International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 06, June-2021

Design and Evaluation of Voltage Control using Static Stabilizer

Ludin Lawrence, Derick Joy, Jeswin Paul, Fathmathul Zuhra ,Sebin Davis
Electrical and Electronics Engineering Department
Sahrdaya College of Engineering and Technology

Abstract- **A good electrical power system ensures the availability of electrical power without any of the interruption to every load connected to it. Generally the power is transmitted through the high voltage transmission lines and the lines which are exposed, causes the chances of their breakdown due to storms damaging of any external objects and also damage to the insulators. Servo Voltage Stabilizer is an electronic device that stabilises voltage from fickle to desired value ranges, resulting in a constant output voltage and a stable secure power supply to the equipment. The preceding paper discusses a static based voltage stabilizer kind of system controlled by a DSPIC based controller, as well as voltage adjustments with a Buck-Boost type transformer.**

Keywords- Stabilization, Power quality, Voltage control, Inverter, Buck converter, Boost converter, matlab , rectifier.

I. INTRODUCTION

Stabilizers are electronic devices that convert unstable voltage into a desired value. Stabilizers provide a constant and secure power supply to equipment that requires a constant voltage, as well as protecting electronics from the majority of mains faults. Voltage stabilizers, like UPS, have shown to be useful in the safety of electrical devices. Electrical equipment is used everywhere; it may be found in homes, offices, businesses, and nearly every other location. The reliance on varied electrical equipment has grown unavoidable, and the electrical equipment's reliability is widely desired. The failure of this electrical equipment results in significant device losses as well as inconveniences. Static voltage stabilizers have no moving parts, unlike servo-based voltage stabilizers, and are easier to manufacture, resulting in higher precision and voltage regulating systems[1].

The main purpose of a stabilizer is to make the output voltage that feeds the connected equipment as close as possible to the ideal electrical power supply, ensuring that the oscillations in electrical power are offset and the output maintains a stable value, preventing the equipment from experiencing them and thus avoiding damage[2]. The difference between a voltage regulator and a voltage stabilizer is that a voltage regulator is typically employed in DC applications, whereas a voltage stabilizer is equipment that ‘stabilizes' a fluctuating AC voltage. AC voltage stabilizers, DC voltage stabilizers, and automatic voltage stabilizers are the three types of voltage stabilizers[3]. Static voltage, an ac voltage stabilizer, is the subject of this paper. The most commonly used stabilizer is the servo stabilizer, which has a number of drawbacks as compared to static voltage stabilizers[4]. Static voltage stabilizers are devices that do not have any motor-controlled portions, unlike servo-controlled voltage stabilizers. The voltage generated to achieve the voltage and time correction is shown here[5]. As a result, the stabilizer has a much higher voltage than a servo-based voltage stabilizer system due to its high primary to secondary ratio for voltage correction speed. Static stabilizers have the function of maintaining constant output voltages and safeguarding equipment linked to an ideal electrical power supply system from damage by ensuring that oscillations in the electrical power supply are offset and the output voltage remains steady[6]. The static stabilizer system's job is to improve the dynamic performance of various power systems, and here the simulation using Matlab studies for the overall system's performance demonstrates that it is adaptive under good performance settings with a wide range of conditions. Voltage stabilizers are divided into two types: DC and AC. The difference between its DC type of applications and the voltage stabilizer on the other side, which stabilises the AC voltage that is fluctuating. For voltage correction, the basic research of SVS uses a Buck-Boost transformer with a high primary to secondary ratio[7]. Uninterruptible power supply, sometimes known as UPS, is a form of voltage stabilizer that protects electronic equipment against power outages. All electrical and electronic equipment is developed and manufactured here to work at maximum efficiency with its typical voltage supply system, intended for its working range limit with code-efficient assembly, ADC, and S/H.

II. LITERATURE REVIEW

When an unstabilized input voltage is fed into the controller, the result is a stable output voltage that is perfectly steady and free of voltage fluctuations. A static system serves as the stability configuration for the voltage variations and transient disturbances that occur in interconnected supply systems[8]. The addition of an adaptive controlled stabilizer loop system to the controller increases the entire power system stabilizer's effectiveness when operating in unfavourable or unusual settings, such as three-phase short circuit systems[9]. The voltage fluctuations generated by the loads will be reduced in high-power applications static systems. Overvoltage shortens the life of the stabilizer and undervoltage lowers efficiency in a continuous supply of AC power involving an electronic system[10]. Fig 1 depicts block diagram of stabilizer.

