SMPTE STANDARD

Dynamic Range Conversion Characterization Metadata — Application #6

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Foreword

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Introduction

This clause is entirely informative and does not form an integral part of this Engineering Document.

The color volume transform for Application #6 Dynamic Range Conversion Characterization Metadata uses dynamic metadata to characterize conversion between High Dynamic Range (HDR) content and Standard Dynamic Range (SDR) content. The main goal of these metadata is to provide a signaling mechanism to help equipment to automatically select or configure the proper conversion adapted to the content producer's requirements, helping the interoperability and mixing of different equipment and technologies in automated workflows.

The dynamic metadata for Application #6 defines five anchor points that characterize the HDR-to-SDR or SDR-to-HDR conversion. Informative Annex A describes Application #6 Dynamic Range Conversion Characterization Metadata-based color volume transform in the framework of the generalized Color Volume Transform Model described in SMPTE ST 2094-1. Informative Annex B provides an illustration of the anchor points defined by the metadata.

In this document, SDR is defined per Recommendation ITU-R BT.709. As only luminance is considered, it can be equally applicable to Recommendation ITU-R BT.2020. HDR is defined per Recommendation ITU-R BT.2100.

1 Scope

This document specifies the color volume transform metadata items for Application #6, a specialized model of the generalized color volume transform defined by the core components document SMPTE ST 2094-1.

This color volume transform is based on five anchor points. The metadata set characterizes HDR-SDR conversions within the mastering process.

2 Conformance

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any clause explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

Recommendation ITU-R BT.709-6 (06/2015), *Parameter values for HDTV standards for production and international programme exchange*

Recommendation ITU-R BT.2100-3 (02/2025), *Image parameter values for high dynamic range television for use in production and international programme exchange*

SMPTE ST 2094-1:2016, *Dynamic Metadata for Color Volume Transform – Core Components*. https://doi.org/10.5594/SMPTE.ST2094-1.2016

4 Terms and Definitions

For the purposes of this document, the terms and definitions given in SMPTE ST 2094-1 and the following apply.

4.1 HDR-SDR anchor

pair of code values { hdr_cv, sdr_cv } that characterize an HDR-to-SDR or SDR-to-HDR conversion

Note 1 to entry: hdr_cv is representative of an HDR content value, and sdr_cv is representative of a corresponding SDR content value.

Note 2 to entry: These values are specified as code values for 10-bit luminance signal coding.

4.2 Narrow Range

signal representation of luminance using N-bit codes with $16 \times 2^{(N - 8)}$ for Black Level and $235 \times 2^{(N - 8)}$ for the Nominal Peak

Note 1 to entry: Narrow Range is the only signal representation specified for SDR content in Recommendation ITU-R BT.709 and the default signal representation for HDR content as specified in Recommendation ITU-R BT.2100.

Note 2 to entry: For 10-bit coding (N = 10), the Narrow Range values for luminance are within the range [64, 940].

4.3 Full Range

signal representation of luminance in HDR content using N-bit codes with 0 for Black Level and $2^N - 1$ for the Nominal Peak

Note 1 to entry: For 10-bit coding (N = 10), the Full Range values for luminance are within the range [0, 1023] as specified in Recommendation ITU-R BT.2100.

Note 2 to entry: For comparison, see 4.2 Narrow Range.

4.4 Extended Range

in a Narrow Range representation, code values outside of the Narrow Range

Note 1 to entry: For SDR content, the Extended Range comprises all the code values that are below the Y Black level down to the video data range minimum value (range 4 to 63 for 10-bit coding) and above the Y Nominal Peak up to the video data range maximum value (range 941 to 1019 for 10-bit coding), as defined in Recommendation ITU-R BT.709.

Note 2 to entry: For HDR content, the Extended Range exists only if the HDR signal is represented in Narrow Range. The Extended Range comprises all the code values that are below the Y′ Black Level down to the video data range minimum value (range 4 to 63 for 10-bit coding) and above the Y′ Nominal Peak up to the video data range maximum value (range 941 to 1019 for 10-bit coding), as defined in Recommendation ITU-R BT.2100.

