Power Flow Improvement in Transmission Line Using UPFC

[1]Jalla Pavan Sai Kumar Reddy, [2]Prasad Janga

[1,2]Dept. of Electronics and Communication Engineering, CMRIT, Hyderabad, Telangana, India

Abstract

This paper proposes a brand new real and reactive power coordination controller for a Unified Power Flow Controller (UPFC). The fundamentalcontrol for the UPFC is such that the series converter of the UPFC controls the transmission line real/ reactive power flow and the shunt converter of the UPFC controls the UPFC bus voltage/shunt reactive power and the DC link capacitor voltage. In constant state, the real power demand of the series converter is offered with the aid of the shunt converter of the UPFC. To prevent instability/lack of DC link capacitor voltage for the duration of transient conditions, a new real power coordination controller has been designed. The need for reactive power coordination controller for UPFC arises from the fact that excessive bus voltage (the bus to which the shunt converter is hooked up) excursions occur throughout reactive power transfers. A brand new reactive power coordination controller has been designed to limit excessive voltage excursions throughout reactive power transfers. Matlab simulation results had been presented to exhibit the improvement in the efficiency of the UPFC manage with the proposed actual power and reactive power coordination controller.

Keywords

FACTS, Unified Power Flow Controller (UPFC), Coordination Controller

I. Introduction

The Unified Power Flow Controller (UPFC) is one of the most widely used FACTs controllers and its main function is to control the voltage, phase angle 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 transformers. 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. So, this inverter will exchange active and reactive power within the line. 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 to the only losses of the inverters and the transformers. 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. So 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.

A. VAR Control Mode

The reference input is a simple var request that is maintained by the control system regardless of bus voltage variation.

B. 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.

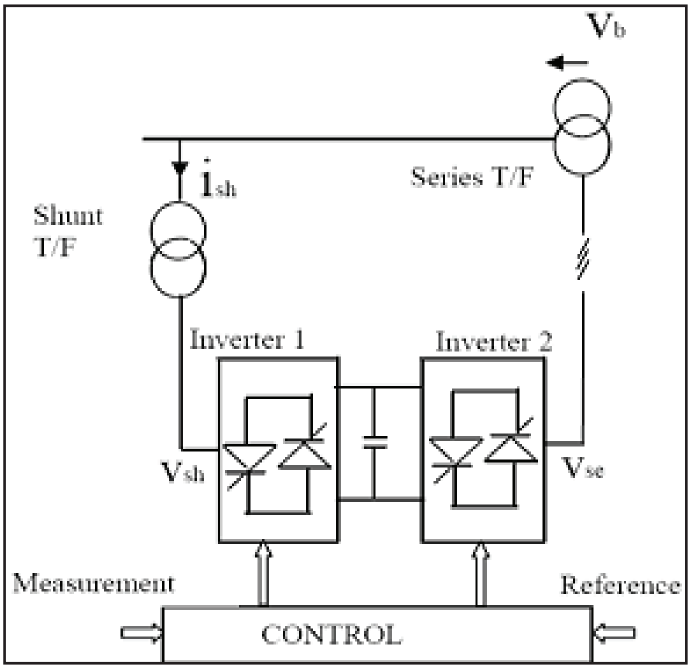

Fig. 1: Shows the UPFC Installed in a Transmission Line

In Particular, the shunt inverter is operating in such a way to inject a controllable current into the transmission line. The fig. 1 shows how the (UPFC) is connected to the transmission line.

II. Control Strategy For UPFC

A. Shunt Converter Control Strategy

The shunt converter of the UPFC controls the UPFC bus voltage/ shunt reactive power and the dc link capacitor voltage. In this case, the shunt converter voltage is decomposed into two components. One component is inphase and the other in quadrature with the UPFC bus voltage. De-coupled control system has been employed to achieve simultaneous control of the UPFC bus voltage and the dc link capacitor voltage.

B. Series Converter Control Strategy

The series converter of the UPFC provides simultaneous control of real and reactive power flow in the transmission line. To do so, the series converter injected voltage is decomposed into two components. One component of the series injected voltage is in quadrature and the other inphase with the UPFC bus voltage. The quadrature injected component controls the transmission line real power flow. This strategy is similar to that of a phase shifter. The inphase component controls the transmission line reactive power flow. This strategy is similar to that of a tap changer.

C. Shunt Converter Control System

Fig. 2 shows the de-coupled control system for the shunt converter. The D-axis control system controls the dc link capacitor voltage and the Q-axis control system controls the UPFC bus voltage / shunt reactive power.