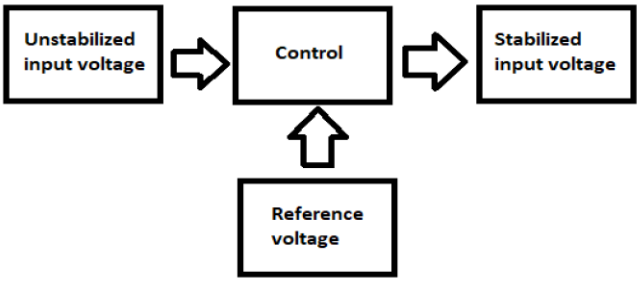

Fig 1: Block diagram of stabilizer

Static stabilizers have the ability to have constant output voltage tracking with an arbitrary range of speed convergences, protection from various common mode type noises, and high momentary capacity for demanding applications and equipment. In constant torque conditions, the PWM control is applied. Microcontroller-based circuitry is used in servo stabilizers. The basic goal of the Static Voltage Stabilizer is to maintain a steady voltage supply without causing any system changes. To build a static voltage stabilizer system with the following characteristics: DSP-based single-card technology, compact size when compared to traditional stabilizers, and low cost. Individual phase control, IGBT pulse width modulation AC to AC switching control Waveform distortion in the output waveform is negligible. It is dependable and does not require any maintenance.

The electrical power delivered by electricity boards will be of poor quality. The voltage of the electrical power supplied may differ from the desired safe range. Many pieces of electrical equipment are voltage-sensitive. The voltage loss could be due to overloaded situations. Rain, falling trees on electric wires, or a loose link in the power line could all cause a spike in supply. Static voltage stabilizers are used to safeguard electrical equipment from mains voltage changes. These stabilizers are employed at the equipment's input, stabilising the mains voltage and restoring anomalous voltages to a safe range. The amount of static voltage stabilisation is determined by the stabilizers utilised. The various stabilizers are chosen mostly based on the electrical demand and the cost of the stabilizers.

A. Servo voltage stabilizers

The servo controlled stabilizers are also known as the motor controlled stabilizers because they are controlled by stabilisation systems that include a Buck-Boost type transformer that collects voltage variations from its input voltages and adjusts the current to correct the output voltage[11]. The control card, comparator, and dimmer govern the output voltage of this sort of stabilizer, which regulates itself in anti-clockwise or clockwise directions. Fig 2 depicts servo stabilizer circuit diagram. The Servo Voltage stabilizer's optional features include main circuit breakers for overload and short circuit protection schemes[12]. The neutral loss is the output cut-off if the neutral is missing at the input; it prevents phase loss circumstances in the stabilizer, provides electronic Overload protection, and aids ground fault monitoring with the trip and leakage current[13]. It serves as both a surge suppressor and a surge protector.

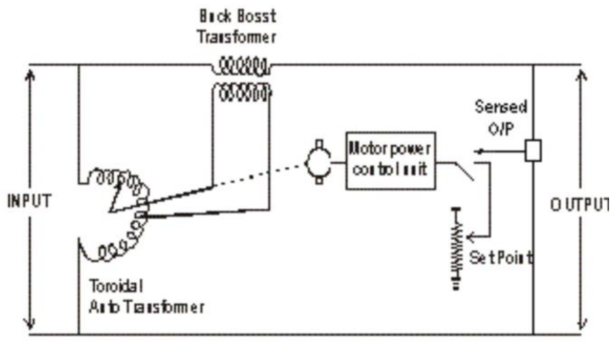

Fig 2: Servo stabilizer circuit diagram

The moving parts in the Servo controlled voltage stabilizer system provide a constant supply of electricity while regulating the supply voltage to the load. Servo stabilizers are commonly found in refrigerators, televisions, and heating equipment[14]. The electrical appliance is intended to work at specified voltage circumstances in order to get the required results. The internal circuit of a Servo voltage stabilizer comprises of an autotransformer or transformer, rectifier units, comparators, relays, and switching circuits that run the load or system within an acceptable voltage range[15].

