



International
Standard

ISO/IEC 21794-5

**Information technology —
Plenoptic image coding system
(JPEG Pleno) —**

**Part 5:
Holography**

*Technologies de l'information — Système de codage d'images
plénoptiques (JPEG Pleno) —*

Partie 5: Holographie

**First edition
2024-11**

Reference number
ISO/IEC 21794-5:2024(en)

Full document details: [ISO IEC 21794-5-2024](#)

 **Documents**
© ISO/IEC 2024 Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

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

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols and abbreviated terms	2
4.1 Symbols	2
4.2 Abbreviated terms	3
5 Conventions	4
5.1 Naming conventions for numerical values	4
5.2 Operators	4
5.2.1 Arithmetic operators	4
5.2.2 Logical operators	5
5.2.3 Relational operators	5
5.2.4 Precedence order of operators	5
5.2.5 Mathematical functions	6
6 Representation of digital holograms	6
6.1 Digital holograms and their signal properties	6
6.2 Functional overview of the decoding process	8
6.3 Encoder requirements	9
6.4 Decoder requirements	9
Annex A (normative) JPEG Pleno Holography superbox	10
Annex B (normative) JPEG Pleno Holography codestream syntax	16
Annex C (normative) Non-binary lossy coding	25
Annex D (normative) Binary lossless coding	33
Annex E (normative) Hologram tiling	37
Annex F (normative) Light propagation models	44
Annex G (normative) Short-time Fourier transform	47
Annex H (normative) Quantization	49
Annex I (normative) Arithmetic coding	53
Annex J (informative) Rate-distortion optimization	57
Bibliography	65

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).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents and <https://patents.iec.ch>. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

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*.

A list of all parts in the ISO/IEC 21794 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 part of a series of standards for a system known as JPEG Pleno and defines JPEG Pleno Holography. It specifies a codec mechanism for holographic modalities and associated codestream syntax and file format elements. JPEG Pleno Holography allows for efficient compression of holograms for a wide range of applications such as holographic microscopy, tomography, interferometry, printing and display and their associated hologram types. Key functionalities include support for both lossy and lossless coding, scalability, random access, and integration within the system architecture of the JPEG Pleno framework.

Information technology — Plenoptic image coding system (JPEG Pleno) —

Part 5: Holography

1 Scope

This document defines the syntax and an accompanying decompression process that is capable of representing binary and continuous-tone holograms while supporting one or multiple color/spectral components. The supported compression mechanisms are lossless for binary holograms and lossy for continuous-tone holograms. Additional information on the encoding tools is provided as well. The document also defines extensions to the JPEG Pleno File Format and associated metadata descriptors specific to holographic modalities.

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 21794-1:2020, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 1: Framework*

ISO/IEC 21794-2:2021, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 2: Light field coding*

ISO/IEC 21794-3, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 3: Conformance testing*

ISO/IEC 21794-4, *Information technology — Plenoptic image coding system (JPEG Pleno) — Part 4: Reference software*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 21794-1, ISO/IEC 21794-2, ISO/IEC 21794-3, ISO/IEC 21794-4 and the following 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/ui>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 holography

technique based on coherent light allowing for the recording and reconstruction of a wavefront, thereby encoding three-dimensional information about objects

Note 1 to entry: This has many applications, including 3D display technology, microscopy, tomography, interferometry, telecommunications, data storage, and non-destructive testing.

3.2

hologram

two-dimensional representation of the complex-valued coherent wavefield of light encoding an interference pattern describing the amplitude and phase of the scalar wavefield

Note 1 to entry: This pattern may be encoded directly in the spatial domain or indirectly using optical transformations such as Fourier-transforming lens systems, magnification, or modulation.

3.3

digital hologram

one or more two-dimensional arrays of coefficients representing the sampled coherent wavefield of light

3.4

tile

a spatial segment of a digital hologram, each coded independently

3.5

window block

unit of a series of 2D windows over the propagated hologram's input coefficients, corresponding to 2D contiguous subsets of input coefficients and serving as input for the STFT

3.6

transform block

coefficient set resulting from applying a transform to a tile

3.7

code block

input coefficient set of the arithmetic coding within a transform block, where each code block is independently arithmetically encoded

3.8

quantization block

unit of quantization within a code block

3.9

transform size

4-tuple of positive integers, describing the number of elements along each dimension of the entire set of coefficients after applying the transform step, which is represented by a 4D array

3.10

source hologram

uncompressed input hologram

3.11

decoded hologram

output decompressed hologram decoded back into raw hologram samples

4 Symbols and abbreviated terms

4.1 Symbols

H	Digital hologram
λ_i	The wavelength of the i^{th} colour channel at which the hologram was recorded or generated
$\odot$	Hadamard product
$\mathcal{F}, \mathcal{F}^{-1}$	Forward and reverse two-dimensional Fourier transform

