Voltage Stability Analysis Using SVC in Modern Power System

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1 Introduction

In the areas of generation of electric power, transmission, delivery and use, today's changing electrical power networks are generating a rising imperative for stability, efficiency, quick reaction and precision. FACTS are modern instruments that are able to modifying voltage, angle and impedance at various points in power systems, emanating from recent advanced developments. Apart from steady-state flow regulation, their rapid reaction has a strong capacity for power system stability improvement. The SVC offers rapid performing dynamic reactive protection for energy assistance through emergency situations within the FACTS controllers, which would otherwise decrease the voltage for a substantial amount of time. Increased purchases also contribute to circumstances where the infrastructure no longer exists in the stable operating area of developing electricity networks. FACTS controls can play an important role in improving the security of the power system. However, it is important to position these controllers optimally in the power system due to high capital expenditure. Because of their versatility and quick control characteristics, FACTS instruments can manage active and reactive power control and respond to voltage scale control simultaneously. Placing these devices in the right position will contribute to line flow regulation and hold bus voltages at the optimal level and thereby increase the margins of voltage stability. One of the phenomenon that culminated in a big outage is voltage instability. Furthermore, the issue of voltage strength has developed into the main problem in deregulated power systems with the accelerated progress of restructuring. It is desirable to schedule necessary steps to enhance the security of the power system and to maximize voltage stability margins in order to ensure the protection of those systems.

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1.1 Structure of SVC

The SVC control consists of the following:

- The positive sequence energy to be regulated is determined by a measuring device. A calculation method based on Fourier that uses a one-cycle running average.
- An energy regulator that uses the voltage error to evaluate the SVC susceptance B required to maintain the device voltage steady (difference between the calculated voltage Vm and reference voltage Vref).
- A distribution unit that specifies the TSCs (and finally TSRs) that have to be switched in and out and measures the TCRs' firing angle.
- A synchronizing device that synchronizes the secondary voltages with a phase-locked loop (PLL) and a pulse generator that gives the thyristors the necessary pulses (Fig. 1).

In two distinct modes, the SVC can work:

- In voltage-control mode;
- In var mode of operation (the susceptance is kept stable). The subsequent V-I characteristic is introduced when the SVC is worked in voltage control mode (Fig. 2).

The voltage is controlled at the reference voltage Vref, as long as the SVC susceptance B remains below the highest and lowest susceptance values imposed by the overall reactive capacity of the capacitor banks (Bcmax) and reactor banks (Blmax).

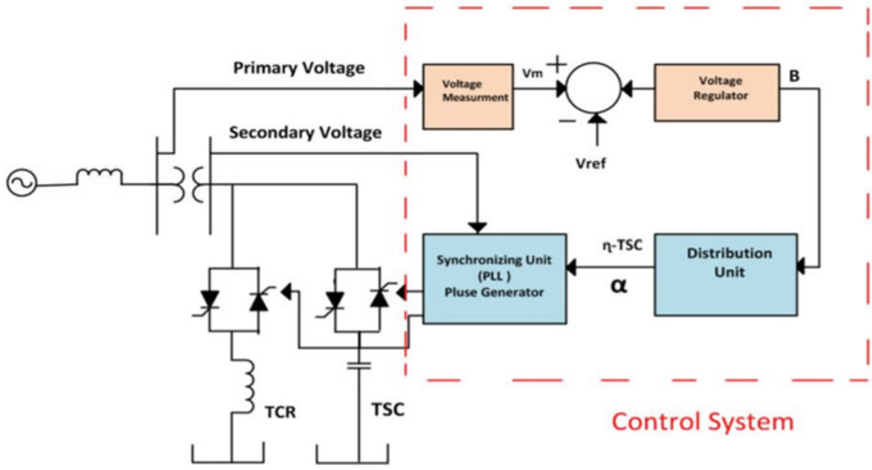
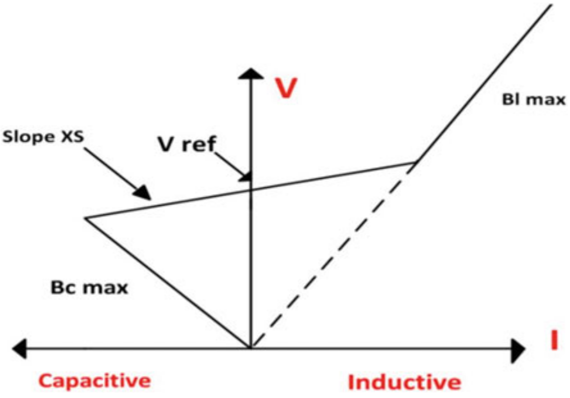


