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Abstract—This paper proposes a novel, Frequency control in a hybrid system for Energy management. Here Microgrid consists of Solar system, Fuel cell unit and a diesel unit for frequency control. In this proposed approach solar output is been controlled and coordinated with other sources by Neuro-Fuzzy controller. During demand increase in the network each source in the network feed the grid according to the priority given and maintains the frequency of the grid thereby, improving the stability of the grid. Here solar power is taken as the primary source that is to be connected during the energy demand. For accurate coordination control in grid maximum power point is tracked from solar.

Keywords—maximum power point tracking(MPPT), Frequency control, Energy Demand, Microgrid, Fuel-Cell (FC), Diesel Generator.

Introduction

Demand of Energy is increasing in a grid connected or isolated system. Thus it is very important to meet the increasing demand. In order to meet the increasing demand alternative energy sources for conventional power has to be used i.e. Renewable energy source such as solar energy, Fuel-Cell, Wind energy, Tidal energy, etc. These sources are clean and abundantly available in nature, they are advantageous over conventional energy system such as low pollution, high efficiency, diversity of fuels, reusability of exhausts, and onsite installation. The main objective of energy management is to include the plan and operation of energy production and energy consumption units. A Microgrid is a “A power distribution network comprising multiple electric loads and distributed energy resources, characterized by all of the following: a) The ability to operate independently or in conjunction with a macrogrid; b) One or more points of common coupling (PCC’s) to the macrogrid; c) The ability to operate all distributed energy resources (DER), including load and energy storage components, in a controlled and coordinated fashion, either while connected to the macrogrid or operating independently; d) The ability to interact with the microgrid in real time, and thereby optimize system performance and operational savings”. Fig 1 shows the typical example of a Microgrid.

Fig. 1 Typical Example of a Microgrid

In this paper, solar-fuel cell-diesel is system is taken as a microgrid sources. During higher demand increase, frequency of the network fails correspondingly. In order to maintain the frequency stability of the network each source of the microgrid is added up with the main grid. This addition will have frequency regulation in the grid which in turn improves voltage stability.

I. SYSTEM DESCRIPTION

Fig 2 will describe the block diagram of the system. Sources such as PV, Fuel Cell, and Diesel Generator are connected to the main grid through relays. During higher load demand in the system each source gets connected to the system to stabilize the frequency disturbances.

Fig. 2 Block Diagram

A. Solar Power

Solar is the most widely used renewable energy system used for economical purpose. Though the
varying output from the solar panel is obtained the impact on the solar power generation is still necessary to future life. The output power from the solar panel is made more enhanced high voltage gain dc to dc converters and MPPT as control algorithm for the maximum use of the power from the solar panel.

II. PROPOSED SYSTEM

In the proposed system, microgrid source supplies the load. During higher demand increase each sources of the microgrid such as PV, Fuel Cell, Diesel generator are added for every demand increase without using external storage. The PV generator is properly derated to deliver a reduced power output than its maximum possible value and hence making its output dispatchable/controllable. The derated amount of power is kept aside and is used as reserve to supply the transients whenever required. In addition, this paper also proposes a novel neural network-based maximum power point tracking (MPPT) algorithm for the PV system. Energy management scheme employs the PV as first, then fuel cell and then Diesel generator will get added up to attain power balance in the network. This proposed scheme is implemented through a central controller.

In this proposed scheme during normal demand in the system, PV will operate at its maximum power point, during demand increase other sources in the microgrid like fuel cell and diesel generator adds up according to the demand increase, to maintain the voltage balance in the network.

Here PV is rated for 100 Watts power, Maximum Power Point Tracking is done by Pertub & Observe (P&O) based Neuro-Fuzzy algorithm. Fuel-Cell is rated for 230 V, 40Watts power and Diesel Generator is rated for 215 V.

III. MPPT

A. PERTURB & OBSERVE

The performance of the proposed tracking mechanism is validated against the well-accomplished perturb and observe (P&O) mechanism. Fig 3 describes the flow chart of P&O algorithm. This algorithm is the most common algorithm because it uses simple parameters for measurement. In this approach, the module voltage is periodically given a perturbation and the corresponding output power is compared with that at the previous perturbing cycle. In this algorithm a slight perturbation is introduce to the system. This perturbation causes the power of the solar module various. If the power increases due to the perturbation then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is zero and next instant decreases and hence after that the perturbation reverses. When the stable condition is
arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the perturbation size is remain very small. The technique is advanced in such a style that it sets a reference voltage of the module corresponding to the peak voltage of the module

![Fig 3. Flow Chart for Perturb & Observe Algorithm](image1)

