ISSN 2321-807X
Volume 12 Number18
Journal of Advances in chemistry

PV STATCOM BASED CONTROL STRATEGIES FOR POWER QUALITY ENHANCEMENT

R.Indhumathi ,PL.Somasundaram
Assistant Professor, M.Kumarasamy college of engineering,karur.
indhumathir.eee@mkce.ac.in
Assistant Professor(Sr.grade),M.Kumarasamy college of engineering,karur.
somasundarampl.eee@mkce.ac.in

ABSTRACT

Due to increasing demands in electric power it becomes more significant to usethe available energy sources efficiently. Renewable energy sources like wind, sun, and hydro are seen as a dependable alternative to the traditional energy sources such as oil, natural gas, or coal. In the current work, a novel concept of utilizing a photovoltaic solar farm inverter as STATCOM, called PV-STATCOM, for improving stable power transfer limits of the interconnected transmission system. The complete inverter rating of the PV solar farm, which remains dormant during nighttime, during daytime the inverter capacity absent after real power production is used to accomplish the aforementioned goal. The validation of the proposed operation is done through MATLAB simulation.

Keywords

STATCOM, Photovoltaic, MATLAB software.

Academic Discipline And Sub-Disciplines

Electrical engineering and Power quality enhancement.

SUBJECT CLASSIFICATION

PV-STATCOM desidn and Power quality improvement.

TYPE (METHOD/APPROACH)

PV-STATCOM is implemented with PI Controller for Improving Power quality.

INTRODUCTION

The application of flexible ac transmission systems controllers, such as static compensator and static synchronous series compensator is increasing in power systems. This is due to their ability to stabilize the transmission systems and to improve power quality in distribution systems. STATCOM is popularly accepted as a reliable reactive power controller replacing conventional var compensators, such as the thyristor switched capacitor and thyristor controlled reactor. The current reference calculation for the control of grid connected voltage source converters meant to operate under voltage unbalanced sags produced by grid faults. The well-known reference calculation method that allows controlling the active power ripple produced by the existence of negative sequence components in the grid voltage is extensively analyzed [1]. Enhancing the operation of wind turbines in front of grid faults is not only an important issue for new wind farms, but also for the existing ones. At the present time, the classical squirrel cage induction generator's wind turbines still represent a 30% of the wind power production. Reinforcing the operation of such facilities can be performed taking advantage of the growing number of modern power systems that are linked to the grid by means of power processors [2].

During voltage dips continuous power delivery from distributed generation systems to the grid is desirable for the purpose of grid support. In order to facilitate the manage of inverter based distributed power generation adapted to the expected change of grid requirements, generalized power control strategies based on symmetric sequence components are to manipulate the delivered instantaneous power under unbalanced voltage dips [3]. Due to the increasing number Distributed power generation systems connected to the utility network, new and stricter standards in respect to power quality, safe running, and islanding protection are issued [4]. In one or two phase faults, the main concern of the for distributed generation inverter is to balance voltages by reducing the negative symmetric sequence and clear the phase jump. Due to system limitations, aequilibrium between these two extreme policies is mandatory [5].

The specification of a power electronic interface is subject to requirements related not only to the renewable energy source itself but also to its effects on the power system operation, especially where the intermittent energy source constitutes a significant part of the total system capacity [6].A control algorithm for inverters for providing a flexible voltage control using reference current generation under grid faults [7]. Voltage control is one of these ancillary services which can ride through and support the voltage under grid faults [8]. Strategies for current reference generation were implemented on the abc stationary reference frame and their effectiveness was demonstrated experimentally, perhaps validating the theoretical analysis even under grid fault conditions [9]. The transforms the effective input characteristic of the converter seen by the solar array into a resistive load, which is prohibited by a microcontroller based unit.
A new control algorithm for the parallel operation of a photovoltaic battery charging system has been introduced [10]. A new voltage control has also been proposed on a PV solar farm to act as an STATCOM for improving the power

transmission capacity. Proposed voltage control functionality with PV systems, none has utilized the PV system for power transfer limit improvement.

