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

Digital sections and digital line system – Optical line
systems for local and access networks

Gigabit-capable passive optical networks (GPON): Enhancement band

Recommendation ITU-T G.984.5

ITU-T

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Recommendation ITU-T G.984.5

Gigabit-capable passive optical networks (GPON): Enhancement band

Summary

Recommendation ITU-T G.984.5 defines wavelength ranges reserved for additional service signals to be overlaid via wavelength division multiplexing (WDM) in future passive optical networks (PON) for maximizing the value of optical distribution networks (ODNs).

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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2.0	ITU-T G.984.5	2014-05-14	15	11.1002/1000/12184

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Recommendation ITU-T G.984.5

Gigabit-capable passive optical networks (GPON): Enhancement band

1 Scope

The purpose of this Recommendation is to define wavelength ranges reserved for additional service signals to be overlaid via wavelength division multiplexing (WDM) in future gigabit-capable passive optical networks (G-PON) for maximizing the value of optical distribution networks (ODNs). Other PON systems, such as B-PON, have wavelength plans based on [ITU-T G.983.3], which includes existing options for enhancement bands. This Recommendation also defines further wavelength ranges reserved for additional service signals to be overlaid via WDM in future PONs whose wavelength allocations are based on [ITU-T G.983.3].

For this purpose, this Recommendation defines and provides:

- wavelength ranges to be reserved; and
- X/S tolerance in PON optical network units (ONUs).

Appendices I, II and III provide:

- sample parameters of a discrete WDM filter that combines and isolates the G-PON up/down signals and enhancement bands at the OLT side;
- examples of wavelength allocation for NGA services and video distribution services;
- methods for calculating required isolation for WDM/CE/CEM devices.

The physical media dependent (PMD) layer specification for G-PON in the absence of an enhancement band is defined in [ITU-T G.984.2]. PMD layer specifications for G-PON in the presence of enhancement bands are defined by the combination of [ITU-T G.984.2] and this Recommendation. Whenever a parameter specified in [ITU-T G.984.2] is not explicitly mentioned in this Recommendation, its value given in [ITU-T G.984.2] remains valid. Whenever a parameter is specified in both this Recommendation and [ITU-T G.984.2], the specification in this Recommendation takes precedence.

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.652] Recommendation ITU-T G.652 (2009), *Characteristics of a single-mode optical fibre and cable*.
- [ITU-T G.671] Recommendation ITU-T G.671 (2012), *Transmission characteristics of optical components and subsystems*.
- [ITU-T G.983.1] Recommendation ITU-T G.983.1 (2005), *Broadband optical access systems based on Passive Optical Networks (PON)*.
- [ITU-T G.983.3] Recommendation ITU-T G.983.3 (2001), *A broadband optical access system with increased service capability by wavelength allocation*.

- [ITU-T G.984.2] Recommendation ITU-T G.984.2 (2003), *Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification.*
- [ITU-T G.987] Recommendation ITU-T G.987 (2012), *10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms.*
- [ITU-T G.987.2] Recommendation ITU-T G.987.2 (2010), *10-Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification.*
- [ITU-T G.989] Recommendation ITU-T G.989 (2014), *40-Gigabit-capable passive optical network (NG-PON2) systems: Definitions, abbreviations and acronyms.*
- [ITU-T G.989.1] Recommendation ITU-T G.989.1 (2013), *40-Gigabit-capable passive optical networks (NG-PON2): General requirements.*
- [ITU-T L.66] Recommendation ITU-T L.66 (2007), *Optical fibre cable maintenance criteria for in-service fibre testing in access networks.*

3 Definitions

This Recommendation makes frequent use of the terms defined in [ITU-T G.983.1], [ITU-T G.983.3] and [ITU-T G.984.2]. For purposes of convenience, the main definitions related to the G-PON enhancement bands are reported in this clause.

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

- 3.1.1 optical distribution network (ODN):** [ITU-T G.984.2].
- 3.1.2 optical line termination (OLT):** [ITU-T G.984.2].
- 3.1.3 optical network unit (ONU):** [ITU-T G.984.2].
- 3.1.4 wavelength division multiplexing (WDM):** [ITU-T G.984.2].
- 3.1.5 10-Gigabit-capable passive optical network (XG-PON):** [ITU-T G.987].
- 3.1.6 TWDM PON:** [ITU-T G.989].
- 3.1.7 PtP WDM PON:** [ITU-T G.989].
- 3.1.8 NG-PON2:** [ITU-T G.989].
- 3.1.9 coexistence element (CE):** [ITU-T G.989].
- 3.1.10 wavelength multiplexer (WM):** [ITU-T G.989].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

