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Chaos Based Fiber Optic Bidirectional Communication

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Abstract **—** In this paper a fiber-optic disorder communication system is explained. Also bidirectional message transmission is constructed. Chaotic waveforms have many applications in the field of communications. Bi directionally attached semiconductors lasers (SL1 and SL2) are of same type are used. Using the outputs of the two semiconductor lasers as communication carriers, two oppositely transmitted elevated frequency analog messages can be encrypted and decrypted between the two terminals of communication. Using a single mode fiber channel this is achieved. In addition to that, two data stream can also be bi directionally encrypted and decrypted with bit-error-rates estimated.

Keywords- Optical communication, Semiconductor lasers, Synchronization.

I. INTRODUCTION

In optical communication systems, chaotic signals have recently been used to encode information and protection. Chaotic waveforms have recently been naked to be attractive for many applications. Benefits of chaotic communications include capable use of the bandwidth of a communication channel, employment of nonlinearities in communication devices, large-signal modulation for proficient use of carrier power, reduced and minimum number of components usage in a system, and defence of communication by chaotic encryption. Most of the examiner conduct in chaotic communications addresses systems based on synchronization of chaos. This is between a transmitter and a receiver related by a transmission channel. For such systems, chaos binding together is mandatory, while the quality of communication measured by the bit-error rate (BER) of a decoded message at the receiver and depends on the accuracy of synchronization.

Here, we are interested in chaotic optical communications based on the synchronization of confusion is generated in semiconductor lasers. Hence, semiconductor lasers are the selected light sources for optical communication systems transmitting messages at high bit rates. Message recovery at allowed receivers can be affected when the receiver is chaos-synchronized to the transmitter. A milestone result of high-speed long-distance visual communications over a trade fiber-optic channel based on chaos synchronization of semiconductor lasers was reported freshly. Vertical-cavity surface-emitting lasers, as a special type of semiconductor laser, have gained increasing important for a wide range of applications because of their price tag. Its design advantages

include compact size, fewer thresholds current and wafer-scale inerrability. There have been some investigations of disarray-synchronization in VCSELs. In recent times the encoding and decoding of messages of up to 200 MHz is unite directionally coupled VCSELs was discussed and reported. In this paper, we study the important problems concerning high-bit-rate chaotic optical communications based on the synchronization of semiconductor lasers.

II. GENERAL ISSUES

A. Laser Systems

Chaos synchronization and message encoding–decoding, with the purpose of chaotic communications, have been dynamically investigated for a number of different systems based on semiconductor lasers fiber ring lasers, and solid state micro-chip lasers. We are interested in optical communications with single-mode semiconductor lasers, which are the primary laser sources for established optical communication systems.

B. Chaos and Synchronization

In this paper, we consider only bidirectional systems as shown in Fig 2.For creating the disorder waveform; a technique called external modulation is opted for this system shown in Fig 1.

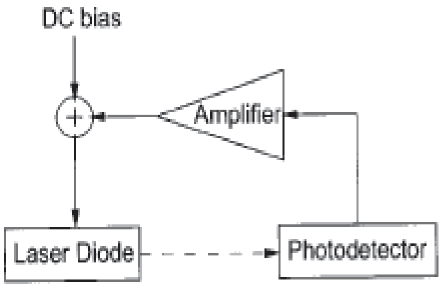

Fig 1: External modulation

C. Encoding and Decoding Schemes

More than a few encryption methods have been considered and verified for chaotic communication systems in optical field. The most important are contain chaos shift keying, chaos masking, chaos modulation, and chaotic pulsation position modulation. In the folder of chaos modulation, in cooperation additive chaos modulation (ACM) and multiplicative chaos modulation (MCM) were considered carefully. The encryption scheme that have been pain tasking in numerical studies and trial demonstrations of message encoding and decoding in chaotic optical message systems reported in the text to date include a choice of algorithm like CSK, ACM, and MCM. Correct synchronization cannot be estimated in the process of message encoding with DES. In this paper, we are not using any algorithm technique to the encryption method for chaotic optical communications. The encoding and decoding schemes for the encryption process in laser system are shown in Fig. 2. The encryption system is implemented by encoding the message from side to side direct current modulation of the source. Decoding of the message is prepared by subtracting the yield of the receiver from the signal that is transmitted to the receiver. In the encryption process, a message is determined on the chaotic yield of the transmitter by basically adding the message to the chaotic waveform being transmitted to the receiver. The message is decoded by subtracting the output of the receiver from the signal that is transmitted to the receiver.

