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PSO and BFO for LFC OF TWO AREA HYBRID WIND SYSTEM WITH V2G

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***Abstract*— In modern world, people are more concerned with uninterrupted and frequent power supply. In conjuncture to this, the thesis presents a proposal to maintain the voltage and frequency to a fixed value in order to have a good quality of power supply. The process of controlling the voltage and active power in a power system is called as Load Frequency Control. The soul of this proposal is to maintain frequency during load changes and also tie line power interchanges. This proposal is based in order to reduce the steady state error. Here we consider vehicle to grid, which is used as a compensating device for reducing the oscillations caused during load changes. A hybrid power system is taken into consideration, consisting of thermal and wind energy along with V2G and load frequency control is determined using integrator, PID controller, FUZZY controller, PSO tuned PID controller and BFO tuned PID controller. The simulation is done using MATLAB Simulink.**

Keywords—LFC; V2G; Hybrid; Frequency controller; integrator, PID, PSO, Fuzzy, BFO

I. INTRODUCTION

To improve the performance of the equipment, it is necessary to ensure the quality of the electrical power. The Quality can be achieved by controlling both real and reactive power based on the load conditions. The active power balance and reactive power balance has to be maintained between the generating and utility devices. These two terms corresponds to frequency and voltage. The frequency is highly dependent on the active power whereas the voltage is highly dependent on the reactive power. A good quality of power system requires both frequency and voltage to remain at standard values during operation. For India, the standard values for the frequency and voltage are 50Hz and 230V respectively. It is hard to maintain to balance of both real and reactive power without control. As a result of imbalance, the frequency and voltage values will deviate from the standard values. Thus the controller is required to reduce the deviation in frequency and to decrease the settling time. The active power and frequency control is referred to load frequency control (LFC). The foremost task of LFC is to keep the frequency constant against the randomly varying loads, which are also referred to as unknown external disturbance. In our case we considered the disturbance as step input. The transfer function of thermal, wind and V2G is considered to achieve the load frequency control. The Vehicle to Grid is used to reduce the magnitude of the peak deviation and to reduce the maximum peak overshoot. The controllers used in our system Integrator, PID controller, PSO tuned PID controller, Fuzzy controller and BFO tuned PID controller. In our research we made an analysis of frequency deviation on the various controllers to suits the K_P, K_I and K_D for the particular system. Our system uses both manual and automatic tuning of K_P, K_I and K_D parameters, so that the settling time of the frequency deviation is reduced to minimum.

A. Reasons for the Need of Maintaing Constant Frequency:

- The blades of the turbines may get damaged due to change in frequency.
- The operation of the transformer is not desirable below the rated frequency and the transformer core goes into the saturation.
- The efficiency of the equipment in the utility side decreases with respect to change in frequency.
- Reduced frequency leads to decrease in blast by ID fans and FD fans thereby generation decreases. By multiplying effect, results in shut down of the plant.

II. LOAD FREQUENCY CONTROL WITH V2G

A. Load Frequency Control

The foremost responsibility of LFC is to preserve the frequency constant against the randomly fluctuating active power loads, which are indicated as external disturbances. In

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addition to this task, the ideology of the LFC is to reduce the tie-line power exchange error and steady state error.

B. *Vehicle to Grid (V2G)*

The battery storage of the electric vehicle is one of the emerging technologies, which can act as a load reacting to the change in power supply. Electric vehicle coupled to electrical network can able to control the load and energy storage mainly by renewable source. It is mainly used to maintain the balance in the electrical grid during the load changes and also reduce the magnitude of deviation, so that equipment will be safe during fluctuations. Vehicle to grid (V2G) systems uses the electric vehicle battery storage to transfer power with the grid when the cars are parked and plugged in to the charging stations at parking lots, at offices or at homes, in which they will have bidirectional power transfer capability. The vehicle to grid can able to utilized during the running conditions with the help of piezoelectric crystal, in which the electricity is produced based on the pressure on the road and it is stored in the storage system from which it can be connected to the grid. In our system we used vehicle to grid system when is at parking condition.

