NCPE 2016, KLESCET, Belagavi
International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 2, 2016 pp. 54-59

Review of Control of Power Oscillations in Integrated Distributed Generation and Control Techniques

Nalini Karchi[1] , D. B.Kulkarni[2]
[1]Dept of Electrical & Electronics, KLE Dr. M S. Sheshgiri College of Engineering & Technology,Belagavi,India
[2]Department of Electrical and Electronics, KLS Gogte Institute of Technology, Belagavi,,India

Abstract — **The key issue in integrated distribution generation is connecting small power plants to large power grid at distribution level. It arises with different technical problems such as power oscillations. The intention of the paper, to focus on need of control and to damp of power oscillations and control method with different techniques studied by researchers till now. This provides the knowledge of methodologies proposed so far. This is an overview as well as survey of different control techniques to damp out the power oscillations in integrated distribution generation**

Index Terms — **Power oscillations, Distribution generation, Power oscillation control techniques.**

I. INTRODUCTION

The Integrated Distribution generation is referred as the interconnection of renewable generation units or small scale conventional units to power grid system. Distribution generation is also small generation unit connected at distribution network.

T he electricity demand is increasing day by day. The conventional source power plants are failing to meet electric energy demand due to shortage of fuel. This shortfall is being solved by the power generators based on alternative sources (wind, solar, micro-hydro, biomass, geothermal, tidal, etc).

These small capacity power generators are integrated to the power grid. The connection of more number of small and intermediate size generators to power grid at generation and distribution which lead the technical problems like power oscillations, distortion in voltage, harmonics, stability and faults of network.

Because of the large integration of non conventional power plants like photovoltaic plants, wind plants, etc into the power system, the power oscillation undesirable phenomenon which is causing serious problem in degrading the power quality.

This paper discusses about power oscillations, cause and effect of these oscillations in integrated distribution generation. It also presents the different control technique proposed by various authors so far in the literature. This survey will aid the researchers and designers in the field of Power Systems.

The paper has been arranged as follows,

- Overviews of power oscillations,
- Modes and classifications of power oscillations,
- Issues of Integrated distributed generation,
- Need of control of power oscillations,
- Control techniques suggested by different authors.

II. OVERVIEW

A. What are power oscillations?

Power oscillations are low frequency oscillations in the range of 0.1 to 3 Hz which is the characteristics of interconnected power systems[5].

B. Different modes of power oscillations;

1. Intraplant mode oscillations:- The oscillations within the generation plant . The machines in the same generating plant oscillate against each other at 2 to 3 Hz.
2. Local plant Oscillations:-In this mode, it is observed at a local point of connection between a single generator and infinite bus. When one generator swings against the rest of the system at 1 to 2 Hz.
3. Interarea mode oscillations:- The oscillations are observed in the large network of power system with groups of generators and generating plants connected by relatively weak tie lines. The low frequency of range 0.3Hz to 0.8Hz is found on the side of the tie oscillating against groups of generators on the other side of the tie.[3]
4. Control mode oscillations:-. The oscillations are found when generators and converters are tuned poorly. Their frequency of oscillation is not fixed and depends on the controller parameters and their observability in measured values depend on the power handling capacity of the controlled equipment and the parameter that is controlled.
5. Torsional mode oscillations:-Torsional modes typically have frequencies in the range of 15 Hz to 40 Hz and they are characterized by resonance conditions between high voltage transmission lines that are compensated with series capacitance and the inter mass mechanical modes of a steam turbine generator.[3]

The oscillations are produced due to insufficient damping which may turn out to network fault.

C. Classification of power oscillations;

As per ***PSERC report on "Avoiding and Suppressing Oscillations"*** December 1999 [6], the The Oscillations can be classified in three groups:

1. Spontaneous oscillation:

Spontaneous oscillations arise when the mode damping becomes negative by a gradual change in system conditions [6].

