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**SERIES O: SPECIFICATIONS OF MEASURING
EQUIPMENT**

Equipment for the measurement of digital and
analogue/digital parameters

**Jitter and wander measuring equipment
for digital systems which are based on
the synchronous digital hierarchy (SDH)**

ITU-T Recommendation O.172



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SPECIFICATIONS OF MEASURING EQUIPMENT

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ITU-T Recommendation O.172

Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)

Summary

This Recommendation specifies instrumentation that is used to generate and measure jitter and wander in digital systems based on the SDH. Measurement requirements for both SDH line interfaces and SDH tributary interfaces operating at PDH bit rates are addressed in this Recommendation.

The requirements for the characteristics of the jitter and wander measuring equipment that are specified in this Recommendation must be adhered to in order to ensure consistency of results between equipment produced by different manufacturers.

Source

ITU-T Recommendation O.172 was approved on 13 April 2005 by ITU-T Study Group 4 (2005-2008) under the ITU-T Recommendation A.8 procedure.

Keywords

Input jitter tolerance, Input wander tolerance, Jitter generation, Jitter measurement, Jitter transfer function, Output jitter, Output wander, Phase transients, Pointer jitter, Pointer sequence generation, Wander generation, Wander measurement, Wander noise transfer.

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Introduction

The timing and synchronization performance of SDH networks and SDH network equipment elements is specified in a number of ITU-T Recommendations, using jitter and wander parameters. This Recommendation specifies the various characteristics of jitter/wander measuring equipment, which are needed in order to support the requirements of these ITU-T Recommendations and to perform other test and measuring tasks.

This Recommendation has been developed to ensure maximum compatibility with the relevant SDH network and equipment measurement requirements, whilst maintaining backwards compatibility with the associated PDH test equipment requirements of ITU-T Rec. O.171 [18] where possible.

ITU-T Rec. O.172 (04/2005)

ITU-T Recommendation O.172

Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)

1 Scope

This Recommendation specifies test instrumentation that is used to generate and measure timing jitter and synchronization wander in digital systems based on the Synchronous Digital Hierarchy (SDH).

This Recommendation also specifies requirements for the measurement of SDH tributaries operating at PDH bit rates.

The test instrumentation consists principally of a jitter/wander measurement function and a jitter/wander generation function. Measurements can be performed at the physical layer of SDH systems. A bit-error rate test set may also be required for certain types of measurements; this may be part of the same instrumentation or it may be physically separate.

Test instrumentation for the generation and measurement of jitter and wander in digital systems based on the Plesiochronous Digital Hierarchy (PDH) is specified in ITU-T Rec. O.171 [18].

It is recommended that ITU-T Recs G.783 [6], G.812 [9], G.813 [10], G.825 [13] and G.798 [15] 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. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [1] ITU-T Recommendation G.691 (2003), *Optical interfaces for single channel STM-64 and other SDH systems with optical amplifiers*.
- [2] ITU-T Recommendation G.693 (2005), *Optical interfaces for intra-office systems*.
- [3] ITU-T Recommendation G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [4] ITU-T Recommendation G.707/Y.1322 (2003), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [5] ITU-T Recommendation G.772 (1993), *Protected monitoring points provided on digital transmission systems*.
- [6] ITU-T Recommendation G.783 (2004), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.
- [7] ITU-T Recommendation G.810 (1996), *Definitions and terminology for synchronization networks*.
- [8] ITU-T Recommendation G.811 (1997), *Timing characteristics of primary reference clocks*.

- [9] ITU-T Recommendation G.812 (2004), *Timing requirements of slave clocks suitable for use as node clocks in synchronization networks*.
- [10] ITU-T Recommendation G.813 (2003), *Timing characteristics of SDH equipment slave clocks (SEC)*.
- [11] ITU-T Recommendation G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.
- [12] ITU-T Recommendation G.824 (2000), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*.
- [13] ITU-T Recommendation G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*.
- [14] ITU-T Recommendation G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.
- [15] ITU-T Recommendation G.798 (2004), *Characteristics of optical transport network hierarchy equipment functional blocks*.
- [16] ITU-T Recommendation O.3 (1992), *Climatic conditions and relevant tests for measuring equipment*.
- [17] ITU-T Recommendation O.150 (1996), *General requirements for instrumentation for performance measurements on digital transmission equipment*.
- [18] ITU-T Recommendation O.171 (1997), *Timing jitter and wander measuring equipment for digital systems which are based on the plesiochronous digital hierarchy (PDH)*.
- [19] ITU-T Recommendation O.181 (2002), *Equipment to assess error performance on STM-N interfaces*.
- [20] ITU-R Recommendation F.750-4 (2000), *Architectures and functional aspects of radio-relay systems for synchronous digital hierarchy (SDH)-based networks*.

