IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 14, Issue 5 Ser. II (Sep. – Oct. 2019), PP 65-71
www.iosrjournals.org

Design and Implementation DSPIC & IGBT Based Static Automatic Voltage Regulator

Apple Mahmud[1], A.R.M. Iftekhar Mahmud[1], Prama Debnath[2], S M Imrat Rahman[3]

[1]*Student, Department of Electrical and Electronics Engineering, American International University – Bangladesh, Dhaka, Bangladesh*
[2]*Student, Department of computer Engineering, American International University – Bangladesh, Dhaka, Bangladesh*
[3]*Senior Lecturer, Department of Electrical and Electronics Engineering, American International University – Bangladesh, Dhaka, Bangladesh*
Corresponding Author:Apple Mahmud

Abstract:*Static voltage regulation is necessary for protecting electrical instrumentation from unstable power supply. In this paper, the design and development of a static automatic voltage regulator has been proposed for maintaining a static voltage level. This voltage regulator will reduce the stabilization problems due to input voltage variation and provide constant output voltage. This design is suitable for stabilizing 148V-250V variation of input to a stable 220V output & power handling capacity is between 5VA-100VA. It can be used with electrical applications such as Industrial automation, Commercial application in high rise buildings, Military applications, Marine application, Medical application etc. The whole system is controlled automatically by dsPIC30F2010 microcontroller and IGBT technology is used for fast switching. The designof this system is simpler than conventional designs with analog control circuitry and it can operate continuouslyfor a long time. Using this voltage regulator, it is possible to protect electrical equipment from abnormal power surge.*

Keywords:*Static voltage Regulator(SVR), Auto Transformer, IGBT, DSP, Relay, Microcontroller, etc.*

Date of Submission:15-10-2019 Date of Acceptance:31-10-2019

I. Introduction

In modern times voltage fluctuation has produced significant impact on electrical appliances. Voltage fluctuation is a continuous change of voltage when a device or appliance that is in need of higher load is widely used. For this reason, Extreme causes of voltage fluctuation can cause heavy damage to our important electric equipment or electric machine. This problem can be solved by using the static automatic voltage regulator.

The chief objective of our work is to design and implement a fixed static automatic voltage regulator. Static voltage regulator (SVR) is an electronic device that automatically maintains a constant voltage in an electrical line. Basically, a voltage regulator controls the voltage of a circuit or regulates it automatically for obtaining a constant alternating voltage at or near a prescribed value with the same input-output frequencies by stabilizing the variation of supply voltage [1,2,3]. depending on the instrument a static voltage regulator would always provide constant output voltage and giving high performance and maintain the stability [4]. SVR is the best option for controlling the output voltage through field excitation in different types of variable speed application [5]. SVR measures and regulates the input voltage for producing stable output voltage and give protection against sag, surge, spike, brownout, over-voltage, under-voltage, over-current, and hysteresis to the sophisticated equipment and machinery. In another paper, there have been discussion about SVR, which is controlled by micro-controller [6]. In different publications, there are different types of research about SVR. Other paper describesthe line and load regulation tests that were carried out on twelve (12) selected brands of commercially available domestic 1kVA Automatic Voltage Stabilizers used by consumers in Nigeria for the protection of their appliances [7]. A microcontroller-based system which is designed in another publication gives the static voltage oscillation by a mulitas transformer in the power side of the voltage regulator [8]. Another paper focused on the electrical hazards within certain types of voltage stabilizers which depend on the servo method. SVR is necessary for protecting the electrical equipment from unstable power supply.

In this project, an automatic voltage regulator has been designed for maintaining a static voltage level. Mainly DSPIC and IGBT has been used here for getting high efficiency and fast switching. IGBT is used as switch and direct AC-AC converter circuit can improve the system so that we can get proper voltage regulation. In future, by using synchronous pulse width modulation (PWM), Itwill be possible to measure more accurately.

II. Overview of The Project Design

A static automatic voltage regulator system maintains a static voltage level. This system provides significant benefits for protecting the electrical instruments from unstable power supply. The system can be used in the large estate houses, factories and industrial manufacturing facilities.

