# A Review on Application of Fuzzy Logic Controller Based DVR to Reduce Harmonic Distortion

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**Abstract-A Dynamic voltage restorer (DVR) is a method that prevents sensitive loads from harmonic distortion within a few milliseconds. Harmonics are the one of the major problems that affects the power quality thereby causes severe damage to sensitive loads are electronic devices. Consumer's demands power that is free of interruption or disturbance. Harmonics extremely affected by zero sequence component , it can be avoided by using DVR which employs zero blocking method using delta-connected blocking transformer installed between the supply and the booster transformer. Can avoid this paper describes application of one of the control methods namely; Fuzzy Logic Controller based DVR to mitigate harmonic distortion using MATLAB/SIMULINK.**

**Keywords-Total Harmonics Distortion (THD), Dynamic Voltage Restorer (DVR), Fuzzy Logic Controller.**

## I. INTRODUCTION

Present day society is fully dependent on the Power generated by generating station. Voltage fluctuation is one of the important factor that determine the quality of electrical power and it is necessary to improve the quality of power before further used. While power disturbances occur on all electrical systems, the sensitivity of today's sophisticated electronic devices makes them more susceptible to the quality of power supply[1].Harmonic distortion is one of the most occurrencedisturbances to the industrial equipment's which contributes27% of overall power quality issues[2]. A harmonic distortion occurs when a fault in the utility system, a fault within the customer's facility or a large increase of the load current, such as starting a motor or transformer energizing. Harmonics occurs in power system converters, transformers, rotating machines, arc furnaces, fluorescent lightings, and abnormal system conditions[3].There are various types of harmonics mitigation techniques and equipments are available among them, one of the most important devices is Dynamic Voltage Restorer also known as Custom Power Device.

Control Unit is the main part of the DVR which detect the voltage disturbances (sag or swell) and harmonics in the electrical distribution system and generate gate signal which is given to operate the Voltage Source Converter (VSC) for supplying required amount of compensating voltage.

## II.DYNAMIC VOLTAGE RESTORER TOPOLOGY

Dynamic Voltage Restorer (DVR) is a custom power device installed in series with distribution system line as can be seen in Figure1.To maintains voltage of sensitive load by injecting voltage whose magnitude, phase, and frequency can be controlled by using semiconductor device in Dynamic voltage restorer topology. The basic principle of DVR is to supply desired voltage so as to maintain voltage at the loads. Whenever there is a any voltage variation in the system,the dynamic voltage senses that and then corrects it according to the nominal set voltage ,if it varies very much then it supplies or absorbs variable voltage and is supplied to the loads. DVR actively corrects the voltage and also compensates active and reactive power. How DVR works to mitigate harmonics is shown in Figure 1. From Figure 1 it can be seen that, DVR can compensate harmonic distortion caused by harmonics [4].

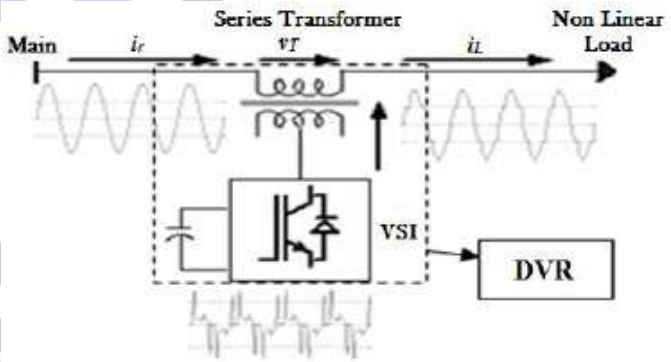


Fig. 1 DVR topology as harmonics compensator

## III. CONTROL METHODS

Fuzzy Logic controller (FLC)

FL controllers are a smart choice when exact mathematicalformulations are time consuming. A detailed understanding of the system isrequired for construction rules to be controlled. Fig.5. represents the FL controller which can be characterized as follows: 2 linguistic variables for derivative error are two inputs ,13 linguistic variables for output and 8 linguistic variables for error. Triangular and trapezoidal membership functions for error in terms of voltage, trapezoidal membership used for derivative error in terms of voltage and triangular membership functions for output variables are considered. A rule base of 16 rules is selected to establish the fuzzy controller [7] and with the use of Mamdani's implication and with defuzzification by a centroid method, the FL controller provides the switching function to carry out best control action and each rule explicit an operating condition in the system.

