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Performance Analysis of a Passive FTTH-PON System Using Hybrid OTDM/WDM Multiplexing

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ABSTRACT

In this paper, we analyze the performance of a FTTH system using multiplexing hybribe OTDM / WDM we compare to FTTH systems using multiplexing OTDM and WDM. It appears from the studies that despite a good bit rate error that OTDM and better quality factor that also have the WDM, the hybrid multiplexer which is a combination of the two multiplexing has a quality factor and a lot bit error rate more better. Another advantage is observed that the hybrid multiplexing not only to share the fiber and increase bandwidth but also to increase the number of subscribers per fiber.

Keywords - OTDM, WDM, Fiber,, FTTH, Quality factor

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I. INTRODUCTION

The concept of structured network within the home is new; it is the last "link" between missing the access network of the telecommunications operator and the end user. It must meet specific requirements in terms of architecture, throughput, range and heterogeneity while remaining simple to install and use by the customer. The arrival of the fiber with the FTTH deployments (Fiber to the Home) will indeed stimulate increased bandwidth domestic applications [1]. Other factors will also motivate this growing demand in terms of speed: the passage of triple play (internet, TV, voice) to the multi-play, changing uses (several family members may connect simultaneously), the proliferation of connected devices (game consoles, smartphones, PC ...) or the enrichment of contents (transition to high definition (HD), appearance of 3D ...) and the number of habitat. Beyond the flow of goals, the home network should be simple for the user (installation, connection of equipment, maintenance ...) and guarantee coverage in very high speed around the houses. This need insist flow in one hand and one or other of the OTDM and WDM technologies as shown authors [2-4] can fill the number of subscribers that can connect to the same on the other fiber. Beyond the flow of goals, the home network should be simple for the user (installation, connection of equipment, maintenance,) and guarantee coverage in very high speed around the houses. This need insist flow in one hand and one or other of the OTDM and WDM technologies as shown authors [2-4] can fill the number of subscribers that can connect to the same on the other fiber. Beyond the flow of goals, the home network should be simple for the user (installation, connection of equipment, maintenance,) and guarantee coverage in very high speed around the houses. This need insist flow in one hand and one or other of the OTDM and WDM technologies as shown authors [2-5] can fill the number of subscribers that can connect to the same on the other fiber.

More significantly, according to rigorous simulation study using OptiSystem software, the hybrid multiplexing surpasses and multiplexing WDM in terms OTDM signal to noise ratio, quality factor and number of subscribers that can be connected on the same fiber. This work is organized as follows. Section II describes the different optical connectivity architectures, multiplexing techniques and their interest in FTTH. Section III presents the results and finally Section IV concludes the work.

II. ARCHITECTURES CONNECTIVE OPTICAL

Two major architectures are now deployed in optical networks to the home (FTTH also called). In both cases, there is no active equipment (requiring power) between the NRO (optical connection node) and the Delivery Point.

II.1.The developed architecture liability period (P2P)

It requires the installation of a continuous fiber and not shared between **NRO** (Node Connection Operator Optical) and the user (this part is never multiplexed). This architecture has the feature to provide each termination of a dedicated fiber network. This technology has the advantage of allowing the allocation of all potentially available bandwidth on a fiber to a subscriber (Figure 1).

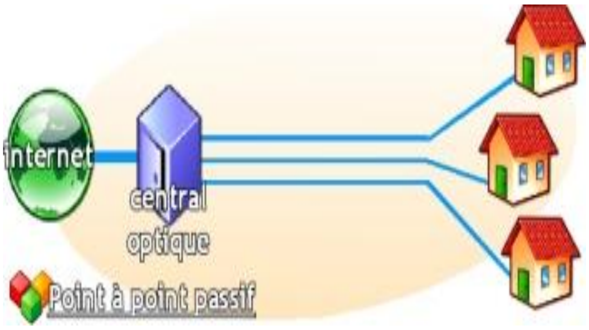

Figure 1: passive point-to-point architecture [2].

