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Analysis of Power Quality Improvement by using BFO-Fuzzy Controlled DVR

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ABSTRACT

Power quality is the one of the major concern in the present era. It has become important, with the introduction of power sensitive devices, whose performance is very sesnsitive to the quality of power supply. Power quality distortion occurrence results in failure of end user equipment. Voltage sags and swells in the medium and low voltage distribution grid are considered to be the most frequent type of power quality problems based on recent power quality studies. Their impact on sensitive loads is severe. The impact ranges from load disruptions to substantial economic losses up to millions of dollars. Different solutions have been developed to protect sensitive loads against such disturbances but the DVR is considered to be the most efficient and effective solution. Its appeal includes lower cost, smaller size and its dynamic response to the disturbance. This research described DVR principles and voltage restoration methods for balanced and/or unbalanced voltage sags and swells in a distribution system. Simulation results were presented to illustrate and understand the performances of DVR under voltage sags/swells conditions. The controlling of DVR is done by controlling the duty cycle of pulse width modulator (PWM). For this, in this thesis bacterial foraging optimization along with fuzzy logic is used. Membership functions of fuzzy logic are optimized by bacterial foraging optimization which is a bio inspired optimization technique and based on the behavior of E. Coli bacteria. Reduction in total harmonic distortion (THD) is compared with PI controller and fuzzy controlled DVR and it has been found that firefly optimized fuzzy logic reduces THD upto a good value

Keywords- DVR,PWM,THD,FUZZY CONTROL

1.INTRODUCTION

Power quality is an issue that is becoming increasingly important to electricity consumers at all levels of usage. Power Quality has now become an issue of great interest for research and analysis in the area of power system and other areas where better power quality is concerned. With the increase in the use of sensitive equipments and non linear loads in the domestic as well as industrial area, an enhanced awareness of power quality is developed amongst electricity consumers. A sinusoidal voltage waveform having constant magnitude and frequency represents the best form of electrical supply. The device named as Dynamic Voltage Restorer, which is connected in series with the line. The DVR is a Power Quality device which can protect sensitive loads against the disturbances i.e., voltage sags and swells related to remote system faults. The VSC must be controlled correctly to inject the required current (in shunt connection) or voltage (in series connection) into the system in order to compensate for a voltage dip. Since a number of sensitive loads can shut down because of a dip or other disturbances. The speed of reaction of the device is an important factor for successful compensation by the device. The combination of above two devices gives a device known as UPQC.

2.DYNAMIC VOLTAGE RESTORER (DVR)

This is a series connected device that has the same structure as that of an SSSC shown in Figure 1. The main purpose of this device is to protect sensitive loads from sag/swell, interruptions in the supply side. This is accomplished by rapid series voltage injection to compensate for the drop/rise in the supply voltage. Since this is a series device, it can also be used as a series active filter. Even though this device has the same structure as that of an SSSC, the operating principles of the two devices differ significantly. Another reason is that the DVR costs less compared to the UPS. Not only the UPS is costly, it also requires a high level of maintenance because batteries leak and have to be replaced as often as every five years. Other reasons include that the DVR has a higher energy capacity and lower costs compared to the SMES device. Furthermore, the DVR is smaller in size and costs less compared to the DSTATCOM.

