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An Enhancement of Power Flow in Transmission Lines by Using Fuzzy Interference System

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Abstract: This paper proposes another real and reactive power coordination controller for a unified power flow controller (UPFC). The fundamental control 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 transport voltage/shunt reactive power and the DC link capacitor voltage. In relentless state, the real power interest of the arrangement converter is supplied by the shunt converter of the UPFC. To stay away from precariousness of DC connection capacitor voltage amid transient conditions, another real power coordination controller has been outlined. The requirement for reactive power coordination controller for UPFC emerges from the way that over the top transport voltage (the transport to which the shunt converter is associated) trips happen amid receptive force exchanges. Another reactive power coordination controller has been intended to confine inordinate voltage outings amid responsive force exchanges. MATLAB/SIMULINK recreation results have been displayed to demonstrate the change in the execution of the UPFC control with the proposed real power also, reactive power coordination controller.

Keywords: High voltage Transmission lines, Unified Power Flow Controller (UPFC), Flexible AC Transmission Systems (FACTS), 4-bus system, MATLAB/SIMULINK

1. INTRODUCTION

Unified Power Flow Controller (UPFC) is most broad multivariable flexible AC transmission system (FACTS) controller. Synchronous control of various power framework variables with UPFC bunches immense inconveniences. In addition, the unpredictability of the UPFC controls increases due to the way that the controlled and the control variables partner with each other. UPFC which includes a course of action and a shunt converter joined by a common dc link capacitor can in the meantime perform the limit of transmission line real/reactive power flow control [2] despite UPFC transport voltage/shunt reactive power control. The shunt [3 to 4] converter of the UPFC controls the UPFC transport voltage/shunt reactive power and the dc join/link capacitor voltage if the information with respect to the arrangement converter real demand is not went on to the shunt converter control framework, it could incite breakdown of the dc link capacitor voltage and coming about removal of UPFC from operation. The real power coordination inspected is considering the known reality that the shunt converter should give the real power demand of the arrangement converter. For this circumstance, the arrangement converter gives the shunt converter control framework an indistinguishable shunt converter real compel reference that fuses as a result of advancement in dc link capacitor voltage and the arrangement converter real power request.

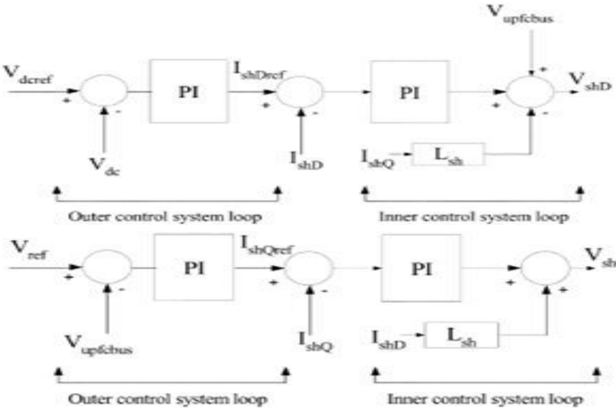


Fig.1 de coupled D-Q axis shunt converter control system

2. CONTROL STRATEGY FOR UPFC

2.1. Shunt Converter Control Strategy:

The shunt converter of the UPFC controls the UPFC transport voltage, shunt reactive power and the dc link capacitor voltage. For this circumstance, the shunt converter voltage is decomposed into two portions. One section is in-phase and the other in quadrature with the UPFC transport voltage. Dc-coupled control framework has been used to perform simultaneous control of the UPFC transport voltage and the connection capacitor voltage.

2.2 Series Converter Control Strategy:

The arrangement converter of the UPFC gives synchronous control of real and reactive power flow control in the transmission line. The arrangement converter imbued voltage is disintegrated into two sections. One section of the arrangement infused voltage is in quadrature and the other in-phase with the UPFC transport voltage. The quadrature imbued part controls the transmission line real power flow. The in-phase fragment controls the transmission line receptive force stream. This technique resembles that of a tap changer.

3. BASIC CONTROL SYSTEM

3.1. Shunt Converter Control System:

Fig. 1 shows the de-coupled control framework for the shunt converter.

