"POWER SYSTEM STABILITY ENHANCMENT USING UPFC AND PFC DAMPING CONTROLLER"

[1]**MUSTAFA ALI AKBER,** [2]**Dr. E VIJAY KUMAR**
[1]M.TECH Scholar, SRK University, Bhopal
[2]Professor & HOD/EE, SRK University, Bhopal
E Mail: mustafa.elec86@gmail.com, eda.vijaykumar@gmail.com

Abstract - The rising of demand of power and difficulties of constructing a newly transmission network causes the power system to be complex and stressed. Due to the stress in the power system there is a chance of losing the stability following to the fault. When the fault occurs in the power system the whole system goes to severe transients. By using PSS and AVR we can easily stabilize the system. FACTS devices (i.e. TCSC, SVC, STATCOM, and UPFC) are extremely important to suppressing the power system oscillations which efficiently control the active and reactive power. This thesis reflects a novel control technique which for faults and it also increasing the damping of the system. The power electronic device named as UPFC is based on Fuzzy Logic technique to provide external controlling signal to UPFC which is mounted in single-machine infinite bus system to suppress low frequency oscillations and also it describes the model of a UPFC with multi-machine system which is externally controlled by the signal which is generated by the newly proposed power flow controller to increase the stability of the system with occurrence of fault in which it connected. The proposed controller consists of Power oscillation damping controller and Proportional Integral Differential controller (POD&PID). The effectiveness of controller for suppressing oscillation due to change in mechanical input and excitation is examined by investigating the change in rotor angle and speed occurred in the SMIB system. FACTS devices are used the existing transmission system very efficiently with the specified stability margin.

Keywords - Renewable Energy, Wind, Solar hybrid Energy, Optimization, Modeling and Simulation, Techno-Economic, Wave Energy, unified power flow controller (UPFC), PFC (power factor correction)

I. INTRODUCTION

Now recent years, the power system design, high efficiency operation and reliability of the power systems have been considered more than before. Due to the growth in consuming electrical energy, the maximum capacity of the transmission lines should be increased. Therefore in a normal condition also the stability as well as the security is the major part of discussion. Several years the power system stabilizer act as a common control approach to damp the system oscillations [1-2].However ,in some operating conditions, the PSS may fail to stabilize the power system, especially in low frequency oscillations[3].As a result, other alternatives have been suggested to stabilize the system accurately. It is proved that the FACTS devices are very much effective in power flow control as well as damping out the swing of the system during fault. Recent years lots of control devices are implemented under the FACTS technology. By implementing the FACTS devices gives the flexibility for voltage stability and regulation also the stability of the system by getting proper control signal [4].The FACTS devices are not a single but also collection of controllers which are efficiently not only work under the rated power, voltage, impedance, phase angle frequency but also under below the rated frequency. Among all FACTS devices the UPFC most popular controller due to its wide area control over power both active and reactive, it also gives the system to be used for its maximum thermal limit It's primarily duty to control both the powers independently. It has been shown that all three parameters that can affect the real power and reactive power in the power system can be simultaneously and independently controlled just by changing the control schemes from one type to other in UPFC. Moreover, the UPFC is executed for voltage provision and transient stability improvement by suppressing the sub-synchronous resonance (SSR) or LFO [5]. For example, in it has been shown that the UPFC is capable of inter-area oscillation damping by means of straight controlling the UPFC's sending and receiving bus voltages. Therefore, the main aim of the UPFC is to control the active and reactive power flow through the transmission line with emulated reactance. It is widely accepted that the UPFC is not capable of damping the oscillations with its normal controller. As a result, the auxiliary damping controller should be supplemented to the normal control of UPFC in order to retrieve the oscillations and improve the system stability.

