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Recommendation G.731

PRIMARY PCM MULTIPLEX EQUIPMENT FOR VOICE FREQUENCIES

(Geneva, 1972; further amended)

7.3 Principal characteristics of primary multiplex equipment

The CCITT,

considering

that pulse code modulation (PCM) multiplex equipments are already used in various countries, in particular to provide a large number of short-distance telephone circuits on certain pairs in existing cables, and in order to minimize the number of different PCM multiplex equipments providing circuits which may be used in international connections,

recommends

that Administrations concerned should make their choice between the two primary PCM multiplex equipments described in Recommendations G.732 and G.733.

Recommendation G.732

CHARACTERISTICS OF
PRIMARY PCM MULTIPLEX EQUIPMENT

OPERATING AT 2048 kbit/s

(Geneva, 1972; further amended)

1 General characteristics

1.1 *Fundamental characteristics*

The encoding law used is the A-law as specified in Recommendation G.711. The sampling rate, load capacity and the code are also specified in that Recommendation.

The number of quantized values is 256.

Note — The inversion of bits 2, 4, 6, and 8 is covered by the encoding law and is applicable only to voice-channel time slots.

1.2 *Bit rate*

The nominal bit rate is 2048 kbit/s. The tolerance on this rate is ± | 0 parts per million (ppm).

1.3 *Timing signal*

It should be possible to derive the transmitting timing signal of a PCM multiplex equipment from an internal source, from the incoming digital signal and also from an external source.

Note — Further study is required on the effect of jitter of the incoming signal on the timing signal, and on the measures to be taken in case of loss of the incoming signal or the external source.

2 Frame structure

Refer to §§ 3.3.1 and 3.3.2 of Recommendation G.704 for frame structure and use of derived channel time slots.

Note — If channel time slot 16 which is assigned to signalling as covered in § 5 below is not needed for signalling it may be used for purposes other than a voice channel encoded within the PCM multiplex equipment.

3 Loss and recovery of frame alignment

The strategy for the loss and recovery of frame alignment should be according to Recommenda tion G.706, § 4.1.

4 Fault conditions and consequent actions

4.1 *Fault conditions*

The PCM multiplex equipment should detect the following fault conditions:

4.1.1 Failure of power supply.

4.1.2 Failure of codec (except when using single-channel codecs).

As a minimum requirement this fault condition should be recognized when, for at least one signal level in the range —21 to —6 dBm0, the signal-to-quantizing noise ratio performance of the local codec is 18 dB or more below the level recommended in Recommendation G.712.

4.1.3 Loss of incoming signal at the 64 kbit/s input port (time slot 16).

Note 1 — The detection of this fault condition is not mandatory when channel associated signalling is used and the signalling multiplex is situated within a few metres of the PCM multiplex equipment.

Note 2 — The detection of this fault condition is not mandatory when contradirectional interfaces are used.

4.1.4 Loss of the incoming signal at 2048 kbit/s.

Note — The detection of this fault condition is required only when it does not result in an indication of loss of frame alignment.

4.1.5 Loss of frame alignment.

4.1.6 Excessive bit error ratio detected by monitoring the frame alignment signal.

4.1.6.1 With a random bit error ratio of | 0^{D}lF261^{4}, the probabiliy of activating the indication of fault condition within a few seconds should be less than 10^{D}lF261^{6}.

With a random bit error ratio of ≥" | 0^{D}lF261^{3}, the probability of activating the indication of fault condition within a few seconds should be higher than 0.95.

4.1.6.2 With a random bit error ratio of ≥" | 0^{D}lF261^{3}, the probability of deactivating the indication of fault condition within a few seconds should be almost 0.

With a random bit error ratio of | 0^{D}lF261^{4}, the probability of deactivating the indication of fault condition within a few seconds should be higher than 0.95.

Note — The activating and the deactivating period specified as ‘‘a few seconds’’ is intended to be in the order of 4 to 5 seconds.

4.1.7 Alarm indication received from the remote PCM multiplex equipment (see § 4.2.3 below).

4.2 *Consequent actions*

Further to the detection of a fault condition, appropriate actions should be taken as specified in Table 1/G.732. The consequent actions are as follows:

4.2.1 Service alarm indication generated to signify that the service provided by the PCM multiplex is no longer available. This indication should be forwarded at least to the switching and/or signalling multiplex equipment depending upon the arrangements provided. The indication should be given as soon as possible and not later than 2 ms after detection of the relevant fault condition.

This specification, taking into account the specification given in § 3 above, is equivalent to recommending that the average time to detect a loss of frame alignment and to give the relevant indication should not be greater than 3 ms.

When using common-channel signalling, the indication should be forwarded to the switching equipment by means of a separate interface on the PCM multiplex equipment.

4.2.2 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenance attention is required locally. When the Alarm Indication Signal (AIS) (see General Notes below to § 4.2) is detected, the prompt maintenance alarm indication associated with loss of frame alignment (see § 4.1.5 above) and excessive error ratio (see § 4.1.6 above) should be inhibited, while the rest of the consequent actions are in accordance with those associated in Table 1/G.732 with the two fault conditions.

Note — The location and provision of any visual and/or audible alarm activated by the alarm indications given in §§ 4.2.1 and 4.2.2 above, is left to the discretion of each Administration.

4.2.3 Alarm indication to the remote end, transmitted by changing bit 3 of channel time-slot 0 from the state 0 to the state 1 in those frames not containing the frame alignment signal. This should be effected as soon as possible.

4.2.4 Transmission suppressed at the analogue outputs.

4.2.5 AIS applied to time-slot 16 64 kbit/s output (see General Notes below to § 4.2). This action should be taken as soon as possible and not later than 2 ms after the detection of the fault condition.

4.2.6 AIS applied to time slot 16 of the output 2048 kbit/s composite signal (if supervision of the incoming 64 kbit/s signal is provided).

General Notes to § 4.2

Note 1 — Yhe equivalent binary content of the AIS is a continuous stream of binary 1s. The strategy for detecting the presence of the AIS should be such that the AIS is detectable, even in the presence of an error ratio of 1 | (mu | 0^{D}lF261^{3}. However, a signal with all bits except the frame alignment in the 1 state, should not be mistaken as an AIS.

Note 2 — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

5 Signalling

5.1 *Signalling arrangement*

Refer to § 3.3.3 of Recommendation G.704. Channel time slot 16 may be used to provide an interface at 64 kbit/s which shall be suitable for use with either common channel or channel associated signalling.

H.T. [T1.732]

TABLE 1/G.732

Fault conditions and consequent actions for the PCM multiplex equipment

Equipment part	{	{					
{	Failure of power supply Failure of codec	Yes Yes	Yes Yes	Yes (if practicable) Yes	Yes (if practicable) Yes	Yes (if practicable)	Yes (if practicable)
Multiplexer only	{	Yes				Yes	
Demulti plexer only	{ Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Loss of trame alignment {	

Alarm indication received from the remote end (bit 3 of time slot 0) Yes *Note* — A *Yes*
| n the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space*
| in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Table 1/G.732 [T1.732], p.

5.2 *Loss and recovery of multiframe alignment in case of channel associated signalling*

Multiframe alignment should be assumed to have been lost when two consecutive multiframe alignment signals have been received with an error.

Multiframe alignment should be assumed to have been recovered as soon as the first correct multiframe alignment signal is detected.

Note — To avoid a condition of spurious multiframe alignment, the following procedure may be used in addition to the above:

— Multiframe alignment should be assumed to have been lost when, for a period of one or two multiframes, all the bits in time slot 16 are in state 0.

— Multiframe alignment should be assumed to have been recovered only when at least one bit in state 1 is present in the time slot 16 preceding the multiframe alignment signal first detected.

5.3 *Fault conditions and consequent actions in case of channel associated signalling*

5.3.1 *Fault conditions*

The signalling multiplex equipment should detect the following fault conditions:

5.3.1.1 Failure of power supply.

5.3.1.2 Loss of 64 kbit/s incoming signal at the input of the signalling demultiplexer.

Note 1 — The detection of this fault condition is not mandatory when the signalling multiplex equipment is situated within a few metres of the PCM multiplex equipment or when this fault condition results in an indication of loss of multiframe alignment.

Note 2 — Where separate circuits are used for the digital signal and the timing signal then loss of either or both should constitute loss of the incoming signal.

5.3.1.3 Loss of multiframe alignment.

5.3.1.4 Alarm indication received from the remote signalling multiplex equipment (see § 5.3.2.3 below).

5.3.1.5 Receipt of the service alarm indication from the PCM multiplex equipment (see § 4.2.1 above).

5.3.2 *Consequent actions*

Further to the detection of a fault condition appropriate actions should be taken as specified in Table 2/G.732. The consequent actions are as follows:

5.3.2.1 Service alarm indication to be forwarded to the switching equipment depending upon the switching and signalling arrangements provided.

5.3.2.2 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenace attention is required locally. If provision is made for detecting the AIS, then on the reception of the AIS, the prompt maintenance alarm indication should be inhibited in the case of loss of multiframe (see § 5.3.1.3 above).

Note — The location and provision of any visual and or audible alarms activated by the alarm indications given in §§ 5.3.2.1 and 5.3.2.2 above is left to the discretion of each Administration.

5.3.2.3 Alarm indication to the remote signalling multiplex equipment, generated by changing from the state 0 to the state 1 bit 6 of channel time slot 16 of frame 0 of the multiframe (see Table 7/G.704); this should be effected as soon as possible.

5.3.2.4 Application of the condition corresponding to state 1 on the line to all receive signalling channels. This condition should be forwarded as soon as possible and not later than 3 ms after the detection of the fault condition.

