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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): Long reach

Recommendation ITU-T G.984.7

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# Recommendation ITU-T G.984.7

## Gigabit-capable passive optical networks (GPON): Long reach


### Summary

Recommendation ITU-T G.984.1 defines the maximum differential distance between any two ONUs on the passive optical network (PON) as 20 km and the GPON logical reach has been defined as 60 km. However, based on practical deployment experience, it has been found that a differential distance of 40 km ranging from 0 to 40 km, 20 to 60 km, or distances in between allows significant flexibility in PON deployment and offers many benefits including the ability to serve sparsely populated areas in an efficient manner. The present Recommendation describes the necessary requirements for GPON to support the differential distance of 40 km.



### History

| Edition | Recommendation | Approval | Study Group |
|---|---|---|---|
| 1.0 | ITU-T G.984.7 | 2010-07-29 | 15 |

### Keywords

Differential distance, GPON, quiet window.

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## CONTENTS

# Recommendation ITU-T G.984.7

## Gigabit-capable passive optical networks (GPON): Long reach

### 1 Scope

This Recommendation contains the set of G-PON physical media-dependent requirements and transmission convergence layer requirements that allow extending the maximum differential fibre distance of a G-PON system to 40 km versus the conventional 20 km differential fibre distance, as required by Recommendation ITU-T G.984.1. This Recommendation introduces additional capabilities to the ITU-T G.984-series Recommendations and does not replace other Recommendations in the series. The appropriate ITU-T G.984-series Recommendations should be selected for the intended application and distance requirements.

### 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.984.1] Recommendation ITU-T G.984.1 (2008), *Gigabit-capable passive optical networks (GPON): General Characteristics.*

[ITU-T G.984.2] Recommendation ITU-T G.984.2 (2003), *Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer specification.*

[ITU-T G.984.3] Recommendation ITU-T G.984.3 (2008), *Gigabit-capable Passive Optical Networks (GPON): Transmission convergence layer specification.*

### 3 Definitions

This clause is intentionally left blank.

### 4 Abbreviations and acronyms

GPON Gigabit-capable Passive Optical Network

ODN Optical Distribution Network

OLT Optical Line Terminal

ONU Optical Network Unit

PLOAM Physical Layer Operations, Administration and Maintenance

PON Passive Optical Network

### 5 Conventions

This clause is intentionally left blank.

## 6 Overview

Figure 6-1 shows the construction of a quiet window for the serial number acquisition in the ITU-T G.984 GPON system, where all ONUs are within the 20 km fibre reach. The quiet window in this case must accommodate the 200 µs variation of the round-trip propagation delay (0 to 200 µs), the 2 µs variation of the ONU processing time (34 to 36 µs), and the 48 µs ONU random delay (0 to 48 µs) (see clause 10.4.2 of [ITU-T G.984.3]). Therefore, the minimum size of the quiet window is 250 µs.

For the sake of specificity, assume that the OLT does not start the quiet window construction until the transmission of the serial number request grant. (See clause 10.4.5 of [ITU-T G.984.3] for the discussion of the alternatives.) In this case, the OLT employs the pre-assigned delay, which is not less than the combined variation of round-trip propagation delay and ONU processing time (202 µs). The minimum offset of the quiet window at the OLT (i.e., the time to earliest arrival of the serial number response after transmission of a serial number request grant) can be determined as 236 µs, a sum of the pre-assigned delay and the minimum ONU response time.

