Advance Approach for Power Efficient LED Driver for LED String Using DC-DC Converter

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Abstract: The Light Emitting Diode (LED) technology is becoming more popular now a days because of low power consumption, better illumination and longer life expectancy. LED lighting system requires drivers with diverse specifications which increases design complexity and manufacturing costs. In this project work we design isolated, fly-back topology based switching type LED driver which uses the passive power factor correction circuit which is known as valley-fill circuit to correct the power factor, the THD can also be minimize. The simple control mechanism will be used to reduce the circuit complexity, and reduces the number of component count. The losses will be reduced hence we can improve the efficiency. Simulation is done by using the PSIM simulation software and results are presented to evaluate the driver's performance.

Keywords- LED Driver, DC-DC Converter, PSIM, Efficiency

I. INTRODUCTION

LED Driver is one type of electrical device which is used to regulate the power of an LED or LED strings. LED driver responds to the changing needs of LEDs by providing constant quantity of power to the LEDs as its electrical properties which is changing with the temperature. We can also say that the LED driver is a self contained power supply having the output that are matched to the electrical characteristics of the LEDs. LED drivers can also offer dimming by means of PWM circuits and it may have more than single channel for separate control of different LED array. LED driver can also be used to maintain the constant power level of LEDs. The electrical properties of LED change throughout the temperature increases or decreases. If we are not using proper driver the LED may become hot and gives unstable and poor performance or failure occurs.

The Light-emitting diode (LED) technology promising some benefits of high efficiency, long lifetime and small size, and the most important feature is the generation of green lighting source because of the environmental friendliness [1]. The driving voltage and current for LED panels are vary widely according to the number of LED devices. They can be connected in series as well as parallel for the LED driver. The number of LED in series can be increased to reduce the number of channels in the driver [2]. The main reason for the drivers short lifetime is the use of smoothing capacitor at the output side of the driver. This is because of the leakage occurs in the capacitor by which the performance of the driver is degrading with the time. Some works on the electrolyte capacitor-less LED drivers have been presented before to maximize the overall lifetime and the efficiency of the LED Driver [5].

A Light-emitting diode can be modeled as shown in fig. The model shown in fig is based on an ideal diode, small resistance and a voltage source is also there. When applied input forward voltage is higher than the break-down voltage, shown as the voltage source the diode is forward biased and emitting light. As the diode allows only the unidirectional flow of current which is goes through the resistance.

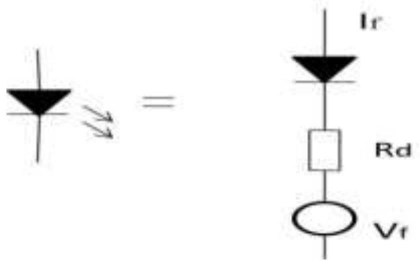

Fig. 1. Electrical model of Light-emitting diode

The voltage and current curve for a single LED can be shown as blow where we can see the voltage current relation for the single LED. The forward voltage drop and the current for the different LEDs are different like for white LED the forward voltage drop is nearly the 3.2V and the current is 5mA probably. And there are also the LEDs are available in different sizes like 3mm, 5mm and 10mm etc., and the voltage drop and the current are different for them, some other kind of LEDs are available now a days called surface mounted LEDs which are also widely used in LED lighting systems. In our project we are using the surface mounted LEDs for the hardware implementation.

