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Radio Over Fiber System for A Four-Store Hospital Building

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Abstract: ***The goal of this project is to design and analyse a radio over fibre system for a four-story hospital with 20 rooms on each floor. The number of ONUs per floor is 20, and it was assumed that each room had an ONU capable of providing network access to voice, data, video, and biometrics. We build an 80-channel WDM optical transmitter using the WDM method. The proposed system includes a transmitter with 20 input channels, a multiplexer, a DE multiplexer, a 45-kilometer optical fibre, and an amplifier. The proposed model was simulated, and the results were evaluated in WDM systems using an optical amplifier.***
The receiver performance analysis of the Optical Communication System is shown by the BER simulation run and the eye diagram graphic, with the threshold set at 0.00120739. Furthermore, the eye height is 0.00141402, and the minimum BER is 5.59009e-006. When the simulated and calculated values of received power and total power loss are compared, the system is efficient.
Keywords: Radio over fibre, Optical Amplifier, WDM system, DE multiplexer, Multiplexer, BER, Optical transmitter

I. INTRODUCTION

Fiber-optics, which was first created in the 1970s and has transformed the telecommunications sector due to its advantages. These advantages include ability to be almost noise free, small diameter and thinner than copper as is composed of glass making it easier to install and considerably increased capacity. Optical fibres are used in a variety of applications, including telephone systems, submarine cable networks, computer networks data links, hospitals and many other applications in the industry. Because multimode fibres have a big diameter, they can easily couple more light into them. Multimode step index multimode fibres make up the majority of the plastic fibres. Radio over Fibre technology (RAUs) encompasses using optical fibre cables to transmit RF signals from a central site to Remote Antenna Units.

Dedicated indoor radio systems are an efficient solution to deliver enhanced in-building coverage and capacity in public spaces, such as office buildings [3]. Due to the enormous bandwidth, ultra-low attenuation, immunity to electromagnetic interference, and low cost of optical fibre, radio-over-fibre (RoF) technology has been regarded as the preeminent solution for implementing mobile fronthaul (MFH) in micro/picocell network designs[1]. Linearity and noise concerns beset analogue optical transport, hence digital alternatives are preferred by the industry. Radio frequency (RF) transfer over analogue intensity-modulated direct detection optical fibre lines has long been associated with RoF, which has been justified by cost savings [2]. WDM (Wavelength Division Multiplexing) is the fundamental technology of optical networking, and it is a way for transporting several separate and independent optical channels over a single fibre [4]. The optical modulation of RF signals, notably in the microwave and millimeter-wave bands, as well as other parameters, impact the performance of a RoF link [5].

II. LITERATURE REVIEW

In [6] examined the key role parameter players in reducing influence of NLD on the Radio over fibre link. On the OptiSystem platform, the simulation was conducted. Electrical cancellation point, output power, oscilloscope visualizer, modulation kinds, and laser power, among other things, are used to investigate the nonlinear effect. The NLD effect reduces the amplitude of the output signal by 97 percent, whereas increasing the laser power increases the output power by 76 percent. The nonlinear distortion impact has also been significantly reduced as a result of the modulation order.

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[7] research on Optical Link Performance Analysis Using EDFA. The optimal results of gain, output power, BER, and Qfactor were reached by properly choosing input power, pump power, EDF length, and erbium ion concentration. The software optisystemv13 was used to obtain the results. They develop and simulate a DWDM system with 320 Gbps data rate over 70 kilometres of fibre in their study. With 344% gain flatness from 1527 nm to 1552 nm bandwidth, the system for 32channel amplification was investigated. For a value of -25 dBm, the best gain values were found. All of the measurements were done at a wavelength of 980 nm and a fibre length of 70 km. The amplification technique yielded superior results. [8] explored the optical amplifier operating parameters by simulating EDFA amplifiers with varied fibre lengths. [9] employed EDFA to enhance multi-channel DWDM signals. In [3] research on performance of WDM and EDFA, he came to the conclusion that the ideal wavelength for use in a WDM system is 1532.68 nm.

III. DENSE WAVELENGTH DIVISION MULTIPLEXING (DWDM)

DWDW transmits data over long distances and is used to boost bandwidth over existing fibre networks by mixing and sending signals at various wavelengths over the same cable at the same time. Passive DWDM and active DWDM are two types of DWDM. Active DWDM, as shown in the block diagram below, is a method of transporting massive volumes of data between locations in a data centre interconnect setup.

