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PV STATCOM for Enhancement of Power Quality

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Abstract - *This paper focuses on the photo voltaic (PV) system with power quality improvement features. Now a days to promote the low carbon energy resources solar energy become the favorite non convention energy recourses but solar energy depends on the solar radiation, it directly converted in electrical energy by the help of Photo Voltaic system. In PV Grid system various power quality issues generated which mitigates by using FACTS device like STATCOM , DVR, SVC etc. in this paper PV STATCOM system are represented for enhancement of power quality like voltage variations (Voltage sags), through Simulink/MATLAB model. Renewable energy sources are being increasingly connected in distribution systems utilizing power electronic converters.*

Key Words: PV STATCOM, Power Quality (PQ), Solar System.

1. INTRODUCTION

In the present power scenario electrical power demand exceeds generation. The demand is steadily increasing because from last few decades onwards the crucial activities such as domestic, municipal, commercial, transportation, agricultural and industrial activities in the society are strongly interconnected with an electrical energy. To meet the capital power burden alternative energy sources such as wind, geothermal, tidal and solar energy sources are considered as suitable alternatives in grid integrated system[1].

Widespread utilization of non-Linear devices in modern power system is greatly affecting the quality of power supply. With the great fast forward advancement in the area of Power Electronics (PE), the characteristics of electrical loads have changed completely. The distorting loads are drawing impure sinusoidal currents, which degrade the quality of power in distribution system. The APFs have been considered over passive filters as effective solution for diminution of the power quality complications in the power systems.

The Shunt Active Power Filters (SAPF) are current controlled, voltage source inverters mainly intended to inject the required and desired compensating current into the proposed distribution system to relieve the electrical power supply from the generated harmonics and reactive currents by distorting loads in the distribution systems. This chapter mainly aims at the designing aspects of PV based shunt APF for magnification of power quality in grid integrated test model. The various modes of operation of PV-Statcom are clearly explained with the help of the phasor diagrams for absorption and or injection of real and reactive powers in the proposed grid tie test model for enhancement of power quality[2]•

2. POWER QUALITY

The 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. Taking into account the prerequisites power quality can have various different meanings and significances[3-4].
Power disturbances generate the power quality problems in the electrical distribution network. The Power disturbances will be generated from external and internal sources in the power distribution system, some of the external sources are [8]

- Lightning
- System faults
- Surges
- Switching Operations
- Accidents involving on electric power lines and feeders.

And some examples of internal sources are :

- Switching of large inductive loads or Motor starting
- Line and capacitor switching
- Harmonic producing loads (Power Electronics based loads).

As per the IEEE definition the power quality disturbances are categorized based on wave shapes. They are[7]

- Voltage variations
- Transients
- Voltage imbalance / unbalance
- Waveform distortions / harmonics
- Voltage fluctuations
- Power frequency variations

Table.1: Power quality effects on various equipment

Equipment	Effect
Capacitor	Reduce life, failure
Transformer	Increased losses, reduced capacity
Motor	Reduced motor life ,mechanical fatigue and inability to load the motor to rated capacity, increased losses
Conductor or cable	Increased heating
Power electronic equipment	Misoperation
Relay	Misoperation
Lamps	Reduced life
Communication equipment	Interference
Semi conductor	Breakdown ,increased heating
Digital equipment	Misoperation
Timing device	Faulty timing signal

3. DESIGN ASPECT OF PV STATCOM FOR ENHANCEMENT OF POWER QUALITY

The VSC based PV-STATCOM is associated in shunt with grid for injection of sufficient real and reactive powers for stable operation of power system. The 3-Phase, 3-Wire diode rectifier power electronic based linear load is energized by major grid source as depicted in Fig.1. In this proposed grid integrated test model the Shunt APF is aligned from photovoltaic solar inverter control[5]. The VSC based active filter is a shunt connected three phase voltage source converter, which actually intended for evacuation of PV produced power The shunt active filter has been utilized to manage the VAR power and current harmonics (current distortions) at t point of common coupling in the power system for diminution of power quality hitches generated due to the sensitive load in the grid integrated system[8].