$\mathbf{s}, \mathbf{s}^{-1}$	Forward and reverse two-dimensional FFTSHIFT operator. This operation rearranges Fourier transform coefficients by shifting the zero-frequency component to the centre of the array, matching its conventional mathematical representation.
H_i	i^{th} monochrome component of the digital hologram H ; Corresponds to λ_i .
p	Hologram pixel pitch sampled on a square lattice
d	Distance parameter for propagation operator
x, y	Symbols for the first and second spatial dimensions
f_x, f_y	Symbols for the first and second frequency dimensions
NT	Number of tiles
NCB	Number of code blocks per tile
NQB	Number of quantization blocks per tile
$XThoc, YThoc$	Tile x and y dimensions
$XTcod, YTcod, UTcod, VTcod$	Power of 2 exponents of the four-dimensional transform block dimensions
$XCBcod, YCBcod, UCBcod, VCBcod$	Power of 2 exponents of the four-dimensional code block dimensions
$XQBcod, YQBcod, UQBcod, VQBcod$	Power of 2 exponents of the four-dimensional quantization block dimensions
$\mathcal{Q}, \mathcal{Q}^{-1}$	Mid-rise quantizer and dequantizer
Λ_1, Λ_2	Lagrangian multipliers for systems 1 and 2, respectively

4.2 Abbreviated terms

2D	Two-dimensional
4D	Four-dimensional
CB	Code block
CBP	Code block payload
DFT	Discrete Fourier transform
FFTSIFT	Fourier transform coefficient shifting operator
L2	Euclidean norm
MRQ	Mid-rise quantizer
MRDQ	Mid-rise dequantizer
QB	Quantization block
QBP	Quantization block payload
RDO	Rate-distortion optimization

SNR	Signal-to-noise ratio
STFT	Short-time Fourier transform
TB	Transform block

5 Conventions

5.1 Naming conventions for numerical values

Integer numbers are expressed as bit patterns, hexadecimal values, or decimal numbers. Bit patterns and hexadecimal values have both a numerical value and an associated length in bits.

Hexadecimal notation, indicated by prefixing the hexadecimal number with "0x", may be used instead of binary notation to denote a bit pattern having a length that is an integer multiple of 4. For example, 0x41 represents an eight-bit pattern with only its second most significant bit and its least significant bit equal to 1. Numerical values that are specified under a "Code" heading in tables that are referred to as "code tables" are bit pattern values (specified as a string of digits equal to 0 or 1 in which the left-most bit is considered the most significant bit). Other numerical values not prefixed by "0x" are decimal values. When used in expressions, a hexadecimal value is interpreted as having a value equal to the value of the corresponding bit pattern evaluated as a binary representation of an unsigned integer (i.e. as the value of the number formed by prefixing the bit pattern with a sign bit equal to 0 and interpreting the result as a two's complement representation of an integer value). For example, the hexadecimal value 0xF is equivalent to the 4-bit pattern '1111' and is interpreted in expressions as being equal to the decimal number 15.

5.2 Operators

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

5.2.1 Arithmetic operators

+	Addition
–	subtraction (as a binary operator) or negation (as a unary prefix operator)
×	Multiplication
/	division without truncation or rounding
<<	left shift; $x \ll s$ is defined as $x \times 2^s$
>>	right shift; $x \gg s$ is defined as $\lfloor x / 2^s \rfloor$
++	increment with 1
--	decrement with 1
umod	Unsigned modulo operator; $x \text{ umod } a$ is the unique value y between 0 and $a-1$ for which $y + Na = x$ with a suitable integer N
&	bitwise AND operator; compares each bit of the first operand to the corresponding bit of the second operand If both bits are 1, the corresponding result bit is set to 1. Otherwise, the corresponding result bit is set to 0.

$\wedge$	bitwise XOR operator; compares each bit of the first operand to the corresponding bit of the second operand If both bits are equal, the corresponding result bit is set to 0. Otherwise, the corresponding result bit is set to 1.
----------	---

5.2.2 Logical operators

$\parallel$	logical OR
$\&\&$	logical AND
$!$	logical NOT

5.2.3 Relational operators

$>$	greater than
$>=$	greater than or equal to
$<$	less than
$<=$	less than or equal to
$==$	equal to
$!=$	not equal to

5.2.4 Precedence order of operators

Operators are listed 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
$[]$	indexing of arrays	left to right
$++, --$	increment, decrement	left to right
$!, -$	logical not, unary negation	
$\times, /$	multiplication, division	left to right
umod	unsigned modulo (remainder)	left to right
$+, -$	addition and subtraction	left to right
$\&$	bitwise AND	left to right
$\wedge$	bitwise XOR	left to right
$\&\&$	logical AND	left to right
$\parallel$	logical OR	left to right
$<<, >>$	left shift and right shift	left to right

< , > , <= , >=

Relational

left to right

5.2.5 Mathematical functions

$ x $	absolute value, is $-x$ for $x < 0$, otherwise x
$\text{sign}(x)$	sign of x , zero if x is zero, +1 if x is positive, -1 if x is negative
$\text{clamp}(x, \text{min}, \text{max})$	clamps x to the range $[\text{min}, \text{max}]$: returns min if $x < \text{min}$, max if $x > \text{max}$ or otherwise x
$\lceil x \rceil$	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 less than or equal to x
$\text{round}(x)$	rounding of x to the nearest integer, equivalent to

