

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.973

(11/2016)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Optical fibre
submarine cable systems

Characteristics of repeaterless optical fibre submarine cable systems

Recommendation ITU-T G.973



International
Telecommunication
Union

Documents
Document Sharing Hub

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
General	G.900–G.909
Parameters for optical fibre cable systems	G.910–G.919
Digital sections at hierarchical bit rates based on a bit rate of 2048 kbit/s	G.920–G.929
Digital line transmission systems on cable at non-hierarchical bit rates	G.930–G.939
Digital line systems provided by FDM transmission bearers	G.940–G.949
Digital line systems	G.950–G.959
Digital section and digital transmission systems for customer access to ISDN	G.960–G.969
Optical fibre submarine cable systems	G.970–G.979
Optical line systems for local and access networks	G.980–G.989
Metallic access networks	G.990–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.973

Characteristics of repeaterless optical fibre submarine cable systems

Recommendation ITU-T G.973 is concerned primarily with the system performance and interface requirements of repeaterless optical fibre submarine cable systems. It considers both single wavelength systems (SWS), wavelength division multiplexing systems (WDMS), and dense wavelength division multiplexing systems (DWDMS). It also covers the aspects related to the applications of discrete optical fibre amplifiers (OFAs) (power amplifiers, pre-amplifiers, remote optically pumped amplifiers) and/or distributed remotely pumped OFAs using Raman amplification.

This edition of the Recommendation introduces a new power budget template for the implementation of coherent systems.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.973	1996-11-11	15	11.1002/1000/3831
2.0	ITU-T G.973	2003-12-14	15	11.1002/1000/7068
3.0	ITU-T G.973	2007-07-29	15	11.1002/1000/9158
4.0	ITU-T G.973	2010-07-29	15	11.1002/1000/10883
5.0	ITU-T G.973	2016-11-13	15	11.1002/1000/13117

Keywords

Repeaterless optical fibre submarine cable systems, remote optically pumped amplifier (ROPA)

* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/1830-en>.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2017

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Table of Contents

		Page
1	Scope.....	1
2	References.....	1
3	Definitions	3
3.1	Terms defined elsewhere	3
3.2	Terms defined in this Recommendation.....	4
4	Abbreviations and acronyms	4
5	Conventions	6
6	Characteristics and performance of the system	6
6.1	Characteristics and performance of the digital line sections (DLS).....	6
6.2	Characteristics and performance of the optical sections	8
6.3	System reliability performance.....	12
6.4	System capacity upgradeability	12
7	Characteristics and performance of the TTE	12
7.1	General	12
7.2	Transmission performance	12
7.3	Actions consequent to an alarm.....	14
7.4	Automatic switching.....	14
8	Characteristics and performance of the submarine cable	14
8.1	Dispersion mapping.....	14
8.2	Dispersion management implementation	14
	Annex A – Implementation of repeaterless optical fibre submarine cable systems	16
A.1	Introduction	16
A.2	System configuration.....	18
A.3	Characteristics of the line signal.....	21
A.4	System operation	22
A.5	Passive branching unit characteristics	22
	Annex B – Repeaterless optical fibre submarine cable systems using ROPA: Optical power budget between optical reference points S and R and line monitoring	24
B.1	Remote optically pumped amplifiers (ROPAs).....	24
B.2	Optical power budget for systems using ROPA.....	24
B.3	Line monitoring for pumping portion.....	25
	Bibliography.....	27

Recommendation ITU-T G.973

Characteristics of repeaterless optical fibre submarine cable systems

1 Scope

This Recommendation is concerned primarily with the system performance and interface requirements of repeaterless optical fibre submarine cable systems; it considers both single wavelength systems (SWS), wavelength division multiplexing systems (WDMS) and dense wavelength division multiplexing systems (DWDMS). It also covers the aspects related to the applications of discrete optical fibre amplifiers (OFAs) as power amplifiers, pre-amplifiers and/or remote optically pumped amplifiers (ROPA) (either erbium-doped transmission fibres using remote pumping from the terminal or the distributed Raman amplification pumped from the terminal).