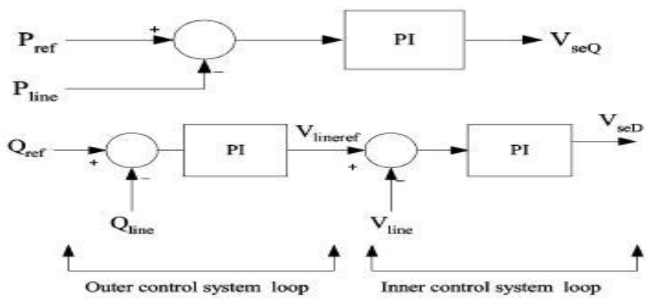


Fig. 1 Series converter real and reactive power flow control system.

The D-turn control framework controls the dc link capacitor voltage and the Q-center control framework controls the UPFC transport voltage, shunt responsive force. The de-coupled control framework has been plot in perspective of direct control framework techniques and it involves an outer circle control framework that sets the reference for the internal control framework circle. The internal control framework circle tracks the reference.

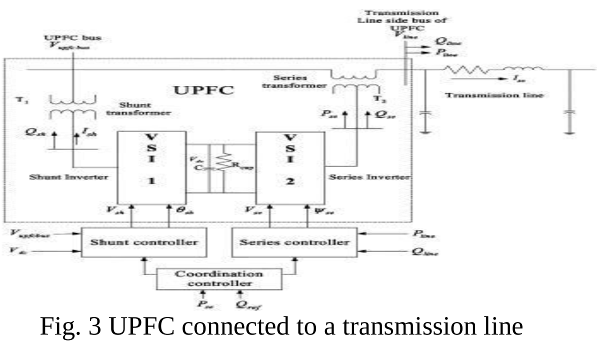
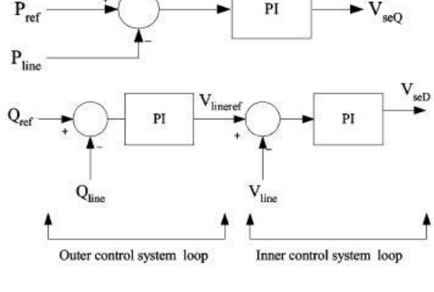


Fig. 3 UPFC connected to a transmission line



3.2. Series Converter Control System:

Fig.2 shows the general arrangement converter control framework. The transmission line real power flow is controlled by mixing a section of the arrangement voltage in quadrature with the UPFC transport voltage. The transmission line reactive power flow is controlled by adjusting the transmission line side transport voltage reference. The transmission line side transport voltage is controlled by mixing a part of the arrangement voltage in-stage with the UPFC transport voltage. The parameters of the PI controllers are given as Transmission line real power flow controller parameters: K_p= 0.1, K_i =4.0.

4. REAL AND REACTIVE POWER COORDINATION CONTROLLER

4.1 Real Power Coordination Controller:

To understand the blue print of a veritable power coordination controller for an UPFC, consider an UPFC connected with a transmission line as showed in Fig. 3 The association between the arrangement infused voltage and the transmission line current prompts exchange of real power between the arrangement converter and the transmission line. The real power demand of the arrangement converter causes the dc link capacitor voltage to either grow or diminishment depending upon the orientation of the real power flow from the arrangement converter. This decrease or increase in dc link capacitor voltage is recognized by the shunt converter controller that controls the dc link capacitor voltage. Then again, the real power demand of the arrangement converter is seen by the shunt converter controller just by the decline/addition of the dc link capacitor voltage. Along these lines, the shunt and the arrangement converter operation are in a way separated from each other. To oblige honest to goodness coordination between the shunt and the arrangement converter control framework, a contribution from the arrangement converter is given to the shunt converter control framework.

