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Optimization of Load Frequency with Inertia Based Wind Farm Control

L Hari Krishna, P.Sri Vidya Devi, R. Vijaya Santhi

Abstract- In this paper, optimization is proposed for Load Frequency Control (LFC) of a power system which consists of non-conventional (incorporated Wind Farm Generation) and conventional using particle swarm optimization algorithm. This study has a unique perspective based on the wind farm collaboration through inertia control, primary frequency control, and supplementary frequency control of the system. A swift power reserve in a stable condition is needed in which wind farm can ameliorate the system frequency response. It is worth saying that the wind farm consists of variable speed turbines, such as a doubly fed induction generator. In conventional power generation it controls the input to generation and so the frequency of the system. But in the case of non-conventional power generation input cannot be controlled, so it is very important to control the frequency of the system. The proposed solution controls the deviation of frequency by using various controlling techniques like integral control, washout filter, the PID controller and also determines the active power variation value in different situations. In order to improve the efficiency of the model, the defined frequency control parameters (i.e., PID coefficients) are optimized based on a multi objective function using particle swarm optimization algorithm.

Keywords: Load Frequency Control, doubly fed induction generator, wind farm, particle swarm optimization,

I. INTRODUCTION

The aim of the Load Frequency Control is to achieve the constant variablefrequency by distributingthe load among generators and to make sure thepower of the tie line topre-set values and to supply the electric power with good quality. Power system should have LFC [1]. The energy production policies of Denmark state that they will achieve to above 50% electricity using wind farm generations by the end of 2020, [2]. A power plant supplies power whole day and it also experiences load changes on it and should generate uniform power. The control systems maintain that the frequency and voltage within the limits and provides economical operation and reliability. The frequency of the system is affected by changesin load andpower is dependence onvoltage variations and less sensitive to frequency. Formaintain thefrequency as constant PI controller is used which controls the turbine which in turn controls the generators and thesteady state frequency deviations are controlled by the controller gains. There are so manyoptions to controls the parameters ofLFC like GA, but it has complex code and low velocity of convergence.

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Out of all optimizationtechniques, in this paper selected Particle Swarm Optimisation (PSO) as it has more advantageslike there is no restriction on the dimension of the problem and solves large scale Non-linearoptimization problem and it has high velocity of convergence. There are several ways to control the system frequency incorporating considerable amount of wind farm generations, one of which is to provide the sufficient power reserve. in order to create an adequate amount of the power reserve through the system, it is necessary to utilize wind farms which are capable of changing their output power. Therefore, this paper considers the wind farm containing the doubly fed induction generator, [3]-[5]. The primary goal of the power system operation control is to provide andmaintain the good quality of power and one of factor that influences the qualityof the power is frequency and it is most affected factor in interconnectedsystems. Many optimization techniques to maintain the frequency within thelimits and frequency can be affected by many factors, by considering that, selected particle swarm optimization technique, a population basedmethod.The other advantages of this method are, it is convenient to implement, computational environment friendly and simple in concept. Hence PSO can beutilized for ruing the parameters of controllers which in turn helps inmaintaining the frequency steady by minimizing the objective function as well. In interconnected systems,PI controller is used in the process of load controlfrequency. Offset value can be decreased by increasing the proportional gain butthis leads to expand the oscillations and by using vital control order, these canbe stabilized, [6]. Based on the survey, PSO tuning technique is improvised one compared to other techniques. Due to this fact, PSO used for tuning the PI controller gain parameters forthe proposedpower system where frequency is controlled by LFC. Themainreason for changes infrequency is changing load on the system and it is also affects the bus voltage in system andas one doesn'thave control on the change in the load, so that corrective stepsof frequencyaberration and power of the tie-line manipulate systems and this error is recognized as integral of square of the fault. In order reduce this fault and optimise the performance guide, the useof regulator which achieve standards are bought the use of aboveprocess is the principalintention of this work, [7]. The standard frequency in India is 50 Hertz and if there is any deviation from strandedvalue, the entire power system will be damaged. in some cases, this may lead to damage the turbine blades and there is direct effect on Motor speed, [8]. The Aim of this work is to control the frequency deviation from standard value which caused by loadvariation and with help of the values which are the outcome of the PSO and applying these values to PI controller.Hence the error of the system has been reduced, [9]

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II. MODELLING OF LOAD FREQUENCY CONTROLWITHWIND FARM

Power plants uses renewable resources andproduces electricityand in order transmit the producedpower to consumers without any deviations from strandedvalue, system must have LFC. However, the load on the systems changes frequently and randomly and this lead to have control mechanism of generation so that there isnoelectricity imbalance and it is a problem to look at it. in order to avoid this, itneed to havea control system which monitors the voltage andfrequency within the limits even though the load on the system ischanging. Frequency has direct dependence on active power and whereas voltage is related to reactive power. [10]

A control system needs raises to maintain the system voltage and frequency with in limited values from the effects of changing load on the systems. Frequency of the system is directly dependent on active power of the system and based on reactive power changes, the voltage of system will be impacted. LFC control is nothing but controlling the active power injunction in the system which in turn controls the frequency of the system. The frequency and voltage of the system will have impacted based upon the changes on the electrical load on the system.

