

Fibre optic communication subsystem test procedures —

Part 2-2: Digital systems — Optical eye pattern, waveform and extinction ratio measurement

The European Standard EN 61280-2-2:2005 has the status of a
British Standard

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National foreword

This British Standard is the official English language version of EN 61280-2-2:2005. It is identical with IEC 61280-2-2:2005. It supersedes BS EN 61280-2-2:1999 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/3, Fibre optic systems and active devices, which has the responsibility to:

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**Fibre optic communication subsystem test procedures
Part 2-2: Digital systems -
Optical eye pattern, waveform and
extinction ratio measurement
(IEC 61280-2-2:2005)**

Procédures d'essai des sous-systèmes de
télécommunications à fibres optiques
Partie 2-2: Systèmes numériques -
Mesure du diagramme de l'œil optique,
de la forme d'onde et du taux d'extinction
(CEI 61280-2-2:2005)

Prüfverfahren für Lichtwellenleiter-
Kommunikationsuntersysteme
Teil 2-2: Digitale Systeme -
Messung des optischen Augen-
diagramms, der Wellenform und
des Extinktionsverhältnisses
(IEC 61280-2-2:2005)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 86C/642/FDIS, future edition 2 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 2005-04-01.

This European Standard supersedes EN 61280-2-2:1999.

Significant changes include updating the extinction ratio measurement and eye-mask definitions to coincide with TIA OFSTP-4A and inclusion of methods for return-to-zero (RZ) eye measurements.

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) | 2006-02-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2008-04-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61280-2-2:2005 was approved by CENELEC as a European Standard without any modification.

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FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 2-2: Digital systems – Optical eye pattern, waveform and extinction ratio measurement

1 Scope

This part of IEC 61280 describes a test procedure to measure 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.

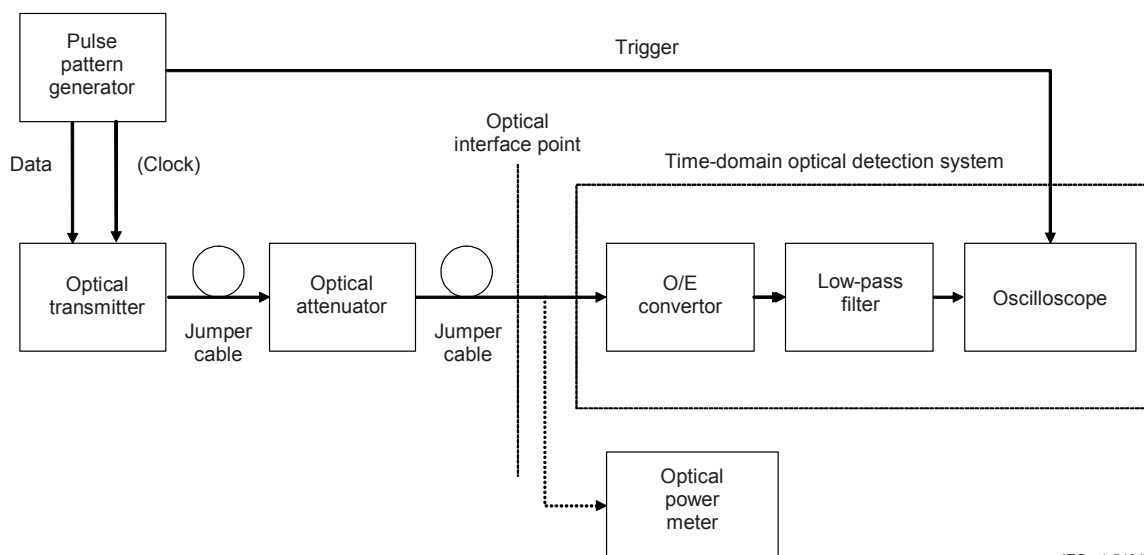
2 Normative references

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.

ITU-T Recommendation G.957:1999, *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*
Amendment 1 (2003)

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.

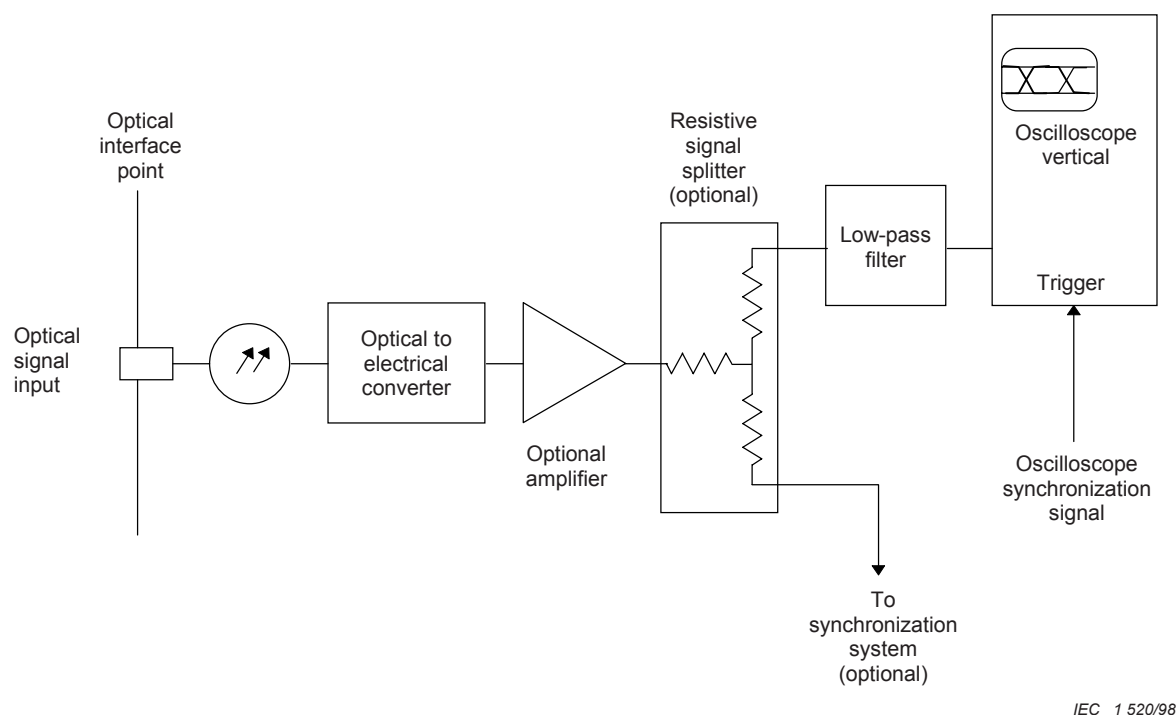


IEC 1 519/98

**Figure 1 – Optical eye pattern, waveform, and extinction ratio
measurement configuration**

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.



IEC 1520/98

Figure 2 – Time-domain optical detection system

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. However, the response of the entire measurement system should conform to the desired frequency response.

- 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. For NRZ format signals 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. For RZ (return-to-zero) format signals spectral content may be significantly higher than the NRZ signal at the same optical bit rate. This may require the reference bandwidth to be in excess of the clock frequency.

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. For NRZ signals a low-pass filter bandwidth of $3,0/T$ is a typical compromise value for this type of measurement. RZ signals can require a bandwidth of $5,0/T$ as a typical compromise.

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 (Exact filter specifications are typically found within the communication standard defining transmitter performance):

- characteristic impedance: 50 Ω nominal;
- -3 dB bandwidth: $0,75/T$, Hz; (Further study required for RZ format)
- filter type: fourth-order Bessel-Thomson (further study required for RZ format)