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A VALLEY-FILL SEPIC-DERIVED POWER FACTOR CORRECTION TOPOLOGY FOR LED LIGHTING APPLICATIONS USING DIGITAL CONTROLLER

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ABSTRACT
The high-brightness white light-emitting diode (LED) has attracted a lot of attention for its high efficacy, simple to drive, environmentally friendly, long lifespan, and compact size. The power supply for LED also requires long life, while maintaining high efficiency, high power factor, and low cost.A dimmable Light Emitting Diode (LED) driving circuit with single ended primary inductance converter (SEPIC) is presented in this paper. The other lighting system, which is in use, is incandescent bulbs, halogen bulbs and even compact fluorescent light bulbs. The losses and environmental problems due to this is more and power quality is also less. Here the SEPIC converter is controlled with the power factor correction technique. The one cycle control technique is done by using the digital controller(PIC16F877a microcontroller) is introduced in this paper for driving the LEDs and maintaining the power factor.

KEYWORDS: Valley fill SEPIC Topology, Power factor correction, PIC 16F877a microcontroller,PWM Dimming Control.

INTRODUCTION
World wide ,about 19% of the electric power is consumed by residential, commercial or industrial lighting. The technological innovations in the electrical lighting efficiency has increased significantly in the developed countries and accordingly by using the advanced lighting materials and power electronics technology to drive these devices. The commonly used technologies of lighting includes incandescent bulbs, halogen bulbs, fluroscent lamps and compact fluroscent lamps (CFL).For incandescent bulbs, the power factor is unity because it is a purely resistive load and inefficient in terms of amount of power consumed. There are two methods of power factor improvement 1)Passive power factor correction (PFC) .2) Active power factor correction. In the passive power factor correction by using the capacitors and inductors the power factor can be achieve closer to the unity. But it requires large value inductors or capacitors so this method is expensive,and also it is not effective as active power factor corrections.

Active power factor correction, it is a power electronic system that changes the nature of the input current waveform drawn by a load to improve the power factor nearer to unity. The advantages of the active PFC includes, the converter can run in continous conduction mode (CCM) that allows for full utilization of components, high power factor over wide input/ output load combinations, and high efficiency. The other approach is that voltage follower, where the input current naturally follows the input voltage by running the converter in discontinuous mode (DCM) and it is widely used in low cost low wattage applications. For example, SMPS with passive PFC can achieve power factor around 0.7.but the SMPS with active PFC can achieve PF up to 0.99.while the SMPS without any PFC has a power factor of only about 0.5 to 0.7 only.

Diode rectifiers are front end converters for the LED drivers which draws a pulsating current from the AC source.
The European standard IEC 61000-3-2 (class C) instructs that the power factor and total harmonic distortion (THD) should be maintained for the lighting equipments exceeds above 25W. Light emitting diode (LED) gradually becomes a commonly used solid-state light source in general lighting applications. It has longer lifetime and has no poison mercury content compared with the conventional fluorescent lamp. Multiple LED lamps are usually connected in parallel for obtaining enough lighting levels. In addition, dimming control is often needed to regulate

lighting levels for human needs as well as to achieve energy saving. The below figure 1 shows the single stage PFC circuit for driving multiple lighting LED lamps.

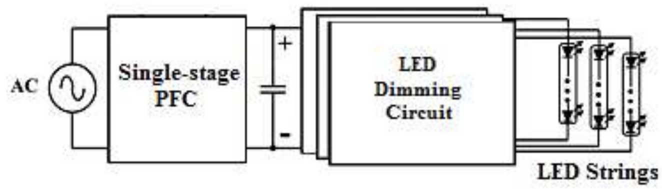

Fig.1. Traditional single-stage structure for driving LED lamps.

The number of topologies can be used as a voltage follower for instance boost, buck boost, cuk and flyback converters. Flyback converters are frequently used topologies for low power low cost ac/dc conversions. Running it in discontinuous conduction mode and also it needs proper snubber circuit to suppress the high voltage ring caused by the leakage inductance of the flyback transformer, so the main disadvantage of flyback converter is requirement of snubber.

The one more topology followed y the buck boost converter i,e single ended primary inductance converter (SEPIC) , compared with the flyback converter “it does not have a transformer ”and associated leakage ring effect “ and also designed for wide range of voltage conversion ratio. The SEPIC converter have advantages of less switching loss, less output voltage noise and power stage can be operated at high frequency than the flyback converter. It can be used for high brightness LED lighting applications without requiring excessive complication and component count up and cost. Valley-Fill circuit is implemented for passive power factor correction for offline applications.Valley fill circuit it is not only to improve power factor, foremost fuctions of the valley fill circuit to reduce the output voltage ripples and THD% is reduced dramatically. Dimming circuit it has simple circuit configuration and it is widely used for dimming application by modulating the current amplitude of the parallel connected LED lamps, and frequently used to control lighting levels of human needs, also consumes energy. There are two types of dimming circuit 1) Analog dimming circuit 2) PWM dimming circuit .In analog dimming ,current through the LED string is adjusted to vary the brightness of the LED, while dimming color variation is the disadvantage of this method. To adjust the LED brightness without color over the full dimming range. 555 timer based dimming methods are widely used because of it is simple and high efficiency operation.