2. Oscillation due to Disturbance:
   Outage of a line or generator under unfavorable conditions can cause oscillations by suddenly reducing damping of a mode. If the mode damping becomes negative, sustained or increasing oscillations result. If the mode becomes poorly damped, the disturbance can excite the mode to cause a transient oscillation [6]
3. Forced Oscillation:
   It is due to incomplete islanding or pulsating loads.[6]

As per "***EPRI Power Systems Dynamics Tutorial"*** EPRI, Palo Alto, CA: 2009. 1016042, Oscillations are classified as:

1. Normal (Positively Damped) Oscillations:
   Such Oscillations may occur due to routine events on the power system. Load changes, generator trips, or switching actions may cause oscillations in power flow, voltage, current, and frequency. Power system provides positive damping to such oscillation in general. The routine positively damped oscillations are classified as normal oscillations. [6]
2. Sustained (Undamped) Oscillations:
   Sustained oscillations are oscillations that appear on the power system and sustain themselves. The cause of normal and sustained oscillations may be the same. The difference is that a normal oscillationeventually disappears (positively damped), while a sustained oscillation does not go away (Undamped) without corrective action.[6]
3. Negatively Damped Oscillations:
   Negatively damped oscillations are the most damaging type of oscillation. If an oscillation appears and then gradually grows in magnitude, it is negatively damped. A negatively damped oscillation may initially appear as a normal or sustained oscillation. As time passes, the oscillation may grow in size until it reaches amplitude that the power system can no longer withstand. [6]

D. Power quality Issues of Integrated distribution generation;

Due to fluctuating renewable energy sources and due to new power conversion technologies, distributed generation may lead power quality stability issues into the power grid. These are divided into major groups. [1]

Group1. Due to the fluctuating nature of distributed energy sources while interacting with power grid.

Group 2. Power electronics devices used to connect DG to power grid, as shown in table.1.

E. Necessity of controlling the power oscillations;

The power oscillations are identified in most of the system

Table 1 Power quality issues due to Integrated Distribution Generation

Group1	Group2
Over voltages during feed-in	Harmonics injection,
Power oscillations	Resonance phenomena
Short and long time voltage fluctuations	Capacitance inrush currents
Frequency deviations	Decreased damping character of the grid through the introduction of nonlinearities.
Voltage dips, Unbalance	

parameters like voltage, transmission line currents, branch powers and the frequency. If these are not damped initially they may take the system to instability state and finally system may collapse.

Modern power system involves large number of generators and associated controllers with large electronic circuit's involvement, different types of loads, control networks. This increases system complexity and it becomes more nonlinear. When it is integrated with distribution generation, power quality issue has become more challengeable. Power quality problems, such as voltage deviation, voltage fluctuation and flicker, voltage unbalance, and harmonics,

Particularly at the background of DG connected into power grid has been paid much attention. Fig. 1 is the statistic number of published papers in *IEEE Explore* database from 1990 to August 2015 with search of index terms as distributed generation" and "power quality".[2]

To ensure the power grid reliability and stability, power system should function efficiently without any disturbance or interruptions. In USA a recent study shows that industrial and digital business firms are losing $45 .7 billion per year due to power interruption. At the same time business sectors lose around $104 billion to $164 billion and due to all other power quality problems it estimates $ 13 billion to $ 24 billion [4]. The power flow oscillations may amount to the entire rating of a power line, when they are superimposed on the stationary line flow and would limit the transfer capability by requiring increased safety margins [7]. Due to oscillation in parameters, protection equipment may undesirably operate leading to trip in power system.

III. Analysis Methods

1. Model based method:
This method requires the accurate and full representation of system equation. This is difficult to obtain, it provides the controllability and observability [7].

2. Measurement based method:
In this method data is obtained from phasor measurement units with high resolution (25 samples/ sec, in Indian grid) can be used for obtaining the modes available in the system. Different techniques such as Prony analysis Matrix

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 2, 2016 pp. 54-59

pencil, Residue method, Henkel Total Least Squares (HTLS), Wavelet etc. enables in finding the dominant modes in the system based on time domain response. [7] It is fast and provides much useful information like the dominant modes, their damping ratio, amplitude, energy and observability. It is limited to observability and need to be supported by model based analysis for controllability aspects. The basic advantage of measurement- based analysis is that it can be computed in real time ,based on measurements obtained from high resolution measuring instruments**.**

IV. Control Method And Techniques

In Integrated distribution generation, the power quality can be improved by three ways. The first way suggests that use traditional power electronics devices such as FACT controllers like Thyristor Controlled Reactor (TCR), Thyristor Controlled Switched Reactor (TCSR), Static VAR Compensator (SVC) or Fixed Capacitor - Thyristor Controlled Reactor (FC - TCR), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Switched Series Reactor (TSSR), Thyristor Controlled Brakening Reactor (TCBR), Thyristor Controlled Voltage Reactor (TCVR), Thyristor Controlled Voltage Limiter (TCVL Thyristor Controlled Switched Series (TSSC),Thyristor Controlled Phase Angle Regulator (TC - PAR) or Thyristor Controlled Phase Shift Transformer (TC - PST), Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM), Distributed Static Synchronous Compensator (D - STATCOM), Generalized Unified Power Flow Controller (GUPFC), Unified Power Flow Controller (UPFC), Inter - link Power Flow Controller (IPFC), Generalized Inter - link Power Flow Controller (GIPFC),and Hybrid Power Flow Controller (HPFC), Semiconductor Magnetic Energy Storage (SMES), Battery Energy Storage (BESS). [9]

