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SIMULATION AND PERFORMANCE EVALUATION OF OTDM IN OPTICAL COMMUNICATION SYSTEM

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ABSTRACT

There is always a need for speed and highly efficient networks which can exploit the existing fiber optic links. For this fiber optic communication technology has been massively developed along with the development of new capacity enhancing components. From time to time several promising solutions have been devised such as signal multiplexing in wavelength, polarization, frequency, code and time. Amongst many of these multiplexing methods Time Division Multiplexing has enormous transmission capability. It can be realized in two ways; one is by Electrical Time Division Multiplexing and other is by employing TDM into optical domain, Optical Time Division Multiplexing. OTDM is a very powerful optical multiplexing technique that delivers very high capacity of data over an optical fiber. The basic principle of this technology is to multiplex a number of low bit rate optical channels in time domain. In this project an optical time division multiplexing link is simulated, along with an OTDM link using MZI switching. In order to determine the maximum transmission performance the link has been designed at different data rates of 20 Gbps, 30 Gbps, 40 Gbps, using different fiber standards.The Bit Error Rate for different lengths, modulation formats and fiber standards have been obtained and the performance has been analysed for the OTDM link. The effect of power on BER has also been analysed. An OTDM Passive Optical Network has also been analysed using different data rates, different number of users, direct and external modulation. The simulation is done by using Optisystem(15.0) software.

Keywords :Time Division Multiplexing (TDM); Optical Time Division Multiplexing (OTDM) ; ElectricalTime Division Multiplexing, Bit Error Rate (BER); Gbps(Giga bytes per second),Q-Factor.

I.INTRODUCTION

Fibre optic communication has revolutionised the telecommunications industry. It has also made its presence widely felt within the data networking community as well. Using fibre optic cable, optical communications have enabled telecommunications links to be made over much greater distances and with much lower levels of loss in the transmission medium and possibly most important of all, fiber optical communications has enabled much higher data rates to be accommodated.Future multi-terabit/s optical core networks require optical technologies capable of managing ultra-high bit rate OTDM (optical time division multiplexing division multiplexing channels at 160 Gbit/s or higher bit rates. OTDM (Optical Time-Division Multiplexing) is a very

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powerful optical multiplexing technique that deliveries very high capacity of data over optical fiber. The basic principle of this technology is to multiplex a number of low bit rate optical channels in time domain. The key functionalities in ultrahigh speed network nodes are all-optical wavelength conversion and demultiplexing of OTDM signals. Advanced optical networking techniques are studied in simulations and their performance evaluated considering 160 Gbit/s OTDM channels.

Optical time-division-multiplexing (OTDM) is an important technique to overcome the electronic bottleneck and achieve single channel high bit-rate system [1]. The commercially available electronic components are limited to around 10Gb/s data rate. The first 100-Gb/s OTDM transmission experiment over a 36-km fiber link was already reported in 1993, OTDM was first demonstrated as early as 1968, primarily as means to increase the capacity of an optical link. OTDM technologies have made a lot of progress toward much higher bit rates and much longer transmission distance. For example, 160-Gb/s transmission.over a record length of 4320 km and on 2.56-Tb/s transmission over 160-km have been reported [2]. Overall, successful demonstration of OTDM up to 400Gb/s has brightened the future of commercial OTDM. This system has the advantage of operating only on a single wavelength. It is possible of running OTDM on a number of existing WDM channels, which improves the overall data capacity. It is purely digital and compliant with the concepts of all-digital network. With rapid advancement in semiconductor technology and integration techniques, it will eventually make possible to manufacture compact, stable and higher performance components for commercial OTDM system.As a result of these advantages, fibre optic communications systems are widely employed for applications ranging from major telecommunications backbone infrastructure to Ethernet systems, broadband distribution, and general data networking

II. DESIGN METHODOLOGY

Optical Time Division Multiplexing (OTDM) is a scalable and powerful technique for investigating high-speed data transmission systems, associated signal processing and monitoring techniques at serial data rates far away from the bandwidth limitation of electronics. As compared to the Wavelength Division Multiplexing (WDM), only single wavelength (color) of light is used. An OTDM system includes a multiplexer at the transmission side and a demultiplexer at the receiving side. The multiplexer (MUX) brings together the bit stream with higher bit-rate from the base band streams, whereas the demultiplexer (DEMUX) rebuilds bit streams at the basic lower bit rate by bit separation in the multiplexed stream.