- 3.2.1 next generation access (NGA):** A possible new optical access system that coexists with G-PON on the same ODN.
- 3.2.2 wavelength blocking filter (WBF):** An optical filter to prevent an optical receiver from receiving unwanted optical signals with different wavelengths.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

- B-PON Broadband Passive Optical Network
- CE Coexistence Element

CEM	Coexistence Element/Multiplexer
CNR	Carrier-to-Noise Ratio
DBA	Determined By Application
DFB	Distributed Feedback Laser
G-PON	Gigabit-capable Passive Optical Network
NRZ	Non Return to Zero
NG-PON2	Next Generation Passive Optical Network phase 2
NGA	Next Generation Access
OAN	Optical Access Network
ODN	Optical Distribution Network
OLT	Optical Line Termination
ONU	Optical Network Unit
OTDR	Optical Time Domain Reflectometer
PMD	Physical Media Dependent
PON	Passive Optical Network
PtP WDM	Point-to-Point Wavelength Division Multiplexing
RF	Radio Frequency
TWDM	Time and Wavelength Division Multiplexing
WBF	Wavelength Blocking Filter
WDM	Wavelength Division Multiplexing
WM	Wavelength Multiplexer
XG-PON	10-Gigabit-capable Passive Optical Network.

5 Conventions

None.

6 Reference architecture

Figure 1 (reproduced for convenience from Figure 5 of [ITU-T G.983.1]) shows the generic physical configuration of an optical access network.

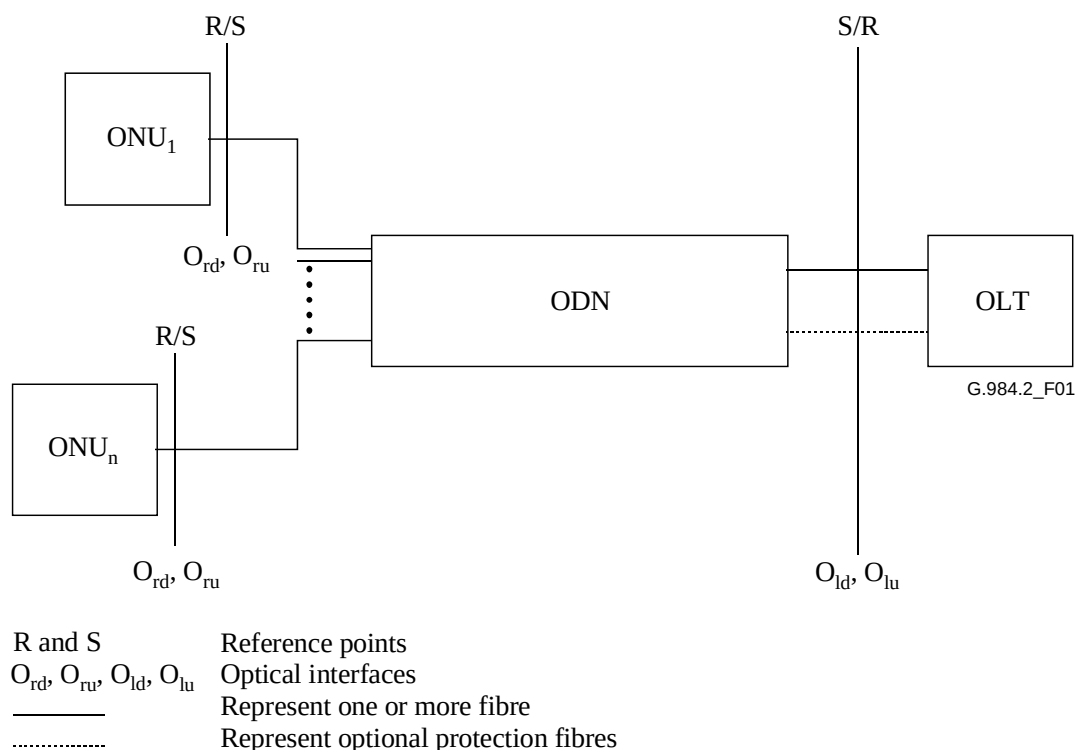


Figure 1 – Generic physical configuration of the optical access network
 (Reproduced from Figure 5 of [ITU-T G.983.1])

The two directions for optical transmission in the ODN are identified as follows:

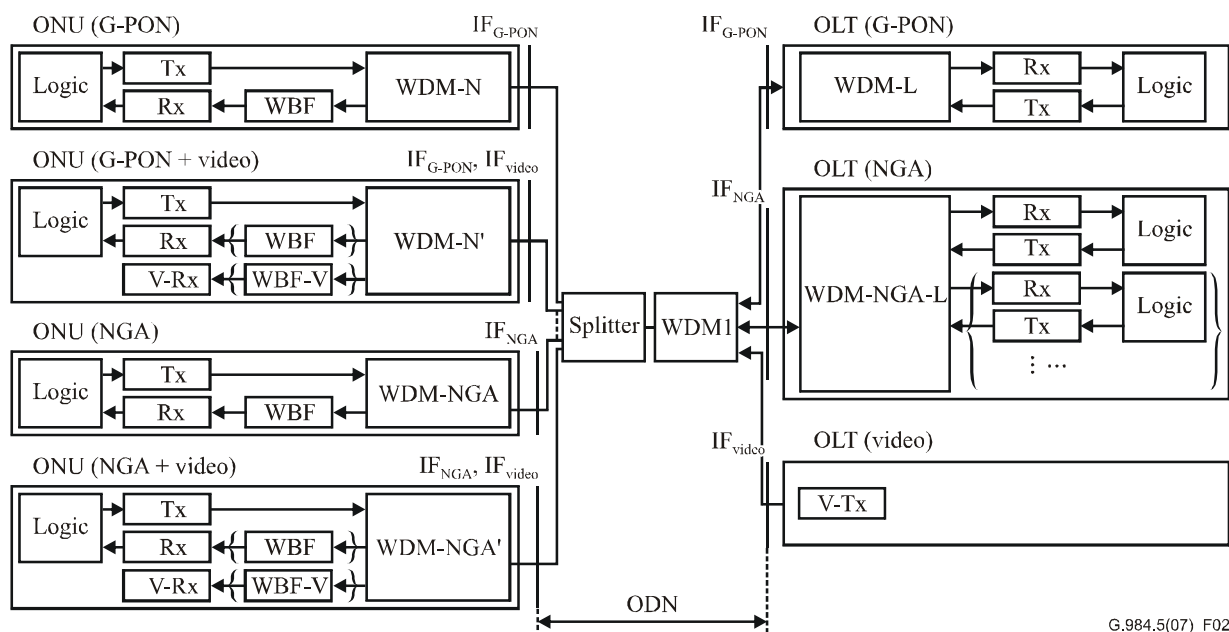
- downstream direction for signals travelling from the OLT to the ONU(s);
- upstream direction for signals travelling from the ONU(s) to the OLT.

According to [ITU-T G.983.1], transmission in downstream and upstream directions can take place on the same fibre and components (duplex/duplex working) or on separate fibres and components (simplex working). This Recommendation covers only duplex working, i.e., bidirectional transmission using different wavelengths over a single fibre.

There can be several types of ODN architectures to achieve the coexistence of G-PON and additional services including next generation access (NGA) and video distribution services.

Figures 2 and 3 are reference diagrams of optical access network (OAN) architectures and assume that wavelength blocking filters (WBF) are used when G-PON, video and NGA share the same ODN.

Note that these reference diagrams only provide reference configurations of the ODN and WBF and are not intended to limit future designs and implementations.



(NOTE – WDM1 can be replaced by WDM1r, CE or CEM.)

