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SMPTE STANDARD

SMPTE 312M-2001Revision of
SMPTE 312M-1999

for Television — Splice Points for MPEG-2 Transport Streams



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NOTE: SMPTE recommends that implementers not use section 7 of the SMPTE 312M Standard when SCTE 35- 2004 may also be in use.

1 Scope

This standard defines constraints on the encoding of and syntax for MPEG-2 transport streams such that they may be spliced without modifying the PES packet payload. Generic MPEG-2 transport streams, which do not comply with the constraints in this standard, may require more sophisticated techniques for splicing.

The constraints specified here are applied individually to programs within transport streams. A program is a collection of video, audio, and data streams which share a common time base. The presence of a video component is not assumed. The standard enables splicing of programs within a multiprogram transport stream either simultaneously or independently. Splice Points in different programs may be presentation-time-coincident, but do not have to be. The standard may also be used with single-program transport streams.

The document specifies constraints for both seamless and nonseamless Splice Points. Seamless Splice Points must adhere to all the constraints. Nonseamless Splice Points must adhere to all constraints except those prefaced with the clause "to enable seamless splicing." A bit stream which is compliant with this standard shall conform to the constraints defined in clauses 5 and 6. Such a bit stream may contain any number of seamless, nonseamless, or both types of Splice Points. If a bit stream does not contain splice event command and control information, the constraints in clause 7 do not apply to the bit stream. Mechanisms for transmission of time code in MPEG-2 transport/elementary bit streams shall be addressed by other standards.

In addition to constraints for creating spliceable bit streams, this standard specifies the technique for carrying notification of upcoming Splice Points in the transport stream. A splice information table is defined for notifying downstream devices of splice events, such as a network break or return from a network break. The splice information table which pertains to a given program is carried in a separate PID stream referred to by that program's program map table. In this way, splice event notification can pass through transport stream remultiplexers without need for special processing. A bit stream which is compliant with this standard and which carries splice event command and control information shall conform to the constraints in clauses 5, 6, and 7.

The standard does not address constraints on splicing devices. Annex A outlines several issues that should be considered in the design of such devices.

NOTE – Numbers given in brackets are subject to confirmation.

2 Normative references

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

ATSC A/53, Digital Television

SMPTE 12M-1999, Television, Audio and Film —
Time and Control Code

ITU-T H.222.0 (02/00) / ISO/IEC 13818-1, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Systems

ITU-T H.262 (02/00) / ISO/IEC 13818-2, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Video

3 Introduction

3.1 Buffer issues

Splicing of MPEG bit streams requires managing buffer fullness of the decoder's buffers. When MPEG bit streams are encoded, there is an inherent buffer occupancy at every point in time (see figure 1). The buffer fullness corresponds to a delay, the amount of time that a byte spends in the buffer. When splicing two separately encoded bit streams, the delay at the Splice Point will not usually match. This mismatch in delay can cause the buffer to overflow or underflow at some time in the future (see figure 2).

To avoid unpredictable underflows and overflows, two splicing techniques have been defined. The seamless splicing method requires that the MPEG encoder match the delay at splicing points to a given value. The nonseamless method does not require the encoder to match the delay. Instead, the splicing device is responsible for matching the delay of the new material and the old material as well as it can. In some cases, this will result in a controlled decoder buffer underflow. This underflow can be masked in the decoder by holding the last frame of the outgoing video and muting the audio until the first access unit of the new stream has been decoded. In the worst case, this underflow may last for a few frame times. Both splicing methods may cause an underflow of the audio buffer, and consequently a gap in the presentation of audio at the receiver. The perceived quality of the splice in both cases will benefit from audio decoders that can handle a gap in audio data gracefully.

3.2 Splice Points

To enable the splicing of compressed bit streams, this standard defines Splice Points. Splice Points in an MPEG-2 transport stream provide opportunities to switch from one program to another. They indicate a safe place to switch, a place in the bit stream where a switch can be made, and result in good visual and audio quality. In this way, they are analogous to the vertical interval used to switch uncompressed video.

Unlike uncompressed video, frame boundaries in an MPEG-2 bit stream are not evenly spaced. Therefore, the syntax of the transport packet itself is used to convey where these Splice Points occur.

