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Design and Fabrication of Low Cost Optical Test Bench for Verification Applications

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Abstract: With the increasing popularity of solid state lighting devices, Visible Light Communication (VLC) is globally recognized as an advanced and promising technology to realize short-range, high speed as well as large capacity wireless data transmission. Before using visible light communication to a large extend, it is important that one should have the basic knowledge about parameters of visible light and how the parameters are different from IR. The low cost optical test bench contains systems for measuring parameters of light such as intensity and dispersion. Also the test bench includes a practical audio transmitter system which uses visible light as the transmission medium.

Keywords: Optical Test bench; Photo goniometer; VLC; Intensity; Dispersion.

I. INTRODUCTION

Visible light has been with human kind from ages before. From the early fire to today's modern led lights, light has governed and guided the mankind. Visible Light Communication (VLC) is an emerging technology which can pave the way to the future. Data transfer through visible light was first introduced by Alexander Graham Bell with the invention of photo phone. Even after this great invention the visible light communication was not so popular because of the complexity of visible light detection.

With the passage of time, Optic fiber technology has found increased applications. The optic fiber technology offers numerous advantages over conventional technologies such as high speed and noise free data transmission. The fiber optics has added a new dimension to communication systems in the form of fiber optic communication system. Recently, light emitting diode (LED) based optical wireless communication (OWC) systems have been developed. Especially, an OWC technology using visible light LEDs, referred to as visible light communication (VLC), has been receiving much attention. The LED is suitable as an optical-signal-sending device because light intensity of the LED can be modulated at high speed in comparison with traditional lighting devices, such as incandescent bulbs and fluorescent lamps. Furthermore, LEDs are inexpensive, already used for lightings and signage, and have high energy efficiency and long operating life. Moreover, basic performances of LEDs are being improved constantly while achieving even lower cost. Therefore, the LED-based OWC system is expected to be a convenient and ubiquitous communication system in the near future. The widespread use of LEDs as light sources has reached into communication field.

To develop any communication system using visible light, it is important that one should have the knowledge about the intensity variations with distance and also the dispersion of light energy. Advanced technologies such as photo- goniometer for the measurement of light parameters, are unaffordable for a common man due to its high complexity and cost. The low cost optical test bench found a better solution for these problems. With the use of simple LED transmitter and Photo diode receiver, the optical test bench could able to measure the intensity and energy dispersion with respect to distance and direction. The test bench also include an audio transmission system using laser beam for the demonstration of cost effective practical visible light communication system.

II. SYSTEM ARCHITECTURE

The overall system architecture consist of light measurement systems which paves the way for the parametric study of light, and a cost effective communication system used for audio transmission. The intensity measurement system and energy dispersion measurement system together coins the light measurement system which is affordable with low cost and less complexity. In audio laser transmission system the sound signal is intensity modulated as light which is transmitted using a laser beam. This beam is detected by a solar panel and demodulated back to an audio signal.

1. Light Measurement System

A. Intensity measurement system

The system used for intensity measurement consist of a transmitter, receiver and a lux meter. The receiver can move along the longitudinal axis so that the intensity variation with respect to the distance can be measured.

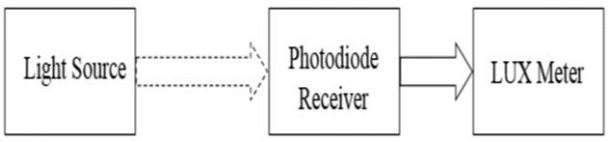

Fig 1: Block diagram of intensity measurement system

LED takes the roll of transmitter, where different dimensions of LEDs can be used. The received light is

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detected by the photodiode and the received intensity can be measured by the lux meter.

B. Dispersion measurement system

In the dispersion measurement system, the photodiode array receiver consists of a reference receiver and sub receivers. The distance between the transmitter and reference receiver can be varied with respect to the longitudinal axis. The sub receivers are placed at constant distance from the reference receiver. By using the Pythagoras theorem the energy dispersion angle by the transmitted light can be measured.

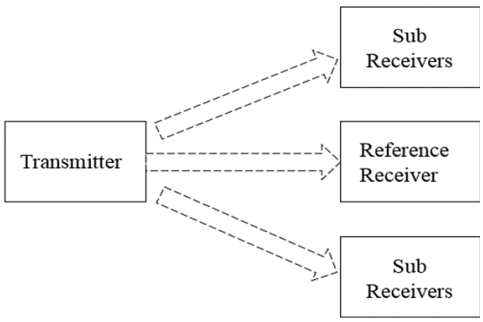

Fig 2: Block diagram of dispersion measurement system

2. Audio laser communication system

The inevitable parts of audio communication system are nothing but the transmitter and the receiver. The input audio signal is given to the audio jack placed at the transmitter using an aux cable. The audio signal is amplified, modulated and converted to light. The low power audio amplifier LM386 is used to amplify the weaker audio signals. The IC is designed to deliver a voltage amplification of 20dB without externaladd-on parts. But this voltage gain can be raised up to 200dB by adding external parts.

