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Voltage Sag Mitigation of DVR using PI and Fuzzy Logic Controller

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Abstract

Voltage sag is the occur by miss operation of several sensitive electronic equipment. That problem can be mitigate with voltage injection process using Dynamic Voltage Restorer (DVR). The analysis and simulation of a DVR with pulse width modulation technique based on controller using Matlab/Simulink presented in this paper. To mitigate the voltage sag using DVR is explained by the parameters like voltage, power. The control technique which involved switching the inverter always used easily by applying DVR to it. The two control techniques used connected to DVR which are Proportional-integral Controller (PI) and Fuzzy Logic Controller which give the result to assess the presentation of controller and capability of DVR for the best power quality solution and continuous simulation with respect to power supply. The modelling and simulation of DVR controlled by PI and Fuzzy has been developed using Matlab/Simulink.

Keywords: *Dynamic Voltage restorer, PI Controller, FLC, SVPWM.*

INTRODUCTION

Power quality difficulty become a main unease of industries due to huge loss in terms of time and money. Hence, there are always burden for good power quality, which positively resulting in reduction of power quality troubles like voltage sag, harmonic and flicker . Voltage sag is always considered as one of the major power quality problems because the frequency of occasion is so high. The general causes of voltage sag are faults or short circuit in the

system, starting of large loads and faulty wiring. This will lead to increase in both production and financial loss for industries There are various types of voltage sag improvement equipment that accessible these days such as continuous Power Supply (UPS), flywheel, and the flexible ac technology (FACTS) devices which have been generally use in the power system due to the dependability to maintain power quality control. One of the most FACTS devices that have been created in improvement the performance of power quality is Dynamic Voltage Restorer (DVR) also known as custom power devices. A new arrangement of Dynamic Voltage Restorer (DVR) with PI controller and fuzzy logic controller is used which is capable of compensate power quality problems associated with voltage sags/swells and maintaining a prescribed level of supply voltage at the different load terminals. The simulation of the proposed DVR is able to use in MATLAB/ SIMULINK. The arrangement of the proposed DVR for different supply disturbances is tested under various operating conditions. arrangement and action

Dynamic voltage restorer (DVR) This is the series connected device that has the similar structure as that of an SSSC. The main purpose of this device is to protect sensitive load from sag/swell, disturbance in the supply side. This is capable by rapid series voltage injection to equilibrium for the drop/rise in the supply energy.

Since this is the series device, it can also be used as a series active filer. yet even if this device has the same understanding as that of an SSSC the operating values of the two devices differ considerably [2].

While the SSSC injects a balance voltage in sequence, the DVR may have to inject disturb voltages to maintain the voltage at the consignment terminal in case of an unbalance sag in the supply side. Furthermore when there is winding in source voltage, the DVR may also have to inject a indistinct voltage to counteract the harmonic voltage Final step. It is also well-known as a static voltage booster (SVB) or a static series compensator (SSC).

Power quality

Power quality can be defined as “the calculate, study, and development of bus voltage, usually a load bus voltage, to

maintain that voltage to be a sinusoidal at rated voltage and frequency." quality may also be defined as "the condition of voltage and system design so that the user of electric power can operate electric energy from distribution system effectively without crossing point or interruption

Power Quality Problems

Power quality problem can be defined as the substandard voltage, current or frequency that outcome in a failure of end use equipment. The power quality problems are more and more felt by felt by customers – manufacturing, commercial and residential. The power quality problems are classify as below.

Voltage sag

Sag can be defined as the momentary decrease in RMS ac voltage (10%-90% of nominal voltage) at the power frequency of duration from 0.5 cycle to few seconds. Voltage sag is normally caused by a short-circuit fault such as single line to ground fault, L-L fault, double line to ground fault, three phase to ground fault and start-up of induction motor of large rating.

Voltage swell

Swell is defined as short duration increase in RMS voltage of supply having range from1.1 p.u to 1.8 p.u of nominal supply. The main reason for voltage swell is switching large capacitor or removal of large load [2]. Interruption If the supply voltage or load current decreases to less than 0.1 p.u for a period of time not more than one minute is known as interruption. Interruption can be caused either by system faults, equipment failures or control mal functions.

