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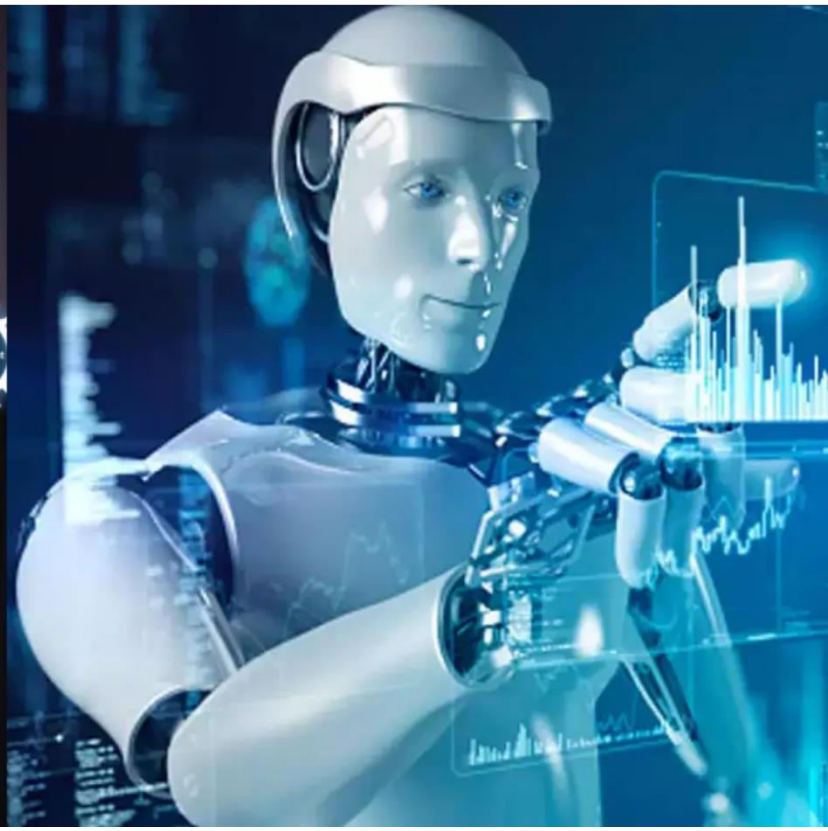
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Enhancement of Solar Farm Connectivity with Smart PV Inverter PV-STATCOM

A.Kumaresan, Manokari .S

Department of Power Electronics and Drives, AVS Engineering College, Military Road, Ammapet, Salem, Tamil Nadu, India

Department of Power Electronics and Drives, AVS Engineering College, Military Road, Ammapet, Salem, Tamil Nadu, India

ABSTRACT: Renewable energy sources are alternative energy source, can bring new challenges when it is connected to the power grid. When the solar power is connected to an electric grid affects the power quality. The effects of the power quality measurements are-the active power, variation of voltage, flicker, harmonics, and electrical behavior of switching operations. The installation of solar power with the grid causes power quality problems are determined by this project. The grid connected solar energy generation system for power quality improvement by using Static Compensator (STATCOM)-control scheme is simulated using SIMULINK in power system block set. The project demonstrates the power quality problem due to installation of solar power with the grid. Also the improvement in power quality on the grid has been presented here according to the guidelines specified in standard provides some norms and measurement. Power quality issues arising due to the usage of non-linear loads at the point of common coupling are addressed with the help of power electronic device interfacing STATCOM to the grid. The work presented in this project consists of Modeling and Simulation of solar energy system and interfacing it to the grid through the interfacing inverter. A suitable control strategy which will add shunt active filter functionality to the STATCOM interfacing device to the grid is also undertaken.

KEYWORDS: Solar PV, VAR Compensation, STATCOM, System faults

I. INTRODUCTION

SMART Inverters (also previously known as Advanced Inverters) represent a paradigm shift in the integration of Distributed Energy Resources (DER). These inverters can perform multiple functions involving both reactive and real power control in addition to their main task of converting DC power to AC power. These functions include voltage regulation, power factor control, active power controls, ramp-rate controls, fault ride through, and frequency control, etc. Various grid support functions offered by smart inverters are presently being demonstrated on real distribution and transmission systems in different counties, to motivate their rapid deployment.

