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EFFECT OF UPFC ON SYSTEM PERFORMANCE UNDER NORMAL AND FAULT CONDITION

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Abstract - This paper deals with the effect of Unified Power Flow Controller (UPFC) on the system performance under normal and fault conditions. Simulink models are developed for 7 bus system with and without UPFC. Digital simulation using MATLAB/SIMULINK is done with these models and the results are presented. The effect of UPFC on real power, reactive power and the voltage is also presented.

Keywords: FACTS, UPFC, Power Quality, MATLAB, SIMULINK.

I. INTRODUCTION

One of the most important aspects of planning and operating electrical power systems is the design of protection systems. Protection systems are designed to detect and remove faults. A fault in an electrical power system is the unintentional conducting path (shortcircuit) or blockage of current (open circuit). The short-circuit fault is typically the most common and is usually implied when most people use the term fault. A fault occurs when one energized electrical component contacts another at a different voltage. This allows the impedance between the two electrical components to drop to near zero allowing current to flow along an undesired path from the one initially intended. The short-circuit fault current can be orders of magnitude larger than the normal operating current. The current from such an event can contain tremendous destructive energy , that can damage electrical equipment and pose safety concerns for both utility and non-utility personnel.

Nowadays FACTS devices can be used to control the power flow and enhance system stability. They can enable a line to carry power closer to its thermal rating. The salient features of a FACTS device are its multiple control functions, such as, power flow control, voltage control, transient stability enhancement, oscillation damping. Voltage sag compensation is necessary for secure system operation. A well designed FACTS Controller can not only increase the transmission capability but also improve the power system stability. UPFC is the most comprehensive multivariable flexible AC transmission systems controller [1-2].Investigations have been carried out to study the effectiveness of these devices in power-quality mitigation such as sag compensation, harmonics elimination, unbalance compensation, reactive power compensation, power-flow control, power factor correction and flicker reduction [5–6]. These devices have been developed for mitigating specific power-quality problemsThis paper is organized as follows. After this introduction, the principle and operation and of a UPFC connected to a network are presented. In section II, the control strategy for UPFC is introduced. Simulation results are presented in sections III. Section IV describes the conclusion.

II. UPFC CHARACTERISTICS

The basic components of the UPFC are two voltage source inverters (VSI's) sharing a common dc storage capacitor, and connected to the system through coupling transformers. One VSI is connected in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer. A basic UPFC functional scheme is shown inFig.1.
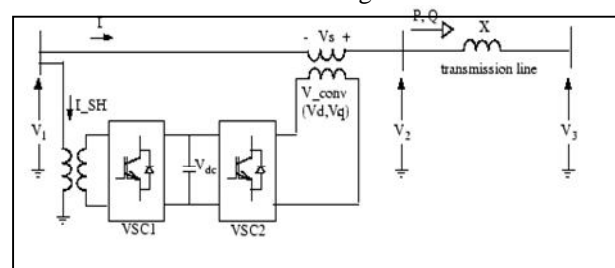

Fig. 1 UPFC functional scheme

The series inverter is controlled to inject a symmetrical three phase voltage system, Vse, of controllable magnitude and phase angle in series with the line to control active and reactive power flows on the transmission line. So, this inverter will exchange active and reactive power with the line. The reactive power is electronically provided by the series inverter, and the active power is transmitted to the dc terminals. The shunt inverter is operated in such a way as to demand this dc terminal power (positive or negative)from the line keeping the voltage across the

storage capacitor Vdc constant. So, the net real power absorbed from the line by the UPFC is equal only to the losses of the two inverters and their transformers. The remaining capacity of the shunt inverter can be used to exchangereactive power with the line so to provide a voltage regulation at the connection point. If the information regarding the series converter real demand is not conveyed to the shunt converter control system, it could lead to collapse of the dc link capacitor voltage and subsequent removal of the UPFC from operation [3-4],[7].The reference input is a simple var request that is maintained by the control system regardless of busvoltage variation. The real and reactive power equations are as follows:

$$P = \frac{V_1 V_2}{X} \sin(\delta_1 - \delta_2) \qquad (1)$$

$$Q = \frac{V_2}{X}(V_1 - V_2) \qquad (2)$$

Specification of Test System:

The effectiveness of the method is carried out on 7-bus system. The 7-bus system has 3 generators nine transmission lines and six load centers with a capacity of 11 kV. The 7-bus test system, which is considered for the purpose of case study, is shown in Fig-2.
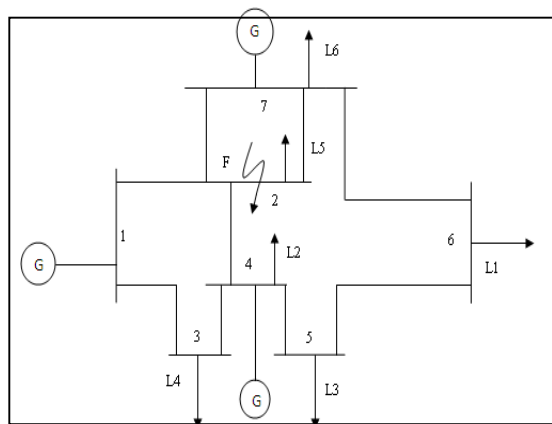

Fig-2. 7 bus test system.