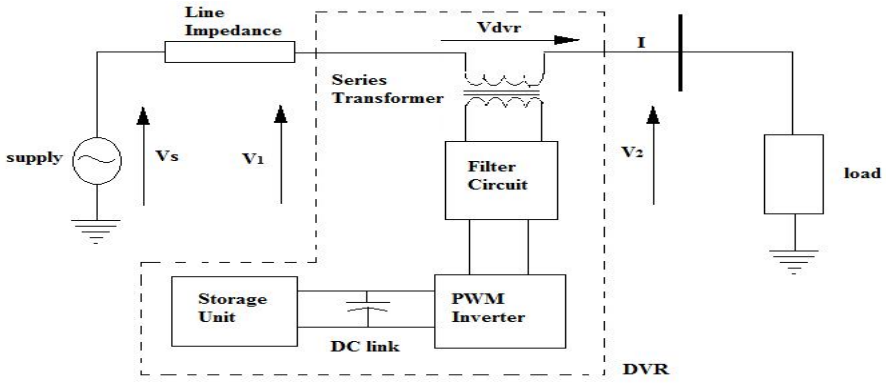


Figure.1 Structure of Dynamic Voltage Restorer

3.EQUATIONS RELATED TO DVR

The load impedance Z_{TH} depends on the fault level of the load bus. When the system voltage (V_{TH}) drops, the DVR injects a series voltage V_{DVR} through the injection transformer so that the desired load voltage magnitude V_L can be maintained. The series injected voltage of the DVR can be written as

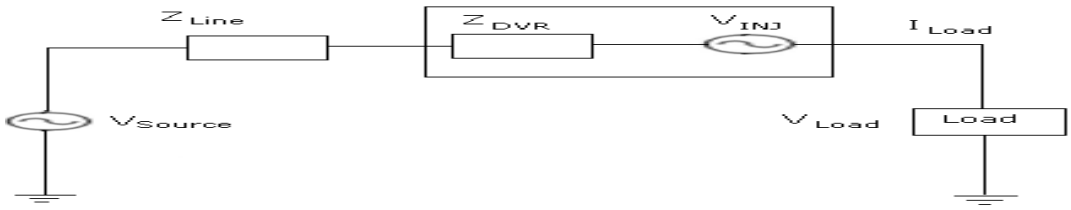


Figure. 2 Equivalent Circuit Diagram of DVR.

$$V_{DVR} = V_L + Z_{TH} I_L - V_{TH}$$

Where

V_L: The desired load voltage magnitude
Z_{TH}: The load impedance.
I_L: The load current
V_{TH}: The system voltage during fault condition
The load current I_L is given by,

$$I_L = \frac{[P_L + jQ_L]}{V_L}$$

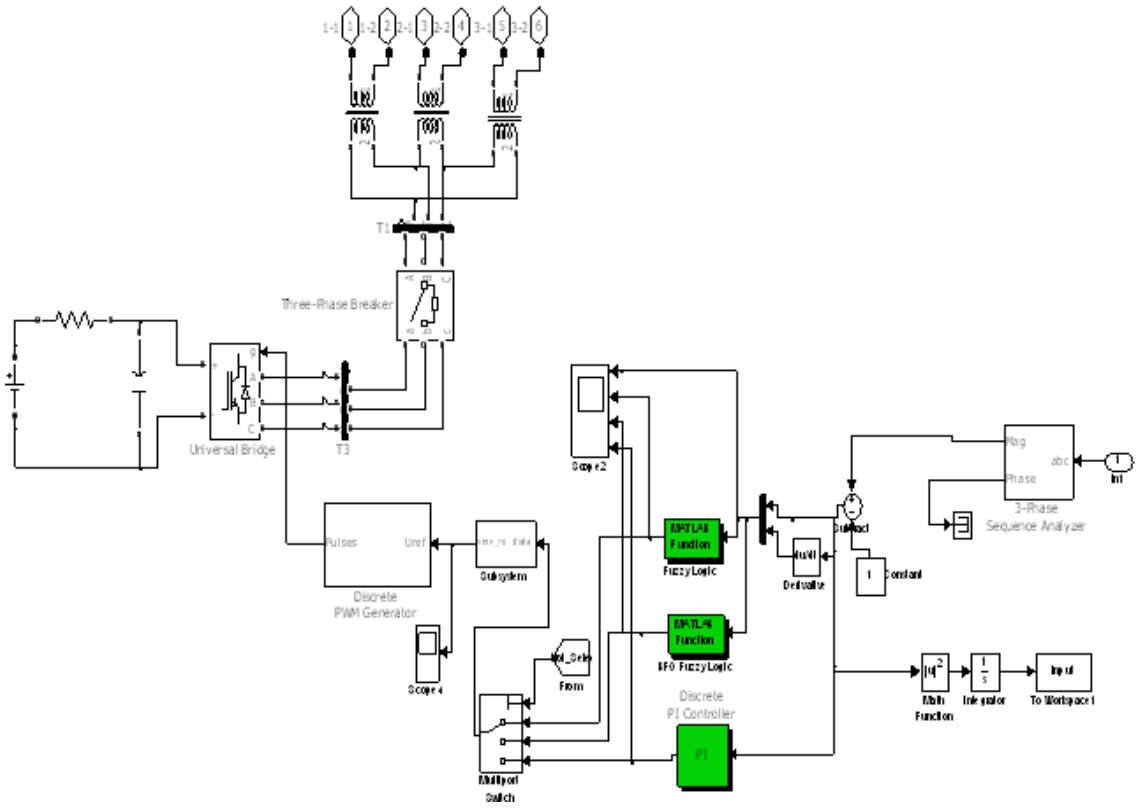
When VL is considered as a reference equation can be rewritten as,

