** performance and guarantee client satisfaction!
There are Three Fundamental Approaches to Improving Contrast and Obtain I.S.C.R. Category Compliance With Contrast Ratio Specifications:
Control Ambient Light
Darken wall color
Eliminate reflective surfaces

This is the most logical and easiest thing to do – and almost always just impossible to do....
2 – Use a More Powerful Light engine

Projectors drive screens, more Lumens help deal with ambient light.

Projectors are not quite as bright as the sunlight coming in from windows.

More Lumens will help white levels – not black levels.

Fortunately, brighter projectors have come down in price.
3 - Ambient Light Rejection Screens

These screens minimize ambient light’s impact on CR

Using gain surfaces can increase Contrast

Fractional Gain substrates will improve Black levels

Some products even deploy physical micro filters

The challenge is always to preserve “Flat Spectral Response” for color fidelity plus increase CR!
Tools Of The I.S.C.R. Trade: Non-Contact Luminance Meters
N.I.S.T. Refers to a “Frustum”
INFOCOMM and CEDIA Have Done An Important Part of Your Work For You

Everyone is entitled to his own opinion, but not his own facts

Daniel Patrick Moynihan
Using these Standards in the Field:

1. Add Standards compliance to your proposals
2. Educate your clients about Industry Standards
3. Design your systems for compliance
4. Deploy “Audit and Control” reports along with your invoices!
5. Use these Standards to document that your installations are world class!
What are Standards Based On?
The Human Eye
Making White for TV Viewers With RGB
What Data is Used For Color Standards?
Calibration Standards for X-RAYs?

NON calibrated

DICOM 14 calibrated

(Digital Imaging and Communications in Medicine)
Radiology Monitor Contrast Issues?
Same Scan – contrast too high versus correct...
ISF Calibrators:

**Must Thank Those Volunteers Who Developed TV Standards**

They enable us to deliver thousands of superior experiences every day at workplaces and homes.
The Market Niche For ISF

International Instant Adopters
Cutting Edge Installations & Service
Automation and integration?
Calibration = Customer care
“Booties” and ISF Calibrators?
Why Has The ISF Market Grown?

1. Calibrated old CRTs had to be dim – RIP CRTs!
2. Calibrated Flat Panels can be bright enough for any room
3. Gamma adjustments are now really common (more later)
4. HD and UHD make calibration’s improvements obvious
5. UHDTV system set up is way too hard for consumers
6. ISF UHDTV menu designs in over 90,000,000 TVs
7. CTA says customers DEMAND both price & service
Recommended Questions for Clients…..

What type of content is displayed?

Movies
TV shows
Sports
Gaming
Photography
Internet or streaming video or PowerPoint
Live Performances, Houses of Worship
Recommended Questions for Clients

Tell us about the room for the display

1 - Is there a display there now?
2 - Lighting & light control
3 - Viewing angles and distances
Critical Recommended question!!

What would you describe as your favorite place to sit in a movie theater?

Do you typically like to sit up close, midway, or further back?
HD Viewing Angles and Visible Artifacts

![Diagram showing viewing angles and visible artifacts](image)

- Viewing Distance to Screen Width Ratio
- Field-of-View at VD/SW Ratio

<table>
<thead>
<tr>
<th>Viewing Distance to Screen Width Ratio</th>
<th>1</th>
<th>1.2</th>
<th>1.4</th>
<th>1.5</th>
<th>1.6</th>
<th>1.7</th>
<th>1.8</th>
<th>1.9</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>10' Screen width</td>
<td>10' VD</td>
<td>12' VD</td>
<td>14' VD</td>
<td>16' VD</td>
<td>17' VD</td>
<td>18' VD</td>
<td>19' VD</td>
<td>20' VD</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>53°</td>
<td>45°</td>
<td>39°</td>
<td>37°</td>
<td>35°</td>
<td>33°</td>
<td>31°</td>
<td>29°</td>
<td>28°</td>
</tr>
</tbody>
</table>

- Field-of-View at VD/SW Ratio
- Viewing Distance to Screen Width Ratio
- 10' Screen width

- HD Viewing Angles and Visible Artifacts
- Diagram showing viewing angles and visible artifacts
- Table showing viewing distances and field-of-view ratios

---

*Image credit: [ISF](https://www.isf.com)"
## 2K 4K 8K Viewing Angles and Distances

<table>
<thead>
<tr>
<th>Image system</th>
<th>Reference</th>
<th>Aspect ratio</th>
<th>Pixel aspect ratio</th>
<th>Optimal horiz. viewing angle</th>
<th>Optimal viewing distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>720 × 483</td>
<td>Rec. ITU-R BT.601</td>
<td>4:3</td>
<td>0.88</td>
<td>11°</td>
<td>7 H</td>
</tr>
<tr>
<td>640 × 480</td>
<td>VGA</td>
<td>4:3</td>
<td>1</td>
<td>11°</td>
<td>7 H</td>
</tr>
<tr>
<td>720 × 576</td>
<td>Rec. ITU-R BT.601</td>
<td>4:3</td>
<td>1.07</td>
<td>13°</td>
<td>6 H</td>
</tr>
<tr>
<td>1 024 × 768</td>
<td>XGA</td>
<td>4:3</td>
<td>1</td>
<td>17°</td>
<td>4.4 H</td>
</tr>
<tr>
<td>1 280 × 720</td>
<td>Rec. ITU-R BT.1543</td>
<td>16:9</td>
<td>1</td>
<td>21°</td>
<td>4.8 H</td>
</tr>
<tr>
<td>1 400 × 1 050</td>
<td>SXGA+</td>
<td>4:3</td>
<td>1</td>
<td>23°</td>
<td>3.1 H</td>
</tr>
<tr>
<td>1 920 × 1 080</td>
<td>Rec. ITU-R BT.709</td>
<td>16:9</td>
<td>1</td>
<td>32°</td>
<td>3.1 H</td>
</tr>
<tr>
<td>3 840 × 2 160</td>
<td>Rec. ITU-R BT.1769</td>
<td>16:9</td>
<td>1</td>
<td>58°</td>
<td>1.5 H</td>
</tr>
<tr>
<td>7 680 × 4 320</td>
<td>Rec. ITU-R BT.1769</td>
<td>16:9</td>
<td>1</td>
<td>96°</td>
<td>0.75 H</td>
</tr>
</tbody>
</table>
Advanced Resolution, Analog and Digital
Credit - ITU State of Ultra High Definition Television, ITU-R BT.2246-1, (08/2012)
Where Did Calibration Come From?

Like in most successful endeavors….

The key to the future is understanding the past.....

Selecting and calibrating the best TVs started 80 years ago.....
TV is Based on Communication Theory

Electronic imaging dictate TV signals and sets speak the same “language”

*International* TV systems were *Regional* since the 1930’s – originally based on radio tower’s transmission range.

1998 DVD was “Heard Around the World”, not just fifty miles – DVD Digital TV instantly went *Global*!
Clearer pictures
The high-definition television revolution

- The Net's top pirated movies
- Internet banned in Afghanistan
1923 - 28 line TV from John Logie Baird’s spinning disc to……..
1935 - 343 line RCA system………..
1936 - 375 In Germany…..USA’s RMA 441i/30
1939 - 525 USA’s NTSC B&W system………..
1941 - 625 Multiple International PAL systems
1998 – 1080 USA’s ATSC HDTV
2010’s – Ultra High Definition TV 4K and 8K
John Logie Baird’s 750 rpm Spinning Disc TV - With 2100 lamps!
1930’s HDTVs – 1800 Lbs!

Eidophor “oil film" Projectors – Philo’s TV!
What did the Entire Planet Agree Was “Great Picture Quality” For almost a Century?

Only one imaging system was recognized as high quality in the 20\textsuperscript{th} Century:

It was delivered on every continent
In every city and town
And played everywhere on Earth….

\textit{35mm Film}
So….Film “WAS” our real competition - in the last century

So….Just how good was 35mm film?

ISF’s #1 Empirical image analysis tool?

THE DEAD PIXEL TEST?

What will you see if you analyze film?
How Many Pixels Equaled Film Quality?

In Digital moving images can and do slide across pixels, causing "Artifacts" which reduce resolution – Just like Multiburst with overscan on

So – what level of Digital resolution is like 35mm Film?
35mm Film’s Resolution? - SMPTE 3/2004

6 Theaters tested with “Release Prints”
“Original Negative/Interpositive/Internegative/Release”

Experts evaluated at 1.5 picture heights
Theaters were Orlando, LA, NY, Montreal, Paris, Milan – 1.85 prints

Conclusion - 35mm Film’s resolution was basically:

A Mere 1 Mega-Pixel!
So - If Film Was ONLY “1” Megapixel?

Why Did Projected Film Look Great to Our Eyes – HDR!

ISF Imaging Hierarchy of Quality Parameters

#1 - **Dynamic Range** = Dark to Bright

#2 - **Color Saturation** = Colorful

#3 - **Colorimetry** = Life-like Color

#4 - **Resolution** = Detailed
Welcome to H.D.R. in the UHDTV Era!
High Dynamic Range + WCG

- Perfectly follows ISF’s hierarchy of imaging
- Will expand dynamic range and color saturation!
- CES HDR demos were some of the best images and some of the WORST!

