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Transmission and Multiplexing (TM); The control of jitter and wander in transport networks

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

National transposition dates	
Date of adoption of this EN:	21 January 2000
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Introduction

In a transport network, jitter and wander accumulate on data paths according to the jitter and wander generation and transfer characteristics of each equipment interconnected. These equipments may be different types of multiplexers/demultiplexers, cross-connects and line systems, for example.

An excessive amount of jitter and wander can adversely affect both digital signals (e.g. by generation of bit errors, uncontrolled slips and other abnormalities) and analogue signals (e.g. by unwanted phase modulation of the transmitted signal). The consequences of such impairment will, in general, depend on the particular service that is being carried and the terminating or adaptation equipment involved.

It is therefore necessary to set limits on the magnitude of jitter and wander at network interfaces, in order to guarantee a proper quality of the transmitted signals and a proper design of the equipment.

The jitter and wander control philosophy of the present document is based on the need:

- to specify a maximum network limit of jitter and wander that should not be exceeded at any relevant interface;
- to specify a minimum equipment tolerance to jitter and wander that should be provided at any relevant interface;
- to establish a consistent framework for the specification of individual digital equipment types; and
- to provide sufficient information and guidelines for organizations to measure and study jitter and wander characteristics in any network configuration.

1 Scope

The present document specifies the relevant parameters and their limiting values that are able to satisfactorily control the amount of jitter and wander present at synchronous digital hierarchy (SDH) and plesiochronous digital hierarchy (PDH) network-network interfaces (NNI).

The present document also provides the minimum jitter and wander requirements at SDH and PDH user-network interfaces (UNI). However, particular terminals or services may have additional jitter and wander requirements and in those cases the relevant standards apply.

The jitter and wander requirements specified in the present document are applicable to the interfaces irrespective of the transport mechanism (PDH, SDH or ATM networks, for example).

The jitter and wander requirements for an interface will be different, depending on whether the signal at the interface is used to transport data only, or synchronization as well. The requirements for synchronization interfaces are specified in EN 300 462-3-1 [7] and reference is made to that document where appropriate.

The present document also specifies the jitter and wander requirements for interfaces using the generic frame structures at PDH rates as described in ETS 300 337 [3].

The electrical characteristics of the relevant network interfaces for SDH and PDH interfaces are described in specification ETS 300 166 [1] and the characteristics of SDH optical interfaces are described in specification ETS 300 232 [2].

2 References

The following documents contain provisions, which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, subsequent revisions do apply.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ETS 300 166: "Transmission and Multiplexing (TM); Physical and electrical characteristics of hierarchical digital interfaces for equipment using the 2 048 kbit/s-based Plesiochronous or Synchronous Digital Hierarchies".

[2] ETS 300 232: "Transmission and Multiplexing (TM); Optical interfaces for equipments and systems relating to the Synchronous Digital Hierarchy [ITU-T Recommendation G.957 (1993), modified]".

[3] ETS 300 337: "Transmission and Multiplexing (TM); Generic frame structures for the transport of various signals (including Asynchronous Transfer Mode (ATM) cells and Synchronous Digital Hierarchy (SDH) elements) at the ITU-T Recommendation G.702 hierarchical rates of 2 048 kbit/s, 34 368 kbit/s and 139 264 kbit/s".

[4] EN 300 417-1-1: "Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment; Part 1-1: Generic processes and performance".

[5] EN 300 462-1-1: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 1-1: Definitions and terminology for synchronization networks".

[6] EN 300 462-2-1: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 2-1: Synchronization network architecture".

[7] EN 300 462-3-1: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 3-1: The control of jitter and wander within synchronization networks".

[8] EN 300 462-4-1: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 4-1: Timing characteristics of slave clocks suitable for synchronization supply to Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH) equipment".

[9] EN 300 462-5-1: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 5-1: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment".

[10] EN 300 462-6-1: "Transmission and Multiplexing (TM); Generic requirements for synchronization networks; Part 6-1: Timing characteristics of primary reference clocks".

[11] ITU-T Recommendation G.803: "Architecture of transport networks based on the synchronous digital hierarchy (SDH)".

[12] ITU-T Recommendation O.150: "General requirements for instrumentation for performance measurements on digital transmission equipment".

[13] ITU-T Recommendation O.171: "Timing jitter and wander measuring equipment for digital systems which are based on the plesiochronous digital hierarchy (PDH)".

[14] ITU-T Recommendation O.172: "Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)".

