



IJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: VI Month of publication: June 2017

DOI:

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AC-DC Converter with Flying Capacitor Using Three Phase Single Stage PFC & PWM

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Abstract: Today the wide usage of non linear loads like variable speed drives has made power factor improvement difficult due to the presence of harmonic currents. These harmonics cause overheating, and the amplification of these harmonics cause failure or damage of Capacitors and other system components. Thus this paper presents a new integrated AC-DC converter with single stage power factor correction with flying Capacitor. Due to the interleaved structure, the proposed converter operates at lower input ripple current and has improved load efficiency along with peak switch currents and soft switch operation. The convertor has improved efficiency and due to single stage 3 level AC-DC converter it has voltage regulation along with power factor correction. This proposed converter is stimulated in the MATLAB software and the design and performance is further studied and analyzed.

Keywords: AC-DC converter, PFC, PWM, SMPS, Matlab

I. INTRODUCTION

With the continuous research and development in the field of semiconductor and power electronics, design and circuit improvements have been made for superior performance, be it by the use of PWM, VSD etc. Inverters and converters have also gained researchers popular interests. A 3 phase voltage source inverter gives out variable voltage and frequency to AC drives. Series and parallel connections are important to get certain current and voltage ratings. Nowadays, multilevel inverters are used because of its better harmonic spectrum and voltage ratings. With increasing use of electrical equipment's, power converter manufacturers have implemented a form of PFC- power factor correction According to the harmonic standards of IEC 1000-3-2. The power converters have high power factor and low input current harmonics as its performance criteria. The power factor correction is broadly of 2 types- Active power factor correction technique and Passive power factor correction technique. In passive PFC, an LC filter is used. This technique is simple but results in heavy and bulky converters as low frequency L and C used are bulky in size and structure. In Active PFC the input current is made in phase with the input voltage by the use of SMPS switched mode power supply technique. In this Active PFC, unity power factor is Achieved along with reduced harmonics, light weight and smaller size but has the drawback of relative complexity and higher cost. Active PFC has two stage scheme, that is it has independent 2 power stages cascaded with PFC stage and DC-DC converter, with a pre regulator for obtaining intermediate DC from sinusoidal input and DC-DC converter gives the desired output voltage but this 2 stage switch mode makes the converter more complex and costly. Hence single stage PFC converters are used as they are comparatively cheaper and simpler than the former. Three phase Single stage PFC converters are preferred for high power applications and systems. This paper deals with a 3 phase single stage PFC converter that generates DC voltage from the input AC with the use of flying Capacitor structure and phase shifted PWM. The analysis of this project is done in Matlab software with the stimulation outputs and graphs for studying the characteristics.

II. CONVERTER TOPOLOGY

The figure below shows the three phase three stage power factor correction AC-DC converter which has the disadvantage of increased complexity and cost.

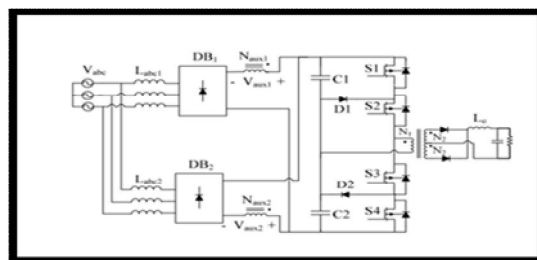


Figure 1- 3phase 3 level PFC AC-DC converter

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We have proposed three phase single stage power factor correction AC-DC converter as it is less complex and less costly compared to above 3 staged PFC.

