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Novel Approach of Power Quality Issues Suppression using Cascaded H-Bridge Multilevel Inverter Based DSTATCOM

P. Sujidha[1], M. Sarojini Devi[2], A. Manjula[3], N. Thillainayagi[4], A. Usha[5]
Assistant Professor, Department of Electrical and Electronics Engineering[1,2,3,4,5]
Mohamed Sathak Engineering College, Kilakarai, India

Abstract: *In modern information society requirements and expectations associated with power quality have become increasingly important. Among the different disturbances affecting the power quality, the voltage sag are considered as a most important power quality problem faced by utilities & industrial consumer & equipment like PLC (Programmable Logic Controller), ASD (Adjustable Speed Drives) which need to be fully investigated. Custom power device are effective means for mitigating the voltage related issues prominently voltage sag, unbalanced load voltage, voltage regulation, sag/ swell etc. by compensating the reactive power with the injection of shunt current. In this paper by using three level H-bridge topology cascaded multilevel inverter based DSTATCOM the Power Quality issues are compensated effectively.*

Keywords: Cascaded Multilevel Inverter, DSTATCOM, Power Quality.

I. INTRODUCTION

Power quality is becoming recently more important issue. Any power problem manifested in voltage, current, or frequency deviation that results in failure or disoperation of customer equipment is a Power Quality (PQ) problem. Nowadays load equipment is more sensitive to power quality variations than equipment used before, because in order to improve power system efficiency there is continuous growth in the application of devices with micro-processor and power electronics control [1]. Out of different power quality problems, such as transients, voltage fluctuations, harmonics, inter-harmonics, voltage unbalance, waveform distortion, dc offset, noise, notches etc. Voltage sag is one of the problems related to power quality [2].Various methods have been applied to reduce or mitigate the PQ problems. The conventional methods are by using capacitor banks, introduction of new parallel feeders and by installing Uninterruptible Power Supplies (UPS). However, the PQ problems are not solved completely due to uncontrollable reactive power compensation and high costs of new feeders and UPS. Another compensating system has been proposed by employing a combination of SVC and active power filter, which can compensate three phase loads in a minimum of two cycles. Nowadays, sensitive equipment's are being used in industries and the voltage sag in the power system is not acceptable. There are several methods that are being used to reduce the voltage sag. In some methods, compensators based on the voltage and current source are used thus, a controller which continuously monitors the load voltages and currents to determine the right amount of compensation required by the system and the less response time should be a viable alternative. Distribution Static Compensator (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. The DSTATCOM (Distribution Static Compensator) has emerged as a promising device to provide not only for voltage sag mitigation but a host of other power quality solutions such as voltage stabilization, flicker suppression, voltage regulation, power factor correction and harmonic control [3]. DSTATCOM is a shunt type compensating device which is connected with distribution system. Suitable adjustment of the phase and magnitude of the DSTATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power. The VSC connected in shunt with the ac system provides a multifunctional topology [4][5]. In this paper for voltage sag mitigation three-level H-Bridge topology is used which is found to be effective. Further three level H-bridge cascaded

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inverter with the effective control scheme [6][7] is used. It is found that the voltage sag can be effectively mitigated using the proposed multilevel inverter based DSTATCOM with suitable control scheme.

II. PROPOSED DSTATCOM TOPOLOGY

Inverters are conventionally controlled as a PWM voltage source in medium and high-power applications because of switching losses. Since the converter is operated as a PWM voltage source, the switching frequency of the devices can be properly controlled. DSTATCOM is a FACTS device generating/absorbing the reactive power between ±QVAr. DSTATCOM consists of inverter, dc-link capacitor, coupling transformer/inductance and control algorithm. Inverter is the basic building of all converter based FACTS devices. Inverter used in power circuit of DSTATCOM must be operated at high switching frequency to response fast any changing in distribution systems. Besides, total harmonic distortion of inverter output voltage can be decreased depending on high switching frequency. Therefore, PWM inverters are more suitable for DSTATCOM application [8]. Recently, multilevel inverters have been used in DSTATCOM applications because of advantageous like direct connection to distribution system and improving the harmonic content of output voltage compared with conventional two-level PWM inverter operating in same switching frequency. Cascaded multilevel inverters among multilevel inverter topologies are the most popular topology because of using the least number of components and flexibility of circuit layout. In cascaded inverter, the number of output voltage levels can be easily increased by adding the H-bridges. The number of lowest voltage-level in the cascaded inverters is three. In addition, dc voltage unbalance doesn't occurred in three-level. In this paper three-level H-bridge inverter level cascaded H-Bridge inverter is preferred for power circuit of DSTATCOM. Flexible structure of this inverter easily allows increasing the number of voltage-level by adding the H-bridges in series to per phase. Power circuit of three-level Hbridge inverter based DSTATCOM is illustrated in Figure 1. DSTATCOM consists of three H-bridge inverters, dc-link capacitors (C)supplying the dc voltages to H-bridge inverters and a coupling inductance with internal resistance (Lf + Rf) connecting to ac grid. The output of this cell will have three levels name +Vdc, 0 and –Vdc. This circuit requires about four switching devices per phase. The circuit has many advantages like simple, modular, improved waveform which results in reduced total harmonic distortion (THD). The Cascaded Multilevel Inverter circuit provides high quality output when the number of levels in the output increases and also this reduces the filter components size and cost.