2.2 Informative references

- [21] ANSI T1.105.03-2003, *Synchronous Optical Network (SONET) – Jitter and Wander at Network and Equipment Interfaces**.
- [22] ANSI T1.105.06-2002, *Synchronous Optical Network (SONET): Physical Layer Specifications.**

3 Definitions

For the purposes of this Recommendation, the following definitions apply (refer to ITU-T Rec. G.810 [7]):

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 that 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).

3.3 time interval error (function): The difference between the measure of a time interval as provided by a clock and the measure of that same time interval as provided by a reference clock.

* T1 standards are maintained since November 2003 by ATIS.

It may be useful to note that ITU-T Rec. G.810 [7] provides additional definitions and abbreviations used in timing and synchronization Recommendations. It also provides background information on the need to limit phase variation and the impairments on digital systems.

4 Abbreviations

This Recommendation uses the following abbreviations:

AU-n	Administrative Unit, level n
CMI	Coded Mark Inversion
MTIE	Maximum Time Interval Error
NRZ	Non Return to Zero
PDH	Plesiochronous Digital Hierarchy
PJE	Pointer Justification Event
PLL	Phase-Locked Loop
ppm	parts per million
PRBS	Pseudo Random Binary Sequence
RMS	Root-Mean-Square
SDH	Synchronous Digital Hierarchy
STM-N	Synchronous Transport Module, level N
TDEV	Time Deviation
TIE	Time Interval Error
TSS	Test Signal Structure
TU-m	Tributary Unit, level m
UI	Unit Interval
UIpp	Unit Interval, peak-to-peak

5 Conventions

For the purposes of this Recommendation, the following conventions are adopted:

- a) Particular interface signals used are denoted either by their standardized signal formats, e.g., STM-1 or by their bit rate, e.g., 139 264 kbit/s. The default physical format of SDH interfaces is considered to be optical and the default physical format of PDH interfaces is considered to be electrical.
- b) Where the electrical form of an SDH interface is specifically used in this Recommendation, the interface is denoted by "e", e.g., STM-1e (refer also to clause 7).
- c) Particular interface signals used may be categorized either as SDH line interfaces, or as SDH tributary interfaces. In this Recommendation, SDH line interfaces refer to those which support STM-N signals, whilst SDH tributary interfaces refer to those which support signals operating at PDH bit rates.

6 Functional block diagram

Figure 1 shows the block diagram of the instrumentation in general form, identifying the main functions that are addressed in this Recommendation. The figure does not describe a specific implementation.

