Comparative Study Of Reducing The Fault Current And Overvoltage In A Distribution System In Autonomous Micro Grids Operation Using PSO UPFC & SFCL

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Abstract This paper proposes a new real and reactive power coordination controller for a unified power flow controller (UPFC). The basic control for the UPFC is such that the series converter of the UPFC controls the transmission line near the micro grid 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 steady state, the real power demand of the series converter is supplied by the shunt converter of the UPFC. To avoid instability/loss of DC link capacitor voltage during transient conditions, a new real power coordination controller has been designed. During the study process, in view of the changes in the locations of the DG units connected to the system, the DG units injection capacities and the fault positions, the active SFCLs current-limiting and over voltage suppressing characteristics are both simulated in MATLAB.A new PSO based reactive power coordination controller has been designed to limit excessive voltage excursions during reactive power transfers. Matlab simulation results have been presented to show the improvement in the performance of the UPFC control with the proposed real power and reactive power coordination controller.

INTRODUCTION

UPFC is the most comprehensive multivariable flexible ac transmission system (FACTS) controller. Simultaneous control of multiple power system variables with UPFC posses enormous difficulties. In addition, the complexity of the UPFC control increases due to the fact that the controlled and the control variables interact with each other. UPFC which consists of a series and a shunt converter connected by a common dc link capacitor can simultaneously perform the function of transmission line real/reactive power flow control in addition to UPFC bus voltage/shunt reactive power control. The shunt converter of the UPFC controls the UPFC bus voltage/shunt reactive power and the dc link capacitor voltage. The series converter of the UPFC controls the transmission line real/reactive power flows by injecting a series voltage of adjustable magnitude and phase angle. The interaction between the series injected voltage and the transmission line current leads to real and reactive power exchange between the series converter and the power system. Under steady state conditions, the real power demand of the series converter is supplied by the shunt converter. But during transient conditions, the series converter real power demand is supplied by the dc link capacitor. 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 UPFC from operation.

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 in-phase 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 in-phase 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 in-phase component controls the transmission line reactive power flow. This strategy is similar to that of a tap changer.

BASIC CONTROL SYSTEM

A. Shunt Converter Control System

Fig. 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. The details of the de-coupled control system design can be found .The de-coupled control system has been designed 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.

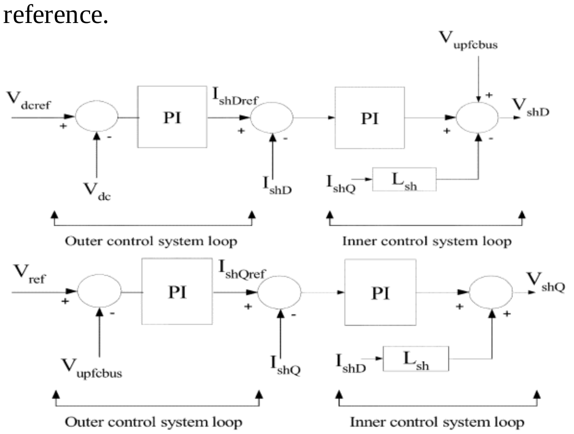


Fig.1 De-coupled D-Q axis shunt converter control system.

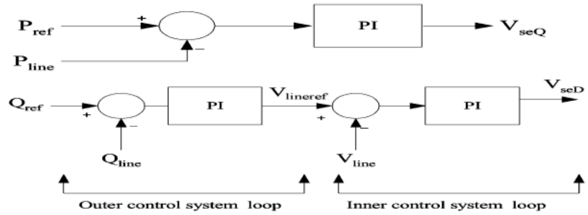


Fig.2 Series converter real and reactive power flow control system.

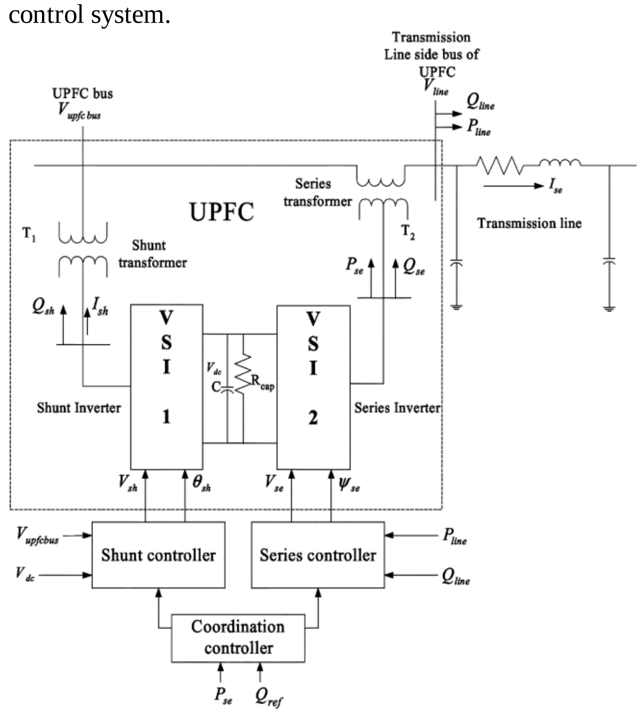


Fig.3 UPFC connected to a transmission line.

