ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 3, Issue 12, June 2014

A Visible Light Communication System for Indoor Application

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Abstract__ White LEDs (Light Emitting Diodes) in Visible Light Communication (VLC) is an emerging technology that is being researched so it can eventually be used for common communications systems. LEDs have a number of advantages, one of which is long life expectancy. LEDs' ability to transfer information signals over light (light which is between 400THz to 800THz of frequency and whose wavelength is between 400nm to 700nm) makes it a very good communication medium. Now the light we use in our daily life is not only be used for providing light but also for communication. However, like many emerging technologies, VLC has many technical issues that need to be addressed. Using visible light for data transmission entails many advantages and eliminates most drawbacks of transmission via electromagnetic waves outside the visible spectrum. For instance, few known visible light-induced health problems exist today, exposure within moderation is assumed to be safe on the human body. We proposed an optical indoor wireless communication system that used white LEDs for transmitting data. We developed a practical implementation of VLC and demonstrated it experimentally.

I. INTRODUCTION

The visible light communication (VLC) refers to the communication technology which utilizes the visible light source as a signal transmitter, the air as the transmission medium, and the appropriate photodiode as a signal receiving component. Visible light communications (VLC) can provide cable free communication at very high bit rates as high as 100Mbps. In addition, it has a major advantage that it causes no interference to RF-based devices. This made wireless communication possible in RF hazardous areas such as hospitals and space station. In addition to these two key advantages, safety, simple installation procedures and band licensing-free characteristic also helped to increase VLC's potential to be developed as an alternative, or even a new standard to the wireless communication scheme.VLC uses white Light Emitting Diodes (LED), which send data by flashing light at speed. VLC uses white Light Emitting Diodes (LED), which send data by flashing light at speeds undetectable to the human eye. In this case, high speed data can be carried by the modulated light from the LED, which makes information transmission possible while lighting our life. When signals reach the receiver through the indoor wireless channel, the photodiode will convert the optical signals to electrical ones and the original information will be recovered. The visible light communication based on LED is a novel developing technique in the optical wireless communication field.

The idea of using visible light for data transmission is not entirely new. Using smoke signals to transfer messages goes back several thousand years and was used by many different cultures, e.g. Native Americans and Romans. Light houses are employed to help ships navigate through dangerous coastal areas by sending out visible beams of light in periodical intervals. "The Pharos of Alexandria" was arguably the first tower which was served as lighthouse and was one of the Seven Wonders of the World. Its construction dates back to 300 BC. The first sophisticated attempt to harness visible light for transmitting data was carried out by the Scottish scientist and inventor Alexander Graham Bell who is credited with inventing among other devices the photo phone. The photo phone was a device that allowed to transmit data on rays of sunlight and was completed in February 1880 by Bell and his assistant Charles Tainter. Using visible light for data transmission entails many advantages and eliminates most drawbacks of transmission via electromagnetic waves outside the visible spectrum. For instance, few known visible light-induced health problems exist today, exposure within moderation is assumed to be safe on the human body. White HB-LED's present themselves as the future of both indoor and outdoor lighting scenarios. By joining the penetration of HB-LED's in our daily lives, and the knowledge available on IR wireless communications, VLC presents itself as a promising technology for the future of wireless communications. It is a ubiquitous technology, generating no interference to human life or existing electronic devices. Unlike RF systems, VLC can be used in hospitals, space stations and other electromagnetic interference sensible locations. Applications such as visible light communication for audio systems, information broadcasting using LED traffic lights and integration of VLC with power-line communications (PLC), are examples of the capabilities of VLC. One of the most important steps towards standardization was made with the establishment of the Visible Light Communications Consortium, a group of mostly Japanese based companies that agreed on sharing information towards the development of this new technology.

II. DESIGN AND IMPLEMENTATION

A. System architecture

The input data from personal computer (PC) transmitter is first coded into a string of pulse electrical signals by microcontroller unit (MCU) though the interface circuit. Then, the electrical signals drive LED source directly through a LED driver circuit, with which electronic to optical conversion is achieved. Because of the high on-off speed characteristic of LED, people cannot perceive the twinkling phenomena so that both lighting and information transmitting can be realized simultaneously. The generated optical signals carrying original information then delivered into the indoor wireless channel. At the receiver, pin photodiode will detect the optical signal and do the optical to- electronic conversion. Then the detected weak electrical signals are delivered into a receive circuit which contains preamplifier for signal amplification to meet the need of the following signal processing. The output data from receive circuit will be decoded into primary signal, and then sent to the PC receiver though the RS -232 interface [3], [5]. The prototype was designed to demonstrate serial communication between two computers with RS-232 interface .The voltage regulator supplies constant voltage to the level shifter from the power supply by maintaining constant DC voltages and avoiding unwanted spikes in current. The level shifter helps to convert the high voltages of RS-232 (which are +/-11V from the model computer) to transmitter and receiver circuit levels (which 0 arête +5V). The electrical data from the computer is converted into optical data using LEDs and transmitted over light; the optical data is captured by the receiver, converted into electrical data by the photodiode and sent it to the client computer [5].

