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ENHANCING POWER QUALITY: DYNAMIC VOLTAGE RESTORER FOR IMPROVED GRID STABILITY

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ABSTRACT: The series-connected Dynamic Voltage Regulator (DVR) adds three-phase compensatory voltages to the main supply by connecting either a three-phase injection transformer or three single-phase injection transformers. The injection transformer raises the voltage of the filtered VSI output to the desired level. In addition, the transformer prevents the distribution system's DVR circuit from touching it. When designing the DVR, essential considerations include the capacity of the voltage source inverter (VSI) and the values of the link filter that connects the VSI to the input transformer. This research project proposes an entirely new topology for a Dynamic Voltage Restorer (DVR). It will be easier to cope with voltage harmonics, swell, and voltage decrease in various fault circumstances if the voltage source inverter (VSI) and link filter are limited in their capabilities. The switching harmonics can be reduced with the new RLC filter. When the inductance is low, the DC source voltage is limited. The new DVR architecture improves voltage quality while remaining highly efficient. For this model, an outline design of the RLC filter parameters is provided. The proposed controlled Dynamic Voltage Restorer (DVR) topology is utilized in MATLAB to simulate and evaluate the new DVR. The control system offers strong control dynamics and minimal transient current overflow.

Keywords: Dynamic Voltage Restorer (DVR), MATLAB, voltage source inverter (VSI)

I. INTRODUCTION

Power quality is a measure of how easily customers may access electricity without encountering any problems, changes, or interruption. Poor power quality can lead to increased operational costs, system faults, and equipment damage for persons in the industrial, commercial, and residential sectors.

Adding a dynamic voltage regulator (DVR) improves power quality. A DVR, or Dynamic Voltage Regulator, is a cutting-edge piece of electrical technology that is intended to prevent voltage drops and spikes that occur when a system malfunctions. It's connected to the electricity grid.

When the voltage at its connection point drops or rises, the DVR adds a voltage of the same size but opposite phase to the system to compensate. Lowering the voltage to the right level protects not only sensitive equipment but also delicate loads.

DVRs are becoming increasingly popular in a variety of business and industrial settings due to their ability to improve power quality. They can also be used to safeguard sensitive equipment against power surges, such as computer systems, medical devices, and manufacturing lines. This increases the overall reliability and efficiency of the electrical system.

DVRs, for example, can be utilized in a variety of business and industrial settings to reduce expenses, protect equipment, and maximize power efficiency.

The voltage, frequency, and consistency of the waveform determine whether electricity is safe and efficient for use with electrical tools. Voltage drops, surges, delays, harmonics, flicker, and other disturbances are all possible causes of poor power quality.

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A dynamic voltage restorer (DVR) is a power electronic device that may smooth out power system issues such as voltage swells and sags by supplying just the correct amount of voltage to keep the load voltage within acceptable limits. The DVR is linked in series with the load, providing the necessary power to compensate for voltage variations. A voltage source converter (VSC), a coupling transformer, a DC capacitor, and control circuitry comprise the DVR. The VSC adds the voltage required to compensate for fluctuations in voltage. The control circuits monitor the current and voltage data and modify the VSC to inject the appropriate amount of voltage. The connecting transformer connects the load to the DVR in a series mode.

Dynamic Voltage Restorers (DVR) in power systems improve power quality, increase efficiency, and shorten response times, among other advantages. The DVR enhances power quality by eliminating voltage fluctuations, reducing machine downtime, and increasing power system reliability.

Power electronics, such as the Dynamic Voltage Restorer, decrease voltage drops, spikes, and other problems in power systems, hence improving power quality. The DVR improves the overall operation of the power system by reducing equipment downtime and increasing reliability.

II. LITERATURE SURVEY

"Harmonic resonance between a multitude of dispersed power inverters and the distribution network" by Johan H. R. Enslin and Peter J. M. Heskes. This research concentrated on the harmonic interaction between the distribution network and a large number of dispersed power converters. The current study investigates the impact of various inverter architectures and control options on network communication. The harmonic interference mechanisms of a number of these inverters are also investigated. Prasad N. Enjeti, Frede Blaabjerg, and Uffe Borup wrote the text. "Inclusion of nonlinear load in parallel-connected three-phase converters." The study looks on the distribution of linear and nonlinear loads in three-stage parallel power converters that work independently. The primary objective of this research is to evaluate the consequences of paralleling two converters with harmonic correction.

