

ALTICE LABS MANUAL

FiberGateway User Manual

GR240BG

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Glossary

Acronyms and abbreviations

3G	Third generation mobile telecommunications
AAA	Authentication, Authorization, and Accounting
AC	Alternating Current
AC	Access Concentrator
ACL	Access Control List
ACS	Auto Configuration Server
AES	Advanced Encryption Standard
ARP	Address Resolution Protocol
AS	Autonomous System
AUTO-MDIX	Medium Dependent Interface Crossover Automatic Choice
BBF	Broadband Forum
BGP	Border Gateway Protocol
CAT5E	Category 5 Cable
CATV	Cable TV
CIFS	Common Internet File System
CLI	Command-line interface
CO	Central Office
CPE	Customer-Premises Equipment
CRC	Cyclic Redundancy Check
DC	Direct Current
DDNS	Dynamic DNS
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DSCP	Differentiated Services Code Point
DSL	Digital Subscriber Line
EAP-SIM	Extensible Authentication Protocol Method for GSM Subscriber Identity Module
FTP	File Transfer Protocol
FTTH	Fiber-To-The-Home
FXS	Foreign eXchange Station
GbE	Gigabit Ethernet
GEM	GPON Encapsulation Module
GEPON	Gigabit Ethernet Passive Optical Network
GPON	Gigabit-capable Passive Optical Network
GSM	Global System for Mobile Communications
GW	Gateway
HG	Home Gateway
HSI	High Speed Internet
ID	Identification

IEEE	Institute of Electrical and Electronics Engineers
IGMP	Internet Group Management Protocol
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPTV	Internet Protocol Television
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISP	Internet Service Provider
ITU-T	Telecommunications International Telecommunication Union
L2	OSI Layer 2
L3	OSI Layer 3
LAN	Local Area Network
LED	Light Emitting Diode
MAC	Media Access Control
MAN	Metropolitan Area Network
MAP	Mobile Application Part
ME	Managed Entity
MEGACO	Media Gateway Control Protocol
MRU	Maximum Receive Unit
MTBF	Mean Time Between Failures
NAS	Network Access Server
NAT	Network Address Translation
NGN	Next Generation Network
NMS	Network Management System
OLT	Optical Line Terminal
OMCI	ONT Management Control Interface
ONT	Optical Network Terminal
OPEX	Operational Expenditure
OSI	Open Systems Interconnection
PC	Personal Computer
PON	Passive Optical Network
PPP	Point-to-Point Protocol
PPPoE	Point-to-Point Protocol over Ethernet
PSK	Phase-Shift Keying
PWLAN	Public Wireless LAN
QoS	Quality of Service
RADIUS	Remote Authentication Dial In User Service
RF	Radio Frequency
RGW	Residential Gateway
RIP	Routing Information Protocol
RJ11	Registered Jack model 11
RJ45	Registered Jack model 45
SAMBA	SMB/CIFS implementation
SC/APC	SC/APC optical connector

SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SIP	Session Initiation Protocol
SMB	Server Message Block
SNTP	Simple Network Time Protocol
SS7	Signalling System No. 7
SSID	Service Set Identifier
STB	Set Top Box
SW	Software
T-CONT	Transmission Container
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TKIP	Temporal Key Integrity Protocol
TR-069	Technical Report 069
TTL	Time to Live
TV	Television
UDP	User Datagram Protocol
URL	Uniform Resource Locator
USB	Universal Serial Bus
UTP	Unshielded Twisted Pair
VAD	Voice Activity Detection
VAP	Virtual Access Point
VID	VLAN Identifier
VLAN	Virtual Local Area Networks
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
WPS	Wi-Fi Protected Setup
xBASE-T	Ethernet over twisted pair technologies

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This User Manual is applicable to the equipment FiberGateway Altice GR240BG with the FCC ID: 2ACJF-FGW-GR240BG

FCC NOTICE

This device complies with FCC part 15 rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference and
2. This device must accept any interference, including interference that may cause undesired operation of the device

Caution:

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to

Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.

- Increase the separation between the equipment and receiver.

- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

- Consult the dealer or an experienced radio/TV technician for help.

This device meets the FCC requirements for RF exposure in public or uncontrolled environments.

RF Exposure Statement

Note: This transmitter must not be co-located or operated in conjunction with any other antenna or transmitter.

This equipment should be installed and operated with a minimum distance of 8.3 inches (21 cm) between the radiator and your body.

This system has been evaluated for RF exposure for humans in reference to ANSI C 95.1 (American National Standards Institute) limits.

The evaluation was based in accordance with FCC OET Bulletin 65C rev 01.01 in compliance with Part 2.1091 and Part 15.27.

The minimum separation distance from the antenna to general bystander is 8.3 inches (21 cm) to maintain compliance.

Compliance with FCC requirement 15.407(c)

Data transmission is always initiated by software, which is then passed down through the MAC, through the digital and analog baseband, and finally to the RF chip. Several special packets are initiated by the MAC. These are the only ways the digital baseband portion will turn on the RF transmitter, which it then turns off at the end of the packet. Therefore, the transmitter will be ON only while one of the aforementioned packets is being transmitted. This device automatically discontinues transmission in case of either absence of information to transmit or operational failure.

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1 Summary

The FiberGateway is an Optical Terminal Equipment (ONT) unit for Passive Optical Networks (PON) termination in a FTTH (Fiber-To-The-Home) service delivery architecture. FiberGateway communicates with the OLT (Optical Line Terminal) for the PON side and with the customer's premises for the client side. This equipment supports triple-play services - high speed internet (HSI), voice (VoIP), video (IPTV) and WPS (Wi-Fi Protected Setup). The use of the GPON fiber access technology does allow a significant service delivery increase when compared with traditional xDSL technologies.

The FiberGateway equipment technology is based on GEM (GPON Encapsulation Method), and complies with ITU-T G.984.x. recommendation as like as G.984.4 (OMCI) ensuring interoperability with major GPON OLT vendors (BBF.247).

These base functionalities, together with the support for bit rates of up to 2.5 Gbps (downstream) and 1.24 Gbps (upstream), an optical network splitting ratio of up to 1:64 in a single fiber and a distance range of up to 60 km, make the GPON technology and the FiberGateway the most efficient option for passive optical network topologies, when integrated service delivery is an issue.

Together with multi-vendor OLT interoperability (BBF.247 certified), other differentiated features of the FiberGateway product include the use of an embedded optical reflective component that increases probing resolution in case of FTTH probing. The FiberGateway is also one of the first single household integrated CPE solution (ONT+GATEWAY).

As opposed to the point-to-point architecture, in which there is one physical port per client in the Central Office, in GPON point-to-multipoint architecture there is only a single laser and photo-detector in the Central Office (CO) to serve up to 128 CPEs. All the Optical Distribution Network is built by means of passive equipment modules with a long live MTBF standards and very low OPEX.

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2 Technical Description

2.1 FiberGateway Main Functionalities

The FiberGateway is aimed for customer premises and complies with the ITU-T G.984.x recommendation in order to transport (over GPON) and deliver (to premises domain) the full broadband service pack.

Broadband service applications are commonly referred as below:

- High speed internet (HSI);
- Voice (VoIP) services (SIP/MEGACO H.248);
- TV (IPTV);
- Wi-Fi.

The multiplay environment is thus reinforced when combining the upper referred services.

2.2 FiberGateway Application Scenario

The next figure shows a possible gateway scenario for FiberGateway equipments when in an FTTx architecture.

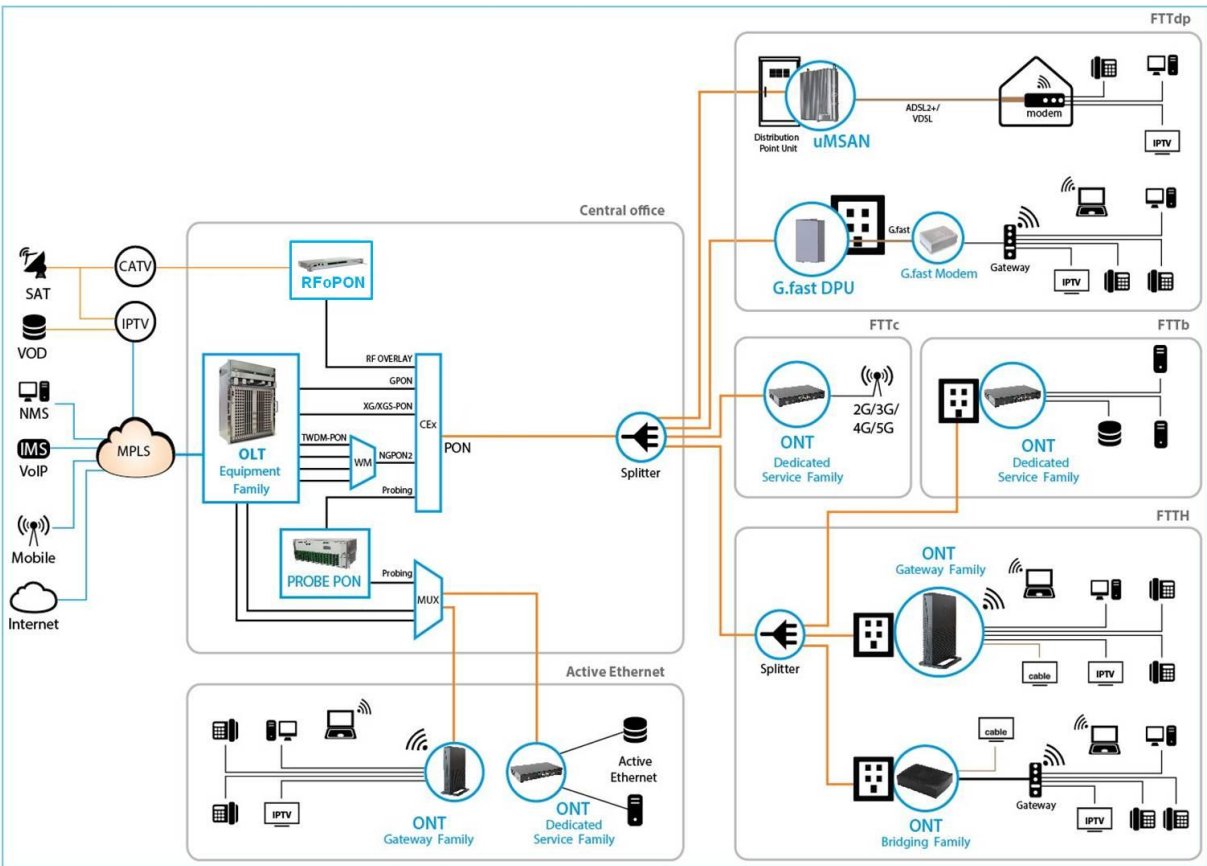


Figure 1: FTTx architecture

2.3 Interoperability

FiberGateway equipment complies with ITU-T G.984.x. recommendation as like as G.984.4 (OMCI) ensuring multi-vendor OLT interoperability with major GPON OLT vendors, as defined in BBF.247 ONU certification program.

