SMPTE RECOMMENDED PRACTICE

Ancillary Data Space Use — 4:2:2 SDTV and HDTV Component Systems and 4:2:2 2048 ×1080 Production Image Formats

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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 Operations Manual.

SMPTE RP 291-2 was prepared by Technology Committee 32NF.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Recommended Practice. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Ancillary data space in a serial digital interface is that space not used by either the main video data stream or synchronizing signals and thus can be used as a transport for data associated with the main data stream. The packetized payload data carried in the ancillary data space is defined in separate application documents conforming to SMPTE ST 291-1.

This document defines the supplementary usage rules for Ancillary data spaces on an interconnecting interface compliant with SMPTE ST 291-1.

The ancillary data space located during the horizontal interval of every video line (between EAV and SAV) is called horizontal ancillary data space (HANC). The ancillary data space located during the vertical interval of each field or frame, (between SAV and EAV) is called vertical ancillary data space (VANC).

Ancillary data packets transported in the ancillary data space need to conform to rules of SMPTE ST 291-1. Some of the rules documented in SMPTE ST 291-1 are also repeated in this document. The packet location in ancillary data space is defined by an application document.

1 Scope

This document provides information on the size of the ancillary data space in 8-bit and 10-bit 4:2:2 component HDTV systems and 10-bit 4:2:2 2048x1080 Production Image formats operating on 1.485 Gb/sec, and 2.97 Gb/sec and dual link 1.485 Gb/sec serial digital interfaces. Additionally, the document covers 8-bit and 10-bit 4:2:2 component SDTV systems operating on 270 Mb/sec serial digital interfaces. The frame rates of the included formats are in range from 24 Hz/1.001, 25 Hz, 30 Hz/1.001, 48 Hz/1.001, 50 Hz, and 60 Hz/1.001 for progressive, progressive segmented frames or interlace formats. This document also describes the rules for carriage of ancillary data packets conforming to SMPTE ST 291-1

The carriage of ancillary data packets in composite SDTV systems, 4:4:4 component systems 360 Mb/sec and 540 Mb/sec and multiple link 2.97 Gb/sec serial digital interfaces, 12-bit interfaces, as well as the carriage of ancillary data packets in file formats are not covered by this document.

Numerical values shown in tables are based on a 10-bit interface word.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:”

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

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

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

Note: All references in this document to other SMPTE documents may use the current numbering style (e.g. SMPTE ST 125:1995) although, during a transitional phase, a reference document as published (printed or PDF) may bear an older designation (such as ANSI/SMPTE 125M-1995). Documents with the same root number (e.g. 125) and publication year (e.g. 1995) are functionally identical.

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

SMPTE ST 125:1995, Television — Component Video Signal 4:2:2 — Bit-Parallel Digital Interface

SMPTE ST 274:2008, Television — 1920 × 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE ST 296:2012 - 1280 × 720 Progressive Image 4:2:2 and 4:4:4 Sample Structure — Analog and Digital Representation and Analog Interface

SMPTE ST 291-1:2011, Ancillary Data Packet and Space Formatting

SMPTE ST 372:2011, Dual Link 1.5 Gb/s Digital Interface for 1920 × 1080 and 2048 × 1080 Picture Formats

SMPTE ST 425-1:2011, Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface

SMPTE ST 2048-2:2011, 2048 × 1080 Digital Cinematography Production Image FS/709 Formatting for Serial Digital Interface

SMPTE RP 165:1994, Error Detection Checkwords and Status Flags for Use in Bit-Serial Digital Interfaces for Television

SMPTE RP 168:2009, Definition of Vertical Interval Switching Point for Synchronous Video Switching

Recommendation ITU-R BT 601-7 (2011), Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios

Recommendation ITU-R BT 656-5 (2007), Interface for Digital Component Video Signals in 525-Line and 625-Line Television Systems Operating at the 4:2:2 Level of Recommendation ITU-R BT.601

Recommendation ITU-R BT 1700 (2005), Characteristics of Composite Video Signals for Conventional Analogue Television Systems

4 Glossary, Definitions of Acronyms and Terms (Informative)

Glossary and definition of acronyms and terms used throughout this document are only valid for this Recommended Practice. Any similar terms used in other documents may deviate from the definitions included in this document, and this difference can be ignored.

4.1 Glossary, Definitions of Acronyms and Terms

4.1.1
ADF
Ancillary Data Flag (3 digital code words – 000h, 3FFh, 3FFh) indicates the start of an Ancillary data packet in all component video.

4.1.2
Ancillary Data Space
Ancillary data space in a serial interface is space not used by the main video data stream or the synchronizing signals and thus can be used as a transport for data transmission associated with the main video data stream. This data space is essentially equal to the space defined by the horizontal or vertical intervals of a given video. The type of payload data carried in the ancillary data space is defined in separate application documents.

4.1.3
Ancillary Data Rate
MWords/sec; a data throughput rate through ancillary space. For calculation of packet data payload throughput via an ancillary packet see Annex B.

4.1.4
Ancillary Data packet Type 1
Ancillary data packets Type 1 use a single digital ID code word called the DID, defined in SMPTE ST 291-1.

4.1.5
Ancillary Data packet Type 2
Ancillary data packets Type 2 use a pair of digital ID code words in combination called DID/SDID, defined in SMPTE ST 291-1.

4.1.6
color difference (C_B/C_R)
Component signals C_B and C_R that represent the color of an image and are derived from the basic red, blue and green color components of an image.

4.1.7
CS
Check Sum word (1 digital code word) is used to determine the validity of the ancillary data packet. CS serves as a detector to indicate if that the ancillary data packet was transmitted over an interface without data corruption. The CS calculation for ancillary data packets is defined in SMPTE ST 291-1

4.1.8
DC
Data Count Word (1 digital code word) indicating the length of the ancillary data packet payload. The use of the DC code word is defined in SMPTE ST 291-1.

4.1.9
DID
Data Identification word (1 digital code word) is the main identification code word used by an Ancillary data packet application for ancillary data packets of Type 1 or as the first word of a pair (DID/SDID) for ancillary data packets of Type 2. Value ranges of DID words is defined in SMPTE ST 291-1.

4.1.10
D-VITC
Digital Vertical Interval Time Code defined in SMPTE ST 266 for SDTV Component Systems.

4.1.11
EAV
End of Active Video – consists of 4 digital data code words; this acronym is used for SDTV.

4.1.12
HANC
Horizontal Ancillary Data Space is the Ancillary Data Space located during the horizontal interval of a video line. The expressions HANC or HANC space are used interchangeably throughout the document.

4.1.13
H-EAV
In HDTV, video End of Active Video (EAV) consists of 8 digital code words; to differentiate from the EAV in SDTV video. Within this document, this is called H-EAV. However, the majority of SMPTE documents use the acronym EAV interchangeably regardless of whether it is related to SDTV or HDTV.

4.1.14
HDTV video
High Definition Television Video; commonly based on use of 720 or 1080 line video; it can be either progressive or interlaced scanning. 2048 x 1080 format is excluded from HDTV nomenclature.

4.1.15
HD-SDI
High Definition Serial Digital Interface – commonly used by 720 and 1080 line video interfaces operating at nominal 1.485 or 2.97 Gb/sec.

4.1.16
"h"
A suffix indicating that a value is shown in a hexadecimal format.

4.1.17
"H"
A subscript indicating that a specific value is referenced to a horizontal time point defined by a specific point on a video line.

4.1.18
Horizontal interval
An interval on each line of a field or frame between time reference points EAV and SAV designated for this purpose. In the past this space used to be called "horizontal blanking interval" and some older documents still use this expression.

4.1.19
luma (Y)
A component signal that presents brightness of an image.

4.1.20
PRE-VANC
The portion of the VANC starting with the line following the end of the active video area and ending with the line before the vertical interval switch point in the vertical interval of a frame or field; see the illustration in Figure 2.

4.1.21
Protected value
Code values that are reserved for synchronization purposes on the serial interface, or for identifying an ancillary data packet and thus are not permitted to be used in data payloads.

4.1.22
RP
An acronym used by SMPTE for a Recommended Practice document. Within the text or tables of this document, prefix SMPTE prior Recommended Practice number will not always be used; therefore the expression SMPTE RP XXX or RP XXX indicates identical document.

4.1.23
SDTV video
Standard Definition Television Video; commonly based on use of 525 or 625 scan lines; it is primarily used for interlaced component video.

4.1.24
SAV
Start of Active Video – consists of 4 digital code data words; this acronym is used equally for both SDTV and HDTV video.

4.1.25
SDI
Serial Digital Interface – commonly used by 525 and 625 television line interfaces operating at 270 Mb/sec.

4.1.26
SDID
Secondary Data Identification word (1 digital code word) is used in combination with a given DID code word

4.1.27
ST
An acronym used by SMPTE for a Standard document. Within the text or tables of this document, prefix SMPTE prior Standard’s number will not always be used; therefore the expression SMPTE ST XXX or ST XXX indicates identical document.

4.1.28
synchronizing words
(3FFh, 000h, 000h, XYZh) – digital data code words providing indication of time events in various TV video.

4.1.29
UDW
User Data Word, representing a word of an ancillary data packet payload; maximum 255 words for each ancillary packet

4.1.30
Vertical interval
An interval is formed by multiple lines of a field or frame located between time reference points designated for this purpose. The vertical interval of a field or frame starts at the beginning of a line following the last line of an active image for field or frame N, and ends at the last line prior to the start of an active image for field or frame N+1. This vertical interval used to be called a “vertical blanking interval” and some older documents still use this expression.

4.1.31
VANC
Vertical Ancillary Data Space is the Ancillary Data Space located between SAV and EAV during the vertical interval of a video frame or field. The expressions VANC or VANC space are used interchangeably throughout the document.

4.1.32
”$_{v}$ “
A subscript indicating that a specific value is referenced to vertical time point defined by a specific line of a video frame

4.2 Ancillary Space Tabulation

This document contains 8 tables which tabulate the sizes of HANC, VANC and POST-VANC ancillary data spaces. Table 1 below provides an overview of the information covered by each table.

Table 1 – Pointers to tables

<table>
<tr><td>Ancillary space</td><td>Interface</td><td>SDTV</td><td>1280 x 720
1920x1080</td><td>2048x1080</td></tr>
<tr><td rowspan="2">HANC space</td><td>Single Link</td><td colspan="3">Table 2a</td></tr>
<tr><td>Dual Link</td><td>NA</td><td colspan="2">Table 2b</td></tr>
<tr><td rowspan="2">VANC space</td><td>Single Link</td><td colspan="2">Table 3a</td><td>Table 3b</td></tr>
<tr><td>Dual Link</td><td>NA</td><td colspan="2">Table 3c</td></tr>
<tr><td rowspan="2">POST-VANC space</td><td>Single Link</td><td colspan="2">Table 4a</td><td>Table 4b</td></tr>
<tr><td>Dual Link</td><td>NA</td><td colspan="2">Table 4c</td></tr>
</table>

5 Ancillary Data Space Definitions

Ancillary data space in a serial digital interface is that space not used by either the main video data stream or synchronizing signals and thus can be used as a transport for data associated with the main data stream. The ancillary data space available in serial digital interface transports is approximately equivalent to horizontal interval space and vertical interval space for a specific video format. The sizes of these ancillary intervals for component video documents are shown in Table 2 thru Table 4.