[15] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply. Additional definitions relating to synchronization networks are provided in EN 300 462-1-1 [5], whilst the architectural principles of synchronization networks are described in EN 300 462-2-1 [6].

traffic interface: these interfaces may be synchronous (i.e. normally PRC-traceable) or asynchronous (e.g. meeting the frequency offset requirements of ETS 300 166 [1]). Network jitter and wander limits are specified in the present document and wander is specified using the MRTIE (Maximum Relative Time Interval Error) parameter. Input jitter and wander tolerance is also specified in the present document. This interface category can be further sub-divided as follows:

- interface is not able to provide synchronization, and is not required to. An example is an interface supporting only 34 368 kbit/s or 139 264 kbit/s PDH signals according to ETS 300 166 [1];

- interface is not able to provide synchronization at the defined performance level, but nevertheless is used to provide timing to other network elements such as terminal equipment, remote concentrators, etc. Examples include 2 048 kbit/s, 34 368 kbit/s and 139 264 kbit/s PDH signals and leased lines transported on SDH, which may be subject to pointer justifications. ITU-T Recommendation G.803 [11] recommends that these interfaces are not used for synchronization, but in some network applications there is little alternative;

- interface is able to provide synchronization at the defined performance level, in which case it is defined to be a synchronization interface. An example is STM-N interfaces. This sub-category may also include interfaces using the generic frame structures at PDH rates as described in ETS 300 337 [3].

synchronization interface: these interfaces are synchronous (i.e. normally PRC-traceable) and their requirements are not specified in the present document. The network limits for synchronization interfaces are specified using MTIE (Maximum Time Interval Error) and TDEV (Time Deviation) parameters with values given in EN 300 462-3-1 [7]. The input jitter and wander tolerance of clock equipment ports is specified in EN 300 462-4-1 [8] (for equipment containing an SSU function) and EN 300 462-5-1 [9] (for equipment containing an SEC function).

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply. Additional abbreviations relating to synchronization networks are provided in EN 300 462-1-1 [5].

ATM	Asynchronous Transfer Mode
CMI	Coded Mark Inversion
MRTIE	Maximum Relative Time Interval Error
MS-AIS	Multiplex Section Alarm Indication Signal
MTIE	Maximum Time Interval Error
NE	Network Element
NNI	Network-Network Interface
PDH	Plesiochronous Digital Hierarchy
pk-pk	peak-to-peak
PLL	Phase Locked Loop
ppm	parts per million
PRBS	Pseudo-Random Binary Sequence
PRC	Primary Reference Clock
RTIE	Relative Time Interval Error
SDH	Synchronous Digital Hierarchy
SEC	SDH Equipment Clock
SSU	Synchronization Supply Unit
STM-1e	Synchronous Transport Module, level 1 (electrical format CMI-encoded signal)
STM-N	Synchronous Transport Module, level N
TDEV	Time Deviation
TIE	Time Interval Error
UI	Unit Interval
UIpp	Unit Interval, peak-to-peak
UNI	User-Network Interface
VC-n	Virtual Container, level n

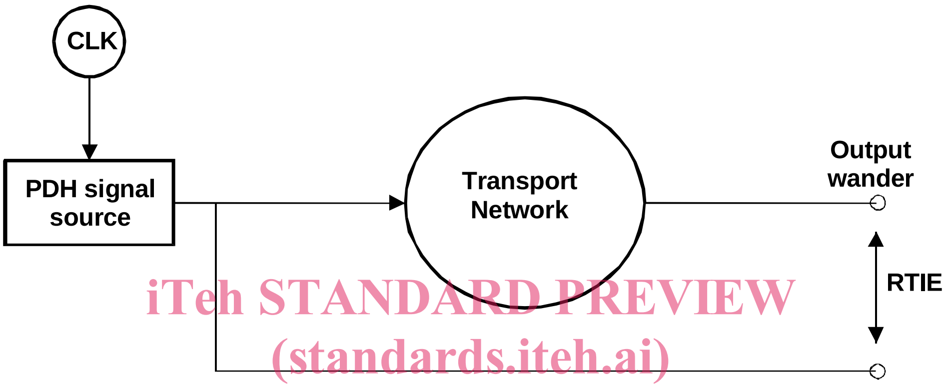
4 Network wander specification

4.1 Wander reference model

Wander is always specified and measured as a Relative Time Interval Error (RTIE) between the signal of interest and some reference clock. However, the reference clock against which the RTIE is specified or measured depends on the type of signal of interest. For the purposes of the present document, two cases can be distinguished.

1) Asynchronous PDH connection

The appropriate reference for specifying the output wander of asynchronous PDH signals is the signal source itself. For measurement purposes, since that source is not normally available for use as the reference clock, it can be substituted by a suitably-filtered version of the output signal. Annex B has further information regarding this. The reference model is illustrated in figure 1.

