Experimental Study on Flicker Mitigation in VLC using Pseudo Manchester Coding

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VLC에서 Pseudo Manchester Coding을 사용한 Flicker 최소화에 관한 실험 연구

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ABSTRACT

Visible Light Communication is one of the promising technologies for wireless communication due to the possibility to use existing LED lightening infrastructure to transmit data. LED has the ability to turn on and off very fast enough that our human eyes can't recognize so it can be used to transmit data via visible light along with illumination. But it faces flicker problem due to the brightness discrepancies between '1' and '0' bit patterns inside a data frame. Various run length limited (RLL) coding scheme like Manchester code, 4B6B, 8B10B or VPPM can be used to solve flickering problem. So we propose pseudo Manchester codding which can transmit data without modifying LED modulator and demodulator circuit as well as solve flickering problem.

Key Words : Visible Light Communication, flickering mitigation, Manchester code, Microcontroller.

요 약

가시광통신은 기존에 설치된 LED등을 사용하기에 무선통신을 위한 방법 중의 하나이다. 본 논문은 이미지 처리 기술을 이용한 광 카메라 통신(OCC: Optical Camera Communications) 기술을 제안한다. LED등은 빠른 속도로 on 및 off를 변경할 능력을 가지고 있기에 인간의 눈이 인지할 수 없을 정도로 일정한 조도와 함께 데이터를 전송해야 한다. 하나의 데이터 프레임에서 비트 '1' 및 '0' 사이의 밝기 불균형에 의해 flickering 문제가 발생한다. Manchester code, 4B6B, 8B10B 및 VPPM과 같은 다양한 Run length limited(RLL) coding 기법이 사용 될 수 있지만 LED 변조기와 복조기 회로를 수정하는 것 없이 데이터를 전송할수 있는 pseudo Manchester codding을 제안한다.

I. INTRODUCTION

Visible light communication is one of the promising technologies for wireless communication especially for indoor wireless communication. Due to the low power consumption with high brightness and longer life of white LED, now a days, they are used everywhere for lightening as well as display purpose. As LED can support high speed lighting and off it is possible to modulate LED with such higher frequencies to transmit data that human eye can't recognize. Thus LED can be used to serve both for lightening and communication purpose [1][2]. There are other advantages in visible light communication over other wireless communication, such as data communication using unlicensed frequency band, low signal-to-noise interference, high data rate, harmlessness to human health etc. VLC can also be applied in many different areas like visible light positioning [3][4][5], intelligent transport system [6][7], LED-ID [8]etc. One of the major challenges for VLC implementation is flicker mitigation especially for indoor environment. Flicker refers to the fluctuation of the brightness of light. When simple OOK modulation are used to modulate LEDs, flicker occur due to random '1' and '0' pulse train. This flicker must be mitigated because

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flicker can cause noticeable, negative/harmful physiological changes in humans. Flicking can be avoided using RLL coding like Manchester code, 4B6B, 8B10B or VPPM. However additional microcontroller is needed to implement those encoding scheme hence cost and complexity of the LED modulator and demodulation circuits are also increased. So we propose pseudo Manchester codding which can able to transmit and receive data without modifying OOK modulator and demodulator circuit and also solve the flickering problem.

Rest of the paper organized as follows section II for VLC flickering and Manchester code. Section III we describe conventional Manchester code implementation in VLC. Section IV we elaborate our idea pseudo Manchester codding and V for numerical analysis and finally we conclude in section VI.

Ⅱ. VLC FLICKERING AND MANCHESTER CODE

OOK modulation is the simplest modulation scheme for VLC, where data bits '1' and '0' are represented by switching LED 'on' and 'off' respectively. But one of the major problems in OOK modulation is Flickering. IEEE 802.15.7 [9] categorizes VLC flickering into two types i.e. intra frame flicker and inter frame flicker. Intra-frame flicker occurs due to the perceivable brightness fluctuation within a frame. Intra-frame flicker appears from the brightness discrepancies between the bit patterns of '1' and '0' inside of a data frame as shown in figure 1. RRL line codes are used to avoid flicker by preventing long runs of 1s and 0s. RRL code guarantees DC balance with equal number of 1s and 0s at the output for any random data symbol. Various RRL line codes such as Manchester, 4B6B, and 8B10B are defined in the standard [9]. In Manchester coding state there is always transition at the mid-point of the data bit frame. Logical '1' is defined as mid-point transition from low to high and mid-point transition is form high to low define as logical '0'. Thus average dc level 50% can be achieved so it mitigates the flicker problem.

