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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 Raman amplifiers and Raman amplified subsystems

ITU-T Recommendation G.665

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ITU-T Recommendation G.665

Generic characteristics of Raman amplifiers and Raman amplified subsystems

Summary

This Recommendation identifies the definitions and test methods of performance parameters of the following fibre Raman amplifiers and Raman amplified subsystems:

- reverse pumped distributed Raman amplifier;
- forward pumped distributed Raman amplifier;
- bidirectionally pumped distributed Raman amplifier;
- reverse pumped distributed, composite Raman amplifier;
- bidirectionally pumped distributed, composite Raman amplifier;
- discrete Raman amplifier.

This Recommendation describes the classification, the type code, and the reference models of various Raman amplifiers. It also outlines the general characteristics of the Raman amplifiers, and defines the performance and testing parameters for the Raman amplifiers.

Source

ITU-T Recommendation G.665 was approved on 13 January 2005 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure.

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ITU-T Recommendation G.665

Generic characteristics of Raman amplifiers and Raman amplified subsystems

1 Scope

This Recommendation identifies the definitions and test methods of performance parameters of optical fibre Raman amplifiers and Raman amplified subsystems. In the case of distributed or discrete Raman amplifiers (forward pumped, reverse pumped, bidirectionally pumped) or composite distributed Raman and discrete amplifiers, the generic characteristics of those amplifiers and subsystems are also specified.

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.662 (1998), *Generic characteristics of optical amplifier devices and subsystems*.
- ITU-T Recommendation G.663 (2000), *Application related aspects of optical amplifier devices and subsystems*.
- ITU-T Recommendation G.664 (2003), *Optical safety procedures and requirements for optical transport systems*.
- IEC 61290 series, *Optical Amplifier Test Methods*.
- IEC 61291 series, *Optical fibre amplifiers (General aspects)*.
- IEC 61292 series, *Technical Reports of Optical Amplifiers*.
- IEC 60825 series, *Safety of laser products*.

3 Abbreviations

This Recommendation uses the following abbreviations:

ASE	Amplified Spontaneous Emission
C	Optical connector associated with the Raman amplifier
DOP	Degree of Optical Polarization
DRS	Double Rayleigh Scattering
EDFA	Erbium-Doped Fibre Amplifier
FP_i	Signal ingress point for the Forward Pumped Raman Amplifier
FP_o	Signal egress point for the Forward Pumped Raman Amplifier
FRA	Fibre Raman Amplifier

GMP	Gain Measurement Point
MPI	Multi-Path Interference
OA	Optical Amplifier
OAR	Optically Amplified Receiver
OAT	Optically Amplified Transmitter
ORL	Optical Return Loss
PDG	Polarization-Dependent Gain
PMD	Polarization Mode Dispersion
RIN	Relative Intensity Noise
RP_i	Signal ingress point for the Reverse Pumped Raman Amplifier
RP_o	Signal egress point for the Reverse Pumped Raman Amplifier
Rx	Receiver (Optical)
SRS	Stimulated Raman Scattering
Tx	Transmitter (Optical)

4 Terms and Definitions

This clause outlines the definitions of various distributed Raman amplifiers and the discrete Raman amplifier. The performance parameters for these Raman amplifiers are also defined in this clause.

4.1 Distributed and discrete Raman amplifier

Definitions of distributed and discrete Raman amplifiers are given in this clause. Further information can be obtained in IEC 61292-3 for these Raman amplifiers.

4.1.1 distributed Raman amplifier: Distributed Raman amplifiers are amplifiers where the amplification effect is achieved via a portion of the optical fibre used for transmission. Such amplifiers are deemed to be distributed since part or all of the transmission fibre is used for amplification purposes. Distributed Raman amplifiers can be further classified into three sub-categories:

- **Forward pumped Raman amplifier:** The pump energy and signal co-propagate along the transmission fibre.
- **Reverse pumped Raman amplifier:** The pump energy and signal propagate in opposite directions in the transmission fibre.
- **Bidirectionally pumped Raman amplifier:** The pump energy is applied in both ends of the transmission fibre. In this case, part of the pump energy co-propagates with the signal and part of the pump energy counter-propagates with the signal inside the transmission media.

4.1.2 discrete Raman amplifier: A discrete Raman amplifier is an amplifier for optical signals whose amplification effect is achieved via the fibre SRS effect, where all of the physical components of the amplifier are completely contained inside the device.

4.2 Optical signal power parameters

Parameters	Definitions	Notes
4.2.1 Equivalent input power	The power at the input reference point when the Raman pump is deactivated.	For a reverse pumped Raman amplifier, the input reference point is at point RP_i in Figure 1. For other Raman amplifier configurations, see 5.3.
4.2.2 Large-signal output stability	see 4.9/G.661	
4.2.3 Saturation output power (gain compression power)	see 4.11/G.661	
4.2.4 Nominal output signal power	see 4.12/G.661	
4.2.5 Maximum total output power	see 4.25/G.661	
4.2.6 Input power range	see 4.28/G.661	
4.2.7 Output power range	see 4.29/G.661	

4.3 Gain parameters

Parameters	Definitions	Notes
4.3.1 Raman on-off gain	IEC 61291-1, 3.1.18 and 3.1.19 The increase in signal optical power at the gain measurement point (GMP) defined in 5.3 when the Raman pump is activated compared to the signal optical power at the GMP when the Raman pump is deactivated.	Applicable to distributed Raman amplifiers.
4.3.2 Net Gain	Net Gain is defined as the combined Raman On-Off gain and the gain from the OA, if applicable, with the loss between the input and output reference points of the amplifier subtracted from it.	
4.3.3 Channel net gain	Net Gain for each channel at a given wavelength in a multichannel configuration.	
4.3.4 Small-signal net gain	see 4.1/G.661	
4.3.5 Reverse small-signal net gain	see 4.2/G.661	
4.3.6 Maximum net small-signal gain	see 4.3/G.661	
4.3.7 Maximum small-signal net gain wavelength	see 4.4/G.661	
4.3.8 Maximum small-signal net gain variation with temperature	see 4.5/G.661	