# Performance of Powersystem to Enhance Power Quality using Fuzzy Logic Controller Based DVR

**Nakka.Mahesh Babu, Md.Aijaz**

*Abstract-This paper accord the Power Quality interpretation to make apparent for electricity consumers been made better power quality with application of DVR.Despite of advantages of DVR, it focuses full extent of the relatedness surrounded by loads, various power networks. DVR is most accepted power device which could be used for better solution for the disturbances of voltages in distribution systems for sensitive loads. For efficiency considerations, the DVR mostly hinge on an act of presenting the control modus, and can be harnessed to switching the inverters. Reliability of hysteresis voltage control with ease in operation under variable switching frequency can be trustworthy for a DVR can introduced and the proposed methods achieves good compensation of voltages under disturbances and can be seen by the simulation by using fuzzy logic controller.*

*Keywords:DVR, FLC , Hysteresis voltage controller, PI controller, phase modulation*

## I.INTRODUCTION

A DVR is proposed to compensate voltage levels. Important design guide lines viz. control delay and filter cutoff frequency are also proposed for the controller of a DVR[1].Controlling of harmonic voltage distortions to acceptable level is a primary role of the filter. DVR performance can be affected by the filter design considerations. DVR inverter rating can be influenced by the establishment of the filter parameter selection. These considerations are very important for a systematic design [3].In circulation DC tie-up capacitor perhaps utilized for voltage smoothening and not for energy storage. Three phase recompense voltages are superimposed by the zero sequence components as per controlling mechanism. Gating signals to the switches of DVR described by inner loop.DVR inverter output based on harmonic spectrum can be designed for filter capacitor for the guaranty of DVR load voltage THD with in prescribed limit with Filter capacitor effect analyzed. fix up of the filter plan, at workability side and burden side, the DVR not only recompense the voltage troubles likewise ensures the power status of the supply which is described in a novel methodology for the construction of DVR.A DVR based on voltage space vector PWM algorithm. A battery charging controlling technique also applied for DVR.A four leg VSC based DVR closed loop controlling, implementing controller functions from digital controller based on Digital Signal Processor (DSP).

A program was developed to resolve three phase variables in to sequence components. For the controlling of DVR, two techniques from SVM **.** They compared between conventional multi level SVM steemed with number of levels and the proposed SVM. The proposed SVM helps in reduction of inverter switching losses and harmonic performance. The dynamic voltage restorer having ability to store additional energy. It has been observed that the sharp variations can be observed in a system. With random improvements in technology, the modern industries utilizing devices of power electronics based devices, PLC (programmable logic controllers) and availability of renewable energy sources. under fault conditions and for improvement obstacle of of power like voltage slumps, bulges and variations of harmonics electronic devices has a tendency to act responsibly and fast acting in operation also they are accurate in getting results. Short of voltages also known as voltage sags are the sudden drops of rms voltages are observed as most undesirable effect to the industrial components DVR's are the class of widely used power devices for providing compatible improvement in power of the distribution systems.DVR uses voltage boost concepts with the use of solid state switches for compensation of raise or fall of rms voltages .The DVR is applicable mostly for loads where sensitive variation is possible that may Cause considerable damage to the systems voltage and equipments. Among the issues 0bstacles of power like slumps, bulges, harmonics etc…, voltage slumps are the severe disturbances .In distribution systems DVR is the most promising device in power electronic devices for its efficient operation.DVR is placed at the location where critical load feeder and utility at common coupling point.

