DATA COMMUNICATION AND APPLIANCE CONTROL USING VLC(VISIBLE LIGHT CONTROL)

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ABSTRACT

The spectrum is the rare coin for communication engineers. Nowadays, with the increasing rapid growth in wireless communications system the problem of using spectrum efficiently has become more important. There are many solutions have been proposed to solve this issue. The one of these solutions is the usage of visible light frequencies to send data. These frequencies are already free and unused. Light fidelity (Li-Fi) is a new short range optical wireless communication technology which provides the connectivity within a local network, by using Light-Emitting Diodes (LEDs) to transmit data depending on light illumination properties. Li-Fi represents Light Fidelity. Li-Fi is the future upcoming technology and this can transmit the information through light at high speed as compared to the present wireless technologies. The Li- Fi technology can transfer the data through LEDs. It is a high speed and low cost wireless communication system, compared to Wi-Fi. It can provide high security, large bandwidth. While using various color LEDs can get the different bandwidth and speed. We design and implement the Li-Fi data transmission system and analyzing its performance.

Key words: OFDM, Wi-Fi, Light spectrum, LED, Photodiode

1. INTRODUCTION

Transfer data from one place to another is one of the most important day-to-day activities. The current wireless networks that connect us to the internet are very slow when multiple devices are connected. As the number of devices that access the internet increases, the fixed bandwidth available makes it more and more difficult to enjoy high data rates and connect to a secure network. Nowadays, Everyone is interested in using his mobile phone, laptop to communicate with other people through Wireless-Fidelity (Wi-Fi) systems, and this technology, Wi-Fi, is widely used in all public areas like home, cafes, hotels and airports by people, also the time usage of wireless systems has been increasing exponentially every year; but the capacity is going down, due to the limitation of Radio Frequency (RF) resources, so we are going to suffer from severe problems.

Despite continuous improvements in wireless communication systems, e.g. 3G, 4G, etc.., a coming crisis is expected due to the lack of sufficient Radio Frequency (RF) resources, this limitation in bandwidth can’t support the growth in demand for high data rates and the large numbers of communication systems, within the bandwidths between 300 kHz and 4 GHz. That’s known as “Spectrum Crunch” [1].

Although, spectrum congestion decreases when we use high frequencies to transfer data, but this is not a practice solution, because this part of spectrum requires complex equipment and causes high cost systems.

Actually, there are numbers of technologies that provide realistic and applicable solutions to this issue. One of them is the “Cognitive Radio”. It is a new sort of wireless communication with a transceiver architecture that can intelligently detect which communication channels are in use and which are not, and instantly move into empty channels to use them to transmit data. Another solution is the transmission of data using visible light illumination which use very high frequency. In general, this technology is known as Visible Light Communication (VLC) [2].

This new technology is known as Light–Fidelity (Li-Fi). It is a short range wireless communication system based on light illumination from LED, and use the visible light as a signal carrier instead of traditional RF carrier as in Wi-Fi [3]. It envisions a future when data for laptops and smart phones are transmitted through the light in a room in a secure way.

2. RELATEDWORKS

[4]Describes high-speed optical wireless systems and to overcome the limited amount of radio-based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum. [5] visualizes a future where data for laptops, smartphones, and tablets is transmitted through the light in a room, butversion is limited by existing LEDs and by the usage of LEDs as transmitters and detectors at the same time. [6] Creates a better LED, which provides a data rate close to 4 Gbps operating on just 5 milliwatt of optical output power and using high bandwidth photodiodes at the receiver. Sends data with a distance of 10 meters between transmitter and receiver and data rate up to 1.1 Gbps with a simple lens, and soon it will increase that up to 15 Gbps. The 802.11ad Wi-Fi standard for the 60 GHz radio band reaches just under 7 Gbps almost one half of data rate with respect to Li Fi communication. [7] Describes “data through illumination”-Lightsystem uses Orthogonal Frequency Division Multiplexing (OFDM) techniques, which allows to vary the intensity of the LEDs output at a very fast rate, invisible to the human eye; for the eye, the bulb would simply be on and providing light. [8] Describes that by fast variation of the current, the light output can be made to vary at extremely high speed. ‘On’ condition of LED transmits a digital ‘1’ otherwise it transmits a digital ‘0’. Strengthen the quality of the receiver byusing photo detector, which convert this light into electric signals and it will give the electric signals to the device connected to it. [9] Discuss the concepts of Voltage regulator and level shifter circuits used on both sides to convert or maintain a voltage level between transmitter and receiver. [10] Compare the Li-Fi with Wi-Fi and conclude that Li-Fi is ideal for high density wireless data coverage in confined area and for reducing radio interference issues. Its features include benefits to the capacity, energy efficiency, safety and security of a wireless system.

