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GENERAL ASPECTS OF DIGITAL TRANSMISSION

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

ITU-T Recommendation G.736

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation G.736 was revised by the ITU-T Study Group XV (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Page

1 General characteristics 1
1.1 Bit rate 1
1.2 Timing signal 1
2 Frame structure 1
3 Frame alignment and CRC procedures 1
3.1 Loss of frame alignment 1
3.2 Recovery of frame alignment 1
3.3 CRC multiframe alignment in time slot 0 1
3.4 CRC bit monitoring 1
4 Fault conditions and consequent actions 2
4.1 Fault conditions 2
4.2 Consequent actions 2
5 Interfaces 4
6 Jitter 4
6.1 Jitter at 2048 kbit/s output 4
6.2 Jitter at tributary outputs 4
6.3 Jitter transfer functions 5

Recommendation G.736

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

(Melbourne, 1988; revised at Helsinki, 1993)

This Recommendation gives the characteristics of a synchronous digital multiplex equipment, to combine up to 31 tributary channels at 64 kbit/s or n × 64 kbit/s in a 2048 kbit/s digital stream.

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 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.

NOTES

1 The possibility of also deriving the transmit timing signal from a 64 kbit/s or n × 64 kbit/s tributary is under study.

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 and 5 of Recommendation G.704 for the basic frame structure and characteristics of the frame structure carrying channels at various bit rates in 2048 kbit/s. Bit 1 of the frame should be used in accordance with 2.2.3 of 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. It could also be used for internal purposes according to Recommendation G.704.

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/G.706.

3.2 Recovery of frame alignment

Refer to 4.1.2/G.706.

3.3 CRC multiframe alignment in time slot 0

Refer to 4.2/G.706.

3.4 CRC bit monitoring

Refer to 4.3/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 Failure 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

NOTES

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

2 Where separate circuits are used for the digital signal and the timing signal, the loss of either or both should constitute the 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 $\leq 1 \cdot 10^{-4}$, the probability of activating the indication of fault condition in a few seconds should be less than 10^{-6}.

With a random bit error ratio of $\geq 1 \cdot 10^{-3}$, the probability of activating the indication of fault condition in a few seconds should be higher than 0.95.

4.1.5.2 With a random bit error ratio of $\geq \cdot 1 \cdot 10^{-3}$, the probability of deactivating the indication of fault condition in a few seconds should be almost 0.

With a random bit error ratio $\leq 1 \cdot 10^{-4}$, the probability of deactivating the indication of fault condition in 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.

4.1.6 Loss of timing signal

The internal oscillator is not locked to the timing signals defined in items a) and b) of 1.2 and in Note 1 of 1.2. The detection criteria for this fault condition are under study.

4.1.7 Alarm condition 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. 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 Note below to 4.2) at a 2048 kbit/s input is detected, the prompt maintenance alarm indication association 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 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 or n x 64 kbit/s outputs and state "1" to corresponding abcd bits in time slot 16 if used (see General Note below to 4.2). This action should be taken as soon as possible and not later than 2 ms after detection of the fault condition.

TABLE 1/G.736

Fault conditions and consequent actions for the 2048 kbit/s synchronous digital multiplex equipment

Equipment part	Fault conditions (see 4.1)	Consequent actions (see 4.2)				
		Prompt maintenance alarm indication generated	Alarm indication to the remote end transmitted		AIS applied to all 64 kbit/s and n × 64 kbit/s outputs	AIS applied to the relevant time slots of the 2048 kbit/s composite signal
			Backward alarm	Forward alarm	State 1 in time slot 16 (Note 1)	State 1 in time slot 16 (Note 1)
Multiplexer and demultiplexer	Failure of power supply	Yes	Yes (if practicable)	Yes (if practicable)	Yes (if practicable)	Yes (if practicable)
	Loss of timing signal	Yes	Yes (Note 2)	Yes (Note 2)		
Multiplexer only	Loss of incoming signal at a 64 kbit/s or n × 64 kbit/s input (see Note under 4.1.2)	Yes				Yes
Demultiplexer only	Loss of incoming signal at 2048 kbit/s	Yes	Yes		Yes	
	Loss of frame alignment (see Note 2 of 4.2 of Rec. G.706)	Yes (see 4.2.1)	Yes		Yes	
	Error ratio $1 \cdot 10^{-3}$ alignment signal	Yes (see 4.2.1)	Yes		Yes	
	Alarm indication received from the remote end					

NOTES

1 Applicable if time slot 16 is used for channel associated signalling or channel associated supervision/maintenance only.

2 In order to enable appropriate actions at the remote end, the indication of loss of timing signal should not be transmitted in bit 3 of time slot 0. The transmission of this indication is under study.

