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Visible Light Communication And Device Switching Using Embedded Web Server

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Abstract: **A wireless optical networking technology that uses light-emitting diodes (LEDs) for transmission of data can be termed as Li-Fi also known as Visible Light Communication. The main purpose of this paper is particularly to show the advantages of Li-Fi technology in audio transmission and device switching using an embedded web server with light as the medium of transmission. Here the LED is used as the source of light for transmitting the necessary information to the receiver. This technology enables in sending more data to the receiving end very quickly. Li-Fi makes use of transmitter fitted with LED lamps that can illuminate a room as well as transmit information. As this technology uses LEDs, there is no need of separate infrastructure to be deployed exclusively for this purpose. Thus existing LED lights in conjunction with a transmitter circuit can be used for data transmission which can be received by the receiver equipped with appropriate circuitry thereby reducing the use of Radio Frequency for wireless transmission of data.**

Keywords: **Li-Fi, LED, VLC, DTMF, LDR, LPC1768, LPC2148.**

I. INTRODUCTION

Radio waves are harmful for human beings as they penetrate the body and may cause mutation. Therefore, Wi-Fi is not safe to be used in hospitals and other various health care sectors. In urban areas, Wi-Fi networks become congested and there is a lot of noise and interference in the signals. RF signals can penetrate through walls and hence they can be easily hacked. Radio waves cannot be used underwater due to absorption by sea water. Li-Fi technology is something that can be of immense use in such situations. Li-Fi is the fastest, cheapest and the most efficient and secure wireless communication system due to low interference, high device bandwidths and high intensity optical output. Li-Fi is ideal for high density coverage in a confined region. The visible light spectrum is unlicensed and free to use unlike the Radio Frequency spectrum. The visible light spectrum is non-hazardous as far as human health is concerned. We are entering an era where every electronic device may be networked and controlled remotely. It makes sense to web-enable any device that either needs monitoring or control. Now-a-days networking hardware is quite inexpensive and can often be incorporated by simply selecting a microcontroller that has integrated Ethernet. Web-based interfaces can be used to provide simple cost-effective and user-friendly interfaces for household appliances. A web page based interface is easier to change as compared to a hardware interface. Widely available and tested network protocols such as TCP/IP and HTTP can be utilized. Certainly, for any device already having a TCP/IP port, this approach is the best suited. Li-Fi can play a major role in reducing the heavy loads on the present RF wireless systems by utilizing huge bandwidth of the visible spectrum without adversely affecting our health. Li-Fi can be the technology for the future where data for various electronic gadgets will be transmitted through the light in a room. Security would not be an issue because light cannot penetrate through walls and data cannot be accessed beyond the boundaries of the room. It can be used in high security military areas where RF communication is prone to eavesdropping.

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II. PROPOSED METHODOLOGY

Presently, powerful microcontrollers are used in most home and office appliances. The objective here is to integrate web server with intelligent devices for controlling them over the local area network and create effective user interfaces in the form of web pages. Keeping in mind the merits, it was decided to incorporate Li-Fi for communicating with the electronic and electrical appliances. Such a system may find applications in office and industrial automation, high speed gaming and medical science. The idea here is to establish a new method of communication using LED, i.e. the concept of 'data through illumination'. Generally Li-Fi is implemented using typical white LED light bulbs at the transmitter. These devices are normally used only for illumination by applying a constant current. However, by applying fast and tiny variations in the current, optical output can be made to switch between the states (on and off) at extremely high speeds.The operational procedure is very simple. If the LED is on, a logical 1 is transmitted and if it is off, a logical 0 is transmitted.

