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Power Quality Enhancement in Distribution Systems Using D-STATCOM with Fuzzy Controller

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Abstract:-There has been increase in the demand for reliable and high quality power distribution systems. In power distribution systems quality in distribution of power is desired. The problems that occur frequently in such systems include low power factor, harmonic distortion and voltage sags. In order to achieve this Distributed Static Compensator (D-STATCOM) is used. This device along with LCL passive filter when used with power distribution systems the quality of power gets improved. By injecting current into the distribution system, the D-STATCOM improves the quality in power distribution. The extensive simulations made in MATLAB's SIMULINK revealed that the proposed approach is effective.

Index Terms:- Voltage sags, D-STATCOM, LCL passive filter**,**

I. INTRODUCTION

High quality power is expected from power distribution systems. If the electrical power is not reliable and providesthe required qualityof services, it results in consequences where the users or organizations have limitations in using them and thus the productivity is jeopardized. There is an increased awareness of power quality among customers. Thecommon problems pertaining to power distribution systems include low power factor, harmonic distortion, andvoltage sags. When there is short reduction in r.m.s voltage magnitude, it is known as voltage sag [1]. There are two parameters pertaining to this problem. They are magnitude/depth or duration. The magnitude range is around10% to 90%. When there is a fault in the utility system it causessag. The utility might be from customer side or distributor side [2], [3]. However, these are the most frequently occurring power problems. For industries this kind of problem causes losses as it results in reduced production and sometime, the equipment gets spoiled. The utilities installed from customer side also can prevent voltage sags to some extent [4].

Harmonic distortion is another power problem caused by harmonic currents that may prevail in the distribution systems. It also causes the additional losses and low power factor problems that result in heating of equipment. Vibration and noise can also be caused by that causing the sensitive equipment to malfunction. Power electronic devices such as FACTS reduced the power problems to some extent. They have new capabilities for controlling such problems [5]. There are various ways to combat power quality problems. Among those devices, D-STATCOM is the most effective device which is controlled by a new PWM-based control scheme. This device can also withstand the reactive power at low voltageand it can serve better by replacing capacitors as explored in [6] and [7]. The remainder of the paper is structured as follows. Section II provides details about D-STATCOM. Section III provides the proposed methodology. Section IV presents experimental results while section V concludes the paper.

II. OVERVIEW OF D-STATCOM

The aim of this paper is to enhance power quality in distribution using D-STATCOM. This section provides an overview of the distribution –static compensator. The D-STATCOM, as shown in figure 1, has a two level Voltage Source Controller (VSC). The D-STATCOM includes a coupling transformer, a controller and a dc energy storage device integrated with a GC network.

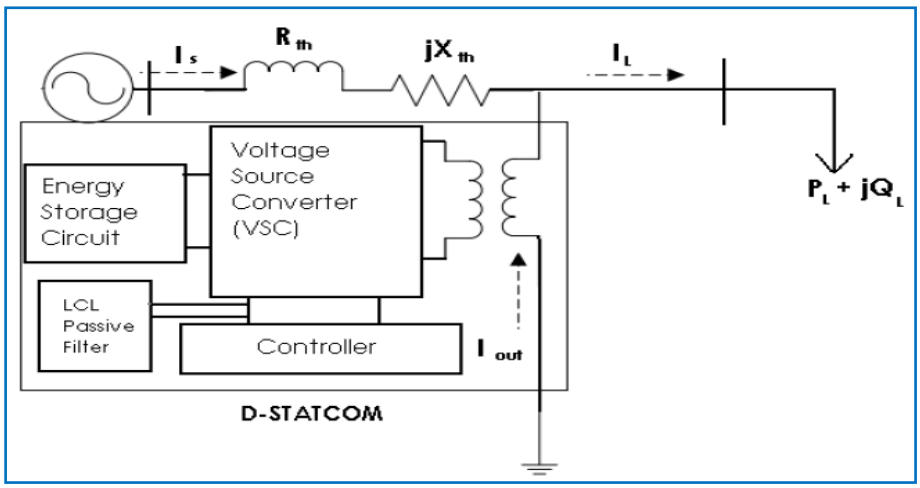

Fig. 1 –Overview of D-STATCOM

As seen in figure 1, the VSCa power electronic device that is either connected to the system directly or in shunt. Sinusoidal voltage can be generated by this device in the magnitudes and frequency as desired. This device is used to inject missing voltage orreplace voltage altogether. The difference between the actual voltage and nominal voltage is known as missing voltage. The VSC device also converts DC voltage to set of three phase AC output voltages across all storage devices [8], [9].The controller has its own role to play. The controller is elaborated and visualized in figure 2.