$$V_{DVR}\angle\alpha = V_L\angle 0 + Z_{TH}\angle(\beta - \theta) - V_{TH}\angle\delta$$

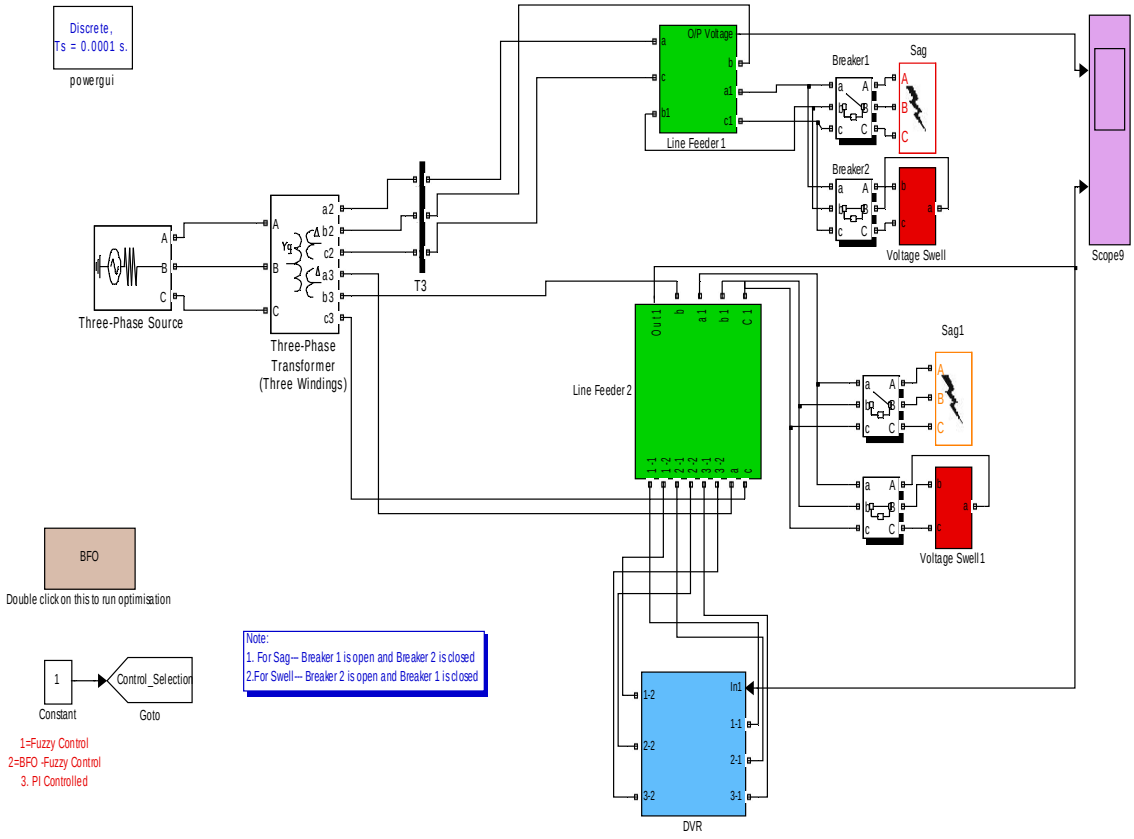
Control. A, β, δ are angles of V_{DVR}, Z_{TH}, V_{TH} respectively and θ is Load power angle. The complex power injection of the DVR can be written as.

