Designing of the Submarine Cable Backhaul Optical Transport Network and the Prediction of OSNR using Artificial Neural Network

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Abstract

In the era of the fast exponential increase of internet traffic, thereby, widespread deployment of IP over Optical Transport Network (OTN) necessitates the designing of a robust and stable backhaul network, so that the Services/Clients don't experience any blackouts and outages from the International Bandwidth. Because of being a terrestrial backhaul transport network, the performance parameter is mostly the Optical Signal to Noise Ratio(OSNR). In this paper, in the 1st phase, motivated by live real network, it's been fully designed the Submarine Cable Backhaul Transport Network from Cable Landing Station(CLS) to Destination with working, protection, and restoration path prioritizing the fidelity of the network. In the 2nd phase, collecting the real-time OSNR time series data from the live circuit, an Artificial Neural Network (ANN) Model has been proposed to predict the OSNR to monitor the performance quality. The Model ANN result shows the network capability for better OSNR assessment and forecasting.

Keywords: Backhaul Optical Transport Network, Optical Signal to Noise Ratio (OSNR) Prediction, GMPLS, Artificial Neural Network (ANN).

1. Introduction

To connect the whole country International Internet Gateway (IIG), International Gateway (IGW), Interconnection Exchange (ICX), Internet Exchange (IX), International Long Distance Telecommunications Services (ILDTS), and International Private Leased Circuit (IPLC) to Singapore, the middle east, and Europe through the submarine cable system, a high-capacity Optical Transport Backhaul Network is a must. The OTN suffers from huge impacts if the signal quality degrades. Therefore, to keep up the integrity of the network, the OSNR plays a vital role because if OSNR falls, the whole network collapses. This paper proposes a design of an OTN network, and for early detection of the OTN failures and anomalies in the OSNR, an ANN has been created there with letting not the signal quality deteriorate by analyzing the ANN forecasted OSNR(Allogba et al., 2022).

1.1   The Network Components

1.1.1   100G Line Card

This 100G line card is where the channel originated and terminated. Being compatible with International Telecommunications Union- Telecommunications sector (ITU-T)G.694.1, the (100G Form factor Pluggable) CFP interface of this card supports from 192 THz-195.95THz(Antil, et al., 2012) at 50GHz

spacing (192 THz+50GHz*79=195.95 THz). The CFP could be tuned to any of these 80 channels (C band), and in the future, it could be extended to 191.35 THz and 196.1THz (extended C Band)(Mubarakah, et al., 2020) and also tunable to transmit (Tx) power. The Tributary board (Client Card) and the line card work with Cross-connect Boards. The Tributary board receives client signals, performs O-E conversion, maps the services into ODUk(Optical Data Unit k=0,1,2,3,4)containers, and sends the ODUk electrical signals to the line card via a cross-connect board. The line card multiplexes and maps ODUkinto OTUk(Optical Transport Unit)and converts the OTUk signals into standard Dense Wavelength Division Multiplexing (DWDM)lamda/channel. The line card receives power must be within -2dBm to -18dBm (the best is -6dBm), and the OSNR sensitivity (B2B) is 13dB. The 100G transceiver uses Polarization Multiplexed Quadrature Phase Shift Keying (PMQPSK) coherent modulation and being coherent modulation/optics, with SD-FEC (Forward Error Correction) and 60,000 ps/nm dispersion tolerances, the 100G Channel can reach up to 3529km without regeneration.

The embedded high-speed Digital Signal Processor(DSP)technology compensates for dispersion and Polarization Mode Dispersion (PMD). The line card can map 80 port ODU0/40 port ODU1/10 port ODU2/2 port ODU3+2 port ODU2 signal sent by cross-connect board to OTU4 and converts it to DWDM standard lamda.

1.1.2 Erbium Doped Fiber Amplifier (EDFA)

Digital coherent detection with SD-FEC enables 100G lamdas to transmit over 4000km with just the implementation of EDFAs- this is the exquisite side of EDFA.

Erbium Doped Fiber Amplifier (EDFA)has an amplification bandwidth of 4THz (80*50 GHz spaced lamda). The EDFA is used (Sajjan et al., 2015) at three locations in a DWDM System:

1.1.2.1 Optical Booster Amplifier (OBA)

It boosts the signal at the transmitter end to compensate relatively low output power of the laser.

1.1.2.2 Optical Pre-amplifier (OPA)

It boosts the signal before the optical receiver to increase receiver sensitivity.

1.1.2.3 Optical Line Amplifier (OLA)

It's directly inserted into the optical transmission link to amplify signals.

Considering the future fiber loss, the 3121 model, 5 dB noise figure (31 is maximum adjustable gain and maximum output power is 21) EDFA has been chosen for our design.

1.1.3 Mux De-mux Unit (MDU)

The MDU, made of thin fiber filter AWG (Array Waveguide Grating), is a 40-channel unit (even and odd), and it's purely passive. Even and odd channels have space of 100GHz according to G.694.1 frequency grid. Even channels cover from 192 THz to 195.9THz, and odd channels cover from 192.5 to 195.95 THz. The 80-channel, i.e., 80*100G=8Tbps per fiber capacity, is achieved after using an Inter-Leaver Unit or ILU (ILU incorporates both the even and odd channels). The MDU can integrate the line cards from another DWDM network-called alien lamda incorporation. The number of MDU is equal to the number of optical pathsANN

1.1.4 Re-configurable Optical Add-Drop Multiplexer (ROADM)

The ROADM is the heart of an agile network. In a ROADM card (Fig.1), signal is received at common port Rx and broadcast across all the Add/Drop Transmit Tx ports – whereas the signal received at Add/Drop Rx ports is selected by Wavelength Selective Switch(WSS) and transmitted over common Tx port.
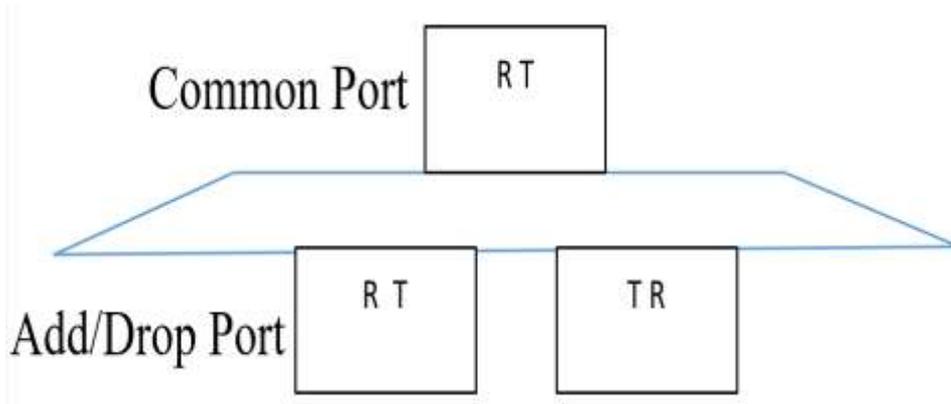

