SMPTE 321M-2002
Revision of
SMPTE 321M-1999

SMPTE STANDARD

for Television — Data Stream Format for the Exchange of DV-Based Audio, Data and Compressed Video over a Serial Data Transport Interface

1 Scope

1.1 This standard defines the format of the data steam for the synchronous exchange of DV-based audio, data, and compressed video (whose data structure is defined in SMPTE 314M and SMPTE 370M) over the interface defined in SMPTE 305M. It covers the transmission of audio, subcode data, and compressed video packets associated with DV-based 25- and 50-Mb/s data structures including faster-than-real-time transmission, and 100-Mb/s data structures for 525/60 SDTI and 625/50 SDTI systems.

1.2 This standard does not include the data stream of a DV-compressed structure as defined in SMPTE 322M.

1.3 Space within SMPTE 305M not used by a data stream conforming to this standard may be used for the transmission of data other than those representing DV-based audio, data, and compressed video.

1.4 In this standard, the 60-Hz system refers to the field frequency 59.94-Hz system and the 50-Hz system refers to the field frequency 50.0-Hz system.

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 274M-1998, Television — 1920 x 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates

SMPTE 296M-2001, Television — 1280 x 720 Progressive Image Sample Structure — Analog and Digital Representation and Analog Interface

SMPTE 305.2M-2000, Television — Serial Data Transport Interface (SDTI)

SMPTE 314M-1999, Television — Data Structure for DV-Based Audio, Data and Compressed Video — 25 and 50 Mb/s

SMPTE 370M, Television — Data Structure for DV-Based Audio, Data and Compressed Video at 100 Mb/s — 1080/60i, 1080/50i, 720/60p

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3 Identification within the serial data transport interface (SDTI)

3.1 SDTI header packet data

The header packet data words of the serial data transport interface (SDTI) associated with this data stream format shall conform to SMPTE 305M. When the SDTI interface is transporting a data stream conforming to this standard, the block type word within the SDTI header packet shall have the value 173_h for transported data contained in fixed-size blocks when ECC (error correction code) is used and the value 233_h when ECC is not used.

3.2 Payload

The payload is composed of consecutive fixed-size blocks (see figure 1). The SDTI data type word shall identify the data type of this payload with the value 221_h.

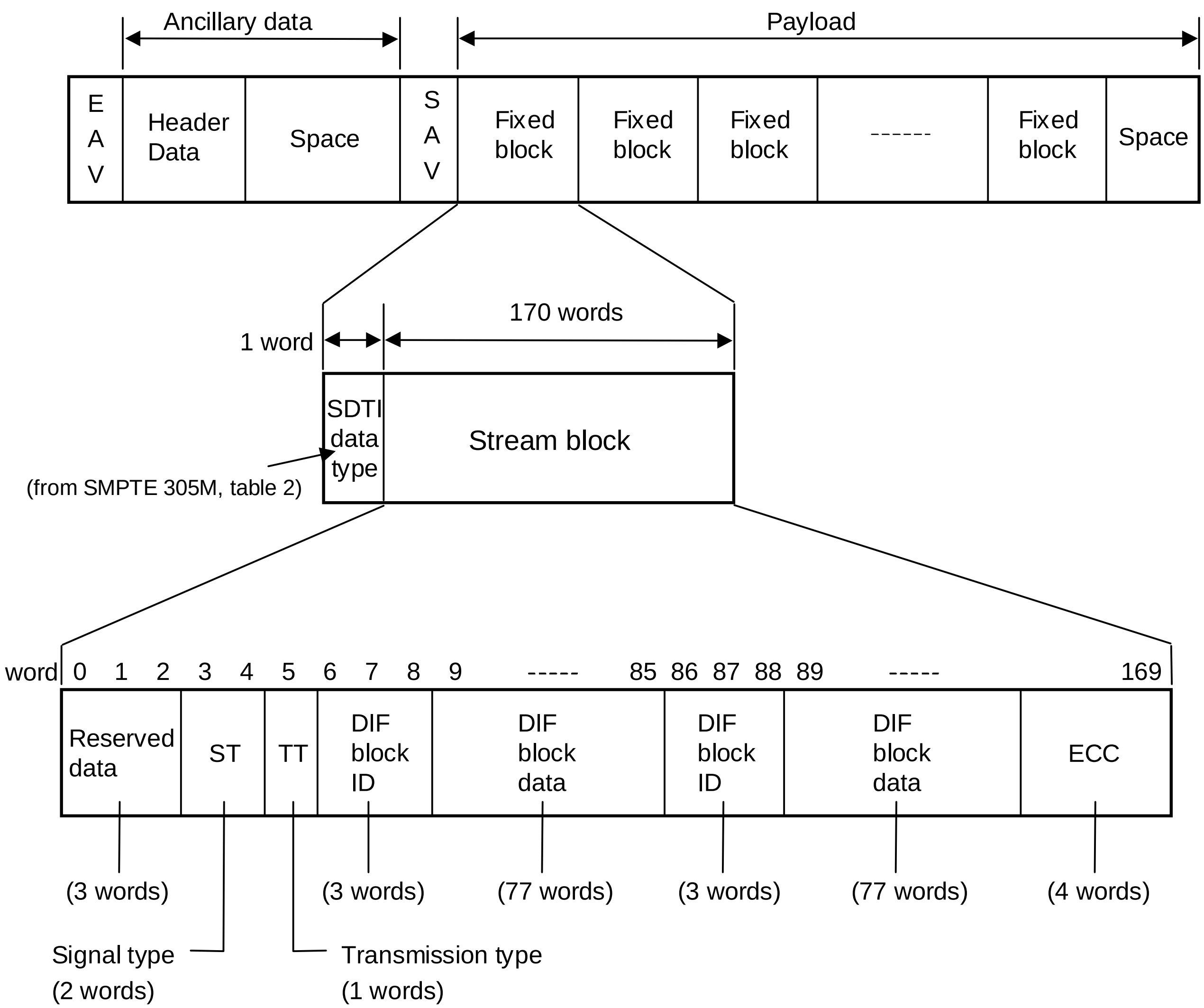


Figure 1 – Stream block format

4 Stream block format

The stream block format is shown in figure 1. The length of each stream block is 170 words, including a secondary header, two DIF (digital interface) block IDs, two DIF block data (of stream data), and an ECC block. The secondary header contains reserved data words, signal type words, and a transmission type word. The complete word structure of the stream block for a compressed video data stream is defined below:

Reserved data:	3 words
Signal type:	2 words
Transmission type:	1 word
DIF block ID:	3 words
DIF block data:	77 words
DIF block ID:	3 words
DIF block data:	77 words
ECC:	4 words

4.1 Reserved data words

The reserved data words shall consist of 3 words and be positioned at the start of the stream block. The default value for the reserved data is 200_h.

4.2 Signal type words

The signal type word (ST) mapping is shown in figure 2. The signal type words shall consist of two words. The first word of ST (word 3) includes the specific type of video frame ID (STVF ID). The second word of ST (word 4) includes the field/frame frequency flag (FF), the DIF structure format, the DIF valid flag (DVF), the frame sequence number flag (FSNF), the transmission rate flag (TRF), and reserved bits.

	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
word 3	$\overline{EP}$	EP	Reserved					STVF ID		
word 4	$\overline{EP}$	EP	FF	DIF structure			Res	DVF	FSNF	TRF

Figure 2 – Signal type (ST) word mapping

Word 3 of ST

The STVF ID shows information mainly related to pictures that have been 3:2 pull-down converted from 480 line/29.98 frame rate progressive pictures.

In the case of the 25- and 50-Mb/s structure for the 525/60 SDTI system, the following applies:

Bits B7 through B3 are reserved bits and shall be set to 00000_b as default values.

Bits B2 through B0 indicate the specific type of video frame ID which shows the type of the converted picture with the following values:

B2	B1	B0		Original	Converted
0	0	0	:	480i / 29.97	-> No change
0	0	1	:	480p / 29.97	-> Segmented frame (see note)
0	1	0	:	480p / 23.98	-> No field sequence ID (3:2 pull down)
0	1	1	:	480p / 23.98	-> A frame (3:2 pull down)
1	0	0	:	480p / 23.98	-> B frame (3:2 pull down)
1	0	1	:	480p / 23.98	-> C frame (3:2 pull down)
1	1	0	:	480p / 23.98	-> D frame (3:2 pull down)
1	1	1	:	480p / 23.98	-> E frame (3:2 pull down)

NOTE – Odd lines of 480p/29.97 are mapped to the first field and even lines of 480p/29.97 are mapped to the second field.

In the case of the 100-Mb/s structure for the 525/60 SDTI system and in the case of the 25-, 50-, and 100-Mb/s structures for the 626/50 SDTI system, the following applies:

All values of bits B7 through B0 are set to 00_h as default values.

Bit B8 of word 3 is equal to the even parity of B7 through B0.
Bit B9 of word 3 is equal to the complement of B8.

Word 4 of ST

Bit B7 indicates the field frequency of the serial digital interface (SDTI) with the following values:

B7		
0	:	60 Hz (59.94 Hz)
1	:	50 Hz

Bits B6 through B4 indicate the DIF structure with the following values:

B6	B5	B4		
0	0	0	:	Reserved
0	0	1	:	Reserved
0	1	0	:	Reserved
0	1	1	:	25-Mb/s structure
1	0	0	:	Reserved
1	0	1	:	50-Mb/s structure
1	1	0	:	100-Mb/s structure
1	1	1	:	Reserved

Bit B3 is the reserved bit and shall be set to 0_b as the default value.

Bit B2 is the DIF valid flag (DVF) and indicates the validity of the DIF data mapped into SDTI.