Fig. 1 Control System of SVC

Fig. 2 V-I Characteristics Curve of SVC



2 Literature Survey

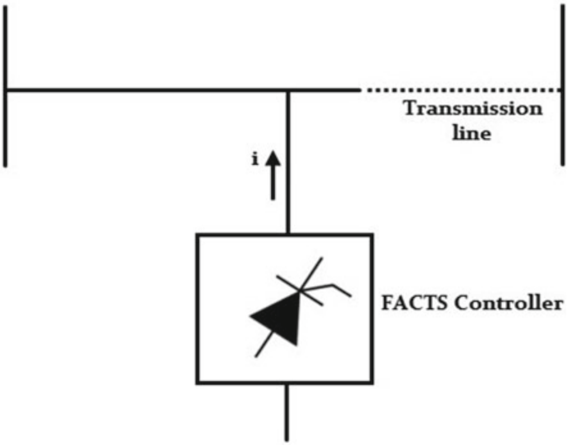
In 2015, Agbar et al. [1] for different case studies, with optimal TCSC and SVC setting criteria, the optimal transmission losses and subsequent generation schedules were also stated. By single and several TCSC and SVC plans through possibility review, the efficiency of the algorithm has been checked for the IEEE-30 Bus framework and does not suffer from computational difficulties. In 2017, Lei Wang et al. [2] this work presents a thyristor-controlled LC (TCLC) compensator in a smart grid framework for complex reactive power compensation. The proposed TCLC will greatly reduce the injection of harmonic currents compared with typical SVCs such as a fixed capacitor-thyristor operated reactor (FC-TCR) that produces low-order harmonic currents. The architecture of the TCLC parameters is discussed in this work, taking into account its reactive power compensation spectrum and the rejection of harmonic currents. The system control based on the generalized principle of instant reactive force is suggested. In 2002, Lei Wang et al. [3], major new resource for the foreign utility sector static reactive power compensators have developed into advanced innovations over the past two decades and have been an essential part of current electrical power systems. In compact AC transmission systems, they are one of the main devices (FACTS). The organization of fixed compensators with additional controllable FACTS equipment promises not only a considerable improvement in the controllability of the power grid, but also the expansion of the performance of the current transmission corridor to similar thermal capacity, thus delaying or even eliminating the need to provide in original transmission installations. Thyristor-Based FACTS Controls for Electrical Transmission Systems offer together with in-depth management of scientific principles and realistic implementations applied to these power compensators, satisfying the need for an adequate text on this new technology. In 2017, Jai Damania et al. [4] discussed TCR. In recent years, however, pioneers of electrical energy have confronted both the financial and environmental challenges of expanding electricity production and communication. These circumstances have prompted power designers to search for innovative systems of techniques to increase the controllability, reliability, and power move capacity of AC communication systems that are FACTS instruments used to monitor the communication grid power flow to alleviate obstruction and reduce flows. Thus, FACTS utilizing Thyristor regulated reactance is used either when the transmission line is charged or when the receiving end has a very low load. In 2019, Dmitry Ivanovich Panfilov et al.'s [5] work illustrates the control theory that relies on the multi-terminal switch of this TSC topology. A proper control scheme is built to aggressively monitor the necessary reactive force for the complex load and to transit completely from one stage to another. The simulation model is used by MATLAB/SIMULINK to show the dynamic output of the TSC during the reactive force correction required for the induction motor in the start-up. In 2017, N. Narasimhulu et al.'s [6] work, the oscillating instant and expense of these integrated devices can, however, are increased considerably. The integrated SVC and STATCOM devices compensate for the reactive strength as well as the harmonic currents of nonlinear loads. The initial expense of the integrated systems will be very large when doing this. For dynamic reactive force compensation in the smart grid, a thyristor-controlled LC (TCLC) compensator is proposed in this work. The simulations can be contrasted to standard types of compensation. The usefulness of TCLC performance can be applied using MATLAB/Simulink.