BBF.247 ONU certification program certifies ONT link layer configuration and management protocol, OMCI, Figure 2, as defined by ITU-T G.984.3, ITU-T G.984.4 and ITU-T G.988.

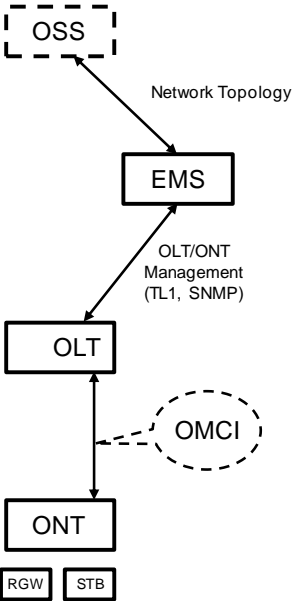


Figure 2: Link Layer Configuration and Management

IP-based services configuration and management is achieved by means of the TR-069 protocol as defined by Broadband Forum. This procedure takes for granted that previously the link layer connectivity has been achieved.

TR-069 is then transparent to the OLT, since the TR-069 connections are established between the ACS and the ONTs, Figure 4.

ONT gateway family equipments integrate gateway functionalities. Link layer configuration and management is achieved by the use of OMCI, while IP-based services (RG functionality and Voice over IP) are configured and managed by TR-069, Figure 3.

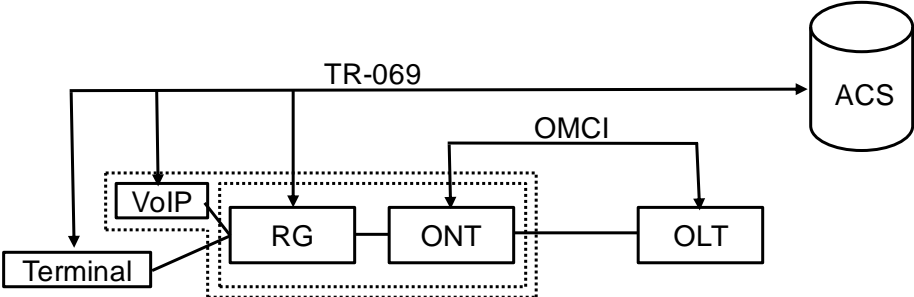


Figure 3: FiberGateway equipment configuration

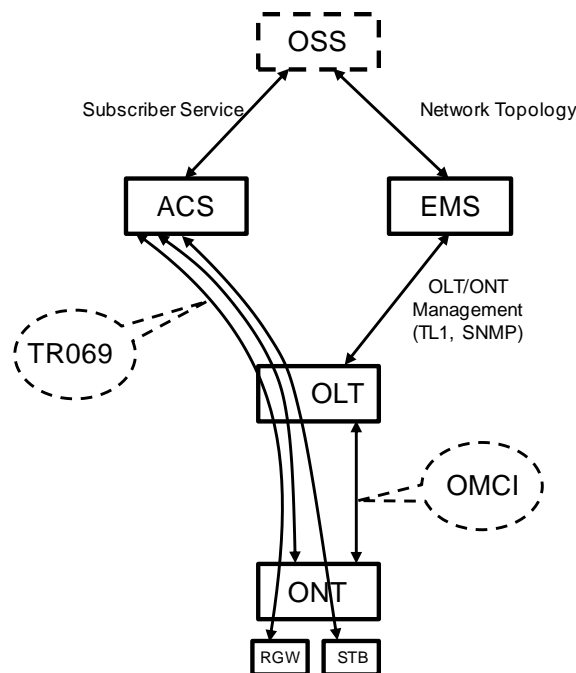


Figure 4: IP Based services-TR069 configuration

2.4 Interfaces

Client interface options are of type:

- 4x 10/100/1000Base-T for Ethernet network connection (RJ45 connectors);
- 2x FXS channels (RJ11 connectors);
- Wi-Fi:
 - MIMO 4x4 @ 2.4GHz wireless interfaces (802.11 b/g/n);
 - MIMO 4x4 @ 5 GHz wireless interfaces (802.11 a/n/ac);
- 1x USB 2.0 Master for printer sharing, media sharing and for 3G/4G backup uplink;
- Control switches for power and Wi-Fi;

Network interface option is of type:

- GPON SC/APC Optical connector (B+/C+).

2.5 General Features

GPON is a point-to-multipoint passive optical network, in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises, typically 1-64.

A PON consists of an optical line terminal (OLT) at the central office and a number of optical network terminals (ONT) at the customer premises. Downstream signals are broadcasted to all premises sharing multiple fibers. Encryption can prevent eavesdropping. Upstream signals are combined using a multiple access protocol (Time Division Multiple Access - TDMA). The OLT queues data to the various ONT terminals in order to provide time slot assignments for upstream communication.

In Figure 5 it is shown a scenario for a multi-service user domain basic architecture through an ISP network.

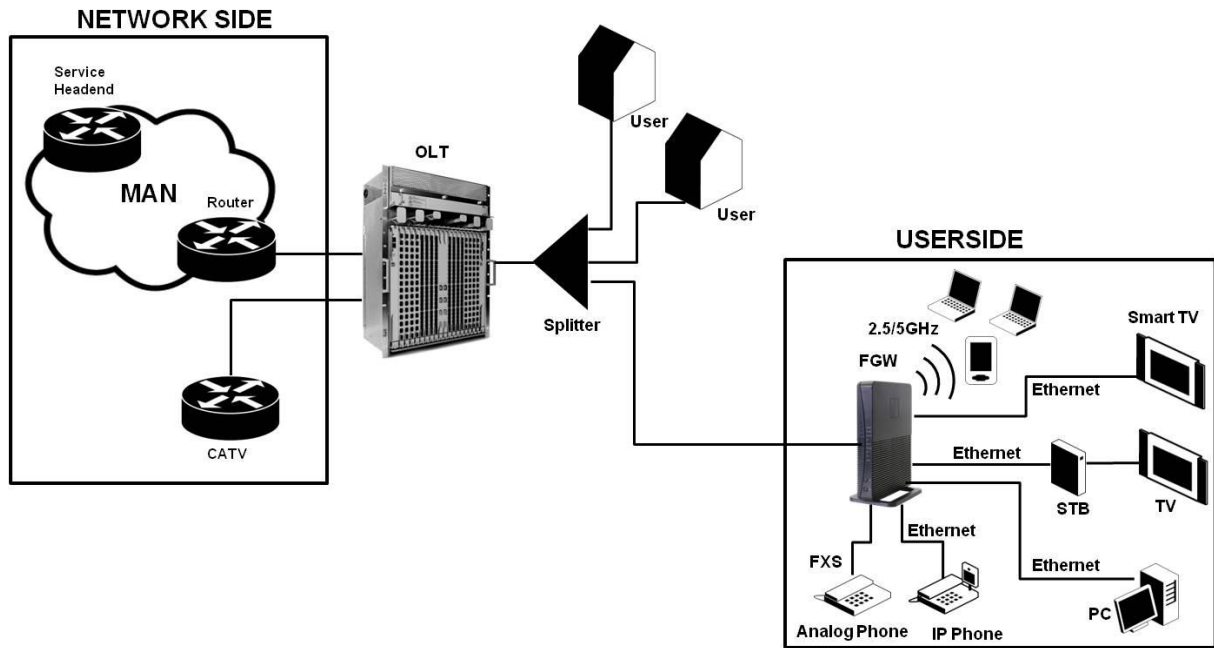


Figure 5: Optical fiber Internet service user access

In the upstream direction, the FiberGateway is connected to the optical splitter and respectively to the OLT through the PON port to provide integrated access services through the service headend.

In the downstream direction, the FiberGateway is connected to various terminals through the following LAN-side ports to implement multi-play services:

- Four 10/100/1000M Base-T Ethernet ports, which can be connected to terminals such as PCs, STBs, and video phones to provide the high-speed data and video services;
- Two FXS ports, which can be connected to telephone sets to provide VoIP services;
- Four Wi-Fi antennas, which can connect to Wi-Fi terminals wirelessly to provide a secure and reliable high-speed wireless network;
- One USB port, which can be connected to a USB storage device to provide convenient storage and file sharing services within a home network;

The communication between client equipment (ONT) and the ISP access routers (MAN edge) is made by an optical fiber-based passive architecture (ITU-T G.984 Recommendation). The GPON network acts as a Layer 2 Ethernet metropolitan network. Access network assures and controls the media (MAC) communication through a TDMA scheme, introducing GEM (GPON Encapsulation Method) in between to adapt TDM layer to Ethernet.

The used protocol stack is shown in Figure 6.

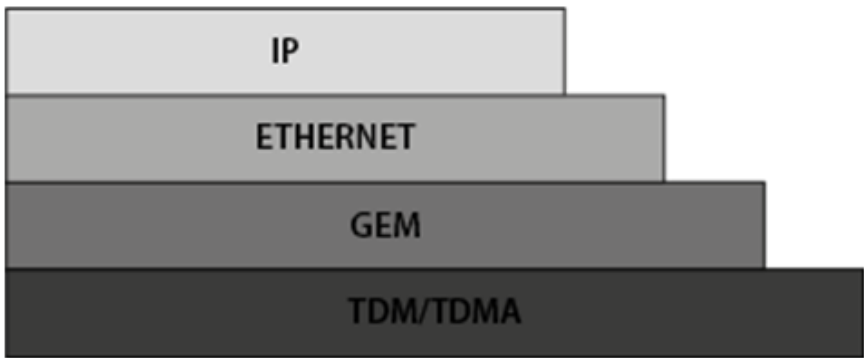


Figure 6: Stack of protocols for GPON architecture

Several transmission containers (T-CONT) are assigned to each user. Each T-CONT has an associated GEM port and each GEM port has a VLAN identifier and an 802.1p priority level.

