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# A FULLY INTEGRATED THREE LEVEL ISOLATED SINGLE STAGEAC-DC POWER FACTOR CORRECTION CONVERTER

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**Abstract**
Many researchers are focusing towards single stage multilevel topologies to achieve the low cost isolated ac-dc PFC converters for high voltage dc link. This paper presents an innovative single stage three level ac-dc power factor correction (PFC) converter for high dc link voltage. The objective of this work is achieved by combining the operation of ac-dc and dc-dc stages effectively, where the semiconductor switches are shared between two functions.With the help of proposed switching scheme and converter, the output voltage regulation and shaping of input current can be attained without inclusion of any extra device or switching operations. In discontinuous conduction mode the centre two switches are triggered on under zero current and switches at the top and bottom are triggeredon under zero voltage. Since the dc link voltage structure is flexible one, for high value of line voltages the obtained power factor is also high.
*Keywords: Power factor correction (PFC), Discontinuous conduction mode, dc link voltage, Conveters*

## 1. Introduction

The capacity of the transmission line can be utilized maximum and grid quality also can increase by operating the ac/dc power converter with higher power factor and minimum total harmonics distortion. In conventional PFC circuits to achieve high power factor at low efficiency PFC converters carry capacitive filters and inductive filters next to Diode Bridge. They need only less line frequency filters which are cumbersome and overwhelming.

In this structure, a first stage ac/dc PFC converter is worked with a switching frequency in the range of tenths to a few hundred kHz for converters made up of Si semiconductors, and from a few many kHz to tenths of MHz with wide-band crevice devices, to make the shape of the input current near sinusoidal waveform in phase with the grid voltage. The second stage dc/dc converter gives the galvanic separation and yield voltage control. The controllers of thetwo stages are totally independent.The adaptability in control permits enhancing power stages, quick yield voltageregulation and working with high PF and low THD. But due to extra components and big size this method is expensive. In addition the efficiency of the converter has become low at light load condition because of constant switching losses like parasitic capacitance losses. To reduce the cost of the system the number of switches involved in ac/dc converter. The capacitor or inductor unit placed between two stages will act as a power buffer. Numbers of PFC ac/dc single stage technologies have been discussed in literature, especially in PFC converter with discontinuous conduction mode. These are mainly focussed towards the low power appliances, where to produce sinusoidal input current waveform and for voltage regulation a flyback converter is used. Even though they give solution for low cost device, the voltage current stresses on the switching device are more. So these converters are applicable for low power ranges less than 200 W. Appliances which operates at medium or high power, more research works focused towards ac/dc single stage full bridge (SSFB) converters. There are two types of SSFB converters, one is Current fed SSFB and the other one is Voltage fed SSFB. In current fed SSFB to shape up the current one inductor has

been employed in the input side of diode bridge and power factor is high. Since there is no dc bus capacitor on the primary side of the transformer, overshoots occur in the dc bus voltage. This drawback is not occurred in Voltage fed SSFB, because of the capacitor connected on the primary side. The proposed methodology give solution and give maximum efficiency for low input voltage.

## 2.Three-Level Isolated Single-Stage PFC AC–DC Converter

A new single stage three level ac-dc power factor correction (PFC) converter for high dc link voltage. The objective of this work is achieved by combining the operation of ac-dc and dc-dc stages effectively, where the semiconductor switches are shared between two functions. With the help of proposed switching scheme and converter, the output voltage regulation and shaping of input current can be attained without inclusion of any extra device or switching operations. The converter proposed in this paper is an incorporation of a boost PFC converter circuit and 3 level isolated dc-dc converter. Here, a diode bridge rectifier with an inductor is connected with the 3 level dc-dc converter. In conventional scheme the duty ratio of switches are fixed and are nearly equal to 50%.

The figure 1 shows the proposed fully integrated 3 level single stage isolated ac-dc converter and switches. A linear transformer receives supply from the switches and is connected to rectifier circuit to give dc supply to the load. The inductor connected at the input side is discontinuous and the switches S2 and S3 are switched at regular duty cycle. Now the power factor is high. The DC link voltage oscillates a little with refer to the input frequency i.e. two times of input frequency. The transformer primary receives only zero voltage when the centre switches are triggered. The transformer receives 50% of the dc link voltage when S1 or S4 is triggered on with one switch in the middle. Meanwhile the accumulated energy in the inductor is transmitted to the dc link. In the overlap conduction period of switches there will be a reduction in input current of inductor under the output voltage.