4.5
Nominal Range

code values from Black Level to Nominal Peak

Note 1 to entry: In SDR content, the Nominal Range is the Narrow Range portion of the signal.

Note 2 to entry: In HDR content encoded in Narrow Range, Nominal Range is the Narrow Range portion of the signal.

Note 3 to entry: In HDR content encoded in Full Range, Nominal Range is the Full Range portion of the signal.

4.6
Y Black Level

code value 64 in 10-bit coding of SDR

Note 1 to entry: Black level for the Y component of SDR content as specified in Recommendation ITU-R BT.709.

4.7
Y Nominal Peak

code value 940 in 10-bit coding of SDR

Note 1 to entry: Nominal Peak for the Y component of SDR content as specified in Recommendation ITU-R BT.709.

4.8
Y′ Black Level

code value 64 in 10-bit Narrow Range coding of HDR or code value 0 in 10-bit Full Range coding

Note 1 to entry: Black level for the Y′ component of HDR content as specified in Recommendation ITU-R BT.2100.

4.9
Y′ Nominal Peak

code value 940 in 10-bit Narrow Range coding of HDR or code value 1023 in 10-bit Full Range coding

Note 1 to entry: Nominal Peak for the Y′ component of HDR content as specified Recommendation ITU-R BT.2100.

5 Application Identification

The **ApplicationIdentifier** value shall be 6 and the **ApplicationVersion** value shall be 0 to identify this version of Application #6.

These two values identify this document as the defining document for the application-specific metadata specified in Clause 7.

6 Color Volume Transform

6.1 HDR Transfer Function

The **HDRTransferFunction** shall specify the non-linear Transfer Function used to encode the HDR content.

The **HDRTransferFunction** shall be a value equal to 0 or 1.

HDRTransferFunction value 0 shall designate HLG Transfer Function per Recommendation ITU-R BT.2100.

HDRTransferFunction value 1 shall designate PQ Transfer Function per Recommendation ITU-R BT.2100.

6.2 HDR Nominal Range

The **HDRNominalRange** shall specify the Nominal Range used to encode the HDR content.

The **HDRNominalRange** shall be a value equal to 0 or 1.

HDRNominalRange value 0 shall designate Narrow Range encoding per Recommendation ITU-R BT.2100.

HDRNominalRange value 1 shall designate Full Range encoding per Recommendation ITU-R BT.2100.

6.3 Nominal Range Anchors

6.3.1 Introduction

The **NominalRangeAnchors** group contains the parameters that define those anchor points in the Nominal Range of the HDR and SDR signals. Anchor points outside the Nominal Range are provided in Clause 6.4.

The **NominalRangeAnchors** group consists of the **DiffuseWhiteAnchor** defined in Clause 6.3.2, the **ReferenceLevelAnchor** defined in Clause 6.3.3 and the **SDRNominalRangeMaxAnchor** defined in Clause 6.3.4.

6.3.2 DiffuseWhiteAnchor

The **DiffuseWhiteAnchor** is an HDR-SDR anchor and shall be a pair
{ **HDRDiffuseWhite**, **SDRDiffuseWhite** }.

The **HDRDiffuseWhite** represents the HDR Reference White or diffuse white value of the HDR content, as defined in Report ITU-R BT.2408. HDR pixels with luminance above **HDRDiffuseWhite** are considered as specular in the HDR content.

The **HDRDiffuseWhite** value shall be a code value in the Nominal Range.

The **SDRDiffuseWhite** represents the diffuse white value of the SDR content. SDR pixels with luminance above **SDRDiffuseWhite** are considered as specular in the SDR content.

The **SDRDiffuseWhite** value shall be a code value in the Nominal Range.

Considering an HDR-to-SDR conversion, **HDRDiffuseWhite** designates which HDR code value shall be mapped to the **SDRDiffuseWhite** SDR code value.

Considering an SDR-to-HDR conversion, **HDRDiffuseWhite** designates to which HDR code value the **SDRDiffuseWhite** SDR code value shall be mapped.

