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A Coordinated Control Scheme of PSS and UPFC devices for Improving Power System Oscillations

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ABSTRACT*:* Now a days, the power transmission network is expanding and is getting more complicated day by day due to the increment in load demand, the major problem due this is increment in Low frequency electromechanical oscillations in the interconnected power system .These oscillations are inevitable characteristics of power systems and they greatly affect the transmission line transfer capability and power system stability. A Unified Power Flow Controller (UPFC) is a typical FACTS device capable of instantaneous control of three system parameters. Unified Power Flow Controller (UPFC) is able to control both the transmitted real power and the reactive power flows at the sending- and the receiving-end, at the midpoint of the transmission line. This paper presents a approach for damping inter area oscillations in a wide area network using unified power flow controllers (UPFCs). An additional power oscillation damping (POD) controller is used along with the UPFC main controller for this purpose. The Coordination Control of UPFC with Supplementary power oscillation damping controller (POD) to damp out the inter-area Oscillation from a multi-machine System. As local PSS not have global observability. Some simulations results on Kundur Two-Area Four Machine system under small disturbance show that the proposed controller effectively damp-out the inter-area oscillations.

KEYWORDS: Inter-area oscillation, Power system stabilizer (PSS), Unified power flow controller (UPFC), Power oscillation damping (POD).

I.INTRODUCTION

Recently, with the increasing of electric power demand, modern power system requires networks to be interconnected more flexibly and efficiently and thus make power system control becomes more complicated.
The main reason for interconnection of electric grids is that it can efficiently utilize various power resources distributed in different areas and achieve the optimal allocation of energy resources. This also optimizes the economic dispatch of power and gets relatively cheaper power, which implies that decrease of system installed capacity and the investment. Moreover, in case of fault or disturbance in operating condition, it can provide additional supporting power of each area of interconnected Power system which can increase the reliability of generation, transmission and distribution system.

The major problem associated with an interconnected power system when connected by a weak line is the low frequency oscillations [0.1 Hz - 1 Hz] are developed. If the damping of the system is not adequate, then these oscillation leads to system separation.

The inter area oscillations inherent to the large inter connected Power System becomes more dangerous to the system's security and the quality of the supply during transient situation. Hence it can be said that the low frequency oscillations put limitations on operation of the power system and network's control security. The increased interconnected network of power system carries out heavy inter change of electrical energy which invokes such poorly damped low frequency oscillations that the system stability becomes major concern. Presently, in industries to damp

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out these oscillations, many different techniques have been introduced, such as application of Automatic Voltage Regulator (AVR) equipped with Power System Stabilizer (PSS) [8].

However, at present, power electronic technologies have been developed. They are more effective in increasing the amount of transmitted power with improving the dynamic performance and more precise to control the route of the power flow. These technologies are referred to use Flexible AC Transmission System (FACTS) in power systems.

Modern utilities are beginning to install FACTS devices in their transmission networks to increase the transmission capacities and enhance controllability. In view of their advantages, there is a growing interest in the use of FACTS devices in the operation and control of power systems. There are two main aspects that should be considered while using FACTS controllers: The first aspect is the flexible power system operation according to the power flow control capability of FACTS controllers. The other aspect is the improvement of stability of power systems. [7]

Due to the technology advancements in power electronics, the trend of using FACTS devices in power systems both transmission and distribution levels is increasing. If FACTS and wide-area power system monitoring and control system (WAMS) technologies are used together, they can help improve the stability performance of power systems. In this study, Unified Power flow Controller (UPFC) which is a series-shunt connected FACTS controller based on Votage Source Conveter (VSC) is used to control the tie-line power flow between two areas of a study power system. Normally, the input control signal of UPFC can be obtained locally from these signals, such as voltage, current, active power flow, frequency, etc. However, in order to obtain better performance, Supplementry POD Controller along with UPFC are installed so damp out inter-area oscillation more effictively . The control signal obtained by POD is used as the control input of UPFC damping controller. Moreover, in this paper, a simple UPFC based controller designed based on change in rotor speed deviation as a input signal.

This paper is divided into six sections. The first section is the introduction mentioning about the problem of power oscillations and the adoption of a UPFC to solve the power oscillation issues. Section II describes the configuration of the study power system. Section III presents the design of the proposed controller for a UPFC. Section V shows the simulation results of the proposed controller and the comparison results. Finally, it ends with the conclusions in section VI.