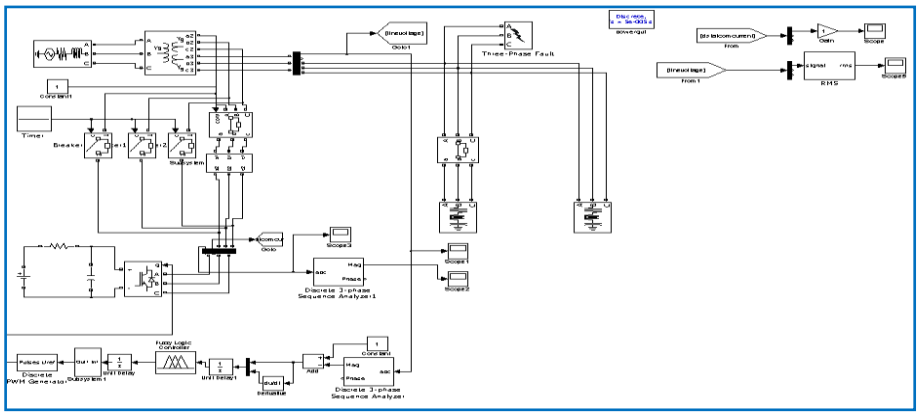

Fig. 2 –Overview of Fuzzy Controller System

As can be seen in figure 2, the controller system is part of the whole distribution system. The traditional PIcontroller is not flexible as its inputs once given can't be changed. The fuzzy controller introduced in this paper is part of the distribution system that works better than the PI controller. In D-STATCOM, the PWM generator is used to generate signals in sinusoidal format. It produces synchronizing signals. It works in tandem with VSC values. The circuit diagram of DC storage is as shown in **figure 3.**

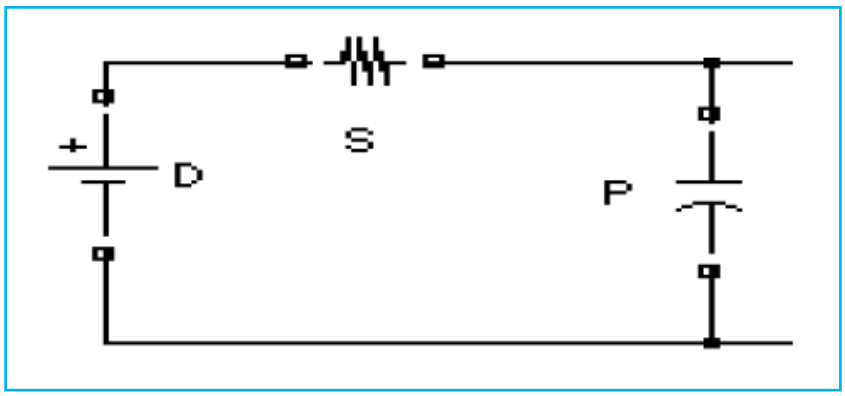

Fig. 3 –DC storage (Circuit diagram)

As seen in figure 3, it is evident that the DC capacitor and DC source are directly connected. The charging to DC capacitor is done either by a converter itself or through battery source.

III. PROPOSED METHODOLOGY

The aim of this paper is to enhance the quality features of power distribution systems. To achieve this D-STATCOM is used. Its architecture and other components that are part of the D-STATCOM have been described in the previous section. The proposed methodology to complete the experiments is as shown in **figure 4.**

