Evaluation of Traffic Monitoring Wireless Sensor Network System under the Effect of Various Climatic Conditions

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ABSTRACT: Wireless Sensor Networks for real time traffic surveillance system in an Intelligent Transportation Systems which is currently considered to be challenging application area for this emerging technology. The promise of an unmanaged infrastructure, with a continuous drop in cost per unit, attracts the attention of both final users and system integrator and thus, opening new business opportunities. This paper describes a Traffic Monitoring Wireless Sensor Network system, based on Wireless Optical Communication System. A practical case study is presented starting from a real problem and reaching the best architectural solution with particular focus on hardware implementation and communication protocol design. Finally, real experience results are shown to highlight the effect of climate over traffic surveillance using Wireless Sensor Network.

Keywords- WSN, Free Space Optics, Attenuation, MCU, TMC, Magnetic flux Laser, and Diode.

1. INTRODUCTION

Nowadays, there is increase in congestion level in public road transport networks all around the world and many reports are published over internet and on social media that support this fact. To mitigate such problem for instance, Traffic Management center (TMC) of U.S. uses measurement of urban intersections to optimize traffic signal light settings based on traffic queue lengths and road user uses this information to better plan their activities and adjust their route[1].

The devices used by this traffic monitoring system are equipped with significant processing, memory and wireless communication capabilities. Emerging low-level and low-power wireless communication protocols can be used to networks for the deployment of the sensors. This capability adds up a new dimension to the capabilities of sensors. Sensors become capable to coordinate among themselves on a higher-level sensing task [1].

Networking inexpensive sensors can revolutionize information gathering in a variety of situations. A sensor node usually consists of four sub-systems:

- A computing subsystem: In a sensor node, the microprocessor (microcontroller unit, MCU) is responsible for functions such as control of sensors and execution of communication protocols.
- A communication subsystem: This comprises of short range radios used to communicate with neighboring nodes and the outside world. These devices work under various modes and have various levels of energy consumption.
- A sensing subsystem: Low power components can help to significantly reduce power consumption.
- A power supply subsystem: It consists of a battery which supplies power to the node [2].

In recent years, aboveground sensors like video image processing [3], microwave radar, laser radar and passive infrared, ultrasonic, passive acoustic array are being used. However, these systems have a high equipment cost and their accuracy depends on environment conditions [4][5].
A basic traffic monitoring system consists of two main parts: firstly a wireless sensor network and secondly an access point (controlled/work with the help of wireless optical systems). The wireless sensor network consists of clusters of node, each having one or more sensors, a processor with limited computation and a battery. They

generate traffic information such as numbers of vehicle, speed and length of the vehicles, based on processed sensor data. The information is sent to the access point over the radio via laser. The basic idea behind vehicle detection is that all vehicles are made up of Ferro-magnetic material so for that purpose sensors with magnetic properties are used. Magnetic sensors now generate some input signals whenever a vehicle comes in the contact of these sensors

But the sensors in whole traffic monitoring system are just to collect data and send it to base station where the analysis is performed. Now the basic work is performed by the wireless optical communication which transfers the data from sensors to next phase.

Wireless optical communications have been the predominant form of communication technique. As Wireless optical communication systems do not exhibit the limitations associated with the installation and maintenance of guided wave coaxial communication systems.

Wireless optical communication is an optical communication technology that uses light propagating in free outer environment to transmit data for telecommunications or computer networking. The receiver's lens able to collect the photon stream from the transmitter converts the signal back to electrical signal. The optical transmitter can modulate the optical signal to carry data. The optical receiver then collects all of the energy of the optical signal and converts the optical signal into an electrical signal. The optical receiver can operate on this electrical signal recover the modulated data. The optical links usually use laser light, although low-data-rate communication over short distances is possible using light-emitting diodes (LEDs). These systems do not exhibit the limitations associated with the installation and maintenance of guided wave coaxial communication systems. It is very useful to establish LAN links between buildings.

2. PROBLEM SOLUTION

The performance of Wireless Optical System can be measured by various set of parameters. These parameters are then divided into two main categories internal parameters and external parameters, but the main factor on which the Wireless Optical System affects are listed in table 1. In this chapter we would concentrate on the performance of the Wireless Optical System under Modulation formats. We simulate the wireless optical system model for comparing the transmission performance of wireless optical system for different data format, maximum transmission distance in different formats and to evaluate the Bit Error Rate (BER) and Q factor performance using optisystem software.