II.STUDY POWER SYSTEM

Fig-1 shows the single line Diagram of the study power system. This system consists of two symmetrical areas connected by two parallel tie-line of length 220 km and 230 kv. Each area is equipped with two identical round rotor generators rated 20 kv/900 MVA. All four generators have identical parameters, except inertia coefficient (H), which are H=6.5s for Gen-1 and Gen-2 in area-1 and H=6.175 s for Gen-3 and Gen-4 in area-2.

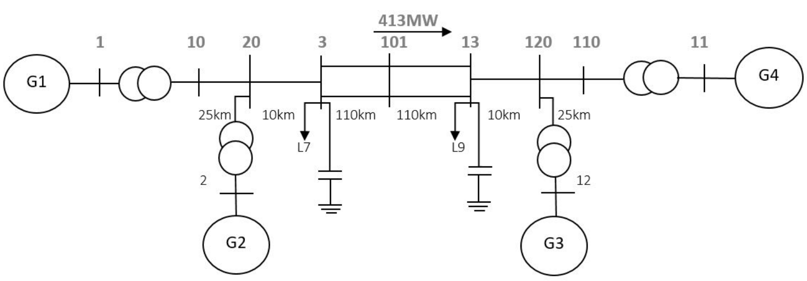

Fig. 1 Kundur two-area four-machine system

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III.THE PROPOSED CONTROL METHOD

a) Unified Power flow controller (UPFC)

The UPFC can provide simultaneous control of all basic power system parameters (transmission voltage, impedance and phase angle). The controller can fulfill functions of reactive shunt compensation, series compensation and phase shifting, meeting multiple control objectives. From a functional perspective, the objectives are met by applying a DC capacitor, shunt connected transformer and voltage source converter in parallel branch and dc capacitor, voltage source convertor and series injected transformer in the series branch.

The two voltage source converters are a so called ”back to back” AC to DC voltage source converters operated from a common DC link capacitor, Fig. 2 The shunt converter is primarily used to provide active power demand of the series converter through the common DC link. Converter 1 can also generate or absorb reactive power, if it is desired, and thereby provides independent shunt reactive compensation for the line. Converter 2 provides the mainFunction of the UPFC by injecting a voltage with controllable magnitude and phase angle in series with the line.

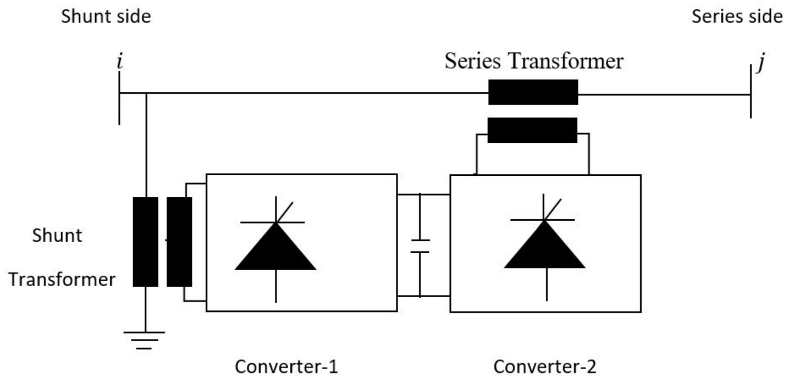

Fig. 2Implementation of the UPFC by back-to-back voltage source converter

b) FACTS POD Controller Design

Supplementary control action applied to FACTS devices to increase the system damping is called Power Oscillation Damping (POD). Since FACTS controllers are located in transmission systems, local input signals are always preferred, usually the active or reactive power flow through FACTS device or FACTS terminal voltages. Fig-3 shows the considered closed-loop system where G(s) represents the power system including FACTS devices and H(s) FACTS POD controller.

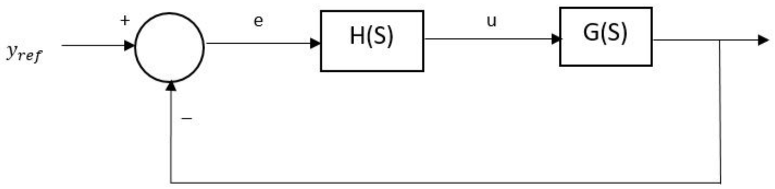

Fig. 3 Closed Loop System With POD Control

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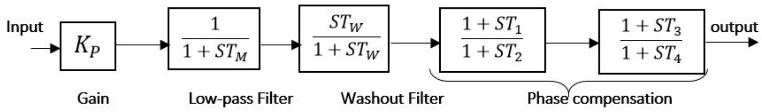

Fig. 4 block diagram of pod Controller

The POD controller consists of an amplification block, a wash-out and low-pass filters and mc stages of lead-lag blocks are as shown in Figure 4. The transfer function, H(s), of the POD controller is given by

$$H(S) = K_p \left(\frac{1}{1+ST_M}\right)\left(\frac{ST_W}{1+ST_W}\right)\left(\frac{1+ST_1}{1+ST_2}\right)\left(\frac{1+ST_3}{1+ST_4}\right) \quad (1)$$

The Parameters of Power Oscillation Damping Controller (POD) are set-up by Hit and Trial Method are tabulated in Table-I.

