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Behavior of Eight Bus System with TC-IPC

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Abstract— Environmental, regulatory and economic constraints have restricted the growth of electric power transmission facilities, and the topologies to enlarge the levels of power transmission and enhance stability through existing transmission lines have become greatly needed. Many approaches have been proposed for solving the stability problems found in power system operations. Considering the diversity of both, the solutions and the problems, it is often difficult to identify the most suitable solution. The main purpose of this paper is to demonstrate the capability of Inter Phase Power Flow (IPC) Controller as a mean for stability improvement in power systems. In this paper 8 bus system is used as a test bed, the results are shown with and without TC-IPC. The results indicate the robustness of this Flexible AC Transmission System (FACTS) controller to the variation of system operating conditions.

Index Terms— Controlled Series Compensator (CSC), Eight Bus System, Flexiable ac transmission system (FACTS), Interphase power controller, Static phase shifting transformer, TC-IPC, UPFC

1 Introduction

The basic operating requirements of an AC power system are that the synchronous generators must remain in synchronism and the voltages must be kept close to their rated values. The capability of a power system to meet these requirements in the face of possible disturbance is characterized by its transient (or first swing), dynamic (or power oscillation), and voltage stability. Transient stability may be defined as the ability of an electric power system to remain in synchronism after being subjected to a major system disturbance (such as a short circuit). According to equal-area criteria transient stability of a power system is maintained if the accelerating area equals the decelerating area during the first rotor swing following the fault clearance.

To avoid stability problems a fast power flow control within the first swing of the generator is required. This can be achieved by different means, such as high performance excitation systems and high ceiling voltage, breaking resistors usage, superconducting magnetic energy storage systems and etc.

The recent availability of solid-state power switching devices with controlled turn off capability has made possible further advances in power conversion and control, leading to the development of a new generation of FACTS devices. FACTS (Flexible AC Transmission Systems) devices, as discussed in references , are first of all, effective tools for dynamic power flow control. On the other hand power flow is clearly related to a system's transient stability problems. As a result FACTS devices,
such as UPFC (Unified Power Flow Controller), SPS (Static Phase Shifting Transformers) , CSC (Controlled Series Compensator) , are presented as an effective tool to mitigate transient stability problems in electric power systems. These devices are power electronic based controllers, which can influence transmission system voltages, currents, influence transmission system voltages, currents, impedances and/or phase angle rapidly. Thus FACTS devices (or controllers) can improve both the security and flexibility of a power system. This paper presents the capability of IPC (Interphase Power Controller) as a mean for power stability improvement. Concerning this matter, it is necessary to replace the conventional PST (Phase Shifting Transformer) with the static PST (SPS). The result of these changes is a new FACTS device, which is referenced to it as Thyristor Controlled IPC or TC-IPC.

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2 Introduction to IPC

One of the problems for interconnected power systems is overrating of circuit breakers and associated substation equipment due to short circuit level. Conventional options to decrease the short circuit levels are splitting existing bus into two or more sections, addition of series reactors in transmission lines and using transformers with high impedance or replacing over-duty substation circuit breakers and associated equipments. However, none of the above methods provide additional transmission capability or ability to control and redirect the power flow.

Splitting an existing bus into more than one section decreases the substation fault problem in a relatively costeffective manner, but operating flexibility and reliability will be decreased. In practice, it may be difficult to obtain permission to change the existing bus configuration. Series reactors can neither completely eliminate the fault current contributions nor efficiently reduce the transmission constraints. At normal conditions, series reactors absorb reactive power. Under heavy loading conditions, this solution can make more problems for voltage regulation. Replacing the underrated circuit breakers and associated substation equipments with higher interrupting devices, is another method to overcome the fault duty problem . Depending on voltage levels, the number of circuit breakers involved and desired new rating for the breakers, the replacement of breakers can be expensive. In addition, scheduling large number of circuit breaker replacements imposes planning and engineering challenges.

