ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Simulation study of single stage multilevel full bridge converter

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ABSTRACT

A new single stage rectifier with three phase system is proposed in this paper. The main features of the proposed rectifier are that it can generate input current that does not have neutral zone and an output current that can be incessant when the converter is operating from maximum load to at least half of the load. Each new converter has a design procedure is demonstrated with an example that was used in the execution of an experimental prototype. The feasibility of the conventional converter has been recognized.

KEYWORDS: Dc-Dc Converter, Ac-Dc Converter.

1. INTRODUCTION

A modern conventional three phase ac-dc converter falls into two converter stages. One is six switch front end dc-dc converter to do power factor correction and another one is four switches full bridge converter to do dc-dc conversion. The front end dc-dc converters to perform some operations that is it able to converts the input ac voltage into a transitional dc bus voltage. And shapes the three phase input current so that they are nearly sinusoidal which is in phase with the three phase input voltage. And in this approach it will allow the ac power source which can be used in a most efficient manner. It Is Very Expensive And Complicated As It Needs Ten Active Switches Along With Associated Gate Drive And Control Circuitry. Moreover, The Front End dc-dc converter require sensing of certain key parameters such as the input current and voltages that must be operated with difficult control methods. For these situations the pulse width modulation techniques can be used. The power electronic researches try to reduce the number of switches in proposed system of the converter that can be used in the two- stage conventional approach in order to reduce cost and simplify the overall AC-DC converter. Proposed alternatives have included: 1) using three separate ac –dc boost converter modules; and 2) using ac-dc converter with reduced switch; 3) using a boost converter with single switch to perform the three-phase ac-dc power conversion with transformer isolation.

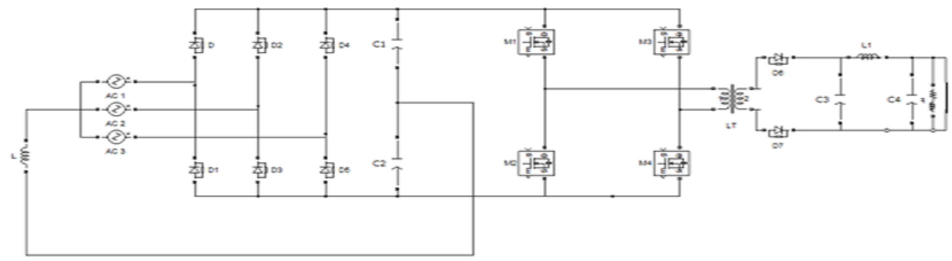

Figure.1.Three phase single stage ac-dc converter

Researchers tried to reduce the cost and complexity connected with single-phase and three phase ac-dc power conversion. PFC can be used and isolated the dc-dc conversion in a single stage power converter. The examples of three-phase single-stage converters are shown in Fig. In the Previous paper a three-phase single- stage ac-dc converters has been used. It has following drawbacks that have limited their widespread use.

1. They are three separate ac-dc single-stage modules were implemented.
2. Converters components are exposed to very high dc bus voltages hence a very high rating of switches and bulk capacitors are needed. The Input currents are indefinite by using power converters to minimize the harmonic generated. The power factor correction techniques have been used. And it contains a low-frequency harmonics because the converter has difficulty to performing dc-dc conversion and power factor correction at the same time.
3. The conventional front end converters used a quasi-resonant technique to reduce switching losses.
4. The output of the inductor must be very low, which makes the output current to be alternating. Then the output ripple is very high in the result. That the resultant diodes with peak current ratings and large output filter capacitor so the ripple is required.

The most common type of single-stage ac–dc full-bridge converter is based on some kind of voltage-fed single-stage pulse width modulation (PWM) converter. This type of converters has a primary-side a large energy storage capacitor of dc bus. They do not have the drawbacks of quasi resonant and current-fed SSPFC converters. They operate with permanent switching frequency, and the bus capacitor prevents voltage overshoots and humming from appearing across the dc bus and the 120-Hz ac component from appearing at the output.