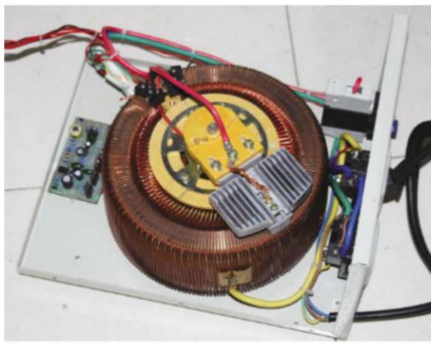

Fig 3: Internal circuit of Servo Voltage Stabilizer

The electrical power distribution is 230 volts for single phase, designed to be operated in the voltage range of operation 220 volts to 240 volts, and voltage fluctuations reflects the change in magnitude of the supply voltage, generally exceeding or below steady state voltage. This voltage fluctuation is tolerated by many electrical appliances.

B. Static voltage stabilizer

The voltage stabilizer we're utilising is static, which has advantages over slow Servo-controlled voltage stabilizers. The basic research of the static voltage stabilizer here incorporates a buck-boost type transformer with primary to secondary ratios for voltage correction. This type of voltage is regulated via a buck and boost circuit that is achieved electronically without any step changes in voltage during system regulation. Various AC-AC converter circuits and power switching devices may be used in this type of system. The enhanced pulse width modulation is a control operation for achieving the desired correction time, in which the overall

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 06, June-2021

response of the system is improved and entails a faster voltage correction speed.

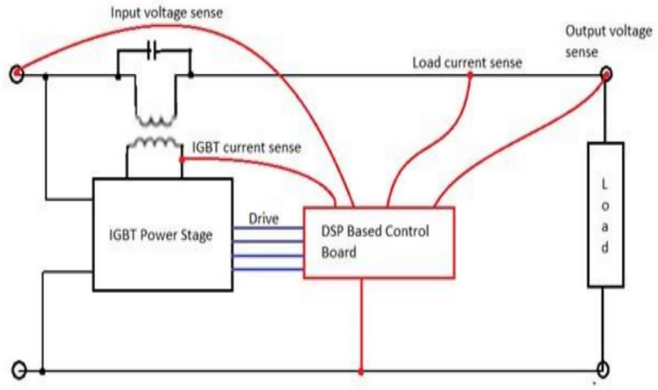

Fig 3: Block Diagram of Static Voltage Stabilizer

III. METHODOLOGY

There are two modes of operation which in which the Static Voltage stabilizers works they are:

Buck mode: Here 40V is generated using a PWM and added with the mains. The difference current of 51A will flow through IGBT. Output voltage is more than its desired voltage Vs which works in the buck mode here the phase and neutral switches are reversed.

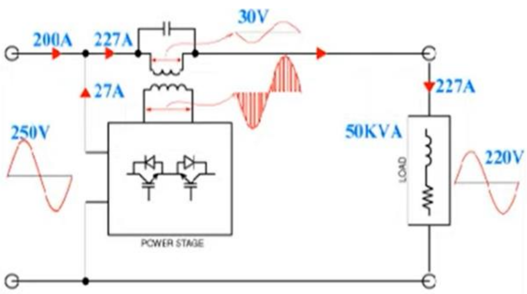

Fig 4: Buck Mode circuit diagram

Boost mode: Here PWM is generating in opposite phase, it is 180 degree out of phase.30V is subtracted from mains. Here 27A will flow back to the mains from IGBT. Here the output voltage is always less than its desired voltage Vs works in the Boost mode of operation.

