[Prajapati, 4(4): April 2017] ISSN 2348 – 8034
DOI-10.5281/zenodo.570072 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

INVESTIGATION OF VOLTAGE SAG AND SWELL PROBLEMS USING DVR SYSTEM WITH MATLAB SIMULATION MODEL

Sandhya Prajapati*1 & A Pachori[2]
*1PG Scholar JEC Jabalpur
[2]Associate prof. JEC Jabalpur

ABSTRACT

The power quality becomes one of the most important factor in our present day economy. The concept of true power mainly depends on how correctly the issues like voltage sag and voltage swell are mitigated. Among all the power quality problems, like voltage sag andvoltage swell mentioned are of key importance. This is because of the most widely use of newly invented as well as the outdated sensitive equipments connected to the load. Sensitivity is the main cause of the above power quality problems and it cannot be eliminated completely as it has many other operating properties. So for solve voltage sag and swell problem caused by the sensitive equipments connected to the faulty loads solve by connect some other system like DVR. The occurrence of sag and swell varies with equipment, environment, process operations, desired control schemes etc. by referring IEEE standards, the power quality events will last only for small instants. Thus the real time detection becomes a really tough task and even a small instant variation will cause a series of problems to the process industry. The dynamic voltage restorer is a special type of power device used for providing consistent and reliable supply power to the load devices. Dynamic voltage restorer uses a vector control strategy for mitigating power quality problems by automatically detecting and injecting the voltage components through an injection transformer. Repeated occurrence of sag and swell will cause these equipments to malfunction

Keywords- *Voltage Sag, Voltage Swell, Dynamic Voltage Restorer*

I. INTRODUCTION

A voltage sag is generate by sudden change in voltage magnitude[1,2] whereas a voltage swell is regarded as a sudden increase in the rms voltage; which is usually caused by a remote fault located somewhere on the equipment or control system. Voltage sags are major causes of the problem which the major process equipments are facing. The various equipments like process controllers, PLC's [3] adjustable speed drives etc. are more sensitive to these power quality problems. These devices are more complex and lengthy as compare to DVR device and sophisticated as they are working on advanced algorithms [4]. The complexity of these devices cannot be avoided, as these devices are closely related to the design process. There are numerous internal factors which affect a good power source. The only possible solution is to mitigate the sag and swell events using certain algorithms [7, 8] and also to reduce the chance of occurrences of these events. By our observation, it is seen that less sensitive equipments like relays, motors etc. are also affected by the power quality problems. Regular occurrences will damage the equipment and will result in an imbalance in reactive power and they will also lead to the shutdown of the whole process. The real time mitigation of sag and swell becomes important because of an objective; ie, to satisfy the customer side as well as the vendor side. This is regarded as the main economic impact of power quality. The lack of true power will make the economy weaken. While considering the economic impacts, the major concern is towards the increased interest in the power quality, [5] and increase in efficiency. Many survey results have proved that the impact of sag and swell [10] have resulted in losing in terms of thousands of dollars in the total economic outcome. The best choice in selecting a suitable algorithm and a non linear device depends on the cost of the problem and also the total operating cost of the process, and generally it is a tough task to estimate the correct value. There are various technologies for improving power quality. They are evaluated in terms of cost, economic efficiency, the expected performance and improvements employed. The performance improvements will normally translate to economic benefits which are generally point towards the total power quality improvements.

Voltage sag analysis [5, 6, 9] is a systematic and periodic analysis of collecting data which can be used to evaluate the network's performance. The characterization of sag events is a complex task and also the duration of the event existence, because these events will change their character with respect to time. The cost factor will also matter. Thus the correct detection will be very important. In normal test conditions, the sags will last to some seconds and a 10% decrease in the level of supply voltage (IEEE 1159) and it means that necessary reactive power is not being transferred to the load. The faults are the main cause for sag occurrence and the faults can happen anywhere in the plant (plant feeder breaker) or in the utility system (substation breaker). The major faults occur in a utility system, maybe of single line to ground fault (SLGF); three phase faults are also seen, but not in common. The SLGF will be caused by the factors like type of conductor, animal contacts, accidents, atmospheric variations, etc. and cannot be eliminated completely. In the test system described here, I am designing a three phase fault, which is easier to analyze than the single phase fault. From the customer side, faults (and, therefore, voltage sags) are inevitable, and therefore it is important to make sure that critical equipment sensitive to voltage sags is adequately protected.

