International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Design and Performance Analysis of Three-Phase Solar PV Integrated UPQC

Mr Nilesh V. Hadpe[1], Prof. Pawan C. Tapre[2], Prof. Amit M. Solanki[3]

[1]M.E. Student, Department of Electrical Engineering, SNDCOE & RC, Yeola, Maharashtra,India
[2]H.O.D, Department of Electrical Engineering, SNDCOE & RC, Yeola, Maharashtra, India
[3]ME Coordinator, Department of Electrical Engineering, SNDCOE & RC, Yeola, Maharashtra, India

---***---

Abstract: Today it is very important to provide clean, reliable and continue power to the consumer from supply authority. due to the increasing customers and use of modern power electronic devices, there is no. of disturbances in quality of power such as voltage sag.swell,harmonics.hence In order to maintain quality of power, different power electronic devices has been used. In this project, we used unified power flow conditioner with solar PV array to maintain good power quality. UPQC is the combination of series and shunt compensator which performs multi task to improve the quality of power. Series converter compensate the grid side power quality problems such as voltage sag and swell as well as maintain load voltage preferably consant.it also regulate the PCC voltage. Shunt compensator compensate the problem of current harmonics due to nonlinear load. It takes power from PV array. Reference signal is generated by using synchronous reference frame control based on moving average filter. The model of upqc is developed and simulated in MATLAB software by using matlab simulink result with and without UPQC is compared.

Index Terms—Power Quality, shunt compensator, series compensator, UPQC, Solar PV, MPPT

I. Introduction

In recent, new trend of power electronics instruments are developed. Due to the use of these power electronic devices, nonlinear current flowing through the instrument causes generation of harmonics as shown in fig 1. The increasing demand of customers at load side may cause voltage sag which may affect on quality of power. It is essential that utility will supply power with best quality and permissible range. Utility should provide supply reliably and continuously. Hence in order to maintain stable voltage at grid as well as load side, multipurpose device is required. Hence this project deals with use of UPQC device with solar PV.The UPQC consists of series and shunt compensator connected back to back via common dc link.

Solae PV is used instead of using inverter which gives the dual benefits of clean energy generation. It gives protection against grid side disturbances which protects the critical load during transients. Compared to shunt and series active power filters, a unified power quality conditioner (UPQC), which has both series and shunt compensators can perform both load voltage regulation and maintain grid current sinusoidal at unity power factor at same time. The combination of UPQC with solar photovoltaic gives dual benefits as clean energy generation along with improved power quality. In this project, synchronous component theory is with moving active filter is used to generate reference signal. The model of active filter with non linear load is using matlab Simulink software.

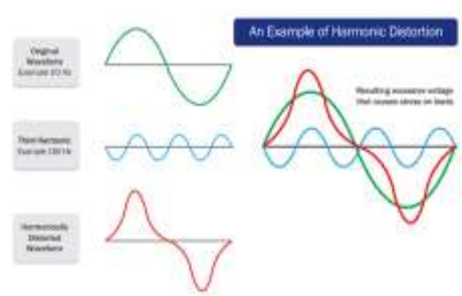

Fig1. Harmonic distortions of waveforms due to non-linear load

II. System Configuration

UPQC is the combination of series and shunt converter.Basic structure of UPQC is as shown in fig 2.The role of series inverter inject compensated voltage in series with load voltage whwn source voltage become unbalanced and non sinusoidal.Series compensator inject or absorb voltage at the required magnitude and phase angle which can solve the problrm of voltage sag,swell and flicker.series inverter absorb or inject real power in addition to reactive power.The shunt converter has the ability to regulate the dc link voltage and compensate the current related PQ issues such as harmonics,interharmonics and reactive power requirement. The structure of the PV-UPQC is shown in Fig3. The PV-UPQC is designed for a three-phase system. The PV-UPQC consists of shunt and series compensator connected with a common DC-bus. At load side, shunt compensator is connected. The solar PV array is directly integrated to the DC-link of UPQC through a reverse blocking diode. The series compensator used to compensate the voltage which can reduce the voltage sag and swell. The shunt and series compensators are connected to the grid through interfacing inductors. A series compensator injects the voltage into the grid by using series injection transformer. Harmonics are generated by converters are eliminated by using filters. The load used is a nonlinear load consisting of a bridge rectifier with a voltage-fed load