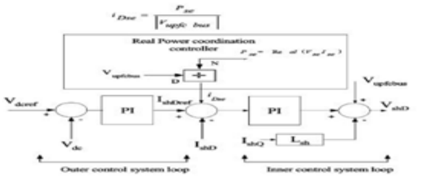


Fig. 4 D-axis shunt converter control system with real power coordination controller

The feedback sign used is the real power demand of the arrangement converter. The real power demand of the arrangement converter is changed over into an indistinguishable D-turn current for the shunt converter . In this way, the shunt converter responds quickly to conformity in its D-turn current and supplies the key arrangement converter real power request. The proportionate D-centre point current is additional information to the D-turn shunt converter control framework as demonstrated in Fig.4 shows the relationship between the arrangement converter real power request and the shunt converter D-centre point current (i_{Dse}).

$$I_{Dse} = \frac{p_{fc}}{V_{upfcbus}} \qquad (1)$$

The real power demand of the arrangement converter is the veritable bit of after effect of the arrangement converter mixed voltage and the transmission line current. address the voltage of the vehicle to which the shunt converter is related and the equivalent additional D-centre point current that should course through the shunt converter to supply the honest to goodness power enthusiasm of the arrangement converter. As showed in Fig.4, the similar D-rotate additional present sign is supported to the inside control framework, in like manner growing the sufficiency of the coordination co arrangement controller. Further, the inside control framework circles are speedy acting PI controllers and ensure fast supply of the arrangement converter genuine force request by the shunt converter.

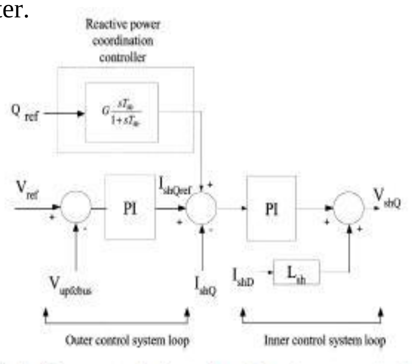


Fig. 5 Shunt converter Q-axis controller with reactive power coordination controller.

4.2 Reactive Power Coordination Controller:

The in-phase part of the arrangement infused voltage which has the same stage as that of the UPFC transport voltage has broad effect on the transmission line receptive force and the shunt converter responsive force. In this way, manufacture in transmission line reactive power is supplied by the shunt converter. Increase or reduction in the transmission line responsive power furthermore has critical effect on the UPFC transport voltage. Reduction in UPFC transport voltage is recognized by the shunt converter UPFC transport voltage controller which causes the shunt converter to extend its receptive force respect help the voltage to its reference regard.

The addition in shunt converter responsive influence yield is decisively proportionate to the augmentation requested by the transmission line responsive influence stream controller (rejecting the arrangement transformer open power disaster). Furthermore, for a reducing in transmission line responsive force, the UPFC transport voltage increases promptly. The augmentation in UPFC transport voltage causes the shunt converter to exhaust receptive power and take the UPFC transport voltage back to its reference regard. In this method, the UPFC transport voltage experiences excessive voltage trips. To diminish the UPFC transport voltage travels, a responsive power stream coordination controller has been sketched out.

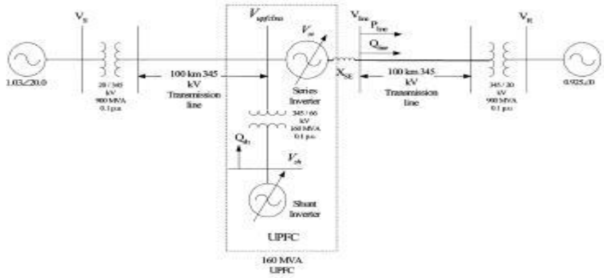


Fig. 6 Power system with UPFC

The information to the reactive power coordination controller is the transmission line reactive power reference. Fig.5 shows exhibits the shunt converter Q-turn control framework with the reactive power coordination controller. The washout circuit addresses the reactive power coordination controller. The expansion of the washout circuit has been chosen to be 1.0. This is by virtue of any form in the transmission line reactive power flow on account of advancement in its reference is supplied by the shunt converter.

