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Circular Polarization Division Multiplexing With DQPSK for Faster Coherent Fiber Optic Communication

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Abstract

The on-going growing demand for greater capacity in optical communication systems, calls for an increase in transmission speed from 10 Gbps to 40 Gbps and beyond, while maintaining signal quality. In this paper, maximizing the fiber spectral efficiency and enhancing bit rate of trans-receiver by using circular polarization along with linear polarization and DQPSK modulation techniques has been proposed. PDM is used in this system for multiplexing linearly polarized and circularly polarized signals. In addition to polarization DQPSK for enhancing bit rate without affecting the spectral width of trans-receiver. Initially linear polarization is used for enhancing the bit rate. Now along with circular polarization the bit rate and efficiency becomes double.

1. Introduction

Optical fiber communication is firmly entrenched as part of the global information infrastructure, that is high performance optical networks are essential for economic growth and well-being of communities. The attraction of transmission over an optical fiber is mainly in its much larger capacity compared to copper counterparts and immunity to electromagnetic interference and other external influence. At present, optical fibre transmission is seen as a dominant technology for both long-haul and short-haul broadband transmission [4].

The on-going growing demand for greater capacity in optical communication systems, calls for an increase in transmission speed from 10 Gbps to 40 Gbps and beyond, while maintaining signal quality. Optical communication systems have predominantly used some form of on/off keying (OOK) as a modulation format. As data rates increase, the inefficiency of these modulation formats from a bandwidth point of view is becoming more apparent. With data rates moving to 40 Gbps and beyond, dispersion in the fiber limits the distance over which the data can be transmitted. Other impairments such as polarization mode dispersion or PMD become significant at 40 Gbps. Using binary modulations, regardless of detection technique, spectral efficiency cannot exceed 1 b/s/Hz per polarization [6, 7].Thus, inter-city transmission, which requires long-distance transmission of more than several hundred kilometers, has not been possible.

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Phase modulated signals coming from the transmitter can be recovered at the receiver through differential detection (in the case DPSK or DQPSK) or a more sensitive method, coherent detection (in BPSK, QPSK, 16-QAM)[3]. Moreover, the complete information of the electric fields at both the transmitter and receiver opens up the possibility of electronic Digital Signal Processing (DSP) for pre-compensation and post-compensation [3,4]. Polarization Division Multiplexing (PDM) improves the spectral efficiency of the fiber optic system and hence doubles the information carrying capacity of the fiber. Therefore, phase modulation technique (BPSK, DPSK, QDPSK, QPSK etc) with differential or coherent detection and PDM have been used in conventional 40G and 100G systems without spilling their spectral widths outside the 50GHz ITU-T grid. However, adding more bits per symbol as in the case of 32-QAM, 64-QAM or 256-QAM reduces.

2. Literature Overview

To satisfy the demands for higher bandwidth of optical transmission systems, advanced optical modulation formats have been intensely investigated. For long haul transmission, the higher order modulation formats minimum shift keying (MSK) and differential quadrature phase shift keying (DQPSK) are aspirants to replace the conventional modulation formats differential binary phase shift keying

(DBPSK) or on-off keying (OOK). They provide a doubled spectral efficiency at moderate additional complexity [3].

Modulation is the process of varying some parameter of a periodic waveform in order to use that signal to convey a message. Normally a high-frequency sinusoidal waveform is used as carrier signal.

There are basically two types of modulation techniques:

- Analog modulation
- Digital modulation

Digital modulation provides more information capacity, compatibility with digital data services, higher data security, better quality communications, and quicker system availability. The three basic types of modulation techniques employed are:

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

2.1 Amplitude shift keying (ASK)

Amplitude-shift keying (ASK) is a form of amplitude modulation represents digital data as variations in the amplitude of a carrier wave.

