DESIGN OF A MULTILEVEL STATCOM FOR REACTIVE POWER COMPENSATION

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Abstract
This Paper introduce the related operation for diagnosing the power quality symptoms in different fault occurring conditions by use of Distribution STATCOM (D- STATCOM) with non-linear and linear loads. This Design and simulation of D-STATCOM is achieved by using voltage regulation block. The major matter is that during faulty conditions, there is a probable disturbance on the load side and this problem is solved by utilization of the D-STATCOM at load side, as well as in mid position of source and load. D-STATCOM is designed with the help of MATLAB simulation program. The model is simulated, first without DSTATCOM and then with DSTATCOM. The results get in both the cases are examined and which shows the effectiveness of tracking the voltage sag and its correction.
Keywords: DSTATCOM, Voltage Source Converter (VSI), Total harmonic distortion (THD, cascaded H-bridge(CHB)

I. INTRODUCTION

As the demand for sensitive load increases on the distribution side, power quality issues emerge as a serious issue. Present distribution system faces the variety of power quality and among them, voltage sag is found to be the most challenging issue faced by industrial consumers according to the power quality surveys[1]. Voltage sag is a momentary dip in RMS voltage magnitude for a duration varying between half a cycle up to some cycles. Voltage dip problems are mainly due to the use of voltage-sensitive loads such as adjustable speed drives (ASD), induction motors, computers, process control managed by etc. Based on inverter systems, there are many voltage sag mitigation schemes[2]. The DSTATCOM is a device to provide a set of power quality solutions such as voltage stabilization, flicker suppression, power factor correction and harmonic control along with the voltage sag mitigation Different control strategies and different converter topologies are used in DSTATCOM[3]. Here the DSTATCOM consists of a five level (CHB) voltage source inverter that allows fast inductive and capacitive compensation. PI control strategies are adopted as the control system . SIMULINK/MATLAB is used for simulation of the compensator and the performance is analyzed. The VSI converts the dc link voltage into a three-phase AC voltages and is coupled through the coupling transformer reactance to the AC system[4]. The DSTATCOM injector absorbs current at the point of common coupling (PCC) as per the requirement. [5]

II. WORKING OF DSTATCOM

The D-STATCOM is a voltage source inverter based device is connected shunt to the AC system. It is connected to the distribution system near the load end. Here voltage-source inverter, which compensates the active and reactive power demanded by the system by converting a DC input voltage into AC output voltage. The connection and schematic view of DSTATCOM is shown in Fig1.The DSTATCOM consists of DC voltage source, DC capacitor, and a coupling transformer. It provides a topology that performs different functions such as[6];

- Voltage correction and compensation of reactive power.
- Power factor improvement
- Current harmonics reduction

The capacitor in the D-STATCOM is used to maintain dc voltage to the inverter. The amplitude of the inverter voltage Vi is proportional to the dc voltage of the capacitor, which is also proportional to the amount of energy stored in a capacitor. If there is any difference in phase shift, active power flows through the inverter, charging or discharging the capacitor. The charging or discharging of the capacitor affects the dc voltage level and alters the amplitude of the inverter AC voltage. DSTATCOM controller makes the voltage stable and thus to improves the power quality[7].

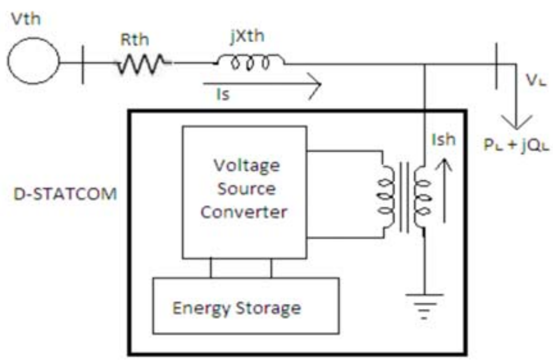

Fig 1 Schematic Diagram of a DSTATCOM

The parallel drawn current I_{sh} put right voltage sag by managing the voltage loss across the system impedance Z_{th}. The value of I_{sh} can be managed by adjusting the output voltage of the converter. The shunt injected current I_{sh} can be written as,

$$I_{sh} = I_L - I_S = I_L - \left(\frac{V_{Th}-V_L}{Z_{Th}}\right) \quad (1)$$

$$I_{sh}\angle\eta = I_L\angle-\theta - \frac{V_{Th}}{Z_{Th}}\angle(\delta-\beta) + \frac{V_L}{Z_{Th}}\angle-\beta \quad (2)$$

