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REDUCE VOLTAGE SAG IN DISTRIBUTION SYSTEM USING FUZZY LOGIC CONTROLLER BASED DYNAMIC VOLTAGE RESTORER (DVR)

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Abstract: Power quality is extensive term to describe the effectiveness and its performances. The main task of power system is to supply their customer a continuity power supply at ever, because of the whole power system is the big network which includes different types of loads, at the instant of common compiling sensitive loads connected in which voltage distortion in supply side or load side is highly repellent. Voltage dip is the most frequent arising power quality issues mainly occurs in distribution system due to faults, connecting nonlinear loads, since it's a main disturbance for domestic and industrial equipment. In this paper to diminish the voltage drop, fuzzy logic controller based dynamic voltage restorer is used in three phase parallel distribution system. Fuzzy logic controller is used manage the DVR output. The performance evolution and result is simuted using MATLAB/SIMULINK. Fuzzy control rule is optimizing using Gaussian membership function by apply if then rule.
Keywords: power quality, voltage sag, fuzzy logic, DVR, park transformation

1. INTRODUCTION

Modern society goes to progress area and they interest not only the supply of power, but also the consistent and good quality of power supply because of human being heavily depended on the electricity hence reliability of system and quality of power this two is the most essential phrase of any power system, we know that group of the entire electric network modules in power system is related to generate the energy and this valuable energy transmit, distribute and utilize by different consumers according to their obligation and at the equivalent instance the excellence and continuity of the electric power is also really significant for the efficient performance of the end user equipment. To make developed nation, recent year India move towards the make inquiries area for the development to lead the research.

The power quality is essential due to newer age group load apparatus, microprocessor based manage and continues growth of adjustable speed drives and switched mode power provisions, shunt capacitors for a power factor correction outcome rising harmonics, electrical disturbance in power system [1].Power quality is a set of electrical restrictions that allow a part of apparatus to function in its proposed manner without the hammering of existences. Power quality problems include variety of trouble in the vein of voltage sag, swell, outage, voltage unbalances, flickers, harmonics, etc. out of this due to some faults voltage sag/swell frequently occurring power problems. In this paper fuzzy logic controller based DVR is used to mitigate the voltage sag in distribution system. Fuzzy logic controller is used to control the output of the DVR, and output of this is applied to generate gate pulse for voltage source inverter.

2. BASIC STRUCTURE AND OPERATING PRINCIPLE OF DVR

Power scheme voltage sag is frequently occurring power problem which is an unexpected drop in the RMS voltage for a short period, the duration of the voltage sag is less than 1 minute but supplementary than an 8 ms and the fall of voltage assessment become 10% to 90% of the nominal voltage. To enhance power supply by reducing voltage sag is analysis by using a DVR.

The power electronic based compensation that protects sensitive load from all type source side disturbances other than outage is known as dynamic voltage restorer [2]. DVR have the capability to generating and absorbing changeable convenient active and reactive power at its ac output. The basic formation of a DVR is given in Figure 1. It contains the following components-

- DC Storage unit: The DC Source or energy storage device is principally set in the DVR to provide the necessary power to the VSI throughout dc link for the generation of essential correcting voltages.
- Voltage source inverter (VSI): In the DVR system, the foremost purpose of VSI is the creation of that quantity of voltage, which is necessary to keep invariable load voltage.
- Series transformer: A series transformer is used to unite the DVR with the distribution feeder. In crate of three phase scheme, an arrangement of three single phase transformers is used to connect the DVR with the power net.
- Filter circuit: Low pass passive filters are used to exchange the PWM reversed non-sinusoidal pulse waveform into a sinusoidal waveform.

