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Information technology — Scalable compression and coding of continuous-tone still images —

Part 3: **Box file format**

Technologies de l'information — Compression échelonnable et codage d'images plates en ton continu —

Partie 3: Format de la liste de fichiers

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

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Foreword

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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*.

This second edition cancels and replaces the first edition (ISO/IEC 18477-3:2015), which has been technically revised.

The main changes are as follows:

— editorial improvements on the usage of the JPEG XT marker segment.

A list of all parts in the ISO/IEC 18477 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

This document is an extension of ISO/IEC 18477-1, a compression system for continuous-tone digital still images, which is backwards compatible with Rec. ITU-T T.81 | ISO/IEC 10918-1. This means that legacy applications conforming to Rec. ITU-T T.81 | ISO/IEC 10918-1 will be able to reconstruct streams generated by an encoder conforming to this document, although it is possible that they will not be able to reconstruct such streams in full dynamic range or quality or using other features defined in this document.

This document provides a flexible and extensible framework to enrich ISO/IEC 18477-1 conforming codestreams with side-channels and metadata. The syntax chosen in this document defines a mechanism to embed syntax elements denoted as "boxes" into Rec. ITU-T T.81 | ISO/IEC 10918-1 conforming codestreams. The box syntax used in this document is identical to that defined in the JPEG series, for example JPEG 2000 image coding system (Rec. ITU-T T.800 | ISO/IEC 15444-1). Boxes will then carry either additional image data, to enable encoding of images of higher bit depth, high-dynamic range (HDR), including alpha channels, etc., or metadata that describes the decoding process of the legacy Rec. ITU-T T.81 | ISO/IEC 10918-1 codestream and the side channels to an extended or HDR image.

This document specifies an extensible file format, denoted as JPEG XT, which is built on top of the existing Rec. ITU-T T.81 | ISO/IEC 10918-1 codestream definition. While typically, file formats encapsulate codestreams by means of additional syntax elements such as boxes, the file format structure specified in this document embeds the syntax elements of the file format, called boxes, into the codestream. The necessity for this unusual arrangement is the backwards compatibility to the legacy standard and the application toolchain built around it. This means that legacy applications conforming to Rec. ITU-T T.81 | ISO/IEC 10918-1 will be able to decode image information embedded in files conforming to this document, although they will only be able to recover a three component, 8 bit per sample, lower quality version of the image described by the full file.

For more demanding applications, it is not uncommon to use a bit depth of 16, providing 65 536 representable values to describe each channel within a pixel, resulting on over 2.8×10^{14} representable colour values. In some less common scenarios, even greater bit depths are used, and sometimes the dynamic range of the image is so high that a floating-point based encoding is desirable. In addition to image information, some applications also require an additional opacity channel, a feature not available from the legacy standard.

Most common photo and image formats use an 8-bit or 16-bit unsigned integer value to represent some function of the intensity of each colour channel. While it can be theoretically possible to agree on one method for assigning specific numerical values to real world colours, doing so is not practical. Since any specific device has its own limited range for colour reproduction, the device's range can be a small portion of the agreed-upon universal colour range. As a result, such an approach is an extremely inefficient use of the available numerical values, especially when using only 8 bits (or 256 unique values) per channel. To represent pixel values as efficiently as possible, devices use a numeric encoding optimized for their own range of possible colours or gamut.

JPEG XT is designed to extend the legacy JPEG standard towards higher bit depth, higher dynamic range, and wide colour gamut content, while simultaneously allowing legacy applications to decode the image data in the codestream to a standard low-dynamic range (LDR) image represented by only 8 bits per channel. The goal is to provide a backwards compatible coding specification that allows legacy applications and existing toolchains to continue to operate on codestreams conforming to this document.

JPEG XT has been designed to be backwards compatible to legacy applications while at the same time having a small coding complexity. JPEG XT uses, whenever possible, functional blocks of Rec. ITU-T T.81 | ISO/IEC 10918-1 to extend the functionality of the legacy JPEG coding system.

Information technology — Scalable compression and coding of continuous-tone still images —

Part 3: Box file format

1 Scope

This document specifies box-based container format, referred to as JPEG XT, which is designed primarily for continuous-tone photographic content.

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 18477-1, *Information technology — Scalable compression and coding of continuous-tone still images — Part 1: Core coding system specification*

Rec. ITU-T T.81 | ISO/IEC 10918-1, *Information technology — Digital compression and coding of continuous-tone still images: Requirements and guidelines*

3 Terms, definitions, abbreviated terms and symbols

3.1 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/

3.1.1
ASCII encoding
encoding of text characters and text strings according to ISO/IEC 10646-1

3.1.2
base decoding path
process of decoding legacy codestream and refinement data to the base image, jointly with all further steps, until residual data is added to the values obtained from the residual codestream

3.1.3
base image
collection of sample values obtained by entropy, decoding the discrete cosine transformation (DCT) coefficients of the legacy codestream and the refinement codestream, and inversely DCT transforming them jointly

3.1.4
bit stream
partially encoded or decoded sequence of bits comprising an entropy-coded segment

3.1.5
box
structured collection of data describing the image or the image-decoding process embedded into one or multiple APP$_{11}$ marker segments

Note 1 to entry: See Annex A for the definition of boxes.

3.1.6
byte
group of 8 bits

3.1.7
compression
reduction in the number of bits used to represent source image data

3.1.8
component
two-dimensional array of samples having the same designation in the output or display device

Note 1 to entry: An image typically consists of several components, e.g. red, green and blue.

3.1.9
continuous-tone image
image whose components have more than one bit per sample

3.1.10
decoder
embodiment of a decoding process

3.1.11
decoding process
process which takes as its input compressed image data and outputs a continuous-tone image

3.1.12
encoder
embodiment of an encoding process

3.1.13
encoding process
process which takes as its input a continuous-tone image and outputs compressed image data

3.1.14
extension image
sample values as reconstructed by inverse quantization and inverse discrete cosine transformation (DCT) applied to the entropy-decoded coefficients described by the refinement scan, residual scan and residual refinement scans

3.1.15
high-dynamic range
HDR
image or image data comprised of more than 8 bits per sample

3.1.16
legacy codestream
collection of markers and syntax elements defined by Rec. ITU-T T.81 | ISO/IEC 10918-1 without any syntax elements defined by ISO/IEC 18477-1, ISO/IEC 18477-2, ISO/IEC 18477-3

Note 1 to entry: In this definition, the legacy codestream consists of the collection of all markers except those APP$_{11}$ markers that describe JPEG XT boxes by the syntax defined in Annex A.

3.1.17
legacy decoder
embodiment of a decoding process conforming to Rec. ITU-T T.81 | ISO/IEC 10918-1, confined to the lossy discrete cosine transformation (DCT) process and the baseline, sequential or progressive modes, decoding at most four components to 8 bits per component

3.1.18
lossless
encoding and decoding processes and procedures in which the output of the decoding procedure(s) is identical to the input to the encoding procedure(s)

3.1.19
lossy
encoding and decoding processes which are not lossless

3.1.20
low-dynamic range
LDR
image or image data comprised of data with no more than 8 bits per sample

3.1.21
marker
2-byte code in which the first byte is hexadecimal FF and the second byte is a value between 1 and hexadecimal FE

3.1.22
marker segment
marker together with its associated set of parameters

3.1.23
pixel
collection of sample values in the spatial image domain having all the same sample coordinates

Note 1 to entry: A pixel may consist of three samples describing its red, green and blue value.

3.1.24
point transformation
scaling of a sample or discrete cosine transformation (DCT) coefficient by a factor

3.1.25
precision
number of bits allocated to a particular sample or discrete cosine transformation (DCT) coefficient

3.1.26
procedure
set of steps which accomplishes one of the tasks which comprises an encoding or decoding process

3.1.27
residual decoding path
collection of operations applied to the entropy coded data contained in the residual data box and residual refinement scan boxes up to the point where this data is merged with the base image to form the final output image

3.1.28
residual image
sample values as reconstructed by inverse quantization and inverse discrete cosine transformation (DCT) applied to the entropy-decoded coefficients described by the residual scan and residual refinement scans

3.1.29
refinement scan
additional pass over the image data that is invisible to legacy decoders, which provides additional least significant bits to extend the precision of the discrete cosine transformation (DCT) transformed coefficients

Note 1 to entry: Refinement scans can be either applied in the base or residual decoding path.

