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An Analysis Of Evaluation And Compensation Of Voltage Sag For Distribution System

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Abstract- In the last 40 years, power quality has become a key problem for both distribution and transmission systems. The system has many flaws, such voltage sag. The advantages of the multi-level inverter (MLI) in extremely high voltage and high power applications with minimal harmonics have drawn a lot of attention in recent years. This project describes how to create the Dynamic Power Restorer system, which uses a microprocessor to operate a multilayer inverter to counteract voltage sags.

In order to shield sensitive electronics from line failures like voltage sag, this project designs a MATLAB simulation of a multi-stage and multi-level dynamic voltage restorer system. This project uses a novel multilayer inverter architecture that produces a seven-level inverter waveform. This project uses a voltage reading circuit to continuously check the input line voltage. One stage of a multi-level inverter will inject voltage into the line if the system's voltage exceeds than 190 volts, and both levels will inject voltage into the system if the level is less than 170 volts.

The analysis of electric vehicle efficiency in many electrical elements is covered in this essay, along with the difficulties and benefits of using them as a logical step toward efficient, environmentally friendly, and sustainable system.

Keywords— Power Quality, Multilevel inverter, Voltage sag, Dynamic voltage restorer.

I.INTRODUCTION

In today's world there is great importance of electrical energy as it is the most famous from of energy and all are massively relying on it. Without supply of electricity life cannot be imagined. At the same time the quality and continuousness of the electric power supplied is also very important for the efficient functioning of the end user equipment. Many of the commercial and industrial loads require high quality undisturbed and constant power. Thus maintaining the qualitative power is topmost important in today's world.

Since electrical energy is the most well-known energy source and is heavily relied upon by everyone in the modern world, it is extremely important. It is impossible to fathom existence without an electricity source. In addition, the effectiveness with which the end customer equipment operates depends critically on the quality and consistency of the power that is supplied. Numerous industrial and commercial loads demand reliable, uninterrupted electricity of the highest caliber. Thus, in the modern world, preserving the qualitative strength is crucial.

The quality of the electric supply is significantly impacted by power electronics equipment. Other issues with power quality include lightning, network failures, and capacitor bank switching. Reactive electrical instabilities and harmonics in the power distribution system are caused by the overuse of non-linear loads (computers, lasers, printers, rectifiers, etc.). Solving this kind of issue is crucial since it might get worse in the future and have negative effects.

Most electronics equipment have the trait of being sensitive to changes in voltage. These differences can cause machines and other delicate equipment to operate worse or even cause the operation they are controlling to shut down. Voltage sags, or disruptions that result in voltages lower than the nominal value, are categorized as voltage fluctuations.

Voltage and power injections into the system for distribution can be used to counteract voltage sags. The DVR can both produce and absorb power, both reactive and active, to guard against drops in voltage. DVR is an affordable option for medium voltage load protection of extremely sensitive loads. In contrast to an uninterruptible power supply, the DVR might not be as expensive for applications requiring lower voltages. The magnitude of the voltage sag is contingent upon several factors, including the fault type, fault location, and fault impedance.

Power quality is a crucial term that includes all aspects related to both the current and voltage waveform's amplitude, phase, and frequency in an electric circuit. A power quality issue is any deviation in voltage, current, or frequency that causes the equipment belonging to the customer to malfunction. The quality of the electric power supply has been significantly impacted by the rise in power electronics-based equipment. Consumers of electricity are impacted by low-quality power in numerous ways. Inadequate power quality can lead to a number of problems, including decreased output, harmed machinery or appliances, higher power outages, communication line interference, and more. It follows that maintaining high standards for power quality is imperative. The main categories of issues with power quality are: Disruption and Voltage sag, voltage swell.

The advantages of the multilayer inverter (MLI) in higher voltages and high power applications with minimal harmonics have drawn a lot of attention in recent years. Because the faults generating the voltage sag have a finite clearance period, voltage sags cannot be avoided. Increased energy storage in the equipment or more intelligent operation of the equipment can both make it more tolerant to sag and prevent their extensive propagation. Installing a single Dynamic Voltage Restorer (DVR) could be a better way to alleviate voltage sags than changing every component, like a factory, to be extremely tolerant of voltage sags. DVR can reduce the chance of load failure at very deep sags and eliminate severe sag.

