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**SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS**

Infrastructure of audiovisual services – Transmission  
multiplexing and synchronization

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## **Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices**

Recommendation ITU-T H.221



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# Recommendation ITU-T H.221

## Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices

### Summary

The purpose of Recommendation ITU-T H.221 is to define a frame structure for audiovisual teleservices in single or multiple B or H<sub>0</sub> channels or a single H<sub>11</sub> or H<sub>12</sub> channel which makes the best use of the characteristics and properties of the audio and video encoding algorithms, of the transmission frame structure and of the existing Recommendations. It offers several advantages:

- It takes into account of such as Recommendations ITU-T G.704, ITU-T X.30/I.461, etc. It may allow the use of existing hardware or software.
- It is simple, economic and flexible. It may be implemented on a simple microprocessor using well-known hardware principles.
- It is a synchronous procedure. The exact time of a configuration change is the same in the transmitter and the receiver. Configurations can be changed at 20 ms intervals.
- It needs no return link for audiovisual signal transmission, since a configuration is signalled by repeatedly transmitted codewords.
- It is very secure in case of transmission errors, since the code controlling the multiplex is protected by a double-error correcting code.
- It allows the synchronization of multiple 64 kbit/s or 384 kbit/s connections and the control of the multiplexing of audio, video, data and other signals within the synchronized multiconnection structure in the case of multimedia services such as videoconference.
- It can be used to derive octet synchronization in networks where this is not provided by other means.
- It can be used in multipoint configurations, where no dialogue is needed to negotiate the use of a data channel.
- It provides a variety of data bit rates (from 300 bit/s up to almost 2 Mbit/s) to the user.

This revised version of this Recommendation introduces a number of enhancements and clarifications to the previous version, primarily the description on the usage of Recommendation ITU-T G.719 and Annex C of Recommendation ITU-T G.722.1 (14 kHz audio) in ITU-T H.320 systems.

### Source

Recommendation ITU-T H.221 was approved on 16 March 2009 by ITU-T Study Group 16 (2009-2012) under Recommendation ITU-T A.8 procedures.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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# Recommendation ITU-T H.221

## Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices

### 1 Basic principle

This Recommendation provides for dynamically subdividing an overall transmission channel of 64 to 1920 kbit/s into lower rates suitable for audio, video, data and telematics purposes. The overall transmission channel is derived by synchronizing and ordering transmissions over from 1 to 6 B-connections, from 1 to 5  $H_0$  connections, or an  $H_{11}$  or  $H_{12}$  connection. The first connection established is the initial connection and carries the initial channel in each direction. The additional connections carry additional channels.

The total rate of transmitted information is called the "transfer rate"; it is possible to fix the transfer rate less than the capacity of the overall transmission channel (values listed in Annex A).

A single 64 kbit/s channel is structured into octets transmitted at 8 kHz. Each bit position of the octets may be regarded as a sub-channel of 8 kbit/s (see Figure 1). The eighth sub-channel is called the service channel (SC), consisting of several parts as described in clauses 1.1 to 1.4.

An  $H_0$ ,  $H_{11}$  or  $H_{12}$  channel may be regarded as consisting of a number of 64 kbit/s time-slots (TS) (see Figure 2). The lowest numbered time-slot is structured exactly as described for a single 64 kbit/s channel, while the other TS has no such structure. In the case of multiple B or  $H_0$  channels, all channels have a frame structure; that is, the initial channel controls most functions across the overall transmission, while the frame structure in the additional channels is used for synchronization, channel numbering and related controls.

The term "I-channel" is applied to the initial or only B-channel, to TS1 of initial or only  $H_0$  channel, and to TS1 of  $H_{11}$ ,  $H_{12}$  channels.

#### 1.1 Frame alignment signal (FAS)

This signal structures the I-channel and other framed 64 kbit/s channels into frames of 80 octets each and multiframes (MFs) of 16 frames each. Each multiframe is divided into eight 2-frame sub-multiframes (SMFs). The term "Frame Alignment Signal" refers to bits 1-8 of the SC in each frame. In addition to framing and multiframing information, control and alarm information may be inserted in the FAS, as well as error check information to control end-to-end error performance and to check frame alignment validity. Other time-slots are aligned to the first.

The bits are transmitted to line in order, bit 1 first.

When an 8 kHz network clock is provided, FAS is transmitted and received in the least significant bit of the octet within each 125  $\mu$ s, e.g., in an ISDN basic or primary rate interface. It should be noted that, where interworking between the audiovisual terminal and the telephone is required, transmission using the network timing is essential. In the receiver side, FAS should be sought in all bit positions. If received the FAS position conflicts with the network octet timing, the FAS position is given priority. This may happen when the receiver utilizes network octet timing while the transmitter does not as in a terminal using codecs separate with ISDN terminal adaptor, or when interworking between 64 kbit/s and 56 kbit/s terminals takes place.

