International Telecommunication Union

ITU-T

TELECOMMUNICATION
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OF ITU

O.174

Amendment 1

(04/2011)

SERIES O: SPECIFICATIONS OF MEASURING EQUIPMENT

Equipment for the measurement of digital and analogue/digital parameters

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Jitter and wander measuring equipment for digital systems which are based on synchronous Ethernet technology

Amendment 1

Recommendation ITU-T O.174 (2009) – Amendment 1

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Recommendation ITU-T O.174

Jitter and wander measuring equipment for digital systems which are based on synchronous Ethernet technology

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Summary

Amendment 1 to Recommendation ITU-T O.174 (2009) contains several modifications and additional discussion of jitter measuring equipment specified in Recommendation ITU-T O.174 to take into account the changes made in revised Recommendation ITU-T G.8262/Y.1362 (2010) and in Recommendation ITU-T G.8261/Y.1361 (2008) Amendment 1.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T O.174	2009-11-13	15
1.1	ITU-T O.174 (2009) Cor. 1	2010-07-29	15
1.2	ITU-T O.174 (2009) Amend. 1	2011-04-13	15

FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Recommendation ITU-T O.174

Jitter and wander measuring equipment for digital systems which are based on synchronous Ethernet technology

Amendment 1

1) Clause 8.4.1, Minimum sinusoidal jitter/wander generation capability

Replace the content of clause 8.4.1 with the following:

The jitter/wander amplitude/frequency characteristics of the generation function shall meet the minimum requirements of Figure 2 for EEC signals.

Table 1 – Minimum amplitude of adjustable generated sinusoidal jitter/wander amplitude versus jitter/wander frequency for EEC signals

EEC signal	Minimum peak-to-peak jitter/wander amplitude [UIpp] (Note 6)				Jitter/wander frequency breakpoints [Hz]							
	A_0	A_1	A_2	A_3	f_0	f_{12}	f_{11}	f_{10}	f_9	f_8	f_1	f_2
1G (Notes 2, 3, 5)	23040	2560	320	2	12 µ	178 µ	1.6 m	15.6 m	125 m	12.1	2.5 k	50 k
10G (Notes 2, 4, 5)	230400	25600	3200	2	12 µ	178 µ	1.6 m	15.6 m	125 m	12.1	20 k	40 k

NOTE 1 – Values based on requirements of Table 11 and Table12 for option 1 of [ITU-TG.8262].

NOTE 2 – There is no specific high band jitter requirement for synchronous Ethernet. The relevant IEEE 802.3 jitter requirements shall be met in addition to the specific synchronous Ethernet wide band jitter requirements specified in this table.

NOTE 3 – 1G includes 1000BASE-KX, -SX, -LX; multilane interfaces are for further study.

NOTE 4 – 10G includes 10GBASE-SR/LR/ER, 10GBASE-LRM, 10GBASE-SW/LW/EW; multilane interfaces are for further study.

NOTE 5 – 1G 1 UI = 0.8 ns

10G (10GBASE-SR/LR/ER,-LRM) 1 UI = 96.97 ps

10G (10GBASE-SW/LW/EW) 1 UI = 100.47 ps

NOTE 6 – Wander generation function up to 10 Hz may provide selectable wander amplitude in seconds as option.

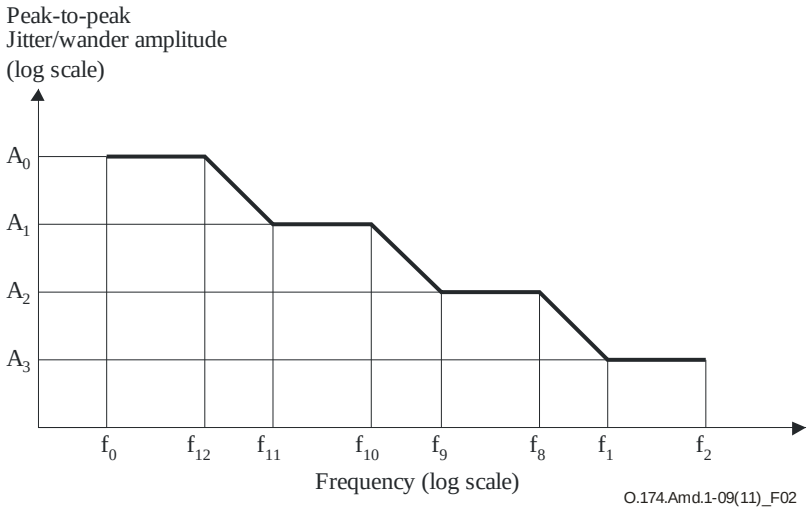

Figure 2 – Generated jitter/wander amplitude versus jitter/wander frequency

2) Clause 8.4.2.1, Phase amplitude error

Replace the content of clause 8.4.2.1 with the following:

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

Q% of setting ±0.02 UIpp

Where *Q* is a variable error specified in Table 2 for EEC signals. The frequencies f_0 and f_1 used in Table 2 are defined in Figure 2.

