Space Vector Modulation Based over Load Control Using in Optimized Fuzzy DVR in Offshore Windmills

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Abstract— This paper deals with the modeling of Dynamic Voltage Restorer (DVR) for maintaining the Power quality of the system. The common problem in voltage restorer is the time taken to perform the control action and also the phase transmission line. In conventional systems, only voltage is controlled and no efforts are taken to maintain the sinusoidal nature of the current. This project introduces a two stage process using space vector modulation, where both voltage and current are maintained constant irrespective of the variation in inputs due to variations in wind speed in wind power systems. To solve this problem, custom power devices are used. 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. Its appeal includes lower cost, smaller size, and its fast dynamic response to the disturbance. This projects presents modeling, analysis and simulation of a Dynamic Voltage Restorer (DVR) using MATLAB. A new control technique is proposed to control the capacitor-supported DVR where the injection voltage or current is based on the charge held by the capacitor. The proposed hybrid system can effectively suppress the voltage fluctuation. The simulation of proposed work is carried out using MATLAB version 2018a.

Keywords: Wind Turbine, Battery, Transformer, Inverter, Matlab/Simulink Software, Various Loads

I. INTRODUCTION

Nowadays, modern industrial devices are mostly based on electronic devices such as programmable logic controllers and electronic drives. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipment. Another power electronic solution to the voltage regulation is the use of a dynamic voltage restorer (DVR). DVRs are a class of custom power devices for providing reliable distribution power quality. They employ a series of voltage boost technology using solid state switches for compensating voltage sags/swells. The DVR applications are mainly for sensitive loads that may be drastically affected by fluctuations in system voltage. The term harmonics referred to Power quality in ideal world would mean how pure the voltage is, how pure the current waveform is in its sinusoidal form. Power quality is very important to commercial and industrial power system designs. Ideally, the electrical supply should be a perfect sinusoidal waveform without any kind of distortion. If the current or voltage waveforms are distorted from its ideal form it will be termed as harmonic distortion. This harmonic distortion could result because of many reasons. In today's world, prime importance is given by the engineers to derive a method to reduce the harmonic distortion. Harmonic distortion was very less in the past when the designs of power systems were very simple and conservative. But, nowadays with the use of complex designs in the industry harmonic distortion has increased as well.

This paper explains the effects of Harmonics in the Power System and steps to reduce the effects of Harmonics and also explain how Harmonic distortion is one of the most important problems associated with power quality and creates several disturbances to the Power System. It includes the Harmonic reduction techniques to improve the power quality and it will also include the simulation for the same.

This paper also explains different types of inverters that are used in the Power System. During the transformation from DC to AC, harmonics affect the power quality a lot. How harmonic reduction will improve the power quality will be explained in detail.

II. EXISTING SYSTEM

A family of wind or solar energy systems with integrated functions of active power transfer, reactive power compensation, and voltage conversion and harmonics elimination is presented. The wind energy systems and photovoltaic systems using solid-state transformer (SST) can effectively suppress the voltage fluctuation without additional reactive power compensator. Anyhow SST design is not our basic work, because it is already suggested in DVR systems

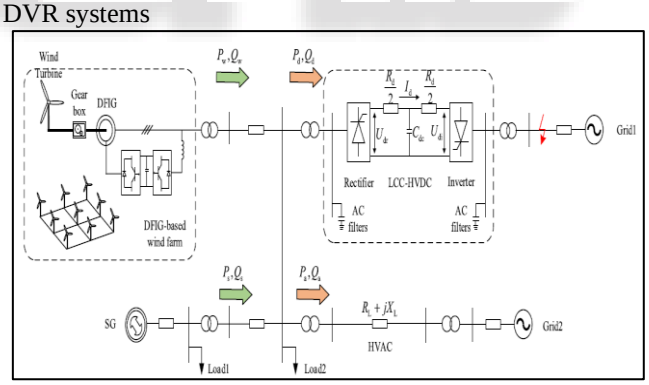

Fig. 1: Schematic layout of existing sysem

Among the power quality problems (sags, swells, harmonics…) voltage sags are the most severe disturbances. In order to overcome these problems the concept of custom power devices 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. 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 also added other features like: line

voltage harmonics compensation, reduction of transients in voltage and fault current limitations.

