Annex A (informative)
Additional data

A.1 Centerlines

The centerlines of the image area are given for convenience in interpreting the standard, facilitating such applications as the optical design of equipment, and assisting in the understanding of suitable mechanical embodiments related to projectable image area.

A.2 Projectable image area

Essentially, the entire image within the maximum established by this standard will be transferred in such operations as reduction or enlargement printing (SMPTE RP 65 and SMPTE RP 66), for television broadcasting ANSI/SMPTE 96), etc. Since the entire area will be presented, it is important that the projectable area include only material that meets recognized standards for technical and artistic excellence.

A.3 Image area for television

It is recognized that home television receivers are adjusted to show a distribution of picture sizes, ranging downward from the maximum. Guides to picture composition, based upon a statistical survey of receivers in use, are presented in SMPTE RP 27.3. Note that some portion of the audience will see the entire transmitted area, but for certainty in presentation of critical information over broadcast television, such information should be confined to a smaller, central area.

Annex B (informative)
Bibliography

ANSI/SMPTE 7-1988, Motion-Picture Film (16-mm) — Camera Aperture Image and Usage

ANSI/SMPTE 48-1989, *Motion-Picture Film (16-mm)* — Printed Areas — Picture and Sound Contact Printing

ANSI/SMPTE 96-1992, Television — 35- and 16-mm Motion-Picture Film and 2 × 2 Slides — Scanned Area and Photographic Image Area for 4:3 Aspect Ratio

ANSI/SMPTE 109-1992, Motion-Picture Film (16-mm) — Perforated 1R and 2R

SMPTE RP 27.3-1989, Specifications for Safe Action and Safe Title Areas Test Pattern for Television Systems

SMPTE RP 65-1991, Step Optical Reduction Printing of 35-mm Images to 16-mm Prints and Duplicate Negatives

SMPTE RP 66-1991, Step Optical Enlargement Printing of 35-mm Images from 16-mm Images

PROPOSED SMPTE STANDARD

SMPTE 12M
Revision of ANSI/SMPTE 12M-1986

for Television, Audio and Film — Time and Control Code

1 Scope

This standard specifies a digital time and control code for use in television, film, and accompanying audio systems operating at 30, 25, and 24 frames per second.

Clauses 4, 5, and 6 specify the manner in which time is represented in frame-based systems. Clause 7 describes the structure of the time address and control bits of the code, and sets guidelines for storage of user data in the code. Clause 8 specifies the modulation method and interface characteristics of a linear time code (LTC) source. Clause 9 specifies the modulation method for inserting the code into the vertical interval of a television signal. Clause 10 summarizes the relationship between the two forms of time and control code.

2 Normative references

The following standards contain provisions which, through reference in the 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.

ANSI/SMPTE 125M-1992, Television — Component Video Signal 4:2:2 — Bit-Parallel Digital Interface

SMPTE 170M, Television — Composite Analog Video Signal — NTSC for Studio Applications

SMPTE 258M, Transfer of Edit Decision Lists

SMPTE 262M, Television, Audio and Film — Storage and Transmission of Data — Binary Groups of Time and Control Codes

SMPTE 240M-1988, Television — Signal Parameters — 1125/60 High-Definition Production System

SMPTE 260M-1992, Television — Digital Representation and Bit-Parallel Interface — 1125/60 High-Definition Production System

SMPTE RP 159-1991, Vertical Interval Time Code and Longitudinal Time Code Relationship

SMPTE RP 164, Location of Vertical Interval Time Code

SMPTE RP 169, Television, Audio and Film Time and Control Code — Auxiliary Time Address Data in Binary Groups — Dialect Specification of Directory Index Locations

CCIR Rec 470-3 Annex, Television Systems

ISO 646:1983, Information Processing — ISO 7-Bit Coded Character Set for Information Interchange

ISO 2022:1986, Information Processing — ISO 7-Bit and 8-Bit Coded Character Sets — Code Extension Techniques

3 Definitions

3.1 Linear time code (LTC)

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

3.2 Vertical interval time code (VITC)

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

3.3 Source

A time and control code source is any device which generates a time and control code signal, or regenerates a time and control code signal from a recorded medium or transmission channel. An original source refers specifically to the device which is generating the time and control code signal.

3.4 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.

4 Time representation in 30-frame systems

4.1 Definitions of real time and NTSC time

4.1.1 In a system running at a frame rate of 30 frames per second, exactly one second of real time elapses during the scanning of 30 frames. An example of such a system is an 1125/60 high-definition system.

4.1.2 In an NTSC television system running at a vertical field rate of 60/1.001 fields per second (~ 59.94 Hz), one second of NTSC time elapses during the scanning of 60 television fields or 30 television frames. Because of the difference in vertical scanning rates, the relationship between real time and NTSC time is:

$$1 = \text{sec}_{NTSC} = 1.001\ \text{sec}_{REAL}$$

4.2 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. Refer to SMPTE 258M for standard formats used to display frame-based time.

The hours, minutes, and seconds follow the ascending progression of a 24-hour clock beginning with 0 hours, 0 minutes, and 0 seconds to 23 hours, 59 minutes, and 59 seconds. The frames shall be numbered successively according to the counting mode (drop frame or nondrop frame) as described below:

4.2.1 Nondrop frame — Uncompensated mode

Frames shall be numbered 0 through 29, successively, with no omissions.

4.2.2 Drop frame — NTSC time compensated mode

Because the vertical field rate of an NTSC television signal is 60/1.001 fields per second (~ 59.94 Hz), straightforward counting at 30 frames per second will yield an error of approximately +108 frames (+3.6 sec_{REAL}) in one hour of running time.

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

When drop-frame compensation is applied to an NTSC television time code, the total error accumulated after one hour is reduced to –3.6 ms. The total error accumulated over a 24-hour period is –86 ms.

4.3 Color frame identification in 525/60 television systems

If color frame identification in the time code is required, the even units of frame numbers shall identify color fields I and II, and the odd units of frame numbers shall identify color fields III and IV.

5 Time representation in 25-frame systems

5.1 Definition of real time

In a system running at a frame rate of 25 frames per second, exactly one second of real time elapses during the scanning of 25 frames. An example of such a system is a 625/50 television system.

5.2 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-hour clock beginning with 0 hours, 0 minutes, and 0 seconds to 23 hours, 59 minutes, and 59 seconds. The frames shall be numbered successively 0 through 24.

5.3 Color frame identification in 625/50 television systems

If identification of the eight-field color sequence in the time code is required, the time address shall bear a predictable relationship with the eight-field color sequence (as specified in CCIR Rec 470-3). This relationship can be expressed using either logical or arithmetic notations as given in 5.3.1 and 5.3.2, respectively.

5.3.1 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 equals the value of the 1's bit of the frame number;
B equals the value of the 1's bit of the second number;
C equals the value of the 2's bit of the frame number;
D equals the value of the 10's bit of the frame number;
E equals the value of the 2's bit of the second number;
F equals the value of the 10's bit of the second number;
| represents the logical OR operation;
^ represents the logical EXCLUSIVE OR operation.

5.3.2 Arithmetic relationship

The remainder of the quotient:

$$\frac{(S + P)}{4}$$

shall be:

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 equals the decimal value of the "seconds" digits of the time address, and P equals the decimal value of the frames digits of the time address.

