RECOMMENDATION ITU-R BR.780-2*

Time and control code standards, for production applications in order to facilitate the international exchange of television programmes on magnetic tapes**

(1992-2002-2005)

Scope

This Recommendation defines linear time code (LTC) and vertical interval time code (VITC) for various applications. The Recommendation also defines the line number of the TV signal where the VITC should be inserted.

The ITU Radiocommunication Assembly,

considering

a) that to assist in the location of required sequences on tape for editing programmes, to enable complex computer-controlled video tape operations to be undertaken, and to synchronize programme elements stored on different supports, the recording of time and control data on tape is beneficial;

b) that two types of time and control codes exist:

– the code recorded on a longitudinal track with audio characteristics (linear time code (LTC)); this time code may be distributed in a similar fashion to audio signals;

– the code recorded as a signal inserted in the field-blanking period of the video signal (vertical interval time code (VITC)); this signal may be present as part of the video signal on signal interfaces;

c) that the VITC can be distributed via the serial digital interface and recorded on digital video tape recorders (VTRs) in the vertical interval as "digital vertical interval time code";

d) that the VITC or the LTC can also be recorded as data in the ancillary data space in VTRs as specified in Recommendation ITU-R BT.1366,

recommends

1 that for production applications, in order to facilitate the international exchange of television programmes on magnetic tape, the parameters defined in Annex 1 should be implemented.

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44.

** International programme exchange is defined as the transmission of television or sound programme material (or components thereof) among professional parties in different countries. It should be based on internationally agreed and widely employed technical standards or operating practices, except by prior bilateral agreement among the parties involved.

Annex 1

This Recommendation defines a time and control code for use in television, film and accompanying audio systems operating at 60, 59.94, 50, 30, 29.97, 25, 24 and 23.98 frames/s (fps). Section 4 describes the structure of the time address and control bits of the code, and sets guidelines for storage of user data in the code. Defined in this Recommendation is the modulation method for LTC, and the modulation method for inserting the time code into the vertical interval of a television signal.

The time code signal may perform different functions depending upon the application. In some applications the time code signal will be a label to identify discrete frames and may not indicate real time, or time of day. In other applications real time may be indicated, with the caveat that accuracy of the displayed time may not meet all requirements

Normative references

Recommendation ITU-R BT.470 – Conventional Television Systems (Annex 1).

Recommendation ITU-R BT.601 – Studio encoding parameters of digital television for standard 4:3 and wide-screen aspect ratios.

Recommendation ITU-R BT.709 – Parameter values for the HDTV standards for production and international programme exchange.

Recommendation ITU-R BT.1543 – 1 280 × 720, 16 × 9 progressively-captured image format for production and international programme exchange in the 60 Hz environment.

Standard SMPTE 170M-2004. Television – Composite Analogue Video Signal – NTSC for Studio Applications (see Recommendation ITU-R BT.1700).

For the purpose of this Recommendation the following nomenclature applies:

Linear time code (LTC)

LTC refers to the linear time code modulation system (referred to as the longitudinal track application of time and control code).

Vertical interval time code (VITC)

VITC refers to the modulation system used to insert the time code signal in the vertical blanking interval of a television signal.

Digital vertical interval time code (D-VITC)

D-VITC is a digitized version of VITC.

Binary coded decimal (BCD)

The binary coded decimal (BCD) system is a means for encoding decimal numbers as groups of binary bits. Each decimal digit (0-9) is represented by a unique four-bit code. The four bits are weighted with the digit's decimal weight multiplied by successive powers of two. For example, the bit weights for a units digit would be 1×2^0, 1×2^1, 1×2^2 and 1×2^3, while the bit weights for a tens digit would be 10×2^0, 10×2^1, 10×2^2 and 10×2^3.

Real time

In a system running at an integer number of N fps, exactly one second of real time elapses during the passage of N frames.

Drop frame time (DFT)

In a television system running at a frame rate of *N*/1.001 fps, one second of time elapses during the scanning of *N* television frames. Because of the difference in frame rates, the relationship between real time and drop frame time is:

$$1 = sec_{DFT} = 1.001\ sec_{REAL}$$

1 Time address representation in 30 and 30/1.001 frame systems

1.1 Time address of a frame

Each TV frame shall be identified by a unique and complete address consisting of an hour, minute, second and frame number. The hours, minutes, and seconds follow the ascending progression of a 24 h clock beginning with 0 h 0 min 0 s to 23 h 59 min 59 s. The frames shall be numbered successively according to the counting mode (drop frame or non-drop frame) as described below.

1.2 Non-drop frame

Frames numbers shall increment 0 through 29, successively.

When the non-drop frame mode is active the drop frame flag contained in the time code signal shall be set to zero.

1.3 Drop frame – DFT time

The field rate of an 60/1.001 television signal is 30/1.001 fps, counting at 30 (≈ 29.97) fps will yield an error of approximately 108 frames (3.6 sec_{EA}) in 1 h of true clock time (i.e. time address lags clock time). Drop frame time code, is a technique to minimize the drift between clock time and the time indicated by the time code.

To minimize the time error introduced by the 60/1.001 field rate , the first two frame numbers (00 and 01) shall be omitted from the frame count at the start of each minute except minutes 00, 10, 20, 30, 40 and 50.

When drop-frame compensation is applied to a 30/1.001 fps time code, the total error accumulated after one hour is reduced to 3.6 ms. The total error accumulated over a 24 h period is nominally plus 86 ms. (i.e. time address leads clock time).

When drop frame compensation is being performed the drop frame flag shall be set to one as specified in § 5.3.1.

1.4 Colour frame identification in NTSC 525/59.94 television system

When colour frame identification in the time code is required, the even units of frame numbers shall identify colour fields I and II, and the odd units of frame numbers shall identify colour fields III and IV as defined by SMPTE 170M-2004. The colour frame flag shall be set to one when the colour frame relationship to the time code is in effect.

2 Time address representation in 25-frame systems

2.1 Time address of a frame

Each frame shall be identified by a unique and complete address consisting of an hour, minute, second and frame number. The hours, minutes, and seconds follow the ascending progression of a 24 h clock beginning with 0 h 0 min 0 s to 23 h 59 min 59 s. The frames shall be numbered successively 0 through 24.

2.2 Colour frame identification in PAL 625/50 television systems

If identification of the eight-field colour sequence in the time code is required, the time address shall bear a predictable relationship with the eight-field colour sequence as specified in Recommendation ITU-R BT.470. This relationship can be expressed using either logical or arithmetic notations. The colour frame flag shall be set to one when the colour frame relationship to the time code is in effect.

2.3 Logical relationship

Given that the frame and second numbers of the time address are expressed as BCD digit pairs, the value of the logical expression (A|B) ^ C ^ D ^ E ^ F shall be:

1 for fields 1, 2, 3 and 4;

0 for fields 5, 6, 7 and 8.

where:

A = value of the 1's bit of the frame number;

B = value of the 1's bit of the second number;

C = value of the 2's bit of the frame number;

D = value of the 10's bit of the frame number;

E = value of the 2's bit of the second number;

F = value of the 10's bit of the second number;

| represents the logical OR operation;

^ represents the logical Exclusive OR operation.

2.4 Arithmetic relationship

The remainder of the quotient of the division (S + P)/4-

0 for fields 7 and 8;

1 for fields 1 and 2;

2 for fields 3 and 4;

3 for fields 5 and 6.

where:

S = decimal value of the seconds digits of the time address and

P = decimal value of the frames digits of the time address.

3 Time address representation in 24-frame systems

3.1 Time address of a frame

Each TV or film frame shall be identified by a unique and complete address consisting of an hour, minute, second and frame number. The hours, minutes, and seconds follow the ascending progression of a 24 h clock beginning with 0 h 0 min 0 s to 23 h 59 min 59 s. The frames shall be numbered successively 0 through 23.

3.2 Operation at 24/1.001 (23.98) Hz (24/1.001 Hz)

There is no drop frame mode for 24/1.001 applications. Where it is desired to maintain a correspondence with 30-frame systems during a conversion to 30 frames, the 30 non-drop frame count mode should be used. For additional details refer to Appendix 2 to Annex 1, § 2.

3.3 Operation at 24.0 Hz

For systems where the TV and film frame rate is 24.0 Hz there is no systematic drift of the time code address relative to clock time.

Where it is desired to maintain a correspondence with 25 frame systems the techniques described in Appendix 2 to Annex 1, § 2 mode should be used.

