Create and Evaluate a Sophisticated Optical Communication System Aimed at Minimizing Losses

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Abstract

We design and analyze an advanced optical communication system for least losses experimentally by using 4x 10 G bps wavelength division multiplexing repeater-less transmission system using non-return to zero pulse generator modulation format over 50km optical fiber. The frequencies used in the channels are 1552.52nm, 1553.52nm, 1554.52nm, 1555.52nm. In this system design, Fiber Bragg grating was deployed at the transmitting and receiving side. The transmission system was pumped bidirectionally with 1445 and 1455 NM wavelengths in a forward direction, and three pump wavelengths of 1430, 1440 and 1450 NM were deployed for the backward direction. The total optical power of the forward and backward raman amplifiers are 0.3 w and 0.6w respectively. The result has minimal effect on non-linearity showing the best performance for a 50km repeaterless transmission system.

1.Introduction

Communication may be broadly defined as the transfer of information from one point to another.[1] when the information is to be conveyed over any distance a communication system is usually required [2]. In a communication repeater less transmission system is proposed as means for cost saving and help the service provider to install the setup in rural areas.[3] There are many benefits for using repeater less transmission system such as system does not require an electrical power feed. Ultimately, help to ease the broadcast communication easier.[4]-[5]

The existing transmission system using fiber optics cables (FOC) functions with 10GBPS dense wavelength division multiplexing (DWDM) with in-line repeaters [1]. there are many disadvantages of using repeaters such as Repeater are unable to reduce network traffic, It cannot connect different network architectures,[6]-[8] It does not segment the network, Repeaters do not separate the device in the collision domain, Most of the repeaters on a network produce noise on the wire and increase the possibility of packet collisions, A device that is separated only by a repeater is part of the same collision domain[9].

2 . Simulation setup

Recent works on repeaterless transmission system have been reported to improved the minimal effect on non-linearity showing the best performance for 300-km repeater less transmission system [10], presented hybrid optical amplification designs (erbium-doped fiber amplifier (EDFA)/Raman amplifier) for 4 x 10 Gbps WDM repeaterless transmission system using asymmetrical dispersion compensation [11].
By taking the reference of the recent work which has been done in the past we design and analyze an advanced optical system for least losses.[12]-[14]
we divide our paper in three section, first is simulation setup where we analyze the functioning of optical fiber in different frequencies for which it provide least losses, second is result where we see which transistor gives least max Q .factor and last is conclusion where we compare the result of all the frequencies we use in this experiment setup and give conclusions about max Q. factors, BER, threshold frequencies etc[15].

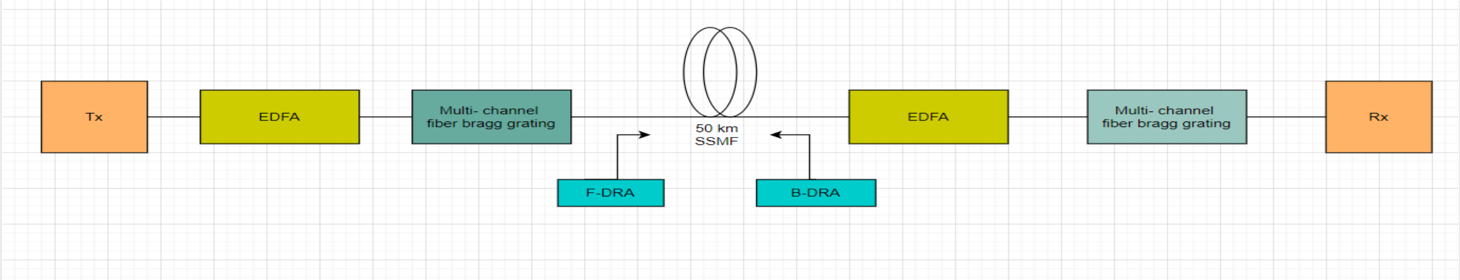


Fig 1. simulation setup

The Fig1. Shown above represents a simulation setup where we use following component in our simulation setup such as a) transmitter, b) EDFA,c) multi-channel fiber bragg grating, d)forward and backward Raman amplifier, e)optical fiber of length 50 km and f) receiver to analyze an advanced optical communication for least losses.

a) Transmitter

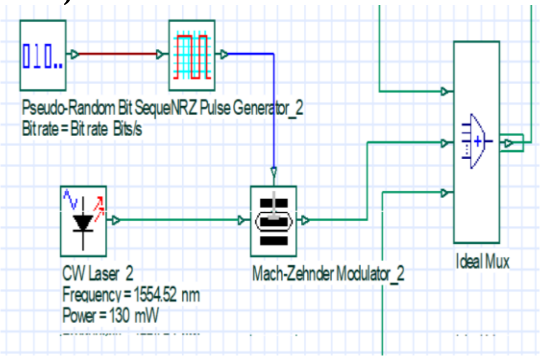


Fig 2 Transmitter

The transmitter shown in the Fig 2. is one of the component that we are use in the complete simulation setup shown in the Fig 1. and the whole setup is attached in the appendix 1 and appendix 2, the advantage of transmitter is that it takes an electrical input and converts it to an optical output from a laser diode or LED. The light from the transmitter is coupled into the fiber with a connector and is transmitted through the fiber optic cable plant.

The transmitter in this experiment uses many useful components such as pseudo-random bit sequence(PRBS), NRZ pulse generator, mach-zehnder modulator and CW laser with different frequencies and power to obtain correct results with least losses .[14]

Each component use there own strength such that PRBS generators are used in telecommunication, such as in analog-to-information conversion, but also in encryption, simulation, correlation technique and time-of-flight spectroscopy. The NRZ pulse generator component allows user to create a sequence of non -return to zero pulses that are coded by a digital signal input, and the mach-zehnder modulator is use to convert electrical signal to digital signal and last we use CW laser with four different frequencies 1552.52nm, 1553.52nm, 1554.52nm, 1555.52nm to obtain result with least loses.

b) Erbium-doped fiber amplifier (EDFA)

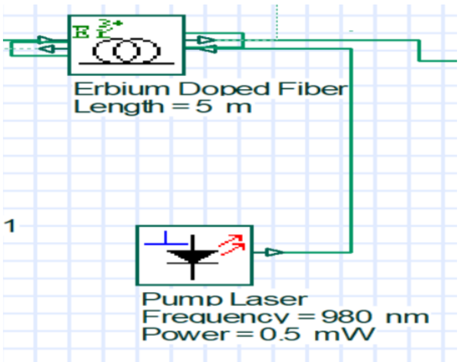


Fig 3 Erbium-doped fiber amplifier

The erbium-doped fiber amplifier shown in the Fig 3. is also component that used in the complete simulation setup shown in Fig 1.and the whole setup is attached in the appendix 1 and appendix 2. The key feature of the erbium doped fiber amplifier is that it simulates a bidirectional Erbium doped fiber considering ESA, Rayleigh scattering, ion-ion interactions, and temperature dependence effects. The component solved numerically the rate and propagation equations in the steady-state case, assuming a two-level Erbium system for an in homogeneous and homogeneous approach. the length we use for erbium doped fiber is 5m and we use a pump laser of frequency 980nm and power of 0.5mW to Generates an optical parameterized signal to be used for optical amplifier pumping . we also connect optical spectrum analyzer to measure and display the distribution of power of an optical source over a specified wavelength span.[3] after we examine the optical spectrum analyzer we find that the max power amplitude is -66.5397dBm and min power amplitude is .100.132dBm and the wavelength start from 1.48345e-006 m and end to 1.61688e-006m.and the resolution bandwidth is 0.01nm.

When we applied an optical spectrum analyzer at the output 1 of the erbium doped fiber amplifier

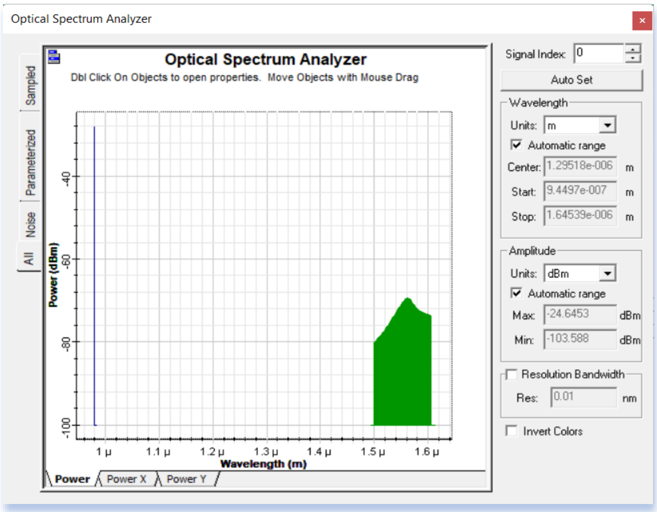


Fig 4 Optical spectrum analyzer

Then a graph shown above in the Fig 4 is generated between power (dbm) vs wavelength (m) with the use of optical spectrum analyzer , after analyze the graph we figure out that the starting point of wavelength is 9.4497e-007 m and stop at the 1.64539e-006m, the center value of wavelength is 1.29518e-006 m. after analyze the wavelength the corresponding power is also calculated from the optical spectrum analyzer shown above i.e. the max power is calculated is -24.6453dbm and the min power is -103.588dbm and the resolution bandwidth is 0.01nm.