LFC regulates the power distributionamongdifferent areas despite the factthat keeping the frequency as constant. As per current demand for the electricity and to supply the demand, all electrical grids are interconnected using tie lines and this leads to addition of some more error in the system. DFIG i.e.Double Fed Induction Generator [11], and mostly used in wind farms to generate electricity and it generally consist of multi-phase wound rotor and slip rings which creates the path to reach rotor windings. It is feasibleto avoid multiphase slip rings and considering the effects on efficiency, size and price, brush less DFIG is feasible with rotor wound, [12]. The working principle of this generator is that the R-windings are connected to electrical grid with help of slip rings and BB voltage source converter which controls current in rotor and grid as well and which can facilitate the frequency changes freely from grid frequency by using the converter which controls the rotor currents. it is always preferable to control the active and reactive power transmission to the electrical grid from the generator stator independently from the speed of the generator [13].

The windigns of the rotor and satror windings is maintained as 1:3 ratio to make sure the volage in rotor will be higher and current will be lower and normally oprational speed vary around the synchronous speed which leads to lower rated current which inturn causes decrease reading in the converter and the main disadvantage of the controlled operation beyond the rated speed is not possible due to the fact that higher rotor rated voltage which in turn increases the transients voltages. A protective device is used to protect the IGBTs and diodes used in the convertor from high voltages and currents and to protect to the rotor wind windings from abnormally high currents and voltages, a short circuit mechanism is used called crowbar [14].

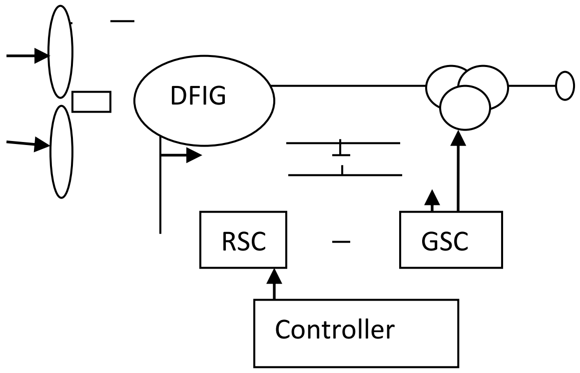

Fig.1 RSC and GSC in DFIG

Rotor side converter coverts ac voltage into dc voltage in the rotor by using active and reactive power control. The active power is determined with the help of frequency regulators and the reactive power is controlled and the system operator provided values are compared with the values which are measured from devices. Grid side converter changes the dcbus voltage to ac voltage the usage of pulse width modulation via voltage oriented control with a decoupled controller. It controls the reactive energy output and additionally the dc bus voltage of the wind unit, DC bus voltage and reactive energy output are defined by means of the power system operator.

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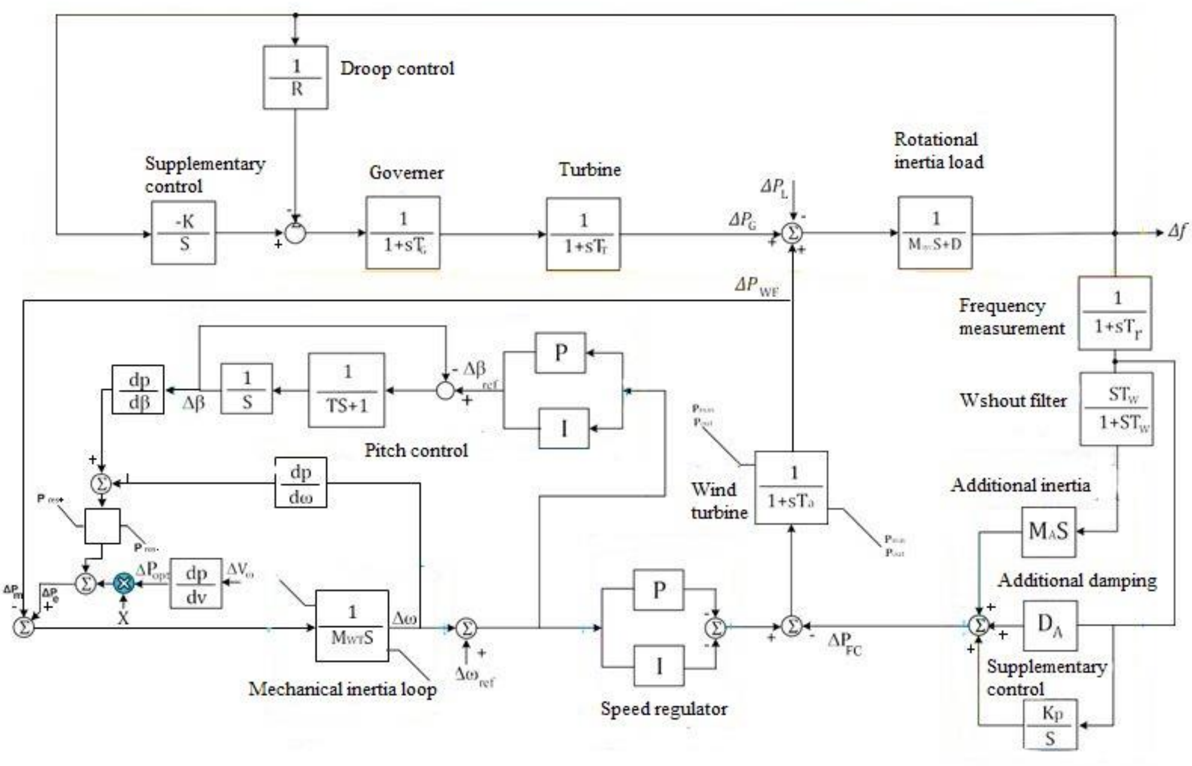

