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Alternating Current Voltage Stabilizer by Using Pulse Width Modulation

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Abstract— To operate the appliance safely and efficiently, a constant AC voltage supply is needed. To make it happen, voltage regulators are required. There are many different techniques for this purpose. Convetionally, for this reason, an electromechanical technique is used. But in novel technique an electronic circuit is used instead of the mechanical part which increases its efficiency and reliability. This electronic circuit generates specific pulse width modulation to drivw transformer to make an appropriate output.

Index Terms— Ac Voltage Stabilizer, Transistor, Pulse Width Modulation (PWM), Power Metal Oxide Semi-Conductor Transistor (Mosfet), Buck-Boost Transformer, PIC Microcontroller, Zener diode, Analog Signal

1 Introduction

AC Voltage stabilizer and regulator is a system which maintains a constant supply of ac voltage across the load. Commonly, it is based on three different configurations: buck (step-down), boost (step-up) or buck boost. The type of configuration depends upon the requirement.

Typically an electromagnetic voltage stabilizer is a combination of two parts, electrical and mechanical. Electrical part drives the mechanical part to produce an appropriate output. Normally this mechanical part consists of servo motor and relay which changes the tapings of the transformer to stabilize the ac output voltage [1]. Moving parts of the servo motor and relay results in wear and tear. Due to this mechanical movement response time could not compensate rapidly the fluctuations in voltage. Despite of this stumpy correction speed there will be voltage overshoot and voltage drop. These drawbacks result a poor voltage regulation and reduces the efficiency and reliability.

In order to reduce these effects electronic circuit is introduced based on some semiconductor or power switching devices which substitute these moving mechanical parts. The power device which is proposed in this paper is power MOSFET IRF-840. This power MOSFET generates an appropriate Pulse Width Modulation in accordance with the input which drives the transformer to stabilize the output ac voltage.

This Pulse Width Modulation buck (subtract) or boost (add) in the main voltage. This serially changes the secondary voltage of buck-boost transformer and it results in a stabilized output voltage available [2].

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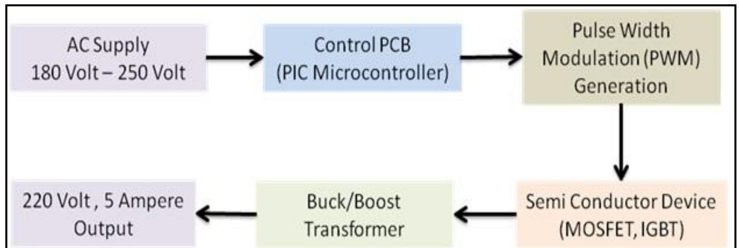


Block Diagram of Propsed Technique

Figure 1

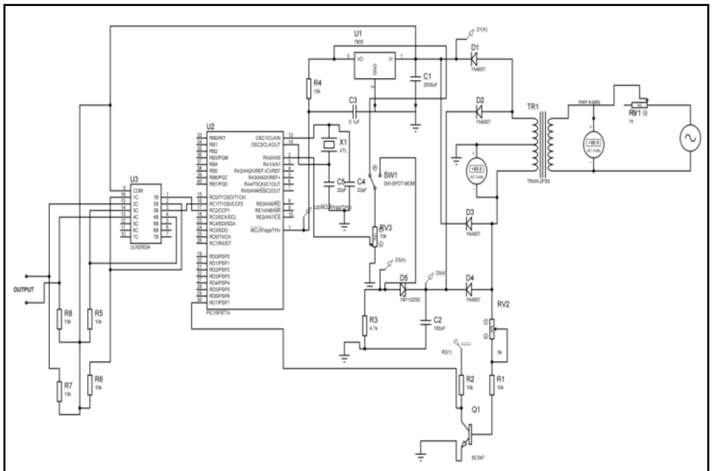
2 Design Configuration

The design is mainly based on two main sections i-e "Controller Section" and "Buck-Boost Section". This proposed design is more efficient, reliable and stable. This technique is very much improves in its operation and performance as compared to conventional one.