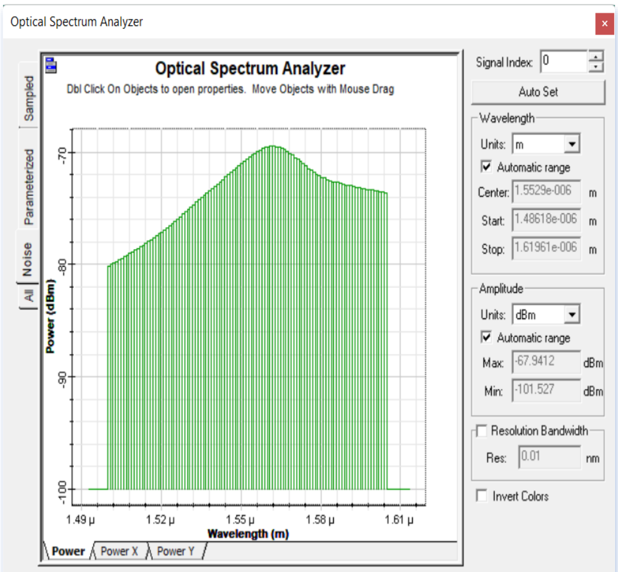


Fig 5 Optical spectrum analyzer

The graph which is shown above in the Fig 5 in this we analyze the wavelength and power with respect of the noise parameter which is generate with the help of optical spectrum analyzer ,the starting point of wavelength is 1.48618e-006 m and stop at the 1.61961e-006 m the center point of the wavelength is 1.5529e-006m .comparatively we also calculate the power also the max power which is calculated is -67.9412dbm and the min power is -101.527dbm and the resolution bandwidth is 0.01nm .

When we applied an optical spectrum analyzer at the output 2 of the erbium doped fiber amplifier

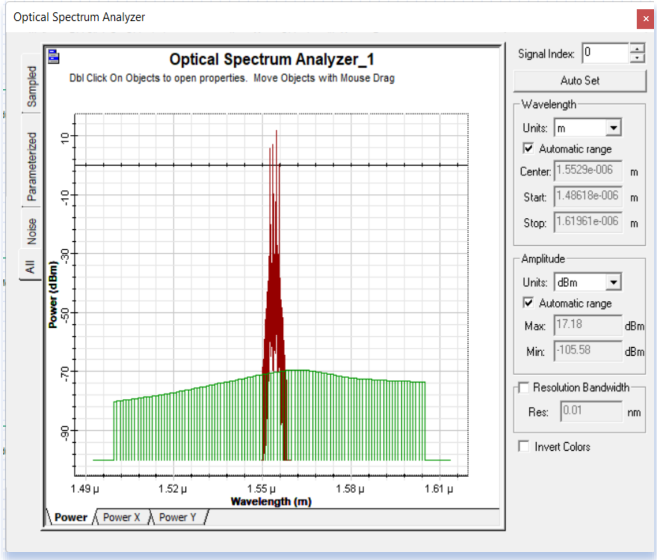


Fig 6 Optical spectrum analyzer_1

Then a graph shown above in the Fig 6 is generated between power (dbm) vs wavelength (m) with the use of optical spectrum analyzer_1, after analyze the graph we figure out that the starting point of wavelength is 1.48618e-006 m and stop at the 1.61961e-006m, the center value of wavelength is 1.5529e-006 m. after analyze the wavelength the corresponding power is also calculated from the optical spectrum analyzer shown above i.e. the max power is calculated is 17.18dbm and the min power is -105.58dbm and the resolution bandwidth is 0.001nm.

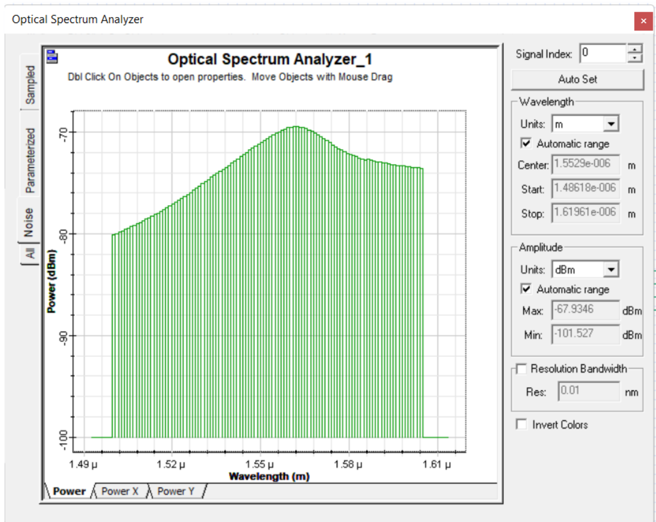


Fig 7 Optical spectrum analyzer_1

The graph which is shown above in the Fig 7. in this we analyze the wavelength and power with respect of the noise parameter after analyze the above graph which is generate with the help of optical spectrum analyzer, the starting point of wavelength is 1.48618e-006 m and stop at the 1.61961e-006 m the center point of the wavelength is 1.5529e-006m. comparatively we also calculate the power also the max power which is calculated is -67.9412dbm and the min power is -101.527dbm and the resolution bandwidth is 0.01nm .

After analyze the above graph the noise parameter is not change in the output 1 port analyzer and the output 2 port analyzer

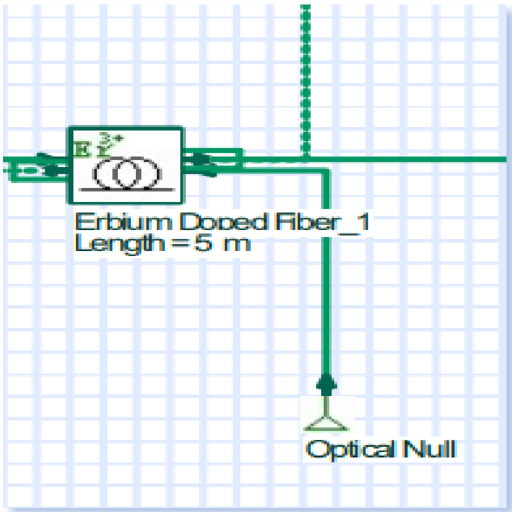


fig 8 Erbium-doped fiber amplifier with optical null connect at the input port 2

When we applied a optical spectrum analyzer at the output 2 of the erbium doped fiber amplifier with optical null connect at the input port 2

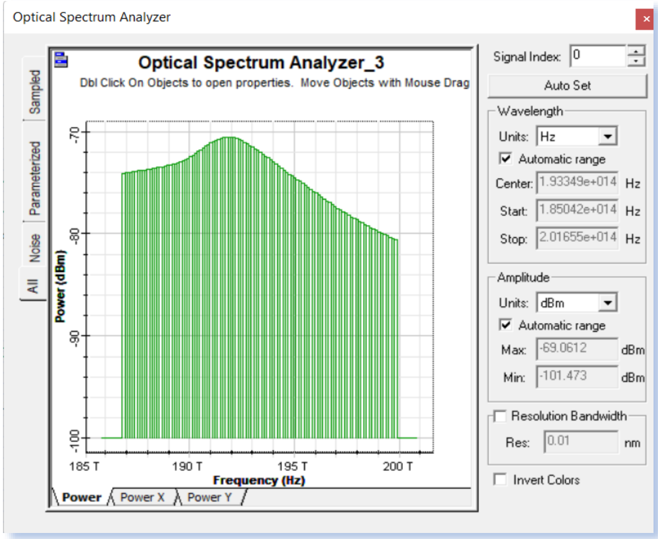


Fig 9 Optical spectrum analyzer_3

Then a graph shown above in the fig 9 is generated between power (dbm) vs wavelength (Hz) with the use of optical spectrum analyzer 3, after analyze the graph we figure out that the starting point of wavelength is 1.85042e+014Hz and stop at the 2.01655e+014hz, the center value of wavelength is 1.93349e+014Hz. after analyze the wavelength the corresponding power is also calculated from the optical spectrum analyzer shown above i.e. the max power is calculated is -69.0612dbm and the min power is -101.473dbm and the resolution bandwidth is 0.001nm.