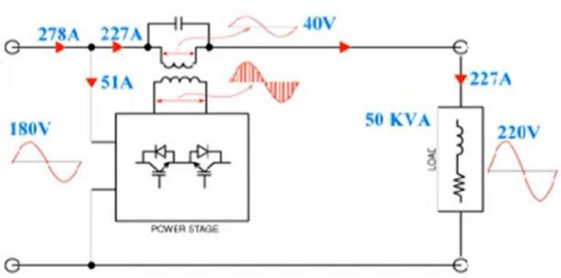

Fig 5: Boost Mode circuit diagram

A.Major components of SVS

1. Buck Boost Transformer: The voltage stabilizer's input and output terminals are connected to the Bucks secondary and boost transformer. Because the static voltage stabilizer's input and output are connected via a common neutral, the voltage formed across the buck boost transformer’s secondary, might add or remove from the input voltage. The IGBT power stage is connected to the primary of the buck boost transformer.

2. IGBT Power Stage: With the help of the PWM approach, the IGBT power stage is responsible for generating a suitable quantity of voltage. As the device's control circuit, the output of the IGBT power stage is sent to the primary. The IGBTs output can be in phase or 180 degrees out of phase along the input line voltages when fed to the primary of the transformer. So, depending on the required voltage at the load, the voltage induced across the secondary of the Buck-Boost Transformer can be added or subtracted.

3. DSP based Control board: The DSP-based control board's main task is to provide PWM to operate the IGBT. With the help of a current transformer and a voltage transformer attached to it, it continuously senses the values of input voltage, output voltage, load current, and IGBT current. And, as feedback, this processed data sends a signal to the IGBT power stage, which uses the PWM approach to generate the appropriate voltage and duty cycle.

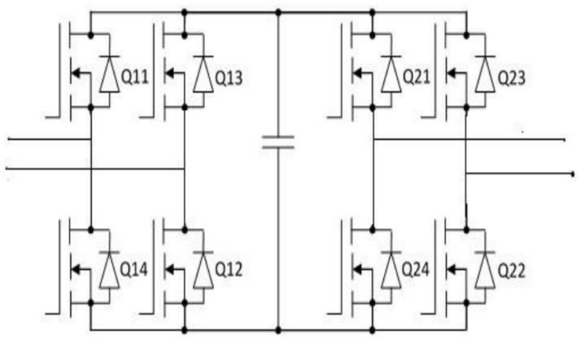

Fig 6: Circuit diagram of Single phase SVS

$V_{out} = V_{in} + [V_{in} d(1-d) V_{in}]n = V_{in}[1 + (2d-1)n]$

V_{out} is the total of the input voltage, V_{in} and transformers voltage that are chopped AC voltages [= n (2d−1)Vin]. n is the ratio of the transformer, d is the duty cycle. We can write for large frequency switching relative to line frequency as,

$$I_{Av\text{-}Q21} = (1/2\pi)\ \{{}_0\int^{(\pi-\varphi)} d\ I_p \sin\omega t\ d\omega t + {}_{(\pi-\varphi)}\int^{\pi} (1\text{-}d)\ I_p \sin\omega t\ d\omega t\}$$

$$= (Ip / 2\pi)\ \{1 - \cos\varphi + 2d\cos\varphi\}$$

$$I_{RMS\text{-}Q212} = (1/2\pi)\ \{{}_0\int^{(\pi-\varphi)} d^2\ Ip^{\,2} \sin^2\omega t\ d\omega t + {}_{(\pi-\varphi)}\int^{\pi} (1\text{-}d)^2\ Ip^{\,2} \sin^2\omega t\ d\omega t\}$$

$$= (Ip^{\,2} / 4\pi)\ \{d^2\pi + (1 - 2d)[\varphi + \sin(2\varphi)/2]\}$$

From the above, we can write,

$$I_{Av\text{-}D21} = (I_p/\pi) - I_{Av\text{-}Q21}$$

$$I_{RMS\text{-}D21}^2 = Ip2/4 - I_{RMS\text{-}Q21}^2$$

IV. RESULT AND DISCUSSION

The simulation model for an open loop Static Voltage Stabilizer is shown below. Four diodes are utilised to rectify the AC input, and the rectified output is routed to IGBTs. In this device, the pulse generator is employed to drive four IGBTs. The positive or negative pulse is sent to two IGBTs at the same time. The main of the Transformer receives the output of the IGBTs. The transformer is then linked to the load. Fig 7 depicts voltage stabilizer circuit designed in MATLAB.

