INTERNATIONAL STANDARD

# IEC 60728-6

First edition
2001-01

## Cabled distribution systems for television and sound signals –

## Part 6: Optical equipment



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IEC 60728-6:2001(E)

## Publication numbering

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# CABLED DISTRIBUTION SYSTEMS FOR TELEVISION AND SOUND SIGNALS –

## Part 6: Optical equipment

## 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.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.



International Standard IEC 60728-6 has been prepared by subcommittee 100D: Cabled distribution systems, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 100/169/FDIS | 100/198/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 3.

The committee has decided that the contents of this publication will remain unchanged until 2002. At this date, the publication will be

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- withdrawn;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

A bilingual version of this standard may be issued at a later date.

# INTRODUCTION

Standards of the IEC 60728 series deal with cable networks for television signals, sound signals and interactive services including equipment, systems and installations

– for headend-reception, processing and distribution of sound and television signals and their associated data signals, and
– for processing, interfacing and transmitting all kinds of interactive multimedia signals using all applicable transmission media.

They cover all kinds of networks such as

– CATV-networks,
– MATV-networks and SMATV-networks,
– individual receiving networks,

and all kinds of equipment, systems and installations installed in such networks.

The scope of these standards extends from antennas and special signal source inputs to headend or other interface points, to networks as a whole up through system outlets, or terminal inputs where no system outlet exists.

The standardization of any user terminals (i.e. tuners, receivers, decoders, multimedia terminals, etc.) is excluded.

# CABLED DISTRIBUTION SYSTEMS FOR TELEVISION AND SOUND SIGNALS –

## Part 6: Optical equipment

## 1 Scope

This part of IEC 60728 lays down the measuring methods, performance requirements and data publication requirements of optical equipment of cable networks for television signals, sound signals and interactive services.

This standard

– applies to all optical transmitters, receivers, amplifiers, splitters, directional couplers, isolators, multiplexers, connectors and splices used in cable networks;
– covers the frequency range 5 MHz to 3 000 MHz;

  NOTE The upper limit of 3 000 MHz is an example, but not a strict value. The frequency range or ranges, over which the equipment is specified, shall be published.
– identifies guaranteed performance requirements for certain parameters;
– lays down data publication requirements with guaranteed performance;
– describes methods of measurement for compliance testing.

All requirements and published data relate to minimum performance levels within the specified frequency range and in well-matched conditions as might be applicable to cable networks for television signals, sound signals and interactive services.



## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60728. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60728 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60068-2 (all parts), *Environmental testing – Part 2: Tests*

IEC 60416, *General principles for the formulation of graphical symbols*

IEC 60417-1, *Graphical symbols for use on equipment – Part 1: Overview and application*

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

IEC 60617 (all parts), *Graphical symbols for diagrams*

IEC 60728-1:1986, *Cabled distribution systems – Part 1: Systems primarily intended for sound and television signals operating between 30 MHz and 1 GHz*

IEC 60728-2, *Cabled distribution systems for television and sound signals – Part 2: Electromagnetic compatibility of equipment* [1)]

IEC 60728-3: 1997, *Cabled distribution systems for television and sound signals – Part 3: Active coaxial wideband distribution equipment*

IEC 60728-5, *Cabled distribution systems for television and sound signals – Part 5: Headend equipment* [1)]

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification, requirements and user's guide* [1)]

## 3 Terms, definitions, symbols and abbreviations

### 3.1 Terms and definitions

For the purposes of this part of IEC 60728, the following definitions apply.

**3.1.1**
**optical transmitter**
device for converting electrical signals into optical signals. It consists of a light source (for example, laser) and its associated components as well as all components between the coaxial input and optical output connectors



**3.1.2**
**optical receiver**
device for converting optical signals into electrical signals. It consists of a detector (for example, PIN-diode) and its associated components as well as all the components between the optical input and coaxial output connectors



**3.1.3**
**optical amplifier**
device for amplifying optical signals direct. It consists of an active medium (and its associated components), which amplifies the optical signal without demodulation or regeneration

**3.1.4**
**optical isolator**
device which transports optical power in one direction only

**3.1.5**
**optical fibre splice**
permanent joint of two fibre ends

**3.1.6**
**splitter**
device in which the signal power at the (input) port is divided equally or unequally between two or more (output) ports

NOTE Some forms of this device may be used in the reverse direction for combining signal energy.

