Smart Grid Power Quality Improvement by using PV-DVR

Mr. Rakesh More[1], Dr. N. R. Bhasme[2]

[1]M. Tech (Electrical Power System)
Government College of Engineering, Aurangabad, Maharashtra, India,
rakeshmore.geca@gmail.com

[2]Associate Professor
Government College of Engineering, Aurangabad, Maharashtra, India,
nrbhasme@gmail.com

Abstract*: Modern Electrical Power System Networks like Smart Grids are implementing with the concept of Distributed Generation. This Distributed generation is achieved from Non-conventional Renewable Energy Sources such as Solar and Wind Power. Smart Grid networks consist of many advanced power electronics circuitry and Non-linear type loads, photovoltaic panels, Batteries, DC loads which makes the power system more vulnerable to power quality issues. This paper proposes a novel structure of Dynamic Voltage Restorer fed up by a Solar Photovoltaic Panel which provides compensation for many power quality issues related to the Voltage. Dynamic Voltage Restorer provides compensation for power quality issues like voltage sag and swells at the grid side by injecting voltage at the Point of common coupling. The proposed structure provides advantages of clean generation and also power quality improvement. The proposed structure is designed, simulated, and validated in the MATLAB/Simulink environment.

***Keywords*: Smart Grid, Distributed Generation System, Power Quality, DVR.**

(Article history: Received: 30th January 2021 and accepted 24th August 2021)

I. INTRODUCTION

The term Smart Grid is meant for upgradation of the present electrical power system network to modernism. The Smartness in the present Electrical Power Grid is achieved by the integration of electrical power network with Information Technologies placed between the Generation Unit and Consumer Unit.[1] For acquiring more efficiency from energy, the implementation of Renewable Energy Sources and Smart Grid Technology is at the higher priorities for Global Energy Firms[2]. Implementation of Distribution Generation Concept in Grid system provides one kind of Smartness. A distributed Generation (DG) system using renewable Energy Sources (RES) is the best alternative for the Conventional Electrical Power Generation System. DG system using RES implements various new electrical power generation systems which fulfill required energy demand, reduces power transmission cost, decreases environmental harmful effects due to pollution from the conventional power plant, improves system reliability as consumption unit increases[3].

Smart Grid system consists of various controller systems, network management system, communication system, sensors with traditional types of equipment[4]. Smart Grid system uses mostly devices based on power electronics and their respected controller for efficient use of electrical energy. In recent days, most of the devices which are used in the Industrial sector are based on power electronics circuitry. Due to this, power quality issues are occurring in a system. The requirement of this device is not only of higher power quality for proper working but also it is majorly caused for the reduction in power quality. Thus, electric supplier authority and demand-side consumers are greatly affected by power quality issues in such a situation.[5] Among the different ways of compensating electrical power quality issues, Active Power Filters (APF) are playing an extensive role in the mitigation of power quality concerns.[6-7] The disturbances like Sag, Swell, Harmonics present in voltage wave are caused for malfunctioning and false tripping of breakers which results in obstacles for many industrial processes.[8],[19] These obstacles may create financial losses. For overcoming the phenomena related to voltage disturbances Series Active Power Filters (APF) are implemented by many industrial consumers.[9] A series active filter or Dynamic Voltage Restorer fed up by the Solar PV System has been proposed in [10]. As the utilization of power electronics devices is rising fastly in modern power systems, generation of harmonics in power system takes place to be more. To overcome this issue, shunt active power filters (APF) are mounted in a system.[10-11]

The comparative study of the various compensation methods such as phase compensation method, the pre sag compensation method[12], were studied. To validate the findings against each other, testing of several disturbance scenarios, including supply-side sag and power factor of load, has been carried out. The self-supported DVR control research model was proposed[13]. Three phase harmonic filters are implements for the harmonic mitigation produced by the voltage source converters. The study gives that low-rate DVRs will provides compensation for sag, swell of voltage and decrease THD voltage on the load end, and maintained it as per IEEE 519. DVR output acquired using Sinusoidal Pulse Control Width Modulation technique and Space Vector Pulse Width Modulation technique has been investigated for sag and load voltage harmonics in[14]. The Synchronous Reference Frame (SRF) approach has been used for the detection of sag/dip voltage and create a modulating signal. Study shows that, THD load voltage used by Space Vector PWM is smaller than the Sinusoidal PWM technique. However, this work does not analyze the output of SVPWM and SPWM with a load voltage swell. Self-energized DVRs have been suggested for the configuration integration of PV systems connected with grid[15]. The device called the "six port converter," which comprising of nine semiconductor switches lesser in number than the previous 12 semiconductor switches. The configurations are capable of working in a number of modes dependent on grid conditions and the generation of PV power[16].

