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Application of D-STATCOM for load compensation with non-stiff sources

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***Abstract*— Now a day's power quality is serious problem in power network. To overcome this problem an innovative device D-STATCOM is used. D-STATCOM (distribution static compensator) is facts device used to solve all power quality problems which connected in parallel with system. The main function of D-STATCOM is, it generates or absorbs the reactive power at point of common coupling (PCC), so that power quality can be maintained. Power quality problems are important issue in distribution system. In this paper new method for D-STATCOM with non-stiff sources is proposed for the load compensation it also considers linear and non linear loads. Load flows from distribution system in presence of feeder impedance due to this distort voltage and current at the PCC in this situation source called as non-stiff source. D-STATCOM also used for compensation of reactive power and unbalance caused by various loads in distribution systems. This method uses the series and shunt filter, one of advantages of this method is losses in inverter are reduced. The switching command of voltage source inverter (VSI) is generated using hysteresis band current control method. The simulation of proposed method is carried out using Matlab Simulink.**

***Keyword*—VSI, PCC, distribution static compensator (D-STATCOM), hybrid method, non-stiff source.**

I. INTRODUCTION

In presents day power quality problems faced by many industries more 80% problems presents in system. So that this problems overcome by using various facts devices such as DVR, D-STATCOM, UPQC etc, DVR is associated with voltage and connected in series with system second is D-STATCOM associated with current and connected in shunt with system and last one is the UPQC combination of both devices[4]. So that in order to improve the power quality in battle condition, D-STATCOM is used. It reduces impact of loads on bus voltage and thus keeps the voltage at desired level to improve power quality. D-STATCOM is voltage source inverter (VSI) based shunt device generally used at distribution side. It is also used for the load compensation. The main advantage of D-STATCOM is that it can generates or absorb the reactive power required to distribution system. The second advantages is as follows,

- Removes the effect of poor power factor on system.
- Minimize the harmonics which is present in system.
- Also the voltage sag and swell is minimized. and compensating reactive power required to the distribution system etc.
- It is also used in grid connected system for voltage fluctuation. It can also protect transmission and distribution system from voltage sag and swell. Operating principle of DSTATCOM is highly depends upon its controller.

II. BASIC OPERATION OF D-STATCOM

The D-STACOM is shunt connected power electronics device used in distribution system. It connected near to the load. Which inject the reactive power at PCC (The common point where source load and D-STATCOM connected). The schematic block diagram of D-STATCOM is shown in fig. no 1.

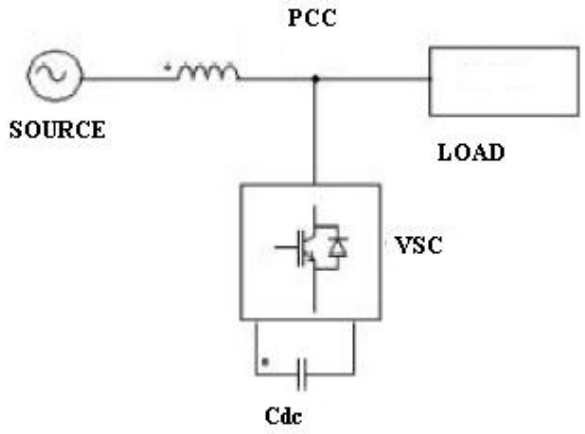


Fig. 1.Basic diagram of D-STATCOM

The D-STACOM is FACTS device, which includes,
Voltage source converter (VSC)- consist of switching devices such as MOSFET or IGBT. These two switches can never turn on in one leg.

DC link capacitor - connected in parallel, which has capability of generating and absorbs reactive power required to the load.

Coupling transformer - placed between distribution system and D-STATCOM for isolation purpose.

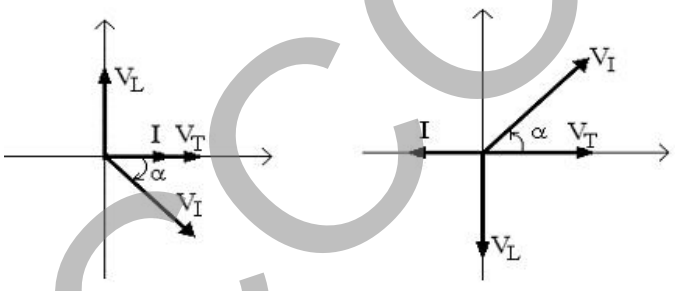
Harmonic filters - which minimize unwanted harmonic produced by VSC and keep this harmonics within permissible limit.

