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Design and Survey of Optical Time Division Multiplexing for Very High Bit-Rate Transmission

Mohammad Umar Ansari[1], A. Ashok[2], A.K. Jaiswal[3], A. Masih[4]

M.Tech Student, Dept of Electronics & Communication Engineering, SHIATS, Allahabad (U.P.), India[1]

Assistant Professor, Dept of Electronics & Communication Engineering, SHIATS, Allahabad (U.P.), India[2]

Professor, Dept of Electronics & Communication Engineering, SHIATS, Allahabad (U.P.), India[3]

Assistant Professor, Dept of Electrical & Electronics Engineering, SHIATS, Allahabad (U.P.), India[4]

Abstract: Optical time division Multiplexing (OTDM) is well known techniques of Electrical time division multiplexing into optical domain. Time multiplexing is used to construct optical streams in OTDM. In this paper, an overview of recent work show the multiplexing and de-multiplexing of incoming data. In this, lower bits (10GBits/S) constructed to a higher bits i.e. (40GBits/S) by multiplexing process. The pulses streams are delayed with respect to one another using delay element. The Delay streams in picosecond order. The de-multiplexing reconstructs the bit streams at the original bit rate (10GBits/s) by separating bits in the multiplexed streams. The Bits are transmitted over long distance using single fiber. In this paper we verified by the results that at the receiver end each bits are separated and show their property such as Q factor, Power, Wavelength, Power Penality etc. On Increasing distance that will decreased power penality means at the receiver end the noise is decreased. Data is transmitted 80 Km using single mode fiber.

Keywords: AM Modulator, NRZ Pulse, Multiplexer, De-multiplexer, loop control, EDFA, Clock recovery.

1. INTRODUCTION

There are the two main approaches used for optical multiplexing. One is optical wavelength division (frequency division) other is optical time division Multiplexing. This paper deals with optical time division Multiplexing.

In optical time division Multiplexing (OTDM), a high bit rate streams constructed directly by time multiplexing of several lower bit rate. At the receiver end of the system very high bit rate data streams de-multiplexed into the lower bit streams before detection and conversion to the electrical signals. This is used for very high data transmission. The technique of time division Multiplexing is purely digital technique. OTDM offer design flexibility, adjustable bandwidth allocation in different baseband channel and simple architecture. This paper also describe the multiplexing & de-multiplexing of the high data bit using new devices due to which losses are decreased. This paper includes the transmission of 4 channel 10Gbits/s data and receives 40Gbits/s data. A clock recovery is used to provide the synchronization between the bits. Data is transmitted over 80 Km using single mode fiber.

1.1 optical time division Multiplexing

This paper is totally based on the optical time division Multiplexing. Time division Multiplexing based on the three sub section: sampling, timing and combining. The sampling function takes sample of the incoming bit. Timing function ensures that the samples are available at the correct time slots on the multiplexed channel. The combining (multiplexing) of all the sampled baseband data streams to generate the higher bit rate multiplexed data stream.

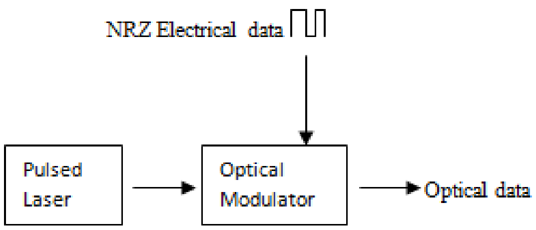

Fig1 Schematic of an E/O converter that sample input data

Fig.1 shows the conversion of an electrical to optical. Signal from Laser diode and electrically data stream i.e. NRZ is incident on an optical modulator (AM Modulator). When the laser and input data are correctly timed, then the modulator is converting the signal into optical signal.

Before the multiplexing operation is performed the incoming bit streams are temporally offset from one another by delay for four channels i.e. 25ps, 30ps, 35ps, 40ps. 4*1 multiplexer is used in this paper. And it assembles the higher bit stream from the baseband signal. It also reduces crosstalk.