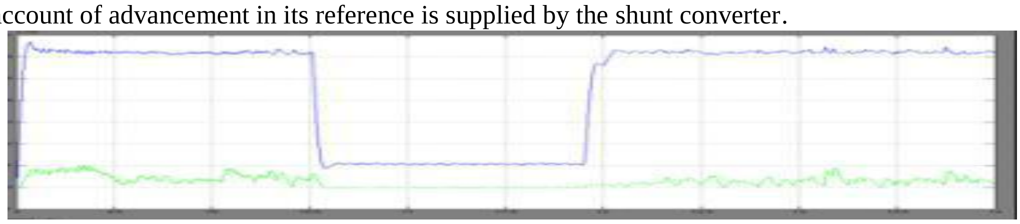


Fig.7 Response of power system to step changes in transmission line real Power reference.

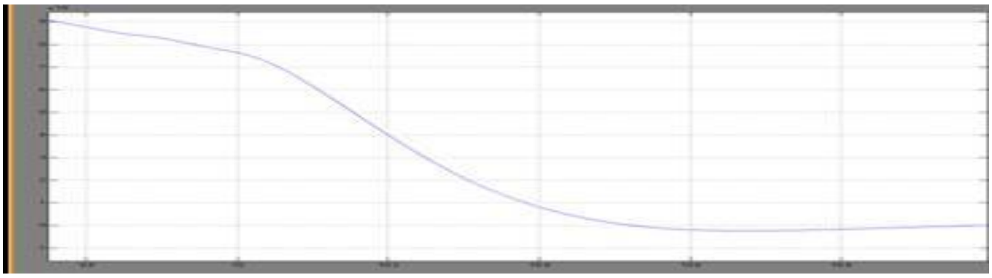


Fig. 8(a) transmission line real power

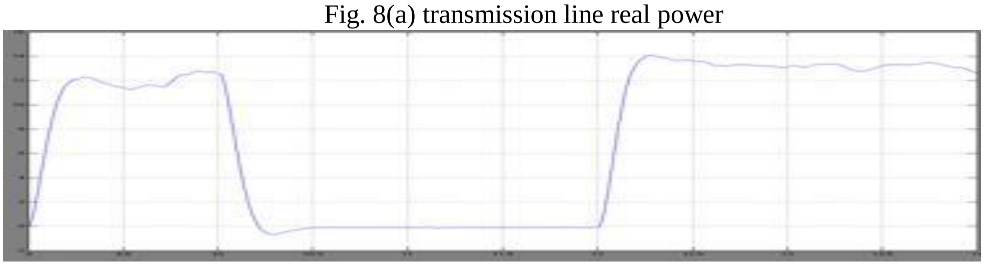


Fig. 8(b) transmission line reactive power

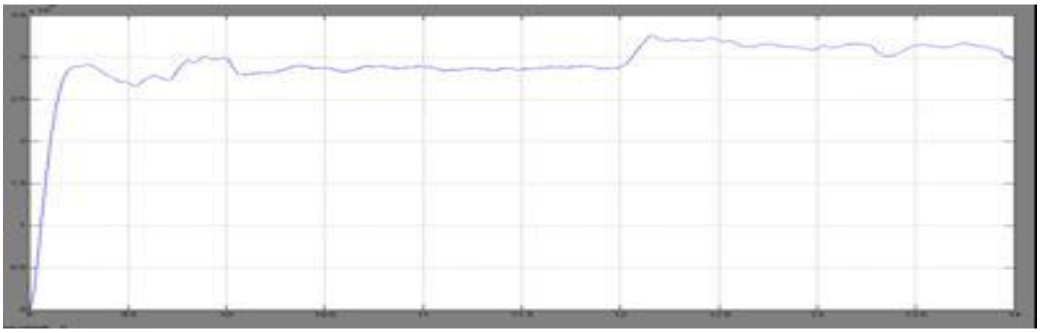


Fig. 8(c) dc link capacitor voltage

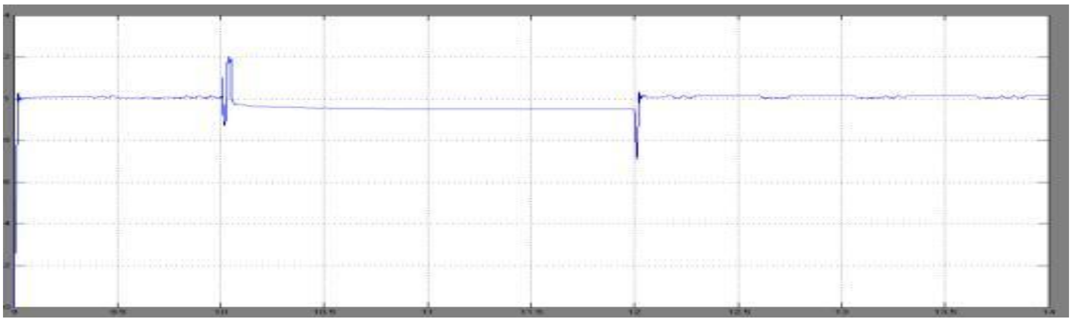


Fig. 8(d) UPFC bus voltage

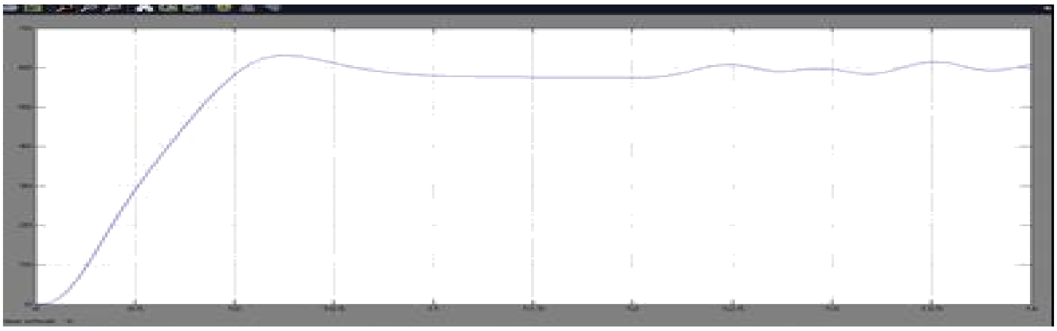


Fig. 8(e) response of the Shunt converter reactive power

