An Application of ANFIS-PID Controller for Multi Area Hybrid Power System

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In this work adaptive fuzzy- PID (ANFIS-PID) controller is presented for frequency and tie-line regulation of multi-area interconnected power systems (IPS). Proposed controller has the properties of both neural network and fuzzy logic. A novel four area power system comprises of two reheat turbine (area1 and area2), one hydro power plant (area 3) with the hydraulic governor and one wind plant (area 4) with pitch actuator. This hybrid interconnected power system model has been built in MATLAB/ Simulink version 2020(a) and the proposed controller is employed with same design of ANFIS model in all areas. Further, the performance of power system model is presented with the suggested controller. The step load change is considered in each area. An HVDC lines are considered in each area to improve the performance of proposed model. Further a fair comparison is made for the conventional PID and Fuzzy-PID controllers. The designed controller performs best compare to the other compared controller for tie-line power and frequency regulation in all four areas of the IPS. The dynamic response of the proposed model improves with AC/DC line as compare to AC line. The sensitivity analysis with change in plant parameters, step load perturbation (SLP) and random load change is also being applied to check the robustness of the controller.

Keywords: ANFIS, Fuzzy, PID, HVDC, Four- Area.

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1 Introduction

As per the united nation department of economic & social affairs dynamics of word population report 2019, the world population will be 9.735 billion in 2050 and the power demand will be 53.6billion MWh [1]. By increasing the world population, the demand for energy also increases. In 2018, 90% of the world's population can use electricity. The world population from 2010 to 2018 without electricity access has been shrunk from 1.2 billion to 789 million [2]. Issues like climate change from traditional sources of energy are worrying the whole world. Researchers all over the world are working to promote alternative energy sources. Solar and Wind Energy Generation sources are being seen as a good alternative to supply the future energy demand.

Frequency stability in an IPS is the major issue [3]. The oscillation present in the system frequency indicates the unbalance between generation and demand that must be minimized with the help of proper control[4]. The demand for power changes rapidly. However, load frequency control (LFC) is an outstanding model for balancing power generation and the demand of load in the power systems. Renewable energy sources (RESs) integration with restructured power systems, the power system operation and control study are very important. The restructured power system has more randomness and uncertainties in power generation. Penetration of RESs increases uncertainties during the abnormal condition power system and creates problems that require further study [5].

Literature Review

The LFC is the major problem in the power framework. The critical issues in large-scale power systems are an imbalance of load demand and losses between generations against the system. So, checking and repairs of a large IPS is more challenging than ever before. In recent years, the LFC has achieved considerable importance due to its distributed characteristics and controllability of Smart Grid (SG) environments. Traditional centralized LFC structures cause many issues. Therefore, decentralized/distributed LFC structures can be effective in developing large-scale information exchange limits, and geographically wide control areas as well as increasing their computation and storage complexities. The way to solve such problems is that distributed control is more practicable, reliable, convenient, and economical [6]. LFC in realistic power systems, thermal reheat turbines, gas, and hydropower plants, and system nonlinearities are considered for the presented system. Further, frequency response and sensitivity analysis are performed [7]. Time delay present in the power system can decrease the controller performance which leads to instability. This problem is pointed out through prediction-based twisting mode control. The applied controller achieves finite-time convergence for tie-line power and frequency. The controller was also validated with random and ramp disturbance with system nonlinearity like GRC and GDB [8].

The generation of power using renewable is also increasing but the power generation by these sources cannot be controlled, unlike conventional sources. The intermittent nature of renewable energy sources enhances the frequency disturbance with changes in load. PI, PID, and Fuzzy Controllers are used for minimizing the frequency deviation [9]. Integration of wind power sources in the power system causes more complexity due to variable sources and loads. A decentralized sliding mode control is proposed for MAPS [10]. Two-area Multi-source RESs integrated power system is studied in this paper and further Multi-Verse Optimization (MVO) is used to tune the PI controller parameters [11]. The frequency of an AC microgrid integrated with reheat thermal and RESs is presented in [12]. MVO algorithm is sued to tune the proposed FOPID controller. The superconducting magnetic energy storage unit effect is also examined. Further, an interconnected microgrid system containing a solar tower, Biodiesel driven generator, geothermal energy conversion, and Archimedes wave energy conversion are studied, and PID with filter (PIDN) controller parameter tuned with different algorithms [13]. Bio-inspired salp-swarm optimization-based PI-PD regulator is proposed for standalone microgrid for frequency stabilization and a comparison has been done with the other well-known controller [14]. A study of Micro-Grid (MG) with various types of DERs has been proposed to prove that the proposed strategy is best to tune the MG controller parameters. The deployed controller reduces the frequency deviation as well as significantly reduces the amount of load shedding. This will increase customer satisfaction. Furthermore, inertia constant considers the minimum objective, and the frequency regulation will be preserved at a lower cost [15]. For the continuous action domain, a data-driven method for LFC issues in intermittent RESs based on deep reinforcement learning is proposed for nonlinearities drive control strategies to reduce the frequency deviation with fast response [16]. Since traditional controllers with static gain do not perform well with several operating environments and they have a bad dynamic response. Further, such problems have been resolved using adaptive scheduled gain that is based on the fuzzy system. Fuzzy PI-based LFC is discussed in [17]. Error and change in error signal given as input to the FLC and further, optimize the PI gain [18].