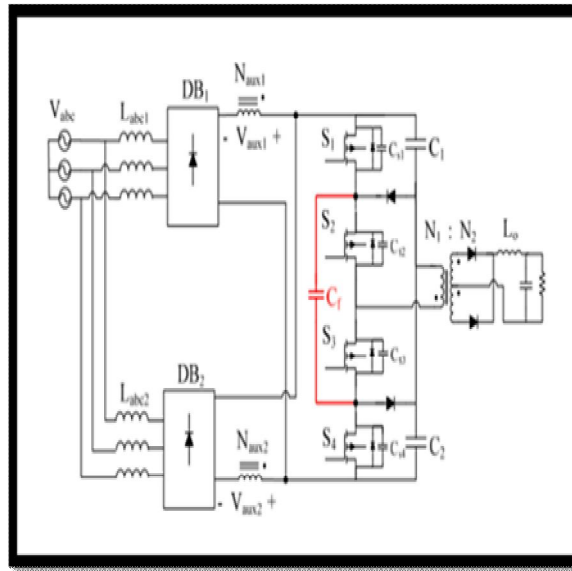


Figure 2- 3phase 1 stage PFC AC-DC converter

The single stage 3 phase AC-DC converter uses auxiliary windings that act as magnetic switches to cancel the DC bus capacitor voltage to make zero voltage at the output of diode bridge. Auxiliary winding 1 cancels DC bus voltage during the positive cycle of input voltage and makes input inductor currents I_{a1} , I_{b1} and I_{c1} to rise while the auxiliary winding 2 cancels DC bus voltage during the negative cycle of input/primary voltage and current I_{a2} , I_{b2} and I_{c2} rises. The total voltage across the DC bus capacitors appears at the output of the diode bridges when voltage across main transformer is zero while the input currents fall. The discontinuous input currents have sinusoidal envelope, in phase with input voltage. The converter works in 5 different modes of operation during a half switching cycle. The different modes of working are shown in the figure below.

