DATA TRANSMISSION USING POWER LINE AND VISIBLE LIGHT COMMUNICATION

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Abstract- Wireless optical communications has been used long before radio communications was first considered. However, over the last century radio communication has been the preferred means to transmit data wirelessly. The purpose of this study is to solve the problems of radio frequency bandwidth, frequency depletion, confusion possibilities, and security that are in current wireless communications systems, and to confirm the possibility of applying those solutions for the next generation network. To solve the problem of current wireless communication system, the combination of power line and visible light communication (VLC) system is created and capacity is analyzed. The exclusive power line communication modem, 8-bit ATmega16 microcontroller, high brightness 5pi light emitting diodes (LED) and PIN phototransistors were used for transmitter and receiver. The performance was analyzed using a designed program and oscilloscope. The voltage change was measured as function of distance from 15-30cm. The proposed system will enable high quality of service by high radiation power from this LED. And, this system does not cause or suffer from radio or electromagnetic interference.

Keywords- Power Line Communication, Visible Light Communication, Light Emitting Diode, 8 Bit Microcontroller.

I. INTRODUCTION

What if every light bulb in the world could also transmit data? Consider the amount of light bulbs that are already installed in the world. And the amount of energy they consume. If this can be used to transmit data, consider the amount of energy saved. Look around us, what we see is a visible light spectrum, the thing that exists everywhere. Something we generally use every day, there is not a single area where we do not need light. With this emerging technology we can use all the light around us that we produce to transmit data, data in the form of bits and bytes. Considering a the amount of dependency that we have in the present world on the use of cell phones or laptops or the internet it is a need of the present world that we check alternate ways to transmit all this huge amount of data we generally use.

The idea of integration of these two systems for indoor networking was pioneered by Komine et.al [1] which was based on single carrier modulation then to improve their old system to overcome the effects of power-line noises they used multi-carrier modulation (OFDM) method [2]. In this paper, the details of the system architecture are described in Section III. By flickering, the light from a single LED, a change too quick for the human eye to detect, they can transmit far more data than a cellular tower using SIM OFDM technique [3] and do it in a way that's more efficient, secure and widespread. Through my proposal I aim to give a glimpse of the possibilities of all that I can do with the visible light and power line. I aim to present the scope of this technology in near future. In one hand we have the visible light communication spectrum and in other hand have large number of power lines which drives the electric power to glow the bulbs, so why not to use them as transmitting medium. Through my proposal I am trying to make combined power line plus visible light communication for data transmission between to end devices. Power lines were used in proposed system because all infrastructures are readily available so it does not require new wires[5,6].

II. ECO-FRIENDLY GREEN TECHNOLOGY

The system is divided into two parts, one part is power line communication system and another part is visible light communication system. In case of power line communication part, power line cables were used for communication which are already exists and depends on home plug network as they are not producing any radiation which help to harm human beings. Where in case of visible light communication, the vital part of Visible light communication (VLC) system is LEDs, which send data by flashing light at speeds undetectable to the human eyes. LEDs are more advantageous than the existing incandescent bulbs and fluorescent tubes in terms of long life expectancy, high tolerance to humidity, low power consumption, and minimal heat generation lighting. There are several advantages of visible light communication based on LEDs for communications over WiFi and IR for indoor access:-

- LEDs are less expensive than laser sources used in IR.
- Visible light communication system is cheap, durable, robust, secure, aesthetic & fashionable with untrammelled bandwidth opportunities.
- The visible light occupies unregulated and unlicensed THz spectrum since it does not cause or suffer from any electromagnetic interference,
whereas interference is common in using WiFi or any other RF systems.

- Visible light communication does not have any possibility of leaking out when the light is isolated, which offers better security than wireless LAN, and does not suffer performance losses even when a variety of computers are connected at once.
- Shadowing effect is much less compared to IR case because LED light fixtures are distributed throughout the room.
- Receiver obtains at least one strong Line of Sight (LOS) signal as the transmitters are on the ceiling. This is not the case in most IR transmission situations.
- Undoubtedly, VLC is free of any health concerns, as it uses eco-friendly green technology rather than microwaves, which can cause harm to the human body.
- The plural LEDs, connected to power-lines, can be employed as internet access points, indoor navigation and positioning in homes, labs, offices. Besides these can be spotted as local information points in shops, airports, railway stations, museum etc... More recently this system has found some applications like Intelligent Transport System (ITS) in particular military aircraft power-line network and onboard aircraft networking [7].