Their names are Pichai Jintakosonwit, Hideaki Fujita, Satoshi Ogasawara, and Hirofumi Akagi. "Implementation and performance of cooperative control of series active filters for harmonic damping in a power distribution system." Voltage sensing is intended to function in tandem with many active filters to reduce harmonics in a power distribution system. The configuration of an actual distribution system could alter in response to faults and/or system performance. The distribution system may also connect and disconnect loads and series capacitors.

John K. Pedersen, Soeren Baekhoej Kjaer, and Frede Blaabjerg composed the piece. "A review of single-phase grid-connected inverters for photovoltaic modules" provides more information on these inverters. This research focuses mostly on the inverter technologies that connect photovoltaic (PV) modules to a single-phase grid. Inverters are grouped into four categories: 1) The sequence of power processing stages; 2) the type of power isolation between the PV modules and the single-phase grid; 3) the presence or absence of a transformer (line or high frequency); and 4) the type of power stage that links to the grid.

The authors of the article are A. V. Timbus, M. Liserre, R. Teodorescu, and F. Blaabjerg. "A comprehensive examination of control and grid synchronization in distributed power generation systems." This book discusses all aspects of Distributed Power Generation Systems (DPGS), which include fuel cells, solar panels, and wind turbines. In addition to demonstrating the grid-side converter's control mechanisms, the concept of removing low-order harmonics is investigated. This text also provides a thorough study of the various techniques to dealing with grid-related issues. The purpose of this research is to examine synchronization mechanisms and explain their importance in control.

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III. PROPOSED SYSTEM

Simulink is used to describe, simulate, and evaluate systems that are changing over time. It could cover systems in continuous time, measured time, or a combination of the two. Each of these systems is capable of handling both linear and nonlinear signals. Simulink's graphical user interface (GUI) for modeling allows users to generate block diagram models by manipulating points on screen. Because of their hierarchical nature, models can be built from the bottom up or the top down. The ability to traverse through the system's levels and see progressively complex models by double-clicking on blocks gives a basic understanding of how the system works.

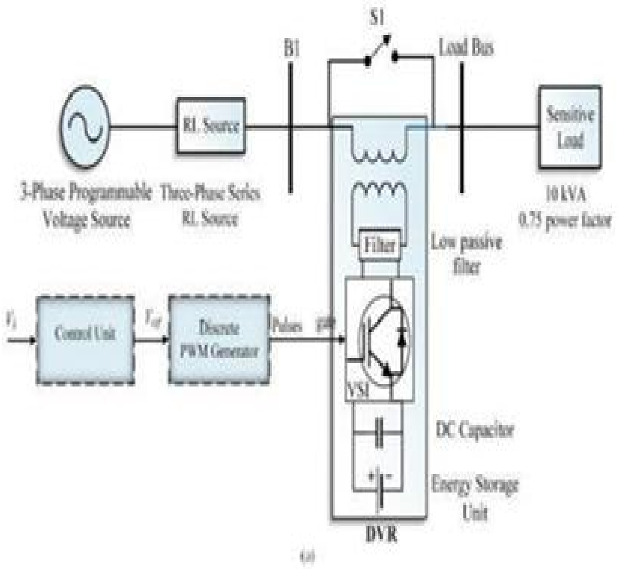

Fig.1: Basic Configuration of DVR.

This method depicts the creation of a model and the interdependence of its components. After a model has been created, it can be simulated using a variety of methods, including entering commands into the MATLAB command window or using the Simulink menus. Scopes and other display elements can be used to observe the game's flow. For "what if" analysis, it is also possible to quickly observe the effects of changing the variables. The MATLAB workspace stores simulation results, making it easier to analyze and visualize them later. Simulink can be used to evaluate real-world dynamic systems such as electrical circuits, shock absorbers, brake systems, as well as mechanical, electrical, and thermodynamic systems. Modeling a dynamic system with Simulink requires two steps. We begin by creating a model of the system that has to be duplicated using Simulink's model constructor. The model mathematically reflects the system's inputs, phases, and outputs as they change throughout time. Simulink is then used to simulate the system's operation for a specific time period. Simulink uses the data entered into the model to complete the exercise.