The ONT classifies the traffic depending on the VLAN and the marked priority, and routes it over the corresponding T-CONT/GEM port. Thus for frame multiplexing, GEM and T-CONT ports are used for uplink while the downlink only use the GEM ports feature.

FiberGateway complies with Broadband Forum TR-142 Technical Report, which defines a framework for the remote configuration and management of IP-based services over PON (Passive Optical Network) and fiber access technology.

TR-142 framework uses TR-069 which is the protocol of choice for the remote management and configuration of IP services over PON and fiber access networks. TR-069 is intended to be used for the remote configuration and management of IP services running over ONT, as well as for some aspects of ONT management.

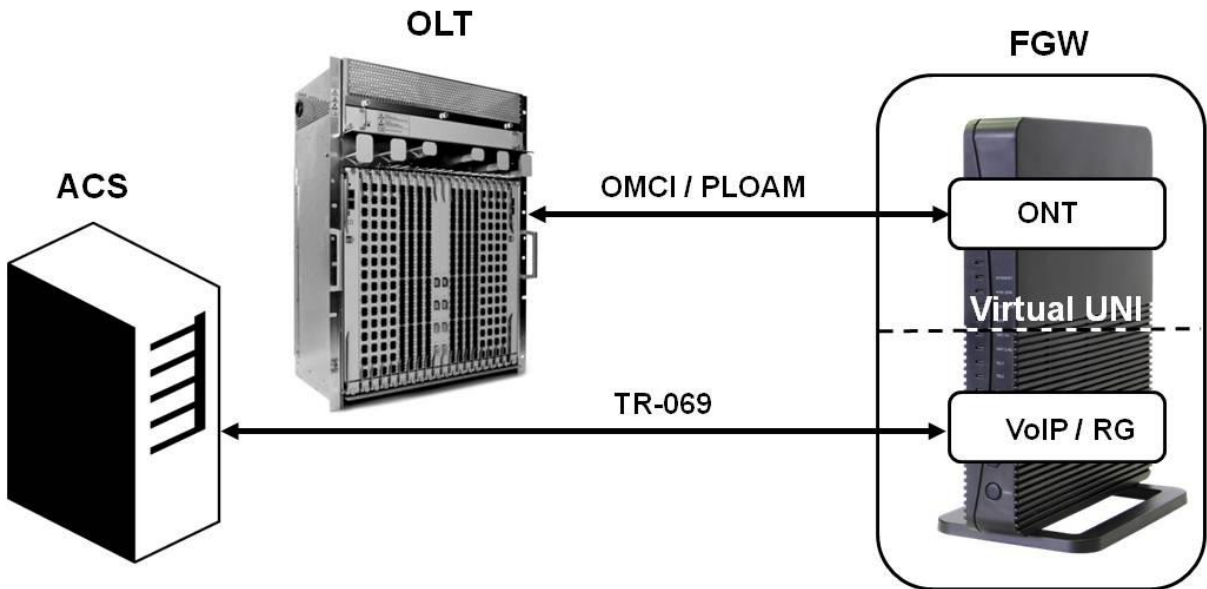


Figure 7: TR-142 Framework

TR-142 framework defines a virtual UNI between the OMCI (ONT Management Control Interface) and TR-069 management domains.

This framework allows PON CPE with L3 layer capabilities to be mass remotely configured, troubleshoot and managed by an ACS (Auto Configuration Server) using TR-069 CPE WAN Management Protocol.

2.6 General Architecture

FiberGateway basic system architecture is hereafter presented.

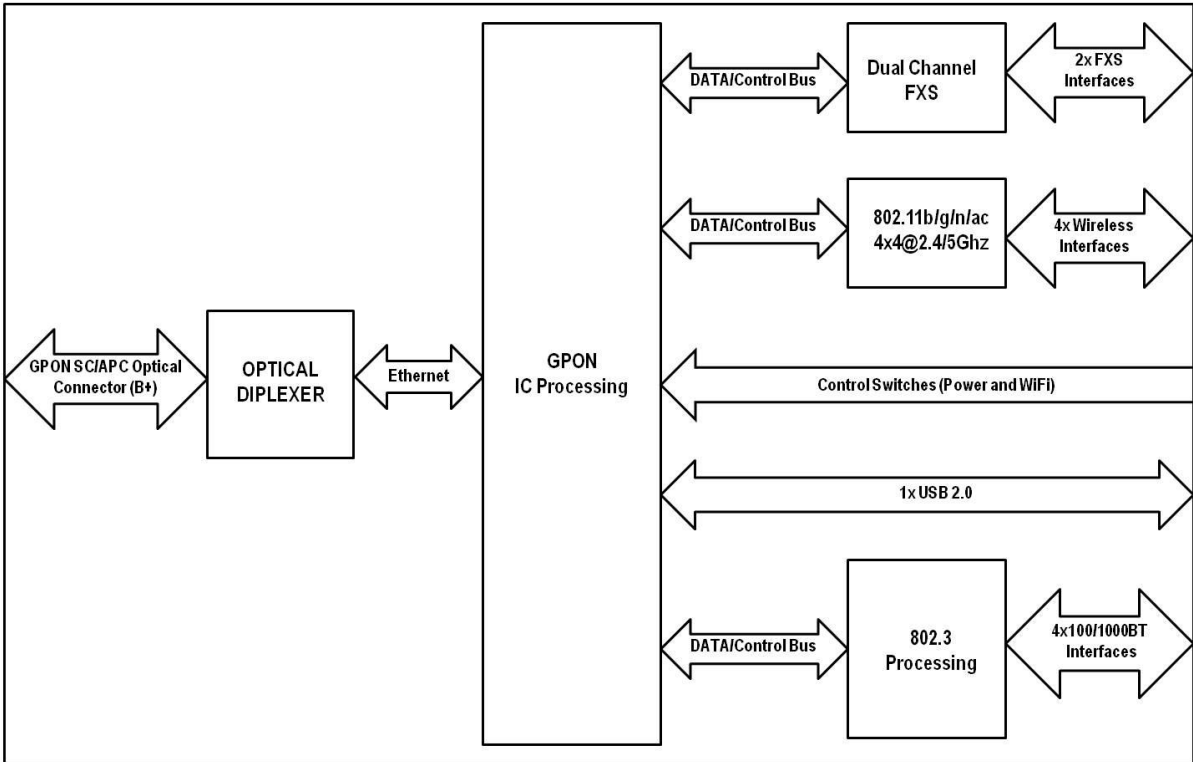


Figure 8: FiberGateway system architecture

The GPON IC Processing unit is the core component inside FiberGateway. It is responsible for the interconnection and processing between client side interfacing and optical GPON Uplink interface.

2.7 GPON

The FiberGateway GPON layer as G.984.x uses 1490nm downstream and 1310nm upstream of the optical wavelength, with 2,488Gbps downstream and 1,244Gbps upstream by using an SC/APC protected optical connector.

2.8 Ethernet

Ethernet is the wired LAN technology and is revised in the IEEE 802.3 standard. At the OSI reference system, Ethernet is at the Data Link layer. In the FiberGateway equipment both WAN and LAN type of physical interfaces are 10/100/1000BASE-T AUTO-MIX Ethernet type over RJ45 connectors.

2.9 IPTV

For the IPTV service the FiberGateway also behaves like a Layer 2 bridging device. For this service, the FiberGateway has a specific GEM PORT for Multicast. This same GEM PORT is requested by the user in order to have access to the various IPTV channels. Every time a user requests a new channel,

the FiberGateway will send to OLT a IGMP packet requesting that Channel. The FiberGateway is also responsible for implementing the snooping for the channels that the user requests.

2.10 Voice

2.10.1 Supported VoIP specifications:

- Call control: SIPv1/v2;
- T.38 Fax relay;
- Fax/Data bypass;
- Echo canceller;
- Echo canceller length;
- Jitter buffer;
- Caller ID generation;
- G.711 PCMU;
- G.711 PCMA;
- G.723.1;
- G.726;
- G.729;
- VAD and CNG;
- Caller ID and call waiting;
- RTP/RTCP packet encapsulation;
- RFC 2833 Support;
- In-band signaling detection and generation (DTMF, call progress tones).
- Automatic Tone generation (dial, busy, ring back, stutter, distinctive ring);
- 3-Way conferencing.

2.10.2 Supported interfaces

FiberGateway voice service provisioning could be made through OLT configurations over OMCI messages or could be downloaded (FTP) from the OLT up to the FiberGateway after its registration on the PON network. FiberGateway equipments have the ability to deliver the Voice service over two types of interface:

2.10.2.1 Logical interface (VLAN encapsulation)

If the FiberGateway has no FXS ports and the VoIP service is transparently forwarded from the OLT up to the Home Gateway (and vice versa) within a previously defined voice VLAN. FiberGateway respects the defined priority and implements the traffic encapsulation from its own Ethernet interface into a specific T-CONT/GEM-Port over the PON interface and up to the OLT equipment.

2.10.2.2 Physical interface (FXS ports)

The FiberGateway has physical RJ11 FXS interfaces. In this version of the FiberGateway equipment, voice interfaces are terminated in the equipment by means of FXS (RJ11) connections. The RJ11 analog terminals adapter function is auto/self-configured, integrated (analog/VoIP) and associated with a defined SIP or Megaco (H.248) user.

The FiberGateway will allow VoIP or NGN (Next Generation Network) traffic from devices connected to the RJ11 or RJ45 interfaces, towards the same internal VLAN.

Apart of the SIP and Megaco (H.248) self-configuration, it is also possible to make modifications in the voice service configurations by updating the FiberGateway SW through download from the OLT via OMCI.

The FiberGateway equipment has a DHCP client to get an IP address, alternatively the FiberGateway could be configured with a static IP. The configuration of the static IP or DHCP client is related to the WAN side and is enabled by the OLT.