6 Time representation in 24-frame systems

6.1 Definition of real time

In a system running at a frame rate of 24 frames per second, exactly one second of real time elapses during the passing of 24 frames. An example of such a system is a film system.

6.2 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-hour clock beginning with 0 hours, 0 minutes, and 0 seconds to 23 hours, 59 minutes, and 59 seconds. The frames shall be numbered successively 0 through 23.

7 Structure of the time address and control bits

7.1 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.

7.2 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. Thus, the entire time address is coded into 26 bits.

7.3 Flag bits

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

7.3.1 Drop frame flag (525/60 television system only)

This flag shall be set to "one" when drop-frame compensation is being performed as specified in 4.2.2. When the count is not drop-frame compensated, this flag bit shall be set to "zero."

7.3.2 Color frame flag (525/60 and 625/50 television systems only)

If color frame identification has intentionally been applied to the time and control code by the original source, as defined in 4.3 or 5.3, this flag shall be set to "one."

Color frame identification may be forced by an original source of time and control code by halting the time address until the color field to time code relationship is satisfied, after which the time address is incremented normally each frame. As long as neither the time address counting sequence nor the color field sequence is changed, the relationship will remain satisfied.

7.3.3 Binary group flags

Three flags provide eight unique combinations which specify the use of the binary groups (see 7.4).

7.3.4 Modulation method specific flag

The remaining flag bit is reserved for use by each modulation method. This flag is defined in 8.2.5 and 9.2.4.

7.4 Use of the binary groups

The binary groups are intended for storage and transmission of data by the 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 sections define the current assignments of the binary group flag states. Table 1 summarizes the present assigned combinations.

7.4.1 Character set not specified (BGF2=0, BGF1=0, BGF0=0)

This combination of binary group flags 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 in any manner without restriction.

7.4.2 Eight-bit character set (BGF2=0, BGF1=0, BGF0=1)

This combination specifies an eight-bit character set conforming to ISO 646 or ISO 2022. If the seven-bit ISO codes *are being used, then 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.

7.4.3 Page/line multiplex system (BGF2=1, BGF1=0, BGF0=1)

This combination specifies the page/line multiplex system described in SMPTE 262M. This multiplex system defines a hierarchy which can be used to encode large amounts of data in the binary groups through the use of time multiplexing. Applications for this encoding scheme include control codes, text data, and production information.

7.4.4 Unassigned binary group flag states

Unassigned combinations of the binary group flags *are reserved and should not* be used until assigned by the SMPTE.

Table 1 – Binary group flag assignments

BGF2	BGF1	BGF0	Assignment
0	0	0	Unspecified
0	0	1	8-bit codes
0	1	0	Unassigned
0	1	1	Unassigned
1	0	0	Unassigned
1	0	1	Page/line
1	1	0	Unassigned
1	1	1	Unassigned

8 Linear time code application

8.1 Code word format

Each LTC code word consists of 80 bits numbered 0 through 79. The bits are generated serially beginning

with bit 0. Bit 79 of the code word is followed by bit 0 of the next code word. Each code word is associated with one television or film frame.

8.2 Code word data content

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

8.2.1 Time address

The time address bits of the frame as defined in 7.2. 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.

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

8.2.2 Flag bits

The drop frame, color frame, and binary group flag bits, as defined in 7.3. The bit positions are listed in table 3. Note that not all flag bits are used by all systems, as designated by the symbol "—." Unused flag bits should be set to zero by original sources and ignored by receiving equipment.

Table 3 – LTC flag bit positions

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

8.2.3 Binary groups

Eight 4-bit binary groups as defined in 7.3. 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 4.

Table 4 – 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

8.2.4 Synchronization word

The synchronization word is a static combination of bits which can be used by receiving equipment to accurately identify the bit position of the serial code. 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 center 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.

Table 5 – LTC synchronization word bit positions and values

Bit	Sync word 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

8.2.5 Biphase mark polarity correction

This flag bit is specific to the LTC modulation method described in 8.3. The position of this flag is listed in table 3.

Because of the nature of the modulation method, the polarity of the first clock transition of the first bit of the synchronization word may differ from code word to code word dependent on the number of logical zeros in the data.

Applications which switch between two sources of time and control code 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. This requirement is summarized as follows:

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," else the polarity correction bit shall be set to "zero."

8.3 Modulation method

The NRZ unmodulated signal is biphase mark encoded according to the following coding rules (see figure 1):

(1) A transition occurs at each bit cell boundary, regardless of the value of the bit.

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

(3) 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.

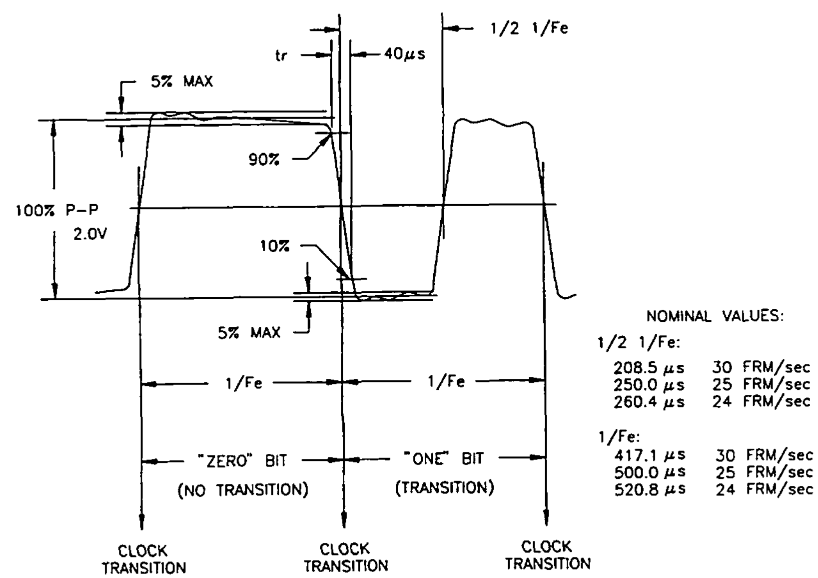


Figure 1 – Linear time code source output waveform

8.4 Bit rate

The bits shall be evenly spaced throughout the address period, and shall occupy fully the address period which is one frame or two television fields. Consequently, the nominal frequency, F_e, at which the bits are generated shall be:

$$F_e = 80 \cdot F_f$$

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

If an original source is generating an LTC signal referenced to a television signal, the bit clock shall be phase locked to the television signal. If an original source is generating an LTC signal without a reference, the frequency tolerance shall be ± 100 ppm.

8.5 Timing of the code word relative to a television signal

8.5.1 525/60 television systems

The first transition of bit 0 of the code word shall occur at the beginning of line 5 of the frame with which it is associated. The tolerance shall be ± 1½ lines (see figure 2a).

8.5.2 1125/60 television systems

The first transition of bit 0 of the code word shall occur at the beginning of line 1 of the frame with which it is associated. The tolerance shall be ± 1 line (see figure 2b).

8.5.3 625/50 television systems

The first transition of bit 0 of the code word shall occur at the beginning of line 2 of the frame with which it is associated. The tolerance shall be ± 1½ lines (see figure 2c).

8.6 Linear time code interface electrical and mechanical characteristics

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

8.6.1 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.

8.6.2 Amplitude distortion

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

8.6.3 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.

