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# ANALYZING THE PERFORMANCE OF D-STATCOM WITH RENEWABLE ENERGY SOURCES

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***Abstract***:. Distribution static compensator is used to compensate the source currents which are affected by the harmonics due to unbalanced and non-linear loads. Here a PV based inverter is used as a shunt active power filter to mitigate the current harmonics. The theory of synchronous reference frame is used to generate the three phase reference currents. Hysteresis current controller (HCC) is used to generate the switching pulses for the gate drives of the grid interfacing inverter. The inverter act as a shunt active power filters to inject the compensated current to the system. The total harmonic Distortion (THDs) of the source currents are reduced by using shunt active power filter (APF). The THDs of the distribution system with and without APF are compared. The whole work is been done in MA TLAB/SIMULINK To repay the reactive power misfortunes in the transmission line and any place in the electrical influence framework, we have completed the writing survey of the different papers and embraced the distinctive procedures to defeat this issue. We have utilized the shunt and series arrangement strategies, in which the compensator like capacitor will be given in parallel and in series to the inductive load. Since there is dependably a voltage and current transient upon the changing the capacitor steps. Henceforth we adopted the FACTS (Flexible AC Transmission Systems) gadgets to beat the responsive force remuneration issue. The studies for the different FACTS gadgets were completed and we discovered the STATCOMs (Static Synchronous Compensators) is the present day and the most productive approach to conquer the responsive force pay. The different strategies were done for the STATCOMS. The genuine investigation was completed in MATLAB and its scientific outflow was inferred utilizing diverse routines for calculation.

***Index Terms* - Power quality, Voltage sag, Voltage swell, Interruption, MATLAB simulatio ,STATCOM, DSTATCOM etc**

## I. INTRODUCTION

Fossil fuels are our main source of energy and they are depleting. Fossil fuels are non-renewable and environmentally damaging. Due to increasing air pollution, global warming concerns, diminishing fossil fuels and their increasing cost have made it necessary to look towards renewable sources as a future energy solution [1]. There are many Renewable Energy Sources (RES) such as wind, solar, tidal power, biomass etc. Solar energy has great potential to supply energy with minimum impact on the environment, since it is clean and pollution free. In finding solutions to overcome a global energy crisis, the Photo Voltaic (PV) system has attracted significant attention in recent years. The government is providing incentives for further increasing the use of grid connected PV systems. Conventionally, grid connected Photo Voltaic energy conversion systems are composed of an inverter. Renewable energy sources (RES) integrated at distribution system is known as distributed generation (DG).After generation, we need to integrate it with already existing power system by using power electronic devices. Generally, current controlled voltage source inverters are used to interface the intermittent RES in the distributed system. A few control strategies for grid connected inverters incorporating PQ solution have been proposed. The inverter acts as an active inductor at a certain frequency to absorb the harmonic current[2]. But the exact calculation of network inductance in real time is difficult and may decrease the control performance.[4]A control technique for renewable interfacing inverter based on p-q theory is proposed. In this work, load and the inverter current sensing is required to compensate the load current harmonics. The extensive use of these non-linear loads causes harmonic injection into the system which affects the quality of the power supply [3]. These harmonics current causes problems like equipment overheating, supplementary losses, EMI related issues and damage devices etc. Harmonics are introduced into the system by diode or thyristor loads. These harmonics are to be filtered to make the system behavior as per the proposed operation. In order to eliminate these harmonics and load devices by using some controlling techniques like p-q theory. In this work, a Photovoltaic based inverter is used as a shunt active power filter (APF) to compensate these current harmonics and current unbalance due to unbalanced and non-linear loads. This APF is connected in shunt to the system as it injects current for harmonic compensation for enhanced power quality. The recent advances in the power semiconductor technology have led to the development of high power switches such as IGBTs, GTOs and thyristors which has enabled the practical implementation of active power filters. Different types of active power filters such as shunt, series and shunt series/series-shunt have evolved (Singh et aI, 1999). These filters applied to power distribution networks are referred as custom power devices [5], [3].Here this PV based inverter is connected in shunt with the system. Synchronous reference frame theory controlling technique is used to generate the reference signals. Hysteresis current controller is used to generate switching pulses to drive the gates of the PV based grid interfacing inverter. Thus with the use of the HCC control technique, the inverter will keep the supply current balanced. Most of the power quality problems are due to harmonics, unbalance and low power factors in the load currents. Hence, these problems can be mitigated using D-STATCOM and it can be implemented practically

