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RECEIVER SENSITIVITY ANALYSIS OF PROPOSED FOUR CHANNEL WDM PASSIVE OPTICAL NETWORK WITH 40 GBPS DOWNSTREAM AND 10 GBPS UPSTREAM DATA RATE

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ABSTRACT: Receiver Sensitivity is an important factor in optical networks to receive optical signal without distortion. As the reach of optical signal increases or the number of end users increases, the more power will be dissipated in the network between OLT (Service) and the OLT (end user). A 40 Gbps downstream and 10 Gbps upstream, four channel WDM-PON has been proposed to increase the No. of end users. In this research, power dissipated in the network due to different components and power budget margin has been analyzed. The result shows that, power budget margin is sufficient in both downstream and upstream channels for data transmission at the distance of 10km.

Keywords: WDM-PON, DQPSK, IRZ, NG-PON, Receiver Sensitivity, Power Budget Margin

INTRODUCTION

The area of Passive Optical Networks (PON's) is widely growing since last few years due to increasing demand of higher data rates from end users (Wey 2018). Next Generation Passive Optical Network (NG-PON2) has been proposed with higher data rates of 40 Gbps for downsream and 10 Gbps for upstream with high split ratio. In (TDM PON) as the number of channels increases the issue of inappropriate bandwidth has been raised. To overcome the issue of bandwidth WDM technology has been introduced in NG-PON 2 (Khan *et al.*, 2019).

Different modulation techniques have been adopted to modulate the signal such as NRZ, RZ, MD-RZ, CSRZ, MDRZ, DPSK, RZ-DQPSK/OOK, Differential Phase Shift Keying (DPSK)/OOK, Carrier suppressed return to zero CSRZ-DQPSK/OOK, NRZ-DQPSK/ASK, DPSK/ IRZ, OFDMA at OLT and ONU (El-Nahal, 2017). Due to high spectrum efficiency, high noise and attenuation tolerance DQPSK and IRZ is preferred at downstream and upstream channel respectively (Rehman *et al.*, 2018; Memon *et al.*, 2019).

Power Budget Margin is also an important factor that affected by increasing reach of passive optical network and split ratio (Wey and Zhang, 2018; Ruchet *et al.*, 2019). To increase the quality of signal, reach of optical network and number of end users, different optical and electrical components has been used, such as: Modulators, Multiplexers, De-multiplexers, Splitters, Amplifiers and Length of Fiber, Demodulators (Ren *et al.* 2017). All these components have some power loses. As the number of components increases in network, the power budget margin will become smaller (Houtsma et al., 2017; Qin *et al.*, 2017).

In this research, A WDM-PON system has been designed with DQPSK modulation at downstream and IRZ modulation at upstream. The system has four channels having 40 Gbps data rate for each at downstream and 10 Gbps data rate at upstream. The system has been designed for the distance of 10 km. In this network power budget has been analyzed with different components existing in the network.

MATERIALS AND METHODS

Power Budget: In this process there are different components used to transmit the signal from OLT to ONU and ONU to OLT. Each component dissipates some power to perform its action. Receiver sensitivity is also the key requirement of optical network. If power budget margin is according to the requirement of receiver sensitivity, the signal received at receiver will have high signal to noise ratio. To calculate the power budget margin following formula will be used (Houtsma *et al.*, 2017).

Power Budget Margin= Receiver Sensitivity (at Standard Bit Error Rate of 1x10-9) – Total Power Loss in transmission Path.

System Architecture: The system consists of service provider named as OLT and service user named as ONU. OLT consist of carrier generator (LASER) and transmitter which transmit data at 4 different channels using different wavelength on fiber. A multiplexer is used to transmit 4 different channels from OLT to ONU via single fiber. There is De-multiplexer at ONU side to separate the data of 4 different channels. There is a receiver to receive the signal and Spectrum analyzer to analyze the quality of the system. At ONU side upstream data is transmitted over same carrier signal used for downstream channel.

A Wavelength Division Multiplexing Passive Optical Network (WDM-PON) is shown in the Figure 1.