8.6.4 Interface connector

The preferred connector for double-ended or balanced outputs shall be 3-pin XLR (MALE) and inputs shall be 3-pin XLR (FEMALE). 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 shall be BCN (FEMALE).

8.6.5 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.

8.6.6 Output amplitude

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

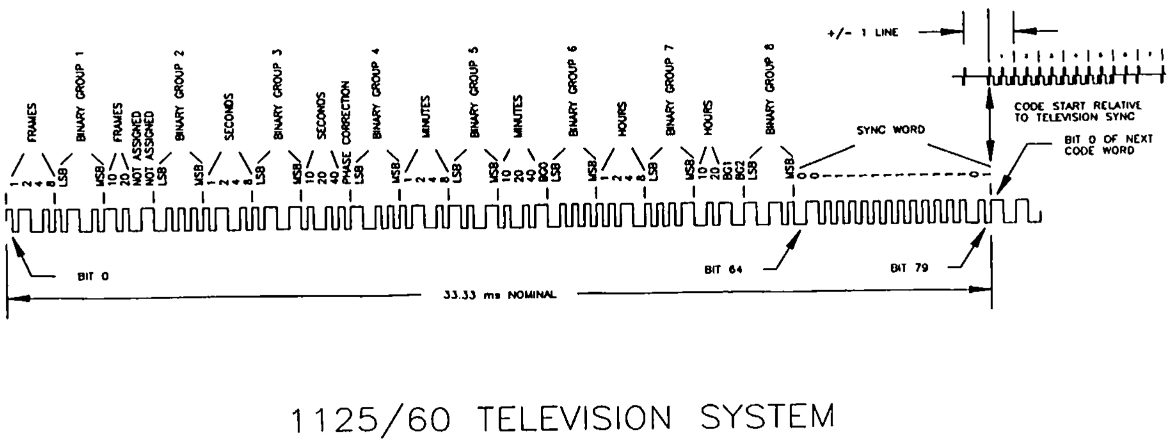


Figure 2b – 30-frame linear time code example

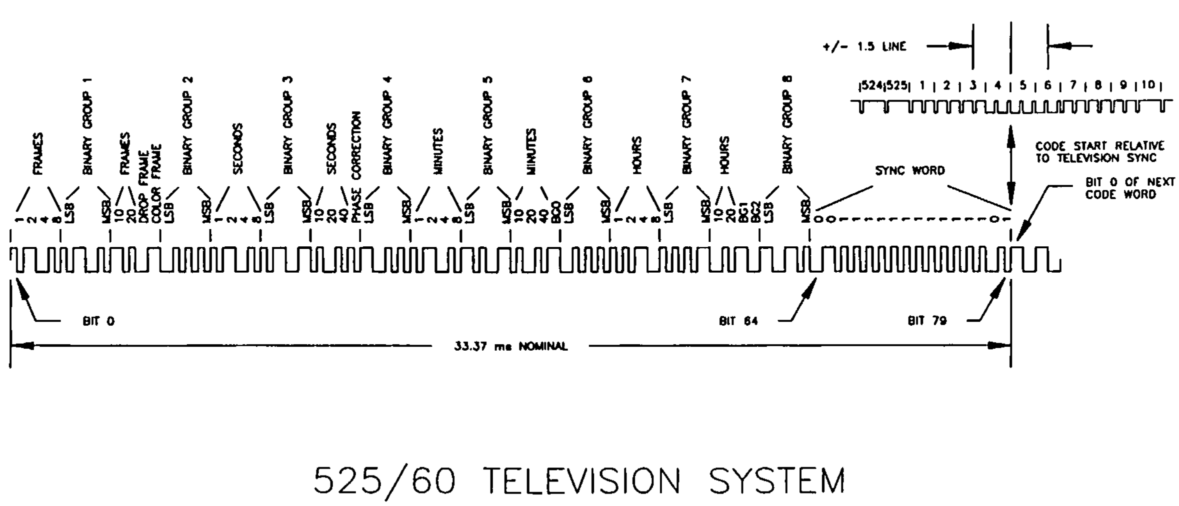


Figure 2a – 30-frame linear time code example

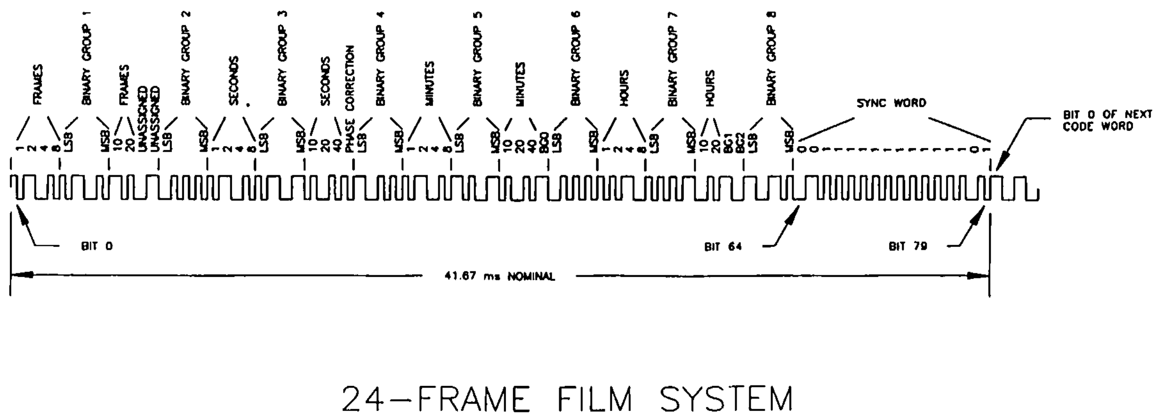


Figure 2d – 24-frame linear time code example

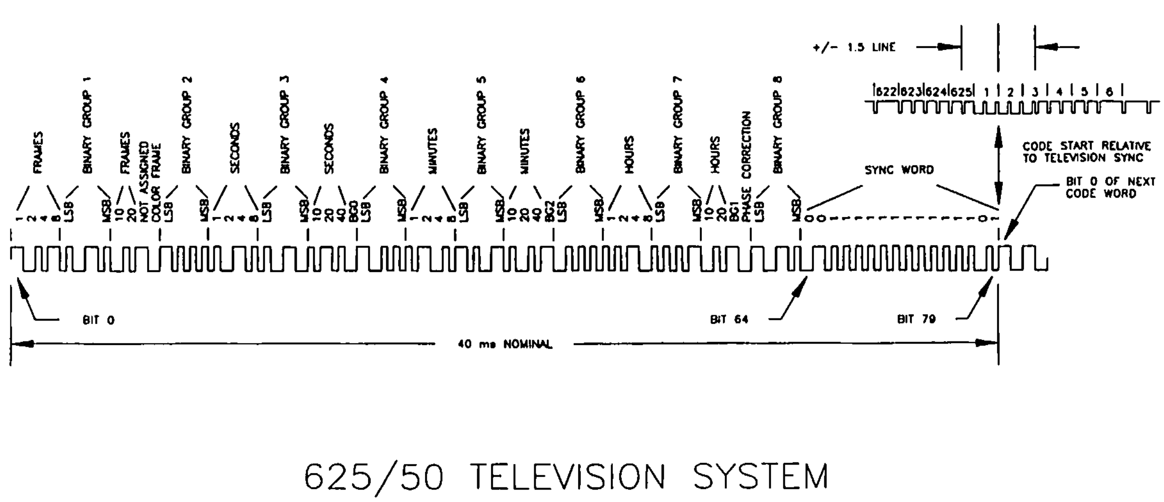


Figure 2c – 25-frame linear time code example

9 Vertical interval application-television systems

9.1 Code word format

Each code word shall consist of 90 bits numbered 0 through 89, organized as nine groups of ten bits. Each ten-bit group starts with a synchronization bit pair, which is a one bit followed by a zero bit. The synchronization bit pair is followed by eight data bits.