Fig.1: ROADM Card

ROADM could be –

1.1.4.1 Colorless

The line card is connected to the fixed frequency MDU port. If the line card is tuned to another frequency, then the patch cord has to shift to the tuned frequency port. For ROADM to be colorless, no matter what frequency the line card is tuned to, the patch cord does not need to be moved, i.e., the port will automatically tune to the line card frequency.
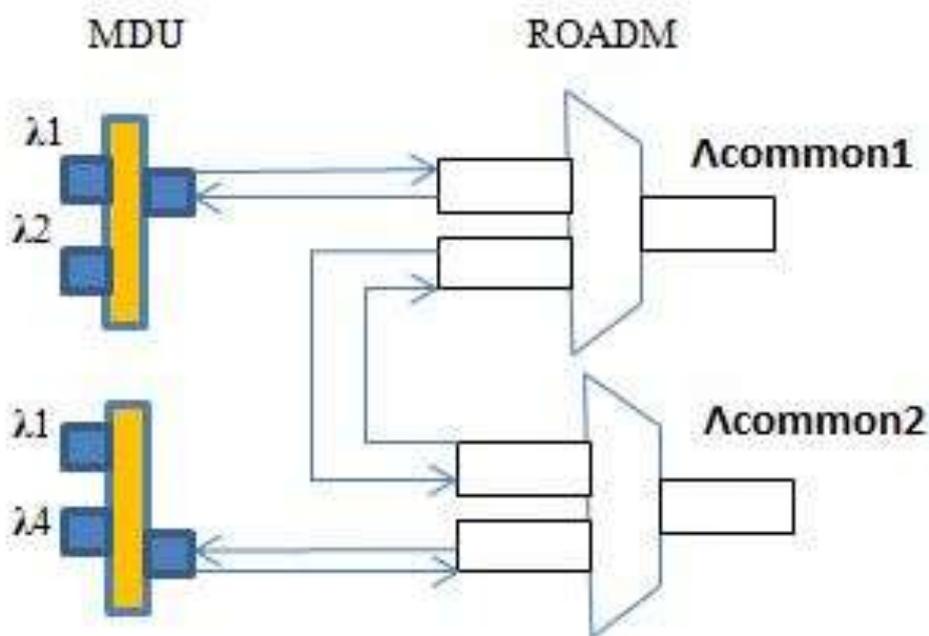
1.1.4.2 Directionless

Fig.2: ROADM connection

Directionless means that any λ can be directed in any direction. In Fig.2, λ1, connected to port-1, can be directed to ROADM common port-2, or λ-common-1 can be directed to λ-common-2.

1.1.4.3 Contention less

The ROADM is contention less if the same λ can be simultaneously added/dropped in different directions. In Figure 2, λ1 at port-1 and λ1 at port-3 could be added and dropped in λ-common-1 and λ-common-2.

1.1.4.4 Flexible Grid

A flexible Grid is when λ spectral width is in the multiple of 12.5 GHz. It provides better spectral efficiency. Spectral width = n*12.5 GHz.

1.1.5 Optical Fiber Cable (OFC)

The OFC deployed in the OTN is the single-mode fiber complying with the G.652 specifications(Sajjan et al., 2015). Two main specifications are the attenuation (0.25dB/km) and dispersion coefficient (17ps/nm-km). Hence, if the 100G line card CFP dispersion tolerance is 60,000 ps/nm-km, then, lamda transmission distance D*17=60,000, thereby D=3529.7km. The 100G lamda can travel around 3529km just using the amplifier in the link.

2. The Network Planning and Designing

The designed network has 8 Tbsp per fiber capacity, but for the time being, it's been configured with only 400G circuits with theworking, protection, and restoration path.
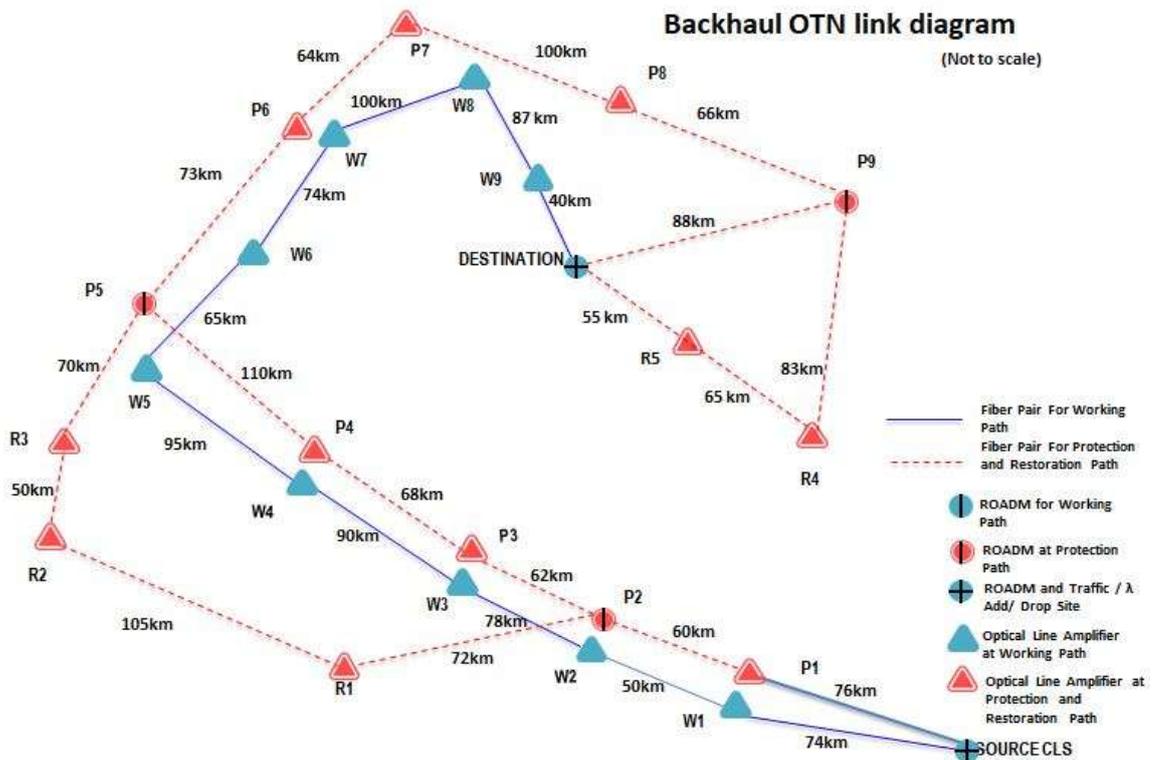

Fig.3: The Backhaul Optical Transport Network Diagram.

