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Simulation of DVR for power Quality Improvement by Using Ultra Capacitor

Pravin Gajanan Bhende[1], Mr.Saurabh H.Thakare[2], Dr.Vijay.G.Neve[3]

[1]P.G. Student, Department of Electrical Engineering ,Padm.Dr.V.B.Kolte COE,Malkapur,M.S., India
[2]Asst.Professor, Department of Electrical Engineering ,Padm.Dr.V.B.Kolte COE,Malkapur,M.S., India
[3]HOD, Department of Electrical Engineering ,Jagadambha COE & Technology,Yavatmal,M.S., India

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Abstract- *Recently power quality is the major important issue. The quality of the power may be improved by using power conditioning equipment. To protect sensitive load from the effect of voltage disturbance on the distribution feeder the Dynamic voltage restorers (DVR) are used. Three phase controllable voltage source is feed by DVR which is basically a power electronic based device during sag event. The DVR connected in series has massive dynamic capability and it is a reliable solution for PQ problems. Within few milliseconds DVR can restore the load voltage. Ultra capacitors (UCAP) have typical characteristics such as low energy density and high power density for the mitigation of voltage sag and swell. This paper presents an enhance DVR topology suitable for delivering extended mitigation for PQ problems. In the proposed DVR, Ultra-Capacitor is used as an energy storage device as it provides extravagant power in a short interval of time. This paper presents modeling and simulation of a DVR for power quality problems. All the simulation work is done in MATLAB software. On observing the results we conclude that DVR is the one of best device to mitigate the Power quality problems.*

Key words: **Dynamic Voltage Restorer (DVR), voltage sag/swell, Ultra-capacitor (UCAP), PI controller.**

I.INTRODUCTION

In the recent years, the concept of PQ in utility side has found to be major factor. Due to the continuous growth of electric load and transfer power via a large interconnected network, the security of power system may reduce and leads to a complex operation. It deals with disturbances such as voltage sags, voltage swells, harmonics, flicker, interruptions. Among these in distribution system voltage sag and swell are the most frequent power quality problems. Voltage swell may occur when the sudden rise of supply voltage with amplitude ranges from 110% to 180% of its rated value. Alternatively, Voltage sag occurs when the supply voltage drops with amplitude varies from 10% to 90% and lasts for time duration of half cycle to one minute.10ms to 1min is the standard typical duration of voltage sag and swell according to IEEE 1159-1195 and IEEE 519-1992 standards. The mitigation can be done with a number of custom power devices available each with its own benefits and limitations. Distribution-STATCOM (DSTATCOM), Uninterruptible Power Supply (UPS), Static VAR Compensator (SVC), Battery Energy Storage Systems (BESS), Unified Power Quality Conditioner (UPQC) and Dynamic Voltage Restorer (DVR). DVR also has added features such as compensation of harmonic and reactive power.

Operating principle of DVR is voltage stabilization by connecting a series voltage source between the source and sensitive load. DVR is one of the most common series compensation devices, which is connected to the ac network through injection transformer. During abnormal conditions in distribution systems this is used to protect against voltage sag and swells. The control scheme must be able to restore sensitive load voltage to its ideal state value. Control and performance of the DVR with various control techniques have been studied by researchers. Mostly proportional-integral (PI) controller is used in a synchronous machines for voltage compensation. This approach is enough to enable voltage sag compensation. Ultra-capacitor required neither cooling nor heating system and there is no moving part this is the best advantages of Ultra-capacitor in application point of view and also there is no any internal chemical changes. In addition, no frequent maintenance is required with reduction in lifetime degradation due to deep cycling and they are very efficient and robust.

This paper presents the integration of UCAP based DVR since DVR can supply only limited amount of real power and is not able to compensate for higher values of PQ problems. UCAPs have high power density and low energy density ideal characteristics for effective compensation of PQ problems such as voltage sag and voltage swell investigating the high quality of power in the distributed power generation.

II. Model of Dynamic Voltage restorer (DVR)

The DVR (Dynamic Voltage Restorer) model is shown in Fig. 1.Itconsists of the Insulated gate bipolar transistor (IGBT), its gate driver, filter circuit consists of the inductance and capacitor and an isolation transformer.

