International Journal of Power Electronics and Drive System (IJPEDS)
Vol. 8, No. 1, March 2017, pp. 316~324
ISSN: 2088-8694, DOI: 10.11591/ijpeds.v8i1.pp316-324

Power Quality Improvement Using Multi-level Inverter based DVR and DSTATCOM Using Neuro-fuzzy Controller

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Article Info

Article history:

Received Oct 20, 2016
Revised Dec 26, 2016
Accepted Jan 05, 2017

Keyword:

Flexible alternating current transmission system
Modular multi-level converters
Static synchronous compensator
Static var compensator
Total harmonic distortion

ABSTRACT

STATCOM is one of the shunt type FACTS controllers which can supply reactive power and improve bus voltage. STATCOM, a controlling device used on alternating current transmission networks, has advantages like transient free switching and smooth variation of reactive power. This paper proposes a cascaded multilevel inverter type DSTATCOM and DVR to compensate voltage sag in utilities in power distribution network. The proposed DSTATCOM is implemented using multilevel topology with isolated dc energy storage and reduced number of switches. A DVR injects a voltage in series with the system voltage and a D-STATCOM implant a current into the system to correct the voltage sag, swell and interruption. The phase shifter PWM technique is described to generate firing pulse to cascaded inverter. The proposed neuro-fuzzy controller follow itself to the sag and provides effective means of mitigation .The voltage sag with the minimum harmonic at the efficacy end. The proposed technique is simulated using MATLAB/Simulink.

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1. INTRODUCTION

FLEXIBLE ac transmission systems (FACTS) are being pre-owned extensively in power system to enhance the system utilization, power transfer capacity conjointly the power quality of ac system interconnections [1]-[2]. As typical shunt FACTS equipment, STATCOM is idolized at the point of common connection (PCC) to ingest or interject the requisite reactive power, through which the voltage quality of PCC is enhanced [3]. In recent years, abounding topologies have been enforced to the STATCOM. Among many types of topology, H-bridge cascaded STATCOM has been extensively acknowledged in high-power functions for the following advantages: quick response speed, small volume, high efficiency, minimum synergy with the supply grid and its individual phase curb capacity [4]–[7]. Compared with a diode-clamped converter or flying capacitor converter, H-bridge cascaded STATCOM can retrieve high number of levels more easily and can be coherent to the grid directly without the unwieldy transformer. This enables us to reduce cost and improve the efficacy of H-bridge cascaded STATCOM [8].

There are two industrial disputes which exist in H-bridge cascaded STATCOM to date. Initially, the restraint method for the current loop is an important factor influencing the compensation attainment. However, many non-ideal factors, such as the finite bandwidth of the output current loop, the time delay lured by the signal detecting circuit, and the allusion command current generation process, will deteriorate the reimbursement effect. Secondly, H-bridge cascaded STATCOM is a complicated system with more number of H-bridge cells in each phase, so the dc capacitor voltage inequality concern which caused by different active power losses among the cells, disparate switching patterns for disparate cells, parameter variations of active and passive components inside cells will clout the authenticity of the system and even lead to the breakdown of the system. Hence, many researches have been concentrated on hunting the solutions to these complications.

In terms of current control loop, the majority of approaches associate the classic linear control method, in which the non-linear equations of the STATCOM model are linearized with a specific equilibrium. The most extensively used linear control schemes are PI controllers [9],[10]. In [9], to regulate reactive power, only a simple PI controller is lugged out. In [10], through a decoupled control strategy, the PI controller is used in a synchronous d–q frame. However, it is hard to find the suitable parameters for designing the PI controller and the performance of the PI controller might degrade with the external disturbance. Thus, a number of intelligent methods have been proposed, the PI controller advances similar to particle swarm optimization [11], neural networks [12], and artificial immunity [13]. In literature [14],[15], adaptive control and linear booming clout have been reported for their anti-external disturbance ability. In literature [16]-[17], a popular dead-beat current controller is used. This control method has the high bandwidth and the agile allusion current tracking speed. The enduring state achievement of H-bridge cascaded STATCOM is enhanced, but the dynamic performance is not improved. In [18], a dc injection elimination method called IDCF is proposed to build an extra feedback loop for the dc component of the output current. It can improve the output current quality of STATCOM. However, the circuit configuration of the cascaded STATCOM is the delta configuration, but not the star configuration. Moreover, an adaptive theory-based improved continuous sinusoidal tracer control method is proposed in [19] and a leaky least mean square-based regulation style is proposed in [20]. But these methods are not for STATCOM with the cascaded structure. By using the traditional linear control method, the controller is characterized by its simple control structure and parameter design convenience, but poor aggressive control stability.