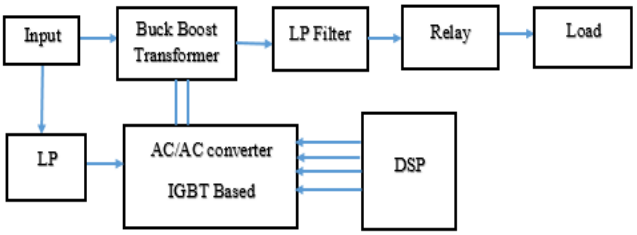

Figure 1: Block diagram of the SVR design

Figure1 shows the functional block diagram of a static automatic voltage regulator system. From the block diagram we can see that input supply is connected to a Buck Boost Transformer and a low pass filter. Buck Boost Transformer is connected to a Low pass filter. IGBT based AC/AC converter is interfaced with DSP, low pass filter & Buck Boost Transformer. Low pass filter is connected with relay. Finally, relay is connected to the load(output).

III. Practical Implementation

Below is a list of necessary tools that were used in this Experiment setup:

Capacitor

A capacitor is a two-terminal electrical component that stores electrical energy. Different types of capacitors have been used in this experiment. Capacitors has been used here as a filter. The filter works to take away unwanted signals.

IGBT FGA50n60

An insulated-gate bipolar transistor (IGBT) is a three-terminal power semiconductor device which used as an electronic switch and by using this can get high efficiency and fast switching. There is a total of eight IGBT FGA50N60 has been used in this study.

Relay

Relay is an electrical switching device. The main operation of this device is to form or break contact with the help of an indication with no human involvement thus on switch it ON or OFF.

Isolated power supply

Isolated power provides transfer power from one circuit to a different while not an instantaneous association between the two circuits. Power isolation protects electronics instrumentation from exposure to high voltage. It conjointly prevents ground loops, that manufacture parasitic current which will disrupt the output voltage regulation and may introduce galvanic corrosion of the conducting traces.

Sensor

An electronic sensor detects and measures a natural phenomenon, like temperature, pressure, force, or acceleration, and provides a corresponding output, usually in the formation of an electronic signal.

Boost Converter

The boost convertor, additionally called a step up transformer, produces a high voltage on the output then received on the input. Its circuits consist of an inductor, a capacitor, a diode and a switch (usually a MOSFET). A boost device is a DC to DC converter with an output voltage above the supply voltage and the output current is under the supply current [9].

Power Converter (Transformer)

A power device is a stationary appliance that changes electrical vitality beginning with one circuit then onto following with no direct electrical association, the assistance of shared acceptance between 2 windings.

Buck Converter

The buck converter, also known as a step –down transformer, produces a low voltage on the output then received on the input. In buck converting operation the inductor assumes an exceptional job to bring down the initial voltage.

dsPIC30F2010

The dsPIC30F2010 Microcontroller is a piece of Microchip's 16-Bit microcontroller family. It has Wide operating voltage range (2.5V to 5.5V). It operates Industrial and Extended temperature ranges. It is Self-

reprogrammable under software control. It could make six pulse with modulation (PWM) but we have used four PWM in this study.

IV. Experimental Setup

The below figure shows the final setup. All the components were used to design the voltage regulating system

