International Standard

ISO/IEC 23090-3

Information technology — Coded representation of immersive media —

Part 3: Versatile video coding

Technologies de l'information — Représentation codée de média immersifs —

Partie 3: Codage vidéo polyvalent

Fourth edition
2026-09

Reference number
ISO/IEC 23090-3:2026(en)

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CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*, in collaboration with ITU-T (as ITU-T H.266).

This fourth edition cancels and replaces the third edition (ISO/IEC 23090-3:2024), which has been technically revised. It also replaces ISO/IEC 23090-3:2024/Amd1.

The main changes are as follows:

— the addition of support for 15 SEI messages specified in Rec. ITU-T H.274 | ISO/IEC 23002-7, namely 1) SEI processing order, 2) processing order nesting, 3) encoder optimization information, 4) source picture timing information, 5) object mask information, 6) modality information, 7) text description information, 8) digitally signed content initialization, 9) digitally signed content selection, 10) digitally signed content verification, 11) generative face video, 12) generative enhancement face video, 13) AI usage restrictions request, 14) packed regions information, and 15) image format metadata.

— some updates to the interface text for support of the two neural-network post-filter (NNPF) SEI messages.

A list of all parts in the ISO/IEC 23090 series can be found on the ISO and IEC websites.

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Introduction

Purpose

This document specifies a video coding technology known as versatile video coding. It has been designed with two primary goals. The first of these is to specify a video coding technology with a compression capability that is substantially beyond that of the prior generations of such standards, and the second is for this technology to be highly versatile for effective use in a broader range of applications than that addressed by prior standards. Some key application areas for the use of this document particularly include ultra-high-definition video (e.g., with 3840×2160 or 7620×4320 picture resolution and bit depth of 10 bits as specified in Rec. ITU-R BT.2100), video with a high dynamic range and wide colour gamut (e.g., with the perceptual quantization or hybrid log-gamma transfer characteristics specified in Rec. ITU-R BT.2100), and video for immersive media applications such as 360° omnidirectional video projected using a common projection format such as the equirectangular or cubemap projection formats, in addition to the applications that have commonly been addressed by prior video coding standards.

Profiles, tiers, and levels

This document is designed to be versatile in the sense that it serves a wide range of applications, bit rates, resolutions, qualities, and services. Applications include, but are not limited to, video coding for digital storage media, television broadcasting, video streaming services, real-time communication. In the course of creating this document, various requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this document is designed to facilitate video data interchange among different applications.

Considering the practicality of implementing the full syntax of this document, however, a limited number of subsets of the syntax are also stipulated by means of "profiles", "tiers", and "levels". These and other related terms are formally defined in Clause 3.

A "profile" is a subset of the entire bitstream syntax that is specified in this document. Within the bounds imposed by the syntax of a given profile it is still possible to require a very large variation in the performance of encoders and decoders depending upon the values taken by syntax elements in the bitstream, such as the specified size of the decoded pictures. In many applications, it is currently neither practical nor economical to implement a decoder capable of dealing with all hypothetical uses of the syntax within a particular profile.

In order to deal with this problem, "tiers" and "levels" are specified within each profile. A level of a tier is a specified set of constraints imposed on values of the syntax elements in the bitstream. Some of these constraints are expressed as simple limits on values, while others take the form of constraints on arithmetic combinations of values (e.g. picture width multiplied by picture height multiplied by number of pictures decoded per second). A level specified for a lower tier is more constrained than a level specified for a higher tier.

Coded video content conforming to this document uses a common syntax. In order to achieve a subset of the complete syntax, flags, parameters, and other syntax elements are included in the bitstream that signal the presence or absence of syntactic elements that occur later in the bitstream.

Encoding process, decoding process, and use of VUI parameters and SEI messages

Any encoding process that produces bitstream data that conforms to the specified bitstream syntax format requirements of this document is considered to be in conformance with the requirements of this document. The decoding process is specified such that all decoders that conform to a specified combination of capabilities known as the profile, tier, and level will produce numerically identical cropped decoded output pictures when invoking the decoding process associated with that profile for a bitstream conforming to that profile, tier and level. Any decoding process that produces identical cropped decoded output pictures to those produced by

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the process described herein (with the correct output order or output timing, as specified) is considered to be in conformance with the requirements of this document.

Rec. ITU-T H.274 | ISO/IEC 23002-7 specifies the syntax and semantics of the video usability information (VUI) parameters and supplemental enhancement information (SEI) messages that do not affect the conformance specifications in Annex C. These VUI parameters and SEI messages may be used together with this document.

Versions of this document

Rec. ITU-T H.266 | ISO/IEC 23090-3 version 1 refers to the first approved version of this document. The first edition published by ISO/IEC as ISO/IEC 23090-3:2021 corresponded to the first version.

Rec. ITU-T H.266 | ISO/IEC 23090-3 version 2 refers to the integrated text additionally containing operation range extensions, a new level (level 6.3), additional supplement enhancement information, and corrections to various minor defects in the prior content of the document. The second edition published by ISO/IEC as ISO/IEC 23090-3:2022 corresponded to the second version.

Rec. ITU-T H.266 | ISO/IEC 23090-3 version 3 refers to the integrated text containing the specification of a new level (level 15.5) for the video profiles to provide a suitable label for bitstreams that can exceed the limits of all other specified levels, additional supplement enhancement information, and corrections to various minor defects in the prior content of the document. This document corresponds to the third version. At the time of publication of this document, a corresponding third edition of Rec. ITU-T H.266 was in preparation for publication by ITU-T.

