

# Mitigation of Voltage Sag, Swell In Hybrid Power System Using Dstatcom

V. Dega Rajaji, K. Chandrasekhar

**Abstract:** This paper describes the solar wind hybrid power system for the generation of electricity over renewable vitality means. The integrated power generation systems are resourceful in generation areas. Power quality issues such as disturbances in voltage, current or frequency in sensitive industrial lots outcomes in leiddown of end handlertackle. This papersignifies the techniques for the perfection of sag,swell and disruption in a supplyschemes with power groundedtackleD-STATCOM(Distribution Static compensator).As this device is most effective and efficient in injecting current and mitigating the sag,swell and reduction in interruption. The D-STATCOM uses 5 level multilevel inverter as Voltage source inverter,the switches are skilful by pulse-width-modulation technique(PWM). The DSTATCOM provides the reactive compensation for voltage stabilization in distribution systems,it also provides the protection over voltage sag which are caused due to reactive current demand. During the transient events the D-STATCOM provides the power factor correction,system stability and load balancing. The compensation characteristics and reliability, control schemes of the planned system is designed and carried out in MATLAB/SIMULINK.

**Keywords:** DSTATCOM, voltage sag, Swell Mitigation, hybrid systems.

## I. INTRODUCTION

Day to day increase in the rate of non-renewable energy source is creating the sourcerequest of power yet inconceivable in distant regions. Sustainable power source is the finest alternative for created nations to delivered electric power (EP) in territory where classy to use the traditional gridprovisions. A large portion of our specialists are going to investigate how to use power and how to delivered power in a well way. For EP generation, Renewable hybrid framework are being utilized. Freely any reasonable in like manner generation of EP yet hybridsystem give steady Power to stack. Step by step request of intensity rapidly expanding. Regardless, Energy generation plant not give that a great deal of power, so there will expanding load coveringglitches. As of this cause Renewable energy sources have advanced toward getting to be import for these days.

Revised Manuscript Received on June 05, 2019

V. Dega Rajaji, Research Scholar, Dept. of EEE, University College of Engineering & Technology, Acharya Nagarjuna University, Guntur

Dr. K. Chandrasekhar, Professor & HOD, Dept. of EEE, RVR&JC College of Engineering, Guntur

In number of use different feasible power source framework are vital to associated burden or matrix [1]. For decent power the board the multiport DC-DC converters are planned to half and half claim. To create adjustable DC into secure DC the DC-DC converter is use. There are various feasible hybrid energy outline work like PV-Hydro, PV-Fuel cell, PV-Biomass, Wind-PV, etc. contamination free and interminable vitality are accessible on earth that is the sun situated energy [2]. PV board can remove the sun situated irradiance and conveyed broad proportion of power. Wind power is the sort of engine vitality and this vitality is alter into whatsoeverclient requests. Windmill is usage in various potentate locale for water siphoning. Wind turbines offersmotorized power and after that with the aid of generator offers EP. From this planned work, Wind-PV cross breed feasible power source associated with burden for proper power the board with usages only a solitary manageable switch. Cohortcontrol from airstream is AC that changed over first into DC by then associated DC-DC Improvement converter. So likewise from PV is DC that direct associated with new converter. This Multi-port DC-DC bolster converter are switch by PI/PID Controller. PV-Wind Hybrid framework gives control ability to secludedhousehold, firm house, space, street light, etc EP dependent upon the essential of wherever the place is use. Purpose of my dare to interface the breeze PV to dc connect capacitor and fulfill all of the prerequisites from client. The relaxing time be diminished than the individual one with expanding yield. The SPWM inverter is associated with converter the DC baseshooked on AC for non-linear AC load. The progression of force equipment gadgets, for example, Flexible AC Transmission System (FACTS)and conventions control contraptions have displayed and rising piece of advancement outfitting the power framework with multipurposenovelswitchabilities[3].There are dissimilar ways to deal with recover control superiority issues in conduction and circulation frameworks. Amid these, the D-STATCOM is a standout amid the best hardware. Another PWM-based control plot has been completed to control the electronic valves in the D-STATCOM. The D-STATCOM has extra capacity to proceed with reactive current at stumpy voltageage, and can be thru as a voltage age and recurrence support by overriding capacitors with series as vitality storing. [4, 5].

In this paper, the setup and plan of the 5level cascaded H-associated D-STATCOM is inspected It moreover is proposal to expand the power quality, for instance, voltage droop, swells and harmonic distortion and low-power factor in conveyance framework. In Section 2 gives insights regarding the framework rundown. Segment 3 give subtleties of the framework demonstrating parts. Segment 4 gives MATLAB simulation with results discussion. Finish of the planned framework in area 5.

## II. PROPOSED SYSTEM

The proposed game-plan of grid related hybrid wind; sun oriented based energy system has appeared in underneath fig1. It is having two separate control units and one voltage source inverter. All of the two energy assets are connected

in parallel to a typical DC transport through two individual dc- dc boost converters. The energy from the two specific assets related in like way DC transport and parallel and using three phase VSI is utilized change over required energy to system and grid.

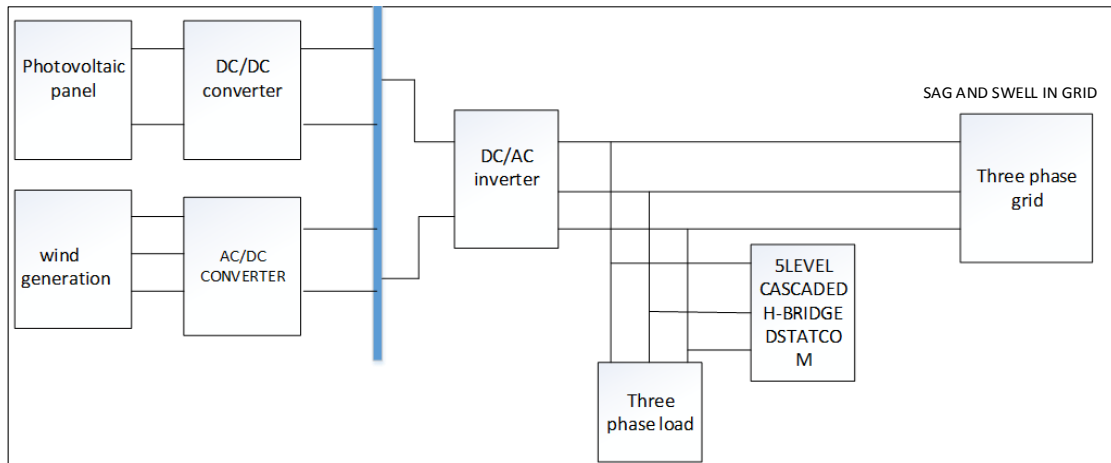


Fig. 1 Hybrid system with DSTATCOM

DC – DC booster converter is utilized for MPPT of sun based system. This proposed blend system isn't actually equivalent to different assets due to control of boost converter and three phase inverter to accomplish DC transport voltage course and adjustment of inverter input if the no less than one sources are merged at DC transport. These outcomes in expanded quality and high power nature of the electric power injected to the system and system from the inverter. At that point execute distribution side strategies load side is 5level cascaded H-associated DSTATCOM (distributed static compensator) to diminished harmonic content and stretches the voltage-steadiness at all times. Shunt associated unused power recompense gadget that is 5 level H-cascaded D-STATCOM to able creating and retaining responsive power. The AC control is acquire since inverter and made to capacity with taking variation. To diminish that difference of voltage droop and swell, D-STATCOM is essential to progress of improvement of supply.

