Performance Analysis of SRF and IRP Control for Power Costom Device to improve the Power Quality

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Abstract— In modern eras increasing in use nonlinear load or power electronics load to satisfied the need of todays industry such as adjustable speed drives, office accessories, Synchronous motor drive, Variable Frequency drive Energy efficient lighting etc. but such types of load is create harmonics in the system which flow from load to source and it will harmful to equipment connected to the system so there need to compensate such type of problems. Already there are various devices available to solve and eliminate such type of problem but every devices having some advantages and drawback. In proposed system use shunt connected based DSTATCOM. In this Paper a three phase three wire Distribution Static Compensator (DSTATCOM) is proposed for power quality improvement. There are traditional methods available to Control DSTATCOM such as Single pulse width Modulation, SPWM, SVPWM. In proposed project result analyses by using SRF and IRP controller the result observed in MATLAB Simulink.

Keywords: Photovoltaic system, MPPT, DC/DC Converter, DC/AC converter, Grid connection, Simulink

I. INTRODUCTION

Poor power quality problems arise wide use of nolinear equipment's in the electricity consumer which is main source of harmonics. all automatic equipment's draw reactive power and inject harmonics into the distribution system. The power quality deives use in distribution system to minimize the PQ problem known as Power custom devices. SVC, DVR is conventional Power quality improvent devices

Among all controllers, DSTATCOM is most effective solution of power quality problems [I,2].DSTATCOM is shunt connected device and it is widely used as power quality mitigation device. The performance of DSTATCOM depends upon the control algorithms [1] those are used to generate reference source current. In this paper PV based DSTATCOM is used so the DC voltage regulation is also very important that can vary with the irradiation level. To control the DSTATCOM, dq and pq based algorithms [7] are used Simulation results demonstrate the effectiveness of controller of DST ATCOM for reactive power compensation, harmonic reduction and load balancing under the unbalanced conditions.

II. PROPOSED METHODOLOGY

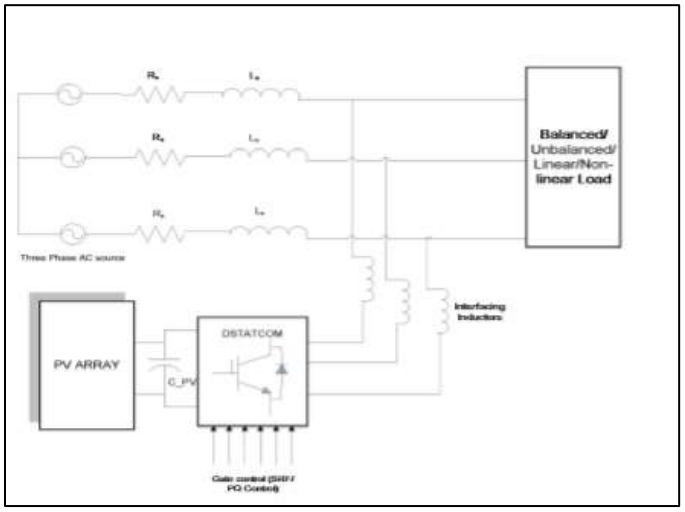

Fig. 1: shows the basic configuration

Fig explain the basic structure of photovoltaic Based DSTACOM. Three phase source is connected with unbalanced load Input fed by Photovoltaic system to the DST ATCOM. It is three phase three leg voltage source inverter connected in shunt with load The DSTATCOM is connected to the line via interfacing resistances and inductors. Modelling and simulation of PV array is done in MATLAB [5]. Controlling of VSI inverter is given through the controller based on SRF and IRP theory.