D. Performance Measures

The regular performance measure of a communication system is the bit rate error ratio for the decoded message as a task of the signal-to-noise ratio in the transmission conduit. The conduit SNR is defined as where is the power of the transmitted message and is the difference of the channel noise with being the power spectral density of the channel noise and being the bit period. The BER of the decoded message is a task of the channel noise and the laser noise, both of which origin synchronization blunder between the transmitter and the receivers. The output waveforms of the transmitter and the receiver respectively, denote the time average. The synchronization slip defined above is a measure of the synchronization quality of the system, with a small value of indicating a high synchronization quality.

In a chaotic communication scheme, the synchronization slip is caused mainly by the noise. It includes the channel noise as well as the transmitter and receiver noise, and by the message encoding process. This varies from one encryption scheme to another. Therefore, the BER performance of a synchronized chaotic communication system is also a function of the encryption scheme used. The synchronization error of a system is contributed by the following two forms of errors: synchronization deviation, which is associated with the accuracy of synchronization, and resynchronization burst, which is associated with the robustness of synchronization. Next we use the projected scheme to simultaneously exchange information between SL1 and SL2.This is done by using a single communication channel i.e. through a single mode fiber. We encode the information by concurrently modulating the bias currents of both lasers with two self-regulating pseudorandom digital messages.

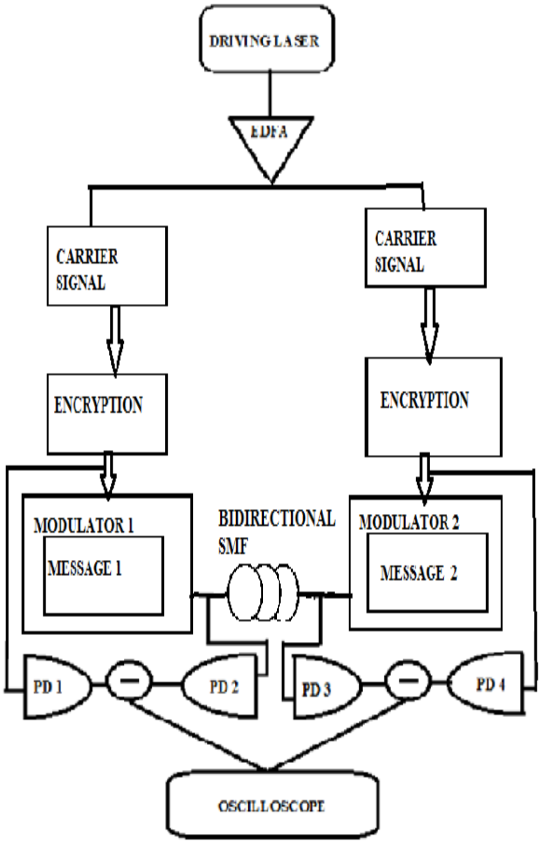

Fig 2: Block diagram of Bidirectional Communication

III. COMPONENTS USED

A. Optical isolator

An optical isolator is a passive magneto-optic device that only allows light to travel in one direction. Isolators are used to protect a source from back reflections or signals that may occur after the isolator. Back reflections can damage a laser source or cause it to mode hop, amplitude modulates, or frequency shift. In high power applications, back reflections can cause instabilities and power spikes.

B. Photo detector

Photo detectors are used primarily as an optical receiver to convert light into electricity. The principle that applies to

Photo detectors are the photoelectric effect, which is the effect on a circuit due to light. Max Planck In 1900 discovered that energy is radiated in small discrete units called quanta; he also discovered a universal constant of nature which is known as the Planck's constant. Planck's discoveries lead to a new form of physics known as quantum mechanics and the photoelectric effect E = hv which is Planck constant multiplied by the frequency of radiation.

C. Step-Index Multimode Fiber

Due to its large core, some of the light rays that make up the digital pulse may travel a direct route, whereas others zigzag as they bounce off the cladding. These alternate paths cause the different groups of light rays, referred to as modes, to arrive separately at the receiving point. Graded-Index Multimode Fiber - Contains a core in which the refractive index diminishes gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding. Due to the graded index, light in the core curves helically rather than zigzag off the cladding, reducing its travel distance.

