

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.987.1

Amendment 1

(04/2012)

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

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

10-Gigabit-capable passive optical networks
(XG-PON): General requirements

Amendment 1

Recommendation ITU-T G.987.1 (2010) –
Amendment 1

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Recommendation ITU-T G.987.1

10-Gigabit-capable passive optical networks (XG-PON): General requirements

Amendment 1

Summary

Amendment 1 to Recommendation ITU-T G.987.1 (2010) includes:

- 1) text describing the operation of XG-PON with IEEE 1588;
- 2) use cases for XG-PON frequency and time-of-day synchronization;
- 3) transport of ESMC messages over PON; and
- 4) clarification of the reference optical configuration for XG-PON coexistence through splitters.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.987.1	2010-01-13	15
1.1	ITU-T G.987.1 (2010) Amd. 1	2012-04-22	15

FOREWORD

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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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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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Recommendation ITU-T G.987.1

10-Gigabit-capable passive optical networks (XG-PON): General requirements

Amendment 1

1 Scope

Amendment 1 of ITU-T G.987.1 includes:

- 1) text describing the operation of XG-PON with [IEEE 1588],
- 2) use cases for XG-PON frequency and time-of-day synchronization,
- 3) text describing the transport of ESMC messages over PON and
- 4) clarification of the reference optical configuration for XG-PON coexistence through splitters.

2 Additional acronyms

Insert the following acronyms alphanumerically in the list of abbreviations and acronyms within clause 4:

ESMC Ethernet Synchronization Messaging Channel

OSSP Organization Specific Slow Protocol

PRC Primary Reference Clock

PTP Precision Timing Protocol

RNC Radio Network Controller

ToD Time-of-Day

3 New Appendix IV

Add the following material as a new Appendix IV:

Appendix IV

Operation with IEEE 1588

(This appendix does not form an integral part of this Recommendation.)

[IEEE 1588] describes a protocol for transferring time and/or frequency information through a packet network. A good explanation of this can be found in [b-Garner].

XG-PON distributes the IEEE 1588 master and slave functionality between the OLT and the ONU. The OLT will perform the slave port function; or, in the case of a shelf, the OLT will receive the frequency and time information from the function in the shelf that performs the slave port function. The OLT synchronizes the PON line rate to the network clock frequency, and transfers the time-of-day information to the ONU using the method in clause 13.2 of [ITU-T G.987.3]. The ONU uses

the methods specified in [ITU-T G.987.2] to recover frequency and [ITU-T G.987.3] to recover time. The ONU will then either function as a master port to subsequent nodes or output the time and frequency information through another interface.

4 New Appendix V

Add the following material as a new Appendix V:

Appendix V

Use cases for frequency and time-of-day synchronization

(This appendix does not form an integral part of this Recommendation.)

There are many applications where precise time and/or frequency information must be transferred through a packet network from a source to a destination. In this appendix, several use cases are described in terms of the methods used to deliver frequency and/or time information. Since most of the use cases mentioned are related to mobile backhauling applications, examples will use the RNC and Node B network elements; however, these use cases are not intended to be exhaustive.

Frequency and/or time-of-day synchronization is provided to the OLT via either:

- 1) Physical timing interface (e.g., synchronous Ethernet (SyncE)) (frequency only)
- 2) [IEEE 1588] + synchronous Ethernet
- 3) [IEEE 1588] + non-synchronous Ethernet
- 4) Physical time-of-day (ToD) interface + SyncE

Frequency and/or time-of-day synchronization is supplied from the ONU via either:

- 1) Physical timing interface (e.g., synchronous Ethernet (SyncE)) (frequency only)
- 2) [IEEE 1588] + synchronous Ethernet
- 3) [IEEE 1588] + non-synchronous Ethernet
- 4) Physical ToD interface + SyncE

The use cases are described in terms of various combinations of these synchronization inputs and outputs, as shown in Table V.1.