3. SYSTEMMODEL

3.1. SYSTEM DESIGN

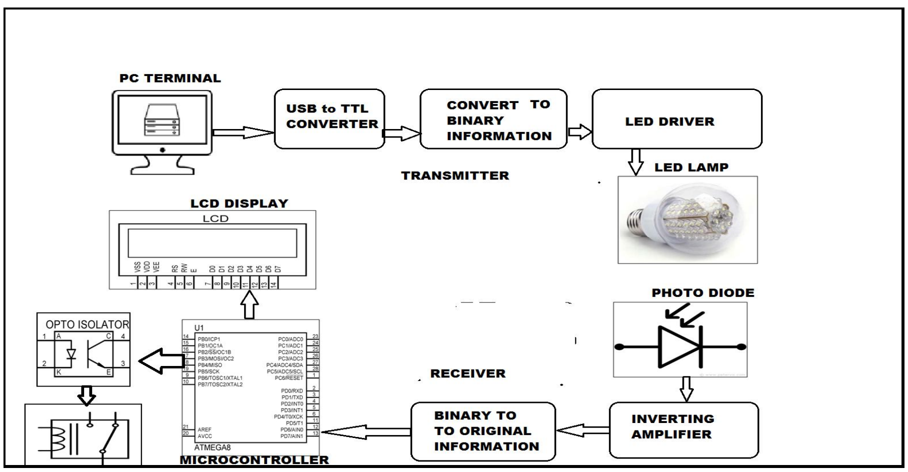


Fig 1 A system overview

The overall block diagram of proposed system design is shown in above Figure 1 A. The communication system is designed to support point-to-point in one direction. Tx-PC is used to transmit data stream in the form of text in ASCII format. The communication between Tx-PC and transmitter circuit is performed using a USB to UART converter. The transmitter circuit will modulate the data received from the Tx-PC and perform data framing. The modulated data will be fed to the analog front end transmitter circuit (Tx-AFE) which consists of LED driver. The LED driver circuit will switch on and off the LED based on the modulated data so that the data will propagate through free space (optical channel).

The data will be received by the photodiode in the receiver. The information contained in the light is converted into electricity. The output signal from the photodiode has suffered from both attenuation and distortion caused by the channelas well as the influence of photodiode optical nonlinearities characteristic. The analog front end receiver circuit (Rx-AFE) will condition the received signal so that Rx microcontroller (Rx-μC) can demodulate the data correctly. The data stream is then displayed on the LCD as a running text. Relay board is connected at receiver circuit which is used to control various appliances like fan, bulb.

3.2. USB TO UART –CP2102

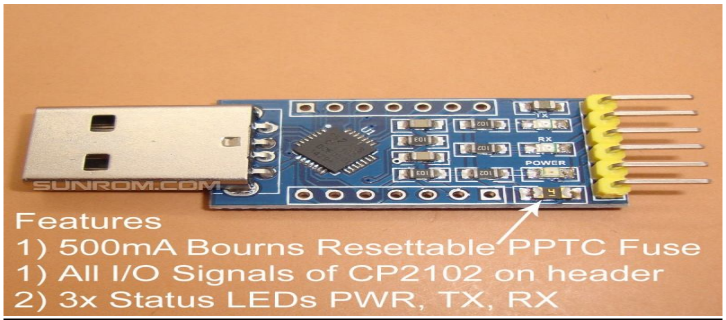
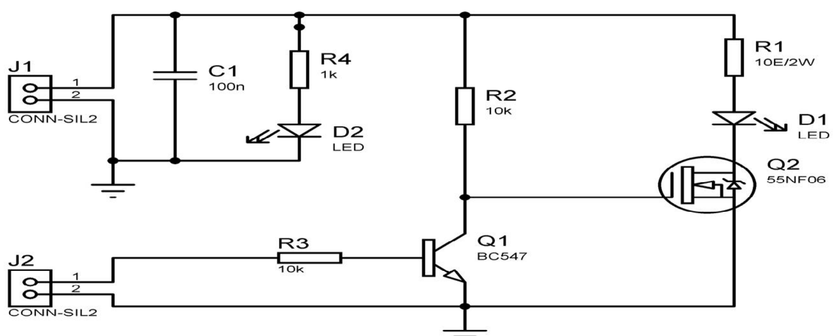


Fig 2 CP2102

The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communicationsubsystem of a computer. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Serial transmission is commonly used with modems and for non-networked communication between computers, terminals and other devices. The CP2102/9 is a highly-integrated USB-to-UART Bridge Controller providing a simple solution for updating RS-232 designs to USB using a minimum of components and PCB space. The CP2102/9 includes a USB 2.0 fullspeed function controller, USB transceiver, oscillator, EEPROM or EPROM, and asynchronous serial data bus (UART) with full modem control signals in a compact 5 x 5 mm QFN-28 package. No other external USB components are required.

