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DECENTRALIZED CONTROL OF POWER FLOW IN DISTRIBUTION SYSTEM

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Abstract—The electrical distribution system is having more than 18% of losses because of long distribution lines and also the conventional energy sources are also depleted, so the Renewable Energy Sources (RES) are used as alternate source for power generation and nearer load. Operating grid along with Distribution Generation DG) is very complicated. So the electrical distribution system is converted into microgrids, grid control is decentralized. As RES are seasonal and time dependent the Microgrid is operated in Islanded Mode or Main Grid connected mode to consume power continuously. In this paper, a decentralized controller used to control the DG systems with Firefly Algorithm (FA) and Maximum Power Point Tracking in solar and Wind sources. The results are verified using MATLAB Simulink.

Keywords- Firefly Algorithm (FA), decentralized controller, Islanded Mode (IM), Distribution Generation (DG).

I. INTRODUCTION

Modern society depends critically on a secure supply of energy. Growing concerns for primary energy availability and aging infrastructure of current electrical transmission and distribution networks are increasingly challenging on security, reliability and quality of power supply. It is very difficult operation and very significant amounts of investment will be required to develop. At present the non-renewable energy sources is also very costly, so the renewable energy sources integration is most important for future energy generation. The renewable energy generation is seasonal one, so it is operation, control and storage is very critical operation. Now, adding of DG in the system is increases the complex, so the distribution system are converting in Microgrid. The Microgrid is a small grid, it is basic building block of smart grid, and it has the DG for satisfying the local loads.

The word "smart grid" means self-healing in nature, in smart Microgrid the minimum level of energy generation and utilized in grid itself. If excess power is needed the microgrids will automatically connect to main grid or more generation the microgrids supply the power to main grid. The distribution level experiencing an evolution that needs more "smartness", in order to facilitate access to distributed generation on a high share, based on RES either self-dispatched or dispatched by local distribution system operators enable local energy demand management, interacting with end-users through smart metering systems benefit from technologies already applied in transmission grids, such as dynamic control techniques, so as to offer a higher overall level of power security, quality and reliability. The distribution grids are being transformed from passive to active networks, in the sense that decision-making and control are distributed, and power flows bidirectional.

The Coordinated Multi-Microgrids Optimal Control Algorithm is used in Smart Distribution System for controlling the more number of microgrids [1]. The potential-function based method for secondary control of a microgrid, in both islanded and grid-connected modes for continues supply to load [2]. The Microgrid is controlled by various decentralized controllers for the maximum use of energy generation in grid. The RES like solar, wind and hybrid systems are used for Distributed Generations (DGs) [3], [4] and [5].DG is the main source for local load satisfaction, so the available energy is converted to electrical energy. The optimization is very important for the generation, the linear dynamic programming is a technique used for optimization [6]. The hydrogen storage is more cost but wind connected DG plant is operated in peak demand in power market operation, due to reduce the system instability [7]. Scheduling the combined heat and power Microgrid, operate economically using Particle Swarm Optimization (PSO) [8]. The power demand is vary in all the time, it needs to constant the grid to vehicle and V2G operation is most important for stability [9].

More number of microgrids is connected in comparative networks for controlling purpose and optimum consuming of RES [10], [11]. Load production is important in generator operation but the partial history sharing gives the more information for load prediction [12].The DGs like solar and wind conversion systems are separately used some time affect the stability and generation, but combined both to improve the grid stability and generation. The solar panels are connected is series or parallel, when climatic conditions vary, the MPP of the PV system also changes its position and several methods have been presented for tracking the MPP and are available in [12]–

[17]. The Permanent Magnet Synchronous Generator (PMSG) based wind energy conversion produce more power when compare to other generators [18], [19]. The MPPT based solar system and PMSG wind systems are combined for maximum energy generation in Microgrid [20].