Fig. 2. Dynamic model of an LFC with wind farm

III. TUNING OF CONTROLLERS BASED ON PSO

Below Fig. 2 shows block diagram of dynamic load frequency control with wind farm. It consists of conventional (upper part) and non-conventional (lower part) generation units. Thefrequency can be maintaining constant by using supplementary and droop controlin conventional generation unit. [9]. In the traditional units, the rotating masses inertia prevents speed adjustments of frequency. Hence, certainduration of time is acquired toadjust the introducedload power by generatorsand by usage of governor and supplementary control. The variation of active power in different situations are determined by using Wash our filter, Integral controller and PID controller in the process of frequency control of Wind farm.

Wind blade power from wind speed is described by the following:

$$P_{opt} = \frac{1}{2}\rho C_P(\lambda,\beta)AV^3{}_{\omega} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Then, CP could be expressed as shown below.

$$C_P(\lambda,\beta) = (0.44 - 0.0167\beta)\sin\frac{\Pi(\lambda-2)}{13-0.3\beta} - 0.00184\times(\lambda-2)\beta \;\ldots\ldots(2)$$

$$\lambda = \frac{\omega R}{V_{\omega}} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

In occurrence of long time periods, it is compulsory to construct a power reserve with less respond time to control the frequency of the system in order to maintain full participation of wind farm and to maintain such power reserve, the wind farm should be operated in De-loading state but in the in this state, the speed of turbine increases beyond permissible level and leading to operate the turbine in over speed state and to avoid this, pitch control method is used.[13].

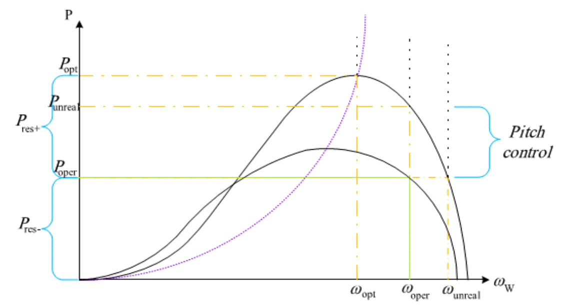

Fig.3 Wind turbine power-speed characteristics

The above Fig. 3 shows that the characteristics obtained by varying the speed and measuring the Power at each interval. The turbine can be operated at rated speeds by using the pitch control and as per the data, the reserve of the wind power plants can be obtained(3.1) by a factor X and shown below.

$$0 \le X \le 1 \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$P_{res+} = P_{opt}(1-X) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

$$P_{res+} = XP_{opt.} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

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The PID coefficients are

1. “Ma” which determines the inertia of wind farm.
2. “Da” which determines damping required in the wind farm.
3. “Kp” which represents the supplementary control which in turn decides the SS output changes.

As mentioned, the wind turbine speed can vary within tolerable limits and if the wind turbine is operated at this state, life time of the mechanical parts which are used in wind farm will increases. The upper branch at ω_{oper} rate, the control of the speed of the turbine retains continuously and also speed of the turbine is controlled at the (Wopt) if the (Ptotal) value of the output power is less the optimal power of the wind farm.The speed of the turbine can be determined based on the power and torques equation which is illustrated in Fig. 3.3 which indicates the output amounts to value (Punreal,Popt).

Therefore, with proposed control scheme, one can limit less power reserve for a wind farm. For example, one can operate the wind farm half rated by setting up the X as0.5 value. during this case, the pitch angle control takes values form turbine speed for increasing the speed the within limits, [16].