Table V.1 – XG-PON synchronization use cases

Use case	Network synchronization to OLT	UNI synchronization from ONU
1	SyncE (frequency only)	SyncE (frequency only)
2	[IEEE 1588] and SyncE	[IEEE 1588] and SyncE
3	[IEEE 1588]	[IEEE 1588]
4	[IEEE 1588]	[IEEE 1588] and SyncE
5	[IEEE 1588] and SyncE	ToD interface and SyncE
6	[IEEE 1588]	ToD interface and SyncE
7	ToD interface and SyncE	ToD interface and SyncE

Figure V.1 depicts use case 1 where frequency only is transferred through the XG-PON network. The clock interface at the OLT input and the ONU output is a physical timing interface such as synchronous Ethernet (SyncE), defined in [ITU-T G.8262]. The OLT synchronizes the PON line

rate to this physical interface. The ONU outputs a physical timing interface such as SyncE, which is synchronous to the PON line rate.

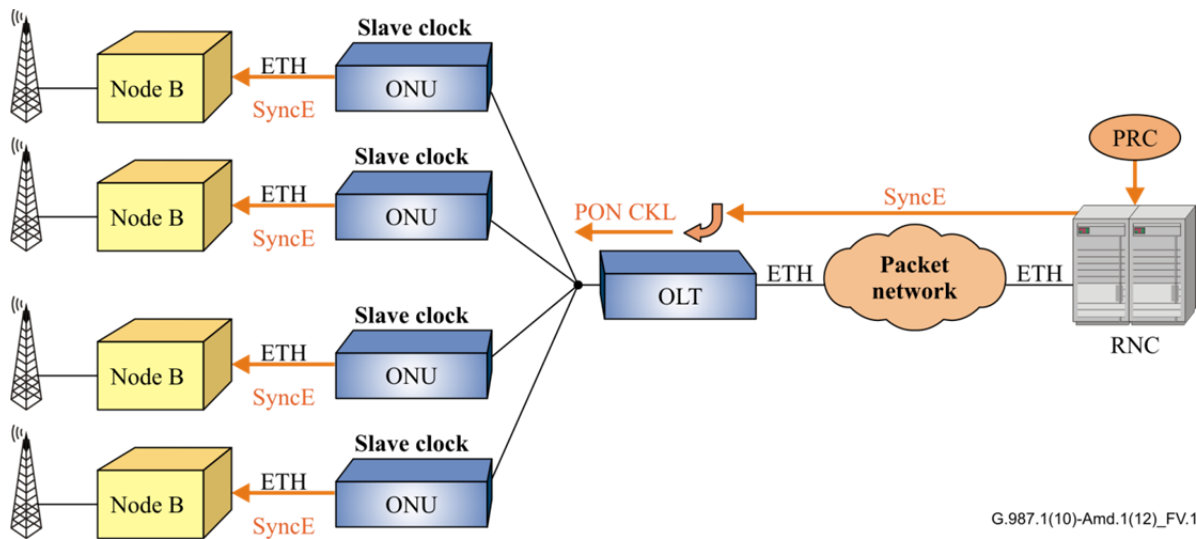


Figure V.1 – Using synchronous Ethernet in XG-PON (use case 1)

There are several use cases of interest (use cases 2 through 6) that use [IEEE 1588], with the following assumptions. The PRC provides a frequency reference. The OLT network interface is Ethernet, with the Ethernet line rate either synchronous to a network frequency reference (synchronous Ethernet) or not synchronous to a network frequency reference. The OLT obtains time-of-day using [IEEE 1588], usually through intervening nodes between the OLT and the PRC. The OLT synchronizes to the network frequency reference either using synchronous Ethernet, [IEEE 1588], or some other physical layer synchronous interface. The OLT transfers the time-of-day to the ONU using the method specified in chapter 13 of [ITU-T G.987.3]. The OLT transfers the network frequency reference to the ONU via its downstream line rate, which is synchronous to the network frequency reference. The ONU user interface is Ethernet, with the Ethernet line rate either synchronous to a network frequency reference (synchronous Ethernet) or not synchronous to a network frequency reference. The ONU may also have a physical time interface (e.g., 1pps).

