

# Voltage Sag Compensation using Dynamic Voltage Restorer with Energy Storage Device

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**Abstract:** One of the significant worries in power industry today is power quality. It turns out to be particularly significant with the presentation of cutting edge and entangled gadgets, whose exhibition is delicate to the nature of intensity supply. The electronic gadgets are touchy to unsettling influences and in this way mechanical burdens become less tolerant to control quality issues, for example, voltage plunges, voltage hangs, voltage flashes, music and burden unbalance and so on. At present, a wide scope of entirely adaptable controllers, which profit by recently accessible force hardware segments, are developing for custom force applications. Among these, D-STATCOM, dynamic voltage restorer (DVR) and brought together force quality conditioner (UPQC) which depends on the VSC rule are utilized for power quality improvement. The primary point of my paper is to plan DVR which is utilized to remunerate voltage quality issues and Fuzzy Logic Controller is utilized to control the inverter. The outcomes are contrasted and ordinary controller. The outcomes will be examined utilizing matlab/simulink programming.

**KEYWORDS:** Dynamic Voltage Restorer, Fuzzy Logic Controller, PI Controller, Fuzzy Inference System, Rule View, Surface View.



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DOI of the Article: <https://doi.org/10.46501/GIETEE19>



Available online at: <https://ijmtst.com/icceeses2021.html>



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**To Cite this Article:**

P. Srikanth; R. Pavan Teja; Shashi Kumar and K. Narendra Babu. Voltage Sag Compensation using Dynamic Voltage Restorer with Energy Storage Device. *International Journal for Modern Trends in Science and Technology* 2021, 7, pp. 132-138. <https://doi.org/10.46501/GIETEE19>

**Article Info.**

Received: 20 May 2021; Accepted: 25 June 2021; Published: 30 June 2021

## INTRODUCTION

Power quality issues in the circulation frameworks are interference, voltage droop and voltage swell because of the expanded utilization of delicate and basic gear's in the framework. A few models are gear's of correspondence framework, process enterprises, exact assembling forms and so on. Force quality issues, for example, homeless people, droops, swells and different twists to the sinusoidal waveform of the stock voltage influence the presentation of these equipment's. A DVR is utilized to remunerate the inventory voltage unsettling influences, for example, droop and swell. The DVR is associated between the stock and

touchy burdens, with the goal that it can infuse a voltage of required extent and recurrence in the conveyance feeder. The DVR is worked with the end goal that the heap voltage extent is controlled to a consistent size, while the normal genuine force retained/provided by it is zero in the relentless state. The capacitor upheld DVR is broadly tended to in the writing [8-11]. The instantaneous reactive power theory (IRPT) [6], sliding mode controller [9], instantaneous symmetrical components [2] etc., are discussed in the literature for the control of DVR. In this project a new control calculation is proposed dependent on the present mode control and relative essential (PI) controllers for the control of DVR. The broad reenactment is performed to exhibit its ability, utilizing the MATLAB with its Simulink and Power System Blockset (PSB) tool compartments.

## POWER QUALITY PROBLEMS

### A. Introduction

Power quality is the mix of voltage quality and current quality. Along these lines power quality is worried about deviations of voltage as well as present from the perfect. Force circulation frameworks, preferably, ought to furnish their clients with a uninterrupted flow of vitality at smooth sinusoidal voltage at the contracted greatness level and frequency. However, by and by, power frameworks, particularly the appropriation frameworks have various nonlinear burdens, which fundamentally influence the nature of intensity supplies. Because of the nonlinear loads, the

immaculateness of the waveform of provisions is lost. This wind up creating numerous Power quality issues.

While power unsettling influences happen on every electrical framework, the affectability of the present advanced electronic gadgets makes them increasingly helpless to the nature of intensity supply. For some touchy gadgets, a fleeting aggravation can cause mixed information, interfered with interchanges, a solidified mouse, framework accidents and hardware disappointment and so on. A force voltage spike can harm significant segments. Force Quality issues envelop a wide scope of unsettling influences, for example, voltage hangs/swells, glimmer, sounds mutilation, motivation transient, and interferences.