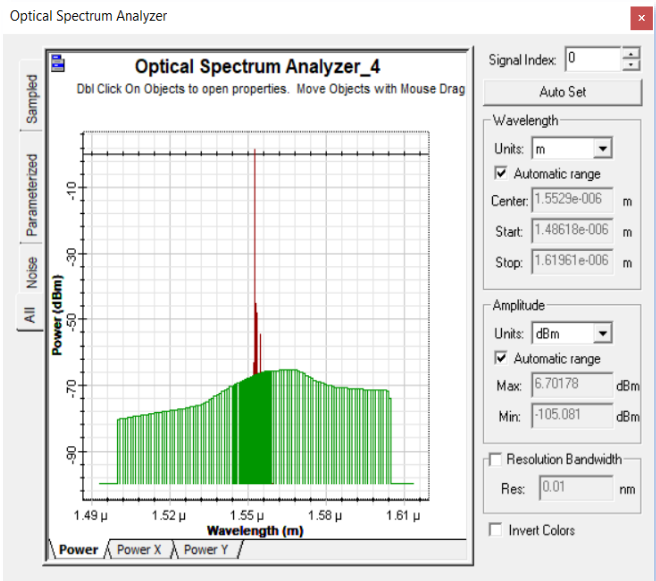


Fig 10 Optical spectrum analyzer_4

A graph shown above in the fig 10 is generated between power (dbm) vs wavelength (Hz) with the use of optical spectrum analyzer_4 , after analyze the graph we figure out that the starting point of wavelength is 1.48618e-006m and stop at 1.61961e-006m, the center value of wavelength is 1.5529e-006m. after analyze the wavelength the corresponding power is also calculated from the optical spectrum analyzer shown above i.e. the max power is calculated is 6.70178dbm and the min power is -105.081dbm and the resolution bandwidth is 0.001nm.

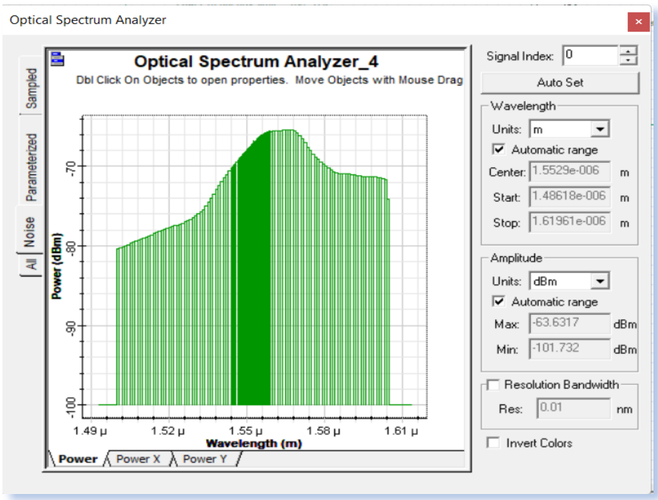


Fig 11 Optical spectrum analyzer_4

The graph which is shown above in the fig 11 in this we analyze the wavelength and power with respect of the noise parameter after analyze the above graph which is generate with the help of optical spectrum analyzer ,the starting point of wavelength is 1.48618e-006 m and stop at the 1.61961e-006 m the center point of the wavelength is 1.5529e-006m. comparatively we also calculate the power also the max power which is calculated is -63.6317dbm and the min power is -101.732dbm and the resolution bandwidth is 0.01nm.

c) Multichannel fiber Bragg grating

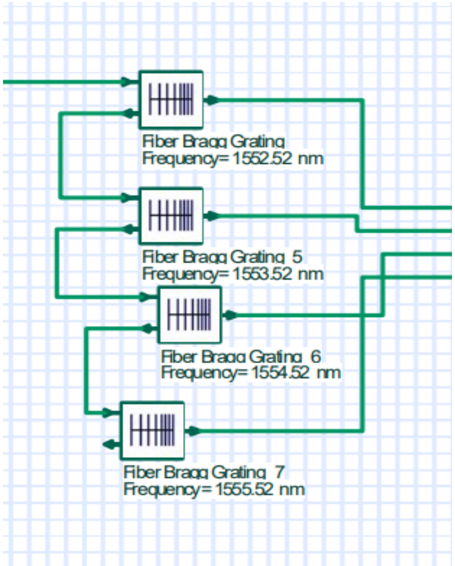


fig 12 Multichannel fiber Bragg grating

the fiber bragg grating shown in the Fig 12 is the key component of the complete simulation setup which shown in the Fig 1. The whole simulation setup of the circuit is attached in the appendix 1 and appendix 2. A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others. This is achieved by creating a periodic variation in the refractive index of the fiber core, which generates a wavelength-specific dielectric mirror. Hence a fiber Bragg grating can be used as an inline optical fiber to block certain wavelengths, can be used for sensing applications,[1] or it can be used as wavelength-specific reflector.

In this experiment we use four fiber Bragg grating with frequencies 1552.52nm,1553.52nm,1554.52nm and 1555.52nm.

d) Forward and backward raman amplifier

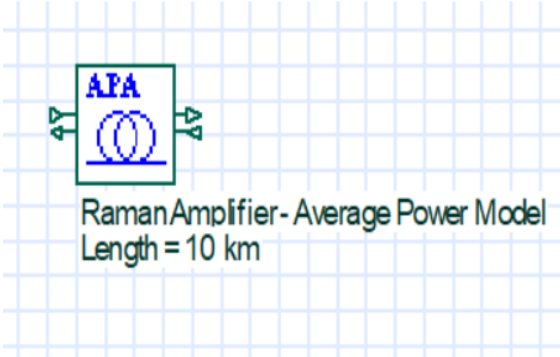


Fig 13 Raman amplifier

The Raman amplifier shown in the Fig 13 is the key component of the complete simulation setup which shown in the Fig 1. The whole simulation setup of the circuit is attached in the appendix 1 and appendix 2. after the multiplexing of fiber Bragg grating this fiber is connected to raman amplifiers by passing through power splitter followed by coupler and then power combiner, when we connect optical spectrum analyzer to coupler then the we again examine the power and wavelength this coupler and result is max and min power obtain in this OSA is 7.18522dBm and -105.104dBm respectively [3]-[4]. and the wavelength start from 1.48618e-006 m and stop to 1.61961e-006m . In this we use both forward and backward Raman amplifiers .The F-DRA has four pump sources whereby two pumps operate at 1445nm and another two pumps at 1455nm. The total power of F-DRA is 0.3 W. For B-DRA, six pumps are used, where every two pumps operate at 1430, 1440 and 1450nm. The total power of B-DRA is 0.6 W.

Now we connect the dual port wdm analyzer between the output port 2 of forward raman amplifier and the output port 2 of erbium doped fiber

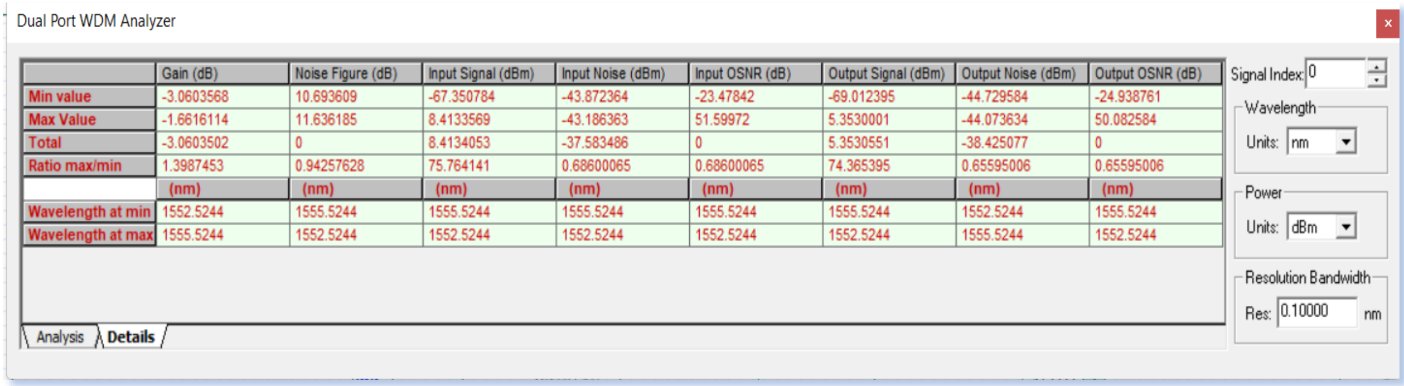
Dual Port WDM Analyzer

Wavelength (nm)	Gain (dB)	Noise Figure (dB)	Input Signal (dBm)	Input Noise (dBm)	Input OSNR (dB)	Output Signal (dBm)	Output Noise (dBm)	Output OSNR (dB)
1555.52	-1.6616114	10.6936	-67.3508	-43.8724	-23.4784	-69.0124	-44.0736	-24.9388
1554.52	-2.1203394	11.0059	-49.2969	-43.7431	-5.55388	-51.4173	-44.3554	-7.06183
1553.52	-2.5789348	11.3269	-41.8465	-43.6458	1.79932	-44.4254	-44.6555	0.230013
1552.52	-3.0603568	11.6362	8.41336	-43.1864	51.5997	5.353	-44.7296	50.0826