Note: Previous SMPTE documents used the nomenclature "Vertical Blanking Interval" which has been changed to "Vertical Interval" in new documents. Similarly, previous SMPTE documents used the nomenclature "Horizontal Blanking Interval" which has been changed to "Horizontal Interval" in new documents.

For an SDTV video, SAV and EAV serial digital interface markers provide demarcation in an active digital video/data space and exist on all SDTV serial digital interfaces regardless of the number of TV lines used by the television video.

For an HDTV video, SAV and H-EAV serial digital interface markers provide demarcation in an active digital video/data space and exist on all HDTV serial digital interfaces regardless of the number of TV lines used by the television video.

This document will not normally differentiate between EAV and H-EAV due to the established practice of using the terms synonymously. The available ancillary data space shown in this document takes account of the different number of words for the EAV and H-EAV markers.

The space located in the horizontal interval of every video line (between EAV and SAV) is called horizontal ancillary data space (HANC). The space located between SAV and EAV of the vertical interval lines of each field or frame is called the vertical ancillary data space (VANC).

Early documented video (525 or 625 line video) used as a timing reference point for vertical alignment a timing point indicated as 0_V and for the horizontal alignment a timing point as 0_H.

The switching point (line) during the vertical interval of a typical video frame, where the switch between different video streams might happen, is different from the vertical timing reference point (0_V) that is defined in television video shown in the reference documents.

Available ancillary data space for ancillary data packet insertion is determined by the image source and streaming interface documents. Additional ancillary data space made available by use of external channels (e.g. alpha channel) and by combining multiple serial digital interfaces forming new structures are excluded from this document due to the complexities involved. Such space is to be identified by relevant mapping documents for those various interfaces.

The type of payload data carried in the ancillary data space is defined in separate application documents for specific types of ancillary data. A listing of existing application documents is available on SMPTE registration Web site. (See Section 13 of this document).

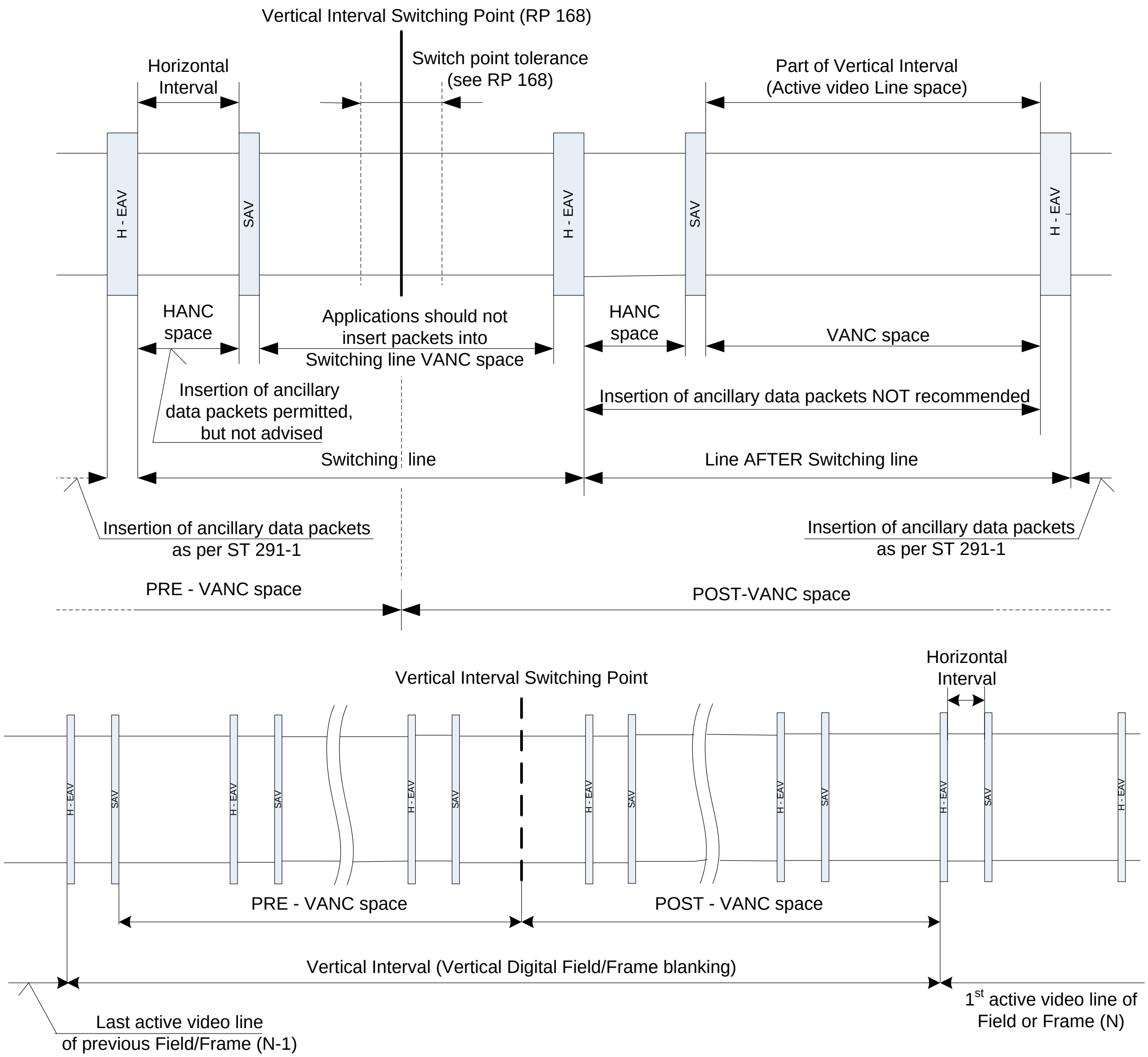

Figure 1 – Horizontal and Vertical Interval around a Switching Line

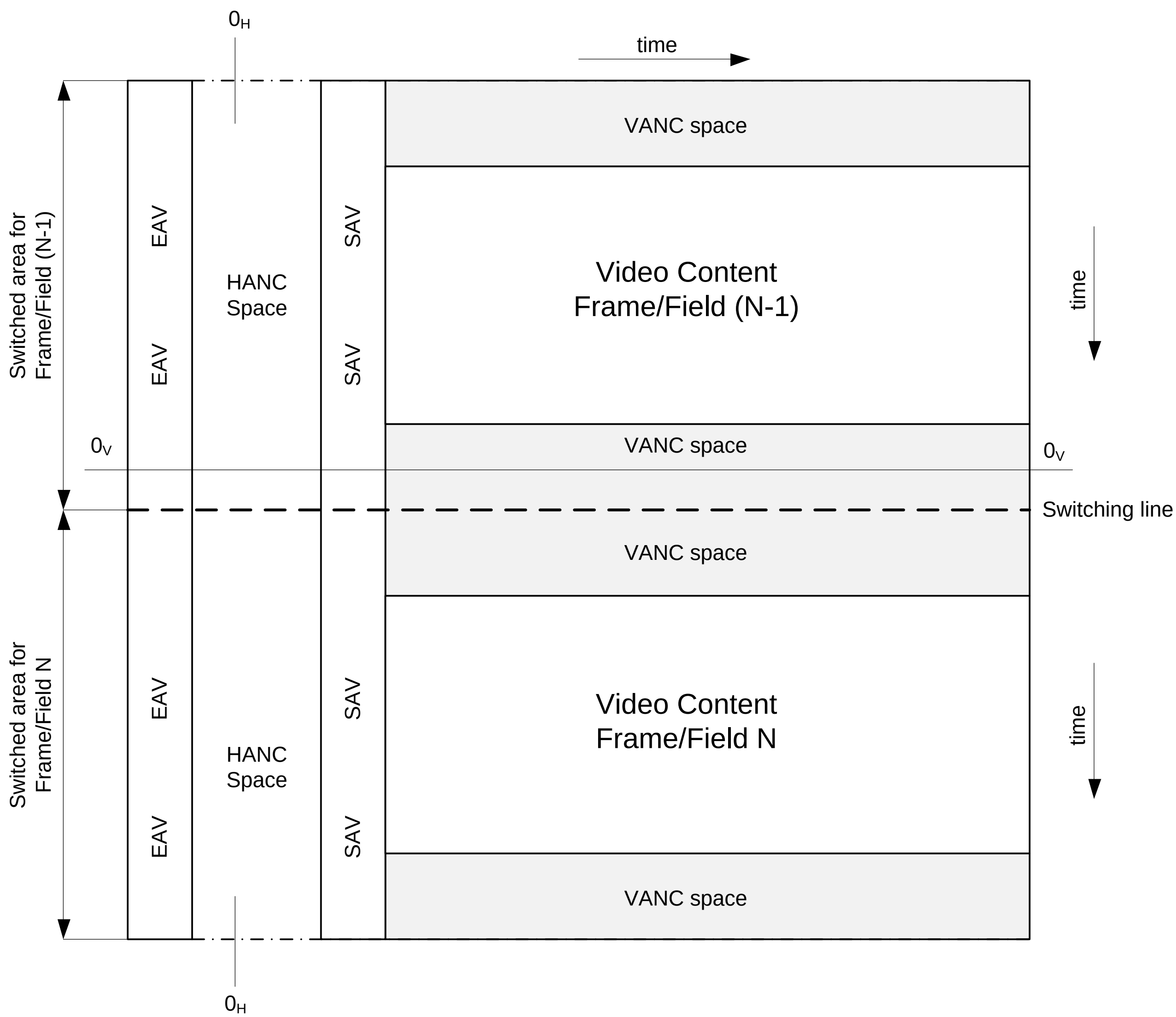

Figure 2 – A switched area of a video frame construct on a digital serial interface

5.1 Horizontal Ancillary Data Space (HANC)

The space located in the horizontal interval of every video line is called horizontal ancillary data space. The size of the ancillary data space available in HANC in different component video formats is indicated in Tables 2a and 2b. These values are derived from the reference documents for the individual image formats and their serial interfaces.

The horizontal ancillary data rate (HANC word rate) shown in Tables 2a, and 2b is in MWords/sec inclusive of ancillary data payload rate as well as the packet overhead

Note: To determine the ancillary data packet payload bit rate for an application HANC or VANC space, see Annex B.

