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A CONTROL SCHEME FOR POWER QUALITY ENHANCEMENT USING DVR.

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Abstract: This paper gives course of action of modeling & analysis of Dynamic Voltage Restorer (DVR) for power quality improvement. This device is one of the power electronic device used in distribution system to protect consumers against sudden changes in voltage magnitude. It is able to maintain load voltage within determined value. Several configuration & control methods are proposed for this device. In this paper, the general idea of the DVR, its functions, design, mechanism, compensating strategies & control methods are evaluated besides device capabilities & limitations. Also the study of PLL design for the inverter grid connection.

Keywords: DVR, Voltage sag, Power Quality, Phase locked loop, MATLAB/Simulink

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INTRODUCTION

The distribution system can provide good quality of power to the consumers at balanced load conditions.

Power quality has gain quite importance in recent years due to its precious role in power system. To judge the performance of any power network, quality of power is taken into consideration. Mostly the power quality disturbances are of voltage quality type. These troubles are voltage sag, voltage swell, harmonic & inter-harmonic voltages, & for three phase systems voltage imbalances occur in the system. The overall financial losses are due to the power quality disturbances. Significant efforts have gone into reducing number of power voltage sags on the structure in order to reduce the high associated costs of equipment disoperation.

The majority of the power quality problems are voltage sag & voltage swell that reduces almost 80% of the distribution PQ problems. According to IEEE standard 1346-1998, voltage sag is a decrease in RMS voltage at the power frequency for duration of 1 minute to less than 0.5 cycles. [5][7]-[9]. The main causes for voltage sag are short circuits, sudden changes in load, energization of transformers. These unwanted sags are said to be the most harmful disturbance which attracts most of the power engineers to put significant efforts in order to mitigate these sags.

The power electronic based custom power devices such as STATCOM, SSTS, DVR etc. are greatly contributing in compensating such problems. At current scenario, with range of very stiff controllers, which make the most of power electronics components, are promising for traditional power applications. Among these devices the working principle of STATCOM & DVR are based on converter technology mainly the voltage source converter. MATLAB/SIMULINK [17], [18] have been implemented in this paper to perform modeling & analysis of DVR controller for testing its performance.

DYNAMIC VOLTAGE RESTORER

The dynamic voltage Restorer is a series controller which injects a voltage in succession with the input voltage to maintain load voltage to its pre-sag value. Therefore, this device is also termed as Series Voltage Booster (SVB) or Static Series Compensator (SSC) [3].

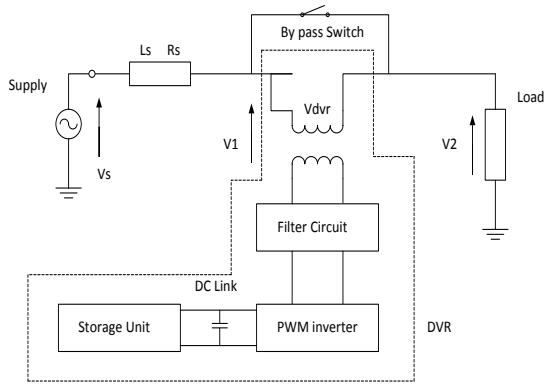


Fig.1 Conventional DVR circuit

Figure 1 shows a basic track of the DVR. The main apparatus of DVR are summarizing below:

- Storage Unit

When fault occurs in the system it gives rise to the voltage sag during that period of time. During voltage sag, the Dynamic Voltage Restorer injects a voltage to re-establish the supply voltages. It requires a resource for this energy. Two types of structure are measured; solitary using the saved energy to supply the required power, and the newer one have no power storage internally, & energy is taken from the incoming supply through a shunt converter.

- Inverter Circuit

The converter which is basically Direct Cycle (DC) to Alternating Cycle (AC) is defined as an inverter. The converter produces sine wave output i.e. the waveform is sinusoidal with respect to voltage [V], freq [rad/s] and phases [a,b,c] which gets the source from a Direct Current (DC)-control supply. This specific waveform is created in the inverter switches which have to be turned ON and OFF at certain period, specified by the preferred modulation approach. These are generally used for medium voltage applications and also for the high power applications where the total harmonics distortion as well reduced. The inverter circuit in DVR in addition seats a vital role in conversion of the power supply and thus an inverter with fewer harmonic is used for the optimal system performance.

- Filter Unit

The characteristics of semiconductor devices are nonlinear which causes distorted waveforms related with high frequency harmonics at the inverter output. To bang this difficulty and give

elevated energy supply, a filtering element is used which removes the harmonics. These can be placed both on the DC-AC converter side and also on the load side.

- Series Transformer used for Injection of voltage

To inject the lost voltage to the system at the load bus three single-phase transformers are used. To put together the transformer is used which inserts voltage correctly into the load, the primary winding voltage, the rating of MVA and the values of current, the transformation ratio and the s.c impedance standards of transformers are compulsory. The use of these transformers permits the design of that device in a lesser voltage level, which depends upon the step up ratio.

