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Control of Power Flow in Transmission Line Using UPFC

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Abstract:
Electrical power systems is a large interrelated network which requires a careful design to maintain the system with constant power flow operation without any limitations. Flexible to improve the system stability of a power system. Unified Power Flow Controller (UPFC) is a flexible device in the FACTS family , which has the ability to together control all the transmission parameters of power systems i.e. voltage, impedance and phase angle which determines the power flow of a transmission line. This project shows a case study to control the power flow of a power system with UPFC. In this paper we see how the upfc raise the transmission capability and decrease the power blocking in the transmission line , this study shows the results that we get by implementing a transmission system in MATLAB. The results of the network with and without UPFC are compared in terms of active and reactive power flow in the transmission line at the bus to analyze the performance of UPFC.
Keywords : *FACTS , UPFC , AC transmission line , statcom , sssc*

INTRODUCTION

The technology of power system utilities around the world has rapidly evolved with considerable changes in the technology along with improvements in power system structures and operation. The continuing expansions and growth in the technology, demand a more optimal and beneficial operation of a power system with respect to generation, transmission and distribution systems [1].In the present scenario, most of the power systems in the developing countries with large interconnected networks share the generation reserves to increase the reliability of the power system.

However, the growing complexities of large interconnected networks had fluctuations in reliability of power supply, which resulted in lack of system stability, difficult to manage the power flow and security problems that resulted large number blackouts in different parts of the world. The reasons behind the above fault sequence.

In order to overcome these consequences and to provide the desired power flow along with system stability and reliability, installations of new transmission lines are needed However , installation of new transmission lines with the large interconnected power system are limited to some of the factors like economic cost, environment related matters . These complexities in installing the transmission lines in a power system challenges the power engineers to research on the ways to increase the power flow with the existing transmission line .

But without reduction in system stability and security. In this process, in the late 1980’s the Electric Power Research Institute (EPRI) introduced a concept of technology to improve the power flow and the system stability and reliability will also become better. This technology of power electronic devices is termed as Flexible Alternating Current Transmission Systems (FACTS) technology provides the ability to increase the Alternating Current Transmission System (FACTS) is an application of a power electronics device to control the power flow and Controllability and the transmission system operation in terms of power flow, stability limits with advanced control technologies in the existing power systems will become good FACTS technology is not a single power electronic device.

A collection of controllers that are applied individually or in coordination with other devices to control one or more interrelated power system parameters such as series impedance, shunt impedance, current, voltage and damping of oscillations. These controllers were designed based on the concept of FACTS technology known as FACTS Controllers [5].FACTS controllers are advanced in relation to mechanical control switched systems that are controlled with ease.

They have the ability to control the power flow and improve the performance of the power system without changing the topology. Since 1980s, a number of different FACTS controllers with advanced control techniques proposed as per the demand of the power systems [5]. Unified Power Flow Controller (UPFC) is one among the different FACTS controllers introduced to improve the power flow control with stability and reliability.

It is the most versatile device introduced in early 1990s designed based on the concept of combined series-shunt FACTS Controller. It has the ability to simultaneously control all the transmission parameters affecting the power flow of a transmission line i.e. voltage, line impedance and phase angle may be due to the systematical error in designing and operation , weak interconnection of the power system , lack of maintenance or due to excessive load of the network .

UNIFIED POWER FLOW CONTROLLER

The upfc is one of the most widely used FACTS controllers and its main function is to control voltage, phase, magnitude, and impedance of the power system thereby modulating the line reactance and controlling the power flow in the transmission line **.**The basic components of the UPFC are two voltage source inverters (VSIs) connected by a common dc storage capacitor which is connected to the power System through a coupling transformer.

One (VSIs) is connected in shunt to the transmission system through a shunt transformer, while the other (VSIs) is connected in series to the transmission line through a series transformer. Three phase system voltage of controllable magnitude and phase angle (Vc) are inserted in series with the line to control active and reactive power flows in the transmission line. This inverter will exchange active and reactive power within the line and 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 and the net real power absorbed from the line by the UPFC is equal to the only losses of the inverters and the transformer

The remaining capacity of the shunt inverter can be used to exchange reactive power with the line so to provide a voltage regulation at the connection point .The two VSI‟s can work independently from each other by separating the dc side. Therefore in that case, the shunt inverter is operating as a (STATCOM) that generates or absorbs reactive power to regulate the voltage magnitude at the connection point. The series inverter is operating as (SSSC) that generates or absorbs reactive power to regulate the current flowing in the transmission line and hence regulate the power flows in the transmission line.

