SLOVENSKI STANDARD
SIST EN 61280-2-2:2001

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Fibre optic communication subsystem basic test procedures - Part 2-2: Test procedures for digital systems - Optical eye pattern, waveform, and extinction ratio (IEC 61280-2-2:1998)

Fibre optic communication subsystem basic test procedures -- Part 2-2: Test procedures for digital systems - Optical eye pattern, waveform, and extinction ratio

Lichtwellenleiter-Kommunikationsuntersysteme - Grundlegende Prüfverfahren -- Teil 2-2: Prüfverfahren für digitale Systeme - Messung des optischen Augendiagrammes, der Wellenform und des Extinktionsverhältnisses

Procédures d'essai de base des sous-systèmes de télécommunication à fibres optiques -- Partie 2-2: Procédures d'essai des systèmes numériques - Mesure du diagramme oculaire, de la forme d'onde et du taux d'extinction

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(IEC 61280-2-2:1998)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 86C/219/FDIS, future edition 1 of IEC 61280-2-2, prepared by SC 86C, Fibre optic systems and active devices, of IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61280-2-2 on 1999-01-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	1999-10-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2001-10-01

Endorsement notice

The text of the International Standard IEC 61280-2-2:1998 was approved by CENELEC as a European Standard without any modification.

In the official version, for annex B, Bibliography, the following note has to be added for the standard indicated:

IEC 60825-1   NOTE: Harmonized as EN 60825-1:1994 + A11:1996.

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Fibre optic communication subsystem basic test procedures –

Part 2-2: Test procedures for digital systems – Optical eye pattern, waveform, and extinction ratio

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61280-2-2 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/219FDIS	86C/226/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.

Annexes A and B are for information only.

FIBRE OPTIC COMMUNICATION SUBSYSTEM BASIC TEST PROCEDURES –

Part 2-2: Test procedures for digital systems –

Optical eye pattern, waveform, and extinction ratio

1 Scope and object

The purpose of this part of IEC 61280 is to describe a test procedure to measure the eye pattern and waveform parameters such as rise time, fall time, overshoot, and extinction ratio. Alternatively, the waveform may be tested for compliance with a predetermined waveform mask.

2 Normative reference

The following normative document contains provisions, which, through reference in this text, constitute provisions of this part of IEC 61280. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61280 are encouraged to investigate the possibility of applying the most recent editions of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ITU-T G.957:1995, *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*

3 Apparatus

The primary components of the measurement system are a photodetector, a low-pass filter, an oscilloscope, and an optical power meter, as shown in figure 1.

3.1 Time-domain optical detection system

The time-domain optical detection system displays the intensity of the optical waveform as a function of time. The optical detection system is comprised primarily of an optical-to-electrical (O/E) converter, a linear-phase low-pass filter, and an oscilloscope. The detection system is shown in figure 2. More complete descriptions of the equipment are listed in the following subclauses.

3.1.1 Optical-to-electrical (O/E) converter

The O/E converter is typically a high-speed photodiode, followed by electrical amplification. The O/E converter is equipped with an appropriate optical connector to allow connection to the optical interface point, either directly or via an optical jumper cable.

The O/E converter (including any optional amplification following the O/E converter) shall be able to reproduce the optical waveform with sufficient fidelity to ensure a meaningful measurement. Precise specifications are precluded by the large variety of possible implementations, but general guidelines are as follows:

a) acceptable input wavelength range, adequate to cover the intended application;

b) input optical reflectance, low enough to avoid excessive back-reflection into the transmitter being measured;

For example, assume that an optical transmitter is specified to tolerate –24 dB reflectance maximum. If the input reflectance of the O/E converter is –30 dB, the converter can be directly connected to the transmitter. If, however, the input reflectance of the O/E converter is –14 dB, a common value, the effective reflectance can be lowered to –24 dB (or less) by inserting either an optical isolator or a low-reflectance attenuator of 5 dB (or more) between the transmitter and the O/E converter.

c) responsivity, adequate to produce a readable display on the oscilloscope;

For example, assume that a non-return-to-zero (NRZ) optical data stream with an average optical power of –15 dBm is to be measured. If the sensitivity of the oscilloscope is 10 mV per division, a responsivity of 790 V/W is required in order to produce a display of 50 mV peak-to-peak (that is, five divisions peak-to-peak).

d) optical noise-equivalent power, low enough to result in an accurately measurable display on the oscilloscope;

For example, assume that a non-return-to-zero (NRZ) optical data stream with an average optical power of –15 dBm is to be measured. If the effective noise bandwidth of the measurement system is 470 MHz, and if the displayed root-mean-square noise is to be less than 5 % of the eye pattern peak-to-peak height, the optical noise-equivalent power shall be 145 pW $Hz^{-1/2}$ or less.

e) lower cut-off (–3 dB) frequency, 0 Hz;

DC coupling is necessary for two reasons. First, extinction ratio measurements cannot otherwise be performed with sufficient accuracy. Second, if AC-coupling is used, low-frequency spectral components of the measured signal (below the lower cut-off frequency of the O/E converter) may cause significant distortion via amplitude modulation of the detected waveform.

f) upper cut-off (–3 dB) frequency, greater than the bandwidth of the low-pass filter following the O/E converter;

In order to ensure repeatability and accuracy, a low-pass filter of known characteristics is inserted in the signal path before the oscilloscope. This filter alone should primarily determine the effective system bandwidth.