I. PLL – Phase Locked Loop

They are commonly used in a variety of signal applications viz. electrical motor control, radio- and telecommunications and computers. The technique can be modified to toil in a broad range of frequency spectrum from a few hertz to the level of gigahertz.

There are mainly three types of PLL systems for phase tracking. The SRF PLL is the one of the best whose performance under imprecise and non-ideal grid conditions are excellent [4] and is therefore in this paper the PLL system to be further study.

The structure of this paper is as given. In Section IV MATLAB/Simulink representation of the system is shown, Section V demonstrates the result of the system with and without DVR. Section VI gives the system with PLL. Finally, Section V concludes the paper.

II. MATLAB/SIMULINK MODEL

Figure-2 gives MATLAB Model of the test system. Two simulations are carried out as follows:-

1) At first the power system contains no DVR and by way of a fault resistance of 0.66 a three-phase short-circuit fault is created at point A, for the period of 300–600 ms. With respect to the reference voltage he voltage sag is at the load point.

2) The same scenario as above but now with using the DVR in operation the second analysis is carried out.

A. System Without DVR

To authenticate the functioning of the device employed to evade voltage sags in short-circuit, a burden is created as shown in figure below which is the fault. The fault is applied on the sensitive load side i.e. the side having R-L load of the bus.

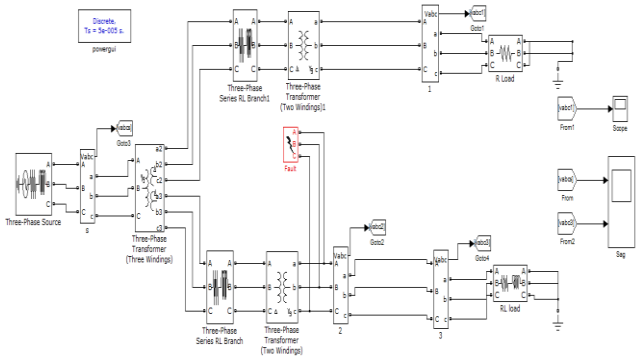


Fig.2 Test system implemented in MATLAB to carry out the DVR simulations.

In MATLAB/SIMULINK the available amenities are used, the Restorer is modeled & is bring into being that it is in operation only for the period of the fault, as it is probable to be the scenario in a realistic condition. State-variable analysis set is meant for use by means of Power System Block in Matlab/Simulink and gives either variable or predetermined integration-step algorithms.

SIMULATION RESULTS

The simulation model of DVR is planned to lessen voltage sags, Firstly the figure 3(a) below shows the sag at the three different levels viz. at the sensitive load side (Fig a), at the resistive load side (Fig b). Figure a & b clearly displays the voltage sag in the system for the said period of fault.

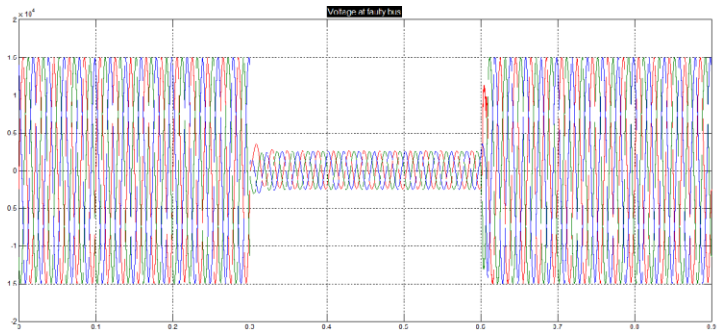


Fig. 3(a)

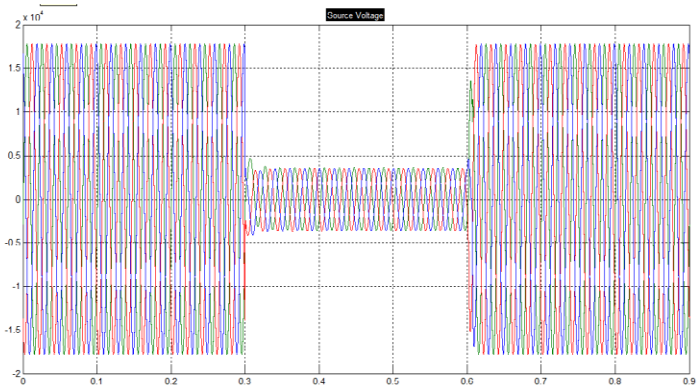


Fig. 3(b)

Fig. 3 (a) and Fig.3 (b) Voltage sag observed at the faulty bus and source side.

B. System With DVR(Analysis)

The Model of Dynamic voltage restorer consists of the systematic modeling of an inverter which helps in converting the dc storage to ac supply for voltage mitigation. The dc storage device has the power of 5 kV. Here the mind behind the inverters switching combination is the pulse width modulation (PWM). There are several different modulation policies to approach. The SVPWM is one of such which is executed in the paper.