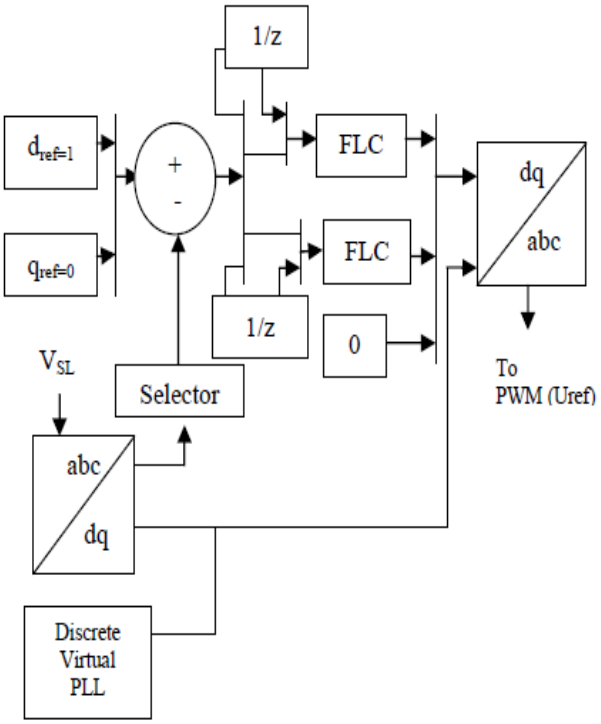


Fig.5 Fuzzy Logic Controller

In this paper, the inputs of the first FL controller are the error in terms of voltage($V_d$) and the derivative of error in terms of voltage ($\Delta V_d$) are considered and the error in terms of voltage ($V_q$) and the derivative of error in terms of voltage

($\Delta V_q$) are considered as the inputs of the second FL controller

The reference voltages for the voltage regulator are the voltages $V_{dref}$ and $V_{qref}$ . FLcontroller consists of 8 linguistic variables from Error which is; Negative (N), Zero (Z), Very Small Positive (VSP), Small Medium Positive (SMP), Medium Positive (MP), Large Medium Positive (LMP), large Positive (LP), and Very large Positive (VLP) and for derivative error, there are two linguistic variables, Negative (N) and Positive (P).

## V. SIMULINK RESULTS AND DISCUSSION

The simulation result was done DVR using FL controller with a three phase to ground fault.

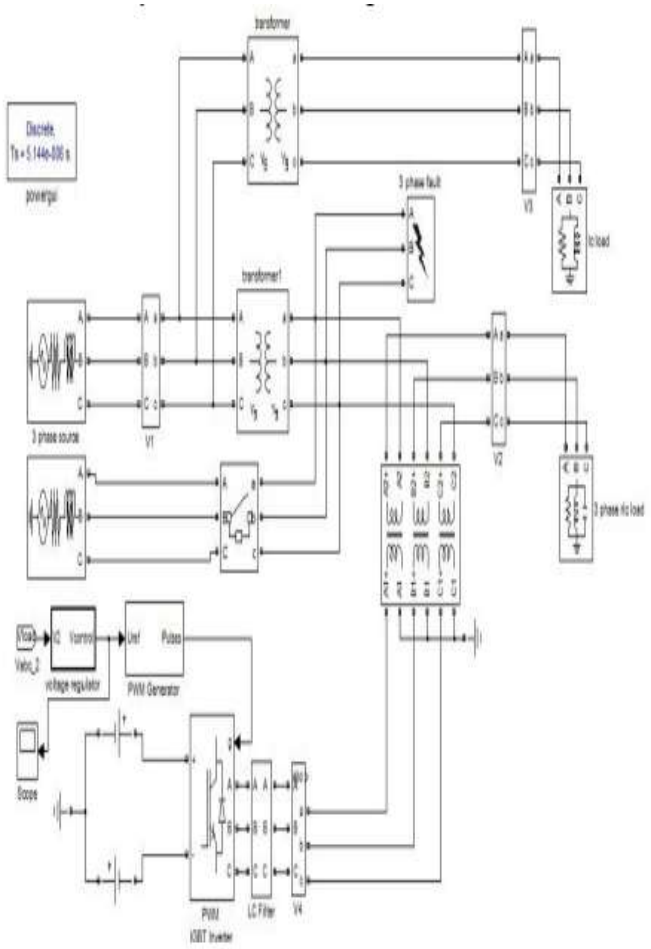

Fig.6 Simulink model of DVR

Fuzzy Logic controller (FLC)

