Asian Journal of Applied Science and Technology (AJAST)
Volume 1, Issue 2, Pages 11-16, March 2017

Accident Avoidance by using Li-Fi Technology in Automobiles

R.Anitha[1], S.Bharathi[2], J.Jayalakshmi[3], J.Nancy[4], M.Thiruppathi[5]

[1]*UG Scholar, Department of ECE, Vivekanandha College of Engineering for Women, India. Email: rajendrananitha4@gmail.com*
[2]*UG Scholar, Department of ECE, Vivekanandha College of Engineering for Women, India. Email: rajendrananitha4bharathi156ss@gmail.com*
[3]*UG Scholar, Department of ECE, Vivekanandha College of Engineering for Women, India. Email: neevijaya15@gmail.com*
[4]*UG Scholar, Department of ECE, Vivekanandha College of Engineering for Women, India. Email: nano15081995@gmail.com*
[5]*Assistant Professor, Department of ECE, Vivekanandha College of Engineering for Women, India. Email: mailtothiruppathi@gmail.com*

Article Received: 19 February 2017 *Article Accepted: 27 February 2017* *Article Published: 02 March 2017*

ABSTRACT

To improve the excellence of Intelligent Transportation System (ITS) with the help of Optical communication technology using an LED in the transmitter side and a camera receiver side, which uses an improved CMOS image sensor which is an optical communication image sensor (OCI). The OCI has a "communication pixel (CPx)" that can effectively respond to light intensity changes and an output section of a "flag image" in which only high-radiant light sources, such as LEDs, have emerge. The vehicle to vehicle communication scheme consists of the LED transmitter located on a moving front vehicle and the camera as receiver is placed on a next followed vehicle. The received information can be used for more subsequent improvement in vehicle control and to prevent from accident collisions.

Keywords: Camera receiver, Communication Pixel, LED Transmitter, Visible Light Communication and Vehicle to Vehicle Communication.

1. INTRODUCTION

Recently, light emitting diode (LED) based optical wireless communication (OWC) systems have been developed [1]-[3]. Especially, an OWC technology using visible light LEDs, referred to as visible light communication (VLC), has been receiving much attention [4]-[6]. The LED is suitable as an optical signal sending device because light intensity of the LED can be modulated at high speed in comparison with traditional lighting devices, such as fluorescent lamps. Furthermore, LEDs are inexpensive, already used for lightings, and have high energy efficiency and long operating life. Moreover, basic performances of LEDs are being improved constantly while achieving even lower cost. Therefore, the LED based OWC system is expected to be a convenient and ubiquitous communication system in the near future. The widespread use of LEDs as light sources has reached into automotive fields. For example, LEDs are used for tail lights, brake lights, headlights, and traffic signals. Accordingly, vehicle-to-vehicle (V2V) and infrastructure-to-vehicle (I2V or V2I) communication systems using LED-based OWC technology have been studied.

Alternatively camera is predicted to be the receiver at the automotive OWC schemes. Cameras have previously been used for security and console applications in the automotive areas. Consequently, using the camera as the optical signal receiver is sensible and straight-forward. Furthermore, the camera receiver provides the non-intrusion communication potential to OWC systems due to the improved spatial division capacity of the image sensor mount in the camera. Thus, the OWC knowledge using a camera (image sensor) achieves non-crosstalk communication with multi-LEDs without a complicated protocol and processing prevents optical signals from being mixed with noise such as directly incident sunlight, and enable simple link designs. This capability is not found in other wireless communication systems and will significantly contribute for realizing the automotive OWC system that has to communicate with multi nodes under out-door areas.

