

Optimization of Hybrid Renewablesystem using Evolutinary Algorithm-PID Controllers

Sampath Kumar.V.Patil, S B Shivakumar



Abstract-Paper proposes with the optimal design methodology to optimize the configuration of hybrid energy system. Due to cost effectiveness and reliability we use hybrid systems. Here it represents Wind-Turbine/PV as a Hybrid RES because of its several advantages. To enable quality power delivery and reliable power transmission,

Battery Energy storage plays an imp role also called Energy Management System (EMS) plays decisive role. Load side variation often causes power outage and even faults in overall grid network. To alleviate such issues, in this research paper a load sensitive adaptive-Energy Management model is developed that considers both Output side variations as well as Input generation patterns. Here used an algorithms such as Adaptive Genetic Algorithm (AGA), FlowerPollunationAlgorithm, Hyper Spherical Search and Particle Swarm Optimization for Optimizing an Hybrid Renewable energy system.

Index terms: Hybrid Renewable System, Solar, Wind, Evolutinary algorithms, Energy Management system

I. INTRODUCTION

In present day scenario, undeniably the existence of a better human life by means of varied civil purposes, industries, scientific and defense system can't be imagined without electricity. The exponential rise in the demand of electricity has motivated academia-industries to explore and achieve sufficient amount of energy to fulfill the civil-industrial as well as scientific-defense related requirements. On the other hand, the depletion of traditional fossils fuels has also alarmed scientific society to obtain other eco-friendly energy solutions [1] [2]. To enable potential energy solution, Energy sources such Wind-Turbine (WT), Photovoltaic (PV) cells, and hydro-electric power generation have emerged as the potential alternatives. To further exploit the efficacy of these power systems, in last few years hybrid generation systems have been suggested that employs multiple RESs (say, RESs interconnection) to generate sufficient electric energy [3] [4]. Wind Turbine RES often gets affected due to variations in wind speed, while in Photovoltaic power systems; change in radiation pattern over time influences Energy Conversion Ratio (ECR) of the RES system. It states that the changing patterns of the RES power generators are dependent on the environmental conditions such as wind speed and solar radiation. Different generation patterns of the RES makes overall power generation and transmission higher complicate and tough task.

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* Correspondence Author

Sampath kumar .V. Patil*, Pursuing PH.D Visvesvaraya Technological University, Belagavi. Karnataka, India.

Dr. S BShiva kuar, Head, RYMEC, Bellary, Karnataka, India.

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Facilitating quality power generation and reliable transmission to the customers has always been a problem for power generation and transmission companies. It becomes tougher under non-linear generation and load variation conditions. On the other hand, load variations to increases the probability of power outage and fault proneness across power system. To alleviate such problems, deriving a novel power control strategy by considering both the load side variations as well as power generation non-linearity conditions might be of paramount significance. One potential approach can be the consideration of load variation and accordingly controlling EMSs charging and discharging process and generator side control. This strategy can significantly help in augmenting generation process by targeting Maximum Power Point (MPP) achievement, according to load changes. On the other hand, controlling charging and discharging of the battery systems can also make overall EMS efficient to meet power demands even under varying load conditions. Considering the power quality and realibility of hybrid power system, charging and discharging of battery, called Energy Management system (EMS) plays an decisive role. Here the charging and Discharging is controlled by PID Parameters. The gain parameters of PID plays an important role. To deal with the dynamic load condition and non linear generation of power a gain parameters of PID cotrollers should be optimized. This is done through the Evolutionary Computing Algorithm approach, in which Adaptive Genetic Algorithm (AGA), Flower Pollunation Algorithm, Hyper spherical search and Particle Swarm Optimization which is used for tuning Controller.

II. OUR CONTRIBUTION

Considering the Non Linear generation of Input side and Variation in input sidem, designed and Controller in such a way that Both sides are controlled using Propotional Derivative controller. The Proptional Derivative Integral Controller is tuned with different algorithm approaches like Adaptive Genetic Algorithm, FlowerPollunation algorithm, Hyper spherical search and Particle swarm Optimization algorithm. Every algorithm is tuned for around 50 Population and Iteration of around 100. Time taken for the every algorithm to run iteration is around 3 to 4 days which is executed with the help of MATLAB GUI. Controller is tuned as per the Energy requirement of batteries. Finally Quality and Reliable is achieved through these algorithm approaches.