## III. SYSTEM COMPONENT MODELLING

### A. PV Modeling

The sunlight based board is convert sun fuel energy into electrical vitality with DC-DC converter to stage up the voltage of the sun based vitality. As a rule present source are associated with similar to the diode canister be signified as a photo-voltaic cell (PVC) [6]. The proportionate circuit also mixture of sequencsconfrontation and shunt-resistancesignified by Rsh whose esteem is huge and Rs value is less. PVC is the semiconductor gadget that engross the energy and change vitality of light into power by the impact of sun oriented radiation and malaise. The equal circuit appeared as follows.

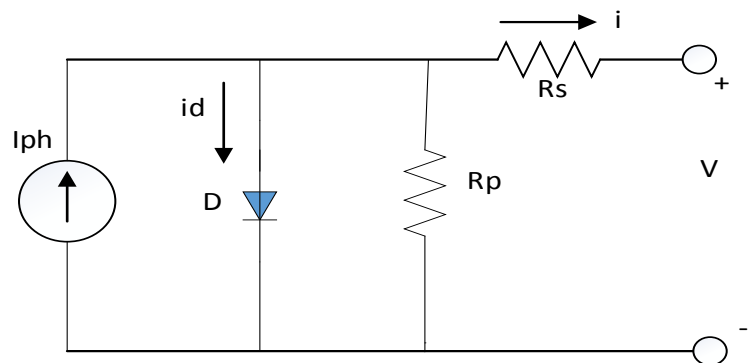


Fig. 2 PV model Equivalent circuit

$$I = I_{ph} - I_o \left( e^{\frac{V+IR_s}{n_s v_T}} - 1 \right) - \frac{V+IR_s}{R_p} \quad (1)$$

This is analikecircuit of a applied PV cell. In numerous literary works it is additionally named as a 5 stricturemodel. It considers diverse properties of sun oriented cell as:

- RS is presented as to reflect the voltage droplets and core loses in because of tide of current.
- RP considers the leak current to the pulverized when diode is converse biased.
- But this classical has disregarded recombination impact of diode, which is the reason it is as yet not the greatest precise model.

### B. WIND TURBINE MODELLING

One of the rapidly developing power on the planet is wind cohort. Wind is the kind of dynamic vitality that changed over to first mechanical with the aid of turbine. For peers of intensity from wind, framework consuming PMSG, inverter, Rectifier. In the framework wind turbine get the vitality since wind, and produceradapt that powered vitality into electrical. With the help of

intensity hardware device changes over mechanical changes over the power from low to high gauge and it control the rotor generator speed. Power delivered by wind turbine-

$$P = \frac{1}{2} \rho A C_p (\lambda) V^3 \quad (2)$$

Here:  $\rho$ =Air density;  $A$ = Area of swept out by turbine;  $V$ =wind speed;  $(\lambda)$ =power coefficient;  $\lambda$ = tip speed ratio

Theoretically, max. value of power coefficient is 0.59. It depends on 2 variable  $\lambda$  and pitch angle.

The ratio of tip speed formulated by

$$\lambda = \frac{Rn\pi}{30V} \quad (3)$$

Here,  $n$ =turbine-rotor speed in R/min

The power coefficient of the wind turbine-

$$C_p(\lambda) = c_1 \left( \frac{c_2}{\lambda_1} - c_3\beta - c_4 \right) e^{\frac{-c_5}{\lambda_1}} - c_6\lambda \quad (4)$$

Where,

$$\lambda_1 = \left[ \frac{1}{\lambda + 0.089} - \frac{0.035}{\beta^2 + 1} \right]^{-1} \quad (5)$$

When  $\beta = 0$  that is the pitch angle then.  $\lambda = 6.325 C_p$  Is maximum value

In this paper use for creating controls since all use PMSG initiator that is an enduring glodestone synchronous generator (SG). Solitary of the principle advantage is that it needn't bother with a reactive charging current. In a SG, attractive field is made by utilizing a perpetuallure, or customary arenasnaking. It tends to be utilized with any gearbox for thrudeterminationrequest [7]. Utilization of PMSG in wind-turbine as of their stuff of own excitation which permits a task of high-power and high-proficiency. Perpetuallure utilize commonly low-power created the application what's more, having minimal effort.

### C. BOOST CONVERTER MODELLING

Boost converter is additionally termed as the step-up converter. Converter is constantly better than that of the input. Figure 3 demonstrates the schematic outline of Boost converter. [8]

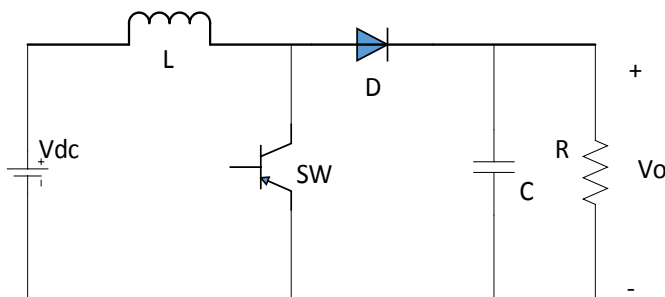


Fig3. Boost converter

Boostconverter includes input voltage source, switch, inductor, diode, capacitor and resistor which goes about as a heap. The switch can be closed or open depends upon the yield need. The yield voltage over the heap or resistor is continually more than that of information voltage. A lift controller can wander up the voltage without a transformer. Due to a lone switch, it has a high proficiency. The information current is persistent. The yield voltage is sensitive to changes in obligation cycle  $D$  in condition. The normal yield current isn't actually the normal inductor current by a factor of  $(1-D)$ , and a much higher rms current would travel through the channel capacitor. If the lift converter works in persistent conduction mode (CCM), by then the estimation of inductance  $L$  from the inductor current swell investigation is given by condition. [8]

$$L_{min} = (1 - D) 2 * D * \frac{R}{2} * f \dots (6)$$

The min. value of filter capacitance that consequences in voltage ripple  $V_r = \Delta V_O / V_O$  is agreed by equation

$$C_{min} = \frac{D}{R} * f * V_r \dots (7)$$

### D. perturb and Observation Algorithm

The perturb and observe (P&O), as the name itself communicates that the figuring relies upon the perception of the cluster yield control and on the irritation (addition or decrement) of the power subject to augmentations of the exhibit voltage or current. In this procedure a slight bother is in present framework. This bother causes the intensity of the sun based module changes. If the power increases as a result of the bother, by then the irritation is continued toward that way. After the pinnacle power is achieved the power at the accompanying minute reductions and in this manner after that the bother pivots. At the point when the enduring state is achieved the strategy wavers around the pinnacle point. So as to keep the power variety little the irritation size is kept exceptionally little. [8] [9].

The rationale of this estimation and the flowchart are explained in Figure 5. The working voltage of the PV framework is pertubated by a little expansion of  $\Delta V$ , and this subsequent change in  $\Delta P$ . If  $\Delta P$  is sure, the pertubated of the working voltage ought to be a comparative method for the addition. Despite what might be expected, if  $\Delta P$  is negative, the got framework working point moves from the MPPT and the working voltage needs to move the other method for the increment. [8][10].

