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SERIES O: SPECIFICATIONS OF MEASURING EQUIPMENT

Equipment for the measurement of digital and
analogue/digital parameters

Timing jitter and wander measuring equipment for digital systems which are based on the plesiochronous digital hierarchy (PDH)

ITU-T Recommendation O.171

(Previously CCITT Recommendation)

ITU-T O-SERIES RECOMMENDATIONS
SPECIFICATIONS OF MEASURING EQUIPMENT

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ITU-T RECOMMENDATION O.171**TIMING JITTER AND WANDER MEASURING EQUIPMENT FOR DIGITAL SYSTEMS
WHICH ARE BASED ON THE PLESIOCHRONOUS DIGITAL HIERARCHY (PDH)****Summary**

The requirements for the characteristics of the jitter and wander measuring equipment which are described below must be adhered to in order to ensure compatibility between equipment produced by different manufacturers.

While requirements are given for the equipment, the realization of the equipment configuration is not covered and should be given careful consideration by the designer and user. In particular, it is not required that all features listed below shall be provided in one piece of equipment. Users may select those functions which correspond best to their applications.

Source

ITU-T Recommendation O.171 was revised by ITU-T Study Group 4 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 19th of April 1997.

Keywords

Jitter generation, jitter measurements, jitter transfer function, output jitter, tolerable input jitter, wander generation, wander measurements.

FOREWORD

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NOTE

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Recommendation O.171

TIMING JITTER AND WANDER MEASURING EQUIPMENT FOR DIGITAL SYSTEMS WHICH ARE BASED ON THE PLESIOCHRONOUS DIGITAL HIERARCHY (PDH)

(Geneva, 1980; amended Malaga-Torremolinos, 1984; Melbourne, 1988; revised in 1997)

1 Scope

The instrumentation specified in this Recommendation will be used to measure timing jitter and wander on digital systems based on the Plesiochronous Digital Hierarchy (PDH). The instrumentation consists of a jitter measuring circuit and a test signal source. Measurements can be performed at the physical layer of PDH systems. An error-ratio meter may also be required for certain types of measurements.

Instrumentation for the measurement of jitter and wander on digital systems based on the Synchronous Digital Hierarchy (SDH) is specified in a separate O-Series Recommendation.

It is recommended that Recommendations G.823 [7] and G.824 [8] be read in conjunction with this Recommendation.

2 References

2.1 Normative references

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. All Recommendations are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- [1] ITU-T Recommendation G.701 (1993), *Vocabulary of digital transmission and multiplexing, and Pulse Code Modulation (PCM) terms.*
- [2] CCITT Recommendation G.703 (1991), *Physical/electrical characteristics of hierarchical digital interfaces.*
- [3] ITU-T Recommendation G.772 (1993), *Protected monitoring points provided on digital transmission systems.*
- [4] ITU-T Recommendation G.810 (1996), *Definitions and terminology for synchronization networks.*
- [5] CCITT Recommendation G.811 (1988), *Timing requirements at the outputs of primary reference clocks suitable for plesiochronous operation of international digital links.*
- [6] CCITT Recommendation G.812 (1988), *Timing requirements at the outputs of slave clocks suitable for plesiochronous operation of international digital links.*
- [7] ITU-T Recommendation G.823 (1993), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy.*
- [8] ITU-T Recommendation G.824 (1993), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy.*

- [9] CCITT Recommendation O.3 (1992), *Climatic conditions and relevant tests for measuring equipment*.
- [10] ITU-T Recommendation O.150 (1996), *General requirements for instrumentation for performance measurements on digital transmission equipment*.

2.2 Bibliographical references

- [11] ANSI Standard T1.102-1993, *Digital hierarchy – Electrical interfaces*.
- [12] HUCKETT (P.): Performance Evaluation in an ISDN – Digital Transmission Impairments, *Radio and Electronic Engineer*, Vol. 54, No. 2, February 1984.
- [13] TRISCHITTA (P.R.): Jitter Accumulation in Fibre Optic Systems, *Rutgers*, The State University of New Jersey, May 1986.
- [14] TRISCHITTA (P.R.), SANUTTI (P.): The Jitter Tolerance of Fibre Optic Regenerators, *IEEE Transactions on Communications*, Vol. 35, No. 12, December 1987.

3 Definitions

This Recommendation defines the following terms (see Recommendation G.810 [4]):

3.1 (timing) jitter: The short-term variations of the significant instances of a digital signal from their ideal positions in time (where short-term implies these variations are of frequency greater than or equal to 10 Hz).

3.2 wander: The long-term variations of the significant instances of a digital signal from their ideal position in time (where long-term implies that these variations are of frequency less than 10 Hz).