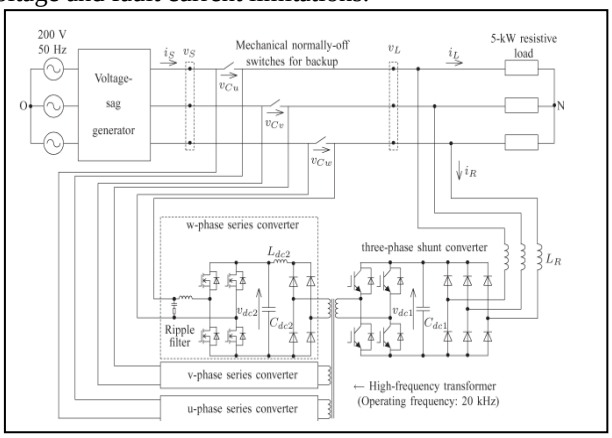

Fig. 2: Circuit diagram of DVR

III. Overview of Proposed System

Here all blocks are connected as per the desired block diagram with the rated parameters, which is shown below in fig 3. Here an enhanced voltage compensation strategy is proposed that mitigates the phase jump in the load voltage (due to over penetration in offshore wind mills) while improving the overall sag and swell compensation time. During swell operation, an inverse voltage is generated so as to compensate the swell. During sag operation voltage in same phase is added to add sufficient voltage. In this project a technique based on space vector modulation is proposed to reduce the compensation time while avoiding phase jump. In this method, once the dc link voltage drops to the threshold limit, the magnitude of injected voltage is reduced by synchronizing the with the pulses generated by SVM. The proposed method aims at regulating the contribution of active power to the least possible value. To avoid the problem of over modulation, in case of deeper sag depth, an iterative loop is employed in the control block. It is found that the proposed method can result in more than 50% additional sag support time when compared with the method.

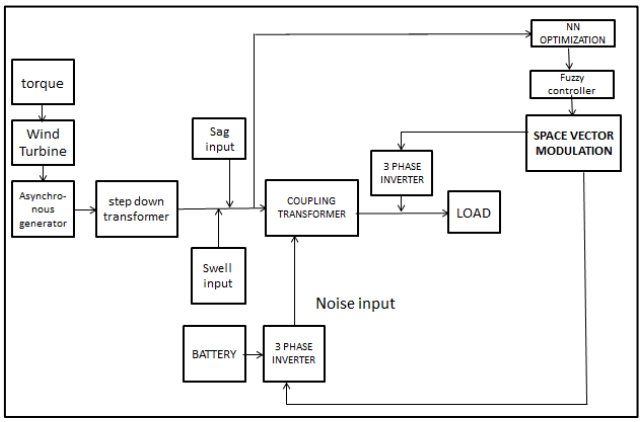

Fig. 3: Block diagram of implemented proposed system

IV. Analysis and Design of Simulink Model

MATLAB is a product apparatus and programming condition that has turned out to be typical among researchers and designers. For the building proficient it is a valuable programming language for logical figuring, information handling, and perception of results. Numerous valuable numerical capacities and graphical highlights are incorporated with the language. The model designed and shown below in fig 4 consists of a wind mill whose outputs are coupled to the transmission line through a step down transformer. The wind mill consists of an asynchronous generator, where the mechanical energy is fed to the system in the form of torque. However, the torque required to drive the mill is obtained from the wind with a specific speed. The Simulink model in the matlab library converts the wind data into equivalent speed and then to equivalent torque. This model has an option of injecting a faulty voltage connected in parallel to the transmission line. The function of the DVR is done in two stages as voltage and current injection. Voltage injection is done in serial using transformer coupling and current injection is done parallel as a direct injection. A resistive load is considered in this paper as only compensation is the main task in this paper. The injection of faulty voltages could be adjusted based on the required timing using circuit breakers.