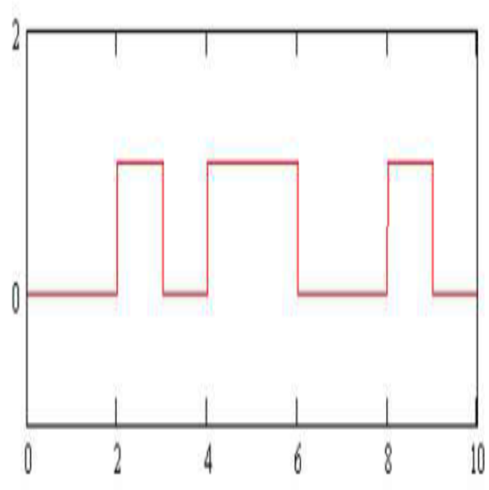

Fig: 1. Baseband Information Sequence-00101100

2.2 Phase Shift Keying (PSK)

An alternative to imposing the modulation onto the carrier by varying the instantaneous frequency is to modulate the phase. This can be achieved simply by defining a relative phase shift from the carrier, usually equidistant for each required state. Therefore a two level phase modulated system, such as Binary Phase Shift Keying, has two relative phase shifts from the carrier, + or - 90^{o}. Typically this technique will lead to an improved BER performance compared to MSK. The resulting signal will, however, probably not be constant amplitude and not be very spectrally efficient due to the rapid phase discontinuities. Some additional filtering will be required to limit the spectral occupancy. Phase modulation requires coherent generation and as such if an IQ modulation technique is employed this filtering can be performed at baseband

2.3 Frequency Shift Keyed (FSK)

As previously stated applying modulation in wireless communications involves modifying the phase or amplitude, or both, of a sinusoidal carrier. One of the simplest, and widest used system, is frequency modulation. This exists in a great variety of forms, as will be discussed later, but in essence involves making a change to the frequency of the carrier to represent a different level. The generic name for this family of modulation is Frequency Shift Keying (FSK).

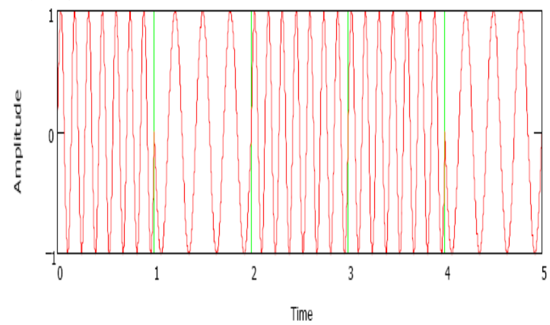

Fig: 2. Binary (2 level) FSK modulation

FSK has the advantage of being very simple to generate, simple to demodulate and due to the constant amplitude can utilize a non-linear PA. Significant disadvantages, however, are the poor spectral efficiency and BER performance. This precludes its use in this basic form from cellular and even cordless systems.

2.4 Quadrature Phase Shift Keyed (QPSK)

Higher order modulation schemes, such as QPSK, are often used in preference to BPSK when improved spectral efficiency is required. QPSK utilizes four constellation points, as shown in figure 8 below, each representing two bits of data. Again as with BPSK the use of trajectory shaping (raised cosine, root raised cosine etc) will yield an improved spectral efficiency, although one of the principle disadvantages of QPSK, as with BPSK, is the potential to cross the origin, hence generating 100% AM.

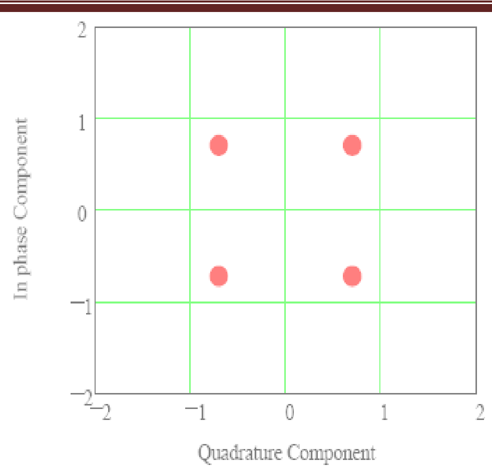

Fig: 3. Constellation points for QPSK.

2.5 DQPSK

As like in the QPSK that every sequential of two pair bits of information will modulate the phase of carrier signal, and determine the output initial phase of the modulated signal. In the QPSK the rules of transmission are:

PAIR BITS INPUT:	PHASE SHIFT
00	π/4 radiant
01	3π/4 radiant
11	5π/4 radiant
10	7π/4 radiant

But for the DQPSK we can't determine as like this way. First step is determines the rule of phase shift as a function of pair bit input. The second step is addition the phase shift with the initial phase of previous signal. The result of its addition is initial phase of the modulated signal at present time, or phase output of the transmitter.

2.6 Polarization

As bit rates increase to meet expanding demand, systems have become increasingly sensitive to polarization-related impairments..