3 Proposed Model

Shunt FACTS regulators, as long as the current is in step quadrature with the voltage, are connected in conjunction with the line and usually insert current into the device at the position of connection (Fig. 3).

In this study, SVC is integrated for load flow analysis into the nine-bus power framework. For the SVC paid method, load flow analysis was carried out by varying

Fig. 3 Controller



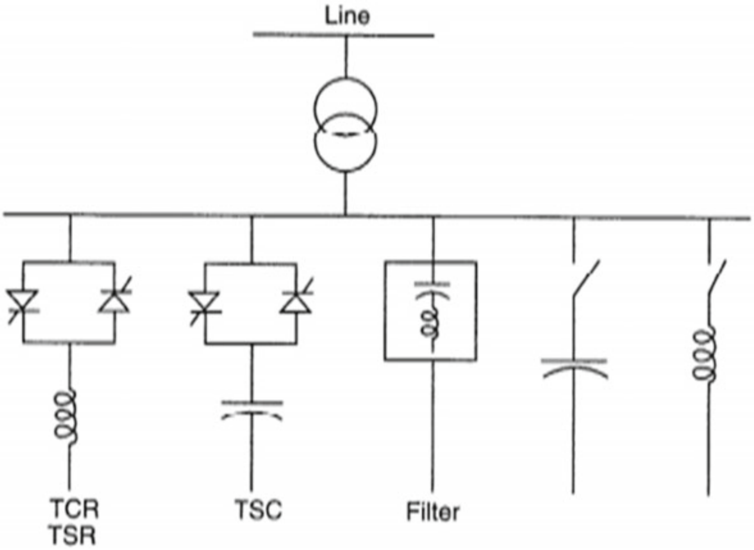


Fig. 4 Single-line diagram of the SVC

the position of SVC from bus1 to bus9 for output study and then it is possible to determine the optimum location.

SVC is a shunt-related form FACTS controller. SVC is attached to the line in parallel. It consists of a set of controls for the absorption of reactive vars such as thyristor-controlled reactor (TCR) or thyristor-switched reactor (TSR) and thyristor-switched capacitor (TSC) for the injection of reactive vars at the time of necessity into the device. It often consists of different filters in the device for filtering out such harmonics. In power factor correction, SVC plays a significant function (Fig. 4).

An SVC may not have some major moving components, unlike a synchronous condenser that is a rotating electrical unit. Power factor compensation was the conservation of large revolving devices such as switched capacitor banks previous to the advent of the SVC. The SVC is an automatic matching mechanism for impedance, which is built to get the machine closer to the power factor of unity. SVCs are used in two main situations:

(1) To control the transmission voltage linked to the power grid (“Transmission SVC”);
(2) Linked close to broad industrial loads to increase the efficiency of electricity (“Industrial SVC”).

To achieve the susceptibility needed by the voltage regulator, the SVC Controller tracks the primary voltage and sends sufficient pulses to the thyristors. Every three-phase bank is attached to the delta such that the zero-sequence triple harmonics stay locked within the delta throughout the regular balanced activity, thereby minimizing harmonic injection into the power system.