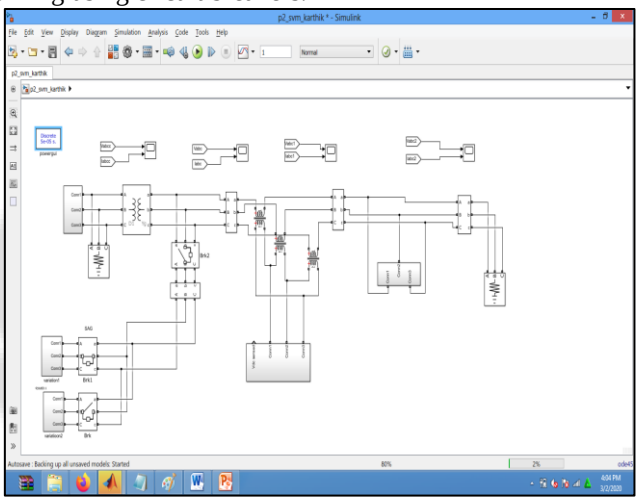

Fig. 4: Simulink model

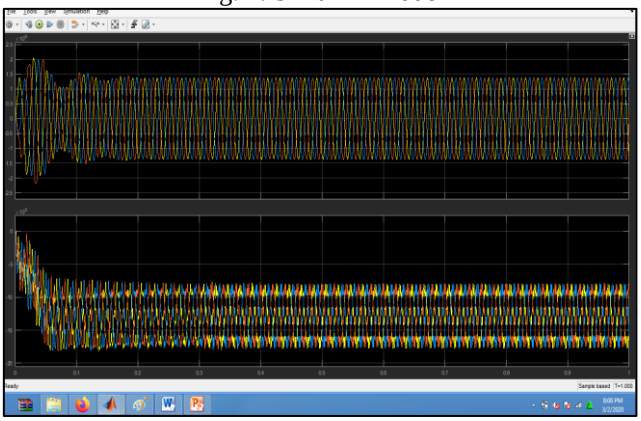

Fig. 5: waveform of voltage compensation alone

The converter section shown in the above model is a novel type where 12 switches are used instead of 6 switches to accomplish the voltage injection based on the support of capacitor. Here a triangular wave is considered as a reference wave where, a sinusoidal reference is compared using a comparator block. This is different from the conventional PWM method. All the upper switches in upper arm and the lower switches of the lower arm are

triggered by the same pulses except an inversion. The concept of injection is controlled based on the charging and discharging of the capacitors connected in parallel.

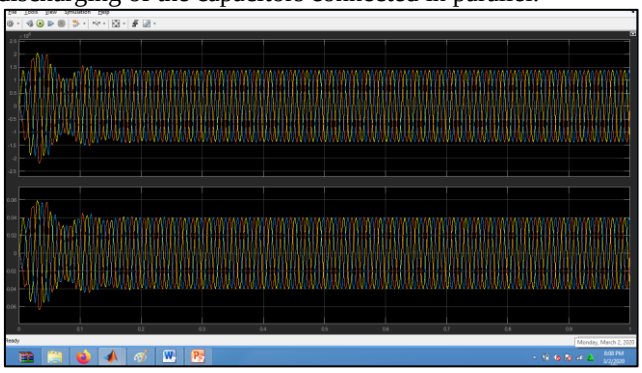

Fig. 6: waveform of load Voltage and load current

The converter section shown above is related to the current injection and current shaping. Here too, is a novel type where 12 switches are used instead of 6 switches to accomplish the voltage injection based on the support of capacitor. Here a triangular wave is considered as a reference wave where, a sinusoidal reference is compared using a comparator block. This is different from the conventional PWM method. All the upper switches in upper arm and the lower switches of the lower arm are triggered by the same pulses except an inversion. The concept of injection is controlled based on the charging and discharging of the capacitors connected in parallel.

V. CONCLUSION

This paper consists of two important modules where voltage is compensated in the first module. Unlike the existing works, in this project an additional module is implemented to control the current and keep it sinusoidal. This method is very helpful to compensate the voltage variation instantaneously. This is highly possible by using the triggering methods using space vector modulation. Simulation using MATLAB model had been done where, sag and swell have been compensated. The operation of a DVR has been demonstrated with a new control technique using various voltage injection schemes using transformers connected in series to the transmission line. Due to the addition of optimization using neural network, the fuzzy control performs good and a better compensated voltage is obtained.

REFERENCES

[1] J. Tu, J. Zhang, J. Wang, J. He, and W. Lin, ‘‘Mechanism analysis on the sending-side instability caused by the receiving-side contingencies of large-scale HVDC asynchronous interconnected power systems,’’ Proc. CSEE, vol. 35, no. 21, pp. 5492–5499, Nov. 2015.

[2] H. Jingbo, L. Mingjie, Y. Jun, C. Qing, X. Tao, and Y. Zhao, ‘‘Research on dynamic characteristics and countermeasures of AC-DC hybrid power system with large scale HVDC transmission,’’ in Proc. IEEE Int. Confer. Power Syst. Technol., Oct. 2014, pp. 799–805.

