REPORT 1088-1

INTERFACES FOR DIGITAL VIDEO SIGNALS IN 525-LINE AND 625-LINE TELEVISION SYSTEMS

(Question 25/11)

(1986-1990)

1. Introduction

CCIR Recommendation 656 specifies interfaces for digital studio equipment, in conformity with the basic parameter values contained in Recommendation 601.

This Report summarizes the contributions received on digital video interfaces which provided the basis for Recommendation 656, it includes supplementary information on the subject, and indicates areas in which further studies are required.

2. Definitions

Interface is a concept involving the specification of the interconnection between two items of equipment or systems. The specification includes the type, quantity and function of the interconnection circuits and the type and form of the signals to be interchanged by these circuits.

A parallel interface is an interface in which the bits of a data word are sent simultaneously via separate channels.

A serial interface is an interface in which the bits of a data word, and successive data words, are sent consecutively via a single channel.

A parallel-serial (hybrid) interface is an interface in which portions of a data word are sent consecutively via separate channels.

3. Primary encoding format

There are features of the basic data organization which are common to the three types of interface defined above and which are the subject of Part I of Recommendation 656. They comprise:

- the organization of the video data into words and blocks;
- the timing reference codes providing video synchronization;
- ancillary data signal structure;
- data signals during blanking intervals;
- details of the multiplexing.

3.1 *Blanking and synchronization considerations*

[CCIR, 1982-86a, b and c] agreed on the form and use of timing reference signals. Each timing reference signal consists of a four-word sequence. The first three words are a fixed preamble. The fourth word contains information defining:

- first or second field identification;
- state of field blanking;
- state of line blanking;
- error protection data.

[CCIR, 1982-86d] proposed that only one timing reference signal should be used, located at the end of each line-blanking period. This identification signal includes a clock burst (for a bit-serial interface), indication of the initial point of the data frame, field-blanking period and first and second field periods. End-of-line information will be obtained by counting clock pulses.

The EBU [CCIR, 1982-86e] suggested that additional codes be included in the data stream and that the beginning and end of the digital active line will be identified in the demultiplexed Y, C_R, C_B data streams. It further proposed that these codes be included at the 4 : 4 : 4 level for both Y, C_R, C_B and R, G, B signals in digital form.

[CCIR, 1982-86f] stated that the timing reference (digital synchronization) codes inserted into the parallel code should be easily usable in a serial code.

Proposals for 525-line and 625-line differ in their definition of digital field-blanking intervals. [CCIR, 1982-86b, c, and d] stated that only 9 lines in both fields 1 and 2 belong to the field-blanking interval. [CCIR, 1982-86a and f] specify the digital field-blanking interval of 24 lines (field 1) and 25 lines (field 2). It may be advisable to shorten the digital field-blanking interval so as to allow for complex vertical filtering, though this problem needs further study.

Amongst other considerations [CCIR, 1982-86g] drew attention to the fact that "timing reference signals" should be referred to as "timing reference codes".

In those data words occurring during digital blanking intervals that are otherwise unspecified, the OIRT [CCIR, 1982-86e] proposed that the digital codes equivalent to blanking level for Y, C_R, C_B be included in the appropriate locations in the multiplex.

3.2 *Ancillary signals*

Provision is made for ancillary data signals to be inserted synchronously into the video multiplex during both horizontal and vertical blanking intervals. It is noted that digital video tape recorders (Rec. 657) do not record any of the horizontal blanking intervals nor some lines in the vertical blanking intervals. For that reason the EBU has allocated only four vertical blanking lines for ancillary signals. The unrecordable blanking periods can be used to transfer data between other studio equipment if required.

[CCIR, 1982-86 d and f] contain some details of the ancillary signals. [CCIR, 1982-86a, b and c] propose the ancillary data signal format.

Time-code is an essential ancillary signal for control of post-production processes and the synchronization of video and audio. Four formats are currently recognised, IEC format [IEC Pub. 461] in the vertical interval and longitudinal forms, audio time code in accordance with Recommendation 647 and time code associated with the R-DAT audio recording format. Ancillary data formats to include this information in the vertical interval are a current study in a number of Administrations and offer possibilities to maintain the synchronism of video and audio through various processes [CCIR, 1986-1990a].

Recommendation 656 specifies only a timing reference code ANC; the data field following the ANC is left unspecified. There have been discussions about various packet formats for the ancillary data.

