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Meta Heuristic Neural Network (MH-NN) Based Tuning Method for PID Controller in Digital Excitation Control System (DECS)

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Abstract

In the conventional control system the PID controllers used the continuous time varying parameter for optimizing the gain of controllers. The existing work includes some drawbacks, such as high settling time, high integral square error, and integral absolute error. To overcome these drawbacks, the novel approach for tuning the proportional, integral, derivative gains of Proportional Integral Derivative (PID) controller to achieve the optimal solution is proposed. The static or rotary excitation is designed with the help of excitation control systems. The generator terminal or a separate external power sources are obtained from the voltage source of an excitation system. The proposed system is a feedback based system. If the error is occurs in the output then the output is feedback to the input of the system. The proposed work utilizes the previous error and the present error for calculating the temporary variable used for energy calculation. The calculated energy is used to tune the PID controllers. Using the proposed Meta heuristic neural network (MH-NN) algorithm. Which results in quick commissioning accomplishment of the generator excitation control system. The proposed method is a Meta Heuristic Neural Network method which minimizes the settling time, peak overshoot and delay time and results in an excellent system performance.

Keywords: Meta Heuristic Neural Based Network, PID controllers, excitation control system, commissioning system, Generator, feedback based system.

INTRODUCTION

A control system controls the behavior of other devices or system by commanding the operations to be performed. It is used in domestic boiler to large industrial control systems. The feedback control system is used in control plant. The control signal is given as the input and output obtained may be a fixed value or a changing value. The output of the control system is compared with the control signal and the difference is obtained from error signal. The feedback control system consists of following components, such as actuators, sensors and control algorithms. These process are work with control loop. To build the control system for predicts the humidity in the buildings, ventilation, heating and air conditioning system. [1]. The

advanced controllers which are used widely Proportional-Integral-derivative (PID) and Model predictive controller (MPC). HVAC systems use PID controllers to achieve energy conservation. The control system includes sensing of the output and it makes use of feedback system. The PID controllers are largely used in the industrial control systems.

The controller is used to calculate an error values and it makes correction based terms such as Proportional, Integral and Derivatives, so it is named as PID.

The integral and the differential applied to the output results are accurate and optimal control. The other type of controllers are classical integer order based integer double derivative based controller, Integral controllers (I), proportional controllers (P), fractional order PID (FOPID) [2]. The parameters of PID controller is interpreted with respect to the time, the parameters are Proportional, Integral and Derivative. The present error indicate as P, the accumulation of past error denotes I and prediction of future error represents D. By adjusting or tuning with three parameters, the certain control action is designed to particular process requirement. The tuning parameters are k_p,k_I andk_d. The parameters are proportional gain, integral gain and derivative gain. These are area used in the output of the PID controller. It is mostly used in distributed control systems and PID controllers are used in multi-rotor drones for self-establishing flight controllers. The controller controls the loop for tuning the control parameters and it achieves the optimum values for obtaining desired response.

The Proportional-Integral (PI) controller and the Proportional integral derivative (PID) controller both are used widely in both industrial and academic environment due to its easy implementation process, better performance and robustness characteristics [3]. The metaheuristic algorithm is used for optimizing and modelling a system. This algorithm is mainly used to produce an acceptable solution on time. The components of a metaheuristic algorithm are as follows:

- Intensification and diversification
- Exploitation and exploration

The desired result is obtained from tune parameters of metaheuristic algorithm. The metaheuristic algorithm provides acceptable solution in a trial and error basis even for a complex problem in a reasonable time. BAT algorithm is one kind of Meta heuristic algorithm and it is used in PD-PID controller for optimization. The function of integral Square Error (ISE) is minimized by the optimization techniques. The PD-PID controller provide the high response compare than PI and PID.

[4]. The block diagram of excitation control system includes amplifier, exciter, generator and feedback. An amplifier is used to increase the amplitude of signal waveform without changing the other parameters of wave forms such as frequency or wave shape. Here, the DC amplifier is used to amplify the DC voltages or very low frequency signals. In many electrical control systems or measuring instruments are used the DC amplifiers. Excitation system offers the current essential for field winding of synchronous generator to produce the rated terminal voltage at generator terminals. The exciter categorized by three, such as DC exciter, AC exciter and static exciter. Here, the proposed system used the DC exciter. This type of exciter separately or self-excited DC generator driven by the motor or connected to the same shaft to the main generator. DC generator is energized through the permanent magnet AC generator, three phase output which is converted to rectifier.