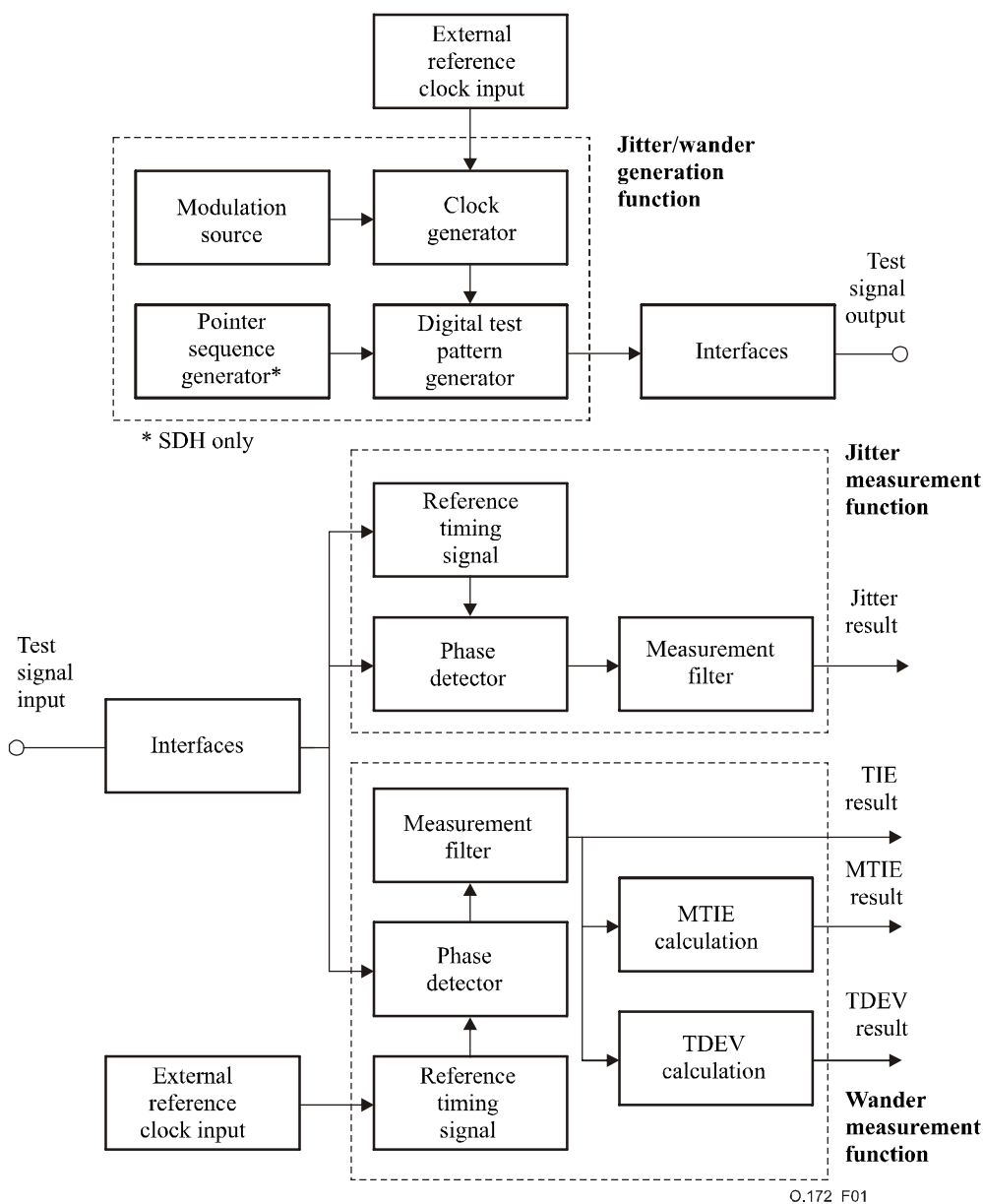


Figure 1/O.172 – Functional block diagram for jitter and wander test set

7 Interfaces

7.1 Optical interfaces

The instrumentation shall be capable of operating at one or more of the following bit rates and corresponding optical interface characteristics as defined in the appropriate clauses of ITU-T Recs G.957 [14] and G.691 [1] and also ANSI T1.105.06 [22] (for 51 840 kbit/s interfaces).

- STM-0 51 840 kbit/s
- STM-1 155 520 kbit/s
- STM-4 622 080 kbit/s

- STM-16 2 488 320 kbit/s
- STM-64 9 953 280 kbit/s
- STM-256 39 813 120 kbit/s

7.2 Electrical interfaces

The instrumentation shall be capable of operating at one or more of the following bit rates and corresponding electrical interface characteristics as defined in the appropriate clauses of ITU-T Rec. G.703 [3] and also ITU-R Rec. F.750-4 [20] (for 51 840 kbit/s electrical interfaces). However, for all bit rates the signal applied to the input of the jitter/wander measuring circuit shall 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.

- 1544 kbit/s
- 2048 kbit/s
- 6312 kbit/s
- 34 368 kbit/s
- 44 736 kbit/s
- 51 840 kbit/s, STM-0e
- 139 264 kbit/s
- 155 520 kbit/s, STM-1e

The jitter/wander measurement function input and jitter/wander generation function output ports shall have a return loss as specified in the appropriate clauses of ITU-T Rec. G.703 [3].

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

7.3 External reference clock input

The measuring equipment shall accept data signals at bit rates of 1544 kbit/s or 2048 kbit/s as a reference. If 2048 kbit/s can be accepted, the equipment shall also accept a clock signal at 2048 kHz as a reference. The characteristics of the clock signals shall be in accordance with ITU-T Rec. G.703 [3].

