

DESIGN & OPERATION OF DC GRID BASED WIND POWER GENERATION SYSTEM IN A MICRO GRID

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ABSTRACT: This paper introduces the plan of a dc lattice based breeze control age framework in a poultry cultivate. The proposed framework permits adaptable task of various parallel-associated wind generators by taking out the requirement for voltage and recurrence synchronization. Proposed fuzzy logic controller offers better transient reaction as for the adjustments in the working conditions is proposed for the control of the inverters. The outline idea is checked through different test situations to illustrate the operational capacity of the proposed microgrid when it works associated with and islanded from the dispersion lattice, and the comes about acquired are examined.

Key Words: Fuzzy logic controller, wind generators, microgrid.

I.INTRODUCTION:

Poultry farming is the raising of domesticated birds such as chickens and ducks for the purpose of farming meat or eggs for food. To ensure that the poultries remain productive, the poultry farms in Singapore are required to be maintained at a comfortable temperature. Cooling fans, with power ratings of tens of kilowatts, are usually installed to regulate the temperature in the farms [1-3]. Besides cooling the farms, the wind energy produced by the cooling fans can be harnessed using wind turbines (WTs) to reduce the farms' demand on the grid. The Singapore government is actively promoting this new concept of harvesting wind energy from electric ventilation fans in poultry farms which has been

implemented in many countries around the world [4]. The major difference between the situation in poultry farms and common wind farms is in the wind speed variability. The variability of wind speed in wind farms directly depends on the environmental and weather conditions while the wind speed in poultry farms is generally stable as it is generated by constant-speed ventilation fans. Thus, the generation intermittency issues that affect the reliability of electricity supply and power balance are not prevalent in poultry farm wind energy systems.

Many research works on dc microgrids have been conducted to facilitate the integration of various DERs and energy storage systems. In [5], [6], a dc microgrid based wind farm architecture in which each wind energy conversion unit consisting of a matrix converter, a high frequency transformer and a single-phase ac/dc converter is proposed. However, the proposed architecture increases the system complexity as three stages of conversion are required. In [7], a dc microgrid based wind farm architecture in which the WTs are clustered into groups of four with each group connected to a converter is proposed. However, with the proposed architecture, the failure of one converter will result in all four WTs of the same group to be out of service. The research works conducted in [8]–[10] are focused on the development of different distributed control strategies to coordinate the operation of various DERs and energy storage systems in dc microgrids. These research works aim to overcome the challenge of

achieving a decentralized control operation using only local variables. However, the DERs in dc microgrids are strongly coupled to each other and there must be a minimum level of coordination between the DERs and the controllers. In [11], [12], a hybrid ac/dc grid architecture that consists of both ac and dc networks connected together by a bidirectional converter is proposed. Hierarchical control algorithms are incorporated to ensure smooth power transfer between the ac microgrid and the dc microgrid under various operating conditions. However, failure of the bidirectional converter will result in the isolation of the dc microgrid from the ac microgrid.

II. SYSTEM DESCRIPTION AND MODELLING:

The overall configuration of the proposed dc grid based wind power generation system for the poultry farm is shown in Fig. 1. The system can operate either connected to or islanded from the distribution grid and consists of four 10 kW permanent magnet synchronous generators (PMSGs) which are driven by the variable speed WTs. The PMSG is considered in this paper because it does not require a dc excitation system that will increase the design complexity of the control hardware. The three-phase output of each PMSG is connected to a three-phase converter (i.e., converters A, B, C and D), which operates as a Rectifier to regulate the dc output voltage of each PMSG to the desired level at the dc grid. The aggregated power at the dc grid is inverted by two inverters (i.e., inverters 1 and 2) with each rated at 40 kW. Instead of using individual inverter at the output of each WG, the use of two inverters between the dc grid and the ac grid is proposed. This architecture minimizes the need to synchronize the frequency, voltage and phase, reduces the need for multiple inverters at the generation side, and provides the flexibility for the plug and play connection of WGs to the dc grid. The availability of the dc grid will also enable the supply of power to dc loads more efficiently by reducing another ac/dc conversion.