By cons, it has the disadvantage of requiring numerous fiber, which is expensive to manage (especially in urban areas) and management complicated (particularly in the NRO) [6-7].

II.2. The architecture point to multipoint passive

In this type of architecture, several units are served from an optical fiber after the NRO, through the insertion of optical couplers. This architecture is also called "G-PON" because it is an interconnect technology has very high speed. A single fiber from central and serves a fiber group at a share point. It is thus possible to serve multiple homes from a single fiber. This architecture offers the advantage of limiting the number of fibers to be deployed but the equipment (splitter) functioning as a hub, each house served receives all information passing over the line [8-9]. It is therefore less secure.

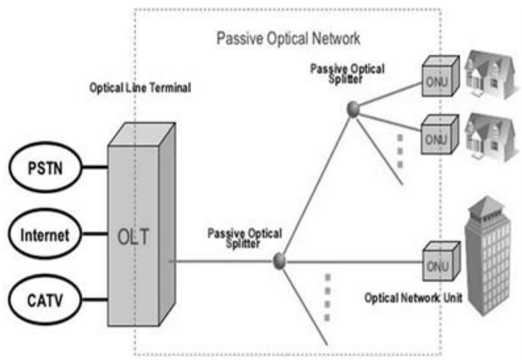

Figure 2. FTTH-PON architecture [7].

But there are other architecture that can be grafted to as FTTH FTTH-BPON, EPON and FTTH-GPON-FTTH.

II.3. Technical multiplexing and interest in the ftth

Multiplexing is a technique that involves passing several information through a single transmission medium. It allows to share a single resource between multiple users. The disadvantages of this type of architecture is the fact that the signal quality is not assured at all subscribers because the number of subscribers on the one hand and their distance to the other NRO. To offset these problems, multiplexing techniques are generally employed. There are three multiplexing techniques commonly used for optical transmission: OTDM, WDM and hybrid TDM / WDM. [10-11]

II.3.1. Time division multiplexing (TDM)

This multiplexing allows, among others, passing synchronous or asynchronous stream over a synchronous link. The time multiplexing can be done optically (OTDM, Optical Time Division Multiplexing). The transmitter consists of N parallel modulated optical sources in the flow Db bits / s. The optical time division multiplexing is not used only to increase the transmitted rates, it also provides a usable access technique in local networks. The different signals are "assembled" to be transmitted on a single optical carrier (Figure 3).

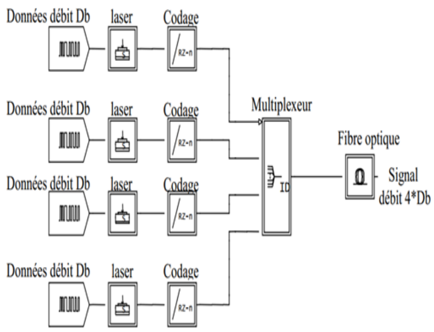

Figure3. Overview of OTDM.

II.3.2 The frequency multiplexing or wavelength.

Multiplexing wavelength, often called WDM (Wavelength Division Multiplexing English), is a technique used in optical communication which can increase the flow rate on an optical fiber by circulating a plurality of different wavelength signals on a single fiber, the mixing at the input using a multiplexer (MUX) and separating them on output using a demultiplexer (DEMUX). The principle is to carry multiple signals on a fiber optic strand. Each signal is placed on a given length through a transponder. Then via an optical multiplexer, all

wavelengths are sent on the same strand of optical fiber. At the other end, a demultiplexer will separate them from each other wavelengths.
An optical multiplexing is wavelength possible for several degrees, the Table 1 shows each.

