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LED Driver for Visible Light Communication Using LI-FI

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Abstract-,Visible Light Communication(VLC) system based on white LEDs has emerged an eco-friendly IT green technology using THz Visible light communication in provision of both lighting and wireless access .Installation of new communication cables between oth-Er fixed network(PC, set-Top box , fiber networks, etc.) and LED light Is expensive, disruptive and time consuming process. Mean white, the power-line communication(PLC)can make it possible to use as power lines as the medium of communication. The utilities of home networking over power-lines can take advantage of the existing of wiring infrastructure for provision of illumination. The integrated system of VLC and PLC is a smart way of fulfilling an premise of as broad band access for home networking, while providing efficient and low-cost lighting. To achieve the higher data rates(MHz), PLC channel is stimulated using DMT-QAM modulation scheme .The pr-opposed LED driver is realized by using a constant current source and a shunt switch in parallel to the LED string. first, the experimental setup demonstrating dual-purpose operation is presented .and then finally, the driver is characterized using the lumen measurement for different dimming ratios.

Index terms-Average current mode control (ACMC) ,dual– pur pose . LED driver ,high-frequency pulse width modulation (PWM) dimming. LED driver ,lumen ,spectral power distribution(SPD), visible light communication (VLC).

1.INTRODUCTION

SOLID-STATE lighting (SSL) uses high-brightness LED(HB-LEDs) as a source of general illumination. unlike conventional illumination sources such as incandescent, halogen, fluroscent, an compact fluroscent lamps, LEDs are energy efficient and are free from hazardous substances such as mercury. The HB-LEDs have longer lifetime compared with all the other general illumination sources. The recent improvements in luminous efficacy, lifetime LEDs, and benefits such as energy savings made the HB-LEDs a ubiquitous replacement for the conventional illumination source LEDs behave as a nonlinear dc load when directly connected to an ac source, as compared with a resistive load offered by conventional incandescent bulbs.

VLC has numerous appli8cations in smart buildings, which re-Quire smart lighting to provide illumination control and communications. In hospitals and aircrafts where electro-magnetic interface is an issue, VLC can be usede. VLC can also be used for Secured data transfer in defense and security applications and for Underwater communications where RF communications is not, dual-purpose usage of HB-LEDs introduces a new paradigm in designing offline LED drivers .Traditionally, PWM dimming in LED drives is carried out at low frequency below audible range <20KHz. PWM dimming with low frequency results in audible noises due to mechanical vibration of inductors of inductors and piezo electric properties of ceramic capacitors. Recently, different drivers using high frequency PWM dimming (.20KHz) techniques for LED drivers using high frequency series PWM dimming and with interleaved convertors have been proposed without VLC. In this paper, using a shunt switch across the LED stiring, high frequency PWM dimming and VLC are achieved. To use a shunt switch across an LED string, it should be supplied by a constant current source convertor. In addition, the convertor should not have an output capacitor (across the LED string).The current source is realized by a buck convertor without an output capacitor.

A current fed dual-purpose LED driver topology with the following features for 450-Im output has been realized. Illumination control with high-frequency PWM dimming and VLC with VPPM scheme. In addition, it is to be noted that HB-LEDs when used with the proposed topology are switched fast in the range of megahertz to transfer data using VPPM. Hence, equivalent models of HB-LED loads used in VLC are derived. This model is used to analyze the dynamics of the convertor for constant current control.