Note — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

6 Interfaces

The analogue interfaces should be in accordance with Recommendations G.712, G.713, G.714 and G.715. The digital interfaces at 2048 kbit/s should be in accordance with Recommendation G.703. The digital interfaces at 64 kbit/s should be of either the codirectional or the contradirectional type specified in Recommendation G.703. The specifications for 64 kbit/s interfaces are not mandatory for channel associated signalling. The interface for external synchronization of the transmitting timing signal should be in accordance with Recommendation G.703.

H.T. [T2.732]

TABLE 2/G.732

Fault conditions and consequent actions for channel-associated signalling multiplex equipment

{

Equipment part {

Multiplexer and demultiplexer	Failure of power supply	Yes	Yes	Yes (if practicable)	Yes (if practicable)
	Loss of incoming signal	Yes	Yes	Yes	Yes
	Loss of multiframe alignment	Yes	Yes	Yes	Yes

Yes Yes {

Yes Yes

Jitter

Jitter at 2048 kbit/s output

Jitter at 64 kbit/s output (for interfaces according to

General characteristics

Fundamental characteristics

Bit rate

Timing signal

Frame structure

Loss and recovery of frame alignment

Demultiplexer only

Fault conditions and consequent actions

Fault conditions

Consequent actions

Rapid indication of loss of frame alignment

Signalling

Signalling *arrangement*

Loss *of* *multiframe* *alignment* *in* *case* *of*

Minimization *of*

actions { { { {	Fault	conditions		Consequent		
practicable) Optional	Failure of power supply	Yes	Yes	Yes (if		
{ alignment Yes	Yes Loss Yes Yes Yes Optional	Yes of Yes	Yes Optional	Yes frame		

Note 1 — A *Yes*
| in the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space*
| in the table signifies that the relevant action should *not*
| be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — Indications of additional fault conditions, such as codec failure and excessive bit errors, are left to the discretion of individual Administrations.

Tableau 1/G.733 [T1.733], p. 3

Figure 1/G.733, p. 4

6 Interfaces

Analogue: Refer to Recommendations G.712, G.713 and G.714.

Digital: Refer to Recommendation G.703.

Reference

[1] CCITT Recommendation *Data channel failure detection* , Vol. VI, Rec. Q.275.

Recommendation G.734

CHARACTERISTICS OF SYNCHRONOUS DIGITAL MULTIPLEX EQUIPMENT OPERATING AT 1544 kbit/s

(former Recommendation G.736 of Volume III of the Yellow Book)

1 General characteristics

This Recommendation defines the characteristics of a synchronous multiplex equipment currently used for applications in dedicated data networks, to combine up to 23 tributary channels at 64 kbit/s in a 1544 kbit/s digital stream.

Note — For applications within an ISDN, it is expected that a 24-channel multiplex will be used that has a frame structure conforming to Recommendation G.733.

1.1 *Bit rate*

The nominal bit rate is 1544 kbit/s.

Note — The tolerance on this rate should be studied and specified.

1.2 *Timing signals*

It should be possible to derive the multiplexer timing signals from the composite clock signal of a centralized clock source as specified in Recommendation G.703, and from the 1544 kbit/s incoming digital stream.

Note — The desirability of also providing a 1544 kHz transmitting timing signal from a centralized clock source should be further studied.

2 Frame structure

2.1 *Number of bits per channel time slot*

There are eight bits per channel time slot, numbered from one to eight.

2.2 *Number of channel time slots per frame*

There are 24 time slots per frame, numbered from 1 to 24. Successive bits for bytes 1 to 24 should be consecutively numbered from 2 to 193. The first bit should be reserved for optional use. The frame repetition rate is 8000 Hz.

2.3 *Channel time slot assignment*

2.3.1 Channel time slots 1 to 23 are assigned to tributaries.

2.3.2 Channel time slot 24 is assigned to frame alignment and service digits. Two alternative methods, as given in Tables 1/G.734 and 2/G.734 for allocation of these signals and associated frame alignment strategy are recommended.

H.T. [T1.734]

TABLE 1/G.734

Allocation of time slot 24, Method 1

Bit number of time slot 24							
1	2	3	4	5	6	7	8
Service digits Frame alignment signal 1	0	1	1	1			0

Note — Loss of frame alignment should be assumed to have taken place when more than three of twelve successive frames have an error in the frame alignment signal and/or in bit 1 of the 193-bit frame. Frame alignement should be assumed to have been recovered when four consecutive correct frame alignment signals have been received.

Table 1/G.734 [T1.734], p.

H.T. [T2.734]

TABLE 2/G.734

Allocation of time slot 24, Method 2

Frame number	Bit number of time slot 24						
	1	2	3	4	5	6	7	8
1	Service digits	Frame alignment signal						
0	0	1	0	1				
2	1	1	0	1	0			

Note — Loss of frame alignment should be assumed to have taken place when seven consecutive pairs of the frame alignment signal (00101, 11010) have been incorrectly received in their predicted positions. Frame alignment should be assumed to have been recovered when two consecutive correct pairs of frame alignment signals have been received.

Table 2/G.734 [T2.734], p.

2.4 *Service digits*

The use of service digits in channel time slot 24 is under study.

Note — The first bit could be considered for framing algorithms.

3 Fault conditions and consequent action

3.1 *Fault conditions*

The digital multiplex equipment should detect the following fault conditions:

— failure of power supply,

— loss of the incoming signal at 1544 kbit/s,

— loss of frame alignment,

— loss of timing signals supplied from the centralized clock,

— alarm indication received from the remote digital multiplex equipment.

Some of the above fault conditions may optionally be detected by auxiliary equipment normally used in association with the digital multiplex equipment.

3.2 *Consequent actions*

Further to the detection of a fault condition, appropriate actions should be taken as specified in Table 3/G.734.

H.T. [T3.734]

TABLE 3/G.734

Fault conditions and consequent actions for the digital multiplex equipment

Equipment part	Fault conditions	{		
		{		
Multiplexer and demultiplexer	Failure of power supply	Yes	Yes (if practicable)	Yes (if practicable)
Demultiplexer only	{ Yes Loss of frame alignment Yes	Yes Yes	Yes Yes	Yes

Note 1 — A *Yes*

| n the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space* in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — These consequent actions may optionally be taken by auxiliary equipment normally used in conjunction with the digital multiplex equipment.

Note 3 — The alarm indication to the remote end may be generated by changing a service bit of time slot 24 from the state 1 to the state 0, if possible.

Note 4 — The binary content of the multiplex out-of-sync signal is under study. One Administration uses 00011010.

Table 3/G.734 [T3.734], p.

4 Multiplexing method

Cyclic byte interleaving in the tributary numbering order should be used. The digital multiplex equipment should translate any incoming byte that contains only 0s into the zero byte suppression code.

Note 1 — The content of the zero byte suppression code is under study.

Note 2 — Further study is needed for the case when the zero suppression code must be extracted.

5 Input jitter and wander

The amount of jitter and wander that should be tolerated at the input of the demultiplexer should be according to Recommendation G.824, § 3.1.1.

6 Digital interface

The digital interface at 64 kbit/s and 1544 kbit/s should be in accordance with Recommendation G.703.

Recommendation G.735

CHARACTERISTICS OF PRIMARY PCM MULTIPLEX EQUIPMENT OPERATING AT 2048 kbit/s AND OFFERING

SYNCHRONOUS DIGITAL ACCESS AT 384 kbit/s AND/OR 64 kbit/s

(former Recommendation G.737 of Volume III of the Yellow Book)

This Recommendation gives the characteristics of a PCM multiplex equipment operating at 2048 kbit/s and providing one or several of the following internal digital access options:

— bidirectional synchronous 64 kbit/s channels (see Figure 1a/G.735);

— unidirectional synchronous 384 kbit/s channels (see Figure 1b/G.735).

The 384 kbit/s channel is based on the allocation of 6×64 kbit/s time slots, e.g. for setting up sound-programme circuits according to Recommendations J.41 and J.42.

Because these circuits are specified as unidirectional, the equipment for insertion/extraction has to be separated as shown in Figure 1b/G.735.

1 General characteristics

1.1 *Fundamental characteristics for voice channel encoding*

The encoding law used is the A-law as specified in Recommendation G.711. The sampling rate, load capacity and the code are also specified in that Recommendation.

The number of quantized values is 256.

Note — The inversion of bits 2, 4, 6 and 8 is covered by the encoding law and is applicable only to voice channel time slots.

1.2 *Bit rate*

The nominal bit rate is 2048 kbit/s. The tolerance on this rate is ± | 0 parts per million (ppm).

1.3 *Timing signal*

It should be possible to derive the transmit timing signal from any of the following:

a) from the received 2048 kbit/s signal,

b) from an external source at 2048 kHz (see § 5),

c) from an internal oscillator.

Note — The provision of a timing signal output, available for the purpose of synchronizing other equipments, is an option that might be required depending upon national synchronization arrangements.

1.4 *Types of access:*

a) access for bidirectional synchronous 64 kbit/s channels (see Figure 1a/G.735);

b) access for unidirectional synchronous 384 kbit/s channels (see Figure 1b/G.735).

Note — The synchronous insertion of a digital sound programme signal into a 384 kbit/s channel requires the internal regeneration of a timing signal T synchronized by the 2048 kbit/s signal I_1. The timing signal is used for synchronizing the sampling frequency of the analogue/digital converters producing the digital sound programme signal.

Figure 1/G.735, p.

2 Frame structure and use of derived channel time slots

2.1 *Frame structure of 2048 kbit/s signal*

Refer to § 2.3 of Recommendation G.704. Bit 1 of the frame should be used in accordance with § 2.3.3 of Recommendation G.704, i.e. for a CRC check bit procedure.

2.2 *Use of derived channel time slots*

2.2.1 *Telephone channels*

It should be possible to assign channel time slots 1 to 15 and 17 to 31 to thirty telephone channels numbered from 1 to 30.

