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EFFICIENT TRIPLE PLAY SEVICES IN SMF OVER 1200 Km USING CML with EDC

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Abstract— In this paper we have simulated the efficient transmission of data using single mode fiber over 100 km using CML (Chirp Managed Laser). Losses occur due to Phase information with direct detection technique as distance increases. To overcome this draw back and also to extend the reach of SMF we used EDC (Electronic Dispersion Compensation). The results of CML were compared with EML (Externally Modulated Lasers). The simulation results shows that CML gives better performance than EML.

Keywords- Chirp Managed Laser (CML), electronic Dispersion Compensation (EDC), Externally Modulated Lasers (EML)

I. INTRODUCTION

High-performance optical transmitters based on external modulator technologies have been used in 10 Gbps telecommunication systems for all applications that extend beyond a few kilometers. Such externally modulated transmitters require a continuous wave (CW) laser to provide the light source and a modulator to encode the digital data into the intensity of the light. Now a new technology may eliminate the external modulators. Until recently, Lithium Niobate Mach-Zehnder (LiNbO3 MZ) modulators were the first choice for metro, regional and long-haul networks. However, its large size (>44 mm long for the modulator alone) and excessive power consumption (requiring a driving voltage of 5 V or more) have left the market open to more efficient alternatives. EMLs (electro absorption-modulated lasers), in which the CW Laser and an electro-absorption modulator have been integrated into a single chip, offer an alternative that is more compact in form factor but suffer in terms of performance. For example, it is very difficult for an EML to simultaneously achieve high output power >0 dBm for transmission distances up to 80 km over DWDM wavelengths.

A new transmitter technology to address the size, power and cost concerns raised by LiNbO3 MZ Modulators is known as Chirp Managed Lasers or CML. These transmitters provide high optical output power, long transmission distances in standard single mode fibers and offer DWDM wavelengths on the ITU grids with 50 GHz spacing. In addition, this new system requires a low driving voltage and by eliminating the external modulator, offers a reduced footprint which fits into a small form factor XFP TOSA (Transmitter Optical Sub-Assembly).In this paper, we will explain the working principles behind Chirp Managed Lasers, compare its performance to LiNbO3 MZ and EML technologies, and describe key applications that benefit significantly from CML technology.

As a main transmission of various in-formation tools, it is of great importance in the future in-formation society. Now, optical communication systems are becoming increasingly complex [1]. These systems often include multiple signal channels, different topology structure, nonlinear devices and non-Gaussian noise sources [2], which make their design and analysis quite complex and require high-intensity work. Its performance can be attached to the device user interface library and can be completely expanded to become a widely used tool. Op-tiSystem meet the booming market to a strong photon and becomes a useful tool for optical system design require-ments [3]. . At last the receiver

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separates the different wavelengths by signal processing, restores the original signal and sends them to different terminal [4].

II. PRINCIPLES

The system uses the non-return-to-zero (NRZ) intensity modulation format. The input data bit stream is mapped to digital samples of the pre-compensating drive current, with 2 samples per bit. To determine the entries of this data, the effect of the modulated power and chirp on pulse propagation and the nonlinear mapping between the input and the output optical power of the DML must be considered. The interaction of the optical field with fiber dispersion beyond 200 km causes Intersymbol-interference (ISI).The optimization is aimed at finding the power profile and its associated chirp at the output of the DML, which results in a minimum log10 *(*BER*)* for a specific fiber length, while using the optical phase at the receiver under direct detection as a degree of freedom. The optical field is subsequently propagated down a linear SMF with a dispersion parameter D = 16.43 ps/km/nm. A standard direct detection receiver (DD-Rx) is used with additive white Gaussian noise (AWGN) loading before calculating the BER while taking ISI into consideration. These entries (optical power samples) are directly optimized . The power samples were constrained to within a physically realizable range.

III. CHIRP MANAGED LASERS

Traditionally 2.5 Gbps links have been widely deployed using directly modulated lasers (DMLs) based on Distributed Feedback (DFB) technology. These links typically reach from 110 km to 175 km, and even up to 300 km with improved performance lasers. However, for 10 Gbps applications using telecom wavelengths ~1550 nm, DMLs can only be used for links less than 10 km due to their chirp properties and the associated detrimental effect on performance over standard single mode fiber, which is inherently dispersive. Chirp manifests in primarily two manners when a semiconductor laser is directly modulated.Chirp which occurs at bit transitions is known as transient chirp while chirp that causes 1 bits to blue-shift relative to 0 bits is known as adiabatic chirp. In order to achieve a good extinction ratio between 1 bits and 0 bits, a DML transmitter is traditionally biased near threshold and a large current swing is used to modulate the laser. However, not only does this introduce amplitude ringing, it also adds significant transient chirp across a broad frequency spectrum. In standard single mode fiber, the positive dispersion works against this transient chirp and hastens pulse spreading. As a result, data signal quality degrades quickly during transmission, limiting transmission distance for DML signals at 10 Gbps to only a few km at ~1550 nm. CML comprises of a directly modulated DFB laser and a multi-cavity etalon filter, also called an optical spectrum reshaper (OSR).Figure 1 shows the schematic of CML