Transport streams are created by multiplexing PID streams. In this standard, two types of Splice Points for PID streams are defined: Out Points and In Points. In Points are places in the bit streams where it is safe to enter and start decoding the bit stream. Out Points are places where it is safe to exit the bit stream. Ways to group In Points of individual PID streams into Program In Points in order to enable the switching of entire programs (video with audio) are defined. Program Out Points for exiting a program are also defined.

Out Points and In Points are imaginary points in the bit stream located between two transport stream packets. An Out Point and an In Point may be co-located; that is, a single packet boundary may serve as both a safe place to leave a bit stream and a safe place to enter it (see figure 3).

The output of a switching operation (see figure 4) will begin with packets from one stream up until its Out Point followed by packets from another stream starting with the first packet following an In Point.

3.3 Program Splice Points

Part of this standard describes requirements for grouping In Points of a set of PID streams into Program In Points and for grouping Out Points of a set of PID streams into Program Out Points. Program In Points and Program Out Points are sets of PID stream In Points or Out Points which correspond in presentation time to the underlying data. In MPEG, audio is typically organized into audio frames. Because video and audio frames have different durations and their presentation times do not necessarily align, this standard defines exactly what it means for PID stream Splice Points to correspond in time.

Figure 5 shows a splice between two programs, one called the old stream and one called the new stream. Each program contains a video PID and an audio PID. The output of the splice is shown below the two input streams. In the old stream, the position of PID stream Out Points which create a program Out Point is shown. In the new stream, the position of PID stream In Points which create a Program In Point is shown.

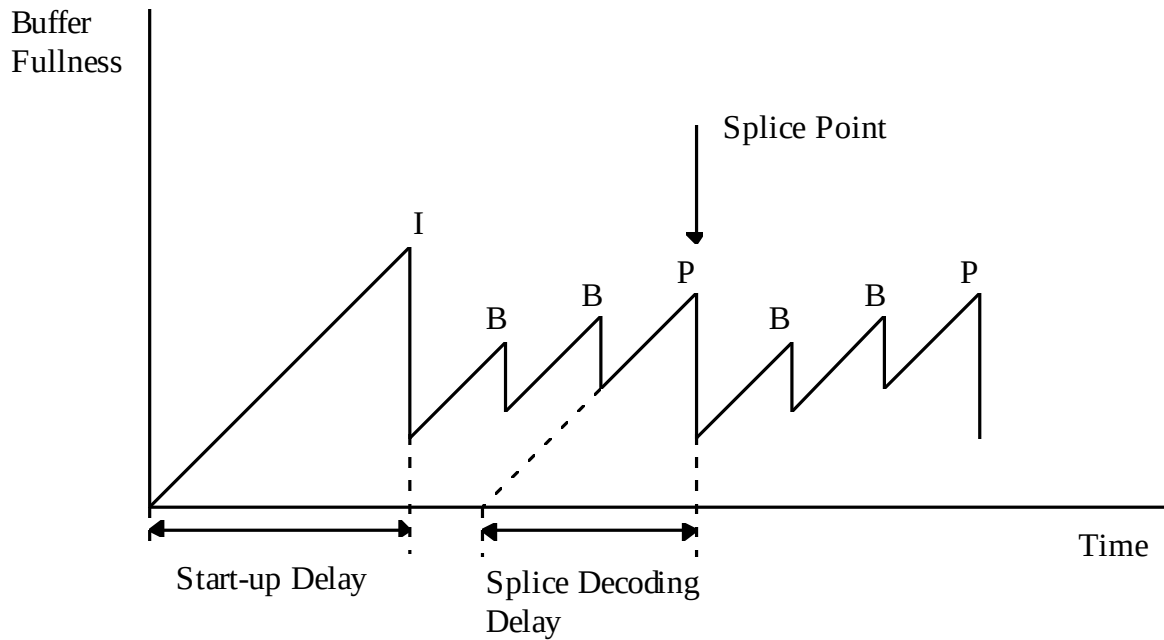


**Figure 1 – Fullness of a theoretical decoder's buffer model
(as described in ISO/IEC 13818-2 annex C)**

Here is an example of an old stream and a new stream that results in a splice overflow.

At the time of the splice bits from the old stream stop entering the buffer and bits from the new stream begin entering.

When spliced the two streams overflow the buffer.