Table 2a – Horizontal Ancillary data space (HANC) for component video (Single Link interfaces SDTV, 1280x720, 1920x1080 and 2048x1080)

System Number (Reference Image Standard)	Total lines per frame	Frame (P) or Field (I) Rate (Hz)	Image Sample Structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)	H interval Interval words on SDI Interface (HANC Words/line)	HANC word rate (MWord/sec)
1 (ITU-R BT.601)	625	25I	720x576	270 (ST 259)	280	4.361
2 (ST 125)	525	30I*	720x483	270 (ST 259)	268	4.201**
3 (ST 296)	750	24P*	1280x720	1485 (ST 292-1)	5666	101.750**
4 (ST 296)		25P			5336	99.917
5 (ST 296)		30P*			4016	90.149**
6 (ST 296)		50P			1376	51.531
7 (ST 296)		60P*			716	32.145**
8 (ST 274)	1125	24P*	1920x1080	1485 (ST 292-1)	1636	44.089**
9 (ST 274)		25P			1416	39.790
10 (ST 274)		30P*			536	18.056**
11 (ST 274)		50P		2970 (ST 425-1 Level A)	1416	79.579
12 (ST 274)		60P*			536	36.112**
13 (ST 274)		50P		2970 (ST 425-1 Level B)	1416	79.508
14 (ST 274)		60P*			536	36.080**
15 (ST 274)		50I		1485 (ST 292-1)	1416	39.754
16 (ST 274)		60I*			536	18.040**
17 (ST 274)		24PsF*			1636	44.049**
18 (ST 274)		25PsF			1416	39.754
19 (ST 274)		30PsF*			536	18.040**
20 (ST2048-1)	1125	24P*	2048 x 1080	1485 (ST 292-1)	1380	37.190**
21 (ST2048-1)		25P			1160	32.596
22 (ST2048-1)		30P*			280	9.432**
23 (ST2048-1)		48P*		2970 (ST 425- 1 Level A)	1380	74.379**
24 (ST2048-1)		50P			1160	65.192
25 (ST2048-1)		60P*			280	18.864**
26 (ST2048-1)		48P*		2970 (ST 425– 1 Level B)	1380	74.313**
27 (ST2048-1)		50P			1160	65.134
28 (ST2048-1)		60P*			280	18.848**
29 (ST2048-1)		24PsF*		1485 (ST 292-1)	1380	37.157**
30 (ST2048-1)		25PsF			1160	32.567
31 (ST2048-1)		30PsF*			280	9.424**

Notes:

1) Frame rates marked with "*" represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).
2) HANC Word rate/sec marked with "**" is based on non-integer frame rate. Implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 2a by 1.001 to derive the actual HANC MWord/sec data throughput.
3) PsF signifies a progressive scanning system over an interlaced interface.

Table 2b – Horizontal Ancillary data space (HANC) for component video (Dual Link interfaces 1920x1080 and 2048x1080)

System Number (Reference Image Standard)	Total lines per frame	Frame (P) or Field (I) Rate (Hz)	Image Sample Structure	10-bit Serial Digital Interface bit rate (Mb/sec) (Reference Interface Standard)		H interval Interval words on SDI Interface (HANC Words/line)	HANC word rate (MWord/sec)
32a (ST 2048-2)	1125	50P	1920 x 1080	1485 (ST 372 DL Link)	A	708	39.754
32b (ST 2048-2)					B	708	39.754
33a (ST 2048-2)		60P*			A	268	18.040**
33b (ST 2048-2)					B	268	18.040**
34a (ST 2048-2)		48P*	2048 x 1080	1485 (ST 372-DL Link)	A	690	37.157**
34b (ST 2048-2)					B	690	37.157**
35a (ST 2048-2)		50P			A	580	32.567
35b (ST 2048-2)					B	580	32.567
36a (ST 2048-2)		60P*			A	140	9.424**
36b (ST 2048-2)					B	140	9.424**

Note:

1) Frame rates marked with "*" represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).
2) HANC Word rate/sec marked with "**" is based on non-integer frame rate. Implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 2b by 1.001 to derive the actual HANC MWord/sec data throughput.
3) DL signifies Dual Link connectivity (SMPTE ST 372).
4) PsF signifies a progressive scanning system over an interlaced interface.

5.1.1 Horizontal Ancillary Data Space (HANC Space) Switching

There is no separate definition of a switch point in Horizontal Ancillary data Space. Switching of HANC space and its data packet stream is accomplished simply by a vertical interval switch compliant with SMPTE RP 168.

Due to the disturbance of the interface stream following such a switch, it is recommended that ancillary data packets are not inserted into the HANC space of the line immediately following the vertical interval switch line.

Insertion of ancillary data packets is permitted into any HANC space with the exception as indicated above. For SDTV systems ancillary data is also prohibited in the HANC space reserved for an EDH data packet defined in SMPTE RP 165. Designers should be aware, that any ancillary data information present in the reserved EDH space may be overwritten by the EDH packet.

5.2 Vertical Ancillary Data Space (VANC)

5.2.1 Total Vertical Ancillary Data Space (VANC)

The space located between SAV and EAV of each vertical interval line of each field or frame is called vertical ancillary data space. This is shown in the shaded areas of Figure 2. The size of the ancillary data space available in VANC in different component video is shown in Tables 3a, 3b and 3c. These values are derived from the reference documents for the individual image formats and their serial interfaces.

The vertical ancillary data rate (VANC word rate) shown in Tables 3a, 3b and 3c is in MWords/sec and includes the ancillary data payload rate as well as the packet overhead.,

The available ancillary data space is limited by the reserved space for switching lines (SMPTE RP 168). For SDTV systems ancillary data is also prohibited in the the lines reserved for D-VITC (SMPTE ST 266). Additionally only a part of the total VANC space shown in Figure 3 (non-shaded space) is currently utilized for VANC data packet insertion.

Table 3a – Total Vertical Ancillary data space (VANC) for component video (Single Link Interfaces SDTV and 1920x1080)

System Number (Image Reference Standard)	Total Lines per frame	Frame (P) or Field (I) rate (Hz)	Image Sample structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)	Vertical lines available on interface (Line No Inclusive)		Vertical lines excluded from use (Line No Inclusive)	VANC interval word rate (Y+C_BC_R) (MWord/sec)
1 (ITU-R BT.601) (ITU-R BT.656)	625	25I	720x576	270 (ST 259)	F 1	624-625; 1-22	6-7; 19+	1.548
					F 2	311 -335	319 -320; 332+	
2 (ST 125)	525	30I*	720x483		F 1	1 -19	10 -11; 14+	1.381**
					F 2	264 -282	273 -274; 277+	
3 (ST 296)	750	24P*	1280 x 720	1485 (ST 292-1)		746 - 750 1-25	7 - 8	1.719**
4 (ST 296)		25P						1.792
5 (ST 296)		30P*						2.148**
6 (ST 296)		50P						3.584
7 (ST 296)		60P*						4.297**
8 (ST 274)	1125	24P*	1920 x 1080	1485 (ST 292-1)		1122 -1125 1-41	7-8	3.959**
9 (ST 274)		25P						4.128
10 (ST 274)		30P*						4.949**
11 (ST 274)		50P		2970 (ST 425-1 level A)				8.256
12 (ST 274)		60P*						9.897**
13 (ST 274)		50P		2970 (ST 425-1 Level B)		1124 -1125 1 -20; 561- 583	7 – 8 569 – 570 583	7.680
14 (ST 274)		60P*						9.207**
15 (ST 274)		50I		1485 (ST 292-1)		1124 – 1125; 1 -20 561-583	7 – 8 569 – 570	3.936
16 (ST 274)		60I*						4.718**
17 (ST 274)	1125	24PsF*	1920 x 1080	1485 (ST 292-1)		1124 – 1125 1 -20 561-583	7 – 8 569 – 570;	3.775**
18 (ST 274)		25PsF						3.936
19 (ST 274)		30PsF*						4.718**

Notes:

1) Frame rates marked with "*" represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).
2) VANC Word rate/sec marked with "**" is based on non-integer frame rate; implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 3a by 1.001 to derive the actual VANC MWord/sec data throughput.
3) Digital interfaces do not support ½ line intervals in vertical blanking in interlaced video.
4) Line numbers marked with **+** indicate lines used for D-VITC (SMPTE ST 266).
5) PsF signifies progressively scanned system carried over an interlaced interface.

Table 3b – Total Vertical Ancillary data space (VANC) for component video (Single Link Interfaces – 2048x1080)

System Number (Image Reference Standard)	Total Lines per frame	Frame (P) or Field (I) rate (Hz)	Image Sample structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)	Vertical lines available on interface (Line No Inclusive)	Vertical lines excluded from use (Line No Inclusive)	VANC interval word rate ($Y+C_BC_R$) (MWord/sec)
20 (ST 2048-2)	1125	24P*	2048 x 1080	1485 (ST 292-1)	1122 – 1125; 1 - 41	7 - 8	4.223**
21 (ST 2048-2)		25P					4.403
22 (ST 2048-2)		30P*					5.279**
23 (ST 2048-2)		48P*		2970 (ST 425 -1 level A)	1122 – 1125; 1 - 41	7 - 8	8.446**
24 (ST 2048-2)		50P					8.806
25 (ST 2048-2)		60P*					10.557**
26 (ST 2048-2)	1125	48P*	2048 x 1080	2970 (ST 425-1 Level B	1124 -1125 1 -20 561 - 583	7 – 8 569 – 570 583	7.856**
27 (ST 2048-2)		50P					8.192
28 (ST 2048-2)		60P*					9.821**
29 (ST 2048-2)		24PsF*		1485 (ST 292-1)	1124 -1125 1 -20 561 - 583	7 – 8 569 – 570	4.026**
30 (ST 2048-2)		25PsF					4.198
31 (ST 2048-2)		30PsF*					5.033**

Notes:

1) Frame rates marked with "*" represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).

2) VANC Word rate/sec marked with "**" is based on non-integer frame rate; implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 3b by 1.001 to derive the actual VANC MWord/sec data throughput.

3) PsF signifies progressively scanned system carried over an interlaced interface.

Table 3c – Total Vertical Ancillary data space (VANC) for component video (Dual Link Interfaces – 1920x1080 and 2048x1080)

System Number (Image Reference Standard)	Total Lines per frame	Frame (P) or Field (I) rate (Hz)	Image Sample structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)		Vertical lines available on interface (Line No Inclusive)	Vertical lines excluded from use (Line No Inclusive)	VANC interval word rate ($Y+C_BC_R$) (MWord/sec)
32a (ST 274)	1125	50	1920 x 1080	1485 (ST 372 DL-LINK)	A	1124 -1125 1 - 20 561- 583	7 – 8 569 – 570 583	7.680
32b (ST 274)					B			
33a (ST 274)		60*			A			9.207**
33b (ST 274)					B			
34a (ST 2048-2)		48*	2048 x 1080	1485 (ST 372 DL-LINK)	A	1124 -1125 1 - 20 561 - 583	7- 8 569 – 570 583	7.856**
34b (ST 2048-2)					B			
35a (ST 2048-2		50			A			8.192
35b (ST 2048-2)					B			
36a (ST 2048-2)		60*			A			9.821**
36b (ST 2048-2)					B			

Notes:

1) Frame rates marked with "*" represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).

2) VANC Word rate/sec marked with "**" is based on non-integer frame rate; implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 3c by 1.001 to derive the actual VANC MWord/sec data throughput.

3) DL signifies Dual Link connectivity (SMPTE ST 372).

