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Fuzzy Based LED Lighting Control Using Integrated Buck Buck Boost Converter

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ABSTRACT: Power factor correction of high frequency switch mode power supply and its application in Fuzzy based LED Lighting control is presented in this paper. A high step-down transformer less single stage single-switch ac/dc converter is designed. The topology integrates a buck-type power-factor correction (PFC) cell with a buck boost dc/dc cell for output voltage regulation. It is a one-stage one-switch AC/DC converter which steps down the voltage without a transformer. It combines a buck type PFC cell with a buck-boost type DC/DC cell. Energy-saving opportunities of sunlight harvesting is utilised in this paper. Classic control systems, based on continuous dimming present some difficulties to adjust their performances to the rapid changes in sunlight. Taking these aspects into account, fuzzy controlled system is presented.

KEYWORDS: Power-factor Correction, Sunlight Harvesting, Fuzzy control.

I.INTRODUCTION

During the last three decades, the electricity consumption in indoor and outdoor lighting systems has continuously increased. For instance, nowadays 30% to 45% of a building's electricity bill is typically for lighting. That is why the implementation of sustainable energy development has addressed this sector as having an important potential regarding energy savings. Due to the increase of environmental concerns, lighting control systems will play an important role in the reduction of energy consumption of the lighting without impeding comfort goals. Energy is the single most important parameter to consider when assessing the impacts of technical systems on the environment. Energy related emissionsare responsible and central to the most serious global environmental impacts and hazards,including climate change, acid deposition, smog and particulates. Lighting is often one of the largest electrical load, but its energy saving potential is often neglected.

To fulfill the requirements about comfort and energy efficiency, building managers have implemented programs to reduce lighting energy requirements by installing more efficient light sources and luminaries. However, this is not sufficient. Lighting energy management has to provide the optimal lighting level for the tasks being performed using the most efficient light source suitable for the application, and providing light only when and where it is needed. This can be achieved by using lighting control strategies and lighting control system. The main purpose of these systems is to reduce energy consumption while providing a productive visual environment.

Nowadays LEDs have the efficiency and light output to be considered for many varied lighting applications. LED luminaries offer significant advantages of higher efficiency, longer lifetime and lower maintenance over conventional lighting sources like incandescent, fluorescent and halogen lamps to enable more energy saving in buildings. However, LED lighting is an inherently dc electrical load whereas the power supply grid installed in buildings is in ac form. Unlike conventional fluorescent lamps powered mainly by ac grid, LED luminaries are dc in nature.In order to operate them on traditional ac powered system ac-dc converter is required. The paper proposes LED Lighting control using integrated buck-buck-boost converter (IBuBuBo). It comprises of a fuzzy logic controller unit and an integrated buck buck boost converter unit.

II. LITERATURE SURVEY

In industrial practice, the most traditional illumination control approach is open loop control, i.e., without light sensor feedback. Following this approach, the users have to manually adjust the dimming levels of the luminaries until they

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are satisfied. The first drawback of this approach is that it is subjective, with no feedback lux measurement information and thus inaccurate.

Within any building of today, the110/230Vac; 60/50 Hz ac power grid is the only power supply available to power both ac and dc electrical loads. An ac-dc power converter is employed to convert the existing 230Vac power source coming from the public utilities into a much lower voltage and safer dc power source to power these dc LED luminaries directly. Among existing ac-dc converters, most of them are comprised of a boost power factor correction (PFC) cell followed by a dc/dc cell for output voltage regulation . For application with low output voltage (e.g., 48V), this high intermediate bus voltage increases components stresses on the dc/dc cell. Therefore, a high step-down transformer is usually employed even when galvanic isolation is not mandatory. Leakage inductance of the transformer causes high spike on the active switch and lower conversion efficiency. To protect the switch, snubber circuit is usually added resulting in more component counts.

High transformerless step down ac/dc converter [2] is suitable for low voltage applications. It is an integrated buck buck boost converter .The converter is able to achieve low intermediate bus and output voltages in the absence of transformer simple control structure with a single-switch; positive output voltage high conversion efficiency due to part of input power is processed once and input surge current protection because of series connection of input source and switch.