[3] J. Li, F. Liu, Z. Li, S. Mei, and G. He, ‘‘Impacts and benefits of UPFC to wind power integration in unit commitment,’’ Renew. Energy, vol. 116, pp. 570–583, Feb. 2018.

[4] B. Zhou, C. Hong, and X. Jin, ‘‘Study of backbone structure change from synchronous to asynchronous in China Southern Power Grid,’’ Proc. CSEE, vol. 36, no. 8, pp. 2084–2092, 2016.

[5] R. Li, S. Bozhko, and G. Asher, ‘‘Frequency control design for offshore wind farm grid with LCC-HVDC link connection,’’ IEEE Trans. Power Electron., vol. 23, no. 3, pp. 1085–1092, May 2008.

[6] Z. Song, Y. Lin, C. Liu, Z. Ma, and L. Ding, ‘‘Review on over-frequency generator tripping for frequency stability control,’’ in Proc. IEEE Power Energy Eng. Conf., Oct. 2016, pp. 2240–2243.

[7] C. Zheng, S. Ma, X. Shen, and D. Liu, ‘‘Definition, connotation and form of strong HVDC and weak AC and countermeasures for stable operation of hybrid power grid,’’ Power Syst. Technol., vol. 41, no. 8, pp. 2491–2498, Feb. 2017.

[8] C.-J. Chou, Y.-K. Wu, G.-Y. Han, and C.-Y. Lee, ‘‘Comparative evaluation of the HVDC and HVAC links integrated in a large offshore wind farm— An actual case study in Taiwan,’’ IEEE Trans. Ind. Appl., vol. 48, no. 5, pp. 1639–1648, Sep./Oct. 2012.

[9] M. H. Athari and Z. Wang, ‘‘Impacts of wind power uncertainty on grid vulnerability to cascading overload failures,’’ IEEE Trans. Sustain. Energy, vol. 9, no. 1, pp. 128–137, Jan. 2018.

[10] Guide on Security and Stability for Power System. Beijing, China: China Electric Power Press, 2001.

[11] M.Buresch: *Photovoltaic Energy Systems Design and Installation*, McGraw-Hill, New York, 1983.

[12] Z.M.Salameh and F.Dagher, “The effect of electrical array configuration on the performance of a PV powered volumetric water pump,” IEEE Trans. on Energy Conversion , Vol.5, pp. 653-658, Dec 1990.

[13] N.Mohan, T.M.Undeland, and W.P.Robbins, *Power Electronics Converters, Applications and Design*, 3rd ed., Jhon Wiley & Sons (Asia) Pte. Ltd., Singapore: 2006.

[14] Y.P.Hsieh, J.F.Chen, T.J.Liang and L.S.Yang, “Novel high setup DC-DC converter for distributed generation system,” IEEE transaction on Industrial Electronics, pp. 1, Jan 2011.

[15] R.J.Wai and R.Y.Duan, “High-efficiency DC/DC converter with high voltage gain,” IEE Proc. Electric Power Applications, Vol.152, No.4, pp.793-802, Jul. 2005.

[16] S.K.Changchien, T.J.Liang, J.F.Chen and L.S.Yang, “Novel high step-up DC-DC converter for fuel cell energy conversion system,” IEEE Trans. Ind. Electronics, Vol. 57, No.6, pp.2007- 2017, June 2010.

[17] J.W.Baek, M.H.Ryoo, T.J.Kim, D.W.Yoo, and J.S. Kim, “High Boost converter using voltage multiplier,” in Proc. IEEE IECON, pp. 567-572, Nov 2005.

[18] A Teke, K Bayindir, and M Tumay, “Fast sag/swell detection method for fuzzy logic controlled dynamic voltage restorer,” IEEE transaction on Generation, Transmission and Distribution, Vol. 4, No.1, pp. 1-12, Jan 2010.

[19] "Photovoltaic Modules TE1300 data sheet," plan my power, Johannesburg, South Africa.
[20] E Duran, M.B Ferrera, J.M Andujar and M.S Mesa, "I-V and P-V curves measuring system for PV modules based on DCDC converters and portable graphical environment" IEEE international symposium of Ind. Electronics, pp. 3323-3328, Nov 2010.