Rec. ITU-T H.266 | ISO/IEC 23090-3 version 4 (the current version) refers to the integrated text containing the specification of 15 additional SEI messages through referencing the Versatile Supplemental Enhancement Information (VSEI) standard (Rec. ITU T H.274 | ISO/IEC 23002 7), namely 1) SEI processing order, 2) processing order nesting, 3) encoder optimization information, 4) source picture timing information, 5) object mask information, 6) modality information, 7) text description information, 8) digitally signed content initialization, 9) digitally signed content selection, 10) digitally signed content verification, 11) generative face video, 12) generative enhancement face video, 13) AI usage restrictions request, 14) packed regions information, and 15) image format metadata. The additions also includes some updates to the interface text for support of the two neural-network post-filter (NNPF) SEI messages and corrections to various minor defects in the prior content of the document. This document corresponds to the fourth version. At the time of publication of this document, a corresponding fourth edition of Rec. ITU-T H.266 was in preparation for publication by ITU-T.

Overview of the design characteristics

The coded representation specified in the syntax is designed to enable a high compression capability for a desired image or video quality. The algorithm is typically not mathematically lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes, although some modes are included that provide lossless coding capability. A number of techniques are specified to enable highly efficient compression. Encoding algorithms (not specified within the scope of this document) may select between inter, intra, intra block copy (IBC), and palette coding for block-shaped regions of each picture. Inter coding uses motion vectors for block-based inter-picture prediction to exploit temporal statistical dependencies between different pictures, intra coding uses various spatial prediction modes to exploit spatial statistical dependencies in the source signal within the same picture, and intra block copy coding uses block displacement vectors to reference previously decoded regions of the same picture to exploit statistical similarities among different areas of the same picture. Motion vectors, intra prediction modes, and IBC block vectors are specified for a variety of block sizes in the picture. The prediction residual can then be further compressed using a spatial transform to remove spatial correlation inside a block before it is quantized, producing a possibly irreversible process that typically discards less important visual information while forming a close approximation to the source samples. Finally, the motion vectors, intra prediction modes, and

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block vectors can also be further compressed using a variety of prediction mechanisms, and, after prediction, are combined with the quantized transform coefficient information and encoded using arithmetic coding.

How to read this document

It is suggested that the reader starts with Clause 1 and moves on to Clause 3. Clause 6 should be read for the geometrical relationship of the source, input, and output of the decoder. Clause 7 specifies the order to parse syntax elements from the bitstream. See subclauses 7.1 to 7.3 for syntactical order and subclause 7.4 for semantics; e.g. the scope, restrictions, and conditions that are imposed on the syntax elements. The actual parsing for most syntax elements is specified in Clause 9. Finally, Clause 8 specifies how the syntax elements are mapped into decoded samples. Annexes A through D also form an integral part of this document.

Annex A specifies profiles, each being tailored to certain application domains, and defines the so-called tiers and levels of the profiles. Annex B specifies syntax and semantics of a byte stream format for delivery of coded video as an ordered stream of bytes. Annex C specifies the hypothetical reference decoder, bitstream conformance, decoder conformance, and the use of the hypothetical reference decoder to check bitstream and decoder conformance. Annex D specifies syntax and semantics for supplemental enhancement information (SEI) message payloads that affect the conformance specifications in Annex C. Rec. ITU-T H.274 | ISO/IEC 23002-7 specifies the syntax and semantics of the video usability information (VUI) parameters as well as SEI messages that do not affect the conformance specifications in Annex C. These VUI parameters and SEI messages may be used together with this document.

The term "this document" is used to refer to this Recommendation | International Standard.

In this document, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capability.

Information marked as “NOTE” is intended to assist the understanding or use of the document. “Notes to entry” used in Clause 3 provide additional information that supplements the terminological data and can contain provisions relating to the use of a term.

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Information technology — Coded representation of immersive media —

Part 3: Versatile video coding

1 Scope

This document specifies a video coding technology known as versatile video coding (VVC), comprising a video coding technology with a compression capability that is substantially beyond that of the prior generations of such standards and with sufficient versatility for effective use in a broad range of applications.

Only the syntax format, semantics, and associated decoding process requirements are specified, while other matters such as pre-processing, the encoding process, system signalling and multiplexing, data loss recovery, post-processing, and video display are considered to be outside the scope of this document. Additionally, the internal processing steps performed within a decoder are also considered to be outside the scope of this document; only the externally observable output behaviour is required to conform to the specifications of this document.

This document is designed to be generic in the sense that it serves a wide range of applications, bit rates, resolutions, qualities and services. Applications include, but are not limited to, video coding for digital storage media, television broadcasting and real-time communication. In the course of creating This document, various requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this document is designed to facilitate video data interchange among different applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 23001-11, *Information Technology — MPEG Systems technologies — Part 11: Energy-efficient media consumption (green metadata)*

Rec. ITU-T H.274 | ISO/IEC 23002-7, *Versatile supplemental enhancement information messages for coded video bitstreams*

ISO/IEC 23090-13, Information technology — *Coded representation of immersive media — Part 13: Video decoding interface for immersive media*

Rec. ITU-T T.35, *Procedure for the allocation of ITU-T defined codes for non standard facilities*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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3.1
access unit
set of *PUs* that belong to different *layers* and contain *coded pictures* associated with the same time for output from the *DPB*

3.2
adaptation parameter set
syntax structure containing *syntax elements* that apply to zero or more *slices* as determined by zero or more *syntax elements* found in *slice headers*

3.3
adaptive colour transform
cross-*component transform* applied to the decoded *residual* of a *coding unit* in the 4:4:4 colour format prior to reconstruction and loop filtering