III. CONTROL STRATEGY

A. Synchronous Reference Theory based Control Theory:

in this Control stratergy three phase currents are transformed into the synchronously rotating dq frame This theory is also known as dq control theory.. This theory uses the following equations for the transformation that is well known Parks transformation Fig 3 shows the basic representation of SRF based control. in the given figure average values of id and iq are estimated after passing these values from low pass filters. Two PI controllers are used, one is to regulate the DC link voltage and another is to maintain the PCC voltage as constant.

$$\begin{bmatrix} i_{Ld} \\ i_{Lq} \end{bmatrix} = 2/3 \begin{bmatrix} \sin\omega t & \sin(\omega t - \frac{2\pi}{3}) & \sin(\omega t + \frac{2\pi}{3}) \\ \cos\omega t & \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \end{bmatrix} \begin{bmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{bmatrix}$$

Fig. 2 shows the basic representation of SRF based control. in the given figure average values of id and iq are estimated after passing these values from low pass filters. Two PI controllers are used, one is to regulate the DC link voltage and another is to maintain the PCC voltage as

constant. These values are represented by ied and ieq and can be find out with the help of following equations

$$i_{cd} = K_{pd}V_{dce} + K_{id}\int V_{dce}\,dt \qquad (4)$$

$$i_{cq} = K_{pa}V_e + K_{ia}\int V_e\,dt \qquad (5)$$

Where

Vdce = Vdc*-Vdc= eror in DC are the reference voltage and actual voltage DSTATCOM Respectively the propotional and integral gains and Ve=Vt*-Vt = error in the PCC voltage reference Voltage at PCC and Actual voltage Respectively = Kpa and Kia are the propotional of the PI controller over the PCC voltage dq frame(Id* and Iq*)

$$\begin{bmatrix} i^*_{sa} \\ i^*_{sb} \\ i^*_{sc} \end{bmatrix} = 2/3 \begin{bmatrix} \sin\omega t & \cos\omega t \\ \sin(\omega t - \frac{2\pi}{3}) & \sin(\omega t + \frac{2\pi}{3}) \\ \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \end{bmatrix} \begin{bmatrix} i^*_{sd} \\ i^*_{sq} \end{bmatrix} \qquad (6)$$

The sensed reference currents (isa * ,isb * ,ise *) are compared with actual reference currents(isa,isb,ise) and error to generate the gate signal for DST A TCOM

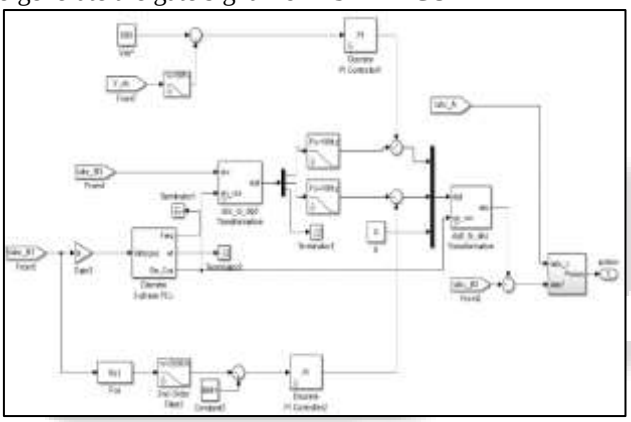

Fig. 2: SRF based control algorithm of DSTATCOM

B. IRP (Instantaneous Reactive Power Control Theory)

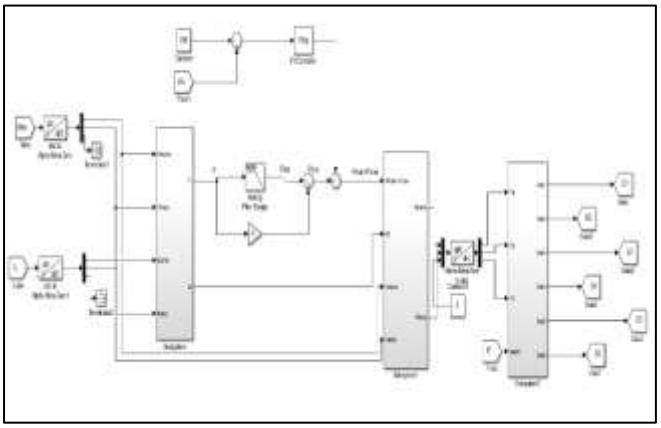

Fig. 3: IRP theory modeling

The block representation of IRP theoryis given in Fig. 3. In this theory, PCC voltage and currents are transformed into a-
frame using the Clark's transformation with the use of following equations:

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{2/3} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix}$$

$$\begin{bmatrix} i_{l\alpha} \\ i_{l\beta} \end{bmatrix} = \sqrt{2/3} \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \qquad (8)$$

with the help of PCC voltage and load current values in a-p frame, instantaneous values of active and reactive power is calculated. It has two components dc and ac. To extract the dc values of load power again low pass filters are used. Reference values active and reactive power can be calculated from the following equation[10]:

$$p^* = p_{dc} + p_{loss} \qquad (9)$$

$$q^* = q_{VR} + q_{dc} \qquad (10)$$

In PFC mode q*is kept zero to maintain the unity power factor and in ZVR mode, an extra reactive power in addition to the load reactive power is supplied by the DST A TCOM to compensate the voltage drop in the source impedance and the active power is supplied by the source. Again two PI controllers are used to maintain the dc voltage and PCC voltage same are used in SRF controller. The estimated power is used to obtain the currents in a-p frame for extracting the reference source currents as

IV. SIMULATION AND RESULT

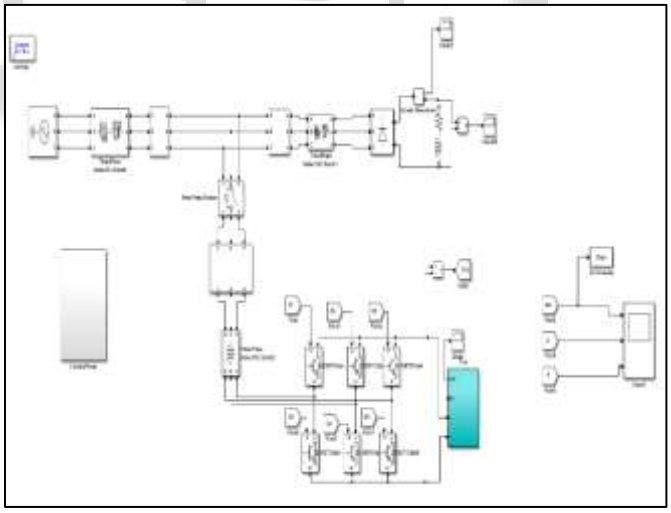

Fig. 10: Test system with D-STATCOM

The above is the test system with three phase source is connected is non-linear load which generates harmonics inside source current. A D-STATCOM with PVA connected on the DC side is interconnected to the test system at 0.2sec. The total simulation time is considered of 0.5sec. The below is the modeling of PVA connected to D-STATCOM.

With the above modules the simulation is run for 0.5sec with D-STATCOM connected at 0.2sec and the difference is observed.

