Chapter 18

Studies and Solutions for Provision of an FTTH Network Infrastructure in a Multicondominial Residential Area

Crossref doi 10.56238/tfisdwv1-018

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ABSTRACT
In recent years, connection providers have invested in their network infrastructure in order to meet user demand for greater bandwidth, with the aim of offering higher quality services. From this perspective, FTTH (Fiber To The Home) networks emerged as a solution for telecommunications companies that sought to offer higher transmission rates with lower maintenance costs, providing higher download and upload rates, in addition to low attenuation, technological factors essential for survival in a competitive market. The work described in this article was deployed an FTTH network for a residential area, based on a passive optical network with Gigabit capability (GPON). We highlight the stages of better network to serve a residential area composed of 4 condominiums in the greater Natal region, solutions for a quantity of 1,103 HP's (Home Potential), quality technological technologies for the project of Internet services, TV and Telephony.

Keywords: FTTH, Internet, GPON, Broadband Services, Multiservice Platform.

1 INTRODUCTION

In recent years, growing user demand for quality fixed broadband services has driven fiber-intensive connection providers across their network infrastructure. Before the emergence of FTTH networks, most of the existing networks in Brazil were hybrid, based on the HFC (Hybrid Fiber Coaxial) topology, which uses fiber optics in its main trunks and passive COAXIAL RF components. In its beginning, the HFC topology emerged as a solution in improving signal quality, since at the time of its emergence, a 100% fiber optic network solution was unfeasible due to the high cost of associated infrastructure (CAMPOS and RESENDE, 2019). On the other hand, the risks involved in the migration process of existing equipment were the main restrictive factors for investments in new projects.

HFC topologies include RF components based onmetal cabling, where manyof these components are used in DSL and HFC technologies. These elementos are sensitive to rain and electromagnetic interference, which end up generating noise and distortion of the transmitted signal. Companies' spending on the purchase of these new components and maintenance of the devices (ZAMBRANO and CÁRDENAS, 2019) is increasing. Concomitantly with this scenario, the growth of PON network technologies (passive optical networks) was advancing, so that at a given time, with the reduction of costs associated with optical networks, it was feasible for connection providers to use new active and passive components for the implementation of a 100% fiber optic network, offering higher transmission rates and better quality in internet and TV services (OLIVEIRA, *et* al; 2021).

According to the National Telecommunications Agency (ANATEL), in Brazil, broadband internet gained more than 5 million new subscribers in 2021, resulting in a growth of 14%, compared to the previous year, reaching the level of 41.4 million hits. The growing demand of users to obtain high transmission rates to meet the growth of social networks, streaming services and corporate networks, forced connection providers to restructure their existing optical junctions (backbones), the basis for topology of HFC networks and replace the other part, called d and branches (coaxial part) by fiber optic, making their networks 100% fiber optic (FTTH), taking the purely optical signal to the user's access location (ONT's, IPTV's). In this way, FTTH networks have become the cost-effective and best quality solution in voice, video and TV data communication services, supporting greater bandwidth and being able to expand service over long distances and with lower latency.

PON networks use passive optical dividers on their links, without the need to provide electrical power for passive components between the FTTH enclosure to the user, where the optical signal in a single fiber is transmitted bidirectionally and can be divided into a network *structure* between OLT (*Optical Line Terminal)* and ONT *(Optical Network Terminal)* for multiple subscribers. In its topology there are no active components between the enclosure (Central with the OLT's) and the final installation in the user (ONT's), where the entire network link is composed of passive components that provide the traffic of optical signals with their specific wavelength values (PINHEIRO, 2017).

The main types of technologies used today in passive optical networks (PON) are: GPON (Gigabit-Capable PON) and EPON (Ethernet Passive Optical Network), which are being widely used in FTTH access networks, characterized by dividing *downstream signals for many* users, where the transmission rate offered on GPON and EPON interfaces is in the order of gigabits per second (JIRACHARIYAKOOL, *et* al; 2017).

The purpose of this work is to present the planning and implementation of a GPON-based FTTH access network project for an area integrated by residentialcondominiums. Based on the performance of a field survey at the service site, we identified and quantified the plots related to the four condominiums, where the project established a configuration for potential service of 1,103 HP's (Home Potential).

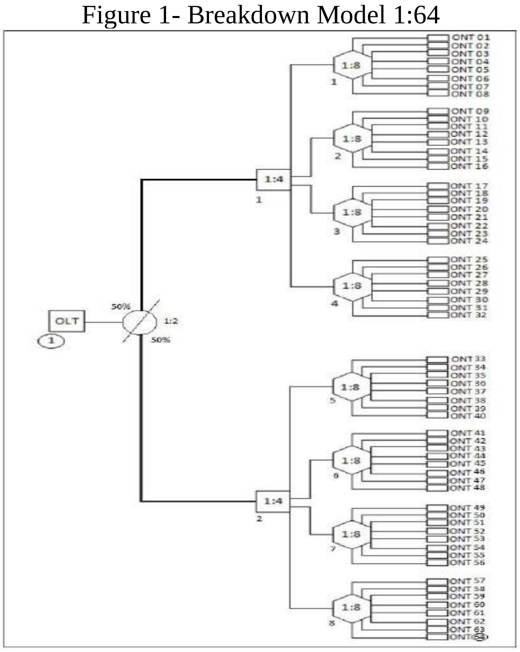
After this introduction the article is divided as the segue. In Section II are presented the theoretical framework with exploration of the fundamental concepts involving optical fibers, FTTH architectures, PON networks, GPON standard, TDM-PON multiplexing. Section III presents the methodology and systemic planning for the elaboration of the condominium area and expansion of the junction to the region. In Section IV, the results obtained are presented and discussed. Finally, Section V addressed the main conclusions of the work.

2 THEORETICAL REFERENCE

The FTTH network is intensively used in the provision of broadband services, being basically composed of passive components (optical cables, *splitters*, connectors, adapters, splicingboxes and optical termination points). In the FTTH network there are also active components such as OLT that is responsible for the management, distribution of access to services and transmission of optical signal to the final installation, maintaining the coordination of the multiplexing of the network terminals and ONT which is the optical element of the network installed on the user where the distribution and division of services is carried out, such as data (Internet), TV via IP protocol (IPTV) and voice by IP (VOIP). Most of the residential FTTH networks deployed are based on EPON technologies, governed by the Institute of Electrical and Electronic Engineers (IEEE 802.3ah) and GPON which is governed by the International Telecommunications Union (ITU-T G.984), the latter being the most popular today (LAM and YIN, 2020). NGPON-based FTTH networks there are several reboot configurations and both can be classified as reboots: 1:16, 1:32, 1:64, 1:128, or up to 1:256. In this work, for the project, the 1:64 allocation was performed, which means that 1(one) OLT is responsible for the management of 64 ONT's, as explained in Figure 1.