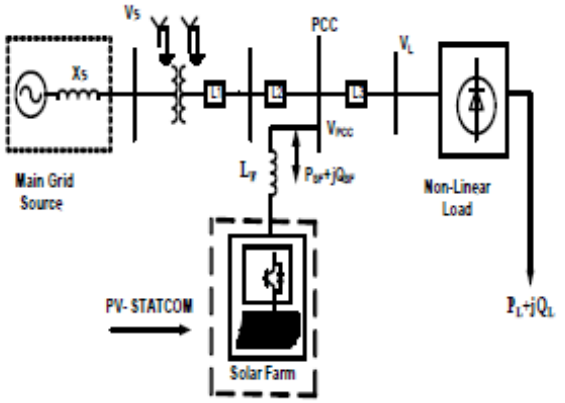

Figure.1: Proposed single line diagram for enrichment of power quality.

4. MODES OF OPERATION OF PV_STATCOM

The active and reactive power injection and absorption by PV-Statcom will be explained in four modes of operation as follows In capacitive mode of operation the inverter voltage is more than that of the system voltage (Vt>Vs , but these voltages are in phase) then an inverter provides only VAR power (Q) to the micro grid system In inductive mode of operation the inverter voltage is less than that of the system voltage , but these voltages are in phase) then the inverter draws reactive power (Q) from the principal grid system[9].

If the inverter voltage is delayed (lagging) in phase (having some magnitude) when compared to the grid voltage then the true power (P) will flow from the principal grid system to inverter. Similarly if the inverter voltage is in advanced (leading) in phase (having some magnitude) when compared to system voltage then the inverter will provide the true power to the micro grid system. All these operations are possible only if the inverter has the energy storage device (like PV system, Battery, Fuel cell) on its DC side (input side) The various modes of operation of PV-Statcom can be explained clearly with the help of the following phasor diagrams to understand it`s active and efficient operation for diminution of power quality concerns in the present test model[11,12].

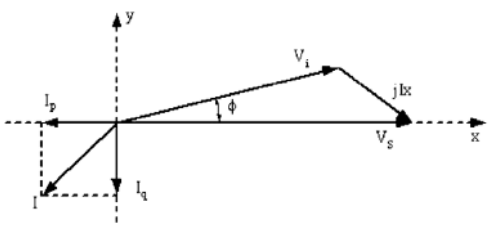

Figure.2: Inductive mode- Active power injection and reactive power absorption

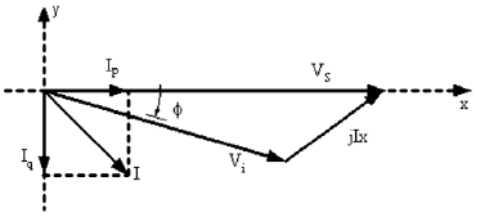

Figure.3: Inductive mode- Absorbing active and reactive powers

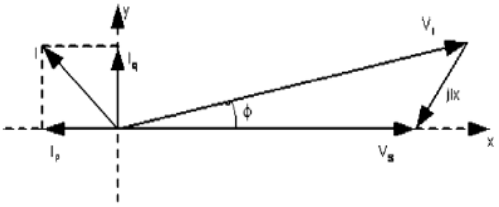

Figure.4: Capacitive mode - Injecting active and reactive powers

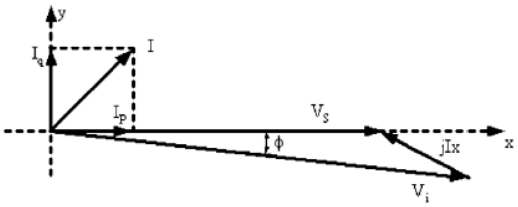

Figure.5: Capacitive mode - Absorbing active power and injecting reactive power

5. APPLICATIONS PV SOLAR FARM AS PV-STATCOM

Recently All the possible applications of photovoltaic solar farm utilized as PV based shunt APF are listed as follows[9].

- Improves the power system performance by increasing system stability.
- Controls damping oscillations.
- Alleviates voltage instability.
- Enhances the transmission line capacity.
- Provides reactive power support and or compensation.
- Provides load balancing.
- Mitigates the current harmonics.
- Improves voltage regulation at PCC.
- Improves Power factor from non-unity PF to unity PF.]

