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Review: Different Technology of AC Voltage Regulator for Electrical Application

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Abstract: There are a variety of system designs available today to control AC voltage for sensitive loads, such as an AC PWM chopper, a unified power factor converter made up of a PWM rectifier and a PWM inverter, or a serial AC voltage regulator, among others. Serial AC voltage regulators can lower the switching strength and rating of the main circuit power devices in these arrangements. It has the smallest rating, which is determined by load capacity and the fluctuating range of supply voltage. As a result, it is rated for significant rating loads.
This paper is review the different techniques for voltage regulator used in power system for voltage profile control. In this paper, the techniques based on artificial intelligence, fuzzy logic, using auto transformer, 9 step level; voltage regulator, coordinated control, predictive control method etc. This paper will be useful in future for students and researcher those interested in work in field of voltage regulator.

***Index Terms* – AC Voltage Regulator (VR), voltage control**

I. INTRODUCTION

Because of the direct relationship between the supply voltage level and the attached electrical or electronic equipment, AC voltage management is crucial. This significance stems from the fact that the intended and produced equipment need a constant AC supply voltage of 220-230Vrms to operate. The supply AC voltage, on the other hand, is subject to fluctuations in supply voltage levels, which are caused by variations in the instantaneous draw currents applied to the associated loads. Many researchers contribute to the topic of AC voltage control by submitting ideas based on various designs and approaches.

The goal of [1]'s study is to create and install an Automatic Voltage Regulator (AVR) to combat the threat to vital electrical and electronic home equipment like as computers, refrigerators, and televisions. The work in [1] addresses the flaw in current systems, which is reflected by the difficulty of oscillating between two output voltage steps and the problem of causing a surge at the output, which can destroy important electronics. Using many taps, this study addressed both flaws and introduced voltage in the bearable range of 215-237 volts. When switching from one level to another, hysteresis was incorporated to prevent oscillation. However, because this design calls for several taps and control contacts, only one tap is connected to the output load at a time, rendering the others worthless, and there is a brief period between steps, which might result in a surge at the regulator's output terminals.

The work in [2] proposes the design and implementation of a Programmable Automatic based on a specific microcontroller unit to address the problem of oscillating between two output voltages, but it does not address the case of off time that occurs between each two taps during jumping time, and it continues to use a multitap transformer.

The research in [3] focuses on three-phase AC-voltage regulator systems employing silicon controlled rectifier (SCR) that are widely used in the industrial sphere, and it employs a revolutionary design of three-phase AC-voltage regulation trigger circuitry of SCR through a microcontroller unit. However, adjusting the conducting angles of six thyristors would result in distorted three phase sine waves, which will cause harmonics difficulties on linked loads and increase the complexity of the design.

[4] is a description of 12 commercially available residential 1kVA Automatic Voltage Stabilizer brands that are suited for line and load regulation testing. In [5], [6], the Sinusoidal Pulse Width Modulation (SPWM) approach is presented to accomplish the AC voltage regulation that manipulates the voltage fluctuation; the work in [5] employed the technique on a voltage stabilizer based on a suitable microcontroller through an AC/DC/AC stabilizer type. The suggested control is accomplished by first rectifying the input AC voltage to a sufficient DC level, then regulating the output voltage using the PWM approach to generate a perfect sinusoidal AC voltage using a filter. The system is accurate, but it is also complex and expensive.

The use of the PWM approach for AC voltage regulation to manage the output voltage of a freestanding wind turbine driven by variable speed wind is also discussed in [6]. The method is used to control the wind turbine's fluctuating voltage. The suggested design and simulation comprises a utility connection, a battery storage system, a PWM inverter, and a controlling device to manage the power supply when the wind-regulated voltage falls below a threshold value owing to low wind speed or no wind.

The research investigations in [7] focus on AC, DC voltage control, and providing with/without Sinusoidal Pulse Width Modulation for delivering the appropriate power to the linked loads. The study [13] focuses on electrical risks, stabiliser kinds, servo voltage stabilisers, and how the need for servo stabilisers is continuously increasing. Despite the study's content, the servo voltage stabilizers' reaction is slow when compared to completely electronic systems with/without relays.