Table1: Source CLS to Destination Route Planning (Fig.3)

Traffic	Path	Route
Source CLS to Destination	Working	Source CLS-W1-W2-W3-W4-W5-W6-W7-W8-W9 - Destination
	Protection	Source CLS- P1-P2-P3-P4-P5-P6-P7-P8-P9-Destination
	Restoration	Source CLS – P1-P2-R1-R2-R3- P5-P6-P7-P8-P9-R4-R5- Destination

The working path (Fig.3 & Fig.4) has09 (Nine) EDFAs (OLAs), 01 (One) OBA and 01 (One) OPA of the 3121 model from source CLS toDestination and vice versa (Fig.4). The working path has 04(Four) channels/lamdas(λ) of 0dBm launching power from 04(Four) line cards at both the ends (Fig.4) and all 4λs are amplified together from source CLS toDestination and vice versa at OBAs, OPAs and OLAs. The lamdas(λ) being fewer in number (4λs), it's been fixed the amplifier output to 2dBm(Table 2).

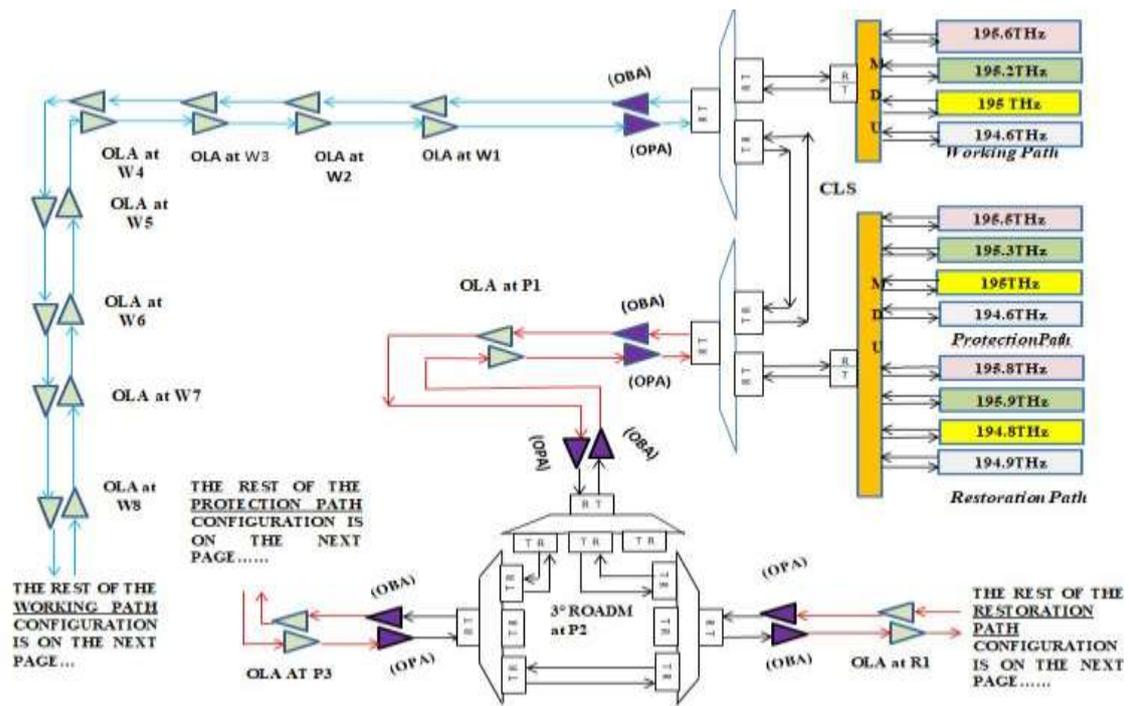Fig4: Complete design of the Network (blue fiber for working and red fiber for protection and restoration path).
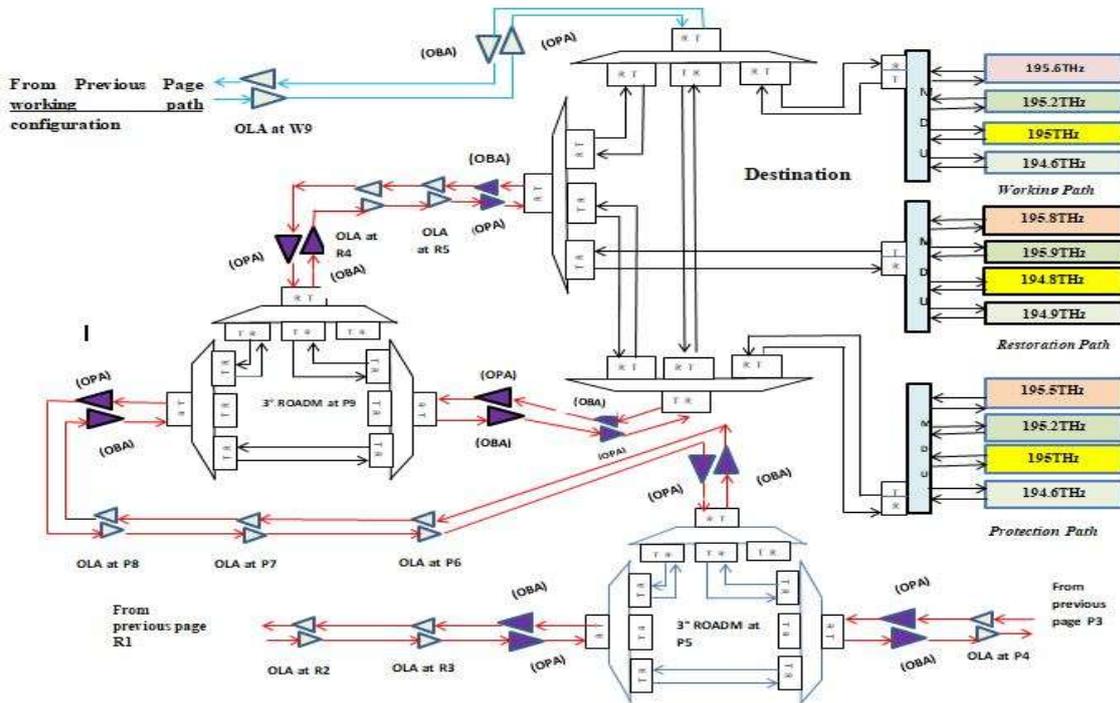

Fig.4: (Continued).