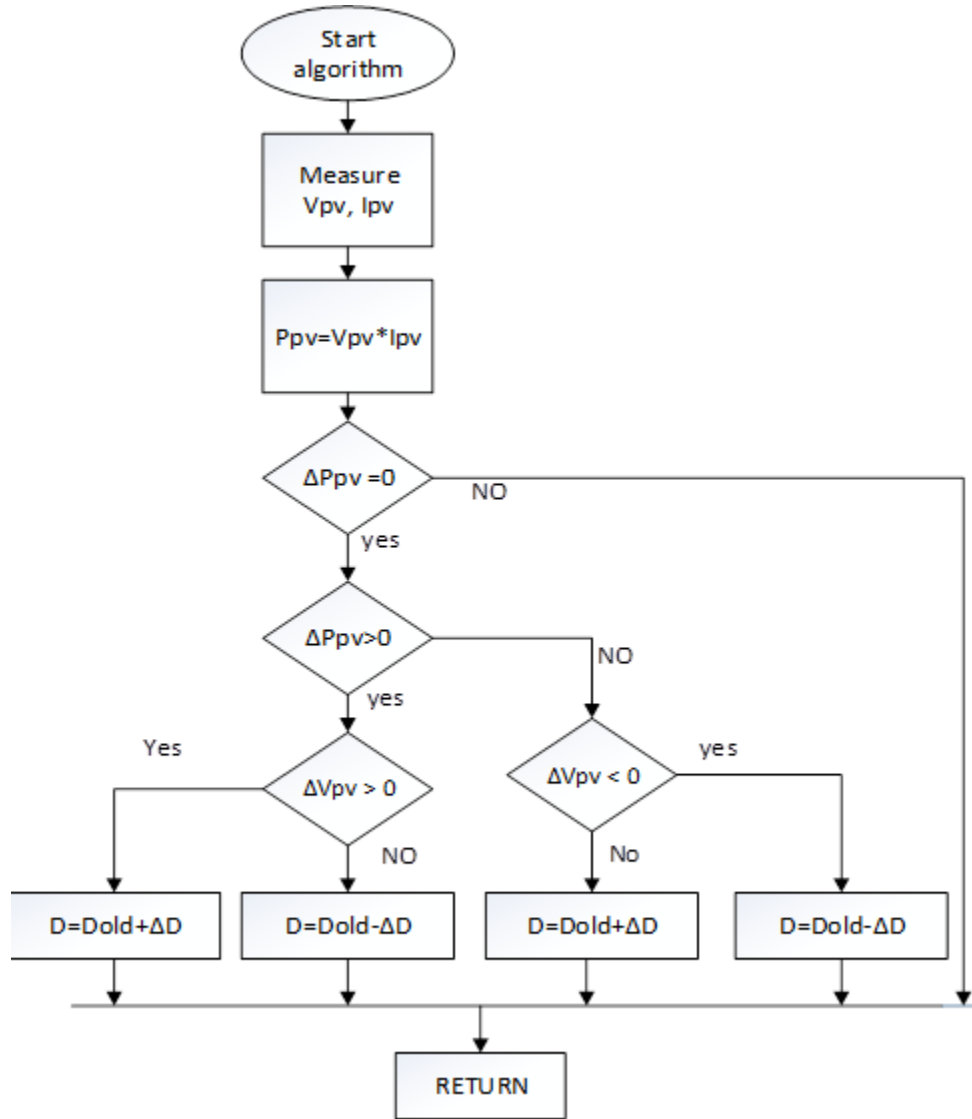


Fig. 4. P&O algorithm-Flow Chart

E. design of voltage source inverter

Fig5 shows the circuit diagram of Voltage source inverter (VSI). This is castoff to change the output of rectifier DC to AC voltage.

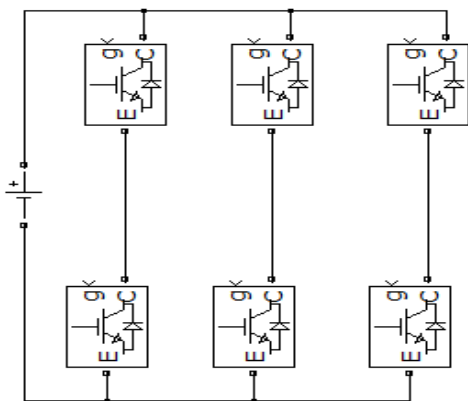


Fig5: voltage source inverter

The control framework exploits 2 control circles: an outside control ring which manages DC interface voltage to +/- 415

V and an inward control ring which directs Id and Iq lattice flows (dynamic and responsive current segments).

Id current orientation is the harvest of the DC voltage outside controller. Intelligence level current orientation is set to focus so as to keep up solidarity power factor. Vd and Vq voltage harvests of the currentsupervisor are altered over to three adjusting signals Uref\_abc used by the PWM three-level heartbeat generator.

F.Design of cascaded H-bridge DSTATCOM

The cascaded H-connect multilevel inverter involve arrangement associated various units of H-bridge cells to deliver high air conditioning voltages. An ordinary five-level CHB inverter setup is showed up in Fig. 6. Where two H-connect cells constrained by two isolated dc supplies of equal voltage V, are set in each stage. The dc supplies are routinely procured by multi pulse diode rectifiers. By exchanging the Switches in appropriate conduction, different dimensions of phase voltages can be acquired. Some voltage levels can be obtained by more than one switching state. The switching state repetition is a general phenomenon multilevel

converters. It gives an extraordinary adaptability to switching pattern design structure.

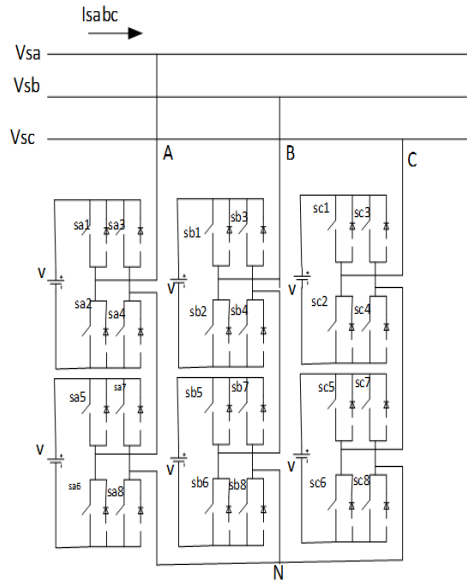


Fig6: 5-level CHB DSTATCOM

The phase-locked loop (PLL) harmonizes on the optimistic order constituent of the 3-phase essential source voltage. The o/p of the PLL (having an angle  $= \omega t$ ) is utilized to compute the direct-axis (d) and quadrature axis (q) works of the AC 3-phase voltage and flows (marked as  $V_d, V_q$  or  $I_d, I_q$  on the test simulation setup). The fundamental molds occupied in the displaying technique are [11].

- The balanced ac supply voltages
- Line resistance and capacitance are ignored.
- Unity power factor
- Ripple free DC output.
- All the filter mechanisms are sensitive and linear in way.
- The harmonic insides of swapping act canister be very small.
- All changes are ideal and linear.