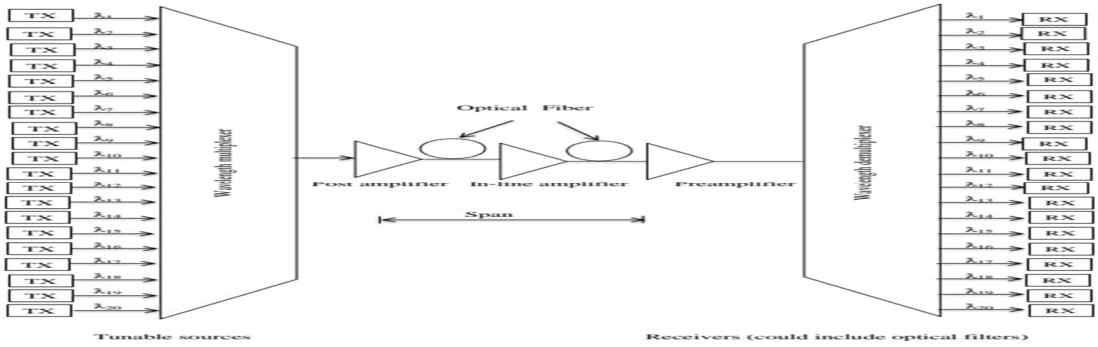


Figure 1: Block Diagram of the DWDM-based Fiber Optic Communication Link

IV. DWDM BLOCK DIAGRAM COMPONENTS DESCRIPTION

1) *Transmitters:* The source signals are provided by transmitter, which are multiplexed afterward.
2) *Receivers:* The receiver detects light pulses and converts the incoming optical signal to electrical form.
3) *DWDM Multiplexer:* The DWDM multiplexer mixes several wavelengths generated by multiple transmitters on separate fibres.
4) *DWDM Demultiplexer:* At the receiving end, the DeMux (demultiplexer) separates all of the individual wavelengths of the composite signal out to individual fibers.
5) *Optical Fibre:* Optical fibres are employed to convey light between the fiber's two ends .
6) *Inline Amplifiers:* The distance between regenerative repeaters is increased by using an inline optical amplifier to compensate for transmission loss.
7) *Pre Amplifiers:* With preamplifiers a weak received optical signal is amplified before photo detection

V. DETAILS OF THE HOSPITAL BUILDING

Number of Floors: 4 Floors
Number of Rooms per Floor: 20 Units

A. Assumptions

Number of ONUs per floor: 20; It is assumed that an ONU capable of providing network access to voice, data, video and biometrics is installed in each room.
Using the WDM method, we implement an 80 channel WDM optical transmitter.
The purpose of using WDM approach is to save the cost of installation of many fiber cables and so with just one fiber cable, a large number of channels can be multiplexed into the fiber cable link.

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VI. SYSTEM PERFORMANCE ANALYSIS

The system specification is shown in the table below

Table 1: Link Budget Design Parameters

Parameter	Value
Operating Wavelength	1550 nm
Maximum Output Optical Power	7.00 dBm
Minimum Receiver Sensitivity	-28 dBm
Optical Fiber Type	Single Mode
Fiber Optic Span	45 km
Attenuation	0.22 dB/km
Number of output ports	20 Channels
Frequency Spacing	100 GHz
Optical Transmit Power	7 dB
Extinction Ratio	30 dB
Modulation Type	NRZ
Numbers of connectors	4
Splice loss	0.1dB
Connector loss	0.75dB
Safety margin	3.0dB

System Link Budget = [fiber length (km) × fiber attenuation per km] + [splice loss × number of splices] +[connector loss × number of connectors] + [safety margin] …… [10]

Link Budget= [45km × 0.22dB/km] + [0.1dB × 4] + [0.75dB × 4] + [3.0dB] = 16.3dB
Therefore, System Link Budget is 16.3dB

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VII. IMPLEMENTATION OF THE SYSTEM IN OPTI WAVE

Single mode fibre is chosen in this design because it has a faster data rate, less dispersion, and can function over extended distances. Optisystem 18.0 was used to simulate the designed system, which transports information through optical carrier waves from the transmitter to the receiver via optical fibre.

