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Cable networks for television signals, sound signals and interactive services - Part 114: Optical transmission systems using RFoG technology

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Cable networks for television signals, sound signals and interactive services - Part 114: Optical transmission systems using RFoG technology

FOREWORD

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IEC 60728-14 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
100/4513/FDIS	100/4560/RVD

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 International Standard 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/publications.

The list of all the parts of the IEC 60728 series, under the general title *Cable networks for television signals, sound signals and interactive services*, can be found on the IEC website.

This standard follows closely (where applicable) the ANSI/SCTE 174 2018 standard "Radio Frequency over Glass / Fiber-to-the-Home (RFoG) Specification / Extension". In agreement with SCTE[1] major parts of ANSI/SCTE 174:2018 have been copied into this standard.

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

– reconfirmed,
– withdrawn, or
– revised.

[1] SCTE = Society of Cable Telecommunications Engineers

INTRODUCTION

Standards and other deliverables of the IEC 60728 series deal with cable networks, including equipment and associated methods of measurement for headend reception, processing and distribution of television and sound signals, and for processing, interfacing and transmitting all kinds of data signals for interactive services using all applicable transmission media. These signals are typically transmitted in networks by frequency-multiplexing techniques:

– regional and local broadband cable networks,
– extended satellite and terrestrial television distribution systems,
– individual satellite and terrestrial television receiving systems,

and all kinds of equipment, systems and installations used in such cable networks, distribution systems and receiving systems.

The extent of this standardization work is from the antennas and/or special signal source inputs to the headend or other interface points to the network up to the terminal input of the equipment of the customer's premises.

The standardization work will consider coexistence with users of the RF spectrum in wired and wireless transmission systems.

The standardization of any user terminals (i.e. tuners, receivers, decoders, multimedia terminals, etc.) as well as of any coaxial, balanced and optical cables and accessories thereof is excluded.

The annexes provide the following information:

Annex A describes implementation notes with design considerations based on the content of this document;

Annex B describes the system loss specification;

Annex C describes multiple CMTS operation;

Annex D gives a design guideline of housings for R-ONU protection;

Annex E contains information on the effect of off-state optical power on the SNR of the transmission signal.

1 Scope

This part of IEC 60728 describes the system and equipment specification of FTTH/FTTB (fibre to the home/fibre to the building) networks where information is transmitted in both forward and return path directions using RF subcarrier multiplexing technology, and where the return path transmission uses additionally time division multiple access technique imposed by the transmission of the return path signals using a TDMA (e.g. TDMA mode of DOCSIS) protocol. Such systems are called RF over glass (RFoG) and consist of an RFoG optical network unit (R-ONU), an optical distribution network based on xPON structure, and an RFoG optical return path receiver. This document specifies the basic system parameters and methods of measurement for RFoG systems in order to assess the system performance and its performance limits.

The detailed description of physical layer is out of the scope of this document and it does not include IP transport technologies.

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 60068-2 (all parts), *Environmental testing*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60728-2, *Cable networks for television signals, sound signals and interactive services - Part 2: Electromagnetic compatibility of equipment*

IEC 60728-3, *Cable networks for television signals, sound signals and interactive services - Part 3: Active wideband equipment for cable networks*

IEC 60728-6:2011, *Cable networks for television signals, sound signals and interactive services - Part 6: Optical equipment*

IEC 60728-10:2014, *Cable networks for television signals, sound signals and interactive services – Part 10: System performance of return paths*

IEC 60728-11, *Cable networks for television signals, sound signals and interactive services - Part 11: Safety*

IEC 60728-13:2010, *Cable networks for television signals, sound signals and interactive services - Part 13: Optical systems for broadcast signal transmissions*

IEC 60728-113:2023, *Cable networks for television signals, sound signals and interactive services - Part 113: Optical systems for broadcast signal transmissions loaded with digital channels only*

IEC 60728-106:2023, *Cable networks for television signals, sound signals and interactive services - Part 106: Optical equipment for systems loaded with digital channels only*

IEC 60794-3-11:2010, *Optical fibre cables - Part 3-11: Outdoor cables - Product specification for duct, directly buried, and lashed aerial single-mode optical fibre telecommunication cables*

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

IEC 61169-2, *Radio-frequency connectors - Part 2: Sectional specification - Radio frequency coaxial connectors of type 9,52*

IEC 61169-24, *Radio-frequency connectors - Part 24: Sectional specification - Radio-frequency coaxial connectors with screw coupling, typically for use in 75 Ω cable networks (type F)*

IEC 61280-1-1, *Fibre optic communication subsystem basic test procedures - Part 1-1: Test procedures for general communication subsystems - Transmitter output optical power measurement for single-mode optical fibre cable*

IEC 61280-1-3, *Fibre optic communication subsystem test procedures - Part 1-3: General communication subsystems - Measurement of central wavelength, spectral width and additional spectral characteristics*

IEC 61754-4, *Fibre optic interconnecting devices and passive components - Fibre optic connector interfaces - Part 4: Type SC connector family*

ISO/IEC/IEEE Standard 8802-3:2021, *Standard for Ethernet*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1.1
equivalent input noise current density
notional input noise current density which, when applied to the input of an ideal noiseless device, produces an output noise current density equal in value to that observed at the output of the actual device under consideration

Note 1 to entry: Equivalent input noise current density can be calculated from the RF signal-to-noise ratio (see IEC 60728-106) of a device or system.

