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A Review on Power Quality Improvement of Distribution Networks Using Dynamic Voltage Restorer

Mohit Srivastava[1], Rakesh Sharma[2]

PG Student [PS&C], Dept. of EE, Babu Banarasi Das University, Lucknow, Uttar Pradesh, India[1]

Assistant Professor, Dept. of EE, Babu Banarasi Das University, Lucknow, Uttar Pradesh, India[2]

ABSTRACT: Power quality has become one of the most specific problems for power companies since last two decades. It is a bunches of concept for a gravity of various types of power system disturbances. A regular increment in the application of power electronics devices such as high-efficiency, ASD and shunt capacitors for power factor correction to reduce losses. This gives the increased harmonics level on power systems, It is very important issue of power quality. Power quality issue is as an unbalance voltage, frequency, current that causes in failure of custom ends equipment. One of the major concerns is the voltage sag. The delicate industrial loads and utility distribution networks all suffer from different types of outages and interruptions which may result in a huge amount of economic loss. To overcome the power quality problem of the system, FACTS devices are used. Like SVR, SSSC, STATCOM, D-STATCOM and TSC, DVR. One of the FACTS device considered in this work is DVR. This review paper presents mathematical modelling, of a Dynamic Voltage Restorer (DVR) systems using MATLAB Simulink. In this paper, PI controller and Discrete PWM pulse generator are used for the controlling purpose of the system. Here, various methods are used to control of the DVR system. The importance of DVR to compensate custom end voltage is investigated during the various fault conditions like voltage sag, swell, single phase to ground, double phase to ground faults. In this paper I am going to use voltage injection method to control DVR system. In this way, the application of DVR to compensate the problem of starting voltage dip for induction motor is also probe.

KEYWORDS: Dynamic Voltage Restorer (DVR), Point of Common Coupling (PCC), Voltage Source Inverter (VSI), Phase Lock Loop (PLL), Adjustable Speed Drive (ASD).

I.INTRODUCTION

Power quality problems encompass a wide range of disturbances such as voltage sags/swells, flicker, harmonic distortion, impulse transients, and interruptions. Although the impact of these disturbances causes minimal financial impact in residential areas, this is not the case for industries that are heavily automated. A brief disturbance in the form of voltage sag can cause the failure or malfunction of a continuous process and heavy financial losses may then incur [1].

Voltage sags and swells have been one of the most important power quality problems. Voltage sag is a momentary decrease in the rms voltage magnitude lasting between half a cycles to few cycles. Voltage fluctuations, sags and swells interrupting and disturbing the sensitive manufacturing processes [3].

It reports practical test results obtained on a medium voltage (10 kV) level using a DVR at a Distribution test facility in Kyndby, Denmark. The reported DVR uses a combined feed-forward and feed-back controller to obtain both good transient and steady-state responses. The controller also incorporates transformer saturation limitation controllers to limit the inverter current at the start of the sag injection, also allowing high utilization of the transformer capacity without an over-current fault occurring in the inverter. The effect of the DVR on the system is experimentally investigated under both faulted and non-faulted system states, for a variety of linear and nonlinear loads. This is important as a majority of the time the DVR will be connected, but not compensating and it should be designed to have minimal effect on the system during these times [2].