The FAS can be used to derive receive octet timing when it is not provided by the network. However, in the latter case, the terminal cannot transmit FAS with correct alignment into the octet-timed part of the network and cannot intercommunicate with terminals which rely only on network timing for octet alignment.

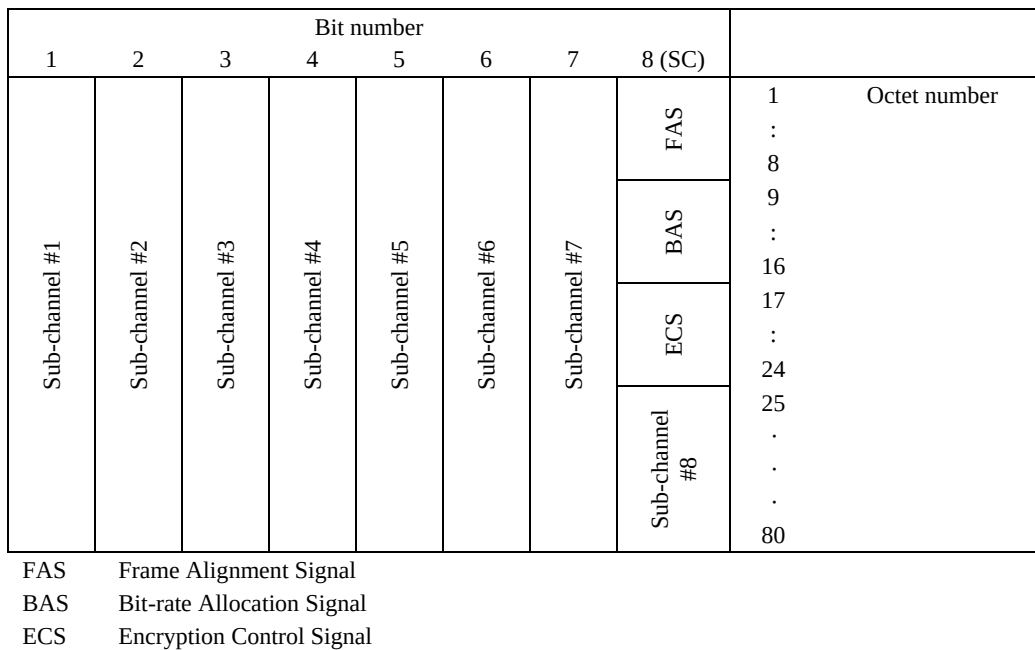


Figure 1 – Frame structure of a single 64 kbit/s channel (B-channel)

