Visible Light Communication Based Video And Audio Transmission

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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. In this paper, we propose a prototype of real-time audio and video broadcast system using inexpensive commercially available light emitting diode (LED) lamps. Experimental results show that real-time high quality audio and video with the maximum distance of 10-15m can be achieved through proper layout of LED sources and improvement of concentration effects. Light fidelity (Li-Fi) is a new short range optical wireless communication technology which provides data transmission like text, audio, video by using Light-Emitting Diodes (LEDs) to transmit data depending on light illumination properties In this technology, LEDs are used to transmit data in the visible light spectrum.*

Keywords- Illuminance, perceptible, accessible spectrum, bandwidth.

I. INTRODUCTION

1.1 BRIEF BACKGROUND

Visible Light Communication (VLC) was first proposed in 2004 by Toshihiki Komine and has progressed rapidly ever since with the development of solid state light sources, especially light emitting diodes (LEDs) [1]. The great popularity of VLC owes largely to the advantages of LED such as high brightness, low cost, small size, low power consumption, long lifetime strengths of both technologies, excess capacity demands of RF channels can be off-loaded to VLC networks, which enable users to seamlessly access to the Internet while keeping high Qos levels and avoiding network congestions and delays. The concept of a full duplex multi-access system for LED-based wireless communications is and low heat radiation. VLC explores the unregulated visible light portion of the electromagnetic spectrum and acts as a supplement rather than substitute of established RF systems. With complementary proposed by Nakagawa laboratories. Simplex and duplex transceiver prototypes have been demonstrated which also prove the effectiveness of replacing existing illumination systems with LED lighting devices. With 300 THz of bandwidth available for VLC, multi- gigabit-per-second data rates could be provided over short distances, for example, using array of LEDs in a multiple-input multiple-output (MIMO) system. Besides wireless connectivity in home environment, combining the function of illumination and transmission is also attractive in specific scenarios where healthy, secured and non-interfered communication is necessary, such as hospital, underground mine, underwater, airplane, etc. In this project, we develop a VLC prototype with large increase in transmission distance and improvement in channel capacity. The optical link which performs as the substitute of connector wire can be widely applied in video conference, real-time video frequency monitoring, smart traffic system and various practical scenarios where illumination and data transmission is in joint demand to serve modern daily life. MATLAB program is used to simulate the illuminance distribution for two practical light source deployments.

1.2 NEED FOR STUDY

LIFI is now unlocking unprecedented data and bandwidth. LIFI is a category of Optical Wireless Communications (OWC).OWC includes infra-red and ultra-violet communications as well as visible light. However, LIFI is unique in that the same light energy used for illumination may also be used for communication.

LIFI is high speed bi-directional networked and mobile communication of data using light. LIFI allows for data to be transmitted by modulating the intensity of light, which is then demodulated into electronic form.

1.3OBJECTIVES

- To develop a system to inform about localization.
- To send the video through Li Fi.

II. EXISTING LI-FI AUDIO TRANSMISSION ARCHITECTURE

2.1 LI-FI AUDIO TRANSMISSION

In today's world where data security is one of the major concerns, it becomes vital to get new methods for the data transmission. Visible Light Communication (VLC) is emerging as new method for data transmission in which data is transmitted through LEDs. This is a much more secure method of transmission compared to existing technologies. Also the data transmission rate is very high around few Gbps. The use of various colored LEDs can produce different speeds and data rates. This project describes the design of Li-Fi audio transmission system and analyzing its performance.

Wi-Fi and Bluetooth are currently the two prominent short range wireless technologies used for various wireless applications. However the radio frequencyspectrum used by these methods is very scarce. There are various drawbacks of these existing technologies like high cost, insecurity of data, high power consumption. So, there is a great need of a technology that could overcome all the drawbacks of existing technologies.

Visible Light Communication (VLC) is emerging as a very good alternative. It is also termed as Li-Fi meaning Light fidelity. This upcoming technology uses light as a mode of transmission. Li-Fi operates in the visible light spectrum which is 10 thousand times that of the radio wave spectrum. It uses visible light as a mode of transmissionrather than the traditional radio waves. Thus, it can be used in places where the use of radio waves is prohibited. Moreover, since light remains confined to a room, the data remains secure and can't be hacked by someone sitting in other room. And the most attractive feature of this upcoming technology is the speed by which data gets transmitted which is 100 times faster thanWi-Fi.

