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TECHNICAL REPORT

Fibre optic communication system design guidelines –
Part 16: Coherent receivers and transmitters with high-speed digital signal processing

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FOREWORD

IEC 61282-16 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
86C/1776/DTR	86C/1782/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61282 series, published under the general title *Fibre optic communication system design guidelines*, can be found on the IEC website.

Future documents in this series will carry the new general title as cited above. Titles of existing documents in this series will be updated at the time of the next edition.

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

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- withdrawn,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

INTRODUCTION

Coherent optical receivers are widely used in long-haul fibre optic communication systems, especially in systems that transmit optical carriers at data rates of 100 Gbit/s and higher. While the principle of coherent detection is very similar to that of super-heterodyne (or homodyne) detection in radio and microwave receivers, its implementation is significantly more challenging. The main reason is that optical frequencies are substantially higher than radio frequencies, so it becomes more difficult to match the local oscillator frequency in the coherent receiver to the frequency of the transmitted optical signal. Furthermore, optical signals tend to be highly polarized, which means that the amplitude of a coherently received signal can be substantially reduced or even vanish if the polarization state of the local oscillator light does not match the polarization state of the received optical signal. This polarization matching is particularly difficult to achieve in fibre optic communications systems, which usually do not preserve the launched state of polarization of the transmitted signal. To overcome these problems, modern coherent receivers typically consist of four parallel coherent optical mixers that provide phase and polarization diversity, and they rely on high-speed digital signal processors to retrieve the transmitted data from the four received electrical signals.

This rather complex coherent receiver architecture is further justified by the fact that it allows the receiver to mitigate various types of signal impairments introduced in the fibre optic link (or in the receiver itself) simply by means of additional electronic signal processing. Most notably, it is possible to substantially reduce the signal distortions caused by polarization-mode dispersion (PMD) or uncompensated chromatic dispersion (CD) in the fibre link, without requiring additional optical PMD or CD compensators. For this reason, coherent optical communication systems generally allow signal transmission at much higher data rates than communication systems using direct-detection receivers. Furthermore, coherent detection with subsequent digital signal processing facilitates the decoding of complex vector-modulated signals, such as quadrature-amplitude modulated signals (QAM) and polarization-multiplexed (PM) signals, and thereby the transmission of higher data rates.

Aside from fibre optic communications systems, coherent optical receivers are also used in various test and measurement instrumentation. Most notable examples are optical modulation analysers (OMAs) and high-resolution optical spectrum analysers (HR-OSAs). Optical modulation analysers are high-performance optical reference receivers and are used to assess the signal quality of complex vector-modulated optical signals. They are typically composed of a carefully calibrated coherent receiver and a high-speed real-time digitizing oscilloscope to record the coherently received signals, which are then analysed with the help of a software-based digital signal processor.

High-resolution optical spectrum analysers are often used to analyse narrowband features of the optical spectrum of a modulated signal, such as a residual optical carrier or other spectral lines. In contrast to OMAs, they typically employ a low-speed coherent receiver, so as to utilize the frequency-selectivity of coherent detection. The key component in these instruments is a continuously tuneable local oscillator, which is scanned over the frequency range of the signal to be analysed while the total power of the coherently received signal is recorded. The spectral resolution of these instruments can be of the order of a few MHz. Other examples of coherent optical test instruments include in-service PMD analysers and in-band optical signal-to-noise ratio analysers for polarization-multiplexed signals.

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1 Scope

This part of IEC 61282 is a technical report on coherent optical receiver and transmitter technologies that are employed in fibre optic communication systems as well as in optical test and measurement equipment. This document describes the principle of operation and functional capabilities of coherent optical receivers as well as the operation of optical transmitters used to generate complex vector-modulated signals. It is intended to serve as a technical foundation for other IEC documents and standards related to coherent optical transmission techniques.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60050-731, *International Electrotechnical Vocabulary (IEV) – Part 731: Optical fibre communication* (available at www.electropedia.org)

IEC TR 61931, *Fibre optic – Terminology*