OPTIMAL LOAD FREQUENCY REGULATION OF MICRO-GRID USING DRAGONFLY ALGORITHM

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Abstract - *The Micro grid consists of an interconnection of wind, electrical vehicle and diesel generator with loads. As the wind energy depends on atmospheric conditions which vary time to time that leads to unbalance between the generation and load demand. Due to unbalance condition in the micro grid, frequency deviations will occur. A PID controller is designed to regulate the frequency deviations to a desired level. The parameters of PID controller drastically affect the performance of the system. An objective function based on integral square error is formulated to improve the system steady state as well as transient performance. The parameters of PID controller are found by using Dragonfly optimization algorithm by minimizing the objective function. The performance of dragonfly optimized micro grid is compared to the PSO tuned system. The simulation results shows the superior performance of the proposed method.*

Key Words: **Load frequency control (LFC); Electrical vehicle (EV); Diesel generator (DG); Vehicle to grid (V2G)**

1. INTRODUCTION

A Micro-grid is a small-scale power supply network that is designed to provide power for a small community. Micro-grid is designed to support power or to strengthen the main power grid during the demand of heavy periods. Generally, a micro-grid operates when it is connected to the grid, but, it can break off and operate on its own using local energy generation in times of crisis like storms or power outages, etc. A micro-grid consists of distributed generation sources, e.g., diesel generators or micro-turbines, loads, solar panel, A micro-grid consists of distributed generation sources, i.e., diesel generators, wind turbine, electric vehicle and micro-turbines, loads, and renewable energy sources [1]. A micro-grid can be operated in two modes, i.e., isolated mode and grid connected mode [2]. If a micro grid is grid connected, the loads can be supplied by the connected electrical power system. Otherwise, the distributed generation has to cope with varying load and fluctuating renewable energy sources in the isolated mode, which requires proper control of micro-grid to ensure frequency and voltage stability in order to supply high quality power to consumers. However, because of fluctuations of renewable sources and limited capacity of distributed generation sources, it is difficult to achieve power balance between generations and loads that is important for critical installations.

In an isolating grid connected mode, the load-frequency control (LFC) capacity is not enough to compensate the unbalance of generation and load demand. In this project, we design a micro grid model consists of diesel generator, electrical vehicle, wind turbine with load. The frequency deviations occur in the micro grid is minimized by using PID controller. By using Integral square error, frequency deviations can be optimized to a desired level.

Initially some PID controller values are assumed to reduce the frequency deviations of the micro grid. But, it is very difficult to assume the best PID values. So, PID controller values can be found by particle swam optimization and Dragonfly algorithms. Finally Dragonfly algorithm is compared with Particle swam optimization algorithm and the best PID values are used to optimize the frequency deviations of the micro grid.

2. Small Signal Model of Micro-Grid

A micro-grid consists of distributed generation sources, e.g., diesel generators or micro-turbines, loads, solar panel, batteries, electric vehicles etc [3]. A micro-grid is designed in two modes, i.e., isolated mode or grid-connected mode [1]. If a micro-grid is grid-connected, the loads can be supplied by the connected electrical power system. Otherwise, feeders are being supplied by micro-sources and the distributed generation has to cope with varying load and fluctuating renewable energy sources in the isolated mode.

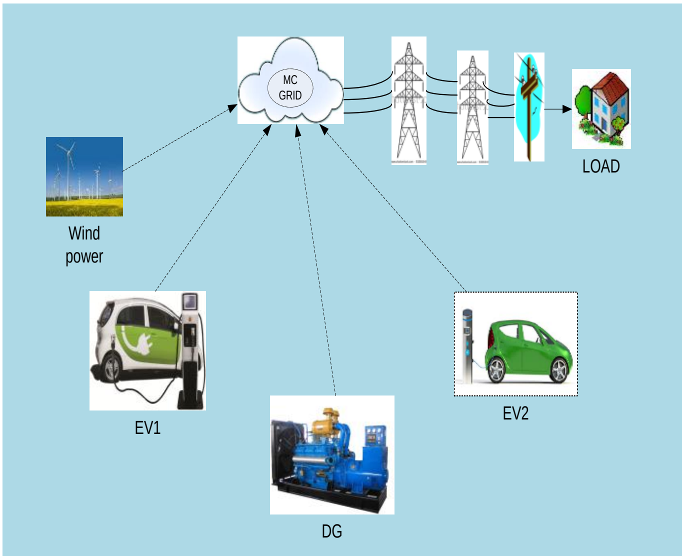

Fig1.isolated micro grid

2.1 DIESEL GENERATOR

Diesel generator is the connection of a diesel engine with an alternator. Diesel generator (DG) is small scale power generation equipment with the features of fast starting speed, durability, and its efficiency will be high. The DG output is varied by the fuel regulation when power demand gets fluctuated [4]. The below fig shows the continuous time transfer function model of the DG for LFC.