IV. RESULTS

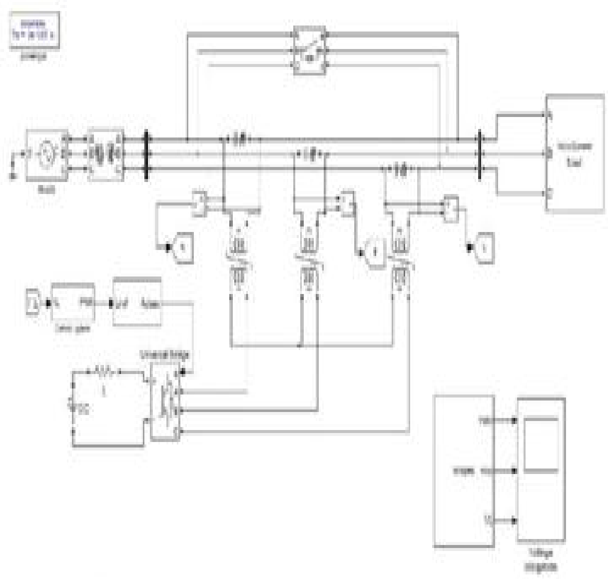

Fig.1: Simulation model of test system with DVR

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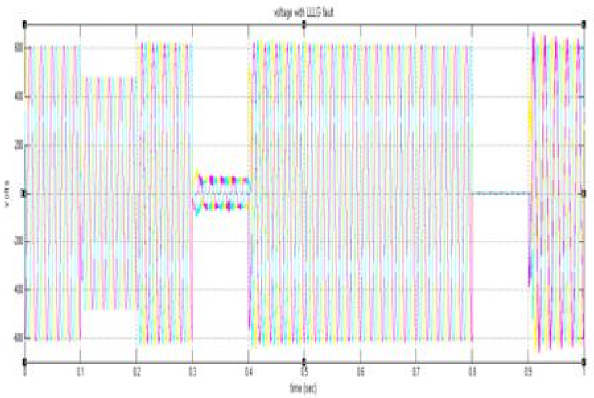
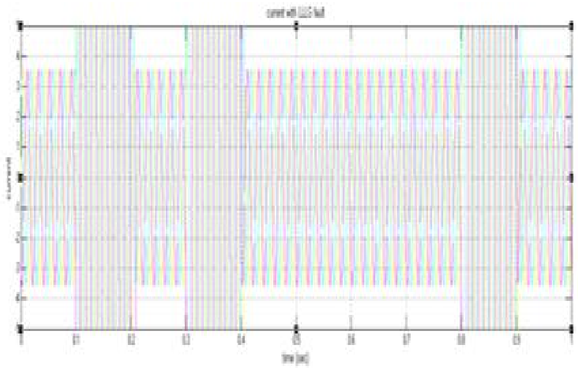
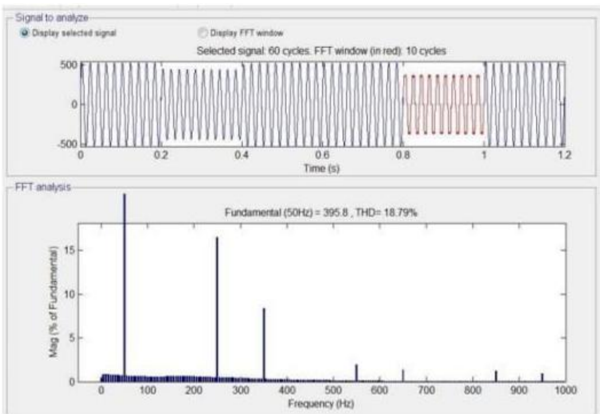