B. Series Converter Control System

Fig.2 shows the overall series converter control system. The transmission line real power flow is controlled by injecting a component of the series voltage in quadrature with the UPFC bus voltage . The transmission line reactive power 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 . The parameters of the PI controllers are given in Appendix

REAL AND REACTIVE POWER COORDINATION CONTROLLER

A. Real Power Coordination Controller

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. The interaction between the series injected voltage and the transmission line current leads to exchange of real power between the series converter and the transmission line. The real power demand of the series converter causes the dc link capacitor voltage to either increase or decrease depending on the direction of the real power flow from the series converter.

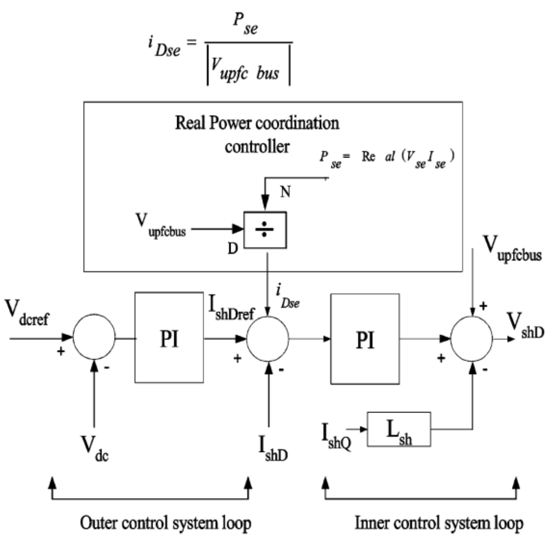


Fig.4 D-axis shunt converter control system with real power coordination controller. This decrease/increase in dc link capacitor voltage is sensed by the shunt converter controller that controls the dc link capacitor voltage and acts to increase/decrease the shunt converter real power flow tobring the dc link capacitor voltage back to its scheduled value. Alternatively, the real power demand of the series converter is recognized by the shunt converter controller only by the decrease/increase of the dc link capacitor voltage . Thus, the shunt and the series converter operation are in a way separated from each other. To provide for proper coordination between the shunt and the series converter control system, a feedback from the series converter is provided to the shunt converter control system. The feedback signal used is the real power demand of the series converter . The real power demand of the series converter is converted into an equivalent D-axis current for the shunt converter . By doing so, the shunt converter responds immediately to a change in its D-axis current and supplies the necessary series converter real power demand. The equivalent D-axis current is an additional input to the D-axis shunt converter control system as shown in Fig. Equation shows the relationship between the series converter real power demand and the shunt converter D-axis current The real power demand of the series converter is the real part of product of the series converter injected voltage and the transmission line current . Represent the voltage of the bus to which the shunt converter is connected and the equivalent additional D-axis current that should flow through the shunt converter to supply the real power demand of the series converter. As shown in Fig. the equivalent D-axis additional current signal is fed to the inner control system, thereby increasing the effectiveness of the coordination

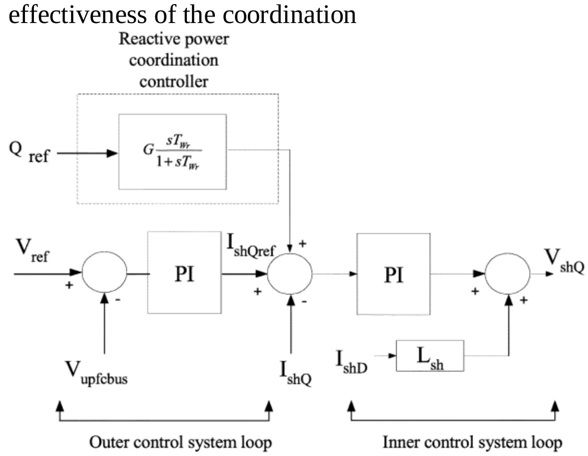


Fig.5 Shunt converter Q-axis controller with reactive power coordination controller.controller. Further, the inner control system loops are fast acting PI controllers and ensure fast supply of the series converter real power demand by the shunt converter.

B. Reactive Power Coordination Controller

The in-phase component of the series injected voltage which has the same phase as that of the UPFC bus voltage, has considerable effect on the transmission line reactive power and the shunt converter reactive power . Any increase/decrease in the transmission line reactive power due to in-phase component of the series injected voltage causes an equal increase/decrease in the shunt converter reactive power. In short, increase/decrease in transmission line reactive power is supplied by the shunt converter. Increase/decrease in the transmission line reactive power also has considerable effect on the UPFC bus voltage. The mechanism by which the request for transmission line reactive power flow is supplied by the shunt converter is as follows. Increase in transmission line reactive power reference causes a decrease in UPFC bus voltage. Decrease in UPFC bus voltage is sensed by the shunt converter UPFC bus voltage controller which causes the shunt converter to increase its reactive power output to boost the voltage to its reference value. The increase in shunt converter reactive power output is exactly equal to the increase requested by the transmission line reactive power flow controller (neglecting the series transformer reactive power loss). Similarly, for a decrease in transmission line reactive power, the UPFC bus voltage increases momentarily. The increase in UPFC bus voltage causes the shunt converter to consume reactive power and bring the UPFC bus voltage back to its reference value. The decrease in the shunt converter reactive power is exactly equal to the decrease in transmission line reactive power flow (neglecting the reactive power absorbed by the series transformer). In this process, the UPFC bus voltage experiences excessive voltage excursions.