2.SYSTEM CONFIGURATION

The inverters are connected on the low voltage side of the transformer and the high voltage side is connected to the grid. The dc link voltages of the inverters are maintained constant and modulation indices are controlled to achieve the required objective. The proposed control scheme is derived from the ac side of the equivalent circuit. The source voltages referred to LV side of the transformer, and are the resistances which represent the losses in the transformer and two inverters, and are leakage inductances of transformer windings, and are the output voltages of inverters 1 and 2, respectively. The leakage resistances of dc link capacitors and, respectively. Assuming and applying KVL on the ac side, the dynamic model can be derived using as,

$$\begin{bmatrix}\frac{di'_a}{d_t}\\ \frac{di'_b}{d_t}\\ \frac{di'_c}{d_t}\end{bmatrix}=\begin{bmatrix}\frac{-r}{L}&0&0\\0&\frac{-r}{L}&0\\0&0&\frac{-r}{L}\end{bmatrix}\begin{bmatrix}i'_a\\ i'_b\\ i'_c\end{bmatrix}+\frac{1}{L}\begin{bmatrix}v'_a-(e_{a1}-e_{a2})\\ v'_b-(e_{b1}-e_{b2})\\ v'_c-(e_{c1}-e_{c2})\end{bmatrix} \qquad (1)$$

Equation (2) represents the mathematical model of the cascaded two-level inverter based multilevel STATCOM in the stationary reference frame. This model is transformed to the synchronously rotating reference frame. The axes reference voltage components of the converter and are controlled as,

$$e*_d = -x_1 + wLi'_q + v'_d \qquad (2)$$

$$e*_q = -x_2 + wLi'_d + v'_q \qquad (3)$$

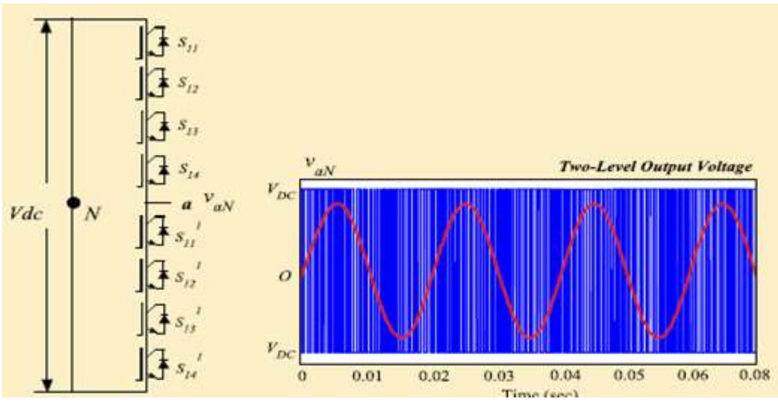

Fig 1: Circuit of the cascaded two level inverter based multilevel.

Equation (4) and (5) gives where the x-axis voltage component of the ac is the source and is y-axes current components of the cascaded inverter, respectively. The synchronously rotating frame is aligned with source voltage vector so that the component of the source voltage is made zero. The control parameters and are controlled as follows,

$$x_1 = \left(k_{p1} + \frac{k_{i1}}{s}\right)(i*_d - i_d) \qquad (4)$$

$$x_2 = \left(k_{p2} + \frac{k_{i2}}{s}\right)(i*_q - i_q) \qquad (5)$$

$$i*_d = \left(k_{p3} + \frac{k_{i3}}{s}\right)(V*_{dc1} - V*_{dc2}) - (V_{dc1} - V_{dc2}) \qquad (6)$$

The x-axis reference current is obtained either from an outer voltage regulation loop when the converter is used in transmission line voltage support or from the load in case of load compensation.

3.CONTROL STRATEGY

The unit signals and is generated from the phase locked loop using three phase supply voltages. The converter currents are transformed to the synchronously rotating reference frame using the unit signals. The switching frequency ripple in the converter current components is eliminated using a low-pass filter. From and loops, the controller generates axes reference voltages, and for the cascaded inverter.With these reference voltages, the inverter supplies the desired reactive current and draws required active current to regulate total dc-link voltage.However, this will not ensure that individual dc-link voltages are controlled at their respective reference values. Hence, additional control is required to regulate individual dc-link voltages of the inverters.