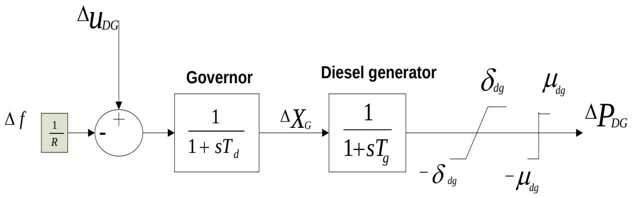

Fig.2 Diesel generator model

2.2 ELECTRIC VEHICLE MODEL

Due to the rising deregulation of recent power industry and increasing combination of renewable energy resources, the utility of EVs in micro-grid has been developing among end users in different countries [6]. The EV technology is the better control technique in current micro-grids and smart grids. EVs can be operated as a bidirectional when it is connected to an isolated grid i.e., the power flow between power grid and the EVs. During their charging time, EVs are treated as load for the grid [7]. While during their discharging time, they act as a power source for the grid [8, 9].

2.3 WIND TURBINE MODEL

Nowadays, the penetration of wind power generation has been developing rapidly. Due to change in speed, wind energy affects the system frequency which leads to instability in output power. Due to change in wind speed and wind direction with respect to time, the output power of the wind turbine will oscillate [10]. The inner characteristics of a wind turbine have little effect on LFC of the micro-grid, due to the performance of EV and DG [11].

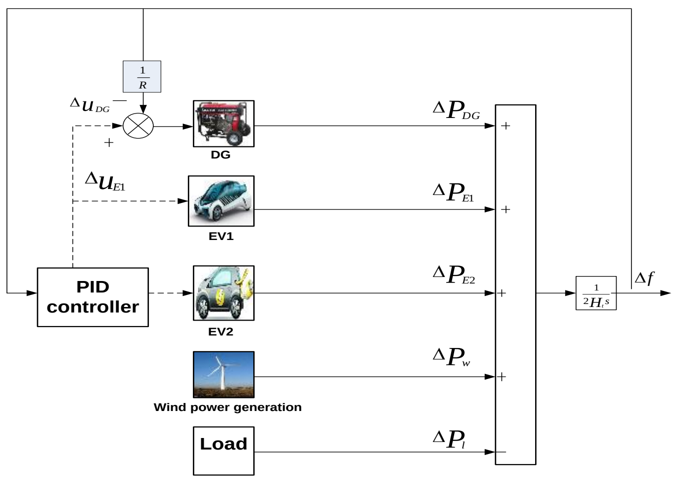

Fig.3 micro-grid model using PID controller

3. OBJECTIVE FUNCTION

The frequency deviations (Δf) of a micro grid are reduced by using load frequency control on PID controller. Δf is very small value. So, frequency deviations of a micro grid are optimized to a desired level by squaring the Δf value. Then Integral Square error is used to find the error value in frequency deviations of micro grid. Therefore the objective of this paper is to regulate the frequency of micro-grid by minimizing the objective function to improve the overall performance of the system.

$$\text{Objective function (F)} = \int [|\Delta f|^2]$$

4. DRAGONFLY ALGORITHM

A dragonfly algorithm was planned to be unique swarm intelligence. These are known as dynamic (migratory) and static (feeding) swarms. Using meta-heuristics the two functions static and dynamic swarms are allied to two stages of optimization those are exploration and exploitation. In exploration phase dragonflies build sub-swarms and fly over various areas. It is known as static swarms [10]. In exploitation phase, dragonflies move in one direction to fly in larger swarms [11].