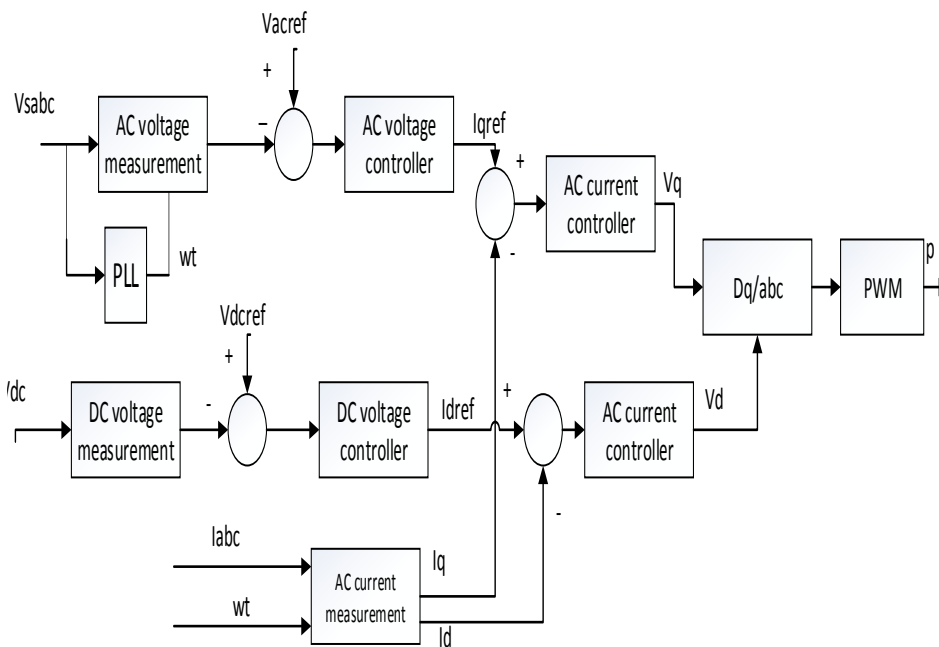


Fig7: controlling of DSTATCOM

#### IV. SIMULATION RESULTS

The Grid interconnected Hybrid framework comprises of a breeze Energy Change System and PV Energy Change System Related to an electrical utility network. The WECS is involved a PMSG. The PV System comprises of PV Array Reinforced with a Boost Converter. The network interconnection changes over the variable recurrence and size yields from the cross breed wind/PV system to the

synchronous recurrence of the utility lattice. The variable recurrence and extent yields voltages from the blend wind/SPV structure are changed over to DC voltages or implied DC joins. The simulation diagrams of hybrid power systems with DSTATCOM and without DSTATCOM has shown in fig 8 and 9 respectively.

# Mitigation of Voltage Sag, Swell In Hybrid Power System Using Dstatcom

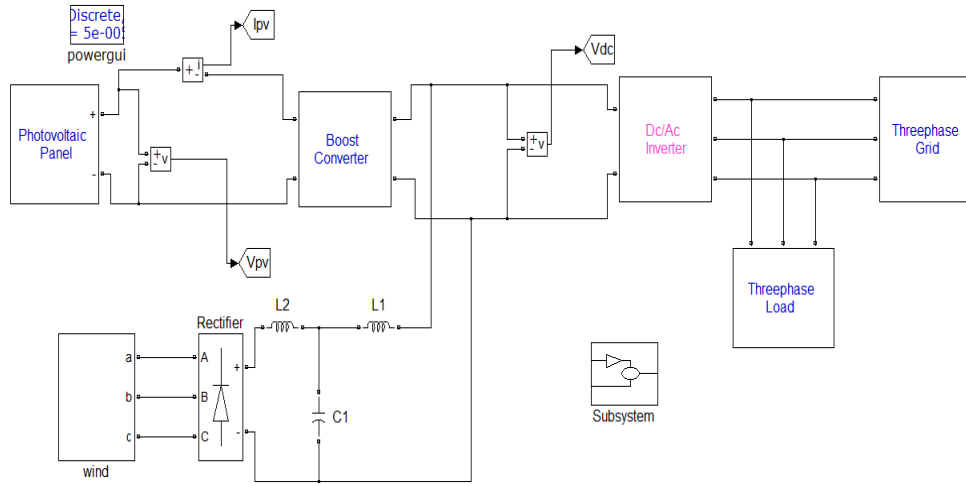


Fig8: simulation diagrams of hybrid power systems without DSTATCOM

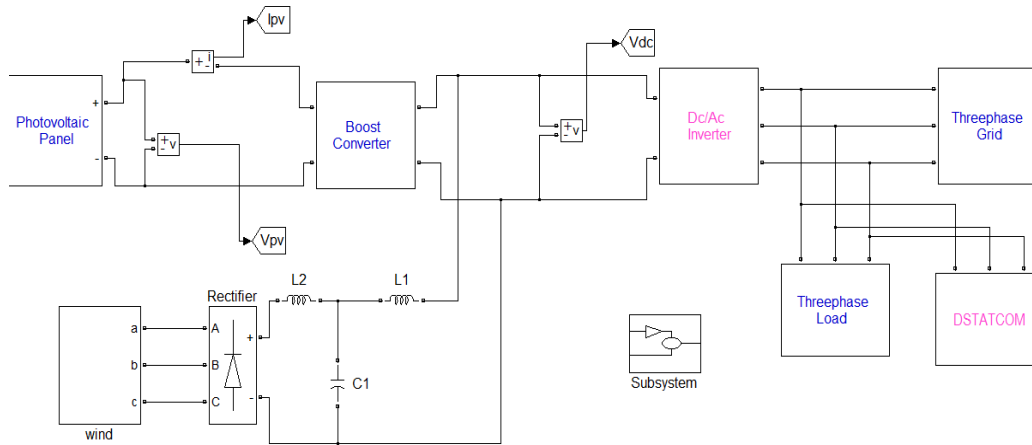


Fig9: simulation diagrams of hybrid power systems with DSTATCOM

The out voltage, current and power wave forms of solar power systems has shown in fig 10.

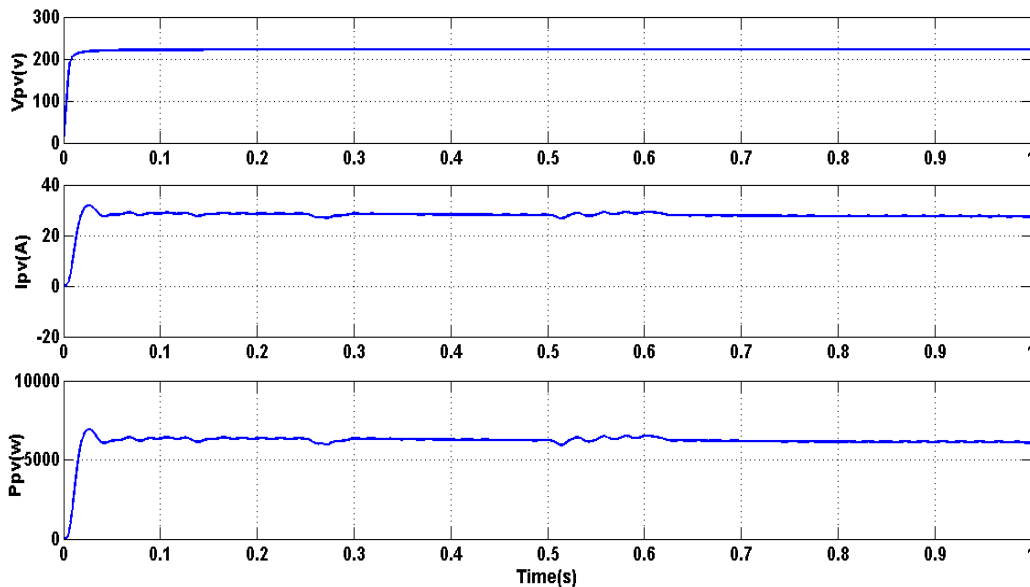


Fig: 10 PV(a) voltage, (b) current, (c) power

In WECS we are taking wind speed of 12 m/sec. the voltage and current s of PMSG based WECS has shown in fig 11 output voltage of wind turbine is 415 and current is 10A. the active and reactive power WECS has appeared in fig 12.

