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PERFORMANCE ANALYSIS FOR ENHANCING POWER QUALITY THROUGH DVR WITH FUZZY LOGIC CONTROL

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ABSTRACT

A number of industrial processes and delicate electronic equipment are vulnerable to voltage sags, which are a major danger to the dependability and stability of electrical systems. The DVR is the central component of our investigation because of its famed capability to introduce compensatory voltages in response to sag occurrences. In order to offer accurate and consistent voltage adjustment, the PI controller—a widely-used control algorithm—is included. In addition, the DVR is equipped with Fuzzy Logic Control, which allows it to better adapt to nonlinear and dynamic system characteristics. In this research, we use MATLAB/SIMULINK to enhance the performance of a DVR-based PI by including a Fuzzy Logic Controller. The DVR functions admirably in both balanced and unbalanced voltage situations.

Keywords: Voltage Sag, Voltage, Fuzzy Logic, Power, Proportional-Integral

I. INTRODUCTION

The uninterrupted functioning of numerous electrical appliances and industrial processes relies on power distribution systems that consistently maintain a stable and dependable voltage profile. The reliability of electrical grids is jeopardized by voltage sags, which are defined as abrupt drops in voltage levels that don't last long. Scientists and engineers have been working hard to find new ways to fix this problem, and the Dynamic Voltage Restorer (DVR) is a device that shows promise. The performance and lifespan of sensitive electronic equipment can be negatively impacted by voltage sags, dips, or swells, which are temporary interruptions in the power supply. Many things can cause these disruptions, including as problems with the system, starting the engine, or unexpected changes in load demand. A drop in voltage can cause production losses, equipment damage, and downtime, all of which are disastrous for data centers, industrial operations, and other mission-critical applications. Hence, to guarantee the dependability of electricity distribution networks, it is critical to create appropriate mitigation techniques.

Reducing voltage drops has never been easier than with the Dynamic Voltage Restorer (DVR). A DVR is essentially a power electronic device that restores the voltage to its nominal level at the point of common connection by injecting compensating voltages during

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sag occurrences. By addressing voltage drops in real-time, this system guarantees that linked loads will continue to operate without interruption. Power storage devices such batteries or capacitors, a management system to regulate the balancing processes, and a voltage source inverter (VSI) are the usual components of a DVR. The development of an efficient control approach is an important part of improving the DVR's performance. One popular control technique that keeps systems stable and accurate is the Proportional-Integral (PI) controller. The DVR can respond quickly and accurately to voltage sag occurrences by including a PI controller, which efficiently regulates the compensating voltage injection. Immediate correction of reference voltage variations and removal of long-term mistakes are both accomplished by the proportional and integral components of the PI controller, which optimizes the DVR's functionality.

Fuzzy Logic Control (FLC) adds intelligence to the DVR, which further improves its usefulness. To handle power system uncertainties and changes, Fuzzy Logic offers an adaptive control technique. FLC allows for the modeling of linguistic variables and imprecise information, simulating human decision-making processes. Within the framework of a DVR, Fuzzy Logic has the potential to improve the controller's adaptability to nonlinear and dynamic system behaviors, making it more resilient and sensitive to different operating situations. In a DVR system, PI control and Fuzzy Logic work together to maximize the benefits of both methods. Fuzzy Logic enhances the system's flexibility and intelligence, enabling it to manage complex and dynamic circumstances, while the PI controller offers a steady and accurate baseline for voltage adjustment. This integration shows a lot of potential for improving the overall performance and reliability of the system by fixing the problems caused by voltage drops in power distribution networks.

II. REVIEW OF LITERATURE

Narnaware, Priyanka & Huchche, Vijaya (2018) Currently, electricity quality concerns are the primary focus of concern. Voltage sag and swell are the most prevalent power quality issues. In order to safeguard the vulnerable load against voltage sags in the electrical grid, a power electronic device called a Dynamic Voltage Restorer (DVR) is positioned between the power source and the sensitive load. DVRs can incorporate additional functionalities like as power factor correction, harmonic compensation, voltage transient reduction, and fault current limiting. This study demonstrates the modeling of a single-phase Dynamic Voltage Restorer (DVR) using MATLAB/SIMULINK. This model utilizes a Proportional Integral (PI) controller and an SPWM pulse generator. A research comparing the performance of a PI controller with a Fuzzy logic controller is conducted. The preference for a fuzzy logic controller over a PI controller stems from its ability to handle fluctuations in system parameters during voltage sag and its straightforward implementation.