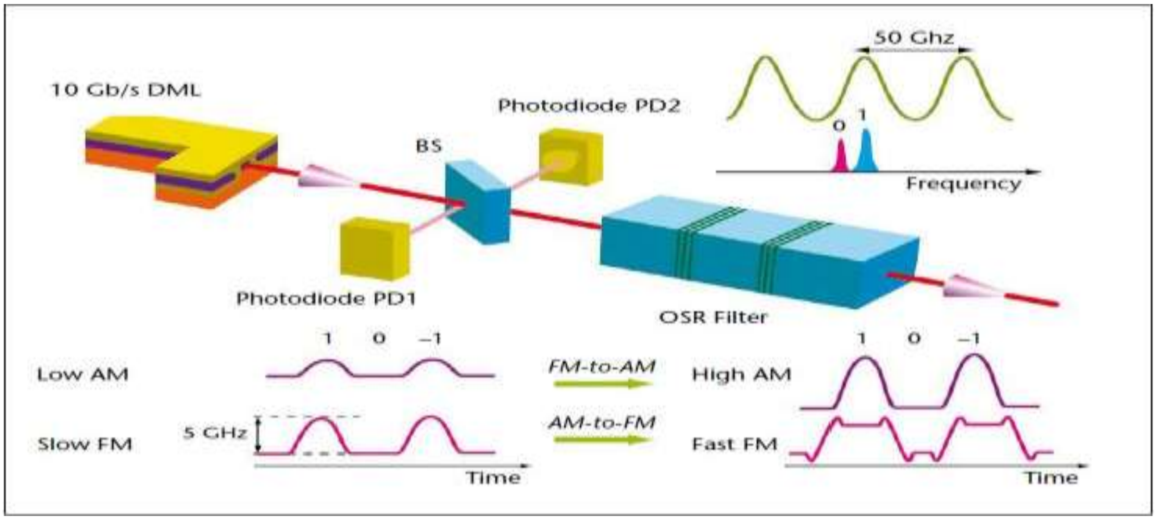


FIG 1. CML principles of operation

In CML, the DFB laser is typically biased at approximately 4 to 5 times the threshold current, and directly modulated by a nonreturn- to-zero (NRZ) signal with a relatively low modulation current swing. This results in an intensity modulation signal with a low extinction ratio (ER ~2 dB). The benefit of a high bias current is that it achieves high output power, wide modulation bandwidth, stable single-mode operation, and low timing jitter, all while suppressing transient chirp. A more important feature is the accompanying adiabatic chirp modulation, which is generated by gain compression in the DFB laser: 1 bits are blue-shifted relative to the 0 bits. By aligning the laser wavelength on the transmission edge of the optical spectrum reshaper OSR, blue-shifted 1 bits are passed while red-shifted 0 bits are attenuated. In this way, the OSR increases the ER in the CML to >10 dB. Due to the limited bandwidth of the OSR, any remaining transient chirp or amplitude ringing, both of which are of high frequency, is also filtered out. This results in a clean eye diagram for the CML, as shown in Figure 2A, which is similar to the eye diagrams of transmitters based on external modulators.

The OSR also acts as a wavelength locker together with two photodiodes and a beam splitter. Since the OSR has a 50 GHz periodicity, the CML can be locked to ITU grids with 50 GHz spacing and also achieve the required +/–2.5 GHz frequency stability for 50 GHz spacing in DWDM networks. Unlike transient chirp, which is usually detrimental to signal integrity in dispersive fiber, adiabatic chirp is actually used to improve the dispersion tolerance of the CML. Adiabatic chirp naturally changes the optical phase of the carrier, which is then adjusted to introduce a beneficial optical duo binary like phase coding to the bits [1]. Consider a “1 0 1”bit sequence from a standard on-off-keyed transmitter

As this signal travels through fiber, dispersion spreads the energy of the 1 bits into adjacent 0 bits. The constructive interference between the 1 bits introduces errors in the 0 bits. For the same “1 0 1” bit sequence in CML the 1 bits are higher in frequency than 0 bits by ½ the bit rate. This is a 5 GHz shift for a 10 Gbps signal and causes the phase of the carrier to slip by 2π x 5 GHz x 100 ps = π during the 0 bit of the sequence, making the second 1 bit π out of phase with the first 1 bit. This phase shift is the key to maintaining a clean 0 bit and keeping the optical eye diagram open after more than 200 km transmission, as shown in Figure 2B. The energy of the 1 bits still spreads into the middle 0 but, as they are added out of phase with each other, they cancel.