B2		
0	:	Invalid
1	:	Valid

Bit B1 is the frame sequence number flag (FSNF) and indicates the validity of the frame sequence number (see 4.3) with the following values:

B1		
0	:	Valid
1	:	Invalid

Bit B0 is the transmission rate flag (TRF) and indicates the validity of the transmission rate (see 4.3) with the following values:

B0
0 : Valid
1 : Invalid

Bit B8 is equal to the even parity of B7 through B0.
Bit B9 is equal to the complement of B8.

4.3 Transmission type word

The transmission type word (TT) mapping is shown in figure 3. The transmission type word shall consist of one word including the frame sequence number and the transmission rate.

	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
word 5	$\overline{EP}$	EP	Frame sequence number				Transmission rate			

Figure 3 – Transmission type (TT) word mapping

Bits B7 through B4 indicate the frame sequence number with the following values:

0_h : 1
1_h : 2
|
F_h : 16

The frame sequence number identifies frames multiplexed within an SDTI frame.

Bits B3 through B0 indicate the transmission rate with the following values:

0_h : 1 x (normal transmission rate) (see note)
1_h : 2 x
2_h : 3 x
3_h : 4 x
4_h : 5 x
5_h : 6 x
6_h : 7 x
7_h : 8 x
8_h - E_h : Reserved
F_h : 16 x

NOTE – The multiple of the normal transmission rate is represented by x. The normal transmission rate corresponding to normal reproduction of the television picture is 1 x.

Bit B8 is equal to the even parity of B7 through B0.
Bit B9 is equal to the complement of B8.

4.4 DIF block ID words

The DIF block ID (ID0-2) shall consist of three words contained in bits A23 through A0 as shown in figure 4. The lower 8-bit portion of these three words is specified in SMPTE 314M and SMPTE xxxM.

	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
word 6 and 86	$\overline{EP1}$	EP1	A7	A6	A5	A4	A3	A2	A1	A0
word 7 and 87	$\overline{EP2}$	EP2	A15	A14	A13	A12	A11	A10	A9	A8
word 8 and 88	$\overline{EP3}$	EP3	A23	A22	A21	A20	A19	A18	A17	A16

Figure 4 – Mapping of DIF block ID

EP1 is equal to the even parity of bits A7 through A0;
EP2 is equal to the even parity of bits A15 through A8;
EP3 is equal to the even parity of bits A23 through A16;
and

$\overline{EP1}$ is equal to the complement of EP1;
$\overline{EP2}$ is equal to the complement of EP2;
$\overline{EP3}$ is equal to the complement of EP3.

4.5 DIF block data words

The DIF block data shall consist of 77 words. The lower 8 bits of each DIF block word represent the DIF block data, as specified in SMPTE 314M and SMPTE xxxM; the higher 2 bits are parity data.

Bits B7 through B0 are DIF block data; Bit B8 is equal to the even parity of B7 through B0.
Bit B9 is equal to the complement of B8.

4.6 Error correction code (ECC) words

Bits B7 through B0 of the words within a stream block (including reserved data words, the ST word, the TT word, and all words of the DIF block ID and DIF block data) are optionally protected by an error correction code (ECC). The ECC shall consist of four words and be inserted at the end of the stream block.

The error correction code is a (170, 166) Reed-Solomon code in GF(256), whose field generator polynomial is shown as:

$$P(x) = X^8 + X^4 + X^3 + X^2 + 1$$

where X^i are place-keeping variables in GF(2), the binary field. The generator polynomial of the code in GF(256) is:

$$G(x) = (x+\alpha)(x+\alpha^2)(x+\alpha^3)(x+\alpha^4)$$

where α is given by 2_h in GF(256).

When the value of the block type in the SDTI header (see 3.1) is 173_h, the Reed-Solomon code shall be contained in C31 through C0 as shown in figure 5. When the value of the block type is 233_h, the ECC shall have the fixed value 200_h.

	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
word 166	$\overline{EP1}$	EP1	C7	C6	C5	C4	C3	C2	C1	C0
word 167	$\overline{EP2}$	EP2	C15	C14	C13	C12	C11	C10	C9	C8
word 168	$\overline{EP3}$	EP3	C23	C22	C21	C20	C19	C18	C17	C16
word 169	$\overline{EP4}$	EP4	C31	C30	C29	C28	C27	C26	C25	C24

Figure 5 – Mapping of ECC

EP1 is equal to the even parity of bits C7 through C0;
EP2 is equal to the even parity of bits C15 through C8;
EP3 is equal to the even parity of bits C23 through C16;
EP4 is equal to the even parity of bits C31 through C24;

and

$\overline{EP1}$ is equal to the complement of EP1;
$\overline{EP2}$ is equal to the complement of EP2;
$\overline{EP3}$ is equal to the complement of EP3;
$\overline{EP4}$ is equal to the complement of EP4.

5 Transmission order

The transmission order within one frame for 25-, 50-, and 100-Mb/s DV-based compression structures consisting of DIF blocks is shown in figures 6, 7, 8, and 9.

In the 100-Mb/s structure, one frame is carried in four channels, which are transmitted in sequence from the first channel to the fourth channel one after another. In the 50-Mb/s structure, each frame is carried in two channels, which are transmitted in sequence one after another. In the 25-Mb/s structure, only a single channel is used.

Each channel consists of 10 DIF sequences in the 60-Hz system or 12 DIF sequences in the 50-Hz system. DIF sequences within a frame are transmitted in a DIF sequence order from 0 to n-1. Each DIF sequence is composed of 150 DIF blocks. DIF blocks within a DIF sequence are transmitted sequentially from DIF block 0 to 149.

