

Study of Solid State Static Voltage Stabilizer Using Buck-Boost Converter

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ABSTRACT: The main aim of static state voltage stabilizer is to provide constant voltage supply without any variations. The development of static voltage stabilizer capable of keeping ac voltage constant has become one of the main task in analog technology. AC voltage sources is being used in many applications. The concept of conventional DC buck boost Converter is used. This project consists of three main units which are voltage and current sensing unit, control unit, and main circuit. These three units will work together to produce constant voltage. The voltage and current will sense the level of input voltage. Control unit in which 16 bit microcontroller is used will control the duty cycles of signal. This microcontroller has features like inbuilt ADC, JTAG, PWM generation etc. The PWM signal produced by this is given to main unit to drive the MOSFET. This circuit makes sure that at output we will get constant voltage. This circuit is implemented as a loop system but future development it can be implemented as a closed loop system.

KEYWORDS: voltage stabilizer

I. INTRODUCTION

AC voltage source is being used in many applications. In order to obtain effective results from it, own of ac voltage should be free from any errors; value of input voltage should not become higher or lower as compared to re-calibrated voltage value. For this purpose many there are many topologies and circuits have been developed such as AC to AC converter. AC line conditioner, AC regulator etc. AC to AC converter regulates the input voltage to a lower or higher output voltage. Many of these are conventional phase-controlled AC controllers using thyristors, which have the advantages of simplicity of the control circuit and large power capability. However, these have the inherent drawbacks that power factor decreases when the firing angle increases and that, since the content of the line current harmonics is relatively large, the size of the passive filter circuit becomes bulky.

A winding transformer is widely used in voltage regulation fields such as power system, motor speed control and so on. However because the winding ratio is changed by servo motor or by manual regulation, it has low regulation speed. Although it has a higher regulating speed than winding transformer, the low input power factor and the large amount of the low-order harmonic current are the major problems. The size of the passive filter becomes larger [2]. Furthermore, these shortcomings affects the power quality [3]. The reactive and harmonic currents generated by the thyristor commutation also produce extra power loss on the transmission lines [5][8].

These problems can be solved by using high switching frequency AC chopper. Basic concept DC buck boost chopper is used to implement AC chopper. MOSFET/ IGBT switches and different topologies of it such as three switches [1] and four switches [6] are used in it. This type of voltage regulator can improve the PF and reduce the power loss caused by the reactive and harmonic currents. The proposed AC chopper have many advantages such as high power factor, low harmonics, high efficiency, high reliability, fast dynamics, easy implementation, high power capacity, and small size of the passive filter.

II. RELATED WORK

AC-AC Buck Boost Chopper

The basic circuit configuration of the proposed converter is shown in fig 1 given below. It is obtained by replacing regular switches with bi-directional switches in dc buck-boost regulator. This circuit has the following characteristics: it can operate directly from the single-phase line and regulate the output voltage higher or lower steplessly. Furthermore, the input voltage phase synchronous circuit is unnecessary in this scheme. As a result, the circuit is simplified and the cost is reduced. In following design unidirectional switches are replaced by bidirectional switches so as to conduct input in both cycles-positive as well negative. In circuit diagram RC filter is used to reduce harmonics present in the input supply.

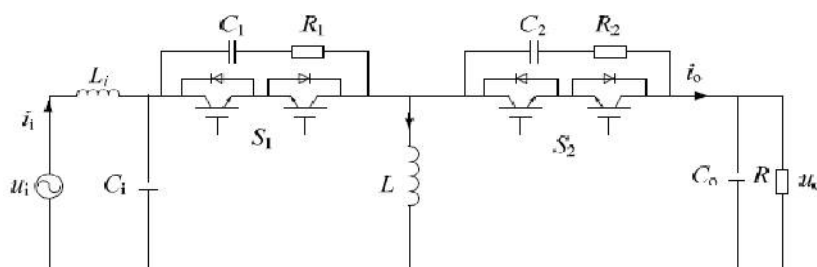


Figure 1: Buck-Boost chopper type AC voltage regulator circuit configuration

The operation is divided into three modes: active mode, freewheeling mode and dead-time mode. The active mode is defined when the switch S1 is turned on. During the active mode, the inductor current is forced to flow through the voltage source via the modulated switch S1 during its on-state periods and the inductor stores the energy. The freewheeling mode is defined when the modulated switch S1 is turned off. Switches S1 and S2 work in complementary mode. Because the output voltage polarity is reversed with the input voltage polarity, the switches S1 and S2 cannot be turned on simultaneously. For the sake of safe commutation, the switching dead-time is necessary. The inductor current paths can be formed by the direction of the load current. In freewheeling mode, the load current freewheels and the inductor L discharges the energy through the switch S2 with the help of its body diodes according to the direction of the load current. Finally, the dead-time mode is defined when the switches S1 and S2 are both turned off. The dead-time t_d shown in Fig. is short, only about several microseconds. The snubber circuits can absorb the bidirectional turn-off spike energy due to line stray inductance. Duty cycles can be used to describe the percent time of an active signal in an electrical device such as the power switch in a switching power supply. Output voltage in terms of duty cycle is given as,

$$V_o = D/D - 1 * V_{in} \quad (3.1)$$

Where,

V_o = Output Voltage

V_{in} = Input Voltage

D = Duty Cycle

Matlab Simulation

AC Buck Boost converter :Matlab simulation has to be done before hardware implementation. AC Buck boost converter whose circuit diagram is described below in fig. 2, is simulated in matlab. Peak of input supply was varied and results were obtained. Duty cycle is varied by PWM generator. Load connected is RL load. Output voltage is inverted with respect to input voltage.

