

**EBU Time-And-Control Code
FOR TELEVISION TAPE-RECORDINGS
(625-LINE TELEVISION SYSTEMS)**

Tech 3097 - E

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INTRODUCTION

The time-and-control code enables complex video tape operations to be carried out, replacing earlier mechanical and physical methods of editing control and tape-length indication. The initial work to define the characteristic of the time-and-control code was carried out by the SMPTE and the basic configuration of the SMPTE code was adapted to 625-line PAL and SECAM television signals by the EBU. The reasons which governed the choice of the fundamental characteristics when the code was devised are described in detail in an article published in the EBU Review [1] which was written by R. van der Leeden (NOS), Chairman of the Ad-hoc Group set up in 1970 by EBU Sub-group G2 to develop the code.

The first edition of the present document, published in October 1972, indicated that some parameters of the time-and-control code were still being studied. The second edition, published in June 1980, was a complete specification and its scope had been extended to include recent developments; in particular, it took account of the need to relate the code addresses to the PAL 8-field sequence. The problems which can be overcome by this means, and reasons for a need to define the subcarrier-to-line-sync phase were explained in another article published in the EBU Review [2]. The author of this article, J. van Dael (NOS), was entrusted with the chairmanship of an EBU Specialist Group investigating a number of problems relating to the use of the code.

The code considered so far was recorded on a longitudinal track with audio characteristics; it is referred to in the present document as the longitudinal time-code (LTC). Since then, new television tape-recording formats with broadcast quality have appeared on the market which can be used at very low tape speeds. It was therefore decided to supplement the EBU longitudinal time-and-control code with a version which can be used when the tape speed is too low for a reliable read-out of the signals from a longitudinal track by a conventional head. The study conducted notably by R.E. Fletcher (BBC) as part of the activities of the Specialist Group referred to above, led to the definition of a code which is inserted in the field-blanking period of the video signal; it is referred to in the present document as the vertical-interval time-code (VITC).

This new edition brings together in a single document the specifications of both types of code. However, it is stated that if the time code is employed on tapes intended for international exchanges, it should be recorded on a longitudinal track.

The EBU code was designed with television tape-machines in mind, but it is now applied in other magnetic recording fields as well. The experience acquired during its development will be useful in other studies aimed at the automation of various operational functions in sound and television broadcasting.

Part A

LONGITUDINAL TIME-AND-CONTROL CODE (LTC)

1. Scope

This part specifies the format and modulation method for a digital code recorded on a longitudinal track which is to be used for timing and control purposes on television tape machines and on the associated audio tape-machines, if any, for recordings made in accordance with the 625-line/50-field television systems defined in CCIR Report 624-2 [3]. The document also specifies the relationship of the longitudinal code signal to other associated signals before and after recording on the tape.

2. Modulation method and bit-rate

2.1. Type of code

The modulation method shall be such that a transition occurs at the beginning of every clock period. In the case of a "zero" there is no second transition within the clock period. In the case of a "one" there is a second transition in the middle of the clock period. This system, commonly known as bi-phase mark, is illustrated in Fig. 1.

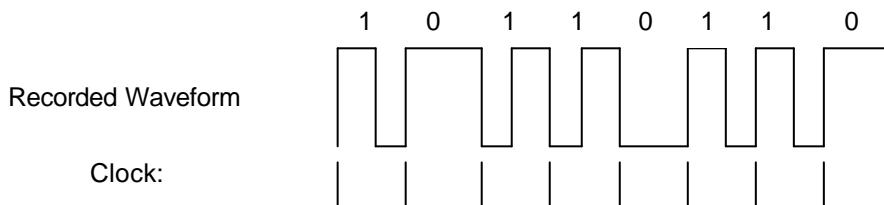


Fig. 1.- Modulation system "bi- phase mark"

2.2. Bit-rate

The bit-rate at nominal speed shall be 80 bits per picture, i.e. 2000 bit/s.

3. Code format

3.1. Rate of change of the code word

Each television picture, comprising an odd-numbered field followed by an even-numbered fields*, shall be identified by a complete code word.

3.2. Composition of the code word

Each code word shall consist of 80 bits, numbered from 0 to 79 inclusive.

3.3. Bit assignment

The bits shall be assigned as shown in Fig. 2 and as described below:

0 - 3	Units of pictures		
4 - 7	First binary group		
8 - 9	Tens of pictures		
10	Unassigned bit (see § 4.6)		
11	Colour lock flag bit (see § 4.4)		
12 - 15	Second binary group		
16 - 19	Units of seconds		
20 - 23	Third binary group		
24 - 26	Tens of seconds		
27	Binary group flag bit (see § 4.3)		
28 - 31	Fourth binary group		
32 - 35	Units of minutes'		
36 - 39	Fifth binary group		
40 - 42	Tens of minutes		
43	Binary group flag bit (see: § 4.3)		
44 - 47	Sixth binary group		
48 - 51	Units of hours		
52 - 55	Seventh binary group		
56 - 57	Tens of hours		
58	Unassigned bit (see § 4.6)		
59	Bi-phase mark phase correction bit (see § 4.5)		
60 - 63	Eighth binary group		
64 - 79	Synchronising word:*	64 - 65	: fixed zero
		66 - 77	: fixed one
		78	: fixed zero
		79	: fixed one

* Odd-numbered fields : fields 1, 3, 5, 7 defined in CCIR Report 624-2 [3]

Even-numbered fields: fields 2, 4, 6, 8

80 bits Per picture

32 user binary spare bits
 16 sync bits
 26 time address bits
 4 flag bits
 2 unassigned address bits

All unassigned bits are Zeros.
 Assignment of these bits is reserved to the EBU

time address	BCD Weight	Bit No	Start of the code word	
PICTURE UNITS	1	0		
	2	1		
	4	2		
	8	3		
		4	BINARY GROUP No 1	
		5		
		6		
		7		
PICTURE TENS	1	8		
	2	9		
		10	UNASSIGNED BIT	
		11	COLOURLOCK FLAG BIT	
		12	BINARY GROUP No. 2	
		13		
		14		
SECONDS UNITS	1	16		
	2	17		
	4	18		
	8	19		
		20	BINARY GROUP No. 3	
		21		
		22		
		23		
SECONDS TENS	1	24		
	2	25		
	4	26		
		27	BINARY GROUP FLAG BIT	
		28	BINARY GROUP No 4	
		29		
		30		
	MINUTES UNITS	1	32	
2		33		
4		34		
8		35		
		36	BINARY GROUP No. 5	
		37		
		38		
		39		
MINUTES TENS	1	40		
	2	41		
	4	42		
		43	BINARY GROUP FLAG BIT	
		44	BINARY GROUP No- 6	
		45		
		46		
	HOURS UNITS	1	48	
2		49		
4		50		
8		51		
		52	BINARY GROUP No. 7	
		53		
		54		
		55		
HOURS TENS	1	56		
	2	57		
		58	UNASSIGNED BIT	
		59	BIPHASE MARK PHASE-CORRECTION BIT	
		60	BINARY GROUP No 8	
		61		
		62		
	SYNCHRONISING WORD		63	
			64	
			65	
		68		
		69		
		70		
		71		
		72		
		73		
		74		
		75		
		76		
	77			
	78			
	79	01		

Fig.2, Constitution of the code word (longitudinal code)

The relationship between LTC 77 1 and VITC is shown in Fig. 7, page 76 79 78

4. Structure of the coded data

4.1.* Structure of the time label

The basic structure of the time label is based upon the Binary Coded Decimal (BCD) system. In those cases where the count does not attain 9, only 2 or 3 bits are required, rather than 4 bits as is normal in the BW code.