The purpose of a repeaterless optical fibre submarine cable system is to establish transmission links between two or more terminal stations located in a restricted geographical area.

A cable system connecting only two terminal stations may be termed an "optical fibre submarine cable link". When it connects more than two terminal stations, it may be termed an "optical fibre submarine cable network".

In a repeaterless submarine cable system, no power feeding equipment (PFE) is necessary as there is no in-line OFA.

As far as the branching unit devices are concerned, those considered in this Recommendation are the passive ones, therefore avoiding electronic components and supervisory and power feeding.

Common implementation aspects of optical submarine cable systems for manufacturing, installing and maintenance are described in [ITU-T G.971]. [ITU-T G.978] contains common aspects of the characteristics of the optical fibre submarine cables. [ITU-T G.979] is also concerned with the characteristics of monitoring systems for repeaterless optical fibre submarine cable systems.

The physical implementation of repeaterless optical fibre submarine cable systems and the implications of the use of ROPA are considered respectively in Annexes A and B.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a standalone document, the status of a Recommendation.

- [ITU-T G.661] Recommendation ITU-T G.661 (2007), *Definition and test methods for the relevant generic parameters of optical amplifier devices and subsystems*.
- [ITU-T G.662] Recommendation ITU-T G.662 (2005), *Generic characteristics of optical amplifier devices and subsystems*.
- [ITU-T G.664] Recommendation ITU-T G.664 (2012), *Optical safety procedures and requirements for optical transport systems*.
- [ITU-T G.665] Recommendation ITU-T G.665 (2005), *Generic characteristics of Raman amplifiers and Raman amplified subsystems*.

- [ITU-T G.692] Recommendation ITU-T G.692 (1998), *Optical interfaces for multichannel systems with optical amplifiers.*
- [ITU-T G.698.1] Recommendation ITU-T G.698.1 (2009), *Multichannel DWDM applications with single-channel optical interfaces.*
- [ITU-T G.701] Recommendation ITU-T G.701 (1993), *Vocabulary of digital transmission and multiplexing, and pulse code modulation (PCM) terms.*
- [ITU-T G.702] Recommendation ITU-T G.702 (1988), *Digital hierarchy bit rates.*
- [ITU-T G.703] Recommendation ITU-T G.703 (2016), *Physical/electrical characteristics of hierarchical digital interfaces.*
- [ITU-T G.707] Recommendation ITU-T G.707/Y.1322 (2007), *Network node interface for the synchronous digital hierarchy (SDH).*
- [ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2016), *Interfaces for the optical transport network*
- [ITU-T G.780] Recommendation ITU-T G.780/Y.1351 (2010), *Terms and definitions for synchronous digital hierarchy (SDH) networks.*
- [ITU-T G.821] Recommendation ITU-T G.821 (2002), *Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Services Digital Network.*
- [ITU-T G.823] Recommendation ITU-T G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy.*
- [ITU-T G.825] Recommendation ITU-T G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH).*
- [ITU-T G.826] Recommendation ITU-T G.826 (2002), *End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections.*
- [ITU-T G.828] Recommendation ITU-T G.828 (2000), *Error performance parameters and objectives for international, constant bit-rate synchronous digital paths.*
- [ITU-T G.921] Recommendation ITU-T G.921 (1988), *Digital sections based on the 2048 kbit/s hierarchy.*
- [ITU-T G.955] Recommendation ITU-T G.955 (1996), *Digital line systems based on the 1544 kbit/s and the 2048 kbit/s hierarchy on optical fibre cables.*
- [ITU-T G.957] Recommendation ITU-T G.957 (2006), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy.*
- [ITU-T G.959.1] Recommendation ITU-T G.959.1 (2016), *Optical transport network physical layer interfaces.*
- [ITU-T G.971] Recommendation ITU-T G.971 (2016), *General features of optical fibre submarine cable systems.*
- [ITU-T G.972] Recommendation ITU-T G.972 (2016), *Definition of terms relevant to optical fibre submarine cable systems.*
- [ITU-T G.975] Recommendation ITU-T G.975 (2000), *Forward error correction for submarine systems.*
- [ITU-T G.975.1] Recommendation ITU-T G.975.1 (2004), *Forward error correction for high bit-rate DWDM submarine systems.*

