Enhancement of Power System Stability Using Thyristor Controlled Series Compensator (TCSC)

Pooja Rani
P.G. Research Scholar in Department of Electrical Engg.
MITM, Hisar, Haryana, India

Mamta Singh
Assistant Prof. in Department of Electrical Engg.
MITM, Hisar, Haryana, India

Atma Ram
Assistant Prof. in Department of Electrical Engg.
YMCAUST, Faridabad, Haryana, India

Abstract- Nowadays power systems are becoming more and more stressed because the demand for electricity is growing and the limitation on the construction of new power systems. So, to utilize it fully Flexible AC Transmission Systems (FACTS) devices are used. With the help of FACTS devices phase angle, voltage and impedance of the high voltage AC lines can be controlled. Thyristor Controlled Series Compensator (TCSC) is a FACTS device which can provide many benefits like controlling power flow and damping power system oscillations. This paper focuses on improving the stability of the system when a fault occurs in a multi-machine four bus system for a very short period using TCSC. In this paper we can implement the four bus power system in Matlab/simulink. This paper shows that TCSC improves the line power flow, voltage stability, rotor speed oscillations and rotor speed deviation.

Keywords - Thyristor Controlled Series Compensation (TCSC), Flexible AC Transmission Systems (FACTS), Proportional-Integral Controller and two area power system.

1. INTRODUCTION

The stability of power system is an important problem for the desired system operation. It has been of great importance since earlier times as various blackouts occur due to power system instability. Nowadays various forms of instability are emerging because of the development of new technologies and control strategies [1]. Like voltage stability, active power, reactive power instability inter-area oscillations and rotor angle stability are occurring frequently nowadays. So, this has forced the power system engineers to clearly understand the different types of instability and their interrelation. Power system stability means the ability of a power system to regain operating equilibrium after being subjected to a physical disturbance with given initial operating condition. As power system deals with the parameters which are changing continually, its stability depends on initial condition and nature of disturbance. The disturbances are of wide range either small and large[2]. When load is changing continually it is called small disturbance and the power system must be able to handle the changes and operate satisfactorily.

Power system stability can be improved through the application of advanced controlled technologies. Power electronics has developed the Flexible AC Transmission System (FACTS). The FACTS devices can be used to control impedance, voltage, phase angle etc of high voltage AC lines. By using FACTS devices power system stability can be improved satisfactory. Thyristor Controlled Series Compensation (TCSC) is a type of FACTS device which can provide many benefits such as damping power system oscillations and controlling power flow in the line. TCSC is very much efficient in improving the power transfer capability, sub-synchronous resonance, voltage stability and supplying reactive power demand[3,4].

38

II. THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC)

A TCSC is a series-controlled capacitive reactance that can control the continuous power flow on ac lines. The principle of variable-series compensation is to increase the fundamental-frequency voltage across a fixed capacitor in a series compensated line by varying the firing angle α . This
Increased voltage, changes the effective value of the series-capacitive reactance [5].
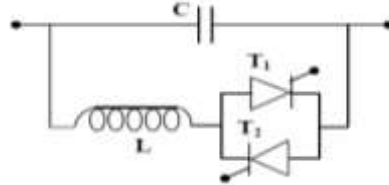

Fig 2.1 A Simple diagram of TCSC device

The basic diagram of TCSC is shown in Fig 2.1. This figure shows that the series compensating capacitor is shunted by a Thyristor Controlled Reactor (TCR). To obtain the desired operating characteristics and voltage ratings various such basic compensators can be connected in series. At the fundamental system frequency TCR is a continuously variable reactive impedance which is controlled by delay angle α . The steady state impedance of the TCSC now becomes as that of a parallel LC circuit, which consists of a fixed capacitive impedance, X_C and a variable inductive impedance, $X_L(\alpha)$. So, the impedance of TCSC becomes, $X_{TCSC}(\alpha) = (X_C * X_L)/(X_L(\alpha) - X_C)$ .Where $X_L(\alpha) = X_L * \pi /(\pi - 2\alpha - \sin\alpha)$, $X_L \leq X_L(\alpha) \leq \infty$. Whereas, $X_L = wL$, and α is the delay angle measured from the crest of the capacitor voltage.
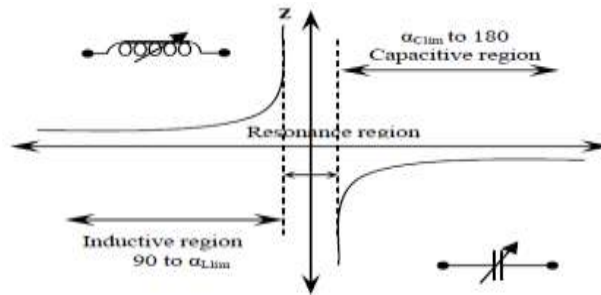

Fig 2.2 Impedance Vs delay angle characteristic curve

The TCSC can be operated in either inductive region or capacitive region according to the delay angle α .As shown in Fig 2.2 if $90 < \alpha < \alpha_{L\lim}$ it means TCSC will operate in inductive region, and if $\alpha_{C\lim} < \alpha < 180$ it will operate in capacitive region. For $\alpha_{L\lim} < \alpha < \alpha_{C\lim}$ it will operate in resonance region [6].

