SMPTE Draft Recommended Practice for Television

Date: 2005-8-23

SMPTE RP227

SMPTE Technology Committee C24 on Video Compression

VC-1 Bitstream Transport Encodings

Document type: Recommended Practice
Document subtype:
Document stage: Draft Recommended Practice
Document language: English

Contents

Page

Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative practices.

SMPTE Recommended Practice was prepared by Technology Committee C24.

Introduction

The purpose of this recommended practice is to define a minimum set of rules for the carriage of a VC-1 elementary stream in MPEG-2 Systems protocols. In particular, this design is intended to provide a generic method for carrying a VC-1 video elementary stream over specific MPEG-2 transport streams, such as the ones defined by ATSC, DVB and SCTE. It is also intended to provide a generic means of carrying a VC-1 video elementary stream in an MPEG-2 Program Stream as used by the DVD Forum or the Blu-Ray consortium. One of the particular aspects of this Recommended Practice is to make sure that any private fields and private values needed in the mapping is properly scoped by an identifier to avoid any collisions or ambiguity in any of these delivery networks or media.

VC-1 Bitstream Transport Encodings

1 Scope

This document describes the protocols for carrying video elementary streams conforming to the SMPTE VC-1 Simple, Main and Advanced Profile over MPEG-2 Transport Streams and MPEG-2 Program Streams. This document does not describe the video bit stream syntax. It describes the encapsulation and signaling of the video bit stream using the respective transport protocols.

The document builts on the synchronization layer specified by MPEG-2 Systems, which is the fundamental mechanism for ensuring Audio/Video/Data synchronization. However, this document does not cover the policies that must be adopted at a transmission system head-end to implement a given quality level of Audio/Video/Data synchronization.

Any field of the MPEG-2 Transport Stream packet header or MPEG-2 PES packet header that is not mentioned in this document shall keep its original meaning.

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.

SMPTE Standard for Television 421M[1]: VC-1 Compressed Video Bitstream Format and Decoding Process

ISO/IEC 13818-1:2000 Information Technology – Generic Coding of Moving Pictures and Associated Audio Information: Systems (2nd Edition).

ISO/IEC 13818-1:2000/Cor.2:2001(E) Information Technology – Generic Coding of Moving Pictures and Associated Audio Information : Systems Corrigendum 2, "Buffer Model Extension".

[1] 421M and VC-1 are used interchangeably in this document to refer to SMPTE 421M.

ISO/IEC 13818-1:2000/AMD2, “Support of IPMP on MPEG-2 Systems”, 2003.

3 Background and Overview

3.1 Background

This document defines the encapsulation and signaling of VC-1 elementary streams in MPEG-2 Transport and Program Streams. In particular, this document is not concerned with the carriage of audio elementary streams or data elementary streams that may be multiplexed with the VC-1 elementary stream in the same MPEG-2 Program Stream or the same MPEG-2 Transport Stream. The synchronization of audio access units in an audio elementary stream with VC-1 video access units in a video elementary stream should be achieved by means of the synchronization layer specified by ISO 13818-1. Likewise, the synchronization of data access units in a synchronized or synchronous data elementary stream should be achieved by means of ISO 13818-1. The synchronization layer in MPEG-2 Systems is based on the reconstruction of a System Time Clock in the receiver and referencing instants on this timeline by means of Decoding Time Stamp and Presentation Time Stamps.

This document relies on ISO 13818-1 as a baseline layer and defines a series of allowed extensions that enable the encapsulation and signaling of VC-1 elementary streams. This results in implementations compatible with ISO 13818-1.

3.2 Overview

This document is organized in two main sections, the first one covering the carriage of VC-1 elementary streams in MPEG-2 Transport Streams and the second covering the carriage of VC-1 elementary streams in MPEG-2 Program Streams, Each section starts with a sub-section dealing with the signaling aspects. For example, in a Transport Stream, Programs are signaled using a collection of tables transmitted cyclically and known as PSI (Program Specific Information). Specifically, a Program Map Table (PMT) provides the Program details and specifics necessary for finding and decoding the component Elementary Streams. Also, as MPEG-2 Systems requires PES encapsulation of video data in order to generate packetized video elementary streams, the next sub-section deals with the packetization specifics for Simple, Main and Advanced Profiles. The last sub-section specifies the Hypothetical Buffer Model definition and defines the operations of this Buffer Model.

This document adopts a particular method for aggregating VC-1 elementary stream data (SMPTE 421M]) and VC-1 metadata (see Annex I and J in SMPTE 421M) to interface with the underlying MPEG-2 Systems packetization and synchronization layer. The mapping of VC-1 elementary streams to MPEG-2 Systems uses this interface but it is not necessarily representative of the interfacing methodology that should be adopted for other transport protocols.

3.3 Abbreviations

This section provides a list of acronyms used in this document. This list is a supplement to the set of acronyms defined in section 2.1 of ISO 13818-1 and in section 4 of SMPTE 421M.

A/V Audio and Video

CRC Cyclic Redundancy Check

DTS Decoding Time Stamp

DTV Digital Television

ES Elementary Stream

ESCR Elementary Stream Clock Reference

PAT Program Association Table

PMT Program Map Table

PCR Program Clock Reference

PES Packetized Elementary Stream

PID Packet Identifier

PSI Program Specific Information

PTS Presentation Time Stamp

PU Presentation Unit

SCR System Clock Reference

SDO Standards Development Organization

STD System Target Decoder

TS Transport Stream

3.4 Definitions

3.4.1 Data Access Unit Definition

The following definition for an access unit shall be applicable for both MPEG-2 Transport Streams and MPEG-2 Program Streams.

An access unit is defined to be a coded representation of a single picture in a VC-1 elementary stream.

In the case of the Advanced Profile, an access unit shall include all the coded data for a picture and any flushing bits that follows it, up to but not including the start code of the next access unit (or any stuffing bytes before it). Coded picture data represents a video frame regardless whether the frame has been encoded as progressive or interlaced progressive mode, interlaced frame interlaced mode or interlaced field interlaced mode. The start of the next access unit shall be the byte of either a sequence start code, an entry point start code or a frame start code. Also, if the frame is not preceded by a sequence start code and a sequence header or an entry point start code and an entry point header, the access unit shall begin with a frame start code. Otherwise, the access unit shall start with the first byte of the first of these structures (excluding any stuffing bytes) before the frame start code. An access unit shall also include any user data start code and user data bytes at the sequence, entry point, frame or field level. The rules defining the scope of the user data constructs are described in Annex F of SMPTE 421M.

In the case of Simple Profile or Main Profile, an access unit shall include all the coded data for a video frame, including the VC-1_SPMP_PESpacket_PayloadFormatHeader() bytes that precedes it as well as any flushing bits present to ensure byte alignment that follows it, up to but not including the start code of the next access unit (or any stuffing bytes before it). The start of the next access unit shall be the first byte in the next VC-1_SPMP_PESpacket_PayloadFormatHeader() which is either a sequence start code or a frame start code.

4 MPEG-2 Transport Stream Encoding

For the description of coded bit streams this document follows the conventional approach used by ISO 13818-1. Data fields are represented using a different font format (e.g. **data_element**). The bit stream syntax is clearly defined in separate tables that use a C-like pseudo-code notation to expose the sequential order of data fields in the stream. These tables are normally followed by precise semantic field definitions.

4.1 SIGNALING OF VC-1 ELEMENTARY STREAMS

MPEG-2 Elementary Streams carrying VC-1 video elementary stream data shall be signaled in a Program Map Table as defined in ISO 13818-1 with Corrigendum 2 and Amendment 2.

The value of the fields in sections 4.1.1 and 4.1.2 are specified for VC-1 elementary streams. The sub-descriptor structures introduced in section 4.1.3 through 4.1.5 may only appear in an MPEG-2 Program Element conveying VC-1 elementary stream data.

4.1.1 Stream Type

The **stream_type** value in the PMT describing a VC-1 Elementary Stream should be set to 0xEA. This value indicates that this Elementary Stream is considered to be a privately-managed stream. The scope of this private value shall be captured by means of the Registration Descriptor defined below.

4.1.2 Registration Descriptor

At least one MPEG-2 **registration_descriptor()** shall be present in the inner descriptor loop of the MPEG-2 Program Element listed in the **TS_program_map_section** corresponding to the VC-1 Elementary Stream. The syntax and semantics for this descriptor appears in Table 1 and in the subsequent text.

