Annex A (informative)
Bibliography

ANSI/SMPTE 229M-1991, Television Analog Recording — 1/2-in Type L — Records

ANSI/SMPTE 230M-1991, Television Analog Recording — 1/2-in Type L — Electrical Parameters, Control Code and Tracking Control

SMPTE RP 144-1991, Basic System and Transport Geometry Parameters for 1/2-in Type L Format

PROPOSED SMPTE STANDARD

for Television —

10-Bit 4:2:2 Component and 4f_{SC} NTSC Composite Digital Signals — Serial Digital Interface

1 Scope

This standard describes a serial digital interface for system M (525/60) digital television equipment operating with either 4:2:2 component signals or 4f_{SC} NTSC composite digital signals. (For 625-line PAL composite implementation, see annex E.) This standard also gives specifications to ensure that the signal loss at 70 MHz (4f_{SC}) or 135 MHz (4:2:2) due to coaxial cable characteristics ($1/\sqrt{f}$) does not exceed approximately 30 dB.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ANSI S4.40-1992, Digital Audio Engineering — Serial Transmission Format for Two-Channel Linearly Represented Digital Audio Data

ANSI/SMPTE 125M-1992, Television — Component Video Signal 4:2:2— Bit-Parallel Digital Interface

SMPTE 170M, Television — Composite Analog Video Signal — NTSC for Studio Applications

SMPTE 244M, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

CCIR Recommendation 601-2, Encoding Parameters of Digital Television for Studios

CCIR Report 624-4, Characteristics of Television Systems

IEC 169-8 (1978), R.F. Coaxial Connectors with Inner Diameter of Outer Conductor of 6.5 mm (0.256 in) with Bayonet Lock — Characteristic Impedance of 50 Ohms (Type BNC), and Appendix A (1990)

IEC 60B Secretariat 200, Helical-Scan Digital Composite Video Cassette Recording System Using 19-mm Magnetic Tape (Format D-2) (NTSC, PAL)

3 Signal levels and specifications

3.1 The output of the generator shall be measured across a 75-ohm resistive load connected directly to the output.

3.1.1 The generator shall have an unbalanced output circuit with a source impedance of 75 ohms and a return loss of at least 15 dB over a frequency range of 5 MHz to 270 MHz.

3.1.2 The peak-to-peak signal amplitude shall be 800 mV ± 10% when measured across a 75-ohm resistor connected to the output terminals.

3.2 The dc offset, as defined by the mid-amplitude point of the signal, shall be nominally 0.0 V ± 0.5 V.

3.3 The rise and fall times, determined between the 20% and 80% amplitude points and measured across a 75-ohm resistive load, shall lie between 0.75 ns and 1.50 ns and shall not differ by more than 0.5 ns.

3.4 The timing of the rising edges of the data signal shall be within ± 0.25 ns of the average

timing of rising edges, as determined over a period of one line.

NOTE – This specification is tentative with further work in progress to determine the measurement method.

3.5 The receiver of the serial interface signal shall present an impedance of 75 ohms with a return loss of at least 15 dB over a frequency range of 5 MHz to 270 MHz.

4 Connector type

The preferred connector shall have mechanical characteristics conforming to the BNC type. Electrical characteristics of the 75-ohm connector shall permit it to be used at frequencies up to 850 MHz.

5 Channel coding

5.1 The channel coding scheme shall be scrambled NRZI.

5.2 The generator polynomial for the scrambled NRZ shall be $G_1(X) = X^9 + X^4 + 1$. The polarity-free scrambled NRZI sequence shall be produced by $G_2(X) = X + 1$. The input signal to the scrambler shall be positive logic. (The highest voltage represents data 1 and the lowest voltage data 0). (See figures A.1 and A.2.)

5.3 Data word length shall be 10 bits.

6 Transmission order

The LSB of any data word shall be transmitted first.

