

An Active PFC with Fly Back Design for Intelligence in Street Light Application

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Abstract

As the requirement of energy demand is increasing due to rapid industrial development, it is necessary to meet the growing demand of energy. This can be achieved in two ways: find alternate resource to supply power or energy; or reduce the energy consumption of present resources available. The proposed work is basically the design and implementation of an intelligent street light of 50 W power output from the offline converter by using power LED. As power LED draws huge non sinusoidal current due to the presence of AC-DC converter, a Boost PFC and a fly back converter is used for better power factor and for dc voltage regulation. Along with this a PIR sensor and LDR sensors are also used. A PIC microcontroller is used for PWM dimming. This makes to reduce the power consumption in street light especially in urban cities in which most of the power is wasted in lighting streets during late night.

Keywords: Intelligent Street Light, Power Factor, Fly Back Converter. PIC Microcontroller, PWM Dimming

I. INTRODUCTION

Industrial development and population growth makes the increase in demand of energy sources. Since world has inadequate capacity to renew the sources, the solution is energy saving. It can be improved by using electrical power efficiently and accurately.

One of the most critical load in power system is lighting load. About 30% of the total electrical power of any country is consumed in lighting the roads and streets [1]. This creates the increase in energy cost and environmental pollution by emitting CO₂.

It realizes that dimming of light, which can reduce energy consumption by 40%, put away light maintenance cost by 50% and extends lamp reliability by 25%.

The proposed work is carried out by using power LED as lighting source for street light and switching control of street light is depends on the PIR and LDR sensor output. The ON & OFF of street light is done based on LDR sensor output and the intensity of light during turn on depends on the PIR sensor output.

As power LED's draws a huge current it requires a special driver circuit which provides a constant current. These driver circuits have AC-DC converters which draw harmonic current at the input terminal from the grid and deteriorate the power factor.

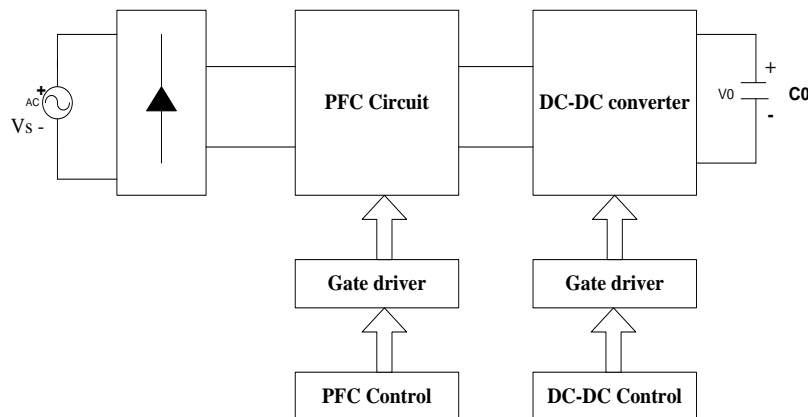


Fig. 1: Block diagram of two stage converter

In this proposed work, the PFC, AC-DC converter can be implement by using two power processing stages. A basic two stage converter is shown in fig (1). The front end PFC input stage which is operating in the transition mode is to reduce the line current harmonics and to improve PF. Most PFC circuit employs boost converter topology [2]-[4]. The second stage which is a high frequency dc-dc converter gives a desired output. A fly back converter is used for obtaining the output which is very simple and cost effective for low power application. PWM dimming is obtained by using a PIC micro controller.

c) Design Parameters

Table – 1
Design Values

Components	Values/Ratings
Boost inductor	1.66mH
Diode	480V/0.835A
MOSFET	480V/0.23A
Output capacitor	22uF/450V
Input capacitor	0.1uF/400V

