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A Novel PQ Coordination Controller For A Unified Power Flow Controller


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ABSTRACT

Nowadays the measurement of reliability indices for proper evaluation of reliability in a power system has become a great challenge to power engineers. The HV lines are now installed in different countries as well as in India also. But the amount as well as quality of power transfer is very much responsible towards congestion in power system. FACTS technologies have been introduced to overcome the various operational difficulties during control of power flow as well as power compensation. By properly locating these FACTS devices the phase angle, impedance and voltage profile of the selected bus can be controlled. The UPFC is the most versatile, multifunction controller which uses the complex power electronic devices for the efficient control as well as optimization of power flowin transmission line. In this paper firstly, the basic operating principle of UPFC has been discussed. Additionally the power transmission capacity has also been improved by implementing the UPFC in a modeled power system which has been implemented in MATLAB.

Keywords: FACTS, UPFC, Power flow Control, MATLAB, SIMULINK, VSC, HYSTERESIS CURRENT CONTROL

INTRODUCTION

In modern power system to increase operating flexibility, controllability, transmission capacity, enhancing transient stability, enhancement of ATC, mitigation of subsynchronous resonance and for precise control of power flow, new types of FACTS devices are extensively used especially for transmission systems in newly deregulated electricity markets. The UPFC [1, 3, 5] is a part of a family of power electronic equipment capable of producing acontrolled synchronous voltage source (SVS) for use in modern electric power transmission system. It may be either connected in series or in parallel to power transmission lines for the purpose of better utilization of electric power system and optimization of power flow. The development of first commercial UPFC is carried out under the joint sponsorshipof the EPRI, AEP and Westing House of USA [2]. In order to realize the mechanism as well as the control strategy of UPFC, Analog and Digital Simulators are normally used. In digital simulation, the electromagnetic transient programs are widely used for UPFC analysis [4]. A power frequency model of UPFC has been developed in MATLAB to interface it into the ac power transmission network for analyzing its various effects on large- scale power systems. Simulation results show that the proposed UPFC control strategy can improve the overall system dynamic performance effectively in addition to independently control the real and reactive power in the transmission line.

Characteristics and Operating Principle of UPFC

UPFC is the representative of the most versatile and last generation of FACTS devices. This new FACTS device represents both the features of STATCOM and SSSC and thus having the capacity of controlling the all

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transmission line parameters (voltage, phase angle and line impedance).The UPFC uses one VSI (act as an SVS) connected in series to the transmission line through a series transformer while another VSI is connected in shunt with the local bus through a shunt transformer. These two VSI are connected back to back through a common dc link including a storage capacitor.

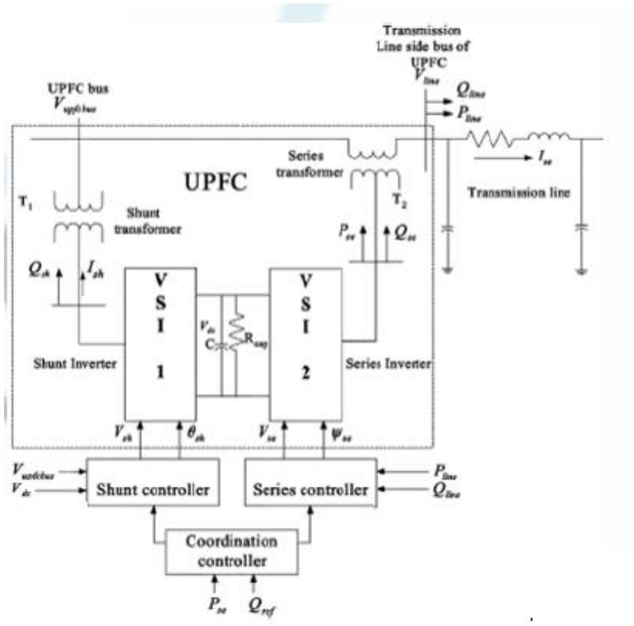

Figure 1: Model Block Diagram of an UPFC connected with transmission line

necessary reactive power by electronic way at its acterminals and thus better voltage regulation is obtained at the connection point. But the drawback of the VSI is unless there is a suitable power source at its dc side terminals, exchange of real power would be improper. Three phase controllable voltage source is connected in series with the line to control both the active & reactive power flow in the transmission line as well as to the load. Here the net real power absorbed from the line by the UPFC equal to the losses of both the VSI as well as the transformers and the exchange of reactive power with the line is provided by the remaining capacity of the shunt connected VSI. However the
two VSI can work independently by separating the dc side.

UPFC Control Block Diagram

Nowadays the FACTS technology provides greater flexibility than the SSSC for controlling the both active and reactive power of transmission line. Here in UPFC mode, the active power is transferred from the shunt connected VSIto the series converter through the DC bus. Contrary to theSSSC where the injected AC voltage (Vs) is constrained to be in quadrature with line current, this injected voltage now may have any angle with respect to line current.

