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TECHNICAL REPORT

colour inside

Dynamic metadata high dynamic range impacts on TV power consumption



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DYNAMIC METADATA HIGH DYNAMIC RANGE IMPACTS ON TV POWER CONSUMPTION

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

Draft	Report on voting
100/3862/DTR	100/3886/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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INTRODUCTION

HDR technologies affect the entire video ecosystem from production and processing, through to distribution and presentation. HDR-capable television sets typically have higher peak luminance and better low-luminance capabilities than non-HDR TVs and can take advantage of HDR video signals which typically represent scenes with much higher luminance and more detailed low-luminance levels than was possible in traditional analogue and digital non-HDR video systems.

As the luminance range of an HDR signal might not match the luminance range capabilities of the display device, the signal must be adjusted before being displayed. This luminance adjustment is called tone-mapping and is implemented as a processing step in the TV. The tone mapping process can be improved with metadata, which describes the properties of the content to be displayed.

Dynamic metadata based HDR tone-mapping approaches and behaviours are seeing an ever-increasing application in consumer televisions; however, representative standardized test content for measurement of the power consumption impact of those technologies on televisions is not available. To prepare objective test materials (video clips), a study of power and luminance behaviour was conducted, the results of which are described in Clauses 5 and 6.

This document assesses the impact of dynamic HDR on TV luminance and power consumption using two technologies currently in deployment.

A small sample of TVs that supported the two technologies were studied using "representative" content prepared by PT100-24 members. Test results show that dynamic metadata HDR content, delivered to a dynamic metadata capable TV, can provide pictures with even greater dynamic range (higher peak luminance and more detailed luminance levels with wider colour gamut) than static HDR at the same or lower TV power consumption versus static HDR or SDR content delivered to that same TV.

DYNAMIC METADATA HIGH DYNAMIC RANGE IMPACTS ON TV POWER CONSUMPTION

1 Scope

This document presents a study of the impact of high dynamic range (HDR) technologies with "dynamic metadata" on TV luminance and power consumption. It compares the power consumption of content with dynamic metadata to the same content without dynamic metadata. Non-dynamic "static metadata" HDR technologies such as HDR10 and non-metadata HDR such as HLG, were previously studied in IEC TR 63274:2021.

This document also reviews the current HDR TV market and analyses existing HDR TV power measurement methods and considerations for any changes to those power measurement standards.

While this document studies the results of content that include Dolby Vision® and HDR10+ dynamic metadata, any comparison of these two technologies is outside of the scope of this document.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

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

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

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

3.1 Terms and definitions

3.1.1
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.

[SOURCE: IEC TR 63274:2021, 3.1.10]

3.1.2
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).

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.

[SOURCE: IEC TR 63274:2021, 3.1.11]

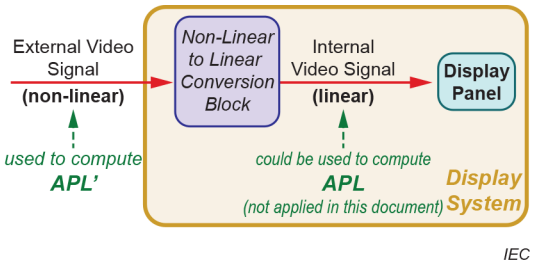


Figure 1 – Occurrence of linear and non-linear signal encodings in context of a typical display processing pipeline and how they can be used to compute APL and APL'

3.1.3
colour gamut
maximum area of chromaticity reproducible by a display

[SOURCE: IEC 62977-2-1:2021, 3.1.5, modified – "area" deleted from term]

3.1.4
colour volume
three-dimensional space of all colours and intensities that a device or signal can reproduce or convey

[SOURCE: ISO/IEC TR 23091-4:2021, 3.6, modified – "three-dimensional" added to definition]

3.1.5
content light level
CLL
integer static HDR metadata value defining the luminance of any single pixel within an encoded HDR video sequence

Note 1 to entry: The CLL is provided in candelas per square metre (cd/m^2).

3.1.6
maximum content light level
MaxCLL
integer static HDR metadata value defining the maximum luminance of any single pixel within an encoded HDR video sequence

Note 1 to entry: The MaxCLL is provided in candelas per square metre (cd/m^2).

Note 2 to entry: CTA-861 provides further explanation.

3.1.7
dynamic metadata
metadata that can be different for different portions of the image essence

[SOURCE: SMPTE ST 2094-1:2016, 4.6]

3.1.8
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.

[SOURCE: IEC TR 63274:2021, 3.1.1]

3.1.9
frame average light level
FALL
integer static HDR metadata value defining the average luminance for all pixels of any single frame within an encoded HDR video sequence

Note 1 to entry: The FALL is provided in candelas per square metre (cd/m^2).

3.1.10
maximum frame average light level
MaxFALL
integer static HDR metadata value defining the maximum average luminance for all pixels of any single frame within an encoded HDR video sequence

Note 1 to entry: The MaxFALL is provided in candelas per square metre (cd/m^2).