The major purpose of the DVR is injecting the voltage of the required magnitude and frequency as preferred by means of the power system net. For the duration of the normal action, the DVR will be there in support mode. During the trouble in the system, the insignificant or rated voltage is compared by means of the voltage deviation and the DVR injects the divergence voltage that is essential by the load [3]. The voltage injected via DVR is articulated as:

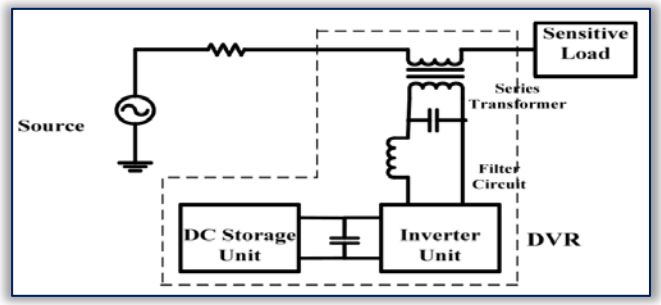

Figure 1. Basic structure of DVR

$$V_{inj} = V_{load} + Z_{load} I_{load} - V_s \qquad (1)$$

where: V_{inj} = required injected voltage, V_{load} = desired load voltage, Z_{load} = load impedance, I_{load} = load current, V_s = source voltage.

To control the dynamic voltage restorer Synchronous reference frame theory based on battery supported (BESS) is applied to execute the control method planned. The Feed-forward control performance utilizing dq0-transformation or generally called Park's Transformation is implemented at this time for DVR controller. An essential segment of the control lane of the DVR is the sag detection circuit. Voltage sag has to be detected very quick and corrected competently with the purpose of is, with smallest amount of error. To start with the considered phase voltage is converting from abc reference frame to dq0-reference frame. From the time when the system and disturbance deal is balanced, the zero-sequence component becomes zero, so, be ignored. The voltage sag is detected by comparing a situate of reference voltage in dq0 frame with deliberate RMS phase-voltages. The relation for recognition of sag is given by

$$V_{error,dq0} > V_{thresold} \qquad (2)$$

In Electrical Engineering, Park's transformation (or dq0 transformation) is an arithmetical conversion method used to make simpler the analysis of three-phase circuits. The equations describing the transformation from abc to dq0 reference frame useful to three-phase voltage, shown below.

$$\begin{bmatrix} V_d \\ V_q \\ V_0 \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \sin \omega t & \sin\left(\omega t - \frac{2\pi}{3}\right) & \sin\left(\omega t + \frac{2\pi}{3}\right) \\ \cos \omega t & \cos\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_C \end{bmatrix} \qquad (3)$$

The DVR voltage as the fame of 'abc' is obtain by using reverse park transformation

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} \sin \omega t & \cos \omega t & 1 \\ \sin(\omega t - 2\pi/3) & \cos(\omega t - 2\pi/3) & 1 \\ \sin(\omega t + 2\pi/3) & \cos(\omega t + 2\pi/3) & 1 \end{bmatrix} \begin{bmatrix} V_d \\ V_q \\ V_0 \end{bmatrix} \qquad (4)$$

The transformation is regularly used to make simpler the examination of three phase piece of equipment or to formulate simpler calculations measured for the control-operation of three-phase inverter.

3. DESIGN OF FUZZY LOGIC CONTROLLER FOR DVR

Fuzzy scheme is the rule based system based on the fuzzy interference; fuzzy rule represents awareness that is subjective. Fuzzy system is distinct by three section i.e.

- Fuzzy input and output variable.
- Fuzzy rule.
- Fuzzy inference mechanism.

Fuzzy inference takes inputs, applied fuzzy rule and turn out output, the degree of membership function is define through a characteristics function called membership function, the characteristics function represents

- ≡ $\mu A(u) = 1$, if u is an element of the set A
- ≡ $\mu A(u) = 0$, IF u is not a function a set of element A,

where 'A' is fuzzy subset of 'u'

Fuzzy logic controller use very flexible set of IF-THEN rules and the solution is applied to the membership function; in the paper consider the Sugeno type fuzzy controller also called Takagi-Sugeno fuzzy system. In Sugeno type system multiple input and single output function is work used for the nonlinear system for appropriates results, working of fuzzy controller is shown in figure 2.