Circuit description: The proposed converters uses semiconductors switches (eg: IGBT) and passive power semiconductors (eg: diode) and passive element (eg: inductor and capacitors) are given in a circuit to convert power from source to load. The power source is three phase with line frequency 50, 60 or 400hz and may or may not needed separation from the power source.

AC-DC power converter connected to the main voltage can generate and current harmonics can be injected into the function mains. The power converters and Power Factor Correction techniques is used to reduce the harmonics.

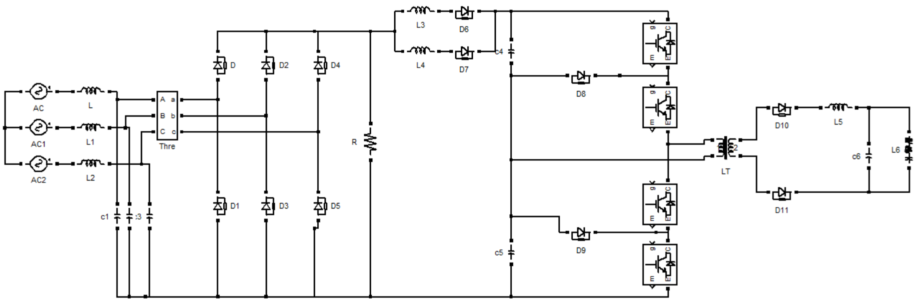

Figure.2.Proposed converter of three phase single stage ac to dc converter

Converter operation: The basic principle at the back the proposed converter is that it uses converter transformer which consist of auxiliary winding to cancel the capacitor voltage of dc bus. That the voltage will appears transversely the output of Diode Bridge is zero. There is voltage which is passes into the main transformer winding and the input inductors has a current it will rises the voltage cancellation will be occurred when it does. When there is no voltage across the main transformer primary winding, the dc bus capacitors has total output voltage appears at the output of the diode bridge; since this voltage is higher than the input voltage, the input currents falls down. If the input currents are alternating, they will be sinusoidal and in phase with the input voltages The design of a three-phase single-stage converter is difficult because the converter must simultaneously performing both PFC and DC-DC conversion over the entire load and input range with only a single controller and without using additional input current sensing and DC bus voltage control. As a result, relatively little research has been successfully. The main focus of the research in this paper has been on three phase AC-DC power converter.

Modes of operation: Mode 1 ($t_0 < t < t_1$) At the beginning t_0 switches S_1 and S_2 is turned. Note that the current increases from zero. And energy get from DC bus capacitor C_1 is transfer to the output load. Since the auxiliary winding will produce an output voltage that is equal to the total DC-link capacitor voltage (sum of C_1 and C_2). Hence capacitor voltage starts reducing towards zero and the input inductor current starts rising, then the voltage across the inductor is the rectified supply voltage. The switch T1 is turned off at zero current. And hence there is no switching losses. The Figure.5 shows the operation of the new converter during Mode1.

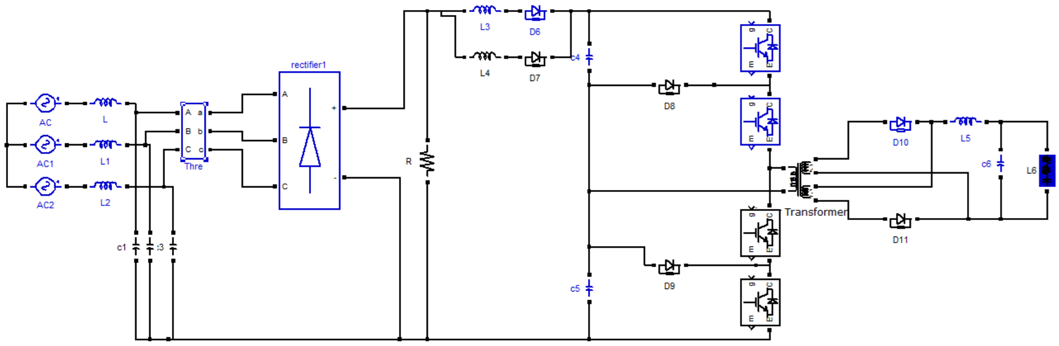

Figure.3.Mode 1 from (t0<t<t1)

Mode 2($t_1 < t < t_2$): At time t_2, switches S_1 is OFF and S_2 turned ON. Capacitor C_{s1} charges and capacitor C_{s4} discharges through C_f until C_{s4}, the output capacitance of S_4, clamps to zero. This mode ends when S_4 turns on with zero-voltage switching (ZVS).The energy stored in the input inductor during the previous mode starts to be transferred into the DC-link capacitors. The Figure.6 shows the operation of the new converter during Mode1.

