POWER FLOW AND VOLTAGE ARE IMPROVED VIA SERIES FACTS DEVICES UTILISING TCSC AND SSSC TECHNIQUES

Mrs.P.GANGA[1], Mr.G.VINOTHBABU[2], Mr.L.GNANAPRAKASH[3]

[1,2,3]Assistant professor, Department of Electrical and Electronics Engineering,AEC,Salem

Abstract:

Due to a lack of new output and an increase in demand, inadequate reactive power has recently led to voltage drops. In this study, the output current and voltage levels are enhanced employing a set of FACTS controllers. The transmission line's impedance is changed by the Series FACTS controllers, which are connected in series to the transmission line, to control the flow of power. The TCSC series FACTS controller links a variable inductance in parallel with a line to change effective line reactance; in sensitive mode, it induces voltage in parallel with the communication line to provide a higher voltage level. The SSSC was an avant-garde FACTS controller that optimises active power flow and voltage profile. The FACTS gadgets The IEEE 14 Bus test system and the MATLAB/SIMULINK system are utilised in this study to evaluate the performance of the TCSC and SSSC for good voltage profile advancement, active power outflow improvement, and mitigation.

1. Introduction

A contemporary power system is a complex network of producers, distribution and transmission, a diverse range of loads, and transformers. Certain transmission lines are handling more traffic than expected when they were built as a result of growing energy usage. When long transmission cables are loaded more heavily, the issue of dynamic response following a significant failure may become a transmission limiting factor [1]. Power engineers are much more concerned about transient stability difficulties as a result of the blackouts in the northeastern U.s., Denmark, Britain, and Italia. Transient stability [2] refers to a system's ability to maintain synchronous functioning in the face of severe interruptions like as multi-phase brief failures or line switching.The original operational characteristics of the system, and also the degree of the disturbance, determine stability. A recent development in power electronics is the FACTS controllers in energy systems. FACTS controllers have the ability to control network conditions very quickly, which can be utilised to improve voltage stability, and also the steady and transient durability of a complicated power system [3]-[8]. This allows for efficient network utilisation, moving closer to its thermal loading and lowering the need for new power lines.

There is a huge need to increase electric power use while ensuring reliability and security in today's extremely complex and linked power systems [1]. Because electricity flows in certain transmission lines far below their typical limitations, other lines are overloaded, causing voltage profiles to deteriorate and system stability and security to deteriorate [2]. As a result, controlling the power flow through transmission lines to satisfy the demands of power transfer becomes increasingly crucial.

The most versatile of the FACTS devices is the UPFC, that can be utilised to increase steady - state condition, static, and transient stability. The UPFC may regulate many parameters independently because it is a combination of the STATCOM and the SSSC. These devices offer an alternative method of dealing with power system oscillations. In various studies, UPFC has been demonstrated to improve the stability of SMIB and device compatibility systems. In terms of stability, the inter-area electricity system is unlike any other. The use of a UPFC to enhance the transient response of a two-area power grid is the subject of this study. A Matlab/Simulink model is constructed for a two-area electricity system with a UPFC.

2. FACTS CONTROLLERS

FACTS controllers can be built on either thyristor or voltage transformer that have a gateway turn-off. FACTS controllers are used to dynamically manage the voltage, impedance, and phase difference of live electrical AC transmission lines. The accompanying FACTS controllers are briefly discussed, as they are used in the two-area power grid under examination.

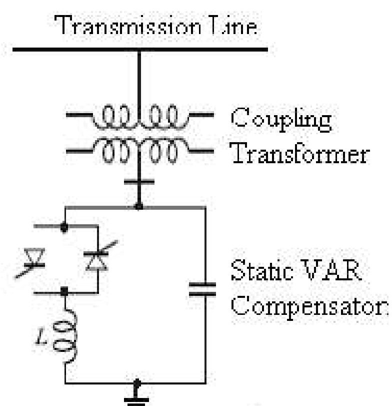


Fig. 1 Configuration of SVC

2.2 TCSC

The TCSC is the most important and very well FACTS components, and it has been used to enhance stability of the system and electrical transmission for many years. The basic circuit of a TCSC is shown in Figure 2. The capacitor bank C, bypass inductance L, and unidirectional thyristors SCR1 and SCR2 are the three main components of the TCSC. To vary the TCSC capacitive coupling, the firing angles of the transistor are altered in accordance with a system control method, which is usually in response to changes in process variables. This process can be defined as a rapid shift between matched reactances provided to the power system as the thyristor fire angle or conductivity angle is changed.

