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Reactive Power Compensation using D-STATCOM

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Abstract: In this paper, A Distribution Static Synchronous Compensator (D-STATCOM) is used for improving the power factor, power quality and to control power flow control in the distribution line. It used to give reactive and active power compensation in the distribution line. The power depends on the power factor of the loads connected to the transmission line. The D-STATCOM used a control strategy based on control symmetrical component theory. To decrease the reactive power and to minimize the undesirable load to require maintains the flow of reactive power. As a result, the power factor of the load descant, leading to the limitation of the active power flow in the line. The D-STATCOM is a power electronics based on advanced device can be used to control power flow in the distribution line. This paper based on the PWM inverter and voltage source inverter to improve the power factor of the load by injecting suitable reactive power in the power distribution line. The simulation of D-STATCOM provides full reactive power compensation and also provides real power compensation in the distribution line for different loads.

Keywords: FACTS, Power flow, Distribution Line, Reactive Power, Real Power, D-STATCOM.

I. INTRODUCTION

The Electrical Power Distribution system is used to provide active and reactive power in the connected loads through the distribution line using the distribution transformer. The load centre is located away from power generation units, so power transmission and distribution network is to meet the load demand. The distribution lines are equivalent more resistive, so in order to minimize the voltage drop being generated by the resistance of the distribution line of real power compensation.
Reactive power is used in the inductive and capacitive loads.
Distribution Static Synchronous Compensator (D-STATCOM) is power electronic based static compensating device that is used in the distribution line to provide reactive and real power compensation. D-STATCOM is also used in energy storage devices for real power support in the distribution line. The main reasons to select D-STATCOM as load compensation, its ability to generate reference compensator current. D-STACOM circuit provides three-phase current in the ac system by tracking the reference current and decreased the disturbances present at the load.

In this paper D-STATCOM is used to provide direct control scheme to generate the gate pulses for switching devices of Voltage Source Converter (VSC) by active and reactive power control and removed the reference current. The D-STATCOM control strategy is providing required power flow control fluctuate load problem.
In this work, D-STATCOM has been modeled to provide current compensation with active and dynamic type non linear load and D-STATCOM as load compensator is used for power factor improvement.

II. NEED FOR COMPENSATION IN DISTRIBUTION LINE

A distribution system is shown in Fig.1 and Table 1. Shows the values of the different of parameters for base system.

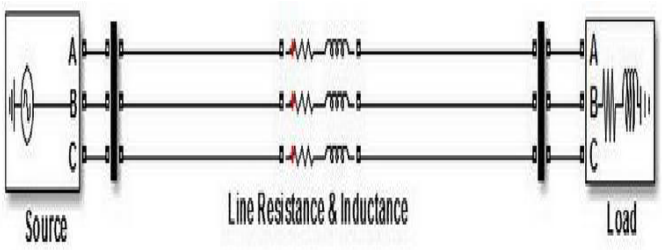

Fig.1. Base System

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TABLE I. PARAMETERS OF BASE SYSTEM

Source Voltage & Frequency	433V (Line to Line), 50Hz
Total Resistance	0.1234Ω
Total Reactance	0.045mH
Load Connected	Different Combinations of Resistive& Inductive (R-L) Loads

To minimize the unsuitable effects caused by loads, the reactive power compensation is required. The distribution loads are approximately more resistive and consequently even by providing reactive power compensation the voltage drop being caused by the resistance of the distribution line can't be fully compensated. So the compensation of this voltage drop, the real power compensation is also essential to be provide increased the reactive power compensation in the distribution line. The voltage control is used to increase the system stability, better performance of machines connected to the system and to decrease the losses associated with the system. Undesirable voltage drops lead to increased losses which need to be supplied by the source and are leading to outages in the line due to stress on the system to carry this imaginary power.