The coordination of the converters and inverters is achieved through a centralized energy management system (EMS). The EMS controls and monitors the power dispatch by each WG and the load power consumption in the microgrid through a centralized server. To prevent excessive circulating currents between the inverters, the inverter output voltages of inverters 1 and 2 are regulated to the same voltage. Through the EMS, the output voltages of inverters 1 and 2 are continuously monitored to ensure that the inverters maintain the same output voltages. The centralized EMS is also responsible for other aspects of power management such as load forecasting, unit commitment, economic dispatch and optimum power flow. Important information such as field measurements from smart meters, transformer tap positions and circuit breaker status are all sent to the centralized server for processing through wire line/wireless communication. During normal operation, the two inverters will share the maximum output from the PMSGs (i.e., each inverter shares 20 kW).

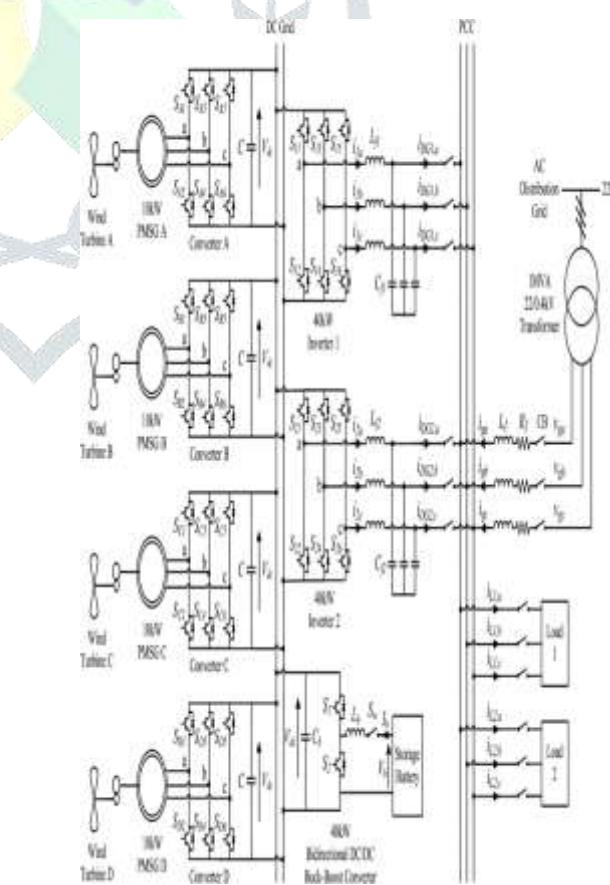


Fig.1. Overall configuration of the proposed dc grid based wind power generation system in a microgrid.

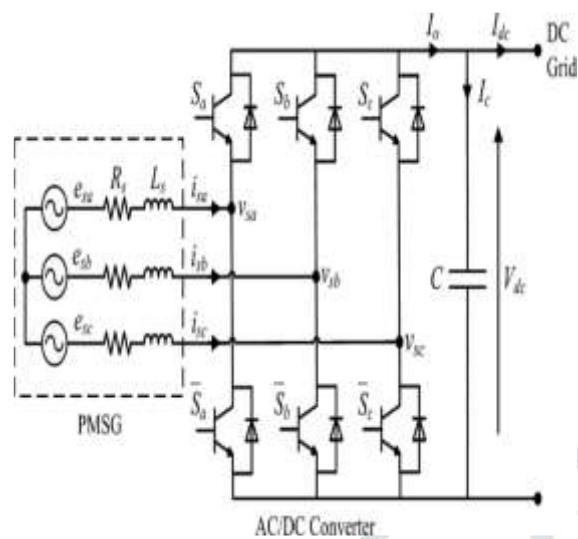


Fig. 2. Power circuit of a PMSG connected to an ac/dc voltage source converter.