4 Time address representation in 50 and 60 frame progressive systems

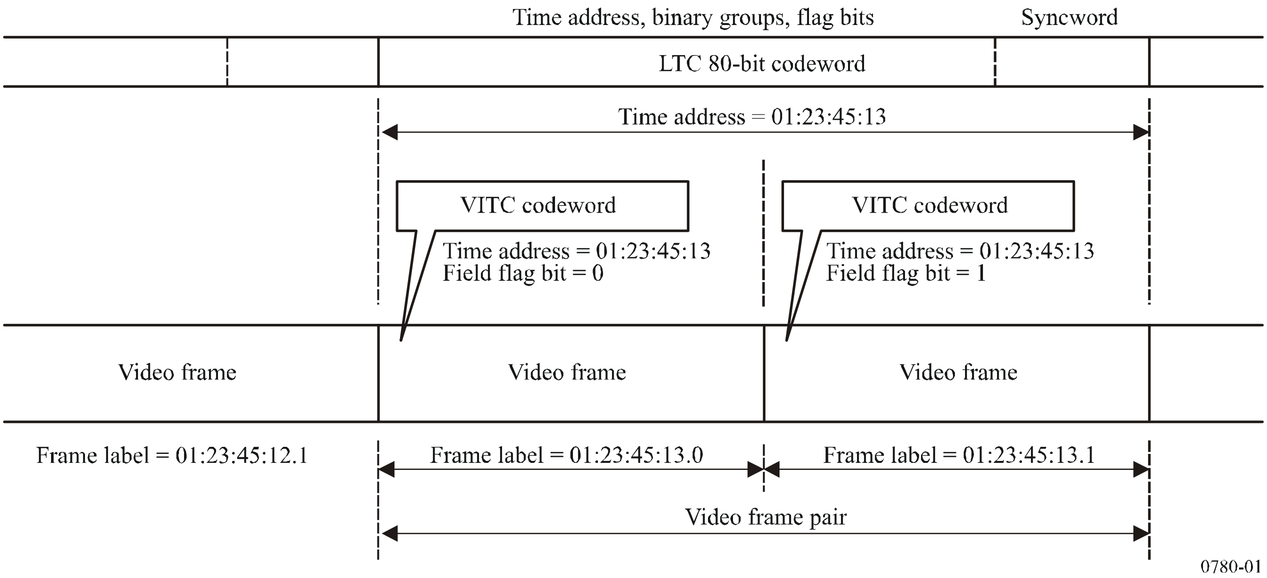
4.1 Time address of a frame

Since the frame rate of 50/60 progressive systems exceeds the frame count capacity of the time code address, the count is constrained to increment every second frame.

Each pair of progressive frames shall be identified by a unique and complete address consisting of an hour, minute, second and frame number. Figure 1 shows an example of frame labelling for these systems.

FIGURE 1

Example of frame labelling for 50 and 60 fps systems



Where the time code is VITC the field mark flag shall be used to identify each of the frames as described in § 6.16.4.4.

Where the time code is modulated as LTC, the time code shall be aligned to start at the beginning of the first frame of the pair of frames and to finish at the end of the second frame. The individual frames may be identified by their timing relative to the LTC with the first frame being aligned with LTC bits 0 through 39 and the second frame aligned with LTC bits 40 through 79.

5 Structure of the time address and control bits

5.1 Digital code

The digital code consists of sixteen 4-bit groups, eight groups containing time address and flag bits, and eight 4-bit binary groups for user-defined data and control codes.

5.2 Time address

The basic structure of the time address is based upon the BCD system, using units and tens digit pairs for hours, minutes, seconds and frames. Some of the digits are limited to values that do not require all four bits to be significant. These bits are omitted from the time address and include the 80's and 40's of hours, 80's of minutes, 80's of seconds and the 80's and 40's of frames. The entire time address is coded into 26 bits.

5.3 Flag bits

Six bits are reserved for the storage of flags which define the operational mode of the time and control code. A device that decodes a time and control code may utilize these flags to interpret properly the time address and binary group data.

5.3.1 Drop frame flag (29.97 Hz or 59.94 Hz systems only)

This flag shall be set to one when drop frame compensation is being used. When the count is not drop frame compensated, this flag bit shall be set to zero.

5.3.2 Colour frame flag (525/59.94 and 625/50 systems only)

If colour frame identification has been applied to the time and control code this flag shall be set to one.

5.3.3 Binary group flags

Three flags provide eight unique combinations that specify the use of the binary groups (see § 5.4.). Three combinations of these flags also specify the time address reference as being related to clock time and these also select subsets of the binary group applications.

5.3.4 Modulation method specific flag

The remaining flag bit is reserved for use by each modulation method. This flag is defined in § 6.7 for LTC and § 6.16.4 for VITC.

5.4 Use of the binary groups

The binary groups are intended for storage and transmission of data by users. The format of the data contained in the binary groups is specified by the value of three binary group flag bits BGF2, BGF1 and BGF0. The following clauses define the current assignments of the binary group flag states. Table 1 summarizes the present assigned combinations.

TABLE 1

Binary group flag assignments

BGF2	BGF1	BGF0	Time address	Binary group	Reference Section
0	0	0	Unspecified	Unspecified	5.5
0	0	1	Unspecified	8-bit codes	5.7
1	0	0	Unspecified	Date and time zone	5.9
1	0	1	Unspecified	Page/line	5.11
0	1	0	Clock time	Unspecified	5.6
0	1	1	Unassigned	Reserved	5.8
1	1	0	Clock time	Date and time zone	5.10
1	1	1	Clock time	Page/line	5.12

5.5 Character set not specified and unspecified clock time (BGF2=0, BGF1=0, BGF0=0)

This combination of binary group flags signifies that the time address is not referenced to an external clock and that the binary groups contain an unspecified character set. If the character set used for the data insertion is unspecified, the 32 bits within the eight binary groups may be assigned without restriction.

5.6 Character set not specified and clock time (BGF2=0, BGF1=1, BGF0=0)

This combination specifies that the time address is referenced to an external clock and signifies an unspecified character set. If the character set used for the data insertion is unspecified, the 32 bits within the eight binary groups may be assigned without restriction.

5.7 Eight-bit character set and unspecified clock time (BGF2=0, BGF1=0, BGF0=1)

This combination signifies that the time address is not referenced to an external clock and that the binary groups contain an eight-bit character set conforming to ISO/IEC 646 or ISO/IEC 2022. If the seven-bit ISO codes are being used, they shall be converted to eight-bit codes by setting the eighth bit to zero. Four ISO codes may be encoded in the binary groups, each occupying two binary groups. The first ISO code is contained in binary groups 7 and 8, with the least significant four bits in binary group 7 and the most significant four bits in binary group 8. The three remaining ISO codes are stored in binary groups 5/6, 3/4 and 1/2 accordingly.

5.8 Unassigned binary group usage and unspecified clock time (BGF2=0, BGF1=1, BGF0=1)

This combination is unassigned and is reserved for future use.

5.9 Date/time zone and unspecified clock time (BGF2=1, BGF1=0, BGF0=0)

This combination is reserved for future additions that contain date and time zone encoding.

5.10 Date/time zone and clock time (BGF2=1, BGF1=1, BGF0=0)

This combination specifies that the time address is referenced to an external clock. Not defined at this time

5.11 Page/line multiplex system and unspecified clock time (BGF2=1, BGF1=0, BGF0=1)

This combination is reserved for future definition of a page/line multiplexing system.

5.12 Page/line multiplex system and clock time (BGF2=1, BGF1=1, BGF0=1)

See § 5.11.

6 Linear time code structure

6.1 Codeword format

Each LTC codeword consists of 80 bits numbered 0 through 79. The bits are generated serially beginning with bit 0. Bit 79 of the codeword is followed by bit 0 of the next codeword. Each codeword is associated with a television or film frame. In the case of 50/60 progressive systems the 80-bit code word is associated with 2 frames (see Fig. 1).

6.2 Codeword data content

Each LTC codeword contains the time address of the frame, flag bits, binary groups, biphase mark polarity correction bit and a synchronization word.

6.3 Time address

The time address bits of the frame as defined in § 5.2. The lowest numbered bit of each group corresponds to the least significant bit of each BCD digit. The bit positions are tabulated in Table 2.

6.4 Flag bits

The drop frame, colour frame, and binary group flag bits, as defined in § 5.3. The bit positions are listed in Table 4. Unused flag bits should be set to zero.

6.5 Binary groups

Eight 4-bit binary groups are defined in § 5.4. The lowest numbered bit of each group corresponds to the least significant bit of that group. The positions of the bits are listed in Table 3.