7 4:2:2 component signal transmission

7.1 The input source for generating a serial 4:2:2 data stream shall be as described in ANSI/SMPTE 125M (see annex G).

7.2 The bit rate for the resulting serial data stream shall be nominally 270 Mb/s.

7.3 Ancillary data, if present on the ANSI/SMPTE 125M interface, shall be passed transparently.

8 $4f_{sc}$ composite NTSC signal transmission

(For 625-line PAL implementation, see annex E.)

8.1 Input source

The input source for generating a serial $4f_{sc}$ composite data stream shall be SMPTE 244M.

8.2 Bit rate

The bit rate for the resulting data stream shall be nominally 143 Mb/s.

8.3 Signal processing

Signal processing of the input signal is necessary to provide timing and synchronizing information in the serial digital domain (TRS-ID).

8.3.1 The TRS and line number ID shall be present only following the sync leading edge which identifies a horizontal rate transition.

8.3.2 The TRS signal shall consist of four words. The TRS word number address shall be 790,791,792,793 with the corresponding values 3FF,000,000,000.

8.3.3 Line number ID shall be one word. Line number/word number address shall be 794 with the following values:

b2	b1	b0		
0	0	0	Line 1 – 263	Field 1
0	0	1	Line 264 – 525	Field 2
0	1	0	Line 1 – 263	Field 3
0	1	1	Line 264 – 525	Field 4

b7 (MSB) b6 b5 b4 b3 (LBS)

$1 \le X1 \le 30$ X1 indicates the line number of each field (odd fields 1-30, even fields 264-293).

X1 = 31 To indicate line number 31 and up of each odd field and line number 294 and up on each even field.

X1 = 0 Not used.

X1 = 16 (b7)+8 (b6)+4 (b5)+2 (b4)+1 (b3)

b8 is even parity for b7 through b0.

$b9 = \overline{b8}$

NOTE – When an 8-field sequence needs to be identified, b2 may be utilized .

8.4 Ancillary data

Ancillary may be present within the following word number boundaries (see figures 1, 2, and 3 and annex F):

795 – 849 for horizontal sync period

795 – 815, 340 – 360 for equalizing pulse period

795 – 260, 340 – 715 for vertical sync period

8.4.1 The data structure for the ancillary data shall be positioned in the video data stream as shown in figures 1, 2, and 3, and shall be as follows (see figure 4):

ANC data flag	[1 word]
Data ID	[1 word]
Data block number	[1 word]
Data count	[1 word]
User data	[255 words maximum within a block]
Checksum	[1 word]

8.4.2 An ANC data flag (ADF) must be present if ancillary data is to be recognized. The ANC data flag shall have a value of 3FC.

8.4.2.1 There may be multiple ANC data flags following the TRS-ID. Each ANC data flag shall identify the beginning of another data block (see figure 5).

8.4.3 The data ID is intended to identify the type of data present in the user data area. (The data ID address is positioned as ADF word address + 1.) (See figure 4.)

8.4.3.1 The data ID may have 256 different states.

8.4.3.2 The data ID word shall consist of 8 bits:

b7 (MSB) through b0 (LSB)

b8 is even parity for b7 through b0

$b9 = \overline{b8}$

8.5 Data block number

Following each data ID, a data block number shall be inserted.

8.5.1 When bits 7 through 0 are set to zero, the data block number is inactive and shall not be used by the receiver to indicate continuity of the data.

The nonactive state is defined as:

b7 (MSB) through b0 (LSB) [all zeros]

b8 is even parity for b7 through b0

$b9 = \overline{b8}$

8.5.2 The data block number, if active, shall increment (by 1) when consecutive data blocks with a common data ID exist, or when data blocks with a common data ID are to be linked.

8.5.3 The data block number shall consist of eight bits and shall increment 1 through 255 according to modulo 255.

b7 (MSB) through b0 (LSB)

b8 is even parity for b7 through b0

$b9 = \overline{b8}$

8.6 Data count

Data count represents the number of user data words to follow, up to a maximum of 255 words. (The data count word is positioned as data block number + 1.) (See figure 4.)

