RECOMMENDATION ITU-R BT.1362*

Interfaces for digital component video signals in 525- and 625-line progressive scan television systems

(Question ITU-R 42/6)

(1998)

The ITU Radiocommunication Assembly,

considering

a) that there is interest in using progressive scan systems as input to enhanced analogue services and for digital television broadcasting;

b) that the progressive signal offers improved vertical and temporal resolution over the conventional interlaced signal;

c) that parameter values for the progressive systems should have maximum commonality with the existing conventional television systems;

d) that a worldwide compatible digital approach will permit the development of equipment with many common features, permit operating economies and facilitate the international exchange of programmes;

e) that to implement the above objectives, agreement has been reached on the fundamental encoding parameters of digital television for studios in the form of Recommendation ITU-R BT.1358;

f) that the practical implementation of Recommendation ITU-R BT.1358 requires definition of details of interfaces and the data streams traversing them;

g) that such interfaces should have a maximum of commonality between 525-line and 625-line versions;

h) that in the practical implementation of Recommendation ITU-R BT.1358 it is desirable that interfaces be defined in serial forms,

recommends

1 that where interfaces are required for component-coded digital video signals described in Recommendation ITU-R BT.1358 in television studios, the interfaces and the data streams that will traverse them should be in accordance with the following description, defining bit-serial implementations.

1 Introduction

This Recommendation describes the means of interconnecting digital television equipment operating on the 525-line or 625-line progressive scan standards and complying with the 4:2:2 encoding parameters as defined in Recommendation ITU-R BT.1358.

Part 1 describes the signal format.

Part 2 describes the characteristics of the bit-serial interfaces.

Supplementary information is to be found in Annex 1.

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2003 in accordance with Resolution ITU-R 44.

PART 1

Common signal format of the interfaces

1 General description of the interfaces

The interfaces provide unidirectional interconnection between a single source and a single destination.

The signal format for the serial interfaces are described in § 2.

The data signals are in the form of binary information coded in 8-bit or, optionally, 10-bit words (see Note 1). These signals are:

– video signals;

– timing reference signals;

– ancillary signals.

NOTE 1 – Within this Recommendation, the contents of digital words are expressed in both decimal and hexadecimal form. To avoid confusion between 8-bit and 10-bit representations, the eight most significant bits are considered to be an integer part while the two additional bits, if present, are considered to be fractional parts.

For example, the bit pattern 10010001 would be expressed as 145_d or 91_h, whereas the pattern 1001000101 would be expressed as 145.25_d or 91.4_h.

Where no fractional part is shown, it should be assumed to have the binary value 00.

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.

2 Video data

2.1 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.

2.2 Video timing reference codes (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).

Each timing reference signal consists of a four word sequence in the following format: FF 00 00 XY. (Values are expressed in hexadecimal notation. FF 00 values are reserved for use in timing reference signals.) The first three words are a fixed preamble. The fourth word contains information defining 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 in Table 1.

TABLE 1

Video timing reference codes

Data bit number	First word (FF)	Second word (00)	Third word (00)	Fourth word (XY)
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 D_1 and D_0 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

P_0, P_1, P_2, P_3: protection bits (see Table 3)

MSB: most significant bit

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 2. At the receiver this arrangement permits one-bit errors to be corrected and two-bit errors to be detected.

TABLE 2

Protection bits

F	**V**	**H**	$\mathbf{P_3}$	$\mathbf{P_2}$	$\mathbf{P_1}$	$\mathbf{P_0}$
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

2.3 Ancillary data

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

2.4 Data words during blanking

The data words occurring during digital blanking intervals that are not used for the timing reference code or for ancillary data are filled with the sequence 80.0_h, 10.0_h, 80.0_h, 10.0_h etc. corresponding to the blanking level of the C_B, Y, C_R, Y signals respectively, appropriately placed in the multiplexed data.

Where the word sequence C_B, Y, C_R, refers to co-sited luminance and colour-difference samples and the following word, Y, corresponds to the next luminance sample.

PART 2

Bit-serial interfaces

1 General description of the interfaces

The multiplexed data stream of 10-bit words is transmitted over a single channel in bit-serial form. Prior to transmission, additional coding takes place to provide spectral shaping, word synchronization and to facilitate clock recovery.

2 Video Data

This standard defines two alternatives for bit-serial interfaces for the 525- and 625-line progressive scan digital signals, as defined in Recommendation ITU-R BT.1358, each having a high degree of commonality with interfaces operating in accordance with Recommendation ITU-R BT.656 and Recommendation ITU-R BT.1302.

2.1 4:2:2p (dual link) Interface

4:2:2p is a dual link interface. Each link operates at 270 Mbit/s, in which the active data in the Y, C_B, C_R format (totally equivalent to 8:4:4), are line sequentially transparently divided into two data streams, each equivalent to the 4:2:2 component signal of Recommendation ITU-R BT.656.

The processing of the data from the 8:4:4 level of the 525- and 625-line progressive scan production (Recommendation ITU-R BT.1358) is illustrated in Fig. 1 and 2. Essentially, the odd lines of one field and the even lines of the next field are selected line by line and formed into the data for one interface link, while the even lines of the field and the odd lines of the next field are selected to form the data for the other interface link. In the output field where the odd-numbered lines of the active input field are interface link A, the F bit of the TRS is set to 0 in both links; where the even-numbered lines of the active input field are in link A, the F bit of the TRS is set to 1.

The video data words are conveyed as a 27 Mword/s multiplex in the following order:

$$C_B, Y, C_R, Y, C_B, Y, C_R, \text{etc.}$$

These data are then converted into two serial streams at 270 Mbit/s data rate in accordance with Recommendation ITU-R BT.656.

The timing difference between these two data streams shall not exceed 100 nsec at the source.

NOTE 1 – Buffering having a minimum duration of one horizontal line is required by this process at each interface, making a minimum transmission delay of two horizontal lines.

NOTE 2 – The resulting data in each link should not be used for interlaced (29.97 frames/s for 525 line and 25 frames/s for 625 line) moving image presentation without spatial filtering, which is required to avoid interline flicker and aliasing.

NOTE 3 – Figure 1 shows how the luminance and colour-difference signals are multiplexed within a transmission package.

2.2 4:2:0p (single-link) Interface

4:2:0p is a single-link interface operating at 360 Mbit/s, in which the active data representing the colour-difference components in the Y, C_B, C_R format (equivalent to 8:4:4) are quincunx down-converted by a factor of two, prior to reformatting with the full luminance data, into a single data stream equivalent to the component signal specified in Recommendation ITU-R BT.1302 (conceptually 8:4:0).

