XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

RECOMMENDATIONS OF THE CCIR, 1990

(ALSO RESOLUTIONS AND OPINIONS)

VOLUMES X AND XI – PART 3

SOUND AND TELEVISION RECORDING

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

CCIR

1. The International Radio Consultative Committee (CCIR) is the permanent organ of the International Telecommunication Union responsible under the International Telecommunication Convention "... to study technical and operating questions relating specifically to radiocommunications without limit of frequency range, and to issue recommendations on them..." (International Telecommunication Convention, Nairobi 1982, First Part, Chapter I, Art. 11, No. 83)*

2. The objectives of the CCIR are in particular:

a) to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient utilization of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;

b) to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications;

c) to collect, exchange, analyze and disseminate technical information resulting from studies by the CCIR, and other information available, for the development, planning and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.

* *See also the Constitution of the ITU, Nice, 1989, Chapter 1, Art. 11, No. 84.*

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CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

92-61-04281-3

Geneva, 1990

PLAN OF VOLUMES I TO XV
XVIIth PLENARY ASSEMBLY OF THE CCIR

(Düsseldorf, 1990)

VOLUME I (Recommendations) *Annex to Vol. I* (Reports)	Spectrum utilization and monitoring
VOLUME II (Recommendations) *Annex to Vol. II* (Reports)	Space research and radioastronomy services
VOLUME III (Recommendations) *Annex to Vol. III* (Reports)	Fixed service at frequencies below about 30 MHz
VOLUME IV-1 (Recommendations) *Annex to Vol. IV-1* (Reports)	Fixed-satellite service
VOLUMES IV/IX-2 (Recommendations) *Annex to Vols. IV/IX-2* (Reports)	Frequency sharing and coordination between systems in the fixed-satellite service and radio-relay system
VOLUME V (Recommendations) *Annex to Vol. V* (Reports)	Propagation in non-ionized media
VOLUME VI (Recommendations) *Annex to Vol. VI* (Reports)	Propagation in ionized media
VOLUME VII (Recommendations) *Annex to Vol. VII* (Reports)	Standard frequencies and time signals
VOLUME VIII (Recommendations)	Mobile, radiodetermination, amateur and related satellite services
Annex 1 to Vol. VIII (Reports)	Land mobile service – Amateur service – Amateur satellite service
Annex 2 to Vol. VIII (Reports)	Maritime mobile service
Annex 3 to Vol. VIII (Reports)	Mobile satelllite services (aeronautical, land, maritime, mobile and radiodetermination) – Aeronautical mobile service
VOLUME IX-1 (Recommendations) *Annex to Vol. IX-1* (Reports)	Fixed service using radio-relay systems
VOLUME X-1 (Recommendations) *Annex to Vol. X-1* (Reports)	Broadcasting service (sound)
VOLUMES X/XI-2 (Recommendations) *Annex to Vols. X/XI-2* (Reports)	Broadcasting-satellite service (sound and television)
VOLUMES X/XI-3 (Recommendations) *Annex to Vols. X/XI-3* (Reports)	Sound and television recording
VOLUME XI-1 (Recommendations) *Annex to Vol. XI-1* (Reports)	Broadcasting service (television)
VOLUME XII (Recommendations) *Annex to Vol. XII* (Reports)	Television and sound transmission (CMTT)
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VOLUME XIV	Administrative texts of the CCIR
VOLUME XV-1 (Questions)	Study Groups 1, 12, 5, 6, 7
VOLUME XV-2 (Questions)	Study Group 8
VOLUME XV-3 (Questions)	Study Groups 10, 11, CMTT
VOLUME XV-4 (Questions)	Study Groups 4, 9

All references within the texts to CCIR Recommendations, Reports, Resolutions, Opinions, Decisions and Questions refer to the 1990 edition, unless otherwise noted; i.e., only the basic number is shown.

DISTRIBUTION OF TEXTS OF THE XVIIth PLENARY ASSEMBLY OF THE CCIR IN VOLUMES I TO XV

Volumes and Annexes I to XV, XVIIth Plenary Assembly, contain all the valid texts of the CCIR and succeed those of the XVIth Plenary Assembly, Dubrovnik, 1986.

1. Recommendations, Resolutions, Opinions are given in Volumes I-XIV and Reports, Decisions in the Annexes to Volumes I-XII.

1.1 *Numbering of texts*

When a Recommendation, Report, Resolution or Opinion is modified, it retains its number to which is added a dash and a figure indicating how many revisions have been made. Within the text of Recommendations, Reports, Resolutions, Opinions and Decisions, however, reference is made only to the basic number (for example Recommendation 253). Such a reference should be interpreted as a reference to the latest version of the text, unless otherwise indicated.

The tables which follow show only the original numbering of the current texts, without any indication of successive modifications that may have occurred. For further information about this numbering scheme, please refer to Volume XIV.

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162	III	380-393	IX-1	487-493	VIII-2
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265	X/XI-3	428	VIII-2	505	XII
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283	IX-1	439	VIII-2	521-524	IV-1
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331, 332	I	460	VII	558	IV/IX-2
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341	V	467, 468	X-1	567-572	XII
342-349	III	469	X/XI-3	573, 574	XIII
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1.2 *Recommendations (cont.)*

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591	VIII-3	638-641	X-1	687	VIII-1
592-596	IX-1	642	X-1	688-693	VIII-2
597-599	X-1	643, 644	X-1	694	VIII-3
600	X/XI-2	645	X-1 + XII	695-701	IX-1
601	XI-1	646, 647	X-1	702-704	X-1
602	X/XI-3	648, 649	X/XI-3	705	X-1 (1)
603-606	XII	650-652	X/XI-2	706-708	X-1
607, 608	XIII	653-656	XI-1	709-711	XI-1
609-611	II	657	X/XI-3	712	X/XI-2
612, 613	III	658-661	XII	713-716	X/XI-3
614	IV-1	662-666	XIII	717-721	XII
615	IV/IX-2	667-669	I	722	XII
616-620	V	670-673	IV-1	723, 724	XII
622-624	VIII-1	674, 675	IV/IX-2		

1.3 *Reports*

Number	Volume	Number	Volume	Number	Volume
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183	III	336*	V	481-485	XI-1
195	III	338	V	488	XII
197	III	340	VI (1)	491	XII
203	III	342	VI	493	XII
208	IV-1	345	III	496, 497	XII
209	IV/IX-2	347	III	499	VIII-1
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214	IV-1	354-357	III	509	VIII-3
215	X/XI-2	358	VIII-1	516	X-1
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224	II	371, 372	I	521, 522	I
226	II	375, 376	IX-1	525, 526	I
227*	V	378-380	IX-1	528	I
228, 229	V	382	IV/IX-2	533	I
238, 239	V	384	IV-1	535, 536	II
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253-255	VI	393	IV/IX-2	543	II
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279	I	439	VII	569	V
285	IX-1	443	IX-1	571	VI
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314	XII	468, 469	X/XI-3	622	X/XI-3

* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3 *Reports (cont.)*

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628, 629	XI-1	795	X-1	980-985	II
630	X/XI-3	798, 799	X-1	987, 988	II
631-634	X/XI-2	801, 802	XI-1	989-996	III
635-637	XII	803	X/XI-3	997-1004	IV-1
639	XII	804, 805	XI-1	1005, 1006	IV/IX-2
642, 643	XII	807-812	X/XI-2	1007-1010	V
646-648	XII	814	X/XI-2	1011, 1012	VI
651	I	815, 816	XII	1016, 1017	VII
654-656	I	818-823	XII	1018-1025	VIII-1
659	I	826-842	I	1026-1033	VIII-2
662-668	I	843-854	II	1035-1039	VIII-2
670, 671	I	857	III	1041-1044	VIII-2
672-674	II	859-865	III	1045	VIII-3
676-680	II	867-870	IV-1	1047-1051	VIII-3
682-685	II	872-875	IV-1	1052-1057	IX-1
687	II	876, 877	IV/IX-2	1058-1061	X-1
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699, 700	II	882-885	V	1073-1076	X/XI-2
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706	IV-1	896-898	VII	1090-1092	XII
709	IV/IX-2	899-904	VIII-1	1094-1096	XII
710	IV-1	908	VIII-2	1097-1118	I
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725-729	VI	917-923	VIII-3	1134-1141	IV-1
731, 732	VII	925-927	VIII-3	1142, 1143	IV/IX-2
735, 736	VII	929	VIII-3 ([1])	1144-1148	V
738	VII	930-932	IX-1	1149-1151	VI
739-742	VIII-1	934	IX-1	1152	VII
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760-764	VIII-3	950	X/XI-3	1187-1197	IX-1
766	VIII-3	951-955	X/XI-2	1198	X-1 ([1])
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774, 775	VIII-2	958, 959	XI-1	1205-1226	XI-1
778	VIII-1	961, 962	XI-1	1227, 1228	X/XI-2
780*	IX-1	963, 964	X/XI-3	1229-1233	X/XI-3
781-789	IX-1	965-970	XII	1234-1241	XII

* Not reprinted, see Dubrovnik, 1986.

([1]) Published separately.

1.3.1 *Note concerning Reports*

The individual footnote "Adopted unanimously" has been dropped from each Report. Reports in Annexes to Volumes have been adopted unanimously except in cases where reservations have been made which will appear as individual footnotes.

1.4 *Resolutions*

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15	I	64	X-1	89	XIII
20	VIII-1	71	I	95	XIV
23	XIII	72, 73	V	97-109	XIV
24	XIV	74	VI	110	I
33	XIV	76	X-1	111, 112	VI
39	XIV	78	XIII	113, 114	XIII
61	XIV	79-83	XIV		

1.5 *Opinions*

Number	Volume	Number	Volume	Number	Volume
2	I	45	VI	73	VIII-1
11	I	49	VIII-1	74	X-1 + X/XI-3
14	IX-1	50	IX-1	75	XI-1 + X/XI-3
15	X-1	51	X-1	77	XIV
16	X/XI-3	56	IV-1	79-81	XIV
22, 23	VI	59	X-1	82	VI
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32	I	64	I	84	XIV
35	I	65	XIV	85	VI
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40	XI-1	67-69	VI	89	IX-1
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1.6 *Decisions*

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6	VI
9	VI
11	VI
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27	I
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43	X/XI-2
51	X/XI-2
53, 54	I
56	I
57	VI
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59	X/XI-3

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70	IV-1
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72	X-1 + XI-1
76	IV-1 + X-1 + XI-1 + XII
77	XII
78, 79	X-1
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98	X-1 + XII
99	X-1
100	I
101	II
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103	VIII-3
105	XIV
106	XI-1

2. **Questions** (Vols. XV-1, XV-2, XV-3, XV-4)

2.1 *Numbering of texts*

Questions are numbered in a different series for each Study Group: where applicable a dash and a figure added after the number of the Question indicate successive modifications. The number of a Question is completed by an *Arabic figure indicating the relevant Study Group.* For example:

- Question 1/10 would indicate a Question of Study Group 10 with its text in the original state;
- Question 1-1/10 would indicate a Question of Study Group 10, whose text has been once modified from the original; Question 1-2/10 would be a Question of Study Group 10, whose text has had two successive modifications.

Note – The numbers of the Questions of Study Groups 7, 9 and 12 start from 101. In the case of Study Groups 7 and 9, this was caused by the need to merge the Questions of former Study Groups 2 and 7 and Study Groups 3 and 9, respectively. In the case of Study Group 12, the renumbering was due to the requirement to transfer Questions from other Study Groups.

2.2 *Assignment of Questions*

In the plan shown on page II, the relevant Volume XV in which Questions of each Study Group can be found is indicated. A summary table of all Questions, with their titles, former and new numbers is to be found in Volume XIV.

2.3 *References to Questions*

As detailed in Resolution 109, the Plenary Assembly approved the Questions and assigned them to the Study Groups for consideration. The Plenary Assembly also decided to discontinue Study Programmes. Resolution 109 therefore identifies those Study Programmes which were approved for conversion into new Questions or for amalgamation with existing Questions. It should be noted that references to Questions and Study Programmes contained in the texts of Recommendations and Reports of Volumes I to XIII are still those which were in force during the study period 1986-1990.

Where appropriate, the Questions give references to the former Study Programmes or Questions from which they have been derived. New numbers have been given to those Questions which have been derived from Study Programmes or transferred to a different Study Group.

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VOLUMES X AND XI, PART 3

SOUND AND TELEVISION RECORDING

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Note – Opinions which already appear in numerical order in the table of contents, are not reproduced in this index.

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INTRODUCTION

1. Classifications of texts

Study Groups 10 and 11, by virtue of their terms of reference, are both entrusted with the study of recording aspects relevant to the international exchange of sound programmes and television programmes. The two Study Groups conduct these studies together, by means of a Joint Interim Working Party, and of a Joint Working Group and its Sub-Groups, and adopt results in common meetings.

Texts drafted by the Joint Working Group and concerned with programme exchange on film or tape can be divided into five classes:

– texts relevant to the exchange of sound programmes on disc or tape;

– texts relevant to the exchange of television programmes on tape;

– texts relevant to the exchange of television programmes on film;

– text relevant to the recording of television programmes on film;

– texts of wider scope or general interest.

A further distinction for television texts can be made between texts relevant to conventional television and texts relevant to high definition television.

2. Work accomplished

The 1986-1990 study period has shown the usual volume of activity in the field of audio recording:

– The concept of the recording duplicating chain, described in Report 800 in its application to tape recording, was extended to other media used for programme exchange (such as digital optical discs).

– Report 950, on digital recording of audio signals, was updated with information on recent proposals for new recording formats made by TDF, Japan and the Federal Republic of Germany.

– Recommendation 564, which referred to an audio cassette recording format now abandoned by the industry, was suppressed.

Other texts on audio recording were updated to reflect the progress of technology.

In the field of conventional television recording of a large volume of activity took place.

A new Question and modifications to Opinion 75 were drafted that address the interconnection of equipment in production installations and for domestic use. Decision 59, which sets out the terms of reference of JIWP 10-11/4, was also updated in order to reflect the new scope of activity proposed for the JIWP. Revision and update of Recommendations 408, 65+, 602, 469 and 407 was carried out.

A new Recommendation 715 was drafted addressing tape recordings for ENG applications.

Modifications were made to Reports 294, 468 and 630 in order to update their content.

Two Reports 1229 and 1230 concerning high definition television were also updated.

Perhaps the highlight of the work has been the complete revision and update of Recommendation 657 "Digital television tape recording". A complete new text of this Recommendation has been generated, which is likely to be of major use to broadcasters and manufacturers in the world, since it will be the only available full text for the D1 digital recording format until the relevant IEC publication is completed and printed.

Study Programme 18L/11 on digital television recording has been completed to include the study of the need for a further digital recording format having a lower bit rate, suitable for "distribution quality" recordings.

Texts on the use of films for conventional television were reviewed and updated as necessary. The same was done for texts of wider scope and of general interest, notably:

– Opinions 74 and 75 were modified to broadly cover the interface connection between sound broadcasting, respectively television broadcasting receivers and associated consumer equipment.

However, by far the largest volume of work was done on texts concerning high definition television.

A new Recommendation 713 was adopted concerning the recording of HDTV images on film. Another Recommendation was adopted regarding the exchange of HDTV programmes on tape.

A further new Recommendation 716 was adopted, that specifies the photogram area scanned on 35 mm films by HDTV telecines.

Three new Reports were adopted that concern:

- the systems currently in operation to transfer HDTV programmes on cinema to graphic film;
- HDTV tape recorders for professional use;
- HDTV tape recorders for consumer applications.

3. Future work

A remarkable and diversified volume of work for the 1990-1994 study period is expected related to sound and television recording and to the use of film in television. Some of its highlights are listed below. Many items of work in this list will need close cooperation with the IEC and the ISO.

Work must progress on the specifications and operating practices for digital audio tape recording for international exchange, covering both recordings on tape and on disk, on the specifications and operating practices for analogue television tape recording for international exchange of programmes for broadcasting purposes, for programme evaluation and for ENG coverages.

High definition television tape recording will need to be addressed urgently, in order to prepare Recommendations on analogue and on digital HDTV recording for programme production and exchange, as soon as possible. The specification of tape formats for HDTV programme exchange is urgently needed by the increasing number of broadcasters and production houses that begin to produce software in HDTV.

SECTION 10/11F: EXCHANGE OF RECORDED SOUND PROGRAMMES

RECOMMENDATION 407-4

INTERNATIONAL EXCHANGE OF SOUND PROGRAMMES RECORDED IN ANALOGUE FORM

(Question 52/10)

(1951-1953-1956-1959-1963-1966-1970-1986-1990)

The CCIR,

CONSIDERING

(a) that the international exchange of monophonic and stereophonic sound programmes between broadcasting organizations, recorded in analogue form, may be made by means of magnetic recordings on tape;

(b) that it is desirable to limit the number of standards and formats in which such recordings may be exchanged;

(c) the content of Opinion 16,

UNANIMOUSLY RECOMMENDS

that, when such recorded sound programmes are exchanged in the form of analogue magnetic recordings on tape, the exchanges should be effected by means of 6.3 mm wide tapes recorded at a speed of 38.1 cm/s or 19.05 cm/s, conforming with IEC Publication 94-1 and with the additional provisions contained in Recommendation 408.

The "IEC-1" recording characteristics of IEC Publication 94-1 is preferred.

RECOMMENDATION 408-5 *

STANDARDS OF SOUND RECORDING ON MAGNETIC TAPE FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES **

(Question 52/10, Study Programme 52A/10)

(1951-1953-1956-1959-1963-1966-1970-1974-1982-1990)

The CCIR

UNANIMOUSLY RECOMMENDS

that monophonic and stereophonic recordings on magnetic tape for the international exchange of programmes should be made in accordance with the current edition of IEC Publication 94, and amendments thereof, with the following additional requirements:

1. Speed of tape

Only two speeds should be used: 38.1 cm/s (15 in./s) nominal value
19.05 cm/s (7½ in./s) nominal value.

2. Width of tape

$$6.3 \text{ mm} \begin{matrix} +0 \\ -0.06 \end{matrix} \left(0.248 \text{ in.} \begin{matrix} +0 \\ -0.003 \end{matrix}\right)$$

3. Strength of tape

The tape should be suitable for use on a machine exerting a maximum (transient) stress of 10 N.

4. Maximum diameter of a full spool

For Type I: 290 mm (11.5 in.)
(In France, the maximum diameter is 270 mm)

For Type II: 267.5 mm (10.5 in.).

5. Additional information on the tape container

MONO or STEREO in Latin characters.

Width of track. (For stereophony only.)

MAXIMUM RECORDED LEVEL (in nWb/m).

6. Additional requirements for stereophonic recordings

The minimum width of a recorded track should be 2 mm.

The outside limits of both tracks should coincide with the edges of the tape.

The distance between the tracks, situated symmetrically with respect to the central axis of the tape should be at least 0.75 mm. (The central axis is defined as a line situated at a distance of 3.125 mm from the reference edge.)

The edge of Track No. 1 is taken as the reference edge.

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* As a consequence of the latest amendments to this Recommendation, Report 800 is hereby deleted.

** This Recommendation should be brought to the attention of the International Electrotechnical Commission (IEC).

7. Beginning of a programme

The programme material should be preceded by a reference signal of 1000 Hz recorded at a level of 9 dB below maximum permitted programme peaks.

On monophonic tapes, this reference signal should have a duration of about 10 s, with a pause of about 5 s before the start of the programme modulation.

On stereophonic tapes, this reference signal should be recorded in the *A*-(left) channel for about 5 s, then in both channels for about 10 s, with a pause of about 5 s before the start of the programme modulation.

Note – The recording of the reference signal in both channels may be followed by the recording of a signal for testing frequency response and phase, in accordance with Report 622.

8. For reference purposes, a hypothetical recording-duplicating chain is specified. It is expected that exchanged recordings will be made by using a chain similar to the hypothetical reference recording-duplicating chain here described.

Note – The basic concept of the recording-duplicating chain can also be adapted to other media for the international exchange of recordings.

The hypothetical reference recording-duplicating chain consists of a master recorder and the duplicating replay-recorder equipment. The input of the recording-duplicating chain is the input of the master recorder. The output of the recording section of the duplicating equipment, i.e. the short-circuit flux of the magnetic tape for the exchange, is the output of the recording-duplicating chain.

The preferred performance characteristics of the hypothetical reference recording-duplicating chain are detailed in § 8.1 to 8.6.

The chain should be considered as a complete system. The chain's overall characteristics are measured by feeding electronic test signals to the input of the reference recorder and measuring the output tape recording produced by the duplicating equipment. This measurement is carried out by means of a test reproducing chain. The amplitude/frequency response of the chain should conform to that of the reproduction chain characteristic for professional equipment as specified in IEC Publication 94.

The performance characteristics of the test reproducing chain should be good enough not to introduce significant distortion into the measurement.

8.1 *Amplitude/frequency response of the two channels**

The tolerances on the amplitude/frequency response of the two channels *A* and *B* shall be as follows:

40 to 125 Hz	:	+2 to −3 dB
125 to 630 Hz	:	+1 to −1 dB
630 to 1250 Hz	:	+0.5 to −0.5 dB
1250 Hz to 10 kHz	:	+1 to −1 dB
10 to 15 kHz	:	+2 to −3 dB.

8.2 *Difference in recorded level between tracks**

In the frequency range of 125 to 10 000 Hz, a difference in level of 1.5 dB is admissible. Beyond these limits, a progressive increase up to 2 dB is admissible at 40 and 16 000 Hz.

8.3 *Phase difference between tracks**

In the frequency range from 250 to 4000 Hz, the maximum phase difference should be 15°. Outside these frequency limits, a progressive increase of this value is admissible; it can reach 30° at 40 Hz and 65° at 16 000 Hz.

8.4 *Crosstalk*

In the frequency range from 250 to 4000 Hz, crosstalk should not exceed −35 dB. Outside these frequency limits, a progressive increase up to −20 dB at 40 Hz and −25 dB at 16 000 Hz is admissible.

* For the special case of quadraphonic matrix recording, stricter specifications may be required, particularly in level and phase differences between tracks.

8.5 *Weighted signal-to-noise ratio*

The weighted signal-to-noise ratio of the *A*, *B* and *M* signals should be at least 51 dB.

Note – This value represents the difference in level between the noise measured with the meter and weighting network defined in Recommendation 468 and a signal, the amplitude of which corresponds to the maximum level of programme peaks indicated.

8.6 *Non-linearity distortions*

The total percentage harmonic distortion of the *A*, *B* and *M* signals should be less than or equal to the following values:

2% from 40 Hz to 125 Hz
1.6% from 125 Hz to 8 kHz.

RECOMMENDATION 648

DIGITAL RECORDING OF AUDIO SIGNALS

(Question 52/10, Study Programmes 52A/10 and 52B/10)

(1986)

The CCIR,

CONSIDERING

(a) that the requirements for digital audio tape recording are for both transparency to high audio quality and allowance for headroom for processing;

(b) that there would be considerable advantages for broadcasters in adopting a common world-wide digital audio tape recording format for use in broadcasting studios;

(c) the studies of the IEC and other international bodies in digital audio recording for professional use,

UNANIMOUSLY RECOMMENDS

1. that a single, world-wide digital audio tape recording format should be adopted for the international exchange of programmes for broadcasting purposes;

2. that for all applications regarding the international exchange of programmes recorded on tape, a sampling frequency of 48 kHz should be used;

3. that for all applications regarding the international exchange of programmes recorded on tape, the coding should have a resolution of at least 16 bits/sample.

RECOMMENDATION 649*

MEASURING METHODS FOR ANALOGUE AUDIO DISK AND TAPE RECORDINGS

(Question 52/10, Study Programme 52A/10)

(1986)

The CCIR,

CONSIDERING

(a) that the international exchange of monophonic and stereophonic recorded analogue sound programmes between broadcasting organizations may be made by means of magnetic recordings on tape or by means of recordings on disks, as stipulated in Recommendation 407;

(b) that the measuring methods for analogue disk players are specified in IEC Publication 98A, "Methods of measuring the characteristics of disk record playing units";

(c) that the same IEC Publication 98A specifies the test records to be used for the measurements in *(b)*;

(d) that measuring methods for the characteristics of magnetic tape analogue recordings and magnetic tape recording equipment are specified in IEC Publication 94-3, "Methods of measuring the characteristics of recording and reproducing equipment for sound on magnetic tape" and in its Amendment No. 1;

(e) that IEC Publication 94-2, "Calibration tapes" specifies the calibration tapes to be used for the measurements in *(d)*;

(f) that the method of measurement of flutter and wow is specified in IEC Publication 386, "Method of measurement of speed fluctuations in sound recording and reproducing equipment";

(g) the contents of Opinion 16,

UNANIMOUSLY RECOMMENDS

1. that the performance of disk players used to reproduce analogue disk records exchanged between broadcasting organizations should be measured as described in IEC Publication 98A, using the appropriate test records indicated in that Publication;

2. that the method of measurement for the characteristics of analogue audio tape recording and reproduction equipment used for the exchanges of sound programmes on tape should conform with IEC Publication 94-3, and its Amendment No. 1; and that the appropriate calibration tapes indicated in IEC Publication 94-2, "Calibration tapes" should be used for such measurements;

3. that the method of measurement of flutter and wow should conform to IEC Publication 386.

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* This Recommendation replaces Recommendations 409, and 563 which are hereby cancelled.

SECTION 10/11G: EXCHANGE OF RECORDED TELEVISION PROGRAMMES

RECOMMENDATION 469-5 *

ANALOGUE TELEVISION TAPE RECORDING

Standards for the international exchange of television programmes on magnetic tape

(Question 18/11, Study Programme 18K/11)

(1970-1974-1978-1982-1986-1990)

The CCIR

UNANIMOUSLY RECOMMENDS

that the magnetic recordings used for the international exchange of television programmes should meet the following standards:

1. Recording systems

1.1 Recording on magnetic tape of television programmes which are the object of international exchange should be carried out in accordance with one of the following classes of television systems:

- 625 lines; 50 fields per second
- 525 lines; 60 fields per second
  (see Report 624).

The recordings should conform with one of the formats specified in the following:

- Transverse-track recording: IEC Publication 347;
- 25.4 mm (one-inch) helical recording Type B: IEC Publication 602 (1980 + Amendment No. 1 (1987));
- 25.4 mm (one-inch) helical recording Type C: IEC Publication 558 (1982 + Amendment No. 1 (1987)).

Note – Hereafter in this Recommendation, the 25.4 mm (one-inch) helical recording formats will be referred to as Type B and Type C respectively.

Prior agreement is necessary between the concerned parties regarding these formats when they are used for programme exchange.

For Type C tighter mechanical tolerances for the audio tracks have been agreed between EBU and SMPTE (see Report 630).

1.2 In the case of transverse-track recording:

1.2.1 Television programmes should be recorded at the following nominal tape speeds:

- 625-line, 50-fields/s systems: 39.7 cm/s (15.625 in./s).
- 525-line, 60-fields/s systems: 38.1 cm/s (15 in./s).

1.2.2 Recordings should use the "high band" characteristics.

1.3 In the EBU, for 625-line 50 field/s Type C recordings, no essential component of an exchange programme tape shall be recorded in the area between audio track 3 and the control track, unless prior agreement has been obtained.

1.4 The most convenient way, from an operational point of view, to define a recording standard, is by means of reference tapes, which are physical embodiments of the standard. The recording channel parameters of video tape recorders should be optimized after alignment of the playback channel using a reference tape. Annex I to this Recommendation contains, as an example, the current specification of the European Broadcasting Union (EBU) for such reference tapes, for transverse-track recordings in 625-lines, 50-fields/s television systems.

* This Recommendation should be brought to the attention of the IEC.

2. Specification for programme sound recording

2.1 *General*

The sound reference level shall correspond to a recorded short circuit flux of 100 ± 5 nWb/m of track width, (r.m.s.), at 1000 Hz. (In some countries, a 400 Hz reference tone is used.) Normal operational practice will result in programme peaks corresponding to a maximum short circuit flux between 250 and 310 nWb/m, (r.m.s.), i.e. about 9 dB above reference level. These maximum recorded levels correspond to the subjective overload level for television tape materials currently used for the international exchange of programmes.

Note – When the programme peaks are measured by means of a programme meter, due account should be taken of the integration time of the instrument (see Report 292).

2.2 *Transverse-track recording*

The television programme sound shall be recorded on the audio track only. In accordance with IEC Publication 94-1, the recording characteristic corresponds to a time constant of 35 μs, for a speed of 38.1 cm/s (15 in./s). (Many countries use an additional time constant of 2000 μs.)

2.3 *Type B and Type C recording*

The following table presents in tabular form the preferred allocation of tracks to audio channels for the case when two synchronous sound channels accompany a picture recorded on Type C or Type B tapes.

Note 1 – More detailed information (including other tape formats) is contained in EBU Recommendation R38-1987.

Note 2 – Although many broadcasting organizations use audio companding for internal purposes (details of the techniques used by EBU members are given in EBU Recommendation R39-1986), the use of audio companding on recordings intended for international exchange is not recommended.

TABLE I

Operation mode	Channel	Format	
		B (1, 2)	C (1, 3)
Exchange of finished monophonic programmes	Monophonic programme mix	track 1	track 1
	International sound (if any)	track 2	track 2
Exchange of finished stereophonic television programmes	Stereo left	track 1	track 1
	Stereo right	track 2	track 2
Exchange of original news recordings	Commentary (if any)	track 1	track 1
	International sound	track 2	track 2

(1) Track 1 is the edge track in format B; it is the inner track in format C.

(2) Audio track 3 in format B is allocated to the time code and may not carry an audio channel except by mutual agreement.

(3) Audio track 3 in format C is allocated to the time code and may not carry an audio channel except by mutual agreement. Audio track 4 is optional and, in the case of an exchange of stereo recordings, it may be used by the sending organization, by mutual agreement, to record the monophonic mix; in the case of an exchange of monophonic programmes, it may be used by the receiving organization to record its own dubbed sound.

3. Specification for cue signal recording

In the case of transverse-track recording, the cue track should not contain information which needs to be reproduced for the exchange of broadcast programmes, except by mutual agreement, when a time and control code signal, or contributions to the final programme sound, such as sound effects, may be recorded on the cue track.

4. Editing

4.1 *Electronic editing*

Editing of tapes intended for the international exchange of programmes should be carried out electronically.

Electronic editing shall maintain an off-tape synchronizing pulse train with a phase relationship to the playback reference of the machine sufficiently close to avoid visible disturbance of the picture.

4.2 *Use of the PAL eight-field information on the control track of Type B and Type C recordings*

Playback modes

– *Four-field lock mode*

  The machine should lock to a PAL four-field sequence. A PAL four-field sequence can be derived from the eight-field edit pulse.

– *Eight-field frame mode*

  The machine should use an eight-field edit pulse to secure eight-field framing but only during the initial lock-up period.

  These two modes shall be switch-selectable.

5. Composition and duration of leaders and trailers

Leader and trailer sections of monophonic recordings should be located on the tape in conformity with the sequence shown in Table II. For stereophonic Type B and Type C recordings, see Table III.

6. Winding of the tape on the spools

6.1 The tape should be wound on the spools specified in IEC Publications 347 and 503, with the start of the recording on the outside. In the case of transverse-track and Type C recordings the magnetic surface should be towards the hub of the spool. In the case of Type B recordings the magnetic surface should be towards the outside of the spool.

Note – For transverse-track recordings, the exchange of tapes wound on spools having a diameter exceeding 356 mm, specified in ISO Standard IS 1860, is subject to mutual agreement.

6.2 The tape must be wound in such a way as to minimize the possibility of damage during transport; e.g. by using a constant winding tension. To prevent unwinding, the head end of the tape should be secured during storage and transport, by a suitable mechanical means, e.g. Scotch 8125 tape or equivalent; the use of a tape collar during transport is recommended.

6.3 Recordings of a single programme of up to 90 min duration should preferably be on one spool.

6.4 Separate programmes should always be on separate spools.

7. Packaging

Programme spools should be packed in containers affording protection against mechanical and environmental damage. The materials of which containers are constructed should not emit toxic fumes in the event of exposure to fire.

TABLE II

<table>
<tr><th colspan="2">Tape section</th><th>Duration
(s)</th><th>Picture</th><th>Sound
(on any channel carrying programme sound)</th><th>Control track signal</th></tr>
<tr><td rowspan="6">Leader</td><td>Protection leader</td><td>10
(minimum)</td><td colspan="3">Blank tape</td></tr>
<tr><td>Alignment leader</td><td>60
(minimum)</td><td>Alignment signal (1)</td><td>1000 Hz at reference level (2)</td><td>Uninterrupted</td></tr>
<tr><td>Optional</td><td>5
(maximum)</td><td colspan="3">Blank tape</td></tr>
<tr><td>Identification leader</td><td>15
(minimum)</td><td>Programme identification</td><td>Spoken identification preferred, or silence</td><td rowspan="5">Uninterrupted</td></tr>
<tr><td rowspan="2">Cue-up leader</td><td>8</td><td>Black or cue (4)</td><td>Silence or cue</td></tr>
<tr><td>2</td><td>Black (4)</td><td>Silence</td></tr>
<tr><td colspan="2">Programme (3)</td><td>Playing time of programme</td><td colspan="2">Programme</td></tr>
<tr><td colspan="2">Run-out trailer</td><td>30
(minimum)</td><td>Black (4)</td><td>Silence</td></tr>
</table>

(1) Examples of suitable alignment signals for transverse-track recordings in 625-lines, 50 field/s systems are given in Annex I.

(2) See § 2.1.

(3) Where the time and control code is recorded on the assigned longitudinal track (see § 3), the time indication of the programme start should be shown on the label accompanying the tape (see § 8.3).

(4) In the case of colour recordings the black signal should be colour black. It is desirable that the colour field sequence (8 fields in PAL, 4 fields in NTSC) should continue uninterrupted in relation to the beginning and end of the programme recording.

TABLE III – *Alignment leader for the exchange of recorded television programmes with stereophonic sound on format B and C tapes*

Tape section		Duration (s)	Picture	Sound track 1	Sound track 2	Control track signal
Leader	Protection leader	10 (minimum)	Blank tape			
	Alignment leader	60 (minimum)	Alignment signal (1)	1000 Hz at reference level (2), interrupted (3) (4)	1000 Hz at reference level (2) (4)	Uninterrupted
	Optional	5 (maximum)	Blank tape			
	Identification leader	15 (minimum)	Programme identification	Spoken identification preferred or silence	Spoken identification preferred or silence	Uninterrupted
	Cue-up leader	8	Black or cue (5)	Silence or cue	Silence or cue	
		2	Black (5)	Silence	Silence	
Programme (6)		Playing time of programme	Programme			Uninterrupted
Run-out trailer		30 (minimum)	Black (5)	Silence	Silence	

(1) Examples of suitable alignment signals for 625 lines, 50 field/s systems are given in Annex I.

(2) See § 2.1. The tones for both tracks must be coherent (i.e. from the same source) and in phase.

(3) The tone should be interrupted for 0.25 s every 3 s to enable identification of stereophonic recordings. The interruption may be made without using automatic equipment by organisations that only very occasionally need to interchange stereophonic video tape recordings. Under these circumstances, it is recognized that the specified interruption duration will not be strictly adhered to.

(4) In Australia the reference tone is on track 1 and the interrupted reference tone is on track 2. This is done to identify tracks and retain compatibility with mono track 1 reference tone.

(5) In the case of colour recordings, the black signal should be colour black. It is desirable that the colour field sequence (8 fields in PAL, 4 fields in SECAM) should continue uninterrupted in relation to the beginning and end of the programme recording.

(6) Where the time and control code is recorded on the assigned longitudinal track, the time indication of the programme start should be shown on the label accompanying the tape.

8. Programme identification

8.1 At least the following information should be supplied with each recorded television tape:

– name of the organization which made the recording;

– title of programme, or title, sub-title and episode number;

– total number of spools, and number of the spool in the sequence when the programme is contained on more than one spool;

- reference number (library number) of programme or of tape;
- total playing-time, and playing-time of the programme material recorded on the tape;
- in the case of 25.4 mm (one-inch) recording: the format, i.e., Type B or Type C;
- line and field system (625/50 or 525/60);
- in the case of transverse-track recording, the recording standard ("high band" or "low band");
- indication of the colour system, for colour recordings;
- which audio tracks have been used;
- the content of each audio track;
- in the case of Type B or Type C recordings: indication of monophonic or stereophonic recording;
- in the case of Type C recordings, whether the sync track is recorded.

8.2 The information required in § 8.1 shall be provided in at least one of the official languages of the ITU.

8.3 The information required in § 8.1 shall be provided on labels affixed both to the programme spool and its container.

Figure 1 (Annex III) gives an example of a label, conforming to the EBU standard, for the use of transverse track recording.

Figure 2 (Annex III) shows as an example the possible dimensions and layout of a new label. It will be noted that space is provided on it for information on the allocation of the various audio tracks available in Type B and Type C recordings. This label is designed along the same lines as the one specified in EBU Document Tech. 3084 for the transverse track format.

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CCIR Documents

[1982-86]: 11/326 (USSR); 11/334 (OIRT).

[1986-90]: 11/537 (Australia).

ANNEX I

EXAMPLE OF TEST SIGNALS FOR USE IN ADJUSTING TELEVISION TAPE MACHINES

(625-line systems)

The present EBU recommendation for test signals to be used in adjusting transverse-track television tape machines for 625-line television systems, is shown below. Test signals for Type B and Type C recordings have not yet been specified.

In the original EBU recommendation for reference tapes, it is required that the recording be made on a specific type of television tape, which is chosen because it is representative of the tapes currently found in operation.

1. Test signals to be recorded on the leaders of television tapes

The alignment video signal on the tape leader indicated in § 5 of this Recommendation, for adjusting the reproducing machine so that the best picture quality may be obtained, should conform with the following specifications:

1.1 for monochrome television recording and SECAM colour television recordings:

- a black-level bar, a white-level bar and, if desired, a Gaussian pulse;
- a frequency "multi-burst";
- a grey-scale or a "saw-tooth" signal.

These signals should appear simultaneously. The part of the picture carrying each signal should be greater than the area scanned by one complete revolution of the head wheel:

1.2 for PAL colour television recordings:

- on the upper part (at least one third) of the picture, a conventional test pattern of colour bars;
- on the lower part (at least one third) of the picture, a uniform area having the same signal as the red bar.