- [ITU-T G.978] Recommendation ITU-T G.978 (2010), *Characteristics of optical fibre submarine cables*.
- [ITU-T G.979] Recommendation ITU-T G.979 (2016), *Characteristics of monitoring systems for optical fibre submarine cable systems*.
- [ITU-T G.8201] Recommendation ITU-T G.8201 (2011), *Error performance parameters and objectives for multi-operator international paths within optical transport networks*.
- [ITU-T G.8251] Recommendation ITU-T G.8251 (2010), *The control of jitter and wander within the optical transport network (OTN)*.
- [IEC 60825-1] IEC 60825-1 (2014), *Safety of laser products – Part 1: Equipment classification and requirements*.
- [IEC 60825-2] IEC 60825-2 (2006), *Safety of laser products – Part 2: Safety of optical fibre communication systems (OCFS)*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

- 3.1.1 **digital line section (DLS)** [ITU-T G.701]
- 3.1.2 **double armoured cable** [ITU-T G.972]
- 3.1.3 **intermediate terrestrial interface (ITI)** [ITU-T G.972]
- 3.1.4 **multiplex section overhead (MSOH)** [ITU-T G.780]
- 3.1.5 **optical fibre amplifier (OFA)** [ITU-T G.661]
- 3.1.6 **receive main path interface reference point (MPI-R)** [ITU-T G.959.1]
- 3.1.7 **rock armoured cable** [ITU-T G.972]
- 3.1.8 **S', R' reference points** [ITU-T G.662]
- 3.1.9 **single armoured cable** [ITU-T G.972]
- 3.1.10 **source main path interface reference point (MPI-S)** [ITU-T G.959.1]
- 3.1.11 **submarine cable optical interface (SCOI)** [ITU-T G.977]
- 3.1.12 **submarine electro-optic interface (SEOI)** [ITU-T G.977]
- 3.1.13 **synchronous digital hierarchy (SDH)** [ITU-T G.780]
- 3.1.14 **synchronous transport module (STM)** [ITU-T G.780]
- 3.1.15 **terrestrial interface (TI)** [ITU-T G.972]
- 3.1.16 **time varying system penalty (TVSP)** [ITU-T G.977]

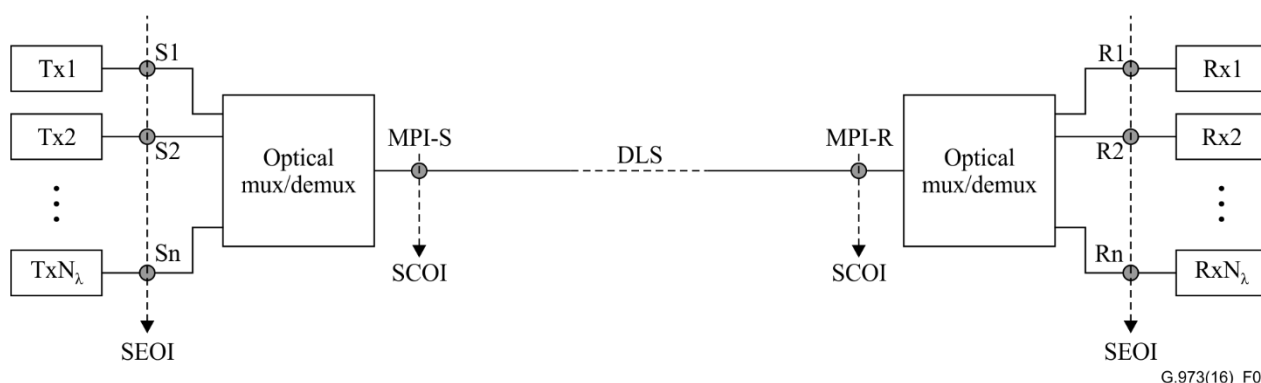


Figure 1 – Representation of optical line system interfaces (multichannel system)

