ENHANCING THE POWER TRANSFERABILITY USING SOLAR PV-STATCOM

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ABSTRACT:

The concept of this paper is the control of PV solar farm as a STATCOM. It can be termed as PV STATCOM. In this proposed system the faults caused by power oscillations in the transmission system are reduced to a greater extent. This system increases the efficiency of real power generation after damping the power oscillations. The pre disturbance level of the real power generation is reached after the operation of PV solar farm as STATCOM and it matches the real power generation before the fault occurred to a great level, enhancing the power transferability of the transmission line. When compared to the other FACT devices such as STATCOMs, The impact of fault or power oscillation on the real power generation is very less in the PV STATCOM. These differences when fault occurs could be observed in the MATLAB simulation. The other advantages of PV STATCOM are it restores the pre disturbance level of real power keeping power oscillation function activated. And it operates with the full inverter capacity at night time. It is cheaper than the conventional STATCOM for providing POD at the same location.

KEYWORDS:

STATCOM, FACTS, reactive power, power oscillation, real power generation

OBJECTIVE:

To bring large savings for transmission utilities and also to bring new revenue making opportunity for solar farms for providing POD.

The STATCOM control has the following limitations:

i) The impact of fault is greater on the real power generation.

ii) It is available only when there is remaining inverter capacity available after real power generation.

iii) Its capability decreases with increasing real power output from solar farm.

To overcome the above drawbacks, the PV-STATCOM can be implemented.

To increase the power transfer capacity of the network.

To enhance the power transferability of the transmission line.

I.INTRODUCTION:

In a power system, low-frequency oscillation continues for a very long period of time, which can threaten the stability of the system. The dominant oscillation modes occur mainly in a frequency range of 2.0 Hz or less, and especially in the wide-area mode at 1.0 Hz or less. Low-frequency oscillations (LFO) exist naturally in power systems due to the power exchange between generating units operating in parallel and when interconnected through long transmission lines and also when undesirable faults occur. FACTS devices are static power-electronic devices installed in AC transmission networks to increase power transfer capability, stability, and controllability of the networks through series and/or shunt compensation. These devices are employed for power oscillation damping (POD).

When the power oscillation occur the PV solar farm discontinues its real power generation and acts as a STATCOM. It makes its entire inverter capacity available to reduce or damp the power oscillations or faults. When the power oscillations or faults are cleared to a certain level the PV STATCOM reaches to its pre disturbance real power generation. This system of working gives us desirable and efficient results. The The impact of fault on the power system is less when the system employs PV STATCOM other than any FACTs devices such as STATCOM, Static VAR compensators etc.

The PV STATCOM has many advantages compared to the conventional STATCOM. The PV STATCOM uses its entire inverter capacity to reduce the power oscillations where as the conventional STATCOM uses the remaining power capacity after the real power is generated. The time in which the PV STATCOM reduces the power oscillations or impact of fault on a power system is very less when compared to the other Flexible AC Transmission devices and voltage stabilizer systems.

This paper discusses about the concept and working of a PV STATCOM in section II. The methodology is discussed in section III. The brief explanation about how the MATLAB/SIMULINK model works is given in section IV along with the proposed model. In section V the results are analysed which were obtained by executing the model. Finally the paper is concluded in section VI.

II. DESCRIPTION:

The PV STATCOM which is being explained and modeled in this paper can work in two modes of operation. The first is partial PV STATCOM mode and the other one is full PV STATCOM mode. The partial mode enables the PV solar farm to use its power which is remaining after the real power generation which can be done in daytime. And the full PV STATCOM mode enables the PV solar farm to use its total inverter capacity to reduce the power oscillations and the impact of faults in a power system network.

When the disturbances occur in the power system network, the PV solar farm discontinues its real power generation and acts as a STATCOM. It makes its entire inverter capacity available to reduce or damp the power oscillations or faults. When the power oscillations or faults are cleared to a certain level the PV STATCOM reaches to its pre disturbance real power generation.

The power compensation is done through the reactive power compensation technique that is the reactive power is absorbed or delivered in the transmission network based on the requirements of the system to drive the real power. Normally the lagging reactive power is generated in the power system network in many cases based on the nature of the loads that is if they are inductive in nature or capacitive in nature. Therefore the working methodology of a PV STATCOM has been discussed.

The STATCOM control has the following limitations:

i) The impact of fault is greater on the real power generation.

power oscillations or faults are cleared to a great extent.

ii) It is available only when there is remaining inverter capacity available after real power generation.

iii) Its capability declines with increasing real power output from solar farm, becoming completely zero during hours of full sun.