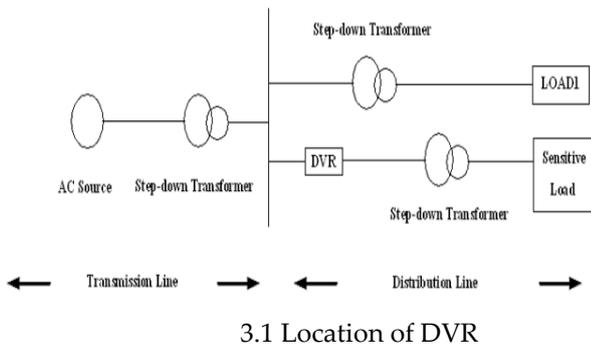
### B. Power Quality Problems

- Voltage dip
- Voltage sag
- Voltage swell
- Voltage 'spikes', 'impulses' or 'surges'
- Voltage transients
- Harmonics
- Flickers

## DYNAMIC VOLTAGE RESTORER

### A. Introduction

Among the force quality issues (droops, swells, sounds) voltage lists are the mostsevere unsettling influences. So as to defeat these issues the idea of custom force gadgets isintroduced as of late. One of those gadgets is the Dynamic Voltage Restorer (DVR), which is themost productive and viable present day custom force gadget utilized in power dispersion networks. DVR is an as of late proposed arrangement associated strong state gadget that infuses voltage into thesystem so as to manage the heap side voltage. It is regularly introduced in a dispersion systembetween the stockpile and the basic burden feeder at the point of common coupling (PCC). Otherthan voltage hangs and swells remuneration, DVR can likewise included different highlights like: line voltage music pay, decrease of homeless people in voltage and issue current impediments.



**B. Basic Configuration of DVR**

The general configuration of the DVR consists of:

- An Injection/ Booster transformer.
- A Harmonic filter.
- A Voltage Source Converter (VSC).
- DC charging circuit.
- A Control and Protection system.

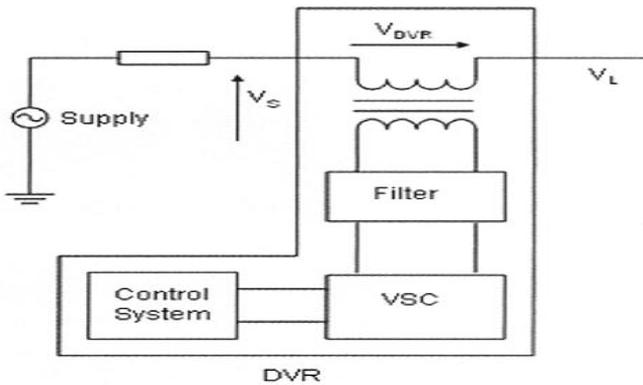


Fig 3.2 Schematic Diagram of DVR

**DVR CONTROL STRATEGY**

**A. DVR Control Strategy**

The proposed algorithm is based on the estimation of reference supply currents. It is similar to the algorithm for the control of a shunt compensator like DSTATCOM for the terminal voltage regulation of linear and nonlinear loads [6].