Table 1 Syntax for the **registration_descriptor()**

Syntax	Bits	Format
registration_descriptor() {		
descriptor_tag	8	0x05
descriptor_length	8	uimsbf
format_identifier	32	0x56432D31
for(i =0; i < K; i++){		
subdescriptor()	N*8	uimsbf
}		
}		

descriptor_tag – This 8-bit field shall be set to 0x05 to identify this data structure as an MPEG-2 registration descriptor.

descriptor_length – This 8-bit field specifies the number of bytes of the descriptor immediately following the **descriptor_length** field.

format_identifier – The value for this 32-bit field shall be set to 0x56432D31

subdescriptor() – A data structure of up to 251 bytes of additional information whose syntax is determined in a case-by-case basis. The first field of a **subdescriptor()** shall be an 8-bit value known as the **subdescriptor_tag** which identifies syntax and semantics for a particular sub-descriptor. Table 2 defines values for the **subdescriptor_tag**.

Table 2 List of values applicable to the **subdescriptor_tag**

Assigned Value	Description
0x00	Indicates a null sub-descriptor. A null sub-descriptor consists only of an 8-bit **subdescriptor_tag** field.
0x01	Profile and Level subdescriptor defined as part of this document.
0x02	Alignment subdescriptor defined as part of this document.
0x03	Buffer size subdescriptor defines as part of this document
0x04 - 0xFE	SMPTE Reserved for future applications.
0xFF	Indicates a null sub-descriptor. A null sub-descriptor consists only of an 8-bit **subdescriptor_tag** field.

In the MPEG-2 Registration Descriptor specified in Table 1 above, the sub-descriptors listed in Table 2 above shall always appear in increasing order of their subdescriptor_tag value.

Note: Whenever there is a need to add a new sub-descriptor to the list in Table 2 above, it is highly recommended that the sub-descriptor tag value assigned to the new sub-descriptor be assigned the lowest available tag value. This constraint added with the aforementioned constraint that the sub-descriptor tag values appear in increasing order ensures that the most recent sub-descriptors always appear at the bottom of the MPEG-2 Registration Descriptor defined in Table 1. In the event that a new sub-descriptor is defined, such discipline ensures that the oldest sub-descriptors always appear at the beginning of the sub-descriptor list and the most recent ones at the bottom of the list. Consequently, a decoder is always capable of parsing and processing all the sub-descriptors it knows and if an unknown sub-descriptor is found, that sub-descriptor and subsequent sub-descriptors in the list, if any, can be ignored.

4.1.3 Profile and Level Subdescriptor

A Profile and Level Subdescriptor shall be used to indicate the Profile and Level applicable to the VC-1 elementary stream. Syntax and semantics for this sub-descriptor are defined in Table 3 and in the subsequent text. The **sd_profile_level()** subdescriptor signals the profile and level for the associated VC-1 Elementary Stream.

Table 3 Syntax for the Profile and Level subdescriptor

Syntax	Bits	Format
sd_profile_level() {		
subdescriptor_tag	8	0x01
profile_level	8	uimsbf

```
}
```

subdescriptor_tag – This 8-bit field shall be set to 0x01 to identify this data structure as the Profile and Level sub-descriptor.

profile_level – This 8-bit field identifies the profile and level used for encoding the VC-1 elementary stream. Given the value of the 4-bit profile metadata field defined in section J.1.1 of the SMPTE 421M specification and given the value of the 3-bit level metadata field defined in section J.1.2 of the SMPTE 421M specification, the value for the profile_level field shall be computed as follows:

```
if( profile == 0 )

    profile_level = (profile << 2) + 0x11 + (level >> 1)

else if( profile == 4 )

    profile_level = (profile << 2) + 0x41 + (level >> 1)

else if( profile == 12 )

    profile_level = (profile << 2) + 0x61 + level
```

Table 4 below shows the resulting values of the profile_level field for Simple, Main and Advanced Profile.

Table 4 List of values for the **profile_level** field

Assigned Value	Description
0x00	SMPTE Reserved
0x11	Simple Profile, Low Level
0x12	Simple Profile, Medium Level
0x13 – 0x50	SMPTE Reserved
0x51	Main Profile, Low Level
0x52	Main Profile, Medium Level
0x53	Main Profile, High Level
0x54-0x90	SMPTE Reserved
0x91	Advanced Profile, Level L0
0x92	Advanced Profile, Level L1
0x93	Advanced Profile, Level L2

0x94	Advanced Profile, Level L3
0x95	Advanced Profile, Level L4
0x96 – 0xFF	SMPTE Reserved

See Table 249 in Clause C.9 of Annex C (Hypothetical Reference Decoder) of SMPTE 421M for the maximum bitrate value and the maximum video Elementary Stream buffer size associated with each profile and level.

4.1.4 Alignment Subdescriptor

This subdescriptor provides an 8-bit **alignment_type** field to define explicitly which type of alignment exists between the coded byte sequence and a PES packet. Table 5 below describes the syntax and the subsequent text describes the semantics for this subdescriptor.

Table 5: Syntax for the Alignment subdescriptor

Syntax	Bits	Format
sd_alignment() {		
subdescriptor_tag	8	0x02
alignment_type	8	uimsbf
}		

subdescriptor_tag – This 8-bit field shall be set to 0x02 to identify this data structure as the Alignment sub-descriptor.

alignment_type – This 8-bit field identifies the alignment, if any, used for encoding the VC-1 elementary stream. Table 6 defines the permitted values.

Table 6: VC-1 Video Elementary Stream alignment values

Alignment Type	Description
0x00	SMPTE Reserved
0x01	Slice or Video Access Unit
0x02	Video Access Unit
0x03	Entry Point or Sequence

0x04	Sequence
0x05	Frame
0x05-0xFF	SMPTE Reserved

4.1.5 Buffer Size subdescriptor

The Buffer Size subdescriptor specifies the minimum size of the video elementary stream buffer EB_n (Transport Stream case - see section 4.4 below) or B_n (Program Stream, case - see section 5.4 below) needed in the decoder to decode the elementary stream conveyed in the MPEG-2 Program Element associated with this subdescriptor. This descriptor is provided to allow receivers to check compatibility of their decoding capability against the decoding requirements for the elementary stream. The buffer size associated with the VC-1 Profile and Level shall be assumed if this sub-descriptor is not present and if there no hrd parameters specified in the sequence header (this last condition is only applicable to Advanced Profile streams). Table 7 below describes the syntax and the subsequent text describes the semantics for this subdescriptor.

Table 7: Syntax for the sd_buffer_size subdescriptor

Syntax	Bits	Format
sd_buffer_size() {		
subdescriptor_tag	8	0x03
reserved	4	0xF
buffer_size_exponent	4	uimsbf
hrd_buffer	16	uimsbf
}		

subdescriptor_tag – This 8-bit field shall be set to 0x03 to identify this data structure as the Buffer Size (BS) sub-descriptor.

buffer_size_exponent – This 4-bit field shall specify the value of the exponent to use in calculating BS_n the size of the video elementary stream buffer B_n. See section 2.4.2 of ISO 13818-1. The calculation of BS_n is provided below.

hrd_buffer – This 16-bit field shall specify the value of the mantissa to use in calculating BS_n, the size of the video elementary stream buffer B_n. The calculation of BS_n is provided below.

This 4-bit **buffer_size_exponent** field and the 16-bit **hrd_buffer** field shall specify the size of the video elementary stream buffer B_n. The mantissa of B_n shall be encoded in the syntax element hrd_buffer, using a fixed length code of 16 bits, and takes the range 0 to 2^{16} -1.The value of the base-2 exponent of B_n shall be encoded in the syntax element buffer_size_exponent using a fixed length of 4 bits, and takes the range from 4 to 19. Thus, BS_n = (**hrd_buffer**+ 1) * $2^{(\mathbf{buffer\_size\_exponent} + 4)}$.

The resulting video elementary stream buffer size value shall not exceed the maximum video elementary stream buffer size for the profile and level associated with the VC-1 elementary stream.

Note: If the buffer size subdescriptor is not present, then the buffer size shall be the size of the video elementary stream buffer associated with the profile and level determined in the profile_level subdescriptor.

