

DSTATCOM Performance for Voltage Sag, Swell Mitigation

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ABSTRACT: The main aim of this paper is to improve the power quality of grid. Modern industrial processes are mainly based on electronic devices and their controls are sensitive to the power quality problems such as voltage sag, voltage swell and harmonics. There are chances of failure or a miss-operation of end user equipments. Voltage sag is most important power quality problem that exit in power system. Distribution static compensator (DSTATCOM) is a promising device to provide not only for voltage sag mitigation but also solution for the voltage stabilization, harmonics, and flickers. DSTATCOM consist of capacitor, inverter models, PWM control strategy, transformer to match the inverter output to the line voltage. In this paper 6-pulse DSTATCOM configuration with IGBT is designed and simulation model is developed using MATLAB SIMULINK. A new PWM based control method has been used to allow the control of the power supplied to electrical devices.

KEYWORDS: DSTATCOM, voltage sag, VSI, controller.

I. INTRODUCTION

Power quality is a perfect power supply to the consumer devices. Technically, power is proportional to the product of voltage and current. It would be difficult to define the quality of this term in any meaningful manner. The power supply system can control the voltage but it has no control over the current that particular might draw. Therefore it becomes necessary to maintain the supply voltage within certain limits. The quality of power can have a direct economic impact on many consumers. So it becomes important to maintain better power quality of power supply. If electrical equipments cannot operate correctly then we would say that the quality of electrical power is not good. The first sign of a power quality problem is distortion in the voltage wave form of power source. The electronic devices which are used in the domestic and industrial processes are very sensitive to disturbances such as voltage sag, swell and harmonics. The most popular power quality problem is voltage sag and it contributes more than 80% power quality problems. The voltage sag is occurs when rms voltage decrease between 10 and 90 percent of nominal voltage for half cycle to 1 minute. It is a reduction in rms voltage for a short duration which can be caused by short circuit, starting large motors or by electrical faults inside the facility or caused by increase in source impedance, typically caused by a loose connection. By definition the voltage swell is an increase in rms voltage between 1.1 pu and 1.8 pu at the power frequency duration from 0.5 to 1 minute[5]. Voltage swell is a momentary increase in voltage and which is the opposite of voltage sag. The voltage swells are almost caused by reduction in loads in circuit, capacitor banks energizing and transfer of loads from one power source to another or by loose neutral connection. A change in voltage causes an increase or a decrease in the amount of energy that supplied to electrical power system components. A decrease in energy during a voltage dip can cause equipment to damage or miss operate. An increase in voltage during voltage sell can cause immediate breakdown of components due to overheating. There are different ways to mitigate voltage sag, swell and an interruption which is occurs in the power system. At present a wide range of very flexible controllers are used for power applications. Among these the DSTATCOM is most effective device to mitigate such type of power quality problems. DSTATCOM provides the most commercial solution to mitigation voltage sag by injecting voltage as well as power into the system. The mitigation capability of DSTATCOM is mainly influenced by the maximum load;

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power factor and maximum voltage dip to be compensated. The maximum load on the grid is an important task for DSTATCOM operation and desired voltage sag compensation. This paper proposes DSTATCOM system designed to maintain a constant RMS voltage value across a sensitive load. It can mitigate voltage sag caused by three phase fault and single line to ground fault. There are various methods which have applied to mitigate voltage sags. The conventional methods are to mitigate voltage sags are use uninterruptible power supplies and capacitor bank. Due to high cost of these conventional devices, the power quality problems are not completely solved. The DSTATCOM has emerged as promising device to mitigate the power quality problems such as voltage sag, voltage swell, harmonics and flicker. DSTATCOM is a shunt connected device which has ability to control the magnitude and phase angle of voltage or current. Generally, the DSTATCOM configuration consists of a DC voltage source, inverter circuit, coupling transformer and control strategy. The VSC converts the dc voltage into the set of three phase ac output voltages. These voltages are in phase and coupled with transmission lines through the reactance of the coupling transformer [2]. The PWM based control method is used which requires RMS voltage measurements and no reactive power measurements are required.

II. DSTATCOM CONFIGURATION

The DSTATCOM consist of dc voltage source, inverter circuit, coupling transformer and associated control strategy. The DSTATCOM is based on the voltage source converter (VSC) principle. The STATCOM is often used in the transmission system but when it is used in distribution system, it is called DSTATCOM. The DSTATCOM has quicker response time and compact structure as compare to the SVC. DSTATCOM is a shunt connected device which includes a voltage source converter (VSC) and dc capacitor, capable of generating and/or absorbing reactive power. The main block of the DSTATCOM is the voltage source inverter that converts dc voltage into the set of three phase output voltage at fundamental frequency.