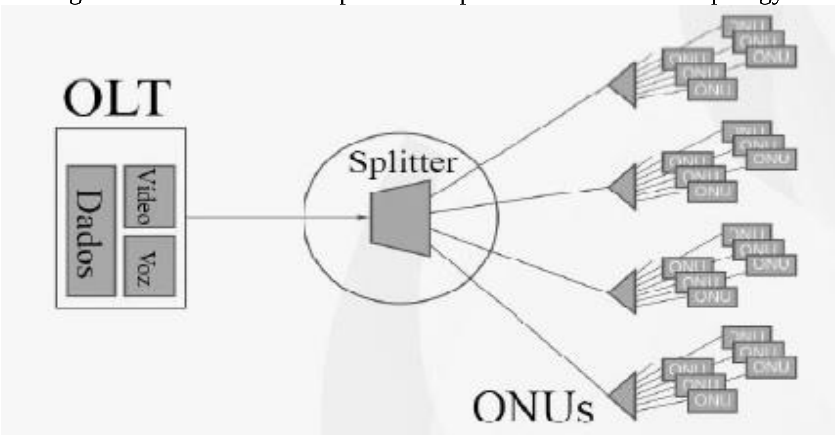
The Passive Optical Network (PON) network is a passive optical network with transmission capability in the Gigabits per second range. Its architecture is point-based multipoint, as presented in Figura 2. PON networks are more prominent for models that implement the FTTH network-sharing topology because they use only one optical fiber with two-way transmission (Upstream/Dowstream) by WDM (Wavelength Division Multiplexing). Thus in a single fiber occurs *the transmission in dowstream* from OLT to the ONT and *upstream transmission* from ONT to OLT, working at different wavelengths (PINHEIRO 2017). The physical range of transmission over the optical network, from the manager cabinet to the end user is as defined in the ITU-G.984 standard.

Figure 1- Breakdown Model 1:64



Source: Cabo Telecom, 2020.

Figure 2- Architecture of a point-multipoint network or tree topology.



Source: Huawei Technologies (2018)

The choice of the PON standard to implement the network basically depends on the bandwidth requirement and the value of the investment. The main technologies or PON standards used are described in Table 1. The Gigabit Passive Optical Network (GPON) architecture, or gigabit passive optical network, is the generation recommended bythe Telecommunications Standardization Sector (ITU-T) according to the G.984 protocol. This pattern is based on the GFP protocol (Generic Framing Protocol) where packets are encapsulated and transported by IP (PINHEIRO 2017).

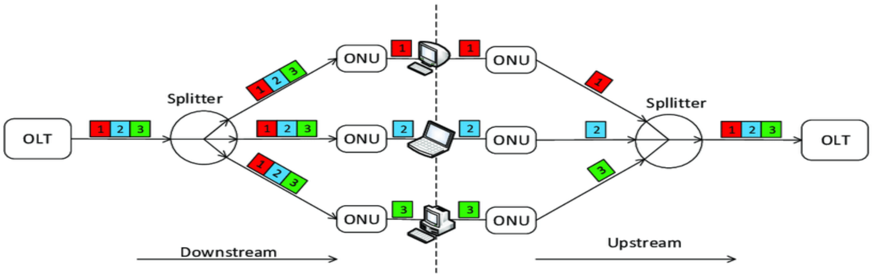
Table 1- Comparison APON/BPON, GPON, EPON, G-EPON, 10G-EPON, XG-PON

CARACTERÍSTICAS	**APON/BPON**	**GPON**	**EPON**	**G-EPON**	**10G-EPON**	**XG-PON**
Padrões	ITU-T G.983	ITU-T G.984	IEEE 802.3ah	IEEE 802.3ah	IEEE 802.3av	ITU-T G.987
Capacidade de transmissão	155/622 Mbit/s	2,5 Gbit/s	1 Gbit/s	1 Gbit/s	10Gbit/s	10Gbit/s
Tamanho dos pacotes de dados	Fixo de 53 bytes	Variável de 53 bytes a 1518 bytes	Variável de 64 bytes a 1518 bytes	Variável de 64 bytes a 1518 bytes	Variável de 64 bytes a 1518 bytes	Variável de 53 bytes a 1518 bytes
Protocolo	ATM	ATM/Ethernet	Ethernet	Ethernet	Ethernet	ATM/Ethernet
Comprimento de onda *downstream*	1480 a 1500 nm	1480 ou 1500 nm	1490 a 1510 nm	1490 nm	1577 a 1590 nm	1575 a 1580 nm
Comprimento de onda *upstream*	1260 a 1360 nm	1260 a 1360 nm	1310 nm	1310 nm	1310 nm	1260 a 1280 nm
Alcance	20 km	20 km	20 km	20 km	20 km	20 km
Taxa de fracionamento	1:32	1:128	1:32 e 1:16	1:16	128	1:64
Largura de banda média por usuário	20Mbit/s	20Mbit/s	30 e 60 Mbit/s	80Mbit/s	80Mbit/s	160Mbit/s
Custos estimados	Baixo	Médio	Mais baixo	Médio	Alto	Alto

Source: Adapted from TELECO, 2013.

The GPON architecture enables encapsulation of ethernet packets, being transmitted on the same channel at equal intervals of time, through time-split multiplexing (TDM) in *dowstream, where packet* extraction and the reverse process is also performed in *upstream, by different* wavelengths. Data packets are transmitted in the broadcast method to all ONTs.

Figure 3: TDM-PON Architecture

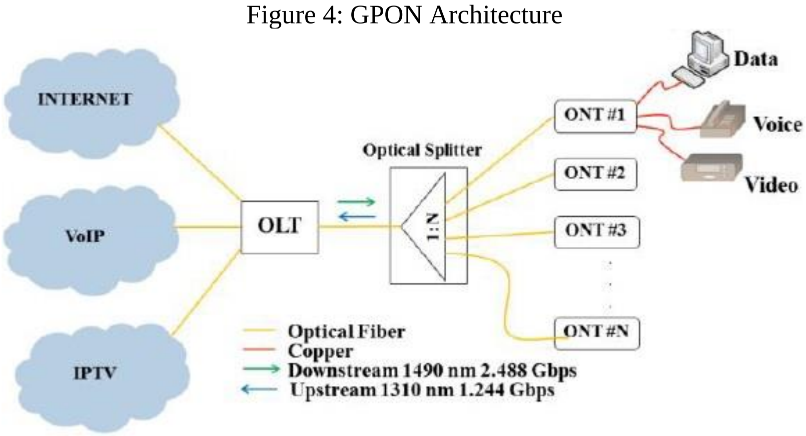


Source: Horvath (2020)

For the project, it was considered a wavelength of 1490nm in *dowstream* and 1310nm in *upstream*, although GPON technology also allows *an upstream wavelength up to* 1550 nm. It is worth noting that GPON technology has a PON band-per-port capacity of up to 2.5Gbps *for dowstream, which in* practice, although the GPON standard can have only 8% *overhead rate in bandwidth* capacity, there is still availability of a compatible band to distribute to users.