III.PROPOSED TOPOLOGY

The sustainable development concept has revived the interest for Sunlight harvestingas any day lit area has very promising energy-saving opportunities.However, sunlight is adynamic source of lighting. Apart the behaviour of human occupants, the lighting controls play a key role inthis action. Lighting controls provide building operators with the means to manage theway lighting energy is used in buildings more efficiently. These systems use various control strategies to (1) reduce wasted hours of lighting in unoccupied spaces, (2) automatically adjust electric light levels in synchrony with available daylight or age-related changes in luminaire output. Unfortunately, daylightis a dynamic source of lighting, i.e. the illuminance from the sky is not constant, and the variations in daylight can be quite large depending on season, location or latitude, and cloudiness. As a result, electric lighting control systems will be needed from time to time to adapt the lighting systems to changing lighting conditions. Classic control systems present some difficulties to adjust their performances to the rapid changes in daylight and to occupant’s preferences. Taking into account these aspects, fuzzy control could be a bettersolution.

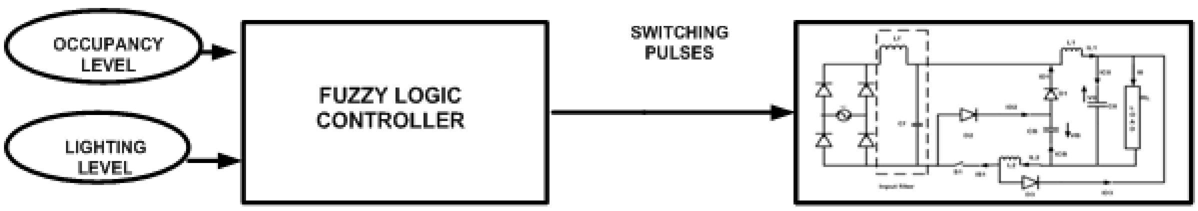

Fig. 1 Proposed Topology

The proposed closed loop system measures the combined lighting from all lighting sources, including daylight and the controlled electric light. The system contains three major components: a power controller, a logic circuit and a sensing device.The sensing device is capable to measure or to detect a physical parameter of interest (e.g., illuminance level) the logic circuit provides appropriate control signal for the power controller; the power controller acts on artificial lighting source in order to obtain the proposed goal.Fig. 1 shows the proposed topology.

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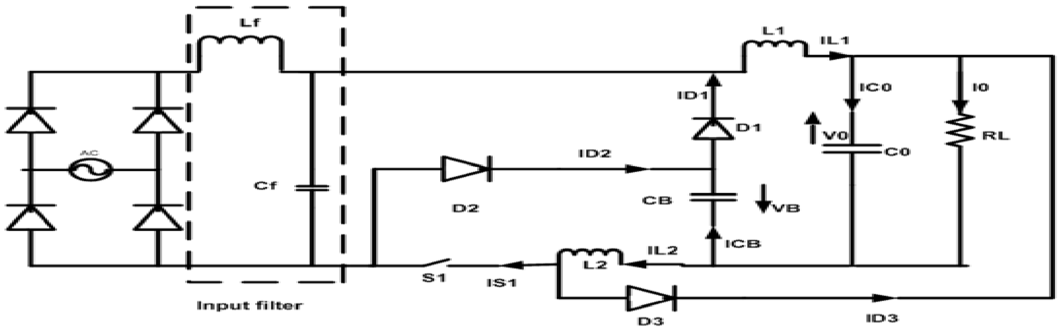

Fig. 2 Integrated buck-buck-boost converter.

Integrated Buck Buck Boost Converter, which integrates a buck based PFC (L1; S1;D1;C0 and CB) and buck boost dc/dc cell (L2; S1;D2;D3;C0 and CB) is illustrated in Fig.2. Moreover,both cells are operated in discontinuous conduction mode (DCM) so there are no currents in both inductors L1 and L2 at the beginning of each switching cycle t0. Due to the characteristic of buck PFC cell, there are two operating modes in the circuit. Operation of converter is divided into two modes mode A and mode B. Modes are determined by comparing the instantaneous value of input voltage and sum of intermediate voltage and output voltage as shown in Fig 3. When the input voltage is smaller than the sum of intermediate bus voltage , and output voltage, the converter operates in mode A.Mode Boccurs when the input voltage is greater than the sum of the bus voltage and output voltage. The intermediate bus voltage of the circuit is able to keep below 150V at all conditions of input and output. Thus, the lower voltage rating of capacitor can be used. Moreover, the topology is able to obtain low output voltage without high step-down transformer. Owing to the absence of transformer, the demagnetizing circuit, the associated circuit dealing with leakage inductance, and the cost of the IBuBuBo converter are reduced.

