Implementation of DSTATCOM using Non Linear Load

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Abstract— Distribution Static Compensator (DSTATCOM) which based on multi-Level Cascaded H - bridge (CHB) Inverter for mitigation of harmonics and compensation of reactive power in Power System. This CHB based inverter provides low harmonic distortion, reduced number of switches and suppression of switching losses. The small signal z domain model is derived. To analyze multi-sampled multilevel inverter. It eliminate the Total Harmonics Distortion (THD) drawn from the nonlinear load such as switch mode power supply (SMPS), uninterrupted power supply (UPS. A level shifted PWM (LSPWM) technique is used to analyze the performance of CHB Inverter. A CHB Inverter is considered for shunt compensation of 11kV distribution system. The results are obtained through MATLAB & Simulink software.

Key words: DSTATCOM, Level shifted Pulse width modulation (LSPWM), Proportional-Integral (PI) control, CHB multilevel inverter

I. INTRODUCTION

In power distribution networks, reactive power is the main cause of increasing system losses.

And various power (DSTATCOM) has the capacity to overcome the above mentioned drawbacks by providing precise control and fast response during transient and steady state, with reduced foot print and weight.

A DSTATCOM is basically a converter based distribution flexible AC transmission controller, sharing many similar concepts with that of a Static Compensator (STATCOM) used at the transmission level. At the transmission level, STATCOM handles only fundamental reactive power and provides voltage support, while a DSTATCOM is employed at the distribution level or at the load end for dynamic compensation. The latter, DSTATCOM, can be one of the viable alternatives to SVC in a distribution network. Additionally DSTATCOM are used, to eliminate unbalance or distortions in the source current supply voltage, as per the IEEE-519 standard limits. Since a DSTATCOM is such a multifunctional device, the main objective of any control algorithm should be to make it flexible and easy to implement, in addition to exploiting its multi functionality to the maximum. The following indices are considered for measurement and control performance with varying nonlinear load, total harmonic distortion (THD), DC link voltage variation and switching frequency. This paper also emphasizes choice of current control technique; it significantly affects the performance of a DSTATCOM. A dynamic simulation model of the DSTATCOM has been developed various control algorithm in Matlab/ Simulink software.

II. BASIC PRINCIPLE OF DSTATCOM

A DSTATCOM is a controlled reactive source, which includes a Voltage Source Converter (VSC) and a DC link capacitor connected in shunt, capable of generating and/or absorbing reactive power. The operating principles of a DSTATCOM are based on the exact equivalence of the conventional rotating synchronous compensator. The AC terminals of the VSC are connected to the Point of Common Coupling (PCC) through an inductance, which could be a filter inductance or the leakage inductance of the coupling transformer, as shown in Fig.1

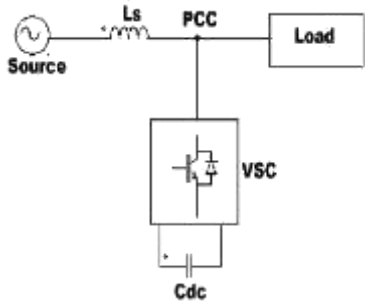

Fig. 1: Block diagram of D-STATCOM

The DC side of the converter is connected to a DC capacitor, which carries the input ripple current of the converter and is the main reactive energy storage element. This capacitor could be charged by a battery source, or could be recharged by the converter itself. If the output voltage of the VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage is greater than the AC terminal voltage, the DSTATCOM is in the capacitive mode of operation and vice versa. The quantity of reactive power flow is proportional to the difference in the two voltages.

III. MULTILEVEL POWER CONVERTERS

Numerous industrial applications have begun to require higher power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power level. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly. As a result, a multilevel power converter structure has been introduced as an alternative in high power and medium voltage situations.

