Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 04, April-2023

A Review on OTDM Transmission

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***Abstract*— Optical Time Division Multiplexing (OTDM) is one of the efficient ways to increase optical communications' transmission speed. Researchers in optical communications employ an optical technique to transform higher-rate electric time division-multiplexing signals into optical signals. The restricted pace of electronic communication is solved by the OTDM system. In this study, we have reviewed the OTDM transmission. We have tried to analyze the performance of the system and figure out how it achieves effective and dependable data transfer, satisfying the rising need for high-speed optical fiber communications bandwidth.**

Keywords—Optical Time Division Multiplexing System (OTDM), Differential Phase-Shift Keying (DPSK), Opti System, Mach-Zender modulator

I. INTRODUCTION

Throughout the previous generation, optical fiber communication has advanced significantly along with the invention of new components to increase capacity. There has been an unstoppable demand for fast, highly efficient network systems that can make use of the current optical fiber lines. Broadband communication services are becoming more and more in demand, necessitating telecommunication networks with line capacity much in excess of those of the available facilities. Even if the maximum data rate for commercially available electrical components is 10 Gbps, there is still a chance to increase the system data rate by using other multiplexing techniques [1]. Several intriguing methods, including signal multiplexing techniques such as wavelength division multiplexing, frequency division multiplexing, code division multiplexing, and time division multiplexing, have been developed. In optical networks, data transmission can be primarily accomplished through the use of time and wavelength division multiplexing. One of the most suitable methods that are utilized to use the enormous amount of accessible bandwidth of the optical fiber is wavelength-division multiplexing (WDM). Every particular wavelength in WDM supports a particular communication channel that operates at maximum electrical speed. The transmission bandwidth is split into wavelength bands that are non-overlapping. Consequently, the enormous bandwidth may be used by enabling numerous WDM channels to transmit signals simultaneously on a single fiber[6]. Notwithstanding the benefits indicated above, there are some drawbacks as well. The emergence of fiber nonlinearities is one such drawback. Typically, each channel needs roughly 1 mW, and when numerous channels are used, the fiber is pumped with several milliwatts. The development of various nonlinear effects such as Stimulated Raman scattering (SRS), Stimulated Brillouin Scattering (SBS), Cross Phase Modulation, and Four-Wave Mixing, is a result of such high powers. The performance of the system degrades as a result of these nonlinear effects [1]. Traditional multiplexing methods include Time Division Multiplexing (TDM). The shared channel in TDM is split up using a time slot for the user. Each user is limited to sending data during the allotted time period. A frame of the ideal size may be communicated in a particular time slot because digital signals are segregated into frames, which are comparable to time slots[2]. TDM, however, has a few shortcomings. One of the largest is that multiplexing is only possible with current electrical technology up to roughly 15Gbps [1]. Therefore, an alternate optical multiplexing technique, such as OTDM, is the right choice.

II. OPTICAL COMMUNICATION SYSTEM

The transmitting block sends the signal, and the receiving block suitably performs the signal reception by converting the signal to the required form. This setup makes up the majority of the simplest sort of communication system. Wire, coaxial cable, or optical fiber can all be used as a system's communication channel. The world of communications underwent a tremendous change with the invention of the telephone in 1876, and for many years, twisted pairs of wires in metallic cables served as the preferred medium. The metallic wires reached their saturation as the increase in the need for telephone facilities boomed, and it became imperative to discover a different medium to meet the need. In 1977–1978, the first feasible fiber systems for commercial deployment were finally created. The following fundamental steps are involved in fiber-optic communication: the process of creating an optical signal, and transmitting it, sending the signal down a fiber, preventing it from getting dispersed, the reception of the signal, and converting it into its original electrical form using a photodetector.

A. Need for Optical fibers

A system that uses optical fibers for connecting to a network or other devices is known as an optical network. An optical system must also include various optical components for the conversion of signals from one form to another after they have been sent across fibers, and guide optical signals through the network in order to support data communication. Essentially, optical networks are those networks that use optical fiber as their primary physical layer technology for transmission. The optical networks can be of two forms that are, single-wavelength or dense wavelength division multiplexing, opaque or all-optical, or any combination of these (DWDM). The advantages of optical fibers are Low signal attenuation, a wide bandwidth, allows for transmission over great distances without the need for repeaters, resistance to electromagnetic interference, good signal security, lack of crosstalk and interferences between fibers of the same cable, and very less signal distortion.

B. Need for Multiplexing

Many applications are now possible because of multiplexing. Particularly in the area of communication, this is significant. In order to make the transmission cost-friendly, multiplexing is a perfect alternative for the utilization of bandwidth effectively. The practice of multiplexing involves integrating several analog or digital signals, sometimes from sluggish equipment, onto one extremely quick communication channel [5]. Frequency-Division Multiplexing (FDM) and Wavelength-Division Multiplexing (WDM) are mainly used for analog systems whereas the third method time division multiplexing is used for digital signals. TDM can be applied in two different ways: by using electrical multiplexing, or electrical time division multiplexing (ETDM), and by using optical time division multiplexing (OTDM).