HDR developers represent some of the world’s top imaging technical companies:

- Dolby Vision
- Technicolor
- Philips
- Samsung HDR 10+
- BBC and NHK - HLG
HDR Adds Color and Dynamic Range!
 HDR Evolves....

**DolbyVision:**
Vizio was the 1st TV Licensee
LG signed on at CES 2016
Philips and TCL in May 2016
Sony Pictures, Universal and MGM will make Dolby Vision movies, more to follow
Christie / Dolby launch Dolby Vision theaters Worldwide
Dolby’s PQ EOTF = SMPTE

Philips and Technicolor join together for HDR TV
BBC and NHK HLG
Samsung’ HDR 10+
Upconverting old content
Encoding SDR and HDR in a single stream with a “System on Chip”
SMPTE ST-2084 is HDR 10 E.O.T.F. from Dolby’s “Perceptual Quantizer”
BBC and NHK HDR Evolve

BBC / NHK Hybrid Log Gamma (HLG)

Designed for real time broadcast – live video coverage

One transmission can include both SDR and HDR simultaneously

Limited “color mapping” capability

(more on this topic shortly)
HDR’s Production Evolves….

SMPTE ST 2084 - High Dynamic Range ElectroOptical Transfer Function of Mastering Reference Displays

SMPTE ST 2085 - Color Differencing for High Luminance and Wide Color Gamut Images

SMPTE ST 2086 - Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images

SMPTE ST 2094 - Content-Dependent Metadata for Color Volume Transformation of High Luminance and Wide Color Gamut Images
What Is An F-Stop

Dynamic range is the ratio of maximum light intensity to minimum light intensity.

In digital cameras, the most common unit for measuring dynamic range is an F-stop, which describes light by a power of 2 – or a doubling of Dynamic Range.
HDR’s Improvement over SDR

Dynamic range of luminosity

- Moonlight
  - Clear
  - Starlight
  - Crescent
  - Full
  - Street Lighting
  - Sunset
  - Sunrise

- Sunlight
  - Overcast
  - Hazy
  - Direct

Illuminance (Nits or cd/m²)

- Standard TV (7 stops)
- HDR TV (14 stops)
How Do F-Stops Relate to SDR / HDR?

Standard Dynamic Range (SDR) is < 10 f-stops
High Dynamic Range (HDR) is > 16 f-stops

What will we see on screen?
10 f-stops = 1,024: 1 contrast ratio
16 f-stops = 65,536: 1 contrast ratio

From Day to Night Humans See 42 Stops!
Where Does HDR Originate?
Arri’s Alexa 65 with 16 Stops!
HDR With 20 Stops at Home?
LG’s 2106 Signature Series OLED
HDR Viewing Experience

In the past content was adapted for distribution to fixed consumer TV products for HD and SD.

In HDR the consumer system will synch to wider color space, HDR, and eventually higher frame rates.

This will require significant EEDID/Metadata exchanges to enable the advances that now include “WCG” - and eventually will include “HFR”.
Dynamic HDR – It That Redundant?
CTA - 861 - G/HDMI

This is CTA’s developing Standard to support Dynamic HDR - requires large amounts of metadata for scene by scene color volume data – an “eInfoFrame”

CTA is aiming at compliance tests to avoid distortion

“Dynamic HDR” is based on the upcoming SMPTE ST 2094 suite for scene by scene, read “live” data
HDMI 2.0a Enables HDR and Much More

Multiple EOTF (Gamma) for Multiple HDRs:

(NO HDR STANDARD Chosen or Defined – Thankfully!)

4K at 50/60 Hz and Dual Viewing

Up to 18 Gb/s

32 Audio Channels and Multi-Stream audio

Dual Viewing, CEC Extensions (we hope)

HDMI 2.1 WILL BE 48 Gb/s
HDMI 2.0a Cannot Do Everything We Want to do Even in 2017

4K 60 4:4:4 (no HDR) = 17.82Gbps

4K 30 4:4:4 10 bit - HDR (no 60fps) = 11.14Gbps

4K 60 4:2:2 10 bit - HDR (no 4:4:4) = 17.82Gbps

4K 60 4:4:4 10 bit - HDR = 22.28Gbps
Real World 18GB Blu-ray

**SIGNAL INFO**

- Timing: 3840x2160P 59.936Hz
- ColorSpace: YUV422 (ITU-R BT.2020)
- Video Type: HDMI
- HDCP: HDCP V2.2
- ColorDepth: 8BIT
- TMDS Bandwidth: 17.801G
- HDR Metadata: Present
- Audio Sampling freq.: 48K
- Audio Sampling Size: Refer to Stream Header
- Audio Ch. allocation: -- -- -- -- -- -- FR FL
- Audio Coding Type: Refer to Stream Header
- ACR N/CTS: 5824/562500
Disc Player OSD for 18 GB
“Premium” Ultra HD Alliance

Performance specs from the “UHD Alliance”:
1. Content mastering criteria for all distribution – not just UHD Blu-ray
2. Color Gamut – at least 90% of P3 (DCI)
3. Capable of accepting ITU 2020 signal input (not displaying it is accepted)
4. Two HDR ranges – one for OLED and one for LCD
5. SMPTE’s 2084 HDR10 EOTF capable
What is a TV’s Color Volume?
The CIE in 3D
Calibrating HDR - Mapping Color Volume?

Dolby Vision’s “Golden Reference”:

Dolby Vision HDR tools are already in CalMAN
Test signals coming from the PC? Can that be a compromise

Murideo Test Signals are in development
Updates to 6G units will be made available

SMPTE 2084 HDR10 tools are not universal quite yet……..

Test discs and more to follow - UHD Blu-ray!
Dolby Vision Calibration
Confidential at the moment – we can show these slides but not share them – yet…..
Homework Project 1: Describing the 4 Quality Parameters

If you can do that you can:

Describe the benefits of investing in a superior HDTV
Describe the benefits of calibration to a client
Why is SDR/HDR Calibration Important?
Matching a display to a source
Matching a system to a room
Getting the whole picture
Getting the right picture
Getting nothing but the picture
Matching to a “Golden HDR” reference?
Accurately displaying a subjective image….
Why match UHDTVs to sources?

Will UHD HDR Disc Players have reference output?  
What will a 10% differential source in hardware parts translate to in the field?  
Can your display’s manufacturer anticipate these differences in sources?  
Will you be mixing HD + SD + PC + Gaming + Photo?  
Will all sources be the same signal?
Why match UHDTVs to room environments?

What Will We Do With HDR?

Variables in ambient light make black level settings in manufacturing a W.A.G.

Fighting ambient light during the day and minimizing viewer fatigue at night requires different calibrations
ISFccc “Day” and “Night” Modes
ITU Digital Video
From 1982!

193 Countries Agree on setting Black and White
Create in Bollywood, play back in Hollywood!

“0 to 255, with 220 quantization levels with the
black level corresponding to level 16 and the
peak white level corresponding to level 235.
The signal level may occasionally excursion
beyond level 235”
“Getting the Whole picture”

ANALOG

Analog “IRE” levels

Institute of Radio Engineers, founded 1912 in NYC
Merged with American Institute of Electrical Engineers to form the IEEE in 1963

100 IRE = White
0 IRE = Black

(7.5 IRE = Black in 1963 when color was added)

0 IRE = Black, Since DVD in 1998 in the US
(0 to -40 IRE = Footroom and Synch)
8 Bit Digital Video is 0 to 255

ITU / HDMI Specs

“0” and “255” are T.R.S. (Timing Reference Signals – AKA Synch)

1 to 254 is the LEGAL range for the entire signal

16 = Is the Black level as per ITU-R BT601 & 709!

235 = Is the White level as per ITU-R BT601 & 709

236 to 254 = “above white”, 1 to 15 = “below black”
Calibrating 16 -235, 4 Simple Steps!

ITU and HDMI specs call for above white and below black so we……

1 - Use test patterns with above White elements!
2 - Use test patterns with below Black elements!
3 - Preserve above White, Visible to 234?
4 – Verify below Black, then Set Black at 16
What About UHD’s 10 Bit and 12 Bit?

“10-bits per sample Rec. 2020 uses video levels where the black level is defined as code 64 and the nominal peak is defined as code 940. Codes 0-3 and 1,020-1,023 are used for the timing reference. Codes 4 through 63 provide video data below the black level while codes 941 through 1,019 provide video data above the nominal peak.”

“12-bits per sample Rec. 2020 uses video levels where the black level is defined as code 256 and the nominal peak is defined as code 3760. Codes 0-15 and 4,080-4,095 are used for the timing reference. Codes 16 through 255 provide video data below the black level while codes 3,761 through 4,079 provide video data above the nominal peak.”
What is improved With 10 Bit?

Color depth

1 bit (2 gradations)
2 bit (4 gradations)
4 bit (16 gradations)
8 bit (256 gradations)
10 bit (1024 gradations)
12 bit (4096 gradations)
We do not believe Test Patterns and Humans can Coexist….Color Bars were on Broadcast TV for 50 years……

ISF / Microsoft Windows 7 and 8 free user friendly basic tools!