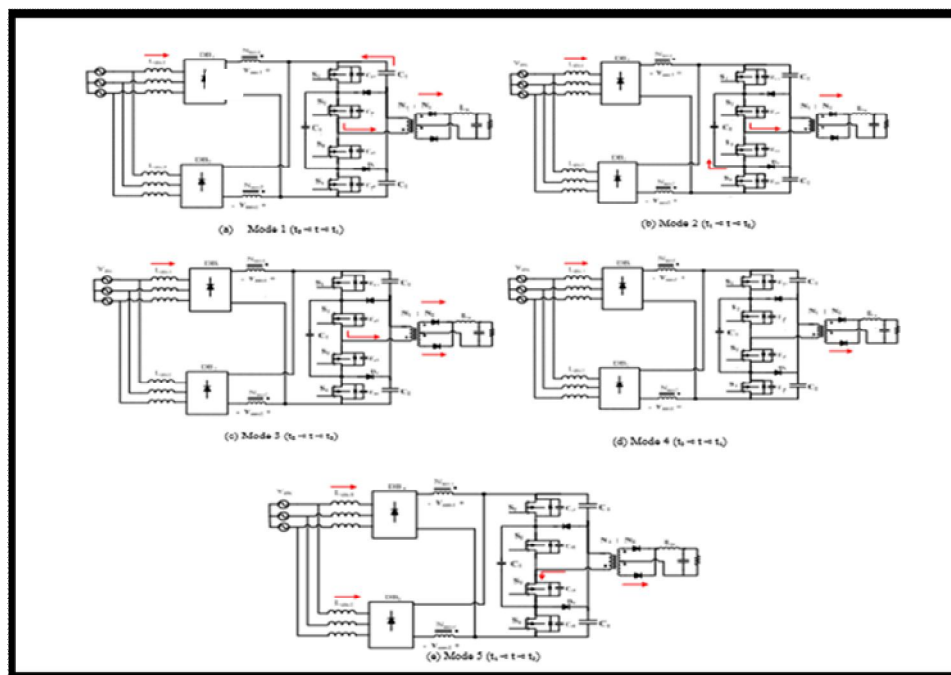


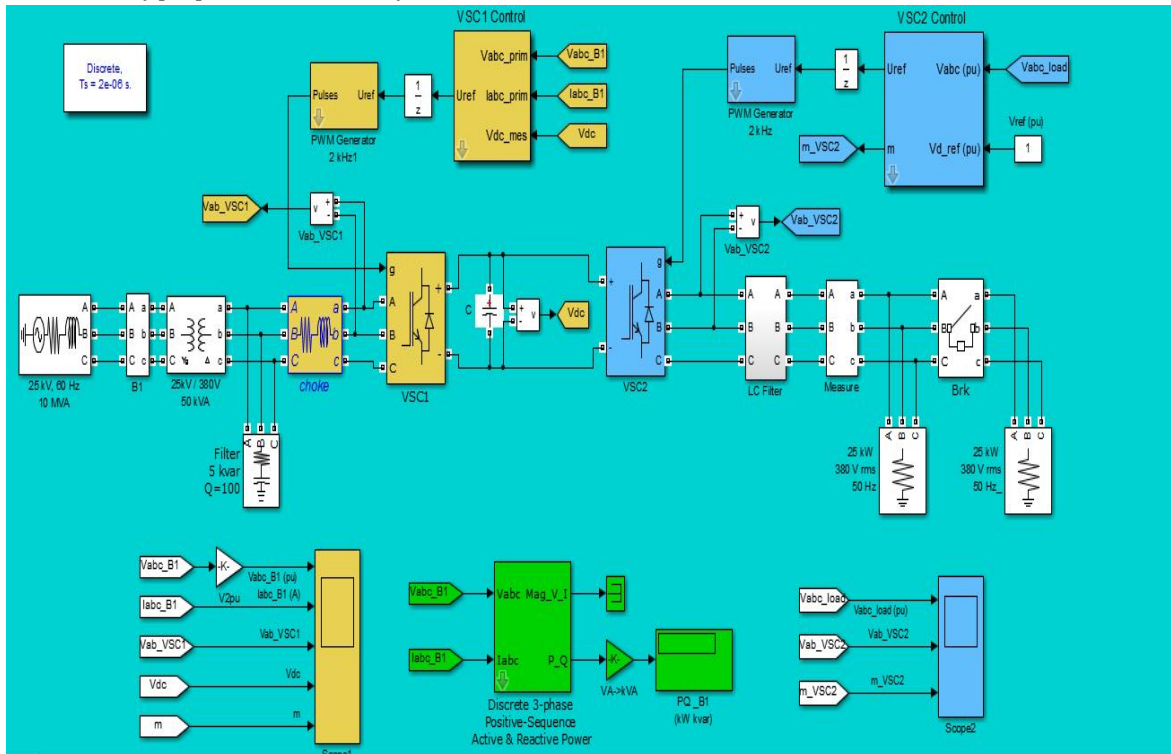
Figure 3 – Different modes of AC-DC converter