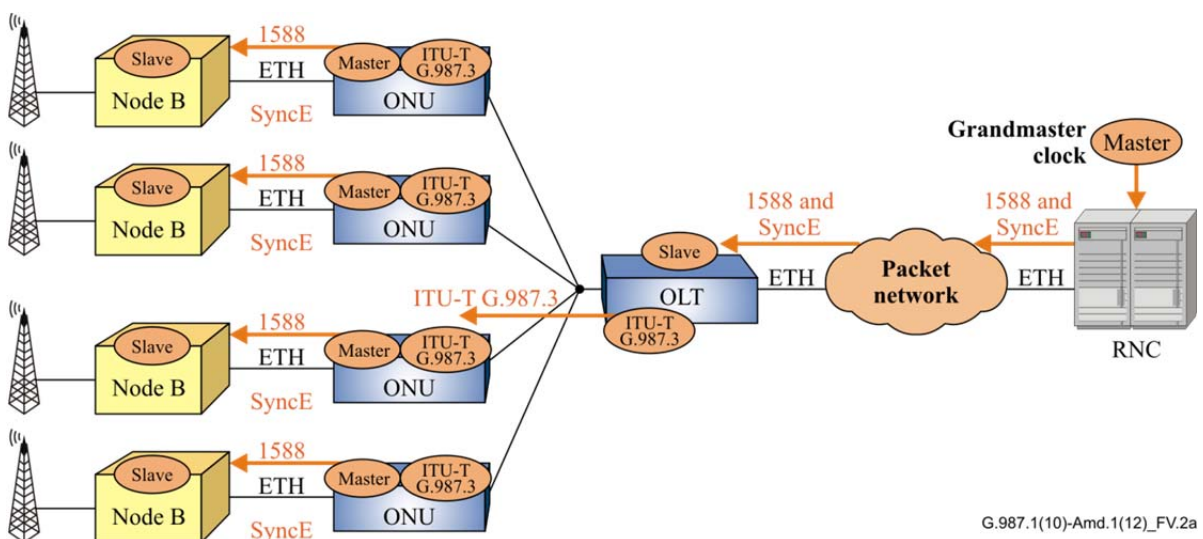


Figure V.2a – PTP use case 2: ONU as IEEE 1588 master, OLT as IEEE 1588 slave with SyncE at both SNI and UNI