2. CONTROL CONCEPT OF UPFC-

The classical connection of UPFC with transmission line shown on the figure.1. The UPFC uses a two back-to back VSCs, operated from a comm. on dc link. The converter 2 injects the controllable voltage both magnitude and angle to the connected line via series transformer. The converter 1S called STATCOM supplies absorbed the real power demand by the converter 2 via dc link which then support the real power exchange between them. Conceptually the UPFC can automatically control all the system parameter that affect the power flow in a line ,namely, voltage ,impedance, and phase angle, hence, the name suggested "unified"[20]. The UPFC provides complete control over power flow in the line. A circuit equivalent diagram of the UPFC is show in the fig.1

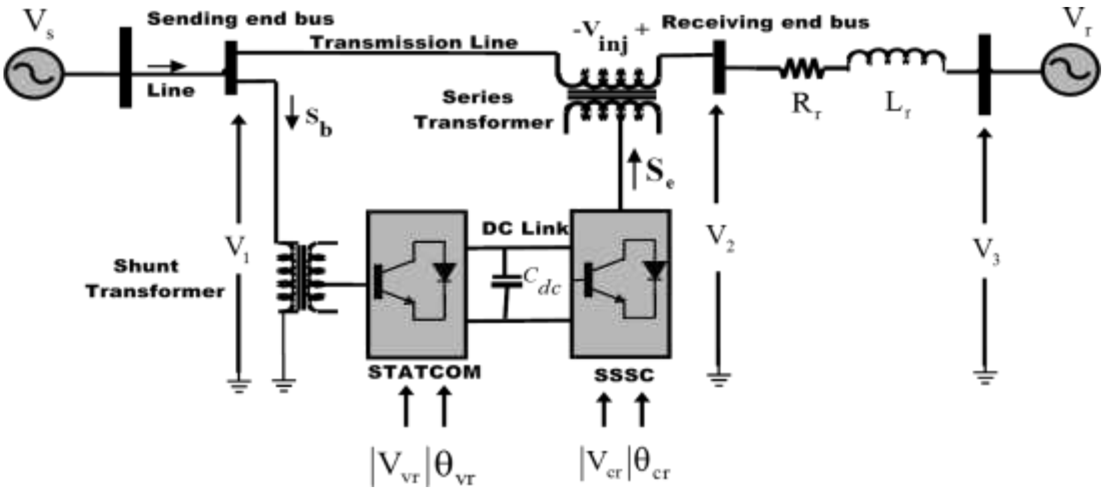

Fig.1.ConnectiondiagramofUPFCwithtransmissionline

3. UPFC BASED CONTROL SYSTEM-

There is two modes of operation, PFC mode or automatic mode and Manual voltage injection made In the power control mode the comparison between the actual and reference values of the active and reactive power is made to produce an error P and Q. This error P and Q again synthesize by two voltage regulator and the VSC to compute the Vd and Vq. component (Vd and Vq are the direct and quadrature axis component with the voltage V1 to control the powerflow in the line). In manual voltage injection mode the use of voltage deregulator is absent. The voltage of the converter is synthesized by the injected voltage Vdref and Vqref [20].Fig.3.3 shows the block diagram of series converter