Spikes

Spikes are a sudden, short surge in voltage. Voltage spikes can be caused by short circuits, or power transitions in large equipment on the same power line

Solution on power quality problems There are two general approaches in the direction of mitigate power quality problems. One advance is to ensure that the process equipment is less sensitive to disturbances, allowing it to ride-through the turbulence [6]. The other approach is to install a custom power device to contain or counteract the turbulence. Many CUPS devices are commercially available in the

market today such as, active power filters

(APF), battery energy storage systems (BESS), distribution static synchronous compensators (DSTATCOM), sharing series capacitors (DSC), dynamic voltage restorer (DVR), power factor controller (PFC), surge arresters (SA), super conducting magnetic energy storage systems (SMES), static electronic tap changers (SETC), solid-state transfer switches (SSTS), solid-state circuit breaker (SSCB), static Var compensator (SVC), thyristor switched capacitors (TSC) and uninterruptible power supplies (UPS).

Focusing on the compensation of voltage dips the number of devices can be pointed down, and in three types of devices have been compared, they are: UPS: Uninterruptible Power Supply. This could be a static converter with double conversion to mitigate most type of power quality disturbances. DVR: Dynamic Voltage Restorer is a series-connected device, which corrects the voltage dip and restore the load voltage in case of a voltage dip. SSTS: Solid State Transfer Switch to change from a faulted feeder to a healthy feeder.

Configuration of DVR

The configuration of a DVR consists of:

1. Injection/Booster/Isolation transformer
2. Harmonic/Passive filter
3. Storage devices/Energy storage systems
4. Voltage source converter/inverter
5. Control and Protection system

Operation OF A DVR

It injects energetically controlled voltages in series with the bus voltage through the booster transformer. The amplitudes of the injected phase voltages are controlled so as to remove the harmful property of a bus fault to the load voltage.

The system impedance Zth depends on the fault level of the load bus. When the system voltage (Vth) drops, the DVR injects a series voltage VDVR through the injection transformer so that the most wanted load voltage magnitude VL can be maintained. The series injected voltage of the DVR is given by,

$$VDVR = V_L + ZthI_L - Vth$$

Concept of Compensation Techniques IN DVR

Voltage injection or compensation methods by means of a DVR depend upon the limiting factors such as DVR power ratings, various conditions of load, and different types of voltage sags. There are four

different methods of DVR voltage injection which are as follows:

1. Pre-sag compensation method
2. In-phase compensation method
3. Voltage tolerance method with minimum energy injection

1. Pre-sag compensation method

The pre-sag method track the supply voltage constantly and if it detects any trouble in supply voltage then it will inject the discrepancy voltage between the sag or voltage at PCC and pre-fault condition, the inject active power cannot be restricted and it is indomitable by external situation such as the sort of faults and load conditions.

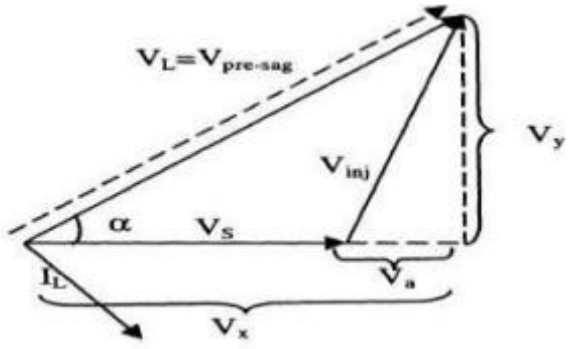


Figure: 1

2. In-phase compensation method

This is the directly forward method. In this method, the injected voltage is in phase with the supply side voltage irrespective of the load current and pre-fault voltage. The phase angles of the pre-sag and load voltage are dissimilar but the most important criteria for power quality that is the constant magnitude of load voltage are satisfied.