III. OPTICAL TIME DIVISION MULTIPLEXING

The fundamental idea behind optical time-division multiplexing is the distribution of a set of time slots to each baseband data stream on a single channel. The desire for faster speeds and more capacity is always rising due to the Internet's explosive data expansion, which has resulted in a sharp increase in interest in optical time division multiplexing. The electrical bottleneck provided by modern electronic components can also be bypassed through OTDM. OTDM sends many data channels as ultra-short duration optical pulses that are bit-interleaved or packet-interleaved into a single high-speed communication channel by precisely controlling their relative delays in the time domain. This differs from WDM, which multiplexes in the frequency domain. Each channel of a particular time slot is extracted at the receiving end using an optical gate for further processing. Many technologies are needed to implement highspeed OTDM systems, even though such systems have the ability to run at speeds far greater (>100Gb/s) than those constrained by electrical components [1].

A. Transmitter

An essential element of an OTDM transmitter is the pulse source. A highly stable and controlled repetition frequency and wavelength must be provided by the pulse source [4]. A pulse width considerably smaller than the multiplexed data signal's bit period, a timing jitter much smaller than the pulse width, little amplitude noise, and a high extinction ratio are also requirements. However, there are additional conditions of the pulse source which are to be met if a phase-modulation format like DPSK or DQPSK is utilized. For instance, the pulse source must be extremely consistent when it comes to carrier phase and wavelength. Lithium-Niobate (LiNbO3) modulators are most typically utilized in OTDM investigations to modify the generated pulse train. Only a small number of OTDM tests used EAMs[3]. LiNbO3 modulators have modulation properties that are highly broad (up to 80 GHz) and barely affected by wavelength in the 1.3 to 1.5 m region. Moreover, a push-pull-operated LiNbO3 Mach- Zehnder modulator is used in DPSK and DQPSK systems to achieve a nearly perfect phase shift.

B. Receiver

For demultiplexing, various optical gates have been employed. The majority of optical gates are fiber-based and use cross-phase modulation (XPM) or four-wave mixing (FWM) in fibers at data rates greater than 160 Gb/s [4]. The nonlinear optical loop mirror (NOLM), the fastest DEMUX ever recorded, is a well-known example. It was used as a DEMUX at data rates up to 640 Gb/s. In a semiconductor optical amplifier, a different class of optical gates is built on XPM and FWM (SOA). The SOA in a Mach-Zehnder interferometer is an illustration of an XPM-based optical gate. The EAM is another optical gate that is utilized in numerous high-speed transmission studies [4]. In this technology, the gate that changes the optical data stream is under the control of an electrical control signal. The DEMUX has been greatly simplified by this. In numerous studies, this switch has served as the DEMUX. The multiplexed data signal's TDM channel can only be chosen by one DEMUX (single-channel output operation). A serial-parallel combination of many of these switches can be used to operate multiple channel outputs. The output of the DEMUX is often linked to the O/E receiver in OTDM transmission experiments through an optical amplifier and an optical filter. In the transmission tests for DPSK and DQPSK, a demodulator is added and positioned between DEMUX and the O/E receiver [7]. The demodulation of the phase-modulated data signal is done by a pair of two complementary amplitude-modulated data streams in the demodulator. A Mach-Zehnder interferometer serves as the demodulator in the DPSK experiment.

C. Transmission Line

An ideal fiber-link length for use in commercial systems is in the range of 1000 km [4]. High-speed data transmission requires both CD and PMD adjustment for these fiber lengths. The most advanced dispersion-compensation method available today uses dispersion compensating fiber (DCF), which concurrently corrects for both D and dD/λ. The DCF is often confined in the repeaters as a small unit and does not affect the duration of the broadcast or length of the fiber. In contrast, inline dispersion-managed fiber (DMF) transmission lines are a further development of DCF. The DMF depicts a pair of transmission fibers that, when combined, across a broad wavelength range, make up for the path-averaged D and dD/λ. High-speed data transmission at 1550 nm has been researched using a variety of transmission fiber types and the corresponding DCF. Examples include dispersion-shifted fiber (DSF), regular single-mode fiber (SMF), and different varieties of nonzero DSF. For the transmission of high bit-rate data, PMD is a serious restriction. A minor birefringence of the fiber and other transmission link components leads to PMD is often caused by birefringence of the fiber and other transmission link components. Most ultrahigh bit-rate transmission tests included manually altering the polarization of the data signal at the transmission link input to account for PMD. Signal deterioration can also result from fiber nonlinearity. In the quasi-linear (pseudo-linear) transmission domain, where the nonlinear length is significantly longer than the dispersion length, high-speed transmission experiments are frequently carried out.

IV. ADVANTAGES AND SCOPE

High bit rate is one of the main benefits of this proposal. The adoption of Mach-Zehnder Modulation makes data recovery simple. There is a wide range of applications for this technology in date bases, servers, and date storage systems where quick transmission is necessary. This method is employed in industrial and commercial settings where precise and quick data transfer is required. These devices support dependable transmission in broadcasting and HDTV connections. It has use in the sensors and actuators of sonar vehicles.

V. CONCLUSION

In this paper, we have analyzed an OTDM system. It will play a big role in optical communication systems in the future. The efficiency and data recovery are great due to the multiplexing of optical signals from several channels. Because it increases the system's bit-rate of transmission and bandwidth, this system is more beneficial. It has incredibly reliable functioning if used in conjunction with modulation formats like DPSK.

ACKNOWLEDGMENT

This research was supported by the electronics and communication department of Guru Nanak Dev Engineering College, Ludhiana. I would like to extend our gratitude to the college faculty for providing a suitable atmosphere to carry out the research. I would also thank my supervisors for their genuine and unconditional support throughout the research work.

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