A more subtle but equally important factor is that the transmission edge of the OSR converts the nonlinear chirp waveform of the laser to a square-shaped waveform with abrupt transitions, resulting in a more uniform phase across pulses. Compared with other types of transmitters, CML introduces two new parameters: the amount of adiabatic chirp and the percentage slope position of the filter where the DFB laser frequency is locked to. Depending on the system configuration, one can vary these parameters to optimize system performance. For example, adjusting the chirp value according to the bit rate optimizes the destructive phase interaction. This results in extended reach transmission distance without the need for dispersion compensation [2, 3]. Alternatively, CML parameters can be adjusted to achieve a high extinction ratio and optimized back-to-back performance for use in conventional dispersion compensated DWDM long haul systems which require very good optical signal to noise ratio (OSNR) performance.

IV. PERFORMANCE OF CML TECHNOLOGY

With dispersion compensation, CML-based modulators can reach up to 300 km with less than a 2 dB sensitivity penalty at BER = 1E – 12 without the use of forward error correction (FEC). In systems employing FEC, CML reach is extended to 250 km with a standard receiver and >300 km using a receiver with electronic dispersion compensation (EDC) without any optical dispersion compensation in either case. CML fits into the compact 16 mm x 6.4 mm x 5.5 mm TOSA form factor, as shown in Figure 3A, and will enable high–performance, hot pluggable XFP transceivers to serve in demanding DWDM line-side applications. By comparison, even though a LiNbO3 MZ-based transmitter provides dispersion tolerance up to 100 km, it could never fit into an XFP module due to its large size and high power consumption. CML based on a single stripe DFB chip can achieve 4 x 100 GHz or 8 x 50 GHz limited tunability by leveraging the temperature wavelength tuning effect of the laser. Due to the 50 GHz periodicity of the OSR, a CML can be naturally extended to achieve full C or L band tunability with any tunable laser as long as the laser chip can be modulated at high speed with a suitable adiabatic chirp.

Each DFB stripe can be directly modulated to achieve the same performance as a fixed wavelength CML. To select a particular ITU channel, an RF switch and MEMS mirror are used in the package to select which particular stripe to operate. Fine tuning of the laser frequency to match the desired ITU channel is achieved by temperature tuning the DFB stripe. In comparison, an EML has minimum tunability for 10 Gbps performance, while a LiNbO3 MZ-based tunable transmitter has to rely on a separate tunable CW laser for its tunability. Such two-chip implementations result in larger physical size, higher cost, and higher power consumption.

V. ELECTRONIC DISPERSION COMPENSATION

A method for mitigating the effects of chromatic dispersion in fiber optic communication links with electronic components in the receiver is called Electronic Dispersion Compensation. Systems for optical fiber communications can be affected by the effect of chromatic dispersion of the fibers used. Dispersion in a fiber optic link broadens and distorts the features of the bit symbols, making it more difficult to decode the signal. Dispersion compensation is normally be done in the optical domain, i.e., before photo detection. However, there are also methods of electronic dispersion compensation, utilizing electronics for that purpose.

Two quite different approaches of electronic dispersion compensation have to be distinguished, which are applied to different types of data receivers:

In a receiver with direct detection,the effect of dispersion cannot be really removed, because it is essentially a frequency-dependent phase change, and the phase information is lost in the detection process. However, there are methods which can at least mitigate the dispersion effect as long as it is not too strong. Typically, such methods rely on *tapped delay line equalizers*(*transversal filters*), where portions of the electronic input signal are subject to different time delays and recombined after amplification with suitable levels. Purely linear equalization techniques can improve the signal processing even in the presence of nonlinear distortions, such as those arising from self-phase modulation due to fiber nonlinearities.

There are also nonlinear equalization techniques. For example, nonlinear decision-feedback equalizers (DFE) can partly compensate for lost spectral information by making decision thresholds dependent on past decisions made in the receiver. Provided that the settings of such systems are carefully optimized, the signal quality can be significantly improved, even though the full potential of true optical dispersion compensation cannot be reached. The parameters may be adjusted automatically using feedback techniques based on digital or analog signal processing, minimizing the bit error rate. Even the effect of intermodal dispersion in multimode fibers (as used in short-distance fiber-optic links) can be mitigated.