Mohammed, Shazly & M. A., Abdel-Moamen (2013) A Dynamic Voltage Restorer (DVR) is an advanced power electronic device designed to safeguard delicate loads against voltage sag. Typically, sensitive loads refer to electrical gadgets that produce harmonics. A typical DVR operates in standby mode when no malfunction occurs. This work introduces a fuzzy controller-based DVR (Dynamic Voltage restorative) that serves as a voltage sag restorative and compensates for voltage distortion induced by harmonics. In a system where the neutral is connected to ground, voltage sag is significantly influenced by the zero sequence component. In order to mitigate the impact of the zero sequence component, a common Dynamic Voltage Restorer (DVR) utilizes a zero blocking technique by including a delta-connected blocking transformer between the power source and the booster transformer. The research reported in this paper utilizes the d-q-0 axis approach, taking into account the value of the neutral axis. This method proves to be highly effective when the neutral axis value is zero. The results indicate that this approach is capable of mitigating voltage sag with a compensation error of 0.99%. By employing this technique, a DVR has the capability to decrease the total harmonic distortion (THD) of voltage from 10.22% to 0.66%.

Babu, Sathish & Kamaraj, Nagappan (2013) This study examines the effectiveness of a Dynamic Voltage Restorer in correcting various degrees of voltage sags caused by different faults. Additionally, it aims to minimize the Total Harmonic Distortion during the mitigation process. The DVR utilizes a three-phase voltage source inverter and is coupled at the point of common coupling to control the voltage on the load side. The remuneration is determined by the utilization of PI and Mamdani Fuzzy Controller. We conducted comprehensive simulation experiments utilizing a fault generator to analyze the effects of varying levels of sag on the load side, both in balanced and unbalanced situations. The examination of simulation results demonstrates that the DVR exhibits flawless performance while utilizing the PI and Fuzzy control methods. Furthermore, the analysis also includes an assessment of the DVR's capabilities and performance for different energy storage capacities and injection transformer ratings. The controllers' performance is verified by simulation results using Matlab/Simulink.

Srisailam, Ch & Sreenivas, A (2012) In order to alleviate voltage sags and swells, Dynamic Voltage Restorer can determine the optimal voltage quality level for the client at the most affordable price. The medium-voltage distribution feeder is linked in series with this device. For DVR control, the PI controller is a frequent choice. One drawback of this traditional controller is that it may not deliver the necessary control performance when the system parameters change since it uses fixed gains. We suggest using a fuzzy logic controller to get around this issue. Also, when compared to the standard PI controller, the simulation results show that the suggested control mechanism substantially boosts the DVR's performance.

Ferdi, B et al., (2010) PI controllers are often used for DVR control. Nevertheless, when operating circumstances or system parameters change, the traditional controller's use of constant gains can make it fail to deliver the necessary control performance. An adaptive PI controller based on fuzzy logic is suggested as a solution to this issue. Fuzzy and PI controllers make up the controller. Online adjustments to the two PI controller parameters may be made by the fuzzy controller in response to changes in operating circumstances, taking into account the control system's error and error rate as well as fuzzy control principles. The results of the simulations show that the suggested control approach outperforms the traditional PI controller when it comes to the DVR's performance.

III. PROPOSED METHODOLOGY

Proportional-Integral (PI) Controller

Figure 1 shows a feedback controller called a discrete PI controller. It controls the plant by taking the integral of the mistake and weighting it. A constant KP multiplied by the error yields the proportional gain, which is used to modify the proportional response.