**3.1.7**
**directional coupler**
splitter in which the attenuation between any two output ports exceeds the sum of the attenuations between the input port and each of those output ports

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[1)] To be published

**3.1.8**
**multiplexer**
device in which the signal energy covering a frequency band at one input port is divided between two or more output ports each of which covers a part of that frequency band

NOTE 1 For example, a diplexer is a two-port multiplexer.

NOTE 2 Some forms of this device may be used in the reverse direction for combining.

**3.1.9**
**extinction ratio**
ratio of the high-level $\phi_h$ optical power to the low-level $\phi_l$ optical power of a modulated optical transmitter:

$$e = \frac{\phi_h}{\phi_l} \qquad (1)$$

This term is mainly used for digital systems

**3.1.10**
**optical modulation index**
the optical modulation index is defined as:

$$m = \frac{\phi_h - \phi_l}{\phi_h + \phi_l} \qquad (2)$$

where $\phi_h$ is the highest and $\phi_l$ is the lowest instantaneous optical power of the intensity modulated optical signal. This term is mainly used for analogue systems



**3.1.11**
**noise figure/factor**
figures of merit describing the internally generated noise of an active device. The noise factor NF is the ratio of the carrier-to-noise ratio at the input to the carrier-to-noise ratio at the output of an active device, assuming the incoming carrier is noise-free:



$$\mathrm{NF} = \frac{C_1 / N_1}{C_2 / N_2} \qquad (3)$$

where

$C_1$ is the signal power at the input;

$C_2$ is the signal power at the output;

$N_1$ is the noise power at the input
(ideal thermal noise for electrical devices; quantum noise for optical devices);

$N_2$ is the noise power at the output.

In other words, the noise factor is the ratio of noise power at the output of an active device to the noise power at the same point if the device had been ideal and added no noise:

$$\mathrm{NF} = \frac{N_{2,\mathrm{actual}}}{N_{2,\mathrm{ideal}}} \qquad (4)$$

The noise factor is dimensionless and is often expressed as noise figure $F$ in dB:

$$F = 10 \lg \mathrm{NF} \qquad (5)$$

**3.1.12**
**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 The value for the RIN can be calculated from the results of a carrier-to-noise measurement for the system (see 4.19).

**3.1.13**
**noise equivalent power (NEP)**
notional optical power which, when applied to the input of a noiseless optical receiver, would give rise to an electrical output noise power density equal to that observed at the output of an actual receiver under consideration

NOTE The *NEP* can be calculated from the carrier-to-noise ratio C/N (see 4.19) of a receiver using:

$$NEP = \frac{mP}{\sqrt{2B}} 10^{-\frac{1}{20}\mathrm{C/N}} \quad (6)$$

In this equation, $m$ is the optical modulation index, $P$ is the received optical power and $B$ is the bandwidth. The *NEP* shall be expressed in units of W/√Hz.

**3.1.14**
**equivalent input noise current density**
notional input noise current density which, when applied to the input of an ideal noiseless device, would produce an output noise current density equal in value to that observed at the output of the actual device under consideration

NOTE It can be calculated from the carrier-to-noise ratio C/N (see 4.19) of a device or system using:

$$I_r = \sqrt{\frac{C}{Z 10^{\frac{1}{10}\mathrm{C/N}}}} \quad (7)$$

In this equation, $C$ is the amplitude of the carrier at the input of the device or system and $Z$ is its input impedance. The equivalent input noise current density shall be expressed in units of A/√Hz.



**3.1.15**
**bit error rate (BER)**
number of erroneous bits at the output of a system divided by the total number of received bits. This term is used in digital transmission systems

**3.1.16**
**responsivity**
ratio of the output current of a photodiode to the incident optical power

$$r_s = \frac{I}{P} \quad \text{(static responsivity)} \quad (8)$$

$$r_d = \frac{dI}{dP} \quad \text{(dynamic responsivity)} \quad (9)$$

For practical purposes, static and dynamic responsivities can be assumed to be equal.

**3.1.17**
**voltage responsivity of an optical receiver**
ratio of the change of output voltage to the change of the incident optical power

$$r_V = \frac{dU}{dP} \quad (10)$$

**3.1.18**
**chromatic dispersion**
minus the change of group travel time per unit length of fibre per change of wavelength

NOTE The velocity at which an optical pulse travels on a fibre depends on its wavelength.