– Over 150,000,000 PCs have it – and virtually nobody knows it is there
The Microsoft / ISF Consumer Tools
Simple to Use Basic Set Up – White Level

The Calibration Wizard is already in over 111,000,000 PCs! Is it in Yours??
ISF Cal Wizard Black Level Tool
Pattern With Above White Details
“Free” ISF UHD 4K Patterns
Pattern With Below Black Details
White “CLIPPING”
Use “White” PLUGE Patterns

Digital Devices “Clip”
Clipped TVs Are *Missing* Parts Of The Picture;
Look at a Ten Step pattern..
Clipped Images *Do* Appear Brighter
Ten Step Pattern B & W Errors
Near White Color Shifting

Use a full field gray scale or a High APL Pluge

Look for interaction between moving the control and the color of Light Gray or Near White changing
“Near White” Color Shifting
Test Black and White Levels Now
Summary for Setting 16 to 235

• **Black Level:**
  Verify under 16 is visible by raising brightness, then........
  Lower brightness to lock in Black at 16

• **White level:**
  Ideally, test pattern elements visibly to 254
  *Real world, get the most elements visible without losing light output!!*
Video 101 Test - How Would You Fix the Left Image?

**NON calibrated**

**DICOM 14 calibrated**

*(Digital Imaging and Communications in Medicine)*
Video 101 Test - How do you fix this Left Image?

*Same Scan – Right one is a correct DICOM 14 image...*
LCD/OLED Backlight – Set With 100 IRE Field BEFORE and AFTER Setting B&W

40 to 50 FtL will work well for most Night Modes!

60 to 150 FtL may be needed for Day Modes
Room conditions will dictate the right settings

These Controls are light output VOLUME controls!

*If you are not sure – GO BRIGHTER!*
LCD Flat Panel Backlight, or Projector Lamp and Iris Settings – Use Full White Field
OLED Requires 18% Windows (Like CRTs and PDPs)

These settings Adjusting Light Output

Meters should be used!!!!

However, setting these levels in 2 modes
to be close enough to be at least
bright enough for Day viewing, and
not too bright to be uncomfortable for
Night viewing is relatively easy

ISF recommends Day and Night light
levels in “Foot Lamberts” and “Nits”

Pattern for setting these controls
LCD LED “Local Area Dimming” – Off for Calibration? - On for viewing

Blacks are of course rendered Black in blocks that are off
The number of LED does not = number of zones.
Example: VF55 LED backlight local-dimming turn LEDs on and off to improve black level – These are numbers for an older LED: The backlight consists of 960 LEDs, positioned in 80 control blocks”

Example: Sharp Elite 2011 had over 300 control blocks!
Artifacts occurred when bright elements on dark backgrounds move from block to block – nicknamed “Tinker Bell Effect”
Projector “Iris” Features

Many projectors offer Iris options

Auto iris will impact calibrations

You must test with all options both on and off

Obtaining good light output and contrast ratio are both objectives

Mechanical Iris functions may be too slow – LED functions are faster and may be preferred
Disc Player “Set Up”

Many disc players are not ITU Compliant
Some Critical options in Disc Player Set Up:

Video Level controls, modes, output formats

Some units are wrong when up-converting
Some just need the Contrast or Brightness set!
Some units will never be correct!
Video Test Generator Versus Test Disk

1. A Disc player itself doesn’t provide a calibrated output.
2. You must Match the player’s output to a reference!

Test generator should be used to calibrate TV input; a reference disk is then used to check/adjust disc player’s internal controls, IF THAT IS POSSIBLE!

Players might not have controls
Player’s controls might not have fine enough adjustments
Measurement Tools

Test Pattern Generators – Reference Sources

• Need reference test pattern source to play into TV.
  • Reference test pattern generator

• Need reference content to play through source device.
  • Reference test disk and/or reference program material
An HDMI Only 2K Video Generator

AV Foundry VideoForge 3D HDMI Video Generator

- HDMI video test signals to 230 MHz pixel clock 12-bit output, with resolution, frame rate, and test pattern selection. Supplied test patterns, plus user-loaded patterns from SD card. **PC control ONLY**
Compact 4K Generator
HDMI Powered
Remote Control or PC Patterns Access
ISF B&W PLUGES
Video Generators 2K and 4K
Including EEDID and HDCP Diagnostic Testing Tools

Quantum Data 780a Handheld Test Instrument for HDMI

• Portable audio/video generator and HDMI troubleshooting tool for testing and adjusting analog or digital input, HDMI input and output tests troubleshoot system interoperability issues.

www.spectracal.com
Murideo SIX G - 4K, 18Gb, HDR

ISF Patterns
HDMI 2.0a
HDR Test
HDCP 2.2 Test
EEDID Reader
Dolby Vision HDR
In Field Updates
“E-EDID” “Plug and Pray” Solutions
HDMI Problems That You Can Not Fix!

TV and a source component talking to each other...

Enhanced Extended Display Identification Data for resolution, timing, color transfer functions and more VESA Standard www.vesa.org

If TV is not compliant - connections will not work!

HDCP is two-way com, like EDID!
HDCP = D.R.M.
Now it is far more robust with **HDMI 2.0 with HDCP 2.2**


**Upgrading Players is REQUIRED!**

*Is this done for clients?*
High-bandwidth Digital Content Protection (HDCP)
HDCP is a content protection technology developed by Intel for HDMI
All HD cable and satellite set-top boxes require HDCP for HDMI
Evolution of SD-SDI (Serial Digital Interface)

Single Coax connection

720p / 1080i over single link / 1080p over dual-link

Broadcast, Commercial & Medical applications

Converters are available for DVI / HDMI

Does NOT pass HDCP – now…..

Can carry 16 channels PCM Audio
HDMI “Under the Hood”

Plug Technology

19-pin plug supports:

- 3 TMDS channels*
  (*Transition Minimized Differential Signaling transmitting high-speed serial data used by the DVI and HDMI video interfaces.)
- Clock
- DDC channel
- CEC channel
- +5V power
- Hot plug detect

- TMDS Data must arrive in precise alignment
  - Requires each cable to be exactly same within 1/20,000 of inch!
- All pins are critical- do not cut any lines
Questionable Video Signal Paths

Built In Switchers In AVRs?
Consider Them SUSPECT until tested!

Stand Alone High Quality Matrix Switchers
ISFccc AVRs! Denon/Marantz
HDMI to Cat and Fiber, HDBaseT, Wireless
ISF Research….conclusion….be careful!
HDMI / Mini-HDMI
High Definition Multimedia Interface – www.hDMI.org

- Single connection can carry Ultra High Definition video, multi-channel audio, format & command data and 100Mbps Ethernet
- Integrated remote control – named CEC for Consumer Electronic Control
- Automatic format adjustment – RGB or Component
- Fully compatible with DVI video
- HDTVs and UHDTVs and Computer Monitors
- Set Top Boxes
- DVD and Blu-ray and UHD Blu-ray disc players
- PCs and Gaming Systems
- Cameras and camcorders
- PDAs and Phones and more to come!
HDMI Cable Categories

www.hdmi.org
Premium HDMI Cable Certification Program

- HDMI cables certified under this program can be branded and promoted as:
  - Premium High Speed HDMI Cables
  - Premium High Speed HDMI Cables with Ethernet
- The products will carry a special anti-counterfeit authentication label to differentiate them from other HDMI cables.
- Once certified, authentication labels will be placed on product packaging.

Premium HDMI Cable Certification Program—Availability

- The Premium HDMI Cable Certification Program will be available to HDMI Adopters by the end of September, 2015.
- Adaptors who wish to participate in the program will sign an Participation Agreement and submit Candidate Cables for testing.
- Once Candidate Cables have been certified to Premium HDMI Cable standards, Adopters will be able to order labels for packaging.
- Premium HDMI Cables may be publicly available as early as Q1, 2016.
## HDMI 2.0

<table>
<thead>
<tr>
<th>Year</th>
<th>HDMI 2.0</th>
<th>HDMI 2.1</th>
<th>HDMI 3.0</th>
<th>HDMI 3.1</th>
<th>HDMI 4.0</th>
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<td>2022</td>
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</table>

### 4k TV era
- 4kx2k/60, 24 bpp
- 120 fps (3D)
- Multi-stream (bi)
- 1 Gbps data
- Compression min
- Legacy cable/conn*  
- New cable/conn  
- Power  
- Pix bw ~20-40 Gbps  
- New control  
- Backward compatible

### 8k TV era
- 8kx4k/60, 30 bpp
- 120 fps (Multi-view)  
- Multi-stream (bi)  
- 4-20 Gbps data  
- Data tunnel (PCI)  
- Compression >4k era  
- New cable  
- Pix bw ~80-160 Gbps  
- Advanced power  
- Discard some legacy

### Beyond 8k
- 16kx8k/60, 36 bpp
- 120 fps (Multi-view)  
- Multi-stream  
- Bi-directional  
- 40-80 Gbps data  
- Compression >8k era  
- Pix bw >>160 Gbps  
- New cable

* may have limited capability
## HDMI 300 MHz or 600 MHz Chipsets?