To overcome the above drawbacks, the PV-STATCOM can be implemented. This increases the power transfer capacity of the network and enhances the power transferability of the transmission line.

III. METHODOLOGY:

When faults or oscillation occurs, the PV STATCOM is enabled. It stops its real power generation and converts its whole inverter capacity for reducing those oscillations or reducing the impact of faults. The whole process of reduction of oscillations takes place in the power system network in the following process.

The PV solar panel array receives the sun light and generates dc current hence inducing dc voltage. The MPPT maximizes the energy which is obtained from PV solar array. It is further given to the inverter which converts dc voltage into ac voltage. The triggering pulses for the inverter are provided by PWM(Pulse Width Modulation). The main function in the whole system is done by the controllers. The inner loop control enables the production of real and reactive power for a rotating plane. It also provides the three phase indices which are used to generate the triggering pulses for inverter. The DC voltage controller is used to control the reference voltage using MPPT. Conventional PV controller is used in normal operation mode. Here the reactive power is zero. The Q-POD controller controls the reactive power of the PV STATCOM which is further used to reduce the power oscillations and impact of faults on the transmission line. The control signal for this controller is considered as the line current of the transmission line. The controller adds effective phase lead or lag to enhance its damping or reducing the oscillations an the impact of faults. Finally PV real power controller is used to restore the pre disturbance value of the real power before the disturbances occurred.

IV. SIMULATION MODEL:

The below fig.1 shows the constructed simulation model of PV STATCOM controller. The simulation model consists of PV solar array, an MPPT algorithm, three phase six pulse solar farm inverter, filters, three phase voltage and current measurement blocks, RLC load, inner loop controller, real power and reactive power (Q-POD) controllers and conventional PV controller.

The PV solar array provides the PV dc current based on its ratings and the PV voltage is generated. The MPPT algorithm is employed in majority of PV inverters. The main function of MPPT is to maximize the energy available from connected solar module arrays at any time during the operation. The three phase six pulse inverter currents and three phase voltages which are obtained as a result of inverter operation. Further an RLC load is connected to the whole network. Now coming to the controllers the inner loop control perform an inverse Park transformation from a dq0 rotating reference frame to a three-phase (abc) signal and also perform a Park transformation from a three-phase (abc) signal to a dq0 rotating reference frame. These are used for generating the inverter triggering pulses using Pulse Width Modulation (PWM).

To output the PV power at unity power factor the PV controller is used. It is applicable only for regulating the acts as a bridge between solar array module and grid. It converts the voltage from DC to AC in order to supply the grid. The RC and RL filters are introduced to reduce the harmonic content in the system voltages and currents.

The three phase voltage and current measurement blocks are introduced in order to measure the three phase PV reactive power. The Q-POD controller is used for controlling the PV STATCOM reactive power which helps in reducing or damping the power oscillations and impact of faults. The real power controller helps in restoring the real power which was present before the disturbance occurred afterreducing or damping the power oscillations and impact of faults. This can take place in full PV STATCOM mode or in partial PV STATCOM mode.