Control scheme- It controls all signals which is required to control the D- STATCOM [3].

The basic operation of DSTATCOM similar to synchronous compensator, the AC side of VSC are connected at point of common coupling (PCC) and DC side is connected to capacitor which is mainly storage device this capacitor is charged by battery source. If output voltage of VSC is equal to the AC terminal voltage then there will no action take place. If output voltage of VSC is greater than AC terminal voltage then D-STATCOM operated in capacitive mode and provides the reactive power to system. And If output voltage of VSC is smaller than AC terminal voltage then D-STATCOM operated in inductive mode and absorbs the reactive power from the system[1],[2]. In short,

Out Put of VSC > AC terminal- (Capacitive mode)
Out Put of VSC< AC terminal- (Inductive mode)

The quantity of power supply is directly proportional to difference of two voltages, So that the load compensation will be achieved. In short load compensation means harmonic filtering; power factor correction and load balancing will be done. In this method considered as non-stiff source due this source voltage and current will be distort in presents of feeder impedance in that situation source turned as non-stiff source.



(a) Absorbs real power (b) Inject real power

Fig. 2 Vector diagram of D-STATCOM

In Fig. 2 shows that output voltage of inverter V_I, System voltage V_T, Reactive voltage V_L and line current I related with magnitude and phase and Fig. (a) ,(b) shows that D-STATCOM absorbs and inject the real power.

In this paper new method of D-STATCOM for load compensation is proposed. The method consist of two capacitors: one series with active filter and another is parallel with active filter. This two have different function such as series filter is used to reduce the dc-link voltage and another one is compensating the reactive power required to the load. So that unity power factor will be maintained, and shunt filter is used to maintain the terminal voltage at desired level in presents of non-stiff source, (due to these source disturbance will be occurred) so that compensation will done[5]. If terminal value of voltage and current are increases then entire cost and size of VSI will be increases so that reduces dc-link voltage storage capacity. In this method dc-link voltage is gate reduced as compared to conventional method. This is one of advantage of this proposed method.

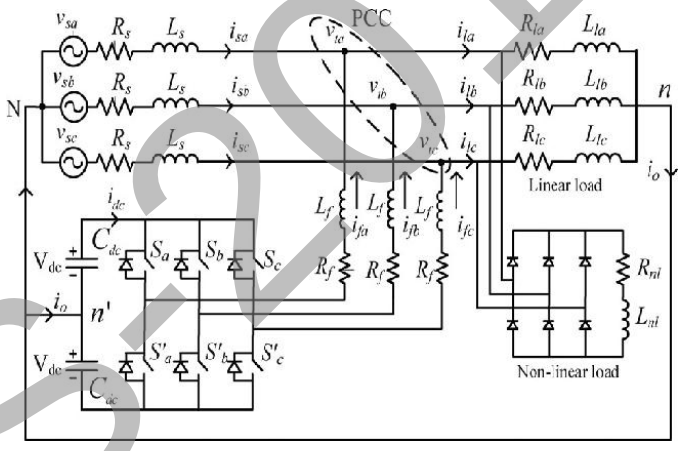


Fig.3 Equivalent circuit of VSI topology based D-STATCOM.

The simulation of these method is carried out using matlab simulink, and detailed results are presented in these paper.

III. CONVENTIONAL AND PROPOSED METHODS OF D-STATCOM

In this section conventional and proposed methods are discussed. Fig.3 shows that power circuit of VSI topology based D-STATCOM this method consist of two storage devices, and each legs of VSI independently controlled. In this figure V_{sa}, V_{sb}, V_{sc} are the source voltages of phases a, b,c respectively. Likewise V_{ta}, V_{tb}, V_{tc} are the terminal voltages at PCC. The source current in each phases are represented as i_{sa}, i_{sb} and i_{sc} and load currents are represented as i_{la}, i_{lb} and i_{lc}. The filter currents are denoted by i_{fa} ,i_{fb}, i_{fc} and i_o is current in neutral. L_s and R_s are the inductance and resistance respectively. In this method consider linear as well as non linear loads. Non linear load called non-stiff source, and voltage across the capacitor considered as 1.6 times as peak value of source voltage, but this method contains harmonics in load currents this drawbacks overcome by using proposed method. Fig.4 shows that power circuit of proposed VSI

topology based D-STATCOM. It is the combination of above system with series capacitor with active filter and shunt capacitor with active filter. The series capacitor is used to maintain unity power factor and shunt capacitor is used to removes the switching losses in VSI.

