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Cable networks for television signals, sound signals and interactive services –

Part 6-1: System guidelines for analogue optical transmission systems

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CABLE NETWORKS FOR TELEVISION SIGNALS, SOUND SIGNALS AND INTERACTIVE SERVICES –

Part 6-1: System guidelines for analogue optical transmission systems

FOREWORD

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IEC 60728-6-1, which is a technical report, has been prepared by technical area 5: Cable networks for television signals, sound signals and interactive services, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
100/1078/DTR	100/1142A/RVC

Full information on the voting for the approval of this technical report 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.

A 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.

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- withdrawn,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.

A bilingual version of this publication 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

- head-end reception, processing and distribution of sound and television signals and their associated data signals;
- processing, interfacing and transmitting all kinds of signals for interactive services using all applicable transmission media.

All kinds of networks like

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

and all kinds of equipment, systems and installations installed in such networks, are within this scope.

The extent of this standardization work is from the antennas, special signal source inputs to the head-end or other interface points to the network up to the terminal input.

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

CABLE NETWORKS FOR TELEVISION SIGNALS, SOUND SIGNALS AND INTERACTIVE SERVICES –

Part 6-1: System guidelines for analogue optical transmission systems

1 Scope

This part of IEC 60728 provides guidelines and procedures for determining the overall performance of optical transmissions systems used in cable networks for television signals, sound signals and interactive services. It is based on the requirements for optical equipment defined in IEC 60728-6 and should be used together with this standard. The information provided is meant to help field engineers and network planners (system designers) in planning and designing optical systems. Though this content is less dense than in a standard, basic knowledge about system parameters of cable networks is needed.

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.

IEC 60728-1, *Cable networks for television signals, sound signals and interactive services – Part 1: Methods of measurement and system performance*

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

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

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

IEC 61931, *Fibre optics – Terminology*

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms, definitions, symbols and abbreviations given in IEC 60728-1, IEC 60728-6 and IEC/TR 61931 apply.

3.1 Symbols

In addition to the symbols given in the above-mentioned references, the following graphical symbol is used in the figures of this technical report.

$\boxed{\text{WDM}}$	wavelength division multiplexer

3.2 Abbreviations

In addition to the abbreviations given in the above-mentioned references, the following abbreviations are used in this technical report.

2HD second harmonic distortion

3HD third harmonic distortion

DFB distributed feedback

DWDM dense wavelength division multiplex

IIN induced intensity noise

IMD2 second-order intermodulation

IMD3 third-order intermodulation

IM-DD intensity modulation – direct detection

I_r equivalent input noise current density of an optical receiver

OMI optical modulation index

MPI multi-path interference

PMD polarization mode dispersion

PMP point-to-multi-point

PTP point-to-point

RMS root-mean-square

SBS stimulated Brillouin scattering

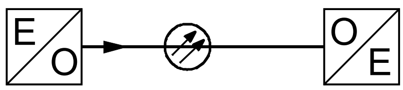
WDM wavelength division multiplexer

4 Topologies used for optical transmission systems in cable networks

The overall performance of optical transmission systems depends on many parameters and conditions. Separating the applications into different categories simplifies the step-by-step analysis and leads to a better overview. A logical way to build up these categories is to distinguish different network topologies because it can be assumed that the network architecture is always known in advance. Starting from this point of view the following five topologies can be identified as relevant for the user.

4.1 Point-to-point system

Point-to-point (PTP) systems consist of a single optical transmitter and a single optical receiver connected by a single line of fibre (Figure 1).



IEC 2154/06

Figure 1 – Point-to-point system

This configuration can typically be found in trunk-line feeding areas cabled with coax (HFC networks). Both wavelengths, 1 310 nm and 1 550 nm, are used for these systems. Most of the optical budget is consumed by the fibre attenuation (long-distance system). At 1 550 nm, optical amplifiers can be used to extend the range of this kind of system.

4.2 Point-to-multi-point system

In point-to-multi-point (PMP) systems, a single optical transmitter feeds more than one optical receiver. The receivers are connected to a main fibre via optical couplers and tap fibres as shown in Figure 2.

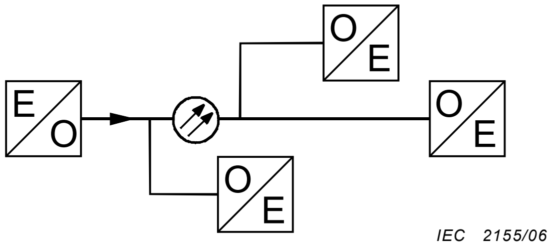


Figure 2 – Point-to-multi-point system

An alternative configuration for feeding more than one receiver from a single transmitter is to use an optical splitter at the transmitter node and individual fibres from the transmitter node to each receiver. This leads to a star topology, which should be treated as multiple PTP systems with a single transmitter.

