Volume 5, Issue 6, June 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Stability Parameters of an Islanding Micro-Grid Using PID/ Fuzzy Controller

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Abstract. The micro grid concept has the potential to solve major problems arising from large penetration of distributed generation in distribution systems. Increasing concerns regarding global warming caused by greenhouse gases, which are mainly generated by conventional energy resources, e.g., fossil fuels, have created significant interest for the research and development in the field of renewable energies. For microgrid in islanded operation, due to the effects of mismatched line impedance, the reactive power could not be shared accurately with the conventional droop method. To improve the reactive power sharing accuracy, this paper proposes an improved droop control method. The proposed method mainly includes two important operations: error reduction operation and voltage recovery operation. The sharing accuracy is improved by the sharing error reduction operation, which is activated by the low-bandwidth synchronization signals. However, the error reduction operation will result in a decrease in output voltage amplitude. Therefore, the voltage recovery operation is proposed to compensate the decrease. The needed communication in this method is very simple, and the plug-and-play is reserved. Simulations and experimental results show that the improve voltage of the microgrid, and also have a good performance.

Keywords— microgrid, wind turbine, Battery, fuzzy logic controller (FLC)

I. INTRODUCTION

Microgrid integrated with renewable energy system receives more and more attention around the world[1-7]. Microgrid, which is formed by grouping a cluster of distributed energy resources, storage devices and controllable loads in a common local area, has attracted widespread attentions [8]. The control strategy in both the grid connected and islanding modes of a microgrid can be found in literature [9]. A microgrid is defined as a part of an electric power distribution network that embeds an appreciable number of distributed generators and energy storage devices, in addition to regional loads; it may be disconnected from the rest of the power system, under emergency conditions or as planned, and operated as an island.

Today's challenge is the implementation of renewable energy into existing power systems. MG provide higher flexibility and reliability as it is able to run in both grid connected and islanded mode of operation and its components may be physically close to each other or distributed geographically [10],[11].

A microgrid can be a residential neighborhood, an industrial or commercial facility, a university campus, a hospital, an off-grid remote community, etc. Micrograds should widely utilize renewable energy resources such as wind, sunlight, and hydrogen1, to play a significant role in the electric power systems of the future, for cleaner air, reduced transmission and distribution costs, and enablement of energy efficiency enhancement initiatives. The economical and environmental benefits of microgrids have motivated extensive research and development efforts towards resolving the technical challenges of this new and fast growing technology[12].

II. SMART MICROGRID DEFINITION

The Smart Micro-grid is a residential smart grid communicative system that manages power between the AC utility grid, storage devices, and on-site renewable generation units - such as solar panels and wind turbines - while maintaining a unique level of user comfort. The SM is conceived starting from the concept of DC micro-grid, enclosing features and advantages proper of such architecture. The interface with the AC utility grid is also provided in order to guarantee benefits for both the user and the grid through an automated approach to the demand-response problem.

Using the communication abilities of the smart grid, modern power electronics, renewable energy, and on-site storage devices an intelligent micro-manage of the power demand of a house is achievable. By enforcing time-of-day (TOD) rates, the utility can get demand response from their residential customers, making them more aware of their power consumption and more likely to reduce it during peak times. If notified of the higher rates ahead of time - with phone calls or emails - the consumer can make informed decisions and consciously reduce their loads. Several organizations have tested this theory with pilot programs but most have had only moderate success [13, 14]. A more tried method takes control of out the customers' hands.

The peaks in power mostly coincide with the peaks in price, meaning the consumer is charged more during these periods. If the loads are managed to stay off the grid during these peak times, consumers could save money and produce at the same time an improvement in the operating of the utility grid. Selected loads - such as water heaters - could be turned on and off automatically during the peak by an intelligent management system. For time-independent loads, this type of work can be easily done with programmable switches. In very simple cases, this does not affect homeowner comfort. For example an oversized water heater acts like an energy storage device, charged only once a day when it is convenient for the utility. The same amount of energy is consumed but with no excessive strain on the grid.