Thus, it becomes necessary that a new technique has to be implemented in a system that can provide both dual purposes first one it can provide generation to power supplier utility, and the second one is that it can be advantageous for consumers. The importance of this era is to provide protection to both power supply utility as well as a consumer due to which sensitive type of load can be protected from the distortions occurring in voltage and also decrease the disturbances occurring at utility side due to loads connected at the customer side. So that, the PV-DVR model is designed which consists of an integration of Distributed System Generation and series active filtering connected. DVR provides compensation for power quality related to the voltage of the grid side[17]. As there is a demand for Clean Energy having Improved power quality for working of Sensitive Electrical Loads, there is a need for a system that can provide multi-functions of the generation of Clean energy and improvement in power quality. Three phase solar energized system that provides compensation for power quality issues at load side is proposed in [18-19]. The DVR integrated with Solar PV array proposed in [20-23].

In this work, three phase DVR is integrated with Solar PV Array is presented. This system provides following advantages-

a) An integration between the Generation of Clean energy and improved Power Quality.

b) Provides stability under the grid conditions like Sag-Swell in Voltage, for Non-linear and unbalance load types.

The output of the proposed system is evaluated in the MATLAB/Simulink Platform for different phenomena observed in the System such as Voltage Sag, Voltage Swell, Non-linear, Unbalanced Load.

II. Configuration and Design of Proposed System

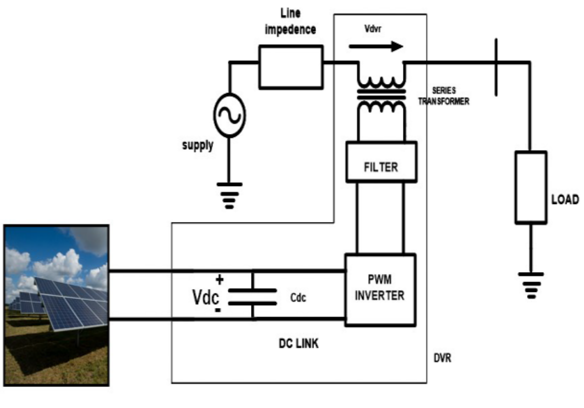

Fig. 1. Block Diagram for Proposed Mode

Dynamic Voltage Restorer (DVR) is a new trending active power filter having a capability to provide mitigation against issues related to the Grid Voltage or supplied voltage like Voltage Sag, Voltage Swell, Voltage Spikes, Surges, Fluctuations. DVR is also called as a Series Active Power Filter (SAPF). It is a solid-state custom power circuitry. It consists of a Bridge converter energized by a voltage source. This series controller device is connected in a series manner with the grid lines between the Grid Voltage Source or Supply Source side and the Load side which has to be protected from supply-side voltage quality issues. Series Active Power Filter or DVR injects a compensating voltage which is dynamically controlled through a series transformer in between supply-source side and load side. And maintains Load-side voltage at Constant reference value and insensitive for supply-side problems.

The block diagram for proposed system is as displayed in the above fig. 1. Here, excitation of DC Voltage for DVR is provided using Solar PV Panel. The overall system consists of the following components

A. Solar PV system

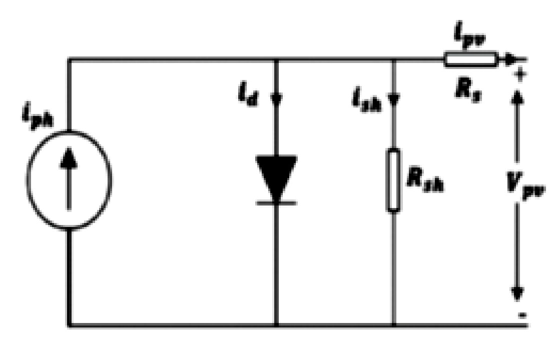

Fig. 2. Equivalent Circuit of Solar Cell

Here in this work, Ddistributed generation is achieved by using Solar Photovoltaic Cell. By connecting solar cell in series and parallel manner required voltage and current is generated respectively. The equivalent circuit configuration of the solar PV cell is shown in fig. 2