<table>
<thead>
<tr>
<th>Video Format</th>
<th>300MHz</th>
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<td>✓</td>
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<tr>
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<td>✓</td>
</tr>
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<td>UHD/24-30 10-bit 4:2:0 HDR*</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>UHD/24-30 10-bit 4:4:4 HDR*</td>
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</tr>
<tr>
<td>UHD/50-60 8-bit 4:2:0</td>
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</tr>
<tr>
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<tr>
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### What Format Needs What Bandwidth?

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<th>Format*</th>
<th>Active Res</th>
<th>Color</th>
<th>HDMI ver</th>
<th>HDCP ver*</th>
<th>Data Rate</th>
<th>Char. Rate</th>
<th>Chipset Speed</th>
<th>TMDS Clock</th>
<th>Bandwidth</th>
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<tbody>
<tr>
<td>1080p/24</td>
<td>1920x1080</td>
<td>8b 4:2:0</td>
<td>1.4b</td>
<td>1.x</td>
<td>2.23Gbps</td>
<td>74.25Mcsc</td>
<td>225MHz</td>
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<td>1920x1080</td>
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<td>1.4b</td>
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<tr>
<td>UHD/24</td>
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<td>8b 4:2:0</td>
<td>1.4b</td>
<td>2.2</td>
<td>8.91Gbps</td>
<td>297Mcsc</td>
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<td>4K/24</td>
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<td>92.82MHz*</td>
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<td>UHD/60</td>
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<td>22.28Gbps</td>
<td>742.5Mcsc</td>
<td>NOT SUPPORTED</td>
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</tbody>
</table>
Real World 17.819 Gbps Test
HDMI 2.2 Terms for HDCP Mapping

RSA – a Cryptosystem with Public and Private Keys

Authentication and Key Exchange (AKE)

128 bit Random, Secret Cryptographic Keys (Master)

Locality Check - Round Trip Time = 20 ms (RTT)

Session Key Exchange (SKE)

HDCP Cipher – Module operating in a Counter (CTR)

(*72 pages on HDMI 2.2 are in our USB drive for you)
HDMI Errors.....
The Very Shortest Summary.....

No Image at all - Why?

Wrong image color or poor image – Why?

Blinking image – Why?

Never guess – save time and use test equipment!
Test Pattern Tour

1 - Visual Test Patterns
2 - Metering Test Patterns
3 - Processing Test Patterns - on Blu-ray
Trust Your Eyes or Your Meter?

Color versus Black and White – Eyes versus Meters

Metering White Fields - Measure the center of the screen, sides and the corners – compare readings!

Are smooth ramps smooth on 8 Bit systems?

SMPTE Color Bar pattern problems on CE HDTVs?

Introduction to instrumentation #101

Computing contrast ratios 101 – pre or post calibration?

Intra Frame vs. Sequential Contrast ratios?
Check video amplifier linearity and gray scale tracking. Sixteen steps. Good reference signal for signal tracing. Always look carefully at 90IRE to 100IRE transitions – and carefully watch for color shifts at every level.
Use a “Full Field” or A “Window”

For Local Area LCD, Projectors

For OLED, Plasma, CRT
Needle Pulse – Obsolete?

White Lines (Top) are equal width to black lines (Bottom)

Grayscale Bars
Top Bar is 100% white
External Focus Pattern versus Internal?

“E”s and “M”s alternating across screen.
Letter size varies with resolution
Traditionally referred to as a “me-me” pattern.

Check for proper operation at both screen center and edges – look for “Chromatic Aberrations”
Luma and Chroma Multiburst

Should we set Disc players to RGB or Component? Perhaps 4:2:2 or 4:4:4?
Check for proper black level setup. Includes alternating black/blacker-than-black and black/just-above-black sections in newest models.
Obsolete White Pluge - HiLo Trk  (HIGH/LOW TRACK)

Black “reference” section
Outer box: 1% above black.
Inner box: 2% above black.

White “adjustment” section
Outer box: 99% of peak white.
Inner box: 98% of peak white.

WHAT IS MISSING?  -  Above White!
QD 780 updates are coming!
Both Disc and PC Based Patterns

The patterns themselves may be OK, but the source hardware output may not be at all!

Verify them with reference generators before you trust them.

PC patterns have even failed at basic white luminance levels for I.S.C.R. testing.
PC “Set Up”

16 to 235 “Enhanced”?  
0 to 255 “Normal”  
LUT? - 1D or 3D?  
Aspect ratio or Scaling?  
RGB or Component?  
EEDID Compliance?  
Inverse Telecine?
Game Console “Set Up”

Super White?
RGB or Component?
4:2:0 or 4:2:2 or 4:4:4?
Aspect Ratio?
Output Format?
Redundant Controls…..

Processors & PCs & Displays & DVD players & Game Consoles & AVR have controls

Four, Six - or more - places to check for problems!

Calibrate everything! Check everything!

**WHAT DO YOU ADJUST FIRST?**

**YOU ABSOLUTELY NEED THESE!**
What do we need to calibrate?

1 - Select best user Mode and Display options for Color Temp and Gamut
2 - Disable Auto Features (for now)
3 - Luminance - Lamp Setting / Iris / Backlight / Cell light / Panel Brightness
4 - Brightness and Contrast, Technically Black level and White level
5 – Gamma / EOTF* Preset
6 - Color &Tint
7 - Bit Mapping Accuracy / Overscan / Geometry
8 - Gray scale 2 Point
9 - Grayscale and Gamma Multipoint / 10 Point / 20 point
10 - Color Management Systems, 3D CMS, Gamut RGBCMY
11 - Video Processing and 1080p HDMI Optimization
Using the equipment for Front Projector Calibration

Always wear an appropriate shirt when using precision equipment.

The room is now a major limitation!
What is Calibration?

Calibration is the matching a device to a standard

In Home Theater, Calibration is balancing science, knowledge and experience with the major compromises made when building today’s hardware.

Calibration should not be confused with hacking

Calibration is now multiple small improvements whose sum is far greater than the parts

Professional video without calibration is not Professional
Video Calibration Benefits

Running Post calibration A/B Demo material defines your skills

Reproduction following the Standard used in content creation!

- Full details in the darkest and brightest parts of all scenes. (Avoids “Crushing” and “Clipping”)
- Match the viewing environment.
- Produce full range *accurate* colors, including flesh tones, grass, sky, and sports jerseys *WITHOUT EXAGARATING COLORS*
- Minimize picture artifacts (distortions).
- Produce a "film look" superior to commercial theaters.
You Cannot Manage What You Cannot Measure! Color Space CIE 1931 Model – Commission Internationale de l’Eclairage

Graphically depicts relationship between hue and saturation

Shows pure spectral colors around the curved border

**3D Space View**

“COLOR SPACE”

Hues form the circumference, Color Saturation is middle to edge, Brightness equates to the 3D “Z” axis
Different Color Space Triangles

<table>
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<th>sRGB</th>
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<td>0.640</td>
<td>0.640</td>
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<tr>
<td>( x )</td>
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<td>0.300</td>
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<tr>
<td>( y )</td>
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<tr>
<td>( x )</td>
<td>0.150</td>
<td>0.150</td>
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<tr>
<td>( y )</td>
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<thead>
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<td>( y )</td>
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<tr>
<td>( x )</td>
<td>0.210</td>
<td>0.310</td>
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<tr>
<td>( y )</td>
<td>0.710</td>
<td>0.595</td>
</tr>
<tr>
<td>( x )</td>
<td>0.140</td>
<td>0.155</td>
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<tr>
<td>( y )</td>
<td>0.080</td>
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<tr>
<th></th>
<th>Adobe 1998</th>
<th>EBU (601)</th>
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<tbody>
<tr>
<td>( x )</td>
<td>0.640</td>
<td>0.640</td>
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<tr>
<td>( y )</td>
<td>0.340</td>
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<td>( x )</td>
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<tr>
<td>( y )</td>
<td>0.060</td>
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</tr>
</tbody>
</table>
Another Way Of Looking at the Visible Spectrum

Light is electromagnetic energy within a narrow range of frequencies.

Each different wavelength of light energy (if seen alone) is perceived by the human eye/brain as a different, fully saturated color.
LED and UHP Projector Spectrum

Look at the difference in the RED – What does that mean?

You See Them The Same – Your Meter Does Not!
Laser Phosphor Projector SPD
Spectrum Differences LED / OLED

White LED Backlit LCD

LG OLED 2015
Spectrum Differences LED / OLED

Samsung QLED 2017

LG OLED 2017
CalMAN’s Biggest Weakness – Wetware! - You! You Must Tell Your Meter What TV It Is Reading!

Colorimeters measure TV’s Spectrums – setting CalMAN for the right type of TV makes your meters more accurate

YOU MUST DO THIS IN ISF CalMAN SET UP EVERY TIME!
Matching LCDs to OLEDs?

