Transmission Performance Of Soliton WDM Signals: A Review

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Abstract

This paper provides an overview of the technology challenges for the implementation of future high capacity systems. As the channel rates grow beyond 40Gb/s to 100Gb/s and higher, one key challenge is to enhance the spectral efficiency of the system. Fiber-optic communication system is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. This paper reviews the technological options for the modulation format for serial optical transmission. Carrier modulation for pass band transmission of digital signal is discussed with DPSK modulation. The advantage bandwidth reduction in Quadrature Phase Shift Keying can be extended to MPSK.
Keywords: *Fiber, Communication, Bandwidth, Modulation format, WDM*

1. Introduction

The information carrying capacity of standard fiber optic system is limited by the available bandwidth and dispersion suffered by a signal while traveling through the fiber. The current efforts of research and development are aiming at increasing the total capacity of medium and long haul optical transmission systems [1]. The transmission distance of any fiber optic communication system is eventually limited by fiber losses. Wavelength Division Multiplexing (WDM) is used to make an efficient use of the available bandwidth by launching waves at different wavelength through the fiber. After transmission on the fiber, the various signals can be separated towards different detectors at the fiber extremity. The multiplexer at the entrance must inject the signals coming from the different sources into the fiber with minimum losses. The component that separates the wavelengths is the demultiplexer. Dense wavelength division multiplexing (DWDM) is the multiplexing of 4, 8, 16, 32 or more wavelengths in the range of 1530 to 1610nm with a very narrow separation between wavelengths. Today WDM applies to DWDM.

An optical fiber has a finite attenuation and thus an optical signal damps while traveling down the fiber. Also, the transmitting distance is limited by attenuation to less than 80km in single mode fiber. Hence, we need to boost an optical signal to transmit information over the longer distance. There are two means by which an optical signal can be strengthened, repeaters and amplifiers. Repeaters are acceptable signal boosters for point to point links, where bit rate and signal format are determined by the use of a single transmitter. However, repeaters don't work for fiber optic networks, where many transmitters send signals to many receivers at different bit rates and in different formats.

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The Bandwidth of an optical network is determined not only by the speed of the light traveling through the glass but also by how much light the fiber can accommodate at any given speed. Because the speed of light is constant and fiber strands are more efficient when super thin, efforts to improve bandwidth have centered on finding ways to push more information through the same tiny pipe.

The increasing application of WDM transmission schemes with high bit rates and narrow channel spacing places a strict requirement on dispersion management. DCF are used to compensate the dispersion and hence the timing jitter at the receiver.

2. Choice of an amplifier

With growing transmission rate, demands in the field of optical communication; electronic regeneration has become more and more expensive [1]. Powerful optical amplifiers came into existence, which eliminated the costly conversions from optical to electrical signal and vice versa. Semiconductor optical amplifiers are more prospective device for optical fiber transmission systems as compared to fiber amplifiers due to their compact size, ultra wide band gain spectrum, low power consumption, ease of integration with other devices and low cost. When semiconductor optical amplifiers (SOAs) work in saturation region, it has high nonlinearity, which restrains it from use in long haul WDM transmission system [11]. The effectiveness of SOAs is that they work in both 1300nm and 1550nm low attenuation windows [7].

In Erbium doped fiber amplifiers (EDFAs), the active medium for operation in 1550 nm window is created by lightly doping silica fiber core with rare earth element such as Erbium (Er) or ytterbium (Yb). The important features of DFAs include the ability to pump the devices at several different wavelengths, low coupling loss to the compatible fiber transmission medium, and very low dependence of gain on light polarization. DFAs are highly transparent to signal format and bit rate. The result is that in contrast to SOAs, gain responses of DFAs are basically constant for signal modulation greater than few kHz. They are immune from interference effects between different optical channels within a broad spectrum of wavelengths that are injected simultaneously into an amplifier.

SOAs and EDFAs are two basic types of optical amplifiers for WDM networks. All optical amplifiers have common basic characteristics including gain, bandwidth and noise performance. The value of gain depends on the principle of amplifiers operation but two general determining factors are to be taken into consideration. The first is gain which depends on the frequency of the input signal. The second important phenomenon is that gain depends on the power of input signal. When the input power is too high, gain decreases. This phenomenon is known as gain saturation.

EDFAs gain decreases when the power of an input signal increases, resulting in gain saturation. The main source of noise in EDFA is amplified spontaneous emission (ASE). An important feature of an EDFA in its use in WDM networks is its ability to keep its characteristics constant when one or more input channels are added/ dropped.

EDFAs cannot work in 1300nm, making SOAs the only amplifier available for this. However SOAs suffer from relatively high crosstalk, when the presence or absence of one channel changes the characteristics of another channel and sensitivity to the state of polarization of incoming signal.

Crosstalk is any distortion of a channel caused by presence of another channel. Interchannel crosstalk is a four wave mixing (FWM) effect. When two channels enter an SOA, their nonlinear interference produces new signals at the beat frequencies [6]. Reason for the generation of new signals is the modulation of excited electrons at beat frequency. These new signals deplete the conduction band that is they steal some gain from the original signals. Thus, amplification of original input signal becomes less and new, undesired signal appear. Crosstalk is not an important factor in EDFA.

3. Choice of Modulation Formats

The various modulation formats, been of research interest and/or have been already deployed, can be compared by their main properties in terms of reception (coherent or non coherent), bits transmitted per symbol, spectral efficiency, error probability etc. Obviously with the reduction of symbol rate, the modulation format realization becomes more and more complex. QPSK, ASK have amplitude variation hence noise interference is more in these techniques. PSK has less noise interference.