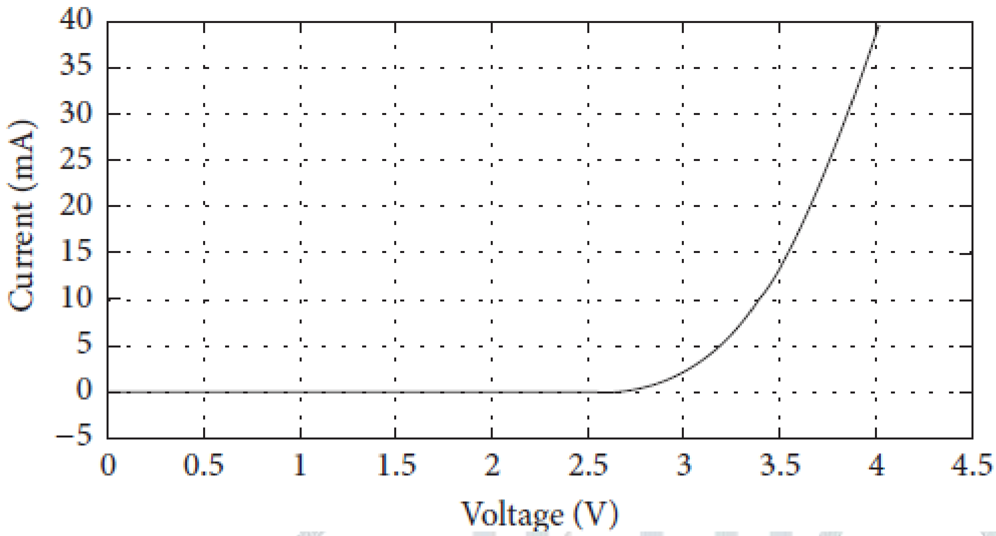

Fig-2 V-I characteristic curve of single LED

In this paper, DC-DC converter based Switching type LED driver is designed using fly-back topology. The basic concept behind the work is to design the LED driver with the better power factor, less component count with the lower price so we can minimize the total cost of the LED driver. In section II the block diagram of the proposed system is explained. In section III the proposed design of the flyback LED string driver is shown. In section IV simulation and hardware results are shown and section VI gives the conclusion of the presented work.

II. LED DRIVER SYSTEM

There are two types of LED Driver systems available, Linear LED driver and the Switching type LED Driver. The Linear LED driver is only beneficial when the load voltage is closer the input voltage whereas the switching regulators can be used when the input voltage is differ from the output whether it is higher voltage of the lower voltage. Now a days the switching type of LED Drivers are most widely used. In our proposed system we are designing the switching mode type LED driver for LED applications using fly-back topology. The block diagram shown below is the proposed block diagram of LED driver for LED string.

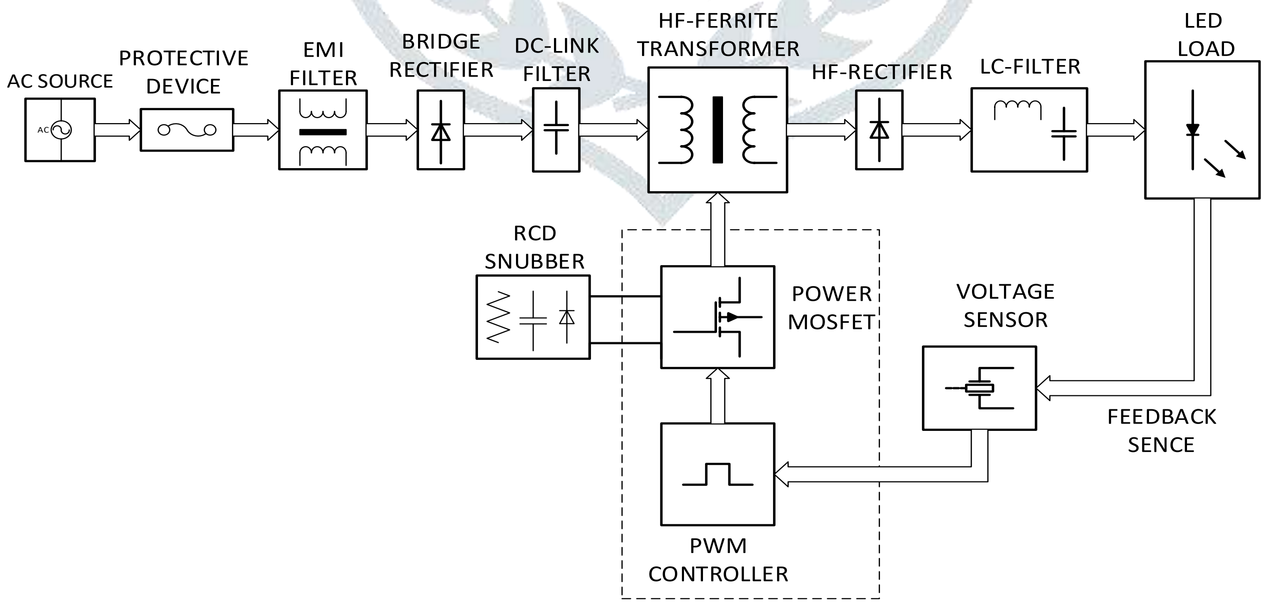

Fig-3 Block diagram of proposed LED Driver

Block diagram represented in Figure 1.3 represents configuration of the LED driver. AC input is given to the bridge rectifier which performs rectification process. But before that the EMI filter and the protective devices are added, the EMI filter is an electronic passive device which is used in order to suppress conducted interference that is present on a signal or power line. The protective devices are used for the overvoltage protection purpose.

