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VOLTAGE SAG AND ITS ELIMINATION THROUGH VOLTAGE RESTORER: A REVIEW

[1]Mrs. Ruchika Nalin, [2]Prof Nishi Singh
[1]Research Scholar, [2]Asst. Prof.
M.Tech (Power System)
Department of Electrical & Electronics Engineering, RNTU Bhopal

Abstract— Power quality is major concern in industries today because of enormous losses in energy and money. With the advent of sophisticated electrical and electronic equipment's which are very sensitive to disturbances and non-linear loads at distribution systems, produces many power quality problems like voltage sags, swells and harmonics and the purity of sine waveform is lost. Hence prototype has been developed in order to validate the Effectiveness of the proposed control solution. In this research for the development of the prototype a Literature review studied is done and finally research gap is created and then the mitigation of issues is done through the MATLAB model in research work. This paper only presents the literature studied.

Key words: Power quality, Sag Elimination

1. INTRODUCTION

Power quality issues are divided into two categories voltage quality and frequency quality. Voltage quality issues are related with voltage sag, voltage swell, under voltage and over voltage while frequency quality issues are related with harmonics and transients. One of the most imperative power quality issues is voltage sag which occurs due to the usage of voltage sensitive devices. It has made industrials processes more susceptible to supply voltage sags Few decades before, most of the research in power system was going on the development of conventional energy-based power generation. But the issues like international oil crisis, limited availability of conventional sources and environmental pollution effect forced the researcher to think about an alternative source of energy that can be the solution for the above issues. The renewable energy sources like wind energy, solar energy, tidal energy etc. can be a possible solution to this. Renewable energy is derived from natural processes that are replenished constantly. All these sources are plentifully available in nature, are recyclable and almost available free of cost.

Electrical energy is the most efficient and popular form of energy and the modern society is heavily dependent on the electric supply. The life cannot be imagined without the supply of electricity. At the same time the quality and continuity of the electric power supplied is also very important for the efficient functioning of the end user equipment. Most of the commercial and industrial loads demand high quality uninterrupted power. Thus maintaining the qualitative power is of utmost important. The quality of the power is affected if there is any deviation in the voltage and frequency values at which the power is being supplied. This affects the performance and life time of the end user equipment. Whereas, the continuity of the power supplied is affected by the faults which occur in the power system. So to maintain the continuity of the power being supplied, the faults should be cleared at a faster rate and for this the power system switchgear should be designed to operate without any time lag. The power quality is affected many problems which occur in transmission system and distribution system. Some of them are like- harmonics, transients, sudden switching operations, voltage fluctuations, frequency variations etc. These problems are also responsible in deteriorating the consumer appliances. In order to enhance the behavior of the power system, these all problems should be eliminated. With the recent advancements in power electronic devices, there are many possibilities to reduce these problems in the power system. One of them is the use of Flexible AC Transmission System (FACTS) devices. The connection of these devices in the power system helps in improving the power quality and reliability. In this project the mitigation of voltage sag using FACTS devices is studied and analyzed.

2. MOTIVATION

The operation of most of the loads depend greatly on the voltage level at which the power is being supplied to them. But in the power system there may be deviations in the voltage and frequency levels due to sudden switching operations, faults etc. In order to maintain the voltage at the Point of Common Coupling (PCC) at a standard level there is a need to connect some device at the PCC. The FACT device suits best for this purpose. In this project a study on different FACT devices for the mitigation of voltage unbalance is carried out.

3. OBJECTIVE OF THIS PROJECT

The main objectives of this project are listed as follows:

- Study of power quality issue's
- Study and analysis of Grid converter control scheme
- Study and analysis of effect of voltage disturbances on grid converter
- Study of Voltage Sag mitigation scheme
- Study of energy storage device for compensation through power electronic devices.
- Finally, to rectify the problems relating to voltage and improve power quality by implementing a new approach in the theses

4. LITERATURE STUDIED FOR THE RESEARCH

2015, Volume: 6, Issue: 1 Peng Yao; Z. J. Shen; Chunming Tu; Fei Jiang; Ying ChengDesign
In this paper Considerations of a Fault Current Limiting Dynamic Voltage Restorer (FCL-DVR) This paper proposes another deficiency current constraining element voltage restorer (FCL-DVR) idea. The new topology utilizes a crowbar bidirectional thyristor switch across the output terminals of a conventional back-to-back DVR. In the event of a load short, the DVR controller will deactivate the faulty phase of the DVR and activate its crowbar thyristor to insert the DVR filter reactor into the grid to limit the fault current.