III SYSTEM STUDY

Consider a two-area power system (Area-1 & Area-2) with series FACTS device, connected by a double circuit long Transmission line as shown in fig.3. Here, the TCSC are equipped between bus-1 and bus-2. The direction of real power flow is from Area-1 to Area-2. In the two-area power system model, the Area-1 consists of Generator 1 (G1) and the Area-2 consists of Generator 2 (G2) . The system data are given in [7-8].
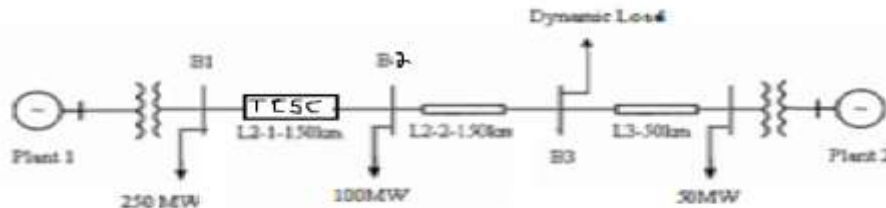

Figure: 3 Two area power system study

39

This system which has been consisting of 4 buses (Bl to B4) connected to each other through three phase transmission lines L1, L2-1, and L3 with the length of 280, 150, and 50 Km. respectively. System has been supplied by two power plants with the phase-to-phase voltage equal to 13.8 Kv. Active and reactive powers injected by power plants 1 and 2 to the power system are presented in per unit by using base parameters Sb=100MVA and Vb=500KV.

IV. SIMULATION RESULTS AND DISCUSSION

Fig-3 show multi-machine system for TCSC controller. It is considered that a 3-phase symmetrical short circuit fault of 100 milli-seconds duration occurs at bus-3 . The system is simulated in MATLAB/Simulink environment and the corresponding results without TCSC controller of line power flow , terminal voltage of area-1 and area-2, rotor speed deviation (dw1-dw2) , and speed oscillation (ωm1-ωm2) are shown in Fig.4 (a-e). Fig.4 there is oscillation in line power, terminal voltage, rotor speed deviation and rotor speed. Fig.5(a-e) shows the response curves of line power flow, terminal voltage of area-1 and area-2, rotor speed deviation (dw1-dw2) , and speed oscillation (ωm1-ωm2) with TCSC. It is seen that with TCSC transient stability of system is improved.
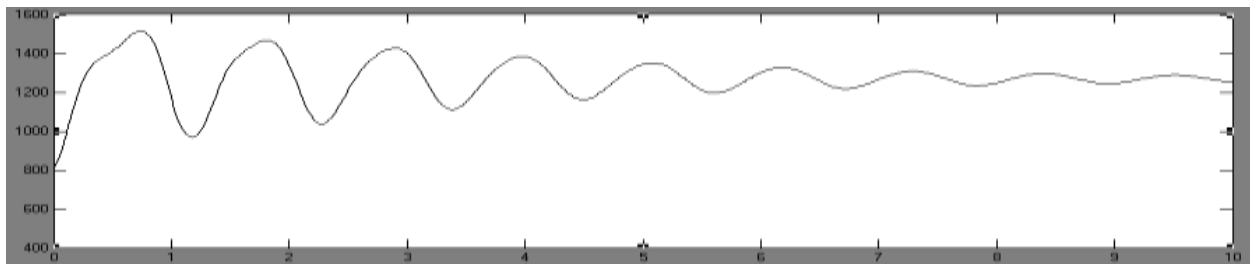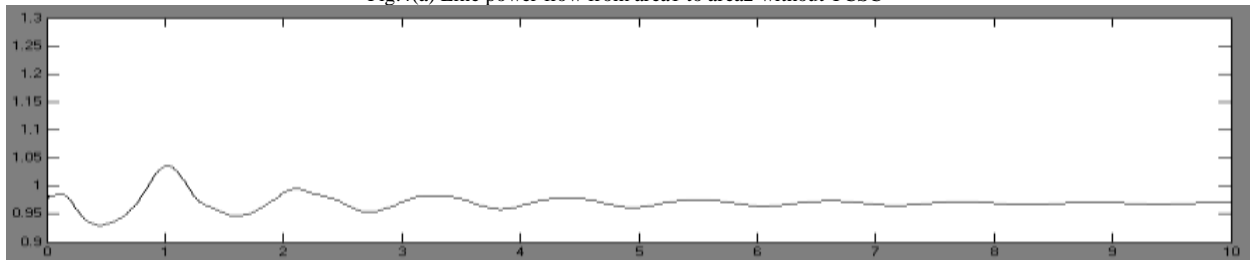