Some information with higher priority and predetermined format might have a fixed data packet length and probably also a fixed time slot in the data stream. Less important ancillary data not having a predetermined format might have variable packet length.

[CCIR 1986-1990b] mentions digital line numbers as possibly useful information which should be considered as an ancillary signal. The document contains a proposal for two modes of digital line numbering. In addition one method for introduction of respective code words into the video data is proposed.

The study of the requirements for sound signals is included in Decision 60 to ensure that any possible effects upon the associated sound signals caused by the video interface parameters will be duly considered. Except for the need to control the relative delay between the video and the sound, no such effects have been identified.

4. Parallel interfaces

A number of proposals [CCIR, 1982-86a, b, c, d and f] suggested using eight conductor pairs, where each should carry, in NRZ format, a multiplex stream of bits (of the same significance) of each of the component signals, namely, Y, C_R, C_B. The eight pairs should also carry timing reference information and may carry ancillary signals that are time-multiplexed into the data stream during video blanking intervals. A ninth pair would provide a synchronous clock at 27 MHz. These proposals, with [CCIR, 1982-86e], contributed to the preparation of Recommendation 656 (see also [EBU, 1983]).

The signals on the interface may be transmitted using balanced conductor pairs for a distance of up to 50 m without equalization and up to 200 m with appropriate equalization [CCIR, 1982-86a].

Appropriate coding of the clock signal, such as the use of an alternating parity (AP) coding, has been shown to extend this distance by reducing the effects of cable attenuation [CCIR, 1982-86h].

5. Serial interfaces

[CCIR, 1982-86d] gives an example of a data sequence using 216 Mbit/s multiplexing. Particular attention is paid to ease of clock extraction and word synchronization by the inclusion of words within the data stream which generate clock bursts.

[CCIR, 1982-86f] refers to channel coding and states that transmission should be effected via 75 Ω coaxial cables for distances up to 1 km.

[CCIR, 1982-86e] contains a detailed consideration of the special requirements for a serial interface and proposes in Annex I a draft Recommendation for a bit-serial interface for the 4 : 2 : 2 level of Recommendation 601. This contributed to the preparation of Recommendation 656 (see also [EBU, 1985]).

In [CCIR, 1982-86e] the transmission of signals is considered in both electrical form, using coaxial cable, and in optical form using an optical fibre. The special requirements for bit-serial signal transmission between studios, or between equipments in a studio are given as:

- low cost and low complexity coupled with high reliability;
- very low intrinsic error rate in the transmission due to the very short distances;
- multiple outputs for monitoring and distribution;
- rapid recovery from errors introduced by switching of the transmission path, the video source or signal interruptions;
- full compatibility with the format of the bit-parallel interface and signal code commonality of both electrical and optical implementations of the bit-serial interface;
- usable over a range of distances from zero to at least 500 m, with a minimum of adjustments and extremely low error rates;
- applicable to a range of cable types.

These requirements are confirmed in [CCIR, 1982-86i], which also points out that in the implementation of a digital video installation, preference would normally be given to the parallel interface for short connection lengths and that recourse would be made to the serial interface mainly in the case of long or complex connection paths, where the cost of the interface terminal equipment would not override the saving in the physical support of the connection itself. Coaxial cables would probably be preferred for connections of medium length, while preference would go to optical fibres for very long connection lengths.

This contribution also suggests that the code used should be structured so as to permit the redundant bits to be employed to implement a system for measuring the bit error ratio (BER) at the receiving end of the connection and thus automatically monitoring its performance.

It further suggests that in a fully integrated digital installation or system it may be useful for all interconnections to be transparent to any appropriate digital stream, irrespective of the message content. Thus, although the interface will be used to transmit a video signal, it should be "transparent" to the message content, i.e., it should not base its operation on the known structure of the message itself.

[CCIR, 1982-86e] reviews the characteristics of transmission media, including interference susceptibility and describes the proposals received for source encoding, channel encoding and error management.

Two methods of source encoding have been proposed. [CCIR, 1982-86j] suggests the use of a parallel scrambler with the addition of a parity bit for synchronization and limited error detection purposes. According to a preliminary investigation, it appears that the sending end, at least, of such an interface could be integrated in a single gate-array chip.

A second method [CCIR, 1982-86e] providing spectrum control, clock and word synchronization by an 8-bit to 9-bit adaptive mapped code, is adopted in Recommendation 656.