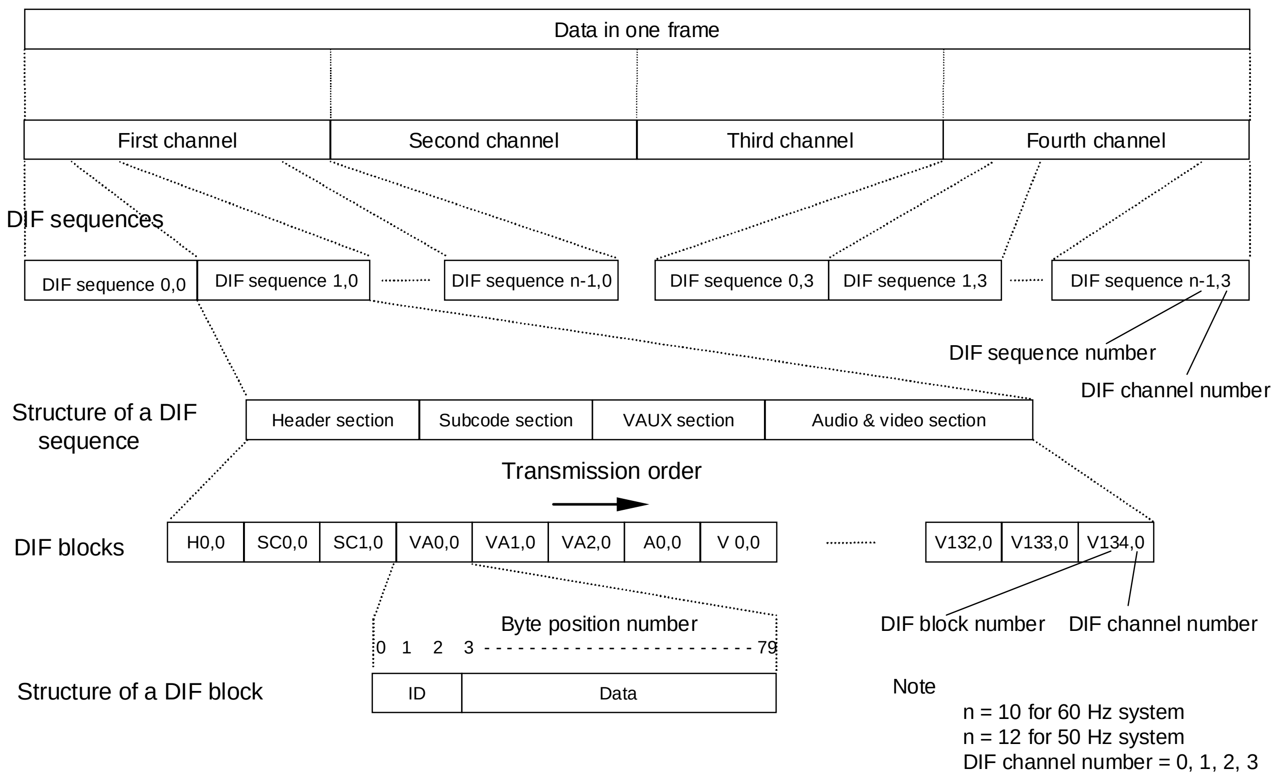


Figure 6 – Transmission order in one frame for the 100-Mb/s structure

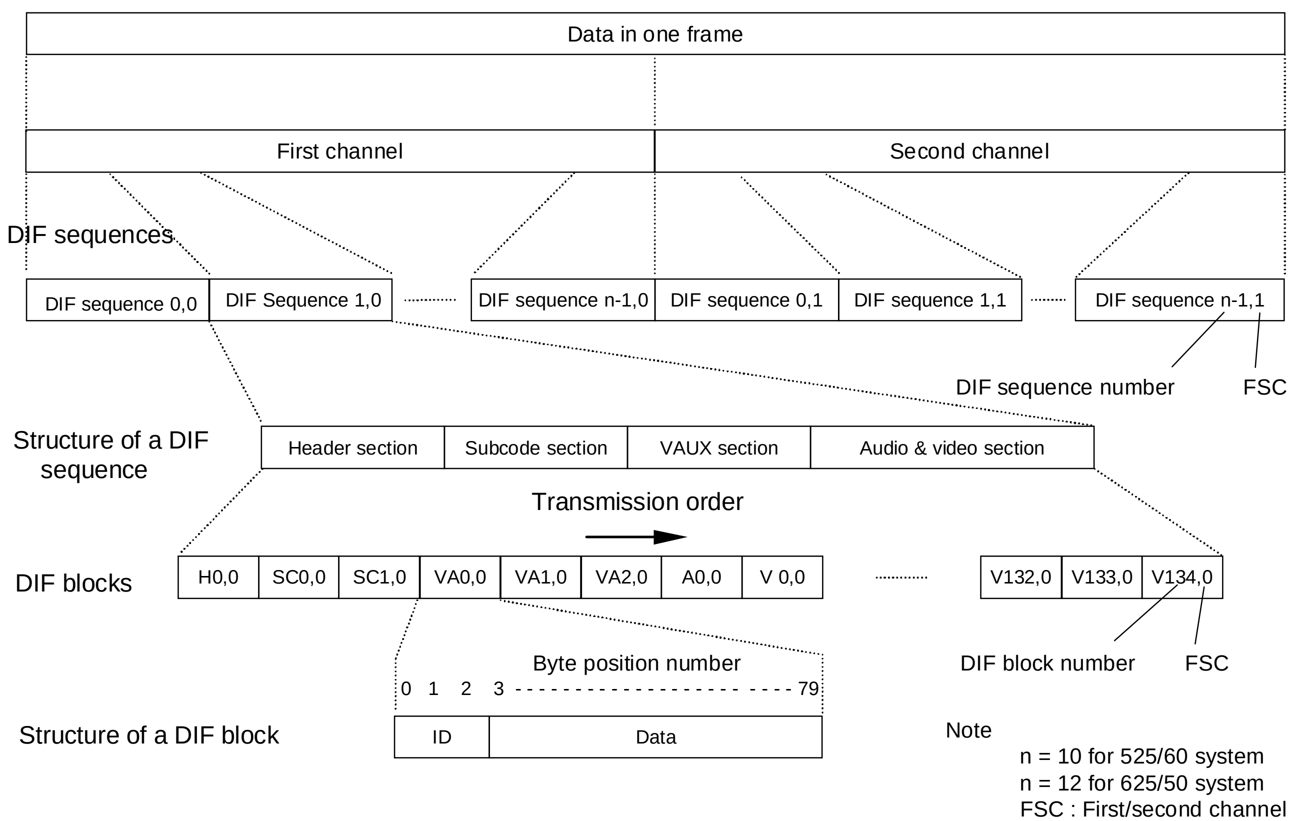


Figure 7 – Transmission order in one frame for the 50-Mb/s structure

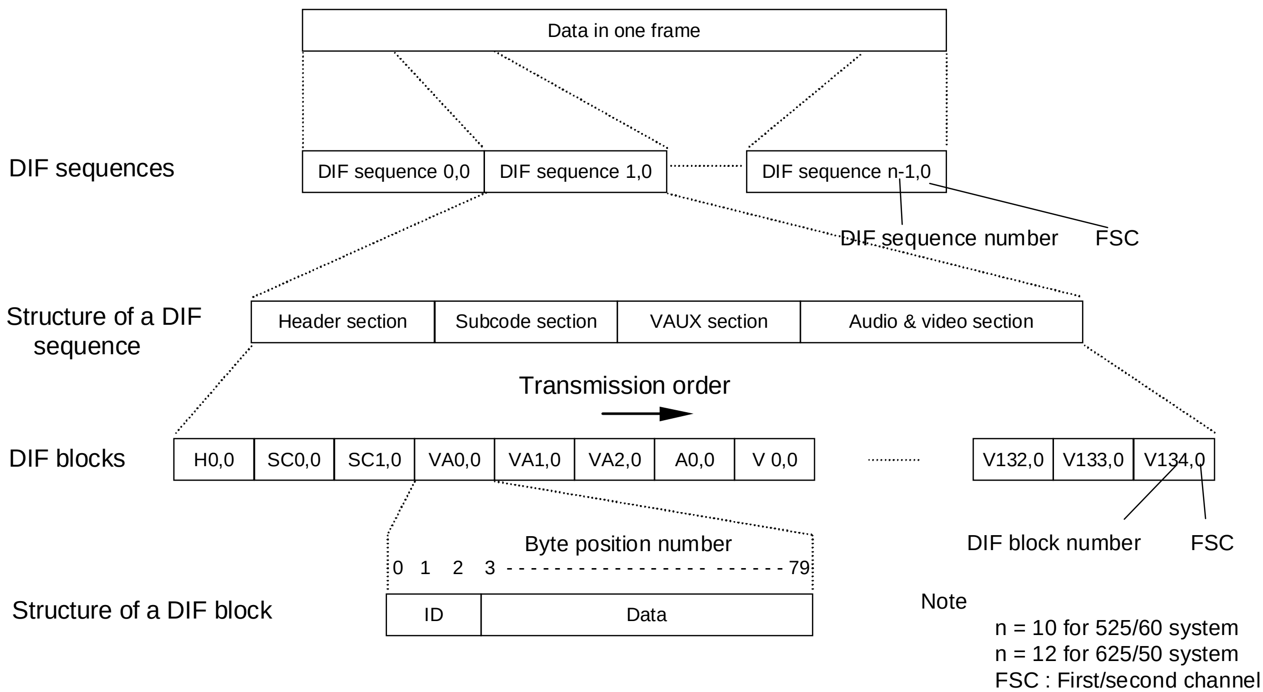
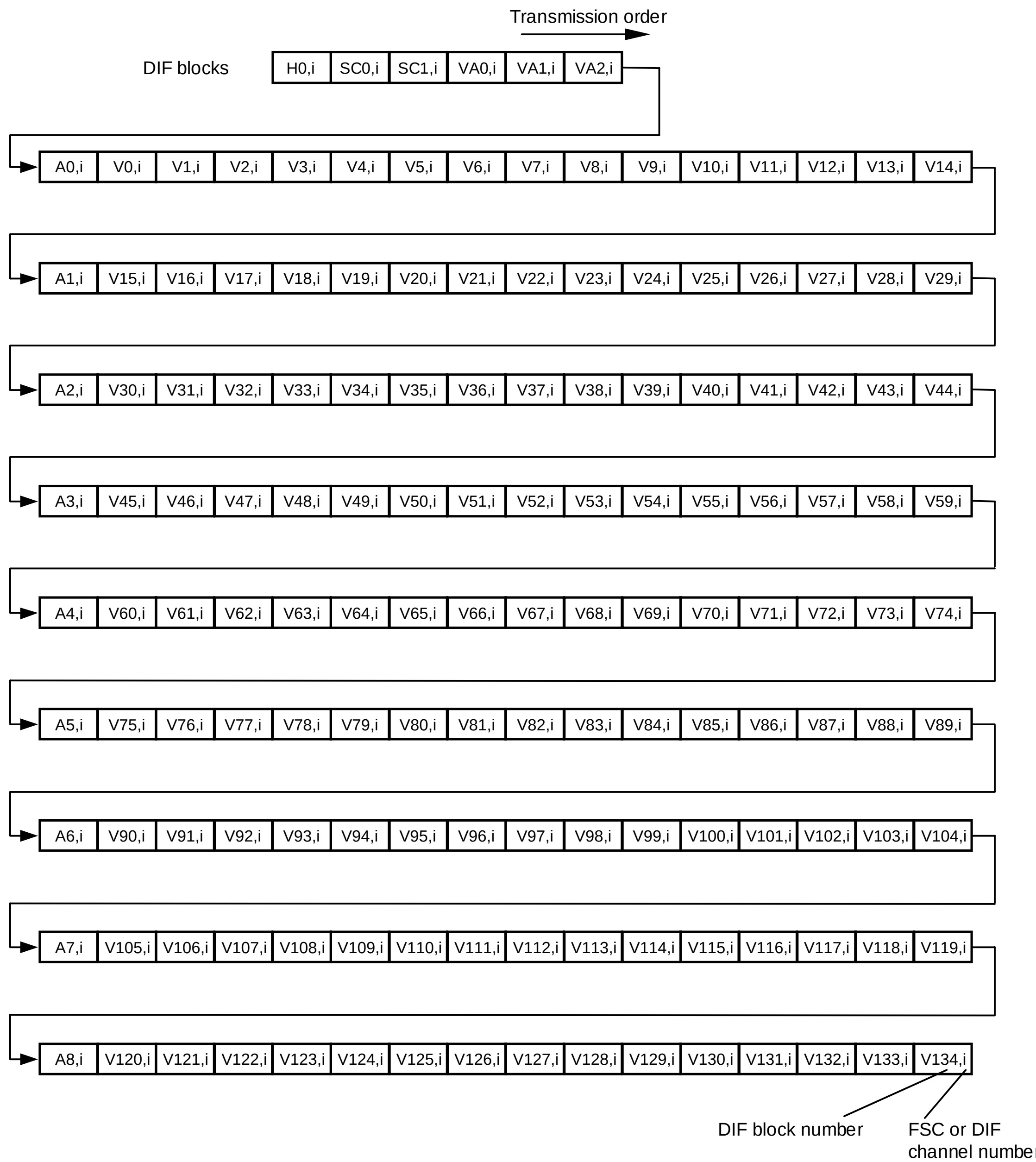


Figure 8 – Transmission order in one frame for the 25-Mb/s structure



NOTES

i : FSC i=0 for 25-Mb/s structure
FSC i=0,1 for 50-Mb/s structure
DIF channel number i=0,1,2,3 for 100-Mb/s structure
H0,i : DIF block in header section
SC0,i to SC1,i : DIF blocks in subcode section
VA0,i to VA2,i : DIF blocks in VAUX section
A0,i to A8,i : DIF blocks in audio section
V0,i to V134,i : DIF blocks in video section
The DIF channel number is defined by FSC and FSP as described in table 5 of SMPTE 370M.

Figure 9 – Transmission order in a DIF sequence

6 Mapping structure

The mapping structure defines where SDTI stream blocks are mapped into SDTI frames.

An SDTI data block of the fixed-block variety (as used by this standard) is based on one stream block; the stream block in turn includes two DIF blocks and associated words, as shown in figure 1.