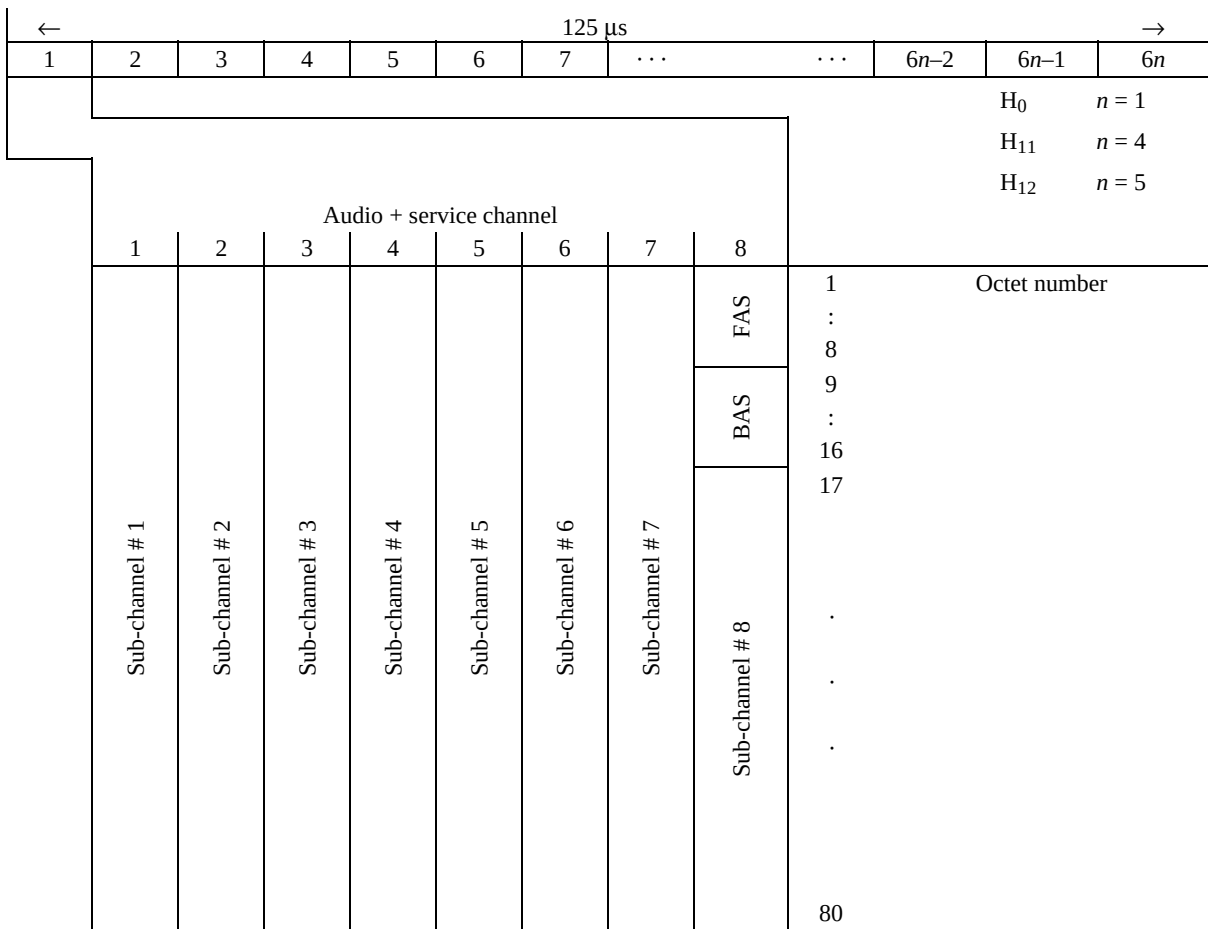


Figure 2 – Frame structure of higher-rate single channels (H<sub>0</sub> H<sub>11</sub>H<sub>12</sub> channels)

## 1.2 Bit-rate allocation signal (BAS)

Bits 9-16 of the SC in each frame are referred to as the BAS. This signal allows the transmission of codewords to describe the capability of a terminal to structure the capacity of the channel or synchronized multiple channels in various ways, and to command a receiver to demultiplex and make use of the constituent signals in such structures. This signal is also used for controls and indications.

NOTE – For some countries having 56 kbit/s channels, the net available bit rates will be 8 kbit/s less. Interworking between a 64 kbit/s terminal and a 56 kbit/s terminal is established according to the frame structure in Annex B.

## 1.3 Encryption control signal (ECS)

Encryption capability requires a dedicated transmission channel. This is provided when required by allocating bits 17-24 of the service channel. This reduces variable data and video transmission rates herein by 800 bit/s. The 800 bit/s is referred to as the ECS channel.

## 1.4 Remaining capacity

The remaining capacity (including the rest of the service channel), carried in bits 1-8 of each octet in the case of a single 64 kbit/s connection, may convey a variety of signals within the framework of a multimedia service, under the control of the BAS. Some examples follow:

- voice encoded at 56 kbit/s using a truncated form of PCM of Rec. ITU-T G.711 (A-law or  $\mu$ -law);
- voice encoded at 16 kbit/s and video at 46.4 kbit/s;
- voice encoded at 56 kbit/s with a bandwidth 50 to 7000 Hz (sub-band ADPCM according to Rec. ITU-T G.722); the coding algorithm is also able to work at 48 kbit/s – data can then be dynamically inserted at up to 14.4 kbit/s;
- still pictures coded at 56 kbit/s;
- data at 56 kbit/s inside an audiovisual session (e.g., file transfer for communicating between personal computers).

## 2 Frame alignment

### 2.1 General

An 80-octet frame length produces an 80-bit word in the service channel. These 80 bits are numbered 1-80. Bits 1-8 of the service channel in every frame constitute the FAS (see Figure 3), whose content is as follows:

- multiframe structure (see clause 2.2);
- Frame alignment word (FAW);
- A-bit;
- E- and C-bits (see clause 2.6).

The FAW consists of "0011011" in bits 2-8 of the FAS in even frames, complemented by a "1" in bit 2 of the succeeding odd frame.