The modulation format designates the approach used to apply the incoming digital information to each of the optical carriers. The most straight forward way to do so at BGb/s is by ASK, that is by switching the laser output light intensity on or off, depending on whether the symbol to be transmitted is a mark (“1”) or a space (“0”), at a rate equal to information frequency B GHz where as ASK formats are used exclusively in products at 10Gbs, DPSK offers better performance at 40 GB/s. In this case, information is carried by the phase itself. PSK modulation format has attracted extensive attention due to its improved performance and robustness to different transmission impairments while comparing with the conventional OOK format [2].Besides these general benefits of PSK format, QPSK format can further enhance the spectral efficiency by a factor of approximately two, compared to BPSK and DPSK data formats [3,4]. With enhanced spectral efficiency, QPSK data format provides a promising alternative for high capacity transmission as it operates at a lower symbol rate for the same total bit rate [5].

4. Soliton

One of the key to the success of ensuing photonics revolution is the use of optical solitons in fiber optic communication systems. The key to solitons formation is the careful balance of the optical forces of chromatic dispersion and self phase modulation.

The chromatic dispersion phenomenon and self phase modulation phenomenon can create major problems

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in a fiber optic communication system when act individually. But if a system is designed such that the effects of dispersion and self phase modulation perfectly cancel each other out, a pulse may propagate through a fiber without any broadening in the time or frequency domains.

5. Experimental Set- up

SOA has attracted much attention for being cost effective as compared to EDFA for optical transmission using DPSK [8]. SOA has wide band gain spectrum, low power consumption, compactness in size and ease of integration as compared to other device [6, 7]. When SOA is working in saturation region, it has high nonlinearity which restrains it from being used in long distance WDM transmission systems [11].

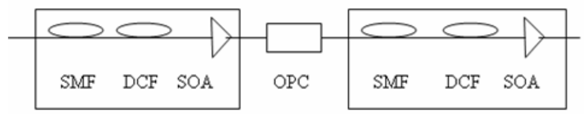
The conventional OOK modulation format has large cross gain modulation (XGM) effect of SOA which may introduce large amount of crosstalk among WDM channels and limits its transmission performance of the system [9]. RZ DPSK provides 3 dB reduction in required received OSNR for given bit error [9]. RZ-DPSK modulation format is preferred due to its constant signal power for this format. So this format is utilized for reduction of XGM in SOA based WDM transmission link. Gain saturation of SOA produces phase noises, which will affect the performance of DPSK signals. SOA changes the noise characteristics and introduces extra phase noise to optical signal [10]. Phase jitter can be reduced substantially by inline phase conjunction that involves the use of nonlinear optical effects to precisely reverse the direction of property of each plane wave in a discretionary beam of light, thereby causing the return beam to exactly revise the path of the incident beam.

Optical phase conjugator (OPC) is a kind of mirror which retro reflects all incoming rays back to their birthplace. Also the amplitude jitter is converted into phase jitter during propagation because larger pulses have a larger phase advance which leads to self phase modulation (SPM) [12].

At the conjugator the sign of phase is flipped, but amplitude remains same. This means that just after conjugator, larger pulses will have more phase delay than smaller pulses. Beyond the conjugator, the larger pulses phase continues to march more rapidly with distance, thus compensating for larger phase advance that accumulated before the conjugation point.

In this paper, a survey is being done on soliton DPSK WDM signal transmission scheme with cascaded in line SOA amplifier. The frequency shift of solitons caused by interactions between different channels is reduced by dispersion compensation. The reduction mechanism is due to cancellation of shifts generated in both normal and anomalous dispersion regimes. The result can get improved with QPSK modulation format, which can become an alternative for high capacity transmission as it operates at a lower symbol rate for the same total bit rate.

The scheme of transmission system is shown in figure.



The transmission system is dispersion managed recirculating fiber loop approx.120 kms in length. Transmission link comprises of SSMF and dispersion compensating fiber(DCF).The SSMF has a dispersion of 16ps/nm-km and DCF has dispersion of -80 ps/nm-km. SSMF is of length 100km.To nullify the residual dispersion, DCF of 20 km is taken Amplifiers are spaced after every 120 km. Analysis can made on the basis of 2 different cases:-

1. Link consists of SSMF and DCF
2. Link consists of SSMF and DCF with OPC used for midway spectral inversion.

S.Singh etal. [11] reported SOA model for long have links up to 5250 Km for 10 * 40 Gb/s soliton DPSK WDM signal J.Singh [12] reported SOA model for long haul link up to 9000 Km for 11 * 40 Gb/s soliton DPSK WDM signal using midway spectral inversion technique. Author also reported that the increase in core effective area of fiber further improves the performance metrics. Y.Gao etal [5] reported that beyond 40 Gb/s DPSK transmission suffers from limited routing flexibility in most of the existing DWDM system. E.Pincemin et.al[14] reported that due to coherent detection, OSNR sensitivity of QPSK is 5dB better than that OOK or still 2dB better than that of DPSK. They also found that their tolerance to PMD is ~30ps at 40Gbps, namely more than 10 times the robustness of standard NRZ-OOK at 10 Gbps. Their tolerance to chromatic dispersion is virtually unlimited.

6. Proposed Model

In the literature it is found that DQPSK can increase further the chromatic dispersion and PMD tolerance of 40 Gbps channels[13]. The DQPSK format is an

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extrapolation of DPSK modulation. Actually, DQPSK concept consists in superimposing into the complex plane a DPSK data stream in quadrature over original DPSK signal [14]. Information is thus carried by transition between four phase states. This technique enables to increase the data rate.

7. Conclusion

With phase conjugated DPSK system, the range of transmission can be extended. For long haul applications, the use of phase conjugator to improve the jitter and Q factor is useful. The proposed scheme provides alternative to existing format in the network internodes.

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