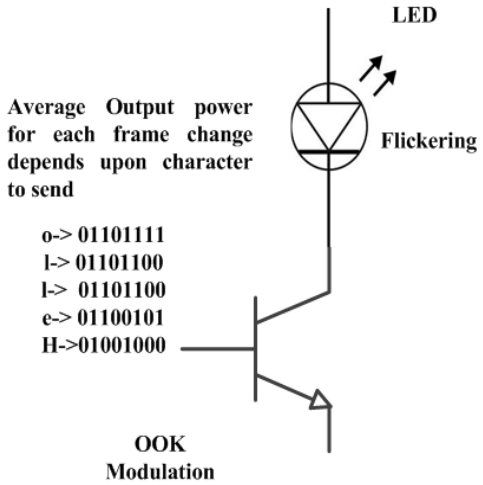

Figure 1. Intra frame flicker in VLC

Ⅲ. CONVENTIONAL MANCHESTER CODE IMPLEMENTATION IN VLC

Figure 3 demonstrate block diagram of VLC implementation. Here data are at fast sent to transmitter PC to modulator circuit where microcontroller encoded that data into Manchester coding then LED driver modulate that data to transmit as optical signal. At the receiver side a PD is used to convert that optical signal to electrical signal and another microcontroller is used to decode that data and encapsulate it into RS 232 frame for sending data to the receiver PC. As microcontroller operates with TTL logic (0 to +5V) level additional level shifter is needed in order to convert voltage level RS 232 (-15V to +15V) to TTL logic level. RS 232 data frame (figure 2) does not support Manchester coding because in asynchronous serial data communication, two devices must agree with same baud rate and receiver first detect the start bit then start sampling every bit according to this baud rate [10] and decision of the logic level of the received bit is taken by the sampling values. As Manchester encoded data has transition at the middle point of each bit, decision of the logic level can't be done by asynchronous data communication circuit. So additional microcontroller is needed before modulator circuit in order to receive encapsulated data with RS 232 frame from PC

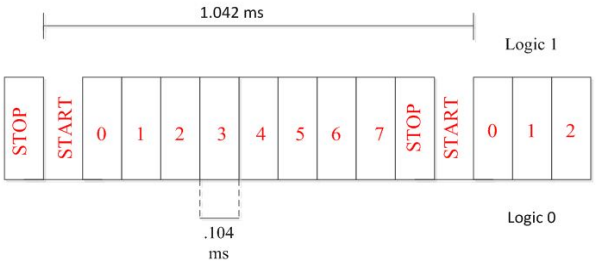

Figure 2. RS 232 frame format for 9600 baud rate

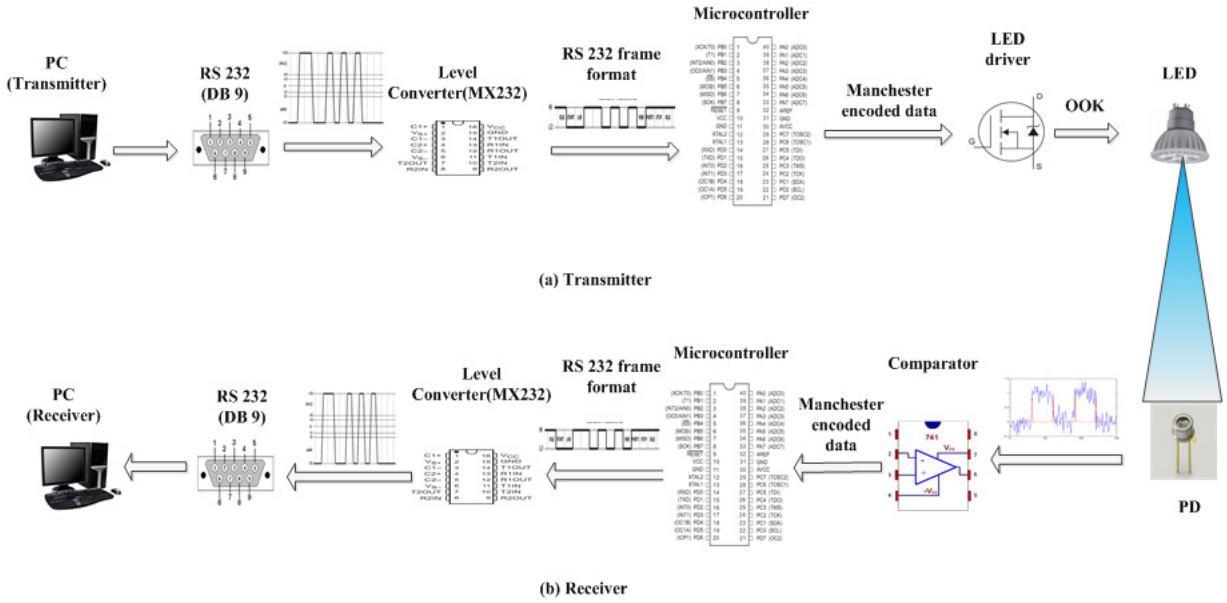

Figure 3. VLC transmitter and receiver block diagram with Flicker mitigation using Microcontroller.

and then convert into Manchester code for LED modulation. On the other hand another microcontroller is needed at the receiver side in order to convert data Manchester code to RS 232 frame format. Microcontroller has UART interface [10] which can communicate with PC RS 232 interface. Microcontroller also supports crystal oscillator thus possible to sample each bit with high frequency. So according to the data rate, mid-point of each bit can be determine and thus possible to use a timer set to expire or interrupt at mid-point interval of each bit. Manchester encoding can be done by making transition at the mid-point interval of each bit.

