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Optical Wireless Communication for Underwater Vehicles

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Abstract: *This paper implements and develops a new method of controlling the electric car by employing accelerometer. Generally in the history of evolution of electric cars, there is a lot of changes take place in almost all aspects of the electric car and tremendous advances have been made in the field of electric vehicles. But the basic operation of steering and acceleration system remains the same. So in addition to these advancements, we introduced a new method of controlling electric vehicles, i.e. basic and traditional type of acceleration and steering control is changed. The accelerometer is in-built in the controller which is given to the driver for controlling the vehicle acceleration and steering. The accelerometer in the controller senses the calibrated input from the driver. The controller itself analyses the input and drives the motor and also controls the speed accordingly to it. It gives a feeling of driving a one manned plane. Since there is no need of using legs to drive these vehicle even a paraplegic persons can drive this kind of electric car easily. This new method of controller used in electric vehicles mainly concerned on ease of driving.*

Keywords*:* Integrated optoelectronics, Lighting control, Optical communication equipment, Optical receivers, Optical transmitters

INTRODUCTION

The growing need for underwater observation and subsea monitoring systems has stimulated considerable interest in advancing the enabling technologies of underwater wireless communication and underwater sensor networks. This communication technology is expected to play an important role in investigating climate change, in monitoring biological, biogeochemical, evolutionary, and ecological changes in the sea, ocean, and lake environments, and in helping to control and maintain oil production facilities and harbors using unmanned underwater vehicles (UUVs), submarines, ships, buoys, and divers. However, the present technology of underwater acoustic communication cannot provide the high data rate required to investigate and monitor these environments and facilities. Optical wireless communication has been proposed as the best alternative to meet this challenge. In this paper, optical communication using LEDs is presented as an improvement over acoustic modems for scenarios where high speed, but only moderate distances, is required and lower power, less complex communication system are desired. A ultra-bright blue LED based transmitter system by optimizing it with opt coupler and a enhanced photodiode based receiver system were developed with the goal of transmitting data at high data rates by using On-Off keying technology.

LITERATURE REVIEW

RF waves

The most common way of wireless communication was through Radio waves or RF waves. But unfortunately these waves suffered high attenuation as their propagation underwater was dependent on their frequency and also the salinity of the water. Another loss suffered by the RF waves is due to the refraction that takes place at the air-water interface this phenomenon again leads to loss of information. For the waves to travel a longer distance they need to be of higher frequency but higher the frequency, higher is the

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attenuation which is also directly dependent on the conductivity.

$$\text{Attenuation in dB / metre} = 0.0173\sqrt{f(conductivity)}$$

f -refers to the frequency of the RF wave used

To overcome this, low frequencies in the range of 10-30 KHz were used but the bit transfer rate using these waves was significantly low.

$$\text{Refraction loss} = -20\log\{(7.4586\text{x}10\text{^}6)/\sqrt{f}/conductivity$$

This loss can be reduced by connecting an antenna under the sea equipment. The saline content in the water made it a conducting medium and reduced the distance up to which the wave could propagate, therefore this method was not preferred for underwater wireless communication.

Acoustics

ACOUSTICS, they refer to the sound waves. When compared to their speed in air, sound waves travel at a greater speed in the water.

Sound speed in Air-340 m/s

Sound speed in Water-1500 m/s

Acoustics solved the problems posed by the RF communication up to major extent. The data rate achieved by using Acoustic modems underwater measured a data transfer rate of up to few hundred kilobits per second when compared to the RF modems. But as all other modes even Acoustics encountered problems in underwater. The major drawbacks of using Acoustics underwater were that, Speed was directly dependent on temperature, pressure and salinity of water. Presence of thermo clines, haloclines also affected the speed and information carrying capacity of the acoustic waves. As all RF waves here also the data transfer was directly dependent on the frequency of the wave.

Electromagnetic Waves

Here, electromagnetic waves which travel at the speed of light 30,00,00,000 m/s, paving way for a faster communication medium. These waves travel at a speed greater than that of sound waves and were considered as an alternative. But not all waves could travel a longer distance into the water and were attenuated due to absorption and scattering at the air-water interface. Only waves of particular wavelength specifically in the range of 400nm-700nm in the visible spectrum region were attenuated less and could be considered for any communication purpose .Even in this spectrum, wavelength 470nm wavelength-blue light was observed to be attenuated the least and penetrated water the most and could be employed for further applications.