4. DVR SIMULINK MODEL

A model for simulation of DVR with PI Controller and Fuzzy Logic Controller is shown in fig 5.6. In this model a three phase star ground connected source of 50 Hz is connected to three phase transformer having winding connections star ground, delta and delta for winding 1, 2 and 3 respectively. Winding 2 terminals of transformer is connected to a three phase series RLC branch through a transmission line and winding 3 terminals are connected to another three phase RLC branch having inductance of 0.005H and resistance of 0.001 Ohms. Output of these RLC branches are directly connected to two different three phase transformers (2 windings). On the upper side transformer, a three phase fault having fault resistance 0.001 Ohms and ground resistance 0.001 Ohms has been put. . A three phase breaker is also used to test the system in case of unbalance loading. Output of three phase breaker is directly connected to secondary windings of 3 linear two windings transformers having a nominal power of 250e6 VA and frequency of 50Hz each.

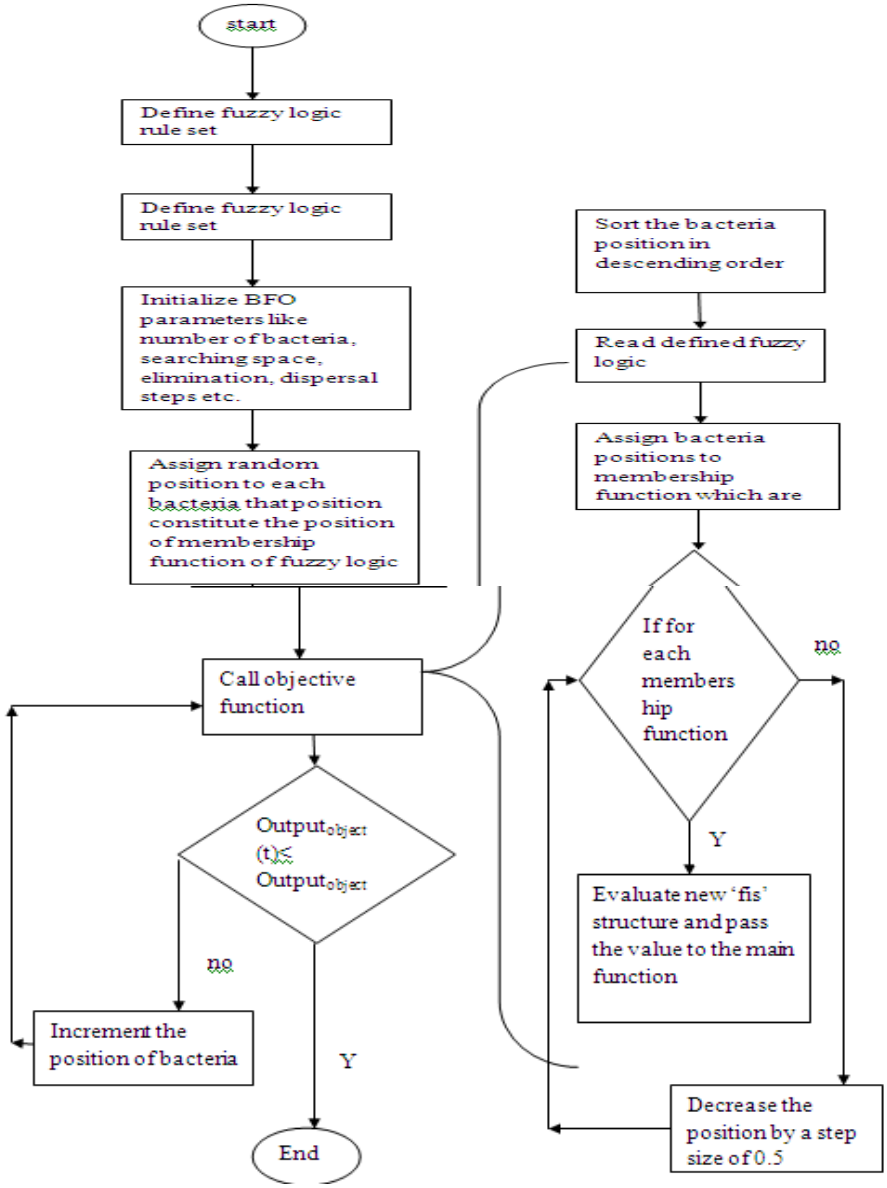


Model 1



MODEL2

5. Flow Chart



6. RESULTS

