Power Quality Improvement of Distributed System By using DVR

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Abstract- Power quality problems become a major anxiety of industries due to loss in terms of time and money. Distribution system needs to be protected against voltage sags & swells that adversely affect the reliability & quality of power supply at the utility end. In this paper, our aim is to improve power quality by using DVR (dynamic voltage restorer).). Dynamic Voltage Restorer can provide the most cost effective solution to mitigate voltage sags and swells by establishing the proper voltage quality level that is required by customer The paper describes the different controllers like PI and fuzzy on the basis of load and output waveform. The effectiveness of different control techniques based DVRs to analyze their feasibility and practicability during voltage sag condition PI based dvr have been investigated during fault case.The distributed systems with loads are simulated and tested using MATLAB/SIMULINK.

Keywords- Power quality, DVR, PI controller, fuzzy controller, voltage sag.

I. INTRODUCTION

The various power quality problems are due to the increasing use of non linear and power electronic loads Harmonics and voltage distortion occur due to these loads. The power quality problems can cause malfunctioning of sensitive equipments, protection and relay system [1].The economy invested in the distribution system is large enough to take into account the concept of equipment protection against various disturbances that affects the reliability of not only the distribution system but the entire power system incorporating generation & transmission too. Distribution system is mainly affected by voltage sag and swell power quality issue. The higher index of reliability & power quality [2] to satisfy the customer has reflected the need for the development & application of compensation systems. Compensating systems [3] also known as the custom power devices offer a handful of protection & security to the system under observation The Dynamic Voltage Restorer (DVR) is a device that detects the sag or swell and connects a voltage source in series with the supply voltage in such a way that the load voltage is kept inside the established tolerance limits It is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR also has added other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitation. Custom power device (CPD) is a powerful tool based on semiconductor switches concept to protect sensitive loads if there is a disturbance from power line. Among the several novel CPD, the Dynamic Voltage Restorer (DVR) are now becoming more established in industry to mitigate the impact of voltage disturbances on sensitive.[6]

II. DYNAMIC VOLTAGE RESTORER

Dynamic Voltage Restorer is a series connected device that injects voltage into the system in order to regulate the load side voltage. The DVR was first installed in 1996 It is normally installed in a distribution system between the supply and the critical load feeder. Its primary function is to rapidly boost up the load-side voltage in the event of a disturbance in order to avoid any power disruption to that load there are various circuit topologies and control schemes that can be used to implement a DVR.
The principle of DVR is toTo inject a voltage of required magnitude and frequency, so that it can restore the load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced or distorted.

A DC to AC inverter regulates this voltage by sinusoidal PWM technique. All through normal operating condition, the DVR injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses. However, when voltage sag occurs in the distribution system, the DVR control system calculates and synthesizes the voltage required to preserve output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load.

CONFIGURATION OF DVR

The general configuration of the DVR consists of a voltage injection transformer, an passive filter, an energy storage device, Voltage Source Inverter (VSI).Each of them is describe below and shown in fig.1

A. Voltage Source Converter (VSC):

A VSI is a power electronic system consists of a storage device and switching devices, which can generate a sinusoidal voltage at any required frequency, Magnitude, and phase angle. In the DVR application, the VSI is used to temporarily replace the supply voltage or to generate the part of the supply voltage which is missing. The single phase VSI topology encompasses a low-range power applications and medium to high power applications are covered by the three phase topology.[10]

B. Injection Transformer:

Injection transformers used in the DVR plays a crucial role in ensuring the maximum reliability and effectiveness of the restoration scheme. It is connected in series with the distribution feeder.

C. Passive Filters:

Passive Filters are placed at the high voltage side of the DVR to filter the harmonics. These filters are placed at the high voltage side as placing the filters at the inverter side introduces phase angle shift which can disrupt the control algorithm.