6.6 Synchronization word

The synchronization word is a static combination of bits, which can be used by receiving equipment to identify accurately the bit position of the serial code relative to the video signal. The LTC synchronization word is unique in that the same combination cannot be generated by any combination of valid data values in the remainder of the code. Bits 65-78 form a unique pattern that is symmetrical about the centre of the synchronization word, allowing detection in either direction. Bits 64 and 79 are complements of each other, allowing a receiver to determine the direction of the code ascending or descending time.

TABLE 2

LTC time address bit positions

Bit	Definition
0-3	Units of frames
8-9	Tens of frames
16-19	Units of seconds
24-26	Tens of seconds
32-35	Units of minutes
40-42	Tens of minutes
48-51	Units of hours
56-57	Tens of hours

TABLE 3

LTC binary group bit positions

Bit	Definition
4-7	First binary group
12-15	Second binary group
20-23	Third binary group
28-31	Fourth binary group
36-39	Fifth binary group
44-47	Sixth binary group
52-55	Seventh binary group
60-63	Eighth binary group

TABLE 4

LTC flag bit positions

30-frame bit	25-frame bit	24-frame bit	Definition
10	–	–	Drop frame flag
11	11	–	Colour frame flag
27	59	27	Polarity correction
43	27	43	Binary group flag BGF0
58	58	58	Binary group flag BGF1
59	43	59	Binary group flag BGF2

TABLE 5

LTC synchronization word bit positions and values

Sync word bit	bit value
64	0
65	0
66	1
67	1
68	1
69	1
70	1
71	1
72	1
73	1
74	1
75	1
76	1
77	1
78	0
79	1

6.7 Biphase mark polarity correction

This flag bit is specific to the LTC modulation method described in § 5.3.4. The position of this flag is listed in Table 4. The nature of the biphase modulation rules require that the polarity of the first clock transition of the first bit of the synchronization word differ from code word to code word depending on the number of logical zeros in the data.

Applications that switch between two sources of time and control code may require the polarity of the two sources to be stable during the synchronization word. In order to stabilize the polarity of the sync word, the biphase mark polarity correction bit shall be put in a state so that every 80-bit word will contain an even number of logical zeros.

If polarity correction of the code word is desired and the number of logical zeros in bit positions 0 through 63 (exclusive of the polarity correction bit itself) is odd, then the polarity correction bit shall be set to one, otherwise the polarity correction bit shall be set to zero.

6.8 Modulation method

The NRZ unmodulated signal is biphase mark encoded according to the following coding rules (see Fig. 2):

– A transition occurs at each bit cell boundary, regardless of the value of the bit.

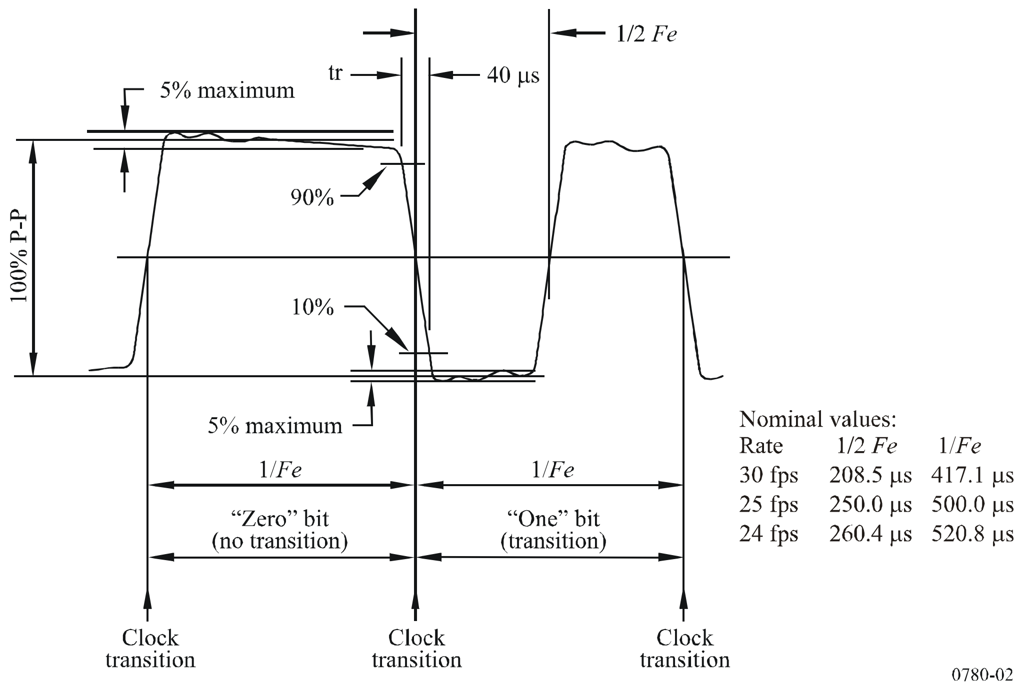
– A logic one is represented by an additional transition occurring at the bit cell midpoint.

– A logic zero is represented by having no additional transitions within the bit cell.

The biphase mark encoded signal has no DC component, is amplitude and polarity insensitive and includes transitions at every bit cell boundary from which the clock may be extracted.

FIGURE 2

Linear time code source output waveform



6.9 Bit rate

The bits shall be evenly spaced throughout the codeword period and shall occupy fully the codeword period. The nominal frequency, Fe, at which the bits are generated shall be:

$$Fe = 80 \times Ff$$

where Ff is the frame rate of the television or film system.

NOTE 1 – For frame rates greater than 30 fps $Fe = 80 \times Ff/2$.

6.10 Timing of the codeword relative to a television signal

The timing reference datum for LTC is the first transition of bit 0 of the 80-bit LTC codeword.

6.11 29.97/30 fps television systems reference timing

6.11.1 Analogue signal references. The reference datum for 525/59.94 systems is at the beginning of line 4. For 720/29.97/P, 1920 × 1080 formats the reference datum is at the beginning of line 1. The tolerance is +160/–32 µs (see Fig. 3a).

The first transition of bit 0 of the codeword shall occur at the reference datum of the frame with which it is associated.

6.11.2 Digital signal references. The reference datum for 59.94 systems is at:

– Digital sample 736 of line 4 for 13.5 MHz systems.

– Digital sample 982 of line 4 for 18 MHz systems.

– Digital sample 1930 of line 1 (for the progressive format the reference datum occurs every second frame).

– Digital sample 2008 of line 1 (for the progressive format the reference datum occurs every second frame).

The first transition of bit 0 of the codeword shall occur at the reference datum of the frame with which it is associated. With a tolerance of +160/–32 µs (see Fig. 3a).

6.12 25/50-fps television systems reference timing

6.12.1 Analogue signal references. The reference datum for 625/50I 1080/50I and 1080/25/P systems is at the beginning of line 1. The tolerance is –32/+160 µs (see Fig. 3b).

6.12.2 Digital signal references. The reference datum for 25 Hz systems is at:

– Digital sample 732 of line 1 for 13.5 MHz systems.

– Digital sample 976 of line 1 for 18 MHz systems.

– Digital sample 2448 of line 1 (for the progressive format the reference datum occurs every second frame).

With a tolerance of –32/+160 µs (see Fig. 3b).

The first transition of bit 0 of the codeword shall occur at the reference datum of the frame with which it is associated.

6.13 23.98/24-fps television system 2 (1920 × 1080 only)

The reference datum for 23.98 Hz and 24 Hz systems, is at sample 2558 of line 1.

With a tolerance of –32/+160 µs (see Fig. 3c).