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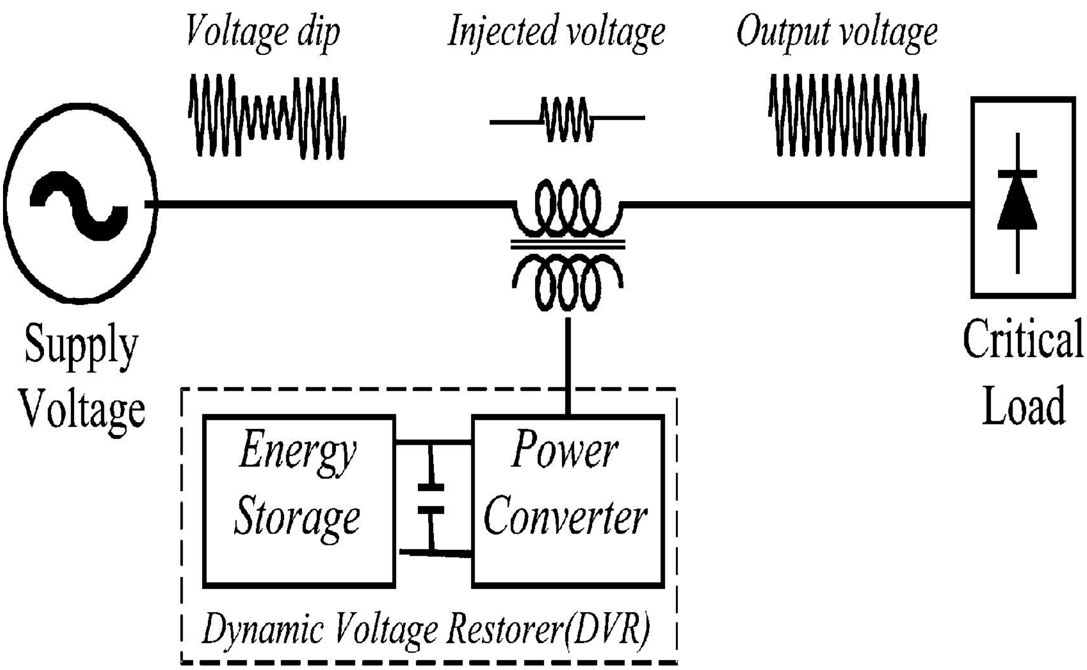

Fig. 1. Dynamic voltage restorer operation.

II. EQUIVALENT CIRCUIT OF DVR

The DVR has two modes of operation which are: standby mode and boost mode. In standby mode ($VDVR$=0), the booster transformer's low voltage winding is shorted through the converter. No switching of semiconductors occurs in this mode of operation, because the individual converter legs are triggered such as to establish a short-circuit path for the transformer connection. Therefore, only the comparatively low conduction losses of the semiconductors in this current loop contribute to the losses. The DVR will be most of the time in this mode. In boost mode ($VDVR$>0), the DVR is injecting a compensation voltage through the booster transformer due to a detection of a supply voltage disturbance [5].

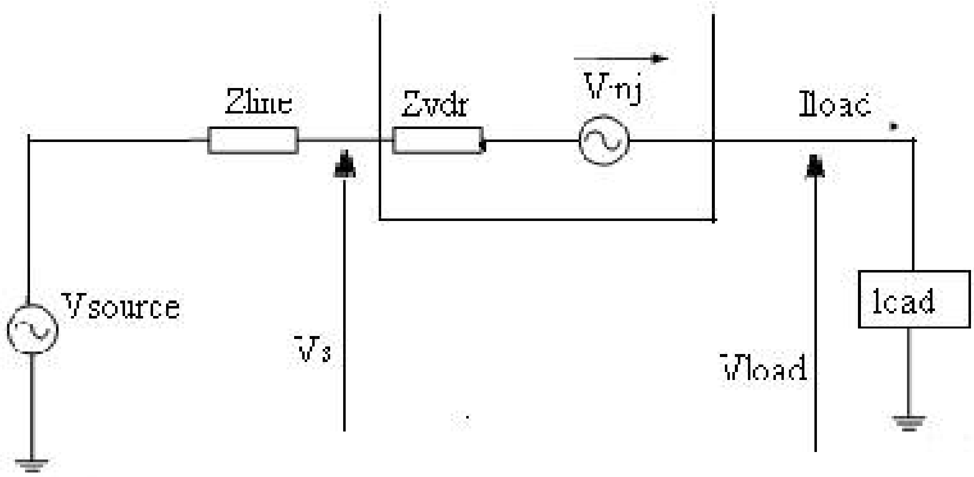

Figure 2: Equivalent Circuit of DVR

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III. PERFORMANCE OF DVR SYSTEM

The power quality problems (sags, swells, harmonics etc.) can be overcome by using the concept of custom power devices which is introduced recently. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks [5]. The location of DVR is as shown in the Fig.2. DVR is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can be also added to other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations [6].

