INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

O.172
Amendment 1
(03/2003)

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)

Amendment 1

ITU-T Recommendation O.172 (2001) – Amendment 1

ITU-T O-SERIES RECOMMENDATIONS

SPECIFICATIONS OF MEASURING EQUIPMENT

General	O.1–O.9
Maintenance access	O.10–O.19
Automatic and semi-automatic measuring systems	O.20–O.39
Equipment for the measurement of analogue parameters	O.40–O.129
Equipment for the measurement of digital and analogue/digital parameters	**O.130–O.199**

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation O.172

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

Amendment 1

Summary

This amendment includes changes to the fixed measurement error, adds a high-pass jitter measurement filter, specifies jitter transfer measurement accuracy, and revises the accuracy specification for TDEV wander noise generation.

Source

Amendment 1 to ITU-T Recommendation O.172 (2001) was prepared by ITU-T Study Group 4 (2001-2004) and approved under the WTSA Resolution 1 procedure on 29 March 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

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, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

ITU-T Recommendation O.172

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

Amendment 1

Introduction

This amendment contains extensions to the 2001 version of ITU-T Rec. O.172.

1) Table 7

Replace Table 7 with the following, which adds the high-pass filter f_{12}:

Table 7/O.172 – Jitter measurement function bandwidth for SDH line signals

Signal	Jitter measurement bandwidth (–3 dB cut-off frequencies)			
	f_1 (Hz) high-pass	f_{12} (Hz) high-pass	f_3 (Hz) high-pass	f_4 (Hz) low-pass
STM-0e, STM-0	100	–	20 k	400 k
STM-1e,	500	–	65 k	1.3 M
STM-1	500	12 k	65 k	1.3 M
STM-4	1 k	12 k	250 k	5 M
STM-16	5 k	12 k	1 M	20 M
STM-64	20 k	–	4 M	80 M
STM-256	80 k	–	16 M	320 M

NOTE 1 – Values for STM-0 are based on the requirements of ANSI T1.105.03 [20].

NOTE 2 – Values for STM-256 are to be considered provisional, since network requirements are not yet defined in ITU-T Rec. G.825 [12].

NOTE 3 – The f_{12} high-pass filter is optional.

2) Table 8

Replace Table 8 with the following, which reduces the fixed error for structured signals in the f_3-f_4 band for STM-0, STM-1, and STM-4 and adds a high-pass filter f_{12}:

Table 8/O.172 – Fixed error (W) of SDH line jitter measurements

Signal	Maximum peak-to-peak jitter error (UIpp) for given digital signals					
	Structured signal			Clock signal		
	f_1-f_4	f_{12}-f_4	f_3-f_4	f_1-f_4	f_{12}-f_4	f_3-f_4
STM-0e	FFS	–	FFS	FFS	–	FFS
STM-0	0.07	–	0.035	0.05	–	0.03
STM-1e	0.07	–	0.025	0.05	–	0.02
STM-1	0.07	0.035	0.035	0.05	0.03	0.03
STM-4	0.1	0.035	0.035	0.05	0.03	0.03
STM-16	0.1	0.05	0.05	0.05	0.03	0.03
STM-64	0.15	–	0.05	0.05	–	0.03
STM-256	FFS	–	FFS	FFS	–	FFS

NOTE 1 – FFS denotes that the value is for further study.

NOTE 2 – Structured digital signals are defined in Annex A.

NOTE 3 – Clock interfaces are optional.

NOTE 4 – Within the frequency ranges f_3-f_4 and f_{12}-f_4, the objective is to reduce fixed error W = 0.05 UIpp to W = 0.035 UIpp for particular applications.

NOTE 5 – The f_{12} high-pass filter is optional.

3) New clause 9.5 – Jitter transfer measurement accuracy

Add the following new clause, and change the current clause number 9.5 to 9.6:

9.5 Jitter transfer measurement accuracy

The specification of SDH equipment jitter transfer characteristics in ITU-T Rec. G.783 [5] uses a gain-versus-frequency mask to limit the maximum transfer gain (P) and the maximum transfer bandwidth (f_C). This mask is specified in-between the frequency range f_L to f_H. The accuracy of the jitter transfer measurement depends on several factors: the repeatability of the jitter generator's performance, the linearity and repeatability of the jitter measurement equipment's performance, and the noise floor of the measurement. Where the jitter frequency f_m is less than f_C, the measurement accuracy affects the determination of whether the gain limit P has been met. Where the jitter frequency f_m is greater than f_C, the measurement accuracy affects the determination of whether the bandwidth limitation mask above f_C is not exceeded.