5.3 Post-Switch and Pre-Switch of Vertical Ancillary Data Space (POST-VANC; PRE-VANC)

The total VANC space within the vertical interval of each video may be further divided into two spaces. The dividing barrier (two lines) between these two spaces is shown in Figure 3 and is defined by the location of the switching line (“line n”) defined in SMPTE RP 168 .

As shown in Figure 1, it is permitted that ancillary data packets may be inserted into HANC space of a switching line (line n), but not advised. Insertion of ancillary data packets into VANC space of a switching line should be avoided due to uncertainty caused by a tolerance on a position of a Vertical Switching point.

Additionally the following line (line n+1) should not be used for insertion of VANC data packets (HANC or VANC space) due to the disturbance caused by the actual switch; which could corrupt the ancillary data packets if they were located on that particular line. However some past applications may not comply with the above rules.

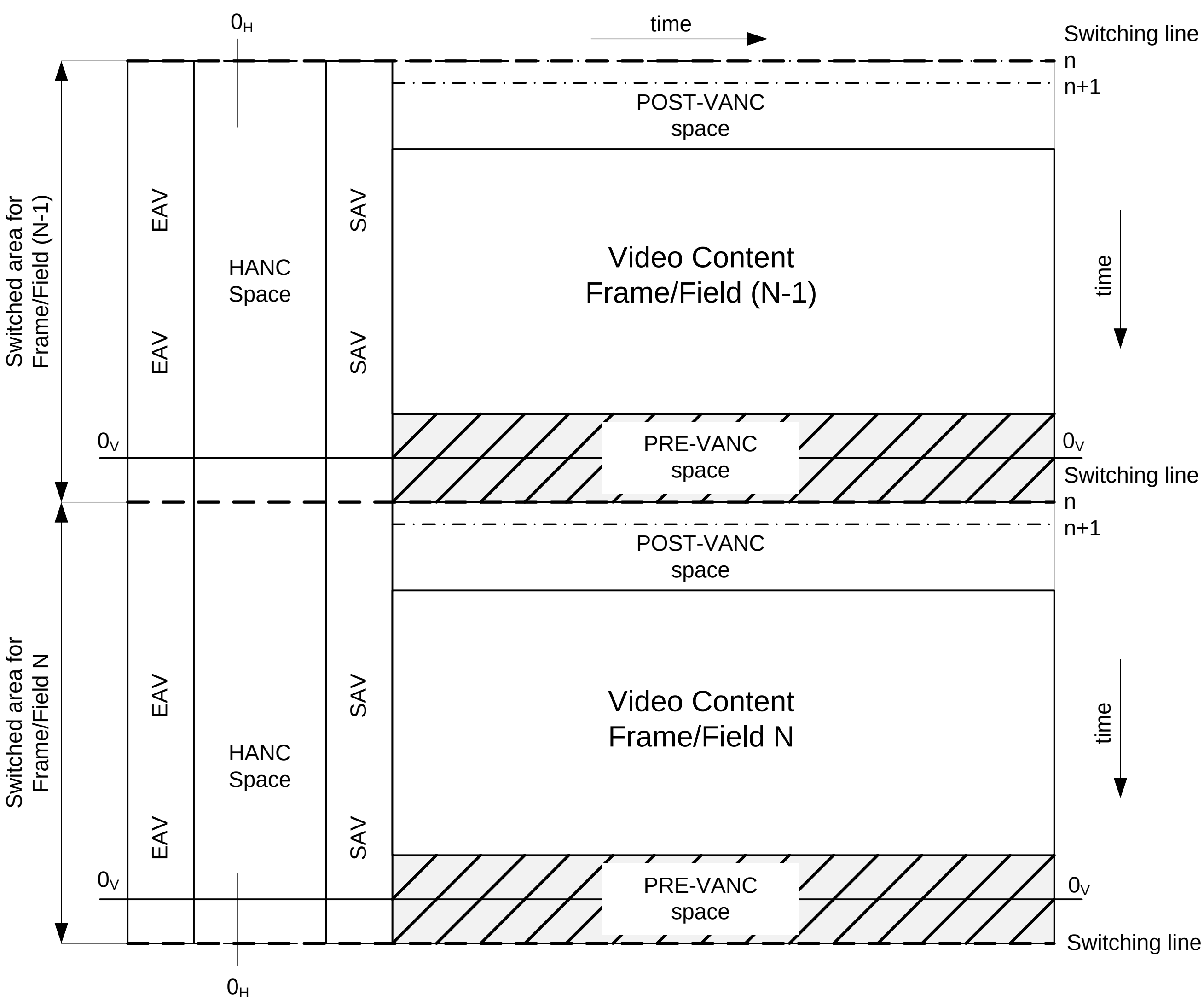

Figure 3 – POST-VANC and PRE-VANC Space

Note: Designers of the ancillary insertion/reading equipment need to be aware that ancillary data application documents defining the specific placement of VANC data packets have typically specified the POST-VANC area at the time of the writing of this Recommended Practice. Use of the PRE-VANC area is not prohibited for use by any ancillary data packets, the use of this space is at the discretion of equipment designers, and is encouraged.

The VANC space between the line following end of active video area and the line before the vertical interval switch point is defined as the Pre-Switch Vertical Ancillary Data Space (PRE-VANC) as illustrated in Figure 3. The total size of VANC space is indicated in Tables 3a, 3b and 3c.

The VANC space between the second line after the vertical interval switch point and the line before the active video area is defined as the Post-Switch Vertical Ancillary Data Space (POST-VANC) as illustrated in Figure 3 and its size is indicated in Tables 4a, 4b and 4c.

5.3.1 Post-Switch Vertical Ancillary Data Space (POST-VANC)

As shown in Figure 2, the POST-VANC space is significantly smaller than the total VANC space. The indicated POST-VANC space in Tables 4a, 4b and 4c excludes protected lines (as defined by other documents) and those are included in the size space determinations. The indicated space POST-VANC in MWords/sec is the space available on the serial digital interface consisting of data words from multiplexed luma and color difference streams.

5.3.2 Pre-Switch Vertical Ancillary Data Space (PRE-VANC)

Figure 3 shows the PRE-VANC space. At the time of writing this document, there is no specific use of the PRE-VANC space. Current and legacy equipment uses only POST-VANC space and therefore, until further development (and the urgent need for more VANC space) use of PRE-VANC space is the responsibility of equipment designer. The rules for ancillary data packets insertion and readout in PRE-VANC space are identical to placement of packets in the POST-VANC space.

Table 4a – Vertical Ancillary data space (POST-VANC) for component video (Single Link Interfaces SDTV, 1280x720 and 1920x1080)

System Number (Image Reference Standard)	Total Lines per frame	Frame (P) or Field (I) rate (Hz)	Image Sample structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)	Vertical lines available on interface (Line No Inclusive)	Vertical lines excluded from use (Line No Inclusive)	VANC interval word rate ($Y+C_BC_R$) (MWord/sec)
1 (ITU-R BT.601) (ITU-R BT.656)	625	25I	720x576	270 (ST 259)	F 1: 8-22	19+	1.008
					F 2: 321 -335	332+	
2 (ST 125)	525	30I*	720x483		F 1: 12 -19	14+	0.604**
					F 2: 275 -282	277+	
3 (ST 296)	750	24P*	1280 x 720	1485 (ST 292-1)	9-25;		1.043**
4 (ST 296)		25P					1.088
5 (ST 296)		30P*					1.304**
6 (ST 296)		50P					2.176
7 (ST 296)		60P*					2.609**
8 (ST 274)	1125	24P*	1920 x 1080	1485 (ST 292-1)	9-41;		3.038**
9 (ST 274)		25P					3.038**
10 (ST 274)		30P*					3.798**
11 (ST 274)		50P		2970 (ST 425-1 Level A)			6.336
12 (ST 274)		60P*					7.596**
13 (ST 274)		50P		2970 (ST 425-1 Level B)	9 -20; 571- 583;	583 on DS2	4.608
14 (ST 274)		60P*					5.524**
15 (ST 274)		50I		1485 (ST 292-1)	9 -20; 571- 583		2.400
16 (ST 274)		60I*					2.877**
17 (ST 274)	1125	24PsF*	1920 x 1080	1485 (ST 292-1)	9 -20; 571- 583		2.302**
18 (ST 274)		25PsF					2.400
19 (ST 274)		30PsF*					4.877**

Notes:

1) Frame rates marked with “*” represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).
2) VANC Word rate/sec marked with “**” is based on non-integer frame rate; implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 4a by 1.001 to derive the actual VANC MWord/sec data throughput.
3) Digital interfaces do not support ½ line intervals in vertical blanking in interlaced video.
4) Line numbers marked with **+** indicate lines used for D-VITC (SMPTE ST 266).
5) PsF signifies progressively scanned system carried over an interlaced interface.

Table 4b – Vertical Ancillary data space (POST-VANC) for component video (Single Link Interfaces 2048x1080)

System Number (Image Reference Standard)	Total Lines per frame	Frame (P) or Field (I) rate (Hz)	Image Sample structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)	Vertical lines available on interface (Line No Inclusive)	Vertical lines excluded from use (Line No Inclusive)	VANC interval word rate ($Y+C_BC_R$) (MWord/sec)
20 (ST 2048-2)	1125	24P*	2048 x 1080	1485 (ST 292-1)	9 – 41		3.241**
21 (ST 2048-2)		25P					3.379
22 (ST 2048-2)		30P*					4.051**
23 (ST 2048-2)		48P*		2970 (ST 425-1 level A)	9 - 41		6.482
24 (ST 2048-2)		50P					6.758
25 (ST 2048-2)		60P*					8.102**
26 (ST 2048-2)	1125	48P*	2048 x 1080	2970 (ST 425-1 Level B	9 -20; 571- 583	583 on DS2	7.856**
27 (ST 2048-2)		50P					8.192
28 (ST 2048-2)		60P*					9.821**
29 (ST 2048-2)		24PsF*		1485 (ST 292-1)	9 -20; 571- 583		2.455**
30 (ST 2048-2)		25PsF					2.560
31 (ST 2048-2)		30PsF*					3.069**

Notes:

1) Frame rates marked with "*" represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).

2) VANC Word rate/sec marked with "**" is based on non-integer frame rate; implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 4b by 1.001 to derive the actual VANC MWord/sec data throughput.

3) PsF signifies progressively scanned system carried over an interlaced interface.