[SOURCE: IEC 60728-14:2014, 3.1.2, modified – The equation in Note 1 to entry and Note 2 entry have been deleted.]

3.1.2
flatness
difference between the maximum and the minimum RF gain or attenuation, not taking into account the slope within the specified modulation frequency range of a device or system

[SOURCE: IEC 60728-14:2014, 3.1.6]

3.1.3
headend system
system comprising modulators, demodulators, CMTS, an optical transmitter with optional optical amplifiers and a WDM for the transmission of analogue video as well as digitally modulated signals located at the central office side of the optical network

Note 1 to entry: The headend system is equipped with an optical return path receiver receiving digitally modulated signals of data in the return path direction to enable e.g. VoIP, VOD and internet services.

Note 2 to entry: V-OLT is a part of the headend system and deals with video transmission in the forward path only.

[SOURCE: IEC 60728-14:2014, 3.1.7]

3.1.4
local broadband cable network
network designed to provide sound and television signals as well as signals for interactive services to a local area (e.g. one town or one village)

3.1.5
WDM device
wavelength selective branching device (used in WDM transmission systems) in which optical signals can be transferred between two predetermined ports, depending on the wavelength of the signal

3.1.6
noise power ratio
NPR
ratio of the signal power density to the power density of the combined noise and intermodulation distortion

3.1.7
off-state optical power

residual optical output power emitted from the fibre of the R-ONU when the laser is switched to off-state

Note 1 to entry: In a typical burst mode transmitter, for fast switching operation, the laser bias may be kept near the threshold bias level to avoid turn-on and turn-off delays. The off-state optical power affects the system performance when a large number of transmitters are connected to the same distribution network.

3.1.8
optical distribution network
ODN
passive optical network (PON) mainly consisting of optical fibres and splitters

3.1.9
optical modulation index
index m defined as

$$m = \frac{\phi_h - \phi_l}{\phi_h + \phi_l} \quad (1)$$

where ϕ_h is the highest and ϕ_l is the lowest instantaneous optical power of the intensity modulated optical signal

Note 1 to entry: This definition does not apply to systems where the input signals are converted and transported as digital baseband signals. In this case, the terms modulation depth or extinction ratio defined in 2.6.79 and 2.7.46 of IEC TR 61931:1998 are used. A test procedure for extinction ratio is described in IEC 61280-2-2.

[SOURCE: IEC 60728-6:2011,3.1.10, modified – In the definition, "optical modulation" has been deleted and Note 1 has been omitted.]

3.1.10
optical return loss
return loss
ORL
ratio of the total reflected power to the incident power from an optical fibre, optical device, or optical system, and defined as:

$$-10\lg\frac{P_r}{P_i} \quad (2)$$

where

P_r is the reflected power;

P_i is the incident power.

Note 1 to entry: When referring to a reflected power from an individual component, reflectance is the preferred term.

Note 2 to entry: For the purposes of this standard, the term reflectance is used for optical amplifiers only. The term optical return loss is used for ports of all other types of equipment.

Note 3 to entry: The term return loss is also used for electrical ports. The definition relates to electrical powers in this case.

Note 4 to entry: The ratio is expressed in dB.

[SOURCE: IEC TR 61931:1998, 2.6.49, modified – Notes 2 to 4 to entry have been added.]

3.1.11
radio frequency over glass
RFoG
transmission technology on optical networks where information is transmitted in both, forward and return path directions, using RF subcarrier multiplexing technology

3.1.12
responsivity
ratio of an optical detector's electrical output to its optical input at a given wavelength

Note 1 to entry: The responsivity is expressed in ampere per watt (A/W) or volts per watt (V/W) of incident radiant power.

Note 2 to entry: "Sensitivity" is sometimes used as an imprecise synonym for responsivity.

Note 3 to entry: The wavelength interval around the given wavelength may be specified.

[SOURCE: IEC TR 61931:1998, 2.7.56]

3.1.13
relative intensity noise
RIN
ratio of the mean square of the intensity fluctuations in the optical power of a light source to the square of the mean of the optical output power

Note 1 to entry: The RIN is usually expressed in dB(Hz^{-1}) resulting in negative values.

Note 2 to entry: The value for the RIN can be calculated from the results of a RF signal-to-noise measurement for the system.

