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

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

Characteristics of optically amplified optical fibre submarine cable systems

Recommendation ITU-T G.977

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Recommendation ITU-T G.977

Characteristics of optically amplified optical fibre submarine cable systems

Summary

Recommendation ITU-T G.977 is concerned with the system performance and interface requirements of repeatered optical submarine systems using optical fibre amplifiers (OFAs) as line repeaters. It covers the aspects related to single wavelength systems (SWS), wavelength division multiplexing systems (WDMS) and dense wavelength division multiplexing systems (DWDMS). The physical implementation of optically amplified fibre submarine systems is considered in Annex A.

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

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Recommendation ITU-T G.977

Characteristics of optically amplified optical fibre submarine cable systems

1 Scope

This Recommendation is concerned with the system performances and interface requirements of repeatered optical fibre submarine cable systems using optical line amplifiers (OFAs) as line repeaters. It covers the aspects related to single wavelength systems (SWS), wavelength division multiplexing systems (WDMS) and dense wavelength division multiplexing systems (DWDMS). Depending on the system specifications, such as the number of terminations, the connectivity, the total capacity, the maximum end-to-end distance, and/or the system cost, one of these three types of systems may be more appropriate to guarantee the system requirements. A high data capacity may be carried by one wavelength using a high data bit-rate, or by several wavelengths using a smaller one.

From a general point of view, the characteristics, performance specifications and requirements of the submerged equipment are mostly identical for SWS, WDMS and DWDMS. Indeed, SWS appears as a specific case of WDMS using one wavelength and, in turn, WDMS can be considered as a specific case of DWDMS with a small number of wavelengths. As a consequence, general statements mentioned in this Recommendation can be applied to SWS, WDMS and DWDMS. However, when necessary, more detailed Recommendations will highlight the specificity of these three types of systems.

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 optical fibre submarine cable systems with repeaters.

The physical implementation of optically amplified fibre submarine systems is considered in Annex A.

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 stand-alone document, the status of a Recommendation.

- | | |
|---------------|---|
| [ITU-T G.661] | Recommendation ITU-T G.661 (2007), <i>Definitions and test methods for the relevant generic parameters of optical amplifier devices and subsystems.</i> |
| [ITU-T G.662] | Recommendation ITU-T G.662 (2005), <i>Generic characteristics of optical amplifier devices and subsystems.</i> |
| [ITU-T G.664] | Recommendation ITU-T G.664 (2012), <i>Optical safety procedures and requirements for optical transmission systems.</i> |
| [ITU-T G.692] | Recommendation ITU-T G.692 (1998), <i>Optical interfaces for multichannel systems with optical amplifiers.</i> |

[ITU-T G.701]	Recommendation ITU-T G.701 (1993), <i>Vocabulary of digital transmission and multiplexing, and pulse code modulation (PCM) terms.</i>
[ITU-T G.702]	Recommendation ITU-T G.702 (1988), <i>Digital hierarchy bit rates.</i>
[ITU-T G.703]	Recommendation ITU-T G.703 (2001), <i>Physical/electrical characteristics of hierarchical digital interfaces.</i>
[ITU-T G.707]	Recommendation ITU-T G.707/Y.1322 (2007), <i>Network node interface for the synchronous digital hierarchy (SDH).</i>
[ITU-T G.709]	Recommendation ITU-T G.709/Y.1331 (2012), <i>Interfaces for the optical transport network.</i>
[ITU-T G.780]	Recommendation ITU-T G.780/Y.1351 (2010), <i>Terms and definitions for synchronous digital hierarchy (SDH) networks.</i>
[ITU-T G.821]	Recommendation ITU-T G.821 (2002), <i>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.</i>
[ITU-T G.823]	Recommendation ITU-T G.823 (2000), <i>The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy.</i>
[ITU-T G.825]	Recommendation ITU-T G.825 (2000), <i>The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH).</i>
[ITU-T G.826]	Recommendation ITU-T G.826 (2002), <i>End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections.</i>
[ITU-T G.828]	Recommendation ITU-T G.828 (2000), <i>Error performance parameters and objectives for international, constant bit-rate synchronous digital paths.</i>
[ITU-T G.870]	Recommendation ITU-T G.870/Y.1352 (2012), <i>Terms and definitions for optical transport networks.</i>
[ITU-T G.921]	Recommendation ITU-T G.921 (1988), <i>Digital sections based on the 2048 kbit/s hierarchy.</i>
[ITU-T G.955]	Recommendation ITU-T G.955 (1996), <i>Digital line systems based on the 1544 kbit/s and the 2048 kbit/s hierarchy on optical fibre cables.</i>
[ITU-T G.957]	Recommendation ITU-T G.957 (2006), <i>Optical interfaces for equipments and systems relating to the synchronous digital hierarchy.</i>
[ITU-T G.959.1]	Recommendation ITU-T G.959.1 (2012), <i>Optical transport network physical layer interfaces.</i>
[ITU-T G.971]	Recommendation ITU-T G.971 (2010), <i>General features of optical fibre submarine cable systems.</i>
[ITU-T G.972]	Recommendation ITU-T G.972 (2011), <i>Definition of terms relevant to optical fibre submarine cable systems.</i>
[ITU-T G.975]	Recommendation ITU-T G.975 (2000), <i>Forward error correction for submarine systems.</i>