2.2.2 *64 kbit/s access*

The number of accessible channel time slots should be at least four and the equipment shall allow access to any of channel time slots 1 to 15 and 17 to 31.

Note — Equipment exists which provides access to at least four channel time slots in the following order of priority: 6 — 22 — 14 — 30 — 2 — 18 — 10 — 26 — 4 — 20 — 12 — 28 — 8 — 24 — 5 — 21 — 13 — 29 — 1 — 17 — 9 — 25 — 3 — 19 — 11 — 27 — 7 — 23 — 15 — 31.

2.2.3 *384 kbit/s access*

The time slot allocation for digital channels with a bit rate at 384 kbit/s is given in Table 1/G.735.

H.T. [T1.735]

TABLE 1/G.735

384 kbit/s channels (Note 1)					
Digital sound-programme access points } A	B	C	D	E	{
1-2-3 17-18-19	4-5-6 20-21-22	7-8-9 23-24-25	10-11-12 26-27-28	13-14-15 29-30-31	I3, T, E3 Figure 1b/G.735

Note 1 — The five possible 384 kbit/s channels in a 2048 kbit/s stream are numbered A to E. Preferably the channel pairs A-B and C-D should be used for stereophonic transmission.

Note 2 — If the channel time slot 16 which is assigned to signalling as covered in § 5 is not needed for signalling, it may be used for purposes other than a voice channel encoded within the PCM multiplex equipment.

Table 1/G.735 [T1.735], p.

3 Frame alignment and CRC procedures

An illustration of the procedure is given in Figure 2/G.706.

3.1 *Loss of frame alignment*

Refer to § 4.1.1 of Recommendation G.706.

3.2 *Recovery of frame alignment*

Refer to § 4.1.2 of Recommendation G.706.

3.3 *CRC multiframe alignment in TSO*

Refer to § 4.2 of Recommendation G.706.

3.4 *CRC bit monitoring*

Refer to § 4.3 of Recommendation G.706.

4 Fault conditions and consequent actions

4.1 *Fault conditions*

The PCM multiplex equipment should detect the following fault conditions:

4.1.1 Failure of power supply.

4.1.2 Failure of codec (except when using single channel codecs).

As a minimum requirement, this fault condition should be recognized when for at least one signal level in the range —21 to —6 dBm0, the signal-to-quantizing noise ratio performance of the local codec is 18 dB or more below the level recommended in Recommendation G.712.

4.1.3 Loss of incoming signals at the 64 kbit/s and 384 kbit/s tributary input ports.

Note 1 — This detection is not mandatory when contradirectional interfaces are used.

Note 2 — The detection of this fault condition is not mandatory for channel time slot 16 when channel associated signalling is used and the signalling multiplex equipment is situated within a few metres of the PCM multiplex equipment.

4.1.4 Loss of the incoming signal at 2048 kbit/s.

Note 1 — The detection of this fault condition is required only when it does not result in an indication of loss of frame alignment.

Note 2 — Where separate circuits are used for the digital signal and the timing signal, the loss of either or both should constitute loss of the incoming signal.

4.1.5 Loss of frame alignment.

4.1.6 Excessive bit error ratio detected by monitoring the frame alignment signal.

4.1.6.1 With a random bit error ratio of | 0^{D}lF261^{4}, the probability of activating the indication of fault condition within a few seconds should be less than 10^{D}lF261^{6}.

With a random bit error ratio of ≥" | 0^{D}lF261^{3}, the probability of activating the indication of fault condition within a few seconds should be higher than 0.95.

4.1.6.2 With a random bit error ratio of ≥" | 0^{D}lF261^{3}, the probability of deactivating the indication of fault condition within a few seconds should be almost 0.

With a random bit error ratio of | 0^{D}lF261^{4}, the probability of deactivating the indication of fault condition within a few seconds should be higher than 0.95.

Note — The activating and the deactivating period specified as ‘‘a few seconds’’ is intended to be in the order of 4 to 5 seconds.

4.1.7 Alarm indication received from the remote PCM multiplex equipment (see § 4.2.3).

4.2 *Consequent actions*

Further to the detection of a fault condition, appropriate actions should be taken as specified in Table 2/G.735. The consequent actions are as follows:

4.2.1 Service alarm indication generated to signify that the service provided by the PCM multiplex is no longer available. This indication should be forwarded at least to the switching and/or signalling multiplex equipment depending upon the arrangements provided. The indication should be given as soon as possible and not later than 2 ms after detection of the relevant fault condition.

This specification, taking into account the specification given in § 4.2.5, is equivalent to recommending that the average time to detect a loss of frame alignment or a loss of the incoming 2048 kbit/s signal and to give the relevant indication should not be greater than 3 ms.

When using common channel signalling the indication should be forwarded to the switching equipment by means of a separate interface on the PCM multiplex equipment.

4.2.2 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenance attention is required locally. When the AIS (see General Notes below to § 4.2) at 2048 kbit/s input is detected, the prompt maintenance alarm indication associated with loss of frame alignment (see § 4.1.5) and excessive error ratio (see § 4.1.6) should be inhibited, while the rest of the consequent actions are in accordance with those associated in Table 2/G.735 with the two fault conditions.

Note — The location and provision of any visual and/or audible alarm activated by the alarm indications given in §§ 4.2.1 and 4.2.2, is left to the discretion of each Administration.

4.2.3 Alarm indication to the remote end transmitted by changing bit 3 of channel time slot 0 from the state 0 to the state 1 in those frames not containing the frame alignment signal. This should be effected as soon as possible.

4.2.4 Transmission suppressed at the analogue voice-frequency outputs.

4.2.5 AIS applied to all 64 kbit/s and 384 kbit/s outputs (see General Notes below § 4.2). For 64 kbit/s outputs, this action should be taken as soon as possible and not later than two ms after the detection of the fault condition.

4.2.6 AIS applied to relevant time slots in the composite 2048 kbit/s output signal (if suspension of incoming 64 kbit/s and/or 384 kbit/s signals is provided).

General Notes to § 4.2

Note 1 — The equivalent binary content of the alarm indication signal (AIS) is a continuous stream of binary 1s. The strategy for detecting the presence of the AIS should be such that with a high probability the AIS is detectable even in the presence of random errors having a mean error rate of 1 in 10^3. Nevertheless, a signal in which all the binary elements, with the exception of the frame alignment signal, are in the state 1, should not be taken as an AIS.

Note 2 — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

5 Signalling

Text as in Recommendation G.732.

6 Interfaces

6.1 *Audio frequency interface*

The analogue audio frequency interfaces should be in accordance with Recommendations G.712, G.713, G.714 and G.715.

6.2 *Digital interfaces*

The digital interfaces at 2048 kbit/s should be in accordance with Recommendation G.703.

The digital interfaces at 64 kbit/s should be of either the codirectional or the contradirectional type specified in Recommendation G.703. The specifications for 64 kbit/s interfaces are not mandatory for channel associated signalling. The interface for external synchronization of the transmitting timing signal should be in accordance with Recommendation G.703.

The need to define a digital interface operating at 384 kbit/s is under study.

Note 1 — It should be noted that, according to the principle of minimizing the number of different types of interfaces, the information rate of 384 kbit/s will be offered to customers at the user/network interface level using the 2048 kbit/s interface as defined in Recommendations I.431 and G.703.

Note 2 — In the case of the 64 kbit/s codirectional interface, the design of the input ports should take account of the need to provide octet alignment, to allow controlled slips when the tributary timing and that of the multiplexer timing source are plesiochronous, and to absorb jitter and wander up to the limits given in Recommendation G.823.

H.T. [T2.735]

TABLE 2/G.735

Fault conditions and consequent actions for the PCM multiplex equipment

Equipment part	{	{					
{	Failure of power supply Failure of codec	Yes Yes	Yes Yes	Yes (if practicable) Yes	Yes (if practicable) Yes	Yes (if practicable)	Yes (if practicable)
Multiplexer only Loss of incoming signal at 64 kbit/s and/or 384 kbit/s inputs (see Note under § 4.1.3) }	{ Yes	Yes					
Demulti plexer only	{ Yes Yes Yes Yes	Yes Yes (see § 4.2.2) Yes (see § 4.2.2)	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	{ { {	

Note — A *Yes*
| in the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space*
| in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Table 1/G.735 + Note { 2.735], p.

7 Jitter

7.1 *Jitter at 2048 kbit/s output*

7.1.1 In the case where the transmitting timing signal is derived from an internal oscillator, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.05 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. See Figure 2/G.823.

7.1.2 In the case where the transmitting timing signal is derived from an external source having no jitter, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.05 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz.

7.1.3 In the case where the transmitting timing signal is derived from the incoming 2048 kbit/s signal having no jitter, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.10 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation O.151.

Note — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

7.2 *Jitter at tributary outputs*

7.2.1 *Jitter at 64 kbit/s output*

In the case where the incoming 2048 kbit/s signal has no jitter, the peak-to-peak jitter at the 64 kbit/s output should not exceed 0.025 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 10 kHz. The equivalent binary content of the test signal applied to the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15} —1 as specified in Recommendation O.151.

Note — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

7.2.2 *Jitter at 384 kbit/s output*

Since the physical and electrical characteristics of a 384 kbit/s interface are identical to those of the 2048 kbit/s interface, the specification of this parameter is the same as that given in § 7.1.3 above.

7.3 *Jitter transfer functions*

7.3.1 The jitter transfer function between the 2048 kHz external synchronisation signal and the 2048 kbit/s output signal should not exceed the gain/frequency limits given in Figure 2/G.735. The 2048 kHz signal shall be modulated with sinusoidal jitter.

