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Comparative Analysis of Different Pon Standards for 96 Users Employing Triple Play

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1. INTRODUCTION

Amplifiers have always been an integral part when it comes to long haul communications. Various amplifiers offer various pros and cons. So our future technology is required to be adaptable to offer large bandwidth and to support large number of new applications. Without amplifiers it would not be possible to transmit such extensively large amount of data at such hefty data rates. To solve this problem optical amplifiers have been developed which uses doped fibers with reflective ends to amplify the travelling signals. Optical amplifiers provide us adequate solution to solve the problem of long distance access network [1]. The BW requirement in the access networks has been increasing very rapidly over past few years. It is impossible to achieve this requirement using copper based infrastructure due to signal distortion and various other issues [2]. Research in the access networks introduced the concept of Fiber-To-The-X, where x can be Home (H), Curb (C) and Building (B) etc. Fiber To The Home (FTTH) is defined as fiber optic cable that replaces the standard copper wire of the local Telecom. FTTH is desirable because it is capable of carrying high-speed broadband services and runs directly to the home or building [3]. FTTH is simply the 100 percent deployment of optical fiber in the access network. Gigabit-capable Passive Optical Network (GPON) is the basic technology to support the structure of the next-generation FTTH system and support speed rate, full services routers network high efficiency, speed rates, full services, robust network, high efficiency and other advantages, and considers the suggestions of service providers at the same time [4].

GPON is regarded as one of the best choices for broadband access network in the future. The cost benefits have enabled increasing deployment of passive optical network delivering fiber to the home. However, in many cases, extended reach requires some form of amplification to overcome the additional losses [5]. Semiconductor based amplifiers offer a cost effective solution with a migration path. Given that the standard uses 1490nm downstream and 1310nm upstream wavelengths, wavelengths which are outside the erbium window, Semiconductor Optical Amplifiers (SOAs) play a clear role in this context. In order to increase transmission distance an amplifier is introduced somewhere between the transmitter and the splitter. Analysis of the effectiveness of the amplifier can be determined by evaluating the Q factor of the systemas the signal travels through the fiber, its power declines due to the presence of various non-linearities in the fiber [6] and ASE noise is also added due to its amplification by fiber. Revolution in the information technology implies that multimedia networks demand for high bandwidth real-time communication services. Presently, optical fiber is the only transmission medium that offers such large bandwidth with low loss communication links. With increasing transmission rates, electronic regeneration becomes more and more costly. Optical amplifiers have truly revolutionized the field of fiber optics communication. Optical amplifiers are in general independent of the bit rate and can amplify signals at different wavelengths at the same time.

The optical amplifiers are chiefly used for simultaneous amplification of all channels in Wave Division Multiplexing (WDM) light wave system called as optical in-line amplifiers. The optical amplifier amplifies the transmitter power by placing an amplifier just after the transmitter called the power booster. The transmission distance can also be increased by putting an amplifier just before the receiver to enhance the power received. The optical amplifier amplifies a signal immediately before it arrives at the receiver called as optical pre-amplifier. Optical amplifiers are mainly classified into two categories i.e. Semiconductor optical amplifiers and Fiber amplifiers. These are further classified into Traveling Wave Semiconductor Optical Amplifier (TW- SOA), Fabry-Perot Semiconductor Optical Amplifier (FP- SOA), Erbium Doped Fiber Amplifier (EDFA), Raman &Brillouin fiber amplifiers [7]. While practically designing the systems, it should always be taken care of and power budget allocations should be done accordingly.

2. SYSTEM DESCRIPTION

All Optical Network Unit (ONU) contain individual transmitter to modulate the data into a laser beam. The data is then transmitted to optical splitter. In case of upstream transmission optical splitter acts as a combiner. The output from an optical splitter travels to the bi-directional fiber and then receiver detects the optical signal at the Optical Line Terminal (OLT). Bit error rate is detected at the OLT side according to the received signal quality.

The bidirectional passive optical network architecture for 96 users is based on a circulator. Optical signal entering at any one port of the circulator exits at the next port of the circulator. Light arriving at port 1 leaves at port 2 and light arriving at port 2 will leave at port 3. It isolates the uplink signal for both uplink and downlink transmission so that bidirectional transmission will take place on a single fiber. Bidirectional circulator is used with insertion and return losses and wavelength dependent isolation.