The first eight groups contain the sixty-four 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 code word, it shall always have the value of one thus there will always be a rising transition at the leading edge of bit 0 to signal the start of the word.

9.2 Code word data content

Each VITC code word consists of a time address, flag bits, binary groups, field mark flag, CRC code, and synchronization bits. Refer to figures 3a, 3b, and 3c for examples of the VITC signal.

9.2.1 Time address

The time address bits of the frame as defined in 7.2. 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.

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

9.2.2 Flag bits

The drop frame, color frame, and binary group flag bits as defined in 7.3. The positions of these flags are listed in table 7. Note that not all flag bits are used by all systems, as designated by the symbol "—". Unused flag bits should be set to zero by original sources, and ignored by receiving equipment.

Table 7 – VITC flag bit positions

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

9.2.3 Binary groups

Eight 4-bit binary groups are defined in 7.4. 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 8.

Table 8 – 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

9.2.4 Field mark flag

The position of this flag is listed in table 7.

9.2.4.1 525/60 television system

Field identification shall be recorded as follows: A "zero" shall represent monochrome field 1 and color field I or III. A "one" shall represent monochrome field 2 or color field II or IV. Color fields I through IV are defined in SMPTE 170M.

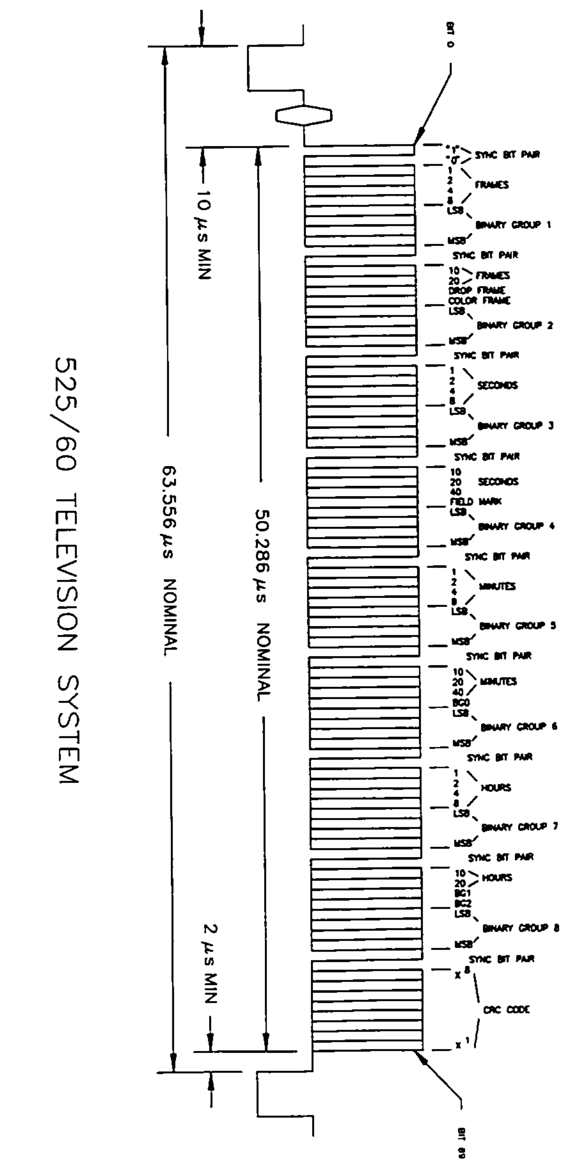


Figure 3a – 525/60 vertical interval time code address bit assignment and timing

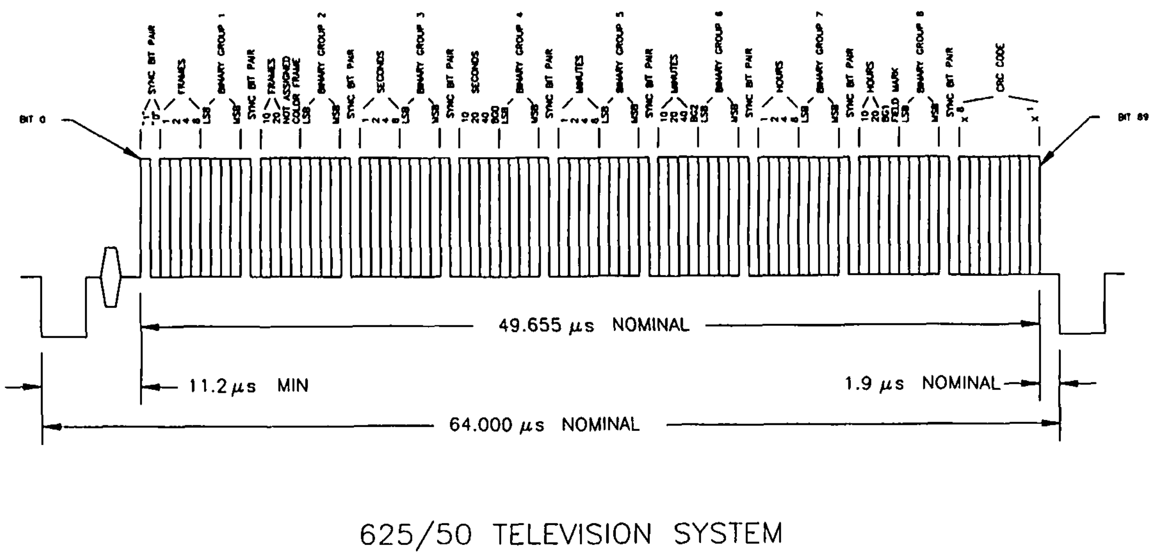


Figure 3c – 625/50 vertical interval time code address bit assignment and timing

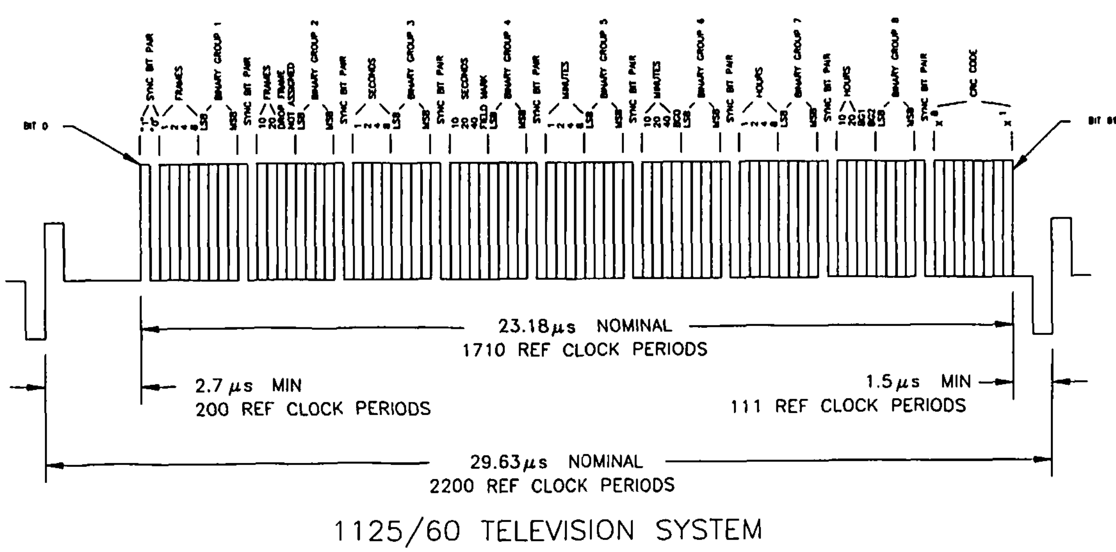


Figure 3b – 1125/60 vertical interval time code address bit assignment and timing

9.2.4.2 1125/60 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 SMPTE 240M.