A hybrid power system having a thermal, solar thermal and electric vehicle (EV) is considered for the study. The EVs integrated with the utility grid, GRC of thermal power plants and time delay in all areas make the system more realistic. Such a system is more complex and needs a robust controller. An MBO and fuzzy optimize Integral double derivative (IDD) are used for the study. Further, robustness analysis is also done to check the strength of the proposed controller [19]. A multi-area IPS containing two or more areas, connected through a tie line. Among all the four areas, each control area can be represented by an equivalent generator, turbine, and governor system. The area control error must be minimized after implementing the suitable controller to make the frequency and the tie-line power deviations of all control areas to zeros. Due to environmental issues, the penetration of renewable sources increases day by day. Lots of intelligent techniques have been developed in recent years for load frequency issues. The new algorithms present best results than the earlier ones in different power systems.

The power system has become more complex due to increasing the penetration of renewable energy sources and nonlinear loading. The use of AI techniques has been increased to address satisfactory performance under small perturbations. Some researchers have used fuzzy-based AI techniques to mitigate the LFC issues in multi-area power systems. A Jaya algorithm optimized fuzzy pi controller [20], Adaptive Neuro-Fuzzy Interface System controller containing SMES-TCPS[21], hybrid Neuro-fuzzy controller [22], Fuzzy gain scheduled PI controller [23], a Firefly algorithm (FA) optimized fuzzy PID controller [24], Fuzzy logic control (FLC) in three areas, conventional PI and Artificial Neural Network [25]. Moreover, in the literature researchers are concerned about EHVAC tie-lines that connect the control areas. Due to these tie-lines severe inter-area oscillations, disturbances and higher fault levels are being transmitted between the areas. All these problems can eliminate by connecting HVDC lines in parallel with AC tie lines [26]–[28]. It has also ensured the quality of electric power delivered to the customers [29]. The genetic algorithm of the optimized controller is used with AC/DC links [17]. The bulk power transmission of power with parallel HVDC lines possesses numerous advantages due to the controllability of HVDC lines by converter control. The HVDC lines have the ability to overcome the transient stability problem of AC lines and other operations of the power system. In the literature, some of the researchers have considered the thermal-thermal or thermal hydro systems assimilated with renewable power sources i.e. wind and solar for the LFC study [30]. The authors have proposed an ANFIS-PID controller for LFC of the current scenario of a power system with four areas including thermal, hydro, and wind power generation, and its dynamic performances are compared with Fuzzy-PID and PID controllers. Furthermore, the proposed controller is simple in concept and easy operation in the developed power system model.

The major research contribution in the presented work:

- To develop an ANFIS-PID controller for the regulation of frequency and power of multi-area wind power generation sources (WPGS) integrated hybrid power system.
- To compare the performance of the proposed model with PID, Fuzzy-PID, and ANFIS-PID controllers with and without HVDC link and consider 1 % load perturbation in each area.
- Sensitivity analysis has been performed to check the robustness of the controller with random load variation and change in plant parameters and improvements in the dynamic performance and ease of use are presented

2. Power system

A four-area wind energy source integrated power system is investigated as shown in Fig. 1. Area-1and area-2 contain thermal reheat power generation sources, area-3 consists of hydro and area-4 contain wind source participating in LFC is simulated by the proposed PID, Fuzzy-PID, and ANFIS-PID controller using MATLAB Simulink. In Fig. 1 R_1, R_2, R_3, and R_4 are regulation parameters of thermal, thermal, hydro, and wind respectively. B_1, B_2, B_3, and B_4 are the tie line frequency bias of each area. T_{sg} is the speed governor time constant (TC) of a thermal unit in a sec, It is the steam turbine TC in a sec, K_r is the steam turbine reheat constant, T_r is the steam reheat turbine TC in a sec, T_{rs} is the hydro turbine speed governor TC in a sec, Tw is the starting time of water in penstock in a sec, T_{rh} is the hydro turbine speed governor transient droop TC in sec, T_{gh} is hydro turbine speed governor main servo TC in sec, T_{w1} and T_{w2} is the TC of hydraulic pitch actuator of a wind turbine in sec, K_{w2} is the hydraulic pitch actuator constant, K_{w3} is pitch constant of a wind turbine, K_{ps} is the gain of the power system, T_{ps} is the TC of the power system, K_{dc} is the gain of HVDC link and T_{dc} is the TC of the HVDC link. ΔF represents an incremental change in frequency. Thermal and hydro power plant parameters has been taken from[24] wind parameters [31].

3. Control strategy

The researchers are focused on searching for a suitable control method to stabilize the frequency deviation. Considering, the issue, in this work the performance of the system is checked for ANFIS-PID. Further, the proposed control strategy is capable to handle several disturbances more efficiently which improves the performance of the system. The controller inputs signal ACE for the individual area is presented in equations (1) to (4) below [32].

$$e_1(t) = ACE_1 = B_1\,\Delta F_1 + \Delta P_{12} \qquad (1)$$
$$e_2(t) = ACE_2 = B_2\,\Delta F_2 + \Delta P_{23} \qquad (2)$$
$$e_3(t) = ACE_3 = B_3\,\Delta F_3 + \Delta P_{34} \qquad (3)$$
$$e_4(t) = ACE_4 = B_4\,\Delta F_4 + \Delta P_{41} \qquad (4)$$

The control methodology (PID, Fuzzy PID, and ANFIS-PID) is described in the preceding section.

3.1 PID Controller

PID controller is a powerful tool that broadly used in industry. It calculates error between the process signal and reference value. It contains three parameters, namely proportional, integral and derivative gains presented in Fig. 2. The parameters of PID must be tuned for ensure the suitable control performance. This controller is generally used to minimize the steady state error and recover the dynamic performance of the framework. The values of gains K_p, K_i and K_d can be automatically achieved by optimization techniques. The proportional parameter is used to provide stability, integral part removes the steady state error and the derivative part is used to reduce the settling time and overshoot of system response [33].