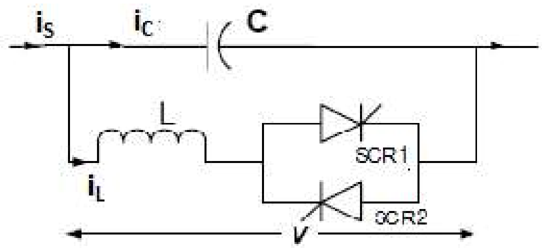


Fig. 2 TCSC Configuration

2.3 SSSC

The SSSC is a recently published FACTS device for electricity distribution series compensation. Because it can infuse a basically sinusoidal signal in series with a communication line with changing and variable amplitude & phase difference, it can be considered a synchronised voltage generator. The voltage injected into the line is virtually unison with the current flowing through it. A little fraction of the injected power that is in sync with the current provides the losses in the converter. An inductive and capacitive reactance is placed in series with the transmission line by the bulk of the inserted voltage, that is in quadrature with both the line current. The changing reactance has an impact on the electric power transmission in the power line.

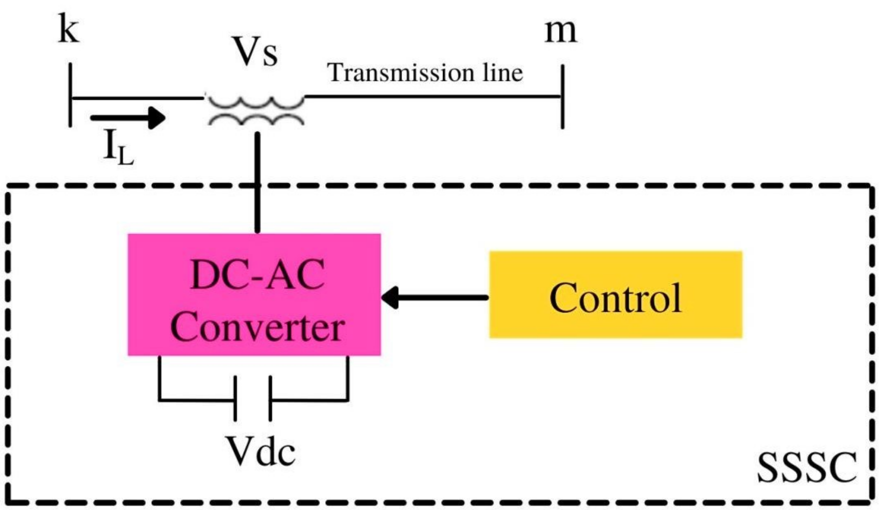


Fig. 3 SSSC

2.4 UPFC

UPFC is the most adaptable FACTS device, with the capacity to improve steady state stability, dynamic stability, and transient stability. Figure 4 depicts the basic structure of a UPFC. The UPFC is made up of two ac/dc converters that can both supply and absorb actual and reactive power. The shunt converter exchanges a current with a regulated magnitude and power factor angle with the power system. The dc bus voltage is often adjusted to balance the real power withdrawn from or injected into the power system by the series converter, plus the losses, by controlling it at a specific value.

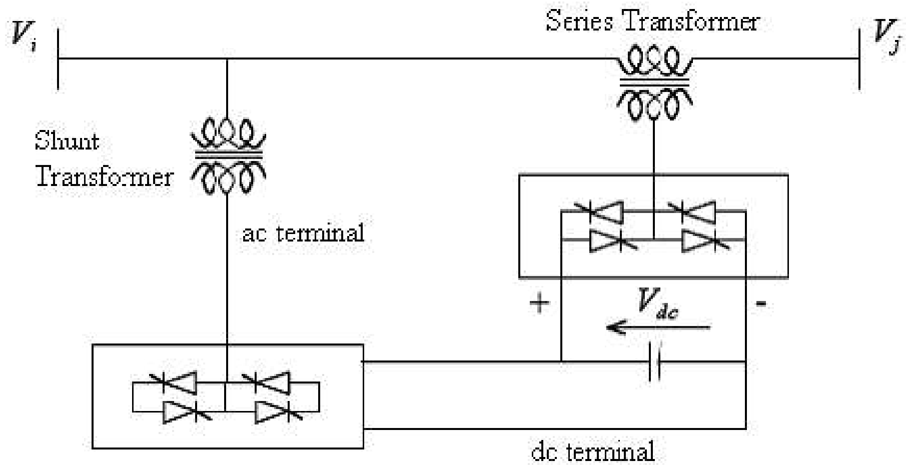


Fig. 4 UPFC Configuration

3. Model of a two-area power system

A two-area power system with series and shunt FACTS devices is connected by a single circuit long transmission line, as shown in Figs. 5 and 6. Series FACTS devices such as UPFC, SSSC, and TCSC are installed between bus-2 and bus-3, whereas shunt FACTS devices such as SVC are installed at bus-2. Actual power is flowing in the direction of Area-1 to Area-2. In the two-area power system paradigm, Area-1 consists of Generator 1 (G1) and Generator 2 (G2), whereas Area-2 consists of Generator 3 (G3) and Generator 4 (G4) (G4). The system's information is made available.