6 Representation of digital holograms

6.1 Digital holograms and their signal properties

Like conventional images, holograms can be optically recorded, computer-generated, or some hybrid thereof. A classic holographic recording setup utilizes interferometry, where a coherent, monochromatic light beam is split into a reference beam and an object beam. Only the object beam will illuminate the sample to be imaged, after which both beams are recombined, forming an interference pattern (cf. [Figure 1](#)). This pattern encodes the complex-valued amplitudes of the object wavefront, thus describing both the wavefront amplitude and phase. Alternatively, one can utilize numerical diffraction simulations in virtual objects and scenes to compute the hologram pattern, called computer-generated holography. Although this approach is not limited by the physics of an optical setup, such as geometrical constraints or optical component nonidealities, it tends to require significant computational resources to calculate.

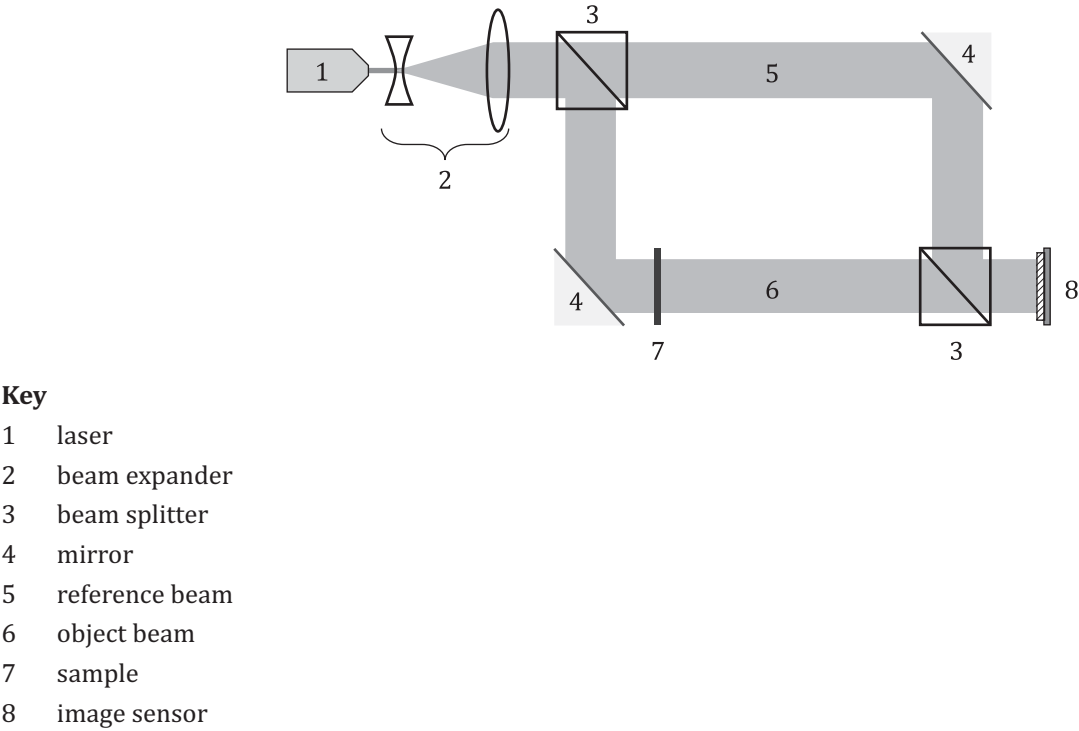


Figure 1 — Simplified diagram of a holographic recording setup, in case of a transparent sample, with corresponding legend.

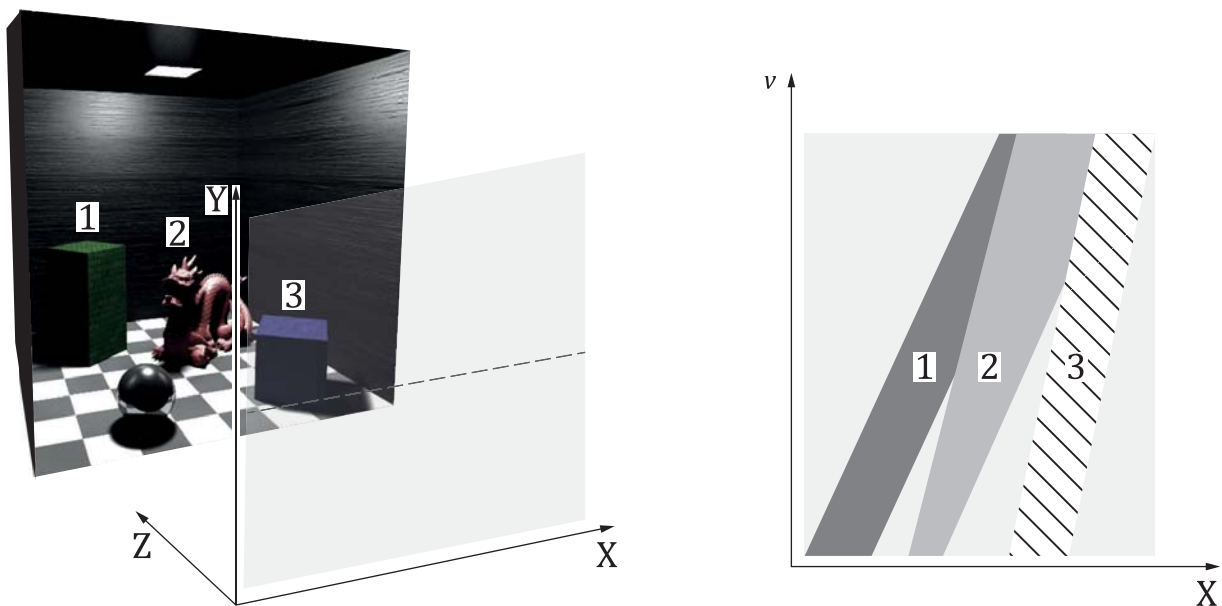
However, holography is often confused with other display techniques that do not involve interference. Many systems that claim to be "holographic" consist of various projection systems that display flat images in mid-air, using, for example, semi-transparent screens. These "false holograms" are produced by technologies such as Pepper's ghost illusion (or its modern variants), lenticular printing, and volumetric displays. These technologies are not addressed in this standard.