The mathematical representation of a PID controller is presented in eq. (5) and the simplified model is presented in the Fig. 2 for the respective:

$$u\,(t) = K_p\ e(t) + K_i \int_0^t e(t)\,.\,dt + K_d \frac{de(t)}{dt} \qquad (5)$$

$$Proportional = K_p\, e(t)$$

$$Integral = K_i \int_0^t e(t)\,.\,dt$$

$$Derivative = K_d \left(\frac{de(t)}{dt}\right)$$

Where *e(t)* is the ACE signal , u(t) is the control variable, K_p proportional gain, K_i integral gain, and K_d derivative gain.

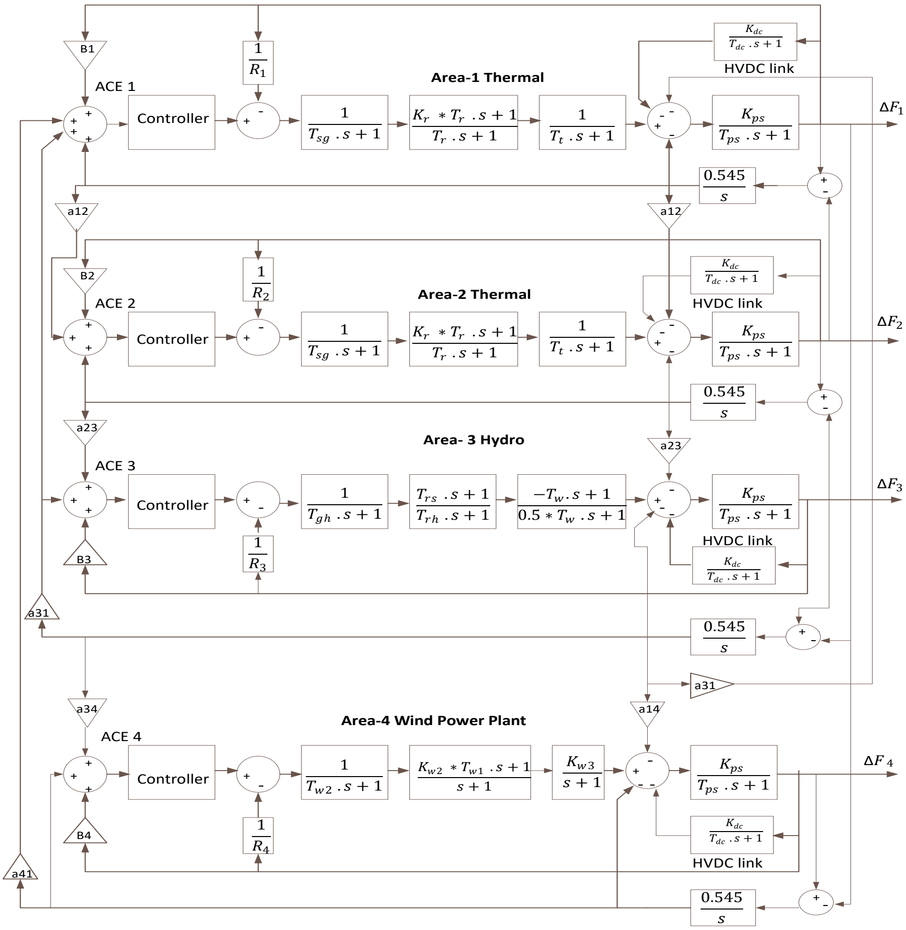

Fig. 1 Proposed Power System Model

3.2 Fuzzy -PID Controller

FLC is an imperative technique for control systems and widely used during the past few decades. It is a powerful tool that helps in constructing human reasoning in control algorithms [34]. The proposed Fuzzy-PID controller is presented in Fig. 3. Fuzzy logic's consist of Fuzzification interface, knowledge base, decision-making division, and defuzzification. The methods of mapping inputs in fuzzy sets with different inputs universe and the drawn data are changed into linguistic terms come under the Fuzzification interface [35]. The database and linguistic governor rules are defined in the knowledge base. The role of the decision-making unit is to motivate human decision-making based on fuzzy perception. The main task of the Defuzzification unit is changing the fuzzy groups assigned to a direct output variable into a value compatible with the given controller. Fuzzy input/output membership functions are shown in Fig. 4 and Fig. 5 respectively.

In this work, a fuzzy tuned PID controller is designed For the LFC problem; the inputs signal for the fuzzy-PID controller is the error (ACE) and derivative of the error (dACE/dt). The output membership function for the fuzzy system is presented in Fig. 5 provides the desired value of controller gains i.e. *Kp, Ki,* and K_d to the controller. Each input/output has been assigned by five membership functions and the notation is mamtioned appendix 2 and the nominal ranges for these functions are defined by ACE. IF-Then rules are formed as mentioned in Table 1 for the given membership function. Fuzzy rules means a conditional statement that clears the relationship between fuzzy variables. With knowledge of previous system behavior, fuzzy rules are developed. For example, if the frequency deviation is more than more controller gain is needed.

In the fuzzy rule are defining as follows:
IF ACE is NH and Δ ACE is NL then output is S.
IF ACE is NH and Δ ACE is Z then output is M.