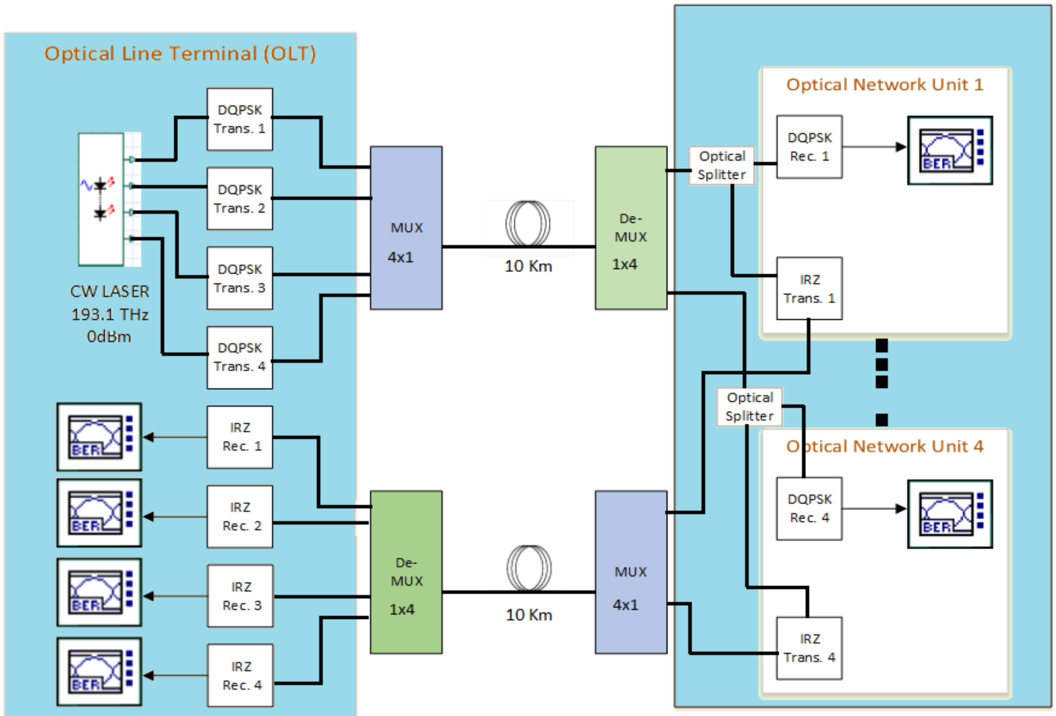

Figure 1: Block Diagram of Four Channel WDM-PON

Simulation Setup: WDM Passive optical network has been designed for four channels with 100 GHz channel spacing. CW laser has been chosen with 0dBm power as optical carrier. DQPSK and IRZ have been selected as modulation technique for downstream and upstream transmission. The distance between OLT and ONU is 10km.

Table 1: Parameter for Proposed WDM PON.

Parameters	Data
Laser Launched Power	0dBm (1mW)
Transmission Distance: OLT to ONU	10Km
ONU to OLT	10Km
Data Rate of 4 DQPSK Downstream Channels	40Gbps
Data Rate of 4 IRZ Upstream Channels	10Gbps
Channels Frequencies	From 193.1THz to 193.4 THz
Dispersion parameter	16.75 ps/nm/km
Non Linear index-coefficient	2.6x10-20
Slop of Dispersion	0.075 ps/nm2/km
Effective Core Area	80 um2
Fiber Attenuation	0.2 dB/km

RESULTS AND DISCUSSION

In Table 2 and 3, power losses have been specified at different stages of transmission path for downstream and upstream channels.

The result shows that, each channel in downstream and upstream have reasonable power margin to transmit the data at 10km distance at higher data rates of 40Gbps and 10Gbps for downstream and upstream respectively.

Table 2: Power Budget Analysis of DQPSK Downstream Channel.