4.DC-LINK BALANCE CONTROLLER

The active power transfer between the source and inverter depends on and is usually small in the inverters supplying var to the grid. Therefore, the x-axis reference voltage component of inverter 2 is derived to control the dc link voltage of inverter 2 as,

$$e*_{q2}=\left(k_{p4}+\frac{k_{i4}}{s}\right)(V*_{dc2}-V_{dc2}) \quad (7)$$

The dc link voltage of inverter 2 is controlled at 0.366 times the dc link voltage of inverter 1.It results in four-level operation in the output voltage and improves the harmonic spectrum. Expressing dc link voltages of inverter 1 and inverter 2 in terms of total dc-link voltage as,

$$V_{dc1} = 0.732V_{dc} \quad (8)$$

$$V_{dc1} = 0.268V_{dc} \quad (9)$$

Since the dc link voltages of the two inverters are regulated, the reference axis voltage component is divided in between the two inverters in proportion to their respective dc link voltage as,

$$e*_{d1} = 0.732Ve*_{d} \quad (10)$$

$$e*_{d2} = 0.268Ve*_{d} \quad (11)$$

The power transfer to inverter 2 is directly controlled, while, for inverter 1, it is controlled indirectly. Therefore, during disturbances, the dc link voltage of inverter 2 is restored to its reference quickly compared to that of inverter 1. Using and the reference voltages are generated in the stationary reference frame for inverter 1 and using and for inverter 2.

The reference voltages generated for inverter 2 are in phase opposition to that of inverter 1. From the reference voltages, gate signals are generated using the sinusoidal pulse width modulation technique. Since the two inverters reference voltages are in phase opposition, the predominant harmonic appears at double the switching frequency.

5.UNBALANCED CONDITIONS

Network voltages are unbalanced due to asymmetric faults or unbalanced loads. As a result, negative sequence voltage appears in the supply voltage. This causes a double supply frequency component in the dc link voltage of the inverter. This double frequency component injects the third harmonic component in the ac side. Moreover, due to negative sequence voltage, large negative sequence current flows through the inverter which may cause the STATCOM to trip. Therefore, during unbalance the inverter voltages are controlled in such a way that either negative sequence current flowing into the inverter is eliminated or reduces the unbalance in the grid voltage. In the latter case, STATCOM needs to supply large currents since the interfacing impedance is small. This may lead to tripping of the converter.

The negative sequence reference voltage components of the inverter and are controlled similarly to positive sequence components in the negative synchronous rotating frame.

$$e*_{dn}= -x_3 + (-wL)i_{qn} + v_{dn} \quad (12)$$

$$e*_{qn}= -x_4 + (-wL)i_{dn} + v_{qn} \quad (13)$$

Where d axes negative sequence voltage components of the supply and are q axes negative sequence current components of the inverter, respectively. The control parameters and are controlled as follows:

$$x_3 = \left(k_{p5}+\frac{k_{i5}}{s}\right)(i*_{dn}-i'_{dn}) \quad (14)$$

$$x_4 = \left(k_{p6}+\frac{k_{i6}}{s}\right)(i*_{qn}-i'_{qn}) \quad (15)$$

The references values for negative sequence current components and are set at zero to block negative sequence current from flowing through the inverter.

6.ALGORITHM FOR PROPOSED SYSTEM

Step 1: Three phase supply is given to Load through Transmission Line.

Step 2: PV STATCOM also connected with transmission line which comprises of Solar unit, PI controller and STATCOM.

Step 3: Actual voltage and Reference voltage is given as a input for PI controller and hence error signal is generated.

Step 4: Basedon the error signal PV STACOMcompensates for unbalanced voltage.

Step 5: PV STATCOM is designed to operatesboth at day and night time.

Step 6: Hence the Load is operated at balance voltage

7.FLOW CHART FOR PROPOSED SYSTEM

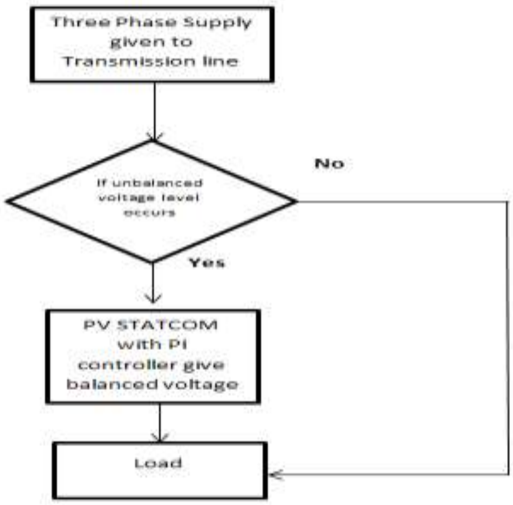

Fig 2: Simulation Diagram of the Proposed System

8.SIMULATION DIAGRAM OF THE OF PROPOSED MULTILEVEL INVERTER

The proposed system was implemented using MATLAB Simulation and the output waveform was studied. The proposed circuit was drawn in MATLAB and the output was obtained from the closed loop configuration using feedback control. Three phase supply is given to the three-phase transformer. Voltage and current in the transmission line have unbalanced voltages and current. This voltage and current value can balance by STATCOM which have PI controller.