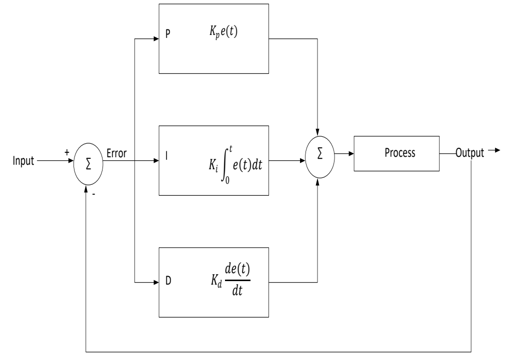

Fig. 2 PID controller

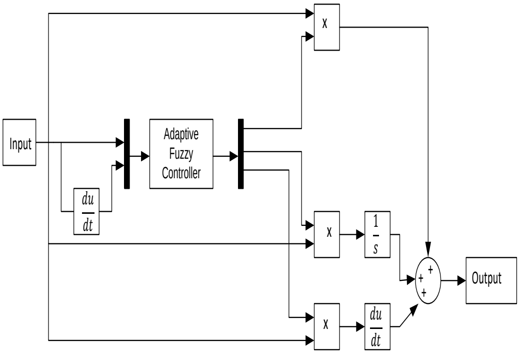

Fig. 3 Proposed ANFIS-PID Controller

3.3 ANFIS-PID Controller

The ANFIS model contains two AI techniques i.e. fuzzy logic and neural network (ANN). ANFIS model has the properties of AI tools. The ANFIS architecture design is presented in the Fig. 6. Important part of ANFIS modeling is formed from a general framework called adaptive network which integrates neural networks and fuzzy models. ANFIS is functionally equivalent to a Fuzzy Inference System (FIS) as it is an adaptive network and can be operated under any adaptive network simulator. A simple rule base model is used to explain the basic idea of the ANFIS architecture. Takagi and Sugeno's controllers is Considered for generating the FIS file [35]. The rule base For the Sugeno fuzzy model, the typical can be expressed as:

If x is A1 and Y is B1 then $f1= p_1x+q_1y+r_1$
If x is A2 and Y is B2 then $f2= p_2x+q_2y+r_2$

Where p, q and r are linear output parameters. The formation of this architecture involved the use of five layers and two if-then rules.

For training FIS parameters for ANFIS, an ANN back propagation technique is used. The ANN use the components of fuzzy system in parametric form before tuning the parameters and the fuzzy systems are changed to a neuro-fuzzy system error and change in error with respect to time are the input for proposed ANFIS model. With the help of these input signals, the fuzzy membership functions generate the optimal gain for the controller. The following steps are used for designing the proposed controller.

Step 1: Initially, the proposed power system model is tested with fuzzy logic controller with above mentioned rule base.

Step 2: Training data is collected from the proposed system simulation with fuzzy logic controller. Further, this data is used for training the ANFIS model.

Step 5: Apply the collected training data in step 2 and generate the .fis with gbell membership function.

Step 6: Save the .fis file. This .fis file is the Neuro-Fuzzy based ANFIS file. This .fis file is imported in the fuzzy tool in Simulink environment.

4. HVDC link

To transmit electric power too long distances HVDC link is used. In HVDC transmission, line reactance and capacitance are absent. Thus the System stability is independent of line length. EHVDC transmission is also used in underground transmission for long distances at extra-high-voltage. In AC transmission cable charging current is do high therefore the temperature of the cable increases that leading to insulation breakdown. Therefore, AC cable is not used beyond a certain limit. In AC transmission, large oscillations are produced with a small change in power that leads to trip the unit or increasing fault current level. The frequency response of the system is improved with HVAC transmission. The HVDC line is can connect in parallel with the HVAC to remove the above problems. HVDC transmission lines have controllable that improve the transient of the system. In the HVDC system converters are used at both ends of the transmission line for the conversion of AC to DC and vice versa. These converters generate more harmonics. Further, filters are requiring mitigating these harmonics. Hence, the overall cost of the system increases. HVDC transmission is not economical for a short distance. The HVDC model is presented in Fig. 7.