6.3.3 ReferenceLevelAnchor

The **ReferenceLevelAnchor** is an HDR-SDR anchor and shall be a pair
{ **HDRReferenceLevel**, **SDRReferenceLevel** }.

The **HDRReferenceLevel** represents a code value in the Nominal Range of the HDR content that is different from the **HDRDiffuseWhite. HDRReferenceLevel** aims at aligning cameras using common test charts or typical objects in a scene, as listed in Tables 1 and 2 of Report ITU-R BT.2408-8 (11/2024).

The **HDRReferenceLevel** value shall be a code value in the Nominal Range.

The **SDRReferenceLevel** represents a code value in the Nominal Range of the SDR content, prescribed to correspond with the **HDRReferenceLevel**. **SDRReferenceLevel** aims at aligning cameras using common test charts or typical objects in a scene.

The **SDRReferenceLevel** value shall be a code value in the Nominal Range.

Considering an HDR-to-SDR conversion, **HDRReferenceLevel** designates which HDR code value shall be mapped to the **SDRReferenceLevel** SDR code value.

Considering an SDR-to-HDR conversion, **HDRReferenceLevel** designates to which HDR code value the **SDRReferenceLevel** SDR code value shall be mapped.

6.3.4 SDRNominalRangeMaxAnchor

The **SDRNominalRangeMaxAnchor** is an HDR-SDR anchor and shall be a pair
{ **HDRLevelForSDRNominalRangeMax**, **SDRNominalRangeMax** }.

The **HDRLevelForSDRNominalRangeMax** value shall be a code value in the Nominal Range.

The **SDRNominalRangeMax** value shall be a code value equal to 940.

Considering an HDR-to-SDR conversion, **HDRLevelForSDRNominalRangeMax** designates which HDR code value shall be mapped to the **SDRNominalRangeMax** SDR code value**.**

Considering an SDR-to-HDR conversion, **HDRLevelForSDRNominalRangeMax** designates to which HDR code value the **SDRNominalRangeMax** SDR code value shall be mapped.

6.4 Extended Range Anchors

6.4.1 Introduction

The **ExtendedRangeAnchors** group contains the parameters that define those anchor points in the Extended Range of the HDR and SDR signals.

The **ExtendedRangeAnchors** group is defined only if the HDR signal is represented in Narrow Range and it consists of the **ExtendedRangeMinAnchor** defined in Clause 6.4.2 and the **SDRExtendedRangeMaxAnchor** defined in Clause 6.4.3.

6.4.2 ExtendedRangeMinAnchor

The **ExtendedRangeMinAnchor** is an HDR-SDR anchor and shall be a pair { **HDRExtendedRangeMin**, **SDRExtendedRangeMin** }.

The **HDRExtendedRangeMin** shall be a code value in the Extended Range of the HDR and shall be in the range [4, 63].

The **SDRExtendedRangeMin** shall be a code value in the Extended Range of the SDR and shall be in the range [4, 63].

Considering an HDR-to-SDR conversion, **HDRExtendedRangeMin** designates which HDR code value shall be mapped to the **SDRExtendedRangeMin** SDR code value.

Considering an SDR-to-HDR conversion, **HDRExtendedRangeMin** designates to which HDR code value the **SDRExtendedRangeMin** SDR code value shall be mapped.

6.4.3 SDRExtendedRangeMaxAnchor

The **SDRExtendedRangeMaxAnchor** is an HDR-SDR anchor and shall be a pair { **HDRLevelForSDRExtendedRangeMax**, **SDRExtendedRangeMax** }.

The **HDRLevelForSDRExtendedRangeMax** value shall be a code value in the range [64, 1019].

The **SDRExtendedRangeMax** shall be a code value in the Extended Range of the SDR and shall be in the range [941, 1019].

Considering an HDR-to-SDR conversion, **HDRLevelForSDRExtendedRangeMax** designates which HDR code value shall be mapped to the **SDRExtendedRangeMax** SDR code value.

Considering an SDR-to-HDR conversion, **HDRLevelForSDRExtendedRangeMax** designates to which HDR code value the **SDRExtendedRangeMax** SDR code value shall be mapped.

