RECOMMENDATION ITU-R BT.799-4*

Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:4:4 level of Recommendation ITU-R BT.601**

(Question ITU-R 42/6)

(1992-1994-1995-1998-2007)

Scope

This Recommendation covers the data structure and dual link serial interface for 525/625-line digital signals as defined in Recommendation ITU-R BT.601-5.

The ITU Radiocommunication Assembly,

considering

a) that there are clear advantages for television broadcasting organizations and programme producers in digital studio standards which have the greatest number of significant parameter values common to 525-line and 625-line systems;

b) that in implementing the above objectives, agreement was reached on the fundamental encoding parameters of digital television for studios in the form of Recommendation ITU-R BT.601;

c) that the worldwide compatible digital approach has permitted the development of equipment with many common features, permitting operating economies and facilitating the international exchange of programmes;

d) that the practical implementation of Recommendation ITU-R BT.601 or complex digital studio processes requires definition of details of an interface at the 4:4:4 level and the data streams traversing them;

e) that such an interface should have a maximum of commonality between 525-line and 625-line versions,

recognizing

a) that in the practical implementation of Recommendation ITU-R BT.601 it is desirable that a serial interface be defined,

recommends

1 that where an interface for the 4:4:4 level is required for component-coded digital video signals conforming to Recommendation ITU-R BT.601 in television studios, the interface and the data streams that will traverse them should be in accordance with Annex 1, defining the bit-serial implementation.

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* This Recommendation should be brought to the attention of ITU-T Study Group 9.

** Recommendation ITU-R BT.601-6 - Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios.

Annex 1

1 Introduction

Part 1 in this Annex describes the digital signal format of the interface.

Part 2 in this Annex describes the particular characteristics of the bit-serial interface.

The particular characteristics of the bit-parallel interface are to be found in Appendix 1 attached to this Annex for information.

The interface for the 4:4:4 level is based on the use of the serial interface already developed for use at the 4:2:2 level and described in Recommendation ITU-R BT.656. Whereas at the 4:2:2 level a single interface carries a multiplex of a wideband luminance and two lower-bandwidth colour-difference video signals, at the 4:4:4 level a pair of signal representations is used, each carrying a multiplex of two wideband video signals; this gives capacity for carrying the green, blue and red primary signals or, alternatively, the luminance and two colour-difference signals, together with a fourth wideband signal such as an associated key signal. In this case the signal is at the "4:4:4:4" level.

The interfaces for the 4:4:4 level have been specified for 10-bit (see Note 1) data words according to Recommendation ITU-R BT.601.

Only two devices will be connected together at one time through one interface.

NOTE 1 – Within this Recommendation, the contents of digital words are expressed in hexadecimal form of 10-bit representation.

For example, the bit pattern 10010001 is expressed as 245_h.

Eight-bit words occupy the left most significant bits of a 10-bit word, i.e. bit 9 to bit 2, where bit 9 is the most significant bit.

PART 1

Digital signal format of the interface

1 Introduction

The interface consists of two unidirectional interconnections between one device and another. The interconnections carry the data corresponding to the television signal and associated data.

The two interconnections are referred to as: link A and link B.

The data signals are carried in the form of binary information coded in ten-bit words. These signals are:

– the video signals themselves,
– digital blanking data,
– timing reference signals,
– ancillary data signals.

These signals are time-multiplexed.

2 Video data signals

2.1 Coding characteristics

The video data signals are derived by coding of the analogue video signal components in accordance with the 4:4:4 level of Recommendation ITU-R BT.601, with the field-blanking definition shown in Table 1.

2.2 Video data format

The data words in which the eight most significant bits are all set to 1 or are all set to 0 are reserved for data identification purposes and consequently only 254 of the possible 256 8-bit words or 1 016 of the possible 1 024 10-bit words may be used to express a signal value.

TABLE 1

Field interval definitions

			625	525
V-digital field blanking				
	Field 1	Start (V = 1)	Line 624	Line 1
		Finish (V = 0)	Line 23	Line 20
	Field 2	Start (V = 1)	Line 311	Line 264
		Finish (V = 0)	Line 336	Line 283
F-digital field identification				
	Field 1	F = 0	Line 1	Line 4
	Field 2	F = 1	Line 313	Line 266

NOTE 1 – Signals F and V change state synchronously with the end of active video timing reference code at the beginning of the digital line.