In main simulink model as shown in figure 5.6 three phase faults are used along with two breakers. For introducing sag in the model breaker 2 should be closed and breaker 1 should be open. Timing for fault introduction can be controlled also. In our experiment it has been taken from 0.1-0.3 sec. Initially PI controller is selected for DVR controlling.

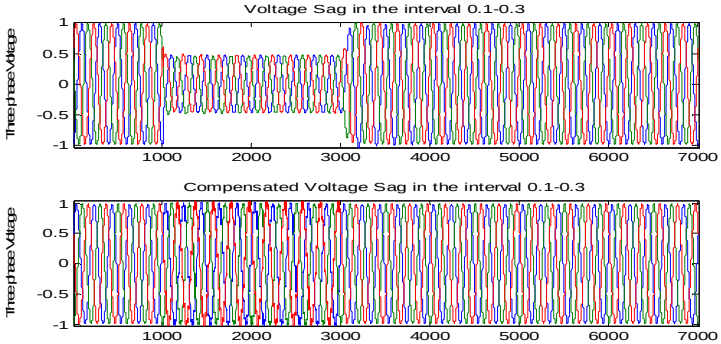


Figure 3. Uncompensated and Compensated output

The PI compensated THD is 0.24 % that means THD has been reduced to a good amount but still there is scope of more reduction in THD. For this purpose we have used fuzzy logic with 49 rules further. The zoomed output of fuzzy logic is shown in figure 5.13 to show the distortions. The total harmonic distortions, as in above case, is shown in figure 5.14. it comes out to be 0.19%, less than the distortions in case of PI controlled DVR. That proves fuzzy logic control is better than PI controlled DVR. this figure shown is zoomed in simulink window and direct taken from there. So because of these distortions total harmonic distortions are measured by FFT analysis. For this, FFT analysis from 'powergui' block is used which is placed in model to set the environment for simpower toolbox in simulink. The THD calculated by that is shown in figure 5.10. The THD in this case is 1.46%.