The total measurement error in the jitter frequency range $f_L = 0.01 \cdot f_C$ and $f_H = 100 \cdot f_C$ or f_4, if f_4 is lower than $100 \cdot f_C$, when using input jitter amplitude equal to the applicable jitter tolerance masks, shall be less than:

$$\pm 0.05 \text{ dB} \pm 0.12 \cdot g$$

where g is the measured jitter transfer gain at the jitter frequency f_m in dB. This measurement error applies for g greater or equal to –45 dB. No accuracy is specified for g less than –45 dB.

4) Clause 11 – TDEV wander noise generation function

i) *Replace paragraphs a) and b) with the following:*

a) The TDEV noise generator shall produce a test signal within ± 20% of the applicable TDEV input noise tolerance mask. This accuracy shall be met when the measurement period $T \geq 12\tau_{max}$, where τ_{max} is the largest value of τ for the mask.

b) The MTIE of the test signal shall be not greater than the upper limit defined in Annex C.

ii) *Delete the last sentence of the Note as follows:* "The maximum allowance for exceeding the MTIE limits is for further study".

5) New clause 12 – MTIE wander noise generation function

Add the following new clause 12 and renumber the existing clause 12 as clause 13:

The capability of generating MTIE wander noise for wander tolerance measurements as described in ITU-T Recs G.812 [8] and G.813 [9] may be provided. To ensure sufficiently accurate, robust and consistent measurements, the following requirements shall be met:

a) The MTIE noise generator shall produce a test signal or set of test signals whose stress is within ± 5% of the applicable MTIE input noise tolerance mask. For a set of test signals, the stress is considered to be the upper envelope of the set of corresponding MTIE curves.

b) The jitter generated by the MTIE noise generator shall not exceed the limits for the applicable network interface output jitter.

NOTE – When a test set is evaluated for compliance to these requirements, the generated wander must be measured with a low-pass filter whose bandwidth is adequate so that its effect on the measured MTIE is less than 1%. See Appendix VI for guidance on evaluating MTIE wander noise generation.

6) Clause A.3.1 – STM-N signal (N ≥ 4)

Replace the text with the following:

The STM-N test signal structure illustrated in Figure A.3 is a PRBS test sequence of length $2^{23} - 1$ bits or $2^{31} - 1$ bits for STM-N ($N \geq 64$) according to ITU-T Rec. O.150 [16], which is applied to all payload bytes of the C-4-Xc concatenated container.

NOTE – This is equivalent to Test Signal Structure 9 (TSS9) defined in Annex C/O.181 [18].

7) Annex C

Replace Annex C with the following:

MTIE upper limit for TDEV wander noise

This annex describes the MTIE upper limit for TDEV wander noise required for the wander tolerance test and the wander transfer test specified in ITU-T Recs G.812 and G.813. The MTIE for TDEV wander noise should be below the MTIE upper limit to prevent application of excessive MTIE stress to the device under test.

The MTIE(τ) for the test signal output from the TDEV noise generator shall satisfy the following relationship:

$$MTIE(\tau) \leq 7\sqrt{4K_1 \int_{K_2/\tau_{max}}^{K_2/\tau_{min}} \left(TDEV\left(\frac{K_2}{f}\right)\right)^2 \frac{\sin(\pi\tau f)}{f} df}$$

where, $K_1 = 0.84$ and $K_2 = 0.42$, $\tau_{min} \leq \tau \leq \tau_{max}$ and $T \geq 12\tau_{max}$, where, τ is the observation interval and T is the measurement period. τ_{min} and τ_{max} are the smallest and the largest observation interval specified for the corresponding TDEV mask. The TDEV(τ) of the corresponding TDEV mask is substituted for TDEV(K_2/f) on the right side of the equation.

