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A Fuzzy Voltage Sag/Swell Controller Employing a Dynamic Voltage Restorer with a Lower Rating

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Abstract*: Variations in voltage have a significant impact on nonlinear loads. Because of its superior performance and inexpensive cost, dynamic voltage restorers are among the most often used compensatory devices. When Park's transformation technique is used, the dynamic voltage restorer's rating is successfully decreased. This paper suggests using a fuzzy logic controller to achieve better results. The MATLAB/Simulink environment is used to verify the results.*

Keywords*: Sag/Swell, Parks, Transformation, Inference, Fuzzy, FACTS controllers*

I. Introduction

At present, electricity is produced and supplied all the time. The papers then present the idea of using conventional series reactor compensation and injection transformers, but these techniques are limited in their ability to balance problems such as voltage sag and swell for high power applications. Harmonics and changes in voltage or current levels are among the power quality issues that the electrical power system encounters in interfaced systems [1]–[5]. Among the various problems with power quality, faults and the usage of sensitive equipment result in most instances of voltage changes.

If these issues persist, they have a serious impact on the power system, leading to equipment failure, power plant shutdowns, and, as previously indicated, current imbalances. This issue also illustrates how consumer loads and the distribution system are affected. The voltage reduction, sometimes referred to as the sag criteria, typically happens at any moment and lasts for less than a minute. The amplitude changes between 10 and 90% of its rated value. In contrast, an increase in the rms voltage at the power with magnitude fluctuations ranging from 1.6 to 1.9 pu is referred to as a voltage swell.

Because voltage swells are less frequent in distribution systems than voltage sags, they are typically not as serious of an issue. We require a special compensating device that can correct for each power quality issue in a unique way in order to safeguard the system against all of these issues [3]. The compensatory techniques discussed in this study have the following drawbacks: they are incompatible with high distribution systems, and they are not appropriate for addressing voltage sag issues in the event of a serious system failure. Therefore, the flexible ac gearbox system is crucial, according to the literature review on power electronic-based converters.

Devices are organized into four types using their control skills and circuit systems: series converters, shunt converters, single converters and converters that use both series and shunt circuits [1]. The only type of fact controller that addresses voltage issues and in particular sag and swell, is the series converter. In this study, we look at a particular converter, called a dynamic voltage restorer, that uses actual facts to guide its work. A new method known as a fuzzy inference system is suggested here to handle the dynamic voltage restorer with a smaller capacity. The results are examined by using total harmonic distortion against the outcomes of the PI controller. On the whole, fuzzy controllers respond to disturbances faster and settle more quickly than traditional PI controllers.

II. Grid Interfacing System

Protecting the power system components from voltage sags and swells greatly depends on having a DVR, unlike many other alternative solutions. Compared to injection transformers, series and shunt reactors and fault limiters, DVR is both efficient and reliable in operation [1]. DVR's primary job is to regulate the voltage across the load by adding additional voltage to the gearbox system [3]. Dynamic voltage restorers are typically found on the distribution side, that is, between the load and the distribution feeder. Figure 1 displays the DVR's schematic diagram.

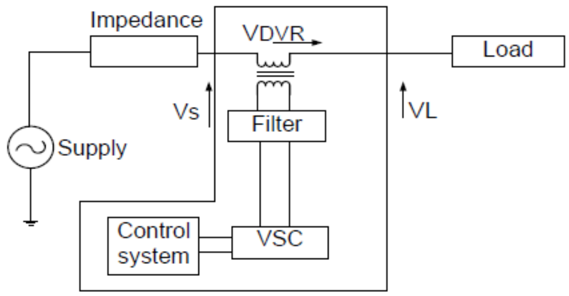

Fig 1: Dynamic Voltage Restorer

DVR is used to dynamically correct for voltage variations. Through a series transformer known as a boosting transformer, the voltage produced by a forced commutated converter is injected into the line. Three main modes can be used to illustrate the fundamental functioning of a DVR: protection mode, standby mode, and injection/boosting mode.