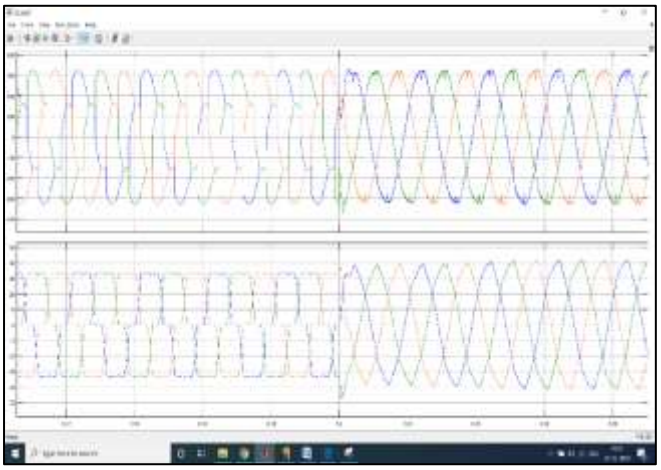

Fig. 11: Source voltages and currents with SRF theory control

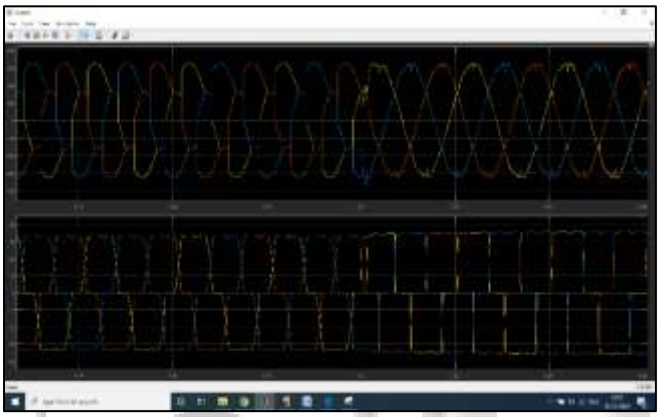

Fig. 12: Load voltages and currents with SRF theory control

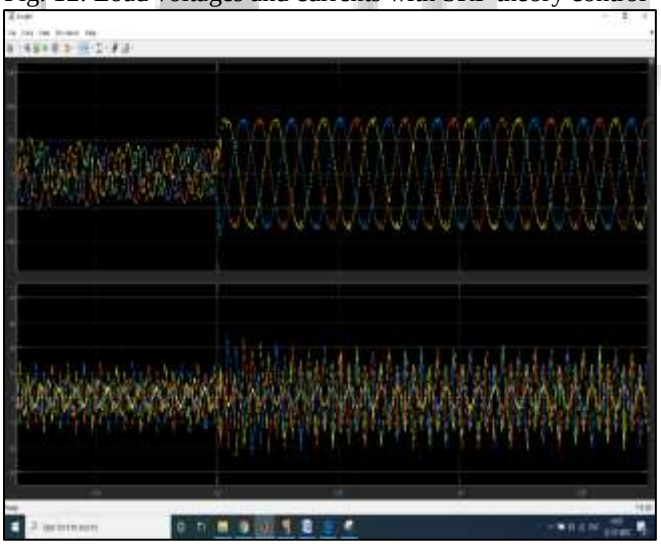

Fig. 13: Converter voltages and currents with SRF theory control

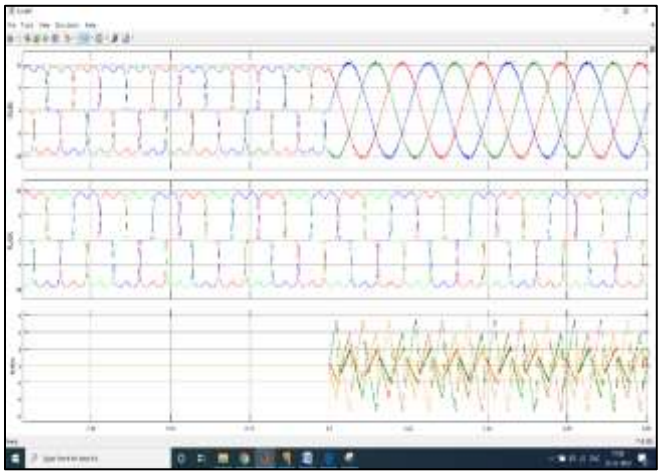

Fig. 14: Source current, Load current and converter current with IRP theory

With the above results there is improvement in source voltages and currents when D-STATCOM is connected. The FFT analysis of the source current before connecting and after connecting D-STATCOM is analyzed with SRF and IRP theory are shown below.