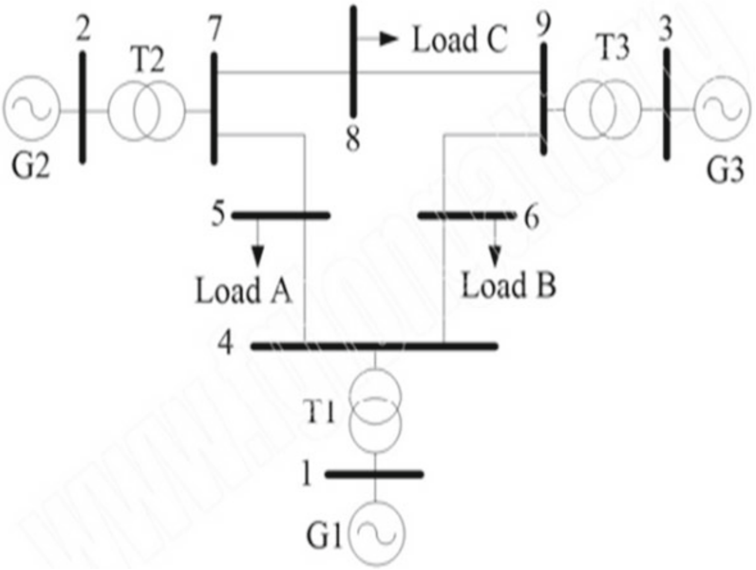


Fig. 5 9 Bus system

The prototype device under investigation is a 3-machine, 9-bus system focused on 1000MVA. Bus 1, bus 2 and bus 3 have three engines. Similarly, bus 5, 6 and 8 are listed as load buses (Fig. 5).

4 Simulation Results

In the MATLAB/Simulink setting, the whole model is simulated. For comparative purposes, two effects have been studied.

(1) Implementation with SVC,
(2) Implementation without SVC.

The influence of the SVC application in the device can be readily interpreted by contrasting the situations where the compensator is applied. Given the subsistence of the load attached to the bus, the operation of the static SVC increases the system voltage. The covering load requires reactive power and the voltage on the device does not decrease if supplied by the compensator on the bus and the overload reactive var supplied by the load, the var compensator absorbs the power and balances the voltage.

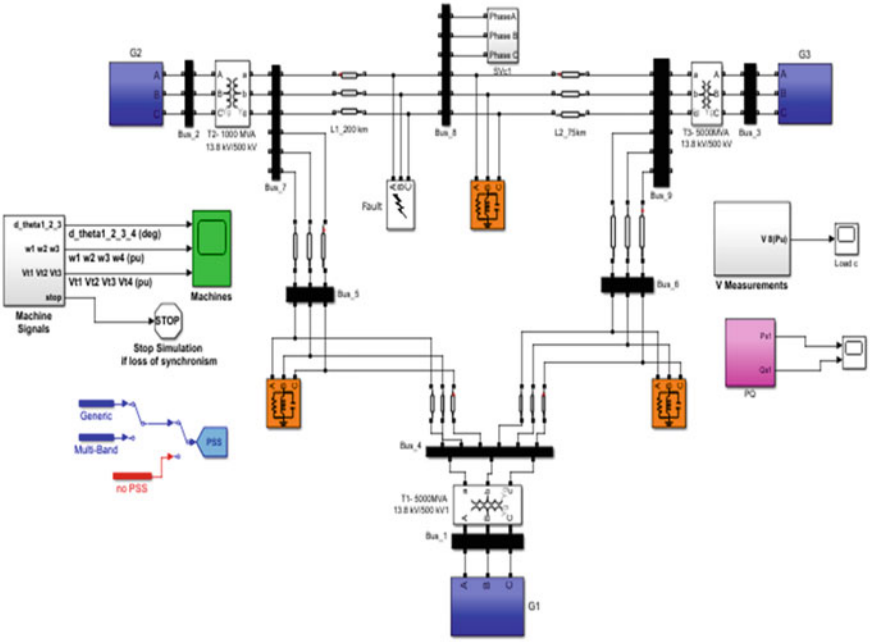


Fig. 6 9 bus system with SVC

4.1 With SVC

The SVC block is linked to the load bus in nine-bus systems described above, as seen in the SIMULINK block diagram below:

Without SVC. It is a nine-bus device whose output is studied in MATLAB/Simulink without using SVC and the effects are observed. In both the transmission line and the load bus, SVC can be used. Here, the implementation of SVC in the load bus was addressed. Simulation is performed as an powergui on discrete. The transmission line's impact on the distribution of reactive electricity is almost ignored. The simulation block of the nine-bus device in Simulink is seen below (Figs. 6, 7, 8 and 9).