Fig 14 dual port wdm analyzer

The table shown above in the fig 14 helps in comparing the various parameters between the transmitters of various wavelength 1552.52nm , 1553.52nm, 1554.52nm, 1555.52nm and the various

parameters are Gain(dB),noise figure(dB), input signal (dBm),input noise (dbm),input OSNR(db), output signal(dbm),output noise (dbm),output OSNR(db). after analyze the above table we conclude that the wavelength 1555.52nm has the max gain(db) of value -1.6616114 db and the wavelength 1552.52nm has the min gain (db) of value -3.0603568db , but in the case of noise figure the wavelength 1552.52nm has the max value of noise figure which is 11.6362db and the wavelength 1555.52nm has the min value of noise figure which is 10.6936 db . when we compare the input signal of the given wavelength then the wavelength 1552.52nm has the max value of input signals and the wavelength 1555.52nm has the min value of input signal.the next parameter which we want to compare is input noise after analyze the above table we conclude that the wavelength 1552.52nm has the max value of input noise of value -43.1864dbm and the wavelength 1555.52nm
has the min value of input noise -43.8724dbm . now we want to compare another parameter from above table is input OSNR(db) in which the wavelength 1552.52nm has the max value of 51.5997db and the wavelength 1555.52nm has the min value of-23.4784db . and now we want to compare the parameters based on the output ,the first parameter based on the output is output signal(dbm) in which when we analyze the above table then we say that the wavelength 1555.52nm has the max output signal of 5.353dbm and the wavelength 1555.52nm has the min output signal of -69.0124dbm .the second parameter based on the output is output noise(dbm) in which when we analyze the above table then we say that the wavelength 1555.52nm has the max output noise of -44.0736dbm and the wavelength 1552.52nm has the min output signal of -44.7296dbm.the third and the last parameter based on the output is output OSNR(dbm) in which when we analyze the above table then we say that the wavelength 1552.52nm has the max output OSNR of 50.0826dbm and the wavelength 1555.52nm has the min output signal of -24.9388dbm .



	Gain (dB)	Noise Figure (dB)	Input Signal (dBm)	Input Noise (dBm)	Input OSNR (dB)	Output Signal (dBm)	Output Noise (dBm)	Output OSNR (dB)
Min value	-3.0603568	10.693609	-67.350784	-43.872364	-23.47842	-69.012395	-44.729584	-24.938761
Max Value	-1.6616114	11.636185	8.4133569	-43.186363	51.59972	5.3530001	-44.073634	50.082584
Total	-3.0603502	0	8.4134053	-37.583486	0	5.3530551	-38.425077	0
Ratio max/min	1.3987453	0.94257628	75.764141	0.68600065	0.68600065	74.365395	0.65595006	0.65595006
	(nm)	(nm)	(nm)	(nm)	(nm)	(nm)	(nm)	(nm)
Wavelength at min	1552.5244	1555.5244	1555.5244	1555.5244	1555.5244	1555.5244	1552.5244	1555.5244
Wavelength at max	1555.5244	1552.5244	1552.5244	1552.5244	1552.5244	1552.5244	1555.5244	1552.5244

Fig 15. dual port wdm analyzer

e) Optical fiber

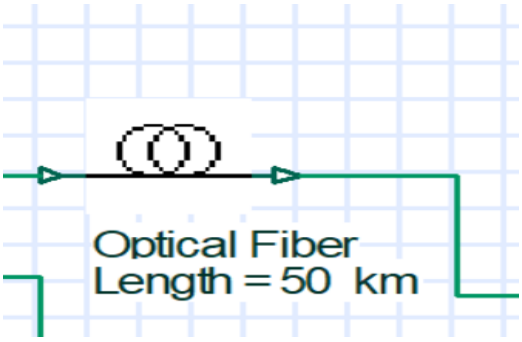


Fig 16 optical fiber

The figure16 shown above represents an optical fiber that simulates the propagation of an optical field in a single-mode fiber[6]-[7] with dispersion and nonlinear effects taken into account by a direct numerical integration of the modified nonlinear Schrodinger (NLS) equation (when the scalar case is considered) and a system of two, coupled NLS equations when the polarization state of the signal is arbitrary[5]. The optical sampled signals reside in a single frequency band, hence the name total field. The parameter signals and noise bins are only attenuated. Iin this setup we use 50 km single mode fiber .

f) Receiver

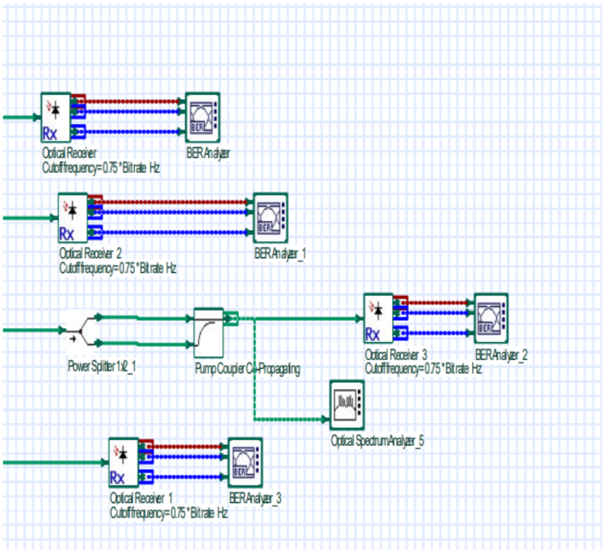


Fig 17 Receiver

The figure 17 represents a receiver side of circuit where fiber optic receivers convert light signals into electrical signals.we connect raman amplifier and receiver by placing pre -amplifier in between them and then we analyze the effect of pre amplifier by connect OSA at the output of preamplifier the max and min power we examine is 6.70178dBm and -105.081dBm and wavelength is starting from 1.48618e-006m and stop to 1.61961e-006m and resolution bandwidth is 0.01nm, in this setup we connect BER analyzer to analyze the max [8]-[9]. Q factor ,min BER ,eye height ,threshold frequency.

