Study of Wireless Communication Technology Between Led-Based Vehicles Using Csk Method

Dae-Won Kong, Sang-Hyun Lee

Abstract: ***The traffic information includes information related to the macroscopic traffic environment such as congestion or delay status of a specific road section, accident status, traffic volume, and traffic speed, and driving information of the vehicle such as speed, destination, and travel route. Traffic information management center provides traffic information through wired / wireless communication network. Providing such traffic information has a very basic level of information providing method such as ADAS (Advanced Driver Assistance System). However, for the sophisticated functions of the intelligent vehicle, there is a need for a method in which a traveling vehicle actively collects traffic information and controls the vehicle, or provides driving information directly to a vehicle traveling in the vicinity of the vehicle. These requirements are limited by the existing centralized traffic information collection and distribution method.***

Therefore, the purpose of this paper is to provide stable and efficient collection and distribution of traffic information by using LED light based inter - vehicle wireless communication method and an important issue in the field of smart car technology.

The development contents of this paper are to study the way to provide and distribute more traffic information efficiently by combining LED light of vehicle and CSK method. In addition, CSK modulation technique, which is variable according to the driving environment of the vehicle in operation, is designed and developed so that the throughput of communication between vehicles can be efficiently maintained according to the driving environment and the reliability can be maintained.

Index Terms: CSK, Wireless communication between vehicles, mixed model, Advanced Driver Assistance System, Color Shift Keying, Visible Light Communication.

I. INTRODUCTION

An important issue in the field of smart car technology is to provide reliable and efficient collection and distribution of traffic information. Traffic information may include information related to a macroscopic traffic environment, such as a traffic congestion or a status of a specific road section, an accident status, a traffic volume, a traffic speed, and vehicle information such as a traveling speed, a destination, have [1].

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The traffic information provided to the vehicle is collected through a magnetic loop sensor installed on the road surface,a traffic information collection camera installed on the ground, a location information module installed in the vehicle, and the collected basic data is transmitted to the traffic information management center. Such traffic information can be provided to a vehicle running on an electric sign board or the like [2,11,12,13,14,15,16,17].

The provision of the above-mentioned traffic information is a very basic information providing method. For the advanced function of the intelligent vehicle such as ADAS (Advanced Driver Assistance System), active vehicle is active or a manner in which the vehicle under operation can directly provide the driving information to the surrounding driving vehicle is required. This approach is limited by the existing centralized traffic information collection and distribution method. In this way, it is necessary to introduce a direct wireless communication between vehicles method to support the more advanced intelligent automobile operating system.

In order to solve these requirements, this paper aims to design and develop a vehicle communication method using the Visible Light Communication (VLC) method which is highly expected as a near field wireless communication technology.

Visible Light Communication (VLC) is a state-of-the-art communication technology for communicating using visible light. An LED (Light Emitting Diode) has a capability of blinking at a high speed, and can transmit data by blinking the visible light element at such a high speed as not to be felt by a human eye. Such visible light communication is a communication technology that uses a carrier of visible light belonging to 380 ~ 780 nm and controls flicker at a high speed to exchange information between transmitting and receiving terminals. It can be used by being fused with existing lighting infrastructure, and can be expanded to various application areas by using lighting used in various places.

LED is a type of semiconductor, which is called a light emitting diode. It converts electricity into light, and PD (Photo Diode) converts light into electricity. Through this principle, data can be transferred through the light by converting the input data into electrical signals, converting electrical signals into light, converting the light back into electrical signals, and converting electrical signals into data.

Therefore, the principle of LED lighting and communication convergence is to transmit and receive by using flicker (on-off switching) of LED and PD, and this is

called VLC (Visual Light Communication) or visible light communication technology.

In IEEE 802.15.7, which is the current standard for visible light communication of LEDs, LED is defined as three kinds of on-off keying (OOK), variable pulse-position modulation (VPPM) and color shift keying In each case, a coding scheme is designed to prevent the influence of such a flicker [6, 7,8,9,10].

In this paper, we design and develop a method for exchanging information between moving vehicles based on the visible light communication technique and devices supporting the same.

II. LED VISIBLE LIGHT COMMUNICATION TECHNIQUE

Visible light communication is a communication technology in which visible light belonging to 380 to 780 nm is used as a carrier wave and information is exchanged between transmitting and receiving terminals by controlling flicker at a high speed.

It can be used by being fused with existing lighting infrastructure, and can be expanded to various application areas by using lighting used in various places. However, the intensity of the light source must be directly changed.