II. DIFFERENT TECHNOLOGY FOR AC VOLTAGE REGULATOR

The design and implementation of FLC for customized servo voltage stabilizers for household and industrial applications was proposed by one of the authors [8]. The FLC firmware for four operational modes has been produced and is implemented in the ATmega 128 controller, while the rest of the work is for a fixed application. A single auto transformer is used in this servo voltage stabilizer, and the FLC controller employs closed loop feedback. For uncontrolled input voltages ranging from 150 V to 300 V, the designed servo voltage stabilizer ensures a satisfactory regulated output voltage.

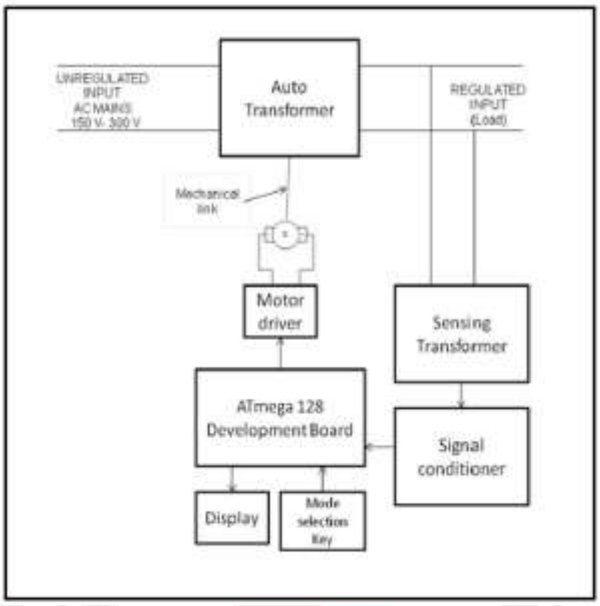

Fig.1. Fuzzy logic control based series active power filter [14]

A customized FLC for a servo stabilizer has been created, simulated in Proteus, and an experimental model has been constructed and tested. The FLC firmware for four specific modes was developed and implemented in an ATmega 128 microcontroller. This system has been tested with an uncontrolled input voltage range of 150 to 300 volts. The regulated output of the FLC servo stabilizer is watched to maintain a steady voltage within the defined limits of the selected mode. The system's dependability will be assessed by using FLC with a stand-alone controller.

Automatic AC voltage control is a prevalent problem in both homes and businesses, especially when load currents change. Many methods based on multi tap transformers are offered on this page; however, in this approach, the steps of voltage control are equal to the number of taps on the transformer. One of the authors designed a one-step secondary winding transformer to offer three steps of AC voltage regulation and to handle the condition of oscillating between two steps of output voltage, which causes a surge at the regulator output terminals when switching between steps using relay contacts [9].

The developed transformer will be utilized in this project to raise and decrease the input AC voltage based on continuous monitoring of the input voltage's instantaneous value. The research presents complete design and simulation findings using the Multiuse and PSIM 2-software packages.

The novel suggested AC voltage regulation concept employs the use of a single secondary winging coil to moderate the fluctuation of input AC voltage in three phases. The selected step is roughly 2o Vrms; in other words, the three stages are increment, no change, and reduction of input AC voltage in order to give less fluctuating AC supply voltage to the associated load.

The suggested work also has the advantage of employing just one secondary winding of a step down transformer, which means that the regulating is simplified because it deals with low voltage control. The second advantage is that the voltage step (of 20 V) is less than 10% of the rated voltage of the input AC supply (of 220 V), thereby preventing a power spike during the controlling leap of relay contacts.

This research presents a unique design and simulation results for a 9-steps automated AC voltage regulator based on a single step-down transformer. The suggested design eliminates the problem of surge at the AC load when managing leap steps. A precise and smooth regulating function is also realised. Instead of expanding the number of taps on the conventional multi tap transformer to cover a wider range of fluctuating AC supply voltage regulation, the suggested design uses just two step down transformers with 10 Vrms and 30 Vrms secondary voltages, respectively.