III. SYSTEM MODEL

Here we briefly discussed about the SolarWind Renewable energy system control through evolutionary algorithm approach.

3.1 System modeling

Here the Combination of wind,Solar and Battery connected model is shown as below.Wind turbine input is provided with 3 KW and solar power input is provided with 1 KW.Approx output without power controller found to be around 2.7 KW

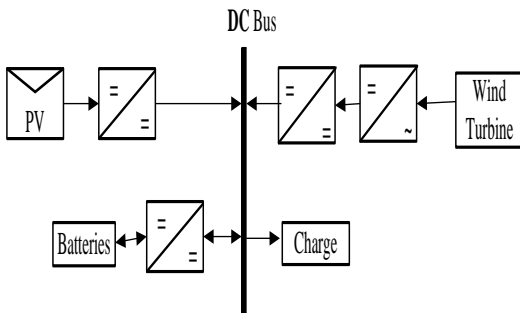


Fig. 1. Hybrid-RESsystem

The following sub-sections briefs about different components used in our proposed Hybrid RES systems and their functional characteristics.

3.2 The DC bus

The coupling of the two RESs, PV and WT and additional components (say, supplementary sources) such as energy storage system or batteries is enabled through a DC bus, is illustrated in Fig. 2. The mathematical expression for the state model is given in equation (1).

$$\frac{dV_{DC}}{dt} = \frac{I_{pv} + I_w + I_{bat} - I_{ch}}{C_{DC}} \quad (1)$$

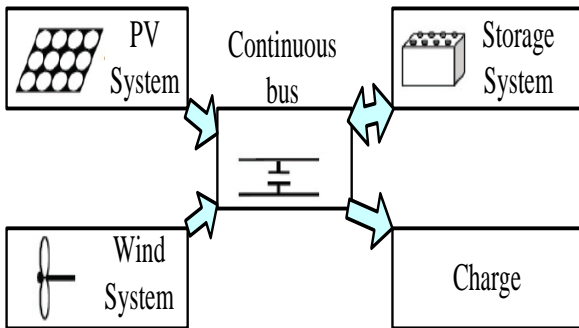


Fig. 2. Coupling of the different components, PV, WECS and Battery units using DC bus

3.3 Objective function (OF)

Normally several indices has been applied for controlling PID Controller performance.some are Integral Square Error (ISE), Integral Absolute Error (IAE), ITAE, and Mean Square Error (MSE). Here we applied ITAEas function to reduce the error.ITAE makes long transient duration to avoid . The efficiency or capability of ITAE to avoid long duration transient.ITAE provide the difference between Generated Power and Load Power.

$$ITAE = \int_0^{\infty} t|e(t)|. dt \quad (4)$$

In order to achieve the Minimum objective function,particular PID Parameters are selected and based on that only Battery operation takes place... In these paper main concentration is given to order minimum objective

function by tuning pid controller and mainly to avoid any outages.

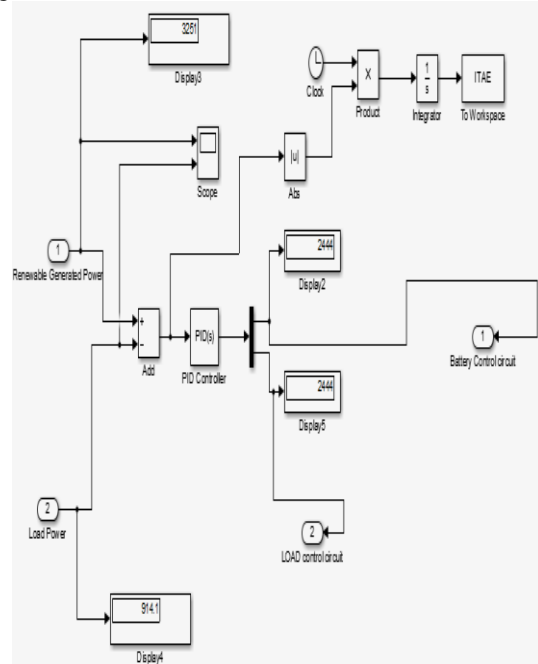


Fig. 5 Evolutionary Computing assisted PID controller for EMS

3.4 Evolutionary Computing Algorithms

Normally, Evolutionary algorithms have cameform the algorithms like such as GA which depends on human evolution;. Same way , other EC algorithms such as Ant Colony Optimization (ACO), Bee Foraging Optimization (BFO), Flower Pollination Optimization (FPO)