In Figura 4 is represented the GPON architecture where it is observed thatin a GPON access network there are at least three main components: the active components (OLT's, ONT's) and passive components (Splitter's, splitters). The OLT GPON is the network manager staying located in the *headend* or external enclosure. Optical *splitters* or optical splitters are located on the link age and allow a single fiber to divide into multiple fibers with the same optical power. Finally, the ONT that performs the conversion of the received optical signal according to its wavelength range, located in the user's dependencies.

Figure 4: GPON Architecture



Source: Jirachariyakool (2017)

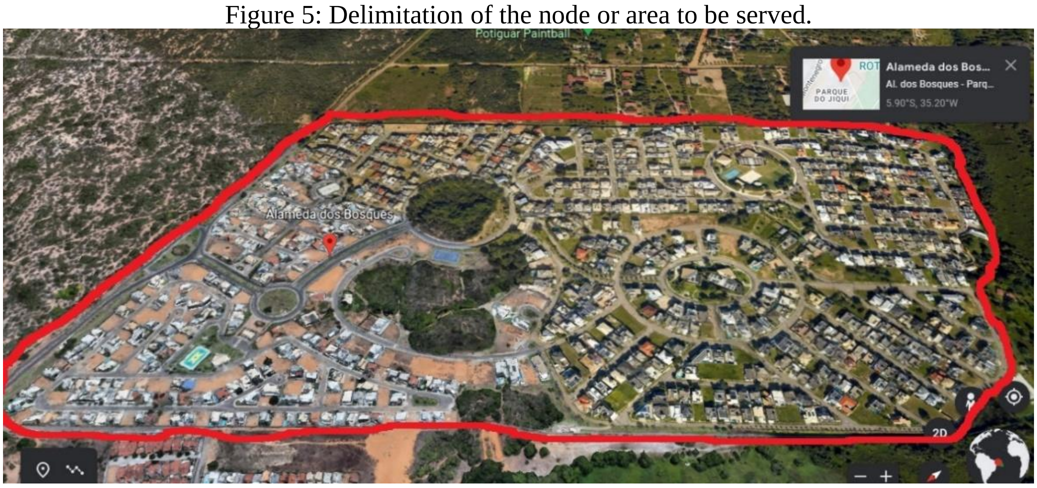
3 METHODOLOGY AND NETWORK PLANNING

Uma efficient optical network in meeting the needs of customers, should be designed based on the applicable technical standardsand obeying a set of planned steps, contemplating the knowledge of the techniques, installation, connection and maintenance of optical cables, as well as full knowledge of the active and passive components of the network , in addition to construction and installation specifications (KEISER, 2014). The present work was developed based on a broad research of theoretical framework, where it was possible to identify the fundamental concepts of optical fiber, PON networks, FTTH network architecture,regulatory standards and FTTH network structure. In sequence, the fundamentals of FTTH network solutions were explored, compatible with the characteristics of the region to be met, being applied the resources of computational tools and equipment for the project development. After extensive survey of the geographical area of service, materials, equipment and evaluation of investments and business model, the project of implementation of ftth network structure, FTTH (headend) cabinet and internal user facilities was developed.

3.1 ÁREA SERVICE FOR DEMAND CONFIRMATION AND BASIC DESIGN

A field survey was carried out in order to obtain the best representations of mapping the demand for services to the region to define the coverage area of the service. For this, satellite images were collected, through the Google Earth software, contemplating an area composed of four condominiums of houses (Bosque dos pássaros, Bosque das Flores, Bosque dos Poetas and Bosque das Palmeiras), located in Nova Parnamirim-RN, metropolitan region of Nata, highlighted in Figure 5. The basic design configures the set of elements to characterize the network, elaborated based on preliminary technical surveys , which defined the penetration rate of the network and ensure its technical and economic viability. Based on this data, it was possible to define an estimate of the amount of domestic potentials (HP's),the counting of termination elements, the power cabling route, the distribution cabling route and choice of network components, and the positioning of the termination points between other definitions . It was necessary to make a technical visit to promote the identification of the streets and the amount of electricity connections in each pole of the concessionaire to allow the estimation of the amount of access points and occupation of the network. Thus, it was possible to obtain all the data necessary for the elaboration of the descriptive memorial of the project, containing information such as: project objective, characterization, executing company, physical medium used and prediction of completion. The calculations of the link for the registration of art (Technical Responsibility Note) and the obtaining of all necessary information for formalization of the use of the poles of the local power concessionaire for anchoring the optical cables were also elaborated.

Figure 5: Delimitation of the node or area to be served.



Source: Cabo Telecom Project Sector (2020).

3.2 DEFINITION OFTHE Q UANTIDADES OF HPS, OLTS AND PASSIVE COMPONENTS

All mapeamento dthe region was produced with the aid of autocad software in format . DWG, defining the amount of hp's maximum or lots identified for service in the region and the total maximum amount of optical termination boxes (CTO) finalized in the 1:8 *splitters* (CTO's), according to Tabela 2.

Table 2- Number of possible HP's according to the number of lots

NODO PARNAMIRIM 10		
CONDOMÍNIOS	LOTES RELEVADOS / QUANTIDADE DE POSSÍVEIS HP'S	QUANTIDADE DE SPLITTER'S 1:8
BOSQUE DOS POETAS	352	44
BOSQUES DAS PALMEIRAS	344	43
BOSQUE DAS FLORES	190	24
BOSQUE DOS PASSAROS	217	28
TOTAL	1103	139

Source: Cabo Telecom (2020)

In the initial formulation of the project, an estimated value of 70% of the accesses was considered, in addition to the users already existingin the legacy network, using theprovider's services through the previous network (HFC). Thus, considering the initial implantation, the estimated value was 768 HP's, corresponding to 96 optical termination boxes (CTO), with the possibility of *duplicating the splitters* of 1:8, according to the subsequent need.