The UPFC has many possible operating modes. VAR control mode and The reference input is a simple var request that is maintained by the control system regardless of bus voltage variation. Automatic voltage control mode:-The shunt inverter reactive current is automatically regulated to maintain the transmission line voltage at the point of connection to a reference value with a defined slope characteristics the slope factor defines the per unit voltage error per unit of inverter reactive current within the current range of the inverter, the shunt inverter is operating in such a way to inject a controllable current into the transmission line. The figure 1 shows how the (UPFC) is

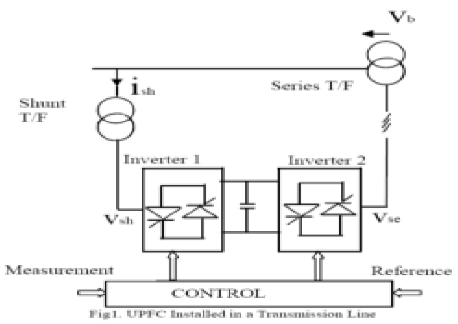


Fig .1 shows the upfc installed in transmission line

SINGLE LINE DIAGRAM OF 500 KV/ 230 KV TRANSMISSION SYSTEM.

Description of a single line diagram –

1. Above shown the single line diagram of a 500kv/230 kv transmission system. The system is connected in a loop configuration consists of 5 buses (b1 to b5), interconnected to 3 transmission line (L1,L2,L3) and two 500kv/230kv transformer bank tr1, tr2 .

2. Two power plants located on 230 kv system, generate a total of 1500 MW power , which is transmitted to a 500kv, 15000 MVA and to a 200 MW RLC load connected at bus B3 . A three phase squirrel cage asynchronous motor is connected with the RLC load. A 3 phase asynchronous motor makes use of induction principal for converting electrical energy to mechanical energy.

3. UPFC is connected at the right end of line L2 is used to control the active and reactive power at the 500 kv bus b3 .Each plant model includes a speed regulator , an excitation system as well as power system stabilizer . The 1200 MW generating capacity power plant p1 is exported to the 500 KV equivalents through two 400 MVA transformer connected between (B4 , B5) BUS .

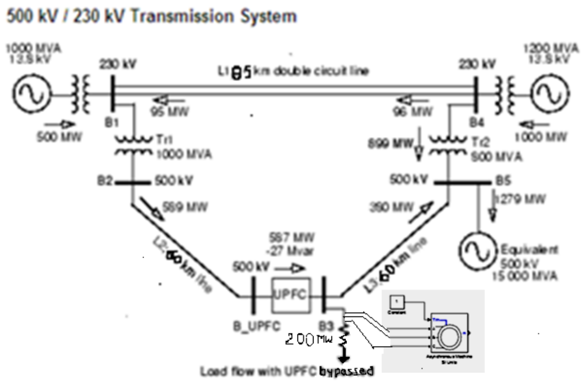


Fig 2 : transmission line using UPFC

4. The UPFC is joined at the right end of line L2 is used to control the active and reactive power at the 500kv bus B3 the UPFC used here include two 100 MVA, IGBT based converters (one series converter and one shunt converter) both the converter are interconnected through a DC bus two voltage source inverter connected by a capacitor charged to a DC voltage realize the UPFC the converter number one which is a shunt converter draws real power from the source and exchange it (minus the losses) to the series converter the power balance between the shunt and series converter is maintained to keep the voltage across the DC link capacitor constant. The single line diagram is implemented on MATLAB Simulink.