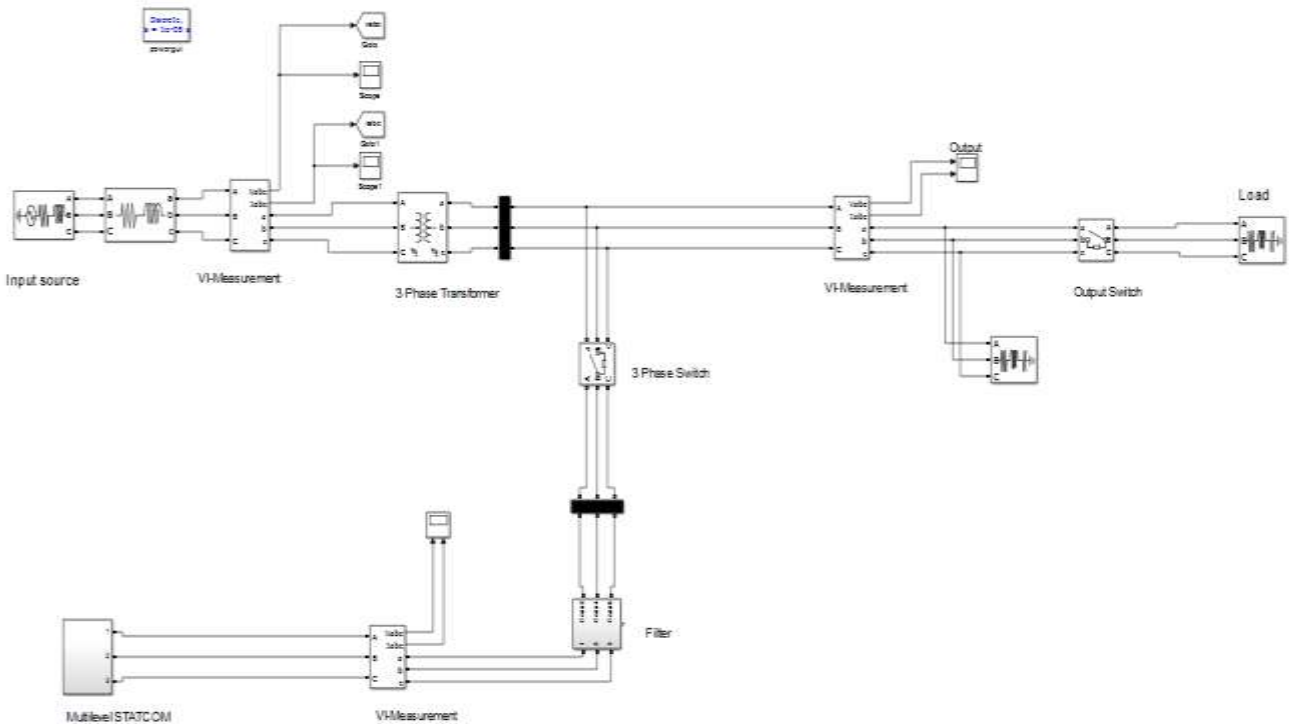

Fig 3: Simulation Diagram of the Proposed System

The output from the STATCOM has harmonics this unwanted harmonics can remove by filters. The balanced Voltage and currently given to the Load. So transmission line capacity can improve. Multilevel STATCOM based on a Power Electronics Voltage source Converter. It can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide action as power. Multilevel STATCOM has a PI Controller. It provides Integral action.