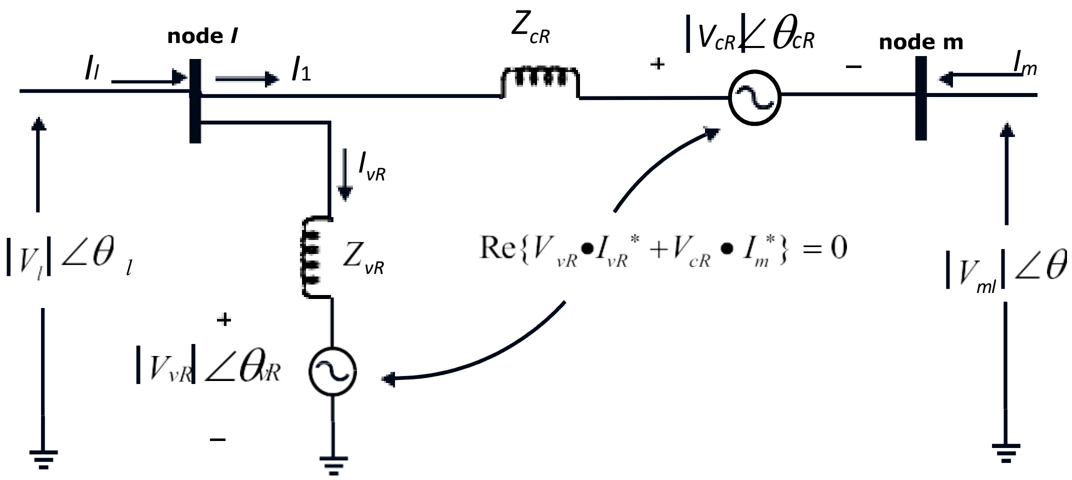

Fig .2. A general circuit equivalent of UPFC

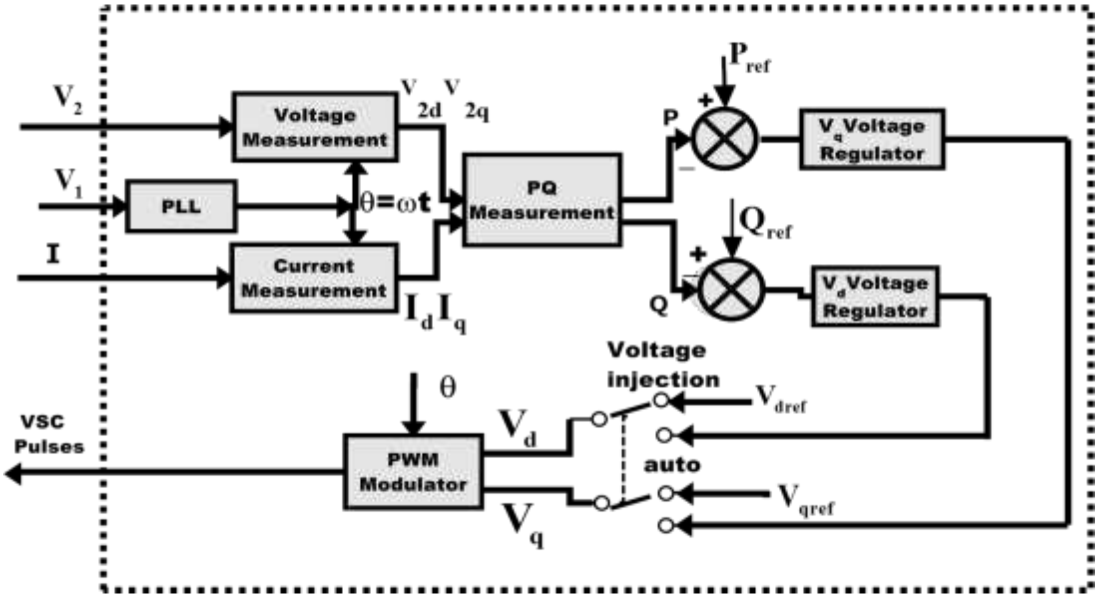

Fig. 3. UPFC based control system

4. POWER SYSTEM MODEL WITH UPFC-

Here model of a modest power system comprising of two-hydraulic power plants connected to a power grid is illustrated [21]. The whole Simulink model shown in figure. 4. A UPFC is connected to regulate the power flow in a 500/230 kV transmission line. The power system used under the study is assembled in a loop arrangement, and it combination of five buses (B1, B2, B3, B4, B5).Three lines L1 to L3 are connected to make a ring system. Each plant having their own PSS, excitation system, speed regulators. The fig.3.4 shows the single line diagram of the two- machine system connected with UPFC. The UPFC is connected to the bus 3 via line 1-2 to control both the powers in the system also it control the voltage at the bus B UPFC using two VSCs via d link capacitor and the coupling reactors and the through transformers. The total generating capacity of 1500MW and load connected are1500 MVA, 500 KV, and 200MW.