The rest of this paper is organized as follows .summarizes different possible approaches for the implementation of dual purpose drivers and their advantages. The proposed dual purpose LED driver circuit with the method for improving power factor, modulation scheme for VLC, and the required startup circuit is discussed. Modeling of HB-LEDs facilitating VLC and control of proposed converted with these loads is reported. Simulation result of the converter are presented. Experimental setup for the validation of the dual purpose usage of the proposed LED driver along with measurement the result is discussed

II.DUAL PURPOSE LED DRIVERS

HB-LED drivers for VLC can be realized using constant

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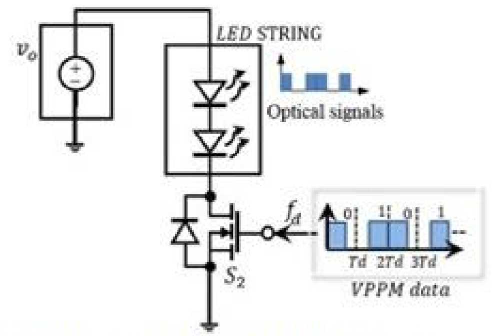
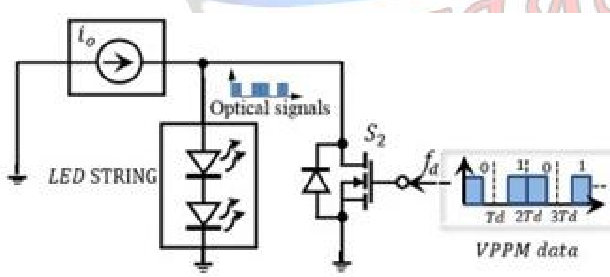
current source or constant voltage source and with an additional switch to switch the LEDs ON and OFF. The section presents the approaches for realizing a dual-purpose LED drivers.



Block diagram of constant voltage fed dual-purpose LED driver

A.Constant Voltage Fed Dual-Purpose LED Drivers

Constant voltage fed LED driver supporting VLC. The constant voltage source can be realized by using any of the conventional power converter topologies such as back, buck-boost, and single-ended primary-inductor converter. To achieve VLC, the LEDs have to be switched ON and OFF, and this can be realized through series switch .switch S2 is switched ON and OFF in synchronization with the data to be transmitted. This modulates the LED string current, hence facilitating VLC.



Block diagram of constant current fed dual-purpose LED driver.

B. Constant Current Fed Dual Purpose LED Drivers

Constant current source fed LED string supporting the VLC. The constant current source for this type of drivers can be realized by using some of the conventional power converter topologies. In this configuration, VLC is achieved by placing a shunt switch in parallel with the current source. LEDs are switched ON and OFF by modulating the switch in synchronization with the data to be transmitted. HB-LEDs have nonlinear and negative temperature coefficient characteristics. Therefore, HB-LEDs are to be preferably driven by constant current sources rather than constant voltage source. Hence, the dual purpose LED driver is realized by using the constant current fed topology.

III. PROPOSED DUAL-PURPOSE LED DRIVER

Here, first the modulation scheme used for VLC is summarized. Next, the proposed dual-purpose topology, its implementation, and the required start-up circuit are presented. Finally, the methods to improve power factor with proposed LED driver are discussed.

A. VPPM:

VPPM is a modulation scheme that is supported by the facilitating both dimming and data transfer for HB-LEDs. In this technique, the duty cycle for logic 0 and logic 1 in the transmitted data is varied based on the dimming level to control the brightness of LED. VPPM data transfer of [001] for different dimming ratios from 20% to 80%. The illumination control through VPPM scheme is achieved by varying the width of transferred data pulses. At the receiver, the starting positions of the optical signals are used for encoding (0s and 1s) the transmitted optical data in free space.

B. Proposed Dual-Purpose LED Driver Topology:

The proposed topology is based on the current fed dual purpose LED driver. The constant current source in the fed dual purpose LED drive is realized by using a buck converter without an output capacitor. The inductor current of the buck converter is controlled through average current mode control (ACMC) to obtain a constant current source. VLC and illumination control are achieved by sending the data with VPPM modulation scheme to the shunt switch. The shunt switch operates at frequencies equal to the data rates (2mbs). The ACMC in the proposed circuit is realized by using PWM controller. VPPM data provided to the shunt switch are optically isolated from the power circuit using a high-speed opto coupler. Christo Ananth et al. [4] discussed about principles of electronic devices which forms the basis for these patterns.