Second way is to use modified DG which is designed to function as power quality compensator along with its own function. Third way is use Power System Stabilizer and Automatic voltage regulator (AVR) on generator rotor side.

There is no effective solution to damp out the power system oscillations. If they are not stabilized initially, they will lead the system blackouts. There are many consequences caused by large area blackouts. Many countries have experienced these blackouts lead to financial losses.

Many authors have taken step to damp the power oscillations. They have tried to develop new methods to control the oscillations as given below.

X.Jin,J.Zhoo and H.F.Wang demonstrates that power oscillations are introduced due to unpredictable change of operation system of Integrated distributed generation and presents artificial immune controller. The artificial theory has been used as immune feedback to generate the signal. This signal controls the thyristor controlled series compensator damping controller output to stabilize the oscillations. The advantage of this method is that it is highly robust to varying operating conditions. And it also doesn't require details information about data and configuration of the power system to be tested [10].

Nguyen T.T., Kandlawala M.F.,has designed Fuzzy logic controlled Static Var Compensator. They have developed fuzzy logic algorithm to set the control signal for static Var Compensator (SVC). This Fuzzy SVC is applied to wind power plant integrated to power grid. The wind plant generates the output from a fluctuating input. The speed varies from time to time due to gusts. The plant injects transients into power grid at terminal of connection. A fu zzy SVC controller minimizes these transients at the generator terminal of a grid connected wind energy conversion system. It is verified by simulation results that damping is obtained by insertion of capacitance at the generator terminal. The capacitive injection is controlled through an optimized fuzzy logic based control of the thyristor firing angle. It holds good damping of oscillations and it is observed to perform in robust way [11].

Cloughley, M.; Muttaqi, K.M.; Haiping Du, has proposed fuzzy logic power system stabilizer to damp the low inertia oscillations.The operation of Power System Stabilizer is controlled by Takagi-Sugeno fuzzy logic technique. It is tested on Austrialian power network with number of distribances. The proposed method has proved that it improves the performance of the network transients with distributed generation by damping local oscillations. [12] Shah, R. suggests a minimax linear quadratic Gaussian-based power oscillation damper (POD) for a large-scale PV plant is proposed for interarea oscillation damping. The performance of the designed controller is evaluated under different operating conditions as compared to the classical POD at PV plant. [13] Magar presents an adaptive control theory to damp inter-area oscillations in power systems through controlling wind farm that is injecting power into the system. Here the power system is modeled as a distributed parameter system using a first order hyperbolic wave equation that is the dynamics of an aggregate rotor model for a system of coupled swing equations. A direct adaptive controller is used to stabilize the power swing in the face of disturbances using power injected from an alternate source like a wind farm. [14]

Sima seidi kharramabadi, Alireza B. have designed an adaptive power control system. This system consists of neuro fuzzy controller and a fuzzy critic agent. Where the fuzzy agent employs a reinforcement learning algorithm based on neuro dynamic programming. The proposed controller is non model based and adaptive structure. In five operational scenarios the performance of the critic based controlled microgrid is studied. Simulation result has proved that the performance of micro grid has been improved by reducing convergence time, output oscillations and tracking error. [15] Using time domain simulations, Author Thype and Jorgen have designed park level active and reactive power based power oscillation damping controllers and demonstrated with a non-linear dynamic model of the 3.6MW Siemens Wind Power WT [16].