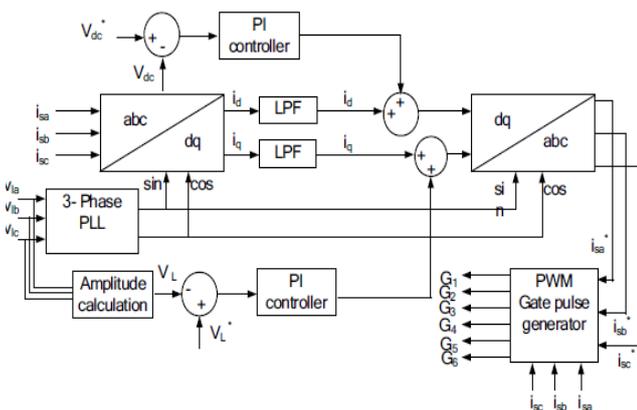


Fig 4.1 Control scheme of the DVR

The arrangement compensator known as DVR is utilized to infuse a voltage in arrangement with the terminal voltage. The hang and swell in terminal voltages are repaid by controlling the DVR and the proposed calculation characteristically gives a self-supporting dc transport to the DVR. Three-stage reference supply currents ( $i_{sa}^*, i_{sb}^*, i_{sc}^*$ ) are inferred utilizing the detected load voltages ( $v_{la}, v_{lb}, v_{lc}$ ), terminal voltages ( $v_{ta}, v_{tb}, v_{tc}$ ) and dc bus voltage ( $v_{dc}$ ) of the DVR as input signals. The synchronous reference outline hypothesis based method is used to acquire the immediate pivot ( $i_d$ ) and quadrature hub ( $i_q$ ) components of the heap current. The heap flows in the three-stages are changed over into the d-q-0 edge utilizing the Park's transformation as,

$$\begin{bmatrix} i_d \\ i_q \\ i_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos \theta & -\sin \theta & \frac{1}{2} \\ \cos(\theta - \frac{2\pi}{3}) & -\sin(\theta - \frac{2\pi}{3}) & \frac{1}{2} \\ \cos(\theta + \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) & \frac{1}{2} \end{bmatrix} \begin{bmatrix} i_{la} \\ i_{lb} \\ i_{lc} \end{bmatrix} \tag{4.1}$$

**FUZZY LOGIC CONTROLLER**

**A. Introduction**

The fundamental utilization of Fuzzy control framework depends on observational principles is progressively successful. Fuzzy frameworks are effectively redesigned by including new standards or new highlights to improve execution. Fuzzy control can be utilized to improve existing conventional control frameworks by adding a layer of insight to the present control technique [7]. The Fuzzy logic controller comprises of Fuzzy Inference System Editor. The reenactment of delicate exchanging circuit is created in this FIS editorial manager. VCr and ICr are the contributions of the fluffy controller. The yield of the controller is fresh worth. This Graphical User Interface comprises of FIS Editor, Membership work Editor, Rule Editor, Rule Viewer and Surface Viewer.

**5.1 Fuzzy Inference Diagram**

The fuzzy derivation outline is the composite of all the littler graphs we've been taking a gander at so far in this area. It at the same time shows all pieces of the fuzzy induction process we've inspected. Data courses through the fuzzy surmising outline. fuzzy surmising is the way toward planning the mapping from an offered

contribution to a yield utilizing fuzzy rationale. The mapping at that point gives a premise from which choices can be made, or designs recognized. The procedure of fuzzy induction includes the entirety of the pieces that are depicted in the past segments: enrollment capacities, fuzzy rationale administrators, and in the event that rules.

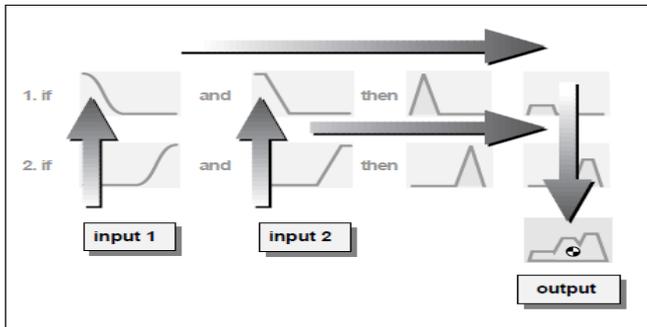


Fig.5.1: Fuzzy Inference Diagram

Fuzzy derivation frameworks have been effectively applied in fields, for example, programmed control, information grouping, choice investigation, master frameworks, and PC vision. In light of its multidisciplinary nature, Fuzzy deduction frameworks are related with various names, for example, Fuzzy standard based frameworks, Fuzzy master frameworks, Fuzzy demonstrating, Fuzzy acquainted memory, fuzzy rationale controllers, and just (and ambiguously) Fuzzy frameworks.