The processing of the data from the 8:4:4 level of the 525- and 625-line progressive scan production (see Recommendation ITU-R BT.1358) is illustrated in Fig. 3 and 4.

The active colour-difference components C_B and C_R are vertically filtered and subsampled to a quincunx pattern as shown in Fig. 5. This results in a sample grid for the colour-difference components that is twice the spacing in both the horizontal and vertical dimensions, respectively. The quincunx arrangement of sampling sites is field alternating vertically. The number of samples in two active lines is now 720 for Y, 720 for Y', and 720 for C_B/C_R combined, for a total of 2 160.

NOTE – Examples of a basic minimal vertical colour-difference filter and an adaptive colour-difference filter are shown in Figs. A.1 and A.2, respectively in Annex 1 § 7. In either case, an appropriate matching delay is required in the luminance data.

The Y, Y', and C_B/C_R data are interleaved at sample level as illustrated in Fig. 3, in the order C_B, Y, Y', C_R, Y, Y', C_B, etc.

TRS data, SAV, and EAV are added with a digital blanking interval of 120 samples for 525-line and 136 samples for 625-line progressive scan, as shown in Fig. 3.

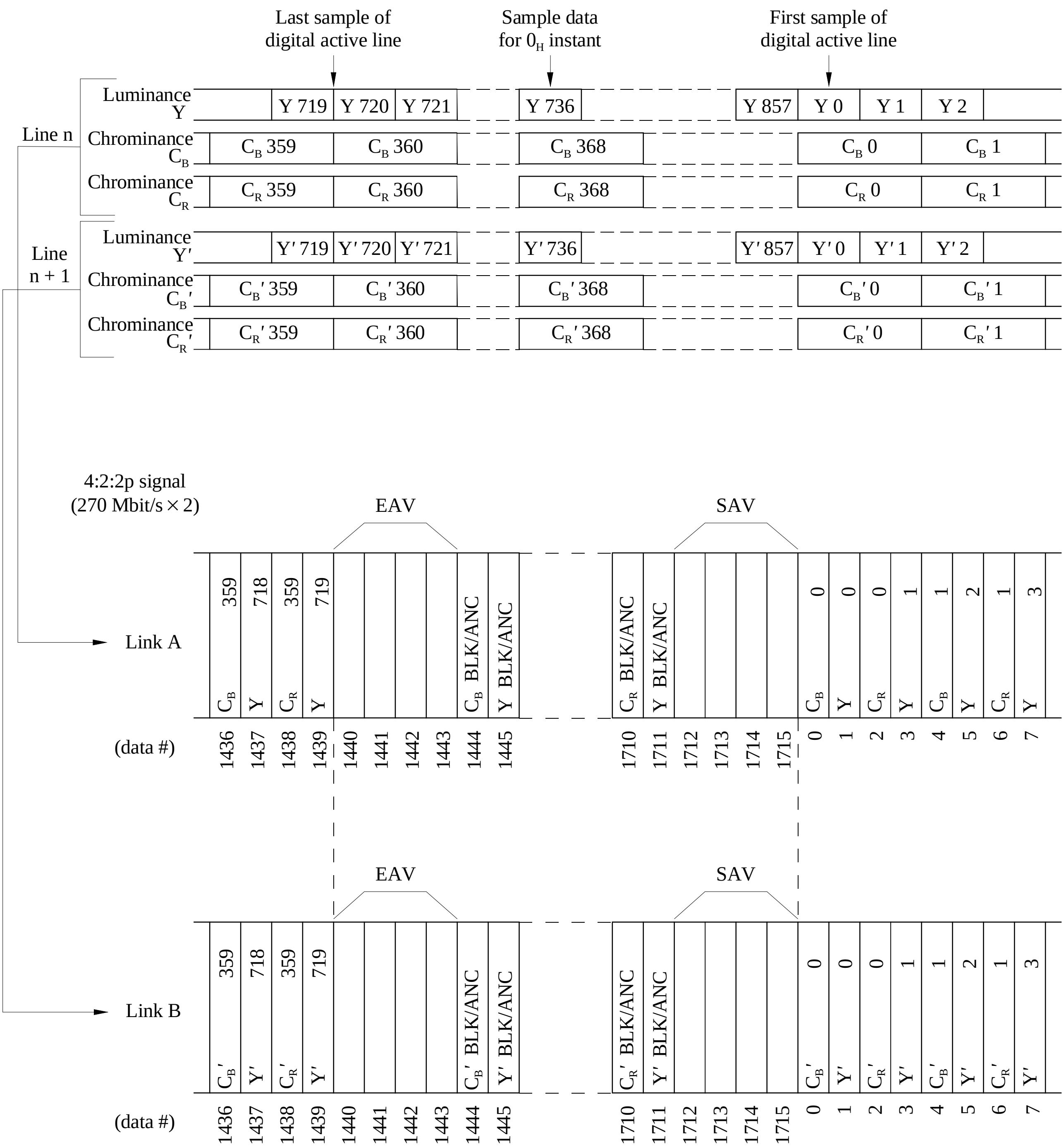
NOTE – The resulting data stream has a data rate in serial form (10 bits) of 360 Mbit/s in the format specified in Recommendation ITU-R BT.1302 only at the transmission level. The total line of 2 288 samples occupies approximately 63.5 µs in 525-line system and 2 304 samples occupies 64 µs in 625-line system.

The F bit in code word 3 in SAV/EAV shall be set to 0 or 1 identifying the quincunx sequence. If the 525- or 625-line interlaced signal studio sync is used as reference, the frame coinciding with the first interlaced field shall be designated as F = 0.

The data are then converted into a serial digital bit stream; the data rate is 360 Mbit/s.

FIGURE 1a

Composition of 4:2:2p data stream for 525-line progressive scan



Note 1 - Y BLK/ANC, C_B BLK/ANC, C_R BLK/ANC denotes blanking data for Y, C_B, C_R or ancillary data.

Note 2 - EAV: end of active video, SAV: start of active video.