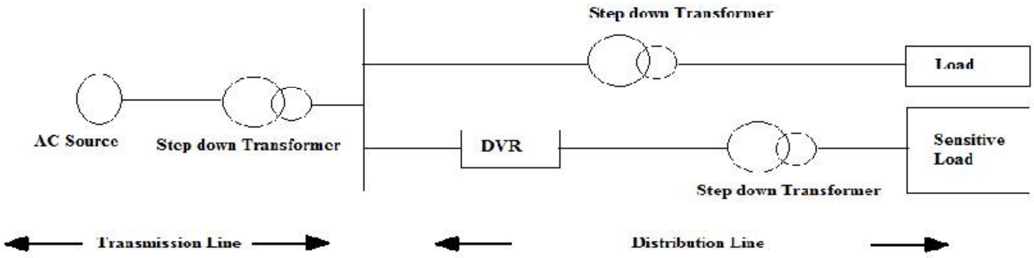

Figure-3 Location of DVR

IV. VOLTAGE SAGS AND SWELLS

Voltage sags and swells are the most common types of power quality disturbances. Voltage sags are normally resulted from a short circuit current flowing into a fault on a transmission or distribution system. Voltage sags can be symmetrical or unsymmetrical. Most of the voltage sags recorded are unsymmetrical. Voltage sags can be induced by three-phase faults, three-phase to ground, two-phase phase, two-phase to ground, single-phase and single-phase to ground. The type of the voltage sag, depth and the duration play an important role in design the DVR. The voltage sag ranges from 0.9 to 0.5 pu of a 1-pu nominal value while the duration last from few milliseconds to a few cycles. Although the voltage swell is less common than the voltage sag, the effect of a voltage swell can often be more destructive than voltage sag [4].

V. CONTROL OF THE DVR

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 presented in Fig. 4 was used to control the DVR with a 3 kHz sampling and switching frequency. It requires measurement of four parameter groups.

1) Three phase-voltages before the DVR to detect voltage sag and for feed-forward control of the output voltage.
2) Three-phase voltages after the DVR for feed-back control of the output voltage.
3) Three currents in the converter to protect the DVR by both saturation control and overcurrent.
4) The dc-link voltage for dc voltage compensation (to decouple the controller from variations in the dc-link voltage), for converter protection, and to provide energy storage information.

With the grid voltage in its normal level the DVR is held in a null state to keep the losses to a minimum. Once voltage sag is detected the DVR converts into active mode to react as fast as possible and inject the required ac voltage to the grid.

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A. VOLTAGE SAG DETECTION

An essential part of the control of the DVR is the sag detection circuit. Voltage sag must be detected fast and corrected with a minimum of false operations. The voltage sag detection method used is based on the rms of the error vector, which allows for detection of symmetrical and asymmetrical sags, as well as the associated phase jump [2]. The detection formula is given by [2].

$$|\bar{u}_{\mathrm{error},dq}| > u_{\mathrm{Threshold}} \tag{1}$$

where the rms of the error is

$$|\bar{u}_{\mathrm{error},dq}| = \sqrt{(u_{\mathrm{ref},d} - u_{\mathrm{supply},d})^2 + (u_{\mathrm{ref},q} - u_{\mathrm{supply},q})^2}. \tag{2}$$

Here, u_{supply} = supply voltage

u_{ref} = load reference voltage

B. LOAD VOLTAGE REFERENCE GENERATION

The next stage of the controller is to determine the desired load voltage reference. A software-based phase-locked-loop (PLL) is used to create sinusoidal load voltage references for the - coordinate system of the controller. The desired response from DVR PLL system is quite different from other applications. This is because the phase of the supply voltage prior to the sag is generally preferred, and if the PLL reacts too quickly to changes in the phase during voltage sag, the post-sag phase may be used. Therefore, the DVR would not be able to compensate for this phase jump. Conventionally, once sag is detected, the target phase of the voltage reference is fixed to the pre-sag phase (i.e., a technique known as freezing [2], to ensure that if the reference is faithfully tracked, then the load voltage phase will remain unaffected [2].