III. Fuzzy Logic Controller:

L. A. Zadeh presented the first paper on fuzzy set theory in 1965. Since then, a new language was developed to describe the fuzzy properties of reality, which are very difficult and sometime even impossible to be described using conventional methods. Fuzzy set theory has been widely used in the control area with some application to dc-to-dc converter system. A simple fuzzy logic control is built up by a group of rules based on the human knowledge of system behaviour. Matlab/Simlink simulation model is built to study the dynamic behaviour of dc-to-dc converter and performance of proposed controllers. Furthermore, design of fuzzy logic controller can provide desirable both small signal and large signal dynamic performance at same time, which is not possible with linear control technique. Thus, fuzzy logic controller has been potential ability to improve the robustness of dc-to-dc converters. The basic scheme of a fuzzy logic controller is shown in Fig 5 and consists of four principal components such as: a fuzzification

interface, which converts input data into suitable linguistic values; a knowledge base, which consists of a data base with the necessary linguistic definitions and the control rule set; a decision-making logic which, simulating a human decision process, infer the fuzzy control action from the knowledge of the control rules and linguistic variable definitions; a de-fuzzification interface which yields non fuzzy control action from an inferred fuzzy control action [10].

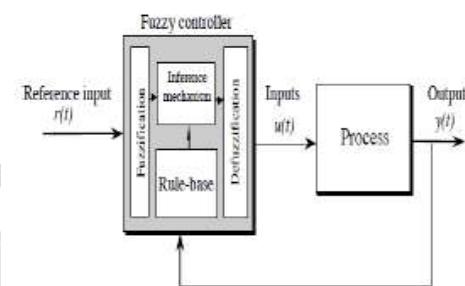


Fig.3. General Structure of the fuzzy logic controller on closed-loop system

The fuzzy control systems are based on expert knowledge that converts the human linguistic concepts into an automatic control strategy without any complicated mathematical model [10]. Simulation is performed in buck converter to verify the proposed fuzzy logic controllers.

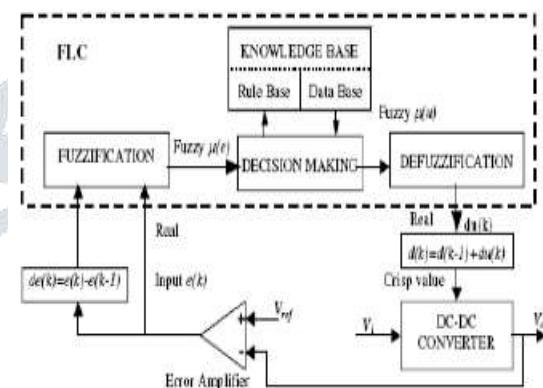


Fig.4. Block diagram of the Fuzzy Logic Controller (FLC) for dc-dc converters

A. Fuzzy Logic Membership Functions:

The dc-dc converter is a nonlinear function of the duty cycle because of the small signal model and its control method was applied to the control of boost converters. Fuzzy controllers do not require an exact mathematical model. Instead, they are designed based on general knowledge of the plant.

Fuzzy controllers are designed to adapt to varying operating points. Fuzzy Logic Controller is designed to control the output of boost dc-dc converter using Mamdani style fuzzy inference system. Two input variables, error (e) and change of error (de) are used in this fuzzy logic system. The single output variable (u) is duty cycle of PWM output.