2.11 Wi-Fi

2.11.1 FiberGateway Block Diagram

FiberGateway circuit block diagram is presented in the figure bellow showing all oscillators in the device and its frequencies, Figure 9. Intentional radiators in the circuit and radio signal path between circuit blocks are also shown.

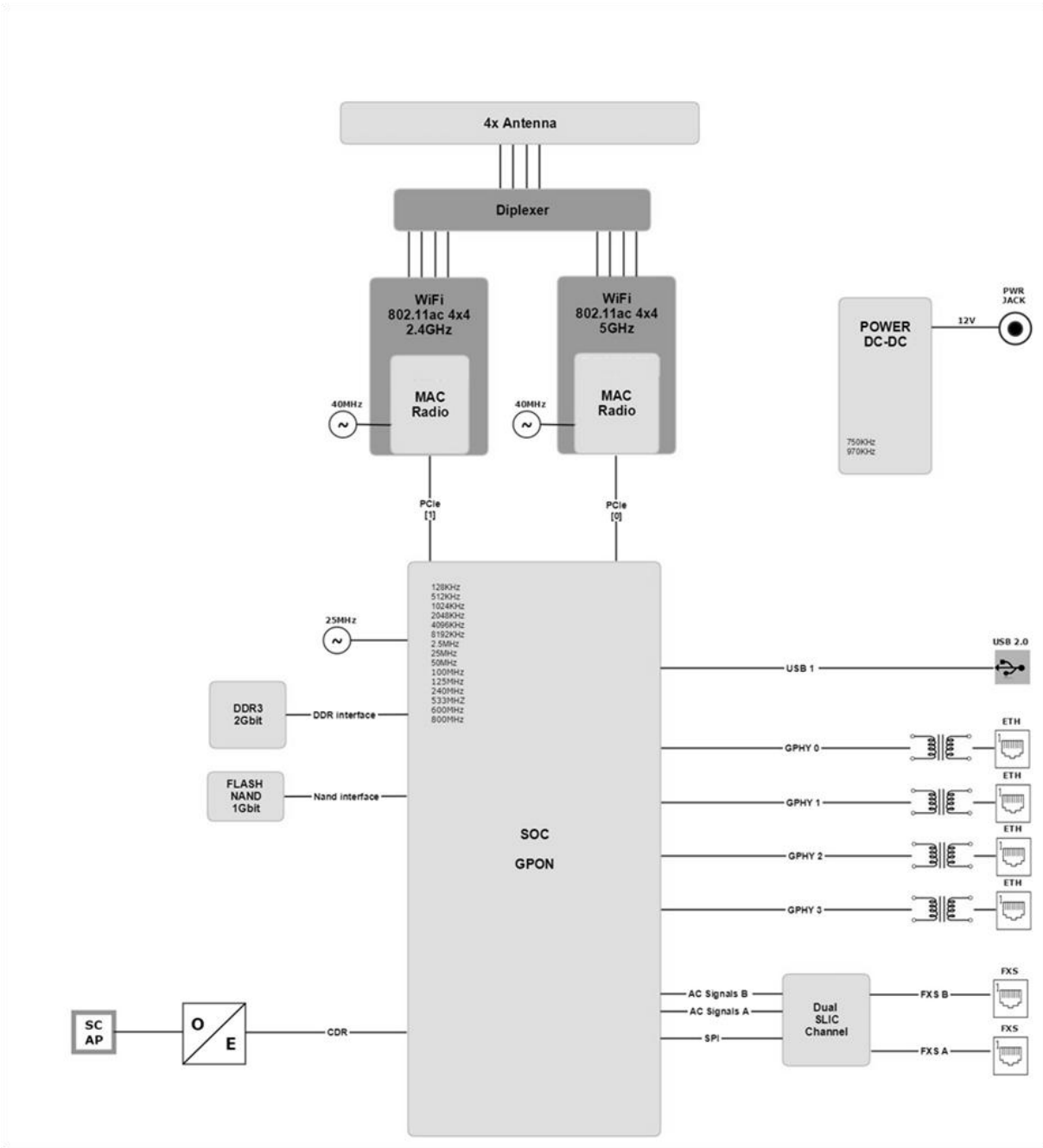


Figure 9: FiberGateway circuit block diagram

2.11.2 Operational Description

The FiberGateway supports Wi-Fi, with Wi-Fi interfaces operating in the 2.4GHz and 5GHz frequencies

The FiberGateway complies with the following standards:

- IEEE 802.11a (5GHz, up to 54 Mbps)
- IEEE 802.11b (2.4GHz, up to 11 Mbps)
- IEEE 802.11g (2.4GHz, up to 54 Mbps)
- IEEE 802.11n (2.4GHz and 5 GHz, up to 600 Mbps)
- IEEE 802.11ac (5GHz, up to 1733 Mbps)

The ONT supports the following features:

- wireless security
 - WEP encryption (64/128 bits)
 - WPA (Wireless Protect Access) TKIP
 - WPA2 AES
 - WPA2 mixed
 - 802.1x Authentication
 - External RADIUS Authentication
 - Client access control through media access control (MAC) filter
 - Dynamic cryptography (TKIP and AES)
 - Multiple SSIDs Profiles
 - WPS (Pushbutton and PIN entry);

2.11.3 Interfaces and features

- Dual-band, concurrent mode 2.4GHz plus 5GHz via internal Wi-Fi antennas,
- Compliant with IEEE 802.11 a/b/g/n/ac and with 4x4 MIMO
- Up to 34dBm EIRP both in the 2.4GHz and in the 5GHz
- Channel Bandwidth: 20, 40, 80, 80+80, 160
- Support of zero wait dynamic frequency selection (DFS): 4x4 with weather radar detection
- Multi User MIMO for better performance per user

2.11.4 Data Rates

- 802.11a : 6,9,12,18,24,36,48,54 Mbps
- 802.11b : 1, 2, 5.5, 11 Mbps
- 802.11g : 6,9,12,18,24,36,48,54 Mbps
- 802.11n : up to 600 Mbps
- 802.11ac : up to 1733 Mbps
- 1024QAM (2.4GHz) : up to 1000 Mbps
- 1024QAM (5GHz) : up to 2166 Mbps

2.11.5 Antennas

- 4x4 MIMO antennas
- Internal antennas with 4~5dBi antenna gain

2.12 Multiple QoS per VLAN

The FiberGateway supports 802.1p QoS per VLAN services in which several flows (one per allowed pbit) are embedded in the same VLAN. According to the applied configuration, the FiberGateway performs a per-flow QoS policy: dropping traffic marked with not allowed pbits and limiting to the configured value the data rate of the allowed flows.

The FiberGateway performs transparent VLAN translation. It is transparent to upper layer protocols, such as ARP, RIP, DHCP, IGMP, PPP, etc.

2.13 Policing/Rate Limiting

2.13.1 Downstream QoS

The OLT system supports traffic classification at the ingress ports (ETH, LAGs, PON, etc) based on P-Bits, IP DSCP and IP.

The OLT system provides several QoS mechanisms, that can be targeted to the flow characterized by one or two VLAN according with the type of service, or can be targeted to the packets priority, where each p-bit/DSCP is mapped in one of eight queues of each port.

For each OLT ports are associated eight queues, for each of these queues is possible to configure the p-bit mapping in one of the queues, the scheduler type (Strict Priority or Weighted Fair Queuing) and the minimum and maximum bandwidth of each queue.

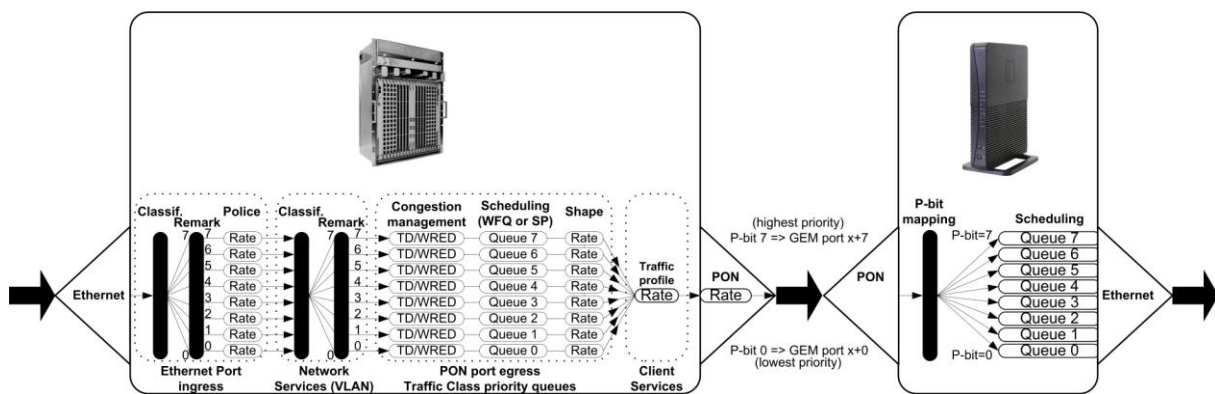


Figure 10: Downstream QoS diagram

In the downstream direction, Figure 10, the ingress traffic can be firstly classified. It passes by a policer and is configured to each ONT service, which is defined by one or two tags. It is remarked and policed per-CoS rate (port profile).

After this, Network services (per VLAN) classification determine the PON port queue where packets will wait for a transmission opportunity, and can remark the CoS (P-bits in VLAN PCP). The traffic is put in a queue according with the p-bit/DSCP->Traffic Class mapping.

Each of these Traffic Classes is associated with a scheduler (WRR or SP) and a policer.

Queue congestion management is used to prevent the queue from overflowing and is performed based on Tail Drop or WRED.

Each queue is served by either a priority or weighted scheduler and rate controlled.

Then Traffic Classes to P-bit remarking is done and the traffic flows to the GPON interface.

Destination ONU/ONT client service downstream profile defines traffic classless policing. The overall PON port may be limited to a percentage of its capacity.

Traffic arriving to the ONU/ONT it will pass by a mapping block which will map the traffic in one of the eight queues according with the p-bits; these queues have a Strict Priority scheduler in order to guarantee that the most prioritized traffic passes first, Figure 10.