4.1.6 Other ISO/IEC 13818-1 Elementary Stream Descriptors

MPEG-2 Systems defines multiple descriptors that under certain conditions could be used to provide additional information about Elementary Streams in a PMT. Some of those descriptors are specific to the carriage of MPEG-2 audio or MPEG-2 video streams, and therefore cannot be used in the context of VC-1 Elementary Streams. Other descriptors provide complementary functionality (e.g. conditional access) and may be used in the context of VC-1 elementary streams. Descriptors defined in ISO 13818-1 that may be associated with a VC-1 elementary stream include:

target_background_grid_descriptor()

video_window_descriptor()

CA_descriptor()

ISO_639_language_descriptor()

multiplex_buffer_utilization_descriptor()

smoothing_buffer_descriptor()

copyright_descriptor()

maximum_bitrate_descriptor()

private_data_indicator_descriptor()

IBP_descriptor()

STD_descriptor

In particular, the data_stream_alignment_descriptor() shall not be used in association with an MPEG-2 Program Element conveying VC-1 elementary stream data. See the **sd_alignment** sub-descriptor defined in section 4.1.4 for a functional equivalent of the data_stream_descriptor() that is specific to VC-1 elementary streams.

4.1.7 PMT Descriptors for Programs or Services

ISO 13818-1 and its Corrigendum 2 and Amendment 2 define descriptors that apply at the MPEG-2 program level. MPEG-2 Program-level descriptors appear in the program-level loop of a PMT (also known as the outer loop). Systems that carry VC-1 Elementary Streams in a program (or service) shall follow the rules and recommendations for program-level descriptors defined in the MPEG-2 suite of documents.

Compliance with other standards that build on top of MPEG-2 Transport Streams, like digital television standards, may require support for additional program-level descriptors which may appear in a PMT for a program using a VC-1 Elementary Stream.

4.2 ENCAPSULATION OF VC-1 ELEMENTARY STREAMS

VC-1 coded data encapsulated in PES packets shall comply with PES encapsulation procedures defined by ISO 13818-1 and its Corrigendum 2 and Amendment 2. This section of the document establishes methods for using PES header fields for VC-1 streams.

The PES packet header fields identified in section 4.2.1 through 4.2.12 are the fields for which the semantics are modified and/or enhanced when the PES packet payload includes VC-1 elementary stream data bytes. Any other fields in the PES packet header shall assume their original semantics as defined in ISO 13818-1.

4.2.1 PES packet length

The semantics associated with the PES_packet_length field value 0 shall be extended to VC-1 video elementary streams.

PES_packet_length – A 16-bit field specifying the number of bytes in the PES packet following the last byte of the field. A value of 0 indicates that the PES packet length is neither specified nor bounded and is allowed only in PES packets whose payload consists of bytes from a video elementary stream contained in Transport Stream packets. The latter definition shall be applicable to VC-1 video elementary stream as long as they are properly signaled in the Transport Stream and constructed according to the rules set forth in section 4.1.1 and 4.1.2 above.

4.2.2 Stream ID

For VC-1 elementary streams encapsulated in PES packets, the value for **stream_id** shall be set to 0xFD to indicate the use of an extension mechanism defined in ISO 13818-1, Amendment 2.

4.2.3 Data Alignment Indicator

This flag is used independently or in conjunction with the Data Stream Alignment descriptor to indicate the type of alignment that exists between a VC-1 elementary bitstream and the start of a PES packet.

For VC-1 elementary streams, the **data_alignment_indicator** shall follow the same semantics as in ISO 13818-1, except that it applies to the Data Alignment subdescriptor values defined in Table 6 above. In particular, the **data_alignment_indicator** in the PES header shall be set to ‘1’ if there is a Data Alignment subdescriptor associated with the VC-1 elementary stream in the PMT. If **data_alignment_indicator** is set to ‘1’ and there is no Data Alignment subdescriptor associated with the VC-1 elementary stream in the PMT, the default alignment type value shall be equal to 0x02. The **data_alignment_indicator** value ‘0’ indicates that the alignment is unspecified. For Simple or Main profile VC-1 elementary streams, the value of the **data_alignment_indicator** field shall always be set to ‘1’ and there shall not be any Data Alignment subdescriptor associated with the VC-1 elementary stream.

4.2.4 Time Stamps (PTS and DTS)

For VC-1 streams, PTS and DTS time stamps are used in exactly the same manner as they are used for MPEG-2 video streams. In particular, the value of the PTS and DTS fields shall pertain to the first video access unit that starts in the payload of the PES packet.

4.2.5 Extension Flags

VC-1 video streams encapsulated in PES packets use the **stream_id_extension** to provide unambiguous identification of video packets. Enabling the use of this field requires providing the proper values for the three flags described next.

- The **PES_extension_flag** shall be set to ‘1’ to enable the insertion of extensions in the PES packet header.

- The **PES_extension_flag_2** shall be set to ‘1’ to enable the insertion of the second group of extensions in the PES packet header.

- The **stream_id_extension_flag** shall be set to ‘0’ to enable the insertion of a valid **stream_id_extension** field.

4.2.6 Stream ID Extension

For VC-1 Elementary Streams, the **stream_id_extension** field defined in ISO 13818-1, Amendment 2 shall have any value in the range between 0x55 and 0x5F. These values are defined within the allowed private range in ISO 13818-1, Amendment 2.

The **registration_descriptor()** in the inner descriptor loop of the MPEG-2 Program Element in the **TS_program_map_section** corresponding to a VC-1 Elementary Stream, together with the combination of **stream_id** and **stream_id_extension,** unambiguously define the stream of PES packets carrying VC-1 video data.[2]

4.2.7 Discontinuity Indicator

For VC-1 Elementary Streams, the discontinuity indicator field shall adopt the following semantics:

discontinuity_indicator – This is a 1-bit field which when set to '1', indicates that the discontinuity state is true for the current Transport Stream packet. When the **discontinuity_indicator** is set to '0' or is not present, the discontinuity state is false. The discontinuity indicator is used to indicate two types of discontinuities, system time-base discontinuities and **continuity_counter** discontinuities.

A system time-base discontinuity is indicated by the use of the **discontinuity_indicator** in Transport Stream packets of a PID designated as a **PCR_PID** (refer to 2.4.4.9 in ISO 13818-1). When the discontinuity state is true for a Transport Stream packet of a PID designated as a PCR_PID, the next PCR in a Transport Stream packet with that same PID represents a sample of a new system time clock for the associated program. The system time-base discontinuity point is defined to be the instant in time when the first byte of a packet containing a PCR of a new system time-base arrives at the input of the Transport System Target Decoder (T-STD).
The **discontinuity_indicator** shall be set to '1' in the packet in which the system time-base discontinuity occurs. The **discontinuity_indicator** bit may also be set to '1' in Transport Stream packets of the same **PCR_PID** prior to the packet which contains the new system time-base PCR. In this case, once the **discontinuity_indicator** has been set to '1', it shall continue to be set to '1' in all Transport Stream packets of the same **PCR_PID** up to and including the Transport Stream packet which contains the first PCR of the new system time-base. After the occurrence of a system time-base discontinuity, no fewer than two PCRs for the new system time-base shall be received before another system time-base discontinuity can occur. Further, except when trick mode status is true, data from no more than two system time-bases shall be present in the set of T-STD buffers for one program at any time.

Prior to the occurrence of a system time-base discontinuity, the first byte of a Transport Stream packet which contains a PTS or DTS which refers to the new system time-base shall not arrive at the input of the T-STD. After the occurrence of a system time-base discontinuity, the first byte of a Transport Stream packet which contains a PTS or DTS which refers to the previous system time-base shall not arrive at the input of the T-STD.