The microgrid definition assumes a cluster of loads and microsources operating as a single controllable system that provides power to its local area [15,16]. Microgrids offer solutions to implementing distributed energy resources such as diesel generators, wind turbines, photovoltaic cells etc. at or near the point of load. This decreases the stress on the electrical transmission system and offers a significant increase in power system reliability as power can be generated locally. From a grid perspective, the microgrid concept is attractive because it recognizes the reality that the traditional grid structure is old and has to change[15]. Microgrids may or may not be connected to the main distribution grid that is maintained and operated by the distribution network operators. Microgrids can also provide premium power through the ability to smoothly move from dispatched power mode while connected to the main utility grid to load tracking while in island mode .

Figure 1. Shown the microgrid that use in this study. This model is consist of two DGs and a collection of loads.

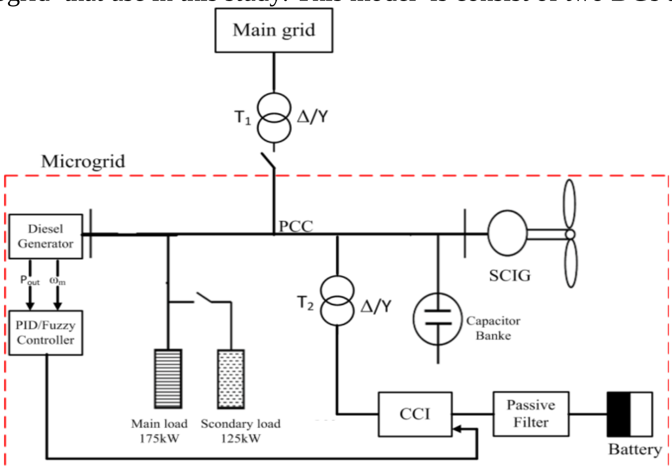

Figure 1: Microgrid Model

A. *Wind turbine*

Wind turbines are packaged systems that include a rotor, a generator, turbine blades, and a drive or a coupling device. As wind blows through the blades, the air exerts aerodynamic forces that cause the blades to turn the rotor. As the rotor turns, its speed is altered to match the operating speed of the generator. Most systems have a gearbox and a generator in a single unit behind the turbine blades.

A wind turbine operates by extracting kinetic energy from the wind passing through its rotor. The power developed by a wind turbine is given by [6]:

$$P_{\omega} = 0.5\rho A V^3 \tag{1}$$

Where

P power (W),

Cp power coefficient,

Vw Wind velocity (m/s),

A swept area of rotor disc(m2),

density of air (1.225 kg=m3).

The force extracted on the rotor is proportional to the square of the wind speed and so the wind turbine must be designed to withstand large forces during storms. Most of the modern designs are three-bladed horizontal-axis rotors as this gives a good value of peak Cp together with an aesthetically pleasing design [17].

The power coefficient Cp is a measure of how much of energy in the wind is extracted by the turbine. It varies with the rotor design and the relative speed of the rotor and wind (known as the tip speed ratio) to give a maximum practical value of approximately 0.4 [17]. The power coefficient Cp is a function of the tip speed ratio, and the pitch angle , whichwill be investigated further. The calculation of the performance coefficient requires the use of blade element theory . As this needs knowledge of aerodynamics and the computations are rather complicated, numerical approximations have been developed . Here the following function will be used:

$$C_P(\lambda,\beta) = c_1\left(\frac{c_2}{\lambda_i} - c_3\beta - c_4\right)e^{\frac{-c_5}{\lambda_i}} + c_6\lambda \tag{2}$$

$$\frac{1}{\lambda i} = \frac{1}{\lambda + 0.008} - \frac{0.035}{\beta^3 + 1} \tag{3}$$

Figure 2 shows Cp(λ, θ) versus λ characteristics for various values of β. Using the actual values of the wind and rotor speed, which determine λ, and the pitch angle, the mechanical power extracted from the wind can be calculated from equations (2)-(3). The maximum value of Cp (cpmax=0.48) is achieved for β = 0 and for λ = 8.1. This particular value of λ is defined as the nominal value (λ nom).