2) Design of Fly Back DC-DC Converter

a) Schematic Diagram

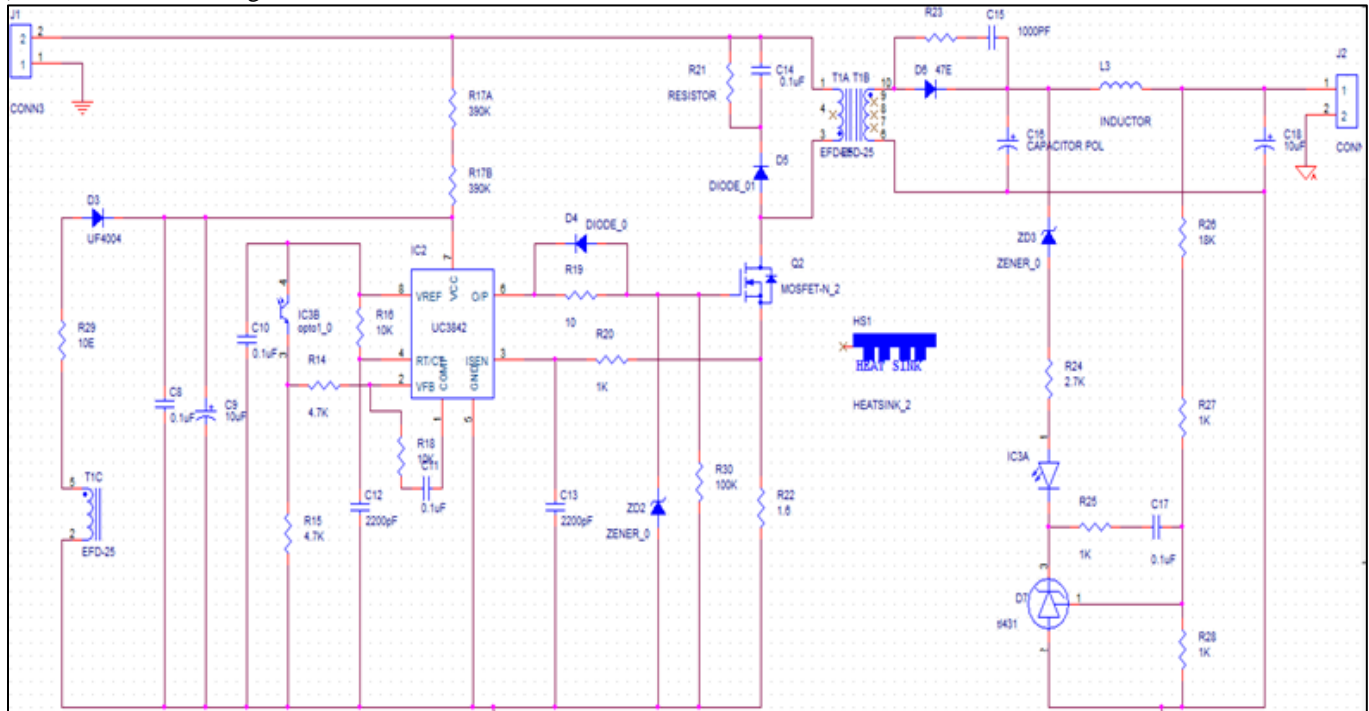


Fig. 3: Circuit diagram of Fly back converter

A design of fly back converter operated in the switching frequency of 100 KHz with DCM mode of operation is shown. Since the input to the fly back converter is 400V dc, the design of fly back transformer is simple and has more efficiency compared to traditional fly back converter operated in AC supply.

b) Design Parameters

The major components of fly back converter are flyback transformer, output diode, input capacitor, output capacitor, MOSFET etc. The designed values of major components are described in table.

