Comparation Frequency Control Using Hybrid PID and Capacitive Energy Storage Based Intelligent Ant Colony Optimization

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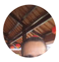
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Comparation Frequency Control Using Hybrid PID and Capacitive Energy Storage Based Intelligent Ant Colony Optimization

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ABSTRACT

The use of electrical load increases, causing frequency fluctuations are very large, so it is affecting the quality of power in renewable energy sources such as wind power. Utilization of diesel power plants have also been getting a lot of use, one of which is being developed is a hybrid system power generation such as wind power and diesel. Hybrid system is a network controlled from several renewable energy power generation such as wind turbines, solar cells, micro-hydro and so on. This research will be proposed one method for load frequency control system and diesel generator hybrid angina, using Capacitive Energy Storage (CES) and the Proportional Integral Derivative (PID) which tuning using intelligent methods based Ant Colony Optimization (ACO). From the research, the system is controlled using a hybrid CES and PID tuning using ACO, showed excellent results shown by the frequency overshoot error system. By using the PID-CES-ACO on the control system Load Frequency Control (LFC) designed, can improve the frequency response of a system Wind-Diesel. This is indicated by the value of a faster settling time which is the value of the fastest settling time and overshoot value of -0.000119 & 3.648e-09 pu which is the smallest overshoot value of the other controller models.
Keyword: Wind-Diesel, PID, CES, ACO, Frequency, Overshoot, Settling time

1. INTRODUCTION

The utilization of new renewable energy sources as a source of electrical energy, has been more widely used. Wind power is already widely used as a driving source of a generator to produce electrical energy. However, the utilization of wind energy is highly dependent on wind conditions in the region, so as to optimize the performance of the power plant is required another plant to be optimized, using diesel. Wind-Diesel Hybrid will be able to serve customers with optimal, because their performance is more optimal than with Wind Stand Alone. Hybrid system is a network controlled from some renewable energy sources such as wind turbines, photovoltaic, micro-hydro, and so forth. But in practice because of differences in the frequency fluctuation setting then this will affect the quality of the existing power supply on the hybrid system [1,2].

In previous research studies discuss the operational stability of hybrid system frequency regulation techniques and discuss the combined technique of fuel cell systems and hybrid electrolysis to improve the system's ability mikrogrid in improving power quality of frequency fluctuation problem. Arrangements proposed and monitoring systems (monitoring) does is to maintain power quality, as well as to maintain the stability of fluctuations in frequency due to power random in the generation as well as on the load side as well to maintain the stability of fluctuations in power flow in tieline power flow due to fluctuations in the frequency of interconnection hybrid system [3,4].

The application of intelligent methods in power systems for tuning PID control has been done, one of them [5], which discusses the application of the cuckoo method for tuning PID parameters. Several studies have addressed the frequency setting on Wind-Diesel, among others, [6-13]. Previous research already widely discussed hybrid system using PID control, and the results of these studies there are still some shortcomings which are still there are still large frequency fluctuations.

Frequency of some regulatory issues that cause fluctuations in power flow in various types of hybrid systems connected generation, the researchers took the theme Setting Frequency In Hybrid Power System with Intelligent Methods Ant Colony Optimization (ACO). Ant Colony method is a method inspired by the behavior of ants in finding food sources.

2. LITERATURE REVIEW

2.1. Hybrid System

The power system of hybrid diesel-wind turbines stand alone may be economically applied in some cases the provision of electrical energy in remote areas eg mountainous regions or islands where the level of wind speed was significant enough to drive a generator to produce electricity but for the supply of energy on a network system connected uneconomical , Expected results of the electric energy generation hybrid system Wind Turbine-Diesel can provide better service to service burden to the consumer, but it all depends on the type and characteristics of the control of generation. This means that the variation frequency of the system should be maintained stability so that the equipment can operate properly and efficiently. Different strategies can be implemented by reducing the differences of generation and load and set the system frequency deviation.

The strategies that can be done by setting a mock load control, load control switching priorities, the use of flywheel, superconducting magnetic energy storage systems and batteries. To be able to display the detailed analysis of the study of diesel hybrid system of wind turbines and micro-hydro with a small transfer signal model. Selection of the optimal gain control of suggested using ISE techniques for case-control continuous and discrete control. Problems that occur in the generation of the oscillation frequency is low. It arises because:

- The high gain setting and low time constant of the Automatic Voltage Regulator (AVR).
- Too many transmission lines are long so the ability is weak (weak line).