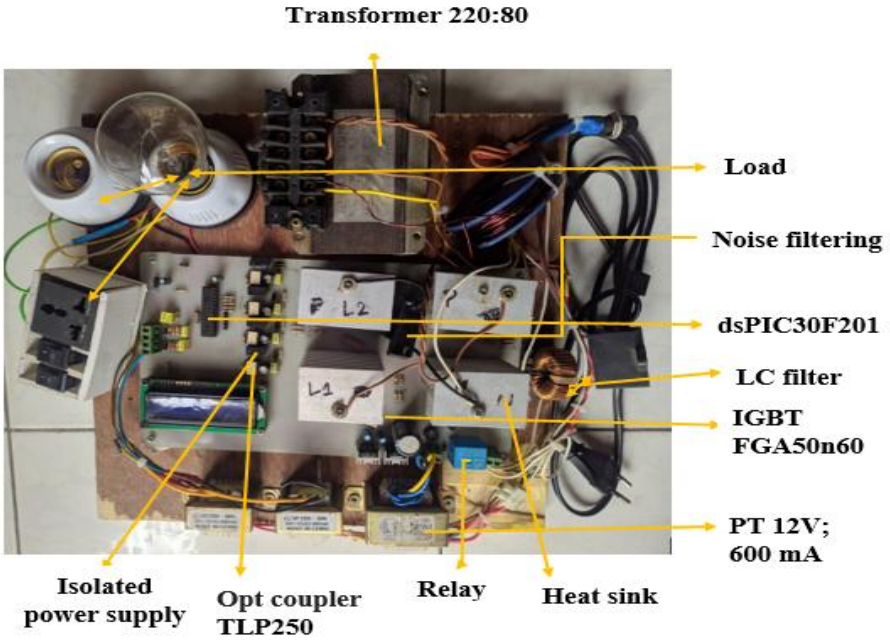

Figure 2: Experimental setup of SVR system

The proposed method is consisting of IGBT FGA50n60, Isolated Power Supply, Sensor, Bridge diode, DSPIC30F 2010, Boost converter, Power converter, Buck converter, Low pass filter, Fuse, Heat sink, Opt coupler etc.

Three transformers have been used in this project. Input supply is connected to a Buck Boost Transformer (220:48). Low pass filter is connected with input. We have used here four-hit sink for decreasing over temperature and Two IGBT (FGA50N60) is connected with every heat-sink circuit so that static signal can pass easily. Capacitors are also connected with heat sink. For minimizing this distortion, capacitors have been used. For passing the signal without distortion, opt coupler also has been used in this circuit. We have used Isolated power supply for preventing ground loops. There is also a power transformer (12V;1000mA) and a PT transformer (12V;600mA). IGBT (FGA50N60) is connected with DSPIC30F 2010. Mainly DSPIC and IGBT has been used here for getting static output voltage, high efficiency & fast switching. LCD monitor has been used this experiment so that we can understand circuit function is working properly or not.

V. Verification & Result Analysis

This part mainly deals with the result analysis of this study.

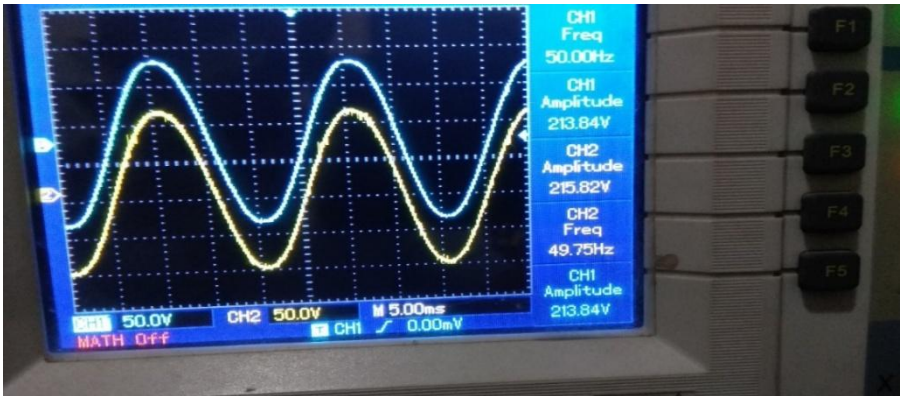

Fig 3: Input Output voltage ratio without static voltage regulator (SVR)

From figure 3 we can see that Input Output voltage ratio without automatic voltage regulator. channel 1 is input (213.84 V) and channel 2 is output (215.82 V). It seems less stable voltage because 220 V is our required voltage.