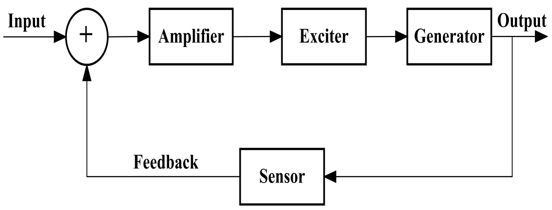

Figure 1: Block diagram of excitation control system

The conventional methods used the optimization techniques like the swarm optimization techniques which is used in natural selection and genetics. It helps to obtained many solutions simultaneously. This method initializes a particle and then applies a velocity to update the particles until the process condition is satisfied. Genetic optimization is another technique that is used for bulky and extended places that has coded variables which led to the optimal solution. The PI controller provides the proportional gain and it provides fast error response. The controller gain is proportional to an integer.

The contributions of metaheuristic neural network (MH-NN) based control system is,

- It proposes a novel metaheuristic algorithm for optimization which in turns tunes the PID controller gains ($k_P, k_I \, and \, k_D$) and obtains optimal result when compared with traditional methods.
- The MH-NN control system results with better international standard error (ISE) and international absolute error (IAE).

The paper organized as follows: The detailed description of the related works regarding comparison of the controller in a control system and the advantages and disadvantages are stated in section II. Section III discusses the proposed novel metaheuristic neural network (MH-NN) based control system. Section IV presents the performance analysis of proposed algorithm over the existing techniques. Finally section V is the conclusion part.

RELATED WORK

This section describes the different kinds of controllers used in control system with their advantages and disadvantages. The theoretical analysis provide important development of proposed MH-NN control system. Richardson and Nayak [5] Proposed Particle Swam Optimization (PSO) for tuning the PI controller. This technique was used to minimize the power loss in grid with PI controller for global and local best fitness of static synchronous compensator system STATCOM which was improved the power quality. The PSO optimization was done by using the principles of natural selection and the genetics. The proportional controller provided the stable process which always produce an error between the set point and the actual point. Even though the PI controller provided the stability at desired set point and the drawback of the DSTATCOM compensate harmonics in the current. Fuzzy controller with DSTATCOM can provide better efficiency than the PI controller.

Yue, et al. [6] developed a network control system with H_∞ controller. This was a delay system model which developed to find out the effect of transmission delay. This event triggering scheme reduced the communication load in the network. This system was developed to determine when the sensor was transmit the signal. The load of network communication in a singular system with quantization was not considered. Zhong [7] proposed the proportional load sharing inverter for robust droop controller. The system was used to reduce the load voltage drop and load effect drop. It was used in inverters output resistive impendence. But this system brought latency into the system. The reactive power was reduced when the voltage increases.Khooban, et al. [8] presented an optimal type-2 fuzzy PID controller for suspicions and external disturbances. The system was used the heuristic algorithm with PSO and random inertia weight. It was obtained an optimal performance with algorithm of RNW-PSO. The input output function membership function was developed by this parameters. The main drawback was not promised the stability and robustness of dynamic power system.

Khooban and Niknam [9] proposed the heuristic algorithm for self-adaptive modified bat algorithm was tuned with PI controllers and it was used to obtain the optimal performances.

This control design was used on large scale power system. The PI controllers in these systems had a power quality issue. The control performance was unsatisfactory due to the nonlinear structure.Amoozegar [10] recommended distribution static synchronous compensator DSTATCOM inverter was based on the power quality conditioner device and it was utilized to improve the power quality. This system was used the PI controller with fixed parameters. The direct and quadrature axes were used in the result of fuzzy PI controller for nonlinear and robust structure of control distribution system. The limitation of the system was not reduce the harmonic disturbances. In addition the load balancing and reactive power compensation was not considered.

Chen, et al. [11] projected the PID controller for hydraulic turbine regulating system and it was used five parameters with tuning of PID controllers. The parameters were chosen to provide more flexible. The fives parameters were proportional, integral, derivative gains and extra differentiation and integration orders. The chaotic non-dominated generic algorithm was used in hydraulic turbine regulating system and it was balanced trade-offs with their performance regulation rate was low. Xu, et al. [12] analyzed the PID control for fractional fuzzy order control. The regulation rate was improved using the fast fuzzy fractional order of PID control method. The Bacterial-Foraging Chemotaxis Gravitational Search Algorithm (BCGSA) was used to optimize the parameters. This system provided high robustness and stability. A refined generator model was not used. Prakash, et al. [13] developed a STATCOM connected distributed system to enhance the power quality. The power quality is determined using the following parameters unsettling influences, voltage sags, harmonics, flicker and so forth. This system used a Gravitational Search Algorithm (GSA) for enhancing the execution of DSTATCOM. It was reduced the harmonic disturbances.