Ⅳ. PROPOSE PSEUDO MANCHESTER CODE

Though flicker mitigation can be achieved using microcontroller our goal is to eliminate the necessity of microcontroller thus possible to reduce cost and complexity in transmitter and receiver circuit (figure 4). So we propose a scheme that will transmit data in RS 232 frame format. As RS 232 frame format doesn't support Manchester code we divide each 8 bit's character into two 4 bits data then transmit that data using two separate RS 232 frames. So each frame contains only 4 bits data. These 4 bits are converted into 8 bits in order to support RS 232 frame format as shown in figure 4. So each '1' is converted into two bits '10' and each '0' is converted into two bits '01'. Thus each 8 bit's character is converted into 16 bit data according to Manchester code then transmit into two separate RS 232 frames. So each frame contains equal number of '1' and '0' that provides the dc balance and mitigates the intra-frame flickering problem. As we use two RS 232 frame to send a single character our data rate is reduced 8 bit per frame to 4 bit per frame. Though our propose method reduce data rate ½ times then the original, it reduce the transmitter and receiver circuit implementation cost and complexity. Now simple OOK modulation circuit without microcontroller can be used to send data using visible light without microcontroller at the receiver side as both transmitter and receiver PC communicate with each other with RS 232 frame format. To achieve same data rates as demonstrate at section 3 we increase the baud rate from 9600 to 19200 as shown in figure 4.

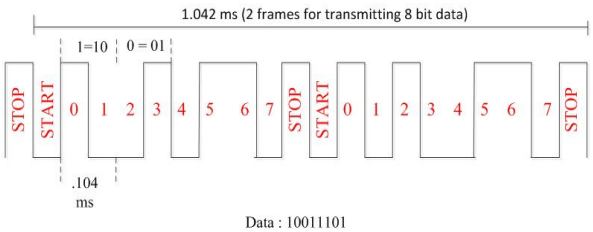

Figure 4. Manchester codding in RS 232 frame format for 19200 baud rate

Ⅴ. NUMERICAL RESULTS & ANALYSIS

Table 1 shows the RS 232 frame format that we choose for our analysis. So our RS 232 frame contain 10 bits per frame including 1 start bit, 8 data bits, 1 stop bit and no parity bit. As baud rate is the total number of bits per second, so we can calculate data bits per sec using baud rate. Figure 5 shows the Baud rate vs. Data bits/s for conventional method and proposed method. In case of Manchester code implementation using microcontroller RS 232 frame contain 8 data bits per frame. But in case of Pseudo Manchester codding we send only 4 data bits as each data bit is represented by two bits. So in Pseudo Manchester case data bits/s is reduced by 1/2 then the Manchester code implementation. As asynchronous serial data communication only support few predefined baud rates i.e. 9600 baud rate, we can measure data bits/s only that baud rates. So the curves are represented in discrete from.

Table 1. RS 232 frame format

Data bit	8
Parity bit	no
Stop bit	1

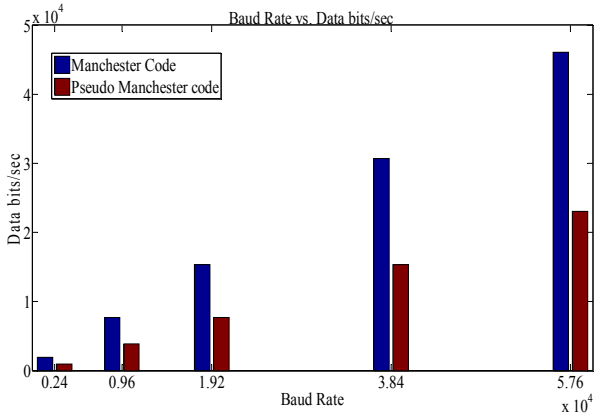

Figure 5. Baud rate vs. Data bits/sec

Ⅵ. CONCLUSION

Flickering problem is one of the major issues in visible light communication. Lot of technique can be implanted to solve this problem. However transmitter and receiver circuits modification are required to implement those techniques. This will increase complexity of the circuit as well as cost. Our aim was to reduce complexity and cost, and our proposed architecture can able to solve flickering problem with modifying transmitter and receiver circuit.

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