Hadi Saghafi has suggested an integrated series converter scheme to damp the power oscillations in micro-grids with decentralized control strategy and with dominated converter-based micro- sources. The author has observed the power oscillations in a microgrid. This oscillation burdens the converter

which converts D.C. Source to A.C. Source. These oscillations are present due to LCL filters placed at the output stage of microsource. A small converter has been designed and connected in series with main parallel converter. The main converter is now relaxed. But the suggested small controller is not robust. It complicated and impractical because it dosen't do voltage regulation and power sharing.[17]
Sudhansu Kumar Samal , Prof. P.C.Panda , the proposed controller consists of Power oscillation damping controller and Proportional Integral Differential controller (POD & PID).The PID controller parameter has been optimized by Ziegler-Nichols tuning method. Here the model of a Unified Power Flow Controller which is controlled externally by a newly designed power system controller. It is tested with heffron-philips model(SMIB). Same is tested with Unified Power Flow Controller, Fuzzy Logic controller (FLC), Hybrid Fuzzy Logic Controller. Simulation results proved that out of these controllers Hybrid Fuzzy Logic Controller gives better performance. It reduces settling time significantly and increases the system stability. [18]
Binod kumar, Sahu,Swagat Pati, Shidhartha, have proposed fuzzy proportional integral derivative(PID) controller The optimum gains of the controller are obtained by hybrid differential evolution particle swarm optimization technique using an integral of time multiplied by absolute value of error criterion.[19]
Jose Luis Rueda, Jaime Cristobal Cepeda, Istvain Erlich, has suggested probabilistic Eigen analysis, a scenario solution technique and a new variant of mean variance mapping optimation algorithm to solve the problem of optimal placement and coordinated tuning of power system supplementary damp controllers. It is demonstrated with England test system .The results are verified with different modern heuristic optimization algorithms which are come out with feasibility and effectiveness [20].
The fault in a network at any place leads to the transient instability in inter area mode of oscillations between different parts of the transmissions. It affects on voltage level as well as power oscillations of the system. Another method is explained by S.Selvaraj and P. Maniraj to control the voltage and intearea power oscillations. This is hybrid connection of fixed capacitor and unified power flow controller. The author has shown that UPFC can be used as a FACT's device and a fixed capacitor which is connected in series with UPFC. The role of FACT device to control both reactive and active in transmission line and capacitor is used to remove significant portion of the reactive line impedance during varies dynamic conditions. The hybrid connection of capacitor and UPFC has been tested with five bus test system in MATLAB simulink software environment.[21]
Ddakka Obulesu, Dr. S.F. Kodad, Dr. B. V. Sankar Ram, has designed fuzzy POD UPFC controller. The designed controller uses fuzzy logic theory to coordinate the parameters of POD UPFC used in nine bus system consists of three generators and three loads. It is observed that the fuzzy POD UPFC coordination give better results. The disturbances in the power angle and post fault settling time got reduced. The System stabilized by damping local mode oscillations. This control strategy has proved that it is simple, reliable and easy to implement in real time applications. [22]

V. Summary

Many methods have been proposed in literature survey to coordinate FACTS controllers as well as PSS. These are categorized in to three groups as shown in table 2, [23]

- Sensitivity based methods:
- Optimized based methods.
- Artificial intelligence based methods.

These methods are intended to control the following system operating parameters,

- Damping of power oscillations.
- Voltage of system.
- Low frequency oscillations,
- Small signal stability, transient stability
- Different power plant like wind power plant, solar plant, conventional generators etc.
- Dynamic performances of different power plants, power system.
- The loading capability of power system
- Operating stability under different fault occurring conditions
- Type of machine, single or multi machine with bus

It is observed that the control techniques are made to operate Power system stabilizer on rotor side and FACTS controller on output side generator at the terminal of connection to power grid. Survey shows that more than one, FACT controller's combinations have been used to stabilize system parameters. Sometime along with PSS, FACTS are used to damp the oscillations. The Facts are been used alone and operated by PID controllers. These PID controllers are used to generate the control signal to monitor the output of FACTS device. And hence the system parameters are kept in the operating condition as well as system stability also have maintained.

Conclusion

This paper has looked into the power oscillations, its classifications and different modes. The focus of literature survey is to study the control techniques/algorithm (figure 2) proposed by various authors to regulate the output of FACTS controllers to stabilize unstable parameter. This paper also discussed about the power quality issues penetrated by integrated distribution generation, because of its nonlinearity characteristics. This paper suggests scope towards the improvement of power quality by controlling the power oscillations. It ensures that the grid stability, quality and reliability can be maintained. It explains that many authors have worked upon it and designed the controller and its different various tuning.
Techniques those are adapted to settle down the power oscillations to improve system performance. After the survey of many papers written by various authors, it is found that these control techniques have worked efficiently. But after the comparison between Sensitivity based methods, Optimized based methods and Artificial intelligence based methods, Sensitivity based methods require more mathematical labor work. They take more time to

International Journal of Technology and Science, ISSN (Online) 2350-1111, (Print) 2350-1103 Volume 3, Issue 2, 2016 pp. 54-59

design. They have poor convergence. They become sluggish if more number of variables is involved.