C. *Modelling of Thermal System*

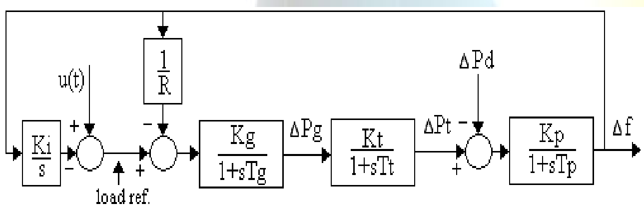


Fig.1 Block of Thermal System

K_g	Generator Gain Constant	1
T_g	Generator Time Constant	0.08
K_t	Turbine Gain Constant	1
T_t	Turbine Time Constant	0.3
K_p	Plant gain constant	120
T_p	Plant time constant	20
R	Regulation	2.4

Table.1 Parameters of Thermal System

D. *Modelling of Vehicle to Grid(V2G)*

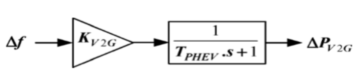


Fig.2 Block of V2G

K_{V2G}	V2G gain max	200
T_{PHEV}	Delay Time	1

Table.2 Parameters of V2G System

E. *Modelling of Wind System*

As a natural source, the output power of a wind turbine is fluctuating due to the time-variant wind direction and the wind speed. When the performance of controllers for V2G and DG is considered, the inner characteristics of wind turbine have little effect on LFC of the micro-grid.

III. Block Diagram of the System

The block diagram of LFC control two area hybrid thermal - wind system consists of two separate area interconnected in the distribution side. Two different areas are considered based on the moment of inertia and damping coefficient. The transfer function of systems is considered and simulated using Matlab Simulink. In our system we consider thermal wind as energy sources and v2g is used as a compensating device to balance the power demand in the electrical grid for a single area, similarly the same system are considered for the area2. Both are interconnected through the summer and deviations of the frequency are visualized in the scope.

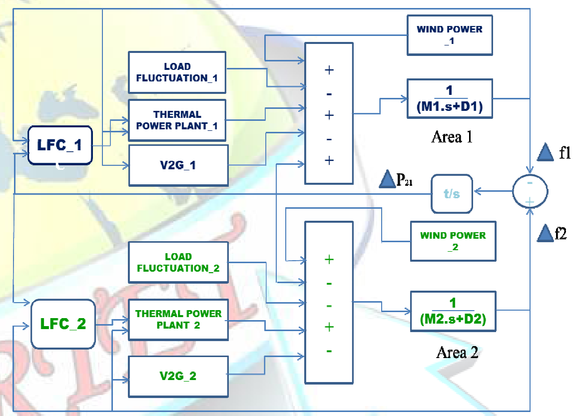
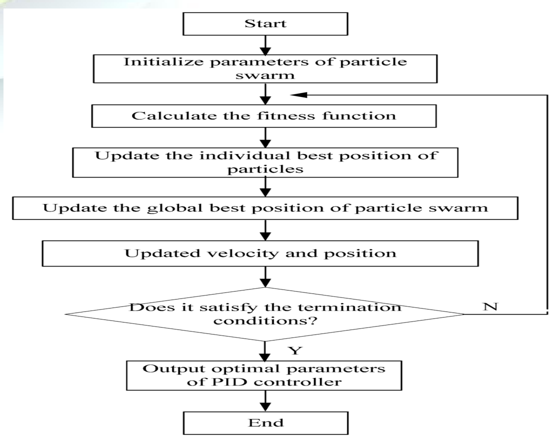


Fig.3 Block Diagram of LFC Control of Two Area Hybrid System

IV. Algorithms Used in the System

A. *PSO Algorithm based tuning of PID Controller*



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PSO tuned PID controller in which it follows the approach of Particle Swarm Optimization to tune the values of K_P, K_I and K_D for the system. It comes under the category of stochastic algorithm where it follows automatic tuning rather than manual tuning. It is an advanced approach compared to conventional method to minimize the steady state error and the settling time.

Fuzzy Logic Controller

ACE/DACE	NB	NM	NS	ZO	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZO
NM	NB	NB	NB	NM	NS	ZO	PS
NS	NB	NB	NM	NS	ZO	PS	PM
ZO	NB	NM	NS	ZO	PS	PM	PB
PS	NM	NS	ZO	PS	PM	PB	PB
PM	NS	ZO	PS	PM	PB	PB	PB
PB	ZO	PS	PM	PB	PB	PB	PB