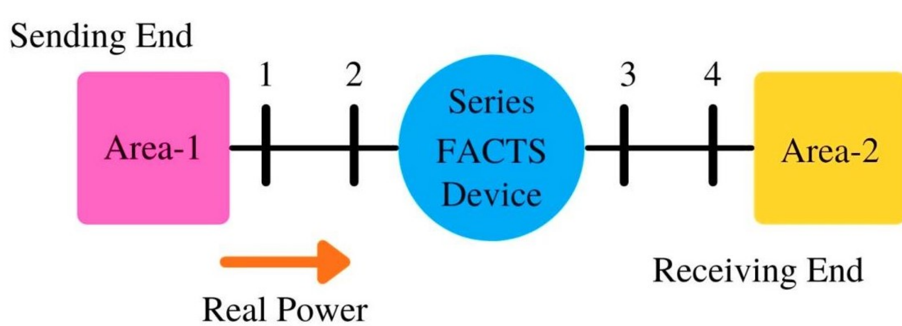


Fig. 5 Two-area power system with FACTS device in series

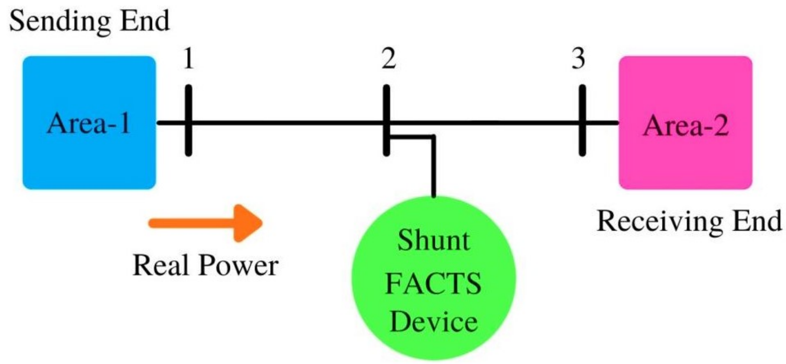


Fig. 6 Shunt FACTS device in a two-area power system

4. Results and discussion

4.1.POWER OSCILALATION DAMPING

Figure 7 depicts a three-machine electric grid as a single line chart. It is made up of 3 main 220 KV buses that are linked in a closed loop, 3 power producing stations, and an 800MW 3-phase demand on bus B3. The first electric generation station is rated at 730 MVA, while the second is rated at 465 MVA and the third is rated at 465 MVA. Three interconnectors L1, L2, and L4 connect the generating facilities 1, 3 to this load. The line L2 is 300 kilometres long and the line L4 is 50 kilometres long; the line L1 is divided into two 140-kilometer parts. The line is connected to the generating substation 2 by the transmission line.