Grid interconnection standards are currently being revised to facilitate the adoption of smart inverter functions. The voltage control related smart inverter functions e.g., Volt/VAR are mainly a set of operating points which are implemented in open-loop with time constants of a few seconds. The ongoing IEEE P1547 Standard Full Revision is contemplating that DERs shall be capable of injecting a finite amount of reactive power (typically 44%) even at 100% of nameplate active power rating (kW). This implies that DER inverters will have to be oversized. The LVRT function requires that the DER shall stay connected even if the voltage goes below a specified limit. However, if the voltage continues to be at a low level for more than a pre-specified period of time, the DER must disconnect. A unique concept of utilizing PV solar farms as STATCOM during night time for providing different grid support functions as well as for providing the same benefits during daytime with inverter capacity remaining after real power generation was studied earlier. STATCOM is a Voltage Source Converter (VSC) based Flexible AC Transmission System (FACTS) device. It can provide dynamic reactive power compensation with a response time of 1-2 cycles, and can provide rated reactive current for voltages as low as 0.2 pu. The utilization of PV solar farm as STATCOM, termed PVSTATCOM, was demonstrated for increasing the connectivity of neighbouring wind farms and enhancing the power transmission capacity during night and day.

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Distributed Generators (DGs) bring several benefits to distribution networks. However, these benefits come along with new challenges. Some of these challenges include steady state overvoltage, temporary overvoltage (TOV), unbalanced voltage, power quality issues such as harmonics, frequent operation of conventional voltage regulators such as load tap changers and capacitor banks, changes in feeder power factor, etc. High penetration of solar farms is known to cause reverse power flows resulting in over voltages at PCC which potentially limit any future DG installations. Traditionally, shunt capacitor banks (SCs), on-load tap changers (OLTC) and step type voltage regulators (SVRs) are utilized for voltage control in the distribution systems. However, these devices are slow acting with a response time ranging from seconds to few minutes. Moreover, these devices such as OLTC and SVR operate based on unidirectional flow of power and cannot operate reliably during bidirectional power flows caused by Distributed Generators e.g. solar farms. Flexible AC Transmission Systems (FACTS) such as Static Var Compensator (SVC) and STATCOM are utilized in general for voltage regulation purposes in power systems. These devices can provide voltage control with a response time of 1-3 cycles with STATCOM being much faster than SVC.

II. LITERATURE SURVEY

Today power quality is the most essential variable in both levels of transmission and distribution. It's very much essential to take care of the acceptable limits of power quality. **N.G hingorani** [1], 1995, has given the basic concept of custom power. It gives the reliability of power flow. Solid state circuit breakers, static compensators, static condensers provide the basis of the custom power.

Chellali Benachaiba et al. [2], 2008, describes DVR, a compelling custom power gadget for moderating voltage swell and sag. Also gave the method of voltage restoration at the PCC i.e. the point of common coupling, DVR principles and also described about the different methods of voltage injection. DVR can handle both unbalanced and balanced situations effectively.

Mehmet Ucar et al. [3], 2008, proposed the p-q theory which is also called instantaneous reactive power theory, another control calculation has been suggested for three-phase four-wire and four-leg parallel active power filter (APF), based on this proposal, for remuneration of reactive power, harmonic currents suppressions, and balancing of the load currents under non-perfect mains voltage conditions and unbalanced non-linear load.

Kamran and Habetler [4],1998,has proposed a new method taking into account the deadbeat control, that treats UPQC inverter association as a solitary unit. The whole concept has been exhibited utilizing a 3-phase series-shunt active filter. It also uses a full-order predictive state observer. Modelling the system as a solitary multi-input, multi-output framework has many advantages. It showed faster dynamic response and steady state precision and thereby giving enhanced control execution over the independently controlled converters.