In novel design, there is no mechanical moving part, therefore it enhances its hardware life and also it needs negligible maintenance as there is no wear and tear. This design compensate the voltage more rapidly than old electromechanical design, as in that conventional design some mechanical switches like relay or servo motor are used to change the tapings of transformer to compensate the voltage. This mechanical process need time and eventually could not compensate rapid surges and spikes. But this new design uses power switch device (power MOSFET IRF840) which has switching time of 0.106 ms [3]. Hence it could increases the efficiency up till 90%. A prominent advantage of this novel configuration is its size and its suitability for heavy loads. Conventional electromechanical stabilizer becomes bigger, inefficient and uneconomical as ac load increases to kilo-volt ampere. But this new design could handle heavy loads more efficiently, economically and effectively.

2.1 Controller Section

This section is based on an electronic circuit consisted on micro-controller [4]. In this proposed topology PIC16F877A is used for above purpose. PIC microcontroller is the most appropriate for the design because it has many built in features related to the solution of the problem stated above. It can tolerate noise created by the analog signal of the input alternating current(ac supply), has built in analog to digital convertor(A/D convertor) and most importantly it has built in PWM (Pulse Width Modulation) module[5],[6].



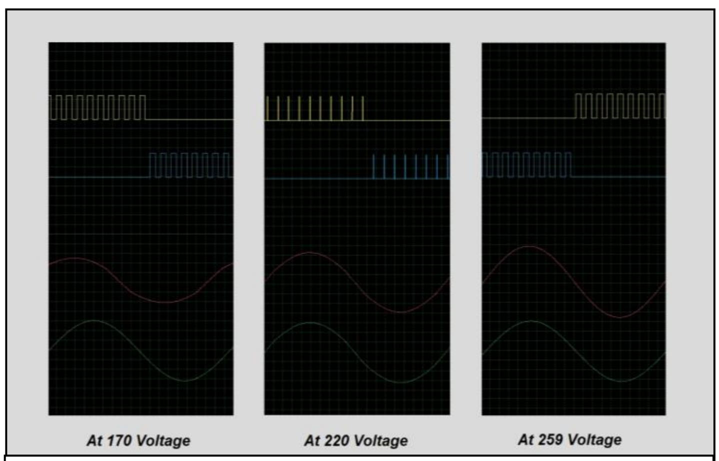
Circuit Diagram of Controller Section

Figure 2

An analog signal will be fed at port 'A' pin 2 of the controller from the transformer. Here ADC (Analog to Digital Converter) converts this analog signal to digital and measures its level according to a reference value. A proportional voltage to the main is supplied from the transformer.

2.1.1 Calculations and Computations

This proportional voltage varies as the main voltage changes. This variation could be calculated by following manner:
For 220 volts main, a 9 volt step down transformer and 10 volt zener diode is used.
Output at control = $9\sqrt{2}$ = 12.7 volts
Voltage supplied to ADC pin = 12.7 – 10 = 2.7 volts
Similarly it will be 5 volt for a rise in 259 voltage in main and drop to zero for 172 voltages. In this way ADC will obtain a range of the fluctuation of ac voltages in mains and measure the compensation. According to voltage level measurement, PIC16F877A generates PWM (Pulse Width Modulation) at pin 16 & 17. This PWM add (boost) or subtract (buck) sine voltage in the main to keep a constant level of ac voltage across the load which is actually the desired objective.



