IJITKM Special Issue (ICFTEM-2014) May 2014 pp. 170-176 (ISSN 0973-4414)

Improvement of Dynamic Performance of Two-Area Thermal System using Proportional Integral & Fuzzy Logic Controller by considering AC Tie line Parallel with HVDC link

Pooja Devi[1], Ram Avtar[2]
[1]M Tech Student, [2]Assistant Professor, Department of EE ,UIET, Kurukshetra University, Kurukshetra, India,
[1]er.pooja68@gmail.com,[2]ramavtar.jaswal@gmail.com

Abstract: In the present work an analysis is done on dynamic performance of a two area interconnected thermal system with AC tie line parallel with HVDC link subjected to parametric uncertainties. The advantage of HVDC link is in stabilizing the frequency oscillation of system. The dynamic response of ac tie line thermal system is degraded and sluggish when compared with ac tie line parallel with HVDC link. The results obtained by PI-FLC are shown in simulation. The performance of the proposed scheme is superior in terms of settling time and overshoot in Automatic Generation Control (AGC).
Keywords- AC – DC Interconnected System, Automatic Generation Control (AGC), Automatic Voltage Control (AVR), AC Tie-line, High Voltage Direct Current (HVDC) link, Fuzzy logiccontroller (FLC).

1. Introduction

The Automatic Generation Control (AGC) and Automatic Voltage Control (AVR) are two technical requirements for the proper operation of an interconnected power system [1][2]. As load changes and abnormal conditions, like outage of generation, frequency mismatches and scheduled tie- line flows can be caused. These mismatches are corrected by controlling the frequency, which is defined as Automatic Generation Control or regulation of power output. Automatic Generation Control is therefore required for maintaining the desired mega output power for large interconnected power system. Low frequency operation affects the power quality. AGC equipments are installed for each generator in the power system. Other important control in power system is Automatic voltage control (AVR) which is also called excitation control. The generator excitation generally maintains generator voltage and reactive power flow. A static accuracy limit in percentage is specified for the voltage regulator, so that the terminal voltage is maintained within that required value[3]. The performance of AVR loop is measured by its ability to regulate terminal voltage of the generator within specified static accuracy limit with in an acceptable speed of response. Fast acting energy storage system e.g. battery storage system, superconducting energy storage etc., can effectively damp oscillations in a power system[4]. A favorable effect on dynamic performance has been achieved considering HVDC/HVAC parallel link. HVDC systems have the ability to rapidly control the transmitted power.The HVDC link quickly acts to control occurrence of transients in case of any sudden disturbance [6].In the conventional method of control the integral of error is taken as control signal. Problem is configured in MATLAB software and results are presented.

In the present paper a fuzzy logic based proportional integral controller is designed to analyze two area interconnected thermal power system with HVAC/HVDC parallel link subjected to parameter uncertainties.Controllers designed based on linear techniques like PI, PID etc., not work satisfactorily on non linear power system.

In recent year's intelligent control strategies like fuzzy logic controller, genetic algorithms (GA) are used in control mechanism. A fuzzy logic controller uses fuzzylogicas a design methodology which can be applied, in developing linear and non linear systems.

2. Two area HVAC/HVDC interconnected power system

To maintain power system frequency to a specified value at power generator and the utilization at the customer end, efficient AGC schemes are required. In AC transmission there is two power component real and reactive powers, so have to balance these two components also.There are two schemes to balance these two components called Automatic Frequency Control (AFC) or Automatic Load Frequency Control (ALFC) and Automatic Voltage Regulator (AVR). AGC tries to balance by maintaining the system frequency and tie-line flows at their schedule values. This action is guided by the area control error (ACE). The area control error is a mismatch between area load and generation taking into account any power interchanges with the neighboring areas.