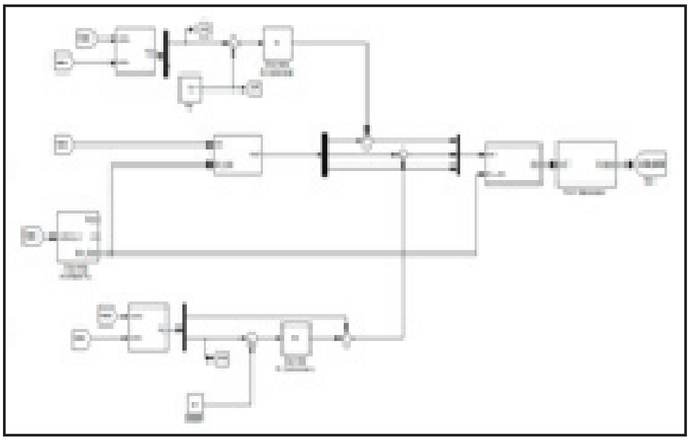

Fig. 2: Series Controller With Coordination

The de-coupled control system has been de-signed based on linear control system techniques and it consists of an outer loop control system that sets the reference for the inner control system loop. The inner control system loop tracks the reference.

D. Series Converter Control Parameters

1. Transmission line real power flow controller parameters Kp=1 ; Ki=4;

E. Series Converter Control System

Fig. 3 shows the overall series converter control system. The transmission line real power flow (Pline) is controlled by injecting a component of the series voltage in quadrature with the UPFC bus voltage (VseQ). The transmission line reactive power (Qline) is controlled by modulating the transmission line side bus voltage reference. The transmission line side bus voltage is controlled by injecting a component of the series voltage in-phase with the UPFC bus voltage (VseD). The parameters of the PI controllers Transmission line reactive power flow controller parameters:

1. Outer loop controller Kp= -0.1; Ki= -1;
2. Inner loop controller Kp= 0.15; Ki= 25;

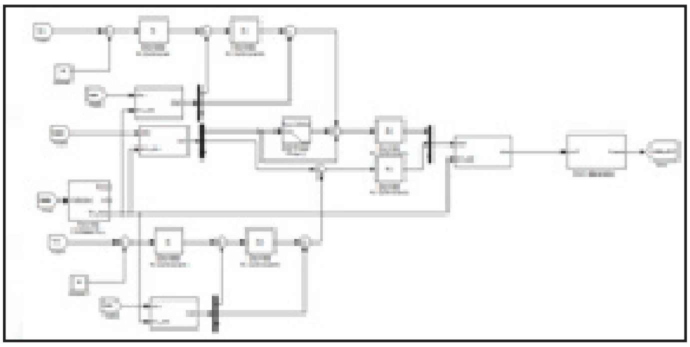

Fig. 3: Shunt Controller With Coordination

III. Proposed Framework

To understand the design of a real power coordination controller for a UPFC, consider a UPFC connected to a transmission line as shown in Fig. 4. The interaction between the series injected voltage and the transmission line current leads to alternate of real power between the series converter and the transmission line. The real power (Pse) demand of the series converter motives the dc link capacitor voltage (Vdc) to both expand and diminish relying on the path of the true power go with the flow from the series converter. This lower/expand in dc link capacitor voltage is sensed by the shunt converter controller that controls the dc link capacitor voltage and acts to increase/decrease the shunt converter actual power drift to convey the dc link capacitor voltage (Vdc) again to its scheduledworth.

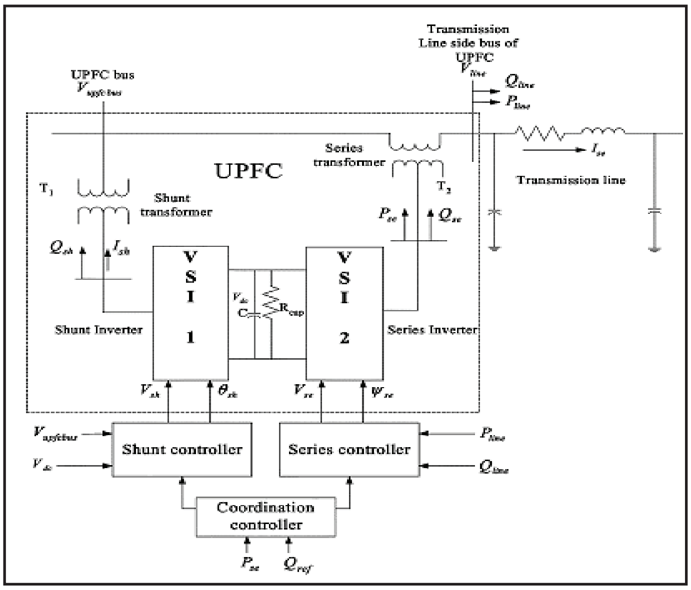

Fig. 4: UPFC Connected to a Transmission Line

On the other hand, the real power demand of the sequence converter is well-known by means of the shunt converter controller best with the aid of thereduce/increase of the dc link capacitor voltage. As a consequence,the shunt and the series converter operation are in a technique separated from every other. To provide for proper coordination between the shunt and the sequence converter manage method, a suggestions from the sequence converter is offered to the shunt convertercontrol procedure. The suggestions signal used is the true power demand of the series converter.