A **continuity_counter** discontinuity shall be indicated by the use of the **discontinuity_indicator** in any Transport Stream packet. When the discontinuity state is true in any Transport Stream packet of a PID not designated as a **PCR_PID**, the **continuity_counter** in that packet may be discontinuous with respect to the previous Transport Stream packet of the same PID. When the discontinuity state is true in a Transport Stream packet of a PID that is designated as a **PCR_PID**, the **continuity_counter** may only be discontinuous in the packet in which a system time-base discontinuity occurs. A continuity counter discontinuity point occurs when the discontinuity state is true in a Transport Stream packet and the **continuity_counter** in the same packet is discontinuous with respect to the previous Transport Stream packet of the same PID. A continuity counter discontinuity point shall occur at most one time from the initiation of the discontinuity state until the conclusion of the discontinuity state. Furthermore, for all PIDs that are not designated as PCR_PIDs, when the **discontinuity_indicator** is set to '1' in a packet of a specific PID, the **discontinuity_indicator** may be set to '1' in the next Transport Stream packet of that same PID, but shall not be set to '1' in three consecutive Transport Stream packet of that same PID.
For the purpose of this clause, a VC-1 access point is defined as follows:

- The first byte of a VC-1 sequence header if there is no sequence start code preceding the sequence header
- The first byte of the sequence start code if a sequence start code immediately precedes the sequence header,

After a continuity counter discontinuity in a Transport packet which is designated as containing VC-1 data is received, the first byte of elementary stream data in a Transport Stream packet of the same PID shall be the first byte of a VC-1 access point or a VC-1 end-of-sequence start code followed by an access point. Each Transport Stream packet which contains elementary stream data with a PID not designated as a **PCR_PID**, and in which a continuity counter discontinuity point occurs, and in which a PTS or DTS occurs, shall arrive at the input of the T-

[2] Note to the Editor: The value of the VC-1 format_identifier field in the MPEG-2 Registration Descriptor as well as the values of the stream_id_extension field used by VC-1 need to be communicated to the appropriate industry SDO's so they can update their code point documents accordingly.

STD after the system time-base discontinuity for the associated program occurs. In the case where the discontinuity state is true, if two consecutive Transport Stream packets of the same PID occur which have the same **continuity_counter** value and have **adaptation_field_control** values set to '01' or '11', the second packet may be discarded. A Transport Stream shall not be constructed in such a way that discarding such a packet will cause the loss of PES packet payload data or PSI data.

After the occurrence of a **discontinuity_indicator** set to '1' in a Transport Stream packet which contains PSI information, a single discontinuity in the version_number of PSI sections may occur. At the occurrence of such a discontinuity, a version of the **TS_program_map_sections** of the appropriate program shall be sent with **section_length** = = 13 and the **current_next_indicator** = = 1, such that there are no program_descriptors and no elementary streams described. This shall then be followed by a version of the **TS_program_map_section** for each affected program with the **version_number** incremented by one and the **current_next_indicator** = = 1, containing a complete program definition. This indicates a version change in PSI data.

4.2.8 Random Access Indicator

For VC-1 elementary streams, the Random Access Indicator field shall adopt the following semantics:

random_access_indicator – The **random_access_indicator** is a 1-bit field that indicates that the current Transport Stream packet, and possibly subsequent Transport Stream packets with the same PID, contain some information to aid random access at this point. Specifically, when the bit is set to '1', the next PES packet to start in the payload of Transport Stream packets with the current PID shall contain the first byte of a VC-1 Access Point as defined in the semantics of the **discontinuity_indicator** field. In addition, a presentation timestamp shall be present in the PES packet containing the first picture following the VC-1 Access Point.

4.2.9 Elementary Stream Priority Indicator

For VC-1 elementary streams, the Elementary Stream Priority Indicator field shall adopt the following semantics:

elementary_stream_priority_indicator – The **elementary_stream_priority_indicator** is a 1-bit field. It indicates, among packets with the same PID, the priority of the elementary stream data carried within the payload of this Transport Stream packet. A '1' indicates that the payload has a higher priority than the payloads of other Transport Stream packets. In the case of a VC-1 elementary stream, this field may be set to '1' only if the payload contains one or more bytes from an intra-coded slice. A value of '0' indicates that the payload has the same priority as all other packets which do not have this bit set to '1'.

4.2.10 Splice Countdown

For VC-1 elementary streams, the Splice Countdown field shall adopt the following semantics:

splice_countdown – The **splice_countdown** is an 8-bit field representing a value which may be positive or negative. A positive value specifies the remaining number of Transport Stream packets, of the same PID, following the associated Transport Stream packet until a splicing point is reached. Duplicate Transport Stream packets and Transport Stream packets which only contain adaptation fields are excluded. The splicing point is located immediately after the last byte of the Transport Stream packet in which the associated **splice_countdown** field reaches zero. In the Transport Stream packet where the **splice_countdown** reaches zero, the last data byte of the Transport Stream packet payload shall be the last byte of a coded audio frame or a coded picture. In the case of VC-1 elementary streams, the corresponding access unit may or may not be terminated by an end-of-sequence start code. Transport Stream packets with the same PID, which follow, may contain data from a different elementary stream of the same type.The payload of the next Transport Stream packet of the same PID (duplicate packets and packets without payload being excluded) shall commence with the first byte of a PES packet. In the case of a VC-1 elementary stream, the PES packet payload shall commence with a VC-1 Access Point as defined in the semantics of the **discontinuity_indicator** field or with a VC-1 end-of-sequence start code followed by an access point. Thus, the previous coded picture aligns with the packet boundary, or is padded to make this so. Subsequent to the splicing point, the countdown field may also be present. When the splice_countdown is a negative number whose value is minus n (−n), it indicates that the associated Transport Stream packet is the n-th packet following the splicing point (duplicate packets and packets without payload being excluded). For the definition of a VC-1 entry point, see semantics of the discontinuity indicator field.

4.2.11 Seamless Splice Flag

For VC-1 elementary streams, the Seamless Splice Flag field shall adopt the following semantics:

seamless_splice_flag – This is a 1-bit flag which when set to '1', indicates that the **splice_type** and **DTS_next_AU** fields are present. A value of '0' indicates that neither **splice_type** nor **DTS_next_AU** fields are present. This field shall not be set to '1' in Transport Stream packets in which the splicing_point_flag is not set to '1'. Once it is set to '1' in a Transport Stream packet in which the splice_countdown is positive, it shall be set to '1' in all the subsequent Transport Stream packets of the same PID that have the splicing_point_flag set to '1', until the packet in which the **splice_countdown** reaches zero (including this packet). When this flag is set and for a VC-1 elementary stream, it shall fulfil the constraints indicated by the splice_type value.

4.2.12 Splice Type

For VC-1 elementary streams, the Splice Type field shall adopt the following semantics:

splice_type – This is a 4-bit field. From the first occurrence of this field onwards, it shall have the same value in all the subsequent Transport Stream packets of the same PID in which it is present, until the packet in which the splice_countdown reaches zero (including this packet). For a VC-1 video elementary stream, the value of this field shall always be set to '0000'.

4.3 PES PACKET PAYLOAD FORMAT HEADER

4.3.1 VC-1 Simple and Main Profile

For VC-1 Simple or Main Profile elementary streams, a VC-1_SPMP_PESpacket_PayloadFormatHeader() structure shall be present at the beginning of every access unit. A VC-1_SPMP_PESpacket_PayloadFormatHeader() shall always start with a **start_code** representing a sequence start code (value '0x0000010F') or a frame start code **(**value '0x0000010D').

With the exception of the actual start code fields, Start Code Emulation Prevention shall be applied to all bytes in the VC-1_SPMP_PESpacket_PayloadFormatHeader() structure and in the PES packet payload bytes following that structure to protect the start codes from occurring in any other locations in the PES packet payload. The start code emulation prevention mechanism is described in Annex E of SMPTE 421M.

The STRUC_SEQUENCE_HEADER_C() structure shown in Table 8 below corresponds to the sequence header for the VC-1 Simple Profile or VC-1 Main Profile. See Clause J..2 in Annex J (External Metadata) of SMPTE 421M for a definition of the STRUCT_SEQUENCE_HEADER_C() metadata structure.

Table 8: VC-1_SPMP_PESpacket_PayloadFormatHeader() structure

Syntax	Bits	Format
VC-1_SPMP_PESpacket_PayloadFormatHeader()		
{		
start_code	32	0x0000010F or 0x0000010D
if(start_code == 0x0000010F)		
{		
frame_width	16	uimsbf

frame_height	16	uimsbf
STRUCT_SEQUENCE_HEADER_C()	32	bslbf
start_code	32	0x0000010D
}		
else if (start_code == 0x0000010D)		
{		
}		
}		

4.3.2 VC-1 Advanced Profile

The format of the PES packet header and PES packet payload shall follow the format defined in ISO 13818-1. There shall not be any VC-1_SPMP_PESpacket_PayloadFormatHeader() structure at the beginning of any PES packet payload.