Table – 2
Design Values

Components	Values/Ratings
Flyback transformer	EFD 25 Core $N1/N2 = 90/15$ Primary inductance=2.3mH
Diode	480V/0.835A
MOSFET	700V/2A
Output capacitor	10uF/63V
Input capacitor	0.1uF/1KV

3) Arrangement of LED driver with PIC Micro Controller

The power converter section is connected to a LED driver to drive the LED in a constant current. The LED's are arranged in a array to form LED street light. There are 5 strings of LED's in which 10 LED's connected in series. Each string has individual LED driver. The LED driver is operated at 48V dc supply. The proposed work uses LM3402 HV LED driver which is having Buck topology. The arrangement of LED array with LED driver is shown in the Fig. 4.

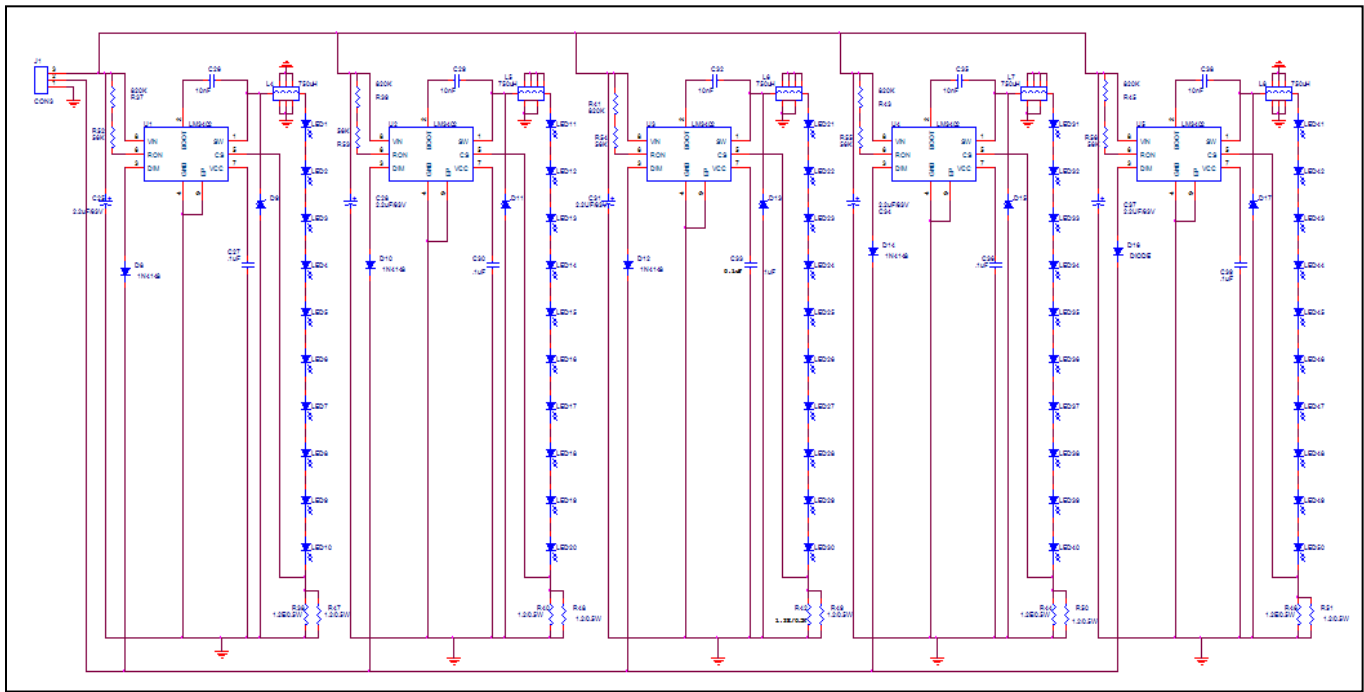


Fig. 4: Arrangement of LED Array

In order to obtain PWM dimming a PIC micro controller of 18F2520 is used. A PIR sensor and LDR sensor is used as the input to the PIC micro controller. According to the signals generated from the sensors a PWM signal is generated by microcontroller and is given to the DIM pin of the LED driver.