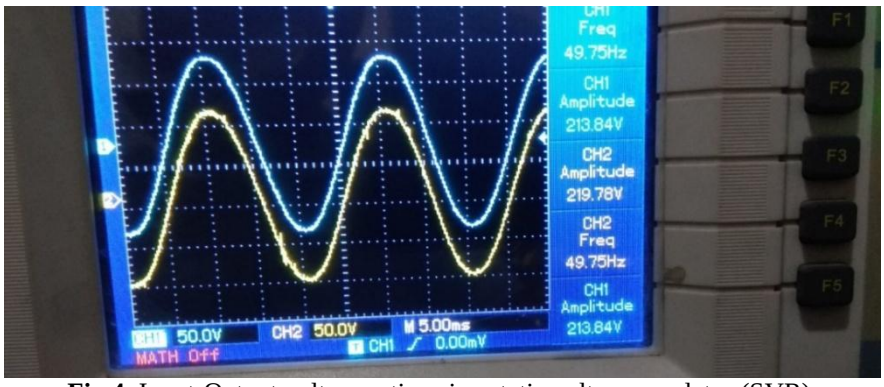

Fig 4: Input-Output voltage ratio using static voltage regulator (SVR)

From figure 4 we see that Input Output voltage ratio using automatic voltage regulator. channel 1 is input (213.84 V) and channel 1 is output (219.78 V). It seems stable voltage because 220 V is our required voltage.

Fig. 5: Input-Output voltage with complete circuit demonstration

Specification:

- Input voltage 148V to 250V
- Stabilized Output voltage 217V to 222V for all input between 148V to 250V
- Input and output frequency are the same
- High cut feature at 255
- Low cut feature at 146
- 4 set IGBT block

Table1: Output Table of normal Voltage at Different Times

Time (h)	Output Voltage (V)
00.00.00	205
00.02.00	218.59
00.04.00	201.15
00.06.00	217.84
00.08.00	199.89

00.10.00	215.82
00.12.00	223.74
00.15.00	210

From Table 1 we can see at initially output voltage is 205 V. After 2 min changing voltage is 218.59 V. Thus voltage is gradually changing & changing ratio is high. So this voltage is unstable.

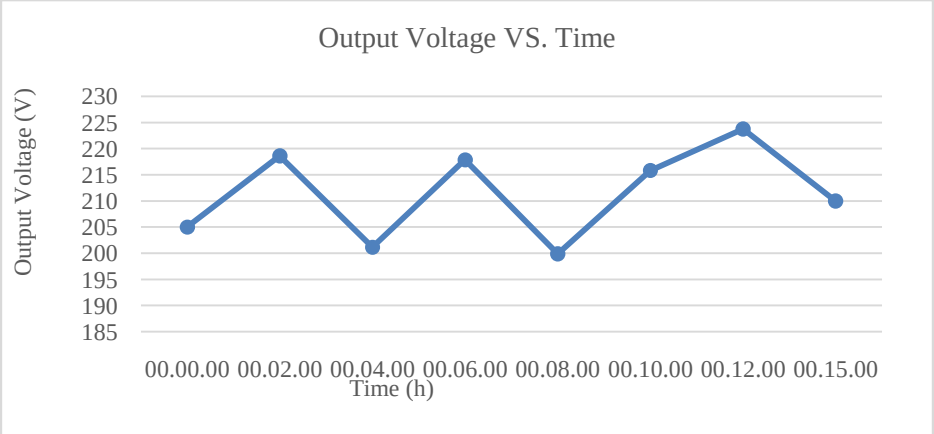

Fig.6: Normal Voltage vs. Time Graph.

The Table 1 and graphical Figure 6 show that normal voltage changing pattern is unstable

Table 2: Output Table of Stabilized Output Voltage at Different Times

Time (h)	Stabilized Output Voltage (V)
00.00.00	0
00.02.00	219.57
00.04.00	219
00.06.00	218.94
00.08.00	219.99
00.10.00	219.78
00.12.00	219
00.15.00	0

From Table 2 we can see at starting output voltage is 0 V because input voltage is lower than minimum (146 V) voltage. After 2 min changing voltage is 219.57 V. Then 2 min new changing voltage is 219 V. Thus voltage is little bit changing but changing ratio is too low. So this voltage is stable.