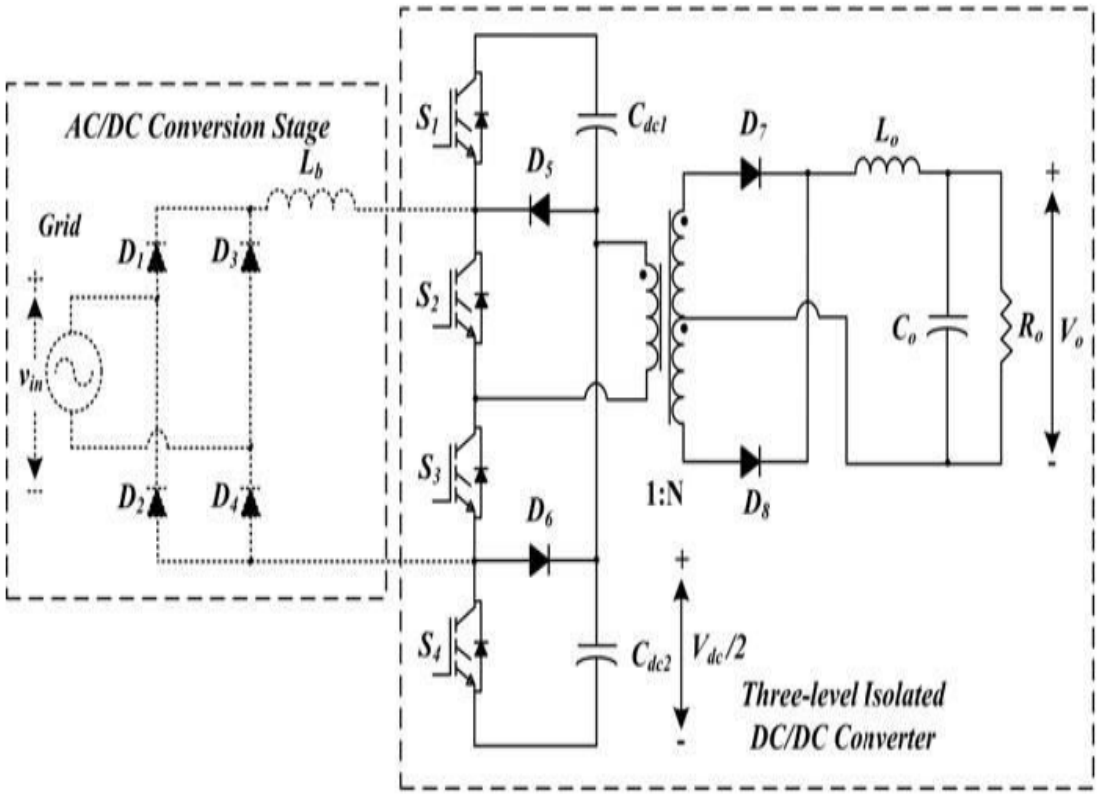


Fig 1 Proposed fully integrated three-level Isolated single-stage PFC ac–dc Converter

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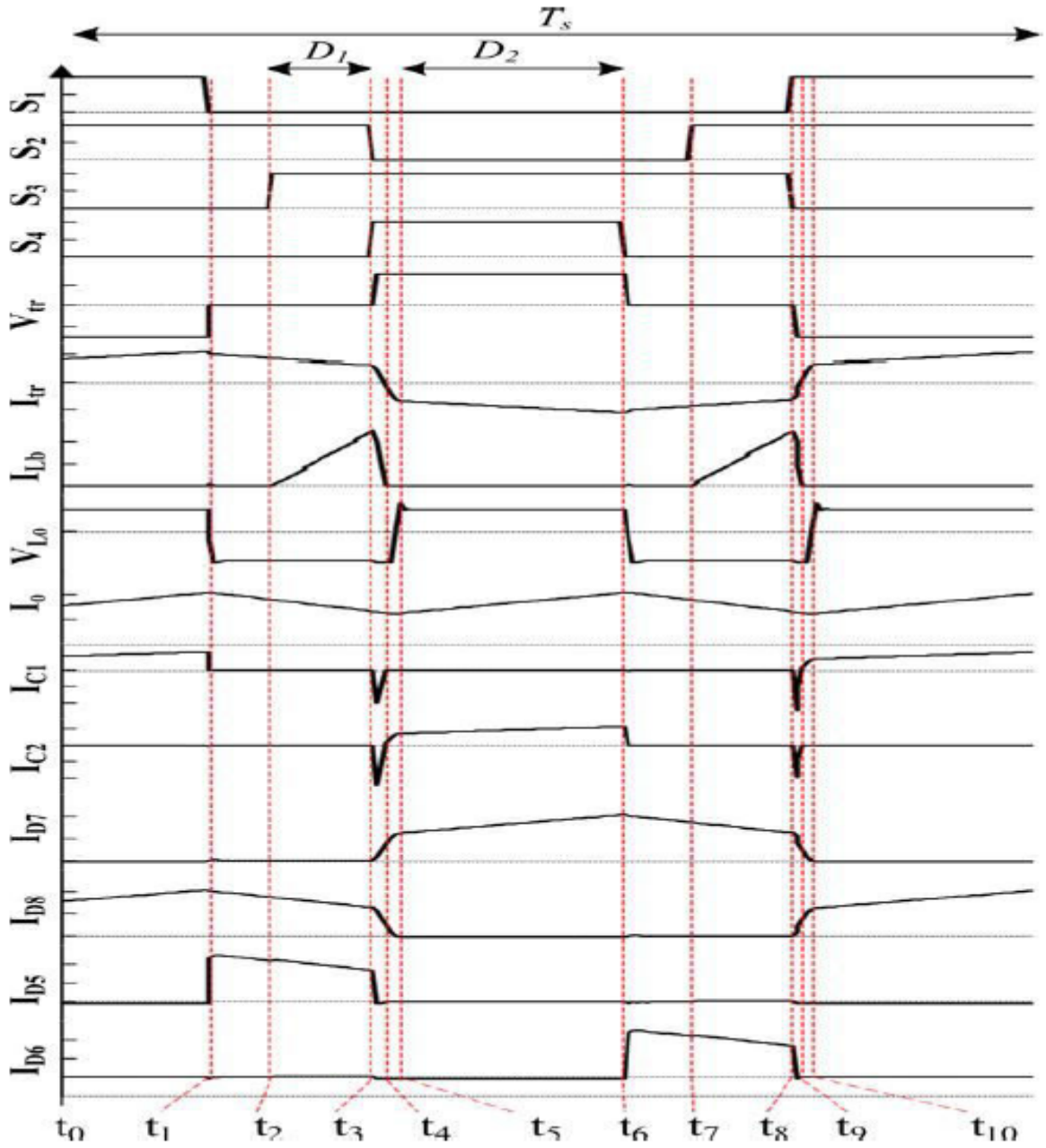