K.H Kwan et al. [5], 2007, propose a model predictive control design for the UPQC. Use of kalman filters makes it easy for the extraction of principal and harmonic parts of the given load current and the supplied voltage. The model predictive controller had been designed based on the state space model of the UPQC. The MPC controller proved beneficial in regulating the error in supplied voltage and the load current thereby regulating both supply voltage and load current. It is helpful in mitigating load variation, sag and swell.

Bhim Singh et al. [6], 2011, proposed a control method for the DVR i.e. dynamic voltage restorer in order to overcome the problems in the quality of power and regulate the terminal voltage. For regulation of dc bus voltage of the DVR and the terminal voltage proportional integral (PI) controllers are used. Synchronous reference frame hypothesis is likewise utilized for the extraction of fundamental component of the terminal voltage.

V.Khadkikar et al. [7], 2004, introduced a control procedure for UPQC. The control methodology depends on UVTG (unit vector template generation). Voltage harmonics present in the utility voltage. Steady state analysis and mathematical analysis of UPQC is given. Parallel APF maintains the overall power balance in the entire network. The current harmonics and input voltage harmonics can be repaid proficiently by the proposed control system.

Yash Pal et al. [8], 2011, present a control methodology for a 3-phase 4-wire UPQC. A 3-phase, 4 leg Voltage source inverter is used for parallel APF and a 3-phase, 3 legs Voltage source inverter for realisation of the series active power filter. Unit vector template control system is utilized for controlling the series APF, while Icosϕ control is utilized for

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controlling the parallel active power filter. These technique guarantees, alleviation of voltage and current harmonics, load balancing, voltage swell and droop and voltage plunges. This method helps effectively in reduction of computational time and number of sensors.

S.P Das et al. [9], 2007, proposed two control scheme models for UPQC. These two control schemes are based on the type of voltage compensation strategy; they are UPQC-Q and UPQC-P. The adequacy of the two control plans is tested. UPQC-Q can effectively share the VAR between the two compensators but not effective in controlling the unbalanced voltage sag. UPQC-P can relieve the supply voltage-unbalancing issue likewise next to controlling the voltage droop and swell.

Ambrish Chandra and Vinod Khadkikar[10],2008, suggested a method as power angle control (PAC) of UPQC so that series inverter of UPQC is used to it most extreme limit. By this PAC concept by controlling the power angle between the source and load voltages properly, both parallel and series inverters can properly share the load reactive power. This proved helpful for reduction of the parallel inverter rating of the UPQC.

III. METHODS

Smart inverters have been studied for PV solar systems to effectively counteract voltage issues. Smart inverter functions such Volt/VAR, Volt/Watt, off-unity power factor, Low/High Voltage Ride Through, Low/High Frequency Ride Through and Dynamic Reactive Current Injection, etc. have been demonstrated in field applications. Grid Codes such as IEEE 1547 have been revised in the interim. The newly proposed smart inverter functions as described in the revised IEEE 1547 (2018) although provide ride through capability but not Temporary Overvoltage mitigation explicitly. A unique control of PV solar farms as STATCOM during night time for providing various grid support functions with full inverter capacity and for delivering the same benefits during daytime with PV inverter capacity remaining after real power generation was introduced in 2009. The control of PV-STATCOM was utilized for increasing the connectivity of wind farms and for improving the power transmission capacity. The above control however has a limitation of available reactive power capacity especially during noontime when the inverter is completely utilized for real power generation.

solar power, at the one end is very much useful source of energy same time when it is connected to the electric grid STATCOM creates some quality issues like voltage sag, swell, harmonics etc. solar power plants are also affected by faults which occur in every power system occasionally. Main advantage of them being environmental friendly, they have an added advantage of being complimentary to each other. In this research the application of Static Compensator (STATCOM) connected to a solar power renewable energy source. The STATCOM can compensate the faulty line voltage sag and solar power can continue its normal operation as demanded in actual grid.