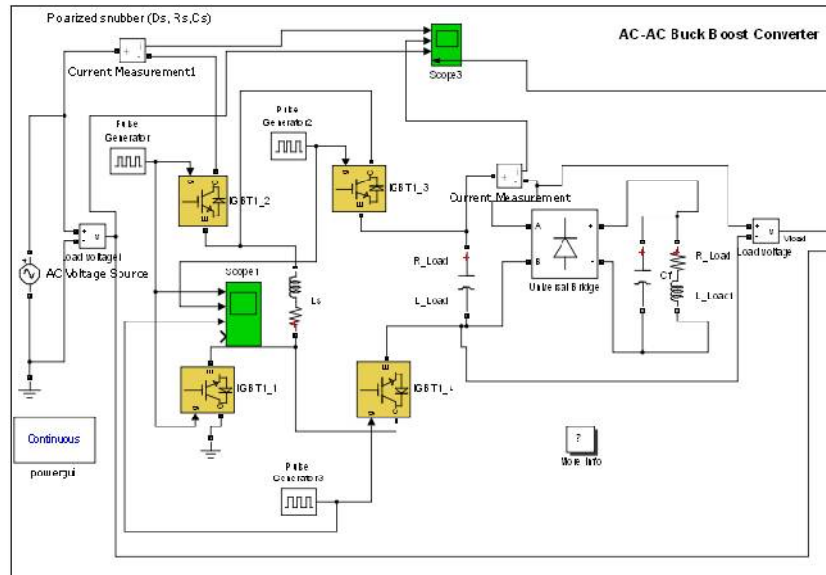


Figure 2 : Simulated schematics of AC-AC buck-boost converter

AC buck boost converter using bidirectional switches is simulated. Input is varied by AC voltage source. By this block we vary various input values and simultaneously check the values.

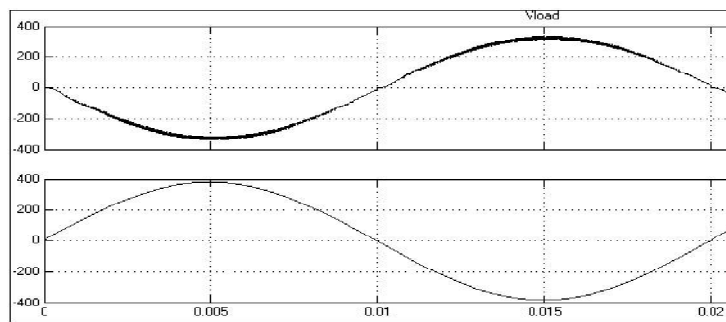


Figure 3:Output Waveforms

In fig.3, first waveform is output voltage waveform and second one is input voltage waveform. This output waveform is for resistive load. Input and output waveforms are inverted because of the flow of current when $s1$ is o_{-} . While simulating the input peak was 370 v but after the buck operation standard output of 230 v is obtained as shown in output waveforms.

III. PROPOSED METHODOLOGY AND DISCUSSION

AC-AC converter AC-AC converter using four diode switches:

AC-AC converter using four diode switches is shown in fig 4. Four diode are connected in bridge configuration. In this model one of the switch is replaced by four diode topology. Peak of input supply was varied and results were obtained. Duty cycle is varied by PWM generator. Load connected is RL load. Output voltage is inverted with respect to input voltage. One bi-directional switch is connected across the bridge which conducts in both positive as well as in negative cycle. In the output waveforms, first waveform is load voltage waveform and second one is input voltage waveform.

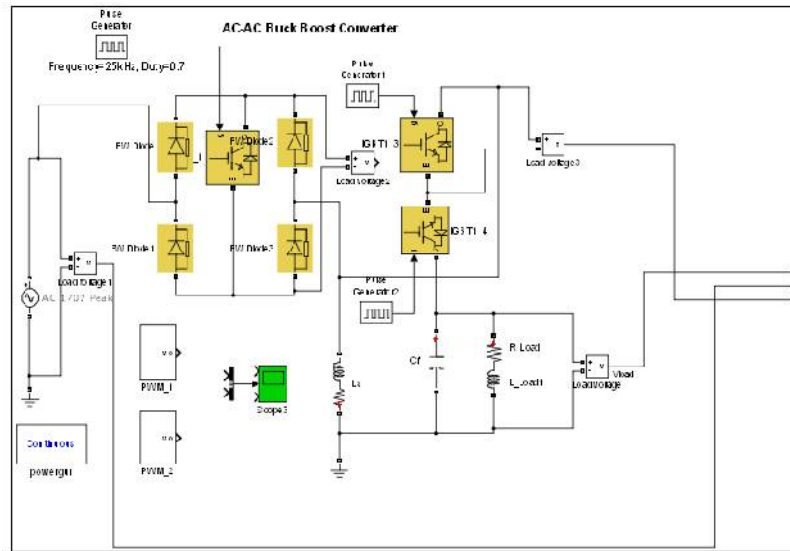


Figure 4: AC-AC converter using 4 diode switch

In the fig.5, waveform is voltage across IGBT used in switch. IGBTs are turned on and off as per the duty cycle. This output waveform is for resistive load. Input and output waveforms are inverted because of the flow of current when the switch is off.