The on-chip programmable ROM may be used to customize the USB Vendor ID, Product ID, Product Description String, Power Descriptor, Device Release Number, and Device Serial Number as desired for OEM applications. The programmable ROM is programmed on-board via the USB, allowing the programming step to be easily integrated into the product manufacturing and testing process. Royalty-free Virtual COM Port (VCP) device drivers provided by Silicon Laboratories allow a CP2102/9-based product to appear as a COM port to PC applications. The CP2102/9 UART interface implements all RS-232signals, including control and handshaking signals, so existing system firmware does not need to be modified. In many existing RS-232 designs, all that is required to update the design from RS-232 to USB is to replace the RS-232 level-translator with the CP2102/9.

3.3.TRANSMITTER SIDE



.**Fig 3**Transmitter circuit

At the transmitter side, the LED driver circuit is developed to control the LEDs for on off switching. The LED driver circuit used in development is shown in below Figure 3. Wherein a Transistor Q2 is used to amplify the voltage as the receiver signal is only 3.3/5 Volt while the LED voltage rating of at least 8-12 Volt, whereas transistor Q1 is used to amplify the current.

3.4. PHOTO DIODE RECEIVER CIRCUIT FOR DATA TRANSMISSION

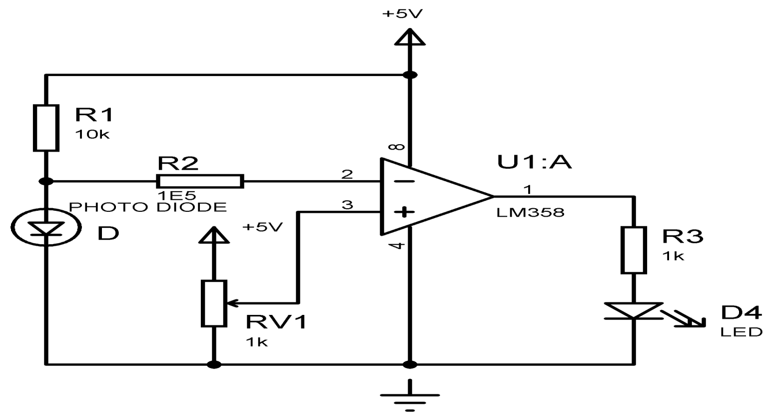


Fig 4 Receiver circuit

Here in the design the analog circuit at the receiver side is used to condition the output signal from the photodiode since the output signal of the photodiode will experience attenuation and distortion. For the output of the photodiode is electrical current, trans-impedance amplifier (TIA) is necessary to convert the current into a voltage. Current to voltage converter is made by the op-amp lm339 as shown inFigure 4.Once the signal is converted into a voltage, it is fed to the comparator to overcome the distortion in it.Variable resistor RV1 is placed and it can be tuned manually to set the comparator threshold. The output of the comparator is then fed with connecting to the Rx pin of microcontroller.

Figure 4 shows the Photo diode receiver circuit for data transmission. In Photo Diode Receiver circuit, op-amp LM358 is used as a comparator mode. A LM358 had high gain and wide bandwidth. It is an open collector comparator. So it can be compatible to all logic levels like TTL, DTL, ECL, and CMOS Logic. If the light illumination varies photo diode current also changes. In receiver side, there are two stages. First stage is a photo detector for current converts to voltage level. In second stage the inverting amplifier which inverts once to get original data information.

4. RESULT

4.1. UART OUTPUT SIMULATION

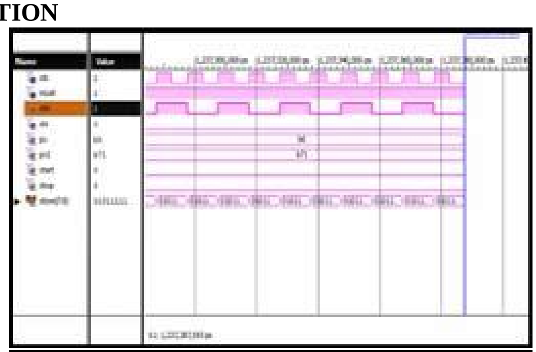


Fig 5UART output simulation

The universal asynchronous receiver transmitter(UART) takes the bytes of data. It transmits the individualbits at a sequential logic. Each UART consists of shift register, which is the basic method of serial conversion. The digital information transferred through a single wire by the Serial transmission. Figure shows that UART simulation result of UART.