FIGURE 3a

30-frame linear time code example

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FIGURE 3b

25-frame linear time code example

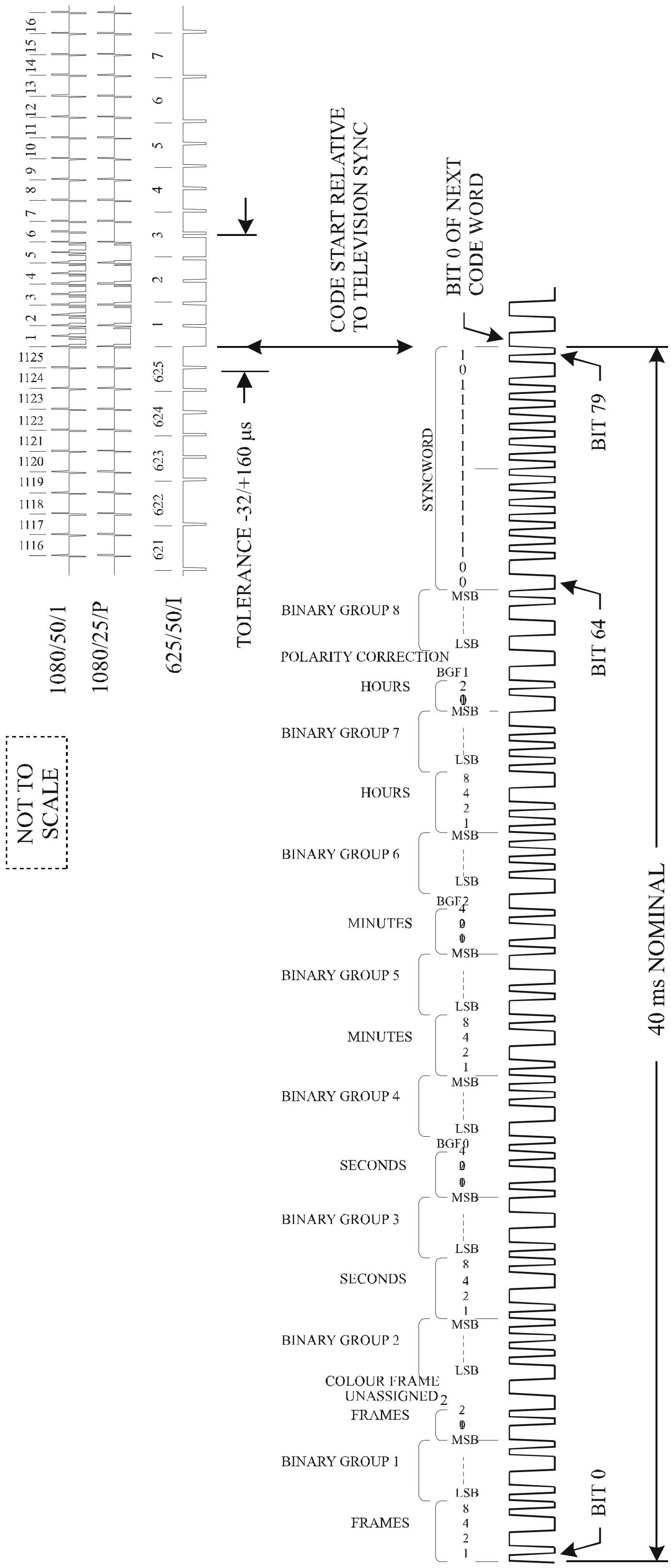

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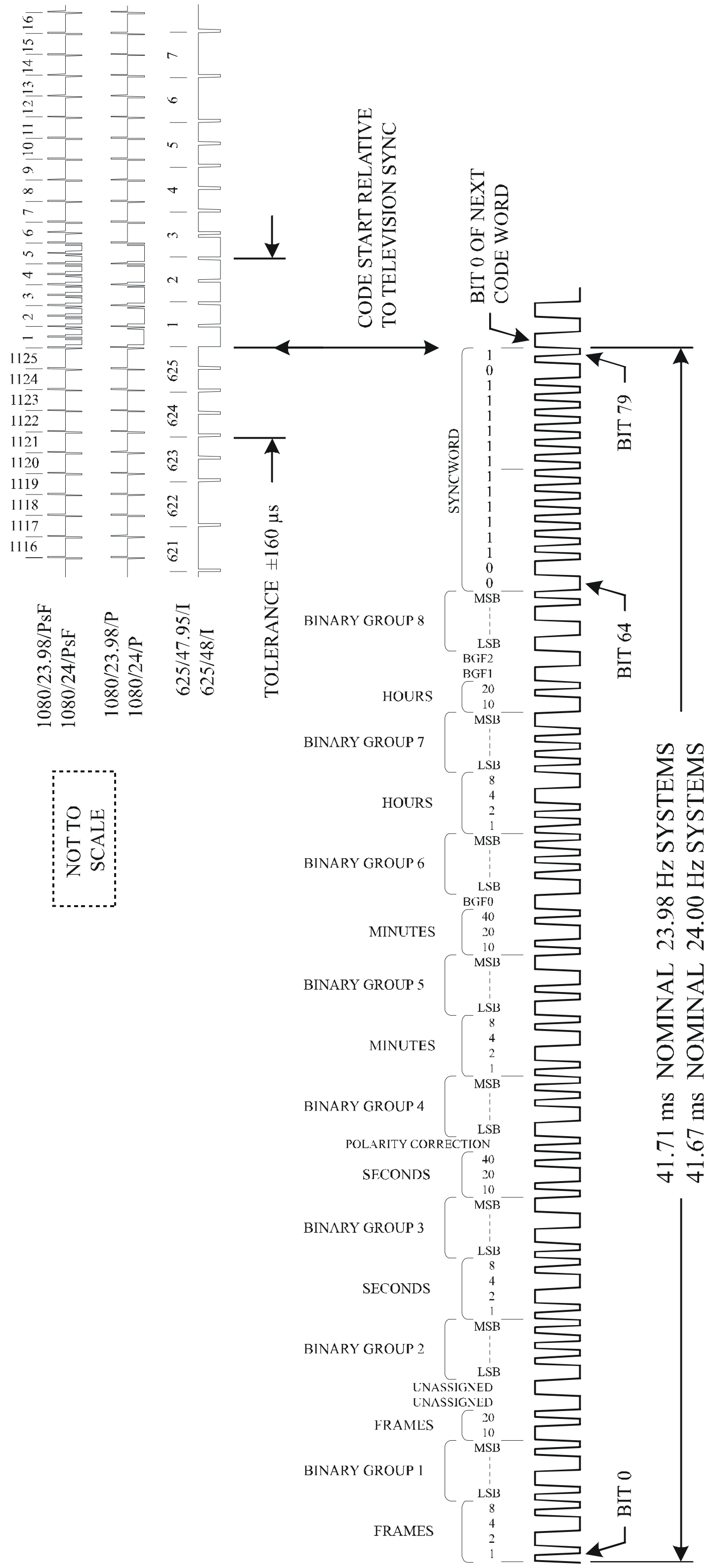
FIGURE 3c

24-frame video linear time code example



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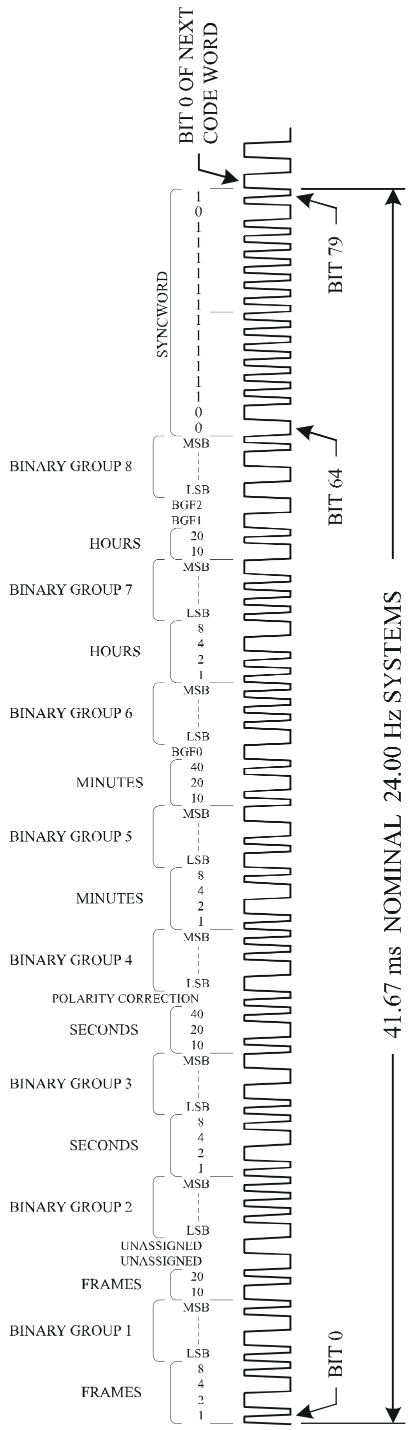
The first transition of bit 0 of the codeword shall occur at the reference datum of the frame with which it is associated.

FIGURE 3d

24-frame film linear time code example



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6.14 Linear time code interface electrical and mechanical characteristics

All measurements shall be made at the interface while driving a resistive load of 1 kΩ.

6.14.1 Rise/fall time

The rise and fall times of the clock and one transitions of the time code pulse train shall be 40 μs ±10 μs, measured between 10% and 90% amplitude points on the waveform.

6.14.2 Amplitude distortion

Any combination of overshoot, undershoot and tilt shall be limited to 5% of the peak-to-peak amplitude of the code waveform.

6.14.3 Timing of the transitions

The time between clock transitions shall not vary more than 1.0% of the average clock period measured over at least one frame. The "one" transition shall occur midway between the two clock transitions within 0.5% of one clock period. Measurement of these timings shall be made at half-amplitude points on the waveform.