3.4
adaptive loop filter
filtering process that is applied as part of the *decoding process* and is controlled by parameters conveyed in an *APS*

3.5
ALF APS
APS that controls the *ALF* process

3.6
associated GDR picture
previous *GDR picture* (when present) in *decoding order*, for a particular picture with nuh_layer_id equal to a particular value layerId, that has nuh_layer_id equal to layerId and between which and the particular *picture* in *decoding order* there is no *IRAP picture* with nuh_layer_id equal to layerId

3.7
associated IRAP picture
previous *IRAP picture* (when present) in *decoding order*, for a particular picture with nuh_layer_id equal to a particular value layerId, that has nuh_layer_id equal to layerId and between which and the particular *picture* in *decoding order* there is no *GDR picture* with nuh_layer_id equal to layerId

3.8
associated IRAP subpicture
previous *IRAP subpicture* (when present) in *decoding order*, for a particular subpicture with nuh_layer_id equal to a particular value layerId and subpicture index equal to a particular value subpicIdx, that has nuh_layer_id equal to layerId and subpicture index equal to subpicIdx and between which and the particular sub*picture* in *decoding order* there is no *GDR subpicture* with nuh_layer_id equal to layerId and subpicture index equal to subpicIdx

3.9
associated non-VCL NAL unit
non-VCL NAL unit (when present) for a *VCL NAL unit* where the *VCL NAL unit* is the *associated VCL NAL unit* of the *non-VCL NAL unit*

3.10
associated VCL NAL unit
preceding *VCL NAL unit* in *decoding order* for a *non-VCL NAL unit* with nal_unit_type equal to EOS_NUT, EOB_NUT, SUFFIX_APS_NUT, SUFFIX_SEI_NUT, FD_NUT, RSV_NVCL_27, UNSPEC_30, or UNSPEC_31; or otherwise the next *VCL NAL unit* in *decoding order*

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3.11
bin
bit of a *bin string*

3.12
bin string
intermediate binary representation of values of *syntax elements* from the *binarization* of the *syntax element*

3.13
binarization
set of *bin strings* for all possible values of a *syntax element*

3.14
binarization process
unique mapping process of all possible values of a *syntax element* onto a set of *bin strings*

3.15
binary split
split of a rectangular MxN *block* of samples into two *blocks* where a vertical split results in a first (M / 2)xN *block* and a second (M / 2)xN *block*, and a horizontal split results in a first Mx(N / 2) *block* and a second Mx(N / 2) *block*

3.16
bi-predictive slice
B slice
slice that is decoded using *intra prediction* or using *inter prediction* with at most two *motion vectors* and *reference indices* to *predict* the sample values of each *block*

3.17
bitstream
sequence of bits, in the form of a *NAL unit stream* or a *byte stream*, that forms the representation of a sequence of *AUs* forming one or more coded video sequences *(CVSs)*

3.18
block
MxN (M-column by N-row) array of samples, or an MxN array of *transform coefficients*

3.19
block vector
two-dimensional vector that provides an offset from the coordinates of the current *coding block* to the coordinates of the reference block in the same decoded *slice*

3.20
byte
sequence of 8 bits, within which, when written or read as a sequence of bit values, the left-most and right-most bits represent the most and least significant bits, respectively

3.21
byte-aligned <bitstream>
positioned an integer multiple of 8 bits from the position of the first bit in the *bitstream*

3.22
byte-aligned <bit or byte or syntax element>
position at which it appears in a *bitstream* is byte-aligned

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3.23
byte stream
encapsulation of a *NAL unit stream* into a series of *bytes* containing *start code prefixes* and *NAL units*

3.24
chroma
sample array or single sample representing one of the two colour difference signals related to the primary colours, represented by the symbols Cb and Cr

Note 1 to entry: The term chroma is used rather than the term chrominance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term chrominance.

3.25
CRA picture
IRAP picture for which each *VCL NAL unit* has nal_unit_type equal to CRA_NUT

Note 1 to entry: A CRA picture does not use inter prediction in its decoding process, and could be the first picture in the bitstream in decoding order, or could appear later in the bitstream. A CRA picture could have associated RADL or RASL pictures. When a CRA picture has NoOutputBeforeRecoveryFlag equal to 1, the associated RASL pictures are not output by the decoder, because they might not be decodable, as they could contain references to pictures that are not present in the bitstream.

3.26
CRA PU
PU in which the *coded picture* is a *CRA picture*

3.27
CRA subpicture
IRAP subpicture for which each *VCL NAL unit* has nal_unit_type equal to CRA_NUT

3.28
coded layer video sequence:
sequence of *PUs* with the same value of nuh_layer_id that consists, in *decoding order*, of a *CLVSS PU*, followed by zero or more *PUs* that are not *CLVSS PUs*, including all subsequent *PUs* up to but not including any subsequent *PU* that is a *CLVSS PU*

Note 1 to entry: A CLVSS PU could be an IDR PU, a CRA PU, or a GDR PU. The value of NoOutputBeforeRecoveryFlag is equal to 1 for each IDR PU, and each CRA PU that has HandleCraAsClvsStartFlag equal to 1, and each CRA or GDR PU that is the first PU in the layer of the bitstream in decoding order or the first PU in the layer of the bitstream that follows an EOS NAL unit in the layer in decoding order.

3.29
CLVSS PU
PU in which the *coded picture* is a *CLVSS picture*

3.30
CLVSS picture
coded picture that is an *IRAP picture* with NoOutputBeforeRecoveryFlag equal to 1 or a *GDR picture* with NoOutputBeforeRecoveryFlag equal to 1

3.31
coded picture
coded representation of a *picture* comprising *VCL NAL units* with a particular value of nuh_layer_id within an *AU* and containing all *CTUs* of the *picture*

3.32
coded picture buffer
first-in first-out buffer containing *DUs* in *decoding order* specified in the *hypothetical reference decoder*

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Note 1 to entry: The hypothetical reference decoder is specified in Annex C.