Fuzzy logic controller with PI controller introduced for the modeling of DVR to enhance the systems performance. The above model's main objective is to improve quality of power during different types of faults like 3-phase fault, single L-G fault and double Line fault points.
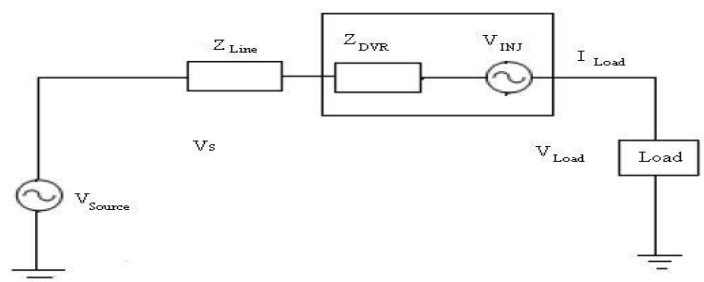


**Figure 3. CONFIGURATION OF DVR.**

From the circuit shown in fig.3. The series inoculate voltage of the DVR can be written as

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$$V_{Dvr}=V_L+Z_{th}-V_{Th}$$
(1)

Where

| $V_L$ | Load voltage |
|-------|--------------|
| $Z_{th}$ | Thevinin impedance |
| $I_L$ | Load current |
| $V_{TH}$ | Thevinin voltage |

Load current is given by

$$I_L= \frac{[P_L+JQ_L]}{V_L}$$
(2)

When $V_L$ is reference equation and can be rewritten as,
$$V_{dvr}\angle\alpha=V_L\angle 0+Z_{th}\angle(\beta-\theta)-V_{th}\angle\delta$$
(3)

The injected DVR complex power can be written as,
$$S_{Dvr}=V_{Dvr}I_L^{*}$$
(4)

## II. CONTROL STRATEGIES WITH PI CONTROLLER

The do ones utmost of the predominance tack is to preserve invariable voltage immensity on the knife edge where a quick to detect load is bridged, beneath the system troubles. The controlling of system only assess the $V_{rms}$ at the work station of load, and not required any reactive power requirements. The changes of (VSC) voltage source converter outlook root on a SPWM execution, which put forward to intelligibility and accurate reaction. Subsequently conventional power is a equivalently low-potential approach, PWM method, offers a more pliable substitution than the FFS methods. The PI controller with set voltage and terminal voltage shown in fig. The importance of the PI controller is to maintain the switching movement to the required value.

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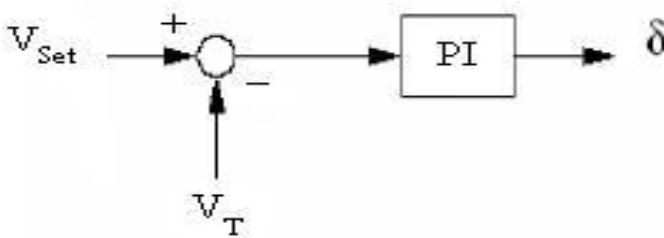


**Figure 4. PI Controller**

The hysteresis voltage controller invariably used to appropriate signals by comparing the set voltage and reference voltage of DVR. When the dissimilarity between the instant and inverter voltage extend to the higher/ under limit, the voltage is weighs to narrows or enlarge as shown in Figure 5.
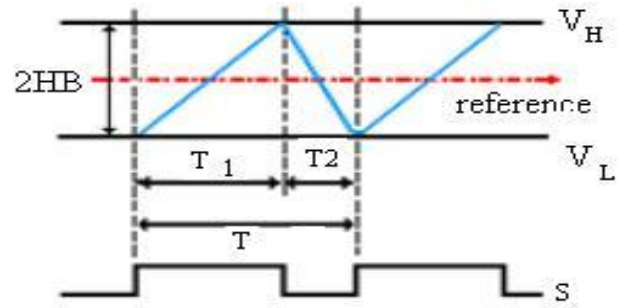


**Figure 5.Hysterisis Band Voltage Control**

## III. FUZZY LOGIC CONTROLLER

FLC provides two real inputs which are named as error and error rate and the actuating signals developed at the output.
$$E_{rrA}=V_{pllA} - V_{sA}$$
(5)
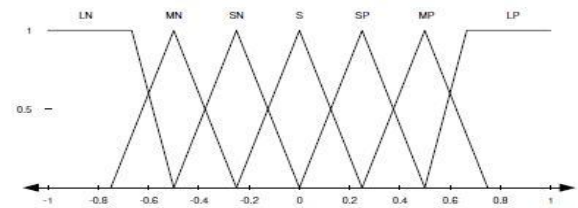$$\Delta ErrA=ErrA(n)-ErrA(n-1)$$
(6)