8.6.1 Data count word shall consist of eight bits.

b7 (MSB) through b0 (LSB)

b8 is even parity for b7 through b0

$b9 = \overline{b8}$

8.7 User data words

User data words may be used to convey information as identified by the data ID word.

8.7.1 The maximum number of user data words identified by a given data ID is 255 words, excluding the checksum.

8.7.2 User data words shall consist of either 8-bit words plus even parity or 9-bit words positioned at b0 through b8; b9 shall be $\overline{b8}$.

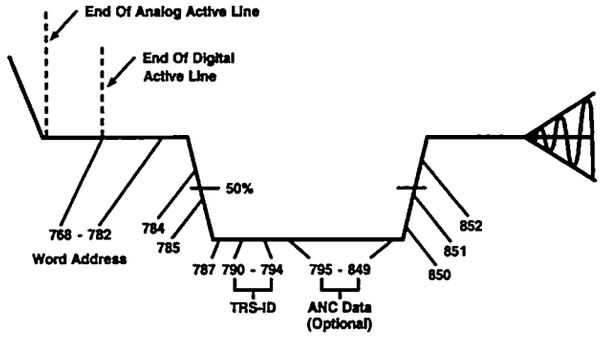


Figure 1 – Composite digital horizontal sync period details

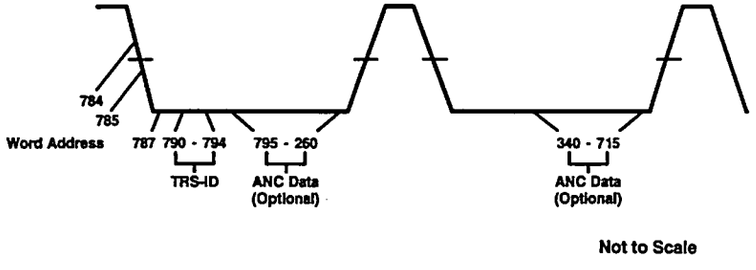


Figure 2 – Vertical sync details

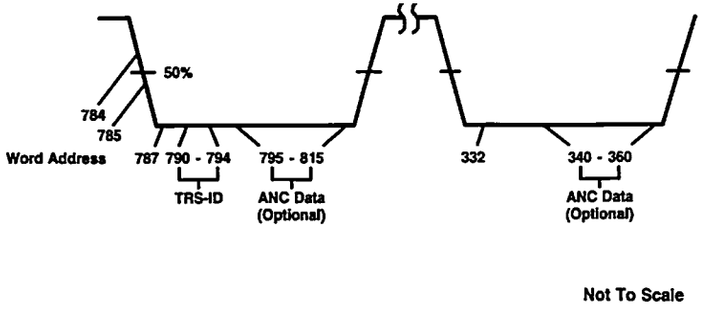


Figure 3 – Equalizing pulse details

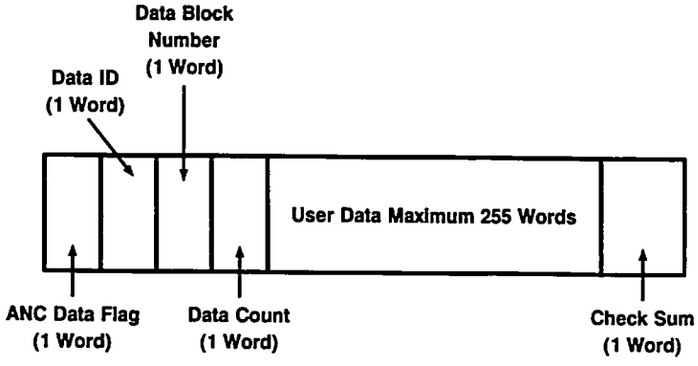


Figure 4 – ANC data format

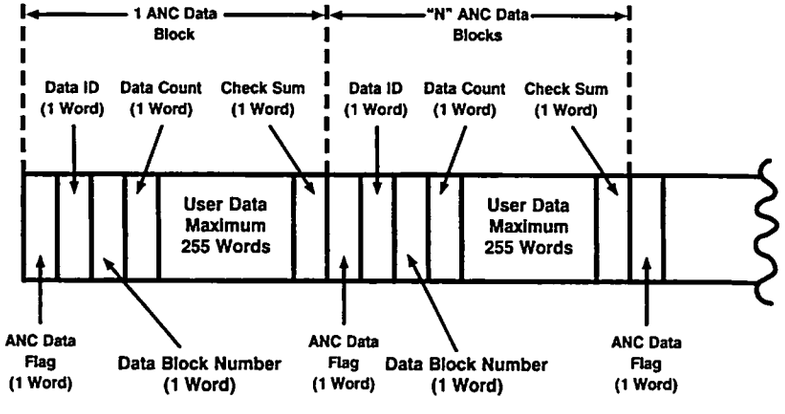


Figure 5 – Multiple ANC data blocks

8.7.3 Location of LSB/MSB of user data shall be defined by a look-up table assigned to the individual data ID.

8.7.4 One state of the data ID is the definition of how a maximum of four channels of AES/EBU audio shall be identified (see annexes D and G):

b7	b6	b5	b4	b3	b2	b1	b0	
1	1	1	1	1	1	1	1	= AES/EBU audio
(MSB)						(LSB)		

Contents of the data stream for AES/EBU audio:

No. of channels = 4 maximum
No. of bits/sample = 27