4.2.* Assignment of the time bits

Pictures

Units	Bits	0 - 3	:	four-bit BW arranged 1, 2, 4, 8 count 0 to 9.
-------	------	-------	---	--

Tens	Bits	8 - 9	:	two-bit BCD arranged 1, 2 count 0 to 2.
------	------	-------	---	--

Seconds

Units	Bits	16 - 19	:	four-bit BCD arranged 1, 2, 4, 8 count 0 to 9.
-------	------	---------	---	---

Tens	Bits	24 - 26	:	three-bit BCD arranged 1, 2, 4 count 0 to 5.
------	------	---------	---	---

Minutes

Units	Bits	32 - 35	:	four-bit BCD arranged 1, 2, 4, 8 count 0 to 9.
-------	------	---------	---	---

Tens	Bits	40 - 42	:	three-bit BW arranged 1, 2, 4 count 0 to 5.
------	------	---------	---	--

Hours

Units	Bits	48 51	:	four-bit BW arranged 1, 2, 4, 8 count 0 to 9.
-------	------	-------	---	--

Tens	Bits	56 57*	:	two-bit BW arranged 1, 2 count 0 to 2.
------	------	--------	---	---

(The 24-hour clock system is used.)

4.3.* Use of binary groups

The binary groups are intended for the storage of supplementary data by the users. The thirty-two bits within the eight binary groups may be assigned in any way without restrictions if the character set used for the data insertion is not specified and the binary group flag bits Nos. 27 and 43 both are zero.

If an eight-bit character set conforming to ISO 646 [41 and ISO 2022 [51 is signalled by the binary group flag bits Nos. 27 and 43, the characters should be inserted in accordance with Fig. 3. The information carried by the user-bits is not subjected to any regulation.

* These points are identical in both the longitudinal and vertical-interval time-codes, with the exception of the bits numbers which are different in the two codes.

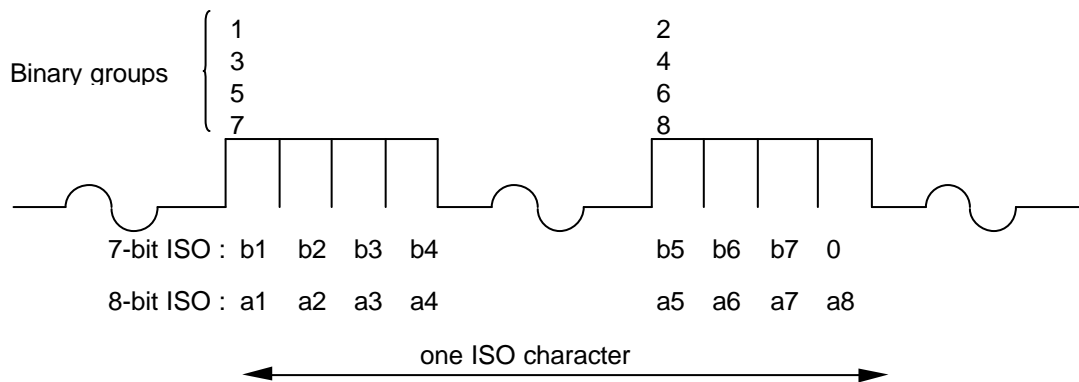


Fig. 3, Use of binary groups of the time-and-control code to describe the ISO characters coded with 7 or 8 bits

At present, the following truth-table applies:

	Bit 27	Bit 43
Character set not specified	0	0
Eight-bit character set conforming to ISO 646 and ISO 2022	1	0
Unassigned	0	1
Unassigned	1	1

The unassigned states of the truth-table cannot be used and their assignment is reserved to the EBU. If it becomes clear that no use is to be expected for them, it is possible that bit No. 43 can again become unassigned and thus available for other applications, while still retaining bit No. 27 to signal, the presence of eight-bit ISO characters.

It should be noted that, in each time code word, some user bits will be de-coded before bits Nos. 27 and 43 are encountered. The data in these earlier user-bit locations must not be lost.

Note. - The International Standard ISO 646 [41] defines two 7-bit Latin character code tables:

- a) the basic code table with control and alpha-numerical characters including punctuation marks, ten free positions for national use and some positions with more than one graphic symbol;
- b) the international reference version (referred to as IRV), where the national positions are filled and a choice is made where more than one graphic symbol is shown in the basic code table.

The International Standard ISO 2022 [5] gives code extension techniques from the 7-bit code of ISO 646 to 8-bit codes, based on the use of the "escape" command of the basic code table of ISO 646. With character-combinations following the "escape" command, access is given to a library of centrally registered character sets. This library consists of national character sets like the American ASCII although versions for special (e.g. broadcast) applications may also be included and registered. This central registration is done by the French national standardisation office, AFNOR.

4.4.* Colour-lock flag bit

The colour-lock flag bit No. 11 shall be set to '1' when the time-code is locked to the associated PAL colour signal in accordance with the eight-field sequence* and when the video signal has the "preferred subcarrier-to-line-sync .phase" (see § 5.1).

4.5. Bi-phase mark phase-correction bit

The purpose of the phase-correction bit is to compensate for phase reversals in the bi-phase mark modulation that could occur when code inserts are performed. Such compensation may be required when code inserts modify the content of any of bits 0 to 63, bit 59 excluded.

In order that the magnetisation transient between bit-cell 79 of one word and bit-cell 0 of the next shall always be in the same direction, bit 59 will be put in a state where every 80-bit word will contain an even number of logic zeros.

This requirement results in the following truth table for bit 59:

Number of logic zeros in bits 0 to 63 (59 exclusive):	Bit 59
Odd	1
Even	0

In drawing up this specification, the use of time-code write/read systems that have equal polarity relations between input/output voltage and the tape magnetisation is assumed.

This specification should not be understood as a requirement for time-code insert capability in television tape-machines in situations where tapes have to be interchanged, until further notice from the EBU.

4.6.* Unassigned bits

Bits 10 and 58 are reserved for future assignment and shall be zeros until specified by the EBU.

* These points are identical in both the longitudinal and vertical-interval time-codes, with the exception of the bits numbers which are different in the two codes.

5. Relationship between the code and the television signals prior to recording

5.1.* Definitions relevant to the present section

The numbering of PAL or SECAM television fields in the respective 4-field sequence is described in CCIR Report 624-2 [3].