III. BASIC STRUCTURE AND OPERATION OF D-STATCOM

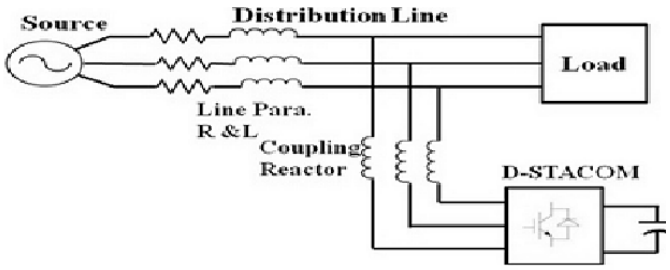

Fig.2. Connection of D-STATCOM to 3-phase Distribution Line

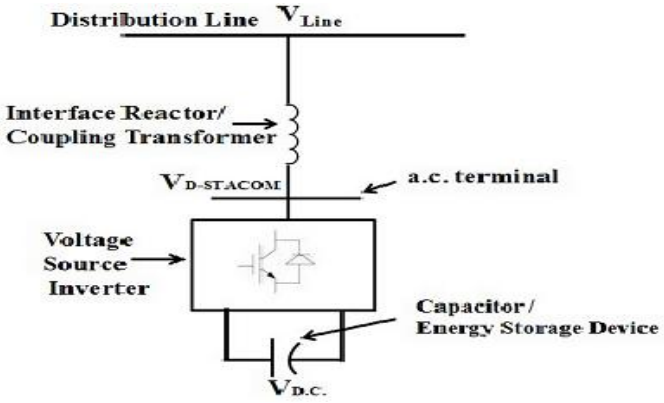

Fig.3. Basic Construction of D-STATCOM

The D-STATCOM is a three-phase and shunt connected power electronics based device. It is connected across the load at the distribution systems. Fig.2 represents the connection of a D-STATCOM to the 3-phase distribution line. D-STATCOM works for transfer reactive & real power with the distribution line. The reactive power & real power is transfer between the distribution line and D-STATCOM is easily controlled by controlling the magnitude & phase angle of the voltage of D--STATCOM respectively. The three phase power supplies transferred at the load side. This load absorbs both real and reactive power, due to its inductive nature; all the loads are not purely resistive. It reduces the power quality. So the compensation of reactive power is necessary, to improve the power quality. So, D-STATCOM is used to compensate the reactive power. It is very beneficial for control the D-STATCOM to inject reactive power to the load for compensation. If the voltage becomes higher then, higher voltage side delivers reactive power to the lower voltage side. Based on this approach the controller achieves and generates pulse to the inverter. The controller depends on the basics of reference frame theory. The D-STATCOM operated as an inverter to convert the DC link voltage Vdc on the capacitor to a voltage source of adjustable magnitude and phase.

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IV. PROPOSED WORK AND CONTROL STRATEGY

In this paper, A D-STATCOM is based on voltage-source converter (VSC), has been used to improve the power factor of the load by injecting suitable reactive power in the power distribution line. The amplitude of the output voltage of the D-STATCOM is become greater than the system voltage for the purpose of controlling the VAR generation. Thus it can internally generate capacitive reactive power.

D-STATCOM needs to give the essential reactive and real power compensation in the distribution line under load changeable conditions. There are many control method used for D-STATCOM but in this paper used a control strategy based on instantaneous symmetrical component theory has been proposed. The symmetrical component theory applied to instantaneous voltages and currents. IN this method the unbalanced voltages & currents can be converted into 3-set of balanced voltages & currents: Positive sequence, negative sequence & zero sequence components. The instantaneous symmetrical component method utilized the positive sequence component of Voltage & Current. It can be written as shown in respectively by Equation .Vsa, Vsb & Vse are represent source voltages and isa, isb & ise are represent currents of phase a, b & c respectively.

$$V_{sa1} = \frac{1}{\sqrt{3}}\left(V_{sa} + aV_{sb} + a^2V_{sc}\right)$$

$$i_{sa1} = \frac{1}{\sqrt{3}}\left(i_{sa} + ai_{sb} + a^2i_{sc}\right)$$

Using this control approach, the values of the reference currents are calculated based on required compensation. Using these reference currents, the gate pulses for all the switching devices of VSC unit of D-STATCOM are generated the basic objective of this proposed control strategy is to make supply currents balanced as shown in Equation.

$$i_{sa} + i_{sb} + i_{sc} = 0$$

Now, if all the reactive power demand of the loads is to be supplied by the D-STATCOM and source should supply only the real power demand of loads, PI, then the Equation can be written.

$$V_{sa}i_{sa} + V_{sb}i_{sb} + V_{sc}i_{sc} = P_l$$

The source in addition to the real power of loads, DSTATCOM should also supply additional real power to meet losses occurring in switching devices of VSI, so Equation would get modified and Equation is obtained.