To specify the amount of OLT's for region, the amount of HP's from the condominium area was considered and for the service of the existing region, the maximum amount of 1,103 HP's was established. Since each FTTH Network PON port manages 64 ONT's, a value of 17.23 OLT's is required, which in practice represents the potential of serving all users to the access provider's services in that region. To meet the initial fase of thepr ojeto, 14 OLT's were implanted to manage the NODE and the amount of CTO's was 96. Considering that the CTO's are not duplicated, there is a limit of only 8 *connections per splitter in* each CTO, thus guaranteed in this configuration the connection of 768 users, equivalent to the initial goal of the project, contemplating a service of approximately 70% of the total amount of HP's.

Table 3- Quantity of materials and equipment used in the node

	PA10										
NODO	Etapa	BAIRRO	HP's	METROS DE REDE	FIBRA 02 FO	FIBRA 12 FO	OLT	1/2	CAIXA DE EMENDA	1/4	CTO 1/8
PA10	4	Nova Parnamirim	1103	10704	100	13807	14	14	9	28	96
TOTAL		-	1103	10704	100	13807	14	14	9	28	96

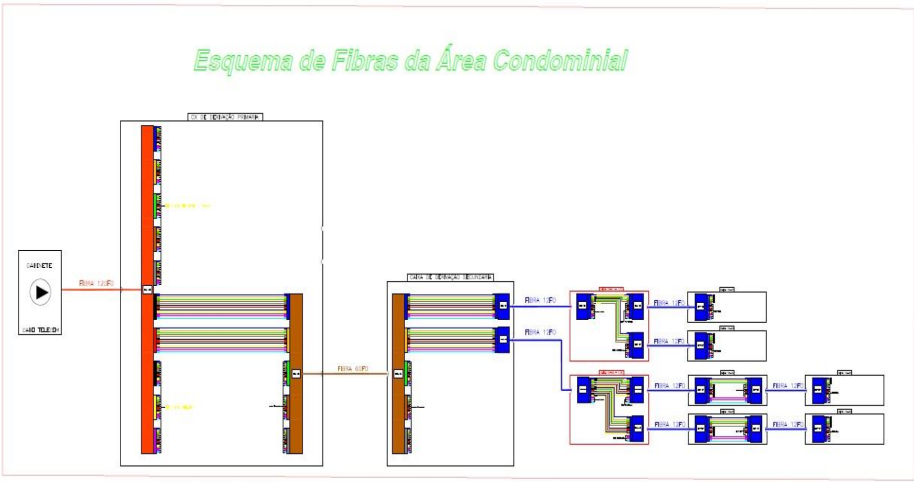
Source: Cabo Telecom, 2020

Regarding the activation of passive components, they are listed following their quantity and patterns:14 *splitters* of 1:2; 28 *splitters* of 1:4; 96 *splitters* of 1:8 (Optical termination box) and 9 Optical splicing boxes distributed in the link.

3.3 FIBER SCHEME FOR ACTIVATION OF *SPLITTERS* IN THE SERVICE REGIÃO

The distribution of users in the service area is essential to define the number and location of *splitters*. No less important is the need to know the amount and lengths of optical cables quantified for the termination elements in which they will be interconnected in the OLT, with each element of UN/ONTs, for provisioning to users. The location of *the first level splitters* can be done in a distribution cabinet or in an appropriate splicing box. For configuration of distribution of the fibers of the network, with a view to the need to locate the poles for *the installation of splitters, the fiber* scheme of the region was developed in the AUTOCAD software, as shown in Figure 6.

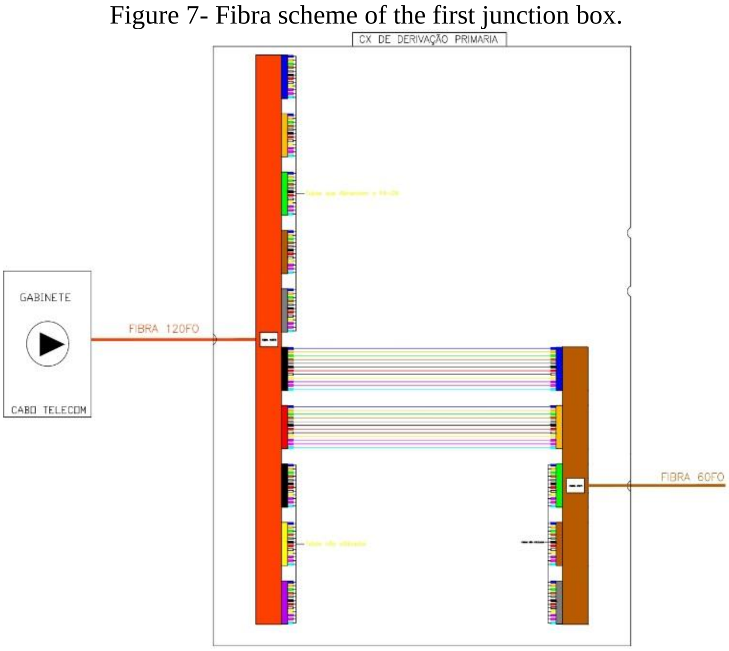
Figure 6- Node fibra scheme.



Source: Cabo Telecom, 2020.

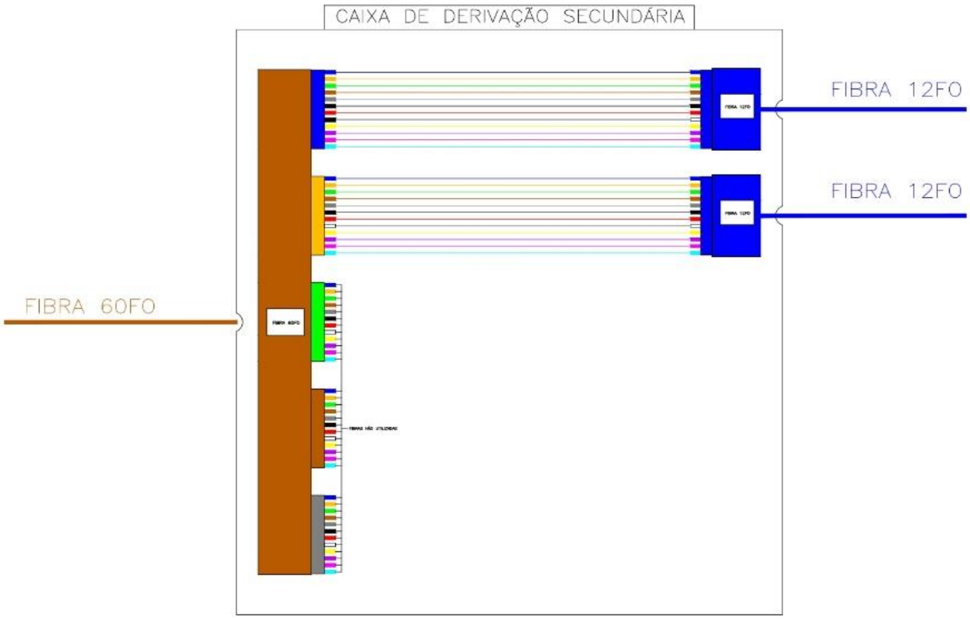
Next, in Figures 7 , 8 , 9 and 10, the blocks will be presented for compliance with the color pattern adopted in the design configuration for the primary and secondary junction boxes, according to international standard EIA598-A.