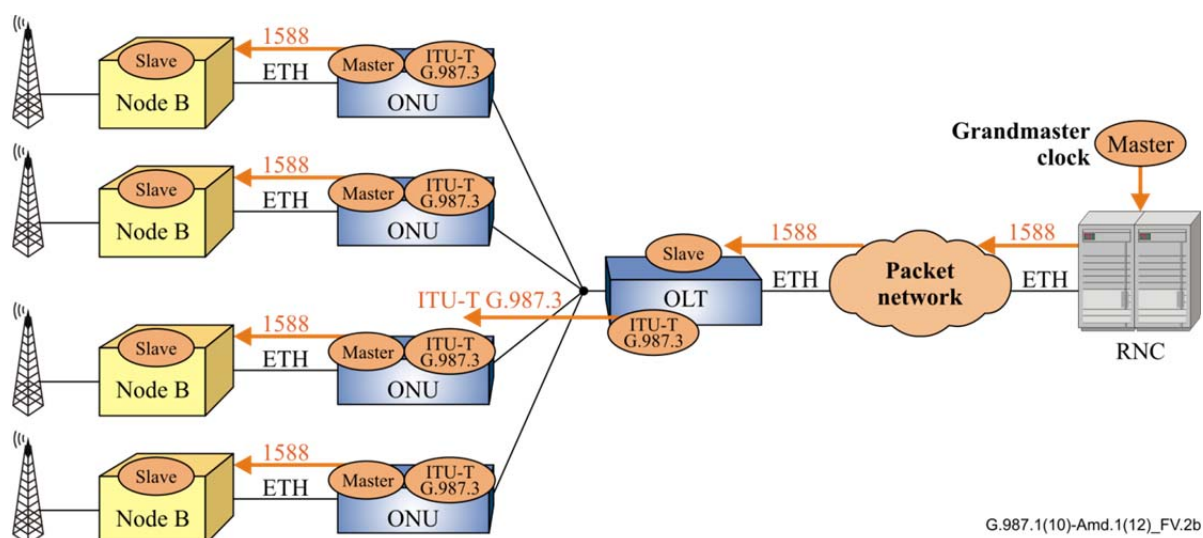


Figure V.2b – PTP use case 3: ONU as IEEE 1588 master, OLT as IEEE 1588 slave without SyncE

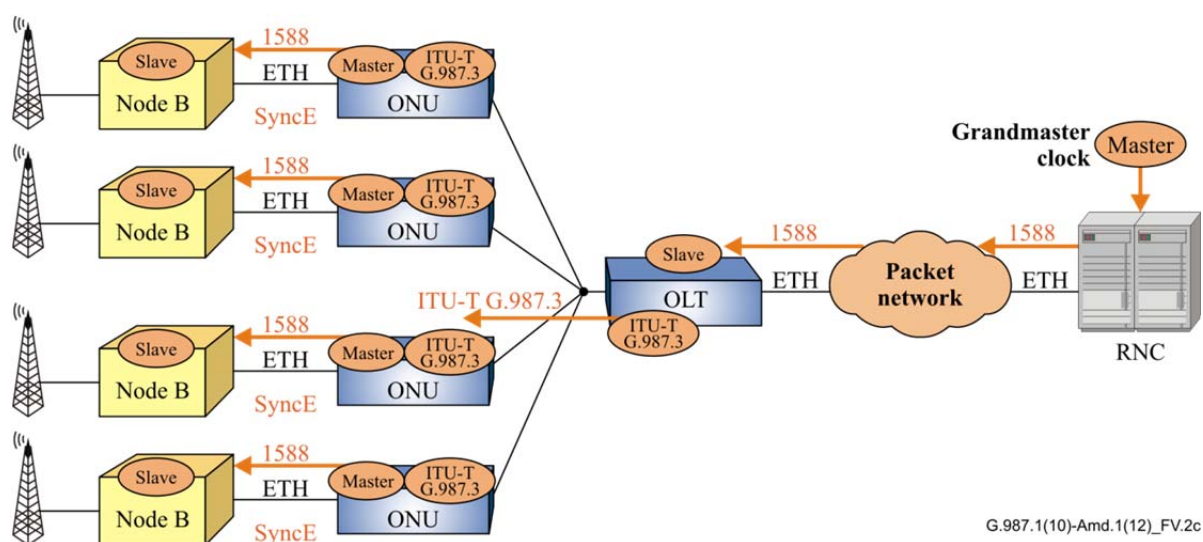


Figure V.2c – PTP use case 4: ONU as IEEE 1588 master, OLT as IEEE 1588 slave, with SyncE at UNI

Figures V.2a and V.2b show use cases 2 and 3 for wireless backhaul. The OLT has an IEEE 1588 slave port at the SNI, which obtains the time of day from the network. This time of day is passed to the ONU as described above, and the ONU passes the time of day from an IEEE 1588 master port to the Node B. If the OLT network feed is synchronous Ethernet (use cases 2), then the OLT will synchronize its downstream PON line rate to the synchronous Ethernet line rate; otherwise the OLT will synchronize its downstream PON line rate to the IEEE 1588 time-of-day (use cases 3). If the link between the ONU and the Node B is synchronous Ethernet (use cases 2), then the synchronous Ethernet line rate will be synchronized to the downstream PON line rate. Synchronous Ethernet ESMC messages would be used in conjunction with the synchronous Ethernet to indicate clock quality.