D. Single Mode Fiber Optic Cable

Single mode fiber optic cable has a small diametric core that allows only one mode of light to propagate. Because of this, the number of light reflections created as the light passes through the core decreases, lowering attenuation and creating the ability for the signal to travel faster, further. This application is typically used in long distance; higher bandwidth runs by Telco's, CATV companies, and Colleges and Universities. Single mode fiber is usually 9/125 in construction. This means that the core to cladding diameter ratio is 9 microns to 125 microns.

E. Optical circulator

An optical circulator is a special fiber-optic component that can be used to separate optical signals that travel in opposite directions in an optical fiber, analogous to the operation of an electronic circulator. An optical circulator is a three-port device designed such that light entering any port exits from the next. This means that if light enters port 1 it is emitted from port 2, but if some of the emitted light is reflected back to the circulator, it does not come out of port 1, but instead exits from port 3. Circulators can be used to achieve bi-directional transmission over a single fiber. Because of its high isolation of the input and reflected optical powers and its low insertion loss, optical circulators are widely used in advanced communication systems and fiber-optic sensor applications. Optical circulators are non-reciprocal optics, which means that changes in the properties of light passing through the device are not reversed when the light passes through in the opposite direction. This can only happen when the symmetry of the system is broken, for example by an external magnetic field. A Faraday rotator is another example of a non-reciprocal optical device.

F. Optical power meter (OPM)

An optical power meter (OPM) is a device used to measure the power in an optical signal. The term usually refers to a device for testing average power in fiber optic systems. Other general purpose light power measuring devices are usually called radiometers, photometers, laser power meters, light meters or flux meters. A typical optical power meter consists of a calibrated sensor, measuring amplifier and display. The sensor primarily consists of a photodiode selected for the appropriate range of wavelengths and power levels. On the display unit, the measured optical power and set wavelength is displayed. Power meters are calibrated using a traceable calibration standard such as a NIST standard. A traditional optical power meter responds to a broad spectrum of light; however the calibration is wavelength dependent. This is not normally an issue, since the test wavelength is usually known, however it has a couple of drawbacks. Firstly, the user must set the meter to the correct test wavelength, and secondly if there are other spurious wavelengths present, then wrong readings will result. Sometimes optical power meters are combined with a different test function such as an Optical Light Source (OLS) or Visual Fault Locator (VFL), or may be a sub-system in a much larger instrument. When combined with a light source, the instrument is usually called an Optical Loss Test Set.

IV. CHAOS COMMUNICATIONS RESULTS

Pin type Photodiode is mainly used to receive the signals. It is highly reliable. It is high sensitivity to low noise. Very less temperature sensitive. It will operate within the operating voltage of 5 to 15 volts. Because of its low cost and low circuit complexity, In this case it is used. Encryption of the carrier signal is performed at the Transmitted end. Decryption of the Carrier signal is performed at the Receiver end.

The data from source is modulated in the modulator and it is encrypted in chaos signal. The encrypted signal and the carrier signal from the laser2 captured in the photo detector. Thereby the carrier signals are getting cancelled leaving out only the message signal at the photo detector. The message signal1 can be viewed at the oscilloscope3. Similarly, the message signal 2 is encrypted and it is send through SMF to the photo detector. The carrier signal from laser1 is captured in the photo detector. Thereby, the carrier signals of message 2 and laser 1 will get cancelled leaving out only the message 2. Figure 2 is our experimental setup for simulating

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Bidirectional communication with a 15 km communication distance. A chaotic driving signal generated by a driving laser subject to external feedback and amplified by an erbium-doped fiber amplifier. Figure 3 shows the chaotic carrier output waveform. Figure 4 shows the same after amplification by EDFA.