VPPM data input to shunt switch and the inductor current over switching cycle of the main switch. Unlike conventional LED drives, in the proposed topology illumination control, information for PWM dimming is encrypted in the VPPM modulation scheme. Hence, the PWM dimming is carried out at frequency, well above the audible range frequencies

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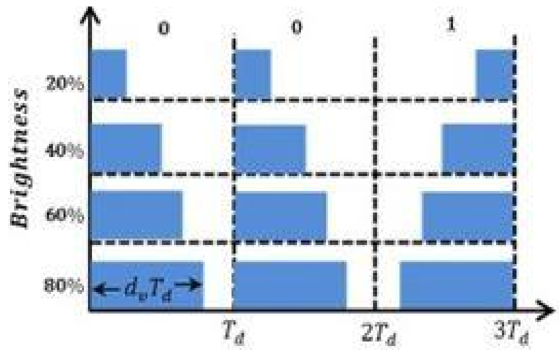
(20KHz), resulting in the elimination of audible noises due to piezo-electric properties of ceramic capacitor and mechanical vibrations of inductor.



VPPM scheme for different PWM dimming levels.

C. Start up circuit of the proposed Topology:

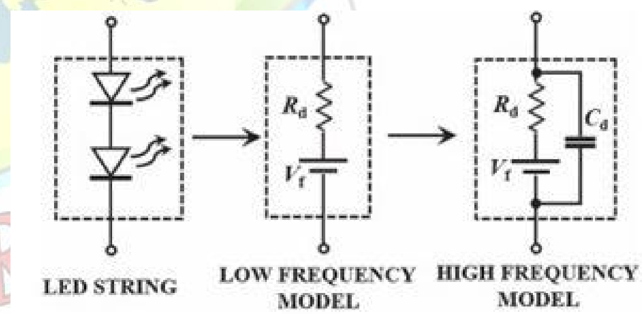
The buck convertor requires the high side driver for driving the main switch. Conventional LED drives are realized using by a buck converter consisting of and output capacitor. During startup capacitor aids in proving the charging path to the boot strap capacitor of the high side driver. Normally, the forward voltage of the LED string is greater than VDD of the high side driver, and hence, the LED string acts as an open circuit during startup.

IV. Modelling and control of Dual-Purpose LED driver

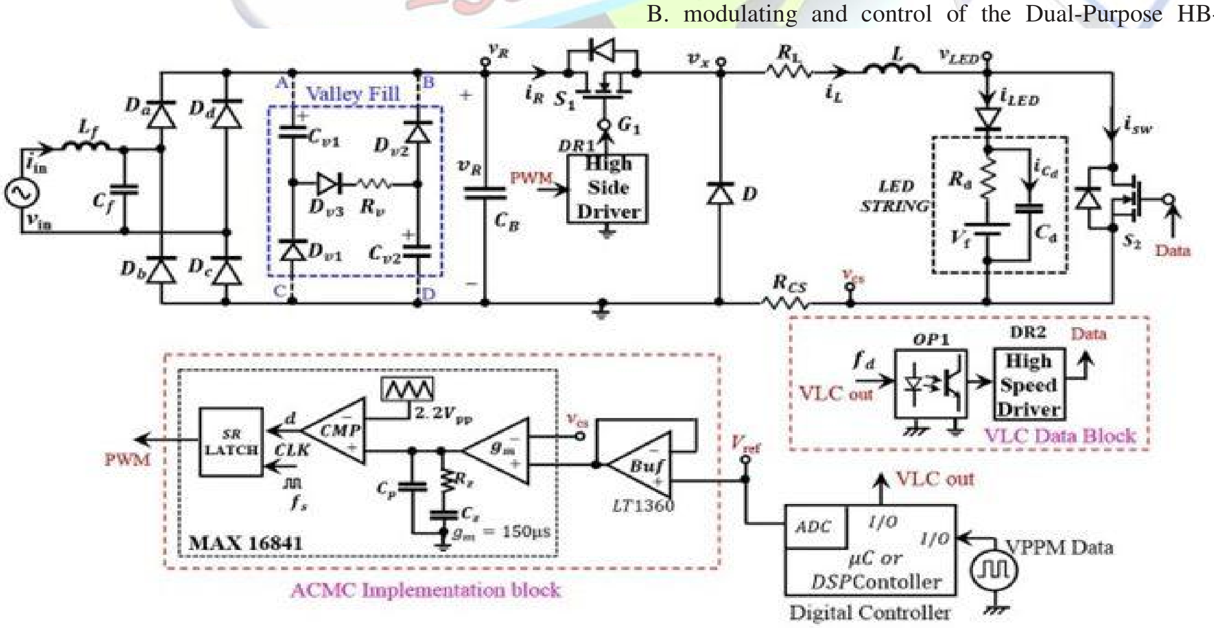
Here, the analytical model of HB-LED load supporting VLC with VPPM is derived. With the derived load module, current fed dual-purpose LED driver topologies are modeled and controlled to realize a constant current source.