Figure V.3a below shows use case 5, while Figure V.3b illustrates use case 6 for wireless backhaul. The only difference between Figure V.2 and Figure V.3 is that the ONU has a physical interface for transferring time information to the Node B, such as a ToD interface. If the OLT network feed is synchronous Ethernet (use case 5), then the OLT will synchronize its downstream PON line rate to

the synchronous Ethernet line rate; otherwise the OLT will synchronize its downstream PON line rate to the IEEE 1588 time-of-day (use cases 6).

Figure V.2c illustrates use case 4 where the OLT does not receive synchronous Ethernet and derives the downstream PON line rate from [IEEE 1588]. In this case the ESMC messages would correspond to the IEEE 1588 clock quality and not a clock quality received via ESMC at the OLT.

Figure V.4 shows use case 7, where a physical ToD interface is provided as an input to the OLT. The OLT processes the ToD information and sends timing information to the ONU according to the description provided in clause 13.2 of [ITU-T G.987.3]. The ONU processes the received timing information and outputs the timing information using a physical ToD interface.

NOTE – The details of the physical ToD interface are for further study.

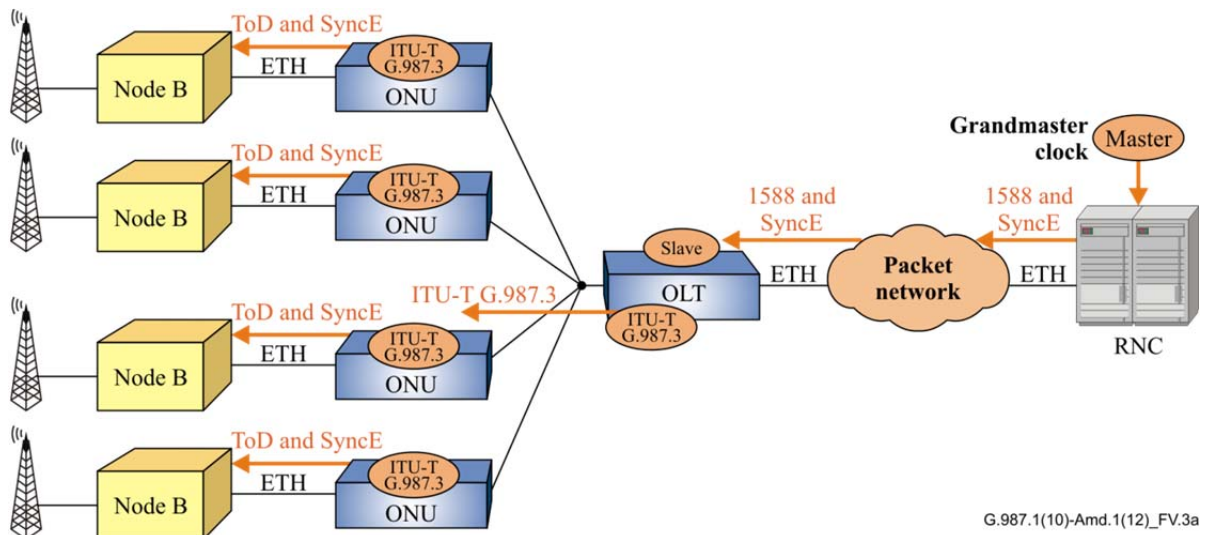


Figure V.3a – PTP use case 5: ONU with physical time interface, OLT as IEEE 1588 slave with SyncE at both SNI and UNI