Some Administrations require that equipment be fitted with jitter reducers limits given in Figure 3/G.735.

7.3.2 In the case where the transmitting timing is derived from the incoming signal, the jitter transfer junction between the 2048 kbit/s input and 2048 kbit/s output shall be as specified in § 7.3.1.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

7.3.3 The jitter transfer function between the 2048 kbit/s and the 64 kbit/s output should not exceed —29.6 dB when measured over the frequency range f_0 to 10 kHz. The frequency f_0 should be less than 20 Hz and as low as possible (e.g. 10 Hz), taking into account the limitations of measuring equipment.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

Note 3 — The jitter reduction of 1/32 due to demultiplexing is equivalent to —30.1 dB.

7.3.4 Since the physical and electrical characteristics of a 384 kbit/s interface are identical to those of the 2048 kbit/s interface, the jitter transfer function between the 2048 kbit/s input and the 384 kbit/s output is the same as that given in §§ 7.3.1 and 7.3.2 above.

Figure 2/G.735, p.

Figure 3/G.735, p.

Recommendation G.736

CHARACTERISTICS OF A SYNCHRONOUS DIGITAL MULTIPLEX EQUIPMENT OPERATING AT 2048 kbit/s

(former Recommendation G.738 of Volume III of the Yellow Book)

This Recommendation gives the characteristics of a synchronous digital multiplex equipment, to combine up to 31 tributary channels at 64 kbit/s in a 2048 kbit/s digital stream. It is foreseen that in the future the need may arise to devote n 64 kbit/s time slots to services requiring more than a single 64 kbit/s channel. The additions to this Recommendation to allow this facility (e.g. definition of proper interfaces at $n \times 64$ kbit/s) are under study.

1 General characteristics

1.1 *Bit rate*

The nominal bit rate is 2048 kbit/s. The tolerance on this rate is ± | 0 parts per million (ppm).

1.2 *Timing signal*

It should be possible to derive the transmit timing signal from any of the following:

a) from the received 2048 kbit/s signal,

b) from an external source at 2048 kHz (see § 5),

c) from an internal oscillator.

Note 1 — The possibility of also deriving the transmitting timing signal from a 64 kbit/s tributary is under study.

Note 2 — The provision of a timing signal output, available for the purpose of synchronizing other equipments, is an option that might be required depending upon national synchronization arrangements.

2 Frame structure

Refer to §2.3 of Recommendation G.704 for frame structure and for use of derived channel time slots. Bit 1 of the frame should be used in accordance with § 2.3.3 of Recommendation G.704, i.e. for a CRC check bit procedure.

Note — In case of interconnection with multiplex equipment using time slot 16 for internal purposes, the use of this time slot for a 64 kbit/s tributary could be excluded.

3 Frame alignment and CRC procedures

An illustration of the procedure is given in Figure 2/G.706.

3.1 *Loss of frame alignment*

Refer to § 4.1.1 of Recommendation G.706.

3.2 *Recovery of frame alignment*

Refer to § 4.1.2 of Recommendation G.706.

3.3 *CRC multiframe alignment in TS0*

Refer to § 4.2 of Recommendation G.706.

3.4 *CRC bit monitoring*

Refer to § 4.3 of Recommendation G.706.

4 Fault conditions and consequent actions

4.1 *Fault conditions*

The digital muldex should detect the following fault conditions:

4.1.1 Failure of power supply.

4.1.2 Loss of the incoming signal at the 64 kbit/s tributary input port.

Note — This detection is not mandatory when contradirectional interfaces are used.

4.1.3 Loss of the incoming signal at 2048 kbit/s.

Note 1 — The detection of this fault condition is required only when it does not result in an indication of loss of frame alignment.

Note 2 — Where separate circuits are used for the digital signal and the timing signal, the loss of either or both should constitute loss of the incoming signal.

4.1.4 Loss of frame alignment at 2048 kbit/s.

4.1.5 Excessive bit error ratio detected by monitoring the frame alignment signal.

4.1.5.1 With a random bit error ratio of | 0^{D}lF261^{4}, the probability of activating the indication of fault condition within a few seconds should be less than 10^{D}lF261^{6}.

With a random bit error ratio of ≥" | 0^{D}lF261^{3}, the probability of activating the indication of fault condition within a few seconds should be higher than 0.95.

4.1.5.2 With a random bit error ratio of ≥" | 0^{D}lF261^{3}, the probability of desactivating the indication of fault condition within a few seconds should be almost 0.

With a random bit error ratio of | 0^{D}lF261^{4}, the probability of of desactivating the indication of fault condition within a few seconds should be higher than 0.95.

Note — The activating and the deactivating period specified as ‘‘a few seconds’’ is intended to be in the order of 4 to 5 seconds.

4.1.6 Alarm indication received from the remote digital muldex (see § 4.2).

4.2 *Consequent actions*

Further to the detection of a fault condition, appropriate actions should be taken as specified in Table 1/G.736. The consequent actions are as follows:

4.2.1 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenance attention is required locally. When the AIS (see General Notes below to § 4.2) at 2048 kbit/s input is detected, the prompt maintenance alarm indication associated with loss of frame alignment (see § 4.1.4) and excessive error ratio (see § 4.1.5) should be inhibited, while the rest of the consequent actions are in accordance with those associated in Table 1/G.736 with the two fault conditions.

Note — The location and provision of any visual and/or audible alarm activated by the alarm indications given in § 4.2.1 is left to the discretion of each Administration.

4.2.2 Alarm indication to the remote end transmitted by changing bit 3 of channel time slot 0 from the state 0 to the state 1 in those frames not containing the frame alignment signal. This should be effected as soon as possible.

4.2.3 AIS applied to all 64 kbit/s outputs (see General Notes below to § 4.2). This action should be taken as soon as possible and not later than 2 ms after the detection of the fault condition.

4.2.4 AIS applied to relevant time slots in the composite 2048 kbit/s output signal (if supervision of incoming 64 kbit/s signal is provided).

General Notes to § 4.2

Note 1 — The equivalent binary content of the alarm indication signal (AIS) is a continuous stream of binary 1s. The strategy for detecting the presence of the AIS should be such that with a high probability the AIS is detectable even in the presence of random errors having a mean error ratio 1 | (mu | 0^{D}lF261^{3}. Nevertheless, a signal in which all the binary elements, with the exception of the frame alignment signal, are in the state 1, should not be taken as an AIS.

Note 2 — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

H.T. [T1.736]

TABLE 1/G.736

Fault conditions and consequent actions for the 2048 kbit/s

synchronous digital multiplex equipment

Equipment part	{	{			
Multiplexer and demultiplexer	Failure of power supply	Yes	Yes (if practicable)	Yes (if practicable)	Yes (if practicable)
Multiplexer only Loss of incoming signal at a 64 kbit/s input (see Note under § 4.1.2) }	{ Yes			Yes	
Demultiplexer only	{ Yes Yes (see § 4.2.1) Yes (see § 4.2.1)	Yes Yes Yes	Yes Yes Yes	{ { {	

Note — A *Yes* | in the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space* | in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if the condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Table 1/G.736 [T1.736], p.

5 Interfaces

The digital interfaces at 2048 kbit/s should be in accordance with Recommendation G.703.

The digital interfaces at 64 kbit/s should be of either the codirectional or the contradirectional type specified in Recommendation G.703. The interface for external synchronization of the transmitting timing signal should be in accordance with G.703.

Note 2 — In the case of the 64 kbit/s codirectional interface, the design of the input ports should take account of the need to provide octet alignment, to allow controlled slips when the tributary timing and that of the multiplexer timing source are plesiochronous, and to absorb jitter and wander up to the limits given in Recommendation G.823.

6 Jitter

6.1 *Jitter at 2048 kbit/s output*

6.1.1 In the case where the transmitting timing signal is derived from an internal oscillator, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.05 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. See Figure 2/G.823.

6.1.2 In the case where the transmitting timing signal is derived from an external source having no jitter, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.05 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz.

6.1.3 In the case where the transmitting timing signal is derived from the incoming 2048 kbit/s signal having no jitter, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.10 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendatoin O.151.

Note — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

6.2 *Jitter at 64 kbit/s output*

In the case where the incoming 2048 kbit/s signal has no jitter, the peak-to-peak jitter at the 64 kbit/s output should not exceed 0.025 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 10 kHz. The equivalent binary content of the test signal applied to the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15} —1 as specified in Recommendation O.151.

Note — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

6.3 *Jitter transfer functions*

6.3.1 The jitter transfer function between the 2048 kHz external synchronisation signal and the 2048 kbit/s output signal should not exceed the gain/frequency limits given in Figure 1/G.736. The 2048 kHz signal shall be modulated with sinusoidal jitter.

Some Administrations require that equipment be fitted with jitter reducers. In this case, the jitter transfer function should not exceed the gain/frequency limits given in Figure 2/G.736.

6.3.2 In the case where the transmitting timing is derived from the incoming signal, the jitter transfer junction between the 2048 kbit/s input and 2048 kbit/s output shall be as specified in § 6.3.1.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

6.3.3 The jitter transfer function between the 2048 kbit/s and the 64 kbit/s output should not exceed —29.6 dB when measured over the frequency range f_0 to 10 kHz. The frequency f_0 should be less than 20 Hz and as low as possible (e.g. 10 Hz), taking into account the limitations of measuring equipment.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

Note 3 — The jitter reduction of 1/32 due to demultiplexing is equivalent to —30.1 dB.

Figure 1/G.736, p.

Figure 2/G.736, p.