The ACE for thei^{th} area is may be defined as:

$$ACE = \Delta P_{tie} + B_1 \Delta f$$

Where $\Delta P_{tie} = P_{tieactual} - P_{tieschedulded}$ and P_{tie} is the net tie line flow.
$\Delta f = f_{actual} - f_{schedulded}$ And f is the system frequency. B_1 is referred to as the frequency biasing factor. This control strategy is referred to as the tie line control. A simulation model is studied at two area interconnected thermal power system. Advantage of using interconnected system is in improving system security and economy of operation. In the control area frequency is considered in static as well as in dynamic conditions. These two areas are connected by a tie line and a HVDC parallel link also connected with the AC link.[6] Transmission lines are used to transmit power between various areas. In the early days this purpose was served by AC power tie lines. However, many problems have been faced with AC power transmission over long distances. These problems have been overcome by adding HVDC link. By this interconnection with HVDC link, frequency deviation is very low and also improvement in quality and continuity of power supply.

a) Mathematic model of HVDC link

For a two terminal DC link, modeling is represented by transfer function instead of a resistance. Here, the time constant T_{dc} represents the delay in establishing the DC current after a step change is given.

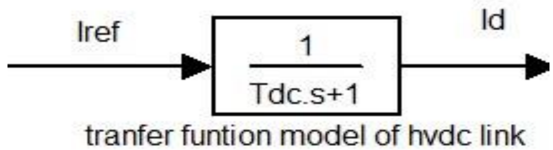

Fig 1

The HVDC Link is superior in conventional frequency control in terms of quick response.[7] When a sudden disturbance occurs in an area, peak value of transients are suppressed by control system quickly starts by HVDC Link.

3. Fuzzy Logic controller

Fuzzy logic is basically a multi-valued logic that allows arriving at a definite conclusion based upon vague, imprecise, noisy or missing input information.Fuzzy system transforms a human knowledge into a mathematical form. There are two inputs in fuzzy controller namely error (e) and change in error d (e). Nowadays fuzzy logic is used in almost all sectors. The main goal of AGC in interconnected power system is to balance the generation and load demand. The fuzzy logic controller design is shown in fig.The fuzzy logic controller comprises of four components.

1. A fuzzification base
2. A knowledge base
3. A decision making logic and
4. A defuzzification interface

Fuzzification implies the process of transforming the crisp inputs to a fuzzy domain. Using five membership functions the two input signals are transformed. The fuzzy logic rules with two inputs represented in matrix form to represent function condition. During fuzzification, a fuzzy controller takes the input data from 0 to 1 based on how well it fits into membership function. The triangular membership function is used to specify the three linguistic variables. A set of membership defined for five linguistic variables are S, M, B, VB, VVB respectively is shown in fig.2 and fig. 3.

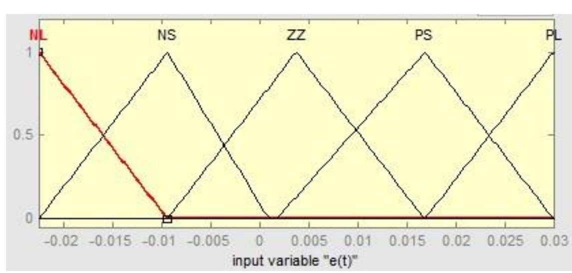

Fig. 2 membership function of ACE

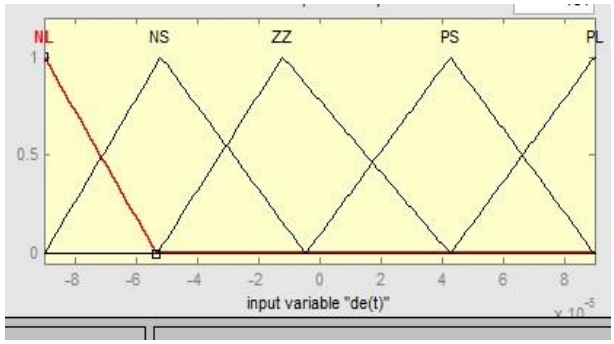

Fig. 3 membership function of dACE

In this paper, two area interconnected system using FLC-PI controller with HVDC link is studied and applied to analyze the effect of HVDC link on the AGC thermal power system. MATLAB software simulation diagram and used controller are shown in fig. 4 and fig.10