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 branching unit (BU): A passive optical submarine piece of equipment inserted into the submarine portion of an optical fibre submarine cable network where the interconnection of more than two cable sections is necessary.

3.2.2 cable jointing box: Box to be installed on optical submarine or land cable, in case of junction or repair of the cable itself, which is designed to provide mechanical, electrical and optical continuity, waterproofness and storage of the fibre splices and fibre extra length.

3.2.3 distributed Raman amplifier (DRA): An OFA using the transmission fibre, as an amplifier medium, that is pumped from the terminal station. The gain is obtained all along the fibre (therefore distributed) using the Raman properties of the fibre until sufficient pump power is available.

3.2.4 remote optically pumped amplifier (ROPA): An OFA consisting of a section of erbium doped fibre that is activated by a pump beam sent from the terminal station.

3.2.5 terminal transmission equipment (TTE): The equipment included into the terrestrial portion of an optical fibre submarine cable system for terminal transmission multiplexing and demultiplexing operations, coding and converting the incoming tributaries into the optical line signal, converting and decoding the received optical line signal in the outgoing tributaries, performing cable termination operations.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ASE	Amplified Spontaneous Emission
BER	Bit Error Ratio
BOL	Beginning Of Life
BU	Branching Unit
COTDR	Coherent Optical Time-Domain Reflectometry
CSF	Cut-off Shifted single mode Fibre
DCF	Dispersion Compensation single mode Fibre
DC PDM-BPSK	Dual Carrier Polarization-Division-Multiplexed Binary-Phase-Shift-Keying

DC PDM-DBPSK	Dual Carrier Polarization-Division-Multiplexed Differential Binary-Phase-Shift-Keying
DLS	Digital Line Section
DRA	Distributed Raman Amplifier
DSF	Dispersion Shifted single mode Fibre
DWDM	Dense Wavelength Division Multiplexing
DWDMS	Dense Wavelength Division Multiplexing System
EDF	Erbium Doped Fibre
EOL	End Of Life
ITI	Intermediate Terrestrial Interface
MPI-R	Receive Main Path Interface reference point
MPI-S	Source Main Path Interface reference point
MSOH	Multiplex Section Overhead
MTC	Marinized Terrestrial Cable
NDSF	Non Dispersion Shifted single mode Fibre
NRZ	No Return to Zero
NZDSF	Non-Zero Dispersion Shifted single mode Fibre
OFA	Optical Fibre Amplifier
OSNR	Optical Signal-to-Noise Ratio
OTDR	Optical Time-Domain Reflectometry
OTN	Optical Transport Network
PDG	Polarization Dependent Gain
PDH	Plesiochronous Digital Hierarchy
PDL	Polarization Dependent Loss
PDM-DQPSK	Polarization-Division-Multiplexed Differential Quadrature-Phase-Shift-Keying
PDM-QPSK	Polarization-Division-Multiplexed Quadrature-Phase-Shift-Keying
PFE	Power Feeding Equipment
PMD	Polarization Mode Dispersion
ROPA	Remote Optically Pumped Amplifier
SCOI	Submarine Cable Optical Interface
SDH	Synchronous Digital Hierarchy
SEOI	Submarine Electro-Optic Interface
SMF	Single-Mode Fibre
STM	Synchronous Transport Module
SWS	Single Wavelength System
TI	Terminal Interface