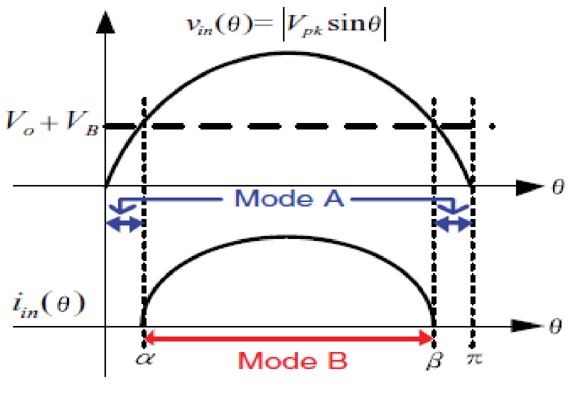

Fig. 3Input voltage and current waveform.

Fig.4 shows the proposed circuit.The input 50HZ AC supply is provided to the integrated buck buck boost ac-dc converter which step down the input voltage to a low output dc voltage. The output of the converter is connected to LED via switch S2. Two dsPIC Controller units are provided. Controller 1 maintains the output of converter at a constant value of 18V (dc). Actual value of the converter output voltage is fed back to the controller 1 through optocoupler . Controller 1 utilizes fuzzy logic to control the switching signals of switch Q1. Controller 2 controls the switching pulses of switch S2 in accordance with signal received from LDR, thus the brightness of LED is varied. The switching frequency of switch S1 is 20kHz and that of S2 is 200Hz.

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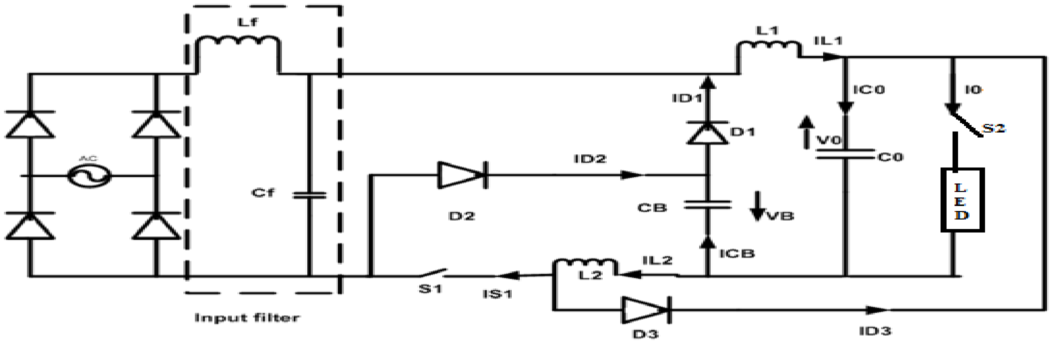