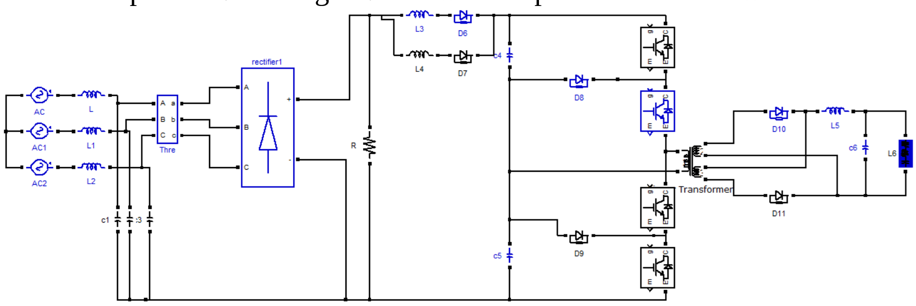

Figure.4.Mode 2 from (t1<t<t2)

Mode 3 ($t_2 < t < t_3$): In Mode 3, S_1 is OFF and S_2 remains ON. The energy stored in the input inductor L_{in} during Mode 1is completely transferred into the DC-link capacitors. The amount of stored energy in the input inductor L_{in} depends upon the rectified supply voltage. This mode ends when the input inductor current reaches zero. Also, during this mode, the load inductor current freewheels in the secondary of the transformer. The Figure.7 shows the operation of the proposed converter during Mode.

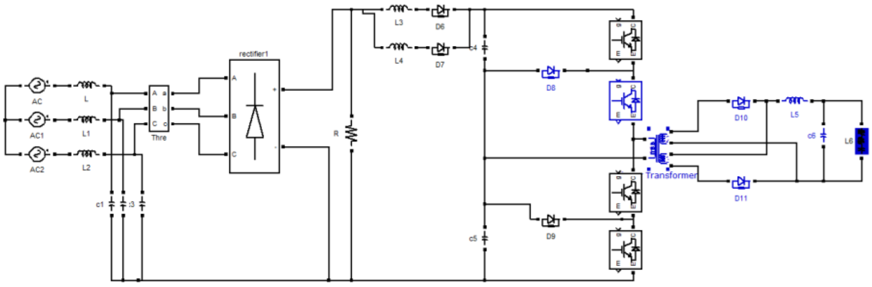

Figure.5.Mode 3 from (t2<t<t3)

Mode 4 ($t_3 < t < t_4$): At time t_3 switch S_1 is OFF, the primary current of the main transformer circulates through diode D_1 and switch S_2, and the load inductor current freewheels in the secondary of the transformer. The Figure.8 shows the operation of the new converter during Mode 4.C2 through the body diode of S_3 and switch S_4. This mode ends when switches S_3 and S_4 are switched on and a symmetrical period begins. In this mode, the load inductor current continues to transfer energy from the input to the output. The Figure.9 shows the operation of the proposed converter during Mode 5.

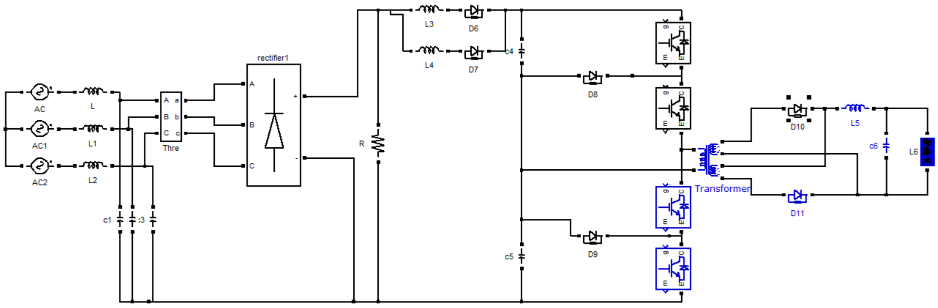

Figure.6.Mode 4 from (t3<t<t4)

Experimental results and proposed system: An experimental prototype consist of proposed converter was built to verify its feasibility. According to the following specifications the prototype was designed.