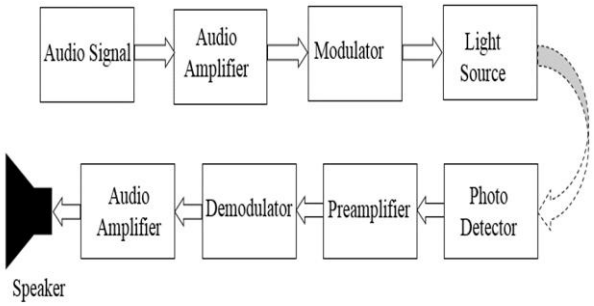

Fig 3: Block diagram of audio communication system

The audio transmission system uses audio signal as the modulating signal and light as the carrier signal. The intensity of the light source varies together with the amplitude of the sound signal. The variation within the intensity of the light source is converted into a variationin the voltage level at the photo detector. These voltage variations are given to the speaker through the audio amplifier.

III. MEASUREMENT PROCEDURES

The low cost optical test bench is used to measure the parameters of light such as intensity and dispersion. These parameters are calculated with the measurements taken from the optical test bench. Intensity and dispersion are the vital parameters of light and the future developments in Visible Light Communications (VLC) can be easily designed with the proper understanding and analysis of these parameters. In order to provide these understandings to the user, the low cost optical trainer kit plays an important role in the Visible Light Communication platform.

1. Intensity Measurement

The term intensity is used to describe the rate at which light spreads over a surface of a given area some distance from a source. The intensity varies with the distance from the source and the power of the source. Power is a property of the light source that describes the rate at which light energy is emitted by the source. Power is often expressed in units of watts. The low cost optical test bench is used to find out the dependence of intensity (I) upon the distance (r) from different light sources having different power levels. The intensities at various distances between transmitter and receiver are noted down. The measurements are arranged in a table for the proper analysis. In Physics, the model for explaining how light travels from a source through space is represented in Figure 4. Light energy emitted by the source (S) travels outward in all directions. The rays indicate the straight line paths of a photon through space. Of course, the greater the distance (r) from the source, the further apart that the rays become. At a distance r from the source, there are nine rays passing through the square area. These rays carry energy through the surroundings. At distances further from the source, the same energy spreads over a wider area. For example, at a distance of 2r, these same nine rays pass through an area that is four times larger than the original square. Thus, the intensity (rate at which light lands upon a surface) decreases with increasing distance from the source.

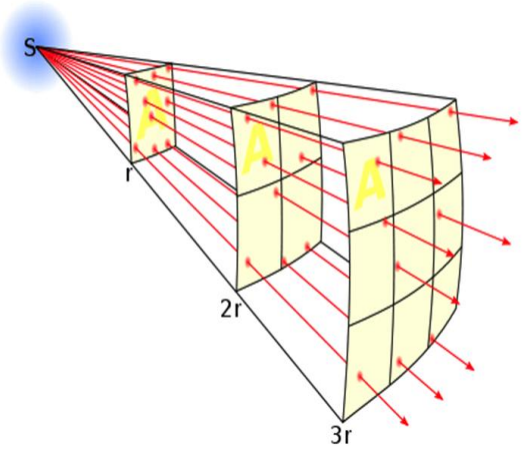

Fig 4: Intensity Distribution

The lux (symbol: lx) is the SI unit of luminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square meter. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes

through a surface. It is analogous to the radiometric unit watts per square meter, but with the power at each wavelength weighted according to the luminosity function, a standardized model of human visual brightness perception.

2. Dispersion Measurement

Dispersion of light is the angle in which the light energy spreads in a set of receivers. The experimental setup for the measurement of dispersion of light source includes transmitter fixed at a constant distance from the reference receiver. Also the distance between the sub receivers and reference receiver are made constant. When the source transmit light at a particular angle of dispersion, the reference receiver and the sub receivers inside this angle will detect the light.

IV. CONCLUSION

In this modern era of Visible Light Communication, the popularity of light based technologies become more common. Visible light communication systems provide an alternative to the current standards of wireless transfer of information, using light from LEDs as the communication medium. In these systems, light-emitting diodes blink at a rapid rate such that the human eye will not notice the change in light intensity, but a sensitive photodiode can detect the on-off behaviour and decode the information embedded within it. The low cost optical test bench paves a new and cost effective way to understand the core parameters of visible light. This system also demonstrates a practical communication system using laser beam. The use of simple audio amplifier and common circuit elements such as resistors and capacitors makes the encoding and decoding simpler and cost effective. Future work will concentrate on real-time digital video/audio transmission and communication link that can be connected to a TCP/IP network. The audio transmission by the use of LED was a grand success in audio transmission system. This provides a better opportunity to develop a practical communication system using low cost LEDs.

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