$$V_{sa}i_{sa} + V_{sb}i_{sb} + V_{sc}i_{sc} = P_l + P_{loss}$$

the equations to calculate reference values of source currents are obtained as shown in Equations.

$$i_{sa} = \frac{V_{sa}}{V_{sa}^2 + V_{sb}^2 + V_{sc}^2}\left(P_l + P_{loss}\right)$$

In this paper hysteresis current control scheme has been used to generate the gate pulses for the switching devices of VSC unit of D-STACOM. Using the proposed control strategy based on instantaneous symmetrical component theory, D-STATCOM can also give real power compensation in the distribution line if an energy storage device is apply for D-STATCOM replacing the capacitor and some adjustment are made in the proposed control strategy.

V. MODELLING AND SIMULATION

TABLE II-: Effects of Load on various parameters of Distribution line

S. No	Source voltage	Power Demand		Power Supplied by source		Power Received by Load		Load Voltage (V)	Current (A)	Source Power Factor
		P(KW)	Q(KVAR)	P(KW)	Q(KVAR)	P(KW)	Q(KVAR)			
1	435	25	20	24.74	19.26	23.98	19.18	430.9	41.14	0.623
2	435	30	20	29.58	19.27	28.76	19.17	424	47.07	0.702
3	435	35	30	34.56	28.45	33.01	28.29	427.8	58.74	0.596

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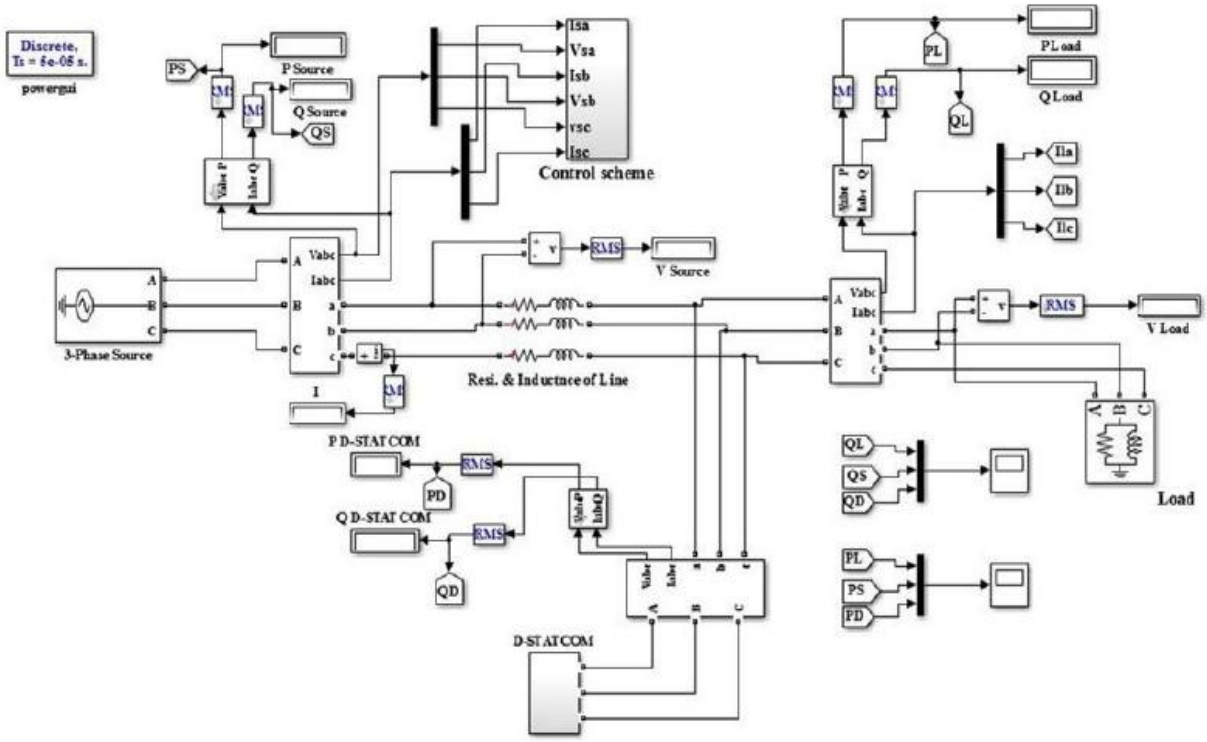