C. COMBINED FEED-FORWARD/FEED-BACK DIGITAL CONTROLLER

The primary control structure is based on a combination of supply voltage feed-forward and PI - load voltage feedback. The feed-forward component provides the required transient response, and uses the dc-link voltage to calculate the required modulation depth to inject the difference between the supply voltage and the load reference voltage. However, this doesn't account for the voltage drop across the filter inductor and other parameters such as the transformer. Therefore, a closed loop load voltage feedback is added, and is implemented in the - frame to minimize any steady state error in the fundamental component. The synchronous - frame implementation also allows for simpler clamping of the injection voltage, to enable the DVR to partially compensate for deep sags whilst still maintaining a sinusoidal injection profile. A further advantage of the closed loop approach is that the feed-back provides some damping for the resonance in the *LC* switching ripple filter. The damping is clearly seen in the simulated step responses in Fig. 4 for feed-forward only and for the combined feed-forward/feed-back controller proposed in this work. This shows that as well as the control system damping effect, the damping is also strongly dependent on the load resistance [2].

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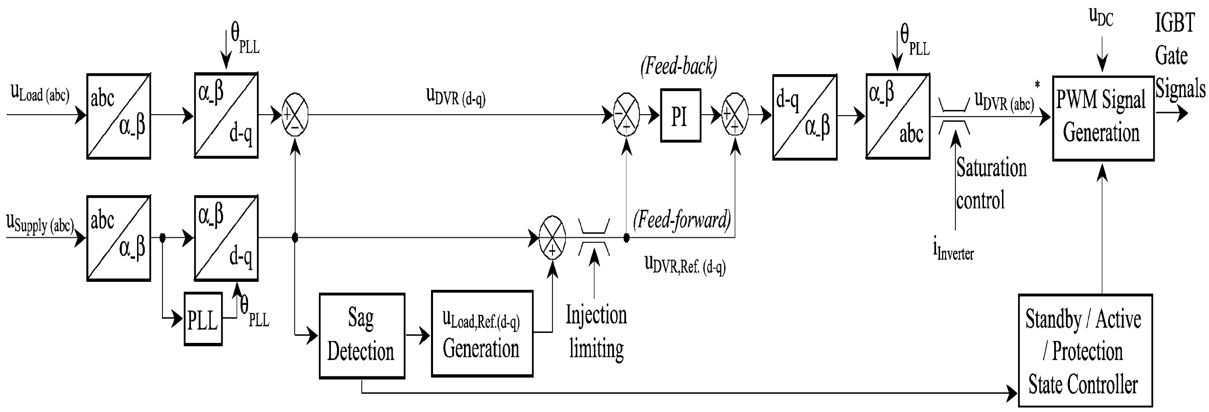

Fig. 4 Control Structure of the combined feed-forward/feed-back MV DVR.

D. VOLTAGE UNBALANCED COMPENSATION USING D-Q-O TRANSFORMATION TECHNIQUE

Rosli Omar and N.A. Rahim discuss the design and development of Dynamic Voltage Restorer (DVR) controller for voltage unbalanced compensation using d-q-o transformation technique. The controller in d-q-o coordinates has better performance than conventional controllers. The controlled variables in d-q-o coordinates are then inversely transformed to the original voltages which produced reference voltages to a DVR [9].

E. REPETITIVE CONTROLLER FOR DVR

Pedro Roncero Sánchez *et al* presents a control system based on a repetitive controller to compensate for key power quality disturbances, namely voltage sags, harmonic voltages, and voltage imbalances, using a dynamic voltage restorer (DVR). The control scheme deals with all three disturbances simultaneously within a bandwidth. The control structure is quite simple and yet very robust; it contains a feed-forward term to improve the transient response and a feedback term to enable zero error in steady state [9].