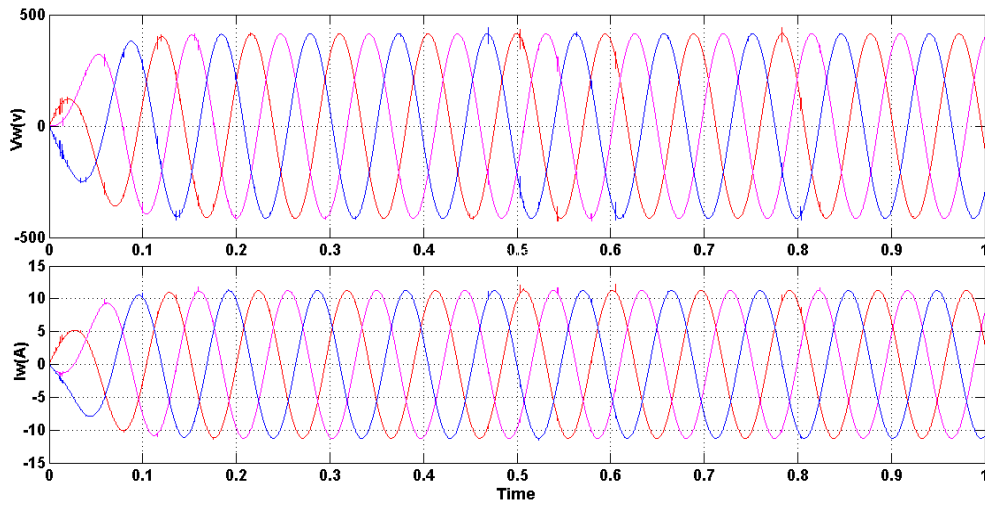


Fig 11 (a) wind voltage (b) wind current

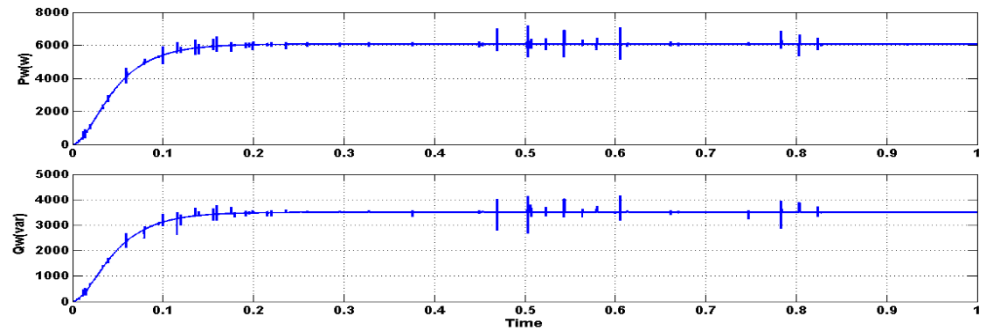


Fig 12 (a)wind Active power (b) wind reactive power

1. Simulation results for resistive load (3-phase balanced sag):

In fig.6, the system for instant incidence of resistive load is exposed for 0.5sec to 0.6sec period through this the stable sag will happen. Grid V, I and load voltage, I waveforms without using DSTATCOM has shown in fig13 and 14 respectively.