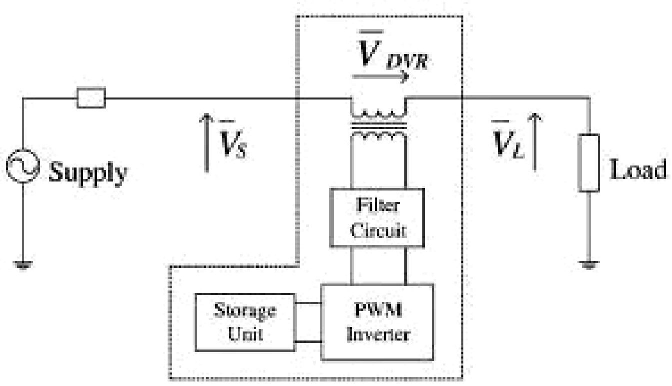

Fig1. Schematic diagram of DVR

III. CONTROL PHILOSPHIES

The aim of the control system is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system of the general configuration typically consists of a voltage correction method which determines the reference voltage that should be injected by DVR and the VSI control which is in this work consists of PWM with PI or Fuzzy Logic controller..Two control philosophies have been used namely, PI and Fuzzy.

A PI CONTROLLER BASED DVR

The linear PI adjust its proportional & integral gains k_p and k_i in order to reduce the steady state error to zero for input. as shown in fig 2. It is widely used in simple control structure but in this paper describes a fault case PI controller based dvr which gives the best compensation.

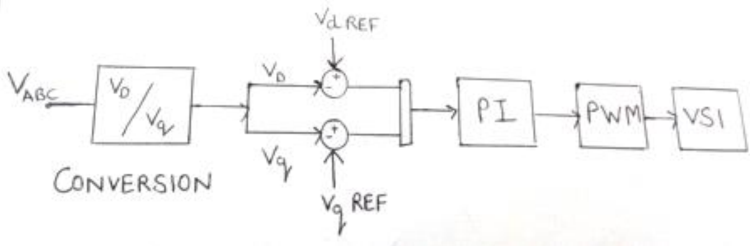

Fig 2 PI controller block diagram

Here V_d and V_q are reference voltage

V_d = d axis voltage.

V_q = q axis voltage

Table I
System Parameters

S.no	system quantities	standards
1	Voltage source	3 phase 50 hz
2	Inverter Parameters	IGBT based,3arms,
3	Pi controller	K_p=0.4 k_i=500 Sample time=10^{-6}s
4	RL load	Active power=1KW,Reactive power=200VAR
5	Two winding transformer	Y/Y 240/240 kV

In simulink model of PI controller based DVR the fault resistance is 0.001 ohm and fault time is 0.4s to 0.7s.