Fig.4(a) Line power flow from area1 to area2 without TCSC
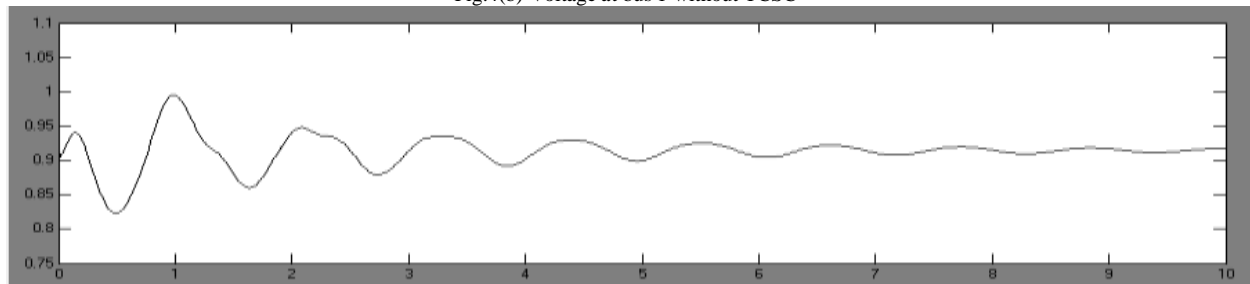

Fig.4(b) Voltage at bus 1 without TCSC

Fig.4(c) Voltage at bus4 without TCSC

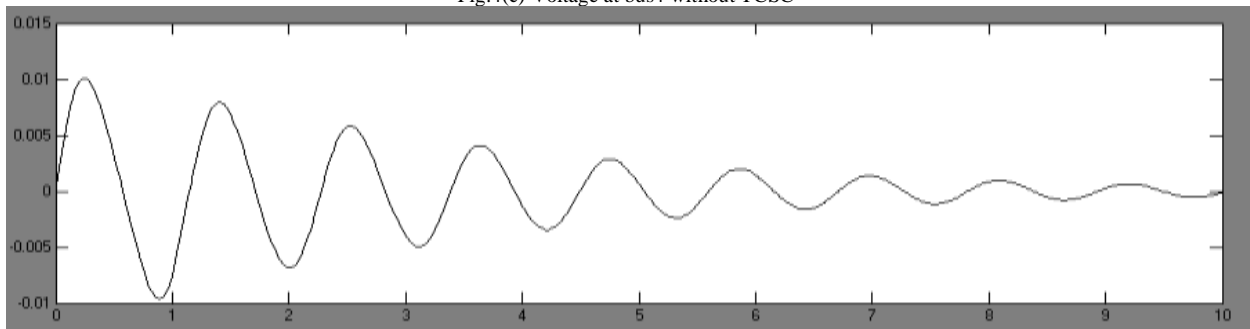Fig.4(d) rotor speed deviation (dw1-dw2) without TCSC

