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EFFICIENT DATA TRANSFER BY USING VISIBLE LIGHT COMMUNICATION UNDER DIMMING

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Abstract—**As a latest creation green lighting resource, the light emitting diode (LED) is quickly replacing traditional incandescent and fluorescent light sources. Apart from providing energy savings, the use of LED illumination technology creates range for an modern optical wireless communication technology known as visible light communication (VLC), which takes advantage of the superior accent ability of LEDs to convey data during a wireless channel. VLC is accomplished of concurrently providing communication as well as illumination. For making commercial implementation of VLC sufficient, it is required to include it through dimming schemes to resolve afford energy savings, moods, and increase the aesthetic value of the place using this technology. However, common dimming techniques include an difficult effect on communication as they limit the possible data rate of a VLC link. This drives the necessity of formulating efficient dimming techniques, which will generate a stability linking the two most essential functions of VLC: illumination and communication. This paper focuses on dimming mechanisms that can be implemented in VLC systems to save energy and afford defined illumination control. The drive following this organize mechanism, current challenges in practical implementation, driver circuitry, recent progress, and future prospects are also concisely presented.**

Keywords—Li-Fi, hacking, lighting, interference, visible spectrum

Introduction

In recent years, with the development of semiconductor lighting technology, the trend in semiconductor lighting replacing traditional lighting is increasingly apparent. With the advent of high power, high brightness and increasing light efficiency of white light emitting diode (LED), the application of semiconductor diode has gradually expanded from the display field to the lighting field, and been developed rapidly [1]. Compared with traditional lighting, LED is characterized by low power consumption, long service life and small size. It is regarded as the fourth generation of energy-efficient and environment-friendly lighting product. Another outstanding advantage of LED is its short-time response, so it can be used for high-speed wireless data communications. These two advantages make LED suitable for both indoor lighting and high-speed optical wireless data communications [2]. It is normally required that the dimming controlling and data transmission can be simultaneously realized in a white LED based indoor visible light communication system.The common ways of dimming controlling include TRIAC (Triode AC semiconductor switch) dimming [3], digital dimming, pulse width modulation (PWM) dimming, analog dimming etc [4]. The TRIAC dimming is to control the average output voltage by chopping through the input AC sine wave, i.e. change the driven current of the LED and its dimming [5]. Through I2C and SPI serial interface, digital dimming utilizes a chip microcomputer or other microcontroller to send digital signal to the LED driver and adjusts the brightness of LED [6]. PWM dimming linearly changes the brightness of LED with the duty cycle of a constant DC voltage at certain frequency [7-9]. In these schemes, the data modulation and the dimming controlling are realized by a single driven circuit. The data transmission is affected by the dimming controlling, especially when the dimming controlling is realized by tuning the driven current. For a visible light communications system, it is desired that the data transmission is not affected by the lighting dimming controlling. In order to realize this, we propose a scheme of separate dimming controlling and data transmission, i.e. to partitioning LEDs for different functions with some LEDs for the diming controlling and the others for data transmission. The

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dimming controlling is realized by an analog dc driver, and the data transmission is realized by NRZ-OOK modulation circuit. In this way, the diming control and data transmission can be realized simultaneously, and the diming control function will not affect the data transmission.

The rest of the paper is organized as the following. The dimming controlling in the proposed scheme is described in section II, and the data transmission is described in section III. The experimental results are demonstrated in section IV. In section V

I. Visible Light Communication

VLC is motivated by several benefits as well as a huge, tolerant bandwidth (THz), license-free function, low-cost electronics, no obstruction with RF systems, and no health concerns. A data waveform can be modulated onto the immediate power of the visual carrier and the visual detector generates a modern proportional to the established instantaneous power, i.e., power modulation with through detection (IM/DD). Due to the potential energy of illumination and communication, it is conventional that VLC has been a subject of increasing interest and development. Nonetheless, there are a number of practical challenges to be addressed before its widespread acceptance.

Paramount to the practical implementation of VLC in lighting is ensuring high-integrity color quality that is reasonable to humans. VLC is distinctive compared to mainly other communication technologies suitable to its dual functionality – communication and ambient lighting. As shown in Fig. 1, nearby the visual detector VLC communication must be aware of a instant type of signal receiver – the human eye. Thus, a consumer VLC system is limited by critical color quality and brightness constraints, which are required to meet resourceful and visual requirements of illumination. Most VLC research to date has primarily focused on achieving increasingly high data rates. Recent experimental setups have demonstrated VLC links above 1 Gbps [11]. Yet, the laboratory conditions for these demonstrations are usually limited to near-field communications instead of conservative home or office spaces along with do not address illumination feature issues. Trade with color-quality and energy use constraint while achieving high data rates is a clear aim to make everywhere VLC systems possible. Industry standards for light quality and human factors will play an important role in defining modulation techniques which deal with the dispute of incorporating broadband VLC with high-quality lighting and lighting state power.