3.33
coded representation
data element as represented in its coded form

3.34
coded slice NAL unit
NAL unit that contains a coded *slice*

3.35
coded video sequence
sequence of *AUs* that consists, in *decoding order*, of a *CVSS AU*, followed by zero or more *AUs* that are not *CVSS AUs*, including all subsequent *AUs* up to but not including any subsequent *AU* that is a *CVSS AU*

3.36
CVSS AU
IRAP AU or *GDR AU* for which the *coded picture* in each *PU* is a *CLVSS picture*

3.37
coding block
MxN *block* of samples for some values of M and N such that the division of a *CTB* into *coding blocks* is a *partitioning*

3.38
coding tree block
N×N *block* of samples for some value of N such that the division of a *component* into *CTBs* is a *partitioning*

3.39
coding tree unit
CTB of *luma* samples, two corresponding *CTBs* of *chroma* samples of a *picture* that has three sample arrays, or a *CTB* of samples of a monochrome *picture*, and *syntax structures* used to code the samples

3.40
coding unit
coding block of *luma* samples, two corresponding *coding blocks* of *chroma* samples of a *picture* that has three sample arrays in the single tree mode, or a *coding block* of *luma* samples of a *picture* that has three sample arrays in the dual tree mode, or two *coding blocks* of *chroma* samples of a *picture* that has three sample arrays in the dual tree mode, or a *coding block* of samples of a monochrome *picture*, and *syntax structures* used to code the samples

3.41
component
array or single sample from one of the three arrays (*luma* and two *chroma*) that compose a *picture* in 4:2:0, 4:2:2, or 4:4:4 colour format or the array or a single sample of the array that compose a *picture* in monochrome format

3.42
context variable
variable specified for the *adaptive binary arithmetic decoding process* of a *bin* by a formula containing recently decoded *bins*

3.43
deblocking filter
filtering process that is applied as part of the *decoding process* in order to minimize the appearance of visual artefacts at the boundaries between *blocks*

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3.44
decoded picture
picture produced by applying the *decoding process* to a *coded picture*

3.45
decoded picture buffer
buffer holding *decoded pictures* for reference, output reordering, or output delay specified for the *hypothetical reference decoder*

3.46
decoder
embodiment of a *decoding process*

3.47
decoding order
order in which *syntax elements* are processed by the *decoding process*

3.48
decoding process
process specified in this document that reads a *bitstream* and derives *decoded pictures* from it

3.49
decoding unit
AU if DecodingUnitHrdFlag is equal to 0 or a subset of an *AU* otherwise, consisting of one or more *VCL NAL units* in an *AU* and the *associated non-VCL NAL units*

3.50
emulation prevention byte
byte equal to 0x03 that is present within a *NAL unit* when the *syntax elements* of the *bitstream* form certain patterns of *byte* values in a manner that ensures that no sequence of consecutive *byte-aligned bytes* in the *NAL unit* can contain a *start code prefix*

3.51
encoder
embodiment of an *encoding process*

3.52
encoding process
process not specified in this document that produces a *bitstream* conforming to this document

3.53
filler data NAL units
NAL units with nal_unit_type equal to FD_NUT

3.54
flag
variable or single-bit *syntax element* that can take one of the two possible values: 0 and 1

3.55
frequency index
one-dimensional or two-dimensional index associated with a *transform coefficient* prior to the application of a *transform* in the *decoding process*

3.56
GDR AU

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AU in which there is a *PU* for each *layer* present in the *CVS* and the *coded picture* in each present *PU* is a *GDR picture*

3.57
GDR PU
PU in which the *coded picture* is a *GDR picture*

3.58
GDR picture
picture for which each VCL NAL unit has nal_unit_type equal to GDR_NUT

Note 1 to entry: The value of pps_mixed_nalu_types_in_pic_flag for a GDR picture is equal to 0. When pps_mixed_nalu_types_in_pic_flag is equal to 0 for a picture, and any slice of the picture has nal_unit_type equal to GDR_NUT, all other slices of the picture have the same value of nal_unit_type, and the picture is known to be a GDR picture after receiving the first slice.

3.59
GDR subpicture
subpicture for which each VCL NAL unit has nal_unit_type equal to GDR_NUT

3.60
hypothetical reference decoder
hypothetical *decoder* model that specifies constraints on the variability of conforming *NAL unit streams* or conforming *byte streams* that an encoding process may produce

3.61
hypothetical stream scheduler
hypothetical delivery mechanism used for checking the conformance of a *bitstream* or a *decoder* with regards to the timing and data flow of the input of a *bitstream* into the *hypothetical reference decoder*

3.62
IDR picture
IRAP picture for which each *VCL NAL unit* has nal_unit_type equal to IDR_W_RADL or IDR_N_LP

Note 1 to entry: An IDR picture does not use inter prediction in its decoding process, and could be the first picture in the bitstream in decoding order, or could appear later in the bitstream. Each IDR picture is the first picture of a CVS in decoding order. When an IDR picture for which each VCL NAL unit has nal_unit_type equal to IDR_W_RADL, it could have associated RADL pictures. When an IDR picture for which each VCL NAL unit has nal_unit_type equal to IDR_N_LP, it does not have any associated leading pictures. An IDR picture does not have associated RASL pictures.