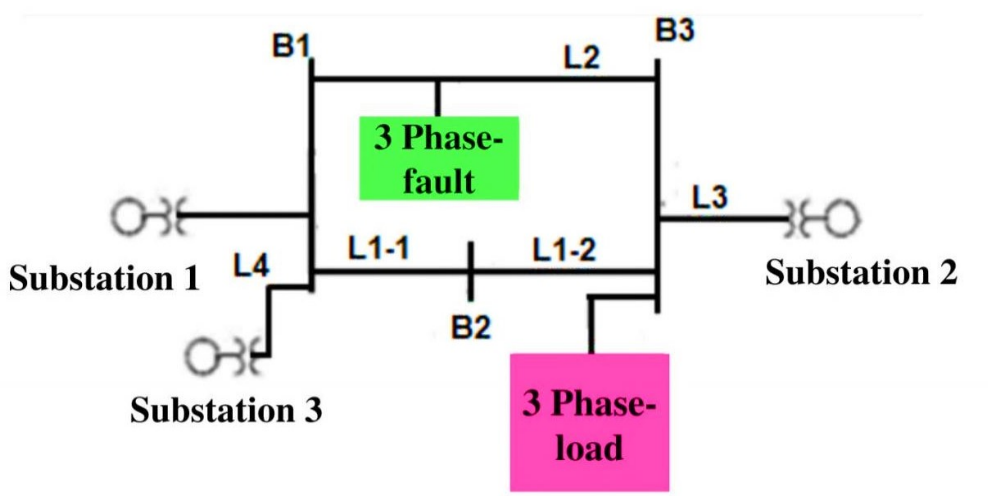
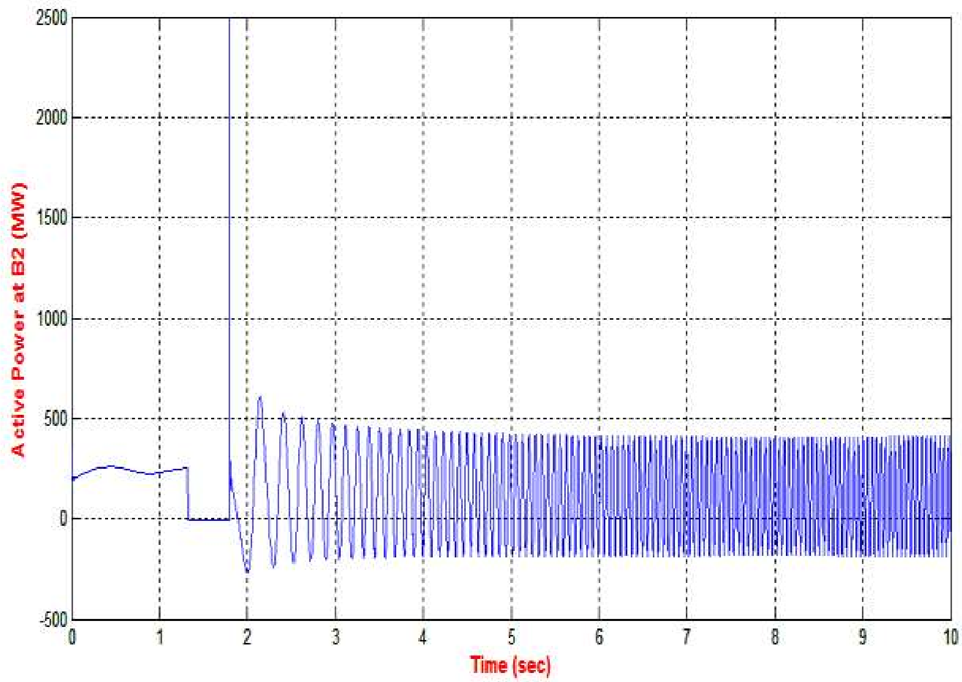


Figure 7 A three-machine power system is depicted in a single line chart.

4.2.Network Without Compensation

The network depicted in figure 3 is modeled in SIMULINK/ MATLAB during a three-phase fault lasting 0.5 seconds on line L2, with the simulated data given in figure 8. We can view the fluctuation that occurs due to the 3 phase fault at L2 in the simulated data. As shown in figure 4, the oscillation lasts for (8s) after the severe fault. It's critical to dampen these fluctuations as soon as potential because they induce robotic wear in power stations and numerous voltage regulation.