[SOURCE: IEC 60728-106:2023, 3.1.24]

3.1.14
RFoG optical network unit
R-ONU
fibre optic terminal comprising an optical receiver for reception of analogue signals and an optical transmitter for the transmission of analogue signals originating from the customer side of the optical network, and a coaxial interface for the transmission of analogue signals to the customer network and reception of analogue signals from the customer network generally consisting of digital data using a TDMA (e.g. TDMA mode of DOCSIS) protocol

3.1.15
signal-to-crosstalk ratio
SCR
level difference of desired signal level and worst case of other services single frequency crosstalk signal measured at RF output port of optical receiver

Note 1 to entry: SCR(R_{SC}) is defined by the following equation:

$$R_{SC} = D - U_{OS} \tag{3}$$

where

D is the nominal level of the desired signal in dB(µV) at RF output port of optical receiver;

U_{OS} is the worst-case level of another service's single frequency crosstalk in dB(µV) at RF output port of the optical receiver.

Note 2 to entry: SCR is expressed in dB.

3.1.16
signal-to-noise ratio
SNR
level difference of desired signal level and noise level

Note 1 to entry: SNR is defined for both analogue and digital modulated signals in IEC 60728-13.

[SOURCE: IEC 60728-1:2014, 3.1.80, modified – The term has been replaced.]

3.1.17
slope
gain or attenuation difference at two defined frequencies between two ports of a device or system

Note 1 to entry: In this document, the term slope relates only to the electrical gain or attenuation of equipment.

Note 2 to entry: In equipment for cable networks, a line of best fit of the amplitude frequency response is considered at the band limits.

[SOURCE: IEC 60728-106:2023, 3.1.29]

3.1.18
stimulated Brillouin scattering
SBS
non-linear scattering of optical radiation characterized by a frequency shift as for the Raman scattering, but accompanied by a lower frequency (acoustical) vibration of the medium lattice; the light is scattered backward with respect to the incident radiation

Note 1 to entry: In silica fibres, the frequency shift is typically around 10 GHz.

[SOURCE: IEC TR 61931:1998, 2.1.88]

3.1.19
wavelength
distance covered in a period by the wavefront of a harmonic plane wave

Note 1 to entry: The wavelength λ of light in vacuum is given by

$$\lambda = \frac{c}{f} \tag{4}$$

where

c is the speed of light in vacuum ($c \approx 2{,}997\ 92 \times 10^8$ m/s);

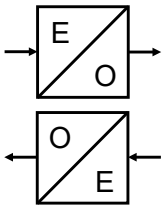
f is the optical frequency.

Note 2 to entry: Although the wavelength in dielectric material such as fibres is shorter than in vacuum, only the wavelength of light in vacuum is used.

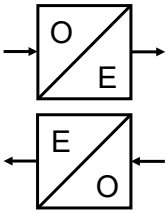
[SOURCE: IEC TR 61931:1998, 2.2.9, modified – Notes to entry have been added.]

3.2 Symbols

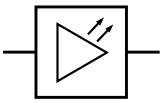
The following graphical symbols are used in the figures of this document. These symbols are either listed in IEC 60617 or based on symbols defined in IEC 60617.



Electrical to optical converter
(Optical transmitter)
based on
IEC 60617-S00213:2001-07

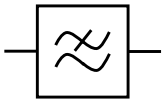


Optical to electrical converter
(Optical receiver)
based on
IEC 60617-S00213:2001-07

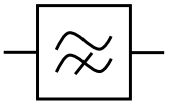


Optical amplifier
based on
IEC 60617-S00127:2001-07 and
IEC 60617-S01239:2001-07

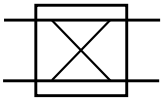
Optical fibre
IEC 60617-S01318:2001-07



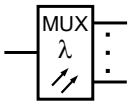
Low-pass filter
IEC 60617-S01248:2001-07,
modified



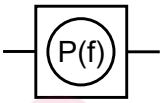
High-pass filter
IEC 60617-S01247:2001-07,
modified



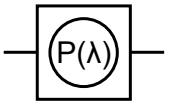
Directional coupler
based on
IEC 60617-S00059:2001-07 and
IEC 60617-S01193:2001-07



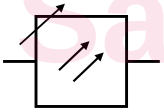
Wavelength-division multiplexer
(WDM)
IEC 60617- S01933:2025-02



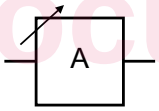
Electrical spectrum analyser
based on
IEC 60617-S00059:2001-07 and
IEC 60617-S00910:2001-07



Optical spectrum analyser
based on
IEC 60617-S00059:2001-07 and
IEC 60617-S00910:2001-07

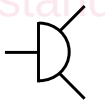


Polarization control device
IEC 60617-S01934:2025-12

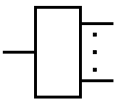


Variable attenuator
IEC 60617-S01245:2001-07

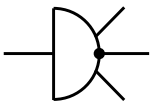
Sine-wave generator
based on
IEC 60617-S00899:2001-07 and
IEC 60617-S01403:2001-09



Splitter, two-way
IEC 60617-S01334:2001-07



Optical splitter based on
[IEC TR 61930:1998 3.33.1]



Splitter, three-way
IEC 60617-S00435:2001-07