In relation to these methods of source encoding, two different approaches to channel encoding have been proposed. In the scrambled system the channel coding is the AMI (Alternate Mark Inversion) for coaxial cable, and NRZ for optical fibre. The AMI code restricts the required bandwidth. In the bit-mapped system the encoded bit-stream, in NRZ format, is suitable for feeding both transmission media.

The bit-parallel interface defined in Recommendation 656 includes the possible addition of two bits to each word, thus enhancing the accuracy of the sample from 8 bits to 10 bits. In some applications, such as computer graphics, this improvement has been found advantageous. In the case of the serial interface of Recommendation 656, this extension is not feasible, thus limiting the application of the serial interface in both its electrical and optical forms. Certain Administrations are studying methods to convey a 10-bit word length in the serial interface, based on scrambled NRZ coding techniques.

6. Parallel-serial (hybrid) interfaces

[CCIR, 1982-86d and f] also discuss an alternative solution in which signals are divided into multiple channels of 108 Mbit/s each in order to reduce the bit rate per channel. This method also enables various members of the extensible family of compatible coding standards to be accommodated within a multi-channel arrangement. However, as stated in [CCIR, 1982-86k], the main advantage advocated for the hybrid interface is that it reduces the bit rate sent on each of the parallel cables, but if 2 parallel cables are used, which is the most frequent proposal, then the bit rate is halved but the new bit rate is still too high to be implemented by means of much cheaper technologies.

On the other hand, the use of a hybrid interface involves complications at the sending and receiving ends, where circuits are needed to multiplex and demultiplex the bit stream, and also to phase the bit streams received on the cables.

These complications, and the cost of the additional cable (or cables) in the hybrid interface, appear overwhelmingly to militate in favour of a fully serial interface, rather than a hybrid interface, in those cases when the parallel interface cannot be used.

7. Optical interfaces

Work has been reported concerning the optimum characteristics of an optical fibre interface for use in the studio, [CCIR, 1986c, d, e]. The use of a single-mode fibre driven by a laser or LED at a wavelength of approximately 1300 nm is suggested. Appendix 1 contains a draft text, as yet incomplete, to form the content of section 7 of Recommendation 656. Administrations are invited to make studies and contributions to complete this section in the current study period.

[CCIR, 1986-90f] describes a new approach to the switching and routing of digital signals by optical means within a large studio centre. An arrangement is suggested in which the central routing switcher is eliminated by conveying all of the signals to every destination along a single optical fibre. The signals are assembled by a combination of time-division multiplexing (TDM) to a bit rate of the order of 2 Gbit/s, and optical wavelength-division multiplexing. The use of TDM means that the system is applicable to a wide range of bit rates including those required for digital HDTV. If this approach proves successful, appropriate interface specifications will be required.

Document [CCIR, 1986-90g] described a method, applicable also to HDTV systems, for the transmission of three analogue wideband (up to 60 MHz) signals (R, G, B) through three optical fibres. The method used consists of the linearization of the characteristics of the optical device. The same document details the advantages of serial digital optical transmission at 1.15 Gbit/s for HDTV on a single fibre.

8. Practical implementation of interfaces

[Grimaldi et al, 1986] describes the all-digital studio in final implementation in France. Although some functions are still analogue (e.g. cameras) the system uses a large number of pieces of digital equipment, in particular a mixer/switcher, video tape recorders and miscellaneous other functions. This equipment is connected by coaxial cables using the serial interface of Recommendation 656, with some minor differences due to the early implementation. An optical link using the same signal format is operative over 6 km. A discussion of the solutions adopted is included.

[Baraclough et al, 1987] provides information on practical experience in the design, installation and operation of an experimental digital television production centre in the United Kingdom employing the parallel interface of Recommendation 656. The solutions adopted for problems encountered are given, incuding, for example, those associated with multiple equipment interconnections, synchronization and timing.

Further contributions on this subject are invited.

9. Interference with other services

Processing and transmission of digital data, such as digital video signals, at high data rates produces a wide spectrum of energy that has the potential to cause cross-talk or interference. In particular, attention is drawn in Recommendation 656 to the fact that the ninth and eighteenth harmonics of the 13.5 MHz sampling frequency (nominal value) specified in Recommendation 601 fall at the 121.5 and 243 MHz aeronautical emergency channels. Appropriate precautions must therefore be taken in the design and operation of interfaces to ensure that no interference is caused at these frequencies. Permitted maximum levels of radiated signals from digital data processing equipment are the subject of various national and international standards, and it should be noted that emission levels for such related equipment are given in CISPR Recommendation: "Information technology equipment – Limits of interference and measuring methods" Document CISPR/B (Central Office) 16.