The output of the rectifier is given to the power factor correction stage which is used to correct the power factor. Load with a low power factor draws more current than a load with a high power factor for the same amount of power. Therefore, PFC is useful so that maintain a high power factor, here we are using valley fill passive power factor correction method for the same. DC link filter which is used to filter the AC component or ripples and gives DC output.

The HF ferrite transformer is used for the isolation between input and output so the any surge can not affect the LED load directly and the LED module will be safe, as well as safety from shock is also maintained. To regulate the output voltage , DC-DC converter is applied.

III. PROPOSED DESIGN OF FLY-BACK LED STRING DRIVER

Fig. 4 shows the schematic diagram for the universal input fly-back LED string driver. The TNY290PG IC used as controller. It is low cost with enhanced flexibility controller, here we have also used PC817 Optocoupler and the TL431 variable Zener for sensing and controlling purpose.

Simulation is performed using PSIM software version 9.1.1 professional. It is specifically use for power electronics simulations, PSIM mainly uses the nodal and the trapezoidal rule integrations on the basis of its simulation algorithm. It also provides a schematic capture with the interface and a waveform viewer Simview.

In this paper the simulation as well as hardware implementations are presented.

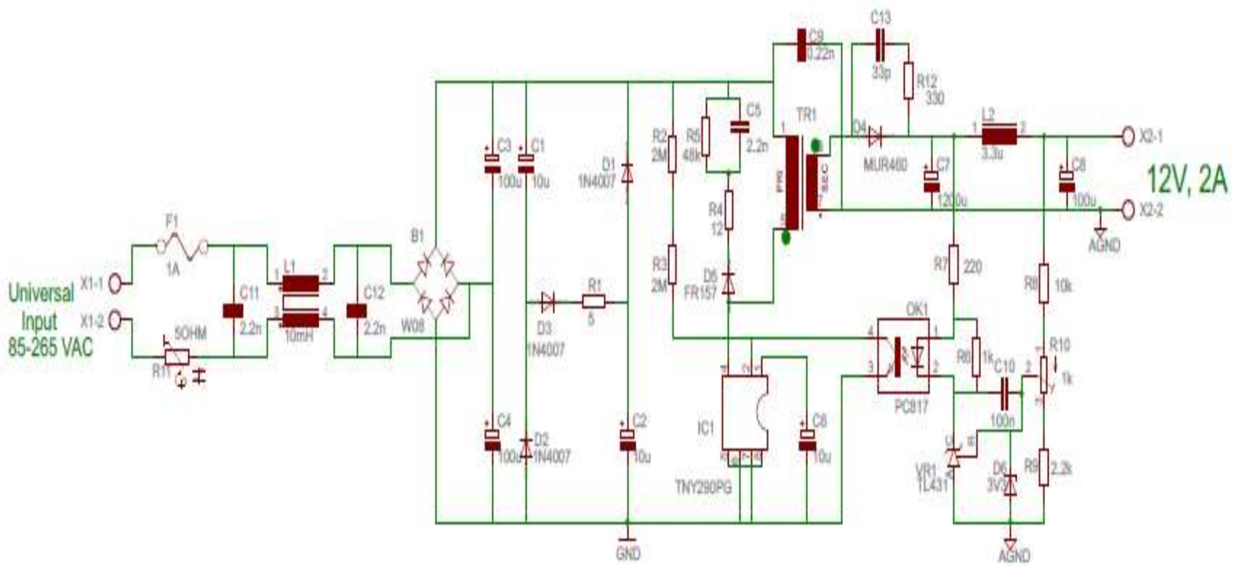

Fig-4 Proposed Fly-back LED String Driver schematic

The circuit shown above is schematic for the proposed LED driver. Which includes the protective circuit like fuse and the NTC for the temperature control purpose. The EMI filter circuit, C1-C4, D1-D3 are the valley fill circuit elements. R4, R5, C5, D5 are the snubber network components, the snubber network improves the efficiency as well as lifespan. The controller IC used is TNY290PG which is an energy efficient as well as low cost IC.