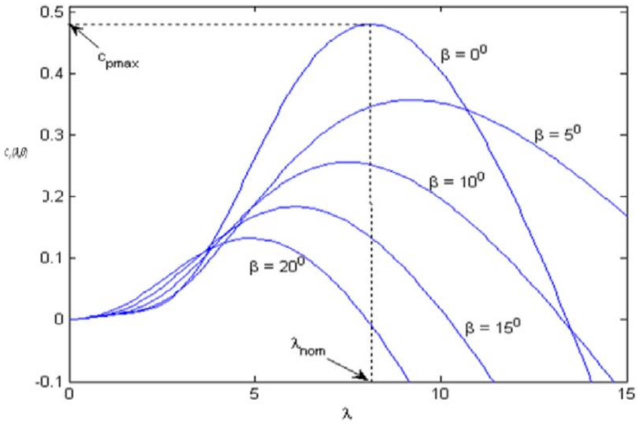

Figure 2: Performance coefficient Cp as a function of the tip speed ratio λ with pitch angel β as a parameter.

The working principles of the wind turbine can be described in two processes, that are carried out by its main components: the rotor which extracts kinetic energy from the wind passing it and converts it into mechanical torque and the generating system, which converts this torque into electricity. Figure 2 illustrates the working principles of a wind turbine.

Basically, a wind turbine can be equipped with any type of a three phase generator. Several generator types may be used in wind turbines, but here three types of wind turbine generators are discussed: Squirrel cage induction generators, Doubly fed induction generators, Direct drive synchronous generators, that in this article Squirrel cage induction generators is the base wind turbine for simulations.

B. Battery Model

The battery block implements a generic dynamic model parameterized to represent most popular types of rechargeable batteries. The equivalent circuit of the battery is shown below:

Discharge model (i* > 0)

$$f_1\left(it,i^*,i,Exp\right) = E_0 - K.\frac{Q}{Q-it}.i^* - K.\frac{Q}{Q-it}.it + Laplace^{-1}\left(\frac{Exp(s)}{Sel(s)}.0\right) \quad (4)$$

Charge Model (i* < 0)

$$f_2\left(it,i^*,i,Exp\right) = E_0 - K.\frac{Q}{Q+0.1.it}.i^* - K.\frac{Q}{Q-it}.it + Laplace^{-1}\left(\frac{Exp(s)}{Sel(s)}.\frac{1}{S}\right) \quad (5)$$

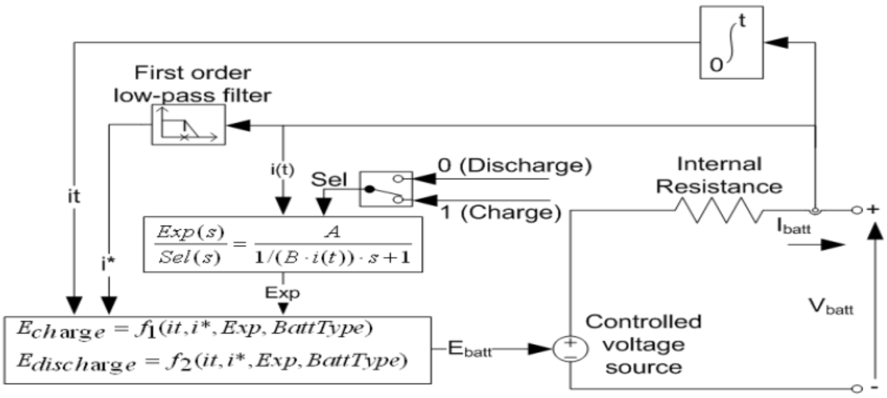

Figure3: Battery model lead acid type in Matlab/Simulink

Nickel–cadmium battery model for discharge model with selected parameter was inserted in equation 4. While for charge model with selected parameter was inserted in equation 5.