6.14.4 Interface connector

The preferred connector for double-ended or balanced outputs is a 3-pin XLR (male) connector and for inputs is a 3-pin XLR (female) connector. Pin 1 is signal ground, pins 2 and 3 carry the double-ended or balanced signals. The preferred connector for single-ended or unbalanced outputs or inputs is a BNC (female) connector.

6.14.5 Output impedance

The output impedance of a single-ended, balanced or unbalanced source shall be no greater than 50 Ω. The output impedance of a double-ended output shall be no greater than 25 Ω for each output side.

6.14.6 Output amplitude

A preferred output is between 1 and 2 Vpeak-to-peak. The allowable range of amplitudes is 0.5 to 4.5 V peak-to-peak.

Vertical interval application – television systems

6.15 Codeword format

Each codeword shall consist of 90 bits numbered 0 through 89, organized as 9 groups of 10 bits. Each 10-bit group starts with a synchronization bit pair, which is a bit 1 followed by a bit 0. The synchronization bit pair is followed by 8 data bits.

The first eight groups contain the 64 time and control code data bits; the ninth contains a cyclic redundancy check (CRC) code used to detect errors in the data. The boundaries of the word are defined as the leading edge of the first bit (bit 0) and the trailing edge of the last bit (bit 89). Since bit 0 is the first synchronization bit of the codeword, it shall always have the value of one.

NOTE 1 – There will always be a rising transition at the leading edge of bit 0 to signal the start of the word.

6.16 Codeword data content

Each VITC codeword consists of a time address, flag bits, binary groups, field mark flag, CRC code and synchronization bits. Refer to Figs. 4a, 4b, and 4c for examples of the VITC signal.

FIGURE 4a

525/59.94 vertical interval time code address bit assignment and timing

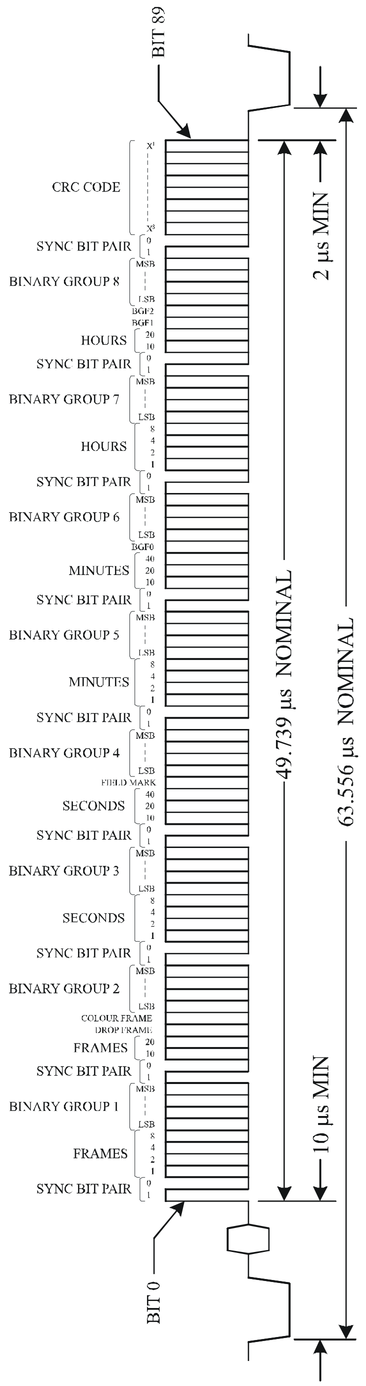

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FIGURE 4b

1 125/60/60/1.001 vertical interval time code address bit assignment and timing

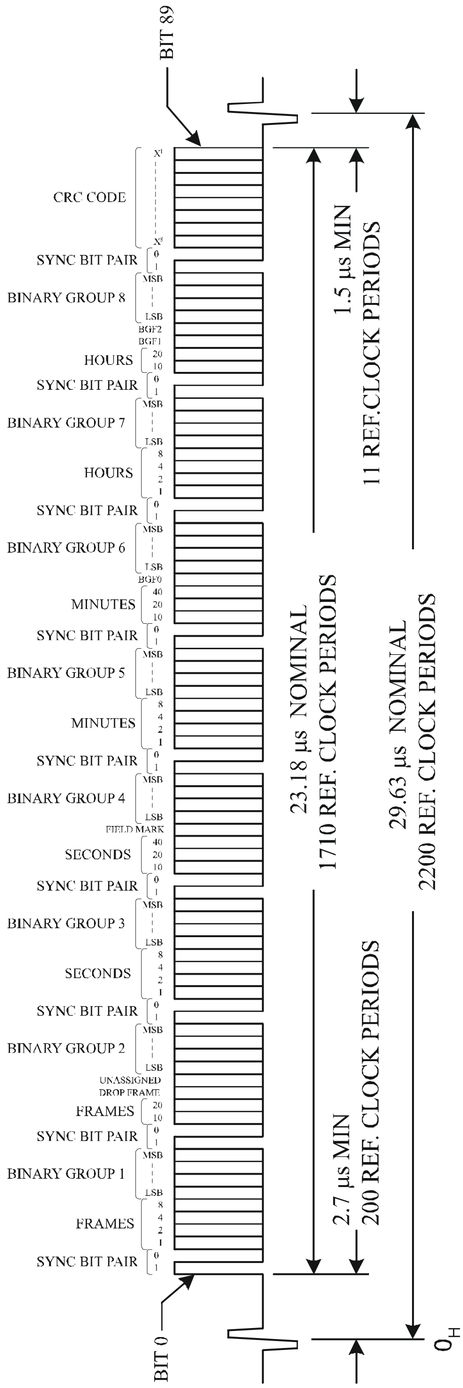
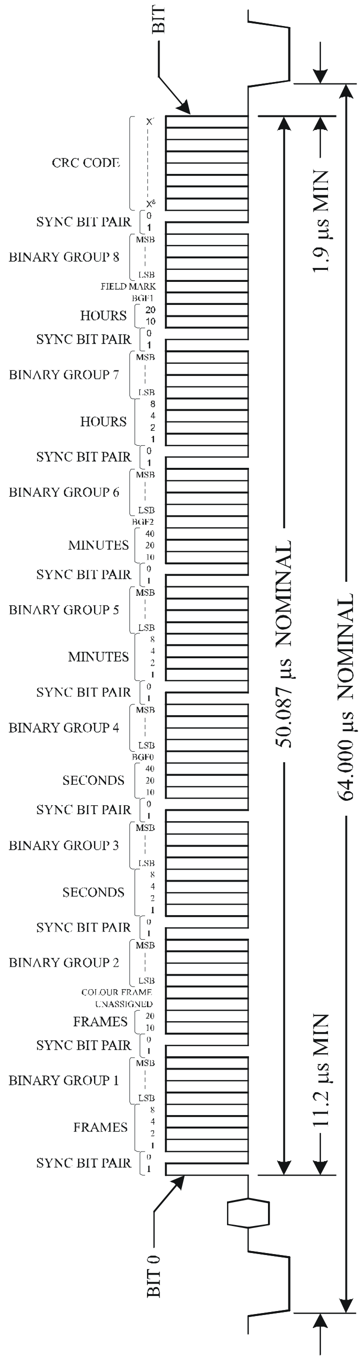


FIGURE 4c

625/50 vertical interval time code address bit assignment and timing



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6.16.1 Time address

The time address bits of the frame as defined in § 5.2. The lowest numbered bit of each group corresponds to the least significant bit of each BCD digit. The positions of these bits are listed in Table 6.

6.16.2 Flag bits

The drop frame, colour frame and binary group flag bits as defined in § 5.3. The positions of these flags are listed in Table 8. Note that not all flag bits are used by all systems. Unused flag bits should be set to zero by original sources and ignored by receiving equipment.

6.16.3 Binary groups

Eight 4-bit binary groups are defined in § 5.4. The lowest numbered bit of each group corresponds to the least significant bit of that group. The positions of these bits are listed in Table 7.

6.16.4 Field mark flag

The position of this flag is listed in Table 8.

6.16.4.1 525/59.94 NTSC system

Field identification shall be recorded as follows: A zero shall represent field 1 and colour field I or III. A one shall represent field 2 or colour field II or IV. Colour fields I through IV are defined in SMPTE 170M-2004.