Fig 2 Modes of Operation Waveform

The current flows through the output inductor increases with the voltage Vdc/2*N* – Vo where S1 or S4 triggered with S2 or S3. Figure 1 gives the cicuit diagram of the single stage 3 level ac-dc converter, which integrates ac-dc converter and dc-dc converter in a single circuit. The load is connected across the second stage. The operating frequency of the circuit is high and in turn it increases the size of the circuit. To decrease the circuit size high frequency two stage power factor correction converters has been proposed here. A capacitor or inductor which acts as an energy storage device is sandwiched between two stages. When the switches S2 and S3 are triggered the inductor is getting charged. The duty ratio is taken as 50% to assure either top three or bottom three switches turned on at time which causes short circuit via dc link capacitors and make the control as simpler one. In between the switching on time of S1 and off time of S3 a gap or dead time should

be included to avoid short circuit. And the same thing should be followed for S2 and S4 also.

## 3.Simulation Diagram

The proposed workwas simulated by using MATLAB/SIMULINK software. Figure 3 gives the SIMULINK model of the circuit. Here the input supply was kept as 48V which is given to the Bridge rectifier and the input side inductor is connected as shown in figure. The output across it can be seen through a scope. The switches (MOSFET) are connected in such a way to produce AC voltage and given to the linear transformer through the diodes (D5,D6). The resistive load is connected across the output side and output can be seen with the help of scope.

## 4. Result and Discussion

For a input supply of 48V two split capacitors are connected to the dc link. The value of the capacitor at the output side is kept as 100 μF. The turns ratio of the linear transformer is taken as 1:2. The MOSFET power switches are linked to the diode bridge rectifier. The output waveform is shown in the figure 5.
The scopes gives the relation between output power and efficiency. At low power less than 50 watts the efficiency is less and for appliances with 100 watts the efficiency is nearly 84%. After 150 watts the increase in efficiency takes place very slowly and at 500 watts output the efficiency is nearly 91%.