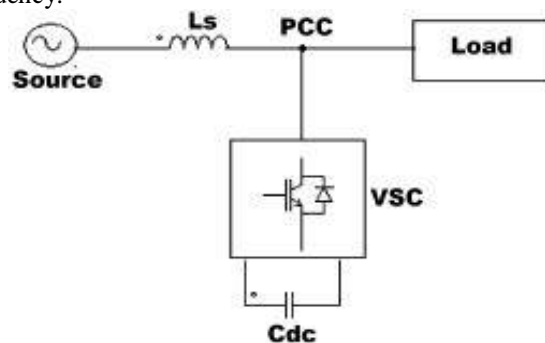


Fig.1. Basic structure of DSTATCOM

The output terminals of the VSC are connected to the Point of Common Coupling (PCC) through an inductance, which could be a filter inductance of the coupling transformer, as shown in figure 1. DC capacitor is the input of voltage source converter (VSC), 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 by the converter itself. No reactive power is delivered to the system, if the output voltage of VSC is equal to the AC terminal voltage. If the output voltage of VSC is greater than the AC terminal voltage then DSTATCOM is in the capacitive mode of operation and vice versa. The DSTATCOM employs an inverter to convert the DC voltage on the capacitor to a voltage source of adjustable magnitude and phase. The reactive power output of the D-STATCOM can be inductive or capacitive depending upon operation mode of the DSTATCOM [1]. The controller of the D-STATCOM is used to operate the inverter in such a way that the phase angle between the transmission line voltage and inverter voltage is dynamically adjusted so that the D-STATCOM absorbs or generates the desired VAR at the point of connection according to the requirement.

The block diagram of the control scheme designed for the DSTATCOM is shown in Fig. 2. It is based only on measurements of the voltage VRMS at the load point. The voltage error signal is obtained by comparing the measured VRMS voltage at a load point with a reference voltage, VRMS_Ref. The controller processes the error which is the difference between these two signals in order to obtain the phase angle δ that is required to drive the error to zero. The

angle δ is used in the PWM generator as the phase angle of the sinusoidal control signal. The modulating angle δ is applied to the PWM generators in phase A and the angles of phases B and C are shifted 120 and 240 degrees, respectively.

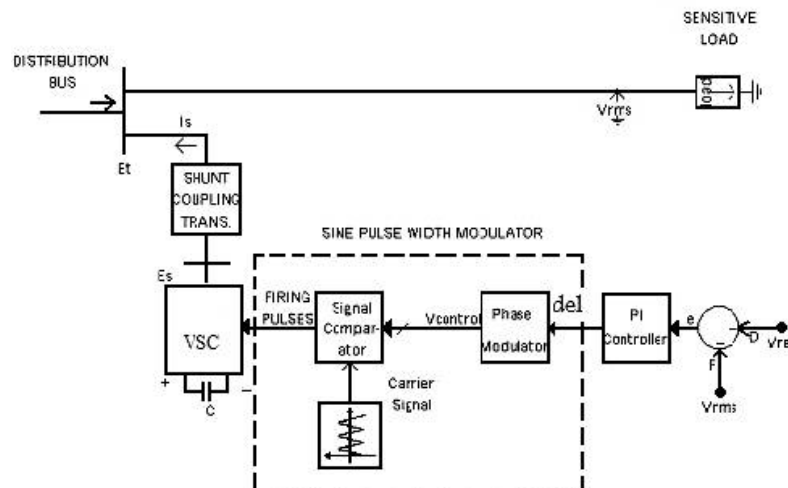


Fig. 2. Control scheme designed for the DSTATCOM

III. VOLTAGE SOURCE CONVERTER(VSC)

Voltage source inverter (VSC) is a power electronic device which is connected in shunt or parallel to the system. VSC can generate a sinusoidal voltage of any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable-speed drives, but it can also be used to mitigate voltage sags. The VSC is used to either completely replace the voltage or to inject the missing voltage. The missing voltage is the difference between the nominal voltage and the actual voltage. It also converts the DC voltage across storage devices into a set of three phase output voltages. The voltage source converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The suitable adjustment of the magnitude and phase of the DSTATCOM output voltages allows effective control of active and reactive power exchanges between DSTATCOM and AC transmission line. The semi conducting devices in the converter is then switched to get the desired output voltage.

