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DIGITAL NETWORKS

THE CONTROL OF JITTER AND WANDER WITHIN DIGITAL NETWORKS WHICH ARE BASED ON THE SYNCHRONOUS DIGITAL HIERARCHY (SDH)

ITU-T Recommendation G.825

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-TS 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-TS Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation G.825 was prepared by the ITU-T Study Group XVIII (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-TS) 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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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.

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Recommendation G.825

THE CONTROL OF JITTER AND WANDER WITHIN DIGITAL NETWORKS WHICH ARE BASED ON THE SYNCHRONOUS DIGITAL HIERARCHY (SDH)

(Helsinki, 1993)

1 Scope of the Recommendation

In a transmission network jitter and wander accumulate according to the jitter and wander generation and transfer characteristics of each equipment interconnected. These equipments may be different types of multiplexers/demultiplexers and line systems.

An excessive amount of jitter and wander can adversely affects both digital (generation of bit errors, uncontrolled slips) and analogue signals (unwanted phase modulation of the transmitted signal). It is therefore necessary to set limits to the presence of jitter and wander at the network interfaces, in order to guarantee a proper quality of the transmitted signals.

The scope of this Recommendation is to define the parameters and the relevant values that are able to control satisfactorily the amount of jitter and wander present at the SDH network interfaces.

SDH network interfaces, to which this Recommendation is applicable, are defined in terms of bit rates in the Recommendation G.707 and of frame structure in Recommendation G.708; their electrical characteristics are described in Recommendation G.703 and the optical characteristics in Recommendation G.957.

The jitter control philosophy is based on the need:

- to recommend a maximum network limit that should not be exceeded at any hierarchical interface;
- to recommend a consistent framework for the specification of individual digital equipments;
- to provide sufficient information and guidelines for organizations to measure and study jitter accumulation in any network configuration.

2 SDH line systems

Recommendation G.958 identifies two different types of regenerators, Type A and Type B, which can be used in SDH line systems. The different regenerator types exhibit different jitter characteristics.

Performance penalities due to excessive alignment jitter place restrictions on the use of both Type A and Type B equipment in the same SDH line system. In other words, the amplitude/frequency characteristics of the accumulated jitter can adversely affect transmission-performance. These limitations must be taken into account by carrier entities who are administering the particular SDH line system.

At network interfaces (e.g. those at international boundaries), STM-N signals must meet interface limits regardless of the individual carrier's equipment choice. lt is therefore desirable that the interface requirement is compatible with the type of jitter expected to appear on both Type A and Type B line systems. The following SDH interface specifications are recommended.

3 Network limits for the maximum output jitter and wander at any hierarchical interface

3.1 Network limits for jitter

At any SDH network interface, the following output jitter specifications must be met.

Timing jitter as measured over a 60-second interval with a band pass filter with a lower cut-off frequency f_1 and a minimum upper cut-off frequency f_4 shall not exceed B_1 Unit Intervals (Ul) peak-to-peak. Also, timing jitter as measured over a 60-second interval with a band pass filter with a lower cut-off frequency f_3 and a minimum upper cut-off frequency f_4 shall not exceed B_2 Unit Intervals (Ul) peak-to-peak. The roll off at lower cut-off frequency and upper cut-off frequency shall be 20 dB/decade.

The arrangements for measuring output jitter at a digital interface are illustrated in Figure 1. The specific jitter limits and values of filter cut-off frequencies are given in Table 1.