Table 1: Comparative Table of WDM mode

	Coarse-WDM	Dense-WDM	Ultra-Dense-WDM
Number of wavelength	up to 16	8-128	> 40
Space Channel	20nm 25nm has	0.4Nm has 1.6nm	0.08nm
spectral window	~1260nm-1620nm	~1500nm-1600nm	~1500nm-1600nm
Speed wavelength	1,25-2,5Gbit / s	10Gbit / s 40Gbit / s	> 40Gbit / s

II.4.Critere evaluation of the quality of a transmission.

Considering all the damage that may suffer the signal during its transport via optical fiber, it was necessary to establish criteria for judging the quality of a transmission. In practice, these criteria are evaluated after signal detection: the eye diagram, the bit error rate (BER), the quality factor (Q). [16]

II.4.1. The bit error rate BER

The bit error rate Bite Error Rate is the ratio of the number of errors on the bits transmitted during measurement.

$$BER = \frac{NbE}{NbT} \quad (1)$$

With: NBE the number of erroneous bit NBT and the number of bit transmitted.
The overall quality measure of a channel-multiplexed system necessarily pass wavelengths by measuring the BER of all the channels. If only one channel among several present mistakes, the BER of the overall system is close to that of the channel with errors. Generally in optical telecommunications it is considered that a good transmission quality for a BER of between 10-9, 10-12 and 10-15 according to the systems.

II.4.2. The quality factor

The quality factor is a parameter that allows the estimation of the bit error rate without having to count the errors. It represents the signal on electrical noise in the receiver input of the decision circuit. Knowing the signal to noise ratio of a transmission system receiver via optical fiber has a direct impact on the performance of this system. The quality factor is often used rather than the bit error rate as long as it is too small to be measured. A transmission system should have a quality factor located around 7,01dB.

II.4.3. The diagram of the eye

The eye diagram is used to view the quality of a signal in the time domain by superimposing a large number of sequences in real time by means of a fast oscilloscope synchronized to the clock signal of the data signal. From the eye diagram, the signal quality can be easily recognized. We say that the eye is open if the levels of symbols "1" are distinct levels of the symbols "0". By cons, we speak of a closed eye (horizontally or vertically) if the deterioration is such that we cannot distinguish the two levels. ".

III. SIMULATION AND PRESENTATION OF RESULTS

The simulations were performed using the software tool OPTISYSTEM. OPTISYSTEM (Optical System Design Software Communication) is a simulation software developed by a Canadian company, to allow researchers and engineers to model and simulate optical telecom den systems to design, test and optimize the entire optical link. In what follows, we consider four (04) located at different distance subscribers NRO and each having an optical outlet. The diagrams below will be composed of three parts, namely: the emission, transmission and reception of the optical signal.
- The transmission part is composed of an optical source emitting at a power of 4dBm (class c) with a range of 1550-1552 nm. The modulation used is NRZ (Non-Return to Zero).
- The carriage portion is made of an optical fiber 0.05km, an attenuation of 0.2 dB / km, a dispersion of 16.75ps / nm / km and an optical amplifier EDFA which willl booster optical signal.
- The reception part of the signal will consist of 4 optical receivers represent the four subscribers.

III.1. OTDM

The architecture of the optical OTDM designed as OPTISYSTEM is given in Figure 4.

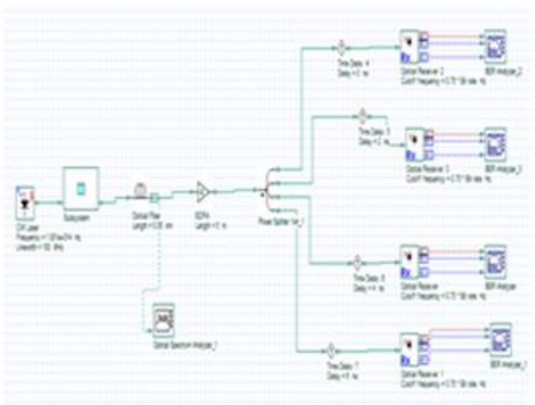

Figure 4. Multiplexing OTDM.