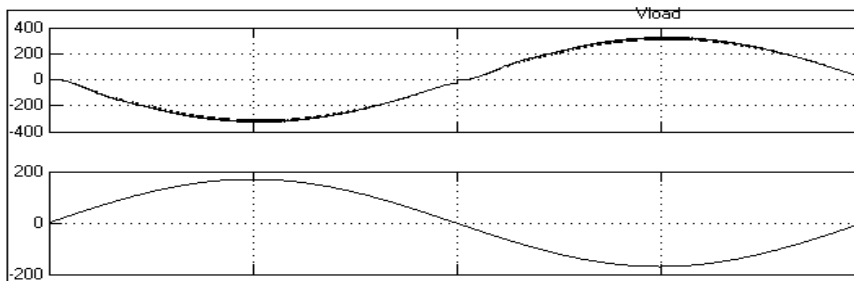


Figure 5: Output Waveforms

Disadvantage of this configuration is diodes should be of high voltage range. It increases size as well as cost of the circuit. Also the switch conducts in both directions i.e. it is always ON throughout the operation which increases the load on it.

Hardware Implementation

Figure 6 explains the block diagram and gives detail of each component within the project, as well as how each section is constructed and interacts with other blocks to result in the stabilization of the AC voltage.

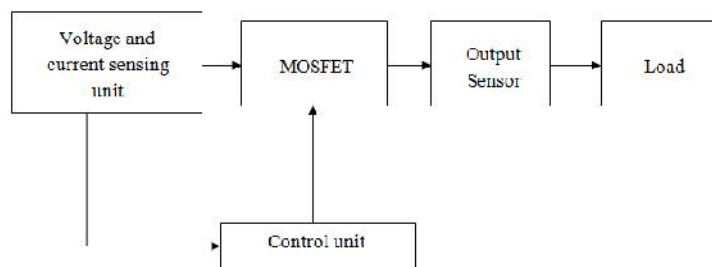


Figure 6: Block Diagram

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Implementation of AC Voltage Stabilizer

The main steps which are followed while implantation of hardware is explained as below:

1. Voltage sensing unit
2. Control unit
3. Driver unit

1.Design of Voltage Sensing Unit:

This unit is responsible for checking the voltage and current range of the input. It will sense the input current and voltage and it will compare it with specified range. If the input signal is within the range then it will convert it into lower input value which is suitable for giving to DSPIC. If it is out of the specified range it will not send it to DSPIC.

It consists of two op-amps. Four resistors of 1 mega ohm are connected at the input side of first amplifier. It is used to reduce the level of input voltage. Output of first amplifier is given as input to second amplifier. Schematics of voltage sensing unit is shown in next figure.

2.Design of Control Unit :

To generate gate triggering pulses required for MOSFET, Microchip microcontrollers dsPIC33FJ06 is used. It is 16-bit microcontroller with modified hardware architecture. It also supports advanced digital processing applications. PWM module of microcontroller is used. It has two to four PWM generators with four to eight I/O. Duty cycle of this wave can be controlled as input varies.

3. Design of Driver Unit :

The driver unit consist of an IC HPCL3148 which is used for driving the switches.

VI. EXPERIMENTAL RESULTS

The simulation work completed in MATLAB simulink version 7.1 AC-AC buck boost converter with different topologies of bidirectional switches. Pulse generator is used to give gate pulses to these switches and to vary duty cycle as per input. As shown in table 1, the output has been observed for different types load like R, RL, and RLC ,the variation in output with changing duty cycles has been observed.

Software :

INPUT	ADJUSTED DUTY CYCLE	OUTPUT
190	54	228
200	53	230
210	52	230
220	51	228
230	50	230
240	48	230
250	47	230

Table 1 : Results

Software gives precise and accurate result but it fails while implementing the actual circuit. Because of the complex circuitry, failure in one module will affect further modules and hence difficult to implement.

While designing the hardware cost, weight are some parameters need to be considered. As the system will be implemented in closed loop complexity of the circuit will increase. The buck boost action keeps the output to the appliance well between 230 to 250 volts with fluctuations ranging from 190 to 250 volts.

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V. CONCLUSION

To design solid state voltage stabilizer, the concept of conventional dc chopper is used In which bidirectional switches using IGBTs are used. The bi-directional switches have different topologies in which they can be implemented. The variations of different topologies are studied using matlab simulations. Accordingly a topology was chosen and the AC buck-boost converter was simulated and result was obtained.

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