The control method employed inspired from a nonlinear control is called one cycle control. It makes use of feed forward control to achieve fast line regulation.In contrast with a feedback control, the feed forward control makes the conversion every switching cycle without dependence on the previous cycle, which enhance the efficiency of converter by reducing the power losses and it is a dynamic loss control technique. There are many conventional switching mode power supply converters were proposed earlier in order to control the converters. The converters are to be designed to work in both DCM and CCM modes of operation. In DCM operation at full load the losses will be more compared with the CCM operation ,so efficiency is affected . The most popular control methods of PFC are analog multiplier based, peak current control, hysteresis control, voltage follower, the main drawback of these methods is inductor current must be sensed and these technologies are not designed to operate at high frequencies.

PROPOSED VALLEY-FILL SEPIC TOPOLOGY WITH ONE CYCLE CONTROL (DIGITAL CONTROLLER).

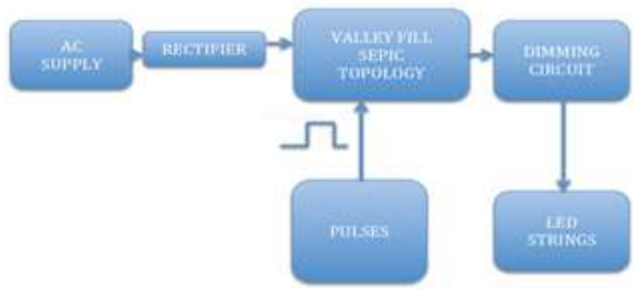

Fig 2. Block diagram of proposed valley fill SEPIC topology with OCC technique (Digital controller).

The figure 2 shows the block diagram of proposed valley fill SEPIC topology with one cycle control (OCC) technique.The harmonics,current ripples are reduced and power factor is improved when the converter is driven with the constant duty ratio by using the simple OCC technique. The OCC technique here done by the PIC 16F877a microcontroller and we can say the proposed valley fill SEPIC topology with digital controller. Objective of the OCC is to operate DC to DC converter in continous conduction mode (CCM) and the input current is controlled for every cycle.The feed forward control will make corrections every switching cycle without dependence on the previous cycle, to achieve fast line regulation. So the input current feedback is very fast,thus allowing this type control to be used for high frequency line (more than 400 Hz). Diode rectifiers are the front end for the all power factor correction topologies.The input 230V AC voltage is applied to the diode rectifier that converts AC to DC ,the problem in this diode rectifier is that it is a non linear device and it draws the non linear input. so here valley fill SEPIC topology used to modify the wave shape by removing current spikes of drawn by the load. The superior method of dimming the LEDs using the pulse width modulation (PWM) technique, with this technique LED bulbs can be driven with the recommended forward current and the dimming can be achieved by turning LEDs ON and OFF at high frequency.

PWM Dimming Control

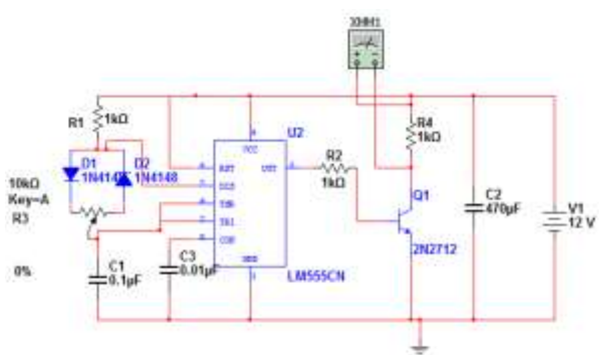

Fig.3. PWM Dimming Circuit

A PWM dimming control is employed as the second stage current regulator.The PIC16F877a microcontroller is used for the output changes its state continuously between high and low without any interventions .The PWM dimming circuit is shown in the fig 3.Potentiometer operates within a duty cycle range of 10% - 90% as the potentiometer is varied. When the potentiometer is adjusted to the minimum position (10%), the obtained output voltage is 11.09 Volts. During this period, the brightness of the LED will be more. If the potentiometer is adjusted to the maximum position (100%), the obtained output voltage is 1.36 Volts. During this period, the brightness of the LED will be less.

