Mitigation of Voltage Sags using Ultra capacitor based Dynamic Voltage Restorer Using PI Control Scheme

Ms. Swati Rambhad[1], S.R. Deore[2]
[1]*Research Scholar, A.C. Patil College of Engineering*
[2]*Professor, A.C. Patil College of Engineering*

***Abstract*- The most severe power quality problems in electrical systems are called as voltage sag and swell. These power quality problems must be compensated accurately. There are two voltage injection strategies to inject controlled voltage via dynamic voltage restorer (DVR) in electrical systems Power Quality (PQ) is that the most vital views at transmission and distribution levels. The availability of high-grade electrical services needed to the purchasers illustrates this idea. The voltage sag and swell square measure the foremost frequent PQ issues that mainly occur within the distribution systems since it's going to cause equipment tripping, failure of drive systems, closure for domestic and industrial instrumentality. The Dynamic Voltage Restorer (DVR) connected nonparallel has splendid dynamic capabilities and is a versatile answer for PQ issues. Ultra-capacitors (UCAP) have ideal characteristics like high power and low energy density essential for the mitigation of voltage sag and swell. This paper presents AN increased DVR topology capable of delivering deep, extended mitigation for power quality issues. Within the planned DVR, UCAP is employed as energy storage because it provides excessive power in an exceedingly short interval of your time. The DVR is integrated into Ultra capacitor via bifacial DC-DC converter which supports in presenting a rigid dc-link voltage, and conjointly helps in compensating temporary voltage sag and voltage swell. PI Controller is employed in DVR for power quality improvement. The simulation model for the proposed system has been developed in MATLAB and therefore the performance over standard DVR is valid with the results obtained.**

***Index Terms*- Ultra-Capacitor (UCAP), DC-DC Converter, Sag/Swell, PI Controller, energy storage integration, phase locked loop (PLL).**

1. INTRODUCTION

The thought of PQ in utility facet has found to be acknowledged within the recent years. As a result of the continual growth of electric load and transfer of high regional power via an oversized interconnected network, the protection of installation could reduce and results in a push operation. It deals with a broad range of disturbances like harmonics, voltage sags, voltage swells, flicker, interruptions and different distortions [1], [2].Among this power quality issues voltage sag and swell square measure the foremost frequent issues within the distribution system. Voltage sag happens when the availability voltage drops with amplitude vary from 100 percent to ninetieth and last for a time period of [*fr1] a cycle to 1 minute. Or else, Voltage swell could occur once the unexpected rise of offer voltage with amplitude ranges from one hundred and tenth to 180% of its par value. A typical period of voltage sag and swell is ten ms to one minute consistent with IEEE 1159-1195 and IEEE 519-1992 standards. The mitigation may be through with a number of obtainable ways exploitation custom power devices such as DSTATCOM, DVR and UPFC [3]. Among the custom power devices, Dynamic Voltage Restorer (DVR) is employed because the most effective device to revive the quality of voltage. The system configurations and analysis reveals the operative performance of

Dynamic Voltage Restorer. The voltage capability of DVR depends on the ability of most voltage injection. Another answer proposed in DVR to make amends for the voltage sag that is done by injecting an insolent voltage in construction with the road current. In the recent past, the value of the reversible energy storage has been drastically decreasing as a result of varied developments in technologies like the star, wind, hybrid electric vehicles (HEVs). varied sorts of reversible energy storage technologies supported flywheels (FESS), batteries (BESS), Superconducting magnets (SMEs) and Ultra capacitors (UCAPs) square measure designed for integration into advanced power applications like

DVR. There has been improved interest to integrate reversible energy storage at the dc-terminal of power quality merchandise like STATCOM and DVR is addressed. Matrix devise primarily based DVR is given in where there's no demand for energy storage device for emergency purpose of the grid however it suffers from drawbacks like high price, high energy demand and in H-bridge with cascaded affiliation in DVR with associate degree inductor controlled by thruster is introduced to reduce the necessity of energy storage. Ultra-capacitors square measure best fitted to many applications among different energy storage technologies which need active power support within the vary of milliseconds to second spacing.