Holograms and discrete light fields (hereupon just called "light fields") are closely related, as both representations encode spatial and angular information. A full-parallax light field can be represented by a 4D array of rectilinear samples with two spatial and two angular dimensions, as specified in ISO/IEC 21794-2.

Because of the discrete sampling, light fields will have a discretized motion parallax and limited depth cues, but they will have fewer samples than a hologram to cover the same spatio-angular range and work with incoherent light. In contrast, holograms can account for all human visual cues, including continuous motion parallax and exact eye-focusing cues.

In holography, frequency components correspond to plane waves whose propagation angle is proportional to the frequency magnitude. Thus, one can characterize the relationship to light fields by looking at phase space, jointly representing space and frequency data using, e.g., a spectrogram. (cf. [Figure 2](#)). This matches closely with the spatio-angular phase space of 4D light fields.

This relationship was the primary rationale for utilizing the short-time Fourier transform for hologram compression in this specification. The size of the transform window will dictate the trade-off between spatial and angular resolution.



a) 3D scene with numbered (coloured) objects, creating a hologram in the x-y plane, analyzing the signal along the dashed horizontal line b) corresponding spatio-frequency phase diagram, with matching numbered (coloured) footprints in phase space

Key

X space
v frequency

Figure 2 — Relationship between objects in 3D space and the phase space representation.

The hologram sample values are represented by discretized two-dimensional arrays of coefficients. These coefficients may encode the complex-valued amplitudes in whole or in part, for example, by only encoding the phase, the real part, or the amplitude of the complex coefficients. Moreover, the hologram coefficients may have different levels of precision, ranging from floating-point numbers down to 1 bit per pixel, denoted as "binary holograms."

A hologram consists of one or more arrays with the same dimensions, denoted "channels," representing different colour components. Every channel may have different wavelengths and pixel pitches.

6.2 Functional overview of the decoding process

This document specifies the JPEG Pleno Holography superbox and the JPEG Pleno Holography decoding algorithm. These are detailed in the annexes; the status of [Annexes A to I](#) is normative, while the status of [Annex J](#) is informative. The generic JPEG Pleno Holography superbox syntax is specified in [Annex A](#).

The overall architecture of JPEG Pleno Holography ([Figure 3](#)) provides the flexibility to configure the encoding and decoding system depending on the requirements of the addressed use case.