For the purpose of mitigating voltage quality disruptions, the dynamic voltage restorer (DVR) is recommended. In order to provide voltage sag mitigation for the single-phase DVR, the real-time implementation of a multifaceted inverter is covered. By comparing a reference voltage produced by the unit's vector template approach with a sensitive load voltage, the controller is achieved. Using the pre-sag and in-phase correction methods, the created DVR is tested using MATLAB Simulink software. Experimental results are presented to validate the suggested DVR topology's ability to mitigate voltage sag.

The majority of the literature addresses how well Voltage Restore (DVR) works and how affordable it is as a means of shielding delicate loads from disruptions. The primary goals are to improve power quality and make up for voltage drops brought on by unusual disruptions at various fault conditions. To lessen the issue, the voltage can be increased with the use of a multi-level inverter. Eight MOSFETS are employed as a multi-level inverter, and they are cascaded to create a seven-level inverter waveform. Where dv/dt tensions low can be produced using this Multilevel Inverter.

II.DIFFRENT TOPOLOGIES OF SYSTEM

Bharti Dwivedi, S. Khalid, [1] explains power quality concerns, challenges, and the effects they have on industry. Power quality is a somewhat broad concept. It can be broadly defined as the arrangement of polarities and system architecture to enable successful and uninterrupted usage of electricity that comes from the system of distribution by power users. With a full understanding of harmonics, electrical quality indices, and variables impacting electric power, this study critically explores power quality difficulties, issues, and related standards. It also assesses shortcomings in power quality and provides strategies for their correction.

The Multifaceted Inverter: A Review of Methodology, Topologies, and Techniques is presented by Anand Mishra and Manoj Solanki [2]. Multi-Level Inverters are becoming more prevalent in Power-Electronic Systems as new topologies that offer alternatives for both medium and high voltage. Multi-level inverters (MLIs) use a variety of DC voltage source to produce the distinctive staircase voltage wave. The DC voltage source can originate from fuel cells, solar cells, or other renewable energy sources. The main disadvantage of the multi-level inverter is its increased system complexity, which is caused by the gate driver circuit. The Multi-level Inverter approach and several topologies, including Diode-clamp, Flying-capacitors, and Transmitted Multi-level Inverters are devices with independent DC sources, were covered in this work. This study also discusses other kinds of switching techniques, such as the pulse width modulation (PWM) scheme, that are employed in multi-level inverter topologies. This study presents the application-based topologies of cascading multi-level inverters (MLI). Due to a number of exceptional benefits, including the ability to link directly to superior quality electricity, medium voltage, high reliability, a high degree of versatility, both input and output, and the control of power flow in the reincarnate version, multi-level inverters have evolved from analytical concepts to practical applications. The applications and latest advancements of these newly suggested topologies, modulation, methods, and control approaches of Multi-Level Inverter units have been covered in this work.

The hardware implementation of an MLI-based dynamic voltage restorer is presented by Smitha Sethumadhavan [3]. A customized power device called the Dynamic voltage restorer (IDVR) has been utilized to shield delicate loads from the impact of voltage sags on the transmission feeder. The DVR system with the MLI operating against voltage sags/swell through the use of a microcontroller is presented in this study. This paper's goal is to reduce voltage fluctuations so that MLI-based DVRs can be used more easily in the voltage restoration process. The implementation of hardware is completed. To provide the highest output voltage levels feasible for a wide variety of voltage sags, a DC-DC converter is utilized to modify the DC link voltage while taking the degree of voltage sag into consideration.

T. Gowrimanoher, D. Mohan Reddy, [4] At now, cascade multilayer inverter-based DVR is being used to mitigate interruption and voltage sag and swell. High reactive energy burden, harmonic currents, load imbalance, excessive neutral current, etc. are some of these power quality issues. The requirements of the equipment being supplied determine the power quality measurement. This article discusses contemporary industrial technologies, such as electronic drives and programmable logic controllers that are primarily based on electronic components. Electronic equipment exhibit high sensitivity to disturbances and little tolerance to power quality issues, including harmonics, voltage sags, and swells. The load side voltage fluctuates as a result of power quality problems such as voltage sag, voltage swell, uneven voltage, flashing, interruptions, etc. Any system's primary need is to keep the voltage on the load side constant. Of all the power quality problems, voltage sag and swell play a significant part. Thus, a 7-level multi-level inverter is used as a dynamic voltage restorer to compensate for voltage sag, voltage swell, and interruption at the load side. In order to adjust for voltage sag, voltage swell, and interruption, a cascading H-Bridge Seven level multilevel inverter is constructed as a dynamic voltage restorer in this study. The Dynamic Voltage Restorer's closed loop control system is intended to improve load voltage regulation. PQ theory is used to create the reference signal for closed loop control. Dynamic Voltage Restorer is used to adjust for sag, swell, and interruptions, and MATLAB models are run to ensure that the load voltage remains constant.