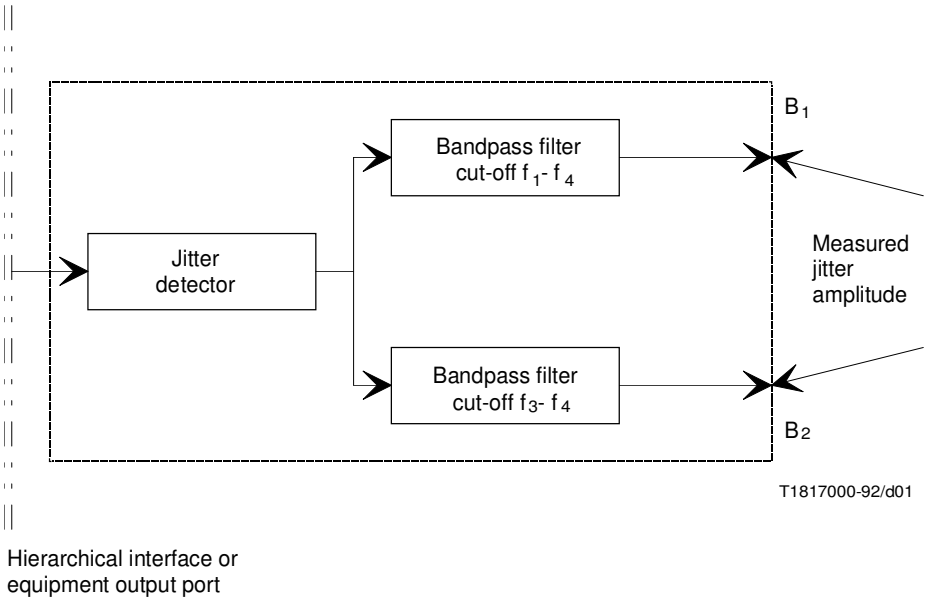

FIGURE 1/G.825

Measurement arrangements for output jitter from a hierarchical interface or an equipment output port

TABLE 1/G.825

SDH network interface output jitter specification parameters

STM level	f_1 (Hz)	f_3 (kHz)	f_4 (MHz)	B_1 (UI_{pp})	B_2 (UI_{pp})
STM-1	500	65	1.3	1.5	0.15
STM-4	1000	250	5	1.5	0.15
STM-16	5000	Under study (Note 2)	20	1.5	0.15

NOTES

1 UI_{pp} = Unit interval

for STM-1, UI = 6.43 ns.
for STM-4, UI = 1.61 ns.
for STM-16, UI = 0.40 ns.

2 A value of 1 MHz has been suggested.

Guidelines for the derivation of the parameters values of Table 1 are given in Annex A.

3.2 Network limits for wander

This issue is for further study.

4 The specification of individual digital equipment

To help ensure that the interconnection of digital equipment does not result in accumulated jitter that exceeds network limits, the jitter transfer and jitter generation characteristics of individual equipments are defined. Also to help ensure equipment can operate properly, given the specified network limits, jitter tolerance characteristics are defined.

4.1 Jitter and wander tolerance of input ports

Requirements on the jitter and wander tolerance of input ports are determined by their amount at the interfaces as described in 3.1.1/G.823 and in 3.1.1/G.824. The SDH equipment port shall tolerate, as a minimum, the input jitter and wander applied according to the mask in Figure 2 with the parameter values specified in Table 2. In the case the SDH port is of Type B, the consideration in 5, item 4) apply.

4.2 Jitter and wander generation

Specifications for jitter and wander generation of SDH regenerators are given in Recommendation G.958 and for SDH multiplexers and cross connect in Recommendation G.783.

4.3 Jitter and wander transfer function

The transfer function for regenerators are given in Recommendation G.958.

This function for SDH muldexes is dependent on the synchronization method used in each equipment. Guidelines and specifications are given in Recommendation G.783.