2.13.2 Upstream QoS

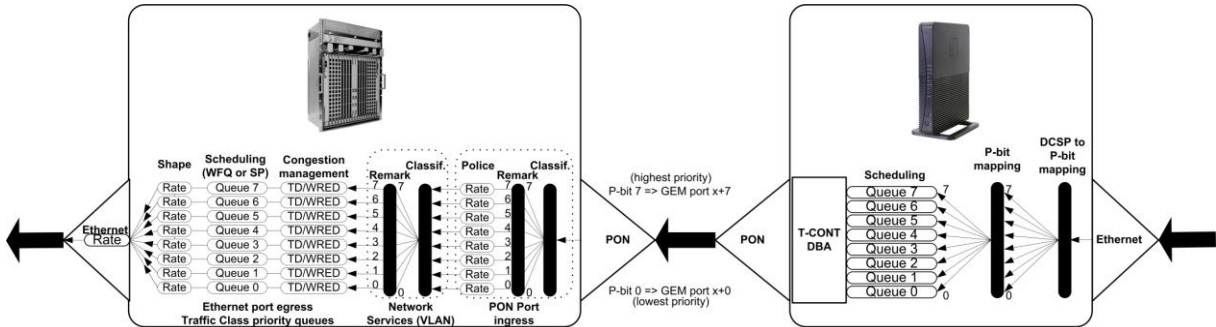


Figure 11: Upstream QoS diagram

In the upstream, Figure 11, for each T-CONT DBA the ingress traffic in the ONT passes by a mapping block that maps the traffic in one of the eight queues according with the p-bit, (in case the ingress traffic is untagged a DSCP->p-bit mapping is performed).

These queues have a Strict Priority Scheduler. Packets are stored at the intended T-CONT priority queue, which is scheduled according to ONT configuration.

The ONT “waits” until the OLT assigns a transmission timeslot for that T-CONT, according to DBA, so that the most prioritized queues are the ones that transmit first.

In the OLT PON ingress port, traffic is remarked and can be policed per-CoS. The traffic is put into a Traffic Class according with what is defined in the p-bit/DSCP->queue mapping.

Each of these Traffic Classes has an associated scheduler and policer. Queue management is performed based on Tail Drop or WRED. Then Traffic Classes to P-bit remarking is done and the traffic is sent to the uplink, Figure 11.

2.13.3 Dynamic Bandwidth Allocation (DBA)

The DBA (Dynamic Bandwidth Allocation) is available in order to optimize the upstream bandwidth. This mechanism consists in defining an adequate T-CONT to the service traffic in question. There are five types of T-CONT, defined by the Fixed, Assured and Maximum Parameters:

- Type 1: Only fixed Bandwidth;
- Type 2: Only Assured Bandwidth;
- Type 3: Assured+Maximum Bandwidth;
- Type 4: Only Maximum Bandwidth (Best Effort);
- Type 5: Fixed+Assured+Maximum Bandwidth.

Table 1: T-CONT types definition

T-CONT	Type 1	Type 2	Type 3	Type 4	Type 5	Units
Fixed BW- R_F	R_{F1}	0	0	0	R_{F5}	[b/s]
Assured BW- R_A	0	R_{A2}	R_{A3}	0	R_{A5}	[b/s]
Max Bw - R_M	$R_{M1} = R_{F1}$	$R_{M2} = R_{A2}$	$R_{M3} > R_{A3}$	R_{M4}	$R_{M5} > R_{F5} + R_{A5}$	[b/s]
Bandwidth Eligibility	0	0	Non-Assured BW - R_{NA}	Best-Effort - R_{BE}	R_{NA} / R_{BE}	

In each GPON interface there are 1024 Alloc-ID (T-CONT identifiers) available, provided to manage ONT services. They are distributed in the following way:

Table 2: Alloc-ID's distribution by T-CONT type

Alloc-ID	Allocation Type
0-127	Default Alloc-ID (Dynamic or Static)
128-255	Reserved
256-639	Dynamic or Static
640-1023	Static

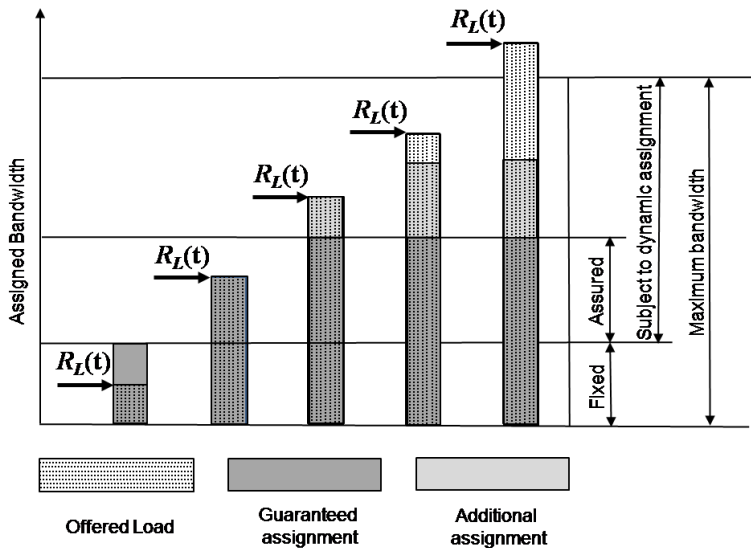


Figure 12: Traffic distribution by service/client

2.13.4 Upstream QoS scenarios

- 8 priority queues
- Strict-priority
- Upstream Scheduling:
 - Strict Priority (currently supported)
 - Strict Priority + rate controller (currently supported)
 - Strict Priority + WFQ (can be SW supported)

3 General Specifications

3.1 Interfaces

3.1.1 GPON

The FiberGateway GPON G.984.x layer uses 1490nm downstream and 1310nm upstream optical wavelengths, with 2.488Gbps downstream and 1.244Gbps upstream by using an SC/APC protected optical connector

3.1.1.1 Optical Interfaces

Table 3: Optical interfaces specifications

Items	Unit	B+	C+
		FiberGateway Tx	FiberGateway Tx
Nominal bit rate	Mbps	1244.16	1244.16
Operating wavelength	nm	1260-1360	1260-1360
Line code	--	Scrambled NRZ	Scrambled NRZ
Minimum ORL of ODN	dB	>32	>32
Mean launched power MIN	dBm	+0.5	+0.5
Mean launched power MAX	dBm	+5	+5
Launched optical power without input to the Tx	dBm	Less than Min sensitivity -10	Less than Min sensitivity -10
Maximum Tx Enable		16	16
Maximum Tx Disable		16	16
Extinction ratio	dB	>8.2	>8.2
Tolerance to the Tx incident light power	dB	>-15	>-15
SLM Laser – MAX -20 dB width	nm	1	1
SLM Laser – MIN SMSR	dB	30	30
		FiberGateway Rx	FiberGateway Rx
Receiving bit rate	Mbps	2488.32	2488.32
Receiving wavelength	nm	1480-1500	1480-1500
Max reflectance of equipment, measured at Rx wavelength	dB	<-20	<-20
Bit error ratio	--	<-10 ⁻¹⁰	<-10 ⁻¹⁰

Items	Unit	B+	C+
Minimum sensitivity	dBm	-27	-30 ⁽¹⁾
Minimum overload	dBm	-8	-8 ⁽²⁾
Upstream optical penalty	dB	0.5	0.5
Consecutive identical digit immunity	bit	>72	>72
Tolerance to reflected optical power	dB	<10	<10

3.1.2 Ethernet

Ethernet is the wired LAN technology and is revised in the IEEE 802.3 standard. At the OSI reference system, Ethernet is at the Data Link layer. In the FiberGateway equipment the LAN type of physical interfaces is 10/100/1000BASE-T AUTO-MIX Ethernet type over RJ45 connectors.

¹ ONT RX= -8~-30 dBm (The equipment sensitivity assumes the use of the optional RS (255,239) FEC capability of the G-PON TC layer with the current class B+ ONU detector technology; The ONU overload is set at -8 dBm to be common with the class B+ value, even though in this application -10 dBm is sufficient).

Optical solution: B+ and C+.

Connector type: SC/APC.

IEC 60825-1: "Class 1 Laser Product".

The B+ and C+ diplexer is embedded on the FiberGateway equipment version.

ONU Single Fiber - G.984.2 (03/2003) + G.984.2 Amd 1 (02/2006) and 2 (03/2008), G.983.3 (03/2001).

Optical Metering – G.984.2 Amd 2 Table IV.1/G.984.2 – Optical Line Supervision related measurement specifications (the accuracy of the measurement is +/-3dBm maximum).

² ditto

3.1.3 FXS

Table 4: FXS interface specifications

Items	State	Description	
DC voltage (V)	48V (21 to 56.5V)	According to ANSI/TI A-1063	
Ringer voltage (V)	DC offset: ≥ 15 Vdc AC voltage: ≥ 55 Vac rms Frequency: 20Hz +/- 3%	Max Voltage: 100 Vp	
Ringing signal cadence	normal ringing	2 sec ring / 4 sec pause	
REN	ringer equivalence numbers	Maximum ringer load: 5	
Loop Current Characteristics (A)	25 mA (max)	-	
Hook flash	on-hook - register recall/hook flash	150 msec	Minimum time of recognition of "on-hook" when hook-flash feature does not exist
	on-hook - register recall/hook flash	1100 msec	Minimum time "on-hook" recognition when hook-flash feature does exist
	off-hook	40 msec	minimum time "off-hook" recognition
	interval	300 msec – 1100 msec	Time calibrated break pulse duration for register recall recognition
Pulse Dialing Detection	Pulse Frequency: 10 Hz (8 Hz to 12 Hz) Pulse Relation (%): 60/40	-	
DTMF Dialing Detection	-	According to ANSI/TI A-1063	
Clip	-	According to ANSI/TI A-1063	
Clip on Call Waiting	-	According to ANSI/TI A-1063	