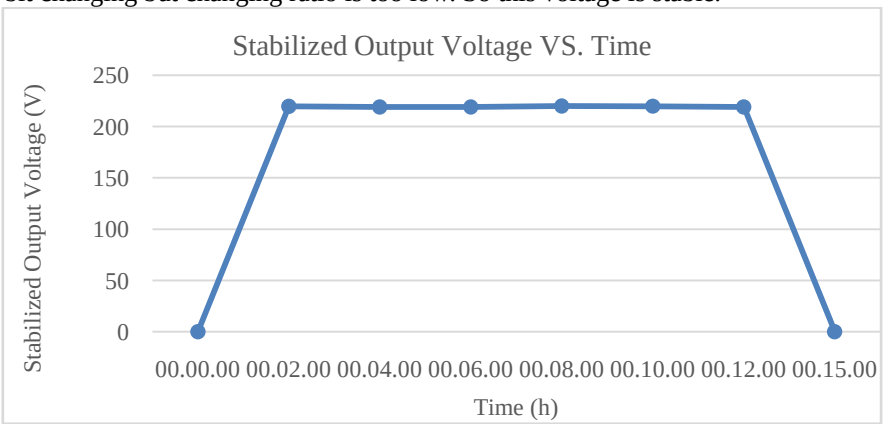

Fig.7: Automatic voltage regulator vs. Time Graph

Table 2 and Figure 7 show that automatic voltage regulator is stable system which is our desire output

Table 3: Output Table of input-output voltage and automatic stabilized regulated voltage at Different Times

Time (h)	Input Vac (V)	Output Vac (V)	Stabilized Output Voltage (V)
00.00.00	146	200	0
00.02.00	151	218.59	219.57
00.04.00	168	209.15	219
00.06.00	185	216.84	218.94

00.08.00	205	204.89	219.02
00.10.00	213	215.82	219.78
00.12.00	247	223.74	219
00.15.00	278	190	0

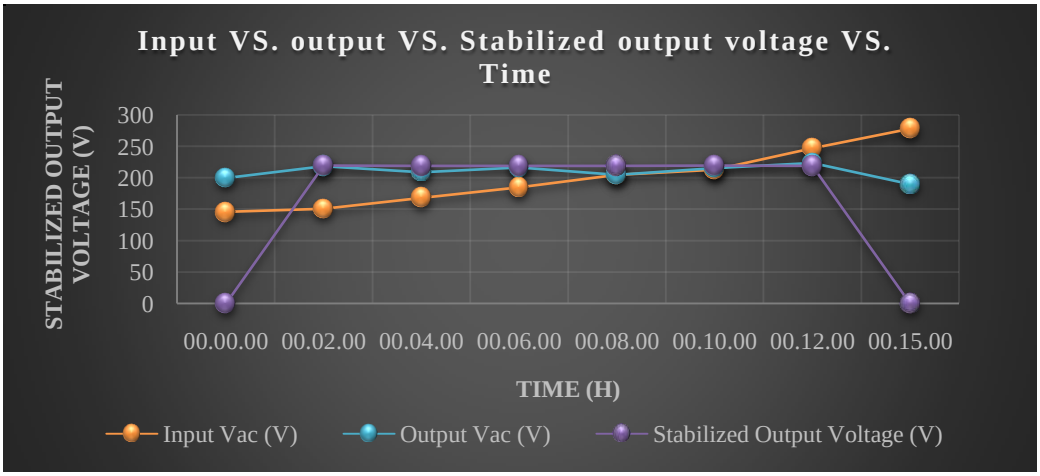

Fig.8: input-output voltage and automatic stabilized regulated voltage vs. Time Graph

Table 3 and Figure 8 is the representation of whole voltage system. From this table and graph we are seeing normally output voltage has some fluctuation, On the other hand, stabilized output voltage static and constant. From this total table and graph analysis we can easily say automatic voltage regulator system is the best system for constant output voltage.