5 Conclusion

The simulation result indicates that the system has increased the transmitting capability of rows. As a consequence of the inclusion of SVC, the severity of the failure was minimized and the major machine errors were also decreased. SVC is renowned for the compensation of reactive resources and it demonstrates power compensation to some degree. SVC's simulation in this paper has confirmed that it can be extended

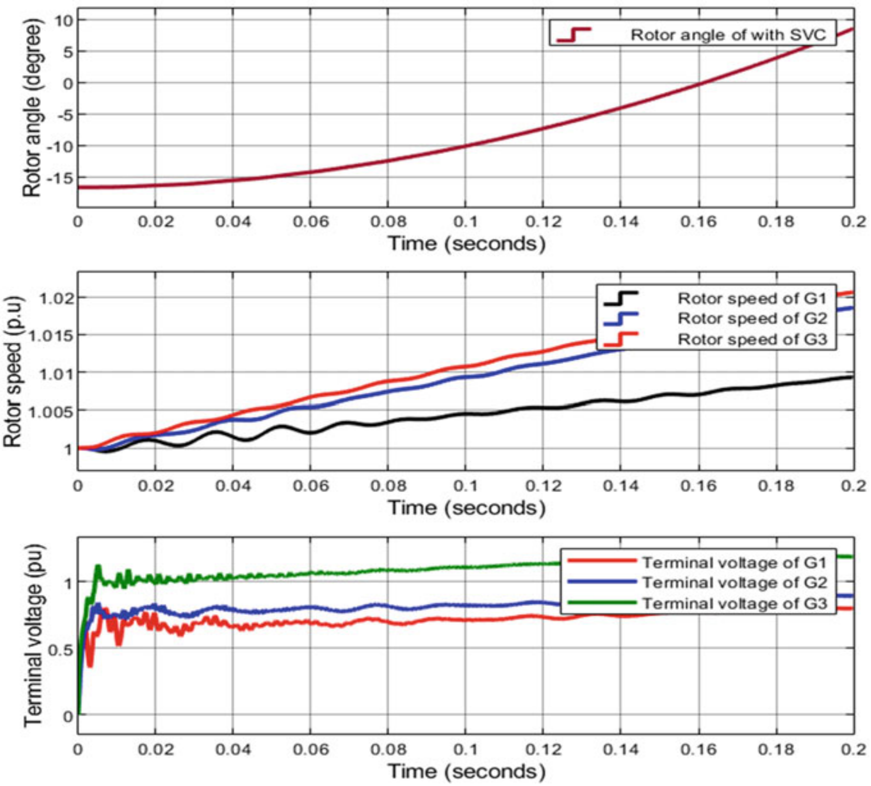


Fig. 7 Machines Signal

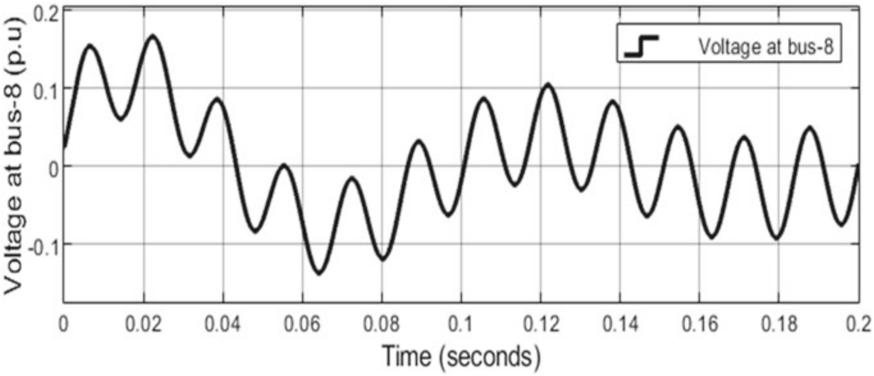


Fig. 8 Voltage of Bus 8

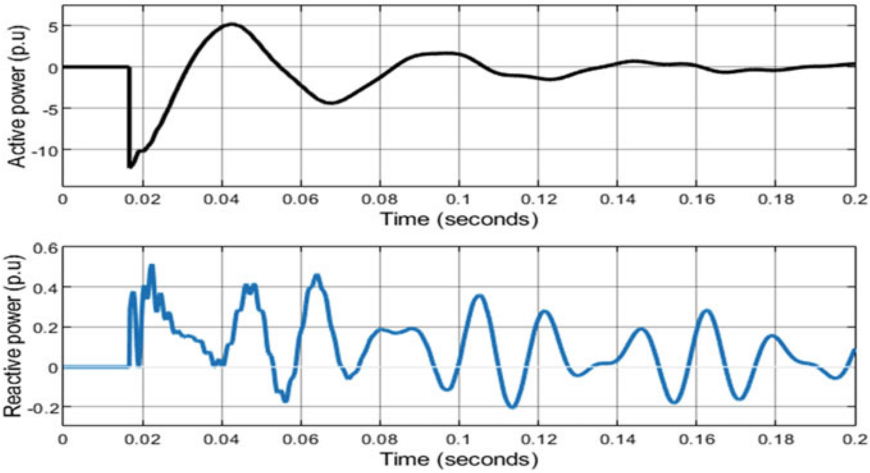


Fig. 9 Active and reactive power of bus 8

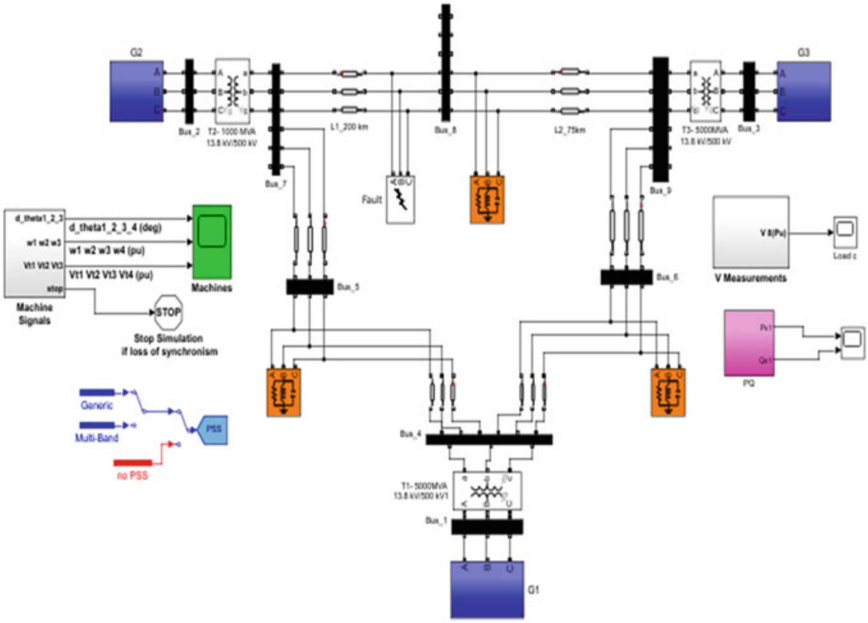


Fig. 10 Nine-bus system without SVC

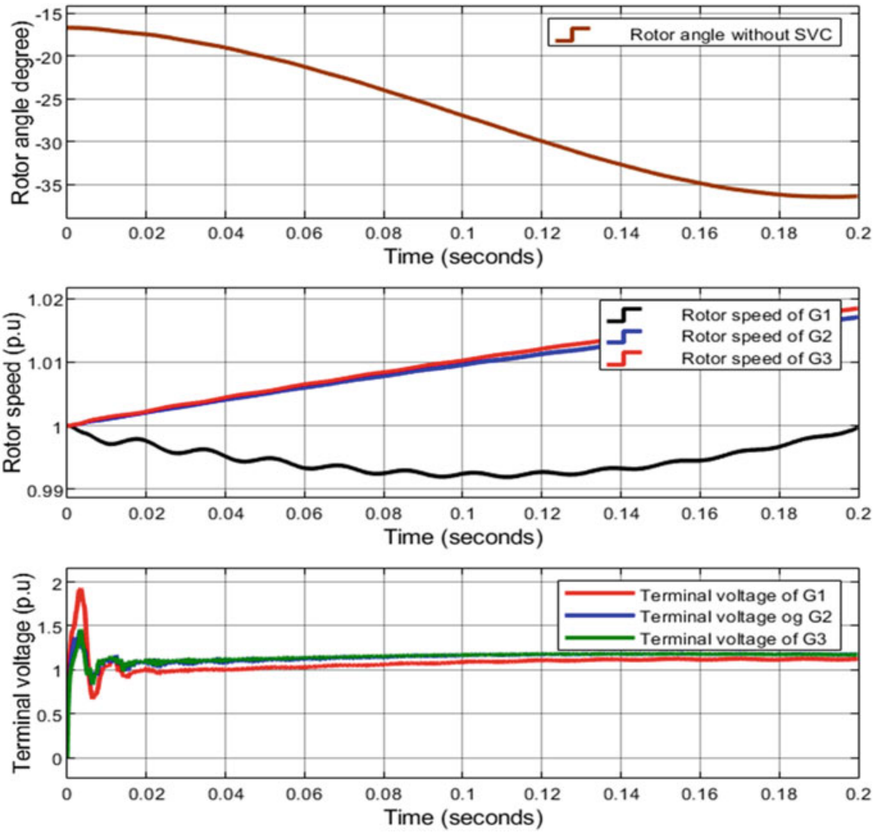


Fig. 11 Machines Signal

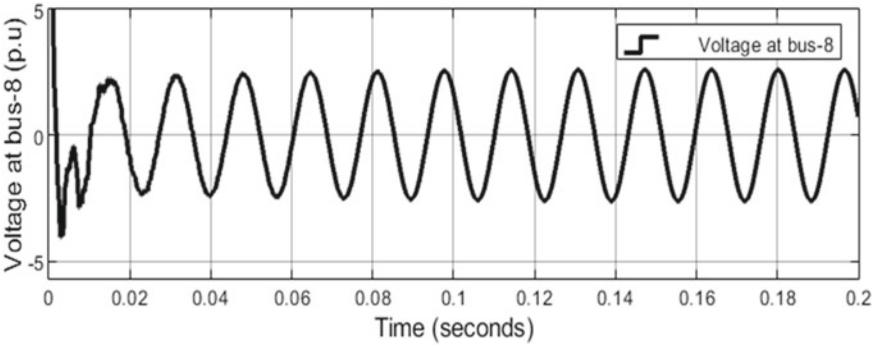


Fig. 12 Voltage of bus 8