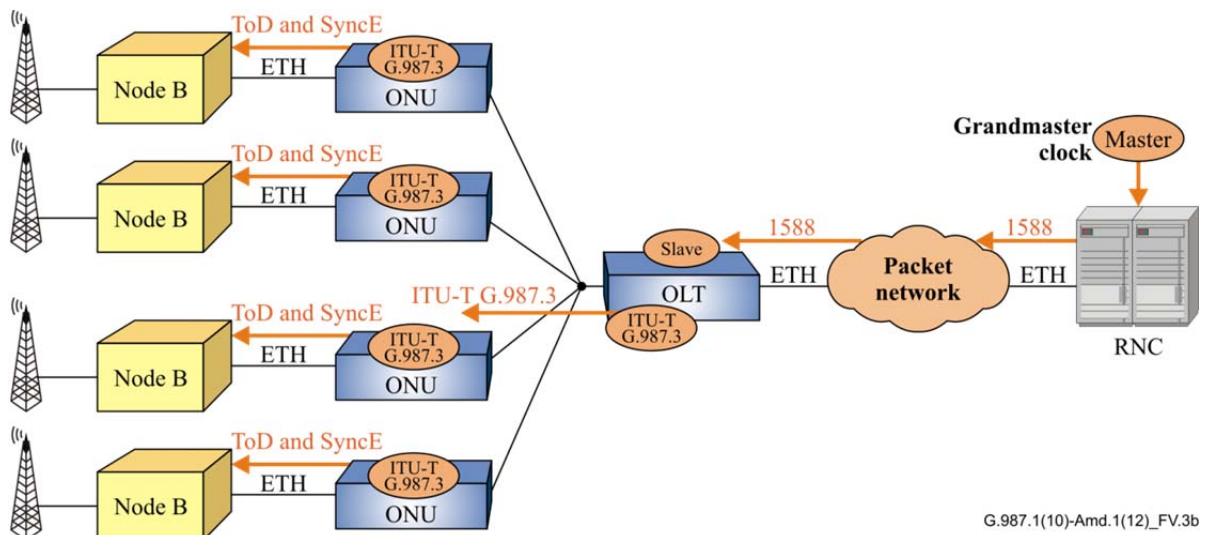


Figure V.3b – PTP use case 6: ONU with physical time interface, OLT as IEEE 1588 slave with SyncE at UNI only

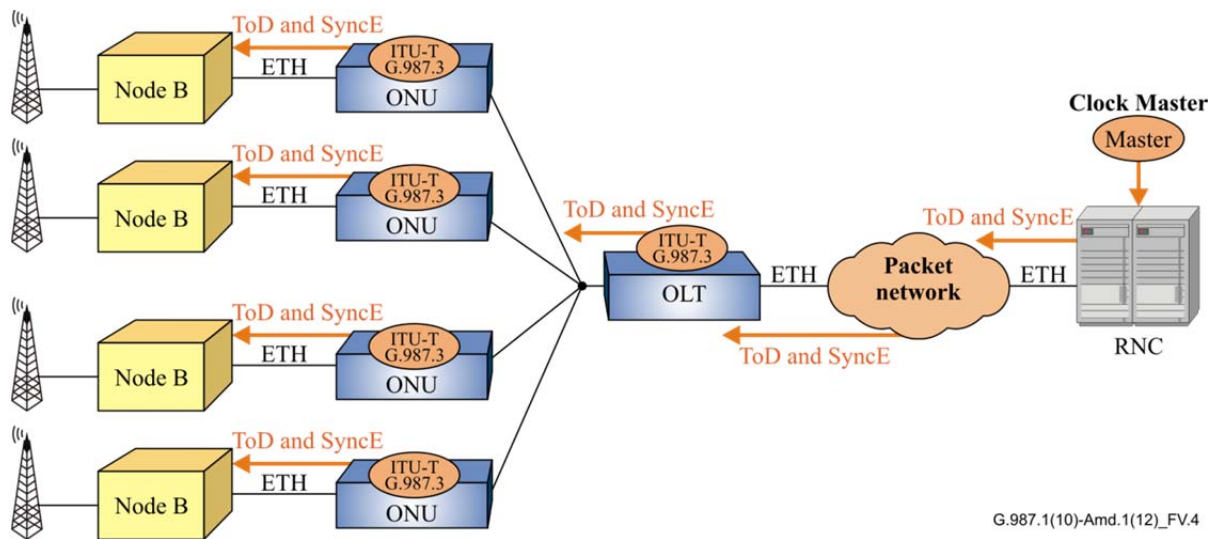


Figure V.4 – Use case 7, ONU and OLT with physical time interface

5 New Appendix VI

Add the following material as a new Appendix V:

Appendix VI

Transport of ESMC messages over PON

(This appendix does not form an integral part of this Recommendation.)

In Appendix V, the use case of synchronous Ethernet over the PON was described and the ESMC was introduced. Appendix VI addresses frequency synchronization over XG-PON, but focuses on a recommended method to transfer the SSM carried in the ESMC (as defined in [b-ITU-T G.8264]) that are used to send the synchronous Ethernet clock quality in a one-way fashion from the clock master to a base station or other end-device. Refer to Figure V.1, for this appendix.

Within the physical layer, synchronous Ethernet is transferred over the OLT/ODN/ONU in the following way. A synchronous Ethernet-capable OLT will lock the XG-PON clock to the received Ethernet clock at the OLT SNI, and a synchronous Ethernet-capable ONU will, in turn, lock the Ethernet clock of one or more provisioned Ethernet port UNIs to the XG-PON clock.

NOTE – [ITU-T G.8262] defines the types of UNIs capable of synchronous Ethernet.

Characteristics of the ESMC include:

- Simple, stateless, unidirectional protocol for communicating the current reference clock quality between nodes.
- Uses the IEEE 802.3 Organization Specific Slow Protocol (OSSP).
- Destination address is the IEEE defined Slow Protocol multicast address.
- One message type, the Synchronization Status Message.
- Sent at approximately one message per second containing the clock Quality Level (QL).

ESMC messages over XG-PON

ESMC messaging must be handled by the OLT/ONU as a system.

The main difference in how a PON must handle ESMC messages, versus an Ethernet switch, is that the OLT-to-ONU link is not a point-to-point Ethernet link but rather uses the XG-PON point-to-multipoint protocol, with the ESMC messages sent via GEM encapsulation. While different in this respect, in all *functional* aspects the OLT and the ONU may handle ESMC messages largely as defined in [b-ITU-T G.8264].

Method for sending Synchronization Status Messages over XG-PON

An OLT that is synchronous Ethernet-capable should provisionably process and act upon ESMC messages that are received on synchronous Ethernet-provisioned SNI ports.

If there are multiple provisioned synchronous Ethernet-capable ports then the OLT should synchronize to, and obtain the clock quality (QL value) from, the best port using the synchronization selection methods defined in [b-ITU-T G.8264] and [b-ITU-T G.781].

The OLT should then send an OSSP ESMC Message of equal clock quality minimizing additional impact on PON traffic. The OLT should not send ESMC messages unless it has been provisioned to do so.

ONUs may be provisioned to recognize ESMC through the normal process of configuring an incidental broadcast GEM port, the appropriate VLAN, and a bridge to the desired Ethernet UNIs. After intercept, the ONU will have obtained the clock quality which will equal that of the ESMC received at the OLT. The ONU should then send ESMC messages that are compliant to [b-ITU-T G.8264] only from UNIs that are members of the ESMC VLAN bridge.