The complex power injection of the D-STATCOM can be expressed as,

$$S_{sh} = V_L I_{sh}^* \quad (3)$$

It may be stated that the capability of the D-STATCOM in correcting voltage dip depends on the value of Z_{th} or level of fault to the load bus. When the injected shunt current I_{sh} is kept in normal with V_L, the needed voltage correction can get without injecting any real power into the system. On the other side, when the value of I_{sh} is minimized, the same voltage correction can get with less apparent power injection into the system. The interchange of imaginary power between the converter and the AC system can be managed by changing the amplitude of the output 3-phase voltage V_c, of the converter. Therefore, if the value of the output voltage is raised above that of the utility bus voltage V_s, then the current will going to flows through the reactance from the converter to the AC system and the converter generates capacitive-reactive power and is said to operate in CAPACITIVE MODE as shown in below Figure.

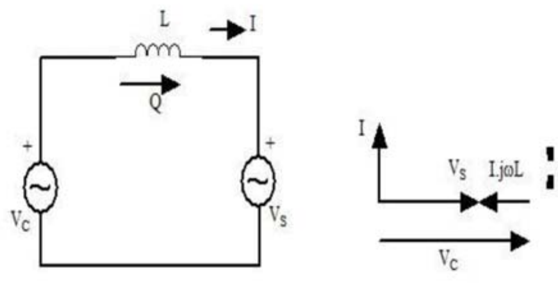

Fig 2(a) Capacitive Mode

If the value of the output voltage, V_c, is decreased down to the utility voltage V_s, then the current flows from the AC system to the converter and the converter absorbs inductive imaginary power from the AC system and it is said to operate in INDUCTIVE MODE as shown in Figure 2(b).

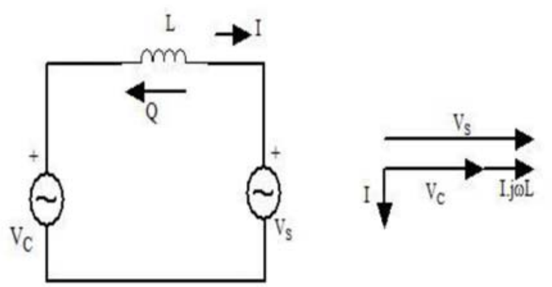

Fig 2(b) Inductive Mode

If the output voltage amplitude, Vc, equals the AC system voltage, the imaginary power flow is zero, and the STATCOM is said to be FLOATING MODE as shown in Figure 2(c) [8].

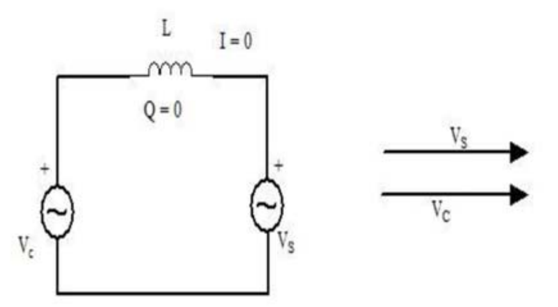

Fig 2(c) Floating Mode

III. VOLTAGE SOURCE CONVERTER (VSC)

A voltage-source converter is a power electronic based device, which is capable of generating sinusoidal voltage with any desired frequency magnitude and phase angle. Also, they can be used as widely in adjustable-speed drives, but can also be used to corrects voltage dips. VSC can either completely supplant the voltage or to inject the lost voltage. The lost voltage is the difference between the actual voltage and the nominal. It is normally based on some type of energy storage, which will provide the converter with a DC voltage. The Switches in the converter is then switched to get the required output voltage. Normally the VSC is not only used for voltage sag mitigation, but also for other power quality issues, e.g. flicker and harmonics. In this case cascaded H-bridge inverter is used [9].

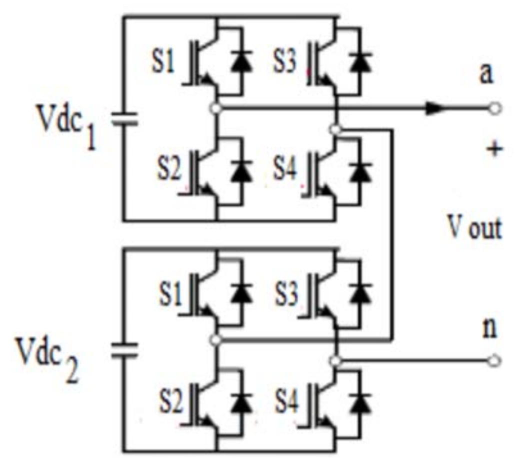

Fig 3 one phase single diagram of 5-level CHB inverter

Operation of Cascaded H-Bridge Multilevel Inverter is based on the switching of different combination of IGBT switches. switching scheme is given in table[10].