Also functions to achieve solution. Exploring in depth it can be found that the classical EC algorithms such as generic GA suffers from the local minima or convergence that confines suitability of these algorithms for real time applications. The classical GA algorithm usually suffers from the issues like .These issues in this research our proposed AGA enables adaptive crossover and mutation probability estimation to yield optimal solution. A brief of the EC algorithms is given as follows:

3.4.1 Adaptive Genetic Algorithm (AGA):

. Noticeably, solutions are signified in binary as the strings of one and zeros..The generation continues till stopping criteria. Here, in all iteration the fitness value of each population is obtained based on which the Higher fitness to provide solution. Further, the selected populations are altered by performing reproduction and mutation to generate a new generation having better fitness and proximity to the optimal solution. The newly obtained population is then processed in the next iteration to achieve better solution than the previous once and this process continues till the stopping criterion is obtained. It might continue iterating till the error ITAE error becomes minimal by maintaining generation and load demands equal. In our proposed AGA scheme, each PID tuning parameters (i.e., P and I gain parameters) .Thus in EMS control design each gain parameter is considered to be the population which are represented in binary form 0's or 1's. These binary strings are applied to perform AGA based PID parameter tuning.

In our optimization model ITAE is considered as the objective function that signifies how efficient the charging and discharging is taking place to meet dynamic load demands, while avoiding any generation side fault (by controlling WT speed).

In addition to the fixed stopping criteria such as 100 number of generation, we have applied additional criteria that estimate the total number of populations having similar fitness value.

In our model, once 95% of the populations are having the same fitness value, optimization program terminates and the obtained gain parameters are assigned to the PID controller to perform control decision.

A brief of the key functions of AGA is given as follows:

a. Selection

Obtaining the fitness value, each member in the population is ranked using AGA selection function.

Here, Higher fitness value function replace its place for regeneration . Here, we have applied Roulette wheel selection technique.

In summary, the individual with higher fitness value would have higher probability to be selected for “reproduction”.

b. Reproduction

Reproduction process signifies the phenomenon of defining each production . This process encompasses two steps, crossover and mutation which are combined to constitute a new individual.

Mutation simulates the affect of errors that take place with low probability during replication..

The optimal selection of the GA parameters P_c and P_m can enable preserving the diversity of GA to avoid local minima. Excessively higher value of these GA parameters can make the approach a primitive random search model.

Classical GA applies static of fixed value of P_c and P_m that result into problems like convergence and local minima. Additionally, it introduces significantly high computational time and cost.

$$(P_c)_{k+1} = (P_c)_k - \frac{C_c * C_{SF}}{5} \tag{5}$$

$$(P_m)_{k+1} = (P_m)_k - \frac{C_m * C_{SF}}{5}$$

In $(P_c)_k$ signifies the present crossover probability in kth generation, while $(P_m)_k$ signifies the mutation probability at kth generation. C_c and C_m present the non-zero positive constants.

We have used $C_1 = 0.01$ and $C_2 = 0.001$, depending on the application for which it has to be applied. In (16), the variable C_{SF} signifies same significant value having more fitness values.

Here, PID parameter tuning, i.e., total number of epoch more no obtained equal fitness values.

Exceeding stopping criteria might lead system saturation. Fig. 10 presents the overall process of the AGA based PID tuning for EMS control.