6.5 Metadata Values Constraints

The metadata items defined in Clauses 6.1 through 6.4 shall meet the following conditions:

1. If (**SDRDiffuseWhite** = 940), then **HDRDiffuseWhite** = **HDRLevelForSDRNominalRangeMax**
2. **HDRReferenceLevel** ≤ **HDRDiffuseWhite** ≤ **HDRLevelForSDRNominalRangeMax** < **HDRLevelForSDRExtendedRangeMax**
3. **SDRReferenceLevel** ≤ **SDRDiffuseWhite** ≤ 940

7 Application Constraints — Metadata Set

A metadata set shall contain exactly one of each of the following:

- **ApplicationIdentifier** (= 6)
- **ApplicationVersion** (= 0)
- **TimeInterval**

  which shall contain exactly one of all metadata items defined in SMPTE ST 2094-1, comprising

  TimeIntervalStart
  TimeIntervalDuration
- **ProcessingWindow**

  which shall contain exactly one of all metadata items defined in SMPTE ST 2094-1, comprising

  UpperLeftCorner
  LowerRightCorner
  WindowNumber
- **TargetedSystemDisplay**

  which shall contain exactly one of all metadata items defined in SMPTE ST 2094-1, comprising

  TargetedSystemDisplayPrimaries
  TargetedSystemDisplayWhitePointChromaticity
  TargetedSystemDisplayMaximumLuminance
  TargetedSystemDisplayMinimumLuminance
- **ColorVolumeTransform**

  metadata items defined in this document (Clause 6):

  shall contain exactly one **HDRTransferFunction** metadata item;

  shall contain exactly one **HDRNominalRange** metadata item;

  shall contain exactly one **NominalRangeAnchors** group, which

  shall contain exactly one **DiffuseWhiteAnchor** HDR-SDR anchor,

  and may contain zero or one **ReferenceLevelAnchor** HDR-SDR anchor,

  and may contain zero or one **SDRNominalRangeMaxAnchor** HDR-SDR anchor;

  may contain one **ExtendedRangeAnchors** group, which

  may contain zero or one **ExtendedRangeMinAnchor** HDR-SDR anchor,
  and shall contain exactly one **SDRExtendedRangeMaxAnchor** HDR-SDR anchor.

Annex A
(Informative)

Mapping of Application #6 to the Generalized Color Volume Transform Model

The diagram in Figure A.1 describes Application #6 Dynamic Range Conversion Characterization Metadata-based color volume transform in the framework of the generalized Color Volume Transform Model described in SMPTE ST 2094-1. The processing block applies Tone Mapping, based on the selection or the configuration of the proper Tone Mapping function, in accordance with the provided metadata.