**SIMULATION RESULTS**

*A. Base System*

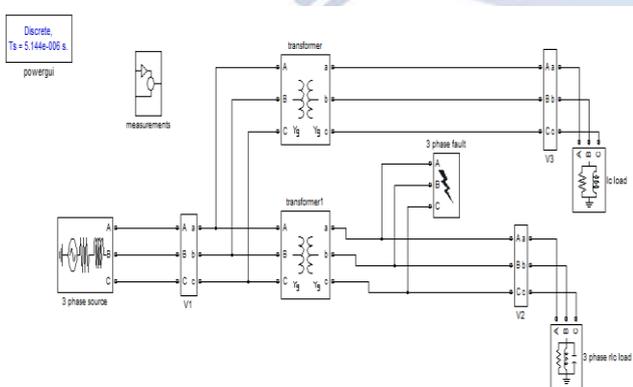


Fig 6.1 Base System

This is the square outline indicating source, burden and transmission line in broken conditions. The deficiency can be of any nature like L-G, L-L-G, L-L or 3-PHASE

FAULT. In these conditions serious deficiency flows course through the lines and there is a drastic drop in line and load voltages.

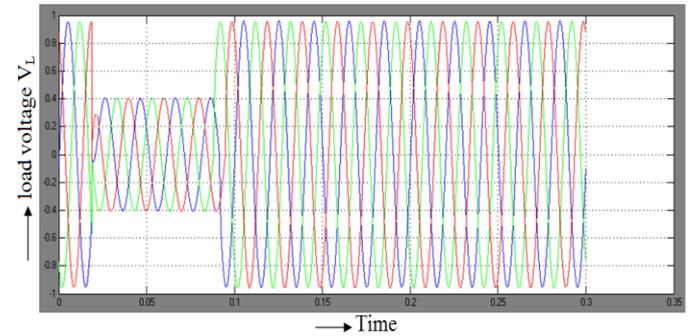


Fig 6.2 Load Voltage

The drop in the load voltage can be seen in above wave form due to fault in transmission line.

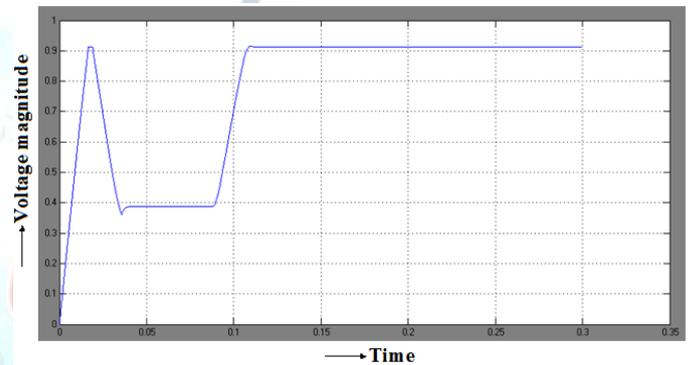


Fig 6.3 Voltage Sag

The sag in the voltage waveform which can be clearly observed in the above figure which is deviating from the actual voltage curve.

*B. Base System With PI Controller*

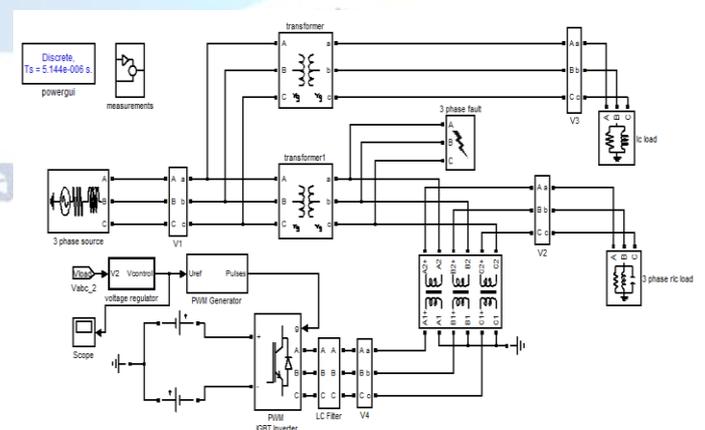


Fig 6.4 Base System with PI Controller

This is the square chart indicating source ,burden and transmission line in flawed conditions . The sort and force of flaw can be distinguished and remedied with

the DVR and its control system . What's more, bring back the voltage levels to the ordinary working an incentive before the event of shortcoming.

