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Performance Analysis of Next Generation Dense Wavelength Division Multiplexing Passive Optical Network (DWDM PON) Based on Inter-Satellite Optical Wireless Communication Employing Triple Play Services

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ABSTRACT: In this paper, high capacity inter satellite Optical Wireless Communication (OWC) system using triple play services for downstream is presented. The propose system is achieve by using 64 channels with Dense Wavelength Division Multiplexing (DWDM) by different methods. This system presents the simulation work on Passive Optical Network over Optical Wireless Communication channel for triple Play services proving access of Audio Data and Video to 64 Users. Dense Wavelength Division Multiplexing Passive Optical Network (DWDM PON) based on Duo binary non return to Zero (DBNRZ) format for downstream. The inter satellite link at 20 GB/s with channel spacing 50GHz and input power 20dBm, covered the distance up to 12000km. To shows the good performance of the proposed system, its eye diagram, optical spectrum and Q factor are shown. The analyze system will be highly useful for present and next generation optical communication between satellite. The overall system is design without amplifier which shows advantage for the network. The downlink 20Gbps signal can achieve a Bit Error Rate (BER) performance of $5.828\times e^{-011}$and Q factor should be 6.437. We evaluate the performance of the network in terms of Bit Error Rate, coverage area and obtain a network with an excellent access property.

KEYWORDS: Inter Satellite Optical Wireless Communication (IS-OWC); Passive Optical Network (PON); Dense Wavelength Division Multiplexing (DWDM); Triple Play Services; Eye diagram; Q factor; Bit Error Rate (BER).

I.INTRODUCTION

Wireless communication is basically use for transferring the information between one point to another point or one point to many points that is not connected by an electrical conductor. Radio technologies are the most common technique use in wireless communication. For televisions, radio waves can be covers the distance with very short range and cover millions of kilometers for deep space radio communication. There are various applications of radio wireless technology includes GPS units, garage door openers, keyboard, radio receivers satellite television and cordless telephones. Wireless devices and technologies have became pervasive much more rapidly than anyone could have imagined thirty years ago and they will continue to be a key element of modern society for the foreseeable future. [1]

The optical wireless communication systems are based on the basic principle of data transmission through air and using light as the carrier. [2] Optical wireless communications are providing an alternate for the bandwidth hungry communications. [3] The signal carrying information is being modulated on a laser which acts as a light source. The

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signal multiplex by multiplexer and send to another satellite in the free space. On the receiver side, light is detected using a photo detector and converted back into electrical signal. Optical Wireless Communication (OWC) is one of the best and efficient technologies which provide to the user higher transmission speed and immunity to interference. In inter satellite optical wireless communication; transmission is governed by free space propagation medium between satellites. [4]

Due to the rapidly growth in broadband data demands, Optical Wireless Communication (OWC) technology has been used in the field of research and development. Most of optical wireless communication system used IR LEDs (Light Emitting Diode) and Laser diodes in the form propagation medium. The most common receiver uses in the OWC links are photodiode like PIN and Avalanche Photo Diode (APD). Dense Wavelength Division Multiplexing (DWDM) is the most advance phenomena in the fiber optical communication which can transmit multiple information signals over the single fiber. When introducing Dense Wavelength Division Multiplexing (DWDM) with Passive Optical Network (PON) architecture, the biggest challenge in terms of optoelectronics components is the transmitter which needs to have a wavelength aligned with a specifically allocated DWDM grid wavelength. [5]

In Today's world, access network have to be compactable with great requirement, high reliability, performance, and be cost efficiently. The need of high speed access for transport new bandwidth consuming services and application like that HD TV, online gaming, VOD, and video conference. [6]

II.SYSTEM DESCRIPTION AND RESULTS

In the fiber optic communication, various number of software is uses to analyze or simulate the network design of some particular system. Opti system 14.0 is an effective optical communication system simulation tool that used for designing, testing and simulating any type of optical link. Opti system software is cost efficient in nature, high simulation speed and have very high level of accuracy. For the analysis or evaluation of this network we prefer opti system 14.0 which adds several new components to make simulation and designing of network simple. Opti system is a complete software simulation design tool and network achieves very excellent and acceptable results.