In this technology data is transmitted using LED bulb. The basic idea is to toggle the LED very fast such that it is not noticeable to human eye. Data can be transmitted at much higher rate compared to Wi-Fi or Bluetooth radio frequency. When LED is „ON" logical "1" is transmitted and when LED is "OFF" logical "0" is transmitted.

In this project they are recording different audio files in APR. The voice or audio that has to be recorded in APR is recorded with the inbuilt microphone in that IC. Different switches are used to store different audio files. APR is controlled by PIC 16F877A microcontroller for sending the audio data file serially to the Li-Fi transmitter module. Theaudio file gets transmitter when the LED of the transmitter module blinks.

The receiver part contains a Li-Fi receiver module which receives the audio file. The receiver module contains a photodiode to detect the transmitted audio. This received data is then sent to the speaker.

2.1 Transmitter Section

The audio is recorded in the transmitter section using APR and istransmitted using Li-Fi audio transmitter via visible light channel.

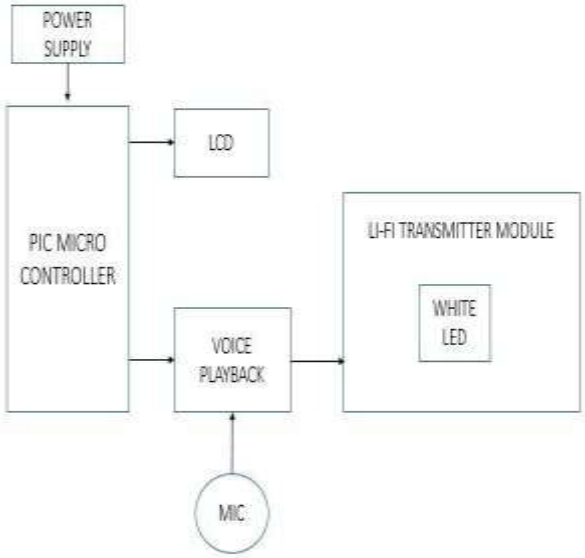

Fig.2.1 Transmitter Section

2.2 Receiver Section

The receiver section consists of a receiving module, PIC microcontroller, amplifier and a speaker. The receiving module receives the audio signals which are then serially passed to the amplifier using microcontroller and then to speaker.

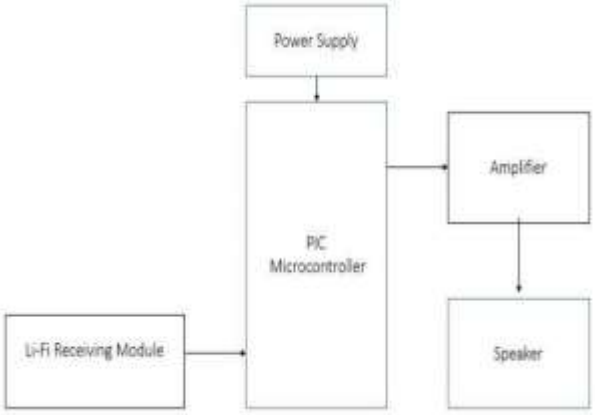

Fig.2.2Receiver section

The receiver module consists of a photo detector. When the light falls in it detects the data that is transmitted via light. The receiving section has to be kept in in line of sight with the transmitting module. Any changes in the position of

any of the modules while transmission can result in the loss of data and in this case audio. This receiver provides an audio signal that corresponds to modulation envelope.

2.4 LIMITATIONS

2.4.1 No video transfer

The light fidelity in this project involves with the transfer of audio data from one end of the transmitter and audio signal which is in the form of analog signal is undergone through many steps of process and converted into light and thus the data of audio signal is transmitted where it was failed to transfer the videos as motion pictures. This remains as a major drawback in the existing system.

2.4.2 Limitations in distance

The Li-Fi technology can transfer the data only where the light covers, the coverage area of light is limited so transfer of data for a long distance is no possible, but in other hand it's secure for this reason that light cannot penetrate through walls so hacking of your personal data is impossible .
A line of sight should be there for communication and it can be used as long where the receiver or receptor. In future, this distance has to be increased so that the performance would be more appreciable.