Fan, et al. [14] proposed a control system for Modular Multilevel Converter (MMC) known as voltage balancing control method. This method was designed for voltage based and control based methods. This control system was used when the number of Sub Modules (SM) is high. Full voting sorting algorithm was used, which avoided unnecessary switching actions. The computational pulse width modulation was high. Xin, et al. [15] proposed the auto chlorination control process of tap water. A self-tuning PID controller with a Particle Swam Optimization (PSO) technique was deled with the nonlinear, time varying and large lagging problems. The relationship of PID controller and deviations were established and the s-function was written as t to complete the design of self-tuning controller with variable parameters. The PSO technique was used to achieve the correction coefficient values of deviation which was sent to the controller which improved the control effect of chlorination system. The percentage of overshoot was better than existing one still the rise time and the settling time was high. Tandan and Swarnkar [16] evaluated a Modified Particle Swam Optimization (MSPO) for self-tuning the PID controller. The parameters of PID controller was used to tune the MSPO. This resulted in a fast convergence, simple structure, population variety was enhanced and also the space search was extended. Modified PSO result was provide the better performance and the algorithm was used to alter the PID controller parameter effectively. The MPSO was increased with rise time, settling time when compared to PSO technique. The percentage of overshoot was four times higher than the PSO.

Edaris and Abdul-Rahman [17] endorsed a water control system with PID controller . This was developed to obtain a response without steady state error and overshoot. The conventional systems used the Zeigler-Nichols (ZN) approach which delivered enormous shoot. Hence the heuristic approach PSO was used. The best tuning parameters were determined using the ZN and PSO approach but still the ZN approach had a difficulty in obtaining a minimum overshoot. The PSO obtained the minimum overshoot. This system was provide the better performance of the PID gain. This PSO approach determined the velocity and optimal particle position in search space. Dynamic tuning was done to obtain the best solution. This was done in offline mode using the PSO and the ZN approach. Multi objective optimization was not used so this approach was not suitable for complex problem of water control system. Afram and Janabi-Sharifi [18] presented a model predictive control used for HVAC control system. The types of controllers are

- Classical controller
- Hard controllers
- Soft controllers

The model predictive control provided better transient response, lower energy consumption, robustness and consistent performance. In HVAC with MPC there were challenges like non-linearity, there was time variation. The energy consumption and the cost of running were not reduced. The MPC controller was included with some advantages were, optimal start-stop control, economizer control and load shifting control. Huang, et al. [19] described a HVAC control system with hybrid model predictive (HMPC) control scheme. This method was minimized by the energy consumption and cost of running HVAC system. This system combined both MPC and neural network feedback linearization method. This system was used RC linearized model and uncertainties were handled by using inverse neural network model. Handling the input constraints was not effective. Robustness was still a challenge. Sahu, et al. [20] suggested the intelligent system for power generation. The PID controller in thermal power plant was used to monitor and control the system. A self-modification PID controller with a Particle Swam Optimization (PSO) technique was nonlinear, time varying and large lagging problems. Raju, et al. [21] proposed the fuzzy proportional integer derivative controller for Automatic Generation Control (AGC) of two unequal area interconnected thermal system. Fuzzy PID controller was used the time teaching learning based optimization algorithm for obtained the performance of the system. Sahu, et al. [22] presented the novel hybrid Teaching Learning Based Optimization (TLBO) based fuzzy-PID controller and the Local Unimodal Sampling (LUS). The Load Frequency Control (LFC) of two-area interrelated multi-source power system with HVDC link and without HVDC link were achieved by this controller. The hybrid LUS and TLBO algorithms were applied to improve the scaling factors of conventional PID controller gain and fuzzy-PID controller. Hence, compared the achieved results with the Differential Evolution (DE) algorithm for the power system. Chakrabarti, et al. [23] developed the Two-Degree-of-Freedom-Fractional Order PID (2-DOF-FOPID) controller. The Automatic Generation Control (AGC) of power system was the main aspects of this work. Primarily tested the proposed controller with the three unequal area thermal systems. The reheat turbines and appropriate generation rate constraints (GRCs) were to be considered. Hence, the settling time and the oscillations has to implement in further improvement. Chung, et al. [24] recommended the SRF electronics modifications in the taiwan light source. The machine protection, adjustment, and optimize the operational parameters were all achieved in this modifications. The upgrade of the existing PID controller at TLS was extended and altered the operation and communication interfaces. Taher, et al. [25] suggested the Fractional Order PID (FOPID) controller for Load Frequency Control (LFC) in an interconnected power system. Therefore, the controller has to be tuned with help of five parameters. The comparative results FOPID with the conventional PID, the two more degrees of freedom was provided. The Imperialist Competitive Algorithm (ICA) were utilized to proper tune of the controller parameters. [26] presented the comparison results between the Conventional PID and Fuzzy Logic Controller. This was mainly due to the reason for controlling the over headed Water Level. The comparison results revealed that the control effect fuzzy control was superior to the PID control. Hence, the time of response, the steady state error and overshoot were to be enhance in further.