A receiver using optical heterodyne detection (or homodyne detection) offers a higher potential for electronic dispersion compensation, as the phase information is not lost. When an electronic filter with an appropriate frequency response is applied to the intermediate frequency signal this can directly remove the effect of chromatic dispersion. Even a non-perfect compensation system can have various benefits, obtained at limited cost. The bit rate or transmission distance can be increased, e.g., by 20% or even 50%. Alternatively, electronic dispersion compensation may allow the use of a cheaper type of transmitter (e.g. a directly modulated laser instead of a system with an external modulator) and thus lead to significant cost savings. A technical challenge of great importance for applications is automatic adaptation of the parameters of the electronic dispersion compensator to the link properties, because the ideal parameter settings depend on the properties of the fiber link and the transmitter, and manual optimization is not cost-effective. Particularly in systems with multimode fibers, the optimum parameters may also drift with time.

VI .SYSTEM DESIGN

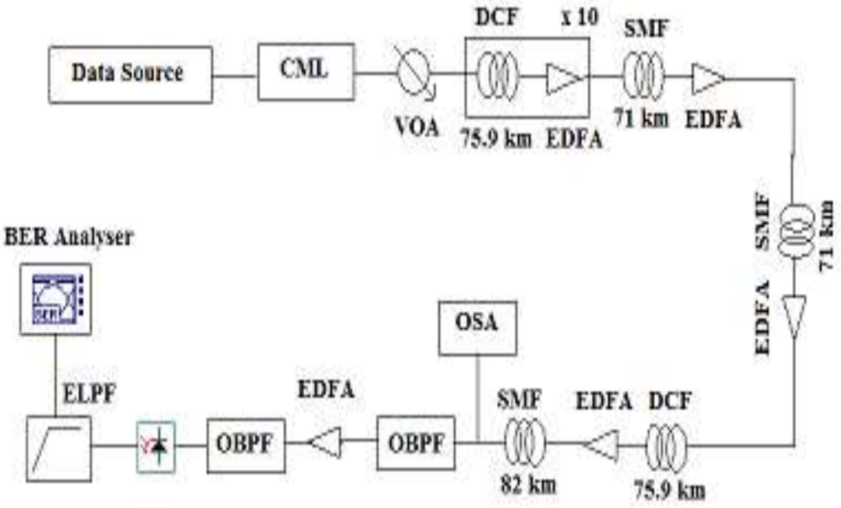


Fig 2 : CML-chirp managed laser.

VII. APPLICATIONS OF CML

Next-generation 10 Gbps Metro DWDM Networks require great flexibility for handling Fiber dispersion. The deployment of ROADM (Reconfigurable Optical Add and Drop Multiplexer) challenges the traditional dispersion compensation scheme since a wavelength can be added or dropped anywhere in the network, making it difficult to predict the accumulated dispersion. CML-based transmitters are well-suited for such applications because of their wide dispersion tolerance window which spans both positive and ne negative values. For a typical Metro network of less than 300 km, the use of CML-based transmitters may enable the elimination of dispersion compensation modules altogether. This not only reduces system cost but substantially simplifies system complexity while improving network agility.

Bandwidth growth and economic reasons continue to drive equipment vendors to keep increasing port density while reducing equipment rack size. Hot pluggable modules such as XFP at 10 Gbps and SFP at lower data rates have dominated the optical module form factor on client-side applications. For line-side applications, so far only discrete line cards and 300-pin transponders are able to provide the required transmission performance for Metro and long haul DWDM systems. With the compact physical size of CML TOSA, XFP modules can now be produced to meet the high-performance requirements of line-side applications as well.

The CML XFP will be available on all ITU channels with 50 GHz spacing in both C band and L band and will provide the high dispersion tolerance and low OSNR capabilities required in Metro and long haul DWDM applications. These efficiencies will enable multiple 10 Gbps ports on each DWDM card, thus increasing bandwidth as well as introducing the other benefits associated with hot pluggable modules. In conclusion, CML provides a compact and high-performance alternative to external modulator-based transmitters. With its performance advantages, CML may be seen as an interesting alternative in a wide range of applications.