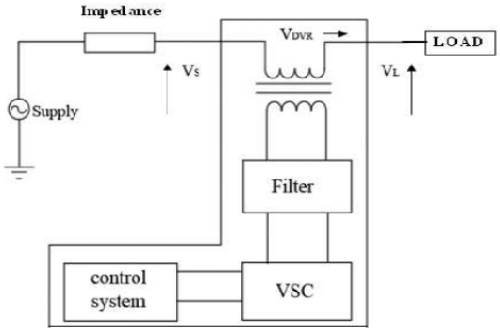

Fig- 1: Model of DVR

The key purpose of a DVR is the protection of sensitive loads from power quality problems such as voltage sag and swell. If a fault arises on the transmission lines, DVR injects a series voltage and pre-fault value is obtained by compensating the load voltage. The injected voltage of the DVR connected in series can be written as

$$V_{DVR}=V_{load}+Z_{TH}I_L-V_{TH} \qquad (1)$$

Where, V_{load} is the required load voltage magnitude, Z_{TH} is the load impedance, I_L is the load current and V_{TH} is the source voltage during sag and swell condition.

The load current can be calculated by given formula,

$$I_L=\frac{Pl+jQl}{Vl} \qquad (2)$$

In order to provide dynamic voltage restoration, there are various methods available to control the inverter connected in series. The control method requires the use of the proportional and integral controller. The output signal of the PI controller is directly proportional to the sequence of measured actuating error signal and its time. The transfer function is given by,

$$\text{Transfer Function}=(K1/s)+KP$$

Power quality problem includes voltage sag and swell are generated at the load terminals by inducing the fault. The sensing of load voltage takes place and is passed through the sequence analyzer and its amplitude is compared with a reference voltage (Vref). In order to maintain the base voltage across the load terminals, the IGBT inverter is controlled by using PI controller. Using DVR, the compensation is achieved by either injecting or absorbing the real and reactive power into the system. The main disadvantage of DVR states that it can supply only limited amount of real power during compensation. For effective compensation to take place, DVR can be connected through the energy storage device.

III. ULTRA-CAPACITOR (UCAP)

The specifics of ultra capacitor construction are dependent on the application and use of the ultra capacitor. The materials may differ slightly from manufacturer or due to specific application needs. The ultra capacitor is consist of a positive electrode, a negative electrode and separator between these two electrodes. The assembly of the ultra capacitors can vary from product to product. This is due in part to the geometry of the ultra capacitor packaging. UCAP can be divided into three categories according to the energy storage mechanism namely Double-Layer Capacitor, organic polymer electrode Ultra-capacitor and metal oxide super capacitor. Double layer Capacitor is shown in following Fig-2.

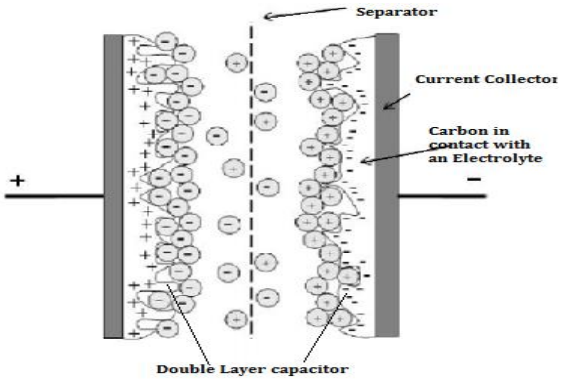

Fig- 2: Ultra-Capacitor Model

While charging, the Positive attracts electrolyte anion and negative attracts cation. When discharging, it can release all stored energy instantly. UCAP is mainly suitable for short term high power application.