The output voltage acquired from above circuit is found out by using the following expression:

$$V_{pv} = \frac{kT}{q}\ln\left(\frac{i_{ph}+i_d-i_{pv}}{i_0}\right) - i_{pv}R_s \qquad (1)$$

Where,
- k = Boltzmann Constant
- T = Temperature
- q = Charge
- i_{ph} = Photo Current
- i_d = Diode Current
- i_{pv} = PV Array output current
- R_s = Series Resistance in Ω

Here, the output dc voltage getting from this Solar Array is 600V.

TABLE I. DETAILS OF SOLAR PANEL

Symbol	Description	Value
V_{oc}	Rated Open Circuit voltage	61 V
I_{Ph}	Phase Current	5.35 A
I_o	Diode Saturation Current	3.4046×10^{-10} A
q	Charge on Electron	1.1602×10^{-19} C
A	Ideality Factor	1.50
k	Boltzman constant	1.38×10^{-23} J/K
R_S	Series Resistance	0.55228 Ω
R_{Sh}	Parallel Resistance	201.8871 Ω
I_{SC}	Short circuit current	5.35 A
K_i	Temperature Coefficient of SC Current	0.069402
T_r	Reference Temperature	301.18 K
E_{gap}	Energy Band Gap for silicon	1.1 eV
n_p	No. of Parallel Cells	10
n_S	No. of Series Cells	10
S	Input Radiation Level of Solar	0~1000 W/m^2
T	Surface Temperature of PV Panel	350K

B. DC link Capacitor

The DC link capacitor is connected between VSC and Solar PV Panel. Sizing of DC link capacitor is found out from voltage level present at DC bus and Power requirement. From the Energy Balancing expression sizing of DC Link Capacitor is find out by:

$$C_{dc} = \frac{3ka V_{ph} I_{sh} t}{0.5*(V_{dc}^2 - V_{dc1}^2)} \quad (2)$$

Where, V_{dc} = DC link Voltage

V_{dc1} = Lower DC Link Voltage

V_{ph} = Phase Voltage

I_{sh} = Phase Current

t = time taken by dc voltage for appearing at rated value

k = Energy variation factor

C_{dc} = DC Link Capacitance

C. Series Connected Injecting Transfrormer

The main function behind the use of the Injecting Transformer is to step-up the voltage level acquired from the power circuitry of DVR present at the primary side of the transformer and these rised voltages are to be injected into the line. The voltage level is to be risen up such that, it has to be matched with the nominal voltage level of grid lines or system and voltage level required for the load. This transformer provides isolation between the DVR system and the grid system. For proper injection of voltage into the lines, the voltage level at the secondary side should be equal to the grid lines voltage level and there should be proper impedance matching.

III. CONTROL STRUCTURE

The controlling subsystem is present in the Simulink Model of PV-DVR for controlling operations of series APF. The Series APF provides compensation to supply-side voltage problems and protects the load from it by injecting the appropriate required voltage which is dynamically controlled.

A. Contorl of Series Active Filter

Series APF provides compensation for voltage quality problems that occurs between the PCC (Point of Common Coupling) and load end. This maintains voltage at the desired magnitude, balanced, and distortion-free. At PCC, problems regarding power quality or distorted input three-phase voltage may be present. For the generation of the unit vector, the source input voltage is sensed in per-unit terms. Then, this per unit voltage is provided to Phase Lock Loop (PLL). PLL is used for synchronization purposes. PLL provides a phase signal matched with the input signal. Here, the disturbed three-phase input voltage is sensed, and then it is provided PLL which gives phase angle ωt. For the computation of three-phase unit vectors which are balanced and 120° displaced and in phase with supply voltage, phase angle ωt is used. The Calculated three-phase unit vectors are then multiplied by the required maximum value of phase voltage of PCC. Here, the required maximum value is calculated by, $(415 * \sqrt{2})/\sqrt{3}$.