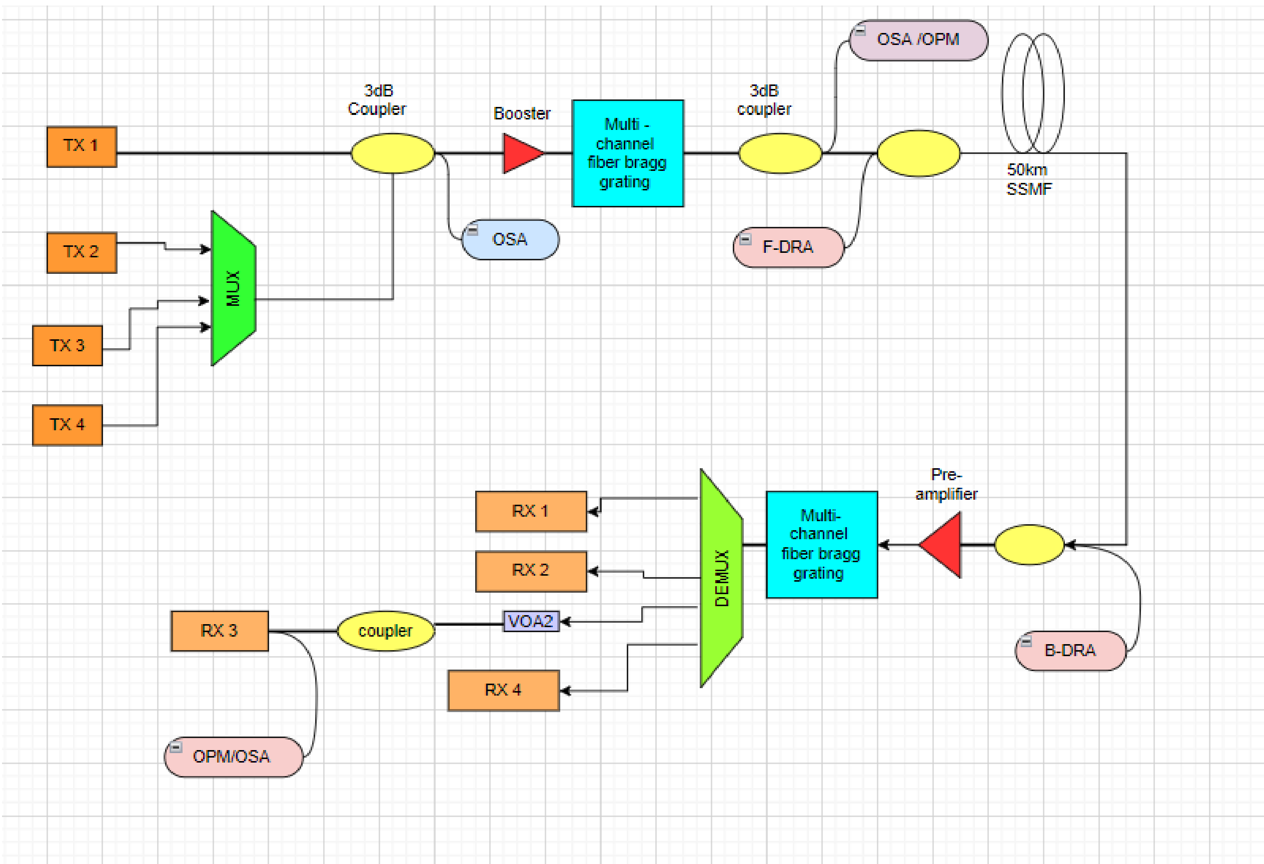


Fig .17 Experiment setup of WDM 50-KM SSMF repeaterless system

3. Results

In this proposed system . The performance of an optical system having 50 km optical fiber has been analyzed on the basis of max. Q factor ,min BER ,eye height ,threshold frequency .we also look at the optical spectrum analyzers for better understanding of the optical fiber .

BER analyzer

By using the BER analyzer we analyze the various parameters such as max Q factor,min BER ,eye height ,threshold frequency

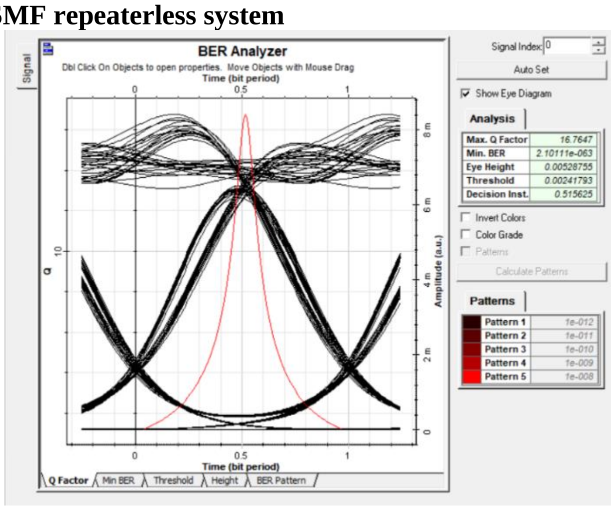


fig 18(BER analyzer of freq 1552.52nm)

First we analyze all this parameter for the transmitter of frequency 1552.5

After analyze the above graph which show in the *fig 18*, between amplitude and time the various result the coming out such as the max Q factor is 16.7647 , min BER is 2.1011e-063 ,Eye height is 0.00528755 , threshold is 0.00241793 and decision inst. is 0.515625.

And now we repeat the above observations for the transmitter of frequencies 1553.52nm.

The above graph shown in the figure 18 is represent by each of there parameters such as when we represent in term of q factor then the graph shown in figure 19 between Q vs time(bit period) is

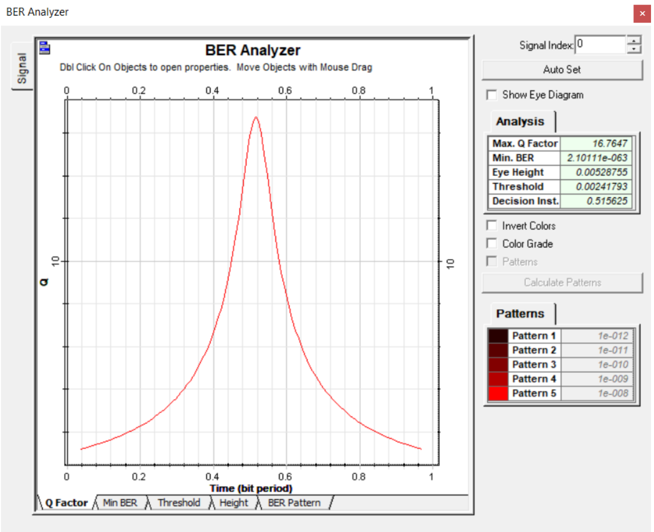


fig 19 (BER analyzer of freq 1552.52nm)

And in term of min BER the graph shown in fig 20. between log of BER vs time (bit period)

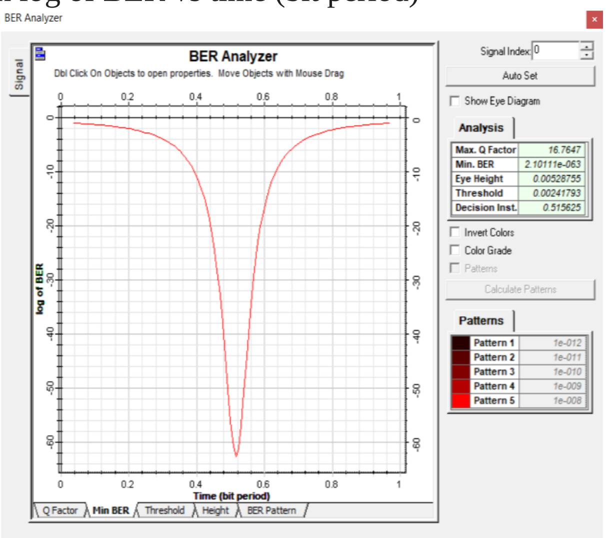


fig 20 (BER analyzer of freq 1552.52nm)

And also in term of threshold graph change in new shape and then the graph shown in figure 21 between amplitude vs time(bit period) is

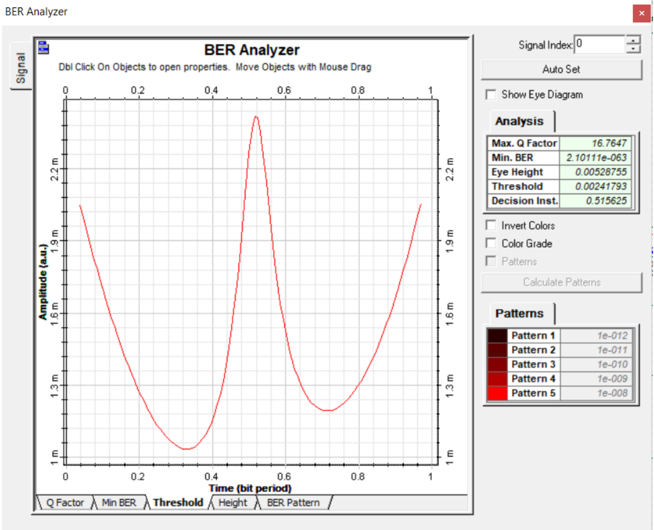


fig 21 (BER analyzer of freq 1552.52nm)

And in term of height the graph shown in the figure 22 between amplitude vs time(bit period)