S.No	Parameter	Value taken
1	Extinction ratio	10
2	Frequency	C BAND 1530-1565 nm
3	Line width	10
4	Transmitter device diameter	5 cm
5	Fiber Cable	Single mode fiber
6	Receiver device diameter	7.5 cm
8	Transmitted loss	0.5 dB
9	Additional loss	0.5 dB
10	Responsivity	1 A/W
11	Dark current	10 nA
12	Distance	In Kms

Table 1: Parameters used for Wireless Optical system

3. OBJECTIVES

We have set the following objectives for our following research:

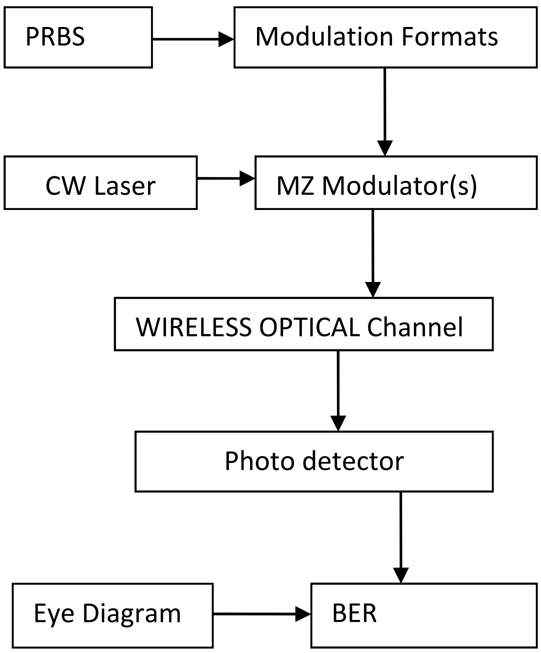
i. There should be receiver and transmitter to send or receive the signals.

ii. In the transmitter we will choose the best type of laser with power control and maximum output with continuous signal.
iii. Frequency of laser should be checked according to the less power consumption. (Freq of laser should be high).

4. EXPERIMENTAL SETUP

For evaluating the parameters of Wireless Optical System we present a setup that is divided into three basic parts which are:
1. Transmission section: The Transmitter consists of a data source, Modulation formats (which are of two types- Return to Zero and Non Return to Zero formats of modulations), Mach-Zehnder (MZ) modulator, Continuous Wave (CW) laser and Pseudo Random Bit Sequence (PRBS) generator.
2. Medium section: The system consists of optical channel for transmitting signal from transmitter to receiver.
3. Receiver section: Receiver consists of PIN receiver, BER tester, Eye Analyzer.

4.1 Block Diagram



As shown above the basic block diagram of the proposed framework that we are going to use for traffic monitoring in contrast to which we will check for our wireless optical system for traffic surveillance. Once block diagram is competed we design setup for wireless optical system.

4.2 Designed Setup

The internal parts of the system are shown below. The transmitter consists of Pseudo Random Bit Sequence (PBRS) generator, NRZ pulse generator, Optical source and Mach-Zehnder modulator. At the receiver subsystem consists of optical receiver as photodiode with BER analyzer

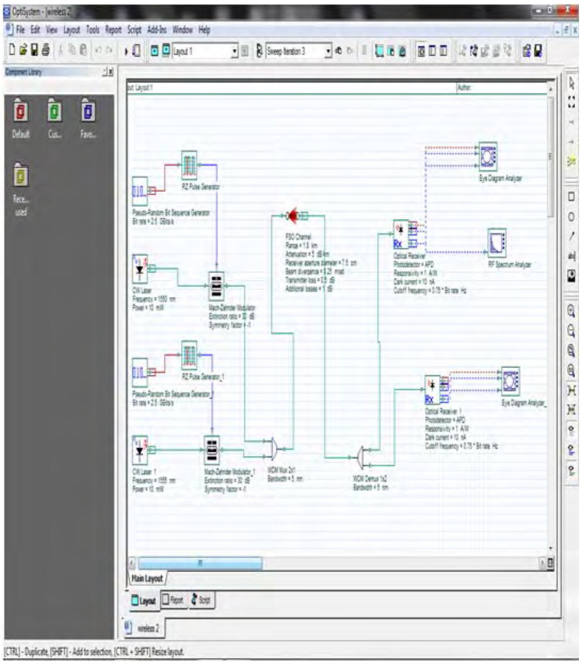


Fig 1.3 shows the design setup for traffic surveillance

The bit rate is first decided to get the proper communication between two points. Bit rate is fixed to a value i.e. 2.5 Gbps. Type of laser id also decided, the setup is using CW laser with wavelength of 1550-1553 nm. RZ (return to zero) format of modulation is used. The attenuation is finalized as 5dB/km. In the results the system calculates the Bit Error Rate which should be less than 10^{-9}. Quality factor is also measured which should be near about 6 or more.

4.3 Eye Diagram

An eye pattern, also known as an eye diagram, is an oscilloscope display in which a digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because, for several types of coding, the pattern looks like a series of eyes between a pair of rails. It is an experimental tool for the evaluation of the combined effects of channel noise and intersymbol interference. It is the synchronized superposition of all possible realizations of the signal of interest viewed within a particular signaling interval.