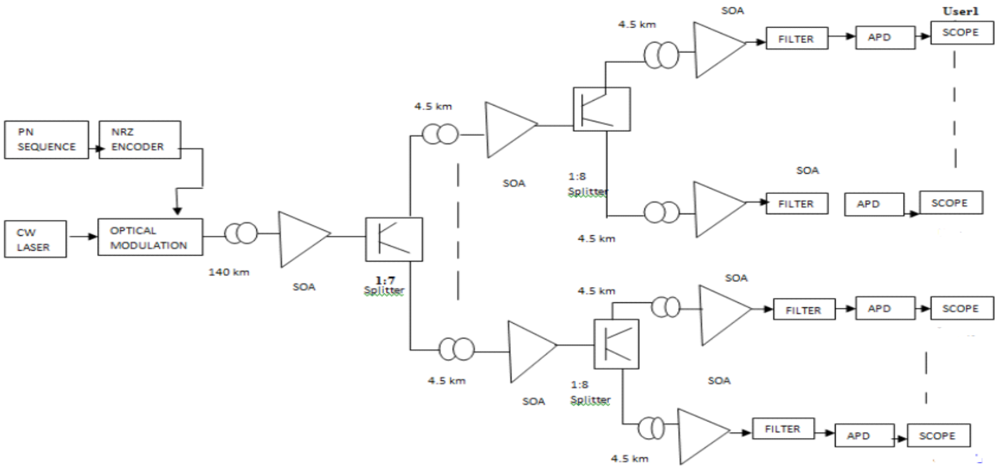

Figure 1- Architecture of PON setup used in simulation

Optical signal delay is produced by the delay element. Delay element is used in transmitter end. The delay is introduced by transmitting null signal to the output port. PIN photo detector is used which performs optical to electrical conversion of a signal. Then the two electrical signal is transmitted to low pass Bessel filter and 3-R regenerator. 3-R regenerator performs reshaping, re-amplifying and retiming of the signal. 3-R regenerator reshapes and recover the original electrical signal. The three signals from 3-R regenerator is coupled to BER analyzer, which gives the value of bit error rate according to the received signal quality.

3. RESULTS AND DISCUSSION

Downlink data transmission takes place at a wavelength of 1550 nm and upstream data transmission takes place at a wavelength of 1300 nm. Both these wavelengths has advantage of low attenuation window. The performance of various Bidirectional Passive Optical Networks (BPON) have been analyzed in detail. TSOA amplifier is placed in between transmitter and fiber. For 15Gbps we obtain an acceptable value of quality factor of 9.43dB for downlink transmission for 96 users and for upstream data transmission we obtain aquality factor of 8.53dB.

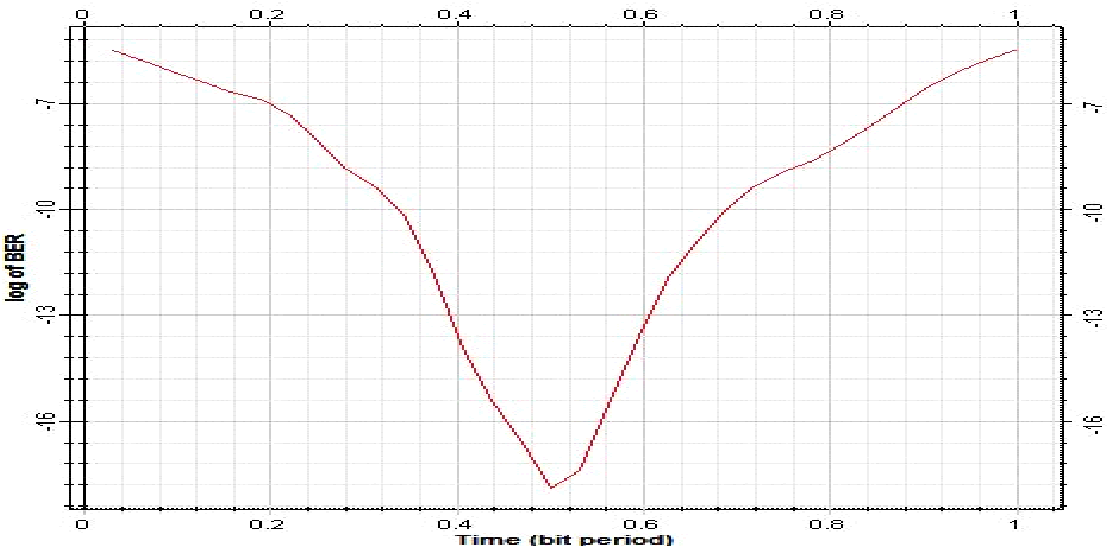

Figure 2 BER analyzer for uplink transmission

Eye diagram for audio signal at varied data rate and at varied distance is shown in fig 3 below. Various PON standard has been compared for audio transmission at a distance of 10Km and 40Km.Here it is observed that as the distance increases quality factor decreases and bit error rate increases.