Note – The colour bar signal chosen for the leader is of the type 100/0/75/0 (according to the nomenclature of Recommendation 471). In the United Kingdom it is of the type 100/0/100/0 and may be followed by a length of dubbed colour bars.

2. Signals to be recorded on the EBU reference tapes

Two types of reference tapes for television tape machines have been standardized for the member organizations of the EBU. They are intended to satisfy two different requirements:

- the physical embodiment of the recording standards used (see § 2.1);
- verification of the characteristics and rapid operational alignment of television tape-machines (see § 2.2).

Tapes of these two types shall have the following characteristics:

2.1 *Primary-standard reference tape*

This tape consists of five successive parts, each of them having a duration of three minutes. The different parts are recorded with the following signals occupying the full frame:

2.1.1 a multiburst signal consisting of six bursts at different frequencies, as specified by the CCIR for insertion in line 18; but preceded by a signal giving the white- and black-reference levels;

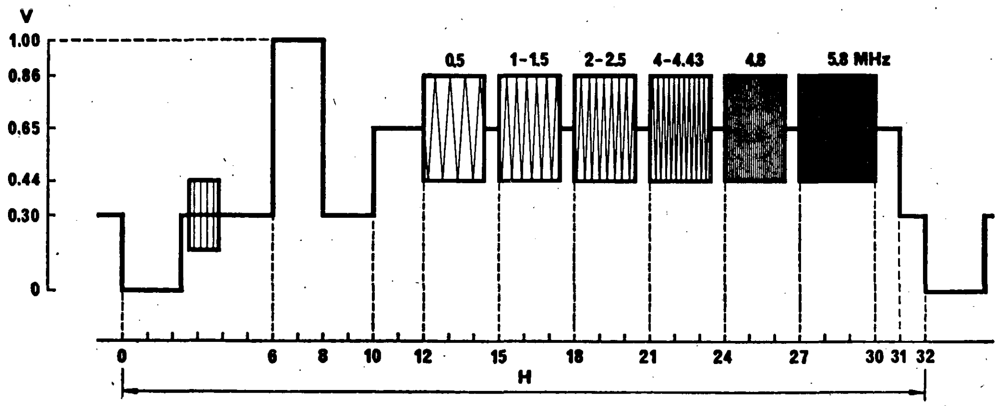


FIGURE 1

2.1.2 the signal specified by the CCIR for insertion in line 17, consisting of the following components: luminance bar, $2T$ sine-squared pulse, composite $20T$ pulse and 5-riser luminance staircase without chrominance signal;

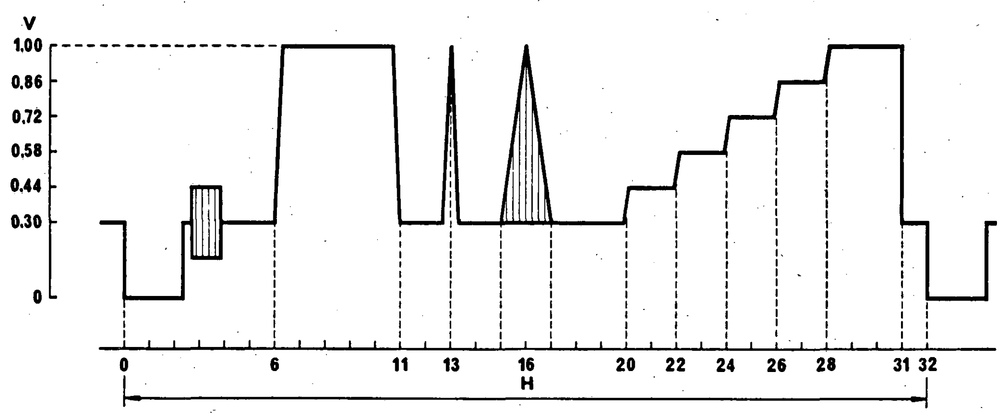


FIGURE 2

2.1.3 the signal specified by the CCIR for insertion in line 330 and consisting of the following components: luminance bar, $2T$ sine-squared pulse and 5-riser luminance staircase with superimposed sub-carrier;

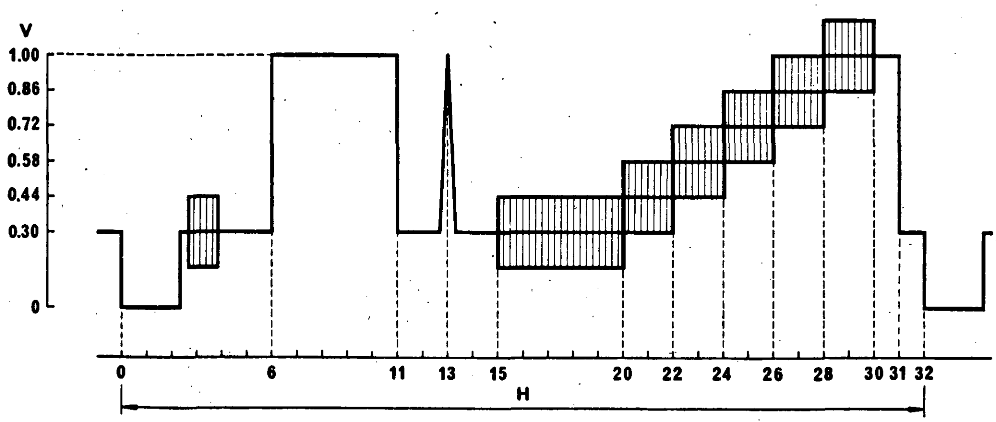


FIGURE 3

2.1.4 a uniform area generated by a sub-carrier of 0.7 V (peak-to-peak) on a luminance level of 50% of the black-to-white transition extending from the beginning to the end of the line (this signal is intended for measurements of moiré and for verification of the correct reproduction of the phase of the colour sub-carrier);

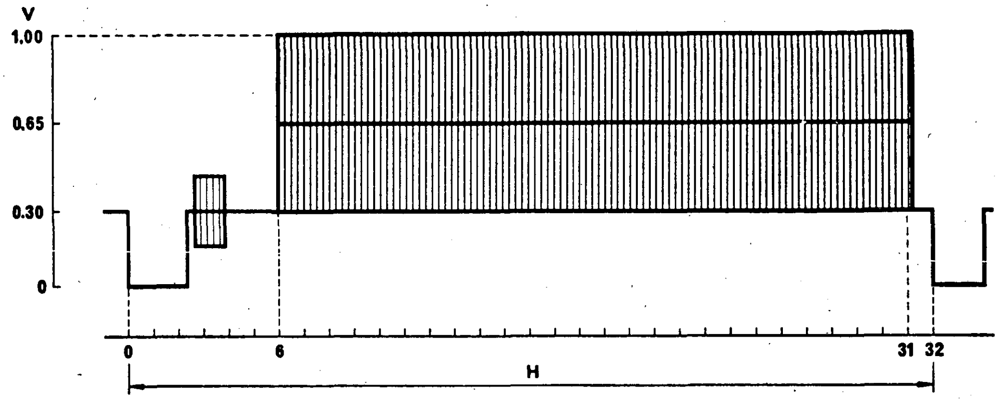


FIGURE 4

2.1.5 a uniform grey area obtained with a luminance level of 30% of the black-to-white transition (this signal is intended for noise measurement).

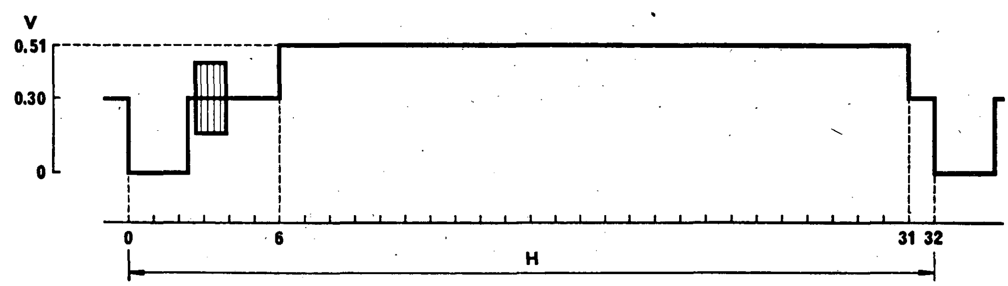


FIGURE 5

All these signals shall include the standard PAL alternating sub-carrier burst during the line-blanking interval. The phase of the sub-carrier used in § 2.1.3 and 2.1.4 shall correspond to the *B-Y* axis referred to the PAL burst.

The recording of these signals shall conform to all the characteristics specified in the relevant EBU, CCIR and IEC documents.

The various recorded sections shall be separated by 15 s of black. The beginning and the end of the tape shall also consist of 15 s periods of black.

The cue track shall be without any recording.

The sound track shall be recorded with alternate announcements in French and English, thus: "EBU reference-tape – bande-étalon de l'UER", followed by the indication of the serial number of the tape, the date of the recording and the name of the manufacturer.

2.2 *Alignment tape for quick verification of the machines*

This operational reference tape shall be recorded with a picture divided into two equal halves in the following way:

2.2.1 the upper half of the picture shall consist of the CCIR insertion signal specified for line 330 repeated on each line: luminance bar, $2T$ sine-squared pulse and 5-riser luminance staircase with superimposed sub-carrier;

2.2.2 the lower half of the picture shall consist of the type 100/0/75/0 colour-bar signal (conforming to Recommendation 471 i.e. the colour-bar signal on the tapes intended for broadcasting organizations in the United Kingdom is of the type 100/0/100/0).

Both these signals shall include the standard PAL alternating sub-carrier burst during the line-blanking interval. The phase of the sub-carrier used in § 2.2.1 shall correspond to the *B-Y* axis referred to the PAL burst.

The recording of these signals shall conform to all the characteristics specified in the relevant EBU, CCIR and IEC documents.

The cue track shall be without any recording.

The sound track shall be recorded with alternate announcements in French and English, thus: "EBU alignment tape – bande de réglage UER", these announcements being interrupted with a few seconds of 1000 Hz tone at the reference level of 100 nWb/m as indicated in this Recommendation.

ANNEX II

PERFORMANCE OF SOUND CHANNELS 1 AND 2 ON FORMAT-B AND FORMAT-C VTRs FOR STEREO APPLICATIONS

The increasing use of stereophonic sound in television has led the EBU to establish guidelines for the desirable characteristics of the accompanying sound (EBU Recommendation R44-1987). These guidelines cover the whole of the recording chain, as indicated in the reference conditions.

For the production of television programmes with stereophonic sound, three major scenarios can be considered:

a) Television programmes where sophisticated sound post-production requires the use of separate multi-channel audio supports for recording and editing.

b) Television programmes where the original sound is recorded on a VTR with sound post-production performed on a separate support.

c) Television programmes which exclusively use VTRs for the recording and editing of both video and sound.

In general, the performance of a separate audio support is superior to that obtained from the audio channels of a VTR, however operation is more costly and time consuming.

The EBU is aware of the increasing importance of operational practices according to scenario c) and senses a need to specify guidelines to broadcasters on the performance of sound channels for stereo applications. In this type of operation, the savings that can be obtained must be balanced by a more careful control of parameters relevant to audio performance. The parameter values listed below give an indication of what is achievable with modern format-B and format-C VTRs.

1. Reference and alignment conditions

For the assessment of the various parameters involved, a simple reference chain is defined consisting of a master recorder, a tape and a replay VTR. This results in a first generation recording with stereo sound recorded on the designated analogue audio tracks.

The final programme will have a performance poorer than that established by the given reference values due to the multiple generation recordings required during editing. Generally, the deterioration of the parameters will be complex. A first-order estimate – where possible – of the law of degradation for the different parameters is given in § 2 below.

The reference chain must be set up, operationally aligned and the parameters measured according to the processes and methods defined in the following EBU documents:

Tech. 3219/1 – Alignment and reference tapes for television tape recorders

Tech. 3219/2 – Operational alignment of television tape-recorders for broadcasting

Tech. 3219/3 – Special electrical measurements for television tape-recorders.

2. Parameters

The following performance criteria can be met by modern format-B and C recorders in the reference configuration without the use of companding and pre-distortion. These parameter values will also ensure satisfactory mono-mix operation. In some older format-C machines, the target specifications can be met by upgrading the equipment with retrofit kits.

2.1 *Amplitude/frequency response of the two channels*

The tolerances on the amplitude/frequency responses of the two sound channels should be as follows:

40 Hz to 125 Hz : +1.5 to −1.5 dB
125 Hz to 10 kHz: +1 to −1 dB
10 kHz to 15 kHz: +1 to −2 dB

Note 1 – Tighter tolerances can be obtained by optimizing the machine-tape combination.

Note 2 – In older machines, head bumping effects in the range of 40 to 125 Hz may dominate the frequency response in this range. They should not exceed +2 dB to −3 dB.

Note 3 – Deterioration during multiple generations is linear.

2.2 *Difference in recorded level between tracks*

In the frequency range from 125 Hz to 10 kHz, a difference in level of 1 dB is admissible. Beyond these limits, a progressive increase up to 2 dB is admissible at 40 Hz and 15 kHz.

Note – Deterioration during multiple generations is linear.

2.3 *Phase difference between tracks*

The maximum phase difference should not exceed 15° at 15 kHz.

Note 1 – Assuming negligible influence of the record/replay electronics, phase differences at other frequencies can be derived assuming linear phase/frequency relationship.

Note 2 – Deterioration during multiple generations is linear.

2.4 *Record crosstalk between audio tracks*

In the frequency range from 125 Hz to 15 kHz, record crosstalk should not exceed −35 dB (crosstalk from unrelated tracks is under study).

2.5 *Weighted signal-to-noise ratio*

The weighted signal-to-noise ratio should be at least 51 dB at a record flux level of 282 nWb/m. This value represents the difference in level between the noise, measured with the meter and weighting network defined in CCIR Recommendation 468, and a signal, the amplitude of which corresponds to the maximum indicated level of programme peaks.

Note 1 – This value is much lower than the subjective threshold criterion of 70 dB defined in CCIR Recommendation 664, Annex IV. The use of companding systems can significantly improve this parameter but will require much tighter control of the frequency response.

Note 2 – Deterioration during multiple generations is r.m.s.

2.6 *Non-linearity distortions*

The third-harmonic distortion at a record flux level of 282 nWb/m should not exceed −30.5 dB (3%).

Note 1 – This value is much lower than the subjective threshold criterion of −52 dB defined in CCIR Recommendation 644, Annex IV. The use of pre-distortion can significantly improve this parameter.

Note 2 – With VTRs format B, the use of TELCOM-C4D companders together with a 4 dB level reduction will also significantly reduce third-harmonic distortion.

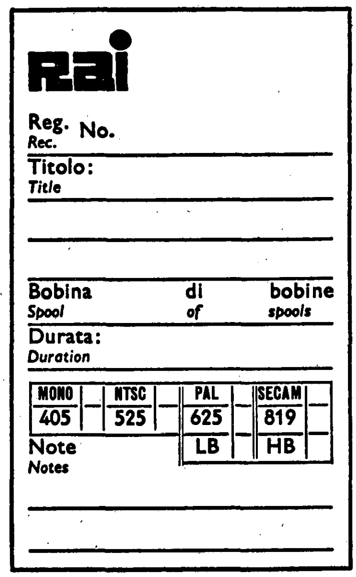
Note 3 – Deterioration during multiple generations is r.m.s.

2.7 *Wow and flutter*

Wow and flutter should not exceed ± 0.1% when measured in accordance with IEC Publication 386.

ANNEX III

EXAMPLES OF STANDARDIZED LABELS FOR TELEVISION TAPE-RECORDING



Drawing of a label conforming to the EBU standard

FIGURE 1 – *Drawing of a label for transverse track recording conforming to the EBU standard*

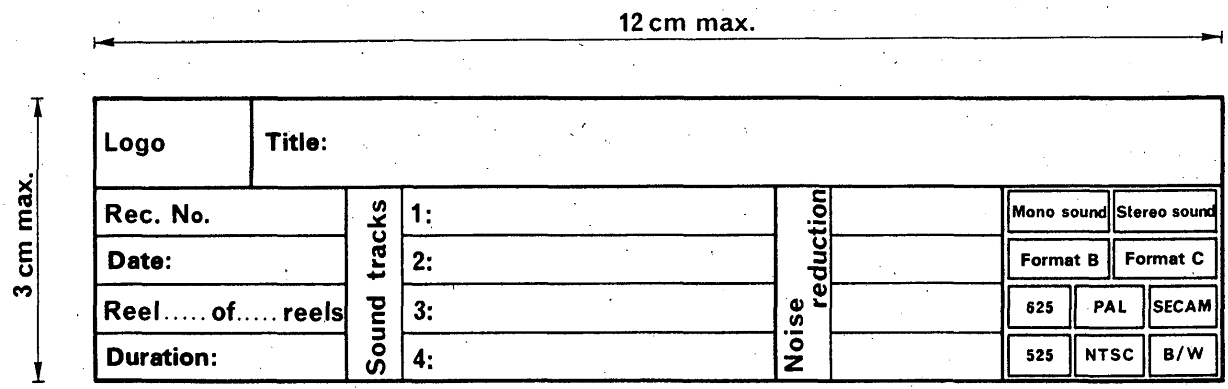


FIGURE 2 – *Example of a possible standard label for format B or format C recordings*

BIBLIOGRAPHY

CCIR Documents

[1966-69]: X/181 (EBU).

[1986-90]: 11/128 (EBU).

ANNEX IV

CODING OF CONTROL SIGNALS ON THE ASSIGNED LONGITUDINAL TRACK

User bits and assignable bits in the EBU time-and-control code

The European Broadcasting Union, recognizing the growing interest in the user bits in the time-and-control code, recommends the following as the initial approach to their exploitation.

1. It is possible to arrange user bits either according to the individual organization's format or to one or more international standards.

2. The combination of bits 27 and 43, previously unassigned, are now assigned within the EBU for use during recording to inform the decoding equipment, during playback, of the format that is employed in the user bits. At present, the following truth table applies:

	Bit 27	*Bit 43*
No user bits, or in-house format	0	0
ASCII characters	1	0
Unassigned	0	1
Unassigned	1	1

3. The data will consist of ASCII bytes only, each occupying two sets of four user bits, in sequence. The information carried in the ASCII bytes is as yet unassigned. Characters to control the display device if any, such as carriage return and line feed, must be included if they are required by the said display device. In the United Kingdom, the use of the "square bracket" characters of the ISO-7 digital code has been reserved to denote shift into and out of machine instructions in the time and control code.

4. Studies are continuing within the EBU on the details of the operational applications of such an ASCII message.

5. If, within a reasonable length of time, no use is made of the two unassigned combinations of bits 27 and 43, it is possible that bit 43 can again become unassigned and thus available for other applications, while still retaining bit 27 to signal the presence of ASCII characters.

6. Manufacturers are reminded that, in each frame, some user bits will be decoded before bits 27 and 43 are encountered. The data in these earlier user-bit locations must not be lost.

RECOMMENDATION 602-1

EXCHANGE OF TELEVISION RECORDINGS FOR PROGRAMME EVALUATION

(Question 18/11, Study Programme 18N/11)

(1982–1990)

The CCIR,

CONSIDERING

(a) that a significant number of television recordings are exchanged by broadcasting organizations for purposes of programme evaluation;

(b) that the U-format (specified in IEC Publication 712) and VHS format (specified in IEC Publication 774) provide good interchangeability between video cassettes recorded on machines supplied by several manufacturers;

(c) that these formats provide programme quality consistent in time and adequate for programme evaluation;

(d) that these formats were originally designed for the consumer market; consequently:

– the recorders and the cassettes are comparatively cheap to buy;

– the recorders can be operated by untrained personnel;

– they are comparatively reliable and robust;

– they are quite widespread and easily available;

(e) that the use of tape cassettes offers advantages in handling and shipping,

UNANIMOUSLY RECOMMENDS

1. that the use of video cassettes conforming with the U-format or the VHS format should be preferred for the international exchange of recorded programmes for programme evaluation, in both the 625 lines, 50 fields/s and the 525 lines, 60 fields/s standards.

Note – In Australia, the Beta format (IEC Publication 767) is used;

2. that these recordings shall comply with the specifications shown in Annex I and Annex II respectively.

For VHS recording, only the "normal speed" recording mode should be used with the sound recorded on the two longitudinal tracks and, when in stereo, the left-channel signal must be recorded on track 1 (inner track) and the right-channel signal on track 2 (edge track).

ANNEX I

SPECIFICATIONS FOR U-FORMAT VIDEO CASSETTE RECORDINGS INTENDED FOR INTERNATIONAL EXCHANGE FOR PROGRAMME EVALUATION

1. Recording format

The recording format shall comply with IEC Publication 712 "Helical scan video tape cassette system using 19 mm (3/4 in) magnetic tape" (1982).

2. Sound recording

2.1 *Monophonic sound*

In the case of monophonic programme sound, the sound will be carried on audio track 2, which is the track furthest from the tape edge.

2.2 *Stereophonic sound*

In the case of stereophonic sound, the left-hand channel shall be carried on track 1, and the right-hand channel shall be carried on track 2.

ANNEX II

SPECIFICATIONS FOR VHS VIDEO CASSETTE RECORDINGS INTENDED FOR INTERNATIONAL EXCHANGE FOR PROGRAMME EVALUATION

The recording format shall comply with IEC Publication 774 ("Helical scan video tape cassette system using 12.65 mm (0.5 in) magnetic tape of type VHS") and its corrigendum (September, 1984).

RECOMMENDATION 657-1 *

DIGITAL TELEVISION TAPE RECORDING

Standards for the international exchange of television programmes on magnetic tape

(Question 18/11, Study Programme 18L/11)

(1986–1990)

The CCIR,

CONSIDERING

(a) that there are clear advantages for television broadcasters and programme producers in digital television recording standards which have the greatest number of identical parameter values for 525-line and 625-line systems;

(b) that a world-wide compatible digital recording format will permit the development of equipment with many common features, permit operating economies and facilitate the international exchange of programmes;

(c) that a single format for international exchange of programmes is highly desirable,

UNANIMOUSLY RECOMMENDS

that, for the international exchange of digitally recorded television programmes conforming to the 4 : 2 : 2 member of the family of standards (Recommendations 601, 656 and 647), the technical and operational criteria should be as follows:

– the magnetic tape should be contained in a cassette, conforming with the appropriate international standards as referred to in § 1 below;
– the tape characteristics should be as indicated in § 2;
– the recording specifications given in § 3 to 9 below should be applied. (Explanation of relevant terms is given in § 8 of Annex II.)

1. Cassette characteristics

1.1 *Mechanical specifications*

Digital television tape cassettes should conform with applicable IEC, EBU and SMPTE standards, namely:

– IEC Publication 1016 (in the course of printing);
– EBU, Document Tech. 3252;
– SMPTE, Document 226M.

Such cassettes are specified in three sizes, corresponding to three different maximum recording times, as shown below:

TABLE I

Cassette type	Dimensions (mm)	Maximum recording time (min)	Tape type (µm)
Small size (D1.S)	172 × 109 × 33	11	16
Medium size (D1.M)	254 × 150 × 33	34	16
Large size (D1.L)	366 × 206 × 33	76	16
		94	13

* This Recommendation should be brought to the attention of the IEC.

1.2 *Programmable user holes*

The cassettes are provided with four user-holes, specified in the references above. User holes are provided with a mechanism allowing users to individually "open" and "close" them as desired.

User hole (1) shall be used for record lock-out; recording shall be inhibited when user hole (1) is "closed".

The use of user holes (2), (3) and (4) will be specified at a later date.

2. Tape characteristics

2.1 *Physical properties of the tape*

2.1.1 *Width of the tape*

The width of the magnetic tape shall be 19.010 ± 0.015 mm.

2.1.2 *Fluctuations of dimensions*

The fluctuation of the magnetic tape width (Δ width) shall not exceed 6 μm, as measured over a tape length of 230 mm with a tension of 0.8 N.

2.1.3 *Reference edge deviation*

The tape reference edge (Fig. 1) is a line through three points on the lower edge of the tape separated by 115 mm (*d*) and constrained to lie on one straight line. This constraint may be a physical deformation or an equivalent mathematical transformation (SMPTE Document 225M). The magnetic coating is on the side facing the observer when the direction of tape travel is as shown in Fig. 1.

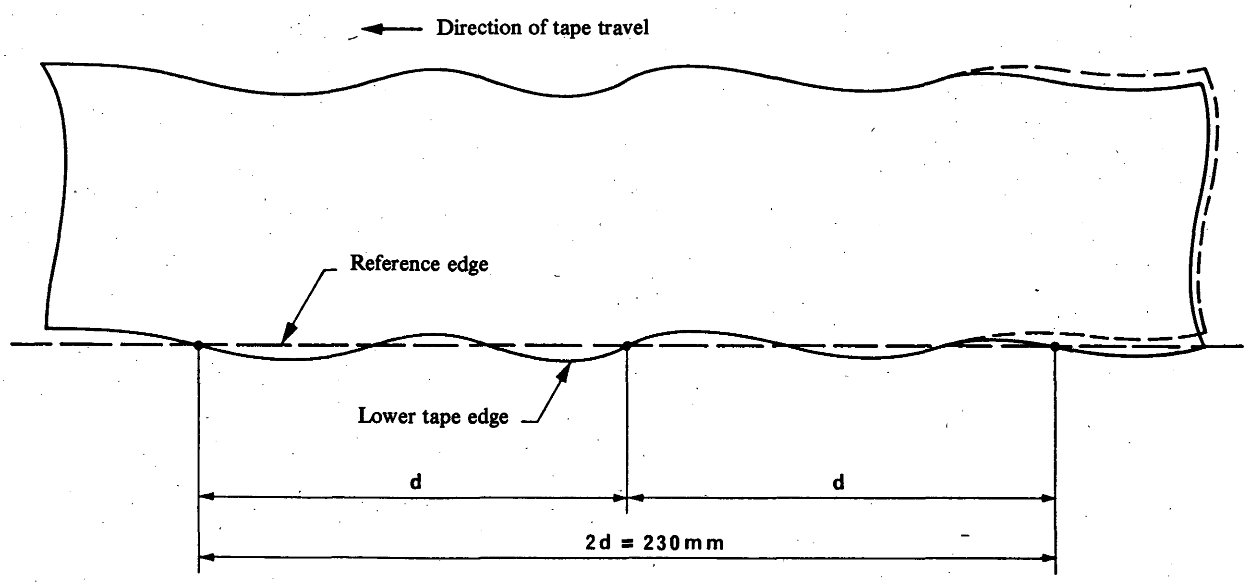


FIGURE 1 – *Reference edge definition*

The maximum deviation of the lower tape edge from the reference edge is 6 μm peak-to-peak.

Edge straightness fluctuation is measured at the edge of a moving tape guided by three guides having contact to the same edge and having a distance of 115 mm from the first to the second guide and having a distance of 115 mm from the second to the third guide. Edge measurements are averaged over 10 mm lengths and are made at a point 5 mm from the mid point between the first and second guides, i.e. 52.5 mm from the first guide.

2.1.4 *Tape thickness*

The thickness of the tape (including all coatings) shall be respectively 13.5 μm to 16.0 μm and 11.0 μm to 13.0 μm.

2.2 *Magnetic properties of the tape*

2.2.1 *Magnetic coating*

The magnetic tape used should have a coating of the improved metal oxide type or equivalent.

2.2.2 *Magnetic orientation*

The magnetic particles shall be longitudinally oriented.

2.2.3 *Coercivity*

The tape coercivity shall be class 68 000 A/m (850 Oe) for metal oxide, when measured with a BH meter in the region of 50 to 60 Hz.

Note – More detailed specifications may be found in EBU Document Tech. 3252 and SMPTE Document 225M.

3. Mechanical parameters of the recording

3.1 *Conditions of measurements*

3.1.1 Tests and measurements made on the tape recorder to check the requirements of this Recommendation shall be made under the following conditions unless otherwise stated:

Temperature:	20 °C ± 1 °C
Relative humidity:	50 ± 2%
Barometric pressure:	96 ± 10 kPa
Tape tension:	0.8 ± 0.05 N

3.1.2 Conditioning of the tape before recording and testing shall be as follows:

Storage conditioning:	not less than 24 h
Environmental:	stabilized to the conditions specified in § 3.1.1
Tape tension:	wound on a reel at a tension of 0.60 to 1.50 N

3.1.3 All dimensions in the tables and figures are to be measured from the reference edge (see Fig. 1). The magnetic coating, with the direction of tape travel as shown in Fig. 2, is on the side facing the observer.

3.2 *Tape speed*

The tape speed shall be 286.6 mm/s ± 0.2% (for 525/60) and 286.9 mm/s ± 0.2% (for 625/50).

3.3 *Record location and dimensions*

Record location and dimensions shall be as specified in Figs. 2 and 3 and Table II.

3.4 *Programme track record curvature*

3.4.1 The centre lines of any 6 consecutive tracks shall be contained within the pattern of the 6 tolerance zones established in Fig. 4.

3.4.2 Each zone is defined by two parallel lines which are inclined at an angle of arc sin (16/170) (basic) with respect to the tape reference edge (see Annex II, § 8.8.1).

3.4.3 The centre lines of all zones shall be spaced 0.045 mm (basic) apart.

The width of zone 1 shall be 0.010 mm (basic).

The width of zones 2 to 6 shall be 0.015 mm (basic). These zones are established to contain track angle errors, track straightness errors, and track pitch errors.

These tolerances shall not be exceeded as a consequence of editing.

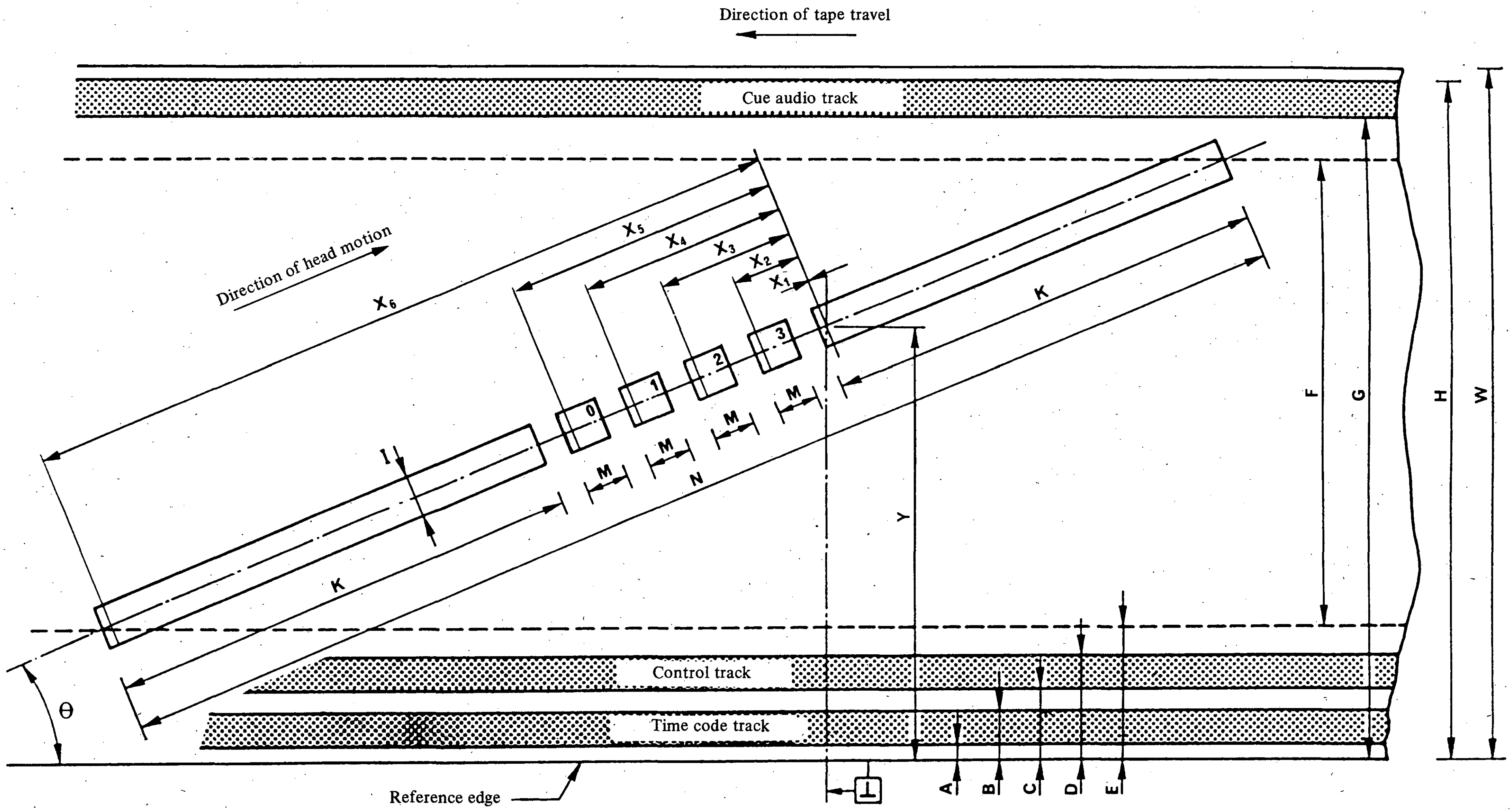


FIGURE 2 – *Relative position of recorded tracks*

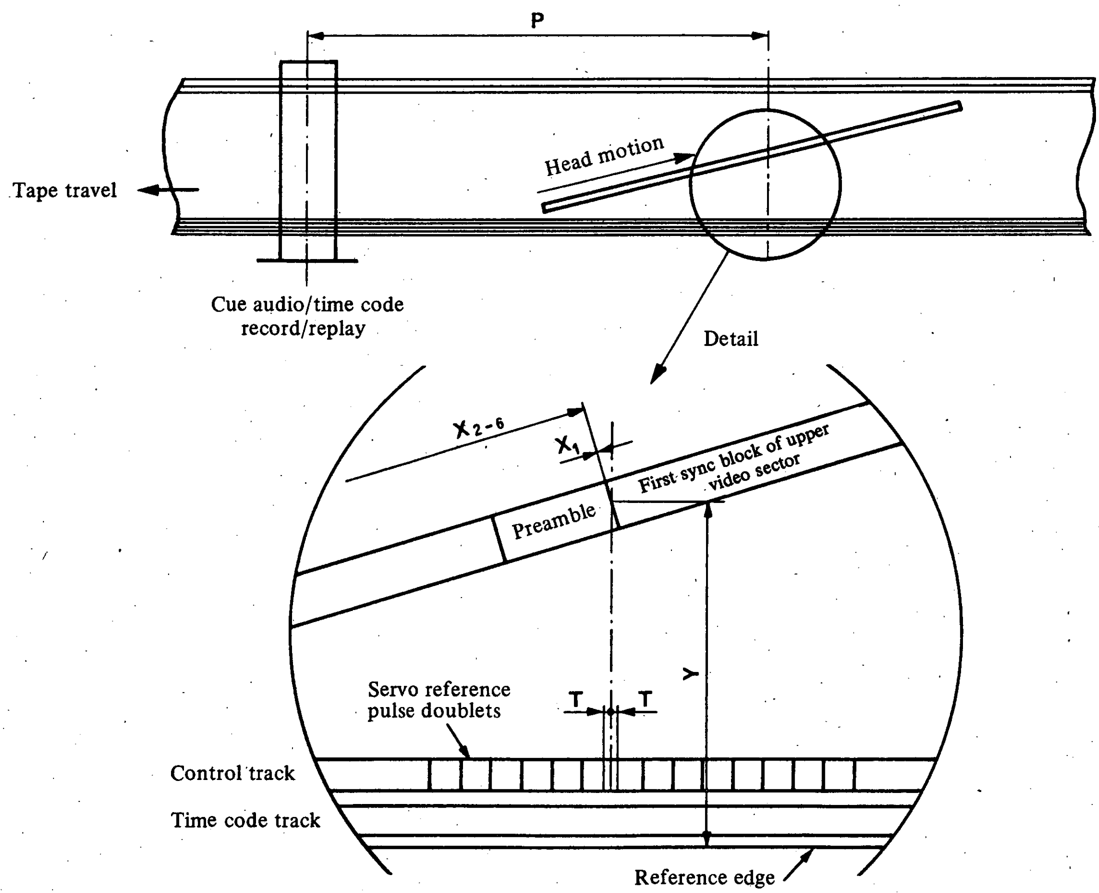


FIGURE 3 – *Locations of cue audio/time code heads and control track*

TABLE II – *Record location and dimensions for 525/60 and 625/50 systems*

Dimensions	Millimeters nominal 525/60	Millimeters nominal 625/50	Tolerance
A: time code track lower edge	0.2	0.2	(± 0.1)
B: time code track upper edge	0.7	0.7	(± 0.1)
C: control track lower edge	1.0	1.0	(± 0.1)
D: control track upper edge	1.5	1.5	(± 0.05)
E: programme area lower edge	1.8	1.8	(Derived)
F: programme area width	16/1.001	16.0	(Derived)
G: audio cue track lower edge	18.1	18.1	(± 0.15)
H: audio cue track upper edge	18.8	18.8	(± 0.2)
I: programme track width	0.040	0.040	(+0/−0.005)
K: video sector length	77.71	77.79	(Derived)
M: audio sector length	2.55	2.56	(Derived)
N: programme track total length	170/1.001	170.0	(Derived)
P: cue audio/time code head location	210.4	210.4	(± 0.3)
T: control track location	0	0	(± 0.10)
θ: track angle arc sin (16/170)	(5°24′02″)	(5°24′02″)	(Basic)
W: tape width	19.010	19.010	(± 0.015)
Y: programme track reference point	10.490	10.490	(Basic)
X_1: location of start of upper video sector	0.0	0.0	± 0.1
X_2: location of start of audio sector 3	3.4	3.4	± 0.1
X_3: location of start of audio sector 2	6.8	6.8	± 0.1
X_4: location of start of audio sector 1	10.2	10.2	± 0.1
X_5: location of start of audio sector 0	13.6	13.6	± 0.1
X_6: location of start of lower video sector	92.1	92.2	± 0.1

Note. – Above measurements shall be made under conditions specified in § 3.1.