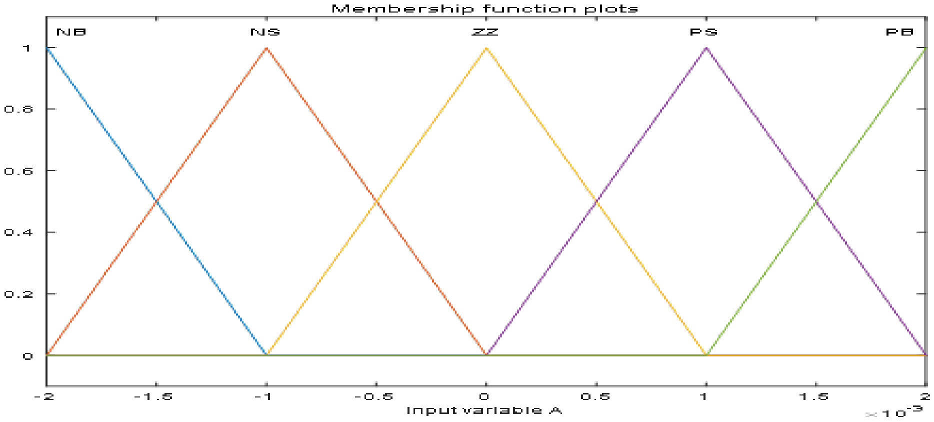

Fig. 4 Membership function for control input variable

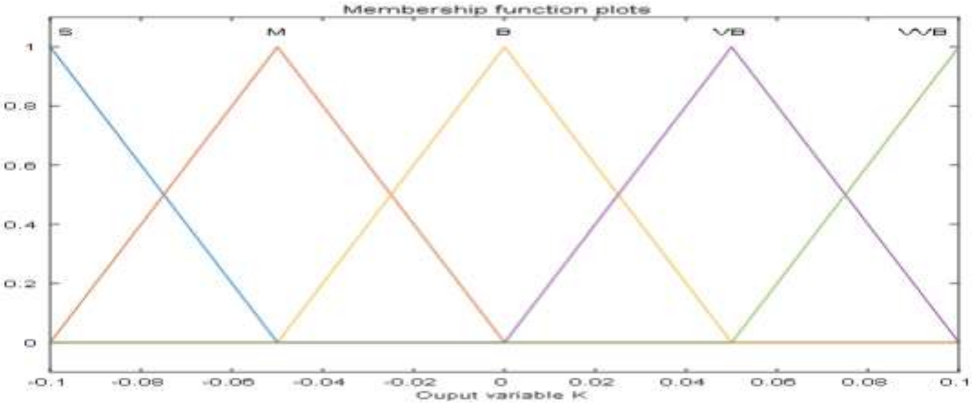

Fig. 5 Membership function for control output variable

Table 1 Fuzzy Rules

ACE/ΔACE	**NL**	**NH**	**Z**	**PL**	**PH**
NL	S	S	M	M	L
NH	S	M	M	L	VB
Z	M	M	L	VB	VB
PL	M	L	VB	VB	VVB
PH	L	VB	VB	VVB	VVB

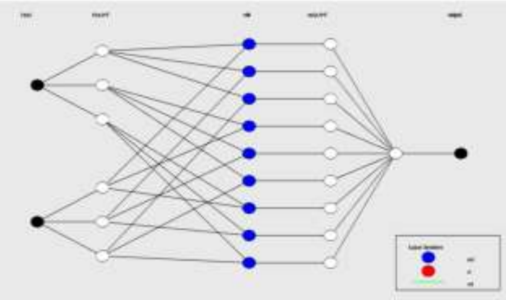

Fig. 6 ANFIS structure

The transfer function for the HVDC line is given in below equation (7).

$$G_{DC} = \frac{K_{dc}}{1+sT_{dc}} \qquad (7)$$

Where K_{dc}, T_{dc} are gain and Time constant of dc-link.

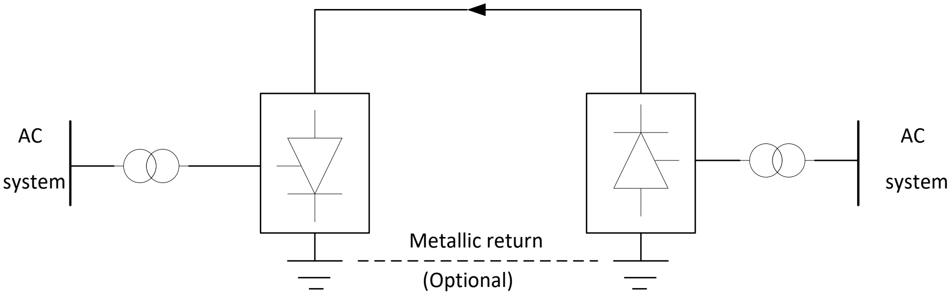

Fig. 7 HVDC model

5. Results

This power system comprises four control areas having two thermal reheat units, one hydro unit, and one wind unit. Each area has one controller at a time and the response obtained by all three controllers PID, Fuzzy PID, and ANFIS-PID is compared without and with the HVDC link. This has been done to test the efficacy of framed controllers for ideal conditions. The results for the ANFIS-PID controller are analyzed and are presented below in Fig. 8(a), 8(b), 8(c), and 8(d) presents the performance comparison of various controllers for frequency deviation, and Fig. 9 presents the tie-line power deviation respectively. This can be analyzed from Fig. 8 that the ANFIS-PID controller has performed best for the frequency deviation response for all four areas as compared to other compared controllers. Further, Fig. 9 presents the comparison of the dynamic response of tie-line power deviation. This can be observed from these figures that the ANFIS-PID controller has generated impressive results as compared to other mentioned controllers. The performance indices are presented in Table 2. This can be studied from table 2 that, the settling time of all four areas frequency response and tie-line power response has been reduced with the proposed controller. Therefore, it is concluded that the proposed controller reduce the oscillation of frequency and tie line power and achieve the steady state faster compare to other compared controller. The results are marked bold for easy attention. It is clear from the table 2 that undershoot of frequency and tie-line power is very less with the proposed controller.