Fig. Rules of the Fuzzy Logic Controller

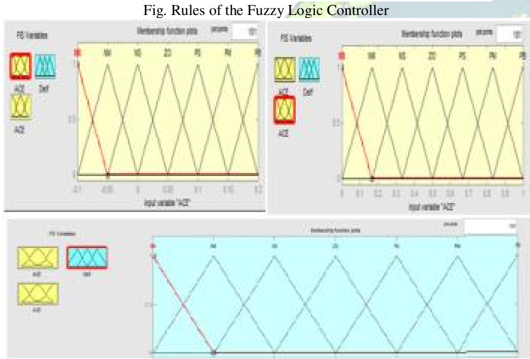

Fig. Input and Output of Fuzzy logic Controller

In our system, we used fuzzy based controller to tune the values for controlling the load frequency. Fuzzy control is based on a logical system called fuzzy logic. It is much close in spirit to human Thinking than classical logical systems. In this work fuzzy logic uses triangular membership function. The change in ACE and ACE is taken as input and Delf is takes as output. Based on the rules of fuzzy the output is obtained. For example Input1 is NB and Input2 is NS then the Output will be NB. Christo Ananth et al.[5] presented a brief outline on Electronic Devices and Circuits which forms the basis of the project.

B. BFO Algorithm based tuning for PID Controller

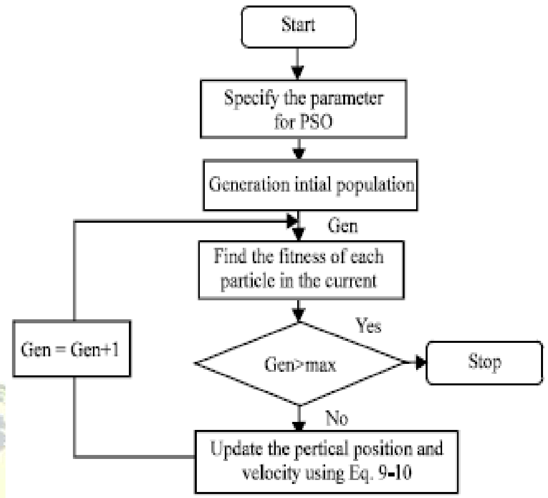

Fig. Flowchart of BFO tuned PID Controller

BFO tuned PID Controller in which it follows the Bacterial Foraging Optimization technique to tune the values of K_P, K_I and K_D for the system. It is an advanced approach of PSO tuned PID controller. It takes the initial values from the PSO and processes it to find the best match of K_P, K_I and K_D values for the system. BFO comes under the category of stochastic algorithm, follows the automatic tuning to minimize the settling time and steady state error.

V. SIMULINK DIAGRAM FOR THE SYSTEM

Thermal andWind System along with Vehicle to Grid (V2G) for two area is modelled using simulation parameters in matlab simulink. The thermal- wind with V2G is simulated with and without controller. The controllers used are Integrator, PID controller, PSO tuned PID controller, Fuzzy logic controller and BFO tuned PID controller. These controllers are used to reduce the steady state error and settling time. The power generated from the wind plant varies from time to time and the change in power is stabilized by using the V2G. Vehicle to Grid is also used to reduce the magnitude of frequency deviation. In our system by using V2G the magnitude of deviations is reduced to 0.015 from 6, so that it helps us to safer the equipment in the consumer side. In the above system we have reduce the settling time to 5 seconds and the peak overshoot has been reduced to 0.025. Among all the controllers, BFO tuned and PSO tuned PID controller gives the optimized results with less settling time and peak overshoot. The above graph and table describe the differences of all the controllers for the thermal + v2g + wind

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system. This thermal + v2g + wind system in the two area network helps us to supply the quality of power to the consumers. The output of the system will be stabilized during the load change as well as TIE line power interchange. By the use of v2g it acts as compensating device to balance the electrical grid.

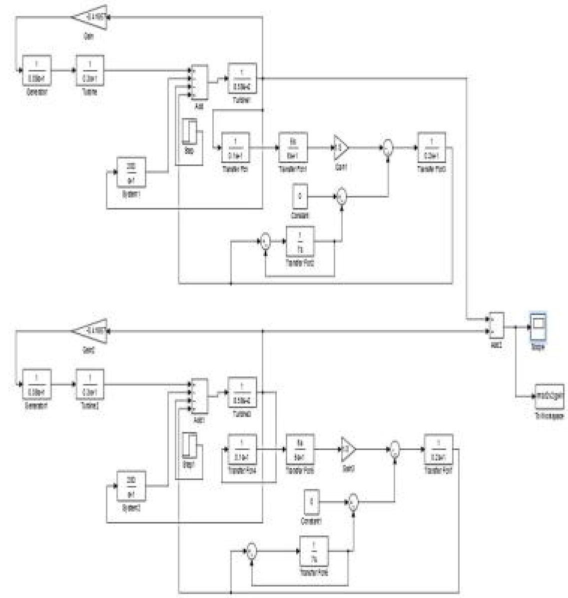


Fig. Simulink Diagram of Thermal + V2G + Wind System in Two Area without Controller