III. RESULTS AND DISCUSSION

In this paper, a detailed model for representation of hybrid system in an isolated network is presented; the dynamic simulation study was performed by the MATLAB/SIMULINK software package. The paper also analyzes a new application of fuzzy logic controller(FLC)into an isolated network with hybrid system for improving the network voltage quality. The FLC is used to control some additional loads especially installed in the network for the purpose of network frequency control.

A basic hybrid system is shown in Figs1. It consists of diesel engine and speed governor, the synchronous generator (SG) and its excitation system, the wind turbine (WT), the small load, the FLC controller, and the interconnecting grid.

This paper develops a nonlinear dynamic model of the wind-diesel system, and provides simulation results obtained by SIMULINK. At the first, the mathematical model of wind turbine generation is sequentially developed to support the model of isolated distribution network. Then, by using MATLAB/SIMULINK, the simulation targets such as the behavior of induction machine, balance of active and reactive power and bus voltage profile are simulated.

The system can disconnect from the utility in case of faults and voltage collapses, and when the power quality from the grid reduces below certain standards. A centralized model controller is set in the micro-grid with the control logic optimization of main power for unplanned and planned mode conversion. When micro-grid works in grid-connected mode, the main power works in PQ mode and when the micro-grid works in islanding mode, the main power works in V-F mode so the control of the micro-grid is "master and slavery" control. The micro-grid work mode can be detected from the micro-grid information such as current, voltage etc .

IV. RESULT

Figures 4 to 7 show the dynamic response of hybrid system under the above operating conditions when provided with the proposed fuzzy logic controller as compared with the PID controller of optimal gains. By inspection of the dynamic response, it can be realized that the fuzzy logic controller offers an improved dynamic response of the hybrid system than using the PID controller: the response is faster, with minimum overshoots. The behavior of the induction machine corresponds to the generator mode. For instance, the rotor speed is always above the synchronous speed of the machine; this means that the slip and torque values are always negative. The small value of electrical torque is obtained by the gearbox function. With a gearbox, a slow rotation and high torque power from the wind turbine rotor can be converted to high speed and low torque power, which is used for generator.

The balance of active and reactive power is one of the factors that maintain the required values for the system frequency and voltage, respectively. Both active and reactive power outputs of the induction machine are proportional to the wind speed, whereas the power output of the diesel generator is significantly influenced by the variation in load consumption. In fact, the power outputThe power system in a State of persistent work in balance between production and consumption to take over, and if the balance of the event stir welding between the nominal value of the microgrid parameters go, will go away. This article is for voltage control and other parameters of the microgrid is used. If not, the control system of the swing can be a lot of damage, even to a production unit shutdown also happens. The output be and other parameters are also two modes of presence and absence of DGs have been analyses.