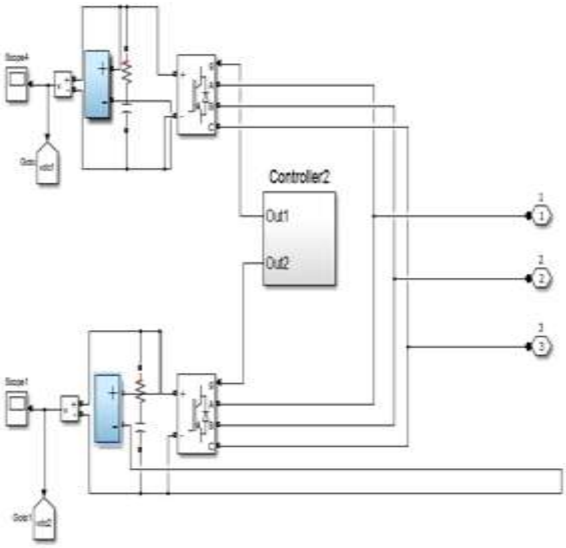

Fig 4: Internal Structure of Multilevel STATCOM

This Controller Unit consists of various data type conversion blocks. It has Boolean Equations, NOT Gate, Double circuits. These are data type conversion units. This converts the Input to the data type and it also gives scaling of the output.The output from the controller given to the IGBT which is connected to the Controller.The PV Solar panel also connected with another side of the IGBT. PV Model subsystem in this circuit which gives the values of Im, Ipv, and Io.

$$I_m = I_{pv} - I_d\left(N_{ss} * N_{pp}\right) \qquad (16)$$

This STATCOM gives the balanced voltage to the transmission line. When the Input supply suddenly reduced, the voltage level becomes unbalanced conditions. So the controller unit used to balance the voltage value. The Output signal from controller given to IGBT.This generates the PWM signals. This pulsated DC signal given to the filter through the VI-Measurement unit. This filter removes unwanted frequency from the signal. Then the balanced values give to the transmission line. Signals gave to the VI-Measurement unit, its measure the Voltage and Current values.

Three phase Switch is connected with the transmission line. When the output switch is opened the load1 gives the current balance for output. Otherwise, the current values become an unbalance condition. When the output switch is closed the Load2 will be activated.STATCOM connected to the transmission line which gives the balance voltage and current values. And it improves the power transfer Capacity.

Table 1. Voltage values depend upon the solar radiations.

Radiation	Voltage
50	44.65
60	53.57
70	62.5
100	89.29
120	107.01
150	133.09
170	151.08
190	169.7
200	178.6
225	200.9
250	223.2

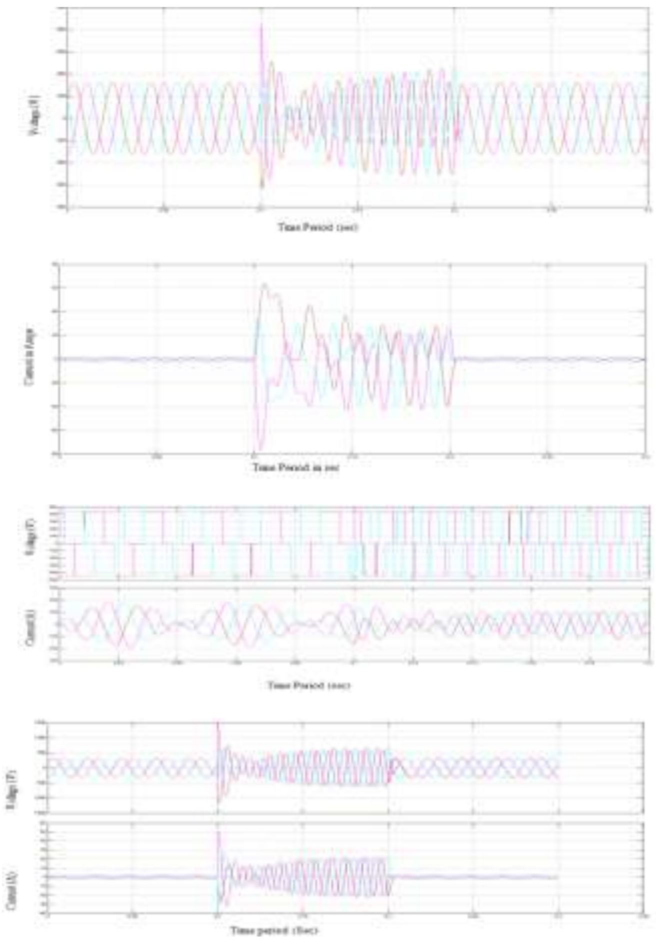

Fig 5: Waveform of Proposed System

9.COMPARISON BETWEEN EXISTING AND PROPOSED METHOD

In the Existing System, voltage and frequency on the Wind Energy Converter terminals are within the allowed limits, the Wind Energy Converter cannot easily detect that it is feeding current into an island grid. In Proposed System, the solar farm where a PV solar farm is utilized as a STATCOM, for performing voltage control, thereby improving system performance and increasing grid connectivity.