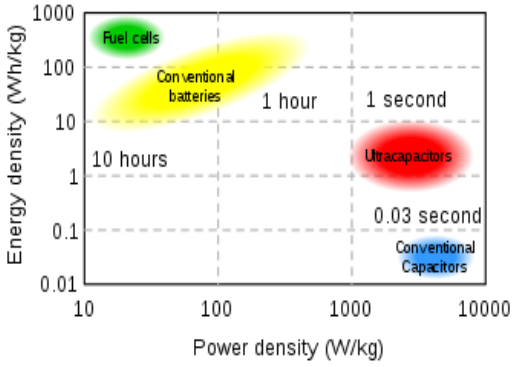

Fig- 3: Graph of Densities of UCAP

Above Fig-3 shows the two densities of Ultra-Capacitor. It is clear that Ultra-capacitors has more energy density than conventional capacitors and less power density than conventional capacitors.

IV.PROPOSED WORK DIAGRAM

The block diagram of the integrated UCAP-DVR system is shown in Fig.4. It consists of three phase series inverter, a bidirectional DC-DC converter connected with UCAP energy storage device and three phase isolation transformer connected to distribution Grid. The three phase supply voltage of 415 V,50 Hz is connected to the sensitive load of 15Ω via line impedance.

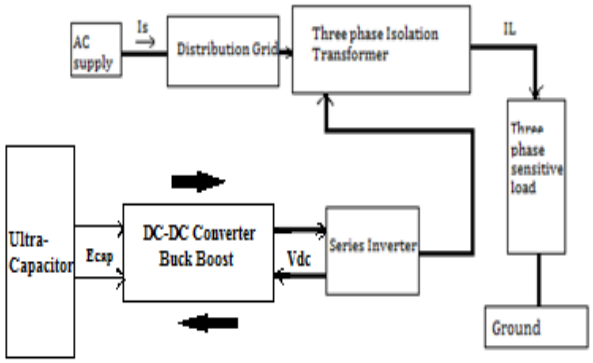

Fig- 4: Block diagram of Integrated UCAP-DVR

The three phase voltage source inverter which acts as a power stage is connected in series to the grid and is responsible for the voltage sag and swell compensation. The energy storage device UCAP is not connected directly to the inverter circuit because to maintain stiff Dc voltage to the inverter.

V. SIMULATION/EXPERIMENTS RESULTS

The simulation of the integrated UCAP-DVR with DC-DC converter is carried out in MATLAB/Simulink for a 415 V, 50Hz system. Fig.5(a) shows the simulation model of three phase DVR Circuit with DC-DC converter and three phase RL load are connected. Between supply and load an injection transformer having 1:1 turn's ratio is connected. Primary of transformer is connected in series with load, while its secondary is connected to the inverter circuit. Three VI measurements are connected at source side, load side and DVR side, so that these voltages are used to see the waveforms on scope and

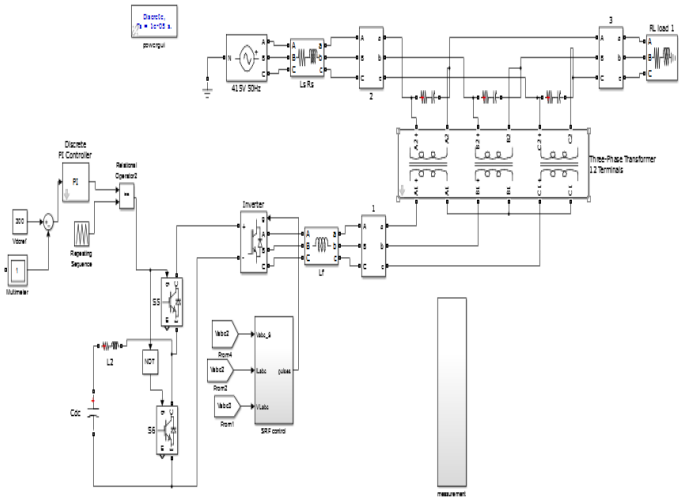

Fig.5(a): Simulation model of Three phase DVR

Fig.5(b) show the main measurement block of the model. A UCAP is connected which act a as input to the bidirectional DC-DC converter. Voltage of the DC storage device is 300volts. SPWM control technique is used in the DVR.