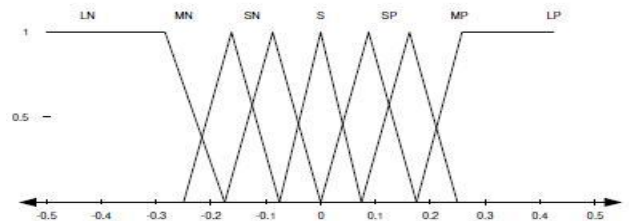**Figure 6.Input variable "Error" membership function**
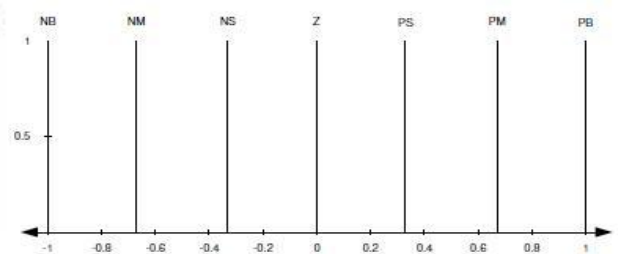


**Figure 7. "Error rate"membership function**



**Figure 8. Output membership.**

The insert space is portray to the membership ranging values from 0 and 1which are wavy that show how every point of input varies between 0 and 1.for the other phases these membership functions are identical.

Fig.6 and fig.7 notifies the inputs with membership functions. Similarly fig.8 shows membership function for output variable.

**Table 1.fuzzy logic control rule view**

| | | Error Rate | | | | | |
|---|---|---|---|---|---|---|---|
| | | LP | MP | SP | S | SN | MN | LN |
| Error | LP | PB | PB | PB | PM | PM | PS | Z |
| | MP | PB | PB | PM | PM | PS | Z | NS |
| | SP | PB | PM | PM | PS | Z | NS | NM |
| | S | PM | PM | PS | Z | NS | NM | NM |
| | SN | PM | PS | Z | NS | NM | NM | NB |
| | MN | PS | Z | NS | NM | NM | NB | NB |
| | LN | Z | NS | NM | NM | NB | NB | NB |

These 49 rules will represents the controlling action and the operating condition can be expressed by each rule. The person's experience and system know behavior helps to define the rules. All rules are evaluated in parallel and the order of the rules is not important. The rule view for FLC is shown in Table1.The outputs of FLC process are the control signals that are used in generation of PWM inverter converting signals by comparing a carrier signal. The generation of converting signals for single phase of the system, where the configuration will be the same for other phases.

## IV.DVR WITH PI AND FLC SIMULATION RESULTS

Main system simulation model without DVR has been created in Mat lab, Simulink shown in fig.9
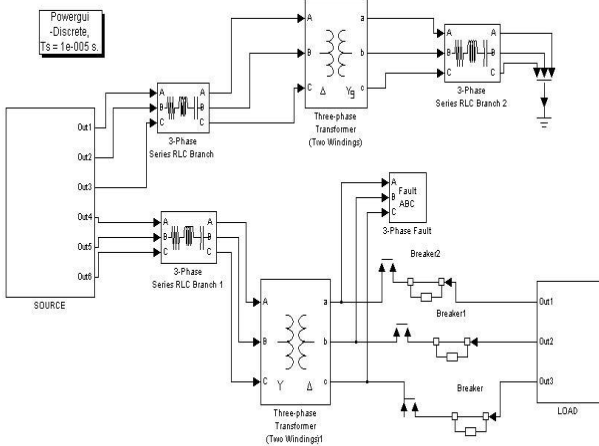