NOVEL METAHERUISTIC NEURAL NETWORK (MH-NN) IN DIGITAL EXCITATION CONTROL SYSTEM

This section illustrates the methods involved in proposed work. Fig 2 shows the overall simulation diagram of the proposed MH-NN tunable PID controller in digital excitation control system. Based on this simulation the block diagram of the MH-NN proposed system is illustrated. The components of the control system are the

- PID controller
- Comparator
- Exciter
- Generator
- Metaheuristic Neural Network system

The block diagram of the proposed metaheuristic neural network (MH-NN) based control system in Fig 3. Step response or time behavior of output control system is given as input to PID controller. It controller with their PID gains tuned by using metaheuristic algorithm for best solutions. The neural network known as Hopfield network and it is used to calculate the energy ‘E’. Based on the energy the metaheuristic algorithm is used to tune the PID controller gain. Then power is passed to exciter and it acts as the DC source, this produces the magnetic field. The exciter is a part of the generator. The generator works based on the Faraday’s Electromagnetic Induction. This system outperforms the existing system and results with a better ISE and IAE. Comparator is used to estimate the difference between input and output terminal signal.

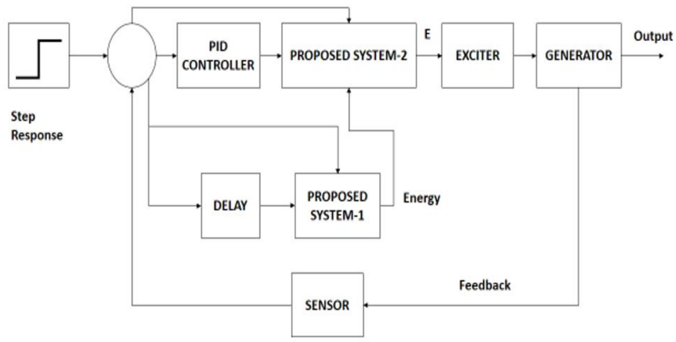

Figure 2: Block diagram of proposed MH-NN digital excitation control system

A. *Metaheuristic neural network (MH-NN)*

The proposed MH-NN is used to estimate the energy 'E' using temp variable ($Temp_v$). The $Temp_v$ calculation is the first part of the algorithm. The algorithm is as follows:

Calculating $Temp_v$

Step1: D_i is a temporary variable to store present error.

Step2: D_j is a temporary variable to store the previous error.

Step3: $\boldsymbol{D_i = e_{present}}$

Step4: If the previous error $e_{previous} \neq 0$

Step5: $D_j = e_{previous}$.

Step6: Else

Step7: $D_j = 1$

Step8: End

Step9: $D_j = \sum D_j$

Step10: $Temp_v = {D_i}/{D_j}$

The present and previous error estimated is stored in the temporary variable D_i and D_j.stores the present error and D_j stores the previous error obtained. If the $e_{previous}$ is not equal to zero then D_j is previous error. If the $e_{previous}$ is zero then the D_j value is said to be one. The values stored in D_j are summed. Finally the value of D_i and D_j are divided and the result is stored in a temporary variable $Temp_v$. The temporary variable is used to calculate the Energy using the weights (w_1, w_2, w_3). The proposed neural network estimates the energy E from the weights. The weights are the output obtained from the PID controller. The energy (E_1, E_2, E_3) obtained with the weights w_1, w_2, w_3 is shown in Fig 4.

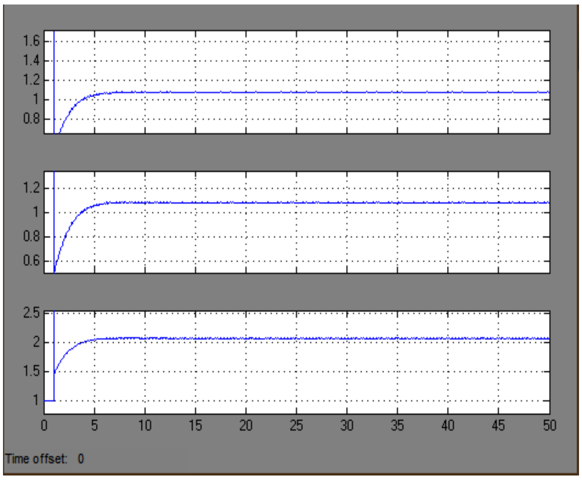

Figure 3: Energy E_1, E2 and E_3.