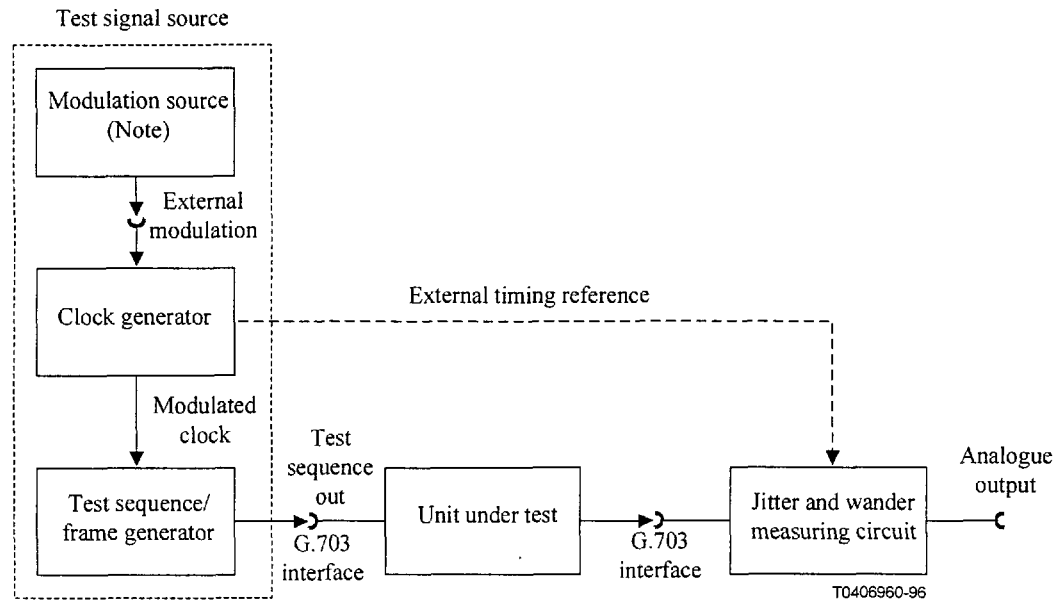
4 Abbreviations

This Recommendation uses the following abbreviations.

AMI	Alternate Mark Inversion
MTIE	Maximum Time Interval Error
NRZ	Non Return to Zero
PDH	Plesiochronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy
TDEV	Time Deviation
TIE	Time Interval Error
UI	Unit Interval

5 Block diagram

Figure 1 shows the block diagram of the instrumentation in general form. The figure does not describe a specific implementation.



NOTE – The modulation source, to test to relevant G-Series Recommendations, may be provided within the clock generator and/or test sequence generator, or it may be provided separately.

Figure 1/O.171 – Simplified block diagram for measuring timing jitter and wander

6 Interfaces

6.1 Electrical interfaces

The instrumentation shall be capable of operating at one or more of the following bit rates and corresponding interface characteristics as described in the appropriate clauses of Recommendation G.703 [2]. However, for all bit rates the signal applied to the input of the jitter measuring circuit should be a nominal rectangular pulse. Other signal shapes may produce inter-symbol interference – which cannot be corrected by simple line equalization – thus affecting measurement accuracy.

- | | |
|----------------------------|--------------------|
| a) 64 kbit/s; ¹ | f) 32 064 kbit/s; |
| b) 1 544 kbit/s; | g) 44 736 kbit/s; |
| c) 6 312 kbit/s; | h) 34 368 kbit/s; |
| d) 2 048 kbit/s; | i) 139 264 kbit/s. |
| e) 8 448 kbit/s; | |

As an option, the jitter measuring circuit shall be capable of measuring jitter at a clock output port when such an access is provided on digital equipment.

¹ References to 64 kbit/s relate to the co-directional interface.

6.2 Interface impedances

The jitter measuring circuit and signal source shall have a return loss as specified in Table 1² under the conditions listed in the Table.

Table 1/O.171 – Return loss test conditions

Bit rate (kbit/s)	Return loss (dB)	Test conditions	
64	≥ 12 ≥ 18 ≥ 14	120 Ω, non-reactive	3 kHz to 6.4 kHz 6.4 to 128 kHz 128 to 192 kHz
1 544	≥ 20	100 Ω, non-reactive	20 kHz to 1.6 MHz
2 048	≥ 12 ≥ 18 ≥ 14	75/120/130 Ω, non-reactive	51 to 102 kHz 102 to 2 048 kHz 2 048 to 3 072 kHz
6 312	≥ 20	75/110 Ω, non-reactive	100 kHz to 6.5 MHz
8 448	≥ 12 ≥ 18 ≥ 14	75 Ω, non-reactive	211 to 422 kHz 422 to 8 448 kHz 8 448 to 12 672 kHz
32 064	≥ 20	75 Ω, non-reactive	500 kHz to 40 MHz
34 368	≥ 12 ≥ 18 ≥ 14	75 Ω, non-reactive	860 to 172 040 kHz 1 720 to 34 368 kHz 34 368 to 51 550 kHz
44 736	≥ 20	75 Ω, non-reactive	500 kHz to 50 MHz
139 264	≥ 15	75 Ω, non-reactive	7 MHz to 210 MHz