3.1.30
sample
one element in the two-dimensional image array which comprises a component

3.1.31
sample grid
common coordinate system for all samples of an image such that the samples at the top left edge of the image have the coordinates (0, 0), the first coordinate increases towards the right, the second towards the bottom

3.1.32
superbox
box that carries other boxes as payload data

3.1.33
zero byte
0x00 byte

3.2 Abbreviated terms

ASCII	American Standard Code for Information Interchange
LSB	least significant bit
MSB	most significant bit
HDR	high-dynamic range
IDR	intermediate-dynamic range
JPEG	informal name of the committee that created this document
LDR	low-dynamic range
TMO	tone mapping operator
DCT	discrete cosine transformation

3.3 Symbols

X	Width of the sample grid in positions
Y	Height of the sample grid in positions
Nf	Number of components in an image
$s_{\mathrm{i,\,x}}$	Subsampling factor of component i in horizontal direction
$s_{\mathrm{i,\,y}}$	Subsampling factor of component i in vertical direction
H_{i}	Subsampling indicator of component i in the frame header

V_i Subsampling indicator of component i in the frame header

$v_{\mathrm{x,\,y}}$ Sample value at the sample grid position x, y

R_{h} Additional number of DCT coefficient bits represented by refinement scans in the base decoding path. 8+R_{h} is the number of non-fractional bits (i.e. bits in front of the "binary dot") of the output of the inverse DCT process in the base decoding path.

R_{r} Additional number of DCT coefficient bits represented by refinement scans in the residual decoding path. P+R_{r} is the number of non-fractional bits of the output of the inverse DCT process in the residual decoding path, where P is the frame-precision of the residual image as recorded in the frame header of the residual codestream.

R_{b} Additional bits in the HDR image. 8+R_{b} is the sample precision of the reconstructed HDR image.

4 Conventions

4.1 Conformance language

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

4.2 Operators

NOTE Many of the operators used in this document are similar to those used in the C programming language.

4.2.1 Arithmetic operators

+ Addition

− Subtraction (as a binary operator) or negation (as a unary prefix operator)

× Multiplication

/ Division without truncation or rounding

umod x umod a is the unique value y between 0 and a-1
for which y+Na = x with a suitable integer N

4.2.2 Logical operators

|| Logical OR

&& Logical AND

! Logical NOT

∈ x ∈ {A, B} is defined as (x == A || x == B)

∉ x ∉ {A, B} is defined as (x != A && x != B)

4.2.3 Relational operators

>	Greater than
>=	Greater than or equal to
<	Less than
<=	Less than or equal to
==	Equal to
!=	Not equal to

4.2.4 Precedence order of operators

Operators are listed below in descending order of precedence. If several operators appear in the same line, they have equal precedence. When several operators of equal precedence appear at the same level in an expression, evaluation proceeds according to the associativity of the operator either from right to left or from left to right.

Operators	Type of operation	Associativity
(), [ ], .	Expression	Left to Right
–	Unary negation	
×, /	Multiplication	Left to Right
umod	Modulo (remainder)	Left to Right
+, –	Addition and Subtraction	Left to Right
< , >, <=, >=	Relational	Left to Right

4.2.5 Mathematical functions

$\lceil x \rceil$ Ceiling of *x*. Returns the smallest integer that is greater than or equal to *x*.

$\lfloor x \rfloor$ Floor of *x*. Returns the largest integer that is lesser than or equal to *x*.

$|x|$ Absolute value, is –x for x < 0, otherwise *x*.

sign(*x*) Sign of *x*, 0 if *x* is 0, +1 if *x* is positive, −1 if *x* is negative.

clamp(*x*,*min*,*max*) Clamps *x* to the range [*min*, *max*]: returns *min* if *x* < *min*, *max* if *x* > *max* or otherwise *x*.

x^a Raises the value of *x* to the power of *a*. *x* is a non-negative real number, *a* is a real number. x^a is equal to exp(*a*×log(*x*)) where exp is the exponential function and log() the natural logarithm. If *x* is 0 and *a* is positive, x^a is defined to be 0.

5 Overview

5.1 General

This clause gives an informative overview of the elements specified in this document. It also introduces many of the terms which are defined in Clause 3.

There are three elements specified in this document:

a) An "encoder" is an embodiment of an "encoding process". An encoder takes as input "digital source image data" and "encoder specifications", and by means of a specified set of "procedures" generates as output a "codestream".

b) A "decoder" is an embodiment of a "decoding process". A decoder takes as input a codestream, and by means of a specified set of procedures generates as output "digital reconstructed image data".

c) The "codestream" is a compressed image data representation which includes all necessary data to allow a (full or approximate) reconstruction of the sample values of a digital image. Additional data can be required that define the interpretation of the sample data, such as colour space or the spatial dimensions of the samples.

5.2 High-level overview on JPEG XT

The high-level syntax of an ISO/IEC 18477-3 conforming codestream is identical to that defined in ISO/IEC 18477-1, which is a subset of the syntax defined in Rec. ITU-T T.81 | ISO/IEC 10918-1. Marker definitions and the syntax of the markers defined in Rec. ITU-T T.81 | ISO/IEC 10918-1 remain in force and unchanged. However, this document defines the APP$_{11}$ marker, reserved in the legacy Recommendation | Standard for encoding additional syntax elements. Legacy decoders will skip and ignore such marker elements, and hence will only be able to decode the image encoded by the legacy syntax elements. This part of a JPEG XT file will be denoted the legacy codestream in the following.

This document extends the legacy standard by a syntax element called “box”, using the APP$_{11}$ marker to hide the extended syntax elements from legacy applications. Boxes and their encoding are specified in Annex A. A common set of boxes used by ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9 are defined in Annex B. A box can either include additional metadata required to decode the complete codestream to full precision, full dynamic range or without loss, or can contain entropy coded image data itself.

How entropy coded data from the side-channels contained in the boxes and entropy coded data in the legacy codestream are merged together is application dependent and defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. It is beyond the scope of this document to define this process.

5.3 Encoder requirements

An encoder is only required to meet the compliance tests and to generate the codestream according to the syntax defined in this document. How the codestream is algorithmically constructed and how the boxes are laid out is implementation-specific and not within scope of this document. ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9 can, however, define additional restrictions and requirements, either within the standard itself, or within profiles that restrict the freedom of the encoder further.

An encoder claiming to conform to one of these profiles then shall conform to the syntax constraints defined in the corresponding profile of the corresponding part of ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9.

5.4 Decoder requirements

A decoding process converts compressed image data to reconstructed image data. A decoder shall interpret the syntax of the box structures, namely the packaging of boxes correctly into APP markers specified in Annex A. It is not required, however, for a conforming decoder to be capable of interpreting the semantics of all box types defined in this document. A decoder implementation should skip over boxes it is unable or not willing to support unless such a box is indicated as a mandatory box in the profile and part of the ISO/IEC 18477 series to which the decoder claims to conform.

Annex A
(normative)

JPEG XT marker segment

A.1 General

This Annex extends the compressed bit stream syntax of ISO/IEC 18477-1:2020, Annex B by introducing additional markers and marker segments carrying side channel and coding parameters that control the decoding process. While the corresponding decoding processes are specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9, this Annex defines a generic mechanism by which such syntax elements are embedded into ISO/IEC 18477-1 conforming files.

The syntax element and the building block defined in this Annex is called a box. This document defines several types of boxes; the definition of each specific box type defines the kind of information that can be found within a box of that type. Some boxes will be defined to contain other boxes. Box types are specified in Annex B.

Boxes are not, unlike in other Recommendations | International Standards, a top-level syntax element, but are themselves wrapped in JPEG XT marker segments introduced in A.2. Since boxes can logically carry more than 64K (65536) bytes of payload data, but marker segments can at most carry 64K of data, a single logical box can need to be broken up into several marker segments. Syntax elements within the marker segment then instruct the decoder how to put the contents in the marker segment back into a single box.