Then, the generated reference voltage is compared with the load voltage, and by using Hysteresis controller, controlling pulses are provided to series active power filter.

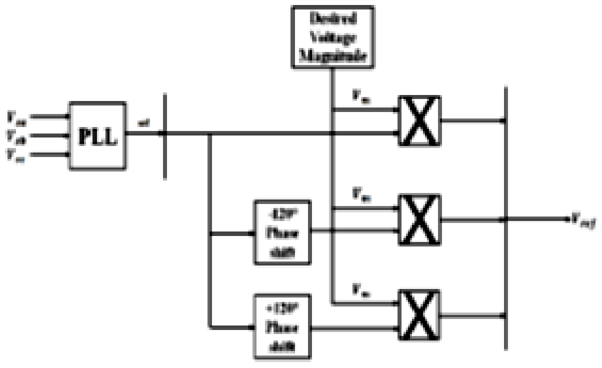

Fig. 3. Generation of Reference Voltage Signal

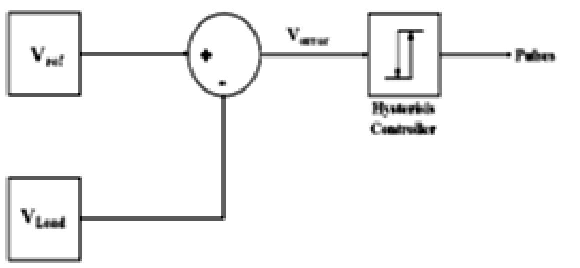

Fig. 4. Pulse Gereration for Series Active Power Filter

IV. Simulation Results

In this paper, PV-DVR is designed for Power Quality improvement in Smart Grid and modeled using MATLAB/Simulink Platform and outcomes are analyzed for various Power Quality Issues occurring in voltage wave like Sag, Swell, and also for Harmonic Contents. The system voltage is 415 V line to line. Here, the result analysis is carried out for the Non-Linear type of Load which consists of Three-Legged Diode Bridge having an RL type of Load. The analysis of results is also carried out for Induction Motor Load. The step size of the Solver configuration used for this Simulation is 2e-5s.

A. PV-DVR performance for Voltage Sag Phenomena

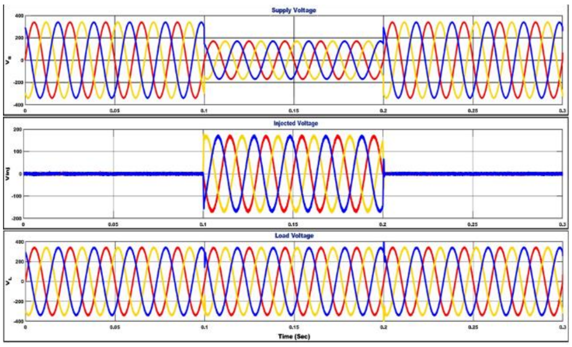

Fig. 5. Performance of PV-DVR during Voltage Sag

The performance of PV-DVR for Voltage Sag Phenomena is shown in above fig. 5.

Here, V_g shows Grid Voltage, V_L shows Load Voltage, V_{inj} shows Injected Voltage. The simulation is carried out for time period of 0.3s. For the time period, 0s to 0.1s the Grid Voltage is maintained at a normal level. During period 0.2s to 0.3s Voltage Sag phenomenon is introduced in a system. In this period, the Grid Voltage is fallen to 0.5pu of normal Grid Voltage. Due to this Load Voltage Level is also fallen to 50% of the Normal Voltage Level. During this period, the Series Active Power Filter or DVR injects Voltage in a system which is in Phase with Grid Voltage through a Series Transformer. This injected Voltage is get added up with Grid Voltage and Voltage Compensation is provided. So, the uniform voltage level is maintained at the Load side even in Voltage Sag phenomena which are as shown above.