Y. Prakash; S. Sankar 2014 Pages: 1 - 6, DOI: 10.1109/PESTSE.2014.6805250
In this paper The dynamic voltage restorer (DVR) is one of the cutting edge gadgets utilized as a part of dispersion frameworks to ensure shoppers against sudden changes in voltage abundancy. In this paper, crisis control in appropriation frameworks is examined by utilizing the proposed multifunctional DVR control technique.

M. Farsadi; A. Gara shahrak; S. Dabbage Tabrizi Year: 2013
In this paper the Wind power is one of the most important kind of renewable energies. Wind farm as a device which receives this energy needs some special conditions to work properly. The most common type of wind turbine is the variable-speed directly connected to the grid. Faults in the power system can originate the disconnection of wind farms.

R. Venkata Rama Raju; A. Karthikeyan; C. Nagamani Year: 2012
This paper researches the utilization of a Dynamic Voltage Restorer (DVR) to help a wind turbine driven doubly-encouraged incitement generator (DFIG) for continuous force supply to the associated lattice even under uneven framework voltage conditions. The DVR control depends on symmetrical parts and vector control.

M. G. Sugirtha; P. Latha Year: 2011
In this paper Wind vitality is one of the quickest developing wellsprings of power in India and around the globe. Despite being shoddy, perfect and copious the consistent variances in the renewable vitality causes huge force quality issues. This paper presents a technical review of power quality problems associated with grid connected wind power plant and describes the Dynamic Voltage Restorer

M. G. Sugirtha; P. Latha Year: 2011
In this paper Wind energy is one of the fastest-growing sources of electricity in India and around the world. In spite of being cheap, clean and abundant the continuous fluctuations in the renewable energy causes significant power quality issues. This paper presents a technical review of power quality problems associated with grid connected wind power plant and describes the Dynamic Voltage Restorer

Yingdong Wei; Lucheg Hong; Qirog Jiang; Zhiyong Wang Year: 2011
In this paper As the penetration of large-scale grid-connected wind farms increasing year by year, low voltage ride-through (LVRT) capability are required by many countries for power quality and fail-safe operation at grid fault. A new dynamic strategy using dynamic voltage restorer (DVR) is proposed in this paper to improve LVRT capability of wind turbine generator

Year: 2009 R. Anil Kumar; G. Siva Kumar; B. Kalyan Kumar; Mahesh K. Mishra
In this paper Dynamic Voltage Restorer (DVR) restores the distribution system load voltage to a nominal balanced sinusoidal voltage, when the source voltage has distortions, sag/swell and unbalances. DVR has to inject required amount of Volt-Amperes (VA) into the system in order to maintain a nominal balanced sinusoidal voltage at the load.

Year: 2007, Volume: 22, Issue: 4 D. Mahinda Vilathgamuwa; Poh Chiang Loh; Frede Blaabjerg
In this paper the dynamic voltage restorer (DVR) is a modern custom power device used in power distribution networks to protect consumers from sudden sags (and swells) in grid voltage. Implemented at medium voltage level, the DVR can be used to protect a group of medium voltage or low voltage consumers. However, the DVR will therefore be tasked to mitigate even more faults involving downstream loads. Large fault currents would flow through the DVR during a downstream fault before the opening of a circuit breaker.

Rini Ann Jerin. A*‡, Palanisamy. K**, Umashankar. S**, Thirumoorthy.A.D***
Accepted:31.12.2015
This paper manages the powerful voltage hang/swell moderation utilizing Dynamic Voltage Restorer (DVR), to direct the terminal voltage of the wind ranch. The DVR uses a food forward vector control based calculation to produce the PWM based terminating signals for infusing proper pay voltages. The actual wind farm field data of the voltage sag and swell events during fault conditions are re- created using MATLAB/Simulink and restored by employing the DVR . The simulation results are shown to verify the operation of DVR during balanced voltage sag and swell conditions.

Arundhati R. Karkhanis Vol. 5, Issue 5, May 2016
This paper presents a new system for integration of a grid-connected photovoltaic (PV) system together with a self supported dynamic voltage restorer (DVR). The proposed system termed as a “six-port converter,” consists of nine semiconductor switches in total. The proposed configuration retains all the essential features of normal PV and DVR systems while reducing the overall switch count from twelve to nine. In addition, the dual functionality feature significantly enhances the system robustness against severe symmetrical/asymmetrical grid faultsand voltage dips.

Sagar P. Joshi Dr. Paresh J. Shah IJRITCC | December 2015
This paper describes the dynamic voltage restorer for maintaining the grid codes to be followed by the doubly fed induction wind turbine system. Because of extended power

handling properties of power electronics devices, it is been used widely in the Electrical Devices. The extensive usage of power electronic devices has raised the problem of power quality issues, resulting into the problem of voltage sag/swell etc. The system to be designed will face the problems of voltage sag/swell & will keep the system healthy throughout the symmetrical & unsymmetrical fault conditions.