III. SIMULATION RESULTS

The purpose of the simulation is to investigating the operation mechanism of the converter and confirming the resultant waveforms with analytical calculation. The circuit shown in Fig.5 has been simulated in MATLAB, which is the closed loop simulation of two stage AC-DC converter. The simulation results are shown Fig.6, 7 and 8. The operating switching frequency is 100 kHz. As Fig.7 shows the input current tracks the input voltage, the power factor is almost unity. Output voltage is regulated at 48V. The simulation is done for 50W AC-DC converter.

A. Simulation Circuit

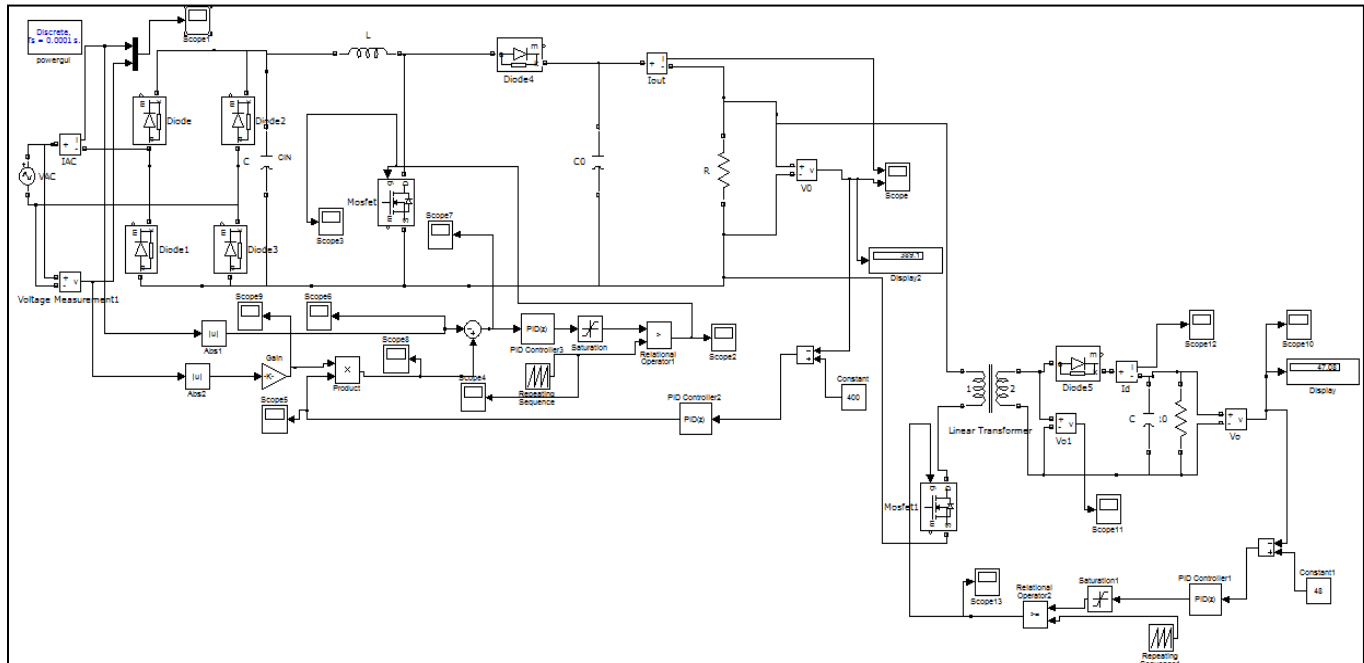


Fig. 5: Simulation Circuit

B. Simulation Results