3.1.4 Wi-Fi

Table 5: Wi-Fi specification

Items	Compliance	Description
	IEEE 802.11 b/g/n/ac	-
Bit Rates	802.11 b/g	Up to 11Mbps (IEEE802.11b) Up to 54Mbps (IEEE802.11g)
	802.11 n	Up to 600Mb/s over four spatial streams in the 2.4GHz band; Up to 600Mb/s over four spatial streams in the 5GHz band
	802.11 ac	Up to 1733Mb/s over four spatial streams in the 5GHz band
SSID	-	Up to 8
Operation Frequencies	-	2.4GHz (ISM) or 5GHz (U-NII)
Channel Bandwidths	-	20MHz and 40MHz channels in the 2.4GHz band; 20MHz, 40MHz, 80MHz and 160MHz channels in the 5GHz band
MIMO	-	4x4
MCS	-	Supported values: 0-31 and 32 for 802.11n 0-9 for 802.11ac Proprietary 10 -11 (1024QAM)
Wireless Security	WEP	40bit secure key and 24 bit as defined in 802.11-2007
	WPA	
	WPA2	
	AES	encryption/de-encryption coupled to TKIP (as defined in 802.11-2007 and 802.1X)
Short Guard Interval	SIG support	-
Space-Time Block Coding	STBC support	-
Transmit Power (e.i.r.p.)	-	Up to +34 dBm in the 2.4GHz band; Up to +26 dBm in the 5GHz UNII-1 band; Up to +34 dBm in the 5GHz UNII-3 band;
Receive Sensitivity	Mode b (8% PER)	1Mb/s: -96dBm 11Mb/s: -88dBm
	Mode g (10% PER)	6Mb/s: -90dBm 12Mb/s: -89dBm 54Mb/s: -75dBm

Items	Compliance	Description
	Mode n/2.4GHz (10% PER)	1Mb/s: -96dBm 54Mb/s: -75dBm M0/20MHz: -88 dBm M0/40MHz: -85 dBm M7/20MHz: -66 dBm M7/40MHz: -63 dBm
	Mode n/5GHz (10% PER)	6Mb/s: -89 dBm 54Mb/s: -74 dBm M0/20MHz: -87 dBm M0/40MHz: -83 dBm M7/20MHz: -64 dBm M7/40MHz: -61 dBm
	Mode ac/5GHz (10% PER)	M0/20MHz: -87 dBm M0/40MHz: -83 dBm M0/80MHz: -80 dBm M9/20MHz: -58 dBm M9/40MHz: -55 dBm M9/80MHz: -52 dBm

3.2 General Features

Table 6: General Features

Features	FiberGateway
GPON	1x Singlemode Optical Fiber Cable (SC/APC Connector)
Ethernet 10/100/1000Base-T	4x Ethernet UTP CAT5E direct or crossover AUTO-MDIX cable (RJ45)
FXS Ports	2x voice / fax RJ11 connector
USB Ports	1x USB 2.0
Wi-Fi (802.11a/b/g/n/ac)	Yes
ON/OFF button	Yes
RESET button	Yes
OLT Interoperability (BBF.247)	Yes
DHCP Client	Yes
Number of GEM ports	256
Number of T-CONT	32
Primary Power Connection (VDC)	12 (\pm 15%)
Primary Power Connection (VAC)	120V AC 60Hz \pm 2Hz

Features	FiberGateway
AC/DC Adapter Max Power (W)	48
AC/DC Adapter Energy Efficiency	European Code of Conduct on Energy Consumption of External Power Supplies V5 U.S. Department of Energy (DoE) Level VI
Energy Efficiency	European Code of Conduct on Energy Consumption of Broadband Equipment V6 Energy Star - Small Network Equipments v1.0
MTBF (h)	800416
Size (HxWxD) (mm")	35 x 244 x 202mm / 1.38" x 9.61" x 7.95"
Temperature (°C/°F)	0 to +50°C / 32°F to 122°F
Humidity (%)	5 to 95 %

3.3 General Service Description

GPON layer per G984.x	<ul style="list-style-type: none"> > Comply with GPON standard: ITU-T G984.1/G984.2/G984.3/G984.4; > GPON Encapsulation Method (GEM) supports Ethernet; > Configurable AES Downstream and FEC Downstream and Upstream; > Bitrates: 2488 Gbps (downstream) / 1244 Gbps (upstream). 	<ul style="list-style-type: none"> > Class B+ optics (28 dB); > T-CONT:32; > GEM-Port-IDs: 32.
L2/L3 layer	<ul style="list-style-type: none"> > VLAN-ID to GEM port-ID mapping (per WT-156): N:1 VLAN; 1:1; > Transparent VLAN; > Classification: IDSCP/TOS, 802.1p TCI, VLAN ID, MAC address; > Traffic Management: up to 8 queues per T-CONT in Priority-controlled mode or up to 16 queues per T-CONT in Rate-controlled scheduling mode. 	<ul style="list-style-type: none"> > 802.1q VLAN processing: Q-in-Q, tagging, removing tag, replacing tag or transparent forwarding; > Routing: Network Access Translation (NAT) and Network Access Port Translation (NAPT); > Firewall; > VPN; > DHCP Client and Server; > PPPoE Client; > Performance: 1000 Mbps Bidirectional.
IPTV	<ul style="list-style-type: none"> > IGMP v1/v2/v3 snooping; > IGMP processing per VLAN ID to support group of channels; > Interactive services (Video On Demand); > IPTV streams forwarding simultaneous: 128; > IPTV prioritization using Quality of Service (QoS) using 802.1p. 	-

VoIP	<ul style="list-style-type: none"> > T.38 Fax Relay; > Fax/Data Bypass; > Echo Canceller; > Echo Canceller Length; > Jitter Buffer; > Caller ID Generation; > G.711 PCMU; > G.711 PCMA; > G.711 VAD and CNG; > G.723.1; > G.726 ADPCM; > G.729 Annex A. > G.729 Annex B 	<ul style="list-style-type: none"> > Caller ID and Call waiting; > RTP/RTCP packet encapsulation; > RFC 2833 support; > In-band signaling detection and generation (DTMF, call progress tones);); > Automatic Tone generation (dial, busy, ring back, stutter, distinctive ring); > 3-Way Conferencing; > RFC 3261 support (SIPv1/v2).
Ethernet	<ul style="list-style-type: none"> > RJ-45 10/100/1000BASE-T; > Support Auto-negotiation; > Support auto MDI/MDIX. 	-
Wi-Fi	<ul style="list-style-type: none"> > IEEE 802.11 a/b/g/n/ac 	<ul style="list-style-type: none"> > 802.11 b/g: 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48 and 54Mb/s; > 802.11n up to 600Mb/s. > 802.11ac up to 1733,3Mb/s
Management	<ul style="list-style-type: none"> > Remote management over the OMCI, PLOAM, OAM and TR-069, TR-098, TR-104, TR-111, TR-140, TR-142, TR-143, TR-181. 	<ul style="list-style-type: none"> > Secure software download upgrade via OMCI or TR-069; > Embedded Telnet server for remote management, > SNMP V3;

3.4 Optical metering

The equipment measures the downstream received power from the OLT in 1490nm and reports this value through OMCI. The accuracy of the measurement is +/- 3dBm, maximum. Optionally, FiberGateway has also the chance to have an embedded optical reflective component in order to increase the FTTH probing capabilities in a 50 centimeters resolution factor, which turns to have a single probing system to probe all GPON network ONTs even when its number increases over Million customers.

3.5 Wavelength filtering

The optical interface has WDM filters that allow GPON coexistence with RF video services (1550-1560nm) and the new generation of NGPON1 technology, according to G.984.5 Recommendation.

ITU-T Rec. G987.1 is also granted for XGPON, (following FSAN NG-PON2).

In order to face the final user's demands, current GPON networks have to confront the first evolution in terms of terminal equipments and actual infrastructure. Migration will be available through a new wavelength planning, by allowing the co-existence of two different technologies over the same fiber. The ITU-T Rec. G987.1 provides a mechanism for GPON to XGPON migration with the possibility to achieve 2.5Gbps upstream path. Nominally downstream will be 10 Gbps.

The next figure depicts the wavelength planning of ITU-T Rec. G987.1:

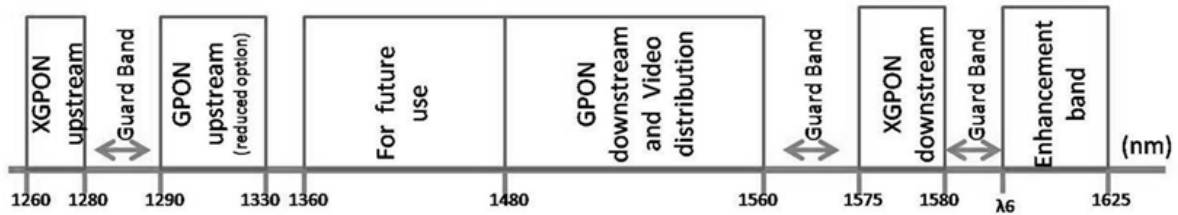


Figure 13: Wavelength planning

In order to accomplish that plan, the upstream wavelength for GPON must be restricted to ONU (ONT) equipment based on the ordinary DFB lasers, while the XGPON downstream signal range is defined from 1575 nm to 1580 nm and the XGPON upstream signal from 1260 nm to 1280 nm. For the coexistence of XGPON and GPON over the same fiber, the CO requires a WDM filter that combines the downstream signal (1490 nm, 1555 nm and 1577 nm), isolating the 1310 nm and 1270 nm upstream signal, with the video signal. Also the wavelength of 1650 nm, used for fiber monitoring, has to be handled.

In addition, ONT devices require the use of a triplexer type transceiver that include an integrated filter or a discrete WDM filter to distinguish the different signals that may be present on the fiber. The current networks, equipped with ONT in accordance with the current ITU-T Rec. G.984.5, will be easily updated to XGPON.

Class B+ optical budget are the nominal requirement for coexistence of GPON and XGPON over the same optical fiber. Taking this requirement into account, the fiber network architecture will not limit the future of the service provider business since GPON architectures, respecting B+ class of the GPON, are easily updated by placing newest terminal equipments, namely XOLT and XONT, and by replacing the current WDM filter by the new one in order to handle the new XGPON signals.

XGPON must support/emulate all GPON legacy services in case of total migration.

Like GPON, XGPON is required to support triple play services (data, voice and video), as well as mobile backhauling (accurate frequency/phase/time synchronization) application through its high quality of service and high bit rate feature capabilities. Access to Ethernet services such as point-to-point, multipoint-to-multipoint and rooted-multipoint Ethernet Virtual Connection services should be provided. Finally, as a global requirement, XG-PON needs to support IPv6.