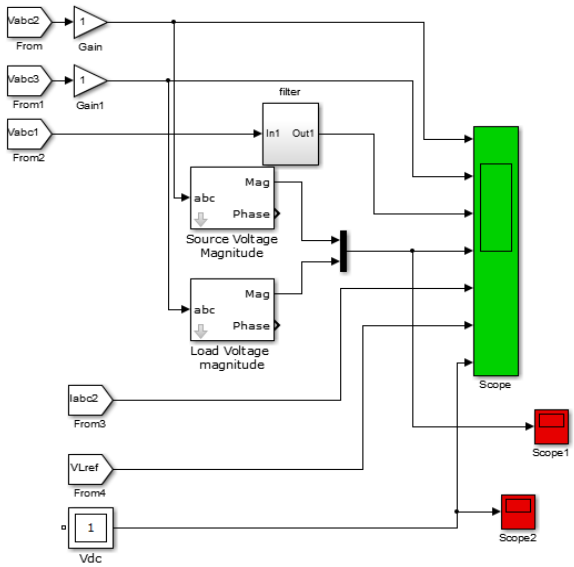

Fig.5(b): Measurement Block of Three phase DVR

When three phase line to line fault is applied on transmission line. Then load side voltage is reduced i.e. generation of sag .Here applying fault for the duration of 0.1s o 0.2s time period for the creation of Voltage sag as shown in Fig.6.(a). Now DVR will be suddenly connected in milliseconds to compensate load voltage and it injects the required voltage, to get constant load voltage on load side as shown in Fig.6 (b) &(c).

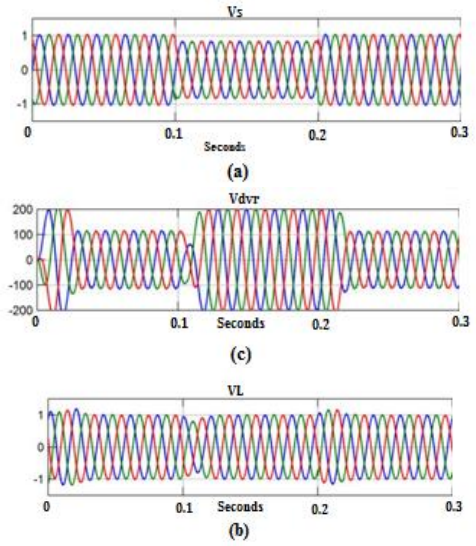

Fig.6.(a): Three phase Source Voltage during fault (Sag) (b) Compensated Load voltage, (c) Injected DVR voltage

The injected voltage of the series inverter for the voltage swell is shown on Fig.7(b). Fig.7(c). represents the compensated voltage swell event. Thus, the voltage sag and swell problems are compensated effectively by the use of Integrated of UCAP with DVR connected via bidirectional DC-DC converter.

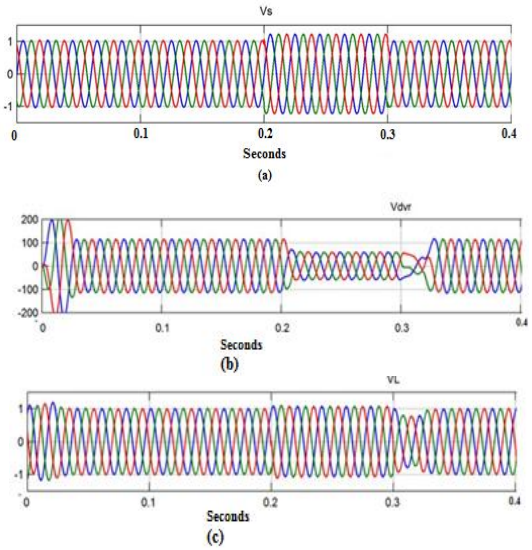

Fig.7.(a): Three phase Source Voltage during fault (Swell) (b) Compensated Load voltage, (c) Injected DVR voltage

Here UCAP-DVR absorbed the active power from the grid during voltage swell event through the bidirectional converter and the inverter. It can be observed that, the magnitude of the source voltage is reduced due to the injected voltage, but the load voltage remains constant and thus the voltage sag event can be compensated. Similarly, the magnitude of source voltage has increased due to the injected voltage, but the load voltage remains constant and thus the voltage swell can be compensated.

