Design of PV in Microgrid as Energy Source and Control Method Using MATLAB/SIMULINK: 1st ICRIL-International Conference on Innovation in Science and Technology (IICIST 2015)

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Abstract

Microgrid in power system has drawn attention widely for the major benefits in recent years. It is the most economical alternative to conventional energy system which uses Renewable Energy (RE) resources. RE sources ensure pollution free and clean environment by emitting zero CO_2. In this paper, a microgrid system using solar photovoltaics (PV) as the Distributed Energy Resources (DERs) and a controlling method for managing the components of microgrid are designed using MATLAB/SIMULINK. The results show that microgrid system is able to become as an alternative energy to replace the fossil fuel based energy system. Also by integrating an effective controller that able to manage the loads and the resources the system is more stable and reliable.

Keywords. Microgrid; Distributed Energy Resources; Photovoltaic; Controller

1 Introduction

Electricity demand is increasing rapidly with the high growth rate of populations. The development in technologies worldwide is also another key factor for high increase in electricity demand. For these reasons, fossil fuels are degrading acutely. Meanwhile, use of carbon based fuels cause harmful effect on environment. Therefore, Microgrid system introduces a solution by using renewable energy sources. This is a very promising alternative of traditional declining energy sources and responsible for cleaner earth by reducing carbon emission also being economic friendly [1-5]. The aim of this project is to design a high performance Microgrid system by integrating DERs and an automated controller.

1.1 Architecture of Micro-grid (MG) System

Typically, microgrid EMS/SEMS can be referred as a system which is able to coordinate and operate loads, a range of Distributed Generators (DGs), Distributed Energy Storages (DESs) etc.[1]. Scenario of a typical MG is shown in **Figure 1** where main components are solar PV, wind turbine, inverters, critical loads, non-critical loads, battery.

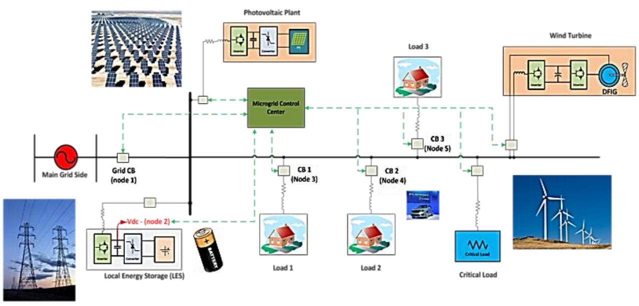

Figure 1: Architecture of Microgrid with multiple DERs, batteries, critical load, noncritical load, PCC, Utility grid [2].

Generally, power system of a microgrid consists of a low voltage distributed network that includes different DERs (i.e. solar photovoltaics, wind turbine, fuel cell, biomass energy etc. and sometimes few non-renewable sources), energy storage module, power forecasting module, power converters, controller units, communication network etc. [3-7]. The RE resources are abundant and available freely as well as environmental friendly **[8]**. In this paper solar photovoltaics are used as energy source for the microgrid.

1.2 Microgrid Controlling System

In microgrid system operation, monitoring, controlling and optimization are some of the technical sectors which need to be fulfilled for a making it reliable and more effective[9]. A controller for the system is needed for balancing energy as well as the loads within a very short time period and for cost effective operation [10]. This paper presents a central controller system for microgrid which is adopted and improved from [11].

2 Methods

The PV generating system and the controller are designed using MATLAB/SIMULINK and the configuration is as in **Figure 2**. The Simulation is performed to identify the effectiveness of the designed controller. Microgrid will be designed using three DERs such as Solar PV, Wind Turbine and Fuel Cell. However, only PV is used in this simulation. There are three operating modes in microgrid [10]:

i. Grid connected mode (Normal mode)
ii. Islanded mode (When faults occur at Main grid)
iii. Transition between grid connected and islanding mode.

Here, islanded mode operation in considered in order to understand the role of the controller. Some critical (i.e. hospital) and non-critical loads (electrical vehicle, residential) are selected as the first type of continuous loads supplied. On the other hand, the non-critical loads which are connected to the microgrid through circuit breakers (CB) can be ignored during the peak time. This situation is applied (non-critical loads disconnect) when the generated power by solar PV is less than the demand in the microgrid. The controller is measuring the AC voltage that having the same voltage level at Point of Common Coupling (PCC).