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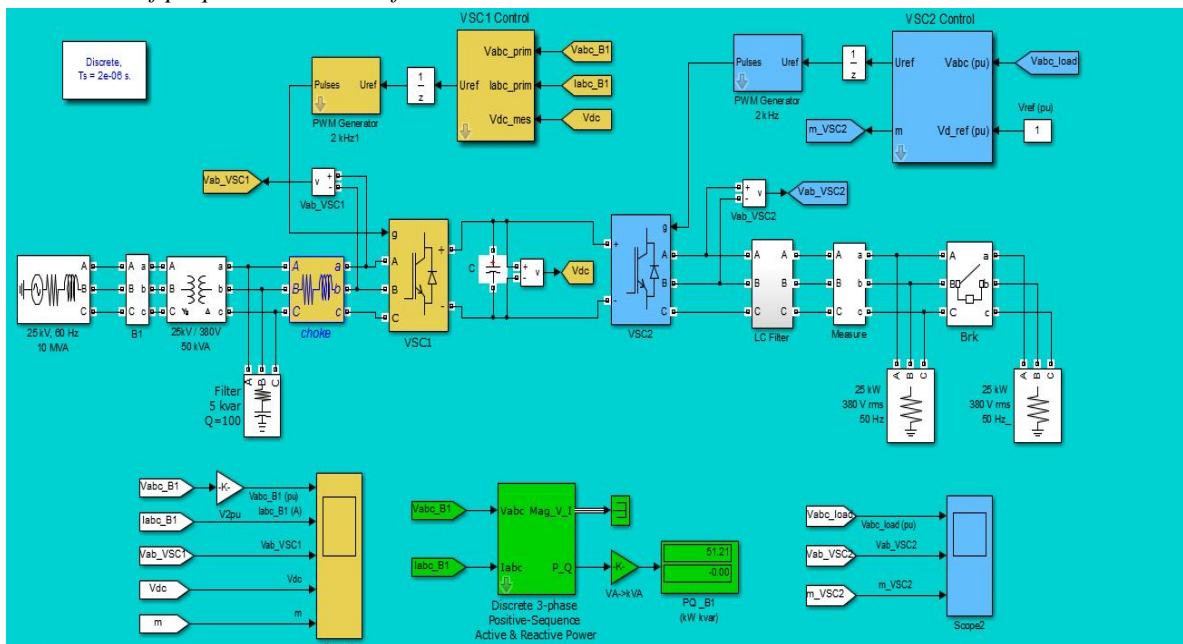
III. MATLAB RESULTS