TABLE 6

VITC time address bit positions

Bit	Definition
2-5	Units of frames
12-13	Tens of frames
22-25	Units of seconds
32-34	Tens of seconds
42-45	Units of minutes
52-54	Tens of minutes
62-65	Units of hours
72-73	Tens of hours

TABLE 7

VITC binary group bits

Bit	Definition
6-9	First binary group
16-19	Second binary group
26-29	Third binary group
36-39	Fourth binary group
46-49	Fifth binary group
56-59	Sixth binary group
66-69	Seventh binary group
76-79	Eighth binary group

TABLE 8

VITC flag bit positions

30-frame bit	25-frame bit	Definition
14	–	Drop frame flag
15	15	Colour frame flag
35	75	Field flag
55	35	Binary group flag BGF0
74	74	Binary group flag BGF1
75	55	Binary group flag BGF2

6.16.4.2 1125/60/60/1.001 television system

Field identification shall be recorded as follows: A zero shall represent field 1. A one shall represent field 2. Field 1 contains lines 1 through 563 inclusive; field 2 contains lines 564 through 1125 as defined in Recommendation ITU-R BT.709.

6.16.4.3 625/50 PAL television system

Field identification shall be recorded as follows: A zero shall represent colour fields I, III, V and VII. A one shall represent colour fields II, IV, VI, and VIII. Colour fields I through VIII are defined in Annex 1 of Recommendation ITU-R BT.470.

6.16.4.4 50- and 60-frame progressive television systems

Frame identification shall be recorded as follows: The field flag is used to identify frame pairs. A zero shall represent the first frame and a one shall represent the second frame of the pair of progressive frames.

6.16.4.5 Progressive segmented frame (PsF) interfaces

For interfaces where the signal is mapped as a PsF signal, the VITC signal for a frame shall be identical for the segmented fields.

6.16.5 Synchronization bits

A synchronization bit pair consisting of a one followed by a zero is inserted preceding every 8 data bits. Bits 0, 10, 20, 30, 40, 50, 60, 70 and 80 are coded as one; bits 1, 11, 21, 31, 41, 51, 61, 71 and 81 are encoded as zero.

6.16.6 CRC code

Eight bits, 82 through 89, are encoded with a CRC code to provide for error detection. The generating polynomial of the CRC, $G(X)$, is defined as $G(X) = X^8 + 1$ with an initial condition of all zeros.

The generating polynomial shall be applied to all bits from 0 to 81 inclusive. The remainder is then encoded in bits 82 through 89 as shown in Table 9. Applying the generating polynomial to the received data bits 0 through 89, inclusive, shall result in a remainder of all zeros when no error exists.

TABLE 9

CRC bit positions

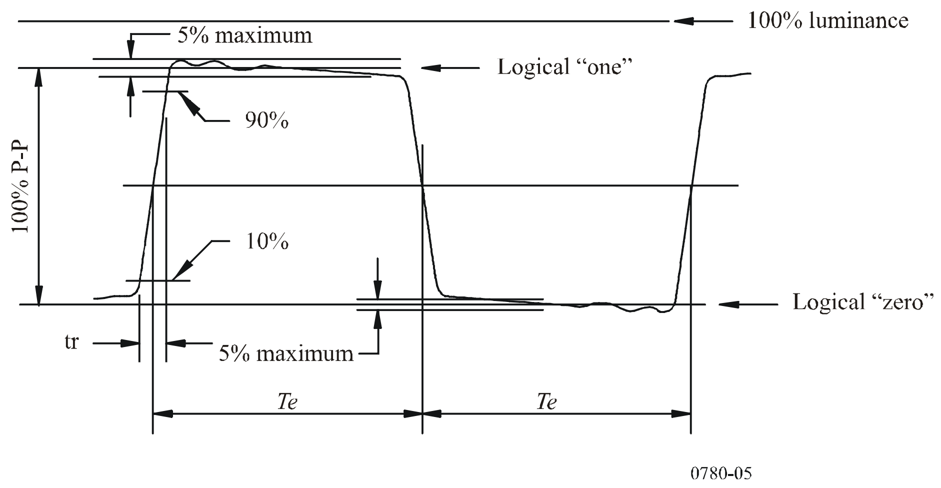
Bit	CRC code bit
82	X_8
83	X_7
84	X_6
85	X_5
86	X_4
87	X_3
88	X_2
89	X_1

6.17 Modulation method

The NRZ unmodulated signal is time compressed and inserted as a burst within the non-blanked interval of a selected television line in the vertical interval (see Fig. 5).

FIGURE 5

Vertical interval time code bit waveform



Since an NRZ code has no self-clocking reference, the signal must be sampled at periodic intervals based on known bit cell timing. The sample period can be adjusted at any available one-zero or zero-one transition.

6.18 Bit timing and waveform characteristics

The waveform characteristics of the VITC signal are shown in Fig. 5.

Each bit of the code word shall have a uniform period, *Te*, related to the horizontal line frequency, *Fh*, as expressed below:

$$Te = 1/(115 \times Fh) \pm 2\%$$

In 1125/60 television systems, if the reference clock is used to generate the bit timing; *Te* shall be equal to 19 times the reference clock as defined in Recommendation ITU-R BT.709.

6.18.1 Logic level

The tolerance ranges specified for logical one and logical zero states are listed in Table 10.

TABLE 10

VITC logic level ranges

Television system	Logical one	Logical zero
525/59.94	70--90 IRE	0--10 IRE
1125	500--600 mV	0--25 mV
625/50	500--600 mV	0--25 mV

6.18.2 Rise/fall time

The rise and fall times, *tr*, of the code shall be 200 ns ±50 ns for 525/59.94 and 625/50 television systems and 100 ns ±25 ns for 1125-line television systems. These measurements are made between 10% and 90% amplitude points on the waveform.

6.18.3 Amplitude distortion

Amplitude distortions, such as overshoot, undershoot and tilt, shall be limited to 5% of the peak-to-peak amplitude of the code waveform.

6.19 Timing of the codeword relative to the line synchronizing signal

The timing reference datum for VITC is the half-amplitude point of the leading edge of bit 0 of the 90-bit VITC codeword.

6.19.1 525/59.94 television system

The half-amplitude point of the leading edge of bit 0 shall occur no earlier than 10.0 µs following the half-amplitude point of the leading edge of the line synchronizing pulse. The half-amplitude point of the trailing edge of bit 89 (logical 1) shall occur no later than 2.1 µs before the half-amplitude point of the leading edge of the following line synchronizing pulse.

6.19.2 1125/60 television system

The half-amplitude point of the leading edge of bit 0 shall occur no earlier than 2.7 µs (200 reference clock periods) following the midpoint of the line synchronizing transition. The half-amplitude point of the trailing edge of bit 89 (logical 1) shall occur no later than 1.5 µs (111 reference clock periods) before the midpoint of the following line synchronizing pulse.

6.19.3 625/50 television system

The half-amplitude point of the leading edge of bit 0 shall occur no earlier than 11.2 µs following the half-amplitude point of the leading edge of the line synchronizing pulse. The half-amplitude point of the trailing edge of bit 89 (logical 1) shall occur no later than 1.9 µs before the half-amplitude point of the leading edge of the following line synchronizing pulse.

6.20 Location of the address code signal in the vertical interval

The VITC codeword shall be inserted on the same line (or lines) in all fields for a given recording. Line numbers shown in parentheses correspond to the equivalent line in field two.

6.20.1 525/59.94 television system

Insertion of the address code shall be on line 14(277) and optionally on line 16(279).

6.20.2 1125/60 television system

Insertion of the address code for interlace signals shall not be earlier than line 8(570) or later than line 19(582). For progressive systems the address code shall not be inserted earlier than line 8 or later than line 40.

6.20.3 625/50 television system

The preferred placement of the VITC code word is on television lines 19(332) and 21(334). Where line 21 is used to carry captions the VITC should be positioned on lines 18(331) and 20(333) only.

The address code may be inserted on multiple lines of the vertical interval provided all lines contain the same time address, drop frame and colour frame data.

7 Relationship between LTC and VITC

7.1 Time address data

Because of the relative timing of the two time code modulation methods, direct interchange of time address bits is not possible in real time. In order to generate a LTC from a VITC, or vice versa, the time address of one frame is incremented by one and used as the time address of the next frame.

This method will produce a one-to-one correspondence between the time address and flag bits of the LTC and the VITC as long as the counting sequence is continuous and ascending. Discontinuities will propagate to the second time code after one frame of delay.

7.2 Binary group data

When transferring binary group data, look-ahead compensation, similar to that used in time address data transfer, may be applied if the nature of the binary group data format lends itself to being predictable. If this is not the case, then no update shall be applied to the data and the transfer will result in a one- or two-frame latency.

The guideline for transferring binary group data between LTC and VITCs shall be as follows:

7.2.1 Transferring vertical interval binary group data to linear binary group data

The binary group data and flag bits from the first line in field 1 of the VITC shall be transferred to the corresponding bits in the linear time code of the next frame.