Figure 7- Fibra scheme of the first junction box.



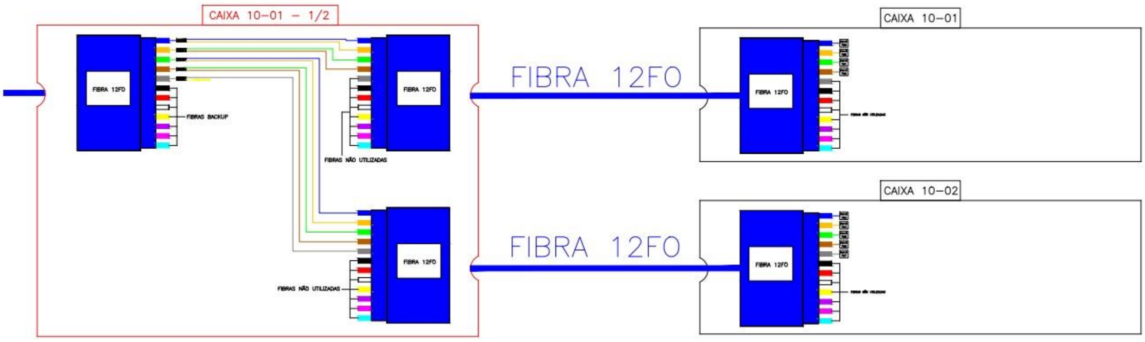
Source: Cabo Telecom, 2020.

Figure 8- Fiber Scheme of the second junction box.



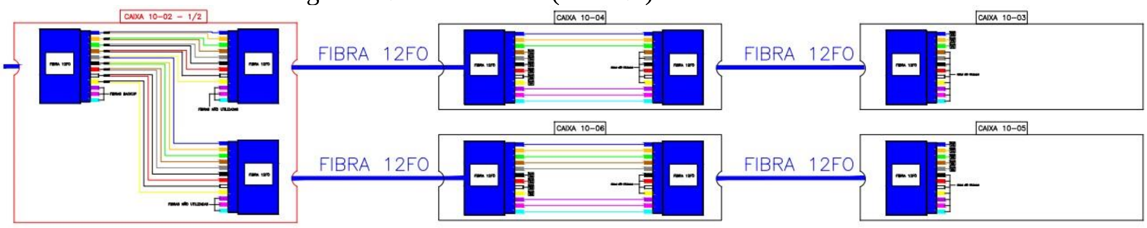
Source: Cabo Telecom, 2020

Figure 9- Fibra scheme (Box 1:2) located on the node



Source: CABO TELECOM, 2020

Figure 10: Fibra scheme (Box 1:2) located on the node



Source: Cabo Telecom, 2020.

3.4 OPTICAL LINK SIZING

3.4.1 Attenuation losses

The design of an optical link includes the choice of passive components that include optical fiber, connectors, couplers, adapters and active devices, such as transmitters and receivers aim to ensure the arrival of the signal at a specificdistance, meeting the specific normative parameters. Thus, the performance of a link isassociatedwith the characteristics of the cables and component devices of the link (AMAZONAS, 2005). For the purpose of obtaining the attenuation calculations for the optical links of this network, the recommendations explained in Pinheiro (2017) were considered, with a view to the needs that the link meets the loss patterns (in dB) with lower tolerances which are presented in Tables 4 and 5, the optical characteristics of some active components are presented. Another important requisit is to meet the minimum sensitivity criteria to ensure the operation of the link. The access network displays in *the splitters the* subdivisions of the signal to the end client. The more divisions are made, the greater the signal power fall to the end customer.

Table 4- Reference values for some passive components

Components	**Reference Value**
Single-mode fiber	0.35dB/km
Amendment by merger	0.1dB
Mechanical splicing	0.5dB
Connector	0.325dB
Splitter 1:2	3.5dB
Splitter 1:4	7.5dB
Splitter 1:8	10.5dB
Splitter 1:16	14.5dB
Splitter 1:32	18.5dB
Splitter 1:64	22.5dB

Source: Adaptado de Pinheiro (2017)

Table 5- Optical characteristics of active components

Parameters	OLT	ONT
Minimum average power	+1.5dBm	+0.5dBm
Maximum average power	+5dBm	+5dBm
Minimum sensitivity	-28dBm	-27dBm
Minimal overload	-8dBm	-8dBm

Source: Adapted from Pinheiro (2017)

3.4.2 Optical power rationing

The optical power budget is the difference between the optical power delivered by the transmitter to the fiber and the power required by the receiver. Losses in the passive elements of the network should be accounted for and a safety margin preventing the ageing of active devices. The dimensioning of a link involvesthe choice of passive optical components, as well as active elements, aiming to ensure the transmission of the optical signal at a certain distance, with a specific transmission rate, following performance quality parameters defined in the project (AMAZONAS, 2005). In this project, the 1:64 distribution model was adopted to consider the average value of the transmission power of the OLT estimated at +5 dBm, according to the OLT datasheet, and all the estimated losses in the passive components in the linkage were observed, namely*:*

- Optical power level at OLT output: +5dBm / 1490nm
- Optical signal loss in splitter's 1:2: -3.5dB Loss
- Optical signal loss in splitter's 1:4: -7.5dB Loss
- Optical signal loss in splitter's 1:8: -10.5dB Loss
- Optical signal loss in mechanical connections: -0.3dB Loss
- Optical signal loss in optical fiber: 0.35dB/km

Based on these referenced losses, you can ensure that the input power na ONT is within its operating range (Sensitivity). For this, the difference between the output power and the signal loss must be greater than the sensitivity of the receiver, and therefore must be fulfilled, according to Pinheiro (2017), the power budget following the equation:

$P_{TX} - At > S_{RX}$

Where Ptx = Output Power (Tx) , At = Total attenuation and Srx = Sensitivity (Rx), are expressed in dBm. According to the aforementioned author, the total attenuation of the link, which is dada by:

$$At = Afo + Pc + Pe + Pp + Ms$$

In which:
Afo = Total attenuation of optical fiber, in dB
Pc= Total loss of connectors, in dB
Pe = Total loss on seams, in dB
Pp = Total loss on passive elements, in dB
Ms = Safety margin, in dB

The purpose of any link is to reliably transmit data, an attribute that stems from an appropriate specification in the garant network to which the devices used perform as expected and offer solutions with reduced potential for failure. Among the most relevant factors to ensure transmission quality is the control of network power losses. The following is the power budget calculation for the project, where the following reference values of the active components were adopted, according to the datasheet of each equipment: transmission power value (Ptx) for each OLT: +5dBm, Rx sensitivity margin for each ONT: -27dBm and minimum overload for each ONT: -8dBm.