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1.2 De-multiplexer

The purpose of de-multiplexer is to direct each bit of the arriving multiplexed bit stream to the appropriate O/E converter. 1*4 de-multiplexer is used.

1.3 Clock Recovery

Generally there is no electrical signal available at the multiplexed bit rate. Therefore a clock signal is given at the de-multiplexer to generate an electrical signal. It provides synchronization between the bits and also reduces crosstalk.

2. EXPERIMENTS

We proposed and simulate the multiplexing and de-multiplexing of high bit data over single mode fiber, Fig 4 shows the block diagram, of 4 channels OTDM, The transmitter section consists of the laser diode with frequency 1550 nm. This section consists of pseudorandom pulses, NRZ, AM Modulators and Optical delay. A laser source produces regular streams of light i.e. 1550nm, Pseudorandom generate the 10Gbits/s pulse with their repetition rate. In the transmitter section the electrical signal convert to optical signal by AM Modulator.

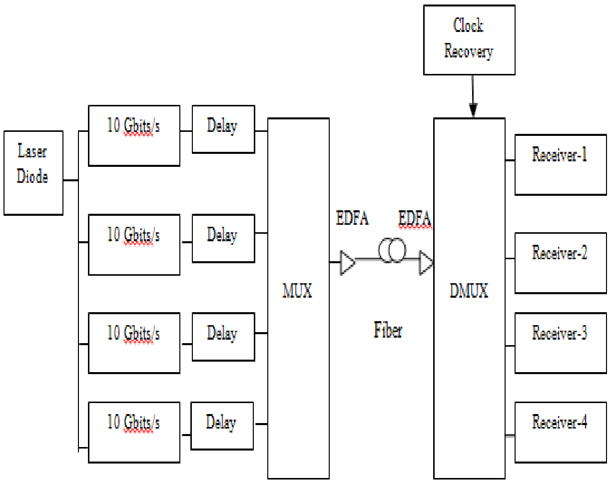

Fig 2 Block Diagram of 4 channel OTDM System

Each of these channels can be modulated independently by an electrical tributary data source at a bit rate, The modulated output are delayed individually by different fraction of the clock period and are then interleaved through an multiplexer to produce an aggregate bit rate N*B Where N is the no of channel an B is the repetition rate, The signal is then transmit through the optical fiber. Loop control is used to increase the length of the fiber for the transmission in a very high distance. For amplification two EDFA is used. These works as a preamplifier and post amplifier. These are include in the link to compensate for splitting and attenuation losses. Pre EDFA amplified before photo detection so that the signal to noise ratio degradation caused by thermal noise in the receiver. It also provides a larger gain factor and a broader bandwidth. These amplifier also increase the power level of the signal. Both EDFA works on C band i.e. 1530 to 1560nm. The receiver section consists of the De-mux and clock recovery. Since in OTDM there is no electrical signal available. It generates the electrical clock signal with the bit rate 10Gbits/s. This technique provides the low crosstalk. Clock recovery at the receiver to drive and synchronize the de-multiplexer. At the receiver end the 40Gbits/s pulses are de-multiplexed in to the original data channel for subsequent electronics signal processing. At the receiver end we see the output in the form of optical spectrum, eye diagram which satisfied that at transmitter and receiver end the signal in combine and split.

3. SIMULATION AND DESIGN CONSIDERATION

3.1Design of Transmitter section

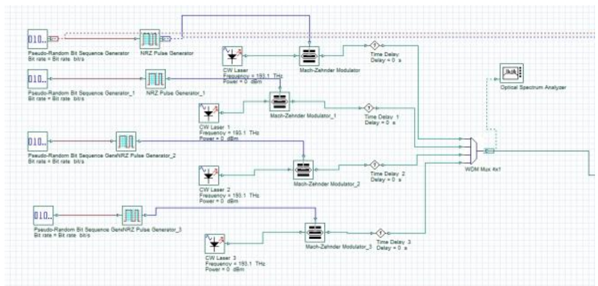

Fig 3 Transmitter section of OTDM

Fig shows the transmitter section we have analyzed the spectrum of these four signals after multiplexing signal. The four data bits i.e. 10Gbits/s is modulated with carrier signal whose frequencies 1550 nm. Each transmitted bits are delayed at a particular time period and this time period is picoseconds range.