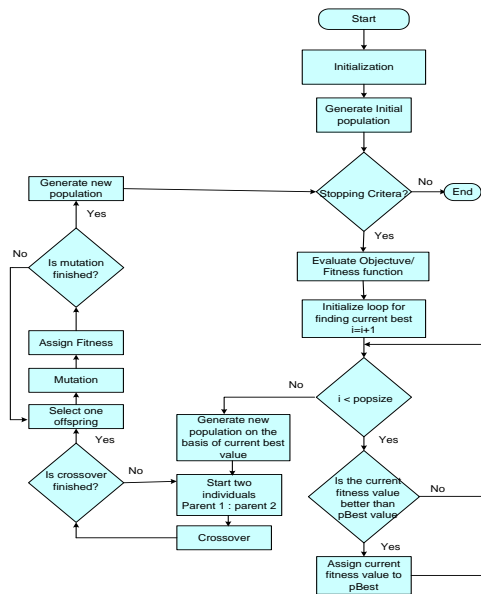


Fig. 6. AGA based optimization

Thus, applying above discussed EC-AGA algorithm, PID parameter tuning has been performed to achieve optimal EMS control. In this paper, in addition to the AGA based PID tuning, we have applied other evolutionary computing approach to perform PID tuning.

IV. RESULTS AND DISCUSSION

Overall Different optimization techniques were used to optimize the parameters of FOPID controller and their respective performance is shown in the figures. Integral Time Absolute Error (ITAE) was used as the objective function and optimization algorithms were used to minimize this objective function.

Table 1 shows the ITAE performance index values for various optimization algorithms. From the table it is HSS based optimization gives best result.

Table 1: Objective function value for optimization algorithms

Kp	Ki	Kd	Lambda	Algorithm	Best	Time Taken
0.57	8.11	0.72	0.3145	FPA	648.86	2 days
2.51	9	0.37	0.5306	GA	589.54	2 days
0.00 1	10	1	0.7547	HSS	654.47	2Days
0.04	9.3	0.31	0.8319	PSO	494.14	4 days

Figure 7 shows the Hybrid Generated power generation variation under different optimized WECS control with different evolutionary algorithm approaches. To achieve stable power generation while fulfilling load demands, controlling wind turbine speed is vital and hence we applied FOPID controller to control WT speed while considering load demands. FOPID controller controls WT speed by considering reference speed (1750 r/s) and the actual speed. Figure also shows the comparison of different algorithm optimized FOPID controller.



Figure 8 presented WT speed control with AGA-FOPID,BPSO,HSS AND FPA assisted EMS for Hybrid-RES system.

The following Table 1 shows the Peak Time,Rise Time settling time ,Overshoot and Kp,Ki,Kd values for a population 50.

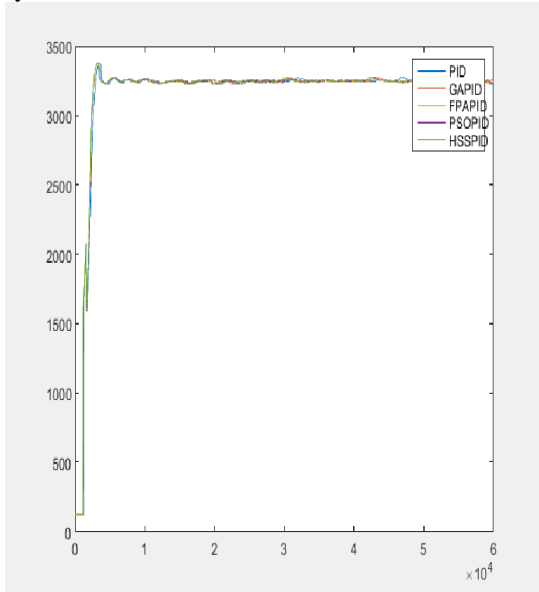


Fig7.Hybrid Generated Power

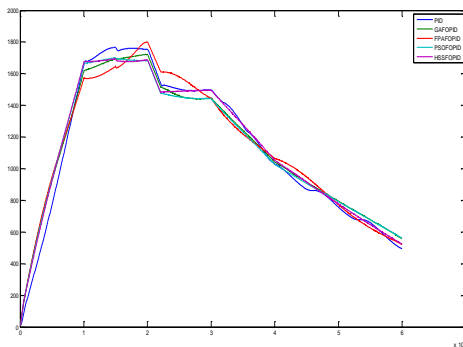


Fig 8.Speed Control Variation Comparison.