IV. CONTROLLER

The aim of the control scheme is to maintain constant magnitude of voltage at the point where a sensitive load is connected, under system disturbances. No reactive power measurements are required; control system only measures the rms voltage at the load point. The switching strategy of VSC is based on a sinusoidal PWM technique which offers simplicity and good response. Modern semiconducting switches such as MOSFETs or IGBTs are suitable components for high efficiency controllers. High switching frequencies can be used to improve on the efficiency of the converter, without incurring significant switching losses in inverter. The input of controller is typically an error signal, which is the difference between reference signal and actual system output signal. The controller input is an error signal obtained from the reference voltage and measured rms voltage of terminal. Such an error is processed by a PI controller and the output is the angle δ , which is provided to the PWM generator. The error signal is generated by comparing the reference value and the actual value. Proportional-integral controller (PI Controller) is a feedback loop controller which drives the system to be controlled with the weighted sum of the error signal and the integral of that value. In this case, PI controller will process the error signal to zero that means the load rms voltage is brought back to the reference voltage by comparing the reference voltage with the measured rms voltages.

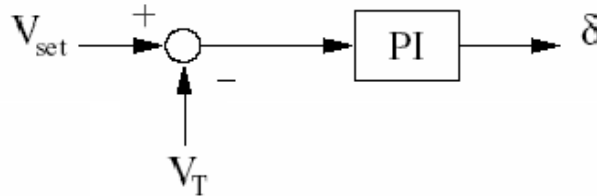


Fig.3 PI controller

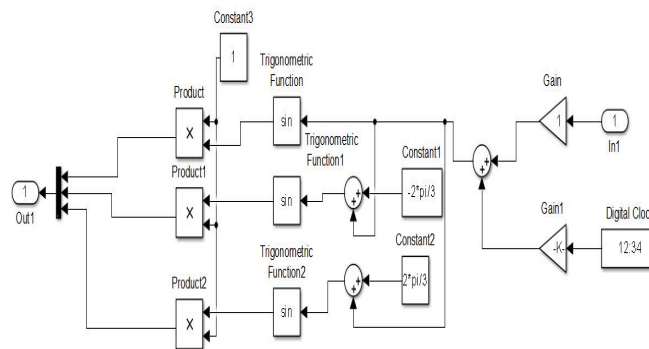


Fig.4 Phase-Modulation of the control angle δ

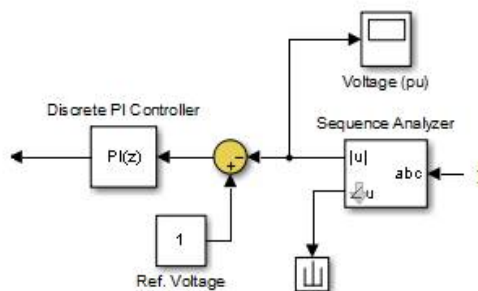


Fig.5 Simulink Diagram of Controller

V. METHODOLOGY

DSTATCOM is connected to the distribution system and designed using MATLAB simulink. The test system comprises a 230kv, 50Hz transmission system. A three phase load is connected to the 11kv, secondary side of the 3 winding transformer connected in Y/Y/Y, 230/11/11 kv. A varying load is connected to the secondary of 3 winding transformer. A two level DSTATCOM is connected to the 11kv of the system. The breaker is used to control the operation period of the STATCOM. On the dc side 75 μ F capacitor provides the DSTATCOM energy storage capabilities. The simulations are carried out for both cases where the DSTATCOM is connected to or disconnected from this system.