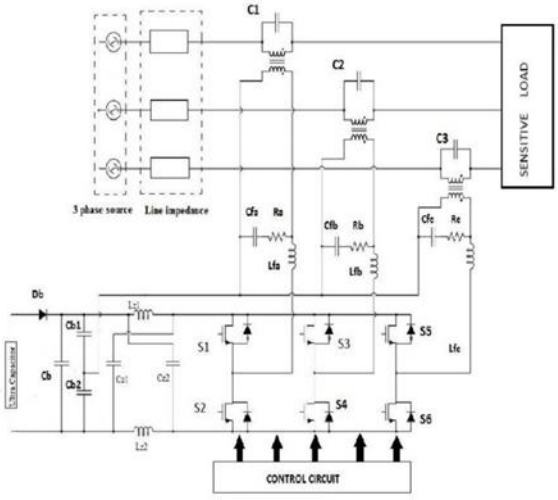

Figure 1 Block diagram of DVR using supercapacitor

The DVR consists of mainly a 3- source converter, passive filter and a control system to regulate the output voltage of VSC. The output from the super capacitor which is DC voltage is fed into the z-source converter which works either as boost or buck operation and the output from the source inverter is fed to the distribution line through the injection transformer as shown in the Figure 1. It is used to isolate the load from the system. PI controller compares the reference voltage and the line voltage to produce the error signal. Based on the error signal, the controller produces the pulses. These switching pulses are fed to the z-source converter to produce 3 phase voltage for injection into distribution line.

II.IN-PHASE VOLTAGE COMPENSATION METHOD

In general, there are three techniques such as presag, in-phase and minimal energy injection techniques are utilized to calculate the injection voltage of DVR. In this paper, in-phase compensation technique is used to calculate the injection voltage of DVR due to its simple implementation and fast response in calculating the compensating voltage. A DVR can compensate the voltage drop across a load by injecting a voltage through a series injection transformer in-phase with the source voltage [21]. The injected voltage across the secondary of the series injection transformer is in-phase with supply voltage, as shown in Fig. 2.

In normal condition, the supply voltage (Vpresag) is equal to the load voltage with zero phase angle. During the voltage sag/swell, the supply voltage decreases or increases to a value less than or greater than its nominal value. The DVR reacts to the sag/swell events and injects the compensating voltage Vinj in-phase with the supply voltage to restore the voltage at nominal value.

The injected voltage of a DVR (Vinj) can be expressed as

$$|V_{inj}| = |V_{presag}| - |V_{sag}| \quad (1)$$

$$V_{DVR} = V_{inj} \quad (2)$$

$$|V_{DVR}| = |V_{presag}| - |V_{sag}| \quad (3)$$

The angle of the injected voltage can be calculated as follows:

$$\angle V_{inj} = \theta_{inj} = \theta_s \quad (4)$$

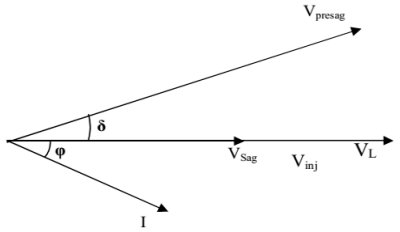

Figure .2 In–Phase compensation

III. CONTROL OF DVR

Voltage sag is created at load terminal via a three-phase fault. Load voltage is sensed and passed through a sequence analyzer. The magnitude

component is compared with reference voltage (Vref). Pulse width modulation (PWM) control technique is applied for inverter switching to produce a three-phase 50 Hz sinusoidal voltage at load terminals. Chopping frequency is in the range of few KHz. The IGBT inverter is controlled with PI controller in order to maintain 1 per unit voltage at the load terminals.

PI controller is a closed loop controller, which drives the plant to be controlled with a weighted sum of the error and the integral of that value. An advantage of a proportional plus integral controller is that the integral term in a PI controller causes the steady state error to be zero for a step input. PI input is an actuating signal which is the difference between the Vref and Vin output of the controller which is shown in Fig. 3.

Output of comparator=V_{ref}-V_{in}
V_{ref} - Equal to Base voltage
V_{in} – Voltage in pu at the load terminals (5)

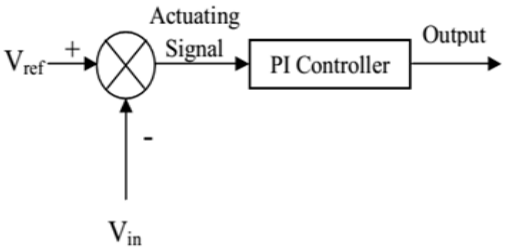

Figure 3 PI Controller

The modulated signal Vinv_ref is compared against a triangular signal in order to generate the switching signals for the VSC valves as shown in Fig. 4. The main parameters of the sinusoidal PWM scheme are the amplitude modulation index of signal and the frequency modulation index of the triangular signal. The VSC switching strategy is based on PWM techniques that offer simplicity and good response. During sag condition, the correct voltage must be injected so that the load voltage become normal again