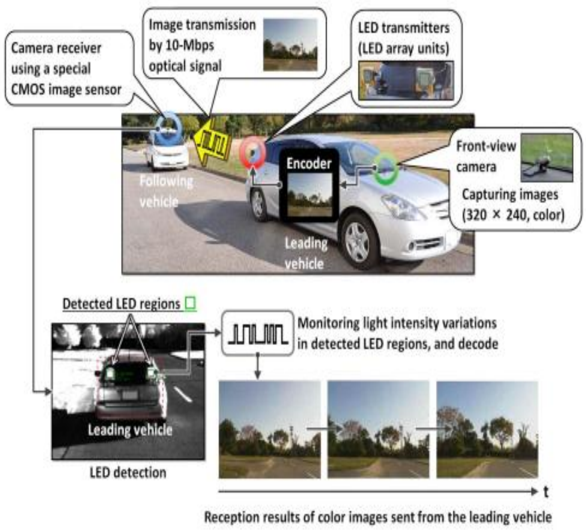

Fig.1. V2V communication system

Different systems, capabilities, and advantages of the camera based receiver OWC arrangement have previously been reported. Though, only a few information have improved and implemented in the camera-based OWC arrangement in a real automotive structure and conducted experiments under real dynamic and outdoor lighting situations. To attain a useful camera-based OWC system for automotive application, obstacles must be overcome one is data rate development and another is precise and quick LED detection. The data rates per pixel of earlier camera receivers are in the tens of kb/s or less than that. For transmitting various vehicle data's (e.g., speed of moving car and braking states) and large multi-media data (e.g., audio, image, and video), even higher data rates more than a less Mb/s pixel are predicted. In addition, the receiver system has to find the LED transmitter in captured images via image processing scheme. However, it is very difficult to correctly and quickly detect LED transmitters from images under outdoor lighting areas with a low cost.

This paper deals on and introduced an OWC technology based optical V2V communication system connected by an LED transmitter and a camera receiver. At the camera receiver, a special CMOS image sensor, i.e., an optical communication image sensor (OCI), is used. The OCI has a non-conventional pixel, a "communication pixel (CPx)," which is dedicated for high-speed optical signal response. Furthermore, it has an output side for a non-conventional picture, a "1- bit flag image," which only reacts to high-intensity light source such as LEDs and thus facilitates the LED exposure. The OCI which employs two key technology providing capability for Mb/s-class optical signal reception and a quick and accurate LED detection to a camera receiver.

This paper improves and introduces a new IS-OWC system based on an LED transmitter and camera receiver along with a newly improved image sensor, which is projected for automotive application, along with vehicle-to-vehicle and vehicle-to-infrastructure communication scheme. The objective data rate is 10 Mbps per pixel or more for concurrently sending color video data and vehicle internal data, such as braking status, vehicle speed, etc. Furthermore, for communicating with vehicle while vehicles are moving, the target LED detection rate is 16.6 ms, which is measured to be a real-time detection.

In this goal, we increase optical communication image sensor (OCI) using complementary metal-oxide-semiconductor (CMOS) equipment that can put together multiple functions. For achieving the required data rate, a generalized pixel for communication, communication pixel (CPx) is designed using pinned photodiode (PD) equipment, which provides significantly improved reaction to light intensity changes when compared to conservative imaging pixels. Additionally, for real-time LED detection, a new detection method that uses B1-bit flag image is projected, and improving and developing this flag image function allow the rapid and highly precise LED recognition.

2. OUTLINE OF OPTICAL V2V COMMUNICATION SYSTEM

In the given figure, a leading vehicle (LV) has LED transmitter array that uses vehicle LED light as a source such as brake lights, tail lights and head lights. A following vehicle (FV) has the camera receiver. The LV collects its own different internal data (such as speed) and sends these data's to the FV by optical communication scheme.

Simultaneously, the camera receiver on the FV detects and captures the images and looks for the LED areas in the captured pictures via image processing technique. The LED regions are enclosed by green rectangles. Later, the receiver system monitors the light intensity changes in the detected LED areas and obtains the optical signals.