7.2.2 Transferring linear binary group data to vertical interval binary group data

The binary group data and flag bits from the linear time code shall be transferred to the corresponding bits in the VITC of the next frame.

If the binary group data format, as identified by the binary group flag bits, supports line or field independence, then the binary group data and flags of the remaining lines in the VITC for that frame shall be set to zero. If the binary group data format is redundant, then the redundant lines in the frame shall contain identical data.

7.3 VITC and LTC code word comparison

Table 11 summarizes the correspondence between the bits of the VITC and LTC codewords for 60- 50-, 30-, 25- and 24-frame systems.

TABLE 11

Summation of VITC and LTC codeword bit definitions

VITC BIT NO.	VALUE (WEIGHT)	COMMON ASSIGNMENT	LTC BIT NO.	30-FRAME/60-FIELD 60-FRAME	25-FRAME/50-FIELD 50-FRAME	24-FRAME/48-FIELD
0	1	VITC SYNC BITS				
1	0					
2	(1)	FRAME UNITS	0			
3	(2)		1			
4	(4)		2			
5	(8)		3			
6	(LSB)	FIRST BINARY GROUP	4			
7	|		5			
8	|		6			
9	(MSB)		7			
10	1	VITC SYNC BITS				
11	0					
12	(10)	FRAME TENS	8			
13	(20)		9			
14	FLAG	FLAG	10	DROP FRAME FLAG	UNUSED BIT	UNUSED BIT
15	FLAG	FLAG	11	COLOUR FRAME FLAG	COLOUR FRAME FLAG	UNUSED BIT
16	(LSB)	SECOND BINARY GROUP	12			
17	|		13			
18	|		14			
19	(MSB)		15			
20	1	VITC SYNC BITS				
21	0					
22	(1)	SECOND UNITS	16			
23	(2)		17			
24	(4)		18			
25	(8)		19			
26	(LSB)	THIRD BINARY GROUP	20			
27	|		21			
28	|		22			
29	(MSB)		23			
30	1	VITC SYNC BITS				
31	0					
32	(10)	SECOND TENS	24			
33	(20)		25			
34	(40)		26			
35	FLAG	FLAG	27	FIELD BIT/LTC POLARITY	BINARY GROUP FLAG 0	FIELD BIT/LTC POLARITY
36	(LSB)	FOURTH BINARY GROUP	28			
37	|		29			
38	|		30			
39	(MSB)		31			
40	1	VITC SYNC BITS				
41	0					
42	(1)	MINUTE UNITS	32			
43	(2)		33			
44	(4)		34			
45	(8)		35			
46	(LSB)	FIFTH BINARY GROUP	36			
47	|		37			
48	|		38			
49	(MSB)		39			
50	1	VITC SYNC BITS				
51	0					
52	(10)	MINUTE TENS	40			
53	(20)		41			
54	(40)		42			
55	FLAG	FLAG	43	BINARY GROUP FLAG 0	BINARY GROUP FLAG 2	BINARY GROUP FLAG 0
56	(LSB)	SIXTH BINARY GROUP	44			
57	|		45			
58	|		46			
59	(MSB)		47			
60	1	VITC SYNC BITS				
61	0					
62	(1)	HOUR UNITS	48			
63	(2)		49			
64	(4)		50			
65	(8)		51			
66	(LSB)	SEVENTH BINARY GROUP	52			
67	|		53			
68	|		54			
69	(MSB)		55			
70	1	VITC SYNC BITS				
71	0					
72	(10)	HOUR TENS	56			
73	(20)		57			
74	FLAG	FLAG	58	BINARY GROUP FLAG 1	BINARY GROUP FLAG 1	BINARY GROUP FLAG 1
75	FLAG	FLAG	59	BINARY GROUP FLAG 2	FIELD BIT/LTC POLARITY	BINARY GROUP FLAG 2
76	(LSB)	EIGHTH BINARY GROUP	60			
77	|		61			
78	|		62			
79	(MSB)		63			
80	1	VITC SYNC BITS				
81	0					
82-89		VITC CRC CODE				
		LTC SYNC WORD	64-79			

8 Digital vertical interval time code (D-VITC)

8.1 Signal definition

D-VITC is an 8- or 10-bit digital data representation of the band-limited analogue signal corresponding to the VITC.

An 8-bit D-VITC shall be carried in the 8 most significant bits of the Recommendation ITU-R BT.601 and Recommendation ITU-R BT.709 signal definitions.

10- and 8-bit interpretations of the values are given in this standard, with 10 bits the preferred expression. For 12-bit implementations only the most significant 10 bits shall be used on any interface.

8.2 Data assignment

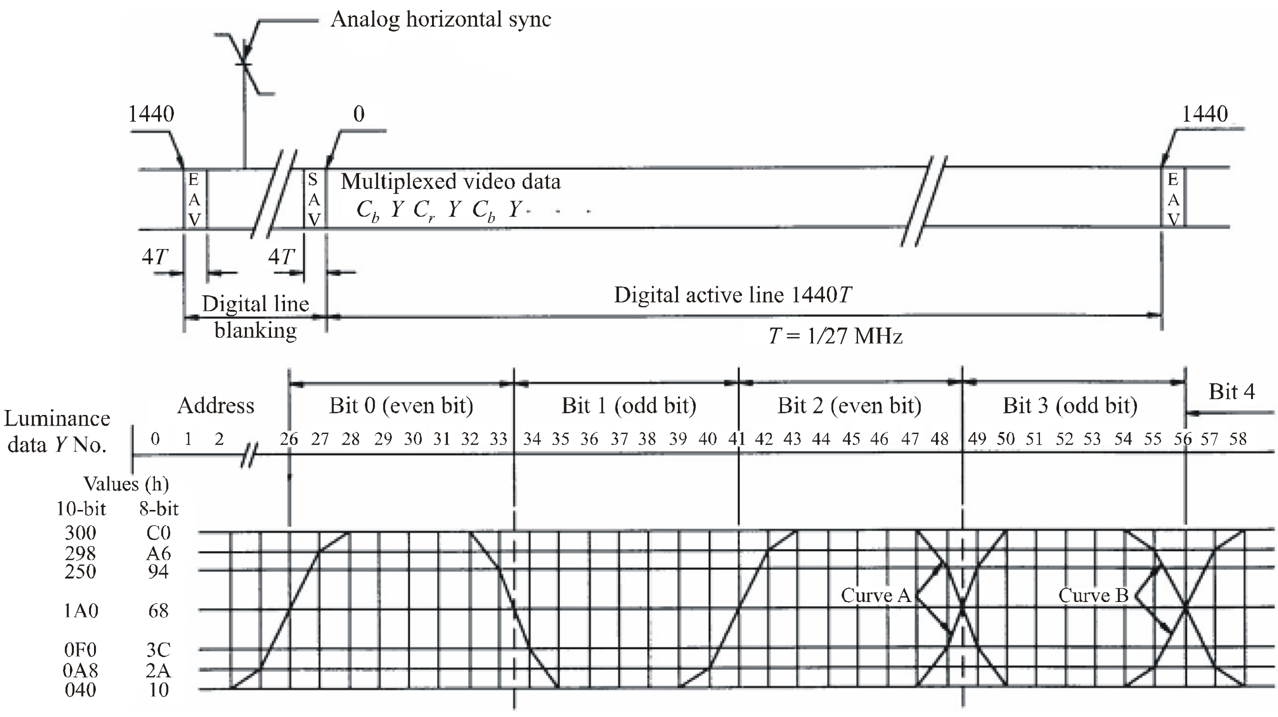
The 90 bits of information in the VITC are carried by 675 consecutive luminance samples. Each D-VITC bit is therefore represented by 7.5 luminance samples.

8.3 Transitions

The shape of transitions between D-VITC bits is defined by the values assigned to luminance samples in the transition region. In some cases the number of luminance samples chosen may be an odd integer multiple of one-half the total number of bits; if this is the case it is necessary to define two distinct transition data sets (see Fig. 6). When viewed in the analogue domain, the resulting transitions are a close approximation to a raised cosine shape.

FIGURE 6

Informative illustration of non-integer luminance sampling (525-line system)



Curve A: transition from even bit to odd bit.
Curbe B: transition from odd bit to even bit.

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9 Digital data

In the following section, 10-bit expressions are given and preferred. Equivalent values for 8-bit representations are given in parentheses.

9.1 The data value associated with a binary state of 1 in the D-VITC shall be 300_h ($C0_h$).

9.2 The data value associated with a binary state of 0 in the D-VITC shall be 040_h (10_h).

9.3 The data values of all luminance samples of the active line period which are not used in forming the D-VITC shall be set to 040_h (10_h).