Same x,y, Y calibration done with $30K meter looks different to the human eye!
Spectral Power Distribution is the issue
Offsets from Manufacturers have helped – but are not perfect
For signage or studio use identical displays are ideal
ISF’s Inspiration for the ISF CalMAN Workflow!

The ISF CalMAN workflow is a step by step compilation of many top calibrator’s methodologies – and is a living breathing process that will continue to develop!

W. Edwards Deming, 1900-1993

THE W. EDWARDS DEMING INSTITUTE®
ISF CalMAN Display Calibration Software – Quick Tour!

C.A.C = Computer Assisted Calibration

The Goals:

1 - A step by step process that will insure more consistent ISF Calibration services worldwide. Since calibration adjustments are interactive, the process must be repeated until no additional adjustments are required throughout one entire step by step workflow!

2 - A framework that makes learning ISF Calibrations easier

3 - A process that speeds the work of experienced calibrators

4 – Software that will make Calibration Hardware more accurate

5 - Producing customer reports that can establish histories and generate referrals

6 – An updateable process that will adapt to upcoming HDTV technologies

7 – An automated network that earns your client’s respect – Now Tour ISF Workflow!
CalMAN PC Set up Check

Is ISF CalMAN open on every PC?

Get ready to follow along on your PC…

We will run a quick tour of all the 1st steps, and then cover complex steps in detail…..

Hands On - Tour some of the Steps - Stop at “Gamma” So We Can Talk About EOTF…..
Goodbye Gamma – Hello EOTF and OETF

Or......

How to confuse as many people as possible for as many decades as possible!
What is Gamma?
Why is it now called EOTF and OETF?
How can you explain it to a client in 30 seconds?
Why are we stuck with it?
How do you determine how to set it best for every installation?
Going From Fixed Black to Fixed White, How Much Brighter Should Each Step Below Be Than the One Before it?
A Linear Display
Input / Output plot:

No “Gamma” or “EOTF”
Humans are hopelessly non linear, and totally analog

If the steps get brighter in equal amounts, people do not see the steps as becoming brighter equally
CRTs to the Rescue – CRTs Have “Human Like” Non-Linear Response

Relation of Input signal to Light output

Input is video signal
Output is the Brightness of the display

This graph shows the nonlinear relationship between input signal voltage and light output for a CRT display.
1 - With Signals from an Analog Tube Camera
2 - Displayed On an Analog CRT TV
3 - These Steps Looked Right to Us Analog Creatures!
Welcome to CRT’s Non-Linear Response, or Gamma!!
Intro to Gamma – *The 1930’s CRT Legacy*

How Digital TVs *should* respond to sources

**Pink Line = OETF**  **Blue Line = EOTF**

![Graph showing CRT distortion and corrected source video]
How does Gamma Change This Picture?
How Does Changing Gamma Settings Change How You See This Pattern?
Where In The Pattern Do You Immediately See Changes?
Gamma Setting

Select the display's gamma setting that produces gamma performance closest to the desired gamma for the intended viewing environment.

To Select a Gamma Setting:
1. Select the first gamma menu selection offered by the display and press the Read Series button to plot gamma performance across the grayscale.
2. Press the Next Tab button (the + sign to the right of the History tab at the top of this page.) Select the next gamma setting and press the Read Series button again to perform another grayscale reading with this gamma setting.
3. Repeat until you have tried all the settings the display offers. Select the setting that is closest to the target.

Background:
A display's gamma performance affects how much light output the display produces at each video input signal level between black and peak white (1-99%). Lower gamma results in more light output at each signal level, appropriate
Matching Digital Displays to CRTs

Professional CRT specs for Gamma were 2.2
Setting reference DLPs to 2.2 did not match CRTs
All Broadcast CRTs did not actually measure 2.2
ISF research showed Pro CRTs to be Higher
Geneva 2008 EBU Tech Spec

**Gamma characteristics**

1) The luminance gamma characteristic (electro-optical transfer function) of the screen should be equivalent to those of a reference CRT with the rendering intent (dim-surround) expected of a TV system. It is **believed** that a nominal value of 2.35 is **appropriate**.
Gamma characteristics

1) The luminance gamma characteristic (electro-optical transfer function) of the screen should be equivalent to those of a reference CRT with the rendering intent (dim-surround) expected of a TV system. It is recommended that a nominal value of 2.35 be used.
ITU 2011 – Finally a spec!

It is a Studio Production Function for Studio Lighting Conditions. It is designed for digital displays – not CRTs. It is close to 2.4, but it is a different curve. Blacks are measured!
Finally! – After 80 Years! – A Gamma (EOTF) Spec
Recommendation ITU-R BT.1886
03/2011
Reference electro-optical transfer function for flat panel displays used in HDTV studio production *(In Red below)*
Bright Room or Dark Room Settings

Home theaters are easy – BT.1886 with excellent light control

Rooms with ambient light require careful evaluation

- Backlight and OLED Light raise the VOLUME of light
- Lamp output settings for projection provide options
- Expanded Color Gamut to compensate for loss of color

Gamma settings simply should be set lower in brighter rooms

Very bright: perhaps 1.8 to 2.0
Medium bright: perhaps 2.2 to 2.35
Studio like lighting: BT.1886!
Home theaters are easy – approx 2.4 with light control

Rooms with ambient light require careful evaluation

Backlight settings for LCDs and OLED light settings raise the VOLUME of light

Lamp output settings for projection provide options

Gamma settings need to be lower in brighter rooms

LED LCDs will perform best in extreme room lighting
Where is BT.1886 Applicable?

It is a Studio Production Function for Studio Lighting Conditions

For CE use – Home Theater Lighting

“ISF Night” Calibration…
Gamma Summary?

Defining Gamma:

New term from the ITU – EOTF

“Non-standard” is not Content Creation Gamma

DCI Gamma is 2.6 as is DICOMM

Day / Night Gamma

“S” shaped Gamma

HDR’s EOTFs can be helpful in high ambient light
EOTF Tech Tip

Running digital signals through multiple components should not change EOTF

Guess what…

Running digital signals through some components can be hazardous to picture quality – see next two slides!
 Gamma Post Calibration No AVR

Select the Display’s Gamma Setting

A display’s gamma performance affects how much light output the display produces at each different video input signal driving level (0-100%). Lower gamma performance results in more light output at each signal driving level, appropriate for a room with more ambient light. Higher gamma performance results in less light output at each driving level, appropriate for a room with less ambient light. Many displays offer a selection of multiple gamma settings in the user menu.

 Gamma Target Recommendations:
 Bright Room: 2.0 gamma
 Dim Room: 2.2 gamma
 Theater Room: 2.4 gamma

Select the display gamma setting that produces gamma performance closest to your desired gamma for the intended viewing environment. Note that a display’s gamma setting may not produce the exact gamma performance that its label indicates.

To Select a Gamma Setting:
1. Test the gamma performance of each of the display’s gamma settings. Select the display gamma setting that produces gamma performance closest to the desired gamma. You can change the target gamma under Options / Gamma / Target Exponent, in the left treeview.

Click the green Next button to continue.
Same TV’s Gamma Through AVR

Select the Display’s Gamma Setting

A display’s gamma performance affects how much light output the display produces at each different video input signal driving level (0-100%). Lower gamma performance results in more light output at each signal driving level, appropriate for a room with more ambient light. Higher gamma performance results in less light output at each driving level, appropriate for a room with less ambient light. Many displays offer a selection of multiple gamma settings in the user menu.

Gamma Target Recommendations:
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Select the display gamma setting that produces gamma performance closest to your desired gamma for the intended viewing environment. Note that a display’s gamma setting may not produce the exact gamma performance that its label indicates.

To Select a Gamma Setting:
1. Test the gamma performance of each of the display’s gamma settings. Select the display gamma setting that produces gamma performance closest to the desired gamma.
2. Click the green Next button to continue.
Different Tools for OLEDs and LEDs!
What Test Patterns to Use for Calibrations?

For Local Area Dimming LED and IMLEDs:
Full Screen Pattern

For OLED, Plasma and CRT:
18% Window Pattern (ANSI)

(Credit Panasonic Engineering, Japan)  
(Credit LG Picture Quality Lab 2016!)
Why are there Gamma Options?

1 – Accuracy and Image Fidelity
   *Match Gamma to content creation in a studio like light environment*

2 – Compensation for Bright Environments
   *Reasonable compromises for rooms that are not like studio light environments*
EOTF Explained:

1 – The 30 second answer?

Multiple TV gamma options enable knowledgeable integrators to optimize a TVs performance to multiple room lighting conditions.

2 – Gamut, light output settings, black level settings, different factory presets, dynamic contrast modes, and local area dimming are other settings to help you deal with sometimes harsh multiple lighting conditions!
Measure All Gamma Options

Go To ISF CalMAN!
- Run Gamma Tests on all HDTVs and components at all options

Check to see if a numerical value is correct, or what Gamma options really measure
Next – Color Encoding and Decoding

Color Decoder
Color and tint patterns (or color bars) are used to check the color decoder adjustment. To adjust the color decoder, we will use a blue only mode in the display (if provided).