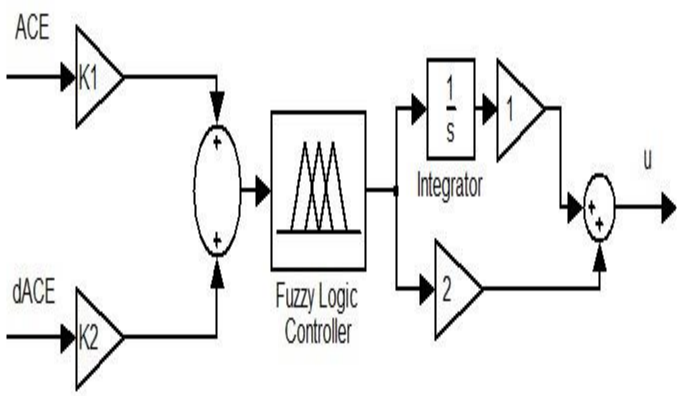

Fig. 4 Fuzzy- PI controller

The interpretation of rules is done as: if error is NL and d/dt error is NL then output is S, if error is PL and d/dt is PL then output is VVL, and so on. This is shown in table 1

Table 1 – Fuzzy rule base

D(E) \ E	NL	NS	ZZ	PS	PL
NL	**S**	**S**	**M**	**M**	**L**
NS	**S**	**M**	**M**	**L**	**VL**
ZZ	**M**	**M**	**L**	**VL**	**VL**
PS	**M**	**L**	**VL**	**VL**	**VVL**
PL	**L**	**VL**	**VL**	**VVL**	**VVL**

4. Simulation results

In this scheme controllers are used for frequency control and results of both approach with and without HVDC link are compared, then it is found that the settling time and the peak overshoots are reduced considerably by the use of HVDC link in parallel of existing HVAC link.Heat and trail method are used for parameters setting. Various response results are shown in figure. Fig. 5 and 6 shows the frequency response of two areas with proposed controller. The terminal voltage of two areas using PID controller is shown in fig. 7 and 8. Fig. 9 shows the tie-line deviation of two areas. Fromvarious results it is observed that HVDC link has considerable effect on reducing the frequency deviations and no effect is observed on performance of the AVR loop.