7.4 Input interface sensitivity

The jitter/wander measurement function is required to operate satisfactorily under the following input conditions:

- a) the specification for equipment optical interfaces defined in ITU-T Recs G.957 [14] and G.691 [1];
- b) the specification for equipment electrical interfaces defined in ITU-T Rec. G.703 [3];
- c) protected monitoring points as defined in ITU-T Rec. G.772 [5].

8 Jitter/wander generation function

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

8.1 Modulation source

The modulation source, required to perform tests in conformance with relevant Recommendations, may be provided within the clock generator and/or digital test pattern generator or it may be

provided separately. In this Recommendation, the modulation source is defined to be sinusoidal. However, other stimuli may be required for certain tests.

8.2 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/wander and the modulating frequencies shall meet the minimum requirements of Table 3 and Figure 3.

If the output interfaces for the modulated clock signal and/or the external timing reference signal are provided, the minimum amplitude shall be 1 Volt peak-to-peak into 75 Ω or 0.25 Volt peak-to-peak into 50 Ω .

8.2.1 Accuracy of the clock generator

The frequency deviation of the internal clock signal from its nominal value shall be less than ± 4.6 ppm.

As an option, the clock generator may provide adjustable frequency offset of sufficient magnitude to facilitate testing across the clock tolerance range of the equipment-under-test, e.g., ± 10 ppm to ± 100 ppm, as defined for the various bit rates in ITU-T Recs G.703 [3] and G.813 [10].

It shall be possible to phase-lock the generation function to an external reference clock source of arbitrary accuracy; refer also to 7.3.

8.3 Digital test pattern generator

The jitter/wander measurement function will normally be used in conjunction with any suitable digital test pattern generator providing the following facilities.

8.3.1 Digital test patterns

The digital test pattern generator shall be capable of providing one or more of the following signals, for use at STM-N bit rates:

- a) framed SDH signals in accordance with ITU-T Rec. G.707/Y.1322 [4];
- b) structured test signals in accordance with ITU-T Rec. O.181 [19], dependent on the type of network element to be tested;
- c) structured test signals defined in Annex A.

8.3.2 Digital test patterns for SDH tributary signals

The test sequence generator shall be capable of providing the following signals:

For use at bit rates of 2048 kbit/s, 6312 kbit/s and 44 736 kbit/s, a pseudo random test sequence of $2^{15} - 1$ length corresponding to 5.3/O.150 [17].

For use at bit rates of 1 544 kbit/s, 6 312 kbit/s and 44 736 kbit/s, a pseudo random test sequence of $2^{20} - 1$ bit length corresponding to 5.5/O.150 [17].

For use at bit rates of 34 368 kbit/s and 139 264 kbit/s, a pseudo random test sequence of $2^{23} - 1$ bit length corresponding to 5.6/O.150 [17].

For use at all bit rates, a 10001000 repetitive test sequence.

As an option and for use at all bit rates:

- a) two freely programmable 8-bit test sequences capable of being alternated at a low rate (e.g., from 10 Hz to 100 Hz);
- b) a freely programmable 16-bit test sequence.

8.4 Pointer sequence generator

In order to test the effect of pointer justification events (PJE) on SDH desynchronizer equipment, the digital test pattern generator shall be capable of generating complete test sequences of pointer justifications in accordance with the appropriate clauses of ITU-T Rec. G.783 [6].

As an option, the equipment may provide additional PJE control functions to facilitate further pointer jitter testing.

Appendix III provides further information regarding the test set configuration and capability for testing using pointer sequences.

8.4.1 Pointer test sequence generation capability

The equipment shall provide a minimum set of pointer test sequences applicable at particular SDH tributary bit rates, denoted by "X" in Table 1, in accordance with clause 10/G.783 [6].

For particular SDH tributary bit rates, the pointer adjustments shall be applied either to the AU-n or the TU-m pointers, as shown in Table 1. The direction or polarity of the pointer test sequence shall be selectable between incrementing or decrementing pointer values.

The test procedure specified in clause 15/G.783 [6] shall be followed.