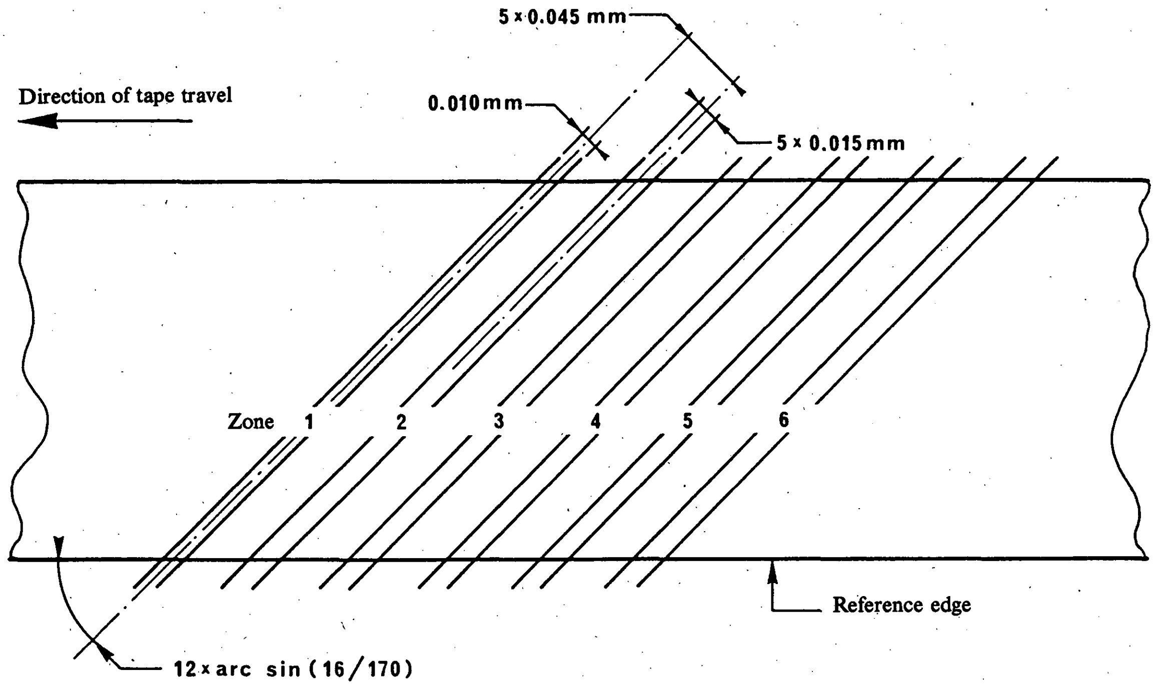


FIGURE 4 – *Position of the programme track centre lines*

The values surrounded by a rectangle are specifications of basic dimensions and, as such, do not carry tolerances

Note – The centre line of any 6 consecutive tracks shall be contained within each zone given.

3.5 *Relative positions of recorded signals*

3.5.1 The programme track reference point is defined as a point corresponding to the end of the preamble in the upper video sector. This point is determined by a line parallel to and spaced 10.490 mm away from the reference edge of the tape (dimension *Y*), intersecting the programme track centre line as shown in Fig. 3.

The position of the sectors along the track is defined by the distance between the end of their preamble and the programme track reference point.

3.5.2 The spatial relationship between the control track signal and the programme track reference point (dimensions *T* and *Y*) is specified in Fig. 3.

3.5.3 The spatial relationship between the cue audio/time code head and the programme track reference point is given by dimension *P* in Fig. 3.

3.6 *Gap azimuth*

3.6.1 The azimuth angle of the head gaps used to produce longitudinal track records shall be perpendicular to the track record.

3.6.2 The azimuth angle of the head gaps used to produce the programme track records shall be perpendicular to the track record within a tolerance of ± 0° 10′.

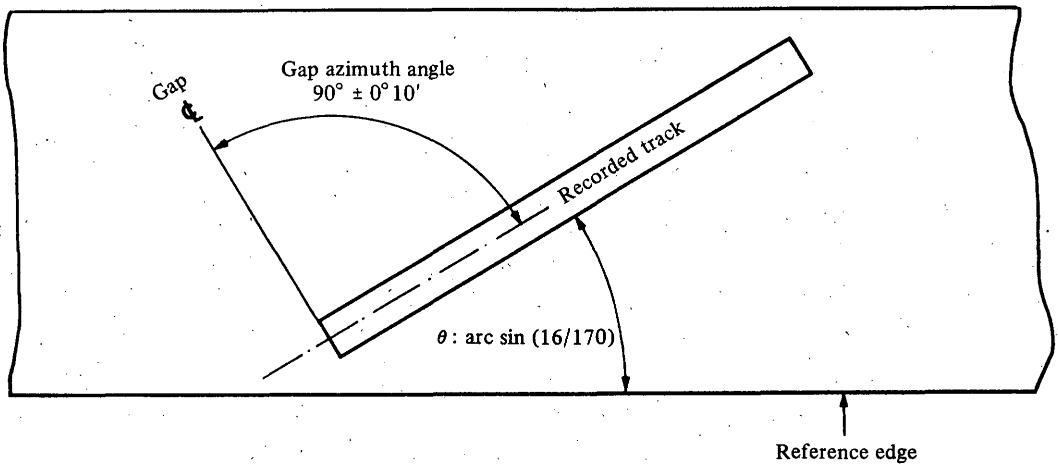


FIGURE 5 – *Specification of programme track azimuth angle*

4. Programme track data arrangement

An outline of the record path processing chain is illustrated in Annex I.

4.1 *Introduction*

Data is arranged in six sectors per track as shown in Fig. 6. Two sectors are employed for video data and four sectors for audio, each containing data from one of the four audio channels. Details of sector assignment are shown in § 5 and 6 of this Recommendation. Each sector is divided into the elements:

- preamble containing a clock run-up sequence, sync. pattern and identification pattern;
- sync. blocks each containing sync. pattern and an identification pattern followed by a fixed length data block with error control;
- postamble containing channel sync. pattern and an identification pattern.

Details of the elements are shown in Fig. 7. The space between sectors may be unrecorded or filled with the clock run-up sequence CC_H. This space is used to accommodate sector timing errors and to allow editing.

A portion of the guard-space at the beginning of the track may contain run-up sequence data pattern CC_H of a length up to 100 bytes.

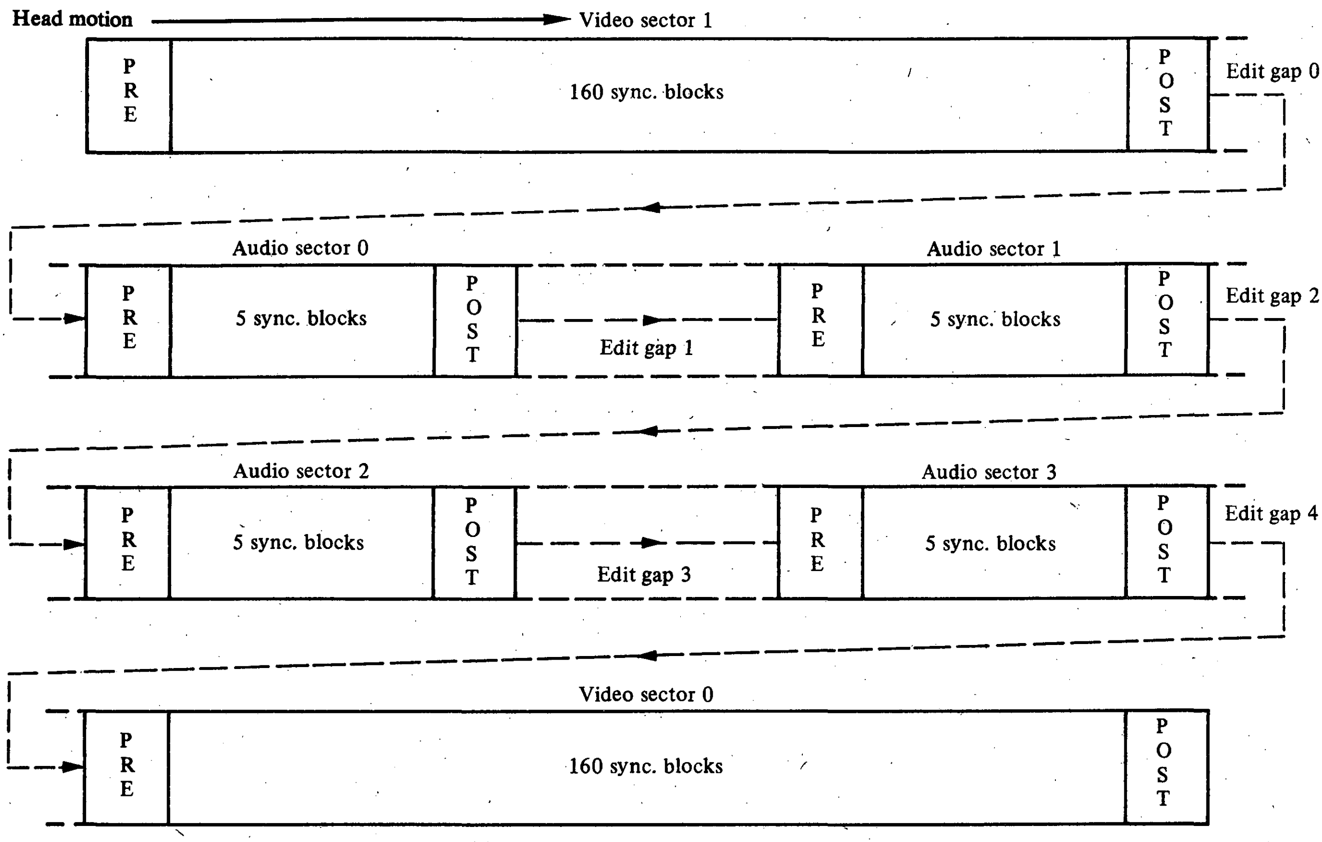
4.2 *Labelling convention*

4.2.1 Least significant bit (LSB) is written on the left and is the first recorded on the tape.

4.2.2 The lowest numbered byte is at left/top and is the first encountered in the input data stream.

4.2.3 Byte values are expressed in hexadecimal notation.

4.2.4 Control words derived from audio source data do not follow this convention, having the most significant bit (MSB) in the leftmost/first position.



PRE: preamble – 30 bytes
POST: postamble – 6 bytes
Sync. block – 134 bytes

Sector Name	Dimension	Size: Blocks	Size: Bytes
V1	K	160	21 476
A0	M	5	706
A1	M	5	706
A2	M	5	706
A3	M	5	706
V0	K	160	21 476
Edit gap	Unrecorded space of length equivalent to 232 bytes		

FIGURE 6 – *Sector arrangement on programme track*

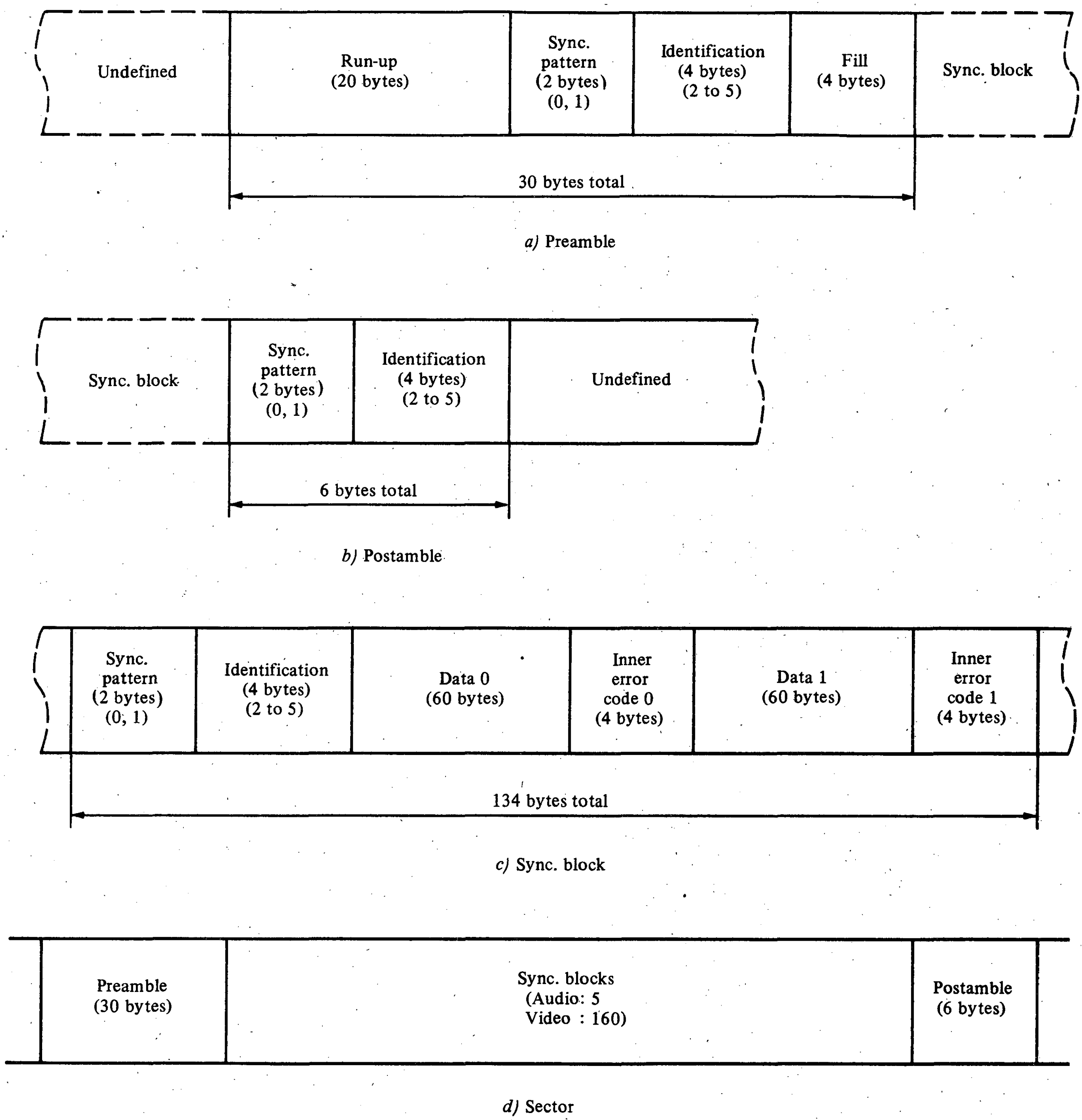


FIGURE 7 – *Sector components*

4.3 *Sector details*

4.3.1 *Sync. block*

Details of the sync. block are shown in Fig. 7c). All sync. blocks consist of 134 bytes consisting of SYNC. PATTERN (2 bytes), IDENTIFICATION PATTERN (4 bytes including error coding) followed by a DATA FIELD of 128 data bytes.

4.3.2 *Sync. pattern*

– Length: 16 bits (2 bytes)
– Pattern: 30 F5 (in hexadecimal notation)

	LSB							MSB
Byte 0	0	0	0	0	1	1	0	0

	LSB							MSB
Byte 1	1	0	1	0	1	1	1	1

– Protection: none
– Randomization: none

4.3.3 *Identification pattern*

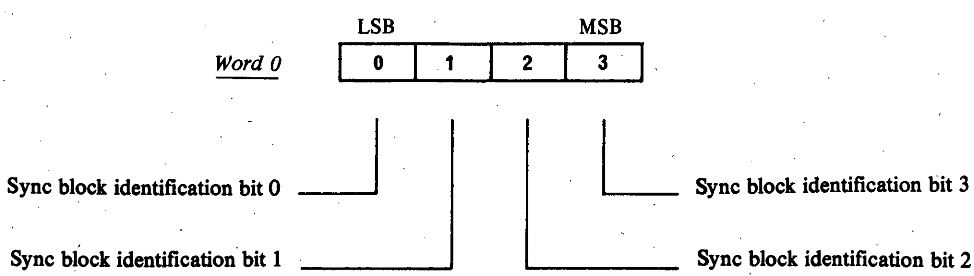
– Length: 32 bits (4 bytes)
– Arrangement:

Byte 2: derived from sync. block identification (see Fig. 8)
Byte 3: derived from sync. block identification (see Fig. 8)
Byte 4: derived from segment and field identification (see Figs. 8 and 9)
Byte 5: derived from field and sector identification (see Figs. 8 and 9).

These bytes are obtained as follows.

BYTE 2

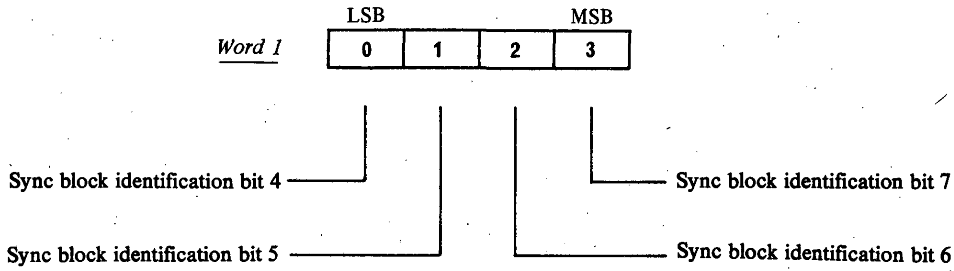
Mapped from Word 0 (4 bits) by Table III



$0_H \leqslant \text{Word } 0 \leqslant D_H$

BYTE 3

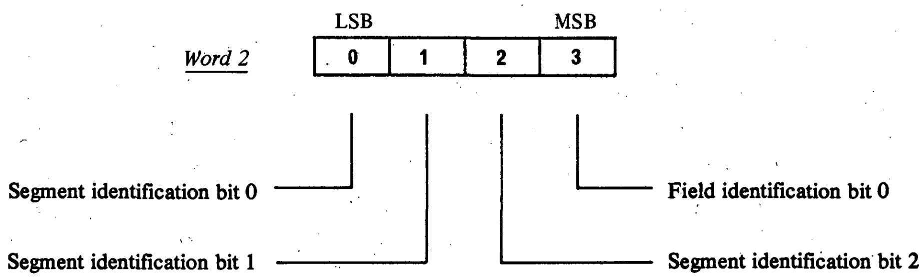
Mapped from Word 1 (4 bits) by Table III



$0_H \leqslant \text{Word } 1 \leqslant D_H$

BYTE 4

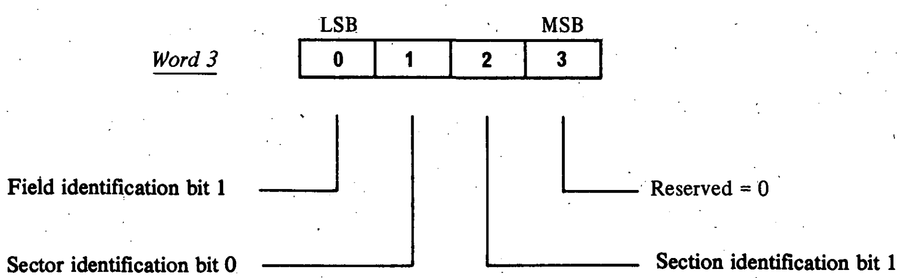
Mapped from Word 2 (4 bits) by Table III



$0_H \leqslant \text{Word } 2 \leqslant D_H$

BYTE 5

Mapped from Word 3 (4 bits) by Table III



$0_H \leqslant \text{Word } 3 \leqslant D_H$

Note. – Sync. block ident. is an 8-bit word formed from two 4-bit words, each lying in the range 0 to D_H, uniquely identifying each sync. block within one sector. Figure 8 specifies these values.

Segment ident. is a 3-bit word lying in the range 0 to 4 (525-line systems) or 0 to 5 (625-line systems). Figure 9 specifies these values.

Field ident. lies in the range 0 to 3 with the origin aligned with frame pulse doublet mark (see § 8). The values of Field ident. are shown in Fig. 9.

Sector ident. is a 2-bit word whose values are specified in Fig. 8.

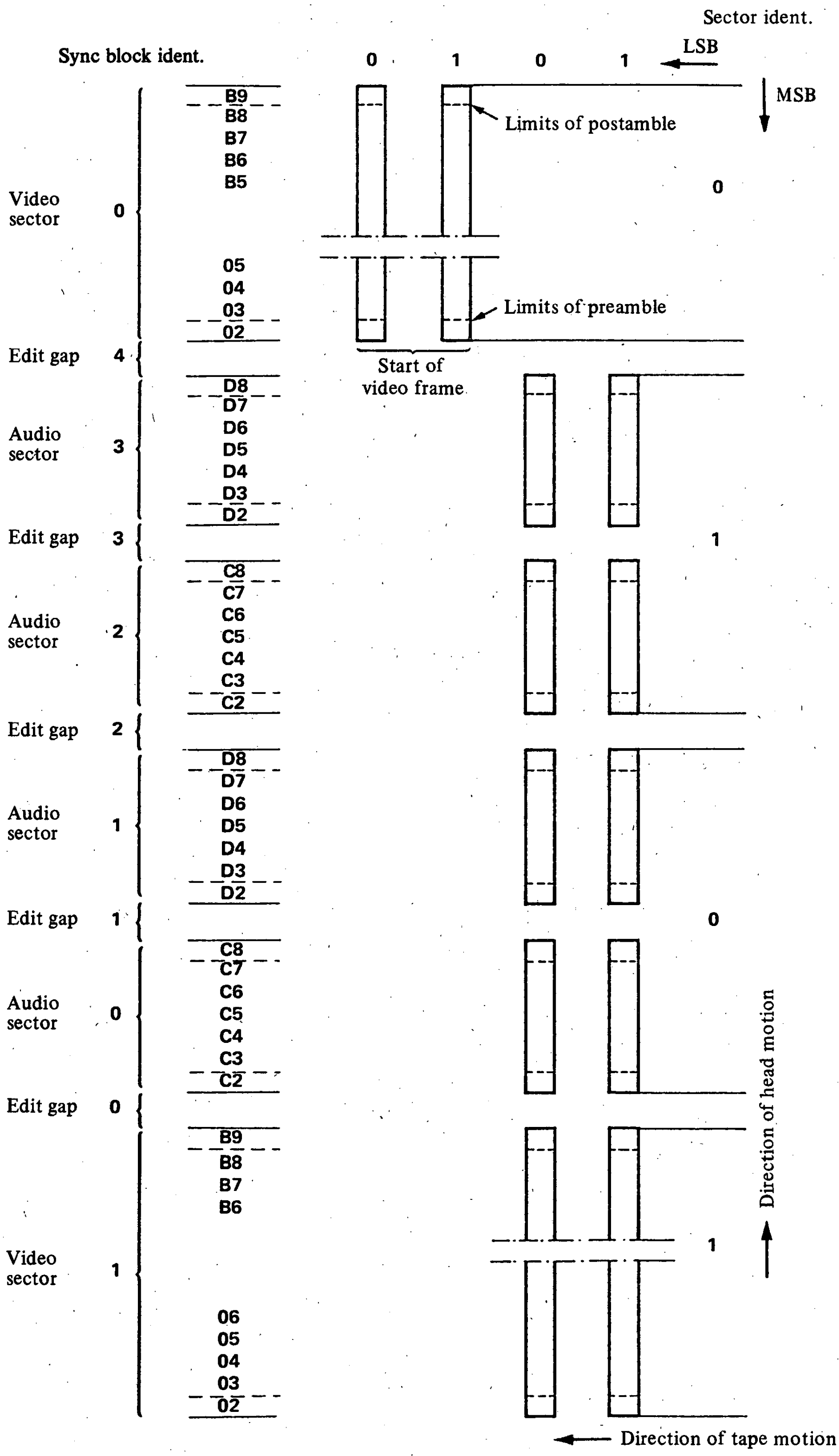


FIGURE 8 – *Values of sync. block identification and sector identification codes*

Note. – Sector ident. LSB: Sector ident. 0
Sector ident. MSB: Sector ident. 1

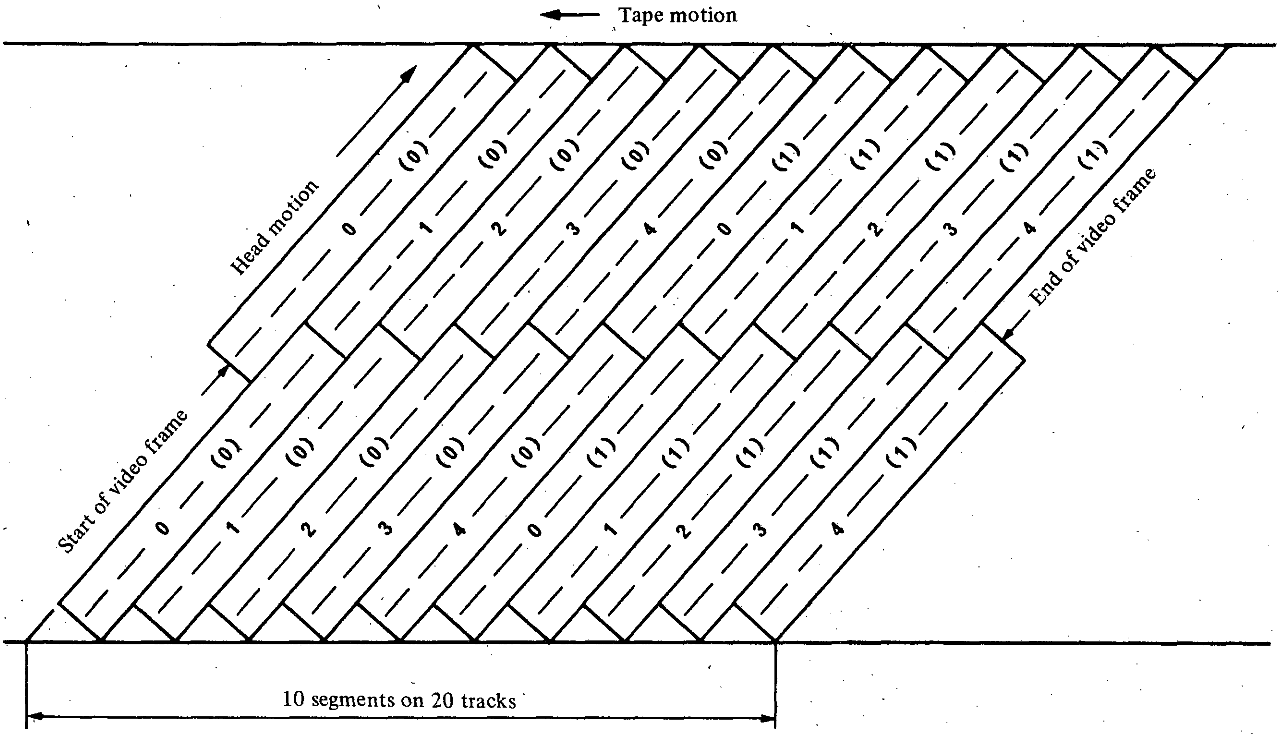


FIGURE 9a – *Segment and field numbers for 525-line systems*

Note 1. – Segment numbers lie in the range 0 to 4 (unbracketed).
Note 2. – Field numbers lie in the range 0 to 3 (bracketed).
Note 3. – Fields 0 to 1 shown. Fields 2 to 3 similar.

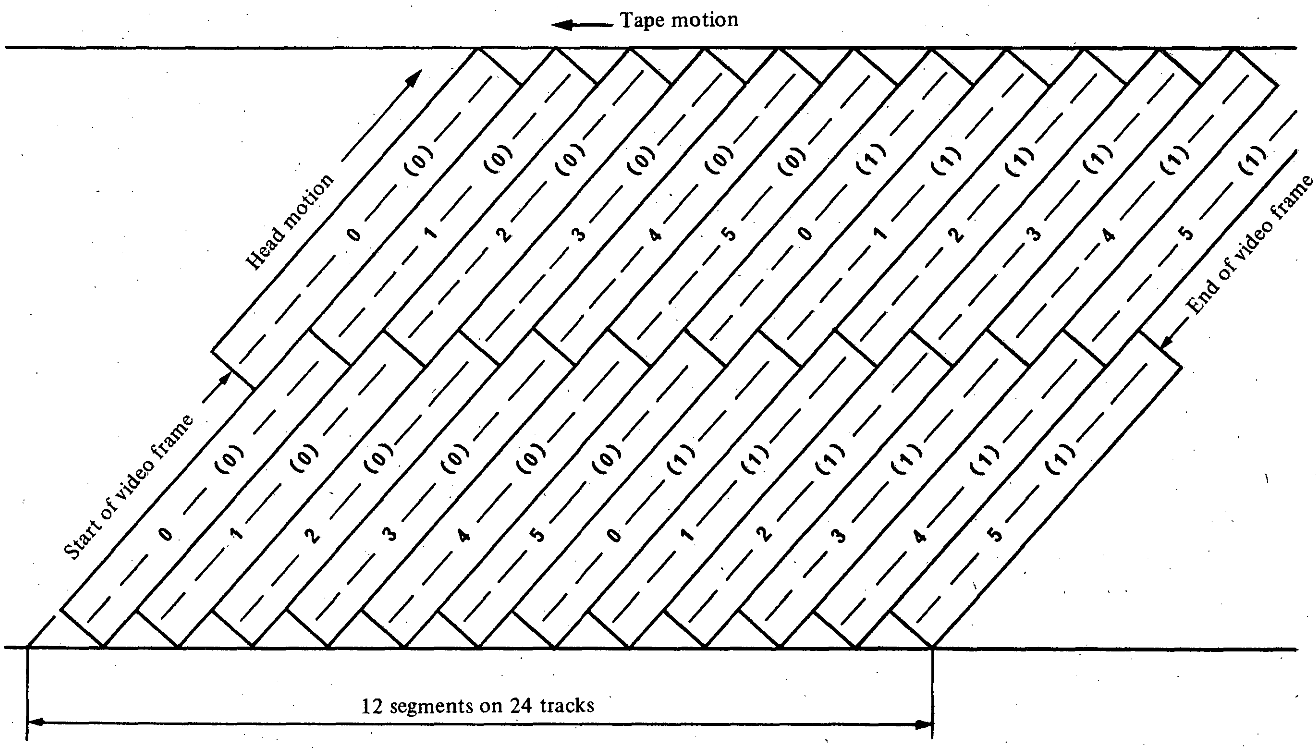


FIGURE 9b – *Segment and field numbers for 625-line systems*

Note 1. – Segment numbers lie in the range 0 to 5 (unbracketed).
Note 2. – Field numbers lie in the range 0 to 3 (bracketed).
Note 3. – Fields 0 to 1 shown. Fields 2 to 3 similar.

– Protection: 4-bit to 8-bit mapping as defined by Table III
– Randomization: none

TABLE III – *4-bit to 8-bit mapping*

Input	Output	Input	Output
0	1B	8	96
1	2E	9	A3
2	35	A	B8
3	47	B	CA
4	5C	C	D1
5	69	D	E4
6	72	E	Illegal
7	8D	F	Illegal

Note. – Values expressed in hexadecimal notation.

4.3.4 *Data field*

This block construction is used for all audio and video data and the associated error correction data.

– Length: 2 inner code blocks; each of 60 data bytes plus 4 inner error-code check bytes. (Outer error-code check bytes are considered as data.)
– Arrangement: see Fig. 7c)
– Protection (inner code)
Type: Reed-Solomon
Galois Field: GF(256)
Field generator polynomial: $x^8 \oplus x^4 \oplus x^3 \oplus x^2 \oplus x^0$
(x^i are place keeping variables in GF(2), the binary field)
Order of use: left-most term is the most significant, "oldest" in time computationally and written first on the tape
Code generator polynomial: $G(x) = (x \oplus \alpha^0)(x \oplus \alpha^1)(x \oplus \alpha^2)(x \oplus \alpha^3)$
in GF(256), α^1 is given by 02_H
Check characters: K_3, K_2, K_1, K_0 in:
$K_3x^3 \oplus K_2x^2 \oplus K_1x^1 \oplus K_0x^0$
obtained as the remainder after dividing
$x^4 \cdot D(x)$ by $G(x)$ where
$D(x) = B_{59}x^{59} + B_{58}x^{58} + \ldots + B_1x^1 + B_0x^0$
Expression of full code: $B_{59}x^{63} + B_{58}x^{62} + \ldots + B_0x^4 + K_3x^3 + \ldots + K_0x^0$

An example of three possible patterns is shown below where pattern 1 is the impulse function where the values in the check locations represent the expansion of the code generator polynomial.

	Data symbols – $D(x)$									Check symbols			
Symbol position	0	1	2	3	4	5	6	58	59	60	61	62	63
Pattern 1	00	00	00	00	00	00	00	00	01	0F	36	78	40
Pattern 2	00	01	02	03	04	05	06	3A	3B	85	24	A9	08
Pattern 3	CC	CC	CC	CC	CC	CC	CC	CC	CC	B6	D4	B6	D4
Symbol identity	B_{59}	B_{58}	B_{57}	B_{56}	B_{55}	B_{54}	B_{53}	B_1	B_0	K_3	K_2	K_1	K_0

– Interleaving: not used.

– Randomization: all data and error correction check character are randomized before being recorded. (Sync., address and fill patterns are not randomized.) The randomizing is equivalent to performing the EXOR operation between the serial data stream and the serial stream generated by the polynomial function $x^8 \oplus x^4 \oplus x^3 \oplus x^2 \oplus x^0$ (in GF(2)). The first term is the most significant and the first to enter the division computation.

In order that successive sync. blocks be randomized with different sequences, the polynomial generator noted above is pre-set to 80_H (Note 1) to read for byte 0 of the sync. block locations having the identification values as follows:

03, 08, 0D, 14, 19, 20, 25, 2A, 31, 36, 3B, 42, 47, 4C, 53, 58, 5D, 64, 69, 70, 75, 7A, 81, 86, 8B, 92, 97, 9C, A3, A8, AD, B4, C3, D3.

Note 1 – This will generate a byte sequence beginning with 80, 38, D2, 81, 49, etc.

Note 2 – Although the sync. and identification patterns are not randomized, the polynomial generator continues to cycle during this period.

4.3.5 *Sector preamble*

All sectors commence with the preamble.

– Length: 30 bytes

– Arrangement: see Fig. 7a)

RUN-UP:	20 bytes minimum of CC_H (for clock reference)
SYNC. PATTERN:	2 bytes (see § 4.3.2)
IDENTIFICATION PATTERN:	4 bytes (see § 4.3.3)
FILL:	4 bytes of CC_H

– Protection: none

– Randomization: none

– Interleaving: none

4.3.6 *Sector postamble*

All sectors terminate with the postamble.

- Length: 6 bytes
- Arrangement: see Fig. 7b)

  SYNC. PATTERN: 2 bytes (see § 4.3.2)

  IDENTIFICATION PATTERN: 4 bytes (see § 4.3.3)
- Protection: none
- Randomization: none
- Interleaving: none

4.4 *Edit gaps*

The space (of nominal length 232 bytes (0.84 mm)) between sectors may be left unwritten, or it may be written with $\hat{CC_H}$.

4.5 *Channel code*

The NRZ data stream shall be recorded directly without further coding.

4.6 *Magnetization*

During the time interval of a recorded data 1, the polarity of data flux shall be such that the North pole of the magnetic domain shall point in the direction of head motion. Similarly, during the time interval of a recorded data 0, the polarity of data flux shall be such to cause the South pole of the magnetic domain to point in the direction of head motion. Magnetization shall bring the tape to saturation.

5. Video processing

5.1 *Recorded data*

Video data to be recorded shall be in accordance with Part I of Recommendation 656. Only the information occurring during the digital active video line is recorded on tape.

5.1.1 *Recorded lines*

The recorded lines are shown in Table IV.

TABLE IV – *Recorded lines*

Standard	Field No. (ref. to Rep. 624)	Field identification in DTTR	Total lines recorded per field	Recorded lines		Video lines	
				First	Last	First	Last
525	Field 1	0 and 2	250	14	263	21	263
	Field 2	1 and 3	250	276	525	283	525
625	Field 1	0 and 2	300	11	310	23	310
	Field 2	1 and 3	300	324	623	336	623

5.1.2 *Digital active line*

720 luminance bytes and 360 bytes for each of the two colour difference components, for a total of 1440 bytes are recorded. These are taken from bytes 0 to 1439 following the 4-byte SAV (start of active video) timing reference signals.

5.1.3 *Source pre-coding*

The input video data stream is pre-coded by a one-for-one mapping of each source data byte as defined in Table V. Data in lines 14 to 20 for 525-line systems and 11 to 22 for 625-line systems, as well as 276 to 282 for 525-line systems and 324 to 335 for 625-line systems, inclusive, is not pre-coded.

TABLE V – *Source video mapping*

Input	Least significant four bits															
Most significant four bits	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	00	80	40	20	10	08	04	02	01	C0	A0	90	88	84	82	81
1	60	50	48	44	42	41	30	28	24	22	21	18	14	12	11	0C
2	0A	09	06	05	03	E0	D0	C8	C4	C2	C1	B0	A8	A4	A2	A1
3	98	94	92	91	8C	8A	89	86	85	83	70	68	64	62	61	58
4	54	52	51	4C	4A	49	46	45	43	38	34	32	31	2C	2A	29
5	26	25	23	1C	1A	19	16	15	13	0E	0D	0B	07	F0	E8	E4
6	E2	E1	D8	D4	D2	D1	CC	CA	C9	C6	C5	C3	B8	B4	B2	B1
7	AC	AA	A9	A6	A5	A3	9C	9A	99	96	95	93	8E	8D	8B	87
8	78	74	72	71	6C	6A	69	66	65	63	5C	5A	59	56	55	53
9	4E	4D	4B	47	3C	3A	39	36	35	33	2E	2D	2B	27	1E	1D
A	1B	17	0F	F8	F4	F2	F1	EC	EA	E9	E6	E5	E3	DC	DA	D9
B	D6	D5	D3	CE	CD	CB	C7	BC	BA	B9	B6	B5	B3	AE	AD	AB
C	A7	9E	9D	9B	97	8F	7C	7A	79	76	75	73	6E	6D	6B	67
D	5E	5D	5B	57	4F	3E	3D	3B	37	2F	1F	FC	FA	F9	F6	F5
E	F3	EE	ED	EB	E7	DE	DD	DB	D7	CF	BE	BD	BB	B7	AF	9F
F	7E	7D	7B	77	6F	5F	3F	FE	FD	FB	F7	EF	DF	BF	7F	FF

MONTAGE: Most significant four bits

5.2 *Sample labelling*

Each television field consists of 250 (300) recorded lines, each sampled at 720 locations for the luminance signal and 360 locations for each colour difference signal. It can be considered as an array of 250 (300) rows by 720 columns, in which each sample is identified by a pair of integers (i, j), where i identifies the row and is numbered 0 to 249 (299) from top to bottom, and j identifies the column and is numbered 0 to 719 from left to right. Columns with even j are associated with a luminance value Y_{ij} and two co-sited chrominance values CB_{ij} and CR_{ij}, where CB and CR designate scaled B-Y and R-Y components respectively. The 4 : 2 : 2 video data sequence for line i is written as follows:

$$CB_{i,0}\ Y_{i,0}\ CR_{i,0}\ Y_{i,1} \ldots\ldots CB_{i,k}\ Y_{i,k}\ CR_{i,k}\ Y_{i,k+1} \ldots\ldots CB_{i,718}\ Y_{i,718}\ CR_{i,718}\ Y_{i,719}$$

$0 \leqslant i \leqslant 249(299)$

$0 \leqslant j \leqslant 719$

and $k = 2(\mathrm{int}(j/2))$

5.3 *Intersector distribution*

Consider the samples in a field, to be numbered according to the convention of § 5.2.