## II. OBJECTIVES

This work proposes the MATLAB SIMULINK model of DSTATCOM which is used for the improvement of power quality at distribution level. The major objectives of this work are summarized as follows:

- To study the model of DSTATCOM along with its controller.
- To investigate the performance of DSTATCOM using dqo transformation control scheme for different loads like active load (wind turbine coupled with asynchronous generator which acts as both source and load) and non-linear load (FOC induction motor drive load).

## III. PROBLEM STATEMENTS

The impedance of transmission lines and the requirement for lagging VAR by most machines in a creating framework brings about the utilization of reactive power, in this way influencing the steadiness furthest reaches of the framework and in addition transmission lines. Pointless voltage drops lead to expanded misfortunes which needs to be supplied by the source and thus prompting blackouts in the line because of expanded weight on the framework to convey this fanciful influence. Therefore we can gather that the remuneration of reactive power mitigates every one of these impacts as well as aides in better transient reaction to blames and aggravations. As of late there has been an expanded concentrate on the systems utilized for the pay and with better gadgets included in the innovation, the remuneration is made more viable. It is all that much obliged that the lines be diminished of the commitment to convey the receptive force, which is better given close to the generators or the heaps. Shunt compensation can be introduced close to the load, in a dispersion substation or transmission substation.

## IV. SYSTEM DESIGN & IMPLEMENTATION

The performance of test system feeding 3-phase 3-wirelinear/ non-linear, balanced and unbalanced loads under variable power requirement is simulated and waveforms of the generator voltage (vabc) current (iabc), load current(iabc), controller current, DC link voltage (Vdc)etc are analyzed in different operating conditions. A 100-kW PV array is connected to a 25-kV grid via a DC-DC boost converter and a three-phase three-level Voltage Source Converter (VSC). Maximum Power Point Tracking (MPPT) is implemented in the boost converter by means of a Simulink® model using the 'Perturb & Observe' technique. Another example uses detailed models for the DC_DC and VSC converters. In this detailed model the MPPT controller is based on the 'Incremental Conductance + Integral Regulator' technique. The model contains the following components.

- PV array delivering a maximum of 100 kW at 1000 W/m^2 sun irradiance.
- DC-DC boost converter
- 3-level 3-phase VSC .
- 200-kVA 260V/25kV three-phase coupling transformer.
- Utility grid

The main difference between the detailed model is in the way that DC-DC boost converter and three-phase VSC are modeled. In this average model the boost and VSC converters are represented by equivalent voltage sources generating the AC voltage averaged over one cycle of the switching frequency. Such a model does not represent harmonics, but the dynamics resulting from control system and power system interaction is preserved. This model allows using much larger time steps than the detailed model (50 microseconds vs 1 microsecond), resulting in a much faster simulation. model the PV-array model contains an algebraic loop. This algebraic loop is required to get an iterative and accurate solution of the PV model when large sample times are used. This algebraic loop is easily solved by Simulink. The 'Perturb and Observe' MPPT algorithm is implemented in the MPPT Control MATLAB® Function block.

The 100-kW PV array consists of 66 strings of 5 series-connected 305.2-W modules connected in parallel (66*5*305.2 W= 100.7 kW). Manufacturer specifications for one module are:

- Number of series-connected cells : 96
- Open-circuit voltage: Voc= 64.2 V
- Short-circuit current: Isc = 5.96 A
- Voltage and current at maximum power : Vmp =54.7 V, Imp= 5.58 A

The PV array block has two inputs that allow you varying sun irradiance (input 1 in W/m^2) and temperature (input 2 in deg. C). The irradiance and temperature profiles are defined by a Signal Builder block which is connected to the PV array inputs.