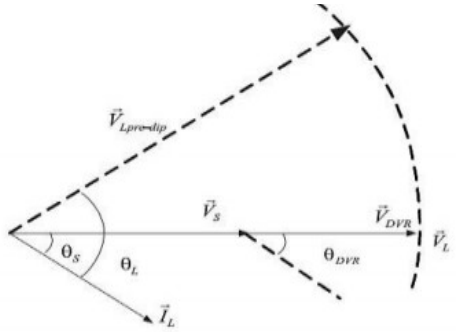


Figure: 2

3. Voltage tolerance method with minimum energy injection

A small drop in voltage and small jump in phase angle can be tolerated by the load itself. If the voltage magnitude lies between 90%-110% of nominal voltage and 5%-10% of nominal state that will not disturb the operation characteristics of loads. Both magnitude and phase are the control parameter for this method which can be achieved by small energy injection.

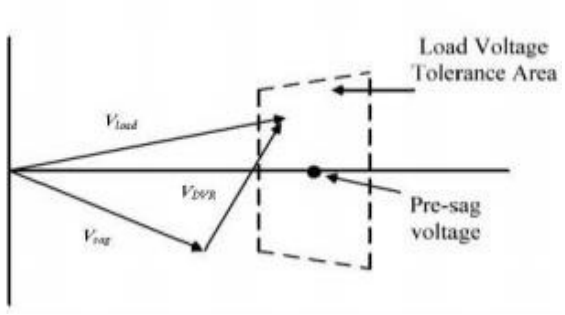


Figure: 3

3. REALIZATION OF COMPENSATION TECHNIQUE

Pi Controller Based Control Scheme

In order to mitigate the simulated voltage sags in the test system of each return technique, also to balance voltage sags in practical application, SPWM-based control scheme is implement, with reference to DVR.A proportional integral (PI) controller shown in figure 5.1 drives the plant to be controlled with a subjective sum of the error (difference between the actual sense output and preferred set-point and the essential of that value.

An advantage of a proportional plus integral controller is that its integral term cause the steady-state error to be zero for a step input. PI controller input is an actuating signal which is the difference among the Vref and Vin. Output of the controller block is of the form of an angle δ, which introduce additional phase-lag/lead in the three-phase voltages.

Fuzzy Logic Controller

In fuzzy logic, basic control is calculated by a set of linguistic rules which are determined by the system. Since numerical variables are converted into linguistic variables, mathematical modelling of the system is not required. The fuzzy logic control is being proposed for controlling the inverter action. The fuzzy logic controller has two real time inputs measured at every sample time, named error and error rate and one output named actuating signal for each phase.

The input signals are fuzzified and represented in fuzzy set notations as membership functions. The defined ‘If … Then …’ rules produce output (actuating) signal and these signals are defuzzified to analog control signals for comparing with a carrier signal to control SPWM inverter.

4. PARAMETERS OF DVR TEST SYSTEM

System comprise of 10 kV, 50 Hz generator, feeding transmission lines through a three-phase, three-winding transformer connected in /Y/Y, 11000/400/400V.

Table 4: System Parameters

SN	System quantity	Parameters used for the given model
1	Source	3 phase, 10kV rms (phase-phase),50Hz, 400 rms Voltage
2	Discrete 3-phase PLL	Sampling time 0.1
3	Linear Load	400V rms (phase-phase), 50 Hz,1000W,
4	Transformer	1000VA , 50Hz, 400 0V,0.002Ω 0.05 Ω