The definition of field 1 in the eight-field sequence of the PAL signal is described in CCIR Report 624-2 [3] and in *Appendix 1*.

The stability conditions to be met by PAL video source equipment when sophisticated editing is required in post-production are detailed in *Appendix 2*.

To permit the sophisticated editing of PAL tapes, the video line-sync-to-burst phase on replay must be held within a certain tolerance. Recommendations on the tolerance required may be found in *Appendix 3*.

5.2. Association of code words and television pictures

In generating the code, each code word is associated with one particular television picture, with which it coincides in time. This relationship must be maintained throughout the whole post-production process.

The EBU Statement describing how this relationship can be maintained is reproduced in *Appendix 4*.

5.3. Timing of the code word

The code word shall start at the beginning of the clock period of the first bit (bit No. 0). The bits shall be evenly spaced, subject to the tolerances specified in Section 6, in such a way that the code word duration shall coincide with the period of one television picture.

The start of the code word shall occur within the period of the sequence of field-synchronising pulses [3], at the beginning of the picture with which the code word is associated (Fig. 4).

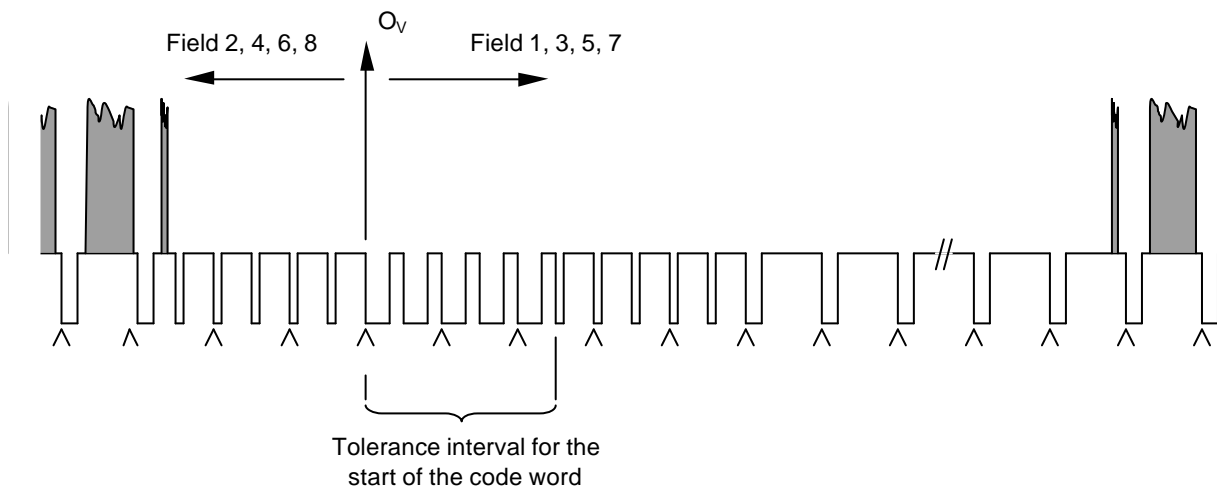


Fig. 4.- Start of tile code word In the field-bliaking Interval

* * This point is identical in both the longitudinal and vertical-interval time-codes.

5.4. * Relationship between the time address and the associated colour television signal

During electronic editing of colour signals recorded on television tape machines, it is important that:

a) in the case of editing in SECAM or simple editing in PAL, the correct four-field sequence be maintained in the edited master **.

b) in the case of sophisticated editing operations on PAL signals, the correct eight-field sequence also be maintained in the edited master, and that the "in-phase" or "out-of-phase" position of a slave tape** can be controlled. Condition b) does not apply to SECAM signals.

These sequences can be preserved with the aid of the time-and-control code, provided that there exists a fixed relationship between the time addresses of the code and the sequence of television fields.

Therefore, it has been agreed that, when necessary, the on-tape relationship between the time address-numbers of the EBU time-and-control code and the associated eight fields of the PAL video signal, shall be as follows:

If bit No. 0 is A,	bit No. 16 is B,	bit No. 1 is C,
bit No. 8 is D,	bit No. 17 is E,	bit No. 24 is F,

in order to fulfil condition a) above the code generator shall be locked to the associated video signal in such a way that:

a) $A \oplus B$ "1" for fields 1 and 2 (and fields 5 and 6) constituting odd pictures
 "0" for fields 3 and 4 (and fields 7 and 8) constituting even pictures,

where \oplus logical "exclusive or".

(For the numbering of fields, see CCIR Report 624-2 [3] and Appendix 1).

When it is also desired to fulfil condition b), in addition to condition a), the code generator shall, additionally, be locked to the associated PAL video signal in such a way that:

b) $(A + B) + C + D + E + F = "1"$ for fields 1 to 4
 "0" for fields 5 to 8.

When the time-code is displayed in decimal numbers, S and P designating the numbers of seconds and pictures respectively, condition a) is expressed as:

a) $S + P$ is odd for fields 1 and 2 and fields 5 and 6
 even for fields 3 and 4 and fields 7 and 8

and condition b) is expressed as:

b) the remainder on dividing $S + P$ by 4 is

0 for fields 7 and 8	2 for fields 3 and 4
1 for fields 1 and 2	3 for fields 5 and 6

* This point is identical in both the longitudinal and vertical-interval time-codes, with the exception of the bits numbers which are different in the two codes.

** *Edited master*: the video tape on the recording television tape-machine in an edit installation. *Slave tape*: the video tape on a play-back television tape-machine in an edit installation.

6. Waveform of the time-and-control code signal

Although time code signals serve for the transmission of data, it is more advantageous, in studio practice, if such signals can be handled as ordinary audio signals. The characteristic described hereafter takes into account this prerequisite*, as well as permitting unambiguous data recovery. This waveform is referred to as the "EBU Standardised characteristic of the time-and-control code signal", and the output of time code generators shall conform to it (Fig. 5).

Rise and fall time	:	50^{+15}_{-10} Vs measured between the 10% and 90% amplitude points of the waveform
Shape of transition	:	similar to the edge of a sine squared pulse
Maximum overshoot,		
	undershoot, tilt	: 5% of peak-to-peak amplitude
Clock period	:	500 Vs (nominal)
Maximum timing error of any clock period	:	± 2.5 vs
Maximum timing error of "one" transition	:	± 2.5 Vs