One Cycle Control by digital controller (PIC 16F877a microcontroller)

This control method employed inspired from the non linear control called one cycle control. It makes use of feed forward control to achieve fast line regulation. In contrast with a feedback control, the feed forward control will make corrections every switching cycle without dependence on the previous cycles these all are done by using PIC 16F877a microcontroller thus it providing an unconditionally stable and robust design. PIC 16F877 is one of the most advanced microcontroller from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices, study purpose, and it is operated Maximum operating frequency is 20MHz.

To enhance the efficiency of the converter ,by reducing power losses in a power stage and it is a dynamic loss control technique.

The full bridge diode rectifier, which converts the input AC voltage to DC voltage and its input and output voltages were measured using the multimeter.

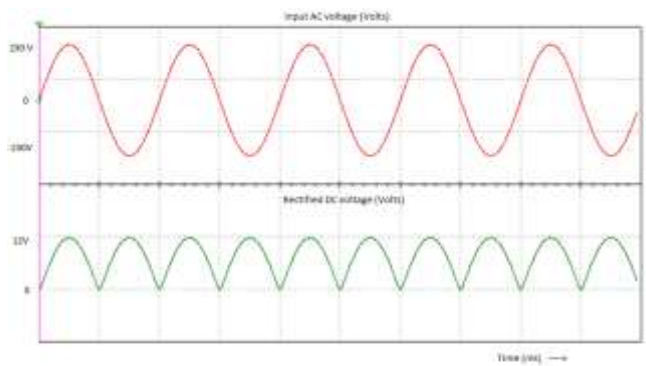

Fig.4. Input and Output Voltage waveform of Diode Rectifier.

In this, a transformer is used to step down the voltage from 230V to 12V In this, a transformer is used to step down the voltage from 230V to 12V. Fig.4 shows the input and output voltage waveforms of the front end diode rectifier.

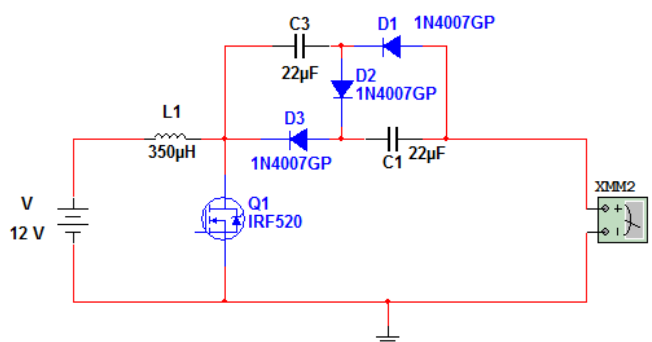

Fig 5 Schematic circuit Valley Fill SEPIC topology.

The valley fill circuit for the passive power factor correction purposes it has a basic full bridge diode rectifier which converts the ac input to dc voltage and this circuit it is not only to improve the input power factor, the foremost fuctions of valley fill circuit it reduces the output voltage ripples and THD% is reduced dramatically. The valley fill

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SEPIC topology schematic circuit shown in the Fig 5,and this topology is very suitable for dc power conversion for high brightness white LED lighting for commercial, residential and industry applications.

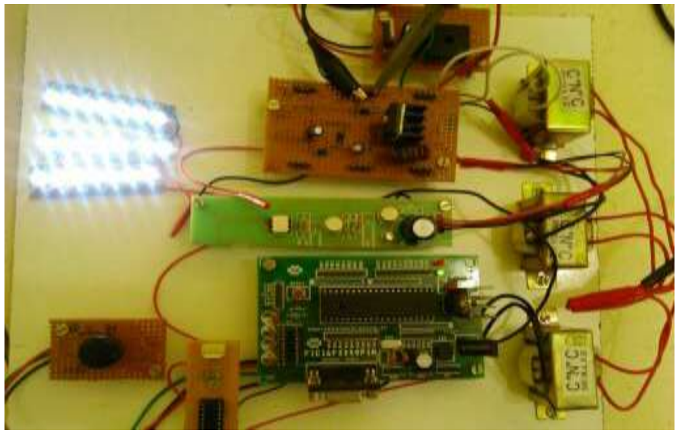

Fig 6 When the potentiometer the minimum duty cycle .

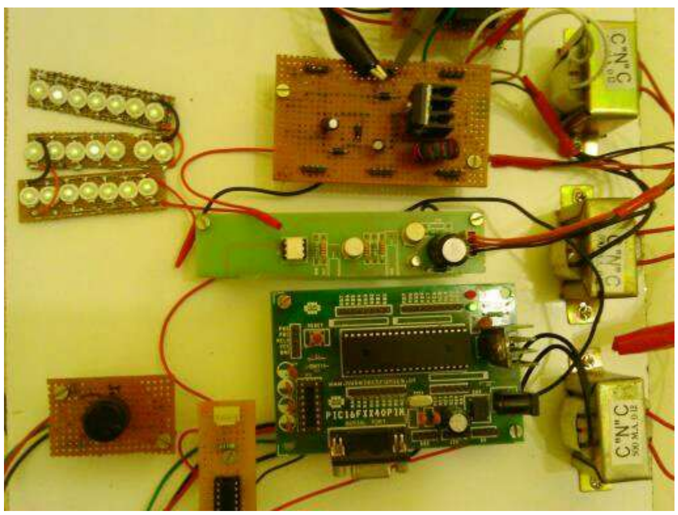

Fig 7 When potentiometer is at the maximum duty cycle .