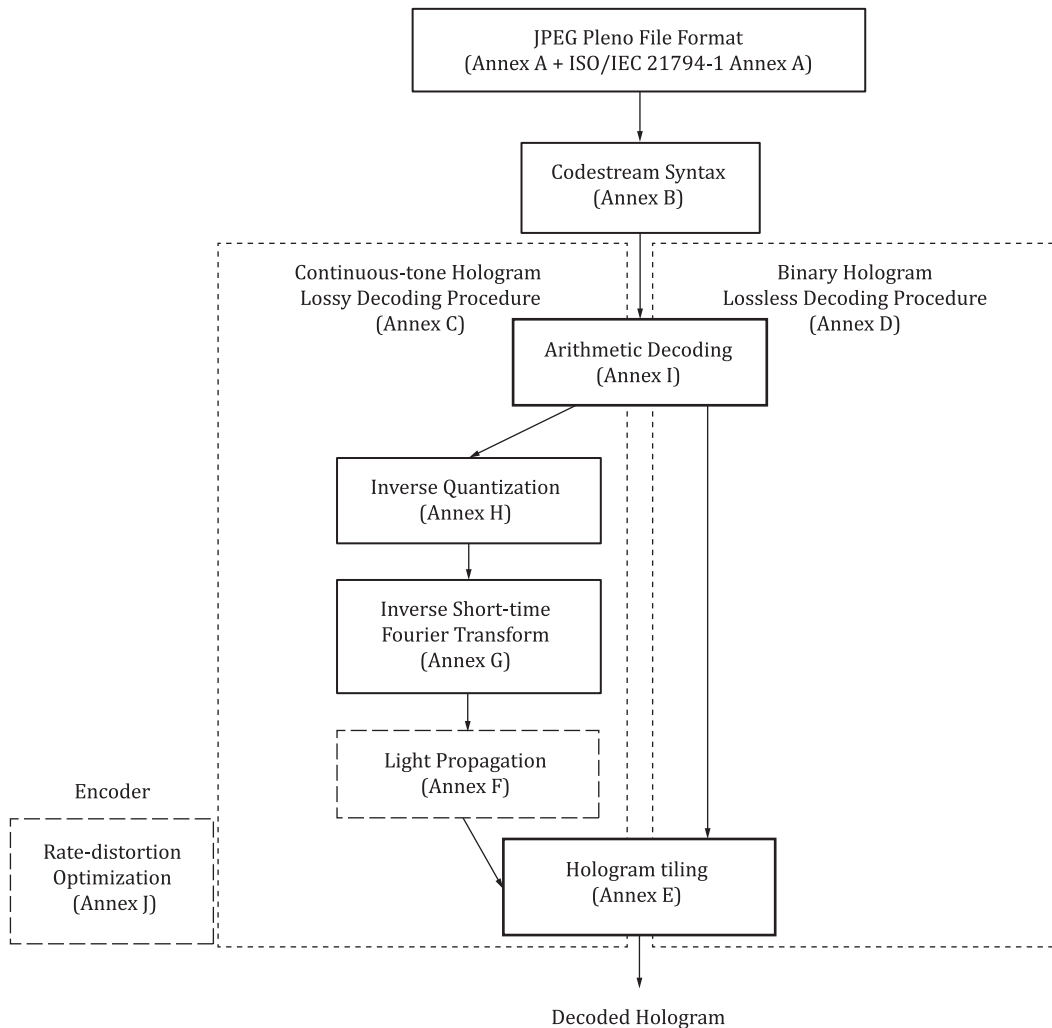


Figure 3 — General JPEG Pleno Holography decoder architecture

As can be seen in [Figure 3](#), each annex provides information about the individual components of the codec architecture. [Annex A](#) provides a description of the JPEG Pleno Holography superbox and its composing boxes. The codestream syntax issued in this specification is specified in [Annex B](#). Subsequently, [Annex E](#) describes the tiling mechanism issued to handle potentially large binary and non-binary holograms.

The annexes specific to the encoding/decoding of non-binary holograms are:

- [Annex C](#) gives a general overview of the non-binary lossy coding pipeline
- To enable the propagation of the hologram to a more suitable plane for compression [Annex F](#) specifies several supported propagation models.

- [Annex G](#) specifies the short-time Fourier transform (STFT).
- Quantization mechanisms are specified in [Annex H](#).
- [Annex I](#) describes the context-based arithmetic codec.
- Finally, [Annex J](#) illustrates how rate-distortion optimization can be implemented.

The module specific to the encoding and decoding of binary holograms is described in [Annex D](#), particularly focused on the Bayesian context-based arithmetic (de)coding mechanism.

6.3 Encoder requirements

An encoding process converts source hologram data to coded hologram data.

To conform with this document, an encoder shall conform with the file format syntax and codestream format syntax specified, respectively, in [Annex A](#) and [Annex B](#) for the encoding process(es) embodied by the encoder.

6.4 Decoder requirements

A decoding process converts coded hologram data to decoded hologram data. The resulting data may or may not be perfectly reconstructed depending on whether the lossless coding mode was used. [Annex E](#) through [Annex I](#) describe and specify the decoding process.

A decoder is an embodiment of the decoding process. To conform to this document, a decoder shall convert all, or specific parts of, any coded hologram data that conform to the file format syntax and codestream syntax specified, respectively, in [Annex A](#) and [Annex B](#) to a decoded hologram.

Annex A (normative)

JPEG Pleno Holography superbox

A.1 General

This annex specifies the use of the JPEG Pleno Holography superbox, which is designed to contain compressed holographic data and associated metadata. The listed boxes shall comply with their definitions as specified in ISO/IEC 21794-1 and ISO/IEC 21794-2.

This document may redefine the binary structure of some boxes defined as part of the ISO/IEC 15444-1 or ISO/IEC 15444-2 file formats. For those boxes, the definition found in this document shall be used for all JPL files (cf. ISO/IEC 21794-1:2020, Annex A).

A.2 Organization of the JPEG Pleno Holography superbox

[Figure A.1](#) shows the hierarchical organization of the JPEG Pleno Holography superbox contained by a JPL file. This illustration does not specify nor imply a specific order to these boxes. The file will often contain several boxes of a particular box type. Each box's meaning depends on the placement and order of that particular box within the file. This superbox comprises the JPEG Pleno Holography Header box containing parameterization information about the hologram, such as size and wavelength parameters.