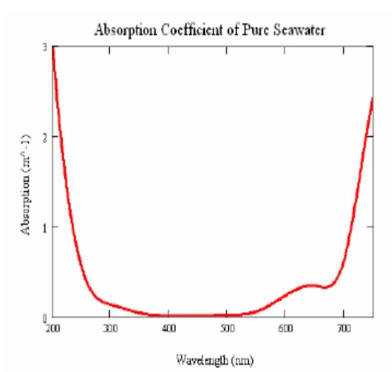

Fig. 1. Absorption coefficient of visible light wavelength

From the above fig 1, it can be inferred that visible spectrum suffered least attenuation. The above figure shows that why blue light was chosen from the visible spectrum. Therefore, from the data we can conclude that blue light suffered least attenuation and could penetrate up to greater depths. Hence it could be employed as the source for transmission underwater.

DESIGN CONSTRAINTS

The main issue that needs to be addressed is that the system has to work in a space-limited vehicle. It has to use minimal power occupy less space and also the system has to work in an environment wherein even though it's not perfectly aligned with the base station it can transmit and receive with least margin of error. More important is that it should be able to support high data rate of communication as in >=1Mbps. Therefore, the priorities can be classified as high speed, low power consumption, maximum distance and low complexity of the system.

SYSTEM DESIGN

The key feature that has to be taken care is that of component features and design. As in every communication system it has the transmitter which gets the data either from the computer or microprocessor this electric signal is converted into optical signal by the suitable photon source. Every state in the electric signal must be switched properly during transmission so that receiver can decode the data without any error. On the receiver side, these optical signals are converted back to electrical signals and the data that has been transmitted will be converted back and displayed either on the computer or any display.

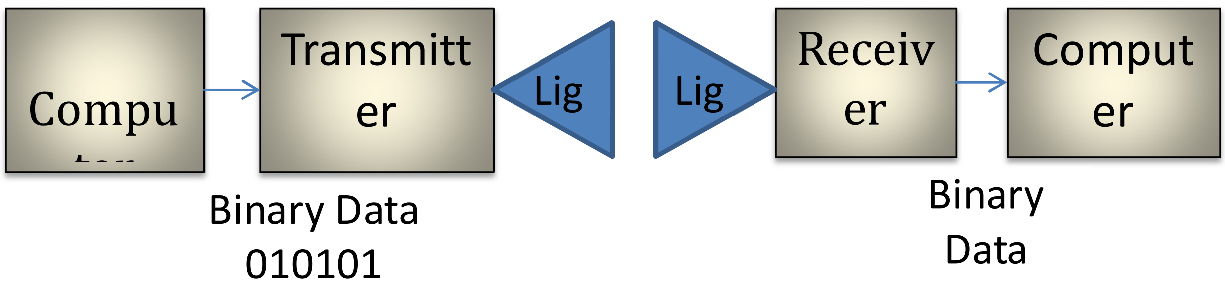

Fig 2 .Wireless optical Communication System Overview

Transmitter

The basic function of transmitter is to convert the data into electric signals and switch this data into optical signals and send it out to the receiver. There is no such special modulation techniques followed during transmission just a simple on-off keying, here ON state represents presence of data and the light glows and OFF represents no data and hence light doesn't glow.

The functional blocks of transmitter can be divided into

- Data from PC
- USB-TTL serial data converter
- Optical driving system
  1. MOSFET Driver
  2. MOSFET
- Photon source

The key design feature is the selection of suitable photon source as the rest of the system drives the photon source. In this design LED was chosen as the photon source from the available sources due to its stability and linearity in the temperature and pressure underwater.

Photon Source

There are many photon sources available anything from a small incandescent bulb to a laser diode can be used as photon source. But, LED's were chosen as they are highly efficient, low-power consumption, more reliable and linear devices.

LED (Light Emitting Diode)

These devices are pn-junction semiconductor devices which emit light when forward biased. It consists of a p-type semiconductor and n-type semiconductor, when forward biased the excited electrons from n-type flow to the p-type junction crossing the energy gap. The wavelength of the light emitted depends upon the band-gap energy between the valence band and conduction band. Unlike, the incandescent bulbs which emit white light consisting of all the wavelengths, LED's are capable of emitting light of specific wavelength as discussed earlier, LED emitting a wavelength of ~470nm was chosen for the design.

The main constraint in choosing the appropriate LED was the recombination time which decides the switching speed of the LED. A recombination time of 1 to 100 ns was chosen as the LED's could reach modulation speeds of several MHz. Moreover, LED's are relatively cheaper and available widely. After deciding upon the photon source, the most suitable LED i.e., ~470 nm has to be selected. For its application as a photo source the LED must emit a minimum luminous flux of 30-60 lumens implying that high power LED's must be chosen. Most of the LED's available emit meager 1-2 lumens. Thereby, a proper LED must be chosen. Here, blue LED

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of 2 Watt- power rating was chosen. High power LED's drawn a current of 500mA-1000mA and requires 2-5 forward voltage drops in series. Though LED's are more efficient even they are very much affected by temperature fluctuations. Therefore, proper heat sinks must be provided to prevent any occurrence of damage.