With the handling of numerous levels a multilevel inverter works with the help of DC-voltages constructing a staircase shaped AC-voltage. The DC source such as capacitors, batteries and renewable energy sources can be used [17]. The harmonics decreases when the voltage level increases. Thus a Cascaded H bridge inverter in this model creates more harmonics than with multilevel bridge. The results of the simple inverter and multilevel inverter makes custom device as shown in figure below. Some transients are observed in the output voltage and as expected the DVR requires a high value of dc storage so as to have a good mitigation to voltage

sag. Further various tests were carried out on the same system but at different fault location and fault resistance. The device is said to have almost mitigated the voltage sag completely and the voltage is maintained at the load point.

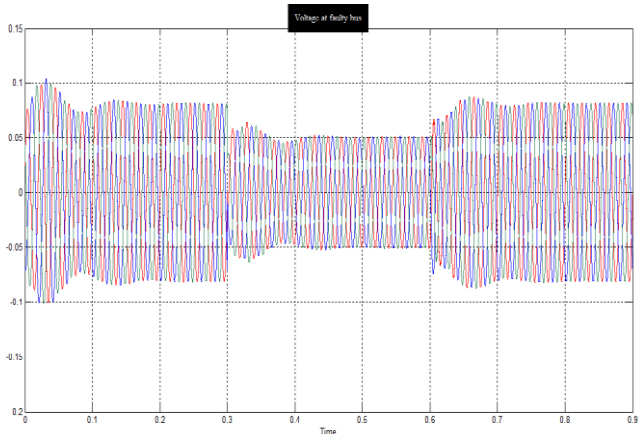
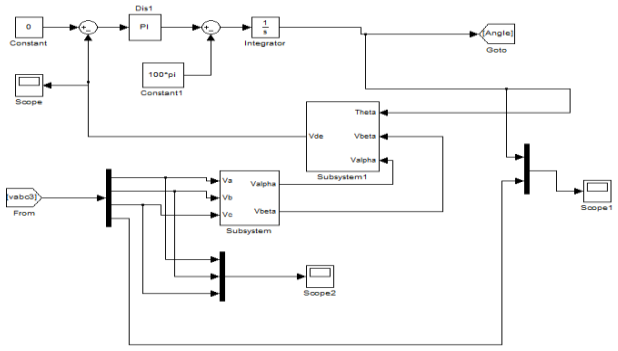


Fig. 4 Voltage at load point.

III. PLL design and Implementation in MATLAB.

The PLL consists of two major parts, the phase detecting device and loop filter. The phase detecting can be readily put into practice by using the dq transform in the three-phase system. The detail model of PLL in MATLAB is as specified in fig.



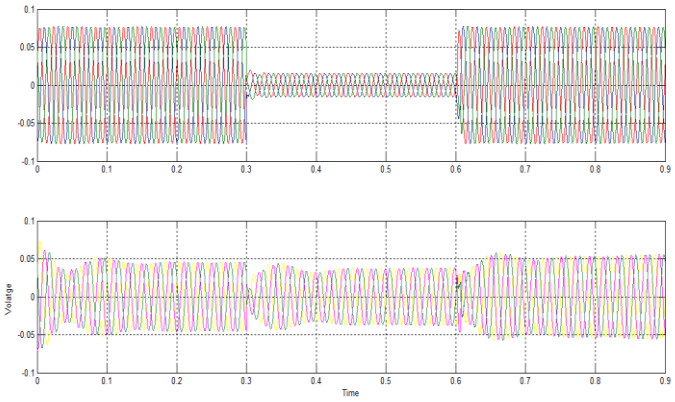


Fig. 4 PLL Implementation in MATLAB and Results Obtained.

For the analysis of the PLL system the sag is formed as above. During voltage dip, the DVR with PLL inserts a voltage in phase with the voltage at Point of Common Coupling (PCC), such that the voltage at PCC is maintained constant throughout the operation. Fig. 5 shows the waveforms of the source voltage, the load voltage. It is examined that the response time, as well as the dip in voltage recognition time and the response of the controller is less than one cycle at the original frequency which gives the effectiveness of the anticipated technique of control for the restructure of voltage dips.

IV. CONCLUSION

This paper has offered the study of one of the custom power equipment and applied to the learning of power quality and transients. SVPWM based multilevel inverter has been successfully implemented which is used in power electronic device.

The merit of this inverter which is multilevel system is that it induces good quality of power, a superior electromagnetic compatible, a reduced quantity of switching losses and elevated capability. The device is said to be stout and very helpful in the improvement of voltage quality.

Also it is pragmatic that the DC storage also plays a crucial role when it is used in dynamic voltage restorer for voltage compensation. This can be replaced by any of the non conventional energy sources available near the system. These non conventional energy sources are predictable to lessen the burden on the system but also will be environmental friendly. To diminishing the switching losses more there are various a methods which are not included in this work and further studies for the same can be done.

Moreover a battery based DVR design with a PLL to mitigate voltage sags in a distribution system has been presented.

APPENDIX

3-phase 2-winding Transformer	**115/11kV(delta/star),50Hz,100MVA**
Fault Resistance	0.66 ohm
Fault type	Three phase fault (L-L-L)
Coupling Transformer	100 MVA, 10% leakage Reactance
DC voltage	5 kV
Power Electronic Switch	IGBT

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