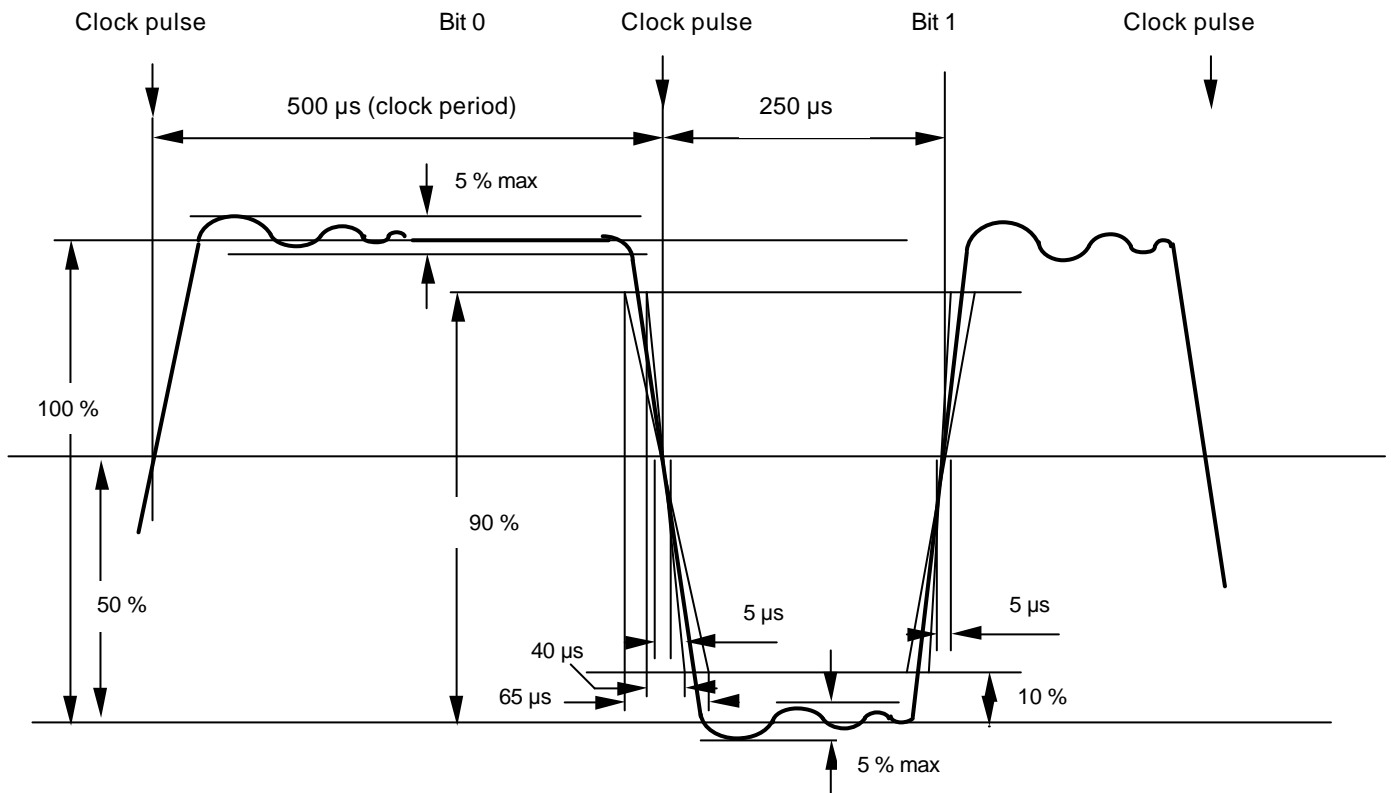


Fig. 5 - Waveform of the modulated code signal

The preferred specifications for the outputs of time code generators are described in the EBU Statement reproduced in Appendix 5.

* The signal described here has harmonics at least 40 dB down at 15 kHz.

7. Operational practices

7.1. Conditions in the use of the code

On tapes intended for international exchanges, the time code, if used, shall be recorded on a longitudinal track.

7.2. Transverse-track recordings

In the case of transverse-track recordings the code signal, if any, shall be recorded with bias on the cue track (see CCIR Recommendation 469-2 [71, 5 3]).

The recorded flux level shall be 700 ± 100 nWb/m, peak-to-peak.

7.3. Format B recordings

In the case of format B recordings, the code signal, if any, shall be recorded with bias on audio track 3 (see EBU Technical Information Sheet No. 7 [8], § 9.2).

The recorded flux level shall be 720 ± 70 nWb/m, peak-to-peak.

7.4. Format C recordings

In the case of format C recordings, the code signal, if any, shall be recorded with bias on audio track 3 (see EBU Technical Information Sheet No. 7 [8], § 9.2).

The recorded flux level is currently under consideration.

7.5. Multitrack audio tape machines

In the case of multitrack audio tape machines, the code signal, if any, shall be recorded with bias on the track having the highest number (see IEC Publication 94 [9], § 5).

The adjacent track should preferably remain unrecorded.

The recorded flux level has yet to be decided.

7.6. Use of companding systems

Companding systems should not be used when an audio track is used for recording the time-and-control code.

The EBU has issued a Statement on this subject, which is reproduced as Appendix 7.

7.7. Specifications for the pulse response of audio tracks

The specifications for the pulse response of audio tracks, which may be used to record either sound signals or the time-and-control code, have not been defined yet.

The EBU has issued a Statement on this subject, which is reproduced as Appendix 7.

PART B

VERTICAL-INTERVAL TIME-AND-CONTROL CODE (VITC)

1. Scope

This part specifies the format and modulation method to be employed when using the vertical-interval time-and-control code for timing and control purposes on television tape-machines for recordings made in accordance with the 625-lines/ 50-field television systems defined in CCIR Report 624-2 [3]. It also specifies the location of the code within the television signal and its relationship to the EBU longitudinal time-and-control code for television tape-recordings defined in Part A.

2. Modulation method and bit-rate

2.1. Type of code

The modulation method shall be such that each state of the signal corresponds to a binary state and a transition occurs only when there is a change in the data contained in adjacent bit cells. No transition shall occur when adjacent bit cells contain the same data. This system, commonly known as non return to zero level (NRZ), is illustrated in Fig. 6.

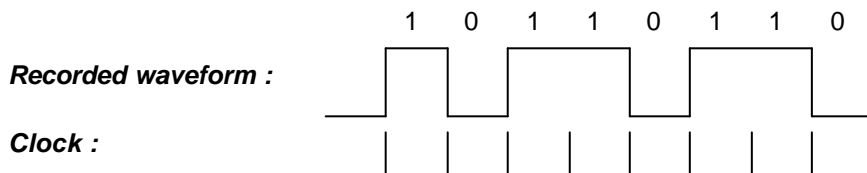


Fig. 6. - Modulation system "non return to zero".

Synchronisation bit pairs shall be inserted as required in § 3.3.

2.2. Bit-rate

The bit-rate F_c shall be as follows

$$F_c = F_h \times 116 \pm 200 \text{ bit/s}$$

where F_h is the line frequency.

Hence the nominal bit-rate is 1812.5×10^3 bit/s. The arrangement of the bit cells over subsequent lines shall result in an orthogonal structure.