LED Driver

Once the photon source was decided it has to be driven in accordance with the input binary data from the computer. This data is converted into equivalent voltage levels, these voltage levels have to be converted into equivalent current levels as LED's are mostly current driven devices. For this purpose of current-voltage conversion, MOSFET is preferred as it acts as a switch to control the current flow in the LED's thereby acts as a voltage to current converter.

MOSFET

MOSFET (an electronically controlled switch) is used to switch the current through the LED's. When there is no voltage drop between the gate and the source the resistance between the drain an source is high, thereby MOSFET remains in "off" state .Once a certain voltage drop exists between the gate and the source the resistance between drain and source terminals decreases thereby turning "on" the MOSFET. Essentially, the voltage drop is minimal between the drain and source causing large amount of current to flow through.

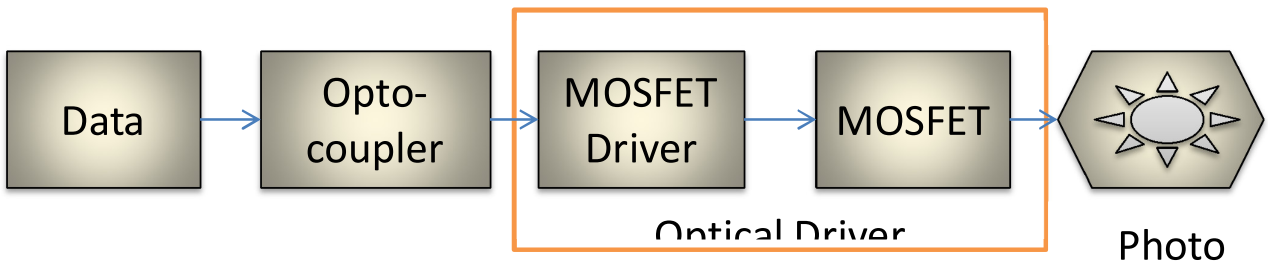

Fig 3. Transmitter System - Overview

SIMULATION TOOL

Introduction

ASAP (Advanced Systems Analysis Program) 2014 V2 from Breault Research Organization (BRO) is an optical engineering software that is used for optical design and analysis. BRO encourages you to select an operating system that supports optimal performance for ASAP, and uses processor resources intensively for its computation, analysis, and graphical output.

Four-step Process in ASAP

Workflow in ASAP is based on a simple, four-step process that is designed into the UI.

1. Define and verify the system geometry (System)
2. Define and verify the system sources (Rays)
3. Trace
4. Analyze

Communicate with ASAP via its spreadsheet interface, its scripting and macro language, or by important geometry from a computer-aided design (CAD) program.

Software Output

STEP 1 & 2 – Define and verify the system geometry (System)

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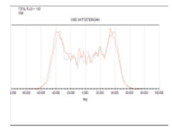

Fig 4. Light LED BB01

STEP 3 - Trace inputs window BB01

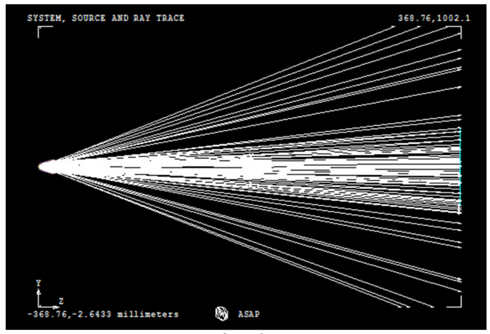

Fig 5. Trace of Light LED BB01

STEP 4 - Analysis window of BB01

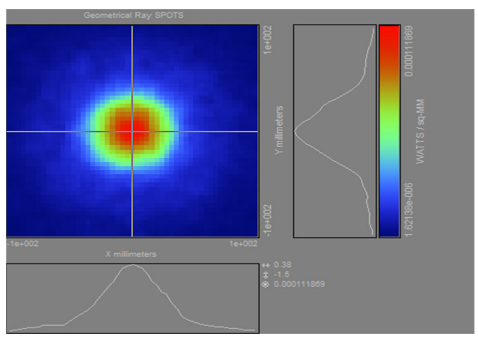

Fig 6. Analysis of Light LED BB01

CONCLUSION

In this paper, I had presented a solution to the need for low-power, cost effective, high-speed wireless communication. I had compared possible wireless communication methods, presented an overview of past work, and covered the necessary background information. Then I had presented my design and compared with various LEDs performance on illuminating luminance intensity by doing four step processes and I had analysed the luminance output using ASAP simulation software.

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