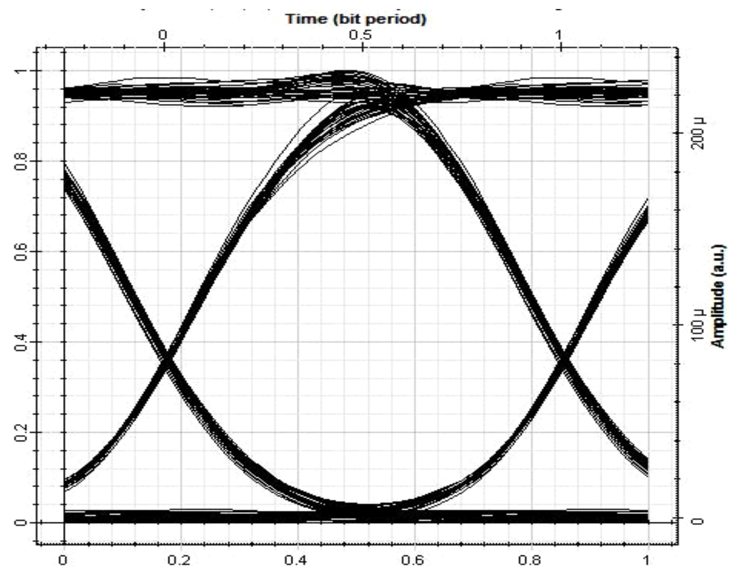

Figure 3(a) Audio signal at 15Gbps for 10Km.

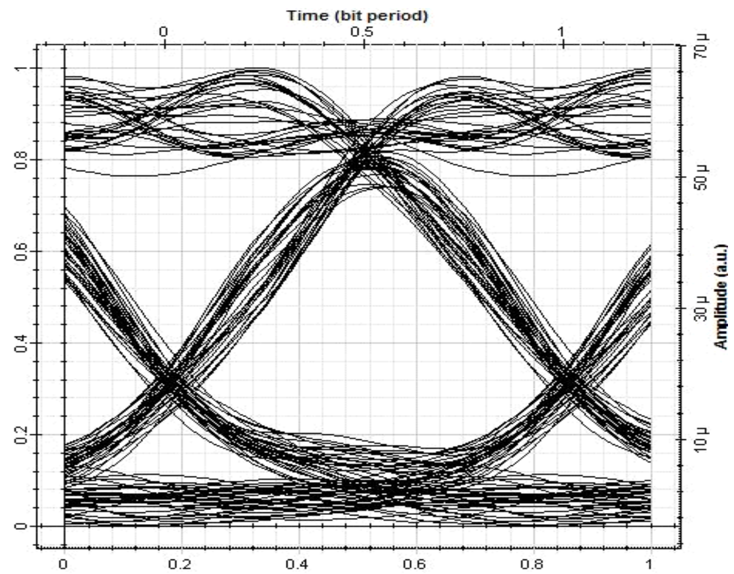

Fig.3 (b) Audio signal at 15Gbps for 10Km.

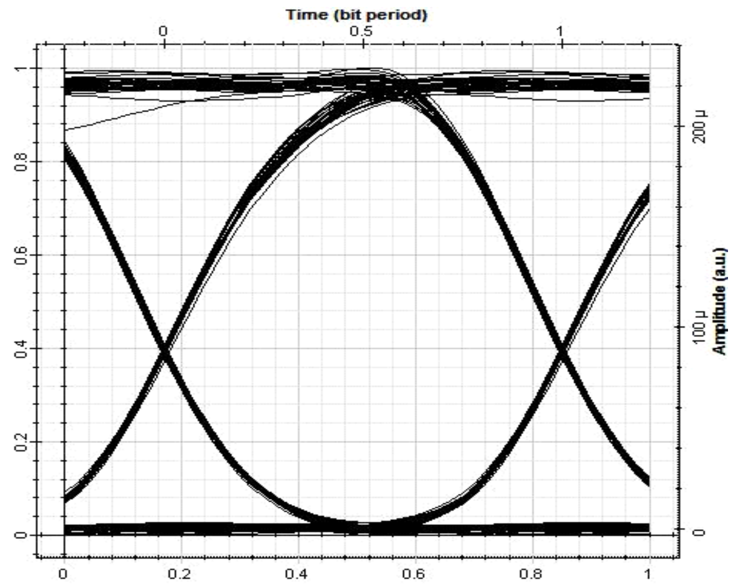

Figure 3(c)Audio signal at 15Gbps for 10Km.