The three-phase AC-DC converter with flying Capacitor was verified with MATLAB; a commercially available software pACKage for power electronic simulations. The circuit is drawn using MATLAB software components. Digital values of voltage and current are displayed by using the display block present in the Simulink. Finally, set the run time value and run the simulation. Simulation results can be viewed by using the scope in the Simulink library.

A. Simulation circuit of proposed converter before execution

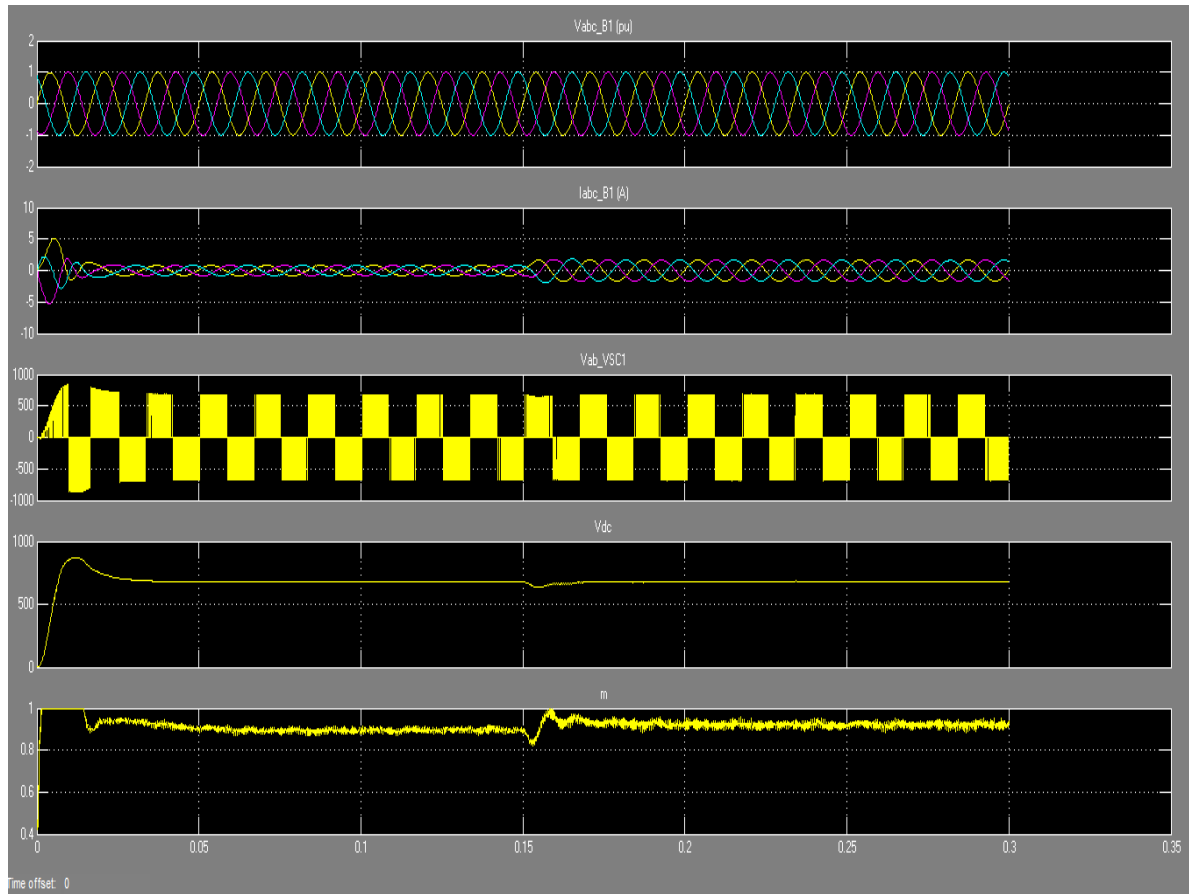


B. Simulation circuit of proposed converter after execution

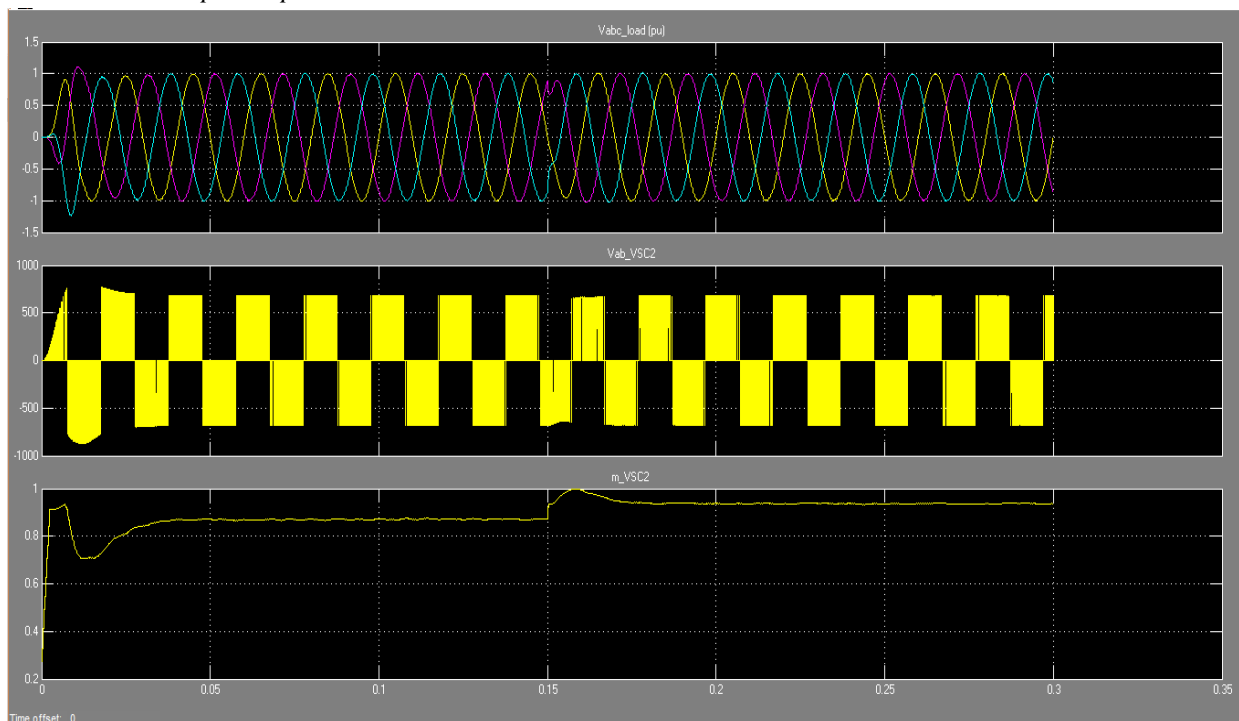


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C. Stimulation results scope1 output



D. Stimulation results scope2 output



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IV. CONCLUSION

Here in this paper we have proposed three phase single stage PFC AC-DC converter using flying Capacitor and standard phase shifted PWM. Matlab software is used to experimentally verified the performance of this converter and to obtain the results. The results and graphs obtain show that the new converter has lower current harmonics and ripples, soft switching and better efficiency under light load conditions. The design aspects can still be improved as the future scope of this project to have more efficient output performance.

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