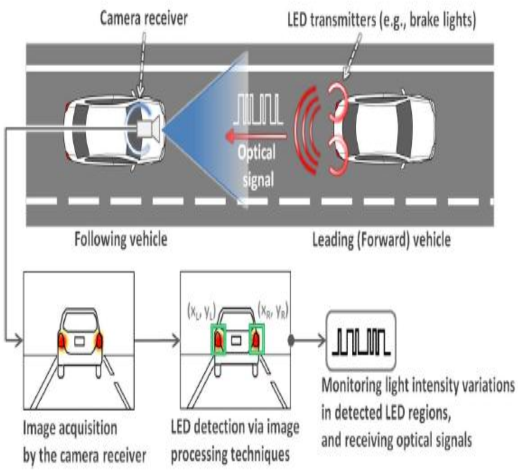

Fig.2. Illustration of the optical v2v communication system

Someday in the future, images captured by the camera receiver will be used for not only LED exposure, but also safety and comfort application, such as pedestrian detection and lane detection. In other terms, the camera receiver for the OWC system and the camera for the image processing system are combined in our system and a single camera will be used for both functions. Hence, the cost increase will be little because most camera equipment can be common, and no extra gap is wanted for the camera receiver. Furthermore, since this structure can combine two results, i.e., the results of data message and the results of image processing, new applications could emerge.

As we known, the OWC is a line- of-sight (LOS) communication. As optical signals spread in a straight line, OWC links are effortlessly blocked by objects which the light cannot penetrate, such as buildings, walls, thick gas, and thick fog. In addition, its communication range is banned in areas overlapping the light ray's angle of the LED transmitter and the angle of view (AOV) of the camera receiver. Conversely, this drawback frees the communication system from the multi-path fading problem and simplifies link designs. In addition, signal noise leakages to unwanted nodes are less and the receiver is unaffected by needless signals outside of the AOV. Moreover, the optical channel doesn't need to consider widely electromagnetic mixtures of noise and are without license the worldwide.

3. CHARACTERISTICS OF IS-OWC TECHNOLOGY

Related to the total structure of an image sensor, the IS-OWC scheme has several advantages and characteristics that are not being found in any other wireless communication systems such as systems using single element or radio waves. Some of these applications are non-interference communication. When an image sensor is being used as a receiver, light sources are almost flawlessly divided on a focal plane (a pixel array) because there are an immense number of pixels, and optical signals are individually output from each pixel. This avoids signals from starting being mixed, thus it allows communication, even if many LED transmitters and surplus lights (noise sources) such as streetlights and sunlight are present.

This ability provides high signal to noise ratio communication, which requires no problematic protocol in use for instantaneous communication with many-LEDs, and thus provides the capability to accept different protocol signals by each LED. This attribute is very useful for automotive process applications that must be performed under real road ways and environments, where many surplus light sources exist and where instantaneous communication with multiple vehicles and traffic signals is necessary.

When the IS-OWC part of system receiving the optical signals, the spatial points, that exactly (x,y)-coordinates, of the LEDs can also be attain from the picture. As a result, the receiver-side part can effectively and clearly being determined by the transmitter and receiver sources which receives data such as a car being moving on the left or right of a car linearly in front without complex processing or GPS tracks the data. Furthermore, since many vehicle users can easily be select communication partners from an picture, there is no need for the difficult signal processing important to filter out surplus information because the LEDs that are not necessary by receivers cannot be noticed entirely. As with the existing character, the optical signal power received by the IS-OWC is constant against changing communication distances.

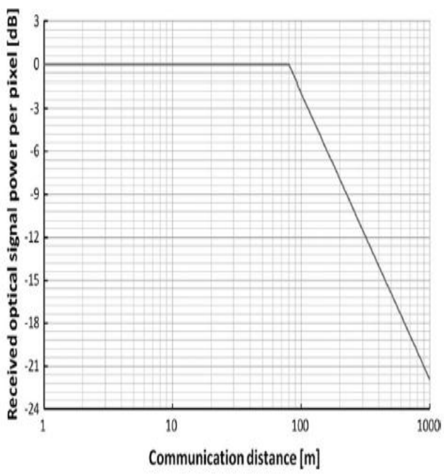

Fig.3. Received optical signal power per pixel versus communication distance

More specifically, the incident light power per pixel remains not changed, despite of communication distance changes, as long as the imaged LED size on the focal plane of the image sensor is greater than the pixel size .A predicted calculation result of the received signal power per pixel as a function of the communication area and distance. As we can be seen in the figure, the result is stable up to 80 m under the conditions of a pixel size of 7:5X7:5 Xm2 , an LED array size of 10 X10 cm2 and a lens focal length of 6 mm is noted. If the distance exceeds 80 m, the received signal power is decreased because the size of the imaged LED is less than the pixel size. Of course, the optical signal can be received in outside of the steady range if an signal to noise ratio requirement is fulfilled.