g) transient response, overshoot, undershoot, and other waveform aberrations should be minor so as not to interfere with the measurement;

The low-pass filter following the O/E converter should primarily determine the system transient response.

h) output electrical return loss, high enough, so that reflections from the low-pass filter following the O/E converter are adequately suppressed, from 0 Hz to a frequency significantly greater than the bandwidth of the low-pass filter;

A time-domain measurement may be very inaccurate if significant multiple reflections are present. Many passive, low-loss, low-pass filters, in addition to being reflective in the stop band, have frequency responses that are strongly dependent on the termination impedances at the input and output. A minimum value of 15 dB for the return loss is recommended when passive low-pass filters are employed following the O/E converter. The effective output return loss of the O/E converter may be improved with in-line electrical attenuators, at the expense of reduced signal levels. Finally, the return loss specification extends to d.c., since otherwise, a d.c. shift in the waveform will occur, causing extinction ratio measurements to be in error.

3.1.2 Resistive signal splitter (optional)

If the trigger signal for the oscilloscope is to be derived from the optical waveform itself, it is necessary to tap into the signal path at some point. A resistive signal splitter (power divider) at the location indicated in figure 2 provides a branch from which to derive the trigger signal.

3.1.3 Linear-phase low-pass filter

Generally, one of the primary purposes of measuring the optical eye pattern is to verify certain performance requirements such as rise and fall time, overshoot, etc. If the measurement system bandwidth is much greater than needed, high frequency (and probably insignificant) details of the waveform will tend to obscure the desired measurement. Also, since different measurement setups would have different bandwidths, repeatability between setups would be almost impossible to achieve.

In order to ensure repeatability and accuracy, a low-pass filter of known characteristics is inserted in the signal path prior to the oscilloscope. This filter alone should primarily determine the effective system bandwidth. The type of measurement being performed determines the bandwidth of the low-pass filter. The bandwidth and transfer function characteristics of the low-pass filter should be explicitly stated in the detail specifications.

One type of eye pattern measurement effectively simulates the signal that would result at the output of a bit-rate-specific optical receiver. This type of receiver typically has a bandwidth that is somewhat less than the clock frequency. For this type of measurement, a low-pass filter of –3 dB bandwidth of 0,75/T (where T is the bit interval, in seconds, of the data signal) is often used. The resulting eye pattern is compared to a "mask" to verify compliance with specification.

A different type of eye pattern measurement involves measuring the rise time, fall time, pulse width, and other time-domain parameters of an optical transmitter unit. For this type of measurement, the system bandwidth shall be greater than described above. The –3 dB bandwidth of the low-pass filter in this case needs to be high enough to allow verification of maximum rise and fall times (for example, one-third of a bit intervals), but low enough to eliminate unimportant high-frequency waveform details. A low-pass filter bandwidth of 3,0/T is a typical compromise value for this type of measurement.

Regardless of the type of eye pattern measurement, the filter should have a linear phase response at frequencies up to and somewhat beyond the filter –3 dB bandwidth. If the phase response is linear (implying that the group delay is constant) up to frequencies of high attenuation, slight variations in filter bandwidths should not significantly affect the waveform measurements (see table 1).

Example low-pass filter specifications for a 0,75/T filter are as follows:

- characteristic impedance: 50 Ω nominal;
- –3 dB bandwidth: 0,75/T, Hz;
- filter type: fourth-order Bessel-Thomson.

Table 1 – Frequency response characteristics

Frequency divided by bit rate	Nominal attenuation dB	Attenuation tolerance dB	Maximum group delay distortion s
0,15	0,1	0,3	–
0,30	0,4	0,3	–
0,45	1,0	0,3	–
0,60	1,9	0,3	0,002*T*
0,75	3,0	0,3	0,008*T*
0,90	4,5	0,3	0,025*T*
1,00	5,7	0,3	0,044*T*
1,05	6,4	0,39	0,055*T*
1,20	8,5	0,64	0,100*T*
1,35	10,9	0,90	0,140*T*
1,50	13,4	1,15	0,190*T*
2,00	21,5	2,0	0,300*T*

3.1.4 Oscilloscope

The oscilloscope that displays the optical eye pattern should have a bandwidth well in excess of the bandwidth of the low-pass filter, so that the oscilloscope is not the bandwidth-limiting item of the measurement system. The oscilloscope is triggered either from a local clock signal that is synchronous with the optical eye pattern, or from a synchronization signal derived from the optical waveform itself.

Figures 4 and 5 illustrate oscilloscope bandwidths that are commonly used in eye pattern measurements.

The oscilloscope shall have a vertical-channel histogram function for extinction ratio measurement.

3.1.5 Overall system response

The eye pattern measurement is obviously a time-domain measurement, and needs to accurately represent the optical waveform. This should be done without introducing undesirable overshoot, ringing, and other waveform aberrations. While the individual components of the measurement system are most conveniently specified in the frequency-domain, the final assembled system may also be required to meet certain time-domain performance limits.

Even an ideal fourth-order Bessel-Thomson filter will have an overshoot of about 1 %, and a rise time (10 % to 90 %) of about 0,35/*B*, where *B* is the bandwidth in hertz. In view of this, the overall measurement system shall be required to demonstrate performance is similar to the following:

rise time, fall time (10 % – 90 %):	0,43/*B* maximum, 0,29/*B* minimum;
rise time, fall time (20 % – 80 %):	0,35/*B* maximum, 0,23/*B* minimum;
overshoot, undershoot:	5 % maximum.