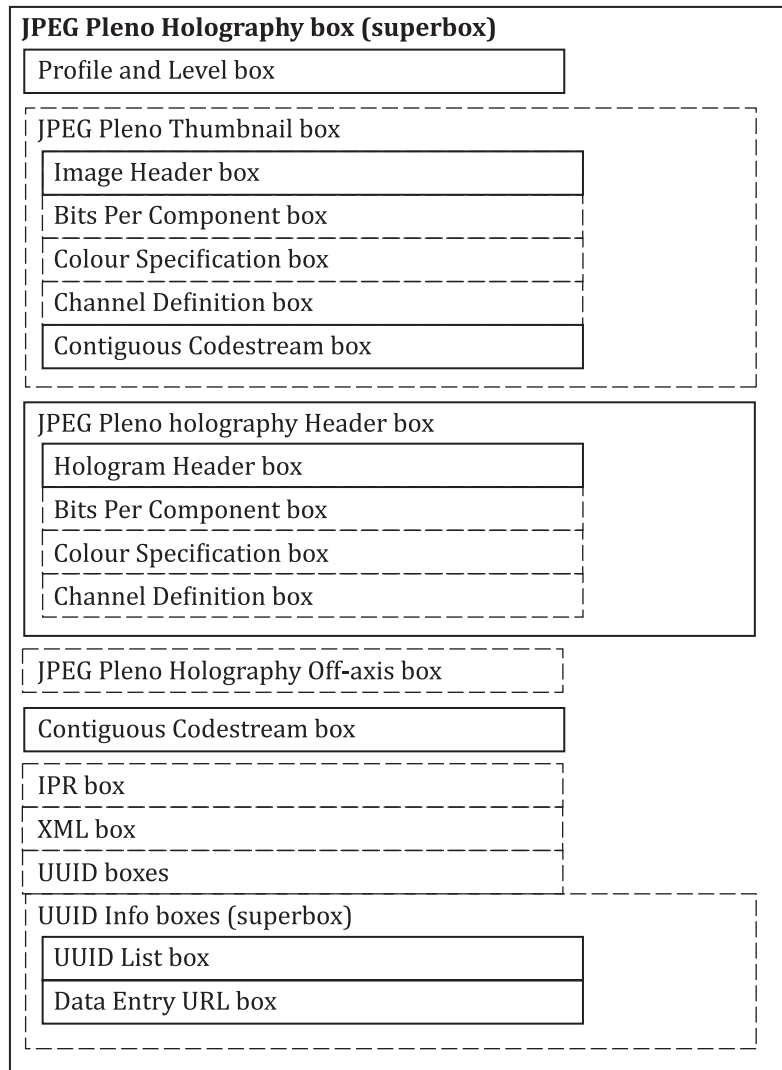


Figure A.1 — Hierarchical organization of a JPEG Pleno Holography superbox

[Table A.1](#) lists all boxes defined as part of this document. Boxes defined as part of the ISO/IEC 15444-1 or ISO/IEC 15444-2 file formats are not listed. A box that is listed in [Table A.1](#) as “Required” shall exist within all conforming JPL files. For the placement and restrictions on each box, see the relevant section defining that box.

The IPR, XML, UUID and UUID boxes introduced in ISO/IEC 15444-1:2024, Annex A can be signalled, as well as at the level of the JPEG Pleno Holography box, to carry hologram-specific metadata.

A.3 Defined boxes

A.3.1 Overview

The boxes in [Table A.1](#) shall properly be interpreted by all conforming readers. Each box conforms to the standard structure defined in ISO/IEC 21794-1:2020, Annex A. The following clauses define the value of the DBox field. It is assumed that the LBox, TBox, and XBox fields exist for each box in the file as defined in ISO/IEC 21794-1:2020, Annex A.

Table A.1 — Defined boxes

Box name	Type	Superbox	Required?	Comments
JPEG Pleno Holography box	'jpho' (0x6A70 6C66)	Yes	Yes	This box contains a series of boxes that contain the encoded hologram, its parameterization and associated metadata. (Defined in ISO/IEC 21794-1:2020, Annex A)
JPEG Pleno Holography Header box	'jphh' (0x6A70 6C6C)	Yes	Yes	This box contains generic information about the file, such as the number of components, bits per component and colour space.
Hologram Header box	'hhdr' (0x6C6C 6472)	No	Yes	This box contains fixed length generic information about the hologram, such as hologram dimensions, number of components, codec and bits per component.

A.3.2 JPEG Pleno Holography Header box

A.3.2.1 General

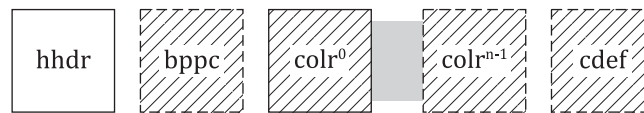
Within a JPEG Pleno Holography superbox, there shall be one and only one JPEG Pleno Hologram Header box. The JPEG Pleno Holography Header box contains generic information about the hologram, such as the hologram size, number of components, and bits per component. This box is a superbox.

The JPEG Pleno Holography Header box may be located anywhere within the JPEG Pleno Holography superbox but should be before the enclosed Contiguous Codestream box containing the hologram codestream.

The JPEG Pleno Holography Header box type shall be 'jphh' (0x6A70 6C6C).