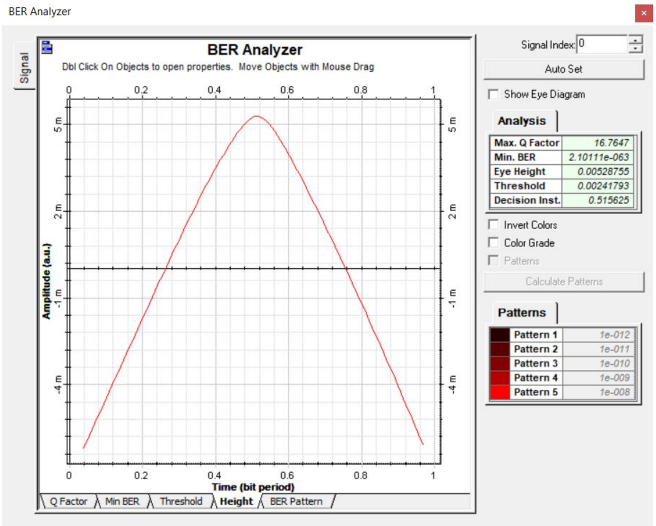


fig 22 (BER analyzer of freq 1552.52nm)

and last the BER pattern of the graph in fig 23 is

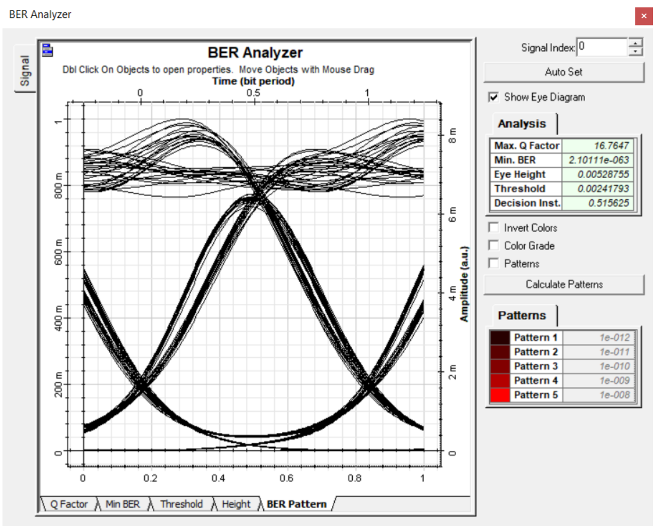


fig 23 (BER analyzer of freq 1552.52nm)

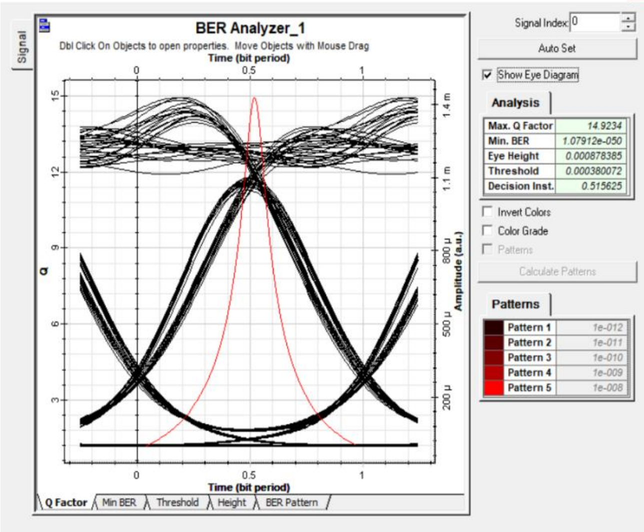


fig 24(BER analyzer of freq 1553.52nm)

After analyze the above graph which show in the *fig 24*, between amplitude and time the various result the coming out such as the max Q factor is 14.9234 , min BER is 1.07912e-052 ,Eye height is 0.000878385, threshold is 0.000380072 and decision inst. is 0.515625.

The above graph shown in the figure 24 is represent by each of there parameters such as when we represent in term of q factor then the graph shown in figure 25 between Q vs time(bit period) is

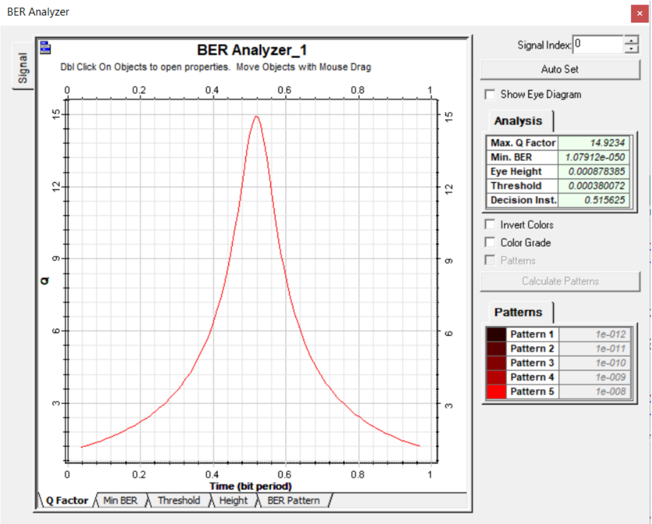


fig 25 (BER analyzer of freq 1553.52nm)

And in term of min BER the graph shown in fig 26 between log of BER vs time (bit period)

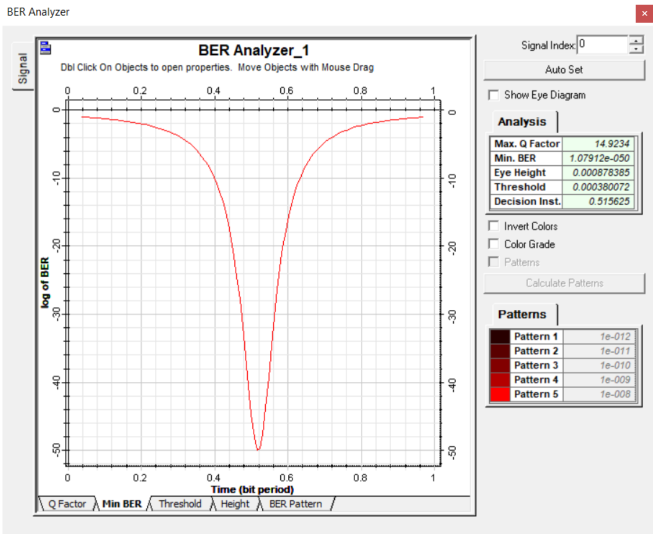


fig 26 (BER analyzer of freq 1553.52nm)

And also in term of threshold graph change in new shape and then the graph shown in figure 27 between amplitude vs time(bit period) is

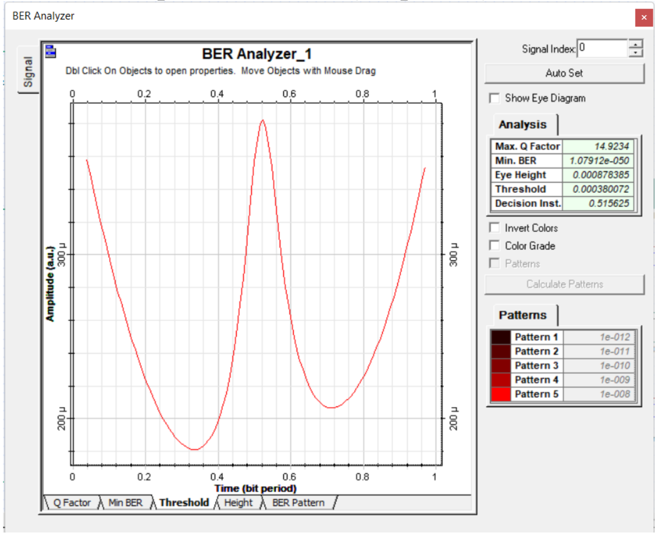


fig 27 (BER analyzer of freq 1553.52nm)

And in term of height the graph shown in the figure 28 between amplitude vs time(bit period)