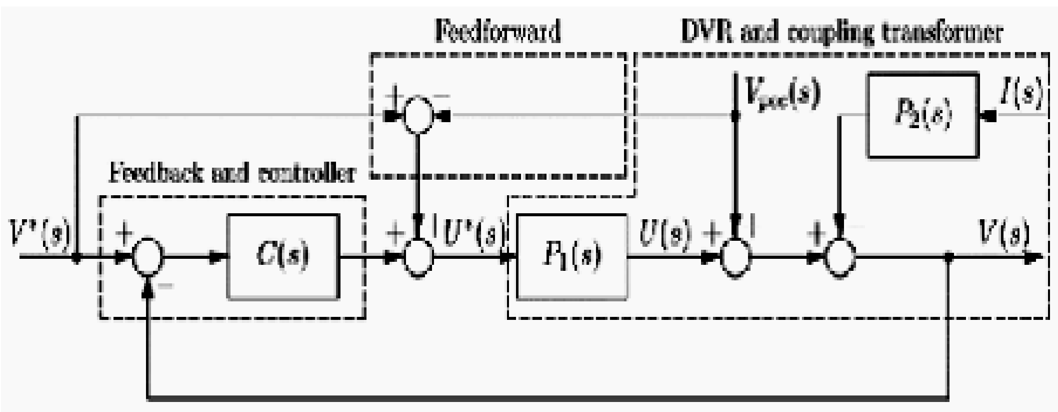

Fig. 5.Closed-loop control scheme

The whole control system is depicted in Figure 7 where C(s) represents the controller. If the switching frequency is high enough, the DVR can be modeled as a linear amplifier with a pure delay P1(s). This delay is the sum of one-sample-period plus the time delay of the inverter due to PWM switching [9].

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F. DYNAMIC CONTROL SCHEME FOR CAPACITOR SUPPORTED SINGLE PHASE DYNAMIC VOLTAGE RESTORER (DVR)

Carl N.M. Ho and Henry S.H. Chung [14] presented a fast dynamic control scheme for the capacitor-supported single phase dynamic voltage restorer (DVR). The scheme consists of two main control loops as inner and outer control loops. The inner loop is used to dictate the gate signals for the switches in the DVR. It is based on the boundary control method with the second order switching surface. The load voltage can ideally be reverted to the steady state in two switching actions during a supply voltage dip. The outer loop is used to generate the DVR output reference for the first loop. It has three control modes for achieving two different functions, including output regulation and output restoration. The first mode is for regulating the capacitor voltage on the dc side of the inverter, so that the output of the DVR is regulated at the nominal voltage [9].

G. VOLTAGE INJECTION METHODS OF DVR

The voltage injection or compensation methods by means of a DVR mainly depend upon the limiting factors such as; DVR power ratings, different conditions of load, and different types of voltage sag. There are different methods of DVR voltage injection which are

i. Pre-sag compensation method
ii. In-phase compensation method
iii. In-phase advanced compensation method

i. PRE-SAG COMPENSATION METHOD

The supply voltage is always tracked and the load voltage is compensated to the pre-sag condition. This scheme results in undisturbed load voltage, but normally requires higher rating of the DVR. Before a sag occur, VS = VL = Vo. Here VS is supply voltage, VL is load voltage and VO is pre sag voltage. The voltage sag results in drop in the magnitude of the supply voltage to VS1. The phase angle of the supply also may shift (see Figure-6). The DVR injects a voltage VC1 such that the load voltage (VL = VS1 + VC1) remains at Vo i.e. pre sag voltage (both in magnitude and phase). It is claimed that some loads are sensitive to phase jumps and it is essential to compensate for both the phase jumps and the voltage sags.