The decentralized controller is reducing the system complex because more number of DG is connected. The Microgrid is implementing in distribution system and DG as the source. The DG is seasonal and time varying so the Microgrid is operated in two modes. The Microgrid having the source it operates in islanded mode and not having sourced it operate in Grid connected mode. The Microgrid is automaticity or self-healing the connection in one mode to another mode based on available source and load.

II. DISTRIBUTED GENERATION

The commonly used DG technologies include wind generators, photovoltaic, and biomass generators with their sizes varying between several kW to a few MW. Energy storage devices are generally used for smooth variations in DG's MW output due to inherent unpredictability and to minimize exchange of power from grid. The energy storage cost also high and the storage device maintenance is creating more expensive, so avoiding this problem direct grid connected is the best option. The RES based DG power generation is variable because of the natural source available is time to time change.

To avoiding the variable generation to use more type of RES then the generated power is some constantly maintain. The grid is more complex network so the DG is connected in Microgrid only it will be easily controlled and operated. The stability of the microgrid is maintained and the available RES is utilized efficiently. The decentralized controller will control all the operation of Microgrid and DG, so the Microgrid and Main Grid stability is maintained.

III. MPPT IN SOLAR AND WIND GENERATION

This paper the solar and wind generation is the source of distribution system. The solar and wind are natural sources so the availability of the power generation is unpredictable. Generally the power generated units are connected in grid system, due to variation of power generation the grid stability will be affected. To avoiding this problem the MPPT is used in solar power generation system. The boost converter is used for sudden change in voltage generation. In wind conversion system the pitch angle control is used for power generation. So the generated power is almost maintain constant. If other than any problem is affect the grid stability the decentralized controller is connect the load to the main grid.

IV. PROPOSED FIREFLY ALGORITHM

The Firefly Algorithm (FA) is a metaheuristic algorithm, inspired by the flashing behavior of fireflies. The primary purpose for a firefly's flash is to act as a signal system to attract other fireflies. Xin-She Yang formulated this firefly algorithm by assuming:

1. All fireflies are unisexual, so that one firefly will be attracted to all other fireflies.

2. Attractiveness is proportional to their brightness, and for any two fireflies, the less bright one will be attracted by the brighter one; however, the brightness can decrease as their distance increases.

3. If there are no fireflies brighter than a given firefly, it will move randomly. The brightness should be associated with the objective function.

Firefly algorithm is a nature-inspired metaheuristic optimization algorithm. The FA is processed on light intensity based, so the higher intensity firefiles are attracted and lower intensity fireflies are attracted. So the attractiveness is proportional to the light intensity or brightness of the fireflies. In program execution the fireflies is not bright than given fireflies then it moves randomly and the brighter flies is the objective function.

Algorithm

Step 1: Start the program
Step 2: Enter the radiation, wing speed and load of system input data
Step 3: The Generate initial population of fireflies
x_i (i = 1, 2, ..., n)
Step 4: To determine Light intensity I_i at x_i is determined By f(x_i)
Step 5: Set the iteration count iter=1
Step 6: To calculate i_{th} firefly for i = 1: n all n fireflies
Step 7: To calculate j_{th} firefly for j = 1:n all n fireflies
Step 8: To check if (Ij> Ii), Move firefly i towards j in ddimension; end if
Step 9: To calculate attractiveness, when Attractiveness varies with distance r.
Step10: To Evaluate new solutions and update light Intensity
Step11: end for j
Step12: end for i
Step13: Rank the fireflies and find the current best
Step14: To evaluate Iter=Iter+1
Step15: Check Iter > Itermax; the condition no means go to step 4.
Step16: Print the results

Step17: Stop the program.

V. CONTROLLER SYSTEM DESIGN

The Microgrid is a small grid system is satisfying the local loads. Initially the Microgrid is operated on Islanded Mode. In some cases the DG power generation is uncertainty due to seasonal effect that time Microgrid is operated in main grid connected mode. The two mode of operation is important in continuous power to load. The generated power is optimized using FA. The power generation of PV array using Maximum Power Point Optimization technique. The maximum power can be generated by controlling the DC-DC converter. At the same case the wind generation is also varying the speed of wind flow, so the power generation is maximized by controlling the AC-DC converter. Both the DC output is connected in common DC Bus.