The "A-bit" of the I-channel is set to zero whenever the receiver is in multiframe alignment, and is set to "1" otherwise (see clause 2.3); for additional channels, see clause 2.7.1.

|                   | Bit number |          |          |          |    |    |    |    |
|-------------------|------------|----------|----------|----------|----|----|----|----|
| Successive frames | 1          | 2        | 3        | 4        | 5  | 6  | 7  | 8  |
| Even frames       | (Note 1)   | 0        | 0        | 1        | 1  | 0  | 1  | 1  |
| Odd frames        | (Note 1)   | 1        | A        | E        | C1 | C2 | C3 | C4 |
|                   |            | (Note 2) | (Note 3) | (Note 4) |    |    |    |    |

NOTE 1 – See clause 2.2 and Figure 4.

NOTE 2 – The first seven bits of the frame alignment word are in the even frames. The eighth bit of the FAW in the odd frame is the complement of the first FAW bit in order to avoid simulation of FAW by a frame-repetitive pattern.

NOTE 3 – A-bit: loss of multiframe alignment indication (0 = alignment; 1 = loss).

NOTE 4 – The use of bits E and C1-C4 is described in clause 2.6 [0 = no error or cyclic redundancy check (CRC) not in use; 1 = error].

**Figure 3 – Assignment of bits 1-8 of the service channel in each frame**

## 2.2 Multiframe structure

Each multiframe contains 16-consecutive frames numbered 0 to 15 divided into eight sub-multiframes of two frames each (see Figure 4). The multiframe alignment signal is located in bit 1 of frames 1-3-5-7-9-11 and has the form 001011. Bit 1 of frame 15 remains reserved for future use. The value is fixed at 0.

|            | Sub-multiframe (SMF) | Frame | Bits 1 to 8 of the service channel in every frame |   |   |   |    |    |    |    |
|------------|----------------------|-------|---------------------------------------------------|---|---|---|----|----|----|----|
|            |                      |       | 1                                                 | 2 | 3 | 4 | 5  | 6  | 7  | 8  |
| Multiframe | SMF1                 | 0     | N1                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            |                      | 1     | 0                                                 | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 2     | N2                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF2                 | 3     | 0                                                 | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 4     | N3                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF3                 | 5     | 1                                                 | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 6     | N4                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF4                 | 7     | 0                                                 | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 8     | N5                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF5                 | 9     | 1                                                 | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 10    | L1                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF6                 | 11    | 1                                                 | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 12    | L2                                                | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF7                 | 13    | L3                                                | 1 | A | E | C1 | C2 | C3 | C4 |
|            |                      | 14    | TEA                                               | 0 | 0 | 1 | 1  | 0  | 1  | 1  |
|            | SMF8                 | 15    | R                                                 | 1 | A | E | C1 | C2 | C3 | C4 |

1-L3 Channel number, least significant bit in L1.

| Channel                     | L3 | L2 | L1 |
|-----------------------------|----|----|----|
| Initial                     | 0  | 0  | 1  |
| Second                      | 0  | 1  | 0  |
| Third                       | 0  | 1  | 1  |
| ...                         | .. | .. | .. |
| Sixth                       | 1  | 1  | 0  |
| Seventh and higher-numbered | 1  | 1  | 1  |

R Reserved for future use, set to 0.

A, E, C1-C4 As in Figure 3.

N1-N4 Used for multiframe numbering as described in clause 2.2; set to 0 while numbering is inactive.

|                   |    | N4 | N3 | N2 | N1 |                         |
|-------------------|----|----|----|----|----|-------------------------|
| Multiframe number | 0  | 0  | 0  | 0  | 0  | (or numbering inactive) |
|                   | 1  | 0  | 0  | 0  | 1  |                         |
|                   | 2  | 0  | 0  | 1  | 0  |                         |
|                   | .. | .. | .. | .. | .. |                         |
|                   | 15 | 1  | 1  | 1  | 1  |                         |

N5 Indicates whether multiframe numbering is active (N5 = 1) or inactive (N5 = 0).

TEA The terminal equipment alarm is set to 1 in the outgoing signal, while an internal terminal equipment fault exists such that it cannot receive and act on the incoming signal. Otherwise, it is set to 0.

**Figure 4 – Assignment of bits 1-8 of the service channel in each frame in a multiframe**

Bit 1 of frames 0-2-4-6 may be used for a modulo 16 counter to number multiframe in descending order. The least significant bit is transmitted in frame 0, and the most significant bit in frame 6. The receiver uses the multiframe numbering to equalize out the differential delay of separate connections, and to synchronize the received signals.

The multiframe numbering is mandatory both in initial and additional channels for multiple B or multiple H<sub>0</sub> communications, but it may or may not be inserted for single B or single H<sub>0</sub> or H<sub>11</sub>/H<sub>12</sub> for other communications where synchronization between multiple channels is not required.

Bit 1 of frame 8 is set to 1 when multiframes are numbered and is set to 0 when they are not.