Input voltage Vin=208

Output voltage Vo=48v

Output power Po=1.5KW switching

Frequency fSW=50HZ

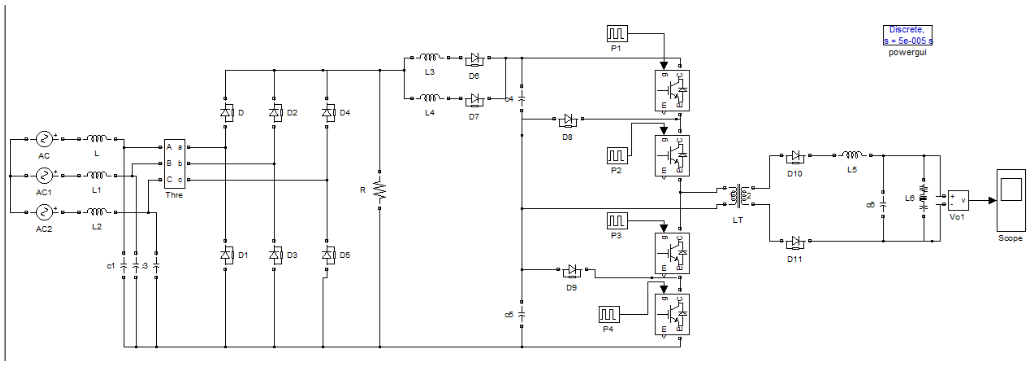

Figure.7.Simulation diagram

The proposed converter is similar to that of previous conventional converter were presented in the project. In order to reduce the voltage stress across the MOSFET switches the capacitor C_f is added between the clamping diode and the snubber capacitors. The Power Factor Measurement circuit is similar to the circuit which was discussed in the previous chapter. Based on the PS-PWM technique the gate pulse produced by converter. The PS-PWM is an efficient technique used for voltage controlled multilevel inverter. PS-PWM is a carrier based PWM which uses multiple carrier. Assume for an M-level inverter the PS-PWM technique requires (M-1) no of carrier and the carrier is shifted by (360/M-1). By considering this for three level output the PS-PWM requires 2 carrier signal each shifted by 180º. Here the triangular signal is used as a carrier signal hence after shifting it remains the same i.e single carrier is enough to produce three level output. The reference signal is compared with the actual signal to produce error signal and fed to the PI controller. The PI controller output is compared with the carrier signal in the relational operator to produce gate pulse.

The resulting waveforms for the proposed converter is discussed in this section. The supply voltage and current of the conventional converter is shown in the Figure.8. The input current is discontinuous and the input voltage is sinusoidal in nature. The current and the voltage are in phase with each other. The magnitude of the voltage is 230VAC.the magnitude of the current is 0.6A AC. The three level supply voltages are obtained similar to the conventional converter. The voltage produced by the auxiliary winding is used to cancel the excess voltage in the capacitors (C_1&C_2). The primary voltage of the transformer is shown in Figure 12. The proposed converter has better power factor correction compared to the conventional converter for low power application. The proposed converter maintained a power factor of 0.99 for 20W RL load conventional converter due its open loop control. The proposed converter implements the closed loop control using PS-PWM technique. Hence variable DC voltage (0-100V DC) is possible in the conventional converter. Due to the closed loop control little distortion is occur at the output of the proposed converter.

Table.1.Comparison of the converter for various load level

Input voltage	Load current	Load voltage	Load	Pf
230V AC	0.05	25V DC	RL	0.95
230V AC	0.1	50V DC	RL	0.999
230V AC	0.15	75V DC	RL	0.995
230V AC	0.2	100V DC	RL	0.988

The proposed SSPFC AC/DC Converter simulated is able to provide any desired voltage between (0-100 V DC) with improved power factor at the supply side. The Table.3 shows the simulation parameters for the conventional and proposed system. The efficiency measured from the converter at light load was about 93%and for full load was 91%.

