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ICS:

35.040.40	Kodiranje avdio, video, multimedijskih in hipermedijskih informacij	Coding of audio, video, multimedia and hypermedia information
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Seventh edition
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Part 1: Systems

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Foreword

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This seventh edition cancels and replaces the sixth edition (ISO/IEC 13818-1:2018), which has been technically revised. It also incorporates ISO/IEC 13818-1:2018/Amd.1:2018.

A list of all parts in the ISO/IEC 13818 series can be found on the ISO website.

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INTERNATIONAL STANDARD ISO/IEC 13818-1
RECOMMENDATION ITU-T H.222.0

**Information technology – Generic coding of moving pictures and associated
audio information: Systems**

Summary

This Recommendation | International Standard specifies the system layer of the coding. It was developed in 1994 to principally support the combination and synchronization of video and audio coding methods defined in ISO/IEC 13818 Part 2 (ITU-T H.262) and Part 3. Since 1994, this standard has been extended to support additional video coding specifications (e.g., ISO/IEC 14496-2, ITU-T H.264 | ISO/IEC 14496-10, ITU-T H.265 | ISO/IEC 23008-2 and ITU-T T.800 | ISO/IEC 15444-1 Annex M JPEG 2000 video), audio coding specifications (e.g., ISO/IEC 13818-7 and ISO/IEC 14496-3), system streams (e.g., ISO/IEC 14496-1 and ISO/IEC 15938-1), ISO/IEC 23009-1 dynamic adaptive streaming over HTTP (DASH), ISO/IEC 13818-11 intellectual property management and protection (IPMP) as well as generic metadata. The system layer supports six basic functions:

- 1) the synchronization of multiple compressed streams on decoding;
- 2) the interleaving of multiple compressed streams into a single stream;
- 3) the initialization of buffering for decoding start up;
- 4) continuous buffer management;
- 5) time identification; and
- 6) multiplexing and signalling of various components in a system stream.

Recommendation ITU-T H.222.0 | ISO/IEC 13818-1 multiplexed bit stream is either a transport stream or a program stream. Both streams are constructed from packetized elementary stream (PES) packets and packets containing other necessary information. Both stream types support multiplexing of video and audio compressed streams from one program with a common time base. The transport stream additionally supports the multiplexing of video and audio compressed streams from multiple programs with independent time bases. For almost error-free environments the program stream is generally more appropriate, supporting software processing of program information. The transport stream is more suitable for use in environments where errors are likely.

Recommendation ITU-T H.222.0 | ISO/IEC 13818-1 multiplexed bit stream, whether a transport stream or a program stream, is constructed in two layers: the outermost layer is the system layer, and the innermost is the compression layer. The system layer provides the functions necessary for using one or more compressed data streams in a system. The video and audio parts of this Specification define the compression coding layer for audio and video data. Coding of other types of data is not defined by this Recommendation | International Standard, but is supported by the system layer provided that the other types of data adhere to the constraints defined in this Recommendation | International Standard.

History

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Keywords

Audiovisual content, multimedia multiplexing, MPEG-2 system, multiplexed bit stream, program stream, transport stream.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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ISO/IEC 13818-1:2019(E)

