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Increasing the Power Transfer Limit of the Transmission System using PV Solar Farm

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***Abstract*—This project presents a new concept of using the solar farm has a STATCOM in increasing the power transmittable limits of a transmission system. By the voltage regulation the available power transmit limits can be increased. This is performed by using entire rating of the solar inverter which is suspended during night time and the left over real power after the real power generation during the day time. The single machine infinte bus system is used for the transient studies where the PV farm is located at the midpoint. The transient studies are performed using MATLAB software. The controller is designed to maintain the Vpcc at 1pu and the post fault clearance settling time of the oscillations to come within 5% of its steady state value. The PV STATCOM can be used to increase the power transfer capability otherwise it requires a shunt or series capacitors or the other FACTS devices which are expensive.**

Keywords- *static synchronous compensator (STATCOM), flexible AC transmission system (FACTS), point of common coupling, photo voltaic cell.*

I. INTRODUCTION

The PV solar farm inverter is used improve the stable power transfer limits of the interconnected transmission system. The entire rating of inverter during the night time is used to support the grid functionality During daytime, the inverter capacity left after real power production is used to accomplish the above objective. Transient stability studies are conducted on a realistic single machine infinite bus power system having a midpoint located PV-STATCOM using EMTDC/PSCAD simulation software [1]. The functions which is to be carried out while connecting the PV system to the power grid in the local level or the regional level. The fault ride through analysis is done by applying three-line-to-ground fault. A PV system, with a rating 600 kW modules is used to demonstrate the capability of voltage regulation and riding through the disturbances without tripping [2]. [3] focuses on the evaluation of the impact of FACTS control on available transfer capability (ATC) enhancement. Technical merits of FACTS technology on ATC boosting are analyzed. An optimal power-flow-based ATC enhancement model is formulated to achieve the maximum power transfer of the specified interface with FACTS control. For better studying the capability of FACTS control, a power injection model of FACTS devices, which enables simulating the control of any FACTS devices, is employed. Studies based on the IEEE 118-bus system with all categories of FACTS devices demonstrate the effectiveness of FACTS control on ATC enhancement.

In the recent years the renewable energy sources are not able to connected to the transmission grid due to the lack of adequate transmission capacity. This paper presents the new concept of using PV solar farm as a PV STATCOM to increase the available power transfer capability. The single machine infinite bus system is for the transient stability studies by using the MATLAB software. The PV STATCOM is connected to the midpoint of the transmission line. By connecting it to the midpoint of the line the transmittable power is increased twice and it makes the line into two equal halves with same transmittable power [4]. In the earlier years the PV solar farm is used to generate the real power but not used for the compensation of the transmission line. In this project, the solar farm when the large real power is generated the left over real power is used for the compensation of the line during day time and in the night where the PV solar farm is not working the DC link capacitor which is charged by the PV solar in the day time is used for the compensation. The controller is modelled to maintain the V_{pcc} (voltage at point of common coupling) at 1 pu and the post fault clearance settling time of the oscillations to the 5% of the steady state value. Here the PV solar farm inverter acts a STATCOM. There are two current loops in the controller where one loop take care of the Vpcc and the other loop DC link voltage and according to this the gating pulses are given to the inverter. When the Vpcc voltage decreases the line is inductive and the capacitive current is injected to the line and when Vpcc voltage increases the line is capacitive and the inductive current is drawn from the grid. From this project, the real power is also generated and the compensation of the line is also achieved which otherwise requires a shunt/ series capacitors or FACTS controllers which are expensive.

II. SYSTEM MODELS

The single line diagram of the system is shown in Fig 1. The system is single machine infinite bus. The PV solar farm connected to the midpoint of the transmission line of 200 km. The transmission-line is segmented as TL1 and TL2shown in fig 1 and represented by pi-circuit. The PV solar DG, is modeled as an equivalent voltage-source with a capacity of 100MW. The incremental conductance MPPT (maximum power point tracking) algorithm is used to operate the solar DG. During the night time, there is no real power generation from the solar farm and little power is taken from the grid to charge the capacitor to support grid functionality. The voltage source inverter has six insulated gate bipolar transistors (IGBT) switches which operates for 120 conduction. The boost converter is used to boost the voltage from the solar farm. The gating signals are generated by the sinusoidal pulse width modulation (SPWM) technique and given to the IGBT switches. The dc link capacitor of size is used.

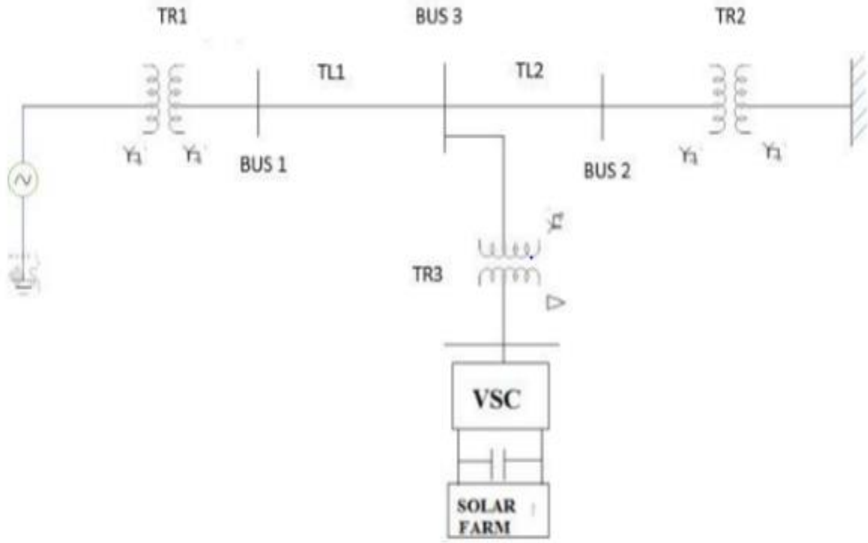

Fig 1 Single line diagram of the transmission system with midpoint connected solar farm.