The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. This method of using rapid pulses of light to transmit data is called Visible Light Communication (VLC). Thus visible light communications works by switching bulbs on and off within nanoseconds, which is too quick to be noticed by the human eye. Although Li-Fi bulbs would have to be kept on to transmit data, the bulbs could be dimmed to the point where they appear to be turned off but are still functional. Web server is implemented using CORTEX M3 LPC 1768 processor. The client accesses the web page based interface available on the web server and submits the commands over the Internet. The web server decodes these commands and passes them on to the Li-Fi transmitter using DTMF. Li-Fi transmitter uses a 1 watt LED driven by constant current. The LED is switched at high speeds to transmit data. An LDR (Light dependent resistor) with good response to visible light acts as the receiving element at the Li-Fi receiver. Any domestic electrical appliance can be connected as a load so that it can be controlled. All parameters are displayed on an LCD display.

III. BLOCK DIAGRAM

The following block diagrams help us to better understand the working of Li-Fi.

A. Transmitter Section:

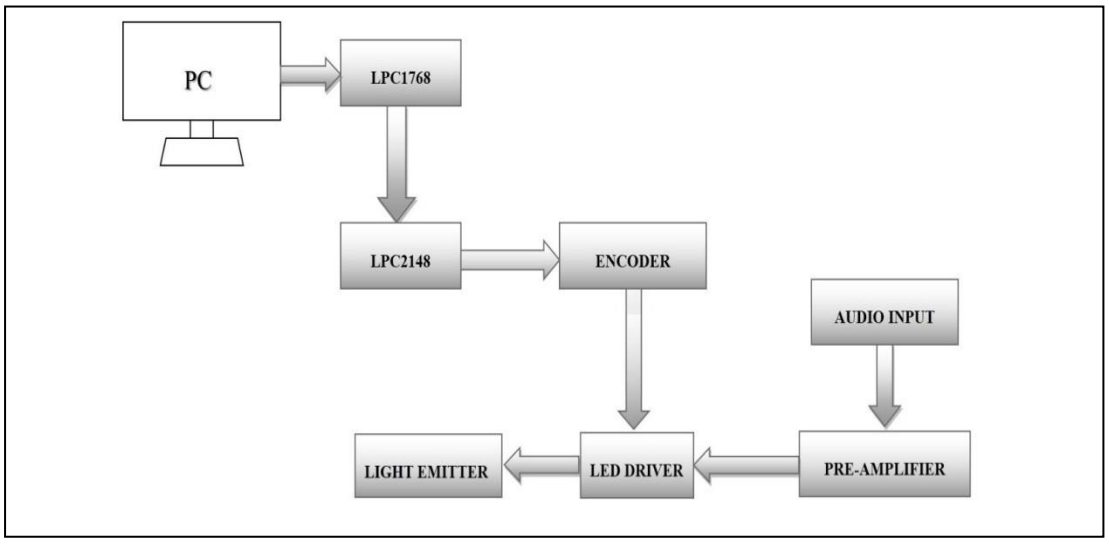

Fig. 1: Block diagram of Li-Fi transmitter section

Fig.1 illustrates the working of a Li-Fi transmitter. Li-Fi controller LPC 2148 receives commands from web server. For generating the DTMF frequencies, a dedicated IC UM95089 is used. This IC requires 3 volts for its operation. For its time base, it requires a quartz crystal of 3.58 MHz. DTMF signals are used as the control codes. The DTMF tones are used for frequency modulation of the carrier. The dual-tone frequencies transmitted from the DTMF transmitter/encoder IC corresponding to each BCD digit can be put in a table form for easy reference as shown in Fig.2.

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Symbol		Tone B [Hz]			
		1209	1336	1477	1633
Tone A [Hz]	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

Fig. 2: DTMF frequencies

Now when the input to the transmitter led bulb is an audio signal from a transducer which is basically very low pitch sound waves, it is applied to the pre-amplifier stage. The pre-amplifier then amplifies the received audio signals and outputs it to the power amplifier. At the power amplifier stage, it amplifies both current and voltage sufficiently and then transmits the signal through light transmitter.