Table-I POD Parameters

Parameters	K_p	T_M	T_w	T_1	T_2	T_3	T_4
POD	50	0.1	10	0.259	0.225	0.259	0.225

IV.SIMULATION RESULTS OF PROPOSED CONTROLLER

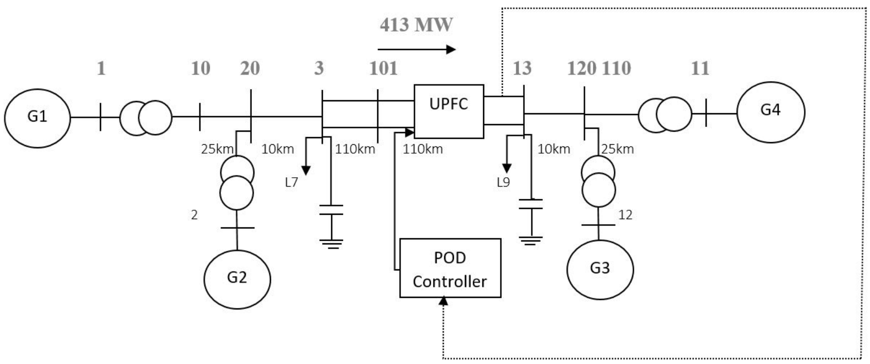

Fig. 5 Two-area four-machine interconnectedpower system with UPFC

The single line diagram of study power system with proposed controller as shown in figure-5. The UPFC-POD controller is installed in Series with the transmission line B-101 and B-13. This system consists of two symmetrical areas connected by two parallel tie-line of length 220 km and 230 kv. Each area is equppied with two identical round rotor generators rated 20 kv/900 MVA. All four generators have identical parameters, except inertia coefficient (H), which are H=6.5s for Gen-1 and Gen-2 in area-1 and H=6.175 s for Gen-3 and Gen-4 in area-2.

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V.SYSTEM PERFORMANCE WITH UPFC

To perform the dynamic analysis of the closed loop test system for Kundur two area four machine system as shown in figure-4, a small pulse with magnitude of 5% as a disturbance was applied to the generator G1 for 12 cycles. The simulation time was of 30 seconds. Then the response of tie-line active power flow from area-1 to area-2, rotor speed, rotor speed deviation , are examined by considering the test system with LPSS and UPFC-POD controller.