No. of words/sample = 3

Transmitted data of AES/EBU format =

Z flag = 1 bit (See annex C.)
CH No (A1 to A4) = 2 bits
Audio data = 20 bits
V = 1 bit
U = 1 bit
C = 1 bit
P = 1 bit

(P = even parity for the 26 bits.)

Bit/address	x3	x3+1	x3+2
b9	$\overline{b8}$	$\overline{b8}$	b8
b8	(2^5)	(2^{14})	P
b7	(2^4)	(2^{13})	C
b6	(2^3)	(2^{12})	U
b5	(2^2)	(2^{11})	V
b4	(2^1)	(2^{10})	MSB (2^{19})
b3	LSB (2^0)	(2^9)	(2^{18})
b2	CH (MSB)	(2^8)	(2^{17})
b1	CH (LSB)	(2^7)	(2^{16})
b0	Z	(2^6)	(2^{15})

8.7.5 Data ID/data structure for data of an unregistered format:

b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	0	0	0	0
(MBS)							(LSB)

b8 = Even parity for b7 through b0
b9 = $\overline{b8}$

(See annex B.)

8.7.6 Data ID

The remaining 254 states remain reserved and undefined:

b7	through	b0
(MSB)		(LSB)

(Undefined and reserved)
b8 = Even parity for b7 through b0
b9 = $\overline{b8}$

8.8 Checksum

The checksum word shall consist of nine bits. The checksum word is used to determine the validity of the data ID through the user data. It is the sum of the nine least significant bits of the data ID:

b8	through	b0
(MSB)		(LSB)

b9 = $\overline{b8}$

Preset all zeros. Carry shall be ignored.

The position of the checksum word is user data + 1 as shown in figure 5.

Annex A (informative)
Generator polynomial

See figures A.1 and A.2.