Table 1/O.172 – G.783 pointer test sequence description

G.783 pointer test sequence		SDH tributary bit rate (kbit/s) and SDH container					
		1544	2048	6312	34 368	44 736	139 264
ID	Description	TU-11	TU-12	TU-2	TU-3	AU-3	AU-4
a	Single Alternating		X	(Note)	X		X
b	Regular + Double		X		X		X
c	Regular + Missing		X		X		X
d	Double Alternating				X		X
e	Single	X				X	
f	Burst					X	
g1	Periodic 87-3					X	X
g2	Periodic 87-3 with Add					X	X
g3	Periodic 87-3 with Cancel					X	X
h1	Periodic	X				X	
h2	Periodic with Add	X				X	
h3	Periodic with Cancel	X				X	
i	Phase Transient					X	
j1	Periodic 26-1	X					
j2	Periodic 26-1 with Add	X					
j3	Periodic 26-1 with Cancel	X					
NOTE – Pointer test sequences for 6312 kbit/s, TU-2 are for further study.							

The time intervals between PJE within a test sequence depend on the particular sequence and the bit rate of the SDH tributary under test. ITU-T Rec. G.783 [6] shall be consulted for precise detail of the pointer sequences applicable to a particular tributary bit rate. Table 2 specifies the time intervals that shall be provided between PJE for particular SDH tributary bit rates, and which are

illustrated in a generic fashion in Figure 2. Time intervals T1 and T2 may be adjustable to values greater than the minimum shown in Table 2.

Table 2/O.172 – Time intervals between G.783 pointer justification events

Time interval	SDH tributary bit rate (kbit/s)					
	1544	2048	6312	34 368	44 736	139 264
T1 (minimum)	30 s	10 s	(Note)	10 s	30 s	10 s
T2 (minimum)	1 s	750 ms	(Note)	(Note)	34 ms	(Note)
T3	2 ms	2 ms	(Note)	(Note)	0.5 ms	(Note)
NOTE – Value is for further study in ITU-T Rec. G.783 [6].						

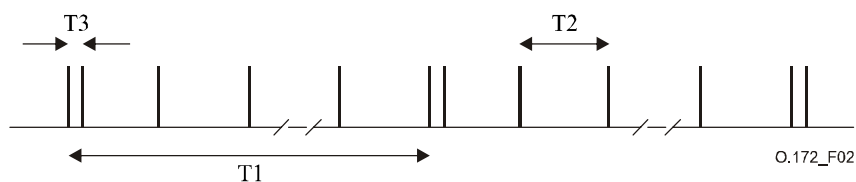


Figure 2/O.172 – Generic G.783 pointer sequence, illustrating the time intervals of Table 1

8.5 Minimum jitter/wander generation capability

The jitter/wander amplitude/frequency characteristic of the generation function shall meet the minimum requirements of Figure 3 and Table 3 for SDH line signals or Table 3a for SDH tributary signals.

Table 3/O.172 – Minimum amplitude of adjustable generated jitter/wander amplitude versus jitter/wander frequency for SDH line signals

Signal	Minimum peak-to-peak jitter/wander amplitude [UIpp]					Jitter/wander frequency breakpoints [Hz]									
	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
STM-0e, STM-0	*	*	20	2	0.2	*	*	*	*	10	30	300	2 k	20 k	400 k
STM-1e, STM-1	3600	400	50	2	0.2	12 μ	178 μ	1.6 m	15.6 m	125 m	19.3	500	6.5 k	65 k	1.3 M
STM-4	14400	1600	200	2	0.2	12 μ	178 μ	1.6 m	15.6 m	125 m	9.65	1 k	25 k	250 k	5 M
STM-16	57600	6400	800	2	0.2	12 μ	178 μ	1.6 m	15.6 m	125 m	12.1	5 k	100 k	1 M	20 M
STM-64	230400	25600	3200	2	0.2	12 μ	178 μ	1.6 m	15.6 m	125 m	12.1	20 k	400 k	4 M	80 M
STM-256	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS

NOTE 1 – Values denoted by "*" are not defined.

NOTE 2 – Values are based on the requirements of ITU-T Rec. G.825 [13].

NOTE 3 – Values for STM-0 are based on the requirements of ANSI T1.105.03 [21].

NOTE 4 – FFS denotes that the value is for further study.