Some new techniques for fault limitation such as series compensation, flexible alternative current transmission systems (FACTS), phase shifting transformer (PST) or Inter phase Power Controller (IPC) in an existing substation can be very attractive options. In the present thesis, the role of IPC is discussed .

3 IPC Description

The basic design goal in IPC technology is to find passive solutions to fundamental frequency problems. Power electronics modules can be added in situations where rapid control action is required to damp oscillations or prevent excessive voltage variations. Hence, basic IPC solutions utilize only conventional equipment, such as capacitors, inductors and phase-shifting transformers. They generate no harmonics and have no commutation losses. Robustly built, they require much less maintenance than power electronics-based devices.

The IPC does not have a fixed configuration, being more a technology for creating different and innovative power flow controllers with diverse characteristics and configurations. Generically, it is a seriesconnected device consisting of two parallel branches, each with an impedance in series with a phase-shifting element (Figure 1). The four design parameters (two impedances and two phase shifts) allow enormous design flexibility and make a wide variety of applications possible. Because of the different characteristics these IPC applications can have, they have their own specific names.

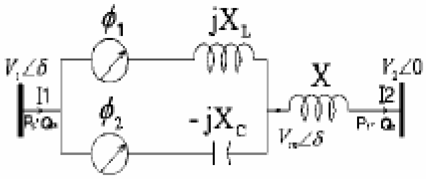

Fig 1: The Single diagram of Generic IPC

IPCs can be adapted to specific operating conditions. In general, the adaptation also results in an optimization. For example, the removal of the phase shift in one of the two branches of the IPC reduces the amount of equipment and relocates the control characteristic to a more favorable position in the power-angle plane. The adaptability of the IPC technology is also demonstrated by the various ways in which the internal phase shifts can be implemented. Conventional phase-shifting transformers (PST) are the first obvious choice, but the IPC characteristics can also be obtained using conventional transformers which have auxiliary windings added to create the desired internal phase shift by injecting series voltages from other phases.

4 Thyristor Controlled Interphase Power Controller (TC-IPC)

In this paper a 8 bus system is implemented with thyristor controlled interphase controller. Based on this model it is demonstrated that the TC-IPC can be very effective to damp power systems oscillations. Simulation results indicate the robustness of this Flexi-

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ble AC transmission system (FACTS) controller to the variation of system operating too, IPC system is shown in the fifure 2(a). Real and reactive powers with α=144^0 and 153^0 are shown in figure 2(b) & 2 (c) respectively.