The proposed 64×20Gbps dense wavelength division multiplexing passive optical network with triple play services optical communication system as shown in fig. 1.1 is modeled by using opti system software. Network shows single transmission communication from Optical Line Terminal (OLT) to Optical Network Unit (ONU). The downstream signals are modulated by duo binary non return to zero with using triple play services. All the downstream link channels use the same wavelength to improve the wavelength utilization efficiency.

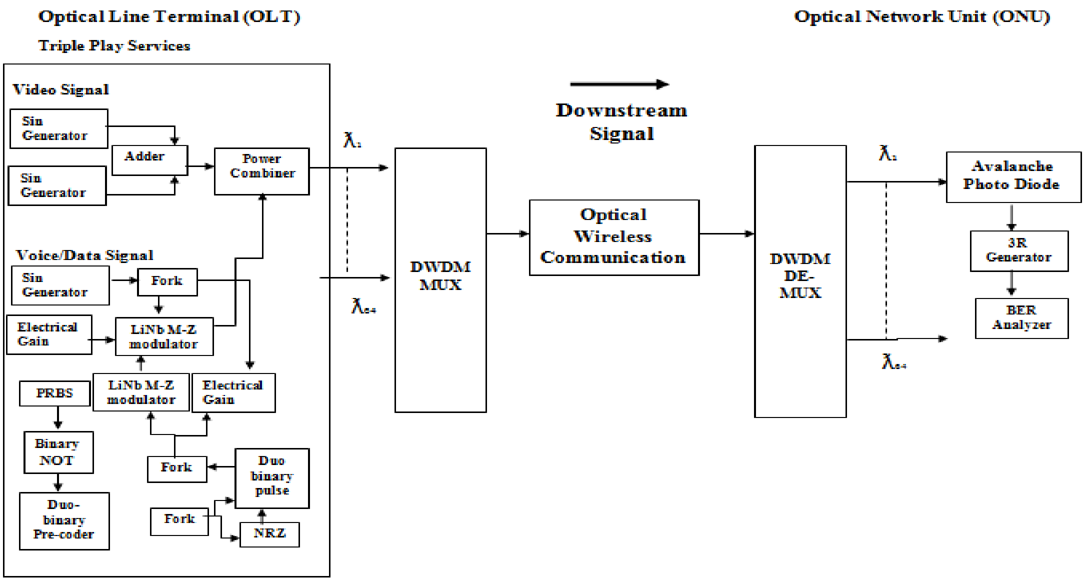

Figure 1.1 Simulation Setup of IS-OWC Channel for DWDM PON carrying triple play services

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Inter Satellite optical wireless communication system based on dense wavelength division multiplexing is represented by the block diagram is shown. The network consists of transmitter, receiver and free space communication channel between them. The video signal is send by two sine pulse generators and electrically adder to the power combiner. Data/Voice signal are transmitted through pseudo random bit sequence generator (PRBS) which is operated at 20 GB/s to generate a random sequence with different mode of operation. At the optical line terminal side, there are 64 distributed laser sources, followed by Duo Binary Non Return to Zero (DBNRZ) modulation scheme. Frequency starts from 193.1 THz with 50 GHz channel spacing to mitigate effects of cross talk in dense wavelength division multiplexing. Continuous wave laser is modulated by DBNRZ using 20dBm power and 20GB/s data rate to generate the desired downstream signal. The signal are multiplexed by a Wavelength Division Multiplexer ES (Equally Spaced) combines the 64 different wavelengths and transmit overall speed of 1280 GB/s followed by optical spectrum analyzer for inspection.
The aggregate signal is transmit over 12000 km long into free space optical communication channel. The advantage of Optical Wireless Communication over Radio Fiber communication are such as, it minimized the size of antenna hence reducing the weight of the satellite, minimized the power consumption with higher data-rate. [7] The frequency range of the optical wireless communication channel is 1550nm. The modulation technique DBNRZ formats are used to achieve long haul and high bit rate communication. The integration of Dense Wavelength Division Multiplexing (DWDM) with Duo Binary Non Return to Zero (DBNRZ) improves the spectral efficiency of Inter satellite optical wireless communication system. The network has one advantage; it does not use of any optical amplifier and without that system achieves very good results. The proposed system is design using opti system 14.0 and parameters used in system design are listed below in table 1.1