The resultant load voltage is equal to the AC supply voltage as well as the relevant voltage step, which may be one of the voltages of +40V, +30V, +20V, +10V, 0V, -10V, -20V, -30V, -40V, as controlled by the recommended design [10] of AV voltage regulator. The electrical circuit connection of step down transformers and relay connections is constructed using PSIM software for power circuit design, while the electronic design is done with Multisim software.

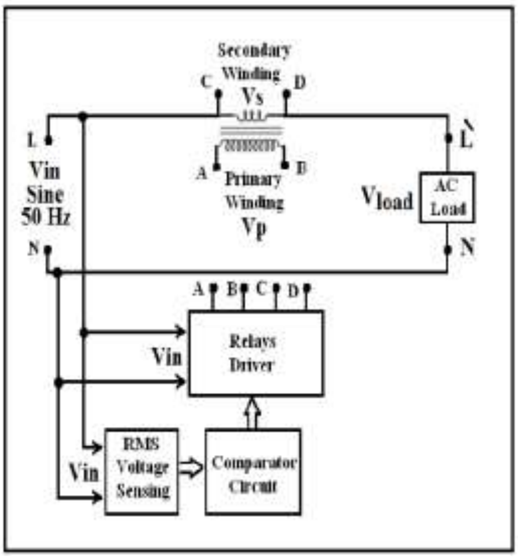

Fig.2. Three phase AC voltage regulator [9]

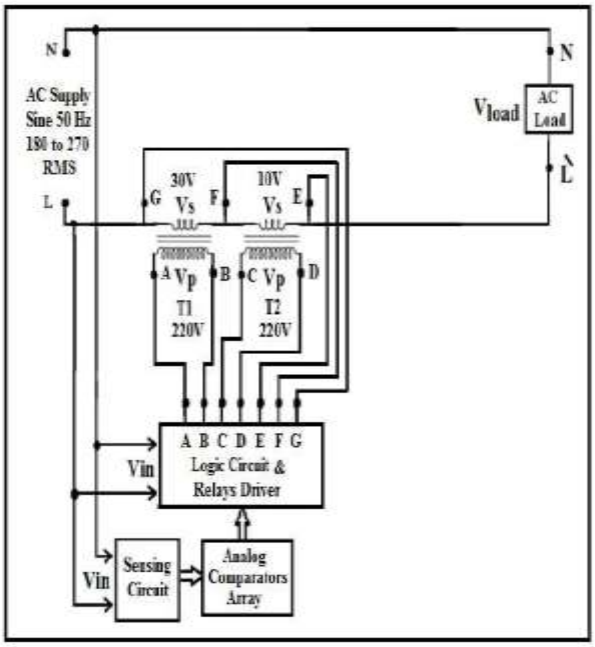

Fig.3. 9 step design of AC voltage regulator block diagram [10]

Because of the growing amount of volatile renewable energy, oscillatory modes in power networks will become increasingly variable. Adding new controllers to power systems or changing current controllers to dampen oscillations is a costly and challenging undertaking. As a result, new functions are needed to make the most use of current controllers for dampening variable oscillations.

Due to the growing amount of volatile renewable energy, oscillatory modes in power networks will become increasingly variable. To dampen such oscillations, adding new or replacing current controllers in power systems is a costly and demanding process. To make the most use of current controllers for dampening variable oscillations, additional functionalities are necessary.

One of the ways [11] shows how to automatically tune existing controllers in AC/DC power systems for better oscillation damping. To do this, we first propose a thorough dynamic model of AC/DC grids with explicit controller parameter relationships. The controllers in the system are then tuned using H-infinity optimization. With thorough rounded-mean-square simulations of a modified IEEE 39 bus power system, the efficiency of the suggested technique is proven.

By changing the settings of current controllers, an H1 tuning algorithm for the minimizing of power oscillations in AC/DC systems after a load shift. The method's effectiveness was shown using a modified IEEE 39 bus system in which power oscillations were avoided by adjusting power plant and converter characteristics. Furthermore, we demonstrated that HVDC cables may contribute significantly to POD even when the source of the oscillations is far away.