Blue Only mode – Many displays have a ‘blue only’ mode that we can enable to ensure the highest level of accuracy (versus looking through a blue filter). This setting is often buried in an advanced menu. You may need to check your display’s user manual to determine whether it is provided. After setting both Color and Tint, click Next.

Note: Blue filters are not recommended for precision calibration. Also, most displays now need minimal adjustment.

Example Color Bars:
Correct Color Bars
Viewing With
Blue Only Mode:

Incorrect Color Bars
Viewing With
Blue Only Mode:
Why Do We Encode and Then Decode When Content Creation Starts as RGB?  
*(Cameras are RGB and CGI are RGB)*

RGB is simply and easy – but bandwidth intensive

Encoding to PAL, NTSC, SECAM, or H.264 saves bandwidth
Bringing Pictures to your HDTV

1 - Cameras capture RGB
2 - We **Encode** to save bandwidth to transmit
3 - HDTVs **Decode** back to RGB

<table>
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<tr>
<td>RGB</td>
<td>to</td>
<td>PAL  (Phase Alternating Line)</td>
<td>to</td>
<td>RGB</td>
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<tr>
<td>RGB</td>
<td>to</td>
<td>SECAM (Sequentiel Couleur Avec Memoire)</td>
<td>to</td>
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<td>RGB</td>
<td>to</td>
<td>MPEG</td>
<td>to</td>
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<tr>
<td>RGB</td>
<td>to</td>
<td>VC1, AVC</td>
<td>to</td>
<td>RGB</td>
</tr>
</tbody>
</table>
1952- Introducing Color in NTSC Creating an Analog Bio/Mechanical Color System

How Many Colors Does the Human Eye See?
Rods & Cones – Which is HD? Key Point!!
100 million rod cells, 5 million cone cells
Color perception is poor for resolution
All Color Compression is Based On:

THIS IS ALL ABOUT HUMAN FACTORS!

Preserve B&W detail for our RODS

Get away with color compression with our CONES

That is why content is delivered in Component!!

ISF considers this just Brilliant.............
Digital Component Color Compression for Our Eyes!
HDTV Video Processing Creates What’s Missing

4:1:1  4:2:0  4:2:2  4:4:4
How do RGB & Component connections differ?

RGB has one cable for each signal plus sync(s)

Component has 1 cable for B & W info (Y) & 2 cables for color info (R – Y) & (B – Y)

Is Component “lossless” compared to RGB?

It is a compressed derivative of RGB!
How RGB Becomes Component

The 3 x 3 Matrix

\[ Y = R + G + B \]

Y = Black and White, or Luminance
1 - RGB is Encoded to Component
2 - Consumer Video is Delivered Component!
3 - Processing and Decoding Component to RGB is *required* for displaying a picture....
SD or HD – Uses Different 3 x 3 Matrix?

1953 SD  “Y” AKA (SMPTE 170M) or (ITU 601)

\[ Y = G + B + R \]

1998 HD  “Y” AKA (SMPTE 296M) or (ITU 709)

\[ Y = G + B + R \] Same or Different?
SD “Y” is Different From HD!

S.D.

\[ Y = 0.2990 \times R + 0.5870 \times G + 0.1140 \times B \]

H.D.

\[ Y = 0.2126 \times R + 0.7152 \times G + 0.0722 \times B \]
The NTSC Decoder Adjustments

**Sharpness**, aka Detail, Aperture

It is “Edge Enhancement”

**Color**, aka Saturation, Chroma

The **Amount**, of color in the picture

**Tint**, aka Hue, Phase *(PAL TV ELIMINATED THIS!)*

The **Type** of color in the picture
Edge Enhancement Artifacts-
AKA - The Sharpness Control

The best way to start calibration demos.
Adjust to max rez and min artifact….judgment call?
HD and SD can and will be different!
USING SMPTE COLOR BARs

Color Bars are designed for “Blue ONLY” modes.
Color filters are NOT Blue Only Modes!!!!
PLEASE TEST FILTERS & BLUE ONLY MODES
ELV RGB FILTERS

Many HDTVs now have Blue Only modes!
Seek those HDTVs out!
Blue Only Incorrect Color & Tint Settings

Look at outer Blue bars for Color – Inner Blue bars for Tint
“Reasonably” Correct Color & Tint

Why “Reasonably” Correct and Not Perfectly Correct?
Resolution/Bit-Accuracy

We will use three patterns to ensure we are getting the correct resolution from the display.

- Sharpness – Sharpness controls add extra pixels at the edges of highly contrasting areas to increase the perceived sharpness. These extra pixels hide actual picture detail. Determine the Sharpness or Edge Enhancement settings that don’t add extra pixels to a Sharpness pattern.

- Overscan – Check that the image is correctly centered and sized to the display. If it is not fitting correctly, check the display’s ratio settings for ‘1:1,’ ‘Just,’ or ‘Pixel Perfect’ setting.

- Resolution – A resolution pattern should show sharp 1-pixel wide lines at your target resolution. Any image scaling or projector keystoning will dramatically decrease the resolution of the image.
Overscan and Geometry Adjustment
Next – Grayscale Setting Tools:
2 Point IRE / Multipoint IRE + Gamma
Delta E Graphs are “Approximations”

The Greek letter Delta (the symbol Δ) is used to indicate a difference and E stands for the German word Empfindung, meaning "sensation." So, "Delta E" literally means "difference in sensation."

Delta E values below 6 are tolerable, below 4 are not perceptible to eye, below 3 considered OK.
How Gray Scale Impacts Content

Credit Tom Norton, Home Theater Magazine
What is “The Color Of Grey”

Commission Internationale de l’Eclairage

x & y coordinates are *precision measurements*

D65 - A Point In Theoretical Space

L*a*b* Color Space in 1976 – a 1931 CIE Variant
Color Temperature vs Brightness

“Perceived” Brightness

Blue Automotive Headlights

Human Factors, Sales and 16,000 Kelvin

Calibrating For Marketing Departments

Calibrating for retail showrooms is a necessary evil
A History of Expressing Colors Numerically

Color Management Requires Measurement!

The Physics we use for measurements are merely High School level concepts.....
Color Temperature & Kelvin

William Thomson, 1st Baron Kelvin (1824-1907), the Belfast born Physicist that the Kelvin Scale Is Named For

International Standard For Thermodynamics
Zero kelvin = -273.15 Degrees Celsius
Scientifically a Kelvin Is Not Considered a Degree
Always say “Kelvin”, never “Degrees Kelvin”
Thank you Max Planck, the German physicist, for “Plank’s Black Body Curve” – What is it?

High School physics – “Things” get red hot, then white hot and then blue hot –

What “Things?” are we talking about? An “Ideal Black Body”
A 24 Year Set Up To Make ISF Calibrators Look Smarter!

Color Temperature Is MISINFORMATION

1994 ISF Editorial Decisions – Write about Kelvin

[D65 vs 6500 “Degrees” vs CCT]

\[D65 = x \cdot 0.313 \text{ and } y \cdot 0.329\]

Correlated Color Temperatures refer to Multiple colors near the black body curve & along ISOTEMPERATURE LINES
xy chromaticity of the black body locus
xy chromaticity chart indicating the black body locus, the isotherm lines and equal Δuv lines.
Correlated Color Temperature

Correlated color temperature was developed to specify near-white colors. Correlated color temperature of can mean any color along the ISOTEMPERATURE line. Since color temperature is an unspecified x,y point, it cannot be relied upon to reach a desired point (D65).
• **White Balance (Hi/Lo) Adjustments**
  – Preset Brightness and Contrast controls, to be in correct operating range.
  – Adjust Gain/Drive controls at high brightness (70-80%) for desired color of white.
  – Adjust Offset/Cutoff controls at low brightness (20-30%) for desired color of white.
  – Repeat adjustments to minimize interaction.
Achieve Proper White Balance

Imagine white balance as a ying and yang. When you adjust one side you will affect the other.
Moving WB Controls Changes?

Moving Red Controls:
Red to Cyan – East/West

Moving Blue Controls:
Blue to Yellow – SW/NE

Moving Green Controls:
TRY TO NEVER MOVE IT!
Ideal Gray Scale Tracking

Calibrate One level near Top & One level near the Bottom EVERY level then measures perfectly

No Top & Bottom Interactivity

Happens often with displays at $80,000 and up
Real World HDTV Tracking

Extreme Interactivity Of Controls

Repetitive Steps To Balance Top & Bottom

Some Errors in the Middle of The Gray Scale
Intro to 10 Point RGB Gamma-precision color balance

Before 10 Point IRE WB

After 10 Point IRE WB
Multipoint Point Grayscale / Gamma

Adjusting BOTH Grayscale and Luminance

Starting at 100 IRE is the most common practice

*Recheck Gamma scan after multipoint adjustments

Results from consumer HDTVs can be SUPERB!
10 Point Grayscale With Internal Patterns
   * Example LG Flat Patterns

Check LG HDTV internal 10 step patterns
Then check with External Test pattern with 10 steps
Then run the calibration with External (Generator)
Are there differences?
IF Grayscale / Gamma Is Not Perfect: YOUR JUDGEMENT IS CRITICAL!