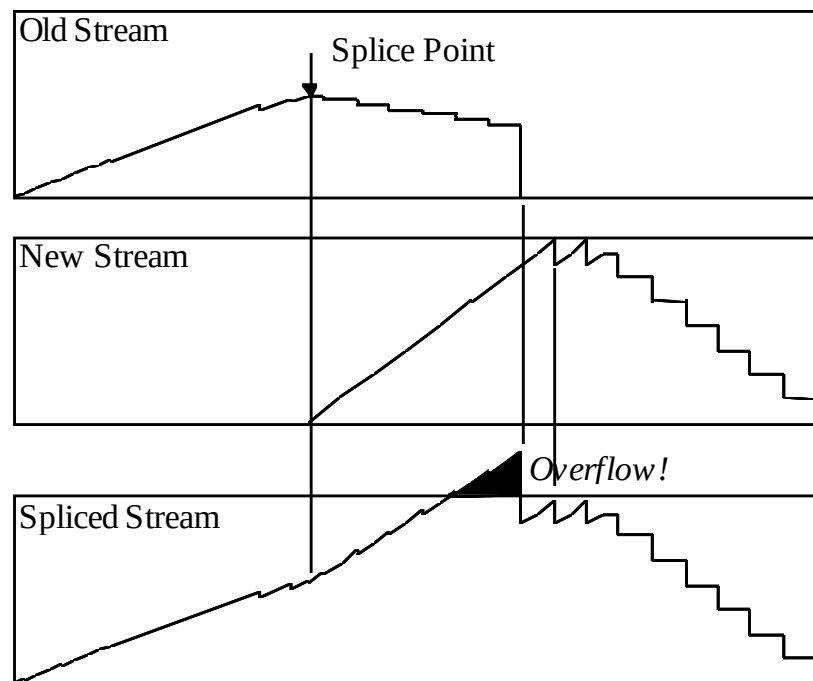


Figure 2 – Example of decoder buffer overflow as a result of an unconstrained splice

