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MITIGATION OF VOLTAGE SAG WITH TRANSIENT AND STEADY-STATE CONTROL USING DYNAMIC VOLTAGE RESTORER

Durga Jhariya[1] , Preeti Jain[2]

djdolly87@gmail.com, pjain18@rediffmail.com2

[1]Department of Electrical Engineering, Jabalpur Engineering College Jabalpur (M.P.)

[2]Research Guide, Department of Electrical Engineering, Jabalpur Engineering College Jabalpur (M.P.)

Abstract :

Due to complexity of power system combined with other factors such as increasing susceptibility of equipment, power quality is apt to waver. With electricity demand growing, low power quality is on the rise & becoming notoriously difficult to remedy [1]. Distribution system needs to be protected against voltage sags, dips & swells that adversely affect the reliability & quality of power supply at the utility end. The Dynamic voltage restorer (DVR), which has been utilized in optimized way so as to improve performance, has been put under new technique of sag detection. Various control strategies have been developed to mitigate the voltage sag/swell and the mitigation of unbalanced voltage dips. The applications of Fuzzy logic controller have taken new dimension in various fields. In this thesis, full panorama of power quality disturbances, with background theory and guidelines on measurement procedures & problem solving techniques are presented.

The essentials of control scheme with immediate voltage generation to regulate the unbalance voltage phase in three phase system and a tested method to improve the reliability within the distribution system is presented. The 11kV system is controlled by linear & non-linear techniques and their performance levels are compared. The simulation results of the recommended system states the better reliability & compatibility of non-linear techniques with non-linear loads than the system with linear techniques with non-linear loads. The capability of DVR is demonstrated using MATLAB/SIMULINK simulation models. From the obtained results, we have considered the feasibility & practicability of the approach for the linear and non-linear load under voltage sag condition.

Key words : Dynamic Voltage Restorer (DVR), MATLAB/SIMULINK , Voltage Swell, Voltage Sag

1.0 Introduction :

This study consists of the design and control of Dynamic Voltage Restorer in medium power systems. Electrical power quality become an important issue because of the change in the characteristics of loads connected to power system due to development of technology and increase in electricity demand. Voltage, current, frequency deviations and waveform distortions that cause equipment failure, economical loss and several negative effects are known as power quality problems. The most severe power quality problems in electrical systems are called as voltage sag and swell. Voltage sag is known as short duration reductions in the RMS voltage. Another problem, voltage swell is defined as an increase in the RMS voltage. Several custom power devices such as UPS, DVR, static series compensator etc. have been improved to solve these problems. Among these several custom power devices, Dynamic Voltage Restorer (DVR) is an effective solution to solve these power quality problems,Power quality issues and resulting problems are consequences of the increasing use of solid state switching devices, nonlinear and power electronically switched loads, electronic type loads .The advent and wide spread of high power semiconductor switches at utilization, distribution and transmission lines have non sinusoidal currents [1]. The electronic type load causes voltage distortions, harmonics and distortion. Power quality problems can cause system equipment mal function, computer data loss and memory mal function of the sensitive equipment such as computer, programmable logic devices [PLC] controls, and protection and relaying equipment [1]. Voltage sag and swell are most wide spread power quality issue affecting distribution systems, especially industries, where involved losses can reach very high values. Short and shallow voltage sag can produce dropout of a whole industry. In general, it is possible to consider voltage sag and swell as the origin of 10 to 90% power quality problems [2]. The main causes of voltage sag are faults and short circuits, lightning strokes, and inrush currents and swell can occur due to a single line-to ground fault on the system, which can also result in a temporary voltage rise on the unfaulted phases [3]. Power quality in the distribution system can be improved by using a custom power device DVR for voltage disturbances such as voltage sags, swells, harmonics, and unbalanced voltage. The function of the DVR is a protection device to protect the precision manufacturing process and sophisticate sensitive electronic equipments from the voltage fluctuation and power outages [4]. The DVR has been developed by Westinghouse for advance distribution. The DVR is able to inject a set of three single-phase voltages of an appropriate magnitude and duration in series with the supply voltage in synchronism through injection transformer to restore the power quality The DVR is a series conditioner based on a pulse width modulated voltage source inverter, which is generating or absorbing real or reactive power independently. Voltage sags caused by unsymmetrical line-to-line, line to ground, double-line-to-ground and symmetrical three phase faults is affected to sensitive loads, the DVR injects the

independent voltages to restore and maintained sensitive to its nominal value. The injection power of the DVR with zero or minimum power for compensation purposes can be achieved by choosing an appropriate amplitude and phase angle [4] [5].