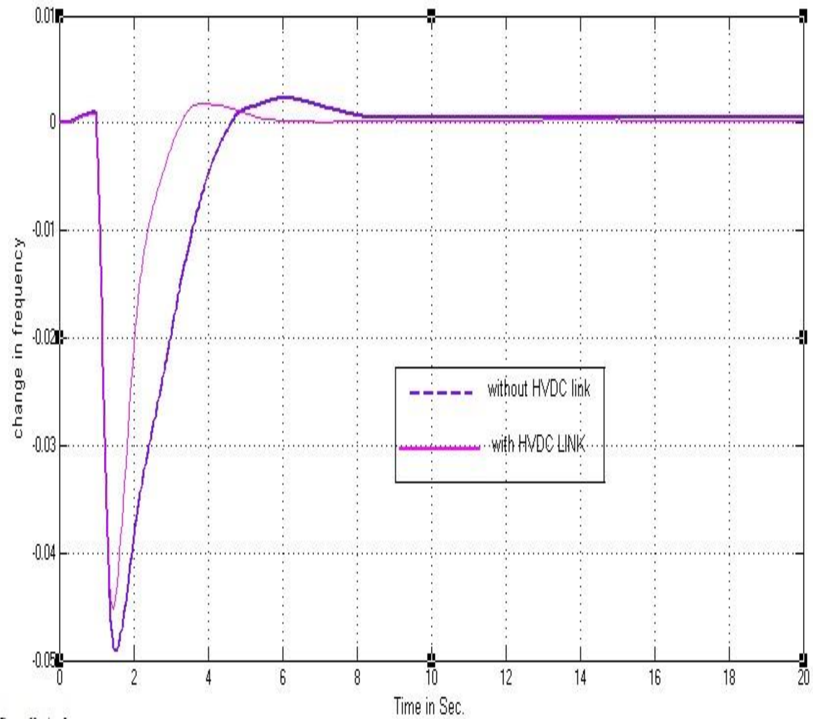

Fig.5 Frequency response of area 1

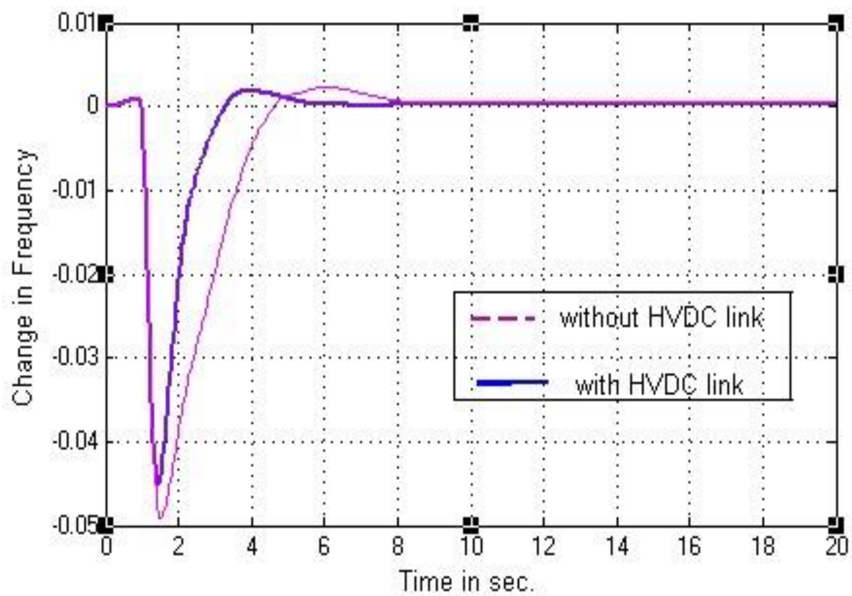

Fig. 6 Frequency response of area 2

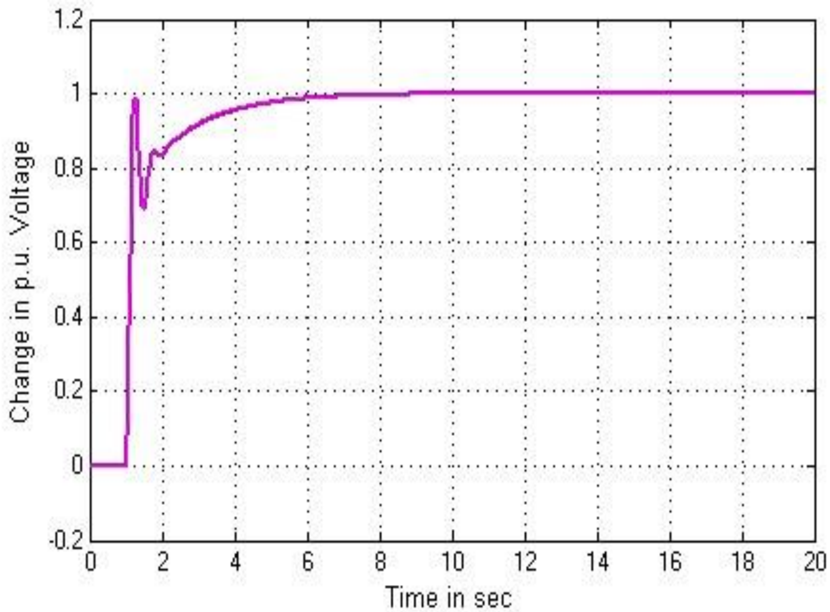

Fig. 7 Terminal voltage of area 1

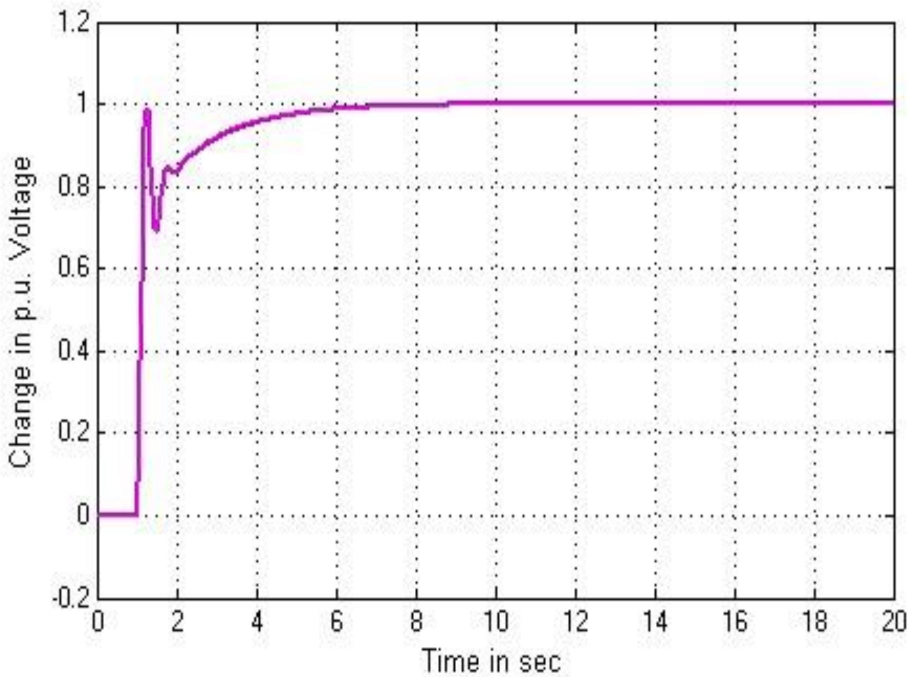

Fig. 8 Terminal voltage of area 2

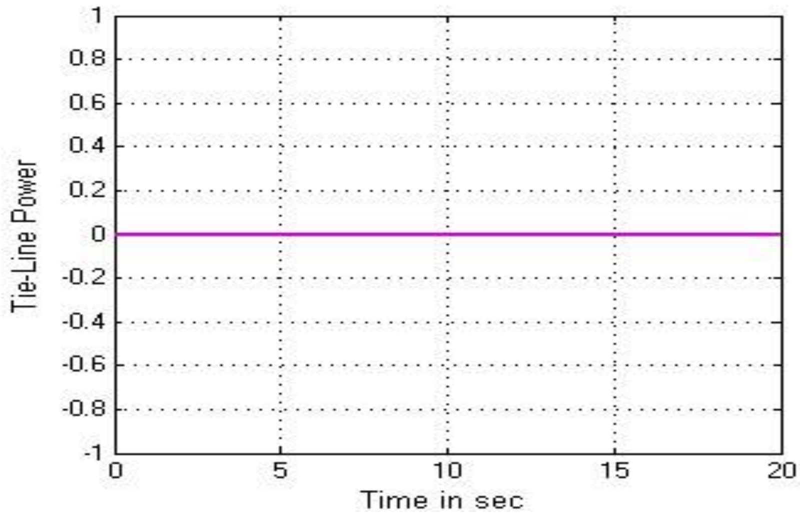

Fig. 9 Tie-line power deviation of two areas

Table 2.showing simulation results for controller with and without HVDC link in power system

CONTROLLER	**FREQUENCY DEVIATION**			
FUZZY- PI	**SETTLING TIME(SEC)**		**MAXIMUM OVERSHOOT**	
	AGC WITHOUT HVDC	**AGC WITH HVDC**	**AGC WITHOUT HVDC**	**AGC WITH HVDC**
AREA 1	**8**	**5.8**	**-0.049**	**-0.045**
AREA2	**8**	**5.4**	**-0.049**	**-0.045**