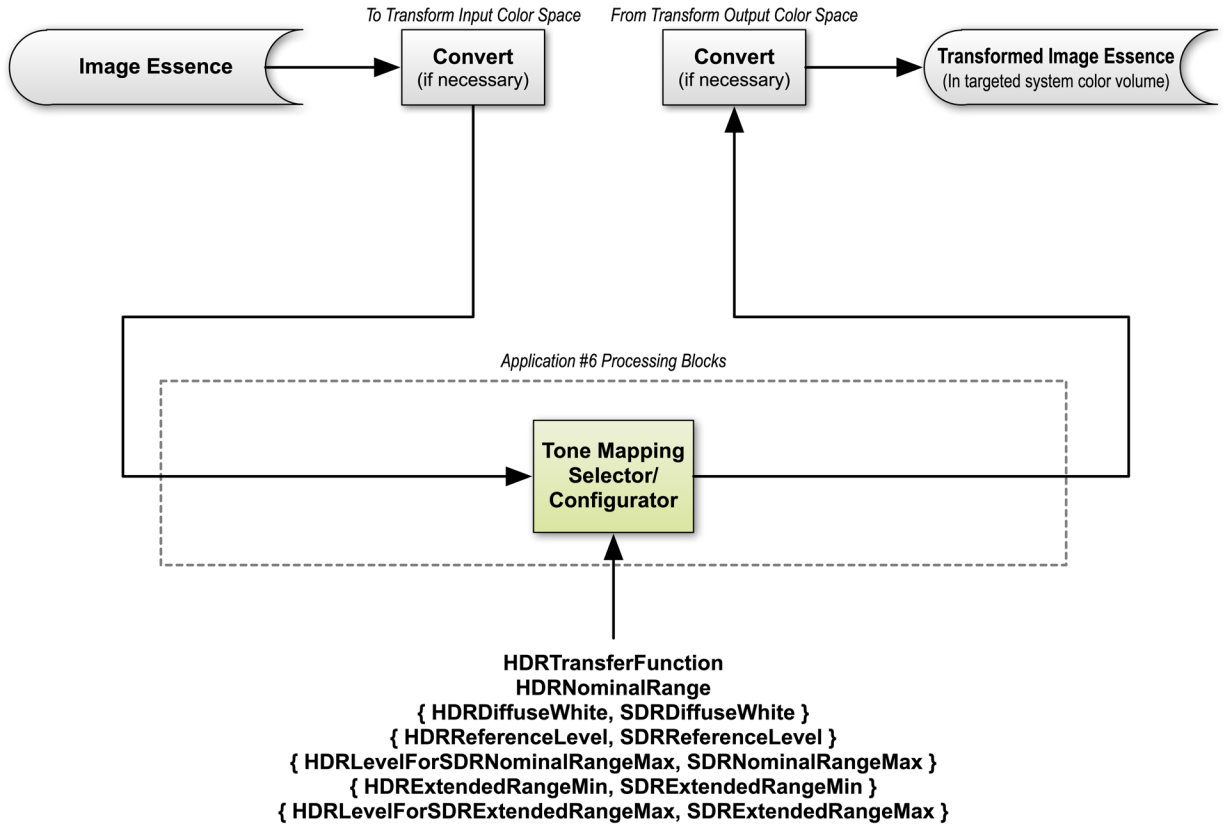

Figure A.1 — Processing blocks used by Application #6

Annex B
(Informative)

Dynamic Range Conversion Characterization Metadata Description

B.1 Introduction – the need for HDR-to-SDR and SDR-to-HDR conversions

High Dynamic Range production is in its early years and there is a transition phase during which both HDR contents and SDR contents will continue to be delivered to end users. Therefore, there exists a need for simultaneous HDR production and SDR production.

The biggest trend in the industry is to create one HDR production and automatically derive the SDR production using automated tools. This is known as Single-Master production and dual-distribution workflow, and can be represented as shown in Figure B.1:

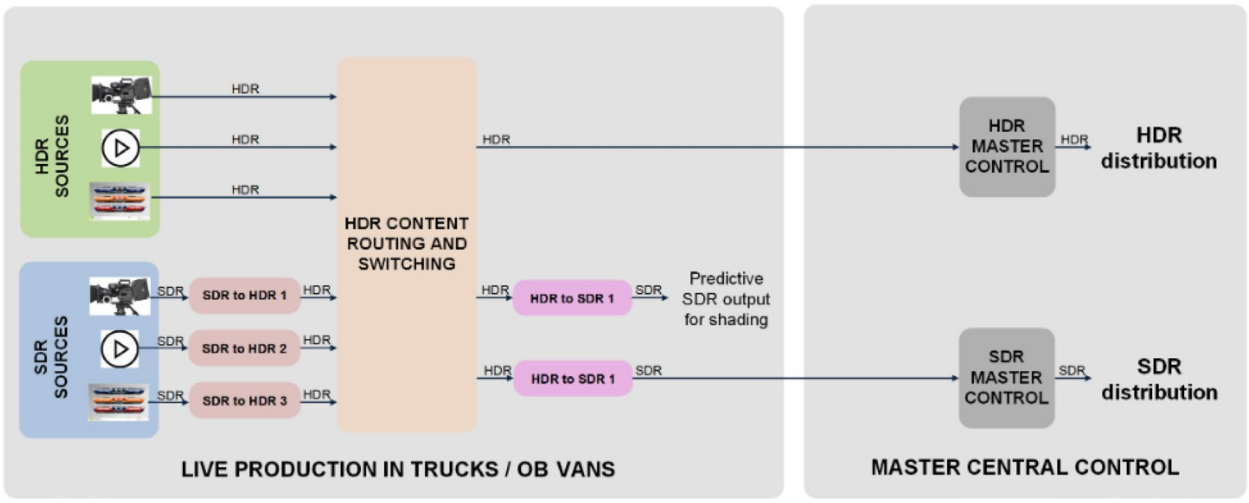

Figure B.1 — Single-Master production and dual-distribution workflow

A distributed HDR program is a mix of native HDR content (from live HDR cameras or HDR post-production) with other types of content, such as live SDR cameras, adverts, graphics for logos and scores. Most of the time, the sources of this added content are SDR, therefore needing to be first converted into HDR before mixing.

Two different conversions are needed:

- SDR-to-HDR up-conversion to convert SDR content into HDR content for HDR program mixing.
- HDR-to-SDR down-conversion to convert HDR content into SDR content for distribution.

Currently, most of the systems use static conversions, implemented in 3D-LUTs; however, dynamic conversions are emerging.

All of these conversions have characteristics (Diffuse White, reference levels, Extended Range) that are different from one static 3D-LUT or from one dynamic conversion to another.

Today, there is no signaling mechanism that informs about the characteristics of the HDR content (Diffuse White levels, reference levels, Extended Range usage), and therefore, there is no mechanism to automatically select or configure the appropriate subsequent HDR-to-SDR conversion. This is prone to misconfigurations in the field and limits system interoperability.

The main goal of these metadata (MD) is to provide a signaling mechanism that helps equipment in the field to automatically select or configure a conversion adapted to the content producer requirements, helping the interoperability and mixing of different equipment and technologies in a real workflow. Operational details for how such metadata is carried, manipulated, or combined is not presented in this document.

Those metadata accompany HDR content, as shown in Figure B.2:

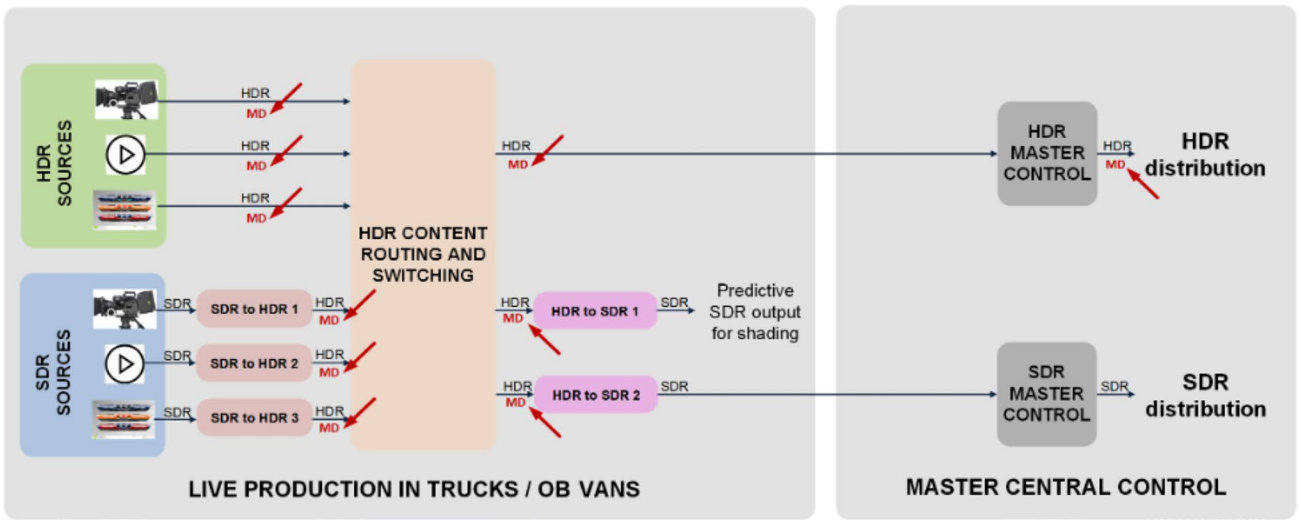

Figure B.2 — Single-Master production and dual-distribution workflow with the metadata