Additionally, a JPEG XT file can contain several boxes of the same box type, though with differing content. The syntax of the marker segment provides a mechanism to distinguish between two logically different boxes of the same box type.

A.2 Marker assignments

The following additional marker is defined in Table A.1.

Table A.1 — Additional markers and marker segments

Code assignment	Symbol	Description	Defined in
0xFFEB	APP_{11}	JPEG XT marker	This document

Each box is encapsulated in at least one JPEG XT marker segment and can extend over several marker segments if the size of its payload data exceeds the capacity of the JPEG XT marker. A.4 explains how to merge JPEG XT marker segments to logical boxes.

A.3 Codestream syntax

The high-level syntax of ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9 codestreams shall follow the syntax specified in ISO/IEC 18477-1, which is a subset of Rec. ITU-T

T.81 | ISO/IEC 10918-1. Specifically, since JPEG XT boxes are represented by APP_{11} marker segments, ISO/IEC 18477-1 conforming implementations that do not implement them, will ignore them.

NOTE Byte stuffing and padding as defined in Rec. ITU-T T.81 | ISO/IEC 10918-1 also applies to entropy coded data contained in APP_{11} markers. In addition, due to the segmentation of entropy coded data into application markers, the last byte of an APP_{11} marker segment can be 0xff, and the corresponding "stuffed" zero byte is part of a subsequent application marker segment. This does not cause a problem for legacy decoders since they are required to skip over unknown application marker segments in first place, without interpreting their content.

A.4 JPEG XT boxes

JPEG XT structures any additional data that remains invisible to legacy decoders in JPEG XT boxes. A box is a generic data container that has both a type and a body that carries its actual payload. The type is a 4-byte identifier that allows decoders to identify its purpose and the structure of its content. A JPEG XT file can also carry several boxes of identical type. To indicate that JPEG extensions marker segments using the same box type are contributing to logically distinct boxes of the same type, the box instance number *En* of such JPEG extension marker segments shall be different (see Figure A.1).

NOTE 1 JPEG extension marker segments that carry the same box instance number *En* but different box types *TBox* therefore assemble to different logical boxes.

Boxes are embedded into the codestream format by encapsulating them into one or several JPEG XT marker segments. Since boxes can grow large in size, a single box can extend over multiple JPEG XT marker segments, and decoders can have to merge multiple marker segments before they can attempt to decode the box content. JPEG XT marker segments that belong to the same logical box and require merging prior to interpretation shall have identical box instance number fields *En*, but differ in the packet sequence number *Z*.

The JPEG XT marker segment consists of the APP_{11} marker that is reserved for this document, the size of the marker segment in bytes (not including the marker), a common identifier identical for all boxes and box types, the box instance number field, the packet sequence number field, the box length, the box type and the actual box payload data. The box length field can be extended by a box length extension field that allows box sizes beyond 2^{32}-1 bytes. Figure A.1 depicts the high-level syntax of a JPEG XT marker segment.

0xFFEB	*Le*	*CI* Common Identifier	*En* Box Instance Number	*Z* Packet Sequence Number	*LBox* Box Length	*TBox* Box Type	*XLBox* *Box Length* *Extension* *(optional)*	Payload Data

Figure A.1 — Organization of the JPEG XT marker segment

The meaning of the fields of the JPEG XT marker segment is as follows:

— The *Le* field is the size of the marker segment, not including the marker. It measures the size from the *Le* field up to the end of the marker segment.

NOTE 2 Since boxes can extend over several marker segments, the *Le* field is typically not derived from the box length field. By the above definition, the *Le* field defines the amount of data carried by a single-marker segment; the box length is the logical size of the box. If a box extends over multiple JPEG XT extension marker segments, the *Le* field measures the total size of each individual marker segment and can differ from segment to segment, whereas the box length field remains identical in all segments that contribute to the same logical box.

— The common identifier *CI* is a 16-bit field that allows decoders to identify an APP_{11} marker segment as a JPEG XT marker segment. Its value shall be 0x4A50. It is identical for all boxes and all box types.

- The box instance number *E*n is a 16-bit field that disambiguates between JPEG XT marker segments carrying boxes of identical type, but differing content, i.e. data that belongs to logically distinct boxes with the same box type differ in their box instance number. Encoders shall concatenate the payload data of those JPEG XT marker segments whose box instance number and type identifier fields are identical in the order of increasing packet sequence numbers *Z*.

- The packet sequence number *Z* is a 32-bit field that specifies the order in which payload data shall be merged. Concatenation proceeds in the order of increasing packet sequence numbers.

- The Box Length *LBox* is a 4-byte field that specifies the box length. It measures the size of the payload data of all JPEG extension markers of the same box type and enumerator combined, plus the size of a single copy of the box type, plus the size of a single copy of the box length, plus the length of a single copy of the box length extender if present. The box length does not include the size of the packet sequence number, the box instance number, the common identifier, the marker length or the marker.

  NOTE 3 A box having a payload data of 32 bytes will have a box length of 32+4+4 = 40. If this box is split evenly over two JPEG XT marker segments, each marker segment will have an *Le* value of 2+2+2+4+(4+4+16) = 50.

  If the size of the box payload is less than 2^{32}-8 bytes, then all fields except the *XLBox* field, i.e. *Le*, *CI*, *E*n, *Z*, *LBox* and *TBox*, shall be present in all JPEG XT marker segments representing this box, regardless of whether the marker segment starts this box, or continues a box started by a former JPEG XT marker segment.

- The Box Type *TBox* is a 32-bit field that specifies the type of the payload data, and thus its syntax. Box types are specified in Annex B and in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. Since ISO and IEC can add additional box types that define additional meta-information on the image later, decoders shall disregard box types that they do not understand.

  If the box length is larger than 2^{32} bytes, the *LBox* field is no longer sufficient to encode the box length and the *XLBox* field is required additionally. In this case, the *LBox* field shall be 1 and the *XLBox* field carries the box size instead. If the box length is larger than 2^{32}, the *XLBox* field shall be present in all JPEG XT marker segments of the same box type and same box instance number, and its value shall be identical in all JPEG XT marker segments of the same box type and same box instance number.

  The payload data carries the contents of the box. Its syntax is specified along with the corresponding box types in this Annex.

  NOTE 4 As indicated in Figure A.1 and Table A.2, *LBox*, *XLBox* and *TBox* are therefore replicated over all JPEG extension marker segments that contribute to the same box, i.e. carry the same *Tbox*, *E*n pair. This means that even the second, third or any further follow-up JPEG extension marker segment carries these fields, while the logical box reconstructed from these JPEG extension marker segments includes only a single *LBox*, *XLBox*, *TBox* triple. This is unlike the box payload data which can be split across multiple JPEG extension marker segments and is not replicated.

Profiles defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9 add additional constraints in how payload data can be broken up into individual JPEG XT marker segments.

Table A.2 — JPEG XT marker parameters and sizes

Parameter	Size (bits)	Value	Meaning
APP_{11}	16	0xFFEB	Identifies all JPEG XT marker segments.
Le	16	18..65535	The length of the marker segment, including the size itself, all parameters, and the size of the payload data contained in this marker segment alone. The *Le* value does not include the size of the marker itself.
CI	16	0x4A50 (ASCII encoding of "JP")	The special value 0x4A50 (ASCII: 'J' 'P') allows readers to distinguish the JPEG extension marker segment from other uses of the APP_{11} marker. APP_{11} markers shall be ignored for the purpose of decoding JPEG extensions if this value does not match.
*E*n	16	1..65535	The box instance number disambiguates payload data of the same box type and defines which payload data is to be concatenated. Only payload data for which the *TBox*, *E*n is identical shall be concatenated. The value 0 is reserved for future use.
Z	32	$1..2^{32}$-1	The packet sequence number defines the order in which the payload data shall be concatenated. Concatenation shall proceed in order of increasing *Z* values. The value 0 is reserved for future use.
LBox	32	1 or $8..2^{32}$-1	Box length is the total length of the concatenated payload data, including a single copy of the *LBox* and *Tbox* field, and a single copy of the *XLBox* field, if present. The values 0 and 2 to 7 are reserved for future use. Regardless of whether this is the first, or later JPEG extension marker segment contributing to the same logical box, this field shall always be present. It is replicated through all JPEG extension marker segments. The *LBox* value shall be identical for all JPEG extension marker segments contributing to the same logical box, i.e. to all JPEG extension marker segments of the same value of the *TBox*, *E*n pair.