9.4 The data values of all chrominance samples of the active line period shall be set to 200_h (80_h).

10 Insertion lines may be a repeat

D-VITC should be inserted on interfaces and recordings as indicated below:

For 525-line/60-field systems, the D-VITC shall be inserted on lines 14 and 277. For 625-line/50-field systems, the D-VITC shall be inserted on lines 19 and 332.

Appendix 1
to Annex 1

Bibliography

ISO/IEC [1991] Standard ISO/IEC 646, Information Technology – ISO 7-Bit Coded Character Set for Information Interchange.

ISO/IEC [1994] Standard ISO/IEC 2022, Corr.1 [1999], Information Technology – Character Code Structure and Extension Techniques.

Appendix 2
to Annex 1

Converting time codes when converting video from 24 fps television systems

(Informative)

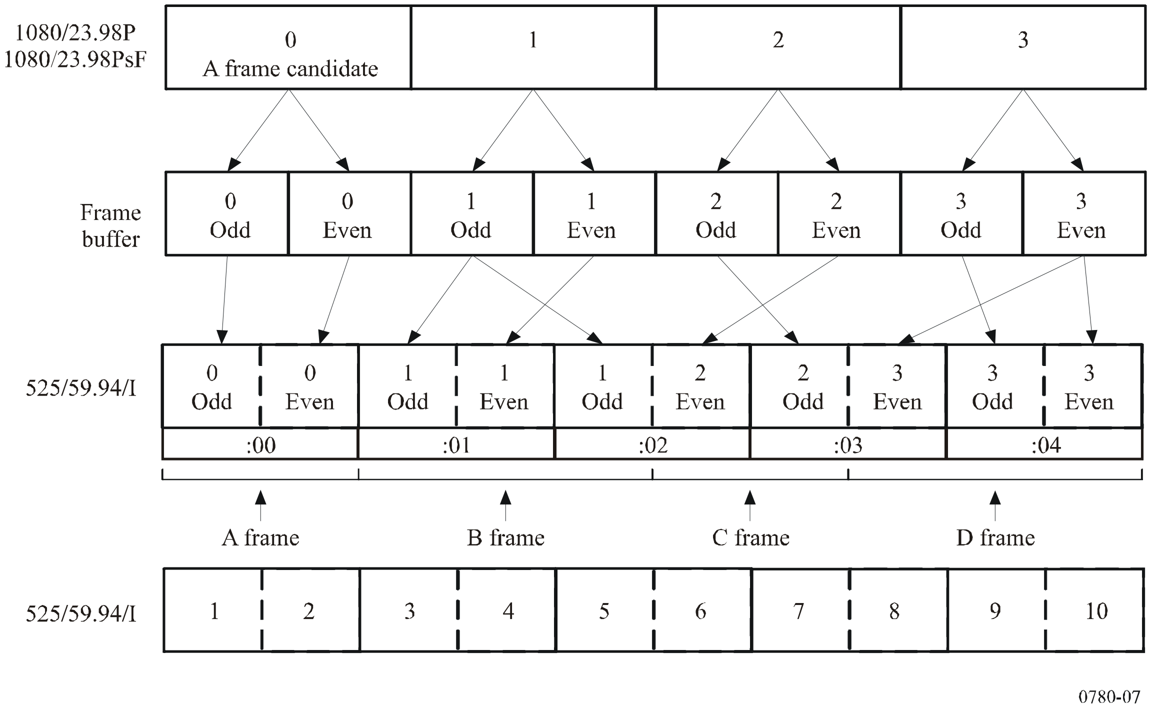
When rate converting 24 fps video to 25 or 30 fps video by periodically replicating video fields/frames, the conversion hardware inserts extra fields/frames of some of the images. In addition the incoming time code must be converted from a nominal 24 fps to 25 fps or 30 fps rate. In other cases the original signal is reproduced at a faster rate than acquisition.

1 Conversion of 23.98 fps video to 59.94 fps video

In order to deterministically move between the 24 and 30 fps formats it is recommended that the video frames of the high-definition material with the time code frame number zero be converted to an A frame as shown in Fig. 7. These frames are called A frame candidate frames. A frames are aligned with the field identified by the field 1 pulse of the 10 field sequence as shown in Fig. 7. It follows then that subsequent high definition frame numbers that are evenly divisible by 4 will also become A frames. As specified in section 6 of this Recommendation, the 30 non-drop frame count mode should be used for the time code of the converted material. It is recommended that the A frame candidate zero frame should be numbered as the zero frame on the converted video, resulting in subsequent A frames of the converted video having time code frame numbers that are evenly divisible by 5.

FIGURE 7

Conversion of 23.98 fps video to 525/59.94/I



As there are delays through the conversion hardware it may not be possible to align the vertical sync at the start of an A frame with the vertical sync at the start of an A frame candidate frame, but the vertical sync at the beginning of the A frame (line 4 for 525-line systems) should be aligned with the vertical sync at the beginning of one of the input frames (line 1).

2 Conversion of 24 fps video to 25 fps video

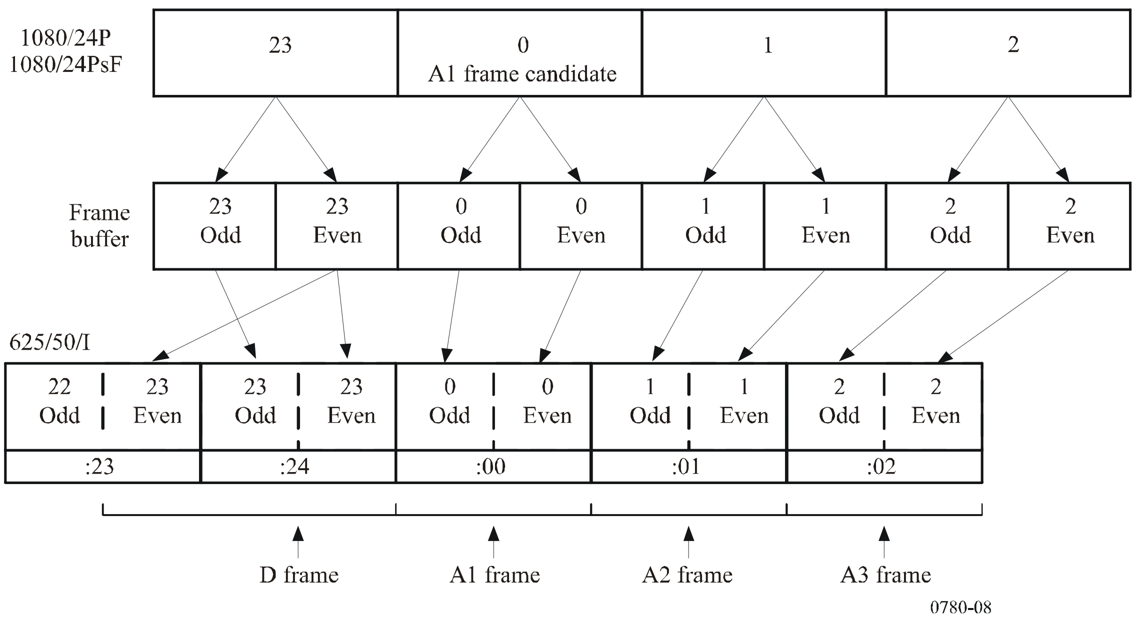
For specific editorial applications it may be necessary to perform an 11(2):3 pull-down conversion between systems operating at 24 fps and 25 fps.

NOTE 1 – Due to the visibility of temporal artefacts of the image this process is not recommended for release material.

In order to deterministically move between the 24 fps and 25 fps formats it is recommended that the video frames of the high definition 24 fps material with the time code frame number zero be converted to the first A frame or the 24:25 frame pull-down sequence as shown in Fig. 8. These frames are called the A1 frame candidate frames. It follows then that each subsequent high definition 24 fps frame number zero will also become an A frame at the start of the 24:25 pull-down cycle. The converted A1 frame should also be numbered as the zero frame of the time code second.

FIGURE 8

Example of conversion from of 24 fps high-definition video to 625/50/I



As there are delays through the conversion hardware it may not be possible to align the vertical sync at the start of an A1 frame with the vertical sync at the start of an A1 candidate frame, but the vertical sync at the beginning of the A1 frame (line 1 for 625-line systems) should be aligned with the vertical sync at the beginning of one of the input frames (line 1).

Appendix 3
to Annex 1

D to A conversion and A to D conversion

When D-VITC is decoded and D to A converted, the resulting analogue signal could deviate from the nominal values given in this Recommendation.

When an analogue signal (VITC) is A to D converted, design engineers should be aware of a potential difference in defined digital values.