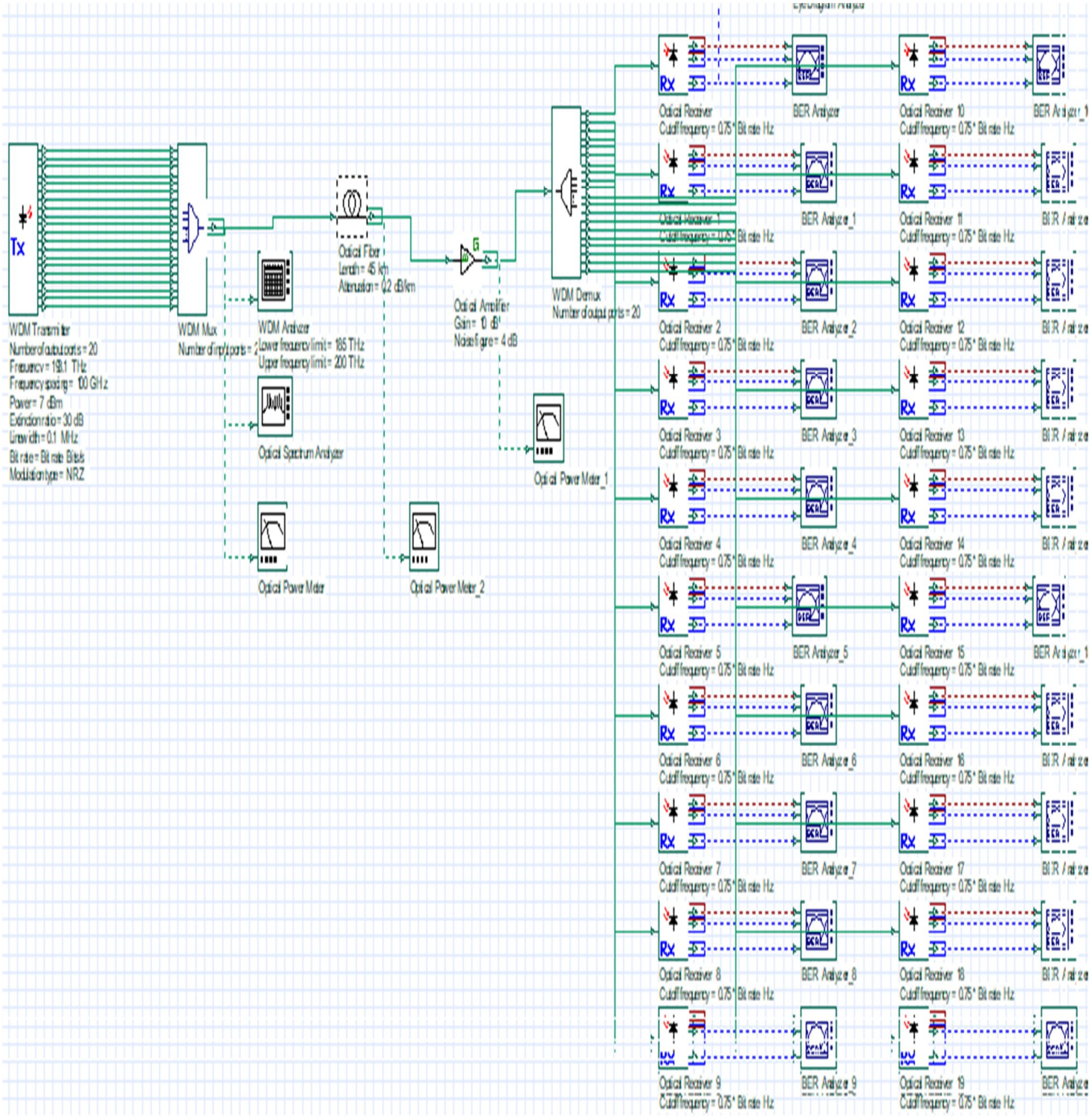
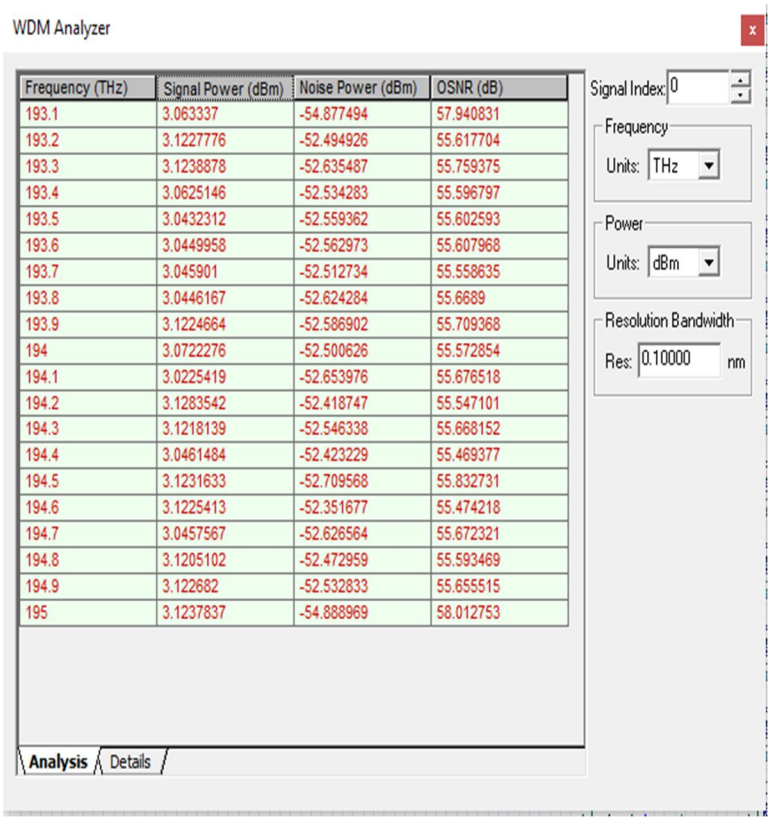