B.2 Illustration of the five HDR-SDR anchors on HDR-SDR conversion curves

The usage of the five anchors to drive the Tone Mapping in an SDR-to-HDR luminance conversion is illustrated in Figure B.3:

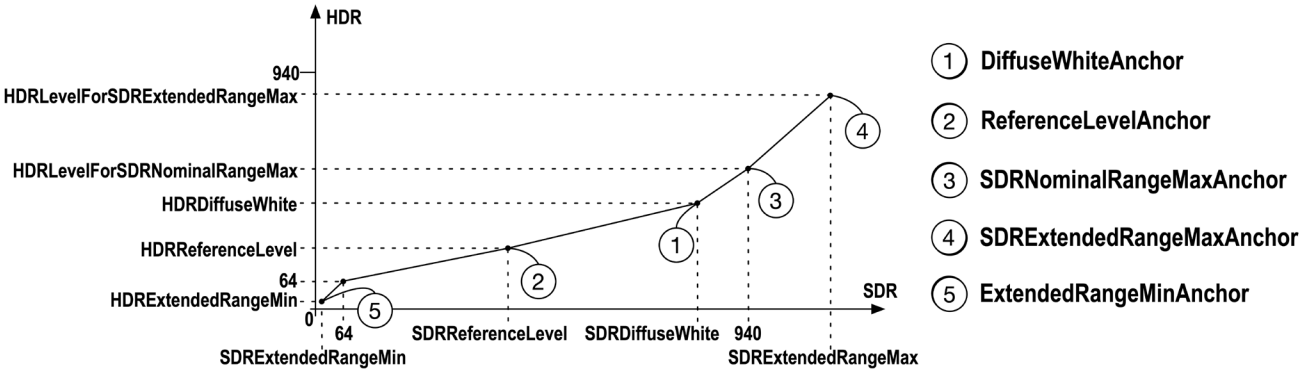

Figure B.3 — Usage of the five anchors in an SDR-to-HDR conversion

The usage of the five anchors to drive the Tone Mapping in an HDR-to-SDR luminance conversion is illustrated in Figure B.4:

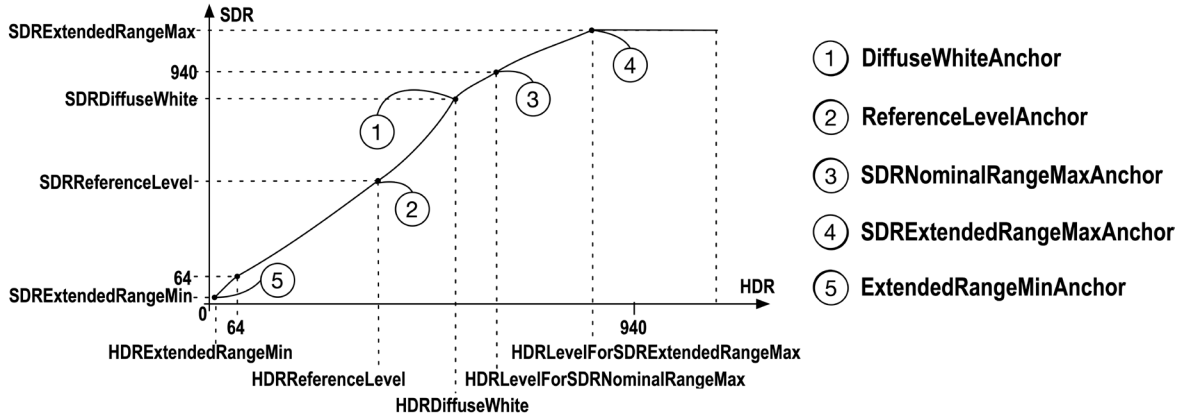

Figure B.4 — Usage of the five anchors in an HDR-to-SDR conversion

Bibliography (Informative)

Recommendation ITU-R BT.2020-2 (10/2015), *Parameter values for ultra-high definition television systems for production and international programme exchange*

Report ITU-R BT.2408-8 (11/2024), *Guidance for operational practices in HDR television production*