Fig. 4 Proposed Cicuit

IV.SIMULINK MODEL AND SIMULATION RESULTS

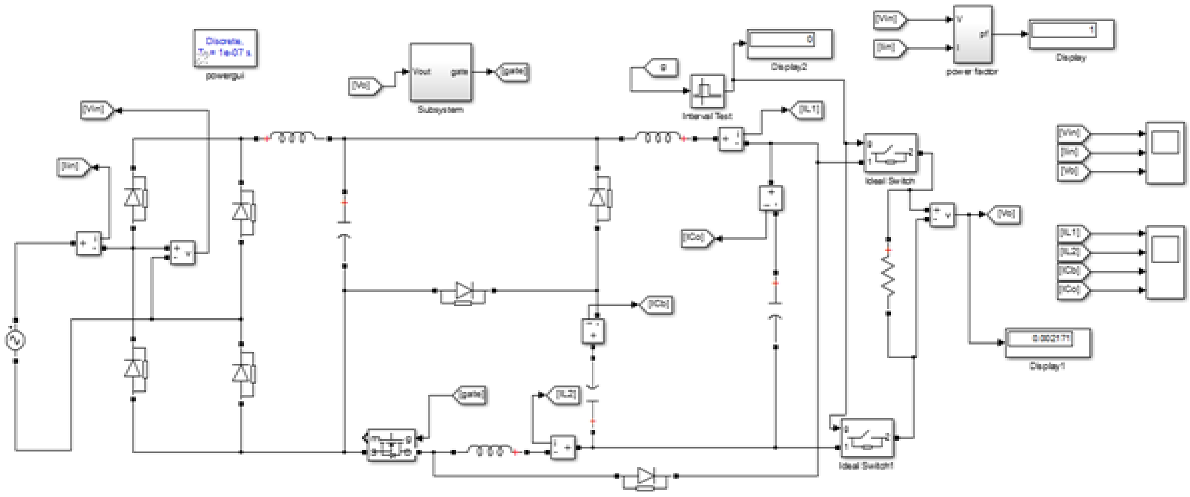

Fig. 5 Simulink model of Proposed Configuration

The proposed day lighting fuzzy control uses sensing devices (occupancy/motion sensor and photo sensors), IBuBuBo for every luminaries aiming the control of the electric lighting output, and a fuzzy controller. The input linguistic variables (signals provided by the photo sensors and occupancy sensors) of the fuzzy controller are the level of the illuminance measured and occupancy level, while the output variable is the level of the control signal sent to control the duty ratio of switching pulse of IBuBuBo converter. Every linguistic variable has various fuzzy values with triangular or trapezoid membership functions. The processing stage invokes each appropriate fuzzy rule and generates a result for each, then combines the results of the rules. The results of all the rules that have fired are defuzzified to a crisp value by proper defuzzification method and gives crisp values of control. The control signal controls the duty ratio of the switching pulses provided to the single switch in IBuBuBo converter and thereby controls its output which in turn controls the light.

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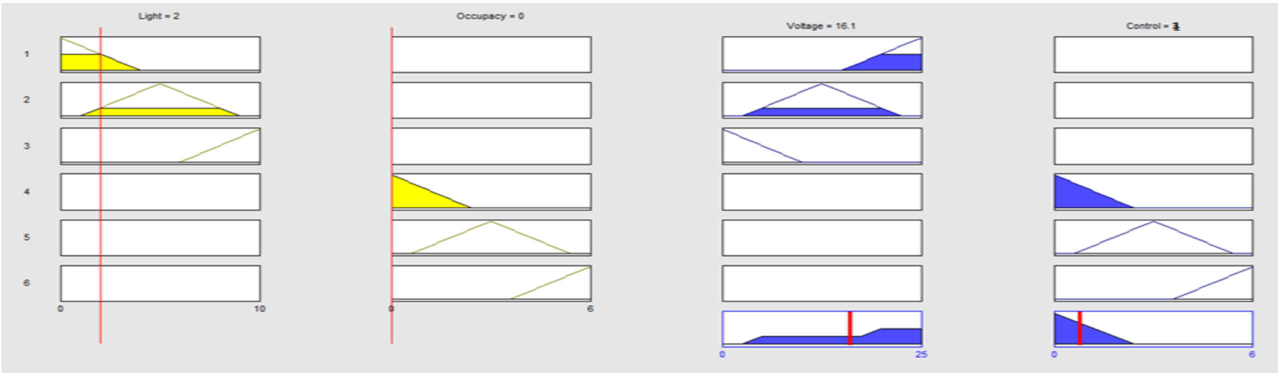

Fig. 6 Controller 1 rule view for zero occupancy

The simulation of the proposed circuit is done for various conditions of occupancy and lighting. Fig 6and Fig 7 shows the rule view of controller 1 for zero and non zero occupancy conditions respectively. For zero occupancy condition, the control signal is very low so that the load will be in off condition. For non zero occupancy condition, the control signal is high, so that the load will be in on condition. From the simulation results it is clear that as the light availability increases,the reference voltage decreases and vice versa. The second controller tries to attain the reference voltage.