– In the 525/60 SDTI system, the compressed video data stream within an SDTI frame is composed of 750 SDTI data blocks (1500 DIF blocks) for the 25-Mb/s compression structure or 1500 SDTI data blocks (3000 DIF blocks) for the 50-Mb/s structure or 3000 SDTI data blocks (6000 DIF blocks) for the 100-Mb/s structure.

– In the 625/50 SDTI system, the compressed video data stream within an SDTI frame is composed of 900 SDTI data blocks (1800 DIF blocks) for the 25-Mb/s compression structure or 1800 SDTI data blocks (3600 DIF blocks) for the 50-Mb/s structure or 3600 SDTI data blocks (7200 DIF blocks) for the 100-Mb/s structure.

6.1 Channel unit

The channel unit structure is shown in figures 10 and 11. A channel unit is a series of SDI raster lines into which SDTI data blocks are mapped. In the case of 25-Mb/s structure transmission, a channel unit is composed of the SDTI data blocks of one frame (see 6.2 for the 50- and 100-Mb/s structures).

A channel unit is thus composed of 750 SDTI data blocks for the 525/60 SDTI system or 900 SDTI data blocks for the 625/50 SDTI system.

In the 525/60 SDTI system, a channel unit occupies 94 lines in the 270-Mb/s interface or 69 lines in the 360-Mb/s interface; in the 625/50 SDTI system, a channel unit occupies 113 lines in the 270-Mb/s interface or 82 lines in the 360-Mb/s interface.

The remaining payload space within a channel unit should be filled with blocks with their value set to the invalid type number 100_h, as defined in SMPTE 305M.

6.2 Mapping rules

The mapping rules are as follows:

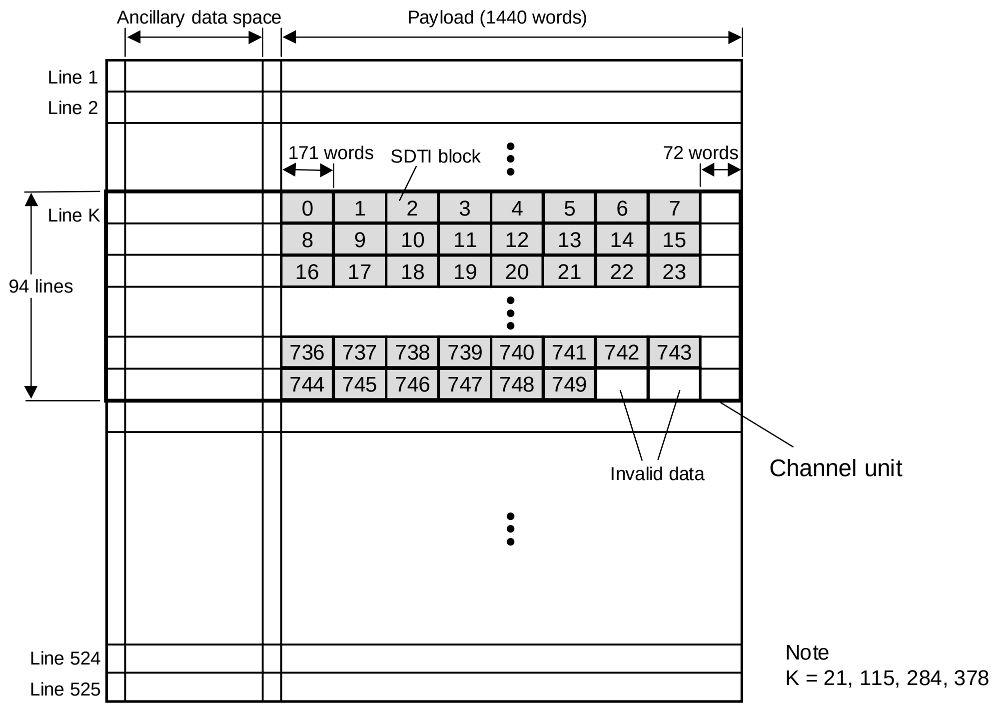
- Channel units consist of contiguous lines with no gaps and shall not use lines 10, 11, 273, or 274 in the 525/60 SDTI system, or lines 6, 7, 319, or 320 in the 625/50 SDTI system.

– The start lines in which a channel unit can be mapped are shown in table 1.

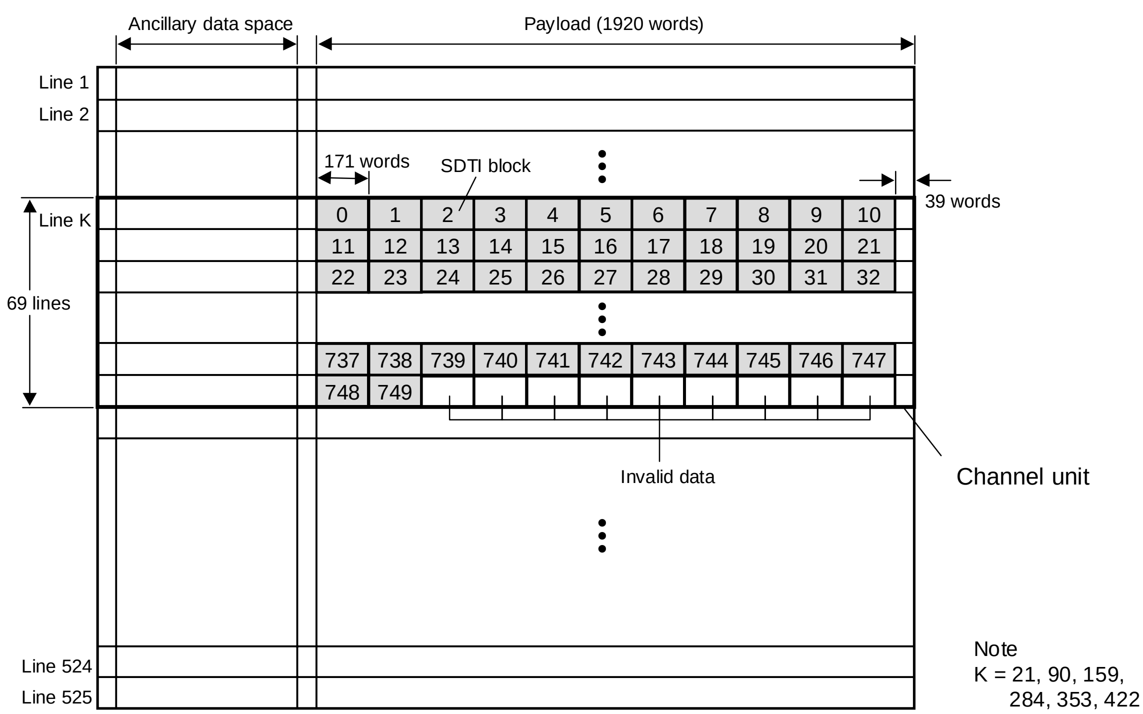
– A channel unit shall be completely contained within an SDI video field.

– Multiple channel units shall not be mapped into the same line and shall not be interleaved with each other.

– For faster-than-real-time transmission, the mapping order of channel units shall be in time sequence.