The wind farm output power is determined by below equation.

$$P_{total} = P_{oper} + P_{M_A} + P_{D_A} + P_{K_P} \text{.................(7)}$$

A reference electricitywhich forcesthe speed to tracka preferred reference velocity is computed as follows.

$$P_m = k_P\left(\omega_{ref}^* - \omega_m\right) + k_I \int\left(\omega_{ref}^* - \omega_m\right)dt \text{...(8)}$$

The energy distinction between the mechanical power (Pm) and electrical power (Pe) creates the rotor acceleration relationship as follows:

$$P_m - P_e = J\omega_m \frac{d\omega_m}{dt} \text{.................................(9)}$$

According to Fig. 3, the energy adjustments for frequency manipulate are received as follows

$$\Delta P_{FC} = P_{M_A} + P_{D_A} + P_{K_P} \text{..........................(10)}$$

The wind power variation can be formulated as follows:

$$\Delta P_{wind} = \Delta\beta \frac{dp}{d\beta} + \Delta\omega \frac{dp}{d\omega} + \Delta V \frac{dp}{dV} \text{...........(11)}$$

Where dp/dβ is the wind output version for a unique change of blade angle,dp/dωis the shareof wind energy variation to the small alternate of turbine angular speed, and dp/dV ability the wind output variant for a definite wind velocity variation.All these implicit by-product terms can be received with the aid of thefollowing formulations:

$$\frac{dp}{d\beta} = \frac{1}{2}\rho A V_\omega^{\ 3} \frac{dc_p}{d\beta} \text{..............................(12)}$$

$$\frac{dc_p}{d\beta} = 0.167 \sin\frac{\Pi(\lambda-2)}{0.3\beta-13} - \left[\frac{0.3\Pi(\lambda-2)}{(0.3\beta-13)^2} \times \cos \times \left(\frac{\Pi(\lambda-2)}{(0.3\beta-13)}\right) \times (0.167\beta - 0.44)\right] - 0.00184(\lambda-2) \text{...(13)}$$

$$\frac{dp}{d\omega} = \frac{1}{2}\rho A V_\omega^{\ 3} \frac{dc_p}{d\lambda}\frac{d\lambda}{d\omega} \text{..........................(14)}$$

$$\frac{dc_p}{d\lambda}\frac{d\lambda}{d\omega} = \left[\frac{R}{V_\omega}\right]\frac{\Pi}{(0.3\beta-13)} \times \cos\left(\frac{\Pi(\lambda-2)}{(0.3\beta-13)}\right) \times (0.167 - 0.44) - 0.00184\beta \text{....................(15)}$$

$$\frac{dp}{dV} = \frac{3}{2}\rho A C_P V_\omega^{\ 2} \text{.....................................(16)}$$

The process of taking the sample variations in frequency of the network changes is completed with the help of an element andthis delay shows effect on function of frequency controller one should take the time delay in modelling stage into account. Low frequency oscillation entrance is eliminated by using wash out filter which is used as subsequent to frequency sample step. In this way, the PID controller sends information to wind farm about power variations. Then the power variations will be nullified by injecting the same amount of power into the system with help of inertia inwind power plants which includes inertia in mechanical loop and speedcontrolling regulators, [8]. By using the pitch angle valuein control loop, the changes of the turbine speed give the blade angle variation value. According to equation11, then the wind power changes gives the available amount of input power. Based on above explanation, the output power of wind farm is varies basedon the speed variation of the wind turbine, the blade anglevalue, in the changes in wind speed, [9]. To determine turbine speed variation, in equation 7, output power is subtracted from the input power. Based on the change is speed of the turbine, the variation in the output power will be calculated and this in turn applied to current output power as a variation by using PI controller. Supplementary inertia, extradamp and rotating reserve our development frequency control park. The supplementary inertia which produced for wind power plants with the help of Ma based on the variations of system frequency. This variation in the power at steady stateof this power plants is determined by Kp and this coefficient gives the wind farm permanent collaboration in the control of the frequency and the extra damp is created by using changes in the the frequency(Δ F) and damping(Da). By using the rotor side converter and a limiter, (ΔP_{FC}) is determined.

IV. PARTICLE SWARM OPTIMIZATION

The method which comes to the mind for tuning the values for error correction is hit and Trial as it is simple in nature but it consumes a lot of time to continue the tuning of values for the parameters which consumes lot of effort which is tedious method and we are also not sure whether, the end result gives the good tuning if that is not the good tuning, the effort spent on this will be wasted.

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Considering all these disadvantages, there is need to develop new method for tuning and to get optimal values. The main advantage of this method, computation approach which is used to look at the search space and it is depend on swarm's Genius and association which leads to populate the initial values, this algorithm is implemented based on the behaviour same as the birds search for the food. This method requires to declare the number of particles which will continually accelerating in the search space to reach the target and by continuously evaluating their positions and velocity based on current values. This method shows that the advantage of social interaction, as every particle compares its position with each and every particle in search space and try to get its position gets adjusted to best of the all particles [10]. There are various advantages of PSOalgorithm:

- ✓ It overcomes the drawbacks of GA.
- ✓ It gives best results with less iterations even for large problems also.
- ✓ Even for large size problems the PSO can resolve.

PSO Algorithm.