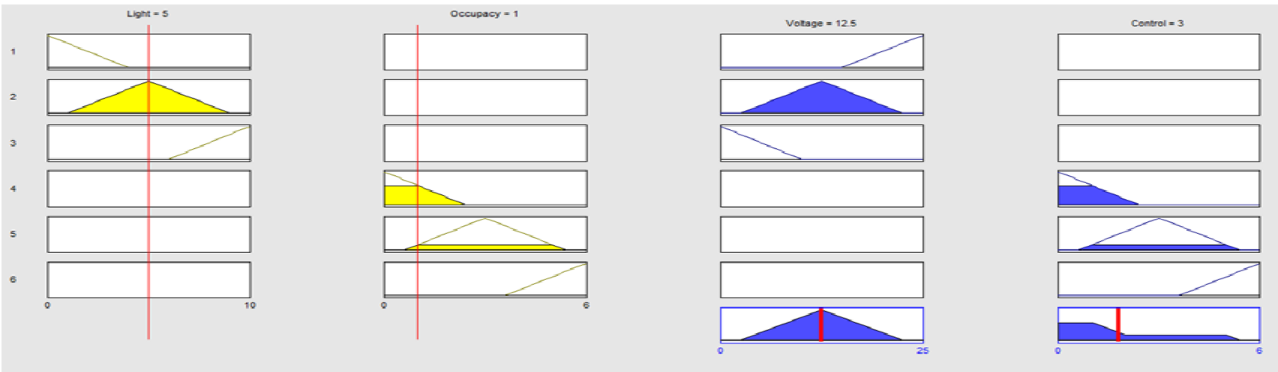

Fig. 7 Controller 1 rule view for non zero occupancy

The control signal directly depends on the occupancy level. if the occupancy is zero, then the control signal will be low which leads to load turn off. If the occupancy is non zero, the control signal will be high leads to load turn on. The voltage signal depends on the lighting level. If the available sunlight is high, reference voltage is lowered. If the available sunlight is low, the reference voltage will be high. The second controller controls the output voltage of the converter by reducing the deviation between actual voltage and reference voltage.

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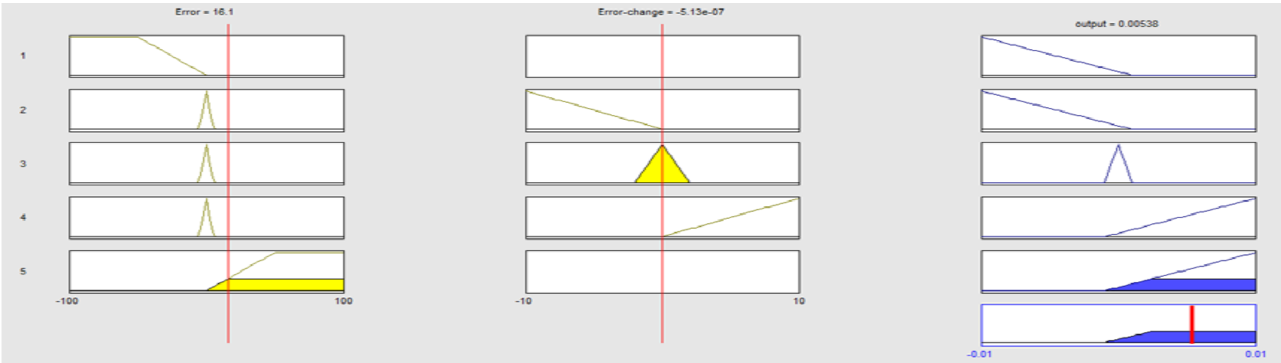

Fig. 8Controller 2 rule view

Fig 9 shows the input voltage and input current waveform of the converter. Fig 10 shows the output voltage waveform of the converter. The output voltage is maintained constant at 18V.