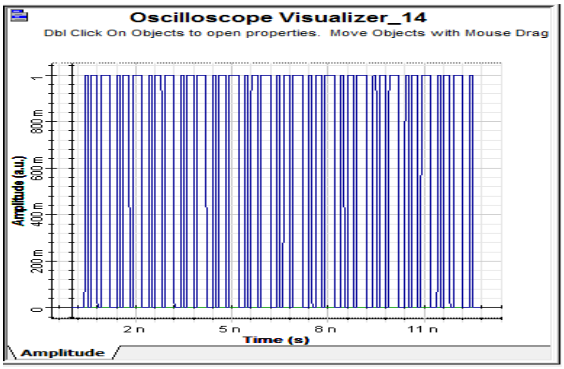

Fig 3: Chaotic carrier waveform

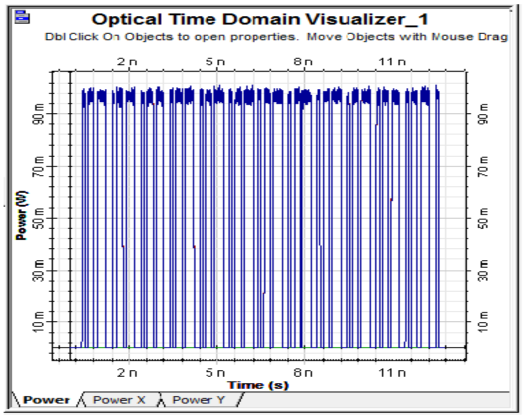

Fig 4: Chaotic data waveform after EDFA

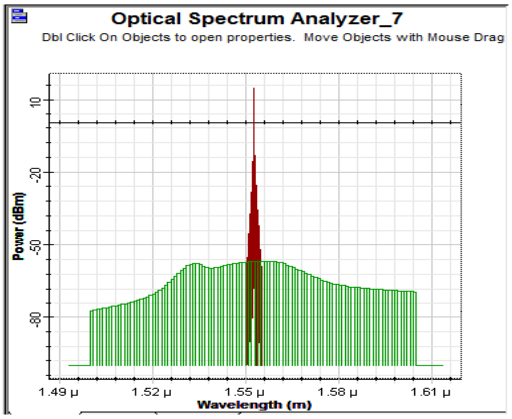

Fig 5: Peak waveform

Figure 5 shows its optical spectrum analyzer output waveform. Figure 6 shows the message 1 data waveform.

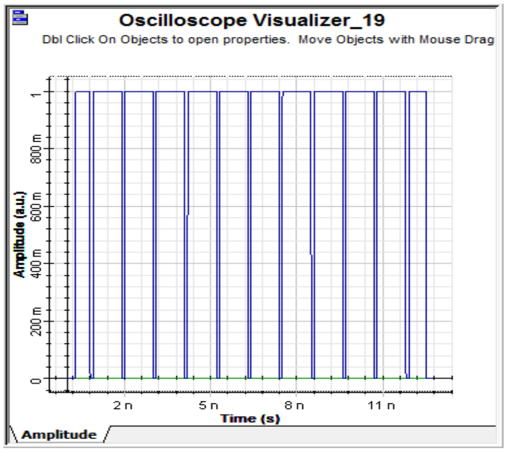

Fig 6: Message1 input bits

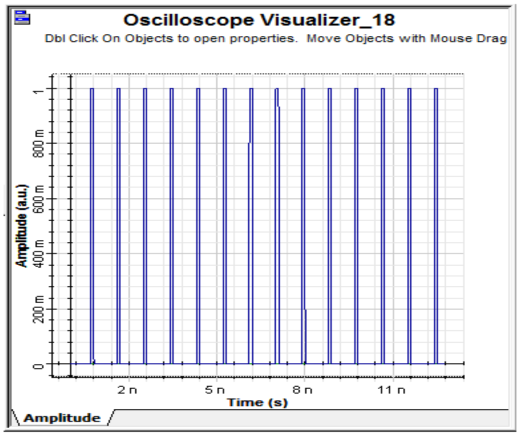

Fig 7: Message 2 input bits

Figure 7 displays the message 2 data waveform. Two sinusoidal messages are respectively encoded into the outputs of Laser 1 and Laser 2, and transport along two opposite directions through the 15 km distance single mode fiber.

The intensity dynamics of the system is detected with a fast photo detector with a bandwidth of 12 GHz. Its signal is amplified and analyzed by a fast digitizing oscilloscope with a temporal resolution limited to 4 GHz.