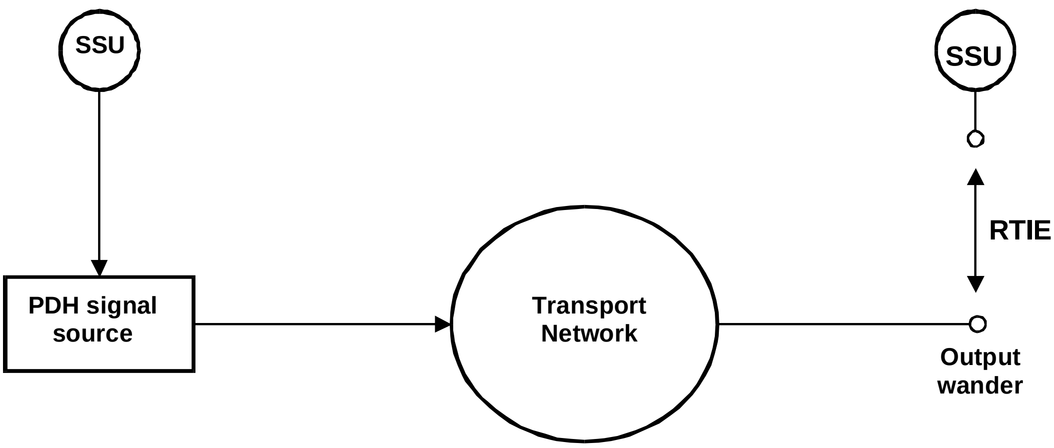


NOTE: CLK frequency offset conforms to bit-rate specifications of ITU-T Recommendation G.703 [15].

Figure 1: Wander reference model for asynchronous PDH connection

2) Synchronous PDH connection

The appropriate reference for specifying the output wander of synchronous PDH signals (i.e. most 2 048 kbit/s signals as well as signals framed according to ETS 300 337 [3]) is the network clock reference used at the PDH signal termination. This means that the wander of two reference clock distribution networks is added to the output wander generated by the transport network. The reference model is illustrated in figure 2.



NOTE 1: SSU outputs conform to EN 300 462-3-1 [7] network wander limit.
NOTE 2: Both SSUs are traceable to a PRC (but not necessarily the same PRC).

Figure 2: Wander reference model for synchronous PDH connection

Although for cases 1 and 2, different wander sources contribute to the total output wander, the resulting measured RTIE will not be very different. This is due to a lack of correlating effects and because statistically-speaking the transport network wander is the dominant source compared with the synchronization network wander. Consequently the same network limits have been set for both cases in the following output wander specifications.

The wander specifications of the present document are consistent with the derivation of limits outlined for the case of SDH network transport in annex A.

4.2 Specification of wander by MRTIE parameter

There are several parameters in use for specifying wander in standard specifications, such as MTIE and TDEV. For the purposes of the present document, MRTIE (Maximum Relative Time Interval Error) has been selected because it is most suitable to allow derivation of consequent equipment performance specifications.

For asynchronous payloads (refer to figure 1) the MRTIE specifies the wander accumulated by the network relative to the input signal phase. This is reasonable because it provides information for designing the filter required for any filtering of the transported signal clock in order to achieve the required phase stability of the payload.

For synchronous payloads (refer to figure 2) the MRTIE specifies the wander of the payload output relative to the clock phase of an input buffer (e.g. located in an exchange). This is reasonable because it provides information for designing the buffer size.

Measurement methodologies used to measure the MRTIE parameter are described in annex B.

5 Network limits for output jitter and wander

5.1 Network limits for output jitter

The limits given in table 1 represent the maximum permissible levels of jitter at interfaces within a digital network. Jitter as measured over a 60 second interval shall not exceed the limits given in table 1, when using the specified measurement bandwidths. The limits shall be met for all operating conditions and regardless of the amount of equipment preceding the interface. In general, these network limits are compatible with the minimum tolerance to jitter that all equipment-input ports are required to provide.

There is a close relationship between network limits and input tolerance such that in terms of specification, the frequency bandwidth used for measurement and the frequency breakpoints used for tolerance, are defined using the same frequencies. In other words, the jitter measurement filter cut-off frequencies used in table 1 have the same values as the jitter tolerance mask corner frequencies used in clause 6. Annex D provides further information about this relationship.

The functional description for measuring output jitter at a digital interface can be found in ITU-T Recommendation O.172 [14].

The high-pass measurement filters of table 1 have a single-order characteristic and a roll-off of 20 dB/decade. The low-pass measurement filters have a maximally-flat, Butterworth characteristic and a roll-off of 60 dB/decade. Further specifications for the frequency response of the jitter measurement function such as measurement filter accuracy and additional allowed filter poles are given in ITU-T Recommendation O.172 [14].

Instrumentation in accordance with ITU-T Recommendations O.172 [14] and O.171 [13] is appropriate for measurement of jitter in SDH and PDH systems, respectively.

ITU-T Recommendation O.172 [14] includes test set specifications for the measurement of SDH tributaries operating at PDH bit-rates, where the test set requirements are more stringent than those relating only to PDH systems. Therefore, instrumentation in accordance with ITU-T Recommendation O.172 [14] shall be used at PDH interfaces in SDH systems.