The results presented relate to a single optical receiver at the subscriber. They will allow us to assess the quality of the optical signal emitted from the source and the signal received.

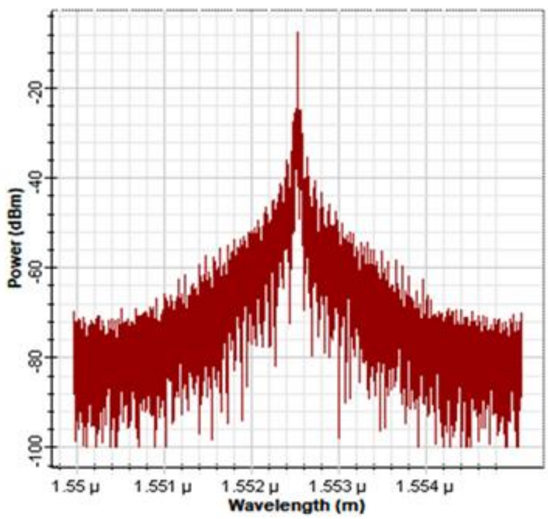

Figure.5. Spectrum of the signal injected into the fiber.

The figure5 shows the signal obtained at the output of the fiber amplifier before the EDFA. The maximum power obtained at the output of the optical fiber is -35dBm.

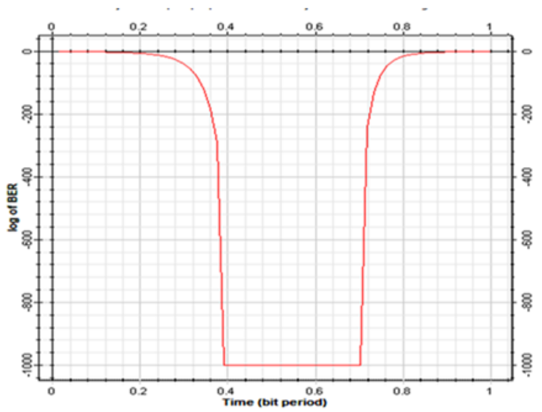

Figure6. Graph of bit error rate

The graph above shows that the bit error rate of the OTDM is not zero, it is equal to 10^{-2}. This value is far away from the normal, this result reflects significant loss of data and therefore poor reception. The graphs below present the diagram of the eye and the quality factor of the OTDM.

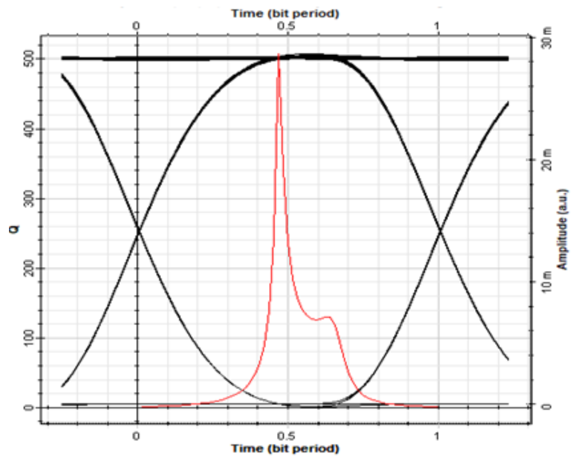

Figure 7. Diagram of the eye (▬), Quality factor (▬).

The eye diagram of OTDM shows us that we have not a good signal quality because it is too open. But the quality of the contrast signal with the high bit error rate met. The quality factor got here is 77, or the standard provided by the ITU provide that the quality factor of a system should not exceed 7.04.