**Figure 9.Main Systems without DVR**

Fig.10 and fig.11 shows DVR with PI &FLC. Alike system is composed by a generation system of 13 kv 50 HZ, supplying two transmission lines through a Y/Δ/Δ 3-winding transformer coupled with 13/115/1 lines feeding two distribution networks through Δ/Y coupled two transformers of 15/11 kV.
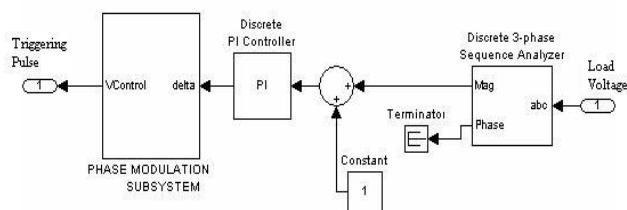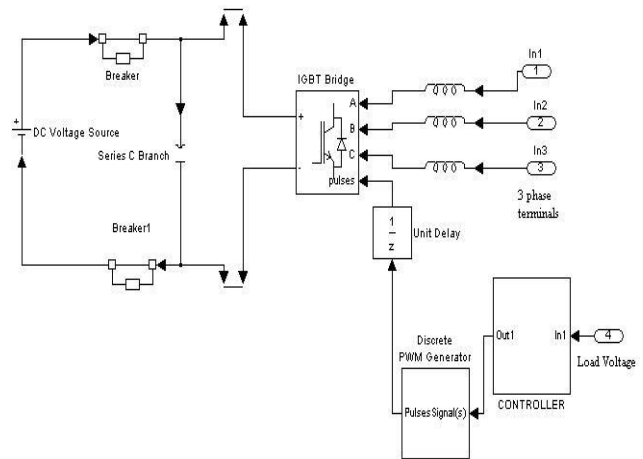


**Figure 10.PI Controller subsystems**

The following test system with no DVR during faults like 3-ph fault, L-G fault and double line fault is analyzed.
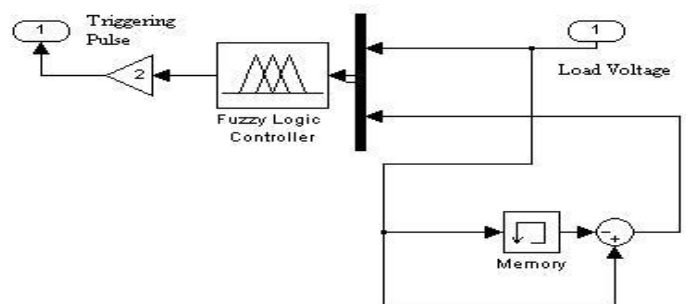
Observed load voltage problems like sag, swell and interruption. Then to overcome these problems DVR is connected for the test system. PI Controller with parameters KP = 0.5, Ki = 50 & sample time 50μsec and FLC for the enhancement of the performance and THD improvement is observed.
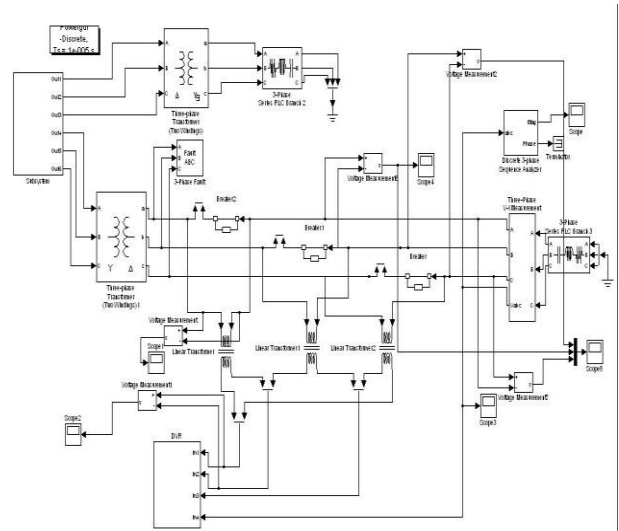