There are two simulations carried out one for the open loop configuration and the other one is for the close loop configuration. And the results are taken for the 230V as well as 110V, the Optocoupler and the variable zener are used for the control for the voltage as well as current at the output by setting the predefined value. If the voltage or current value is increased or decreased from the predefined value the voltage or current can be controlled by that mechanism. So it is one of the advantages of this LED driver that we can control voltage as well as current.

Table I shows the simulation parameters of the simulation model for the system we have designed. The proposed LED driver design converts 230V, 50Hz AC in to the 12V, 2A current 24Watts of power. It is also a low cost lighting products range with compact size.

Table 1. Simulation Parameters

Parameter	Value
Input AC voltage	230 V
Primary inductance	10mH
Winding ratio	4
Leakage percentage	0.1%
Output voltage	12V
Output current	2A
Output power	24W
Switching frequency	132kHz

IV. SIMULATION RESULT

By using the proposed Driver design, the voltage is properly regulated. The voltage and current sensor used is able to monitor the voltage as well as the current. The valley fill circuit used to improving the power factor is improves the power factor up to the 0.85 and the output voltage and the currents are shown for open loop, and close loop simulation models and the output of power factor improvement is also shown as below.

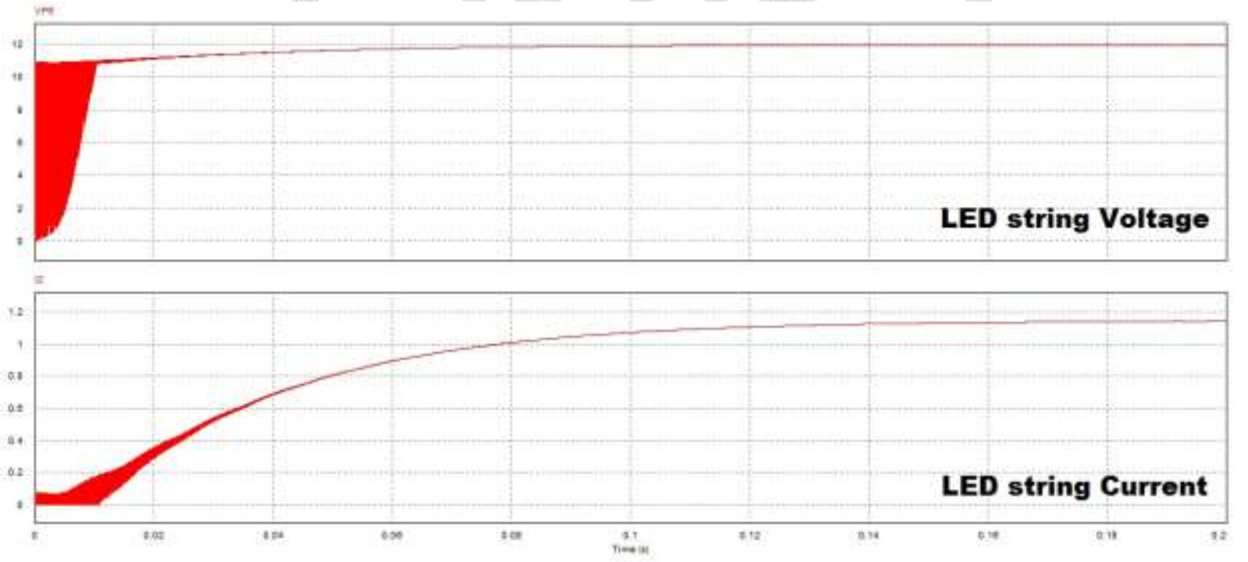

Fig-5 output voltage and current at 230V input (open loop)