9.2.4.3 625/50 television system

Field identification shall be recorded as follows: A "zero" shall represent color fields 1, 3, 5, and 7. A "one" shall represent color fields 2, 4, 6, and 8. Color fields 1 through 8 are defined in CCIR Report 624-4.

9.2.5 Synchronization bits

A synchronization bit pair consisting of a "one" followed by a "zero" is inserted preceding every eight 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.

9.2.6 Cyclic redundance check code

Eight bits, 82 through 89, are encoded with a CRC code to provide for error detection by cyclic redundance.

The generating polynomial of the cyclic redundance check, 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.

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

Applying the generating polynomial to the received data bits 0 through 89, inclusive, shall result in an remainder of all zeros when no error exists.

9.3 Modulation method

The NRZ unmodulated signal is time compressed and inserted as a burst within the nonblanked interval of a selected television line in the vertical interval (see figure 4). Signal level to logic level specifications are listed in 9.8.1.

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. Because of the insertion of fixed-value synchronization bits, a transition is guaranteed to occur at least every ten bits.

9.4 Bit timing

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

$$T_e = \frac{1}{115 \cdot F_h} \pm 2\%$$

NOTE – Previous definitions of the bit timing for 525/60 and 625/50 television systems are different from that given here, but do lie within the tolerance range given.

In 1125/60 television systems, if the reference clock is used to generate the bit timing, then T_e shall be equal to 19 times the reference clock as defined in SMPTE 240M.

9.5 Timing of the code word relative to the television signal

9.5.1 525/60 television system

The half-amplitude point 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.

9.5.2 1125/60 television system

The half-amplitude point 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.

9.5.3 625/50 television system

The half-amplitude point 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.

9.6 Location of the address code signal in the vertical interval

The VITC code word 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.

9.6.1 525/60 television system

Insertion of the address code shall not be earlier than line 10(273) or later than line 20(283). The preferred placement of the VITC code word is outlined in SMPTE RP 164.

9.6.2 1125/60 television system

Insertion of the address code shall not be earlier than line 7(569) or later than line 40(602).

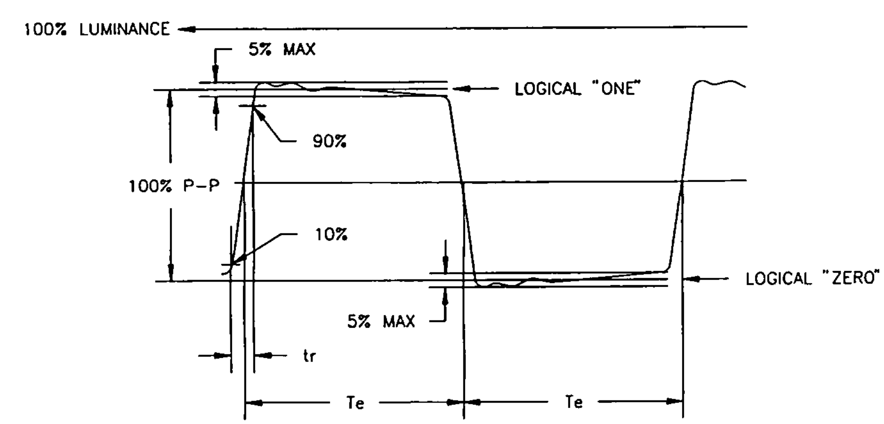
9.6.3 625/50 television system

Insertion of the address code shall not be earlier than line 6(319) or later than line 22(335).

9.7 Redundancy

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

Redundancy of the binary group data is dependent on the binary group flags and the requirements of the encoding system which their values indicate.



NOTE – See 9.8 for values and tolerances of T_e, t_r, logic "one," and logic "zero."

Figure 4 – Vertical interval time code waveform

9.8 Vertical interval time code waveform characteristics

This section specifies the waveform characteristics of the VITC signal (refer to figure 4).

9.8.1 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"
525/60	70–90 IRE	0–10 IRE
1125/60	500–600 mV	0–25 mV
625/50	500–600 mV	0–25 mV

9.8.2 Rise/fall time

The rise and fall times of the code shall be 200 ns ± 50 ns for 525/60 and 625/50 television systems, and 100 ns ± 25 ns for 1125/60 television systems. These measurements shall be made between 10% and 90% amplitude points on the waveform.

9.8.3 Amplitude distortion

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

10 Relationship between LTC and VITC

10.1 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 linear time code from a vertical interval time code, or vice versa, the time address of one frame is incremented by one and used as the time address of the next frame. Drop frame and color frame flag bits (if applicable) are maintained.

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

10.2 Binary group data

When transferring binary group data, a one-frame update, 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-frame delay.

The guideline for transferring binary group data between linear and vertical interval time codes shall be as follows:

10.2.1 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 vertical interval time code shall be transferred to the corresponding bits in the linear time code of the next frame.

10.2.2 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 vertical interval time code 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 vertical interval code 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.

10.3 VITC and LTC code word comparison

Table 11 summarizes the correspondence between the VITC and LTC code words for 30-, 25-, and 24-frame systems.

Table 11 – Summation of VITC and LTC code word bit definitions

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

PROPOSED SMPTE STANDARD

for Television, Audio and Film –

Storage and Transmission of Data — Binary Groups of Time and Control Codes

1 Scope

This standard specifies a directory index to classify various types of data to be recorded into the binary groups (user bits) of the SMPTE time and control code. The directory index, located in two binary groups of the time and control code frame, fully specifies the type of data stored in the remaining binary groups of that frame.

This standard also specifies the group assignments of timing, application, and control data types to subsets of the directory index. It applies to both linear and vertical interval time code applications. Specifications of application dialects will be developed in related documents.

2 Normative references

The following documents 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 documents indicated below.

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

SMPTE RP 169, Television, Audio and Film Time and Control Code — Auxiliary Time Address Data in Binary Groups — Dialect Specification of Directory Index Locations

ISO 646:1983, Information Processing — ISO 7-Bit Coded Character Set for Information Interchange

ISO 2022:1986, Information Processing — ISO 7-Bit and 8-Bit Coded Character Sets — Coded Extension Techniques

3 Data structure

3.1 Frame format (see figure 1)

3.1.1 Binary group labels

The binary group containing the lowest frame address bit numbers is referred to as binary group 1 (BG 1), and the binary group containing the highest bit numbers is referred to as binary group 8 (BG 8). Within a binary group, the lowest bit number contains the least significant bit of data.

