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A Review on Optical Time Division Multiplexing

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Abstract: The optical time-division multiplexing (OTDM) incorporates and expands the techniques of time division multiplexing (TDM) in the optical domain. In the OTDM, building of the optical data streams is done by multiplexing a variety of optical streams with a lower bit rate. Researchers have focused on approaches based on Wavelength Division Multiplexed (WDM) in which the wavelength of the light is utilized as the degree of freedom to provide a route to the signals using the optical selection or filtering stages. An extensive investigation has been done on the use of the wavelength not only for closed user broadcast networks but also for the single as well as multihopping transport networks. We hereby present a summary of the recent works on the optical time-division multiplexing (OTDM) and de-multiplexing. We define the design considerations that emphasis on factors that restrict the system performance. These design considerations include multiplexed channel cross-talking that that affect system architecture.

Keywords: Multiplexing, OTDM, WDM, EDFAs, optical sources, time division multiplexing, lasers, multiplexers.

INTRODUCTION

The reason for OTDM [1] and WDM [2] systems to be primarily operated in 1.55 pm transmission window relies on the availability of EDFAs [3] called as Erbium-Doped-Fiber-Amplifiers, preferably the favor dispersion shifted fiber, and this is because of the need of the low fibre chromatic dispersion for maximizing the system lengths. However, the concepts of OTDM apply equally to the 1.3 pn range.

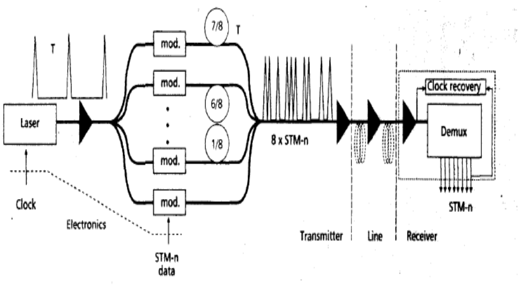

Fig. 1: Representation of an OTDM Transmission System

OPTICAL SOURCES

In order to allow demultiplexing [4] with the low interchannel crosstalk [5], there is a need for OTDM transmission systems to be operated with the optical pulses significantly below the permitted time slot length so as to allow the demultiplexing that considers low interchannel crosstalk. An improvement over this is to use long systems in the case where soliton transmission is needed.

This means that somehow the source will produce relatively short optical pulses, usually of a very low lops length, for a device operating at more than 40 GB / s. Furthermore, the pulses must be a spectrally pure so that the reason of interaction between the source chip and the fibre chromatic dispersion, minimizes the pulses.

The definition of figure of merit [6] of pulses is defined as the product of time-bandwidth. Ideally, the value of "transform limited" value is 0.32-0.45

for the time bandwidth product. This is dependent on the shape of the pulse.

Figure 2 shows a diagram of an OTDM based transmission system for (N=8) channels. A train made up of optical clock pulses that are of picosecond (ps) length from an appropriate laser source is actually split into N ways. There is a modulation of each train due to a tributary of electrical data signals (e.g., STM-17) independently, hence resulting in N optical RZ data channels.

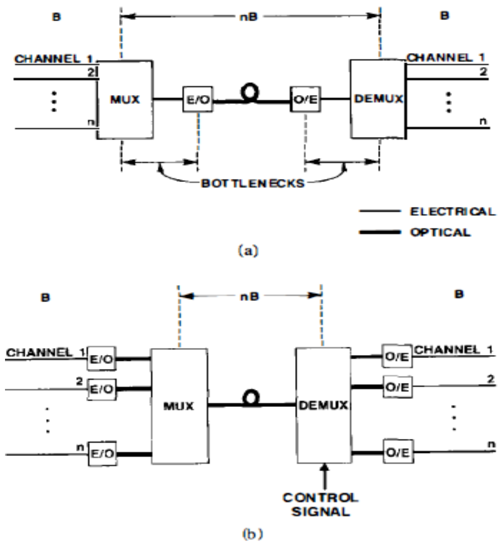

Fig.2: Time Division Multiplexing of Light Wave Systems (a) Electrical, (b) Optical