In power electronics systems, the predictive control paradigm is becoming increasingly used. It may also be utilized to improve power quality in systems. The ideas of a model predictive control hybrid transformer (HT) with matrix converter are presented in this article (MC). On the secondary side, the proposed HT comprises of a power transformer coupled to a power electronic converter that regulates the output voltage. The suggested control method's merits include its ease of implementation and the ability to maximize a variety of predetermined criteria. Simulation studies have shown that voltage sags, swells, and harmonics in the power system are compensated.

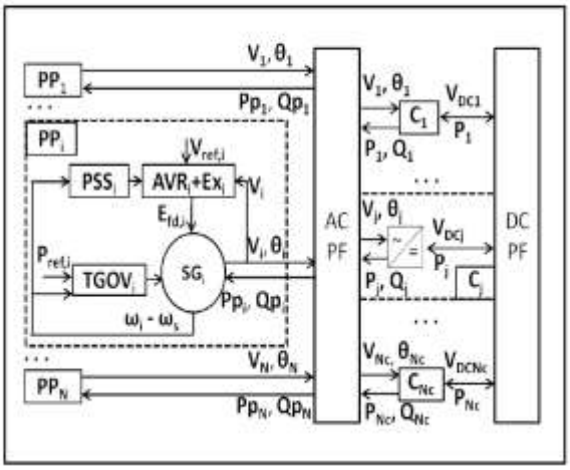

Fig.4. Power system model with automatic voltage restorer [11]

The collected findings show that the suggested technique has a lot of promise and outperforms traditional space vector modulation control methods substantially. The employment of a system with a model predictive technique to adjust for stochastic grid voltage distortions is a notable addition of the article.

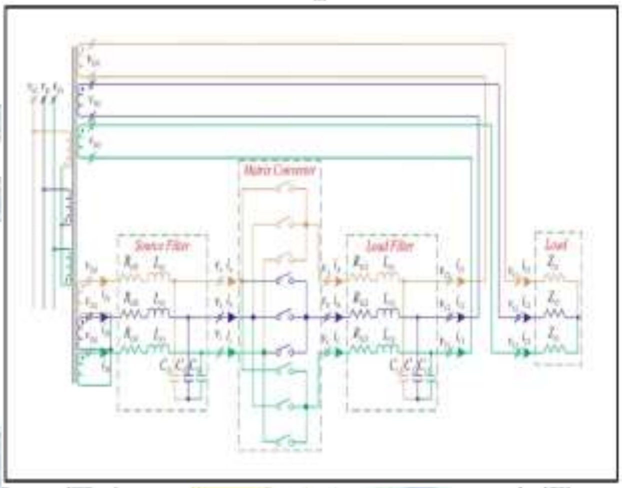

Fig.5. Hybrid transformer based voltage regulator [12]

A model predictive control has been presented by one of the authors [12] for adjustment of source voltage sag/swell and harmonics. The proposed control mechanism provides a number of benefits as well as some drawbacks. The primary restriction stems from the large measurement and control system that implements the predictive technique, as well as the measurement and control system that implements the predictive method.

To detect three-phase voltages and currents at the compensator's input and output, as well as in the compensator circuit, the control system will require a high number of analog-to-digital converters and sensors (current and voltage). Furthermore, the predictive technique accounts for the complicated models of two filters as well as the transformer characteristics, which necessitate a high number of arithmetic computations. The transformer parameters have not been considered in this text. They will be crucial in the control of a genuine system, and they will be studied further.

One approach [13] examines the low frequency stability issues that might arise in a generic DC microgrid system. Fundamental principles are used to derive the prerequisites for system stability. The DC microgrid is intended to be stabilized using a capacitive energy storage system-based active voltage stabilizer that regulates power fluctuations inside the system during transient situations.

The active stabilizer, which is based on a bidirectional DC-DC converter, is described in detail, and an appropriate control approach is provided. Only local voltage sensing is used in the proposed active stabilizer and its related control system, which does not change the general DC microgrid structure. Analytical models and circuit simulations are used to validate the suggested method.

An active stabilizer based on a dual active bridge (DAB) converter is constructed, and hardware-based experimental findings from a laboratory test-bench are presented to evaluate the suggested approach's functionality and efficacy.