VI. Simulation Results

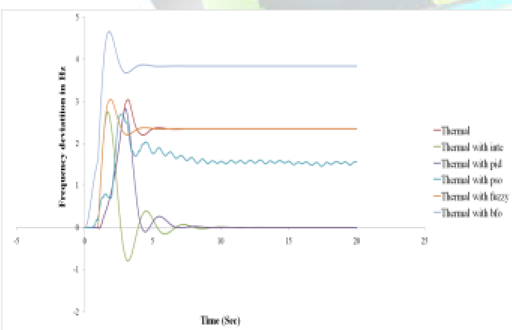
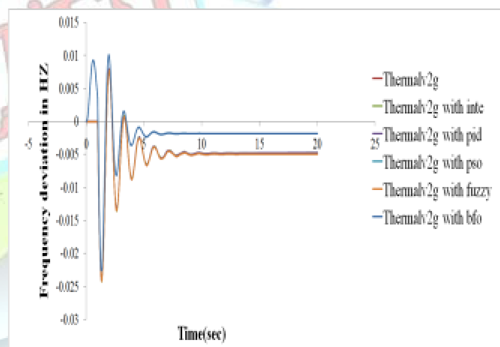


Fig. Results of Thermal System in Single Area with different Controllers



Fig, Results of Thermal V2G System in Single Area with different Controllers

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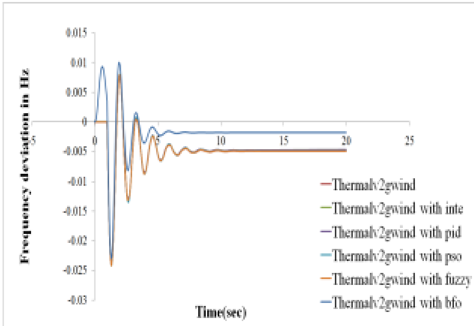

Fig. Results of Thermal V2G Wind System in Single Area with different Controllers

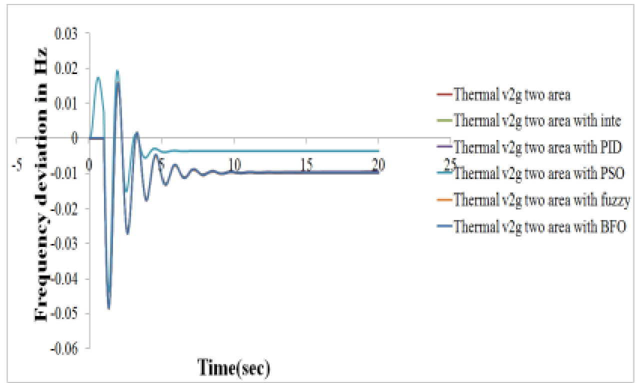

Fig. Results of Thermal V2G System in Two Area with different Controllers

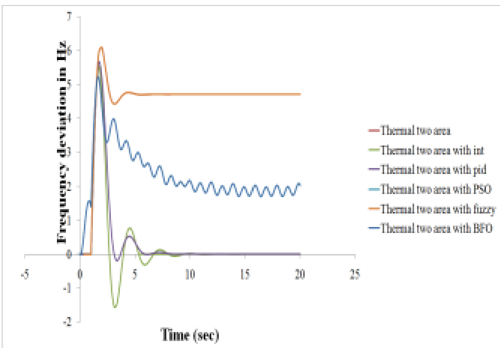

Fig. Results of Thermal Two Area System with different Controllers

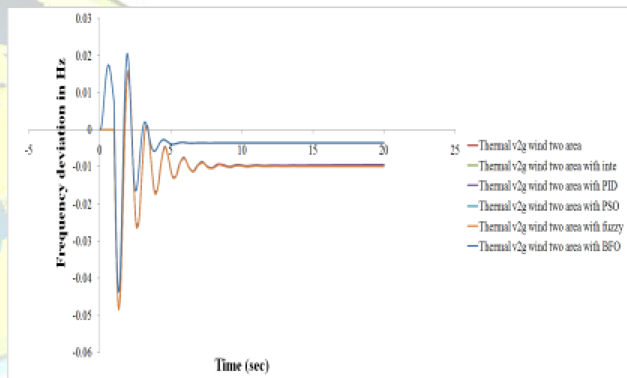

Fig. Results of Thermal V2G Wind System in Two Area with different Controllers

VII. Tabulation and Results

Parameters	System without controller	System with integrator	System with PID control	System with PSO control	System with Fuzzy control	System with BFO control
$C(t_p)$ (p.u)	3.1	2.8	2.8	2.6	3.1	4.6
Peak Time (sec)	2	1.8	1.8	1.8	2	1.8
Settling Time (sec)	3	9	8	18	5	5
Peak Overshoot (p.u)	0.8	2.8	2.8	1.1	0.7	0.8

