

TECHNICAL REPORT

IEC TR 60728-6-1

First edition
2006-12

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

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

© IEC 2006 — Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, 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
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE

X

For price, see current catalogue

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references.....	7
3 Terms, definitions, symbols and abbreviations.....	7
3.1 Symbols.....	7
3.2 Abbreviations.....	7
4 Topologies used for optical transmission systems in cable networks.....	8
4.1 Point-to-point system.....	8
4.2 Point-to-multi-point system.....	8
4.3 Multi-point-to-point system.....	9
4.4 Real wavelength division multiplex system.....	10
4.5 Combinations.....	10
5 Influences of equipment and fibre parameters on the system performance.....	10
6 Optical modulation index.....	11
6.1 Single wavelength system.....	12
6.2 WDM systems.....	13
6.3 Choosing the right input level at the transmitter.....	13
7 Carrier-to-noise ratio.....	14
7.1 Short-haul links with a single transmitter.....	14
7.2 Long-haul point-to-point link.....	15
7.3 Multiple transmitter systems (WDM).....	16
7.4 Transmission systems with optical fibre amplifier.....	16
8 Linearity.....	17
8.1 Composite second order (CSO).....	18
8.2 Composite triple beat (CTB).....	20
9 Flatness.....	21
10 Output level.....	21
Annex A (informative) Brillouin scattering in optical fibres.....	22
Annex B (informative) Noise sources of optical transmission systems.....	24
Annex C (informative) Non-linear distortion in optical transmission systems.....	29
Bibliography.....	44
Figure 1 – Point-to-point system.....	8
Figure 2 – Point-to-multi-point system.....	9
Figure 3 – Multipoint-to-point system.....	9
Figure 4 – Real wavelength division multiplex system.....	10
Figure 5 – Definition of OMI for an optical transmitter.....	12
Figure C.1 – Distortion of Volterra series expansion.....	30

Figure C.2 – Weighted second- and third-order distortion repartition for the 42 carriers frequency allocation map defined in Table C.1 of IEC 60728-3 (software window capture)	31
Figure C.3 – Polarization-mode dispersion in single-mode fibre	33
Figure C.4 – Static curve of a laser showing the clipping effect.....	34
Figure C.5 – Transmitted and back-scattered power in the range of the Brillouin threshold	35
Figure C.6 – Cause of self-phase modulation.....	35
Figure C.7 – CSO caused by laser chirping and chromatic dispersion	37
Figure C.8 – CSO degradation without PDL	38
Figure C.9 – CSO degradation with PDL = 0,5 dB [12]	38
Figure C.10 – Simulated and measured intermodulation due to laser clipping	39
Figure C.11 – Zoom on a CTB	43
Table 1 – Interdependencies between equipment and system properties and performance parameters	11
Table C.1 – Weightings of HD2, HD3, IMD2 and IMD3	30

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. 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 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 IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

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*