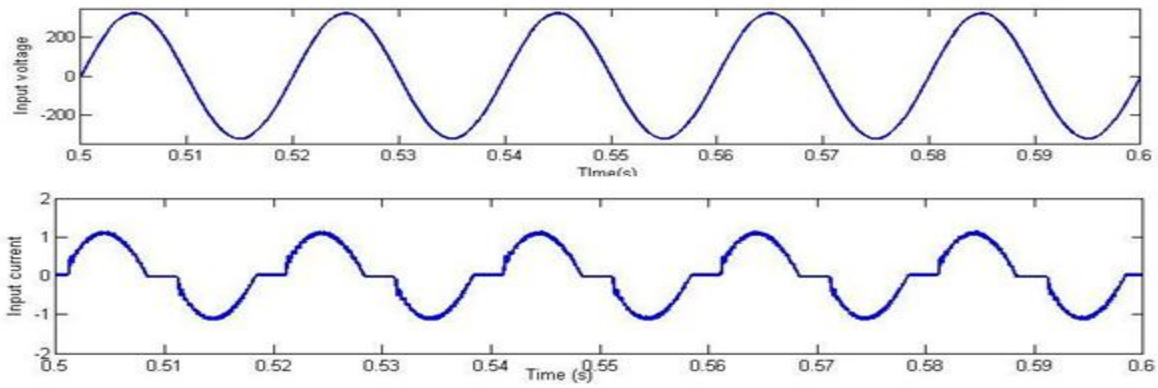

Fig. 9 Input voltage and current waveform

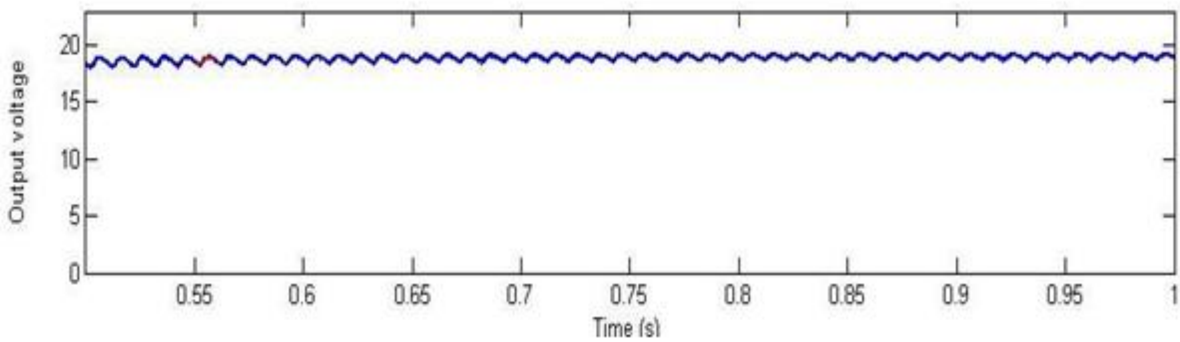

Fig. 10Output voltage waveform

V.EXPERIMENTAL RESULTS

Hardware models fuzzy based lighting control system based on integrated buck buck boost converter (IBuBuBo)converter was developed. Available sunlight is measured using an LDR and the output of LED is controlled accordingly. The system consist of:

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- Power Supply
- Integrated Buck Buck Boost Converter
- MOSFET gate drives
- dsPIC Controller unit for PWM generation
- LED Lights

Fig. 11 Hardware Setup

The input 50HZ AC supply is provided as input and constant dc voltage of 18V is obtained at the output. Fig.11 shows the input voltage waveform. Fig.17 shows the output voltage waveform. Fig.14 shows the switching pulses provided to switch S1. As the lighting conditions vary, the duty ratio of the switching pulses provided to Switch S2 is varied over a wide range. Fig. 15 shows switch S2 switching pulses at low light condition. Fig. 16 shows switch S2 switching pulses at high light condition.

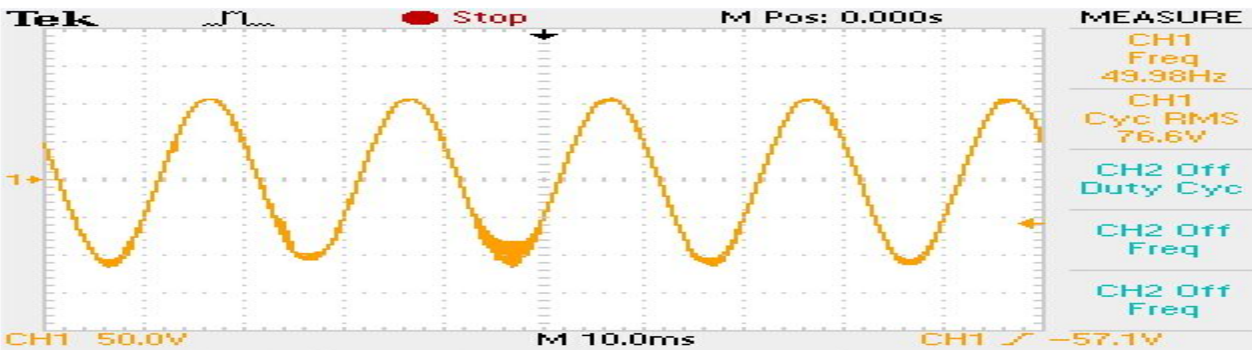

Fig. 12 Input Voltage

Fig. 13 shows the waveform of the line-input voltage along with its current at 46 V_{rms}.Fig. 12 shows the waveform of the input voltage..