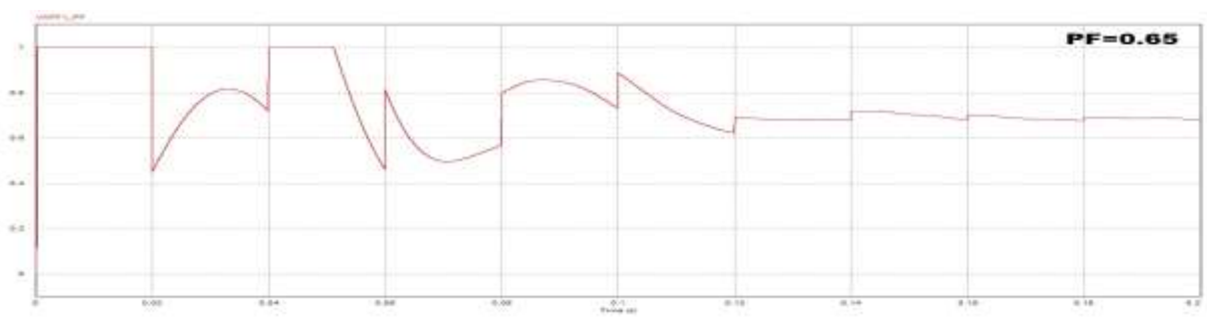

Fig-6 power factor output without using valley-fill circuit

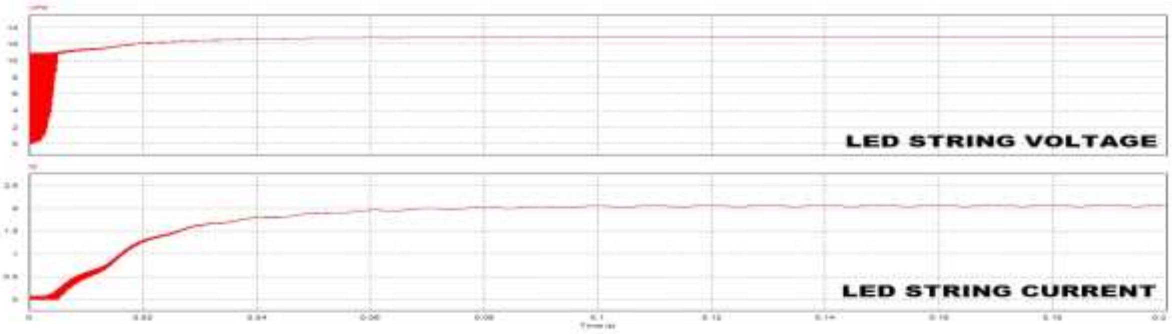

Fig-7 Output voltage and current with valley fill circuit

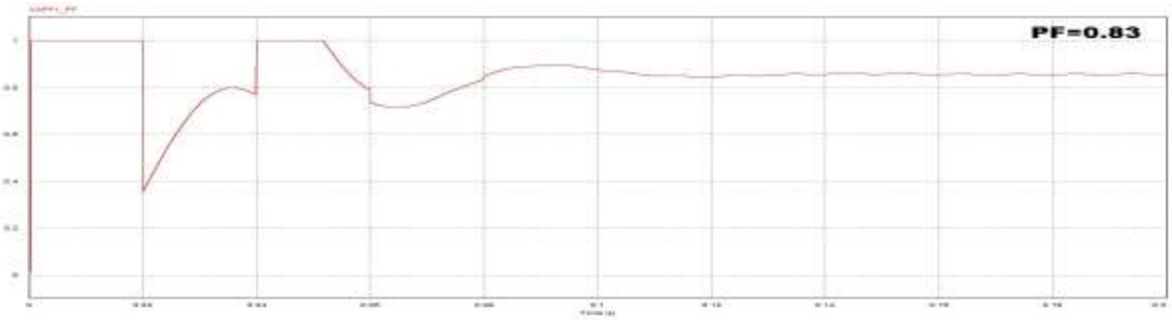

Fig-8 Power factor with valley-fill circuit

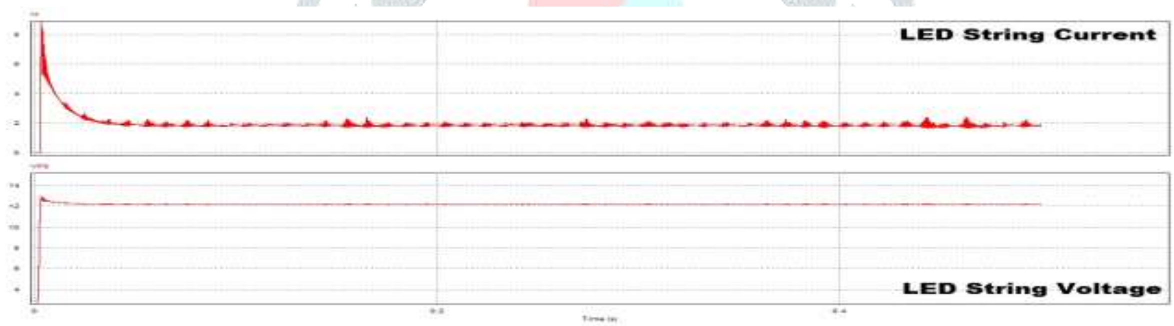

Fig-9 Output voltage and current close loop (110V)