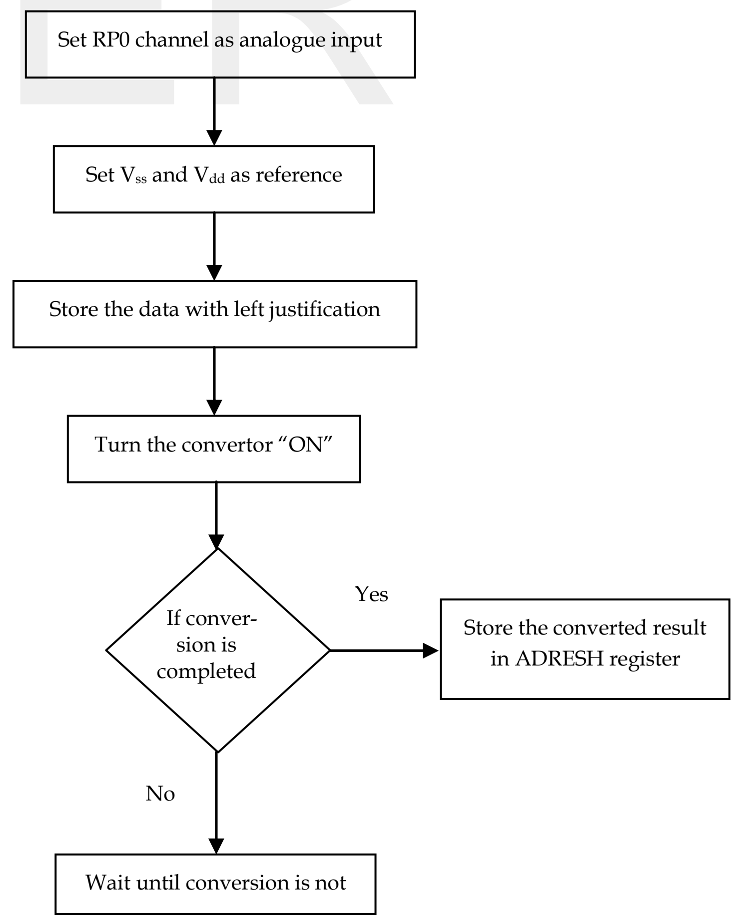
PWM train during Buck and Boost Mode
Yellow, Blue = Pulse Width Modulation Train
Red = Input Ac Voltage
Green = Output

Figure 3

These pulses are then enhanced by using a high current driver ULN2003. After this a pulse train will be produced which is provided to buck-boost section. Transistor BC547 is attached at port D which produces a rectangular pulse from the half-wave rectified low voltage (9V) from the transformer (9V-0-9V). Frequency of 50Hz from main source will be used as reference for positive and negative half cycles. This will produce the pulses at A and B points in turn. These pulses which change in their width and are therefore called pulse width modulation.