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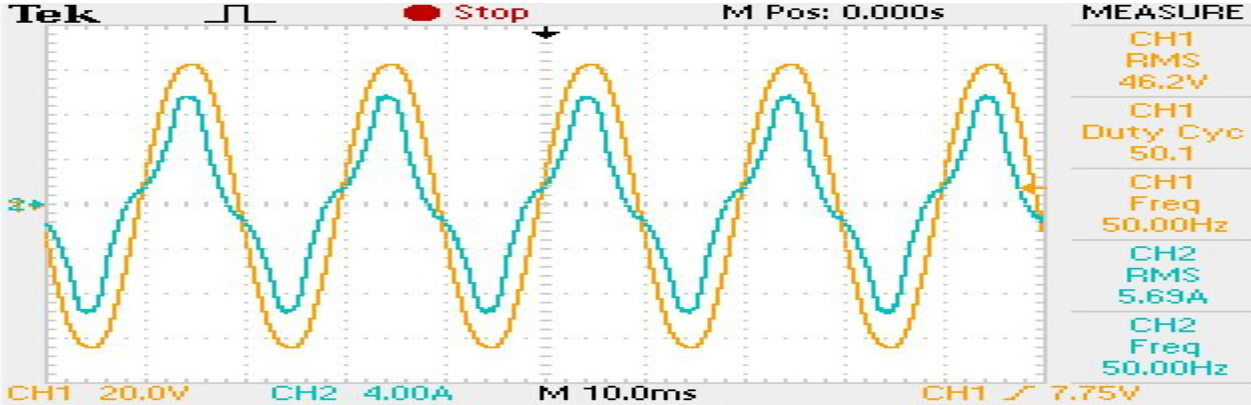

Fig. 13Input Voltage and Input Current

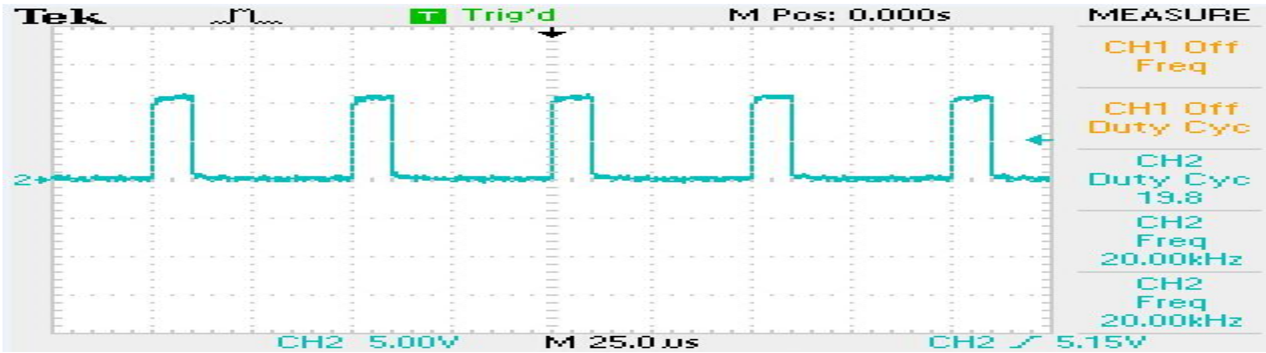

Fig. 14 Switching Pulse to Switch S1

Switch S1 is provided with 20kHz switching pulses by the controller 1. As the input voltage conditions vary the controller varies the duty ratio and maintains output voltage constant at 18V.