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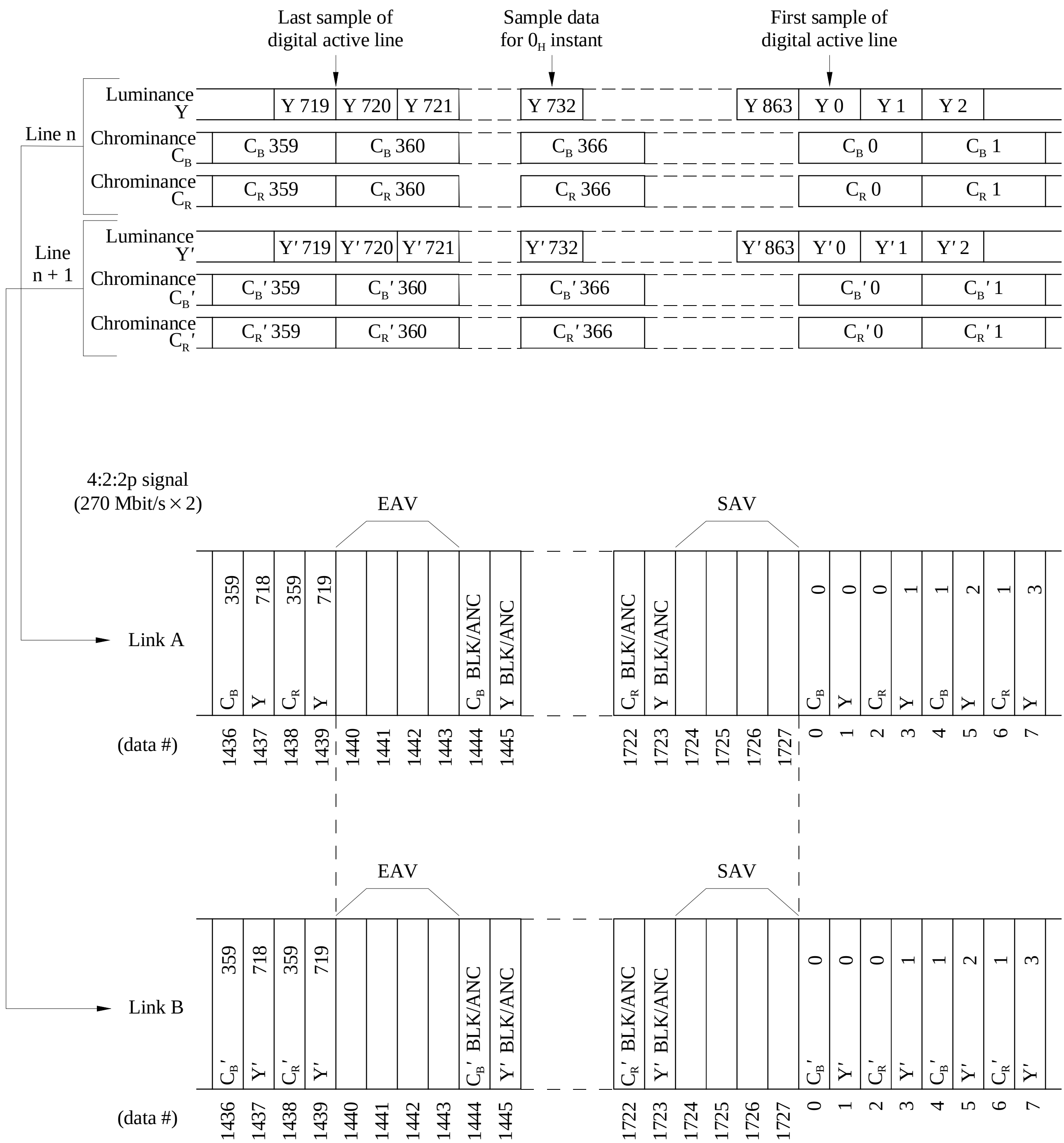
FIGURE 1b

Composition of 4:2:2p data stream for 625-line progressive scan



Note 1 - Y BLK/ANC, C_B BLK/ANC, C_R BLK/ANC denotes blanking data for Y, C_B, C_R or ancillary data.

Note 2 - EAV: end of active video, SAV: start of active video.

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FIGURE 2a

4:2:2p line numbering and packaging in the two 270 Mbit/s serial data for 525-line progressive scan

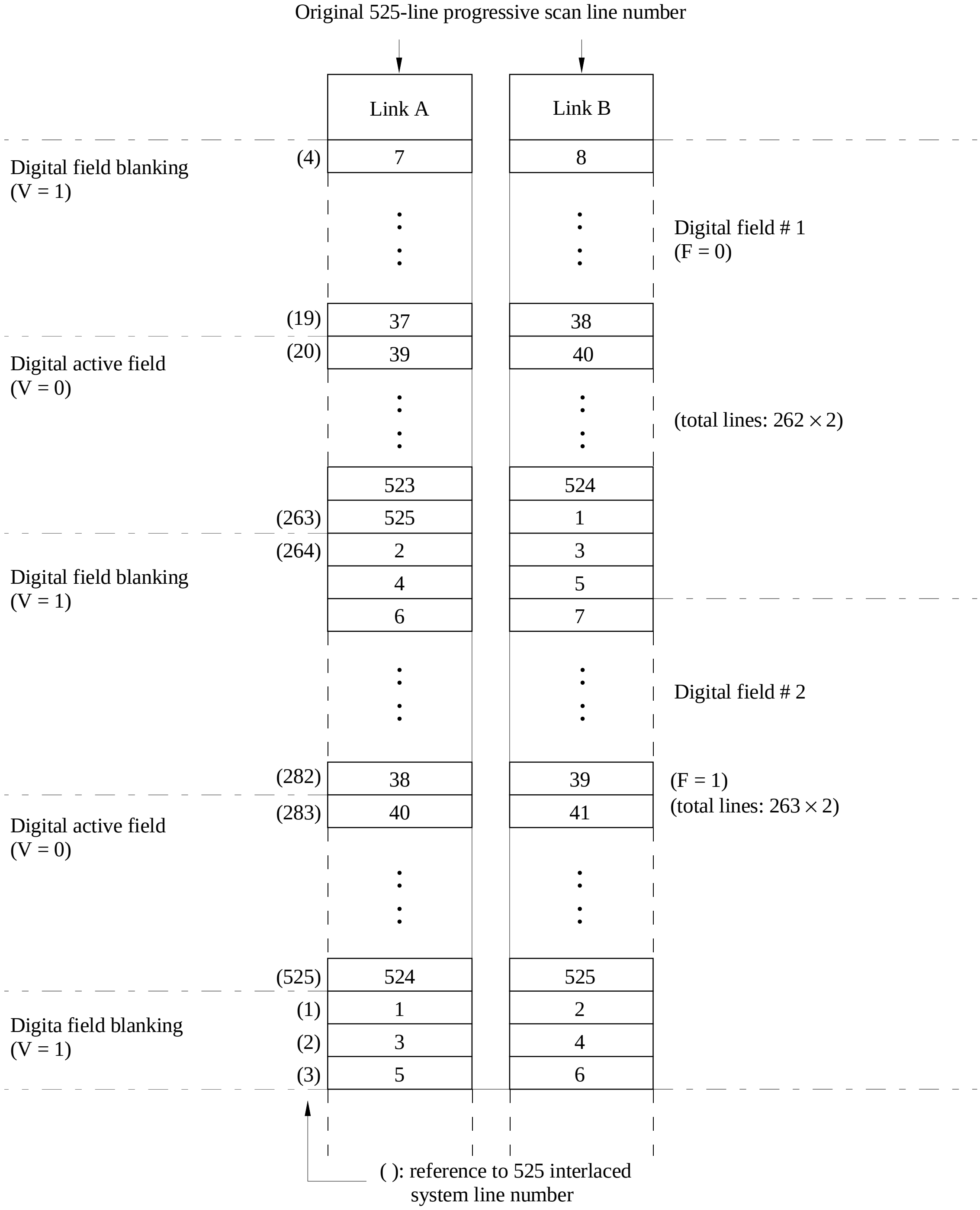

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FIGURE 2b

4:2:2p line numbering and packaging in the two 270 Mbit/s serial data for 625-line progressive scan