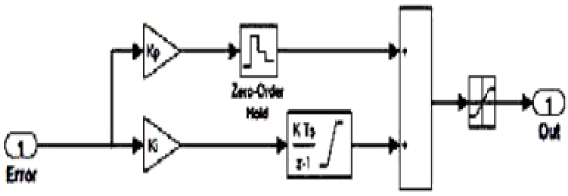

Figure 1: Discrete PI Controller

The integral term's contribution grows in direct proportion to the error's magnitude and duration. To get the corrected cumulative offset, we multiply the error by the integral gain, Ki, and then integrate the result.

The Matlab/Simulink control circuit is displayed in Figure 2. The three-phase V-I measurement at load in pu provides the output voltage, V3, which is used as an input by the controller. The dq term, which is a space vector representation of the instantaneous, is then applied to V3. Taking readings of the discrepancy between the dq-voltage and the standards allows one to identify voltage drops. The rated voltage is assigned to the d-reference and zero to the q-reference. After comparing the dq components of the load voltage with the reference values, the error signal is sent to the PI controller. When it comes to error signal-d and error signal-q, two distinct PI controller blocks are utilized. While KP is set to 40 for error signal-d and Ki to 100 for error signal-q, the corresponding values are 30 and 150 for Ki. To make sure the error signals d and q are stable and respond appropriately to disturbances in the system, all of the gains that were chosen are used for tuning. once that, the PWM generator receives the PI controller's outputs once they've been converted back into Vabc.

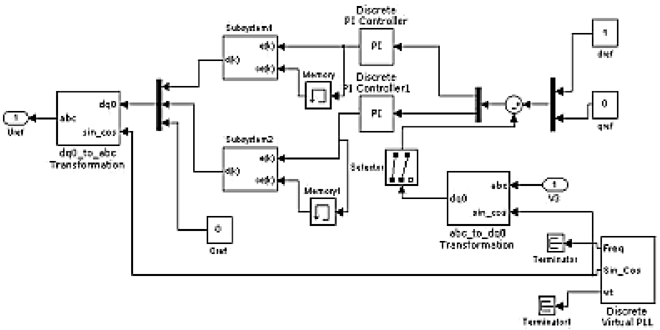

Figure 2: Control circuit using PI with fuzzy logic controller

Fuzzy Logic Controller (FLC)

The states (membership values) in fuzzy logic can only be between 0 and 1, in contrast to Boolean logic. The usage of verbal variables instead of numerical ones is one of its defining

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characteristics. It is possible to use fuzzy sets to describe linguistic variables, which are those whose values are phrases in a natural language (e.g., little and huge). As seen in Figure 3, there are four main parts to an FLC's overall structure:

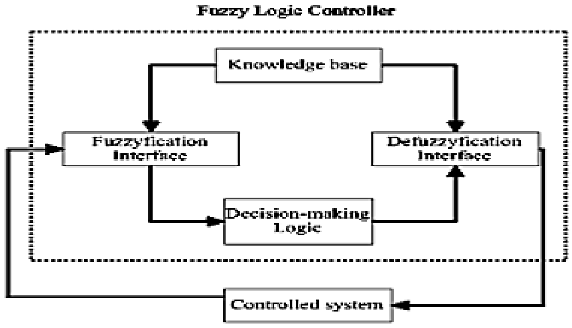

Figure 3: Basic configuration of FL controller

- An interface for fuzzyfication, which transforms raw data into appropriate language values;
- A database containing the relevant language definitions and control rules;
- A decision-making logic, mimicking human decision-making, infers the fuzzy control action using the knowledge of control rules and linguistic variable definitions;
- An interface for defuzzyfication, which transforms an inferred fuzzy control action into a nonfuzzy one.

Two FL controller blocks, as illustrated in Figure 2, are utilized for error signal-d and error signal-q in this research. Just as previously, but using Fuzzy Logic as the controller instead of Logic, the method is same. The FL controller takes three input linguistic variables—Negative (N), Zero (Z), and Positive (P)—for each block, error signal-d and q. Figure 4 displays all of the linguistic variables' parameters for the error signal. There are three language variables for delta error: negative (N), zero (Z), and positive (P). The two variables can be illustrated in Figure 5.