6 Revised Figure 5-6 and new note

Replace Figure 5-6 with the following figure and note:

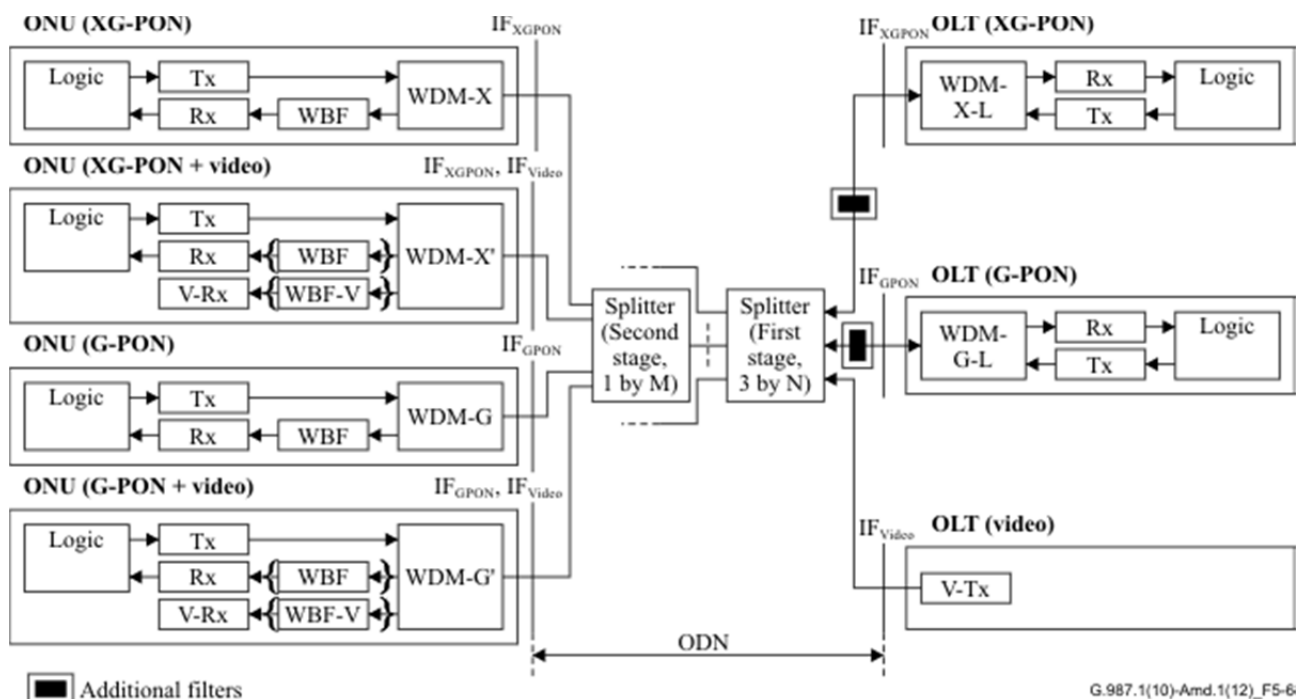


Figure 5-6 – Reference optical configuration for XG-PON coexistence through splitters

NOTE – In case coexistence of XG-PON through splitters is envisioned, strengthened filtering or additional filtering, as shown in Figure 5-6, should be used at OLT for implementation of the WDM-X-L and WDM-G-L to offer the required isolation. Those filters, when part of OLT implementation choices, are out of scope of ITU-T G.987-series of Recommendations.

7 Additional references

Insert the following items in the Bibliography:

- [b-ITU-T G.781] Recommendation ITU-T G.781 (in force), *Digital terminal equipments – Principal characteristics of multiplexing equipment for the synchronous digital hierarchy*.
- [b-ITU-T G.8264] Recommendation ITU-T G.8264 (in force), *Distribution of timing information through packet networks*.
- [b-Garner] Garner, G., *Tutorial on IEEE 1588 Version 2*, 2008 International IEEE Symposium on Precision Clock Synchronization for Measurement, Control and Communication.
<<http://www.ieee802.org/1/files/public/docs2008/as-garner-1588v2-summary-0908.pdf>>

Insert the following item in clause 2, References:

- [ITU-T G.987.3] Recommendation ITU-T G.987.3 (2010), *10-Gigabit-capable passive optical networks (XG-PON): Transmission convergence (TC) layer specification*.

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