The Value of series capacitor is taken as 65 μF and the value of shunt capacitor is taken as 50 μF.

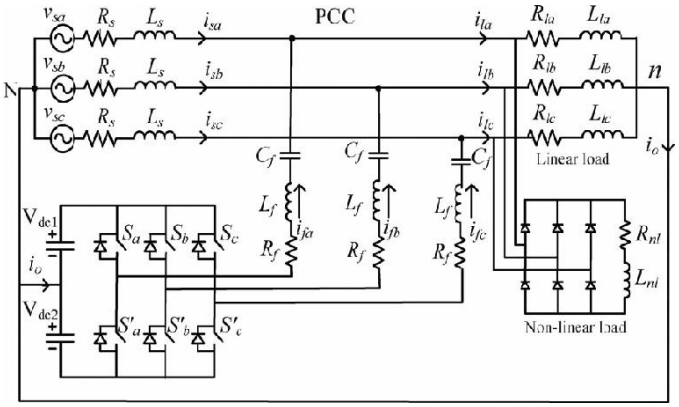


Fig.4 Equivalent circuit of proposed VSI topology based D-STATCOM(hybrid system).

IV. Important parameters of VSI

The following parameters are carefully designed for proper operation of VSI, detailed design process explained in paper [6].

The selection of dc-link value is becomes very important which depended on sag and swell period of voltage the dc-link capacitor is given by,

$$C_{dc}= ((2X-X/2)nT) / (1.8V_m)^2-(1.4V_m)^2 \quad (1)$$

Where V_m is peak value of voltage, X rating of system n is no of cycle and T is time.

The proper selection of inductance is next important parameter in design of VSI the interfacing inductance is,

$$L_f = 1.6V_m/4hf_{swmax} \quad (2)$$

Where,

$$h=(k_1(2m^2-1))/k_2 4m^2)^{1/2} f_{swmax} \quad (3)$$

Where k_1 and k_2 are the constants, f_{swmax} is maximum frequency and f_{swmin} is minimum frequency of the switch and m is given by,

$$m=1/(1-f_{swmax}/f_{swmax})^{1/2} \quad (4)$$

In that system hysteresis band h is considered as 0.5 and The generation of switching command for VSI is using hysteresis band current control method, commands are issued whenever crosses the limit of hysteresis band [7]. In this paper currents are generated using instantaneous symmetrical theory which is explained in paper [8].

V. Simulation parameters

Sr. No	Parameter name	Value
1.	System voltage	230v,50hz
2.	Feeder impedance	Z_s=3+j1.141
3.	Linear load	Z_{la}=34+j47.5 Ω
		Z_{lb}=81+j39.6 Ω
		Z_{lc}=31.5+j70.9 Ω
4.	Non linear load	Three phase full bridge rectifier load feeding a R-L load of 150 Ω-300 mH
5.	VSI parameters	C_{dc}=3300μF,V_{dcref}=1.6,V_m=520v, L_f=26mH, R_f =0.1Ω
6.	PI controller gains	K_p=2,k_i=0.5
7.	Hysteresis band (*h*)	±0.5 A

VI. MATLAB Simulation Results

Without D-STATCOM.