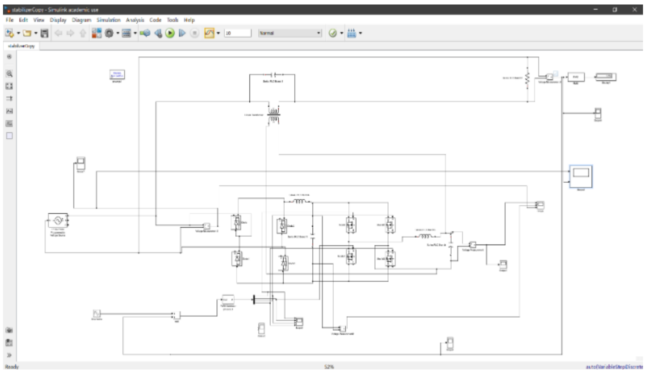

Fig 7: Simulink Circuit

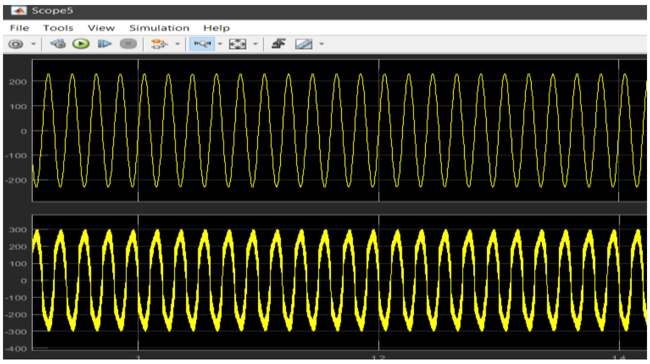

Fig 8: Simulink simulation results for Step up mode operation

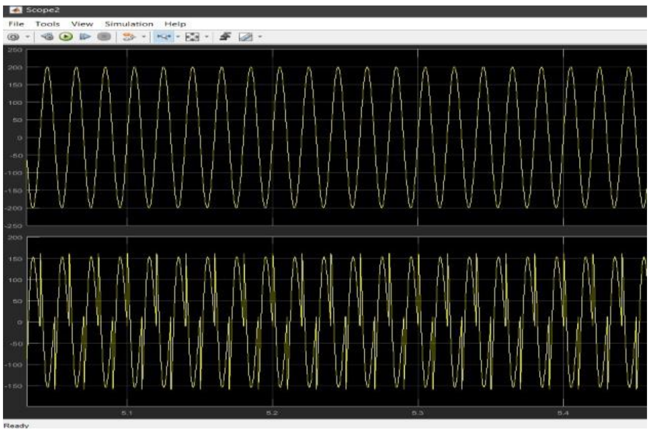

Fig 9: Simulink simulation results for Step down mode operation

Simulink has simulated the following graphs for Step up mode operation and step down mode operation as depicted in Fig 8 and Fig 9 respectively.

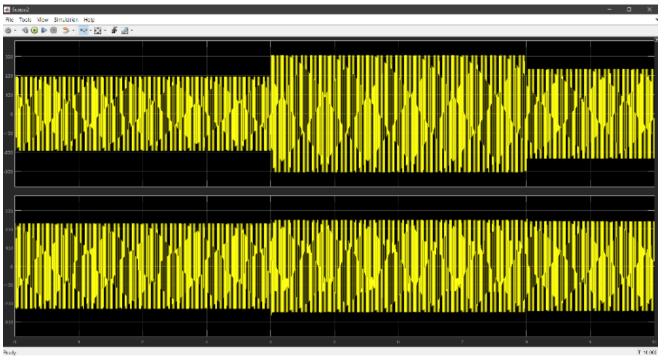

Fig 10: Simulink simulation results for the SVS system.

The stabilizer designed aids in voltage regulation. The fig 10 indicates Simulink simulation. The result shown in the graph corresponds to the working of step up and step down operations and hence maintains a steady voltage.

V. CONCLUSION

The above paper demonstrates the development and implementation of a Static Voltage Stabilizer to provide a constant output voltage. The Static Voltage system is implemented using MATLAB, which is an open loop form of software, or the Simulink software model. According to this, the hardware model for the above-mentioned Static Stabilizer system is also being built. The signals are created as pulse width modulated signals, which are then sent to IGBT modules and HCPL driver circuits. Capacitors of the electrolytic variety are used to remove noises.