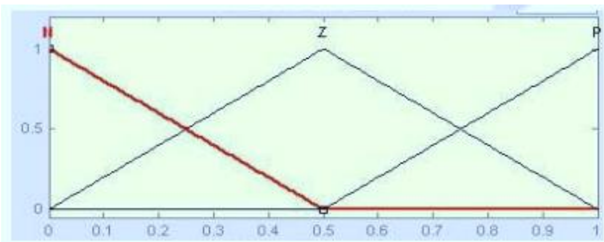

Figure 4: Linguistic variables from error

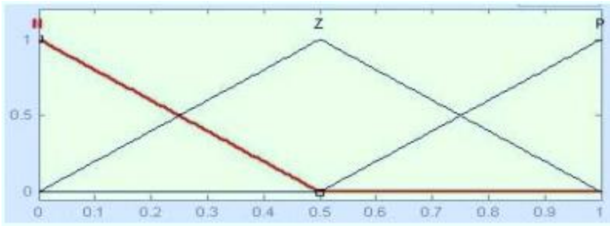

Figure 5: Linguistic variables from delta error

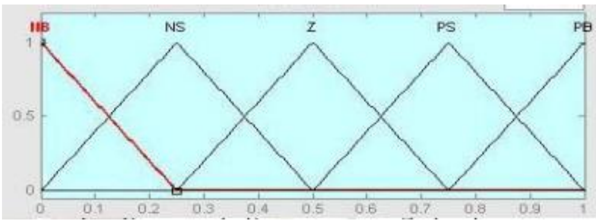

Figure 6: Parameter for each output signal

IV. RESULTS AND DISCUSSION

Figure 7 shows the implementation of a small distribution network that helps to understand the DVR's performance and control. Utilizing the MATLAB/SIMULINK program, a variety of fault scenarios, including normal system, single line to ground, double line to earth, three phase, and voltage sag, were meticulously simulated. As a means of control, PI is paired with fuzzy logic controllers. An auxiliary transformer was used to link the DVR system to the power distribution network.

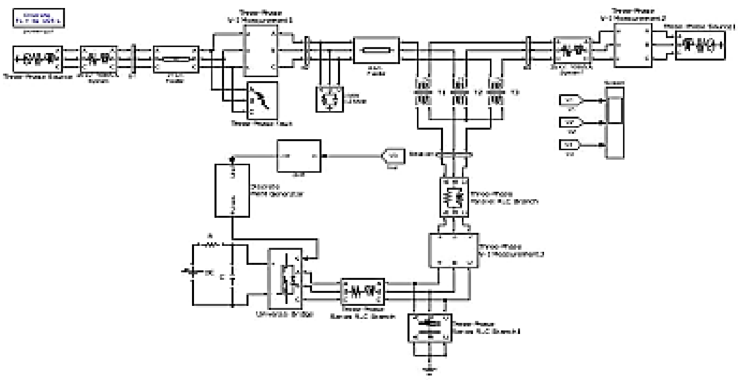

Figure 7: Simulink Model of DVR Test System

Various fault circumstances, such as normal operation, single line to ground, double line to ground, three phase, and voltage sag with feeder, can occur in this system. The fault resistance ranges from 20 ohms to 0.001 ohms, and the length of the sag ranges from 0.25s to 0.35s. Below are the output results for the system mentioned before.

Table 1: THD for Vdc

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Sl.No.	Vdc (V)	THD (%)
1.	250	0.41
2.	200	0.28
3.	150	0.25
4.	100	0.19
5.	50	0.09

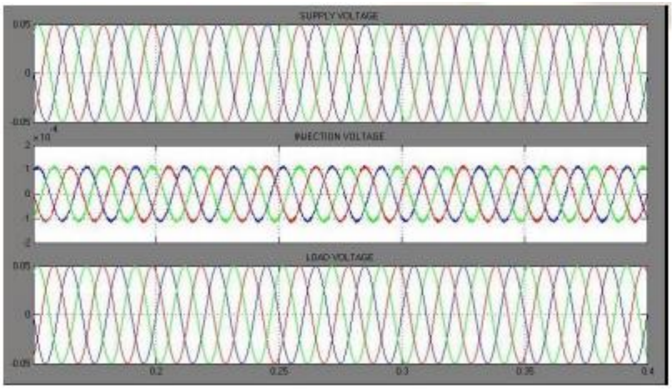

Figure 8: Normal system (a) Supply voltage, (b) Injection voltage, and (c) Load voltage