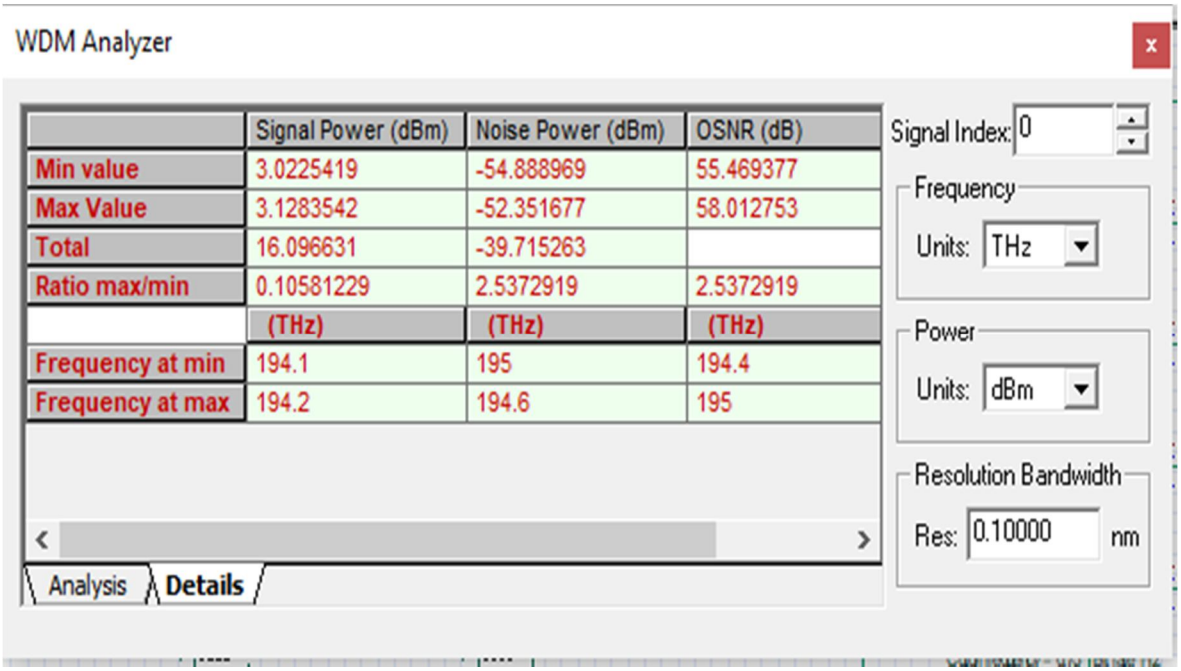
Figure 2: A 20 Channel WDM Fiber Communication System