Table A.2 *(continued)*

Parameter	Size (bits)	Value	Meaning
TBox	32	$0..2^{32}$-1	Box type defines the syntax of the concatenated payload data. The box type and the box instance number also specify which payload data to merge. Regardless of whether this is the first, or later JPEG extension marker segment contributing to the same logical box, this field shall always be present. It is replicated through all JPEG extension marker segments.
XLBox	0 or 64	$16..2^{64}$-1	If the *LBox* field is 1, this field contains the size of the concatenated payload data plus the box overhead instead. Otherwise, this field is omitted. The presence and the value of this field shall be consistent throughout all JPEG extension marker segments of the same *TBox*, *E*n pair. The values 0 to 15 are reserved for future use.
Payload data	Varies	Varies	The syntax of the concatenated payload data is defined in Annex B of this document or in other documents that use the box embedding mechanism specified in this Annex.

The size of the *XLBox* field itself also contributes to the box length, hence creating a corner case for boxes larger than 4GB. If an encoder detects that the value of the *LBox* field, computed as the sum of the payload data size and the box overhead, overruns the 4GB boundary *LBox* is able to express, it is not sufficient to create an *XLBox* field and store the sum there. The box size needs to be enlarged by the size of the *XLBox* field as well, namely by 8 bytes.

A.5 Boxes and superboxes

Some boxes can carry other boxes as payload data. Such boxes are denoted as superboxes. The payload size of a superbox is given by the sum of the box lengths of all the boxes it contains.

Boxes within superboxes do not consist of a JPEG XT marker. None of the following shall be present:

- a marker size;
- a common identifier;
- a box instance number;
- a packet sequence number.

They start with the *LBox* field. The additional fields are not required since their composition from markers into boxes is unambiguous.

NOTE The length of a box within a superbox is derived in the same way from the size of the payload data as for top-level boxes within JPEG XT marker segments. Neither top-level boxes nor boxes within superboxes count the *Le*, *En* and *Z* fields as part of their length. A box within a superbox can be a superbox again and can contain further boxes. The layout of such boxes is also given in Figure A.2.

LBox Box Length	*TBox* Box Type	*XLBox* *Box Length* *Extension* *(optional)*	Payload Data

Figure A.2 — Organization of a box within a superbox

Annex B
(normative)

Common box types

B.1 General

This Annex defines box types that are common to ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9. These documents reference to this Annex as required.

B.2 Integer table lookup box

This box shall appear at the top level of the file. It shall not be a sub-box of any superbox. This box defines a lookup process of the decoder and can be used to implement a point transformation as used in the base or range mapping operations which are part of the merging process for combining the LDR and residual image information to reconstruct a high dynamic range (HDR) image. This table carries integer data of up to a 16-bit precision and is indexed by integer values.

There shall be at most one integer or floating-point table lookup or parametric curve box for each value of *M* within the same superbox or within the codestream at top level.

The type of this box shall be 0x544f4e45, ASCII encoding of "TONE".

The box organization is defined in Figure B.1 and the parameters and sizes in Table B.1.

M	R_d	D_k

Figure B.1 — Organization of the integer table lookup box

Table B.1 — Integer table lookup box, parameters and sizes

Parameter	Size (in bits)	Value	Meaning
M	4	0..15	Table destination. Up to 16 tables can be defined.
R_d	4	0..9	Specifies the output precision of the table entries. Table entries shall be integers in the range [0, 2^{8+Rd}-1]. R_d shall fit to the application of the table (see Annex C).
D_k	16 or 32	0..2^{Rt+8}-1	Table contents. For $R_b \leq 8$, each entry is a 16-bit unsigned integer. For R_b>8, each entry is a 32-bit unsigned integer. All numbers shall be represented in big-endian format. The number of table entries can be derived from the box length. The size of the table shall be a power of two that fits to the application of the table (see Annex C).

The value of R_t defines the output range of the table lookup process in bits. The length of the table depends on the input precision required for the application of the table. The number of table entries shall be 2^l, where l is an application dependent integer.

B.3 Floating-point table lookup box

This box shall appear at the top level of the file. It shall not be a sub-box of any superbox. This box defines a lookup process at the decoder and can be used to implement a point transformation as used in the base or range mapping operations, which are part of the merging process for combining the LDR and residual image information to reconstruct an HDR image. This table carries floating-point data of 32-bit precision and is indexed by integer values.

There shall be at most one integer or floating-point table lookup or parametric curve box for each value of M within the same superbox or within the codestream at top level.

The type of this box shall be 0x46544f4e, ASCII encoding of "FTON".

The box organization is defined in Figure B.2 and the parameters and sizes in Table B.2.

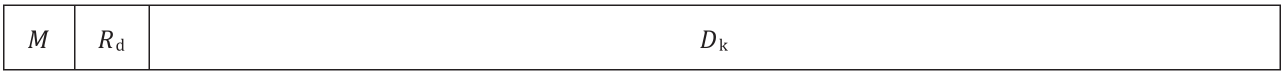


Figure B.2 — Organization of the floating-point table lookup box

Table B.2 — Floating table lookup box, parameters and sizes

Parameter	Size (in bits)	Value	Meaning
M	4	0..15	Table destination. Up to 16 tables can be defined.
R_d	4	0	Reserved for future use.
D_k	32	non-negative numbers	Table contents. Each entry is an IEC 60559 big endian single precision 32-bit floating-point number. The number of table entries can be derived from the box length. The size of the table shall be a power of two that fits to the application of the table (see Annex C).

The length of the table depends on the input precision required for the application of the table. The number of table entries shall be 2^l, where l is an application dependent integer.

B.4 Parametric curve box

This box shall either appear at the top level of the file, or it shall be a sub-box of the merging specification box or alpha merging specification box. A parametric curve box as a sub-box shall replace a parametric curve box at the top level of the file with the same value of M.

This box defines a decoder mapping process in the form of a parameterized curve, which can offer a more efficient coding than a look-up table. The parametric curve box maps integer, fixed-point or floating-point numbers to floating-point numbers.

There shall be at most one integer or floating-point table lookup or parametric curve box for each value of M within the same superbox or within the codestream at top level.

The box type of this box shall be 0x43555256, the ASCII encoding of "CURV".

The box organization is defined in Figure B.3 and the parameters and sizes in Table B.3.

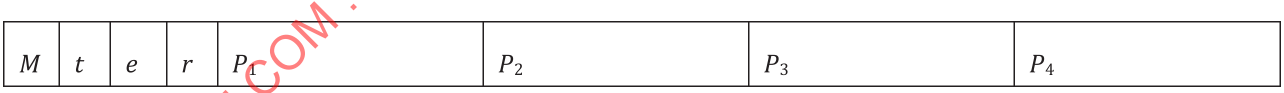


Figure B.3 — Organization of the parametric curve box

Table B.3 — Contents of the parametric curve box

Parameter	Size (in bits)	Value	Meaning
M	4	0..15	Table destination. Up to 16 curves can be defined.
T	4	0..15	Curve type. Curve types are defined in Table B.4.
e	4	0..1	Rounding mode (see Annex C for details).
R	4	0	Reserved for ITU | ISO/IEC purposes. This field shall always be 0.
P_1	32	Depends on *t*	Curve parameter 1, encoded as big-endian IEC 60559 single precision floating-point value
P_2	32	Depends on *t*	Curve parameter 2, encoded as big-endian IEC 60559 single precision floating-point value
P_3	32	Depends on *t*	Curve parameter 3, encoded as big-endian IEC 60559 single precision floating-point value
P_4	32	Depends on *t*	Curve parameter 4, encoded as big-endian IEC 60559 single precision floating-point value

The parametric curve to be applied is defined by the *t* parameter. Depending on *t*, the parameters P_1 through P_4 further specify the curve. All parameters are always present, regardless of the actual curve type. They are, however, eventually ignored. Table B.4 specifies the available parametric curve types.