III. PROPOSED LI-FI VIDEO AND AUDIO TRANSMISSION

3.1 LI-FI VIDEO AND AUDIO TRANSMISSION ARCHITECTURE

3.1.1 Transmitter Section:

Li-Fi which can be the future of data communication appears to be fast and cheap optical version of Wi-Fi. Being a Visible Light Communication (VLC), Li-Fi uses visible light of electromagnetic spectrum between 400 THz and 800 THz as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information in wireless medium.

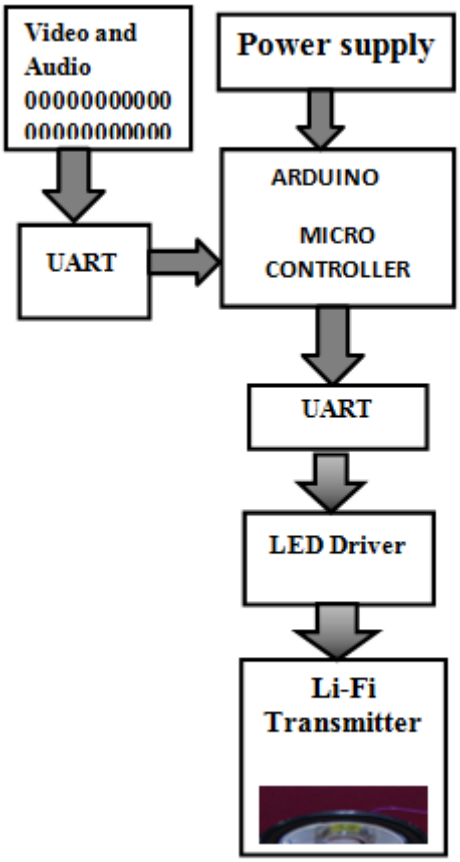

Fig.3.1 Li-Fi Transmitter

MAX -232 is used to convert the signals from the PC RS - 232 serial ports to TTL compatible signals to be used by the microcontroller. AT mega 89c2051 microcontroller has been used for conversion of these decimal signals to binary signals which hence flicker the LED for data transmission.

The White Power LED is available with colour temperatures ranging from 2700K to 10000K. The low profile package design is suitable for a wide variety of applications especially where height is a constraint and the package foot print is compatible with most high power LEDs available in the market today, which consists of a VLC wireless LOS link with two optical channels.

VLC is free space optical communication, and line of sight (LOS) is the common link between two points in optical wireless communication system, where the transmitter directsthe visible light beam in a straight and unobstructed path to the receiver, the prototype for data transmission.

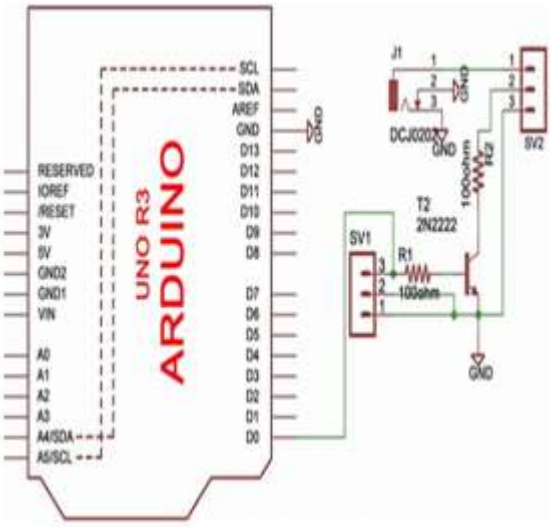

Fig.3.2 Transmitter circuit

3.1.2 Receiver Section

The receiver (photo detector) on the receiving end receives the data as light signal and decodes the information, which is then displayed on the device connected to the receiver. The receiver registers a binary '1' when the transmitter (LED) is ON and a binary '0' when the transmitter (LED) is OFF. Thus flashing the LED numerous times or using an array of LEDs (few different colors) will eventually provide data rates in the range of hundreds of Mbps