NOTE 2 – Definition of line numbers is to be found in Recommendation ITU-R BT.1700. Note that digital line number changes state prior to O_H as described in Recommendation ITU-R BT.601.

NOTE 3 – Designers should be aware that the "1" to "0" transition of the V-bit may not necessarily occur on line 20 (283) in some equipment conforming to previous versions of this Recommendation for 525-line signals.

2.3 Multiplex structure

The video data words are conveyed in two separate 27 Mword/s data-streams.

The multiplex sequence is:

– for links carrying colour primaries

link A: ..B_0 G_0 R_0 G_1 B_2 G_2 R_2 G_3 B_4...

link B: ..B_1 K_0 R_1 K_1 B_3 K_2 R_3 K_3 B_5...

where R, G and B represent the red, green and blue signal data words, and K represents the key signal data words, if present. The first sample of the digital active line shall be B_0 for link A and B_1 for link B.

The distribution of the red, green, blue and key signals between link A and link B is shown in Fig. 1a);

– for links carrying luminance and colour-difference signals

link A: ..$C_B0\ Y_0\ C_R0\ Y_1\ C_B2\ Y_2\ C_R2$...

link B: ..$C_B1\ K_0\ C_R1\ K_1\ C_B3\ K_2\ C_R3$...

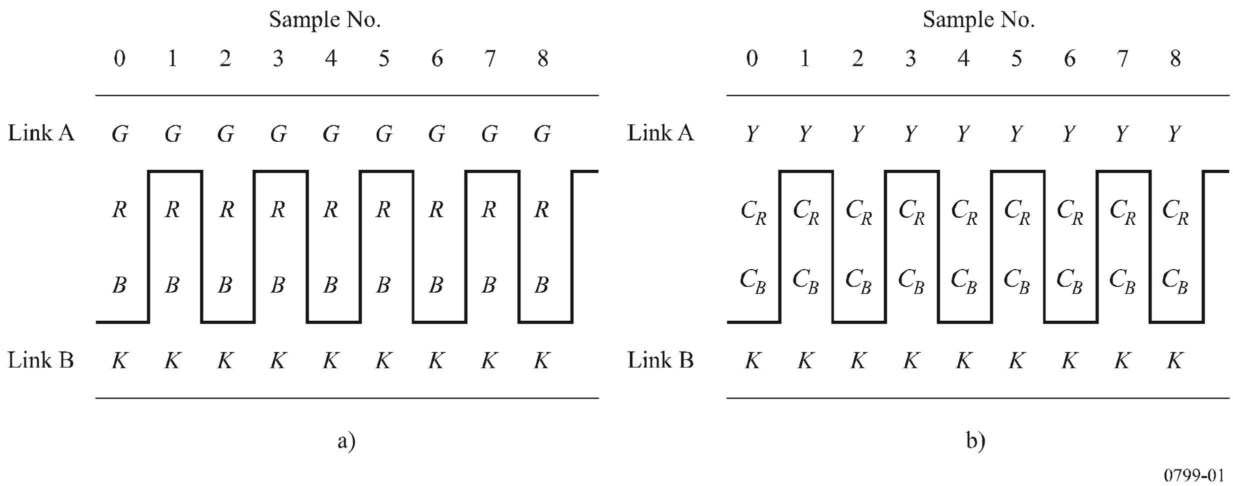
where Y, C_B and C_R represent the luminance and colour-difference signals respectively, and K represents the key signal data words, if present. The first sample of the digital active line shall be $C_B\,0$ for link A and C_B1 for link B. The distribution of the luminance, colour-difference and key signals between link A and link B is shown in Fig. 1b).

2.4 Interface signal structure

Figure 2 shows the ways in which the video sample data is incorporated in the interface data stream. Sample identification in Fig. 2 is in accordance with the identification in Recommendation ITU-R BT.601.

FIGURE 1

Link contents when used for *R, G, B, K* and *Y, C_R, C_B, K* signals



2.5 Video timing reference signals (SAV, EAV)

There are two timing reference signals, one at the beginning of each video data block (start of active video, SAV) and one at the end of each video data block (end of active video, EAV) as shown in Fig. 2.

