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5-Level Distributed Static Compensator for Power Quality Enhancement

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Abstract:
This paper presents an investigation of 5-Level Cascaded H - bridge (CHB) Inverter as Distribution Static Compensator (DSTATCOM) in Power System (PS) for compensation of reactive power and harmonics. The advantages of CHB inverter are low harmonic distortion, reduced number of switches and suppression of switching losses. The DSTATCOM helps to improve the power factor and eliminate the Total Harmonics Distortion (THD) drawn from a Non-Liner Diode Rectifier Load (NLDRL). In this paper, a control scheme with constant power and sinusoidal current compensation [1, 2] is exploited. In order to correct the power factor, a power factor control loop is required and therefore included in the control block. A CHB Inverter is considered for shunt compensation of a distribution system. To verify its use, power distribution feeder with a three-phase rectifier load was tested. Results showed that integration of the proposed reactive power control loop can correct the power factor of the controlled feeder to be unity power factor.

Index Terms: ***H–bridge, DSTATCOM, CHB Inverter.***

I. INTRODUCTION

In the last decade, the electrical power quality issue has been the main concern of the power companies. Power quality is defined as the index which both the delivery and consumption of electric power affect on the performance of electrical apparatus. From a customer point of view, a power quality problem can be defined as any problem is manifested on voltage, current, or frequency deviation that results in power failure. The power electronics progressive, especially in flexible alternating-current transmission system (FACTS) and custom power devices, affects power quality improvement. This present system can be implemented by using a 5-level voltage source inverter as a shunt compensating FACTS device. This will have improved harmonic performance compared to present system. And its harmonic performance is measured in terms of THD parameter calculation (Total harmonic distortion).

A DSTATCOM is a device which is used in an AC distribution system where, harmonic current mitigation, reactive current compensation and load balancing are necessary. The building block of a DSTATCOM is a voltage source converter (VSC) consisting of self commutating semiconductor valves and a capacitor on the DC bus. The device is shunt connected to the power distribution network through a coupling inductance that is usually realized by the transformer leakage reactance. In general, the DSTATCOM can provide power factor correction, harmonics compensation and load balancing. The major advantages of DSTATCOM compared with a conventional static VAR compensator (SVC) include the ability to generate the rated current at virtually any network voltage, better dynamic response and the use of a relatively small capacitor on the DC bus. Fig. 1 shows the schematic diagram of a DSTATCOM connected to a three phase AC mains feeding three phase loads. Three phase loads may be a lagging power factor load or an unbalanced load or non-linear loads or mixed of these loads. For reducing ripple in compensating currents, interfacing inductors (Lf) are used at AC side of the voltage source converter (VSC). A small series connected capacitor (Cf) and resistor (Rf) represent the ripple filter installed at PCC in parallel with the loads and the compensator to filter the high frequency switching noise of the voltage at PCC. The STATCOM used in distribution systems is called DSTACOM (Distribution STACOM) and its configuration is the same, but with small modifications. It can exchange both active and reactive power with the distribution system by varying the amplitude and phase angle of the converter voltage with respect to the line terminal voltage. A multilevel inverter can reduce the device voltage and the output harmonics by increasing the number of output voltage levels. There are several types of multilevel inverters: cascaded R-bridge (CRB), neutral point clamped, flying capacitor [2-5]. In particular, among these topologies, CRB inverters are being widely used because of their modularity and simplicity.

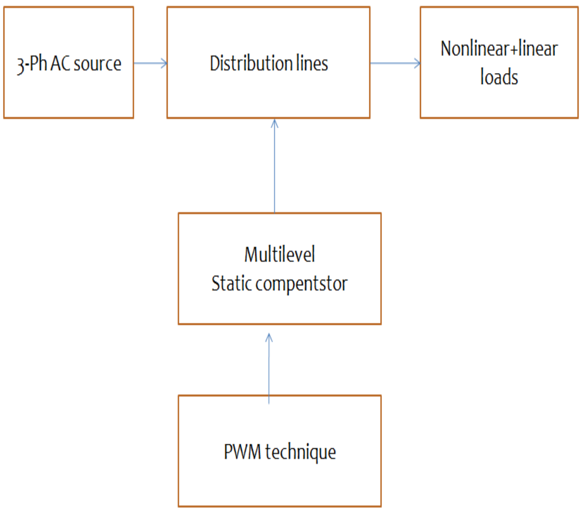


Fig 1 Proposed System Block Diagram

II. DESCRIPTION OF D-STATCOM OPERATION

A D-STATCOM is a shunt device that regulates the system voltage by absorbing or generating reactive power at a point of coupling connection. The schematic diagram of a DSTATCOM is shown in Fig 1. The D-STATCOM is a solid state DC/AC power switching converter that consists mainly of a three-phase PWM voltage source converter (VSC) bridge having six IGBTs with associated anti-parallel diodes. It is connected to the distribution network via the impedance of the coupling transformer. A DC-link capacitor provides constant DC link voltage.