A. Modeling of HB-LED Load With VLC by VPPM Scheme:

To model dual purpose LED driver topologies, HB-LED load models supporting VLC have to be derived. The high frequency equivalent circuit model for HB-LED loads can be represented by its forward voltage, dynamic resistance and capacitance. To transfer VLC data by VPPM , these HB-LEDs loads have to be switched ON and OFF with data rate frequency modulating switch placed in parallel to HB-LED the block diagram of the offline dual-purpose converter with an HB-LED load supporting VLC by VPPM.



B. modulating and control of the Dual-Purpose HB-LED



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drive:

The HB-LEDs loads supporting VLC by VPPM are modeled as a constant current source with voltage. The dynamics of the converter with these load are to be modeled for designing the desired closed loop that controls the converter to provide a constant current source with bandwidth.

V. Experimental Results

Here, first, the experimental setup demonstrating dual-purpose operation is presented. Next, the efficiency and loss distribution of the dual-purpose LED driver with the temperature of switch and different PWM dimming levels are discussed. Finally, the driver is characterized by using lumen measurement for different dimming ratios

A. Experimental Setup And VLC Optical Measurements:

A prototype of the proposed dual-purpose LED driver has been built with a same components that are used in SPICE simulations.

The experimental prototype does not contain any digital controller. The reference voltage to control constant current was provided by an external source. An arbitrary waveform generator generating continuous pattern of (010101)…. is used to emulate the VPPM data and the data are directly given as input at the node VLC OUT. The desired dimming ratios are obtained by varying the width of zeros and ones from the data generated from suit the VPPMN technique. To validate VLC, the optical signals transmitted in the free space have to be detected. In this work an avalanche photo-diode(APD110A2) from thorlabs is used as a receiver for experimental validation.

The illumination control is achieved by varying PWM dimming from 20% to 80?% using VPPM scheme. And APD voltage at 50% dimming for 2-Mb/s data transfer.
Although the blue LEDs in phosphor converted white LEDs have optical 3-db bandwidth of 7-8MHz, with the phosphor conversion, the optical 3-db bandwidth of white LEDs in limited to 2-3MHz. Therefore , low rise and fall time in the optical response are detected in APD voltages. To validate that the phosphor-based LED have lesser 3db optical.