Each timing reference signal consists of a four word sequence in the following format: 3FF 000 000 XYZ. (Values are expressed in hexadecimal notation. Words 3FF, 000 are reserved for use in timing reference signals.) The first three words are a fixed preamble. The fourth word contains information defined field 2 identification, the state of field blanking, and the state of line blanking. The assignment of bits within the timing reference signal is shown below in Table 2.

Bits P_0, P_1, P_2, P_3, have states dependent on the states of the bits F, V and H as shown in Table 3. At the receiver this arrangement permits one-bit errors to be corrected and two-bit errors to be detected.

2.6 Ancillary data

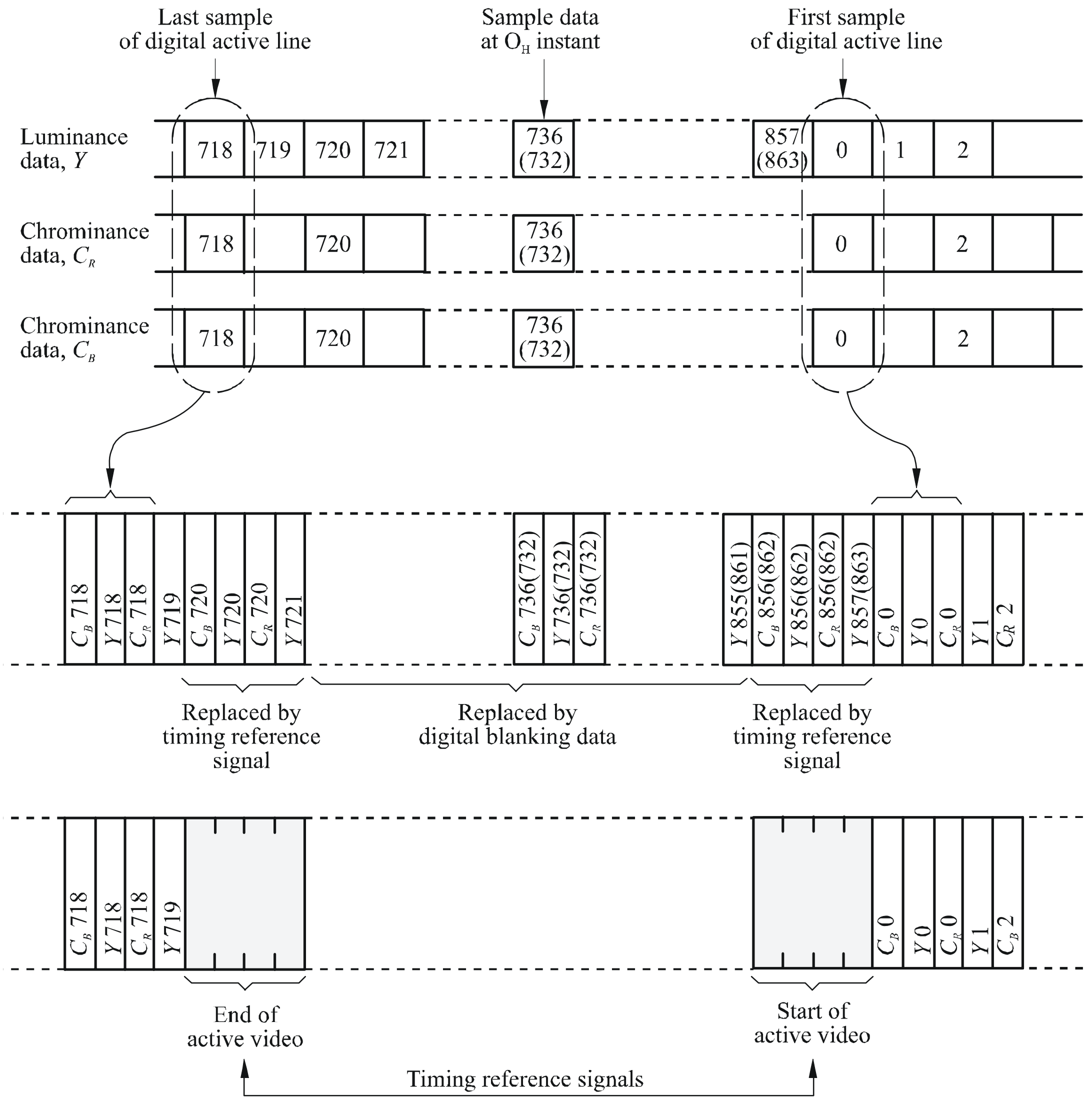
The ancillary signals should comply with Recommendation ITU-R BT.1364.