OTDM transmits multiple data channels in the form of ultra-short duration optical pulses which are interleaved into a single high-speed data stream by accurate control of their relative delay in the time domain. At the receiving end, an optical gate is used to extract one base rate tributary from the aggregate data stream for subsequent processing. Although such systems can potentially operate at speed much higher (>100Gb/s) than that limited by electronic components, several technologies are required to realize high speed OTDM systems.These include high repetition rate ultra-short pulse sources, high speed demultiplexing and clock recovery. Some of these technologies are still at the research stage. OTDM is an effective way to increase the transmission capacity of a fibre system. Compared to conventional WDM transmission systems, it may offer several advantages.

2.1 BLOCK DIAGRAM OF OTDM

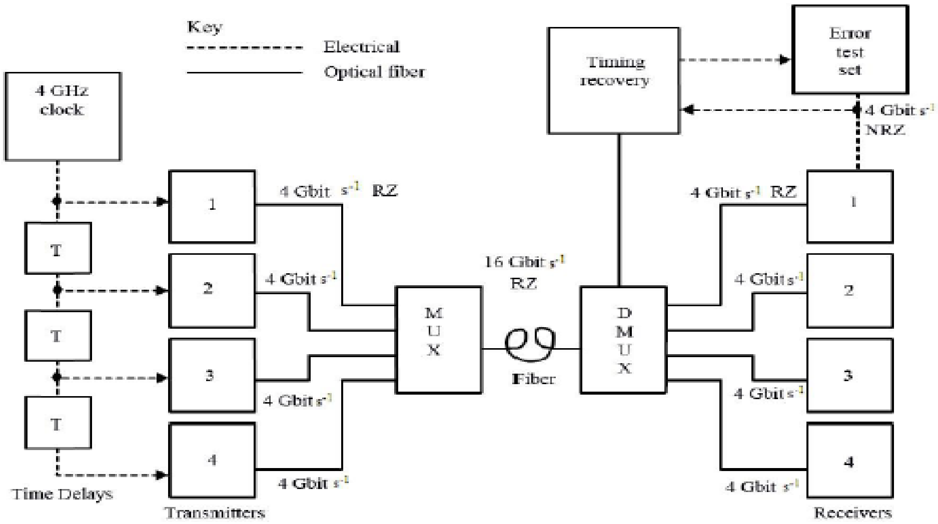

Fig 1.Block diagram of OTDM

These include high repetition rate ultra-short pulse sources, high speed demultiplexing and clock recovery. Some of these technologies are still at the research stage. OTDM is an effective way to increase the transmission capacity of a fibre system. Compared to conventional WDM transmission systems, it may offer several advantages

1.In terms of transmission performance, since only one wavelength is used in a pure OTDM system, the gain tilt problem and dispersion tilt problem associated with wide-band WDM transmission can be eliminated. Also, the major limiting nonlinear effects for WDM systems, such as Four Wave Mixing (FWM) and Stimulated Raman Scattering (SRS) can be avoided.

2. OTDM is not incompatible with WDM. For point-to- point applications, OTDM can be used to increase the data rate of WDM channels to reduce the overall of the system. This is also a potential approach for enhancing the spectral efficiency for WDM system.

3. By manipulating data in the electrical domain, a carefully organized OTDM transmission system may provide a truly high-speed low-latency data link with maximum parallelism. This may have important applications in both the distributed computing industry and scientific acquisitions.