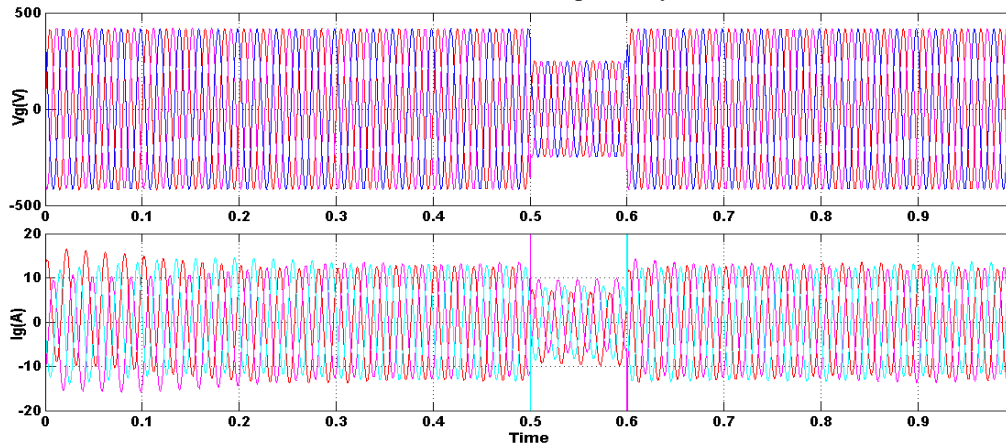


Fig 13 (a)grid voltage (b) grid current with out DSTATCOM

# Mitigation of Voltage Sag, Swell In Hybrid Power System Using Dstatcom

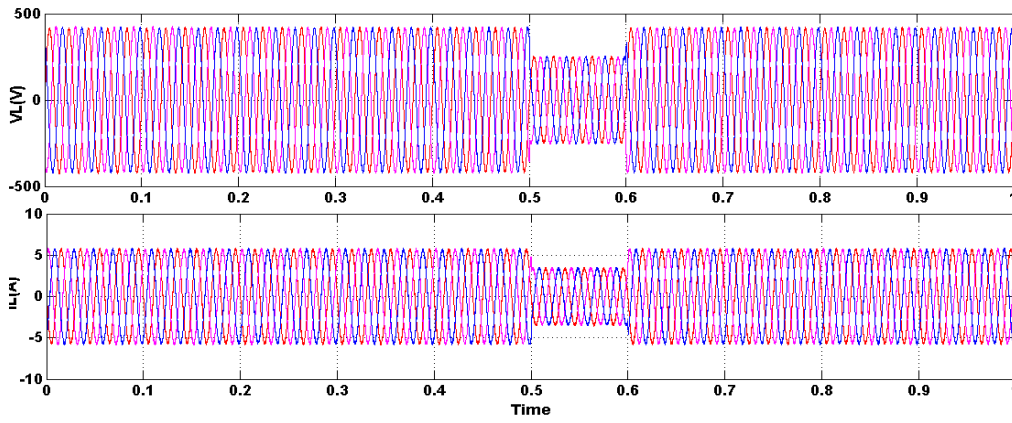


Fig 14 Load (a) Voltage (b) Current with out DSTATCOM

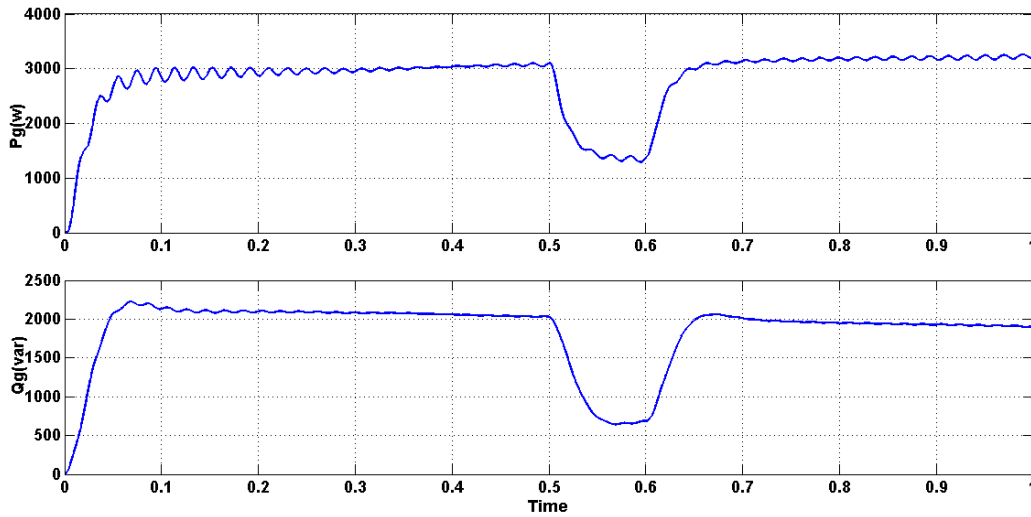


Fig 15 Grid (a) Active power (b) Reactive power with out DSTATCOM

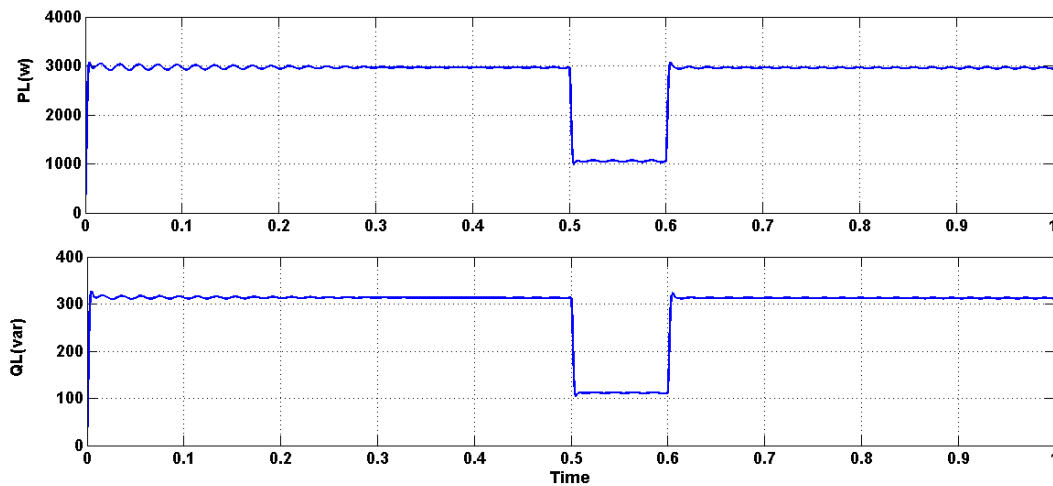


Fig 16 (a) Load active (b) Load reactive powers with out DSTATCOM

DSTATCOM is connected at the PCC the voltage, current wave forms of Load has shown in fig17.the active and reactive powers using DSTATCOM has appeared in fig18.



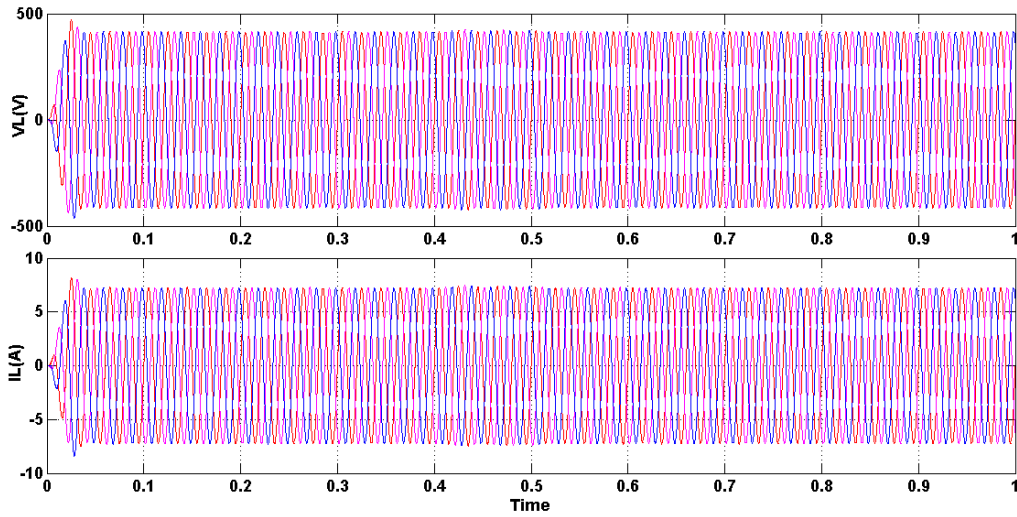


Fig 17 (a) Load voltage (b) Load current with DSTATCOM

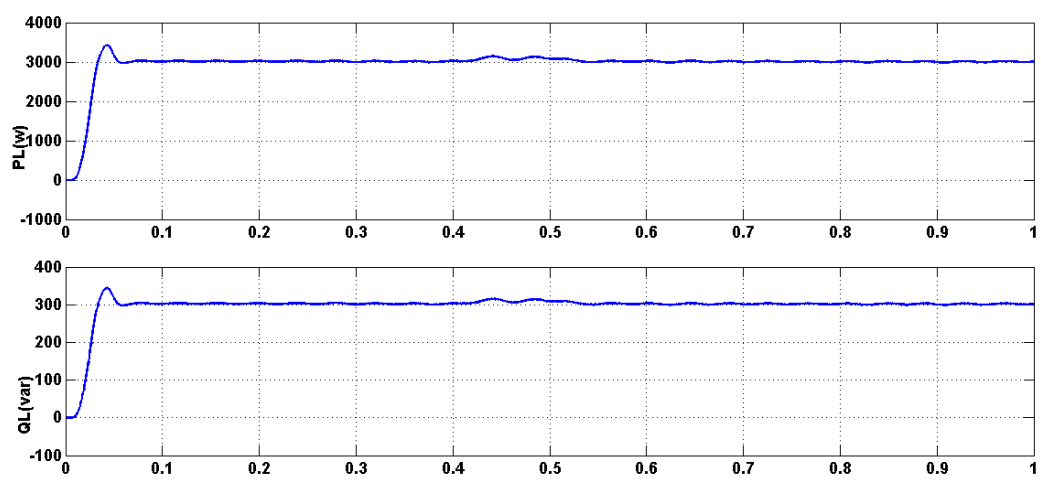


Fig 18 (a) Load active (b) Load reactive powers with DSTATCOM

2. Simulation results for resistive load (3-phase balanced swell):

In fig.6, the system for instant incidence of resistive load is exposed for 0.5sec to 0.6sec period through this the stable

swell will occur. Grid I, V and load voltage, I waveforms without using DSTATCOM has shown in fig19 and 20 respectively.