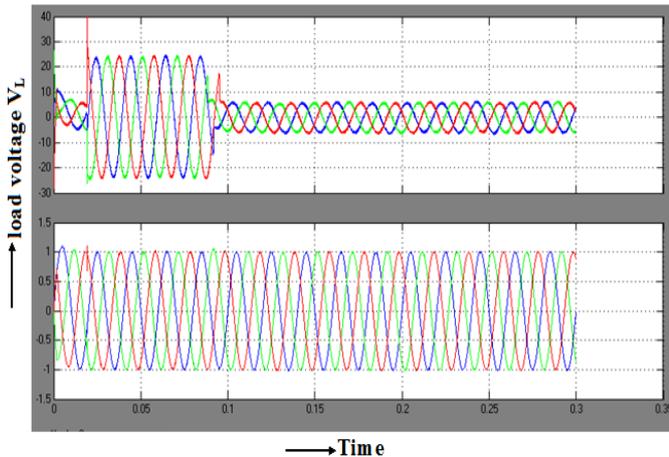


Fig 6.5 injected voltage by the DVR

In the above figure the principal waveform infers the infused voltage by the DVR into the lines to remunerate the voltage drop. The subsequent waveform suggests the repaid load voltage at the buyer side.

C. Base System With Fuzzy Controller

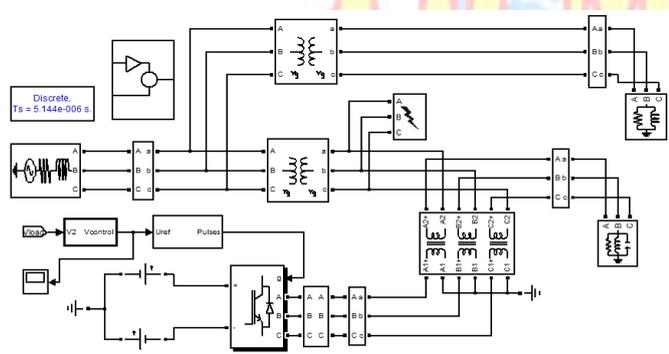


Fig 6.6 Base System with Fuzzy Controller

This is the square chart indicating source, burden and transmission line in broken conditions. The sort and power of flaw can be distinguished and rectified with the DVR and its control instrument. What's more, bring back the voltage levels to the typical working an incentive before the event of issue.

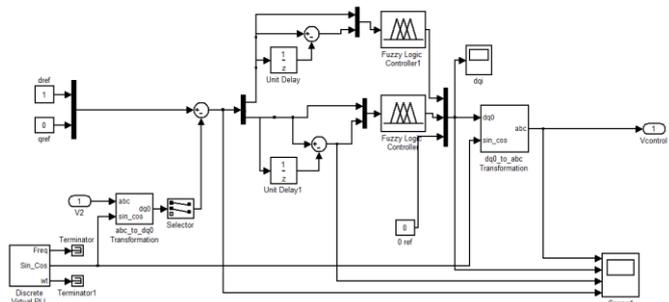
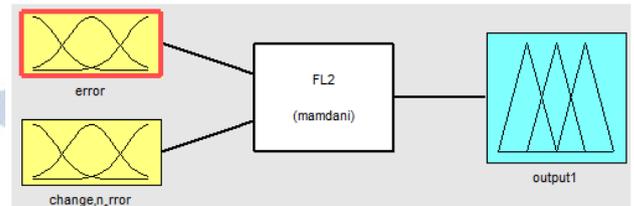


Fig 6.7 Subsystem of Fuzzy Controller

The controller utilized in the above reproduction hardware is fluffy controller .Since fluffy being a propelled controller there is no need of tuning the controller, thus fluffy controller is liked to ordinary controllers.

D. Design and Simulation of Fuzzy Controller



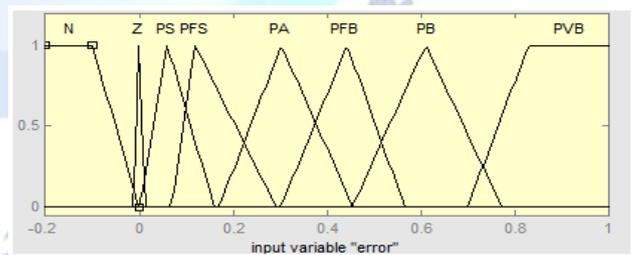
FIS editor  
Fig 6.8 FIS Editor

FIS editor is used for giving the number of input and output variables for the fuzzy controller.