Fig.6 shows the response of the power system to step changes in transmission line reactive power reference. The initial real and reactive power flow in the transmission line are 290MWand 125 MVAR, respectively. The initial shunt converter reactive power is 80 MVAR.

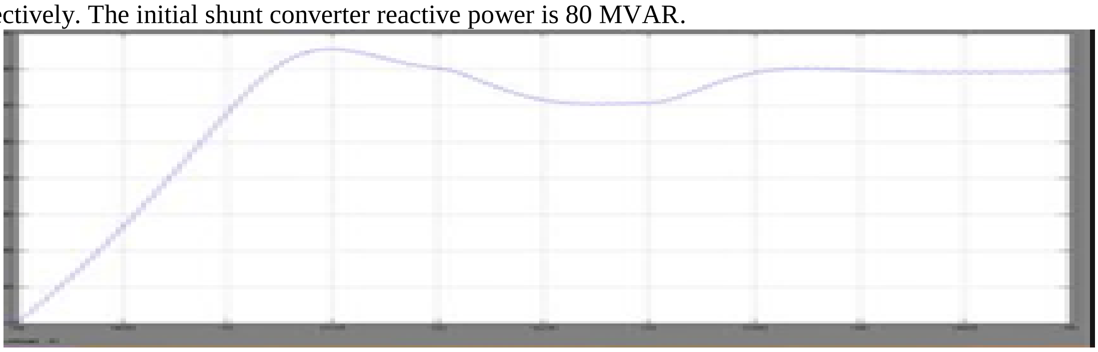


Fig. 9(a) Generator G_2 electrical power with UPFC

Plot-1 through plot-4 of Fig. 9 (a) shows the response of the system with UPFC for a three phase fault at bus-C for 110 ms. The generator G2 oscillations are well damped. The UPFC has regulated the dc link voltage at 60 kV, the shunt converter reactive power at zero and the transmission line real power flow to 400 MW.