Table of Contents

	<i>Page</i>
SECTION 1 – GENERAL	1
1.1 Scope	1
1.2 Normative references	1
SECTION 2 – TECHNICAL ELEMENTS	4
2.1 Definitions	4
2.2 Symbols and abbreviations	11
2.3 Method of describing bit stream syntax	13
2.4 Transport stream bitstream requirements	14
2.5 Program stream bitstream requirements	60
2.6 Program and program element descriptors	74
2.7 Restrictions on the multiplexed stream semantics	143
2.8 Compatibility with ISO/IEC 11172	148
2.9 Registration of copyright identifiers	148
2.10 Registration of private data format	148
2.11 Carriage of ISO/IEC 14496 data	149
2.12 Carriage of metadata	160
2.13 Carriage of ISO 15938 data	169
2.14 Carriage of Rec. ITU-T H.264 ISO/IEC 14496-10 video	169
2.15 Carriage of ISO/IEC 14496-17 text streams	185
2.16 Carriage of auxiliary video streams	187
2.17 Carriage of HEVC	187
2.18 Carriage of green access units	201
2.19 Carriage of ISO/IEC 23008-3 MPEG-H 3D audio data	203
2.20 Carriage of Quality Access Units in MPEG-2 sections	205
2.21 Carriage of Sample Variants	206
2.22 Carriage of Media Orchestration Access Units	207
Annex A – CRC decoder model	208
A.1 CRC decoder model	208
Annex B – Digital storage medium command and control (DSM-CC)	209
B.1 Introduction	209
B.2 General elements	210
B.3 Technical elements	212
Annex C – Program-specific information	218
C.1 Explanation of program-specific information in transport streams	218
C.2 Introduction	218
C.3 Functional mechanism	218
C.4 The mapping of sections into transport stream packets	219
C.5 Repetition rates and random access	219
C.6 What is a program?	220
C.7 Allocation of program_number	220
C.8 Usage of PSI in a typical system	220
C.9 The relationships of PSI structures	221
C.10 Bandwidth utilization and signal acquisition time	223
Annex D – Systems timing model and application implications of this Recommendation International Standard	226
D.1 Introduction	226
Annex E – Data transmission applications	235
E.1 General considerations	235
E.2 Suggestion	235
Annex F – Graphics of syntax for this Recommendation International Standard	236
F.1 Introduction	236
Annex G – General information	240
G.1 General information	240

Annex H – Private data.....	241
H.1 Private data.....	241
Annex I – Systems conformance and real-time interface	242
I.1 Systems conformance and real-time interface.....	242
Annex J – Interfacing jitter-inducing networks to MPEG-2 decoders.....	243
J.1 Introduction.....	243
J.2 Network compliance models	243
J.3 Network specification for jitter smoothing.....	244
J.4 Example decoder implementations	245
Annex K – Splicing transport streams	246
K.1 Introduction	246
K.2 The different types of splicing point	246
K.3 Decoder behaviour on splices.....	247
Annex L – Registration procedure (see 2.9)	249
L.1 Procedure for the request of a Registered Identifier (RID)	249
L.2 Responsibilities of the Registration Authority	249
L.3 Responsibilities of parties requesting an RID	249
L.4 Appeal procedure for denied applications	250
Annex M – Registration application form (see 2.9).....	251
M.1 Contact information of organization requesting a Registered Identifier (RID).....	251
M.2 Statement of an intention to apply the assigned RID	251
M.3 Date of intended implementation of the RID	251
M.4 Authorized representative	251
M.5 For official use only of the Registration Authority	251
Annex N – Registration Authority Diagram of administration structure (see 2.9)	252
Annex O – Registration procedure (see 2.10).....	253
O.1 Procedure for the request of an RID.....	253
O.2 Responsibilities of the Registration Authority	253
O.3 Contact information for the Registration Authority	253
O.4 Responsibilities of parties requesting an RID	253
O.5 Appeal procedure for denied applications	253
Annex P – Registration application form.....	255
P.1 Contact information of organization requesting an RID	255
P.2 Request for a specific RID	255
P.3 Short description of RID that is in use and date system that was implemented	255
P.4 Statement of an intention to apply the assigned RID	255
P.5 Date of intended implementation of the RID	255
P.6 Authorized representative	255
P.7 For official use of the Registration Authority	255
Annex Q – T-STD and P-STD buffer models for ISO/IEC 13818-7 ADTS	256
Q.1 Introduction	256
Q.2 Leak rate from transport buffer	256
Q.3 Buffer size	256
Q.4 Conclusion	257
Annex R – Carriage of ISO/IEC 14496 scenes in Rec. ITU-T H.222.0 ISO/IEC 13818-1.....	259
R.1 Content access procedure for ISO/IEC 14496 program components within a program stream	259
R.2 Content access procedure for ISO/IEC 14496 program components within a transport stream	260
Annex S – Carriage of JPEG 2000 part 1 video over MPEG-2 transport streams	264
S.1 Introduction	264
S.2 J2K video access unit, J2K video elementary stream, J2K video sequence and J2K still picture	264
S.3 Optional J2K block mode for high resolution support	264
S.4 Optional J2K stripe mode for Ultra-Low Latency.....	265
S.5 Elementary stream header (elsm) and mapping to PES packets.....	265

ISO/IEC 13818-1:2019(E)