*Chaudhary Sanjay Haribhai, **Indrodia Nayna p. Volume 1, Issue 2 (October 2012) International Refereed Journal of Engineering and Science (IRJES)
This paper presents aintroduction and use of facts controller inwind power station for improve voltage profile damping oscillations,load ability,reduce active and reactive power losses,sub-state-of-the-art on enhancement of different performance parameters of power systems such as voltage profile, sub-synchronous resonance (SSR) problems, transient stability, and dynamic performance, by optimally placed of FACTS controllers such as TCSC, SVC, STATCOM, SSSC, UPFC, IPFC, HPFC in wind power Systems. Also this paper presents the current status on enhancement of different performance parameters of power systems by optimally placed of FACTS controllers in wind power Systems.

ARUNDHATI KARKHANIS (NCETET) : 30/01//2016 , (IJES) || Volume || 4 || Issue || 11 || 2015
This paper presents a new system configuration for integrating a grid-connected photovoltaic
(PV) system together with a self-supported dynamic voltage restorer (DVR). The pro- posed system termed as a “six-port converter,” consists of nine semiconductor switches in total. The proposed arrangement holds all the key components of typical PV and DVR frameworks while decreasing the general switch tally from twelve to nine. Likewise, the double usefulness highlight altogether upgrades the framework strength against extreme symmetrical/hilter kilter network faults and voltage plunges. A detailed study on all the possible operational modes of six-port converter is presented. extensive simulation as well as experimental studies under different operating conditions.

Christian Wessels, Fabian Gebhardt and Friedrich W. Fuchs, 2010 IEEE
In this paper the application of a Dynamic Voltage Restorer connected to a wind turbine driven doubly fed induction generator (DFIG) is investigated. The setup allows the wind turbine system an uninterruptible fault ride through of voltage dips. The Dynamic Voltage Restorer can compensate the faulty line voltage while the DFIG wind turbine can continue its nominal operation as demanded in actual grid codes. Simulation results for a 2 MW wind turbine and measurement results on a 22 kW laboratory setup show the effectiveness of the Dynamic Voltage Restorer in comparison to the low voltage ride through of the DFIG using a crowbar which does not allow continuous reactive power production.

Subramanian Chandrasekaran March 2014, Bologna, Italy
In this The dynamic model of DFIG wind turbine includes models for both mechanical components as well as for all electrical components, controllers and for the protection device of DFIG necessary during grid faults. The viewpoint of this project is to carry out different simulations to provide insight and understanding of the grid fault impact on both DFIG wind turbines and on the power system itself. The dynamic behavior of DFIG wind turbines during grid faults is simulated and assessed by using a transmission power system generic model developed and delivered by Transmission System Operator in the power system simulation toolbox Digsilent, Matlab/Simulink and PLECS.

K.R. Prajapat1 , Arpit Khandelwal2, ISSN: 2348 – 8379
This paper is an investigation of a system consisting of DVR connected in series to a DFIG wind turbine. The DVR is used to maintain the voltage level during fault condition, voltage sag, voltage swell and consecutive sag and swell in DFIG wind turbine system. The primary aim of DVR is to inject the voltage in series to the stator side. The series converter continuously monitors the grid voltage and provides compensation accordingly to accomplish this aim. The synchronization of operation remains established in all three conditions, namely pre fault, during fault and post fault..

Ujjwal Kumar*, M Chilambarasan**, Volume 4, Issue 12, December 2014 2 ISSN 2250-3153
In this paper this work presents a control strategy of a dynamic voltage restorer (DVR) to improve the doubly fed induction generator (DFIG) based wind turbine in case of fault. The application of a dynamic voltage restorer (DVR) connected to a doubly fed induction generator (DFIG) based wind-turbine-driven is investigated.Voltage in faulty line can be compensated using DVR, while nominal operation of DFIG wind turbine is continued as demanded in actual grid codes. A dynamic voltage restorer based on the dqo algorithm is discussed. The proposed control scheme is very effective to detect any disturbance or fault in distribution systems. Simulation results for a 1.5 MW wind turbine using Matlab/Simulink are presented to verify the effectiveness of the proposed scheme.