3.1.2 Binary byte labels

The data content of the binary groups may be specified as 8-bit character sets, in which case the characters should be inserted in accordance with SMPTE 12M. Thus, binary groups 1 and 2 form binary byte 1, binary groups 3 and 4 form binary byte 2, binary groups 5 and 6 form binary byte 3, and binary groups 7 and 8 form binary byte 4. Within a binary byte, the lower numbered binary group contains the four least significant bits of data.

3.1.3 Directory index

Binary groups 7 and 8 shall be used as a directory index for page-line user bit applications. Binary group 8 shall specify a directory page totalling 16 pages, and binary group 7 shall specify a directory line totalling 16 lines per page.

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VITC BIT NO.	VALUE (WEIGHT)	COMMON ASSIGNMENT	LTC BIT NO.	
0	1	VITC SYNC BIT		
1	0	VITC SYNC BIT		
2	(1)	TV FRAME UNITS	0	
3	(2)	TV FRAME UNITS	1	
4	(4)	TV FRAME UNITS	2	
5	(8)	TV FRAME UNITS	3	
6	(LSB)	FIRST BINARY GROUP	4	— LSB —
7		FIRST BINARY GROUP	5	
8		FIRST BINARY GROUP	6	
9	(MSB)	FIRST BINARY GROUP	7	
10	1	VITC SYNC BIT		
11	0	VITC SYNC BIT		
12	(1)	TV FRAME TENS	8	BINARY BYTE 1
13	(2)	TV FRAME TENS	9	
14	FLAG	FLAG	10	
15	FLAG	FLAG	11	
16	(LSB)	SECOND BINARY GROUP	12	
17		SECOND BINARY GROUP	13	
18		SECOND BINARY GROUP	14	
19	(MSB)	SECOND BINARY GROUP	15	— MSB —
20	1	VITC SYNC BIT		
21	0	VITC SYNC BIT		
22	(1)	TV SECONDS UNITS	16	
23	(2)	TV SECONDS UNITS	17	
24	(4)	TV SECONDS UNITS	18	
25	(8)	TV SECONDS UNITS	19	
26	(LSB)	THIRD BINARY GROUP	20	— LSB —
27		THIRD BINARY GROUP	21	
28		THIRD BINARY GROUP	22	
29	(MSB)	THIRD BINARY GROUP	23	
30	1	VITC SYNC BIT		
31	0	VITC SYNC BIT		
32	(1)	TV SECONDS TENS	24	BINARY BYTE 2
33	(2)	TV SECONDS TENS	25	
34	(4)	TV SECONDS TENS	26	
35	FLAG	FLAG	27	
36	(LSB)	FOURTH BINARY GROUP	28	
37		FOURTH BINARY GROUP	29	
38		FOURTH BINARY GROUP	30	
39	(MSB)	FOURTH BINARY GROUP	31	— MSB —
40	1	VITC SYNC BIT		
41	0	VITC SYNC BIT		
42	(1)	TV MINUTES UNITS	32	
43	(2)	TV MINUTES UNITS	33	
44	(4)	TV MINUTES UNITS	34	
45	(8)	TV MINUTES UNITS	35	
46	(LSB)	FIFTH BINARY GROUP	36	— LSB —
47		FIFTH BINARY GROUP	37	
48		FIFTH BINARY GROUP	38	
49	(MSB)	FIFTH BINARY GROUP	39	
50	1	VITC SYNC BIT		
51	0	VITC SYNC BIT		
52	(1)	TV MINUTES TENS	40	BINARY BYTE 3
53	(2)	TV MINUTES TENS	41	
54	(4)	TV MINUTES TENS	42	
55	FLAG	FLAG	43	
56	(LSB)	SIXTH BINARY GROUP	44	
57		SIXTH BINARY GROUP	45	
58		SIXTH BINARY GROUP	46	
59	(MSB)	SIXTH BINARY GROUP	47	— MSB —
60	1	VITC SYNC BIT		
61	0	VITC SYNC BIT		
62	(1)	TV HOURS UNITS	48	
63	(2)	TV HOURS UNITS	49	
64	(4)	TV HOURS UNITS	50	
65	(8)	TV HOURS UNITS	51	
66	(LSB)	SEVENTH BINARY GROUP	52	— LSB —
67		SEVENTH BINARY GROUP	53	
68		SEVENTH BINARY GROUP	54	
69	(MSB)	SEVENTH BINARY GROUP	55	
70	1	VITC SYNC BIT		
71	0	VITC SYNC BIT		
72	(1)	TV HOURS TENS	56	BINARY BYTE 4
73	(2)	TV HOURS TENS	57	
74	FLAG	FLAG	58	
75	FLAG	FLAG	59	
76	(LSB)	EIGHTH BINARY GROUP	60	
77		EIGHTH BINARY GROUP	61	
78		EIGHTH BINARY GROUP	62	
79	(MSB)	EIGHTH BINARY GROUP	63	— MSB —
80	1	VITC SYNC BIT		
81	0	VITC SYNC BIT		
82–99		VITC CRC CODE		
		LTC SYNC WORD	64–79	

Figure 1 – Frame format (vertical interval and linear track)

3.2 Directory index format (see figure 2)

3.2.1 Time or media address data

All address data contained on pages 0, 1, and 2 relate to program timing and should be processed accordingly. Two types of address dialects can be stored in these pages, auxiliary time address and media address.

Auxiliary time address data can be stored at directory index lines 0 through 9 of pages 0 and 1, and lines 0 through 3 of page 2, which correspond to auxiliary time address hours 00 through 23. This dialect, as specified in RP 169, provides a second time address with the same order and format as the primary time address data.

Media address data other than time address can be stored in directory index lines 10 through 15 of pages 0 and 1 and lines 4 through 15 of page 2.

3.2.2 Control data

One page (page 15) containing 16 lines is assigned to control data which consists of instructions requiring real-time command and execution. A frame carrying control data shall include an 8-bit checksum and have highest priority for encoding (see 3.4.5).

3.2.3 Applications data

Twelve pages, for a total of 192 lines, are reserved for user application subsets. A particular application dialect may specify a group of page-line subsets.

3.3 Use of binary groups

3.3.1 Binary group flag bits

When the data structure conforms to this format, the binary group flag bits shall be set in accordance with SMPTE 12M for page-line applications.

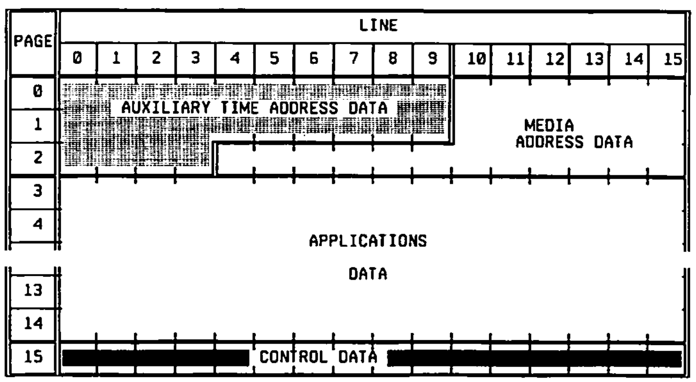

Figure 2 – Page-line directory

Table 1 – Binary group flag values for page-line encoding

Binary group flag	Bit value	24- and 30-fps systems LTC bit	24- and 30-fps systems VITC bit	25-fps systems LTC bit	25-fps systems VITC bit
BGF2	1	59	75	43	55
BGF1	0	58	74	58	74
BGF0	1	43	55	27	35

3.3.2 Subset applications

Each frame of time and control code may contain only one type of data, identified by the value of the directory index. The choice of data types and their repetition frequency is left to the discretion of the user.