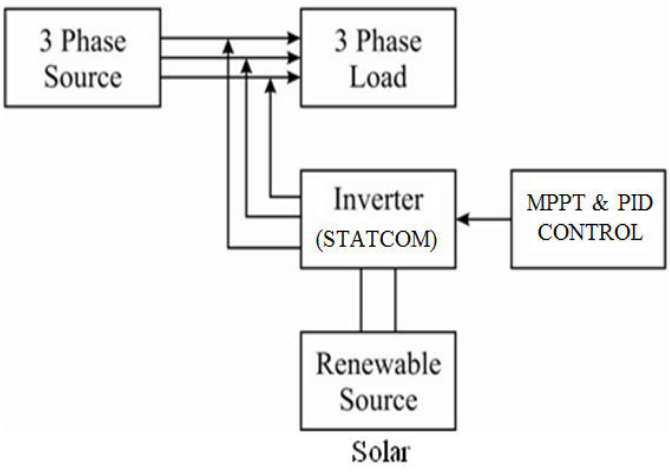


Fig 1: PROPOSED BLOCK DIAGRAM

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A consistent amplitude and one constant frequency sinusoidal signal is considered as an ideal current or voltage signal. Quality of voltage taken from the utility or that delivered to the consumer is referred as voltage or current quality. The fluctuation of voltage, current or frequency from its optimal worth that may prompt mal-operation of 4 he equipment can be considered as issue in the power quality. The term electromagnetic compatibility is also used in place of power quality, they are strongly related but not the exactly same. As indicated by the IEEE principles, Power quality can be characterized as the technique for grounding and supplying sensitive equipment with power so as to get a reasonable and agreeable performance of the equipment .Overall power quality represents a blend of quality of the current and voltage. Voltage quality at the point of connection is governed by the network operator whereas the quality of current at the connection point is governed by the client's load.

IV. RESULT AND DISCUSSION

The smart inverter PV-STATCOM under study provides TOV mitigation using the full inverter capacity both during night and anytime during the day as needed by the grid. It provides steady state voltage control throughout the night. During daytime, it is assumed in this study that light load conditions do not arise during full noon hours i.e., when the solar system is producing its rated power. Hence there is some remaining inverter capacity available for steady state voltage regulation in Partial STATCOM mode. Under the revised IEEE Standard 1547 - 2018, the PV inverters are also expected to provide reactive power injection and absorption capability of 44% and 25% of nameplate apparent power rating, respectively.

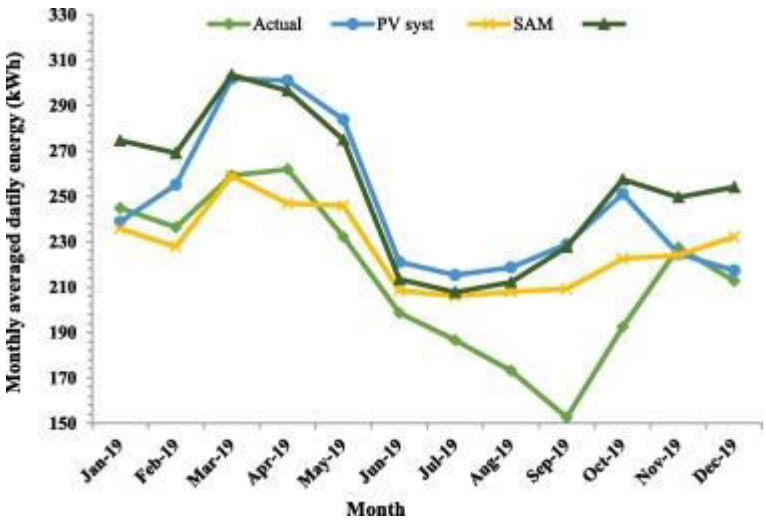


Fig 2: Advancing simulation tools specific to floating solar photovoltaic systems

This over sizing will further leave room for adequate steady state voltage control in the Partial PV-STATCOM mode. In the worst case, if light load conditions do arise due to a disturbance during noon hours, the solar farm can switch to Full PV-STATCOM mode for voltage control as long as the disturbance lasts. In other words, the proposed control offers the full functionality of a STATCOM for voltage control during day or night.