VI. SIMULINK MODEL FOR THE TEST SYSTEM

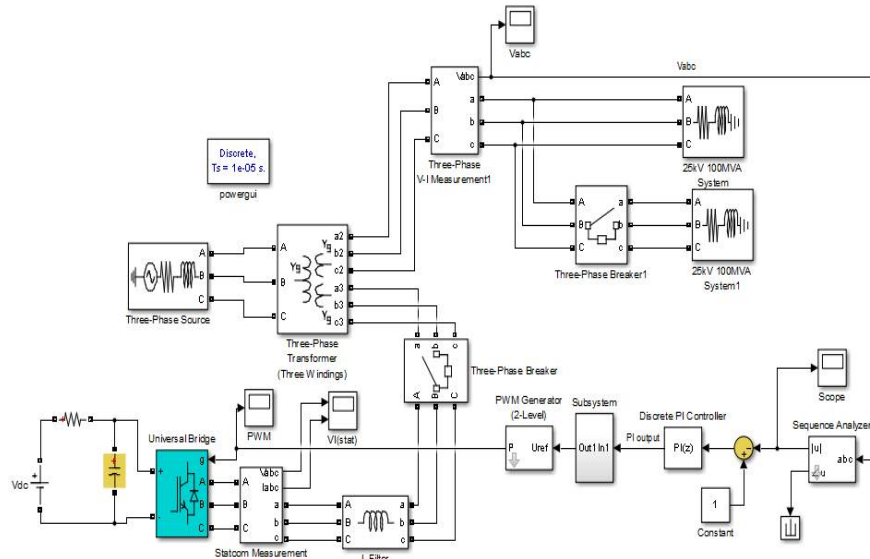


Fig 6

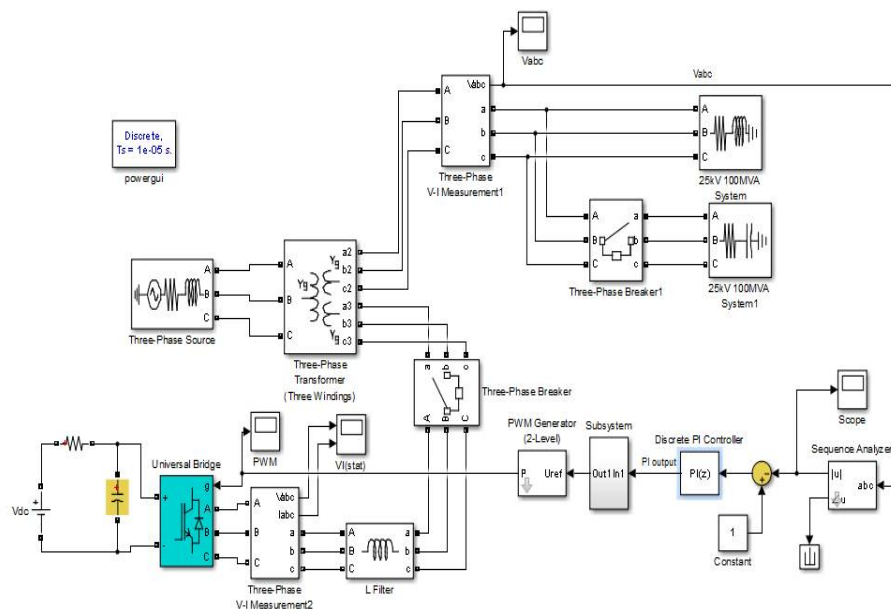


Fig7

VII. SIMULATION RESULTS

A. Simulation results for inductive load (3 phase balance sag) The immediately occurrence of inductive load is shown in fig7 for the duration 500ms to 900ms during this the balanced sag will occurs.

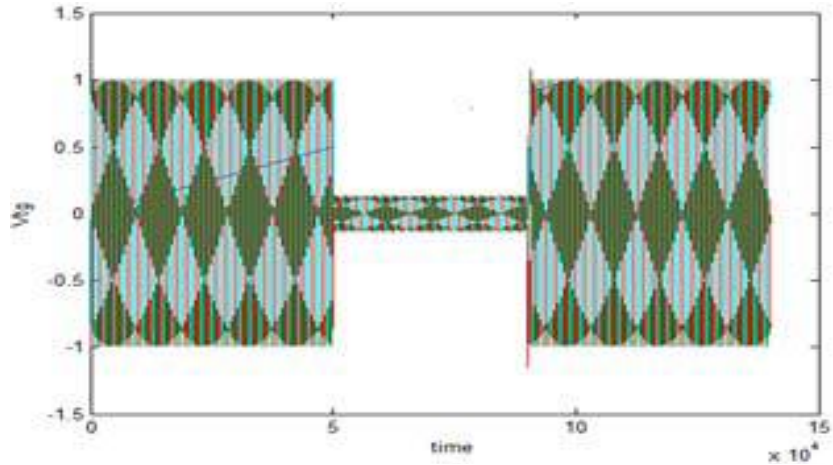


Fig. 6.1 Three phase profile at load point Simulation results of Vrms at load point