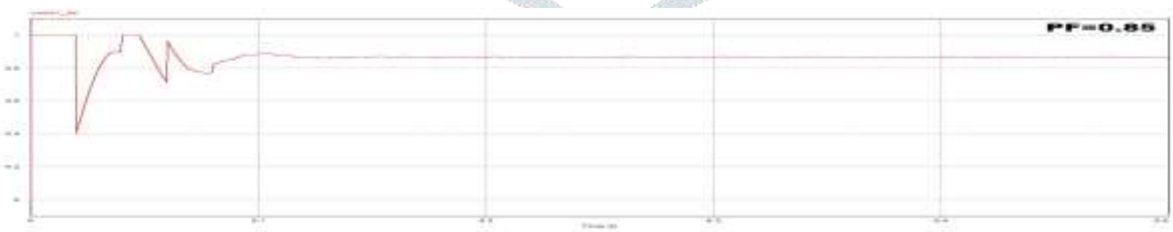

Fig-10 Power factor with valley-fill circuit close loop (110V)

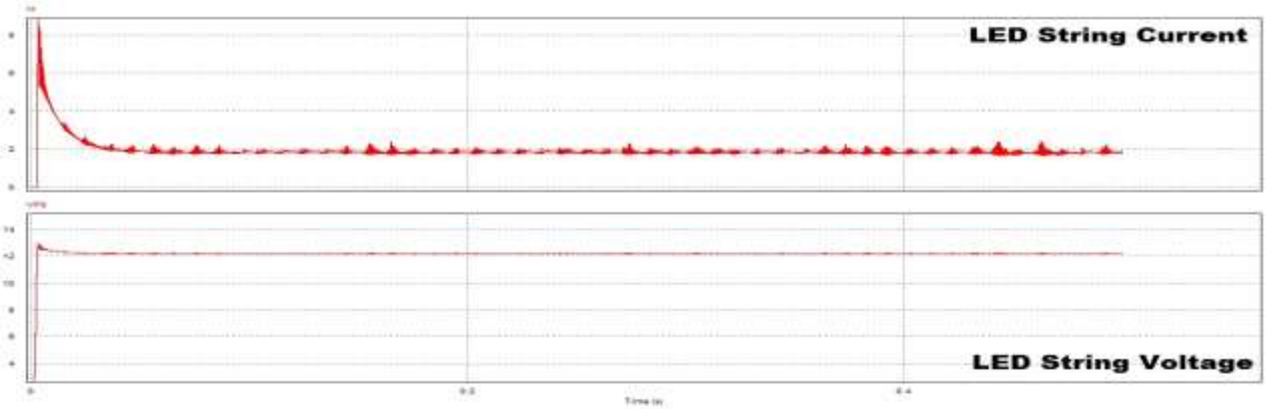

Fig-11 Output voltage and current with valley-fill circuit close loop (230V)

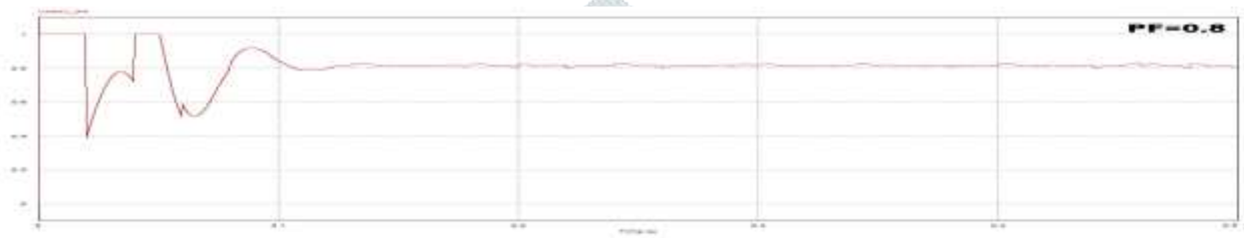

Fig-12 Power factor with valley-fill circuit close loop (230V)