Let m designate the number of a given line within a segment, then $m = i \bmod 50$.

Let r designate the sector number within a segment, $0 \leqslant r \leqslant 3$.

The samples within each segment are evenly distributed between the four corresponding sectors as shown in Fig. 10 and by the following equations:

– for the luminance (Y) samples:

$$r_y = 2[(f + g + j) \bmod 2] + \mathrm{int}[((j + 2(m \bmod 2)) \bmod 4)/2]$$

and for the colour difference samples (CB and CR):

$$r_c = 2[(f + g + \mathrm{int}(j/2)) \bmod 2] + \mathrm{int}[((\mathrm{int}(j/2) + 2(m \bmod 2)) \bmod 4)/2]$$

where:

g: segment in which a given line i falls, $g = \mathrm{int}(i/50)$ and

f: least significant part of the field identification for 525 system only.

Note – The function $\mathrm{int}(x)$ yields the integer part of (x).

This results in 180 luminance samples and 90 pairs of colour difference samples per line in each sector of a segment.

The distribution of samples in each sector is further described by Fig. 10.

For $(f + g) \bmod 2 = 0$

Even line numbers ($m \bmod 2 = 0$)

j	= 0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 ...
r_y	= 0 2	1 3	0 2	1 3	0 2	1 3	0 2	1 3	0
r_c	= 0	2	1	3	0	2	1	3	0

Odd line numbers ($m \bmod 2 = 1$)

j	= 0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 ...
r_y	= 1 3	0 2	1 3	0 2	1 3	0 2	1 3	0 2	1
r_c	= 1	3	0	2	1	3	0	2	1

For $(f + g) \bmod 2 = 1$

Even line numbers ($m \bmod 2 = 0$)

j	= 0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 ...
r_y	= 2 0	3 1	2 0	3 1	2 0	3 1	2 0	3 1	2
r_c	= 2	0	3	1	2	0	3	1	2

Odd line numbers ($m \bmod 2 = 1$)

j	= 0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16 ...
r_y	= 3 1	2 0	3 1	2 0	3 1	2 0	3 1	2 0	3
r_c	= 3	1	2	0	3	1	2	0	3

FIGURE 10 – *Intersector shuffling for odd and even lines*

5.4 *Intrasector shuffling*

The intrasector shuffling sequence during the record process will be described in terms of two successive shuffling processes:

- an intraline shuffle which shuffles video and ancillary words within a single line prior to outer error coding;
- a sector array shuffle which shuffles data and error correction code words within the sector, prior to being written on the tape.

The sector array has dimensions 32 rows by 600 columns. Each column corresponds to one outer code block, and contains 30 video data bytes plus 2 outer correction check bytes. The sector array is further divided into 10 contiguous sub-arrays, each having dimensions 32 rows by 60 columns. The 60 data bytes within a single sub-array row correspond to one inner code block on tape.

5.4.1 *Intraline shuffle*

Let the horizontal sample index, j, be normalized to the range (0 . . . 179) following the intersector distribution described in § 5.3.

- For the luminance component,

$$j'_y = \text{int}(j_y/4)$$

- For the colour difference components (CB and CR),

$$j'_c = 2\,\text{int}(j_c/8)$$

where j' indicates a normalized index.

Then the sector data sequence for a given line contains 360 bytes as follows:

k	0	1	2	3	4	5	6	7	//	356	357	358	359
Byte	CB_0	Y_0	CR_0	Y_1	CB_2	Y_2	CR_2	Y_3	//	CB_{178}	Y_{178}	CR_{178}	Y_{179}

The 360 luminance and chrominance bytes are distributed among 12 outer code blocks as shown in Table VI. Each column of Table VI represents an outer code block. The last two bytes $KV1$, $KV0$ are outer correction check bytes added by the outer coder. The byte number refers to the byte position within an outer code block.

Let k be the position of a video data byte within a line of the sector data sequence, following the intersector distribution as described above, $0 \leqslant k \leqslant 359$. Let Oblk be the outer block column index of Table VI, $0 \leqslant \text{Oblk} \leqslant 11$. Let Obyt be the outer block byte number of Table VI, $0 \leqslant \text{Obyt} \leqslant 31$.

Then the intraline shuffle described by the following formulae is applied:

$$\text{Oblk} = 4\,\text{int}(k/120) + (k \bmod 4)$$

$$\text{Obyt} = \text{int}[(k \bmod 120)/4] \qquad \text{for } 0 \leqslant \text{Obyt} \leqslant 29$$

The inverse mapping is given by the formula:

$$k = 120\,\text{int}(\text{Oblk}/4) + (\text{Oblk} \bmod 4) + 4 \times \text{Obyt}$$

5.4.2 *Sector array shuffling*

The sector array may be divided into 150 4-column groups, ranging from 0 to 149. The 4 columns within a column group contain (CB, Y, CR, Y) pel data bytes, respectively. Along a given row within a column group, CB and CR are co-sited with respect to the source data, and co-sited (or nearly so) with the first Y sample byte, while the second Y sample byte is horizontally offset from the first with respect to the source data.

TABLE VI – *Intraline shuffle memory map*

Byte No. (Obyt)	Outer block number within line (Oblk) 0	1	2	3	4	5	6	7	8	9	10	11
0	CB0	Y0	CR0	Y1	CB60	Y60	CR60	Y61	CB120	Y120	CR120	Y121
1	CB2	Y2	CR2	Y3	CB62	Y62	CR62	Y63	CB122	Y122	CR122	Y123
2	CB4	Y4	CR4	Y5	CB64	Y64	CR64	Y65	CB124	Y124	CR124	Y125
3	CB6	Y6	CR6	Y7	CB66	Y66	CR66	Y67	CB126	Y126	CR126	Y127
4	CB8	Y8	CR8	Y9	CB68	Y68	CR68	Y69	CB128	Y128	CR128	Y129
5	CB10	Y10	CR10	Y11	CB70	Y70	CR70	Y71	CB130	Y130	CR130	Y131
6	CB12	Y12	CR12	Y13	CB72	Y72	CR72	Y73	CB132	Y132	CR132	Y133
7	CB14	Y14	CR14	Y15	CB74	Y74	CR74	Y75	CB134	Y134	CR134	Y135
8	CB16	Y16	CR16	Y17	CB76	Y76	CR76	Y77	CB136	Y136	CR136	Y137
9	CB18	Y18	CR18	Y19	CB78	Y78	CR78	Y79	CB138	Y138	CR138	Y139
10	CB20	Y20	CR20	Y21	CB80	Y80	CR80	Y81	CB140	Y140	CR140	Y141
11	CB22	Y22	CR22	Y23	CB82	Y82	CR82	Y83	CB142	Y142	CR142	Y143
12	CB24	Y24	CR24	Y25	CB84	Y84	CR84	Y85	CB144	Y144	CR144	Y145
13	CB26	Y26	CR26	Y27	CB86	Y86	CR86	Y87	CB146	Y146	CR146	Y147
14	CB28	Y28	CR28	Y29	CB88	Y88	CR88	Y89	CB148	Y148	CR148	Y149
15	CB30	Y30	CR30	Y31	CB90	Y90	CR90	Y91	CB150	Y150	CR150	Y151
16	CB32	Y32	CR32	Y33	CB92	Y92	CR92	Y93	CB152	Y152	CR152	Y153
17	CB34	Y34	CR34	Y35	CB94	Y94	CR94	Y95	CB154	Y154	CR154	Y155
18	CB36	Y36	CR36	Y37	CB96	Y96	CR96	Y97	CB156	Y156	CR156	Y157
19	CB38	Y38	CR38	Y39	CB98	Y98	CR98	Y99	CB158	Y158	CR158	Y159
20	CB40	Y40	CR40	Y41	CB100	Y100	CR100	Y101	CB160	Y160	CR160	Y161
21	CB42	Y42	CR42	Y43	CB102	Y102	CR102	Y103	CB162	Y162	CR162	Y163
22	CB44	Y44	CR44	Y45	CB104	Y104	CR104	Y105	CB164	Y164	CR164	Y165
23	CB46	Y46	CR46	Y47	CB106	Y106	CR106	Y107	CB166	Y166	CR166	Y167
24	CB48	Y48	CR48	Y49	CB108	Y108	CR108	Y109	CB168	Y168	CR168	Y169
25	CB50	Y50	CR50	Y51	CB110	Y110	CR110	Y111	CB170	Y170	CR170	Y171
26	CB52	Y52	CR52	Y53	CB112	Y112	CR112	Y113	CB172	Y172	CR172	Y173
27	CB54	Y54	CR54	Y55	CB114	Y114	CR114	Y115	CB174	Y174	CR174	Y175
28	CB56	Y56	CR56	Y57	CB116	Y116	CR116	Y117	CB176	Y176	CR176	Y177
29	CB58	Y58	CR58	Y59	CB118	Y118	CR118	Y119	CB178	Y178	CR178	Y179
30	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1
31	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0

A column map, which is a permutation of the integers 0 to 149, is used to define the sequence in which column groups are stored in the sector array. A row map, which is a permutation of the integers 0 to 31, is used to define the sequence of rows in which data for a given column is stored in the sector array. The starting point of the row map is different for each column group, and in addition the starting point of the row map sequence for the fourth column of each column group is further offset by a constant from the starting point of the row map sequence for the first 3 columns of the column group.

The sector array shuffling is defined by the algorithm given in § 5.4.2.1. Tables VIIa to VIIj show the result of this algorithm and Fig. 11 shows a conceptual block diagram of the method. The algorithm may be considered to operate as follows:

The column counter is cleared at the beginning of each 50-line segment, and incremented every outer block or 12 times per TV line. The least significant 2 bits of the column counter select a column within a 4-column group. The most significant 8 bits are used to address a PROM containing the column map function. The row start PROM is used to select an initial starting point for the row map sequence for each column group, except for the fourth column of the column group, which has a different initial starting point for the row map sequence. The row counter is loaded with the row start pre-set data at the beginning of each outer block and increments mod 32 every data byte. The row map PROM is used to select the actual row address where the byte is stored in the sector array.

Tables VIIa to VIIj explicitly list the relation between every byte in the sector array and its location in the input data stream. The array values represent normalized sample indices, j'_y or j'_c, as defined in § 5.4.1.

5.4.2.1 *Algorithm for intrasector shuffling*

Let m designate the line number within a segment,

$0 \leq m \leq 49.$

Let Oblk designate the outer block number within a line, as defined in § 5.4.1,

$0 \leq \text{Oblk} \leq 11.$

Let Obyt designate the outer block byte index, as defined in § 5.4.1,

$0 \leq \text{Obyt} \leq 31.$

Define the outer block number counting from beginning of the segment, Icnt,

$\text{Icnt} = \text{Oblk} + 12\,m,\ 0 \leq \text{Icnt} \leq 599.$

Define the unpermuted 4-column group number, Igrp,

$\text{Igrp} = \text{int}(\text{Icnt}/4),\ 0 \leq \text{Igrp} \leq 149.$

Define the permuted 4-column group number, Jgrp,

$\text{Jgrp} = (41 \times \text{Igrp}) \bmod 150.$

Define the sector array column index, Col,

$\text{Col} = 4 \times \text{Jgrp} + (\text{Icnt} \bmod 4),\ 0 \leq \text{Col} \leq 599.$

Define $u = 0$ for $(\text{Icnt} \bmod 4) = 0, 1, 2$; $u = 1$ for $(\text{Icnt} \bmod 4) = 3$.

Define the row count starting value, Rstart,

$\text{Rstart} = (30 \times \text{Igrp} + 5\,u) \bmod 32.$

Define the row count value, Rcnt,

$\text{Rcnt} = (\text{Obyt} + \text{Rstart}) \bmod 32.$

Define the sector array row address, Row,

$\text{Row} = (7 \times \text{Rcnt}) \bmod 32.$

Col and Row define the sector array location where a data byte (either video data or outer correction check) is located.

For field 0, sectors 0 and 2, data is read from the sector array in a "raster scan" sequence and written on the tape. (That is, the data in row 0, columns 0 to 599 is read, then row 1, columns 0 to 599, and so forth, to row 31.)

For sectors 1 and 3, which are adjacent to sectors 0 and 2, respectively, on tape, the data is read out with a 16-row offset relative to sectors 0 and 2. In addition, there is a further variation of the row address over a 4-field sequence. Table VIII summarizes the row address modification necessary, depending on field and sector number.

TABLE VIIa – *Intrasector shuffle memory map for sub-array 0*

Jgrp:	0		1		2		3		4		5		6		7		8		9		10		11		12		13		14	
Igrp:	0		11		22		33		44		55		66		77		88		99		110		121		132		143		4	
Line:	0		3		7		11		14		18		22		25		29		33		36		40		44		47		1	
Col:	0	3	4	7	8	11	12	15	16	19	20	23	24	27	28	31	32	35	36	39	40	43	44	47	48	51	52	55	56	59
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	0	5	10	15	20	25	30	3	8	13	18	23	28	1	6	11	16	21	26	31	4	9	14	19	24	29	2	7	24	29
Row:																														
0	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	76	67
1	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	KV0	113
2	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	104	95
3	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	86	77
4	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	68	KV0
5	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	114	105
6	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	96	87
7	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	78	69
8	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	60	115
9	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	106	97
10	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	88	79
11	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	70	61
12	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	116	107
13	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	98	89
14	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	80	71
15	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	62	117
16	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	108	99
17	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	90	81
18	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	72	63
19	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	118	109
20	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	100	91
21	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	82	73
22	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	64	119
23	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	110	101
24	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	92	83
25	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	74	65
26	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	KV1	111
27	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	102	93
28	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	84	75
29	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	66	KV1
30	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	112	103
31	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	94	85

Note 1. – Columns 1 and 2 have the same distribution as column 0, columns 5 and 6 the same as 4, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIb – *Intrasector shuffle memory map for sub-array 1*

Jgrp:	15		16		17		18		19		20		21		22		23		24		25		26		27		28		29	
Igrp:	15		26		37		48		59		70		81		92		103		114		125		136		147		8		19	
Line:	5		8		12		16		19		23		27		30		34		38		41		45		49		2		6	
Col:	60	63	64	67	68	71	72	75	76	79	80	83	84	87	88	91	92	95	96	99	100	103	104	107	108	111	112	115	116	119
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	2	7	12	17	22	27	0	5	10	15	20	25	30	3	8	13	18	23	28	1	6	11	16	21	26	31	16	21	26	31
Row:																														
0	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	152	143	72	63
1	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	134	125	118	109
2	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	KV1	171	100	91
3	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	162	153	82	73
4	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	144	135	64	119
5	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	126	KV1	110	101
6	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	172	163	92	83
7	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	154	145	74	65
8	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	136	127	KV1	111
9	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	KV0	173	102	93
10	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	164	155	84	75
11	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	146	137	66	KV1
12	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	128	KV0	112	103
13	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	174	165	94	85
14	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	156	147	76	67
15	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	138	129	KV0	113
16	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	120	175	104	95
17	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	166	157	86	77
18	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	148	139	68	KV0
19	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	130	121	114	105
20	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	176	167	96	87
21	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	158	149	78	69
22	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	140	131	60	115
23	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	122	177	106	97
24	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	168	159	88	79
25	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	150	141	70	61
26	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	132	123	116	107
27	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	178	169	98	89
28	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	160	151	80	71
29	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	142	133	62	117
30	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	124	179	108	99
31	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	170	161	90	81

Note 1. – Columns 61 and 62 have the same distribution as column 60, columns 65 and 66 the same as 64, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIc – *Intrasector shuffle memory map for sub-array 2*

Jgrp:	30		31		32		33		34		35		36		37		38		39		40		41		42		43		44	
Igrp:	30		41		52		63		74		85		96		107		118		129		140		1		12		23		34	
Line:	10		13		17		21		24		28		32		35		39		43		46		0		4		7		11	
Col:	120	123	124	127	128	131	132	135	136	139	140	143	144	147	148	151	152	155	156	159	160	163	164	167	168	171	172	175	176	179
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	4	9	14	19	24	29	2	7	12	17	22	27	0	5	10	15	20	25	30	3	8	13	30	3	8	13	18	23	28	1
Row:																														
0	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	64	119	48	39	148	139	68	KV0
1	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	110	101	30	21	130	121	114	105
2	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	92	83	12	3	176	167	96	87
3	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	74	65	58	49	158	149	78	69
4	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	KV1	111	40	31	140	131	60	115
5	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	102	93	22	13	122	177	106	97
6	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	84	75	4	59	168	159	88	79
7	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	66	KV1	50	41	150	141	70	61
8	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	112	103	32	23	132	123	116	107
9	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	94	85	14	5	178	169	98	89
10	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	76	67	KV1	51	160	151	80	71
11	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	KV0	113	42	33	142	133	62	117
12	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	104	95	24	15	124	179	108	99
13	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	86	77	6	KV1	170	161	90	81
14	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	68	KV0	52	43	152	143	72	63
15	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	114	105	34	25	134	125	118	109
16	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	96	87	16	7	KV1	171	100	91
17	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	78	69	KV0	53	162	153	82	73
18	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	60	115	44	35	144	135	64	119
19	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	106	97	26	17	126	KV1	110	101
20	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	88	79	8	KV0	172	163	92	83
21	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	70	61	54	45	154	145	74	65
22	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	116	107	36	27	136	127	KV1	111
23	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	98	89	18	9	KV0	173	102	93
24	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	80	71	0	55	164	155	84	75
25	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	62	117	46	37	146	137	66	KV1
26	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	108	99	28	19	128	KV0	112	103
27	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	90	81	10	1	174	165	94	85
28	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	72	63	56	47	156	147	76	67
29	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	118	109	38	29	138	129	KV0	113
30	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	100	91	20	11	120	175	104	95
31	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	82	73	2	57	166	157	86	77

Note 1. – Columns 121 and 122 have the same distribution as column 120, columns 125 and 126 the same as 124, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIId – *Intrasector shuffle memory map for sub-array 3*

Jgrp:	45		46		47		48		49		50		51		52		53		54		55		56		57		58		59	
Igrp:	45		56		67		78		89		100		111		122		133		144		5		16		27		38		49	
Line:	15		18		22		26		29		33		37		40		44		48		1		5		9		12		16	
Col:	180	183	184	187	188	191	192	195	196	199	200	203	204	207	208	211	212	215	216	219	220	223	224	227	228	231	232	235	236	239
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	6	11	16	21	26	31	4	9	14	19	24	29	2	7	12	17	22	27	0	5	22	27	0	5	10	15	20	25	30	3
Row:																														
0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	140	131	60	115	44	35	144	135	64	119
1	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	122	177	106	97	26	17	126	KV1	110	101
2	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	168	159	88	79	8	KV0	172	163	92	83
3	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	150	141	70	61	54	45	154	145	74	65
4	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	132	123	116	107	36	27	136	127	KV1	111
5	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	178	169	98	89	18	9	KV0	173	102	93
6	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	160	151	80	71	0	55	164	155	84	75
7	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	142	133	62	117	46	37	146	137	66	KV1
8	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	124	179	108	99	28	19	128	KV0	112	103
9	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	170	161	90	81	10	1	174	165	94	85
10	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	152	143	72	63	56	47	156	147	76	67
11	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	134	125	118	109	38	29	138	129	KV0	113
12	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	KV1	171	100	91	20	11	120	175	104	95
13	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	162	153	82	73	2	57	166	157	86	77
14	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	144	135	64	119	48	39	148	139	68	KV0
15	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	126	KV1	110	101	30	21	130	121	114	105
16	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	172	163	92	83	12	3	176	167	96	87
17	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	154	145	74	65	58	49	158	149	78	69
18	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	136	127	KV1	111	40	31	140	131	60	115
19	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	KV0	173	102	93	22	13	122	177	106	97
20	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	164	155	84	75	4	59	168	159	88	79
21	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	146	137	66	KV1	50	41	150	141	70	61
22	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	128	KV0	112	103	32	23	132	123	116	107
23	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	174	165	94	85	14	5	178	169	98	89
24	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	156	147	76	67	KV1	51	160	151	80	71
25	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	138	129	KV0	113	42	33	142	133	62	117
26	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	120	175	104	95	24	15	124	179	108	99
27	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	166	157	86	77	6	KV1	170	161	90	81
28	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	148	139	68	KV0	52	43	152	143	72	63
29	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	130	121	114	105	34	25	134	125	118	109
30	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	176	167	96	87	16	7	KV1	171	100	91
31	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	158	149	78	69	KV0	53	162	153	82	73

Note 1. – Columns 181 and 182 have the same distribution as column 180, columns 185 and 186 the same as 184, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIe – *Intrasector shuffle memory map for sub-array 4*

Jgrp:	60		61		62		63		64		65		66		67		68		69		70		71		72		73		74	
Igrp:	60		71		82		93		104		115		126		137		148		9		20		31		42		53		64	
Line:	20		23		27		31		34		38		42		45		49		3		6		10		14		17		21	
Col:	240	243	244	247	248	251	252	255	256	259	260	263	264	267	268	271	272	275	276	279	280	283	284	287	288	291	292	295	296	299
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	8	13	18	23	28	1	6	11	16	21	26	31	4	9	14	19	24	29	14	19	24	29	2	7	12	17	22	27	0	5
Row:																														
0	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	36	27	136	127	KV1	111	40	31	140	131	60	115
1	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	18	9	KV0	173	102	93	22	13	122	177	106	97
2	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	0	55	164	155	84	75	4	59	168	159	88	79
3	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	46	37	146	137	66	KV1	50	41	150	141	70	61
4	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	28	19	128	KV0	112	103	32	23	132	123	116	107
5	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	10	1	174	165	94	85	14	5	178	169	98	89
6	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	56	47	156	147	76	67	KV1	51	160	151	80	71
7	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	38	29	138	129	KV0	113	42	33	142	133	62	117
8	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	20	11	120	175	104	95	24	15	124	179	108	99
9	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	2	57	166	157	86	77	6	KV1	170	161	90	81
10	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	48	39	148	139	68	KV0	52	43	152	143	72	63
11	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	30	21	130	121	114	105	34	25	134	125	118	109
12	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	12	3	176	167	96	87	16	7	KV1	171	100	91
13	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	58	49	158	149	78	69	KV0	53	162	153	82	73
14	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	40	31	140	131	60	115	44	35	144	135	64	119
15	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	22	13	122	177	106	97	26	17	126	KV1	110	101
16	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	4	59	168	159	88	79	8	KV0	172	163	92	83
17	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	50	41	150	141	70	61	54	45	154	145	74	65
18	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	32	23	132	123	116	107	36	27	136	127	KV1	111
19	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	14	5	178	169	98	89	18	9	KV0	173	102	93
20	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	KV1	51	160	151	80	71	0	55	164	155	84	75
21	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	42	33	142	133	62	117	46	37	146	137	66	KV1
22	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	24	15	124	179	108	99	28	19	128	KV0	112	103
23	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	6	KV1	170	161	90	81	10	1	174	165	94	85
24	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	52	43	152	143	72	63	56	47	156	147	76	67
25	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	34	25	134	125	118	109	38	29	138	129	KV0	113
26	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	16	7	KV1	171	100	91	20	11	120	175	104	95
27	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	KV0	53	162	153	82	73	2	57	166	157	86	77
28	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	44	35	144	135	64	119	48	39	148	139	68	KV0
29	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	26	17	126	KV1	110	101	30	21	130	121	114	105
30	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	8	KV0	172	163	92	83	12	3	176	167	96	87
31	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	54	45	154	145	74	65	58	49	158	149	78	69

Note 1. – Columns 241 and 242 have the same distribution as column 240, columns 245 and 246 the same as 244, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIIf – *Intrasector shuffle memory map for sub-array 5*

Jgrp:	75		76		77		78		79		80		81		82		83		84		85		86		87		88		89	
Igrp:	75		86		97		108		119		130		141		2		13		24		35		46		57		68		79	
Line:	25		28		32		36		39		43		47		0		4		8		11		15		19		22		26	
Col:	300	303	304	307	308	311	312	315	316	319	320	323	324	327	328	331	332	335	336	339	340	343	344	347	348	351	352	355	356	359
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	10	15	20	25	30	3	8	13	18	23	28	1	6	11	28	1	6	11	16	21	26	31	4	9	14	19	24	29	2	7
Row:																														
0	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
1	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
2	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
3	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
4	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
5	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
6	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
7	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
8	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
9	10	1	174	165	94	85	14	5	178	169	98	89	18	9	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
10	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
11	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
12	20	11	120	175	104	95	24	15	124	179	108	99	28	19	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
13	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
14	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
15	30	21	130	121	114	105	34	25	134	125	118	109	38	29	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
16	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
17	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
18	40	31	140	131	60	115	44	35	144	135	64	119	48	39	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
19	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
20	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
21	50	41	150	141	70	61	54	45	154	145	74	65	58	49	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
22	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
23	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
24	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
25	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
26	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
27	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
28	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
29	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
30	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
31	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65

Note 1. – Columns 301 and 302 have the same distribution as column 300, columns 305 and 306 the same as 304, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIg – *Intrasector shuffle memory map for sub-array 6*

Jgrp:	90		91		92		93		94		95		96		97		98		99		100		101		102		103		104	
Igrp:	90		101		112		123		134		145		6		17		28		39		50		61		72		83		94	
Line:	30		33		37		41		44		48		2		5		9		13		16		20		24		27		31	
Col:	360	363	364	367	368	371	372	375	376	379	380	383	384	387	388	391	392	395	396	399	400	403	404	407	408	411	412	415	416	419
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	12	17	22	27	0	5	10	15	20	25	30	3	20	25	30	3	8	13	18	23	28	1	6	11	16	21	26	31	4	9
Row:																														
0	40	31	140	131	60	115	44	35	144	135	64	119	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
1	22	13	122	177	106	97	26	17	126	KV1	110	101	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
2	4	59	168	159	88	79	8	KV0	172	163	92	83	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
3	50	41	150	141	70	61	54	45	154	145	74	65	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
4	32	23	132	123	116	107	36	27	136	127	KV1	111	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
5	14	5	178	169	98	89	18	9	KV0	173	102	93	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
6	KV1	51	160	151	80	71	0	55	164	155	84	75	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
7	42	33	142	133	62	117	46	37	146	137	66	KV1	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
8	24	15	124	179	108	99	28	19	128	KV0	112	103	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
9	6	KV1	170	161	90	81	10	1	174	165	94	85	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
10	52	43	152	143	72	63	56	47	156	147	76	67	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
11	34	25	134	125	118	109	38	29	138	129	KV0	113	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
12	16	7	KV1	171	100	91	20	11	120	175	104	95	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
13	KV0	53	162	153	82	73	2	57	166	157	86	77	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
14	44	35	144	135	64	119	48	39	148	139	68	KV0	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
15	26	17	126	KV1	110	101	30	21	130	121	114	105	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
16	8	KV0	172	163	92	83	12	3	176	167	96	87	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
17	54	45	154	145	74	65	58	49	158	149	78	69	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
18	36	27	136	127	KV1	111	40	31	140	131	60	115	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
19	18	9	KV0	173	102	93	22	13	122	177	106	97	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
20	0	55	164	155	84	75	4	59	168	159	88	79	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
21	46	37	146	137	66	KV1	50	41	150	141	70	61	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
22	28	19	128	KV0	112	103	32	23	132	123	116	107	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
23	10	1	174	165	94	85	14	5	178	169	98	89	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
24	56	47	156	147	76	67	KV1	51	160	151	80	71	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
25	38	29	138	129	KV0	113	42	33	142	133	62	117	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
26	20	11	120	175	104	95	24	15	124	179	108	99	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
27	2	57	166	157	86	77	6	KV1	170	161	90	81	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
28	48	39	148	139	68	KV0	52	43	152	143	72	63	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
29	30	21	130	121	114	105	34	25	134	125	118	109	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
30	12	3	176	167	96	87	16	7	KV1	171	100	91	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
31	58	49	158	149	78	69	KV0	53	162	153	82	73	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61

Note 1. – Columns 361 and 362 have the same distribution as column 360, columns 365 and 366 the same as 364, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIh – *Intrasector shuffle memory map for sub-array 7*

Jgrp:	105		106		107		108		109		110		111		112		113		114		115		116		117		118		119	
Igrp:	105		116		127		138		149		10		21		32		43		54		65		76		87		98		109	
Line:	35		38		42		46		49		3		7		10		14		18		21		25		29		32		36	
Col:	420	423	424	427	428	431	432	435	436	439	440	443	444	447	448	451	452	455	456	459	460	463	464	467	468	471	472	475	476	479
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	14	19	24	29	2	7	12	17	22	27	12	17	22	27	0	5	10	15	20	25	30	3	8	13	18	23	28	1	6	11
Row:																														
0	36	27	136	127	KV1	111	40	31	140	131	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
1	18	9	KV0	173	102	93	22	13	122	177	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
2	0	55	164	155	84	75	4	59	168	159	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
3	46	37	146	137	66	KV1	50	41	150	141	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
4	28	19	128	KV0	112	103	32	23	132	123	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
5	10	1	174	165	94	85	14	5	178	169	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
6	56	47	156	147	76	67	KV1	51	160	151	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
7	38	29	138	129	KV0	113	42	33	142	133	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
8	20	11	120	175	104	95	24	15	124	179	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
9	2	57	166	157	86	77	6	KV1	170	161	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
10	48	39	148	139	68	KV0	52	43	152	143	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
11	30	21	130	121	114	105	34	25	134	125	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
12	12	3	176	167	96	87	16	7	KV1	171	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
13	58	49	158	149	78	69	KV0	53	162	153	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
14	40	31	140	131	60	115	44	35	144	135	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
15	22	13	122	177	106	97	26	17	126	KV1	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
16	4	59	168	159	88	79	8	KV0	172	163	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
17	50	41	150	141	70	61	54	45	154	145	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
18	32	23	132	123	116	107	36	27	136	127	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
19	14	5	178	169	98	89	18	9	KV0	173	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
20	KV1	51	160	151	80	71	0	55	164	155	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
21	42	33	142	133	62	117	46	37	146	137	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
22	24	15	124	179	108	99	28	19	128	KV0	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
23	6	KV1	170	161	90	81	10	1	174	165	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
24	52	43	152	143	72	63	56	47	156	147	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
25	34	25	134	125	118	109	38	29	138	129	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
26	16	7	KV1	171	100	91	20	11	120	175	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
27	KV0	53	162	153	82	73	2	57	166	157	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
28	44	35	144	135	64	119	48	39	148	139	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
29	26	17	126	KV1	110	101	30	21	130	121	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
30	8	KV0	172	163	92	83	12	3	176	167	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
31	54	45	154	145	74	65	58	49	158	149	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1

Note 1. – Columns 421 and 422 have the same distribution as column 420, columns 425 and 426 the same as 424, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIi – *Intrasector shuffle memory map for sub-array 8*

Jgrp:	120		121		122		123		124		125		126		127		128		129		130		131		132		133		134	
Igrp:	120		131		142		3		14		25		36		47		58		69		80		91		102		113		124	
Line:	40		43		47		1		4		8		12		15		19		23		26		30		34		37		41	
Col:	480	483	484	487	488	491	492	495	496	499	500	503	504	507	508	511	512	515	516	519	520	523	524	527	528	531	532	535	536	539
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	16	21	26	31	4	9	26	31	4	9	14	19	24	29	2	7	12	17	22	27	0	5	10	15	20	25	30	3	8	13
Row:																														
0	32	23	132	123	116	107	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
1	14	5	178	169	98	89	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
2	KV1	51	160	151	80	71	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
3	42	33	142	133	62	117	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
4	24	15	124	179	108	99	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
5	6	KV1	170	161	90	81	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
6	52	43	152	143	72	63	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
7	34	25	134	125	118	109	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
8	16	7	KV1	171	100	91	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
9	KV0	53	162	153	82	73	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
10	44	35	144	135	64	119	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
11	26	17	126	KV1	110	101	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
12	8	KV0	172	163	92	83	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
13	54	45	154	145	74	65	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
14	36	27	136	127	KV1	111	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
15	18	9	KV0	173	102	93	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
16	0	55	164	155	84	75	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
17	46	37	146	137	66	KV1	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
18	28	19	128	KV0	112	103	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
19	10	1	174	165	94	85	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
20	56	47	156	147	76	67	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
21	38	29	138	129	KV0	113	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
22	20	11	120	175	104	95	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
23	2	57	166	157	86	77	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
24	48	39	148	139	68	KV0	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
25	30	21	130	121	114	105	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
26	12	3	176	167	96	87	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
27	58	49	158	149	78	69	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
28	40	31	140	131	60	115	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
29	22	13	122	177	106	97	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
30	4	59	168	159	88	79	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
31	50	41	150	141	70	61	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117

Note 1. – Columns 481 and 482 have the same distribution as column 480, columns 485 and 486 the same as 484, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV0* and *KV1* are outer ECC check bytes.

TABLE VIIj – *Intrasector shuffle memory map for sub-array 9*

Jgrp:	135		136		137		138		139		140		141		142		143		144		145		146		147		148		149	
Igrp:	135		146		7		18		29		40		51		62		73		84		95		106		117		128		139	
Line:	45		48		2		6		9		13		17		20		24		28		31		35		39		42		46	
Col:	540	543	544	547	548	551	552	555	556	559	560	563	564	567	568	571	572	575	576	579	580	583	584	587	588	591	592	595	596	599
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstart:	18	23	28	1	18	23	28	1	6	11	16	21	26	31	4	9	14	19	24	29	2	7	12	17	22	27	0	5	10	15
Row:																														
0	28	19	128	KV0	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
1	10	1	174	165	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
2	56	47	156	147	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
3	38	29	138	129	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
4	20	11	120	175	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
5	2	57	166	157	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
6	48	39	148	139	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
7	30	21	130	121	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
8	12	3	176	167	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
9	58	49	158	149	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
10	40	31	140	131	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
11	22	13	122	177	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
12	4	59	168	159	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
13	50	41	150	141	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
14	32	23	132	123	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
15	14	5	178	169	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
16	KV1	51	160	151	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
17	42	33	142	133	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
18	24	15	124	179	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
19	6	KV1	170	161	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
20	52	43	152	143	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
21	34	25	134	125	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
22	16	7	KV1	171	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
23	KV0	53	162	153	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
24	44	35	144	135	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
25	26	17	126	KV1	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
26	8	KV0	172	163	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
27	54	45	154	145	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
28	36	27	136	127	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
29	18	9	KV0	173	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
30	0	55	164	155	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
31	46	37	146	137	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113

Note 1. – Columns 541 and 542 have the same distribution as column 540, columns 545 and 546 the same as 544, etc.

Note 2. – Numeric table entries represent horizontal position of byte within TV line. *KV*0 and *KV*1 are outer ECC check bytes.

TABLE VIII

Field	Sectors 0 and 2	Sectors 1 and 3
0	R = Row	R = (16 + Row) mod 32
1	R = (31 − Row) mod 32	R = (15 − Row) mod 32
2	R = (8 + Row) mod 32	R = (24 + Row) mod 32
3	R = (7 − Row) mod 32	R = (23 − Row) mod 32

Let p designate the inner block number on tape,

$0 \leq p \leq 319$.

Let q designate the byte number within an inner block on tape,

$0 \leq q \leq 59$.

Then $p = 10R + \text{int}(\text{Col}/60)$.

$q = \text{Col} \bmod 60$.

The byte at location (Row, Col) in the sector array thus appears at location $60p + q$ on the tape.

The sync. block ident. number written on tape for even p is $(\text{int}(p/2)+3)$ base 14.

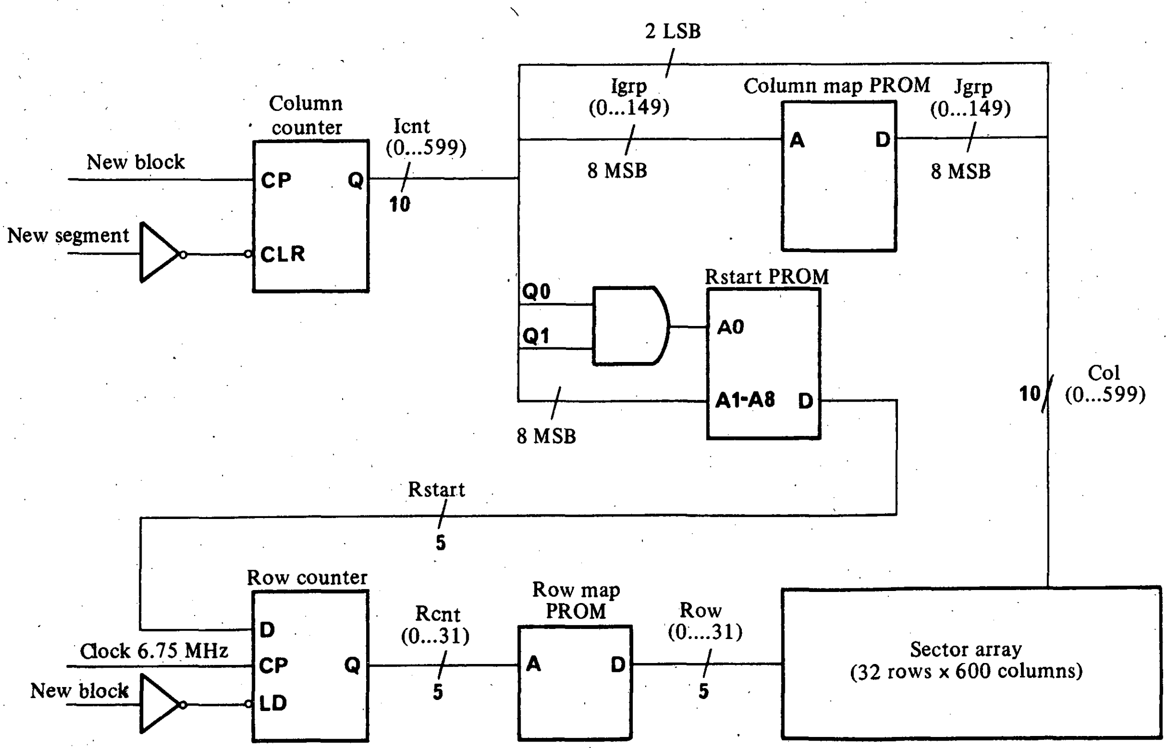


FIGURE 11 – *Block diagram of sector array shuffling*

5.5 *Outer code error protection*

Two rows of each video product block contain the error correction check data associated with each column of 8-bit bytes.