This box contains several boxes. Other boxes may be defined in other documents and may be ignored by conforming readers. Those boxes contained within the JPEG Pleno Holography Header box that are defined within this document are shown in [Figure A.2](#):

- The Hologram Header box specifies information about the hologram size, bit depth, and the number of components. This box shall be the first box in the JPEG Pleno Holography Header box and is specified in subclause [A.3.2.2](#).
- The Bits Per Component box specifies the bit depth of the components in the file in cases where the bit depth is not constant across all components. Its structure shall be as specified in ISO/IEC 15444-1.
- The Colour Specification boxes specify the colour space of the decompressed image. Their structures shall be as specified in ISO/IEC 15444-2. There shall be at least one Colour Specification box within the JPEG Pleno Header box. Using multiple Colour Specification boxes gives a decoder multiple optimization or compatibility options for colour processing. These boxes may be found anywhere in the JPEG Pleno Holography Header box, provided they come after the Holography Header box. All Colour Specification boxes shall be contiguous within the JPEG Pleno Holography Header box.
- The Channel Definition box defines the channels in the image. Its structure shall be as specified in ISO/IEC 15444-1. This box may be found anywhere in the JPEG Pleno Holography Header box, provided that it comes after the Hologram Header box.

**Key**

hhdr	Hologram Header box
bppc	Bits Per Component box
colr ⁱ	Colour Specification boxes
cdef	Channel Definition box

Figure A.2 — Organization of the contents of a JPEG Pleno Holography Header box**A.3.2.2 Hologram Header box****A.3.2.2.1 General**

This box contains fixed-length generic information about the hologram field, such as hologram dimensions, number of components, codec, and bits per component. The contents of the JPEG Pleno Holography Header box shall start with a Hologram Header box. Instances of this box in other places in the file shall be ignored. The length of the Hologram Header box shall be 24 bytes, including the box length and type fields. Much of the information within the Hologram Header box is redundant, with information stored in the codestream itself.

All references to "the codestream" in the descriptions of fields in this Hologram Header box apply to the codestream found in the first Contiguous Codestream box embedded in the current JPEG Pleno Holography superbox. Files containing contradictory information between the Hologram Header box and the first codestream are not conforming. However, readers may attempt to read these files by using the values within the codestream.

The type of the Hologram Header box shall be 'hhdr' (0x6C6C 6472) and the contents of the box shall have the format shown in [Table A.3](#):

- **Width (Xhoc):** The value of this parameter indicates the width of the sample grid. This field is stored as a 4-byte big-endian unsigned integer.
- **Height (Yhoc):** The value of this parameter indicates the height of the sample grid. This field is stored as a 4-byte big-endian unsigned integer.
- **Number of components (NC):** This parameter specifies the number of components in the codestream and is stored as a 2-byte big-endian unsigned integer. The value of this field shall be equal to the value of the NC field in the HOC marker in the codestream (as defined in subclause [B.5.3](#)). If no Channel Definition Box is available, the order of the components for colour images is R-G-B-Aux or Y-U-V-Aux.
- **Type (Thoc):** The value of this parameter indicates the hologram type. This field is stored as a 1-byte big-endian unsigned integer. Legal values for this field are 0 if the hologram is real-valued (includes amplitude-only), 1 if the hologram is complex-valued in Cartesian coordinates (real-imaginary), 2 if the hologram is phase-only and 3 if the hologram is complex-valued in polar coordinates (amplitude-phase). All other values are reserved for ISO/IEC use.
- **Data type (DThoc):** The value of this parameter indicates the hologram data type. This 8-bit field is configured as '00TT00GG', where every symbol denotes a different bit. TT=00 for signed integer values, TT=01 for unsigned integer values, TT=10 for floating-point, and TT=11 for packed binary. In the case of floating-point values, the maximum exponent value equals 2^{3+GG} , where "GG" represents a 2-bit unsigned integer. All other values are reserved for ISO/IEC use ([Table A.4](#)).
- **BPC:** This parameter specifies the bit depth of the components in the codestream, minus 1, and is stored as a 1-byte field ([Table A.5](#)). The low 7 bits of the value indicate the bit depth of the components. The high-bit indicates whether the components are signed or unsigned. If the high-bit is 1, then the components contain signed values. If the high-bit is 0, then the components contain unsigned values. If the components

vary in bit depth or sign, or both, then the value of this field shall be 255, and the Hologram Header box shall also contain a Bits Per Component box defining the bit depth of each component (as defined in subclause [A.3.2.2.1](#)).