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

Table 2 – Variable error (*Q*) of EEC signal jitter/wander generation

EEC signal	Error, *Q*	Frequency range
1G, 10G	FFS	f_0 to f_1
	±8%	f_1 to 500 kHz

3) Clause 8.4.2.2, Intrinsic jitter/wander of generation

Replace the existing paragraph in clause 8.4.2.2 with the following:

The intrinsic jitter of the jitter generation function measured in the bandwidth f_1-f_2 for jitter as defined in Table 1 with the amplitude set to zero shall be less than:

0.04 UIpp Intrinsic jitter in the bandwidth f_1-f_2, for test signal defined in clause 8.3;

0.02 UIpp Intrinsic jitter in the bandwidth f_1-f_2 for a clock signal.

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

4) Clause 9, Jitter measurement function

Replace the content of clause 9 with the following:

The jitter measurement methodology for Ethernet interfaces is defined in [IEEE 802.3]. Ethernet assumes that there are essentially two jitter mechanisms: deterministic jitter, and random jitter. Separate requirements are specified for transmitters and receivers. The jitter measurement for synchronous Ethernet according to [ITU-T G.8261] and [ITU-T G.8262] is defined in this clause.

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; however, for reasons of compatibility, the jitter amplitude/jitter frequency characteristic of the jitter measurement function shall meet the minimum requirements of Figure 3 and Table 3 for EEC line 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 3 – Minimum amplitude of measured jitter versus jitter frequency

EEC 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
1G	320	2	0.2	10	12.1	2.5 k	50 k	500 k	10 M
10G	3200	2	0.2	10	12.1	20 k	400 k	4 M	80 M
NOTE – The accuracy of the instrument is specified between frequencies f_1 and f_4.									

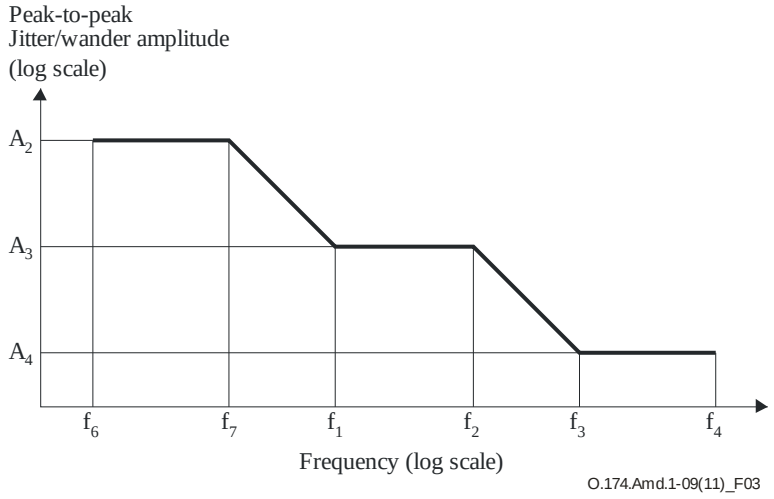

Figure 3 – Measured jitter amplitude versus jitter frequency

9.3 Measurement bandwidths

The measurement bandwidth shall be limited in order to measure the specified jitter spectra as defined in relevant Recommendations and for other uses. The bandwidth f_1-f_4 of the jitter measurement function shall be in accordance with Table 4 for EEC signals.

Table 4 – Jitter measurement function bandwidth for EEC signals

EEC signal	Jitter measurement bandwidth (–3 dB cut-off frequencies)	
	f_1 [Hz] high-pass	f_4 [Hz] low-pass
1G	2.5 k	10 M
10G	20 k	80 M

9.3.1 Frequency response of jitter measurement function for EEC signals

The response of all filters within the pass band shall be such that the accuracy requirements of the jitter measurement function are met (refer to clause 9.4).

For all EEC line bit rates, the following requirements apply to the jitter measurement function when the measurement filters at frequencies f_1 and f_4 are used:

a) The high-pass measurement filter with cut-off frequency f_1 has a first-order characteristic and a roll-off of 20 dB/decade.

b) The nominal f_1 cut-off frequency for each bit rate is specified in Table 4, and the nominal –3 dB point of the measurement filter shall be at a frequency $f_1 \pm 10\%$.

c) The low-pass measurement filter with cut-off frequency f_4 has a maximally-flat, Butterworth characteristic and a roll-off of –60 dB/decade.

d) The nominal f_4 cut-off frequency for each bit rate is specified in Table 4, and the –3 dB point of the measurement filter shall be at a frequency $f_4 \pm 10\%$.

e) The maximum attenuation of the measurement filters shall be at least 60 dB.