Parametric curves are applied in three steps to map an input value to an output value:

- First, the input value *x* is normalized to the input scale of the channel as specified in Annex C using a procedure that depends on the *e* parameter. The result of this process is a scaled input value *y*.
- Second, the parameter *t* is used to select one out of several curve types. The value of *y* and the curve parameters P_1 through P_4 then compute from the scaled input *y* a scaled output *f(y)*.
- Third, the output *f(y)* is again scaled by a suitable factor depending on *e* to match the output range of the channel, where scaling is defined in Annex C again.

Table B.4 — Predefined parametric curves

Curve type, value of t	Inverse tone mapping to be performed	Remarks
0, 1		Reserved for ITU | ISO/IEC purposes.
2	$f(x) = x$	Identity transformation, input data is passed through, though scaling of input and output applies. P_1 through P_4 are ignored.
3		Reserved for ITU | ISO/IEC purposes
4	$f(x) = \{(x+P_3)/(1+P_3)\}^{P2}$ for $x \geq P_1$ and $f(x) = \{(P_1+P_3)/(1+P_3)\}^{P2}\times x/P_1$ for $x < P_1$	This is an inverse gamma mapping with parameters P_1 through P_3.[a]
5	$f(x) = x\times(P_2-P_1)+P_1$	Linear ramp with start value P_1 and end value P_2. P_2 shall be larger than P_1. P_3 and P_4 are ignored.
6	$f(x) = P_3\times\exp(x\times(P_2-P_1)+P_1)+P_4$	Exponential map from a linear ramp.
7	$f(x) = \mathrm{sign}(P_1)\times\log((\lvert P_1\rvert\times x)^{P2}+P_3)+P_4$	Logarithmic map. The parameters P_2 through P_3 shall be positive.
8	$f(x) = (P_2-P_1) \times x^{P3} + P_1$	Inverse gamma mapping without toe region followed by scaling to the range $[P_1, P_2]$.
9..15		Reserved for ITU | ISO/IEC purposes.

[a] For P_1=0. 04045, P_2=2. 4, P_3=0. 055, this is the sRGB non-linearity.

B.5 Fix-point linear transformation box

This box shall either appear at the top level of the file, or it shall be a sub-box of the merging specification box or alpha merging specification box. A fix-point linear transformation box as a sub-box shall replace a fix-point linear transformation box at the top level of the file with the same value of M.

There shall be at most one floating-point linear transformation box or integer linear transformation box for each value of M within the same superbox, or within JPEG XT markers at the top level of the codestream.

The box below defines a free-form table based linear transformation. It defines nine parameters which specify the entries in a 3×3 matrix:

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

Up to 11 free form transformations can be defined; its entries are fixed-point numbers that are preshifted by 13 bits.

The type of this box shall be 0x4D545258, ASCII encoding of "MTRX".

Figure B.4 describes the organization of this box segment and Table B.5 shows the parameters and parameter sizes.

M	t	a_{11}	a_{12}	a_{13}	a_{21}	a_{22}	a_{23}	a_{31}	a_{32}	a_{33}

Figure B.4 — Organization of the fixed-point linear transformation box

Table B.5 — Fixed-point linear transformation box contents

Parameter	Size (in bits)	Value	Meaning
M	4	5..15	Table destination. Up to 11 free form linear transformations can be defined.
t	4	13	Reserved for ITU | ISO/IEC purposes.
a_{11}	16	−32768 to 32767	First parameter of the 3×3 transformation. This and all following parameters are represented by big-endian 16-bit integers.
a_{12}	16	−32768 to 32767	Second parameter
a_{13} through a_{33}			All other parameters in the same format.

NOTE Due to scaling that is applied, the integer coefficients of the transformation matrix for t=13 can also be understood as fix-point numbers which are pre-shifted by 13 bits.

B.6 Floating-point linear transformation box

This box shall either appear at the top level of the file, or it shall be a sub-box of the merging specification box or alpha merging specification box. A floating-point linear transformation box as a sub-box shall replace a floating-point box at the top level of the file with the same value of M.

There shall be at most one floating-point linear transformation box or integer linear transformation box for each value of M within the same superbox, or within JPEG XT markers at the top level of the codestream.

The box below defines a free-form table based linear transformation. It defines nine parameters which specify the entries in a 3×3 matrix:

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

Up to 11 free form transformations can be defined; its entries are floating-point numbers encoded according to singe precision as specified in IEC 60559 and stored in big-endian byte order.

The type of this box shall be 0x46545258, ASCII encoding of "FTRX".

Figure B.5 describes the organization of this box segment and Table B.5 shows the parameters and parameter sizes.

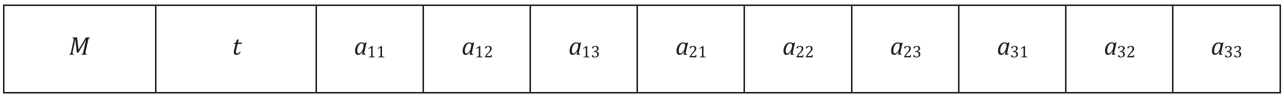


Figure B.5 — Organization of the floating-point linear transformation box

Table B.6 — Floating-point linear transformation box contents

Parameter	Size (in bits)	Value	Meaning
M	4	5..15	Table destination. Up to 11 free form linear transformations can be defined.
t	4	0	Reserved for ITU | ISO/IEC purposes.
a_{11}	32	arbitrary	First parameter of the 3×3 transformation encoded as 32-bit single precision big-endian IEC 60559 number.
a_{12}	32	arbitrary	Second parameter
a_{13} through a_{33}			All other parameters in the same format.

B.7 Legacy data checksum box

This box keeps a checksum over the legacy codestream content, i.e. all data except those contained in application markers (APP$_{00}$ through APP$_{15}$) using the algorithm defined in Annex D. Decoders can use this data to test for the integrity of the legacy codestream, and thus to test whether the base image data has been tampered with. A JPEG XT file shall contain at most one legacy data checksum box.

NOTE If a decoder detects that the checksum over the received data differs from the checksum recorded in this box, it can either abort decoding, or only decode the base image and reject the residual stream or attempt a full decoding at its discretion.

The type of this box shall be 0x4C43484B, ASCII encoding of "LCHK".

Figure B.6 describes the organization of this box segment and Table B.7 shows the parameters and parameter sizes.

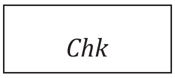


Figure B.6 — Organization of the legacy data checksum box

Table B.7 — Legacy data checksum box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
Chk	32	Varies	Checksum over the legacy codestream, to be computed by the algorithm defined in Annex D.

B.8 File type box

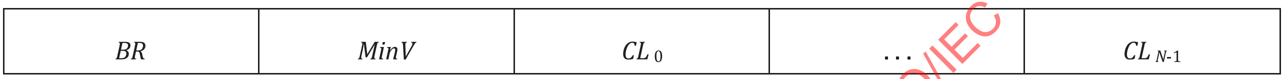
This box shall appear as the first box in the first JPEG XT marker segment of a JPEG XT codestream. It shall not be a sub-box of any other box and it shall not be broken up into multiple JPEG XT marker segments

The file type box specifies the document which completely defines all of the contents of this file, as well as a separate list of readers, defined by other Recommendations | International Standards, with which this file is compatible, and thus the file can be properly interpreted within the scope of that other standard. This differentiates the standard which completely describes the file, from other standards that interpret a subset of the file.

All files shall contain one and only one file type box at the top level of the file, and this box shall be the first box in the file.

The type of the file type box shall be 0x66747970, ASCII encoding of "ftyp".

The organization of this box is depicted in Figure B.7 and its parameters and fields are shown in Table B.8.