Transmission Stage	Received Power (dBm)			
	Channel 1	Channel 2	Channel 3	Channel 4
Laser Launched Power	0	0	0	0
Transmitter DQPSK (Modulator 1)	-2.47	-2.48	-2.46	-2.47
Transmitter DQPSK (Modulator 1)	-2.59	-2.61	-2.59	-2.58
Multiplexer (4x1)	-2.66	-2.68	-2.66	-2.65
10 Km Fiber Length	-4.67	-4.68	-4.66	-4.65
De- Multiplexer	-4.74	-4.75	-4.74	-4.72
Splitter for Re-Modulation (1x2)	-7.75	-7.77	-7.75	-7.74
Receiver (Total Loss)	-9.00	-8.99	-9.00	-9.01
Receiver Sensitivity	-31.25	-33.0	-32.75	-34.25
Budget Margin	22.25	24.01	23.75	25.24

In figure 2 graphical representation of power dissipation at each stage of the network and power budget margin has been shown at downstream channels.

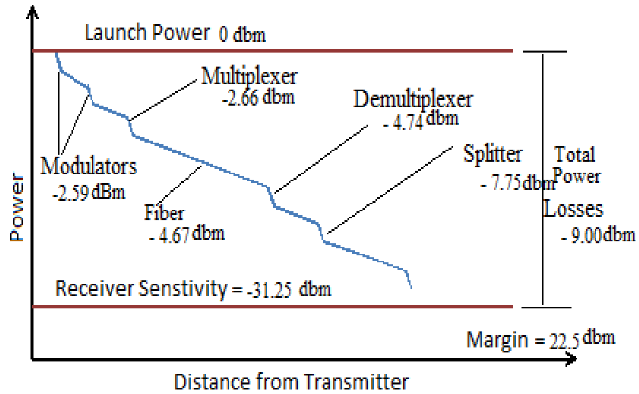

Figure 2: Graphical Representation of Power Budget Margin

Table 3: Power Budget Analysis of IRZ Upstream Channel.

Transmission Stage	Received Power (dBm)			
	Channel 1	Channel 2	Channel 3	Channel 4
Optical Filter	-25.27	-29.51	-26.14	-24.37
Mech-Zehnder Modulator	-34.43	-38.67	-35.31	-33.54
Multiplexer (4x1)	-34.46	-38.70	-35.35	-33.58
10 Km Fiber Length	-36.46	-40.70	-3735	-35.58
De-Multiplexer (1x4)	-36.50	-40.73	-37.38	-35.61
IRZ Receiver (Total Loss)	-42.00	-40.33	-36.98	-35.21
Receiver Sensitivity	-44.5	-45.25	-43.5	-45.00
Budget Margin	2.5	4.92	6.52	9.79

In figure 3 graphical representation of power dissipation at each stage of the network and power budget margin has been shown at upstream channels.

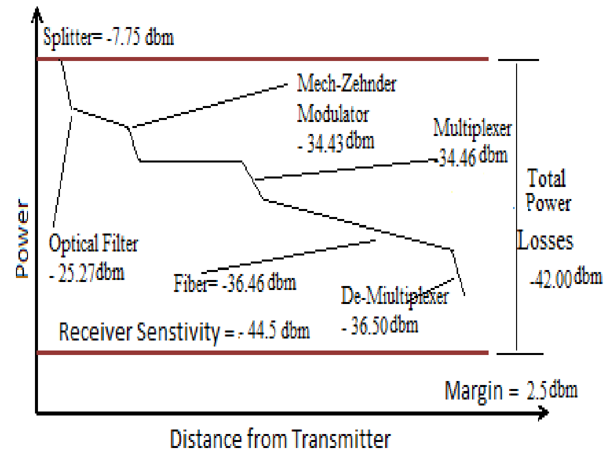

Figure 3: Graphical Representation of Power Budget Margin for Channel 1 in Upstream.

Conclusion: In this research, power budget margin of four channels WDM-PON has been analyzed. It has been observed that, in all downstream channels and upstream channels power budget margin is suitable to transmit the data at the rate of 40 Gbps for DQPSK downstream channels and 10 Gbps for IRZ upstream channels up to the distance of 10 Km.

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