Step1: Assign values to the Size of the swarm and Steps required& Dimension of theproblem.Step2: Assign velocities and position to the Swarm.Step3: Initialize all variables. Step4: find out the distance between Swarm – target.Step5: calculate local best for every particle.Step6: calculate global bestbased on minimal ISE.Step7: Run iteration 1.Step8: Now Update the swarm positions based on iteration-1.Step9: Repeat step-4.Step10: Now calculate and update pbest and gbest based on the new best positions.Step11: Now calculate and Update velocity for each and every particle.Step12: Run iteration 2.Step13: calculate and Check if iteration=maximum iteration, then go to step 8 else continue.Step14: Finally, will get global best position of the swarm.

To achieve the control model, it is needed to find the best values of the gains of frequency(Ma,Da and Ka) including wind farm De-loading. On the other side, in case of fewest De-loading factor, the desirable frequency response is obtained by adjusting the parameters of frequency.

Table 1: Model constants used for case study

Symbol	Description	Value
M_{Wu}	Equivalent wind unit inertia	4.5s
T_A	Wind turbine time constant	0.2s
k_p	Speed regulator proportional constant	5
k_i	Speed regulator integral constant	100
k_p	Pitch angle control proportional constant	50
k_i	pitch angle control integral constant	150
M_A	Additional inertia	73.51
D_A	Additional damping	58.8
K_P	Supplementary gain	9.85
X	de-loading factor	0.105

In order to get economical operation of wind farm, it should operate at maximum output power. So, we need to reduce the reloading value of factor by considering the economic aspect and the power reserve. Second, the increase of wind power inertia level he is determined by the parameter Ma. In order to get a smooth variation of frequency response, a high amount of parameters Ma are required. Third, the damping off frequency response can be modified with the increase of Da parameter. Further, the Kp parameter in the proposed model access supplementary control. In this study, a multiobjective function is regarded to locate the best value of parameters for the proposed frequency manipulate scheme as follows:

$$OF(K_P, D_A, M_A) = \alpha \times X + \beta \times \int |\Delta f|^2 dt + \gamma \times ST + \sigma \times MSFC \quad \dots (17)$$

Where two X is the deloading factor of the wind farm

$\int |\Delta f|^2 dt$ is the integral squared error of the frequency, ST is setting time of the responseand

MSCF is the maximum slope of the frequency response.

The limit levels of the above parameters are:

$$0 \le X \le 0.15 \quad \dots\dots(18)$$

$$50 \le M_A \le 90 \quad \dots\dots(19)$$

$$50 \le D_A \le 90 \quad \dots\dots(20)$$

$$0 \le K_P \le 0.10 \quad \dots\dots(21)$$

To define the dimension of the search space two main important parameters,present in the PSO algorithm. First one is number of swarms and second one is number of swarms in each based on wrighter's intention.

So, the search space matrix can be represented as

$$X_{Search-space} = \lfloor x_{ij} \rfloor_{n \times m} \quad \dots\dots(22)$$

The speed vector of PSO algorithm is defined as follows

So, the search space matrix can be represented as

$$X_{Search-space} = \lfloor x_{ij} \rfloor_{n \times m} \quad \dots\dots(23)$$

Throughout the preliminary method of PSO algorithm, aproducing system of random quantity units a cost for every aspect of search space while all inequality constraints, specifically (3.21)–(3.24), are satisfied. After that it is time topass theparticles tothe nice role in which the multiobjective feature introduced in (3.20) is at its minimal point.

The speed vector of PSO algorithm is defined as follows:

$$V_k^{k+1} = \omega V_i^k + c_1 \cdot rand_1 \cdot \left(P_{best_i^k} - X_i^k\right) + c_2 \cdot rand_2 \cdot \left(G_{best_i^k} - X_i^k\right) \quad \dots\dots(24)$$

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Where V_i^k is speed of particle i at iteration k,w is the weight parameter, c1 and c2 are weighted factors, rand1 and rand2 are random numbers between zero and 1, X_i^k is the role of individual i, Pbest is the exceptional role of individual i until new release k, and Gbest is the fine role of the group until new release k.

The individual strikes from the modern function to the next function by

$$X^{k+1} = X^{k} + V^{k+1} \quad \text{.................................(25)}$$

Where

s_i^{k+1}, $s_i^k$are current search points after modification.

v_i^{k+1} = Velocity of the particle after modification

Table 2: Parameter values tuned for PSO Algorithm

Parameters	Values
Population size	100
Inertia weight(w)	0.9
Cognitive coefficient(c1)	1.2
Number of iterations	10
Social coefficient(c2)	0.12