VIII. SYSTEM ANALYZER



Frequency (THz)	Signal Power (dBm)	Noise Power (dBm)	OSNR (dB)
193.1	3.063337	-54.877494	57.940831
193.2	3.1227776	-52.494926	55.617704
193.3	3.1238878	-52.635487	55.759375
193.4	3.0625146	-52.534283	55.596797
193.5	3.0432312	-52.559362	55.602593
193.6	3.0449958	-52.562973	55.607968
193.7	3.045901	-52.512734	55.558635
193.8	3.0446167	-52.624284	55.6689
193.9	3.1224664	-52.586902	55.709368
194	3.0722276	-52.500626	55.572854
194.1	3.0225419	-52.653976	55.676518
194.2	3.1283542	-52.418747	55.547101
194.3	3.1218139	-52.546338	55.668152
194.4	3.0461484	-52.423229	55.469377
194.5	3.1231633	-52.709568	55.832731
194.6	3.1225413	-52.351677	55.474218
194.7	3.0457567	-52.626564	55.672321
194.8	3.1205102	-52.472959	55.593469
194.9	3.122682	-52.532833	55.655515
195	3.1237837	-54.888969	58.012753

Figure 3: The WDM Analyzer result at the output of the WDM Optical Multiplexer



	Signal Power (dBm)	Noise Power (dBm)	OSNR (dB)
Min value	3.0225419	-54.888969	55.469377
Max Value	3.1283542	-52.351677	58.012753
Total	16.096631	-39.715263	
Ratio max/min	0.10581229	2.5372919	2.5372919
	(THz)	(THz)	(THz)
Frequency at min	194.1	195	194.4
Frequency at max	194.2	194.6	195

Figure 4: The WDM Analysis summary at the output of the WDM Optical Multiplexer

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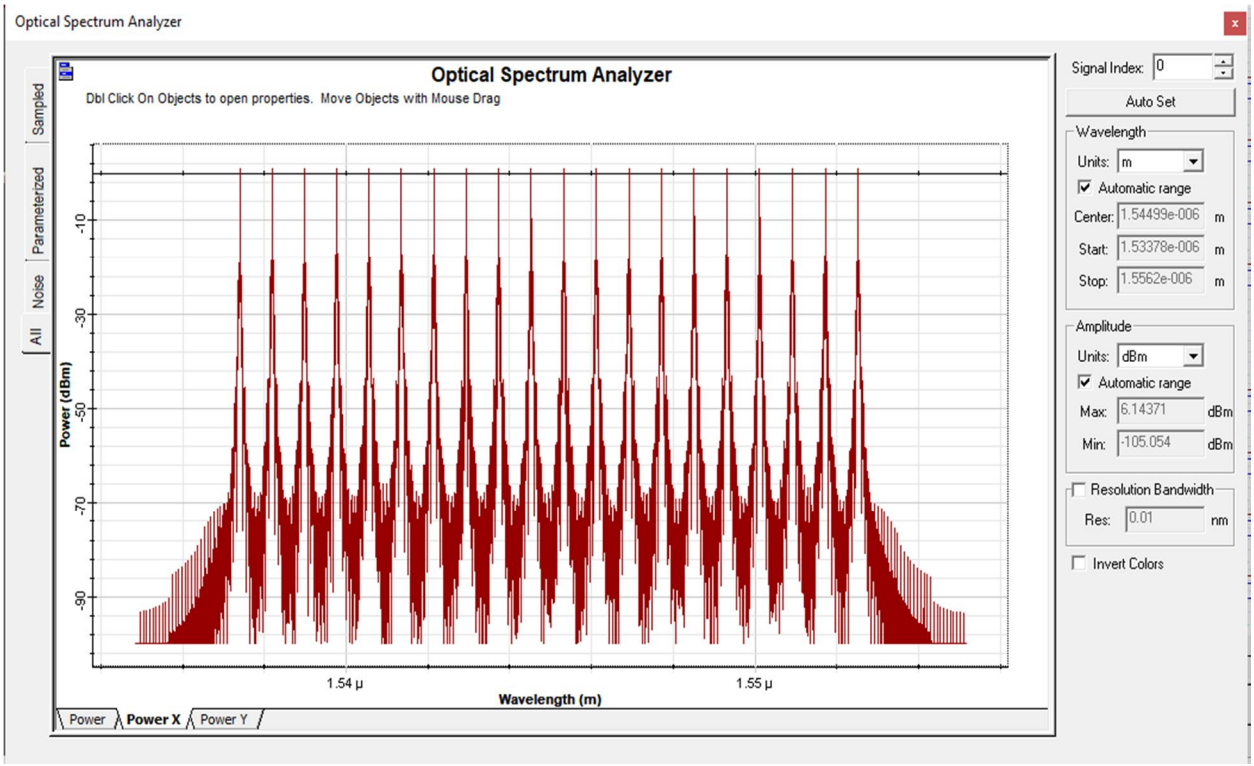