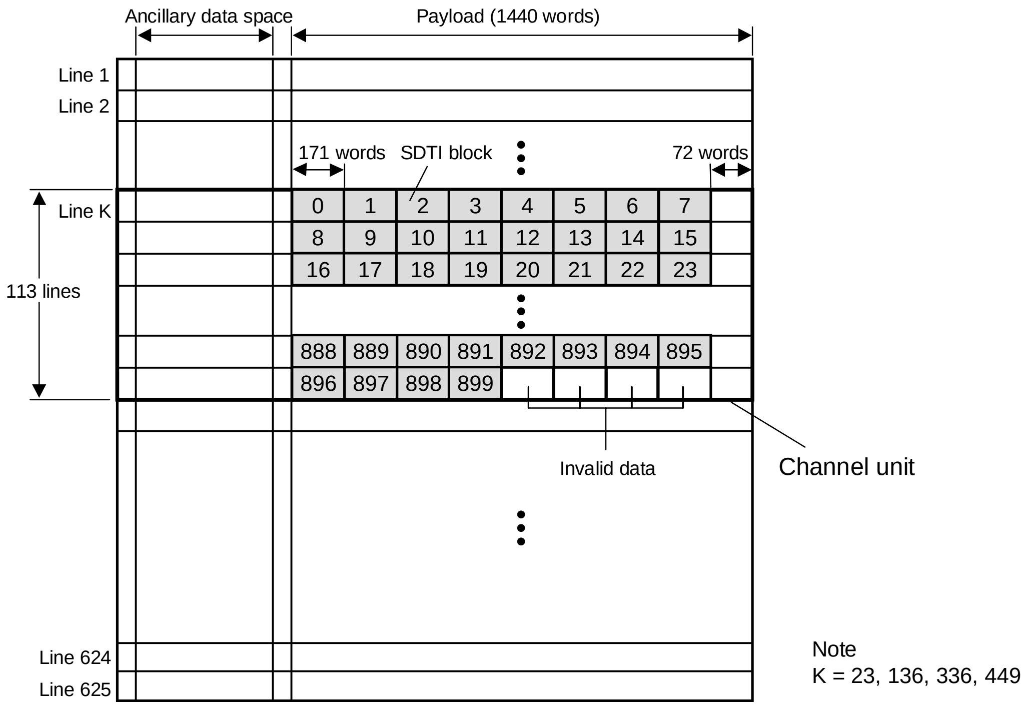


a) for 270 Mb/s system

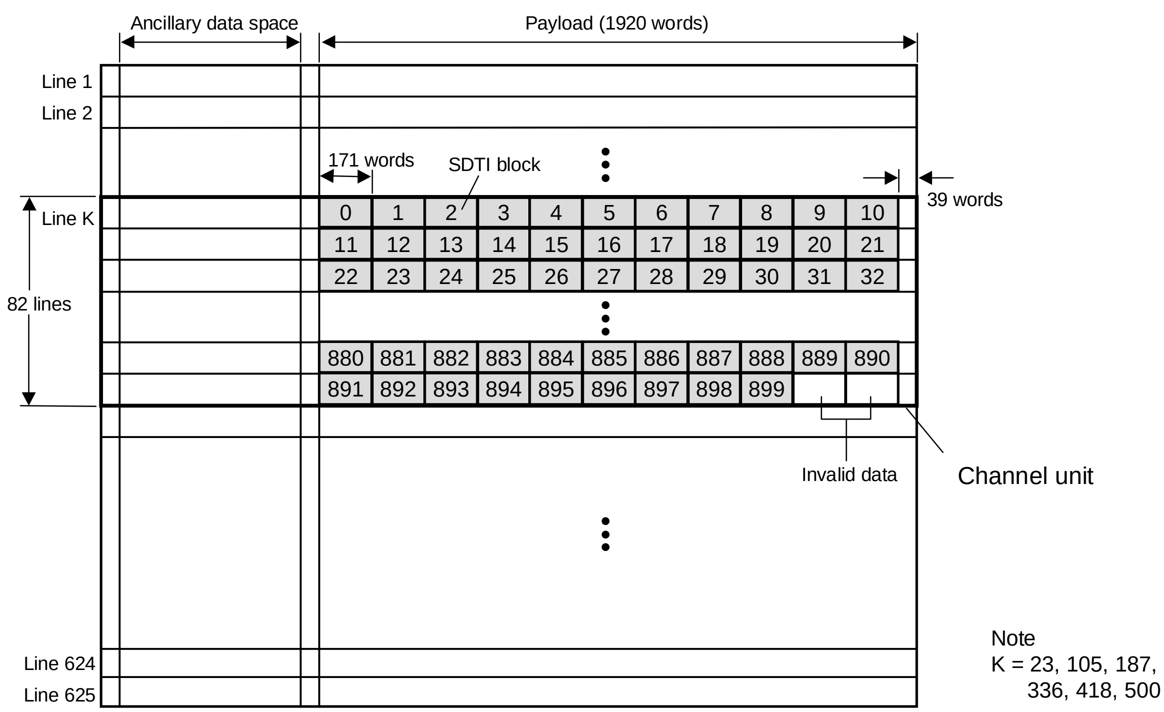


b) for 360 Mb/s system

Figure 10 – Channel unit mapping for the 25-Mb/s structure (525/60 SDTI system)



a) for 270 Mb/s system



b) for 360 Mb/s system

Figure 11 – Channel unit mapping for the 25-Mb/s structure (625/50 SDTI system)

Table 1 – Start lines of channel units

525/60 SDTI system	270-Mb/s interface	21, 115, 284, 378
	360-Mb/s interface	21, 90, 159, 284, 353, 422
625/50 SDTI system	270-Mb/s interface	23, 136, 336, 449
	360-Mb/s interface	23, 105, 187, 336, 418, 500

In the case of synchronized multichannel unit transmission, the mapping of channel units shall be in fixed positions as shown in figures 12 and 13. One SDTI frame shall contain 4-channel units with the 270-Mb/s interface or 6-channel units with the 360-Mb/s interface.

In the case of 50-Mb/s structure transmission, one frame shall use two adjacent channel units as shown in figures 14 and 15. The first part of one frame shall use the first channel unit and the second part of the frame shall use the second channel unit.

In the 525/60 system, 1500 SDTI data blocks are mapped into 188 lines for the 270-Mb/s interface or into 138 lines for the 360-Mb/s interface.

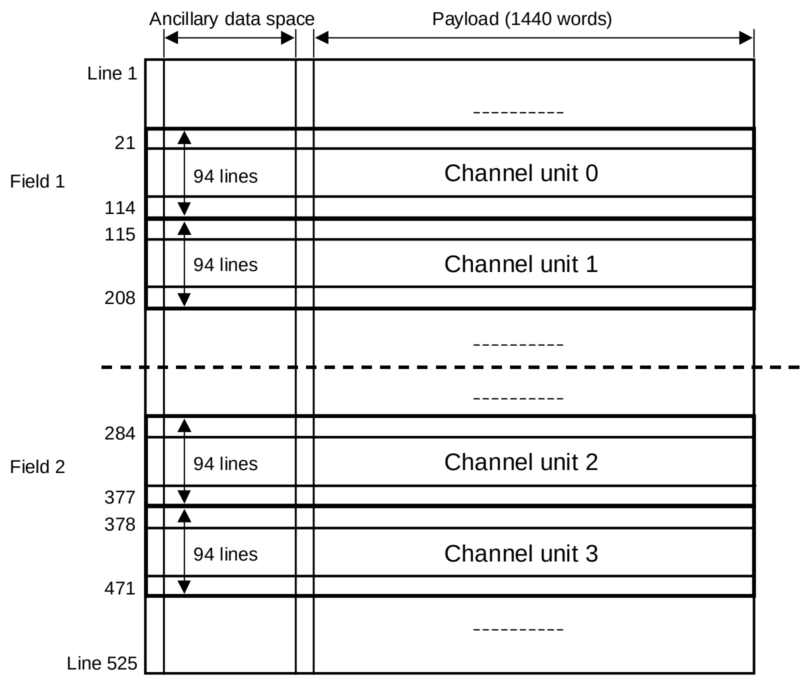
In the 625/50 system, 1800 SDTI data blocks are mapped into 226 lines for the 270-Mb/s interface or into 164 lines for the 360-Mb/s interface.

In the case of 100-Mb/s structure transmission, one frame shall use four adjacent channel units as shown in figures 16 and 17. The first part of one frame shall use the first channel unit, the second part of the frame shall use the second channel unit, the third part of the frame shall use the third channel unit, and the fourth part of the frame shall use the fourth channel unit.

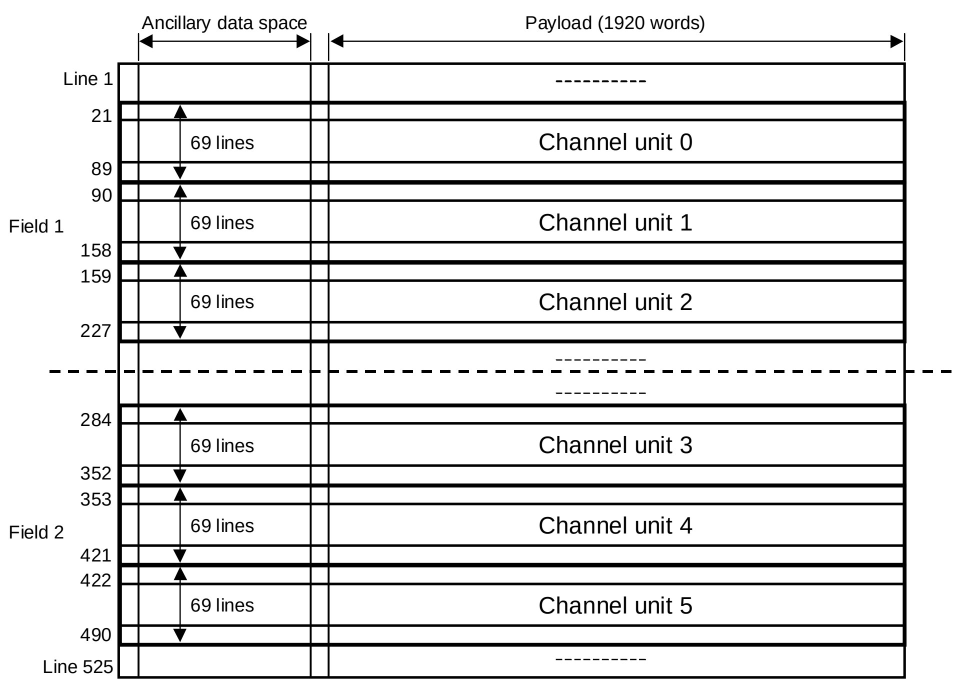
In the 525/60 SDTI system, 3000 SDTI data blocks are mapped into 376 lines for the 270-Mb/s interface or into 276 lines for the 360-Mb/s interface.

In the 625/50 SDTI system, 3600 SDTI data blocks are mapped into 452 lines for the 270-Mb/s interface or into 328 lines for the 360-Mb/s interface.

In the case of faster-than-real-time transmission, SDTI data blocks are mapped into adjacent multiple channel units.