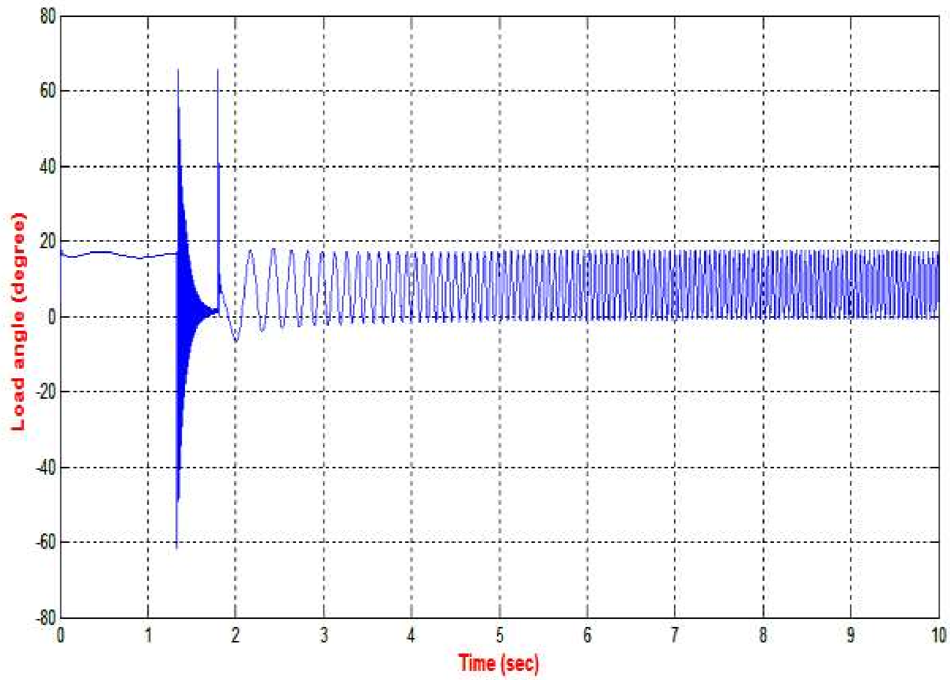


Figure 8 Network Without Compensation

4.3.Network With FC

Examine the impact of FC on the energy oscillation derived from Figure 4's simulation. Figure 9 shows how to place the FC at B2. The FC is not capable of dampening the oscillation, according to the simulated data.

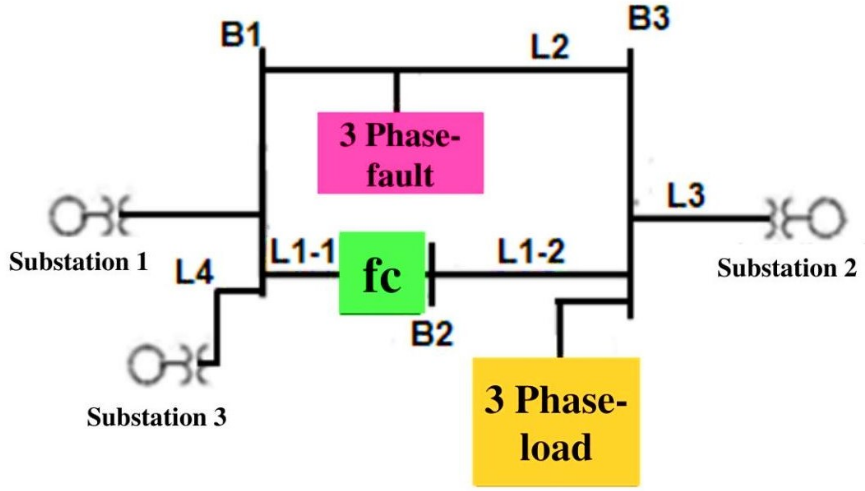
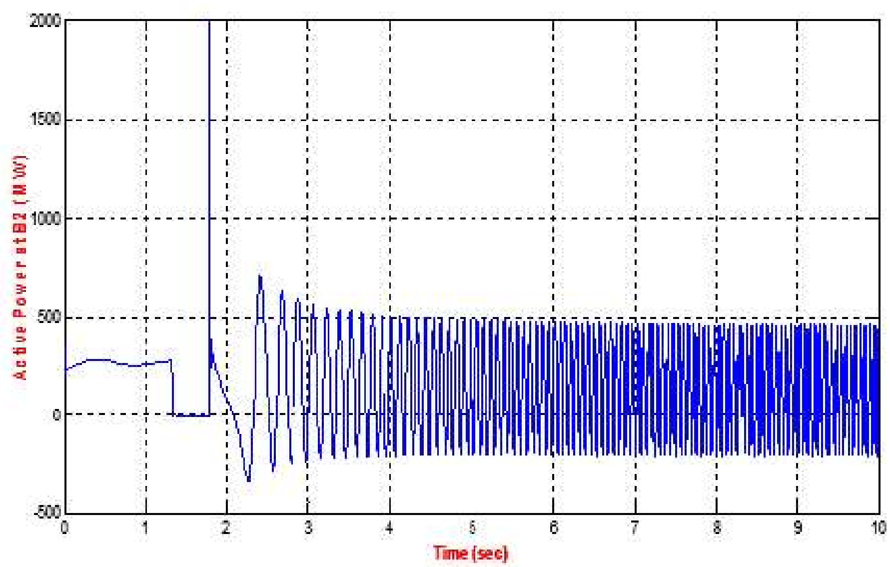


Figure 9 Network at abnormal operation with (FC)