Other curbs access nonlinear control which directly compensates for the system nonlinearities without requiring a linear approximation. In [21], an input–output feedback linearization controller is designed. By enumerating a damping term, the oscillation amplitude of the internal dynamics can be effectively decreased. However, the stability cannot be guaranteed [22]. Then, many new modified damping controllers are designed to strengthen the controllability and performance of the internal dynamics [23]-[26].

2. CONFIGURATION OF STATCOM AND DVR

STATCOM is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of power it can also provide active AC power. It is a member of the FACTS family of devices and the Standard configuration of STATCOM is shown in Figure 1 and standard configuration, schematic diagram of DVR is shown in Figure 2 & 3 respectively.

One of the main reasons for installing an SVC or STATCOM in transmission networks is to increase the power transfer capability where limited by post-contingency voltage criteria or under voltage loss of load probability. Determining the optimum mix of dynamic and switched compensation is a challenge. Control systems are designed to keep the normal operating point within the middle of the SVC or STATCOM dynamic range. The voltage-sourced converter (VSC) is the basic electronic part of a STATCOM, which converts the dc voltage into a frequency, and phase. There are different methods to realize a voltage-sourced converter for power utility application. Based on harmonics and loss considerations, pulse width modulation (PWM) or multiple converters are used. Inherently, STATCOMs have a symmetrical rating with respect to inductive and capacitive reactive power.

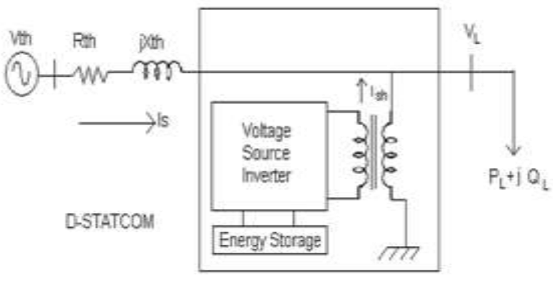

Figure 1. Standard configuration of STATCOM

For asymmetric rating, STATCOMs need a complementary reactive power source. Shows Static Synchronous Compensator (STATCOM) used for midpoint voltage regulation on a 500-kV transmission line. STATCOM, by injecting current in parallel with transmission line could control bus voltage and active power. Also, required active power for series section is supplied by DC-link capacitor. The block and circuit diagram of proposed seven level and nine level inverter based multilevel inverter based STATCOM and DVR is shown in Figure 4 & 5 respectively.