Figures C.1 and C.2 show examples of TDEV masks and the corresponding MTIE upper limits for TDEV wander noises. For reference, the MTIE tolerance mask specified for the same equipment is also shown by the broken line in each figure.

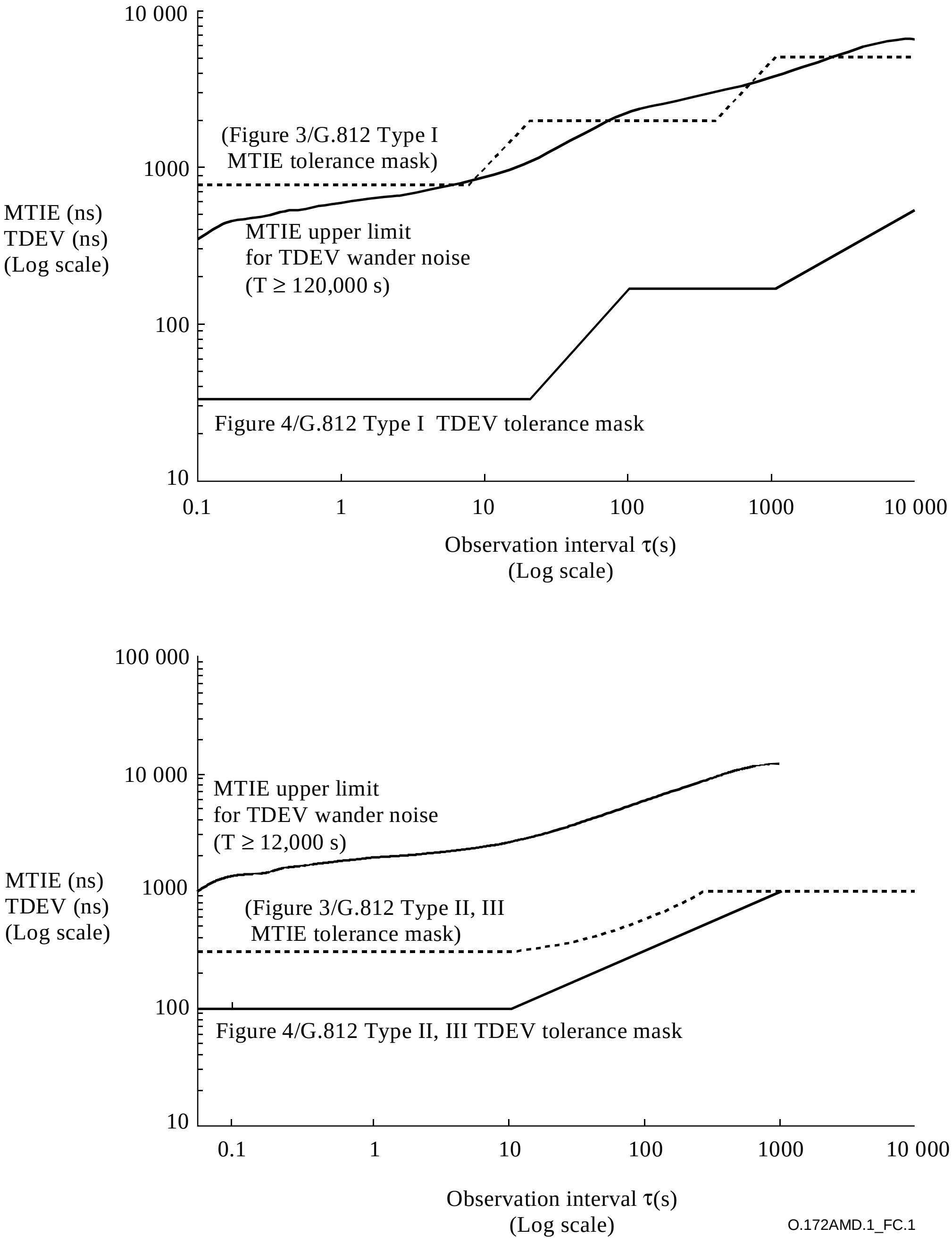

Figure C.1/O.172 – MTIE upper limit for TDEV wander tolerance test in G.812

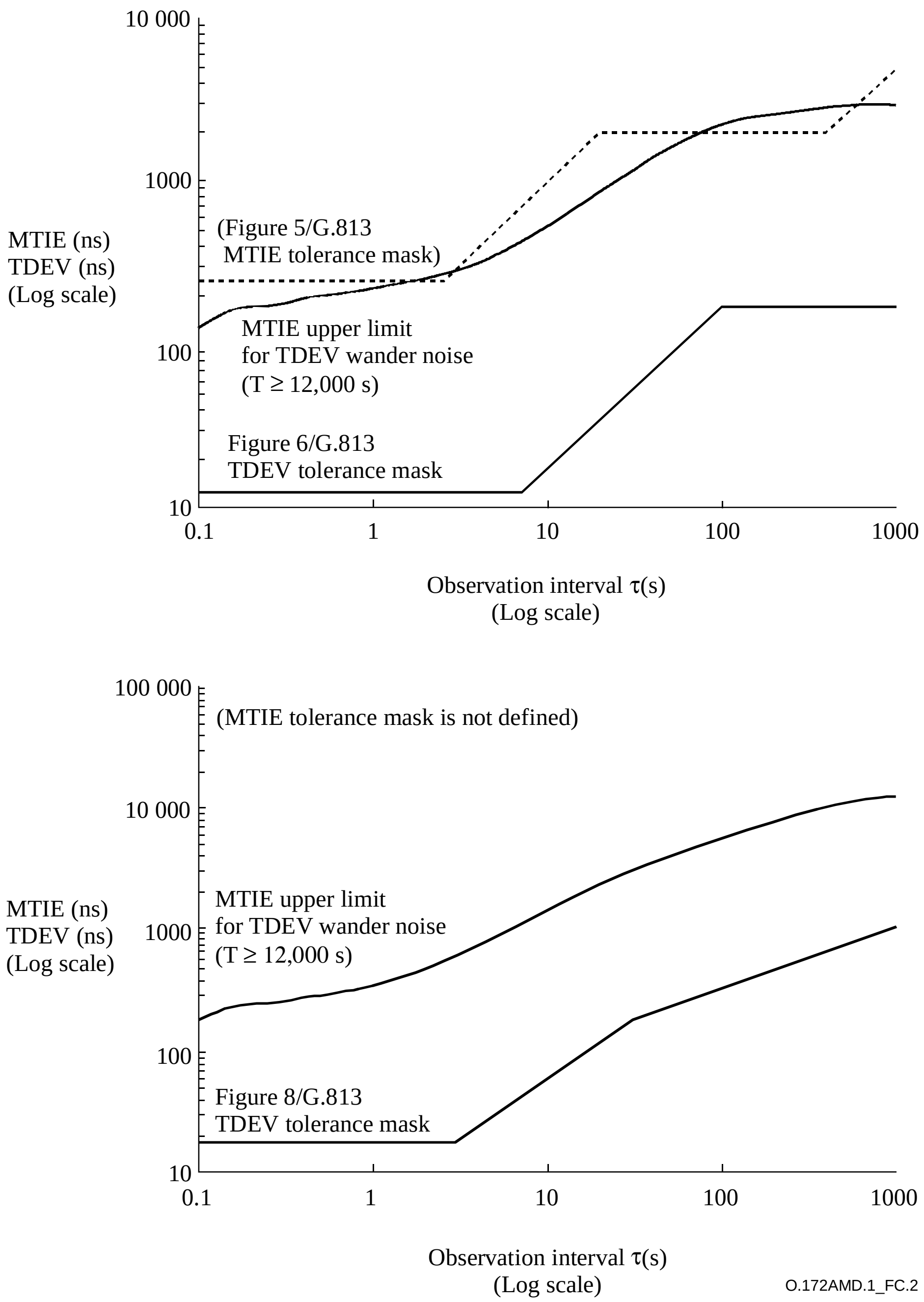

Figure C.2/O.172 – MTIE upper limit for TDEV wander tolerance test in G.813

8) New Appendix VI

Add the following new Appendix VI:

MTIE generation evaluation

The requirement of MTIE wander tolerance mask generation capability of the test instrument is that the accuracy specification should be met without the attenuation of a low pass wander measurement filter. This means that the MTIE wander tolerance generation may be as required and, within specification, however, the MTIE measurement may show attenuation effects of the wander measurement filter, typically at 10 Hz. For accurate measurement of the MTIE stress waveform, it is recommended that a bandwidth which has an effect of less than 1% of the result shall be used, this being a minimum of 500 Hz.