3.3.3 Error detection

Error detection may be provided for as an 8-bit checksum. This consists of the twos complement of the least significant byte (modulo 256) of the sum of the specified binary bytes.

3.4 Message formats

3.4.1 Control codes (see figure 3)

This format consists of 2-byte instructions conveying real-time commands in binary bytes 2 and 3. Binary byte 1 carries an 8-bit checksum of binary bytes 2, 3, and 4.

3.4.2 Single-frame messages (see figure 3)

This format consists of a 3-byte message transmitted within binary bytes 1, 2, and 3. Certain applications dialects may specify binary byte 1 as an 8-bit checksum of binary bytes 2, 3, and 4.

3.4.3 Message strings (see figure 4)

A string of formatted data can be encoded as a message string comprising three types of frames: prefix frame(s), message frame(s), and suffix frame(s), each of which is assigned a unique directory index. The maximum message length shall be constrained to 256 frames.

The prefix and suffix frames shall be structured as follows: Binary byte 1 carries an 8-bit checksum of binary bytes 2, 3, and 4. Binary bytes 2 and 3 provide message specifier information, such as message ID, destination address, and message length. Multiple prefix and suffix frames may be specified for a message string, as required by the application dialect. Each prefix and suffix frame shall be identified as such by a unique directory index allocation.

The message frame shall be structured as follows: Each message frame carries message data in binary bytes 1, 2, and 3, while binary byte 4 carries the directory index, indicating a message frame.

When transmitting a message conforming to ISO 646 and ISO 2022, unused bytes of the message frame preceding the first suffix frame shall be null filled. Use of the parity bit provided with this data type allows error detection on the message data.

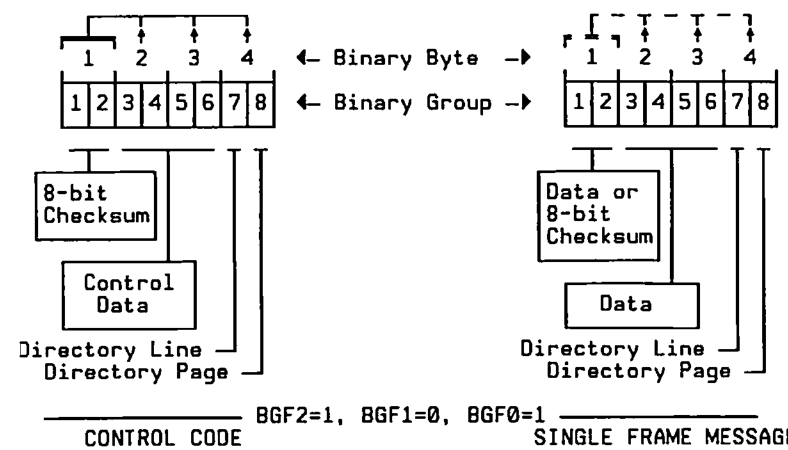

Figure 3 – Control code and single-frame message formats

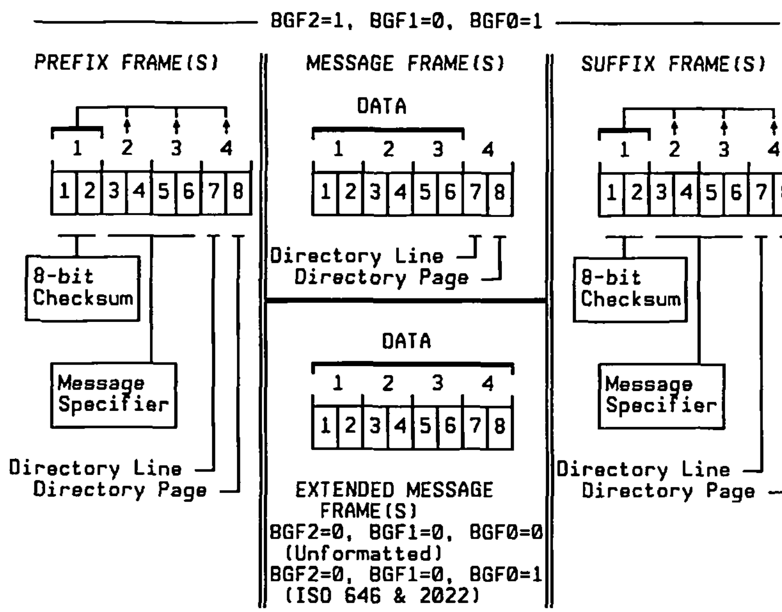

Figure 4 – Message and extended message formats

3.4.4 Extended message strings (see figure 4)

A string of unformatted data conforming to ISO 646 and ISO 2022 can be combined with the message prefix and suffix frames, as defined in 3.4.3, to provide an extended message string format. The data type carried in the extended message frames is signalled by the binary group flag bits, in accordance with SMPTE 12M.

3.4.5 Message encoding priority

In the absence of other applications guidelines, and in the event that multiple sources of directory index data request encoding to the binary groups of the same time address location, the higher page numbered directory index application shall take priority. Similarly, priority shall be given to higher line numbered applications for time-coincident directory index data of the same page number. Applications dialects should specify source priority coding for situations where time-coincident data of the same page and line number may occur.

PROPOSED SMPTE RECOMMENDED PRACTICE

Television, Audio and Film Time and Control Code – Auxiliary Time Address Data in Binary Groups – Dialect Specification of Directory Index Locations

1 Scope

This practice specifies a method of coding an auxiliary time address into the binary groups of SMPTE time and control codes, thus providing a second time address storage and storage location.

The dialect used provides auxiliary time address hours information conforming to the directory index 00 through 23 (decimal), as specified in SMPTE 262M. It also conforms to the coding structure of the primary time code located in the time address portion of the time code word.

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 12M, Television, Audio and Film — Time and Control Code

SMPTE 262M, Television, Audio and Film — Storage and Transmission of Data — Binary Groups of Time and Control Codes

3 Data structure

3.1 Bit assignment

Auxiliary time address data stored in binary groups shall be assigned as shown in table 1. This dialect conforms to the directory index in that the directory page index corresponds to the tens of hours of the auxiliary time address. Similarly, the directory line index corresponds to the units of hours of the auxiliary time address.

Table 1 – Auxiliary time address bit assignment

LTC bits	VITC bits	Binary group	Assignation
4–7	6–9	1	Frames units
12–13	16–17	2	Frames tens
14	18	2	Drop frame flag
15	19	2	*Color frame flag*
20–23	26–29	3	Seconds units
28–30	36–38	4	Seconds tens
31	39	4	Unassigned
36–39	46–49	5	Minutes units
44–46	56–58	6	Minutes tens
47	59	6	Unassigned
52–55	66–69	7	Hours units (line index)
60–61	76–77	8	Hours tens (page index)
62–63	78–79	8	Zero (page index)

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3.2 Binary group drop frame flag

If certain numbers are being dropped to resolve the difference between real time and color time, a "1" shall be recorded. This flag refers only to the auxiliary time address data.