S.6	J2K transport constraints	268
S.7	Interpretation of flags in adaptation and PES headers for J2K video elementary streams	269
S.8	T-STD extension for J2K video elementary streams.....	269
Annex T	– MIME type for MPEG-2 transport streams	272
T.1	Introduction	272
T.2	MIME type and subtype	272
T.3	Security considerations	273
T.4	Parameters	273
Annex U	– Carriage of timeline and external media information over MPEG-2 transport streams	275
U.1	Introduction	275
U.2	TEMI access unit and TEMI elementary stream	276
U.3	AF descriptors	277
Annex V	– Transport of HEVC tiles.....	286
V.1	Introduction	286
V.2	HEVC tile substream identification example	286
V.3	Subregion layout example	287

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Introduction

The systems part of this Recommendation | International Standard addresses the combining of one or more elementary streams of video and audio, as well as other data, into single or multiple streams which are suitable for storage or transmission. Systems coding follows the syntactical and semantic rules imposed by this Specification and provides information to enable synchronized decoding of decoder buffers over a wide range of retrieval or receipt conditions.

System coding shall be specified in two forms: the transport stream and the program stream. Each is optimized for a different set of applications. Both the transport stream and program stream defined in this Recommendation | International Standard provide coding syntax which is necessary and sufficient to synchronize the decoding and presentation of the video and audio information, while ensuring that data buffers in the decoders do not overflow or underflow. Information is coded in the syntax using time stamps concerning the decoding and presentation of coded audio and visual data and time stamps concerning the delivery of the data stream itself. Both stream definitions are packet-oriented multiplexes.

The basic multiplexing approach for single video and audio elementary streams is illustrated in Figure Intro. 1. The video and audio data is encoded as described in Rec. ITU-T H.262 | ISO/IEC 13818-2 and ISO/IEC 13818-3. The resulting compressed elementary streams are packetized to produce PES packets. Information needed to use PES packets independently of either transport streams or program streams may be added when PES packets are formed. This information is not needed and need not be added when PES packets are further combined with system level information to form transport streams or program streams. This systems standard covers those processes to the right of the vertical dashed line.

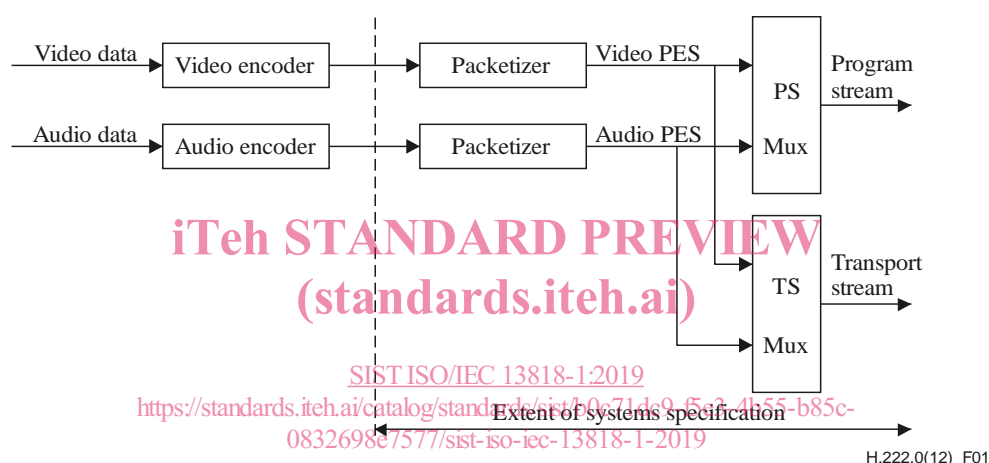


Figure Intro. 1 – Simplified overview of the scope of this Recommendation | International Standard

The program stream is analogous and similar to the ISO/IEC 11172 systems layer. It results from combining one or more streams of PES packets, which have a common time base, into a single stream.

For applications that require the elementary streams that comprise a single program to be in separate streams that are not multiplexed, the elementary streams can also be encoded as separate program streams, one per elementary stream, with a common time base. In this case the values encoded in the SCR fields of the various streams shall be consistent.

Like the single program stream, all elementary streams can be decoded with synchronization.

The program stream is designed for use in relatively error-free environments and is suitable for applications which may involve software processing of system information such as interactive multi-media applications. Program stream packets may be of variable and relatively great length.