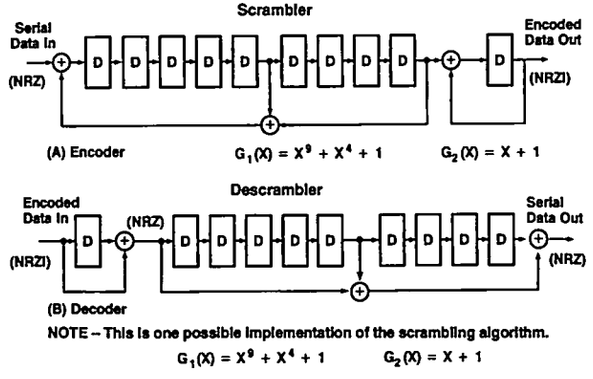


Figure A.1 – Generator polynomial

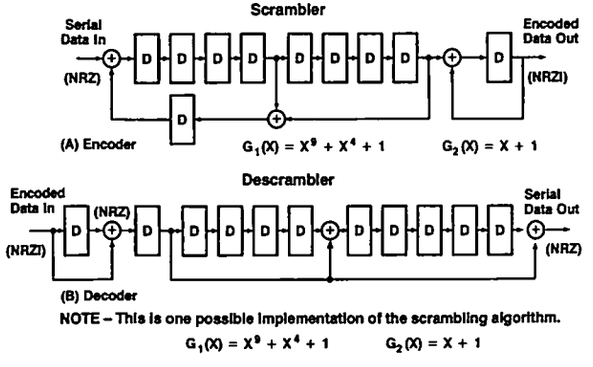


Figure A.2 – Generator polynomial

Annex B (informative)
Data ID 00

Data ID 00 indicates that the data which follows is not in a format registered by the SMPTE.

Annex C (informative)
Z bit

The Z bit may be referred to as preamble 1 or preamble B by some interface documents.

Annex D (informative)
AES/EBU audio data

The 48-kHz samples of the AES/EBU audio data shall be locked to video in the following manner:

525 lines: $48\ kHz = F_H \times \frac{1144}{375}$

625 lines: $48\ kHz = F_H \times \frac{384}{125}$

Annex E (informative)
625-line PAL composite operation

E.1 For 625 PAL composite serial digital transmission, the following input source shall be used (see IEC 60B Secretariat 200, table 8):

b2 (MSB)	b1	b0 (LSB)		
0	0	0	Line 1 – 313	Field 1
0	0	1	Line 314–625	Field 2
0	1	0	Line 1 – 313	Field 3
0	1	1	Line 314–625	Field 4
1	0	0	Line 1 – 313	Field 5
1	0	1	Line 314–625	Field 6
1	1	0	Line 1 – 313	Field 7
1	1	1	Line 314–625	Field 8

E.1.1 The nominal bit rate of this serial transmission shall be 177 Mb/s.

E.1.2 Signal processing of the input signal is necessary to provide timing and synchronizing information in the serial digital domain (TRS-ID).

E.1.2.1 The TRS and line number ID shall be present only following the sync leading edge which identifies a horizontal transition.

E.1.2.2 The TRS shall consist of four words. TRS word number address shall be 967,968,969,970 with corresponding values 3FF,000,000,000.

E.1.2.3 Reset of the TRS position relative to the H-sync edge shall take place once per field on lines 1 and 314. Reset is necessary due to the 25-Hz offset. Therefore, from a sample numbering standpoint, all lines will have 1135 samples except lines 313 and 625 which will have exactly 1137 samples. The additional samples on lines 313 and 625 will be numbers 1135 and 1136 just prior to the first active picture sample 000. This does not affect the continuous signal concept where all but two lines in a field have 1135 samples and the other two have 1136. (The line numbers with 1136 are a function of exact SCH phase and the criteria for determining which samples fall in which lines.)

Designers should note that sample locations figure E.1 represent only line 1, field 1 as per figure 44 in IEC 60B Secretariat 200. Nearby low-line numbers will be similar, but the samples are slightly earlier on each line due to the 25-Hz offset. Initial determination of the position of TRS should, therefore, be done on line 1 or a nearby subsequent line. Considering the 0 SCH phase requirement of IEC 60B Secretariat 200 and the sample numbering system defined in this annex, the TRS location is known and starts exactly with sample 967 on each line, but its distance from the leading edge of sync varies due to the 25-Hz offset.