Table 1.1 Parameters of the proposed System

Parameters	**Values**
Modulation	DBNRZ
Type of Signal	Video, Voice/Data
Capacity	64 Channels
Power	20dBm
Data Rate	20 GB/s
Frequency Spacing	50 GHz
Transmission Distance	12000 Km
Centre Frequency	193.1 THz
Bandwidth	80 GHz
Photo Detector	APD
Wavelength Range	1550 nm
Dark Current	10nA
Responsivity	1A/W

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At the Optical Network Unit side, the WDM signals are de multiplexed by DE-MUX ES (Equally Spaced) where signals with various wavelengths are sent to different Optical Network Unit (ONU) with channel spacing 50GHz. At the receiver side 64 signals are detected by the receiver diodes. Optical line terminal side 64 numbers of channels are de-multiplexing by DEMUX ES and receive by Avalanche Photo Diodes (APDs). An APD is suitable for applications requiring high sensitivity and long distance communications. [8] In this network, APD photo diodes are used for detection of the signal which is to be passed through low pass filter and detected by Bit Error Rate (BER) visualizes. As compare with other diodes like PIN or other Optical receiver; APD diodes have better sensitivity and good quality factor performance.

III.DOWNSTREAM TRANSMISSION PERFORMANCE AND RESULTS DISCUSSION

The Dense Wavelength Division Multiplexing Passive Optical Network (DWDM PON) system is simulated using opti system package from optiwave. The Bit Error Diagram of downlink at 20 GB/s of Duo Binary Non Return to Zero (DBNRZ) modulated signal with channel spacing 50 GHz are shown in Figure 1.4

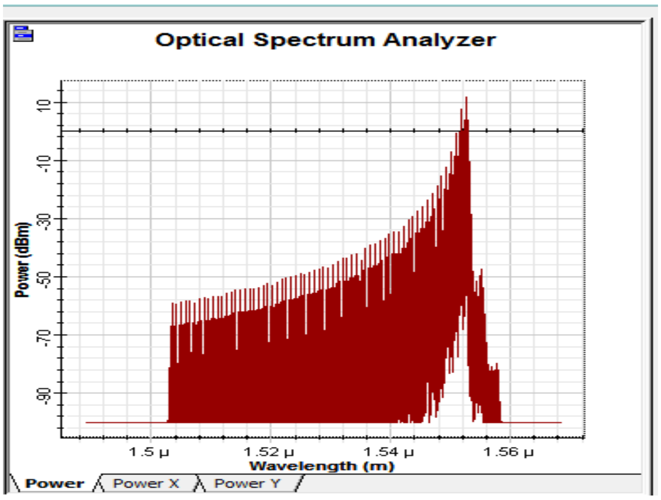

Figure 1.2 Optical Spectrum of Duo Binary NRZ modulation 64 channels by 20Gbit/s signal

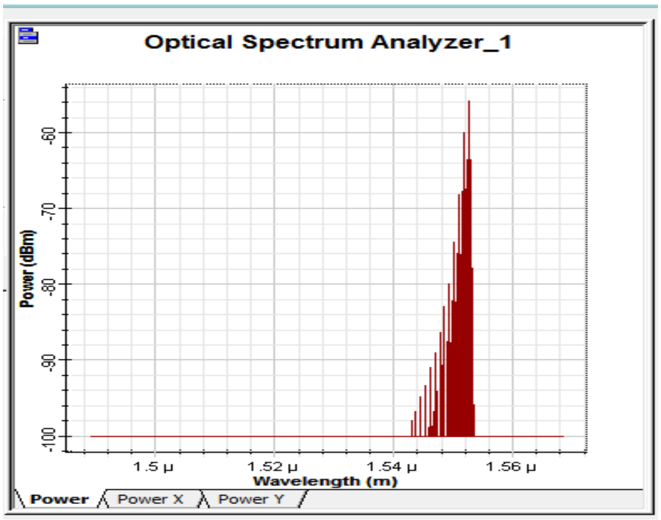

Figure 1.3 Optical Spectrum of optical wireless communication modulated channels at distance of 12000km