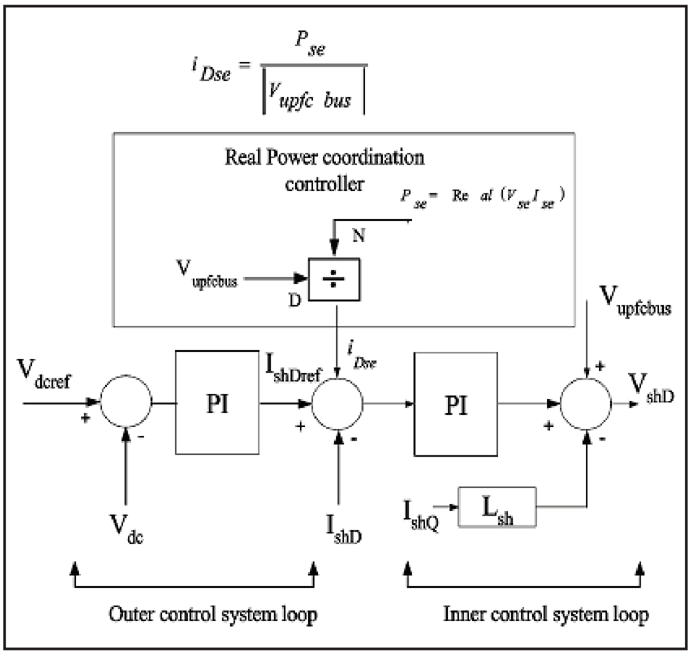

Fig. 5: D-axis Shunt Converter Control System With Real Power Coordination Controller

The true power demand of the sequence converter is changed into an identical D-axis current for the shunt converter. With the aid of doing so, the shunt converter responds right away to a transformation in its D-axis current and supplies the quintessential series converter real power demand. The identical D-axis present is a further input to the D-axis shunt converter control process as proven in fig. 5

III. Results and Discussions

The power flow in a 500 kV /230 kV transmission systems is shown in single line in Fig 6. The system is connected in a loop configuration, consists of five buses (B1 to B5) interconnected through three transmission lines (L1, L2, L3) and two 500 kV/230 kV transformer banks Tr1 and Tr2. Two power plants located on the 230 kV system generate a total of 1500 MW (illustrated in Fig. 6) which is transmitted to a 500 kV, 15000 MVA equivalent and to a 200 MW load connected at bus B3. Each plant model includes a speed regulator, an excitation system as well as a power system stabilizer (PSS). The single line diagram is implemented on MATLAB Simulink.

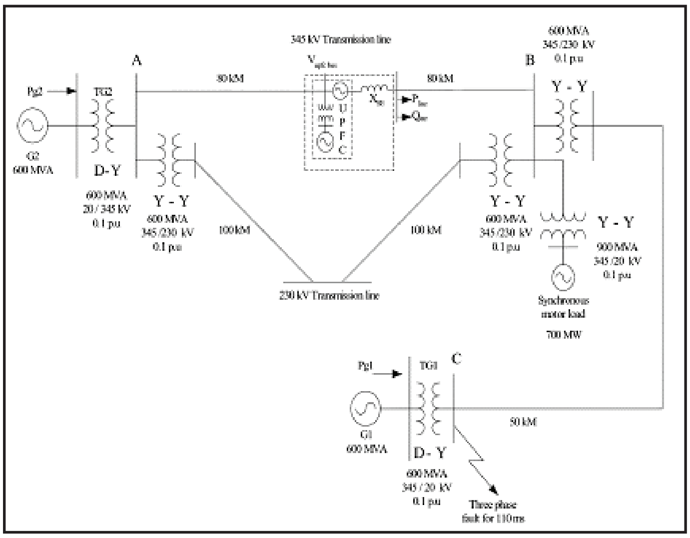

Fig. 6: Power system with UPFC

Fig 7 Shows MATLAB Simulink model of above single line diagram transmission system using UPFC