6. MATLAB MODEL AND RESULT

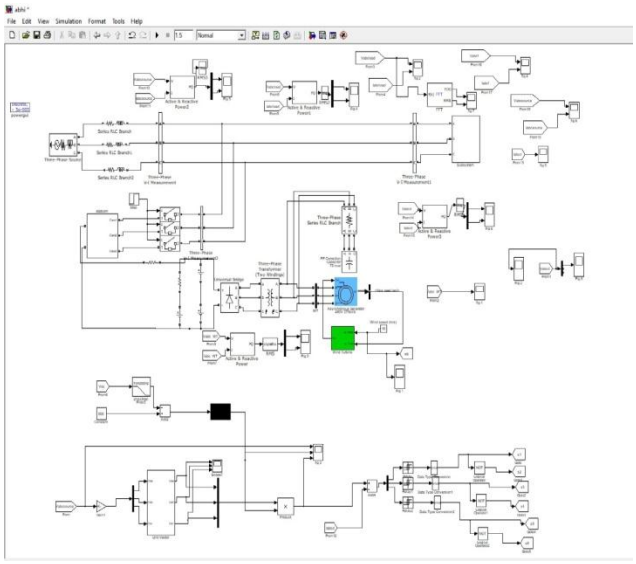

Figure.6: MATLAB Model of PV STATCOM

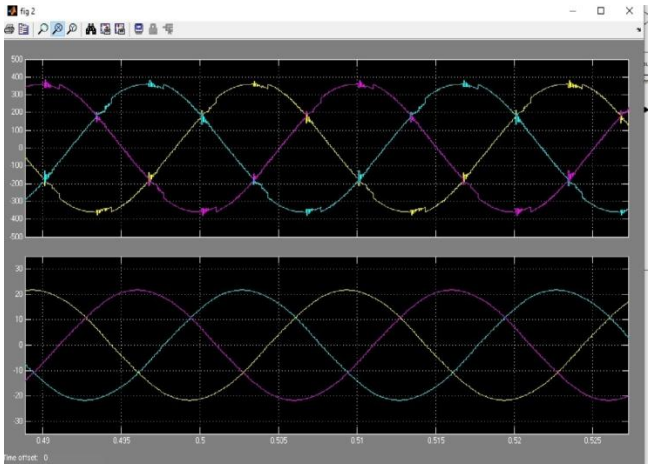

Figure.7: Simulink Output of PV STATCOM

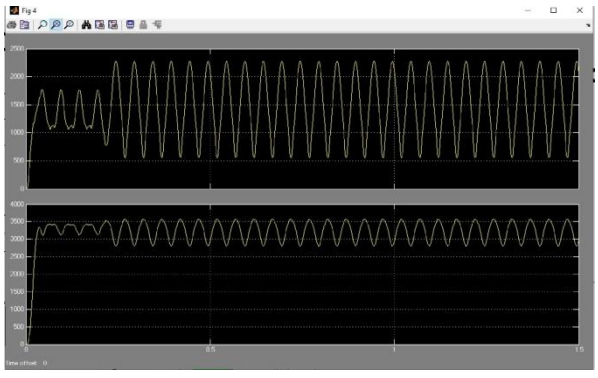

Figure.8: PV STATCOM Compensator Output

7. CONCLUSIONS

The This research work represents the effectual and beneficial performance of a PV solar farm as static synchronous compensator for the attenuation of power quality hitches due to power electronic based loads in the grid integrated test model. This work also briefly describes about the various control strategies for generation of reference current signals and different topologies for shunt APFs and various applications of Photovoltaic solar farm as shunt compensator. The various modes of operation of PV based Statcom for injection and absorption of both real and reactive powers for attenuation of power quality complications in the distribution system are clearly explained. It also recaps the designing aspects of a PV based shunt APF and generation of gate currents with the proposed control strategies for active participation of VSC based shunt compensator for power quality improvement in distribution systems. The MATAB simulations are carried out to demonstrate the active operation of PV based Statcom for harmonic diminution, active and reactive power injection and absorption where and when it is needed

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