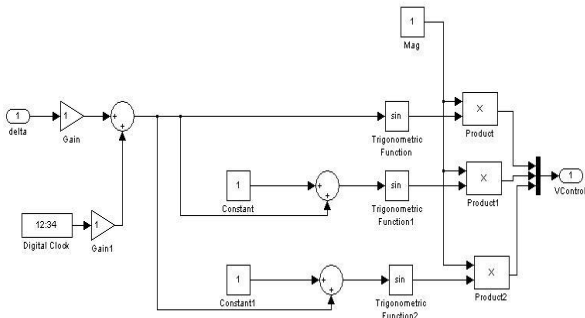**Figure 11. DVR with Fuzzy Logic Controller**



**Figure 12.DVR subsystem**



**Figure 13.Fuzzy Logic Controller subsystems**

# Performance of Powersystem to Enhance Power Quality using Fuzzy Logic Controller Based DVR



## V. SIMULATION RESULTS FOR SAG VOLTAGE DURING SINGLE L-G FAULT

The test system fig.V.a shows RMS voltage without DVR. In fig.V.b, DVR with PI Controller & DVR with FLC are in operation. The simulation period of total 1400 ms.
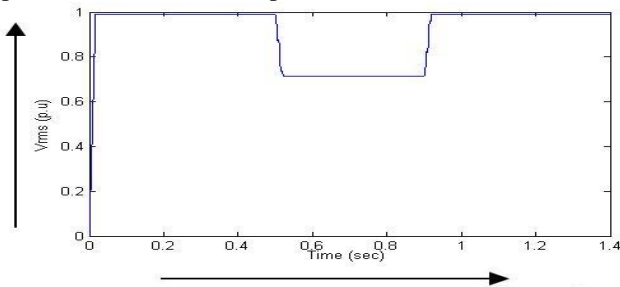


**Figure (V. a)Voltage $V_{RMS}$ of load without DVR**
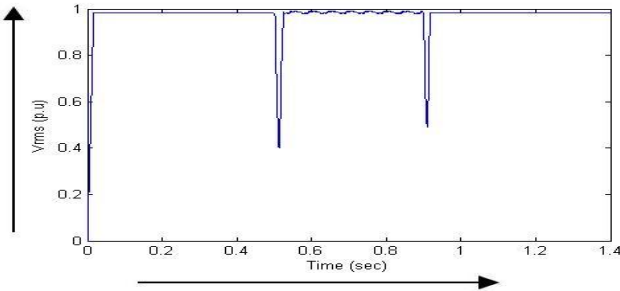
The RMS voltage is 98%, shown in Figure V. b.



**Figure (V .b) VRMS at the load with 6.5KV Energy Storage**

The DVR response is smooth, stable and rapid to mitigate sag under single L-G fault. Figure V.b, Figure V.c, Figure V. d. and Figure V.e. Shows DC energy storage of 6.5KV, 6KV, 4KV and 8KV respectively.
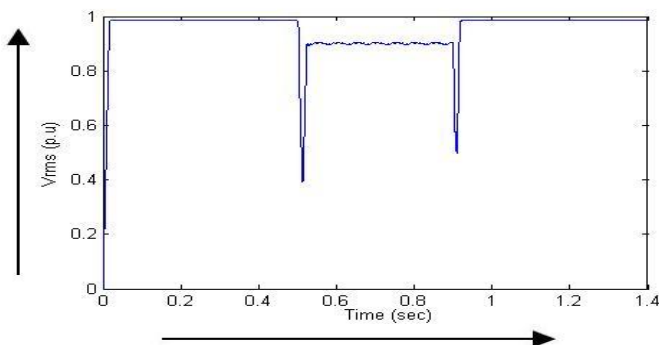