VITC bit No.				L TC bit No.	
0	"0"		SYNCHRONISATION BIT		
1	"1"		SYNCHRONISATION BIT		
2		1		1	0
3		2		2	1
4		4		4	2
5		8	UNITS OF PICTURES	8	3
6					4
7					5
8			FIRST BINARY GROUP		6
9					7
10	"0"		SYNCHRONISATION BIT		
11	"1"		SYNCHRONISATION BIT		
12		10	TENS OF PICTURES	10	8
13		20		20	9
14			UNASSIGNED BIT		10
15			COLOUR-LOCK FLAG		11
16					12
17					13
18			SECOND BINARY GROUP		14
19					15
20	"0"		SYNCHRONISATION BIT		
21	"1"		SYNCHRONISATION BIT		
22		1		1	16
23		2		2	17
24		4	UNITS OF SECONDS	4	18
25		8		8	19
26					20
27					21
28			THIRD BINARY GROUP		22
29					23
30	"0"		SYNCHRONISATION BIT		
31	"1"		SYNCHRONISATION BIT		
32		10	TENS OF SECONDS	10	24
33		20		20	25
34		40		40	26
35			BINARY GROUP FLAG BIT		27
36					28
37					29
38			FOURTH BINARY GROUP		30
39					31
40	"0"		SYNCHRONISATION BIT		
41	"1"		SYNCHRONISATION BIT		
42		1		1	32
43		2		2	33
44		4	UNITS OF MINUTES	4	34
45		8		8	35
46					36
47					37
48			FIFTH BINARY GROUP		38
49					39
50	"0"		SYNCHRONISATION BIT		
51	"1"		SYNCHRONISATION BIT		
52		10	TENS OF MINUTES	10	40
53		20		20	41
54		40		40	42
55			BINARY GROUP FLAG BIT		43
56					44
57					45
58			SIXTH BINARY GROUP		46
59					47
60	"0"		SYNCHRONISATION BIT		
61	"1"		SYNCHRONISATION BIT		
62		1		1	48
63		2		2	49
64		4	UNITS OF HOURS	4	50
65		8		8	51
66					52
67					53
68			SEVENTH BINARY GROUP		54
69					55
70	"0"		SYNCHRONISATION BIT		
71	"1"		SYNCHRONISATION BIT		
72		10	TENS OF HOURS	10	56
73		20		20	57
74			UNASSIGNED BIT		58
75			FIELD MARK BIT		59
76			PHASE CORRECTION BIT		60
77					61
78			EIGHTH BINARY GROUP		62
79					63
80	"0"		SYNCHRONISATION BIT		
81	"1"		SYNCHRONISATION BIT		
82					64
83					65
84					66
85					67
86			CRC CODE		68
87					69
88					78
89					79

Fig. 7. Relationship between vertical-interval time-code and longitudinal time-code

3. Code format

3.1. Rate of change of the code word

Each television picture, comprising an odd-numbered field followed by an even-numbered field*, shall be identified by a complete code word. A code word shall also include a field identification as specified in § 4.5 (field-mark bit).

3.2. Composition of the code word

Each code word shall consist of 90 bits, numbered 0 to 89 inclusive.

3.3. Bit assignment

The bits shall be assigned as described below. Their relationship to the EBU longitudinal time-and-control code, as specified in Part A, is shown in Fig. 7.

0 1	Sync bits	0: fixed one;	1: fixed zero
2 5	Units of pictures		
6 9	First binary group		
10 - 11	Sync bits	10: fixed one;	11: fixed zero
12 - 13	Tens of pictures		
14	Unassigned bit (see 9 4.6)		
15	Colour lock flag bit (see 9 4.4)		
16 - 19	Second binary group		
20 - 21	Sync bits	20: fixed one;	21: fixed zero
22 - 25	Units of seconds		
26 29	Third binary group		
30 31	Sync bits	30: fixed one;	31: fixed zero
32 34	Tens of seconds		
35	Binary group flag bit (see 5 4.3)		
36 39	Fourth binary group		
40 - 41	Sync bits	40: fixed one;	41: fixed zero
42 - 45	Units of minutes		
46 - 49	Fifth binary group		
50 - 51	Sync bits	50: fixed one;	51: fixed zero
52 - 54	Tens of minutes		
55	Binary group flag bit (see 5 4.3)		
56 - 59	Sixth binary group		

* Odd-numbered fields : fields 1, 3, 5 7 defined in CCIR Report 624-2 [3]

Even-numbered fields: fields 2, 4, 6 8

60 61	Sync bits 60: fixed	one; 61:	fixed zero
62 65	Units of hours		
66 69	Seventh binary group		
70 71	Sync bits 70: fixed one; 71: fixed zero		
72 73	Tens of hours		
74	Unassigned bit (see 5 4.6)		
75	Field mark bit (see 5 4.5)		
76 79	Eighth binary group		
80 - 81	Sync bits	80: fixed one; 81:	fixed zero
82 - 89	Cyclic redundancy check group (seeS 3.4).		

3.4. Cyclic redundancy check

Eight bits, 82 to 89, are set aside at the end of the code word for error detection by means of cyclic redundancy checking. The generating polynomial of the cyclic redundancy check $G(x)$ will be applied to all bits from 0 to 81 inclusive and shall be as follows:

$$G(x) = x^8 + 1$$

Note. - An explanation of cyclic redundancy checking is given in *Appendix 6*.

4. Structure of the coded data

4.1.* Structure of the time label

The basic structure of the time label is based upon the binary coded decimal (BCD) system. In those cases where the count does not attain 9, only 2 or 3 bits are required, rather than 4 bits as is normal in the BCD code.

4.2.* Assignment of the time bits

Pictures

Units	Bits	2 - 5	:	four-bit BCD arranged 1, 2, 4, 8 count 0 to 9.
Tens	Bits	12 - 13	:	two-bit BCD arranged 1, 2 count 0 to 2.

Seconds

Units	Bits	22 - 25	:	four-bit BCD arranged 1, 2, 4, 8 count 0 to 9.
Tens	Bits	32 - 34	:	three-bit BCD arranged 1, 2, 4 count 0 to 5.

Minutes

Units	Bits	42 - 45	:	four-bit BCD arranged 1, 2, 4, 8 count 0 to 9.
Tens	Bits	52 - 54	:	three-bit BCD arranged 1, 2, 4 count 0 to 5.

Hours

units	Bits	62 - 65	:	four-bit BCD arranged 1, 2, 4, 8 count 0 to 9.
Tens	Bits	72 - 73	:	two-bit BCD arranged 1, 2 count 0 to 2.

(The 24-hour clock system is used.)

4.3.* Use of binary group

The binary groups are intended for the storage of supplementary data by the users. The thirty-two bits within the eight binary groups may be assigned in any way without restrictions if the character set used for the data insertion is not specified and the binary group flag bits Nos. 35 and 55 both are zero.

If an eight-bit character set conforming to ISO 646 [41 and ISO 2022 IS] is signalled by the binary group flag bits Nos. 35 and 55, the characters should be inserted in accordance with Fig. 8. The information carried by the userbits is not subjected to any regulation.

* These points are identical in both the longitudinal and vertical-interval time-codes, with the exception of the bits numbers which are different in the two codes.