Figure 5: The Optical Spectrum Analysis at the output of the WDM Optical Multiplexer

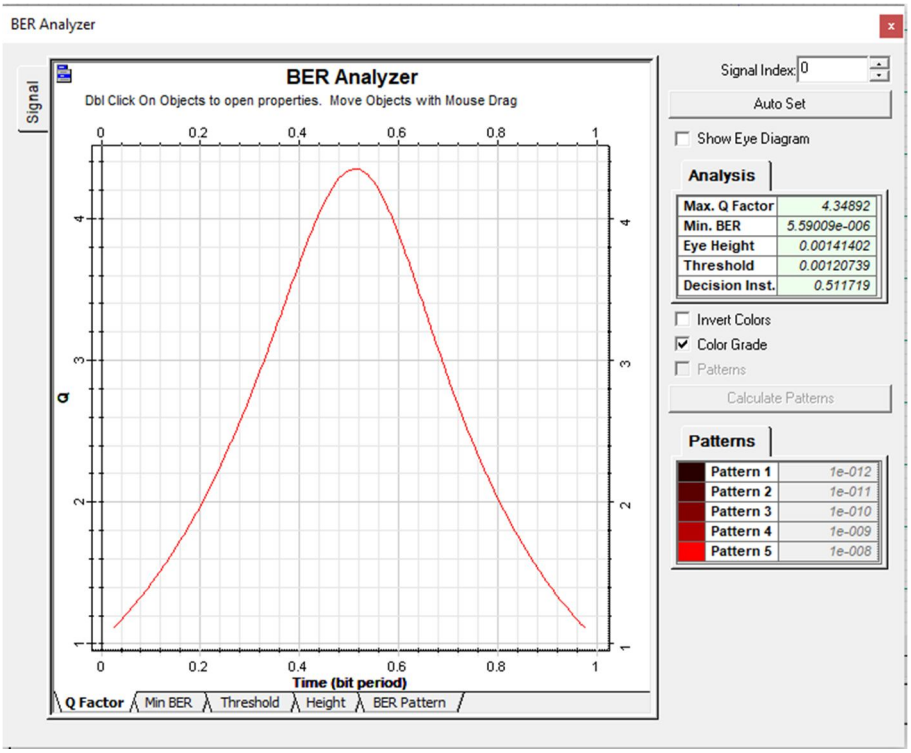


Figure 6: The Q Factor Curve from the BER Analyzer at the Optical Receiver for CH 1