Table I Switching table for 5-level CHB Inverter

Switches Turn On (Upper Bridge)	Switches Turn On (Lower Bridge)	Voltage Level
S1, S4	--	Vdc
S1, S4	S1, S4	2Vdc
S2, S4	S2, S4	0
S3, S2	--	-Vdc
S3, S2	S3, S2	-2Vdc

IV SIMULATIONS OF A SIMPLE POWER SYSTEM

SIMULINK model of DSTATCOM is shown in Fig 3.It having the different blocks. The system parameters for simulation study are source voltage of 415v, 50 Hz AC supply, Source resistance of 0.04 ohm and inductance of 0.5mH, Inverter series resistance and capacitance 5 ohm and 5 μF respectively.Load resistance and inductance are chosen as 8 ohms and 100mH respectively.

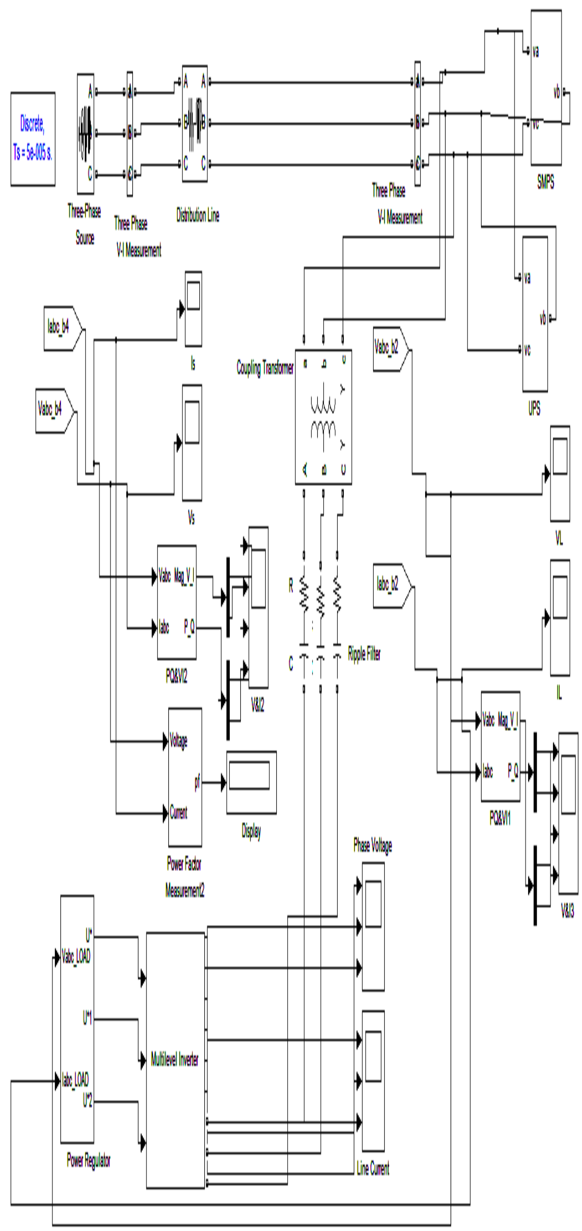

Fig 4 Matlab/Simulink model of overall system

V SIMULATION RESULTS

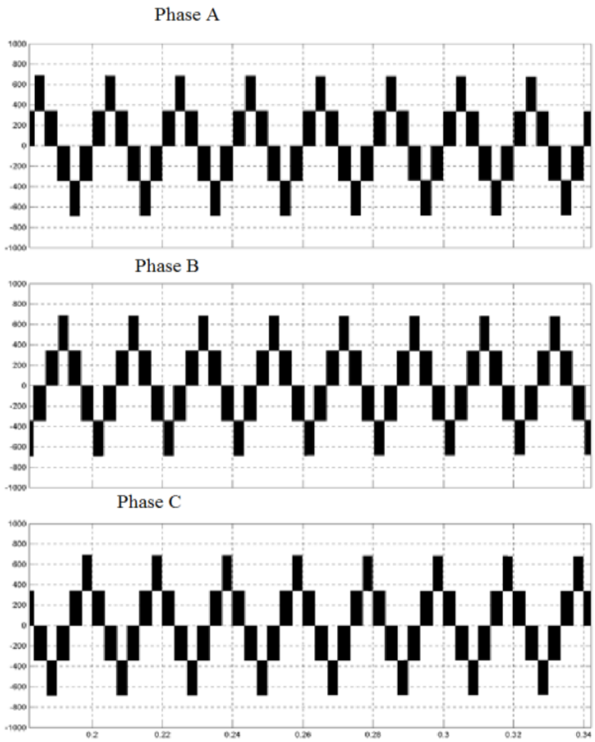

Fig 5 Five-level voltage output LSC-PWM output

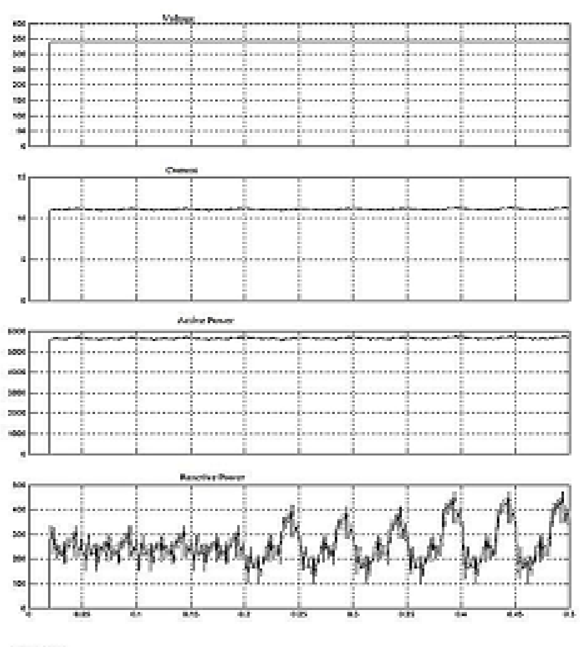

Fig 6 Simulation graph of Voltage ,current, Active power, reactive power sending end without DSTATCOM

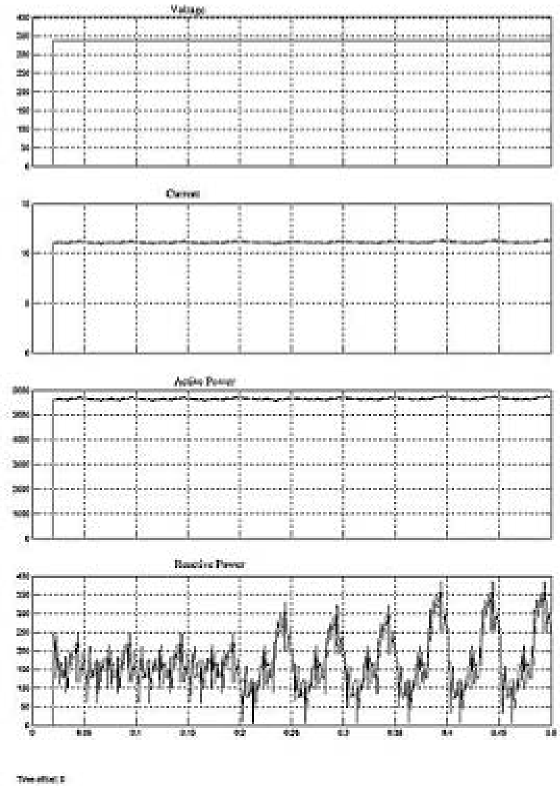

Fig 7 Simulation graph of Voltage, current, Active power, reactive power receiving end without DSTATCOM

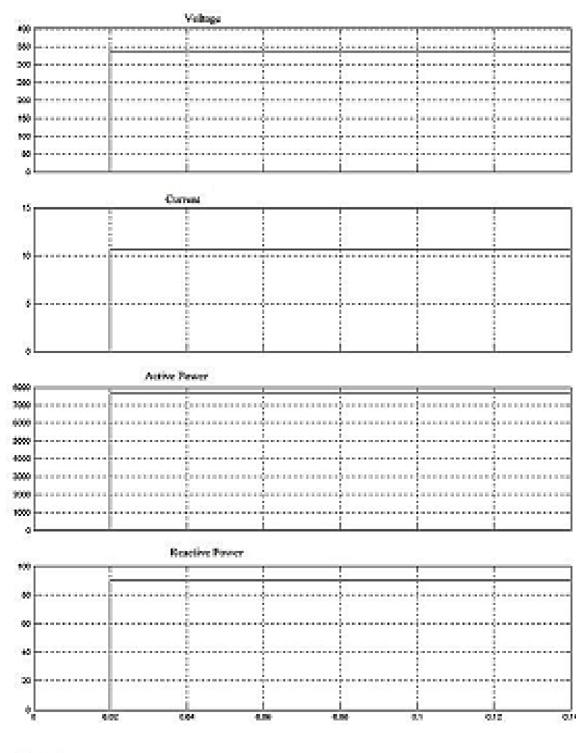

Fig 8 Simulation graph of Voltage, current, Active power, reactive power sending end with DSTATCOM