4.4 T-STD BUFFER MODEL FOR VC-1 STREAMS

4.4.1 Transport System Target Decoder

Delivery of VC-1 Elementary Streams in MPEG-2 Transport Streams shall be governed by a Transport System Target Decoder Buffer Model (T-STD) as defined in ISO 13818-1.

The T-STD model for delivery of VC-1 Elementary Stream 'n' includes a transport buffer TB_n , a multiplex buffer MB_n and a Element Stream Buffer EB_n prior to decoding each individual video access unit. Figure 1 illustrates the model and Table 9 describes the elements and the notation used for the block diagram.

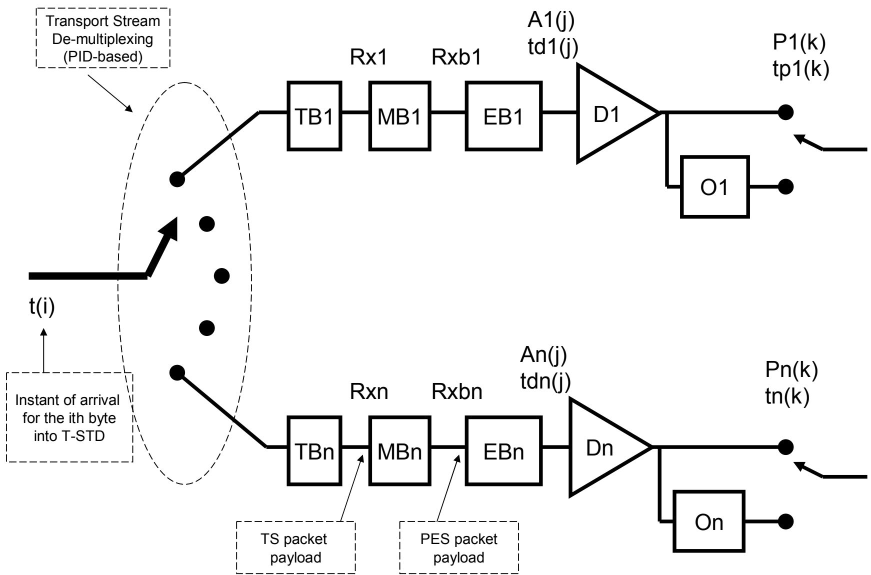

Figure 1: Transport System Target Decoder for VC-1 streams

Table 9 Buffer Model Elements and Terms

TB_n	The transport buffer for VC-1 Elementary Stream 'n'
MB_n	The multiplexing buffer for VC-1 Elementary Stream 'n'.
EB_n	The Elementary Stream buffer for VC-1 Elementary Stream 'n'
TBS_n	The size of buffer TB_n
BS_n	The size of buffer MB_n
EBS_n	The size of buffer EB_n
D_n	The decoder for VC-1 Elementary Stream 'n'.
O_n	The re-order buffer for VC-1 Elementary Stream 'n'.
Rx_n	The rate at which data are removed from TB_n.
Rbx_n	The rate at which PES packet payload data are removed from MB_n when the leak method is used.
$A_n(j)$	The j^{th} access unit in VC-1 Elementary Stream 'n'. $A_n(j)$ is indexed in decoding order.
$td_n(j)$	The decoding time, measured in seconds, in the system target decoder of the jth access unit in Elementary Stream 'n'.
$P_n(k)$	The k^{th} presentation unit in VC-1 Elementary Stream 'n' resulting from

decoding $A_n(k)$. $P_n(k)$ are indexed in presentation order.

$tp_n(k)$ The presentation time, measured in seconds, in the system target decoder of the k^{th} presentation unit in Elementary Stream 'n'.

t(i) The time in seconds at which the i^{th} byte of the Transport Stream enters the system target decoder.

4.4.2 Mode of Operation

The main model constraints impose that buffer TB_n shall not overflow. Also, buffer MB_n and buffer EB_n shall not overflow. Furthermore, buffer EB_n shall not underflow except when the value of the HRD_PARAM_FLAG field in the sequence header of the VC-1 elementary stream is equal to '0', in which case the codec operates in variable delay mode as described in section C.7 of SMPTE 421M.

4.4.3 Operation of Buffer TBn

Complete Transport Stream packets containing data from the n-th VC-1 Elementary Stream are passed to the transport buffer for stream 'n', TB_n. This includes duplicate Transport Stream packets and packets with no payload. Transfer of the i-th byte from the system target decoder input to TB_n is instantaneous, so that the i-th byte enters the buffer for stream 'n', of size TBS_n, at time t(i).

All bytes that enter the buffer TB_n are removed at the rate Rx_n specified below. Bytes which are part of the PES packet or its content are delivered to the multiplexing buffer MB_n. Other bytes (for example, bytes from the Transport Stream packet header) are not delivered to the multiplexing buffer MB_n and may be used to control the system. Duplicate Transport Stream packets are not delivered to B_n.

The size of buffer TB_n, known as TBS_n, shall be equal to 512 bytes. The buffer TB_n shall be emptied as follows:

- When there is no data in TB_n,

$$Rx_n = 0$$

- Otherwise,

$$Rx_n = 1.2 \times R_{max}[\text{profile, level}]$$

where R_{max}[profile, level] is specified in Table 249 in Clause C.9 of Annex C (Hypothetical Reference Decoder) of SMPTE 421M.

The rate Rx_n shall be measured with respect to the System Time Clock reconstructed in the receiver.

4.4.4 Operation of Buffer MBn:

The multiplexing buffer size BS_n is defined as follows:

$$BS_n = BS_{mux} + BS_{oh}$$

where BS_{oh} accounts for the PES packet overhead buffering and is defined herein as:

$$BS_{oh} = (1/750)\text{ seconds} \times R_{max}[\text{profile, level}]$$

and BS_{mux} accounts for additional multiplex buffering and is defined herein as:

$$BS_{mux} = 0.004 \text{ seconds} * R_{max}[\text{profile, level}]$$

The transfer of data from MB_n to EB_n shall be governed by a leak method. Use of a leak method shall be signaled via one of the following two methods:

- There is no MPEG-2 **STD_descriptor()** present in the inner descriptor loop of the MPEG-2 Program Element in the **TS_program_map_section** corresponding to the VC-1 Elementary Stream.
- An MPEG-2 **STD_descriptor()** is present in the inner descriptor loop of the MPEG-2 Program Element in the **TS_program_map_section** corresponding to the VC-1 Elementary Stream and the **leak_valid** flag has the value '1'

The leak method transfers data from MB_n to EB_n using the leak rate Rbx_n where

$$Rbx_n = R_{max}[\text{profile, level}]$$

If there is PES packet payload data in MB_n and the buffer EB_n is not full, PES packet payload bytes are transferred from MB_n to EB_n at rate Rbx_n. If EB_n is full, data is not removed from MBn. When a byte of data is transferred from MB_n to EB_n, all PES packet header bytes that are in MB_n and immediately precede that byte are instantaneously removed and discarded. When there is no PES packet payload data present in MB_n, no data is removed from MB_n. All data that enters MB_n leaves it. All PES packet payload data bytes except any stuffing bytes appearing before a start code enter EB_n instantaneously upon leaving MB_n. This means that only access unit bytes enter the video elementary stream buffer. Any stuffing bytes before a start code do not enter EB_n and are discarded but may be used to control the system.

4.4.5 Operations of Buffer EBn

The default size of the Elementary Stream buffer EB_n , EBS_n , shall be the VBV_{max}[profile, level] associated with the profile and level of the VC-1 Elementary Stream, as specified in SMPTE 421M. The profile and level may be identified by the field **profile_level** in the **sd_profile_level()** sub-descriptor.