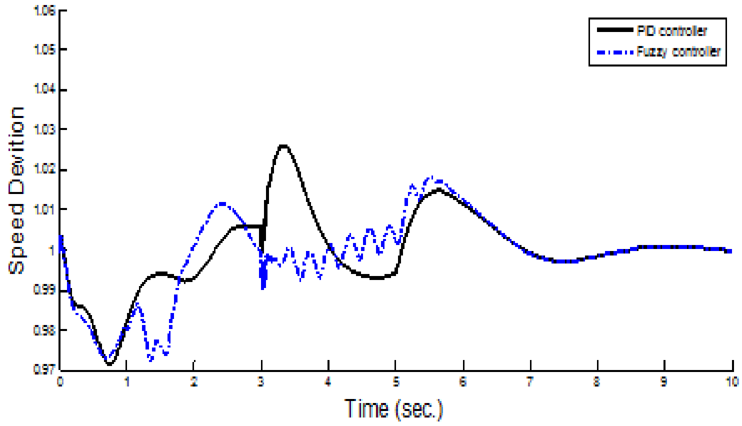

Figure 4: Changes speed of synchronous machine

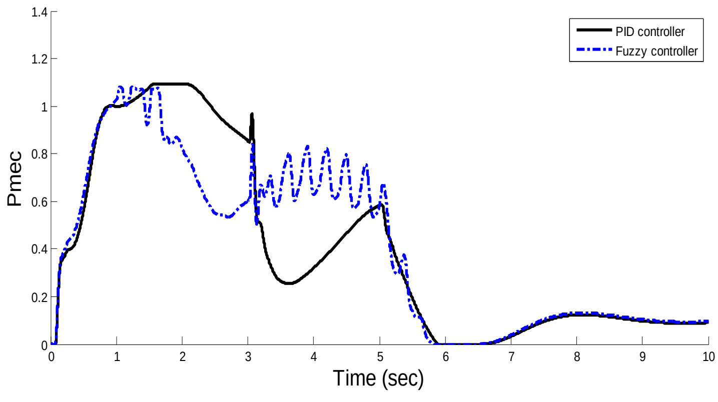

Figure 5: Mechanical power of synchronous machine

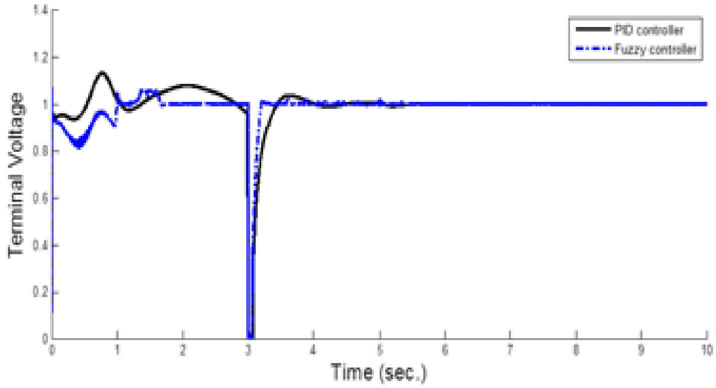

Figure 6: -Efficient voltage of system

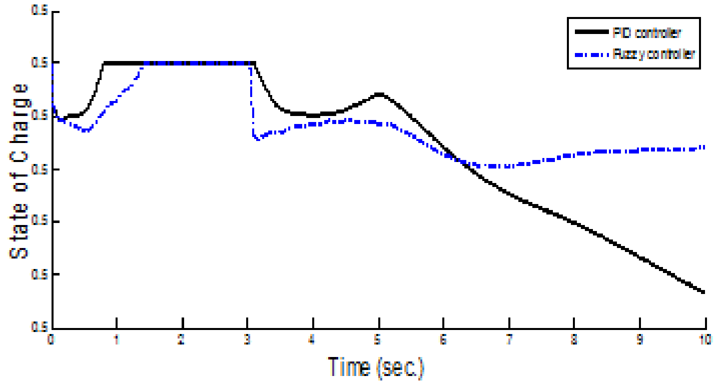

Figure 7: The rate of charge and discharge of battery

V. CONCLUSIONS

This paper proposes a novel method for network voltage control in an isolated power system including a hybrid system by using a fuzzy logic controller. Simulation results are performed and analyzed under different operating conditions. From the comparative study between the proposed controller and the conventional PID controller, it has been shown that the proposed FLC is very effective on the stabilization of network frequency in an isolated small power system. Therefore the proposed method can contribute to expand wind energy utilization into isolated power systems like small islands.

REFERENCES

[1] J. M. Guerrero, J. C. Vasquez, J. Matas, L. G. de Vicu˜na, and M. Castilla, "Hierarchical control of droop-controlled AC and DC microgrids—A general pproach toward standardization," IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 158–172, Jan. 2011.