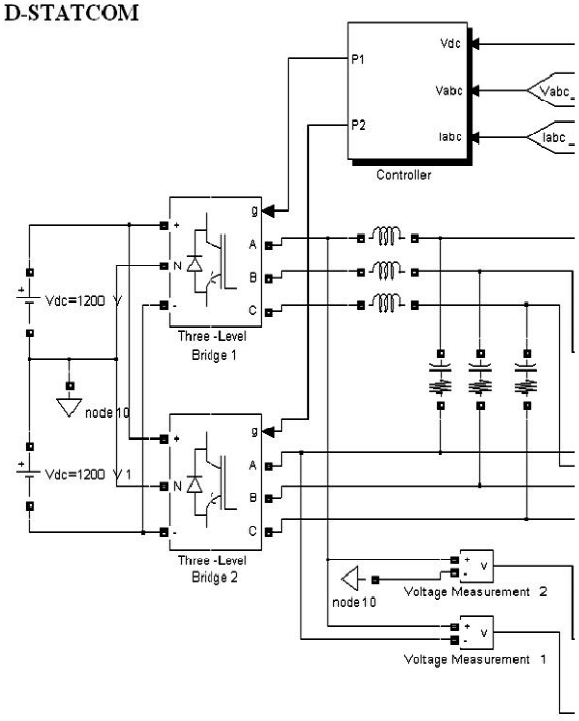

Fig. 1. Three Level Cascaded H-Bridge Based DSTATCOM

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III. EXPERIMENT AND RESULT

This is the main circuit of the voltage sag control. For the mitigation of voltage sag 3-level H-Bridge Inverter based DSTATCOM is used. For simulation purpose the fault is created at 0.02sec& clear at 0.08sec with simulation run time 0.5 sec. The fault impedance is kept constant. The fault is created at bus B1 & corresponding sag occur at bus B3.For generating the gate pulses for the H-Bridge inverter In Phase Disposition (IPD) sinusoidal pulse width modulation technique is used because IPD gives the better harmonic profile as compared to other sinusoidal pulse width modulation technique.