1.1 DVR

The dynamic voltage restorer (DVR) is the most effective and economical custom power device applied to protect sensitive loads from voltage sags and swells. Dynamic voltage restorer is a series connected device located between sensitive load and grid in system, it both detects voltage sags/swell problems and injects controlled voltage to system. To perform this process, a conventional DVR consists of inverter, dc-link capacitor, filter and transformer which will be extensively explained in thesis. A schematic diagram of the DVR incorporated into a distribution network is shown in Figure 1. Us is the incoming supply voltage before compensation, Uo is the load voltage after compensation, Ui is the series injected voltage of the DVR, and I is the line current. The restorer typically consists of an injection transformer, the secondary winding of which is connected in series with the distribution line, a voltage-source PWM bridge inverter is connected to the primary of the injection transformer and an energy storage device is connected at the dc-link of the inverter bridge. The inverter bridge is filtered in order to mitigate the switching frequency harmonics generated in the inverter. The injection of an appropriate Voltage in the face of an up-stream voltage disturbance requires a certain amount of real and reactive power supply from the DVR. It is quite usual for the real power requirement of the DVR be provided by the energy storage device in the form of a battery, a capacitor bank, or a flywheel. The reactive power requirement is generated by the inverter.

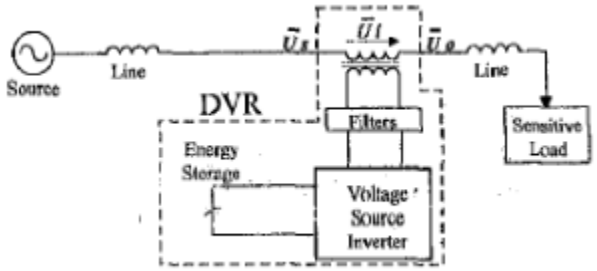

Fig1 DVR

2.0 SCOPE OF WORK

Power quality gains its importance with the introduction of sophisticated electrical gadgets. Nowadays, non-linear loads cause the distortion of sinusoidal waveform which adversely affect the power quality performance. Switching of heavy loads, capacitors, and transformers and unbalanced load on a three phase system are some of the sources that contribute to voltage sag. Due to these voltage sags, the performance and the life of the equipments deteriorate considerably. This calls for the introduction & usage of Custom Power devices (CPD) with philosophy of improvement of the power quality. As per the literature review, the DVR provides excellent voltage regulation capabilities in the influence of various power quality problems. The objective of the proposed dissertation is to

promise power quality & reliability in the distribution network with the simulation of various control strategies of DVR .The three control schemes namely PI Fuzzy PI-Fuzzy controllers provide almost equivalent compensation for linear loads but the difference in compensation occurs during non-linear loads. The capability of DVR control schemes is demonstrated using MATLAB/SIMULINK simulations. The Simulink models have been developed for the distribution networks with linear and non-linear loads. The effectiveness of PI controller based DVR, Fuzzy controller based DVR and hybrid PI Fuzzy controller based DVR in these distribution network is investigated.