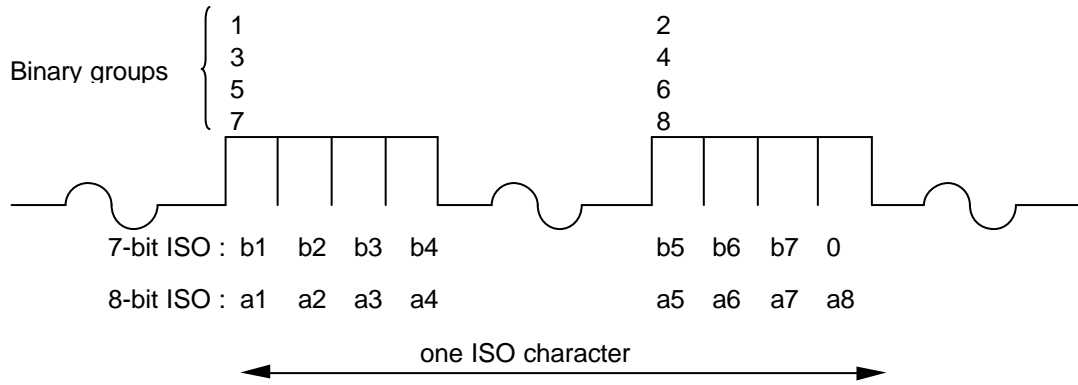


Fig. 8 - Use of binary groups of the time-and-control code to describe

At present, the following truth-table applies:

	Bit 35	Bit 55
Character set not specified	0	0
Eight-bit character set conforming to ISO 646 and ISO 2022	1	0
Unassigned	0	1
Unassigned	1	1

The unassigned states of the truth-table cannot be used and their assignment is reserved to the EBU. If it becomes clear that no use is to be expected for them, it is possible that bit No. 55 can again become unassigned and thus available for other applications, while still retaining bit No. 35 to signal the presence of eight-bit ISO characters.

It should be noted that, in each time code word, some user bits will be decoded before bits Nos. 35 and 55 are encountered. The data in these earlier user-bit locations must not be lost.

Note. - The International Standard ISO 646 [4] defines two 7-bit Latin character code tables:

- a) the basic code table with control and alpha-numerical characters including punctuation marks, ten free positions for national use and some positions with more than one graphic symbol;
- b) the international reference version (referred to as IRV), where the national positions are filled and a choice is made where more than one graphic symbol is shown in the basic code table.

The International Standard ISO 2022 [51] gives code extension techniques from the 7-bit code of ISO 646 to 8-bit codes, based on the use of the "escape" command of the basic code table of ISO 646. With character-combinations following the "Escape" command, access is given to a library of centrally registered character sets. This library consists of national character sets like the American ASCII although versions for special (e.g. broadcast) applications may also be included and registered. This central registration is done by the French national standardisation office AFNOR.

4.4.* Colour-lock flag bit

The colour-lock flag bit, No. 15, shall be set to "1" when the time-code is locked to the associated PAL colour signal in accordance with the eight-field sequence and when the video signal has the preferred subcarrier-to-line-sync phase (see 5 5.1).

4.5. Field-mark bit

The field-mark bit, No. 75, shall be set to "1" during fields 2, 4, 6 and 8, and to "0" during fields 1, 3, 5 and 7. The field-mark bit enables a VITC decoder to identify odd- and even-numbered fields without reference to the field synchronising signal.

4.6.* Unassigned bits

Bits 14 and 74 are reserved for future assignment and shall be zeros until specified by the EBU.

* These points are identical in both the longitudinal and vertical-interval time-codes, with the exception of the bits numbers which are different in the two codes.

5. Relationship between the vertical-interval time-code and the television signals prior to recording

5.1. Definitions relevant to the present paragraph

The numbering of PAL or SECAM television fields in the respective 4-field sequence is described in CCIR Report 624-2 [3].

The definition of field 1 in the eight-field sequence of the PAL signal is described in CCIR Report 624-2 [3] and in Appendix 1.

The stability conditions to be met by PAL video source equipment when sophisticated editing is required in post-production are detailed in Appendix 2.

To permit the sophisticated editing of PAL tapes, the video line-sync-to-burst phase on replay must be held within a certain tolerance. Recommendations on the tolerance required may be found in Appendix 3.

5.2. Association of code words and television fields

Each code word is associated with the particular television field at the beginning of which it is generated. It is an important operational requirement that decoding delays are compensated where possible, so as not to corrupt the production and post-production process. See Appendix 4.

5.3. Timing of the code word

5.3.1 Duration of the code word

The code word starts at the leading edge of the first synchronising bit (bit 0). The 90 bits shall be evenly spaced and, nominally, shall occupy 49.655 μs of the television line (see Fig. 9).

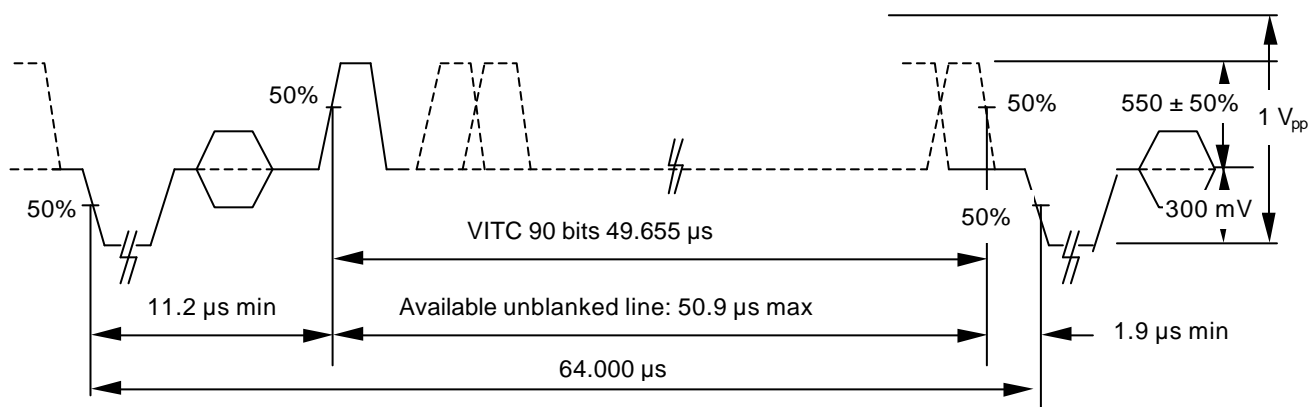


Fig. 9. - Position of the code word on the line

* This point is identical in both the longitudinal and vertical-interval time-codes.

5.3.2. *The position of the code word on the line*

It is important that the data signal does not corrupt the line-blanking interval of the video signal. For this reason, the half-amplitude point of the leading edge of the first data bit shall not occur earlier than 11.2 μ s after the half-amplitude point of the leading edge of the line synchronising pulse. Likewise, if the last data bit in the code word is a "one", the half-amplitude point of its trailing edge shall occur not later than 1.9 μ s before the half-amplitude point of the leading edge of the following line synchronising pulse. Hence 50.9 μ s of the available unblanked line may contain the code word (see Fig. 9).