Table2: The EDFA (OBA/OLA/OPA) Gain Power Adjustment from Source CLS to Destination for working path.

Sl. No.	OLA/OBA/OPA site Name	Fiber Loss(dB) (.3/km)	ROADM Insertion Loss(dB)	MDU Insertion Loss(dB)	EDFA Input Power (dBm)	Gain Adjustment(dB)	EDFA Output Power(dBm)
1	Source CLS (OBA)	0	8	7	-15	17	2
2	W1 OLA	23	0	0	-21	23	2
3	W2 OLA	15	0	0	-13	15	2
4	W3 OLA	24	0	0	-22	24	2
5	W4 OLA	27	0	0	-25	27	2
6	W5 OLA	29	0	0	-27	29	2
7	W6 OLA	20	0	0	-18	20	2
8	W7 OLA	22	0	0	-20	22	2
9	W8 OLA	30	0	0	-28	30	2
10	W9 OLA	27	0	0	-25	27	2
11	Destination OPA	12	0	0	-10	19	9

Similarly, (Fig.4) the gain power adjustment is calculated from Destination to Source CLS of the working path.

The protection path (Fig.3 & Fig.4) has 06 (Six) OLAs, 08 (Eight) OBAs and OPAs of the same3121model between source CLS to destination and vice versa. Whereas, in between there're 03 (three) 3 degree ROADMs (P2, P5 & P9) and they switch and amplify the lamdas of both the protection

and restoration paths. The protection path also has 04(Four) channels/lamdas (λ) of 0dBm launching power from 04(Four) line cards at both the ends (Fig.4) and all 4λs are amplified together from source CLS toDestination and vice versa at OBAs, OPAs and OLAs. The lamdas (λ) being fewer in number (4λs), it's been fixed the amplifier output to 2dBm(table 3).

Table3: The EDFA (OBA/OLA/OPA) Gain Power Adjustment from Source CLS to Destination for Protection Path

Sl. No.	OLA/OBA/OPA site Name	Fiber Loss(dB) (.25/km)	ROADM Insertion Loss(dB)	MDU Insertion Loss(dB)	EDFA Input Power (dBm)	Gain Adjustment (dB)	EDFA Output Power(dBm)
01	Source OBA	0	8	7	-15	17	2
02	P1 OLA	19	0	0	-17	19	2
03	P2 OPA	16	0	0	-14	16	2
04	P2 OBA	0	16	0	-14	16	2
05	P3 OLA	16	0	0	14	16	2
06	P4OLA	17	0	0	-15	17	2
07	P5 OPA	28	0	0	-26	28	2
08	P5OBA	0	16	0	-14	16	2
09	P6OLA	19	0	0	-15	17	2
10	P7OLA	16	0	0	-14	16	2
11	P8 OLA	25	0	0	-23	25	2
12	P9 OPA	17	0	0	-15	17	2
13	P9 OBA	0	16	0	-14	16	2
14	Destination OPA	22	0	0	-20	29	9

In the same way, the gain power adjustment is calculated from the Destination to the Source CLS of the protection path.

Following (Table4) is the gain adjustment for the restoration path. The protection and restoration paths are the same from source CLS to P2 and P5 to P9. The P2 to P5 and P9 to destination alternate routes are added for the restoration path (Table1 & Fig.3), hence, the restoration path has 09 (Nine) OLAs, 08 (Eight) OBAs & OPAs of the same3121 model between source CLS to destination and vice versa. Whereas, in between there're 03 (three) 3 degree ROADMs (P2, P5 & P9). The restoration path also has 04(Four) channels/lamdas (λ) of 0dBm launching power from 04(Four) line cards at both the ends (Fig.4) and all 4λs are amplified together from source CLS toDestination and vice versa at OBAs, OPAs and OLAs. The lamdas (λ) being fewer in number (4λs), it's been fixed the amplifier output to 2dBm (table 4).

As in this design, the 100G line card CFP works in the best state for -6dBm received power, hence, the Destination OPA output power (Table2, Table3 & Table4) has been fixed to 9dBm (9-15= -6dBm, 15dB is ROADM and MDU total insertion loss)

Table4: The EDFA (OBA/OLA/OPA) Gain Power Adjustment from Source CLS to Destination for Restoration Path.

Sl. No.	OLA/OBA/OPA site Name	Fiber Loss(dB) (.25/km)	ROADM Insertion Loss(dB)	MDU Insertion Loss(dB)	EDFA Input Power (dBm)	Gain Adjustment(dB)	EDFA Output Power(dBm)

01	Source OBA	0	8	7	-15	17	2
02	P1 OLA	19	0	0	-17	19	2
03	P2 OPA	16	0	0	-14	16	2
04	P2 OBA towards R1	0	16	0	-14	16	2
05	R1 OLA	16	0	0	-14	16	2
06	R2 OLA	17	0	0	-15	17	2
07	R3 OLA	28	0	0	-26	28	2
08	P5 OPA from R3	18	0	0	-16	18	2
09	P5 OBA towards P6	0	16	0	-14	16	2
10	P6 OLA	19	0	0	-17	19	2
11	P7 OLA	16	0	0	-14	16	2
12	P8 OLA	25	0	0	-23	25	2
13	P9 OPA from P8	17	0	0	-15	17	2
14	P9 OBA towards R4	0	16	0	-14	16	2
15	R4 OLA	21	0	0	-19	21	2
16	R5 OLA	17	0	0	-15	17	2
17	Destination Restoration OPA	14	0	0	-12	21	9