Table 4c – Vertical Ancillary data space (POST-VANC) for component video (Dual Link Interfaces 1920x1080 and 2048x1080)

System Number (Image Reference Standard)	Total Lines per frame	Frame (P) or Field (I) rate (Hz)	Image Sample structure	10-bit SDI interface bit rate (Mb/sec) (Reference Interface Standard)		Vertical lines available on interface (Line No Inclusive)	Vertical lines excluded from use (Line No Inclusive)	VANC interval word rate ($Y+C_BC_R$) (MWord/sec)
32a (ST 274)	1125	50	1920 x 1080	1485 (ST 372 DL-LINK)	A	9 -20; 571- 583		4.608
32b (ST 274)					B		583	
33a (ST 274)		60*			A			5.524**
33b (ST 274)					B		583	
34a (ST 2048-2)		48*	2048 x 1080	1485 (ST 372 DL-LINK)	A	9 -20; 571- 583		4.714**
34b (ST 2048-2)					B		583	
35a (ST 2048-2		50			A			4.915
35b (ST 2048-2)					B		583	
36a (ST 2048-2)		60*			A			5.892**
36b (ST 2048-2)					B		583	

Notes:

1) Frame rates marked with “*” represent a non-integer frame rate (divide by 1.001 to get the actual frame rate).
2) VANC Word rate/sec marked with “**” is based on non-integer frame rate; implementations operating with an integer frame rate ought to multiply the MWord/sec rate value in Table 4c by 1.001 to derive the actual VANC MWord/sec data throughput.
3) DL signifies Dual Link connectivity (SMPTE ST 372).

6 Ancillary Data Packets, Ancillary Data Space, Space Limitations and Rules

The basic rules for the insertion of ancillary data packets are established in SMPTE ST 291-1. Those rules are repeated in this document (see Section 7) with additional information on the space use and insertion.

6.1 Types of Ancillary Data Packets

SMPTE ST 291-1 defines two types of ancillary data packets and these are:

- Ancillary Data packet Type 1
- Ancillary Data packet Type 2

6.1.1 Type 1 Ancillary data packet format

The Type 1 ancillary data packet uses in its construct Ancillary Data Flag, Data ID, Data Block number, Data Count followed by User Data Words and ending with a Checksum. Details of the permitted DID code values for Type 1 packets are defined in SMPTE ST 291-1.

This type of ancillary data packet is used by applications that may require multiple packets to be linked together by a Data Block Number forming a message of multiple packets. Their use is quite constrained due to the limited available address space for the DID codes for Type 1 packets. The address space is limited to only 96 addresses, which includes 16 addresses dedicated to proprietary user applications.

6.1.2 Type 2 Ancillary data packet format

The Type 2 ancillary data packet format uses in its construct Ancillary Data Flag, Data ID, Secondary Data ID, and Data Count followed by User Data Words and ending with a Checksum. Details of the permitted DID and SDID code values for Type 2 packets are defined in SMPTE ST 291-1.

This type of ancillary data packet is used by most applications where the payload carried in the ancillary data packet payload is short (less than 255 words).

6.2 Ancillary Data Packet Payload Update Rate

Designers of ancillary data insertion equipment need to be aware that the data transmission rate is significantly different (higher) for HANC space as compared to VANC space.

The data transmission rate in VANC space is mostly based on the frame rate for a given video, while in HANC space the packet data transmission rate is defined by the line frequency. To expect faster transmission of packet payloads than the frame rate for VANC packets or line rate for HANC packets would violate the basic Nyquist rule for sampled systems.

NOTE: For the above reason, audio packets (see SMPTE ST 272 and SMPTE ST 299-1) use HANC space. Data that needs to be used for faster than the frame rate control can be placed into HANC space. However, that means a packet carrying such fast control data will need to be detected by a receiver buried within many HANC packets carrying audio information. If any ancillary data packet is inserted into HANC space, the newly inserted packet cannot overwrite any packet existing within the HANC space except when updating a specific ancillary packet data payload. If this process of replacing audio ancillary packets in existing HANC space is used, the designer needs to be aware that ancillary audio control packets are located in a different space of the stream needs and may to be updated.

6.3 Protected words in ancillary data space

The serial digital interface uses a specific line synchronizing sequence consisting of four words, a pattern called SAV and EAV. These synchronizing sequences are protected and shall not be used by the inserted data payload in any ancillary data space.

In HDTV video, four additional words carrying the line number and CRC data follow the EAV synchronization sequence to form an 8 word H-EAV sequence. Those additional data words are the Line Number words (LN0 and LN1) and the CRC0 and CRC1 words defined in SMPTE ST 292-1. The H-EAV marker is therefore eight words long.

The synchronizing pattern for ancillary data packets consists of a 3 word pattern; that is defined in SMPTE ST 291-1. This pattern is called the ADF and is protected to enable detection of the start of an ancillary data packet.

The relevant image format standards define the actual size of the ancillary data space for a specific image format. These image standards may support not only 10-bit, but also 8-bit, transmission and data insertion applications. To achieve a secure transmission for video, ancillary data packets, and their data payloads shall not use the prohibited codes.

6.4 10-Bit Ancillary Data Space Synchronization Protection

Protection of the prohibited codes of the EAV, SAV and ADF synchronizing words in a 10-bit video is achieved by setting bit 8 of all words in a given packet (with the exception of ADF and CS), to even parity for the lower 8-bits of the word and bit 9 to the inverse of bit 8. This particular algorithm assures that no synchronizing words are generated by any data combination in the data word; however, it limits the packet payload to transport of only 8-bit data.

6.5 8-Bit Ancillary Data Space Synchronization Protection

For protection of the prohibited codes of the EAV, SAV and ADF synchronizing words in an 8-bit video, the DID and SDID words, Data Count word and packet data payload must be protected by a mechanism that shall be defined within the application document that specifies a specific ancillary data packet application.

6.5.1 8-bit Data Identification word, Data Block Number, Data Count and data packet payload

According to SMPTE ST 291-1, only Type 2 ancillary data packets are permitted in an 8-bit interface and their DID word address space is limited to values between 04h and 0Fh.. To ensure that the DID word does not generate prohibited values during serial digital interconnection between 8-bit and 10-bit based equipment (as the lower two bits in a 10-bit video will get truncated to zero), the available DID address space is further limited to values 04h, 08h and 0Ch. These addresses have the lower bits equal to zero.

The Secondary Data ID number associated with ancillary data packet Type 2 needs to be selected such that generating protected patterns is impossible. To ensure that SDID words do not generate prohibited values, they are limited to values x0h, x4h, x8h and xCh with the SDID value of 00h is excluded.

To ensure the protection of the synchronizing words, the value of Data Count (the length of the ancillary data payload) must be one of the values permitted for SDID.

The payloads of these packets shall not generate the reserved synchronizing words 00h and FFh. As a result, some method (e.g. re-mapping 8-bit data into a 6-bit payload space) must be defined within the application document. For additional information see section 8.

6.5.2 Special cases of ancillary data space protection

The Error Detection and Handling (EDH) data packet conforming to SMPTE RP 165 is located in a fixed location for SDTV video (namely line 9 and line 272 for 525-line video and line 5 and 318 for 625 line video).

Ancillary data packets representing header packets for Serial Data transmission over SDI (“SDTI”) need to be always located immediately after EAV in HANC data space as defined in SMPTE ST 305.

6.6 Transposition of Ancillary Data Packets Between Different Video Formats

When conversions between SDTV and HDTV video are performed, designers need to be aware that they must take into account the differences in the ancillary space shapes and sizes for the involved video format. The ancillary data spaces are not of identical shape and size (e.g. HDTV ancillary data space is significantly larger than SDTV ancillary data space) therefore, the amount of ancillary data space and its location may impact the process of transposing data from one video into another.

It is desirable that ancillary data packets located in the originating video on a specific line in VANC space or in a specific horizontal interval in HANC space are placed into similar locations of the second video.

Furthermore, during the ancillary data packet transposition between different HDTV video formats, designers of ancillary data insertion equipment need to consider the differences in the ancillary space shape and size of the involved HDTV video, as they may impact ancillary data packet locations.

7 Basic and Expanded Insertion Rules for Ancillary Data Packets

SMPTE ST 291-1 defines the basic insertion rules for inserting Ancillary data packets. Past practices indicate that some additional rules may be required, and these are included within this section.

7.1 Basic Insertion Rules

The following insertion rules, defined in SMPTE ST 291-1, are repeated here for the reader's convenience.

- The first ancillary data packet within an ancillary data space interval shall immediately follow the interval's leading boundary (i.e. packets shall be left justified).
- Ancillary data packets shall be placed contiguously within the interval boundaries of ancillary data space
- Ancillary data packets shall be wholly contained within the ancillary data space interval in which they are inserted.
- Contiguity of packets between different ancillary data intervals (horizontal or vertical) is not required.
- Application documents defining the use of ancillary packets and their payloads shall provide information on the recommended packet locations in ancillary data space and the relevant Y' or C'_B C'_R stream data space.

  Note: Some existing application documents do not define stream locations for the insertion of ancillary data packets or specify insertions of identical ancillary packets into both streams (luma and color difference streams).

- Receiving equipment shall detect a specific application ancillary data packet only by its DID for Type 1 and DID/SDID combination for Type 2 ancillary packets.
- Insertion equipment shall not overwrite an existing packet in ancillary data space, unless that packet is marked for deletion.
- The ancillary data packet location used by insertion equipment shall conform to the relevant application document.
- There is no guaranteed (or protected) location for any ancillary data packets except the special cases indicated in Section 6.5.2.
- An ancillary data packet may be marked for deletion by replacing the original Data ID (DID) word of the ancillary data packet with a DID equal to 80h (180h in 10-bit video) and reinserting a new checksum for the packet. This process will mark that ancillary data packet as invalid while maintaining the contiguity of data within the ancillary data space. The rest of the marked ancillary data packet including its data payload remains unchanged.

- Insertion of ancillary data packets into HANC space of a switching line is permitted but not advised. Insertion of ancillary data packets into VANC space of a switching line should be avoided.

- It is recommended that ancillary data packets not be transmitted within an ancillary data space (HANC or VANC space) of a line following the vertical interval switching point line defined in SMPTE RP 168. It should be noted some past applications do not conform to this rule.

  Note: The ancillary data space indicated in Tables 3a, 3b and 3c and Tables 4a, 4b and 4c already excludes the switching line and the horizontal interval after the switching line from the calculated available ancillary data space.

- Receiving equipment needs to be able to process all ancillary data packets located in any ancillary data space (including switching line and the line after switching line), as some existing equipment might not conform to the recommendation above on the switching point.

- Multiple ancillary data packets with identical ID words (DID or combination of DID/SDID) may be located in any ancillary data space defined as available for ancillary data.

7.2 Extended Insertion Rules

- Ancillary data processing equipment operates on the principle of “first come, first served” meaning first application that inserts ancillary data packets into an ancillary data space, inserts its application packet immediately after an EAV or SAV depending on which ancillary space (HANC or VANC) is used.

- Processing equipment should be agnostic to any application data packet and pass unprocessed packets transparently through with the content stream to the output interface.

- Note: Not all existing installed user equipment (production switchers, DVE, signal processing equipment of various kinds, and some storage equipment) supports transparent passage of all ancillary data packets from the serial stream input interface to the output interface. The specific user documentation for this equipment needs clearly state the limitations of ancillary data packet passage (e.g., which packets are passed through and which are dropped.)

- Multiple ancillary data packets may use identical DID or DID/SDID codes on one or more lines in VANC or HANC space. Multiple packets are often used to carry a message that is longer than 255 bytes; therefore the message needs to be split into multiple packets. Processing equipment may reorder these packets and so, in order to reconstruct the message, it is important to know the sequence of the packets when they were created. Type 1 ancillary packets have a defined mechanism for tracking the sequence of multiple packets (DBN) while Type 2 ancillary packets do not have such method intrinsically. The application document for carrying messages using multiple Type 2 ancillary data packets must define the mechanisms to track the sequence of packets.