The examples below show 2 MTIE waveforms, both of which are compliant with O.172 and both generating the correct amount of MTIE stress for the given network interface (Table 10/G.812).

Figure VI.1 shows the first waveform and the effect of a 10 Hz wander measurement filter, and Figure VI.2 the corresponding MTIE. Figure VI.3 shows the second waveform and the effect of a 500 Hz wander measurement filter, and Figure VI.4 the corresponding MTIE. The 500 Hz result is within 1% of the MTIE stress at the interface, while the 10 Hz measurement shows up to 50% error.

Figure VI.5 shows a modified waveform used to generate the same MTIE stress. Figure VI.6 shows the result this time within 1% measured with a 10 Hz wander measurement filter, for $\tau > 0.1$ s.

The difference between the 2 MTIE stress waveforms is the minimum bandwidth needed to measure correctly the maximum MTIE stress each produces. Both give the correct MTIE stress, but the potential error, when measuring the first waveform in a 10 Hz bandwidth, indicates to the user that a 500 Hz minimum bandwidth be used to ensure accurate characterization of the test equipment.

Figures VI.1 a) and b) show a test pattern $x(t)$ for Table 10/G.812. Here the repetitive transients in Figure VI.1 are three superimposed triangular waveforms, $w_1(t)$, $w_2(t)$ and $w_3(t)$. Their amplitudes are $A_1 = 0.3$, $A_2 = 0.7$ and $A_3 = 0.097$ µs and their rise times are $\tau_1 = 0.05$, $\tau_2 = 280$ and $\tau_3 = 10000$ s, respectively. The dotted line in Figure VI.1 b) is the $u(t)$ output from the 10 Hz wander measurement filter. In Figure VI.1 b), the peak-to-peak value of $u(t)$ is decreased because the fundamental frequency of $w_1(t)$, which is one component of $x(t)$, is equal to the cut-off frequency of the wander measurement filter.

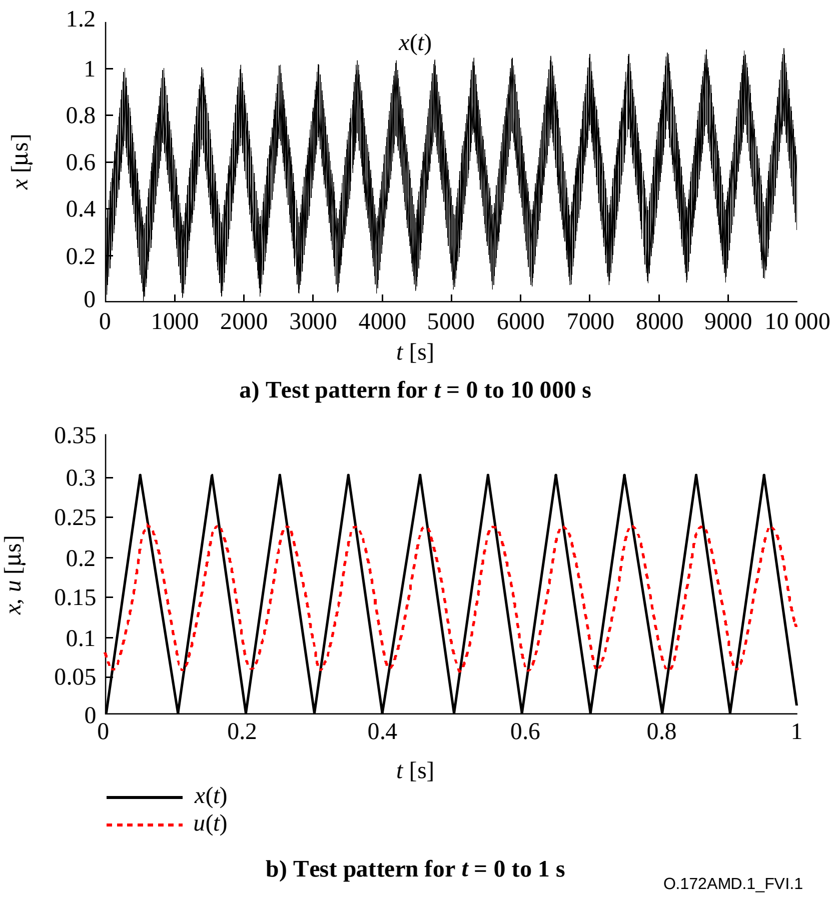

Figure VI.1/O.172 – Test pattern for Table 10/G.812 MTIE mask generated by repetitive transient (10 Hz low pass measurement filter)