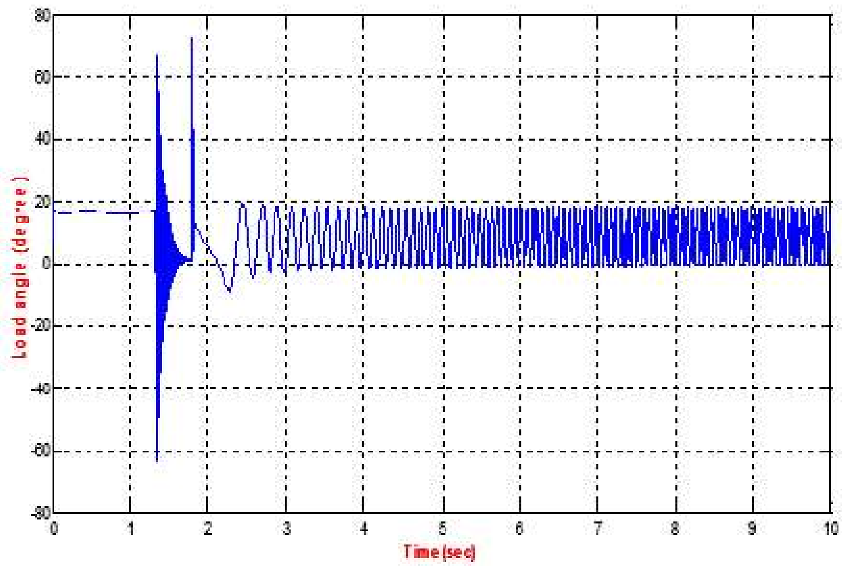
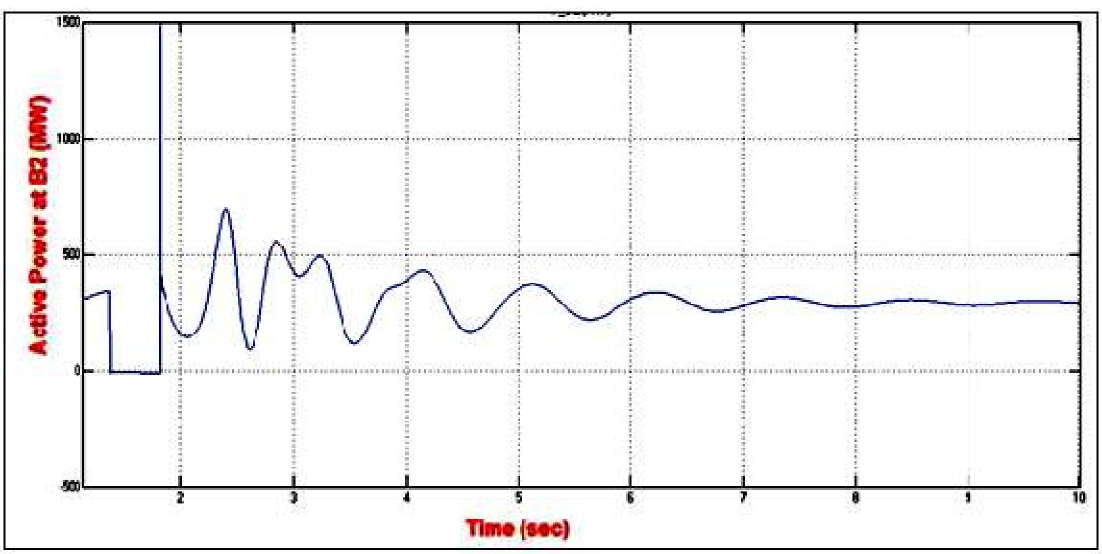


Figure 10

4.4.Network With TCSC

Figure 5 shows the results of replacing the FC with the TCSC, and Figure 11 shows the simulation model. The fluctuation of the power was attenuated in a few moments in the existence of the TCSC, according to the simulated data.