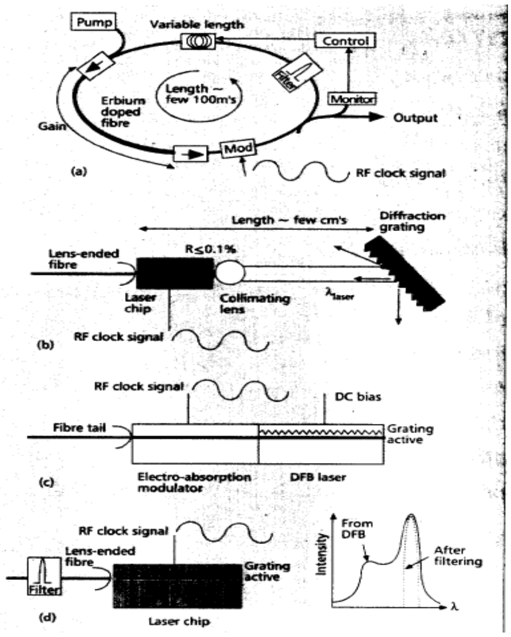

Fig.3: Representation of Different Sources of PS Pulses Employed In OTDM Systems

Fig. 3 shows the similarities and disparities between multiplexed light-wave systems that are electrical and optical in nature. In this diagram as well as in the following figures, thick lines are used for the optical (fibre) signal path and the thin lines are used for the electrical signal paths.

Usually, an electrically time-multiplexed system uses electrical domain to carry out the process of multiplexing [7]. This is done before the process of electrical-to-optical (E / O) conversion. Demultiplexing takes place after the process of optical-to-electrical conversion (0/E).

MULTIPLE LASER SYSTEMS

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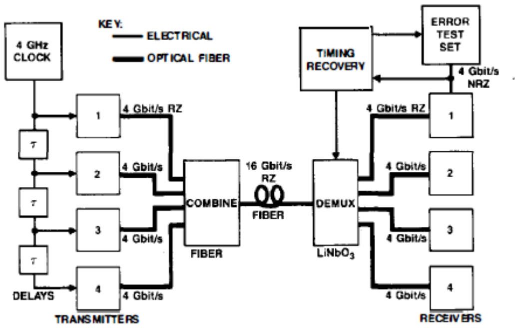

Fig. 4: Block Diagram of A 4 Channel OTDM System

Using the multiple and laser [8] architecture presented in figure 4 of this article, the data that is obtained from the two experimental systems is presented. In one system, baseband channels are utilized and in the other one four baseband channels are utilized. The base-band data rate for both the systems considered here is 4 Gbits/sec.

A common clock of 4 GHz drives its four transmitters through a series of microwave [9] dependent delay lines that are actually adjusted to ensure that the optical pulses are timed correctly. Just two transmitters have been used in this type of the two-channel system. This is clearly reported in the transmitter shown in figure 5.

Since the clock drives not only the laser but also the word generator, that ensures the synchronization of the electrical data with the optical pulses. In the above mentioned experiments, the laser used is of the type of an extended fibre-cavity. In a fibre, all the lasers have zero first-order wavelength of chromatic dispersion [10] within the range of 8 nms. Four multiplexed lasers had a combined spectral range of 10 nms.

Due to economic reasons, modulation with the pseudorandom data is modulated with just a single channel. Different combinations of periodic 4-GHz and 2-GHz capacity pulse trains are used to simulate the data on three other channels for economic reasons.

Figure 5 illustrates a demultiplexer and its associated electronics in the form of a block diagram. The first switch consists of a 5 mllimeters long fiber-pigtailed Ti: LiNb03 that is actually a traveling-wave that is called a reversal directional coupler toggle and is powered by a sinusoidal voltage based control of 8 GHz.

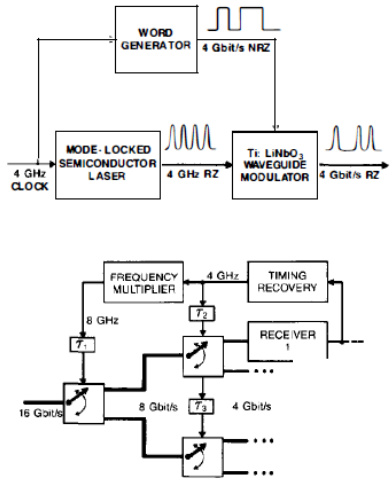

Fig.5: Block Diagram and Electronic Circuitry of a Demultiplexer

CONCLUSION

We have briefed on the possibility of optical amplifiers being used in the OTDM systems. The Optical amplifiers provide exciting opportunities through the compensation for losses to improve the performance of a system and its flexibility.

For increasing the transmitted power in the systems, they are found to be particularly attractive. This is done using single laser transmitters that utilise a split and recombine architecture for the multiplexing of many baseband channels.

Moreover, traveling-wave based optical amplifiers have been shown to amplify the pulses having high repetition rate and picoseconds and that too without any distortion, but still, there are several areas yet to be investigated until the full capacity and constraints of the optical amplifiers in the OTDM systems could be assessed.

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