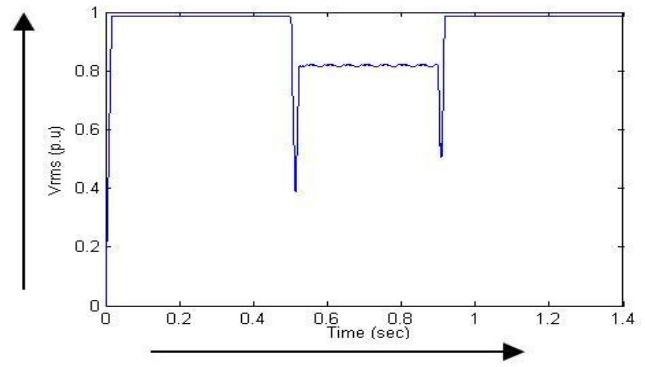**Figure (V. c)$V_{RMS}$ of load with 6KV Energy Storage**



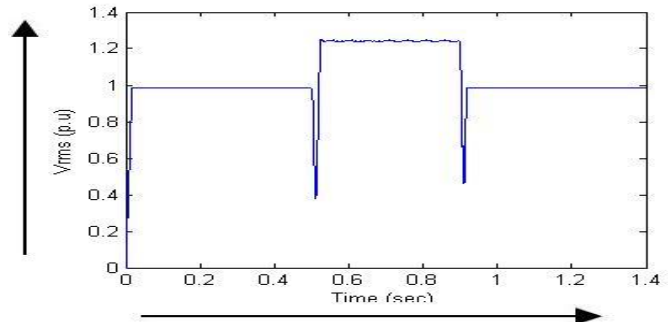**Figure (V. d) $V_{RMS}$ of load with 4KV Energy Storage**



**Figure (V. e) $V_{RMS}$ of load with 8KV Energy Storage**

## VI. SIMULATION RESULT OF SAG VOLTAGE DURING

### L-L FAULT

The test system in fig.a shows RMS voltage without DVR
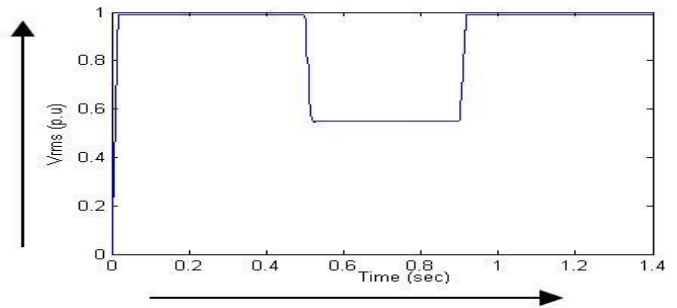


**Figure VI.(a)$V_{RMS}$ of load without DVR**

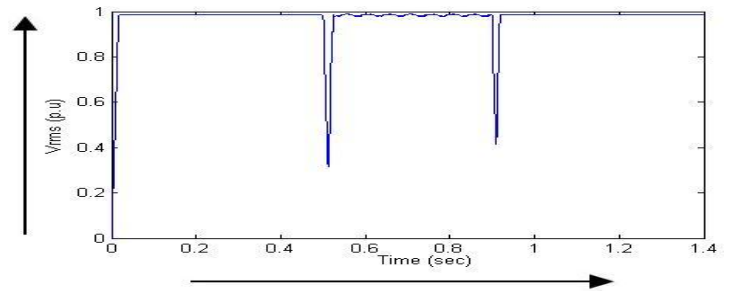The RMS voltage is 98%, as shown in Figure VI. b.



**Figure VI. (b)$V_{RMS}$ of load with DVR Energy Storage of 6.68KV**

Figure VI. b, Figure VI. c, Figure VI. d and Figure VI. e, shows the potentiality of DVR depending upon capacity of 6.68KV, 6.2KV, 5.6KV and 8KV respectively.
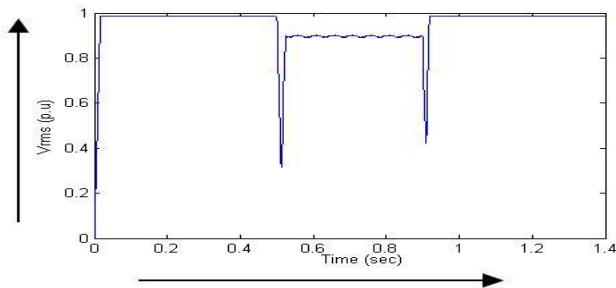