In what follows, we seek to determine the best quality factor that may have varying the length of the fiber. We will take the lengths of the following fibers: L =5km, L =14km, L = 23km, L = 41km, L = 50km. The above results will be presented on the following graph (figure8)

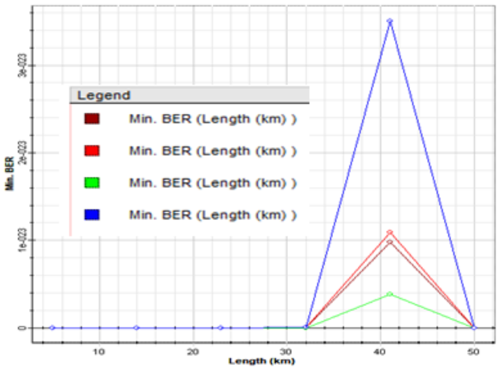

Figure8. Variation of the bit error rate depending on the length of the fiber.

The results obtained in the simulations are contained in Table 2 below.

Table 2. Variation of BER and quality factor.

Fiber length (Km)	5	14	23	32	41	**50**
BER	10^{-2}	10^{-121}	10^{-54}	10^{-27}	10^{-24}	$\mathbf{10^{-28}}$
Quality Factor (Q)	77	23.04	15.38	10.65	10	$\mathbf{10^{-89}}$

We see from this table that for distances L = 5Km, L = 14km, L =23km the quality factor increases and starts to become stable from 32Km.

Despite the good bit rate error obtained with the OTDM few lengths of fiber, it has a poor quality factor. This quality factor will have a significant effect on the quality of the signal provided to the subscriber especially when one wants to transmit data to high flow rates.

III.2. MULTIPLEX WDM

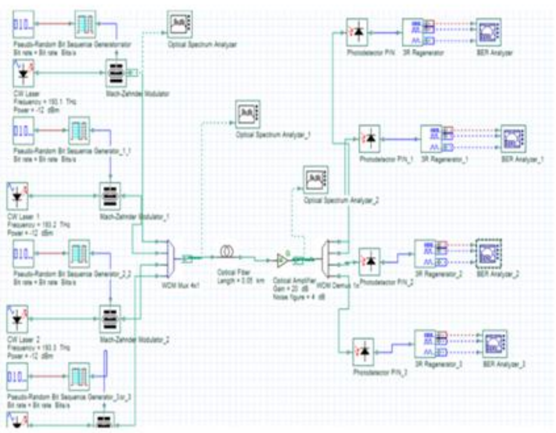

Figure9. WDM multiplexing architecture

The transmission part of the above architecture (Figure9) consists of four light sources that emit the power of -12 dBm with a 193.1THZ frequency. The conveying part is composed of a 0.05Km optical fiber length, an attenuation of 0.2 dB / km, a dispersion of 16.75 ps / nm / km and an EDFA to 20dB. The receiving part is composed of four optical receivers, which have the same characteristics as those that emit the signal. Figure10 shows the presence of four optical sources with different wavelengths signal at the output of the fiber.

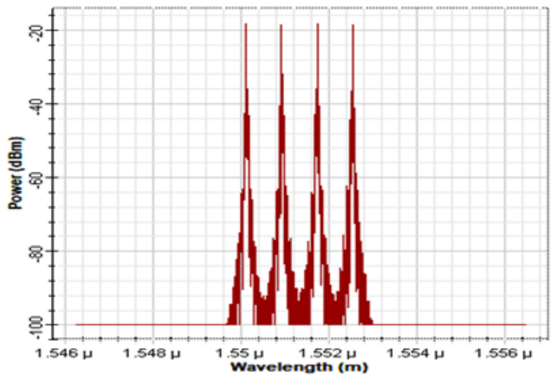

Figure10. Spectrum of the signal injected into the fiber.

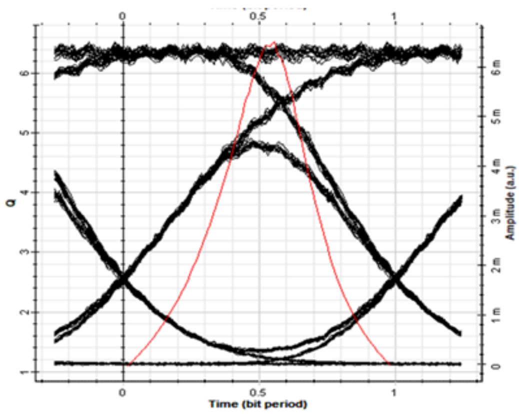

Figure 11. Diagram of the eye (▬) Quality factor (▬).