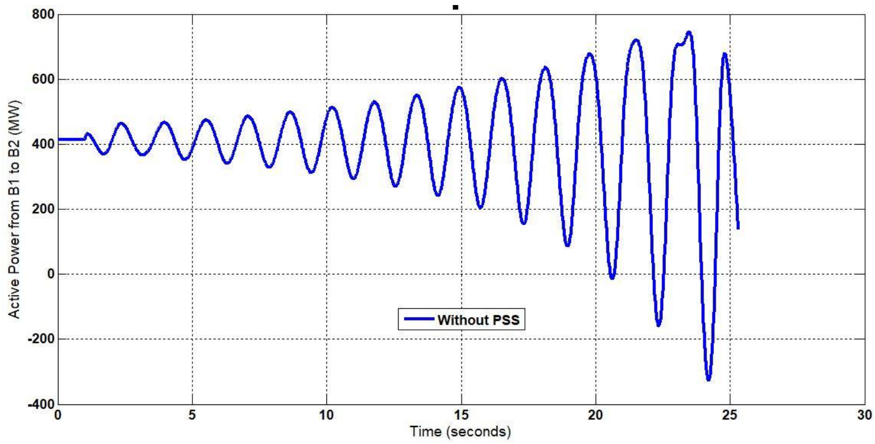

Fig. 6 Tie-line active power flow without any controller

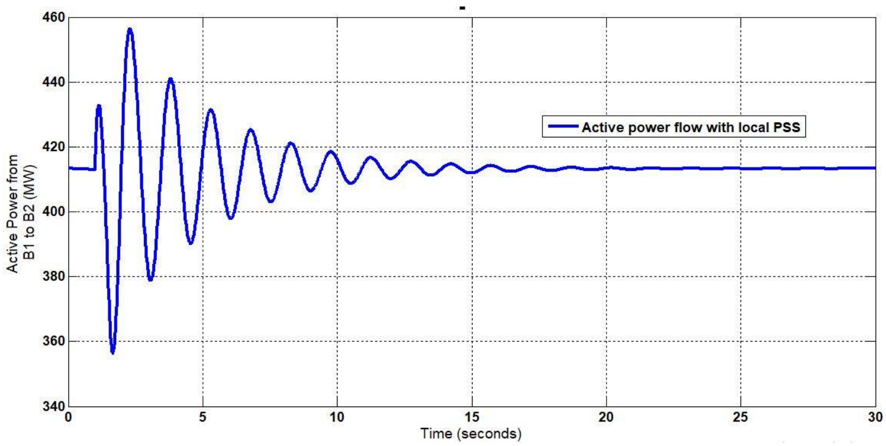

Fig. 7 Tie-line active power flow with local PSS

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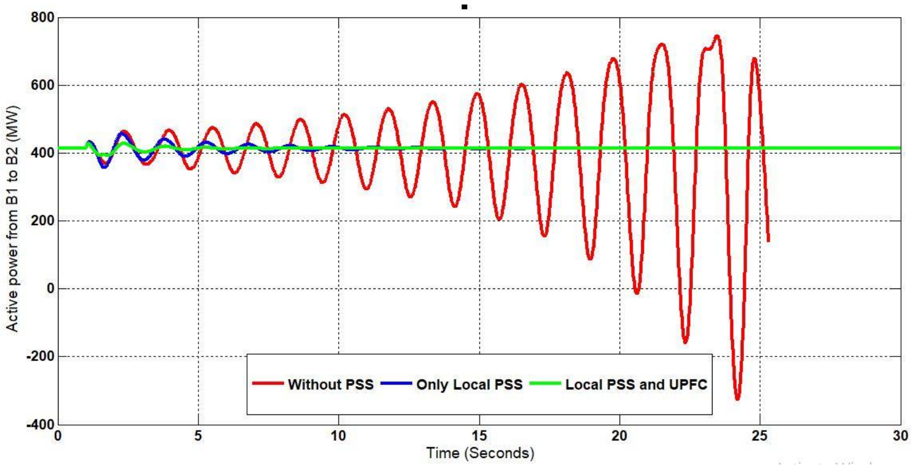