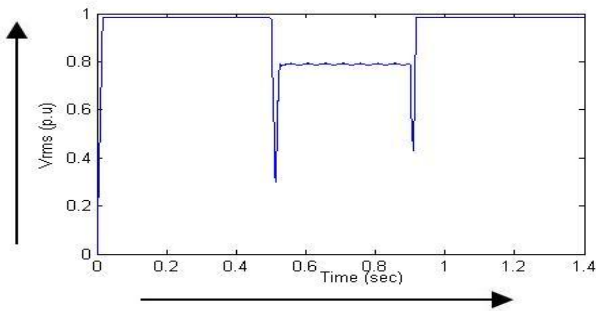**Figure VI. (c) V$_{RMS}$ of load with 6.2KV Energy Storage**



**Figure VI. (d).V$_{RMS}$ of load with 5.6KV Energy Storage**
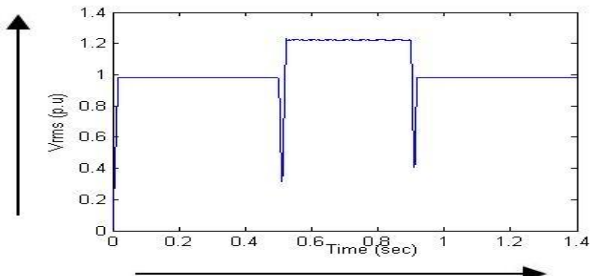


**Fig VI. (e)Voltage V$_{RMS}$ of load with 8KV Energy Storage**

**VII.VOLTAGE INTERRUPTION DURING THREE-PHASE FAULT SIMULATION RESULTS**

The test system in fig.VII.a. shows RMS voltage without DVR.
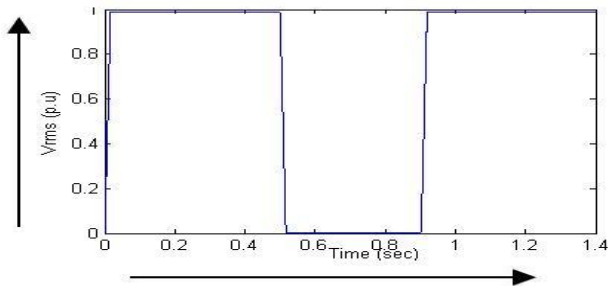


**Figure VII. (a)V$_{RMS}$ at the load without DVR**

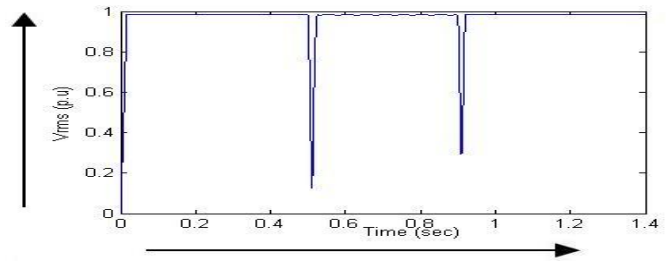The RMS voltage is 98%, as shown in Figure VII.b.