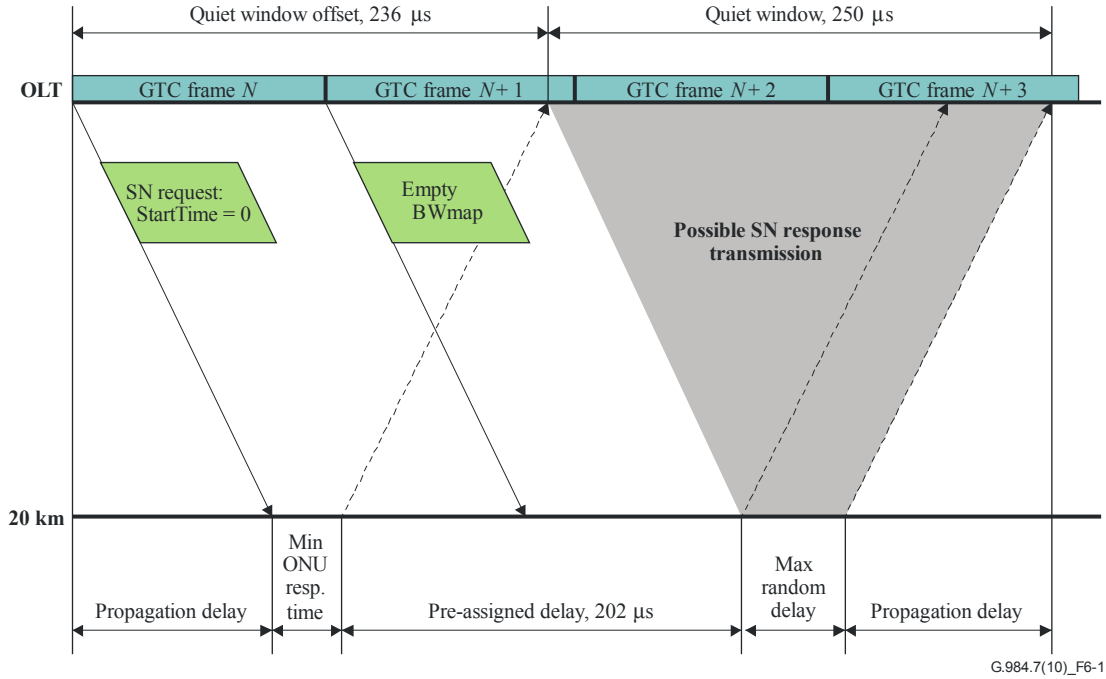


**Figure 6-1 – Construction of GPON quiet window with the 0 to 20 km distance range**

Figure 6-2 shows the quiet window construction for serial number acquisition in a GPON system where the fibre distances of all ONUs vary between 20 km and 40 km. The maximum differential fibre distance is the same as in the example above, i.e., 20 km. Since ONU's design and protocol parameters depend on fibre distance only, through the maximum differential fibre distance, they too remain the same. The minimum quiet window size in this case is also 250 µs. On the other hand, the round-trip propagation delay now varies from 200 to 400 µs, and the minimum round-trip propagation contributes to the quiet window offset, which becomes 436 µs.

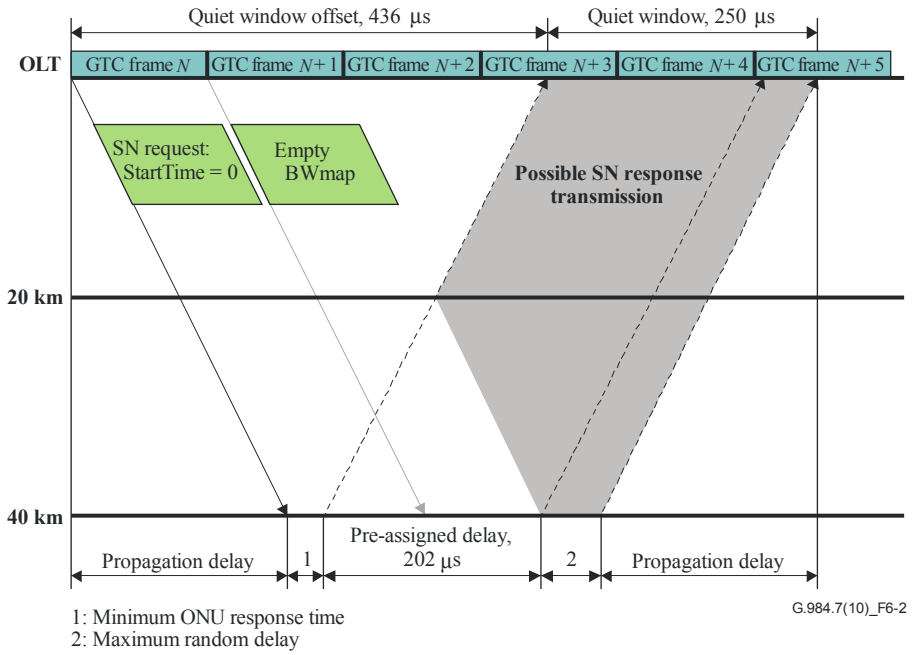


**Figure 6-2 – Construction of GPON quiet window with the standard differential distance and 20 km to 40 km distance range**

In a GPON system with extended differential reach (an EDR GPON system) the differential fibre distance is increased so that the ONUs could be placed anywhere between 0 and 40 km. This increases the variation of round-trip propagation delay to 400 µs (ranging from 0 to 400 µs). Therefore, the size of the quiet window that the OLT has to open for serial number acquisition in such a system, with other parameters being invariant, must be at least 450 µs. Figure 6-3 shows the construction of the quiet window for EDR GPON. Following the pattern adopted earlier, the pre-assigned delay is assumed to be equal to the combined variation of round-trip propagation delay and ONU processing time, i.e., 402 µs. The offset of the quiet window in this case is can be determined as 436 µs.