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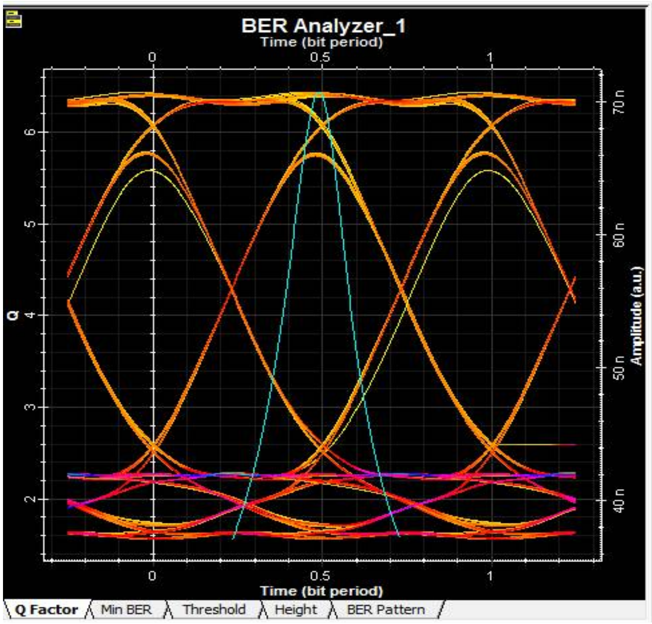

Figure 1.4 Eye diagram for downstream 1st channel with optical wireless communication at distance of 12000km

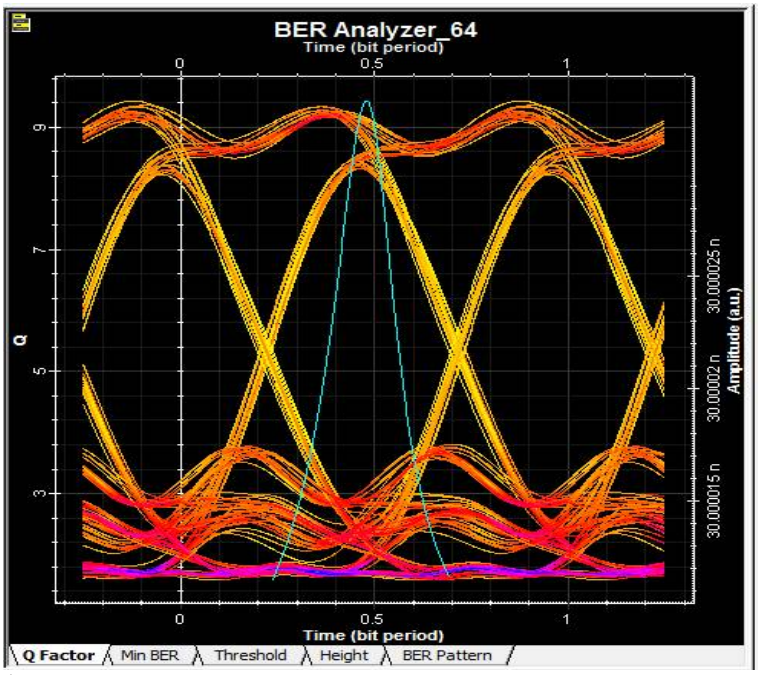

Figure 1.5 Eye diagram for downstream 64th channel with optical wireless communication at distance of 12000km

The above diagrams show the eye graph of 1^{st} ad 64^{th} channels placed at the optical network unit side. The downlink first channel can achieve a Bit Error Rate (BER) performance of $5.828\times e^{-011}$and Q factor should be 6.437 and the last channel can achieve a Error Rate (BER) performance of $1.89\times e^{-021}$and Q factor should be 9.43.