Fig. Comparison of Thermal System in Single Area with Different Controllers

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Parameters	System without controller	System with integrator	System with PID control	System with PSO control	System with Fuzzy control	System with BFO control
$C(t_p)$ (p.u)	0.0075	0.0075	0.0075	0.01	0.0075	0.1
Peak Time (sec)	2	2	2	1.8	2	2
Settling Time (sec)	9	9	8	7	8	6
Peak Overshoot (p.u)	0.0075	0.0075	0.0075	0.015	0.0075	0.015

Table. Comparison of Thermal V2G System in Single Area with different Controllers

Parameters	System without controller	System with integrator	System with PID control	System with PSO control	System with Fuzzy control	System with BFO control
$C(t_p)$ (p.u)	0.0075	0.0075	0.0075	0.01	0.0075	0.01
Peak Time (sec)	2	2	2	1.9	2	1.9
Settling Time (sec)	9	9	8	6	7	6
Peak Overshoot (p.u)	0.008	0.008	0.008	0.0125	0.008	0.0125

Table. Comparison of Thermal V2G Wind System in Single Area with different Controllers

Parameters	System without controller	System with integrator	System with PID control	System with PSO control	System with Fuzzy control	System with BFO control
$C(t_p)$ (p.u)	6	5.5	5.8	5.2	6	5.2
Peak Time (sec)	2	1.8	1.8	1.8	2	1.8
Settling Time (sec)	5	10	8	-	5	-
Peak Overshoot (p.u)	1.3	5.5	5.8	3.2	1.2	3.2

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Table. Comparison of Thermal Two Area System with different Controllers

Parameters	System without controller	System with integrator	System with PID control	System with PSO control	System with Fuzzy control	System with BFO control
$C(t_p)$ (p.u)	0.015	0.015	0.015	0.018	0.015	0.02
Peak Time (sec)	2	2	1.8	2	1.8	2
Settling Time (sec)	9	9	8	5	8	5
Peak Overshoot (p.u)	0.02	0.02	0.02	0.023	0.002	0.023

Table. Comparison of Thermal V2G System in Two Area with different Controllers

Parameters	System without controller	System with integrator	System with PID control	System with PSO control	System with Fuzzy control	System with BFO control
$C(t_p)$ (p.u)	0.015	0.015	0.015	0.02	0.015	0.02
Peak Time (sec)	2	2	2	2	1.8	2
Settling Time (sec)	10	10	9	5	8	5
Peak Overshoot (p.u)	0.028	0.028	0.028	0.025	0.028	0.025

Table. Comparison of Thermal V2G Wind System in Two Area with different Controllers

VIII. Conclusion and Future Scope

A. Conclusion

The project "Load Frequency Control of Hybrid Thermal-Wind with V2G" proposed to reduce the frequency deviation in the system to a minimum during load changes using different controllers like integral controller, PID controller, PSO tuned PID controller, Fuzzy logic controller and BFO tuned PID controller. Among all the controllers, The PSO and BFO tuned PID controller gives the best results with less settling time and peak overshoot. The implementation of vehicle to grid reduces the magnitude of deviations closer to zero which safeguards the equipments in the consumer side and also it is used to balance the electrical grid (i.e. acts as a compensating device). The stability and performance of the two area power system is improved by reducing the deviations and settling time.

B. Future Scope

Load frequency control becomes more predominant, when a large amount of renewable power supplies like wind power generation are introduced. This V2G is well suited and essential to support the integration of large amounts of fluctuating wind power in future. The V2G is a feasible solution for a large future reserve power requirement which could substitute the traditional generation resources. In future V2G can also be utilized while it is running on the road with the help of piezoelectric crystal. The piezoelectric crystal produces electricity based on the pressure of the road and it is fed to the battery which is used to maintain balance in

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electrical grid. Further this work may be extended to multi-area smart power grids with robust control as future extension.

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