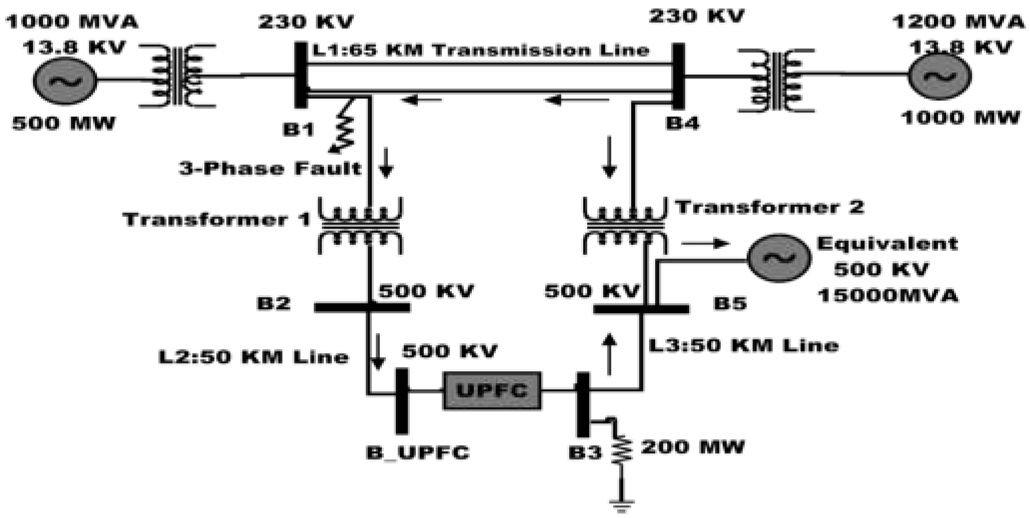

Fig.4. Single line diagram of two-machine power system with UPFC controller

5. DESIGN OF POWER FLOW CONTROLLER

The projected power flow controller consist of two different controllers, A. PID controller which is tuned by Ziegler-Nichols tuning method, B. POD controller.

6. PID Controller Tuning Process:

Input to the PID controller is the machine angular speed deviation and gives the output as an error signal. The PID tuning is done to selecting the proper controller parameter to meet the desire performance at particular condition. Most PID controllers are adjusted on-site, many types of tuning rules have been proposed in different literatures . The dynamic equation of PID control is given as:

Block diagram of PID controller Parameters is shown in the figure.3.5, for selecting the proper controller parameter, Ziegler-Nichols PID tuning method which is being used for the known system dynamic s of the given plant is used. The parameter is selected as $\tau_i=\infty, \tau_d=0$. By means of the proportional controller action the Kp is increased from 0 to critical value K_{cr}which is shown in figure..6.,Fig. .7 shows the out put of the sustained oscillation.