Note 2 to entry: CTA-861 provides further explanation.

3.1.11
high definition
HD
spatial video resolution ranging from 1 280 × 720 to 1 920 × 1 080

[SOURCE: IEC TR 63274:2021, 3.1.6]

3.1.12
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 or hybrid log gamma (HLG) specified in ITU-R BT.2100 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. The luminance range of an HDR image is typically constrained between 0,005 cd/m^2 to 4 000 cd/m^2.

[SOURCE: IEC TR 63274:2021, 3.1.2, modified – The last sentence of Note 2 to entry has been added.]

3.1.13
hybrid log-gamma
HLG
one set of HDR transfer functions offering a degree of backwards compatibility to SDR 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.

Note 2 to entry: HLG is used both as a description of a dedicated transfer function and as a video format name.

[SOURCE: IEC 62087-2:2023, 3.1.9, modified – Added 'to SDR'.]

3.1.14
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, 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) and HDR10+ (SMPTE ST 2094-40).

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

[SOURCE: IEC TR 63274:2021, 3.1.9]

3.1.15
perceptual quantizer
PQ
one set of HDR 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.

[SOURCE: ISO/IEC TR 23008-15:2018, 3.8, modified – In the definition, "brightness" has been replaced with "luminance".]

3.1.16
signal identification metadata
identifiers describing the properties of an image stream

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

[SOURCE: IEC TR 63274:2021, 3.1.8]

3.1.17
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 /BT.1886 and IEC 61966-2-1 (sRGB).

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.

[SOURCE: IEC TR 63274:2021, 3.1.3]

3.1.18
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 primary function.

[SOURCE: IEC 62087-3:2023, 3.1.1]

3.1.19
ultra high definition
UHD
Ultra HD
spatial video resolution above 1 920 × 1 080

[SOURCE: IEC TR 63274:2021, 3.1.7]

3.1.20
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 is considered to provide WCG while BT.709 does not.

[SOURCE: IEC TR 63274:2021, 3.1.4]

3.2 Abbreviated terms

ARC	audio return channel
ATSC	Advanced Television Systems Committee
BDP	Blu-ray™ disc player[1]
CIE	International Commission on Illumination (Commission Internationale de l'Éclairage)
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 (formally known as Collaborative Labelling and Standards Program)[2]
CRT	cathode ray tube
CTA	Consumer Technology Association (formerly Consumer Electronics Association)
DV	Dolby Vision®[3]
FPS	frames per second

[1] Blu-ray™, Blu-ray Disc™ and Ultra HD Blu-ray™ are trademarks of the Blu-ray Disc Association. 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.

[2] CLASP, https://www.clasp.ngo/

[3] Dolby® and Dolby Vision® are trademarks of Dolby Laboratories, 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.

HDMI®	High-Definition Multimedia Interface[4]
HDR10	HDR10[5] media profile
HDR10+	HDR10+[6] media profile
HEVC	high-efficiency video coding
Hz	hertz
ITU-R	International Telecommunication Union, Radiocommunication Sector
NABA	North American Broadcasters Association
NEEA	Northwest Energy Efficiency Alliance
OTT	over-the-top
PCL	Pacific Crest Labs[7]
SMPTE	Society of Motion Picture and Television Engineers
sRGB	standard Red Green Blue colour space specified in IEC 61966-2-1:1999
TV	television set

4 Dynamic metadata high dynamic range video

4.1 Introduction to dynamic metadata HDR video

4.1.1 Overview

Older video creation, broadcast and television receiver technologies, collectively called "Standard Dynamic Range" (SDR) for the purposes of this technical report, do not provide images that accurately represent the light distribution and detail of real-world scenes[8]. Significant technological progress in video content creation, distribution and displays now permit consumers to receive and display almost life-like programming by adding several key aspects missing from older SDR technologies. Specifically:

– higher pixel counts (up from 1 920 × 1 080 image pixels Full HD to UHD with 3 840 × 2 160 or more image pixels);

– higher image frame rates (up from a maximum of 60 Hz to 120 Hz or more);

– greater dynamic range (image peak brightness up to 10 000 cd/m^2);

– wider colour gamut embracing more of the CIE 1931 (x, y) chromaticity space vs the common limit to ITU-R BT.709 colour primaries with SDR images.

Roughly a decade ago, HDR technologies entered the market. Since then, many consumers have been enjoying video content offering much of the key aspects described above in a form this report refers to as "static metadata HDR". Static metadata in this report's context means that for a given "static metadata" HDR video programme, the content author provides ancillary data along with the programme. This data describes several characteristics of the video which

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4 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.

5 HDR10 is an open standard HDR media profile announced in August 2015 by the Consumer Technology Association. 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.

6 HDR10+ is a trademark of HDR10+ Technologies, LLC. 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.

7 Pacific Crest Labs, https://www.pacificcrestlabs.com/

8 'Real-world' refers to physically accurate representations of light distribution as well as spatial and temporal detail that are captured e.g., by a camera but also includes artistically created or adjusted content.