To overcome the problem of high gain at AVR, before we discuss briefly the transfer function of the AVR to make it easier to understand the effect of the gain and time constant AVR. Basically a high gain on the AVR have a purpose:

- The higher the gain, the terminal voltage of the generator to be controlled properly, because the goal of the AVR is making the terminal voltage stable.
- The higher the gain on the AVR, it also raises the side effects, namely the weakening of the damping ability (negative damping) of the generator so that the potential emergence of low frequency oscillations.
- Of the two reasons above, it can be concluded that setting the gain on the AVR is something very important, because if it is too low will cause instability monotic and if it is too high will cause low frequency oscillations.

Models in this case study is composed of sub-systems: dynamic models of wind turbines, diesel dynamic model, speed control of wind turbine blades and generator dynamic model.

2.2.Ant Colony Optimization (ACO)

ACO algorithm introduced by melting and Faieta (1994). The algorithm is an algorithm that mimics the behavior of ants, ant larvae corpse and sorting. The principle of ant in the ant larvae collecting and sorting is used reference in this algorithm. ACO algorithms to provide relevant partisiyang of data without knowledge of the initial cluster centers. There are ants agents who make the shift randomly on a two-dimensional grid within the grid where there are objects that are scattered randomly, and the grid size depends on the number of objects. Ant agent selected or allowed to move in the grid, would take an object and dropping of objects that are affected by the similarities and the density of the object.

The probability of making objects of ant agents will be enhanced in an environment of low density, and decreased if the high similarity of objects around it. Instead probability of dropping of objects will increase high-density environments. Ants and objects in the grid can be in two situations, namely (a) the ant agent holds objects and evaluate the possibility of dropping at the current position. (B) ant agent without holding a moving object in the grid and evaluate the possibility of taking an object. Finally, ant agent will categorize objects based on the object that is similar to one another.

Local Pheromone update rule in ACS

At the time of the tour to find the solution, ants passing lane and change the level of pheromones in the lane by applying local pheromone update rule shown by the following equation.

$$\tau_{ij}(t)=(1-\rho)\tau_{ij}(t-1)+\rho\tau_0 \quad (1)$$

With,

ρ = constant evaporation (evaporation)

τ_0 = an initial value of the initial pheromone

Flowchart of the whole process described ACO-section of the section above can be seen in the following figure.

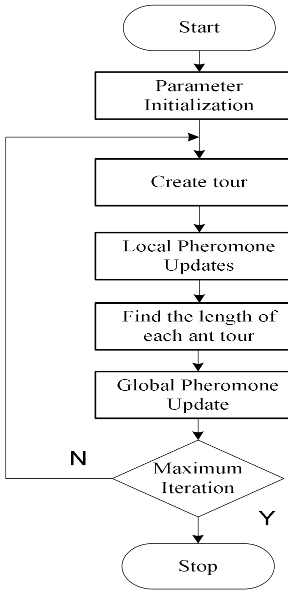

Figure 1. ACO Flowchart

2.3. Capacitive Energy Storage (CES)

CES is a device for storing and releasing large amounts of power simultaneously. CES stores energy in the form of an electric field in the capacitor. A CES consists of a storage capacitor and Power Conversion System (PCS).

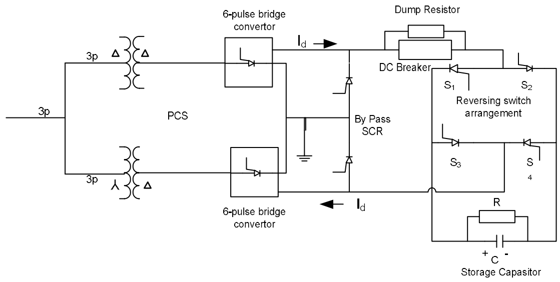

Figure 2. Capacitive Energy Storage

Storage capacitor consists of several discrete capacitors connected in parallel, with capacitance C. Leaking losses and dielectric capacitor bank at CES modeled by a resistance R connected in parallel to the capacitor. Storage capacitor connected to the grid through the Power Conversion System (PCS) 12-pulse. PCS consists of ac to dc rectifier and dc to ac inverter. Thyristor bypass serves to provide a path for current flow I_d when converter failure occurs. DC breaker allows current I_d energy diverted to discharge energy of resistor R_D if the converter fails. By ignoring losses, bridge voltage E_d is as equation:

$$E_d = 2E_{d0}\cos\alpha - 2I_d R_D \quad (2)$$

$$E_d = \frac{[E_{d\max}^2 + E_{d\min}^2]^{1/2}}{2} \quad (3)$$

During the system disturbance occurs, if the capacitor voltage is too low and if other disorders occur before the voltage back to normal values, the energy will be more withdrawn from the capacitor which can cause intermittent control. To solve this problem, the lower limit for the capacitor voltage, taken 30% from the rating value E_{d0}. thus,

$$E_{d\min} = 30\,E_{d0}$$

CES voltage must be returned to the initial value quickly, so after a load disturbance occurs CES unit is ready to work for the next load disturbance. Therefore, the capacitor voltage deviation is used as a negative feedback signal in a control loop CES so fast voltage recovery is achieved.

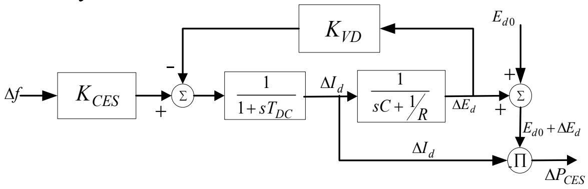

Figure 3. Diagram Block of CES

Here capacitor voltage deviation ΔE_d,

$$\Delta E_d = \left[\frac{1}{sC + 1/R} \right] \Delta I_d \qquad (4)$$

Output power CES that is released into the system in the event of load changesas follows,

$$\Delta P_{CES} = (E_{d0} + \Delta E_d).\Delta I_d \qquad (5)$$

2.4. PID Tunning Using *ACO*

Figure 2 shows a flow diagram ACO algorithm method used in this research to tune PID parameters. The objective function is used to Integral Time Absolute Error (ITAE).

$$ITAE = \int_0^t t\left|\Delta\omega(t)\right| dt \qquad (6)$$

PID parameters are tuned by the ACO is Kp, Ki and Kd.Berikut modeling for each model of control in Matlab Simulink, 2013, to Wind-Diesel without control, with PID-ACO, ACO and the CES-PID-CES-ACO.