Table-2 Simulation results

	PF	Voltage	Current
Open-loop 110V	0.82	11.9V	0.9A
230V	0.83	12.8V	2A
Close-loop 110V	0.85	12.2V	2A
230V	0.8	12.8V	2A

V. HARDWARE IMPLEMENTATION

Table-3 Key component for hardware

Component	Value
F1	1A
Input EMI filter	10mH
C1-C3	10µF
D1-D3	1N4007
IC1	TNY290PG
D4	MUR 460
Qk1	PC817
VR1	TL430
Fs	132kHz
LED string	12V, 2A

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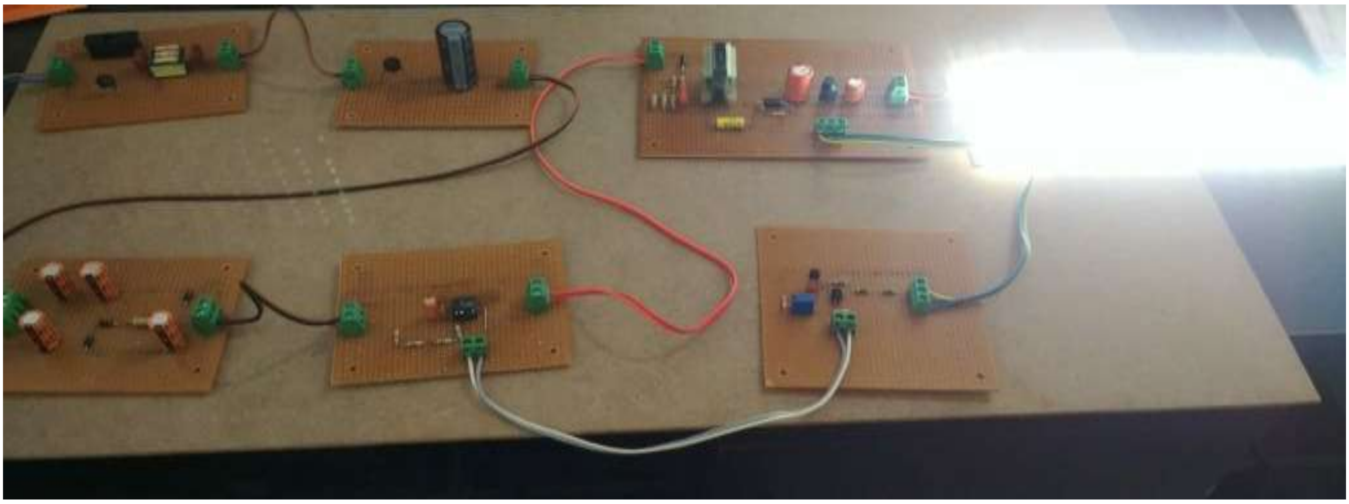