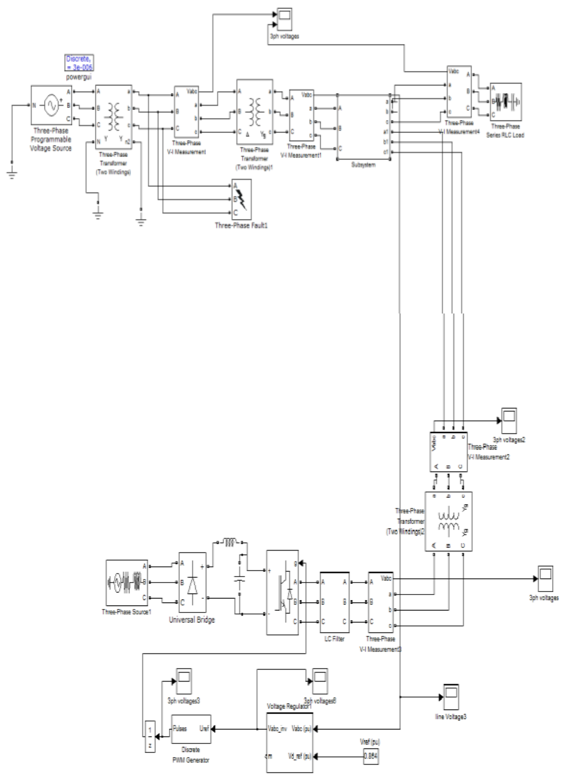

Fig 3.Simulink model of PI controller based dvr

B FUZZY CONTROLLER BASED DVR

The fuzzy logic controller unlike conventional controllers does not require a mathematical model of the system process being controlled. However, an understanding of the system process and the control requirements is necessary. The fuzzy controller designer must define what information data flows into the system (control input variable), how the information data is processed (control strategy and decision) and what information data flows out of the system (Solution output variable). The drawback suffered by PI controller is overcome by Fuzzy. In comparison to the linear PI controller, this is a non-linear controller that can provide satisfactory performance under the influence of changing system parameters & operating conditions [11][12]. The function fuzzy controller is very useful as relieves the system from exact & cumbersome mathematical modelling & calculations. The performance of fuzzy controller is well established improvements in both transient & steady state [8] The fuzzy controller comprises of four main functional modules calculations. The performance of fuzzy controller mechanism & Defuzzification. The FLC controller of the tested system exploits the Mamdani type of inference method. It defuzzifies the crisp input-output variables into fuzzy trapezoidal membership function and reverse process of Defuzzification is based upon the Centroid method as given in tableIII. The controller core is the fuzzy control rules as shown in table II. which are mainly obtained from intuitive feeling and experience[14].

The general structure of an FLC is represented in Fig.4 and comprises four principal components:• a fuzzyfication interface which converts input data into suitable linguistic values; • a knowledge base which consists of a data base with the necessary linguistic definitions and control rule set;

• a decision making logic which, simulating a human decision process, infers the fuzzy control action from the knowledge of the control rules and the linguistic variable definitions; and

• a defuzzyfication interface which yields a nonfuzzy control.

Here the block diagram shown below:

Here V_d and V_q are reference voltage

V_d = d axis voltage.

V_q = q axis voltage

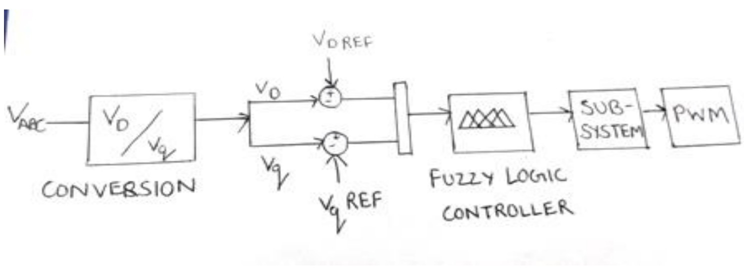

Fig 4 Fuzzy controller block diagram

Fuzzy logic controller is very useful as relives the system from exact modelling & calculation.

The fuzzy controller rules is shown below:

e/“ce	LP	MP	SP	S	SN	MN	LN
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

Table II Fuzzy controller rules

Table III
FIS details

FIS Variables	Input-2 ,Output-1
FIS Name	DVR Fuzzy
FIS Type	Mamdani
Membership Function	Trapezoidal
And Method	Min
OR Method	Max
Implication	Min
Aggregation	Max
Defuzzification	Centroid

