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ITU-T

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STANDARDIZATION SECTOR
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G.662

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

Transmission media characteristics – Characteristics of optical components and subsystems

Generic characteristics of optical amplifier devices and subsystems

ITU-T Recommendation G.662

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ITU-T Recommendation G.662

Generic characteristics of optical amplifier devices and subsystems

Summary

The purpose of this Recommendation is to provide the generic characteristics needed for the specification of Optical Amplifiers as devices and subsystems, primarily for applications in digital transmission, and to ensure maximum compatibility with ITU-T G-series Recommendations relating to line systems and equipments.

Source

ITU-T Recommendation G.662 was approved on 14 July 2005 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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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.

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ITU-T Recommendation G.662

Generic characteristics of optical amplifier devices and subsystems

1 Scope

This Recommendation applies to discrete Optical Amplifier (OA) devices and subsystems to be used in transmission networks. It covers both Optical Fibre Amplifiers (OFAs) and Semiconductor Optical Amplifiers (SOAs).

The object of this Recommendation is to identify those generic characteristics specifiable for the use of OA devices (as power amplifiers, pre-amplifiers or line amplifiers) and OA subsystems (as optically amplified transmitters or optically amplified receivers), primarily for applications in digital transmission, ensuring the maximum compatibility with ITU-T G-series Recommendations relating to line systems and equipments, for example, Recommendations such as ITU-T Recs G.957 or G.959.1.

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 Recommendation G.661 (1998), *Definition and test methods for the relevant generic parameters of optical amplifier devices and subsystems*.

– ITU-T Recommendation G.663 (2000), *Application related aspects of optical fibre amplifier devices and subsystems*.

– ITU-T Recommendation G.665 (2005), *Generic characteristics of Raman amplifiers and Raman amplified subsystems*.

ITU-T Recommendation G.691 (2003), *Optical interfaces for single channel STM-64 and other SDH systems with optical amplifiers*.

– ITU-T Recommendation G.692 (1998), *Optical interfaces for multichannel systems with optical amplifiers*.

– ITU-T Recommendation G.955 (1996), *Digital line systems based on the 1544 kbit/s and the 2048 kbit/s hierarchy on optical fibre cables*.

– ITU-T Recommendation G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

– ITU-T Recommendation G.959.1 (2003), *Optical transport network physical layer interfaces*.

3 Abbreviations

This Recommendation uses the following abbreviations:

BA Booster (power) Amplifier

LA Line Amplifier

OA Optical Amplifier

OAR Optically Amplified Receiver

OAT Optically Amplified Transmitter

OFA Optical Fibre Amplifier

PA Pre-Amplifier

Rx (optical) Receiver

SDH Synchronous Digital Hierarchy

SOA Semiconductor Optical Amplifier

Tx (optical) Transmitter

4 Classification of OA devices

Different OA application categories are defined depending on the technology used and the utilization of the OA itself. Classification of optical amplifier technologies is given in IEC 61292-3.

These categories are identified by a capital letter, a number and a lower case letter, as defined in clause 5/G.661.

The *power amplifier* is a high saturation-power OA device to be used directly after the optical transmitter to increase its signal power level.

The *pre-amplifier* is a very low noise OA device to be used directly before an optical receiver to improve its sensitivity.

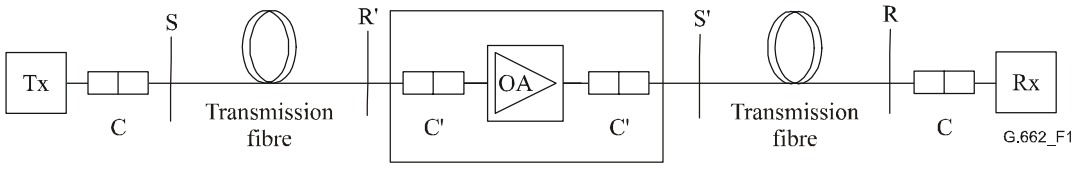
The *line amplifier* is a low noise OA device to be used between passive fibre sections to increase the distance covered before regeneration is necessary or in correspondence with a point-multipoint connection to compensate for branching losses in the optical access network.

The *OAT* is an OA subsystem in which a power amplifier is integrated with an optical transmitter, resulting in a higher power transmitter.

The *OAR* is an OA subsystem in which a pre-amplifier is integrated with an optical receiver, resulting in a higher sensitivity receiver.