The real and reactive power equations are as follows:-

P = V1 V2/x sin ($1 -$) -----------1

Q = V2/x (V1- V2) ---------------2

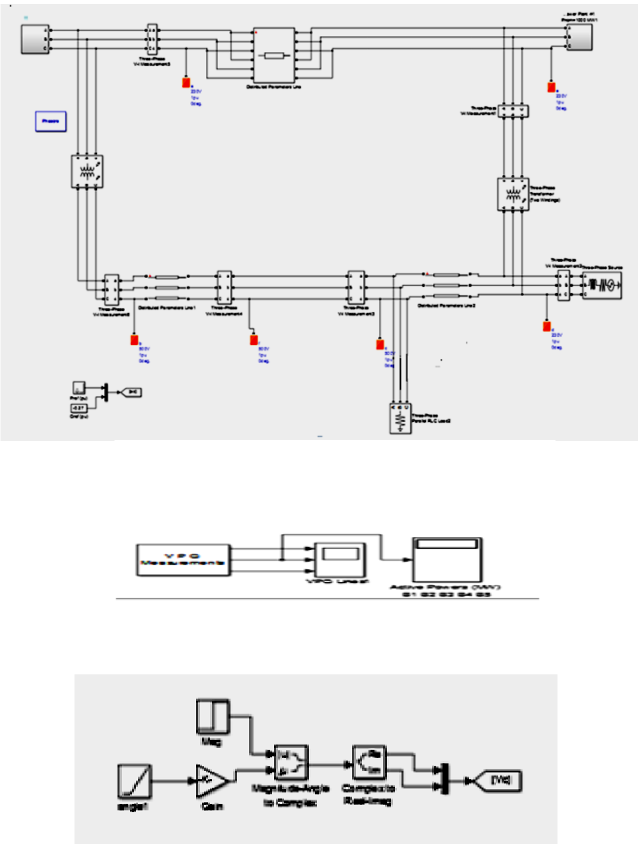


Fig 3:- MATLAB Simulink model of single line diagram of above transmission line without using UPFC.

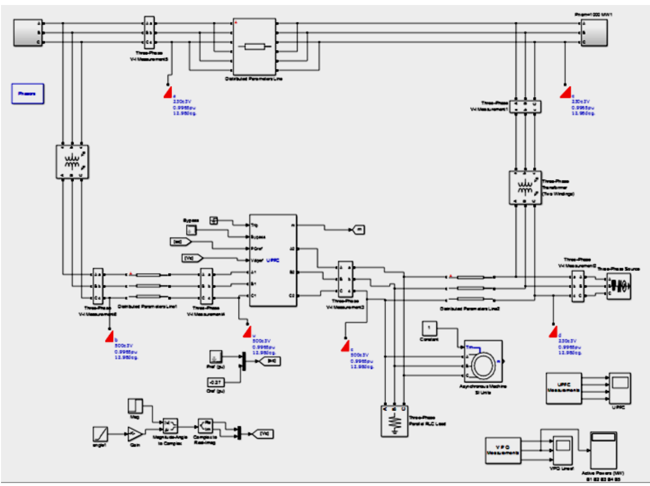
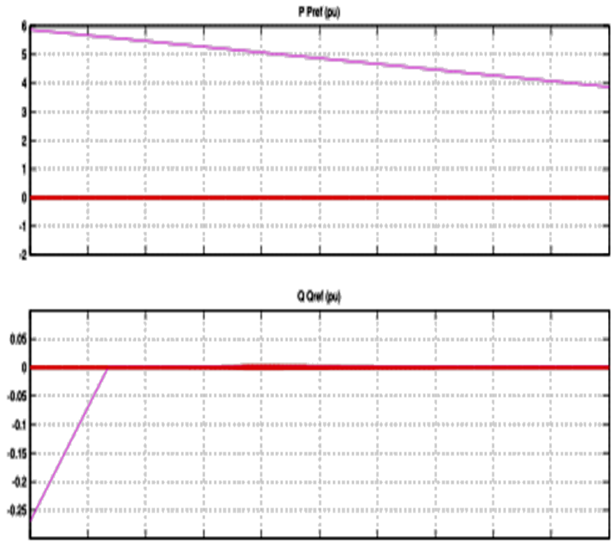


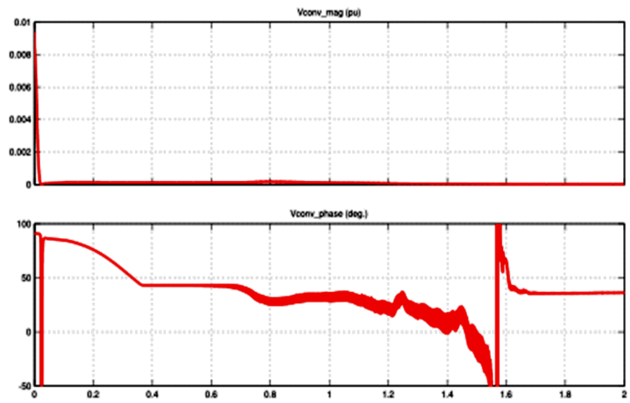
Fig 4 :- MATLAB simulink model of a single line diagram of transmission system using UPFC