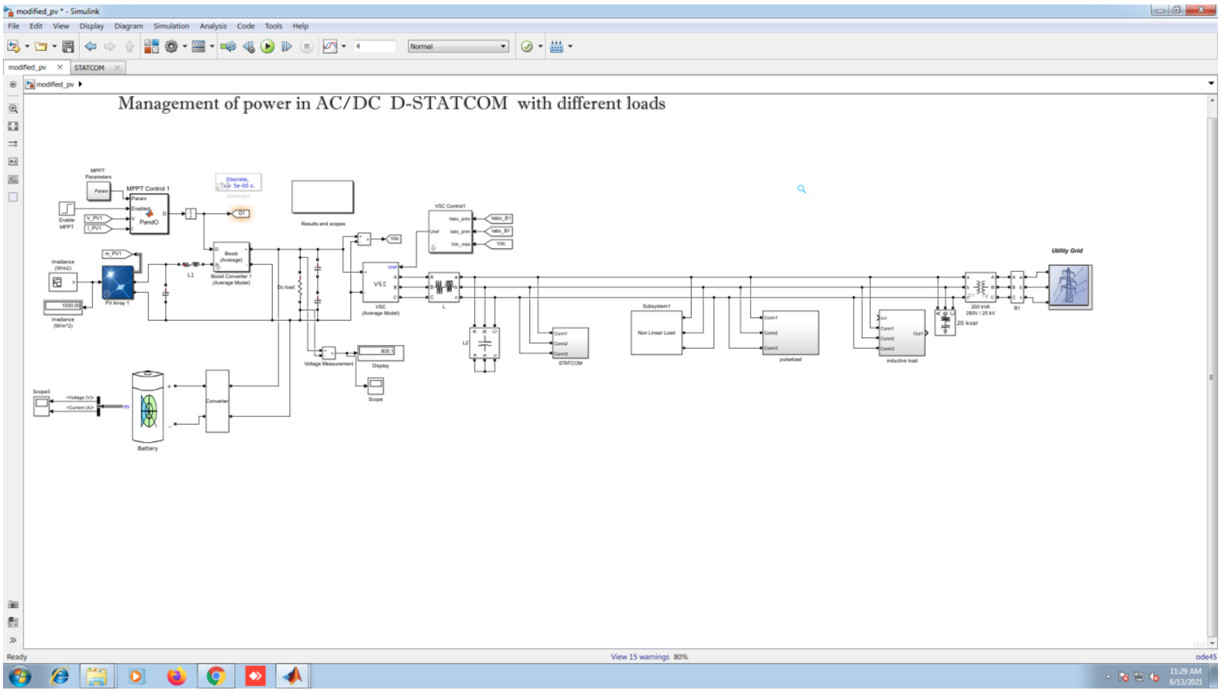


Figure: - Simulation Model

## V. DSTATCOM

This is a shunt connected device that has the same structure as that of a STATCOM and connected to the point of common coupling (PCC) in distribution system having unbalanced and nonlinear loads and is shown in Fig. This can perform load compensation, i.e., power factor correction, harmonic filtering, load balancing etc. when connected at the load terminals. The main function of DSTATCOM is to supply reactive power (as per requirement) to the system in order to regulate the voltage at the PCC. Active power can also be supplied if a storage battery is available on dc-side of the DSTATCOM

## VI. RESULT & DISCUSSION

Run the model and observe the following sequence of events on Scopes. Simulation starts with standard test conditions (25 deg. C, 1000 W/m^2). From t=0 sec to t= 4 sec, duty cycle of boost converter is fixed. Resulting PV voltage is therefore V= (1-D)*Vdc= (1-0.5)*500=250 V (see V_PV trace on PV scope). The PV array output power is 96 kW (see Pmean trace) whereas specified maximum power with a 1000 W/m^2 irradiance is 100.7 kW. Observe on Grid scope that phase A voltage and current at 25 kV bus are in phase (unity power factor).At t=4 sec MPPT is enabled. The MPPT regulator starts regulating PV voltage by varying duty cycle in order to extract maximum power. Maximum power (100.7 kW) is obtained when duty cycle is D=0.453.