The EDFA amplifies all the lamda altogether with the function of automatic gain control, but after amplification together, the per-channel power difference has to be less than 3dB for a healthy network. The bar chart in Fig.5 shows the per channel power:
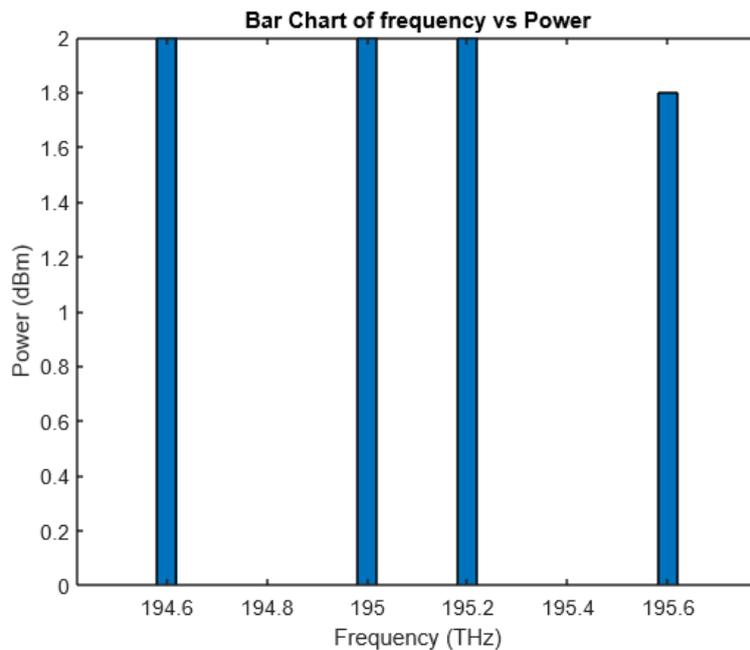
Fig.5: Depiction of per channel power.

3. The Network Configuration

3.1 Network components port connection

The ports are to connect physically with patch cords as well as on the software; the source port and the destination port are configured bi-directionally, viz, the MDU common ports are to connect with the ROADM add/drop ports, the add/drop ports of one ROADM are to connect with another ROADM add/drop ports. The ROADM common ports are to connect (unidirectional) with the OPA/OBA (Fig.2).

3.2 The Lamda switching/connections

The lamda can be switched from MDU common port/MDU add/drop ports to ROADM add/drop ports or common ports (directionless ROADM) (Fig.2).

3.3 The Network Performance Parameter

The key parameters that indicate the channel as well as the network robustness:

3.3.1 OSNR

The OSNR indicates the channel, circuit's healthiness, and better transmission quality. Higher the OSNR, the better the transmission performance (Gumaste et al., 2003). Factor affecting the OSNR is the Amplified Spontaneous Emission (ASE) noise from the EDFA than the nonlinearities (Self Phase Modulations (SPM), Cross Phase Modulation (XPM), and Four Wave Mixing (FWM)), i.e., the EDFA is the predominant source for OSNR penalty and degradation(Ibragimov,et al., 2018).

The OSNR calculation for the working path (Submarine CLS to Destination):

The empirical formula (Sun et al., 2017; Gumaste et al., 2003) for OSNR calculation is-

OSNR (dB) =CFP Tx (dBm) + 58-Total Link Loss-EDFA Noise Figure (NF)-10 log (No. of Amplifier)

Here, CFP (Tx) =0dBm,

EDFA Noise Figure (NF) = 5,

Submarine CLS to Destination Working Path Total Length L=753km,

Fiber Loss= 753km*0.3=226dB,

No. of Span in the Working Path=10,

No. of EDFA (Amplifier) N=11, 10log (N) =10.41,

End-End (MDU+ROADM) Insertion Loss= 15*2=30dB.

Total Link Loss= (Fiber Loss+ Insertion Loss)/No. of Span= (226+30)/10=25.6dB,

Therefore,

OSNR=0dBm+58-25.6-5-10.41

= 16.99=17dB (approx.); if it's calculated the same way for the working path from Destination to Submarine CLS, then the result would be the same.

3.3.2 Bit Error Rate (BER)

The OSNR indirectly reflects the BER – providing the calculation of BER from OSNR as follows:

$$BER = \sqrt{2/pi * OSNR)} * (\exp(-OSNR/8) = \sqrt{(2/pi * 17)} * \exp(-17/8) = 0.193515 * 0.119432 = 2.3*10^{-2}$$

Table5: Working path channels (4λ) with OSNR and BER for WSON.

Working Path Channel (THz)	OSNR (dB)	BER	Uncorrected Bit after FEC
194.6	16.9	2.3*10^-2	0
195	17.3	2.2*10^-2	0
195.2	17.8	2*10^-2	0
195.6	18	1.9*10^-2	0

Table6: Protection path channels (4λ) with OSNR and BER for WSON.

Protection Path Channel (THz)	OSNR (dB)	BER	Uncorrected Bit after FEC
194.6	16.5	2.49*10^-2	0
195	16.5	2.49*10^-2	0
195.2	16.5	2.49*10^-2	0
195.5	16.7	2.4*10^-2	0

Table7: Restoration path channels (4λ) with OSNR and BER for WSON.

Restoration Path Channel (THz)	OSNR (dB)	BER	Uncorrected Bit after FEC
194.8	16	2.69*10^-2	0
194.9	16	2.69*10^-2	0
195.8	16	2.69*10^-2	0
195.9	16.2	2.6*10^-2	0

If the OSNR would be less than the B2B tolerance of the line card (13dB), uncorrectable bit errors would be generated. However, in this case, the OSNR being higher than 13dB, the uncorrectable bits are 0 in number.

3.4 Generalized Multi-Protocol Label Switching (GMPLS)and the creation of circuits

GMPLS is the defacto control plane protocol for Wavelength Switched Optical Networks Wavelength Switched Optical Network (WSON). DWDM /OTN networks are WSON, where switching happens based on lamda.On the GMPLS enabledsystem, circuits can be added only while more parallel paths are running between the lamda-originated node and lamda terminated node, and at a time, at least two paths are active.