The electrical signal is converted in to the optical signal using AM modulator and this optical signal is repeated at a particular repetition period. The lower bit signal is multiplexed and converted in to the higher bits i.e. 40Gbits/s.

3.2 Design of Receiver Section

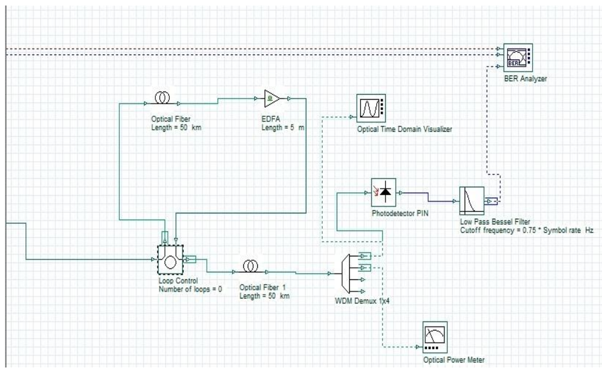

Fig 4 Receiver section of OTDM

The receiver section consists of the Demux and clock recovery.. The receiver generates a clock from an approximate frequency reference this process is commonly

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known as **clock and data recovery** (CDR). It is very closely related to the problem of carrier recovery. It generate the electrical clock signal with the bit rate 10Gbits/s. Clock recovery provide the synchronization between the clock. At the receiver end by the different visualizer like eye diagram, optical spectrum etc. we differenceated the each bit.

4. RESULT AND DISCUSSION

4.1Wave Length Spectrum of Multiplexed Signal

The spectrum of the multiplexed signal shown in the fig. the graph is drawn between the Wavelengths (in m) versus Power (in dbm). From the figure we observe the peak power of the multiplexed signal obtained at wavelength 1550 nm. In this spectrum all the lower bits are muxed which is shown in fig. Small lines show the presence of other signal.

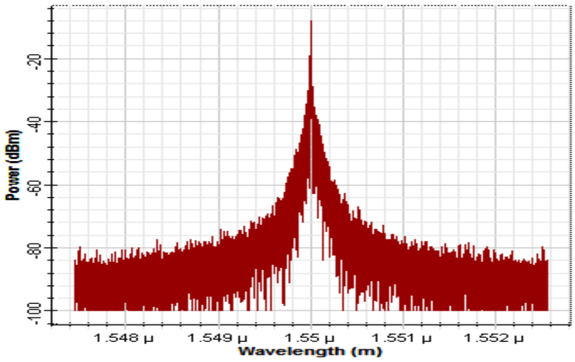

Fig 5 Spectrum of multiplexed signal

4.2Wave Length Spectrum of De-multiplexed Signal

From the spectrum it is clear there is very little noise is generated. The frequency is obtained at 1550 nm. In the multiplexer side optical spectrum show the noise. Fig shows that at the receiver side bit is de-multiplexed with the peak power obtained at 1550 nm which is laser frequency.

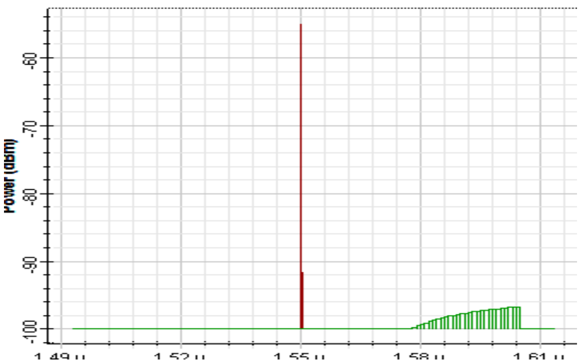

Fig 6 Spectrum of de-multiplexed signal

4.3Eye diagram of Multiplexed Signal

Fig. shows the eye diagram of multiplexed signal. From figure we conclude that eye height is good but at the upper side signal is distorted. Jitter is good & quality factor is also very good i.e. 98.54.