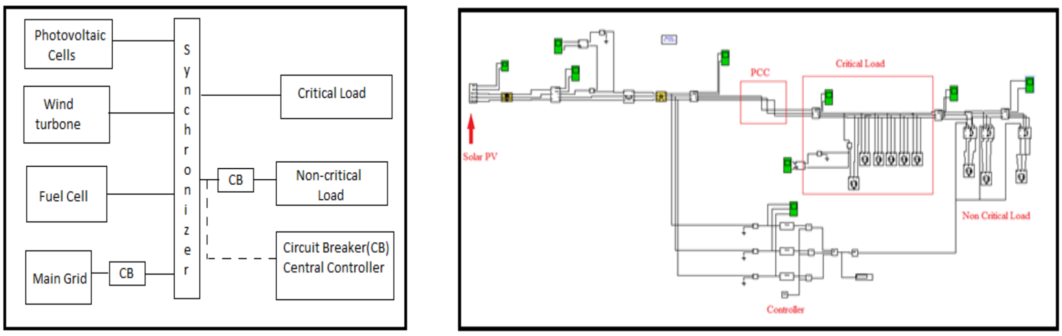

Figure 2 : Block diagram of a microgrid with central controller[11] (Left) and proposed Microgrid system designed in SIMULINK using PV with controller (Right).

3 Results and Discussion

In the simulation, during the period when generated output power by PV is more than load demand the line voltage at the PV side and load side is set at 415V [11]. When the total power produced by the MG is less than the total load, the voltage and current levels at PCC, critical and non-critical load conditions are shown in **Figure 3 to Figure 6.**

In the case of without controller, the voltage level at PCC, critical and non-critical load side has been reduce by 25% and this is due to less output power than the load demands (refer **Figures 3** and **4**).

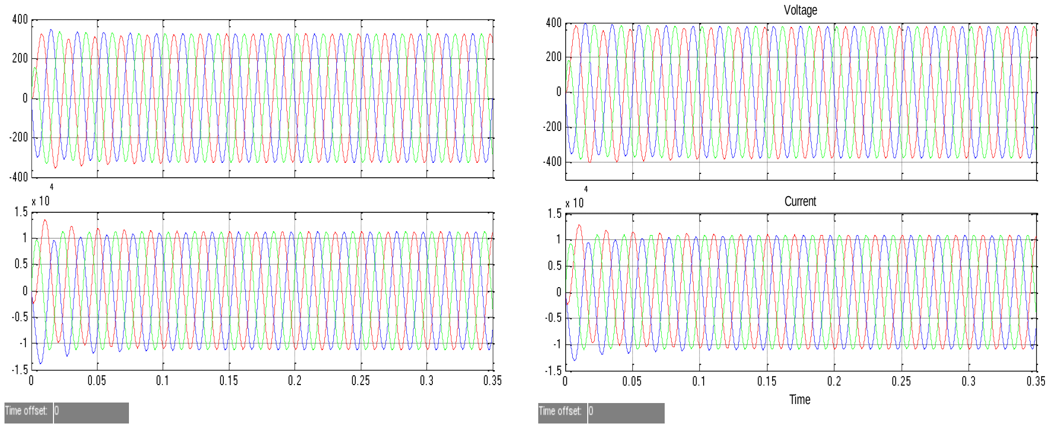

Figure 3: Voltage (top) and current (bottom) signals at PCC (in left side Line voltage dropped below 400V and in right side Line voltage increased to 400V after using the controller).