III. SIMULATION DESIGN AND IMPLEMENTATION

The simulation layout for the analysis of an OTDM link is mainly consists of four parts , the transmitter, control signal, Symmetrical Mach-Zahnder interferometer (SMZ) and receiver. Transmitter consists of PRBS generator, mode locked laser, electrical generator, time shifting blocks, optical multiplexer and an optical normalizer.

Multiple channels from the laser are modulated with PRBS patterns and hence generate multiple output patterns, with every one dissimilar from the other one and at the same bit rate. It is designed for four channels operating on the same wavelength 1550 nm and with dissimilar pseudo random bit sequence (PRBS) modulated with NRZ and RZ modulation. After the modulation process, every channel is delayed. Data and control signals are multiplexed and delayed signals co propagate and time delay between two control pulses is equal to the switching window duration

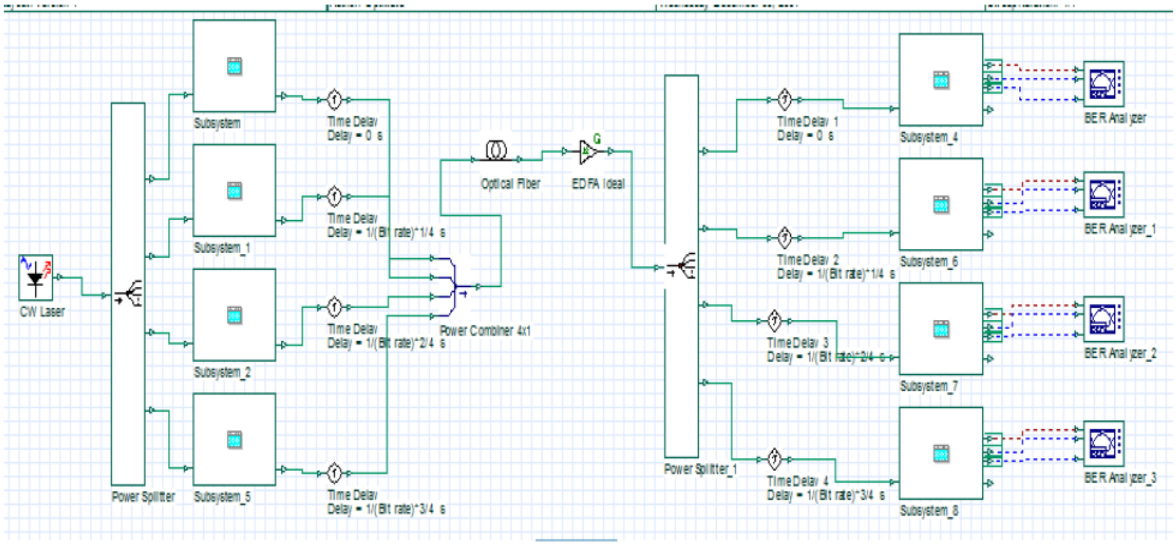

Fig 2. A proposed four users system OTDM

The demultiplexer used switch having two arms. Each arm has optical couplers and semiconductor optical amplifiers. The outputs are switched using optical control pulses generated with suitable delays so that the desired channel is selected. Further channel and control power levels are fixed by the Optical normalizer and polarizer selects the signal with matching polarization. A polarization or wavelength filter is used at the output to reject the control signal and to pass the data signals. OTDM system will be evaluated here fordifferent bit rates and lengths of SMF. The proposed 4 users OTDM system is CW laser diode with a frequency of 193.1 THz is used. The splitter divides the optical power between the four OLTs. Each subsystem included in the OLT consists of a PRBS generator at a specific rate and a AM modulator. In each branch there is a time delay with time of [(1/bit rate)* i/N)] where i = 0, 1,…, N-1. So each user capable of transmitting information at a specific time slot. Then combining the output from each user by the optical power combiner and sent through a single mode fiber SMF. At the end of the SMF of variable length, the multiplexed signal is amplified by an erbium dopped fiber amplifier EDFA. The emerging signal is splitted and distributed among the ONUs at the receiver side and time delay unit is used at each ONU in order to synchronous with that of the OLT. Each user is allowed to access the network at certain time slot with delay time which limits the throughput of each user. Then, the signal is detected and demodulated at each channels to extract the original information.