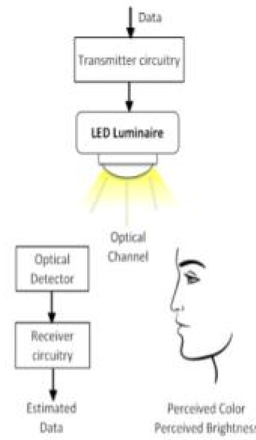

Fig.1Dual functionality of VLC

II. Features of VLC signals

The VLC communication signal sequence includes the LED resource and a modulation system suitable for the optical channel. An LED is a p-n junction-based semiconductor diode that emits a narrow range light in reaction to an electric modern, a incident known as electroluminescence. As shown in Fig. 2, the dominant wavelength of the LED, corresponding to the color, is a product of the semiconductor materials used and the “energy gap” linking them. There are two major methods used to create the white light. The cheapest and most popular is phosphor conversion, during blue LED is covered through a yellow phosphor to emit broad-spectrum white light. The second approach combines monochromatic LEDs of different colors to produce white. This method also offers color-tunable lighting by varying the intensity of individual colors.

The VLC channel has a number of unique features: (1) the optical carrier modulation is only achieved through power modulation, i.e., no incidence or phase information, (2) the transmitted waveform is modulated onto the instantaneous power, resulting in a real and positive waveform, (3) the regular transmitted influence is the indicate of the input power signal relatively than the mean square of the indication amplitude as in RF communication, and (4) the magnitude of the transmitted power is constrained to a prescribed value. This previous item (4) is owed to eye safety consideration, power utilization constraints, and LED vibrant range limitations. Signal poverty arises from the mutual property of the proportionality of the signal-to-noise ratio (SNR) toward the square of the common received visual signal power (path-loss), ambient shot noise, sunlight and artificial lighting, thermal shot noise is always within the required receiver electronics, and inter-symbol interference (ISI) from multipath propagation.

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Channel conditions of VLC systems are a function of the environment and/or lighting settings. Settings may be manually distinct (e.g., using a dimmer switch on a wall or wireless devices), or automatically actuated by a smart illumination control scheme. This is in contrast to RF wireless communication systems, in which end-users have little effect on the channel conditions besides influencing the location of mobile devices. where an RF system is mainly anxious with communications presentation, a lighting system equipped with VLC must arbitrate the needs of both communication and lighting quality.

III. Modulation based dimming schemes

In VLC, modulation schemes are used to incorporate data into the strength of the light source performing as the transmitter. One of the most accepted modulation schemes use in VLC is on-off keying (OOK), wherever binary bit '1' and '0' be represent by 'ON' and 'OFF' pulses, in that order. OOK dimming can be achieved by either altering the 'ON' and 'OFF' levels of the OOK symbol toward contain a lesser strength, or the duty cycle of the waveform can be distorted with the levels kept stable by inserting compensation time into the modulation waveform by income of a time multiplexing scheme. The first method power source chromaticity shift due to the LEDs creature under-driven, but it gives a constant bit rate. On the supplementary hand placing of return time lowers the possible bit rate as the brightness dims. The variable-OOK (VOOK) plan was also planned where OOK is mutual with a PWM indication by filling the stationary portion of the duty cycle with also ones or zeros based on the dimming goal. Pulse position modulation (PPM), wherever binary bits are represented by the arrangement of the pulses in a time enclose, was proposed to boost the power efficiency. To realize dimming in PPM, variable-PPM (VPPM) was planned, which combine PPM with PWM. VPPM is easy to apply and is talented of given that a full dimming range to the VLC link. However, the message range may be reduced due to low energy per bit at low intensity levels. reproduction based comparison of these pulsed modulation based dimming schemes in conditions of indistinct efficiency and power condition can be found in [12]. Light dimming control can be directly achieved by pulse dual slope inflection (PDSM) without the need for an added control algorithm. In PDSM, the edges of the pulses represent binary '1' or '0'. Dimming is achieved by controlling the grade of the edges of the transmit pulse. In other words, the rise time and fall time of the pulses settle on the brightness level of the light source. Recently, orthogonal frequency division multiplexing (OFDM) is striking gradually more popular for VLC systems since superior data rates are achieved with high SNR and spectral value. In OFDM, data bits and idleness bits are multiplexed addicted to similar stream, both of which is transmit in divide sub-carriers. OFDM can be cast into PWM dimming; however, the data throughput decreases due to the moderately low PWM line rate of profitable LED drivers. Research has shown that high speed can be achieved if the PWM dimming signal has double the frequency of the largest sub-carrier frequency of the OFDM signal. In the case of unevenly clipped optical-OFDM (ACO-OFDM) modulation proposed in [13], simulation results show that the CCR technique achieves higher luminous efficacy compared to the PWM dimming technique. In order to combine the fast optical-OFDM (O-OFDM) with the moderately measured PWM dimming signal, turn around polarity O-OFDM (RPO-OFDM) was planned where the data rate was not limited by the PWM frequency and the LED dynamic range was fully utilized [14]. The polarity of the symbol was reversed during the 'ON' duration of the PWM signal by utilizing a scaling factor, which helps the overall optical signal power in the direction of be concurrently prohibited by the PWM dimming signal and ACO-OFDM signal getting on for data transmission.