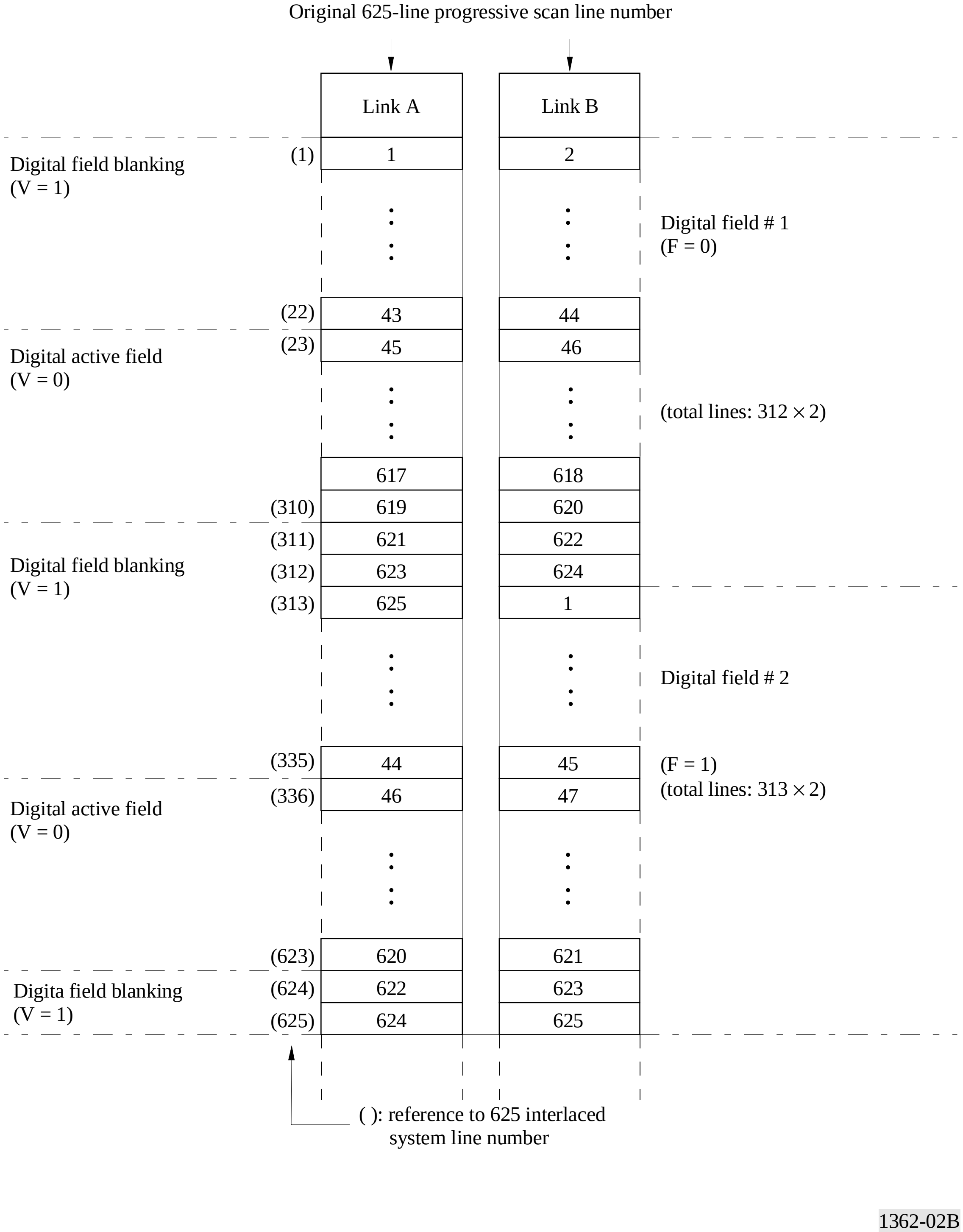

FIGURE 3a

Composition of 4:2:0p data stream for 525-line progressive scan

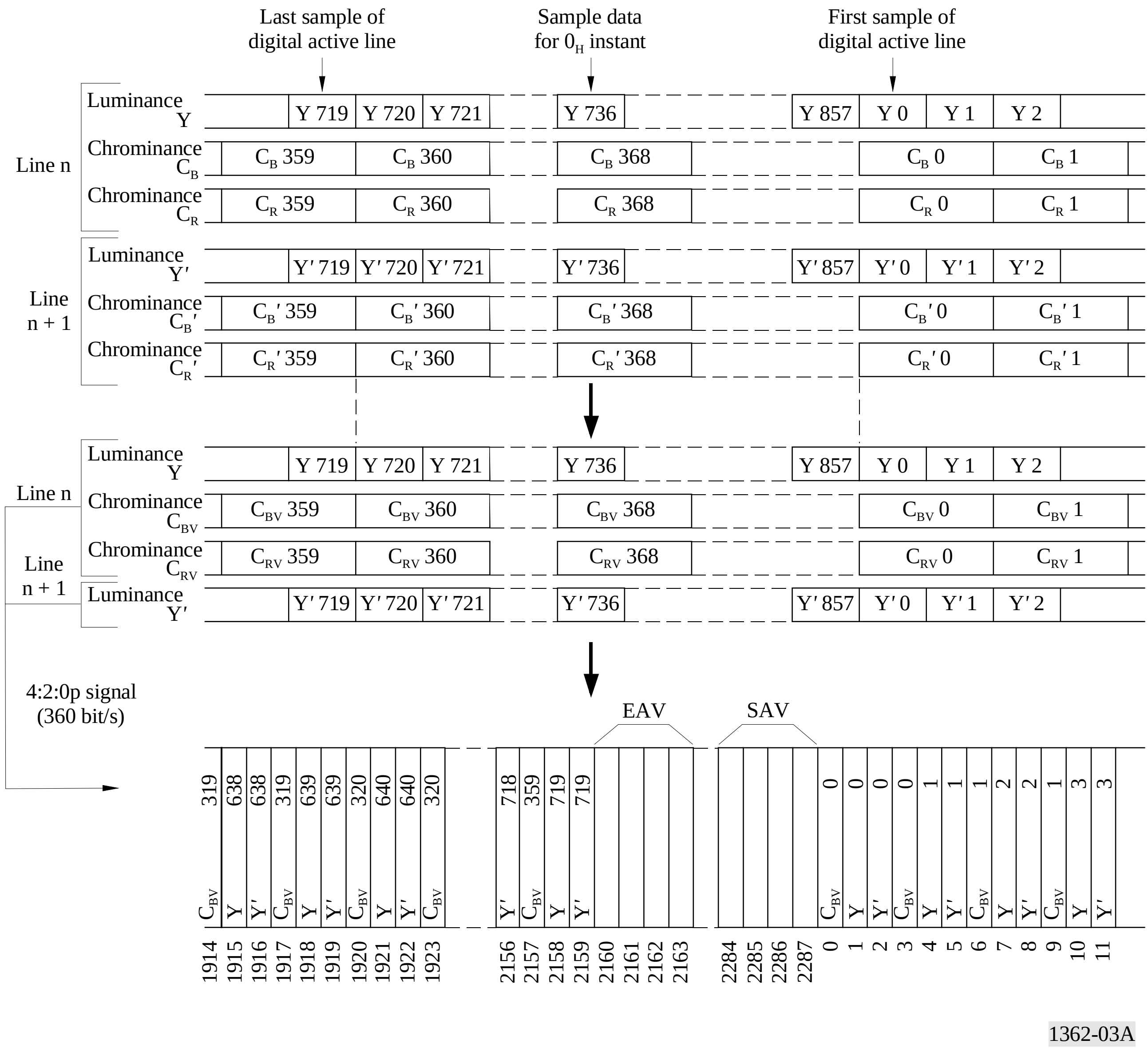

FIGURE 3b