N. Karpagam1,* , S. Dhanalakshmi2 and B. Juhi Jahan 3, VFSTR Journal of STEM Vol. xx, No.xx (2015)
This paper proposes Fuzzy Logic Controller (FLC) based DVR along with dq0 transformation for Power Quality Improvement in a distribution system. Discrete PWM pulse generator with Phase Locked Loop (PLL) was used as a control strategy in this work. In addition to this, to meet the power demand in the distribution system renewable energy resources are employed. Here Doubly fed Induction Generator (DFIG) wind farm as Distributed generation (DG). Simulations are carried out in the MATLAB/SIMULINK software.

M.SAMPATH KUMAR1, N. SUMATHI 2ISSN: 2278-7844 2012 IJAIR.
This paper introduces a new solution for doubly fed induction generators to stay connected to the grid during voltage sags. The main idea is to increase the stator voltage to a level that creates the required flux to keep the rotor side converter current below its transient rating. To accomplish this goal, a Multi-Level Inverter (MLI) based dynamic voltage restorer

(DVR) is used to inject voltage in series to the stator side line. To keep the current at its minimum, a control strategy has been developed to keep the injected voltage and line voltage in phase during and after the fault.

R. Janakiraman , S. Paramasivam IJERTV2IS70759
In this paper, the Simulation of Power Quality Enhancement on Grid Integrated Wind Energy
System (PQEGWES) using Solar Powered STATCOM is to be presented. This scheme has to be improving the power quality of the grid integrated wind energy system using solar power, is used to be charging the capacitor in STATCOM. The injection of the wind power into the grid is affects the power quality of the system. Some of the power quality issues like voltage sag and harmonics. In this proposed system, simulation model of 3-phase system without compensation and with compensation are modelled and simulated.

Year: 2007, Volume: 22, Issue: 4 D. Mahinda Vilathgamuwa; Poh Chiang Loh; Frede Blaabjerg
In this paper the dynamic voltage restorer (DVR) is a modern custom power device used in power distribution networks to protect consumers from sudden sags (and swells) in grid voltage. Implemented at medium voltage level, the DVR can be used to protect a group of medium voltage or low voltage consumers. However, the DVR will therefore be tasked to mitigate even more faults involving downstream loads. Large fault currents would flow through the DVR during a downstream fault before the opening of a circuit breaker.

Rini Ann Jerin. A*‡, Palanisamy. K**, Umashankar. S**, Thirumoorthy.A.D***
Accepted:31.12.2015
This paper deals with the effective voltage sag/swell mitigation using Dynamic Voltage Restorer (DVR), to regulate the terminal voltage of the wind farm. The DVR utilizes a feed forward vector control based algorithm to generate the PWM based firing signals for injecting appropriate compensation voltages. The actual wind farm field data of the voltage sag and swell events during fault conditions are re- created using MATLAB/Simulink and restored by employing the DVR. The simulation results are shown to verify the operation of DVR during balanced voltage sag and swell conditions.

Arundhati R. Karkhanis Vol. 5, Issue 5, May 2016
This paper presents a new system for integration of a grid-connected photovoltaic (PV) system together with a self-supported dynamic voltage restorer (DVR). The proposed system termed as a “six-port converter,” consists of nine semiconductor switches in total. The proposed configuration retains all the essential features of normal PV and DVR systems while reducing the overall switch count from twelve to nine. In addition, the dual functionality feature significantly enhances the system robustness against severe symmetrical/asymmetrical grid faultsand voltage dips.

Sagar P. Joshi Dr. Paresh J. Shah IJRITCC | December 2015
This paper portrays the dynamic voltage restorer for keeping up the network codes to be trailed by the doubly encouraged instigation wind turbine framework. As a result of broadened force taking care of properties of force hardware gadgets, it is being utilized generally as a part of the Electrical Devices. The broad use of force electronic gadgets has raised the issue of force quality issues, coming about into the issue of voltage droop/swell and so forth. The system to be designed will face the problems of voltage sag/swell & will keep the system healthy throughout the symmetrical & unsymmetrical fault conditions. in the direction of wind flow.