Fig-13 Proposed Prototype hardware

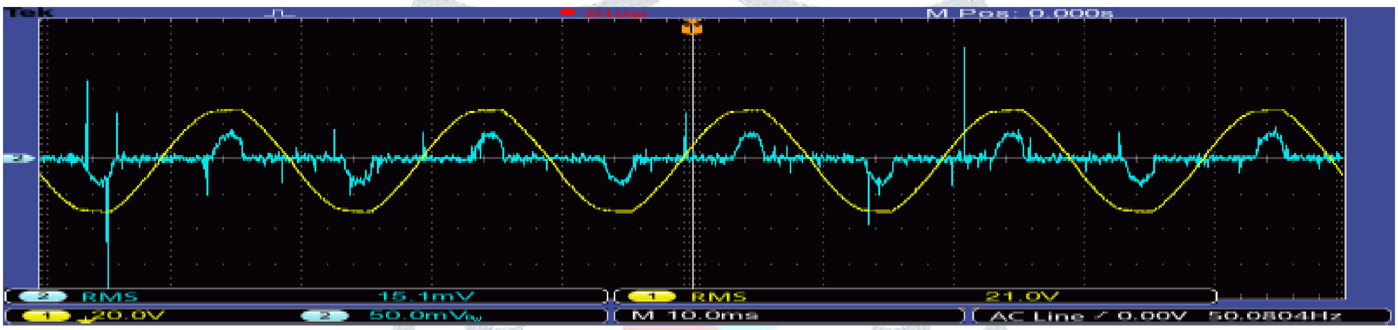

Fig-14 Output of VI phase of proposed design

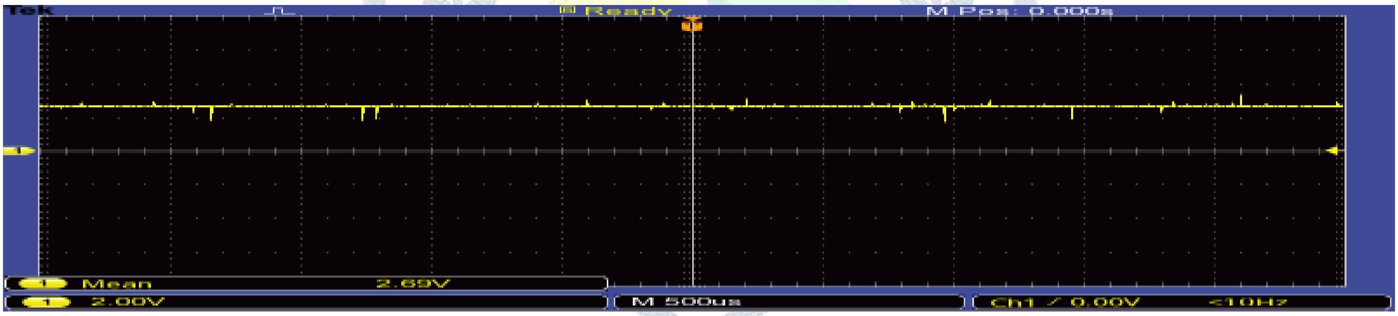

Fig-15 output current of Proposed design

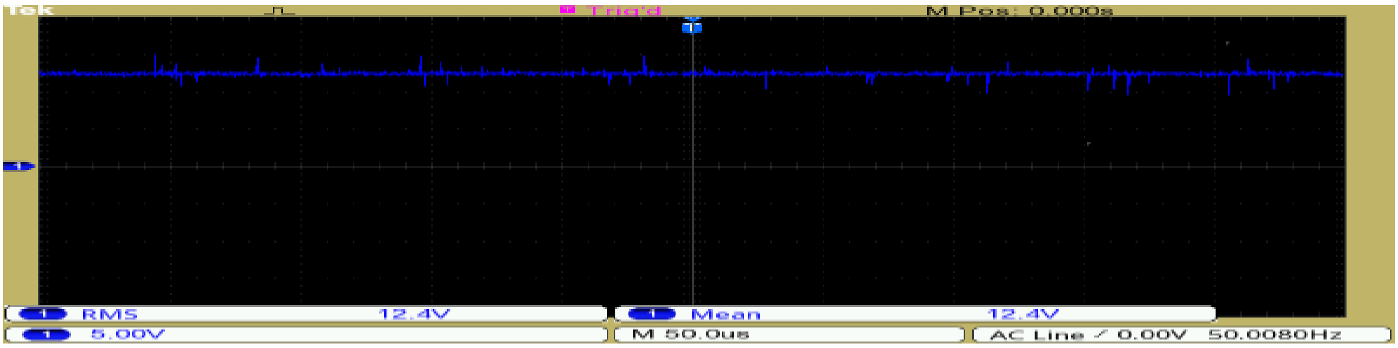

Fig-16 Output voltage of proposed design

Table-4 Experimental results

Description	Value
Input Voltage	230 V
Input current	0.117 A
Input power	26.9 W
Output voltage	12.4 V
Output current	2 A
Output power	24.8 W
Efficiency	92.19 %

$$\eta = \frac{24.8}{26.9}\ 92.19\ \%$$

VI. CONCLUSION

The proposed fly-back LED string driver is low cost and power efficient design in which we have used minimum no of component so that the size of the design is reduced, by using some protective devices the losses are minimized. The overall cost of the system is reduced.

By using the low cost valley-fill circuit the power factor is improved from 0.6 to 0.8. This design can be used for the low power application in LED lighting systems. The design proves the high efficiency over 92.19% for the hardware.

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