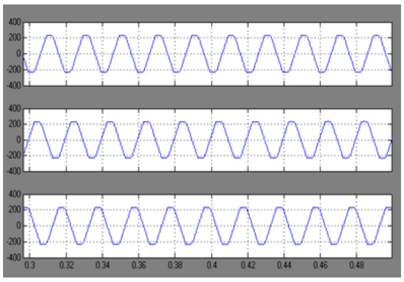
Figure.8.Phase voltage waveforms

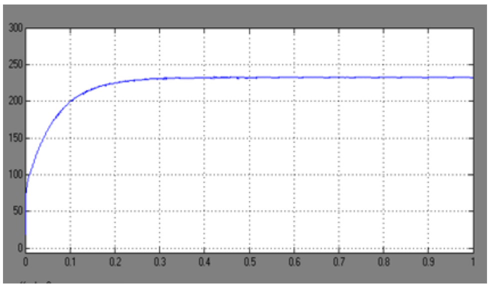
Figure.9.Rectifier output voltage

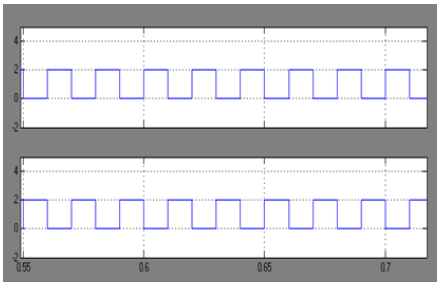
Figure.10.Switching Pulses applied to S1 and S2

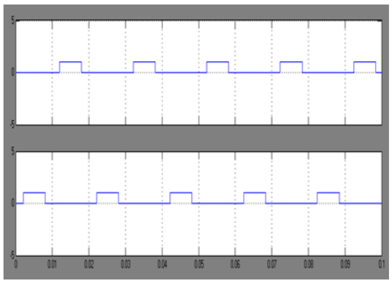
Figure.11.Switching pulses applied to S3 &S4

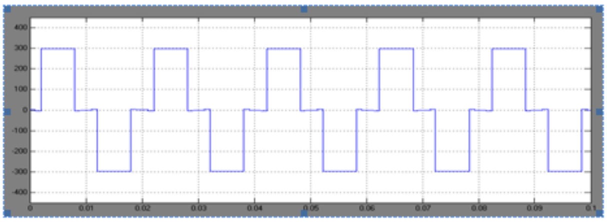
Figure.12.Primary voltage of the main transformer

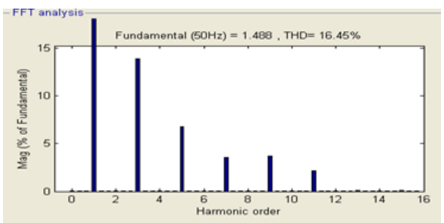

Figure.13.FFT Analysis of Input current harmonics at Vin =220 Volt

2. CONCLUSION

For the single-stage multilevel type full-bridge converter for closed loop control was developed in the proposed converter. In this paper a single phase SSPFC AC/DC converter that operates with a single controller to regulate the output voltage was presented. This converter has capacitor voltage can be cancelled out in the auxiliary circuit and the input inductor act as a single stage PFC is included in the boost converter. The outstanding features of the rectifier it can produce input currents that do not have neutral regions (sometimes called as dead zone) .There is no action will occurs in the single domain (the system is dead)output is zero. Voltage regulator used in the dead band region. And an output current that can be continuous when the converter is operating from maximum load to at least half of the load. The converter can operate with lower peak voltage stresses across the switches and the DC bus capacitors as it is a three-level converter. This converter provides variable output voltage with improved power factor. This allows for greater improved power factor. This allows for greater flexibility in the design of the converter and ultimately improved performance. The proposed output inductor can be designed to work in CCM mode over a wide range of load variation. This result in a lower current ripple found in other two-level single –stage converter and lower peak current stresses for the secondary components.

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