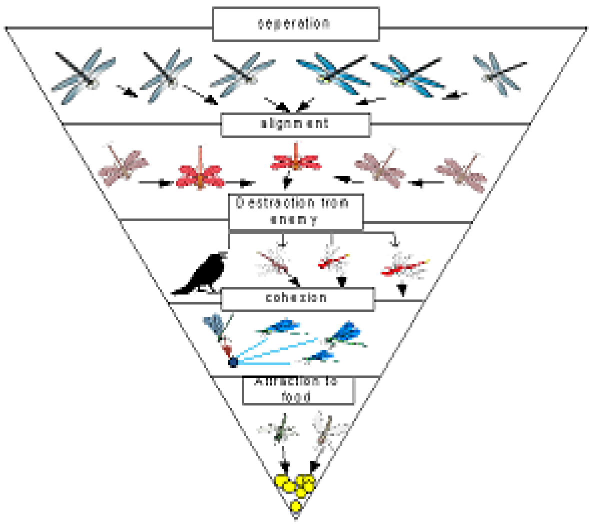

Fig.4 Patterns between different individuals in a swarm of dragonfly algorithm

The Dragonfly Algorithm for solving the optimal power flow problem can be summarized in following steps:

i. Read data of the given power system.
ii. Set the maximum iteration count (IT_MAX).
iii. Assume lower bound and upper bound of variables and assume no. of search agents N, dimensions
iv. Assume step vector ΔX_i where i=1,2,3,…n
v. Assume food fitness and enemy fitness to infinite value
vi. Calculate all the objective function values of all the n dragonflies
vii. Set iteration count=1 and restore radius, weight, alignment, separation, cohesion, attraction to food and distraction from enemies

viii. Update food source and enemy
ix. Calculate the values of S,A,C,F and E using equations from (3.1) to (3.5)[12]
x. Update neighboring radius
xi. If a dragonfly in its neighborhood, has at least one dragonfly, then update the velocity vector by means of (3.6) and position vector using (3.7) [12]
xii. Else, update position vector using (3.8)[12]
xiii. On the basis of the lower and upper boundaries of the variables, check and make corrections in the new position values.
xiv. Set IT = IT+1. If IT<ITMAX go to step vi. Otherwise go to the step xiv.
xv. Stop.

5. SIMULATION RESULTS

The load on the micro-grid is suddenly increased to 0.05p.u at 2 seconds. Due to sudden increment load, frequency deviations are occurring from two seconds. When load reaches to 0.05p.u (constant), the frequency deviations are nearly equal to zero. Dragonfly algorithm was optimizing the frequency deviations to a desired level with in the less time than the Particle swam optimization. The frequency deviations with respect to time are shown in fig (5 & 6). Fig (5) explains about the frequency deviations without wind turbine and fig (6) explains about frequency deviations with wind turbine. In fig (7), integral square error value of Dragonfly algorithm is compared with Particle swam optimization algorithm for the load changes in the micro grid. Dragonfly algorithm has small value than PSO.

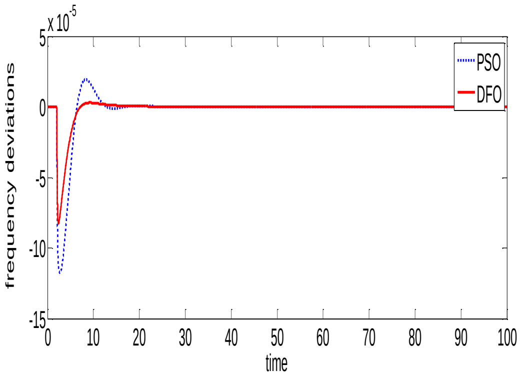

Fig.5 Frequency deviations without wind turbine

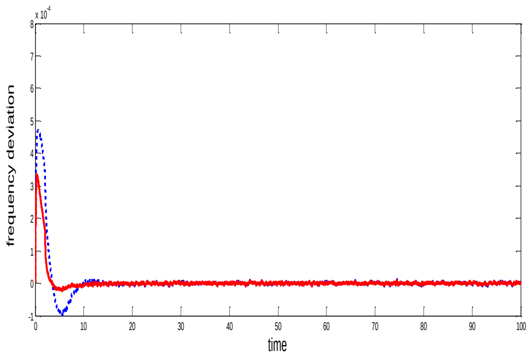

Fig.6 Frequency deviations with wind turbine

6. CONCLUSION

Due to stochastic nature of the renewable energy sources minimization of frequency deviation in micro grid is important issue. In this paper, a PID controller is used for LFC in an isolated micro-grid with V2G technique has been implemented under varying operation conditions with changing renewable energy generation and load demand. Using dragonfly algorithm the output of EVs and DG can be coordinate through a process optimization and feedback compensation. Time-domain simulations with different micro-grid operation conditions are employed to investigate the effectiveness and robustness of the proposed algorithm. Comparing with PSO algorithm and dragonfly algorithm, simulation results demonstrate that the dragonfly algorithm can obtain better robust performance on LFC with complex operation situations, namely, random renewable energy generation and continuous load disturbances.