II. OPERATION OF DYNAMIC VOLTAGE RESTORER

Dynamic Voltage Restorer (DVR) is a device [11, 12] used to produce a sustainable and reliable power to the sensitive electrical equipment during the occurrence of power quality problems, DVR is mainly used to detect and mitigate voltage sag and swell. The DVR is different from conventional voltage regulators [13] with no voltage source. The DVR uses an additional energy source, which is used to boost the energy levels during the dip occurrences, and this is interconnected to an energizing transformer. But this energy source is limited. Thus this mitigation technique will be successful only for short term happenings. But the DVR is found very effective in improving the transient responses and harmonic compensation, finally reducing the total harmonic distortion. Normally a DVR is connected in series to the supply after the fault happening. The DVR can provide a maximum of 50% compensation [14, 15] to the distorted supply level and this is based on active power supplied by the energy devices. The main feature of DVR includes its reliability, lower cost, smaller size, fast response to faults etc. The DVR has an inbuilt capacity to control the active power flow inside the component. In normal operating conditions, the DVR stands in the stand-by mode and will be active only if a disturbance occurs. In the injection point, the amplitude and phase angle of the injected voltages are different and variable, depending on the type

Performance of DVR system-

A Schematic diagram of a conventional DVR incorporated into a distribution network is shown in Fig. 1.and duration of the problem occurrence.

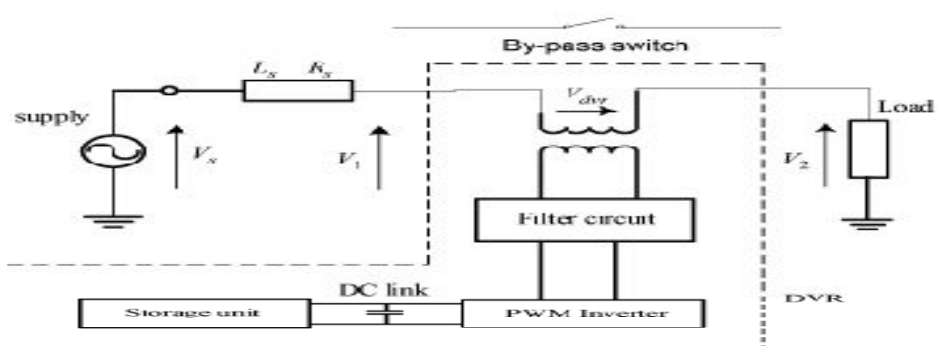

Fig.1. Representation of DVR system Injection/ booster transformer.

The Injection / Booster transformer is a specially designed transformer that attempts to limit the coupling of noise and transient energy from the primary side to the secondary side. Its mainly connects the DVR to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage. In addition, the Injection / Booster transformer serves the purpose of isolating the load from the system (VSC and control mechanism).The PWM produces the pulses and it is amplified by the driver circuit. This voltage is then injected by the transformer to the transmission line.. When the load is connected and disconnected there occurs a sag and swell in the system.