B. *Estimating the Energy for tuning PID gain*

The Energy 'E' is calculated by using the $Temp_v$ in which the calculations of the present and previous error are stored. The algorithmic steps to perform the Energy calculation are listed as follows:

Energy Estimation

Step1: $D_{Temp_{v.present}Temp_{v.previous}} = Temp_{v.previous} \sim Temp_{v.present}$

Step2: weights w_1, w_2, w_3 are calculated

Step 3: $w_1 = w_1 + D_{Temp_{v.present}Temp_{v.previous}}$

Step 4: $w_2 = w_2 + Temp_{v.preseent}$

Step 5: $w_3 = w_3 + (Temp_{v.present} + 1)^2$

Step 6: $E_1 = w_1 \sim Temp_{v.present}$

Step 7: $E_2 = w_2 \sim Temp_{v.present}$

Step 8: $E_3 = w_3 \sim Temp_{v.present}$

Step9: $E = (K_1E_1 + K_2E_2 + K_3E_3) + (E_1 + E_2 + E_3)$

Initially, the energy estimation is calculated with the help of weight and energy. In primary step calculates the difference between the previous and present temperatures. Next, the weight (w_1, w_2, w_3) is calculated. Next stage, the difference between temperatures are added with w and it is denoted as w_1. Similarly the w_2 and w_3 are calculated. Next the sub energies (E_1, E_2, E_3) are calculated. E_1 is calculated by the subtraction of present temperature and w_1. The E_2 is calculated by the subtraction of present temperature and w_2. The E_3 is calculated by the difference between the present temperature and w_3. Finally, the energy is calculated. It is calculated by the summation of constant value and sub energies values and these values are added with three sub energies value.

The energy

$$E = (K_1E_1 + K_2E_2 + K_3E_3) + (E_1 + E_2 + E_3) \quad (1)$$

Where K is a constant (K_1, K_2, K_3).

Here $K_1 = K_2 = K_3 = 0.5$

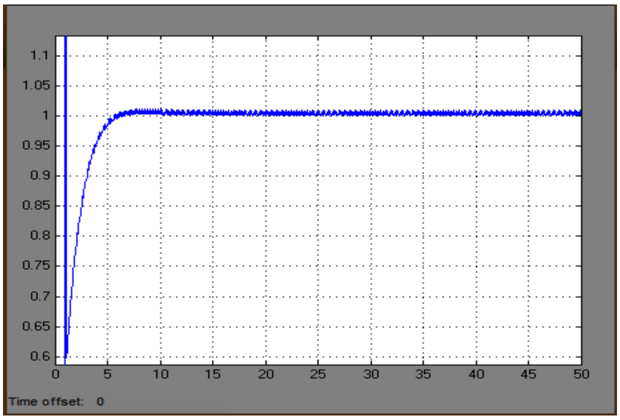

Figure 4: Total Energy E

The weights (w_1, w_2, w_3) are the output of the PID controller. The energy is calculated using the weights obtained from the PID controller. Using the Energy E_1, E_2, E_3 the gains of the PID controller are tuned to obtain the better performance than the existing controllers. The total energy E is obtained using equation (1). Fig 5 shows the total energy obtained.

C. *Tuning methodology for PID Controller*

The PID controller is tuned in order to obtain optimal gains which results provide better performance of the control system. The PID controller gain are K_p, K_I, K_D , where as

- K_p is the proportional gain.
- $K_{I,}$ is the Integral gain.
- K_D is the Derivative gain.

The equations in which the controller gains are tuned are as follows:

$$K_P = \frac{0.5}{E} \quad (2)$$

$$K_I = \frac{0.5535}{E} \quad (3)$$

$$K_D = \frac{0.138}{E} \quad (4)$$

Once the PID controller gains are tuned the values are applied to the following equations:

$$u(t) = K_P e(t) + K_I \int e(t)dt + K_D \frac{de(t)}{dt} \quad (5)$$

The output obtained from the PID controller based on the optimization process of MH-NN algorithm is then subjected to the exciter.

The transfer function of the exciter is,

$$\frac{1}{0.4s+1} \quad (6)$$

The exciter output is subjected to the generator. The transfer function of the generator is,

$$\frac{1}{s+1} \quad (7)$$

The response obtained from the generator is then sensed by the sensor for providing the feedback. The transfer function of the sensor is

$$\frac{1}{0.05s+1} \quad (8)$$

This proposed metaheuristic neural network algorithm (MH-NN) achieves better performance than the other controllers like PI, P, I and PID with the fuzzy and PSO techniques. The proposed MH-NN control system along with the metaheuristic algorithm and the MH-NN results with reduced peak overshoot to an extreme and reduced the time delay and the settling time is fast and stable.