BR	*MinV*	CL_0	...	CL_{N-1}

Figure B.7 — Organization of the file type box

Table B.8 — File type box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
BR	32	0x6a707874 ASCII value of "jpxt"	This field specifies the document which completely defines this file. This field is specified by a 4-byte ASCII string. The value of this field shall be "jpxt", indicating that the file is conforming to ISO/IEC 18477-3 (this document).
MinV	32	0	Minor version. This parameter defines the minor version number of the JPEG XT specification for which the file complies. The parameter is defined as a 4-byte big-endian unsigned integer. The value of this field shall be 0. However, readers shall continue to parse and interpret this file even if the value of this field is nonzero.
CL_i	32	varies	Compatibility list. This field specifies a code representing this document, another standard, or a profile of another standard, to which this file conforms. This field is encoded as a 4-byte string of ASCII characters. A file that conforms to this document shall have at least one CL_i field in the file type box, and shall contain the value “jpxt” in one of the CL_i fields. All conforming readers shall properly interpret all files with “jpxt” in one of the CL_i fields. Other values of the compatibility list fields are reserved for future use. The number of CL_i fields is determined by the length of this box.

B.9 Sample unit box

This optional box shall appear on the top level of the JPEG XT codestream. If it is exists, it defines the unit of the sample values, i.e. a conversion factor from sample values to absolute radiance as given in cd/m^2 (nits). If this box is present, sample values represent absolute radiance values, otherwise only relative radiance is encoded. If this box is present, the absolute radiance, L_a of a sample in candela per square metre (cd/m^2) is given by:

$$L_\mathrm{a} = \mathrm{nits} \times L_\mathrm{r}$$

where

L_r is the decoded sample value;

nits is the parameter in the sample unit box.

The type of the sample unit box shall be 0x554E4954, ASCII encoding of "UNIT".

The organization of this box is depicted in Figure B.8 and its parameters and fields are shown in Table B.9.

nits

Figure B.8 — Organization of the sample unit box

Table B.9 — Sample unit box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
nits	32	>0	This multiplier converts the sample values into an absolute radiance, measured in cd/m^2 (nits) and hence defines the unit in which the sample values are represented in the codestream. This field is encoded encoded in single precision according to IEC 60559 and stored in big-endian byte order.

B.10 Primary colour coordinate box

This optional box shall appear on the top level of the JPEG XT codestream. If it is exists, it defines the *x* and *y* coordinates in the XYZ colour space of the primary colours encoded by the samples. This box shall only exist if the number of components (Nf) encoded in the codestream is 3. If this box does not exist, the colour coordinates of decoded sample values is defined by other means not specified by this document.

The type of the primary colour coordinate box shall be 0x50434f43, ASCII encoding of "PCOC".

The organization of this box is depicted in Figure B.9 and its parameters and fields are shown in Table B.10.

x_0	y_0	x_1	y_1	x_2	y_2

Figure B.9 — Organization of the sample unit box

Table B.10 — Primary colour parameter box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
x_0	32	≥ 0	This parameter specifies the *x* chroma coordinate in the XYZ colour space of the first component. This field is encoded in single precision according to IEC 60559 and stored in big-endian byte order.
y_0	32	≥ 0	This parameter specifies the *y* chroma coordinate in the XYZ colour space of the first component. This field is encoded in single precision according to IEC 60559 and stored in big-endian byte order The *z* coordinate of the first colour primary is given as $z_0=1-x_0-y_0$
x_1	32	≥ 0	This parameter specifies the *x* chroma coordinate in the XYZ colour space of the second component. This field is encoded in single precision according to IEC 60559 and stored in big-endian byte order
y_1	32	≥ 0	This parameter specifies the *y* chroma coordinate in the XYZ colour space of the second component. This field is encoded in single precision according to IEC 60559 and stored in big-endian byte order
x_2	32	≥ 0	This parameter specifies the *x* chroma coordinate in the XYZ colour space of the third component. This field is encoded in single precision according to IEC 60559 and stored in big-endian byte order
y_2	32	≥ 0	This parameter specifies the *y* chroma coordinate in the XYZ colour space of the third component. This field is encoded in single precision according to IEC 60559 and stored in big-endian byte order

B.11 Residual data box

This box encapsulates entropy coded segments extending the base image in the spatial domain. The process for merging the base image with the extension image contained in the residual data box is defined by either the merging specification box or alpha merging specification box, or both, and specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9.

The residual data box shall only appear at the top-level of the codestream and not as a sub-box of a superbox. Data contained in this box defines residual data that extends the base image encoded in the base JPEG stream to an IDR or HDR image. The sample precision of the samples within the codestream shall be either 8 or 12. While sub-sampling factors can be different from the base image, the Nf in the residual codestream and the image dimensions shall be identical to those signaled in the legacy codestream.

The type of this box shall be 0x52455349, ASCII encoding of "RESI". There shall be at most one stream of residual data after concatenating all JPEG extension marker payload data belonging to this box type.

NOTE Unlike refinement coding, residual coding merges all data into one single box. This box can, however, extend over several JPEG XT marker segments.

The structure of this box is defined in Figure B.10 and the parameters and sizes are shown in Table B.11.

Entropy Coded Data, conforming to Rec. ITU-T T.81 | ISO/IEC 10918-1

Figure B.10 — Organization of the residual data box

Table B.11 — Residual data box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
Data	Varies	Varies	Entropy coded data segment of variable lengths.

B.12 Residual refinement data box

This box encapsulates entropy coded data segments that extend the bit-precision of the extension image(s) in the DCT domain. The syntax of the encapsulated data and the decoding algorithm of this data is specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. The residual refinement data box shall only appear at the top-level of the codestream and not as a sub-box of a superbox. If the number of additional residual refinement bits, the R_r-parameter of the refinement specification sub-box, is non-zero, residual refinement data encapsulated in residual refinement data boxes shall be present.

The type of this box shall be 0x5246494e, ASCII encoding of "RFIN".

The structure of the payload data of this box is defined in Figure B.11 and the parameters and sizes are shown in Table B.12.

Entropy Coded Data

Figure B.11 — Organization of the residual refinement data box

Table B.12 — Residual refinement data box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
Data	Varies	Varies	Entropy coded data segment of variable lengths.

B.13 Refinement data box

This box encapsulates entropy coded data segments that extend the bit-precision of the base image(s) in the DCT domain. The syntax of the encapsulated data and the decoding algorithm of this data is specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. It shall only appear at the top level of the codestream and not as a sub-box of a superbox. If the number of additional base refinement bits, the R_h-parameter of the refinement specification sub-box of the merging specification box, is non-zero, refinement data encapsulated in residual refinement data boxes shall be present.

The type of this box shall be 0x46494e45, ASCII encoding of "FINE".

The structure of the payload data of this box is defined in Figure B.12 and the parameters and sizes are shown in Table B.13.

Figure B.12 — Organization of the refinement data box

Table B.13 — Refinement data box, parameters and sizes

Parameter	Size (bits)	Value	Meaning
Data	Varies	Varies	Entropy coded data segment of variable lengths.

B.14 Output conversion box

This box defines the final bit depth of the reconstructed samples and defines the conversion process from the result of the base image/residual image merging process to the final output samples. This box shall never appear at the top level in the file. It shall be a sub-box of the merging specification box or alpha merging specification box. Exactly one output conversion box shall appear in the merging specification box if a merging specification box exists, and exactly one output conversion box shall appear in the alpha merging specification box if such a box exists.

The operations performed by the output conversion process are as follows:

- First, the data shall be clipped to range if the *Ce* flag is set to one. The interval to clip depends on the value of the *Oc* bit, and the algorithm for clipping is further specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9. If the *Ce* flag is zero, no clipping is performed.
- Second, if the *Oc* flag is set, the data shall be converted from integer to floating point by a map that is further specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9.
- If the *Ol* flag is set, the output shall be further transformed by a non-linear point transformation as specified in Annex C, and which is defined by the curves or tables addressed by the parameters to_0 through to_3. The *Ol* flag and the *Oc* flag shall not be both set at the same time.

  If *Ol* is set, the to_i value selects for component i a non-linear transformation by the algorithm specified in B.16. The non-linear transformation is either defined by a table lookup through the boxes specified in B.2 or B.3, or by applying a parametric curve (see B.4).