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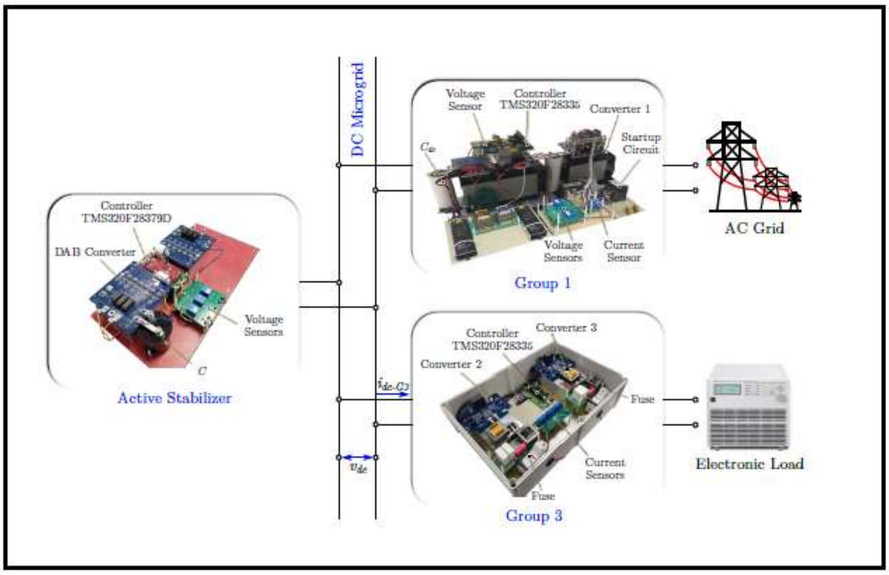

Fig.6. DC microgrid voltage regulator topology [13]

For a generic DC microgrid, an active voltage stabiliser is developed that controls power fluctuations during transients and enhances system stability margins. The active stabiliser and its accompanying control approach are used to simulate a small-signal impedance across the DC bus. By increasing the system stability margins, this method helps to prevent any unwanted impedance interactions inside the system.

Analytical models and circuit simulations are used to verify the active stabilizer's functioning as well as the proposed control method. In addition, the suggested active stabiliser idea has been tested in a DC microgrid test bench in the lab. The feasibility, functionality, and efficacy of the suggested technique are demonstrated using a DAB converter-based active stabiliser prototype. Because the active stabiliser isn't rated for continuous power, the cooling overhead may be reduced, allowing for more power dense solutions.

Today's power needs are steadily growing, and the most difficult task is maintaining a consistent voltage for customers under varying load situations. The performance of the associated load is affected by fluctuations in nominal voltage levels. A voltage stabiliser is a device that balances voltages in the presence of changing load circumstances. Traditional voltage stabilisers, on the other hand, have a delayed transient reaction and are prone to sparking due to electromechanical relays. The use of a TRIAC-based automated voltage stabiliser eliminates these issues.

Overvoltage protection, overload protection, and short circuit protection are also included. With a similar number of transformer taps, TRIACs are used as switching devices. A TRIAC-based automated voltage stabilizer is simulated in Proteus and then built and implemented using a PIC microcontroller in this research article. Using a TRIAC-based automated voltage stabilizer, the drawbacks of delayed transient response and excessive relay sparking in traditional voltage stabilizers were satisfactorily corrected.

The hardware implementation of a PIC driven TRIAC based automated voltage stabilizer that used a tap changing transformer to produce nominal AC voltage is presented in this work [14]. The stabilizer is put to the test under various load circumstances. It delivers good results. Overvoltage protection, under-voltage protection, overload protection, and short circuit protection are all included.

In generating stations, the AVR (Automatic Voltage Regulator) is crucial. To keep the generator's voltage stable, the terminal voltage should be kept constant at all times. Manual regulation is substantially more difficult in a big linked system, hence automatic generation and voltage regulation is required. Automatic voltage regulators are employed at each producing station to maintain a steady voltage level.

AVR (Automatic Voltage Regulator) is a technology that is primarily designed to maintain a steady voltage level automatically [14]. It is an instrument that regulates voltage by means of an automated control mechanism and is used in the power system to stabilise voltage that arises as a result of load variation.