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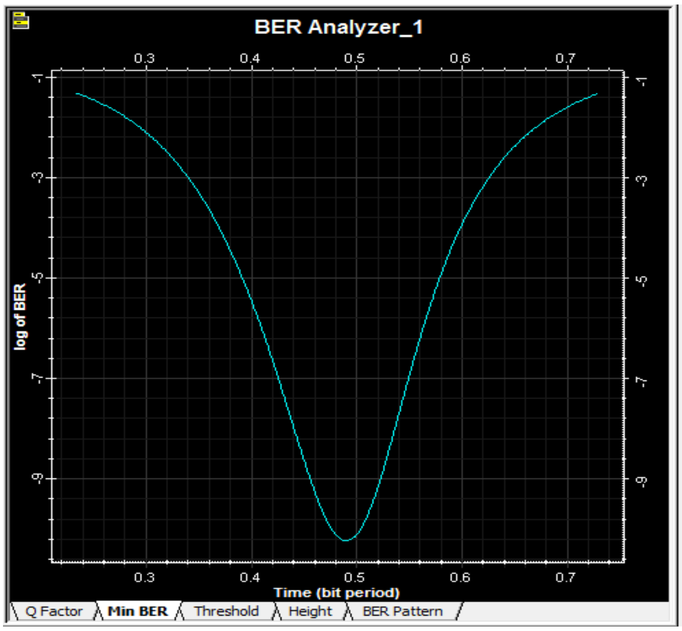

Figure 1.6 The Min BER (Bit Error Rate) Curve of downstream at a distance of 12000 Km

The network achieve clear eye opening which means the system is error free and noise free transmission can be observed. The downstream 20Gbps signal can observe a bit error performance of and Q factor should be with Duo Binary non return to zero (DBNRZ). Results shows a clear eye opening which means system is noise free.

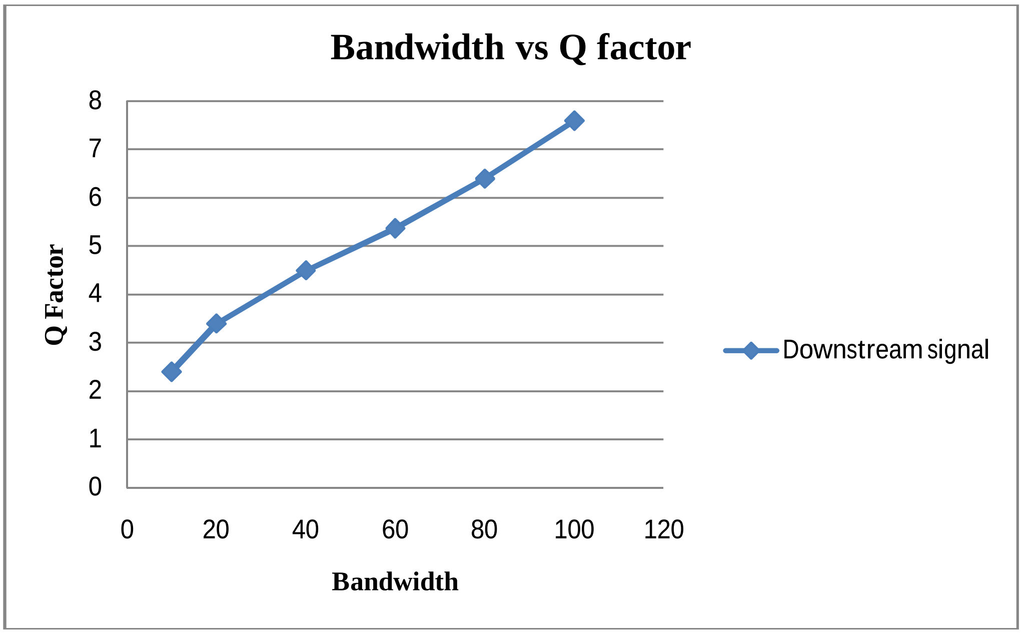

Figure 1.7 Graphical representation of system between bandwidth and Q factor for downlink