This feature is helpful for obtaining stable quality communication. If a larger focal length lens is used, the maximum steady power distance is lengthened by the zooming effect. Though, on the other side of the book, an angle of view is narrowed. In accordance with application requirements, a proper lens selection is very important.

4. OPTICAL COMMUNICATION IMAGE SENSOR

In this paper, a special CMOS image sensor is used in the camera receiver end. The optical communication image sensor (OCI) is created and fabricated by 0.18-mCMOS image sensor method. To obtain receptions of high-speed optical signals, the CPx is founded. The CPx is designed by pinned-PD technology, which provides substantially more improved response to speed of light radiation variations, and it has already being demonstrated 20 Mb/s optical signal reception per pixel unit. The OCI pixel array consists of the CPx and the image pixel (IPx) arrays which are made in different shifts. The IPx array which capture images to find the LED transmitters, and the CPx array received optical signals. This hybrid pixel array is joined in the OCI with peripheral circuits that drive both pixel arrays and process the captured image signals and received light signals. First, the OCI outputs are of two kinds of images captured by the IPx array. One kind is a conservative gray image, and the other is a 1- bit flag image for easy LED detection. The flag image which is taken in a very short intensity exposed time compared with the gray image and is binaries by comparator circuits in the marginal circuits for image signals.

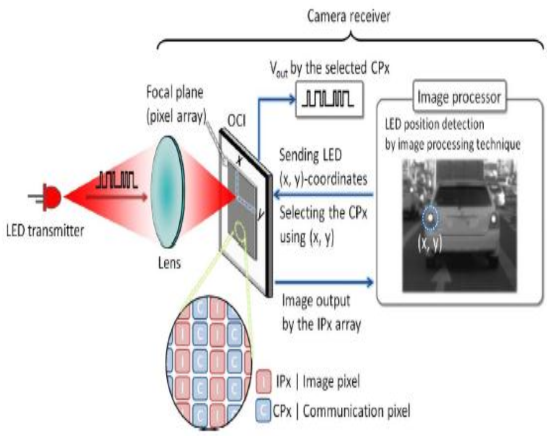

Fig.4. Entire operation of the OCI

Therefore, low light intensity materials are perfectly rejected. In contrast, high light intensity objects, such as LEDs, remain as “1” in the flag image side .When the flag image is being used for LED detection, the measured time and the misdetection rate are greatly decreased because most unnecessary images are removed. After the flag image is send to an image processor on an external unit, the LED areas are detected and the central coordinates of the LED regions are found out via basic image processing method. Next, the obtained (x,y) coordinates are inputted to the X and Y positions generators of the OCI. Then the CPx depended to the inputted (x,y) coordinates are selected by the address generators, and the selected CPx is being activate. Finally, the optical signal received at the selected CPx is out putted through readout amplifiers in the peripheral circuits for the communication signals. This whole operation is repeated repeatedly, and so high-speed optical signals are received while the LED transmitter is being tracked.

5. LED TRANSMITTER AND CAMERA RECEIVER SYSTEMS

Transmitter structure consists of an LED array unit and a controller together with raspberry PI consisting with PC. The controller gets different data for transfer, and it packetizes and encodes the transferred data. The LED display unit has LED drivers and 10 X10 LEDs, and its optical power is up to 4 W. In this method, 870 nm near infrared (NIR) LEDs ability of being modulated at high speed (fc: 55 MHz) are used uncertainly.