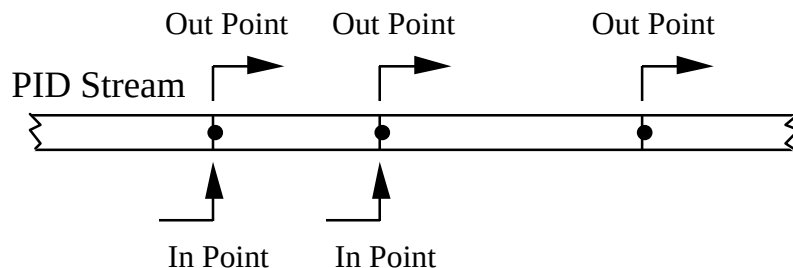


Figure 3 – In Points and Out Points in a PID stream

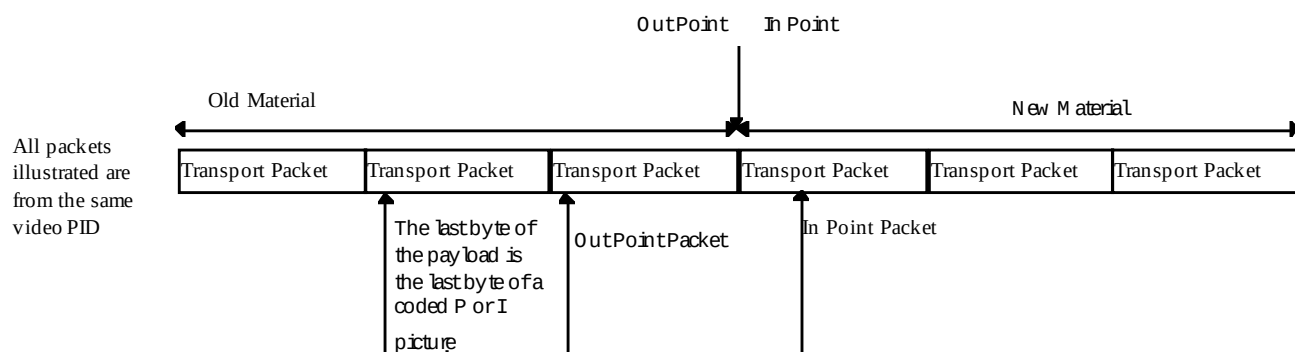


Figure 4 – Example of a co-located Out Point and In Point in a video PID stream

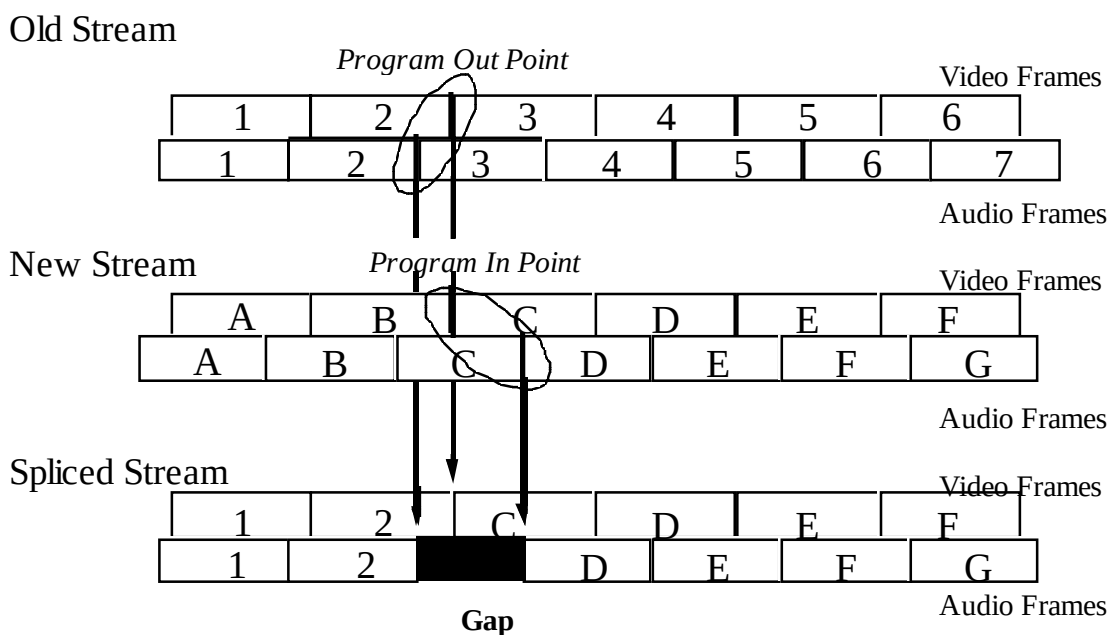


Figure 5 – Presentation time representation of a Program Out Point and a Program In Point

Although Splice Points in a Program Splice Point correspond in presentation time, they do not usually appear near each other in the transport stream. Because compressed video takes much longer to decode than audio, the audio Splice Points may lag the video Splice Points by as much as hundreds of milliseconds and by an amount that can vary from moment to moment (this relationship is shown in figure 6). This standard defines the relationship of Splice Points in bit stream order as well as in presentation time.

3.4 Splice events

This standard provides a method for in-band signaling of schedule, preroll, and execute splice event messages to downstream splicing equipment. A splice event identifies which Splice Point to use for a splice. A splice information table carries splice events. Each splice event is analogous to a cue tone. The splice information table incorporates the functionality of cue tones and extends it to enable the scheduling of splice events in advance.

This standard establishes that the splice information table be carried on a per-program basis in a PID stream with a designated stream_type. The program's splice information PID is designated in the program's program map table. In this way, the splice information table is switched with the program as it goes through remultiplexing operations. A common stream_type identifies all PID streams which carry splice information tables. Remultiplexers may use this stream_type field to drop splice information prior to sending the transport stream to the end-user device.

4 Definition of terms

Throughout this standard the terms below have given specific meanings. Because some of the terms which are defined in ISO/IEC 13818 have very specific technical meanings, the reader is referred to the original source for their definition. For terms defined by this standard, brief definitions are given below. More extensive descriptions of some terms are given in 3.2. Constraints in clause 5 provide the specific technical definition.

4.1 ATSC: Advanced Television Systems Committee.

4.2 bs1bf: Bit string, left bit first, where left is the order in which bit strings are written.

4.3 decoding delay: The time from when a packet enters the decoder buffer until it is removed.