- Nesting of additional packet payloads within a single ancillary data packet payload is permitted as defined in an application document for such a data packet payload. The size of the combined data packet shall not exceed the maximum packet payload length of 255 words. The application document needs to define the nesting method and its details. For more information, see Annex D.

8 Processing 8-Bit and 10-Bit Ancillary Data

SMPTE ST 291-1 supports not only 10-bit streams, but also 8-bit streams. As a result, designers of ancillary data insertion equipment need to be aware that 8-bit stream processing requires special attention so the protected codes defined in SMPTE ST 291-1 and discussed further in Sections 6.3 and 6.5 are not violated.

8.1 8-Bit Stream Space

In 8-bit video image standards, the video is digitized using 8 bits per sample. Video data is limited to a maximum excursion between decimal value 16 for black and 235 for white. However, due to filtering and sampling of the input signal, digital samples lower than 16 and higher than 235 may be occasionally encountered. Therefore, the allowed operating space is between decimal value 1 and value 254. Value 0 and 255 must be protected at all times to protect the synchronizing sequences.

Ancillary data payload values may exist which violate the protected data values. Solutions to the problem of transmitting the full 8-bit data range through an ancillary data space within these limitations shall be defined within the application document if it allows the ancillary data packets to be carried on an 8 bit interface. Possible solutions might be:

- Use only an ancillary data packet payload that occupies a lesser payload space than 8-bits. An example of such an application is SMPTE ST 12M-2.

- Re-mapping of the packet payload data from 8-bit word lengths into 6 or 7-bit word lengths. As a result of the re-mapping process, an increase in packet payload length would be expected.

The DID or SDID of the packet structure for this application shall be chosen from an 8-bit reserved range for such purposes as indicated in SMPTE ST 291-1 (also see Section 6.5.1 and Annex C).

Streams that originated in a 10-bit space need to be carefully processed to accommodate the limitation of 8-bit space if that data is to be carried in an 8-bit environment (see Annex C).

Note: Equipment designers also need to be aware that for an interface that connects 10-bit and 8-bit equipment, additional processing of the total stream is required.

8.2 10-Bit Stream Space

As indicated before in Section 6.4, 10-bit space accommodates 8-bit data in ancillary data packets without any limitations. That is achieved by setting bit-8 to even parity for all words in each ancillary data packet and setting bit-9 to inverse of bit-8. For additional details, see SMPTE ST 291-1 and Annex C.

9 DID Address Space Categories

SMPTE ST 291-1 defines several categories of address spaces. The specific DID address ranges defined are:

- **Reserved** – The indicated address space of an ancillary data packet is reserved by SMPTE for future applications.

- **SMPTE Registered** – This address space is assigned by SMPTE for use in various application documents. To ensure there is no interference between different applications, each ancillary data packet contains a unique ID (a DID for Type 1 packet or a DID/SDID for a Type 2 packet) defined in an application document developed by SMPTE. In those applications, documents ID addresses are assigned and registered by SMPTE.

- **Reserved for 8-bit application** - This address space is assigned for registered 8-bit ancillary data packet applications to ensure that the assigned packet ID will pass through 8-bit equipment.

- **SMPTE Registered External User Entity Space** – This address space is assigned for SMPTE registered IDs for applications developed by External Entities.

Note: Prior to the 2010 revision of SMPTE ST 291-1, IDs registered to entities external to SMPTE were included in the SMPTE registered space.

- **User applications** – This address space range is provided for Users for proprietary implementations. These ancillary data packet IDs are not registered by SMPTE and no information is necessary to describe a packet application, its ID value and its payload by Users. It is noted that some SDOs use DIDs in the User application address space for applications which they have developed. Use of addresses for these ancillary data packets from this space may be confidential; therefore, it is impossible to rule out any conflict as to the uses of a specific packet ID between different Users. It is encouraged that possible Users communicate with each other which packet ID address is in use and come to a resolution of any conflict between them.

  Prior to the 2010 revision of SMPTE ST 291-1, two SMPTE registered IDs were assigned in the user application space. These IDs (50h/01h and 51h/01h) shall not be used for proprietary user applications.

Packets that use IDs from any of these indicated address spaces should be passed equally through processing equipment without any preference for any packet's application or location.

9.1 Packet Marked for Deletion

Ancillary data packets may not be deleted until the specific application that is built for a specific packet ID value declares the packet obsolete. To delete a packet that is present in the stream, the ancillary data packet DID is set to the assigned 80h value and the Checksum for the packet corrected, otherwise another data packet reader/receiver might consider that a packet error has occurred and attempt to perform a correction. The process of setting the DID to 80h and recalculating the Checksum ensures contiguity of the ancillary data space. Using this process, a Type 2 packet is changed to Type 1 packet; therefore, there is no need to change the SDID code.

Processing equipment for ancillary data packets, if capable of doing so, may delete the packet marked for deletion, but that device needs to provide a left-shift of remaining packets that were present following the marked packet that was deleted. Deleting the packet without performing the left-shift process, results in ancillary data space that is non-contiguous and will stop reading devices from processing the data packets following the deleted packets.

10 Ancillary Data Processing Equipment Recommendations (Informative)

Experience gained from the use of ancillary data space over time, from when SMPTE ST 291-1 was first published (approximately 1995) to the present, indicates that certain guidance on the use of ancillary data packets is necessary. This guidance is for both the insertion equipment and the receiving equipment.

10.1 Ancillary Data Packet Location in a Serial Digital Interface Stream

The specific functionality for an ancillary data packet should be specified in the application document which defines the packet ID, its size and payload. Multiple application documents for various functionalities carried in ancillary data packets have been published and those documents define the purpose of these ancillary data packets that are located in a serial digital interface stream. A register of the assigned packet ID codes and their application documents is contained on the SMPTE Registration Authority web site.

Ancillary data packets are logically inserted in the parallel domain during the process of forming the serial digital interface. A complete parallel digital stream, containing image and ancillary data is used to form the serial digital stream that appears at the output of equipment.

For HDTV video, the serial video stream at the interface consists of two streams; the luma stream and the color difference stream. The ancillary data packets might be placed into either the luma or the color difference stream of the interface. The recommended location for placement of specific ancillary packets is found in the application document. The application document needs to provide information where and in which stream these ancillary data packets are found relative to the frame structure of the serial interfaces.

Note: As indicated before in Section 6.2, HANC data packets are generally used for the carriage of audio information while VANC data packets are used for carriage of various metadata.

There is no difference in data payload space or size between the luma or color difference streams.

10.2 Packet Insertion Equipment Recommendations

A survey of the actual use of ancillary data space performed by SMPTE indicated that certain recommendations for on insertion equipment would be helpful. These recommendations are indicated below:

- Ancillary data insertion equipment should allow insertion of multiple ancillary data packets with different functions on any given line in either VANC space or HANC space if sufficient space is available for insertion. Ancillary data packets in general are short and the efficient use of ancillary data space is desirable.

- Insertion equipment needs to scan the incoming stream for available space in each ancillary data space (VANC or HANC) to find where a new packet can be placed. The search ought to use data packet ADF and DC to find the location of existing packets and to determine the next location where the new packet can be inserted. This process ensures contiguity of the ancillary data space.

- As indicated before in Section 7.2, there is no preference for any type or function of registered ancillary data packet insertion unless defined by the supporting application document. All packets, as long as there is available ancillary data space, need to be accommodated. Any existing packet in the incoming stream is not allowed to be overwritten.

- Ancillary data packet equipment can support a “clean-up” function which deletes those packets marked to be deleted (DID=80h) during the packet insertion process. If this task is performed and the specific packet is deleted, the insertion equipment needs to left-shift the remaining packets located after the deleted packet so the contiguity of the ancillary data space is maintained. The insertion equipment can insert a new packet into the erased ancillary data space; however, the condition of packets contiguity needs to be strictly observed after the insertion process.

- The contiguity of the ancillary data space needs to be maintained even if a packet is moved from a specific line to another line. The insertion equipment needs to left-shift all remaining packets in the ancillary data space from which the data packet was moved, so that the contiguity condition is maintained.

- To maintain interoperability between different processing equipment, it is necessary that all operations finding space for a new packet need to be based on detection of ancillary data packets in that space and identifying free space for new packet insertion rather than on some pre-defined location.

- Insertion equipment needs to be capable to insert data packets selectively into various spaces (HANC or VANC) as per User needs without violating the contiguity rule.

- Due to various operational practices of Users, it is recommended that Users select a particular location for a specific line in their insertion/processing equipment if such data space is available. That does not mean that the newly inserted packet can override any existing packet in that space. If the desired space is not available, then the insertion equipment should insert the packet into next available ancillary data space.

- Implementers of insertion equipment ought to provide information to Users into which stream and ancillary space (VANC or HANC) ancillary data packets are placed. .

- If there is a need to replace specific ancillary data packets with a different packet of identical packet length, that can be done by replacement of the existing packet with the new packet. Another technique could be to mark the original packet as deleted and insert the new packet after the last packet in a given ancillary data space. In the case where there is not sufficient space, the packet can be placed into next available ancillary data space.

- In some cases it may be desirable to replace only the UDW of an ancillary packet. This may be done provided that the length of the new UDW is identical to the original UDW. In this case the packet insertion equipment must recalculate the value of the check sum digital code word, after the UDW of the data packet is modified

10.3 Packet Receiving Processing Equipment Recommendations

Packet receiving equipment needs to accommodate the following functions for packet processing:

- Packet receiving equipment needs to find the desired ancillary data packet based on packet ID (DID or DID/SDID) and not on specific packet location.

- Packet receiving equipment needs to expect that the location of a packet is always flexible and its location is not guaranteed.

- If the receiving equipment needs to process a specific payload by removing a packet from the stream and later it re-inserts a modified or original packet back into the stream (e.g. storage devices), it would be desirable to place the packet into the same location where the original packet was located.

- If placement of the stored packet into the same location as the original packet is impossible due to change in size of the packet or space availability, then the processing equipment needs to ensure that contiguity of the ancillary data space in the stream is maintained.

- It is recommended that receiving/processing equipment pass transparently all packets in the stream that were not used by the receiver equipment.

11 Existing Equipment Legacy Issues (Informative)

Since SMPTE established the definitions for ancillary data space and the ancillary data packet structure in approximately 1992 prior publishing, some applications have been documented. The original purpose for ancillary data packets was to carry audio within the video stream in a single SDI signal. Such a video also implied use of storage equipment for audio ancillary data packets. These packets were passed through HANC space. The VANC space started to be used later for carriage of other stream related metadata that was related to a specific video frame.

The major legacy issue related to ancillary data packet usage is transparent passage of all packets, which are present on the connecting SDI interface.

Designers of equipment and video integrators need to be aware of the limitations on the passage of ancillary data packets by some equipment, and each video design needs to take this into consideration.