2.7 Data words during blanking

During digital blanking the luminance or *R*, *G*, *B* sample values should be set to black, level 40_h, and the colour-difference samples set to zero, level 200_h. The key samples should be set to peak white, level $EB.0_h$, when not carrying a key signal.

FIGURE 2

Composition of the data multiplex and position of the timing reference signals, EAV and SAV (shown here for link A carrying Y, C_R, C_B as an example)



Note 1 – Sample identification numbers in parentheses are for 625-line systems where these differ from those for 525-line systems. (See also Recommendation ITU-R BT.803.)

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TABLE 2

Video timing reference signal

Data bit number	First word (3FF)	Second word (000)	Third word (000)	Fourth word (XYZ)
9 (MSB)	1	0	0	1
8	1	0	0	F
7	1	0	0	V
6	1	0	0	H
5	1	0	0	P_3
4	1	0	0	P_2
3	1	0	0	P_1
2	1	0	0	P_0
1 (Note 2)	1	0	0	0
0	1	0	0	0

NOTE 1 – The values shown are those recommended for 10-bit interfaces.

NOTE 2 – For compatibility with existing 8-bit interfaces, the values of bits D1 and D0 are not defined.

F = 0 during field 1
1 during field 2

V = 0 elsewhere
1 during field blanking

H = 0 in SAV
1 in EAV

P0, P1, P2, P3: protection bits (see Table 3)

MSB: most significant bit

Table 1 defines the state of the V and F bits.

TABLE 3

Protection bits in the timing reference signal

F	V	H	P_3	P_2	P_1	P_0
0	0	0	0	0	0	0
0	0	1	1	1	0	1
0	1	0	1	0	1	1
0	1	1	0	1	1	0
1	0	0	0	1	1	1
1	0	1	1	0	1	0
1	1	0	1	1	0	0
1	1	1	0	0	0	1

PART 2

Bit-serial interface

1 General

A serial interface is an interface in which the bits of a data word, and successive data words, are sent consecutively via a single transmission channel. The serial interface is capable of carrying video, audio, and ancillary data. It may also be used for carrying packetized data in accordance with Recommendation ITU-R BT.1364.

The transmission of signals can be achieved in both electrical form, using coaxial cable, and in optical form using an optical fibre. Coaxial cables would probably be preferred for connections of medium length (e.g. 300 m), while preference would go to optical fibres for very long connection lengths.

It is possible to implement a system for detection of the occurrence of errors at the receiving end of the connection and thus automatically monitoring its performance.

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.

The multiplexed data stream of 10-bit words (as described in Part 1) is transmitted over two links in bit-serial form. Prior to transmission, additional coding takes place to provide spectral shaping, word synchronization and to facilitate clock recovery.

The 10-bit data for each link is transferred across the interface as a serial data-stream in unbalanced form and at an impedance of 75 Ω.

2 Link-to-link timing relationship

The interface must operate correctly when the electrical lengths of the two interconnections between line sender and receiver differ by up to 10 ns.

3 Coding

The uncoded serial bit-stream is scrambled using the generator polynomial $G1(x) \cdot G2(x)$, where

$G1(x) = x^9 + x^4 + 1$ to produce a scrambled NRZ signal, and

$G2(x) = x + 1$ to produce a polarity-free NRZI sequence.

4 Order of transmission

The least significant bit of each 10-bit word shall be transmitted first.

5 Logic convention

The signal is transmitted in NRZI form, for which the bit polarity is irrelevant.

6 Transmission medium

The bit-serial data-stream can be conveyed using either a coaxial cable (§ 7) or fibre optic bearer (§ 8).

7 Characteristics of the electrical interface

7.1 Line driver characteristics *(source)*

7.1.1 Output impedance

The line driver has an unbalanced output with a source impedance of 75 Ω and a return loss of at least 15 dB over a frequency range of 5-270 MHz.

7.1.2 Signal amplitude

The peak-to-peak signal amplitude lies between 800 mV ± 10% measured across a 75 Ω resistive load directly connected to the output terminals without any transmission line.

7.1.3 DC offset

The DC offset with reference to the mid amplitude point of the signal lies between +0.5 and –0.5V.