[ITU-T G.975.1]	Recommendation ITU-T G.975.1 (2004), <i>Forward error correction for high bit-rate DWDM submarine systems</i> .
[ITU-T G.976]	Recommendation ITU-T G.976 (2014), <i>Tests methods applicable to optical fibre submarine cable systems</i> .
[ITU-T G.978]	Recommendation ITU-T G.978 (2010), <i>Characteristics of optical fibre submarine cables</i> .
[ITU-T G.979]	Recommendation ITU-T G.979 (2012), <i>Characteristics of monitoring systems for optical submarine cables</i> .
[ITU-T G.8201]	Recommendation ITU-T G.8201 (2011), <i>Error performance parameters and objectives for multi-operator international paths within optical transport networks</i> .
[ITU-T G.8251]	Recommendation ITU-T G.8251 (2010), <i>The control of jitter and wander within the optical transport network (OTN)</i> .
[IEC 60825-1]	IEC 60825-1 (2007), <i>Safety of laser products – Part 1: Equipment classification and requirements</i> .
[IEC 60825-2]	IEC 60825-2 (2007), <i>Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)</i> .

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

- 3.1.1 compression factor:** See [ITU-T G.976].
- 3.1.2 digital line section (DLS):** See [ITU-T G.701].
- 3.1.3 forward error correction (FEC):** See [ITU-T G.972], [ITU-T G.975] and [ITU-T G.975.1].
- 3.1.4 gain flatness:** See [ITU-T G.976].
- 3.1.5 maximum channel power difference:** See [ITU-T G.692].
- 3.1.6 noise figure:** See [ITU-T G.661].
- 3.1.7 nominal gain:** See [ITU-T G.976].
- 3.1.8 nominal signal input power:** See [ITU-T G.976].
- 3.1.9 nominal signal output power:** See [ITU-T G.976].
- 3.1.10 optical fibre amplifier (OFA):** See [ITU-T G.661].
- 3.1.11 optical transport network (OTN):** See [ITU-T G.870].
- 3.1.12 polarization-dependent gain:** See [ITU-T G.661].
- 3.1.13 polarization-dependent loss:** See [ITU-T G.661].
- 3.1.14 polarization hole burning:** See [ITU-T G.661].
- 3.1.15 polarization mode dispersion:** See [ITU-T G.661].
- 3.1.16 S, R reference points:** See [ITU-T G.955].
- 3.1.17 S', R' reference points:** See [ITU-T G.661] and [ITU-T G.662].

3.1.18 small signal gain: See [ITU-T G.661].

3.1.19 synchronous digital hierarchy (SDH): See [ITU-T G.780].

3.1.20 synchronous transport module (STM): See [ITU-T G.780].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms. Figures 3-1, 3-2, 3-3 and 3-4, which illustrate these definitions, describe terminal equipment for wavelength division multiplexing system (WDMS) and dense wavelength division multiplexing system (DWDM). In case of a single wavelength system (SWS), the optical multiplexer/demultiplexer interface should be removed so that only one wavelength should be concerned as shown in Figures 3-3 and 3-4.

3.2.1 branching unit (BU): A piece of optical submarine equipment inserted into the submarine portion of an optical fibre submarine cable network where the electrical and optical interconnection of three cable sections is necessary.

3.2.2 dense wavelength division multiplexing (DWDM): An aggregate of a large number of line optical channel (LOCs) to be carried through part or the whole of the submarine line on the same line fibre.