The *distributed amplifier* is a device configuration that provides amplification over an extended length of the optical fibre used for transmission, as by Raman pumping, and is thus distributed over part or all of the transmission span.

According to this criterion, an OA device (BA, PA or LA), inserted along an optical path, shall be considered a separate element placed between the reference points S and R defined in the ITU-T G-series Recommendations for line terminals and regenerators, as shown in the scheme of Figure 1. In the case of a booster amplifier, there would be no transmission fibre between the transmitter and the amplifier. Similarly, for a pre-amplifier, there would be no transmission fibre between the amplifier and the receiver. With reference to this figure, the input and output characteristics of the OA device shall be specified at reference points R' and S', before and after the OA device, respectively. It is understood that, since the OA device is not a regenerator or a terminal equipment, these are virtual R and S points.



S Reference point of the optical fibre just after the optical connection (C) of the transmitter
R Reference point of the optical fibre just before the optical connection (C) of the receiver
S' Reference point of the optical fibre just after the optical connection (C') of the OA device
R' Reference point of the optical fibre just before the optical connection (C') of the OA device

Figure 1/G.662 – Scheme of insertion of an OA device

A PA may include an optical filter, e.g., to minimize the contribution of OA device noise to the total noise as detected by the optical receiver, or to separate signals in some multiwavelength applications. Such a filter can be tuneable, manually or automatically, to the signal wavelength and, in systems with multiple signals at different wavelengths, filtering may be needed around each wavelength.

According to the definitions of BA, PA and LA, and with reference to Figure 1, the possible configurations of OA device applications can be schematized as follows (here LA can represent one single line amplifier or two or more cascaded line amplifiers):

a) Tx + BA + Rx;

b) Tx + PA + Rx;

c) Tx + LA + Rx;

d) Tx + BA + PA + Rx;

e) Tx + BA + LA + Rx;

f) Tx + LA + PA + Rx;

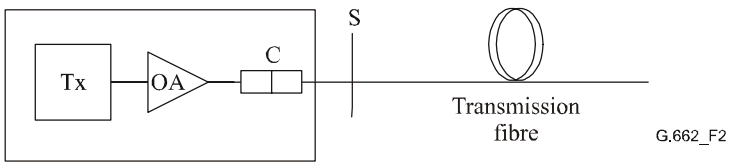
g) Tx + BA + LA + PA + Rx.

5 Types of OA subsystems

OA subsystems covered by this Recommendation are OAs integrated either with the optical transmitter or with the optical receiver, in which either the output or the input port, respectively, is specified only.

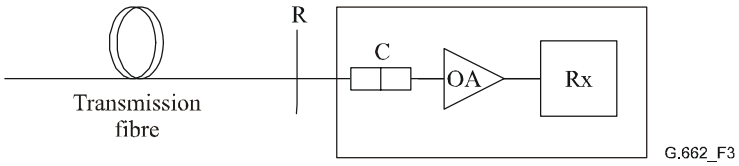
Both kinds of integration imply that the connection between the transmitter or the receiver and the OA is proprietary and shall not be specified. Consequently, a reference point S only can be defined for the specification of the OAT output characteristics after the OA, as shown in Figure 2, and a reference point R only can be defined for the specification of the OAR input characteristics before the OA, as shown in Figure 3.

As the PA, also the OAR may include an optical filter which can be tuneable, manually or automatically, to the signal wavelength.



S Reference point of the optical fibre just after the optical connection (C) of the OAT

Figure 2/G.662 – Scheme of insertion of an OAT



R Reference point of the optical fibre just before the optical connection (C) of the OAR

Figure 3/G.662 – Scheme of insertion of an OAR

6 Characteristics of power amplifiers

6.1 Single-channel applications

The following is the minimum list of relevant parameters for the specification of an OA device used as BA for single-channel applications:

a) Input power range.

b) Output power range.

c) Power wavelength band.

d) Signal-spontaneous noise figure.

e) Input reflectance.

f) Output reflectance.

g) Pump leakage to input (applicable to OFAs only).

h) Maximum reflectance tolerable at input.

i) Maximum reflectance tolerable at output.

j) Maximum total output power.