5.3.3. *The position the code word in the field-blanking interval*

There is no need to precisely define the position of the VITC word in the field blanking interval. It is recommended, however, that each broadcaster selects the position of the VITC words in the vertical interval as required, taking notice of the following points:

- In order to protect the VITC reading process against drop-outs, the VITC word should be repeated on two non-adjacent available lines in the vertical interval of the recorded video signal, but not earlier than line 6(319) or ,later than line 22(335). It must be kept in mind that for certain recordings the use of some of these lines might interfere with other signals inserted in the field-blanking interval of a television signal, as indicated in CCIR Report 314-5 [61, and that in SECAM lines 7 to 15 (320 to 328) are occupied by field-identification signals.
- To avoid decoding errors which may arise in the presence of skew, an adequate margin should be allowed between the video head switching points and the recorded VITC words.

5.4. * **Relationship between the time address and the associated colour television signal**

During electronic editing of colour signals recorded on television tape-machines, it is important that:

- a) in the case of editing in SECAM or simple editing in PAL, the correct four-field sequence be maintained in the edited master**
- b) in the case of sophisticated editing operations on PAL signals, the correct eight-field sequence also be maintained in the edited master, and that the "in-phase" or "out-of-phase" position of a slave tape** can be controlled.

Condition b) does not apply to SECAM signals.

These sequences can be preserved with the aid of the time-and-control code, provided that there exists a fixed relationship between the time addresses of the code and the sequence of television fields.

* This point is identical in both the longitudinal and vertical-interval time-codes, with the exception of the bits numbers which are different in the two codes.

** Edited master: the video tape on the recording television tape-machine in an edit installation Slave tape: the video tape on a play-back television tape-machine in an edit installation.

Therefore, it has been agreed that, when necessary, the on-tape relationship between the time address-numbers of the EBU time-and-control code and the associated eight fields of the PAL video signal, shall be as follows:

If bit No. 2 is A, bit No. 22 is B, bit No. 3 is C,
bit No. 12 is D, bit No. 23 is E, bit No. 32 is F,

in order to fulfil condition a) above the code generator shall be locked to the associated video signal in such a way that:

"1" for fields 1 and 2 (and fields 5 and 6) constituting odd pictures

a) $A \oplus B$ "0" for fields 3 and 4 (and fields 7 and 8) constituting even pictures,

where \oplus logical "exclusive or".

(For the numbering of fields, see CCIR Report 624-2 [3] and Appendix 1).

When it is also desired to fulfil condition b), in addition to condition a), the code generator shall, additionally, be locked to the associated PAL video signal in such a way that:

b) $(A + B) \oplus C \oplus D \oplus E \oplus F$ "1" for fields 1 to 4

"0" for fields 5 to 8.

When the time-code is displayed in decimal numbers, S and P designating the numbers of seconds and pictures respectively, condition a) is expressed as:

a) $S + P$ is odd for fields 1 and 2 and fields 5 and 6

even for fields 3 and 4 and fields 7 and 8 and condition b) is expressed as:

b) the remainder on dividing $S + P$ by 4 is

0 for fields 7 and 8 2 for fields 3 and 4

1 for fields 1 and 2 3 for fields 5 and 6

6. Specification of the characteristics of the VITC signal prior to recording

6.1. Pre-filtering of the data signal prior to its addition to the video signal

To avoid distortion of higher-order harmonics of the VITC signal by the chrominance circuits of some types of equipment, the data signal should be low-pass filtered before it is added to the video signal. The transient response of the filter should be such that the data signal meets the overshoot and rise-time specified in § 6.2.

6.2. Waveform of the VITC signal

The data signal added to the video signal should conform to the following specifications:

Data amplitude:	logic "0"	:	blanking level
Data amplitude:	logic "1"	:	+ 550 ± 50 mV with respect to blanking level
Clock period		:	0.55 µs approx (see § 2.2)
Rise and fall times of data transitions		:	200 ns ± 50 ns
Maximum overshoot/undershoot		:	5% of peak-to-peak amplitude
Shape of data transitions		:	similar to the edge of a sine-squared pulse.

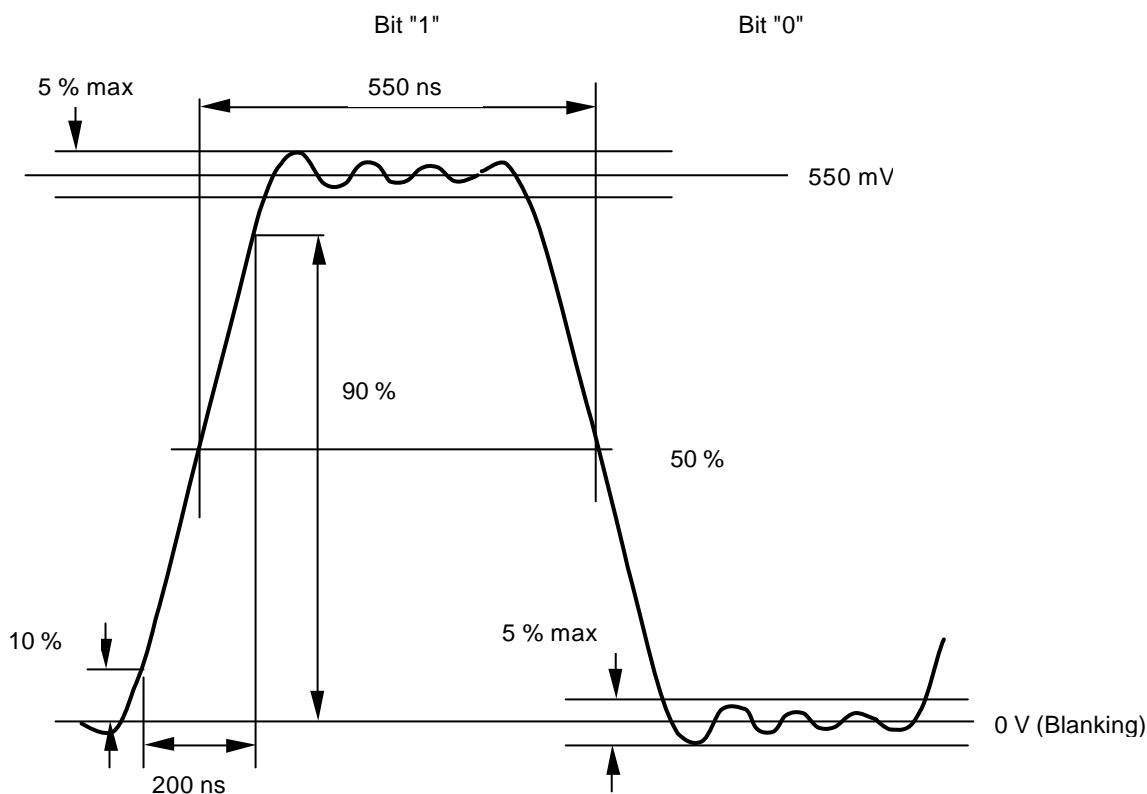


Fig. 10. Waveform of the modulated code signal.