With the assumption that the incoming service delivery rate R is known (for example, by means of the **ES_rate_flag** and the **ES_rate** field in the PES header), a receiver may opt to use a smaller Elementary Stream buffer for its internal representation of the Hypothetical Reference Decoder. However, the size of the Elementary Stream buffer shall always be equal or the minimum buffer value B_{min} specified by the Generalized Hypothetical Reference Decoder for rate R. See Section C.2 and C.4 of SMPTE 421M. In this case, the size of the Elementary Stream buffer may be computed from the value of the fields **bit_rate_exponent**, **buffer_size_exponent, hrd_buffer[], hrd_rate[]** and the **bit_rate_exponent** fields listed in the **hrd_parameters()** structure of the sequence header, if present. The buffer size $EBS_n[k]$ for the kth buffer model in **hrd_parameters()** may be computed from its respective **hrd_buffer[k]** and **buffer_size_exponent** fields as follows:

$$EBS_n[k] = (hrd\_buffer[k]+1)\ 2^{\,buffer\_size\_exponent+4} \text{ (in units of bits)}$$

and the associated rate R[k] may be computed from the hrd_rate[k] and the bit_rate_exponent fields as follows:

$$R[k] = (hrd\_rate[k]+1)\ 2^{\,bit\_rate\_exponent+6} \text{ (in bits/sec)}$$

The value ESB_n selected for the Elementary Stream buffer EB_n shall not exceed the value of VBV_{max}[profile, level] associated with the profile and level for the VC-1 Elementary Stream as specified by the field **profile_level** in the **sd_profile_level()** sub-descriptor.

4.4.6 Decoding and Presentation

Each VC-1 Video Access Unit within an Elementary Stream shall be extracted from buffer EB_n at time $td_n(j)$ and is decoded instantaneously by decoder D_n and may be delayed in a re-order buffer O_n before being presented at the output of the T-STD. Re-order buffers are used only in the case of a VC-1 video stream where some access units are not carried in presentation order. These access units shall be re-ordered before presentation. In particular, if $P_n(k)$ is an I-picture or a P-picture carried before one or more B-pictures, then it shall be delayed in the re-order buffer, O_n, of the T-STD before being presented.

Any picture previously stored in O_n is presented before the current picture may be stored. $P_n(k)$ should be delayed until the next I-picture or P-picture is decoded. While it is stored in the re-order buffer, the subsequent B-pictures are decoded and presented.

The time at which $P_n(k)$ shall be presented is $tp_n(k)$. For presentation units that do not require re-ordering delay, $tp_n(k)$ shall be equal to $td_n(j)$ since the access units are decoded instantaneously; this is the case for B-frames. For presentation units that are delayed, $tp_n(k)$ and $td_n(j)$ shall differ by the time that $P_n(k)$ is delayed in the re-order buffer, which is a multiple of the nominal picture period.

Decoding times $td_n(j+1)$, $td_n(j+2)$, ... of access units without encoded DTS or PTS fields which directly follow access unit 'j' in the same PES packet may be derived from the frame or field rate information in the Elementary Stream.

For any access unit associated with one or more hrd_fullness[] values (the first access unit after an Entry Point Header), the decoding time shall be the instant of the System Time Clock corresponding to the time when the buffer fullness is achieved in the video elementary stream buffer.

4.4.7 Decoding of first Access Unit following an Entry Point start code

To minimize start-up latency and with the assumption that the incoming service data rate R is known (for example, by means of the **ES_rate_flag** and the **ES_rate** field in the PES header), a decoder may opt to use the **hrd_fullness[]**, the **hrd_rate[]** and **bit_rate_exponent** fields listed in the **hrd_parameters** structure of the sequence header and the corresponding value of the **hrd_fullness[]** fields in the entry point header to determine when to initiate the decoding of the first video access unit following an Entry Point header. However, the value of the Elementary Stream Buffer fullness used in this situation shall always be equal or greater than the minimum fullness value F_{min} specified by the Generalized Hypothetical Reference Decoder for data rate R. See Section C.2 and C.4 of SMPTE 421M.

4.4.8 Rates and Buffer Sizes

The rates and buffer sizes for the different profiles and levels supported by VC-1 are listed in Table 249 in Clause C.9 of Annex C (Hypothetical Reference Decoder) of SMPTE 421M.

5 MPEG-2 Program Stream Encoding

5.1 SIGNALING OF VC-1 ELEMENTARY STREAMS

The stream type value 0xEA as defined in section 4.1.1 and the usage of the registration descriptor and sub-descriptors as defined in section 4.1.2 through 4.1.5 shall also be applicable to the carriage of a VC-1 elementary stream in an MPEG-2 Program Stream. The only difference is the fact that in the case of an MPEG-2 Program Stream, the structure where these fields and structures are used is the Program Stream Map as opposed to the Program Map Table which is only relevant to MPEG-2 Transport Streams. Also, in MPEG-2 Program Streams, use of the registration descriptor and its sub-descriptors as described in sections 4.2.2 through 4.2.5 is optional

5.2 ENCAPSULATION OF VC-1 ELEMENTARY STREAMS

Encapsulation of a VC-1 Elementary Stream in an MPEG-2 Program Stream shall follow the same rules defined for MPEG-2 Transport Streams in section 4.3.

5.3 PES PACKET PAYLOAD FORMAT HEADER

Payload format shall be identical to the format described in section 4.4.

5.4 P-STD BUFFER MODEL FOR VC-1 STREAMS

5.4.1 Program Stream Target Decoder

Delivery of VC-1 Elementary Streams in MPEG-2 Program Streams shall be governed by a Program System Target Decoder Buffer Model (P-STD) as defined in ISO 13818-1.

The P-STD model for delivery of VC-1 Elementary Stream 'n' includes an input buffer B_n prior to decoding each individual video access unit. Figure 2 illustrates the model and Table 11 describes the elements and the notation used for the block diagram.

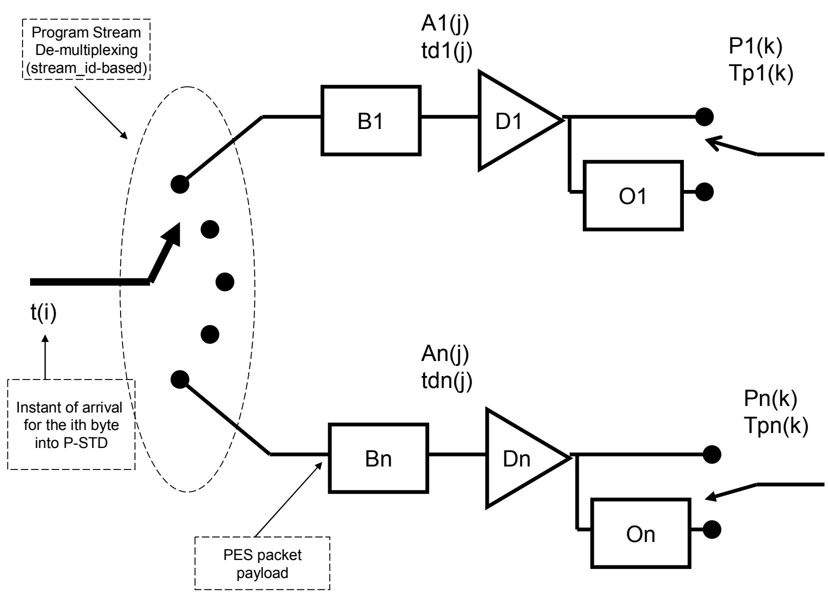

Figure 2: Transport System Target Decoder for VC-1 streams

Table 11: Buffer Model Elements and Terms

B_n	The input buffer for VC-1 Elementary Stream 'n'
BS_n	The size of buffer B_n

D_n The decoder for VC-1 Elementary Stream 'n'.

O_n The re-order buffer for VC-1 Elementary Stream 'n'.

$A_n(j)$ The j^{th} access unit in VC-1 Elementary Stream 'n'. $A_n(j)$ is indexed in decoding order.

$td_n(j)$ The decoding time, measured in seconds, in the system target decoder of the jth access unit in Elementary Stream 'n'.

$P_n(k)$ The k^{th} presentation unit in VC-1 Elementary Stream 'n' resulting from decoding $A_n(k)$. $P_n(k)$ are indexed in presentation order.

$tp_n(k)$ The presentation time, measured in seconds, in the system target decoder of the k^{th} presentation unit in Elementary Stream 'n'.

t(i) The time in seconds at which the i^{th} byte of the Programt Stream enters the system target decoder.