1) Output Voltage Waveform

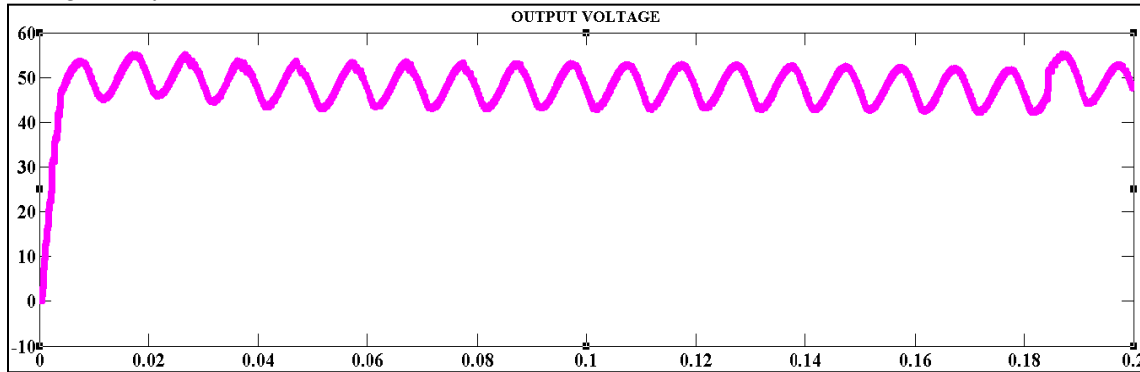


Fig. 6: Output Voltage

2) Input Current and Voltage Waveform

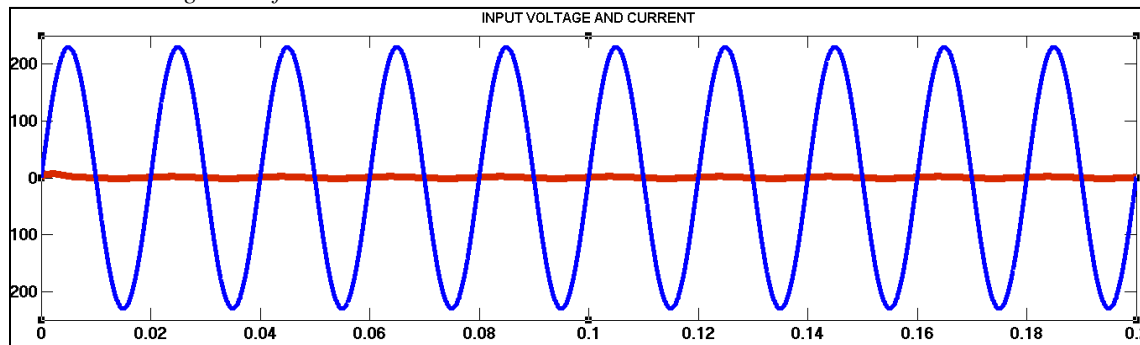


Fig. 7: Input Voltage and Current

3) Input Current Waveform

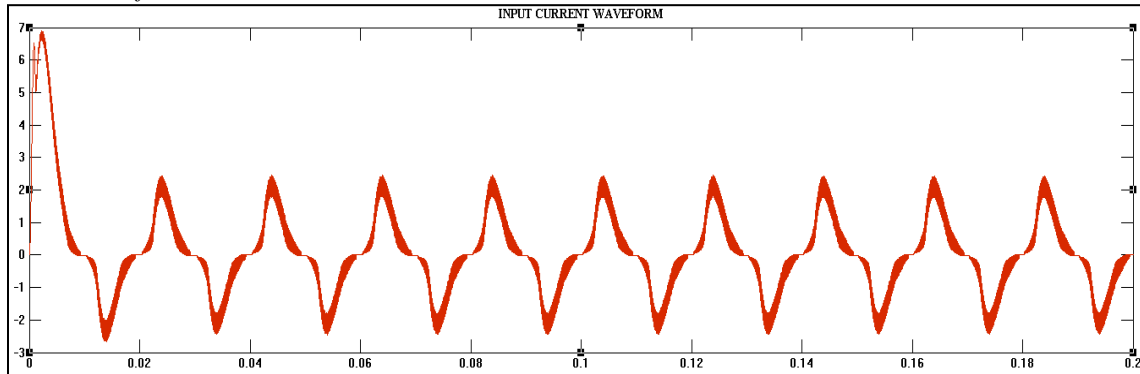


Fig. 8: Input Current Waveform

C. Analysis of Simulation Results

The closed loop simulation of two stage AC-DC converter is done in MATLAB using Simulink model. The component values used in model is taken from the designed values of AC-DC converter. The output voltage of Flyback topology is 48V with less ripple. The input voltage and current are in phase and sinusoidal, so that the converter will achieve a better power factor.