LED lighting there are various advantages over conventional communication in communication using visible light. First of all, since the LED visible light region is safe for humans, it is possible to transmit a high power called a wattage used for illumination as it is. Since the illumination is installed everywhere, it is possible to construct a wireless environment simply by adding a communication function to the lighting device.

A. CSK(Color Shift Keying) Overview

Figure 1 shows a system diagram of the CSK modulation scheme using Band *i, j, k*. Through the scrambling and channel coding, the data is converted into the *X, Y* color coordinates through the mapping rule of the color codec. The channel estimation sequence compensates for the aging of the LED and degradation of performance.

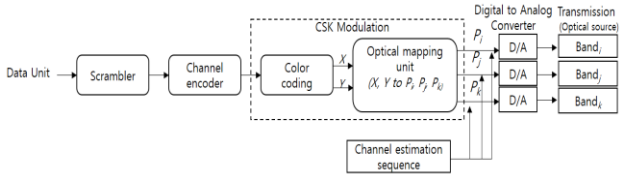

Fig. 1 CSK Modulation Diagram

The CSK modulation method consists of three LEDs (Lighting source). These three LEDs must form the shape of the triangle in the Chromaticity Diagram. Each vertex of the triangle represents the center wavelength of each LED.

Fig. 1 is a block diagram illustrating a configuration of a CSK-based transmission apparatus according to an embodiment of the present invention. The transmission apparatus includes a data generation unit, a scrambler, a channel encoder, a CSK modulator, a DAC (Digital to Analog Converter).

The data generating unit may generate a data frame including vehicle driving and surrounding traffic information to be transmitted, and may generate a frame header including control information necessary for analyzing a data frame in the receiving apparatus. The frame header may include a modulation technique field indicating the modulation scheme of the data frame and a length field indicating the length of the data frame. Hereinafter, a frame header and a data frame are collectively referred to as a data unit. The data unit may be generated with a bit sequence. A frame header within a data unit may be located before the data frame and may be implemented to be received first by the receiving apparatus.

The scrambler may scramble the bit sequence of the data unit. Scrambling can be used to ensure the encryption of the bit sequence, prevent bit blocks with repetitive patterns, prevent continuity of bit values, and the like.

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Fig. 2 is an example of a scrambler according to an embodiment of the present invention. According to fig. 2, the scrambler may include 15 delay units (D) and two summer units. Thus, the generated polynomial g (D) of the scrambler can be expressed by the following equation (1).

$$g(D) = 1 + D^{14} + D^{15}, \quad (1)$$

where D is a single bit delay element

The polynomial generator g (D) is given by the following equation (1).

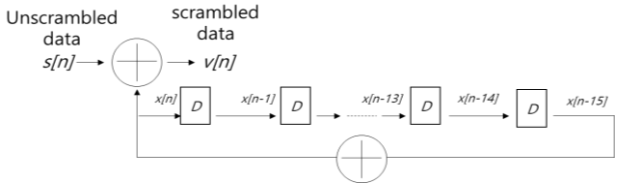

Fig. 2 Scrambler basic structure

Visible light communication systems can experience performance degradation due to multiple color imbalances, multiple inter-color interference, and interference from other lights. In order to reduce the performance degradation, the CSK system can compensate for performance degradation at the receiver.

Fig. 3 is a CSK system diagram with color calibration. Before transmitting the data, the CSK system uses the orthogonal signal included in the channel estimation sequence to check the channel status. The channel propagation matrix uses a 3x3 matrix as shown in equation (2).

$$\begin{bmatrix} h_{ii} & h_{ij} & h_{ik} \\ h_{ji} & h_{jj} & h_{jk} \\ h_{ki} & h_{kj} & h_{kk} \end{bmatrix} \quad (2)$$

The distortion of the received signal can be compensated by multiplying the received signal by the channel propagation matrix as shown in the following equation (3).

$$\begin{bmatrix} Pi \\ Pj \\ Pk \end{bmatrix} = \begin{bmatrix} h_{ii} & h_{ij} & h_{ik} \\ h_{ji} & h_{jj} & h_{jk} \\ h_{ki} & h_{kj} & h_{kk} \end{bmatrix}^{-1} \begin{bmatrix} Pi' \\ Pj' \\ Pk' \end{bmatrix} \quad (3)$$

Fig. 3 CSK system with color calibration

III. THE PROPOSED METHOD

Generates a data frame containing the traffic information of the vehicle, and proceeds in the format shown in fig. 4 to generate a frame header including control information for the data frame.