E.1.2.4 Line number ID shall be one word. Line number/word number address shall be 971 with the following values:

b7 (MSB)	b6	b5	b4	b3 (LSB)	
0	0	0	0	0	Not used
0	0	0	0	1	Line 1 [314]
0	0	0	1	0	Line 2 [315]
0	0	0	1	1	Line 3 [316]
1	1	1	0	1	Line 29 [342]
1	1	1	1	0	Line 30 [343]
1	1	1	1	1	Line >30 [344]

X1 = 16 (b7) + 8 (b6) + 4 (b5) + 2 (b4) +1 (b3)

b8 is even parity for b7 through b0

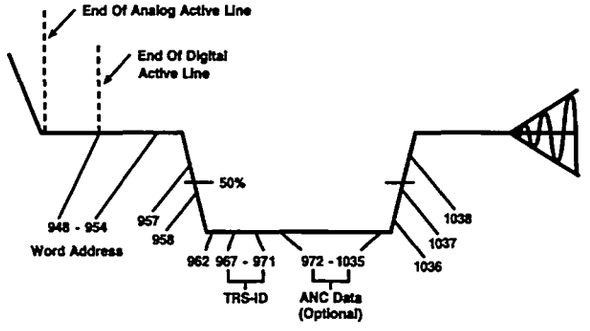
$b9 = \overline{b8}$

E.2 Ancillary data may be present within the following word-number boundaries (see figures E.1, E.2, and E.3):

- 972 – 1035 for horizontal sync
- 972 – 994 for equalizing pulse period
- 404 – 426 for equalizing pulse period
- 972 – 302 for vertical sync period
- 404 – 869 for vertical sync period

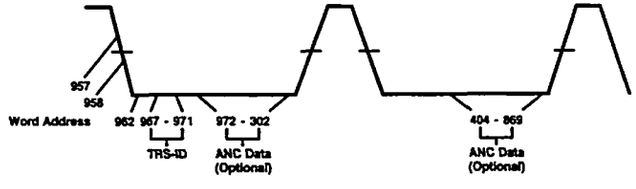
E.2.1 The ancillary data block structure is the same for 625-line operation as it is for 525-line operation.

E.3 The ancillary data area (also identified as HANC in SMPTE 125M) should be considered to be a communications channel with a finite data rate. System design engineers should be aware of data-rate constraints, error rate through the system, and the possibility of the signal being switched.



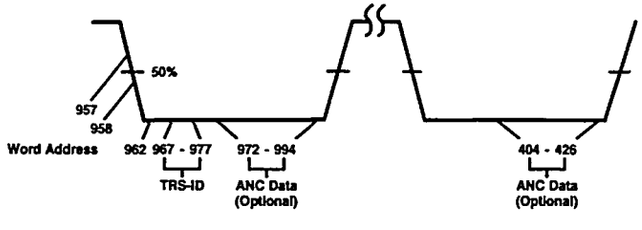
Not To Scale

Figure E.1 – 625 PAL composite digital horizontal sync period details



Not To Scale

Figure E.2 – 625 PAL composite digital vertical sync details



Not To Scale

Figure E.3 – 625 PAL composite digital equalizing pulse details

Annex F (informative)
Data ID

Definitions of data (data ID) will be defined in a separate document at a later date. Readers are advised to contact SMPTE Headquarters to determine the current status of any current work.

Annex G (informative)
Interfaces

Because some ANSI/SMPTE 125M interfaces may carry only eight bits of video data, it is necessary for the data serializer to identify this condition and to add the necessary data to convert the 8-bit signal to a 10-bit representation. EAV and SAV of 8-bit signals should be converted in the following manner (see ANSI/SMPTE 125M):

8 bit	10 bit
FF	3FF
00	000
00	000
XY	PQR (= 4xXY)

PROPOSED SMPTE STANDARD

for Television — 10-Bit Serial Digital Television Signals: 4:2:2 Component and $4f_{SC}$ NTSC Composite — AMI Transmission Interface

1 Scope

This standard describes an interface which transmits serial digital video data coded in scrambled bipolar NRZI per SMPTE 259M, via alternate-mark-inversion (AMI) communication channels.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

SMPTE 259M, Television — 10-Bit 4:2:2 Component and $4f_{SC}$ NTSC Composite Digital Signals — Serial Digital Interface

3 Reference communications channel

3.1 The reference communications channel for this interface is assumed to have an attenuation proportional to the square root of frequency from 1 MHz to freq = (bit rate), and a maximum voltage attenuation of 22 dB at freq = (bit rate)/2.