Improving the Cascaded H-bridge dependent Interline Dynamic Power Restorer's Performance is presented by Masoud Shahabadini and Hossein Iman-Eini [5]. This research presents a novel configuration that enhances the IDVR's capacity for compensation at high power factors while simultaneously improving the compensator's ability to mitigate deep sags at relatively moderate power factors. Lowering the load's power factor during the sag state allowed for these benefits. This method continually senses the source voltages, and upon detecting a voltage sag, shunt reactance’s are inserted into the circuit to reduce the load power ratios and enhance IDVR performance.

Tarun Tailor, Lokesh Chadokar, and Girish Singh Kushwaha [6] The current multilevel inverter-based dynamic voltage restorer. This study uses a multilayer inverter (MLI) based on a DVR (dynamic voltage restorer) to reduce voltage sags and enhance the system's power quality. The medium voltage (MV) transmission network with a secondary power system is the application and testing grounds for the used method. To assess their performances, the 5-level MLI-based DVRs are gradually linked in the compensated feeder. Research has been done on the effectiveness of various MLI control strategies. When comparing the load voltage waveform and frequency spectrum of a 3-level DVR built on MLI to a 5-level DVR based on MLI, the THD level is successfully decreased from 40.16% to a significantly lower number of 28.95%. The results of the simulations show that a 5-level MLI based compensation scheme can improve the system's performance and lead to a notable increase in power quality.

Alexander Kara [7] Dynamic voltage restorer: An enhancement in the quality of the current power supply. The technical aspects of developing a Dynamic Voltage Restorer in terms of reaction time, allowable line voltage deviations, fault duration, and voltage dip magnitude are presented in this article in order to fulfill the strict criteria of voltage dip mitigation. An overview of the IGCT technology is provided, utilizing the most recent transparency anode GTO (I-GTO) and gate technology. We talk about the DVR's performance using digital simulations. An explanation of a real-time simulator model based on hardware is provided for evaluating DVR's efficacy in mitigating voltage dips. Digital simulations and real-time simulator results are contrasted. Lastly, the DVR's safety and control ideas are emphasized.

Drs. K. Uma Rao and A. Jaya Laxmi [8] Current Single Phase Dynamic Voltage Restorer Hardware Implementation. This document sets up the DVR hardware protocol concept. By keeping the load voltage level at the required voltage and the total harmonic distortion (THD) within acceptable bounds, the suggested approach may both detect and mitigate voltage sags. With just one switching used every phase, the suggested method is straightforward. In contrast to the widely used DVR or STATCOM, the system is therefore easy to use, affordable, and doesn't need an energy storage device. Theoretical findings validate the suggested device's performance, which is determined to be adequate. Pre-sag compensation is the best control method for delicate loads that cannot tolerate phase angle jumps. In-phase injection compensation works best for minimal voltage injection. Phase advance adjustment works best for the DVR to inject the least amount of energy, but it needs more voltage injection.

Mohammed Shazly A., Cerrada Aurelio G., Abdel-Moamen M. A., and Hasanin B. [9] A system for compensating for voltage sags called a dynamic voltage restorer (DVR). Power and power quality issues, including voltage swells and sages, are discussed in this study. A summary of dynamic voltage restorers, or DVRs, is also provided. DVRs are a modern, efficient bespoke power gadget that may be used to compensate for voltage swells and sags. In order to maintain the load voltage regulated and constant at its nominal level, they quickly rectify any anomalies in the supply voltage by injecting the appropriate voltage component. The tiny size and quick dynamic reaction of the Dynamic Voltage Restorer (DVRs) make it an effective option despite its comparatively modest cost.