4.2 SIMULTION OUTPUT FOR TRANSMITTER CIRCUIT

Fig 6simulation output for data transmitter

By using the CRO probe locate the 18 pin of the ULN2803 IC. This IC voltage level is around 24V. Computer 1 sends the information through the hyper terminal. It converts the text value to ASCII (American Standard Code for Information Interchange) Value. Hyper terminal serially transfer data to UART. The Baud Rate of the hyper terminal should be 9600. Figure-6 shows the Simulation result for data transmitter.

4.3SIMULATION OUTPUT FOR RECEIVER CIRCUIT

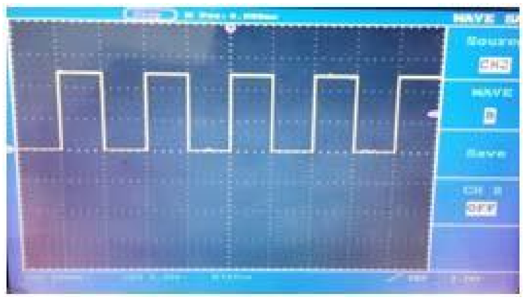


Fig 7 simulation output for data receiver

Figure-7 shows that simulation output for the Receiver. In Receiver circuit side have to do the two stages of amplification process. One is photo diode current is converted to voltage signal which is by inverting amplifier. For getting the original information again one more time have to invert by LM339 operational amplifier. When the light illumination varies means photo diode current also changes.

5. APPLICATIONS

1. **In Sensitive Areas or in Hazardous Environments**

   Li-Fi provides a safe communication in environments such as mines and petrochemical plants, because it doesn’t cause electromagnetic interference which appears in RF communications. Li-Fi can also be used in petroleum or chemical plants where other frequencies could be hazardous.

   For example, power plants like nuclear power plants require grid integrity and monitoring of the station temperature that need fast, inter-connected data systems. Wi-Fi and many other radiation types are bad for sensitive areas surrounding the power plants. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations.

   Moreover this technology also enables us to control plants and their growth without direct presence.

2. **Traffic Management**

   Li-Fi can help in managing the traffic in a better manner and the accident numbers can be decreased. Traffic lights can communicate to the car and with each other to manage the traffic in the street.

   Traffic light can play the role of the sender of the data to provide information to the car on the status of the road or about the situation of other cars. Also cars can communicate with each other and prevent accidents by exchanging information. For example, LED car lights can alert drivers when other vehicles are too close.

3. **Airways**

   We have to switch off mobiles in aircrafts to prevent overlapping of mobile phone signals with navigation and control signals used by aircraft. Li-Fi can be safely used on planes because it doesn't interfere with RF. Since Data is present where light is present, we can use the lights above the seats in the plane as hotspot.

4. **Blind Indoor Navigation System**

Indoor navigation is convenient for everyone, and it is especially indispensable for the visually impaired. We proposed such a navigation system for the visually impaired people. LED lights emit visible light with location data and an embedded system or smartphone with a visible light receiver which receives the data. The embedded system or smartphone calculates the optimal path to a designation and speaks to the visually impaired through a headphone.

5. **Disaster Management**

Li-Fi can be used as a powerful means of communication at times of disaster such as earthquake or hurricanes, for example places like subway stations and tunnels which are common dead zones for most emergency communications, don't pose obstruction for Li-Fi, so it can be used there, as emergency communication.

6. FUTURE SCOPE

By using *Li-Fi* we can have Energy saving Parallelism. With growing number of people and their devices access wireless internet, it is easy to transfer data at high speed and at cheap cost. In future we can have LED array beside a motorway helping to light the road, displaying the latest traffic updates and transmitting internet information to wirelessly to passengers Laptops, Notebooks and Smart phones. This is the kind of extra ordinary, energy saving parallelism that is believed to deliver by this pioneering technology.

7. CONCLUSION

The possibilities are numerous and can be explored further because the concept of Li-Fi is currently attracting a lot of eye-balls because it offers a genuine and very efficient alternative to radio based wireless. It has a good chance to replace the traditional Wi-Fi because as an ever increasing population is using wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. In the future, data for laptops, smart phones and tablets can be transmitted through light in the room by using Li- Fi. Researchers are developing micron sized LED which are able to flicker on and off around 1000 times quicker than larger LED. If this technology can be put into practical use, every bulb can be used as a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. This concept promises to solve issues such as the shortage of radiofrequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

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