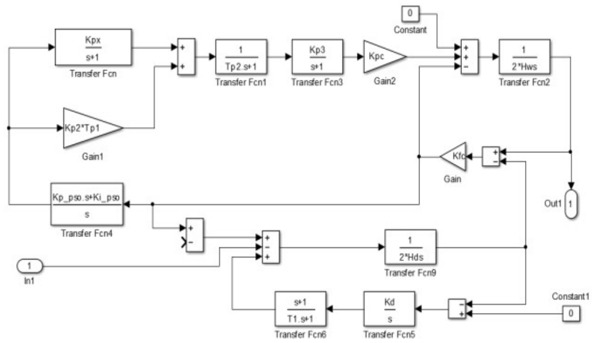

Figure 4. Simulink Modeling of Uncontrol

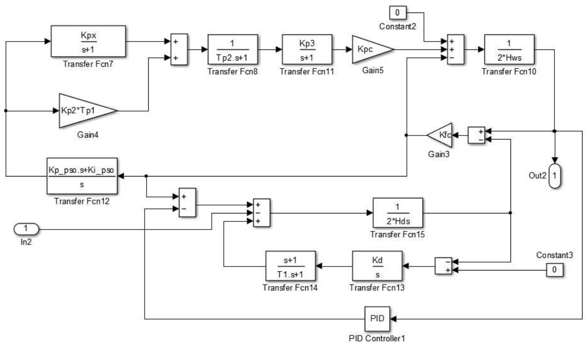

Figure 5. Simulink Modeling of PID ACO

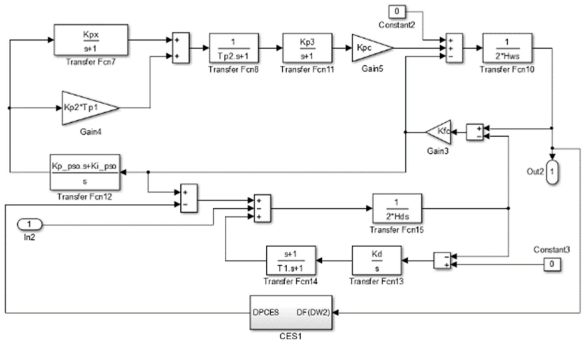

Figure 6. Simulink Modeling of CES ACO

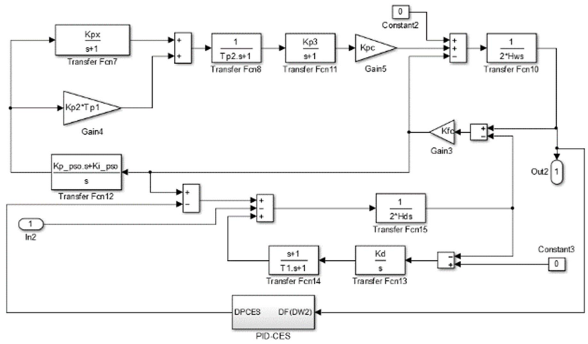

Figure 7. Simulink Modeling of PID-CES ACO

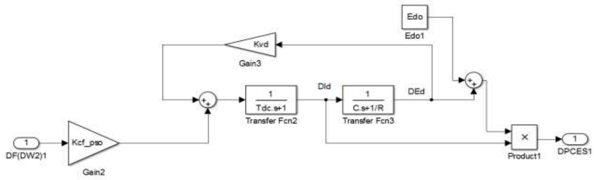

Figure 8. CES Modeling

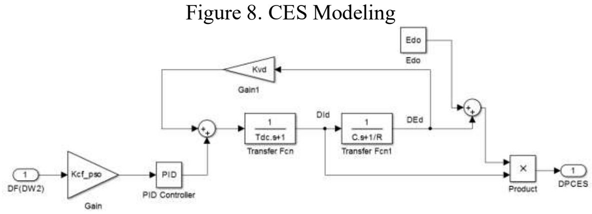

Figure 9. PID-CES Modeling

3. METHOD

The ACO parameter data as follows.

Table 1. ACO Parameters

Parameters	Value
Node	100
Max_It	50
Alpha	1
Beta	2
rho	0.1
c	100
L_Best	Inf
T_Best	0

Flowchart of research shown in the following figure 10. Results ACO optimization fitness function values obtained by 4.0799e-05, with 50 iterations.

Table 3. Results CES-PID Parameter Tuning

Parameter	Constraint		ACO Results
	Lower	Upper	
Kp_pso	0	100	1.9656
Ki_pso	0	100	0.0166
Kcf_pso	0	10	4.0060
Kp_c	0	10	4.8426
Ki-c	0	10	0.4984
Kd_c	0	10	4.8482