These jitter measurement functional requirements are compatible with [ITU-T G.8261] and [ITU-T G.8262].

9.4 Measurement accuracy

9.4.1 Measurement result accuracy

The measuring accuracy of the jitter measurement function is dependent upon several factors such as fixed intrinsic error, frequency response and digital test pattern-dependent error of the internal reference timing circuits. In addition, there is an error that is a function of the actual reading.

The accuracy of the jitter measurement shall not be affected by frequency offset on the input signal that is within the limits defined for the various bit rates in [ITU-T G.8261] and [ITU-T G.8262].

The measurement accuracy is specified using an input signal with structure defined in clause 8.3 for EEC signals and physical characteristics of either:

a) an electrical signal in conformance with [IEEE 802.3] having the nominal terminated signal level and with no additional frequency-dependent loss; or

b) an optical signal in conformance with [IEEE 802.3] and with a nominal power in the range –10 dBm to –12 dBm. Operation at higher input power levels may be permitted at 1G and 10G in accordance with the mean launch powers specified in [IEEE 802.3].

The total measurement error shall be less than:

$$\pm R\% \text{ of reading } \pm W$$

where R is the variable error specified in Table 6 and W is the fixed error of Table 5, which includes any contribution from the internal timing extraction function.

9.4.2 Fixed error of EEC jitter measurements

For the EEC bit rates and for the indicated digital signals, the fixed error of the jitter measurement function shall be as specified in Table 5 within the frequency ranges f_1-f_4 indicated. Frequencies f_1, and f_4 used in Table 5 are defined in Table 4.

Table 5 – Fixed error (W) of EEC jitter measurements

EEC signal	Maximum peak-to-peak jitter error [UIpp] for given digital signals	
	Structured signal	Clock signal
	f_1-f_4	f_1-f_4
1G	0.1	0.05
10G	0.1	0.05
NOTE 1 – Structured digital signals are defined in clause 8.3. NOTE 2 – Clock interfaces are optional.		

9.4.3 Variable error of EEC jitter measurements

The variable error R shall be as specified in Table 6 for EEC signals. Frequencies f_1 and f_4 used in Table 6 are defined in Table 4.

Table 6 – Variable error (R) of EEC jitter measurements

EEC Signal	Error, R	Frequency range
1G, 10G	±7%	f_1 to 300 kHz
	±8%	300 kHz to 1 MHz
	±10%	1 MHz to 3 MHz
	±15%	3 MHz to 10 MHz
	±20%	10 MHz to f_4

9.4.4 Digital test signal-dependent error

The accuracy requirements stated in previous subclauses shall be met when digital test signals defined in clause 8.3 are used to perform the jitter measurement. When using other structured signals, pseudorandom or random signals, larger measurement errors could be expected.

9.5 Additional facilities

9.5.1 Analogue output

The jitter measurement function may provide an analogue output signal to enable measurements to be made externally to the jitter measurement function, e.g., by using an oscilloscope or an RMS meter.

5) Clause 10.1.2, Calculation algorithm accuracy

Replace the content of clause 10.1.2 with the following:

In some cases, the MRTIE calculation algorithm can be separated functionally from the TIE measurement, when the following accuracy requirements apply to the stand-alone algorithm.

When provided with a given set of TIE measurement data, an algorithm used to calculate RTIE and MRTIE shall yield results within a certain error of the values calculated in accordance with the standard estimator formulae given in clauses II.2.2.2 of [ITU-T G.823] and II.5 of [ITU-T G.810].

The total MRTIE calculation error shall be less than:

$\pm 2\%$ of MRTIE value $\pm Z_1(\tau)$

where $Z_1(\tau)$ is specified in Table 7 and τ is the observation interval.

Table 7 – Fixed error (Z_1) of MRTIE calculation algorithm

$Z_1(\tau)$ (ns)	Observation interval, τ (s)
$0.5 + 0.0055\ \tau$	$0.05 \leq \tau \leq 1000$
NOTE – These requirements are based on [ITU-T G.823] and [ITU-T G.8261].	

6) Clause 10.1.3, Measurement result accuracy

Replace the content of clause 10.1.3 with the following:

The total measurement error (i.e., including error from TIE measurement and error from MRTIE calculation algorithm) shall be less than:

$\pm 7\%$ of MRTIE value $\pm Z_3(\tau)$

where $Z_3(\tau)$ is specified in Table 8 and τ is the observation interval.

Table 8 – Fixed error (Z_3) of MRTIE measurement result

$Z_3(\tau)$ (ns)	Observation interval, τ (s)
$3 + 0.033\ \tau$	$0.05 \leq \tau \leq 1000$
NOTE – These requirements are based on [ITU-T G.823] and [ITU-T G.8261].	

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