Composition of 4:2:0p data stream for 625-line progressive scan

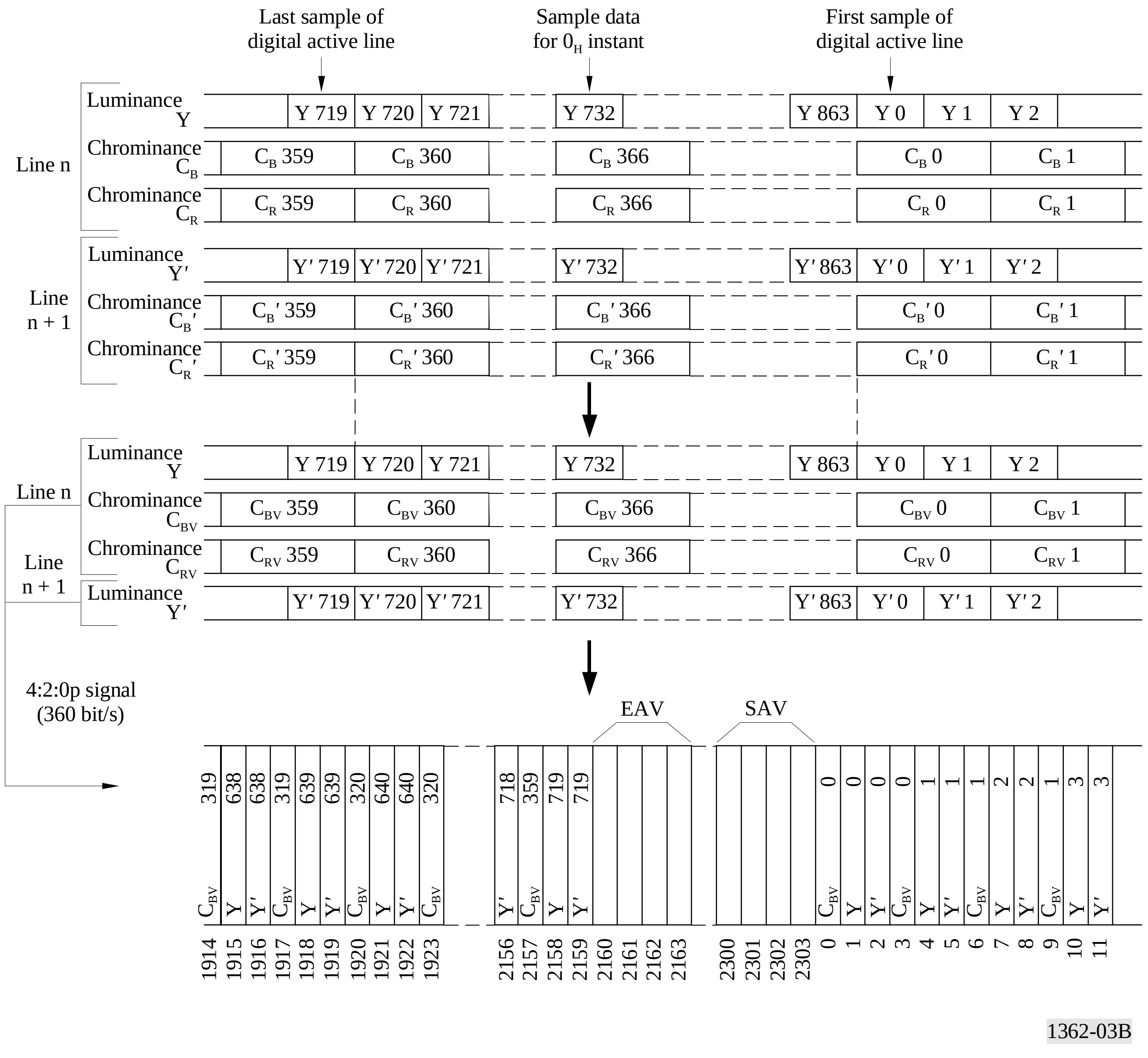

FIGURE 4a

4:2:0p (single-link) interface line numbering and packaging for 525-line progressive scan