B. Receiver Section:

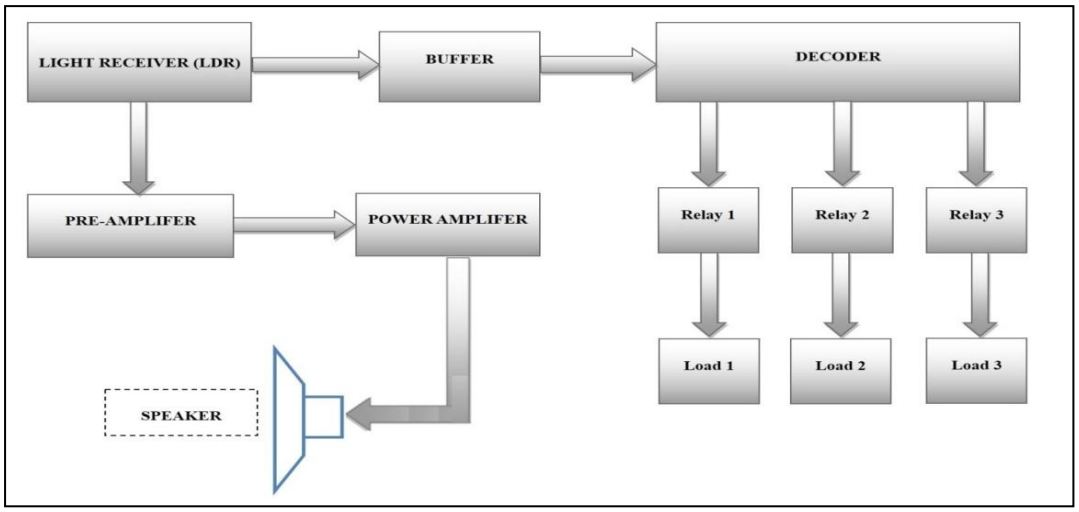

Fig. 3: Block diagram of Li-Fi transmitter section

Fig.3 illustrates the block diagram of a Li-Fi receiver. If an audio signal is detected by the light detector, in this case a LDR, then the received audio signal is passed through a pre-amplifier and a power amplifier. At the pre- amplifier stage, the received weak audio signals are amplified and then passed through the power amplifier which boosts both the current and voltage sufficient enough to drive a speaker. But in case of device switching, the DTMF decoder intercepts the frequency modulated signals to obtain DTMF tones. The DTMF signals transmitted are received and decoded using a DTMF receiver/decoder IC MT8870. The four BCD outputs obtained from the DTMF receiver/decoder IC corresponding to each digit together with the associated dual-tone frequencies can be put-it in a table form for easy reference as given in TABLE I.

TABLE I: FONT AND PARAGRAPH SPECIFICATIONS

Button	Low DTMF frequency (Hz)	High DTMF frequency (Hz)	Binary coded output			
			Q1	Q2	Q3	Q4
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0

Since the digital outputs cannot sink much current, they are not capable of driving relays directly. BCD outputs obtained from the DTMF receiver/decoder IC are connected to an AND-NOT logic whose output is used to drive the electrical appliances through relays. Buffers are used to provide extra current drive at the output, but can also be used to regularize the logic present at the interface.

IV. FUTURE APPLICATIONS

Some of the possible applications would be like

- Smart lighting such as street lights can be used as public access points.
- In aircraft cabins during the flight.
- In RF restricted environments like petrochemical plants.
- In under water communications.
- Indoor navigation.

Li-Fi has great potential in the field of wireless data transmission. There are many devices accessing the internet so there is network congestion and in turn airwaves are getting clogged because of which it is difficult to transfer data at high speeds. Numerous possible applications can be explored in the near future. By practically implementing this technology, each and every LED bulb can be used as a Hotspot to transmit and receive data. Some of the advantages are:

- Overcomes the limitations of radio spectrum.
- High speed of 10 Gbps can be achieved.
- Li-fi can solve for the essential problems of wireless communications these days.
- Enable smaller cells without the need for new infrastructure.

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