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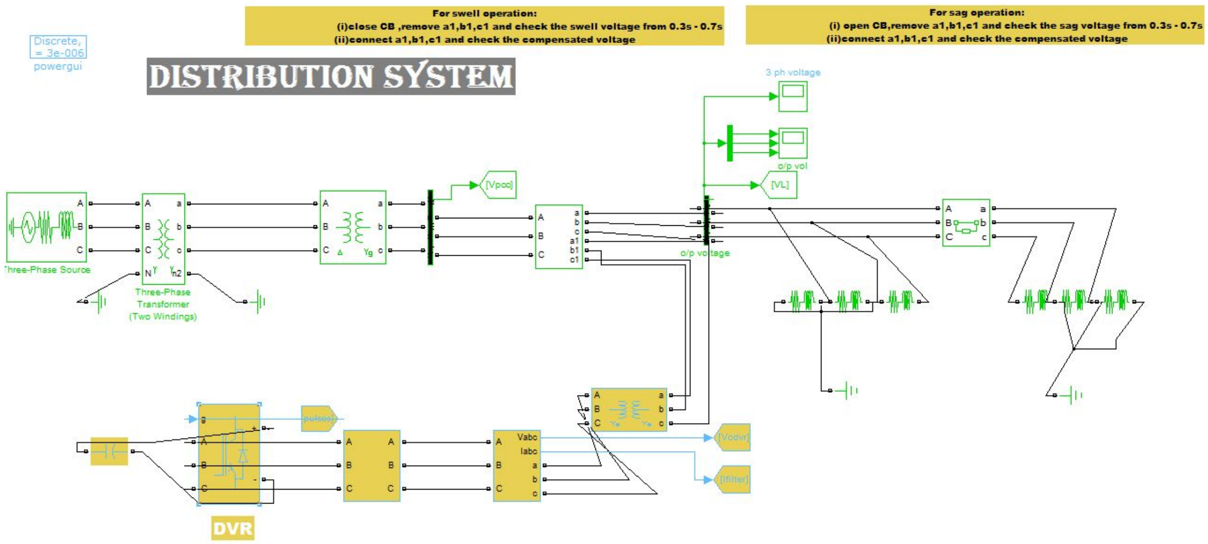


Fig.2. Simulation with feedback

The second load when connected from time 0.3s to 0.7s there occurs a sag in the voltage which is when the DVR comes into action. The DVR injects voltage into the system and the voltage sag gets compensated. During normal operation of the system the DVR gets charged and the charge is stored in the battery which is then used under voltage sag conditions. The real and reactive power of the system can be compensated with the help of this system. The control circuit of DVR system is as shown in fig 3.