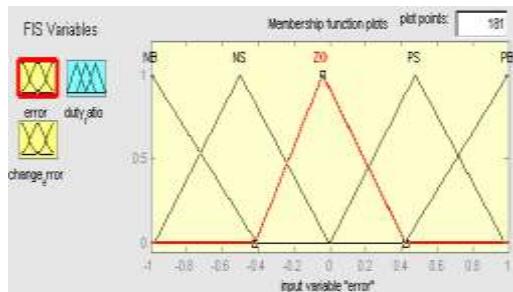


Fig.5. The Membership Function plots of error

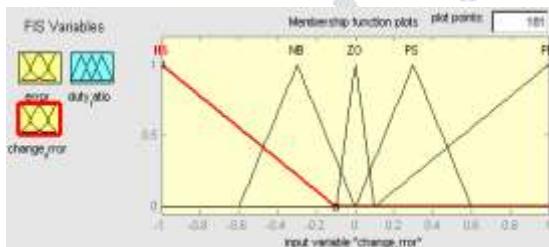


Fig.6. The Membership Function plots of change error

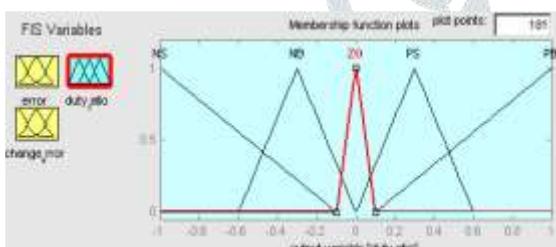


Fig.7. the Membership Function plots of duty ratio

error can be referred in the table that is shown in Table I as per below:

Table I
Table rules for error and change of error

(e) (de)	NB	NS	ZO	PS	PB
NB	NB	NB	NB	NS	ZO
NS	NB	NB	NS	ZO	PS
ZO	NB	NS	ZO	PS	PB
PS	NS	ZO	PS	PB	PB
PB	ZO	PS	PB	PB	PB

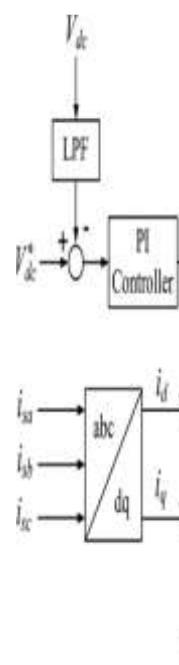
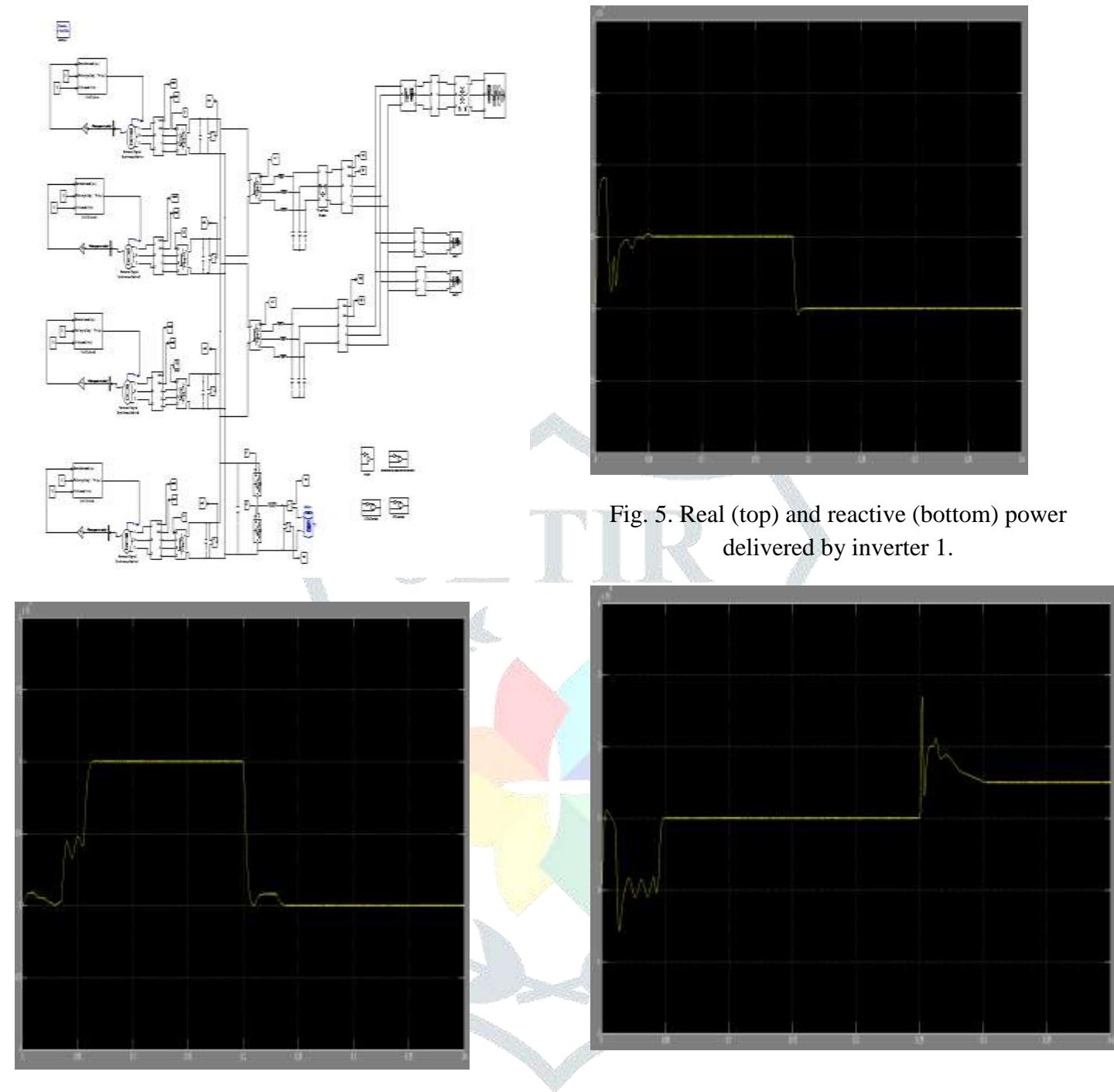