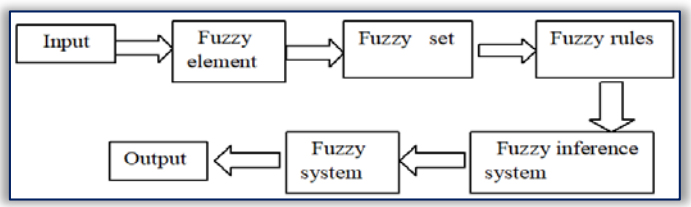

Figure 2. Fuzzy control system working

We can take intermediate values like small, medium and large, error and change in error is consider as two input and one output is produce, seven membership function is consider for each input and output, in Sugeno type interference system create the square time of the rule according to their membership function shown below Table 1, where: er = error, cer = change in error, ln = large negative, lp = large positive, mn = medium negative, mp = medium positive, sn = small negative, sp = small positive, z = zero

The rules are written as

— If (error is ln) and (cerror is ln) then (output is ln).
— If (error is ln) and (cerror is mn) then (output is ln).
— If (error is ln) and (cerror is sn) then (output is ln).

Fuzzy logic controller is used to in this control model in order to reduce the error zero as fast as possible, fuzzy logic designer is shown in figure for membership function for two inputs and one output shown in figure (3), (4), (5) and Surface view of inputs and output is shown in figure 6.

Table 1. FL Controller Rules

er / cer	ln	mn	sn	z	sp	mp	lp
ln	ln	ln	ln	ln	mn	sn	z
mn	ln	ln	ln	mn	sn	z	sp
sn	ln	ln	mn	sn	z	sp	mp
z	ln	mn	sn	z	sp	mp	lp
sp	mn	sn	z	sp	mp	lp	lp
mp	sn	z	sp	mp	lp	lp	lp
lp	z	sp	mp	lp	lp	lp	lp

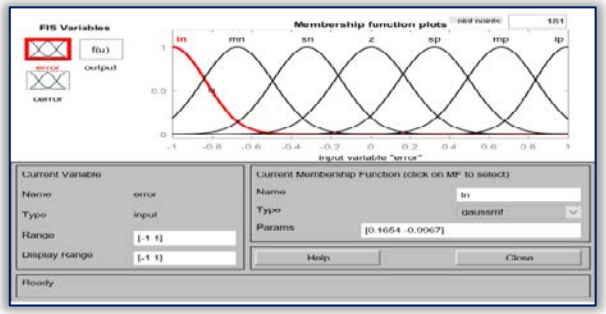

Figure 3. Membership function plots for input variable "error"

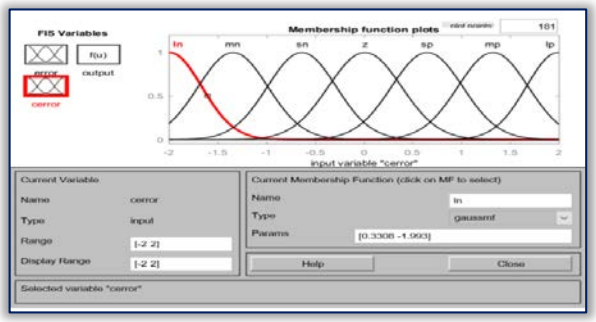

Figure 4. Membership function plots for input variable "error"

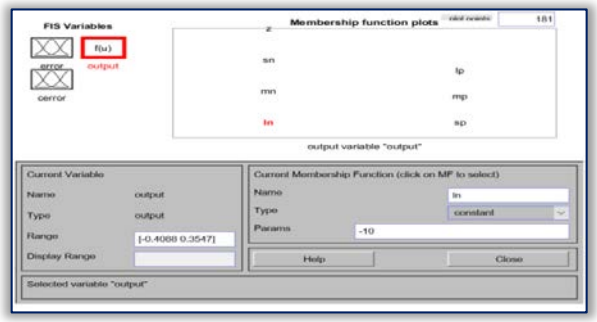

Figure 5. Membership function plots for output variable

4. SIMULATION DESIGN AND MODELING OF DVR:

In order to analysis of voltage sag two parallel distribution feeder is consider as test system and feeder-1 creates a different time of fault then see that at the fault duration voltage sag is automatically created in feeder-2. The system is implemented in MATLAB Simulink as shown in figure 6, to learn the analysis of voltage sag and act of DVR, also its control strategy to improve the power quality problem.