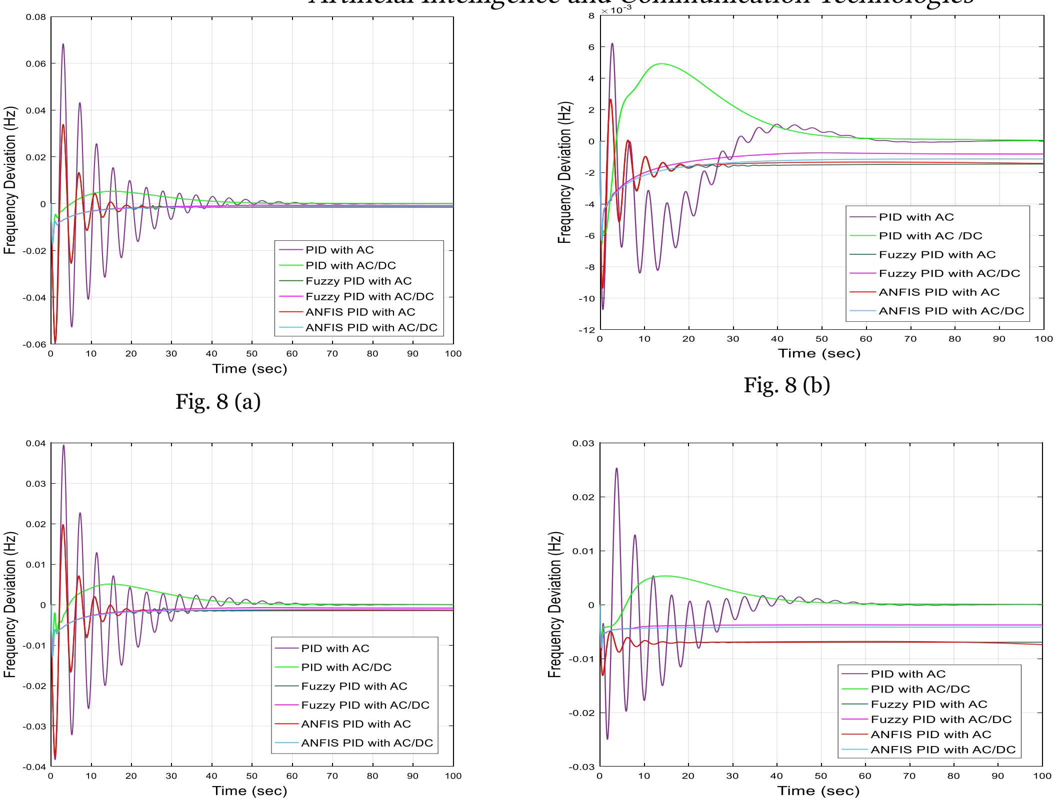

Fig. 8 (a)

Fig. 8 (b)

Fig. 8 (c)

Fig. 8(d)

Fig. 8 Frequency Response of Fig 8(a) area-1, Fig. 8(b) area-2, Fig. 8 (c) area-3 and Fig. 8(d) area-4

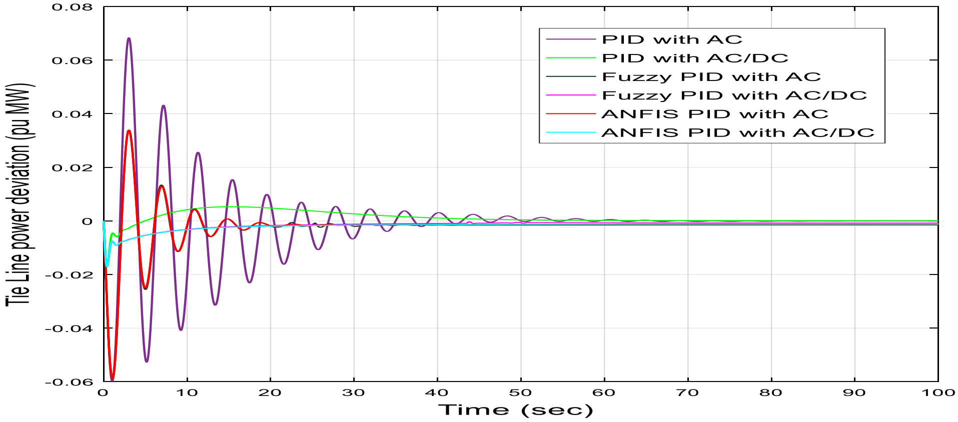

Fig. 9 Tie line power deviations (ΔPtie41)

Table 2 Comparison of control techniques

Control Techniques	Settling Time					*Undershoot*				
	ΔF1	**ΔF2**	**ΔF3**	**ΔF4**	**Ptie41**	***ΔF1***	***ΔF2***	***ΔF3***	***ΔF4***	P_{tie41}
PID with AC link	70	72	75	70	73	-0.060	-0.038	-0.0108	-0.0250	-0.060
PID with AC/DC link	65	60	70	65	65	-0.017	-0.012	-0.0064	-0.0078	-0.017
Fuzzy PID with AC link	40	45	42	40	41	-0.059	-0.038	-0.0087	-0.0130	-0.0590
Fuzzy PID with AC/DC link	50	40	39	38	52	-0.017	-0.0128	-0.0063	-0.0080	-0.0017
ANFIS PID with AC link	36	35	40	40	39	-0.059	-0.038	-0.0094	-0.0120	-0.0590
ANFIS PID with AC/DC link	**35**	**34**	**37**	**32**	**37**	**-0.017**	**-0.0128**	**-0.0063**	**-0.0080**	**-0.017**

5.1 Sensitivity Analysis

Sensitivity is the ability of a system to work effectively while its variables change within a certain tolerable range. In this section the strength of the power system is checked by changing the loading conditions and plant parameter variation. A change in the load also changes the parameters of the power system.

5.1.1 Change in Plant parameters

The parameters of the study system have been varied within the range of ±25 % without a change in the optimal values of the controller gain. Fig. 10 (a), 10(b), and 10(c) present the frequency response of area-1 with change in the plant parameters B, R, and T_g respectively. It is examined that the proposed controller approach provides impressive results. Further, in table 4 it is clearly depicted that undershoots of frequency deviation, tie line power deviation and settling time are varying due to the change in plant parameters proposed controller.

5.1.2 Random Load Disturbance

In this section random and step load pattern is generated and is presented in Fig. 11(a) and Fig. 12 (a). Further, Fig. 11(b), 11 (c) and Fig. 12 (b), 12 (c) shows the comparative dynamic response of frequency deviation and power line deviation of area-1. This can be observed from the presented results for this section that, the proposed ANFIS-PID controller has performed efficiently as compare to the other considered controllers with random and step disturbance.

6. Conclusion

This article proposed an ANFIS controller strategy to maintain the reliable operation of renewable-based multi-area hybrid power systems. The frequency deviation and tie-line power deviation of the proposed model remain within the desired limit. Performance indicators i.e. setting time and undershoot have quit less compared to other test controllers. To show the robustness of the proposed controller sensitivity analysis is performed by subjected to different load and plant parameters variation. The proposed controller with the proposed power system performs well and a satisfactory response has been observed. Further, the HVDC line in parallel with the AC tie line improves the dynamic stability of the proposed model and also lowers the cost index.