3.2.3 dense wavelength division multiplexing system (DWDM): A bidirectional optical system carried on a large number of line optical channels (LOCs).

3.2.4 fixed optical add/drop multiplexing-branching unit (FOADM-BU): A branching unit (BU) with optical add/drop multiplex (OADM) function where the wavelengths that are added, dropped and passed through are fixed.

3.2.5 full fibre drop-BU (FFD-BU): A branching unit (BU) where the optical interconnection between the three submarine cables is made by physically connecting fibre pairs between any two cables.

3.2.6 gain equalizer: Gain equalizer is the means used to adapt the submerged plant gain profile characteristics suitable for transmission.

3.2.7 intermediate terrestrial interface (ITI): It is to be noted that the terminal transmission equipment (TTE) can be composed of two distinct pieces of equipment interfaced together, the first piece called submarine cable transmission terminal equipment (SCTTE), on the submarine cable side, and the second piece, called terrestrial network transmission terminal equipment (TNTTE), on the terrestrial network side. In this case, an intermediate interface is required which links the two pieces of equipment. This interface is composed of bidirectional data interfaces and, where applicable, of an extra link used to exchange information between the two pieces of terminal transmission equipment (TTE).

3.2.8 line optical channel (LOC): A bidirectional optical data channel carried on a specific optical frequency/wavelength for each transmission direction.

3.2.9 LOC-TTE: A terminal transmission equipment (TTE) whose submarine cable optical interface (SCOI) is composed of only one line optical channel (LOC).

3.2.10 N-WDM: A wavelength division multiplexing (WDM) or dense wavelength division multiplexing (DWDM) of N line optical channel (LOCs) (N being an integer).

3.2.11 optical submarine equalizer (OSE): Optical submarine equalizer is the submerged equipment used to compensate for, or to handle, the accumulative gain ripple and tilt along a submarine digital line section (SDLS) in order to be compliant with the pre-emphasis capability of

the terminal transmission equipment (TTE) at the transmitter side, and with the corresponding impairment allocated in the power budget table.

3.2.12 reconfigurable optical add/drop multiplexing-branching unit (ROADM-BU): A branching unit (BU) with optical add/drop multiplexing (OADM) function where the wavelengths that are added, dropped and passed through can be dynamically modified.

3.2.13 shunt fault: A shunt fault is a current leakage path between the power conductor and the sea water without a break in the power conductor.

3.2.14 single wavelength system (SWS): A bidirectional optical system carried on only one line optical channel (LOC).

3.2.15 slope equalizer: Slope equalizer is the means used for wavelength division multiplexing system (WDMS) to provide the equalization of the residual gain/wavelength slope which accumulates when the signal is transmitted through a chain of submerged repeaters.

3.2.16 submarine cable optical interface (SCOI): The bidirectional optical interface between the submarine cable (including the terrestrial cable section) and the terminal transmission equipment (TTE). This signal is composed of a line optical channel (LOC) or a wavelength division multiplexing (WDM).

3.2.17 submarine cable transmission terminal equipment (SCTTE): See definition on intermediate terrestrial interface (ITI).

3.2.18 submarine digital line section (SDLS): A bidirectional continuous optical path along which one line optical channel (LOC) links two terminal transmission equipments (TTEs) at the submarine electro-optic interface (SEOI) level.

3.2.19 submarine electro-optic interface (SEOI): The bidirectional interface inside the terminal transmission equipment (TTE) where an electro-optic conversion and an electrical regeneration are performed between a line optical channel (LOC) and an electrical channel.

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

3.2.21 terrestrial interface (TI): The interface between the submarine system and the terrestrial network.

3.2.22 terrestrial network transmission terminal equipment (TNTTE): See definition on intermediate terrestrial interface.

3.2.23 tilt equalizer: Tilt equalizer is the means used for wavelength division multiplexing system (WDMS) to provide the equalization of the residual gain/wavelength tilt, which accumulates when the signal is transmitted through a chain of submerged repeaters.

3.2.24 umbilical: The extra link used at intermediate terrestrial interface (ITI) to exchange information between the two pieces of terminal transmission equipment (TTE), which are the submarine cable transmission terminal equipment (SCTTE) and the terrestrial network transmission terminal equipment (TNTTE).

3.2.25 wavelength demultiplexer (WD): The equipment required to split a wavelength division multiplexing (WDM) into several line optical channels (LOCs) and/or WDM to be carried on different fibres.