B. PV-DVR performance for Voltage Swell Phenomena

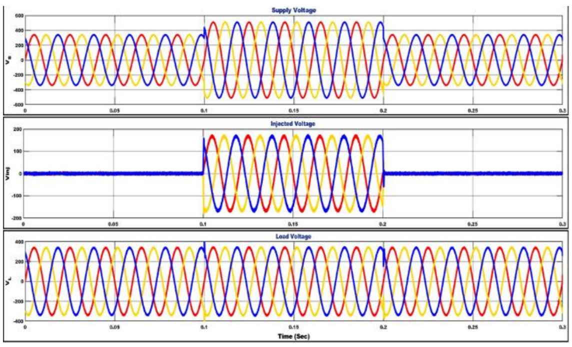

Fig. 6. Performance of PV-DVR during Voltage Swell

The performance of PV-DVR for Voltage Swell Phenomena is shown in above fig. 6.

Here, the Simulation is carried out for 0.3s. During period 0s to 0.1s, the Grid Voltage Level is maintained at a normal level. The voltage Swelling phenomena are introduced in a system for the time period of 0.1s to 0.2s. During this period, the Grid Voltage Level is raised by 50% above to normal Grid Voltage Level. Due to this, the Load Voltage is raised to 1.5pu. For the time period of 0.1s to 0.2s, Series Active Power Filter or DVR provides a voltage in the system through a series transformer. This provided voltage is opposite in phase of swelled Grid Voltage. The Load Voltage waveform is shown in the above fig.6 which shows that Load Voltage is maintained effectively at the desired constant uniform level. The excess power supplied during voltage swelling condition is return fed back to the supply source.

C. PV-DVR performance for harmonics Phenomena

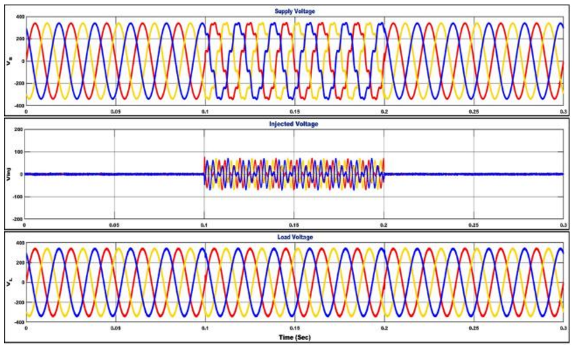

Fig. 7. Performance of PV-DVR during Distorted Voltage Condition

The performance of PV-DVR for Voltage Distortion Phenomena is shown in above fig. 7.

The performance analysis is carried out by running the simulation for 0.3s. For the time period of 0s to 0.1s, Grid Voltage is maintained at a normal level. The effect of 5th and 7th order harmonics is introduced in a system during a time period of 0.1s to 0.2s. Due to this harmonics content, distortions are occurred in Grid Voltage. This distorted voltage is getting appeared across Load. The harmonics content in Voltage causes to Load heating, Load mal-functioning problems. PV-DVR injects reverse order harmonics in a system in opposition to occurred harmonic contents. So that, harmonic contents are get canceled out and compensation is provided to the system. Thus, Voltage distortions are avoided and Uniform voltage is provided to the load. The injected voltage and compensated voltage for a load is shown in fig.7

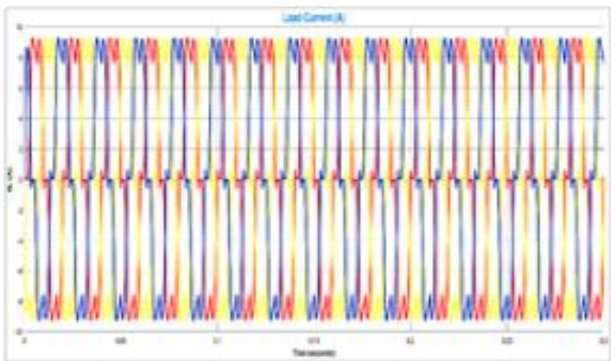

Fig. 8. Load Current of 3-Leg Diode Bridge Rectifier

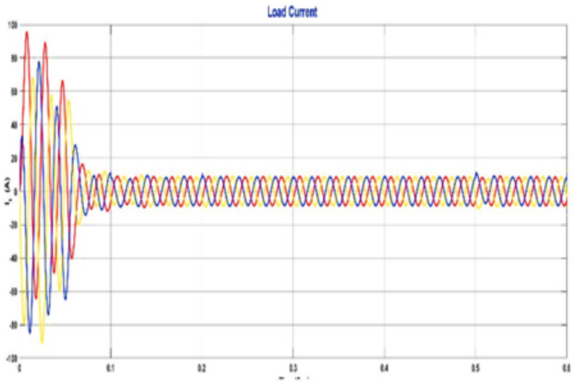

Fig. 9. Load Current for Induction Motor Load

Fig. 8 & Fig. 9 depicts the load current waveform. During the simulation, it is observed that for various power quality issues the load current waveform is maintained at a constant level. So that, Load operations due to distorted current cannot be disturbed.