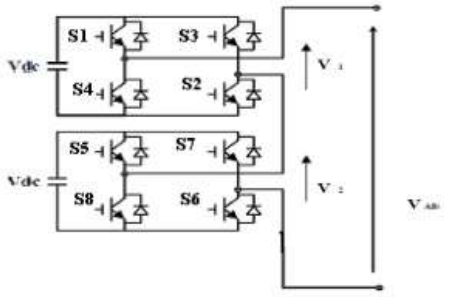

Fig. 2: Block diagram of 5-level CHB inverter model

Switches turn on	Voltage level
S1,S2	Vdc
S1,S2,S5,S6	2Vdc
S4,D2,S8,D6	0

S3,S4	-Vdc
S3,S4,S7,S8	-2Vdc

Table 1: Switching table for 5 level CHB inverter

IV. PWM TECHNIQUES FOR CHB INVERTER

The most popular PWM techniques for CHB inverter are

- Phase Shifted Carrier PWM (PSCPWM)
- Level Shifted Carrier PWM (LSCPWM)

A. Level Shifted Carrier PWM

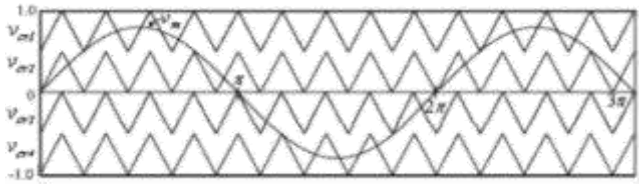

Fig. 3: Level shift carrier PWM

Figure 3 shows level shift carrier Pulse width modulation. Each cell is modulated independently. References multilevel inverters by making the use of several triangular carrier signals and one reference signal per phase. For an m-level inverter, m-1 carriers with the same frequency fc and same peak-to-peak amplitude Ac are disposed such that the bands they occupy are contiguous. The reference, or modulation, waveform has peak-to-peak amplitude Am and frequency fm, and it is centered in the middle of the carrier set. The reference is continuously compared with each of the carrier signals. If the reference is greater than a carrier signal, then the active device corresponding to that carrier is switched on; and if the reference is less than a carrier signal, then the active device corresponding to that carrier is switched off. In multilevel inverters, the amplitude modulation index, ma, and the frequency ratio, mf, are defined as

ma = Am/(m-1) Ac …….. i

mf = fc/fm …….. ii

V. CONTROL STRATEGIES

Satisfactory performance, fast response, flexible and easy are the main objectives variables and signal conditioning

- Measurements of system
- Extraction of reference compensating signals
- Generation of firing angles for switching devices

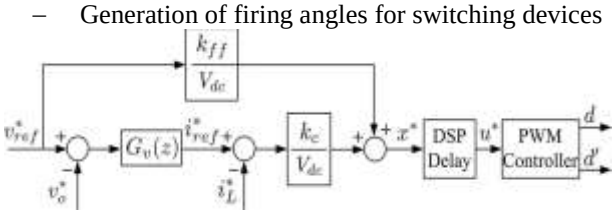

Fig. 4: Digital controller of the single-phase H-bridge inverter

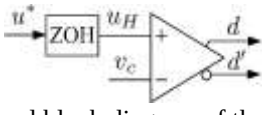

Fig. 5: Functional block diagram of the PWM controller

Digital controller of the single-phase H-bridge inverter. The controller of the stand-alone inverter is a cascaded linear controller composed of an internal current control loop and an external voltage control loop with duty-ratio feed forward (kff = 1), as is shown in Fig.4.The ideally sampled output voltage and inductor current are represented by V_0* and I_L respectively A proportional feedback controller is used in the internal loop with the gain of kc , while a proportional plus resonant controller is applied to the external voltage loop. The compensator of the voltage control loop represented by

$$G_v(z) = k_v + k_r \sum_{k=1}^{h} H_k(z),$$

Where Hk (z) is digitized band pass filter resonating at kth odd harmonic frequency. The ideally calculated (without delay) digital duty-ratio is x* which is updated into the PWM controller with a DSP delay period (analog-to-digital conversion delay and computation delay).The functional block diagram of the PWM controller is shown in figure 5.The PWM controller updates duty ratio signal μ* which is then converted to uH to the triangle carrier vc .The drive signal d and d' are generated. The drive signal for insulated gate bipolar transistor (IGBT) 1 and 4 is d,Whereas as for IGBT 2 and 3 is d'.Signal d and d' are complementary.

VI. MATLAB/SIMULINK MODELING AND SIMULATION RESULTS

Simulink Model Of DSTATCOM Is Shown In Fig. 6.It having the blocks is source block, control block, non linear load are connected such as switch mode power supply (SMPS), uninterrupted power supply (UPS) and measurements block. The system parameters for simulation study are source voltage of 11kv, 50 Hz AC supply, Source resistance of 0.1 ohm and inductance of 0.09 H, Inverter series inductance 10mH, Load resistance and inductance are chosen as 60 ohms and 30mH respectively and use battery source instead of capacitor.

