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TECHNICAL REPORT

colour inside

Power consumption of high dynamic range television sets

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POWER CONSUMPTION OF HIGH DYNAMIC RANGE TELEVISION SETS

FOREWORD

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IEC TR 63274, which is a Technical Report, has been prepared by Technical Area 19: Environmental and energy aspects for multimedia systems and equipment, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this Technical Report is based on the following documents:

DTR	Report on voting
100/3348/DTR	100/3397/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
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INTRODUCTION

High dynamic range (HDR) video is emerging as a new technology that affects the entire video ecosystem from production and processing, through to distribution and presentation. HDR television sets potentially have higher peak luminance level capabilities, and HDR video signals can represent pictures with much higher luminance levels than was the case in traditional analogue and digital video systems.

Current television set power consumption measurement methods, including those standardized in the IEC 62087 series (see [1][1], [2]and [3]), consider only televisions that accept a traditional, standard dynamic range (SDR) signal. It is likely that an HDR-capable television's power consumption will differ when presented with an HDR signal versus an SDR signal.

IEC TC100 TA19 has identified a standardization opportunity related to the method of measuring the power consumption of HDR television sets, including the development of a related HDR test signal.

This document assesses the current HDR technology for the parameters relevant for TV power consumption and sets the groundwork for the subsequent development of a measurement standard for the power consumption of HDR TV sets.

1 Numbers in square brackets refer to the Bibliography.

POWER CONSUMPTION OF HIGH DYNAMIC RANGE TELEVISION SETS

1 Scope

This document introduces high dynamic range video technology, describes current television set power consumption measurement methods, discusses the HDR TV market, analyses HDR TV power measurement challenges, and considers a path forward for HDR TV power measurement standards development.

2 Normative reference

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions

3.1.1
electro-optical transfer function
EOTF
mathematical function for transferring an electrical signal into a desired optical signal

EXAMPLE EOTFs are typically non-linear and monotonic and aim to incorporate behaviour of the human visual system, e.g. on a display device. Some are absolute, addressing luminance values directly, while others are of relative nature.

3.1.2
high dynamic range video
HDR video
capability of components in a video pipeline to capture, process, transport or display luminance levels and tone gradations that exceed capabilities of conventional SDR imaging pipelines components

Note 1 to entry: An HDR video signal typically uses a greater bit depth, luminance and colour volume than standard dynamic range (SDR) video. It also typically utilizes different tone curves such as perceptual quantizer (PQ) as specified in SMPTE ST 2084 [4] or hybrid log gamma (HLG) specified in ITU-R BT.2100 [5] instead of gamma, as used with SDR. When the HDR video signal is rendered on an HDR display, it is possible to see greater luminance ranges and wider colour gamuts

Note 2 to entry: HDR video can provide an enhanced viewer experience and can more accurately reproduce scenes that include, within the same image, dark areas and bright highlights, such as emissive light sources and reflections.

3.1.3
standard dynamic range video
SDR video
capability of components in a video pipeline to capture, process, transport or display luminance levels and tone gradations that can be characterized by the dynamic range, colour rendering and tone gradation capabilities essentially compatible with cathode ray tube (CRT) displays

EXAMPLE ITU-R BT.709 [6]/BT.1886 [7] and IEC 61966-2-1 (sRGB) [8]

Note 1 to entry: The luminance range of an SDR image is typically constrained between 0,1 cd/m^2 to 100 cd/m^2.

3.1.4
wide colour gamut
WCG
colour space that covers a larger percentage of visible colours compared to the sRGB/Rec. ITU-R BT.709 colour space

EXAMPLE ITU-R BT.2020 [9] is considered to provide WCG while BT.709 [6] does not.

3.1.5
television set
TV
equipment for the reception and display of television broadcast and similar services for terrestrial, cable, satellite and broadband network transmission of analogue and/or digital signals

Note 1 to entry: A television set can include additional functions that are not required for its basic operation.

[SOURCE: IEC 62087-3:2015, 3.1.19]

3.1.6
high definition
HD
spatial video resolution ranging from 1 280 × 720 to 1 920 × 1 080

3.1.7
ultra high definition
UHD
Ultra HD
spatial video resolution above 1 920 × 1 080

3.1.8
signal identification metadata
identifiers describing the properties of an image stream

EXAMPLE Format, resolution, colour space, chroma subsampling, bit-depth, image compression, image transport.

3.1.9
image-related metadata
identifiers describing intrinsic image properties in form of both static metadata valid throughout the content and dynamic metadata for frame-specific image parameters

EXAMPLE 1 Minimum and maximum luminance, average picture level, properties of the grading display.

EXAMPLE 2 HDR image related static metadata are MaxCLL and MaxFall as specified in CTA-861-G [10], section 6.9.1 and Appendix P, sections P.1 and P.2 for algorithms to calculate each.