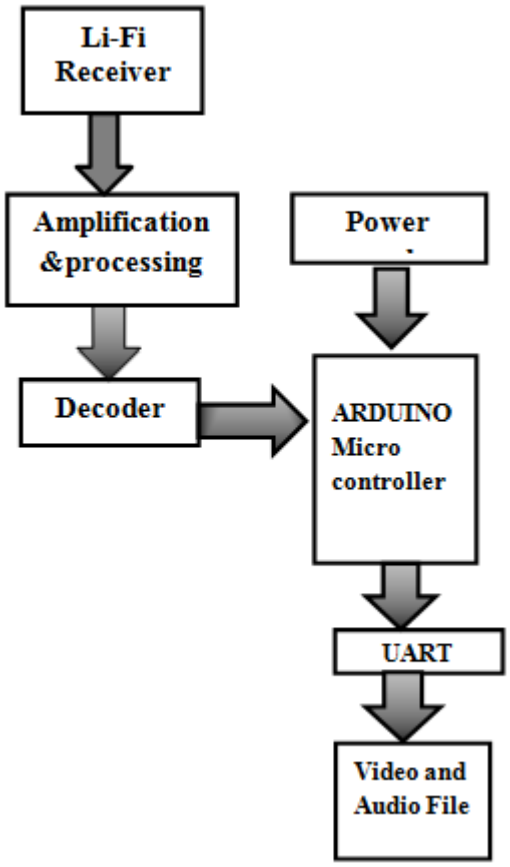

Fig.3.3 Li-Fi ReceiverFig.3.4Receiver circuit

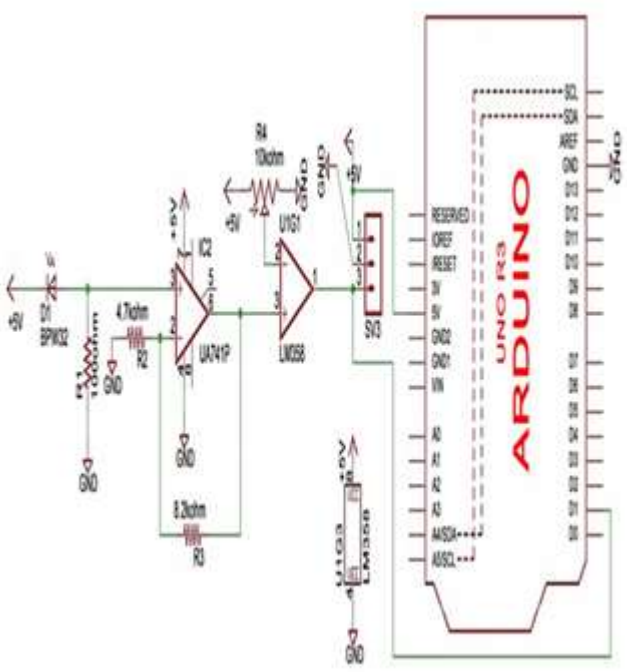

Fig.3.4Receiver circuit

4.2 TRANSFER DATA

4.2.1 Data Acquisition

Data transfer within a system is generally in parallel. All the bits of the data where transferred in parallel at the same instant from a digital system. In some cases, particularly in transferring data over long distances, it is preferred to transfer the data in serial form. The data word from a transmitting system is converted to stream of serial bits, and one bit is transferred on a single line to a receiving system at a time. At the receiving end, the data is reconstructed by serial to parallel conversion. The speed of data transmission in serial communications is specified by baud rates. Asynchronous data transfer is used for the serial communication which is done lower speed, typically at standard rates such as 2400, 4800, 9600, 19200 baud etc.

The synchronizing clock or timing signal is not used in the Asynchronous communication. Information being transferred between data processing equipment and peripherals is in the form of digital data which is transmitted in either a serial or parallel mode. Parallel communications are used mainly for connections between test instruments or computers and printers, while serial is often used between computers and other peripherals. Serial transmission involves the sending of data one bit at a time, over a single communications line. In contrast, parallel communications require at least as many lines as there are bits in a word being transmitted (for an Serial transmission is beneficial for long distance communications, whereas parallel is designed for short distances or when very high transmission rates are required.

4.2.2 Data to light conversion

4.2.2.1 Source data

The source of data is either one side of the transmitter such as computer or mobile which stores the complete data that has to be transmitted. The entire system data may consists of either audio or video sometimes it maybe both audio and video overloaded each other. All the data which has to be transmitted is available in only analog signals where as they are transmitted to next process.