3.3 Binary group color frame flag

If color frame ID has been intentionally applied to time address data stored in the binary groups, a "1" shall be recorded. In such cases, the time address numbers shall identify the color frames in the manner as specified by SMPTE 12M.

3.4 Unassigned bits

Unassigned bits shall be set to "0" until assigned by SMPTE.

4 Binary group flag bits

When the data structure conforms to this format, the binary group flag bits shall be set in accordance with SMPTE 12M as shown in table 2. For vertical interval applications, this flag designation shall be repeated in both fields.

Table 2 – Binary group flag values for page-line encoding

		24- and 30-fps systems		25-fps systems	
Binary group flag	Bit value	LTC bit	VITC bit	LTC bit	VITC bit
BGF2	1	59	75	43	55
BGF1	0	58	74	58	74
BGF0	1	43	55	27	35

PROPOSED SMPTE RECOMMENDED PRACTICE

RP 173

Loudspeaker Placements for Audio Monitoring in High-Definition Electronic Production

1 Scope

This practice describes a hierarchy of monitoring loudspeaker arrangements for single- and multi-channel sound systems used in high-definition electronic production.

2 Definition

The reference listening position is defined as that point located on a line bisecting the width of the display screen and at a distance of three picture heights (3H) from the screen. The reference listening position is labelled "3H" in figure 1.

3 Loudspeaker arrangements

3.1 The release format monitoring loudspeaker arrangements include the following categories:

– 1 front loudspeaker: (1/0) monophonic sound;

– 2 front loudspeakers: (2/0) conventional two-channel stereo;

– 3 front loudspeakers: (3/0) three-channel stereo, which includes a hard center channel;

– 3 front loudspeakers, 2 rear loudspeakers: 3/2 surround sound.

3.2 Figure 1 shows loudspeaker arrangements with respect to the display screen for all the above formats. Any of these formats may optionally include a subwoofer for base reinforcement.

4 Center loudspeaker

4.1 When a perforated projection screen is used, the center (C) loudspeaker should be placed behind the screen, centered from left to right. When a nonperforated screen or a CRT or LCD display is used, the center loudspeaker should be placed above or below the screen.

4.2 A variation on the above is illustrated in figure 2. Figure 2 shows two center-channel loudspeakers (C), one loudspeaker being located at the left side and another at the right side of the display screen, with left-channel and right-channel loudspeakers (L and R, respectively) being spaced further out from the screen on the left and right sides, respectively. The two "C" loudspeakers are fed identical center-channel audio signals, and their amplitudes are balanced to produce a phantom center image. Caution: The listening position is critical with this arrangement. It has been demonstrated that a phantom center image delivers less clarity and a frequency response different from that delivered by a hard center loudspeaker. This arrangement is not recommended, but is included here as recognition that it is frequently used when no other alternative exists.

4.3 The following loudspeaker arrangements refer to figure 1. The center-channel speaker is located behind, above, or below the display screen as specified above. All speakers in the front listening plane should be at approximately similar heights. In figure 1, *screen* refers to the display screen. Its aspect ratio is 16 × 9.

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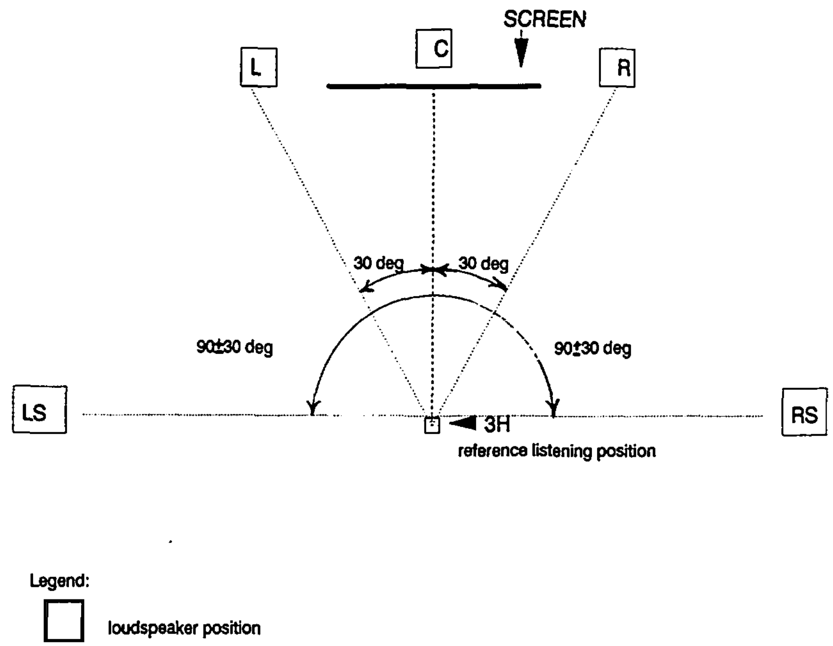

Figure 1 – Monitor loudspeaker arrangements for HDEP

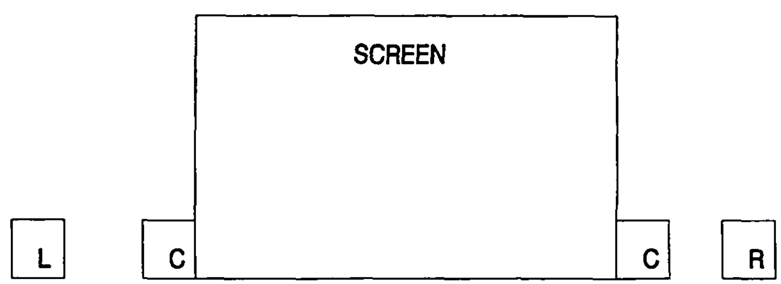

Figure 2 – Center-channel alternate arrangement

5 Monophonic sound

The monophonic loudspeaker is represented by the loudspeaker designated "C" in figure 1. It is located behind, above, or below the screen, centered from left to right, as nearly flush to the front of the display screen as practicable.

6 Two-channel stereo

The left-channel and right-channel loudspeakers are located in the positions marked by the boxes "L" and "R" in figure 1. They are located on the left-hand and right-hand sides of the screen, respectively. The "L" loudspeaker is located on a line 30° counterclockwise from a line bisecting the width of the display screen and perpendicular to it, passing through the point designated as "3H." The "R" loudspeaker is located on a line 30° clockwise from the line bisecting the display screen and passing through "3H." The L and R loudspeakers are positioned as nearly flush with the front of the display screen as practicable.

7 Three-channel stereo

The left- and right-channel loudspeakers are located as specified above for two-channel stereo; while the center channel loudspeaker is located as specified above for monophonic sound.

8 3/2 surround sound

The front loudspeakers, L, C, and R, are positioned as described above for two-channel stereo. The left- and right-surround loudspeakers are located within the zones designated "LS" and "RS," respectively, which are 60°–120° counterclockwise and 60°–120° clockwise, respectively, from the line bisecting the screen's width and passing through 3H. Precise surround loudspeaker placement is noncritical, except that the loudspeakers should be no closer to the listener than the front loudspeakers. This surround loudspeaker positioning applies both when a single surround channel signal is fed to both loudspeakers and when stereo surround channels are used.

9 Subwoofer placement

If a subwoofer is used, its placement is noncritical, except that it should be located in the front listening plane.