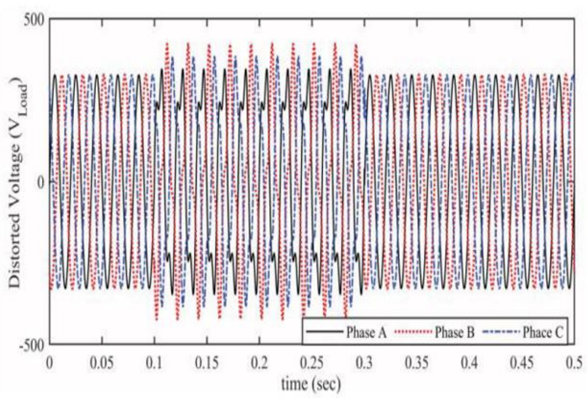
Voltage profile without DVR



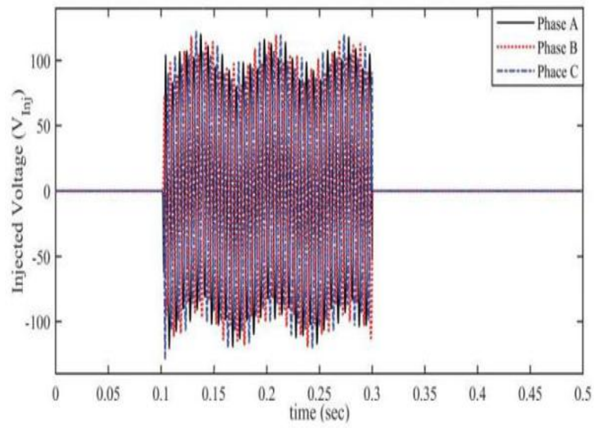
Current profile without DVR



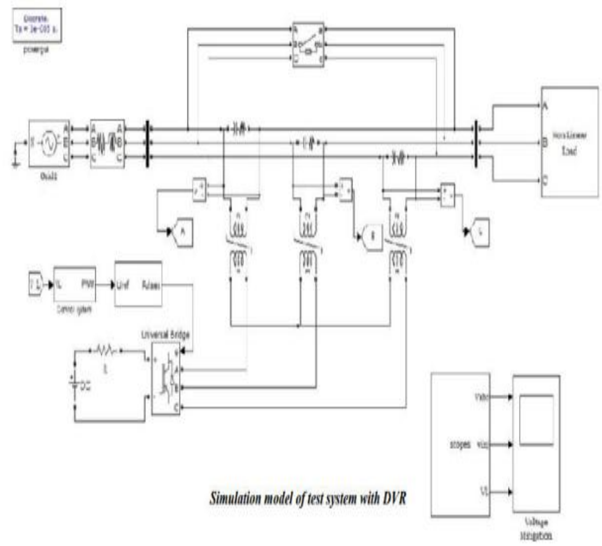
Total harmonic distortion



Disorted load voltage waveform before compensation



Injected voltage (Vinj) by DVR in all three phases



Simulation model of test system with DVR

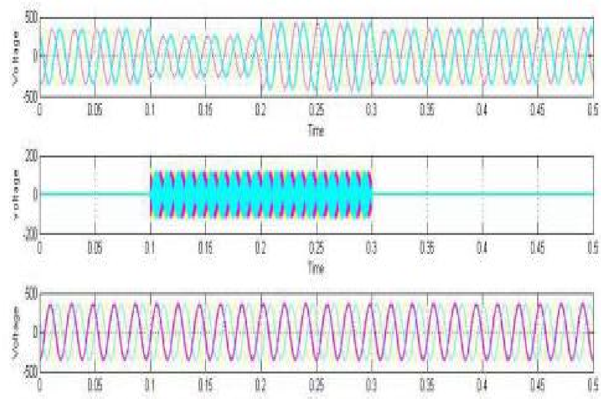


Fig.2: Output waveforms with using DVR

V. CONCLUSION

Because of its excellent performance and practical value, the DVR is frequently recognized as the ideal technology for increasing power quality. A DVR with a power circuit was created and simulated using the MATLAB/Simulink platform. This is accomplished by combining a power system structure and modeling with a control circuit designed specifically for a sensitive load.

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There are two methods for testing the DVR: with and without the test system, in which a different system replaces the DVR. Following the presence of the third harmonic, a programmable voltage source incorporates the fifth harmonic into the main voltage.

The outcome is voltage distortion. The proposed DVR-based control technique improved the voltage profile by reducing distorted load voltages. This resulted in a more consistent, stable output with lower harmonic distortion. The DVR can resolve voltage source issues by including the appropriate voltage component. This maintains the load voltage in the right range and stability. The total harmonic distortion (THD) was reduced by approximately 4% without affecting the voltage profile. Similarly to example 1, the voltage profile indicated total harmonic distortion (THD) values of 2.69%, 2.40%, and 2.69%.

The THD values in case 2 were 3.74%, 4.04%, and 3.60%. The observed reduction in total harmonic distortion (THD) in load voltage illustrates the efficacy of the DVR-based control method employed in this investigation. To increase power quality, soft computing-based control techniques such as adaptive NeuroFuzz controllers might be researched further. The authors previously employed STATCOM to create Type-2 Neuro Fuzzy controls, which increased the power system's reliability. If any new issues about power quality arise inside the power system network, appropriate compensation should be provided to the impacted parties. Fuzzy controlled systems and PI controllers are also viable alternatives for resolving issues with dynamic voltage restorers.

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