V. CONCLUSION

In this study, an advanced concept of utilizing a PV solar farm as a STATCOM on a 24/7 basis, for supporting the grid. Such applications will of course require grid code approvals and appropriate agreements amongst the different stakeholders, i.e., the solar farm owner, inverter manufacturer, the interconnecting utility and system operator. This PV-STATCOM function also opens up a potential revenue making opportunity for the PV solar farm by providing similar grid support. It is also suitable for controlling the steady state overvoltage and more importantly, mitigation of Temporary Overvoltages. This novel control in Partial STATCOM mode regulates the steady state over voltage to the desired reference value within one and half cycle. Further, this smart inverter control in Full STATCOM mode

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successfully reduces the TOV caused during both single line to ground fault and line to line to ground fault to within utility acceptable values within one cycle.

REFERENCES

[1] D. Cheng, B. A. Mather, R. Seguin, J. Hambrick, and R. P. Broadwater, "Photovoltaic (PV) impact assessment for very high penetration levels," IEEE Journal of Photovoltaics, vol. 6, pp. 295-300, 2016.
[2] R. J. Bravo, R. Salas, T. Bialek, and C. Sun, "Distributed energy resources challenges for utilities," Proc. 2015 IEEE 42nd Photovoltaic Specialist Conference, PVSC 2015, 2015.
[3] Jeff Smith and Matt Rylander, "PV Hosting Capcity on Distribution Feeders", Proc. 2014 IEEE PES GM, Washington, USA, 2014
[4] SJ Steffel, PR Caroselli, AM Dinkel, JQ Liu, RN Sackey, and NR Vadhar, "Integrating solar generation on the electric distribution grid," IEEE Transactions on Smart Grid,, vol. 3, pp. 878-886, 2012
[5] Y. Kabasawa, T. Noda, K. Fukushima and K. Nemoto, "Consumer voltage regulation using coordinated control of distributed static synchronous compensators - STATCOMs," in Proc. 2012 3rd IEEE PES Innovative Smart Grid Technologies Europe, pp. 1-7.
[6] Rajiv K. Varma and Ehsan Siavashi, "PV-STATCOM – A New Smart Inverter for Voltage Control in Distribution Systems", IEEE Transactions on Sustainable Energy, IEEE Xplore Early Access, Digital Object Identifier: 10.1109/TSTE.2018.2808601
[7] R. K. Varma, "Multivariable Modulator Controller for Power Generation Facility", PCT Application (PCT/CA2014/051174) filed Dec. 6, 2014
[8] Yazdani, A. R. Di Fazio, H. Ghoddami, et al., "Modeling guidelines and a benchmark for power system simulation studies of three-phase single-stage photovoltaic systems," IEEE Transactions Power Delivery, vol. 26, no. 2, pp. 1247–1264, 2011.
[9] M. Liserre, F. Blaabjerg, and S. Hansen, "Design and control of an LCL-filter-based three-phase active rectifier," Industry Applications, IEEE Transactions on, vol. 41, no. 5, pp. 1281–1291, 2005.
[10] Yazdani and R. Iravani, "Voltage-sourced converters in power systems: modeling, control, and applications". John Wiley & Sons, 2010.
R. G. Wandhare and V. Agarwal, "Reactive power capacity enhancement of a PV-grid system to increase PV penetration level in smart grid scenario," IEEE Trans. Smart Grid, vol. 5, no. 4, pp. 1845–1854, 2014. [12] S. Sayah, "Modified differential evolution approach for practical optimal reactive power dispatch of hybrid AC–DC power systems," Appl. Soft Comput. J., vol. 73, pp. 591– 606, 2018.
[13] M. Ghaljehei, Z. Soltani, J. Lin, G. B. Gharehpetian, and M. A. Golkar, "Stochastic multi-objective optimal energy and reactive power dispatch considering cost, loading margin and coordinated reactive power reserve management," Electr. Power Syst. Res., vol. 166, no. October 2018, pp. 163–177, 2019.
[14] W. S. Sakr, R. A. EL-Sehiemy, and A. M. Azmy, "Adaptive differential evolution algorithm for efficient reactive power management," Appl. Soft Comput. J., vol. 53, pp. 336–351, 2017
[15] S. Ahsan and A. S. Siddiqui, "Dynamic compensation of real and reactive power in wind farms using STATCOM," Perspect. Sci., vol. 8, pp. 519–521, 2016



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