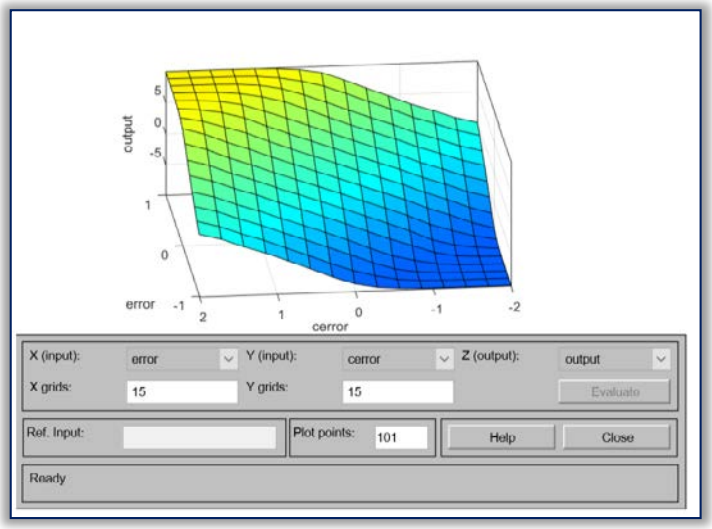

Figure 6. Surface view of inputs and output function

To diminish the voltage sag an error signal is obtain by comparing a reference signal to supply voltage measured at the load side. The error signals is then proceed to fuzzy logic control where error signal is evaluate with change in error signal by applying a fuzzy rule and obtained an output signal shown in figure 7, this output signal is converts to abc frame signal and feed to the PWM generator. This signal is get to IGBT voltage source inverter. Voltage required for the compensation is obtain by output of VSI, which is then feed to injected transformer primary winding shown in figure 8.

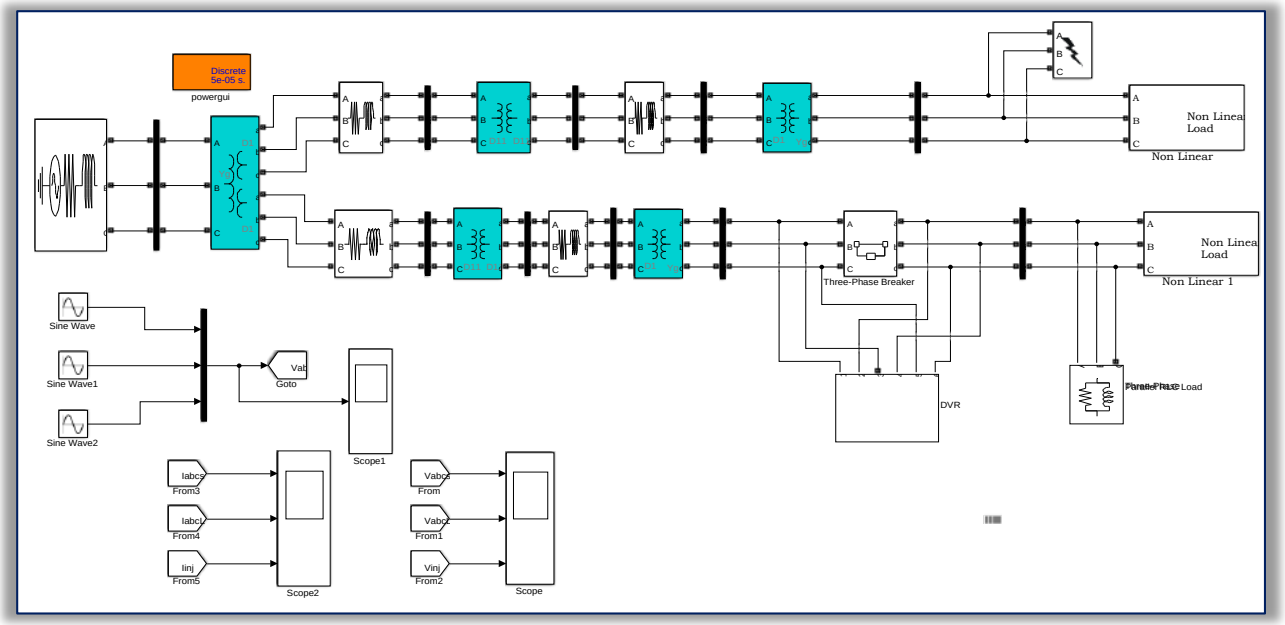

Figure 7. Simulation model of test system.