Besides the limitations of some equipment on passage of ancillary data packets, various types of processing equipment such as production switchers, frame synchronizers, digital video effects equipment (DVE), and similar equipment might limit the passage of ancillary data packets by dropping them.

Legacy storage equipment usually provided limited capacity for ancillary data packets in the VANC space, sometimes passing only a few VANC lines. If equipment could not store all the ancillary data packets, the other packets were dropped. Limited passage of ancillary data packets in the VANC space through storage equipment is still an issue today.

Distribution equipment such as distribution amplifiers, routers, etc., customarily pass the whole stream, including VANC without any impact on ancillary data.

12 Requirements of an Application Document (Informative)

When an External Entity plans to submit a request for Type 2 packet DID/SDID to SMPTE, there are specific requirements for the documentation. The following list of requirements is repeated here for convenience. The complete rules can be found in SMPTE ST 291 -1

- Name and address for the applying Entity as well contact information.
- Intended use and purpose for the ancillary data packets.
- A draft application document describing the intended ancillary data payload functionality. This permits interoperable equipment to be built.
- The final application document, when published, needs to be available from a public registry or Standards development Organization (SDO).
- Patent and Intellectual Property Rights issues need to be addressed as per SMPTE rules defined in SMPTE ST 291-1 and the SMPTE Operations Manual.
- All documentation needs to be submitted in the English language.

13 Tabulation of Existing Ancillary Data Packet Application Documents (Informative)

For a list of specific DID/SDID and use of ancillary data packets that are currently registered see the SMPTE registry:

http://www.smpte-ra.org/S291/S291_reg.html

The SMPTE registry provides a listing of assigned DID/SDID values and full titles of the application documents.

Annex A Bibliography (Informative)

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 12-2:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 12M-2-2008). Documents with the same root number (e.g. 12-2) and publication year (e.g. 2008) are functionally identical.

SMPTE ST 12-2:2008, Television — Transmission of Time Code in the Ancillary Data Space

SMPTE ST 259:2008, Television — SDTV1 Digital Signal/Data — Serial Digital Interface

SMPTE ST 266:2012, SD Digital Component Systems — Digital Vertical Interval Time Code

SMPTE ST 272:2004, Television — Formatting AES Audio and Auxiliary Data into Digital Video Ancillary Data Space

SMPTE ST 292-1:2012, 1.5 Gb/s Signal/Data Serial Interface

SMPTE ST 299-1:2009, 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface

SMPTE ST 305:2005, Television — Serial Data Transport Interface

SMPTE RP 165:1994, Error Detection Checkwords and Status Flags for Use in Bit-Serial Digital Interfaces for Television

SMPTE RP 186:2008, Video Index Information Coding for 525- and 625-Line Television Systems

SMPTE OM: 2011, SECTION XIII – ENGINEERING Operations Manual

Annex B Packet Payload Throughput Rate (Informative)

The format of ancillary data packets is defined in SMPTE ST 291-1. The ancillary data packet format consists of 7 data words of overhead and can support up to 255 User Defined Words 8-bit data payload (See Figure 1a or Figure 1b).

Serial digital interfaces, over which the data packets are transmitted, can be either 8-bit or 10-bit wide. Due to the protected values for synchronization, only 8-bit wide ancillary data can be transmitted transparently thru a 10-bit interface, while for 8 bit interfaces the number of packet payload bits is smaller.

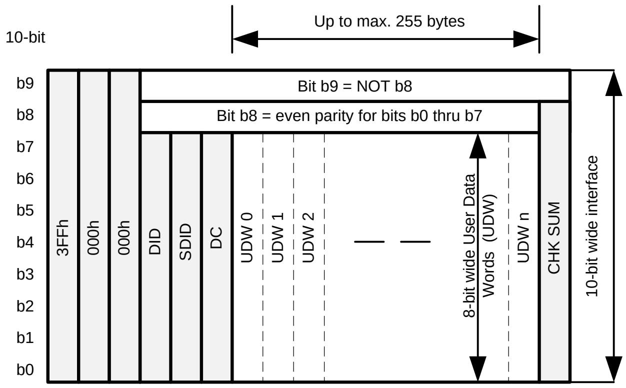

Figure 1a – Ancillary data packet 10-bit interface

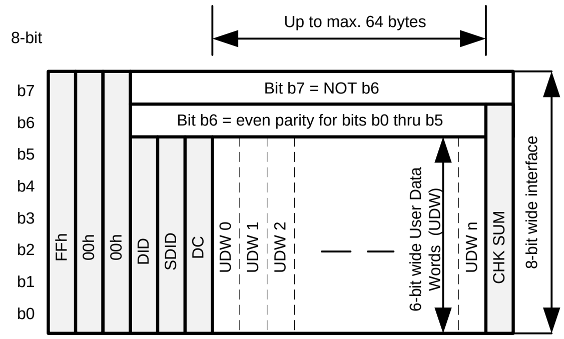

Figure 1b – Ancillary data packet 8-bit interface

Note to Figure 1b: In case a parity check is not required for a specific application, bit b6 could be used to expand the 6-bit UDW to a 7 bit UDW.

Tables 2a and 2b, Tables 3a, 3b and 3c through Tables 4a, 4b and 4c of this document indicate the data throughput in MWord/sec for both HANC and VANC ancillary data spaces. For example, to arrive at a maximum bit-rate/sec throughput for HANC ancillary data space on a 10-bit interface, the throughput number from Table 2a, 2b needs to be multiplied by 10.

The useful data payload throughput over serial interface using ancillary data packets is reduced by packet overhead; it also depends on the number of ancillary data packets and on the length of the data in each packet.

Requirements for minimum ancillary bit stream capacity (bits/sec) for a specific application using ancillary packets is given by a formula:

$$N * (F/ I) * (7+ UDW) * K = \text{minimum ancillary bit stream requirement [bits/sec]}$$

Where:

N	number of ancillary packets/frame for specific application
F	frames/sec for given video
I	non-integer constant I = 1.001 for 24*Hz; 30*Hz; 60*Hz based video. All other video I = 1
UDW	number of User Data Words (content of packet payload)
K	a constant (bit depth); equals 10 for a 10-bit interface; 8 for an 8-bit interface

Example:

The SMPTE ST 12-2 Standard defines the ancillary data application for transmission of Ancillary Time Code (ATC).

The ATC data packets are identified by DID = 60h; SDID = 60h; and DC = 10h.

The ATC packet payload was designed to be carried through either 8-bit or 10-bit interfaces without additional payload re-mapping.

The total ATC packet length, including ADF, DID, SDID, DC, 16 words of payload and CS is 23 words long. ATC packets are inserted into a 720P (1280 x 720 at 60*Hz) interface once per frame into HANC space.

Minimum required HANC stream bit rate for a single ATC packet:

1 * (60/1.001) * (7 + 16) * 10 = 13786.21bits/sec ~ 13.8 kbits/sec stream capacity requirement

ATC packet time code payload requirement throughput: (NOTE: useful packet payload - only 5 bits):

16 * 5 * (60/1.001) = 4795.2 bits/sec ~ 4.8 kbits/sec

Notes:

(1) ATC packet transmission can be considered inefficient (35%) due to packet overhead, its payload length and the payload mapping. Its virtue is in an identical packet format regardless of interface bit depth (8, 10, or even 12 bits).

(2) For a 1080i interface, the ATC packets are inserted once per field.

Annex C 8-Bit and 10-Bit Video Considerations (Informative)

C.1 Introduction

The parallel and serial digital video component interfaces are capable of passing 10-bit data words; however, some equipment in service is capable of passing only 8-bit data words.

The passage of a 10-bit signal through such 8-bit equipment results in truncation and the loss of two LSBs. Although this is tolerated for digital video data, it has the effect of destroying the ancillary data signal unless precautions are taken. The subsequent serializing of the truncated 8-bit signal for transmission through the 10-bit serial interface results in two additional bits — usually zeroes — being appended to the signal data bits (see Figure C.1).

Similarly, data words originated in 8-bit form become extended to 10-bit form because of passage through a serial interface. Although the two additional bits are usually both zeroes, this cannot be guaranteed. Consequently, for detection of the line synchronizing words (EAV and SAV) and ancillary data flags (ADF), data values in the ranges 000h – 003h and 3FCh – 3FFh (10-bit) need to be processed identically as 00h and FFh (8-bit), respectively.

C.2 8-Bit Compatibility

It is possible to design an ancillary data signal that is usable in both 8-bit and 10-bit video, provided recognition is given to the effects of passage through 8- and 10-bit video.

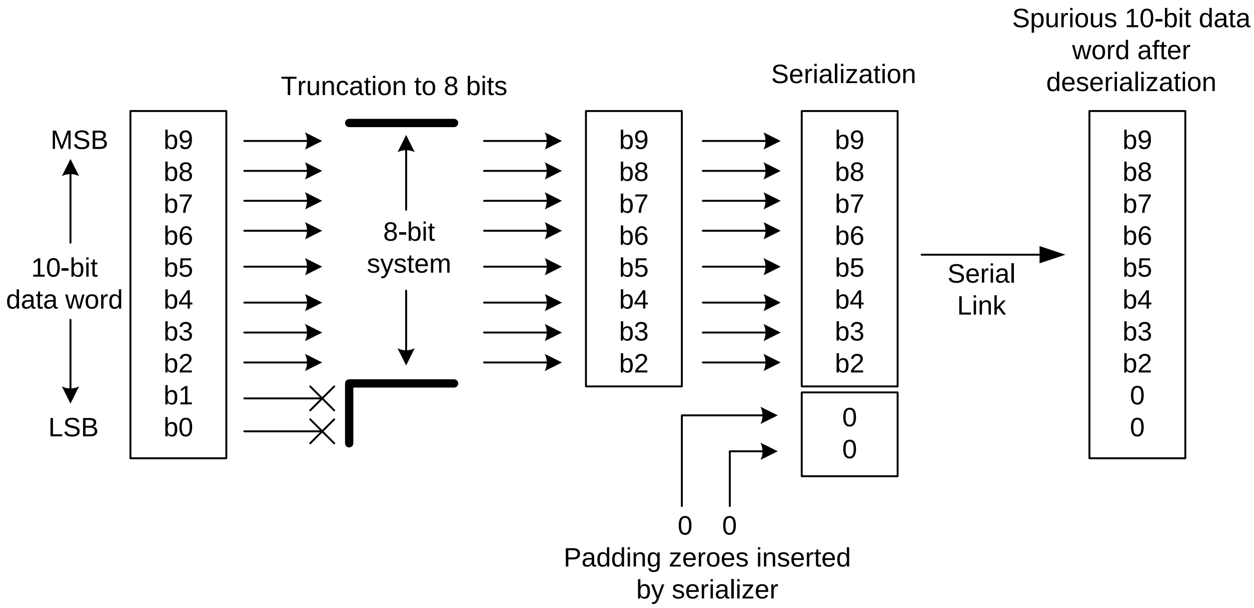

Figure C.1 – Corruption of a data word

C.2.1 Data Identification

Ancillary data signals designed for 8-bit applications are Type 2 signals and contain both DID and SDID data words. DID words shown in SMPTE ST 291-1 as reserved for 8-bit applications are restricted to three values in the range shown.