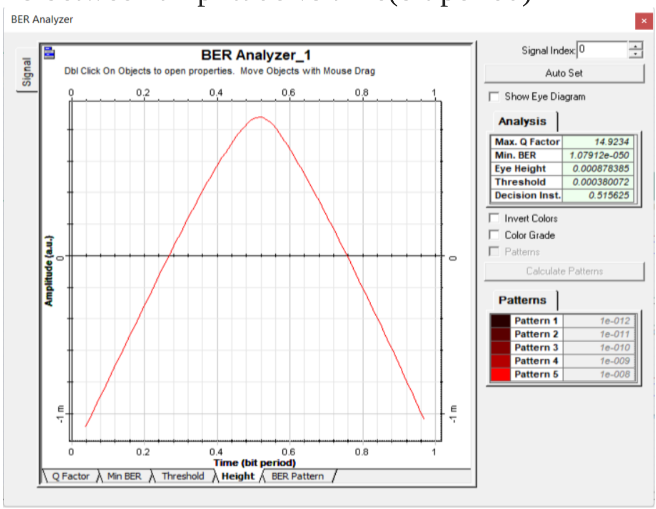


fig 28 (BER analyzer of freq 1553.52nm)

and last the BER pattern of the graph in fig 29 is

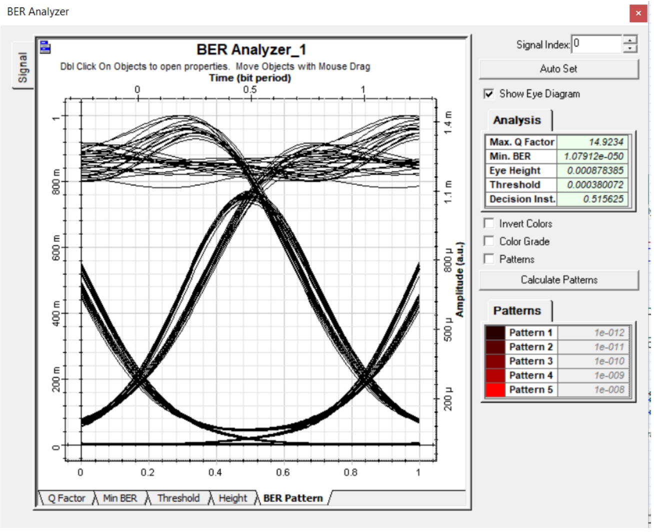


fig 29 (BER analyzer of freq 1553.52nm)

And now we repeat the above observations for the transmitter of frequencies 1554.52nm

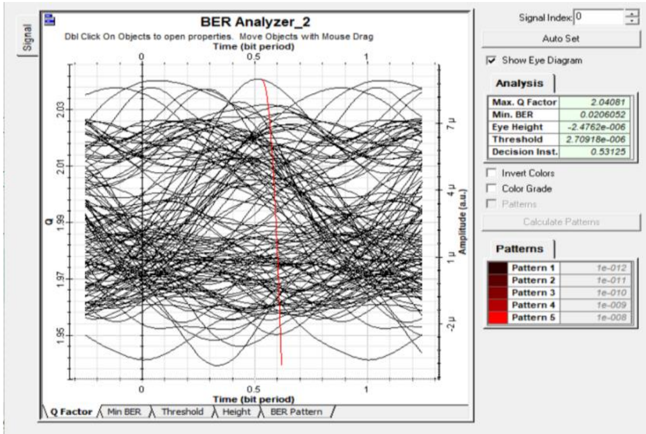


fig 30(BER analyzer of freq 1554.52nm)

After analyze the above graph which show in the *fig 30*, between amplitude and time the various result the coming out

such as the max Q factor is 2.04081 , min BER is 0.0206052 ,Eye height is -2.4762e-006 , threshold is 2.70918e-006 and decision inst. is 0.53125.

The above graph shown in the figure 3.3 is represent by each of there parameters such as when we represent in term of q factor then the graph shown in figure 31 between Q vs time(bit period) is

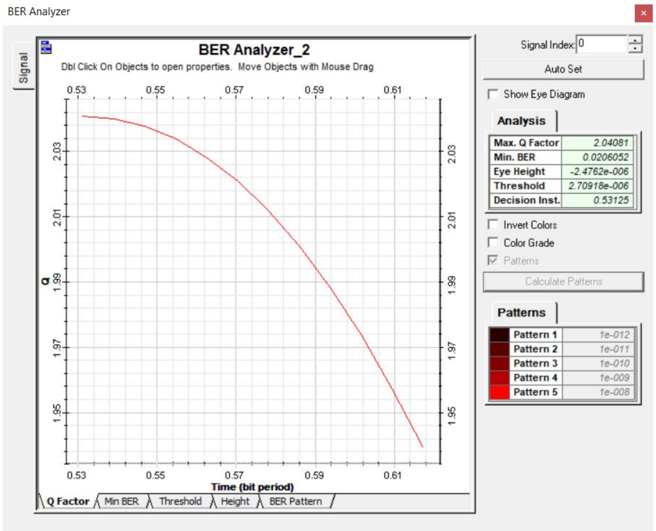


fig 31 (BER analyzer of freq 1554.52nm)

And in term of min BER the graph shown in fig 32 between log of BER vs time (bit period)

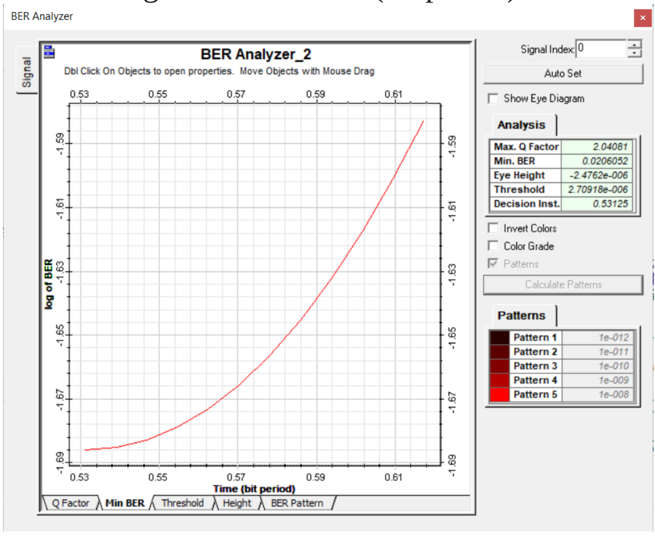


fig 32 (BER analyzer of freq 1554.52nm)

And also in term of threshold graph change in new shape and then the graph shown in figure 33 between amplitude vs time(bit period)

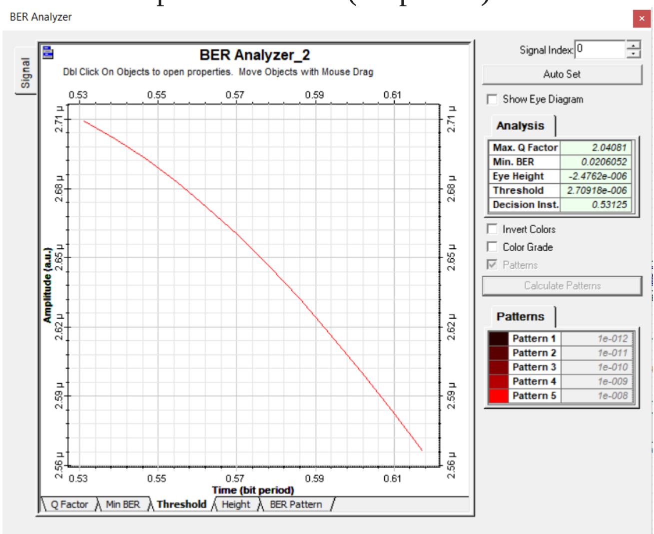


fig 33 (BER analyzer of freq 1554.52nm)

And in term of height the graph shown in the figure 34 between amplitude vs time(bit period)

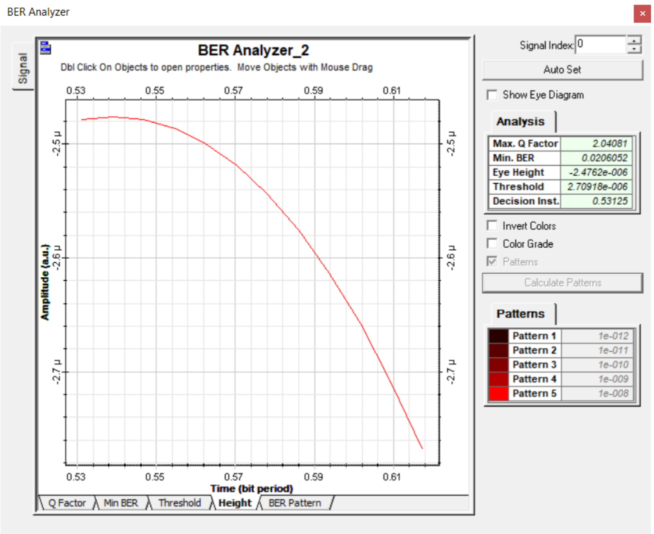


fig 34 (BER analyzer of freq 1554.52nm)

and last the BER pattern of the graph in fig 35 is

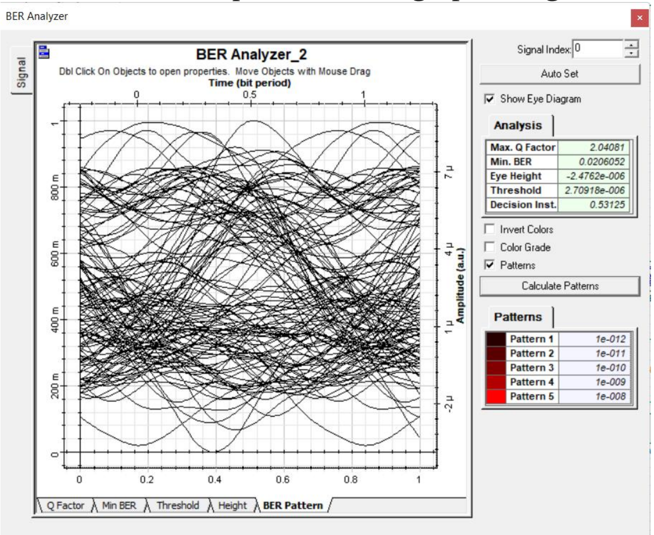


fig 35 (BER analyzer of freq 1554.52nm)