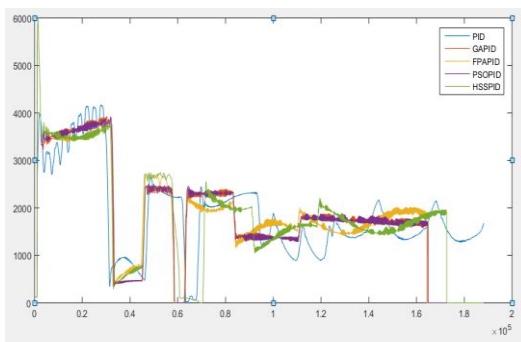


Fig 9.Load Side Demand Variation with Different Evolutionary algorithms.

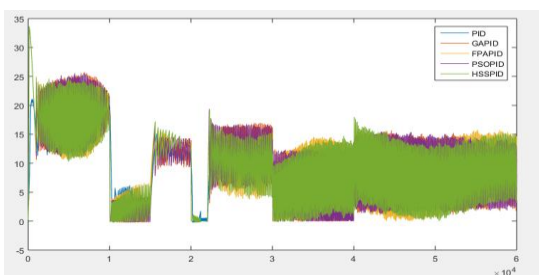


Fig 10.Represents Electrical Torque of a DC motor with Different Evolutionary algorithm approaches.

Table 1:FPA Algorithm Result

FPA RESULTS	VALUES
Kp	1.3915
Ki	5.4137
Kd	0.3052
Population Size	50
Number of Iterations	100
Objective Function Value	685.07
Rise Time	2144.7726
Settling Time	59016.752
Settling Min	454.61810
Settling Max	1737.4743
Overshoot	244.74795
Peak	1737.4743
Peak Time	19837.000

Table 2:FPA Algorithm Result

HSS RESULTS	VALUES
Kp	0
Ki	10
Kd	0.2892
Population Size	50
Number of Iterations	100
Objective Function Value	588.133
Rise Time	2073.4487
Settling Time	58077.349
Settling Min	452.31742
Settling Max	1792.6760
Overshoot	257.55069
Peak	1792.6760
Peak Time	20015.00

Table 3:PSO Algorithm Result

PSO RESULTS	VALUES
Kp	0
Ki	7.5117
Kd	0.1967
Population Size	50
Number of Iterations	100
Objective Function Value	588.7338
Rise Time	2261.378
Settling Time	58234.050
Settling Min	482.8712
Settling Max	1794.856
Overshoot	235.2764
Peak	1794.8561
Peak Time	19865.00

Table 4:AGA Algorithm Result

GA RESULTS	VALUES
Kp	3.816
Ki	9.593
Kd	0.588
Population Size	50
Number of Iterations	100
Objective Function Value	691.36
Rise Time	2177.634
Settling Time	58994.87
Settling Min	455.8427
Settling Max	1737.550
Overshoot	243.7992
Peak	1737.550
Peak Time	20009.00

V. CONCLUSION

Here considering both Non Linear Power generation and Load side variation a Robustness controller is used which used PID Controller based HSS ,FPA,AGA and BPSO Algorithm is used..For a Population size of 50 and Iteration of around 100 the Best Objective Function value is used which determines Rise Time,Settlingtime,Peak time for Both HSS and FPA Algorithm by charging and Discharging controller...Comparing Both the Algorithms Objective Function Values Rise time and Settling time ,it find HSS is the Best algorithms Compared to all other Algorithms.

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AUTHORS PROFILE



Sampathkumar V Patil, was born 15th June 1990 . He received the B.E. degree in Electrical Engineering from the Visveswaraya Technological University, India, in 2012 and the M.Tech in Power system Engineering from Jawaharlal Technological University in 2014. He is Currently Pursuing Ph.D from VTU, Belagavi.



Dr. S B Shiva Kumar, was born July 8 th, 1968. He received the B.E. degree in Electrical Engineering from the Gulbarga University, India, in 1983 and M.Tech in Power system Engineering from University of Mysore in 1991 and Ph.D. degree from the Visveswaraya Technological University, Belagavi in 2008. He is currently working as Head of Department in RYMEC, Bellary, Karnataka, India. He has presented several National and International Journal Papers and attended conferences.