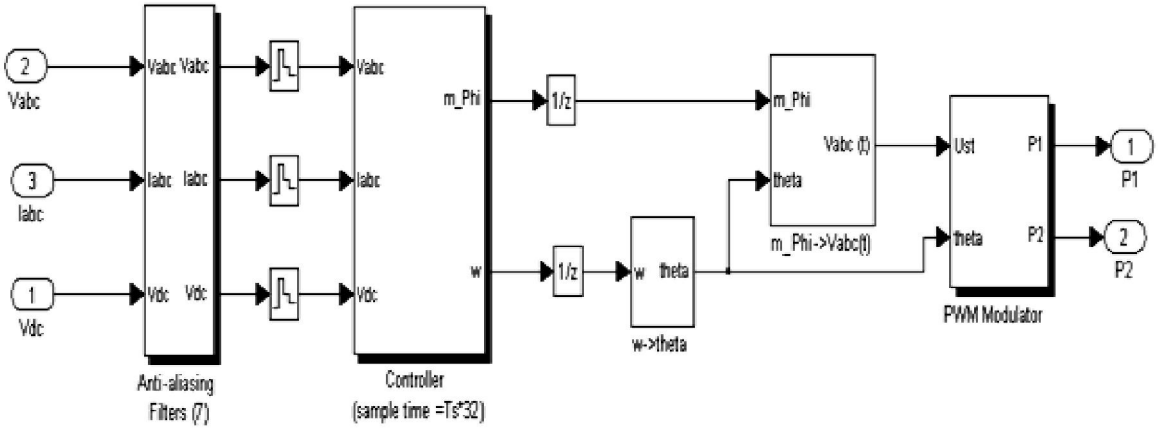

Fig. 2.Main Circuit for DSTATCOM controller

3.1 Voltage During SAG

This shows the Voltage sag occur at bus3 during the three phase fault at bus1

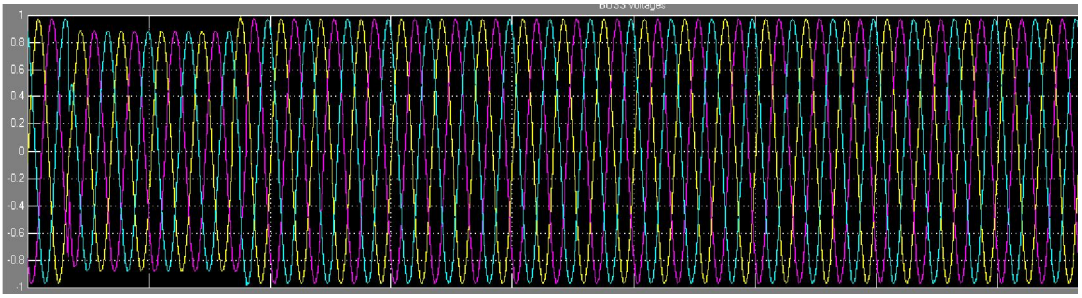

Fig 3.Voltage during Sag

3.2 Injected Current by Dstatcom for Sag

During the three phase fault period, the required boost up Current was injected by DSTATCOM.

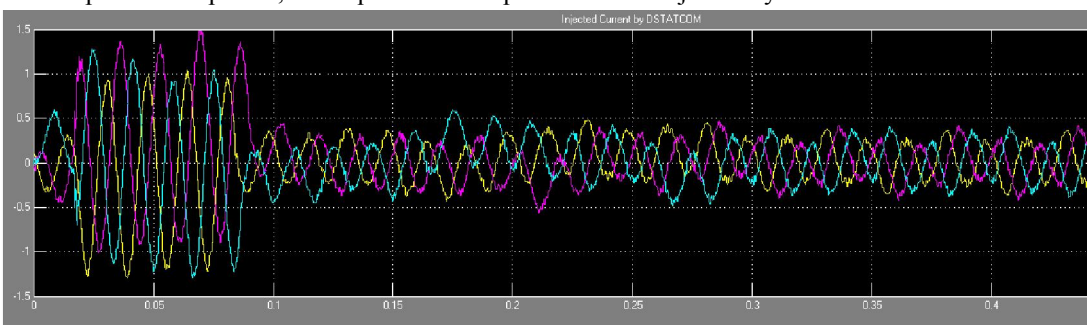

Fig.4 Injected current by DSTATCOM for sag

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3.3 Compensated Voltage By DSTATCOM for Sag

After the current injection by DSTATCOM, Voltage sag was compensated. This shows the fig.4

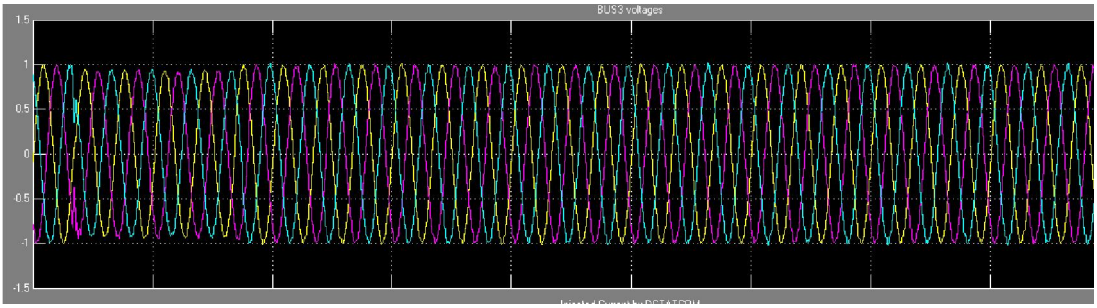

Fig.5.Compensated Voltage by DSTATCOM for sag

3.4 Active, Reactive Power and Voltage Magnitude During Fault Without DSTATCOM for Sag Mitigation

During sag there is a drop in active and reactive power at the bus B3. and also magnitude drop in voltages at bus B1 & B2 without DSTATCOM. This shows the fig.6