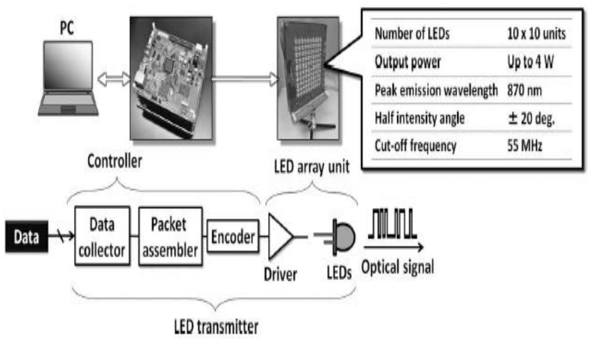

Fig.5. Photographs and block diagram of LED transmitter system

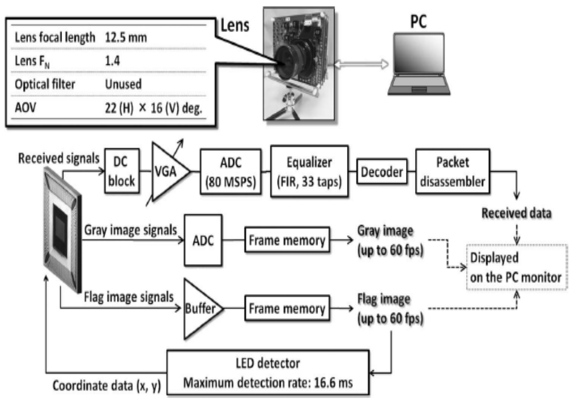

Fig.6. Photographs and block diagram of camera receiver system

A 12 .5 mm lens is closed to receiver side and the Angle of View is 22 (H) degrees. X 16 (V) degrees. Lens does not use the optical filter, a receivable light wavelength collection is from the visible to NIR light. Various parameters will be set to the camera receiver and has it has the software to display received data, flag images, and gray images. Inside the receiver ,From the OCI the output of gray image signals and the flag image signals are built on the frame recollections, and every image will be completing in a period of 16.6 ms(at up to 60 fps). For display the gray images are used. The full flag image is delivered to the light detector, and light is detected by using a characteristic linked element tagging method in a period up to 16.6ms. The carried data from detector is send back to the OCI, then only the CPx related to the (x, y) coordinates is activated, as explained in the earlier segment. By receiving the optical signal then it will activated CPx are digitized by the 80-MSPS Analog to Digital Convertor and equalized by a 33 tap (FIR) filter. Finally, stable signals are decoded, and data are chosen from the packets.

A packet consists of a 32-bit preamble and unique word. And it has 2392 bit payload, and 8 -bit post amble. An already reported rate is (20 Mb/s), Now the data rate is reduced to 10 Mb/s, which is the rate of to make sure the consistency and stability of the communication superiority. The encoding technique is Manchester coding. The packet transfer cycle is up to 0. 5 ms and will properly be altered depending on types of experiments. As respond to measures next to errors, the BCH code and block code interleaving are used. Here the , BCH codes are able to correcting up to 1- bit and 3 bit errors are arranged, and either one of the 1 bit and 3 bit error corrections will be select by results of field experiments. By using the 1 bit or 3 bit error correction, the accurate payload size is minimized to nearly 2164 bits and 1708 bits, correspondingly. This format is uncertainly designed for confirming the performance of this system and non-usual format.

Consequently, the receiver system selects a labeled aim and receives optical signals individually. For instance, when the data o f A (x1;y1) is effectively received, the camera receiver chooses B(x2 ; y2) as the next objective . When the data response of the final objective is completed, the camera receiver selects the first labeled aim once more. This circle operation is constant until the after that the target positions are obtained from the next flag image. When the next objective positions are obtained, each fresh objective is labeled over again by the similar routine. As a result, targets that do not have information, such as the sun and street illumination, are skipped in a specified time.

6. PROPOSED SYSTEM

The whole system is to constitute the transmitter and receiver in which we are using LED for transmitting the data with the help of LED driving circuit and image sensor that is (camera) as a receiver for capturing the image which is further being processed for obtaining the transmitted data with the rates.

6.1 Transmitter Section

The transmitter system which consists of an LED array unit and a controller including a PC. The vehicle internal data which consists of a vehicle ID,LED ID, vehicle speed, operating states of various devices (brake, head lights, and left and right blinkers) and many details. The controller collects various information for packetizing and encoding it before transmitting it .The encoded technique used is Manchester coding [6] for the LED to mitigate the optical noise mixtures. No feedback or optical filtering is required in this process. Other benefit of the Manchester coding is that it can provide signal synchronization and which improve the clock recovery. The LED array unit has LED drivers and few LEDs, and its optical power is up to 4 W. Fig. 6 shows a block diagram of an LED transmitter side system. In this system, 870-nm near infrared lights capable of being modulated at high speed (fc: 55 MHz) are used timidly. The modulation technique suggested is ON-OFF keying.