Z-Source Inverter is presented by Fang Zheng Peng [10]. An impedance-source power converters for dc-to-ac, ac-to-dc, and dc-to-dc power conversion has been presented in this study. In order to pair the converter primary circuit to the power source, the Z-source converter uses a special impedance network, or circuit. This allows it to provide special features that are not possible with the conventional voltage-source and current-source converters, which use an inductor and a capacitor, respectively. The Z-source converter offers a revolutionary power conversion paradigm by overcoming the theoretical and conceptual obstacles and limits of the conventional voltage-source and current-source converters. Almost all dc to ac, dc to dc, ac to ac, and dc to dc energy conversions may be handled using the Z-source principle. The Z-source inverter example utilised in fuel-cell applications was the main topic of this study. The study explained the working principle, examined the circuit features, and proved the concept's superiority through the example. The Z-source inverter has the ability to minimise component count, improve buck voltage, increase efficiency, and lower cost.

Gajanan Dhole, Saurabh S. Jadhav, and Mohan B. Tasare [11] demonstrates the use of DVR in a three-phase, four-wire distribution network for sagging and imbalance mitigation. The reduction of the voltage sag in the distribution system is presented in this study. The most frequent disruptions in the electricity system are voltage sags.

Zero-sequence components also exist in a three-phase, four-wire neutral ground distribution system because of the imbalanced nature of the load. These zero-sequence elements are not wanted because they might lead to excessive insulation costs in the distribution network and terminal voltage unbalance for balanced three-phase loads connected on the same feeder. In order to reduce the zero-sequence elements in the distribution system and rectify voltage sag, this research suggests a control technique for the Dynamic Voltage Restorer. In this study, a Dynamic Voltage Restorer is used to reduce distribution network sag and imbalance by utilising synchronised reference frame theory and hysteresis control. The system is simulated in the MATLAB/Simulink environment. By controlling DVR with the help of d-q theory, the developed control method maintains balanced loads voltage at its nominal level. Additionally, the suggested technique reduces the zero-sequence component, which lessens the imbalance in the distribution system.

T. Vijayakumar, A. Nirmal Kumar, and N. S. Sakthivel Murugan[12] presents a hardware implementation and simulation of a dynamic voltage restorer (DVR) based on multilayer inverters. Because the DVR employs a nine-level inverter, it injects high-quality voltage. With less harmonic content, this DVR receives a superior voltage sag reduction solution. By injecting voltage with the appropriate amplitude and phase angle, DVR regulates the voltage delivered to the load. The modelling and experimental findings of a nine-level DVR based on an inverter are presented in this work. Relative to a single PWM inverter, THD is shown to be much lower. The nine-level inverter outperforms conventional inverters because it inverts higher-quality electricity. The outcomes of the simulation and the experiment are comparable. To increase the power quality, the nine-level converter is a competitive substitute for the current inverters.

Presents P. Kiruthika and K. Ramani [13] A multilayer inverter literature review. This manuscript has been suggested in the apprehensive technical literatures. More lucrative goods are based on multilayer inverter structures and the expansion of multilevel inverter stirring, thanks to designs and their modulation techniques. Several multilayer inverters and control strategies are presented in this work and reviewed. A percentage-based review of the literature is conducted to evaluate the various topologies of multilevel inverters. This work proposes an MLI approach that may be used to minimise overall harmonic distortion by controlling the output voltage using various modulation techniques. This work aims to provide an extensive comparative analysis of several methods for MLI topology and control.

A. Kiruthiga, R. Vanithamani, M. Mahendiran, J. Shanmuga Priya, [14] demonstrates how to use a diode-clamped multi-level inverter with the DVR technique to mitigate voltage sag. This research proposes a Dynamic Voltage Restorer (DVR) with energy storage devices that is based on a multi-level inverter. It explains the issue of voltage swells and sags and how it seriously affects sensitive or nonlinear loads. Dynamic voltage restorers, or DVRs, are becoming more and more well-liked as an affordable way to shield delicate loads from spikes and dips in voltage. With a diode clamped multilayer inverter, compensation voltages in the DVR are controlled. This approach, which is fairly straightforward to formulate, offers the series dynamic filter design a tremendous deal of versatility.