Case Study and Results

The seven bus system is considered for simulation studies by using MATLAB/SIMULINK is shown in fig.3. The circuit model of seven bus system is simulated for 0.7 sec, at t=0.25 sec, a single line to ground fault is created near load 5 (L5). Due to this fault,the voltages at various load drops this simulated results are shown in fig.4. In order to over come this, UPFC is connected at various places and studied the effectiveness of the UPFC to get better performance and improved voltage profile.
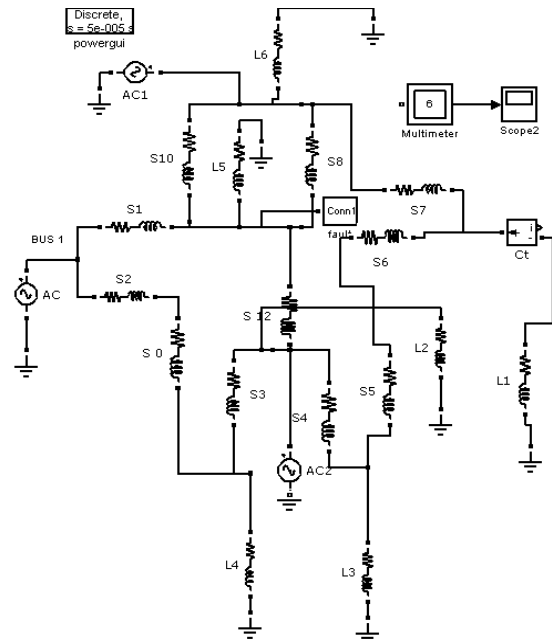

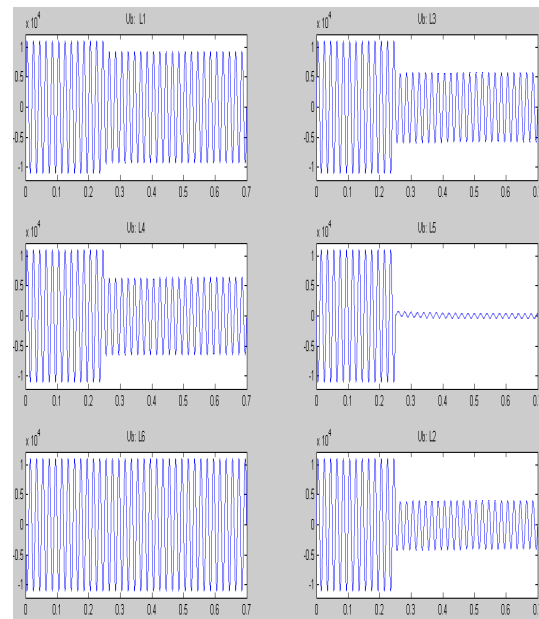Fig-3. MATLAB/SIMULINK model of the test system without UPFC

Fig-4. Voltages at various loads without UPFC

The voltage profile under fault conditions can be improved by connecting UPFC at various locations. Fig 5 shows the test system with UPFC between bus-2 and bus-4.In this paper the placement of UPFC is considered, between bus-2 and bus-4 , between bus-4 and bus-5 , between bus-6 and load 1 ,between bus-5 and bus-6 and the voltage profile respectively are shown in Fig 6, Fig 7, Fig 8 and Fig 9.
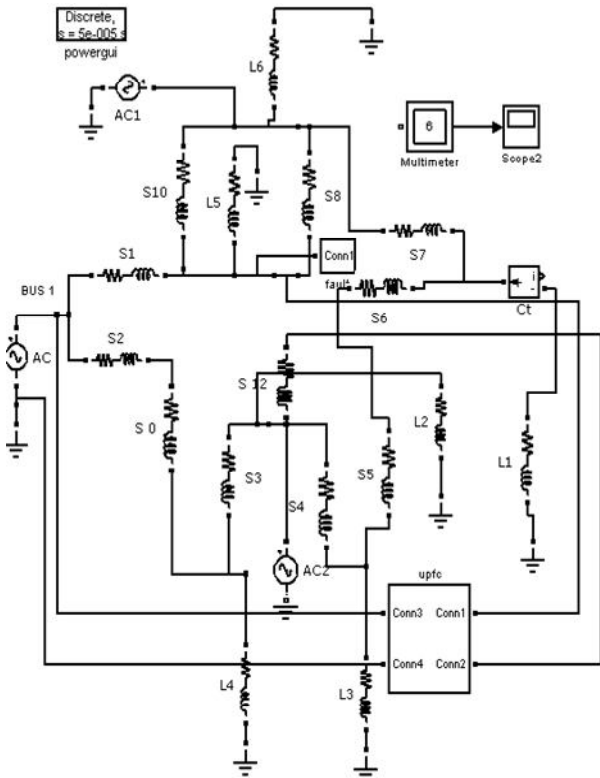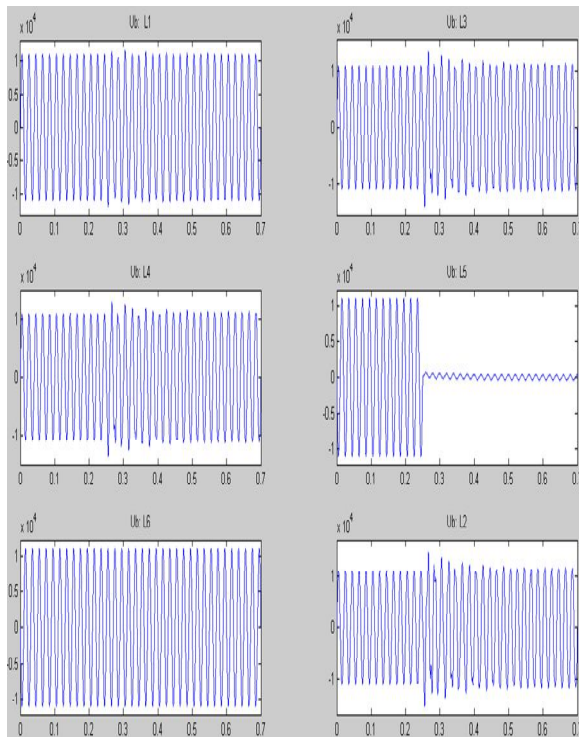
Fig-5. Test system with UPFC