6.2 Receiver section

A 12.5-mm lens is connected to receiver side and the AOV is 22 (H) deg. 16 (V) deg. Since optical filters are not used on the lens, a receivable light wavelength range is from the visible to NIR light. The personal computer sets different parameters to the camera receiver and has application software [7] which is to display received data, flag images, and gray images. A block diagram of a camera receiver system which includes a PC. In the receiver system, the gray image signals and the flag image signals which are outputted from the OCI are constructed on the frame memories, and each image which can be completed in a period of up to 16.6 ms (at up to 60 fps).

In this system, the gray image is used for displaying purposes. The completed flag image is send to the LED detector, and LED regions are detected by using a typical connected parameters labeling method in a period of up to 16.6 ms. Optical signals received by the activated CPx are digitized by the 80-MSPS ADC and equalized by a 33-tap FIR filter.

Consequently, the receiver system selects a fixed target and receives optical signals one-by-one. For example, when the data of A(x1, y1) is successfully being received, the camera receiver which selects B(x2,y2) as the next target as shown in Fig 5. When the data which is received at the final target end is completed, the camera receiver which selects the first targeted image again. This loop operation is continuously repeated until the next target positions are got from the next flag image. When the next target positions are attained, each new target is labeled again by the same routine repeatedly. If a preamble of a packet is not obtained and captured from a selected target during arbitrary set times, that target will be skipped to the next labeled are skipped in a given time.

7. EXPERIMENTS

In this paper, several experimental outputs are presented. All experiments are conducted while driving outside. Outdoor lighting conditions which change constantly with intensity and considerably, and so are unpredictable. The experimental periods are from morning time to night time. The maximum vehicle speed is 25 km/h. The speed of each vehicle and the inner vehicle distance are freely predicted by each driver, and thus are not constant. The experimental road is created with asphalt and occasionally has an uneven area. (License numbers are being the vehicles in all result images are masked.)

7.1. Experimental Results of LED Detection

All sides of each result image are the gray image and flag image, respectively. Obtained results are presented by green rectangles in both pictures. In this experiment, small regions are under nine pixels in the flag image and are judged as noise and are not counted. Experimental results (a) and (b) are obtained from morning time lighting situations. While numerous surplus objects which totally disappear from the flag image, the LED regions will remain and are constantly detected in real time. Also, at night time (c), the LED regions are perfectly found without flaw detections. In (d) and (e), the leading vehicle body reflects the direct sunlight. As with the LED regions, the reflection areas are detected. In (f), the brake lights are turned on, and these are detected in addition to the LED areas. This LED detection technique using the flag image finds not only LED units, but also objects that have strong light radiation which is equivalent to or exceeding the light intensity of the LED array unit.

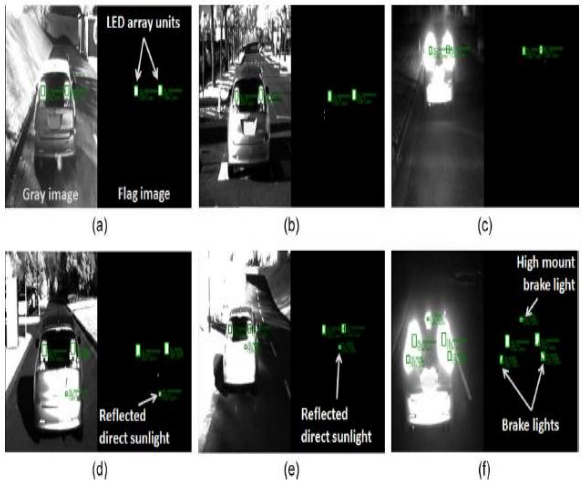

Fig.7. Experimental results

However, as previously said, since regions that have no data are being skipped, these regions have very less influence on communication performances. These results show that the proposed method [8] using the flag image is very effective and it achieves the correct and real-time LED detection even in very difficult outdoor lighting environments.