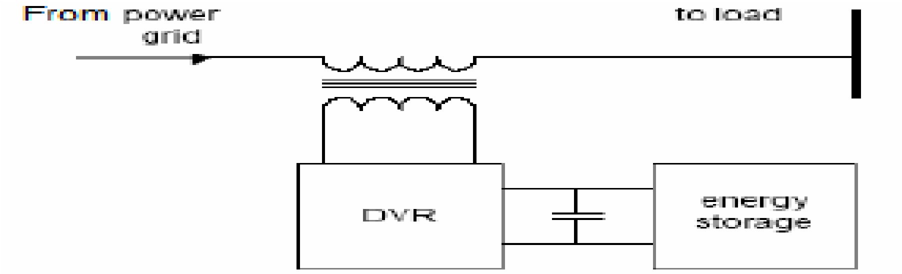

Figure 2. Standard Configuration of DVR

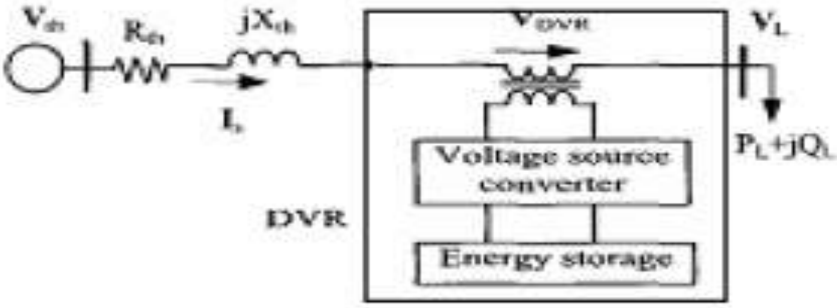

Figure 3. Schematic diagram of DVR

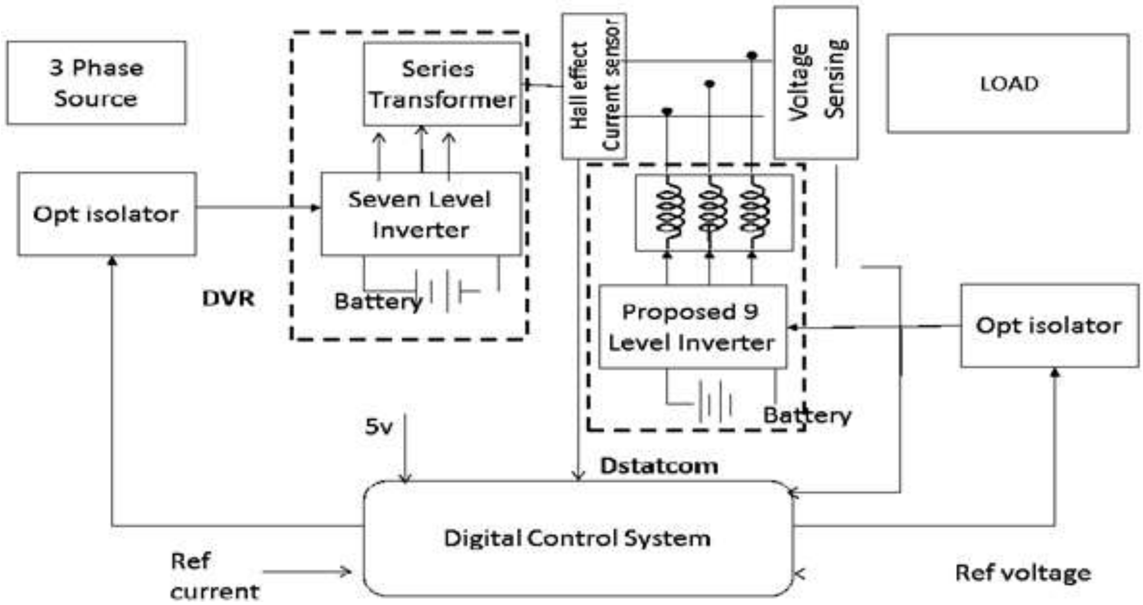

Figure 4. Block Diagram of proposed MLI

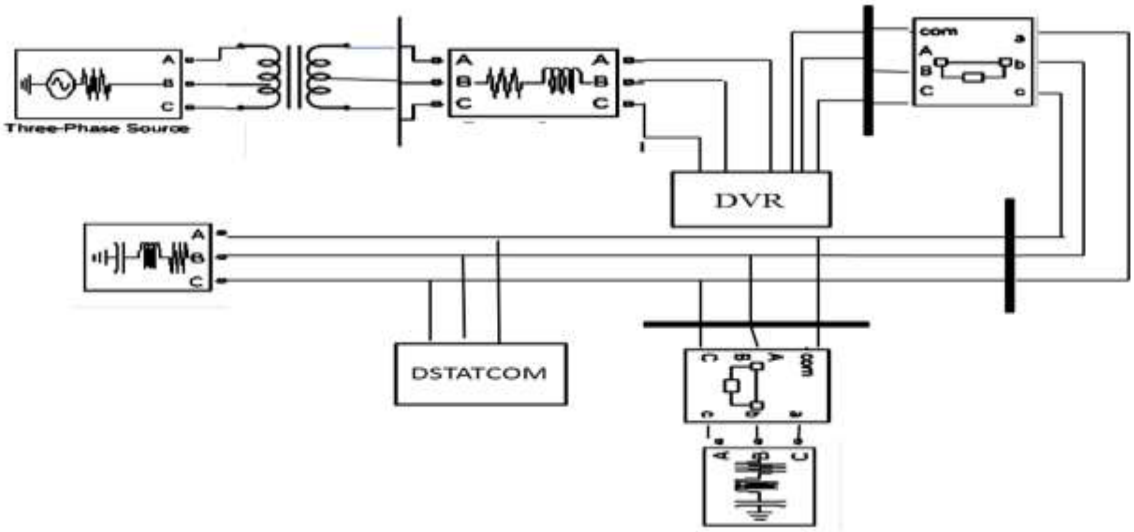

Figure 5. Circuit Diagram of proposed MLI

3. SIMULATION RESULT

The comparison of seven level and nine level based STATCOM and DVR systems is done using MATLAB and the result are presented here. The circuit diagram of MLI based STATCOM and DVR without compensation is shown in Figure 6 output of non-linear load, voltage and current waveform and PWM waveform of non-linear load is shown in Figure 7-13 respectively. Output of MLI without compensation is shown in Figure 14. Figure 15 shows the Simulation diagram of MLI based DSTATCOM & DVR with compensation**.** Table 1 shows the Comparison of MLI based DSTATCOM and DVR with and without compensation and output with compensation is shown in Figure 16. Figure 17 shows hardware model of MLI based DSTATCOM and DVR.