Table 3a/O.172 – Minimum amplitude of adjustable generated jitter/wander amplitude versus jitter/wander frequency for SDH tributaries

Signal [kbit/s]	Minimum peak-to-peak jitter/wander amplitude [UIpp]					Jitter/wander frequency breakpoints [Hz]									
	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
1544	40	*	20	10	0.5	12 μ	50 m	*	*	100 m	5	10	400	8 k	40 k
2048	50	*	30	10	0.5	12 μ	12 m	*	*	20 m	3.3	10	900	18 k	100 k
6312	150	*	50	10	0.5	12 μ	3 m	*	*	10 m	0.4	2	1600	32 k	60 k
34 368	200	*	50	10	0.5	10 m	50 m	*	*	200 m	20	100	1 000	20 k	800 k
44 736	1000	*	100	10	0.5	12 μ	11 m	*	*	110 m	2.19	21.9	5000	100 k	400 k
139 264	800	*	200	10	0.5	10 m	33 m	*	*	130 m	5	100	500	10 k	3500 k

NOTE 1 – Values denoted by "*" are not defined.
NOTE 2 – These requirements are based on consideration of ITU-T Recs G.823 [11] and G.824 [12].

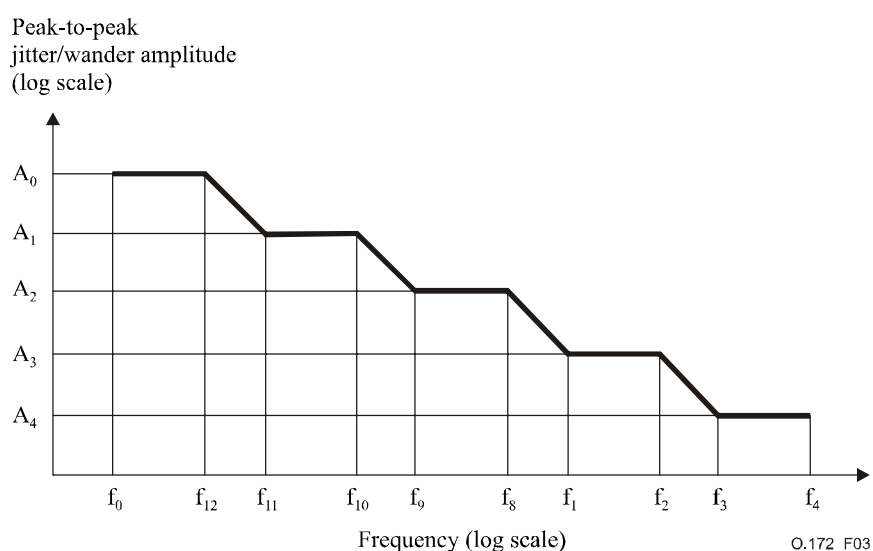


Figure 3/O.172 – Generated jitter/wander amplitude versus jitter/wander frequency

8.6 Generation accuracy

The test signal source shall be compatible with the jitter/wander measurement function in such a way that the overall measuring accuracy is not substantially deteriorated. The generation accuracy may be increased by measuring the jitter/wander applied to the unit under test using a corresponding jitter/wander measuring device.

The generating accuracy of the jitter/wander generation function is dependent upon several factors such as fixed intrinsic error, setting resolution, distortion and frequency response error. In addition, there is an error that is a function of the actual setting.

8.6.1 Phase amplitude error

The amplitude error of sinusoidal jitter/wander generation shall be less than:

$$Q\% \text{ of setting } \pm 0.02 \text{ UIpp}$$

where Q is a variable error specified in Table 4 for SDH line signals and in Table 4a for SDH tributary signals. The frequencies f_0 , f_1 , f_4 and f_9 used in Tables 4 and 4a are defined in Tables 3 and 3a.

NOTE – This Recommendation excludes any wideband intrinsic jitter/wander components.

8.6.2 Phase slope error

The band-limited peak-to-peak phase slope error in UI/s shall be less than:

$$\frac{(\pm 2.5 \cdot Q\% \text{ of setting } \pm 0.05 \text{ UIpp}) \cdot 2\pi f_m}{\sqrt{1 + (f_m / f_{3\text{dB}})^2}}$$

over the range:

$$10 \text{ Hz} \leq f_m \leq 2 \cdot f_3$$

where f_m is the modulation frequency, $f_{3\text{dB}} = 2 \cdot f_3 \pm 10\%$ is the bandwidth of the low-pass filter, f_3 is defined in Table 3 for SDH line signals and in Table 3a for SDH tributary signals, and Q is a variable error specified in Table 4 for SDH line signals and in Table 4a for SDH tributary signals. The frequencies f_0 , f_1 , f_4 and f_9 used in Tables 4 and 4a are defined in Tables 3 and 3a.