Type:	Reed-Solomon
Galois Field:	GF(256)
Field generator polynomial:	$x^8 \oplus x^4 \oplus x^3 \oplus x^2 \oplus x^0$ (x^i are place-keeping variables in GF(2), the binary field)
Order of use:	Leftmost term is the most significant, "oldest" in time computationally and written first on the tape
Code generator polynomial:	$G(x) = (x \oplus \alpha^0)(x \oplus \alpha^1)$, in GF(256), α^1 is given by 02_H
Check characters:	K_1 and K_0 in $K_1x^1 + K_0x^0$, obtained as the remainder after dividing $x^2 \cdot D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by: $D(x) = B_{29}x^{29} + B_{28}x^{28} + \ldots + B_1x^1 + B_0x^0$
Expression of full code:	$B_{29}x^{31} + B_{28}x^{30} + \ldots + B_0x^2 + K_1x^1 + K_0x^0$.

The following table shows an example of three possible patterns, where pattern 1 is the impulse function, where the values in the check location represent the expansion of the code generator polynomial.

	Data symbols – $D(x)$								Check symbols	
Symbol position	0	1	2	3	4	5	28	29	30	31
Pattern 1	00	00	00	00	00	00	00	01	03	02
Pattern 2	00	01	02	03	04	05	1C	1D	6B	6A
Pattern 3	CC	CC	CC	CC	CC	CC	CC	CC	4D	4D
Symbol identity	B_{29}	B_{28}	B_{27}	B_{26}	B_{25}	B_{24}	B_1	B_0	K_1	K_0

6. Audio processing

6.1 *Introduction*

Audio data to be recorded shall be in accordance with Recommendation 647.

Audio in each of the four channels is processed independently and identically into two product blocks for each channel of dimensions 60 × 7. The audio samples of each channel are distributed alternately into these two blocks and are then shuffled after the addition of error-correction data in the vertical (7) direction. Error correction in the horizontal (60) dimension is common with video data, as is synchronization and channel coding. Control words are multiplexed with the audio data in the product block to provide housekeeping in the interface and in processing.

6.2 *Source coding*

Audio records are formed independently for each of the four audio channels, from audio and ancillary data at the input interface. This data includes audio data, channel status data (C), user data (U) and validity data (V). Parity bits are checked for correctness of data and then discarded. The resulting bit positions in the audio data word are reserved (R) for future use. Block sync marks for ancillary data are also processed.

6.3 *Source processing*

6.3.1 *Introduction*

Audio data is processed in segments corresponding in duration to four helical tracks. Each segment contains approximately 320 audio samples for an audio channel with associated status, user and validity data. In addition, a number of control and user words are added to the data in the last complete block received.

6.3.2 *Segment*

Each segment of audio data is processed into two audio blocks of dimensions 10 × 60 bytes, each corresponding to a sector. One block contains even numbered words and the other odd numbered words. The data portion of the block is 7 × 60 bytes with the remainder being outer error correction words. For convenience, data is processed in 4-bit words.

Audio data words: 318 to 322 data words with associated C, U, V, R bits (20 bits total per word)

Interface control words: six words of 4 bits and two words of 8 bits. (For security, one word, LNGH, is written four times in each block)

Processor control words: nine words of 4 bits. (For security, two words, B CNT and SEQN, are written four times in each block)

User control words: eight words of 8 bits are included in each block, giving a total of 16 bytes per segment for user data

6.3.3 *Audio data word processing*

Input data is formed into words of 20 bits in the following sequence:

(a) assignment of the 20-bit word to audio and associated data is controlled by user input as follows:

TABLE IX

Word mode	Bit				
	0	1	2	3	4 to 19
0 (000)	C	U	V	R	Audio 0 - 15
1 (001)	C	U	V	Audio 0 (LSB)	Audio 1 - 16
2 (010)	C	V	Audio 0 (LSB)	Audio 1	Audio 2 - 17
3 (011)	C	U	Audio 0 (LSB)	Audio 1	Audio 2 - 17
4 (100)	C	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3 - 18
5 (101)	V	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3 - 18
6 (110)	U	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3 - 18
7 (111)	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3	Audio 4 - 19

Note. – Modes 0, 3 and 7 are the recommended modes for general use.

The most significant bit of the audio word is bit 19 and unused bits of lower significance are removed. The interface control word (ICW) LNGH (4 bits) signals the word mode selected;

(b) the 20-bit words formed as in (a) above are separated into two groups by selection of alternate words into EVEN (0, 2, 4, etc.) and ODD (1, 3, 5, etc.) beginning at the start of the sequence;

(c) each group of 20-bit words is divided into 8-bit bytes as shown in Fig. 12 beginning with the LSB of the first word of the word group;

(d) each group (ODD or EVEN) is distributed into the product block in accordance with Fig. 13, words 159 (bytes 9, 55; 9, 56; 9, 57) and 160 (bytes 3, 55; 3, 56; 3, 57) may not be present in all blocks dependent on the current relationship between video and audio clock synchronization and phasing. When not used, this space is zero filled. The processing control word (PCW) B CNT specifies the length of the block between 397½ bytes (159 audio data words) and 402½ bytes (161 audio data words);

(e) in the case where audio data is synchronous with a 29.97 Hz video frame frequency, (525-line systems), the sequence of blocks is as follows:

TABLE X

Frame No.	Segment No.	Audio sample count		
		Even block	Odd block	Frame
0	00	160	160	1602
	01	161	160	
	02	160	160	
	03	161	160	
	04	160	160	
1	05	160	160	1601
	06	160	160	
	07	161	160	
	08	160	160	
	09	160	160	
2	0A	160	160	1602
	0B	161	160	
	0C	160	160	
	0D	161	160	
	0E	160	160	
3	0F	160	160	1601
	10	160	160	
	11	161	160	
	12	160	160	
	13	160	160	
4	14	160	160	1602
	15	161	160	
	16	160	160	
	17	161	160	
	18	160	160	

The start of audio frame 0 is related to the control track reference pulse described in § 7.

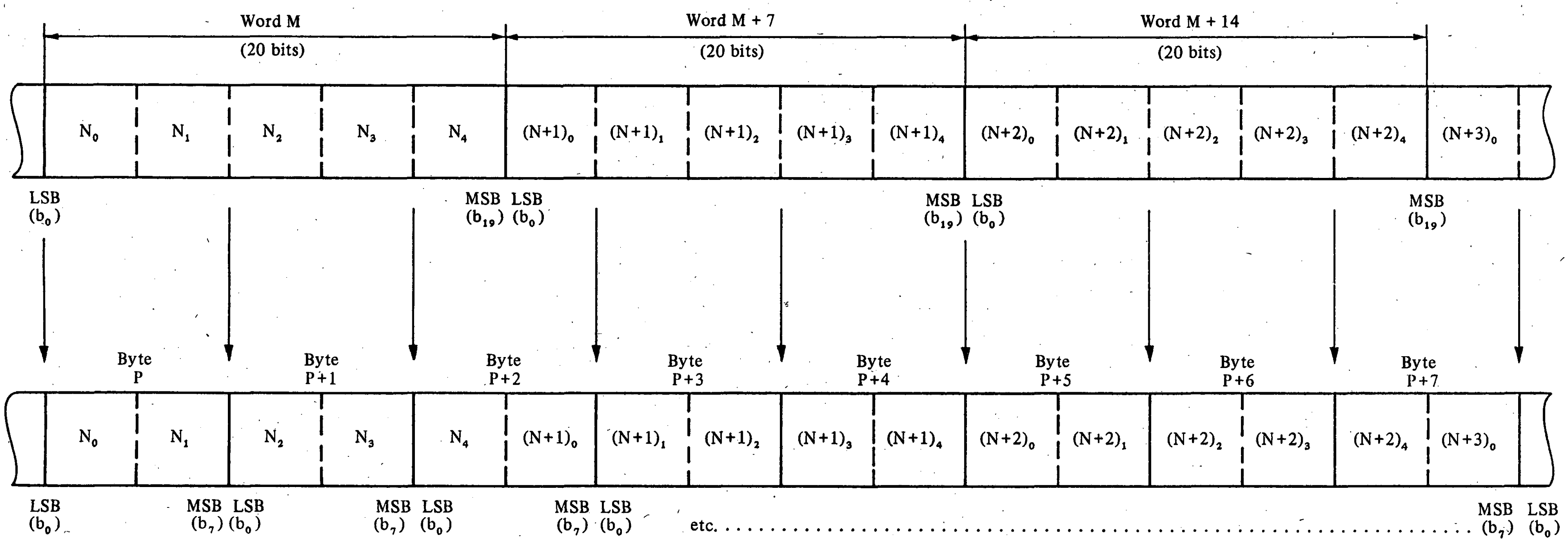


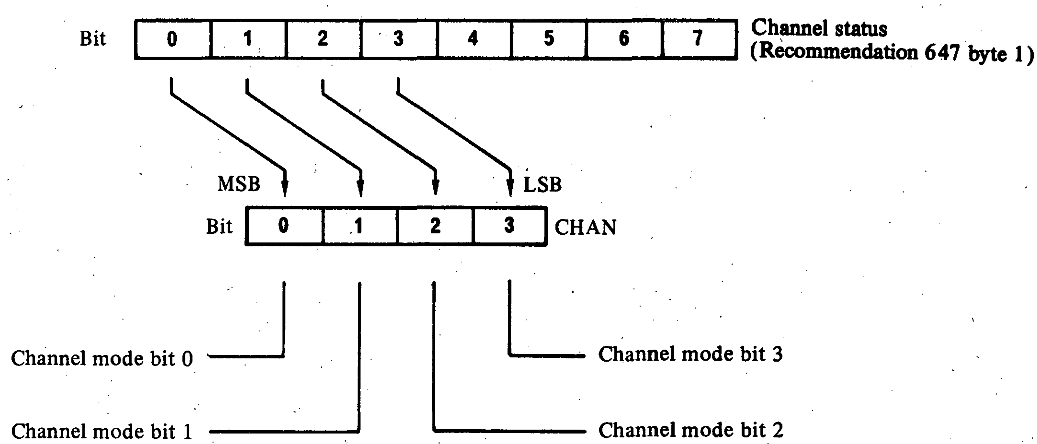
FIGURE 12 – *Word to byte conversion digital audio*

6.4 *Interface control words*

Interface control words (ICW) are generated at the input interface from incoming data or by user selection and serve to signal this information to the output interface. ICWs have a length of 4 or 8 bits.

6.4.1 *Channel use (CHAN) – 4 bits*

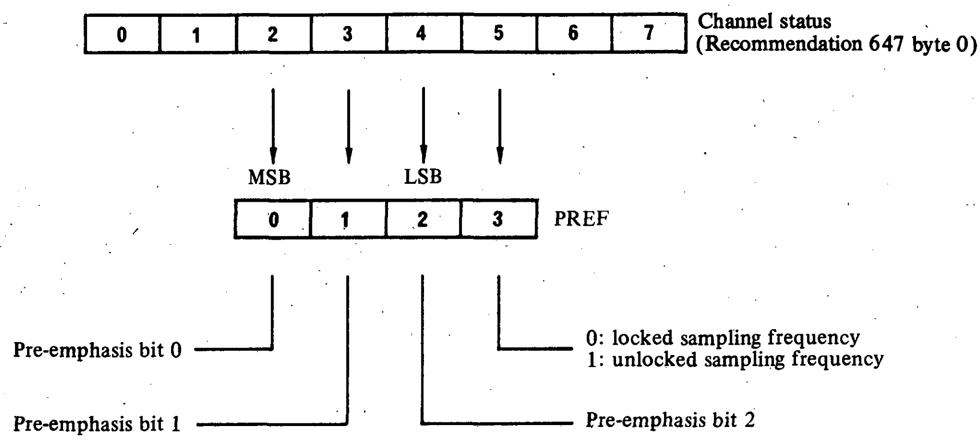
Specifies the usage of the two input channels in an interface data stream. CHAN is derived from channel status byte 1. CHAN is inserted in bits 4 to 7 of byte (1, 57) of both audio product blocks.



Mode	CHAN				Value
	0	1	2	3	
0	0	0	0	0	2 channel – default
1	0	0	0	1	2 channel
2	0	0	1	0	Single channel
3	0	0	1	1	Primary/secondary 2 channel
4	0	1	0	0	Stereophonic
5	0	1	0	1	Undefined
Through	Through				Undefined
F	1	1	1	1	Undefined

6.4.2 *Pre-emphasis (PREF) – 4 bits*

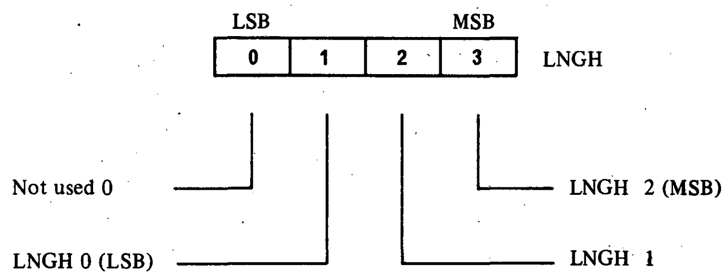
Specifies the usage of pre-emphasis in the audio coding. PREF is derived from channel status byte 0. PREF is inserted in bits 4 to 7 of byte (3, 57) of both audio product blocks.



Mode	PREF bit			Value
	0	1	2	
0	0	0	0	Pre-emphasis off (default)
1	0	0	1	Reserved
2	0	1	0	Reserved
3	0	1	1	Reserved
4	1	0	0	Pre-emphasis off
5	1	0	1	Reserved
6	1	1	0	50/15 μs (CD type)
7	1	1	1	CCITT Recommendation J.17: 6.5 dB at 800 Hz

6.4.3 *Audio data word mode (LNGH) – 4 bits*

Specifies the audio word length and the usage of the ancillary bits status, user, and validity. LNGH is derived from user control inputs and is inserted in bits 0 to 3 in column 58, rows 0, 2, 6, 8.



Mode	Bits			Audio length (bits)	Ancillary bits			
	3	2	1		C	U	V	R
0	0	0	0	16	X	X	X	X
1	0	0	1	17	X	X	X	–
2	0	1	0	18	X	–	X	–
3	0	1	1	18	X	X	–	–
4	1	0	0	19	X	–	–	–
5	1	0	1	19	–	–	X	–
6	1	1	0	19	–	X	–	–
7	1	1	1	20	–	–	–	–

6.4.4 *Block sync. location S MARK 0, S MARK 1 – 8 bits*

Specifies the location of the first and last block sync. associated with channel status and user data as defined in § 6 of ANSI Doc. S.4.40-1985 and in the appropriate section of EBU Tech. Doc. 3250.

S MARK 0 contains the word count, in the current block, of the first block sync. detected, i.e. the word address in the ODD or EVEN block pointing to the first sample *after* the block sync. mark. S MARK 1 identifies the last block sync. detected. Where multiple marks are encountered, only the last one will be stored. S MARK 0 is inserted in byte (1, 58) of each block, with the default value AA_H placed in the corresponding location in the block (ODD or EVEN) not containing the mark. S MARK 1 is inserted similarly in byte (9, 58).

LSB							MSB	
0	1	2	3	4	5	6	7	S MARK 0 S MARK 1

$00_H \leqslant$ S MARK $\leqslant A1_H$

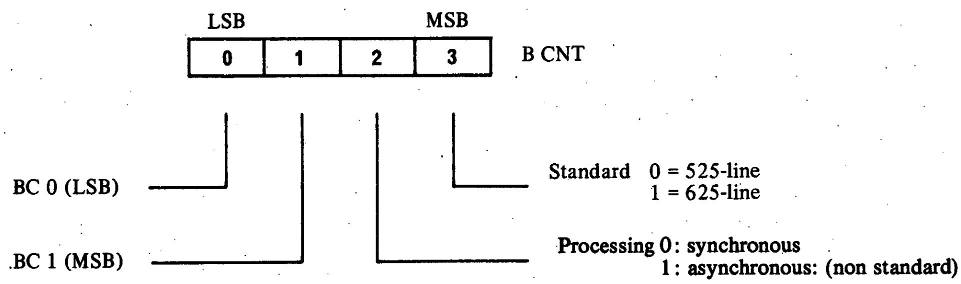
S MARK $= AA_H$ if no mark is found within the defined range.

6.5 *Processing control words*

Processing control words (PCW) are employed to pass control information from the record processor to the play-back processor. They consist of 4-bit or 8-bit words.

6.5.1 *Word count (B CNT) – 4 bits*

Specifies the number of useful data words in the current block, a number lying between 159 and 161 words (397.5 to 402.5 bytes). B CNT is inserted in bits 4 to 7 of bytes (0, 57), (2, 57), (6, 57), (8, 57) of the associated block.



Data length	Bit	
	1	0
159 words	0	1
160 words	0	0
161 words	1	0
Illegal	1	1

6.5.2 *Overlap edit (E LAP) – 4 bits*

Specifies the segment associated with an overlapped edit transition, during which time the new (downstream) audio data replaces the old (upstream) audio data only in the duplicate audio sector rows 2 and 3. E LAP is inserted in bits 4 to 7 of byte (9, 57) of both blocks.

LSB			MSB	
0	1	2	3	E LAP

E LAP = F_H for an overlap segment

E LAP = 0_H otherwise

6.5.3 *Sequence (SEQN) – 4 bits*

Specifies a sequence of 15 blocks (each of 4 fields) to aid processing in high-speed data recovery. SEQN advances in binary count, modulo 15 from an arbitrary origin and is inserted in bits 4 to 7 of column 58 in rows 0, 2, 6, 8. SEQN may be discontinuous after editing operations.

LSB			MSB	
0	1	2	3	SEQN

6.6 *User control words*

User control words (UCW) serve to pass user information from the record processor to the play-back processor. They are of 8-bit length. Their contents are not specified herein. UCWs are provided as follows:

TABLE XI

UCW	Block	Byte
0	EVEN	(3, 58)
2	EVEN	(0, 59)
4	EVEN	(8, 59)
6	EVEN	(2, 59)
8	EVEN	(6, 59)
10	EVEN	(1, 59)
12	EVEN	(9, 59)
14	EVEN	(3, 59)
1	ODD	(3, 58)
3	ODD	(0, 59)
5	ODD	(8, 59)
7	ODD	(2, 59)
9	ODD	(6, 59)
11	ODD	(1, 59)
13	ODD	(9, 59)
15	ODD	(3, 59)

6.7 *Outer error protection*

Rows 4, 5, 7 of the blocks contain the error-protection data associated with each column.

Type:	Reed-Solomon
Galois Field:	GF(16)
Field generator polynomial:	$x^4 \oplus x^1 \oplus x^0$ (x^i are place-keeping variables in GF(2), the binary field)
Order of use:	Leftmost term is the most significant, "oldest" in time computationally and written first on the tape
Code generator polynomial:	$G(x) = (x \oplus \alpha^0)(x \oplus \alpha^1)(x \oplus \alpha^2)$ in GF(16), α^1 is given by 02_H
Check characters:	K_2, K_1, K_0 (identified respectively as PV_2, PV_1, PV_0) in $K_2x^2 + K_1x^1 + K_0x^0$, the remainder after dividing the polynomial $x^3 \cdot D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by: $D(x) = B_6x^6 + B_5x^5 + \ldots + B_1x^1 + B_0x^0$
Expression of full code:	$B_6x^9 + B_5x^8 + \ldots + B_0x^3 + K_2x^2 + K_1x^1 + K_0x^0$

Outer-code check characters in each column of the 60 × 10 blocks are calculated using the data order existing prior to the rearrangement into the pattern shown in Fig. 13, i.e. in ascending sample order.

The check characters K_2 to K_0 are used as the vertical protection characters PV_2 to PV_0 respectively and inserted in their associated column at rows 4, 5, 7.

The following table shows an example of three possible patterns, where pattern 1 is the impulse function, where the values in the check locations represent the expansion of the code generator polynomial.

	Data symbols – $D(x)$							Check symbols		
Symbol position	0	1	2	3	4	5	6	7	8	9
Pattern 1	0	0	0	0	0	0	1	7	E	8
Pattern 2	0	1	2	3	4	5	6	B	0	C
Pattern 3	C	C	C	C	C	C	C	6	9	3
Symbol identity	B_6	B_5	B_4	B_3	B_2	B_1	B_0	K_2	K_1	K_0

6.8 *Inner protection and channel coding*

The generation of the inner code check characters PH_0 to PH_3 is fully described in § 4 of this specification, as this coding is common with the video processor.

6.9 *Order of transmission to inner coding*

The block of data shown in Fig. 13 is passed sequentially to the inner coding process in the order:

Row 0 – col 0 to 59
Row 1 – col 0 to 59
Row 2 – col 0 to 59
Row 3 – col 0 to 59
Row 4 – col 0 to 59
Row 5 – col 0 to 59
Row 6 – col 0 to 59
Row 7 – col 0 to 59
Row 8 – col 0 to 59
Row 9 – col 0 to 59

6.10 *Sector usage*

Audio data from each of the four recording channels is placed on tape as shown in Fig. 14. Each data block (ODD and EVEN) from a channel (1, 2, 3, 4) is recorded twice. During the overlap period of an edit, the new data is recorded only in audio sector rows 2 and 3 and the existing data is retained in audio sector rows 0 and 1.

7. Tracking control record

7.1 The tracking control record shall be a series of double pulses recorded on the track as shown in Fig. 15. The location of the tracking control record is defined in § 3.

7.2 During the time interval A of the record, the polarity of the tracking-control flux shall be such that the South poles of the magnetic domain should point in the direction of normal tape travel and similarly during time interval B the North pole shall be thus oriented.

7.3 The peak recorded flux level shall be 185 ± 20 nWb/m of track width. The residual peak flux level from any previous recording shall be more than 30 dB below the peak flux level of the specified recording.

7.4 The recorded pulse doublets shall each have a half-width T, where T is 1/64 times the period of four helical tracks. The record current rise and fall times shall be less than 15 µs (10 to 90%), and be matched within 5 µs.

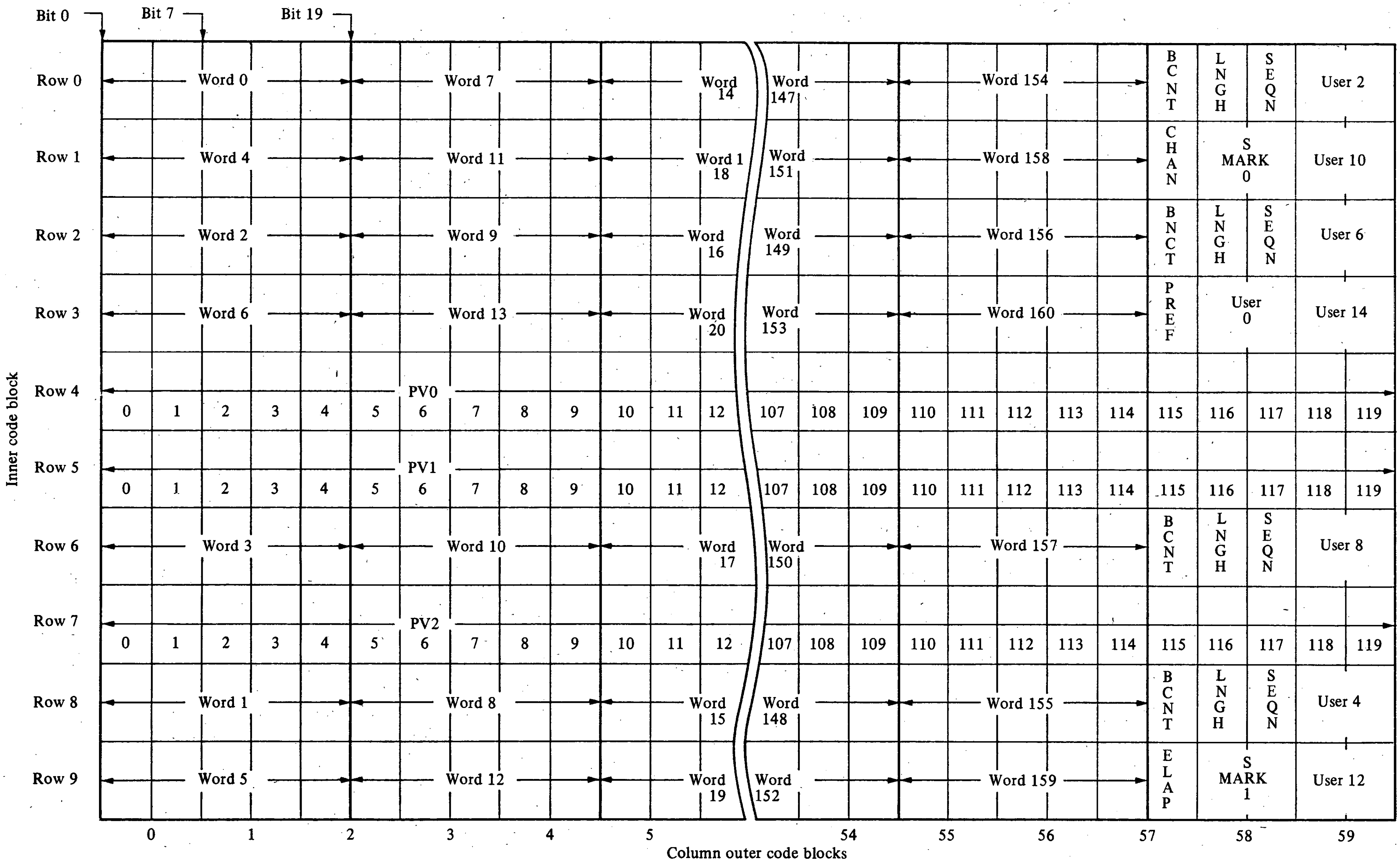


FIGURE 13 – *Audio data block layout*

(Even block shown – odd is similar)

Note 1. – Words 159, 160 may not be data filled in all blocks.

Note 2. – Words 0, 1, 2, 3 ... refer to a sequence of even audio data words in an even audio product block, and corresponding to the odd audio data words in an odd audio product block.

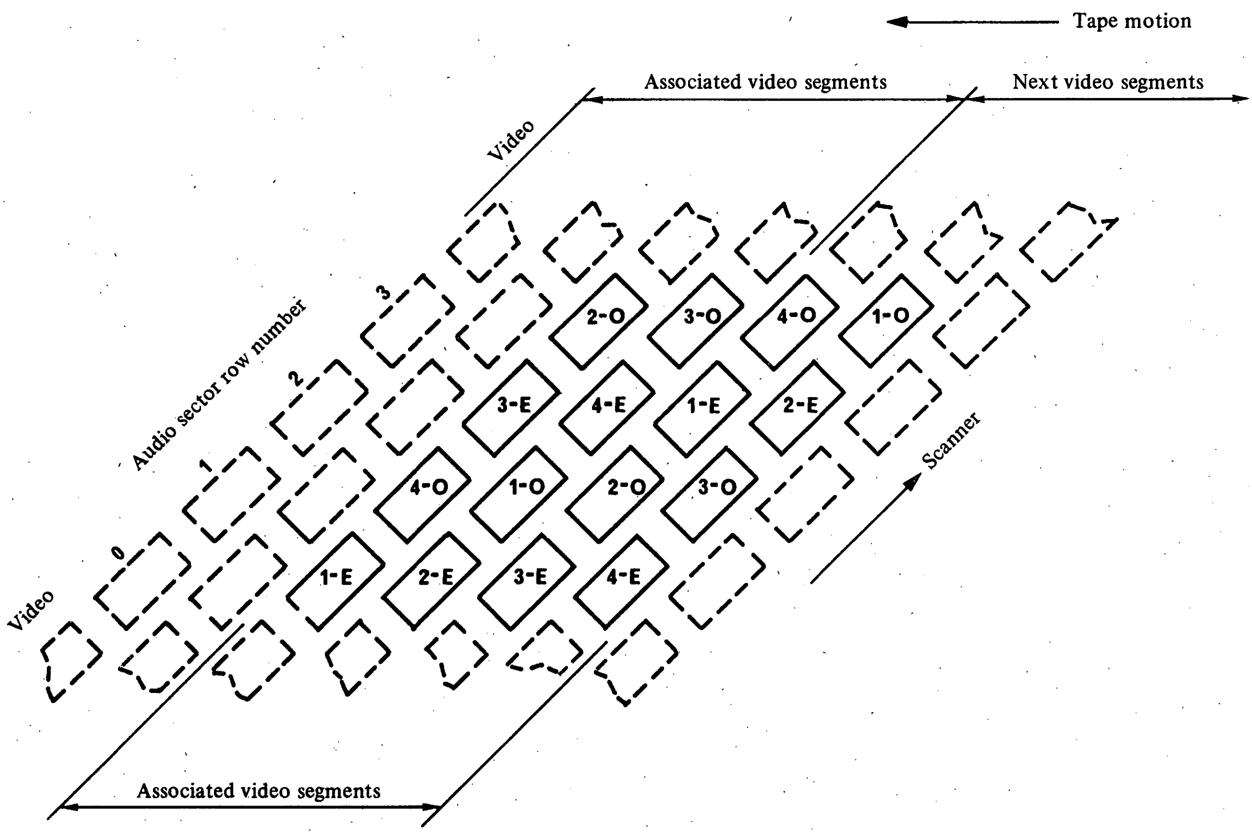


FIGURE 14 – *Audio sector arrangement*

Note. – 1, 2, 3, 4, indicate channel numbers
O: ODD samples
E: EVEN samples

7.5 Servo reference pulse doublets shall be separated by a pitch distance equivalent to four helical tracks (150 Hz nominal frequency). They are aligned with the end of the preamble for video sector 0, as shown in § 3.

7.6 A second pulse doublet shall indicate the first segment of the video frame. It shall be located at a distance $4T$ after the servo reference pulse doublet that occurs in segment 0, field 0. (The video frame begins when $F = 0$ in the EAV (end of active video) timing reference signal, as shown in Recommendation 656, Part I.)

7.7 In 525 systems only, a third pulse doublet shall, when present, indicate the start of a five-frame audio sequence (see § 6.3.3 (e) of this Recommendation). It shall be located at a distance $8T$ after the servo reference pulse doublet.

7.8 A fourth pulse doublet shall indicate the start of a frame sequence. It shall be located at a distance $12T$ after the servo reference pulse doublet. This pulse may be referenced to an external signal to indicate the colour frame sequence of a decoded composite signal.

7.9 Any edit shall take place in the unmagnetized space between pulse groups.

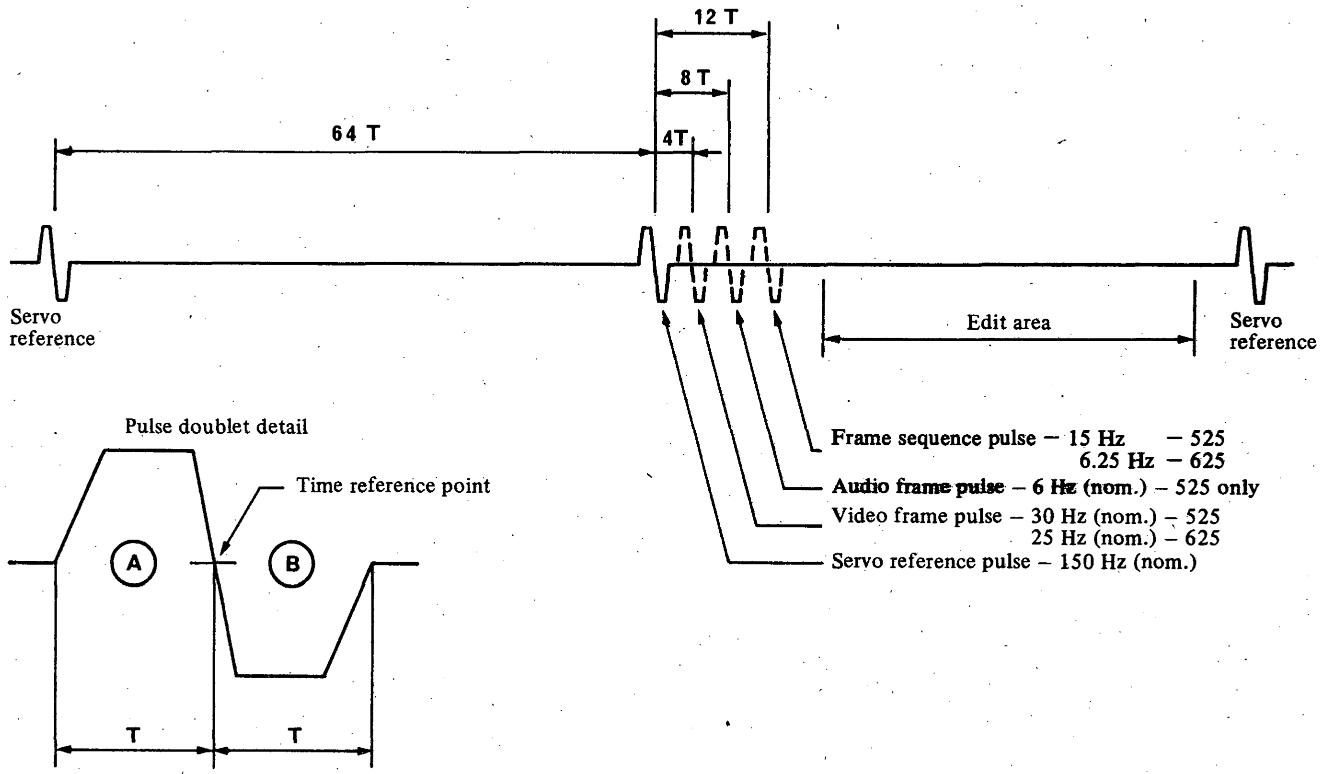


FIGURE 15 – *Tracking control record signal (Waveform and timing)*

Note 1. – T is 1/64 the period of 4 helical track (i.e. 1 video segment).
T = 104 μs (nom.).

Note 2. – Rise/fall time of pulse doublet is < 15 μs.

8. Cue audio track

8.1 *Method of recording*

The signals on this track shall be recorded using the anhysteretic (a.c. bias) method.

8.2 *Flux level*

The recorded reference audio level shall correspond to an r.m.s. magnetic short-circuit flux level of 70 ± 10 nWb/m of track width at 1000 Hz.

8.3 *Recorded flux characteristic*

When a tape is recorded from a constant voltage level applied to the input terminals of the recording system, the recorded short circuit tape flux level versus frequency shall be constant.

8.4 *Reproducer flux/frequency response*

When a tape record having a short circuit tape flux level versus frequency given in § 8.3 is reproduced, the output voltage level of the reproducer versus frequency shall be constant.

8.5 *Relative timing*

Cue audio information shall be recorded on tape at a point referenced to the associated video information as defined by dimension P (§ 3.5.3, Fig. 3) within a tolerance of +0, −2 mm (i.e., cue audio may be up to approximately 100 TV lines early).

9. Time and control code record

9.1 *Content*

Each video frame shall contain a longitudinal time and control code, as specified in IEC Publication 461 (second edition).

9.2 *Method of recording*

The signals shall be recorded using the anhysteresis (a.c. bias) recording method.

9.3 *Flux level*

The recorded peak-to-peak flux shall correspond to an r.m.s. magnetic short-circuit flux level of 185 ± 20 nWb/m of track width.

9.4 *Channel code*

Data shall employ bi-phase mark coding (see Fig. 16).

9.5 *Relative timing*

The location of bit zero of the time code on tape shall be in advance of a distance P ahead of sector zero of field 1 of the associated video data (see Fig. 3).

The time relationship of the start of the time code sync word with respect to the vertical sync pulse of the related video picture shall be as described in IEC Publication 461 (second edition).

The start of the address (the clock edge before the first address bit) shall occur at the beginning of field 1 (625), field 1 or 3 (525), at the beginning of line number 2 (625), number 5 (525), with a tolerance of ± 1 line at the input, and ± 1 line (tentative) at the output of the recorder.