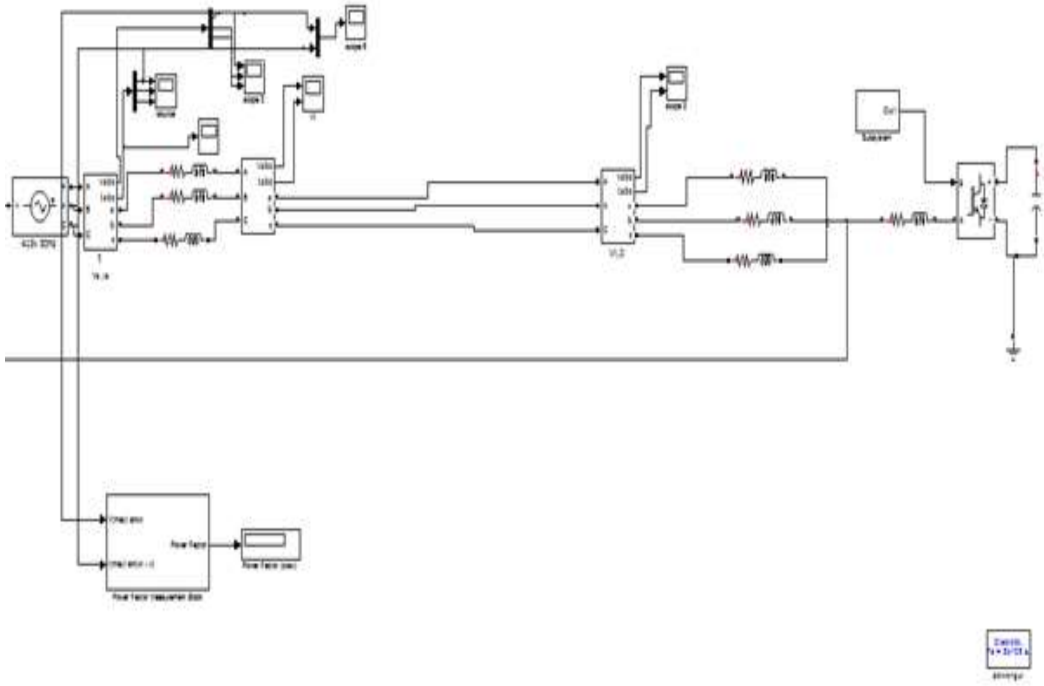

Figure 6. Simulation diagram of non-linear load

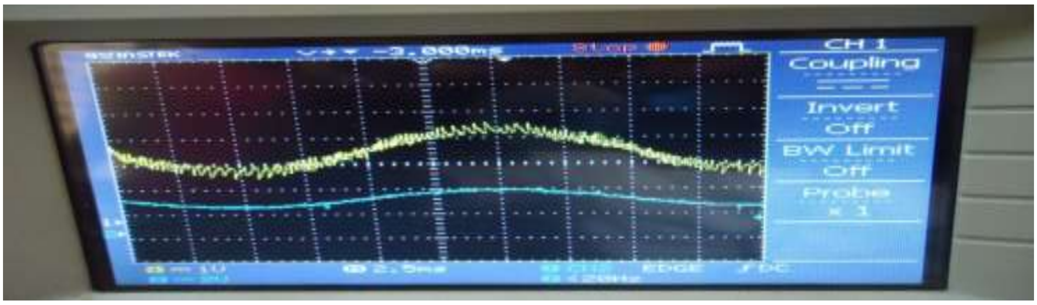

Figure 7. Non-linear load waveform 1

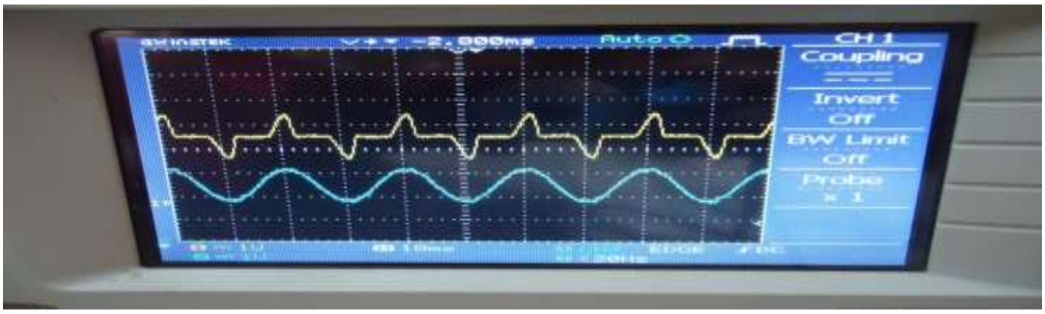

Figure 8. Non- linear load waveform 2

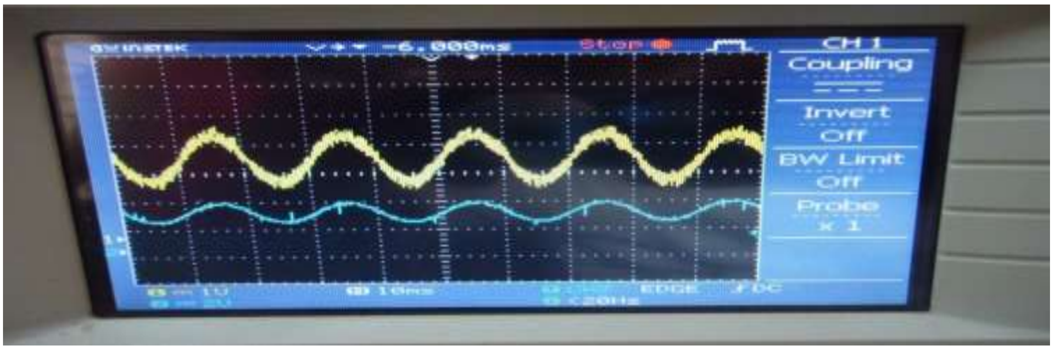

Figure 9. Voltage and current waveform

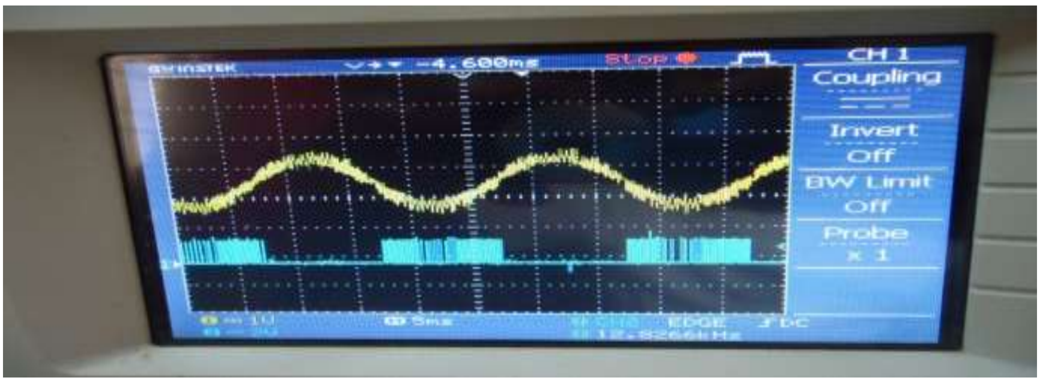

Figure 10. Low PWM waves 1

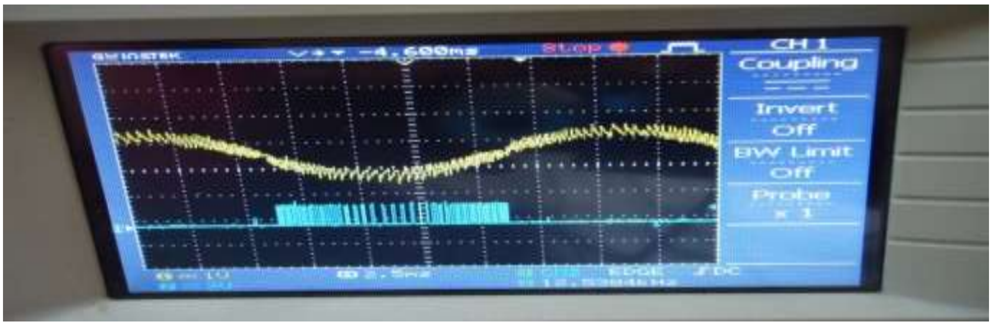