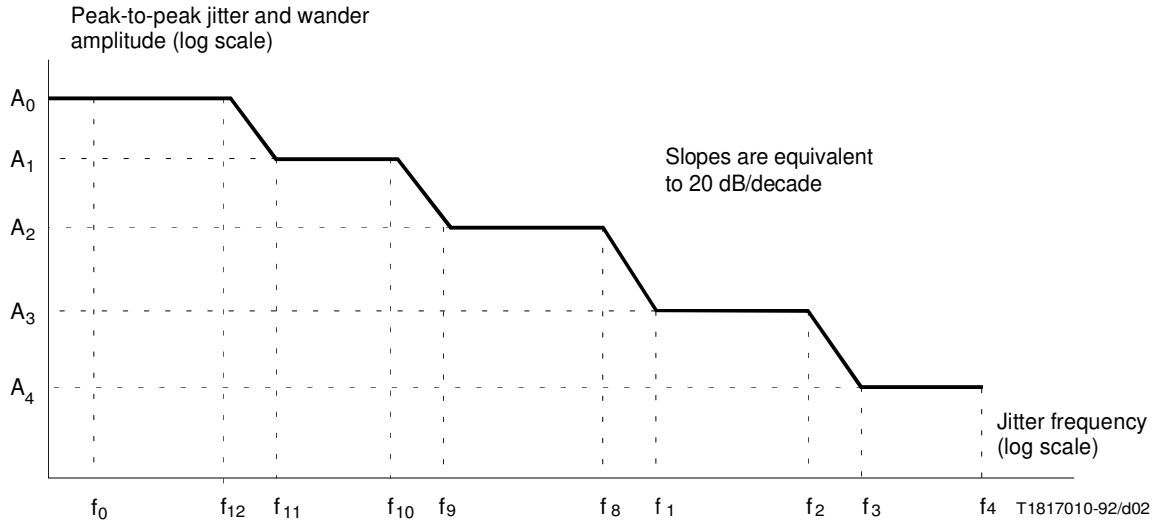

FIGURE 2/G.825

Lower limit of maximum tolerable input jitter and wander

TABLE 2/G.825

Parameter values for jitter and wander tolerance

STM level	Peak-to-peak amplitude (Unit interval))					Frequency (Hz)									
	A_0 (18 µs)	A_1 (2 µs)	A_2 (0.25 µs)	A_3	A_4	f_0	f_{12}	f_{11}	f_{10}	f_9	f_8	f_1	f_2	f_3	f_4
STM-1	2 800	311	39	1.5	0.15	12 µ	178 µ	1.6 m	15.6 m	0.125	19.3	500	6.5 k	65 k	1.3 m
STM-4	11 200	1244	156	1.5	0.15	12 µ	178 µ	1.6 m	15.6 m	0.125	9.65	1000	25 k	250 k	5 m
STM-16	44 790	4977	622	1.5	0.15	12 µ	178 µ	1.6 m	15.6 m	0.125	12.1	5000	Under study (Note 1)		20 m

NOTES

1 A value of 1 MHz has been suggested for f_3 fequency; the value of f_2 can be derived from f_3.

2 Values shown are provisional.

It must be noted that this specification depends also on the equipment timing source, and a Recommendation to provide this information is under study.

it must be further noted that in some cases the equipment may be timed by an external 2 Mbit/s or 2 MHz signal, for which the relevant Recommendations apply.

5 Interworking implications

Taking into account the characteristics of the Type A and Type B regenerators and the above interface specifications, the following equipment interworking implications can be derived:

1) the magnitude of jitter expected to accumulate on all SDH line systems employing only Type A equipment falls-within the bounds specified in Table 1;

2) the magnitude of jitter expected to accumulate on all SDH line systems employing only Type B equipment falls within the bounds specified in Table 1;

3) an equipment exhibiting Type A jitter tolerance characteristics will tolerate that jitter which meets the limits given in Table 1;

4) an equipment exhibiting Type B jitter tolerance characteristics will tolerate the jitter expected to accumulate on Type B SDH line systems. Such equipment, however, may require some jitter reduction for input signals that just approach the limits given in Table 2. This is expected to be the case when Type B equipment follows a chain of Type A regenerators. This represents the only interworking consideration required by the SDH Interface specifications proposed in this Recommendation.

6 Jitter and wander measurement methods

For further study.

7 Jitter and wander accumulation in SDH networks

Beside the accumulation mechanisms present in the plesiochronous systems, in

SDH networks other factors contribute to this phenomenon. Among them the equipment clock characteristics, the network synchronization strategy, the equipment synchronization method. This matter requires further study.

Annex A

(to Recommendation G. 825)

Derivation of the parameter values of Table 1

(This Annex forms an integral part of this Recommendation)

The value of f_1 reflects the narrowest timing circuit cutoff frequency expected in a line system. The timing circuit may time a regenerator's output signal and could be implemented as a Phase-Locked Loop (PLL). Jitter at frequencies higher than the bandwidth of this PLL will be partially absorbed by the PLL's buffer. The portion not absorbed could cause transmission errors due to buffer spill. Jitter at frequencies lower than this bandwidth will simply pass through without affecting transmission performance. The value of f_1 therefore represents the narrowest bandwidth that might be used in this output timing circuit. The value of f_3 is related to the bandwidth of input timing acquisition circuitry. Jitter at frequencies higher than this bandwidth will constitute alignment jitter and will cause an optical power penalty due to its effect on the eye pattern. This high frequency jitter must therefore be limited to the same degree that equipment specifications limit optical power penalty through jitter tolerance.

The value of f_4 reflects reasonable measurement limitations and is listed to establish minimum measurement bandwidth requirements. f_4 is chosen to include all expected, significant alignment jitter. A value one decade beyond the widest expected cutoff frequency (see Type A jitter transfer, Recommendation G.958) was chosen.

The values of B_1 and B_2 are directly related to input sinusoidal jitter tolerance. These parameters have built-in margin and are reasonably conservative because:

1) Sinusoidal jitter represents worst case jitter with respect to input jitter tolerance; and

2) Accumulated SDH line jitter will not be sinusoidal (instead, it will be noisy).