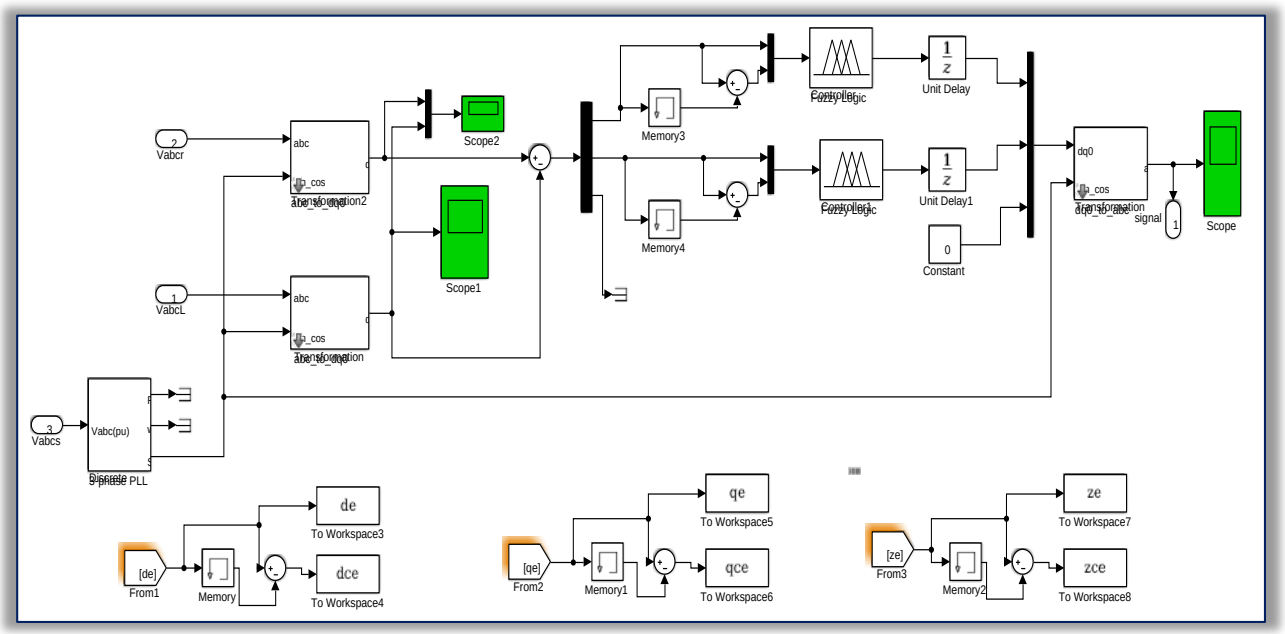

Figure 8. Model of reference frame theory control method of DVR

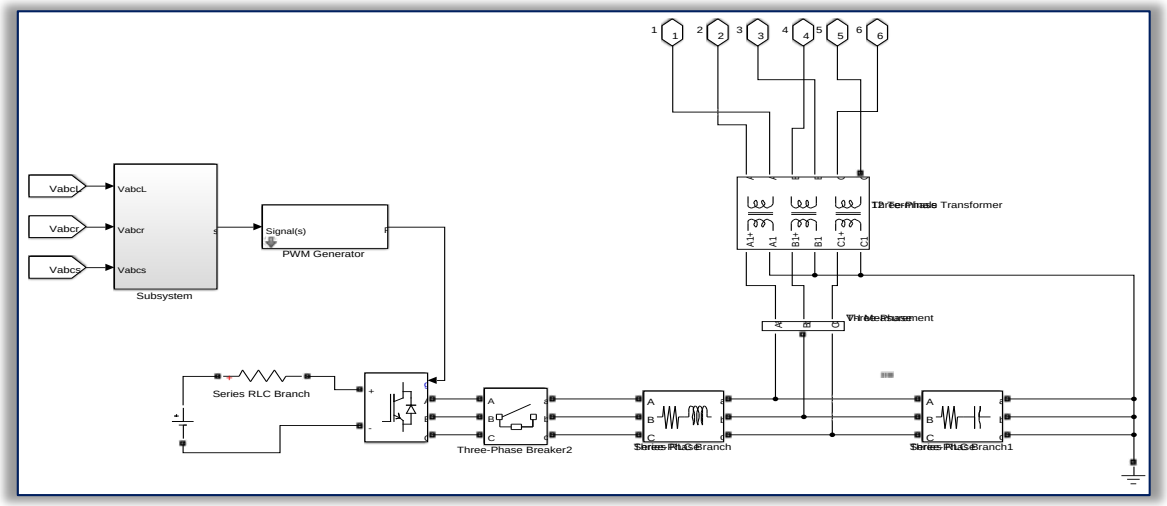

Figure 9. DVR Connection Model

5. SIMULINK RESULT

The different type of fault is creating in feeder-1 to analyze the sag at the duration of 0.4 sec to 0.6 sec with fault resistance of 0.001Ω and ground resistance 0.001Ω, at the same time symmetrical and unsymmetrical voltage sag is occurred in second feeder. Using DVR this drop is compensated; figure (10, 11,12) shows SLG, LLG, and three phase to ground faults occurs then sag in feeder-2 is cleared shows source voltage, load voltage and injected voltage waveform, by injecting the voltage the load side voltage sag is clear, also ABC to dq0 reference signal is shown in figure 13 and also the FFT analysis is shown in figure 14 here the voltage harmonics is 0.61% which is in the range and very small.