3 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.

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 NOTE to 4.2 – 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 $\leq 1 \cdot 10^{-3}$. 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 – 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. This interface should be used for both n × 64 kbit/s tributaries and 2048 kbit/s multiplexed signal.

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 transmit timing signal should be in accordance with G.703.

NOTE – 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. In the case of the n × 64 kbit/s interface, the design of the input ports should similarly take account of the need to provide frame alignment to allow controlled slips.

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 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.

6.2 Jitter at tributary outputs

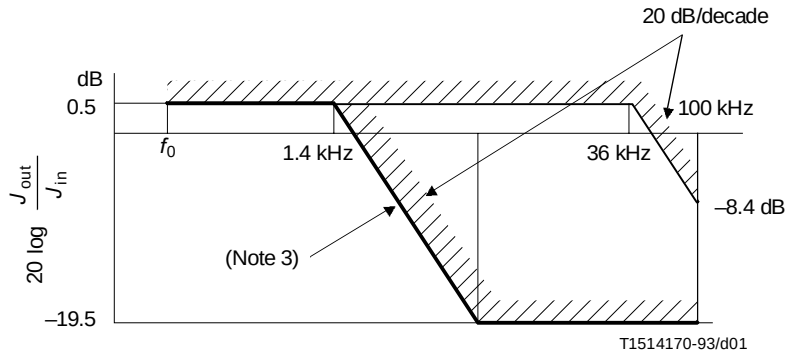
6.2.1 In the case where the incoming 2048 kbit/s signal has no jitter, the peak-to-peak jitter at the 64 kbit/s output should not exceed 0.025 UI when it is measured within the range from $f_1 = 20$ Hz to $f_4 = 10$ kHz. The equivalent binary content of the test signal applied to the 2048 kbit/s input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

6.2.2 The peak-to-peak jitter value for the 2048 kbit/s tributary signal when there is no jitter at the 2048 kbit/s input signal should not exceed 0.10 UI when measured within the range from $f_1 = 20$ Hz to $f_4 = 10$ kHz.

NOTE – In order to carry out these measurements without invoking AIS at the 64 and n × 64 kbit/s outputs 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 synchronization signal and the 2048 kbit/s output signal should not exceed the gain/frequency limits given in Figure 1. The 2048 kHz signal shall be modulated with sinusoidal jitter. This may also be applicable to the n × 64 kbit/s tributary output.



NOTES

1 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.

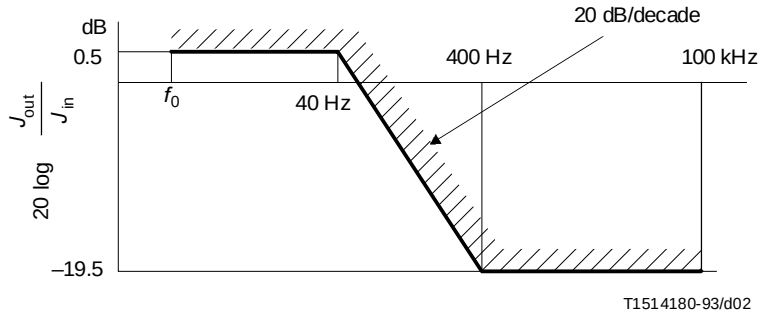
2 To achieve accurate measurements, the use of a selective method is recommended with a bandwidth sufficiently small referred to the relevant measurement frequency but not wider than 40 Hz.

3 For interfaces within national boundaries, this characteristic may be used.

FIGURE 1/G.736

Jitter transfer function without jitter reduction

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



NOTES

1 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.

2 To achieve accurate measurements, the use of a selective method is recommended with a bandwidth sufficiently small referred to the relevant measurement frequency but not wider than 40 Hz.

FIGURE 2/G.736

Jitter transfer function with jitter reduction

6.3.2 In the case where the transmitting timing is derived from the incoming signal, the jitter transfer function between the 2048 kbit/s input and 2048 kbit/s output or n × 64 kbit/s tributary signal shall be as specified in 6.3.1.

NOTES

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

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 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 possible (e.g. 10 Hz), taking into account the limitations of measuring equipment.

The jitter transfer function between the 2048 kbit/s input signal and a n × 64 kbit/s tributary output signal shall be as specified in 6.3.1.

NOTES

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

2 In order to carry out these measurements without invoking AIS at the 64 and n × 64 kbit/s outputs it will normally be necessary to include a frame alignment signal in the test signal.

3 In the case of 64 kbit/s tributaries, the jitter reduction of 1/32 due to demultiplexing is equivalent to −30.1 dB.