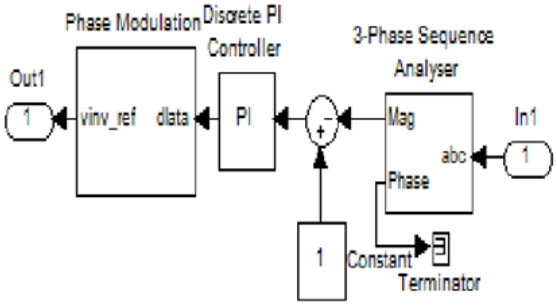

Figure. 4 Simulink model of PI controller

IV. SIMULATION RESULTS AND DISCUSSION

In the distribution line, due to fault occurrence or increase in the load, voltage distortion takes place. This was avoided by using z source inverter based DVR using super capacitor as an energy storage device as shown in the Figure 5. During fault occurrence time 0.2 sec, the DVR get activated and injects voltage of distorted voltage. This range of distortion was detected by voltage for sag detection or swell detection. With the help of PI controller, the voltage distortion was compensated. The fault gets cleared at 0.3 sec, and then the DVR get deactivated

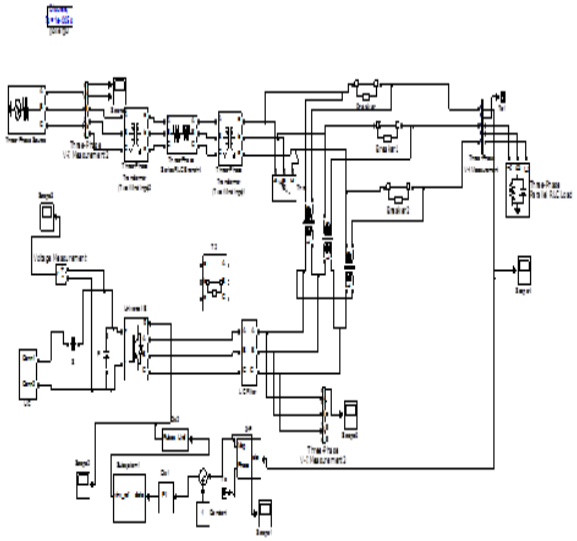

Figure 5 Closed loop simulation circuit

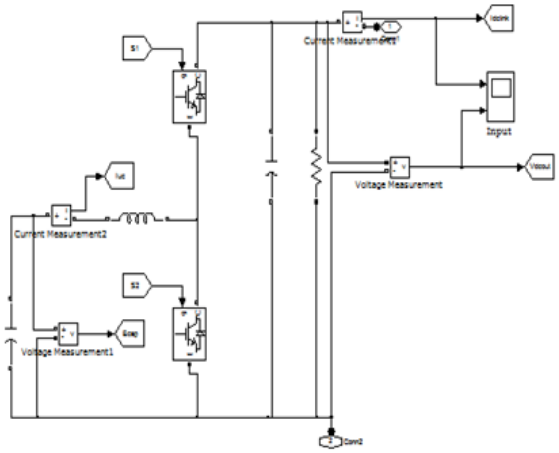

Figure 6 Sub system of super capacitor

The super capacitor is used to produce dc output which is the input to the z source inverter and produces 3 phase output voltage; it has to beinjected by DVR for compensation of distorted voltage as shown in the Figure 6. The converter which injects

the 3 phase voltage to the distribution line at the time of fault or due to addition of loads. The input to the vsc-source inverter is obtained from the super capacitor. The filter circuit has been simulated in MATLAB. It helps to reduce the harmonics in the injecting voltage which is obtained from the z-source inverter. the controller which produces the pulses to the switches used in the z source converter .This compares the reference voltage with the distribution line voltage, if there is any error in it; they produce signals which are helpful in the production of pulsesThe VSC boosts the voltage from the super capacitor and helps to produce 3 phase voltage which is injected into the distribution system. Hence the distorted voltage is compensated when fault occurs. The supply voltage is but due to the addition of another load, voltage gets dipped to at a period of 0.15 sec. DVR gets activated and the voltage is injected into the system to compensate the sag and DVR gets deactivated when the load is removed at the time period of 0.25 sec as shown in the Figure 7