EXAMPLE 3 Dynamic metadata is utilized by Dolby Vision® (SMPTE ST 2094-10 [11]) and HDR10+ (SMPTE ST 2094-40 [12]).

Note 1 to entry: They can be used as recommendations and guidance for image rendering and display.

3.1.10
average picture level
APL
average level of all the pixels of a single video signal frame in the linear luminance domain

EXAMPLE Display equipment such as television sets or computer monitors that internally use linear encoding after undoing the non-linearity of the input signal.

3.1.11
average picture level based on non-linear input signal
APL′
average level of all pixels of a single video signal frame in the non-linear luminance domain

EXAMPLE Display equipment such as television sets or computer monitor receive input signals that encode luminance in a non-linear way. Examples for such non-linear encoding are PQ or HLG EOTFs (ITU-R BT.2100-1) [5].

Note 1 to entry: APL′ is defined as a percentage of the range between reference black and reference white level.

Note 2 to entry: This is not a measure of the linear signal that might be available inside of some display equipment and delivered to the display device. The external and internal video signals are shown in Figure 1.

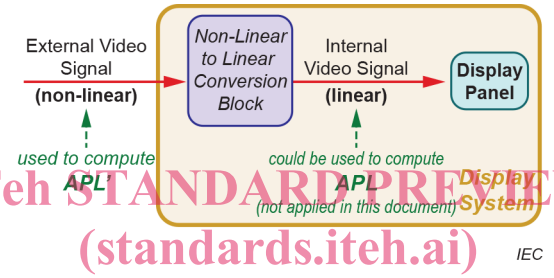

Figure 1 – Occurrence of linear and non-linear signal encodings in context of a typical display processing pipeline and how they can be used to compute APL and APL'

3.1.12
hybrid log-gamma
HLG
one set of transfer functions offering a degree of backwards compatibility by more closely matching the previously established television transfer curves

Note 1 to entry: Sets of transfer functions related to HDR signals are specified in Rec. ITU-R BT.2100-1.

[SOURCE: ISO/IEC TR 23008-15:2018, 3.4]

3.1.13
perceptual quantizer
PQ
one set of transfer functions addressing a very wide range of absolute luminance levels for a given bit depth using a non-linear transfer function that is finely tuned to match the sensitivity of the human visual system

Note 1 to entry: Sets of transfer functions related to HDR signals are specified in Rec. ITU-R BT.2100-1 [5].

[SOURCE: ISO/IEC TR 23008-15:2018, 3.8]

3.2 Abbreviated terms

ABC	automatic brightness control
ARIB	Association of Radio Industries and Businesses
ATSC	Advanced Television Systems Committee
BBC	British Broadcasting Corporation
CLASP	non-profit organisation supporting the development and implementation of policies and programs to improve the energy and environmental performance of appliances and equipment we use every day (Collaborative Labelling and Standards Program)
CLL	content light level
CRT	cathode ray tube
CTA	Consumer Technology Association (formerly Consumer Electronics Association)
FALD	full array local dimming
FALL	frame average light level
FIFA	Fédération Internationale de Football Association
FPS	frames per second
HD+ (HD-Plus)	high-definition satellite television platform for German-speaking users, owned by SES
HDMI® [2]	High Definition Multimedia Interface
HEVC	high efficiency video coding
Hz	hertz
ICDM	International Committee on Display Metrology
ICtCp	patented colour representation format specified in ITU-R BT.2100-2 [5]
ITU-R	International Telecommunication Union, Radiocommunication Sector
MDD	motion-based dynamic dimming
NC+	Polish satellite platform
NEEA	Northwest Energy Efficiency Alliance
NOS	Nederlandse Omroep Stichting (Dutch Broadcast Foundation)
OTT	over-the-top
PCL	Pacific Crest Labs
RTP	Rádio e Televisão de Portugal
SES	global satellite operator with its head office in Luxembourg
SMPTE	Society of Motion Picture and Television Engineers
sRGB	standard Red Green Blue colour space
TF1	French free-to-air television channel
TFT	thin-film transistor
TNT	American TV network operated by Turner International (originally Turner Network Television)
UGC	user generated content
YCbCr	colour space model used for digital video

2 HDMI® and HDMI® High-Definition Multimedia Interface are trademarks of HDMI Licensing Administrator, Inc. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4 Overview

4.1 High dynamic range video

HDR video signals are able to represent pictures that can be displayed with much higher peak luminance levels and much darker black levels compared to traditional SDR signals. HDR signals can potentially change the related power consumption of HDR-capable televisions. For more information on the history, nature, and ranges of HDR video, see IEC TR 62935:2016, Clause 4 [14].

For information on the early HDR Standards and Related Activities, see IEC TR 62935:2016, Clause 5 [14].

However, most of the standards outlined in IEC TR 62935:2016, Clause 5 [14] have been updated or superseded since its publication.