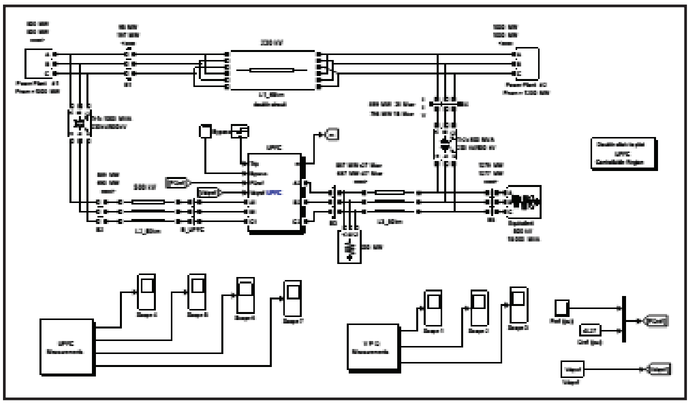

Fig. 7: MATLAB Simulink Model of Single Line Diagram Transmission

Series injected voltage in PU through a (VSIs) connected in series to the transmission line Through a series transformer without using UPFC. Note- X-axis represents time in second and Y-axis represents series injected voltage in PU For both upfc and without UPFC.

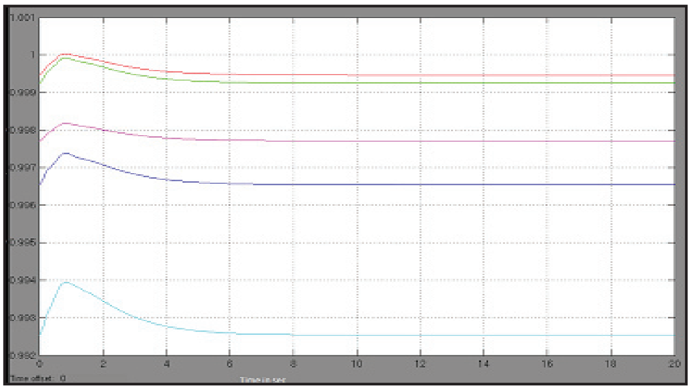

Fig. 8: Graphical Result Without Using UPFC

Series injected voltage in PU through a (VSIs) connected in series to the transmission line through a series transformer using UPFC.