Fig. 8 Tie-line active power flow with UPFC-POD and Local PSS

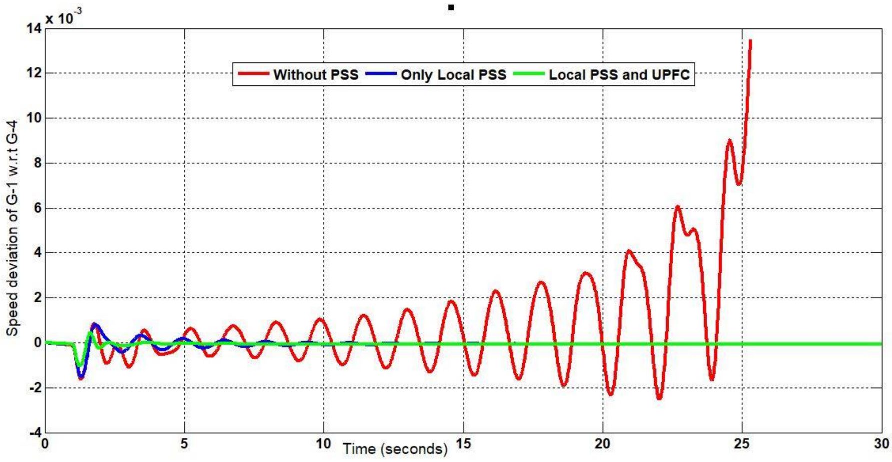

Fig. 9 Speed deviation of G-1 w.r.t G-4 with UPFC-POD and local PSS

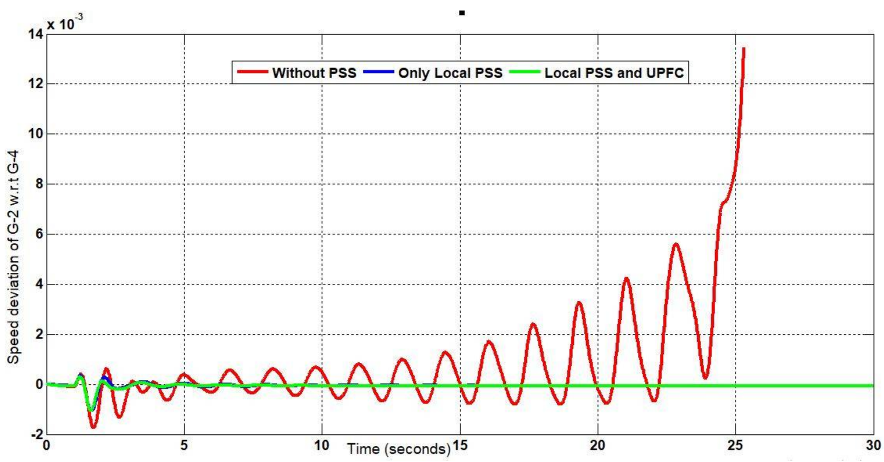

Fig. 10 Speed deviation of G-2 w.r.t G-4 with UPFC-POD and local PSS

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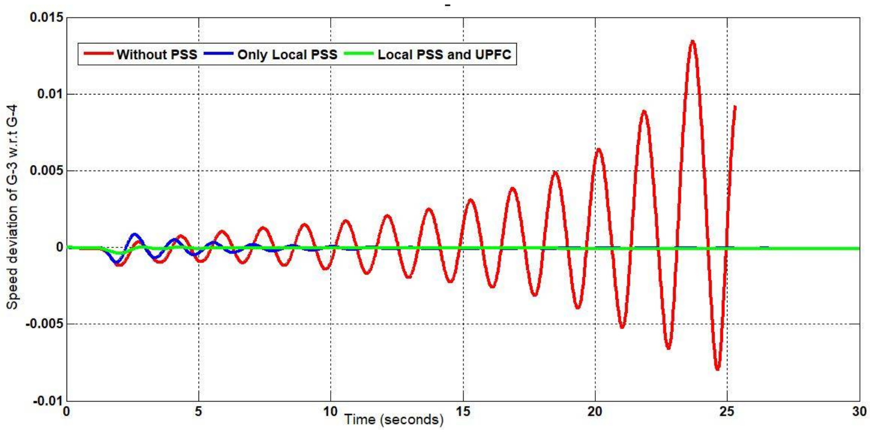

Fig. 11 Speed deviation of G-3 w.r.t G-4 with UPFC-POD and local PSS

VI.CONCLUSION

In this paper researcher designed FACTS damping controller to damp out the inter-area oscillations in a large scale power system using UPFC-POD controller. Some simulation results are carried out to verify the effectiveness of proposed controller under small disturbance. From the simulation results, it reveals that the proposed controller damps out the inter-area oscillations effectively.

REFERENCES

[1] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission System, IEEE Press, 2000.
[2] H.F.Wang, F.J.Swift," A Unified Model for the Analysis of FACTS Devices in Damping Power System Oscillations Part I: Single-machine Infinite-bus Power Systems**"**, IEEE Transactions on Power Delivery, Vol. 12, No. 2, April 1997, pp.941-946**.**
[3] L. Gyugyi, C.D. Schauder, S.L. Williams, T.R.Rietman, D.R. Torgerson, A. Edris, "The UnifiedPower Flow Controller: **A** New Approach to PowerTransmission Control", IEEE Trans., 1995, pp. 1085-1097. Wolanki, F. D. Galiana, D. McGillis and G. Joos, "Mid-Point Sitting of FACTS Devices in Transmission Lines," IEEE Transactions on Power Delivery, vol. 12, No. 4, 1997, pp. 1717-1722.
[4] M. Noroozian, L. Angquist, M. Ghandari, and G. Anderson, "Use of UPFC for optimal power flow control", IEEE Trans. on Power Systems, vol. 12, no. 4, 1997, pp. 1629–1634.
[5] A Nabavi-Niaki and M R Iravani. 'Steady-state and Dynamic Models of Unified Power Flow Controller (UPFC) for Power System Studies.' IEEE Transactions on Power Systems, vol 11, 1996, p 1937.
[6] K S Smith, L Ran, J Penman. 'Dynamic Modelling of a Unified Power Flow Controller.' IEE Proceedings-C, vol 144, 1997, pp.7.
[7] Hingorani NG, Gyugyi L. Understanding FACTS: concepts and technology of flexible AC transmission systems. New York: IEEE Press; 2000.
[8] Kundur P, Power System Stability and Control. New York: McGraw-Hill, 1994.