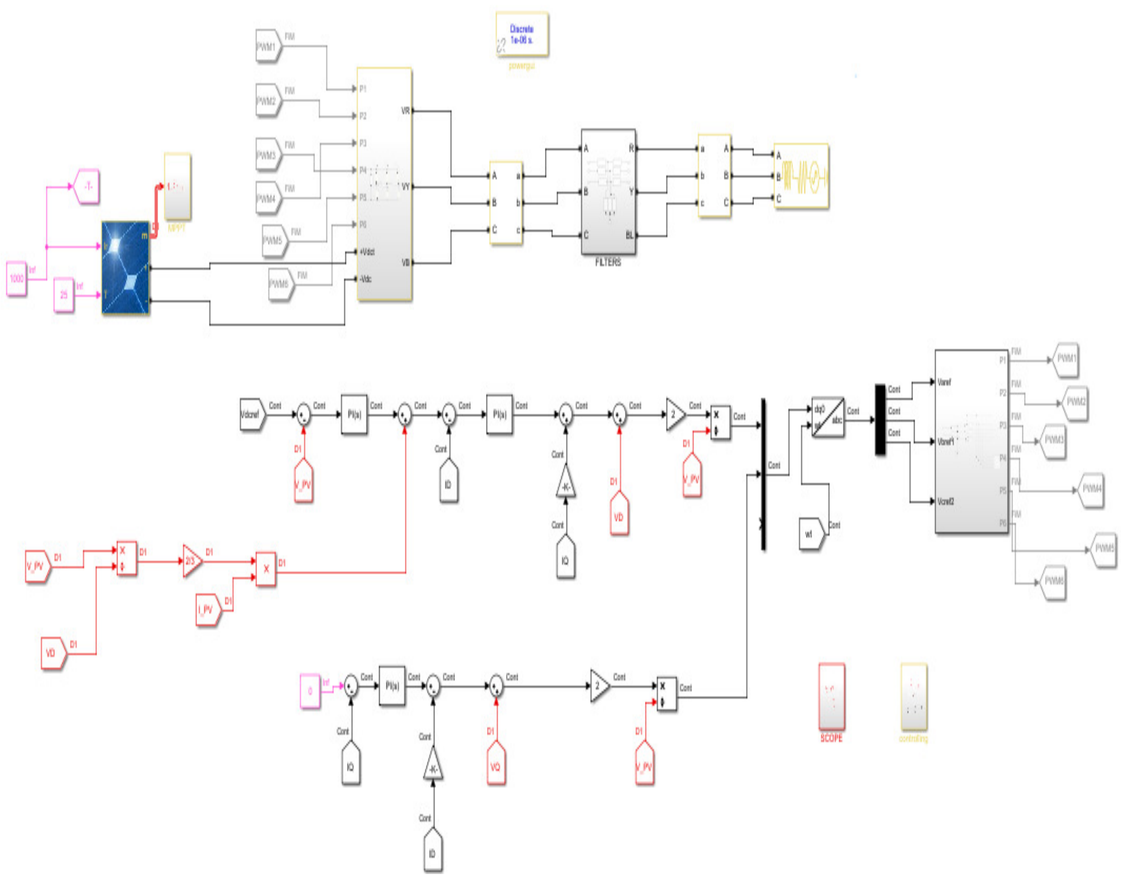

Fig. 1. Model of PV STATCOM controller

V. SIMULATION RESULTS:

The below figures 2,3,4,5 and 6 depict the results after the simulation model is run. Fig. 2 shows the PV array voltage Vs time. The voltage generated from the PV array module in volts is depicted here. The fig. 3 shows the three phase voltages Va, Vb, Vc Vs time. These voltages are obtained as the output of inverter. The fig.4shows the three phase voltage Vabc Vs time. Fig. 5 shows the PV real power and midline real power with PV STATCOM control Vs time. Here the real power generation is restoring to its pre disturbance level. The oscillations are present but they are only in less numbers when compared to the other FACTS devices. Fig.6

depicts the real power and reactive power with PV STATCOM control Vs time. Even in this case the oscillations are present but they are only in less numbers when compared to the other FACTS devices. The voltages are in volts, and the power is in watts and the time is represented in seconds.

