Management Strategy of Hybrid Microgrid to Reduce Multiple Conversion

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***Abstract*—In the past few years, renewable energy sources (RES) demand has grown. Distributed generation based on wind, solar energy, biomass, microhydro become alternative power generation sources. Variation of the power generated by each source and the load that connected to microgrid system makes microgrid system become complicated. The application requires variation of power converter, like inverter, rectifier, boost, etc. Power converter is a power electronics equipment that is non linear, so the amount of power transformer equipment will increase the current and voltage harmonics on the microgrid system. This paper proposed management of hybrid microgrid. The concept introduces the reduction of multiple reverse conversions in an individual ac or dc microgrid and also facilitates connection to variable renewable ac and dc sources and loads to power systems. The model and simulation was built with Simulink/Matlab to verify the proposed system. Beside reduce the multiple conversion, DC and AC Microgrids can support each other, they operate togather and share surplus energy.**

Keywords— Hybrid Microgrid; Renewable Energy Source; Bidirectional Converter

I. INTRODUCTION

The conventional energy resources are depleting day by day. Soon it will be completely vanished from the earth so we have to find another way to generate electricity. The new source should be reliable, pollution free and economical. The alternative are using renewable energy sources (RES) like geothermal, tidal, wind, solar etc. Some RES has many drawbacks, like tidal energy that can only implemented on sea shores and geothermal energy that needs very larger step to extract heat from earth.

Among the various types of RES, solar energy and wind energy have become the most promising and attractive, because it has simple way to generate.

Indonesia is a country with abundant renewable energy resources. The existence of Indonesia on the equator provides the opportunity for sun shines all year round. Microhydro, wind and tidal are few types of renewable energy that has great potential to be developed. Even their potential, solar energy has drawback that it could not produce electrical energy in rainy and cloudy season so we need to overcome this drawback we can use two energy resources so that any one of source fails, other source will keep generating the electricity. And in good weather condition we can use both of them. The combination between two or more kind of energy ac or dc source named hybrid microgrid system.

Based on the power generated by RES makes hybrid microgrid system becomes complicated, because it contains varying load type. The application requires many power converters[1]. Power converter is a power electronics equipment. That is non linear, so the application amount of power converter equipment not only will increase the harmonics in the microgrid system but olso expensive. This paper proposed management of hybrid microgrid. The aim of this management is to reduce multiple conversion.

II. HYBRID MICROGRID SYSTEM

A. Hybrid Microgrid Systen

Hybrid microgrid system are system that generate energy from two or more raw energy source and units that contribute to each ather correspondingly. The aim of hybrid systems is to increase capacity and to cover an existing shortfall. There are many advantages of hybrid power generation systems. These advantages can be listed as below[2].

- The possibility to combine two or more renewable energy source, based on the natural local potential of the users.
- Environmental protection especially in terms of CO2 emission reduction.
- Low cost – wind energy, and also solar energy can be competitive with nuclear, coal and gas especially considering possible future cost trends for fossil and nuclear energy.

- They provide diversity and security of supply.
- They provide rapid deployment – modular and quick to install.
- The fuel is abundant, free and inexhaustible.
- Cost are predictable and not influenced by fuel price fluctuations

The universal hybrid microgrid is shown in Fig. 1

B. Interfacing Converter Management

In the generator sector, many distributed energy resources, such as PV that generate dc power. Many modern electrical loads, as well as energy storage systems, are either internally dc or work equally well with dc power and connect to the ac system through converters. That's way, converter become the most important power electronics device. This device will connect the power source to the load, distribution device or storage devices such as batteries or flywheel.