4.4 DTS: Decoding time stamp (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.5 DTS_next_AU: DTS value of the next access unit (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.6 first presentation unit (FPU): In regard to an In Point, the presentation unit which follows the given In Point that has the earliest presentation time.

4.7 4:2:2P@ML: 422 Profile at Main Level (see ITU-T H.262 / ISO/IEC 13818-2).

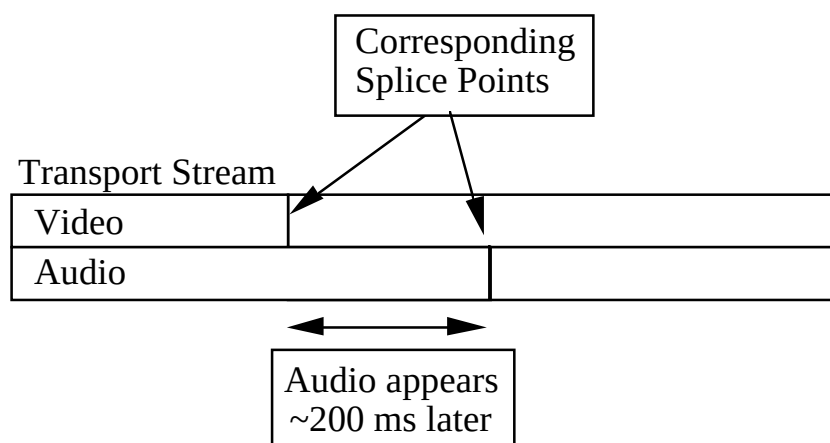


Figure 6 – Bit stream order representation of a Program Out Point

4.8 In Point: A point in a PID stream where a splicing device may enter.

4.9 In Point packet (IPP): The first packet after an In Point in a PID stream.

4.10 last presentation unit (LPU): In regard to an Out Point, the presentation unit which precedes the given Out Point that has the latest presentation time.

4.11 max_splice_rate: (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.12 MP@HL: Main Profile at High Level (see ITU-T H.262 / ISO/IEC 13818-2).

4.13 MP@ML: Main Profile at Main Level (see ITU-T H.262 / ISO/IEC 13818-2).

4.14 Out Point: A point in a PID stream where a splicing device may exit.

4.15 Out Point packet (OPP): The last packet prior to an Out Point in a PID stream.

4.16 PCR: Program clock reference (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.17 PCR_flag: (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.18 PCR_PID: Identifier carried in the program map table. The PID contained in a program that has been selected to carry the PCR (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.19 PES: Packetized elementary stream (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.20 picture_structure: (see ITU-T H.262 / ISO/IEC 13818-2).

4.21 PID: Packet identifier; a unique 13-bit value used to identify the type of data stored in the packet payload (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.22 PID stream: All the packets with the same PID within a transport stream.

4.23 PMT: Program map table (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.24 Profile@Level: Designation of the subset of the MPEG-2 video coding specification (see ITU-T H.262 / ISO/IEC 13818-2).

4.25 program: A collection of video, audio, and data PID streams which share a common time base.

4.26 Program In Point (PIP): A group of PID stream In Points which correspond in presentation time. This standard defines correspondence. PID streams with In Points contained in a Program In Point may be a subset of all PID streams contained within a program as defined by the PMT.

4.27 Program Out Point (POP): A group of PID stream Out Points which correspond in presentation time. This standard defines correspondence. PID streams with Out Points contained in a Program Out Point may be a subset of all PID streams contained within a program as defined by the PMT.

4.28 program splice point (PSP): Either a Program Out Point or a Program In Point.

4.29 progressive_frame: (see ITU-T H.262 / ISO/IEC 13818-2).

4.30 progressive_sequence: (see ITU-T H.262 / ISO/IEC 13818-2).

4.31 PTS: Presentation time stamp (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.32 repeat_first_field: (see ITU-T H.262 / ISO/IEC 13818-2).

4.33 rpchof: Remainder polynomial coefficients, highest order first.

4.34 seamless_splice_flag: (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.35 sequence_end_code: (see ITU-T H.262 / ISO/IEC 13818-2).

4.36 splice_countdown: (see ITU-T H.222.0 / ISO/IEC 13818-1).

4.37 splice_decoding_delay: (see ITU-T H.222.0 / ISO/IEC 13818-1).