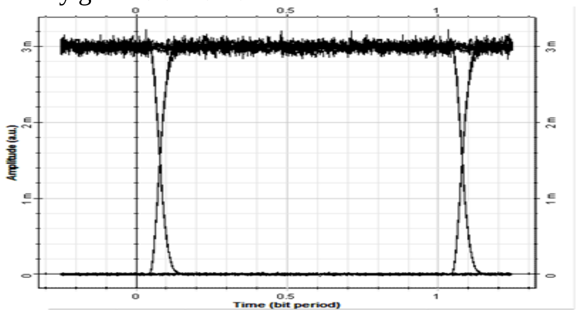

Fig 7 Eye diagram of multiplexed signal

4.4Eye Diagram of De-multiplexed Signal

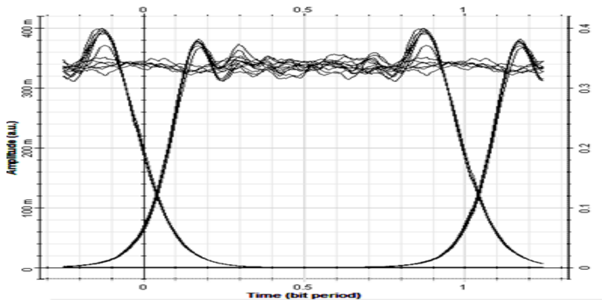

Fig 8 Eye Diagram of Receiver signal

Fig. shows the eye diagram of demultiplexed signal. From the fig it is clear that there is less distortion created in the receiver side. Fall and rise time clear from the fig. Overshoot is clear but Q factor is reduced i.e. 82.78.

4.5 Power penalty

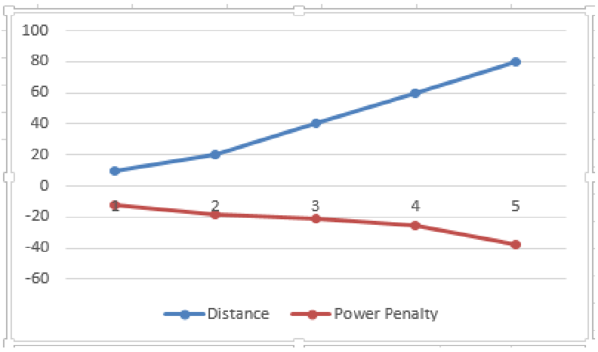

Fig 9 Power penalty verses Distance

The reduction in SNR is known as the power penalty. The optical power falling on the photo detector is a defined of time within the statistical nature of quantum detection process. When any of the impairment effects are present in a link, there is a reduction in the signal to noise ratio (SNR) of the system from the ideal case. The main power penalty is due to the chromatic and polarization mode dispersion, model and speckle noise. From the fig we concluded that as well as distance is increased power penalty reduced means the noise in also reduced in receiver side.

Power Penalty = -10 Log SNR (Impair)/SNR (Ideal).

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5. CONCLUSION

OTDM is used for multi gigabit per picoseconds point to point transmission system. We have shown that multiplexing, de-multiplexing and timing recovery can be achieved without the need for very wide bandwidth electronics and have demonstrated a transmission bit rate that is higher than in any previous time multiplexed system.

In this paper we describe several theory, different graph and different fig. From this we concluded that

1) In this paper 40Gbits/s signal is transmitted over 80 KM distance.
2) Optical spectrum is shown that at the multiplexer side signal is combined and noise is generated but at the receiver side multiplexed signal is split and noise is also very less.
3) Eye diagram shown at the multiplexer side there is difficult to see the difference between under and overshoot but at the receiver side it is clear.
4) Power Penalty show as well as distance is increased noise is reduced so this system is useful for high distance.
5) Optical amplifier is also attractive for compensating the accumulated losses in de-multiplexes side.
6) Q factor is also reduced as well as distance increased means there is some dispersion produced in the fiber.

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