**Figure VII. (b)V$_{RMS}$ of load with DVR Energy Storage of 4.9KV**

Figure VII. b. and Figure VII. c. are the compensating capability of DVR rely on the ability of the DC Energy Storage.
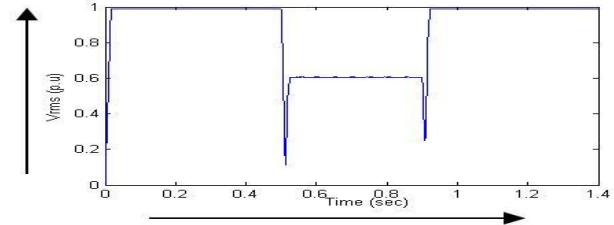


**Figure VII.(c) V$_{RMS}$ of load with 3KV Energy Storage**
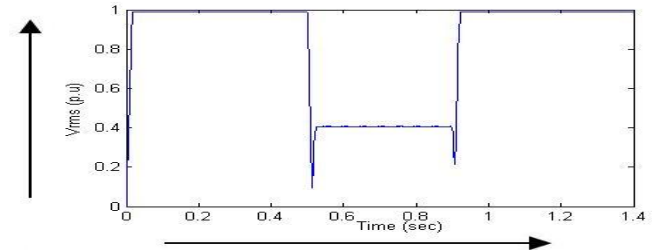


**Figure VII. (d)V$_{RMS}$ of load with 2KV Energy Storage**

Figure VII.e. shows that the storage energy is more than the required it will give bulge at the load.



**Figure VII.(e)Voltage V$_{RMS}$ of load with 7KV Energy Storage**

**VIII.SIMULATION RESULT OF VOLTAGE SWELL**

The test system in Figure. VIII .a.shows RMS voltage without DVR.



**Figure VIII.(a)V$_{RMS}$ of load without DVR**

The test system fig.VIII.b, is carried out using the same outlined as above but with DVR in operation.

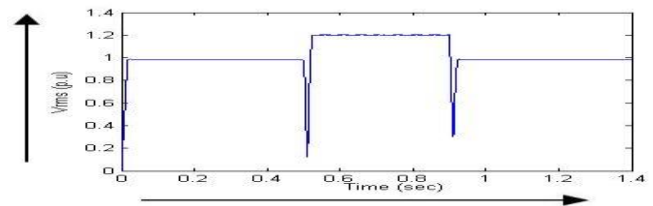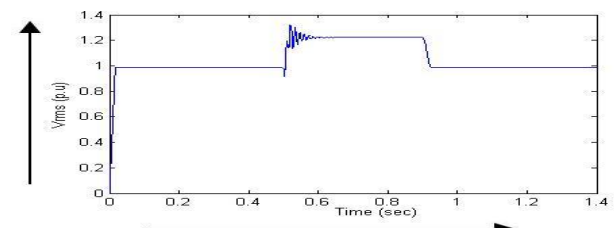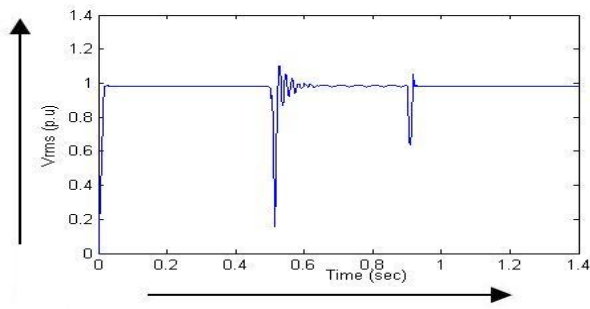The total simulation time is 1400 ms.The voltage swell is almost mitigated completely and the RMS voltage at the quick detecting load is continued normal, as shown in Figure.VIII.b.



**Figure VIII.(b)V$_{RMS}$ at the load with DVR Energy Storage of 6.8KV**

### IX.CONCLUSION

DVR is come up with series connected rigidly in order to inject & regulate the voltages into the system &the load side. DVR also having additional capability Other than voltage sags and swells compensation, it can also having other attributes, those are line voltage harmonics compensation, reduction of transients in voltage and fault current limitations and then analyze the dynamic and steady-state performance of DVR. The results of voltage and current waveforms of DVR using PI Controller and Fuzzy Logic Controller with voltage sag during three phase fault sag voltage during single L-G fault, sag voltage during double line fault, voltage interruption during 3 phase fault and voltage swell points are analyzed. DVR with Fuzzy Logic Controller performs better among DVR with PI and FLC.

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