FAM table

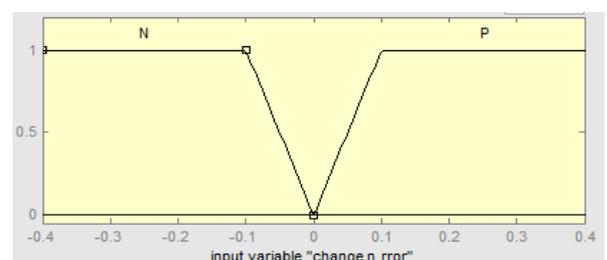
E	N	Z	PS	PFS	PA	PFB	PB	PVB
DE	N	Z	PS1	PFS1	PA1	PFB1	PB1	PVB
P	N	Z	PS2	PFS2	PA2	PFB2	PB2	PVB

The input and output variables are plotted in the form of membership functions with the help of FAM table only. FAM table is a collection of statistical data regarding the system used in simulation.



Membership function of error input

Fig 6.9MF of error



Membership function of change in error input

Fig 6.10 MF of change in error

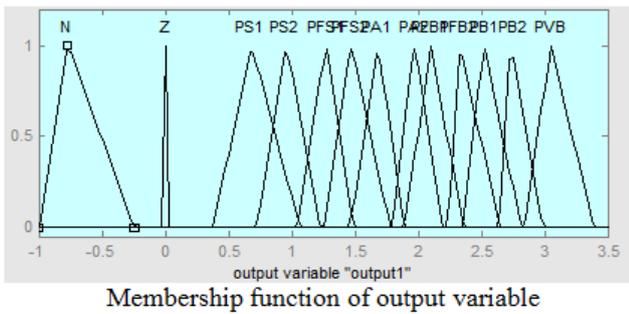
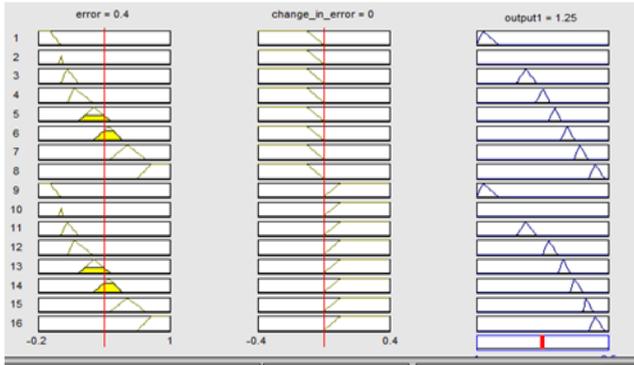


Fig 6.11 MF of output



Rule Viewer  
Fig 6.12 Rule viewer

Rule viewer is fundamentally a window in fuzzy controller recreation to discover the ideal arrangement in the yield looking at different info blends as appeared previously.

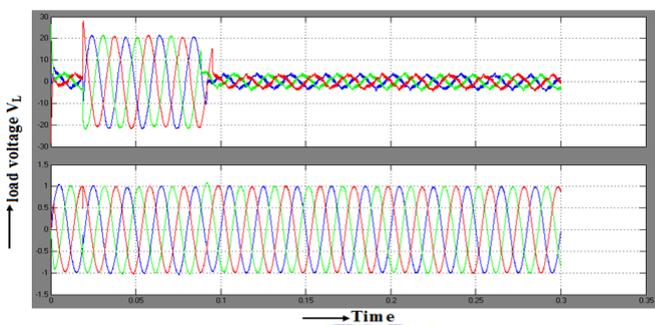


Fig 6.13 Injected voltage by the DVR fuzzy

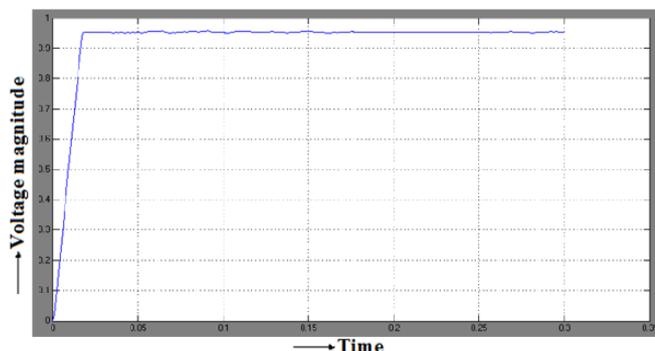


Fig 6.14 voltage sag with fuzzy

With the use of fuzzy controller in the control hardware of DVR we can take out the voltage drop in the lines and