The FFT analysis has been carried out in the MATLAB/Simulink platform for computing the THD Level. From the analysis of the result, it is observed that the Load has a THD Level of 22.27%. By using compensation with the help of PV-DVR, THD level is reduced up to 1.17% which is shown in the above fig. where the upper part shows the signal waveform and the lower part shows the fundamental component and provides THD Level in percentage.

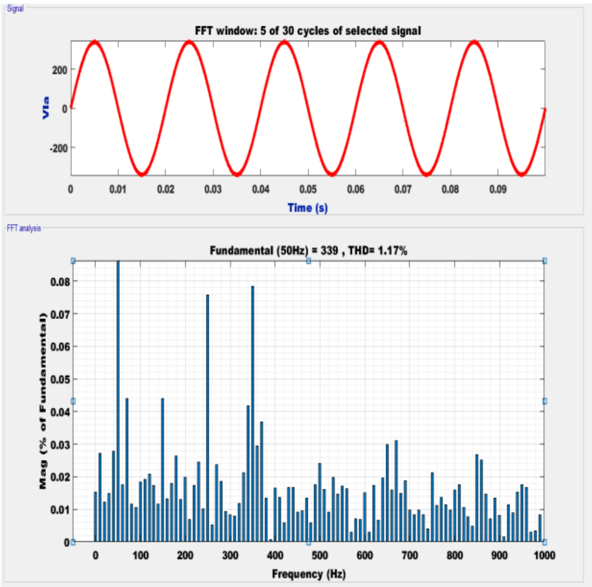

Fig. 10. Output THD after compensation

The Simulation and analysis of the Proposed System are carried out for 30%, 40%, and 50% Voltage Sag and Swell. The analyzed values of the proposed system for Non-linear Load and Induction Motor are depicted in observation tables no. II and III.

TABLE II. ANALYSED DATA FOR NON-LINEAR DIODE BRIDGE RECTIFIER LOAD

Scenarios	30% Voltage Sag	30% Voltage Swell	40% Voltage Sag	40% Voltage Swell	50% Voltage Sag	50% Voltage Swell
Source Voltage						
Phase A (Volt)	71.88	311.5	95.84	335.4	119.8	359.4
Phase B (Volt)	71.88	311.5	95.84	335.4	119.8	359.4
Phase C (Volt)	71.88	311.5	95.84	335.4	119.8	359.4
Load Voltage						
Phase A (Volt)	238.2	240.5	237.5	240.8	237.8	241.2
Phase B (Volt)	238	240.4	237.7	240.7	237.9	241.2
Phase C (Volt)	238.2	240.4	237.6	240.7	237.9	241.3
Injected Voltage						
Phase A (Volt)	166.3	70.95	141.7	94.68	118	118.2
Phase B (Volt)	166.1	71.06	141.8	94.73	118.1	118.2
Phase C (Volt)	166.3	71.04	141.8	94.71	118.1	118.1

TABLE III. ANALYSED DATA FOR INDUCTION MOTOR LOAD

Scenarios	30% Voltage Sag	30% Voltage Swell	40% Voltage Sag	40% Voltage Swell	50% Voltage Sag	50% Voltage Swell
Source Voltage						
Phase A (Volt)	71.88	311.5	95.84	335.4	119.8	359.4
Phase B (Volt)	71.88	311.5	95.84	335.4	119.8	359.4
Phase C (Volt)	71.88	311.5	95.84	335.4	119.8	359.4
Load Voltage						
Phase A (Volt)	237.7	240.5	237.5	240.7	238	241.1
Phase B (Volt)	237.8	240.4	237.7	240.8	238	241.1
Phase C (Volt)	237.8	240.5	237.5	240.8	238	241.1
Injected Voltage						
Phase A (Volt)	165.8	70.98	141.7	94.74	118.2	118.3
Phase B (Volt)	165.9	71.05	141.9	94.65	118.2	118.3
Phase C (Volt)	165.9	70.99	141.7	94.66	118.2	118.3