3.6 GPON/Ethernet characteristics

GPON/Ethernet characteristics supported, both functional level and GTC-OMCI configuration, corresponds with the general mandatory characteristics defined in ITU-T G.984.3, G.984.4 and G.988 Recommendation:

- PON interface: downstream operating rate 2.488 Gbits/s, upstream operating rate 1.244 Gbits/s;
- 32 T-CONT and 256 simultaneous GEM ports;
- 1:64 SR is granted once optical power transmission from the OLT side is up from -27/30dBm;
- Unmarked or marked bandwidth management;
- Upstream and downstream FEC;
- Downstream AES encryption;
- Ethernet flow control in client's port: 802.3x and 802.3ab;
- Ability to classify and modify VLAN labels (single or double labeling);
- Ability to support multiple VLAN tags per service (Internet, IPTV, VoIP, ACS, etc) from Residential Gateway. And ability to translate those VLAN to one specific service VLAN on

OLT side, like, IPTV service VLAN, Internet Service VLAN (SVLAN and CVLAN), and VoIP Service VLAN;

- 802.1 DSCP for CoS support;
- IEEE 802.1Q and 802.1p support;
- Multicast snooping support IGMPv2 and IGMPv3;
- Firmware upgrade through the PON interface following the mechanisms specified in the ITU-T G.984.4 and G.988, including a safe dual firmware updates image system and the ability of back-up, allowing the SINGLE PORT FiberGateway start in case the software download fails, to enable a new software update.

3.7 Standards

Table 7: Standards compliance

EMC	Emissions	FCC CFR 47 Part 15 Subpart B Section 15.107 – Conducted Emissions – Class B FCC CFR 47 Part 15 Subpart B Section 15.109 – Radiated Emissions – Class B
Radio	2.4 GHz	FCC CFR 47 Part 15 Subpart C Section 15.247
	5 GHz	FCC CFR 47 Part 15 Subpart E Section 15.407 (U-NII-1, U-NII-2A, U-NII-2C and U-NII-3)
Safety		UL 60950-1:2007 Ed.2 + R: 14 Oct 2014
Certifications		ETL Intertek Listing Certification
		FCC Certification

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4 Setup

4.1 Equipment Connectivity

FiberGateway connections are located at the back side of the equipment; WPS and INFO (for status LEDs information) push buttons, are located at the front side of the equipment, Figure 17.



Figure 14: FiberGateway connectivity general view

Table 8: FiberGateway connectivity description

Number	Name	Description
1	RESET	Configuration RESET button
2	TEL (1, 2)	2x RJ11 – FXS Ports
3	LAN (1, 2, 3, 4)	4x RJ45 Ports - 10/100/1000Base-T Ethernet with AUTO-MDIX
4	USB	1x USB 2.0 port
5	ON OFF	ON/OFF button

Number	Name	Description
6	PWR	12V DC Power Supply Connector
7	PON	Equipment Optical port GPON; SC/APC
8	WPS	Wi-Fi Protected Set-up Button; <ul style="list-style-type: none"> • Switches on/off Wi-Fi if pressed for 5 seconds • With the Wi-Fi interface on, in order to connect a device the interface, pressing the WPS button for 1second will start the association process.
9	INFO	Energy saving button. In order to verify the status of all LEDS press the button. If not pressed only POWER and Radio Signal LEDs (WPS, WIFI 5G and WIFI2.4G) have updated status information.

4.2 FiberGateway LEDs

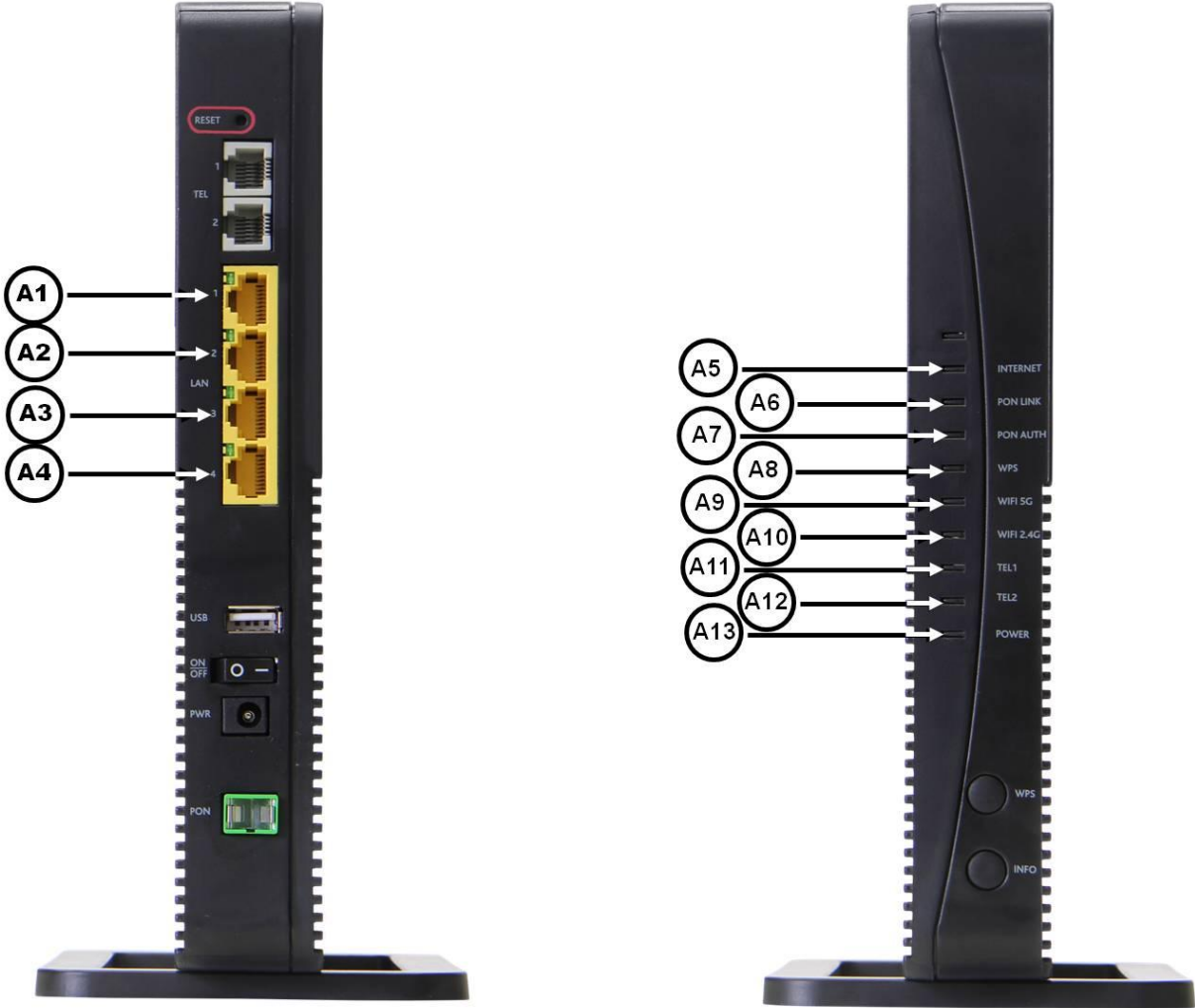


Figure 15: FiberGateway Status LEDs

Table 9: LEDs Status information

LED	Identification	LEDs Status	Description
A1 a A4 ⁽¹⁾	LAN	ON	With Ethernet connection (green)
		OFF	No Ethernet connection
		Flashing	Ethernet IN/OUT activity (green)
A5 ⁽¹⁾	INTERNET	ON	With Internet connection (green)
		OFF	Inactive port
		Flashing	Internet IN/OUT activity (green)
A6 ⁽¹⁾	PON LINK	See table bellow	
A7 ⁽¹⁾	PON AUTH		

A8 ⁽¹⁾	WPS	ON	WPS active (blinking green)
		OFF	WPS inactive
A9 ⁽²⁾	WIFI 5GHz	ON	Wi-Fi Radio Signal active
		OFF	Wi-Fi Radio Signal inactive
A10 ⁽²⁾	WIFI 2.4GHz	ON	Wi-Fi Radio Signal active
		OFF	Wi-Fi Radio Signal inactive
A12, A13	TEL1, TEL2	ON	Service configured and authenticated (green)
		OFF	Service not configured or registration failure
		Flashing	Telephone off the hook
A14 ⁽²⁾	POWER	ON	Power supply ON (green)
		OFF	Power supply OFF

NOTES:

- (1) To obtain these status LEDS information INFO button must be pressed.
- (2) These status LEDS are always update (pressing INFO button is not required).

Table 10: LEDs Status information (PON LINK & PON AUTH)

ONT FiberGateway 4x4 Status	LEDs Status		Description
	PON LINK	PON AUTH	
1. Initial	OFF	OFF	Initial Status
2. Standby	Flashing	Flashing	ONT is waiting for initial configuration by the OLT
3. Serial Number	Flashing	Flashing	The OLT is configuring the ONT
4. Ranging	Flashing	Flashing	ONT and OLT synchronization
5. Operation	ON	ON	ONT normal operational status

4.3 Typical FiberGateway usage scenario

Figure 16 bellow shows a FiberGateway Type usage scenario showing Home Network connections for triple play service provisioning. FiberGateway connectors' description can be found in Table 8 and connecting cables are described in Table 11..