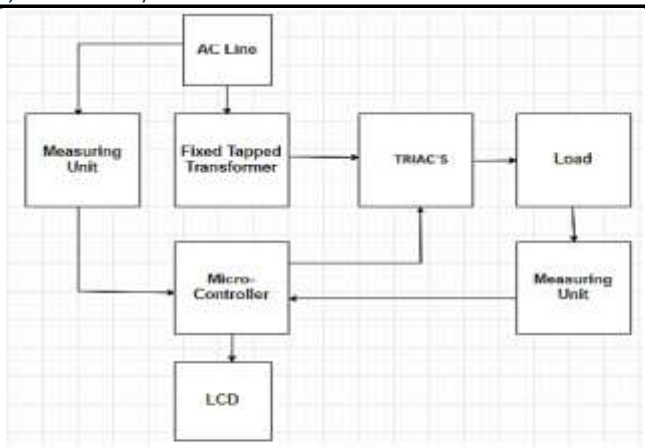

Fig.7. Voltage regulator using TRIAC [14]

Variation in voltage is mostly caused by variations in load in the supply system, and variations in voltage harm equipment, thus it is vital to stabilize that voltage, which is why an Automatic Voltage Regulator is employed in the system.
This study is the first to present a revolutionary single-phase pulse width modulation (PWM) direct ac-ac converter based on two-level non-differential dual-buck ac chopper legs with inverting and non-inverting operations. When employed as a distributed flexible voltage conditioner, it can tackle both voltage sag and swell problems at the same time (DFVC).
When compared to a standard ac-ac converter, it offers substantially higher system dependability since there are no shoot-through difficulties even when all switches on each ac chopper leg are switched on, and hence no PWM dead-time is required, resulting in better duty cycle utilisation. Only half of the switches in the proposed converter are switched at high frequency for a switching duration at maximum, reducing total switching loss by [16]. The converter's two biggest benefits are that it keeps the input and output's common ground and uses the same buck/boost operation technique for non-inverting and inverting modes.

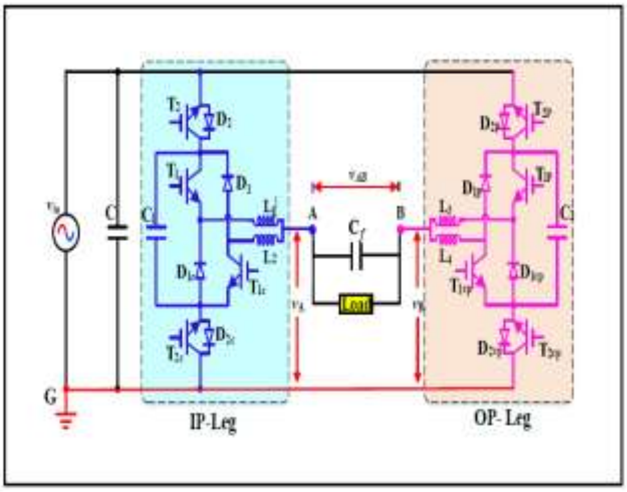

Fig.8. Block diagram of bipolar type AC-AC voltage regulator [16]

It can achieve bipolar output voltage gain, which means it may produce an in-phase or out-of-phase output voltage with the input voltage. As a result, when utilised in a DFVC, it can correct for both voltage sag and swell. The suggested ac-ac converter features the same buck/boost operation mechanism for non-inverting and inverting modes, ensuring a constant average current supply to the low-voltage output side without the need for a high-value capacitor to sustain power. Furthermore, because the input and output share a similar ground, the characteristic that the output can reverse or retain phase angle with the input is well supported.
The suggested converter addresses the commutation problem and enhances duty cycle utilization due to no dead-time by using two-level non-differential dual-buck ac chopper legs with two separation inductors. To reduce switching loss, partial free-wheeling diodes with quick reverse recovery properties can be used individually.

III. CONCLUSION

This paper is reviewing the different techniques for voltage regulator used in power control. In this paper, the techniques based on artificial intelligence, fuzzy logic, using 9 step auto transformer, coordinated control, predictive control method etc. this paper will be useful for students and researchers those interested in work in field of voltage regulator for power system.

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