III.CONTROL STRATEGY

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.

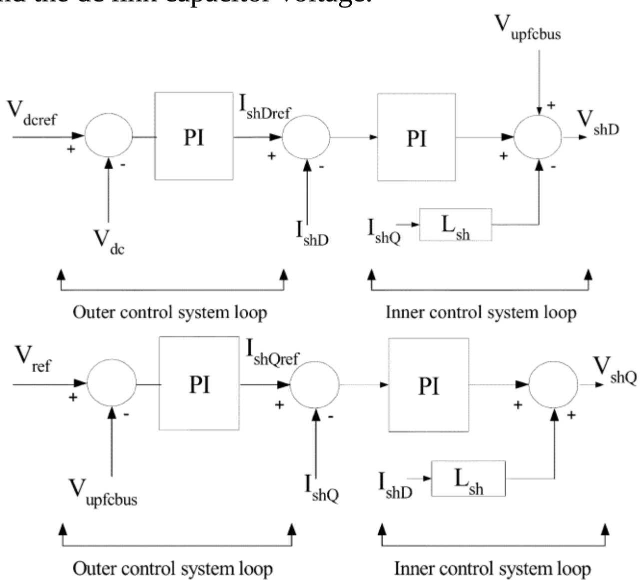

Fig. 3 . De-coupled D-Q axis shunt converter control system.

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

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component of the series injected voltage is in quadrature and the other in-phase with the UPFCbus 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.

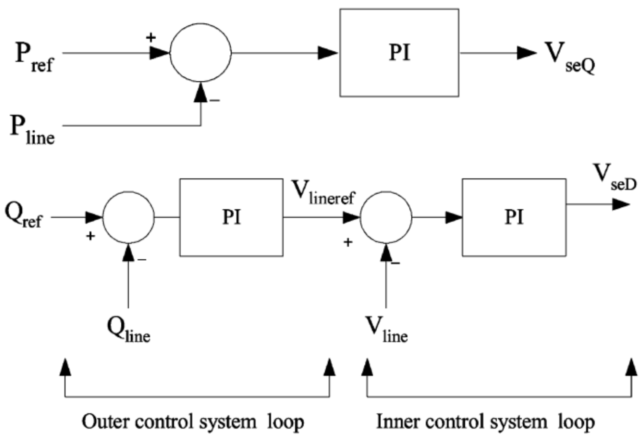


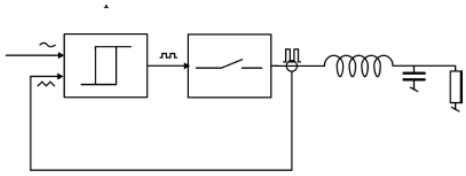
Fig. 4. Series converter real and reactive power flow control system.

HYSTERESIS CURRENT CONTROL

Basic self oscillating controllers based on hysteresis are well described in the literature [1,2]. The hysteresis controller can be made with either a current- or a voltage loop. The benefits of hysteresis controllers are primarily the linear modulation caused by the sawtooth-shaped carrier with ideally straight slopes, and by the infinite power supply rejection ratio,PSRR, if the supply variation can be considered very slow compared to the switching frequency. Power supply variations at higher frequencies are not suppressed totally, and will result in sum and difference products of the reference signal and the power supply variation, but these still meets high suppression.

For use in audio amplifier applications, the hysteresis controller is very desirable due to the high linearity and simple design.

However, hysteresis controllers suffers from a switching frequency dependent on the modulation index, M, of the amplifier. All other basic types of self oscillating modulators suffer from this phenomena too.