In the case of the bit-parallel interface [CCIR, 1982-86l] states that according to studies and experiments effected at the Canadian Broadcasting Corporation (CBC), with a correct shielding of the cables, no interference problem with other services is to be expected. This contribution recommends that radiation levels should comply with the limits given in Table I [CSA, 1983]. These limits are equivalent to those of the FCC in the United States of America.

TABLE I – *Limits of spurious emissions (CSA Class A)*

Frequency (MHz)	Maximum field strength dB(μV/m) at 30 m
30 to 88	30
88 to 216	50
216 to 1000	70

In relation to the bit-serial interface [CCIR, 1982-86e] states that transmission by optical fibres eliminates radiation generated by the cable and also prevents conducted common-mode radiation, but the performance of coaxial cable can also be made near-perfect. It is believed that the major portion of any radiation would be from the processing logic and high-power drivers common to both methods. It adds that due to the wideband, random nature of the digital signal, little is gained by frequency optimization.

Note.- See Report 1209.

10. Further studies

Further studies are required:

- on interfaces for the 4 : 4 : 4 level, and for lower members of the family of digital coding standards;
- to establish the types of ancillary signals to be carried, including their characterization and location in the data stream, and to propose international standards as necessary;
- to determine what special provisions may be necessary in relation to the associated sound channels, for example, to avoid excessive relative time delays;
- on the practical methods required to ensure acceptably low levels of radiated interference from the digital signals;
- on optical interfaces for bit-serial signals.

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EBU [1983] EBU parallel interface for 625-line digital video signals. Tech. Document 3246.

EBU [1985] EBU serial interface for 625-line digital video signal. Tech. Document 3247.

GRIMALDI, J.L., NASSE, D. and CAYET, A. [1986] - An experimental all-digital television centre, J.S.M.P.T.E., Vol. 95 No. 1, Pt. 1, pp 13-19.

CCIR Documents

[1982-86]: **a.** 11/126 (EBU); **b.** 11/61 (United States of America); **c.** 11/94 (Canada); **d.** 11/24 (Japan); **e.** 11/291 (IWP 11/7); **f.** 11/136 (OIRT); **g.** 11/336 (Italy); **h.** 11/347 (Italy); **i.** 11/335 (Italy); **j.** 11/356 (Italy); **k.** 11/354 (Italy); **l.** 11/385 (Canada).

[1986-90]: a. IWP 11/7-257 (Australia); b. IWP 11/7-186 (OIRT); c. IWP 11/7-115 (United Kingdom); d. 11/112 (Canada); e. 11/124 (Canada); f. IWP 11/7-141 (United Kingdom); g. 11/28 (Thomson-CSF).

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Appendix 1

Proposed draft additions to Recommendation 656 concerning an optical interface

7. Characteristics of the Optical Interface

7.1. Source Characteristics

7.1.1. Output Wavelength

1300nm nominal

Maximum spectral line width 150nm between half power points.

7.1.2. Output Power

Maximum 0dBm

Minimum -25dBm

7.1.3. Logic Convention

Maximum power output corresponds to the signalling of a logical 1.

7.1.4. Rise and Fall Times

To be decided.

7.1.5. Jitter

To be decided.

7.1.6. Isolation

Transmitter must withstand 10% of its output power returned by reflection.

7.2. Optical Fibre Link

FIBRE (compatible with optical fibre specified in CCITT Rec. G.652)

Fibre type	- single mode
Dimensions: mode field dia.	- 9-10 um +/-10%
cladding	- 125 um
Operating window	- around 1300 nm
Mode field concentricity	- < 3 um
Cladding non circularity	- < 2%
Cut-off wave length	- 1100-1280 nm
Attenuation at 1300 nm	- < 1 dB/km
Max. dispersion (1270-1340 nm)	- 6 ps/nm.km

CONNECTOR

Type	- biconical

7.3. Destination Characteristics

7.3.1. Sensitivity

Input power for a mean bit error rate of 1 in 10^9 -35dBm.

Maximum input power -20dBm.

7.3.2 Maximum Input Power

Receiver shall operate with a mean bit error rate better than 1 in 10^9 up to a power Level of -20 dBm.