3.2 Equalization of the communications channel is assumed. The equalized communications channel is assumed to exhibit a linear phase/frequency characteristic, with a maximum delay difference of 10 ns from 1 MHz to freq = (bit rate) X 2.

NOTE - The referenced channel does not preclude equipment being designed for higher or lower attenuation, or for different loss characteristics.

4 Channel coding

The channel coding shall be bipolar alternate-mark-inversion, with alternate logic ones (level transitions) of the input NRZI data coded as +V ... –V ..., and logic zeros coded as level 0.

5 Generator

5.1 The generator shall have an unbalanced output with a source impedance of 75 ohms and a minimum return loss of 15 dB over a frequency range of 5 MHz to freq = (bit rate).

5.2 The output of the generator shall be measured across a 75-ohm resistive load connected directly to the generator.

5.2.1 The signal amplitude shall be +V = +400 mV, –V = –400 mV, ± 10%.

5.2.2 The dc offset shall be 0.0 V ± 0.05 V.

5.2.3 The output waveform shall be approximately sine squared in shape with rise/fall times, measured between 10% and 90% amplitude, of 2.1–3.0 ns at 143.2 Mbit/s and 1.1–1.6 ns at 270 Mbit/s. Rise and fall times shall be equal within ± 0.5 ns.

5.2.4 The timing of the leading edges of data shall be within ± 0.25 ns of the average timing of leading edges as determined over a period of one horizontal line.

5.3 Preferred data connectors shall have mechanical characteristics conforming to standard BNC type, with a characteristic impedance of 75 ohms.

6 Receiver

6.1 The receiver shall present an input impedance of 75 ohms, with a return loss of 15 dB minimum over a frequency range of 5 MHz to freq = (bit rate) X 2.

6.2 Preferred data connectors shall have mechanical characteristics conforming to standard BNC type, with a characteristic impedance of 75 ohms.

PROPOSED SMPTE RECOMMENDED PRACTICE

RP 165

Error Detection Checkwords and Status Flags for Use in Bit-Serial Digital Interfaces for Television

1 Scope

1.1 This practice describes the generation of error detection checkwords and related status flags to be used optionally in conjunction with the serial digital interface for system M (525/59.94) and systems B, G, H, and I (625/50) digital television equipment operating with either 4:2:2 component digital signals or $4f_{sc}$ composite digital signals. Although it is preferred that this error checking method be used in all serial transmitters and receivers, it is recognized that some equipment must minimize complexity.

NOTE – Line numbers in tables 2 and 3 for 625/50 systems are tentative, and subject to change pending decisions on vertical interval switching for serial signals.

1.2 Two checkwords are defined: one based on a field of active picture samples and the other on a full field of samples. This two-word approach provides continuing error detection for the active picture when the digital signal has passed through processing equipment that has changed data outside the active picture area without recalculating the full-field checkword.

1.3 Three sets of flags are provided to feed forward information regarding detected errors to help facilitate identification of faulty equipment. One set of flags is associated with each of the two field related checkwords. A third set of flags is used to provide similar information based on evaluating all of the ancillary data checksums within a field.

1.4 The checkwords and flags are combined in an error data packet which is included as ancillary data in the serial digital signal. At the receiver, a recalculation of checkwords may be compared to the error data packet information to determine if a transmission error occurred.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ANSI/SMPTE 125M-1992, Television — Component Video Signal 4:2:2 — Bit-Parallel Digital Interface

SMPTE 244M, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

SMPTE 259M, Television — 10-Bit 4:2:2 Component and 4fsc NTSC Composite Digital Signals — Serial Digital Interface

SMPTE RP 168, Definition of Vertical Interval Switching Point for Synchronous Video Switching

IEC 60B(Sec)200, Helical-Scan Digital Composite Video Cassette Recording Using 19mm Magnetic Tape (Format D-2) (NTSC, PAL), Section Five, Video Interface

EBU Tech 3267-E, Parallel Interface for 625-Line Digital Video Signals