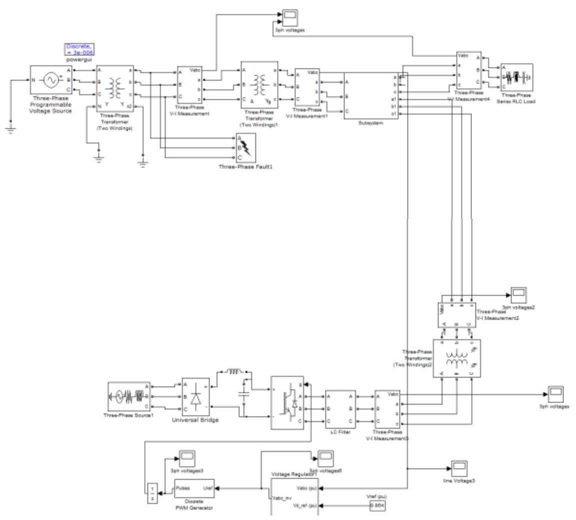

Fig 5 Simulink model of Fuzzy controller

IV. SIMULATION RESULT

In the SIMULINK model, two feeders are drawn from the same supply using 2-winding transformer. One of the feeders is compensated using DVR while the other uncompensated. These are further connected identical loads so that their performances are fairly compared. The PI controller based DVR and fuzzy controller based DVR controller based DVRs are connected one by one in the compensated feeder to compare their performances. This paper investigated voltage sag compensated in fault case.

A CASE I

In the SIMULINK model, two feeders are drawn from the same supply using 2-winding transformer. One of the feeders is compensated using DVR while the other uncompensated. The PI controller based DVR in fault case is investigated. From the simulation results, it is seen that that the PI controller based DVR in fault case the simulation shows of three phase voltage sag is simulated. The simulation started with the supply voltage having fault at 0.04 to 0.07s, 50% sagging. Figure 6(a) also shows a 50% voltage sag initiated at 0.3s and it is kept until 0.37s, with Total voltage sag duration of 0.07s. Figures 6 (b) show the voltage injected by the DVR and the corresponding load voltage with compensation. As a result of DVR, the load voltage is kept at 2 pu.

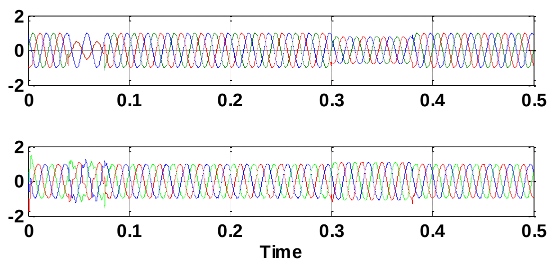

Fig 6 (a) & (b)

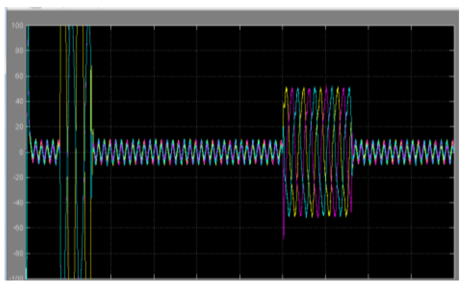

Fig 7 DVR voltage

B CASE II

In this case, fuzzy logic controller is employed to compensate the uncompensated system shown in fig8 Unlike, linear PI control scheme as discussed in case (A), it is a non-linear technique that uses trapezoidal membership function & rule base system as given in table II to adjust accordingly to the varying system parameters & conditions.