IV. Multi subcarrier Techniques

Orthogonal Frequency Division Multiplexing (OFDM) be able to be useful to VLC to develop spectral effectiveness of the modulated signal. though, since a modulation strategy for dimming it is not acceptable by itself, but can be combined with other dimming techniques. As shown in Fig. 2, two conventional schemes are used to realize a real-valued OFDM signal suitable for IM/DD, namely DC biased optical OFDM (DCO-OFDM) and asymmetrically concise visual OFDM (ACO-OFDM). [10] proposed a system which uses intermediate features of maximum overlap wavelet transform (IMOWT) as a pre-processing step. The coefficients derived from IMOWT are subjected to 2D histogram Grouping. This method is simple, fast and unsupervised. 2D histograms are used to obtain Grouping of color image. This Grouping output gives three segmentation maps which are fused together to get the final segmented output.
An OFDM indication can be direct onto the PWM dimming-controlled signal all through the 'on' period (Fig. 6). Though, this confines data throughput toward the moderately low PWM procession rate of profitable LED drivers (tens of KHz). Achieve high-speed relations with this move toward is only possible as soon as the PWM dimming signal is by least

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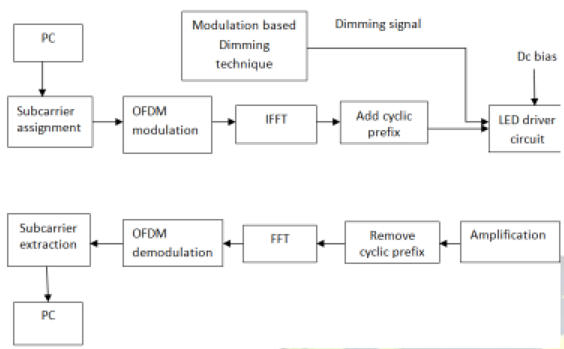
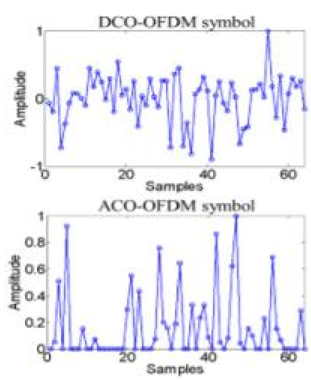
double the frequency assign to the leading subcarrier frequency of the OFDM signal to keep away from subcarrier obstruction. However, this limitation is not convenient for profitable LEDs with partial inflection bandwidth and confines the occasion to use predictable LED drivers.



Therefore, OFDM schemes with dimming are being developed to consider existing LED and driver technologies. For instance, the proposed move toward utilize the whole phase of a PWM indication for OFDM signal conduction, maintaining the data rate for a wide dimming range independent of the PWM frequency. This move toward also maintain the signal contained by the active range constraint of the LED. Also, for an OFDM signal superimposed on a DC bias level (analog dimming), the signal must be adaptively scaled to control the effective brightness and to minimize the induced noise due to signal clipping.
Although OFDM continually gains in popularity due to its attractive communication performance, additional research focus is necessary to observe its consequence on light eminence in realistic scenarios. But such scheme permanent with power and color organize techniques prove to be acceptable to the human eye, OFDM stands toward be a front position candidate during the future of almost adoptable VLC systems to assure illumination requirements



V. Conclusion

The revolution in lighting with the adoption of LED devices has an prospect to develop the observable spectrum for wireless interactions. Energy-efficient dimming, or color intensity control, remains a key challenge in achieving the need for efficient along with speedy data modulation whereas supporting human lighting requirements. In this article we have reviewed the challenges to achieving this 'dual use,' with an eye towards identifying strategy to will direct to winning commercial approval in the illumination industry. With the continuing efforts on global energy use reduction and the rapid adoption of mobile devices, it appears in the direction of both the require for restricted wireless capability and energy-efficient illumination will maintain unabated.

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