40
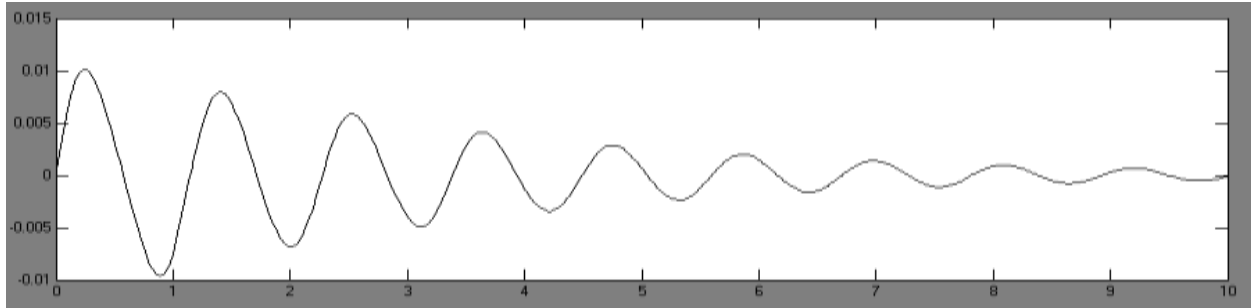
Fig.4(e) Rotor speed oscillations(wm1-wm2) without TCSC
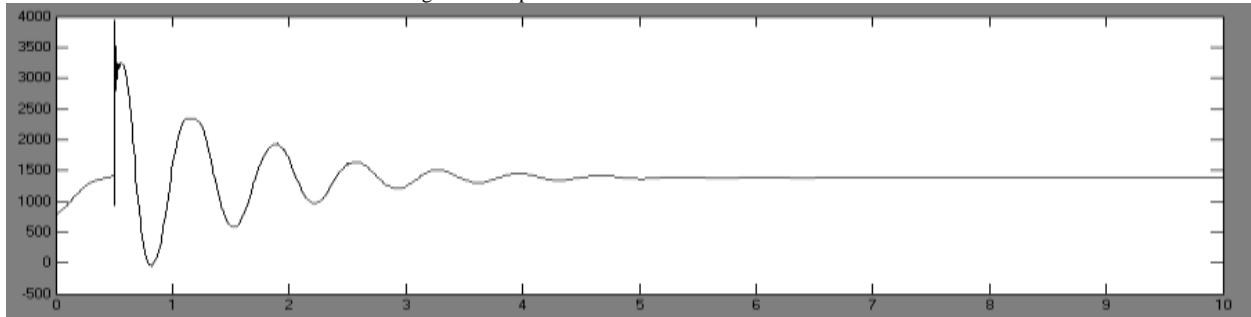
Figure: 4 Response curves without TCSC controller

Fig.5(a) Line power flow from area1 to area2 with TCSC

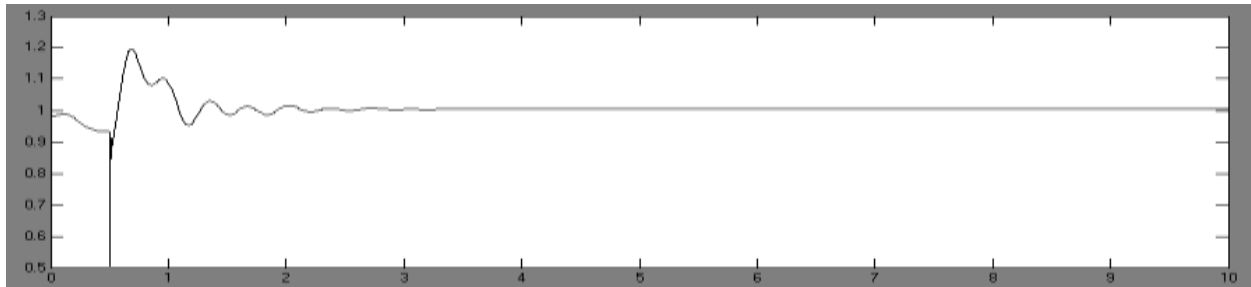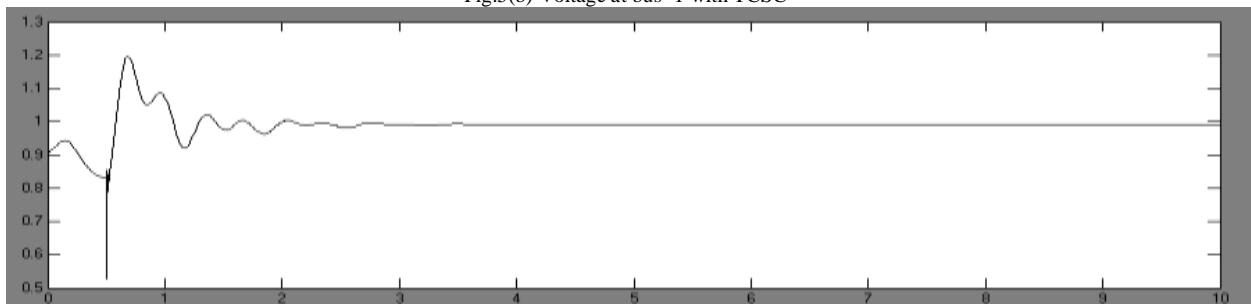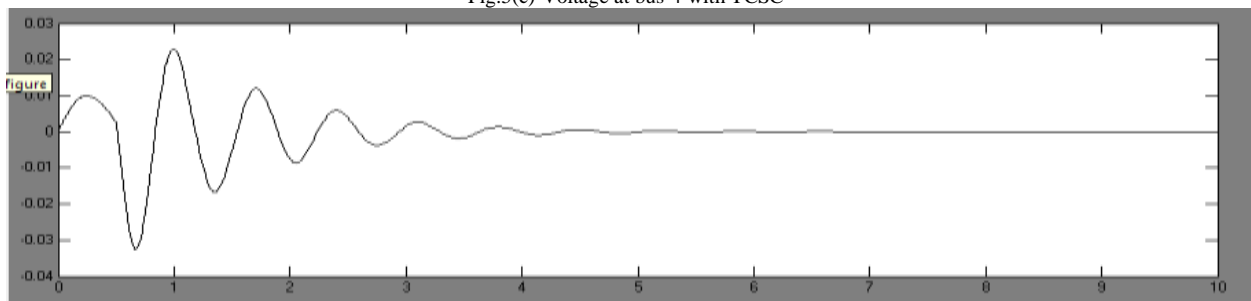Fig.5(b) Voltage at bus -1 with TCSC