VI. Component List & Their Prizes

Table 4: Equipment list and their cost

Components name	Quantity	Rate	Price (BDT)
IGBT FGA50n60	8	120	960
LCD 16X2	1	150	150
Buck Boost Transformer, 220:48	1	2,000	2,000
Power transformer, 12V,1000mA	1	75	75
PT, 12V,600mA	2	65	130
Isolated power module 12BS12	4	300	1,200
TLP250	4	75	300
LM7812	1	15	15
LM7805	1	15	15
Heat sink 4inch	4	35	140
Heat sink small	2	10	20
Filter Coil	1	100	100
Filter Capacitor	1	45	45
Capacitor: 1000uF/50V	1	15	15
Capacitor: 100uF/50V	4	5	20
Capacitor: 10uF/50V	4	2	8
Cap. 104/50V Ceramic	8	2	16
Diode UF4007	4	4	16
Diode 1N4007	3	1	3
Bridge Diode 2W10	1	8	8
Relay 12V	1	25	25
Transistor BC547	1	3	3
dsPIC30F2010	1	1	350
Resistors 1/4W	50	0	8
PCB	1	500	500
Cables and Fittings	1	100	100
		Total	6,222(BDT)/ $74

6222 BDT = 74 US Dollars

Cost Analysis:

The cost of components and their prices are given in Table 4. We can see from Table complete expense is 74 US Dollars. To stabilize voltage this system cost is very lower than other voltage stabilize system. This Static Voltage Regulator is cost efficient for shielding electrical hardware from abnormal power.

VII. Discussion

An automatic static voltage regulator (SVR) has been designed to automatically maintain a steady output voltage level. It's a microprocessor-based negative feedback circuit with high correction speed & better potency. It regulates unsteady voltages in a very precise manner & constitutes a high-level spike suppression system that protects the instrumentation by nearly eliminating any transients within the distribution network.

This static voltage regulator and stabilizer is mainly designed considering the requirements of industrial machinery and its applications. Static voltage regulator IGBT based switching technology ensures stable output voltage even when large input changes. Direct AC-AC convertor improve the system response and quick voltage correction. This static voltage regulator may be used with almost all kind of electrical and electronics equipment such as Auto testing equipment, Broadcasting, Industrial automation, Commercial application in high rise buildings, Military applications, Process control, Marine application, Medical application & Mobile communication.

This design is suitable to regulate 148V-250V variation of input to stable 220V output & It's power capacity is 5VA-100VA. In future, By Using synchronous pulse width modulation(PWM); It may be possible to measure every Nano second's pwm. By adding multiple taps at the secondary side of the auto transformer and relays we can make a new automatic voltage regulator which can regulates input voltage range of 80VAC-390VAC to a stable 220VAC output voltage.

References

[1]. WILLIAM D. STEVENSON, "Elements of power system Analysis" Fourth Editon,337-341,354-365,1982.
[2]. "Voltage Regulator and Power supply," http://www.zen 22142.zen.co.uk.
[3]. BL THERAJA AND A.K THERAJA, "A text book of Electrical Technology",23th Editon,335-338,1029-1035,1098-1104,2002.
[4]. C.Valdez,"Voltagestabilizer of Generator output Through Field Current Controlled Using Fuzzy Logic," http://eprints.uthm.edu.my/4326/1/CLARA_VALDEZ.pdf.
[5]. C. S. Hoong, S. Taib MIEEE, K. S. Rao and I. Daut, "Development of Automatic Voltage Regulator for Synchronous Generator," National Power & Energy Conference (PECon) 2004 Proceedings, Kuala Lumpur, Malaysia.
[6]. PIC16F876A, 28/40/44-Pin Enhanced Flash Microcontrollers Data Sheet, Microchip Technology Incorporated, ISO 9001/ QS-9000. The U.S.A. in 2003.
[7]. AkinloluAdediranPonnle, "Performance of Domestic AC Voltage Stabilizers in Meeting Low Voltage Problems in Nigeria: Performance of A Case Study of 12 Different Brands", *International Journal of Engineering and Technology*, Vol. 5 No. 6 June2015.
[8]. Mohammad MurshadulHoque, "Design, implementation and performance structure programmable automatic voltage regulator", *Journal of Electrical Systems*, Vol. 10, No. 4, pp. 472-483,2014.
[9]. Texas Instruments. Understanding Boost Power Stage in Switchmode Power Supplies. Texas Instruments, Mar. 1999. PDF.

Apple Mahmud. "Design and Implementation DSPIC & IGBT Based Static Automatic Voltage Regulator". IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), vol. 14, no. 5, 2019, pp. 65-71.