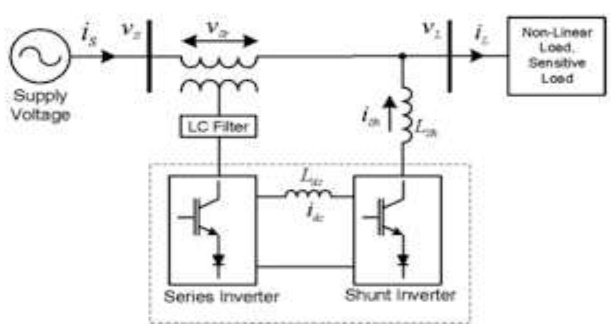

Fig 2.Basic structure of UPQC

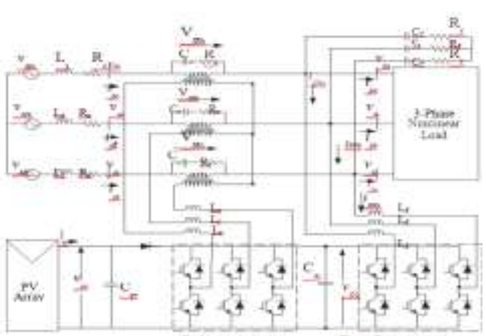

Fig 3.System configuration of UPQC

III. Control strategy

A. Control Strategy for shunt converter

The measured load current is transformed into the synchronous dqo reference frame. By this transform, the fundamental positive- sequence component, which is transformed into dc quantities in the *d* and *q* axes, can be easily extracted by low-pass filters (LPFs). Also, all harmonic components are transformed into ac quantities with a fundamental frequency shift.

The shunt compensator extracts the maximum power from the solar PV array by operating at its maximum power point .The maximum power point tracking(MPPT) algorithm generates the reference voltage for the DC link of UPQC. Current from dc link is converted to the reference grid currents. The reference grid currents are compared with the sensed grid currents is given to hysteresis controller. Hysteresis controller generate the gating pulses for shunt converter

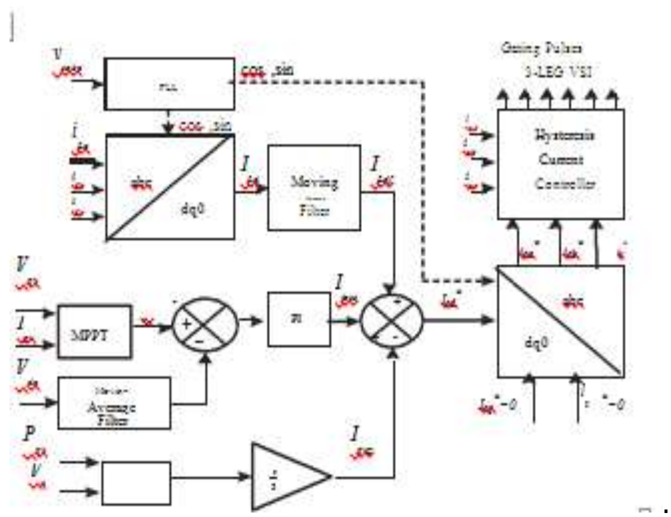

Fig.4.Control Structure of shunt Compensator

B. Control of Series Compensator

The bus voltage is detected and then transformed into the synchronous dq0 reference frame The control strategy for the series compensator are pre-sag compensation, in-phase compensation and energy optimal compensation. In this work, the series compensator injects voltage in same phase as that of grid voltage, which results in minimum injection voltage by the series compensator. The control structure of the series compensator is shown in Fig.5. The fundamental component of PCC voltage is extracted using a PLL which is used for generating the reference axis in d-q-0 domain. The reference load voltage is generated using the phase and frequency information of PCC voltage obtained using PLL. The PCC voltages and load voltages are converted into d-q-0 domain. As the reference load voltage is to be in phase with the PCC voltage, the peak load reference voltage is the d-axis component value of load reference voltage. The q-axis component is kept at zero. The difference between the load reference voltage and PCC voltage gives the reference voltage for the series compensator. The difference between load voltage and PCC voltage gives the actual series compensator voltages. The difference between reference and actual series compensator voltages is passed to PI controllers to generate appropriate reference signals. These signals are converted to abc domain and passed through pulse width modulation (PWM) voltage controller to generate appropriate gating signals for the series compensator.