Fig: 4 - Main Simulation Circuit

TABLE III-: Simulation Result

Case	Source voltage (V)	Power Demand		Power supplied by Source		Power supplied by D-SATCOM		Power Received by Load		Load voltage (V)	Load Current (A)	Source Power Factor
		P(kW)	Q (KVAR)	P (KW)	Q(KVAR)	P (KW)	Q(KVAR)	P(KW)	Q(KVAR)			
Before compensation	435	25	20	24.74	19.26	0	0	23.98	19.18	430.9	41.4	
After full Reactive power compensation				24.67	3.79	3.28	19.62	24.1	19.25	431.80	32.68	0.977
Before compensation	435	30	20	29.58	19.27	0	0	28.76	19.17	424	47.07	0.702
After full reactive power compensation				29.79	3.48	3.33	19.58	28.88	19.24	424.6	39.91	0.98
After full Reactive + partial Real power compensation				30.77	3.65	9.19	29.45	38.45	28.82	424.3	40.94	0.986
After full Reactive + partial Real power compensation				24.38	3.97	6.09	29.33	28.93	28.89	431.9	32.22	0.974
Before compensation	435	35	30	34.56	28.45	0	0	33.01	28.29	427.8	58.74	0.596
After full Reactive power compensation				33.97	3.93	3.5	28.41	33.23	28.45	428.6	44.97	0.987
After full Reactive + partial real power compensation				24.04	3.62	10.94	29.2	33.76	28.91	431.9	31.7	0.978
After full Reactive + partial real power compensation				27.25	3.91	7.71	28.92	33.59	28.76	430.8	35.84	0.98

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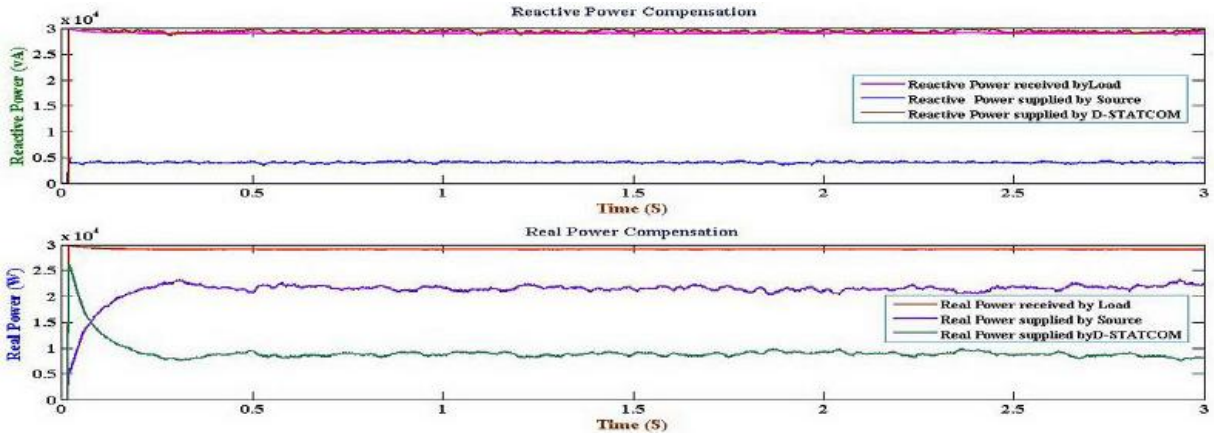

Fig:-5 Results of compensated Power Flow, Load and D-STATCOM

VI. CONCLUSION

This paper based on the simulation for the implementation of D-STATCOM and its controller. D-STATCOM which works on low voltage and compensate of reactive power, equally injects the reactive power in the line. D-STATCOM operates as VSC which can be employment at the load side of the system which improve the voltage profile of system and reduce the power losses. By using this approach enhances the power factor of the load by injecting suitable reactive power in the power distribution line and improve of the overall electrical system performance by decreasing the line losses.

The simulation results show that when D-STATCOM is used as full reactive power compensation, the source no need to essential supplying any reactive power and all reactive power supply by D-STATCOM .This system also provide continue support of the source voltage and current in phase with each other after compensation. So, the power factor of the utility supply is always remaining at unity. Thus D-STATCOM provides compensation in the distribution line and hence overall performance of distribution network also gets enhanced.

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