PMP systems are typically used when different coaxial parts of a network shall be supplied with the same signal saving as much fibre as possible (optical distribution systems). Depending on the fibre lengths, both wavelengths are used. At 1 550 nm, optical amplifiers can be used to compensate for the fibre and splitting losses.

4.3 Multi-point-to-point system

Multi-point-to-point systems consist of at least two transmitters with different wavelengths sending their signals to a common receiver. The transmitter signals may be combined by an optical coupler or, if the link loss is critical, by a wavelength multiplexer (Figure 3).

Figure 3 – Multipoint-to-point system

Since optical receivers usually have a very broad input wavelength range, the central wavelengths of the transmitters may be extremely different (for example, 1 310 nm and 1 550 nm). In order to avoid signal mixing in the receiver, the optical spectrums of the transmitters shall differ at least by the upper limit of the receiver's electrical frequency range. If only signals in the 1 550 nm wavelength range are used, optical amplifiers can be employed for extending the fibre length. Since all input signals of the system are provided at the same system output, different frequency ranges have to be used for modulating the transmitters.

This kind of topology is typically chosen if part of a network shall be provided with signals from different locations.

4.4 Real wavelength division multiplex system

Real wavelength division multiplex systems consist of at least two PTP systems operating on the same fibre. The transmitter signals are combined at the transmitter node with a wavelength multiplexer or, if the link loss is not critical, by an optical coupler. At the receiver node, the different signals are separated by another wavelength multiplexer and led to individual receivers (Figure 4).

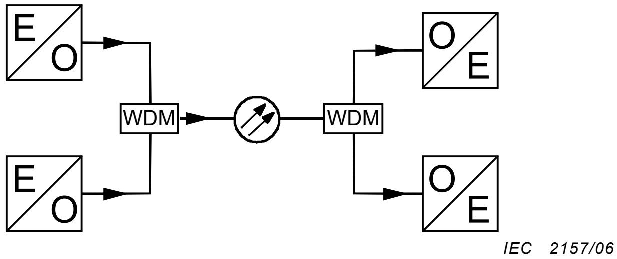


Figure 4 – Real wavelength division multiplex system

For only two different wavelengths, this configuration can be built up easily combining a 1 310 nm system and a 1 550 nm system. If wavelength dependent fibre losses cannot be tolerated, or more than two PTP systems have to be combined, closer spacing of the wavelengths shall be chosen (DWDM = dense WDM). This is usually done in the 1 550 nm wavelength range. Optical amplifiers can be used to achieve longer link lengths in this case. Care has to be taken to avoid overlapping of the transmitters spectrums. Narrow wavelength spacing means high efforts to control the transmitter wavelengths and high costs for the wavelength division multiplexers.

The main reason for using this configuration is to save fibres. This approach allows for the transmission of digital and analogue modulated signals over the same fibre.

4.5 Combinations

The basic configurations described above can be combined to more complex architectures. The best way of dealing with such complex structures is to split them up into their basic parts which could be treated separately.

5 Influences of equipment and fibre parameters on the system performance

The performance of analogue optical transmission systems depends not only on various equipment parameters but also on the properties of the fibre installation. Some of these parameters and properties interact in a way making it necessary to look at the transmission system at a whole. The interdependencies between the equipment and system properties and the performance parameters are shown in Table 1. The numbers in the table refer to the clauses of this technical report containing the relevant information.

Table 1 – Interdependencies between equipment and system properties and performance parameters

Equipment properties and effects		System performance parameters				
		C/N	**CSO**	**CTB**	**Flatness**	**Output level**
TX	OMI	Clauses 6 and 7	Clause 6, 8.2	Clause 6, 8.1	(Clause 9)	Clauses 6 and 10
	CSO		8.1			
	CTB			8.2		
	Line width	B.1.2				
	Chirping	7.2	C.3.7.1, C.3.7.2	C.4.1		
	RIN	Clause 7				
	Power	Clause 7				Clause 10
	λ	(7.3)				
	Flatness				Clause 9	
RX	I_r	Clause 7				
	CSO		8.1			
	CTB			8.2		
	Flatness				Clause 9	
	AGC range				Clause 9	Clause 10
OFA	F	7.4				
	Power	7.4				Clause 10
	Gain	7.4	(8.1.2)	(8.2)		
	λ	7.4				
Fibre	Dispersion		C.3.7.1, C.3.7.2	(8.2)		
	SBS	(7.2)	(8.1.2)	(C.4.3)		
	SPM		C.3.10			
	PMD		(8.1.1)			
	Loss	Clause 7				Clause 10
Passive	Return loss	(B.1.3)				
	PDL		(C.3.7.2)			
	Loss	Clause 7				Clause 10
X: relevant		(X): can be relevant				

This table can be used as an entry point and quick reference to the contents of this technical report.

6 Optical modulation index

The optical modulation index (OMI) is one of the most important parameters of analogue optical links. It shall be chosen very carefully in order to obtain the best carrier-to-noise ratio without getting too much distortion due to clipping effects (see C.3.3).