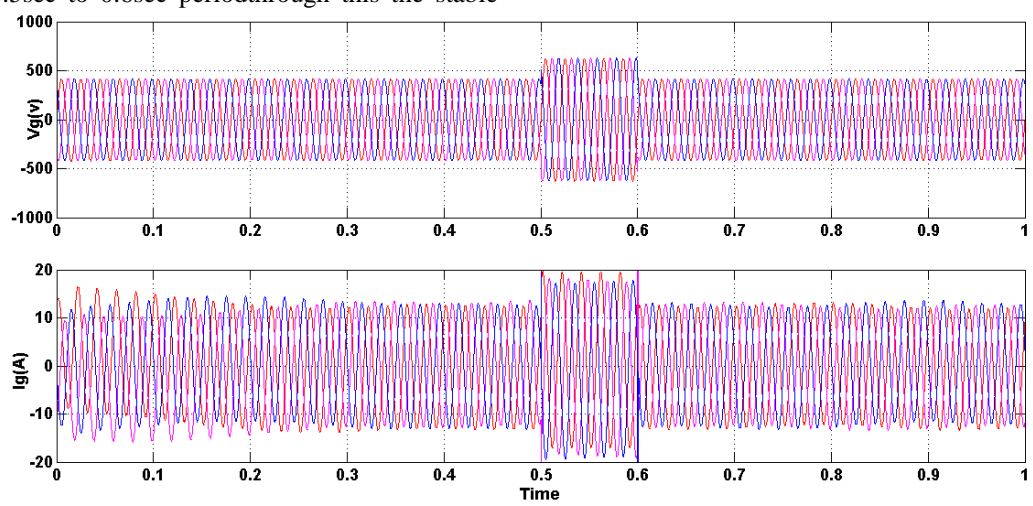


Fig 19 (a) grid voltage (b) grid current with out DSTATCOM

## Mitigation of Voltage Sag, Swell In Hybrid Power System Using Dstatcom

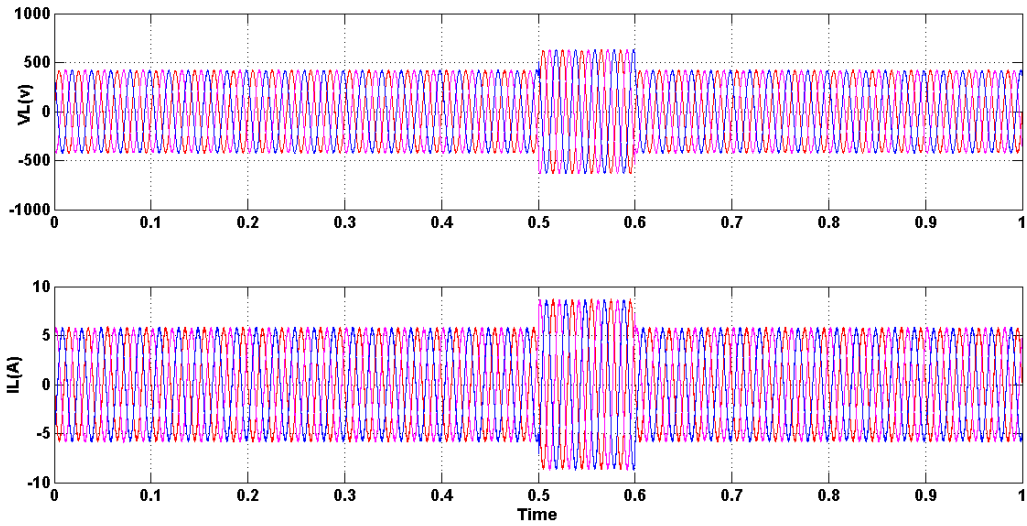


Fig 20 Load (a)Voltage (b)Current with out DSTATCOM

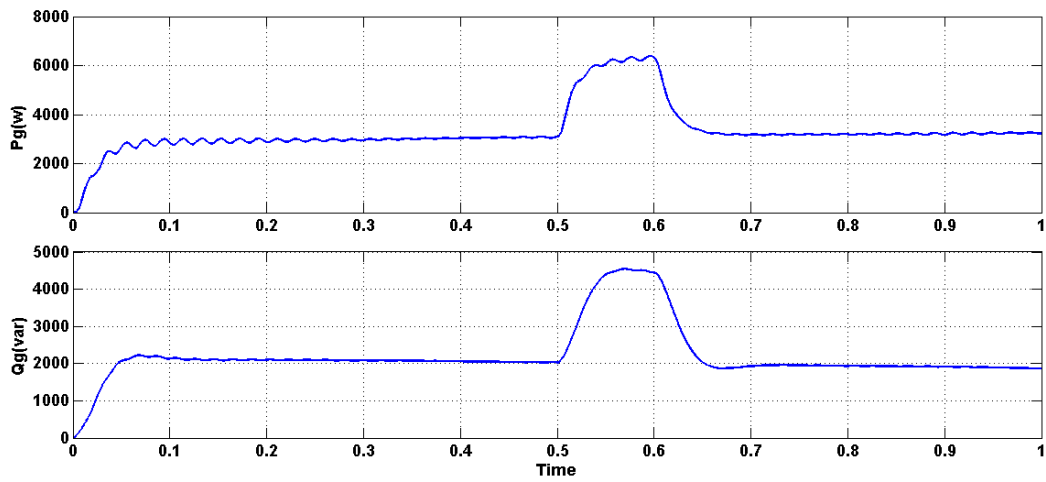


Fig 21 Grid (a)Active power (b)Reactive power with out DSTATCOM

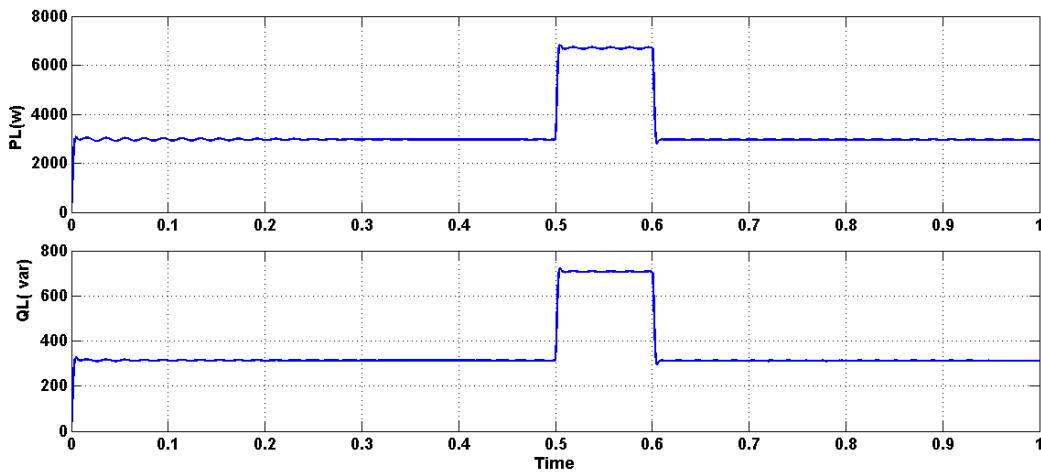


Fig 22(a)Load active (b) Load reactive powers with out DSTATCOM

DSTATCOM is connected at the PCC the voltage, current wave forms of Load has shown in fig23.the active and reactive powers using DSTATCOM has appeared in fig24.