VI. CONCLUSION

A new approach was proposed in this paper to improve the power quality of distribution power system. As DVR is a FACTS device and DVR is energy storage device, so the proposed model is equipped with DVR as a suitable FACTS device and UCAP as rapid energy storage system. As UCAP cannot be directly connected to the dc-link of the DVR so design and modeling of bidirectional DC-DC converter were discussed. The UCAP plays an important role; since they can provide very high power in a short duration of time and to explore the feasibility and stability of the energy storage system for improving the electric power quality and this is a cheap solution of solving PQ problems in the distribution grid. Simulation result shows that the proposed DVR provide compensation in efficient and deep manner. The UCAP based energy storage can be adopted in the future on various distribution grid in order to prevent sensitive loads from disturbances.

VII.REFERENCES

[1]. Mahmoud A. El-Gammal "Dynamic Voltage Restorer (DVR) for Voltage Sag Mitigation" in International Journal on Electrical Engineering and Informatics, Vol- 3, no.-1, 2011.

[2].R. J. Satputaley," Hardware Enactment for Sagacious CompensationbySingle Phase Dynamic Voltage Restorer",Asian Power Electronics Journal, Vol. 8, No. 2, Nov 2014.

[3].J.Mangalanathan," Hardware Implementation of Single Phase Dynamic Voltage Restorer in Mitigating Voltage Sag & Swell", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 3, May 2014.

[4].T.Sundar," Simulation and Investigation of Prototype DVRfor Power Flow Control", 2013 International Conference on Renewable Energyand Sustainable Energy.

[5].Deepa Francis," Mitigation of Voltage Sag and Swell Using Dynamic Voltage Restorer", International Conference on Magnetics, Machines & Drives (AICERA-2014 iCMMD).

[6]. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty, "Electrical Power Systems Quality," Tata McGraw Hills publications, 3rd Edition 2012.

[7].Venmathi M. and Ramesh L., "The impact of Dynamic Voltage Restorer on voltage sag mitigation," Sustainable Energy and Intelligent Systems (SEISCON 2012), IET Chennai 3rd International on, pp.1-7, 27-29 Dec. 2012.

[8].Benachaiba C. and Ferdi B., "Power Quality Improvement Using DVR," American Journal of Applied Sciences, vol. 6, no. 3, pp. 396-400, 2009.

[9].Omar R. and Rahim N.A., "Modeling and simulation for voltage sags/swells mitigation using dynamic voltage restorer (DVR)," Power Engineering Conference, 2008. AUPEC '08. Australasian Universities, vol. 1, no. 5, pp. 14-17, Dec. 2008.

[10]. O. Anaya-Lara and Acha E., "Modeling and analysis of custom power systems by PSCAD/EMTDC," IEEE Trans. Power Delivery, vol. 17, no.1, pp. 266-272, January 2002.

[11]. Ghosh A. and Ledwich G. F., "Power Quality enhancement Using Custom Power Devices," Kluwer Academic Publishers, 2002.

[12].Pal Y., Swarup A. and Singh B., "A Review of Compensating Type Custom Power Devices for Power Quality Improvement," Power System Technology and Power India Conference, IEEE, (POWERCON),vol.1, no.8, pp.12-15, Oct. 2008.

[13].Chang C.S., Ho Y.S. and Loh P.C., "Voltage quality enhancement with power electronics based devices," Power Engineering Society Winter Meeting, IEEE , vol.4, pp.2937-2942 , 2000.

[14]. Ghosh A. and Ledwich G., "Compensation of distribution system voltage using DVR," Power Delivery, IEEE Transactions on, vol.17, no.4, pp.1030-1036, Oct 2002.

[15].Posad C.J., Ramirez J.M and Correa R.E., "Voltage compensation for common disturbances at the distribution level," Innovative Smart Grid Technologies (ISGT Latin America), IEEE PES Conference onpp.1-6, 19-21 Oct. 2011.