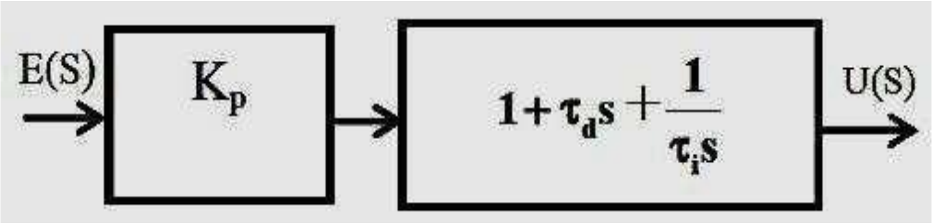

Fig..5 Block diagram of PID controller Parameters

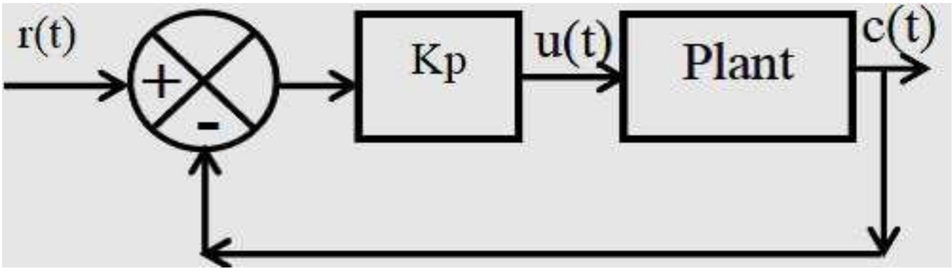

Fig..6 Proportional action of PID controller

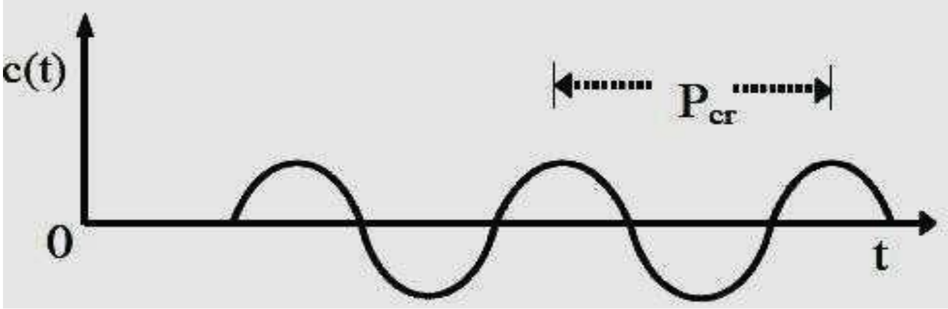

Fig. .7 Calculation of sustained oscillation (P_{cr})

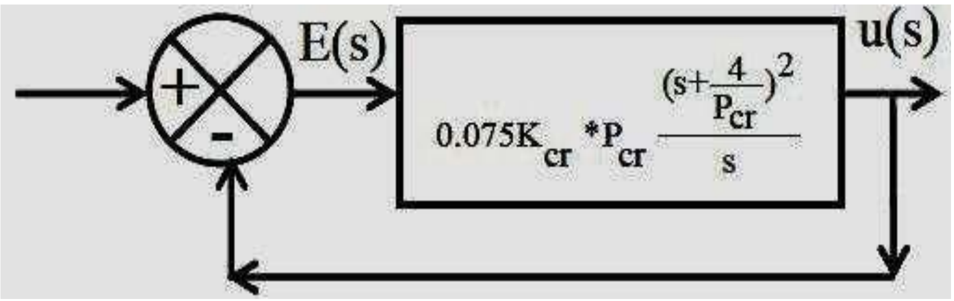

Fig..8 PID controller with tuning parameters

7. SIMULATION RESULTS AND DISCUSSION

The simulation is carried out for two different types of fault condition.

CaseA.S-L-G fault

CaseB.3-øfault

Case A.1: S-L-G fault (without UPFC)When S-L-G fault happened at 0.1s and the fault breaker unlocked at 0.2s (3-phase 4-cycle fault), as there is no UPFC connected the whole system voltage and power turn out to be unstable. The responses of the system are shown infig.3.andfig 3.

CaseA.2:S-L-Gfault (UPF with out power flow controller)

If UPFC is connected, the responses of thesystemareshowninfig.3.14andfig. 5.

CaseB.1:3-ø(with out UPFC)

Throughout3-Phase faults ,if UPFC is not connected, then again system voltage and power going to be unstable. The simulation results are shown in figure.3.16andfigure. 7.

CaseB.2:3-øfault(UPFC with out power flow controller)

During Three- Phase faults, If UPFC is connected to the system, the simulation results are shown in thefigure.3.and figure. 9.

CaseA.3:S-L-Gfault(UPFC with power flow controller)

If UPFC with PFC is connected to the system, the simulation results are shown in fig.3. and fig.3.

CaseB.3:3-ø fault (UPFC with power flow controller)

During Three-Phase faults, If UPFC is connected to the system, the simulation results are shown in thefigure.3.22and figure.3.23.