For microgrid with dc output power such as PV and fuel cell, the interfacing converters can be classified as single-stage and double stage configuration [3]. These configuration shown in Fig. 2

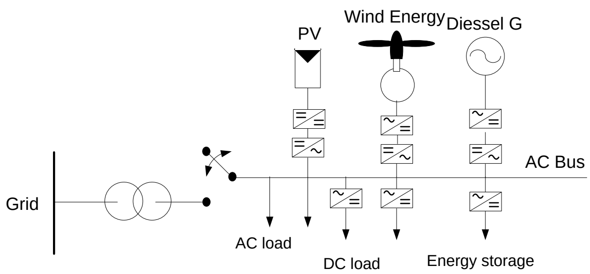

Fig. 1. Distributed AC bus architecture of hybrid microgrid

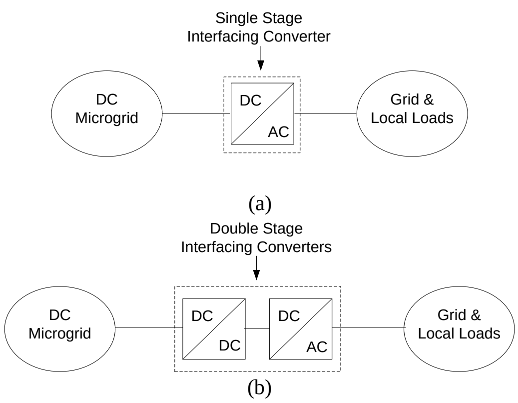

Fig. 2. Power electronic interfaces for microgrid with dc output powers (a) Single stage dc-ac interfacing converter (b) Double stage dc-dc and dc-ac interfacing converter

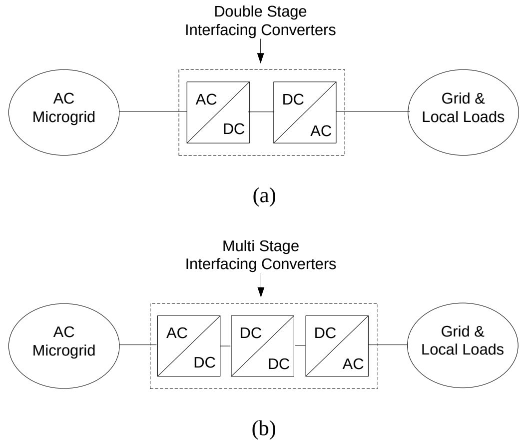

Fig. 3. Power electronic interfaces for microgrid with ac output powers (a) Double stage ac-dc and dc-ac interfacing converter (b) Multi stage ac-dc, dc-dc and dc-ac interfacing converter

The double stage topology is the traditional solution. In this topology, the first stage dc-dc converter is mainly used for two purposes, as boost the dc link voltage and control microgrids output power with maximum power point tracking (in PV) or maximum efficiency operation (in fuel cell). The second stage dc-ac converter can work on dc bus voltage control mode, or output power current control mode depending on different control requirements.

On the other hand, the single-stage topology is becoming more popular in recent years. It features higher efficiency with less power electronics converter and power conversion process. However its drawback include compromised control flexibility and limited operating range.

Moreover, this topology needs an overrated inverter and high dc output voltage from microgrid [4]. Multilevel converters have been increasingly used in the single-stage topology with better dc voltage utilization and output power quality.

In microgrid with ac output power such as wind turbine or microturbine, the power electronic interfaces can be classified as double stage or multi-stage converters as show in Fig. 3. In the double stage converters, the front-end PWM rectifier is usually used, and dc bus voltage is controlled by this rectifier. While in multi-stage topology, lower cost diode rectifier can be used, and dc-dc converter controls dc bus voltage. From cost point of view, the multi-stage topology could be more cost effective although it has low efficiency in comparison to two-stage topology [5].

C. Reducing Converter Strategy

This paper developed a new hybrid microgrid system based on the power generated. The scenario is using two distributed buses, ac bus and dc bus, by grouping of power generated with the same type of load. Mean dc RES will localize with dc load and ac RES is locallize with ac load. With this strategy every load that added in hybrid microgrid will connect with

The similar bus, they no need converter again to change the power. The purpose to maintain the stability of the hybrid microgrid used bidirectional converter. This equipment connecting dc bus and ac bus. The bidirectional converter can works as a rectifier or inverter as needed, so that if there is a bus that requires power, it can be supplied from another bus without need to add converter again. The system built can be ilustrated in Fig. 4.