Fig 6 shows the flow chart of MH-NN system. The process starts with calculating the errors. The calculated present and previous errors are stored. This estimates the temp variable $Temp_v$. The $Temp_v$ variable is calculated by the difference obtained between the $er(k)$ and $er(k-1)$. Where $er(k)$ is the present error and $er(k-1)$is the previous error.

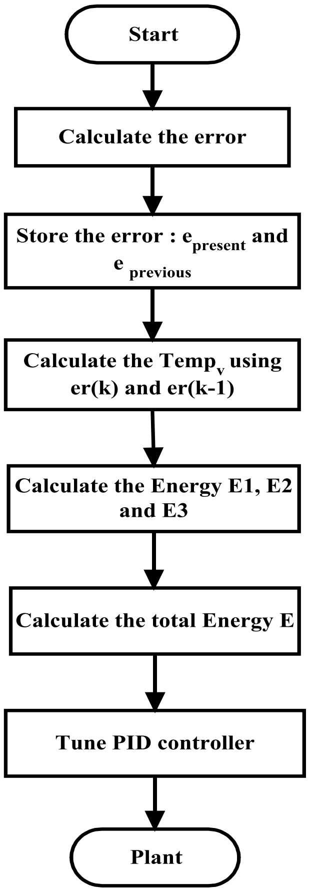

Figure 5: Flow chart of MH-NN control system

Using the temporary variable the energy E1, E2 and E3 are calculated. The total E is calculated using equation (1). Finally the PID controller gains are tuned using the energy E obtained.

PERFORMANCE ANALYSIS

This section discuss the performance of proposed Metaheuristic Neural Network for tuning PID controller in Digital excitation control system and illustrates the simulation. This MH-NN digital excitation control system intensifies the performance of the control system with a combination of metaheuristic algorithm along with the MH neural network. The topics discussed in this section are, the integral errors calculation and its comparison with the existing controllers ISE and IAE.

A. *Simulation Environment*

The proposed system is designed by MATLAB Simulink 2013.MATLAB includes some features, such as high level language for numerical computation, visualization and application development and it provides tools for building applications with custom graphical interfaces and the functions for integrating MATLAB based algorithm with external applications.

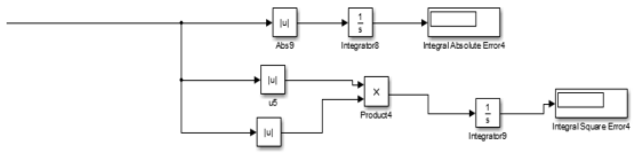

Figure 6: Simulation diagram for calculation of ISE and IAE

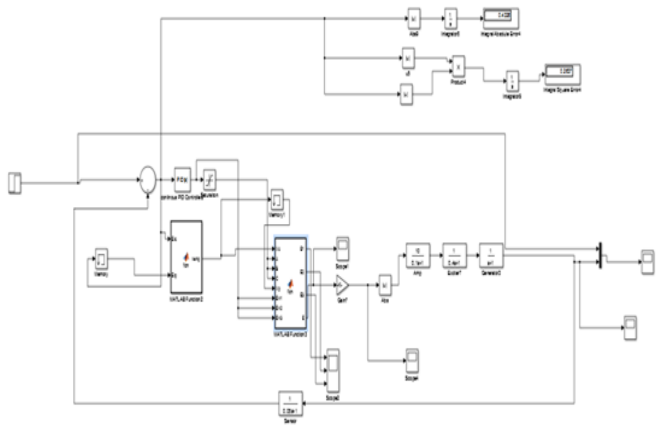

Figure 7: Simulation diagram of proposed system

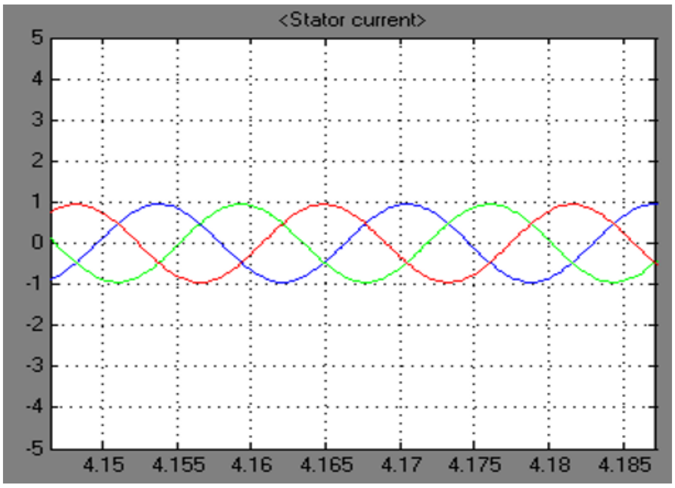

Figure 8: stator current

Fig 8 shows the stator current of generator. The x axis denotes the time and y axis denotes the stator current value. The load is connected to the three phase resistive load and it is connected with star topology.