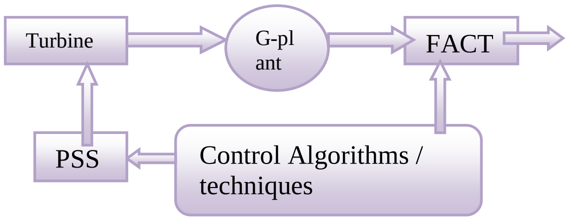

Figure 1.Control Scheme for FACTS and PSS device

Whereas the AI methods have enormous advantages because of their learning ability, fast and fit for non-linear modeling. They also suffer from proper selection of training methodology. But still they are becoming popular because of simplicity and require less computational work. Other angle of this review is noticed that is complexity due to multi controllers. Tuning of these multi controllers may affect to each other and may lead to unstable conditions.

This will help to understand the modes of oscillations, cause and effect of oscillations, controllers used to suppress these oscillations in Integrated Distributed Generation. This paper will be useful to the researchers to get the information about different FACTS controllers in multi machine power system directed by various control techniques.

Table 2 FACTs and Control techniques.

Control techniques applied to coordinate the FACTs			
FACTs Devices			
Thyristor Controlled Reactor (TCR), Thyristor Controlled Switched Reactor (TCSR), Static VAR Compensator (SVC) or Fixed Capacitor - Thyristor Controlled Reactor (FC - TCR), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Switched Series Reactor (TSSR), Thyristor Controlled Brakening Reactor (TCBR), Thyristor Controlled Voltage Reactor (TCVR), Thyristor Controlled Voltage Limiter (TCVL Thyristor Controlled Switched Series (TSSC),Thyristor Controlled Phase Angle Regulator (TC - PAR) or Thyristor Controlled Phase Shift Transformer (TC - PST), Static Synchronous Series Compensator (SSSC), Static Synchronous Compensator (STATCOM), Distributed Static Synchronous Compensator (D - STATCOM), Generalized Unified Power Flow Controller (GUPFC), Unified Power Flow Controller (UPFC), Inter - link Power Flow Controller (IPFC), Generalized Inter - link Power Flow Controller (GIPFC),and Hybrid Power Flow Controller (HPFC), Semiconductor Magnetic Energy Storage (SMES), Battery Energy Storage (BESS)	**1.Sensitivity based method**	**2.Optimized based method**	**3.Artificial based method**
	Eigen value analysis based method	Dynamic optimization programming algorithm	Genetic algorithm
	Residue based method	Non linear optimization programming techniques	Tabu search algorithms
	Pole placement technique	Linear optimization programming techniques	Simulated annealing based technique
	Frequency response technique	Immune based optimization algorithm	Artificial neural network based algorithm
	Root locus technique		Fuzzy logic based
	Projective control methods		Adaptive neuro fuzzy inference system technique
	Non linear feed control methods		H- infinity optimization
			μ-synthesis techniques
			Linear matrix inequality technique
			Prony methods
			Riccati equation technique
			Relative gain array theory
			Load flow control technique

REFERENCES

[1] Dr. Christian Ruester, Stefan Hoppert, Jurgen Blun,"Power Quality issues in modern distribution grids: Identification and Mitigation",CIRED Workshop-Rome,11-12 June 2014

[2] Lanfang Li, Ming Ma, Baiyu Xu, Zhengfu Liu, Yuan Li, and Honggeng Yang ,"Power-Quality of Distribution Networks with High Penetrated Intermittent Distributed Generation: A Survey", 2014 International Conference on Power System Technology (POWERCON 2014), Chengdu, 20-22 Oct. 2014, Paper No CP3443

[3] Bikash Pal, Balarko Chaudhuri " Robust control in power systems" ISBN: 978-0-387-25949-9 (Print) 978-0-387-25950-5 (Online) ,Springer

[4] Schneider Electric – Data Center Science Center White Paper 18 Rev 1,IEEE Recommended Practice for Monitoring Electric Power Quality, IEEE Std. 1159- 1995

[5] FINAL REPORT FOR PSerc PROJECT, "Avoiding and Suppressing. Oscillations" December 1999, POWER SYSTEMS ENGINEERING RESEARCH CENTER

[6] Report on Power System oscillations experienced in Indian Grid on 9th, 10th , 11th and 12th August 2014, Power System Operation Corporation Limited. INDIA (POSOCO)

[7] EPRI Power Systems Dynamics Tutorial. EPRI, Palo Alto, CA: 2009. 1016042.