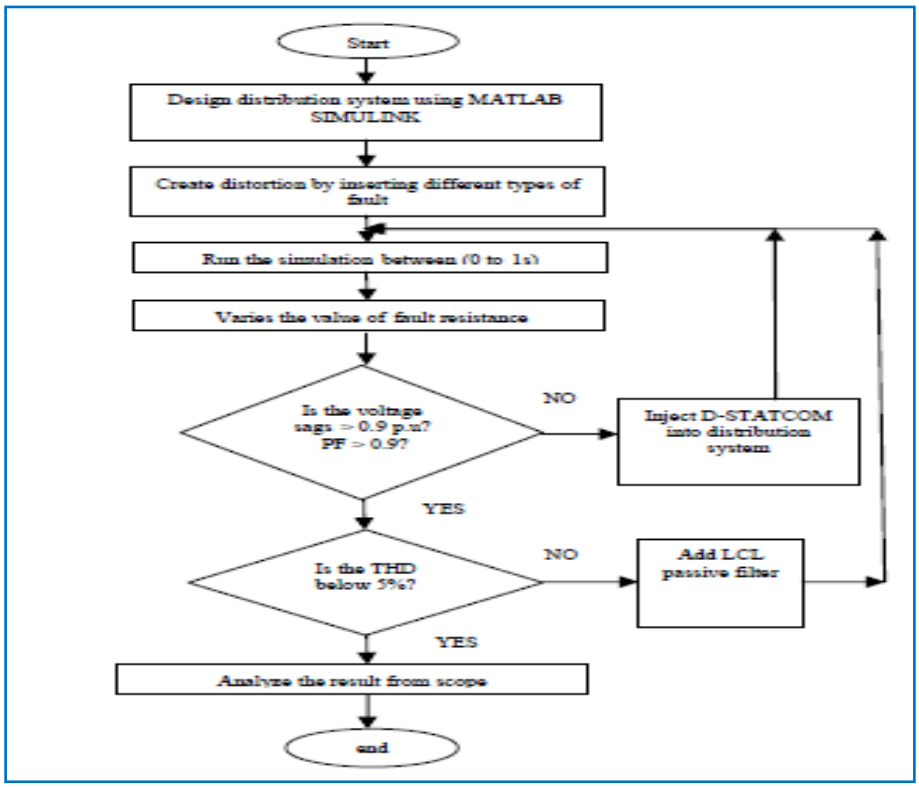

Fig. 4 –Proposed methodology

As seen in figure 4, the proposed methodology is presented in the flow chart. As per the methodology experiments have been conducted in MATLAB. The simulation results are presented in the next section.

IV. EXPERIMENTAL RESULTS

Experiments are made in terms of voltage and load points besides the power quality enhancements in a power distribution system. The test system designed in MATLAB Simulink is as shown in **figure 5.**

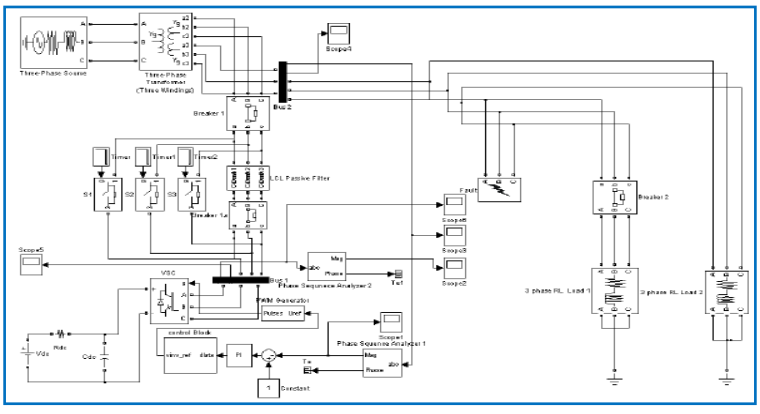

Fig. 5 –Overview of test system

Experiments are made with the test system in place. The experiments are made in terms of Three Phase to Ground (TPG), Single Line to Ground (SLG), Line to Line (LL), and Double Line to Ground (DLG). The results are as presented in **figure 6, 7, 8 and 9**.

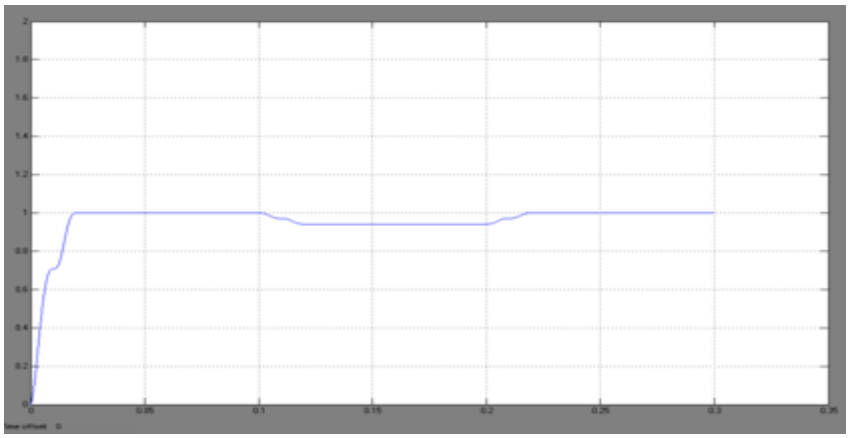

Fig. 6 –Voltage sags for TPG faults

As can be seen in figure 6, the result of voltage sags is presented. The voltage sags increase when the fault resistance increases for various types of faults.