REFERENCES

[1] Tran, D. Khambadkone, A.M. “Energy management for lifetime extension of energy storage system in micro-grid applications”. IEEE trans. Smart Grid 2013, 4, 1289-1296.

[2] De Souza Riberia, L.A.; Saavendra, O.R.; de Lima, S.L.; Gomes de Matos. J.Isolated micro-grids with renewable hybrid generation: The case of Lenocis island IEEE Trans. Sustain. Energy 2011, 2, 1-11.

[3] Nour EL Yakine Kouba, Mohamed Menaa, Mourad Hasni and Mohamed Boudour “A novel optimal frequency control strategy for an isolated wind–diesel hybrid system with energy storage devices” Wind Engineering 2016, Vol. 40(6) 497–517.

[4] Mohammad-Hassan Khooban, Taher Niknam, Frede Blaabjerg, Pooya Davari, Tomislav Dragicevic, “a robust adaptive load frequency control for micro grids”, ISA Transactions 2016.

[5] Jun Yang, Zhili Zeng, Yufei Tang, Jun Yan, Haibo He and Yunliang Wu ,”load Frequency control in isolated micro-grids with electrical vehicles based on multivariable generalised predictive theory”, Energies, 18 March 2015

[6] Zhang F, Sun C, Wei W, et al. 2015,“Control strategy of electric charging station with V2G function based on DC micro-grid”. In: Proceedings of the IEEE first international conference on DC micro-grids, Atlanta, GA, 7–10 June, pp. 222–227. New York: IEEE

[7] ElNozahy, M.S.; Salama, M.M.A. “Studying the feasibility of charging plug-in hybrid electric vehicles using photovoltaic electricity in residential distribution systems”. Electr. Power Syst. Res.2014, 110, 133–143

[8] Bremermann, L.E.; Matos, M.; Lopes, J.A.P.; Rosa M.” Electric vehicle models for evaluating the security of supply”. Electr. Power Syst. Res. 2014, 111, 32–39

[9] Falvo MC, Graditi G and Siano P “Electric vehicles integration in demand response programs”. In: Proceedings of the international symposium on power electronics, electrical drives, automation and motion (SPEEDAM), Ischia, 2014, 18–20 June, pp.548–553. New York: IEEE.

[10] Wikelski M, Moskowitz D, Adelman JS, Cochran J, Wilcove DS, May “ML Simple rules guide dragonfly migration”. 2006, Biol Lett 2: 325–329

[11] Russell RW, May ML, Soltesz KL, Fitzpatrick JW” Massive swarm migrations of dragonflies” (Odonata) in eastern North America, 1998. Am Midl Nat 140:325–342.

[12] Reynolds CW (1987) Flocks, herds and schools: “a distributed behavioral model”. ACM SIGGRAPH Computer Gr 21:25–34.

[13] Seyedali Mirjalili, “Dragonfly algorithm: a new meta-heuristic optimization technique for solving single-objective, discrete, and multi-objective problems” Neural Computer Applications, 2016 27:1053–1073.

[14] Tummala Ayyarao, Prasad, Hemanth,” Optimal Load Frequency Control of Electric Vehicle Based Micro-Grid Using Grey Wolf Optimization”, ICCPEIC-17, March, 2017.

[15] Pilla, R., A. S. Tummala, and M. R. Chintala. "tuning of extended kalman filter using self-adaptive differential evolution algorithm for sensorless permanent magnet synchronous motor drive" International Journal of Engineering-Transactions B: Applications 29.11 (2016): 1565.

[16] Sailaja, G. M., and T. Ayyarao. "A statistical analysis of loss factor: a case study in APEPDCL-Kakinada." Int. J. Eng. Sci. Technol 5.2 (2013): 430-435.

[17] Tummala, Ayyarao SLV, and P. V. Ramanarao. "Tuning of Extended Kalman Filter for Power Systems using Two Lbest Particle Swarm Optimization.", IJCTA, 2017.

[18] Ravikiran, C., et al. "Effective Elimination of Harmonics by means of a Hybrid Series Active Filter (HSAF)." International Journal of Engineering Research and Applications 2.5 (2012): 96-101.

[19] Rambabu, M., et al. "Three Zone Protection By Using Distance Relays in SIMULINK/MATLAB." (2015).

[20] Ayyarao, T. S. L. V., G. I. Kishore, and M. Rambabu. "Adaptive control of saturated induction motor with uncertain load torque." International J. of Recent Trends in Engineering and Technology 3.4 (2010).