Dr. Usha Rani, Smitha Sethumadahvan, [15] presents a digital model of a DVR based on MLI. The primary job of the DVR is to infuse the voltage differential into the power line, which keeps the load side of the voltage at its ideal level. The modelling features of the DVR systems with the MLI operating against voltage sags/swells through simulation are presented in this research. MATLAB/Simulink is used to execute the digital simulation. To ensure that the highest output voltage values are produced for a variety of voltage sags, a dc/dc converter is employed to modify the voltage across the DC link in consideration of the voltage sag.

In this, the system experienced voltage sag beginning at t=400 ms and continuing until t=700 ms, for a total energy sag lasting 300 ms, throughout a 1000 ms run time. The FFT analysis of the MLI output voltage is also shown, and the transmitted seven level MLI pulses of switching are employed.

Dr. K. S. Aprameya, Vaishali N B, [16] demonstrates how to improve power quality in a distribution system utilising DVR. A MATLAB simulation of a basic distribution network is used to demonstrate how well DVR mitigates voltage sags. A series transformer that can inject a maximum current of 50% of the system voltage in phase with earth is used to connect a DVR to a system. It employs the in-phase compensation approach. DVR easily manages balanced and unbalanced scenarios by injecting the proper voltage component to quickly rectify any divergence in the supply voltage and maintain the load's voltage consistent at the nominal level. The DVR's primary benefits are its inexpensive cost, quick reaction time, and easy operation. The electrical sag compensation is effectively provided by the PWM control method, which makes use of fuzzy and PI controllers. Unlike basic frequency switching strategies that are already included in MATLAB/SIMULINK, this PWM system of control necessitates just voltage data. It is perfect for low-voltage bespoke power applications because of this feature. Being a number of device, the DVR's primary drawback is its incapacity to minimise total disruptions.

Voltage Sag Analysis Case Studies are presented by Jeff Lamoree, Dave Mueller, Paul Vinett, William Jones, and others [17]. The findings from several distinct voltage sag studies are included in this report. In these experiments, the performance of the voltage sag at an end-user facility is characterised, and the sensitivity of the equipment to various voltage sag durations and magnitudes is assessed. Additionally, potential fixes for voltage sag sensitivity issues are explained. Numerous options are discussed for both customers and utilities. Although defects in the system cannot entirely be eliminated, utilities can enhance their performance. Customers will therefore be able to ride through critical equipment at their premises more easily. Either the device itself or power conditioning may do this. Improving the real process equipment's voltage drop ride through capabilities will show to be more cost-effective in the long run. One example would be drives with adjustable speeds. It is now possible for certain manufacturers to re-synchronize the ASD outputs into a rotating motor. This enables the majority of voltage sag occurrences to be traversed by using the motor's inertia.

K. P. Singh, Anjani Kumar Prajapati, [18] demonstrates how to use a dynamic voltage restorer to enhance power quality under various fault conditions. In this article, the DVR is modelled, analysed, and simulated using MATLAB/SIMULINK. The DVR is controlled by a discrete PWM generator and a PI controller. This study presents the simulation results of the DVR's performance under various fault scenarios, including a single line connection to the ground fault, double line to ground fault, dual line fault, three phase fault, etc. The outcomes clearly show how well the DVR performs in terms of improving voltage quality. The device is utilised in conjunction with a PI controller to enhance performance for distribution networks that include static linear and non-linear loads. In the simulation part, the test system is examined and the findings are shown. Conclusion: Compared to other bespoke power devices, DVR enhances distribution network power quality more effectively. The findings show that DVR performs satisfactorily in distribution networks under various fault scenarios.

III. CONCLUSION

This paper presents the MATLAB implementation of an MLI-based DVR system for sag voltage analysis and correction. A novel architecture has been introduced, and the multilevel inverter is designed to produce seven-level waveforms. One stage of a multilayer inverter introduces voltage in line when the voltage drops (less than 190V), and both stages 1 and 2 injected voltage in line if the voltage drops (less than 170V). Compared to other inverters, the 7 level inverter inverts electricity with higher quality. The compact size and quick reaction of the MLI-based DVR make it an effective option. This essay discusses the benefits and drawbacks as well as how they can be a sensible step towards an efficient, environmentally responsible, and sustainable system.

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