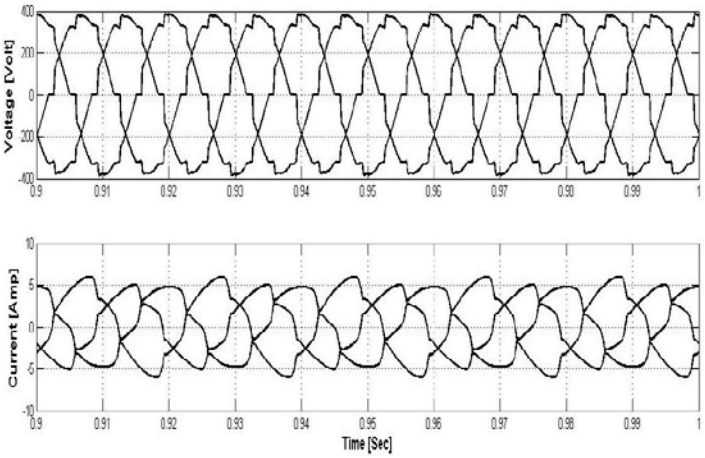


Fig. 5 Load voltage and current

1. Conventional method
2. Proposed method.

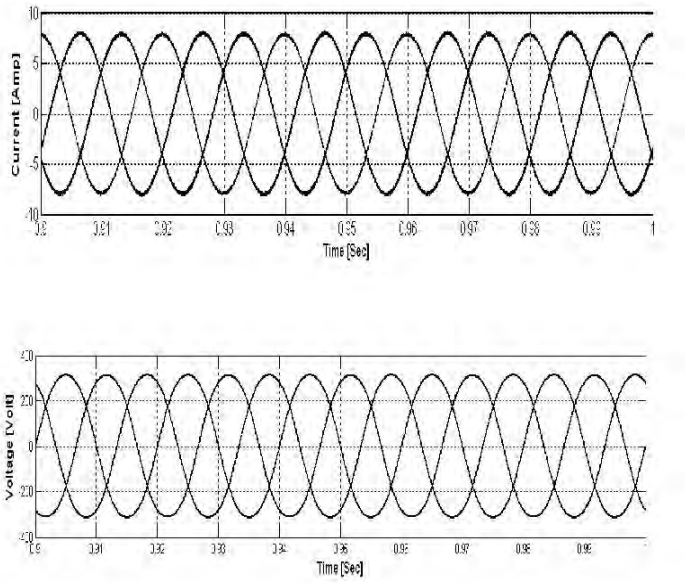


Fig.6 Source voltage and current after compensation

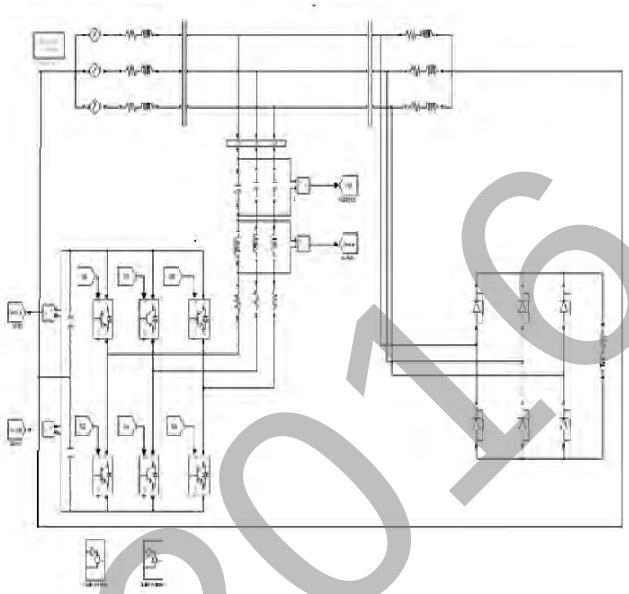


Fig.8 Matlab Simulation diagram of proposed method

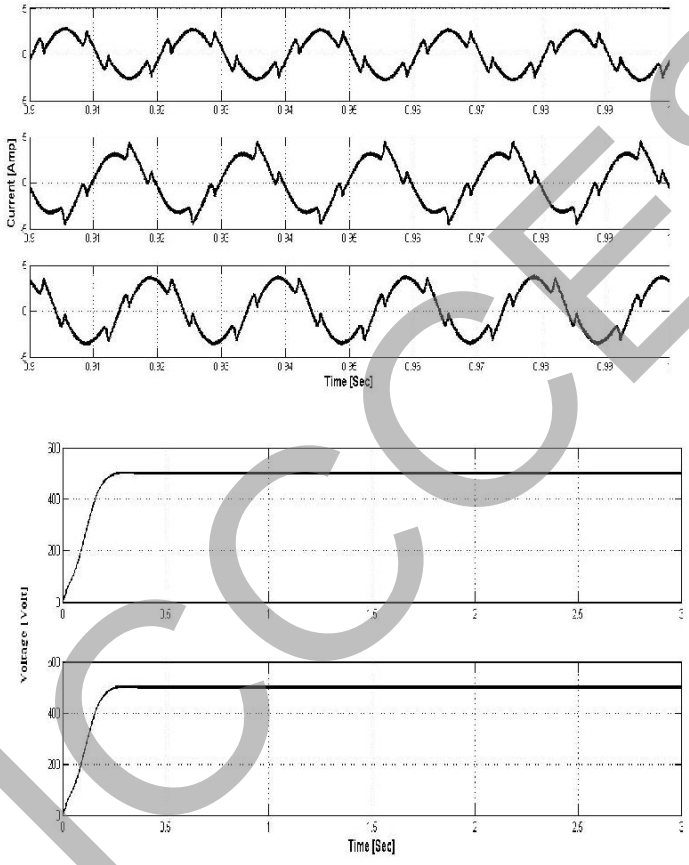


Fig.7 Filter currents and DC voltages

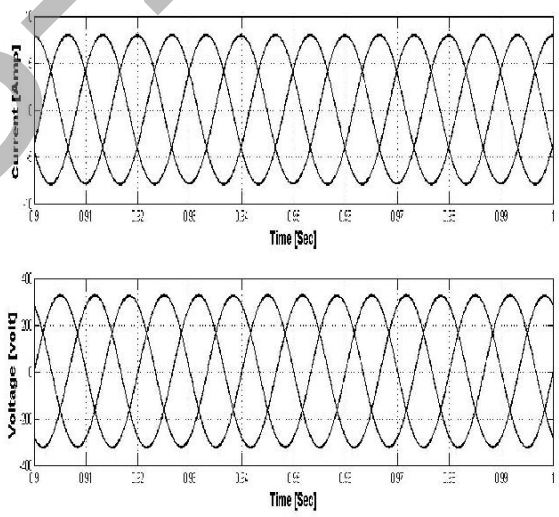


Fig.9 source current and voltage after compensation

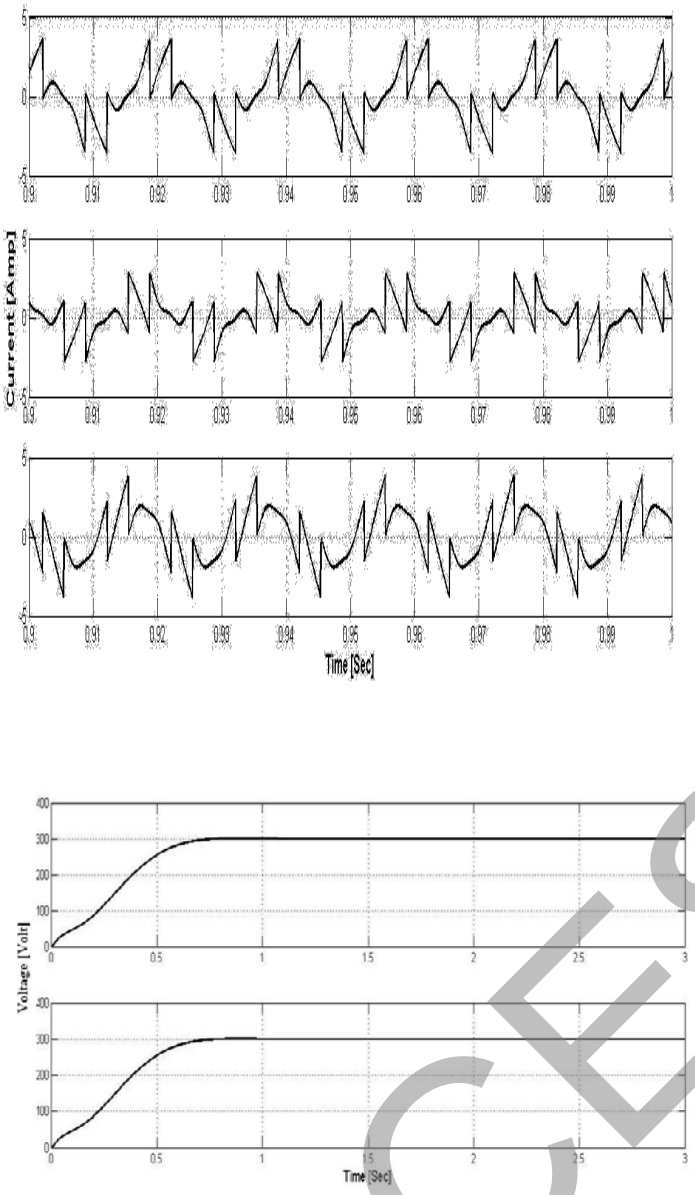


Fig. 10 Filter Currents and DC voltages.

VII. CONCLUSION

A new hybrid D-STATCOM topology has been proposed in this paper, which has the capability of compensating the load at a lower dc-link voltage under non-stiff source. And detailed design parameters of VSI are explained. The proposed method is validated through simulation. Detailed comparative studies are made for the conventional and proposed hybrid D-STATCOM topologies. From This study, it is found that the proposed topology has less average Switching frequency, with reduced dc-link voltage as compared to the conventional DSTATCOM topology.

VIII. REFERENCES

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