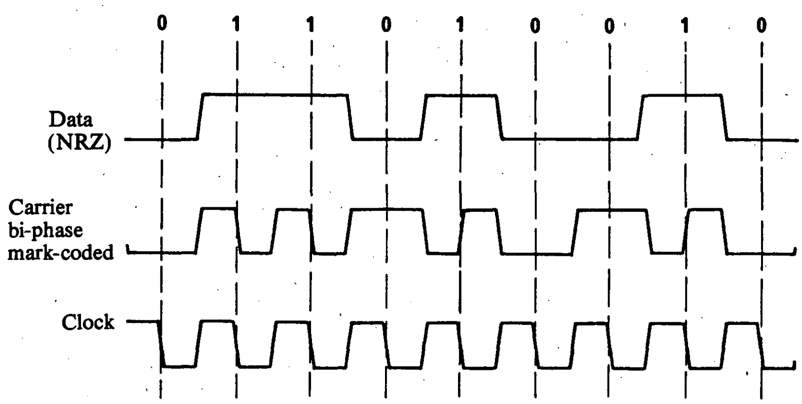
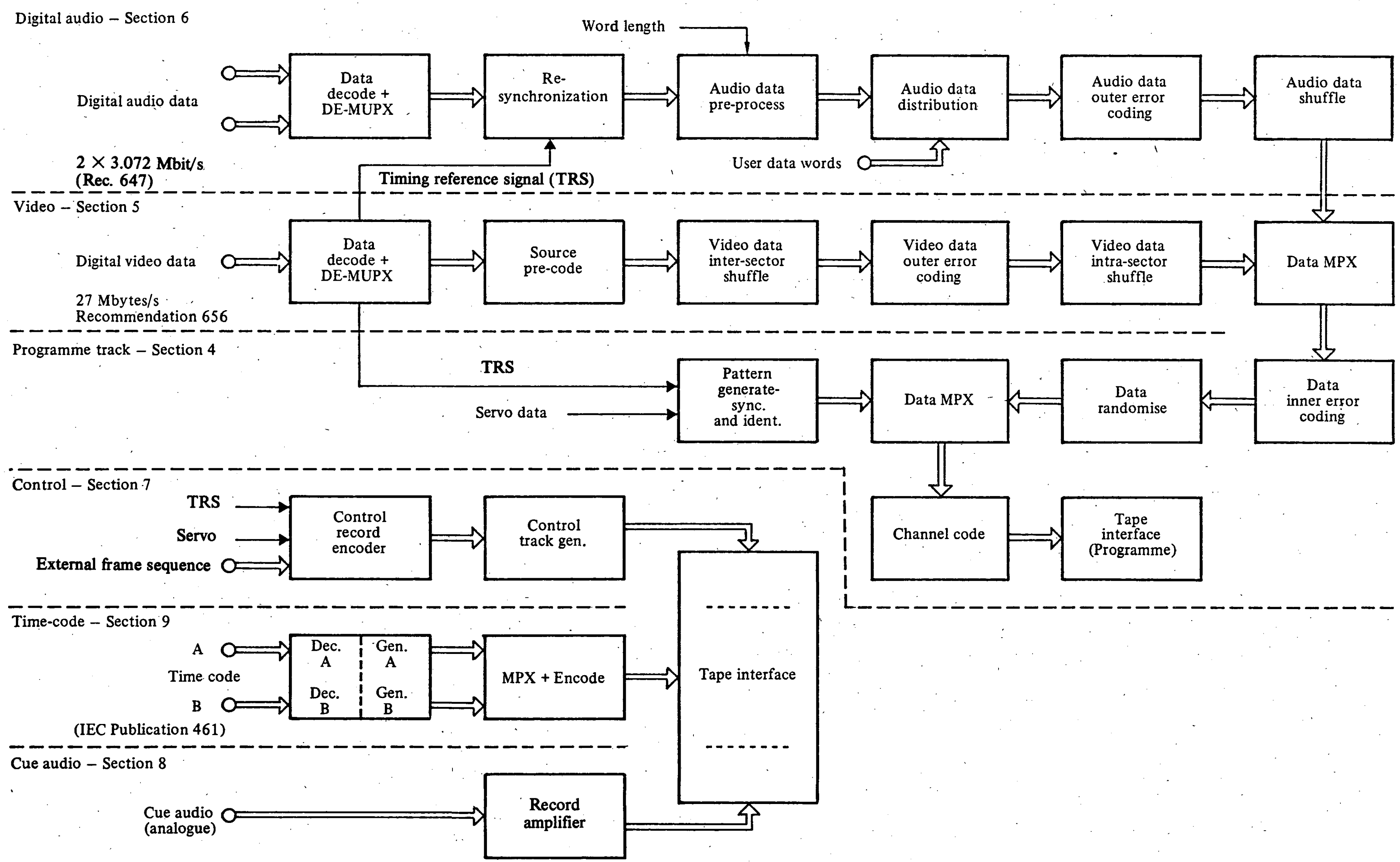


FIGURE 16 – *Bi-phase mark coding*

ANNEX I

FUNCTIONAL BLOCK DIAGRAM 4 : 2 : 2 DIGITAL RECORDER
RECORD PATH PROCESSING



ANNEX II

BASIS FOR THE DIGITAL TELEVISION TAPE RECORDING STANDARD

Introduction

The following text describes the background for the choice of parameters for the digital television tape-recording format specifications given in this Recommendation.

The specifications are based on inputs received by the CCIR from a number of sources and notably from the EBU, the OIRT and the USA, the latter describing work carried out in the SMPTE. The documentation that has provided the basis for this Recommendation is listed in Annex I of [CCIR, 1982-86].

The operating requirements on which the specifications are based were agreed among a majority of users in the bodies above, although some spread of opinions was observed among users.

The technological feasibility and viability of the specified format was confirmed in the same bodies, by means of consultations between the users and the manufacturers.

The following text is structured in several sections, and it parallels to some degree the structure of the main text of this Recommendation.

Section 1 – Users' requirements for digital television tape recorders

Section 2 – Parameters of the tape format

Section 3 – Mechanical characteristics of tape cassettes

Section 4 – Source coding parameters for the digital video and audio signals

Section 5 – Signal processing in the DTTR

Section 6 – Parameters of signals recorded on the longitudinal tracks

Section 7 – Recommended operating practices

Section 8 – Explanation of terms

1. Users' requirements for digital television tape recorders

1.1 *General requirements*

1.1.1 A digital television tape recorder (DTTR) should record digital video signals according to the 4 : 2 : 2 standard specified in Recommendation 601 and 4 digital sound signals according to the standard specified in Recommendation 646 (sampling frequency of 48 kHz and at least 16 bits/sample linear coding). The timing relationship between the 4 digital audio channels should be adequate to permit any combination of 2 channels to be used for stereo pairs.

1.1.2 The DTTR should employ cassettes that will protect the tape from dust and other similar hazards. The cassettes should use reels with two full flanges. There should be a family of cassette sizes that can be used interchangeably in the full studio version DTTR.

1.1.3 The number of different cassette sizes should be kept to a minimum but should be adequate to cover the unique requirements of a series of recorders such as a production/post-production recorder, a portable recorder and a multi-cassette recorder.

The largest cassette size should be adequate to provide 76 min of record/play time with current 16 µm thick tape, so allowing for 94 min with 13 µm thick tape. The medium and small size cassettes should be able to contain 34 min and 11 min respectively, of 16 µm thick tape.

1.1.4 Consideration should be given in the design of DTTRs to the use of these recorders, and their initial application, in an analogue TV studio environment. Optional composite and/or component video analogue inputs and outputs shall be available to meet this need. Similarly, provisions shall be made for optional analogue audio input and output signals.

1.1.5 Two of the longitudinal tracks are user requirements. One track shall be capable of recording audio for use as a cue channel to aid in editing and the other is to be for recording a form of time and control code. They should be independent of the main digital audio and video channels and should be readable at shuttle and search speed over the range 0.1 to 50 times normal speed in both directions.

1.1.6 For the 525-line systems, lines 14 to 263 and 276 to 525 should be recorded and for the 625-line systems, lines 11 to 310 and 324 to 623.

1.1.7 Provision should be made for ancillary data to be included with the video and each of the audio signals; concealment should not be applied during field blanking when ancillary data may be carried.

1.1.8 It would be desirable if a DTTR built for a given level of the family of digital TV standards (see Recommendation 601) were able to handle lower levels (at least, the replay of recordings made at lower levels).

1.2 *Performance parameters in normal play mode*

1.2.1 Assuming no uncorrectable errors due to the record/play-back process, the DTTR should be transparent with regard to the digital inputs as specified in § 1.1.1.

1.2.2 After 10 generations, essentially there should be no perceptible impairment to the audio and video signals, with critical programme material.

1.2.3 After 20 generations, the impairment should preferably not exceed 1/2 grade and certainly not exceed 1 grade of the 5-grade CCIR impairment scale. For further generations, the increase in impairment should be gradual.

1.2.4 The analogue editing audio channel should provide a bandwidth of the order of 10 kHz.

1.2.5 The accuracy of the recording and the replay of the digital audio and video information should be adequate to ensure that after 10 video and/or audio edits, or 10 video and/or audio generations, the accumulated relative timing error at any stage will be less than 40 ms.

1.2.6 The output time and control code signal on the longitudinal time and control track shall have a maximum timing error on interchange of ± 1 ms with respect to the output video.

1.3 *Operational requirements*

The DTTR format shall offer the possibility of the same operational features and editing flexibility as the most advanced present-day recorders. In this respect, the most sophisticated production/post-production recorder shall be capable of at least the following features:

1.3.1 *General features*

- Broadcastable pictures at continuously variable speeds from about minus two times through still frame to about three times normal playing speed.
- Full quality picture and sound over a range of about 90% to 110% of normal playing speed. Audio should be full quality but not correct pitch unless an optional feature is fitted.
- Recognizable pictures at speeds from 0 to 20 times normal playing speed in both directions. The digital audio recovered in this mode shall have recognizable content and would have minimal change in pitch.
- Shuttle speeds from 20 to 50 times normal playing speed in both directions with major scene changes perceptible.
- Fully locked picture and sound in less than 1 s from standby (slack tape and head spinning) mode and instant start from still frame.
- It is a desirable option that video/audio simultaneous record/replay be available for confidence in record checking.
- It is desirable that the transport provide switchable 525/625 operation.
- Variable forward and reverse broadcastable fast motion up to a maximum of 6 times normal speed would be desirable.

1.3.2 *Additional editing features*

- Video editing with single field resolution and a minimum duration of one field.
- Insert and assemble modes.
- Independent editing of all channels (video, each of the four digital audios, analogue editing audio, longitudinal time code) and any combination of audio and video split edits in the same pass.
- Transfer of audio from any audio channel to any other with no delay introduced.
- An option is required that permits extracting the play-back audio digital bit streams from the DTTR in advance to compensate for external processing delays and re-recording it on an audio channel maintaining the original timing relationship.
- Video time code usable up to about 20 times normal playing speed in either direction.

- Operation by remote control using a standard machine control interface, such as the ES bus system developed by the SMPTE and EBU (EBU Document Tech. 3245 and Supplements).

- Digital audio editing with better than 6.7 ms resolution, with one field minimum insert duration and with overlap transitions of not less than 4 ms for the simplest recorder. For recorders with audio read-modify-write capability, the overlap duration should be adjustable to accommodate programme characteristics (4 to 50 ms).

1.4 *Other requirements*

1.4.1 The DTTR should be highly reliable and easy to operate.

Operating requirements are as follows:

- the DTTR should be designed to be operated by non-technical personnel with minimal training;
- the alignment controls required for routine operations should be minimum;
- the DTTR should operate reliably even in rather poorly controlled environmental conditions.

1.4.2 The DTTR should be easy to maintain. Maintenance requirements are as follows:

- the DTTR should be modular in concept to ease the identification of failed modules and to minimize the amount of realignment necessary after the replacement of a module;

- the DTTR should have indications to advise the operator (when possible) of out-of-limit conditions that could signify imminent failure; an example of this might be an abrupt increase in raw error rate.

- indicators should be provided to indicate a failure condition to advise the operator and maintenance personnel of the action to be taken, self-diagnostic or test routines should be provided to aid in isolating the failed module;

- the design of modules should be such that users can conveniently locate and replace failed components.

2. Parameters of the tape format

2.1 *Basic assumptions*

The track configuration described in this Recommendation was based on a number of assumptions and on the needs of users. The assumptions were that:

- the magnetic coating would be of the improved metal oxide type;

- on such a coating, the minimum recorded wavelength would be 0.9 μm;

- one wavelength would correspond to the recording of two bits;

- the number of lines recorded per television field would be 250 in the 525-line system and 300 in the 625-line system;

- the DTTRs would be of the helical-scan type;

- the total bit rate (corresponding to the video and audio signals together, recorded on the programme track with the appropriate protection, and the edit space between them) would be 227 Mbit/s;

- there would be a ratio of 5/6 between the number of tracks per field in 525 and 625-line systems (this assumption, implemented in conjunction with the previous assumptions, aims at allowing the common use, in 525 and 625-line DTTRs, of as high a number of elements as possible);

- the recording of one television field would be carried out on a total of 10 tracks in the 525-line system and 12 tracks in the 625-line system;

- the tape would be packaged in a cassette for programmes of at least one hour; the extension of the duration to one and a half hours would be foreseen.

Some of these assumptions were based on preliminary feasibility studies, and are briefly described below; others were arrived at, as optimal compromises, in the course of the definition of the recording standard.

2.2 *Choice of helical scan recording*

The high bit rate to be recorded on tape requires a very high writing speed; the data rate exceeds 200 Mbit/s, when unnecessary redundancy is removed, but necessary auxiliary and error protection signals are added. The application of some sort of multi-channel recording with stationary heads was considered inadequate, and therefore a system using rotary heads was the obvious choice. Previous experience of that kind of recorder has shown the major positive advantages of helical recording which was accordingly selected.

2.3 *Choice of the magnetic material*

Some theoretical studies, and practical experiments, have shown that metal particles, and more particularly metal evaporated tapes, can offer higher packing densities, than conventional oxide ones. Extensive research and development in the field of "metal" tapes is under way, but it seemed inadvisable to base the standardization on tape technology which has not been proven; improved oxide tapes were the logical choice. It was found that a viable full quality professional digital video tape recorder is achievable with present technology, and that the advent of "metal" tapes in the future may offer an increase of the operational security margin.

2.4 *Choice of the minimum recorded wavelength*

At the beginning of the standardization process it seemed that 1 µm was the smallest practical value for the shortest wavelength to be recorded. It was also known that video heads could be manufactured for shorter wavelengths, and that these wavelengths offered better packing densities, although at shorter wavelengths the effects caused by drop-outs became more critical. Considerations of overall reliability led to the adoption of a value of 0.9 µm for the shortest wavelength.

2.5 *Choice of the video tape width*

One of the major issues was the tape width. Initially it was assumed that the optimum width would be 1 inch (25.4 mm), but it soon became evident that other dimensions were also practicable, and in some aspects perhaps even more suitable.

Eventually the discussion centred on the selection between 25.4 and 19 mm wide tapes. The final choice was based on the assessment of such critical parameters as:

- cassette playing time;
- guidability of the tape;
- forces involved at different points of the tape path;
- aspects of the portable DTTR;
- search time.

The longest cassettes were expected to offer 94 min playing time with 13 µm thick tape, and consequently 76 min with 16 µm thick tape. When a comparison was made between the dimensions of the cassettes for 25.4 mm and 19 mm tape width, it was found that differences in size, volume and weight were finely balanced and did not significantly favour any of the two proposed tape widths. However, the assessment of the behaviour of the two tapes on the machine transport indicated some important differences. The mechanical analysis showed that for a given thickness of tape, the guidability of the tape and the mechanical forces at some critical points on the tape path depend on tape width, and that a narrower tape offers advantages which become more significant when the tape thickness is reduced.

The penalties of adopting the narrower tape were judged of negligible significance to broadcasters but the advantages of the narrower tape, which could result in the same mechanism being usable in a range of recorders for a variety of applications, were considered to be significant.

These considerations led to the choice of 19 mm for the tape width.

2.6 *Design of the track pattern*

The track pattern was designed so that it would meet the following requirements:

- recording of the component digital video signal;
- recording of four independent digital programme audio signals;
- recording of a time and control code;
- recording of a control track;
- not to preclude the achievement of a broadcastable picture at speeds other than normal and a recognizable picture at shuttle speed;

- providing a "recognizable" audio at speeds other than normal;
- providing maximum 525/625 equipment commonality.

The final result of the definition of the track pattern is shown in Fig. 1 of this Recommendation.

Three longitudinal tracks are provided, allocated to:
- the tracking control signal;
- the time and control code;
- an analogue "editing" or "cue" audio signal.

The transport for the DTTR employs a helical segmented format for video recording. For reasons of complexity and economics, the programme audio tracks are multiplexed with the video track but in such a way that video and all audio channels can be individually recovered and edited. The channel coding, data rate and format, and packing density, are identical for audio and video. The minimum recorded wavelength is approximately 0.9 µm in a 45 µm track pitch. There are 20 tracks per TV frame in 525 lines (24 in 625 lines) and audio bursts are recorded in duplicate. It was found convenient from error-rate considerations to locate the audio data in the centre of the track. The audio data is written in two different positions in such a way that scratches, head failures and channel failure have a minimum effect. Gaps are provided to allow independent video and audio editing on tape, and it should be noted that each burst contains only audio from a single audio source. The arrangement lends itself also to a number of additional features in editing.

2.7 *Editing*

On-tape editing of video and audio has been stated to be an important feature of the DTTR by the users, who request that each channel be individually editable, to the smallest possible increment. It should be noted that in addition to the editing capabilities of the DTTR itself, the digital recording process enables any data to be transferred to other editing systems (e.g. computer or disc based) processed and returned to the tape with minimum impairment, thereby allowing complex editing, improvements, etc., to be handled very effectively in conjunction with the DTTR.

The format proposed makes provision for several modes of operation:

2.7.1 *Cut edits*

At the edit point, the relevant sectors of the previously recorded programme are replaced by those of the incoming material, by gating in the record circuits during the appropriate time intervals. For video, this is the only envisaged mode and it provides a time increment of one field (but the off tape signals must be kept synchronous with the incoming video at frame rate). For an audio channel, an increment of four tracks (6.7 ms) is established, no processing is involved and the protection of the audio data is not affected. A transient may however be generated due to the very sharp transition between segments in play-back.

2.7.2 *Simple overlap audio edits*

At the beginning of the overlap period, the content of one of the two pairs of audio sectors is replaced by the new data without changing the other pair containing the old data. At the end of the overlap period both bursts are replaced. The new bursts written during the overlap period contain a flag to indicate the overlap. This edit method is very applicable to portable machines due to its basic record-mode simplicity, but audio is somewhat less secure during overlap due to the loss of redundancy. It has an increment of four tracks (6.7 ms).

2.7.3 *Processed overlap audio edits*

More elegant audio editing can be obtained by performing a read-modify-write operation on the audio sectors, using an advanced-read head to ensure that the modified data bursts are returned to the tape at the correct locations. Due to the digital nature of recording, no impairment is introduced by this operation. The resolution of this method of operation is theoretically one sample or 20 µs. The additional complexity to perform edits of this nature will likely limit its application to studio level machines.

3. Mechanical characteristics of tape cassettes

3.1 *The users' requirements*

Outlining their views on the future digital video tape recorder, the users stated that an open reel machine might be acceptable for the "first generation" of digital machines, but that the ultimate goal should be a cassette configuration. The need to protect the tape as much as possible from ambient dust and handling stresses (which could considerably increase the drop-out activity) made the cassette principle the only possible approach for a general purpose digital television tape recorder.

The users also pointed out their expectation that the future digital recorder should become available not only as a studio (or OB) machine, but also as a multi-transport machine for short programme segments, and, in a more distant future, as a portable recorder. In order to provide for all these needs three cassette sizes were selected, and completely mechanically defined:

- small (S);
- medium (M);
- large (L).

3.2 *The design of the cassette*

The starting point of the new family of cassettes was the existing 8 mm cassette design. It was decided that for professional use reels with two flanges were mandatory in the cassette.

The design of a new tape cassette for professional use offered the possibility of implementing some specific features like programmable "holes". Four holes in the base plate of the cassette would be at the manufacturers' disposal and used to indicate features like tape coating material, thickness, etc. Four additional holes on the same plate would be reserved for users, for "record inhibit" and similar functions. The position of the holes should allow their detection when cassettes of different size (S, M and L) are played on the same machine.

Since it is considered that standardization of the mechanical characteristics of cassettes is a task for the IEC rather than the CCIR, the present CCIR Recommendation on digital television tape recording does not go into the details of cassette standardization, but refers the reader to available documentation, pending a formal standard to be issued by the IEC.

4. Source coding parameters for the digital video and audio signals

4.1 *Source coding of the digital video signals*

The starting point for the complete standardization process is the requirement that the DTTR should be able to accept at its input and deliver at its output digital component video signals in full conformity with CCIR Recommendation 601. The interface is in accordance with Recommendation 656.

The DTTR records only 300 lines (625/50) or 250 lines (526/60) per field. Most of these lines carry picture information, but the remainder may carry ancillary data information and in the play-back mode they should not be subject to error concealment techniques which should only be applied to the active picture area. Only 1440 samples of the active line are recorded.

4.2 *Source coding of the digital audio signals*

The audio input and output signals complying with Recommandation 647 are serial data streams which may carry two audio signals (e.g. a stereo pair), each with its own status and user data.

A minimum of two such data streams is required to feed the four channels of the DTTR. However, there may be applications where individual data-streams-per-channel are required, with the second signal in each unused.

The capacity of each data stream corresponds to two 24 bits/48 kHz audio signals, each with a 48 kbit/s status channel and user and housekeeping channel containing, e.g. sample validity, parity and synchronization bits. There may also be some applications where analogue signals are directly encoded at the DTTR and in this case only the audio data will be present.

Four audio connectors, numbered 1 through 4, are provided for the application of individual sound programmes to the four channels of the DTTR. However, connectors 1 and 3 may also be used for stereo pairs.

In the case of monophonic programme sound, this should be carried on digital audio channel number 1.

In the case of stereophonic programme sound, the left and right channels should be carried on digital audio channels numbers 1 and 2, respectively. This stereo pair may be applied through connector 1.

If additional programme sound components are needed, they should be recorded on digital audio channels numbers 3 and 4. If these components are a stereo pair, they may be applied through connector 3.

It is possible to satisfy almost all possible applications and practices, and still preserve the necessary compatibility by selecting eight different modes of organizing the 20-bit audio words obtained by rounding off the original 24-bit words.

In these eight modes the length of the audio word varies from 16 bits (with one status, one user, one validity and one unassigned bit) to 20 bits when only audio data is present (in the case, for example, when the analogue audio is directly encoded at the recorder input). In the play-back mode the audio data are re-formatted into the format of Recommendation 647 so that the output is normally identical to the input signal.

5. Signal processing in the DTTR

5.1 *Outline of the record and play-back processing*

Digital audio data is multiplexed in blocks with video data to obtain a high packing density and to take advantage of the economies of common error correction, heads, read/write amplifiers, clock recovery, etc.

Annex I to this Recommendation shows a conceptual block diagram of the digital treatment of video and audio.

The mechanism of saturation recording on magnetic tape is essentially simple but the signal processing required to use this recording mode in the most efficient way is relatively complex due to the need for effective control of the resulting data errors at the packing density required. On the record side of the DTTR, the processor must assemble blocks of words representing video, audio, status/user data and internal control data, and add to them the necessary redundant words to allow very secure detection of word errors and a good level of error correction, invoking error concealment when correction overflows. The processor must also add the necessary sychronizing information and block identification to allow block recovery and orderly reassembly of the data stream. The data is coded into a recording format which has appropriate spectral characteristics for the actual channel used, and also includes a strong clock recovery capability. In this process, the sequence of video or audio words is shuffled, so that adjacent samples of the input signals are separated and well spaced on the tape. This permits more effective concealment when burst errors occur. Finally, the record processor outputs the data in burst mode to different heads so duplicating the audio blocks on two separate tracks. This additional spatial redundancy greatly improves the probability of successful recovery of the data in the presence of major errors caused by tape scratches or head-clogging and also provides some useful edit features. By the time it is recorded on tape the data has grown by about 290% compared to the original data at the input to the recorder.

To simplify the design of the recorder, part of the error-correction processor and most of the sync. and clock processing, channel coding and read/write logic for the audio channels can be integrated with that of the video channel.

The recovery of the data from the tape is the inverse of the record processer-channel, i.e. decoding, sync. recovery, identity check, error detection, correction and concealment, and demultiplexing into the various streams for the output processor and the internal DTTR controls. While audio or video data can be concealed (interpolated) if uncorrectable errors are detected, such is not the case for status or user data, or for control words and these must be processed differently. The output processor retimes the data and reassembles the original data stream of video samples, audio samples, status, user information and sync. data, and fills the null areas where no data is available such as in the four LSBs of the audio word, dropped in the input round-off. Except for these bits the output signals are a precise copy of the input except during infrequent concealments, consequently numerous generations can be made without the accumulation of impairments.

5.2 *Error control*

Data recovered from the tape is impaired by a number of artifacts added during the record and play-back process:

- random errors due to noise, interference, tracking imperfections;
- burst errors due to head/tape contact failures, tape drop-outs and tape roughness;
- large burst errors due to failures such as tape scratches, head clogging, channel failures.

As the objectives established for the DTTR include an audio quality grade of 4.5 on the CCIR 5-point scale after about 20 generations (i.e after about 20 generations, one-half of a group will be unable to hear any difference compared to the original) errors must be eliminated to a very large degree, and in such a way that the burden placed on the DTTR channels is minimized. A further complication is that the most economical arrangement of the DTTR is achieved if there is a maximum of commonality between the video and audio channel hardware, bearing in mind that the audio represents only 2% of the total data, but requires a final error rate about 100 times better than video. In addition, both the video and audio data are autocorrelated (i.e. there exists an implied relationship beween adjacent samples), and so missing or damaged samples can be replaced by an approximation derived from adjacent samples, while the status, user and control data must be considered random and hence cannot be estimated in the general case. This may result in different error objectives for audio, video, and data in the same data stream. Clearly, error control is a very important factor in the design of the DTTR audio system.

Based on the above considerations and taking into account that:

– the code must provide near-perfect detection of errors;
– the code must add a minimum of overhead;
– the expected error statistics are known;
– commonality of coding of the audio channels with the video channel is desirable;

the choice was made of a Reed-Solomon product code based on a common (60 + 4) bytes inner code in Galois Field 256 (GF 256). The inner code provides the basic protection against short duration random error sources, such as noise or short drop-outs, and enables it to correct these errors. However, the same code should also serve to reliably detect more extensive error sources such as long drop-outs and scratches since these can be suitably processed by the outer code.

The inner code also requires to be active during replaying at shuttle speed. The number of errors is very high in such circumstances and is likely to overload any reasonably complex correction code. Allowance must therefore be made for the use of concealment.

For video, the outer code block size is set at 30 data bytes plus 2 Reed-Solomon check bytes in GF(256) to give a product block which is (60 + 4) by (30 + 2). Ten such product blocks yield the total array having a row dimension of (600 + 40) bytes and the column dimension of 30 bytes with 2 check bytes. During the recording, the inner code blocks are sequentially written on tape, one row at a time. In play-back, the inner code blocks are normally decoded first.

The data corresponding to successive picture elements in the television line, which arrive at the recording heads after being spread into blocks and accompanied by protection data, are recorded on four successive sectors in order to facilitate the protection strategy by distributing the effects of head failure.

In order to deal with error bursts corresponding to extended drops in level, the product code uses the inner code to determine the locations of the drop-out by employing the error detection capability of the inner code. Once the location of the drop-out is found, then the outer (or vertical) code is used to correct the drop-out error. This outer code is, in effect, through the action of the product code, operating on words which have been interleaved to a depth of 600 bytes.

Since the outer code can correct any two rows known to be in error, the maximum correctable drop-out length is 1200 bytes (equivalent to 4.8 mm of track length). Further, the outer code provides for double error correction, and consequently the correction of multiple short bursts, guaranteeing the correction of all double drop-outs up to 600 bytes in length. Multiple bursts beyond two in each product block can be corrected but correction is not guaranteed as it depends on the drop-out lengths and locations.

In order to reduce the effect of uncorrectable drop-outs and scratches which generally run along the length of the tape, and to improve pictures in shuttle, the distribution of video data words in each of the four recording channels is completed by a shuffling along each video sector.

Without shuffling, a scratch or roughness resulting in a large drop-out would be likely to cause, in a part of a picture segment, a simultaneous local loss of information from two of the four heads. In the case of a scratch this would repeat in every picture segment and from field to field. Since an uncorrected error tends to be very much more visible than a concealed error, when the error correction is overloaded the best approach is to conceal all the words that are reasonably suspect.

Concealment can be best achieved when any errored word is well isolated from other words in error. However, the better the isolation, the lower the number of errors that can be concealed. It is necessary, therefore, to arrange, as far as possible, that as the word error rate increases, the errors are spread uniformly and do not cluster in parts of the picture, since this would make error concealment impossible.

The algorithm chosen for the shuffling has the characteristic that as the drop-out length increases so does the density of errors, but the density will always be substantially uniform throughout the affected segment of 50 lines.

Under normal play conditions, concealment will be used relatively infrequently but during shuttle the situation is totally different and the words requiring concealment may exceed the number of correct words. If the loss of information were substantially equal in all segments, the resulting shuttle picture would be more than adequate for editing purposes. However, at certain critical shuttling speeds, the loss of information could vary significantly between the segments and the loss of information could repeat from field-to-field if the same shuffling were used. The four-field variation of the shuffling sequence, provided by the algorithm, decreases the incidence of critical shuffling speeds.

For audio, the product code is based on a (60 + 4) inner code, common with the video channel, and a (7 + 3) Reed-Solomon GF(16) outer code. This provides the necessary burst-error correction. This coding is backed up with full duplicate writing on the tape, to overcome major faults and to give powerful correction of burst errors. Given the error statistics of the channel, a concealment rate of one or two per minute is anticipated for the audio at the 20th generation, providing very acceptable levels of performance. Undetected errors are at a negligible rate. The audio data is shuffled in the block prior to writing on tape to improve error concealment over 6.7 ms. Based on these error-correction methods, the DTTR is expected to provide audio performance limited only by the selected word length and the performance of the initial A/D coder and filter, for many generations, and thus providing a high level of technical transparency.

5.3 *Tape data format*

After the useful data has passed through the outer error coding, shuffling, interleaving and inner error coding, it is arranged in blocks of fixed length, corresponding to one row of the inner coding. By the addition of sync. and identification (ID) information, it is converted to a sync. block, the smallest unit of data recoverable from tape. This then passed through the channel coder to prepare it for the head-to-tape interface. Sync. words are of identical structure for video and audio blocks. 160 sync. blocks are included in a video sector and 5 sync. blocks are in an audio sector. Sectors start with a preamble sequence and end with a postamble sequence. Sectors are separated by an unrecorded edit gap to allow some positional tolerance. Audio sectors are written on to the tape at two locations using different heads to improve the probability of successful recovery.

The channel coder, common to all data written by the rotating heads, modulates the channel with the data-stream in a manner that improves data reliability by spectral shaping (e.g. elimination of d.c. and low frequency components) and eases clock recovery in play-back over the speed range of interest.

Data recovery is a complementary process to that previously described, i.e. channel decoding, clock and data recovery, sync. and ident. recovery followed by inner error detection and correction. Up to this point the video and audio share the same path. Subsequent processing is performed separately, i.e., deshuffling, outer correction followed by concealment of any residual errors that are detected but not corrected.

6. Parameters of signals recorded on the longitudinal tracks

6.1 *Cue audio track*

In editing operations there is a need for audio recovery to be intelligible over a wide range of speeds and it is clear that the digital tracks using burst techniques cannot provide this capability in a simple manner. A longitudinal editing track is thus included in the format and for the sake of simplicity conventional a.c.-biased analogue recording is specified with a track width of about 600 μm. Analogue recording does not overcome the distortion and print-through problems due to the very thin coating and base thickness (13-16 μm) used for the digital recording media, but performance at variable speed is better for a given complexity level and is adequate for the purpose of providing approximate points for editing.

6.2 *Time-code track*

For reasons similar to those described for the longitudinal cue audio track, a time-code track is included to carry video-related time-code for edit control and scene access.

It is noteworthy that the four digital audio channels each carry a double time-code in their status bits and hence a total of nine time-codes and user bits may be present in the DTTR.

Studies to record additional time-code information within the existing data capacity of the format, such as user bits of the time, are in process.

6.3 *Control track*

The control track modulation is 3-state and consists of pulse doublets separated by mid-level intervals and has an average d.c. component of zero.

The servo reference doublets occur every two video segments, that is 5 times per frame for 525-line systems, 6 times for 625-line systems; they have a nominal frequency of occurrence of 150 Hz. An additional doublet occurs once per television frame to provide a frame reference.

Since there will be 1601.6 audio samples per 525-line frame, giving 8008 samples per 5 television frames, an additional doublet is used to mark the control track every 5 television frames. For 625 lines there are 1920 audio samples per frame, so this pulse doublet is not required.

An additional pulse doublet has been defined to provide a reference for editing video frames in proper sequence. In addition, this pulse doublet can be used to indicate colour frame start, should this be required, for synchronizing the DTTR to an external colour reference.

The period after the end of this optional doublet, up to the start of the next servo reference doublet, is the time when an edit may occur and is reserved for this purpose.

6.4 *Timing relationships*

In a practical analogue machine, the timing relationships at the input and output must be specified, and usually the audio and video are time coincident. The timing relationships on the tape are specified to take account of the physical constraints of head placement and to minimize the need for compensating delays, particularly on the record side. In the case of the digital recorder, further complications exist due to the timing relationship between the audio and video sampling clocks, the use of burst-mode operation for the audio, multiplexed into the video channel and the use of interleaving and shuffling to improve error correction and concealment.

The DTTR will follow conventional practices and have the audio and video coincident at the input and output with time-coincident bursts of audio and video data in the same tracks. Cue audio and time-code on longitudinal tracks are offset 210 mm from the corresponding digital tracks.

7. Recommended operating practices

As an example, Appendix I shows a proposal submitted by the CBS.

As a further example, Appendix II shows a proposal for the allocation of audio channels submitted by the EBU (EBU Recommendation R48-1988).

8. Explanation of terms

8.1 *General definitions*

8.1.1 *Programme area.* The programme area is that part of the tape on which is recorded the programme digital video and digital audio signals.

8.1.2 *Programme area track pattern – Video and audio sectors.* A head which is recording during an entire scan of the programme area lays down a helical track consisting of six sectors of digital video and digital audio in the sequence video-audio-audio-audio-audio-video. 20 such tracks in the 525 system and 24 in the 625 system contain a video recording equivalent to the period of two television fields and audio recordings corresponding to 33.37 ms in the 525-line and 40 ms in the 625-line system for each of the audio channels. The recordings of a television field, however, commence at the start of a video segment.

8.2 *Track pattern allocation – Video and audio segments*

8.2.1 *Video segment.* A video segment contains the digital video data originating from one fifth (in the 525-line system) or one sixth (in the 625-line system) of a television field, and comprises four video sectors. These are located in four adjacent helical tracks being the upper adjacent video sectors in the first pair of tracks and the lower adjacent video sectors in the second pair of tracks.

8.2.2 *Audio segment.* An audio segment initially contains the digital audio originating from a 6.7 ms period of an audio channel and comprises four audio sectors, distributed among four adjacent tracks. Hence, the four audio segments corresponding to a given time period are associated with two video segments corresponding to the same time period, and are physically recorded at the end of the video segments.

8.3 *Electrical signal allocation*

8.3.1 *Video and audio sector allocation – preamble, sync. block, postamble.* Each video sector consists of a preamble, 160 sync. blocks and a postamble. Each audio sector consists of a preamble, five sync. blocks and a postamble.

8.3.1.1 *Preamble.* A preamble consists of a run-up sequence, a sync. pattern, an identification pattern and a fill sequence.

8.3.1.1.1 *Run-up sequence.* A run-up sequence consists of a sequential bit pattern chosen to facilitate the locking of data extraction circuits.

8.3.1.1.2 *Sync. pattern.* A sync. pattern consists of two consecutive bytes whose bit pattern is chosen to be a robust indication of the start of a sync. block.

8.3.1.1.3 *Identification pattern.* An identification pattern consists of four consecutive bytes, providing a unique address of the position of a sync. block within four fields of recorded data, coded such as to remove d.c. and provide error protection.

8.3.1.1.4 *Fill sequence.* A sequence of bytes whose purpose is to maintain clock synchronization and not to carry useful data.

8.3.1.2 *Sync. block.* A sync. block consists of a sync. pattern followed by an identification pattern followed by two inner code blocks.

8.3.1.3 *Inner code block.* An inner code block consists of 60 bytes of video data, audio data or outer code check data, followed by four bytes of inner code check data.

8.3.1.4 *Postamble.* A postamble consists of a sync. pattern followed by an identification pattern.

8.4 *Sub-sets of binary data*

Usually, for convenience in parallel digital processing, binary information is processed in groups of bits referred to in the literature as words and bytes. These terms have generally understood meanings but are not unambiguously defined. For the purpose of this terminology the following definitions are assumed.

8.4.1 *Byte.* A byte consists of 8 bits of binary information. It may have an identity other than being a convenient processing unit (see for example video data word), but generally this is not implicit.

8.4.2 *Video data word.* A video data word is a byte in which the 8 bits represent the possible 256 quantum levels of a video sample.

8.4.3 *Audio data word.* An audio data word consists of 20 bits. In the most basic operating mode, 16 bits represent the possible 2^{16} quantum levels of an audio sample and 4 bits are used for auxiliary signals. Other modes are defined in which one, two, three or four of the auxiliary bits are used to extend the dynamic range of the audio sample quantization.

8.5 *Error protection strategy*

Various methods are used to reduce the effect of digital errors on the objective and subjective quality of the replayed video or audio.

The appropriate combination of methods to achieve an optimum result is generally known as the error protection strategy.

8.5.1 *Error correction.* The use of mathematically related check data recorded with the video and audio data, to locate and correct digital errors.

8.5.2 *Error concealment.* The replacement of erroneous samples by estimate values derived from related error-free samples.

8.5.3 *Source pre-coding.* The transcoding of video data words, so that for the most probable distribution of digital errors, there is a reduction in the peak error produced in a video sample.

8.6 *Error protection – data organization*

Error correction for both video data and audio data is of the product block type in which each data word is included in the computation of two sets of check data known as outer code check data and inner code check data respectively.

Additionally the video and audio data are redistributed from their naturally occurring sequences in order to reduce the effect of burst errors.

8.6.1 *Video data sector array.* For the application of product block error correction, the 18 000 video data words to be recorded in a video sector are considered as a rectangular array with a row dimension of 600 video data words and a column dimension of 30 video data words.

8.6.1.1 *Video outer code check data – video outer code block.* Video outer code check data consists of two bytes computed from a column of the video data array and regarded as being appended to that column. The resulting 32 bytes are known as a video outer code block.

8.6.1.2 *Video inner code check data – video inner code block.* Video inner code check data consists of four bytes computed from a 60-byte sub-set of a row of the video array (or a row of the video outer code check data) and appended to that sub-set. The resulting 64 bytes are known as a video inner code block.

8.6.1.3 *Video product block.* The array defined by 32 video inner code blocks and the corresponding 60 video outer code blocks is known as a video product block. There are 10 such video product blocks in a video sector.

8.6.2 *Audio data array.* An audio sector contains either odd audio data words or even audio data words. For the application of product block error correction, the 168 words of 20 bits each to be recorded in an audio sector are considered as a rectangular array with a row dimension of 120 words of four bits and a column dimension of seven 4-bit words.

8.6.2.1 *Audio outer code check data – audio outer code block.* Audio outer code check data consists of three 4-bit words computed from a seven 4-bit word column of the audio data array and regarded as being appended to that column. (In practice the audio outer code check data is distributed within the column.) The resulting ten 4-bit words are known as an audio outer code block.

8.6.2.2 *Audio inner code check data – audio inner code block.* Audio outer code check data consists of four bytes computed from a row of the audio array (or the appended audio outer code check data). The resulting 64 bytes are known as an audio inner code block.

8.6.2.3 *Audio product block.* The array defined by the 10 audio inner code blocks or by the corresponding 60 audio outer code blocks, is known as an audio product block. There is one audio product block in an audio sector.