B. System design

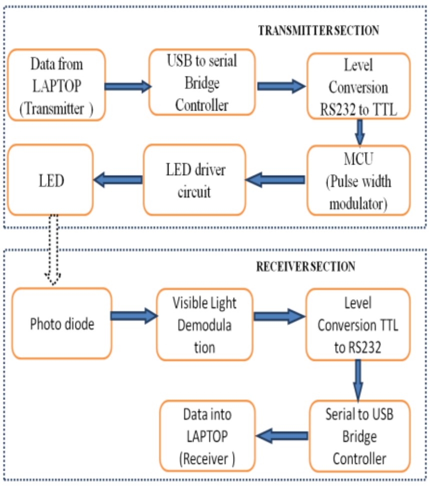

Fig 1: Block diagram of VLC

Transmitter

Every kind of light source can theoretically be used as transmitting device for VLC. However, some are better suited than others. For instance, incandescent lights quickly break down when switched on and off frequently [9]. These are thus not recommended as VLC transmitters. More promising alternatives are fluorescent lights and LEDs. VLC transmitters are usually also used for providing illumination of the rooms in which they are used. This makes fluorescent lights a particularly popular choice, because they can flicker quickly enough to transmit a meaningful amount of data and are already widely used for illumination purposes [10]. However, with an ever-rising market share of LEDs and further technological improvements such as higher brightness and spectral clarity, LEDs are expected to replace fluorescent lights as illumination sources and VLC transmitters.

Receiver

The receiver consists of an optical element to collect and concentrate the radiation onto the receiver photo detector; photodiode convert visible light into an electrical signal biased the photodiode operates in the photoconductive mode generating a current proportional to the collected light. This current is of a small value and a preamplifier is used to convert it into a voltage. This preamplifier should have low distortion and a large GBW. The resulting voltage is then applied to a low-pass filter to remove any high frequency noise. The resulting voltage signal is then further amplified in the final voltage amplifier stage. amplifying and filtering stages, which helps reduce the DC noise component of the captured signal as well as low-frequency components. The final voltage signal should correspond to the received light pulses which are then decoded in the final decoder block, thus extracting the digital data [5],[8]. This final block performs the inverse function of the emitter’s encoder block, but it can also be implemented with a microprocessor.

C. System Implementation

The current prototype is shown in figure2. It consists of PIC18F877A microcontroller, MAX232 level converter which converts RS-232 voltage level to TTL voltage level and TTL voltage level to RS-232 voltage level, white LED for the transmission of data, LED driver circuit in order to limit the current through the LED also it performs electronic to optic conversion, and Photodiode for detecting the data from the visible light,

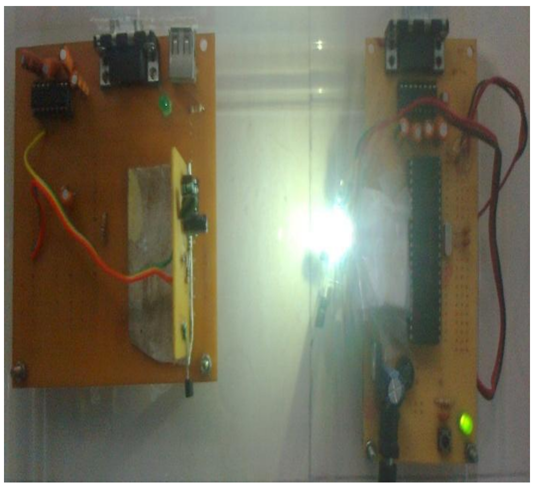

Fig 2: VLC System

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III. RESULTS AND CONCLUSION

In this project we implemented a low cost VLC system for indoor and applications. We have demonstrated that the system is capable for communication in a power efficient manner. The system is also capable of functioning at distances comparable to the distances between workspaces and overhead lighting. The presented system can be rapidly implemented and provides personalized entertainment and services by wireless media. Visible Light Communication (VLC) using LEDs can become a viable option for last mile access and ubiquitous availability. Visible Light Communication (VLC) present fascinating challenges for using appropriate techniques to construct cheap processing units and high brightness LEDs. Where LEDs lighting technology is being considered as the next generation lighting devices, VLC using LEDs would be promising technology for ubiquitous communication. The technology promises a great mix of importance, from high energy saving using Solid State Lighting technology and high rate data transmission in indoor applications to traffic safety in outdoor environment. The optical wireless communication system is a very good replacement for the regular communication systems Visible Light Communication is a rapidly growing segment of the field of communication. There are many advantages to using VLC. There are also many challenges. VLC will be able to solve many of the problems people have been facing for many years, mainly environmental and power usage issues. VLC is still in its beginning stages, but improvements are being made rapidly, and soon this technology will be able to be used in our daily lives. It is intended that this research will provide the starting steps for further study and development on USB to TTL interfaces where white LEDs can be used for data transmission. In spite of the research problems it is our belief that the VLC system will become one of the most promising technologies for the future generation in optical wireless communication.

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