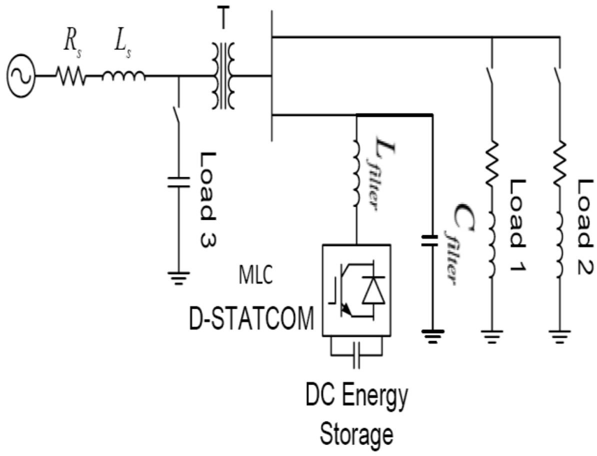


Fig. 2. Simplified power system equipped with a D-STATCOM

The output voltage of the D-STATCOM is generated by a DC/AC voltage source converter operated from an energy storage capacitor. From the DC input voltage, provided by a charged capacitor, the converter produces a set of controllable three-phase output voltages at the frequency of the AC power system. Each output voltage is in phase with and coupled to the corresponding AC voltage via coupling reactance. By varying the magnitude of output voltage produced, the reactive power exchange between D-STATCOM and AC system is controlled. If the amplitude of output voltage is increased (or decreased) above the AC system voltage, the converter generates (or absorbs) reactive power for the AC system. DSTATCOM acts as a shunt compensator connected in parallel to the system so that it can inject appropriate compensation currents [9-10]. The D- STATCOM has several advantages, compared to a conventional static var compensator (SVC). It gives faster responses and can produce reactive power at low voltage. Also, it does not require thyristor-controlled reactors (TCR) or thyristor-switched capacitors (TSC) that normally produce low order harmonics.

III. MULTI LEVEL CONVERTER

By using single H-Bridge we can get 3 voltage levels. The number of output voltage levels of CHB is given by 2n+1 and voltage step of each level is given by

Vdc/2n, where n is number of H-bridges connected in cascaded.

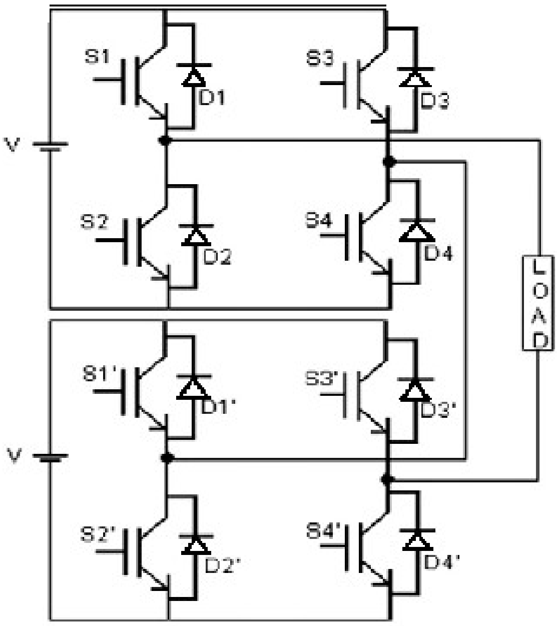
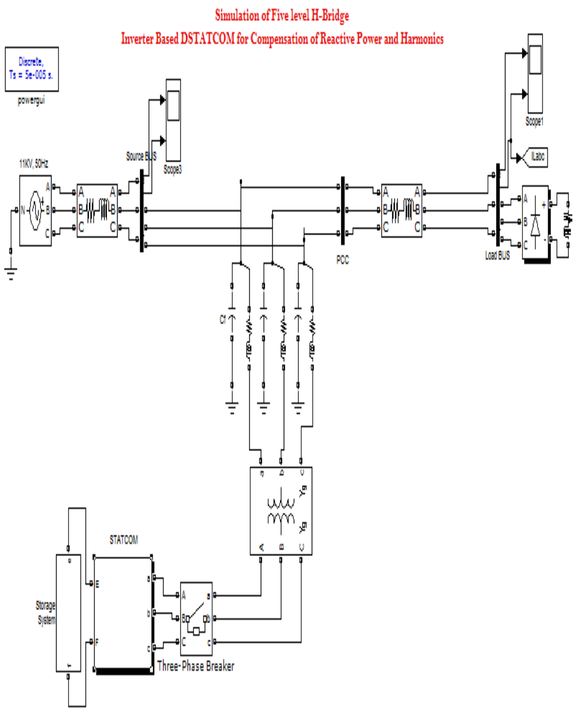