Current mode hysteresis controller

IV.SIMULATION RESULTS

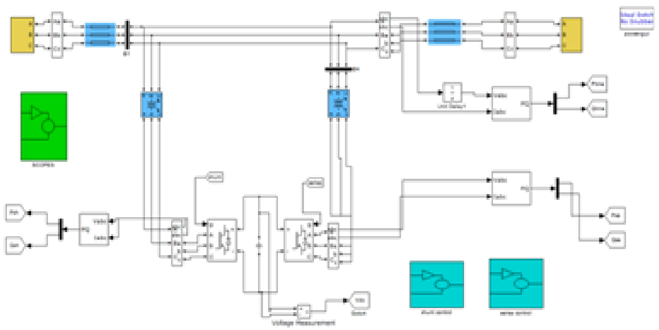


Fig.5 Simulation circuit of upfc without fault

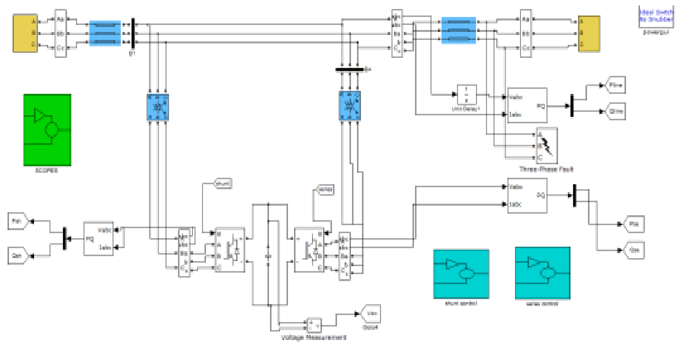


Fig.6 Simulation circuit of upfc with fault

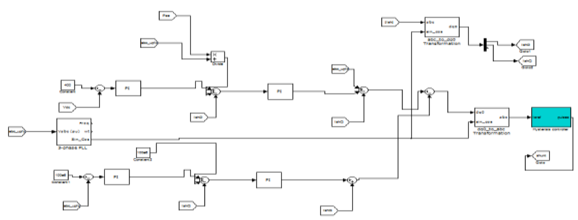


Fig .7 Shunt control block

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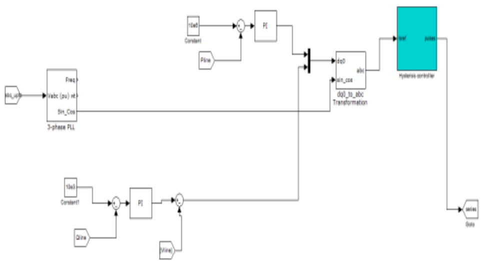

Fig. 8 Series control block

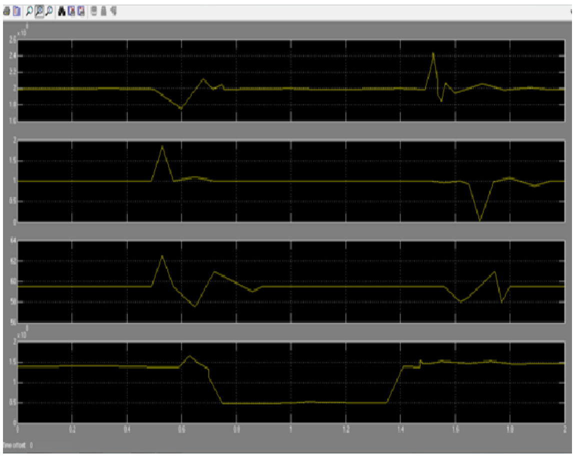

Fig.9 Response to step change in reactive power reference P line (MW), V upfc bus (p.u), V dc(KV),Q line(MVAR)

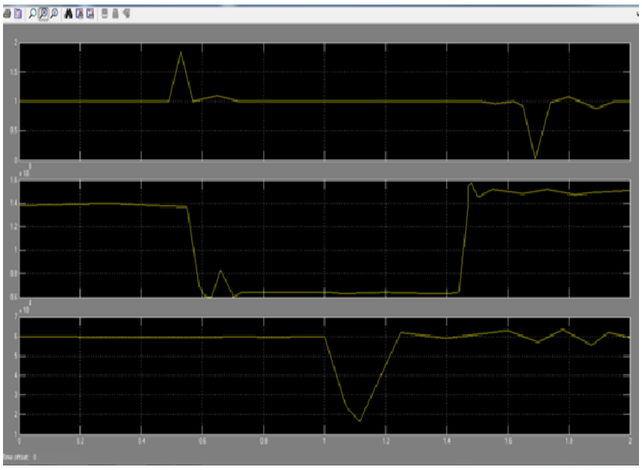

Fig10 Impact of reactive and real power coordination control V upfcbus(p.u), Q line (MVAR),V dc (KV)

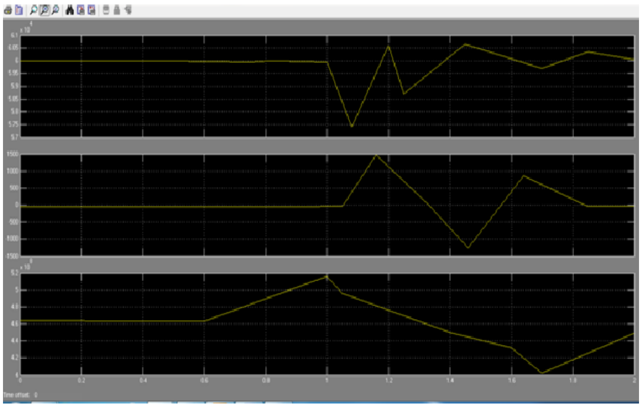

Fig.11 Response of the power system to three phase fault with UPFC V dc (KV), Q sh (MVAR),P line (MW)

V.CONCULSION

The following conclusion is obtained from the above outputgraphs:Congestion is eliminated and better power flow control is obtained Transient stability is improved. Voltage profile across different types of load is enhanced.

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AUTHOR DETAILS

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