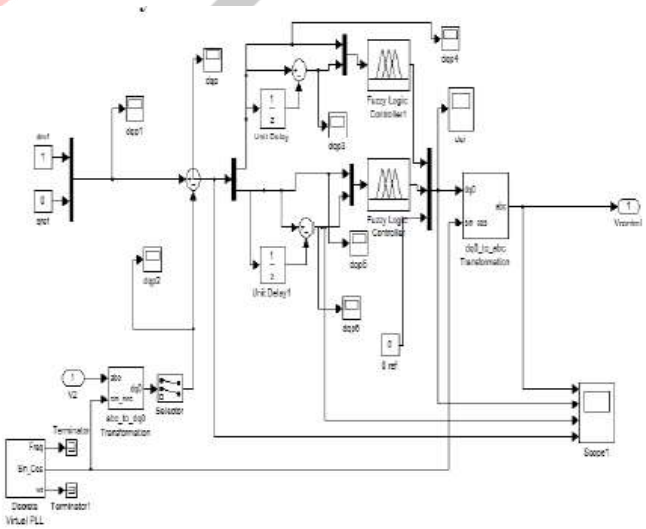

Fig.12. Simulink model of Fuzzy Logic Controller

Fig.12 shows Simulink model of Fuzzy Logic Controller. The output waveforms of source voltage, load voltage and injected voltage of DVR with Three Phase Fault Using FL Controller is shown below Fig.13.

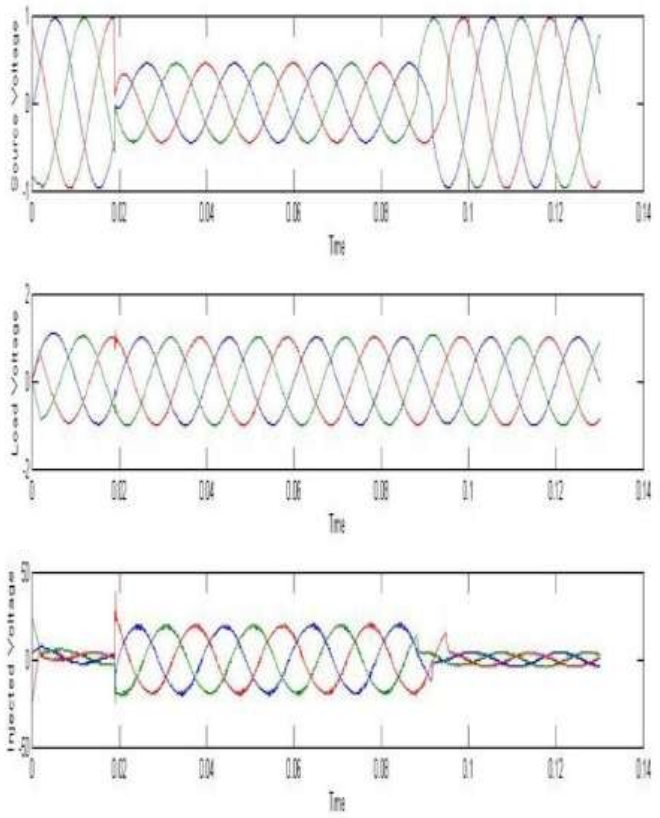


Fig.13. Sag Mitigation using DVR with FL Controller for Three Phase to Ground Fault.

Source Voltage:

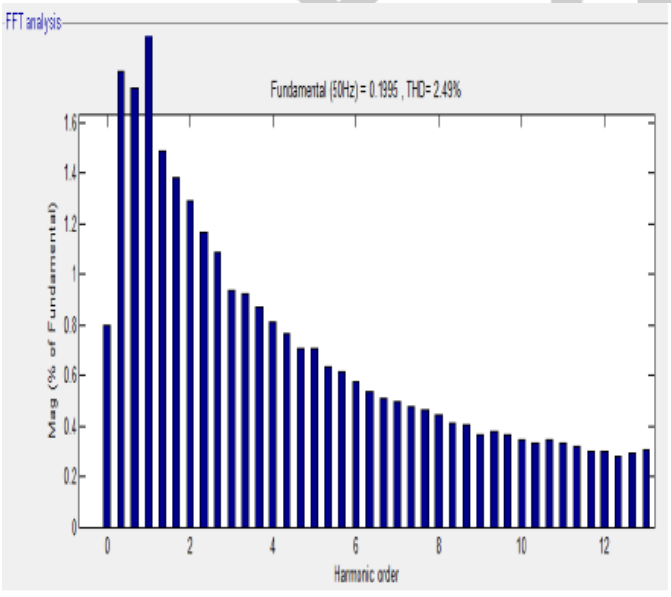


Fig.14. THD value is 2.22% is obtained with fuzzy controller

Load Voltage:

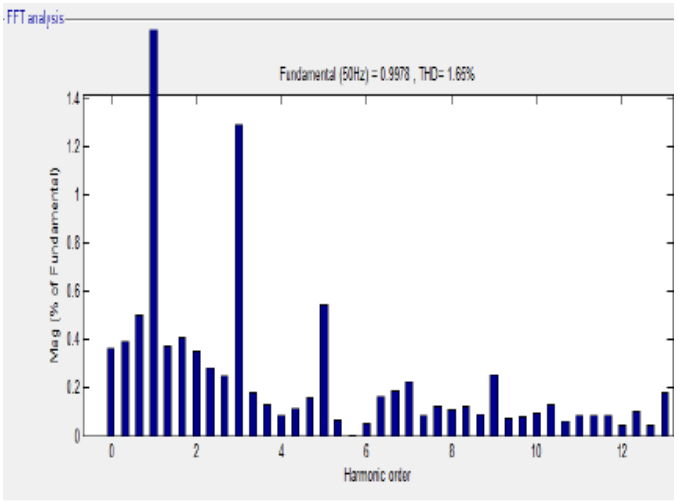


Fig.15. THD value is 1.68% is obtained with fuzzy controller

Injected Voltage for Three Phase Fault:

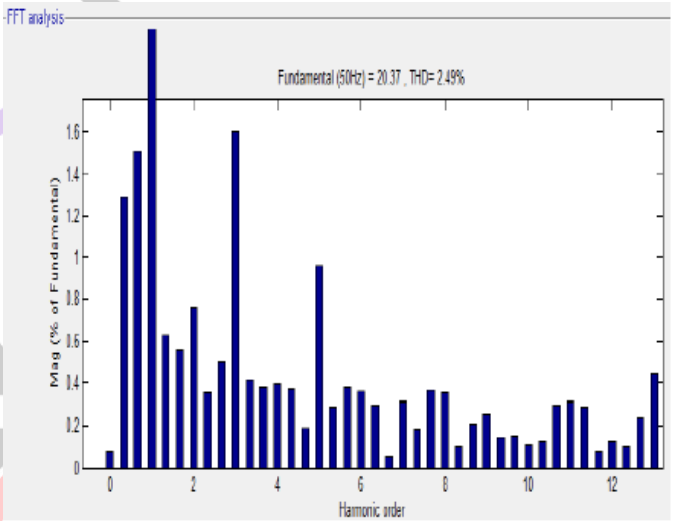


Fig.16. THD value is 2.91% is obtained with fuzzy controller

THD analysis of source voltage, load voltage and injected voltage using different controllers for the L-G fault condition is shown in the table1.

| control | Source Voltage | Load Voltage | Injected Voltage |
|---|---|---|---|
| PI | 2.22% | 1.78% | 3.15% |
| Fuzzy | 2.19% | 1.38% | 2.79% |

TABLE 1: THD Analysis for L-G Fault

THD analysis of source voltage, load voltage and injected voltage using different controllers for the L-L-G fault condition is shown in the table 2.

| | Source Voltage | Load Voltage | Injected Voltage |
|---|---|---|---|
| PI | 2.24% | 1.23% | 2.93% |
| Fuzzy | 2.23% | 1.47% | 2.85% |

TABLE 2: THD Analysis for L-L-G Fault

THD analysis of source voltage, load voltage and injected voltage using different controllers for the L-L-L-G fault condition is shown in the table 3.

| | Source Voltage | Load Voltage | Injected Voltage |
|---|---|---|---|
| PI | 2.27% | 1.78% | 4.18% |
| Fuzzy | 2.22% | 1.68% | 2.91% |

TABLE 3: THD Analysis for L-L-L-G Fault

From the above three tables we can say that the THD is reduced drastically with the Fuzzy Logic controllerr for different fault like single line to ground, double line to ground fault and three phase fault[8].

## VI. CONCLUSION

In this work, cost effective dynamic voltage restorer (DVR) is proposed to reduce the problem of harmonics in fault conditions in industrial distribution systems, specially consisting of sensitive loads. The effectiveness of DVR using Fuzzy Logic controller compared with the simulation results. The simulation results clearly showed the more efficient performance of the DVR with fuzzy logic controller

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