Fig-6. Voltages at various loads with UPFC connected between Bus-2 and Bus 4.
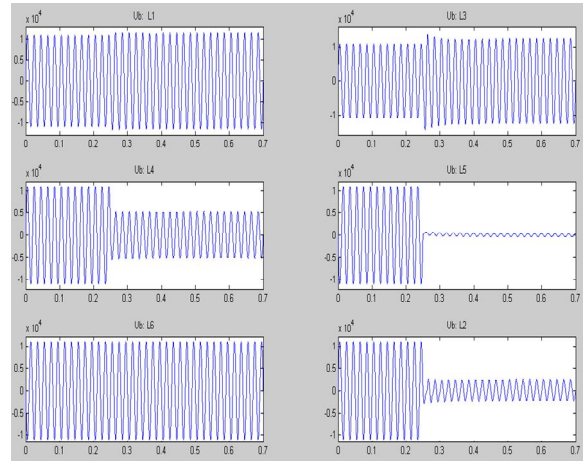

Fig-7. Voltages at various loads with UPFC connected between Bus-4 and Bus 5
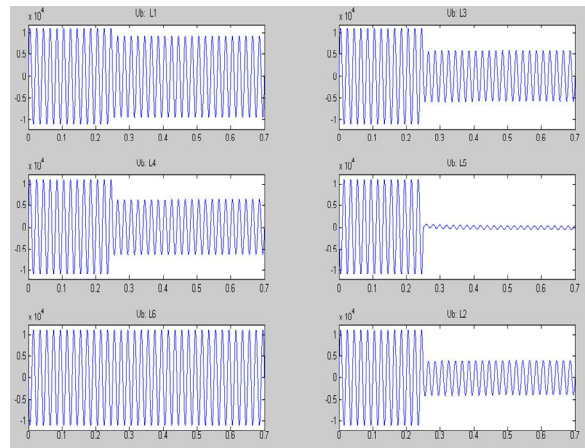

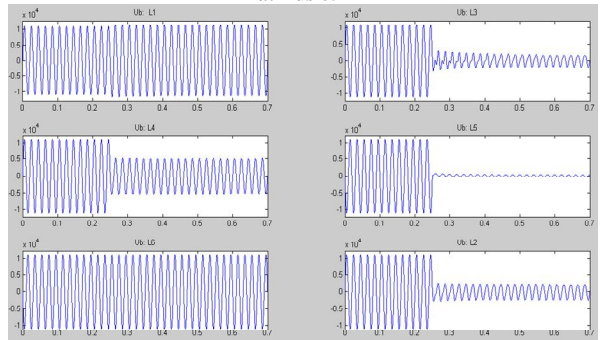**Fig-8. Voltages at various loads with UPFC connected between at Bus 6.**

Fig-9. Voltages at various loads with UPFC connected between Bus-5 and Bus 6.

From the results it is evident that in all cases the voltage profile under fault condition has improved. The more effective results are obtained by placing UPFC between bus-2 and bus-4 as shown in Fig 6.

IV. CONCLUSION:

In the simulation study, MATLAB/SIMULINK environment is used to simulate the model of seven bus system. This paper presents the control scheme for the UPFC which is used for improvement of voltage profile at various loads during fault conditions. Simulation results confirm that by proper tuning and control of UPFC can improve the voltages at various loads therby improving the stability of the system. It is found that there is an improvement in the voltages at various loads when UPFC is introduced. The effectiveness of UPFC is obtained when it is connected between bus-2 and bus-4. The simulation results are inline with the predictions.

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