Recommendation G.737

CHARACTERISTICS OF AN EXTERNAL ACCESS EQUIPMENT OPERATING AT 2048 kbit/s OFFERING SYNCHRONOUS

DIGITAL ACCESS AT 384 kbit/s AND/OR 64 kbit/s

(former Recommendation G.739 of Volume III of the Yellow Book)

This Recommendation gives the characteristics of equipment (external to PCM muldexes) operating at 2048 kbit/s and providing one or several of the following tributaries into/from channel time slots of a 2048 kbit/s composite signal:

— bidirectional synchronous 64 kbit/s access (Figure 1a/G.737);

— unidirectional synchronous 384 kbit/s access (Figure 1b/G.737).

The 384 kbit/s channel is based on the allocation of 6 × 64 kbit/s time slots, e.g. for setting up sound-programme circuits according to Recommendations J.41 and J.42. Because these circuits are specified as unidirectional the equipment for insertion/extraction has to be separated as shown in Figure 1b/G.737.

Figure 1/G.737, p. 16

1 General characteristics

1.1 *Bit rate*

The nominal bit rate is 2048 kbit/s. The tolerance on this rate is ± | 0 parts per million (ppm).

1.2 *Types of external access*

a) Bidirectional synchronous insertion/extraction of 64 kbit/s data channels (see Figure 1a/G.737).

Note 1 — The timing signal for the insertion side should be derived from the 2048 kbit/s incoming signal at the insertion side (I_0): the timing signal for the extraction side should be derived from the 2048 kbit/s incoming signal at the extraction side (E_1).

Note 2 — The provision of a timing signal output, available for the purpose of synchronizing other equipments, is an option that might be required depending upon national synchronization arrangements.

Note 3 — Further study is required on the possible need for an internal clock.

b) Unidirectional synchronous insertion and extraction of a digital sound-programme signal into/out of a 384 kbit/s channel (see Figure 1b/G.737).

Note — The synchronous insertion equipment for 384 kbit/s signals requires the internal regeneration of a timing signal synchronized by the 2048 kbit/s input signal I_0. This timing signal output of the synchronous insertion equipment is used for synchronizing the sampling frequency of the analogue/digital converter.

2 Frame structure and use of derived channel time slots

2.1 *Frame structure of the 2048 kbit/s signal*

Refer to § 2.3 of Recommendation G.704. Bit 1 of the frame should be used in accordance with § 2.3.3 of Recommendation G.704, i.e. for a CRC check bit procedure.

2.2 *Use of derived channel time slots*

Time slots not accessed flow transparently through the equipment.

Note — Further study is required as to whether the binary content of time slots used at the access points should be replaced, after extraction from the composite signal, by the AIS.

2.2.1 *64 kbit/s access*

The number of accessible channel time slots should be at least four and the equipment shall allow access to any of channel time slots 1 to 15 and 17 to 31.

Note — Equipment exists which provides access to at least four channel time slots in the following order of priority: 6 — 22 — 14 — 30 — 2 — 18 — 10 — 26 — 4 — 20 — 12 — 28 — 8 — 24 — 5 — 21 — 13 — 29 — 1 — 17 — 9 — 25 — 3 — 19 — 11 — 27 — 7 — 23 — 15 — 31.

2.2.2 *384 kbit/s access*

The time slot allocation for digital channels with a bit rate at 384 kbit/s is given in Table 1/G.737.

H.T. [T1.737]

TABLE 1/G.737

384 kbit/s channels (Note 1)					
Digital sound-programme access points } A	B	C	D	E	{
1-2-3 17-18-19	4-5-6 20-21-22	7-8-9 23-24-25	10-11-12 26-27-28	13-14-15 29-30-31	I3, T, E3 Figure 1b/G.735

Note 1 — The five possible 384 kbit/s channels in a 2048 kbit/s stream are numbered A to E. Preferably the channel pairs A-B and C-D should be used for stereophonic transmission.

Note 2 — If the channel time slot 16 which is assigned to signalling as covered in § 5 is not needed for signalling, it may be used for purposes other than a voice channel encoded within the PCM multiplex equipment.

Table 1/G.737 [T1.737], p.

3 Frame alignment and CRC procedures both at insertion (I↓0) and extraction (E↓1) sides

An illustration of the procedure is given in Figure 2/G.706.

3.1 *Loss of frame alignment*

Refer to § 4.1.1 of Recommendation G.706.

3.2 *Recovery of frame alignment*

Refer to § 4.1.2 of Recommendation G.706.

3.3 *CRC multiframe alignment in TSO*

Refer to § 4.2 of Recommendation G.706.

3.4 *CRC bit monitoring*

Refer to § 4.3 of Recommendation G.706.

4 Fault conditions and consequent actions

4.1 *Fault conditions*

The equipment should detect the following fault conditions:

4.1.1 Failure of power supply.

4.1.2 Loss of incoming signal at I_2or $_3$.

Note — This detection is not mandatory when contradirectional interfaces are used.

4.1.3 Loss of the incoming signal at 2048 kbit/s both at insertion (I_0) and extraction (E_1) sides.

Note 1 — The detection of this fault condition is required only when it does not result in an indication of loss of frame alignment.

Note 2 — Where separate circuits are used for the digital signal and the timing signal, the loss of either or both should constitute loss of the incoming signal.

4.1.4 Loss of frame alignment both at insertion (I_0) and extraction (E_1) sides.

4.1.5 Excessive bit error ratio detected by monitoring the frame alignment signal at both the insertion (I_0) and extraction (E_1) sides.

Note — The detection of this fault condition at insertion side (I_0) depends on the type of application of this equipment in a network and therefore is not mandatory.

4.1.5.1 With a random bit error ratio of $0^{\mathrm{D}}\mathrm{lF261}^{4}$, the probability of activating the indication of fault condition within a few seconds should be less than $10^{\mathrm{D}}\mathrm{lF261}^{6}$.

With a random bit error ratio of ≥"$10^{\mathrm{D}}\mathrm{lF261}^{3}$, the probability of activating the indication of fault condition within a few seconds should be higher than 0.95.

4.1.5.2 With a random bit error ratio of ≥"$10^{\mathrm{D}}\mathrm{lF261}^{3}$, the probability of deactivating the indication of fault condition within a few seconds should be almost 0.

With a random bit error ratio of $0^{\mathrm{D}}\mathrm{lF261}^{4}$, the probability of deactivating the indication of fault condition within a few seconds should be higher than 0.95.

Note — The activating and the deactivating period specified as ‘‘a few seconds’’ is intended to be in the order of 4 to 5 seconds.

4.2 *Consequent actions*

Further to the detection of a fault condition, appropriate actions should be taken as specified in Table 2/G.737. The consequent actions are as follows:

4.2.1 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenance attention is required locally. When the AIS at the 2048 kbit/s inputs (I_0, E_1) is detected (see General Notes below to § 4.2), the prompt maintenance alarm indication associated with loss of frame alignment (see § 4.1.4) and excessive error ratio (see § 4.1.5) should be inhibited, while the rest of the consequent actions are in accordance with those associated in Table 2/G.737 with the two fault conditions.

Note — The location and provision of any visual and/or audible alarm activated by the alarm indications given in § 4.2.1 is left to the discretion of each Administration.

4.2.2 AIS applied to E_2or $_3$outputs (see General Notes below to § 4.2). This action should be taken as soon as possible and not later than 2 ms after the detection of the fault condition.

4.2.3 AIS applied to relevant time slots in the composite 2048 kbit/s output signal at insertion side (I_1) if supervision of the incoming $I_2$and I_3signal is provided.

4.2.4 Inhibition of I_2or $_3$digital information insertion.

4.2.5 Both 2048 kbit/s signals are bypassed.

Note — The provision of this consequent action depends on the type of application of this equipment in a network and therefore is not mandatory.

4.2.6 AIS applied to the 2048 kbit/s output, extraction side (E_0).

Note — The provision of this consequent action depends on the type of application of this equipment in a network and therefore is not mandatory.

4.2.7 AIS applied to the 2048 kbit/s output, insertion side (I_1).

Note — The provision of this consequent action depends on the type of this equipment in a network and therefore is not mandatory.

General Note to § 4.2

Note 1 — The equivalent binary content of the alarm indication signal (AIS) is a continuous stream of binary 1s. The strategy for detecting the presence of the AIS should be such that with a high probability the AIS is detectable even in the presence of random errors having a mean error ratio 1 | (mu | 0^{D}lF261^{3}. Nevertheless, a signal in which all the binary elements, with the exception of the frame alignment signal, are in the state 1, should not be taken as an AIS.

Note 2 — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

5 Interfaces

The digital interfaces at 2048 kbit/s should be in accordance with Recommendation G.703.

The digital interfaces at 64 kbit/s should be either of the codirectional or the contradirectional type specified in Recommendation G.703.

The need to define a digital interface operating at 384 kbit/s is under study.

Note 1 — It should be noted that according to the principle of minimizing the number of different types of interfaces, the information rate of 384 kbit/s will be offered to customers at the user/network interface level using the 2048 kbit/s interface as defined in Recommendations I.431 and G.703.

Note 2 — In the case of the 64 kbit/s codirectional interface, the design of the input ports should take account of the need to provide octet alignment, to allow controlled slips when the tributary timing and that of the multiplexer timing source are plesiochronous, and to absorb jitter and wander up to the limits given in Recommendation G.823.

H.T. [T2.737]

TABLE 2/G.737
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Fault conditions and consequent actions for the external access equipment
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Failure of power supply	Yes				Yes	Yes (if practicable)	Yes (if practicable)	
{ Loss of incoming signal at I 2 or I 3 inputs (see Note under § 4.1.2) }	Yes			Yes				
{	Extr.s. (E 1)	Yes	Yes	Yes	Ins.s. (I 0)	Yes	Yes	Yes
{	Extr. s. (E 1)	Yes (see § 4.2.1)	Yes	Yes	Ins. s. (I 0)	Yes (see § 4.2.1)	Yes	Yes
{	Extr.s. (E 1)	Yes (see § 4.2.1)	Yes	Yes	Ins.s. (I 0)	Yes (see § 4.2.1)	Yes	Yes

Note — A *Yes* | in the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space* | n the table signifies that the relevant action should *not* | be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Table 2/G.737 [T2.737], p.