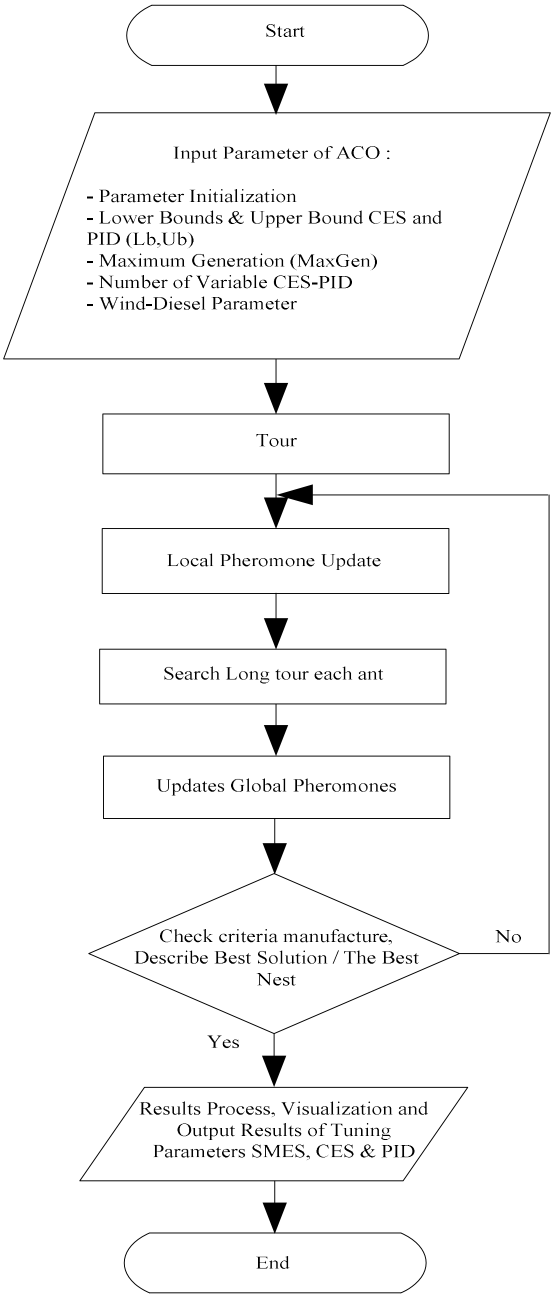

Figure 10. Research Flowchart

4. SIMULATION RESULTS AND ANALYSIS

4.1 Wind-Diesel Frequency Response Controller

The first simulation is a simulation of open-loop wind-diesel without a controller. The following graph simulation results shown in wind-diesel without a controller.

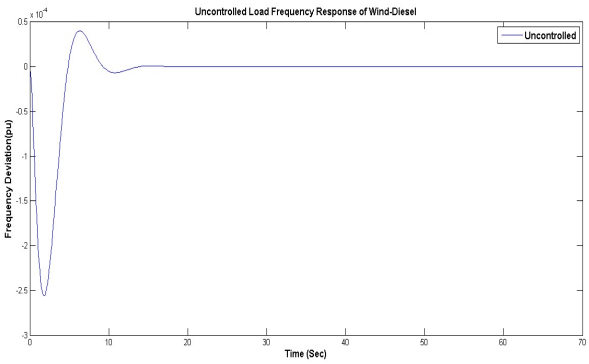

Figure 11. Graph frequency Wind-Diesel without controller

Pictures of the graph above shows the frequency response graph Wind-Diesel equipped open-loop or without a controller. From the above chart values obtained overshoot and settling time Wind-Diesel very large, as in the following table.

Value overshoot and settling time resulting from Wind-Diesel plant simulation without the controller above is the value of overshoot and settling time which is the largest among all the simulation, that is equal to -0.0002557 & 4.017e-05. This is because of the frequency control system is only done or charged to the governor alone, so the system is not equipped controller's frequency on the generator were the most unstable among other systems by the controller.

4.2 Wind-Diesel Frequency Response Using PID Controller-ACO

Next simulation using PID control-ACO, the simulation results obtained from the following graph:

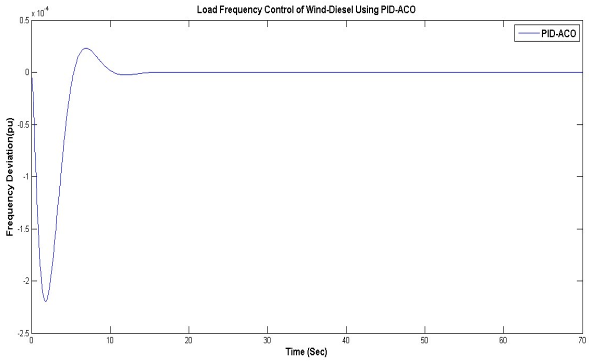

Figure 12. Graph Wind-Diesel frequency response with PID controller-ACO

Can be seen from the image above that when the load changes or disturbances (in this case the change of the load), the frequency of the oscillating system before reaching tunaknya conditions (steady state). Can be seen from the value stated in the table above that with the installation of a PID controller-Trial Error, the system frequency oscillating between -0.0002194 & 2.293e-05. When compared with the frequency response of the system is not equipped with a PID controller, its value becomes smaller overshoot, but is not recommended for use as a controller.