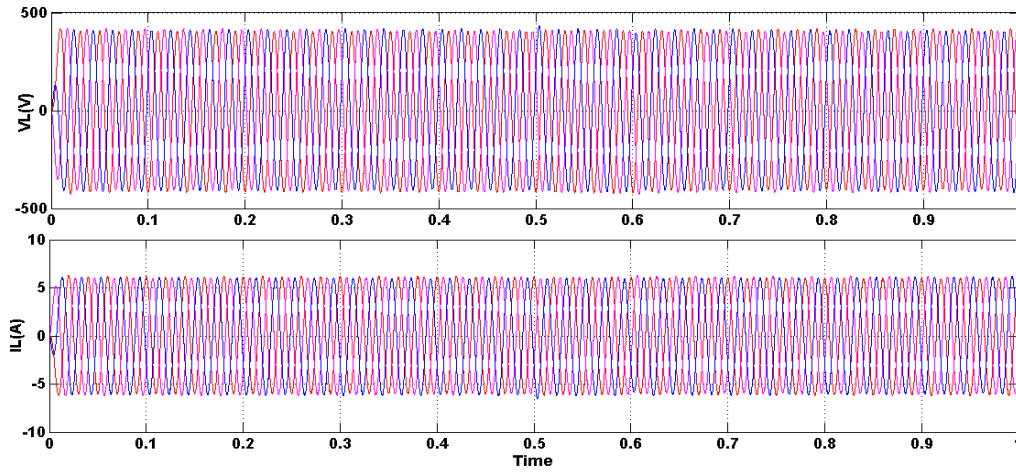


Fig 23(a)Load voltage (b) Load current with DSTATCOM

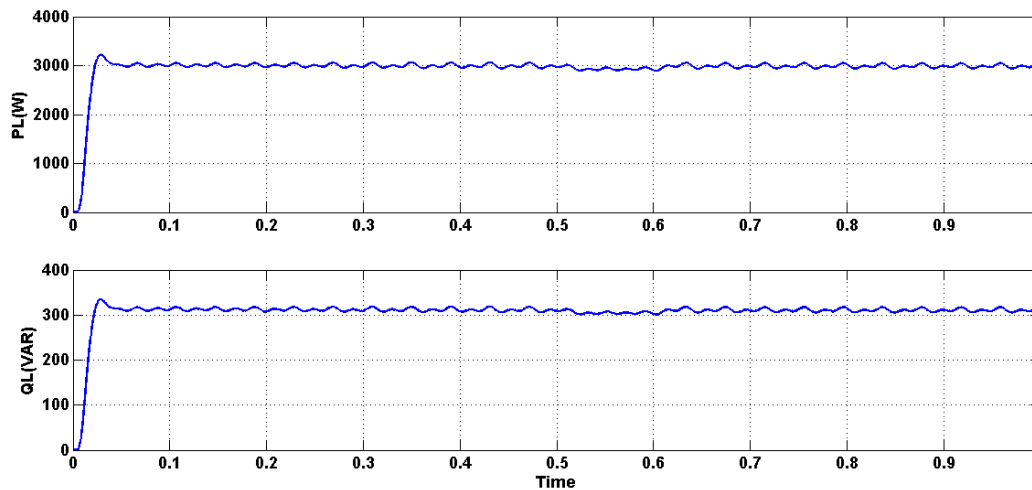


Fig 24 (a)Load active (b) Load reactive powers with DSTATCOM

The THD estimations of framework voltage and grid currents are analyzed. Table 1 demonstrates the comparison of total harmonic distortion (THD) between the with and without DSTATCOM. The THD estimates for network voltage and current is 1.23% and 2.62% without DSTATCOM and for with DSTATCOM is 0.45% and 0.53% during voltage sag condition. The THD estimates

for network voltage and current is 1.29% and 2.62% without DSTATCOM and for with DSTATCOM is 0.45% and 0.69% during voltage swell condition. With DSTATCOM gives a superior execution because of fewer harmonic.

	Without DSTATCO M(sag)	With DSTATCO M(sag)	Without DSTATCOM (swell)	With DSTATCOM(s well)
Load voltage	1.23%	0.45%	1.29%	0.45%
Load current	2.62%	0.53%	2.62%	0.69%

Table 1: THD comparison

### V. CONCLUSION

To progress control nature of the half breed framework it needs the investigation all things considered and actualities gadgets. In this exertion, a quick and financially savvy D-Statcom is planned for diminishing the issues of sounds and keep up AC voltage at together side in circulation framework. The paper presents five Level H connect Cascaded Multi Level Inverter as DSTATCOM. The consequence of the reproduction are appeared and without

D-Statcom. The execution of a DSTATCOM in relieving voltage list/swell is exhibited with the assistance of MATLAB. The displaying and recreation aftereffects of a DSTATCOM are exhibited. From above reproduction results we presume that DSTATCOM is talented gadget which is utilized for voltage droop, swell moderation at dispersion side.

### REFERENCES:



## Mitigation of Voltage Sag, Swell In Hybrid Power System Using Dstatcom

1. Govindaraj T, Bharnidharan K, "Stability and Reliability Improvement in SW Hybrid PS with BESS," IJET-EE, vol. 10, no. 3, pp.49-57,2014.
2. Gilbert M. "Renewable and Efficient EPS", John Wiley Pub.,2004.
3. Hamad A.E "Comparing the VSC of Present and future VARC Techniques in TS, IEEE Trans., Power Delivery, 1(1), 1995.
4. Meinsiki R "Shunt Compensation for PQI Using a STATCOM controller Modelling and Simulation", IEEE Proce., 151 (2), 2004.
5. Ahmid M. Atalliah," Implementation of P&O of pv system with DC method using B and BBC," ETEIE: An international journal,1 (1), pp.31-45, 2014
6. Prerna B, S.B. Prakash," Modeling and Simulation of 2 MW-PMSG WECS,"IOSR Journal of EEE, 9 (7), pp.53-58, 2014
7. T.Chaitanya, Sai Ch "Modeling and Simulation of PVA and its Performance Enhancement Using MPPT (P&O) Technique", IJCSCN, 1(1), 2011.
8. U.T.Kute, S Preethi. " Literature survey on MPPT technique for PV system, IJAREAS 2(12), 2013.
9. Pradip A, K.Yadav "Comparison of MPPT Algorithms for DC-DC Converters Based PV Systems, IJAREEIE 1 (1), 2012.
10. Abhijith A.Eril P,"Voltage Regulation of STATCOM using FST-PI Controller"ICCPCT, 2016.