6 Jitter

6.1 *Jitter at 2048 kbit/s output*

When there is no jitter on the 2048 kbit/s inputs (I_0, E_1) the peak-to-peak jitter at the 2048 kbit/s outputs (I_1, E_0) should not exceed 0.10 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation O.151. See Figure 2/G.823.

Note — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

6.2 *Jitter at E*

6.2.1 The jitter at the E_2(64 kbit/s) output when there is no jitter at the 2048 kbit/s input (E_1) should not exceed 0.025 UI when measured within the frequency range from f_1 = 20 Hz to f_4 = 10 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation O.151.

Note — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

6.2.2 Since the physical and electrical characteristics of a 384 kbit/s interface are identical to those of the 2048 kbit/s interface, the jitter at the E_3(synchronous 384 kbit/s) output when there is no jitter at the 2048 kbit/s input (E_1) is according to § 6.1 above.

6.3 *Jitter transfer functions*

6.3.1 The jitter transfer function between the 2048 kbit/s input (I_0, $_1$) and the output (I_1, E_0) should not exceed the gain/frequency limits given in Figure 2/G.737.

Some Administrations require that equipment be fitted with jitter reducers limits given in Figure 3/G.737.

Note 1 — The 2048 kHz signal shall be modulated with sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

6.3.2 The jitter transfer function between the 2048 kbit/s input (E_1) and the E_2(64 kbit/s) output should not exceed —29.6 dB when measured over the frequency range $f_0$to 10 kHz. The frequency $f_0$should be less than 20 Hz and as low as possible (e.g. 10 Hz), taking into account the limitations of measuring equipment.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

Note 3 — The jitter reduction of 1/32 due to demultiplexing is equivalent to —30.1 dB.

6.3.3 Since the physical and electrical characteristics of a 384 kbit/s interface are identical to those of the 2048 kbit/s interface, the jitter transfer function between the 2048 kbit/s input (E_1) and E_3(synchronous 384 kbit/s) output is according to § 6.3.1 above.

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Figure 2/G.737, p.

Figure 3/G.737, p.

Recommendation G.738

CHARACTERISTICS OF PRIMARY PCM MULTIPLEX EQUIPMENT OPERATING AT 2048 kbit/s AND OFFERING SYNCHRONOUS

DIGITAL ACCESS AT 320 kbit/s AND/OR 64 kbit/s

(Melbourne, 1988)

This Recommendation gives the characteristics of a PCM multiplex equipment operating at 2048 kbit/s and providing one or several of the following internal digital access options:

— bidirectional synchronous 64 kbit/s channels (see Figure 1a/G.738);

— unidirectional synchronous 320 kbit/s channels (see Figure 1b/G.738).

The 320 kbit/s channel is based on the allocation of 5 × 64 kbit/s time slots, e.g. for setting up sound-programme circuits according to Recommendations J.43 and J.44. Because these circuits are specified as unidirectional, the equipment for insertion/extraction has to be separated as shown in Figure 1b/G.738.

1 General characteristics

1.1 *Fundamental characteristics for voice-channel encoding*

The encoding law used is the A-law as specified in Recommendation G.711. The sampling rate, load capacity and the code are also specified in that Recommendation.

The number of quantized values is 256.

Note — The inversion of bits 2, 4, 6 and 8 is covered by the encoding law and is applicable only to voice-channel time slots.

1.2 *Bit rate*

The nominal bit rate is 2048 kbit/s. The tolerance on this rate is ± 50 parts per million (ppm).

1.3 *Timing signal*

It should be possible to derive the transmit timing signal from any of the following:

a) from the received 2048 kbit/s signal;

b) from an external source at 2048 kHz (see § 5);

c) from an internal oscillator.

Note — The provision of a timing signal output, available for the purpose of synchronizing other equipments, is an option that might be required depending upon national synchronization arrangements.

1.4 *Types of access*

a) access for bidirectional synchronous 64 kbit/s channels (see Figure 1a/G.738);

b) access for unidirectional synchronous 320 kbit/s channels (see Figure 1b/G.738).

Note — The synchronous insertion of a digital sound-programme signal into a 320 kbit/s channel requires the internal regeneration of a timing signal T synchronized by the 2048 kbit/s signal I_1. The timing signal is used for synchronizing the sampling frequency of the analogue/digital converters producing the digital sound-programme signal.

2 Frame structure and use of derived channel time slots

2.1 *Frame structure of 2048 kbit/s signal*

Refer to § 2.3 of Recommendation G.704. Bit 1 of the frame should be used in accordance with § 2.3.3 of Recommendation G.704, i.e. for a CRC check bit procedure.

FIGURE 1/G.738, p.

2.2 *Use of derived channel time slots*

2.2.1 *Telephone channels*

It should be possible to assign channel time slots 1 to 15 and 17 to 31, to 30 telephone channels numbered from 1 to 30.

2.2.2 *64 kbit/s access*

The number of accessible channel time slots should be at least four and the equipment shall allow access to any of channel time slots 1 to 15 and 17 to 31.

Note — Equipment exists which provides access to at least four channel time slots in the following order of priority: 6 — 22 — 14 — 30 — 2 — 18 — 10 — 26 — 4 — 20 — 12 — 28 — 8 — 24 — 5 — 21 — 13 — 29 — 1 — 17 — 9 — 25 — 3 — 19 — 11 — 27 — 7 — 23 — 15 — 31.

2.2.3 *320 kbit/s access*

The time slot allocation for digital channels with bit rate at 320 kbit/s is given in Table 1/G.738.

H.T. [T1.738]

TABLE 1/G.738

320 kbit/s channels (Note 1)						
Digital sound-programme access points } A	B	C	D	E	F	{
{ 1 - 2 - 3 - 4 - 5						
} 6 - 7 - 8 - 9 - 10	{					
} 11 - 12 - 13 - 14 - 15	{					
} 17 - 18 - 19 - 20 - 21	{					
} 22 - 23 - 24 - 25 - 26	{					
} 27 - 28 - 29 - 30 - 31	{					
} I3, T, E3 Figure 1b/G.738 }	{					

Note 1 — The six possible 320 kbit/s channels in a 2048 kbit/s stream are numbered A to F. Preferably the channel pairs A-B, C-D and E-F should be used for stereophonic transmission.

Note 2 — If the channel time slot 16 which is assigned to signalling as covered in § 5 is not needed for signalling, it may be used for purposes other than a voice channel encoded within the PCM multiplex equipment.

Table 1/G.738 [T1.738], p.

3 Frame alignment and CRC procedures

An illustration of the procedure is given in Figure 2/G.706.

3.1 *Loss of frame alignment*

Refer to § 4.1.1 of Recommendation G.706.

3.2 *Recovery of frame alignment*

Refer to § 4.1.2 of Recommendation G.706.

3.3 *CRC multiframe alignment in TSO*

Refer to § 4.2 of Recommendation G.706.

3.4 *CRC bit monitoring*

Refer to § 4.3 of Recommendation G.706.

4 Fault conditions and consequent actions

4.1 *Fault conditions*

The PCM multiplex equipment should detect the following conditions:

4.1.1 Failure of power supply.

4.1.2 Failure of codec (except when using single channel codecs).

As a minimum requirement, this fault condition should be recognized when for at least one signal level in the range —21 to —6 dBm0, the signal-to-quantizing noise ratio performance of the local codec is 18 dB or more below the level recommended in Recommendation G.712.

4.1.3 Loss of incoming signals at the 64 kbit/s and 320 kbit/s tributary input ports.

Note 1 — This detection is not mandatory when contradirectional interfaces are used.

Note 2 — The detection of this fault condition is not mandatory for channel time slot 16 when channel associated signalling is used and the signalling multiplex equipment is situated within a few metres of the PCM multiplex equipment.

4.1.4 Loss of the incoming signal at 2048 kbit/s.

Note 1 — The detection of this fault condition is required only when it does not result in an indication of loss of frame alignment.

Note 2 — Where separate circuits are used for the digital signal and the timing signal, the loss of either or both should constitute loss of the incoming signal.

4.1.5 Loss of frame alignment.

4.1.6 Excessive bit error ratio detected by monitoring the frame alignment signal.

4.1.6.1 With a random bit error ratio of 10^{-4}, the probability of activating the indication of fault condition within a few seconds should be less than 10^{-6}.

With a random bit error ratio of $\geq 10^{-3}$, the probability of activating the indication of fault condition within a few seconds should be higher than 0.95.

4.1.6.2 With a random bit error ratio of $\geq 10^{-3}$, the probability of deactivating the indication of fault condition within a few seconds should be almost 0.

With a random bit error ratio of 10^{-4}, the probability of deactivating the indication of fault condition within a few seconds should be higher than 0.95.

Note — The activating and deactivating period specified as ‘‘a few seconds’’ is intended to be in the order of 4 to 5 seconds.

4.1.7 Alarm indication received from the remote PCM multiplex equipment (see § 4.2.3).

4.2 *Consequent actions*

Further to the detection of a fault condition, appropriate actions should be taken as specified in Table 2/G.738. The consequent actions are as follows:

4.2.1 Service alarm indication generated to signify that the service provided by the PCM multiplex is no longer available. This indication should be forwarded at least to the switching and/or signalling multiplex equipment depending upon the arrangements provided. The indication should be given as soon as possible and not later than 2 ms after detection of the relevant fault condition.