The total attenuation (At) of the link will therefore be:

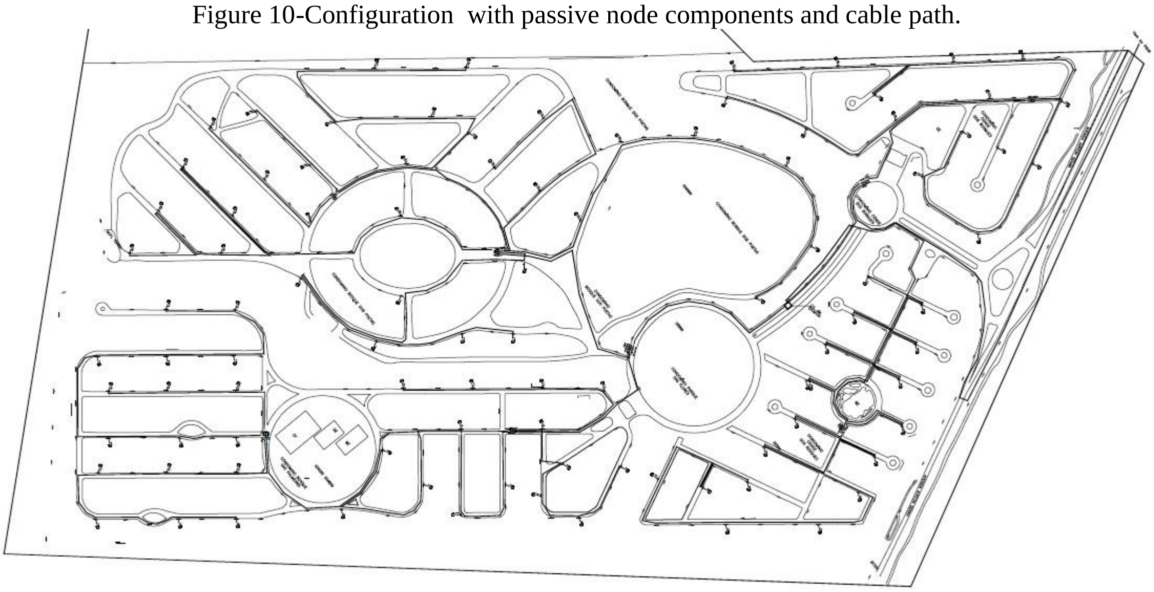
$$At = (6.95km\ link \times 0.35dB) + (2\ connectors \times 0.325dB) + 0.5dB + 21.5dB + 0.2dB$$

$$At = 25.28dB$$

Thus, since the ratio (Ptx - At > Srx) must be met, we will have (+5dBm - 25.28dB) > -27dBm. Considering that - 20.28dBm (optical signal value predicted in ONT) > -27dBm (reference value for a viable link), the technical feasibility of the link is established, since the above calculation met the insertion criteria within the sensitivity margin of the ONT.

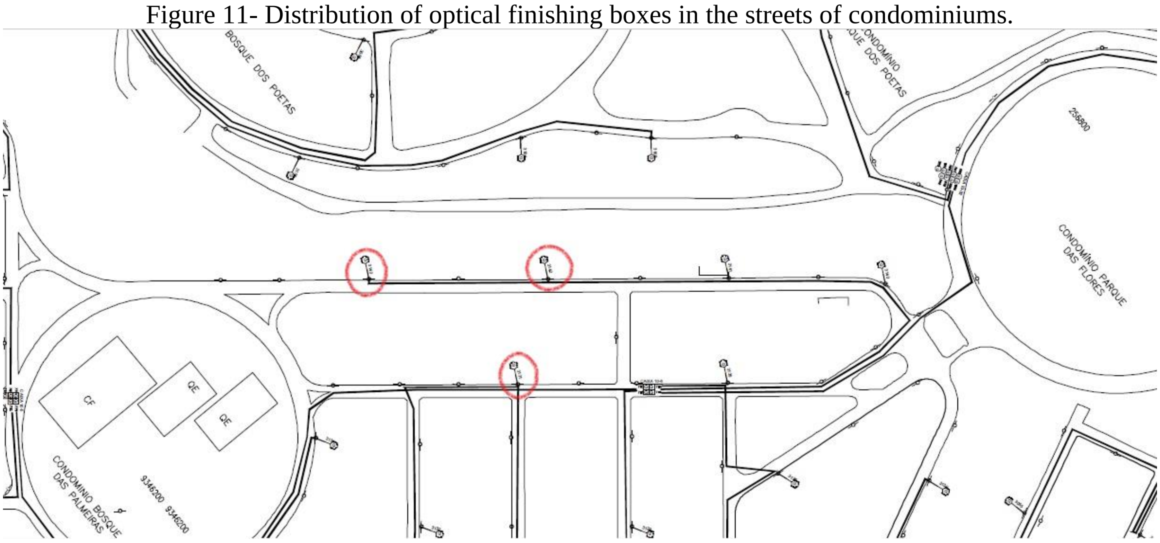
The diagram with the configurations with all passive components of the region and the path of the cables and the distribution of the optical termination boxes are available respectively in F iguras 10 and 11.

Figure 10-Configuration with passive node components and cable path.



Source: Cabo Telecom, 2020.

Figure 11- Distribution of optical finishing boxes in the streets of condominiums.



Source: Cabo Telecom (2020).