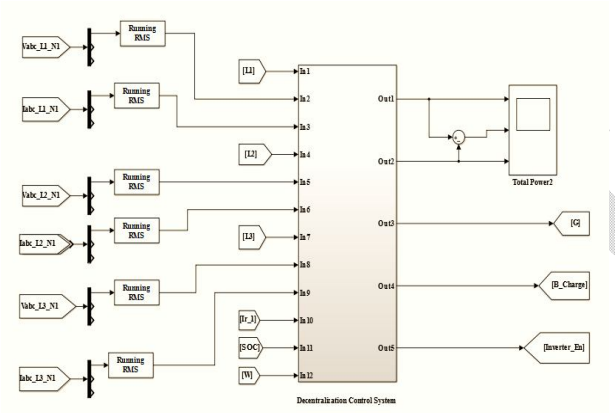

Fig 1 : Decentralized Controller

The main grid voltage and current can be taken as reference and given to Voltage Source Controller (VSC) to synchronize the grid. PI controller is to calculate the error signal and makes the error zero to interface the main grid. The fig 1 shows the decentralized controller, the controller is operated in FA. The Microgrid cannot satisfy the demand it automatically synchronize the main grid. At the time the demand power only is consumed by the Microgrid. In some time the excess power is also supply to the main grid. In all operations are automatically done by the controller.

VI. SIMULATION RESULTS

The Microgrid system is mainly operated in islanded mode, in some cases it operates in operate both modes. The load is also non-linear load so the load variation is not equal to power generation so the Microgrid is operated in combined mode.

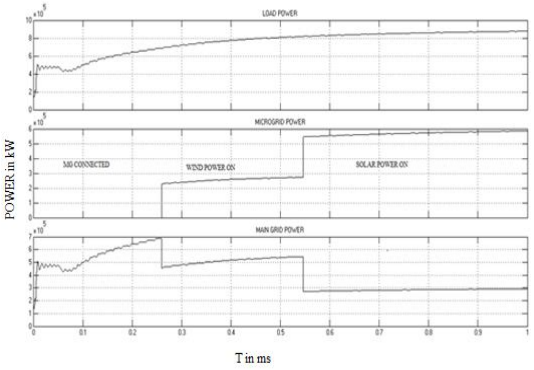

Fig 2 : Simulation Output

The fig 2 shows the simulation results of Microgrid, the power consume by the load is always in the DG. The graph shows the Microgrid operated modes. Initially the Microgrid operated in grid connected mode that time load consume the full power in grid. After the DG power generation the load consume by the grid is reduced.

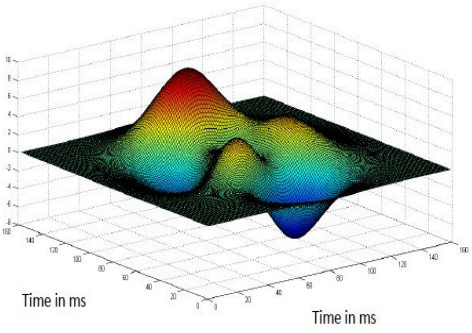

Fig 3 : Stability Time

The fig 3 shows the power consumption for the load in different sources, here the main grid is also a one of the source. The system stability is important. In simulation the system takes 350ms for stable operation.

VII. CONCLUSION

Fairfly Algorithm is proposed for tracking maximum power from the PV array and wind plant. It integrates the multiple power sources thus enhancing the reliability of power supply. The main advantage of Distribution System is self-healing. The algorithm is stabilized the system in 350ms. In future the stabilization time will be reduced for using the different optimization techniques. Hence optimization algorithms can give better efficiency for real world applications.

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