Fig. 8. Configuration of the proposed controller for the ac/dc converter.

IV. MATLAB/SIMULATION RESULTS:

B. Fuzzy Logic Rules:

The objective of this dissertation is to control the output voltage of the boost converter. The error and change of error of the output voltage will be the inputs of fuzzy logic controller. These 2 inputs are divided into five groups; NB: Negative Big, NS: Negative Small, ZO: Zero Area, PS: Positive small and PB: Positive Big and its parameter [10]. These fuzzy control rules for error and change of



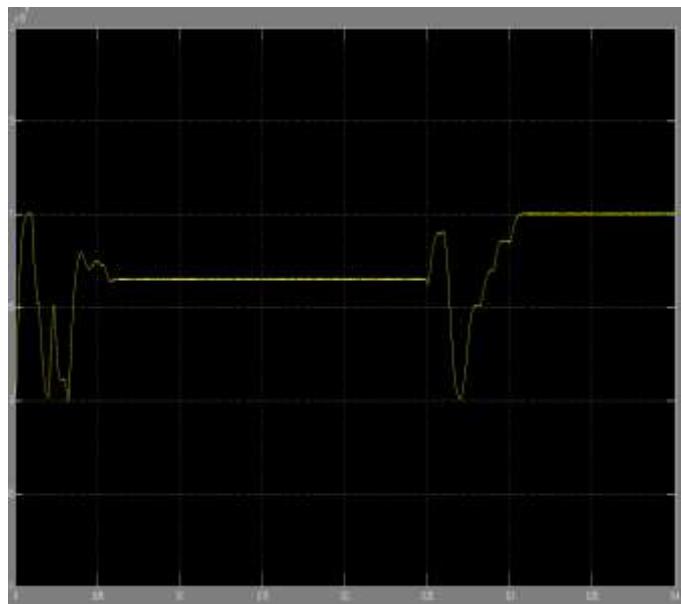


Fig. 6. Real (top) and reactive (bottom) power delivered by inverter 2.