### III. DISCRIMINATION OF PROPOSED SYSTEM

#### A. OSI layer framework

The free space visible light beam is the advanced PHY layer of the combined PLC-VLC system. These two technologies converge at MAC layer and it is called as inter-MAC. The cross-layer mechanism of the integrated system consists of a 2.5 OSI layer able to hide the heterogeneity of communication technologies which constitute the home network. The inter-MAC layer is capable of forming a unified network as well as integrating its heterogeneous wired and wireless links. Functions such as quality-of-service (QoS) control, load sharing, and dynamic path selection are made possible in such unified networks.

The VLC system is standardized by IEEE 802.15.7 and the IEEE P1901 is a working group developing PLC medium access control and physical layer specifications. ITU-T adopted Recommendation G.hn/G.9960 as a standard for high-speed power line communications.

#### B. Architecture of combined system

The proposed system is shown in Figure 1. The main features of the proposed system are easy wiring and easy installing. We assume that power-line modem has been plugged into and power-line network has already been built. The system shown, proposes the bridging of power line communication over visible light communication. The design in this study uses a 230 V/50Hz power line network.

The power line communication system uses a commercial alternating current electric power source 230 V/50Hz power line and an RS-232C cable as a communication medium, and consists of visible light communication parts including PLC receiving and transmitting parts. The system developed in this study transmits the input data from a computer to a PLC transmitter modem through an RS-232C port. This signal is converted into the transistor-transistor logic (TTL) signal level through a MAX232N chip, and is transmitted to the PLC receiver through power line cable after the data is transmitted to an exclusive PLC modem chip through a microcontroller and LCD to view data transmitted. Data that is transmitted after these processes is received by an exclusive PLC chip that is attached to the PLC receiver, and this signal passes through the microcontroller and is transmitted to the visible light communication light emitting parts. After the data is received from the visible light receiving sensor through the LED of the visible light communication light emitting parts, the lowered data signal is amplified by the OP-amp circuit, and the RS-232C cable issued through the Microcontroller and LCD to the MAX232N chip to send the data to other computers.

#### 1. PLC Transmitter Circuit

The PLC transmitter circuit, as shown in Figure 2, mainly consists of the PLC modem, automatic voltage regulator (AVR based on microcontroller ATMega16 chip), and level-shifter (MAX232 chip) to make the RS232 voltage level compatible with TTL signal level. The data is transmitted from the RS-232 cable to the power line through the exclusive PLC modem. The PLC modem offers a suitable one-chip solution for switching of an access-point of visible light communication into or out of a PLC network. The properly programmed microcontroller varies the duty cycle of the PWM signal which has the task of regulating the current in the LED.
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2. PLC Receiver and VLC Transmitter Circuit

Figure 3 shows circuit of PLC receiver circuit which has little bit same approach as PLC transmitter circuit, except that amplification and driving circuitry are added to the LED transmitter parts to work as VLC transmitter. The signal that comes through the AC power line is received through the exclusive PLC modem, and is converted to current form by an operational amplifier, then biased with DC source. A DC-current level is chosen such that the device operates in a linear regime. The biased current is fed to LED driver unit. The power of LED is varied according to the waveform of data signal.

LED will act as visible light transmitter module depending upon data rate they used to flick but their flickering is not detectable by human eyes. So for human beings it will act as one of simple light source.

3. VLC receiver circuit

At the receiver side as shown in Figure 4, the practical active high technique is used, in which a PIN photodiode sensor produces a current proportional to the appearing light power, i.e. proportional to the square of the received electric field. Filtering is used to remove the slow yellow light. The mA current from photodiode needs to be amplified by an operational amplifier. Then by making it TTL compatible to communicate with microcontroller and client PC, the data is reached to client PC by RS232 cable as shown in figure 4.