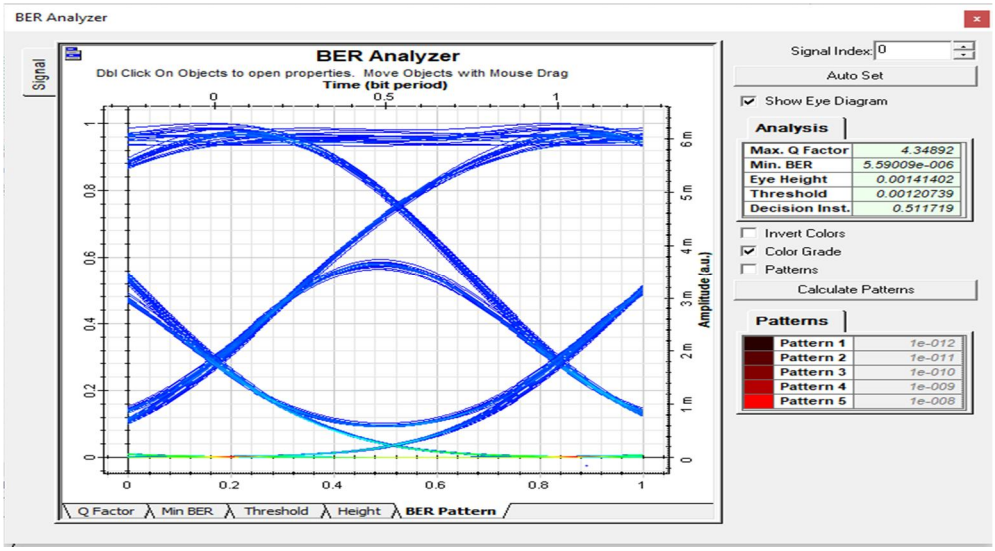


Figure 7: The Eye Diagram of the Optical communication system for CH 1

The parameter settings were graphically examined to get the best values. The proposed system includes a transmitter with 20 input channels, a multiplexer, a demultiplexer, a 45-kilometer optical fibre, and an amplifier. The proposed model was simulated, and the results assessed . The receiver performance analysis may be seen in the BER simulation run and the eye diagram diagram.
From the diagram figure 3.7 for Channel 1, the Max Q-factor is 4.34892 while the threshold is 0.00120739. Also, the minimum BER is 5.59009e-006 and the Eye height is 0.00141402.

IX. COMPARISON OF THE DESIGNED SYSTEM'S PERFORMANCE WITH SIMULATION RESULTS

Comparing the simulated and calculated values of the received power and total power loss shows that the system is efficient and they are as shown below:

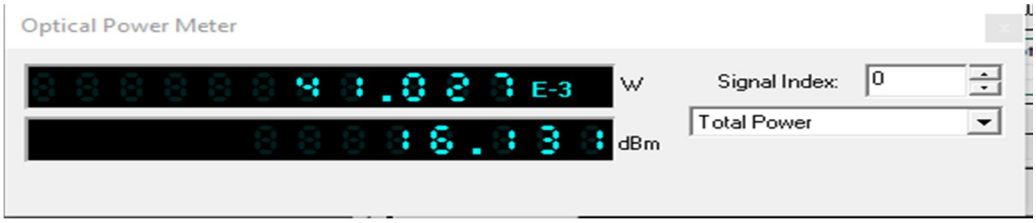


Figure 3.8: The Power Output of the Optical Multiplexer

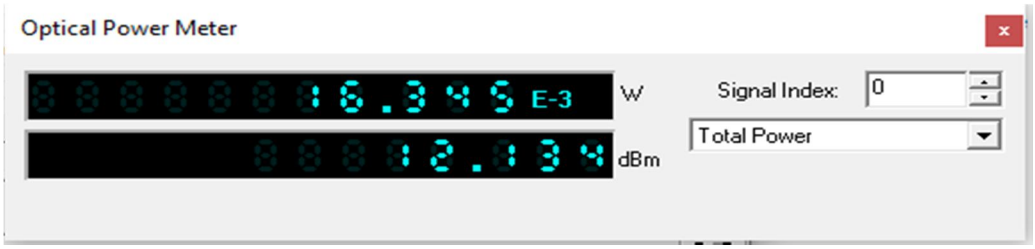


Figure 3.9: The Power Input to the Optical Demultiplexer

$$P_{in} = P_{out} - loss + gain$$
$$loss = 0.2 * 45 = 9\ dB$$
$$P_{in} = 16.131 - 9 + 5$$
$$P_{in} = 12.131\ dBm$$

X. NUMBER OF CHANNELS THE SYSTEM CAN ACCOMMODATE TO THE MAXIMUM

To determine the maximum number of channels that can be accommodated in the system;

$$\Delta f = \frac{\Delta\lambda}{\lambda^2} * C$$

$$\Delta f = \frac{0.8 * 10^{-9}}{(1550 * 10^{-9}) * (1550 * 10^{-9})} * 3 * 10^{8}$$