IV. EXPERIMENTAL SETUP AND HARDWARE RESULTS

The hard ware is done according to the designed values and compared the wave forms with theoretically. The complete hardware set up is shown in Fig.10 and Fig.11. Fig.10 shows the intensity of light when no activity is detected in late night. That is during DIM mode and Fig.11 shows the high brightness when any activity is detected by sensors. Fig.12 and Fig.13 shows the PWM signals generated from the PIC micro controller.

A. Hardware Results

1) When no activity is detected in late night

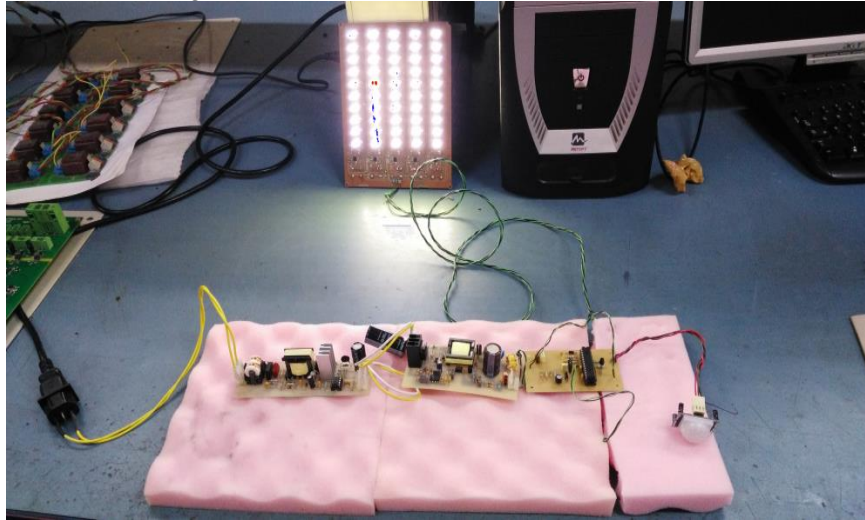


Fig. 9: Dimming Mode

2) When activity is detected in late night

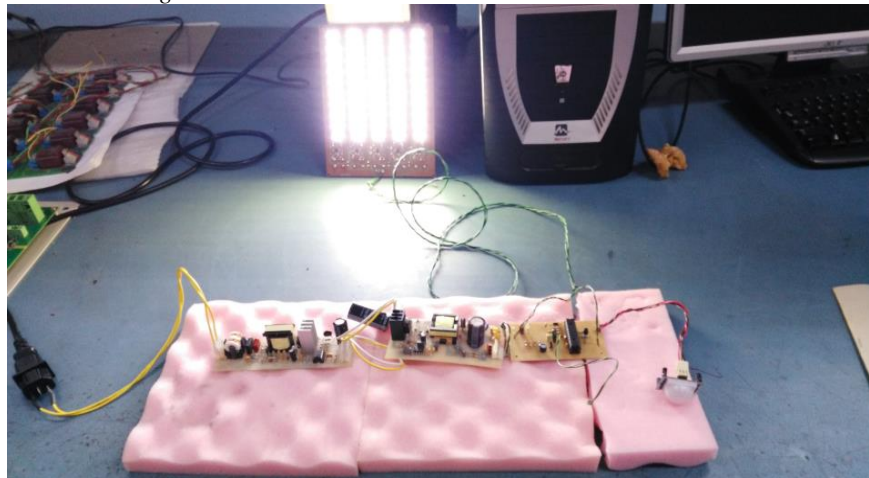


Fig. 10: Bright Mode

3) PWM signal generated by PIC micro controller when activity is detected in late night