REFERENCES

[1] Patchett, G. N. 1968. "Transistors in the Regulating Unit of Electronic Voltage Stabilizers." *Radio and Electronic Engineer*. https://doi.org/10.1049/ree.1968.0089.

[2] Ahmadi, Hamed, and Mazana Armstrong. 2020. "Grid-Connected Low-Voltage Power Supply to Equipment on Transmission Line Structures." *2020 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE)*. https://doi.org/10.1109/ccece47787.2020.9255707.

[3] Yedewar, Pranjali, Sandip Wadhai, and Arun Banpurkar. 2020. "AC and DC Voltage Electrowetting on Ferroelectric Polymer for Low Voltage Applications." *DAE SOLID STATE PHYSICS SYMPOSIUM 2019*. https://doi.org/10.1063/5.0017318.

[4] Du, Guest Editor Jianping. 2016. "A Novel Improved Voltage Stabilizer Using a Power System Stabilizer (PSS) and Static Var Compensator (SVC)." *International Journal of Simulation: Systems, Science & Technology*. https://doi.org/10.5013/ijssst.a.17.47.09.

[5] Neher, L. K. 1958. "NOTES ON THE DESIGN OF FLOW DISCHARGE VOLTAGE STABILIZERS FOR PHOTOMULTIPLIER TUBE POWER SUPPLIES." https://doi.org/10.2172/4301139.

[6] Pergushev, Aleksey, Vladimir Sorotsky, and Anatoly Ulanov. 2019. "Output Voltage PWM Conversion Inaccuracies in Envelope Tracking Power Supply for High Peak-to-Average Power Ratio Applications." *2019 IEEE International Conference on Electrical Engineering and Photonics (EExPolytech)*. https://doi.org/10.1109/eexpolytech.2019.8906854.

[7] Tooley, Mike. 2019. *Electronic Circuits: Fundamentals and Applications*. Routledge.

[8] Fang, Tianzhi, Xinbo Ruan, and C. K. Tse. 2009. "Control Strategy of Achieving Input Voltage Sharing and Output Voltage Sharing for Input-Series-Output-Series Inverters System." *2009 IEEE Energy Conversion Congress and Exposition*. https://doi.org/10.1109/ecce.2009.5316289.

[9] "Fuzzy Logic Controller as a Power System Stabilizer." 2009. *Electric Power Applications of Fuzzy Systems*. https://doi.org/10.1109/9780470544457.ch5.

[10] Ashour, Hamdy Ahmed. 2008. "A New Electronic Step-Up/down Voltage Stabilizer Topology Based on H-Bridge AC Chopper." *2008 12th International Middle-East Power System Conference*. https://doi.org/10.1109/mepcon.2008.4562400.

[11] Hashiguchi, Takuto, Seiya Abe, and Satoshi Matsumoto. 2015. "A Fully Digitally Controlled Multiple Input and Output Voltage Buck-Boost POL for Power Supply on Chip." *2015 IEEE International Telecommunications Energy Conference (INTELEC)*. https://doi.org/10.1109/intlec.2015.7572318.

[12] "Short Circuit Currents." 2002. *High Voltage Circuit Breakers*. https://doi.org/10.1201/9780203910634.ch2.

[13] Jia, Qing-Quan, Chun-Xia Dou, Zhi-Qian Bo, Ning Wang, and Jie Tian. 2007. "An Integrated Phase to Ground Fault Protection for Neutral Compensated Power Networks." *2007 IEEE Power Engineering Society General Meeting*. https://doi.org/10.1109/pes.2007.386244.

[14] Cirstea, Marcian, Andrei Dinu, Jeen Ghee Khor, and Malcolm McCormick. 2002. *Neural and Fuzzy Logic Control of Drives and Power Systems*. Newnes.

[15] Sturmer, Henryk. 2010. "Voltage Division over the Interrupter Units of a High Voltage Circuit Breaker without Grading Capacitors." *2010 9th International Conference on Environment and Electrical Engineering*. https://doi.org/10.1109/eeeic.2010.5490033.