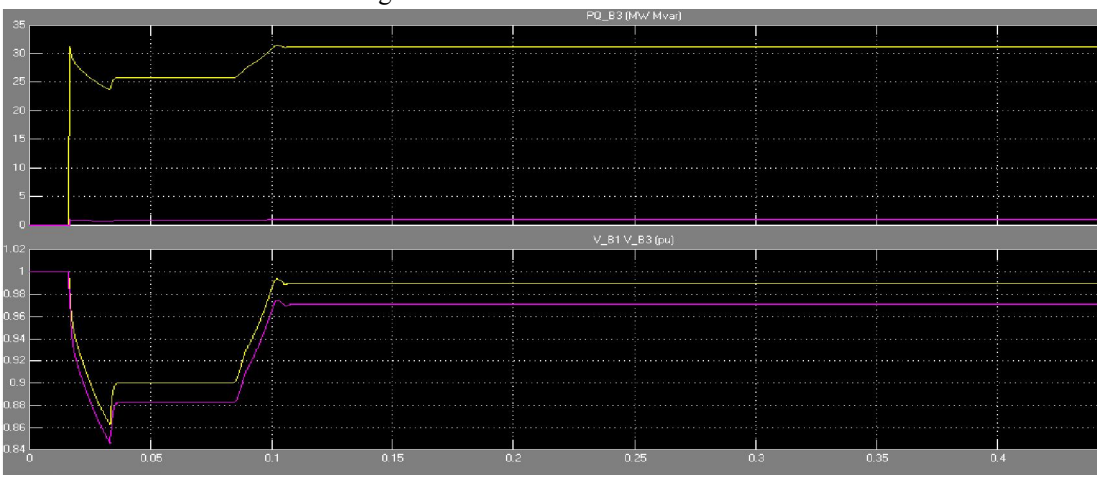

Fig 6.Active, Reactive Power and Voltage Magnitude during Fault without DSTATCOM for Sag Mitigation

3.5 Active, Reactive Power and Voltage Magnitude During Fault With DSTATCOM for Sag Mitigation

During sag there is a drop in active and reactive power at the bus B3 and also magnitude drop in voltages at bus B1 & B2 with DSTATCOM. This shows the fig.7

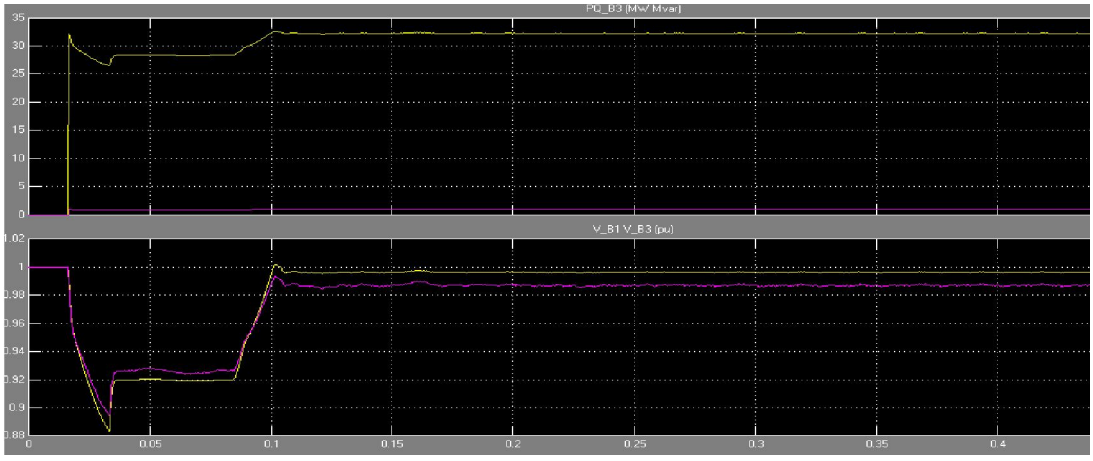

Fig.7.Active, Reactive Power and Voltage Magnitude during Fault with DSTATCOM for Sag Mitigation

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IV. CONCLUSION

The principle of operation of cascaded H-bridge converter and simulation studies on cascaded converter based DSTATCOM using Sinusoidal PWM control. It is observed that the DSTATCOM is capable of supplying the reactive power demanded by the load both during steady state and transient operating conditions also it is more effective than conventional inverter.

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