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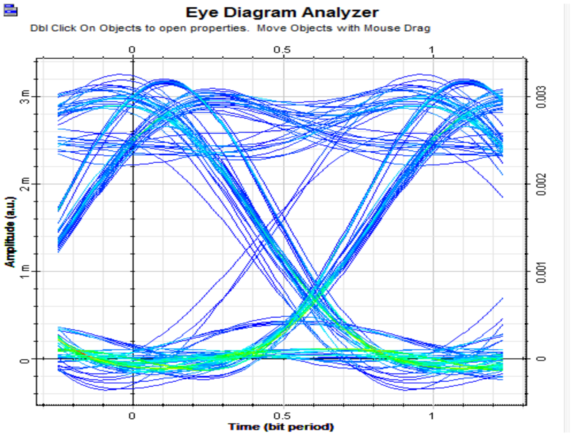

Fig 8: Message 1 eye diagram

Figure 8 and figure 9 displays the eye diagram s of message 1 and message 2 respectively. Figure 10 and 11 displays the experimental performance decoded waveforms of message 1 and 2 respectively. Thus we got required decoded output which was earlier encrypted by the sender and transmitted across 15 km distance through single mode fiber.

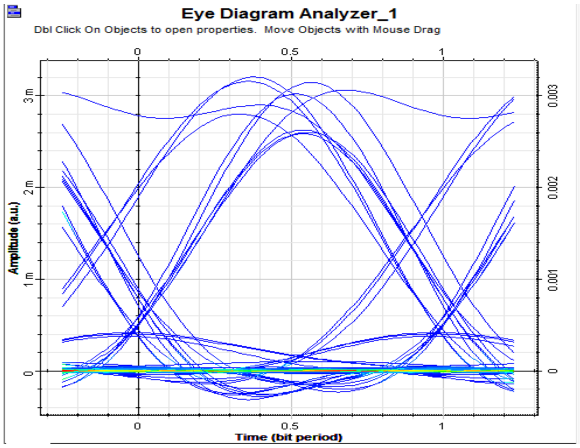

Fig 9: Message 2 eye diagram

Figure 8 and figure 9 displays the eye diagram s of message 1 and message 2 respectively. Figure 10 and 11 displays the experimental performance decoded waveforms of message 1 and 2 respectively. Thus we got required decoded output which was earlier encrypted by the sender and transmitted across 15 km distance through single mode fiber.

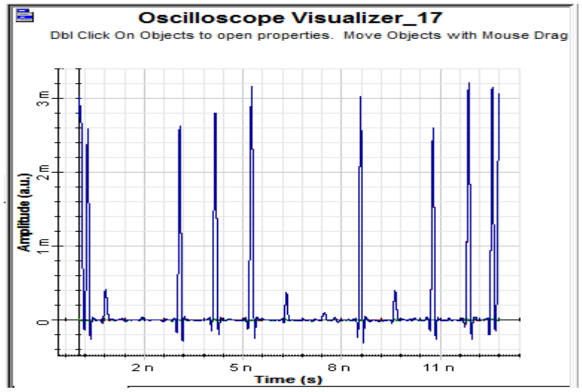

Fig 10: Message 2 Decoded output waveform

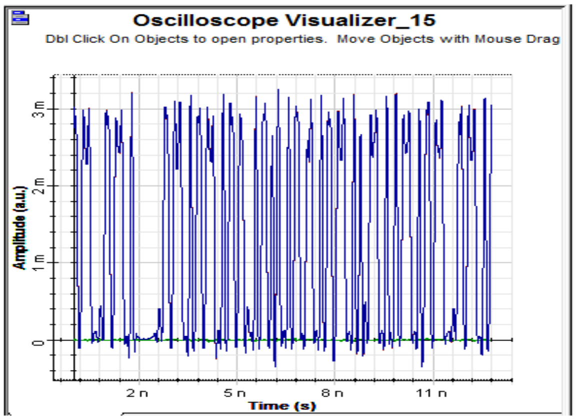

Fig 11: Message 1 Decoded output waveform

V. CONCLUSION

The proposed chaos communication setup has demonstrated an efficient and robust solution for optical chaos communications. Length of the fiber will be increased. Applying different modulators and determine the communication efficiency. Analysis the Bit Error Rate and quality factor for different modulator. Since reliability and efficiency of chaos communications have been now achieved with rather basic architectures, future work will be definitely devoted to the analysis and the enhancement of the related security. Analogue optical signal processing protocols would need to be designed, making use of the numerous available components developed.

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