To create/add the 400G (40*10G) circuits between the source cable landing station and destination, the four 10*10G tributary/client cards, four 100G line cards for the working path, four 100G line cards for the protection path, and four 100G line cards for restoration path have to be arranged into 04(four) different shelves at both the ends (source CLS and destination), where in one shelf there'd be one 10*10G client card and three 100G line cards (one is for the working path, one is for the protection path and another is for the restoration path)(Fig.6).
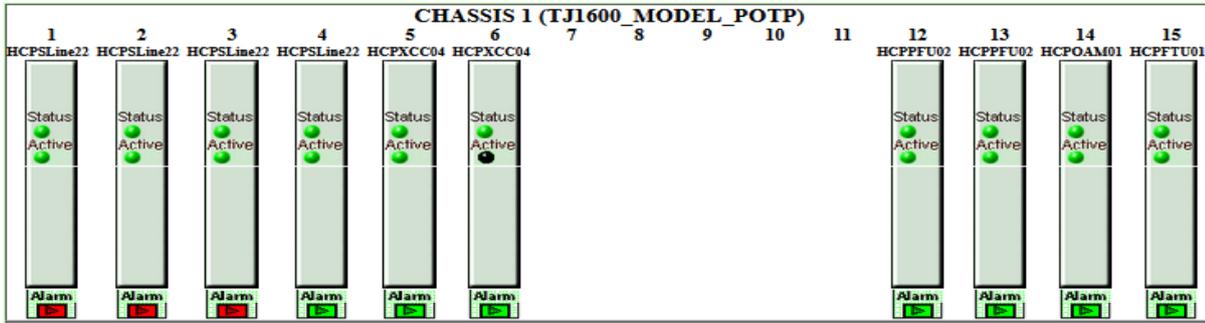
Fig.6: One Shelf View with one tributary card and threeline cards.

In the above Fig6 there's a shelf where slot no. 01 is a 10*10G tributary card, and slot no. 2,3,4 are 100G line cards. Likewise, there'd be 3 other shelves like the above Fig.6 (04 shelves are at source CLS and 04 shelves are at destination), and each such shelf has distinct IP address.

Table8: Shelf-wise source and destination IP address.

Shelf no. at Source CLS	IP Address
01	10.202.34.91
02	10.202.34.92
03	10.202.34.93
04	10.202.34.94
Shelf no. at Destination	IP Address
01	10.202.34.1
02	10.202.34.2
03	10.202.34.3
04	10.202.34.4

3.5 Adding the GMPLS-Circuits

In a GMPLS-enabled circuit, the configuration can be done at any end, and the optical path (line card) would be selected automatically based on the OSNR received.

Before creating the circuits, the first thing to do is to make all the 10G ports (P1 to P10) of both ends' tributary cards UP and configure the ports as STM-64/10 GE LAN/ODU2/ODU2e as per the plan. Next, it needs to select circuit parameters (Fig.7), including the other end's IP address, and also select the slot number and port number under the ingress work channel option, and the egress work channel option to add/create a 10G circuit from one tributary card to another tributary card (Fig.8)(say, source CLS to destination). Among the three paths (working, protection, and restoration), the working path shows (comparing tables 5, 6, and 7) the best OSNR. Autmatically, the working path is selected for the automatic cross-connection of the 10G port with the 100G line card. In the same way, we'd finish adding the 40*10G circuits.

Fig.7: GMPLS circuit creation
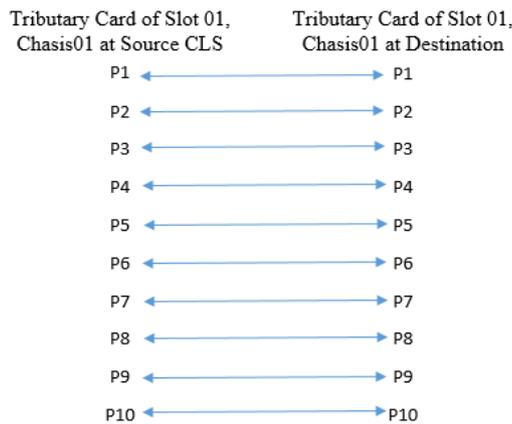
Fig.8: Tributary cards' port to port 10 10G circuits.

Fig.9: Circuit-wise ODU Cross-connections.

In Fig.9, at first row, source ODU2ek-1-1-6-0 means 6th no. 10G port (out of 10 no. physical 10G ports)of slot 01, shelf/chassis 01, and the destination ODU2ej-1-3-1-1 means the first 10G port (out of 10 virtual 10G ports)of one 100G channel, slot (three) 03, and shelf/chassis 01.

4. Artificial Neural Network for forecasting the OSNR

To predict the OSNR and any anomalies in it, a Feed-Forward Back Propagation Neural Network (FFBPNN) has been created. The neurons are arranged into 03 (three) layers - the input layer, the hidden layer, and the output layer.
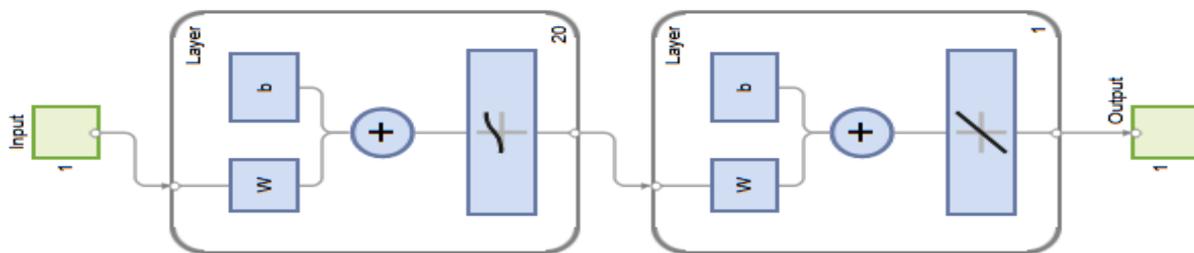
4.1 The Network Configuration

Fig.10: The Model Artificial Neural Network Configuration for OSNR Prediction.

The network hidden layer has 20 neurons with "logsig" as a transfer function, and the output layer has 1 neuron with "purelin" as a transfer function (Fig. 10). For the FFBPNN training, the "trainlm" activation function has been used. The Mean Squared Error (MSE) has been used as the default performance function.