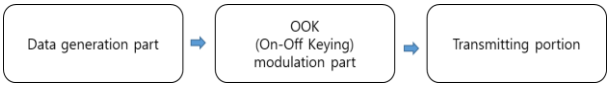

Fig. 4 On-Off Keying (OOK) Modulation-based transmission device configuration diagram

The data generation part generates a data frame including surrounding traffic information including self-driving information to be transmitted. The on-off keying (OOK) modulation part processes the bit sequence transmitted from the data generation part together with a clock signal to generate a modulated signal using Manchester coding. An example of signal modulation by the On-Off Keying (OOK) modulation part can be found in fig. 4.

The transmitting portion may include one or more LED lights and an optical receiver for reading light signals, and may be implemented as a Vehicle headlights, signal or backlight of the vehicle.

The transmitting portion can transmit the modulated signal to another vehicle by adjusting the LED light installed on the front / rear of the vehicle according to the modulated signal of the on-off keying (OOK) modulation part.

That is, traffic information can be transmitted to another vehicle by blinking the LED light according to whether the bit value of the Manchester coded signal is '0' or '1'.

The receiving device of the other vehicle receives the coded signal according to the blinking state of the LED light of the vehicle to which the traffic information is to be transmitted and decodes it considering the same clock signal as shown in fig 5. It is possible to reconstruct and interpret the data bit sequence.

However, this technique has an advantage that the OOK modulation technique is easy to apply, but when the amount of traffic information to be transmitted is large, it takes a long time to transmit one information.

Fig. 2 X, Y color coordinates in Chromaticity diagram

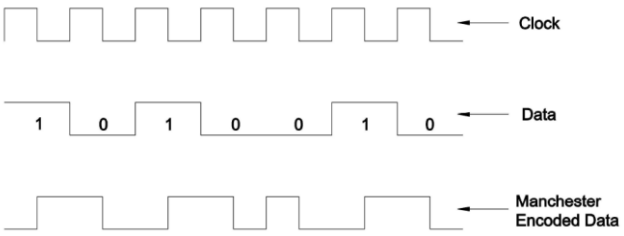

Fig. 5 On-Off Keying (OOK) Modulation Technique

In addition, LED flashing may cause aging of LEDs and deterioration of performance, and driver of other vehicle may have fatigue due to LED blinking. Therefore, CSK (Color Shift Keying) signal modulation can be applied to provide more efficient and high-performance traffic information.

As shown in fig. 2, a data frame is scrambled by the following equation (1) using a scrambler including 15 delayers (D) and two summers, and an error is detected during transmission of information through the channel of the scrambled data frame And encodes it by detecting and correcting noise, interference, and fading on the channel.

The encoded data frame is color-coded according to the CSK modulation technique, the color mapping is determined by points *XP* and *YP* by the intensity of P_i, P_j and P_k, which are the output powers of the *R*, *G* and *B* LED light sources, is determined by equation (3).

For inter-vehicle communication, it is required that a communication device according to a specific communication protocol be mounted, and the characteristics of the physical layer according to the communication protocol must be considered. This is because the communication coverage due to frequency characteristics, because it can be determined by the characteristics of the physical layer.

As a result of this study, we have studied the wireless communication method between LED light based vehicles. By applying the LED light of the vehicle and the CSK method, it is possible to efficiently provide and distribute a greater amount of traffic information.

In addition, since the variable CSK modulation technique is applied according to the driving environment of the vehicle in operation, the throughput of the inter-vehicle communication can be adaptively maintained according to the driving environment, and the reliability can be maintained.

IV.CONCLUSION

In this paper, the interference resistance is low when the traffic of the vehicle is congested, so there is a problem that the data transmission speed

of the wireless local area communication is lowered and additional communication equipment is required for the vehicle.

Visible light wireless communication technology was used to eliminate this problem. Visible light wireless communication technology is a new optical wireless

communication technology that uses LED, which is a semiconductor lighting, which has been spotlighted as a next generation lighting, and has information function for lighting function and simultaneous information.

LED light is widely used in real life such as indoor / outdoor white light, landscape light, general / special lighting, electric signboard, traffic light, and indicator, backlight unit of LCD display, car headlight and tail light by semiconductor technology. The use range and the usage rate are rapidly increasing. Considering this point, applying visible light wireless communication technology as a wireless communication technology for a vehicle having LED lights forward and rearward can be a very efficient method.

In this paper, by applying the LED light based vehicle communication method using the LED light of the vehicle and the CSK method, it is possible to efficiently provide and distribute a larger amount of traffic information.

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