4 DEPLOYMENT NETWORK TESTS

4.1 FTTH ENCLOSURE ASSEMBLY

The enclosure is the site of network management, that is, it accommodates the OLT's and the boards called optical chassis. In addition to the entire management part of the OLT's, there is also the power connection scheme that it receives from the concessionaire. The ftth cabinet assembly activities stage was carried out simultaneously with the work of expanding the optical cables in the region

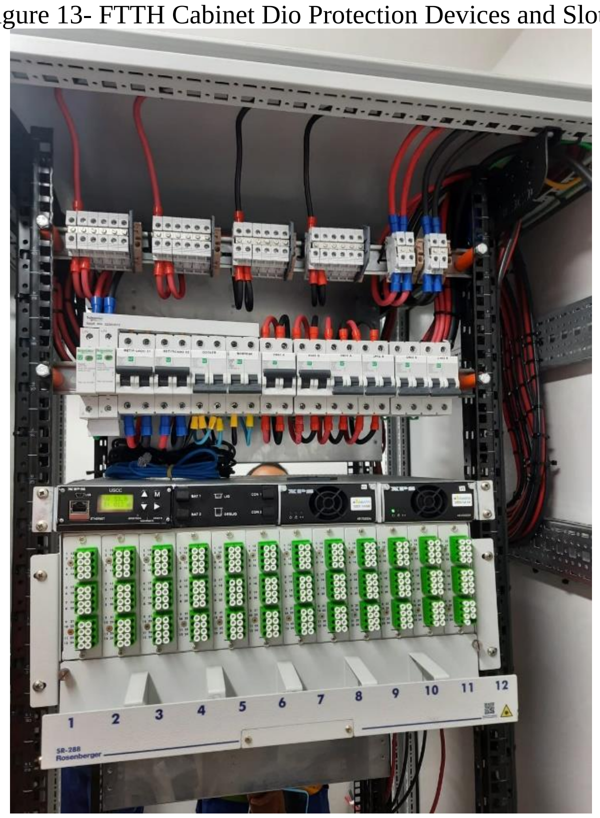
The power structure of the enclosure consists of an electrical power system that contains protective devices (circuit breakers), electrical current rectifiers and battery bank. In the FTTH enclosure, there are also slot's DIO (optical internal distributor) to accommodate the in/out fibers, optical chassis composed of plates with OLT's and optical cords connecting the OLT's with the dio's slot's, presented in Figura 12. The idea of maintaining a standard of organization of optical cables establishes that the active and passive components of an optical network are mounted in an appropriate structure, in order to ensure a good capacity of management of the physical network in order to provide ease for carrying out preventive maintenance.

Figure 13 shows the existence of digital rectifier modules where its main function in the system is to rectify the alternating current in 220 VAC, making it continuous and suitable for feeding the cabinet equipment (54VDC). In Figure 14, we also see a bench composed of 8 93Ah batteries and rated voltage of 12V connected in series, which will only be activated in the absence of phase of the electrical network in the inverter circuit, being another safety mechanism for the cabinet.

Figure 12- Accommodation of optical cables in the FTTH Enclosure.

Source: The Authors, 2020.

Figure 13- FTTH Cabinet Dio Protection Devices and Slots.



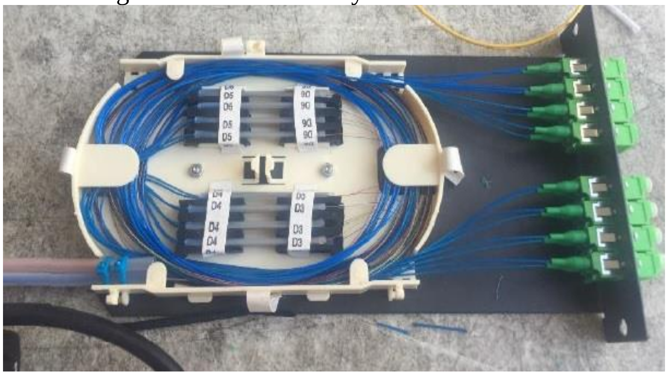
Source: The Authors, 2020.

Figure 14- FTTH Cabinet battery bank ready for operation.

Source: The Authors, 2020.

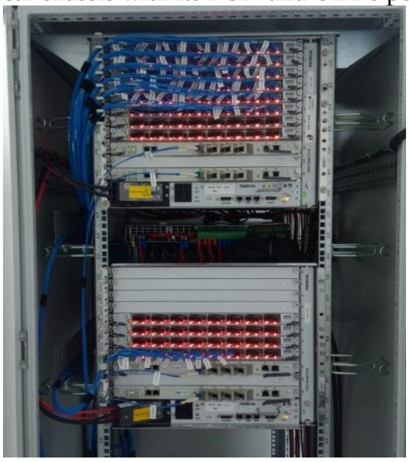
Figure 15 shows that the optical cords that comeout of the OLTs reach the DIOs slots, and then depart for the linkage. In figura 16 we see all active and ready-to-operate PON ports, where on each optical chassis board there are 8 PON ports, referringto a PON port covers 64 ONTs, each card manages a total of up to 512 ONTs. The optical chassis for the project was considered with a value of 64 PON ports, 8 cards with 8 slot's for OLT's.

Figure 15- Fibers already fused in dio's slots.



Source: The Authors, 2020.

Figure 16- Optical chassis with its PON and OLT's ports in operation



Source: Own authorship, 2020.