3.63
IDR PU
PU in which the *coded picture* is an *IDR picture*

3.64
IDR subpicture
*IRA*P subpi*cture* for which each *VCL NAL unit* has nal_unit_type equal to IDR_W_RADL or IDR_N_LP

3.65
inter coding
coding of a *coding block*, *slice*, or *picture* that uses *inter prediction*

3.66
inter-layer reference picture
picture in the same *AU* with the current *picture*, with nuh_layer_id less than the nuh_layer_id of the current *picture*, and is marked as "used for long-term reference"

3.67
inter prediction

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prediction derived from blocks of sample values of one or more *reference pictures* as determined by motion vectors

3.68
intra block copy prediction
prediction derived from blocks of sample values of the same decoded *slice* as determined by block vectors

3.69
intra coding
coding of a *coding block, slice*, or *picture* that uses *intra prediction*

3.70
intra prediction
prediction derived from neighbouring sample values of the same decoded *slice*

3.71
IRAP AU
AU in which there is a *PU* for each layer present in the CVS and the *coded picture* in each *PU* is an *IRAP picture*

3.72
IRAP picture
coded picture for which all *VCL NAL units* have the same value of nal_unit_type in the range of IDR_W_RADL to CRA_NUT, inclusive

Note 1 to entry: An IRAP picture could be a CRA picture or an IDR picture. An IRAP picture does not use inter prediction from reference pictures in the same layer in its decoding process. The first picture in the bitstream in decoding order is an IRAP or GDR picture. For a single-layer bitstream, provided the necessary parameter sets are available when they need to be referenced, the IRAP picture and all subsequent non-RASL pictures in the CLVS in decoding order are correctly decodable without performing the decoding process of any pictures that precede the IRAP picture in decoding order.

Note 2 to entry: The value of pps_mixed_nalu_types_in_pic_flag for an IRAP picture is equal to 0. When pps_mixed_nalu_types_in_pic_flag is equal to 0 for a picture, and any slice of the picture has nal_unit_type in the range of IDR_W_RADL to CRA_NUT, inclusive, all other slices of the picture have the same value of nal_unit_type, and the picture is known to be an IRAP picture after receiving the first slice.

3.73
IRAP PU
PU in which the *coded picture* is an *IRAP picture*

3.74
IRAP subpicture
subpicture for which all *VCL NAL units* have the same value of nal_unit_type in the range of IDR_W_RADL to CRA_NUT, inclusive

3.75
intra slice
I slice
slice that is decoded using *intra prediction* only

3.76
layer
set of *VCL NAL units* that all have a particular value of nuh_layer_id and the *associated non-VCL NAL units*

3.77
leading picture
picture that precedes the *associated IRAP picture* in *output order*

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Note 1 to entry: As constrained in subclause 7.4.2.2, a leading picture associated with an IRAP picture is either a RADL picture or a RASL picture. Consequently, a non-leading picture associated with an IRAP picture, e.g., a trailing picture, follows the IRAP picture in output order.

3.78
leading subpicture
subpicture that precedes the *associated IRAP subpicture* in *output order*

3.79
leaf
terminating node of a tree that is a root node of a tree of depth 0

3.80
level <constraints>
defined set of constraints on the values that may be taken by the *syntax elements* and variables of this document

Note 1 to entry: The same set of levels is defined for all profiles, with most aspects of the definition of each level being in common across different profiles. Individual implementations could, within the specified constraints, support a different level for each supported profile.

3.81
level <transform coefficient value>
value of a *transform coefficient* prior to *scaling*

3.82
list 0 (list 1) motion vector
motion vector associated with a *reference index* pointing into *reference picture list 0* (*list 1*)

3.83
list 0 (list 1) prediction
inter prediction of the content of a *slice* using a *reference index* pointing into *reference picture list 0* (*list 1*)

3.84
LMCS APS
APS that controls the *LMCS* process

3.85
long-term reference picture
picture with nuh_layer_id equal to the nuh_layer_id of the current *picture* and marked as "used for long-term reference"

3.86
luma
sample array or single sample representing the monochrome signal related to the primary colours, represented by the symbol or subscript Y or L

Note 1 to entry: The term luma is used rather than the term luminance in order to avoid implying the use of linear light transfer characteristics that is often associated with the term luminance. The symbol L is sometimes used instead of the symbol Y to avoid confusion with the symbol y as used for vertical location.

3.87
LMCS
luma mapping with chroma scaling
process that is applied as part of the *decoding process* that maps *luma* samples to particular values and in some cases also applies a scaling operation to the values of *chroma* samples

3.88
motion vector

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two-dimensional vector used for *inter prediction* that provides an offset from the coordinates in the *decoded picture* to the coordinates in a *reference picture*

3.89
multi-type tree
tree in which a parent node can be split either into two child nodes using a *binary split* or into three child nodes using a *ternary split*, each of which could become the parent node for another split into either two or three child nodes

3.90
NAL unit
syntax structure containing an indication of the type of data to follow and *bytes* containing that data in the form of an *RBSP* interspersed as necessary with *emulation prevention bytes*

3.91
NAL unit stream
sequence of *NAL units*

3.92
operation point
temporal subset of an OLS, identified by an OLS index and a highest value of TemporalId

3.93
output layer
layer of an output layer set that is output

3.94
output layer set
set of layers for which one or more layers are specified as the output layers

3.95
OLS layer index
index, of a layer in an OLS, to the list of layers in the OLS

3.96
output order
order of pictures or subpictures within a CLVS indicated by increasing POC values, and for decoded pictures that are output from DPB, this is the order in which the *decoded pictures* are output from the *DPB*

3.97
output time
time when a *decoded picture* is to be output from the *DPB* (for the *decoded pictures* that are to be output from the *DPB*) as specified by the *HRD* according to the output timing *DPB* operation

3.98
palette
set of representative *component* values

3.99
palette prediction
prediction derived from one or more *palettes*

3.100
partitioning
division of a set into subsets such that each element of the set is in exactly one of the subsets

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3.101
picture
array of *luma* samples in monochrome format or an array of *luma* samples and two corresponding arrays of *chroma* samples in 4:2:0, 4:2:2, and 4:4:4 colour format

Note 1 to entry: A picture is either a frame or a field. However, in one CVS, either all pictures are frames or all pictures are fields.