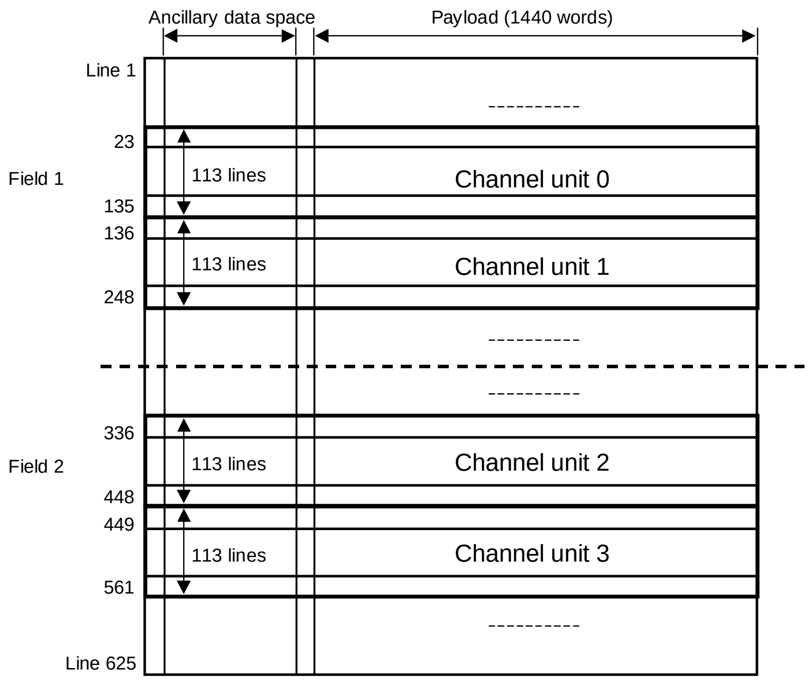


a) for 270 Mb/s system

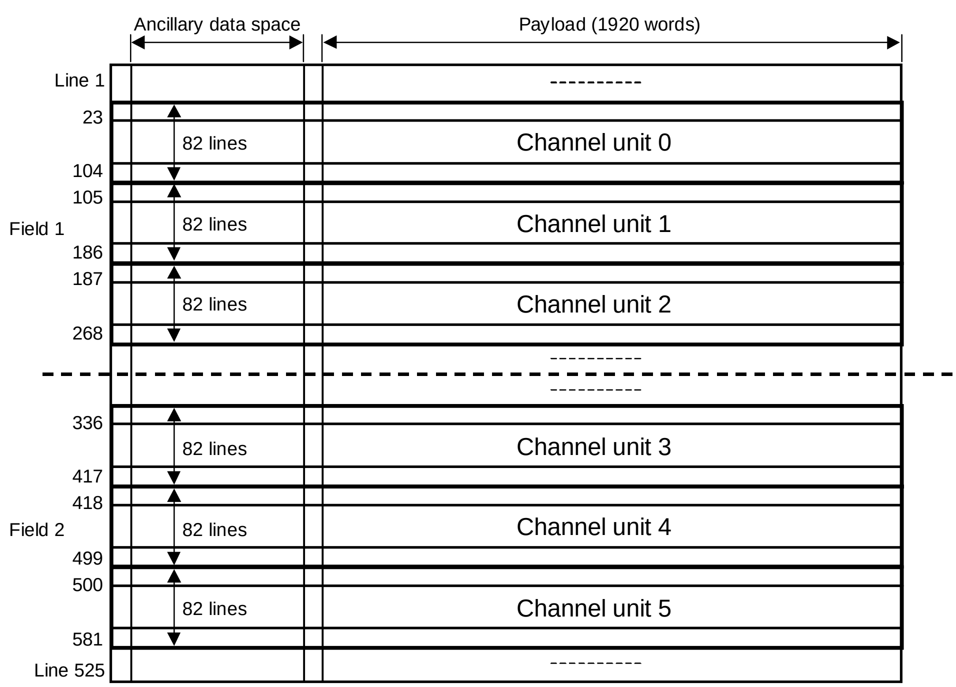


b) for 360 Mb/s system

Figure 12 – Channel unit mapping in a synchronized multichannel unit transmission (525/60 SDTI system)

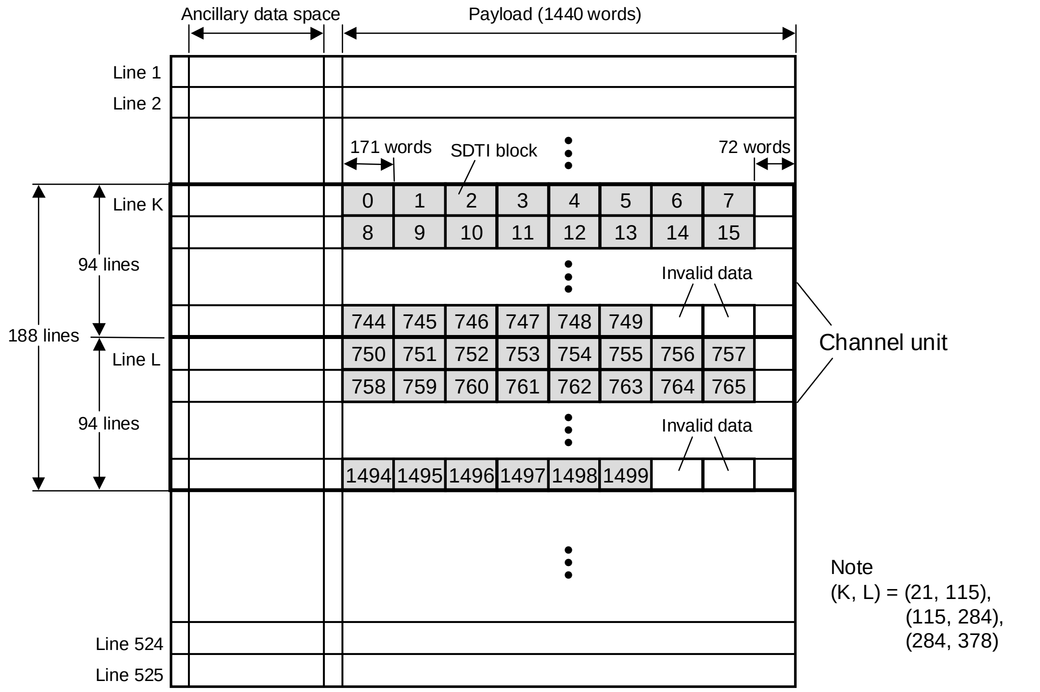


a) for 270 Mb/s system

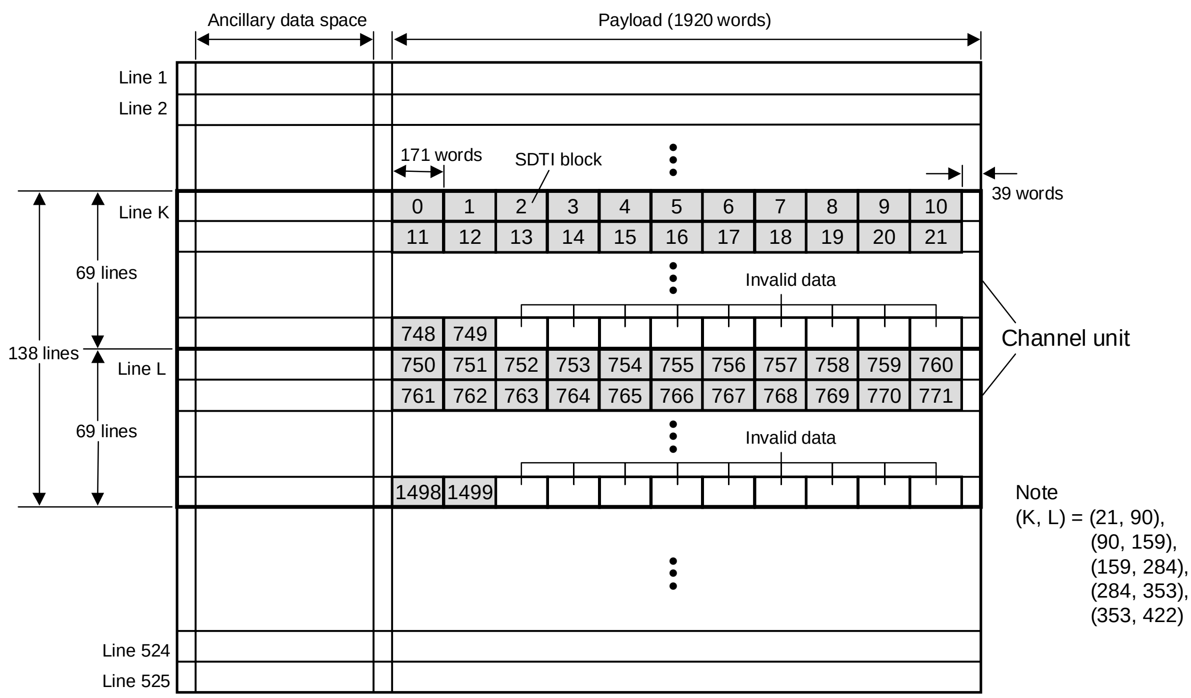


b) for 360 Mb/s system

Figure 13 – Channel unit mapping in a synchronized multichannel unit transmission (625/50 SDTI system)