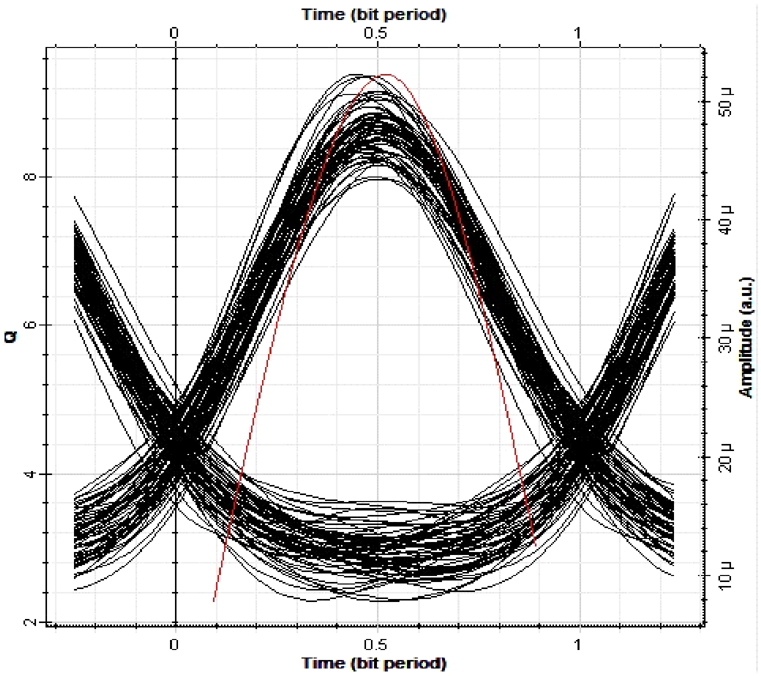

Figure 3(d) Audio signal at 15Gbps for 10Km.

It is observed that as the distance increases the quality factor of the system decreases

Table 1 Effect of distance on Q-factor of audio signal for various PON standards

Distance (Km)	2.5Gbps	5Gbps	10Gbps	15Gbps
10	44.59dB	41.79dB	40.59dB	32.02dB
20	39.38dB	32.45dB	31.04dB	24.64dB
30	38.25dB	29.44dB	23.69dB	15.45dB
40	28.13dB	28.08dB	15.72dB	9.43dB

For example at a distance of 10 km the value of quality factor is 45.59 but as distance increases to 40Km the quality factor of the system reduces to 15.72.