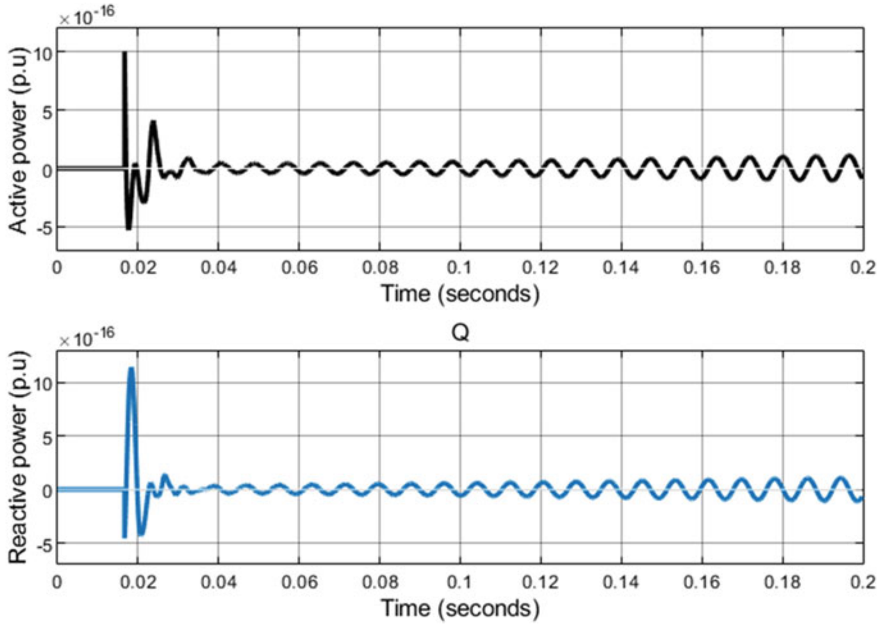


Fig. 13 Active and reactive power of bus 8

to the power transmission line to compensate for the reactive power and to increase the voltage profile as well. A change in the voltage profile in the nine-bus system was demonstrated by the usage of the SVC. The power device is used to maximize the transient voltage behavior of the power system.

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