7.1.4 Rise and fall times

The rise and fall times, determined between the 20% and 80% amplitude points and measured across a 75 Ω resistive load connected directly to the output terminals, shall lie between 0.75 and 1.50 ns and shall not differ by more than 0.50 ns.

7.1.5 Jitter

The output jitter is specified as follows:

output jitter	f_1 = 10 Hz
(see Note 1)	f_3 = 1 kHz
	f_4 = 1/10 of the clock rate
	A_1 = 0.2 UI (UI; unit interval)
	A_2 = 0.2 UI

NOTE 1 – 1 UI corresponds to 3.7 ns 0.2 UI corresponds to 0.74 ns.

Specification of jitter and jitter measurements methods shall comply with Recommendation ITU-R BT.1363 (Jitter specifications and for methods jitter measurement of bit-serial signals conforming to Recommendations ITU-R BT.656, ITU-R BT.799 and ITU-R BT.1120).

7.2 Line receiver characteristics *(destination)*

7.2.1 Terminating impedance

The cable is terminated by 75 Ω with a return loss of at least 15 dB over a frequency range of 5 to 270 MHz.

7.2.2 Receiver sensitivity

The line receiver must sense correctly random binary data either when connected directly to a line driver operating at the extreme voltage limits permitted by § 7.1.2, or when connected via a cable having a loss of 40 dB at 270 MHz and a loss characteristic of $1/\sqrt{f}$.

7.2.3 Interference rejection

When connected directly to a line driver operating at the lower limit specified in § 7.1.2, the line receiver must correctly sense the binary data in the presence of a superimposed interfering signal at the following levels:

DC ±2.5 V	
below 1 kHz:	2.5 V peak-to-peak
1 kHz to 5 MHz:	100 mV peak-to-peak
Above 5 MHz:	40 mV peak-to-peak.

Specification of jitter and jitter measurements methods shall comply with Recommendation ITU-R BT.1363.

7.3 Cables and connectors

7.3.1 Cable

It is recommended that the coaxial cable chosen should meet any relevant national standards on electromagnetic radiation.

NOTE 1 – 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. It should be noted that the ninth and eighteenth harmonics of the 13.5 MHz sampling frequency (nominal value) specified in Recommendation ITU-R BT.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 related equipment are given in CISPR Recommendation: "Information technology equipment – limits of interference and measuring methods" (Document CISPR/B (Central Office) 16). Nevertheless, RR No. 4.22 prohibits any harmful interference on the emergency frequencies (see also Recommendation ITU-R BT.803).

NOTE 2 – 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. Due to the wideband, random nature of the digital signal, little is gained by frequency optimization.

7.3.2 Characteristic impedance

The cable used shall have a nominal characteristic impedance of 75 Ω.

7.3.3 Connector characteristics

The connector should have mechanical characteristics conforming to the standard BNC type (IEC 61169-8 (2007-2))* – Part 8: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 6.5 mm (0.256 in) with bayonet lock-characteristic impedance 50 Ω (type BNC), Annex A (Normative) Information for interface dimensions of 75 Ω characteristic impedance, and for a usable frequency range of up to 3.5 GHz.

*NOTE – IEC 61169-8 (2007-2) is available in electronic version at the following address: http://www.itu.int/md/R03-WP6A-C-0145/en.

8 Characteristics of the optical interface

Specifications for the characteristics of the optical interface should comply with general rules of Recommendation ITU-R BT.1367 (Serial digital fibre transmission system for signals conforming to Recommendations ITU-R BT.656, ITU-R BT.799 and ITU-R BT.1120).

To make use of this Recommendation the following specifications are necessary.

Rise and fall times < 1.5 ns (20% to 80%)

output jitter	f_1 = 10 Hz
(see Note 1)	f_3 = 1 kHz
	f_4 = 1/10 of the clock rate
	A_1 = 0.135 UI (UI; unit interval)
	A_2 = 0.135 UI

NOTE 1 – Specification of jitter and jitter measurements methods shall comply with Recommendation ITU-R BT.1363.

Appendix 1
(Informative)

Bit-parallel interface[1]

1 General

The 10-bit video data for each link is transferred across the interfaces on ten parallel data pairs together with a clock signal on an eleventh pair.