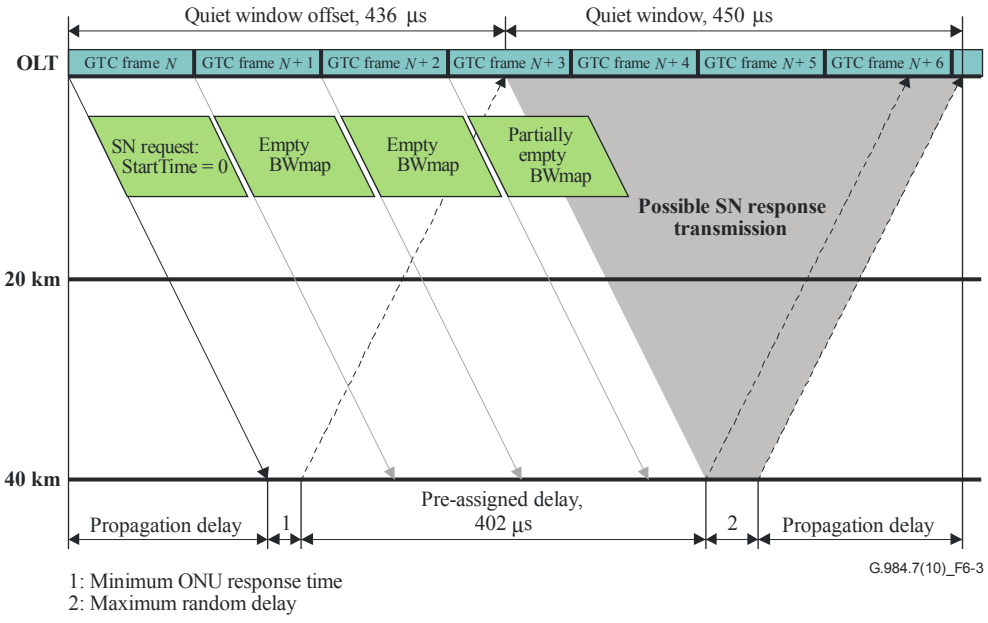


**Figure 6-3 – Construction of GPON quiet window with proposed extended differential distance (0 to 40 km)**

Note that serial number acquisition requires a broadcast PLOAM grant, and that multiple ONUs may attempt to respond. The random delay (0.48 μs) helps to reduce the probability of collision. When the OLT opens a quiet window for ranging, it uses a unicast grant with no possibility of contention, so that the minimum quiet window sizes are 202 μs for the case of the 20 km differential fibre distance case and 402 μs for the 40 km differential fibre distance case.

# 7 Physical layer requirements

## 7.1 Spectral width

[ITU-T G.984.2] defines certain PMD specifications for the OLT and ONU. For a GPON system operating at 2488 Mbps downstream rate and 1244 Mbps upstream rate, the 20 dB spectral width was originally specified as 1 nm. In order to serve ONUs deployed 0-40 km, 20-60 km or at distances in between with a 40 km differential distance from the OLT, the OLT laser 20 dB spectral width needs to be less than or equal to 0.6 nm.

## 7.2 Attenuation range

An EDR GPON system shall employ the optical components and maintain the optical power levels consistent with one of the standard attenuation range classes: Class B+, Class C, and Class C+. It shall support the maximum fibre distance and the maximum differential fibre distance as specified in the following table.

**Table 1 – Physical medium dependant layer parameters of ODN**

| Attenuation class | Attenuation range, dB | Max physical reach, km | Max differential fibre distance, km |
|---|---|---|---|
| Class B+ | 13-28 | 40 | 40 |
| Class C | 15-30 | 40 | 40 |
| Class C+ | 17-32 | 60 | 40 |

## 7.3 ODN topology

The ODN shall be based on ITU-T G.652 fibre and shall possess the topology, including the location and degree of the power splitter and possible use of passive optical attenuators, to ensure that the minimum loss requirement is met for each ONU.

An ODN accommodating the differential fibre reach approaching 40 km may employ an unbalanced cascade of splitters, where the shortest fibre branches experience the highest degree of split. An example of a Class B+ ODN supporting 13-28 dB attenuation range with maximum physical reach of 40 km and differential fibre reach of 40 km is shown in Figure 2.1. In this example, the ONUs with shorter fibre distance experiences the higher degree of split than the remote ONUs. Specifically, assuming, in the first approximation, 3.5 dB attenuation per binary split and 0.4 dB per kilometre of fibre, one can obtain for the group of near ONUs the total attenuation of 17.5 dB and for the group of remote ONUs the total attenuation of 26.5 dB, both values being within the allowed window for the class.

Other topologies may be possible, provided the ODN meets the specifications given in [ITU-T G.984.2].

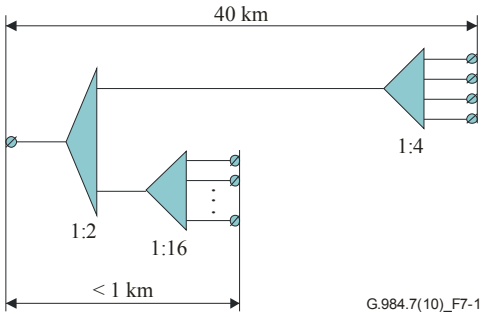


**Figure 7-1 – An example of Class B+ ODN supporting the differential fibre reach of 40 km**

# 8 GPON Transmission convergence layer requirements

## 8.1 OLT side considerations

At the serial number acquisition and ranging phases of the activation process, the OLT shall be able to create a quiet window appropriate for a 40 km differential fibre distance between the farthest and closest ONUs.

While the possibility to use narrow quiet windows based on the previous knowledge of ONU location is for further study, it should be noted that on the first ONU activation no a priori fibre distance information is available.

## 8.2 ONU side considerations

An ONU in an EDR GPON system has to provide enough buffering for the upstream traffic arriving at the ONU within the quiet window, which is approximately twice as large as in a conventional GPON system.

An ONU in an EDR GPON system shall support larger storage to accomodate twice as many BWmaps as a conventional GPON system.

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