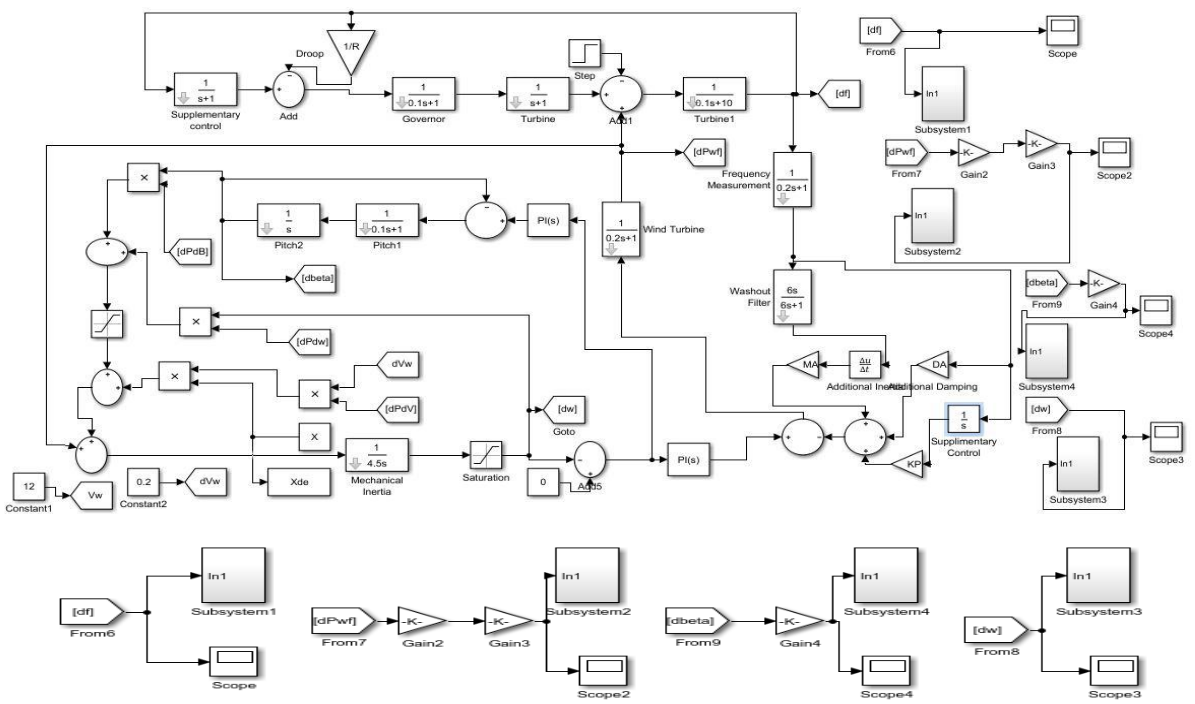

Fig.4 Proposed Model of LFC and wind form with Control

V. RESULTS AND DISCUSSION

Fig. 4 shows the implemented control model of load frequency control with wind farm. The non-conventional unit uses washout filter and damping and supplementary control to maintain the frequency constant.

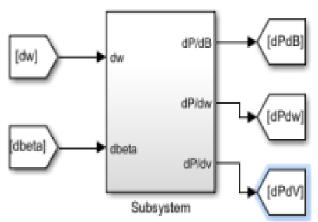

Fig. 5 Sub system of the implemented proposed model

Fig. 5 shows the subsystem of the proposed model.Generally three parameter values are required for the proposed model and these three values are derived from the equation analysis,so the equation analysis is implemented in this subsystem.The implemented equation analysis as the block diagrames using the matlab simulink library.

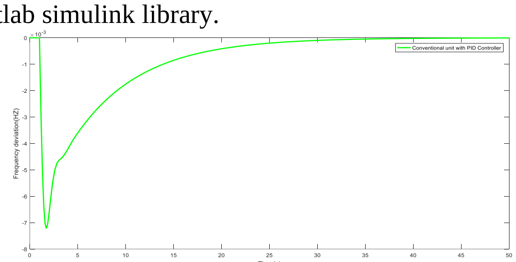

Fig. 6 Frequency deviation for conventional control with PID

Fig. 6 shows the frequency deviation of conventional generation unit with the PID controlled. By using PID control the undershoot value of the frequency is -0.045 and the settling time of the curve is 40s.

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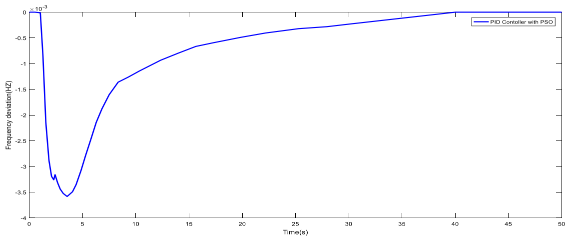


Fig. 7 Frequency deviation for the proposed method without control.