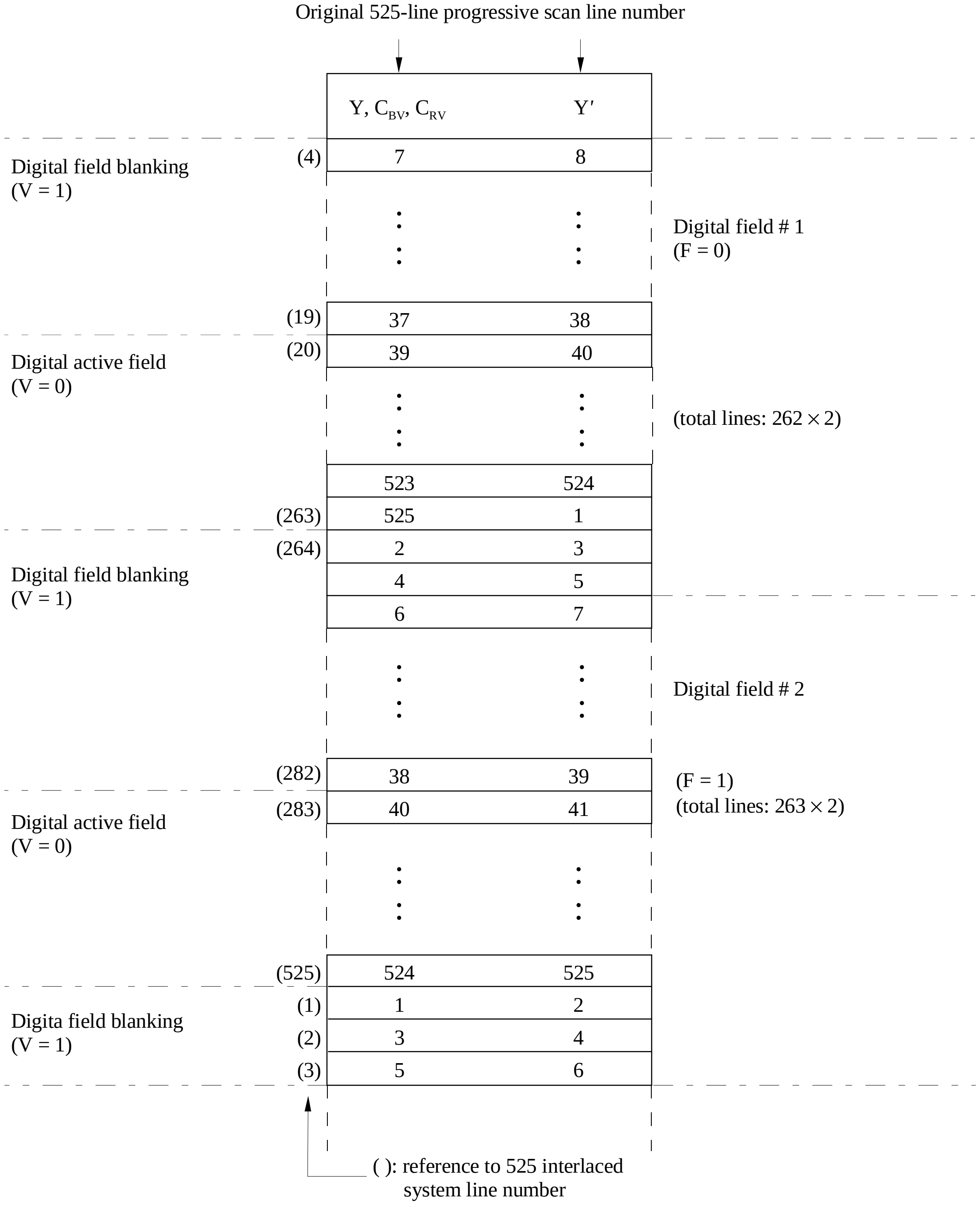

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FIGURE 4b

4:2:0p (single-link) interface line numbering and packaging for 625-line progressive scan