Bit 1 of frames 10-12-13 shall be used to number each channel in a multiconnection structure so that the distant receiver can place the octets received in each 125  $\mu$ s in the correct order.

Information bits in the multiframe should be validated by, for example, being received consistently for three multiframes.

### 2.3 Loss and recovery of frame alignment

Frame alignment is defined to have been lost when three consecutive frame alignment words have been received with an error.

Frame alignment is defined to have been recovered when the following sequence is detected:

- for the first time, the presence of the correct first seven bits of the frame alignment word;
- the eighth bit of the frame alignment word in the following frame is detected by verifying that bit 2 is a 1;
- for the second time, the presence of the correct first seven bits of the frame alignment word in the next frame.

If frame alignment is achieved but multiframe alignment cannot be achieved, then frame alignment shall be sought at another position.

When the frame alignment is lost, A-bit of the next odd frame is set to 1 in the transmit direction.

### 2.4 Loss and recovery of multiframe alignment

Multiframe alignment is needed to number and synchronize two or more channels, and possibly also for encryption. Terminals such as those having only single-channel capabilities which have no use for the multiframe structure shall transmit the multiframe structure, but need not check for multiframe alignment on the incoming signal: they may transmit outgoing A = 0 when frame alignment is recovered.

NOTE – Such a terminal cannot transmit TEA, terminal equipment alarm (see Figure 4).

After multiframe alignment has been validated, the other functions represented by bit 1 of the service channel can be used. When multiframe alignment of the distant terminal has been signalled (A = 0 received), the distant terminal is expected to have validated BAS codes and to be able to interpret BAS codes.

Multiframe alignment is defined to have been lost when three consecutive multiframe alignment signals have been received with an error. It is defined to have been recovered when the multiframe alignment signal has been received with no error in the next multiframe. When multiframe alignment is lost, even when an unframed mode is received, the A-bit of the next odd frame is set to 1 in the transmit direction. It is reset to 0 when multiframe alignment is regained. It is reset in additional channels when multiframe alignment and synchronism with the initial channel is regained.

### 2.5 Procedure to recover octet timing from frame alignment

When the network does not provide octet timing, the terminal may recover octet timing in the receive direction from bit timing and from the frame alignment. The octet timing in the transmit direction may be derived from the network bit timing and an internal octet timing.

#### 2.5.1 General rule

The receive octet timing is normally determined from the FAS position. But at the start of the call and before the frame alignment is gained, the receive octet timing may be taken to be the same as the internal transmit octet timing. As soon as a first frame alignment is gained, the receive octet

timing is initialized at the new bit position, but it is not yet validated. It will be validated only when frame alignment is not lost during the next 16 frames.

### 2.5.2 Particular cases

- a) When, at the initiation of a call, the terminal is in a forced reception mode, or when the frame alignment has not yet been gained, the terminal may temporarily use the transmit octet timing.
- b) When frame alignment is lost after being gained, the receive octet timing shall not change until frame alignment is recovered.
- c) As soon as frame and multiframe alignment have been gained once, the octet timing is considered as valid for the rest of the call, unless frame alignment is lost and a new frame alignment is gained at another bit position.
- d) When the terminal switches from a framed mode to an unframed mode (by means of the BAS), the octet timing previously gained shall be kept.
- e) When a new frame alignment is gained on a new position, different from that previously validated, the receive octet timing is re-initialized to the new position but not yet validated and the previous bit position is stored. If no loss of frame alignment occurs in the next 16 frames, the new position is validated; otherwise, the stored old bit position is re-utilized.

### 2.5.3 Search for frame alignment signal (FAS)

Two methods may be used: sequential or parallel. In the sequential method, each of the eight possible bit positions for the FAS is tried. When FAS is lost after being validated, the search shall resume starting from the previously validated bit position. In the parallel method, a sliding window, shifting one bit for each bit period, may be used. In that case, when frame alignment is lost, the search shall resume starting from the bit position next to the previously validated one.

## 2.6 Description of the CRC-4 procedure

In order to provide an end-to-end quality monitoring of the connection, a 4-bit cyclic redundancy check (CRC-4) procedure may be used and the four bits C1, C2, C3 and C4 computed at the source location are inserted in bit positions 5 to 8 of the odd frames. In addition, bit 4 of the odd frames, the E-bit, is used to transmit an indication as to whether the most recent CRC block, received in the incoming direction, contained errors or not.

When the CRC-4 procedure is not used, bit E shall be set to 0, and bits C1, C2, C3 and C4 shall be set to 1 by the transmitter. Provisionally, the receiver may disable reporting of CRC errors after receiving eight consecutive CRCs set to all 1s, and it may enable reporting of CRC errors after receiving two consecutive CRCs each containing a 0 bit.