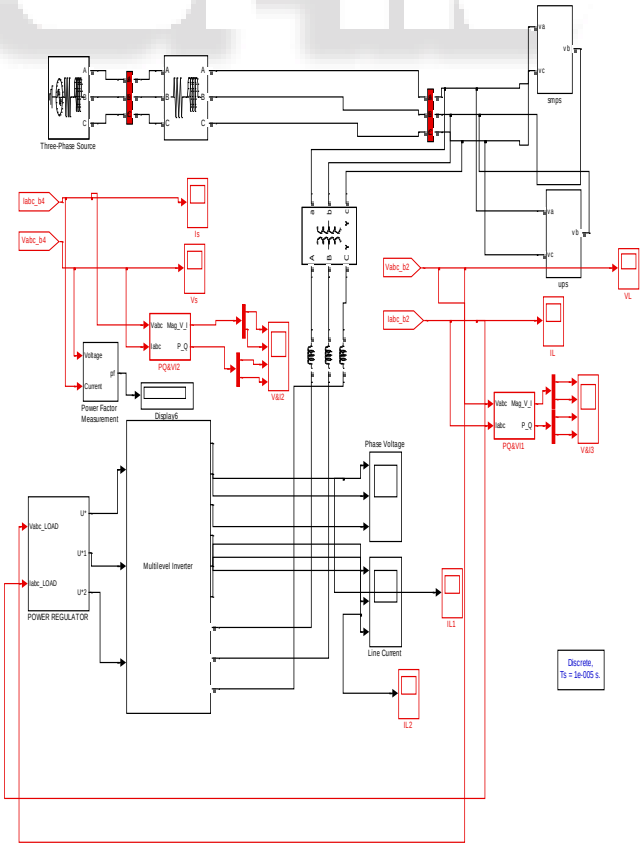

Fig. 6: Matlab/Simulink model of DSTATCOM

The load voltage, current, active and reactive power without
DSTATCOM In Figure 7

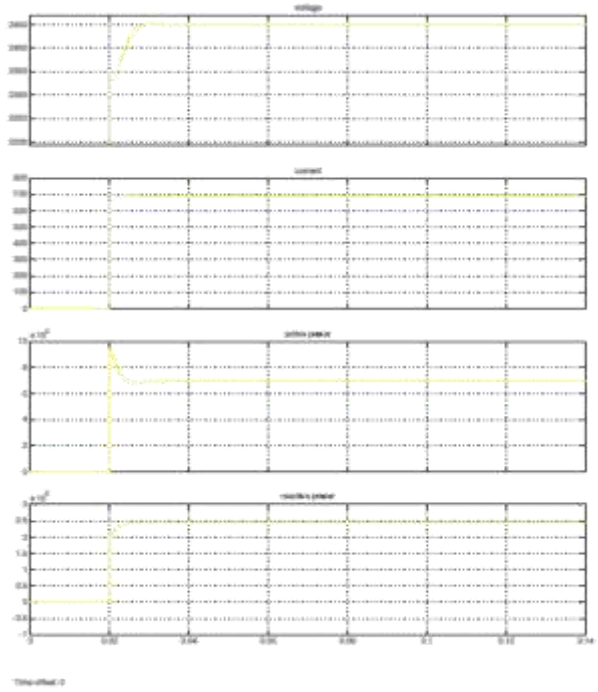

Fig. 7: Load Current, Active and Reactive Power without DSTATCOM

Figure 7 that reactive power reaches upto 250 KVAR.