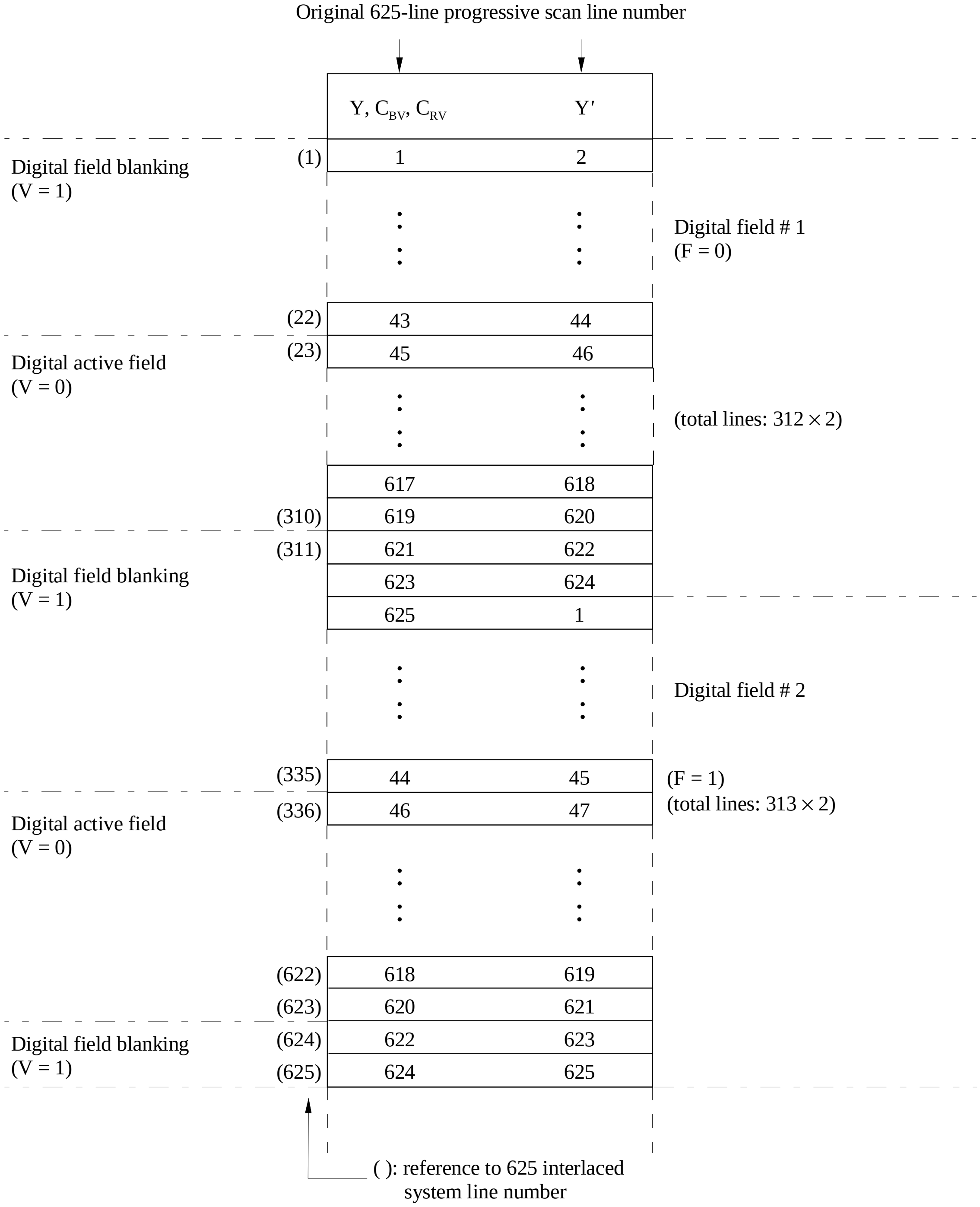

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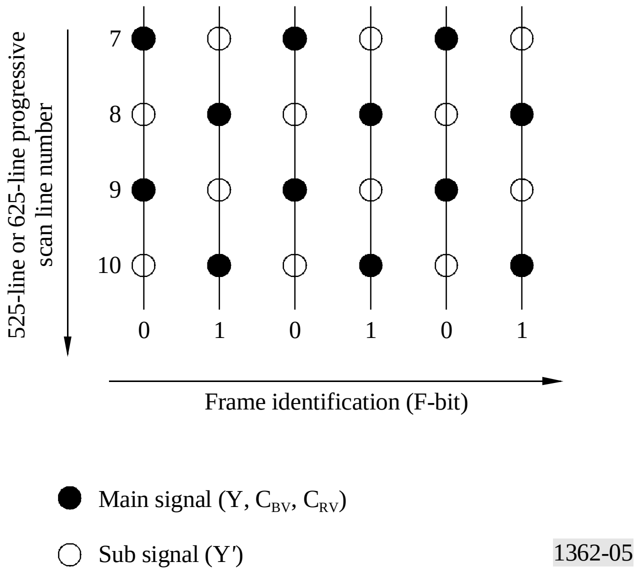
FIGURE 5

Sampling grid for color-difference data in line/field quincunx pattern in 4:2:0p



3 Coding

The uncoded serial bit-stream is scrambled using the generator polynomial $G1(x) \times G2(x)$, 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 (see § 7) or fibre-optic bearer (see § 8).

7 Characteristics of the electrical interfaces

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 MHz to the clock frequency of the signal being transmitted.

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 d.c. offset

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

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 0.5 and 1.50 ns.

7.1.5 Jitter

1) The output jitter is specified as follows:

Output jitter (1)
$f_1 = 10$ Hz
$f_3 = 100$ kHz
$f_4 = 1/10$ of the clock rate
$A_1 = [0.2$ UI] (UI; unit interval) (2)
$A_{2_2} = 0.2$ UI

NOTE 1 – 1 UI and 0.2 UI correspond to 3.7 ns and 0.74 ns.

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

NOTE 2 – 0.2 UI for timing jitter is often used in other specifications. There are considerations in specifying 1 UI for timing jitter.

2) Input jitter

Input jitter tolerances needs to be defined. Input jitter is measured with a short cable (2 m).

Specification of jitter and jitter measurements methods shall comply with Recommendation ITU-R BT.1363 (Jitter specifications and jitter measurement methods of bit-serial signals conforming to 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 MHz to the clock frequency of the signal being transmitted.

7.2.2 Receiver sensitivity (see Note 1)

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

NOTE 1 – Parameters defined in § 7.2.2 are target values and may be refined in the future with regard to practical implementations of the system.

7.2.3 Interference rejection (see Note 1)

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

– d.c. ±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.

NOTE 1 – Parameters defined in § 7.2.3 are target values and may be refined in the future with regard to practical implementations of the system.

7.3 Cables and connectors

7.3.1 Cable

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

NOTE 1 – It should be noted that the fourth and ninth harmonics of the 27 MHz sampling frequency (nominal value) specified in Recommendation ITU-R BT.1358 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. Emission levels for related equipment are given in CISPR Recommendation: "Information technology equipment – limits of interference and measuring methods" (Doc. 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.)

7.3.2 Characteristic impedance

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

7.3.3 Connector characteristics

The connector shall have mechanical characteristics conforming to the standard BNC type (IEC Publication 169-8), and its electrical characteristics should permit it to be used at frequencies up to 850 MHz in 75 Ω circuits.

8 Characteristics of the optical interfaces

Specifications for the characteristics of the optical interfaces should comply with general rules of Recommendation ITU-R BT.1367 (Serial Digital Fibre Transmission Systems for Signals Conforming to 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 (1)	f_1 = 10 Hz f_3 = 100 kHz f_4 = 1/10 of the clock rate A_1 = 0.135 UI (UI; unit interval) A_2 = 0.135 UI

Input jitter needs to be defined. Input jitter is measured with a short cable (2 m).

NOTE 1 – Specification of jitter and jitter measurements methods shall comply with Recommendation ITU-R BT.1363 (Jitter specifications and jitter measurement methods of bit-serial signals conforming to ITU-R BT.656, ITU-R BT.799 and ITU-R BT.1120).

Annex 1

Notes concerning interfaces for digital video signals in 525-line and 625-line television systems

1 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 the present Recommendation to the fact that the fourth and ninth harmonics of the 27 MHz sampling frequency (nominal value) specified in Recommendation ITU-R BT.1358 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”, Doc. CISPR/B (Central Office) 16.

Radiation levels should comply with the limits given in Table 3. These limits are equivalent to those of the FCC in the United States of America.

TABLE 3

Limits of spurious emissions

Frequency (MHz)	Maximum field strength at 30 m (dB(mV/m))
30-88	30
88-216	50
216-1 000	70

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.

2 Vertical colour-difference filter

An example of a vertical colour-difference filter and subsampling principles in 4:2:0p single-link interference are shown in Fig. 6.

To avoid vertical frequency loss in the pass band, especially when multiple conversions between dual-link (4:2:2p) and single-link interface (4:2:0p) signals are required, an adaptive colour-difference filter is recommended. An example of this type of filter is shown in Fig. 7. The luminance signal shall be delayed to match the colour-difference filtering delay.

3 Conclusion

Further studies are required:

– on the practical methods required to ensure acceptable low levels of radiated interference from the digital signals.