### 2.6.1 Computation of the CRC-4 bits

The CRC-4 bits C1, C2, C3 and C4 are computed for each B/H<sub>0</sub>/H<sub>11</sub>/H<sub>12</sub> channel<sup>1</sup>, for a block made of two frames: one even frame (containing the first seven bits of FAW) followed by one odd frame (containing the eighth bit of FAW). The CRC4 block size is then 160/960/3840/4800 octets for a B/H<sub>0</sub>/H<sub>11</sub>/H<sub>12</sub> channel and 320/480/640/1280/1920/2880/3680 octets for a 128/192/256/512/768/1152/1472 kbit/s channel and the computation is performed 50 times per second.

NOTE – This is still valid for the case of H<sub>0</sub>/H<sub>11</sub> or 128/192/256/320/512/768/1152/1472 kbit/s transfer rate in restricted networks, the stuffed bits being included in the computation. For restricted B, see Annex B.

<sup>1</sup> If the transfer rate is such that a part of any H<sub>0</sub>/H<sub>11</sub>/H<sub>12</sub> channel is unoccupied, then the computation is made only for that part covered by the transfer rate.

### 2.6.1.1 Multiplication-division process

A given C1-C4 word located in block N is the remainder after multiplication by  $x^4$  and then division (modulo 2) by the generator polynomial  $x^4 + x + 1$  of the polynomial representation of block (N – 1).

When representing contents of a block as a polynomial, the first bit in the block shall be taken as being the most significant bit. Similarly, C1 is defined to be the most significant bit of the remainder and C4 the least significant bit of the remainder.

This process can be realized with a four-stage register and two exclusive-ORs.

### 2.6.1.2 Encoding procedure

- i) The CRC bit positions in the odd frame are initially set at zero, i.e.,  $C1 = C2 = C3 = C4 = 0$ .
- ii) The block is then acted upon by the multiplication-division process referred to in clause 2.6.1.1.
- iii) The remainder resulting from the multiplication-division process is stored ready for insertion into the respective CRC locations of the next odd frame.

NOTE – These CRC bits do not affect the computation of the CRC bits of the next block, since the corresponding locations are set at zero before the computation.

### 2.6.1.3 Decoding procedure

- i) A received block is acted upon by the multiplication-division process, referred to in clause 2.6.1.1, after having its CRC bits extracted and replaced by zeros.
- ii) The remainder resulting from this multiplication-division process is then stored and subsequently compared on a bit-by-bit basis with the CRC bits received in the next block.
- iii) If the decoded calculated remainder exactly corresponds to the CRC bits sent from the encoder, it is assumed that the checked block is error-free.

## 2.6.2 Consequent actions

### 2.6.2.1 Action on bit E

Bit E of block N is set to 1 in the transmitting direction if bits C1-C4 detected in the most recent block in the opposite direction have been found in error (at least one bit in error). In the opposite case, it is set to zero.

### 2.6.2.2 Monitoring for incorrect frame alignment (see Note)

In the case of a long simulation of the FAW, the CRC-4 information can be used to re-initiate a search for frame alignment. For such a purpose, it is possible to count the number of CRC blocks in error within two seconds (100 blocks) and to compare this number with 89. If the number of CRC blocks in error is greater than or equal to 89, a search for frame alignment shall be re-initiated.

The values 100 and 89 have been chosen in order that:

- for a random transmission error rate of  $10^{-3}$ , the probability of incorrectly re-initiating a search for frame alignment, because of 89 or more blocks in error, should be less than  $10^{-4}$ ;
- in case of simulation of frame alignment, the probability of not re-initiating a search of frame alignment after a two-second period should be less than 2.5%.

NOTE – Values in this and the next subclause exemplify the case of a 64 kbit/s channel. For  $H_0$ ,  $H_{11}$  or  $H_{12}$  channels, the details will differ but the principles are still applicable.

### 2.6.2.3 Monitoring for error performance

The quality of the 64 kbit/s connection can be monitored by counting the number of CRC blocks in error within a period of one second (50 blocks). For instance, a good evaluation of the proportion of seconds without errors as defined in Rec. ITU-T G.821 can be provided.

For information purposes, Table 1 gives the proportions of CRC block in error which can be computed for randomly distributed errors of error rate  $P_e$ .

By counting the received E-bits, it is possible to monitor the quality of the connection in the opposite direction.

**Table 1**

| $P_e$                             | $10^{-3}$ | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ |
|-----------------------------------|-----------|-----------|-----------|-----------|-----------|
| Percentage of CRC blocks in error | 70%       | 12%       | 1.2%      | 0.12%     | 0.012%    |

## 2.7 Synchronization of multiple connections

Some audiovisual terminals will be able to communicate over multiple B or  $H_0$  connections (see Note). In this case, a single B or  $H_0$  initial connection is established, the possibility for more connections is determined from the transfer rate capability BAS of Annex A and the additional connections are then established and synchronized by the terminal using the multiframe structure.