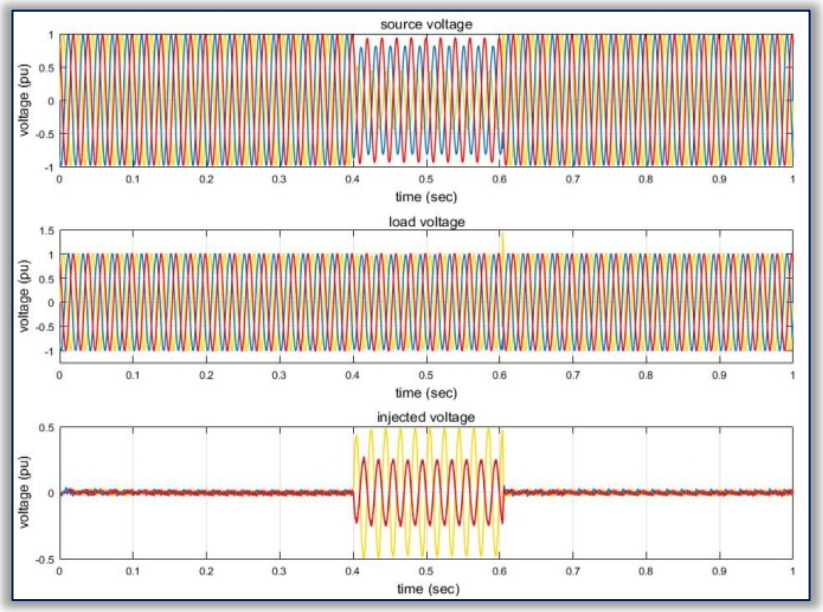

Figure 10. When single line to ground fault then sag cleared

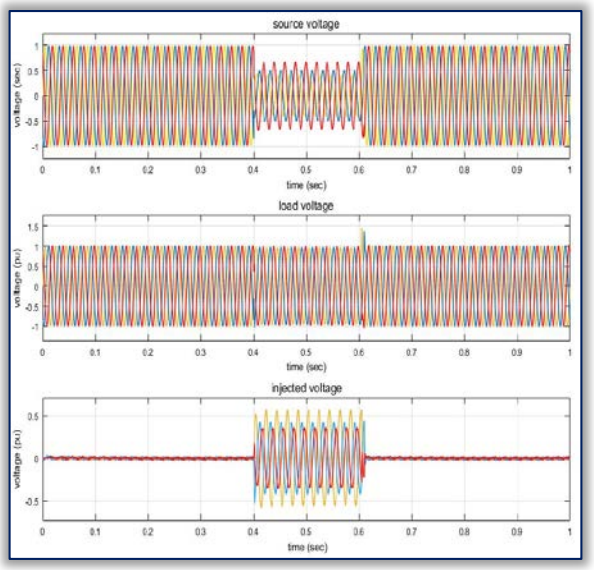

Figure 11. When double line to ground fault then sag cleared

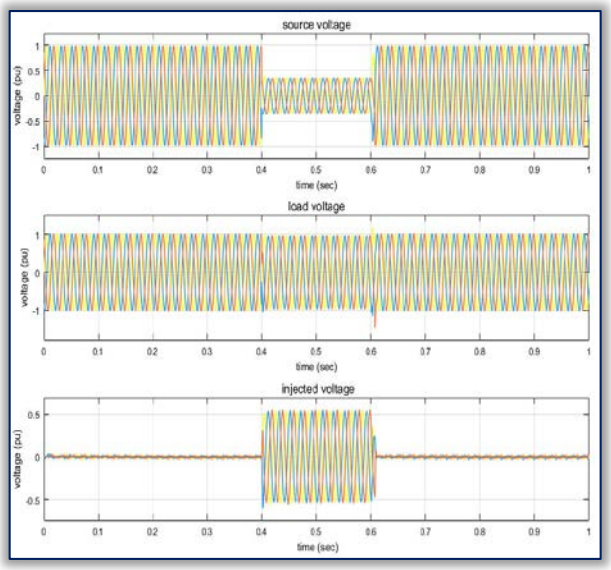

Figure 12. three phase to ground fault then sag cleared

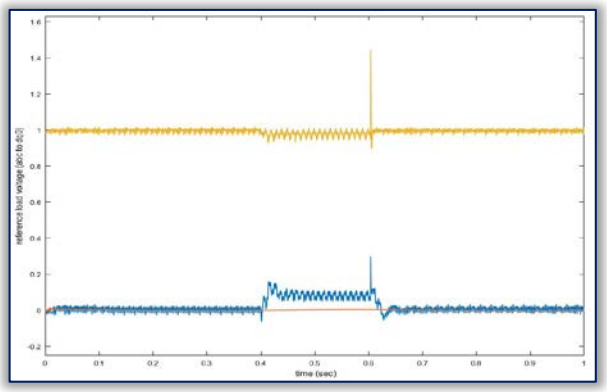

Figure 13. Reference load voltage (abc to dq0 transformation)

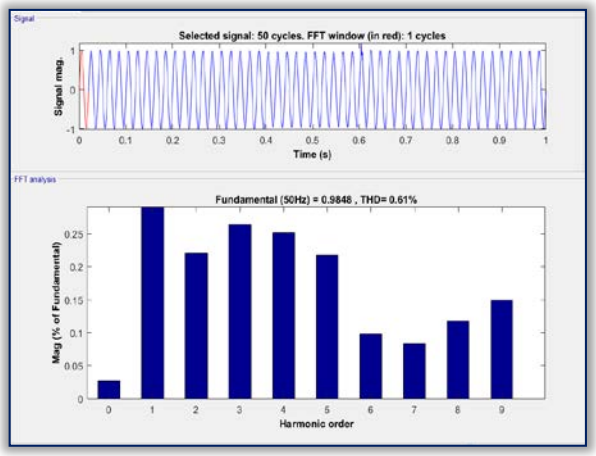

Figure 14. FFT analysis

6. CONCLUSIONS

This paper present performance of voltage sag reduction by using a fuzzy logic controller based dynamic voltage restorer. Voltage sag is frequently occurring power problem due to faults occurring in system, which affect the performance of the system. Fuzzy logic organizer is use in this; the main aim of controller required is error should become zero at fast as possible.

Table 2. Parameter required for the system

SN.	System parameter	Values
1.	Source voltage	440V
2.	System frequency	50 Hz
3.	Injected transform ratio	1:2
4.	Dc voltage	600V
5.	Linear load	1000W
6.	Nonlinear load	R= 60ohm, L= 0.15mh
7.	PWM carrier frequency	1350 Hz

Fuzzy logic is used for the reason that of they have following benefit:

- Time of tuning is less.
- Response time is fast.
- It's a rule based design, arithmetical equation not necessary.

The simulation results showed that the load voltage was compensated using the dynamic voltage restorer, also the voltage harmonic is reduce i.e. 0.61% which is very less. This entire attempt is done by via MATLAB/ SIMULINK program.

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