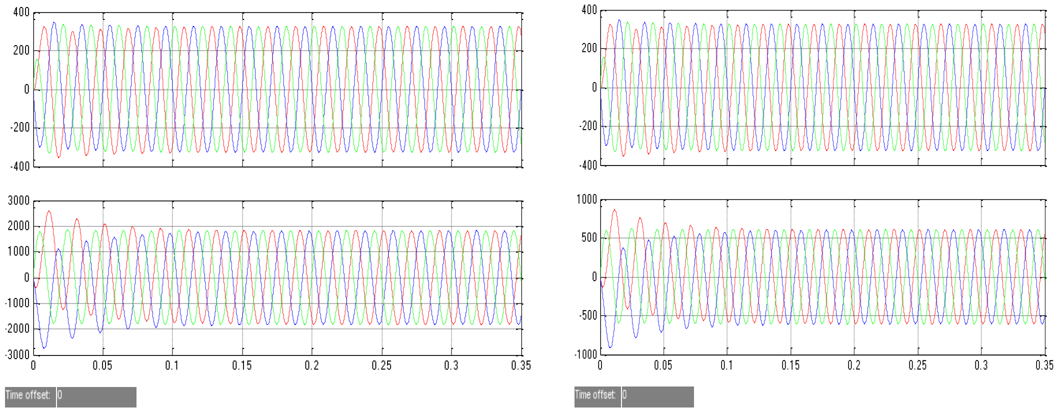

Figure 4: Voltage and current signals at critical load side (left) and at non-critical load side (right) (Line voltage dropped below 400V).

For the case when the controller is in operation, as the power level is less than demand, the controller will instruct the circuit breakers for non-critical loads to be disconnected. This will maintain the voltage level that supplying the critical loads. The controller compares in RMS value of voltage signals as in **Figure 5** at PV side. **Figure 6** indicates the current flow for the non-critical load is zero meaning that it was disconnected. In addition, when the RMS value is below 300V, the controller will cuts off the non-critical loads and all the power is being delivered to critical load hence the voltage level is increased again. This means the controller sense the RMS voltage is below threshold level (the set point is 300V).

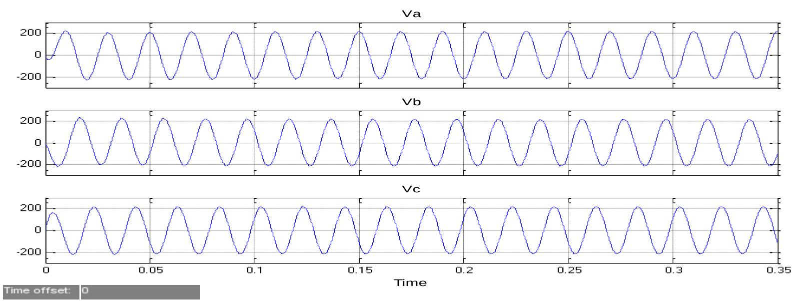

Figure 5: Three phase Voltage (RMS) values in MG side.

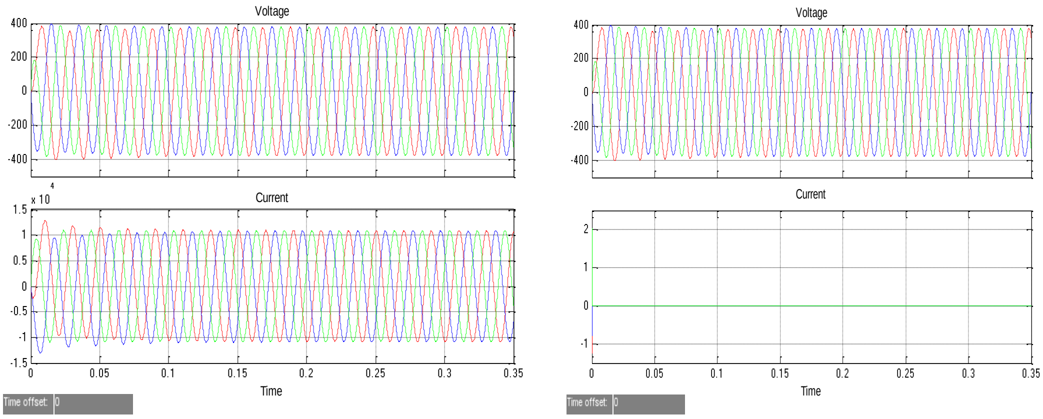

Figure 6: Voltage and current signals at critical load side (left) and at non-critical load side (right). Line voltage increased to 400V. But line current is zero at non-critical load side.

4 Conclusion

The simulation on the microgrid system that uses DERs (PV) with and without controller employing critical and non-critical loads has been presented. Continuous power supply to the critical loads and disconnecting the non-critical loads when the voltage level in microgrid side is lower than the threshold level is maintained effectively by the controller. Further study will be focused on controlling MG at Grid failure period (in grid connected mode) using all three DERs such as solar PV, wind turbine and fuel cell.

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