4.3. Wind-Diesel Frequency Response Using the Controller CES-ACO

Next simulation using PID controller-ACO, from the simulation results obtained as follows:

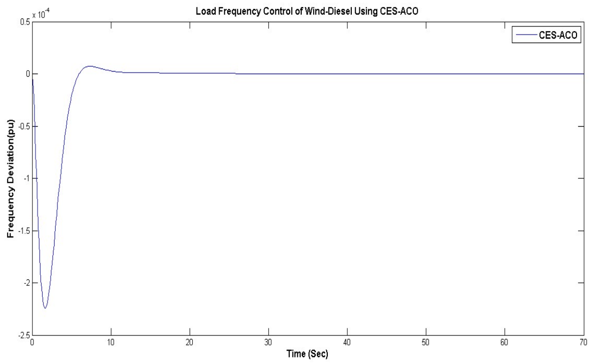

Figure 13. Graph of the frequency response of Wind-Diesel equipped controller CES-ACO

Can be seen from the image above, the results of the frequency response for Wind-Diesel system with PID controller-ACO. Value overshoot on these systems become smaller, amounting -0.000224 & 7.183e-06 shows that when the system is experiencing changes in the load or disturbances, the system frequency drops by -0.000224 pu insulated, and will return to its steady-state value more quickly.

4.4 Wind-Diesel Frequency Response Using PID-CES-ACO

Last control type using PID control-CES-ACO, following simulation results shown in the graph wind-diesel with PID controller-CES-ACO.

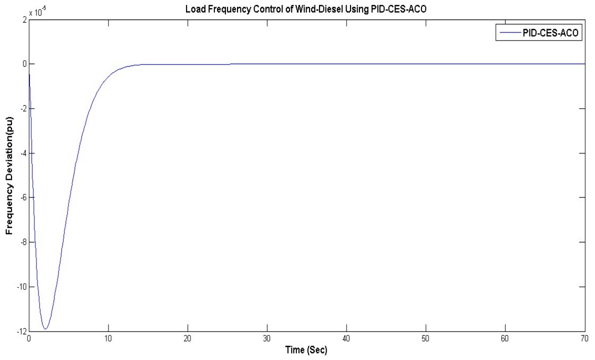

Figure 14. Graph frequency Wind-Diesel with PID Controller-CES-ACO

Pictures of the graph above shows the frequency response graph Wind-Diesel controlled by using a hybrid combination of PID-CES-ACO. Value overshoot and settling time resulting from Wind-Diesel plant simulation without the controller above is the value of overshoot and settling time is the smallest among all the simulation models, which amounted -0.000119 & 3.648e-09. Combination PID and CES generates optimal control to dampen oscillation frequency on wind power and diesel.

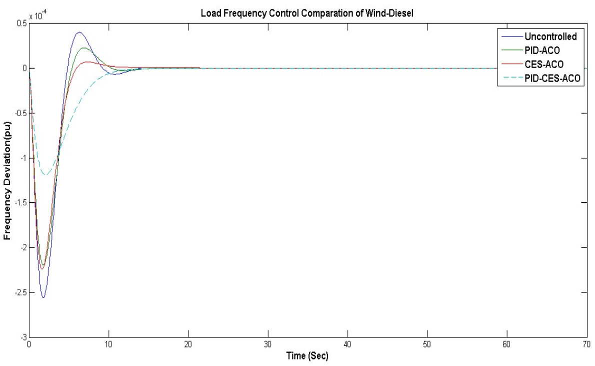

Figure 15. Comparison Chart frequency Wind-Diesel with PID Controller-CES-ACO

The picture above is a graph comparing the response of each model control. Of the three types of control models of wind power systems hybrid-diesel that has been simulated, it can be concluded that a wind-diesel power plant controller as a damper requires absolute frequency oscillations caused by load changes. PID Controller-CES ACO proposed in this study had a significant influence on the oscillation damping and suitable to be applied to hybrid generating system Wind-Diesel, where the analysis method using artificial intelligent methods, Intelligent Ant Colony Optimization.

5. CONCLUSION

By using intelligent methods AntColony Optimization (ACO) as a method of tuning controllerPID, showed the value of PID tuning parameters are optimal.

From the comparison of the model control, obtained for each model is as follows controlling the overshoot amounted -0.0002557 Uncontrolled Systems & 4.017e-05, System-ACO with PID control overshoot amounted -0.0002194 & 2.293e-05, with a control system CES- ACO overshoot amounted to 0.000224 & 7.183e-06.

Model Control Using PID-CES-ACO on the control system Load Frequency Control (LFC) designed, can improve the frequency response of a system Wind-Diesel. This is indicated by the value of a faster settling time which is the value of the fastest settling time and overshoot value of -0.000119 & 3.648e-09 pu which is the smallest overshoot value of the other controller models.

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