5.4.2 Mode of Operation

The input buffers B1 through Bn in the P-STD shall not overflow. Furthermore, they shall not underflow except when the value of the HRD_PARAM_FLAG field in the sequence header of the VC-1 elementary stream is equal to '0', in which case the codec operates in variable delay mode as described in section C.7 of SMPTE 421M.

5.4.3 Operation of Buffer Bn

Data enter the P-STD at the rate specified by the value of the field program_mux_rate in the pack header. The PES packet data bytes from VC-1 elementary stream n are passed to the input buffer Bn. Transfer of byte i from the system target decoder input to Bn is instantaneous, so that byte i enters the buffer for stream n, of size BSn, at time t(i). Bytes present in the pack header, system headers, Program Stream Maps, PES packet headers of the Program Stream do not enter Bn and may be used to control the system. Any stuffing bytes before a start code do not enter B_n. This means that only data access unit bytes enter the video elementary stream buffer.

Unless specified by the P-STD_buffer_scale and P-STD_buffer_size field in the PES header, the input buffer sizes BS1 through BSn are equal to the sum of the vbv_max[profile,level] value associated with the profile and level of the VC-1 elementary stream and the value BSadd as defined in clause 2.7.9 of ISO 13818-1.

With the assumption that the incoming service delivery rate R is known (for example, by means of the **ES_rate_flag** and the **ES_rate** field in the PES header), a receiver may opt to use a smaller Elementary Stream buffer for its internal representation of the Hypothetical Reference Decoder. However, the size of the Input Buffer shall always be equal or the minimum buffer value B_{min} specified by the Generalized Hypothetical Reference Decoder for rate R. See Section greater that C.2 and C.4 of SMPTE 421M. In this case, the size of the Elementary Stream buffer may be computed from the value of the fields **bit_rate_exponent**, **buffer_size_exponent, hrd_buffer[], hrd_rate[]** and the **bit_rate_exponent** fields listed in the **hrd_parameters()** structure of the sequence header, if present. The buffer size $BS_n[k]$ for the kth buffer model in **hrd_parameters()** may be computed from its respective **hrd_buffer[k]** and **buffer_size_exponent** fields as follows:

$$BS_n[k] = \text{hrd\_buffer}[k]\ 2^{\text{buffer\_size\_exponent}+4} \text{ (in units of bits)}$$

and the associated rate R[k] may be computed from the hrd_rate[k] and the bit_rate_exponent fields as follows:

$$R[k] = \text{hrd\_rate}[k]\ 2^{\text{bit\_rate\_exponent}+6} \text{ (in bits/sec)}$$

The value BS_n selected for the Elementary Stream buffer B_n shall not exceed the value of VBV_{max}[profile, level] associated with the profile and level for the VC-1 Elementary Stream as specified in Table 249 in Clause C.9 of the Annex C of SMPTE 421M]. The profile and level may be identified by the field **profile_level** in the **sd_profile_level()** sub-descriptor.

5.4.4 Decoding and Presentation

Decoding and presentation rules are identical to those described in section 4.5.7

5.4.5 Decoding of first Access Unit following an Entry Point start code

Use of the information in the hrd_parameters structure of the VC-1 elementary stream is similar to that described in section 4.5.8

5.4.6 Buffer sizes

The values of vbv_max[profile,level] are listed in Table 249 in Clause C.9 of Annex C (Hypothetical Reference Decoder) of SMPTE 421M.

6 Bibliography

ATSC A/65B, Program and System Information Protocol for Terrestrial Broadcast and Cable (Revision A) and Amendments No. 1A, 2, and 3.

ANSI/SCTE 65 2002, Service Information Delivered Out-Of-Band for Digital Cable Television, 2002.

ETSI EN 300 468. Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems.

ATSC A/53B, ATSC Standard: Digital Television Standard, Revision B, with Amendment 1.

ATSC T3-580, Draft Amendment No. 2 to ATSC Digital Television Standard.

ANSI/SCTE 54 2004 Digital Video Service Multiplex and Transport System for Cable Television, 2004.

ETSI TR 101 154 v1.4.1, Digital Video Broadcasting (DVB); Implementation guidelines for the use of MPEG-2 Systems, Video and Audio in satellite, cable and terrestrial broadcasting applications.

ATSC T3-548, ATSC Usage of the MPEG-2 Registration Descriptor, Technology Group Report, October 9, 2001.

ATSC T3-549, Collision Avoidance for Private Fields and Ranges, Technical Group Report, October 9, 2001.

Microsoft "Advanced Systems Format (ASF) Specification," http://www.microsoft.com/windows/windowsmedia/format/asfspec.aspx .

Annex A (informative)[3]

Graphics of Syntax for this SMPTE Recommended Practice

A.1 Introduction

This annex is an informative annex preseting graphically the Transport Stream and Program Stream syntax for VC-1 elementary stream syntax. In order to produce clear drawings, not all the fields have been fully described or represented. Reserved fields may be omitted or indicated by areas with no detail. Field lengths are indicated in units of bits.

Section F.0.1 (Transport Stream Syntax), F.0.3 (Program Association Section), F.0.4 (CA section), F.0.6 (Private Section) and F.0.7 (Program Stream) of Annex F in ISO 13818-1 remain unchanged and are not reproduced herein

A.2 PES packet

See Figure A.1

[3] Figures derived from ISO/IEC 13818-1:2000, Annex F, and used with permission of ISO