V. CONCLUSION

For Conventional Generation system, the Classic Dynamic Voltage Restorer with Battery is used to compensate the Power Quality issues related to Voltage Wave. The non-linearities are identified in the Classic model due to Total Harmonic Distortion which causes poor Load Voltage profile at Smart Grid Power System applications. To compensate the Non-linearities at Load Voltage, a new integrated Solar PV-DVR is introduced. In this paper, the performance analysis of PV-DVR has been carried out in MATLAB/Simulink software environment. The simulation results have shown better performance and provides compensation for power quality issues such as Voltage Sag/Dip, Voltage Swell and Distorted Voltage Condition under various testing conditions such as 30%, 40% and 50% values. The performance of the PV-DVR with Non-linear loads such as 3-Leg Diode Bridge Rectifier and Inductive Load is analyzed for Three-phase Source Voltage. From the data, it can be concluded that the improvement of Load Voltage profile and Lower THD Level is achieved as per IEEE519 standard.

REFERENCES

[1] O. Ceaki, G. Seritan, R. Vatu and M. Mancasi, "Analysis of Power Quality improvement in Smart Grids," 2017 10th International Symposium on Advanced Topics in Electrical Engineering (ATEE), Bucharest, 2017, pp. 797-801, doi: 10.1109/ATEE.2017.7905104.

[2] A. Javadi, L. Woodward, and K. Al-Haddad, ``Real-time implementation of a three-phase THSeAF based on a VSC and a PCR controller to improve the power quality of weak distribution systems," IEEE Trans. Power Electron., vol. 33, no. 3, pp. 2073-2082, Mar. 2018.

[3] M. J. E. Alam, K. M. Muttaqi and D. Sutanto, "Effective Utilization of Available PEV Battery Capacity for Mitigation of Solar PV Impact and Grid Support With Integrated V2G Functionality," in IEEE Transactions on Smart Grid, vol. 7, no. 3, pp. 1562-1571, May 2016, doi: 10.1109/TSG.2015.2487514.

[4] I. Axente, J. N. Ganesh, M. Basu, M. F. Conlon and K. Gaughan, "A 12-kVA DSP-Controlled Laboratory Prototype UPQC Capable of Mitigating Unbalance in Source Voltage and Load Current," in IEEE Transactions on Power Electronics, vol. 25, no. 6, pp. 1471-1479, June 2010, doi: 10.1109/TPEL.2010.2040635.

[5] A. Ghosh, Arindam, G. Ledwich, Gerard, "Power Quality Enhancement Using Custom Power Devices", Boston M.A. Kluwer 2002.

[6] H. Akagi, "Active Harmonic Filters", Proc. IEEE, vol. 93, no. 12, pp. 2128-2141, Dec-2005

[7] A. Javadi, A. Hamadi, L. Woodward and K. Al-Haddad, "Experimental Investigation on a Hybrid Series Active Power Compensator to Improve Power Quality of Typical Households," in IEEE Transactions on Industrial Electronics, vol. 63, no. 8, pp. 4849-4859, Aug. 2016, doi: 10.1109/TIE.2016.2546848.

[8] B. Singh, A. Chandra and K. A. Haddad, Power Quality: Problems and Mitigation Techniques. London: Wiley, 2015

[9] S. Devassy and B. Singh, "Modified p-q theory based control of solar pv integrated upqc-s," IEEE Trans. Ind. Appl., vol. PP, no. 99, pp. 1–1, 2017.

[10] M. A. Mansor, M. M. Othman, I. Musirin, S. Z. M. Noor, "Dynamic Voltage Restorer (DVR) in a complex voltage disturbance compensation", International Journal of Power Electronics and Drive System (IJPEDS), Vol. 10, No. 4, December 2019, pp. 2222-2230, SSN: 2088-8694, DOI: 10.11591/ijpeds.v10.i4.pp2222-2230.