Fig.5(c) Voltage at bus-4 with TCSC
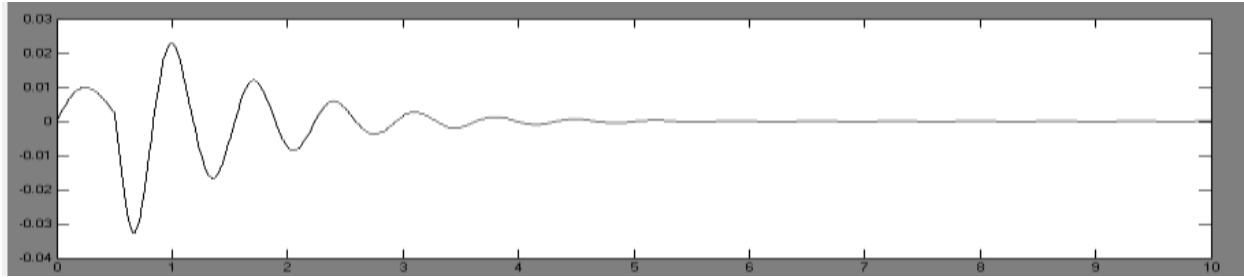

Fig.5(d) Rotor speed deviation (dw1-dw2)with TCSC

41

Fig.5(e) Rotor speed oscillation(wm1-wm2) with TCSC

Figure:5 Response curves with TCSC Controller

V. CONCLUSION

In this paper the advantages of TCSC to improve the power system stability are shown. TCSC damp out the power system oscillations very efficiently. The result shows that whenever a fault or transient causes the power system oscillations in voltage, active power and reactive power, then the settling time of the system can be reduced with the help of TCSC. And the system is able to retain its stability quickly. This paper shows that TCSC damp out the power system oscillations very fast in a system whenever there is a disturbance occur in a system due to fault of very short duration .Rotor speed deviation and rotor speed synchronism is also improved. The overall system stability is improved.

REFERENCES

[1]   Ranjit Kumar Bindal," A Review of Benefits of FACTS Devices in Power System", International Journal of Engineering and Advanced Technology (IJEAT), Volume-3, ISSN: 2249 – 895, Issue-4, April 2014,pp:105-108.
[2]   P. Kundur, 1994, "Power System Stability and Control," McGraw-Hill, New York
[3]   K.R. Padiyar, 2002, "Power System Dynamic Stability and Control," Second Edition, BS Publications, Hyderabad.
[4]   N.G. Hingorani, L. Gyugyi, 1999, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems," IEEE Press, New York.
[5]   Alok Kumar Mohanty and Amar Kumar Barik," Power System Stability Improvement Using FACTS Devices", International Journal of Modern Engineering Research (IJMER), Vol.1, Issue.2, pp:666-672, ISSN: 2249-6645.
[6]   Venu Yarlagadda , Dr. B.V.Sankar Ram and Dr. K.R.M. Rao," Automatic Control of Thyristor Controlled Series Capacitor (TCSC)", International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622 ,Vol. 2, Issue 3, May-Jun 2012, pp. 444-449.
[7]   Sunita Tiwari and S.P. Shukla," Compensation by TCSC In Open Loop Control System", International Journal of Advanced Engineering Technology, IJAET/Vol.III/ Issue I/January- March2012, E-ISSN 0976-3945,pp:175-179.
[8]   Avnish Kumar Gaur , Aziz Ahmed, Tanmoy Deb and Ravindra Pratap Singh,"Power Flow and Static Voltage Stability Improvement using TCSC and SVC",International Journal of Computer Applications (0975 – 8887) ,Volume 97– No.5, July 2014.