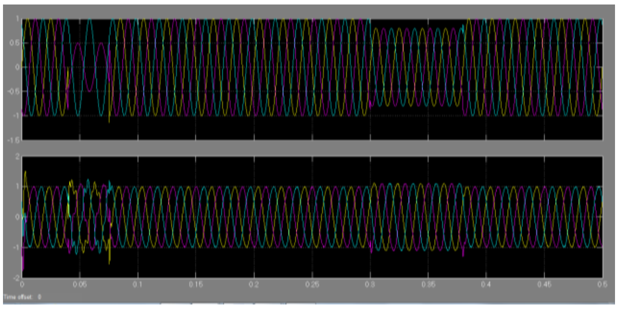

Fig 8 i/p and o/p voltage

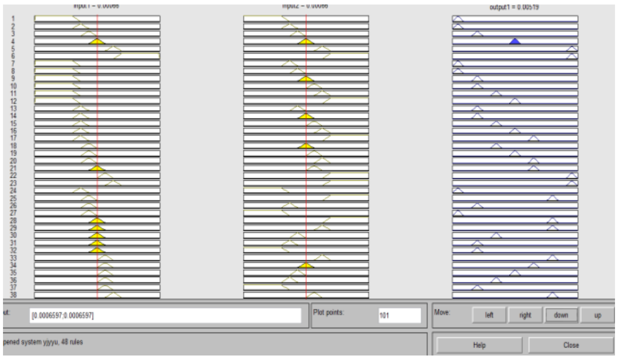

Fig.9 rule –viewer of reference

V CONCLUSION

The modelling and simulation of a DVR using MATLAB/SIMULINK has been presented in this project. A control system based on d-q-o technique which is a scaled error of the between source side of the DVR and its reference for sags correction has been presented. The simulation shows that the DVR performance is satisfactory in mitigating voltage sags.
Simulation results also show that the DVR compensates the sags quickly and provides excellent voltage regulation. The DVR handles both balanced and unbalanced situations without any difficulties and injects the appropriate voltage.
In this project the two controlling techniques i.e. for PI controller and FL controller are presented from the results it is concluded that compared to FL, PI controller is giving better performance in fault case.

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REFERENCES

[1] C. Sankaran, *Power quality*, (CRC Press LLC, 2002).[2] An Luo,Ci Tang,Zhikang Shuai,Jie Tang, Xian Yong Xu,Dong Chen, Fuzzy-PI-based direct-outputvoltage control Strategy for the statcom used in utility distribution systems, IEEE transactions on industrial electronics, Vol. 56, No. 7, July 2009.
[3] S.Chauhan, V. Chopra, S.Singh, Power system transient stability improvement using Fuzzy-PI based
STATCOM controller, 2nd International Conference on Power, Control and Embedded Systems, pp.1-6,
2012.
[4] B.Ferdi, C.Benachaiba, S.Dib, and R.Dehini, "Adaptive PI control of Dynamic Voltage Restorer Using Fuzzy Logic", Journal of Electrical Engineering: Theory and Application Vol.1,Iss.3, pp.165-173, 2010.
[5] Md. R.Azim, Md. A. Hoque, A Fuzzy Logic based Dynamic Voltage Restorer for Voltage Sag and
Swell Mitigation for Industrial Induction Motor Loads, International Journal of Computer Applications,Volume 30– No.8, September 2011.
[6] H.P. Tiwari and Sunil Kumar Gupta *"Dynamic Voltage Restorer against Voltage Sag",* International Journal of Innovation, Management and Technology vol.1,no.3, pp. 232-237, 2010.
[7]B.Panda, A.K. Mahapatra and D.P. Bagarty***** And S. Behera****** *"Fuzzy Logic Controller - Based Dynamic Voltage Restorer For Mitigation of Voltage Sag"* International Journal of Engineering Science and Technology (IJEST) Vol. 3 No. 2 Feb 2011, pp. 996-1007.
[8.] R. H. Salimin and M. S. A. Rahim *"Simulation Analysis of DVR Performance for Voltage Sag Mitigation"* The 5th International Power Engineering and Optimization Conference (PEOCO2011), Shah Alam, Selangor, Malaysia: 6-7 June 2011, pp. 261-266.
[9] S. Chen, G. Joos, L. Lopes, and W. Guo, "A nonlinear control method of dynamic voltage restorers," in 2002 IEEE 33rd Annual Power Electronics Specialists Conference, 2002, pp.88- 93.
[10] S. S. Choi, B. H. Li and D. D.Vilathgamuwa, *"Dynamic Voltage Restoration with Minimum Energy Injection," IEEE Trans.* Power Syst, vol. 15, pp. 51–57, Feb. 2000.
[11]. R. H. Salimin, M. S. A. Rahim, Simulation analysis of DVR performance for voltage sag mitigation, The
5th International Power Engineering and Optimization Conference, 6-7 June 2011.
[12]. Jurado, Francisco, Valverde, M, Fuzzy logic control of a dynamic voltage restorer, IEEE International
Symposium on Industrial Electronics, pp.1047-1052 vol. 2, 2004.

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