The Figure 11 shows the bit error rate (BER) and the eye diagram. We find that the signal is more smooth and stable with a bit error rate $8{,}1\text{x}10^{-7}$ and a quality factor of 4.7.

We see that with the same parameters used for TDM, we have a better signal quality factor and reduced error rates, which confirms the fact WDM comes here to fill the limitations presented by the CT.

As before for OTDM, we analyzed the output results by varying the length of the fiber. The Figure12 shows the variation of the quality factor depending on the length of the fiber.

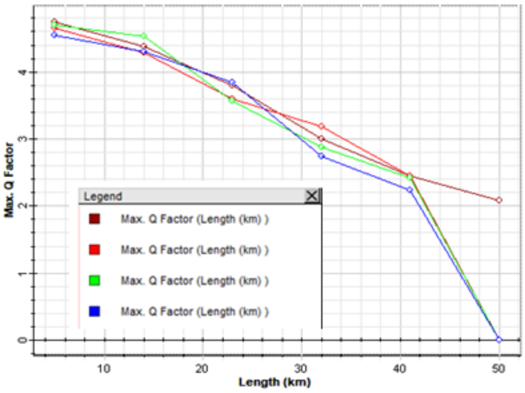

Figure12. Change the quality factor depending on the length of the fiber.

All the results are contained in Table 3.

Tableau3.Variation BER and the quality factor depending on the length of the fiber.

Fiber length (km)	BER	Quality Factor (Q)
5	$8.1 * 10^{-7}$	4.7
14	$5.7 * 10^{-6}$	4.37
23	$6 * 10^{-5}$	3.8
32	0.0012	2.99
41	0.0069	2.45
50	0.018	2.07

WDM 0,05km presents a better quality factor (6.34) and a bit error rate of 10-11 which complies with the standard provided by ITU optical transmission which is of the order of 10- 12 for the bit error rate and 7.03 to the quality factor. The WDM is more efficient than the OTDM because he comes here to fill the limitations of the OTDM and allows broadband transmissions.

III.3.MULTIPLEXAGE HYBRID

The hybrid multiplexing is done using the same parameters as in previous simulations in order to make a fairly logical comparison that will draw an acceptable result.

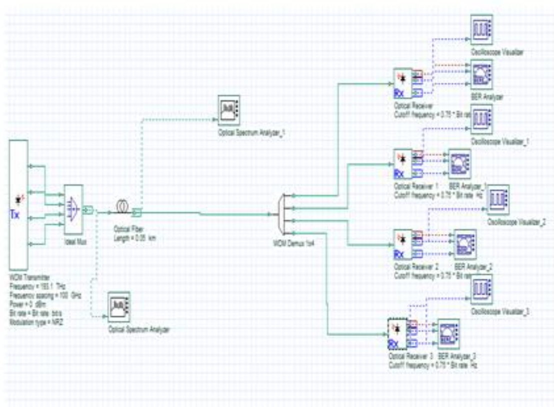

Figure13. Architecture of the hybrid multiplexing.

Figure13 shows the mounting assembly of the hybrid multiplexing OTDM / WDM. The pattern is composed of three parts, namely: transmission, transmission and reception portion of the optical signal. The transmission part is composed of an optical source emitting at a power of 0dBm (class c) with a range of 1550-1552 nm and an ideal multiplexer to perform the combination of the two multiplexing techniques.