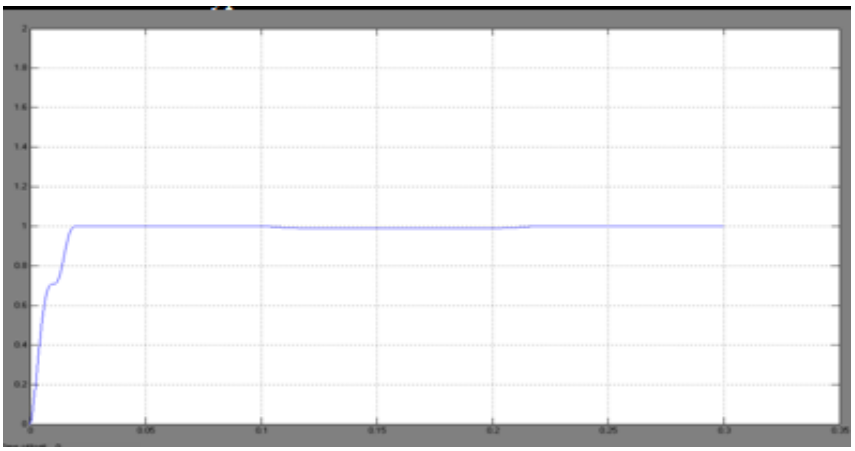

Fig. 7 – Voltage sags for DLG faults

As can be seen in figure 7, the result of voltage sags is presented. The voltage sags increase when the fault resistance increases for various types of faults. For DLG faults the results are presented in **figure 7.**

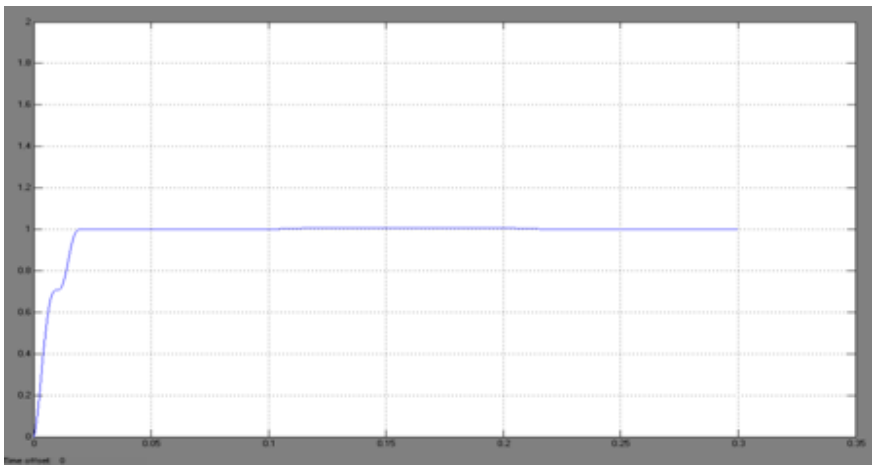

Fig. 8 – Voltage sags for LL faults

As can be seen in figure 7, the result of voltage sags is presented. The voltage sags increase when the fault resistance increases for various types of faults. For LL faults the results are presented in **figure 8.**

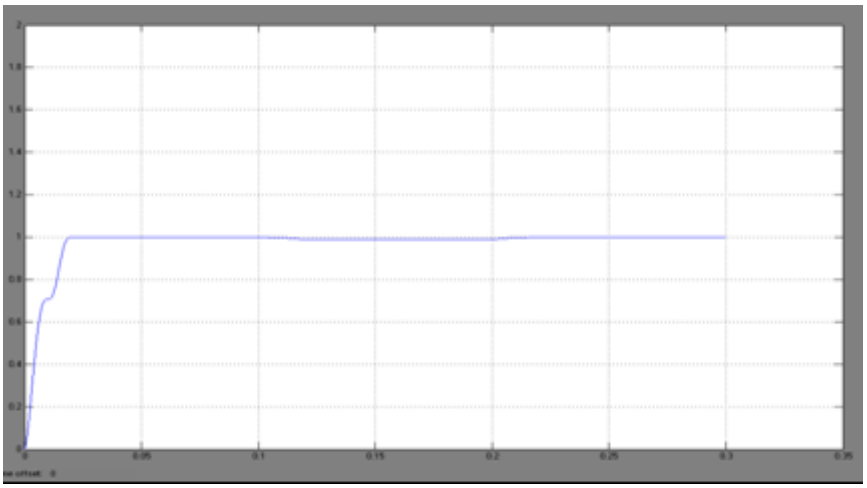

Fig. 9 – Voltage sags for SLG faults

As can be seen in figure 9, the result of voltage sags is presented. The voltage sags increase when the fault resistance increases for various types of faults. For SLG faults the results are presented in figure 8.

V. CONCLUSION

In this paper we studied the usage of D-STATCOM for improving quality of power distribution system. The controller we replaced with fuzzy controller for efficiency. The proposed scheme is capable of controlling power in such a way that it improves overall performance of the distribution system. The experiments are made in terms of Three Phase to Ground (TPG), Single Line to Ground (SLG), Line to Line (LL), and Double Line to Ground (DLG).The results revealed that the proposed scheme is feasible and effective in improving quality in power distribution systems.

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