4.2.2.2 Digital bits

An analog-to-digital converter (abbreviated ADC) is a device that converts a continuous quantity to a discrete timedigital representation. Typically, an ADC is an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current. However, some non-electronic or only partially electronic devices, such as rotary encoders, can also be considered ADCs.

The digital output may use different coding schemes. Typically the digital output will be a two's complement binary number that is proportional to the input, but there are other possibilities. An encoder, for example, might output a Gray code.

4.2.2.3 Optical conversion

The voice module is analog signal (audio signal).The microcontroller is connected to li-fi transmitter and its converting the audio signal into the electrical signals and electrical signals is converted to light signals using optical amplifier. A constant current is applied across the LED and by varying the current very fast, the optical output can be made to vary at high speeds, the transmitting side will transmit the data and it is connected to array of LEDs through which the data is transferred.

4.2.2.4 Light form of data

Light signal are amplified by a self-designed amplifier and then super imposed onto two LED lamps respectively by the aid of a bias-T circuit. Thus, the output light rays changes in intensity corresponding to the variation in signal, which however is insensitive to human eyes due to the rapid frequency response of LED devices.

4.2.3 Light data transmission

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4.2.4 Light data reception

4.2.4.1 Receiving light data

At the receiver, two highly sensitive Si PIN photodiodes are used to detect light transmitted over two separate optical channels. After detection,Optical signals are

converted into photo electric current proportional to the variation of incident light, which then is amplified and filtered by a low pass filter (LPF).

4.2.4.2 Light to data conversion

A photo detector is designed to convert the received digital signal into analog signal. Finally, the audio is played real time on the screen of a further processing such as simple cutting, filtering or storing. In the proto-type, transmission distance of nearly 5m can be achieved without any light focusing measures and can be increased to 5m with a focusing lens inserted between the transmitter and receiver. The details are viewed via LCD display.

4.3 TIME REQUIRED FOR TRANSMISSION

Li-Fi could transmit up to 100 Gbps and possibly higher, but this would require a change in lighting technology. A survey reports that the average Wi-Fi speeds are 10 Mbps, and that Li-Fi can be fast as 1 Gbps. It is important to highlight that 1 Gbps transmission speeds from an off-the-shelf commercial LED light bulb have not been demonstrated, yet. The visible light spectrum is 1000 times larger than the entire 300 GHz of radio, microwave and mm wave radio spectrum, so there is a big untapped reservoir of resources for wireless systems.

4.4 PRECISION AND ACCURACY

Li-Fi Communication is one of the emerging areas of wireless communication system. Due to its low noise ratio makes its one of the well-suited communication medium for exchange of information. Currently light communication is adopted in satellite communication for space research activities and due to its efficiency on low noise ratio, inexpensive, low power and its flexibility and its resistance to the radio interferences makes light communication as one of research area in wireless communication.

Li-Fi communications systems work similarly to fibre optic links, except the beam is transmitted through free space. In light Communication, the transmitter and receiver must require line-of-sight conditions and light communications systems have the benefit of eliminating the need for broadcast rights and buried cables. Light communications systems can be easily deployed since they are inexpensive, small, low power and do not require any radio interference studies.

4.5 Data transmission

LightFidelity(LiFi)technologyisawirelesscommunicationsystembasedontheuseofvisible light between the violet (800 THz) and red (400 THz). Unlike Wi-Fi which uses the radio part of the electromagnetic spectrum, Li-Fi uses the optical spectrum i.e. Visible light part of the electromagnetic spectrum. The principle of Li-Fi is based on sending data by amplitude modulation of the light source in a well-defined and standardized way. LEDs can be switched on and off faster than the human eyes can detect since the operating speed of LEDs is less than 1 microsecond. This invisible on-off activity enables data transmission using binary codes. If the LED is on, a digital '1' is transmitted and if the LED is off, a digital '0' is transmitted. Also these LED scan be switched on and off very quickly which gives us a very nice opportunity for transmitting data through LED lights, because there are no interfering light frequencies like that of the radio frequencies in Wi-Fi. Li-Fi is thought to be 80% more efficient, which means it can reach speeds of up to 1Gbps and even beyond.

The working of Li-Fi is very simple. There is a light emitter on one end i.e. an LED transmitter, and a photo detector (light sensor) on the other. The data input to the LED transmitter is encoded in to the light (technically referred to as Visible Light Communication) by varying the flickering rate at which the LEDs Flicker.