See Annex B for the definition of band-limited peak-to-peak phase slope error.

NOTE – This Recommendation includes modulation harmonics (within the low-pass filter bandwidth) due to distortion, but it excludes any wideband intrinsic jitter/wander components.

Table 4/O.172 – Variable error (Q) of SDH line jitter/wander generation

Signal	Error, Q	Frequency range
STM-0e, STM-0	FFS	f_9 to f_1
	$\pm 8\%$	f_1 to f_4
STM-1e, STM-1	FFS	f_0 to f_1
	$\pm 8\%$	f_1 to 500 kHz
	$\pm 12\%$	500 kHz to f_4
STM-4, STM-16, STM-64	FFS	f_0 to f_1
	$\pm 8\%$	f_1 to 500 kHz
	$\pm 12\%$	500 kHz to 2 MHz
	$\pm 15\%$	2 MHz to f_4
STM-256	FFS	FFS
NOTE – FFS denotes that the value is for further study.		

Table 4a/O.172 – Variable error (Q) of SDH tributary jitter/wander generation

Signal	Error, Q	Frequency range
1544, 2048, 6312, 44 736	$\pm 8\%$	f_1 to f_4
34 368	$\pm 8\%$	f_1 to 500 kHz
	$\pm 12\%$	500 kHz to f_4
139 264	$\pm 8\%$	f_1 to 500 kHz
	$\pm 12\%$	500 kHz to 2 MHz
	$\pm 15\%$	2 MHz to f_4

8.6.3 Intrinsic jitter/wander of generation function

The intrinsic jitter of the jitter/wander generation function measured in a bandwidth f_1 - f_4 as defined in Table 7 with the amplitude set to zero shall be less than:

0.04 UIpp for an output signal with structure defined in Annex A; or

0.02 UIpp for a clock signal.

The specification for maximum allowable intrinsic wander is for further study.

9 Jitter measurement function

9.1 Reference timing signal

A reference timing signal for the phase detector is required. For end-to-end measurements of jitter, it may be derived in the jitter measurement function from the input digital test pattern. For looped measurements, it may be derived from a suitable clock source.

9.2 Measurement capabilities

9.2.1 Measurement range

The jitter measurement function shall be capable of measuring peak-to-peak jitter. The measurement ranges to be provided are optional but for reasons of compatibility the jitter amplitude/jitter frequency characteristic of the jitter measurement function shall meet the minimum requirements of Figure 4 and Table 5 for SDH line signals or Table 5a for SDH tributary signals. The frequencies f_6 to f_4 define the range of jitter frequencies to be measured; capability to measure the range of frequencies lower than f_1 is optional.

NOTE – Operation of the jitter measurement function over one continuous frequency range f_6 to f_4 is optional.

Table 5/O.172 – Minimum amplitude of measured jitter versus jitter frequency

Signal	Minimum peak-to-peak jitter amplitude [UIpp]			Jitter frequency breakpoints [Hz]					
	A_2	A_3	A_4	f_6	f_7	f_1	f_2	f_3	f_4
STM-0e, STM-0	20	2	0.2	10	30	300	2 k	20 k	400 k
STM-1e	50	2	0.1	10	19.3	500	3.25 k	65 k	1.3 M
STM-1	50	2	0.2	10	19.3	500	6.5 k	65 k	1.3 M
STM-4	200	2	0.2	*	10	1 k	25 k	250 k	5 M
STM-16	800	2	0.2	10	12.1	5 k	100 k	1 M	20 M
STM-64	3200	2	0.2	10	12.1	20 k	400 k	4 M	80 M
STM-256	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
NOTE 1 – Values denoted by "*" are not defined.									
NOTE 2 – The accuracy of the instrument is specified between frequencies f_1 and f_4 .									
NOTE 3 – Values for STM-0 are based on the requirements of ANSI T1.105.03 [21].									