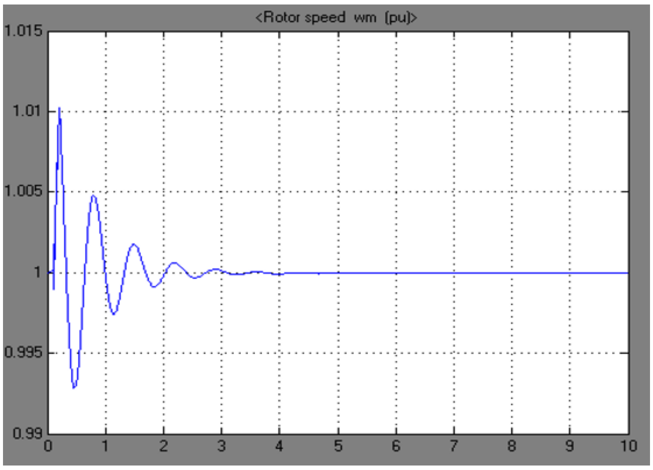

Figure 9: Rotor speed

Fig 9 represents the rotor speed of the generator. The x axis signifies the time in seconds and y axis shows rotor speed. Initially, load is high so the speed of rotor is high and it is fluctuated. At the time period of 3s, the current is maintained at constant.

B. Performance comparison of Integral Errors

The Integral error is estimated for the proposed system and it is compared with the existing controller ISE and IAE. The tuning relationship is intended to decrease the integral of the error. The integral square error is calculated using the equation,

$$ISE = \int \varepsilon^2 \, dt \tag{9}$$

The ISE and IAE are obtained for comparing existing and proposed controller (MH-NN) are illustrated in Fig 7 and 8.

The Integral square error obtained for PID is 1.117, PI is 1.401, P is 0.679, I is 1.788 and that of the proposed MH-NN PID controller is 0.2866. This proposed MH-NN control system results with the minimum ISE when compared with other existing controllers. It eliminates large errors and allows the small error which are present in longer period of time. The MH-NN system results in quick response, low amplitude and minimum fluctuation.

The Integral absolute error is calculated using the equation

$$IAE = \int |\varepsilon| \, dt \tag{10}$$

IAE does not add any weight to the errors in the system response.

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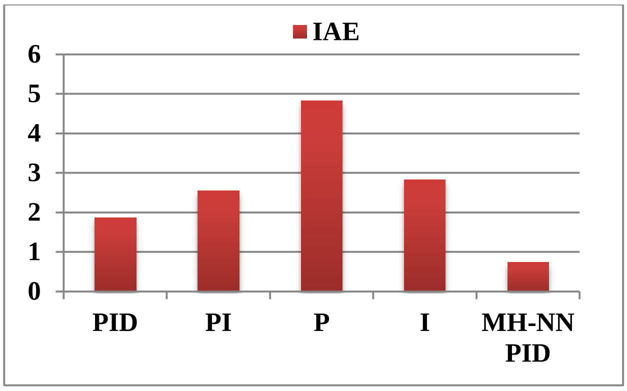

Figure 10: Integral Absolute Error IAE comparison

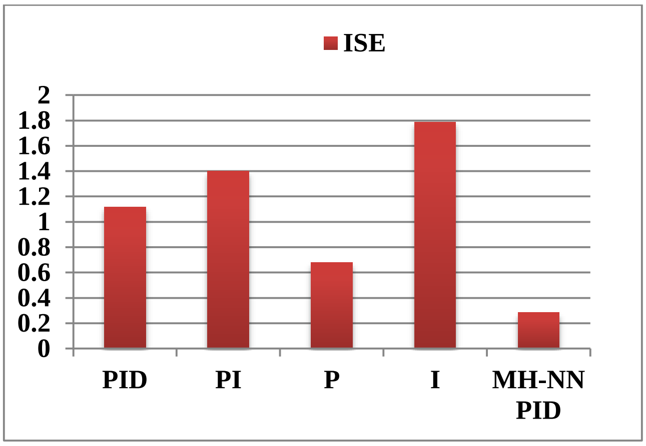

Figure 11: Integral Square Error ISE comparison

The integral absolute error obtained for the existing controllers are, for PID the IAE is 1.867, PI is 2.547, P is 4.284, I is 2.829 and for the proposed MH-NN PID controller is 1.944. The integral absolute error integrates the absolute error over time. When compared with other controllers the IAE for MH-NN PID controller is low, and is the value is closer to the ordinary PID controller. This makes the quality of the proposed system being relevant.