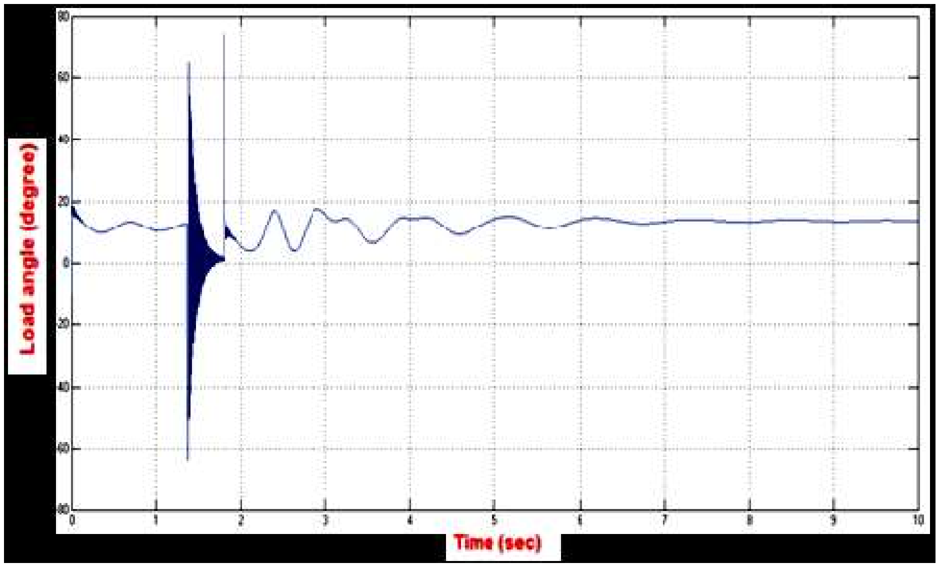
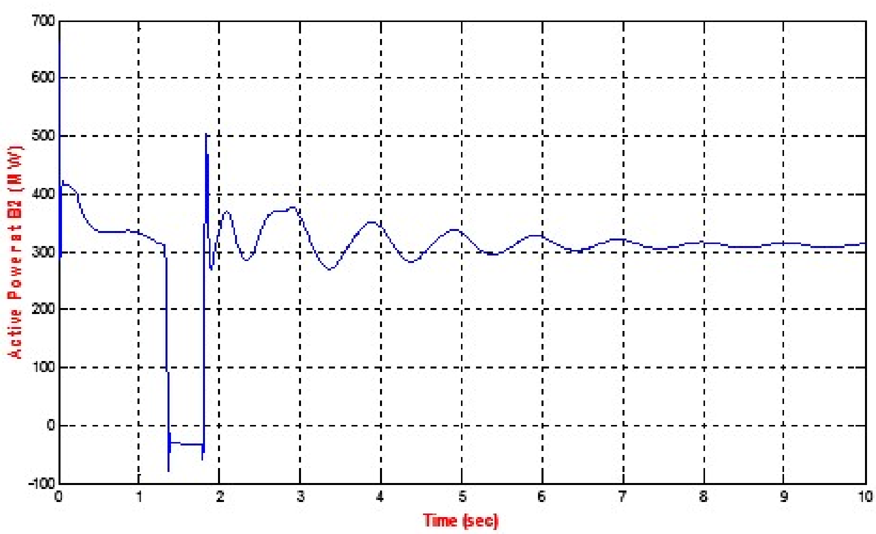


Figure 11 Network With TCSC

4.5.Network With SSSC

In Figure 6, the SSSC was used rather than the network's FC. Figure 12 depicts the simulation outcomes. According to the simulated data, the SSSC based (POD) microcontroller is more successful in damping energy system oscillations, as seen in figure 8. It is apparent that SSSC has a high damping capability on the system.



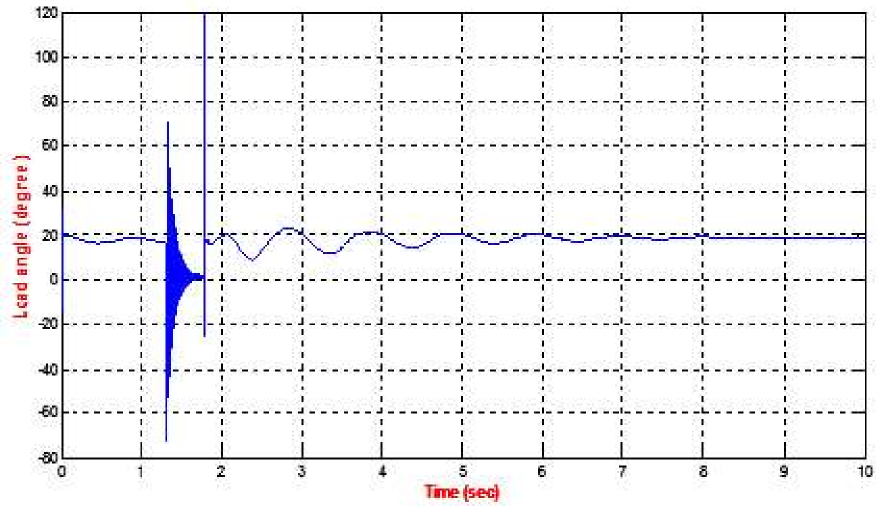


Figure 12 Network With SSSC

5. Comparison Between TCSC, SSSC and FC on Power Oscillation Damping

Figure 6 indicates that the FC has no influence on the power oscillations caused by a three-phase breakdown in the network (see Figure 8). Figure 13 indicates that the TCSC has a faster dynamic connection speed and is more efficient at dampening power oscillations than the FC. Figure 10 illustrates that the SSSC outperforms the TCSC and FC in terms of power fluctuation attenuation and dynamic responsiveness.