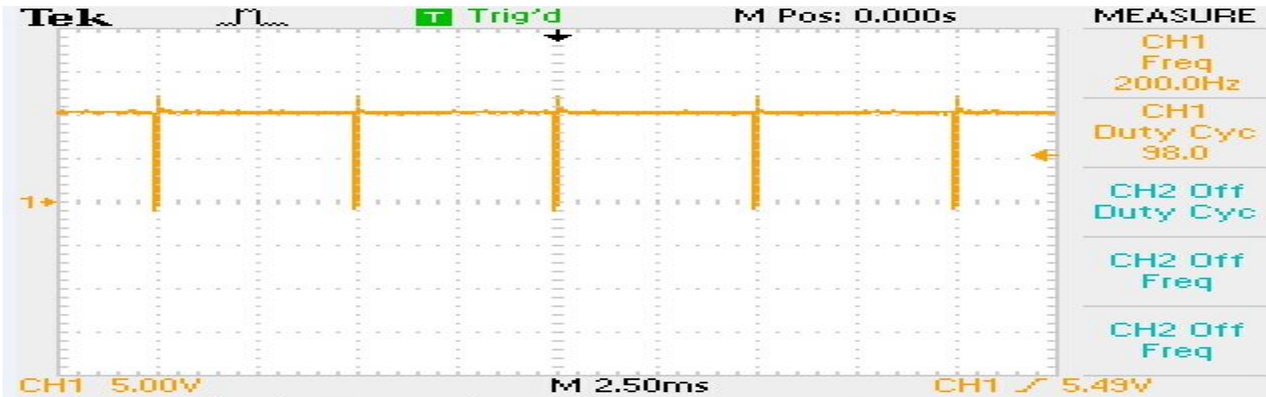

Fig. 15 Switching Pulse to Switch S2 at low light conditions

At low light conditions, controller 2 increases the duty ratio of the S2 switching pulses accordingly so that light output of LED increases. The high duty ratio switching pulses are shown in Fig. 15.

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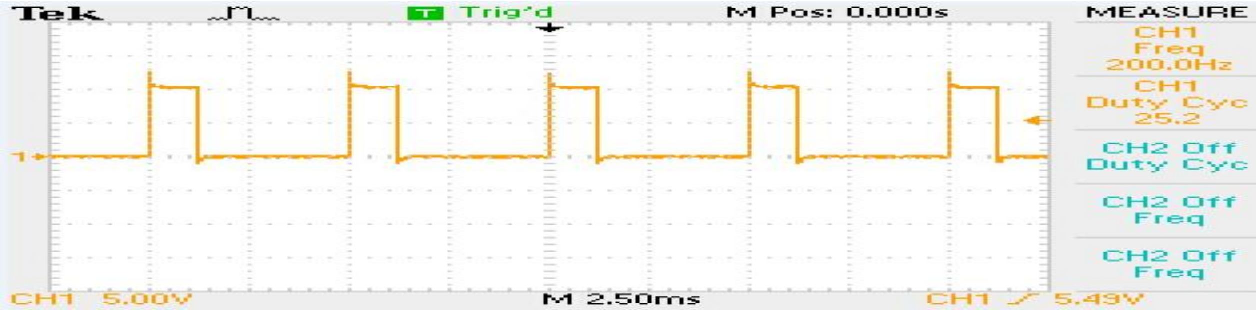

Fig. 16 Switching Pulse to Switch S2 at High light conditions

At High light conditions, controller 2 decreases the duty ratio of the S2 switching pulses accordingly so that light output of LED decreases. The low duty ratio switching pulses are shown in Fig. 15.

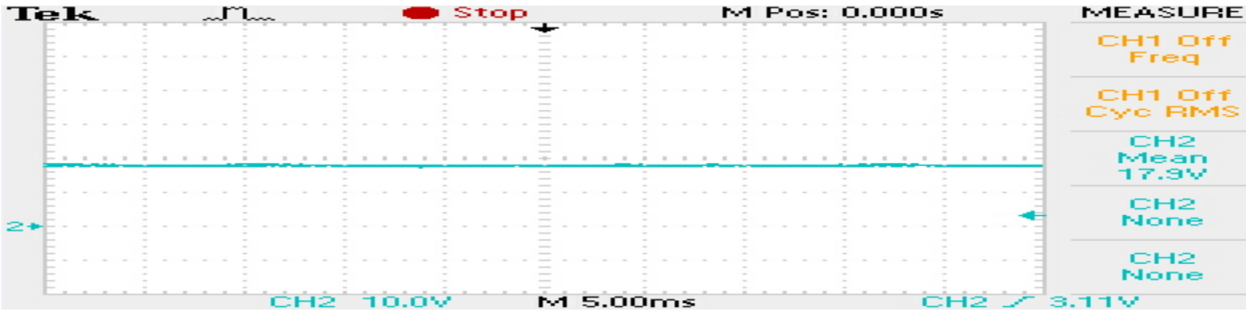

Fig. 17 Output Voltage

VI.CONCLUSION

Daylighting has a very promising energy-saving potential and became an attractive alternative to conventional indoor electric lighting systems. Classic control systems, based on continuous dimming, present some difficulties to adjust their performances to the rapid changes in daylight depending on season, location or latitude, and cloudiness. Taking into account these aspects, fuzzy control could be a better solution in implementation of day lighting, an issue that cannot be easily represented by mathematical modelling because datais unavailable, incomplete, or too complex.By controlling the intensity of LED lighting to reach the satisfactory level and in combination with the use of the day lighting, it is seen that the energy is used efficiently with the best effort for energy saving. The integrated buck-buck-boost converter (IBuBuBo) is able to achieve high power factor.

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