Figure 11. Low PWM waves 2

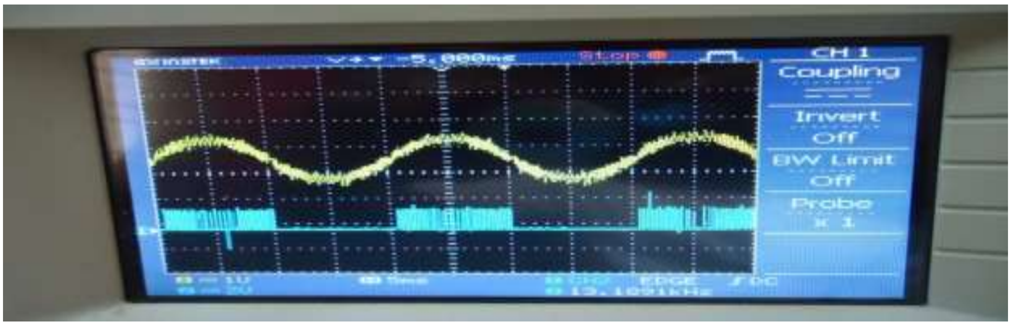

Figure 12. Upper PWM waves 1

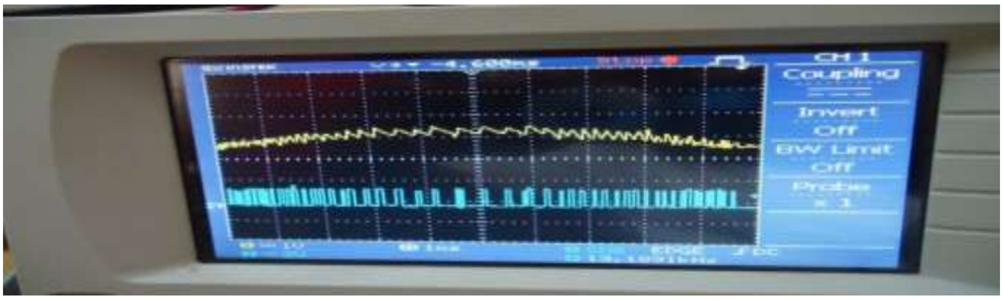

Figure 13. Upper PWM waves 2

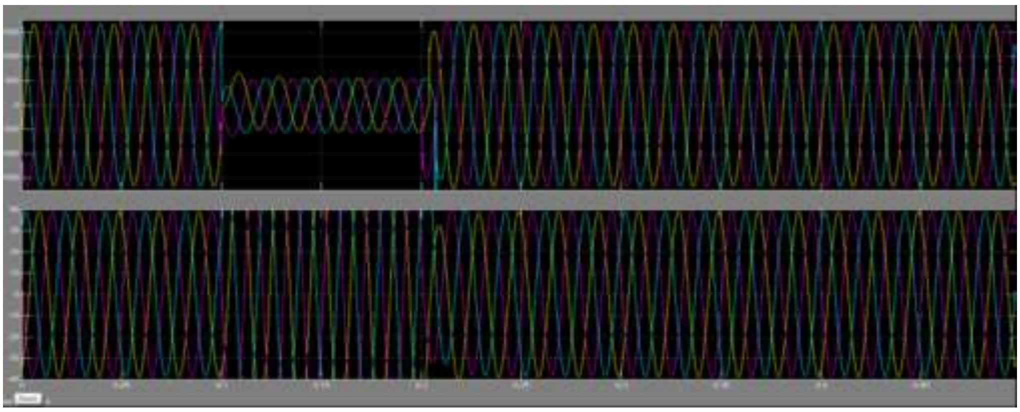

Figure 14. Output without compensation

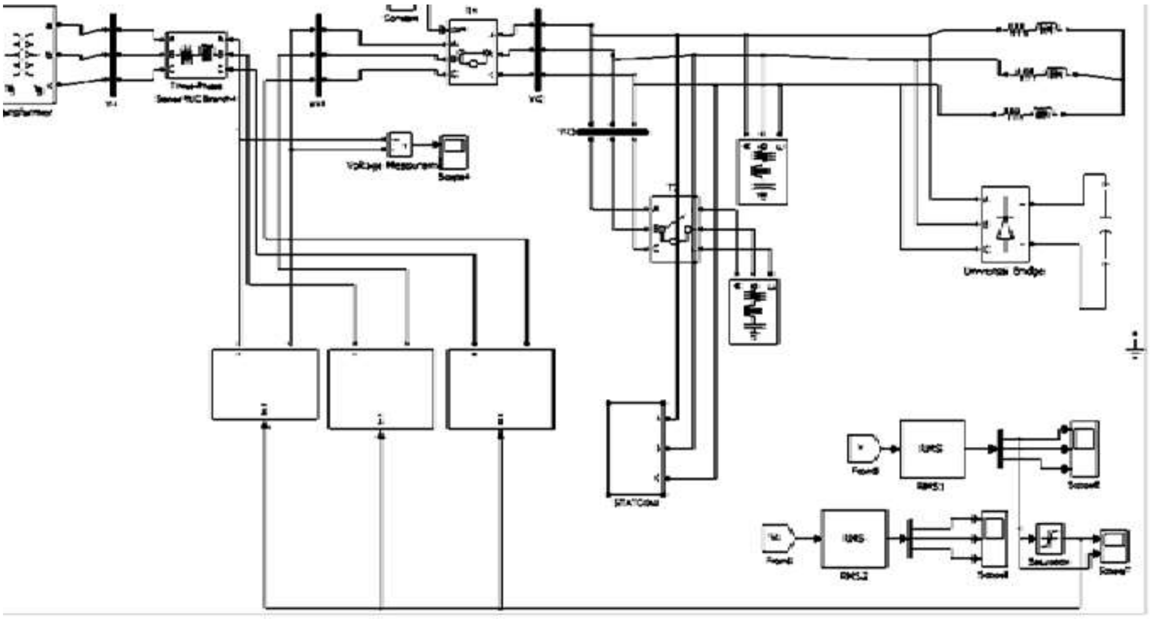

Figure 15. Simulation diagram of MLI based DSTATCOM & DVR with compensation

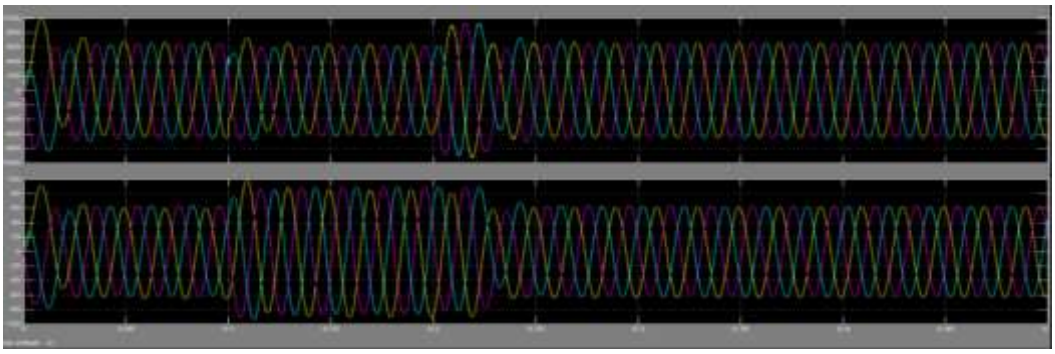

Figure 16. Output with compensation

