Multi-User Visible Light Communication

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***Abstract*—As the number of users of wireless communication are soaring, radio frequency spectrum will soon become very difficult to be accessible for all users. So, another means to wireless communication is necessary to adjust the highly increasing demand for wireless traffic. Visible Light Communication (VLC) systems is an ideal alternative to the current wireless transfer of information, where light from LEDs acts as the medium for communication. In VLC systems, light-emitting diodes (LEDs) blink at a fast rate such that the change in light intensity is not noticeable to a human eye, but a photodiode is sensitive enough to the change in this light intensity. So it can detect the on-off behavior of the LED and decode the information sent by it. In this paper, we deal with the implementation of Multi-User Visible Light Communication (MU-VLC) where multiple signals are transmitted simultaneously using Time Division Multiplexing (TDM).**

Keywords—LED; MU-VLC; Photodiode; TDM

I. INTRODUCTION

Visible Light Communications (VLC), first put forward by researchers at Keio University in Tokyo, These VLC systems, use visible LED (light-emitting diode) lamps which are energy-efficient and transmit information along with their use as lighting devices. They are eye-safe (visible light does not cause damage to the human eye), due to which higher transmission power LEDs can be used. Interference is a major concern for many present wireless communication systems. Simultaneous use of a frequency band will cause interference because of the electromagnetic nature of most wireless devices, which may result in incorrect transfer of information or loss of information for the users involved. Compared to other communication systems VLC systems have more flexibility and integrity in many regards. As visible light is the medium for transmission in VLC systems and not RF waves that can penetrate walls, the issue of security is solved because light cannot leave the room, containing data and information in one location. There is absolutely no way of retrieving and accessing the information by an unauthorized user because in VLC system Line Of Sight (LOS) is required to receive the information. In addition, LEDs are highly efficient and are more durable, adding to the integrity of these systems. The major disadvantage is the limited bandwidth of LED devices, generally in MHz [5].

In order to accommodate multiple signals in a single frequency we are employing Time Division Multiplexing (TDM)[1]. This transmitted signal will be de-multiplexed at the receiver. These individual signals will be sent to different users present at the receiver. In this paper we deal with the implementation of Multi-User Visible Light Communication. In section 2, we describe the system model of MU-VLC [1][2]. In section 3, we discuss the results obtained by the implementation of MU-VLC. In section 4, we draw the conclusions and future works.

II. SYSTEM DESCRIPTION

A VLC system generally has two modules, one is the transmitter module, and the other is the receiver module. Here the communication is unidirectional i.e. communication happens from transmitter to receiver.

The modulation technique that we have adopted in our transmitter circuit is ON-OFF keying modulation which is a type of amplitude-shift keying, (ASK) modulation. Here the Carrier wave determines the representation of digital data. The presence of a carrier represents a binary one, while its absence represents a binary zero [3].

For multiplexing and de-multiplexing in Multi-User VLC we used IC 4051. The 4051 is an 8 channel analog multiplexer / de-multiplexer. By using 4051 as a Multiplexer we can choose any of the 8 different inputs and select just one we would like to read at the time. By using 4051 as a de-multiplexer we can choose any of the 8 different outputs and select just one we would like to write at the time.

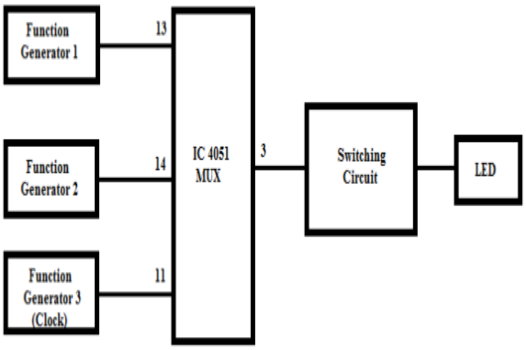

Fig.1 Block diagram of transmitter

A signal from the output of function generator is given to pin number 13 and 14 of 4051 multiplexer as shown in Fig. 1. A clock is provided to pin number 11 of 4051 multiplexer through a function generator to enable Time Division Multiplexing of the two input signals. The TDM signal is taken out from pin 3 and given as an input to a modulation circuit. It passes through the group of two transistors to make the LED on and off according to the signal at the input. At the first transistor we get an inverted signal of the input as per the transistor working and at the second transistor we get the exact input signal. The LED connected to the collector of the second transistor will blink according to the input signal and transmit the same to the medium. The distance it can transmit the information depends on the number of LEDs used. More the LEDs, more the distance it transmits. A 12V DC supply is provided for the entire circuit and the resistor values are taken as per the output signal requirement