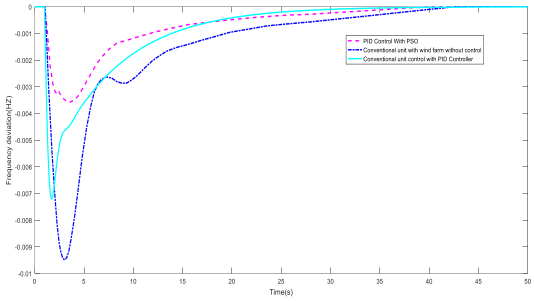


Fig. 7 Shows the frequency deviation for the proposed method without control. As discussed above the unde
Fig. 8 Frequency variations for proposed
Control method

R shoot value of the two-area control with PID is -0.045, whereas the undershoot value of the proposed model without control is -0.095, from these two one can conclude that to maintain frequency constant PID control is better. From Fig. 8 the frequency variation is concluded that theundershoot value is -0.035, which is very less when compared to the previous two, one is conventional area with PID control and the other is proposed control method without control. The below Fig. 9 shows that the frequency behaviour for the model which is used for evaluating the proposed solution in different scenarios.

Case-1: No wind power: The plot which is highlighted inorange colour is shows the frequency response in the absence of wind power and it is the variant of -0.0044.
Case-2: 50% wind power: The plot which is highlighted in red colour is shows the frequency response in the case of equal supply from both conventional and Non-conventional systems and it is the variant of -0.0094.

Case-3: 100% wind power: The plot which is highlighted in green colour is shows the frequency response in the case of 100% supply from both conventional and Non-conventional systems and it is the variant of -0.0034.On comparing the results of above two cases, the maximum frequency is occurred at 2.9 S and high value achieved in 3.5 seconds and this leads in expansion of inertia in the system and also frequency is controlled at best value and with this, it is concluded, the proposed method is a good alternative for collaborative operation of both wind power plants and conventional farms.

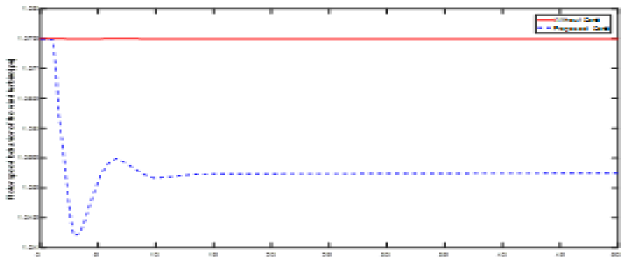
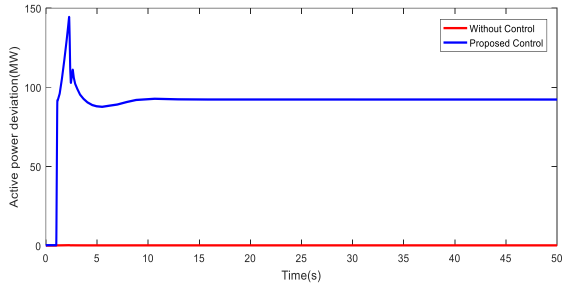


Fig. 10 Active power deviations injected by wind farm for different control methods.

From the Fig. 10 one can observe the active power continuously increases upto the 90MW, this is because of the available active power within the inertia of the wind farm. After 90MW the slope becomes smoother than before, and this is surplus active power which is obtained during changes of speed reduction and angles of the blades. After 10 seconds the active power becomes study state.



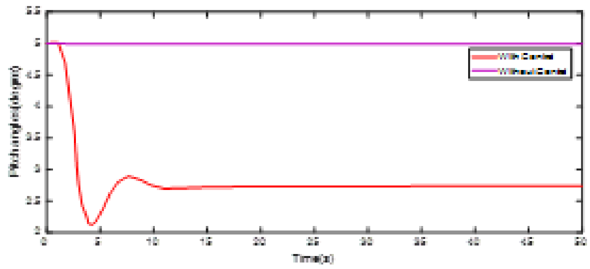


Fig.11. Wind turbine rotor rotation speed for different control methods.

The below Fig. 11 shows that rotor velocity variations in different methods used for the control.

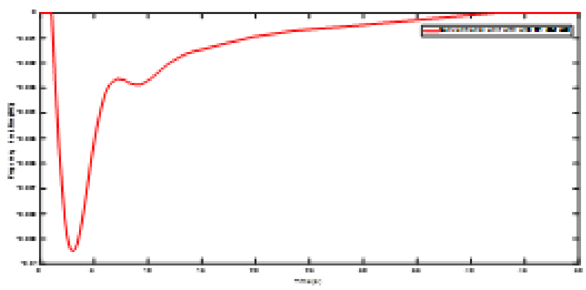


Fig.12. Pitch angles behaviours of the wind turbine for different control methods.

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In this section, the PID coefficients values are tuned using PSO for two below cases and their outputs are shown in below tables. The Table 3 represents the simulation outcomes regarding the first optimization case, when the optimization process is utilized to the system ten times. On comparing the values in above two tables. The worst value and best value and the common values of the 50 iterations can be observed and gives the better tuning of the PI parameters provided by PSO in different cases. The optimization technique should have less handful and the convergence curve is very significant representative

The below Fig.13 is the comparison between different iterations. One is for the iteration 20 and population 50, other one is iteration 50 and population is 100. By comparing these two curves one can say the better result will be obtain if the iterations increase.