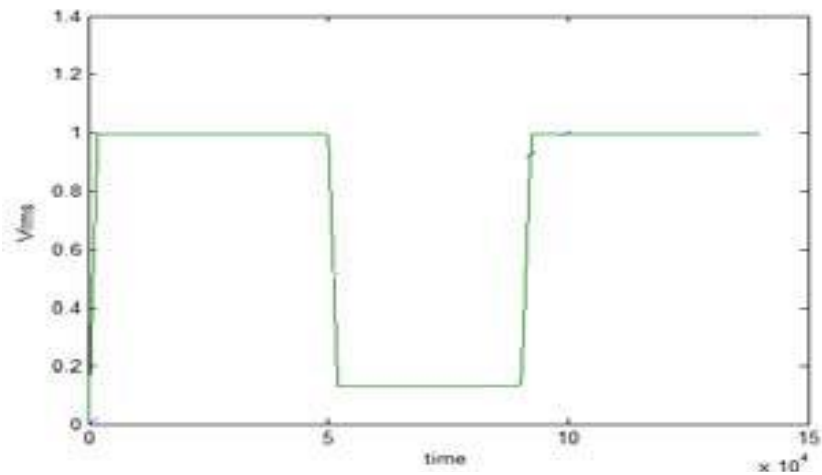


Fig.6.2 Simulation results after compensation at load side

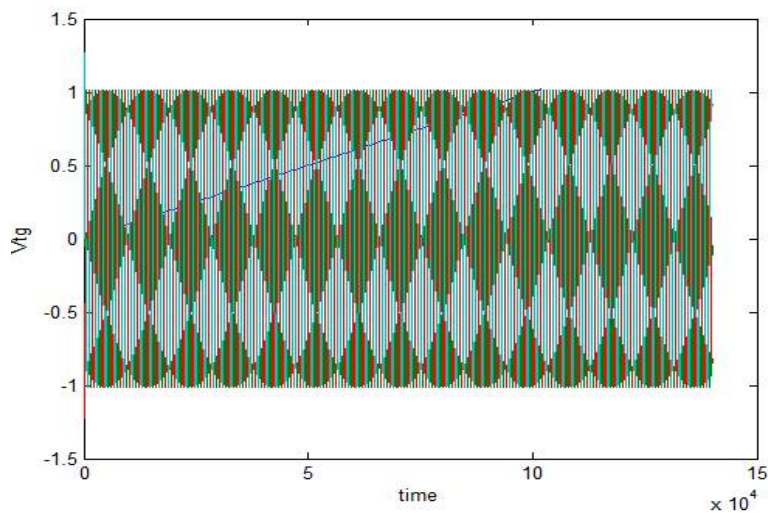


Fig.6.3 Simulation results of Vrms after compensation at load point

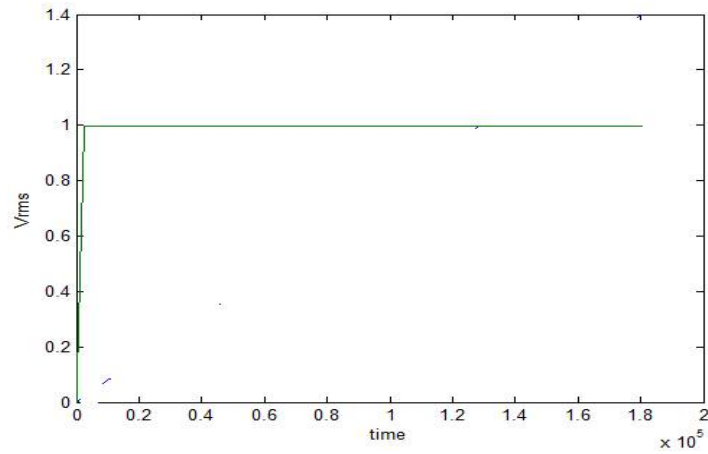


Fig.6.4 2. simulation result for capacitive load (voltage swell)