5. SIMULATION MODELS OF THE TEST SYSTEM

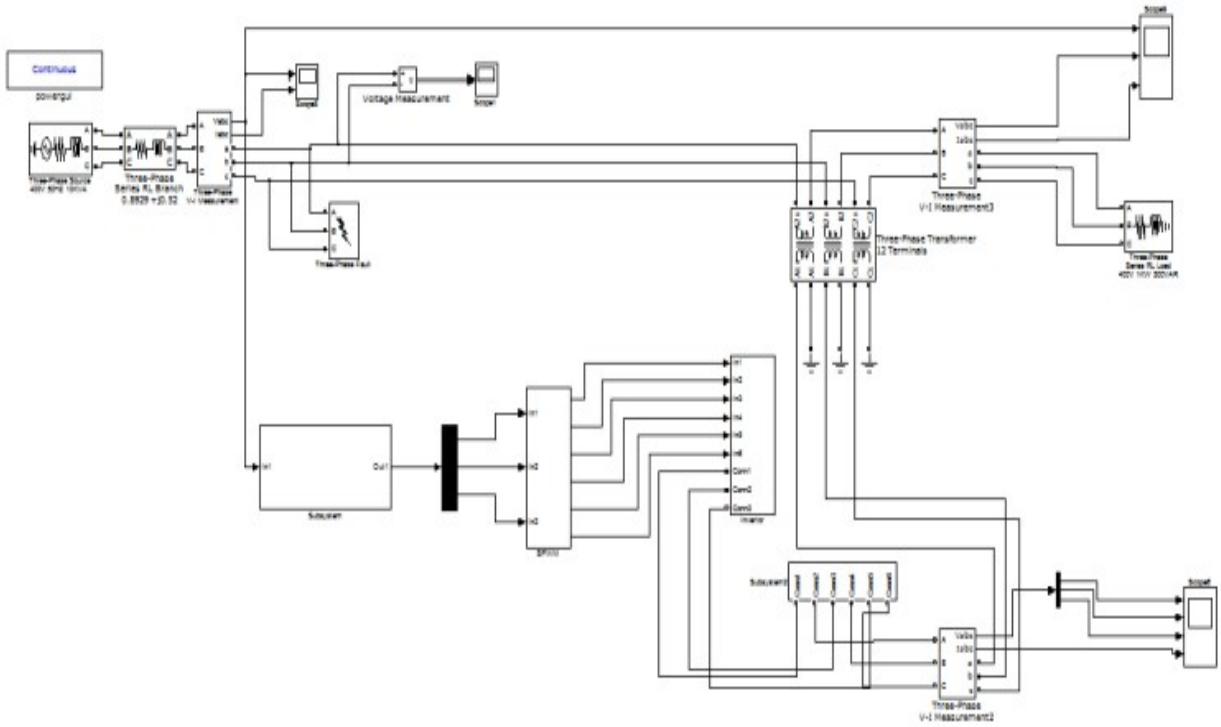


Fig. 5.1 PI controller simulink model of the test system

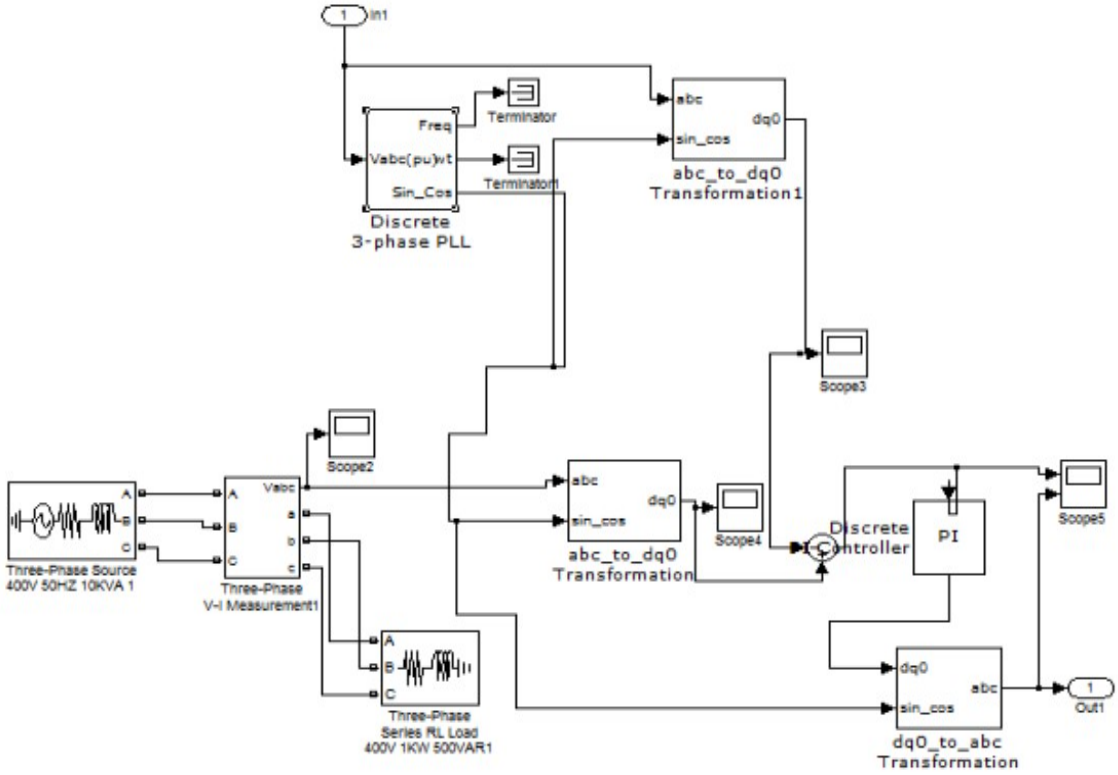


Fig 5.2 PI controller Simulink model of the test system

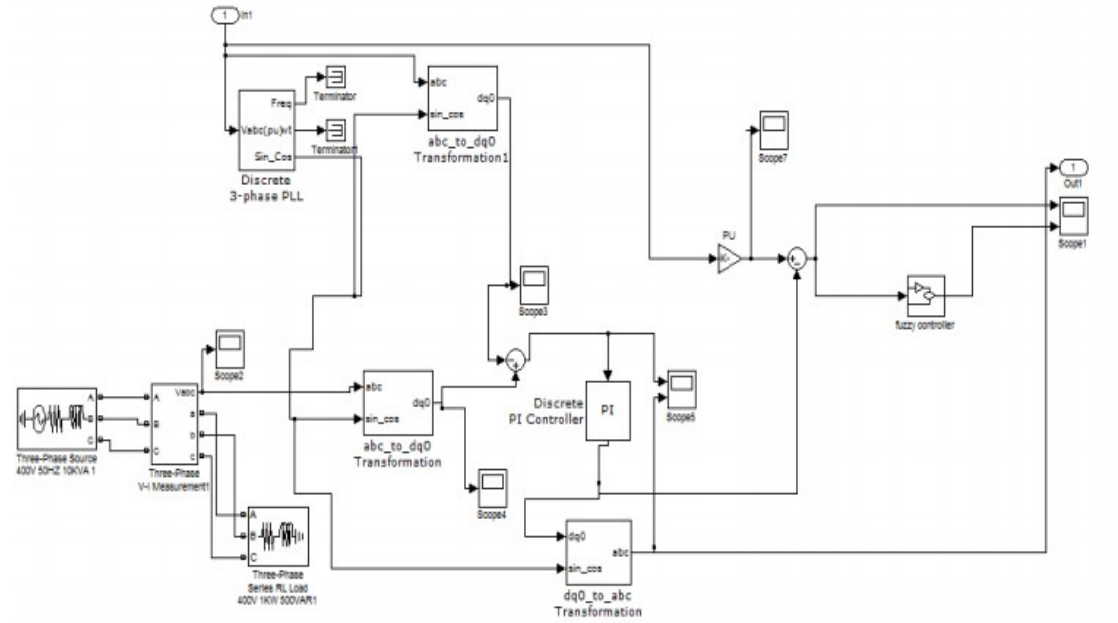


Fig 5.3 Fuzzy logic controller Simulink model of the test system

6. SIMULATION RESULTS AND ANALYSIS

By using MATLAB/SIMULING DVR gives the simulation results. The system performance is analysed for compensate the load voltage in distribution networks under fault condition.