7. *Operational practices*

The vertical-interval time-code should be used only in conjunction with the longitudinal time-code for international exchanges.

The vertical-interval time-code is meant as a facility additional to LTC for tape recording formats with broadcast quality that offer slow and stop-motion modes in which reliable read-out of LTC might be impossible. The decision to use the VITC and the choice of the position of the VITC in the vertical interval within the boundaries given in 5.5.3 are therefore determined only by the considerations of the individual broadcaster.

Bibliographical references

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- [8] Helical-scan television recording on 25.4-m tape.
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- [9] Magnetic tape recording and reproducing systems: dimensions and characteristics.
IEC Publication 94, 3rd edition, 1968.

APPENDIX 1

Definition of field one in the eight-field sequence of the PAL signal

(EBU Statement D14-1978 withdrawn)

A complete repetition period of the synchronising signals of the PAL video signal consists of a sequence of eight fields.

For the sake of clear communication, the EBU and the CCIR have numbered the successive fields of one repetition period of a PAL video signal by adopting the following definition of field one of the eight successive fields:

At the half-amplitude point of the leading edge of the line synchronising pulse of line 1 of field 1, the phase of the extrapolated E_U' component of the video burst may accept the following values:

$$- 90^\circ < \mathbf{f}_{E_U'} < 90^\circ$$

Note. - The E_U' component of the video burst is defined in CCIR Report No. 624-2 ([3], Fig. 4).

APPENDIX 2

Synchronising pulse generators for 625-line/50-fields PAL signals

(EBU Statement D25-1979 (withdrawn))

When sophisticated editing is required, it is essential that the video signals involved have an adequate stability; for this aim, it is necessary that:

- a) the signals recorded on the tape of the previous generation should have . the preferred Sc-H phase;
- b) the TBC in the playback machine should introduce a consistent signal delay under identical external conditions;
- c) the editing and the time-code equipment should be supplied with "field one" information.

If it is desired to achieve this, it is necessary that SPG equipment have the following performance:

- constant synchronising-pulse relationships, including that between the Sc-H phase and eight-field information of composite signals, and the various pulses, on a day-to-day basis and after power-supply switching;
- Sc-H phase stability: jitter < 1.5 ns ($\pm 2.5^\circ$)
 drift < ± 1.5 ns 2.5*)
 except when genlocked.

The requirement under c) may be met, as an example, by means of a modified PAL pulse signal or by means of an additional output of the SPG, providing a black-and-burst signal having the preferred Sc-H phase for on-tape video signals and a white pulse inserted in line 7 of field 1.

APPENDIX 3

See EBU Statement D 23-1999: Timing relationship between the subcarrier reference and the line synchronizing pulses for 625-line PAL television signals

APPENDIX 4

See EBU N12, Appendix 2 section 3

APPENDIX 5

See EBU N12, Appendix 2 section 4

APPENDIX 6

The use of cyclic redundancy check codes for error detection

Fundamentally the encoding of CRC is equivalent to dividing the information data, in this case the VITC signal, interpreted as a binary number by some other binary number (divisor), and appending the result to the data block. The new binary number so obtained is an exact multiple of the divisor so that if the division is repeated a zero remainder will result, unless errors exist in the total data block. It is possible that multiple errors will also result in a zero remainder and the choice of the divisor is important in reducing the likelihood of this occurrence, bearing in mind the way errors may be introduced.

The division is not an exact arithmetic process since, for example, carry terms are ignored (we make $1 + 1 = 0$), but it is sufficiently analogous to be interpreted as a polynomial division with powers of x representing positions in a binary sequence where the coefficients are 0 or 1. Thus the polynomial used in the VITC encoding scheme $x^8 + 1$ is equivalent to 10000001. If the information data is also represented as a polynomial, then performing a modified algebraic division will provide the required remainder.

For example, consider data sequence 1010,1101 divided by 10001, expressing both as polynomials, leads to

$$\begin{array}{r}
 \overline{x^3 } \\
 x^4 + 1 \\
 \underline{x^7 } \\
 x^5 \\
 \underline{x^5 } \\
 x^2
 \end{array}$$

subtraction is interpreted as addition without borrow

remainder

The remainder is then 0111. Appending this to the data sequence gives 101011010111 which as a polynomial is:

$$x^{11} + x^9 + x^7 + x^6 + x^4 + x^2 + x + 1.$$

Division of this polynomial by $x^4 + 1$, gives

$$\begin{array}{r} x^7 + x^5 + x^2 + x + 1 \\ x^4 + 1 \overline{) x^{11} + x^9 + x^7 + x^6 + x^4 + x^2 + x + 1} \\ \underline{x^{11} + x^7} \\ \phantom{x^{11} + } x^9 + x^6 \\ \underline{\phantom{x^{11} + } x^9 + + x^5} \\ \phantom{x^{11} + } + x^6 + x^5 + x^4 + x^2 + x + 1 \\ \phantom{x^{11} + } \underline{x^6 + x^2} \\ \phantom{x^{11} + } + x^5 + x^4 + x + 1 \\ \phantom{x^{11} + } \underline{x^5 + x} \\ \phantom{x^{11} + } + x^4 + 1 \\ \phantom{x^{11} + } \underline{x^4} \\ \phantom{x^{11} + } + 1 \end{array}$$

zero remainder

The Important feature of the CRC is the ease of Implementation, in which the process of division is provided by shift registers with feedback paths.

Thus for the polynomial $x^8 + 1$, an eight stage shift register with an exclusive-OR addition of output to input is all that is required. During the passage of information data, the switch is in position (1) and the data is fed to the channel while simultaneously the division is performed in the shift register. After all the input data is transmitted the shift register contains the remainder and after switching to position (2) this may be clocked out to the channel. When the process is repeated on decoding, the shift register should contain all zeros if no errors exist.

A further important property is that CRC coding has known properties when burst errors are encountered, e.g. in magnetic recording. Irrespective of the length of the information sequence a fixed probability of misdetection occurs which, in the case of the polynomial $x^8 + 1$, for example, is $1/256$ for burst errors of 10 or longer. This is sufficient in practice, particularly when supplemented by other knowledge of how well the VITC signal is recovered.

APPENDIX 7

Performance of audio tracks used for recording time-code signals on television tapes (EBU Statement D20-1979)

The EBU is aware of the fact that one of the available longitudinal tracks in each of the broadcast recording formats has been assigned to time-code recording, but may be used at other times for audio as well. The EBU feels that the specification defining the response of such tracks is not sufficiently complete.

Taking into account that, each time the code signal is reproduced from tape at a different speed from the recording one, unavoidable distortion of the code waveform is produced, the EBU considers that the pulse response of audio channels should be specified, at least at normal speed, in order to avoid an unacceptable accumulation of waveform distortions.

For the same reasons, the use of any companding system is not recommended when such an audio channel is used for code recording.