- **C:** This parameter specifies the coding algorithm used to compress the hologram data. It is encoded as a 1-byte unsigned integer. If the value is 0, the ISO/IEC 21794-5 codec is used. All other values are reserved for ISO/IEC use.
- **UnkC:** This field specifies if the actual colour space of the hologram data in the codestream is known. This field is encoded as a 1-byte unsigned integer. Legal values for this field are 0 if the colour space of the hologram is known and correctly specified in the Colour Space Specification boxes within the file or 1 if the colour space of the hologram is not known. A value of 1 will be used in cases such as the transcoding of legacy holograms where the actual colour space of the image data is not known. In these cases, while the colour space interpretation methods specified in the file may not accurately reproduce the hologram with respect to an original, the hologram should be treated as if the methods do accurately reproduce the hologram. Values other than 0 and 1 are reserved for ISO/IEC use.
- **IPR:** This parameter indicates whether this JPL file contains intellectual property rights information related to the holographic content. If the value of this field is 0, this file does not contain rights information, and thus the file does not contain an IPR box. If the value is 1, then the file does contain rights information and thus does contain an IPR box as defined in ISO/IEC 15444-1. Other values are reserved for ISO/IEC use.

Table A.3 — Format of the contents of the Hologram Header box

Field name	Size (bits)	Value
WIDTH	32	1 to $(2^{32} - 1)$
HEIGHT	32	1 to $(2^{32} - 1)$
Type	32	0
Data Type	32	See Table A.4
NC	16	1 to 16 384
BPC	8	See Table A.5
UnkC	8	0 to 1
IPR	8	0 to 1

Table A.4 — Data Type values

Values (bits) MSB LSB	Component sample precision
x000 0000 to x010 0101	Component bit depth = value + 1. From 1 bit deep to 38 bits deep respectively (counting the sign bit, if appropriate).
0xxx xxxx	Components are unsigned values.
1xxx xxxx	Components are signed values.
1111 1111	Components vary in bit depth.
	All other values reserved for ISO/IEC use.

Table A.5 — BPC values

Values (bits) MSB LSB	Component sample precision
00xx0000	8-bit datatype values
00xx0001	16-bit datatype values
00xx0010	32-bit datatype values
00xx0011	64-bit datatype values
000000xx	Signed integer datatype values
000100xx	Unsigned integer datatype values
001000xx	Floating-point datatype values
001100xx	Packed binary datatype values
	All other values reserved for ISO/IEC use.

Annex B (normative)

JPEG Pleno Holography codestream syntax

B.1 General

This section specifies the marker and marker segment syntax and semantics defined by this document. These markers and marker segments provide codestream information for this document. Further, this subclause provides a marker and marker segment syntax that is designed to be used in future specifications that include this document as a normative reference.

This document does not include a definition of conformance. The parameter values of the syntax described in this annex are not intended to portray the capabilities required to be compliant.

B.2 Markers, marker segments, and headers

This document uses markers and marker segments to delimit and signal the characteristics of the source image and codestream. This set of markers and marker segments is the minimal information needed to achieve the features of this document and is not a file format.

The main header is a collection of markers and marker segments. The main header is found at the beginning of the codestream.

Every marker is 4 bytes long, using the “0xFFFFXX” pattern, where the last marker byte, “XX,” defines the type of marker segment and can have any value in the range 0x01 to 0xFE.

A marker segment includes a marker and associated parameters, called marker segment parameters. When a marker segment that is not specified in the document appears in a codestream, the decoder shall discard the marker segment.

The proposed codec does not put any direct restrictions on the payload byte structure of the arithmetic encoder. This maximizes flexibility and reduces average file sizes compared to, for example, ISO/IEC 15444-1 (JPEG 2000), which forbids the signalling of 0xFF bytes, thereby reducing average compression efficiency.

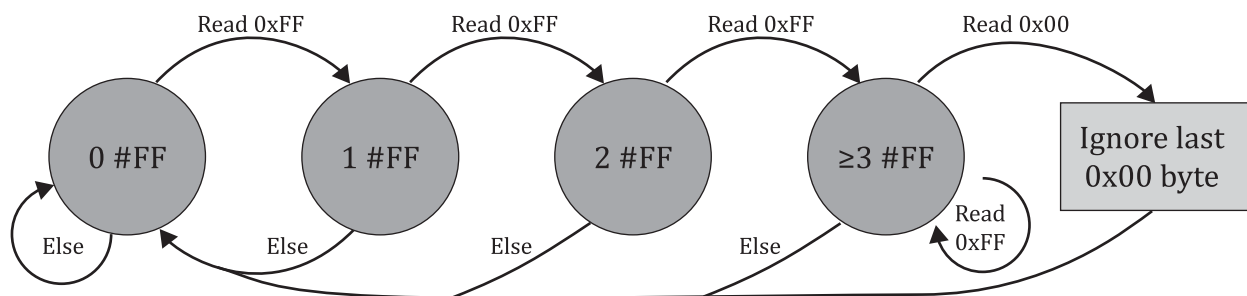


Figure B.1 — Marker segment manipulation.

Rarely, sequences of 3 or more subsequent 0xFF bytes may be signalled in the payload. To avoid the signalling of spurious marker segments, an “escape sequence system” is introduced, as shown in the state machine diagram illustrated in [Figure B.1](#). To achieve this, the marker bytes 0x00 and 0xFF are reserved, and may not be used as part of the 4-byte marker segment code.

Whenever 3 consecutive 0xFF bytes are encountered in the payload, the state machine will check for escape bytes (state “≥3 #FF” in the diagram above). Any extra 0xFF bytes will be decoded as payload while