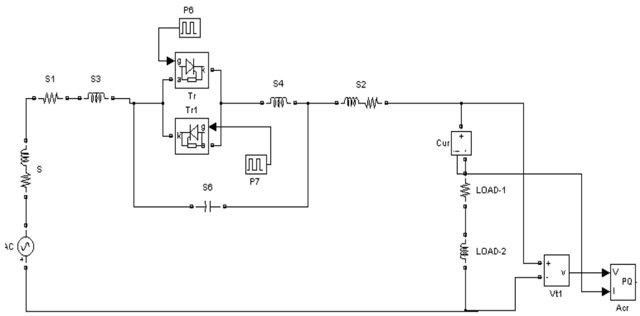

Fig2 (a): Interphase controller with Thyristors

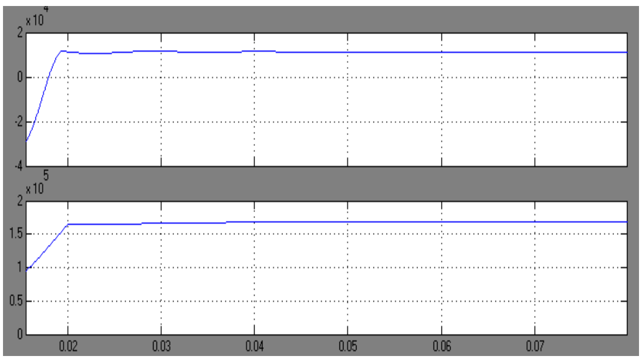

Fig 2(b) : Real and Reactive Power at Alpha =144 Degree

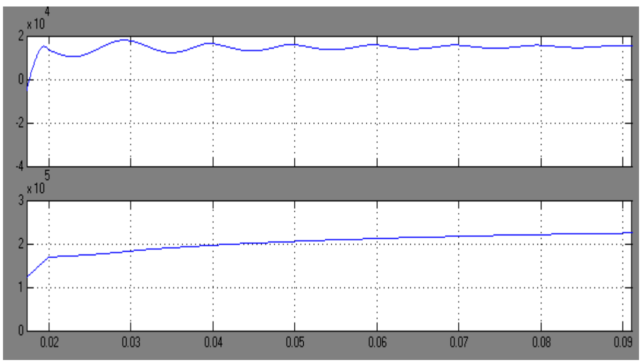

Fig 2(c) : Real and Reactive Power at Alpha =153 Degree

It have been shown that real and reactive power could be controlled by Varying "alpha" in Thyristor controlled-Inter phase power controller.

Eight bus system without TC-IPC is shown in figure 3(a). Real and reactive powers are shown in figure 3(b), current and voltage at bus 3 is shown in figure 3(c).