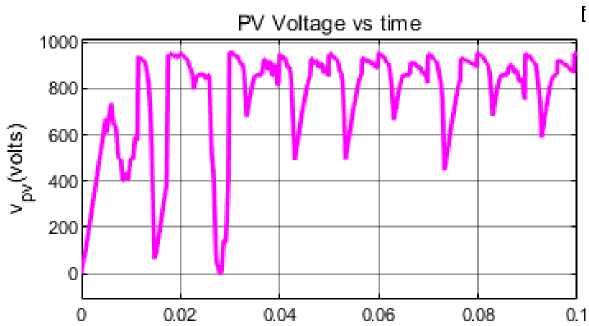

Fig. 2. PV array voltage Vs time

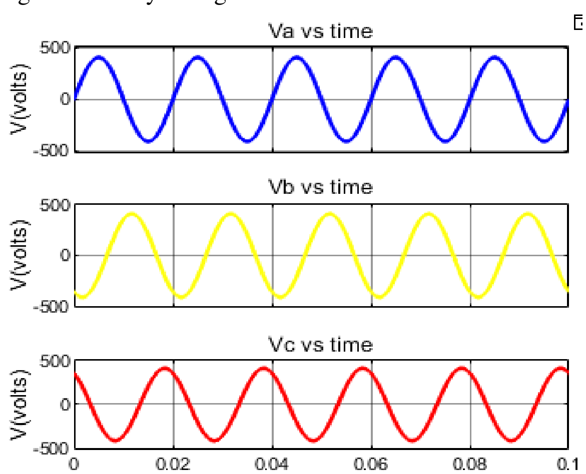

Fig. 3. Three phase voltages Va,Vb,Vc Vs time

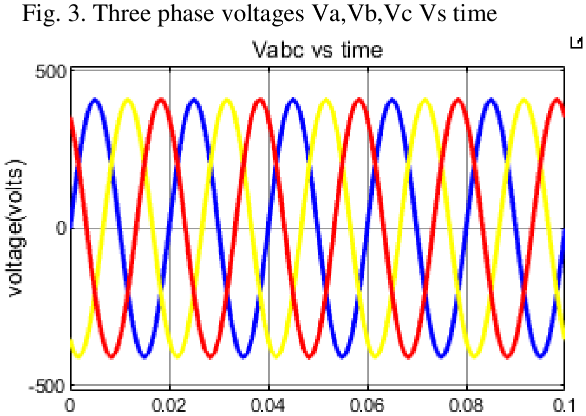

Fig. 4. Three phase voltage Vabc Vs time

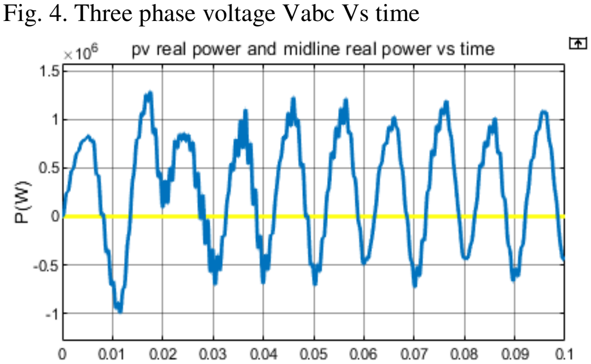

Fig. 5. Real power and midline real power with PV STATCOM control

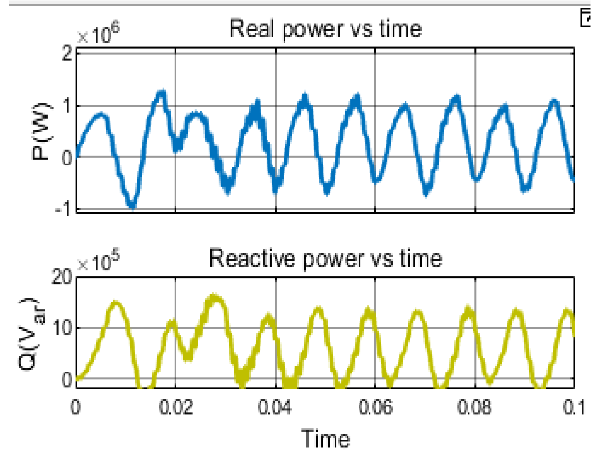

Fig. 6. Real power and Reactive power of PV STATCOM

VI. CONCLUSION:

The objective of this paper is the control of PV solar farm as a STATCOM. It can be termed as PV STATCOM. In this proposed system the faults caused by power oscillations in the transmission system are reduced to a greater extent. This system increases the efficiency of real power generation after damping the power oscillations. The results are obtained in the proposed paper. This PV-STATCOM is expected to be about 50-100 times lower in cost than an equivalent STATCOM.It also opens a new revenue for transmission connected solar farms to provide 24/7 STATCOM functionality at a lower cost. The power transferability of the transmission network is increased when PV STATCOM is used. These type of controls can be established where the solar farms are available. Hence there is no separate installation charges are required to setup a PV STATCOM. The drawbacks of a conventional STATCOM can be overcome to a desirable extent while using the PV STATCOM in a power system network. Further to work in a very efficient way and to adapt different conditions this type of control needs advance design and control features extension.

VII. REFERENCES:

1.N. Mithulananthan, C. A. Canizares, J. Reeve, and G. J. Rogers, "Comparison of PSS, SVC, and STATCOM controllers for damping power system oscillations," IEEE Trans. Power Systems, pp. 786-792, 2003.

2. A. M. Simões, D. C. Savelli, P. C. Pellanda, N. Martins, and P. Apkarian, "Robust design of a TCSC oscillation damping controller in a weak 500-kV interconnection considering multiple power flow scenarios and external disturbances," IEEE Trans. power systems, vol. 24, pp. 226-236, 2009.

3. R. K. Varma, V. Khadkikar, and R. Seethapathy, "Nighttime Application of PV Solar Farm as STATCOM to Regulate Grid Voltage," IEEE Trans. Energy Conversion, vol. 24, pp. 983-985, 2009.

4. R. K. Varma, S. A. Rahman, and T. Vanderheide, "New Control of PV Solar Farm as STATCOM (PV-STATCOM) for Increasing Grid Power Transmission Limits During Night and Day," IEEE Trans. Power Delivery, vol. 30, pp. 755-763, 2015.

5. R. Shah, N. Mithulananthan, and K. Y. Lee, "Large-scale PV plant with a robust controller considering power oscillation damping," IEEE Trans. Energy Conversion, vol. 28, pp. 106-116, 2013.