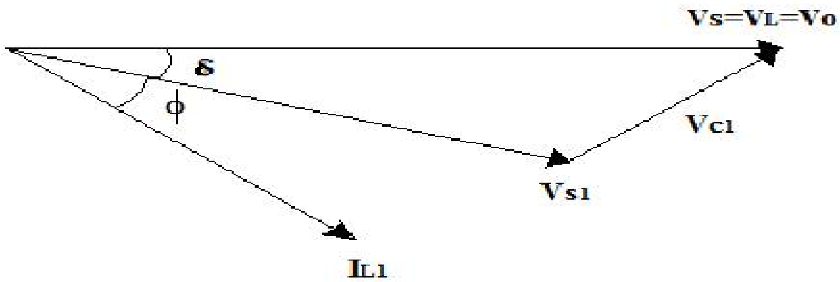

Figure-6 Phasor diagram showing injected voltage by DVR

ii. IN PHASE COMPENSATION

The voltage which is injected by the DVR is always in phase with the supply voltage in spite of the load current and the pre-sag voltage (V_o). This control strategy results in the minimum value of the injected voltage (magnitude). However, the phase of the load voltage is disturbed. For loads which are not sensitive to the phase jumps, this control strategy results in optimum utilization of the voltage rating of the DVR. The power requirements for the DVR are not zero for this approach.

iii. IN PHASE ADVANCED COMPENSATION

In this method the real power which is injected by the DVR is reduced by reducing the power angle between the voltage during sag condition and load current. The minimization of injected energy is achieved by making the active power component zero by having the injection voltage phasor perpendicular to the load current phasor. In this technique the values of load current and voltage are fixed in the system so only the phase of the voltage during sag is changed. This technique is only appropriate for a limited range of sag because this technique uses only reactive power and unfortunately, but al1 the sags cannot be mitigated without real power.

VI.CONCLUSIONS

The Dynamic Voltage Restorer (DVR) is a promising and effective device for power quality enhancement due to its quick response and high reliability. The role of a DVR in mitigating the power quality problems in terms of voltage sag, swell is explained. In this paper voltage injection based technique is used to control the system. The DVR handles both balanced and unbalanced situations without any difficulties and injects the appropriate voltage component to correct rapidly any deviation in the supply voltage to keep the load voltage balanced and constant at the nominal value. The efficiency and the effectiveness in voltage sags/swells compensation showed by the DVR makes him an interesting power quality device compared to other custom power devices.