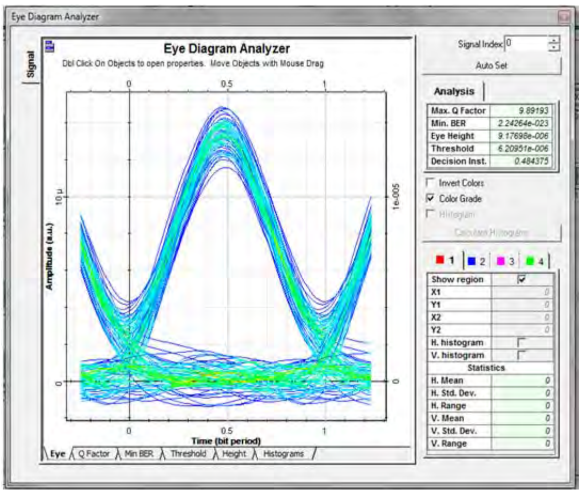


Fig 1.4 Eye diagram representation

5. RESULTS

The results of simulation of Wireless optical system for various climate change can be measured by the change in attenuation of the whole experimental model for traffic surveillance and how attenuation values gets effected by various weather are shown in the table 1 that denotes what type of weather condition produces different attenuation values.

ATTENUATION	WEATHER CONDITION
1-5	Clear Weather
5-10	Mist
10-20	Rain Fall
20-30	Heavy Rain Fall
30-40	FOGG
40-50	HEAVY FOGG
>50	SNOW FALL

Table 1: Set of attenuation values for different weather conditions

Now after obtaining the values of attenuation for different weather condition we now put those values in our proposed framework and with the help of eye diagram analyzer we conclude as shown in table 2 for wavelength of 1553 nm and power of 10 mw only.

Wavelength (nm)	Power (mw)	Attenuation	Distance (m)
1553 nm	10 mw	5	1800 m
1553 nm	10 mw	10	1200 m
1553 nm	10 mw	20	800 m
1553 nm	10 mw	30	640 m
1553 nm	10 mw	40	510 m
1553 nm	10 mw	50	410 m
1553 nm	10 mw	60	330 m

Table 2: Set of Input attenuation and distance corresponding to different attenuation

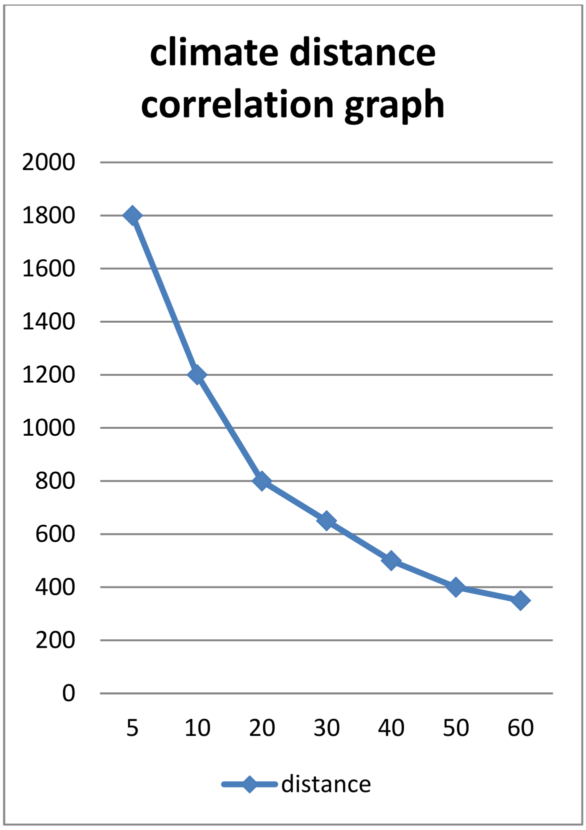


Fig 1.5: Eye diagrams value with attenuation and distance

6. CONCLUSION

We have used return to zero formats for modulation; we have sent data to the receiver in different frequency for CW laser, and analyzed all conditions by eye diagrams. We have sent data up to 2.5 Gbps with low bit error rate and with less attenuation. We have used frequency of 1553 nm and power of 12 mw and we conclude with the help of data that range between transmitter and receiver decreases to 33.33% when the attenuation ranges changes from 5-20 and after that there occurs a decrement of 20% in the transmission of data from transmitter to receiver for the attenuation range of 20-60.

6. FUTURE SCOPE

This research work aims to give an overview of traffic surveillance using wireless optical communication. The future researcher can use some other laser for communication purpose with less power consumption, and can improve the communication distance. The improvement like implementation in remote area is also possible where human interference is not possible. Repeaters can also be introduced to improve the distance of communication.

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