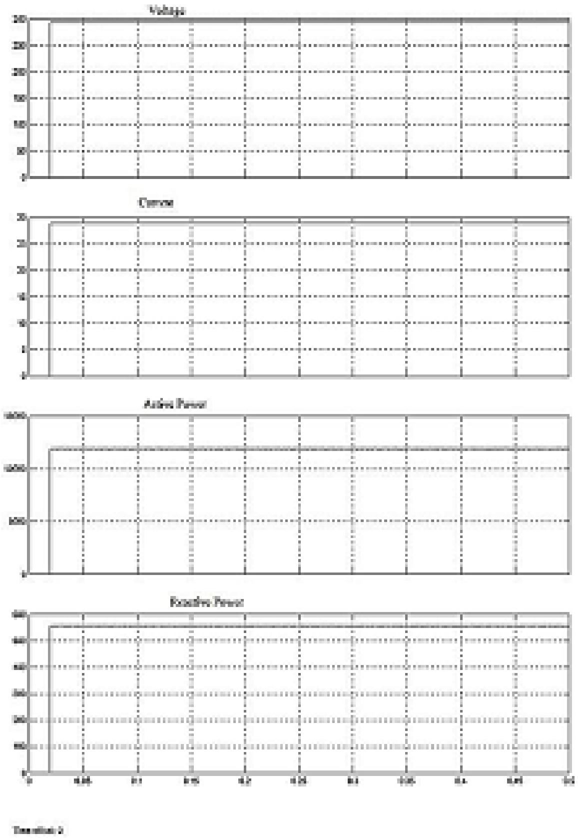

Fig 9 Simulation graph of Voltage, current, Active power, reactive power receiving end with DSTATCOM

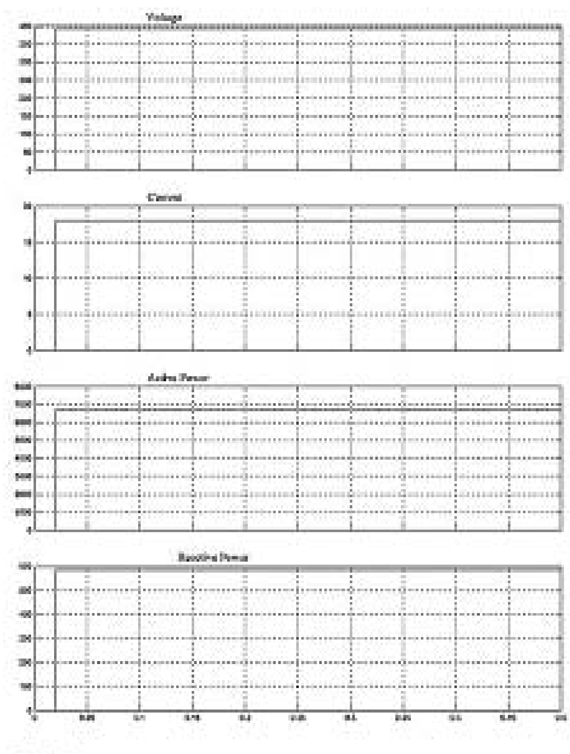

Fig 10 Simulation graph of Voltage, current, Active power, reactive power DSTATCOM

Table II Result without DSTATCOM

Parameter	Grid side	Load side
Voltage (V)	340	338
Current (A)	11	11
Active Power (W)	5691	5672
Reactive Power(VAR)	379	291

Table III Result with DSTATCOM

Parameter	Grid side	Load side	DSTATCOM side
Voltage (V)	338	294	392
Current (A)	10.6	29	18
Active Power (W)	7640	11189	6710
Reactive Power(VAR)	90	556	585

VI CONCLUSIONS

Level shift Pulse width modulation (LSPWM) constructed and assess its execution DSTATCOM with five level CHB inverter is displayed in this thesis. The source current, source voltage, load current, load voltage, active power, reactive power, power factor comes under nonlinear load with STATCOM and without STATCOM are displayed. Utilizing multilevel converters to minimize the total harmonics distortion and improve the power factor. The Total harmonics distortion of source current& load current measured after connecting DSTATCOM is within the acceptable limit given by IEEE 519

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