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Postopki preskušanja optičnega komunikacijskega podsistema – 2-11. del: Digitalni sistemi – Ugotavljanje s povprečno vrednostjo faktorja Q z uporabo ocenjevanja amplitudnega histograma za nadzorovanje kakovosti optičnega signala (IEC 61280-2-11:2006)

Fibre optic communication subsystem test procedures – Part 2-11: Digital systems – Averaged Q-factor determination using amplitude histogram evaluation for optical signal quality monitoring (IEC 61280-2-11:2006)

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Fibre optic communication subsystem test procedures Part 2-11: Digital systems - Averaged Q-factor determination using amplitude histogram evaluation for optical signal quality monitoring

(IEC 61280-2-11:2006)

Procédures d'essai des sous-systèmes de télécommunications à fibres optiques
Partie 2-11: Systèmes numériques -
Détermination du facteur de qualité moyenné par l'évaluation d'histogramme d'amplitude pour la surveillance de la qualité des signaux optiques
(CEI 61280-2-11:2006)

Prüfverfahren für Lichtwellenleiter-Kommunikationsuntersysteme
Teil 2-11: Digitale Systeme -
Bestimmung des mittleren Q-Faktors durch Auswertung des Amplitudenhistogramms zur Qualitätsüberwachung optischer Signale
(IEC 61280-2-11:2006)

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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/682FDIS, future edition 1 of IEC 61280-2-11, 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 61280-2-11 on 2006-02-01.

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)	2006-11-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2009-02-01

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Annex ZA has been added by CENELEC.

Endorsement notice

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE Where an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 61280-2-2	- [1]	Fibre optic communication subsystem test procedures Part 2-2: Digital systems - Optical eye pattern, waveform and extinction ratio measurement	EN 61280-2-2	2005 [2]
ITU-T Recommendation G.959.1	- [1]	Optical transport network physical layer interfaces		

[1] Undated reference.
[2] Valid edition at date of issue.

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Procédures d'essai des sous-systèmes de télécommunications à fibres optiques –

Partie 2-11: Systèmes numériques – Détermination du facteur de qualité moyenné par l'évaluation d'histogramme d'amplitude pour la surveillance de la qualité des signaux optiques

Fibre optic communication subsystem test procedures –

Part 2-11: Digital systems – Averaged Q-factor determination using amplitude histogram evaluation for optical signal quality monitoring

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
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FIBRE OPTIC COMMUNICATION SUBSYSTEM TEST PROCEDURES –

Part 2-11: Digital systems – Averaged Q-factor determination using amplitude histogram evaluation for optical signal quality monitoring

FOREWORD

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International Standard IEC 61280-2-11 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/682/FDIS	86C/687/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61280 consists of the following parts under the general title *Fibre optic communication subsystem test procedures* [1]:

Part 1: General communication subsystems [2]

Part 2: Digital systems [3]

Part 4: Cable plant and links [4]

Part 3 is in preparation.

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.

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1) The general title of the IEC 61280 series has changed. Previous parts were published under the general title *Fibre optic communication subsystem basic test procedures*

2) The title of Part 1 has changed. Parts 1–1 and 1–3 were published under the title *Test procedures for general communication subsystems.*

3) The title of Part 2 has changed. Parts 2–1, 2–2, 2–4 and 2–5 were published under the title *Test procedures for digital systems.*

4) The title of Part 4 has changed. Part 4–2 was published under the title *Fibre optic cable plant*.

0 INTRODUCTION

0.1 Background

Signal quality monitoring is an important issue for operation and maintenance of optical transport networks (OTN). From the network operator's point of view, monitoring techniques are required to establish connections, protection, restoration, and/or service level agreements. In order to establish these functions, the monitoring techniques used should satisfy some general requirements: in-service (non-intrusive) measurement, signal deterioration detection (both SNR degradation and waveform distortion), fault isolation (localize impaired sections or nodes), transparency and scalability (irrespective of the signal bit rate and signal formats), and simplicity (small size and low cost).

There are several approaches, both analog and digital techniques, that make it possible to detect various impairments: bit error rate (BER) estimation [1,2], error block detection, optical power measurement, optical SNR evaluation with spectrum measurement [3, 4], pilot tone detection [5,6], Q-factor monitoring [7], pseudo BER estimation using two decision circuits [8,9], and histogram evaluation with synchronous eye diagram measurement [10]. A fundamental performance monitoring parameter of any digital transmission system is its end-to-end BER. However, the BER can be correctly evaluated only with outside service BER measurements, using a known test bit pattern in place of the real signal. On the other hand, in-service measurement can only provide rough estimates through the measurement of digital parameters (e.g., BER estimation, error block detection, and error count in forward error correction) or analog parameters (e.g., optical SNR and Q-factor).