Figure 2 – Optical access network architecture reference diagram 1

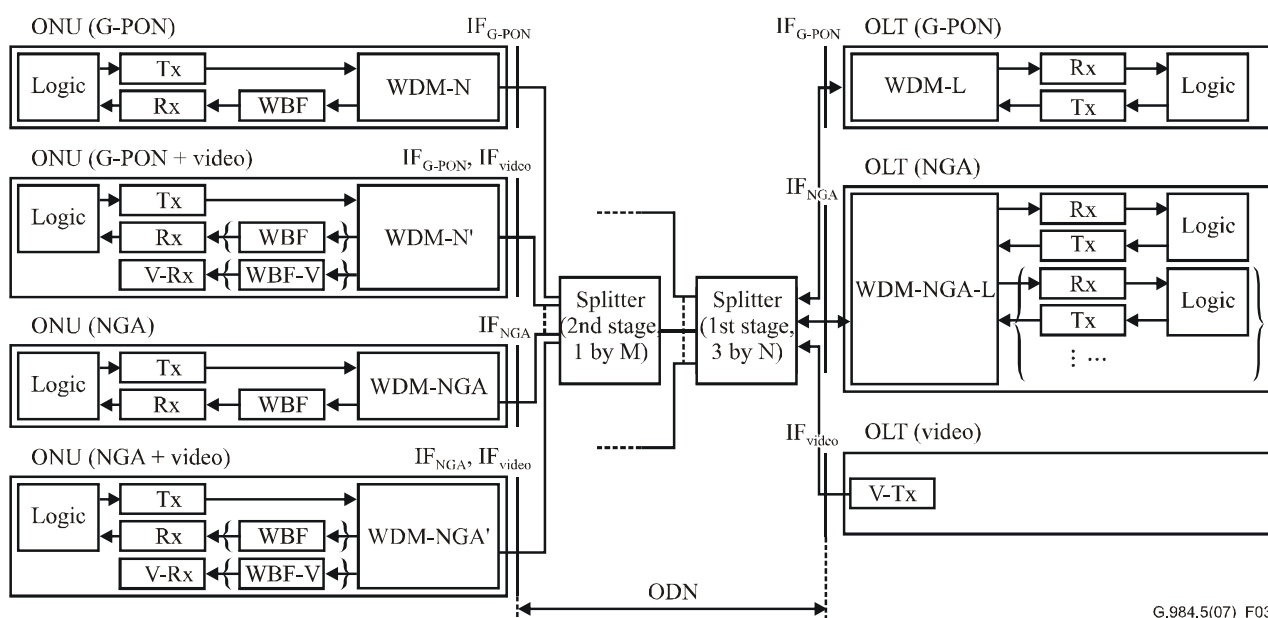


Figure 3 – Optical access network architecture reference diagram 2

The following abbreviations are used in Figures 2 and 3:

- CE Coexistence element that may be located in the central office to combine/isolate the wavelengths of NG-PON2 and legacy PON signals and which occasionally combines the video signals and/or OTDR signals
- CEM Coexistence element that may be located in the central office to combine/isolate the wavelengths of TWDM PON, PtP WDM PON and legacy PON signals and which occasionally combines the video signals and/or OTDR signals
- Rx Optical receiver
- Tx Optical transmitter
- V-Rx Video receiver

V-Tx	Video transmitter
WBF	Wavelength blocking filter for blocking interference signals to Rx
WBF-V	Wavelength blocking filter for blocking interference signals to V-Rx
WDM-N	WDM filter in G-PON ONU to combine/isolate the wavelengths of G-PON upstream and downstream
WDM-N'	WDM filter in G-PON ONU to combine/isolate the wavelengths of G-PON upstream and downstream and isolate the video signal(s)
WDM-NGA	WDM filter in NGA ONU to combine/isolate the wavelengths of NGA upstream and downstream
WDM-NGA'	WDM filter in NGA ONU to combine/isolate the wavelengths of NGA upstream and downstream and isolate the video signal(s)
WDM-L	WDM filter in G-PON OLT to combine/isolate the wavelengths of G-PON upstream and downstream
WDM-NGA-L	WDM filter in NGA OLT to combine/isolate the wavelengths of NGA upstream and downstream of one or more channels
WDM1	WDM filter that may be located in the central office to combine/isolate the wavelengths of G-PON and NGA signals and which occasionally combines the video signals and/or OTDR signals
WDM1r	WDM filter that may be located in the central office to combine/isolate the wavelengths of G-PON and XG-PON signals and which occasionally combines the video signals and/or OTDR signals.

7 Operating wavelength

The wavelength range of the G-PON downstream signal (single fibre system) is specified in [ITU-T G.984.2] as 1480 nm to 1500 nm and that of the G-PON upstream signal as 1260 nm to 1360 nm. This Recommendation redefines the reserved wavelength range and specifies the tolerance for interference signals of G-PON ONUs to enable the coexistence of G-PON and additional services including NGA and video services.

Figure 4 and Table 1 define the wavelength allocation plan including the wavelength bands reserved for additional services. The wavelength range of the G-PON downstream signal is referred to as the "basic band". Reserved bands are referred to as the "enhancement band". Applications for the enhancement band include video services and NGA services. The wavelength range for video services remains as defined in [ITU-T G.983.3].

A guard band separates the G-PON upstream and/or basic band from the enhancement band. Interference between signals in these two bands causes signal degradation to each. This signal degradation must be kept to a negligible level. Wavelength blocking filters (WBFs) are used to obtain the required isolation outside the guard band. The wavelength values specified in Table 1 take into account guard bands that may be achievable by commercially available low-cost WBFs.

NOTE – Wavelengths in the enhancement band may be used not only for downstream but also for upstream signal transmission in the WDM scheme.