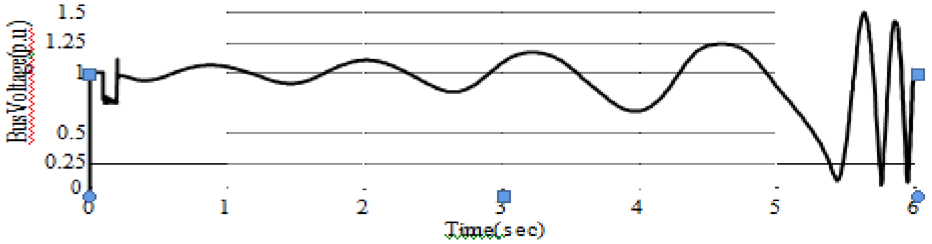

Fig.3.12 Busvoltage(B1)inp.u.withoutUPFC

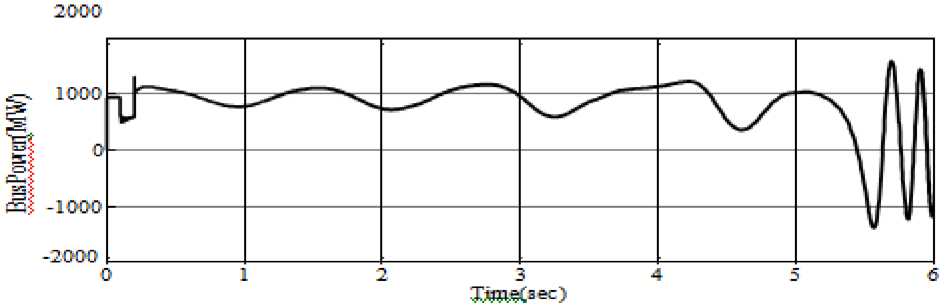

Fig.3.13 Buspower(B1) inMW withoutUPFC

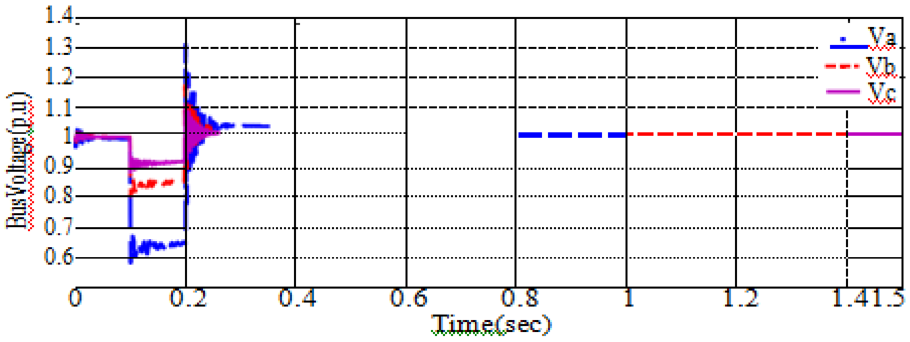

Fig.3.14 Busvoltageinp.u.(UPFCwithoutpower flowcontroller)

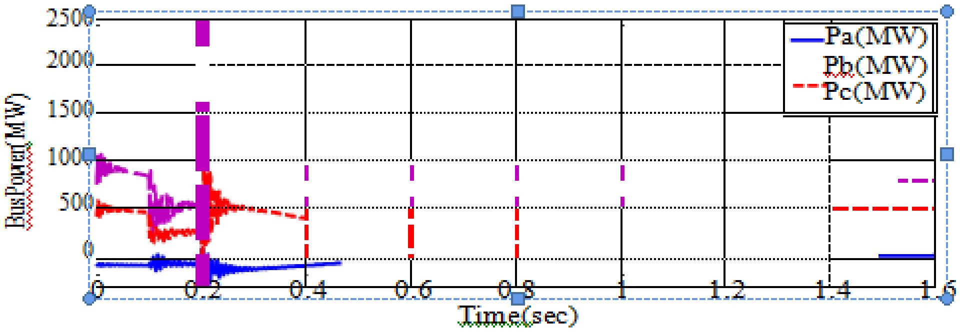

Fig.3.15 BuspowerinMW (UPFCwithoutpowerflowcontroller)

The performance of UPFC with Power Flow Controller having same 500KV transmission line is summarized in table 1.Below.

		SETTLINGTIME			
		1-PhaseFault		3-PhaseFault	
Status	UPFC	Voltage	Active Power	Voltage	Active Power
No UPFC	NO				
UPFC	100MVA	1.5s	1.6s	1.5s	2.1s
UPFC+PFC	15MVA	0.6s	1.25s	0.3s	1.4s

Table.2 The performance of UPFC with PFC having same 500KVtransmissionline

DISCUSSION: -

The above simulation results gives an idea about that UPFC not only significantly increase transient stability limits but also compensates the power system oscillations during both single phase and three phase faults. The UPFC with power flow controller very much effective to control the both active and reactive power flow of power system by injecting suitable reactive power during fault condition and damp the oscillation for active power in just 1.25s for single phase and 1.4 s for three phase faults and for voltage it is 0.6s single phase and 0.3s for three phase.. We also conclude that if the fault clearing time is less, more stability improvement. On the other hand less transient stability improvement occurs if fault clearing time is more.