Fig. 7. Real (top) and reactive (bottom) power delivered by the grid.



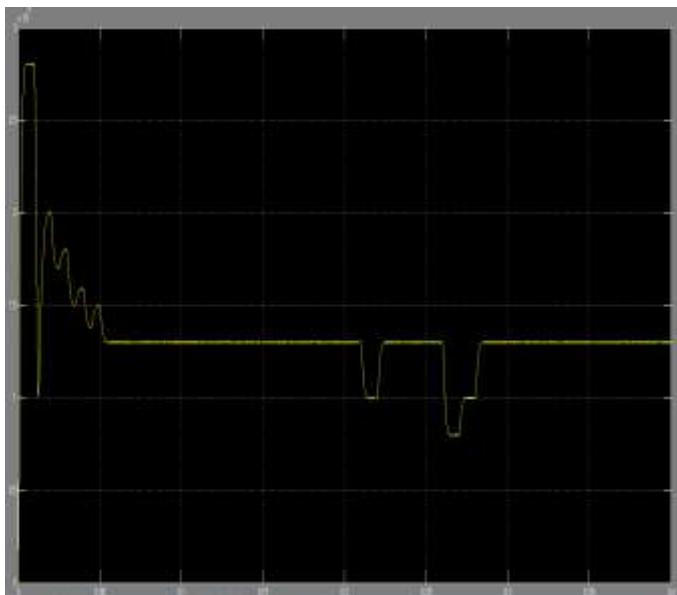


Fig. 8. Real (top) and reactive (bottom) power consumed by the loads.

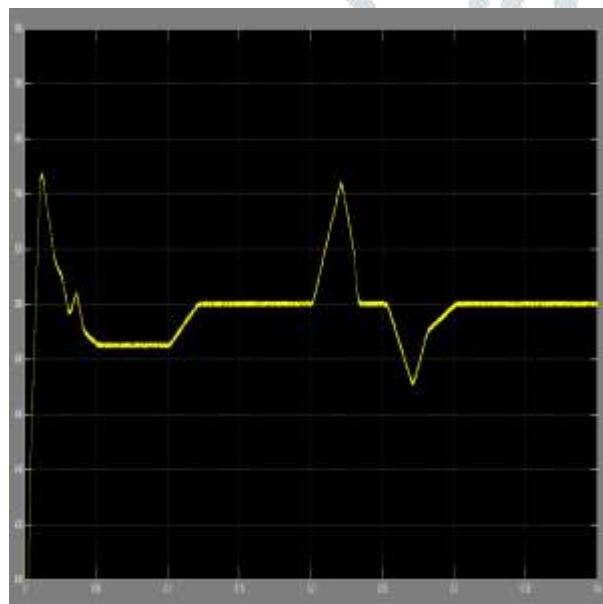


Fig. 9. DC grid voltage.

V. CONCLUSION:

In this paper, the design of a dc grid based wind power generation system in a microgrid that enables parallel operation of several WGs in a poultry farm has been presented. As compared to conventional wind power generation systems, the proposed microgrid architecture eliminates the need for voltage and frequency synchronization, thus allowing the WGs to be switched on or off with minimal disturbances to the microgrid operation. The design concept has been verified through various test scenarios to demonstrate the operational capability of the proposed microgrid and the simulation results has shown that the proposed design concept is able to offer increased flexibility and reliability to the operation of the microgrid. However, the proposed control design still requires further experimental validation because measurement errors due to inaccuracies of the voltage and current sensors, and modelling errors due to variations in actual system parameters such as distribution line and transformer impedances will affect the performance of the controller in practical implementation. In addition, fuzzy relies on the accuracy of model establishment; hence further research on improving the controller robustness to modelling inaccuracy is required. The simulation results obtained and the analysis performed in this paper serve as a basis for the design of a dc grid based wind power generation system in a microgrid.

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