3.102
picture header
syntax structure containing *syntax elements* that apply to all *slices* of a coded picture

3.103
picture-level slice index
index, defined when pps_rect_slice_flag is equal to 1, of a slice to the list of slices in a picture in the order as the slices are signalled in the PPS when pps_single_slice_per_subpic_flag is equal to 0, or in the order of increasing subpicture indices of the subpicture corresponding to the slices when pps_single_slice_per_subpic_flag is equal to 1

3.104
picture order count
variable that is associated with each *picture*, uniquely identifies the associated *picture* among all *pictures* in the *CLVS*, and, when the associated *picture* is to be output from the *DPB*, indicates the position of the associated *picture* in *output order* relative to the *output order* positions of the other *pictures* in the same *CLVS* that are to be output from the *DPB*.

3.105
picture parameter set
syntax structure containing *syntax elements* that apply to zero or more entire *coded pictures* as determined by a *syntax element* found in each *picture header*

3.106
picture unit
set of *NAL units* that are associated with each other according to a specified classification rule, are consecutive in *decoding order,* and contain exactly one *coded picture*

3.107
prediction
embodiment of the *prediction process*

3.108
prediction process
use of a *predictor* to provide an estimate of the data element (e.g., sample value or motion vector) currently being decoded

3.109
predictive slice
P slice
slice that is decoded using *intra prediction* or using *inter prediction* with at most one *motion vector* and *reference index* to *predict* the sample values of each *block*

3.110
predictor
combination of specified values or previously decoded data elements (e.g., sample value or motion vector) used in the *decoding process* of subsequent data elements

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3.111
profile
specified subset of the syntax of this document

3.112
quadtree
tree in which a parent node can be split into four child nodes, each of which could become the parent node for another split into four child nodes

3.113
quantization parameter
variable used by the *decoding process* for *scaling* of *transform coefficient levels*

3.114
random access
act of starting the decoding process for a *bitstream* at a point other than the beginning of the *bitstream*

3.115
RADL picture
coded picture for which each *VCL NAL unit* has nal_unit_type equal to RADL_NUT

Note 1 to entry: All RADL pictures are leading pictures. A RADL picture with nuh_layer_id equal to layerId is not used as a reference picture for the decoding process of any picture with nuh_layer_id equal to layerId that follows, in output order, the IRAP picture associated with the RADL picture. When sps_field_seq_flag is equal to 0, all RADL pictures, when present, precede, in decoding order, all non-leading pictures of the same associated IRAP picture.

3.116
RADL PU
PU in which the *coded picture* is a *RADL picture*

3.117
RADL subpicture
subpicture for which each *VCL NAL unit* has nal_unit_type equal to RADL_NUT

3.118
RASL picture
coded picture for which there is at least one *VCL NAL unit* with nal_unit_type equal to RASL_NUT and other VCL NAL units all have nal_unit_type equal to RASL_NUT or RADL_NUT

Note 1 to entry: All RASL pictures are leading pictures of an associated CRA picture. When the associated CRA picture has NoOutputBeforeRecoveryFlag equal to 1, the RASL picture is not output and might not be correctly decodable, as the RASL picture could contain references to pictures that are not present in the bitstream. RASL pictures are not used as reference pictures for the decoding process of non-RASL pictures in the same layer, except that a RADL subpicture, when present, in a RASL picture in the same layer could be used for inter prediction of the collocated RADL subpicture in a RADL picture that is associated with the same CRA picture as the RASL picture. When sps_field_seq_flag is equal to 0, all RASL pictures, when present, precede, in decoding order, all non-leading pictures of the same associated CRA picture.

3.119
RASL PU
PU in which the *coded picture* is a *RASL picture*

3.120
RASL subpicture
subpicture for which each *VCL NAL unit* has nal_unit_type equal to RASL_NUT

3.121
raster scan
mapping of a rectangular two-dimensional pattern to a one-dimensional pattern such that the first entries in the one-dimensional pattern are from the first top row of the two-dimensional pattern scanned from left to

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right, followed similarly by the second, third, etc., rows of the pattern (going down) each scanned from left to right

3.122
raw byte sequence payload
syntax structure containing an integer number of *bytes* that is encapsulated in a *NAL unit* and is either empty or has the form of a *string of data bits* containing *syntax elements* followed by an *RBSP stop bit* and zero or more subsequent bits equal to 0

3.123
RBSP stop bit
bit equal to 1 present within a *raw byte sequence payload (RBSP)* after a *string of data bits*, for which the location of the end within an *RBSP* can be identified by searching from the end of the *RBSP* for the *RBSP stop bit*, which is the last non-zero bit in the *RBSP*

3.124
reference index
index into a *reference picture list*

3.125
reference picture
picture that is a *short-term reference picture*, a *long-term reference picture,* or an *inter-layer reference picture*

Note 1 to entry: A reference picture contains samples that could be used for inter prediction in the decoding process of subsequent pictures in decoding order.