NOTE – A connection is an individual call between the terminals. A channel is the transmission in one direction over the connection.

### 2.7.1 Multiple B-connections

FAS and BAS are transmitted in each B-channel (see Note).

NOTE – The actual bit rates allowed by this Recommendation for these audio codings within a 64 kbit/s I-channel are 64 and 56 kbit/s, commands (000) [4/5 and 18/19], respectively. Thus, in a 2B audiovisual call, it is not permitted to transmit framed ITU-T G.711 audio in the I-channel and video in the additional channel. The two channels shall be synchronized, the audio shall be set to 56 kbit/s, and when the video is ON, it shall occupy the remaining 68.8 kbit/s.

FAS operation is as follows:

- Multiframe numbering is used to determine relative transmission delay between B-channels as described in clause 2.2.
- The channel numbers are transmitted in the FAS, as described in clause 2.2, with the channel of the initial connection being numbered 1 and there being up to twenty-three additional connections.
- The channel numbers of the additional channels are also transmitted in the BAS according to Table A.5.
- The outgoing A-bit is set to 1 in the additional B-channel of the same connection whenever the received additional channel is not synchronized to the initial channel.
- When receive synchronization is achieved between the initial and additional channels by introducing delay to align their respective multiframe signals, the transmitted A-bit is set to 0.
- The E-bit for each additional B-channel is transmitted in the additional B-channel in the same connection, because it relates to a physical condition of the transmission path.

The BAS operation in additional connections is restricted to the transmission of the additional channel number (according to Table A.5) and TIX (see Rec. ITU-T H.230) (thus, the channel numbering of any additional connection shall be sent both in BAS according to Annex A and in the FAS as in clause 2.2), while channel numbering of the initial channel is sent only in FAS.

The distant terminal, upon receiving the A-bit set to zero with respect to sequentially numbered channels, can add their capacity to the initial connection by sending the transfer rate BAS in Annex A. The order of the bits transmitted in the channels is in accordance with the examples given in clause 4.

### 2.7.2 Multiple $H_0$ connections

FAS and BAS are transmitted in the first time-slot of each  $H_0$ .

FAS operation is as in clause 2.7.1, except that the channel number is used to order the six octets received each 125  $\mu$ s with respect to the six octet groups received in other channels.

The BAS operation in additional channels is as specified in clause 2.7.1.

## 3 Bit-rate allocation signal

### 3.1 Encoding of the BAS

The bit-rate allocation signal (BAS) occupies bits 9-16 of the service channel in every frame. An eight bit BAS code ( $b_0, b_1, b_2, b_3, b_4, b_5, b_6, b_7$ ) is complemented by eight error correction bits ( $p_0, p_1, p_2, p_3, p_4, p_5, p_6, p_7$ ) to implement a (16,8) double error correcting code. This error correcting code is obtained by shortening the (17,9) cyclic code with generator polynomial:

$$g(x) = x^8 + x^7 + x^6 + x^4 + x^2 + x + 1$$

The error correction bits are calculated as coefficients of the remainder polynomial in the following equation:

$$p_0x^7 + p_1x^6 + p_2x^5 + p_3x^4 + p_4x^3 + p_5x^2 + p_6x + p_7 \\ = RES_{g(x)}[b_0x^{15} + b_1x^{14} + b_2x^{13} + b_3x^{12} + b_4x^{11} + b_5x^{10} + b_6x^9 + b_7x^8]$$

where  $RES_{g(x)}[f(x)]$  represents the residue obtained by dividing  $f(x)$  by  $g(x)$ .

The BAS code is sent in the even-numbered frame, while the associated error correction bits are sent in the subsequent odd-numbered frame. The bits of the BAS code or the error correction are transmitted in the order shown in Table 2 to avoid emulation of the frame alignment word.

**Table 2**

| Bit position | Even frame | Odd frame |
|--------------|------------|-----------|
| 9            | $b_0$      | $p_2$     |
| 10           | $b_3$      | $p_1$     |
| 11           | $b_2$      | $p_0$     |
| 12           | $b_1$      | $p_4$     |
| 13           | $b_5$      | $p_3$     |
| 14           | $b_4$      | $p_5$     |
| 15           | $b_6$      | $p_6$     |
| 16           | $b_7$      | $p_7$     |

The decoded BAS value is valid if:

- the receiver is in frame and multiframe alignment; and
- the FAW in the same sub-multiframe was received with two or fewer bits in error.