And now we repeat the above observations for the transmitter of frequencies 1555.52nm

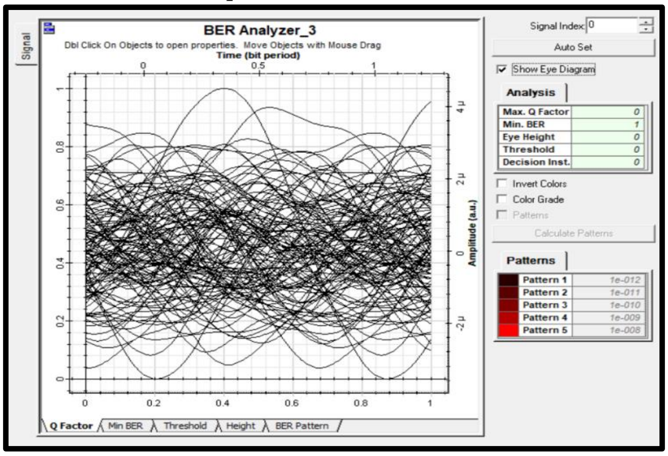


fig 36(BER analyzer of freq 1555.52nm)

After analyze the above graph which show in the *fig 36*, between amplitude and time the various result the coming out such as the max Q factor is 0 , min BER is 1 ,Eye height is 0 , threshold is 0 and decision inst. is 0.

We summarize the above result from all four different frequencies In the form of table and compare all parameters.

frequency	Max Q.factor	Min BER	Eye height	Threshold
1552.52nm	16.7647	2.10111e-063	0.00528755	0.00241793
1553.52nm	14.9234	1.07912e-050	0.000878385	0.000380072
1554.52nm	2.04081	0.0206052	-2.4762e-006	2.70918e-006
1555.52nm	0	1	0	0

By using of above table we compare all the parameters ,

The **max Q factor** is highest in 1552.52nm frequencies which means losses through the circuit are decreased, and the tuned circuit becomes sharper, and now more energy is stored in the circuit.

4. Conclusion:

We have to perform a simulated design study of an advanced optical communication system for least losses . This has been achieved with 4 x 10 G-bps wavelength division multiplexing repeaterless transmission system using non-return to zero pulse generator modulation format over 50km optical fiber and the frequencies used for this design are 1552.52 , 1553.52 , 1554.52 , 1555.52 NM , for this design we use Fiber Bragg grating which was deployed at the transmitting and receiving sides , and the transmission system was pumped bidirectionally with 1445 and 1455 NM wavelengths in a forward direction , and three pump wavelengths of 1430 , 1440 and 1450 NM were deployed for the backward direction . The total optical power of the forward and backward raman amplifiers are 0.3 w and 0.6w respectively. In a practical emplacement system, the least losses of the system could be obtained by the max Q factor of the circuit which is measured by the BER analyzer. In this simulation design the max Q factor is from the transmitter whose frequency is 1552.52nm and the least Q factor is from the transmitter whose frequency is 1555.52nm.

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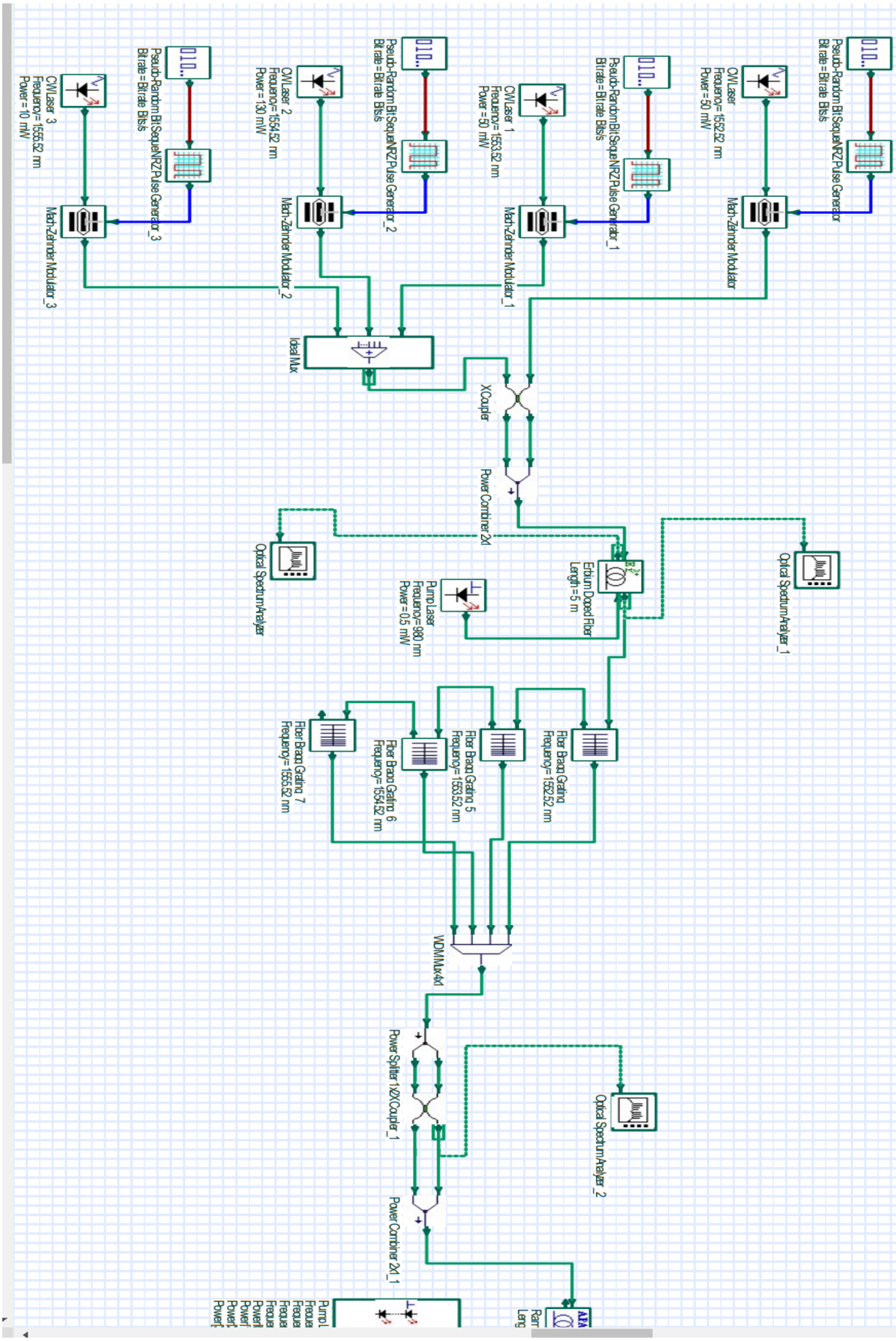
COMPLETE SIMULATION SETUP

Appendix 1



CW Laser_3
Mach-Zehnder Modulator_3
CW Laser_2
Mach-Zehnder Modulator_2
CW Laser_1
Mach-Zehnder Modulator_1
CW Laser
Mach-Zehnder Modulator
Ideal Mux
X Coupler
Power Combiner 2x1
Optical Spectrum Analyzer
Erbium Doped Fiber
Length = 5 m
Pump Laser
Frequency = 980 nm
Power = 0.5 mW
Optical Spectrum Analyzer_1
Fiber Bragg Grating 7
Frequency = 1555.52 nm
Fiber Bragg Grating 6
Frequency = 1554.52 nm
Fiber Bragg Grating 5
Frequency = 1553.52 nm
Fiber Bragg Grating
Frequency = 1552.52 nm
WDM Mux 4x1
Optical Spectrum Analyzer_2
Power Combiner 2x1_1

Appendix 2.