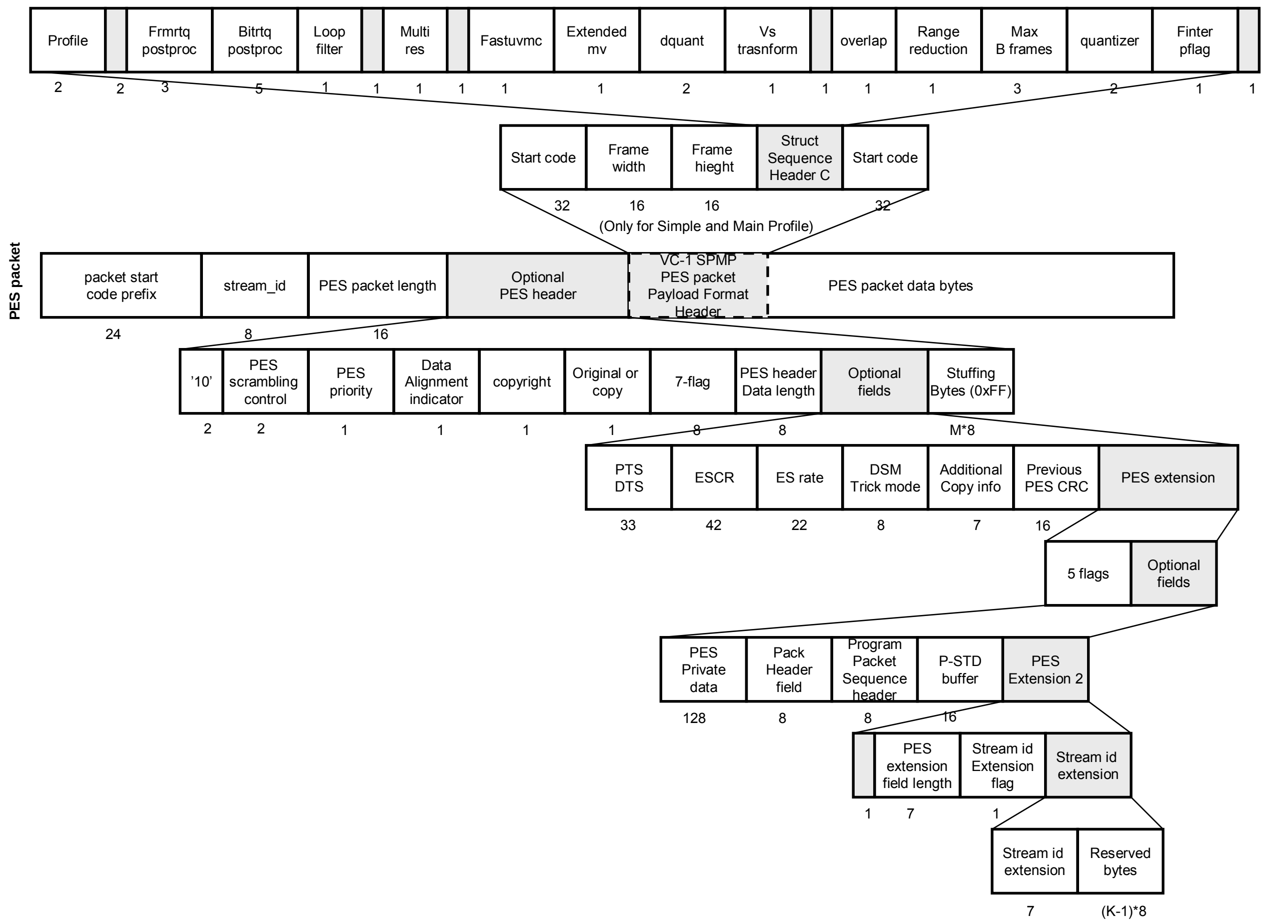

Figure A.1 – PES packet syntax diagram for VC-1 elementary stream

A.3 TS Program Map Section

See Figure A.2

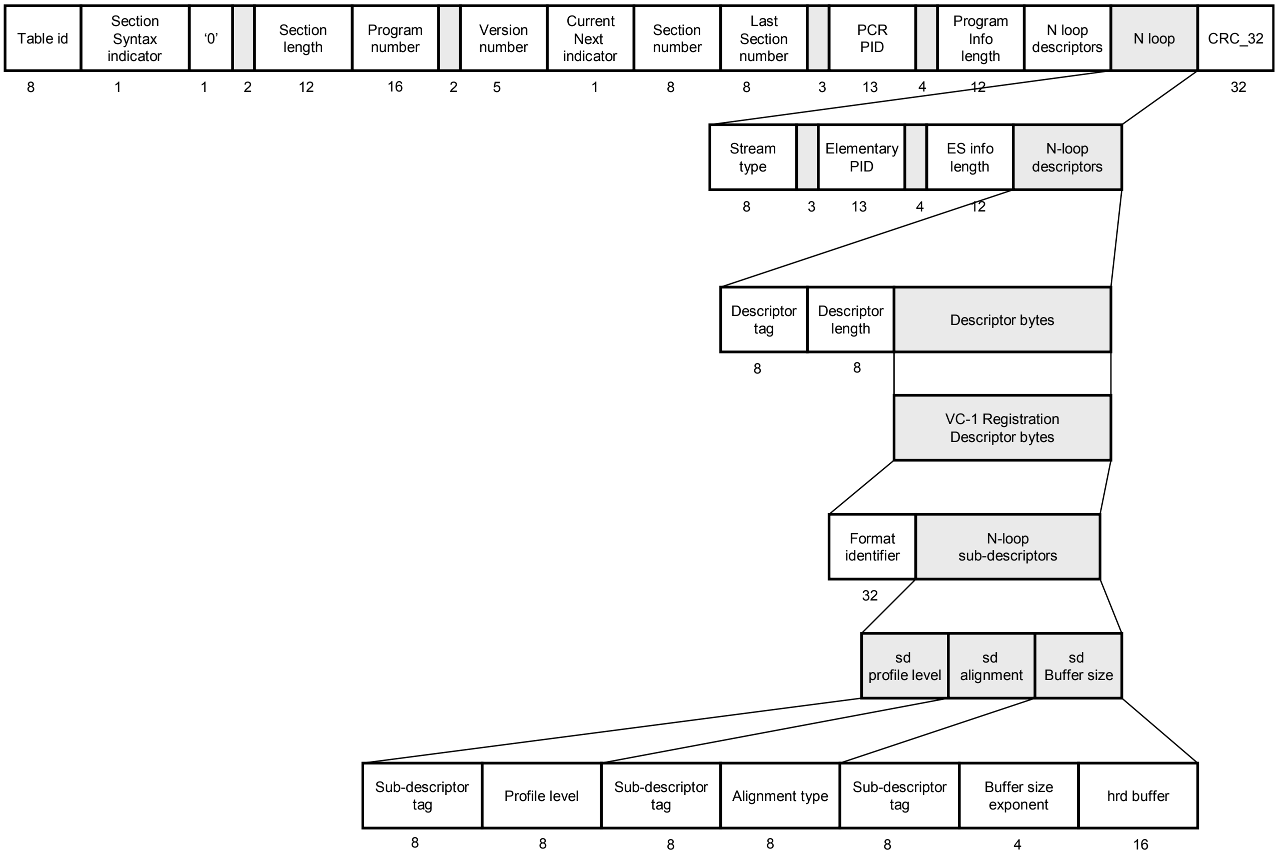

Figure A.2 – TS Prgram Map Section diagram for VC-1 elementary stream

A.4 Program Stream Map

See Figure A.3

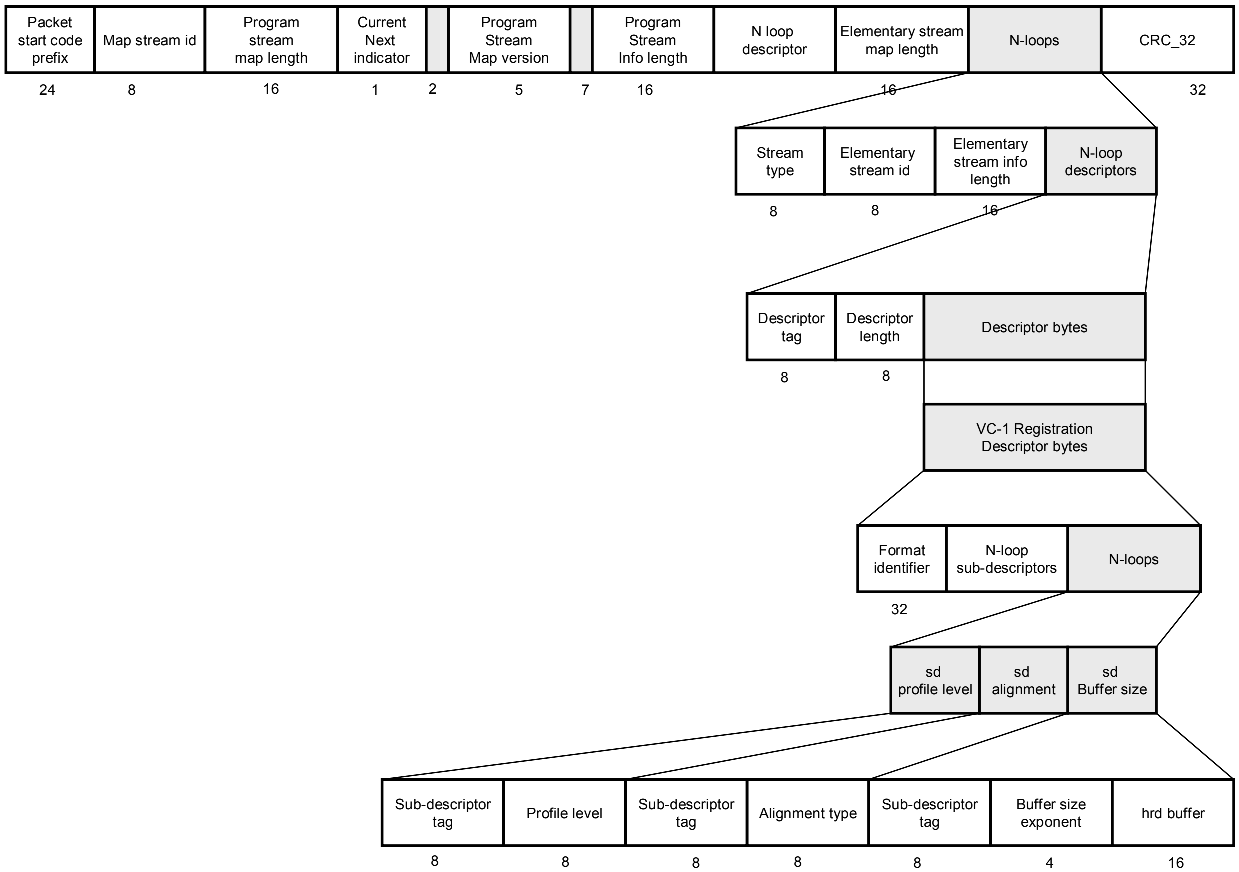

Figure A.3 – Program Stream Map diagram for VC-1 elementary stream