The transport stream combines one or more programs with one or more independent time bases into a single stream. PES packets made up of elementary streams that form a program share a common timebase. The transport stream is designed for use in environments where errors are likely, such as storage or transmission in lossy or noisy media. Transport stream packets are 188 bytes in length.

Program and transport streams are designed for different applications and their definitions do not strictly follow a layered model. It is possible and reasonable to convert from one to the other; however, one is not a subset or superset of the other. In particular, extracting the contents of a program from a transport stream and creating a valid program stream is possible and is accomplished through the common interchange format of PES packets, but not all of the fields needed in a program stream are contained within the transport stream; some must be derived. The transport stream may be used to span a range of layers in a layered model, and is designed for efficiency and ease of implementation in high bandwidth applications.

ISO/IEC 13818-1:2019(E)

The scope of syntactical and semantic rules set forth in the systems specification differs: the syntactical rules apply to systems layer coding only, and do not extend to the compression layer coding of the video and audio specifications; by contrast, the semantic rules apply to the combined stream in its entirety.

The systems specification does not specify the architecture or implementation of encoders or decoders, nor those of multiplexors or demultiplexors. However, bit stream properties do impose functional and performance requirements on encoders, decoders, multiplexors and demultiplexors. For instance, encoders must meet minimum clock tolerance requirements. Notwithstanding this and other requirements, a considerable degree of freedom exists in the design and implementation of encoders, decoders, multiplexors, and demultiplexors.

Intro. 1 Transport stream

The transport stream is a stream definition which is tailored for communicating or storing one or more programs of coded data according to Rec. ITU-T H.262 | ISO/IEC 13818-2 and ISO/IEC 13818-3 and other data in environments in which significant errors may occur. Such errors may be manifested as bit value errors or loss of packets.

Transport streams may be either fixed or variable rate. In either case the constituent elementary streams may either be fixed or variable rate. The syntax and semantic constraints on the stream are identical in each of these cases. The transport stream rate is defined by the values and locations of program clock reference (PCR) fields, which in general are separate PCR fields for each program.

There are some difficulties with constructing and delivering a transport stream containing multiple programs with independent time bases such that the overall bit rate is variable. Refer to 2.4.2.3.

The transport stream may be constructed by any method that results in a valid stream. It is possible to construct transport streams containing one or more programs from elementary coded data streams, from program streams, or from other transport streams which may themselves contain one or more programs.

The transport stream is designed in such a way that several operations on a transport stream are possible with minimum effort. Among these are:

- 1) Retrieve the coded data from one program within the transport stream, decode it and present the decoded results as shown in Figure Intro. 2.
- 2) Extract the transport stream packets from one program within the transport stream and produce as output a different transport stream with only that one program as shown in Figure Intro. 3.
- 3) Extract the transport stream packets of one or more programs from one or more transport streams and produce as output a different transport stream (not illustrated).
- 4) Extract the contents of one program from the transport stream and produce as output a program stream containing that one program as shown in Figure Intro. 4.
- 5) Take a program stream, convert it into a transport stream to carry it over a lossy environment, and then recover a valid, and in certain cases, identical program stream.

Figure Intro. 2 and Figure Intro. 3 illustrate prototypical demultiplexing and decoding systems which take as input a transport stream. Figure Intro. 2 illustrates the first case, where a transport stream is directly demultiplexed and decoded. Transport streams are constructed in two layers:

- a system layer; and
- a compression layer.

The input stream to the transport stream decoder has a system layer wrapped about a compression layer. Input streams to the video and audio decoders have only the compression layer.

Operations performed by the prototypical decoder which accepts transport streams either apply to the entire transport stream ("multiplex-wide operations"), or to individual elementary streams ("stream-specific operations"). The transport stream system layer is divided into two sub-layers, one for multiplex-wide operations (the transport stream packet layer), and one for stream-specific operations (the PES packet layer).

A prototypical decoder for transport streams, including audio and video, is also depicted in Figure Intro. 2 to illustrate the function of a decoder. The architecture is not unique – some system decoder functions, such as decoder timing control, might equally well be distributed among elementary stream decoders and the channel-specific decoder – but this figure is useful for discussion. Likewise, indication of errors detected by the channel-specific decoder to the individual audio and video decoders may be performed in various ways and such communication paths are not shown in the diagram. The prototypical decoder design does not imply any normative requirement for the design of a transport stream decoder. Indeed non-audio/video data is also allowed, but not shown.