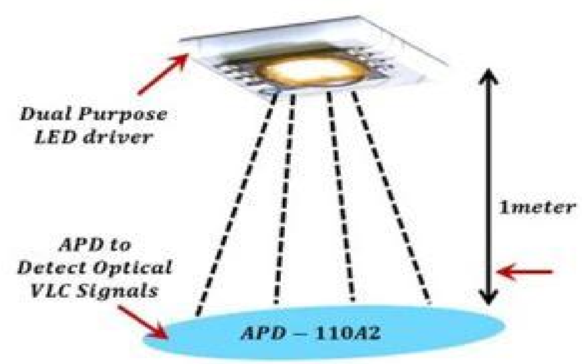
B. Thermal measurements:

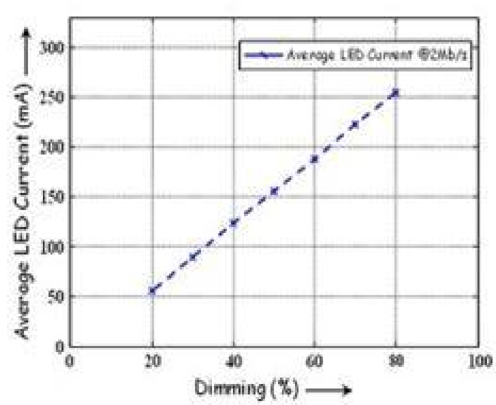
Another important parameter that has to be monitor is the temperature rise in S2 for different dimming ratios. The top view of the printed circuit board with LEDs. As the shunt switch is operated in MHz, to avoid parasitics due to high frequency switching, switch has to be placed near the LED string. The placement of S2 near the LED string will affect the temperature rise in S2 hence, it is important to measure the temperature rise in switch S2.

The steady state variation of S2 case temperature is measured for different PWM dimming ratio are brightness levels with ambient temperature of 25degree. The side view of the PCB with LEDs and heat sink. The heat sink is placed at the bottom of the PCB. The steady state temperature variation of the case and LED thermal pad for different PWM dimming levels are shown.

The temperature measurements for each PWM dimming levels are measured approximately for time intervals of 1h. It is shown that that LEDs dissipate maximum amount of heat when drivrn with full current (330Ma), with response and lower optical rise and fall times,the entire LED string of the prototypr has be replaced with blue LEDs foe lumens leds, and the same experiments are carried out for 50% dimming and 2Mbs data rate.
It is shown that APD voltage of blue LEDs has faster rise and optical fall times than that phosphor based white LEDS.

Experimental setup to Validate VLC





Variation opf average LED current with PWM dimming

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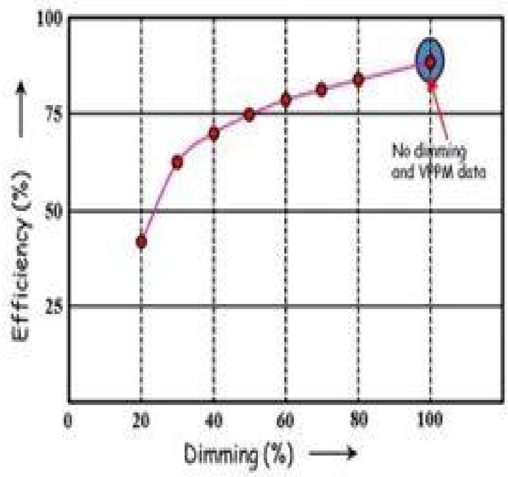
percentage Encoded in VPPm scheme for 2Mb/s



VI. Conclusion

A dual purpose offline LED driver providing both illumination control and VLC using VPPM Scheme has been presented. The proposed LED drive is realized by using a constant current source and a shunt switch in parallel to the LED string. In this paper , the constant current source is realized by using ACMC through a buck converter without an output capacitor. The same approach can be applied on the convertors such as cuk to implement dual-purpose LED drivers. The HB-LED load models are derived for constant current fed dual purpose LED drivers. With proposed topology, PWM dimming is carried out at frequencies greater than the audible range. The effect of phosphor in phosphor-based white LEDs on VLC and illumination control with high frequency dimming is experimentally validated.

The PWM dimming linearity is experimentally verified with lumen measurement . VLC with illumination control is demonstrated as ta a distance of 1m by using an APD as an optical receiver. In addition, the concept of current fed dual-purpose LED driver with high frequency dimming can be employed to LED drivers based on DC-DC convertors, such as for automotive LED lighting.

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