PI Controller and fuzzy logic controller is used for the control purpose-

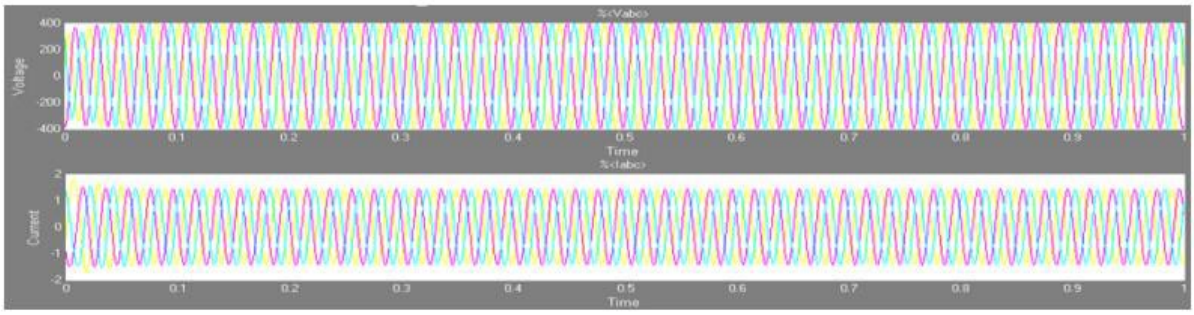


Fig 6.1 Simulation of PI controller without fault for Voltage and Current

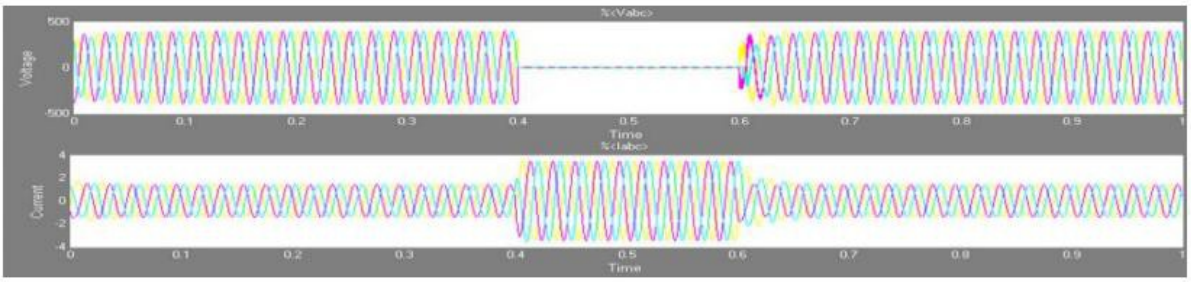


Fig 6.2 Simulation of PI controller with fault for Voltage and Current

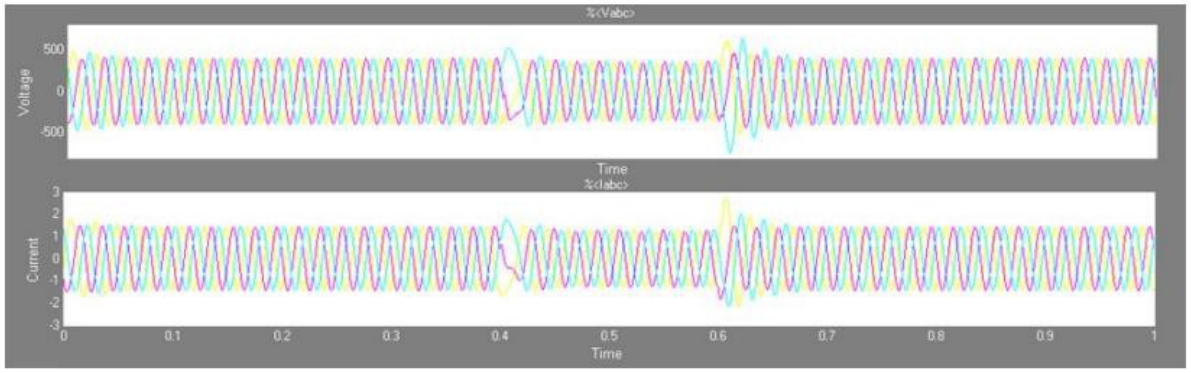


Fig 6.3 Simulation of PI Controller after Compensation for Voltage and Current

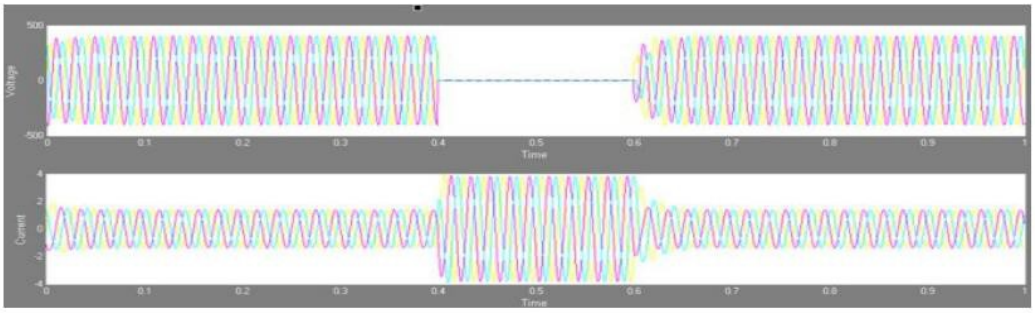


Fig 6.4 Simulation of fuzzy logic controller with fault for Voltage and Current

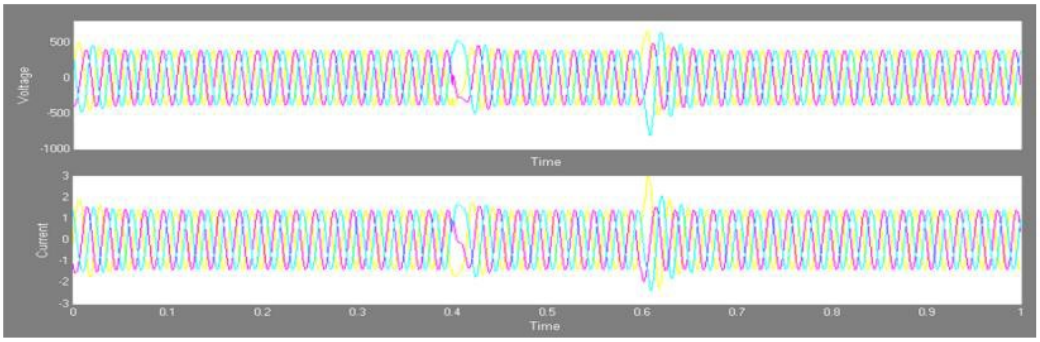
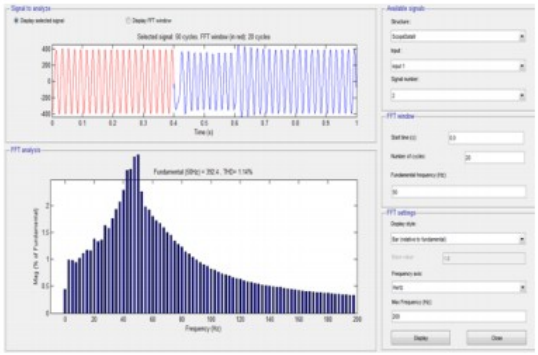
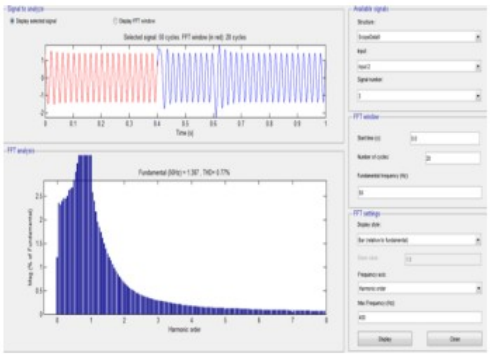


Fig 6.5 Simulation of fuzzy logic controller for Load after compensation for Voltage and Current





Total harmonic distortion	PI controller	Fuzzy Logic Controller
	1.14%	0.77%

Graph 6.1: THD levels of the test systems

7. COMPARISON OF THD LEVELS FOR PI AND FUZZY LOGIC CONTROLLER

The evaluation of THD levels under SLG fault condition with or without DVR is shown in graph 6.1. It is understandable from the THD examine that DVR effectively removes harmonics from load voltage and makes it level.

CONCLUSION

In this paper, the modelling and simulation of DVR controlled by PI and FL Controller has been determined by using Matlab/Simulink., the simulation effect show that the DVR compensate the sag rapidly (70μs) and provide brilliant voltage parameter for PI and FUZZY controller. DVR contain all types, balanced and unbalanced fault without any difficulties and injects the correct voltage issue to correct any fault state ensue in the supply. Both controller show an excellent performance and create low THD (<5%). However, FL Controller give better show with THD creates with only 0.77 %whilst PI generated 1.14% THD.

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