3.2.26 wavelength division multiplexing (WDM): An aggregate of several line optical channels (LOCs) to be carried through part or the whole of the submarine line on the same line fibre.

3.2.27 wavelength division multiplexing system (WDMS): A bidirectional optical system carried on several line optical channels (LOCs).

3.2.28 wavelength multiplexer (WM): The equipment required to combine several line optical channels (LOCs) and/or wavelength division multiplexing (WDM) coming from different fibres into a common WDM composed of all the combined LOCs.

3.2.29 wavelength division multiplexing-branching unit (WDM-BU): A branching unit (BU) where the optical interconnection between the three submarine cables is made through wavelength multiplexer (WM) and wavelength demultiplexer (WD), that is, adding and dropping one or more line optical channels (LOCs) out of the N-WDM.

3.2.30 wavelength division multiplexing-terminal transmission equipment (WDM-TTE): A terminal transmission equipment (TTE) equipped with wavelength multiplexer (WM) and wavelength demultiplexer (WD), whose submarine cable optical interface (SCOI) is a wavelength division multiplexing (WDM) or dense wavelength division multiplexing (DWDM).

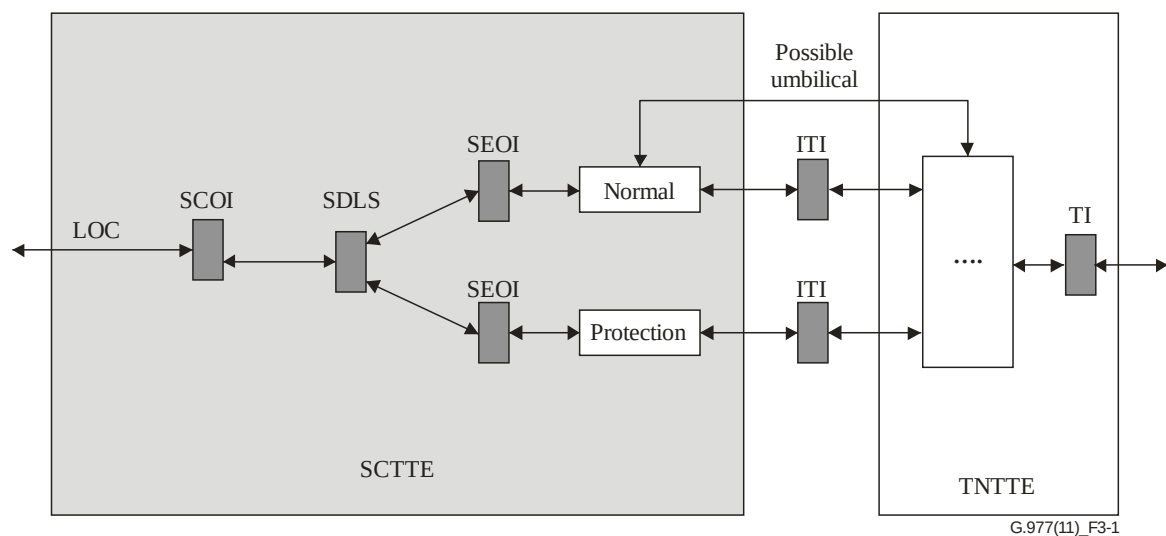


Figure 3-1 – Terms and definitions for SWS

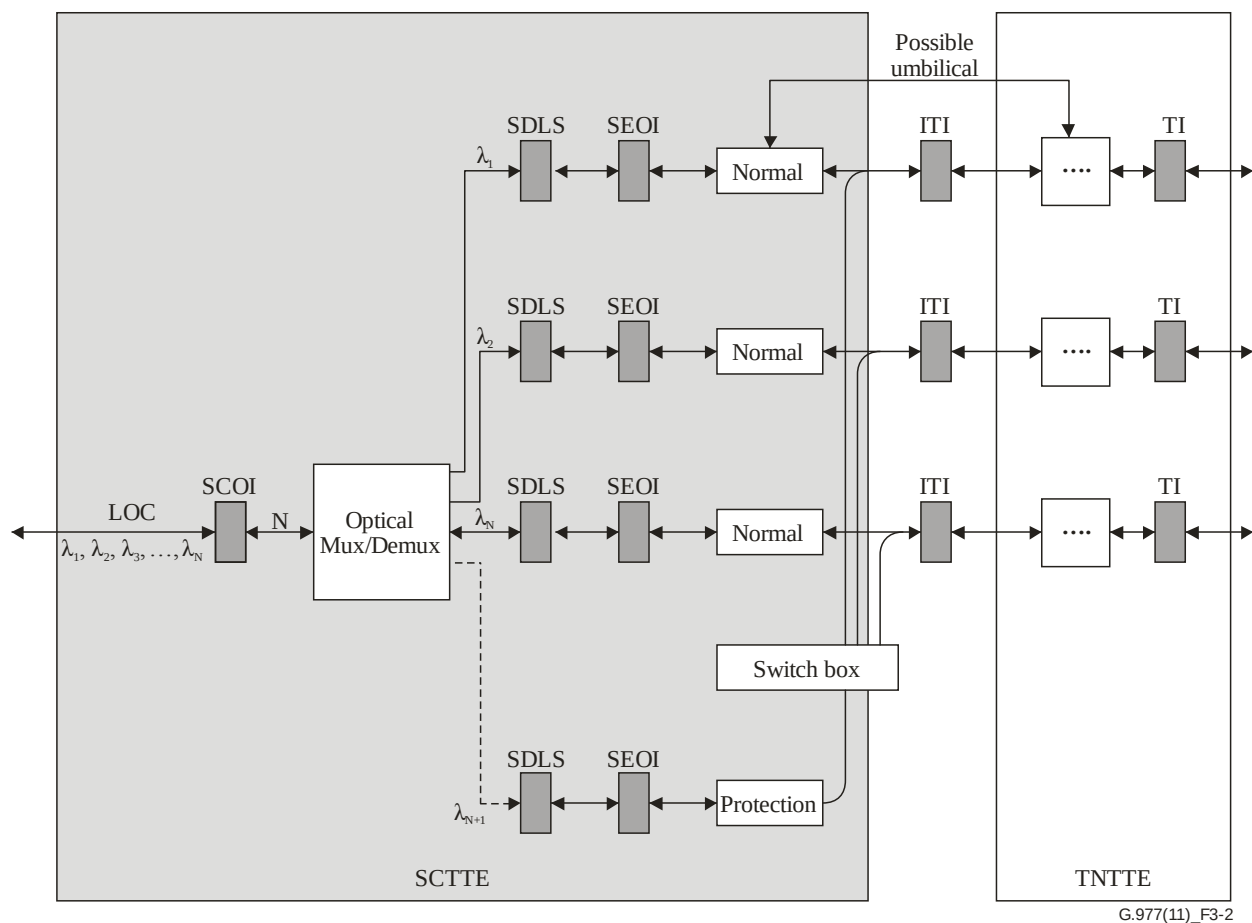


Figure 3-2 – Terms and definitions for WDMS

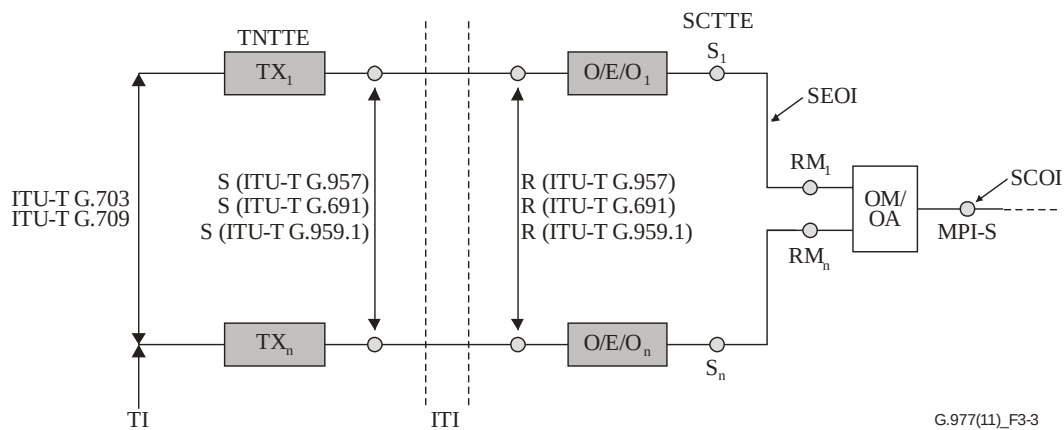


Figure 3-3 – Transmit side