In light and all other kinds of electromagnetic waves, the oscillating electric and magnetic fields are always directed at right angles to each other and to the direction of propagation of the wave. In other words the fields are transverse, and light is described as a **transverse wave**. Since both the directions and the magnitudes of the electric and magnetic fields in a light wave are related in a fixed manner, it is sufficient to talk about only one of them, the usual choice being the electric field. Now although the electric field at any point in space must be perpendicular to the wave velocity, it can still have many different directions; it can point in any direction in the plane perpendicular to the wave's direction of travel.

Any beam of light can be thought of as a huge collection of elementary waves with a range of different frequencies. Each elementary wave has its own unique orientation of its electric field; it is **polarized.** If the polarizations of all the elementary waves in a complex beam can be made to have the same orientation all the time then the light beam is also said to be polarized. Since there is then a unique plane containing all the electric field directions as well as the direction of the light ray, this kind of polarization is also called **plane polarization**. It is also known as **linear polarization**. However, the usual situation is that the directions of the electric fields of the component wavelets are randomly distributed; in that case the resultant wave is said to be **randomly polarized** or **unpolarised**.

Plane polarization is not the only way that a transverse wave can be polarized. In **circular polarization** the electric field vector at a point in space rotates in the plane perpendicular to the direction of propagation, instead of oscillating in a fixed orientation, and the magnitude of the electric field vector remains constant.

3. Proposed Work

3.1 Transmitter Configuration

In the proposed transmitter configuration (Figure 3.1) light beam from a CW diode laser is split into two orthogonal circular polarizations, either using a CPBS or a combination of PBS and Quarter Wave Plate (QWP) or a piece of Polarization Maintaining Fiber (PMF) with required length. Each of the CP beam when passed through a PBS produces two LP beams as horizontal and vertical components. Each LP component can be Quadrature phase modulated with two 25Gbps signals (In-phase and Quadrature components). Therefore, the total bandwidth of the transmitter goes up to 200 Gbps, instead of 100 Gbps with a traditional transmitter which does not use CP beams. the present proposal is an extension to the existing DQPSK transmitters for faster and accurate operation.

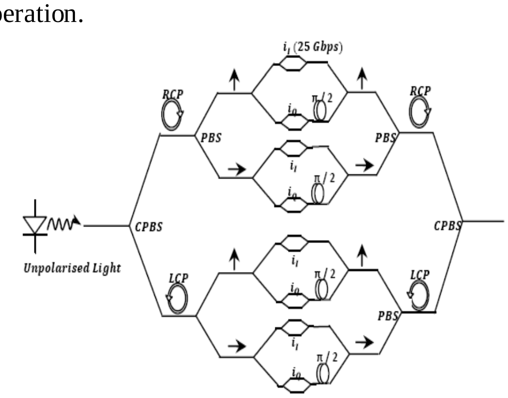

Fig: 4. Transmitter Configuration

3.2 Receiver Configuration

In the proposed coherent receiver, light from a local oscillator (LO) and the incoming fiber (from transmitter) are split into the CP components, RCP and LCP, by employing two separate CPBS or PBS and QWP/PMF combination (Figure 3.2). RCP and LCP emerge from both the CPBSs which are again split into vertical and horizontal polarizations by employing four PBSs. Finally, the respective polarizations from both the fiber and LO are mixed using a 3dB coupler and fed into DQPSK demodulators which can recover the transmitted data in its original electrical form [1, 2].

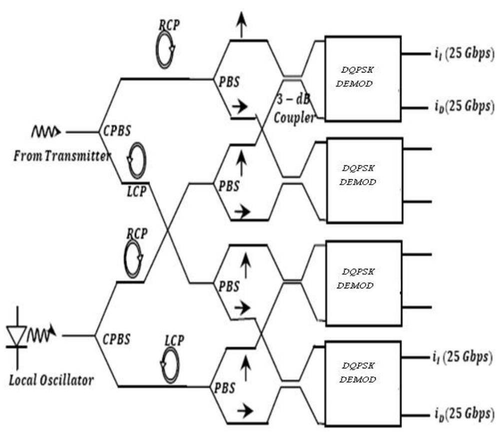

Fig: 5. Receiver Confrigurationn

4. Conclusion

In this the use of circular polarization along with linear polarization leads to increase the spectral efficiency and bit rate without affecting the bandwidth. By using circular polarization the bit rate approximately doubles itself. After then the use of DQPSK modulation techniques made the circuitry easy and also prevent from various types of losses and distortion. Till now the proposed configuration of transmitter and receiver has been proposed for increasing the bit rate from 100Gbps to 200Gbps, just doubles.

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