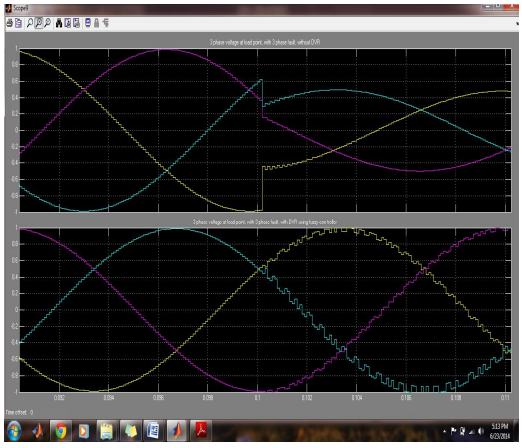


Fig 4. Distortions in the PI compensated waveform

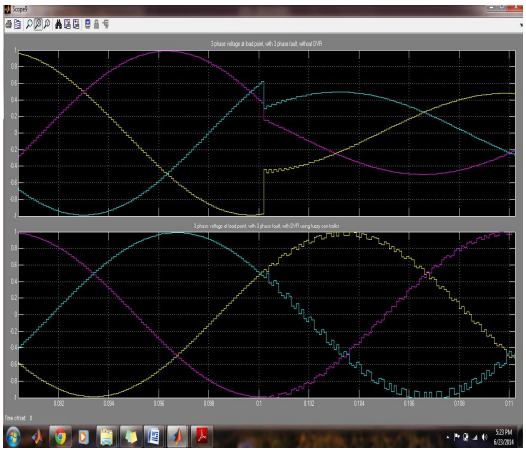


Figure 5. distortions in fuzzy logic compensated output

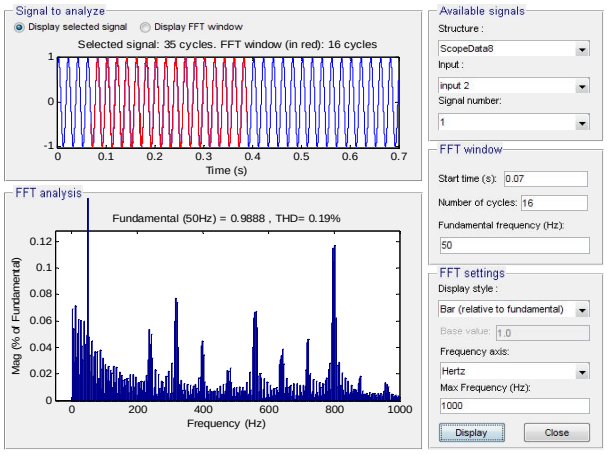


Figure 6. THD in case of fuzzy controlled DVR

Table 1 : Parameters used for BFO

Dimension Of Search Space	12
The Number Of Bacteria	6
Number Of Chemotactic Steps	6
Limits The Length Of A Swim	4

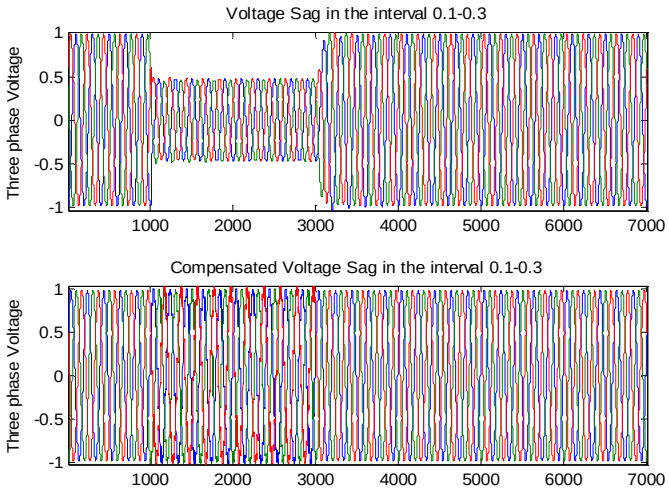


Figure 7. Output of BFO fuzzy logic

7 .CONCLUSION

The conclusions drawn from the different aspects of the study in this thesis are summarized in this chapter. The scope for further study in this area is also dwelt upon at the end. Nonlinear loads and disturbances due to faults produce harmonic currents that can propagate to other locations in the power system and eventually return back to the source. Therefore, harmonic current propagation produces harmonic voltages throughout the power systems. Mitigation techniques have been proposed and implemented to maintain the harmonic voltages and currents within recommended levels by a custom power device DVR. DVR with PI Controller and Fuzzy Logic Controller has been designed to mitigate the effects of the power quality problems during three phase fault condition. But since there is always scope of improvement in minimizing distortions, so membership function of fuzzy logic are optimized by bacterial foraging optimization (BFO) and it has been successfully recorded that total harmonic distortions are very less as compared to other two techniques. The investigation of DVR installation on a power distribution system with mainly focus on harmonic reduction and voltage regulation performance has been successfully demonstrated in MATLAB/Simulink. It is found that BFO-Fuzzy Logic Control is more effective than PI Control and fuzzy control technique in operation of DVR as a custom power device.

8. FUTURE SCOPE

The study made in the thesis mainly concentrates on the power quality improvement through DVR (Custom power Device) with optimized technique like Fuzzy Logic Controller for the distribution power system. Furthermore one can evaluate that some more analysis can be done in area of the custom power devices for improvement of power quality in different angles like advanced PWM methodologies, hysteresis and space vector (symmetrical or asymmetrical) implementations with programmable digital signal processors for the optimum control of the filtering devices through various advanced Artificial Intelligent Techniques like expert

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