[8] Bindeshwar Singh, K. S. Verma, Pooja Mishra, “Introduction of FACT’s Controllers: A Technological Literature Syrvey”, International Journal of Automation and Power Engineering, Vol-1,Issue-9,DEC-2012

[9] Jin,X,Zhao.J,Wang.H.F. “On –line Stability control of power Integrated Distribution Generation Systems”, Unversities Power Engineering Conference, 2006, 41st Proceedings.

[10] Nguyen, T.T.; Kandlawala, M.F., "An optimal fuzzy-logic controller of a FACTS device for damping oscillations in power system with wind generation," Advances in Power System Control, Operation and Management (APSCOM 2009), 8th International Conference on , vol., no., pp.1,6, 8-11 Nov. 2009 .

[11] Cloughley, M.; Muttaqi, K.M.; Haiping Du, "Damping of low-inertia machine oscillations using Takagi-Sugeno fuzzy stabiliser tuned by genetic algorithm optimisation to improve system stability,"Generation, Transmission & Distribution, IET , vol.8, no.2, pp.339,352, February 2014

[12] Shah, R.a , Mithulananthan, N.a , Lee, K.Y. “Large-scale PV plant with a robust controller considering power oscillation damping “ (Article) b IEEE Transactions on Energy Conversion,Volume 28, Issue 1, 2013, Article number 6381478, Pages 106-116.

[13] Magar, K.T.; Balas, M.J.; Gayme, D.F., "Adaptive control of inter-area oscillations in wind-integrated power systems using distributed parameter control methods," American Control Conference (ACC), 2014 , vol.1, no.1, pp.903,907, 4-6 June 2014,doi: 10.1109/ACC.2014.6859245

[14] Sima Seidi Khorramabadi, Alireza Bakhshai, “Intelligent Control of grid-Connected Microgrids:An Adaptive Critic-Based Approach” IEEE Journal of EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS, Vol. 03, No. 2, June 2015.

[15] Thyge Knüppel1, Jørgen N. Nielsen2,” Power oscillation damping capabilities of wind power plant with full converter wind turbines considering its distributed and modular characteristics” IET Renew. Power Gener., 2013, Vol. 7, Iss. 5, pp. 431–442 431doi: 10.1049/iet-rpg.2012.0030

[16] Hadi Saghafi , Hamid Karshenas, Hamid Karshenas “Power Oscillation Damping in Standalone MicrogridsUsing Integrated Series Compensator”

[17] Sudhansu Kumar Samal , Prof. P.C.Panda,” Damping of Power System Oscillations by Using Unified Power Flow Controller with POD and PID controller”, 2014 International Conference on Circuit, Power and Computing Technologies [ICCPCT].

[18] Binod Kumar Sahu 1 ; Swagat Pati ; Sidhartha Panda ,”Hybrid differential evolution particle swarm optimization optimized fuzzy proportional integral derivative controller for automatic generation control of interconnected power system”, IET Generation, Transmission & Distribution, Volume 8, Issue 11, November 2014, p. 1789 – 1800.

[19] José Luis Rueda ,Jaime Cristóbal Cepeda , “Probabilities approach for optimal placement and tuning of power system supplementary damping controllers”, IET Gneration, Transmission and Distribution, Vol-8,Issue-11,November- 2014,1831-1842

[20] S.Selvaraj , P, Maniraj“Voltage Control And Damping Of Inter Area Oscillations Using Hybrid Scheme”, Proceedings of 4th IRF International Conference on 19th April 2015, Cochin, India, ISBN: 978-93-82702-98-6

[21] Ddakka Obulesu, Dr. S.F. Kodad, Dr. B. V. Sankar Ram “Damping of oscillations in Multi-machine Integrated Power Systems using Hybrid Fuzzy Strategies”, International Journal of Research and Reviews in Applied Sciences, Volume 1, Issue 2(November 2009), ISSN: 2076-734X, EISSN: 2076-7366.

[22] Bindeshwar Singh, N. K. Sharma, A. N. Tiwari, “ Classification of Co ordinate Control Techniques of FACTS Controllers in Emerging Power Systems: A Review”, IJETS, Vol 1(1) 2010,18-34.