There Will be Errors in Gray Scale Tracking
How severe an error is acceptable
Plus or Minus .004 is the conventional solution
– ISF specifies zero plus error on Green (y)
Hazards Of “Antique” Digital Service Modes

Getting Access To Them

Tripping The Wrong Codes

Document Factory Presets - Work With A SAFETY NET!
TAKE A DIGITAL 16x9 PICTURE!!

MODERN HDTV DESIGNS HAVE CONTROLS READILY ACCESSABLE – NO SERVICE MODES!
Next - Tools Of The Trade
Color Analyzers – TriStimulus Devices
What are we paying for when investing in metrics?
The instrumentation’s Calibration!
Spectroradiometers

Examples:

- Konica Minolta CS-2000
- Konica Minolta CS-200
- Photo Research PR-655
- JETI Specbos
- X-Rite i1 Pro2
Part 3 – Budget Spectroradiometers

Inexpensive units can be used as accessories for Tristimulus meters to check and improve accuracy for Projection systems, LED and other displays.

They do have limitations as stand alone devices.
## Comparisons of Measuring Techniques

Credit Steffen Goerlich at JETI Technische Instrumente GmbH

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<thead>
<tr>
<th></th>
<th>Tristimulus</th>
<th>Spectral</th>
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<tr>
<td>Advantages</td>
<td>• Fast measurement (larger sensors, more energy per sensor)</td>
<td>• No matching errors or matching errors of CMFs</td>
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<td></td>
<td>• Straightforward number of influences to measuring uncertainty</td>
<td>• Spectral data available - extended calculation possibilities, e.g. of Color Rendering Index or spectral weighted data</td>
</tr>
<tr>
<td></td>
<td>• More economic (in general)</td>
<td></td>
</tr>
<tr>
<td>Disadvantages</td>
<td>• Matching errors plus additional matching errors of CMFs</td>
<td>• Not as fast (spectrometer: small aperture input, many tiny sensors)</td>
</tr>
<tr>
<td></td>
<td>• Therefore matrix correction to individual spectrum is necessary (profiling)</td>
<td>• More influences to measuring uncertainty</td>
</tr>
<tr>
<td></td>
<td>• Limited number of data sets for CMFs</td>
<td>• More expensive (in general)</td>
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Go Calibrate Grayscales!

1 - Use 2 point Grayscale 1\textsuperscript{st}

2 - Then if needed and if possible use Multipoint Grayscale

3 - Than if needed and if possible use Multipoint Gamma
Two Piece Projection Calibration

The Impact Of Screens
Projectors & Screen vs Amplifiers & Speakers

Non-Contact meters are recommended
More Variables For Calibrating a Projector

Sizing, Lens Shift and Focus Must All Be Optimized 1st

All available “Auto-IRIS” Settings must be CAREFULLY researched. *May need to be defeated for Calibration!!*

Fixed Iris settings are used for light output and black levels

Again - Grayscale requires non contact meters.
Analyzers & Front Projection

Contact & Non/Contact Meters
Use the right tool for the right job

Tripod Mount Sensors & Read Away

THE SCREEN IS PART OF THE SYSTEM!!
D65 Light Coming Out Of A Projector?

Might Not Accomplish Anything!

ISF Certified Flat Spectral Response Screens

Color Shift In Mirrors & Screens
ISF Reference Screens...

Screen Gain

Viewing Angle

Gain

Reff
B
D
E
Angular Reflective Screens
“Gain Screens”
Reflective Screens – The Law of Reflection
The Angle of Incidence Equals The Angle of Reflection – so where do you put the unit?
“High or Low, Near or Far”
The “Billiard Table” Analogy
“Matte” Screen Technologies

“Matte” or light scattering “Lambertian Emitters” (more on this later)

The light bounces off such screens in a uniform manner that is independent of the incident angle – The billiard analogy…..

When do we use these screens?
Rear Projection Screen Technologies

Rear projection
Lenticular and Fresnel combinations
Interaction with pixel structure
Diffusion screens
Loss of resolution with screen thickness....
Bring lots of Lumens.....
Contrast Enhancing Dark Screens
Ambient Light Rejection Screens

All are based on rejecting light from select angles
Most Start With Fractional Gain Grey Substrates
Some use Gain – others use Filters
The challenge is to preserve ‘Flat Spectral Response’
“Acoustic” Screen Technologies

Acoustically “Transparent” Perforated/Woven screens?
Screens that let sound through will cost you…..
Currency….always
Resolution? From what distance?
Light….sometimes more than other times
Sound….sometimes more than other times
Audiophile or Videophile or **Design** priorities??
All front speakers behind the screen?
Screen Gain Pro & Cons

Efficiency Of a Mirror is less than 100%

Gain As Measured Against A Reference “Lambertian” surfaces, Magnesium Carbonate Gain = Multiple of Light off the reference

Legacy Technology? Gain on Light Valves?
CRT & Light valves benefit for opposite reasons
Negative, or *Fractional* Gain Screens?

Tools for challenging applications & technologies.

Developed for applications with projection technologies with less than perfect blacks

Valid for rooms that challenge projection systems
Screen Surface Selection Logistics

Client Interview and On-Site Screen Size Evaluation

- Viewing angles
- Seating preferences
- Room environment
- Content applications
- Light output numbers

Client’s input!

CEA ISF “r10wg3” spec!
Screen Surface Selection Logistics

*Lamp Light Falloff* – a known issue normally ignored!
LED/Laser Phosphor projector features will change this!

Room’s ambient light issues must all be dealt with

Test projector’s “real” light output post calibration?

Screen calculator tools can fail using factory specs!
Screen Surface Selection Logistics

**ISCR and CTA Contrast Ratio Performance Specs!**

CTA ISF R10 specs – meet and/or exceed commercial theaters…

(Both Sequential and Intra-frame must be determined)

*From this perspective Contrast Enhancing Screens are tools to:*

- Match or Exceed ISF CEA/CEDIA and ISCR specs
- Resolve room issues
- Compensate for projector black level issues
- Continue dialogue with clients to balance budgets and realities

*Metering Black level limits is now a major issue!*
Screen Surface Selection Logistics

_Screens for Ideal System Designs_

Lambertian Emitters – a concept finally comes of age in CE

Required for deployment:

Ideal Room Environment + Ideal Projector + Ideal Calibration

_Utity Gain Reference Screens – Only for the Very Best Rooms!_
Physical Projector Set Up Guidelines

Placement and Stability - (CRITICAL FOR ALL PROJECTOR TECHNOLOGIES!)

3 Way Measurements + Throw Distance

Manufacturers Guidelines for:
- Distance from screen
- Projector height - determines angle

There is no real flexibility without focus compromises or digital “Keystone” losses
“Aziz LIGHT!”

DCI specifies 14Ft.L for correct Digital Cinema – that is your minimum target FOR THE LIFE OF LAMP.

High End projectors have lamp light stabilization.

You will need double 14Ft.L when new if your lamp light output degrades over time!
Periodic Maintenance & C.S.I.

The key to Customer all Satisfaction Indexes

Referrals - Will the original client possibly see the new client’s projector?

Document light output for reference performance when new JS changes client’s lamps when output goes down 30%

Keep a history – think Mr. Demming!

Documentation enables recurring revenue and CSI
Next – Color Management Systems
Color Gamut
Different Color Space Triangles

HDTV (709)

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sRGB

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NTSC

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SMPTE C

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Adobe 1998

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EBU (601)

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# Do Not Forget the Secondary Colors!

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<th>NTSC SMPTE C</th>
<th>ATSC HDTV</th>
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<tbody>
<tr>
<td>Yellow</td>
<td>x .421 y 0.507</td>
<td>Yellow x .419 y .505</td>
</tr>
<tr>
<td>Cyan</td>
<td>x .231 y .326</td>
<td>Cyan x .225 y .329</td>
</tr>
<tr>
<td>Magenta</td>
<td>x .314 y .161</td>
<td>Magenta x .321 y .154</td>
</tr>
</tbody>
</table>
Light Measurement Overview

Three characteristics define the way the human eye/brain sees light.


Hue: Dominant wavelength, color or tint of the color.

Saturation: Degree of purity from light of other wavelengths (zero saturation = white; equal energy of all wavelengths)

Brightness: Perceived light energy level
Light Measurement Units:
(Two light measurements used to relate light to human sight)

Luminance (brightness):

Foot-lambert: U.S. unit of luminance (radiated light), 1 lumen per square foot

Candela (cd/m²): Standard International unit of luminance (radiated light), 1 candela per square meter – also called NITS

1 Footlambert = 3.42625 Candelas P.M.SQ. (Nits)

Color (hue and saturation):

CIE chromaticity coordinates (x, y): From 1931/1976 CIE Chromaticity Diagram

What color?
Understanding Units of light

The human eye does not see illuminance; it sees luminance. You can feel illuminance and see luminance.

**Luminance** is Foot Lamberts Measurement Of Light coming off of a surface.

**Illuminance** is the measure of light falling on a surface per unit area.
Different CMS Objectives for Primary versus Secondary colors

LUMINANCE ("Y") is the critical objective to get right for RGB PRIMARY colors.