From t=2 sec to t=3 sec, Due to this huge load we obtain certain results in voltage, current and magnitude of voltage Waveform. Due to the large value we can see in first window the voltage waveform gets reduced and current rises high which is due to inductive nature, this is because of the load which receives large power from the supply side. we see results that there are fewer drops in voltage due to injection of reactive power by the D-STATCOM. The top window shows the variation in voltage waveform in which the magnitude of voltage is been improved to some value and current waveform gets reduced.

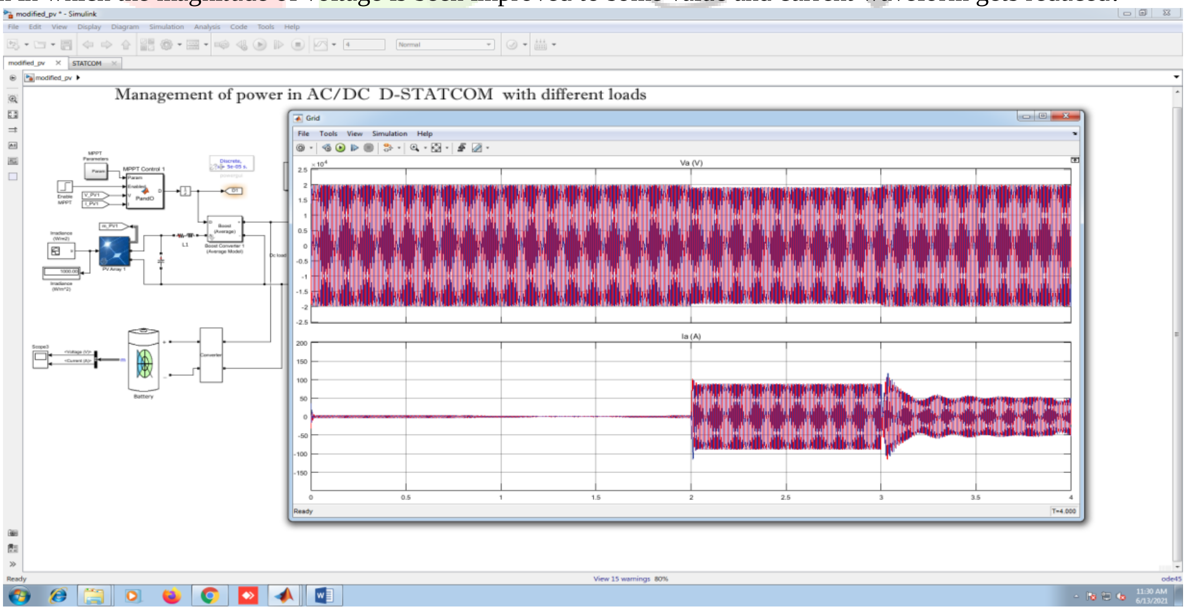


Figure 1: - Voltage & Current waveform

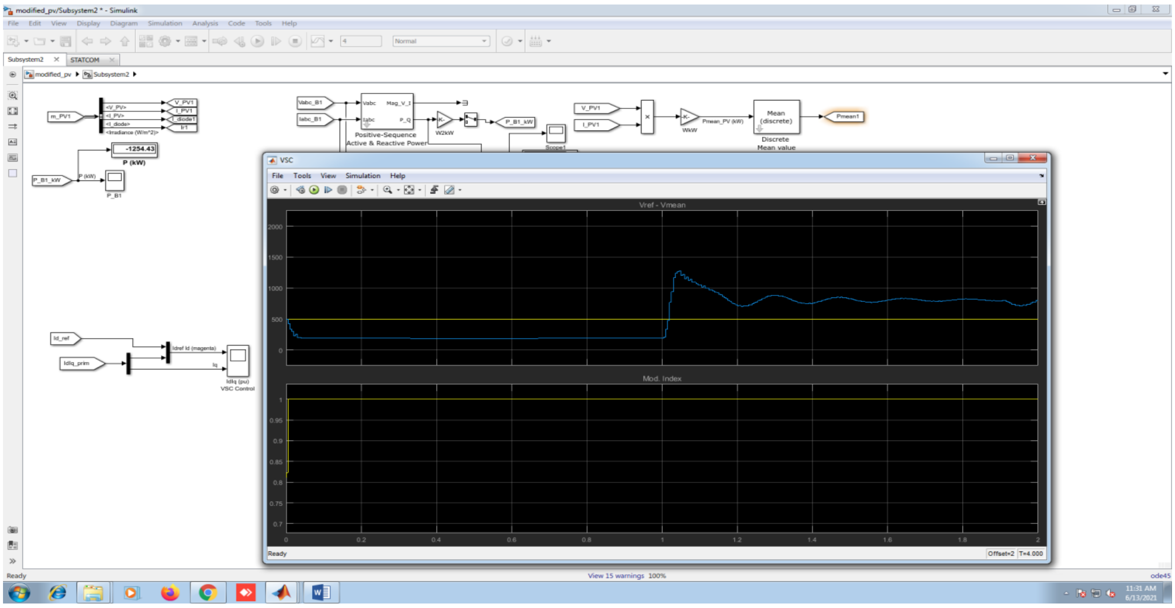

Figure 2: - Vref & Modified Index

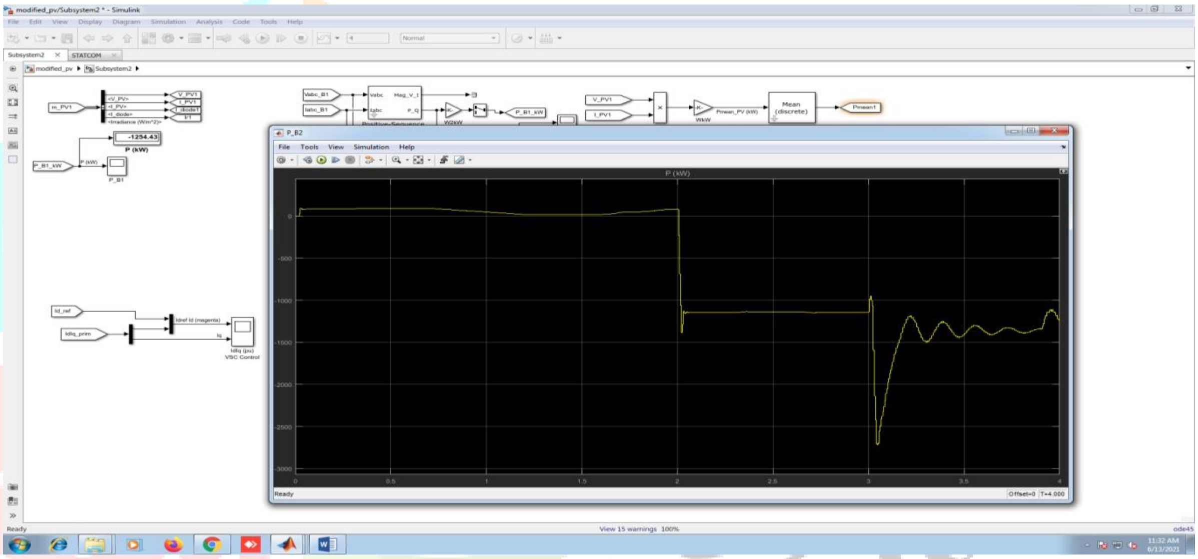

Figure 3: - Power

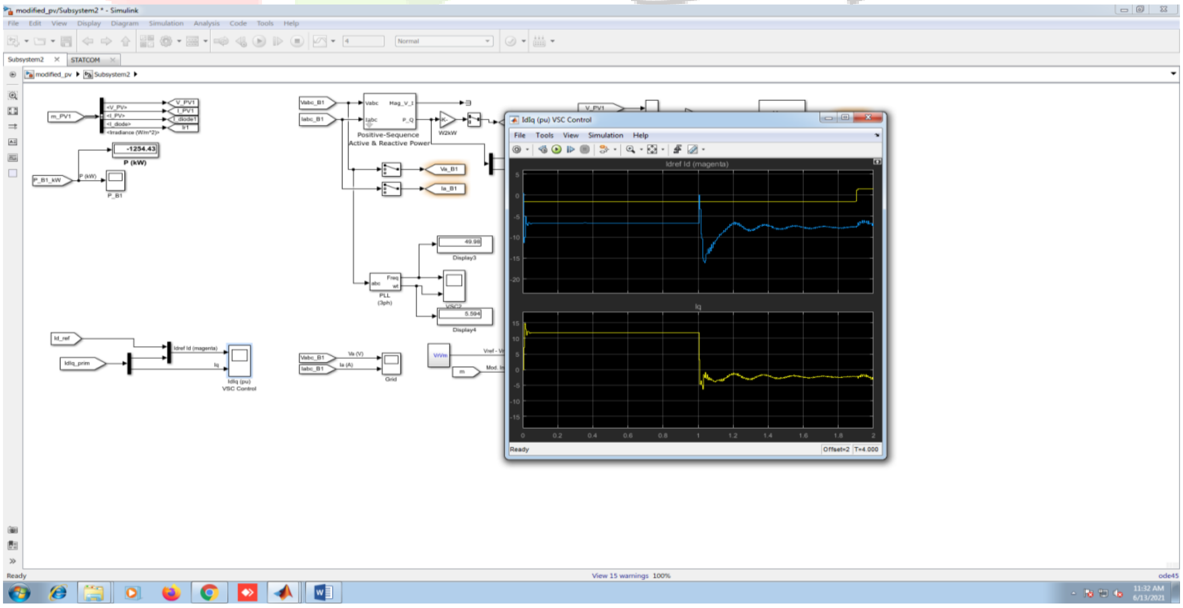

Figure 4 :- Id & Iq Variations

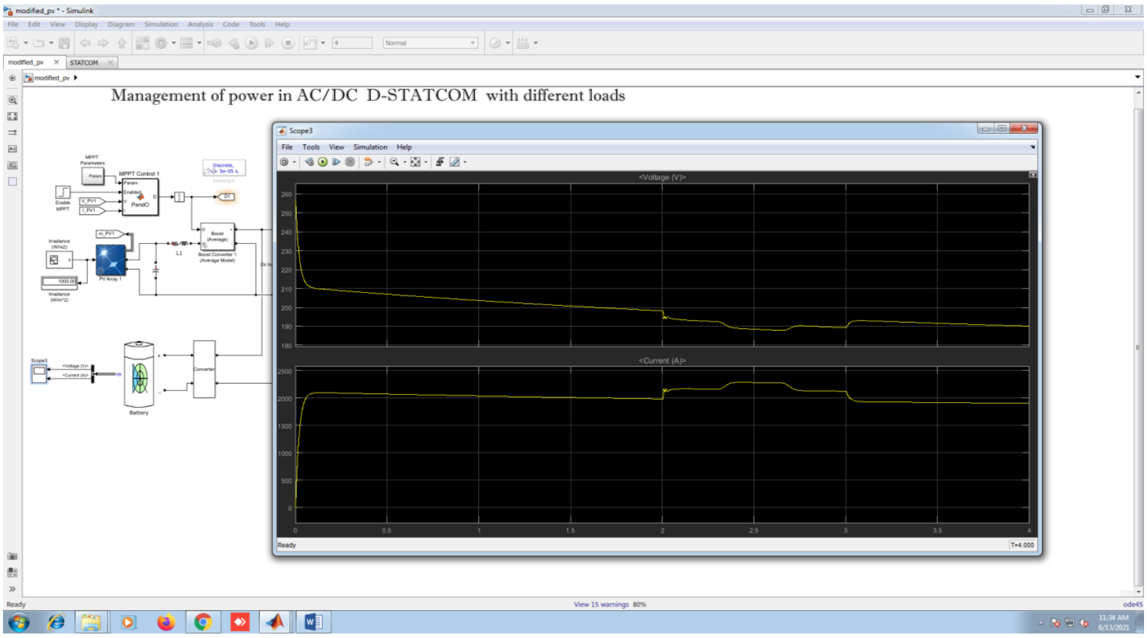


Figure 5: - Battery Parameter

## VII. CONCLUSION

The performance of a shunt active filter is studied by using multi-function grid interfacing inverter under various load conditions. The power quality problems like current harmonics, current unbalance due to unbalanced and nonlinear load connected to the PCC is compensated effectively by using shunt active power filter (APF). The hysteresis current controller is used to generate the switching pulses for the gate drives of grid interfacing inverter.

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