**B. NEURO-FUZZY**

Neuro-Fuzzy refers to combinations of artificial neural networks and fuzzy logic. The proposed scheme utilizes Sugeno-type Fuzzy Inference System (FIS) controller, with the parameters inside the FIS decided by the neural-network back propagation method. The ANFIS is designed by taking speed error (EN) and change in speed error (d(EN)/dt) as the inputs. The output stabilizing signals is computed using the Fuzzy membership functions depending on these variables. ANFIS-Editor is used for realizing the system and implementation. Fig 4 describes the Neuro-Fuzzy frame work

![Fig 4. Neuro-Fuzzy Frame Work](image2)

Rules are framed in neuro-fuzzy for controlling the supply of sources to be connected during demand increase and their inverter duty cycle ratio is controlled through the neuro-fuzzy network. Fig 5 describes the Rule Frame Work for Neuro-Fuzzy.

![Fig 5. Rule Frame Work for Neuro-Fuzzy](image3)

![Fig 6. Input layer and Hidden Layers of Neuro-Fuzzy](image4)

**IV. SIMULATION RESULT**

In order to validate the control strategies the proposed system is modeled. The simulation result for the proposed method is analyzed with the MATLAB software. Simulation is analyzed for the proposed method. Fig 7 describes the proposed system SIMULINK model.

![Fig 7. SIMULINK MODEL of Proposed System](image5)
A. MAIN GRID VOLTAGE & CURRENT

Grid source voltage and current are analyzed in this section. Initially it supplies a voltage of 400 V to the load when demand of the load increases by time this result in voltage imbalance in the system; this is stabilized by adding sources to the load to maintain the grid voltage. Fig 8 describes the Source Voltage and Current. Real power of the grid during normal condition and during demand increase is estimated and shown in Fig 9.

![Fig 8. Source Voltage and Current](image1)

During higher demand condition disturbance in voltage stability occurs, in addition; frequency also gets disturbed. Due to the coordinated control of the micro-grid system, frequency is maintained throughout the system. This can be analyzed from Fig 10.

![Fig 10. Frequency of the Grid](image2)

B. PV VOLTAGE & CURRENT

Here PV panel is the base source during higher demand increase of load. MPPT is implemented using P&O based Neuro-Fuzzy. PV output voltage is shown in Fig. 11 and Real power of the PV is shown in Fig. 12.

![Fig 11. PV Output Voltage Variation](image3)

C. FUEL-CELL VOLTAGE & POWER

Fuel-Cell is taken as the second alternate source of PV during higher demand increase. Inverter connected will have controlled duty cycle according to its demand in the network. Fig. 13 shows the Real power variation.

![Fig. 12 Real Power Variation in PV](image4)

It is connected to the main grid during higher power demand in the network; it also gets connected during maximum load exceeding the PV supplied.

D. DIESEL GENERATOR VOLTAGE & POWER

Diesel Generator is taken as the third alternate source during higher demand increase for voltage stability and frequency regulation. Fig. 14 shows the Real power variation.

![Fig. 13 Real Power Variation in Fuel-Cell](image5)
Fig. 14 Real Power Variation in Diesel Generator

Fig. 15 describes the load or demand control for each source in the microgrid as the demand increase in the network. Source is controlled through neuro-fuzzy algorithm.

Fig. 16 Neuro-Fuzzy Rules for Control of PV source

Neuro-fuzzy control is a method for time-varying and non-linear processes. In neural fuzzy systems, both artificial neural network and fuzzy system work independently from each other. The ANN tries to learn the parameters from the fuzzy system. This can be either performed offline or online while the fuzzy system is applied. Neural networks can only come into play if the problem is expressed by a sufficient amount of observed examples. On the one hand no knowledge will be provided about the problem. On the other hand, however, it is not straightforward to extract comprehensible rules from the neural network's structure.

Fig. 17 Power variation of Sources

During the higher demand increase in the network the sources will get added up to the network, each source addition can be analysed in Fig 18.

Fig. 17 Power variation of Sources

F. CONCLUSION

In this paper a novel control scheme is proposed for regulating frequency and voltage stability of the network through coordinated control of micro-grid by Neuro-Fuzzy Algorithm. Sources for a micro-grid are PV, Fuel Cell and Diesel Generator. Maximum Power Point Tracking (MPPT) is done for PV through P&O based Neuro-Fuzzy algorithm. PV generator is controlled to operate at maximum voltage during higher demand increase. Depending on the difference between the demand and the generation, the PV generator is controlled in coordination with DDG and FC outputs along with DRC to deliver transient as well as steady-state frequency regulation in a DDG-PV-FC based Hybrid ac microgrid system without any storage.
REFERENCE