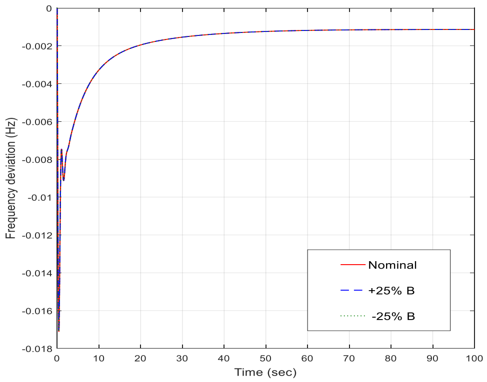

Fig. 10 (a)

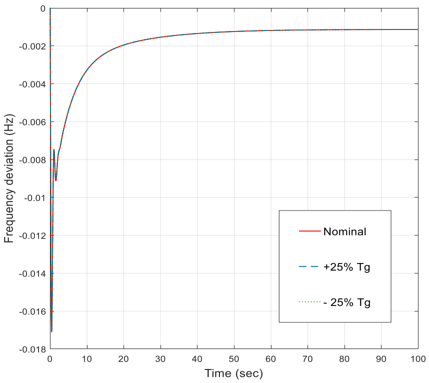

Fig. 10(b)

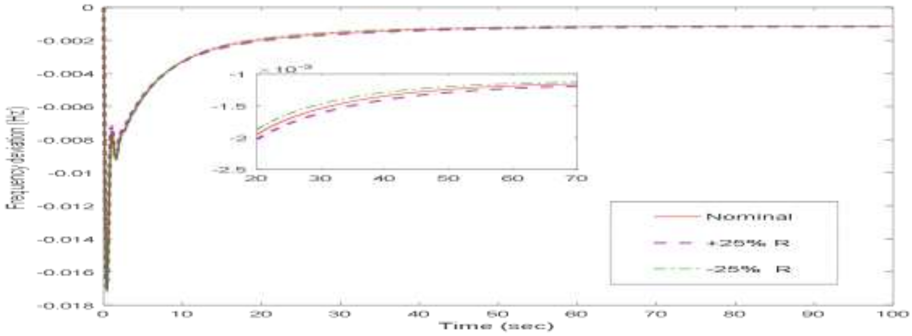

Fig. 10 (c)

Frequency response of area-1 fig. 10(a) varying frquency bias B, fig. 10(b) varying in R, fig. 10(c) varying T_g

Table 3 Robustness analysis of proposed controller

Parameter Variation	**%Change**	**With HVDC link Settling Time (sec)**					**With HVDC link Peak Undershoot* 10^{-3}**				
		ΔF_1	ΔF_2	ΔF_3	ΔF_4	$\Delta P_{tie\,41}$	ΔF_1	ΔF_2	ΔF_3	ΔF_4	$\Delta P_{tie\,41}$
Nominal	0	35	34	37	32	37	-17	-12.8	-6.3	-8	-17
B	+25	35	34	37	32	37	-17	-12.8	-6.3	-8	-17
	-25	35	34	37	32	37	-17	-12.8	-6.3	-8	-17
R	+25	34	34	37	32	37	-17.1	-12.8	-6.3	-8	-17
	-25	35	34	36	31	37	-17.1	-12.8	-6.3	-8	-17
T_g	+25	35	34	37	32	37	-17	-12.8	-6.3	-8	-17
	-25	35	34	37	32	37	-17	-12.8	-6.3	-8	-17

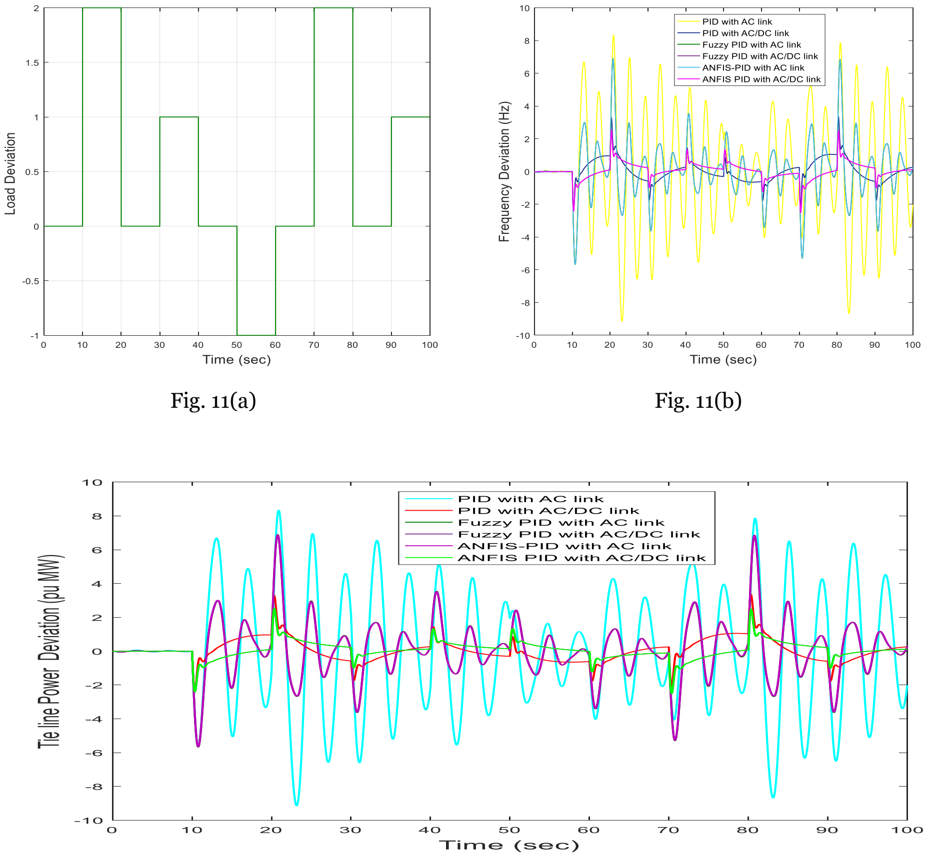

Fig. 11(a)