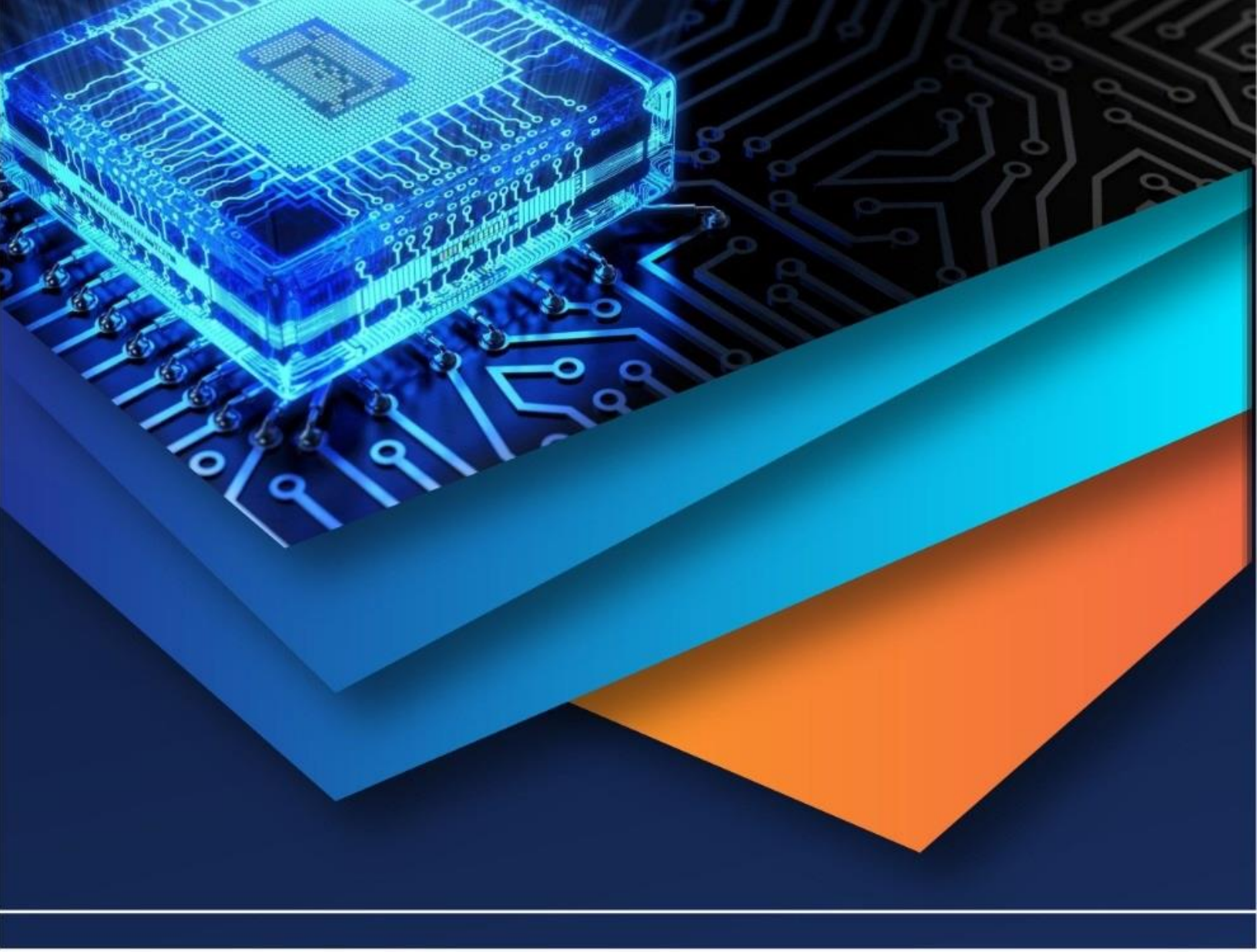
$$\Delta f \approx (9.99 * 10^{10}) channels$$

XI. CONCLUSION

The system has been designed and simulated based on specification. The BER simulation run and the eye diagram graphic show the receiver performance analysis.of the Optical Communication System, while the threshold is 0.00120739. Also, the Eye height is 0.00141402 and the minimum BER is 5.59009e-006. The system is efficient when the simulated and calculated values of received power and total power loss are compared.

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