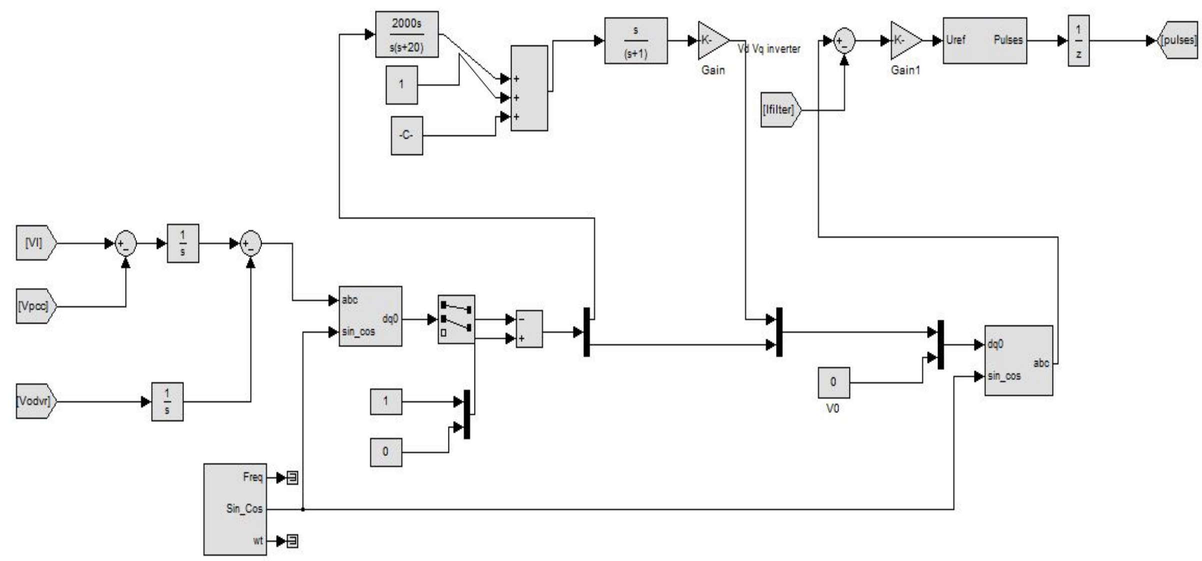


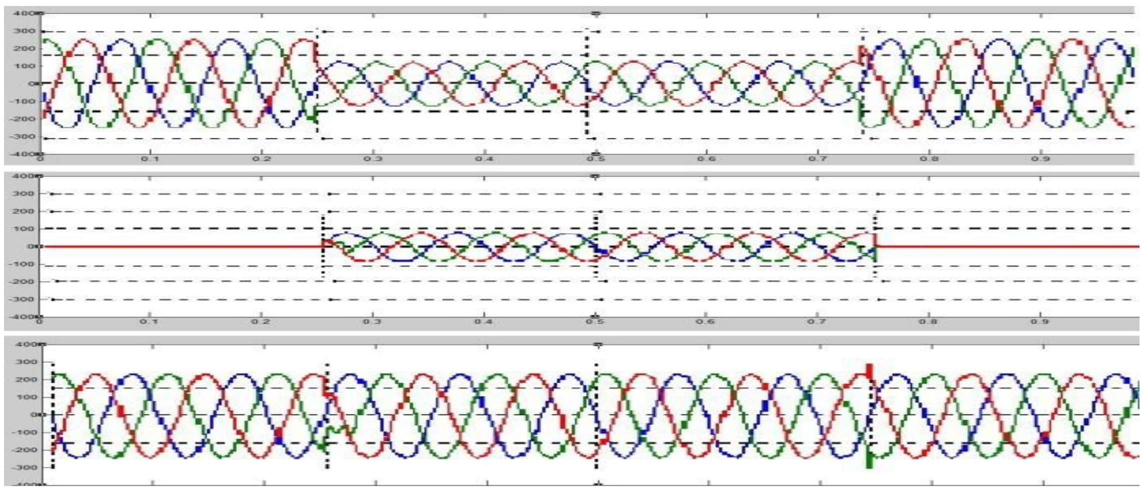
Fig.3. Control circuit of DVR system

III. SIMULATION RESULTS

The Vl and Vpcc voltages are compared and the error voltage is integrated using an integral controller to reduce the settling time of the system. Vdvr voltage is also integrated and then this is compared with the error voltage obtained. This isin three phase as abc which is then converted into a voltage in the d-q axis. This is done because small variations cannot be found in abc plane.The output of this posicast controller is multiplied with gain. The output of

ISSN 2348 – 8034
Impact Factor- 4.022

this posicast controller is then multiplexed with the dq axis output. This output is then converted into a three phase signal in the abc plane. The output of this block is then compared with the filter output and then after multiplying with a gain is given to the discrete PWM generator.The simulation results of sag and swell is as fig.4 To mitigate the sag and swell the DVR is then connected to the system. The compensated voltage is shown in fig.5.



Simulation results for voltage sag; (a) sag occurrence for a 230V/50Hz supply for duration of 0.25-0.75 seconds, (b) DVR injected voltage, (c) final load output voltage after compensation.

IV. CONCLUSION

In this research paper, the power quality events like voltage sag and voltage swell are simulated in Matlab. The mathematical models are formed in test environment. The performance of the DVR is evaluated in this paper. DVR has a tremendous application for voltage sag compensation for sensitive loads. The major operation principles of DVR includes, the compensation techniques, the transformer voltage injection methods, PWM inverter, PI based control of PWM etc. are also discussed. Finally a Fuzzy system is developed to increase the reliability of the compensation system. Mamdani type fuzzy logic controller is selected and designed on the required rule base. The above hybrid test system has the capability to compensate for voltage sags at the distribution side. The proposed controller has fast dynamic response, and the THD is lowered when compared to the conventional techniques. The DVR itself is a simple system which consists of low cost, easy design, lesser computational complexity, etc. The designed FLC is capable of dealing with a large number of samples**.**

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