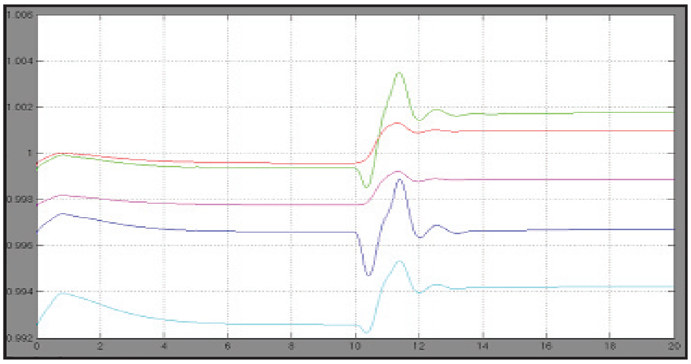

Fig. 9: Graphical Result by Using UPFC

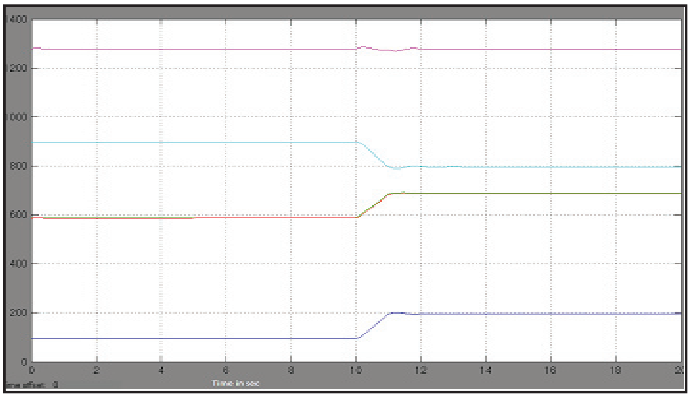

Fig. 10: Graphical Result by using UPFC

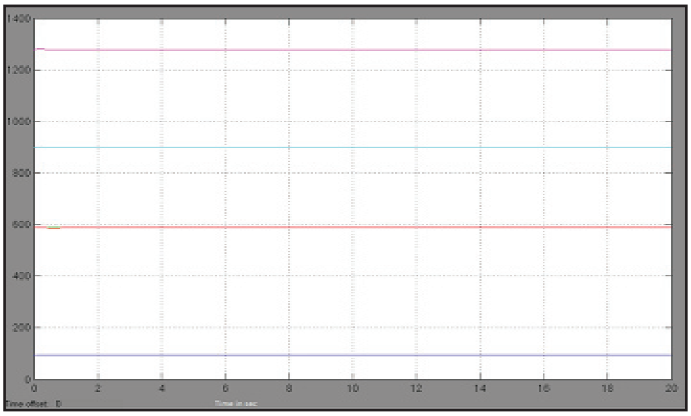

Fig. 11: Graphical Result Without Using UPSC

Comparison between reactive power flows in the transmission line with and without using UPFC. Note Y-axis represents the reactive power in MVAR.

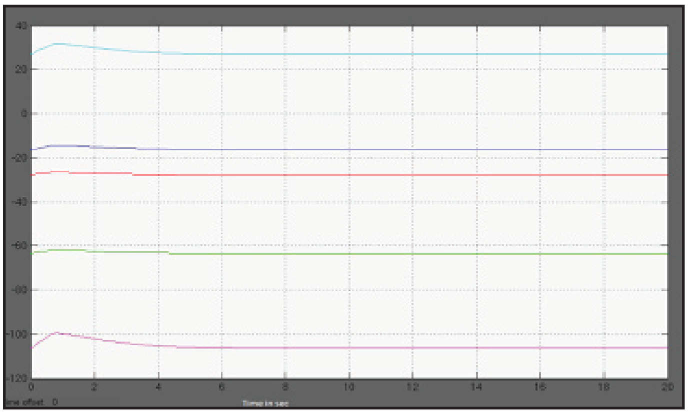

Fig. 12: Graphical Result Without Using UPFC

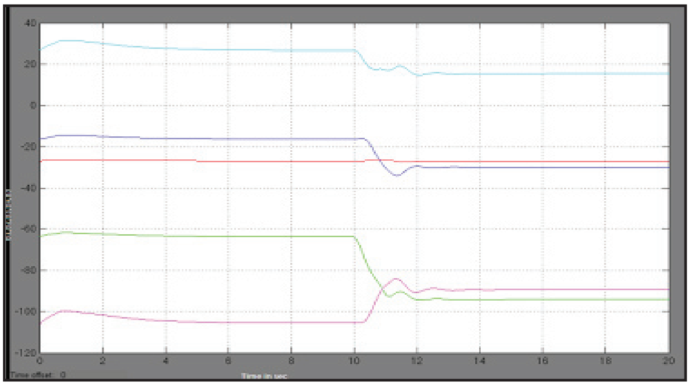

Fig. 13: Graphical Result by Using UPFC

IV. 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 improvement 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 powers.

References

[1] VibhorGupta,"Study and effects of UPFC and its control system for power flow control and voltage injection in power a power system", International journal of engineering science and technology, Vol. 2 (7), pp. 2558-2566, 2010.

[2] Hingorani, N.g.,"High power Electronics and Flexible AC Transmission System", IEEE Power Eng. REV., July 1988.

[3] M. Noroozian, L. Angquist, M. Ghandhari, G. Andersson, "Use of UPFC for optimal power flow", IEEE Transactions on Power Delivery, Vol. 12, No. 4, October 1997.

[4] Phasor Model of UPFC control, MATLAB v 7.6, help"-UPFC power flow control.

[5] Control Block of UPFC - M. Toufan, U.D. Annakkage, "Simulation of The Unified Power Flow Controller performance Using PSCAD/EMTDC," Electrical Power System Research Vol. 46, 1998, pp. 67-75.

[6] A. J. F. Keri, X. Lombard, A. A. Edris, "Unified Power Flow Controller (UPFC): Modeling and Analysis", IEEE Trans. On Power Delivery, Vol. 14, No. 2, April 1999, pp. 648-654.

[7] L. Xu, V.G. Agelidis,"Flying Capacitor Multilevel PWM Converter Based UPFC", IEE Proc. of Electronic Power Application, Vol. 149, No. 4, July 2003. pp. 304-310.

[8] Narain G. Hingorani, Laszlo Gyugyi,"Understanding FACTS:Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Marketing, 1999, pp. 297-352, pp. 407-424.

[9] C. D. Schauder, D.M. Hamai, A. Edris,"Operation of the UnifiedPower Controller (UPFC) under practical constraints", IEEE transaction on Power Delivery, Vol. 13, No. 2, April 1998.

[10] I. Papic, P. Zunko, D. Povh,"Basic control of Unified Power Flow Controller", IEEE Trans. on Power Systems, Vol. 12, No. 4, November.