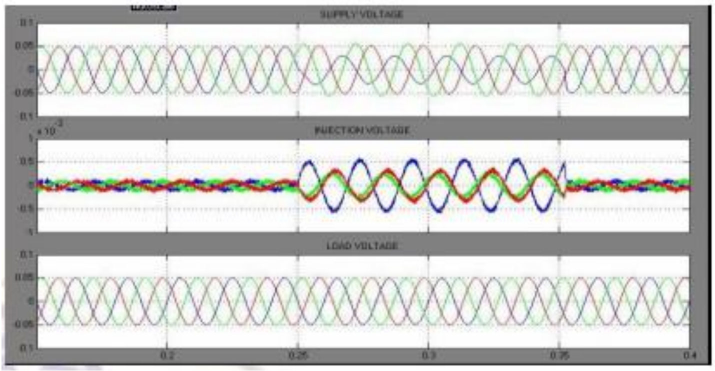

Figure 9: Single line to ground fault; (a) Supply voltage, (b) Injection voltage, and (c) Load voltage

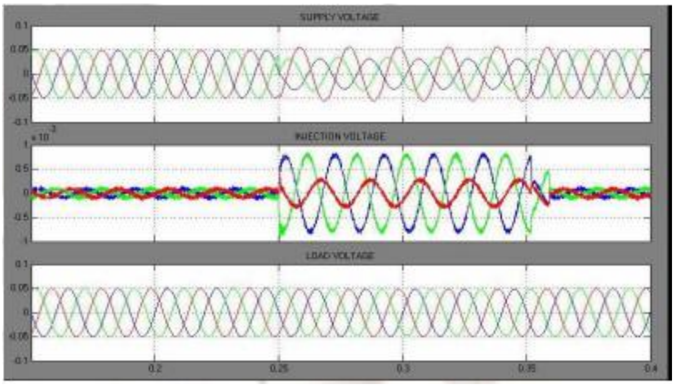

Figure 10: Double line to ground fault; (a) Supply voltage, (b) Injection voltage, and (c) Load voltage

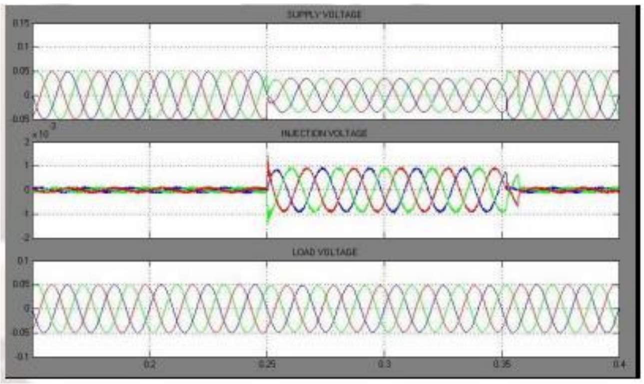

Figure 11: Three phase fault; (a) Supply voltage, (b) Injection voltage, and (c) Load voltage

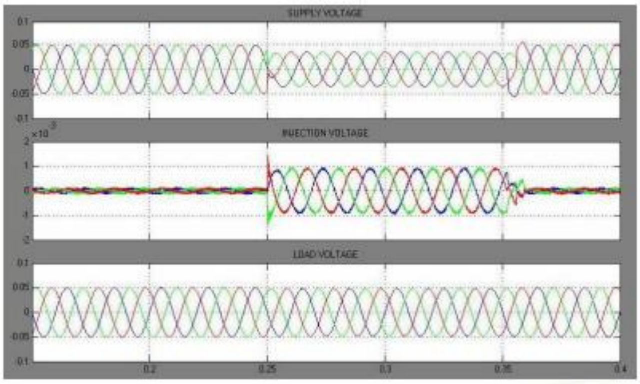

Figure 12: Voltage sag; (a) Supply voltage, (b) Injection voltage, and (c) Load voltage