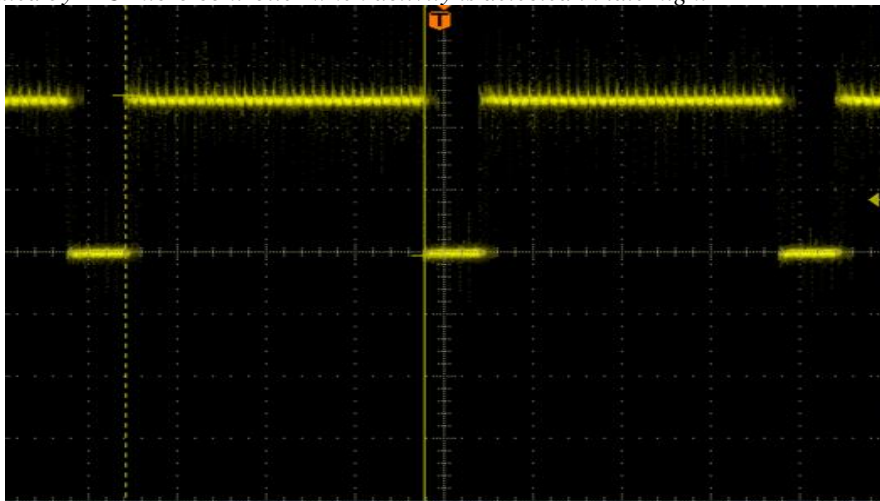


Fig. 11: PWM Signal during Bright Mode

4) PWM signal generated by PIC micro controller when no activity is detected in late night

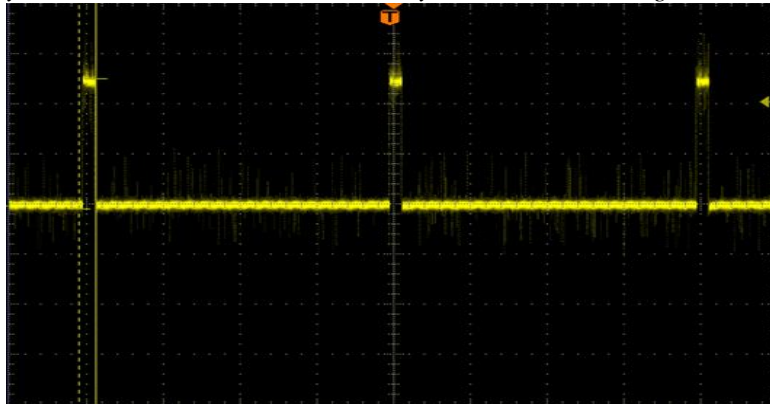


Fig. 12: PWM signal during dimming mode

B. Analysis of Hardware Results

The hardware results show that the energy consumption during late night can be reduced. Around 3 watts of energy is consuming during dim mode. This will save the energy.

V. CONCLUSION

This paper has proposed a two stage power-processing ac-dc converter with a high power factor and high power efficiency. The proposed converter has low line current harmonics and it achieves a power factor of about 0.997. And an overall efficiency of 86% is obtained.

Also, analysis, design, and experimental results for the pro-posed converter have been presented. The converter combines the full-bridge diode rectifier, a Boost PFC circuit and fly back dc-dc converter.

From hardware results the wastage of energy can be reduced and the energy efficiency can be achieved. By this proposed work, the calculation shows that a 50W of power is used during high brightness and in dim mode only 3W of power is consuming. This result shows how much amount of energy can be saved. The proposed system can autonomously adjust the minimum light intensity value to enhance both energy efficiency and user satisfaction. The main advantage of the proposed system is power saving. It requires the initial cost only for designing and installation and not for utilization. Hence this type of systems is very much useful for the government to reduce the utilization of conventional power.

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