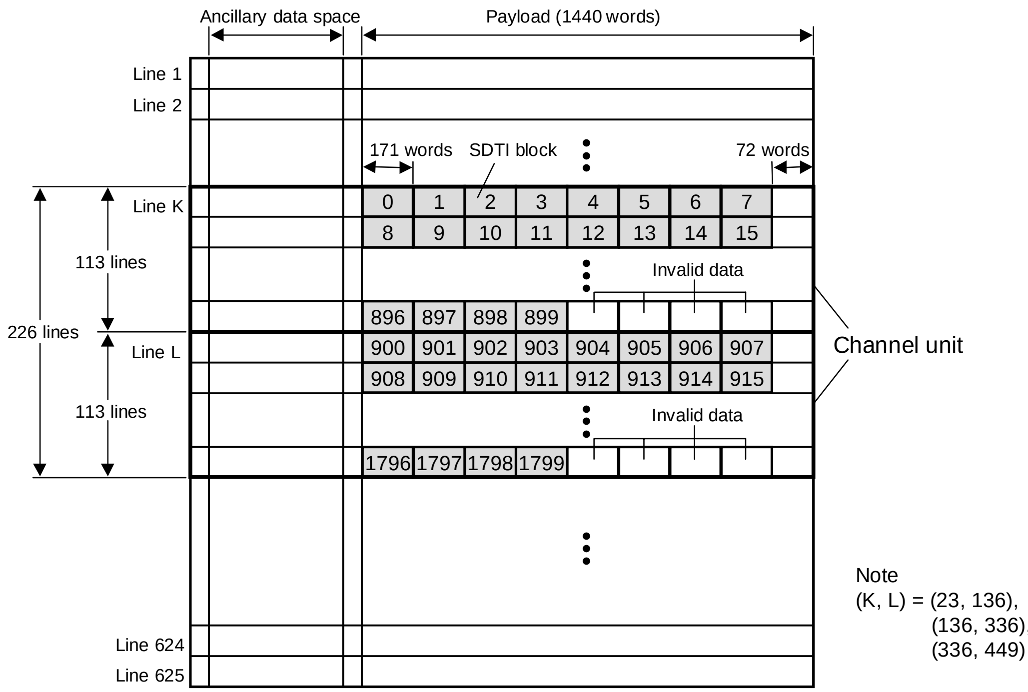


a) for 270 Mb/s system

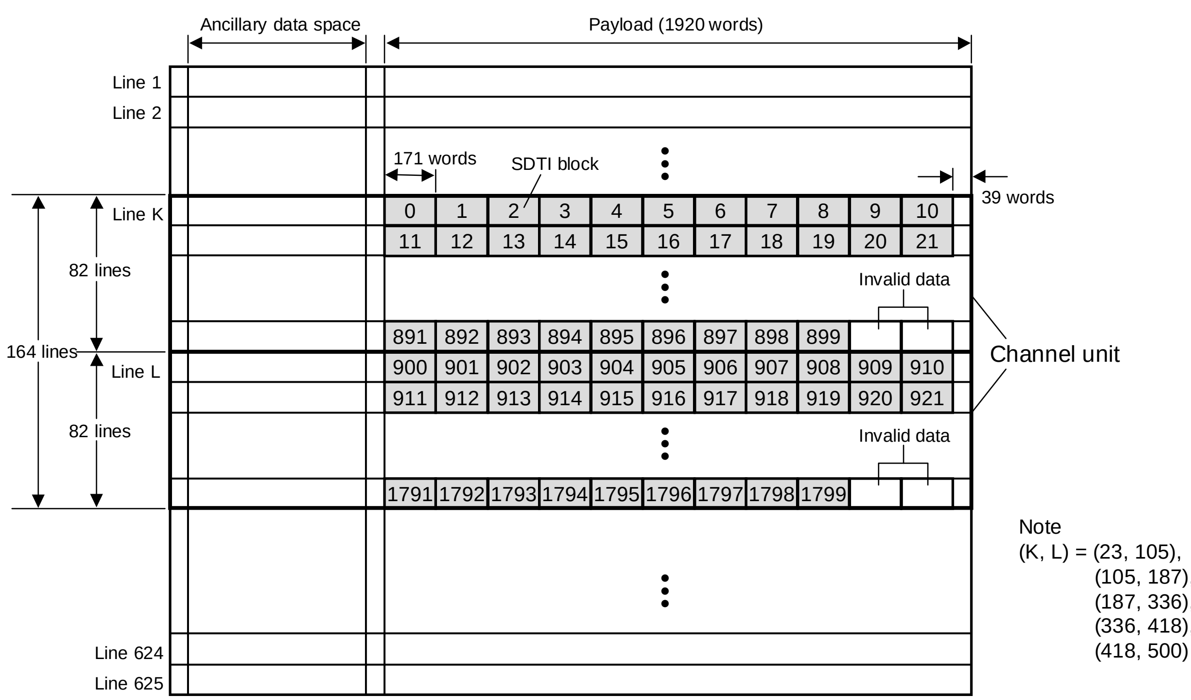


b) for 360 Mb/s system

Figure 14 – Channel unit mapping for the 50-Mb/s structure (525/60 SDTI system)

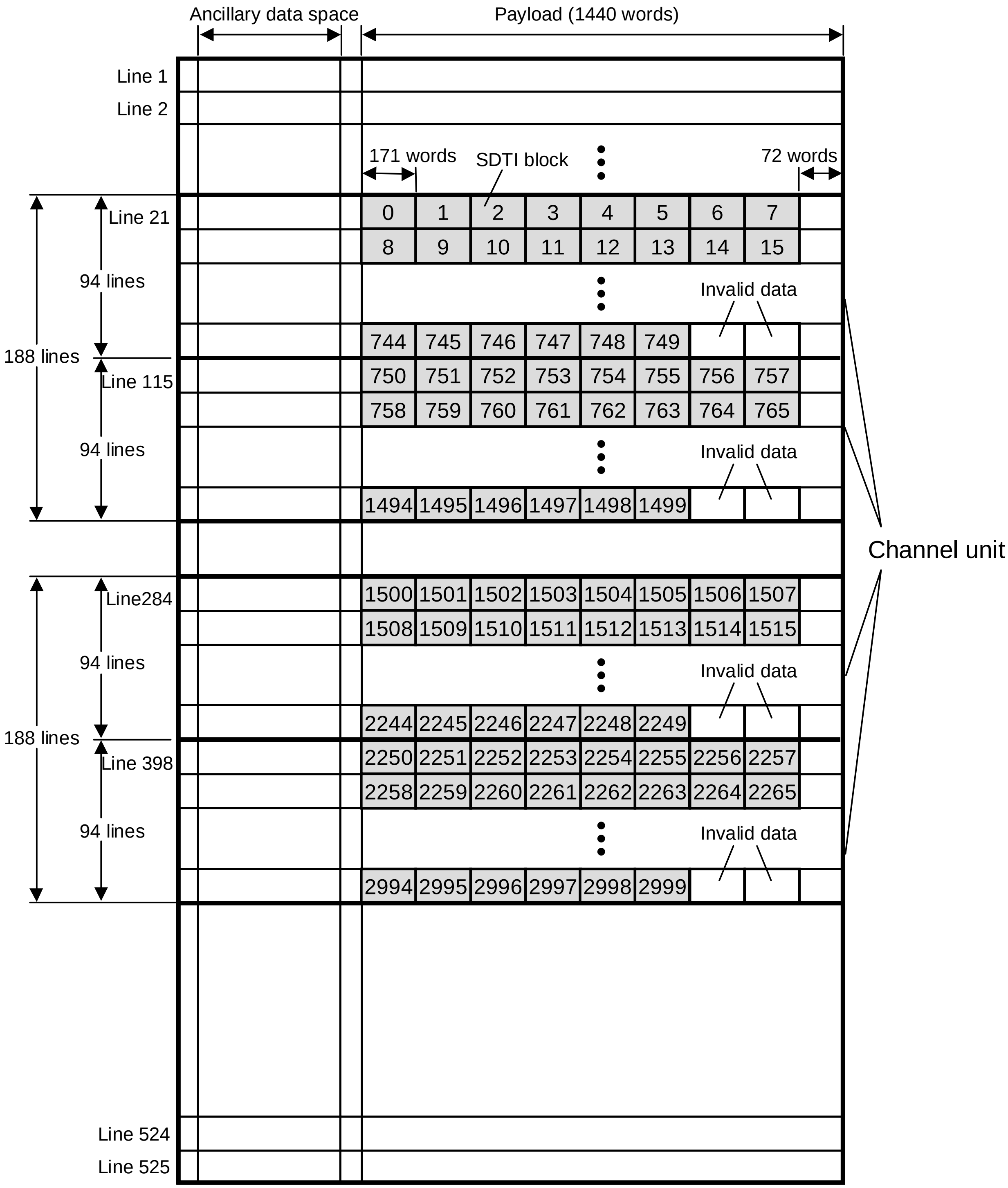


a) for 270 Mb/s system



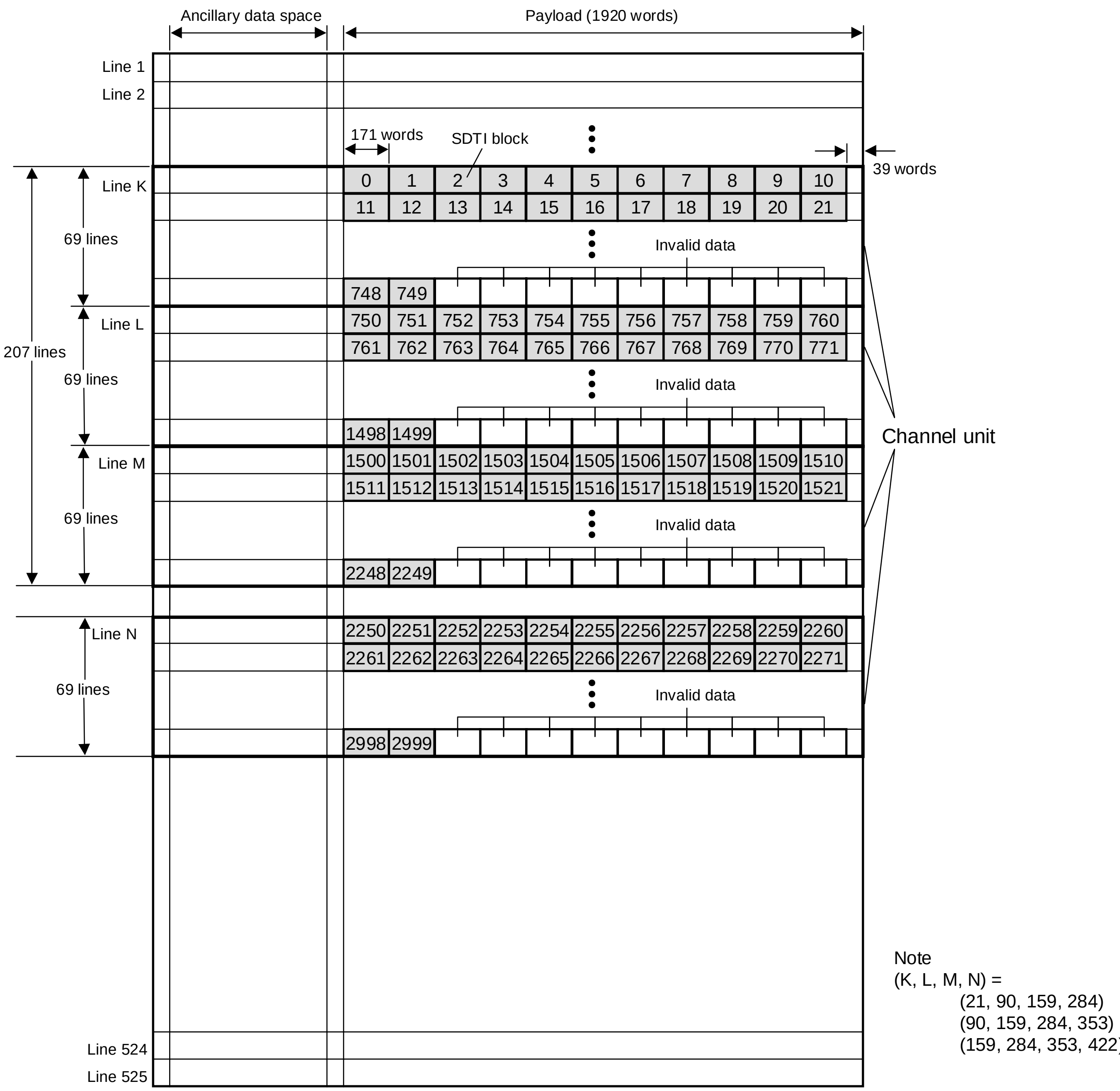
b) for 360 Mb/s system

Figure 15 – Channel unit mapping for the 50-Mb/s structure (625/50 SDTI system)