5.RESEARCH GAP FROM LITERATURE STUDIED

TITLE AND JOURNAL	YEAR AND AUTHOR	REMARK
Design Considerations of a Fault Current Limiting Dynamic Voltage Restorer (FCL-DVR)	2015, Volume: 6, Issue: 1 Peng Yao; Z. J. Shen; Chunming Tu; Fei Jiang; Ying Cheng	This paper proposes a new fault current limiting dynamic voltage restorer (FCL-DVR) concept. The new topology uses a crowbar bidirectional thyristor switch across the output terminals of a conventional back-to-back DVR. In the event of a load short, the DVR controller will deactivate the faulty phase of the DVR and activate its crowbar thyristor to insert the DVR filter reactor into the grid to limit the fault current.
Power quality improvement using DVR in power system	Y. Prakash; S. Sankar 2014 Pages: 1 - 6, DOI: 10.1109/PESTSE.2014.6805250	The dynamic voltage restorer (DVR) is one of the modern devices used in distribution systems to protect consumers against sudden changes in voltage amplitude. In this paper, emergency control in distribution systems is analyzed by using the proposed multifunctional DVR control strategy.
R with fuzzy logic controller photovoltaic for improving operation of wind farm	M. Farsadi; A. Gara shahrak; S. Dabbage Tabrizi Year: 2013	Wind power is one of the most important kind of renewable energies. Wind farm as a device which receives this energy needs some special conditions to work properly. The most common type of wind turbine is the variable-speed directly connected to the grid. Faults in the power system can originate the disconnection of wind farms.
hanced decoupled power trol of wind turbine drive d DFIG usingDVR under balanced grid voltage	R. Venkata Rama Raju; A. Karthikeyan; C. Nagamani Year: 2012	This paper investigates the application of a Dynamic Voltage Restorer (DVR) to assist a wind turbine driven doubly-fed induction generator (DFIG) for uninterrupted power supply to the connected grid even under unbalanced grid voltage conditions. The DVR control is based on symmetrical components and vector control.
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REFERENCE

[1] Peng Yao; Z. J. Shen; Chunming Tu; Fei Jiang; Ying ChengDesign , Considerations of a Fault Current Limiting Dynamic Voltage Restorer (FCL-DVR) 2015, Volume: 6, Issue: 1 IEEE

[2] Y. Prakash; S. Sankar emergency control in distribution systems is analyzed by using the proposed multifunctional DVR control strategy. 2014 Pages: 1 - 6, DOI: 10.1109/ PESTSE.2014.6805250

[3] M. Farsadi; A. Gara shahrak; S. Dabbage Tabrizi . Wind farm as a device which receives this energy needs some special conditions to work properly Year: 2013 IEEE

[4] R. Venkata Rama Raju; A. Karthikeyan; C. Nagamani of a Dynamic Voltage Restorer (DVR) to assist a wind turbine driven doubly-fed induction generator (DFIG) for uninterrupted power supply Year: 2012 IEEE

[5] M. G. Sugirtha; P. Latha a technical review of power quality problems associated with grid connected wind power plant and describes the Dynamic Voltage RestorerYear: 2011 IEEE

[6] Yingdong Wei; Lucheg Hong; Qirog Jiang; Zhiyong Wang dynamic strategy using dynamic voltage restorer (DVR) is proposed in this paper to improve LVRT capability of wind turbine generatorYear: 2011 IEEE

[7] Year: 2009 R. Anil Kumar; G. Siva Kumar; B. Kalyan Kumar; Mahesh K. Mishra paper the dynamic voltage restorer (DVR) is a modern custom power device used in power distribution networks to protect consumers from sudden sags

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[9] Rini Ann Jerin. A*‡, Palanisamy. K**, Umashankar. S**, Thirumoorthy.A.D***
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[11] Sagar P. Joshi Dr. Paresh J. Shah IJRITCC | December 2015, dynamic voltage restorer for maintaining the grid codes to be followed by the doubly fed induction wind turbine system

[12] *Chaudhary Sanjay Haribhai, **Indrodia Nayna p. Volume 1, Issue 2 (October 2012) International Refereed Journal of Engineering and Science (IRJES) improve voltage profile damping oscillations,load ability,reduce active and reactive power losses,

[13] ARUNDHATI KARKHANIS (NCETET) integrating a grid-connected photovoltaic
(PV) system together with a self-supported dynamic voltage restorer (DVR). : 30/01//2016 , (IJES) || Volume || 4 || Issue || 11 || 2015

[14] Christian Wessels, Fabian Gebhardt and Friedrich W. Fuchs, The Dynamic Voltage Restorer can compensate the faulty line voltage while the DFIG wind turbine can continue its nominal operation as demanded in actual grid codes 2010 IEEE

[15] Shaheen, S.A, Hasanien, M., Badr, M.A.,"Study On Doubly-Fed Induction Generator Control", MPECON'10,December 19-21,2010, ID 251

[16] Leban, K.,'' Doubly fed induction generator fault simulation'', Institute of Energy Technology Aalborg 2009.

[17] Cortajarena,J.A., Marcos. J.D.,Alvarez. P., Vicandi. V.J., Alkorta. P.,'' Start up and control of a DFIG wind turbine test rig'', IEEE, 2011

[18] Tumay . M.,Teke. A., Bayindur K.C., Cuma M.U., "SIMULATION AND MODELLING OF DYANAMIC VOLTAGE RESTORER"