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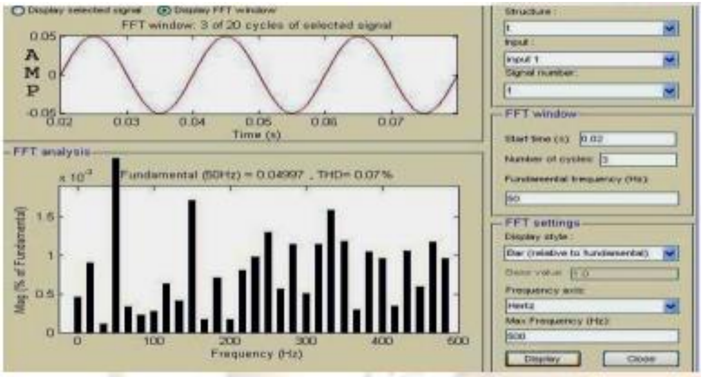

Figure 13: THD for load voltage using PI with Fuzzy Logic controller

V. CONCLUSION

The Dynamic Voltage Restorer, with its capacity to inject compensatory voltages during sag occurrences, offers a viable alternative. By including a PI controller, the system may achieve accurate and steady voltage correction, allowing it to quickly respond to any deviations from the desired voltage level. The proportional and integral components of the PI controller are crucial for ensuring system stability and precision. Moreover, the use of Fuzzy Logic Control enhances the DVR system by introducing a level of flexibility and cognitive capabilities. The utilization of Fuzzy Logic in power systems allows the controller to effectively manage uncertainties and variances that are intrinsic to the system, by imitating the decision-making processes of humans. The DVR's adaptive capabilities improve its performance by efficiently navigating dynamic and nonlinear system dynamics.

REFERENCES: -

1. Narnaware, Priyanka & Huchche, Vijaya. (2018). Control Methods to Mitigate Voltage Sag Using Dynamic Voltage Restorer. 147-150. 10.1109/ICSEDPS.2018.8536018.

2. Bhat, Abdul Hamid. (2018). Fuzzy logic controlled dynamic voltage restorer for mitigation of various power quality problems. International Journal of Industrial Electronics and Drives. 3. 185-198.

3. askar, K.. (2015). Simulation of PI with Fuzzy Logic Controller Based Dynamic Voltage Restorer as Voltage Sag Restorer in Distribution System. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 04. 6257-6267. 10.15662/ijareeie.2015.0407038.

4. Mohammed, Shazly & M. A., Abdel-Moamen. (2013). Fuzzy Logic Controller Based Dynamic Voltage Restorer as Voltage Sag Restorer and Harmonics Compensator. 2. 2165-8277.

5. Babu, Sathish & Kamaraj, Nagappan. (2013). Performance investigation of dynamic voltage restorer using PI and fuzzy controller. Proceedings of 2013

International Conference on Power, Energy and Control, ICPEC 2013. 467-472. 10.1109/ICPEC.2013.6527702.

6. Srisailam, Ch & Sreenivas, A. (2012). Mitigation Of Voltage Sags/Swells By Dynamic Voltage Restorer Using Pi And Fuzzy Logic Controller. International Journal of Engineering Research and Applications. 2.

7. Sandhya, K. & Laxmi, A.J. & Soni, M.P.. (2012). Design of PI and Fuzzy Controllers for Dynamic Voltage Restorer (DVR). AASRI Procedia. 2. 149–155. 10.1016/j.aasri.2012.09.027.

8. B.PANDA, & MAHAPATRA, & Bagarty, Durgesh & S, BEHERA. (2011). FUZZY LOGIC CONTROLLER-BASED DYNAMIC VOLTAGE RESTORER FOR MITIGATION OF VOLTAGE SAG. International Journal of Engineering Science and Technology. 3.

9. Ferdi, B & Benachaiba, Chellali & Dib, S & Rachid, Dehini. (2010). Adaptive PI Control of Dynamic Voltage Restorer Using Fuzzy Logic. Journal of Electrical Engineering: Theory and Application. 1.