8. SYSTEM IMPLEMENTATION

This system can be implemented by the use of Raspberry PI as a controller in the transmitter as well as receiver end. In the transmitter side of the controller will be receiving the data from the data source and the data will be started and forwarded to arrays of LED's using LED driver circuit at the end. On the other hand at receiver side the camera will be capturing multiple images of emitting LED's which will be intersected to Raspberry PI board and the data will be recovering by the use of image processing techniques in open CV or Mat lab software [9]. Finally the collected data will be preceded to a LCD screen for the display.

9. CONCLUSION

We presented a visible light communication system which consists of an LED transmitter and camera receiver that is targeted at V2V applications in the system, and introduced its characteristics features and capabilities are increased. To obtain the 10 Mbps class data rate and the real-time LED exposure, a novel CMOS image sensor called an OCI has been developing and installed in the camera receiver. The two things are which are very important during development of the OCI i.e. the CPx for high-speed signal acceptance and the 1-bit flag image output function for easy and efficient LED detection. In future we will be trying to use this data for the control of vehicle and avoid collision. In addition, while the paper is targeting on the vehicle to vehicle communication, it is accepted that the system can be used in other areas too, such as factory automation, mobile phones, and wireless LAN networks.

ACKNOWLEDGMENT

It is our massive pleasure to work on this project, accident avoidance by using LIFI technology in automobiles. It is only the approval of my delightful master which has prompted and mentally equipped us to undertake the study of this project. Here we would like to thank, Principal Dr.S.Suresh kumar, Vivekanandha College of Engineering for Women for giving us such a chance to enhance practical understanding about subject. We are grateful to Dr.D.Sasikala, Head of Electronics and Communication Engineering Department for her valuable support at each part of our project work. I put forward my frank thanks to my lead Prof.M.Thiruppathi kindly encourages us to work on the subject and gave his helpful assistance time to time.

REFERENCES

[1] Mehboob Raza Haider, Manoj M.Dongre, “Vechicle to Vehicle Communication Using Visible Light Communication Technology”, *IRF International Conference,* April 2015.

[2] Sridhar Rajagopal, Richard.D.Roberts and Sang Kyu Lim, “IEEE 802.15.7 Visible Light Communication: Modulation Scheme sand Dimming Support”, *IEEE Communications Magazine,* March 2012.

[3] C.W.Chow, C.H.Yeh, Y.F.Liu, and P.Y.Huang, “Mitigation of optical background noise in light-emitting diode (LED) optical wireless communication systems”, *IEEE Photon. J.,* vol. 5, no. 1, Feb. 2013.

[4] Isamu Takai, Tomohisa Harada, MichinoriAndoh, Keita Yasutomi, Keiichiro Kagawa Shoji Kawahito, “Optical Vehicle-to-Vehicle Communication System Using LED Transmitter and Camera Receiver”, Volume 6, Number 5, October 2014 .

[5] Y.Oike, M.Ikeda, and K.Asada, “A smart image sensor with high-speed feeble ID-beacon detection for augmented reality system”, *in Proc. 29th Eur. Solid-State Circuits Conf.,* Sep. 2003, pp. 125–128.

[6] N.Matsushita et al., “ID CAM: A smart camera for scene capturing and ID recognition,” *in Proc. 2nd IEEE/ACM Int.Symp. Mixed Augmented Reality*, Oct. 2003, pp. 227–236.

[7] D.Yamanaka, S.Haruyama, and M.Nakagawa, “The design of high-speed image sensor chip for receiving the data of visible-light ID system”, *IEICE Tech. Rep.,* vol. 107, no. 300, 2007, pp. 97–102.

[8] I.Takai et al., “LED and CMOS image sensor based optical wireless communication system for automotive applications”, *IEEE Photon. J.,* vol. 5, no. 5, p. 6801418, Oct. 2013.

[9] S. Hranilovic, L. Lampe, and S. Hosur, “Visible light communications: The road to standardization and commercialization (Part 1)”, *IEEE Communication. Mag.,* vol. 51, no. 12, pp. 24–25, Dec. 2013.