Out of the values 04h – 0Fh reserved for 8-bit applications, the only valid values are 04h, 08h, and 0Ch. Other values in the reserved range would be truncated to these three values. The two most-significant bits of the data words used for DID or SDID carry an even parity bit and its inverse. Consequently, in 8-bit applications, only 6 bits are available in the SDID data words as shown in Figure C.2. This results in 64 possible values, as indicated below:

x0h, x4h, x8h, xCh

where x may be any value in the range 0h – Fh.

Setting aside the value 00h for the undefined format, the remaining 63 values in the SDID, combined with the 3 assigned values available in the DID for 8-bit applications, give a maximum of 189 different identification values.

C.2.2 Data Count

When an ancillary data packet intended to be used in, or is generated by an 8-bit application, bits b0 and b1 are either not present (8-bit interface) or are set to zero (10-bit interface). Consequently, the DC consists of the following:

bit b7 (MSB) – b2 (LSB) are the 6 MSBs of the data count

bit b8 is the even parity bit for bits b7 – b2

bit 9 = NOT b8

Only 6 bits are available in the DC to specify the number of user data words in an 8-bit ancillary data signal.

C.2.3 User Data Words

It is a requirement that the protected values 00h and FFh do not appear under any circumstances in the user data words. Methods used to achieve this are not part of this document, but each application must define it. As examples, one method is the use of 2 bits block (see Figure C.2) plus a single parity bit in each word. A second method is the use of just 7 data bits, while a third method would be defining restriction to the coding range to exclude the protected values.

C.2.4 Checksum

In 10-bit applications, the checksum value is equal to the 9 least significant bits of the sum of the 9 least significant bits of the DID, the DBN or the SDID, the DC, and all UDWs in the packet.

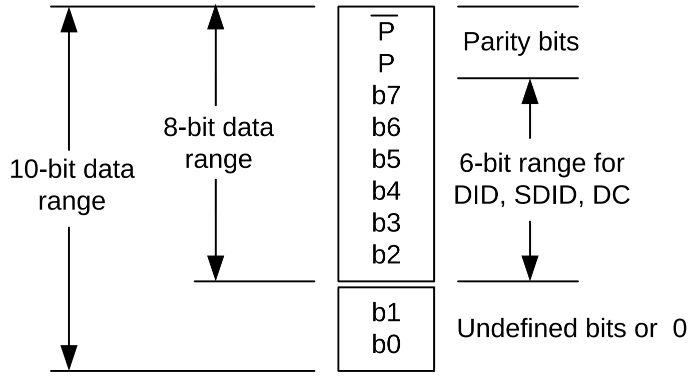

Figure C.2 – Coding range for 8-bit DID, SDID/DBN and DC

In 8-bit applications, where the two LSBs of every 10-bit word in the packet are set to zeroes, the CS word is calculated in the same way as for 10-bit applications. The LSBs produce a zero sum themselves and hence produce no carry bit to affect the checksum.

Annex D Ancillary Data Packets Nesting (Informative)

For some applications, it is possible to use nested data packets within a single ancillary packet payload space.

An application document that defines such a requirement needs to describe the method (encoding) of how the additional data packets are nested. It is possible to nest more than a single data packet within the data packet payload; however, the fundamental limitation remains; that the payload length of the overall ancillary data packet cannot exceed 255 bytes.

The relevant rules for the nested packets are defined in the application document.

Figure D.1 shows an example of nesting of packets.

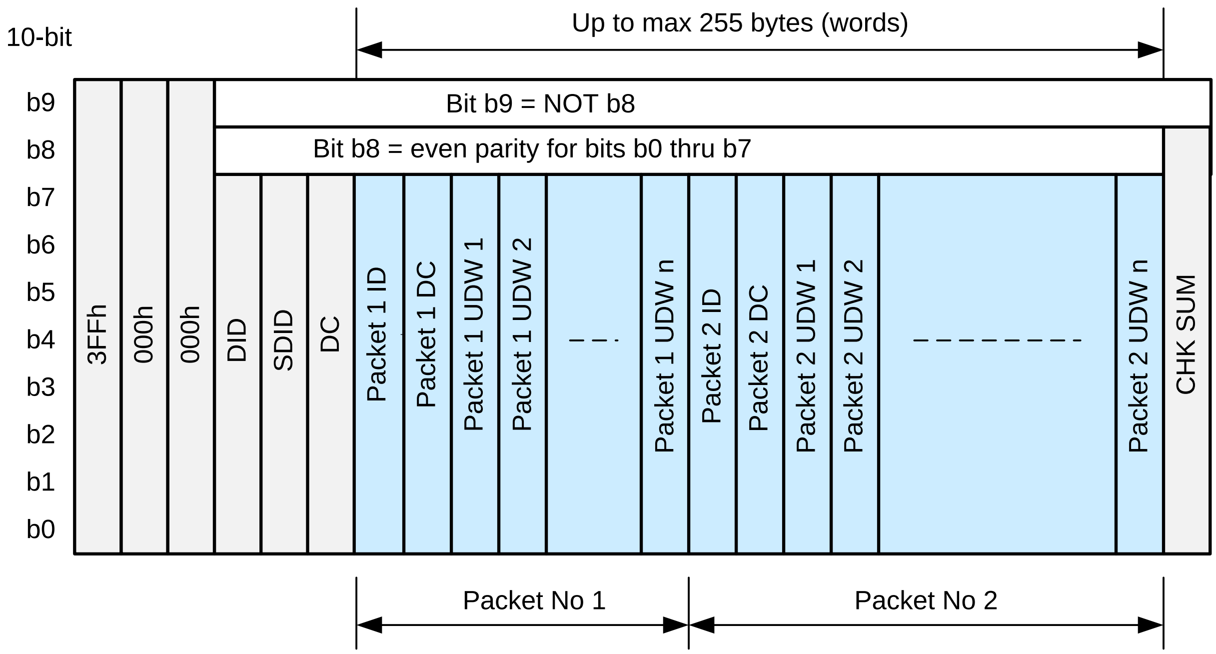

Figure D.1 – An example of packet nesting

Annex E Ancillary Space Calculations (Informative)

The numbers shown in Tables 2a and 2b to 4a, 4b and4c can be derived from applying formulas relevant to the particular video formats. This annex details the formulas used and lists special conditions that are applicable in some video formats.

SAV = Length of SAV = 4

EAV = Length of EAV = 4

ASPL = Active Samples per line

TSPL = Total Samples per line

HSPL = HANC samples per line

TL = Total Lines per frame

AL = Active Lines per frame

FR = Frame rate (Frames per second)

SR = Sample Rate

E.1 Standard Definition Calculations

For Standard Definition video formats, there is one ancillary data stream that consists of multiplexed Luma and color difference samples. The SAV and EAV synchronizing sequences are 4 words long each.

The calculations below allow the reader to derive the values from the encoding parameter tables in SMPTE ST 125 and ITU-R BT 601.

TSPL is the same as Samples per Total Line

ASPL is the same as Samples per Active Digital Line and is 720

The total number of luminance samples per line is calculated as:

TSPL = SR / (TL * FR)

Lines available for VANC data per field is calculated as:

VANC_Lines = Total_VBI_Lines_per_Field – VANC Reserved_lines

The total lines per frame is the sum of the lines available in each field.

Note: For Standard definition interlaced formats, there are 3 lines per field where it is not permitted to place VANC data. These are the switch line, the line following the switch line and the line reserved for D-VITC (SMPTE ST 266) and Video Index (SMPTE RP 186).

Samples available for VANC data = ASPL * 2

VANC MWords per Second per field is calculated as:

VANC_MWords_per_second = (VANC_Lines * ASPL * 2 * FR)/ 1000000

Samples available per line for HANC data is calculated as:

HSPL = (TSPL – ASPL) * 2 – (SAV +EAV)

Lines available for HANC:

HANC_Lines = TL – HANC reserved Lines

Note: For Standard definition interlaced formats, there are 2 line intervals where it is not permitted to place HANC data (the line after the switch line). Insertion of ancillary data packets is permitted into any HANC space with the exception as indicated above and HANC space reserved for an EDH data packet defined in SMPTE RP 165.

E.2 High Definition Calculations

For High Definition video formats, there are two ancillary data streams; one carried in luma and the other in the color difference. The SAV synchronizing sequence is 4 words long. The EAV 4 word sequence is followed by a 2 word line number and a 2 word CRC, to make the High Definition EAV sequence a total of 8 words. The SAV and High Definition EAV sequences occur in each data stream, thus reducing the amount of HANC data space.

The calculations below allow you to derive the values from the analog and digital timing relationship figures and their associated tables in SMPTE ST 274, SMPTE ST 296 and SMPTE ST 2048-2.

TSPL is the same as Dimension C in SMPTE ST 274, SMPTE ST 296 and SMPTE ST 2048-2.

ASPL is 1920 for SMPTE ST 274, 1280 for SMPTE ST 296, and 2048 for SMPTE ST 2048-2.

HSPL is the same as Dimension B + 8 in SMPTE ST 274, SMPTE ST 296 and SMPTE ST 2048-2.

The total number of luminance samples per line is calculated as:

TSPL = SR / (TL * FR)

For interlaced formats the lines available for VANC data per field is calculated as:

VANC_Lines = Total_VBI_Lines_per_Field – VANC Reserved_lines

The total lines per frame is the sum of the lines available for each field.

For progressive formats the number of lines available for VANC data per frame is calculated as:

VANC_Lines = TL-AL– VANC Reserved_lines

Note: For High Definition interlaced formats, there are 2 lines per field where it is not permitted to place VANC data. These are the switch line, and the line following the switch line. For High Definition progressive formats, there are 2 VANC lines per frame where it is not permitted to place VANC data. These are the switch line, and the line following the switch line.

Samples available for VANC data = ASPL * 2

VANC MWords per Second per field is calculated as

VANC_MWords_per_second = 2 * (VANC_Lines * ASPL * FR)/ 1000000

Samples available per line for HANC data is calculated as

HSPL = 2 * ((TSPL – ASPL) – (SAV +EAV+4))

Lines available for HANC

HANC_Lines = TL – HANC reserved Lines

Note: For High Definition interlaced formats, there are 2 line intervals (the line after each switch line) where it is not permitted to place HANC data. In High Definition progressive formats there is one HANC interval (the line after the switch line) where it is not permitted to place HANC data.

E.3 Mapping of 1080p/50/60 to Dual link 1.5 Gb/s Interface

According to SMPTE ST 372, when 1080p/50/60 is mapped onto a dual link 1.5 Gb/s interfaces, Link A has the same available VANC data space as 1080i/50/60. Link B has one more reserved line due to the non-symmetrical mapping of data onto the interface.

E.4 Mapping of 1080p/50/60 to 3 Gb/s Level B-Dual Link Interface

Level B-DL mapping in SMPTE ST 425-1 is a word multiplex of all the data that exists on the dual link SMPTE ST 372 interfaces; hence, the attainable data space on this interface is exactly the same as the space available on SMPTE ST 372.