[11] A. Moreno-Munoz; D. Oterino; M. Gonzalez; F. A. Olivencia; J. J.Gonzalez-de-la-Rosa,"Study of Sag Compensation with DVR", IEEE Mediterranean Electrotechnical Conference (MELECON), Malaga Spain, pp. 990-993, 2006.

[12] Amit Kumar; Nidhi Singh Pal; M. A. Ansari, "Mitigation of Voltage Sag/Swell and Harmonics using Self-Supported DVR", First IEEE Conference on Power Electronics, Intelligent, Control and Energy Systems (ICPEICES), New Delhi, India, pp: 1-5, 2016.

[13] A. M. Rauf and V. Khadkikar, "Integrated photovoltaic and dynamic voltage restorer system configuration," IEEE Transactions on Sustainable Energy, vol. 6, no. 2, pp. 400–410, April 2015.

[14] Abdul Mannan Rauf and Vinod Khadkikar, "Integrated Photovoltaic and Dynamic Voltage Restorer System Configuration", IEEE Transactions on Sustainable Energy, Volume: 6, Issue: 2, pp. 400-410, 2015.

[15] 1159-1995-IEEE Recommended Practice for Monitoring Electric Power Quality, New York, USA.

[16] E. Hossain, M. R. Tur, S. Padmanaban, S. Ay, and I. Khan, "Analysis and mitigation of Power Quality issues in Distributed Generation systems using Custom Power Devices," IEEE Access, vol. 6, pp. 16816-16833, 2018.

[17] K. Hasan, M. M. Othman, N. F. A. Rahman, M. A. Hannan, and I. Musirin, "Significant implication of Unifed Power Quality Conditioner in power quality problems mitigation," Int. J. Power Electron. Drive Syst., vol. 10, no. 4, p. 2231, Dec. 2019.

[18] Y. Singh, I. Hussain, B. Singh, and S. Mishra, "Single-phase Solar Grid interfaced system with active filtering using adaptive linear combiner filter-based control scheme," IET Generation, Transmission Distribution, vol. 11, no. 8, pp. 1976–1984, 2017.

[19] T.-F. Wu, H.-S. Nien, C.-L. Shen, and T.-M. Chen, "A single-phase inverter system for PV Power injection and active power filtering with nonlinear inductor consideration," IEEE Trans. Ind. Appl., vol. 41, no. 4, pp. 1075–1083, July 2005.

[20] S. Devassy and B. Singh, "Design and performance analysis of three phase solar pv integrated upqc," in 2016 IEEE 6th International Conference on Power Systems (ICPS), March 2016, pp. 1–6.

[21] K. Palanisamy, D. Kothari, M. K. Mishra, S. Meikandashivam, and I. J. Raglend, "Effective utilization of unified power quality conditioner for interconnecting PV modules with grid using power angle control method," International Journal of Electrical Power and Energy Systems, vol. 48, pp. 131 – 138, 2013.

[22] A. Kiswantono, E. Prasetyo and Amirullah, "Mitigation Voltage Sag/Swell and Harmonics Using DVR Supplied by BES and PV System," 2018 Electrical Power, Electronics, Communications, Controls and Informatics Seminar (EECCIS), Batu, East Java, Indonesia, 2018, pp. 36-41, doi: 10.1109/EECCIS.2018.8692788.

AUTHOR PROFILE

Mr. Rakesh More received his Bachelors in Engineering in 2017 from Dr. Vithalrao Vikhe Patil College of Engineering, Ahmednagar, (MH) India affiliated to Savitribai Phule Pune University, Pune. He is currently working towards his post-graduation degree of M. Tech in Electrical Power System from Government College of Engineering, Aurangabad, (MH) India. His areas of research interest include Power Quality, Electrical Machines, Power Electronics and Renewable Energy Systems. He has been published a review paper on Power Quality issues in Smart Grid.

Dr. Nitin Bhasme is working as an Associate Professor in Electrical Engineering at Government College of Engineering, Aurangabad since 1998. He has completed under graduation in Electrical Engineering in 1993 from Government College of Engineering, Aurangabad. Thereafter completed post-graduation and Ph.D. from same institute. He has guided more than 30 students at PG level and more than 150 students at UG level. Currently he is a Research Guide in Electrical Engineering and his areas of interest are Power Electronics, AC and DC Drives and Renewable Energy Systems.