The calculated MTIE for $x(t)$ and $u(t)$ in Figure VI.1 is shown in Figure VI.2. The MTIE of $x(t)$ matches the MTIE mask. However, the MTIE of $u(t)$ is lower than the MTIE mask. Since the wander measurement function can only calculate the MTIE of $u(t)$, it is not possible to confirm whether the MTIE of the test pattern $x(t)$ matches the MTIE mask.

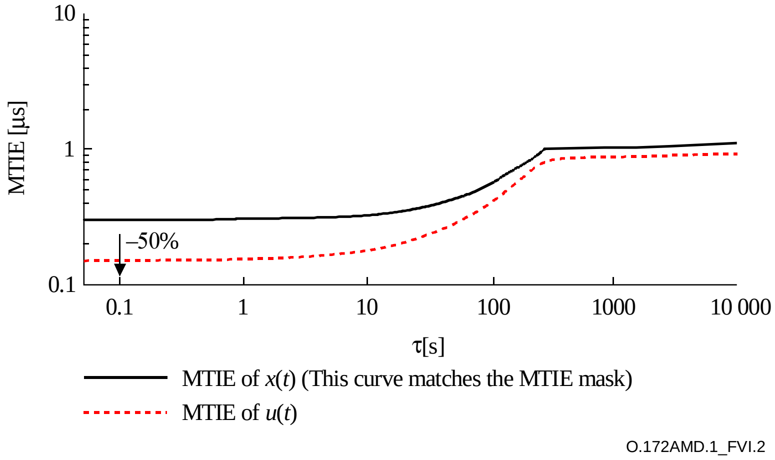

Figure VI.2/O.172 – MTIE of $x(t)$ and $u(t)$ in Figure VI.1

Figure VI.3 below shows the same signal $x(t)$ when filtered with a 500 Hz wander measurement filter, and Figure VI.4 the resultant MTIE. The MTIE stress, when measured in a 500 Hz filter, is now shown as less than 1% different from the MTIE being generated.

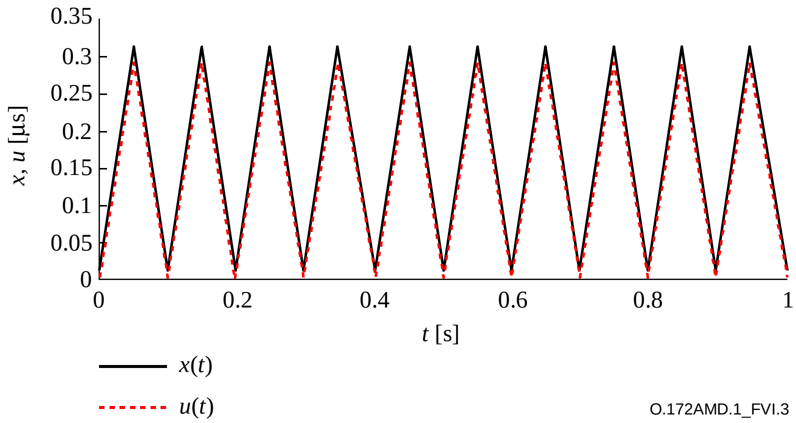

Figure VI.3/O.172 – Test pattern for Table 10/G.812 MTIE mask generated by repetitive transient (500 Hz low pass measurement filter)