3.126
reference picture list
list of *reference pictures* that is used for *inter prediction* of a *P* or *B slice*

Note 1 to entry: Two RPLs, RPL 0 and RPL 1, are generated for each slice of a picture. The set of unique pictures referred to by all entries in the two RPLs associated with a picture consists of all reference pictures that could be used for inter prediction of the associated picture or any picture following the associated picture in decoding order. For the decoding process of a P slice, only RPL 0 is used for inter prediction. For the decoding process of a B slice, both RPL 0 and RPL 1 are used for inter prediction. For decoding the slice data of an I slice, no RPL is used for for inter prediction.

3.127
reference picture list 0
reference picture list used for *inter prediction* of a *P slice* or the first of the two *reference picture lists* used for *inter prediction* of a *B slice*

3.128
reference picture list 1
second *reference picture list* used for *inter prediction* of a *B slice*

3.129
residual
decoded difference between a *prediction* of a sample or data element and its decoded value

3.130
scaling
process of multiplying *transform coefficient levels* by a factor, resulting in *transform coefficients*

3.131
scaling list
list that associates each *frequency index* with a scale factor for the *scaling* process

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3.132
scaling list APS
APS with syntax elements used to construct the *scaling lists*

3.133
sequence parameter set
syntax structure containing *syntax elements* that apply to zero or more entire *CLVSs* as determined by the content of a *syntax element* found in the *PPS* referred to by a *syntax element* found in each *picture header*

3.134
short-term reference picture
picture with nuh_layer_id equal to the nuh_layer_id of the current *picture* and marked as "used for short-term reference"

3.135
slice
integer number of complete *tiles* or an integer number of consecutive complete *CTU* rows within a *tile* of a *picture* that are exclusively contained in a single *NAL unit*

3.136
slice header
part of a coded *slice* containing the data elements pertaining to all *tiles* or *CTU rows* within a *tile* represented in the *slice*

3.137
source
term used to describe the video material or some of its attributes before encoding

3.138
start code prefix
unique sequence of three *bytes* equal to 0x000001 embedded in the *byte stream* as a prefix to each *NAL unit*

Note 1 to entry: The location of a start code prefix can be used by a decoder to identify the beginning of a new NAL unit and the end of a previous NAL unit. Emulation of start code prefixes is prevented within NAL units by the inclusion of emulation prevention bytes.

3.139
STSA picture
coded picture for which each *VCL NAL unit* has nal_unit_type equal to STSA_NUT

Note 1 to entry: An STSA picture does not use pictures in the same layer and with the same TemporalId as the STSA picture for inter prediction reference. Pictures following an STSA picture in decoding order in the same layer and with the same TemporalId as the STSA picture do not use pictures prior to the STSA picture in decoding order in the same layer and with the same TemporalId as the STSA picture for inter prediction reference. An STSA picture enables up-switching, at the STSA picture, to the sublayer containing the STSA picture, from the immediately lower sublayer of the same layer when the coded picture does not belong to the lowest sublayer. STSA pictures in an independent layer always have TemporalId greater than 0.

3.140
STSA PU
PU in which the *coded picture* is an *STSA picture*

3.141
STSA subpicture
subpicture for which each *VCL NAL unit* has nal_unit_type equal to STSA_NUT

3.142
string of data bits

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sequence of some number of bits representing *syntax elements* present within a *raw byte sequence payload* prior to the *raw byte sequence payload stop bit*, where the left-most bit is considered to be the first and most significant bit, and the right-most bit is considered to be the last and least significant bit

3.143
sub-bitstream extraction process
specified process by which *NAL units* in a *bitstream* that do not belong to a target set, determined by a target OLS index and a target highest TemporalId, are removed from the *bitstream*, with the output sub-bitstream consisting of the NAL units in the *bitstream* that belong to the target set

3.144
sublayer
temporal scalable layer of a temporal scalable *bitstream*, consisting of *VCL NAL units* with a particular value of the TemporalId variable and the associated *non-VCL NAL units*

3.145
sublayer representation
subset of the *bitstream* consisting of *NAL units* of a particular *sublayer* and the lower *sublayers*

3.146
subpicture
rectangular region of one or more *slices* within a *picture*

3.147
subpicture-level slice index
index, defined when pps_rect_slice_flag is equal to 1, of a slice to the list of slices in a subpicture in the order as they are signalled in the PPS

3.148
SEI message
syntax structure with specified semantics that conveys a particular type of information that assists in processes related to decoding, display or other purposes but is not needed by the *decoding process* in order to determine the values of the samples in *decoded pictures*

3.149
syntax element
element of data represented in the *bitstream*

3.150
syntax structure
zero or more *syntax elements* present together in the *bitstream* in a specified order

3.151
ternary split
split of a rectangular MxN *block* of samples into three *blocks* where a vertical split results in a first (M / 4)xN *block*, a second (M / 2)xN *block*, a third (M / 4)xN *block*, and a horizontal split results in a first Mx(N / 4) *block*, a second Mx(N / 2) *block*, a third Mx(N / 4) *block*

3.152
tier
specified category of *level* constraints imposed on values of the *syntax elements* in the *bitstream*, where the *level* constraints are nested within a *tier* and a *decoder* conforming to a certain *tier* and *level* would be capable of decoding all *bitstreams* that conform to the same *tier* or the lower *tier* of that *level* or any *level* below it

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3.153
tile
rectangular region of *CTUs* within a particular *tile column* and a particular *tile row* in a *picture*

3.154
tile column
rectangular region of *CTUs* having a height equal to the height of the *picture* and a width specified by *syntax elements* in the *picture parameter set*

3.155
tile row
rectangular region of *CTUs* having a height specified by *syntax elements* in the *picture parameter set* and a width equal to the width of the *picture*

3.156
tile scan
specific sequential ordering of *CTUs partitioning* a *picture* in which the *CTUs* are ordered consecutively in *CTU raster scan* in a *tile* whereas *tiles* in a *picture* are ordered consecutively in a *raster scan* of the *tiles* of the *picture*

3.157
trailing picture
picture for which each *VCL NAL unit* has nal_unit_type equal to TRAIL_NUT

Note 1 to entry: Trailing pictures associated with an IRAP or GDR picture also follow the IRAP or GDR picture in decoding order. Pictures that follow the associated IRAP picture in output order and precede the associated IRAP picture in decoding order are not allowed.