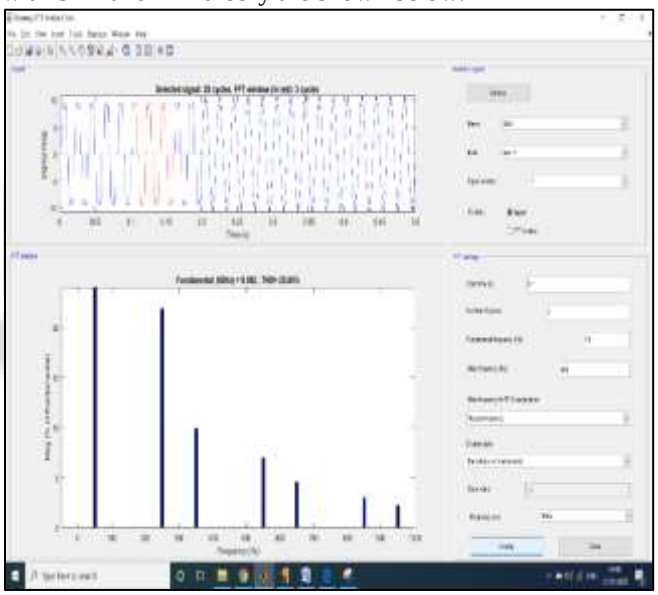

Fig. 15: THD analysis before connecting D-STATCOM

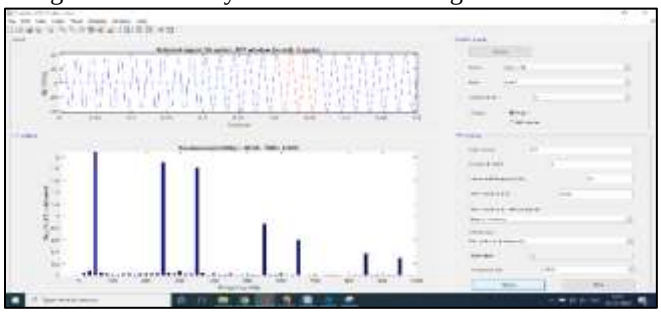

Fig. 16: THD analysis after connecting D-STATCOM with SRF theory

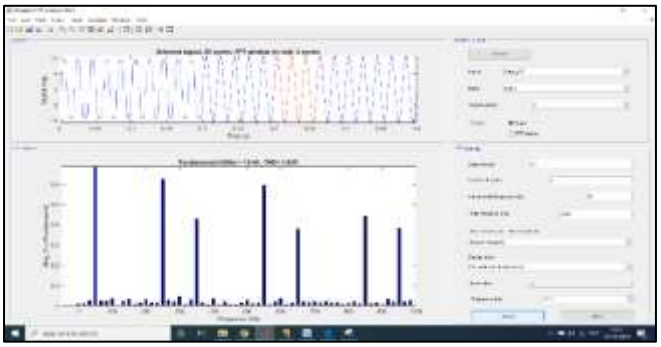

Fig. 17: THD analysis after connecting D-STATCOM with IRP theory

Performance of the proposed system is analyzed using SRF and IRP based control theory. The THD of the source current is 25% which is improved to 2.9% and 1.8% for SRF and IRP theory respectively.

Sr. NO	THD Without DSTATCOM	THD With SRF	THD with IRP
1	25%	2.9%	1.8%

V. CONCLUSION

In this paper complete simulation model of PV based DST A TCOM is developed using MAT AB/SIMULINK. Performance of the proposed system is analyzed for PFC and ZVR modes using SRF and IRP based control theories. DC bus voltage regulation is also achieved in each case. Power Quality Improvement is achieved in terms of Power factor improvement, Harmonic reduction and DC bus voltage control. The THD of the source current is 25% which is improved to 2.9% and 1.8% for SRF and IRP theory respectively. In both the theories the THD is maintained below 5% after D-STATCOM is connected.

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