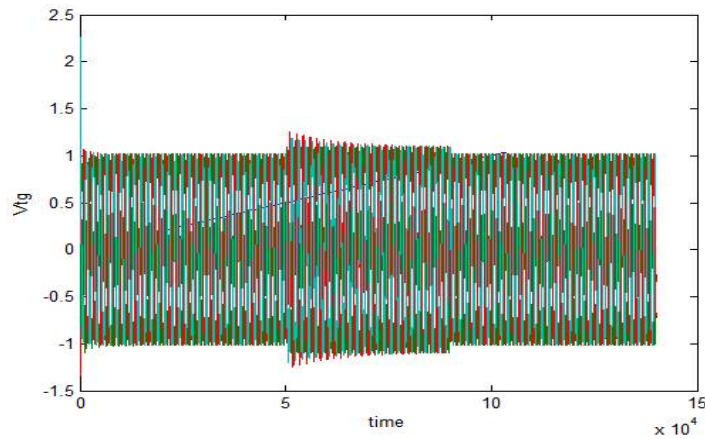


Fig. 6.5 Simulation result of Voltage Vrms at load point without D-STATCOM

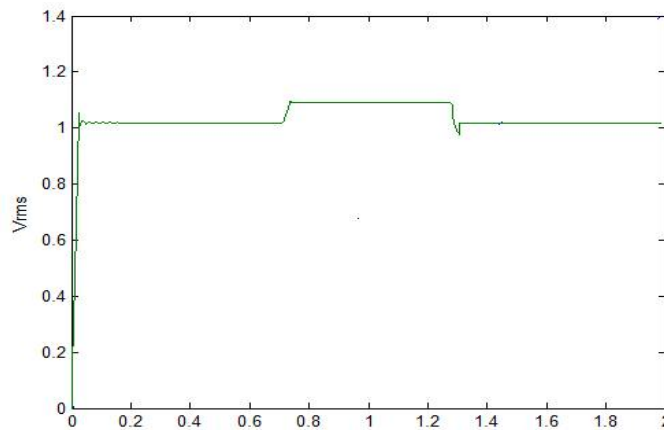


Fig. 6.6 Simulation result of after compensation at load point

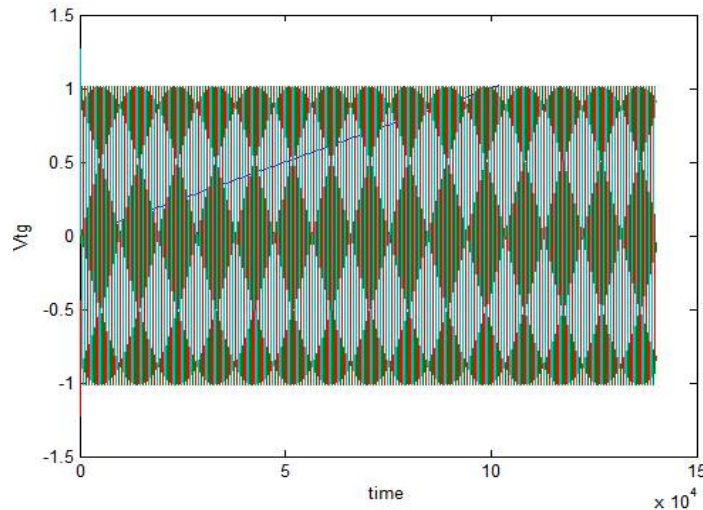


Fig. 6.7 Simulation result of Voltage Vrms at load point with DSTATCOM

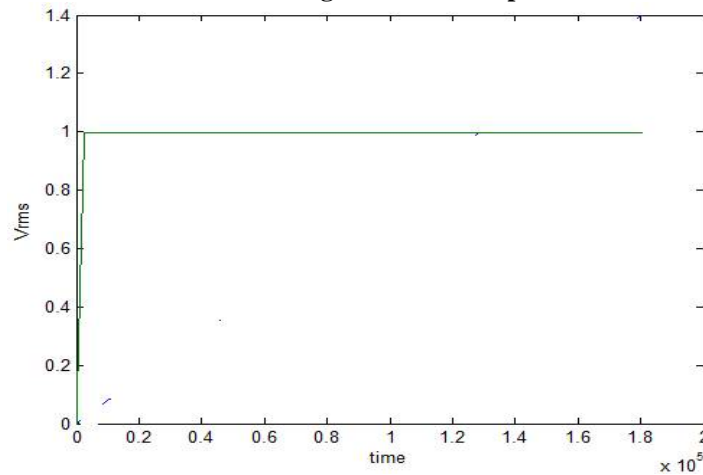


Fig. 6.8

VIII. CONCLUSION

This paper presents analysis and improvement of power quality (voltage sag, swell) performance of smart grid connected inverter used in distributed generation. From the above simulation results we can conclude that D-STATCOM is promising device and only the Vrms value is required to measure, so that complexity is reduced. DSTATCOM is used to mitigate the voltage sag, voltage swell at distribution side. It was observed that load voltage is very close to the reference value that is 1 pu and voltage sag and voltage swell are completely minimized.

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