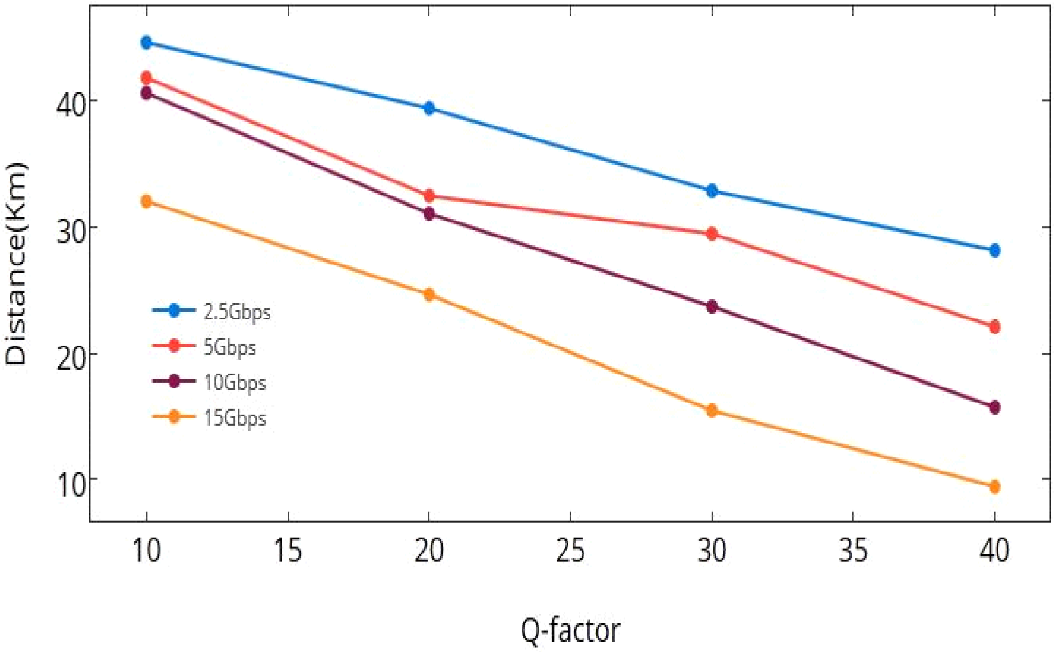

Figure 4 Distance versus quality factor for audio signal

Table indicates the effect of varied distance on quality factor of video signal transmission for various PON standards.

Table 2: Effect of distance on Q-factor of video signal for various PON standards

Distance(Km)	2.5Gbps	5Gbps	10Gbps	15Gbps
10	87.19dB	71.01dB	46.89dB	40.80dB
20	58.63dB	45.15dB	36.74dB	24.91dB
30	40.99dB	28.16dB	23.08dB	15.80dB
40	29.10dB	17.73dB	14.97dB	9.58dB

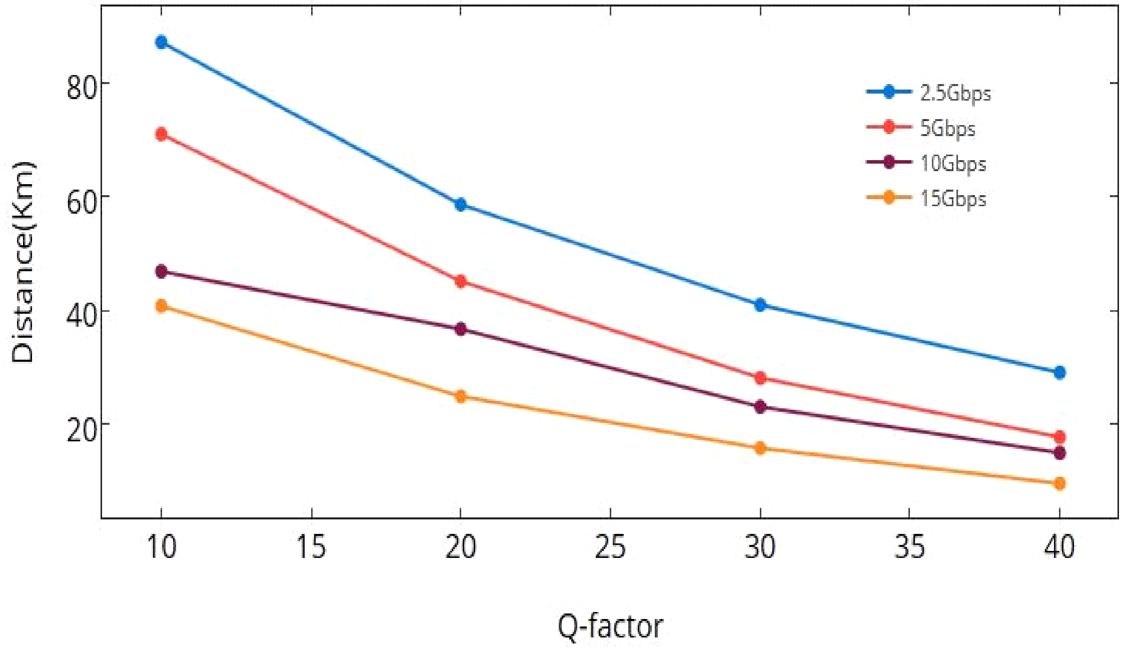

Figure 5 Distance versus quality factor for video signal

In above figures various PON standards have been compared for both audio and video transmission. In Figure 6 the impact of varied distance on quality factor of the system for 32, 64 and 96 number of users is shown. If we increase the distance the quality factor of the system shows a sharp decrease for varied number of users.