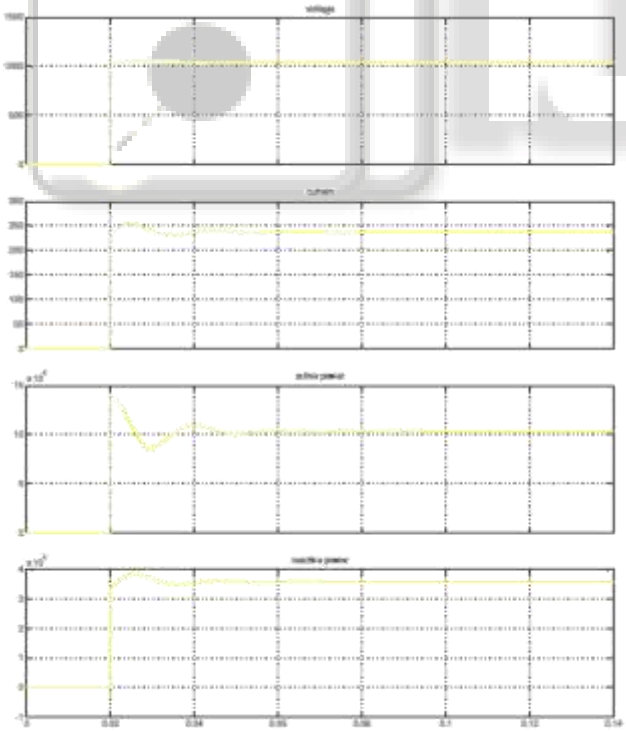

Fig. 8: The load voltage, current, active and reactive power with DSTATCOM.

Fig.8 shows that increase in reactive power with DSTATCOM and reaches upto 360 KVAR.

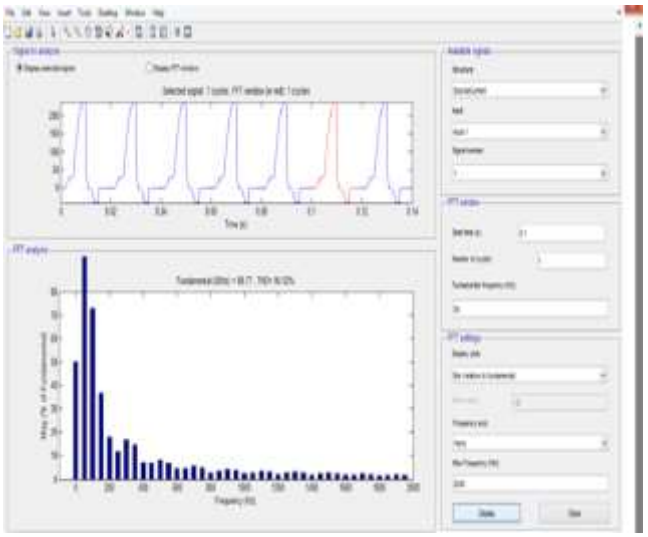

Fig. 9: Total Harmonics Distortion of Source Current without DSTATCOM.

Figure 9 shows that THD of source current without DSTATCOM is 90.28%.

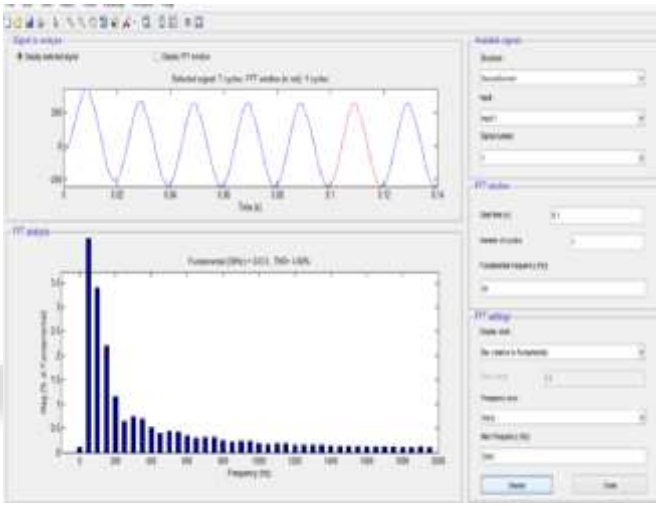

Fig. 10: Total Harmonics Distortion of Source Current with DSTATCOM.

Figure 10 show that THD of source current with DSTATCOM is 4.60%.

VII. CONCLUSION

A DSTATCOM with five level CHB is investigated. The mathematical model for CHB inverter is investigated. The THD found to be maximum without DSTATCOM and minimum when DSTATCOM is connected. With DSTATCOM total harmonics distortion are reduced. Finally Matlab/Simulink based model is developed and simulation results are presented.

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