SO, To reduce the UPFC bus voltage excursions, a reactive power flow coordination controller has been designed. The input to the reactive power coordination controller is the transmission line reactive power reference. Fig. shows the shunt converter Q-axis control system with the reactive power coordination controller.

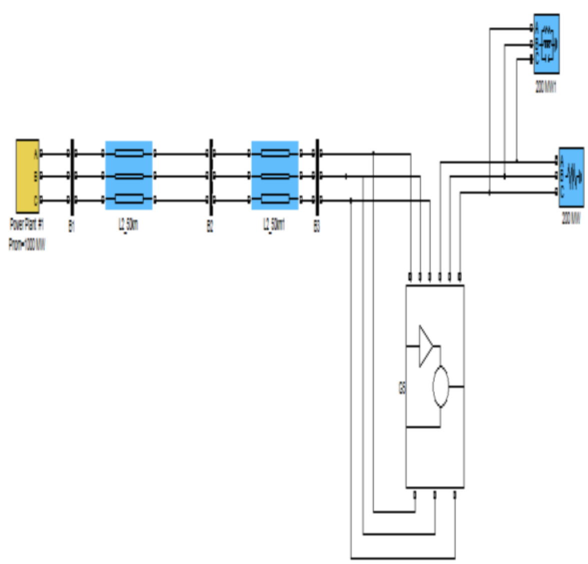
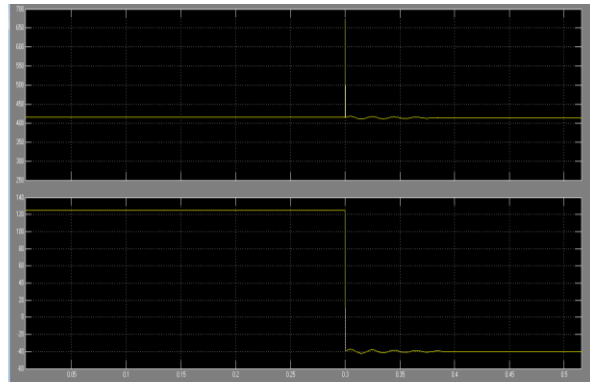
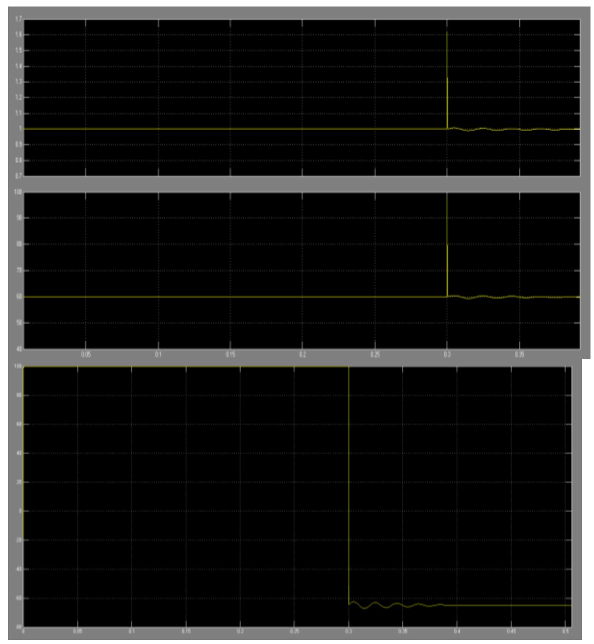


Fig.6 Power system with UPFC





The washout circuit represents the reactive power coordination controller. The gain of the washout circuit has been chosen to be 1.0. This is because, any increase/decrease in the transmission line reactive power flow due to change in its reference is supplied by the shunt converter. The washout time constant is designed based on the response of the power system to step changes in transmission line reactive power flow without the reactive power coordination controller.

CONCLUSION

This paper has presented a new real and reactive power coordination controller for a UPFC. The basic control strategy is such that the shunt converter of the UPFC controls the UPFC bus voltage/shunt reactive power and the dc link capacitor voltage. The series converter controls the transmission line real and reactive power flow. The contributions of this work can be summarized as follows. Two important coordination problems have been addressed in this paper related to UPFC control. One, the problem of real power coordination between the series and the shunt converter control system. Second, the problem of excessive UPFC bus voltage excursions during reactive power transfers requiring reactive power coordination. Inclusion of the real power coordination controller in the UPFC control system avoids excessive dc link capacitor voltage excursions and improves its revovery during transient conditions.

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