6.2 Multichannel applications

The following is the minimum list of relevant parameters for the specification of an OA device used as BA for multichannel applications:

a) Channel allocation.

b) Total input power range.

c) Channel input power range.

d) Channel output power range.

e) Channel signal-spontaneous noise figure.

f) Input reflectance.

g) Output reflectance.

h) Pump leakage to input (applicable to OFAs only).

i) Maximum reflectance tolerable at input.

j) Maximum reflectance tolerable at output.

k) Maximum total output power.

l) Channel addition/removal (steady-state) gain response.

m) Channel addition/removal (transient) gain response.

7 Characteristics of pre-amplifiers

7.1 Single-channel applications

The following is the minimum list of relevant parameters for the specification of an OA device used as PA for single-channel applications:

a) Input power range.

b) Output power range.

c) Small-signal gain wavelength band.

d) Available signal wavelength band.

e) Tuneable wavelength range.

f) Signal-spontaneous noise figure.

g) Input reflectance.

h) Output reflectance.

i) Pump leakage to output (applicable to OFAs only).

j) Maximum reflectance tolerable at input.

k) Maximum reflectance tolerable at output.

l) Maximum total output power.

m) Small-signal gain.

7.2 Multichannel applications

The following is the minimum list of relevant parameters for the specification of an OA device used as PA for multichannel applications:

a) Channel allocation.

b) Total input power range.

c) Channel input power range.

d) Channel output power range.

e) Channel signal-spontaneous noise figure.

f) Input reflectance.

g) Output reflectance.

h) Pump leakage to output (applicable to OFAs only).

i) Maximum reflectance tolerable at input.

j) Maximum reflectance tolerable at output.

k) Maximum total output power.

l) Channel addition/removal (steady-state) gain response.

m) Channel addition/removal (transient) gain response.

n) Channel gain.

o) Multichannel gain variation (inter-channel gain difference).

8 Characteristics of line amplifiers

8.1 Single-channel applications

The following is the minimum list of relevant parameters for the specification of an OA device used as LA for single-channel applications:

a) Input power range.

b) Output power range.

c) Saturation output power.

d) Small-signal gain wavelength band.

e) Signal-spontaneous noise figure.

f) Input reflectance.

g) Output reflectance.

h) Maximum reflectance tolerable at input.

i) Maximum reflectance tolerable at output.

j) Maximum total output power.

k) Small-signal gain.

l) Polarization Mode Dispersion (PMD).

8.2 Multichannel applications

The following is the minimum list of relevant parameters for the specification of an OA device used as LA for multichannel applications:

a) Channel allocation.

b) Total input power range.

c) Channel input power range.

d) Channel output power range.

e) Channel signal-spontaneous noise figure.

f) Input reflectance.

g) Output reflectance.

h) Maximum reflectance tolerable at input.

i) Maximum reflectance tolerable at output.

j) Maximum total output power.

k) Channel addition/removal (steady-state) gain response.

l) Channel addition/removal (transient) gain response.

m) Channel gain.

n) Multichannel gain variation (inter-channel gain difference).

o) Multichannel gain-change difference (inter-channel gain-change difference).

p) Multichannel gain tilt (inter-channel gain-change ratio).

q) Polarization Mode Dispersion (PMD).

9 Characteristics of optically amplified transmitters

9.1 Single-channel applications

The following is the minimum list of relevant parameters for the specification of an OA subsystem used as OAT for single-channel applications:

a) Bit rate.

b) Application code.

c) Operating signal wavelength range.

d) (Signal) output power range.

e) Signal linewidth.

f) Side mode suppression ratio.

g) Extinction ratio.

h) Eye mask.

i) Output optical signal-to-noise ratio.

j) Output reflectance.

k) Maximum reflectance tolerable at output.

l) Maximum total output power.

9.2 Multichannel applications

The following is the minimum list of relevant parameters for the specification of an OA subsystem used as OAT for multichannel applications:

Under study.

10 Characteristics of optically amplified receivers

10.1 Single-channel applications

The following is the minimum list of relevant parameters for the specification of an OA subsystem used as OAR for single-channel applications:

a) Bit rate.

b) Application code.

c) Operating signal wavelength range.

d) Sensitivity.

e) Overload.

f) Dispersion penalty due to optical path.

g) Tunable wavelength range.

h) Input reflectance.

i) Maximum reflectance tolerable at input.

j) Bit error ratio

10.2 Multichannel applications

The following is the minimum list of relevant parameters for the specification of an OA subsystem used as OAR for multichannel applications:

Under study.

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