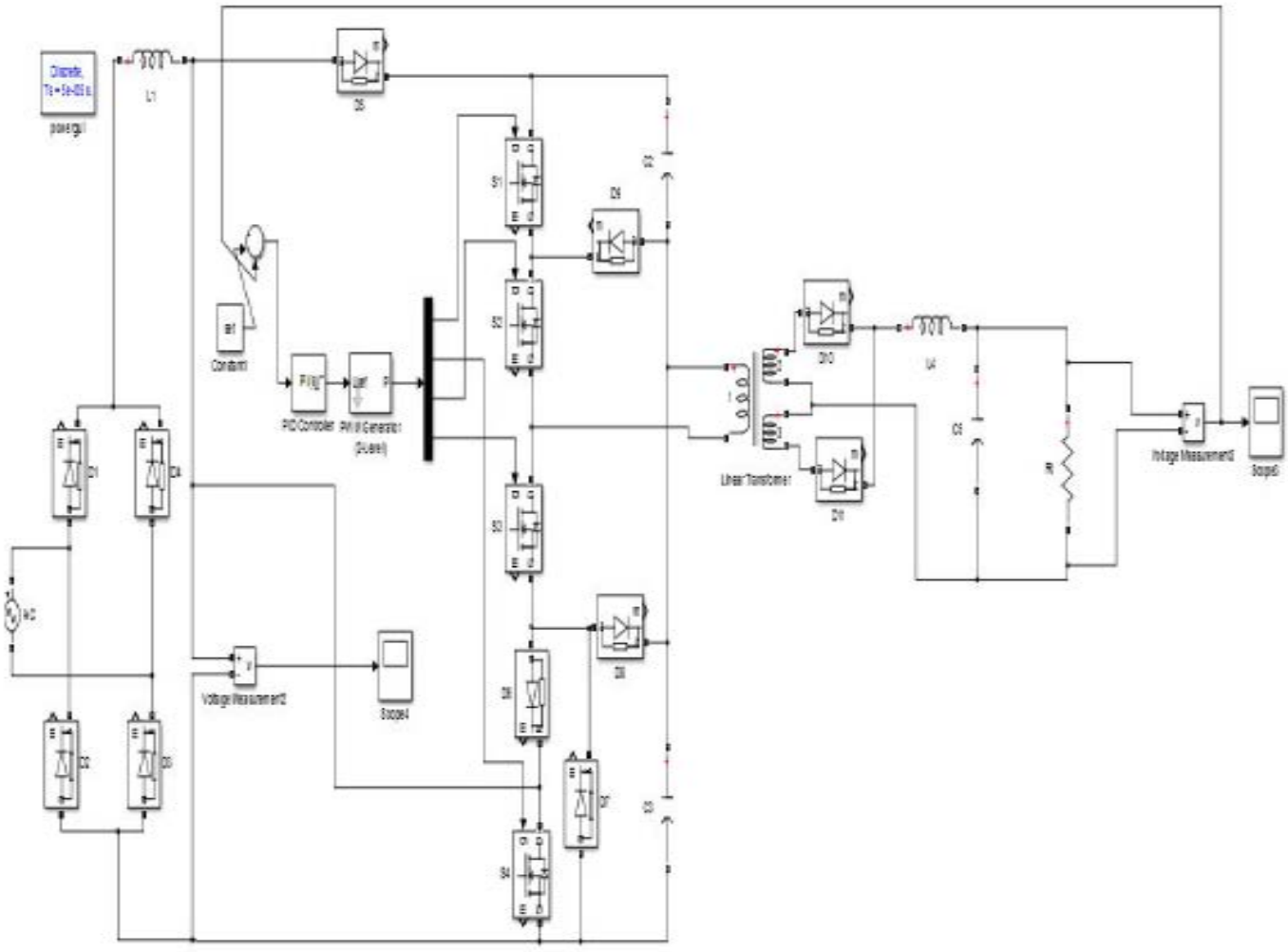

Fig 3 Simulation Diagram of Three Level Single Stage AC-DC Converter

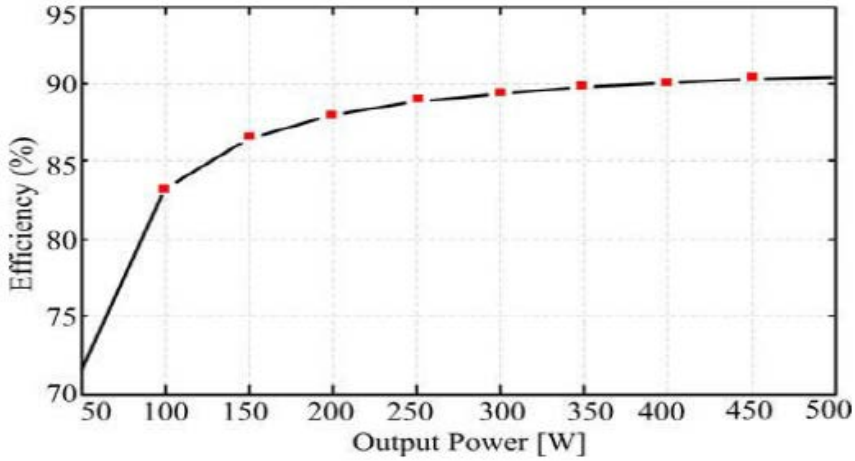


Fig 4 Output Power Vs Efficiency

## 5. Conclusion

This paper discussed about the performance of fully integrated three level integrated single stage ac-dc converter. Without including any additional devices high power factor can be achieved for low power appliances. It incorporates two circuits, ac/dc converter and dc/dc converter. For ac to dc conversion diode bridge rectifier circuit is used and for dc to dc converter MOSFET devices working in DCM is used. The simulation diagram of the proposed system is discussed in the paper. The waveform shows the performance of the fully integrated three level integrated single stage ac-dc converter.

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