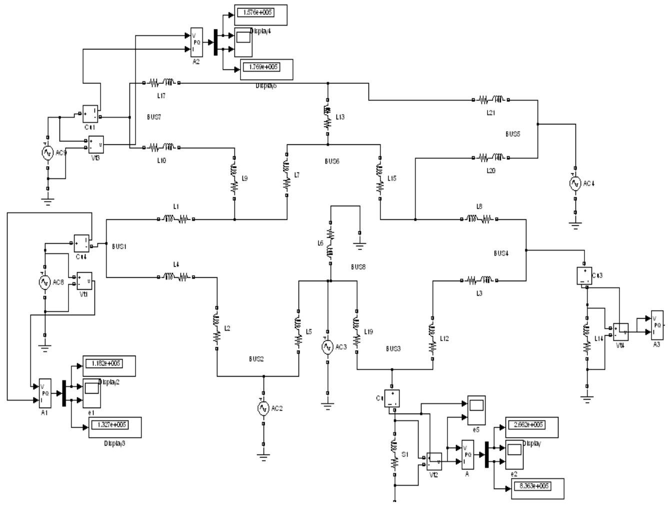

Fig 3(a): 8 Bus System without TCIPC

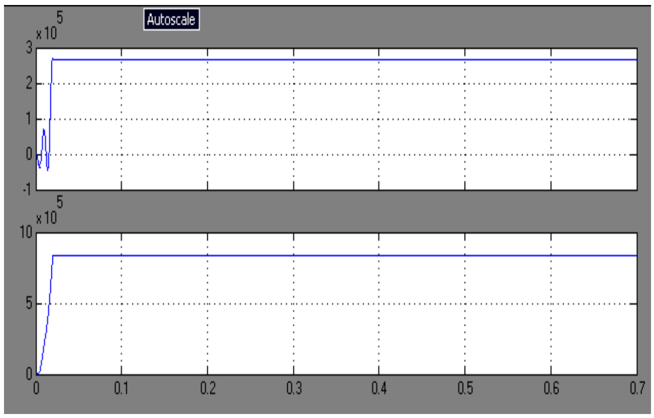

Fig 3(b): Real and reactive power across bus-3

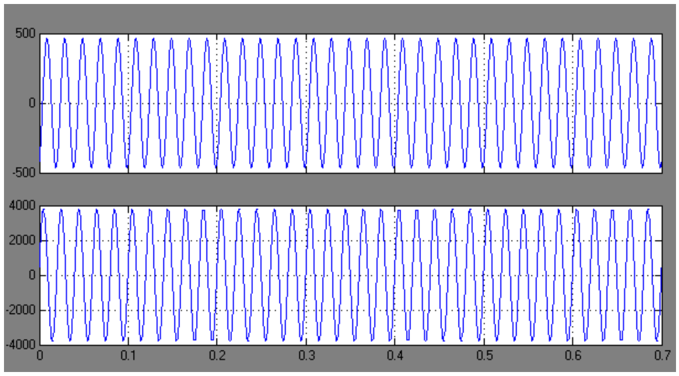

Fig 3(c): Current and volatge across bus-3

Eight bus system with TC-IPC is shown in figure 4(a). Real

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and reactive power at busses 7,1,3 & 4 are shown in figure 4(b) to 4(e), voltage and current at bus 3 are shown in figure 4(f). Reactive power with and without TC-IPC are shown in Table-1.