Fig.4.5 Data Transmission

V. HARDWARE AND SOFTWARE REQIREMENTS

5.1 HARDWARE REQUIREMENTS

5.1.2 RS232

RS-232 devices may be classified as Data Terminal Equipment (DTE) or Data Communication Equipment (DCE); this defines at each device which wires will be sending and receiving each signal. The standard recommended but did not make mandatory the D-sub miniature 25 pin connector. In general and according to the standard, terminals and computers have male connectors with DTE pin functions, and modems have female connectors with DCE pin functions. Other devices may have any combination of connector gender

and pin definitions. Many terminals were manufactured with female terminals but were sold with a cable with male connectors at each end; the terminal with its cable satisfied the recommendations in the standard.

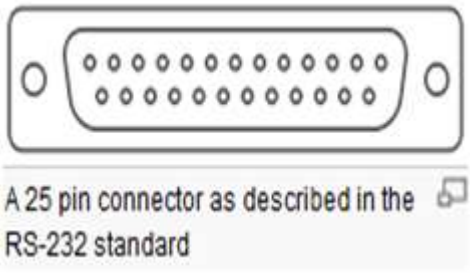

Fig.5.1 25 pin RS232

5.1.3 Arduino Uno

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

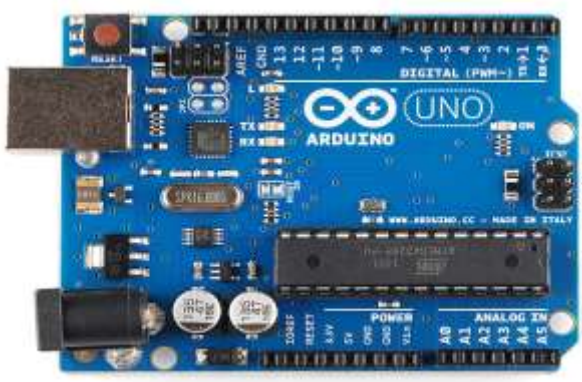

Fig.5.2 Arduino Uno

5.1.4 Li-Fi transmitter module

The li-fi transmitter module consists of transmitter phase where the analog bits are converted into digital bits and then into light packages. It is composed of optical amplifier and crystal oscillator that generate the signal to be transmitted.

5.1.5 Optical Amplifier

In order to transmit signals over long distances (>100 km) it is necessary to compensate for attenuation losses within the fiber.

- Initially this was accomplished with an optoelectronic module consisting of an optical receiver, regeneration and equalization system, and an optical transmitter to send the data.
- Although functional this arrangement is limited by the optical to electrical and electrical to optical conversions.

5.1.6 Li-Fi Receiver module

Li-Fi receiver module consists of low pass filters, and photo detector where the photo detector is used for receiving and converting the light signal into original form. The filters are used to avoid unwanted noise signals in the transmission.

5.1.7 Photo detector

A photo detector operates by converting light signals that hit the junction to a voltage or current. The junction uses an illumination window with an anti-reflect coating to absorb the light photons. The result of the absorption of photons is the creation of electron-hole pairs in the depletion region. Examples of photo detectors are photodiodes and phototransistors. Other optical devices similar to photo detectors are solar cells which also absorb light and turn it into energy.

5.1.8 LCD Display

A liquid crystal display (LCD) is a flat panel display, video display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly. LCDs are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have replaced cathode ray tube (CRT) is played in most applications.

5.2 SOFTWARE REQUIREMENTS

5.2.1 Arduino software

Arduino is a prototype platform (Open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programmed (referred to as micro controller) and readymade software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

5.2.2 Embedded C

An embedded system is an application that contains at least one programmable computer (typically in the form of a microcontroller, a microprocessor or digital signal processor chip) and which is used by individuals who are, in the main, unaware that the system is computer-based.

This type of embedded system is all around us. Use of embedded processors in passenger cars, mobile phones, medical equipment, aerospace systems and defence systems is widespread, and even everyday domestic appliances such as dishwashers, televisions, washing machines and video recorders now include at least one such device.

VI. CONCLUSION

Thus the Li-Fi system used for transmission provides a very good experimental result where the data rate and speed of transmission is higher than the wireless fidelity.

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