ITU-R Recommendation BT.2020-1 has been updated to BT.2020-2 [9] and now includes the higher frame rates of 100 Hz and 120/1,001 Hz. ITU-R has also now published Recommendation BT.2100-2 [5] that defines HDR formats for both HD and UHD resolutions. These formats use the same colour primaries as BT.2020-2 [9] but with two different transfer functions that may be used for HDR:

- perceptual quantizer (PQ), which was previously standardized in SMPTE ST 2084 [4];
- hybrid log-gamma (HLG), which was previously standardized as ARIB STD-B67 [15].

BT.2100-2 [5] also adds support for ICtCp constant luminance colour representations, but deprecates YCbCr from ITU-R BT.2020-2 [9].

CEA standards have now become CTA standards, with exactly the same number, as a result in the name change of the association from the Consumer Electronics Association to the Consumer Technology Association. CTA-861-F [16] has now been superseded by CTA-861-G [10], which adds support for signalling the HLG EOTF and adds the capability to support alternative dynamic HDR metadata systems SMPTE ST 2094-10 [11] (also known as Dolby Vision®[3] dynamic metadata format) and SMPTE ST 2094-40 [12] (also known as HDR10+).

In December 2016, the HDMI Forum extended its original HDMI® 2.0b specification, adding additional support for HDR video transport, in line with CTA-861-G [10], to include metadata signalling for hybrid log-gamma (HLG). The HDMI Forum included the following notice on its website:

> NOTICE: Previously, HDMI Specification Version 2.0b (HDMI 2.0b) only supported HDR (High Dynamic Range) video transport in the SMPTE ST 2084 EOTF (as applied in the media profile commonly known as HDR10), by referencing the CTA-861.3 specification. The Consumer Technology Association (CTA) has recently notified the HDMI Forum of the adoption of a new version of the CTA-861 Specification, CTA-861-G. This new version provides additional support for HDR Video transport by including (among others) an extension to the static metadata signalling to include the HLG (Hybrid Log Gamma) EOTF. The HDMI Forum has assessed the applicability of the CTA-861-G Specification to HDMI 2.0b. The HDMI Forum has confirmed that the extension of the static metadata signalling to include HLG can be utilized under the existing HDMI 2.0b Specification. This means that HLG Video Transport functionality can be implemented on HDMI 2.0b compliant devices.

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In November 2017, the HDMI Forum released its HDMI® 2.1 [17] specification, which enabled even higher spatial resolutions and support for higher frame rates (10K at 120 Hz maximum) and included Dynamic HDR for specifying HDR metadata on a scene by scene basis or even a frame by frame basis.

4.2 HDR TV market

IEC TR 62935:2016, Clause 6 [4] presents an overview of the market related to HDR video content.

A small number of HDR-capable TVs were introduced to the market in 2015. In general, these televisions were able to stream HDR content from Internet-based video services. In some cases, these television sets included at least one HDMI® 2.0a interface, which enables the TV to accept HDR video from external devices such as Blu-ray™[4] discs. In early 2016, the Ultra HD Alliance announced technical requirements and a certification program for the Ultra HD Premium™[5] logo and three TV manufacturers introduced Ultra HD Premium™ television sets at the U.S. CES show in 2016. High-end TVs from the major brands supported HDR, initially just HDR10, but followed very quickly by HLG, and, by 2018, it was hard to find a 4K/UHD TV that didn't support both HDR10 and HLG. Support for other HDR formats, such as Dolby Vision®, HDR10+ and SL-HDR, varies by brand.

Various Ultra HD Blu-ray™ discs also were announced in March 2016. As more and more HDR movies are released, there will be more content available for streaming and for cable and satellite providers to eventually deliver.

ATSC published its next-generation A/341, ATSC 3.0 Standard: Video – HEVC [18], [4] in May 2017. That standard supports HDR coding using PQ or HLG transfer characteristics, and WCG ITU-R BT.2020 [9] colour space. ATSC 3.0 is now deployed in South Korea, however, until ATSC 3.0 has been widely deployed, broadcasters face the challenge of not only delivering HDR video content that was produced offline, but also should consider the challenges of live HDR production as well as backward compatibility with SDR TVs. "Over-The-Top" (OTT) 4K, WCG content is being provided by a number of streaming services such as NETFLIX[6], Hulu[7], and Amazon[8]. As HDR broadcasting emerges, high dynamic range will be applied to content types beyond pre-produced material such as movies and TV series. Examples are sports, news, daytime television, cartoons and other popular video genres.

In Europe, UHD HDR Broadcasting has started. TravelXP became Europe's first full time 4K HDR channel in December 2017, launched on Eutelsat's Hotbird satellite and on the HD+ platform in Germany over an SES satellite. TravelXP 4K, is offered in 4K resolution, 10-bit Rec ITU-R BT.2020 [9] wide colour space, 50 frames per second, with HLG HDR.

BT Sports became the first UK broadcaster to show top-flight football in HDR when it broadcast a UEFA Champions League game to mobile viewers using the BT Sport app in March 2018.

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