This specification, taking into account the specification given in § 4.2.5, is equivalent to recommending that the average time to detect a loss of frame alignment or a loss of the incoming 2048 kbit/s signal and to give the relevant indication should not be greater than 3 ms.

When using common channel signalling the indication should be forwarded to the switching equipment by means of separate interface on the PCM multiplex equipment.

4.2.2 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenance attention is required locally. When the AIS at 2048 kbit/s input is detected (see General Notes below to § 4.2), the prompt maintenance alarm indication associated with loss of frame alignement (see § 4.1.5) and excessive error ratio (see § 4.1.6) should be inhibited, while the rest of the consequent actions are in accordance with those associated in Table 2/G.738 with the two fault conditions.

Note — The location and provision of any visual and/or audible alarm activated by the alarm indications given in § 4.2.1 and § 4.2.2, is left to the discretion of each Administration.

4.2.3 Alarm indication to the remote end, transmitted by changing bit 3 of channel time slot 0 from the state 0 to the state 1 in those frames not containing the frame alignment signal. This should be effected as soon as possible.

H.T. [T2.738]

TABLE 2/G.738

Fault conditions and consequent actions for the PCM multiplex equipment

Equipment part	{						
{	Failure of power supply Failure of codec	Yes Yes	Yes Yes	Yes (if practicable) Yes	Yes (if practicable) Yes	Yes (if practicable)	Yes (if practicable)
Multiplexer only	{	Yes				Yes	
Demultiplexer only	{ Yes Yes Yes Yes	Yes Yes (see § 4.2.2) Yes (see § 4.2.2)	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	{ { {	

Note — A *Yes*

| in the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space* in the table signifies that the relevant action should not be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Tableau 2/G.738 [T2.738], p.

4.2.4 Transmission suppressed at the analogue voice-frequency outputs.

4.2.5 AIS applied to all 64 kbit/s and 320 kbit/s outputs (see General Notes below to § 4.2). For 64 kbit/s outputs this actions should be taken as soon as possible and not later than 2 ms after the detection of the fault condition.

4.2.6 AIS applied to relevant time slots in the composite 2048 kbit/s output signal (if suspension of incoming 64 kbit/s and 320 kbit/s signals is provided).

General Notes to § 4.2

Note 1 — The equivalent binary content of the alarm indication signal (AIS) is a continuous stream of binary 1s. The strategy for detecting the presence of AIS should be such that with a high probability the AIS is detectable even in the presence of random errors having a mean error rate of 1 in 10^3. Nevertheless, a signal in which all the binary elements, with the exception of the frame alignment signal, are in the state 1, should not be taken as an AIS.

Note 2 — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

5 Signalling

Text as in Recommendation G.732.

6 Interfaces

6.1 *Audio frequency interface*

The analogue audio frequency interfaces should be in accordance with Recommendations G.712, G.713, G.714 and G.715.

6.2 *Digital interfaces*

The digital interfaces at 2048 kbit/s should be in accordance with Recommendation G.703.

The digital interfaces at 64 kbit/s should be of either the codirectional or the contradirectional type specified in Recommendation G.703. The specification for 64 kbit/s interfaces are not mandatory for channel-associated signalling. The interface for external synchronization of the transmitting timing signal should be in accordance with Recommendation G.703.

The need to define a digital interface operating at 320 kbit/s is under study.

Note 1 — It should be noted that, according to the principle of minimizing the number of different types of interfaces, the information rate of 320 kbit/s will be offered to customers at the user/network interface level using the 2048 kbit/s interface as defined in Recommendation I.431 and Recommendation G.703.

Note 2 — In the case of the 64 kbit/s codirectional interface, the design of the input ports should take into account the need to provide octet alignment, to allow controlled slips when the tributary timing and that of the multiplexer timing source are plesiochronous, and to absorb jitter and wander up to the limits given in Recommendation G.823.

7 Jitter

7.1 *Jitter at 2048 kbit/s output*

7.1.1 In the case where the transmitting timing signal is derived from an internal oscillator, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.05 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. See Figure 2/G.823.

7.1.2 In the case where the transmitting timing signal is derived from an external source having no jitter, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.05 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz.

7.1.3 In the case where the transmitting timing signal is derived from the incoming 2048 kbit/s signal having no jitter, the peak-to-peak jitter at the 2048 kbit/s output should not exceed 0.10 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation O.151.

Note — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

7.2 *Jitter at tributary outputs*

7.2.1 *Jitter at 64 kbit/s output*

In the case where the incoming 2048 kbit/s signal has no jitter, the peak-to-peak jitter at the 64 kbit/s output should not exceed 0.025 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 = 10 kHz. The equivalent binary content of the test signal applied to the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation O.151.

Note — In order to carry out this measurement without invoking AIS at the 64 kbit/s output it will normally be necessary to include a frame alignment signal in the test signal.

7.2.2 *Jitter at 320 kbit/s output*

Since the physical and electrical characteristics of a 320 kbit/s interface are identical to those of the 2048 kbit/s interface, the specification of this parameter is the same as that given in § 7.1.3 above.

7.3 *Jitter transfer functions*

7.3.1 The jitter transfer function between the 2048 kbit/s external synchronization signal and the 2048 kbit/s output signal should not exceed the gain/frequency limits given in Figure 2/G.738. The 2048 kHz signal shall be modulated with sinusoidal jitter.

Some Administrations require that equipment be fitted with jitter reducers. In this case, the jitter transfer functions should not exceed the gain/frequency limits given in Figure 3/G.738.

7.3.2 In the case where the transmitting timing is derived from the incoming signal, the jitter transfer function between the 2048 kbit/s input and the 2048 kbit/s output shall be as specified in § 7.3.1.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

7.3.3 The jitter transfer function between the 2048 kbit/s input and the 64 kbit/s output should not exceed —29.6 dB when measured over the frequency range f_0 to 10 kHz. The frequency f_0 should be less than 20 Hz and as low as possbile (e.g. 10 Hz), taking into account the limitations of measuring equipment.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignement signal in the test signal.

Note 3 — The jitter reduction of 1/32 due to demultiplexing is equivalent to —30.1 dB.

7.3.4 Since the physical and electrical characteristics of a 320 kbit/s interface are identical to those of 2048 kbit/s interface, the jitter transfer function between 2048 kbit/s input and 320 kbit/s output is the same as that given in §§ 7.3.1 and 7.3.2 above.

Figure 2/G.738, p.

Figure 3/G.738, p.

Recommendation G.739

CHARACTERISTICS OF AN EXTERNAL ACCESS EQUIPMENT OPERATING AT 2048 kbit/s OFFERING SYNCHRONOUS

DIGITAL ACCESS AT 320 kbit/s AND/OR 64 kbit/s

(Melbourne, 1988)

This Recommendation gives the characteristics of equipment (external to PCM muldexes) operating at 2048 kbit/s and providing one or several of the following tributaries into/from channel time slots of a 2048 kbit/s composite signal:

— bidirectional synchronous 64 kbit/s access (Figure 1a/G.739);

— unidirectional synchronous 320 kbit/s access (Figure 1b/G.739).

The 320 kbit/s channel is based on the allocation of 5 × 64 kbit/s time slots, e.g. for setting up sound-programme circuits according to Recommendations J.43 and J.44. Because these circuits are specified as unidirectional, the equipment for insertion/extraction has to be separated as shown in Figure 1b/G.739.

1 General characteristics

1.1 *Bit rate*

The nominal bit rate is 2048 kbit/s. The tolerance on this rate is ± 50 parts per million (ppm).

1.2 *Types of external access*

a) Bidirectional synchronous insertion/extraction of 64 kbit/s data channels (see Figure 1a/G.739).

Note 1 — The timing signal for the insertion side should be derived from the 2048 kbit/s incoming signal at the insertion side (I_0); the timing signal for the extraction side should be derived from the 2048 kbit/s incoming signal at the extraction side (E_1).

Note 2 — The provision of a timing signal output, available for the purpose of synchronizing other equipments, is an option that might be required depending upon national synchronization arrangements.

Note 3 — Further study is required on the possible need for an internal clock.

b) Unidirectional synchronous insertion and extraction of a digital sound-programme signal into/out of a 320 kbit/s channel (see Figure 1b/G.739).

Note — The synchronous insertion equipment for 320 kbit/s signals requires the internal regeneration of a timing signal synchronized by the 2048 kbit/s input signal I_0. This timing signal output of the synchronous insertion equipment is used for synchronizing the sampling frequency of the analogue/digital converter.

2 Frame structure and use of derived channel time slots

2.1 *Frame structure of the 2048 kbit/s signal*

Refer to § 2.3 of Recommendation G.704. Bit 1 of the frame should be used in accordance with § 2.3.3 of Recommendation G.704, i.e. for a CRC check bit procedure.

2.2 *Use of derived channel time slots*

Time slots not accessed flow transparently through the equipment.

Note — Further study is required as to whether the binary content of time slots used at the access points should be replaced, after extraction from the composite signal, by the AIS.

2.2.1 *64 kbit/s access*

The number of accessible channel time slots should be at least four and the equipment shall allow access to any of channel time slots 1 to 15 and 17 to 31.

Note — Equipment exists which provides access to at least four channel time slots in the following order of priority: 6 — 22 — 14 — 30 — 2 — 18 — 10 — 26 — 4 — 20 — 12 — 28 — 8 — 24 — 5 — 21 — 13 — 29 — 1 — 17 — 9 — 25 — 3 — 19 — 11 — 27 — 7 — 23 — 15 — 31.

Figure 1/G.739, p.

2.2.2 *320 kbit/s access*

The time slot allocation for digital channels with bit rate at 320 kbit/s is given in Table 1/G.739.