8.6.3 *Data redistribution for video and audio*

8.6.3.1 *Interleaving.* The systematic re-ordering of data so that originally adjacent words of video or audio are separated, thus reducing the effect of burst errors on the error-correcting capability. The separation in words is known as the interleave distance.

8.6.3.2 *Shuffling.* The systematic re-ordering of video or audio data words to increase the probability that uncorrectable words are surrounded by error-free data words, for the application of error concealment.

8.7 *Other electrical definitions*

8.7.1 *Channel coding.* The process by which binary information obtained from the digital logic circuits, used in the processing of video and audio data, is converted to a waveform suitable for the recording on to a magnetic medium.

8.7.2 *Randomization.* The reduction of correlation in a serial bit sequence so that it statistically approximates to a random sequence.

8.7.3 *Scrambling.* Alternative term for randomization.

8.7.4 *Transcoding.* The recoding of data, by computation look-up table, so that there is a defined one-to-one relationship between each original code word and the derived code word.

8.8 *Mechanical terms*

8.8.1 *Basic dimensions.* A basic dimension is a fundamental dimension to which no tolerance is applicable.

8.8.2 *Derived dimension.* A derived dimension is obtained from other fundamental dimensions by computation and is given for reference purposes only.

8.9 *Definitions related to editing*

8.9.1 *Edit gap.* The space between adjacent sectors, to which edit transitions must be confined, between the end of the trailing sector postamble and the leading sector preamble.

8.9.2 *Cue audio track.* The longitudinal track reserved for the recording of analogue audio frequency signals which are to be used for production purposes.

8.9.3 *Control track.* The longitudinal track consisting of up to four sets of pulse doublets. Used for servo reference, indication of video frame, start of five-frame audio sequence (in 525/60 system) and may indicate, when required, the start of a colour frame sequence.

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[1986-90]: 11/22 (EBU); 11/32 (10/18) (JIWP 10-11/4); 11/129 (10/89) (EBU).

APPENDIX I TO ANNEX II

RECOMMENDED OPERATING PRACTICES

1. Exchange of recorded programmes

The exchange of television programmes digitally recorded on magnetic tape should only be effected by means of recordings conforming with the specifications provided in this Recommendation.

Until such time when digital television tape recorders are used worldwide, such exchanges should be subject to prior agreement between the concerned broadcasters and programme suppliers.

2. Presentation of recordings

Recordings of a single programme of a duration up to the maximum cassette play time should be contained in one cassette.

Separate programmes should always be on separate cassettes.

3. Programme identification

The content of a recorded digital television cassette should be identified by at least the following information, to be provided on a label attached to the cassette itself, and on another label attached to the cassette container:

a) name of the organization which made the recording;

b) title of the programme, or title, sub-title and episode number;

c) library number (reference number) of the programme or of the cassette;

d) total number of cassettes, and number of the cassette in the sequence, if the programme is on more than one cassette;

e) total playing time, and playing time of the programme material recorded on each cassette;

f) longitudinal time code address for the start of the programme;

g) television scanning standard (625/50 or 525/60);

h) monophonic or stereophonic programme sound, and allocation of the digital audio channels to additional programme sound components, if any.

It would be beneficial, in view of the implementation of fully automated television stations, if at least information items b), c) and d), were also provided in the form of a bar code to be printed on an appropriate label attached on each recorded cassette. A suitable form of bar code is under study.

The information required above should be provided in at least one of the official languages of the ITU.

4. Leaders

Programme material recorded on digital television cassettes should be preceded and followed by appropriate leaders as shown below:

	Duration	*Picture and sound content*
Thread up leader	5 s	Blank tape
Identification leader	15 s	Aural and/or visual identification
Cue-up leader	8 s	Aural and/or visual count-down, 10 to 2
	2 s	Black and silence
		PROGRAMME MATERIAL
Run-out trailer	30 s	Black and silence (minimum)

Information shown on the identification leader should match the one shown on the labels (§ 3 of this Appendix.)

The cue-up leader, the programme material and the run-out trailer should appear on the tape as an uninterrupted recording.

5. Cue audio track

In the case of a complete programme, the longitudinal (editing) audio should preferably be a replica of the programme sound, complete with its identification and countdown leader; it may however be interspersed with additional cues to identify segments of the programme, as needed.

6. Time and control code

The time address information to be used as reference for the exchange of recordings should be the one carried on the longitudinal time and control track. In the case of the exchange of a finished edited programme, such time address information should be continuous and monotonically increasing, furthermore, the same time addresses should preferably (but not mandatorily) appear also on the time and control code multiplexed with the video information, and on the time and control code multiplexed on the digital audio channel that carries the finished programme sound. Programme data carried in the user bits of the longitudinal time and control signals should match information shown on the programme identification label.

APPENDIX II TO ANNEX II

ALLOCATION OF AUDIO CHANNELS IN THE DIGITAL TELEVISION TAPE-RECORDING FORMAT

Case	1 Monophonic programme	2 Stereo programme	3 Two complete stereo programmes	Programmes with separate commentary			7 Non-mixed monophonic programme
				4 Monophonic	5 Stereo effects	6 Stereo	
Channel 1	Complete mono mix	Complete mix, left	First programme complete mix, left	Commentary	First commentary	Commentary, left	Speech (Commentary)
Channel 2	Blank	Complete mix, right	First programme complete mix, right	Blank	Second commentary	Commentary, right	Music
Channel 3	International sound	International sound, left	Second programme complete mix, left	International sound	International sound, left	International sound, left	Effects 1
Channel 4	Blank	International sound, right	Second programme complete mix, right	Blank	International sound, right	International sound, right	Effects 2

Case 1 — Single monophonic programme content

This is the case where a single monophonic sound accompanies the video content of the programme. In such a case, the monophonic programme content represents the complete programme sound mix but, for the purpose of international exchange, it can be accompanied by the so-called "international sound" — the complete monophonic mix of music, effects, etc., lacking only the speech which can be added in the dubbing process in order to obtain a complete monophonic programme sound mix in a language different from the original one.

Case 2 — Single stereo programme content

This case is similar to case 1, i.e. a single complete stereo programme sound accompanies the video content of the programme. In this case, as in case 1, the stereo programme sound represents the complete programme sound mix and it can be accompanied by a complete stereo mix of music and all effects — a stereo international sound — which may be used by the receiving organisation for dubbing.

Case 3 — Two complete stereo programme contents

In this case, the video content of the recorded television programme is accompanied by two somewhat different complete stereo programme mix sounds. The difference may be the language or any other component.

Note — In the case where two different stereo programme sounds are recorded with the same video programme content, the sending organisation should provide written information on the nature of each of the two sounds.

Case 4 — Monophonic programme with separate commentary

When original news or documentary recordings with monophonic sound are exchanged, it is always expected to have the possibility to dub them in a different language; they should therefore contain a complete international sound, i.e. the sound recorded on the spot with all ambiance, original speech, etc., which can be mixed later by the receiving organisation, with a new commentary in its own language.

Case 5 and Case 6 — Stereophonic programme with separate commentary

There is a similarity between these cases and case 4 but, since we are dealing here with a stereo sound, all channels are used and the sound dubbing has to be done on a copy of the original recording where, again, the complete stereo mix can be recorded on channels 1 and 2, or the stereo commentary in a different language and the stereo international sound can be recorded on channels 1, 2, 3 and 4 respectively.

Case 7 — Single monophonic programme content non-mixed

In this case, the video content of the programme is accompanied by a non-mixed monophonic programme sound, i.e. the speech or commentary, the music and the effects are not mixed together.

Such a configuration permits mixing at a later stage during the re-recording or dubbing of that particular tape. In general, such a case may appear when unfinished programmes, or programme segments, are exchanged (for example: one broadcasting organisation may collect inserts from different sources in order to assemble a combined programme).

Longitudinal cue audio channel

In all the cases described above, the cue audio channel should preferably contain a complete monophonic programme mix or, if this is not practicable, the content of audio channel 1.

RECOMMENDATION 714

INTERNATIONAL EXCHANGE OF PROGRAMMES ELECTRONICALLY PRODUCED BY MEANS OF HIGH-DEFINITION TELEVISION

(Question 18/11)

(1990)

The CCIR,

CONSIDERING

(a) that there will be a need to exchange programmes produced in high-definition television among broadcasters;

(b) that the programmes produced in high-definition television and stored on videotape can be converted to 35 mm film at 24/25 frames/s but with some loss of spatial and significant loss of temporal resolution capability;

(c) that the conversion from film to high-definition television may also result in additional loss of spatial resolution,

UNANIMOUSLY RECOMMENDS

that when programmes produced in high-definition television are exchanged between broadcasters, in order to preserve the best quality, they should be exchanged in video form, e.g. live or videotape.

RECOMMENDATION 715*

INTERNATIONAL EXCHANGE OF ENG RECORDINGS

(1990)

The CCIR,

CONSIDERING

(a) that Electronic News Gathering (ENG) is widely used in broadcasting in several parts of the world;

(b) that videotape recording is a fundamental element in ENG operation;

(c) that it would be beneficial to broadcasters in their ENG recording operation if common ENG interface standards, recording formats and operating practices were adopted in the world; while a variety of standards would be wasteful and impede the international exchange of ENG recordings and, possibly the compatibility of equipment,

UNANIMOUSLY RECOMMENDS

1. that in order to facilitate the interconnection of ENG equipment of different models, uniform interfaces should preferably be used in ENG equipment; it is noted that, in the case of analogue component ENG equipment, an EBU Recommendation exists for the camera-to-VTR interface (see Annex I) and an EBU standard exists for the parallel analogue component video interface (see Annex II);

2. that in order to facilitate the international exchange of ENG recordings, uniform ENG recording formats should preferably be used; it is noted that the format presently still used in several European countries for analogue composite ENG recording is described in EBU Document Tech. 3233 (July, 1980): "ENG helical-scan video cassette system using 19 mm (3/4 in) tape (U-matic H format)"; and that the EBU has recommended to its members that, for electronic news gathering equipment using analogue component signals, they should use the recording format described in IEC Publication 961, i.e., format L (so-called BETACAM system) presently under examination by the IEC, the EBU Recommendation has the reference R32-1984;

3. that, in order to facilitate the use of exchanged ENG recordings, the operating guidelines shown in Annex III should be followed;

4. that, in order to preserve picture quality in international exchange of ENG recordings, at the present state of technology, only recordings of generations not greater than the second (that is, the first copy from the original) should preferably be offered for international exchange, when 19 mm (3/4 in) ENG video tape recordings (VTR) are used: when using analogue component ENG VTR machines of format L, if the signal remains in the analogue component domain, recordings of up to the third generation may be used, and certainly not more than the fourth;

5. that, in order to facilitate the use by receiving organizations, of programmes originated from ENG recordings and relayed over transmission facilities, the guidelines described in Annex IV should preferably be followed.

Note – Normally, ENG tape recordings can undergo several further generations of copying by full-broadcast quality VTR machines, without significant deterioration in picture quality.

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* This Recommendation should be brought to the attention of the IEC, Broadcasting Unions and the SMPTE.

ANNEX I

EBU TECHNICAL RECOMMENDATION R34

INTERFACE FOR THE INTERCONNECTION OF ENG CAMERAS AND PORTABLE VTRs USING NON-COMPOSITE SIGNALS

This interface is designed to enable the ENG signals produced in a non-composite form to be sent through a parallel link between a camera and a portable VTR which are separated by about 5 to 10 metres, instead of being combined in a "camcorder".

The specification includes the electrical characteristics that the interface must satisfy in order to transmit the programme signals produced by the camera (audio and video components) and those fed back to the viewfinder (video playback), as well as the operational controls and the monitoring indications. The specification includes only those characteristics considered to be essential to facilitate the interconnection of equipment produced by different manufacturers. In order to prevent damage due to incorrect connections, it is necessary to make sure that the equipment concerned complies with these specifications, and furthermore that the additional connections provided by the manufacturers in the case of particular systems are not incompatible with these specifications.

One system has been recommended by the EBU for the production of non-composite ENG signals (Recommendation R32). The detailed specification of the interface for this system is given in an annex to Recommendation R32, and the correspondences between the contacts in that case and the signals taken into account by the EBU are indicated.

1. Electrical characteristics of the interface

1.1 *Programme signals*

In practice, component video signals are generally designated by the letters *Y*, *R-Y*, and *B-Y*, but in the following the notation adopted by the CCIR has been used: E'_Y, E'_{CR} and E'_{CB}.

Luminance signal (camera → VTR)

The luminance signal is the same as that defined in CCIR Report 624-2. In accordance with Table II of that Report, it is obtained from the primary signals by means of the equation:

$$E'_Y = 0.299\ E'_R + 0.587\ E'_G + 0.114\ E'_B$$

where E'_R, E'_G and E'_B are the primary signals after gamma pre-correction. In the present application, the amplitude range of the primary signals is 0.700 V.

The luminance signal should include synchronizing pulses and line and field blanking in accordance with CCIR Report 624-2 (Tables I, I.1 and I.2).

The amplitude of this signal should comply with the following specifications:

Peak-to-peak amplitude (including sync.):	1 V
Nominal value of the d.c. component:	0 V at blanking level or a.c. coupled output
Input and output impedance:	$Z_o = Z_i = 75\ \Omega$.

Colour-difference signals (camera → VTR)

The colour-difference signals are obtained from the E'_Y signal and the primary signals specified above. When the amplitude range of the primary signals is 0.7 V, the colour-difference signals comply with the following equations, which are the same as those given in the CCIR Report 629-2:

$$E'_{CR} = 0.713\ (E'_R - E'_Y)$$

$$E'_{CB} = 0.564\ (E'_B - E'_Y)$$

Both these signals should include line and field blanking in accordance with CCIR Report 624-2 (Tables I, I.1 and I.2). Neither of them should include sync. pulses.

The amplitude of the E'_{CR} and E'_{CB} signals should comply with the following specifications:

Peak-to-peak amplitude:	0.700 V for 100/0/100/0 colour bars.
	0.525 V for 100/0/75/0 colour bars
Nominal value of the d.c. component:	0 V at blanking level or a.c. coupled output.
Input and output impedance of the interface:	$Z_o = Z_i = 75\ \Omega$.

All three signals E'_Y, E'_{CR} and E'_{CB} should be simultaneous in real time and convey time-coincident information.

Their characteristics are illustrated in Fig. 1.

The specification does not include any band-limitation for the luminance or colour-difference signals; if necessary, in order to ensure that the equipment operates correctly, such limitation should be applied at the input stages of the equipment.

The insertion of signals during the field-blanking period is reserved by the EBU. The use of lines 12/325 in the E'_{CR} and E'_{CB} signals to identify the colour fields in the case of preliminary composite processing is, however, under study. The use of other lines in all three signals to carry an amplitude and phase reference is under study.

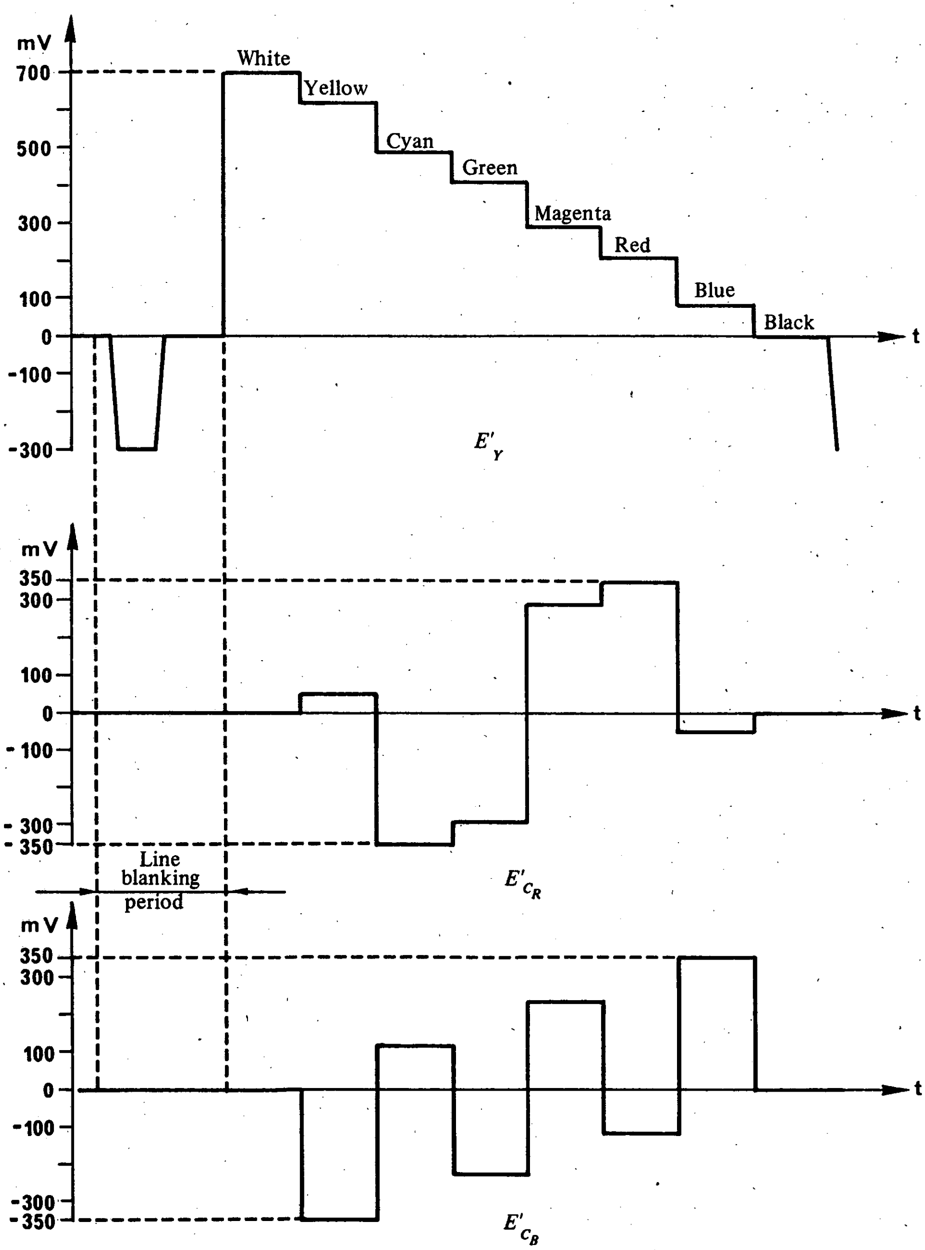


FIGURE 1 – *Waveform of video signals for 100/0/100/0 colour bars*

Playback video signal (VTR → camera)

The specifications applicable to this signal are as follows:

Peak-to-peak amplitude (including sync.): 1 V
Nominal value of the d.c. component: 0 V at blanking level or a.c. coupled input
Input and output impedance: $Z_o = Z_i = 75\ \Omega$.

A manual switch may be provided on the camera to route this signal to the viewfinder, but it is also possible to provide an automatic switch, the control of which is transmitted through the interface from the VTR. Such a system does not form part of this specification. However, if both automatic and manual switches are provided, the latter should be able to force the viewfinder to show the camera picture, whatever control signal is received from the VTR.

Audio signal (camera → VTR)

The signal produced by the microphone should comply with the following specification:

Level $\geqslant -60$ dBu, balanced.
$Z_o = 200\ \Omega$ $Z_i = 3$ to $10\ \mathrm{k\Omega}$.

1.2 *Power supply* (VTR → camera)

Voltage (at the output of the VTR):

12 V nominal (minimum: 10.6 V, maximum: 17 V).

The camera should be able to operate with the power supply provided by the VTR, taking account of the voltage reduction due to the supply cable. However, in order to make allowance for the case of cameras having their own battery, arrangements should be made in the camera to automatically prevent the interconnection of the battery in it with that in the VTR.

1.3 *VTR start/stop control*

The start/stop control for the VTR should comply with the following specification:

Start: 5 V nominal (4 to 8 V, CMOS).
Stop: 0 V nominal (0 to 0.5 V, CMOS).

1.4 *Indication of recording/VTR fault*

The appearance of this signal is shown in Fig. 2.

The specifications of this signal are as follows, with an input impedance of $Z_i = 20\ \mathrm{k\Omega}$:

Recording in progress: 5.0 V nominal (4.5 to 6.0 V).
Recording halted: 2.5 V nominal (2.0 to 3.0 V).
VTR disconnected: 0 V nominal (0 to 0.3 V).
VTR fault: alternating 5.0 V/2.5 V (with the same tolerances as given above).
Duty cycle: 50% nominal (40 to 60%).
Frequency: 1 Hz nominal (0.8 to 1.2 Hz).

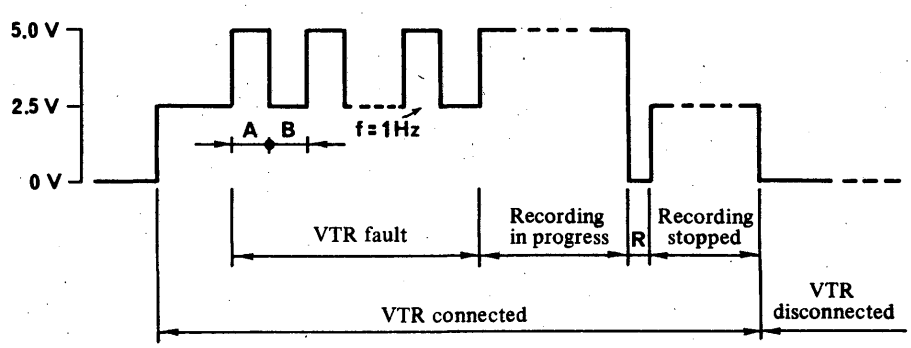


FIGURE 2 – *Indication of recording/VTR fault*

Note – The transition from signal "Recording in process" to signal "Recording stopped" is unambiguously defined by the R ("Record reset") pulse.

$$\frac{A}{A + B} = 50 \pm 10\% \qquad R = 10 \text{ to } 100 \text{ ms}$$

This signal indicates, at the camera, whether the VTR is recording or not, and also provides information on its operating state. The interface does not make provision for particular warnings (e.g. battery discharged). All the warnings generated by the system concerned are transmitted by the same signal. Various individual alarms can also be provided at the camera, but they are not covered by this specification.

The other signals (e.g. other audio inputs to the VTR or reference video signals for locking the camera's sync. pulse generator) should be connected by means of special sockets on the camera or VTR. They are not covered by this specification, and neither is the composite video interface that may be found on equipment of this type.

2. Characteristics of the connector

It is not considered necessary to specify a special connector for this interface, as manufacturers are using different models for the interconnection of their equipment. The importance of this specification lies in the characteristics of the signals which make it possible to provide interfaces between items of equipment that would otherwise be incompatible.

ANNEX II

EBU TECHNICAL STANDARD N10

PARALLEL COMPONENT VIDEO INTERFACE FOR NON-COMPOSITE ENG SIGNALS

This interface is designed to enable component video signals to be carried by parallel interconnections between ENG VTRs and other equipment that may be found in ENG post-production installations using component signals*.

This specification does not cover the interface needed for the connection of the audio and auxiliary signals (time-and-control code, remote control, etc.), nor does it deal with the interfaces for composite video signals that are sometimes provided in equipment of this type.

1. Types of signal carried by the interface

Three separate connectors should be provided to carry the following components of the video signal:

- luminance signal (with sync.),
- red colour-difference signal (without sync.),
- blue colour-difference signal (without sync.).

In practice, these signals are generally represented by the symbols *Y*, *R-Y* and *B-Y*, but in the following the notation adopted by the CCIR has been used: E'_Y, E'_{CR} and E'_{CB}.

2. Waveform of the signal

The luminance signal E'_Y should include sync. pulses and line and field blanking in accordance with CCIR Report 624-2 (Tables I, I.1 and I.2).

The two colour-diference signals E'_{CR} and E'_{CB} should include line and field blanking in accordance with CCIR Report 624-2 (Tables I, I.1 and I.2). Neither of them should include sync. pulses.

All three signals (E'_Y, E'_{CR} and E'_{CB}) should be simultaneous in real time and carry time-coincident picture information.

The insertion of signals in the field-blanking period is reserved by the EBU. The use of lines 12/325 of the E'_{CR}/E'_{CB} signals for the identification of the colour fields in the case of preliminary composite processing is, however, under study. The use of other lines in the three signals to convey amplitude and phase reference signals is under study.

* For copying, but no other purpose, a different interface may be used if necessary (such an interface must not be used for other applications, as it will depend on the format).

3. Electrical characteristics of the interface

3.1 *Luminance*

The luminance signal is the same as that obtained in CCIR Report 624-2. In accordance with Table II of that Report, it is obtained from the primary signals by means of the equation:

$$E'_Y = 0.299\ E'_R + 0.587\ E'_G + 0.114\ E'_B$$

where E'_R, E'_G and E'_B are the primary signals after gamma pre-correction. In this application, the amplitude range of the primary signals is 0.700 V.

The amplitude of the E'_Y signal should comply with the following specifications:

Peak-to-peak amplitude (including sync.): 1 V

Nominal value of the d.c. component: 0 V at blanking level or a.c. coupled output.

Input and output impedances of the interface:

$$Z_o = 75\ \Omega \qquad Z_i = 75\ \Omega$$

These characteristics of the signals are shown in Fig. 1.

3.2 *Colour-difference signals*

The colour-difference signals are obtained from the E'_Y signal and the primary signals specified above. When the amplitude range of these signals is 0.7 V, the colour-difference signals comply with the following equations, which are the same as those given in CCIR Report 629-2:

$$E'_{CR} = 0.713\ (E'_R - E'_Y)$$
$$E'_{CB} = 0.564\ (E'_B - E'_Y)$$

The amplitude of the signals E'_{CR} and E'_{CB} should comply with the following specification:

Peak-to-peak amplitude: 0.700 V for 100/0/100/0 colour bars.
0/525 V for 100/0/75/0 colour bars.

Nominal value of the d.c. component: 0 V at blanking level or a.c. coupled output.

Input and output impedances of the interface:

$$Z_o = 75\ \Omega \qquad Z_i = 75\ \Omega$$

Neither of these signals includes sync. pulses, but both include clamping periods.

The characteristics of the signals are shown in Fig. 1.

3.3 The specification does not require any limitation of the pass-band; if necessary, such limitation should be applied in the input stages of the equipment.

4. Mechanical characteristics

The interface takes the form of type BNC connectors, with the female part mounted on VTRs and other equipment.

ANNEX III

OPERATING GUIDELINES FOR THE INTERNATIONAL EXCHANGE OF ENG RECORDINGS

1. Allocation of audio tracks

All the prevailing types of ENG recorders have two (or more) audio tracks. When only one programme sound signal is recorded with the programme material, this should be on the most protected audio track (e.g. a track away from the edge of the tape rather than a track on the edge of the tape).

2. Information on the recording label

Suitable information should be provided, preferably on a label affixed to the tape cassette or tape reel as appropriate, to identify the content of exchanged ENG recordings. However, in the case of ENG recordings it does not seem essential to provide all the programme information described in Recommendation 469, § 8.1. It appears that only the following information is really necessary:

- name of organization which originated the recording,
- programme number or cassette number,
- location of each event,
- date of each event,
- subject of each event and shot list,
- playing time of each event,
- recording format,
- television standard,
- content of audio tracks.

The same information should also be provided on a label affixed to the tape or cassette container.

3. Identification of different shots on a recorded ENG video cassette

When several shots of the same event are included in an ENG recording their location on the tape can be identified by means of the tape counter, provided that care is taken to reset the tape counter to zero at the start of the tape. Alternatively, the location of the shots on the tape can be identified by means of the time and control code, if used.

ANNEX IV

GUIDELINES FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES ORIGINATED FROM ENG RECORDINGS

ENG pictures carried across national boundaries for international exchange should be suitable for direct broadcasting, for standards conversion, for transcoding, or for recording on full-broadcast quality machines, without any additional timing corrections. If this is not the case, broadcasters must reprocess the signal, perhaps through a digital time-base corrector, since it is not easy to tell, with normal monitoring equipment, whether the ENG signals are suitable for broadcasting purposes; however, continued reprocessing of the ENG signal is not only wasteful of equipment time, but steadily reduces the picture quality.

Such ENG pictures should, in principle, conform to one of the standards in Report 624 "Characteristics of television systems" and, for 625-line systems, Recommendation 472, "Video-frequency characteristics of a television system to be used for the international exchange of programmes between countries that have adopted 625-line colour or monochrome systems". However, for such purposes, a video bandwidth smaller than the usual value may be admitted during the initial stage.

Any equipment for noise reduction or image improvement should be sited as close to the source of degradation as is practicable.

Repeated processing of the ENG signal should be avoided as far as possible, since it is likely to steadily reduce the picture quality.

SECTION 10/11H: USE OF FILM IN TELEVISION

RECOMMENDATION 265-6*

STANDARDS FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES ON FILM FOR TELEVISION USE

(Question 41/11, Study Programmes 41A/11 and 41B/11)

(1956-1959-1963-1966-1970-1974-1982-1986-1990)

The CCIR

UNANIMOUSLY RECOMMENDS

that the films for television use intended for the international exchange of programmes should meet the following definitions and standards:

1. Definitions

The types of film referred to in this Recommendation are designated by code words as defined below. The code words should be placed on the identification leader of any film intended for international exchange of programmes and should be used in any related correspondence. The code word consists of a letter and a number (or numbers) followed by a two- or three-syllable word, for example: C 35 COMOPT.

The first letter indicates either monochrome, B, or colour, C, film type. The number, usually 16 or 35, indicates the nominal width of the film in millimetres. The first syllable indicates either a combined sound and picture recording, COM, or separate sound and picture recording, SEP. The last syllable indicates whether the sound recording is magnetic, MAG, or optical, OPT:

- 35-mm colour film with an optical track is C 35 COMOPT;
- 16-mm monochrome film with a magnetic stripe is B 16 COMMAG;
- 16-mm colour film with sound on a separate magnetic film, having one or more tracks, is C 16 SEPMAG.

1.1 For picture films without sound, the designation is MUTE, for example: B 16 MUTE.

1.2 If the picture and the sound films have the same width, this is indicated by a single number. If not, then two numbers separated by an oblique stroke are used, the first indicating the width of the picture film, for example:

- 35-mm picture film with magnetic sound track on 16-mm film is 35/16 SEPMAG.

2. Types of films recommended for international exchange of television programmes

2.1 The international exchange of recorded television programmes on monochrome and colour (types B and C) films should be effected by means of one of the following types:

1 – 35 COMOPT
2 – 16 COMOPT
3 – 16 COMMAG
4 – 16 SEPMAG
5 – 35 MUTE
6 – 16 MUTE
7 – 35 COMMAG
8 – 35 SEPMAG

* The Director, CCIR, is requested to transmit this Recommendation to the ISO and the IEC, in accordance with Opinion 16.

An identification of the tracks utilized must be added after the word SEPMAG.

For example:

35 SEPMAG (tracks 1 and 2) or
35 SEPMAG (track 1) or
35 SEPMAG (tracks 1 and 3) or
16 SEPMAG (edge track) or
16 SEPMAG (both tracks), etc.

2.2 Films of types 7 and 8 cannot be exchanged unless there is agreement between the organizations concerned.

Note – Although the quality of sound obtainable with 16 COMOPT films is marginal, this type cannot be excluded because of its widespread use. A reduction of the number of recommended types of sound recordings appears to be impossible at present.

2.3 The fundamental technical parameters of each type listed in § 2.1 should conform to the standards given below.

3. Standards common to all types of film

3.1 Safety film must be used.

3.2 Normally the image on the film should be a photographic positive.

3.3 The picture (frame) frequency should be either 25 or 24 per second. The picture frequency should accompany any reference to programme duration.

3.4 For accurate reproduction of films in television systems some limitations should be placed on the film density range. In colour systems the colour balance of films should also be defined.

All film densities specified below are measured in singly-diffused light.

The spectral characteristic of the densitometer should conform with ISO Standard 5-1974 for diffuse visual density, Type V.Ib. (ISO: International Organization for Standardization.)

3.4.1 For monochrome film the density corresponding to television white level should be 0.3 to 0.4 but in the case of dyed-base film the total density corresponding to television white level should not exceed 0.5.

Note – Television white level preferably corresponds to a fully-lit object in the scene, having a reflectance of about 60%. This results in reproduction of fully-lit human faces having reflectances of about 15% to 35% at film densities between 0.2 and 0.5 greater than the density corresponding to television white level.

The maximum density of a film is determined by the scene contrast and the film transfer characteristic. The gradation in areas in the film having densities in excess of 1.6 above that corresponding to white level may be distorted or lost entirely.

3.4.2 For colour film the density corresponding to television white level should be 0.3 to 0.4.

Note 1 – Television white level preferably corresponds to a fully-lit object in the scene, having a reflectance of about 60%. This results in reproduction of fully-lit human faces having reflectances of about 15% to 35% at film densities between 0.2 and 0.5 greater than the density corresponding to television white level.

The maximum density of a film is determined by the scene contrast and the film transfer characteristic. Shadow areas, in which the reproduction of detail is not essential to the picture, may have densities in the range of 2.0 to 2.5, but it must be recognized that in such areas both image gradation and colour may be distorted or lost entirely. The density range for optimum colour reproduction is expected to be between 0.5 and 1.7.

Since the white point of colour television systems is either CIE (Commission internationale de l'éclairage (International Commission on Illumination)) Illuminant C or CIE Illuminant D_{65}, adequate prints of both 35 mm and 16 mm colour films may be obtained if the print is balanced for projection by an illuminant approximating in spectral distribution to a black body of a colour temperature of 5400 K. The print, when so illuminated, should provide a pleasing reproduction of neutral grey and skin colours.

Note 2 – This neutral grey balance is very close to a metameric match with a neutral grey in the scene. (The metameric match of two colours of which the spectral compositions are different is obtained when the visual comparison of these two colours does not permit them to be distinguished by the CIE standard observer.)

3.4.3 Optimum viewing conditions for films intended for colour television are specified in Recommendation 501.

3.5 The dimensions of the films and images recorded thereon should conform to appropriate international standards (see ISO Standard 2939-1975 for 35-mm film and ISO Standard 4243-1979 for 16-mm film).

3.6 When films are produced for television by conventional cinematographic methods, allowances should be made for the loss of picture area that occurs both in film-scanning and in domestic receivers. The television-scanned area, the action field and the title and sub-title areas should conform with appropriate international (ISO Recommendation R1223) or equivalent national standards.

3.7 The normal position for the emulsion side of 35-mm films is internationally recognized as facing the light source when projecting on a reflecting-type screen.

For 16-mm film the position of the emulsion is dependent on the process of preparation and either emulsion-to-light source or emulsion-to-objective-lens orientations may be encountered. The actual position of the emulsion should be indicated on the leader and on the label of the film by clear statement or diagram, as defined in ISO Standard 4241-1978.

3.8 Film splices should be carried out in accordance with appropriate international or national standards.

3.9 A leader for protection and identification should be attached to each film.

3.9.1 The minimum length of the protection and identification leader should be 3 m (10 ft).

3.9.2 The minimum information given on the identification leader should be as follows:

- name of sending organization,
- title of programme,
- code word (see § 1),
- position of emulsion (see § 3.7),
- total programme duration and picture frequency,
- total number of reels,
- reel number,
- duration or length of the film on the reel.

Further information may be given, such as: production methods used, for example, telerecording or a code word according to ISO.

3.9.3 The identification leader should have the same type of base and perforations as the film to which it is attached. Leaders should be attached to the film in such a manner that the emulsion on both leader and film is on the same side.

3.10 Films may be transported on flanged reels or on cores as specified in the appropriate international or national standards. The boxes in which films are transported should be identified with labels carrying the same information as the corresponding film leader (see § 3.9.2).

3.11 The diameter of a flanged reel or the outer diameter of the film on a core should not exceed 380 mm (15 in.). It is desirable that 16-mm films exceeding 300 m (1000 ft) in length should be on flanged reels.

3.12 Cores and reels intended for films with magnetic sound stripe should be made of non-magnetic material.

4. Special standards for certain types of film

4.1 *COMOPT types*

The preferred types of optical sound tracks are variable area, bilateral or double bilateral.

The nominal optical sound-recording characteristic for 35-mm and 16-mm film is that which produces a constant modulation of its optical transmission as a function of frequency within the given frequency range on the sound track of the film when a sine-wave signal of constant amplitude is fed into the input of the recording channel.

The corresponding nominal reproducing characteristic is that which produces a sine-wave output signal whose level is independent of frequency when reproducing a sound-track recorded with the nominal recording characteristic specified above.

Note – The preferred method of measurement of the recording characteristic of optical sound tracks is by reference to the output signal of an ideal replay chain. (An ideal replay chain is defined as having a signal output proportional to the modulation of the optical transmission of the sound-track when this is scanned by a slit whose width is negligible in relation to the shortest recorded wavelength on the film.) This condition may be verified by measuring the modulation of the optical transmission of the film by means of a microdensitometer adjusted to have a slit-width which is negligible in relation to the shortest recorded wavelength on the film.

The preferred method of calibrating a reproducing chain is by means of a standard test film recorded with a number of audio sine-waves producing constant modulation of the optical transmission.

4.1.1 *35 COMOPT*

The location and dimensions of picture frames and sound-track should conform with appropriate international standard (ISO Standard 2939-1975).

The useful audio-frequency range is 40 Hz to 8000 Hz.

4.1.2 *16 COMOPT*

The location and dimensions of picture frames and sound-track should conform with appropriate international standards (ISO Standard 359-1977 and ISO Standard 4243-1979).

The useful audio-frequency range is 50 Hz to 5000 Hz.

4.2 *16 COMMAG*

4.2.1 The dimensions and position of the magnetic sound stripes should be as given in Fig. 1.

4.2.2 The sound record should be in advance of the centre of the corresponding picture by 28 ± 1/2 frames.

4.2.3 The magnetic stripe should be on the side of the film that faces the light source of a projector arranged for direct projection onto a reflecting-type screen.

4.2.4 The maximum additional thickness due to the magnetic coating should be 0.02 mm (0.0008 in.).

4.2.5 If a balancing magnetic stripe is used, it should have the same thickness as the main magnetic stripe. No sound recording should be made on the balancing stripe.