3.158
trailing subpicture
subpicture for which each *VCL NAL unit* has nal_unit_type equal to TRAIL_NUT

Note 1 to entry: Trailing subpictures associated with an IRAP or GDR subpicture also follow the IRAP or GDR subpicture in decoding order. Subpictures that follow the associated IRAP subpicture in output order and precede the associated IRAP subpicture in decoding order are not allowed.

3.159
transform
part of the *decoding process* by which a *block* of *transform coefficients* is converted to a *block* of spatial-domain values

3.160
transform block
rectangular MxN *block* of samples resulting from a *transform* in the *decoding process*

3.161
transform coefficient
scalar quantity, considered to be in a frequency domain, that is associated with a particular one-dimensional or two-dimensional *frequency index* in a *transform* in the *decoding process*

3.162
transform coefficient level
integer quantity representing the value associated with a particular two-dimensional frequency index in the *decoding process* prior to *scaling* for computation of a *transform coefficient* value

3.163
transform unit <single tree>

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transform block of *luma* samples and two corresponding *transform blocks* of *chroma* samples of a *picture*, when using a single *coding unit tree* for *luma* and *chroma*, and *syntax structures* used to transform the *transform block* samples

3.164
transform unit <dual tree>
transform block of *luma* samples or two *transform blocks* of *chroma* samples, when using two separate *coding unit trees* for *luma* and *chroma*, and *syntax structures* used to transform the *transform block* samples

3.165
tree
set of hierarchically organized nodes with a unique root node

3.166
VCL NAL unit
collective term for *coded slice NAL units* and the subset of *NAL units* that have *reserved* values of nal_unit_type that are classified as VCL NAL units in this document

4 Abbreviated terms

ACT	adaptive colour transform
ALF	adaptive loop filter
AMVR	adaptive motion vector resolution
APS	adaptation parameter set
AU	access unit
AUD	access unit delimiter
AVC	advanced video coding (Rec. ITU-T H.264 | ISO/IEC 14496-10)
B	bi-predictive
BCW	bi-prediction with CU-level weights
BDOF	bi-directional optical flow
BDPCM	block-based delta pulse code modulation
BP	buffering period
CABAC	context-based adaptive binary arithmetic coding
CB	coding block
CBR	constant bit rate
CCALF	cross-component adaptive loop filter
CLVS	coded layer video sequence
CLVSS	coded layer video sequence start
CPB	coded picture buffer
CRA	clean random access
CRC	cyclic redundancy check
CREI	constrained RASL encoding indication
CTB	coding tree block
CTU	coding tree unit

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CU	coding unit
CVS	coded video sequence
CVSS	coded video sequence start
DPB	decoded picture buffer
DCI	decoding capability information
DRAP	dependent random access point
DU	decoding unit
DUI	decoding unit information
EDRAP	extended dependent random access point
EG	exponential-Golomb
EGk	k-th order exponential-Golomb
EOB	end of bitstream
EOS	end of sequence
FD	filler data
FIFO	first-in, first-out
FL	fixed-length
GBR	green, blue, and red
GCI	general constraints information
GDR	gradual decoding refresh
GPM	geometric partitioning mode
HEVC	high efficiency video coding (Rec. ITU-T H.265 | ISO/IEC 23008-2)
HRD	hypothetical reference decoder
HSS	hypothetical stream scheduler
I	intra
IBC	intra block copy
IDR	instantaneous decoding refresh
ILRP	inter-layer reference picture
IRAP	intra random access point
LFNST	low frequency non-separable transform
LPS	least probable symbol
LSB	least significant bit
LTRP	long-term reference picture
LMCS	luma mapping with chroma scaling
MIP	matrix-based intra prediction
MPS	most probable symbol

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MSB	most significant bit
MTS	multiple transform selection
MVP	motion vector prediction
NAL	network abstraction layer
OLS	output layer set
OP	operation point
OPI	operating point information
P	predictive
PH	picture header
POC	picture order count
PPS	picture parameter set
PROF	prediction refinement with optical flow
PT	picture timing
PU	picture unit
QP	quantization parameter
RADL	random access decodable leading (picture)
RASL	random access skipped leading (picture)
RBSP	raw byte sequence payload
RGB	red, green, and blue
RPL	reference picture list
SAO	sample adaptive offset
SEI	supplemental enhancement information
SH	slice header
SLI	subpicture level information
SODB	string of data bits
SPS	sequence parameter set
STRP	short-term reference picture
STSA	step-wise temporal sublayer access
TR	truncated Rice
TU	transform unit
VBR	variable bit rate
VCL	video coding layer
VPS	video parameter set
VSEI	versatile supplemental enhancement information (Rec. ITU-T H.274 | ISO/IEC 23002-7)
VUI	video usability information
VVC	versatile video coding (this document: Rec. ITU-T H.266 | ISO/IEC 23090-3)

5 Conventions

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