III. Voltage Control Method

The output voltage of DC and AC microgrid are maintained constant at a certain value. Stable voltage makes equipment is not easily damaged. Voltage control is needed to maintain voltage stability. The basic block diagram of the voltage control method is shown in Fig. 5

Voltage control method of microgrid converter uses the output voltage as the control signal which produces voltage in the same frequency and phase angle with the grid voltage. The reference voltage, V_{ref} is obtained from oscillator that is synchronized to the grid voltage. The converter output, V_C is filtered with LC filter and used as feedback signal. The magnitude of the reference voltage and V_C is fed to a summing point, resulting in an error signal, V_{error}. Through PI controller the V_{error} controlled and multiply with generated sinusoidal signal. The modulated sinusoidal signal is comparing with triangular carrier signal to produce a pulse width modulation signal for getting the full bridge IGBT's. When the converter magnitude is lower or higher then the reference, the width of the PWM pulse will be changed accordingly until the error signal is minimized. It means the output voltage of the converter is maintained constant with respect to the reference voltage.

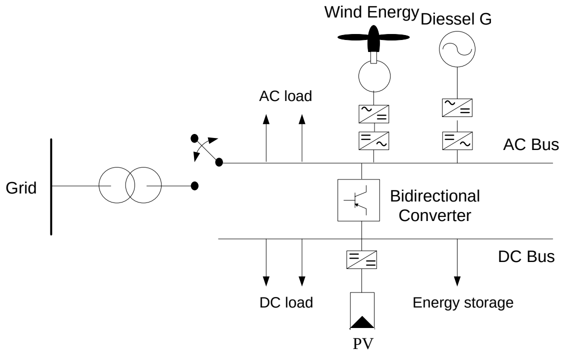

Fig. 4. Distributed AC – DC bus architecture of hibrid microgrid

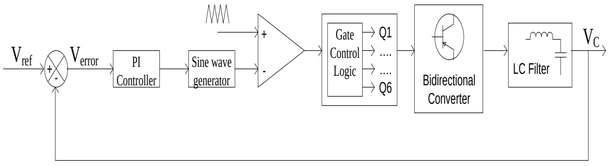

Fig. 5. Basic block diagram of the voltage control method

IV. Simulation and Result

Simulation was performed using Simulink/Matlab. The system was built with two sources, DC and AC. DC sources represent DC microgrid so did the AC source that represents AC microgrid. In DC system, voltage were setting on 300V and the first load 1 kΩ plus 10 kΩ in parallel when 0,65 mili second. In AC system voltage were setting on 380V and the first load 2,5 kΩ plus 20 kΩ in parallel when 0,65 mili secon until 1,35 mili second.

In isolated simulation the respond in dc and ac currents are describe in Fig. 6. While ac and dc system connected by bidirectional converter, the response is shown in Fig. 7. During simulation the system connected to grid in 1,35 mili second. This connection makes fluctuation in dc current and ac current.

In Fig. 8 shown voltage and current in grid during simulation. voltage is reduced when the grid is connected to the system, another case with the current grid, it is highly increased.

In Fig. 9 shown voltage and current in ac source, the voltage controlled by the converter and the current increased when the second load added in the system. The grid connected does not influence the ac source voltage and current.