3.0 MODELING AND SIMULATION

The main considerations for the control system of a DVR include: detection of the start and finish of the sag, voltage reference generation, transient and steady-state control of the injected voltage, and protection of the system. The control system was used to control the DVR with a sampling and switching frequency System performance is analyzed for compensating voltage sag with different DC storage capacity so as to achieve rated voltage at a given load. Various cases of different load condition are considered to study [4] the impact DC storage on sag compensation

have been compared on account of the amount of compensation being injected into the system under voltage sag condition for linear & nonlinear loads. The three

System Quantities Standards

1. Source 3 phase, = 25e3 KV, 50 Hz
2. Inverter Parameters = IGBT based, 3 arms, 6 pulse, Carrier frequency= 1080 Hz , Sample time = 50 μs
3. PID Controller (2)= Kp1=20, Ki1=154, Sample time = 50 μs Kp2=25, Ki2=260, K_d =.001 Sample time = 50 μs
4. RL load Active power= 1KW, Inductive Reactive power= 500 VAR
5. Two winding transformer= Yg/Δ, 11/11KV
6. Transmission Line Parameter R= .001omh, L= 5e-3H

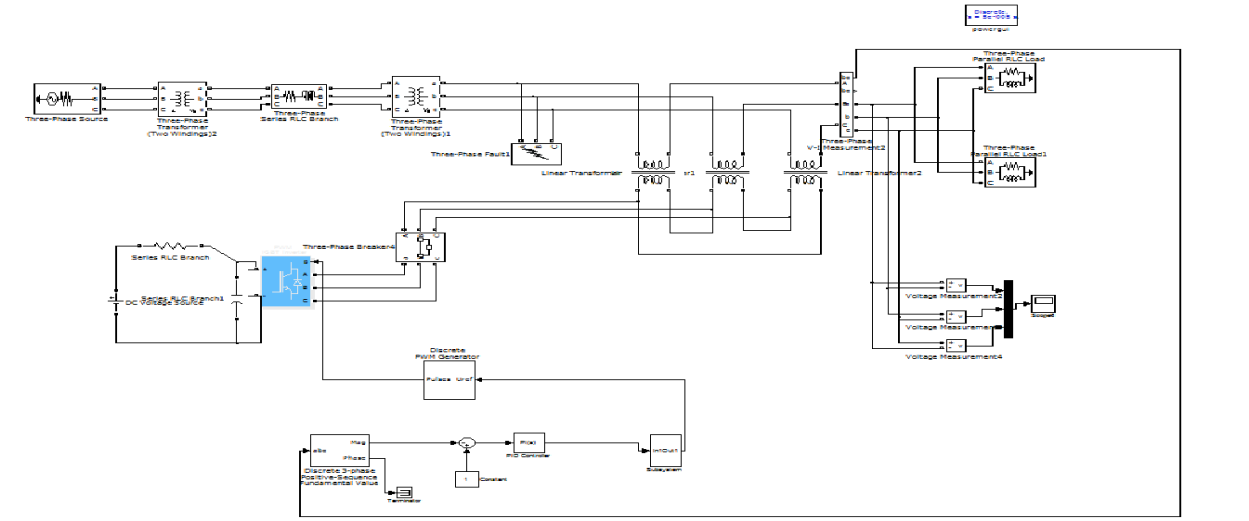

Fig 2 DVR SIMULATION

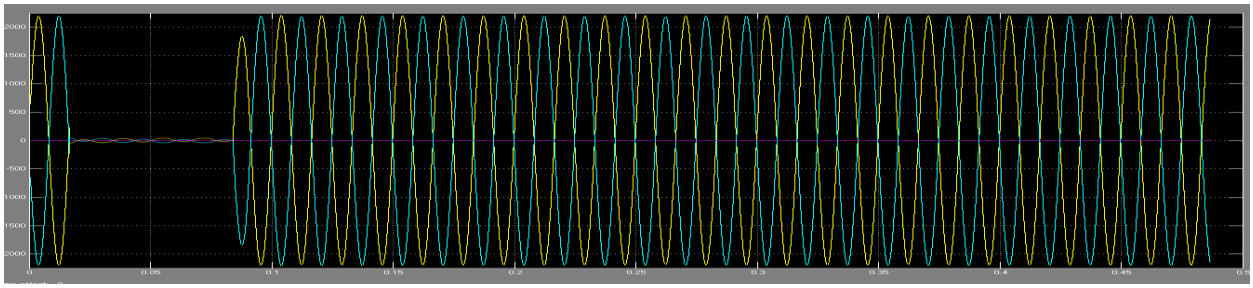

Fig 3 three phase output voltage without DVR

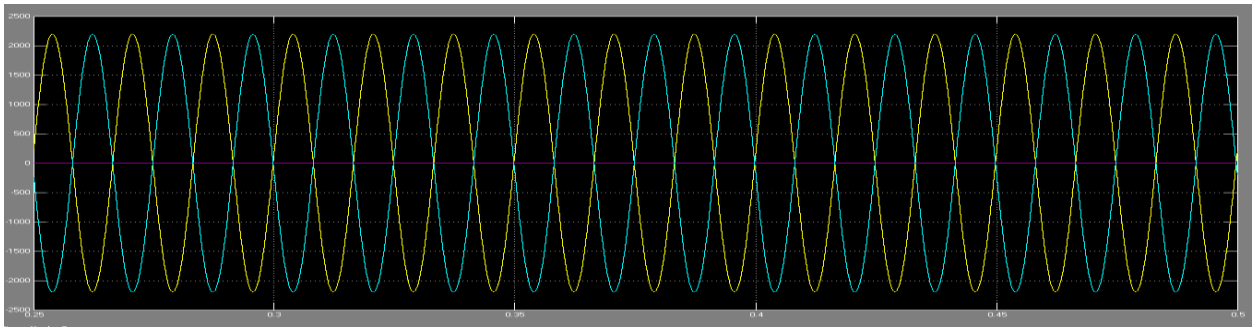

Fig 4 three phase output voltage with DVR

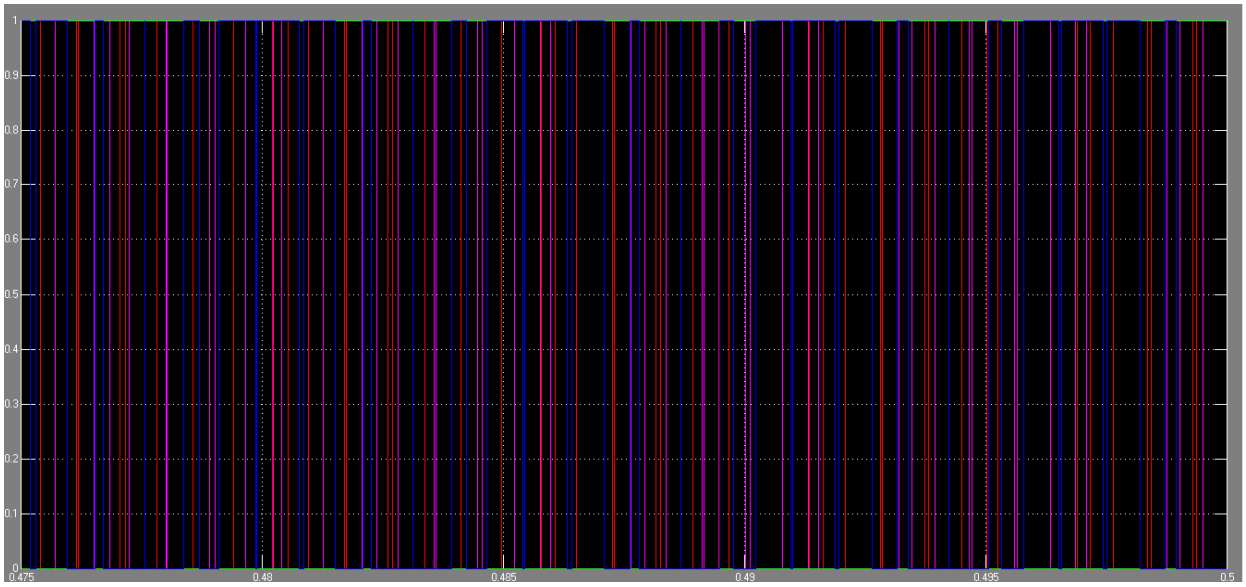

FIG 5 PWM

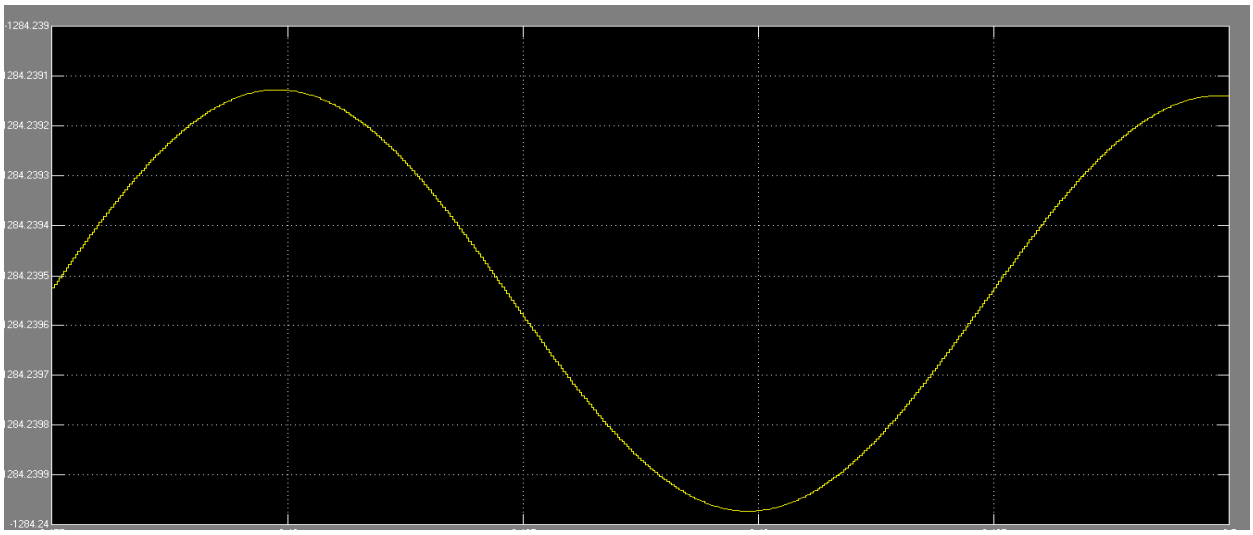

FIG 6 PI CONTROLLER OUTPUT

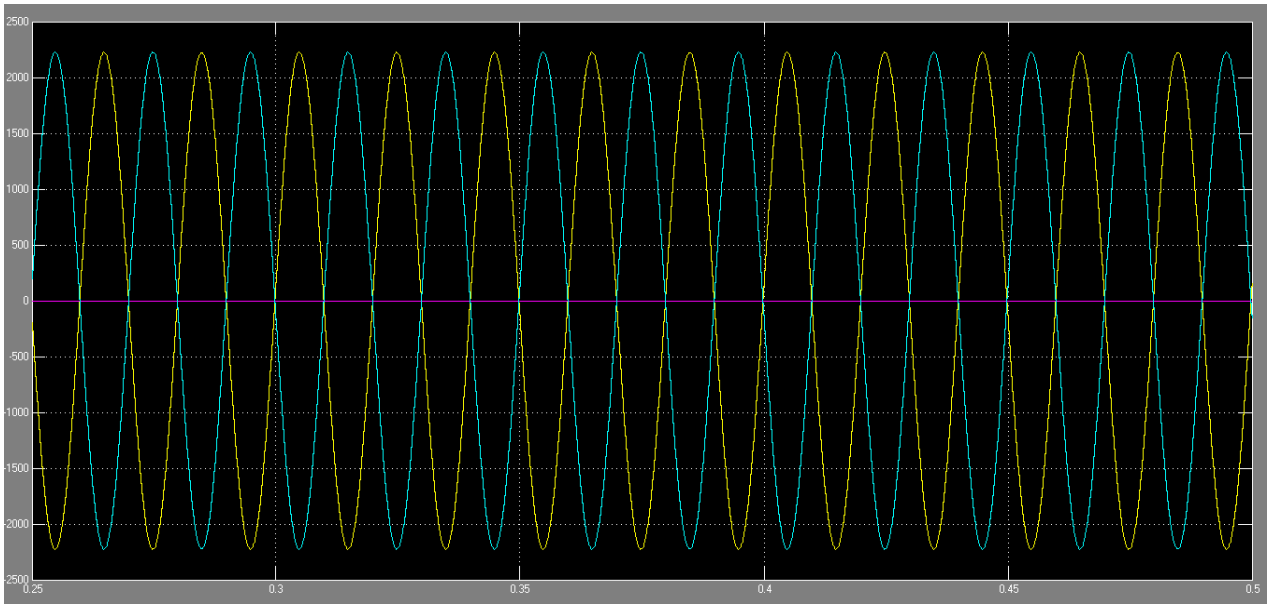

FIG 7 DVR OUTPUT 3 PAHSE LINE

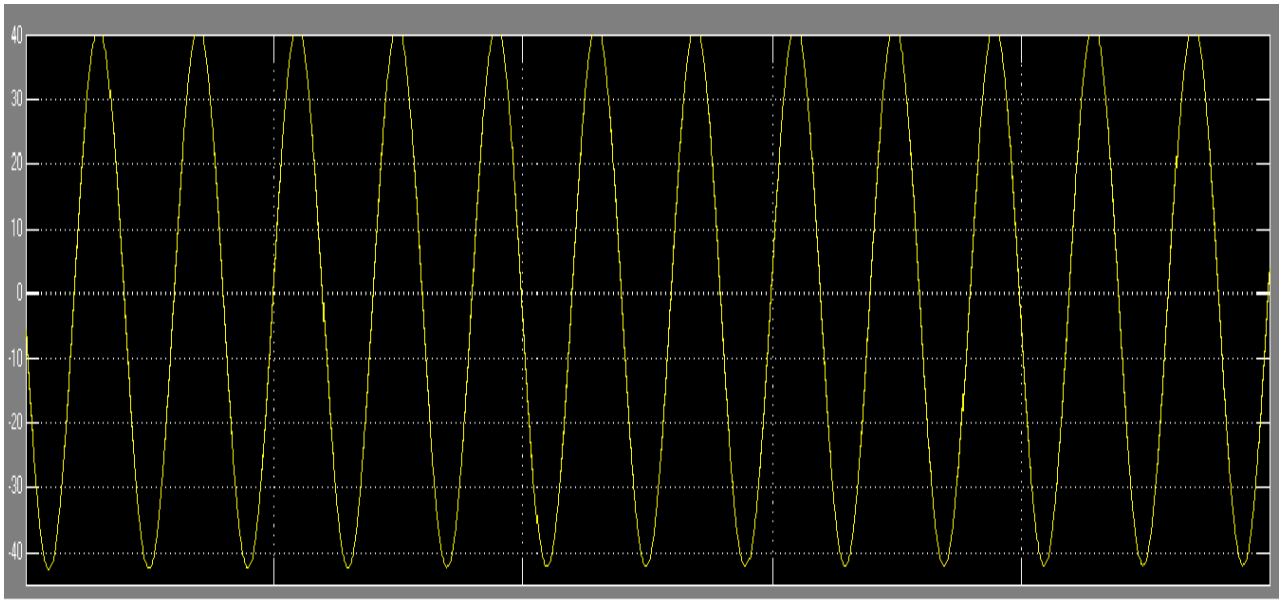

FIG 8 BUS OUTPUT VOLTAGE WITH DVR

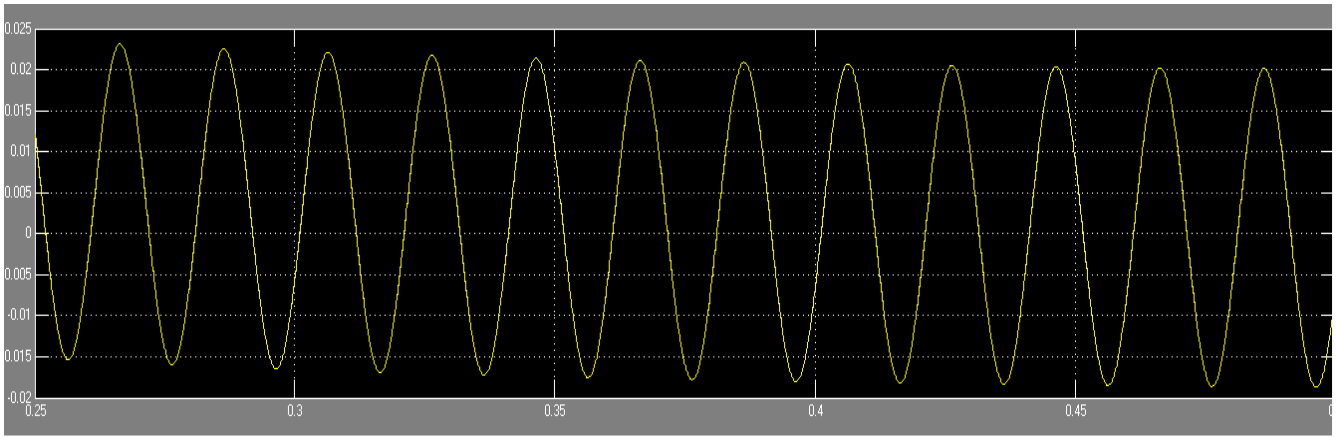

FIG 9 BUS OUTPUT VOLTAGE WITHOUT DVR

4.0 Conclusion

Based on this study, one of the methods to mitigate the voltage sag is by using dynamic voltage restorer system. In order to investigate whether the DVR is able to deal with this problem, Matlab Simulink was selected in order to simulate the system and mitigate the voltage sag. Based on the simulation that had been done, it can be proved that DVR is the dynamic fast response devices that able to overcome the devices. Even though the system cannot compensate 100 