VIII. SIMULATION RESULTS

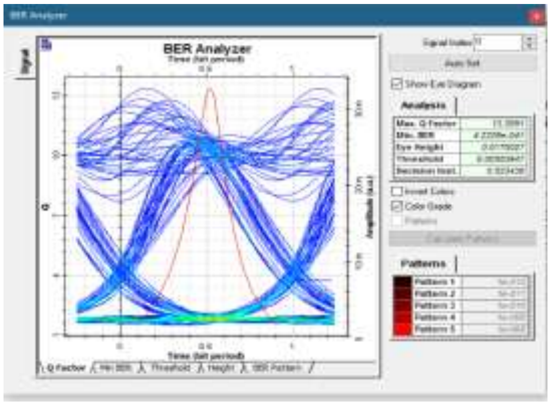


FIG 3**:** Eye diagram of EML for 200 km

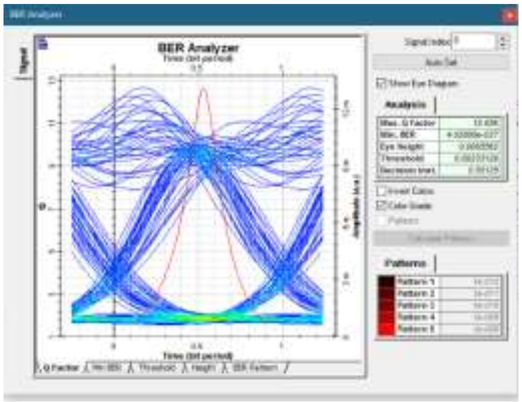
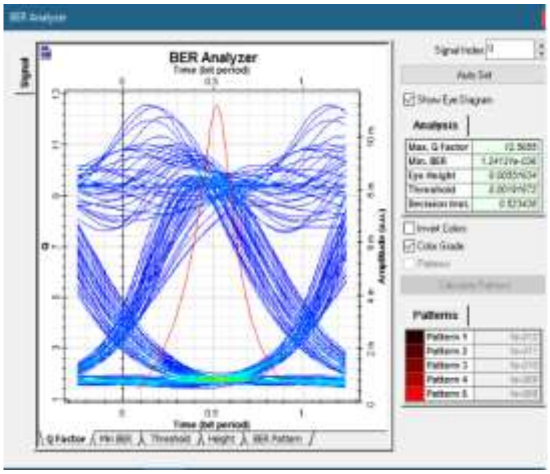


FIG 4**:** Eye diagram of EML for 240 km



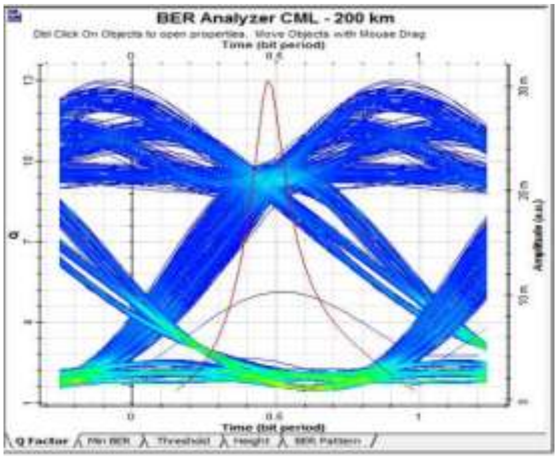


FIG 5**:** Eye diagram of EML for 280 km

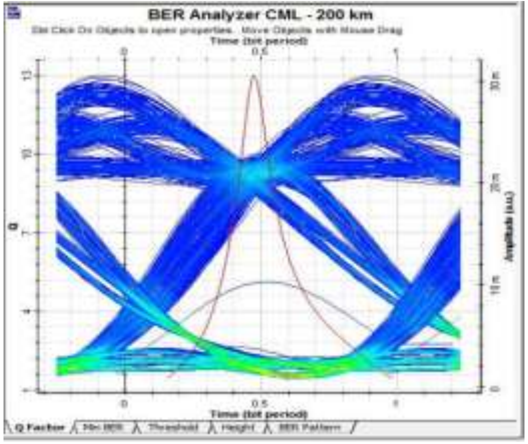


FIG 6**:** Eye diagram of CML for 200 km

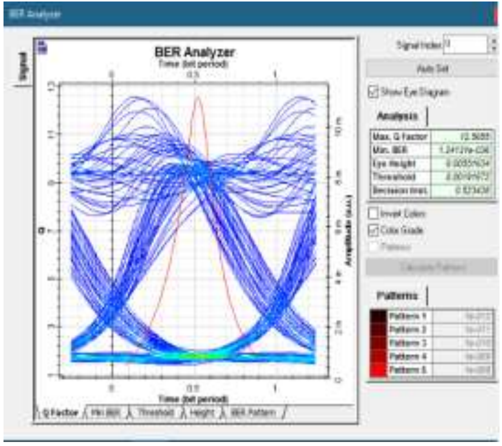


FIG 7**:** Eye diagram of CML for 240 km

FIG 8**:** Eye diagram of CML for 280 km

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