HUE ("x,y") is the critical objective to get right for CMY SECONDARY colors.

**If you see “Absolute Luminance” RGB errors you should not deploy a CMS feature at all!**
CMS Calibration Features

Obsolete 2D CMS had 12 Controls
- Hopefully, we can calibrate a color in color space along a line heading to the target color point from the white point
- Some controls adjust both saturation and tint together – CAUTION!

Current 3D CMS have 18 Controls
- These controls often have confusing names
- x,y and Y are the ideal functions and nomenclature
- Some work well – others cause easily visible errors!

Colorimeter GUIs help us learn how controls work and interact!
One Brand’s 3D CMS x,y Functions:
Basic Chart to Follow How, or If Controls Work:

Color Squares = Targets
Black Dots = Will Show CalMAN During Readings

*Move controls — observe changes — ELV the CMS!*
Define x, y, Y, Target x, Target y, Target Y
If Primaries CANNOT Match CIE Targets....Native Colors May Be Wrong
ITU Ultra HD Gamuts Go Way Beyond What We Have Seen in HDTV!
2020 / REC 709 and “Pointer’s Gamut”

(Approximation of visible colors reflected of of surfaces)
HDTV DCI and 2020 Gamuts
Go Calibrate TV’s CMS

Run through RGBCMY adjustments
Check all levels on all CalMAN charts
If Luminance levels are not correct - Check for decoding errors!
Did CMS solve problems or create them?
Calibrate Through Video Processors & AVRs

Evaluate and Calibrate basic HDTV settings 1st

Then Check the **One Output** Calibration

  - Gamma Factor
  - Color Gamut
  - Color Decoder
  - Re-check Color Gamut
  - Grayscale/Gamma

Then Check All **Multiple Input** Calibrations

  - Source device output resolution
  - Source device picture controls
  - Processor Input Picture controls
Next ISF CalMAN Steps:
Recheck Everything at Least Once!

Check Interactivity
Since calibration adjustments are often interactive with each other, we suggest you recheck gamma, grayscale, and color gamut before proceeding to Post-Calibration Settings.

Click the Back to Display Settings button to run through the CalMAN 5 ISF workflow one more time to check interactivity or Post Calibration to finish.

Back to Display Settings
Post Calibration
Post Calibration Scan and Reports
Now That the Display Is Calibrated, We Can Evaluate Video Processing

The BEST Video Processor is built inside the?

HDTV
Disc player
Set top box ( probably NOT )
Audio Video Receiver
Stand alone processors/switcher
Home Theater PC Video Card

WHICH ONE SHOULD YOU USE?
Overview of Steps in Video Processing

1. Confirm HDMI EEDID and HDCP functionality
2. Upconvert to RGB 4:4:4 from 4:2:0, 4:1:1, or 4:2:2
3. Deinterlace if content format is interlaced
4. Scale software to match display hardware
5. Change aspect ratio if desired
6. Optimize motion and minimize noise
7. Match color reproduction to content creation
Configuring HD Set Top boxes “Native”

Is there a “Native Resolution” output option?  

*What will that enable?*

*Are there other names for “Native”*

What problems might occur with that option?

What will produce superior pictures?

The only “perfect” processing is...........

*NO processing*

Always Test....never guess!
Overview 2 / 3 Pulldown

Also known as reverse Telecine or Film or movie Mode, as well as other names
Film To Video Transfer Problem

#1

If we transfer film to video by creating one even field and one odd field from every film frame what would film look like on television?

What do we do in PAL in 50Hz markets?

What do we do in NTSC – 2/3 Pulldown
The 60Hz 2/3 Pulldown Solution….

- Film is 24 frames per second
- Interlaced Video is 30 frames per second, remember there are 2 fields per frame & 60 images per second!
Past 2/3 Pulldown Problems

There were only minor “judder” 3/2 Pulldown problems until deinterlacing devices created visible artifacts from film content

72/96/120/240/480 Hz IMAGING....
2/3 Pulldown De-interlaced Errors

The diagram illustrates the process of pulldown de-interlacing in video and film frames. It shows the relationship between film frames and video frames, with fields marked to indicate the sequence of frames in a pulldown process.

The diagram includes:
- Film Frame A
- Field 1A
- Video Frame A
- Field 1B
- Field 1C
- Field 1C AGAIN
- Field 2B
- Field 2C
- Field 2C AGAIN

The diagram visually represents how fields and frames are interrelated in the de-interlacing process.
Using 2/3 Pulldown.....

Film Frame

Field 1A

Field 2

Field 1A AGAIN

Film Frame

Field 2B

Field 1B

Film Frame

Field 2C

Field 1C

Field 2C AGAIN

Video Frame

A

Video Frame

B

Video Frame

C
2/3 Pulldown Preservation

Film Frame

Field 1

Video Frame A-1

Video Frame A-2

Video Frame A-3

Field 2

Film Frame B

Field 1

Video Frame B-1

Video Frame B-2

Field 2

Film Frame C

Field 1

Video Frame C-1

Video Frame C-2

Field 2

Video Frame C-3
Why **Must** you understand 2/3 Pulldown Film Mode Video Processing?

1 – Many HDTV presets do not have their film modes turned on

2 – Calibrators must know how to **TURN ON** 2/3 Pulldown modes for their end users for superior looking, artifact free Film content!
Motion Tests on SD and HD Test Discs

AVIA Pro for Legacy SD Upconversion
HQV DVD
Spears & Munsil
Qdeo by Marvell
WOW by Disney
1080i Guitar String Close Up – Shallow Angles
Test Everything via Different Signal Paths

HDMI Direct to HDTV
HDMI through multiple components
Cat5 and Fiber and HDBaseT

Should all digital paths test the same?

Never Guess – ALWAYS TEST!
We Fail at 3D AGAIN! - 3D Technologies…

Glasses Mounted Micro Display, one picture for each eye
Spectral Separation (ancient and old fashioned two color)
The three major current Technologies:
1 - Polarization Separation
2 - Time-Sequential with IR synchronized shuttered glasses
3 - Dolby and Panavision Wavelength based Discrete Separation
AutoStereoscopic – Major failures again
3D has failed to find a market repeatedly for 100 years
Perhaps VR or AR will succeed?
Specialized 3D Camera – Circa 2010
Calibrating 3D Cameras?
Credit MIT Technology Review and ESPN
Viewing Angles and 3D

Camera angles are critical

Home viewing angles are also critical

Expect end user issues

Perceived distortion from to incorrect viewing position:

New geek terms, Percival’s Zone of Comfort, Retinal Disparity

“Vergence-Accommodation” issues cause user fatigue & discomfort

Early 3D efforts at low refresh rates actually caused nausea

“The Hobbit” by Peter Jackson is 1st 3D shot at 48Hz!
1.4a 3D Variants Bit Map Nomenclature
Credit Quantum Data

FP = Frame Packing
LAlt = Line Alternative
SbSF = Side-by-Side (Full)
TB = Top-and-Bottom
HHOO = Side-by-Side (Half), Horizontal sub-sampling, odd/left, odd/right
HHOE = Side-by-Side (Half), Horizontal sub-sampling, odd/left, even/right
HHEO = Side-by-Side (Half), Horizontal sub-sampling, even/left, odd/right
HHEE = Side-by-Side (Half), Horizontal sub-sampling, even/left, even/right
HQOO = Side-by-Side (Half), Quincunx matrix, odd/left, odd/right
HQOE = Side-by-Side (Half), Quincunx matrix, odd/left, even/right
HQEO = Side-by-Side (Half), Quincunx matrix, even/left, odd/right
HQEE = Side-by-Side (Half), Quincunx matrix, even/left, even/right
3D Method of Calibration

Active shutter and Polarized passive glasses impact imaging

When watching a 3D movie we are effectively looking through sunglasses. The glasses cut a substantial amount of light and usually color shift.

- Active 3D glasses rely on liquid-crystal shutter elements
- These vary in transmission efficiency and color transparency
- Passive glasses also impact image light and color
3D Black and White Level Setup

When setting the display’s contrast and brightness for proper dynamic range make sure you are wearing the 3D glasses - and that active ones are on.
3D Metering Set Up

Carefully position meters to read through 3D glasses

Emulate user’s exact H&V viewing position
ISF Certification Test

Your tests will just be reminders of what we covered – make sure we have your EMAIL address.

They will be short ones, but there WILL be some essay questions.

Completed tests must be emailed to ISF and then an oral review will follow – that is basically an hour of private 1 on 1 tutoring on us!

Your free tutoring is only free for 30 days……
Future “Resistant” Calibration Gear?

“Future Proof” is never possible

ISF Equipment Recommendations:

- Tristimulus meters with upgrade paths
- Spectral meters for profiling Tristimulus meters
- Displays change faster now so your gear must keep up

We strive to keep you up to date!
Continuing in the Field

**Practicing** will help you to master the new model features delivered each year – we expect innovations constantly!

We hope that you enjoy your work as much as we do – and we wish for you many productive years with many happy clients!

Fini