purchaser side giving a steady voltage at the heap end. This can be closed by watching the above voltage charts.

E. THD Comparison between Controllers

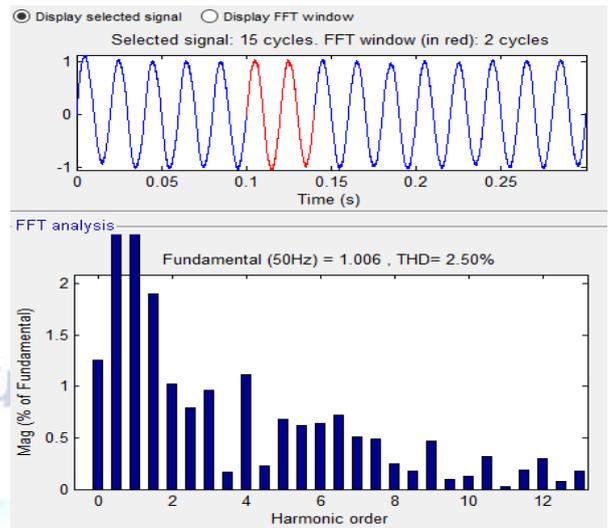


Fig 6.15 THD with PI

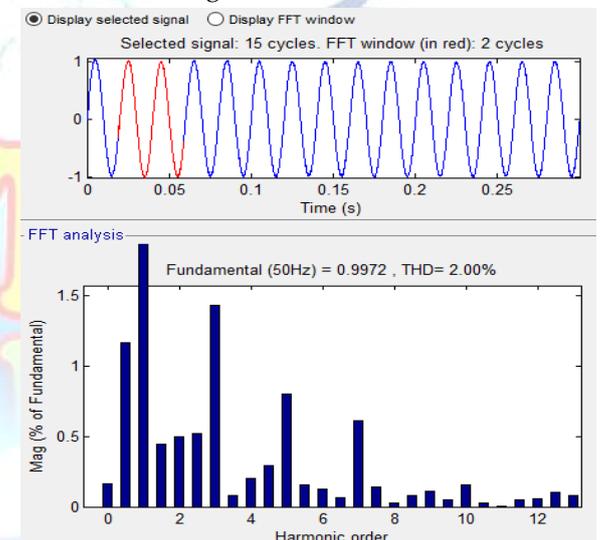


Fig 6.16 THD with Fuzzy

Here two controllers utilized to control voltage drop i.e, PI and Fuzzy. To propose the best controller for filling the necessary need of voltage control the Total Harmonic Distortion (THD) of two controllers are thought about. The controller with less THD is recommended as the best controller. By watching the over two figures it was unquestionably Fuzzy controller with less THD and henceforth it is the best controller when contrasted with its partner.

CONCLUSION

In this paper, a DVR obtained by means of the series connection of two three-phase inverters through an OEW transformer was presented. The ability of a Dynamic voltage restorer (DVR) to compensate voltage

sag depends upon the capacity of energy storage device. Here we had considered a distribution system with a three phase to ground fault. A voltage sag of 0.4V (pu) has occurred in the distribution line and there is said to be a drop in load voltage. PI and Fuzzy Logic controller are simulated and performance of DVR is analysed. Both the controllers gave an optimum performance and have the ability to bring the source voltage back to 1.0pu in faulty conditions. The fuzzy controller gave a better performance than the PI in terms of total harmonic distortion of 2.00% than PI (2.50%) in improving the source voltage to normal conditions. The future scope for the project is design of a DVR with Artificial Neural Network as a controller.

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