The non-linear transformation itself follows the specifications of Annex C. It requires four additional parameters, the input range R_w, R_e and the output range R_t, R_f. The parameters shall be as follows:

R_w=1 R_e=0

R_t=1 R_f=0

The value of the rounding mode *e* shall be 0. Note that its value is, however, ignored for the above choice of R_t and R_w.

The type of this box shall be 0x4F434F4E, ASCII encoding of "OCON".

Figure B.13 describes the organization of this box and Table B.14 shows the parameters and parameter sizes of the box.

R_b	*Lf*	*Oc*	*Ce*	*Ol*	to_0	to_1	to_2	to_3

Figure B.13 — Layout of the output conversion box

Table B.14 — Parameters of the output conversion box

Parameter	Size (in bits)	Value	Meaning
R_b	4	8	Number of additional bits available for HDR data. The bit precision of the reconstructed HDR image shall be computed as $8+R_b$.
Lf	1	0..1	This field indicates whether DCT compression is lossy or lossless/near lossless. This field can be used to indicate that the DCT implementation is constrained to particular algorithms defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. If this field is 0, the only constraint on the DCT implementation is that it shall satisfy the error bounds of Rec. ITU-T T.83 | ISO/IEC 10918-2.
Oc	1	0..1	If this flag is set, clipped samples are rounded to integer and converted to floating point by a map that is further specified in additional parts of ISO/IEC 18477. If this flag is set, *Ol* shall be 0
Ce	1	0..1	This field indicates whether the output shall be clipped to range before processing the data further. If the *Ce* flag and the *Oc* flag are both enabled, clipping is applied before conversion to floating point. The interval depends on the value of the *Oc* flag. ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9 define the interval to clip to.

Table B.14 *(continued)*

Parameter	Size (in bits)	Value	Meaning
Ol	1	0..1	This field indicates whether an output lookup or point transformation is required. If enabled, the output transformation is specified by the to_0 through to_3 fields.
to_0	4	0	If *Ol* is one, this field defines the output table for component 0. If *Ol* is 0, this field is ignored.
to_1	4	0	If *Ol* is one, this field defines the output table for component 1. If *Ol* is 0, this field is ignored.
to_2	4	0	If *Ol* is one, this field defines the output table for component 2. If *Ol* is 0, this field is ignored.
to_3	4	0	Reserved for ITU/ISO purposes.

B.15 Refinement specification box

This box defines the number of refinement scans for both the base and the residual coding process and delivers the parameters R_h and R_r required elsewhere in this document. At most one refinement specification box shall exist as a sub-box of the merging specification box and alpha merging specification box. This box shall not appear at the top-level of the file, and it shall present if and only if the file includes either refinement data boxes or residual refinement boxes.

The value R_h shall be identical to the number of refinement scans adding least significant bits (LSBs) to the base image and is thus identical to the number of refinement data boxes. If the refinement specification box is absent, its inferred value is 0.

The value R_r shall be identical to the number of residual refinement scans adding LSBs to the residual image and is thus identical to the number of residual refinement boxes at the top level of the file. If the refinement specification box is absent, the inferred value of R_r is 0.

The type of the refinement specification box shall be 0x52535043, ASCII encoding of "RSPC".

Figure B.14 describes the organization of this box and Table B.15 shows the parameters and parameter sizes.

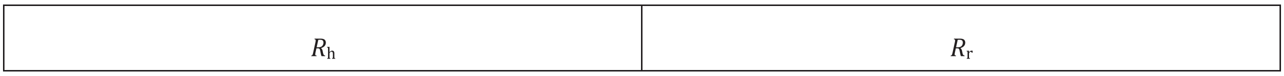


Figure B.14 — Layout of the refinement specification box

Table B.15 — Parameters of the base transformation box

Parameter	Size (in bits)	Value	Meaning
R_h	4	0..4	Number of refinement scans in the base decoding path.
R_r	4	0..4	Number of refinement scans in the residual decoding path.

B.16 Non-linear point transformation specification box

This subclause defines multiple boxes (see Table B.16) that are all used to specify a non-linear process in the merging process of the base image and the extension image. Details on the box types and their intended use are found in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9. All boxes defined in this subclause share the same box layout and the same syntax. See Figure B.15 and Table B.17.

Boxes of these types shall only exist as sub-boxes of the merging specification box or the alpha merging specification box; they shall not appear at top-level of the file.

Table B.16 — Boxes and box types defined by this subclause

Box name	Box type	ASCII encoding of the box type
Base non-linear point transformation specification box	0x4C505453	"LPTS"
Secondary base non-linear point transformation specification box	0x52505453	"CPTS"
Residual non-linear point transformation specification box	0x5152505453	"QPTS"
Intermediate residual non-linear point transformation specification Box	0x44505453	"DPTS"
Secondary residual non-linear point transformation specification box	0x52505453	"RPTS"
Pre-scaling non-linear point transformation specification box	0x53505453	"SPTS"
Post-scaling non-linear point transformation box	0x50505453	"PPTS"

The non-linear point transformation selected by a non-linear point transformation specification box is an integer table lookup box, a floating-point lookup box or a parametric curve box. The corresponding boxes referenced by this box appear at the top level of the ISO/IEC 18477-3 (this document) conforming file or as sub-boxes of the merging specification box or alpha merging specification box.

The non-linear point transformation for component *i* is found by matching the value td_i of this box against the value of *M* of all parametric curve boxes, integer table lookup boxes or floating-point lookup boxes found in the same super box or at the top-level of the file. If a box with a matching *M* value exists both as a sub-box of the same encapsulating superbox and on the top-level of the file, the box within the super box takes precedence.

The non-linear point transformation itself is given by the process specified in Annex C of this document. It requires five additional parameters, the value of the parameter *e*, the input range R_w, R_e and the output range R_t, R_f. The value of these parameters depends on the box type and is specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9.

Figure B.15 depicts the following process: A JPEG XT decoder reserves 16 slots for non-linear transformations. Each slot can be occupied by a non-linearity that is either specified by an integer table lookup box (see B.2), or a floating-point table lookup box (see B.3), or a parametric curve box (see B.4). The *M* value, present in all the above box types, selects the slot to be populated by the corresponding box.

Each non-linear point transformation specification box and the output conversion box now select up to four non-linearities by referencing the slot indices of the transformation to be used for each component. Non-linearities can be re-used by referencing their slot numbers multiple times.

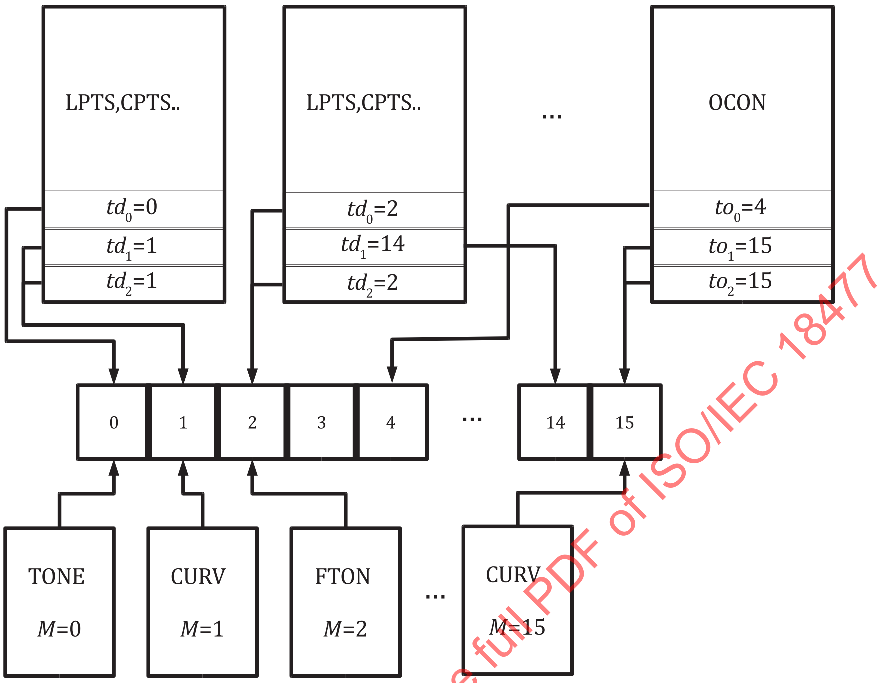


Figure B.15 — Selection of non-linearities through indirection by slot-indices

In Figure B.15, 16 slots are shared by integer lookup boxes, floating-point lookup boxes and Parametric Curve boxes. The value of *M* selects the slot a box occupies. The linear transform boxes and the output conversion box reference slots by their td_i or to_i values. A slot may be used multiple times by multiple boxes.