Table 1. Comparison of MLI based DSTATCOM and DVR with and without compensation

S. NO	WITHOUT COMPENSATION	WITH COMPENSATION
1	INPUT 1500	INPUT 1500
2	OUTPUT 1000(SAG 500V)	OUTPUT 1500

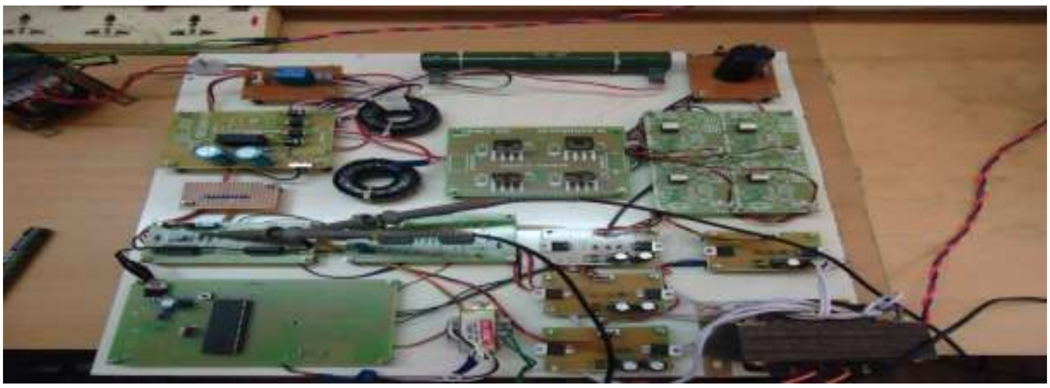

Figure 17. Hardware model of MLI based DSTATCOM and DVR

4. CONCLUSION

A seven level and nine level multilevel inverter with reduced number of switches based STATCOM and DVR system are successfully designed; Modelled and simulated using MATLAB and the corresponding results are presented. The result identified that no ripple voltage in the case of seven level and nine level multilevel inverter based STATCOM and DVR system. The present work deals with open loop controlled seven level and nine level based STATCOM and DVR system. The investigation on closed loop system will be done in future.

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