Fig. 11(b)

Fig. 11(c)

Fig. 11 (a) Random Load (b) Frequency devtation of area-1 (c) Tie Line power deviation

The major finding of the paper is as follows:

- The proposed model has efficiently deployed to well-known AI techniques i.e. ANFIS-PID. This is an earlier attempt for deploying this AI technique for frequency regulation multi-area hybrid power systems.
- The obtained results indicate that the ANFIS-PID controller is the best-suited controller for the framed renewable-based model.
- The proposed controller design produced inspirational results for a wind power source with variable parameters and load conditions.

This can be analyzed from the obtained results that, the proposed design of the controller is robust at nominal conditions as well as presents steady performance with wide deviation in system parameters load perturbation. The obtained results are impressive and endorse the proposed controller design. The model has achieved the set objectives. In the future, the framed model may be deployed to solve various practical engineering problems with numerous objectives.

The results obtained are impressive because the proposed controller model is performed for a large multi-area in a controlled environment and known parameters. However, for other renewable energy sources the results may be slightly different as these sources are highly intermediate by nature and some parameters in the system may be unknown.

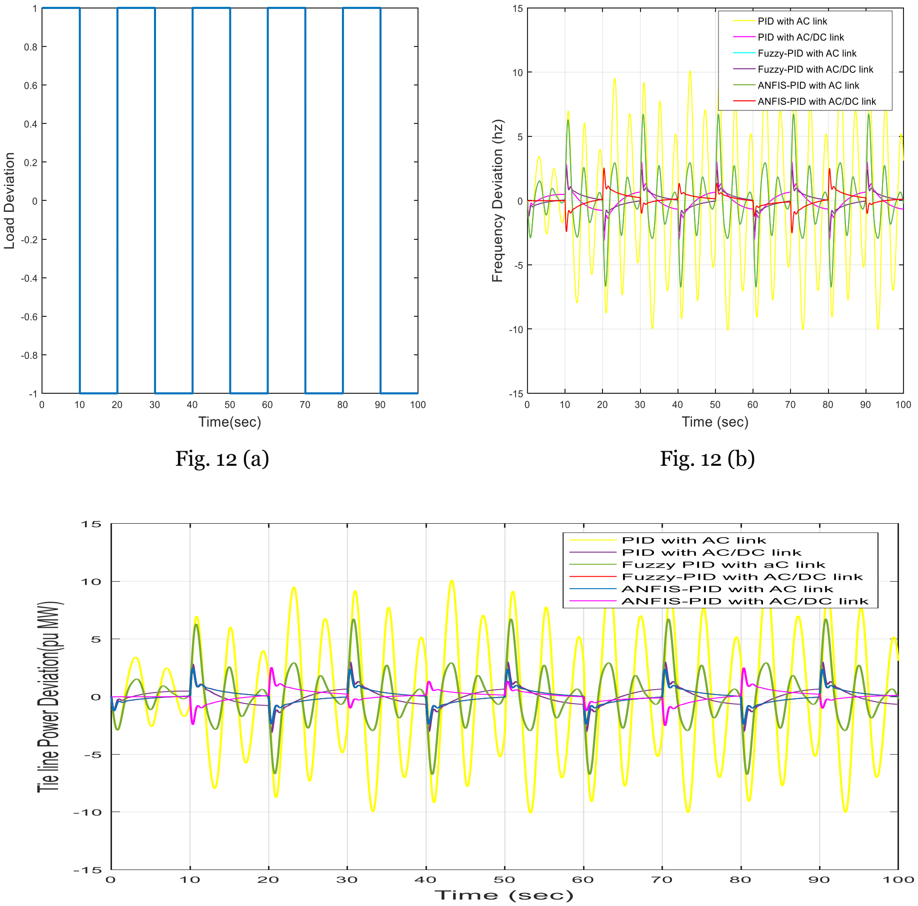

Fig. 12 (a)

Fig. 12 (b)

Fig. 12 (c)

Fig. 11 (a) Step Load perturbation (b) Frequency deviation (c) Tie Line power deviation

Appendix A Power System Parameters

f = 60 Hz; Rating of PS = 2000 MW (rating), P = 1840 MW (loading); $B1 = B2$ = 0.439 pu MW/Hz;

$R_1, R_2, R_3,$ and R_4 = 2.4 Hz/pu MW; T_r = 10.2 s; T_{sg} = 0.08 s;K_r = 0.3; T_t = 0.3 s; T_{gh} = 0.2 s; T_{rh} = 28.75 s; T_{rs} = 5 s; T_W = 1.1 s; Kw2 = 1.25; K_{w3} = 1.3; T_{w1} = 0.6 s; T_{w2} = 0.041 s; K_{w2} = 1.25pu; K_{dc} = $1pu$; T_{dc} =0.2s; T_{ps} = 20 s; a12 = −1; K_{ps} = 120 Hz/pu MW; T_{12} = 0.0545 pu.

Appendix B

Inputs	Notation	Outputs	Notation
Negative Low	NL	Small	S
Positive Low	PL	Medium	M
Zero	Z	Large	L
Positive Low	PL	Very Large	VL
Positive High	PH	Very very Large	VLL

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