C. Channel Model of PLC-VLC system

1. Power-line Channel & PLC Noises: - The transfer function of the PLC channel can be modeled as below [8]:

$$H(f) = \sum_{l=1}^{N} g_l e^{-j(\omega_0 + \omega_1 l^2)} e^{-j2\pi f t_1}$$

Where $g_l$ is a weighting factor representing the product of the reflection and transmission factors along the path; $\omega_0$, $\omega_1$, $k$ are constants. The variable $l$ represents the delay introduced by the path which is calculated by dividing the path length $l_p$ by the phase velocity $v_p = 150 \times 106$ m/sec. and $N$ is the total number of reflection paths. Unlike the other telecommunications channels, the power line channel does not represent an AWGN, but it includes a superposition of five noise types: colored background noise, narrowband noise, periodic impulsive noise asynchronous to the main frequency, periodic impulsive noise synchronous to the main frequency, asynchronous impulsive noise. Thus, all these three can be summarized in one noise class that is seen as colored PLC background noise class and is called “Generalized Background Noise (GBN)” [8].

2. Optical Wireless Channel: - The VLC channel is modeled as a linear AWGN channel and is given as:

$$I_p = R_P(t) \otimes h(t) + n(t)$$

Where $P(t)$ is instantaneous transmitted optical power, $h(t)$ is the channel impulse response, $n(t)$ is the signal independent additive noise. This AWGN noise is independent of the optical power. When little or no ambient light is present, the dominant noise source is receiver preamplifier noise, which is also signal-independent and Gaussian (though often non-white). Thus we usually model the noise as Gaussian and signal-independent. Multipath fading in VLC can be ignored because an information carrier is in the order of $10^{14}$ Hz. Detector dimensions are in the order of hundreds of wavelengths, which leads to efficient spectral diversity that minimizes the effects of multipath fading [10].

IV. SIMULATION AND RESULTS
To simulate the power line communication channel, the parameters are needed to be set as:

\[ g_1 = [0.5, -0.5, -1, -1.5], a_0 = 0, a_1 = 8 \times 10^{-6}, r_1 = [1, 1.25, 1.92, 2.56], N=4, k=0.5, l_i=[152, 180, 255, 402]. \]

The power line modem transmits and receives data at the rate of 9600 bps. Figure 5 shows the simulation result for LCD interfacing with controller and testing circuit of PLC modem.

While simulating visible light circuit some results are obtained, figure 6 shows the values obtained from voltage change through visible light receiving sensor from a voltage that 5 V is approved by distance using an oscilloscope. In the case of the white LED, the voltage at a distance from 10-35 cm was constant, but the voltage for a distance over 5 cm showed a dramatic voltage decrease. A voltage loss of 0.67 V was confirmed, with a voltage of 4.32 V at 10 cm to a voltage of 3.65 V at 50 cm. Also, in the case of the red LED, the voltage from 10-30 cm was constant, but there was a dramatic voltage decrease at distances over 30 cm. At a distance of 50 cm, the voltage was 3.26 V, so that 1.06 V was confirmed as the voltage loss. The voltage loss of the green LED is 1.46 V, and the voltage loss of the blue LED is 0.47 V, which shows the best performance among the LEDs.

Figure 6 Changes in voltage values depending on LED color used from different distance

Figure 7 Manufactured PLC-VLC system

CONCLUSION

In this study, the data transmission using power line and visible light communication is created, and a value is calculated, which is detected by the visible light receiving sensor using an oscilloscope. The transmitting and receiving waveforms can be checked and verified as shown in Figure 7 as it shows manufactured system.

Figure 8 Results from PLC-VLC System

Figure 8 shows the hyper terminal version 1.9 outputs with LCD which shows the data sent from master PC to client PC. The program that general can easily take and adapt by adding letters to verify successful data transmissions between two personal computers. In this manner, letters "SUJIT" was used as the input and was transmitted to the other computer. The results were checked, and the blue LED showed the best performance when evaluated using an oscilloscope.
simple experiment was created to verify the best performance at distances from 15-30 cm, and there were no problems in the hyper terminal program while the letters were transmitted and received. As the distance increased from 15 cm, however, the processing speed decreased due to the weak signal treatment and the background lights, which made it hard to receive precise data. Also, new issues were found by using the estimated values. In this study, the performance under changing conditions was evaluated, and the efficiency of the light emitting part and the receiving sensor of the visible light were studied so that better communication conditions can be achieved in the future. Continuous study and improvement are required. This study also confirmed the possibility of applying this technology for the next generation of communication network.

REFERENCES