The signals on the interface are transmitted using balanced conductor pairs. Cable lengths of up to 50 m (≃160 feet) without equalization and up to 200 m (≃650 feet) with appropriate equalization may be employed.

Each interconnection employs a twenty-five pin D-subminiature connector equipped with a locking mechanism (§ 5).

Video data is transmitted in NRZ form in real time (unbuffered) in blocks, each comprising one active television line.

2 Data signal format

The interface carries data in the form of 10 parallel data bits and a separate synchronous clock. Data is coded in NRZ form. The recommended data format is described in Part 1.

3 Link-to-link timing relationship

The clock transitions for the two links shall lie within 10 ns of each other at the receiver.

[1] NOTE – The bit-parallel interface is no longer in use, it is documented to support legacy installations. The data structure is used as the input to the serial digital interface serializer.

4 Clock signal

4.1 General

The clock signal is a 27 MHz square wave where the 0-1 transition represents the data transfer time. This signal has the following characteristics:

Width: 18.5 ± 3 ns

Jitter: Less than 3 ns from the average period over one field.

NOTE 1 – This jitter specification, while appropriate for an effective parallel interface, is not suitable for clocking digital to analogue conversion or parallel to serial conversion.

4.2 Clock-to-data timing relationship

The positive transition of the clock shall occur midway between data transitions as shown in Fig. 3.

5 Electrical characteristics of the interface

5.1 General

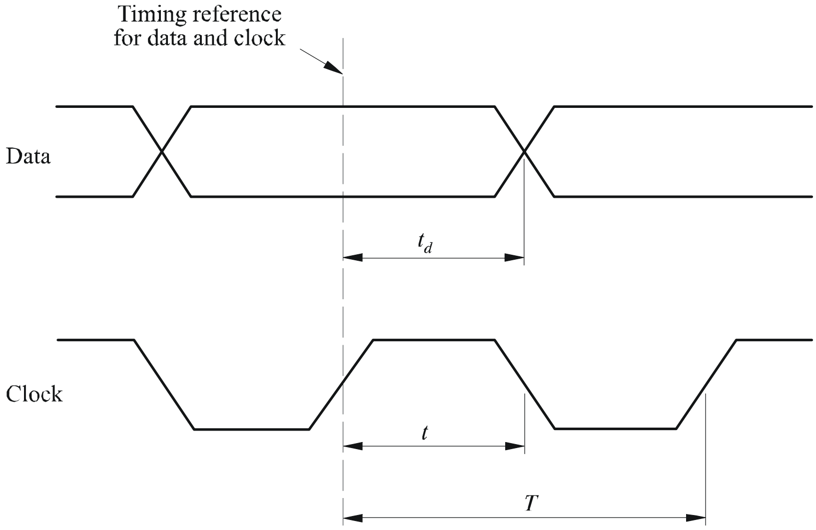
Each line driver (source) has a balanced output and the corresponding line receiver (destination) a balanced input (see Fig. 4).

Although the use of ECL technology is not specified, the line driver and receiver must be ECL-compatible, i.e. they must permit the use of ECL for either drivers or receivers.

All digital signal time intervals are measured between the half-amplitude points.

FIGURE 3

Clock-to-date timing (at source)



Clock period (625): $T = \frac{1}{1\,728\,f_H} = 37$ ns

Clock period (525): $T = \frac{1}{1\,726\,f_H} = 37$ ns

Clock pulse width: $t = 18.5 \pm 3$ ns

Data timing – sending end: $t_d = 18.5 \pm 3$ ns

f_H: line frequency

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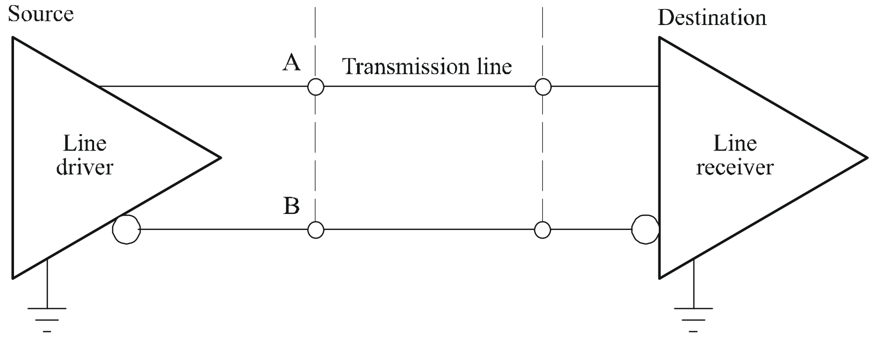
FIGURE 4

Line driver and line receiver interconnection



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5.2 Logic convention

The A terminal of the line driver is positive with respect to the B terminal for a binary 1 and negative for a binary 0 (see Fig. 4).