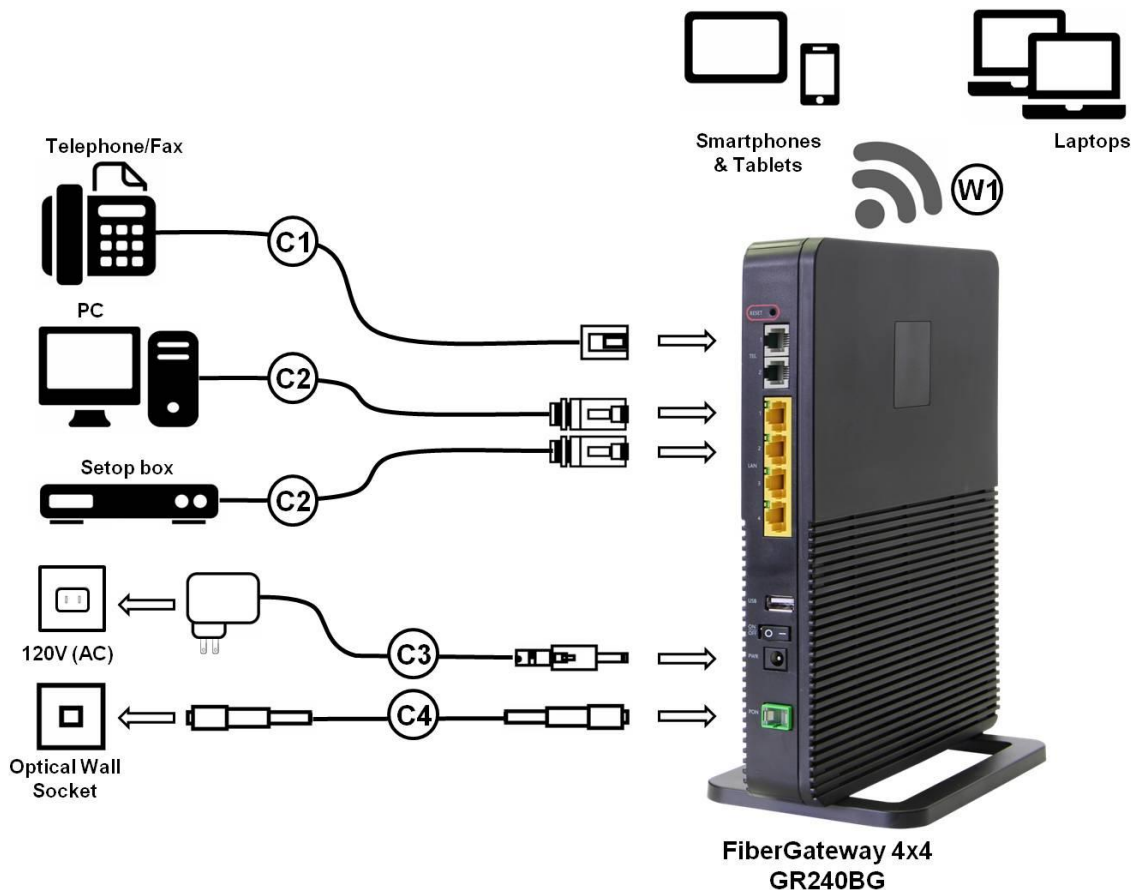


Figure 16: FiberGateway Typical usage scenario -Home network connections

Connection	Description
C1	RJ11 Telephone cable
C2	Ethernet Cable UTP CAT56 cable (direct or crossover)
C3	12V DC Adapter
C4	Single-mode Optical Cable with SC/APC Connector (GPON)
W1	Wi-Fi

4.4 Before installing the FiberGateway equipment

4.4.1 Safety Warnings

- Check for site’s environmental conditions and look for power and optical access points nearby;
- Do not install the device in environments where the temperature or humidity exceeds the standard limits;
- This device is a passive cooling device. To prevent equipment overheating do not obstruct the ventilation grids on of the equipment;

- The FiberGateway device is not designed for outdoor setup. Please place it in a convenient indoor/cabinet environment;
- Use only the provided power kit. The use of a third party power adapter may not guarantee its proper operation;
- To avoid eye hazard, never look directly into a fiber optic port or connector;

4.4.2 Wireless network installation best practices

In order to achieve FiberGateway wireless network best performance the following installation rules should be observed:

- FiberGateway front side should be oriented towards the area where the wireless network is to be used;
- FiberGateway installation place should be at least 1 meter high and without :
 - Interference sources nearby, such as Microwave ovens, DECT 2.4 GHz phones, Audio/Video transmitters, Bluetooth equipment, Baby Monitors, etc.
 - Obstacles such as walls, stairs, ceilings, doors, Metal Objects, Windows, etc between the installation place and the Wi-Fi usage area.

4.5 Connections

FiberGateway connections are located at the back side of the equipment; WPS and INFO (for status LEDs information) push buttons, are located at the front side of the equipment, Figure 17.



Figure 17: FiberGateway connections general view

Table 11: FiberGateway connections description

Number	Name	Description
1	RESET	Configuration RESET button
2	TEL (1, 2)	2x RJ11 – FXS Ports
3	LAN (1, 2, 3, 4)	4x RJ45 Ports - 10/100/1000Base-T Ethernet with AUTO-MDIX
4	USB	1x USB 2.0 port
5	ON OFF	ON/OFF button
6	PWR	12V DC Power Supply Connector
7	PON	Equipment Optical port GPON; SC/APC
8	WPS	Wi-Fi Protected Set-up Button; <ul style="list-style-type: none"> Switches on/off Wi-Fi if pressed for 5 seconds With the Wi-Fi interface on, in order to connect a device the interface, pressing the WPS button for 1second will start the association process.
9	INFO	Energy saving button. In order to verify the status of all LEDS press the button. If not pressed only POWER and Radio Signal LEDs (WPS, WIFI 5G and WIFI2.4G) have updated status information.

4.6 FiberGateway Setup

FibeGateway is intended to be installed on a flat surface.

The following table identifies the set of materials that may be required to install the equipment, depending on the home network scenario.

Table 12: Material required for instalation

Installation phase	Item	Supplied	Mandatory
Powering	Power Adapter and Power Cord 230VAC/50Hz or 110VAC/60Hz 12VDC (4A) + 15%	(1)	√
Network Provider	Optical Patchcord (SM fibre ITU-T G.657B3) with connectors SC/APC, Figure	(1)	√

Connection	18, b)		
	Optical connector cleaning kit	-	√
Home Network Connections	Ethernet cables CAT6 568B	(1)	(2)
	RJ11 Telephone Cable	(1)	(2)
	Device with Wi-Fi connectivity (laptop/smartphone/ ...)	-	(2)

- (1) Depending on the ordered model
- (2) Home network scenario dependent

4.6.1 Network Provider Connection

An Optical Patchcord (SM fibre ITU-T G.657B3) with connectors SC/APC, Figure 18, b), and Optical connector cleaning material will be required.



Figure 18: Network provider connection

- Clean the optical connectors of the optical patchcord, Figure 18, b), of the equipment PON port, Figure 18, a), and the optical wall socket, Figure 18, before connecting using appropriate optical connector cleaning material;
- Plug one of the patchcord cleaned SC/APC optical connectors on the FiberGateway PON port, Figure 18, a), observing the alignment mechanism, (a click indicates the connector is secure into place)
- Plug the other end optical patchcord SC/APC connector on the optical wall socket

- Accommodate the patchcord excessive length avoiding small bend radius on the patchcord (30mm minimum bend radius).

4.6.2 Mains connection and power up

- Connect the power adaptor output connector to the 12-VDC power port on the equipment;
- Plug the power adaptor appropriate power cord into an approved 100 to 230 VAC outlet, Figure 16;
- Switch on the equipment, ON-OFF button

After executing a power-up sequence the equipment will be ready for operation.

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5 Configuration

Configuration of the FiberGateway equipment is done remotely, using OMCI and TR-069.

5.1 FiberGateway Activation

The equipment activation process has a distributed set of procedures that allow the connection of an inactive equipment to a PON network. This configuration is done following the procedure described in the OMCI protocol.

5.2 Customization

For customization process, the requirements specified in the G.984.4, G.984.5 and 'Implementer's Guide' in the G.984.4 v1 are taken into account.

5.2.1 Software download from the OLT

The software download is made following the OMCI-based procedure included in the 'Implementer's Guide' of the G.984.4 Recommendation.

The Managed Entity (ME) in charge of managing the software download is named Software Image. Per each ME containing independently-manageable software, the FiberGateway creates two software images. Each image will have three attributes:

- Valid - if it has been verified that it's content is an image with executable code;
- Committed - if once the FiberGateway is rebooted, it is loaded and executed;
- Active - if it is loaded and it is being executed in the FiberGateway.

There can be only one active image and only one committed image at a given moment. The FiberGateway goes through a series of states in order to download and activate a software image. Each state is defined according to the states of the variables of both images. The OLT controls the FiberGateway state through a series of commands:

- Start download
 - It starts the software download sequence. This action is only valid for inactive and non-committed software images;
- Download section
 - It downloads a section of a software image. This action is only valid for an image that is being downloaded;
- End download
 - It indicates the end of a download sequence, providing the CRC and information about version for the final verification of the downloaded software image. This action is only valid for a software image that is being downloaded;
- Activate image
 - It loads/executes a valid software image. When this action is applied to an inactive software image, the execution of the current code image is suspended, the associated software image is loaded from the non-volatile memory and the execution of the new code image is started. When this action is applied over a software image that is active, a reboot is executed;

- Commit image
 - It selects a valid SW image to be loaded and executed by default when the FiberGateway is restarted;
- Composition of the Software Image
 - A software image is divided into sections of 31 bytes, with one section per OMCC message and each section protected by the CRC of the OMCC. A group of sections makes up a window, and a group of windows constituting the image.

6 Troubleshooting

The table below, according to the equipment LEDs' status, (Table 9, Table 10), identifies a possible cause and describes the procedure to fix the problem.

Table 13: Troubleshooting Procedures

LED	State	Possible Cause	Solution
POWER (A14)	OFF	No power supply to the equipment	<ul style="list-style-type: none"> Check that the power cable is correctly connected to both the equipment and the adapter at the electrical socket. Check that the switch button (5) is at the ON position.
ETHERNET (A1 to A4)	OFF	ETHERNET cable incorrectly connected	<ul style="list-style-type: none"> Check that the ETHERNET cable is properly connected to the equipments' ETHERNET port. Change the ETHERNET cable. Check that the equipment connected to the ONT on this Ethernet port is switched ON.
PON LINK (A7)	OFF	Anomaly in the optical fiber signal	<ul style="list-style-type: none"> Check that the optical cable is correctly inserted in both the equipment's internal optical connector and the optical socket. Check if the optical connectors are in good state condition and clean; Check that the optical patchcord is intact, has not been cut or twisted.
PON AUTH (A8)	OFF		
PON LINK (A7)	ON	Equipment deactivated by the administrator	<ul style="list-style-type: none"> Contact the technical support
PON AUTH (A8)	OFF		
TEL1, TEL2 (A12, A13)	OFF	VoIP deactivated in the equipment	
PON LINK (A7)	Flashing	Error in equipment authentication	



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