Otherwise, the decoded BAS value is ignored.

When the receiver actually loses frame alignment, it may be advisable to undo any changes caused by the three previously decoded values as they may well have been erroneous even after correction.

### 3.2 Values of the BAS

The encoding of BAS is made according to an attribute method. The first three bits of an attribute represent its number describing the general command or capability, and the other five bits identify the "value" – the specific command or capability. The BAS codes are defined in this Recommendation, but all procedures governing their use are to be found in Recs ITU-T H.242, ITU-T H.243, ITU-T H.244, ITU-T J.52 or other Recommendations referenced therefrom.

The following attributes are defined in Tables A.1, A.2, A.4 and A.6:

| Attribute | Table A.1                | Table A.2              | Table A.4                 | Table A.6                 |
|-----------|--------------------------|------------------------|---------------------------|---------------------------|
| 000       | Audio coding commands    | Reserved for commands  | Reserved for commands     | Reserved for commands     |
| 001       | Transfer rate commands   | Au-ISO commands        | Reserved for commands     | Reserved for commands     |
| 010       | Video and other commands | Reserved for commands  | Commands                  | Commands                  |
| 011       | Data commands            | HSD/H-MLP commands     | Commands                  | Commands                  |
| 100       | Capabilities             | Au-ISO capabilities    | Capabilities              | Capabilities              |
| 101       | Capabilities             | HSD/H-MLP capabilities | Reserved for capabilities | Capabilities              |
| 110       | Capabilities             | Capabilities           | Reserved for capabilities | Reserved for capabilities |
| 111       | Escape codes             | Forbidden              | Forbidden                 | Forbidden                 |

The values of these attributes are listed and defined in Annex A. They provide for the following facilities:

- transmission at various total rates and on single and multiple channels, on clear channels and on networks subject to restrictions to 56 kbit/s and its multiples;
- audio transmission, digitally encoded to various recommended algorithms;
- video transmission, digitally encoded to various recommended algorithms;
- low-speed data (LSD) within the I-channel, or TS1 of a higher rate initial channel;
- high-speed data (HSD) in the highest-numbered 64 kbit/s channel or time-slots (excluding the I-channel);
- data transmission within a standardized protocol, in a logical sub-channel either in the I-channel (MLP) or in capacity other than the I-channel (H-MLP);
- an encryption control signal;
- loopback towards the network for maintenance purposes;
- signalling for control and indications;

- a message system for, *inter alia*, conveying information concerning equipment manufacturer and type.

The command BAS attributes have the following significance: on receipt of a BAS command code in one (even) frame and its error-correcting code in the next (odd) frame, the receiver prepares to accept the stated mode change beginning from the subsequent (even) frame; thus, a mode change can be effected in 20 ms. The command remains in force until countermanded (see clause 12 of Rec. ITU-T H.242). The bit positions occupied by combinations of BAS commands are exemplified in Figures 5a to 5g.

The capability BAS attributes have the following significance: they indicate the ability of a terminal to receive and properly treat the various types of signal. It follows that having received a set of capability values from the remote terminal Y, terminal X shall not transmit signals lying outside that declared range.

Value [0] of the attribute (111) is reserved for setting the BAS channel to a new class of operation. Values [1-14] are reserved. Equipment conforming to this Recommendation shall treat these values as unknown SBE, ignoring the following byte and not entering a fault condition. This change from the early versions of this Recommendation opens the way to eventual use of these escape codes without entering a new family or class of codes.

The values [15-23] of the attribute (111) are temporary escape BAS codes of single byte extension (SBE), forming a pointer to one of eight possible escape BAS tables of 224 entries each (codes beginning with 111 are not used in the escape BAS tables). Then, the next received BAS indicates the specific entry in the escape BAS table.

The value (111) [24] is the capability marker (see clause 14 of Rec. ITU-T H.242) which is followed by normal BAS codes, not by any escape values.

The last seven attribute values of the attribute (111) are of multiple byte extension (MBE) and are used to send messages as specified in clause A.9.

## 4 Bit positions for audio, video and data stream

### 4.1 LSD streams

| Bit number |     | Octet number |
|------------|-----|--------------|
| 7          | 8   |              |
| 1          | FAS | 1            |
| 2          |     | 2            |
| :          |     | :            |
| 8          |     | 8            |
| 9          | BAS | 9            |
| :          |     | :            |
| 16         |     | 16           |
| 17         |     | 17           |
| 18         | 18  | 18           |
| 19         | 20  | 18           |
| :          | :   | :            |
| 143        | 144 | 80           |

Figure 5a – Bit numbering and position for 14.4 kbit/s LSD