5.3 Line driver characteristics *(source)*

5.3.1 *Output impedance:* 110 Ω maximum.

5.3.2 *Common mode voltage:* –1.29 V ± 15% (both terminals relative to ground).

5.3.3 *Signal amplitude:* 0.8 to 2.0 V peak-to-peak, measured across a 110 Ω resistive load.

5.3.4 *Rise and fall times:* less than 5 ns, measured between the 20% and 80% amplitude points, with a 110 Ω resistive load. The difference between rise and fall times must not exceed 2 ns.

5.4 Line receiver characteristics *(destination)*

5.4.1 *Input impedance:* 110 Ω ± 10 Ω.

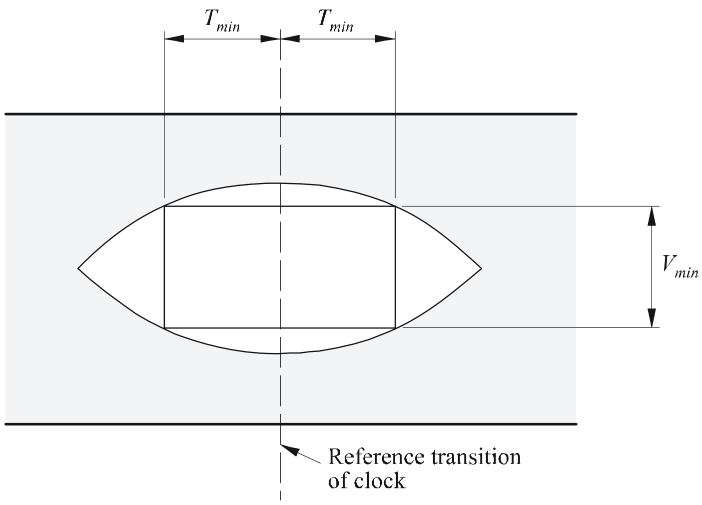
5.4.2 *Maximum input signal:* 2.0 V peak-to-peak.

5.4.3 *Minimum input signal:* 185 mV peak-to-peak.

However, the line receiver must sense correctly the binary data when a random data signal produces the conditions represented by the eye diagram in Fig. 5 at the data detection point.

FIGURE 5

Idealized eye diagram corresponding to the minimum input signal level



T_{min} = 11 ns

V_{min} = 100 mV

Note 1 – The width of the window in the eye diagram, within which data must be correctly detected comprises ± 3 ns clock jitter, ± 3 ns data timing (see § 4.2), and ± 5 ns available for differences in delay between pairs of the cable. (See also Recommendation ITU-R BT.803.)

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5.4.4 *Maximum common mode signal:* ± 0.5 V, comprising interference in the range 0 to 15 kHz (both terminals to ground).

5.4.5 *Differential delay:* Data must be correctly sensed when the clock-to-data differential delay is in the range between ±11 ns (see Fig. 5).

6 Mechanical details of the connectors

The interface uses the 25 contact type D subminiature connector specified in ISO Document 2110-1980, with the contact assignment shown in Table 4.

TABLE 4

Contact assignments

Contact	Signal line
1	Clock
2	System ground A
3	Data 9 (MSB)
4	Data 8
5	Data 7
6	Data 6
7	Data 5
8	Data 4
9	Data 3
10	Data 2
11	Data 1
12	Data 0
13	Cable shield
14	Clock return
15	System ground B
16	Data 9 return
17	Data 8 return
18	Data 7 return
19	Data 6 return
20	Data 5 return
21	Data 4 return
22	Data 3 return
23	Data 2 return
24	Data 1 return
25	Data 0 return

NOTE 1 – The cable shield (contact 13) is for the purpose of controlling electromagnetic radiation from the cable. It is recommended that contact 13 should provide high-frequency continuity to the chassis ground at both ends, and, in addition, provide DC continuity to the chassis ground at the sending end (see also Recommendation ITU-R BT.803).