III. CONTROL SYSTEM

The control system consists of controller which consists of proportional-integrator (PI) and a MPPT control. In the MPPT control the PV voltage and current is measured and the pulses generated is given to the boost converter switch in which it controls the DC link voltage. The VSC control used to give the gating signals to the voltage source converter switches. The PCC voltage is measured and gating signals generated according to the voltage at that point. if the voltage is less than 1 pu then the reactive current is injected and if the more than 1 pu then the reactive current is observed. The synchronization is maintained by the Phase Locked Loop (PLL) control. The using of the DC link capacitor eliminates the use of other energy source.

IV. SIMULATION STUDY

The simulation studies are performed done by the MATLAB/Simulink. The simulation diagram is shown in fig 2. Table I shows the increase in the power transfer limit with and without compensation.

TABLE I :- Power flows and voltages for with and without control

	Gen bus	Middle bus			Infinite bus
	Pg	Vpcc	P solar	Q solar	Pinf
Without control	463	0.9673	448	171	433
With control	530	1.02	513	109	265

The reactive power exchanged between SF and the distribution network(leading/lagging), and the self-supporting dc-bus voltage Vdc profile validates the proposed concept of utilization of SF as STATCOM to regulate the PCC voltage. The performance of system under a three-line to ground (3LG) fault condition (for six cycles) Is shown in Fig.3(a)and(b). It is evident that the SF as STATCOM helps achieve better fault recovery.

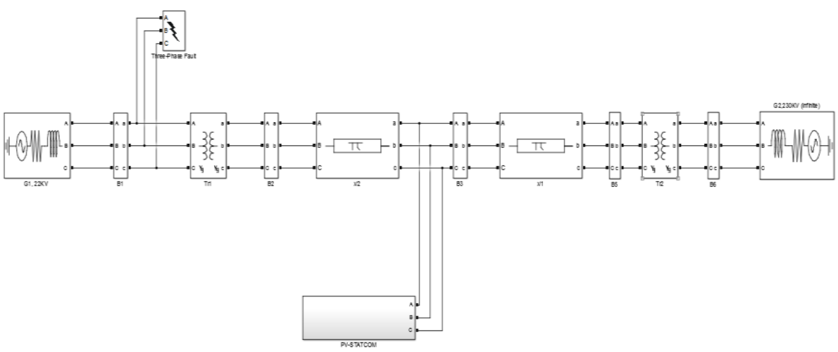

Fig 2. The simulation diagram of PV STATCOM

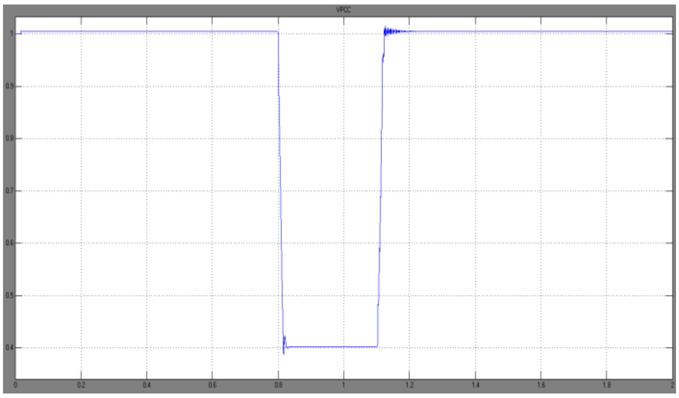

Fig 3(a) 3LG fault without the controller

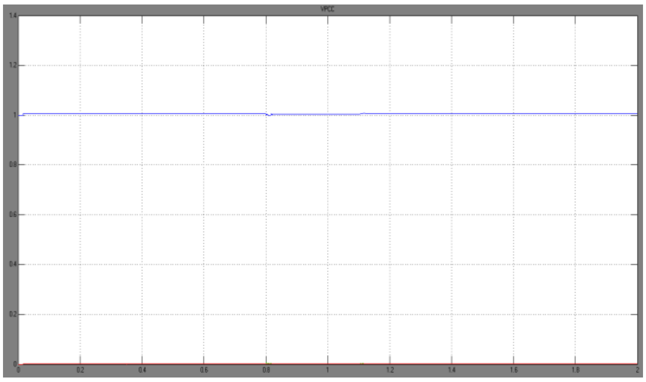

Fig 3(b) 3LG fault with the controller

V. CONCLUSION

A new control uses the solar farm which is inactive during night for regulating the PCC voltage which in turn increasing the power transfer limit. Therefore, in effect, the PV solar plant may become a utility tool at night (control is passed on to the utility supervisory control and data acquisition (SCADA) operator). Other wise to the expensive shunt/series capacitors or the other FACTS devices are used. This may pose interesting questions on ownership/partnership/lease options, license to operate, etc., and possible code changes by the regulator.

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