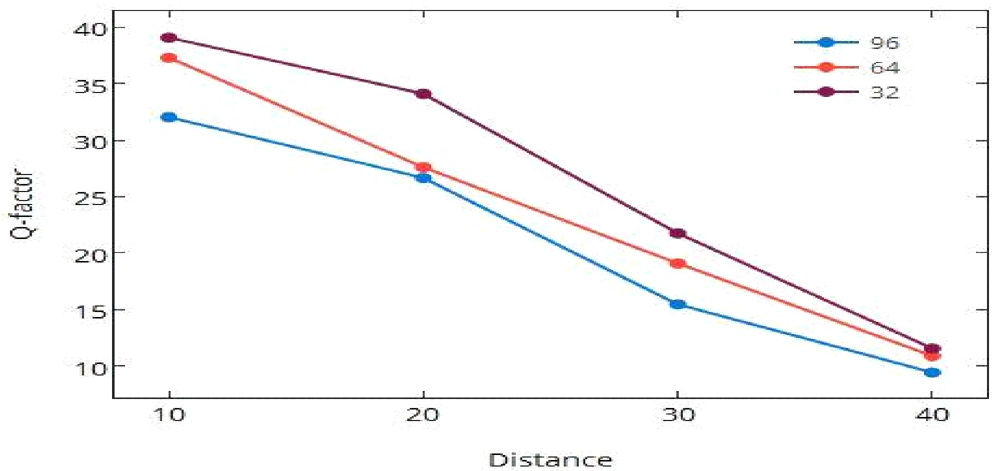

Figure 6 Q factor versus distance for varied number of users

This shows that there is a tradeoff between quality factor, distance and the number of users. As power of the system increases quality factor also increases. So there is some tradeoff between power and quality factor of the system. As power of the system increases the quality factor for audio and video signal transmission increases which is shown by table.

Table 3-Effect of varied power on Q-factor of audio and video signal

Power	Audio	Video
-15	0dB	0Db
-10	4.42dB	3.77Db
-5	11.86dB	10.41dB
0	24.64dB	24.91dB
5	33.41dB	45.81dB

The effect of varied power is measured at constant distance of 20Km for 15Gbps. For Audio signal transmission at -5dBm power, the quality factor of the system is 11.86 dB but as the power is increased to 5dBm the quality factor of the system reaches to 33.41dB. This demonstrate that with increase in the system power the quality factor of the system increases sharply. The relationship between power and quality factor of the system is depicted below in the figure 7.

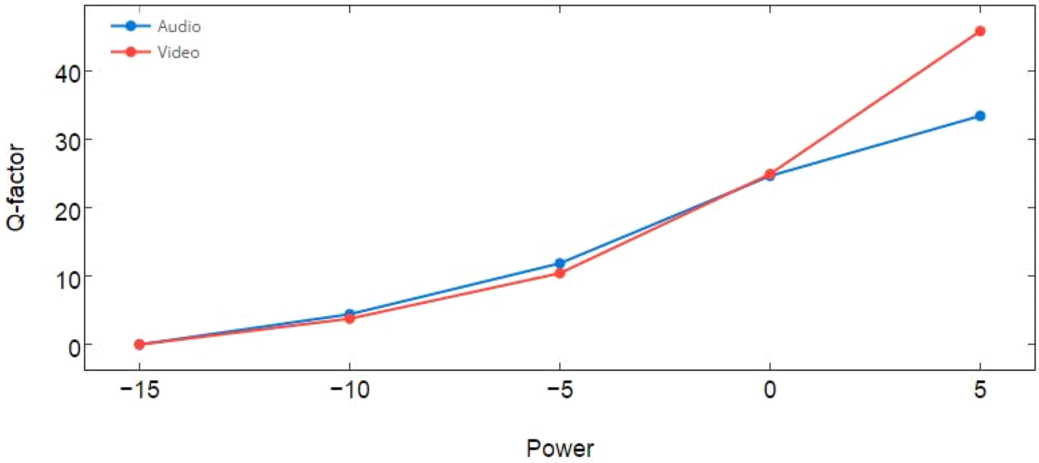

Figure 7: Q-factor versus power for audio and video signal

CONCLUSION

In this work, we designed bidirectional passive optical network using single fiber. We analyzed the performance of system for 96 users for both uplink and downlink transmission. We compared various PON standard at varied distance and power. We observed that as we increase the distance the quality factor of the system decreases and as we increase the power the quality factor of the system increases. We showed that with 15Gbps of data rate error free performance can be achieved over 40Km of bidirectional fiber for 96 number of users. Quality factor shows that the operation of our system is good for 15Gbps for both upstream and downstream transmission. At 15Gbps for upstream transmission Q-factor of 8.53dB is achieved. Value of bit error rate is also acceptable for 15Gbps in both upstream and downstream transmission. At 15Gbps for downstream transmission BER of 1.99e-021 and 4.39e-022 is achieved for audio and video respectively. These performance and reliability results are sufficient for high data rate applications.

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