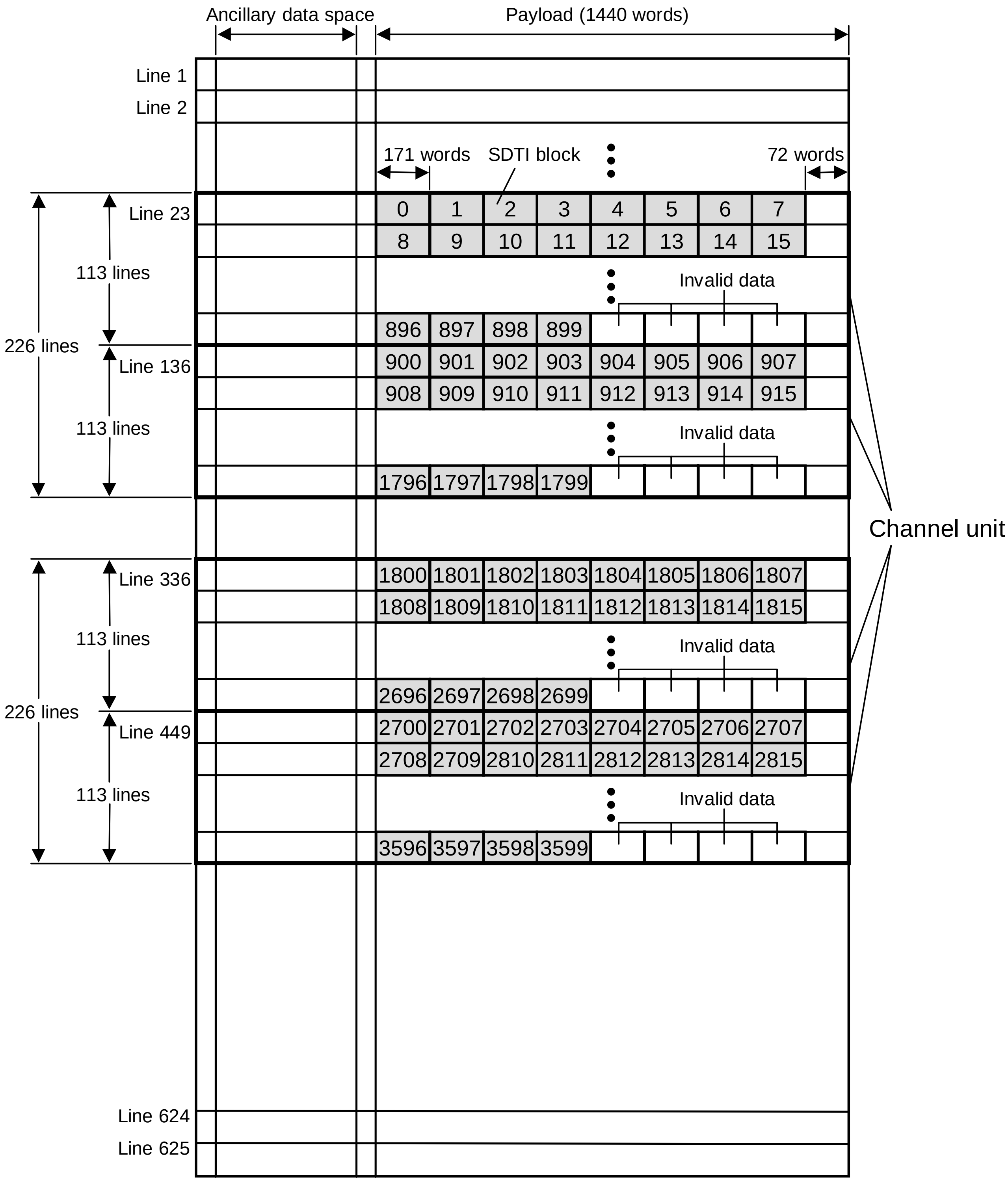
a) for 270 Mb/s system

Figure 16a – Channel unit mapping for the 100-Mb/s structure (525/60 SDTI system)



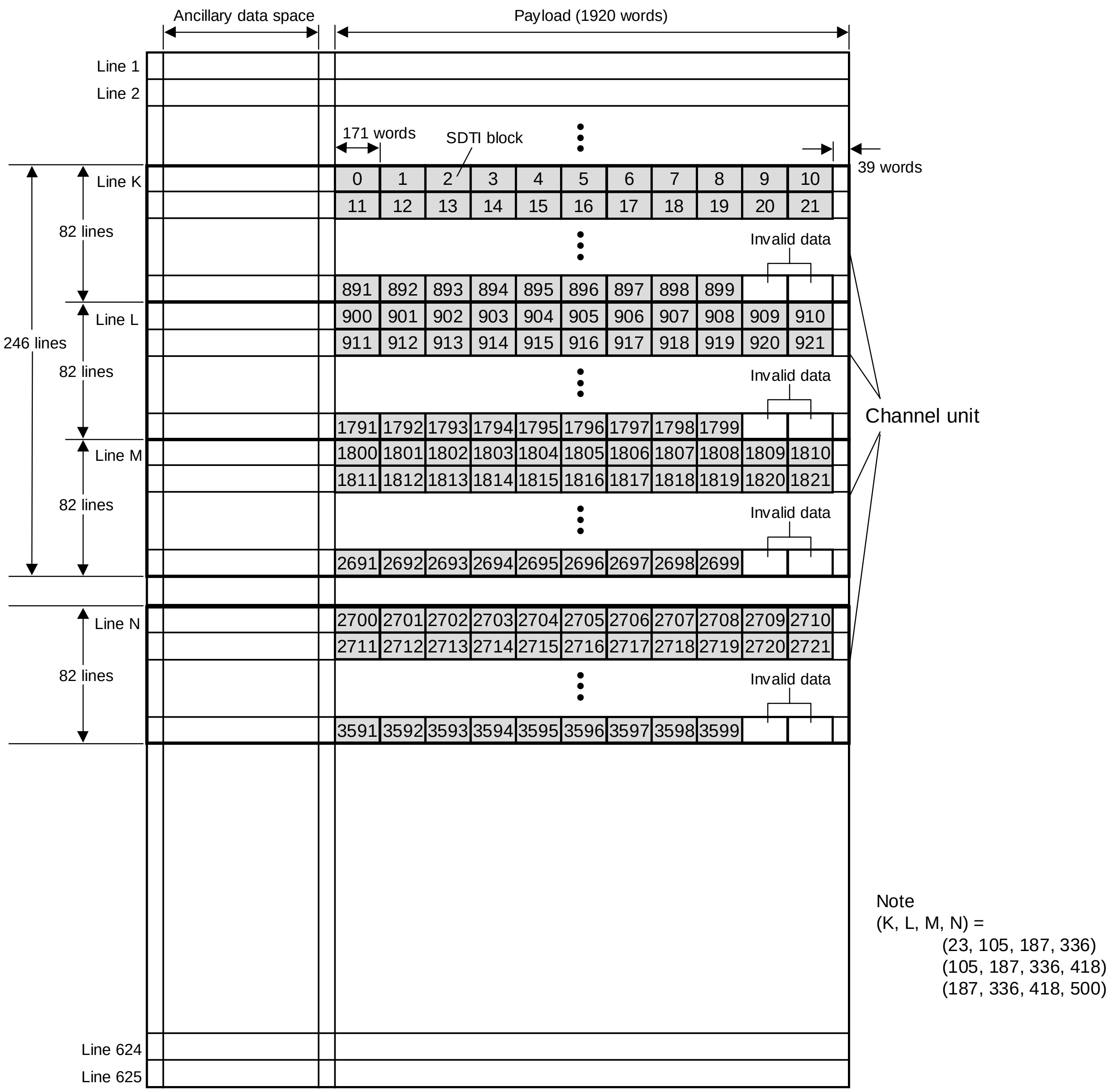
b) for 360 Mb/s system

Figure 16b – Channel unit mapping for the 100-Mb/s structure (525/60 SDTI system)



a) for 270 Mb/s system

Figure 17a – Channel unit mapping for the 100-Mb/s structure (625/50 SDTI system)



b) for 360 Mb/s system

Figure 17b – Channel unit mapping for the 100-Mb/s structure (625/50 SDTI system)

Annex A (informative)
Abbreviations and acronyms

SDI:	Serial digital interface
SDTI:	Serial data transport interface
ECC:	Error correction code
DIF:	Digital interface
ST:	Signal type
STVF:	Signal type of video frame
FF:	Field/frame frequency flag
DVF:	DIF valid flag
FSNF:	Frame sequence number flag
TRF:	Transmission rate flag
TT:	Transmission type

Annex B (informative)
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IEC 61834-2 (1998-08), Recording — Helical-Scan Digital Video Cassette Recording System Using 6,35 mm Magnetic Tape for Consumer Use (525-60, 625-50, 1125-60 and 1250-50 Systems) — Part 2: SD Format for 525-60 and 625-50 Systems