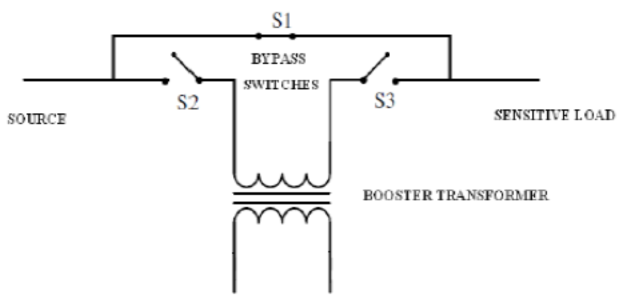

Fig 2: DVR Protection Mode

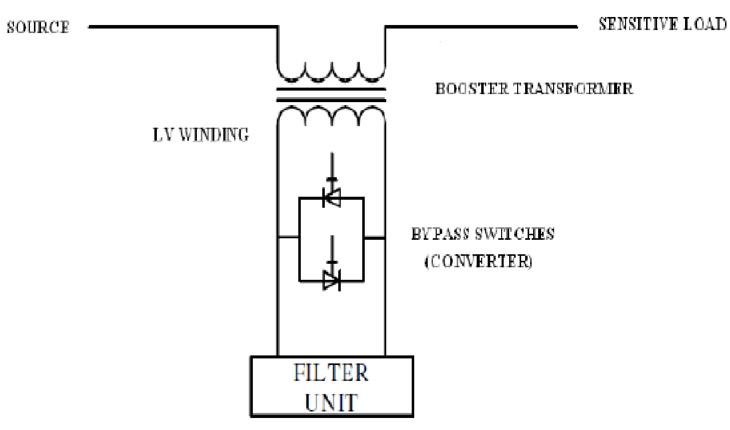

Fig 3: DVR standby mode

In-phase compensation is an easy method to use. Even though the system load or pre-condition changes, this technique makes sure the injected voltage keeps in step with the incoming supply voltage [5]. Although these two voltages may be out of phase, the controller still helps preserve good power quality by adjusting for the load voltage.

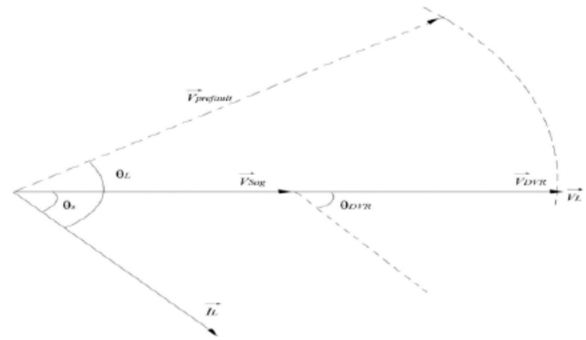

Fig 4: Compensation Method In-Phase

DVR's primary purpose is to safeguard consumer-side sensitive loads and power system components in the event of a malfunction. The sensitive loads are used to determine the DVR's location. The DVR is connected in series with the transmission line in case of a transmission line fault. Variations in the load voltage are caused by any gearbox system faults. The load may be impacted as a result of these modifications. Therefore, the DVR uses the power electronic converter to inject the additional voltage in order to compensate for this issue.

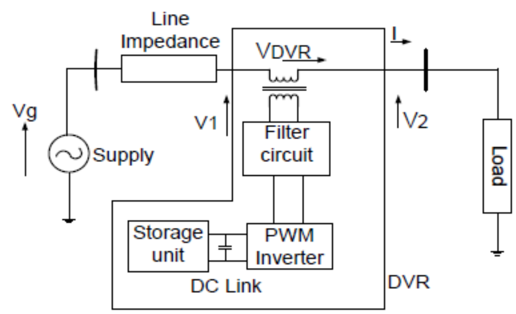

Fig 5: DVR Circuit block diagram

III. DVR Control Strategy

The control block diagram for the dynamic voltage restorer is seen in Figure 6. Specifically, these pulses for gate triggering the converter are calculated with reference to the voltage at the point of common coupling and the load voltage.