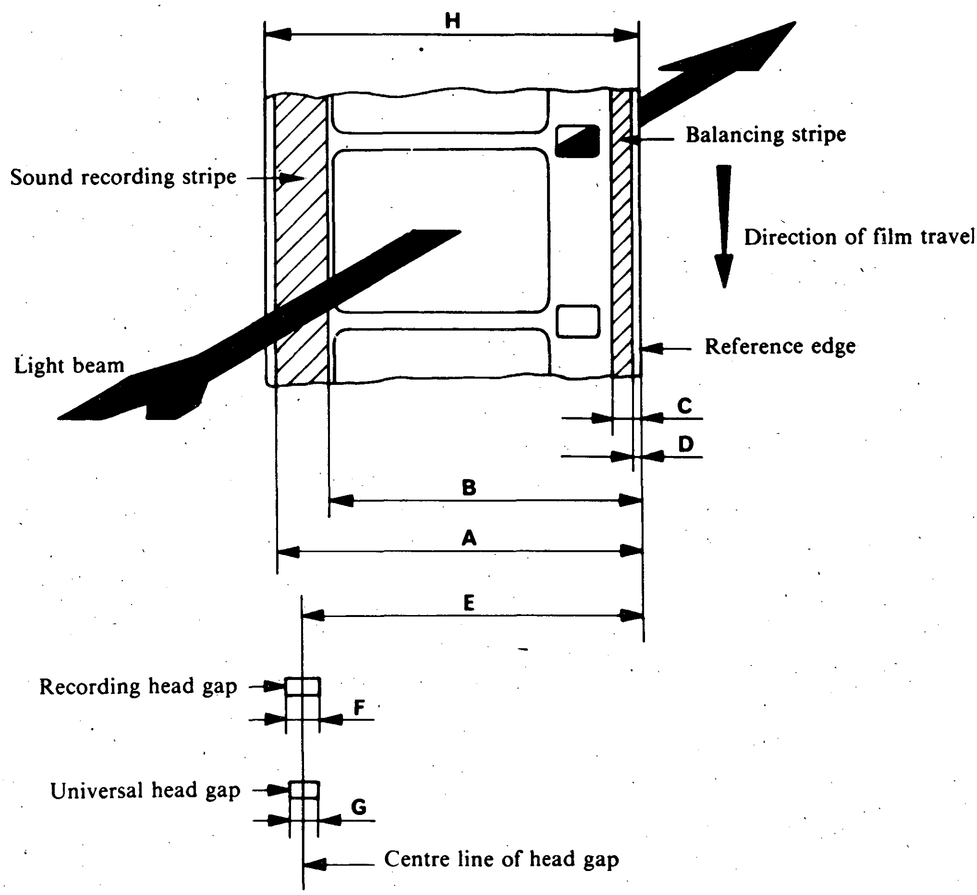
4.2.6 The recording and reproducing characteristics should be those standardized by the ISO (Standard 1188-1974: Specification for recording characteristics for magnetic sound record on 16 mm motion-picture film).

4.3 *16 SEPMAG*

4.3.1 The location and dimensions of sound tracks should conform to ISO Standard 4242-1980, as given in Fig. 2.

4.3.2 The COM and SEP types should not be combined. That is to say, if one or more sound tracks are provided on a separate film, only the SEP tracks should be used for reproduction.

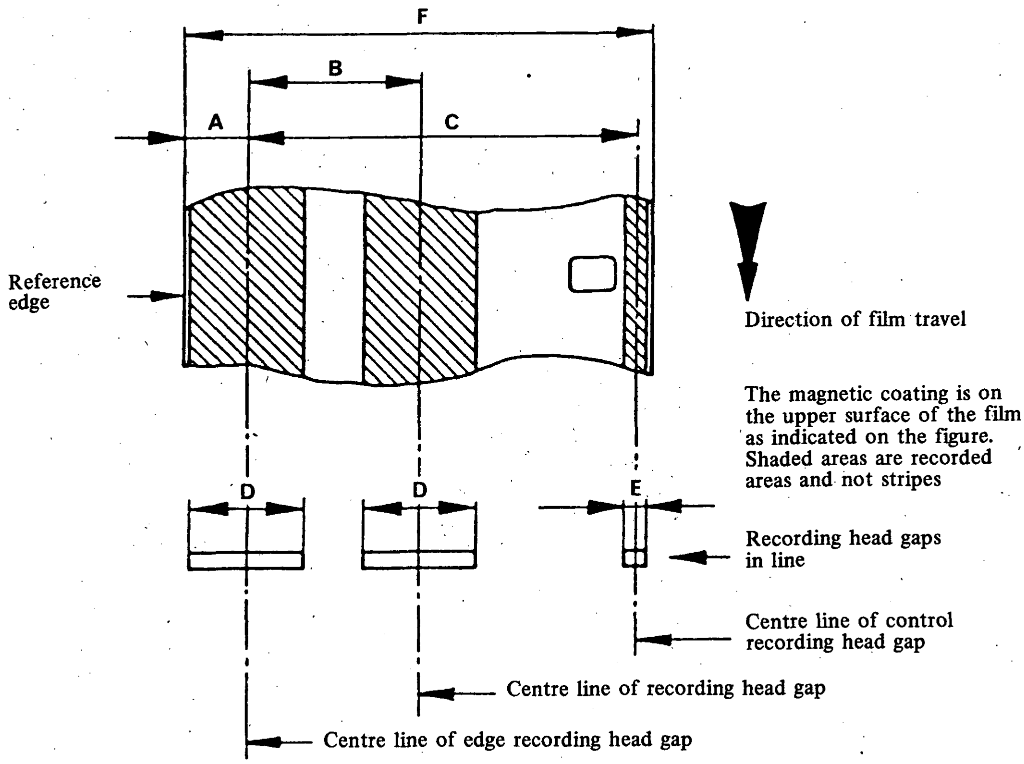
4.3.3 The recording and reproducing characteristics should be those standardized by the ISO (Standard 1188-1974: Specification for recording characteristics for magnetic sound record on 16 mm motion-picture film).



Dimensions		
	Millimetres	Inches
A min.	15.80	0.622
B	$13.25\ {}^{0}_{-0.15}$	$0.522\ {}^{0}_{-0.006}$
C	$0.80\ {}^{0}_{-0.15}$	$0.031\ {}^{0}_{-0.006}$
D max.	0.15	0.006
E	14.55 ±0.05	0.573 ±0.002
F	2.35 ±0.10	0.092 ±0.004
G (1)	2.15 ±0.10	0.085 ±0.004
H ref.	15.95	0.628

(1) When it is desired to employ a single head for the dual function of recording and reproducing, the universal head dimensions shall apply.

FIGURE 1 – *Sound recording on film type 16 COMMAG*



Dimensions		
	Millimetres	Inches
A	2.05 ±0.05	0.081 ±0.002
B	5.95 ±0.05	0.234 ±0.002
C (1)	13.45 ±0.05	0.529 ±0.002
D (2)	$4.0^{\,0}_{-0.1}$	$0.157^{\,0}_{-0.004}$
E	$0.7^{\,0}_{-0.1}$	$0.028^{\,0}_{-0.004}$
F (reference)	15.95	0.628

(1) The inch dimension C deviates from the standard conversion practice to reflect the practices in those countries where that system is used.

(2) To prevent the erase head overlapping the film edge, a dimension of

$$3.8^{\,0}_{-0.1}\ \text{mm}\ \left(0.150^{\,0}_{-0.004}\ \text{in}\right)$$

is preferred in some countries.

FIGURE 2 – *Sound recording on film type 16 SEPMAG*

4.4 *35 COMMAG*

4.4.1 The dimensions and position of the magnetic sound stripe should be as given in Fig. 3.

4.4.2 The sound record should be 28 ± 1/2 frames behind the centre of the corresponding picture.

4.4.3 The magnetic sound stripe should be on the side of the film towards the lens of a projector arranged for direct projection on to a reflecting screen.

4.4.4 If a balancing stripe is used, it should have the same thickness as the magnetic sound stripe. No sound recording should be made on the balancing stripe.

4.4.5 The recording and reproducing characteristics should be those standardized by the ISO (see ISO Standard 1189-1975: Specifications for recorded characteristics for magnetic sound records on 35 mm motion-picture film).

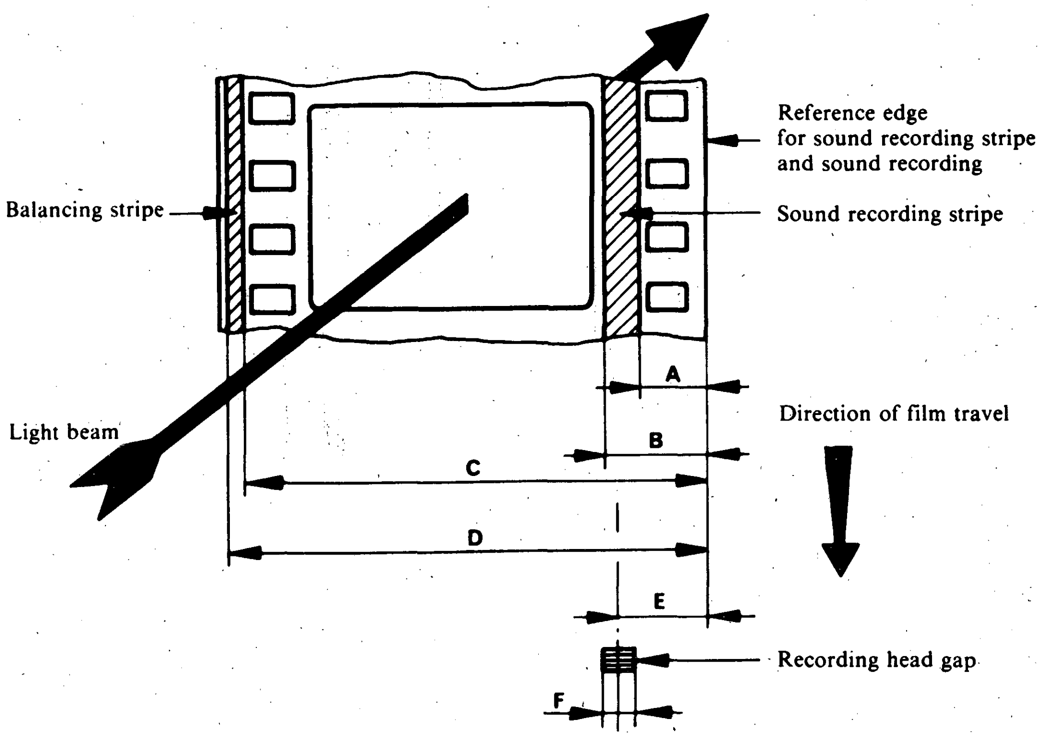
4.5 *35 SEPMAG*

4.5.1 The second (sound) film should be a standard 35-mm magnetic film.

4.5.2 The position of the sound tracks is specified in ISO Recommendation R162. If only one sound track is used, it should be track No. 1 (see Fig. 4). If a second sound track is used, it should be track No. 2.

4.5.3 The COM and SEP types should not be combined. That is to say, if one or more sound tracks are provided on a separate film, only the SEP tracks should be used for reproduction.

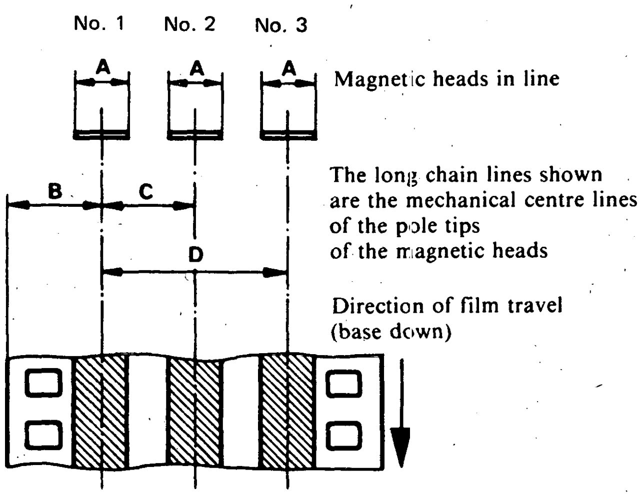
4.5.4 The recording and reproducing characteristics should be those standardized by the ISO (see ISO Publication 1189-1975: Specifications for recorded characteristics for magnetic sound records on 35 mm motion-picture film).



Dimensions		
	Millimetres	Inches
A	$5.10\ ^{0}_{-0.10}$	$0.200\ ^{0}_{-0.004}$
B	$7.60\ ^{+0.1}_{0}$	$0.300\ ^{+0.003}_{-0.001}$
C	$33.25\ ^{0}_{-0.10}$	$1.309\ ^{0}_{-0.004}$
D	$34.70\ ^{+0.10}_{0}$	$1.366\ ^{+0.004}_{0}$
E	6.35 ± 0.05	0.250 ± 0.002
F	2.35 ± 0.05	0.093 ± 0.002

Note. – If the magnetic sound stripe increases the thickness of the film, a balancing stripe shall be applied to equalize the thickness of the two edges of the film. The balancing stripe shall be of the same material and thickness as the main magnetic stripe and its location and dimensions should be as referred to in the figure and given in the table. For television programme exchange, no programme recording shall be made on the balancing stripe.

FIGURE 3 – *Sound recording on film type 35 COMMAG*



Dimensions		
	Millimetres	Inches
A	$5.0 \begin{smallmatrix} +0.1 \\ 0 \end{smallmatrix}$	$0.200 \begin{smallmatrix} +0.004 \\ 0 \end{smallmatrix}$
B	8.6 ±0.05	0.339 ±0.002
C	8.9 ±0.05	0.350 ±0.002
D	17.8 ±0.05	0.700 ±0.002

Note. – The metric dimensions in the table are based upon the practice of countries using the metric system, and similarly the inch dimensions follow the practice of those countries using the inch system.

In some instances, the values are not exact conversions, the differences are small and magnetic head assemblies made to either system of dimensions will, for all practical purposes, be interchangeable.

FIGURE 4 – *Sound recording on film type 35 SEPMAG with one or more tracks*

RECOMMENDATION 501-2*

APPRAISAL OF PROGRAMMES ON COLOUR FILM INTENDED FOR TELEVISION USE

(Question 41/11, Study Programme 41A/11)

(1974-1978-1990)

The CCIR,

UNANIMOUSLY RECOMMENDS

1. that the appraisal of films intended for the international exchange of programmes for colour television should be by means of optical projection. The optical projection arrangements must conform to standards of colour temperature and viewing conditions which are defined in § 3 (attention is drawn to the fact that the required viewing conditions are not the same as those which are conventionally accepted for the cinema theatre);

2. that broadcasting authorities should aim to provide a standard of telecine performance such that any film which appears to be of good technical quality when evaluated under the special optical viewing conditions can also be expected to appear to be of good quality when transmitted by colour television. They should not require the film to have any abnormal colour balance or special characteristic to suit a particular telecine specification;

Note – Recommendations concerning the technical parameters of colour motion picture films intended for the international exchange of colour television programmes are contained in Recommendation 265. To make a reliable visual appraisal of the technical quality of a colour motion-picture film intended for television presentation, it is necessary to take into account the different circumstances under which the picture will be viewed when it is so presented.

In colour television, the displayed picture is relatively small; it has a white point corresponding to Illuminant D_{65} and is normally viewed in familiar surroundings with a considerable amount of ambient light. The field of view of the observer therefore includes not only the television screen but also other objects in the room which provide a constant reference of colour balance and this increases his sensitivity to errors in colour reproduction in the picture. There are also frequent programme changes to signals derived from television cameras and these offer comparisons with a different type of picture source.

In the cinema the environment is dark and there are no external colour references; consequently there is a tendency for the observer to adapt to whatever balance the film may have. Furthermore, it is found that when a bright object, such as the projected picture, is viewed in an otherwise dark field, the eye exercises a contrast-reducing effect upon the viewed picture and the contrast (gamma) in film for cinema presentation is desirably made substantially greater than unity. This effect is much less pronounced under normal domestic television viewing conditions and less contrast, although still greater than unity, is desirable in the television display. Hence, the appraisal of films by optical projection in an otherwise dark review theatre is not the best procedure when films are intended for television presentation.

3. that colour motion pictures intended for television presentation should be appraised in optical review theatres which have been arranged to give viewing conditions more suited to the purpose than the conventional review theatre. The projected picture should be surrounded by a relatively large illuminated area, of a standard fraction of the brightness of whites in the projected picture and a standard correlated colour temperature. The following characteristics are recommended:

3.1 the projection screen should be of such a size that the viewer is seated at a distance of between four times and six times the height of the picture. The absolute dimensions of the screen will depend upon the number of observers that it is desired to accommodate simultaneously. (The experimental results upon which this Recommendation is based are known to be valid for screens having diagonals of between 50 cm and 1.5 m. For larger review theatres, it may be necessary for the broadcaster to carry out special experiments to confirm the consistency of results.);

* The Director, CCIR, is requested to transmit this Recommendation to the ISO, in accordance with Opinion 16.

3.2 either front projection or back projection may be used. The display must have reflectance or transmittance over angles wide enough to ensure satisfactory uniform brightness from all viewing positions;

3.3 the illuminated surround to the projection screen should extend the illuminated field of view symmetrically to an area which is preferably not less than three times the width and three times the height of the projection screen, with the latter placed centrally in this area;

3.4 the illumination of the surround may be from the front on to a reflecting surface or from the rear to a diffusing, translucent material;

3.5 since the white point of colour television systems is either International Committee on Illumination (CIE) Illuminant C or D_{65}, the correlated colour temperature of the light reflected from, or transmitted by, the projection screen under open-gate conditions should be near to 6500 K for the most critical evaluation of television films. However, the range around 5400 K attained by Xenon projection systems will provide an acceptable white point for evaluation purposes;

3.6 the correlated colour temperature of the illumination of the surround should match that reflected from, or transmitted by, the projection screen, under open-gate conditions, to ± 200 K. There should be no significant departure from the black-body locus in either case, neither should the spectral emission have very pronounced peaks;

Note – A simple check of the accuracy of the match of colour temperature between the surrounding illumination and that of the white point of the projection system can be made in the following manner:

The light flux from the projector, *in open-gate condition, should be attenuated without changing its colour temperature* and the brightness of the projection screen should be reduced until it closely approximates to that of the surround. It will then be possible visually to judge the colour match between the light reflected from the projection screen and that from the surround. A satisfactory match may be achieved by adjustment of the colour temperature of the projector or that of the surround; any remaining difference in colour should be significantly less than that created when a 05 CC Wratten colour compensating filter of appropriate colour is placed in the light path of the projector.

3.7 for screens as described in § 3.1, and fitted with illuminated surrounds as described in §§ 3.3 and 3.4, the brightness of whites in the projected picture should lie in the range 51 cd/m^2 (15 fL) to 68 cd/m^2 (20 fL). For films made in conformity with Recommendation 265, this corresponds to an open-gate brightness of not less than 115 cd/m^2 (33.5 fL) and desirably about 140 cd/m^2 (41 fL);

3.8 the surround to the screen should be illuminated reasonably uniformly to approximately one third that of picture whites, for example, 14 cd/m^2 (4 fL) to 22 cd/m^2 (6.5 fL);

Note 1 – The surround brightness is chosen as a compromise between light levels where the observer is most critical of quality and light levels where the eye suffers fatigue.

Note 2 – When it is important to visually appraise the density of colour film intended for the international exchange of television programmes, it is useful to have comparison fields, composed of reference luminance and chrominance areas, placed in the surround in the immediate vicinity of the projection screen (see Annex II).

3.9 care must be taken to ensure that the characteristics of the remainder of the review room do not affect the performance of the projection system, screen and surround. The wall facing the screen should be of low reflectance and the remaining walls, floor and ceilings should not reflect light onto the screen; their total reflectance should integrate approximately to a neutral grey;

3.10 for normal appraisal purposes no ambient light should be used in the room since it would modify the standardizing effect of the surround. It may, however, be considered desirable for special test purposes, to have available a controlled degree of light of appropriate colour temperature which falls on the screen, further to reduce the luminance range.

Note – To create optimum review room conditions which will give the most complete indication of the effects likely to be observed during television presentation, some users may find it desirable to cause a small amount of additional light to fall upon the screen in such a way that it simulates the effects of optical flare in the television system, and possibly that of ambient light in the room where television viewing takes place. The level of light which is intended to simulate optical flare in the television system and its colour temperature will be a function of the picture content; this can simply be produced by some mild diffusing means in the optical projection system. If also desired, the effect of ambient light falling upon the receiver could be simulated by a constant amount of light falling upon the projector screen. In either case, the precise arrangement used would be at the discretion of the user and a suitable choice would be based upon practical experience of the performance of the television system.

ANNEX I

OPTIMUM VIEWING CONDITIONS FOR THE ASSESSMENT OF COLOUR FILMS INTENDED FOR TELEVISION USE

The appraisal of colour films for television use intended for the international exchange of programmes has frequently involved difficulties due to differing standards of performance in telecine channels. Telecine apparatus exists in a wide range of technical specifications which may vary from a highly complex design incorporating many refinements, both colorimetric and electronic, to a simple uncorrected colour analyser, and many problems of film quality are ultimately found to be attributable to telecine performance. Difficulties also arise because the majority of interests involved in the production of films, particularly film-processing laboratories, do not have television apparatus and are found to carry out their quality control under very variable conditions. It is clearly desirable that when a film is a subject of international exchange, the successive appraisals of its technical characteristics should be carried out in a standard manner.

In addition to its universal availability, optical projection has fewer variables than a colour television system and, until a world-wide standard for telecine performance can be realized, it is to be preferred for appraisal purposes.

Note – European Broadcasting Union (EBU) Technical document 3091-F contains, besides the substance of this Recommendation, examples of installations at present used by members of the EBU.

BIBLIOGRAPHY

CTP [June, 1969] Canadian Telepractices Committee. Recommended practice CTP-1; Viewing conditions for the evaluation of color film for television use. *JSMPTE*, Vol. 78, 483-484.

SMPTE [1970] Colour and luminance of review room screens used for 16 mm colour television prints. Society of Motion Picture and Television Engineers (USA). Recommended practice RP41.

ANNEX II

APPRAISAL OF THE DENSITY OF COLOUR FILM FOR TELEVISION USE INTENDED FOR THE INTERNATIONAL EXCHANGE OF PROGRAMMES, BY MEANS OF OPTICAL PROJECTION

The accuracy of appraisal of colour film density may be considerably improved by means of comparison fields containing reference luminances and chromaticities.

Two of the comparison areas should be visually similar to neutral grey and have luminances corresponding to the film densities of 0.3 and 2.0 which correspond approximately to the picture-white and picture-black levels.

The luminance of the colour areas on the chart should correspond to that of the thematically important image details on the film. Each reference area should be between 1 to 2% of the projection screen area.

Comparison fields may be formed by means of a back-illuminated transparency in an assembly attached to the projection screen [CCIR, 1974-78]. This assembly contains a light source, a light diffuser and neutral grey and colour filters. The correlated colour temperature of the light from neutral greys in the comparison areas should fall between those of the main surround field and the light reflected from the screen under open-gate conditions.

REFERENCES

CCIR Documents

[1974-78]: 11/407 (USSR).

RECOMMENDATION 716*

SCANNED AREA OF 35 mm MOTION PICTURE FILM IN HDTV TELECINES (NON-ANAMORPHIC PICTURES)

(1990)

The CCIR,

CONSIDERING

(a) the content of ISO Standard 2906 "Image area produced by the camera aperture on 35 mm motion picture film";

(b) the content of Recommendation 713 "Recording of HDTV images on film" which is based on ISO Standard 2906;

(c) the content of ISO Standard 2907 "Maximum projectable image area on 35 mm motion picture film";

(d) that there is a need to utilize programmes on 35 mm positive film for electronic distribution in the form of HDTV signals;

(e) that HDTV telecines may also find use for special applications such as the scanning of negative film or other image-processing operations,

UNANIMOUSLY RECOMMENDS

1. that the preferred nominal dimensions of the non-anamorphic images scanned by HDTV telecines on 35 mm positive film be those shown in Table I, item 1, which is based on ISO Standard 2907. (The scanned image dimensions for anamorphic film are under study);

2. that, for certain special applications, HDTV telecines should also be optionally switchable to scan a set (currently under study) of smaller or larger images, the maximum dimensions of the image being those shown in Table I, item 2.

TABLE I

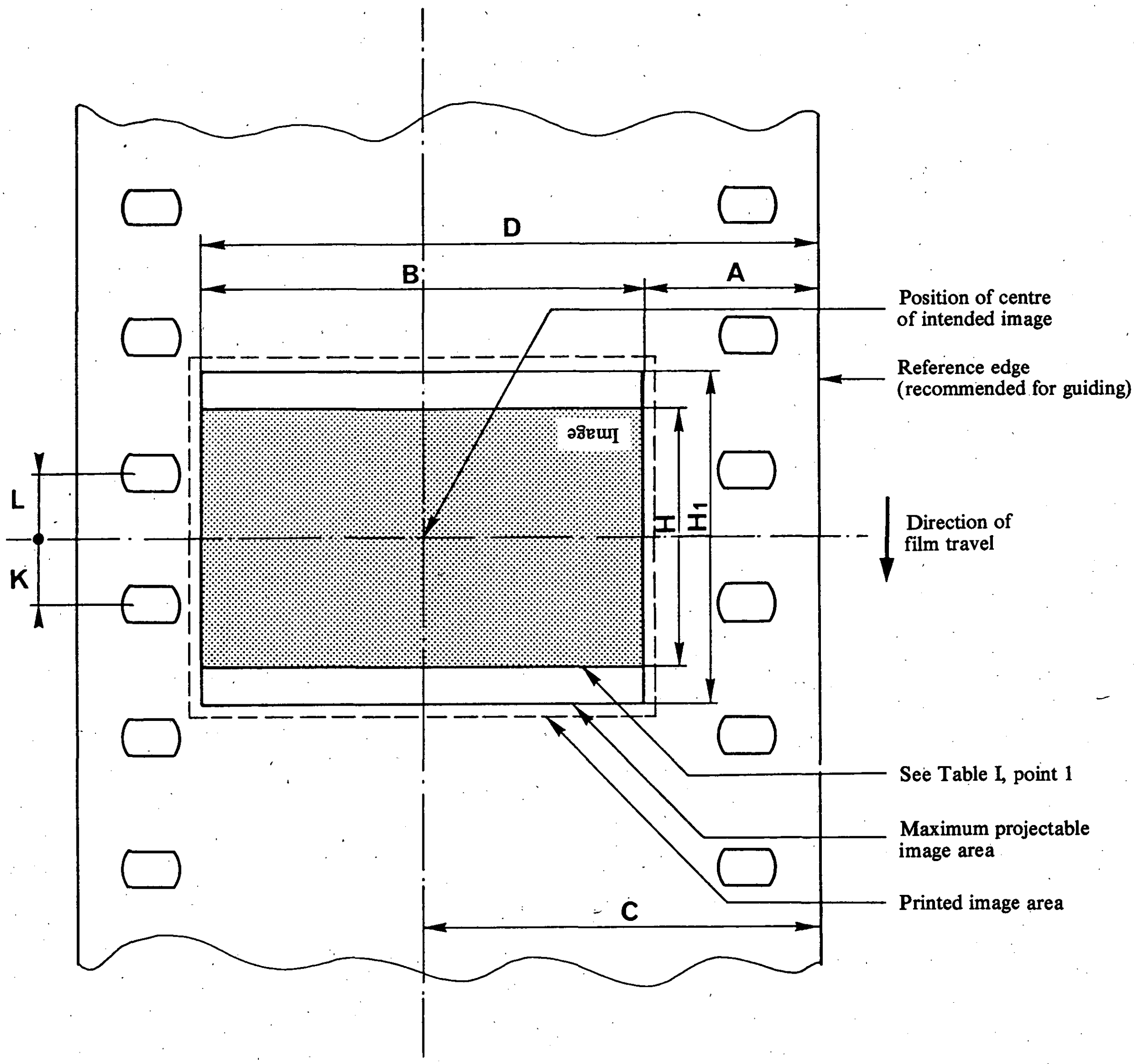
Item	Parameter	Width (mm)	Height *H* (mm)
1	Nominal scanned image (normal) (1)	21.11	11.87
2	Nominal scanned image (maximum) (2)	24.89	18.72

(1) This image has an aspect ratio of 16 : 9 and a width equal to that specified in ISO Standard 2907 for the maximum projectable image area (dimension B, see Fig.1).

(2) This image covers the full width of 35 mm camera film between the sprocket holes and a full height equivalent to four sprocket hole pitches. It does not result in an aspect ratio of 16 : 9.

* This Recommendation should be brought to the attention of the ISO, the IEC and the SMPTE.

Adapted from ISO 2907-1934 (E)



Dimension	Non-anamorphic pictures (mm)
A (min.)	8.20
B (nominal)	21.11
C (nominal)	18.75
D (max.)	29.31
H_1 (max.)	15.29
K and L	approximately equal

FIGURE 1 – *Maximum projectable image area and preferred HDTV scanned area*
(the film is shown as seen from inside the projector looking towards the lens)

RECOMMENDATION 713*

RECORDING OF HDTV IMAGES ON FILM

(Question 18/11, Study Programme 18T/11)

(1990)

The CCIR,

CONSIDERING

(a) the need of broadcasters and programme producers to transfer HDTV programmes to 35 mm films;

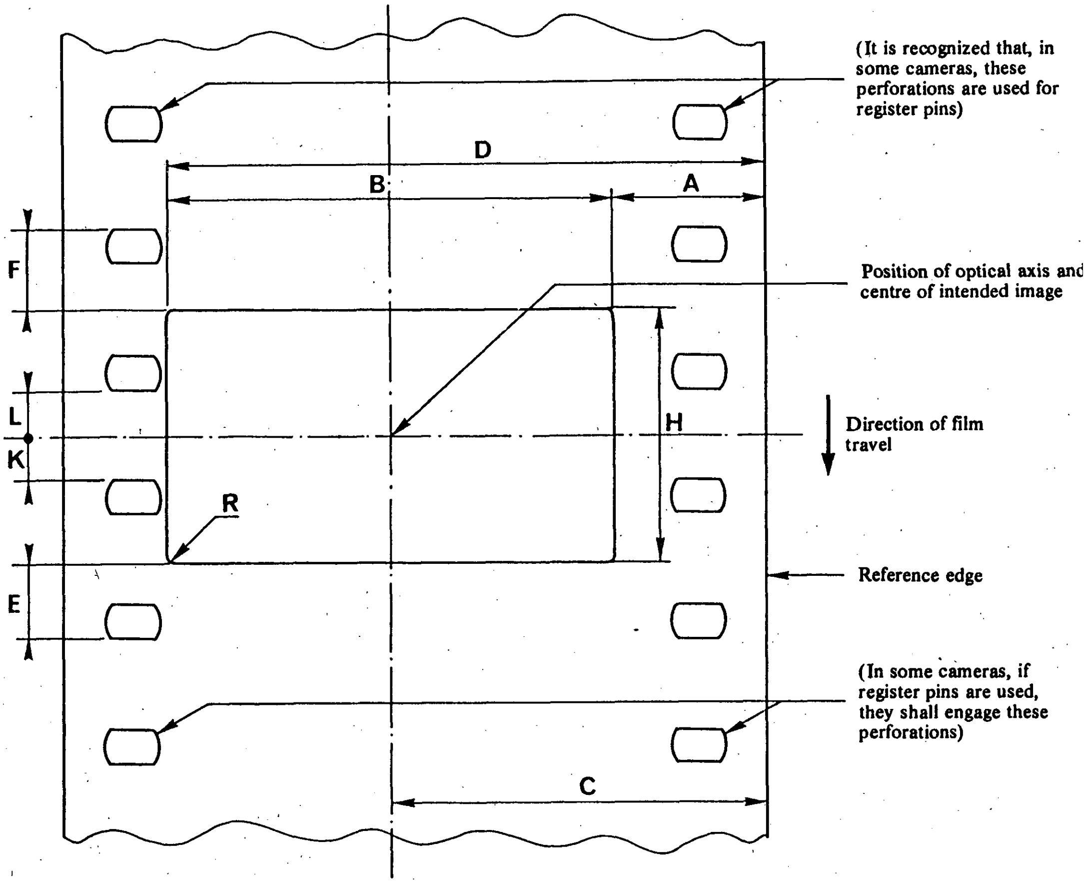
(b) the 16:9 aspect ratio established for HDTV image;

(c) the contents of ISO Standard 2906 concerning the image area produced by the camera aperture in 35 mm motion picture film,

UNANIMOUSLY RECOMMENDS

that when HDTV pictures are transferred to 35 mm film, the dimensions of the image on the film be as shown in Fig. 1.

* This Recommendation should be brought to the attention of the ISO.



Dimension	(mm)
A (max.)	7.80 (1)
B (min.)	21.95 (1)
C (nominal)	18.75 (1)
D (min.)	29.75 (1)
H	$12.34 \begin{smallmatrix} +0.05 \\ -0.00 \end{smallmatrix}$
R (max.)	0.8
K, L	approximately equal (1)
E, F	equal ± 0.1 (1)

(1) As specified in ISO Standard 2906.

Note 1 – The measurements of the image are to be made on recently exposed and processed film.

Note 2 – The horizontal edge of the image shall be at substantially 90° to the edge of the film with the vertical edge parallel to the edge of the film.

Note 3 – Figure 1 shows the film image seen from the inside of the camera looking towards the lens.

FIGURE 1 – *HDTV image on film*

BIBLIOGRAPHY

ISO [1984] ISO Standard 2906 – cinematography. Image area produced by the camera aperture on 35 mm motion-picture film.

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SECTION 10/11I: UTILIZATION AND SYNCHRONIZATION OF DIFFERENT PROGRAMME SUPPORTS

There are no Recommendations in this Section.

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OPINIONS

OPINION 16-3*

ORGANIZATIONS QUALIFIED TO SET STANDARDS ON SOUND AND TELEVISION RECORDING

(1956-1970-1978-1986)

The CCIR,

CONSIDERING

(a) that standards for the international exchange of recorded programmes among broadcasting organizations are the concern of the CCIR;

(b) that the world-wide definition of standards for the recording of sound and television on discs and on magnetic tape is among the institutional tasks of the IEC;

(c) that the world-wide definition of standards for the recording of motion pictures and sound on cinematographic film is among the institutional tasks of the ISO;

(d) that unnecessary duplication of work and a multiplicity of standards should be avoided,

IS UNANIMOUSLY OF THE OPINION

1. that the CCIR should determine the technical and operational criteria which may be necessary to facilitate the international exchange of recorded programmes;

2. that the CCIR should determine the acceptability of existing international standards such as those issued by the IEC and the ISO, and should collaborate with the IEC, ISO and other international organizations in formulating new standards when the existing ones are unsuitable for the international exchange of programmes;

3. that CCIR texts should make reference to existing standards that are judged to be acceptable; references should refer directly to the relevant information without involving successive cross-references; these texts may also include brief descriptive excerpts from these standards when this may help the reader to grasp quickly the full technical content of a specification;

4. that the Director, CCIR, should keep in close touch with the IEC and the ISO, with a view to avoiding unnecessary duplication of work;

5. that to inform the IEC and the ISO of CCIR studies and decisions, the Director, CCIR, should transmit all relevant documents to these organizations inviting them to take CCIR views into account.

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* This Opinion also concerns Study Group 11.

OPINION 74-1 *

SYSTEMS FOR SIGNAL INTERFACE CONNECTION BETWEEN SOUND-BROADCASTING RECEIVERS AND ASSOCIATED EQUIPMENT

(1982-1990)

The CCIR,

CONSIDERING

(a) the importance of facilitating the enhancement and greater efficiency of broadcast systems;

(b) that the introduction of such improvements has heretofore often been delayed by the need to wait until equipment in the hands of the public has become obsolete;

(c) that such delays could be shortened if appropriate means were provided for the connection of associated equipment;

(d) the CCIR studies decided in Study Programmes 46G/10 and 46H/10,

IS UNANIMOUSLY OF THE OPINION

that the IEC should be invited to study and set standards for signal interface connection between sound broadcasting receivers, audio recorders and players, decoders for sound broadcasting supplementary services, and other associated equipment intended for use by the public, taking into appropriate account the studies that will be carried out by the CCIR on this subject.

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* The Director, CCIR, is requested to bring this Opinion to the attention of the CCITT and the IEC. This Opinion has also been brought to the attention of Study Group 11.

OPINION 75-1

SYSTEMS FOR SIGNAL INTERFACE CONNECTION BETWEEN TELEVISION RECEIVERS AND ASSOCIATED EQUIPMENT

(1982-1990)

The CCIR,

CONSIDERING

(a) the importance of facilitating the enhancement and greater efficiency of broadcast systems;

(b) that the introduction of such improvements has heretofore often been delayed by the need to wait until equipment in the hands of the public has become obsolete;

(c) that such delays could be shortened if appropriate means were provided for the connection of associated equipment;

(d) the CCIR studies decided in Study Programme 18U/11,

IS UNANIMOUSLY OF THE OPINION

that the IEC should be invited to study and set standards for signal interface connection between receiving equipment, recorders, teletext decoders and other associated equipment intended for use by the public for conventional television, enhanced television and high-definition television, taking into appropriate account the studies that will be covered by the CCIR on this subject.

Note – The Director, CCIR, is requested to bring this Opinion to the attention of the CCITT and IEC. This Opinion has also been brought to the attention of Study Group 10.

OPINION 90*

EQUIPMENT INTERCONNECTION IN PROFESSIONAL PROGRAMME PRODUCTION INSTALLATIONS

(1990)

The CCIR,

CONSIDERING

(a) the importance of facilitating the easy interconnection of equipment in programme production installations for sound broadcasting and television; this covers:

- interconnections to carry programme signals from equipment to equipment,
- interconnections to coordinate operation of equipment, e.g. control and tally functions;

(b) that developing countries would particularly benefit from easy interconnectability of equipment in their installations;

(c) that the CCIR possesses the expertise required to define and recommend essential elements of specifications for equipment interconnection in professional broadcast installations, that optimally meet the system engineering requirements of broadcasters and programme producers (several such Recommendations have been successfully set by the CCIR in the past);

(d) that IEC Technical Committee 84 is engaged in work on audio and audiovisual equipment interconnection with special attention to audiovisual equipment for domestic use;

(e) the content of Opinion 16,

IS UNANIMOUSLY OF THE OPINION

that the IEC should be invited to take into appropriate consideration the results of relevant CCIR studies, and the relevant CCIR Recommendations, in its own work on equipment interconnection for domestic and professional audio and audiovisual equipment.

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* The Director, CCIR, is requested to bring this Opinion to the attention of the IEC.

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