4.2 Network Parameter

The learning rate controls the weight size and bias change and is set to a value of 0.01. The Epoch determines when the train will stop and is set to 8000. The RMSE or RootMean Squared Error is the square root of the sum of the squared difference between network target and actual output divided by no. of patterns. The goal is set to 1exp (-25). MSE calculation in MATLAB:

$$\text{mse} = \left(\frac{1}{501}\right) \sum_{1}^{501} (\text{Target} - \text{ANN generated output})^2$$

```
>> f=(x-u).^2;
>> g=sum(f(:));
>> h=g/501;
>> mse=g/501

mse =

    0.0375
```
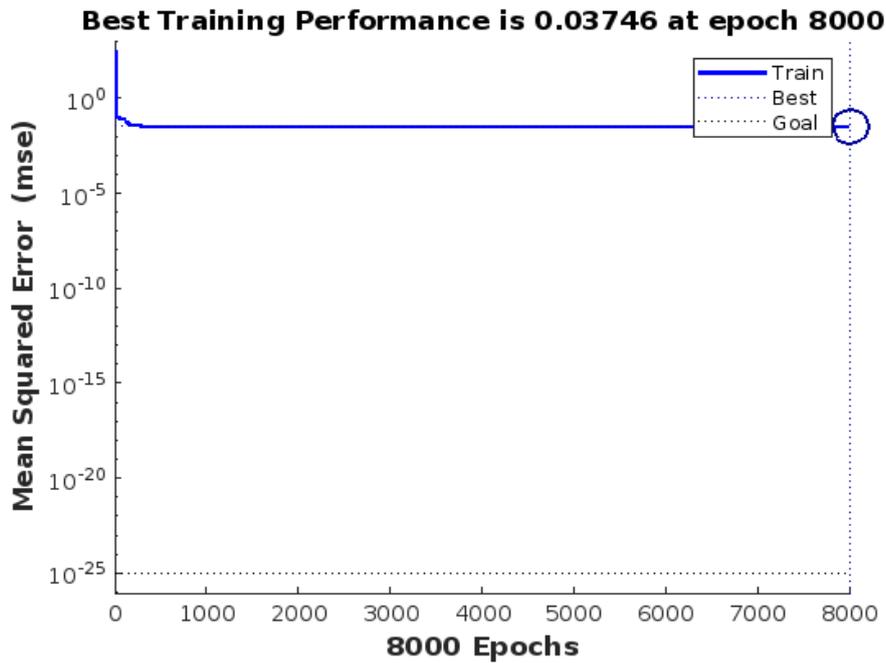
$\text{RMSE} = \sqrt{.0375} = 0.193$

Fig11: Training Epochs vs. MSE

Here, (Fig.11) the ANN training entails tuning the values of weights and biases for network performance optimization. At 8000 epoch, the best performance is at mse=0.03746.

Table9: Collected Data Sample

Hour of the day	Corresponding Time Series	Target OSNR (dB) (Working path)	Target OSNR (dB) (Protection path)
10:00AM	0	16.9	15.9
10:15AM	0.01	16.9	16
10:30AM	0.02	16.8	16
10:45AM	0.03	16.8	16
11:00 AM	0.04	16.9	16
11:15AM	0.05	16.8	16.4
11:30AM	0.06	16.8	16.4
11:45AM	0.07	16.8	16.7
12:00PM	0.08	16.8	16.7
12:15PM	0.09	16.8	16.8
12:30PM	0.1	16.8	16.8
12:45PM	0.11	16.8	16.8
1:00PM	0.12	16.8	17
1:15PM	0.13	16.8	17
1:30PM	0.14	16.8	17.3
1:45PM	0.15	16.8	17.3
2:00PM	0.16	17.7	17.3
2:15pm	0.17	17.7	17.6
2:30pm	0.18	17.8	17.6
2:45pm	0.19	16.9	17.6

The Table9 (Collected Data Sample) shows how every 15min the field OSNR data is collected for 125hrs. The time unit 0 to 5 indicates 0 to 125 hrs (Allogba, Et al., 2021).70% of the total collected data

is used for training the network, and the left 30% is used to get the network to generate the OSNR (for testing and validation).
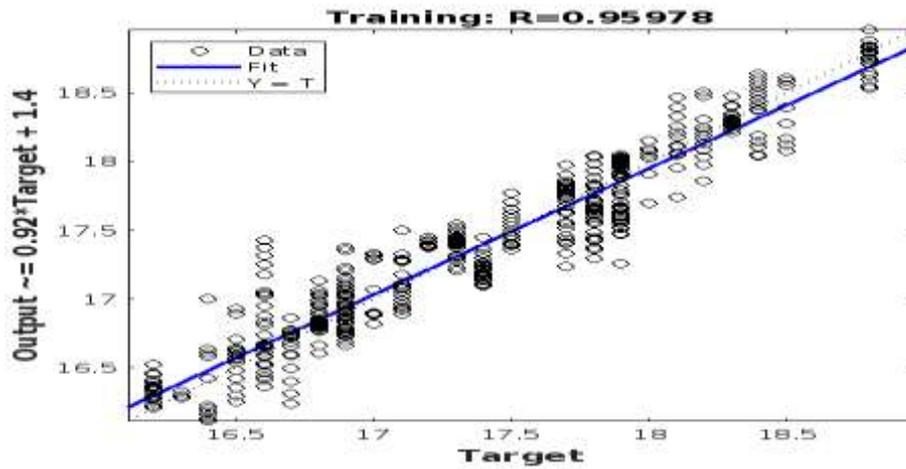

Fig.12: Target vs. ANN Output best fitting with the least anomalies.
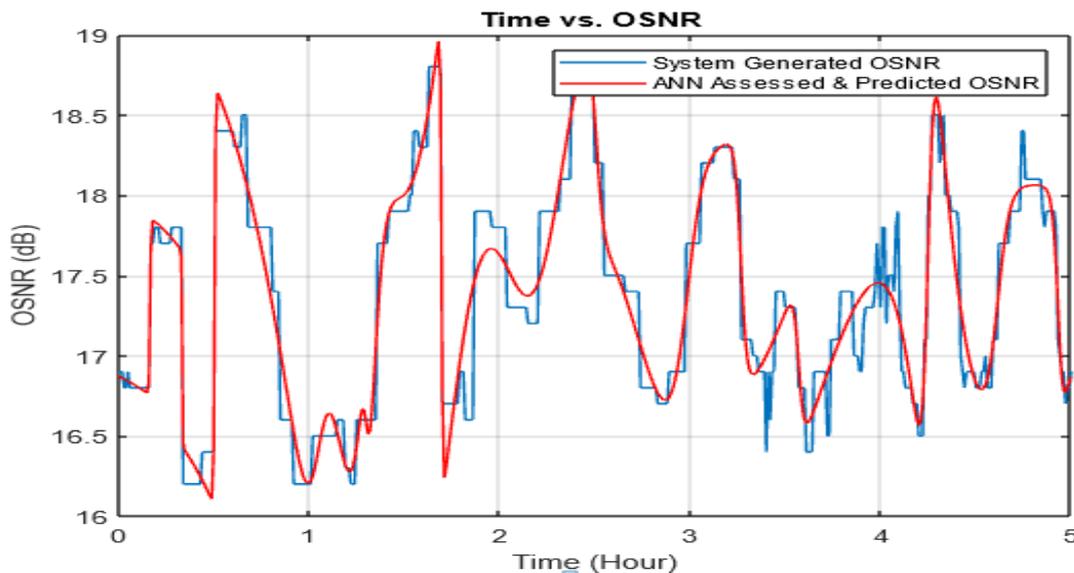

Fig13: The OSNR Prediction Scenario.