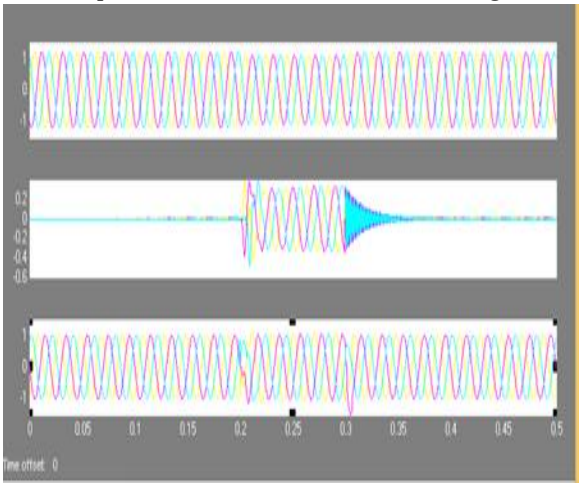

Figure 7. Simulation result for three phase voltage sag compensation using DVR

V. CONCLUSION

A new approach was projected to boost the voltage profile of distribution installation. The projected model is provided with DVR as an acceptable FACTS device and UCAP as speedy energy storage system. The look and modeling of bifacial DC-DC device were mentioned as UCAP cannot be directly connected to the dc-link of the DVR. The UCAP plays terribly important} role; since they'll give very high power in an exceedingly short length of your time and to explore the practicableness and stability of the energy storage system for up the electric power quality and this can be an inexpensive answer to determination PQ problems within the distribution grid. Simulation result shows that the projected DVR give compensation in economical and deep manner. The results that obtained are compared with conventional DVR in terms of ThD. UCAP based mostly energy storage can be adopted within the future on varied distribution grid so as to prevent sensitive hundreds from disturbances.

REFERENCES

[1] M. H. J. Bollen, “Understanding Power Quality issues,” Piscataway, NJ, USA: IEEE, 2000.

[2] Norbert EDOMAH, 2009, “Effects of Voltage Sags, Swell and different disturbances on Electrical instrumentality and their Economic Implications,” twentieth International Conference on Electricity Distribution, Prague.

[3] A. Ghosh and G. Ledwich, “Power Quality sweetening Using Custom Power Devices,”London, U.K.: Kluwer, 2002.

[4] C. Benachaiba, and B. Ferdi “Power quality improvement using DVR”, yankee Journal of Applied Sciences 6(3): 396-400, 2009.

[5] H.Igarashi and H. Akagi, “System Configurations and operating performance of a dynamic voltage trained worker,” IEEE Trans. Ind. Appl., vol. 123-D no. 9, pp. 1021-1028, 2003. Uncompensated standard integrated UCAPDVR % THD SYSTEMS.

[6] D. M. Vilathgamuwa, A. A. D. R. Perera, and S. S. Choi, “Voltage sag compensation with energy optimized dynamic voltage trained worker,” IEEE Trans. OnPower Delivery, vol. 18, no. 3, pp. 928-936, Jul.

[7] D. M. Vilathgamuwa, A. A. D. R. Perera, and S. S. Choi, “Voltage sag compensation with energy optimized dynamic voltage trained worker,” IEEE Trans. OnPowe Delivery, vol. 18, no. 3, pp. 928-936, Jul. 2003.

[8] Jing Shi, Yuejin Tang, Kai Yang, Lei Chen, Li Ren, Jingdong Li, and Shijie Cheng, “SMES primarily based Dynamic Voltage RestorerforVoltage Fluctuations Compensation,”

IEEE transactions on applied electrical conduction, vol. 20, no. 3, June 2010.

[9] Ali Yazdanpanah Goharrizi, Seyed Hossein Hosseini, Mehran Sabahi, and Gevorg B. Gharehpetian, "Three-Phase HFLDVR With severally Controlled Phases," IEEE transactions on power physics, vol. 27, no. 4, April 2012.

[10] Pychadathil Jayaprakash, Bhim Singh, D. P. Kothari, Ambrish Chandra, and Kamal Al-Haddad, "Control of Reduced-Rating Dynamic Voltage trained worker With A battery Energy Storage System," IEEE transactions on trade applications, vol. 50, no. 2, March/April 2014.

[11] A. B. Arsoy, Y. Liu, P. F. Ribeiro and F. Wang, "StatCom- SMES," IEEE Ind. Appl. Mag., vol. 9, no. 2, pp. 21-28, Mar. 2003 III. IN-PHASE VOLTAGE COMPENSATION