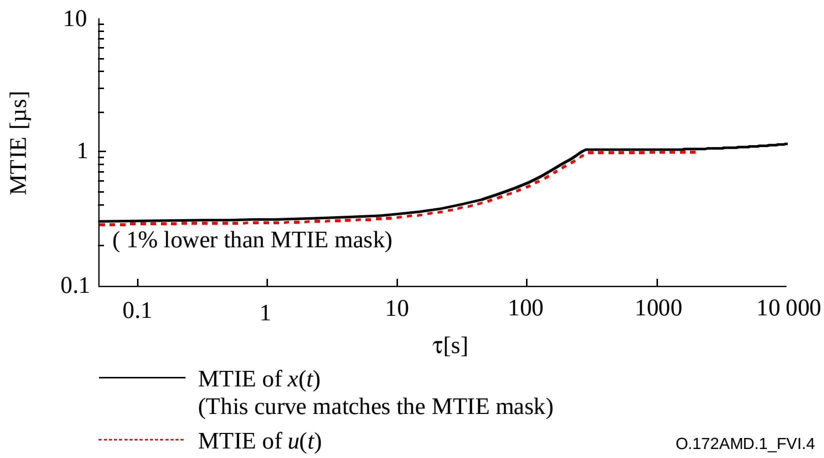

Figure VI.4/O.172 – MTIE of *x*(*t*) and *u*(*t*) in Figure VI.3

The modified $x(t)$, which uses a trapezoid waveform, is shown in Figure VI.5 as a solid line. The dotted line, $u(t)$, shows the waveform when filtered in a 10 Hz bandwidth.

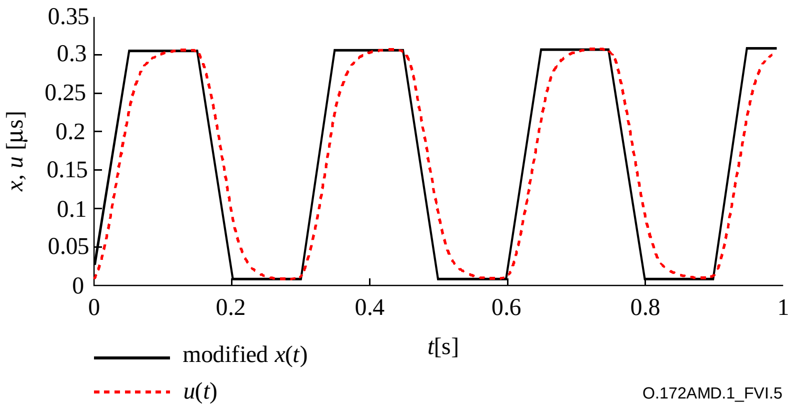

Figure VI.5/O.172 – Modified test pattern for t = 0 to 1 s with repetitive transient $w_1(t)$ in Figure VI.1 b) (10 Hz low pass measurement filter)

The MTIE of the modified test pattern $x(t)$ and the MTIE of $u(t)$ are shown in Figure VI.5. The MTIE of $u(t)$ matched the MTIE mask within 0.1% for $\tau > 0.1$ s.

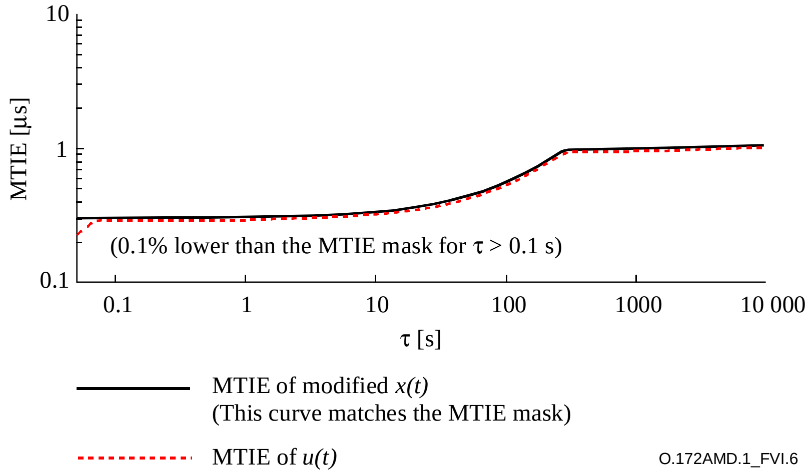

Figure VI.6/O.172 – MTIE of *x*(*t*) and *u*(*t*) in Figure VI.5

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	**Specifications of measuring equipment**
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2003