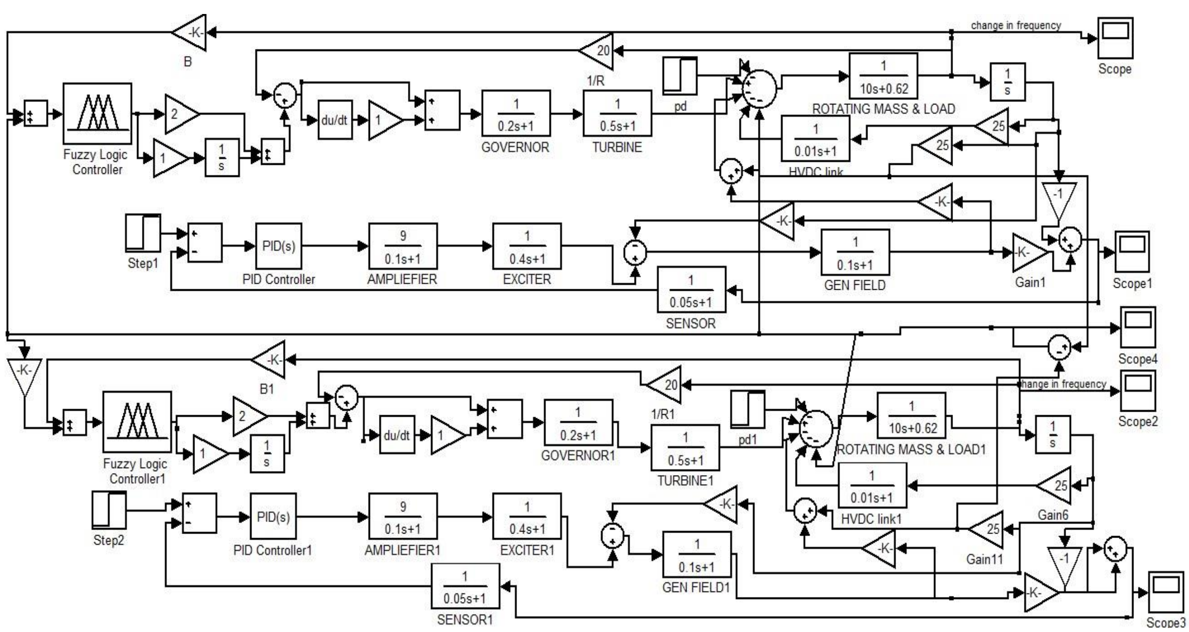

Fig. 10 The block diagram of power system with two areas considering HVDC link

5. Conclusion

In this paper, sophisticated proposed scheme is used in controlling the deviations of thermal power system and achieves good performance in stabilizing of frequency deviations. The simulation results show that performance of power system is significantly improved by the use of a fuzzy- PI controller with HVDC link. Considering the HVDC link response is less sluggish. HVDC link has no effect on the performance of the automatic voltage regulator (AVR) loop but frequency settling time is reduced. Further improved performance in controlling can be obtained by suitably tuning the fuzzy controller and using hybrid controller like Fuzzy-GA [8].

References

[1] I J Nagrath, D P Kothari, (2002), "Electric Machinery" KhannaPublishers.vol. 7,pp34-67

[2] ReenaKumari, Mr. Ram Avtar, (may 2013), "Frequency Stabilization of Two Area Interconnected Power System Using Fuzzy Logic Controller and PID Controller ", International Journal of Research & Technology(IJERT), vol.2 Issue 5

[3] G. A. Chaun, R.C. Hartman(1998), Member, SAIEE "Design and Experience with a fuzzy logic controller for Automatic Generation Control (AGC)", IEEE Transaction on Power system, vol.13, no.3

[4] FidaHasanMd Rafi, MdZahidAnsary, MdHafizurRahman, Md Abu ShahabMollah, MdAtifurRahman, Abu FarzanMitul,(2013) "Load Frequency Control Analysis using AGC, TCPS and SMES", 978-1-4799-6/13, IEEE

[5] J. Nanda, J. S. Sakkaram, "Automatic Generation Control with Fuzzy Logic Controller cconsidering Generation Rate Constraint", Proceeding of the 6th International Conference on Advances in Power System Control, Operation and Management, APSCOM 2003, Hong Kong , nov. 2003

[6] Rani Thottungal, P Anbalangan, T. Mohanaprakash, A. Sureshkumar, G.V.Prabhu, (2006), "Frequency Stabilization in Multi Area System using HVDC Link", 1-4244-0726-5/06, IEEE

[7] YogendraArya, Narendra Kumar, Hitesh DattMathur (march 2012), " Automatic Generation Control in Multi area Interconnected Power System by using HVDC Links", International Journal of Power Electronics and Drive System(IJPEDS), vol.2, pp 67-75

[8] Hyun- Joon Cho, Kwang-Bo Cho, Bo-Hyeun Wang "Fuzzy –PID hybrid control: Automatic rule generation using Genetic Algorithms", Fuzzy Sets and Systems 92 (1997) 305-316