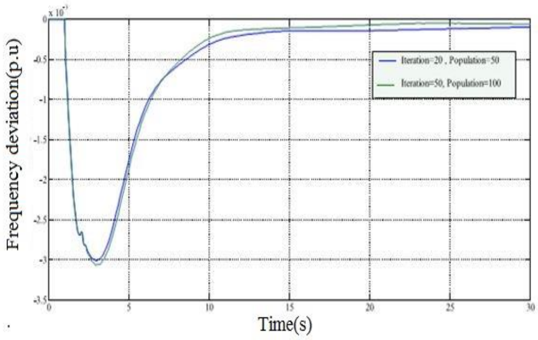

Fig. 13. Frequency responses using the best values of PID coefficients obtained by the PSO algorithm in two different cases

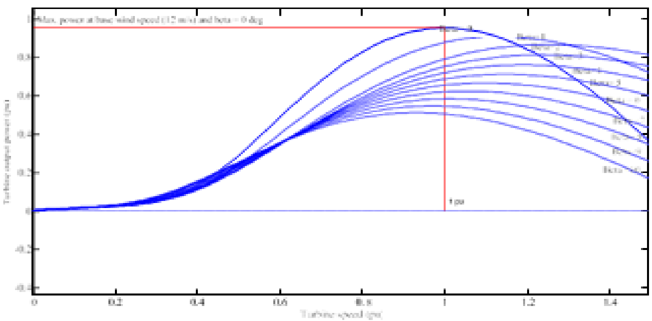

Fig. 14. Turbine power characteristic for the proposed method.

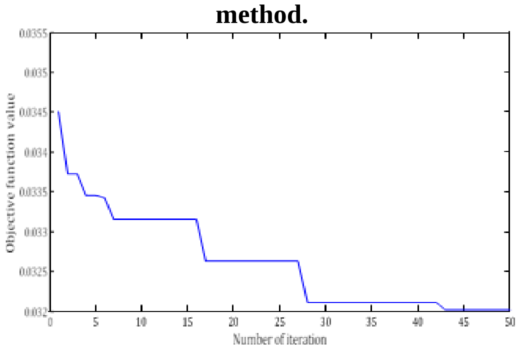

Fig. 15 Convergence curve of the PSO method while the number of iteration= 50, and the number of generation=10

Fig. 15 shows the turbine power characteristics for the implemented method at base wind speed 12m/s and beta (blade angle value) is zero.

Table 3: Simulation result obtained by the pso algorithm in the first case, iteration=20, population=50, number of program running =10

	OF	X	M_A	D_A	K_P
Best	0.0326	0.1084	88.5470	56.6636	10.0000
Average	0.0332	0.1053	67.8173	53.4232	9.7294
Worst	0.0340	0.0995	59.3743	53.4232	9.2248

Table 4: Simulation results related to the second scenario of the optimization, iteration=50,population= 100,number of program running=10

	OF	X	M_A	D_A	K_P
Best	0.032	0.1106	85.4386	51.3101	9.8662
Average	0.0328	0.1089	72.7014	53.5194	9.9313
Worst	0.0332	0.1082	72.7786	53.1988	9.9102

From the curve it is clearly find that as the iterations increases the value of the objective function decreases.

Table 5: Different control methods.

Type of control	Undershoot	Settling time
LFC without control	-0.009	45s
PID control	-0.004	43s
PSO Algorithm	-0.003	39s

The above table5.Shows comparison between different plots of changes in frequency variation. From the above with the proposed optimisation technique the stability and performance is increased.

VI.CONCLUSION

One of the main challenge in supplying the clean electricity to consumers is to create some controllers which works optimally, and it should have monitoring and corrective capabilities like checking the frequency and voltages and takes corrective action if any deviations in their operating values. To create the such type controllers, so many techniques are available and from all of them, PSO is used in this paper for tuning the parameter values of PI controller based on its advantages over all of the techniques. In this paper, A system is designed to understand and to evaluate the proposed method and it is the combination of Conventional and Non-Conventional power plants and integral error of the system is considered as objective function and evaluated the system frequency behaviour in different scenarios and on comparing results obtained in these scenarios, the PSO provided parameters controlled the change in frequency with better values.

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The system stability and performance can be increased further by using the combinations of different optimizing techniques which are listed below along with PSO.In future the work is extended using Type-I and Type-II fuzzy logic controllers.

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APPENDIX

A.Doubly Fed Induction Generator
Sn(MVA) = 1.5,
Vn(kV) = 0.69,
Rs(p.u.) = 0.0084,
Xs(p.u.) = 0.167,
Rr (p.u.) = 0.0083,
Xr(p.u.) = 0.1323,
Xm(p.u.)=6.3 ,
Ws(rpm) = 1800,
No. of poles = 4,
DC voltage(V) = 800
B.Wind Turbine
No. of blades =3,
Rotor diameter =80 m, Air density=1.255 ⁄ ,
Cut-in speed =4 ⁄ , Cut-off speed =25 ⁄

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