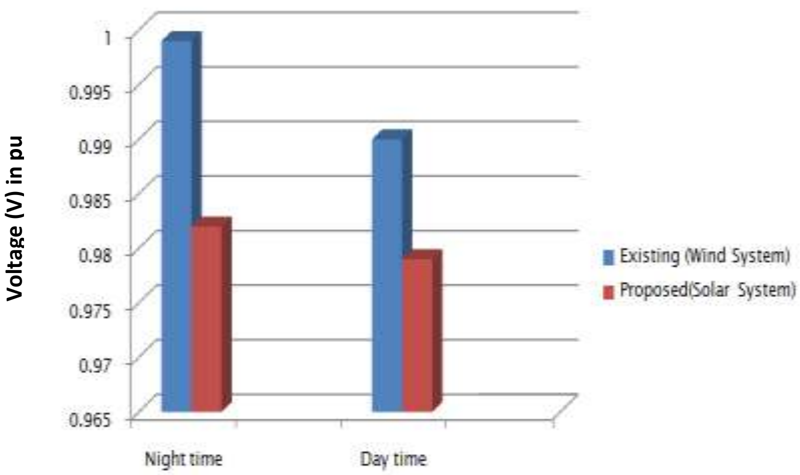

Fig 6: Voltage control Comparison between Existing and Proposed Method

ISSN 2321-807X
Volume 12 Number18
Journal of Advances in chemistry

The y-axis represents Voltage values in p.u, an x-axis represents time periods. The voltage in Transmission line controlled after connecting by Solar PV STATCOM, Whereas Wind farm operation does not control the Voltage Values. Here x-axis represents the time period and the y-axis represents Percentage of Power Transfer Capacity. All Wind Forms exactly the same moderate technical capabilities might lead to insufficient grid support at weak grid connection points.

So the Power transfer Capacity does not improve. But new voltage control has also been proposed on a PV solar farm to act as a STATCOM for improving the power transmission capacity. Although, voltage controls functionality with PV systems, none has utilized the PV system for power transfer limit improvement. PV solar farm inverter to act as a STATCOM, increasing transient stability and consequently the power transmission limit.

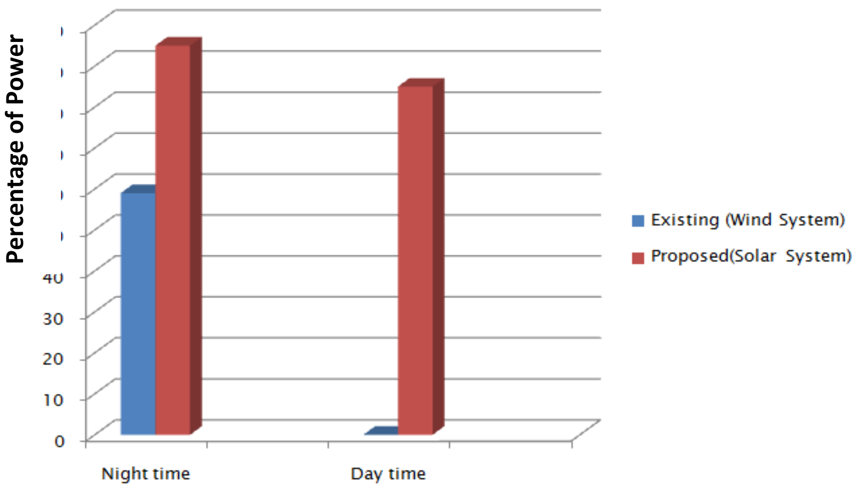

Fig 7: Power Transfer Capacity Comparison between ExistingAnd Propose Method.

It utilizes the entire solar farm inverter capacity in the night and the remainder inverter capacity after real power generation during the day time. The PV STATCOM improves the stable transmission limits substantially in the night and during the day, even while generating large amounts of real power. Cost wise the Solar System is efficient in contrast with wind System.

10.CONCLUSION

Solar farms are idle during nights. PV solar farms operate during the night as a STATCOM with full inverter capacity and during the day with inverter capacity remaining after real power generation, for providing significant improvement in the power transfer limits of transmission systems. The effectiveness of the proposed control, power transmission capacity, improved during day time also. These are pure voltage control, pure damping control, and a combination of voltage control and damping control. Wind system where the Power Transfer Capacity in below 60% during Night Time and 0% during the day. Solar System, Power transfer capacity can reach above 90% during Night time and it gives above 80% in a day time. The PV-STATCOM operation opens up a new opportunity for the PV solar Distributed Generator to earn revenues in the night time and day time in addition to that from the sale of real power during the day.