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IV. RESULTS AND ANALYSIS

The performance of OTDM system will be evaluated here for different bit rates and lengths of SMF. The proposed 4 users OTDM system is shown in Figure (5). A CW laser diode with a frequency of 193.1 THz is used. The splitter divides the optical power between the four OLTs. Each subsystem included in the OLT consists of a PRBS generator at a specific rate and a RZ Machzehnder modulator. In each branch there is a time delay with time of [(1/bit rate)* i/N)] where i = 0, 1,…, N-1. So each user capable of transmitting information at a specific time slot. Then combining the output from each user by the optical power combiner and sent through a single mode fiber SMF. At the end of the SMF of variable length, the multiplexed signal is amplified by an erbium dopped fiber amplifier EDFA. The emerging signal is splitted and distributed among the channels at the receiver side and time delay unit is used at each channel in order to synchronous with that of the OLT. Each user is allowed to access the network at certain time slot with delay time which limits the throughput of each user. Then, the signal is detected and demodulated at each channel to extract the original information.

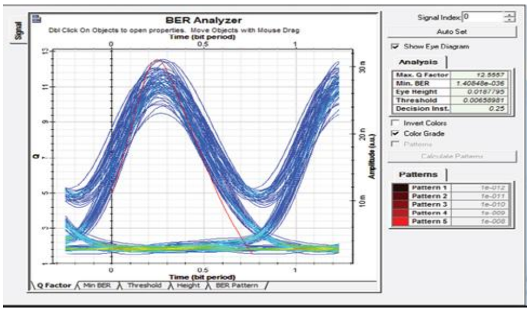

Fig 3.Output of OTDM

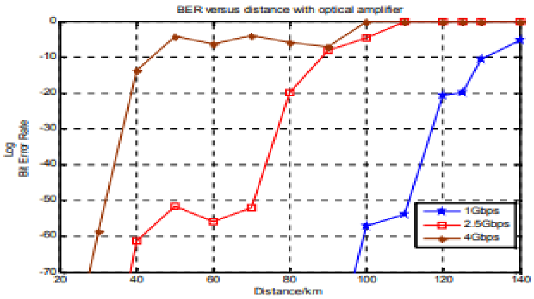

Fig 4. BER versus distance with optical amplifier

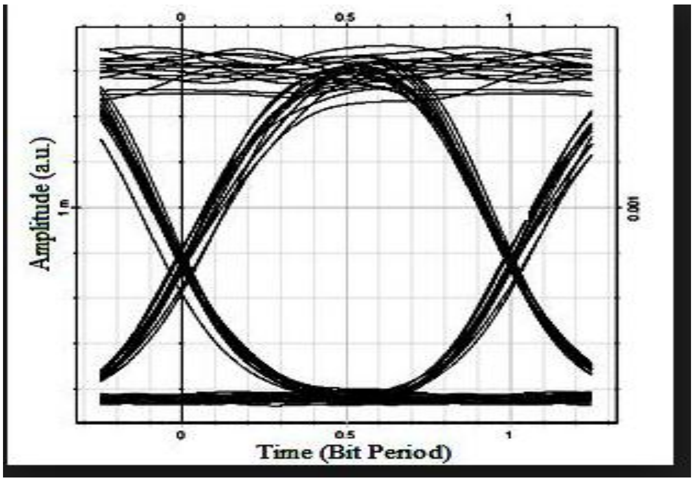

Fig 5. Eye diagram at 160 Gbps

V. CONCLUSION

The proposed 160 Gbps OTDM access network was designed using four users each transmitting at 40 Gbps has been successfully evaluated in this research work. The system operated over a distance of 352.89km with a BER of 10-10 . In OTDM, the performance depends on both bit rate and length of the fiber as the bit rate increased the BER of the system decreased. The use of the EDFAs enhances the system performance and the link length.

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