Figure B.16 describes the organization of this box and Table B.17 shows the parameters and parameter sizes.

td_0	td_1	td_2	td_3

Figure B.16 — Layout of the non-linear point transformation specification boxes

Table B.17 — Parameters and sizes of the non-linear point transformation specification boxes

Parameter	Size (in bits)	Value	Meaning
td_0	4	0..15	The value of td_0 selects the integer or floating-point table lookup or parametric curve box whose *M* value matches the value td_0. This table or parametric curve is applied as non-linear point transformation of component 0.
td_1	4	0..15	The td_1 value is used to select the non-linear point transformation for component 1 if it is present. Otherwise, the value is ignored.
td_2	4	0..15	The td_2 value is used to select the non-linear point transformation for component 2 if it is present. Otherwise, the value is ignored.
td_3	4	0..15	Reserved for ITU | ISO/IEC purposes.

B.17 Linear transformation specification box

This subclause defines multiple boxes (see Table B.18) that all describe a linear transformation between the components of the base or extension image. Boxes of this type are used in multiple stages of the merging process of base and extension image defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. All boxes defined in this subclause share the same box layout and the same syntax (see Figure B.16 and Table B.19). Boxes of the types listed in Table B.18 shall only exist as sub-boxes of the merging specification box or alpha merging specification box.

Table B.18 — Boxes and box types defined by this subclause

Box name	Box type	ASCII encoding of the box type
Residual transformation box	0x52545246	"RTRF"
Colour transformation box	0x43545246	"CTRF"
Residual colour transformation box	0x44545246	"DTRF"
Pre-scaling transformation box	0x53545246	"STRF"

This box shall only exist as a sub-box of the merging specification box. It shall only exist if the Nf in the image (base or extension) equals 3. If the Nf equals one, the transformation is the identity implicitly.

Xt values 0 to 4 correspond to pre-defined linear transformations that are defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. *Xt* values between 5 and 15 are user-defined transformations.

The matrix for user-defined linear transformation is found by matching the value *Xt* of the linear transformation specification box against the value of *M* of all fixed-point and floating-point linear transformation boxes found in the same super box or at the top-level of the file. If a box with a matching *M* value exists both as a sub-box of the encapsulating super box and on the top-level of the file, the box within the super box is selected.

If *Xt* is below 5, the algorithm for the linear transformation is defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 or ISO/IEC 18477-9. If *Xt* is 5 or above, the linear transformation is given by a matrix multiplication of the column vector of the three-component input with the matrix contained in the fixed-point or floating-point linear transformation box whose *M* value matches the *Xt* value.

Figure B.17 depicts the following process: A JPEG XT decoder reserves 16 slots for linear transformations. Five of the slots are pre-occupied with standard-defined transformations. All other slots can be user defined and can be occupied by either a fixed-point or a floating-point linear transformation box. The *M* value, present in both box types, selects the slot to be populated by the corresponding box.

Each linear transformation specification box now selects one linear transformation by referencing the slot indices of the transformations they are supposed to apply to the data. Linear transformations can be re-used by referencing their slot numbers multiple times.

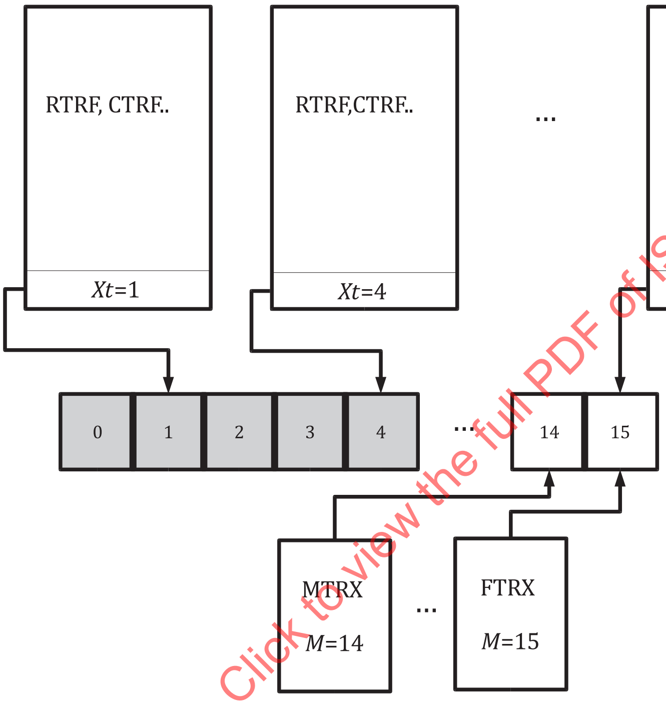


Figure B.17 — Selection of linear transformations through indirection by slot-indices

In Figure B.17, linear transformation specification boxes reference slots by their *Xt* values. A slot may be used multiple times by multiple boxes. 16 slots are shared by floating-point transformation boxes and fixed-point linear transformation boxes. Slots 5 to 15 can be filled by fix-point linear transformation boxes or floating-point linear transformation boxes. They select the slot to fill by their *M* value. Slots 0 to 4 are predefined and cannot be filled by boxes.

Figure B.18 describes the organization of this box segment and Table B.19 shows the parameters and parameter sizes.

Xt	*Re*

Figure B.18 — Layout of the linear transformation specification boxes

Table B.19 — Parameters and sizes of the linear transformation specification box

Parameter	Size (in bits)	Value	Meaning
Xt	4	0..15	Defines the linear transformation to be used. Valid choices and interpretation of this value are specified in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9.
Re	4	0	Reserved for ITU | ISO/IEC purposes

B.18 DCT specification box

This subclause specifies multiple boxes (see Table B.20) that define the DCT transformation in either the base or residual decoding pass required for lossless or near-lossless decoding. Boxes of this type shall be present if and only if the *Lf* flag of the output conversion box is one. All boxes defined in this subclause share the same box layout and the same syntax (see Figure B.19 and Table B.21). Boxes of the types listed in Table B.20 shall only exist as sub-boxes of the merging specification box or alpha merging specification box.

Table B.20 — Boxes and box types defined by this subclause

Box name	Box type	ASCII encoding of the box type
Base DCT specification box	0x4C444354	"LDCT"
Residual DCT specification box	0x52444354	"RDCT"

The encoding of the *dct* and *Ns* fields of this box, as well as the DCT itself is defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9. Valid choices for the parameters depend on the box type that is also specified there.

Figure B.17 describes the organization of this box and Table B.21 shows the parameters and parameter sizes.

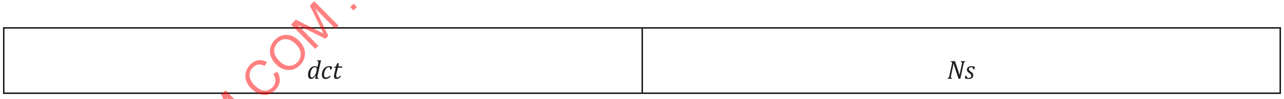


Figure B.19 — Layout of the DCT specification boxes

Table B.21 — Parameters and sizes of the base DCT specification box

Parameter	Size (in bits)	Value	Meaning
dct	4	0..15	Selects the DCT that shall be used for reconstruction. Valid choices are defined in ISO/IEC 18477-6, ISO/IEC 18477-7, ISO/IEC 18477-8 and ISO/IEC 18477-9.
Ns	4	0..15	Defines other processing options in the absence of a DCT in the decoding path.