REFERENCES

[1].H.F.Wang,F.J.Swift,“AUnifiedModelfortheAnalysisofFACTSDevicesinDampingPower System Oscillations Part I: Single-machine Infinite-bus Power Systems,” IEEETransactionson Power Delivery, Vol. 12, No. 2, April,1997, pp.941-946.
[2].H.F.Wang,F.J.Swift,“AUnifiedModelfortheAnalysisofFACTSDevicesinDampingPower System Oscillations Part II: Multi-machine Power Systems,” IEEE Transactions onPowerDelivery, Vol. 13,No. 4, October,1998, pp.1355-1362.
[3].HaiFeng Wang, *Member, IEEE*, “A Unified Model for the Analysis of FACTS Devicesin Damping Power System Oscillations”—Part III: Unified Power Flow Controller, IEEETransactionson Power Delivery, vol. 15,no. 3, july2000.
[4].A. A. Eldamaty S. O. Faried S. Aboreshaid, “damping power system oscillations usinga fuzzy logic based unified power flow controller”,IEEE conference, CCECE/CCGEI,Saskatoon,May2005,0-7803-8886-0/05/$20.00@2005IEEE.
[5].N.Tambey, M.L.Kothari, “Damping of Power System Oscillations with Unified PowerFlow Controller”, IEE Procdceding-Gener.Trans.Distri., Vol.150, No 2, March 2003.
[6].R.H.Adware,P.P.JagtapandJ.B.Helonde,“PowerSystemOscillationsDampingusing UPFCDampingController”,IEEEconference,ThirdInternationalConferenceonEmergingTrendsinEngineeringandTechnology, 2010.
[7].N. Bigdeli, E. Ghanbaryan, K. Afshar., “low frequency oscillations suppression viacpsobaseddampingcontroller,“journalofoperationandautomationinpowerengineering”,vol. 1, no.1, March 2013.
[8].R.Manrai, Rintu Khanna, B.Singh, P Manrai, “Power system Stability using FuzzyLogicbasedUnifiedPowerFlowControllerinSMIBPowerSystem”,IEEEConference,978-1-4673-0449-8/12/$31.00©2012IEEE.
[9].RavindraSangu,VeeraReddy.V.C,Sivanagaraju.“Dampingpowersystemoscillationsby sssc equipped with a hybrid damping controller”, IJAREEIE, Vol. 2, Issue 7, July2013.
[10].S.Tiwari,R.Naresh,R.Jha,“NeuralnetworkpredictivecontrolPredictivecontrolofUPFCfor improving transient stability Performance of power system”, Applied Soft Computing,Volume11,Issue 8, December 2011,Pages4581-4590,ISSN1568-4946.
[11]. Gyugyi, L. "Unified power-flow control concept for Flexible AC Transmission Systems," Generation, Transmission and Distribution, IEEE Proceedings, vol.139, no.4, pp.323-331,Jul 1992.
[12].K. Ogata, Modern Control Engineering, Fourth Edition, Prince Hall, 2002, Chapter, 10.
[13].Md.HabiburRahman, Md.Harun-Or-Rashid, SohelHossain,“ stability improvement of power system by using PSC controlled UPFC”, IJSETR, Volume 2, Issue 1, January2013.
[14].MeysamEghtedari,RezaHemmati, and Sayed Mojtaba Shirvani Boroujeni,” MultiobjectivecontrolofUPFCusingPIDtypeControllers”InternationalJournalofthePhysicalSciencesVol 6(10), pp. 2363-2371, 18 May, 2011.
[15].S.N. Dhurvey and V.K. Chandrakar: “Performance Comparison of UPFC in Coordinationwith Optimized POD and PSS On Damping of Power System Oscillations”, WSEASTransactionson Power Systems, Issue 5, Vol. 3, pp.287-299, May2008.