percent of voltage during sag, it is an acceptable because the output voltage after compensation still in range of the nominal value. The simulation was implemented by using the distribution network where the effectiveness of the DVR system is better compared to the transmission network. Since DVR is the custom power devices, there were so various combinations of main component that can be combined in order to get better results. For example, using GTO as a switching device, using SVPWM as the device for generating gating signal or maybe can use the other type of filter in order to eliminate the harmonics In this chapter, reviews of all the major research literatures, presented in the area of power quality improvements, are given. Further, power quality issues like voltage sag, swell and harmonics are also explained. It is clear that majority of the research works focus on voltage sag, harmonics and swell. However, the existing compensation devices have not focused on long voltage interruption problem and also the utilization of photovoltaic energy source. The compensating system with DVR does not compensate sustained interruption of power supply, rather it compensates short interruptions. The proposed system mitigates the power quality problems and thereby, provides effective solutions for the power quality issues. Potential mitigation of long voltage interruption and the provision of active power supply to the system are the major requirements. Consequently, there is a huge requirement

for fast response systems compared with the traditional methods. The proposed system improves considerably the power quality with respect to voltage sag, swell, harmonics and long voltage interruption.

a. Advantages

- DVR is mostly preferred because it is less expensive. If compared to DSTATCOM and UPS, DVR is a lot cheaper.
- UPS requires a lot of maintenance which may be due to problems of battery leakage and replacement. DVR is small in size and is a better power effective device as compared to others link UPS, SMES and DSTATCOM.
- SVC cannot control active power flow that creates a reason of preference for DVR in spite of the fact that SVC is better than DVR.

b. Limitations

- DVR has a limited current conduction and voltage injection capability which is due to such design of DVR to keep its cost low as well as to reduce the voltage drop across it in standby mode.

In order to reduce the cost of DVR, the energy storage size of DVR is kept low. Due to voltage dips, the stored energy can deplete fast and therefore to avoid load tripping due to insufficient stored energy, an adequate control is required.

This paper presents Compensation of Voltage Sag using Dynamic voltage restorers (DVR) . The power and voltage quality problems such as voltage sage, swells and others can also be solved effectively. Also an overview of dynamic voltage restorer (DVR) is presented. DVRs are effective recent custom power devices for voltage sags and swells compensation. They inject the appropriate voltage component to correct rapidly any anomaly in the supply voltage to keep the load voltage balanced and constant at the nominal value. The Dynamic Voltage Restorer (DVR) is considered to be an efficient solution due to its relatively low cost and small size; also it has a fast dynamic response show in fig 3 to 9

5.0 References

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