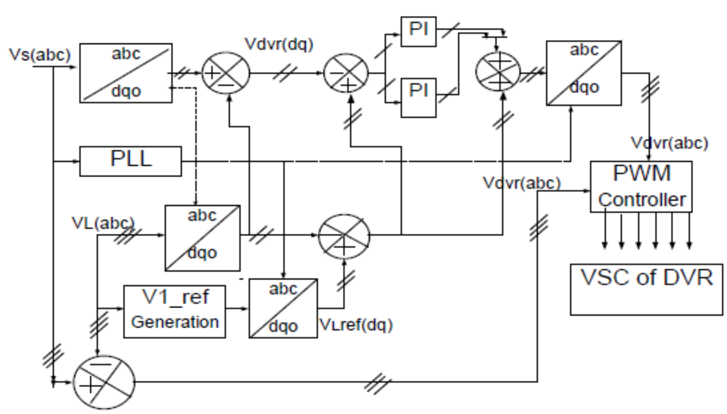

Fig 6: DVR Control block diagram

Mainly, the idea is to change the three-phase electrical machine voltages into the two-phase reference frame using the Parks transformation approach. Changing the voltage from the source to the direct and quadrature axes is another important task of the park's transformation. After comparing the source and load voltages, the PI controller is brought into play. The controller generates gate control pulses to the voltage source converter using the error.

IV. Fuzzy Logic Controller

The PI controller-based control method was covered in the preceding section. However, the PI controller has a huge steady state error and a high settling time. This paper suggests the use of a fuzzy logic controller (FLC) to address this issue. In general, one of the most significant software-based adaptive approaches is the FLC. The FLC exhibits reduced steady state errors and a short settling time as compared to earlier controllers. Four steps can be used to demonstrate how a fuzzy controller works.

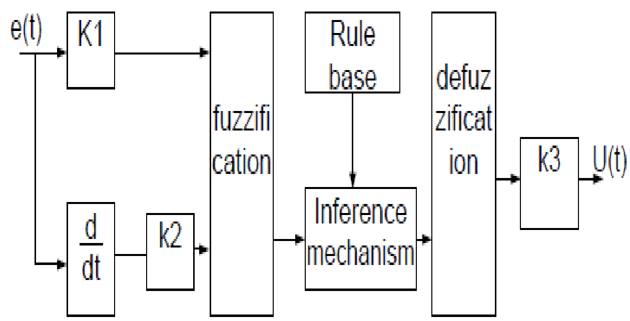

Fig 7: Fuzzy logic controller

V. Simulation Diagram and Result

The below Figure displays the DVR's simulation diagram, as seen below.