7 Test signal source

Tests of digital equipment may be made with either a jittered or a non-jittered digital signal. This will require the test sequence generator, frame generator, clock generator and modulation source shown in Figure 1.

7.1 Modulation source

The modulation source, required to perform tests in conformance with relevant Recommendations, may be provided within the clock generator and/or test sequence generator or it may be provided separately. In this Recommendation it is assumed that the modulation source is sinusoidal. However, random stimuli may be required for certain tests. Details need to be studied.

7.2 Clock generator

It shall be possible to phase modulate the clock generator from the modulation source and to indicate the peak-to-peak phase deviation of the modulated signal.

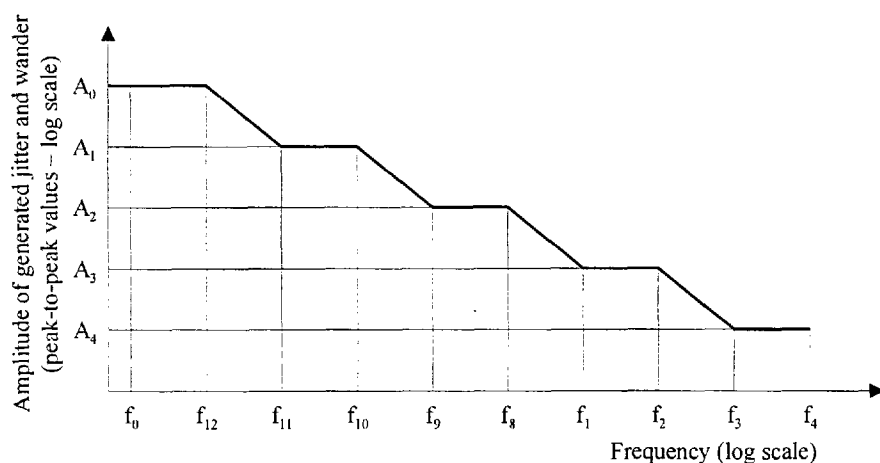
The generated peak-to-peak jitter and the modulating frequencies shall meet the minimum requirements of Figure 2 and Table 2.

² In the case of 1544 kbit/s, the test signal source shall have the following return loss: 20 kHz to 500 kHz ≥ 14 dB and 500 kHz to 1.6 MHz ≥ 16 dB.

The modulating input sensitivity of the clock generator shall be at least:

1 volt peak-to-peak into 75 Ω for bit rates up to and including 139 264 kbit/s.

The minimum output of the modulated clock signal and the external timing reference signal shall be 1 volt peak-to-peak into 75 Ω .



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Figure 2/O.171 – Generated jitter amplitude versus jitter frequency

Table 2/O.171 – Minimum amplitude of adjustable generated jitter amplitude versus jitter frequency

Bit rate (kbit/s)	A ₀	A ₁	A ₂	A ₃	A ₄	f ₀	f ₁₂	f ₁₁	f ₁₀	f ₉	f ₈	f ₁	f ₂	f ₃	f ₄
	in UI					in Hz									
64			a)	5	0.5				a)	a)	a)	2	600	6 k	20 k
1 544				10	0.5							2	400	8 k	40 k
2 048	40		20	10	0.5	12 μ					5	10	900	18 k	100 k
6 312				10	0.5							2	1 600	32 k	60 k
8 448	200		20	10	0.5	12 μ			a)	a)	10	20	400	8.5 k	400 k
32 064				10	0.5							2	1 600	32 k	400 k
34 368	1 000		20	10	0.5	a)			a)	a)	50	100	1 000	20 k	800 k
44 736				10	0.5							2	5 000	100 k	400 k
139 264	3 000		20	10	0.5	a)			a)	a)	50	100	500	10 k	3 500 k

a) Values under study in Recommendation G.823.

NOTE to Figure 2 and Table 2 – Jitter amplitudes are specified as peak-to-peak values in Unit Intervals (UI). Values are based on Table 2/G.823 and Figure 3/G.823 for the 2048 kbit/s hierarchy and on Table 2/G.824 and Figure 3/G.824 for the 1544 kbit/s hierarchy.