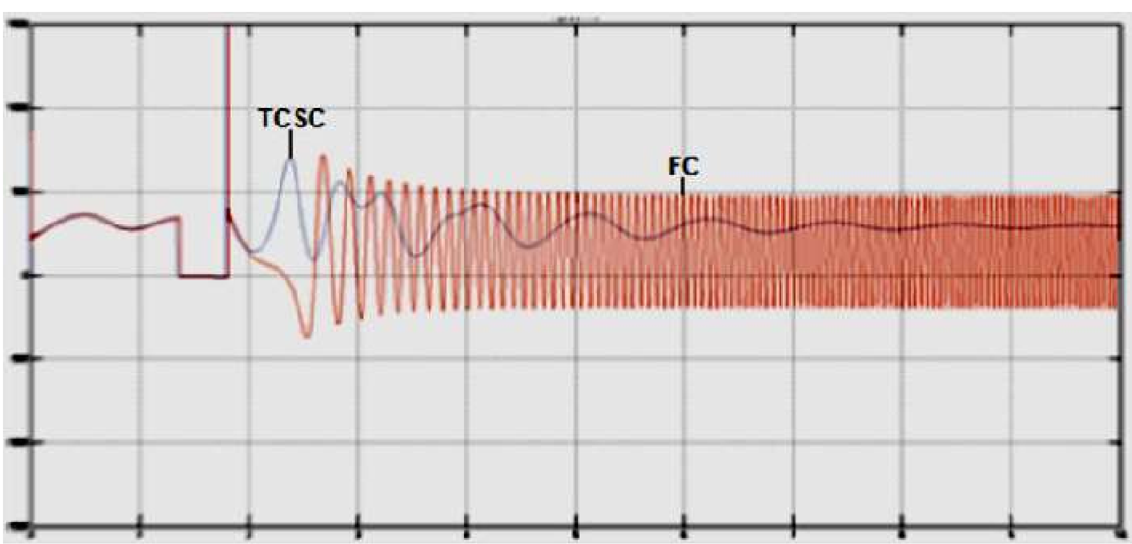


Figure 9 different between FC and TCSC

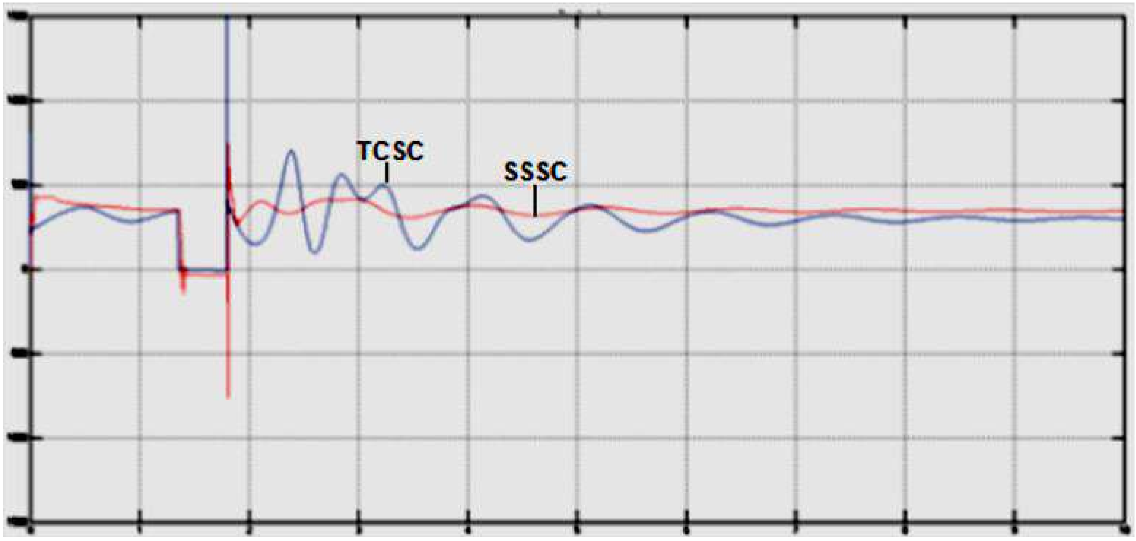


Figure 13 different between SSSC and TCSC

6. Conclusions:

This study shows how the TCSC and SSSC FACTS devices increase power flow, losses minimization, and voltage spectrum enhancement. Thus, the TCSC FACTS device produces 1.045 P.U voltage, active Energy Flow is 27.88MW, and power failure was 28.3 KW, whereas the SSSC FACTS device produces 1.06 P.U voltage, active Power Flow is 30.194MW, and power failure is 26.34 KW, as seen in table1. The system voltage flow in line 4-5 increases, and the TCSC and SSSC minimise losses even more. When the acquired findings are compared, the SSSC outperforms the TCSC. These gadgets can be used to investigate the mitigation of SSSR and POD by including the TCSC and SSSC FACTS devices in the future.

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