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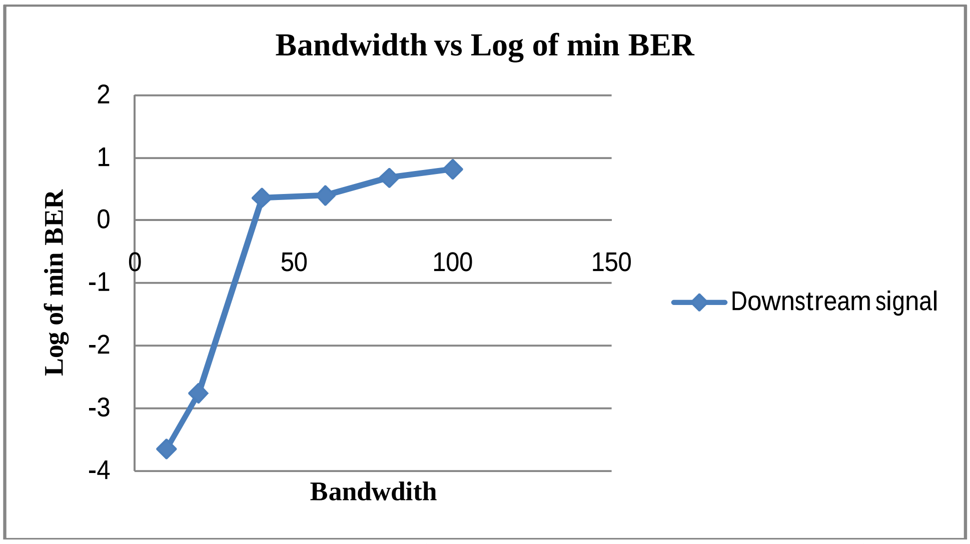

Figure 1.8 Graphical representation of network between Bandwidth and Log of min BER

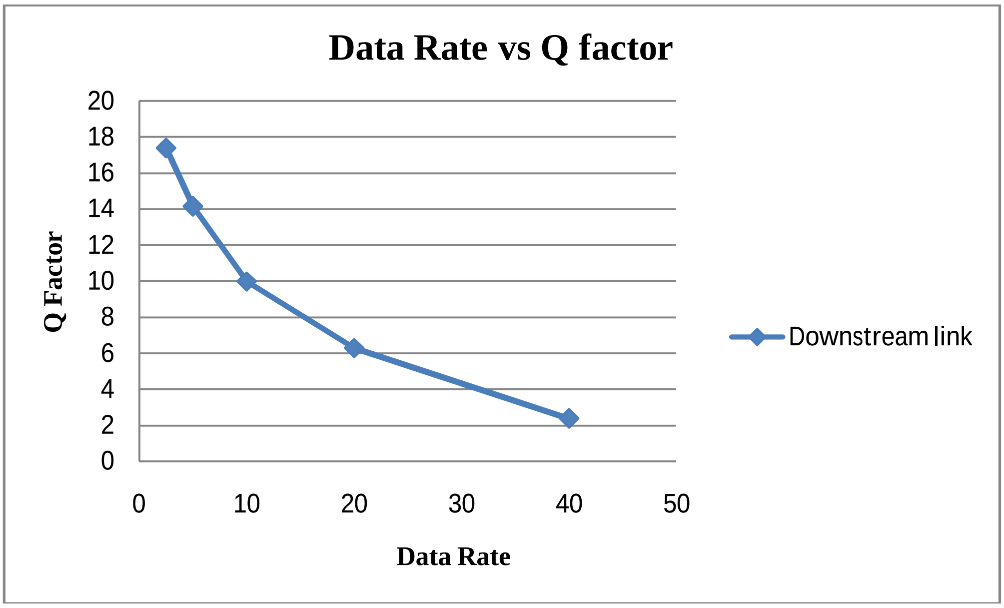

Figure 1.9 Graphical representation of data rate with respect to Q factor

IV.CONCLUSION

This paper proposed a inter satellite long distance transmission up to a distance of 12000 km for DWDM system. Dense wavelength division multiplexing is very effective technique for providing high data rates with very low bit error values in optical wireless communication. Multi carrier source are based on a single laser using different wavelengths. In this work, 64 channels, each carrying 20 GB/s data are transmitted independently by using Duo Binary Non Return to Zero (DBNRZ) modulation technique for downstream signal. The performance of the design dense wavelength division multiplexing passive optical network transmission system is evaluated in terms of Q factor, Bit Error Rate

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(BER) and total received power and eye diagrams. We calculated the performance of the network in terms of Bit error rate, distance covered, and Q factor and observe a system with an excellent access property.

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