H.T. [T1.739]

TABLE 1/G.739

320 kbit/s channels (Note 1)						
Digital sound-programme access points } A	B	C	D	E	F	{
{ 1 - 2 - 3 - 4 - 5 }	{					
6 - 7 - 8 - 9 - 10 }	{					
11 - 12 - 13 - 14 - 15 }	{					
17 - 18 - 19 - 20 - 21 }	{					
22 - 23 - 24 - 25 - 26 }	{					
27 - 28 - 29 - 30 - 31 }	{					
I3, T, E3 Figure 1b/G.738 }						

Note 1 — The six possible 320 kbit/s channels in a 2048 kbit/s stream are numbered A to F. Preferably the channel pairs A-B, C-D and E-F should be used for stereophonic transmission.

Note 2 — If the channel time slot 16 which is assigned to signalling as covered in § 5 is not needed for signalling, it may be used for purposes other than a voice channel encoded within the PCM multiplex equipment.

Table 1/G.739 [T1.739], p.

3 Frame alignment and CRC procedures both at insertion (I↓0) and extraction (E↓1) sides

An illustration of the procedure is given in Figure 2/G.706.

3.1 *Loss of frame alignment*

Refer to § 4.1.1 of Recommendation G.706.

3.2 *Recovery of frame alignment*

Refer to § 4.1.2 of Recommendation G.706.

3.3 *CRC multiframe alignment in TSO*

Refer to § 4.2 of Recommendation G.706.

3.4 *CRC bit monitoring*

Refer to § 4.3 of Recommendation G.706.

4 Fault conditions and consequent actions

4.1 *Fault conditions*

The equipment should detect the following conditions:

4.1.1 Failure of power supply.

4.1.2 Loss of incoming signal at I_2or $_3$.

Note — This detection is not mandatory when contradirectional interfaces are used.

4.1.3 Loss of the incoming signal at 2048 kbit/s both at insertion (I_0) and extraction (E_1) sides.

Note 1 — The detection of this fault condition is required only when it does not result in an indication of loss of frame alignment.

Note 2 — Where separate circuits are used for the digital signal and the timing signal, the loss of either or both should constitute loss of the incoming signal.

4.1.4 Loss of frame alignment both at insertion (I_0) and extraction (E_1) sides.

4.1.5 Excessive bit error ratio detected by monitoring the frame alignment signal at both the insertion (I_0) and extraction (E_1) sides.

Note — The detection of this fault condition at insertion side (I_0) depends on the type of application of this equipment in a network and therefore is not mandatory.

4.1.5.1 With a random bit error ratio of 10^{D}lF261^{4}, the probability of activating the indication of fault condition within a few seconds should be less than 10^{D}lF261^{6}.

With a random bit error ratio of ≥" 10^{D}lF261^{3}, the probability of activating the indication of fault condition within a few seconds should be higher than 0.95.

4.1.5.2 With a random bit error ratio of ≥" 10^{D}lF261^{3}, the probability of deactivating the indication of fault condition within a few seconds should be almost 0.

With a random bit error ratio of 10^{D}lF261^{4}, the probability of deactivating the indication of fault condition within a few seconds should be higher than 0.95.

Note — The activating and deactivating period specified as ‘‘a few seconds’’ is intended to be in the order of 4 to 5 seconds.

4.2 *Consequent actions*

Further to the detection of fault condition, appropriate actions should be taken as specified in Table 2/G.739. The consequent actions are as follows:

4.2.1 Prompt maintenance alarm indication generated to signify that performance is below acceptable standards and maintenance attention is required locally. When the AIS at the 2048 kbit/s inputs (I_0, E_1) is detected (see General Notes below to § 4.2), the prompt maintenance alarm indication associated with loss of frame alignment (see § 4.1.4) and excessive error rate (see § 4.1.5) should be inhibited, while the rest of the consequent actions are in accordance with those associated in Table 2/G.739 with the two fault conditions.

Note — The location and provision of any visual and/or audible alarm activated by the alarm indications given in § 4.2.1 is left to the discretion of each Administration.

4.2.2 AIS applied to E_2, E_3 outputs (see General Notes below to § 4.2). This action should be taken as soon as possible and not later than 2 ms after the detection of the fault condition.

4.2.3 AIS applied to relevant time slots in the composite 2048 kbit/s output signal at insertion side (I_1) if supervision of the incoming I_2 and I_3 signal is provided.

4.2.4 Inhibition of I_2 or $_3$ digital information insertion.

4.2.5 Both 2048 kbit/s signals are bypassed.

Note — The provision of this consequent action depends on the type of application of this equipment in a network and therefore is not mandatory.

4.2.6 AIS applied to the 2048 kbit/s output, extraction side (E_0).

Note — The provision of this consequent action depends on the type of application of this equipment in a network and therefore is not mandatory.

4.2.7 AIS applied to the 2048 kbit/s output, insertion side (I_1).

Note — The provision of this consequent action depends on the type of this equipment in a network and therefore is not mandatory.

General Notes to § 4.2

Note 1 — The equivalent binary content of the alarm indication signal (AIS) is a continuous stream of binary 1s. The strategy for detecting the presence of the AIS should be such that with a high probability the AIS is detectable even in the presence of random errors having a mean error ratio 1×10^{D}lF261^{3}. Nevertheless, a signal in which all the binary elements, with the exception of the frame alignment signal, are in the state 1, should not be taken as an AIS.

Note 2 — All timing requirements quoted apply equally to restoration, subsequent to the fault condition clearing.

5 Interfaces

The digital interfaces at 2048 kbit/s should be in accordance with Recommendation G.703.

The digital interfaces at 64 kbit/s should be either of the codirectional or the contradirectional type specified in Recommendation G.703.

The need to define a digital interface operating at 320 kbit/s is under study.

Note 1 — It should be noted that according to the principle of minimizing the number of different types of interfaces, the information rate of 320 kbit/s will be offered to customers at the user/network interface level using the 2048 kbit/s interface as defined in Recommendations I.431 and G.703.

Note 2 — In the case of the 64 kbit/s codirectional interface, the design of the input ports should take into account the need to provide octet alignment, to allow controlled slips when the tributary timing and that of the multiplexer timing source are plesiochronous, and to absorb jitter and wander up to the limits given in Recommendation G.823.

H.T. [T2.739]

TABLE 2/G.739
{
Fault conditions and consequent actions for the
external access equipment
}

{	{ { { { { { { {							
Failure of power supply	Yes				Yes	Yes (if practicable)	Yes (if practicable)	
{ Loss of incoming signal at I 2 or I 3 inputs (see Note under § 4.1.2) }	Yes			Yes				
{	Extr.s. (E 1)	Yes	Yes	Yes	Ins.s. (I 0)	Yes	Yes	Yes
{	Extr.s. (E 1)	Yes (see § 4.2.1)	Yes	Yes	Ins.s. (I 0)	Yes (see § 4.2.1)	Yes	Yes
{	Extr.s. (E 1)	Yes (see § 4.2.1)	Yes	Yes	Ins.s. (I 0)	Yes (see § 4.2.1)	Yes	Yes

Note — A *Yes*
| in the table signifies that an action should be taken as a consequence of the relevant fault condition. An *open space* in the table signifies that the relevant action should not be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Table 2/G.739 [T2.739], p.

6 Jitter

6.1 *Jitter at 2048 kbit/s output*

When there is no jitter on the 2048 kbit/s inputs (I_0, E_1) the peak-to-peak jitter at the 2048 kbit/s outputs (I_1, E_0) should not exceed 0.10 UI when it is measured within the frequency range from f_1 = 20 Hz to f_4 =100 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation 0.151. See Figure 2/G.823.

Note — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

6.2 *Jitter at E*

6.2.1 The jitter at the E_2(64 kbit/s) output when there is no jitter at the 2048 kbit/s input (E_1) should not exceed 0.025 UI when measured within the frequency range from f_1 = 20 Hz to f_4 = 100 kHz. The equivalent binary content of the test signal applied at the 2048 kbit/s input shall be a pseudo-random bit sequence of length 2^{15}—1 as specified in Recommendation O.151.

Note — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

6.2.2 Since the physical and electrical characteristics of a 320 kbit/s interface are identical to those of the 2048 kbit/s interface, the jitter at the E_3(synchronous 320 kbit/s) output when there is no jitter at the 2048 kbit/s input (E_1) is according to § 6.1 above.

6.3 *Jitter transfer functions*

6.3.1 The jitter transfer function between the 2048 kbit/s input (I_0, $_1$) and the output (I_1, E_0) should not exceed the gain/frequency limits given in Figure 2/G.739.

Some Administrations require that equipment be fitted with jitter reducers limits given in Figure 3/G.739.

Note 1 — The 2048 kHz signal shall be modulated with sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — It may be necessary to include a frame alignment signal in the test signal to enable the measurement to be carried out.

6.3.2 The jitter transfer function between the 2048 kbit/s input (E_1) and the E_2(64 kbit/s) output should not exceed —29.6 dB when measured over the frequency range $f_0$to 10 kHz. The frequency $f_0$should be less than 20 Hz and as low as possible (e.g. 10 Hz), taking into account the limitations of measuring equipment.

Note 1 — The 2048 kbit/s test signal shall be modulated by sinusoidal jitter. The equivalent binary content of the test signal shall be 1000.

Note 2 — In order to carry out this measurement without invoking AIS at the 64 kbit/s output, it will normally be necessary to include a frame alignment signal in the test signal.

Note 3 — The jitter reduction of 1/32 due to demultiplexing is equivalent to —30.1 dB.

6.3.3 Since the physical and electrical characteristics of a 320 kbit/s interface are identical to those of the 2048 kbit/s interface, the jitter transfer function between the 2048 kbit/s input (E_1) and E_3(synchronous 320 kbit/s) output is according to § 6.3.1 above.

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Figure 2/G.739, p.

Figure 3/G.739, p.