What has been much desired and studied is some methods for signal quality monitoring that will provide a good measure of signal quality without the complexity of termination. When the system BER is too low to be measured within a reasonable length of time, it is useful to adopt Q-factor measurements. However, all sampling-based methods require synchronization and then some analysis, which makes them similar to protocol-aware termination in terms of cost and complexity. In fact, synchronous sampling requires timing extraction by complex equipment that is specific to each BER and each format.

The above situation has, fortunately, very recently begun to change. A simple, asynchronous histogram method was developed for Q-factor measurement [11],[12]. Different degradation types (i.e., SNR degradation and wavelength distortion due to chromatic dispersion) can be monitored [13], thus providing information about the origin of the degradations [14]. Asynchronous sampling allows bit-rate independent Q-factor monitoring, and the same equipment covers bit rates of up to 160 Gbit/s [15]. Moreover, the monitoring is applied to both NRZ and RZ optical signals [11], and is independent of the bit rate and signal format used by the wavelength division multiplexed (WDM) channel [16]. Performance monitoring can be performed at different monitoring points such as optical line repeaters, regenerators, or optical switching nodes (requires pre-measurement) [17]. In other words, this method is expected to be applied to the monitoring points where electrical termination is impossible. If we think of the future all-optical network, an optical switching node has performance monitoring without electrical regeneration.

Average Q-factor, Q_{avg}, measurement through asynchronous sampling is a cost-effective alternative to BER measurements. This is one of the promising performance-monitoring approaches for intensity modulated direct detection (IM-DD) optical transmission systems. This method can be utilized for monitoring both relative and absolute values of optical signal quality.

With the averaged Q-factor obtained from amplitude histogram parameters (the standard deviation and average level), the over-all effect of the optical signal quality degradations due to the integral of the causes (such as ASE and Chromatic dispersion) can be monitored. Due to asynchronous sampling scheme, the averaged Q-factor is insensitive to the optical signal quality variations created by timing jitter. The following sections define the averaged Q-factor and provide a procedure to measure the optical signal quality via the averaged Q-factor. With the amplitude histogram parameters, it is also possible to distinguish the origins of the BER degradation (SNR degradation, waveform distortion). The information about the dependence of the amplitude histogram parameters on OSNR and chromatic dispersion is shown in Annex F (informative).

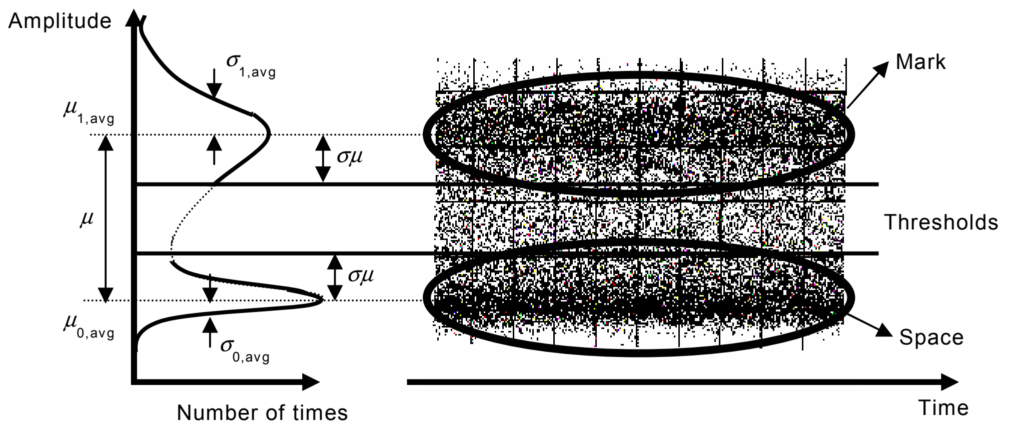
0.2 Averaged Q-factor formula

Figure 1 uses a typical asynchronous eye-pattern and its amplitude histogram, obtained by asynchronous optical sampling, to illustrate the principle of this method. Among the sampling points that constitute the histogram, it is determined that those points whose level is higher than a predetermined threshold level, μ_{th1}, belong to level "Mark" (i.e., "1"), while those points whose level is lower than a predetermined threshold level, μ_{th0}, belong to level "Space" (i.e., "0").

The averaged Q-factor, Q_{avg}, is defined by

$$Q_{avg} = |\mu_{1,avg} - \mu_{0,avg}| / (\sigma_{1,avg} + \sigma_{0,avg}) \quad (1)$$

where $\mu_{i,avg}$ and $\sigma_{i,avg}$ are the mean and standard deviation of the Mark (i = 1) and Space level (i = 0) distributions, respectively [12-17]. The data obtained by asynchronous sampling includes unwanted cross-point data in the eye-diagram, which decreases the measured value of the averaged Q-factor. The two threshold levels are set (μ_{th1} and μ_{th0}) in order to remove the cross-point data.



IEC 2563/05

Figure 1 – Asynchronous eye-pattern and amplitude histogram

The essence of this method is that timing extraction is not used and asynchronous eye diagrams are evaluated. That is why this method provides signal format, modulation format and bit rate flexibility.