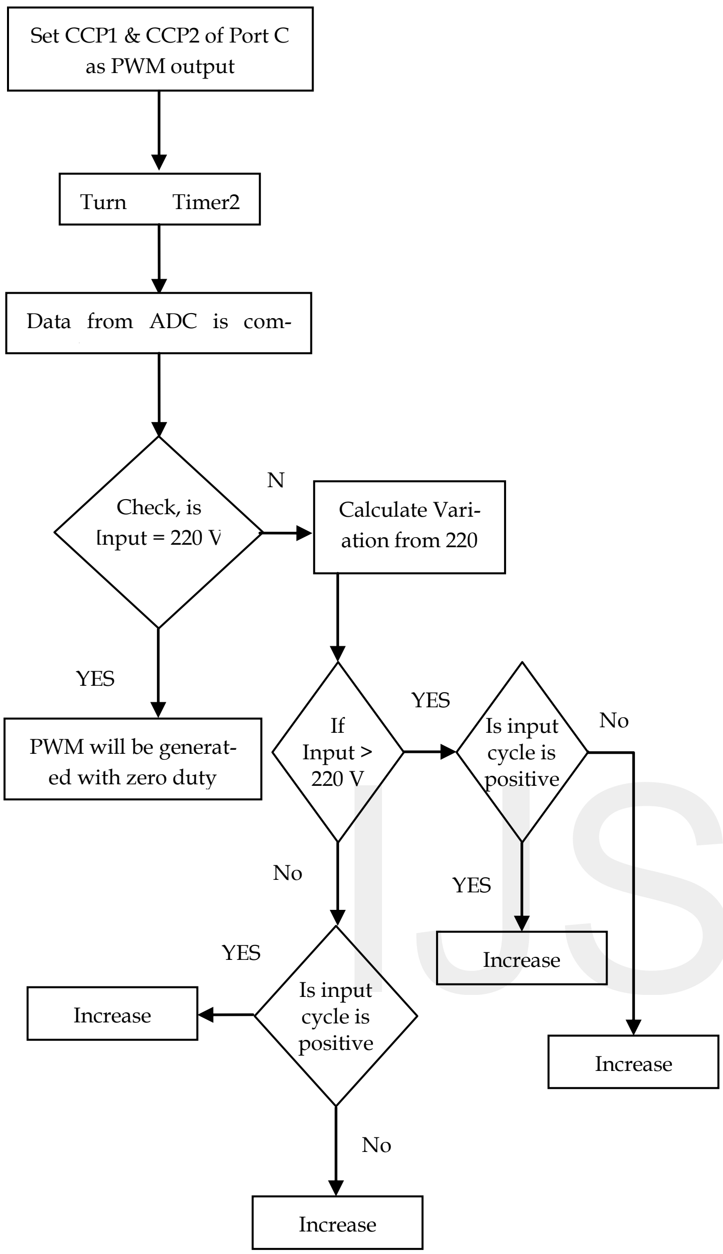
2.1.2 Microcontroller Programming

During the initialization of PIC16F877A, port A is set as input, and port B and port C is set for output. Port B will display main AC voltage which is to be stabilized. Pin 16 and 17 of port C will be used to feed pulse width modulation to the power Mosfet IRF 840 [4]. Intially, highest value of period is set, than pre-scaler and post-scaler values are set to '1' [6].
After initializing, timer is set to be 'on' and analog signal is received at port A. Here analog to digital converter digitalize this receiving signal by using 'V_{ss}' and V_{dd}' as reference [5]. Then this digitalized data is compared and change the duty cycle of PWM which is receiving as output from port C. Then this PWM is algebraically added in disturbed input. When the output voltage becomes stabilized, controller will wait in this state until an interrupt or change in the input voltage occurs.



Flow Sheet for Analogue to Digital Convertor

Figure 4

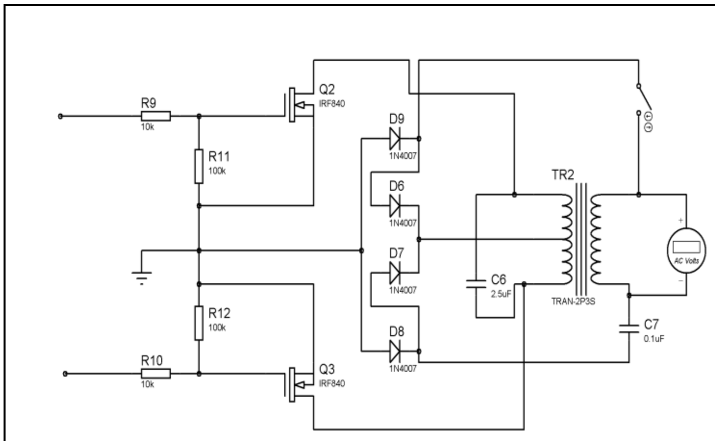


Flow Sheet for Pulse Width Modulation

Figure 5

2.2 Buck-Boost Section

Pulses which are generated from ULN2003 are introduced to buck-boost section. The gate pins of power MOSFETs (IRF840) are fed by these pulses [7]. The windings of a center tap transformer are energized by the gate of MOSFET. This MOSFET (IRF840) switches the rectified sine wave coming through the bridge rectifier to produce unfiltered sinusoidal wave.
Finally compensating voltages at the secondary side of transformer is added serially to the main input voltage to stabilize the output voltage. To smooth out this unfiltered sine wave which is produced due to power MOSFET, a fan capacitor is used. This wave adds or subtract to the mains voltage to produce a stabilized ac output voltage.



Circuit Diagram of Buck Boost Section

Figure 6

3 CONCLUSION

In this research, an improved novel design of voltage stabilizer with low cost, micro-controller and more precised and accurate type is discussed. This design is highly efficient and stable in the following manner:

- Direct AC-AC conversion without rectifying to DC, this improves efficiency, reliability and reduces components
- Generation of pulse width modulation (PWM) at power stage to increase the efficiency
- Use of feedback system using digital signal processing
- To minimize the output distortion up to 7%
- Longevity as no wear tear is involved

This design is for just 5 amperes of current and 220 volt AC. Further, some more power switching devices like IGBT or other semi-conductor devices with high switching speed and of higher current ratings could be used for heavy load and increase the efficiency. Moreover this design could be easily advanced for heavy industrial loads and three phase systems as well.

4 ACKNOWLEDGMENT

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