REFERENCES

1. J. Praveen, B. P. Muni, S. Venkateshwarlu and H. V. Makthal, "Review of dynamic voltage restorer for power quality Improvement," 30th Annual Conference of IEEE Industrial Electronics Society, 2004. IECON 2004, 2004, pp. 749-754 Vol. 1.DOI: 10.1109/IECON.2004.1433408.
2. PalaparthiAnanthababu, K. Ram Charan, BurleTrinadha, "Performance of Dynamic Voltage Restorer (DVR) against Voltage Sags and Swells Using Space Vector PWM Technique", Advances in Computing, Control, and Telecommunication Technologies, International Conference on, vol. 00, no. , pp. 206-210, 2009, doi:10.1109/ACT.2009.59s.
3. Y. Prakash and S. Sankar, "Power quality improvement using DVR in power system," 2014 POWER AND ENERGY SYSTEMS: TOWARDS SUSTAINABLE ENERGY, Bangalore, 2014, pp. 1-6. doi: 10.1109/PESTSE.2014.6805250.
4. E. Babaei, M. F. Kangarlu and M. Sabahi, "Mitigation of Voltage Disturbances Using Dynamic Voltage Restorer Based on Direct Converters," in IEEE Transactions on Power Delivery, vol. 25, no. 4, pp. 2676-2683, Oct. 2010. doi: 10.1109/TPWRD.2010.2054116.
5. Changjiang Zhan et al., "Dynamic voltage restorer based on voltage-space-vector PWM control," in IEEE Transactions on Industry Applications, vol. 37, no. 6, pp. 1855-1863, Nov/Dec 2001. doi: 10.1109/28.968201.
6. J. G. Nielsen, M. Newman, H. Nielsen and F. Blaabjerg, "Control and testing of a dynamic voltage restorer (DVR) at medium voltage level," in IEEE Transactions on Power Electronics, vol. 19, no. 3, pp. 806-813, May 2004. sdoi: 10.1109/TPEL.2004.826504.
7. R. Omar and N. A. Rahim, "Modeling and simulation for voltage sags/swells mitigation using dynamic voltage restorer (DVR)," 2008 Australasian Universities Power Engineering Conference, Sydney, NSW, 2008, pp. 1-5.
8. F. AL Jowder, "Modeling and Simulation of Dynamic Voltage Restorer (DVR) Based on Hysteresis Voltage Control," IECON 2007 - 33rd Annual Conference of the IEEE Industrial Electronics Society, Taipei, 2007, pp. 1726-1731. doi: 10.1109/IECON.2007.4459890.
9. ReenaAsati and Dr. N.R. Kulkarn, “A Review on the Control Strategies used for DSTATCOM and DVR,” International Journal of Electrical, Electronics and Computer Engineering 2(1): 59-64(2013), ISSN No. (Online): 2277-2626.
10. DeepaPatil, DattaChavan, “Review of Control Techniques for DynamicVoltage Restorer,” International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064.
11. Fawzi AL Jowder “Modeling and Simulation of Different System Topologies for Dynamic Voltage Restorer” Electric Power and Energy Conversion Systems, EPECS '09.International Conference, IEEE, pp. 1-6, 2009.
12. A. KhoshkbarSadigh, Student Member, IEEE, and K. M. Smedley, Fellow, IEEE, “Review of Voltage Compensation Methods in Dynamic Voltage Restorer (DVR),” 978-1-4673-2729-9/12/$31.00 ©2012 IEEE.
13. Ms.Santoshi Gupta, Prof.ParamjeetKaur, “A REVIEW PAPER ON REGULATION TECHNIQUE FOR VOLTAGE SAG AND SWELL USING DVR,” International Journal of Scientific Development and Research (IJSDR) March 2016 IJSDR | Volume 1, Issue 3.
14. Vivek Prasad, "Voltage compensation in a grid connected hybrid system using Dynamic Voltage Restorer", Power Instrumentation Control and Computing (PICC) 2015 International Conference on, *pp. 1-5, 2015*.
15. Sheng Xiaoguang, Tongzhen Wei, QunhaiHuo, "Optimal configuration of multi-DFACTS joint operation in distributed network", Transportation Electrification Asia-Pacific (ITEC Asia-Pacific) 2014 IEEE Conference and Expo, pp. 1-5, 2014.
16. Kapil P. Radadiya1, Dr.Chirag K. Vibhakar2, Sachin V. Rajani3andKishan J. Bhayani4, “Voltage Sag/Swell Compensation Using Dynamic Voltage Restorer (DVR)”, International Journal of Application or Innovation in Engineering & Management (IJAIEM).
17. Roshani patel1, S.N. Purohit2, “Voltage Quality Improvement using Dynamic Voltage Restorer ”, International Journal of Engineering Development and Research.
18. Fawzi AL Jowder “Modeling and Simulation of Different System Topologies for Dynamic Voltage Restorer” Electric Power and Energy Conversion Systems, EPECS '09.International Conference, IEEE, pp. 1-6, 2009.

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BIOGRAPHY

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Mohit Srivastava is a M. Tech student in the department of Electrical Engineering BBDU, Lucknow. He received his B.Tech degree in Electrical Engineering from UP Technical University, Lucknow, India

Rakesh Sharma, he is presently Assistant Professor in the Department of Electrical Engineering, Babu Banarsi Das University, Lucknow. He has authored numbers of research paper in International Journal having good citation. He received his M. Tech Degree in the Department of Electrical Engineering, IET, Lucknow from UP Technical University, Lucknow, India. He received his B.Tech degree in Electrical Engineering from UP Technical University, Lucknow, India. He has total 07 years of teaching experience in IET, Lucknow, His research area of interest includes DFIG wind energy conversion system, fault analysis and performance enhancement

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