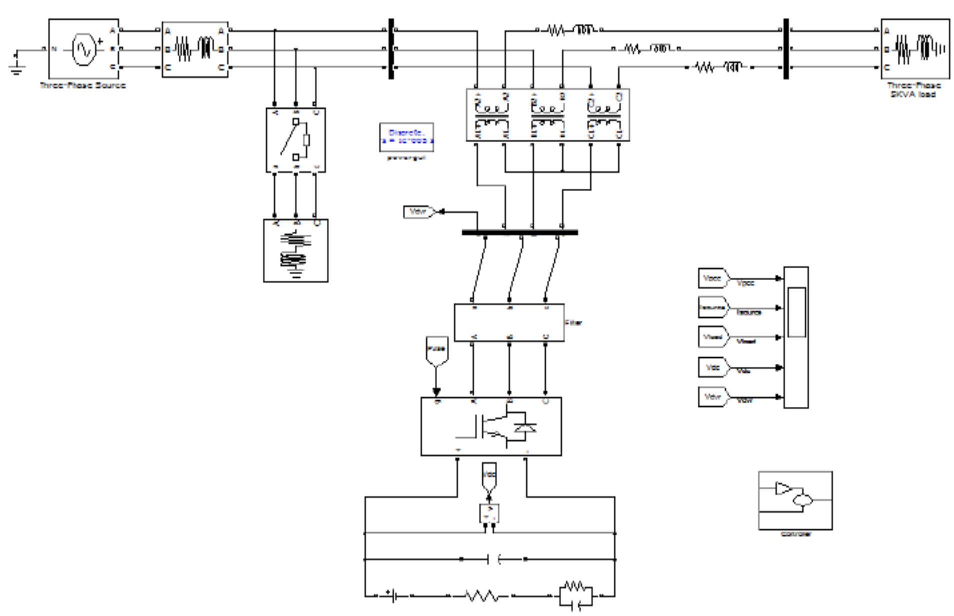

Fig 8: Dynamic Voltage Restorer simulation diagram

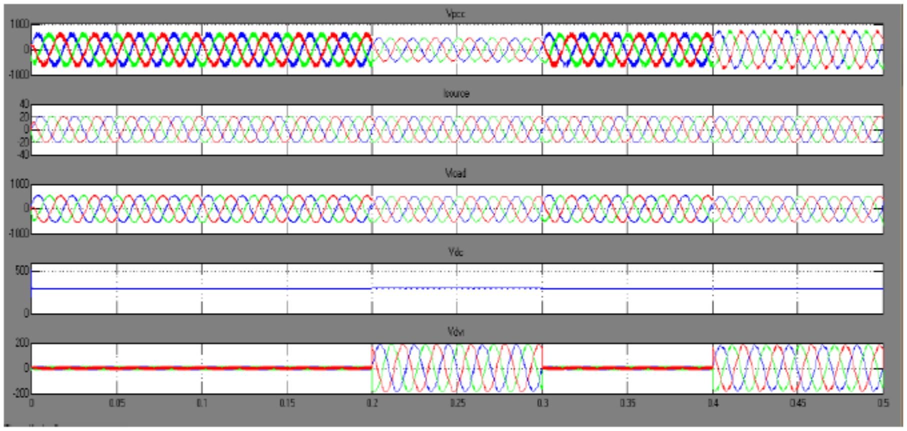

Fig 9: PI Controller simulation

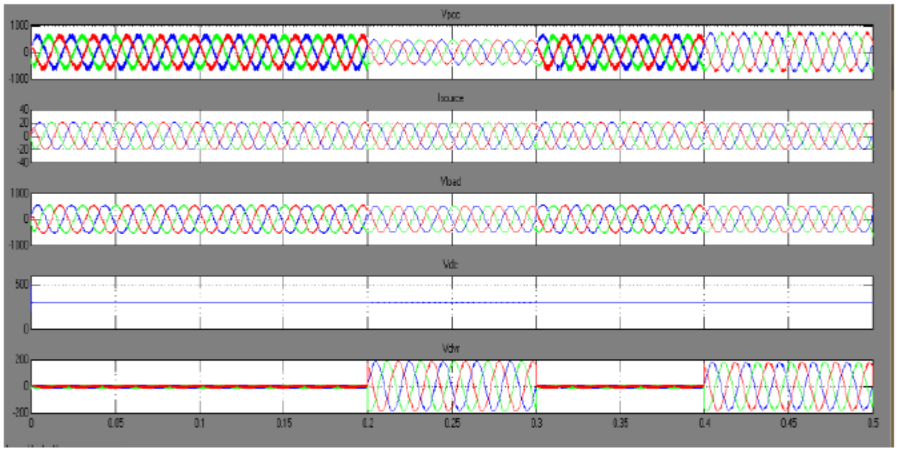

Fig 10: Fuzzy controller simulation

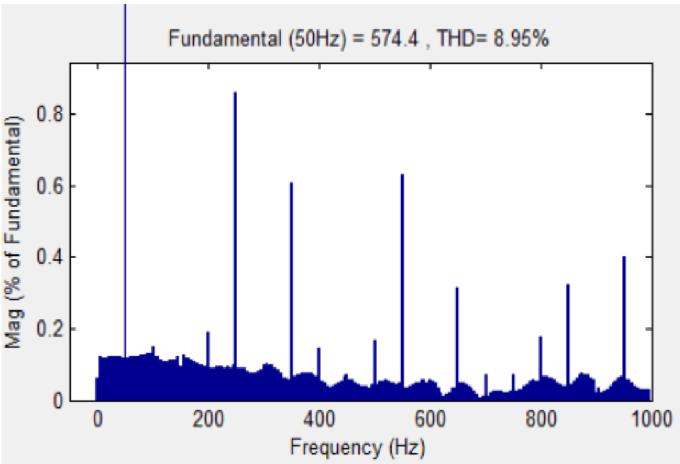

Fig 11: THD for Voltage with PI Controller

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