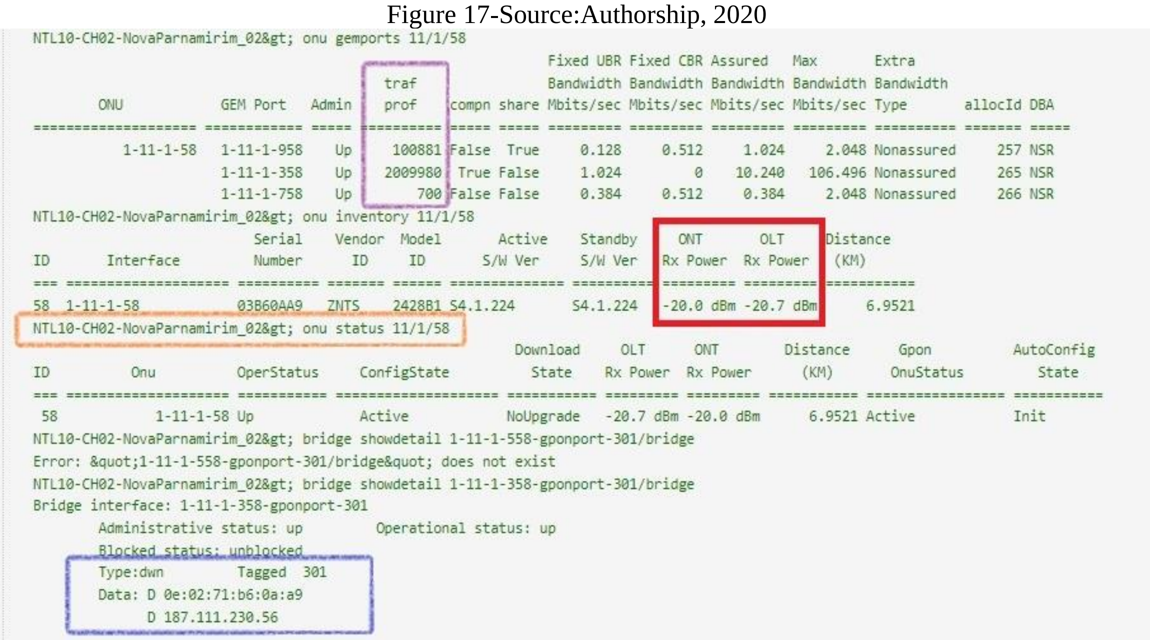
4.2 INSTALAÇÃO IN THE USERAND THE SPECTOS OF THE NETWORK MANAGEMENT

After the entire process of expansion and access of users to the services offered, the connection provider begins to manage the bandwidth made available to the user through the equipment supervision system, where it contains the packages with the services adquiridos by the client. Through the network management process, ONT obtains IP through virtual local area network (VLAN's) in the same broadcast domain. On the other hand, OLT centralizes and distributes the optical signal to ONT, having the function of distributing data, VOIP and IPTV to PON network.

Figure 17 for representation purposes is identified some ofthe user ont management devices that an access provider uses on a GPON-based FTTH network. Among them stands out the identification of the receiving power of ONT and OLT, and in addition tothe band rgura allocated to ONT. Themanagement system provides information on several other parameters, namely:

- Optical signal of downstream (ONT): -20,0dBm;
- Optical signal of upstream (OLT): -20.7dBm;
- Bandwidth to beuploaded to ONT: 200 megabits for download and 80 megabits for upload;
- NODO, optical chassis position and PON port position: NTL10-CH02/11/1/58;
- ONT MAC obtaining public IP through the data VLAN;
- Link distance, in Km, from OLT to ONT: 6.95Km (used in power budget calculation)

Figure 17-Source:Authorship, 2020



```
NTL10-CH02-NovaParnamirim_02&gt; onu gemports 11/1/58
                                                        Fixed UBR Fixed CBR Assured   Max       Extra
                                       traf                       Bandwidth Bandwidth Bandwidth Bandwidth Bandwidth
        ONU           GEM Port   Admin  prof   compn share Mbits/sec Mbits/sec Mbits/sec Mbits/sec Type       allocId DBA
==================== ============ ===== ========= ===== ===== ========= ========= ========= ========= ========== ======= =====
          1-11-1-58  1-11-1-958    Up    100881 False  True     0.128     0.512     1.024     2.048 Nonassured     257 NSR
                     1-11-1-358    Up   2009980  True False     1.024         0    10.240   106.496 Nonassured     265 NSR
                     1-11-1-758    Up       700 False False     0.384     0.512     0.384     2.048 Nonassured     266 NSR
NTL10-CH02-NovaParnamirim_02&gt; onu inventory 11/1/58
                           Serial    Vendor  Model        Active     Standby      ONT       OLT     Distance
ID       Interface         Number      ID     ID        S/W Ver     S/W Ver   Rx Power  Rx Power    (KM)
=== ==================== ========== ======= ====== ============== ========= ========= ========= ===========
58  1-11-1-58            03B60AA9   ZNTS    2428B1 S4.1.224       S4.1.224  -20.0 dBm -20.7 dBm      6.9521
NTL10-CH02-NovaParnamirim_02&gt; onu status 11/1/58
                                                      Download     OLT       ONT       Distance      Gpon          AutoConfig
ID         Onu          OperStatus    ConfigState       State    Rx Power  Rx Power      (KM)      OnuStatus         State
=== ==================== =========== ==================== =========== ========= ========= =========== ================= ===========
 58           1-11-1-58 Up            Active            NoUpgrade   -20.7 dBm -20.0 dBm      6.9521 Active            Init
NTL10-CH02-NovaParnamirim_02&gt; bridge showdetail 1-11-1-558-gponport-301/bridge
Error: &quot;1-11-1-558-gponport-301/bridge&quot; does not exist
NTL10-CH02-NovaParnamirim_02&gt; bridge showdetail 1-11-1-358-gponport-301/bridge
Bridge interface: 1-11-1-358-gponport-301
        Administrative status: up        Operational status: up
        Blocked status: unblocked
        Type:dwn            Tagged  301
        Data: D 0e:02:71:b6:0a:a9
              D 187.111.230.56
```

We highlight that the network is designed to manage an amount of 64 ONT's per PON port, however if there is a need to increase the amount of connected ONTs, as well as the d-and-bandwidth *width in both the upstream* (1.2Gbps per PON port) *and the downstream* (2.5Gbps per PON tip) can be adjusted for compatibilization. With referenceto the average transfer rate in *dowstream and upstream* per GPON interface, it is also supervised to ensure convenient balance of band by pon port on the network.

Figure 18- Optical signal measured on the ONT optical bead

Source: Author, 2020.

5 CONCLUSION

The infrastructure of telecommunications networks has undergone a process of significant changes, evolving into a rigid and hierarchical architecture for a flat and integrated architecture, formed by a diversity interconnected equipment and different architectures and technologies. Given this new context of the structure of the networks, for the development of this work was carried out a broad research on optical networks based on the ftth architecture being identified that the GPON standard has been the most adopted solution by the providers, because it allows better quality in the services for providing voice data communication, video, as well as good flexibility for increased bandwidth and adequate support for long distances, plus lower latency.

The project was based on a broad theoretical framework that allowed the application of the main requirements in the technical, commercial, operation and maintenance aspects, which should be followed for the elaboration of optical network projects, including the standards and standards adopted in ftth network design, in order to ensure that the results provided for in the provision of services to the market in question were achieved satisfactorily.

For the preparation and execution of this project, a wide survey of the service area, materials, equipment, in addition to the evaluation of investments and business model was carried out, which enabled the execution of the ftth network implementation project. We highlight that the experience in the implementation of optical fiber evidenced the requirement of attention and care, compliance with the standard in the fusion and organization of fibers integrated in optical cables. We also report that for the expansion of the link, network auditing is fundamental for the execution of projects of this type, because without the commissioning of the FTTH network corrective maintenance becomes more frequent in the future.

At the conclusion of this project, it was possible to see advantages of an FTTH network compared to traditional networks (HFC and DSL). The GPON technology used allows to create a network infrastructure with fewer components, lower cost, greater reach, and proposesto the user a considerable increase in traffic capacity. In addition, GPON also allows for greater bandwidth control, security, and network management.

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