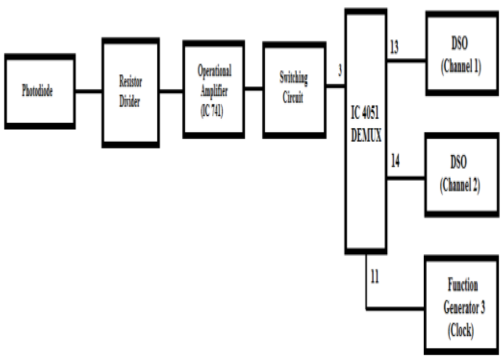

Fig.2Block diagram of receiver

The emitted light from the LED is received by the photodiode in the form of a current signal and that is converted to the voltage signal by the resistor divider as shown in Fig. 2. The signal which has amplitude in the range of milli volts is then passed to the main amplifier stage where it gets amplified to a level that is needed. Here in this circuit we have provided a gain of 100 (Rf =100k, Rin=1k). Then it is passed to the pair of inverters (where the resistor values are chosen as per the requirements of the output signal) after which we get the desired signal, same as the input signal sent by the LED. The received signal is taken out from receiver circuit and given as input to pin3 of 4051 de-multiplexer which divides the TDM signal into individual signals that can be seen at pins 13 and 14 using a Digital Signal Oscillator (DSO).Same clock is provided to both MUX and DEMUX to synchronize both transmitter and receiver.

III. RESULTS

We are exhibiting simplex communication based on VLC. In order to increase the range of transmission between the transmitter and receiver any one of the following two methods may be adopted:

a) Fabricate an LED array to increase the intensity per area
b) Use a powerful LED (like a torch or lamp) and convex lenses

We chose the latter due to its compactness. Also, troubleshooting is much simpler in case of option 'b'

The clock frequency given for IC 4051 is 35 Hz. When an opaque object e.g. a finger or card were inserted between the LED and the photodiode, the voltage received would suddenly dip proving that the visible light cannot pass through opaque objects and hence eavesdropping is practically impossible with this system. The same can be shown by means of a DSO. The Maximum frequencies at which both the signals are received correctly is around 30 KHz. Fig. 3 Shows the output waveforms of the LED as seen on the Digital Signal Oscillator. The rectangular blocks in the waveforms represent the information being transmitted at different instances of time through Time Division Multiplexing (TDM).

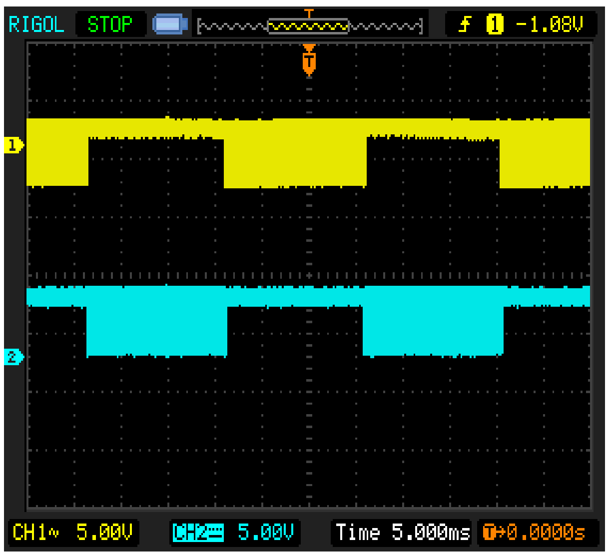

Fig.3Experimental result of Multi-User VLC as seen in DSO

IV. CONCLUSION

We have designed and implemented Multi-User Visible Light Communication [1][2] using off-the-shelf LEDs. Visible Light Communication has several advantages like high security because there is absolutely no way of retrieving and accessing the information by an unauthorized user because in VLC system Line Of Sight (LOS) is required to receive the information. It has no electromagnetic interference and does not cause damage to the eye. As the demand for VLC is increasing the available bandwidth has to be allocated efficiently. Multi-User VLC provides a proper solution to allocate the bandwidth efficiently by using Time Division Multiplexing.

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