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Fibre optic communication subsystem test procedures –
Part 2-3: Digital systems – Jitter and wander measurements

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FOREWORD

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International Standard IEC 61280-2-3 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

The text of this standard is based on the following documents:

FDIS	Report on voting
86C/885/FDIS	86C/905/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

A list of all parts of the IEC 61280-2 series, published under the general title *Fibre optic communication subsystem test procedures – Digital systems,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version may be published at a later date.

FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 2-3: Digital systems – Jitter and wander measurements

1 Scope

This part of IEC 61280 specifies methods for the measurement of the jitter and wander parameters associated with the transmission and handling of digital signals.

1.1 Types of jitter measurements

This standard covers the measurement of the following types of jitter parameters:

a) jitter tolerance
   1) sinusoidal method
   2) stressed eye method
b) jitter transfer function
c) output jitter
d) systematic jitter
e) jitter separation

1.2 Types of wander measurements

This standard covers the measurement of the following types of wander parameters:

a) non-synchronized wander
b) TDEV tolerance
c) TDEV transfer
d) synchronized wander

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60825-1, Safety *of laser products – Part 1: Equipment classification and requirements*

ITU-T Recommendation G.813, *Timing characteristics of SDH equipment slave clocks (SEC)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE See also IEC 61931.

3.1
jitter
the short-term, non-cumulative, variation in time of the significant instances of a digital signal from their ideal position in time. Short-term variations in this context are jitter components with a repetition frequency equal to or exceeding 10 Hz

3.2
jitter amplitude
the deviation of the significant instance of a digital signal from its ideal position in time

NOTE For the purposes of this standard the jitter amplitude is expressed in terms of the unit interval (UI). It is recognized that jitter amplitude may also be expressed in units of time.

3.3
unit interval (UI)
the shortest interval between two equivalent instances in ideal positions in time. In practice this is equivalent to the ideal timing period of the digital signal

3.4
jitter frequency
the rate of variation in time of the significant instances of a digital signal relative to their ideal position in time. Jitter frequency is expressed in Hertz (Hz)

3.5
jitter bandwidth
the jitter frequency at which the jitter amplitude has decreased by 3dB relative to its maximum value

3.6
alignment jitter
jitter created when the timing of a data signal is recovered from the signal itself

3.7
timing jitter
jitter present on a timing source

3.8
systematic jitter
jitter components which are not random and have a predictable rate of occurrence. Systematic jitter in a digital signal results from regularly recurring features in the digital signal, such as frame alignment data, and justification control data. This is sometimes referred to as deterministic jitter and is composed of periodic uncorrelated jitter and data dependent jitter

3.9
periodic uncorrelated jitter
a form of systematic jitter that occurs at a regular rate, but is uncorrelated to the data when the data pattern repeats. Periodic uncorrelated jitter will be the same independent of which edge in a pattern is observed over time. Sources of periodic uncorrelated jitter include switching power supplies phase modulating reference clocks or any form of periodic phase modulation of clocks that control data rates

3.10
inter-symbol interference jitter
caused by bandwidth limitations in transmission channels. If the channel bandwidth is low, signal transitions may not reach full amplitude before transitioning to a different logic state. Starting at a level closer to the midpoint between logic states, the time at which the signal edge then crosses a specific amplitude threshold can be early compared to consecutive identical digits which have reached full amplitude and then switch to the other logic state

3.11
duty cycle distortion
occurs when the duration of a logic 1 (0-1-0) is different from the duration of a logic 0 (1-0-1). For example, if the logic 1 has a longer duration, rising edges will occur early relative to falling edges, compared to their ideal locations in time

3.12
data dependent jitter
represents jitter that is correlated to specific bits in a repeating data pattern. That is, when a data pattern repeats, the jitter on any given signal edge will manifest itself in the same way for any repetition of the pattern. It is due to either duty cycle distortion and/or inter-symbol interference

3.13
waiting time jitter
applies to plesiochronous multiplexing and is defined as the jitter caused by the varying delay between the demand for justification and its execution

3.14
jitter tolerance
maximum jitter amplitude that a digital receiver can accept for a given penalty or alternatively without the addition of a given number of errors to the digital signal. The maximum jitter amplitude tolerated is generally dependent on the frequency of the jitter

3.15
jitter generation
process of adding jitter impairment to a data signal

3.16
input jitter
magnitude of the jitter occurring at a hierarchical interface or the input port of equipment or a device

3.17
output jitter
magnitude of the jitter occurring at a hierarchical interface or the output port of equipment or a device

3.18
jitter transfer
amount of jitter transferred from the input to the output of an equipment or device. It is usually expressed as a ratio (in dB) of the output jitter to the input jitter

3.19
total jitter
the summation (or convolution) of deterministic and random jitter. Total jitter is expressed as a peak value

3.20
jitter bathtub curve
display of bit-error-ratio as a function of the time location of the BERT error detector sampling point. The resulting curve is then a display of the probability that a data edge will be misplaced at or beyond a specific location (closer to the centre of a bit) within a unit interval

3.21
wander
long-term, non-cumulative, variation in time of the significant instances of a digital signal from their ideal position in time. Long-term variations in this context are jitter components with a repetition frequency less than 10 Hz

NOTE For the purpose of this document, the wander amplitude is expressed in units of time (s). It is recognised that wander amplitude may also be expressed in terms of unit interval (UI).

3.22
time interval error
TIE
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. Mathematically, the time interval error function TIE ($t;\tau$) can be expressed as:

$$TIE(t;\tau) = \left[T(t+\tau) - T(t)\right] - \left[Tref(t+\tau) - Tref(t)\right] = x(t+\tau) - x(t) \qquad (1)$$

where τ is the time interval, usually called observation interval

3.23
maximum time interval error
MTIE
maximum peak-to-peak delay variation of a given timing signal with respect to an ideal timing signal within an observation time ($\tau = n\tau_0$) for all observation times of that length within the measurement period (T). It is estimated using the following formula:

$$MTIE(n\tau_0) \cong \max_{1\le k\le N-n}\left[\max_{k\le i\le k+n} x_i - \min_{k\le i\le k+n} x_i\right] \qquad n = 1,2\ldots N-1 \qquad (2)$$

3.24
time deviation
TDEV or σx
measure of the expected time variation of a signal as a function of integration time. TDEV can also provide information about the spectral content of the phase (or time) noise of a signal. TDEV is in units of time. Based on the sequence of time error samples, TDEV is estimated using the following calculation:

$$TDEV(n\tau_0) \cong \sqrt{\frac{1}{6n^2(N-3n+1)}\sum_{j=1}^{N-3n+1}\left[\sum_{i=j}^{n+j-1}(x_{i+2n} - 2x_{i+n} + x_i)\right]^2} \qquad n = 1,2\ldots,\text{int}\quad part\left(\frac{N}{3}\right) \qquad (3)$$

where

x_i denotes time error samples;

N denotes the total number of samples;

τ_0 denotes the time error-sampling interval;

τ denotes the integration time, the independent variable of TDEV;

n denotes the number of sampling intervals within the integration time t.

3.25
bit error ratio
BER
number of bits received in error as a ratio of the total number of bits received

3.26
errored second
time of 1 s duration that contains one or more digital errors in a data stream