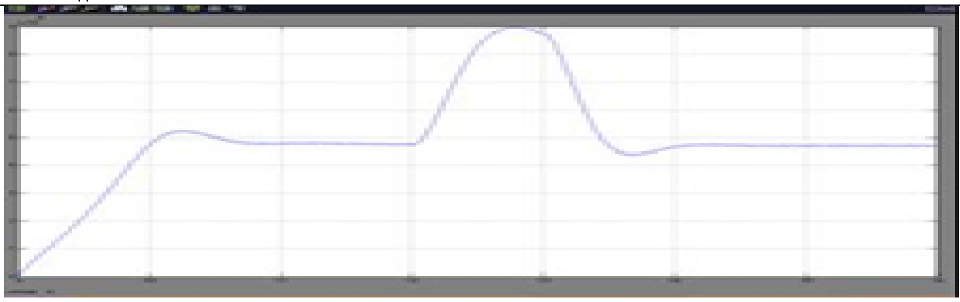


Fig. 9(b) Generator G_2 electrical power without UPFC.

A three-phase fault is applied at the high voltage bus of generator G1 (bus-C) at 12 s for 110 ms and removed without any change in the network configuration. Fig. 9(b) shows the electrical power oscillations of the generator G_2 without the UPFC for the three-phase fault.