[2] J. M. Guerrero, M. Chandorkar, T. L. Lee, and P. C. Loh, "Advanced control architectures for intelligent microgrids—Part I: Decentralized and hierarchical control," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1254– 1262, Apr. 2013.

[3] J. M. Guerrero, P. C. Loh, T. L. Lee, and M. Chandorkar, "Advanced control architectures for intelligentmicrogrids—Part II: Power quality, energy storage, andAC/DC microgrids," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1263–1270, Apr. 2013.

[4] J. He and Y. W. Li, "An enhanced microgrid load demand sharing strategy," IEEE Trans. Power Electron., vol. 27, no. 9, pp. 3984–3995, Sep. 2012.

[5] J. C. Vasquez, J. M. Guerrero, A. Luna, P. Rodriguez, and R. Teodorescu, "Adaptive droop control applied to voltage-source inverters operation in grid-connected and islanded modes," IEEE Trans. Ind. Electron., vol. 56, no. 10, pp. 4088–4096, Oct. 2009.

[6] Y. W. Li and C. N. Kao, "An accurate power control strategy for power electronics-interfaced distributed generation units operating in a low voltage multibus microgrid," IEEE Trans. Power Electron., vol. 24, no. 12, pp. 2977–2988, Dec. 2009.

[7] J. He, Y. W. Li, D. Bosnjak, and B. Harris, "Investigation and active damping of multiple resonances in a parallel-inverter-based microgrid," IEEE Trans. Power Electron., vol. 28, no. 1, pp. 234–246, Jan. 2013.

[8] R. H. Lasseter, "Microgrids", IEEE Power Engineering Society Winter Meeting, Vol. 01, pp. 305-308, New York, NY, 2002.

[9] J. A. P. Lopes, C.L. Madureira, "Defining control strategies for analysing microgrids islanded operation", in Proc. IEEE St. Petersburg PowerTech, St. Petersburg, Russia, 2005.

[10] A. Nagliero, R. A. Mastromauro, V.G. Monopoli, M. Liserre and A. Dell'Aquila, "Analysis of a universal inverter working in grid-connected, stand-alone and micro-grid", IEEE International Symposium on Industrial Electronics, Bari, 2010, pp. 650- 657.

[11] Mazheruddin H. Syed, H.H. Zeineldin and M.S. El Moursi, "Grid Code Violation during Fault Triggered Islanding of Hybrid Micro-grid", IEEE PES Innovative Smart Grid Technologies, Washington DC,2013, pp. 1-6.

[12] N. Hatzaiargyriou, H. Asano, R. Iravani, C. Marnay, "Micro-grids: An overview of ongoing research, development and demonstration projects", IEEE Power and Energy magazine, pp. 78-94, July/August 2007.

[13] Savage P.N., Robert R., Jamieson S.P., DC Microgrids: Benefits and Barriers, Yale School of Forestry & Environmental Studies, USA, 2010, p. 51-66.

[14] Specs K., Lave L., Demand Response and Electricity Market Efficiency, Carnegie Mellon Electricity Industry Center Working Paper, July 2007, p. 69-85.

[15] R. H. Lasseter and P. Paigi, "Microgrid: a conceptual solution," in Power Electronics Specialists Conference, 2004. PESC 04. 2004 IEEE 35th Annual, 2004, pp. 4285-4290 Vol.6.

[16] R. H. Lasseter, "MicroGrids," in Power Engineering Society Winter Meeting, 2002. IEEE, 2002, pp. 305-308 vol.1

[17] J. G. Slootweg, S.W. H. de Haan, H. Polinder, andW. L. Kling. Modeling wind turbines in power system dynamics simulations. In Power Engineering Society Summer Meeting, 2001. IEEE, volume 1, 22 – 26, Vancouver, Canada, 15-19, July 2001.