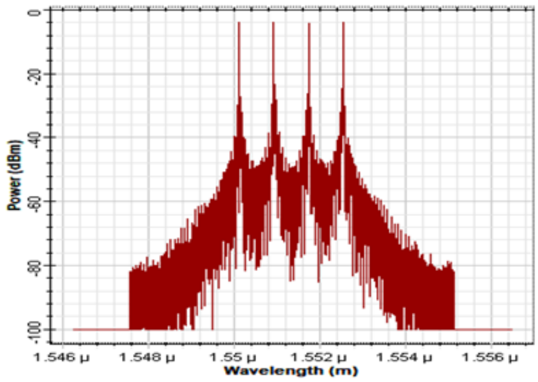

Figure 14. Spectrum of the hybrid signal.

The figure14 represents the four wavelengths sent into the fiber.

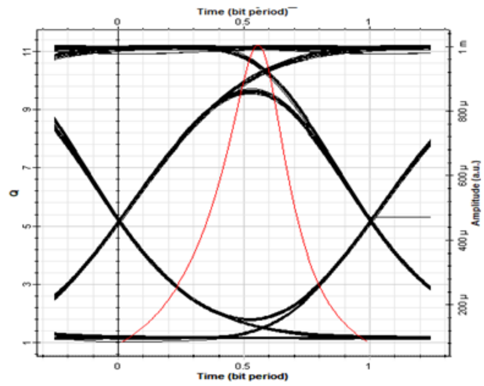

Figure15. Diagram of the eye (▬) Quality factor (▬).

We find that the hybrid multiplexing has an error rate of about 10-27 compared to CT was 10-2 and 10-7 WDM, this result is better than before but can still be improved. The diagram of the eye and the quality factor shows that the signal is much better than that of the WDM and TDM.

As before we will vary the length of the fiber and gather information about the BER and the quality factor.

Table 4. Variation of BER as a function of the length of the fiber.

Distance (km)	TEB	Quality Factor (Q)
5	10^{-30}	11.28
14	10^{-27}	10.7
23	10^{-23}	9.89
32	10^{-18}	8.69
41	10^{-15}	7.78
50	**10^{-13}**	**7.04**

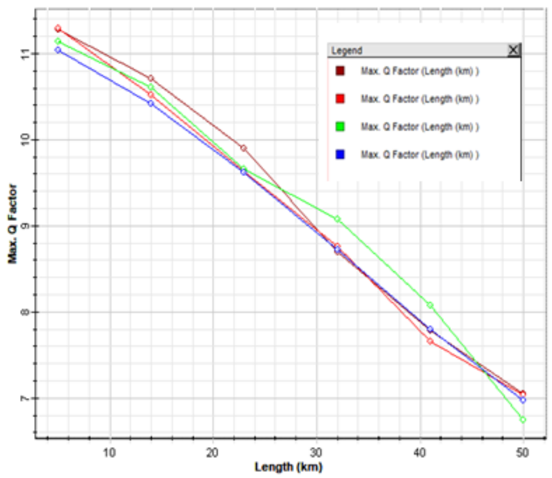

Figure16. Change the quality factor depending on the length of the fiber.

The figure16 and Table 4 shows that the error rate and the quality factor is reduced to and as the fiber length increases to the value of the quality factor of 7.04 for a bit error rate 10-13. However, the results are acceptable because they will allow sharing the fiber, increasing bandwidth and increasing the number of subscribers per fiber.

IV. CONCLUSION

Throughout this paper, it was a question for us to make a comparative study of the performance of hybrid multiplexing in an FTTH system with the other type of multiplexing conventionally used and to identify its interests. After a brief presentation of the different FTTH architectures using WDM, OTDM multiplexing and the OTDM / WDM hybrid we presented a certain number of criteria (bit error rate, quality factor etc ...) which allowed us to assess the signal quality of FTTH systems using different types of multiplexing. For the simulations, we used the Optiperformer software to analyze performance through several simulations. In the following, the results obtained from the different simulations, we were able to make an evaluation and conclude that hybrid-multiplexing presents better performance than these two counterparts do.

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