**3.1.19**
**wavelength**
the wavelength $\lambda$ of light in vacuum is given by

$$\lambda = \frac{c}{f} \tag{11}$$

where

c is $2{,}99793 \times 10^8$ m/s (speed of light in vacuum);

$f$ is the optical frequency.

Although the wavelength in dielectric material such as fibres is shorter than in a vacuum, only the wavelength of light in a vacuum is used

**3.1.20**
**chirp**
incidental frequency modulation caused by the intensity modulation of a laser diode

NOTE Chirping effectively broadens the laser spectral bandwidth. Due to the chromatic dispersion of the fibre, parts of the spectrum travel at different speeds, resulting in harmonic distortion of the transferred signal.



**3.1.21**
**polarization**
projection of the electric vector on a plane perpendicular to the direction of transmission of the polarized light wave

**3.1.22**
**linewidth**
spectral bandwidth of an individual mode of a laser, defined as the difference between those optical frequencies at which the amplitude reaches or first falls to half of the maximum amplitude

**3.1.23**
**coherence time and coherence length**
coherence time is the time which light needs to travel the coherence length; coherence length is the reciprocal of $2\pi$ times the linewidth. Both values are used to describe the phase stability of a light source

**3.1.24**
**well-cleaved**
well-cleaved end of a fibre has a clean plane front perpendicular to the axis of the fibre

**3.1.25**
**amplified spontaneous emission (ASE)**
part of an optical amplifier's output power caused by photons emitted from excited ions whose lifetime was over before their energy was used for amplification

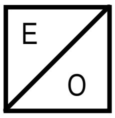
**3.1.26**
**directivity**
attenuation between the output port and interface port minus the attenuation between input and interface port, of any equipment or system

**3.1.27**
**central wavelength**
average of those wavelengths at which the amplitude of a light source reaches or last falls to half of the maximum amplitude

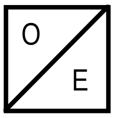
**3.1.28**
**spectral width**
difference of those wavelengths at which the amplitude of a light source reaches or last falls to half of the maximum amplitude

## 3.2 Symbols

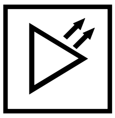
The following graphical symbols are used in the figures of this standard. These symbols are either listed in IEC 60617 or based on symbols defined in IEC 60617.

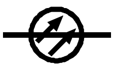


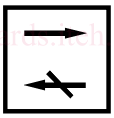
Optical transmitter [10-14-01]

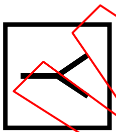


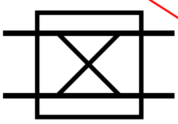
Optical receiver [10-14-01]

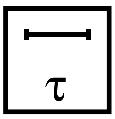

Optical amplifier [02-09-01, 10-15-01]


Optical fibre [10-23-1]

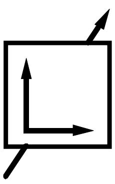

Isolator [10-08-20]

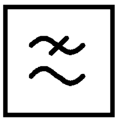

Coupler [02-01-01, 10-09-04]

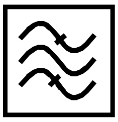

Directional coupler [02-01-01, 10-09-09]

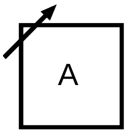


Delay line [10-16-23]

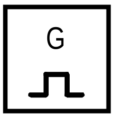

Polarization control device


Low-pass filter [10-16-5]

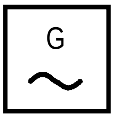

Bandpass filter [10-16-6]



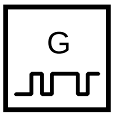
Variable attenuator [10-16-02]



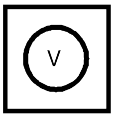
Pulse generator [10-13-04]



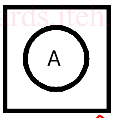
Sine-wave generator [10-13-02]



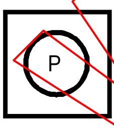
Bit pattern generator



Voltmeter [02-01-01, 08-02-01]

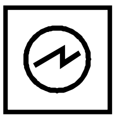


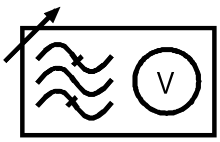
Current meter [02-01-01, 08-01-01]



Power meter [02-01-01, 08-01-01]

Bit error detector [02-01-01, 08-01-01]


Oscilloscope [02-01-01, 08-02-10]



Selective voltmeter [02-01-02, 02-03-01, 08-01-01, 10-16-06]