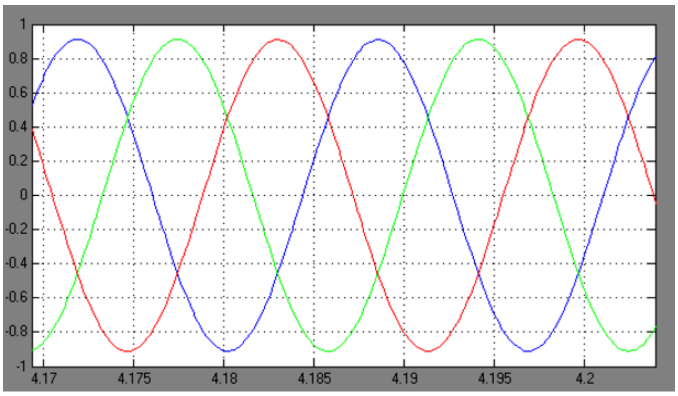

Figure 12: Output terminal voltage

Fig 10 shows the output voltages of proposed system. The X axis denotes the time (s) and y axis represents the voltages in volts. Here the voltage varies from -1 to 1volt. 180° Phase shift occurs in the output.

C. Comparison of parameter metrics

The MH-NN PID controller is tuned based on the estimated energy E. The metaheuristic algorithm makes it easier to discover the optimal tuning parameters of the MH-NN PID controller. The tuning of PID gain is according to the energy E and it achieves reduced peak over shoot, settling time and delay time.

Table 1: Performance metrics comparison

	PT	ST	POS	DT	SSE
PID	8.14	14.5	0.9	2.54	0
PI	6.130	22.4	19.62	2.75	0
P	1.629	10	46.52	1.24	0.1
I	6.53	24.6	16.4	3.18	0
MH-NN PID	4	9.8	3.96	1.37	0

Table 1 shows the performance metrics of existing and proposed MH-NN PID controllers. The parameter metrics measured are Peak Time (PT), Settling Time (ST), Peak Overshoot (POS), Delay Time (DT) and the Steady State Error (SSE).The peak time for the proposed MH-NN is 4, the settling time is 9.8, the peak overshoot is 3.96 and the delay time is 1.3726. This has eventually resulted with zero steady state error. The controllers that are compared with the proposed system are P controller, I controller, PI controller, and PID controller. The peak time of the proposed is minimized when compared with the PID, PI, and I controller. The settling time obtained is less when compared with other controllers. The peak overshoot of the proposed system is less when compared with the PI, P and I. The delay time is less than the PID, PI, and I.

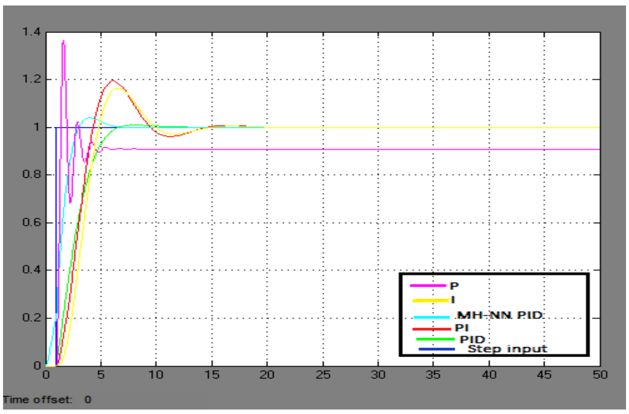

Figure 13: Comparison graph

Fig 13 shows the comparison graph of existing controllers (P, PI, PID and step input) with the proposed MH-NN PID controller. The X-axis denotes the time (s) and the Y-axis represents the amplitude (v). The proposed system takes less or minimum settling time compare than existing system. The proposed system provide the best results compare than existing system.

CONCLUSION AND FUTURE WORK

In this paper, the MH neural network and the metaheuristic algorithm together obtains the best tuning of PID controller gain. The developed MH-NN control system stabilizes and minimizes the peak overshoot, settling time, and the delay time. The proposed MH-NN PID controller is analyzed with the other controllers like P, PI, and PID. It prove that the Integral Square Error (ISE) and Integral Absolute Error (IAE) are minimized. The peak time, peak overshoot, settling time, delay time has reduced drastically in the proposed MH-NN and this has improved the performance of the control system notably. The MH-NN control system achieves peak overshoot of 3.96, delay time of 1.3726 and settling time of 9.8, and peak time is 4, which resulted with a zero steady state error. The future work can be done with other optimization techniques like PSO, dragon fly, and moath flame along with this proposed MH-NN control system to obtain a much reduced the settling time.

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