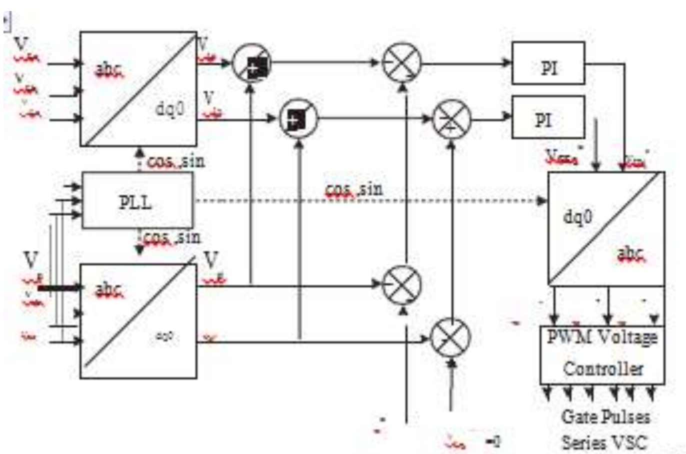

Fig 5. Control Structure of Series Compensator

IV. Simulation model

A Unified power Quality Conditioner (UPQC) is used to regulate voltage on an 11-kv distribution network. A feeder (100 km) transmits power to loads connected at bus. The performance of UPQC is evaluated by using the MATLAB/SIMULINK 2016 as a simulation tool The load of 15KVA & 25KVA load is connected between and also at the same time, nonlinear load is connected. We compensate for source side voltage and current. Test parameter of the system as shown below. The first set of simulation was done with no UPQC. The waveform of voltage, current and power without load and without UPQC is as shown in fig 9. and then the nonlinear load connected with UPQC. The result of swell and sag is observed as shown in fig 10,11,12,13 Below figures shows the RMS voltage at load point when the system operates with and without UPQC. When the UPQC is in operation the voltage interruption is compensated almost completely and the RMS voltage at the sensitive load point is maintained at normal condition. The voltage sag value is about 0.5 per unit. The D-STATCOM can compensate the source voltage sag and swell effectively.

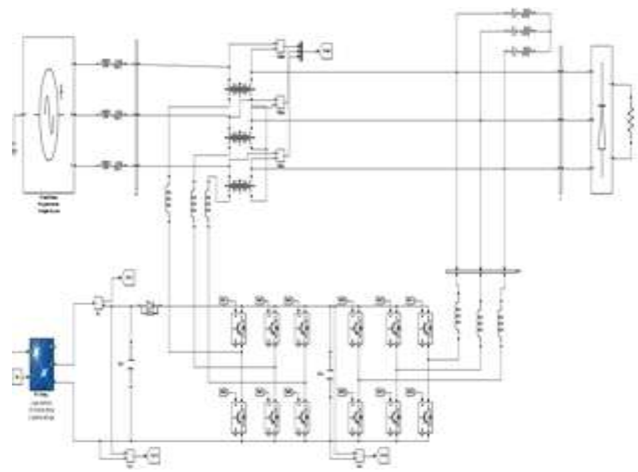

Fig 8.Simulation model of UPQC

V. Simulation result

Fig 9.Load voltage, current and power without load, without UPQC

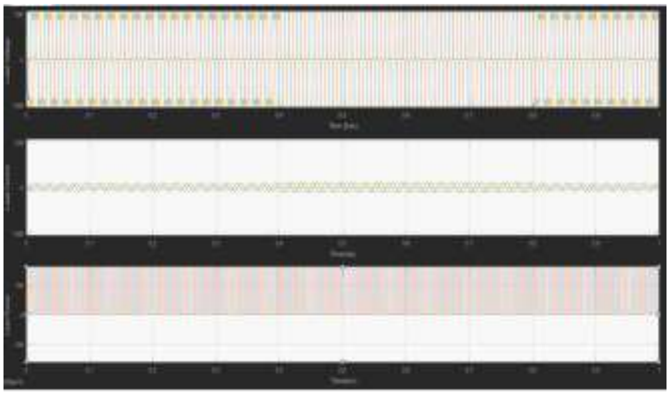

Fig10.Load voltage, current and power with load without UPQC(generation of swell)