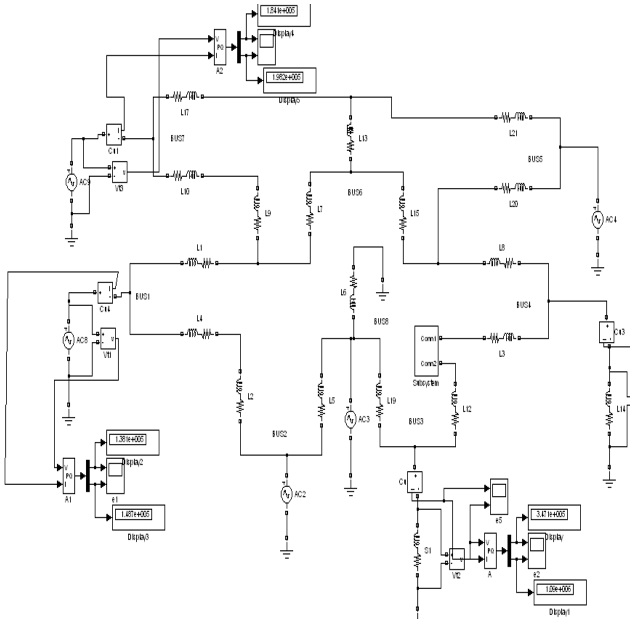

Fig 4(a): Bus System with TCIPC

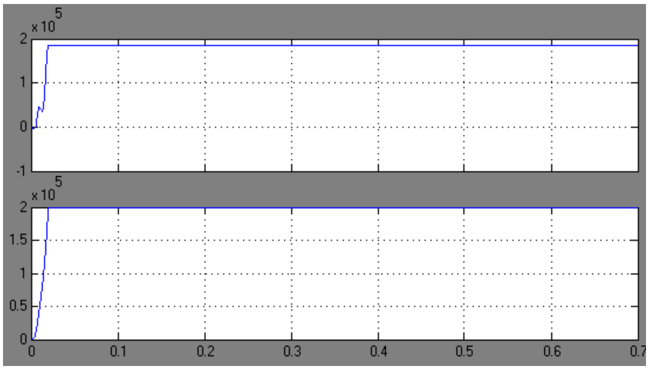

Fig 4(b): Real and reactive power across bus-7

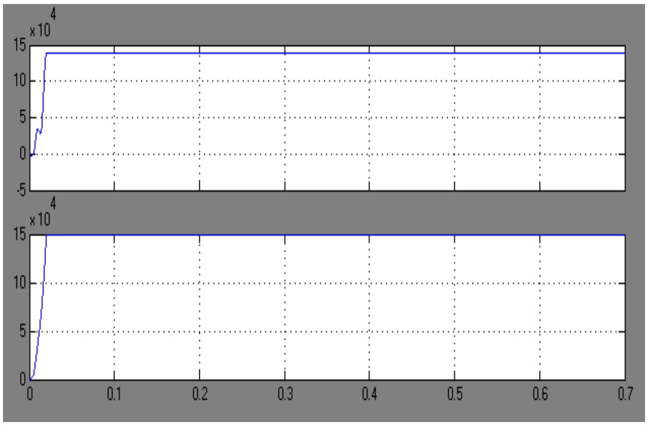

Fig 4(c): Real and reactive power across bus-1

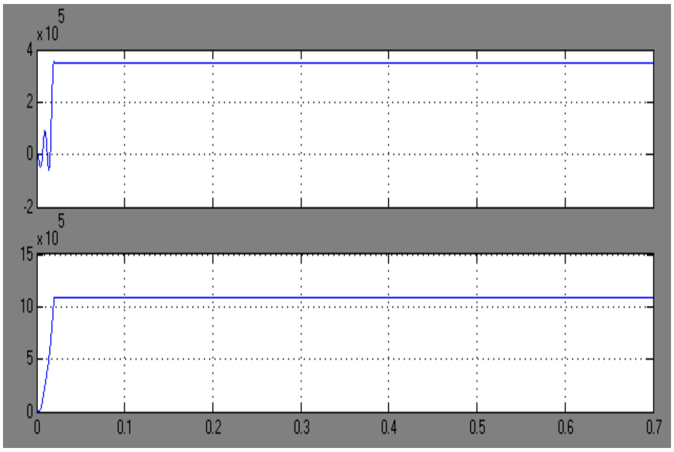

Fig 4(d): Real and reactive power across bus-3

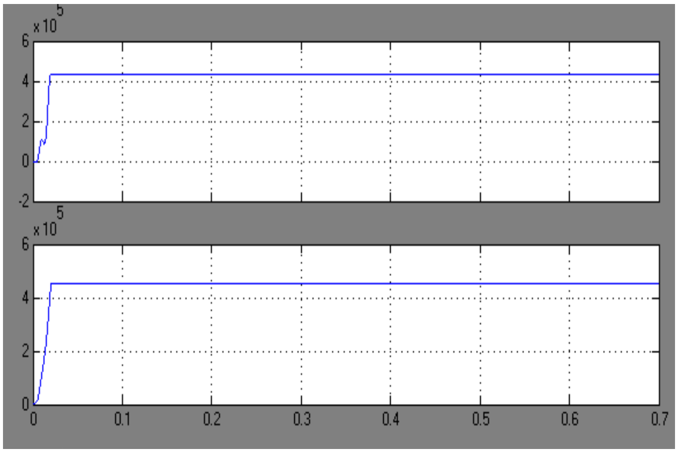

Fig 4(e): Real and reactive power across bus-4

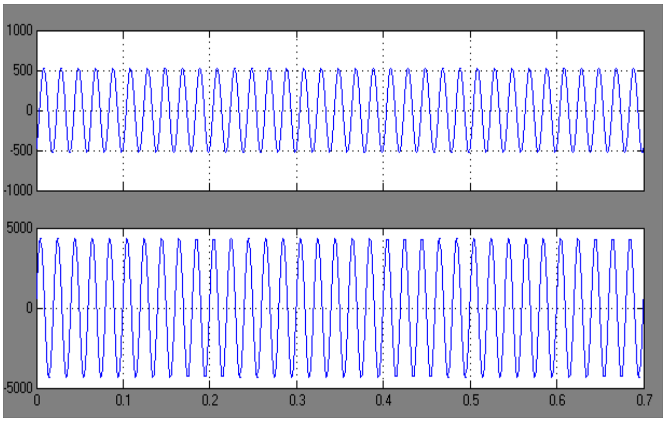

Fig 4(f): Current and volatge across bus-3

Table1: Reactive Power with and without TC-IPC

BUS NO:	REACTIVE POWER (MVA) WITHOUT TCSC	REACTIVE POWER (MVA) WITH TCSC
BUS-7	0.174	0.198
BUS-1	0.133	0.148
BUS-3	0.836	1.090
BUS-11	0.663	0.456

6 Conclusion

This paper presents the simuation resuts of 8 bus system with and without TC-IPC, simuation resuts shows that TC-IPC can improve the system stabiity and mean while preserved the merits of conventiona IPC, simuation resuts indicate that TC-IPC as a FACTS controller can improve the dynamic performance of the system. Simuation results indicate that TC-IPC can increase the real and reactive powers in the line.

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