FIGURE 6

An example of a minimal color-difference filter and subsampling principles in 4:2:0p single-link interface

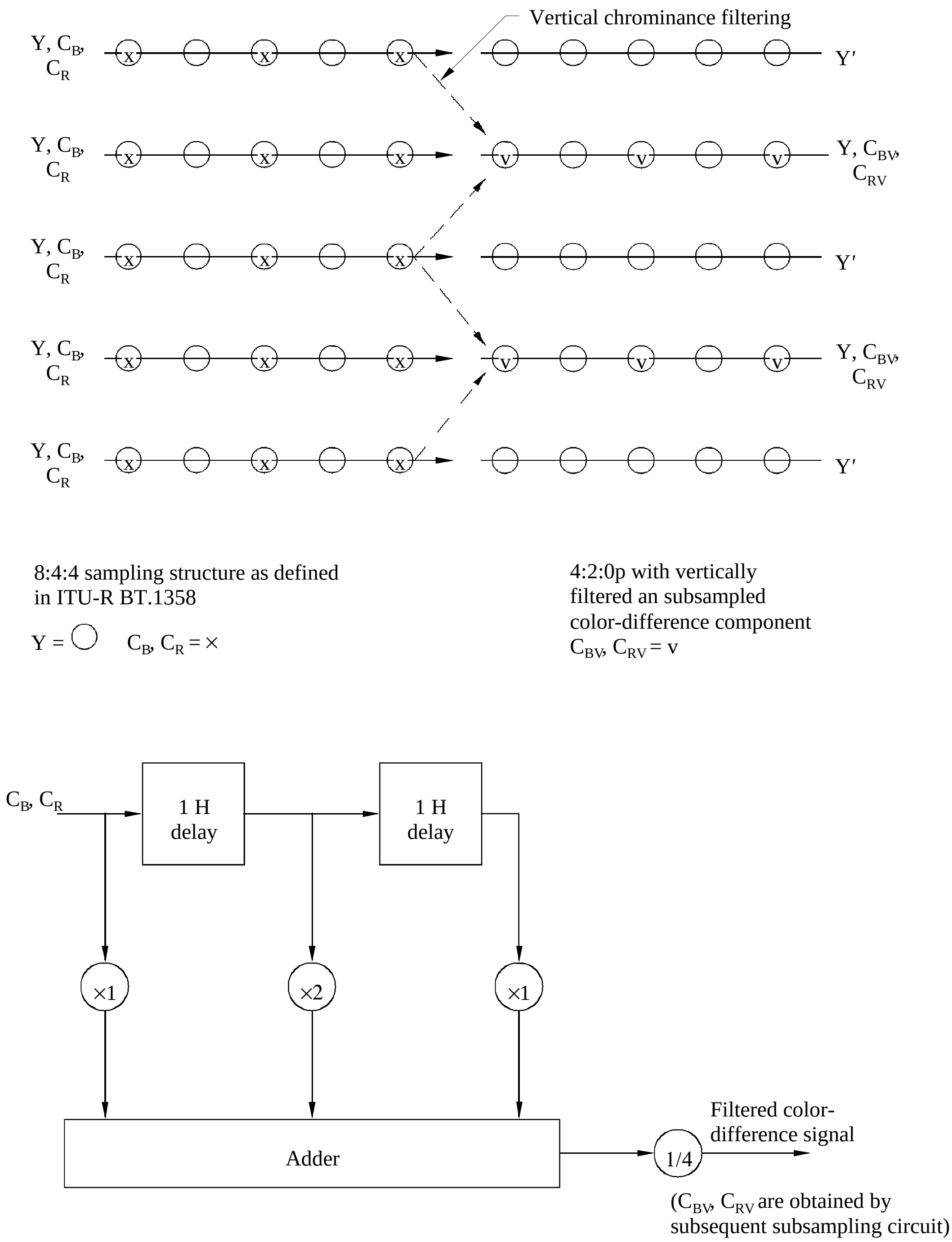


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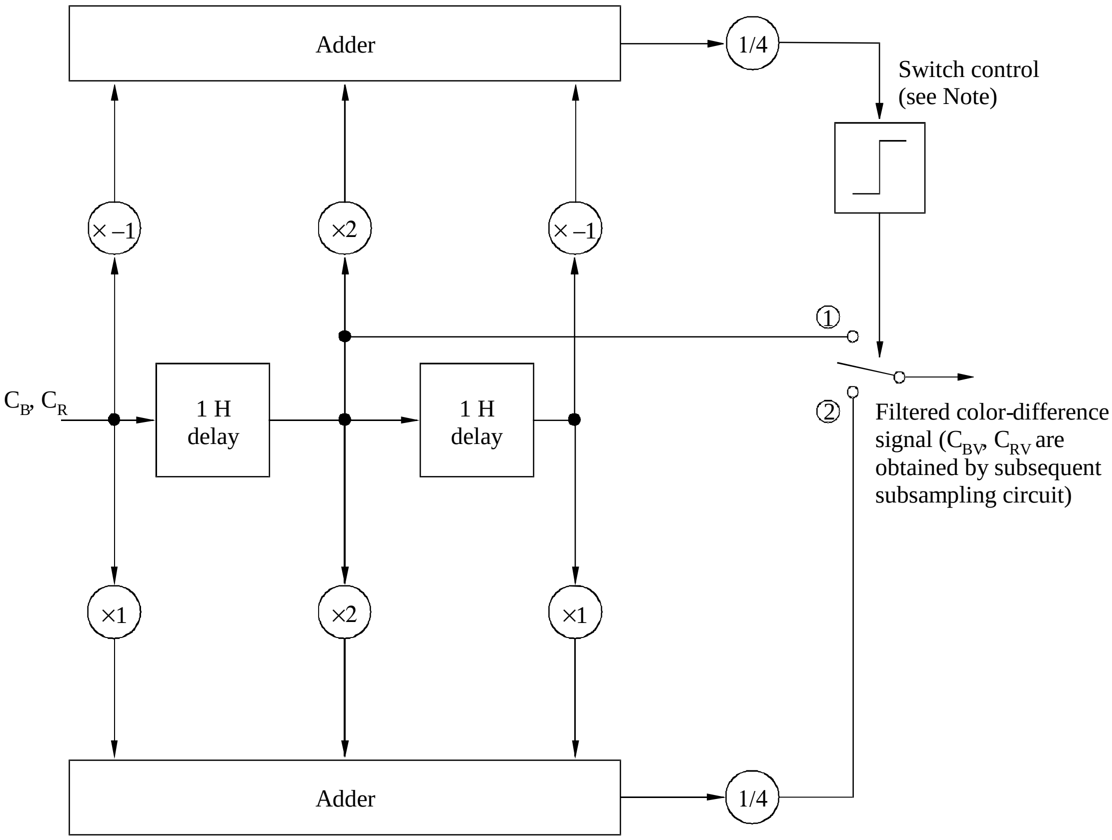
FIGURE 7

An example demonstrating an adaptive filter used for the color-difference components before subsampling the 8:4:4 data into a 4:2:0p quincunx signal



Note - Switch control logic: if the absolute color-difference data value is more than or equal to 6/255, use switch position 2. Otherwise, the switch shall be in position 1.

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