Hence, from Fig.12 above and Table9, it's apparent that the target OSNR and the ANN generated OSNR have a good co-relation, matching and alignment. There're nominal anomalies in the ANN generated OSNR- thereby predicting the best OSNR (Fig.13), thereby forecasting the best signal quality.

Table10: Working and Protection path Forecasted OSNR Sample.

Working path ANN forecasted OSNR (dB)	Protection path ANN forecasted OSNR (dB)
16.8707	15.9243
16.8653	15.9468
16.8597	15.9919
16.8539	16.0551
16.8479	16.1232
16.8417	16.357
16.8353	16.3927

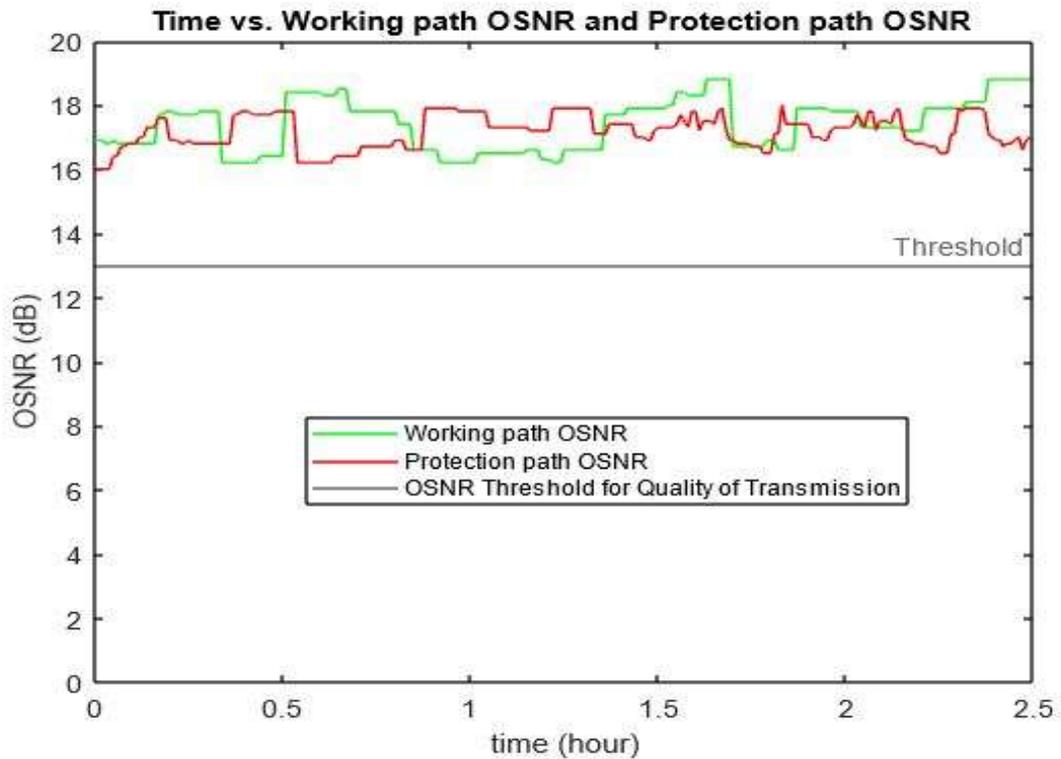|	
16.8286	16.6411
16.8217	16.689
16.8146	16.8235
16.8073	16.8354
16.7996	17.0109
16.7917	17.0811
16.7836	17.1194
16.7752	17.1406
16.7679	17.1488
16.8423	17.1478
17.6752	17.2401
17.8441	17.12

Fig 14: Best OSNR and Light Path Selection for Quality of Transmission.

In the Fig.14 and Table 10,it's visible that both the Working and Protection path OSNR are above the Threshold(Allogba et al., 2022).

5. Summary

The system parameters indicate the system as a robust one. However, there is still and always some rooms for improvement. In the first case scenario from the designing phase, it is observed that the working and protection paths are separately running in parallel (there're no connections between them). The protection path gets cut frequently and then the system becomes reliant on the working path (the protection and restoration path shares 439km of Fiber). In case indispensably some maintenance works run on the working path, then the 400G circuits get into a blackout. If both protection and working paths

would be connected at the same node (ROADM) at some strategic locations, lamdas (λ) could be rerouted, and circuits would be more stable.

In the second phase of ANN prediction of OSNR, for best forecasting and early detection of OSNR, instead of using the FFBPNN, the OSNR data being sequential; it'd deliver more accurate result if the time series OSNR data could be fed into a Long Short-Term Memory (LSTM) Recurrent Neural Network (RNN) or Gated Recurrent Unit(GRU) RNN.

6. Conflicts of interest

Authors have no conflicts of interest.

Authors' Biography

Mohammad Rakibur Rahman received the B.Sc. in Engineering in Electrical and Electronics Engineering from the University of Dhaka at the examination of 2013. During his Bachelor degree, he worked in the field of Artificial Neural Network-application to the power system. He started his career as an Optical Transmission Engineer at BTCL and worked closely with the SDH, DWDM/OTN Networks. Later on he'd gone through several trainings on SDH and DWDM network Designing and Configuration. At present, he's in charge of DGM at Optical Transmission Division, BTCL. His research interest includes Optical Fiber Communication System and the Artificial Neural Network.

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Abdullah Al Mahbub completed his Bachelor of Science in Electrical and Electronics Engineering from Faridpur Engineering College in 2021, an affiliated college of the University of Dhaka. Currently, he is working at Perlucidus Engineering Kernel Bangladesh(https://perlucidusbd.web.app). He specializes in MATLAB and Power Systems. His research interest is in sustainable power systems and communication systems. Over the last couple of years, he has completed five research papers based on his interest in overcoming certain barriers in his home country. He secured sixth place in Bangladesh Science Olympiad in 2013 and continues his brilliant success as a good student.

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