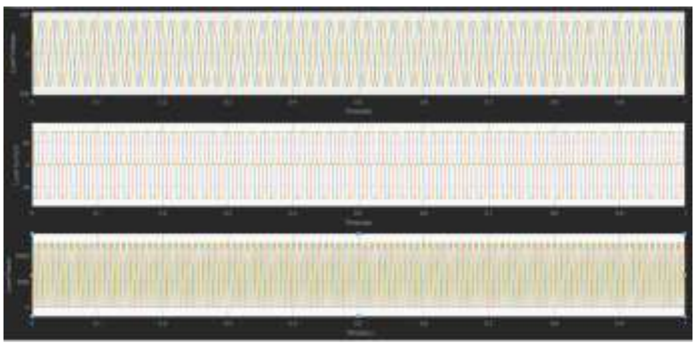

Fig11.Load voltage, current and power with load with UPQC

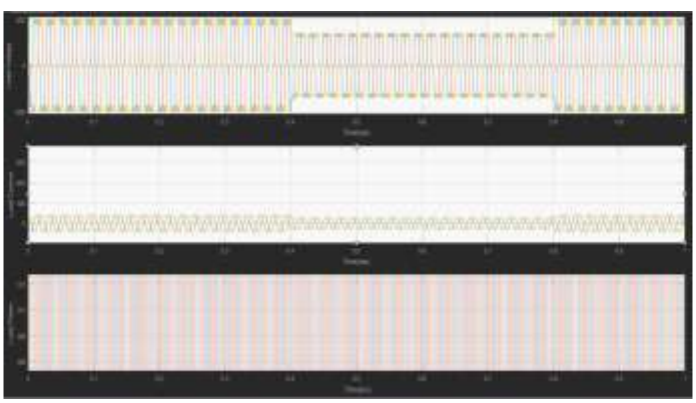

Fig 12.Load voltage, current and power with load without UPQC(generation of sag)

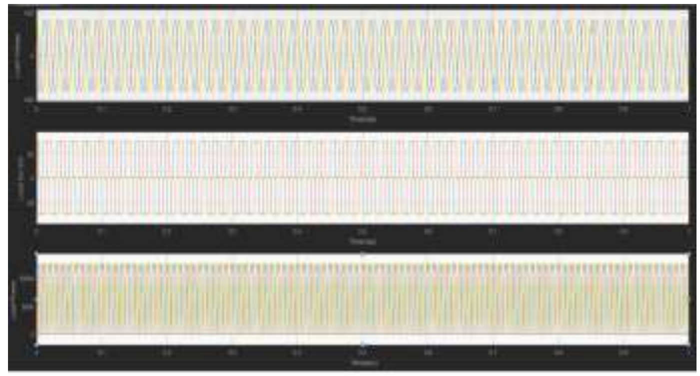

Fig 13.Load voltage, current and power with load with UPQC

Conclusion:

In this work modeling and simulation of UPQC with necessary control strategy is implemented. The simulation results showed clearly the performance of the UPQC in mitigating the voltage sag and swell. The UPQC is modeled in conjunction with solar photovoltaic for multicontrol function. The source voltage and source current harmonic re eliminated by shunt controller and Voltage sag and swell are eliminated by series controller. The use of solar photovoltaic gives dual function as it gives clean energy with improvement of power quality. In this paper. The nonlinear load is connected to the system and result of voltage, current and power is observed with and without UPQC.

References:

1. B. Mountain and P. Szuster, “Solar, solar everywhere: Opportunities and challenges for australia’s rooftop pv systems,” IEEE Power and Energy Magazine, vol. 13, no. 4, pp. 53–60, July 2015.
2. A. R. Malekpour, A. Pahwa, A. Malekpour, and B. Natarajan, “Hier-archical architecture for integration of rooftop pv in smart distribution systems,” IEEE Transactions on Smart Grid, vol. PP, no. 99, pp. 1–1, 2017.
3. Y. Yang, P. Enjeti, F. Blaabjerg, and H. Wang, “Wide-scale adoption of photovoltaic energy: Grid code modifications are explored in the distribution grid,” IEEE Ind. Appl. Mag., vol. 21, no. 5, pp. 21–31, Sept 2015.
4. M. J. E. Alam, K. M. Muttaqi, and D. Sutanto, “An approach for online assessment of rooftop solar pv impacts on low-voltage distribution networks,”

IEEE Transactions on Sustainable Energy, vol. 5, no. 2, pp. 663–672, April 2014.
5. J. Jayachandran and R. M. Sachithanandam, "Neural network-based control algorithm for DSTATCOM under nonideal source voltage and varying load conditions," Canadian Journal of Electrical and Computer Engineering, vol. 38, no. 4, pp. 307–317, Fall 2015.
6. A. Parchure, S. J. Tyler, M. A. Peskin, K. Rahimi, R. P. Broadwater, and M. Dilek, "Investigating pv generation induced voltage volatility for customers sharing a distribution service transformer," IEEE Trans. Ind. Appl., vol. 53, no. 1, pp. 71–79, Jan 2017.
7. E. Yao, P. Samadi, V. W. S. Wong, and R. Schober, "Residential demand side management under high penetration of rooftop photovoltaic units," IEEE Transactions on Smart Grid, vol. 7, no. 3, pp. 1597–1608, May 2016.
8. B. Singh, A. Chandra and K. A. Haddad, Power Quality: Problems and Mitigation Techniques. London: Wiley, 2015.
9. M. Bollen and I. Guo, Signal Processing of Power Quality Disturbances. Hoboken: Johm Wiley, 2006.
10. Sachin Devassy, Member, IEEE and Bhim Singh, Fellow, IEEE, Design and performance analysis of three phase solar PV integrated UPQC