REFERENCES

1. Adri a JunyentFerr, J.Marques, E.Quitmann, and S.Wachtel,“Wind energy converters with FACTS Capabilities for optimized integration of wind power into trans. and dist. systems,” in Proc. CIGRE, Calgary, AB, Canada, 2009.
2. Alvaro Luna, Voltage Sourced Converters in Power Systems Modeling, Control and Applications. Piscataway, NJ,USA: IEEE/Wiley, 2011.
3. FeiWang,F.L.Albuquerque,A.J.Moraes,G.C.Guimaraes,S.M.R.Sanhueza, and A. R. Vaz, “Photovoltaic solar system connected to the electric power grid operating as active power generator and reactive power compensator,”Solar Energy, vol.84, no.7, pp.1310–1317,Jul.2010.
4. Mohanraj, R. Lalitha, “Grid support functions implemented in utility scale PV systems,” in Proc. IEEE Power Energy Soc, Transm. Distrib. Conf. Expo., 2010, pp. 1–5.
5. Feltes, H. Wrede, F. Koch, and I. Erlich, “Enhanced fault ride-through method for wind farms connected to the grid through VSC-based HVDC transmission,” IEEE Trans. Power Syst., vol. 24, no. 3, pp. 1537–1546, Aug. 2009
6. FredeBlaabjerg,K.Chatterjee,B.G.Fernandes, and G.K.Dubey,“An instantaneous reactive volt ampere compensator and harmonic suppressor system, IEEETrans.PowerElectron” vol.14, no.2, pp.381–392, Mar.1999.

7. Gomis-Bellmunt, J. Liang, J. Ekanayake, R. King, and N. Jenkins, “Topologie so multi terminal HVDC–VSC transmission for large off shore wind farms,” Electr. Power Syst. Res., vol. 81, pp. 271–281, 2011.
8. Juan C. Vasquez, I. Muta, T. Hoshino, and M. Osakada, “Maximum photo voltaic power tracking an algorithm for rapidly changing atmospheric conditions,” Proc. Inst. Elect. Eng., Gen., Transm. Distrib., vol. 142, no. 1, pp. 59–64, Jan. 1995.
9. Juan Manuel Carrasco,M. F. Schonardie and D. C. Martins, “Three-phase grid connected photovoltaic system with active and reactive power control using transformation, inProc.PESC” 2008, pp.1202–1207.
10. Junyent-Ferr´e,O.Gomis-Bellmunt,A.Sumper,M.Sala,andM.Mata, “Modeling and control of the doubly fed induction generator wind tur- bine,” Simul. Model. Practice Theory, vol. 18, no. 9, pp. 1365–1381, 2010.
11. Study of Intelligent PI-Fuzzy supervisory speed control scheme for 4 Phase Sensorless SRM drive JUA Jeevanandham International Journal of Applied Engineering Research 9 (22), 16581-16594
12. Ravi Kumar S. V, Siva Nagaraju S., “Simulation of D-Statcom and DVR in Power Systems” ARPN Journal of Engineering and Applied Sciences Vol. 2, No. 3, June 2007.
13. Zhan, M. Barnes, V.K. Ramachandaramurthy, and N. Jenkis, “Dynamic Voltage Restorer with Battery Energy Storage for Voltage Dip Mitigation” Power Electronics and Variable Speed Drives, 18-19, Conference Publication No. 475, IEEE September 2000.
14. Yvonne Coughlan, Paul Smith, Alan Mullane, Member, IEEE and Mark OMalley, — Wind Turbine Modelling for Power System Stability Analysis –A system operator Perspectivell, IEEE Transaction on Power System, Vol. 23, No. 3, pp. 345-375, August 2007.
15. Comparison and Performance Analysis of FACTs Controller in System Stability DR KarthikeyanCircuits and Systems, 2948-2958
16. Subhro Paul, Pradip Kumar Saha, Gautam Kumar Panda, “Power Quality Improvement Using New Control Algorithm Based Dynamic Voltage Restorer” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 1, Issue 3, September 2012.
17. Cascaded control of multilevel converter based STATCOM for power system compensation of load variation K Sundararaju, AN KumarInternational Journal of Computer Applications 40 (5), 30-35