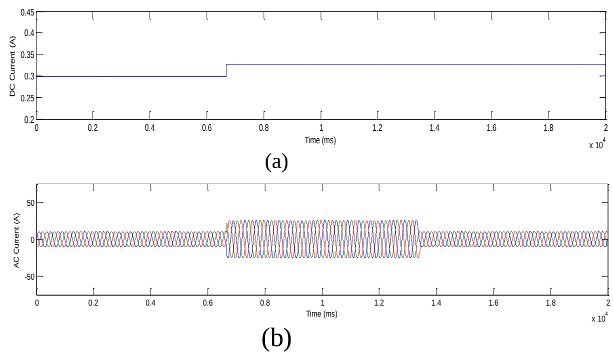

Fig. 6. Isolated Current (a) DC current (b) AC current

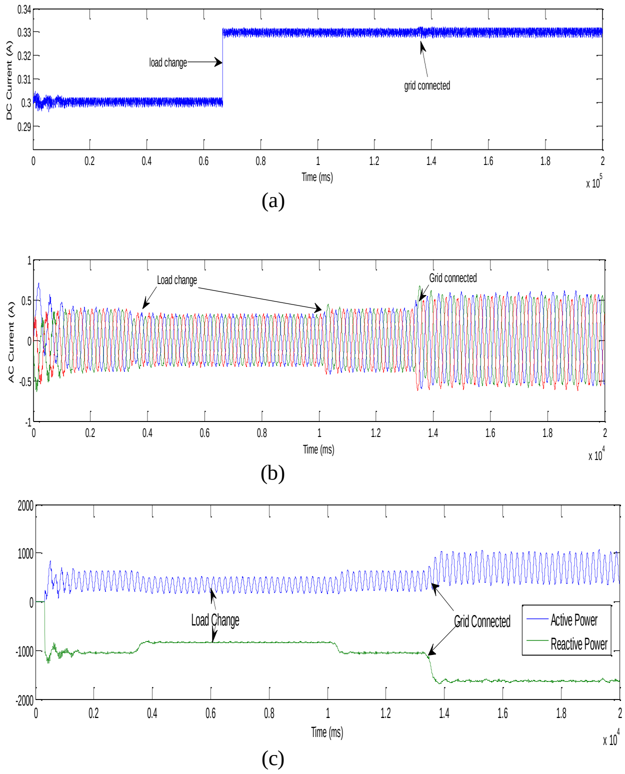

Fig. 7. Connected by bidirectional converter and grid (a) DC current (b) AC current (c) AC power

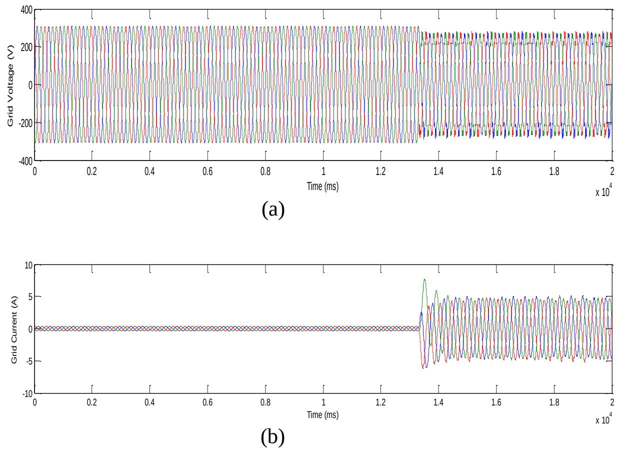

Fig. 8. Grid (a)Voltage (b) Current

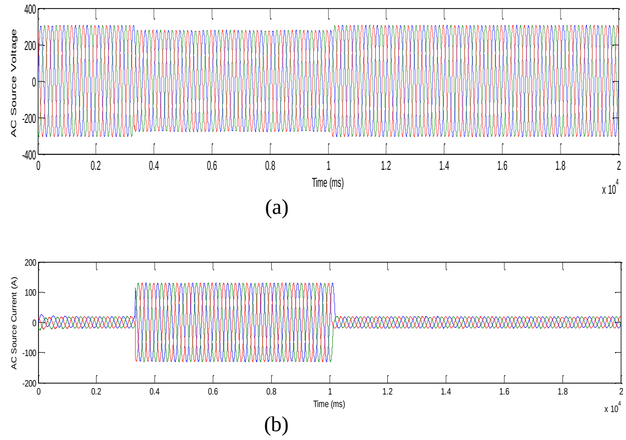

Fig. 9. AC Source (a) Voltage (b) Current

V. CONCLUSION

A new hybrid microgrid is proposed and briefly studied. The simulation result show that using two bus (ac and dc) system can reducing multiple converter. This is because load connected to the similar bus. The connection between ac and dc bus using bidirectional converter is running well. Stable ac and dc bus voltage can guaranteed when the operating condition or load capacities change and grid connected, beside that function the bidirectional converter ensuring the security of energy supply.

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