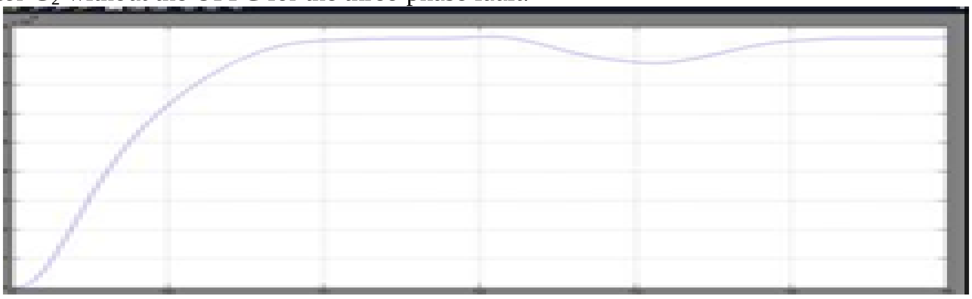


Fig. 10(a) Dc link capacitor voltage with The real power coordination

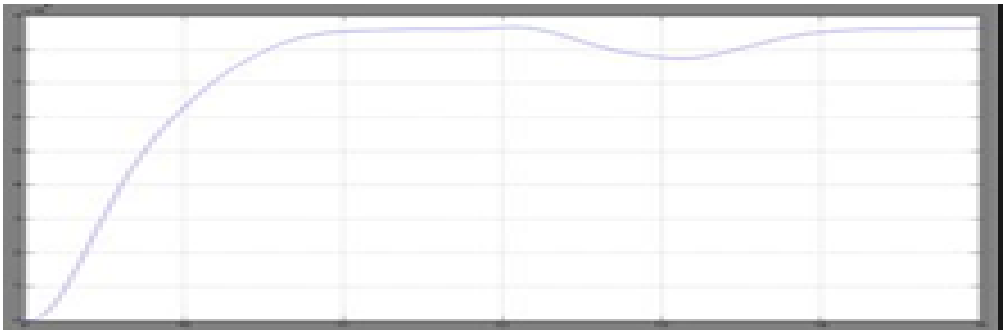


Fig. 10(b) Dc link capacitor voltage Without the real power coordination

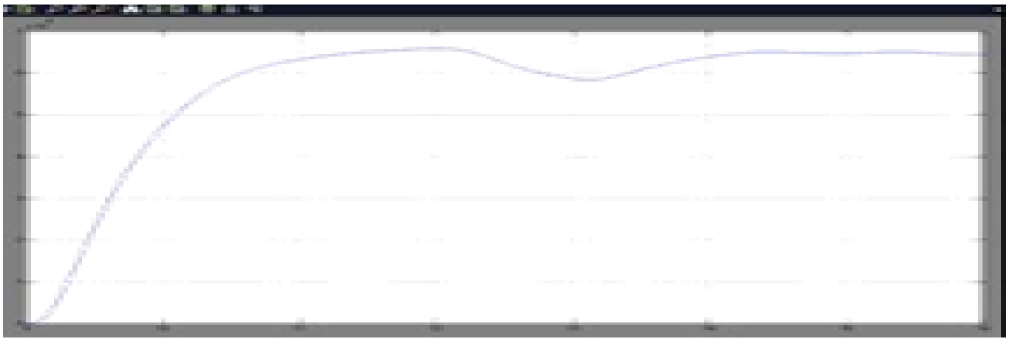


Fig.11(a) response of the Generator G2 electrical power

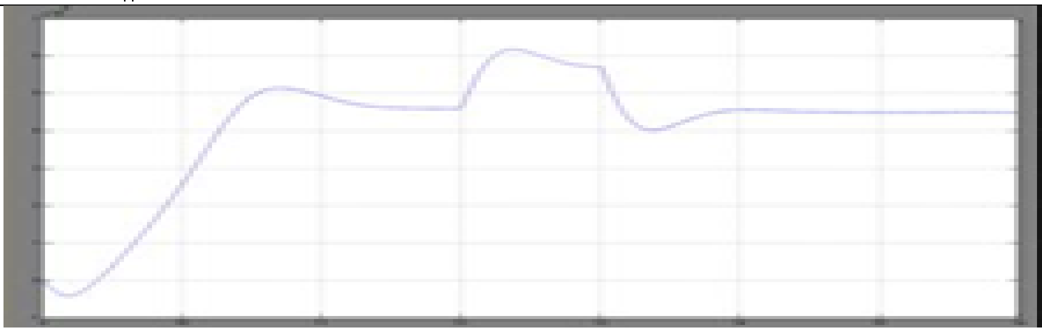


Fig.11 (b) Shunt converter reactive power

Fig.11 shows Response of the power system to three phase fault with UPFC and the comparison between the response of the generator G2 electrical power with UPFC and without UPFC. It is evident from Fig.11 that the UPFC has significantly improved the damping of generator G2 power oscillations. The extension of the given proposed system can be done by adding the IEEE 24 Bus to the power flow improvement in transmission line using UPFC.

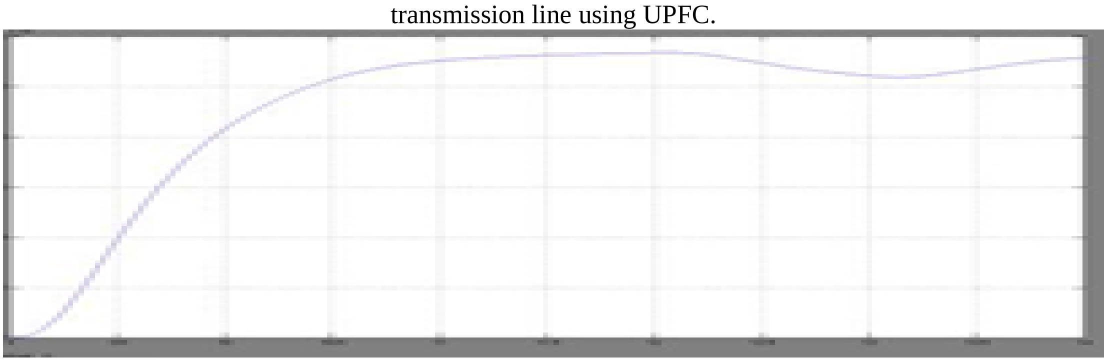


Fig.12 Dc link capacitor voltage

6. CONCLUSION

This project has presented another real and reactive power coordination controller for an UPFC. The fundamental control methodology is such that the shunt converter of the UPFC controls the UPFC transport voltage/shunt reactive power and the dc join/link capacitor voltage. The arrangement converter controls the transmission line real and reactive power flow. The responsibilities of this work can be plot as takes after. Two fundamental coordination issues have been tended to in this project related to UPFC control. One, the issue is of real power coordination between the arrangement and the shunt converter control framework. Second, the issue is of superfluous UPFC transport voltage excursions in the midst of reactive power trades obliging reactive power coordination. PSCAD-EMTDC re-enactments have been coordinated to affirm the adjustment in dc join/link voltage ventures in the midst of transient conditions.

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