The fig.6and fig.7 shows the brightness of LEDs when potentiometers at minimum and maximum duty cycle.

COMPARISION OF RESULTS OBTAINED

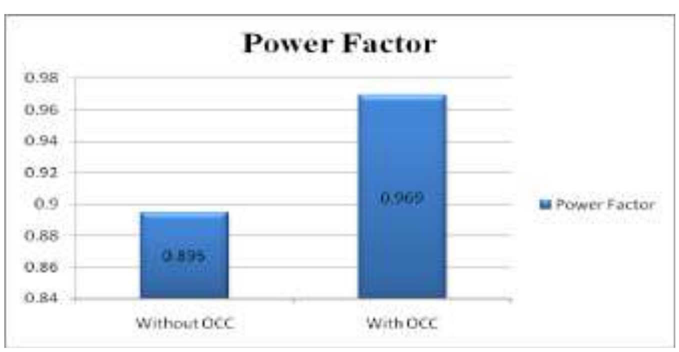

Fig.8 . Improved Power [2].

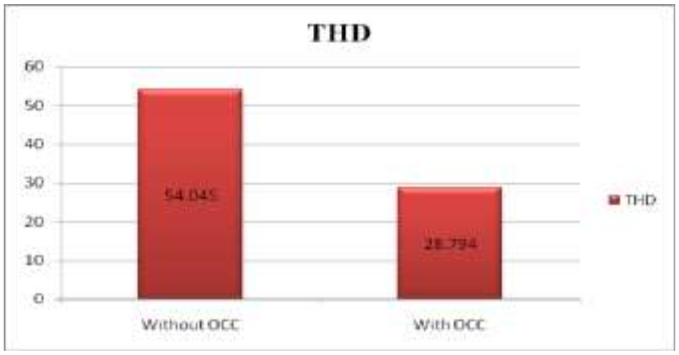

Fig 9 Reduction in THD [2].

In the above chart, the comparison of the power factor and the total harmonic distortion for the proposed system with and without the one cycle control technique is shown in Fig 8 and fig 9 respectively. From this the proposed topology is more efficient when the Valley-Fill SEPIC PFC topology is controlled using the digital controller.

By reducing the total hormonic distortion improve efficiency and hardware designed for the different power levels. Fig 10 shows the power factor and efficiency for different power levels.In the future the brightness of LED lights can be controlled automatically using the photo diode instead of potentiometer.

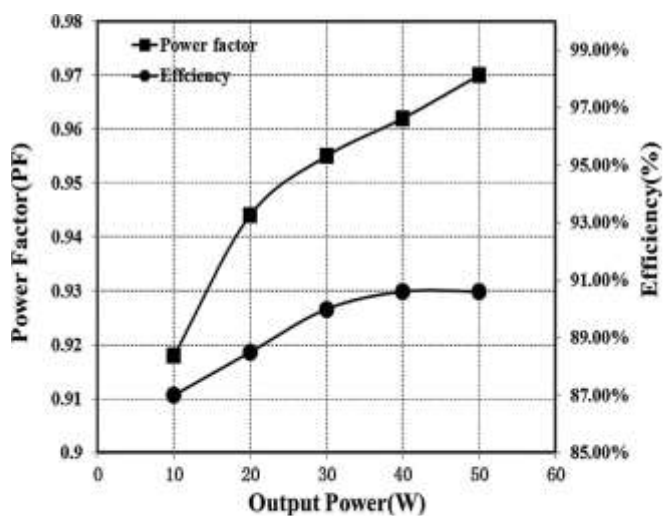

Fig 10 Power Factor and efficiency against different power levels [11].

CONCLUSION

In this paper, the proposed Valley-Fill SEPIC topology for the power factor factor correction for the LED lighting applications using OCC technique by digital controller (PIC16F877a microcontroller) has been presented .power factor is closer to the unity and by reducing the THD% efficiency can improve for designed different power levels, handle high power with reduced number of component count up. This topology contains only passive components and also there is no need of using any controlled power switches and no auxiliary power supply.The advantages of proposed topology are small size ,one stage of power conversion, less cost and simple feed back control and can be use to drive a wide number of high brightness of LEDs adusted according to the industrial or commercial lighting applications.

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