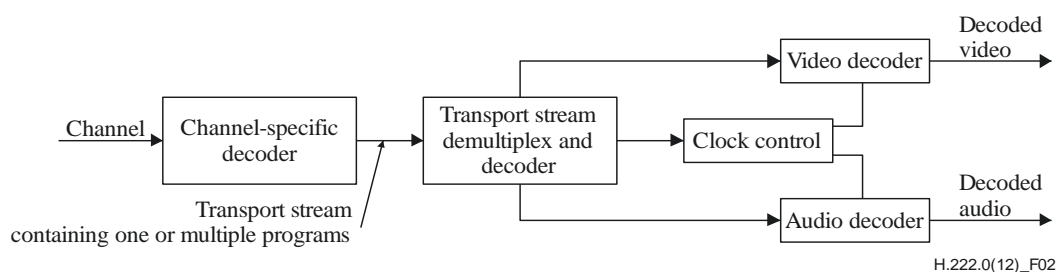


Figure Intro. 2 – Prototypical transport demultiplexing and decoding example

Figure Intro. 3 illustrates the second case, where a transport stream containing multiple programs is converted into a transport stream containing a single program. In this case the re-multiplexing operation may necessitate the correction of program clock reference (PCR) values to account for changes in the PCR locations in the bit stream.

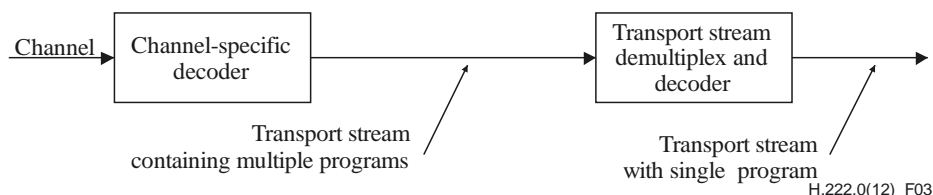


Figure Intro. 3 – Prototypical transport multiplexing example

Figure Intro. 4 illustrates a case in which a multi-program transport stream is first demultiplexed and then converted into a program stream.

Figures Intro. 3 and Intro. 4 indicate that it is possible and reasonable to convert between different types and configurations of transport streams. There are specific fields defined in the transport stream and program stream syntax which facilitate the conversions illustrated. There is no requirement that specific implementations of demultiplexors or decoders include all of these functions.

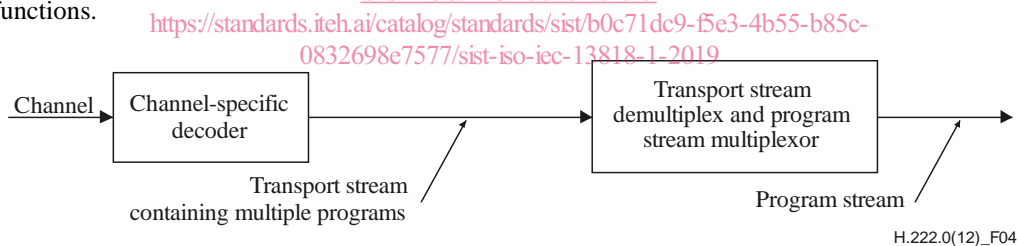


Figure Intro. 4 – Prototypical transport stream to program stream conversion

Intro. 2 Program stream

The program stream is a stream definition which is tailored for communicating or storing one program of coded data and other data in environments where errors are very unlikely, and where processing of system coding, e.g., by software, is a major consideration.

Program streams may be either fixed or variable rate. In either case, the constituent elementary streams may be either fixed or variable rate. The syntax and semantics constraints on the stream are identical in each case. The program stream rate is defined by the values and locations of the system clock reference (SCR) and mux_rate fields.

A prototypical audio/video program stream decoder system is depicted in Figure Intro. 5. The architecture is not unique – system decoder functions including decoder timing control might as equally well be distributed among elementary stream decoders and the channel-specific decoder – but this figure is useful for discussion. The prototypical decoder design does not imply any normative requirement for the design of a program stream decoder. Indeed non-audio/video data is also allowed, but not shown.