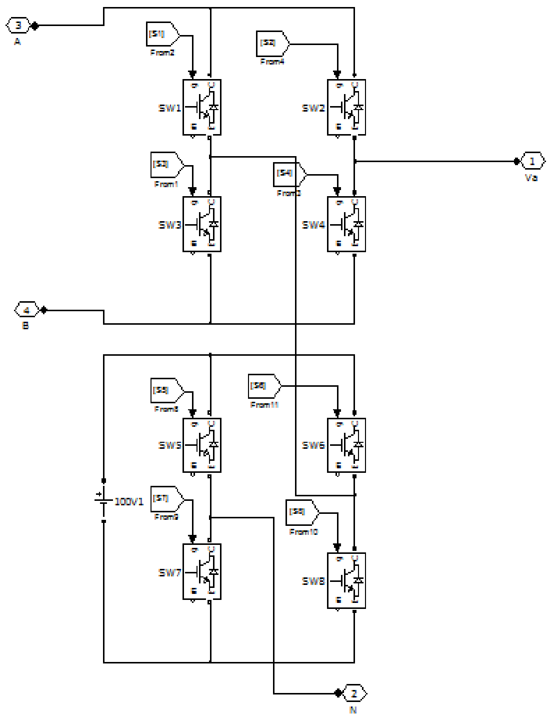
Figure-3 Single phase view of 5-level CHB inverter model

IV. SIMULATION OUTPUT

Simulation Circuit

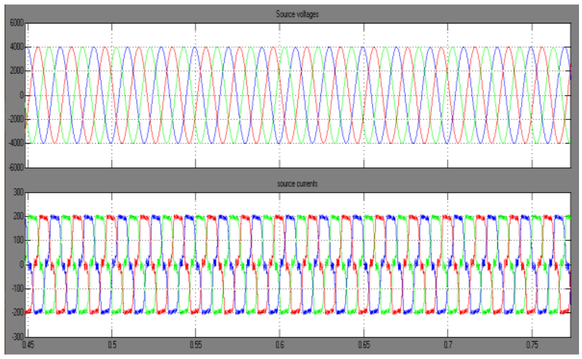


5-Level MLC Circuit

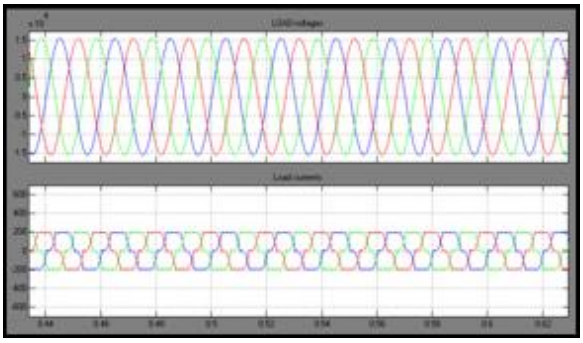


V. WAVE FORMS

a) Source Voltages & Currents



b) Load Voltages & Currents



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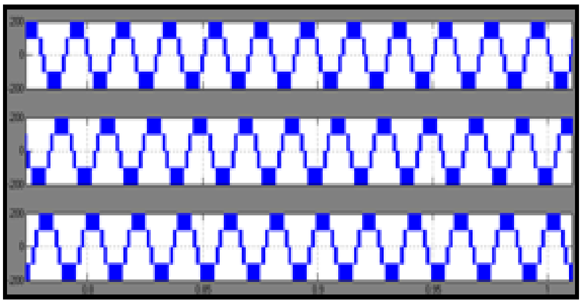
c) MLC Output



VI. CONCLUSION

5-Level Cascaded H - bridge (CHB) Inverter as Distribution Static Compensator (DSTATCOM) in Power System (PS) for compensation of reactive power and harmonics. The advantages of CHB inverter are low harmonic distortion, reduced number of switches and suppression of switching losses. The DSTATCOM helps to improve the power factor and eliminate the Total Harmonics Distortion (THD) drawn from a Non-Liner Diode Rectifier Load (NLDRL). In this paper, a control scheme with constant power and sinusoidal current compensation [1,2] is exploited. In order to correct the power factor, a power factor control loop is required and therefore included in the control block. A CHB Inverter is considered for shunt compensation of a distribution system. To verify its use, power distribution feeder with a three-phase rectifier load was tested. Results showed that integration of the proposed reactive power control loop can correct the power factor of the controlled feeder to be unity power factor.

VII. REFERENCES

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