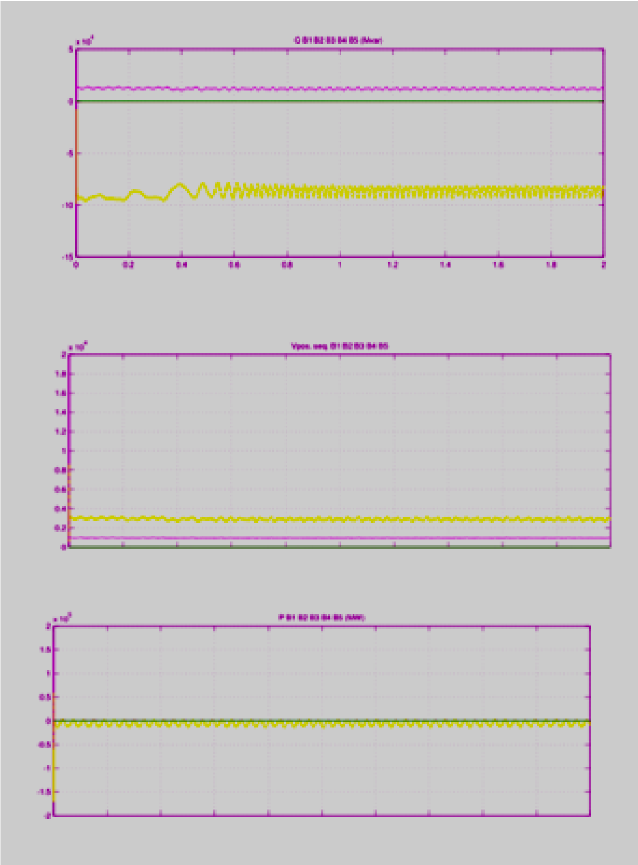
GRAPHICAL REPRESENTATION USING UPFC

Fig 5:- X- axis represents time in second and Y-axis represents injected voltage in pu, for both UPFC and without UPFC.



Active and reactive power flows in the transmission Line .





Real and reactive power in transmission line

Fig 6: - Graphical Representation Without using UPFC

RESULTS

In the single line diagram the (UPFC) is interconnected to bus B3 and the simulink results thus we get shows that how the (UPFC) reduces the reactive power in the line, without using (UPFC) the reactive power at bus B3 is -26 MVAR and real power at bus B3 is 585 MW and remain stable up to t=20sec. but with (UPFC)for a series voltage addition from 0.0094 to 0.1 pu at t= 10 sec and the angle of injected voltage start varying at a rate of 45deg/sec the shunt converter is in voltage control mode and the series converter is in power flow control mode the (UPFC) active and reactive power are set in magenta blocks labeled Pref (pu) and Qref (pu) at first the bypass breaker is closed and the resulting power flow at bus B3 is 585 MW and the reactive power flow is -26 Mvar at t=10sec when the breaker opened the net real power of the(UPFC) is raised by 100 MW .

The increase in real power tends to decrease the blocking on bus 5 this can be seen from the simulink result thus we obtained above when the breaker opened the oscillation of reactive power was finished and the reactive power was then constant at -26 Mvar. After t=10sec the real power increased by the 100 MW i.e. from 585 MW to 685 MW.

CONCLUSION

It is necessary to maintain the voltage magnitude, phase angle and line impedance of the transmission system. In this paper the (UPFC) simulation study, matlab simulink is used to simulate the model of UPFC connected to a 3 phase transmission system. This paper presents the control & performance of the UPFC used for power quality improvement. The real and reactive powers increase with the increase in angle of injection. Simulation results show the effectiveness of UPFC to control the real and reactive powers. It is found that there is an up gradation in the real and reactive powers through the transmission line when UPFC is introduced. The UPFC system has the advantages like reduce maintenance and ability to control real and reactive power.

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AUTHOR PROFILE

Priyanka Rajput received the B.E. degree in Electrical and Electronics from VNS institute of technology and science, Bhopal in 2011 and ME (PE) from SATI Vidisha 2012-14 .