Modelling and simulation of off-grid microgrid using Matlab/Simulink

Conference Paper · November 2023

CITATIONS
0

READS
1,656

2 authors, including:

Abdel Djabar Bouchaala
University of Skikda
2 PUBLICATIONS **4** CITATIONS

SEE PROFILE

Modelling and simulation of off-grid microgrid using Matlab/Simulink

Abdel Djabar Bouchaala [1], Ahcene Boukadoum [1]
bouchaalaabdeljabar@gmail.com boukadoum2003@yahoo.fr

[1]Department of Electric al Engineering, Laboratoire d'électrotechnique de Skikda «LES», Université du 20 Août 1955, Skikda 21000, Algeria

Abstract – Microgrid energy system is considered part of the main electricity network system, it can be alone isolated from the main grid, which we see on the islands, in an area far from the electricity network, or in an industrial area. Microgrids generally consist of sub-sources such as wind energy, solar energy, or a diesel generator. Microgrid (MG) is classified into two types: On-Grid or Off-Grid. This paper presents the modelling and simulation of the MG Off –Grid .The components of the system consists the photovoltaic array and wind turbine with battery storage system are connected the variable and fixed loads . The photovoltaic (PV) power generation is connected by the boost converter (DC/DC) and the bus direct continue DC ,the output power is taken by regulator maxim power tracker MPPT. The wind turbine (WT) is connected by the inverter (AC/DC) and the bus (DC) .the battery storage system (BSS) is related with conventional power bi-directional buck-boost converter (DC/DC) . The results obtained gave good results in the flow of power between the different sources and loads it gave, using the Matlab/Simulink .

Keywords: Microgrid, Photovoltaic, Wind turbine ,battery storage system ,Matlab /Simulink.

I. Introduction

Today, the world is preparing new changes in the consumption of electrical energy. This is due to the different of sources of production and consumption of electricity. This diversity has led to an increase in the need for clean energy which allowed researchers to develop the exploitation of energy sources represented by the integration renewable energy source [1].

The most common renewable energies are solar photovoltaic energy and wind energy, and this is due to the availability of the radiation solar and the constantly increasing wind speed in various regions of the Earth[2,3], It can be used in a microgrid depending on the consuming region, the reasons for resorting to clean energy have played a major role in the rapid development in the field of distributed renewable energy Resource DRR) [4]. Integration renewable energy sources into the energy supply system has faced difficulties because they are not sustainable due to climate challenges. To meet the challenges, a storage system was created [5].

The microgrid is divided into two parts. The first part is connected to the main electrical grid and is called On Grid. It represents the connection of the renewable energy source with the grid using the electrical control switch for distribution generators (DGs) and the energy management system (EMS). The second part is disconnecting from the main grid, or off-grid, which we see in isolated islands and areas far from the main network[6,7]. Microgrid energy sources can be used to distribute energy at different voltage levels such as medium voltage (MV) and low voltage (LV). The importance of microgrid lies in exploiting renewable energy sources such as wind energy, solar energy, fuel cells, etc.

Research suggests many researches on microgrid modeling and simulation. Ahmed Al-Zahrani and al. System of Systems (SoSs) and building new models that capture the dynamic behavior of the microgrid. A practical example from Missouri S&T [8] was implemented and simulated. Modeling and simulation of a vehicle-to-grid (V2G) system within a microgrid taking into account the requirements of the different components of the microgrid system that relies on the control and scheduling of charging and discharging of electric vehicles (PEVs) and PEVs by the charging station and as described in [9] . Modeling and simulation model for grid-connected AC/DC hybrid microgrid. The system consists of a wind turbine, a small gas turbine, a photovoltaic cell, a fuel cell, and a super capacitor for energy storage using Matlab/Simulink software [10]. This paper presented simulation and power management in a DC microgrid model [11].

In this paper, off-grid microgrids provide modelling and simulation of all components - a microgrid using a renewable energy-based power generation system consisting of a photovoltaic array, a wind turbine (WT), electronic energy inverters of a battery storage system (ESS), and local loads shown in Fig1. The paper discusses detailed modelling of a microgrid served by a PV energy storage system and a wind turbine/battery. The PV array is connected to a DC bus via a boost converter to enhance the PV output using a maximum power point (MPPT) controller. The wind turbine is connected to the DC bus by an AC/DC rectifier, the output power WT depends on the wind speed, the wind turbine is connected to a permanent magnet synchronous generator (PMSG), the battery is connected to the

common DC bus by a DC/DC buck boost converter, and it is charged and discharged. Depending on the nature of the energy produced and consumed in the system. The proposed model of power management and microgrid components was simulated using Matlab/Simulink software. The simulation results showed significant results in good energy distribution in our proposed system**.**

II. Microgrid Proposed system

The microgrid modelling components of this system contain two sources of renewable generation, namely photovoltaic systems, wind turbines, battery storage, loads, and all components associated with power converters. The PV source is connected to the DC bus by the power converter represented by the boost converter DC/DC, and the wind turbine is connected by the DC bus connected by the AC/DC rectifier. Battery banks connected to a buck boost converter and connected to a DC bus are charged and discharged. Power generation loads are received from system sources only and connected to an inverter (DC/AC). Fig. 1 below depicts simplified block diagram of the proposed microgrid (DC/AC). Fig. 1 below depicts simplified block diagram of the proposed microgrid.

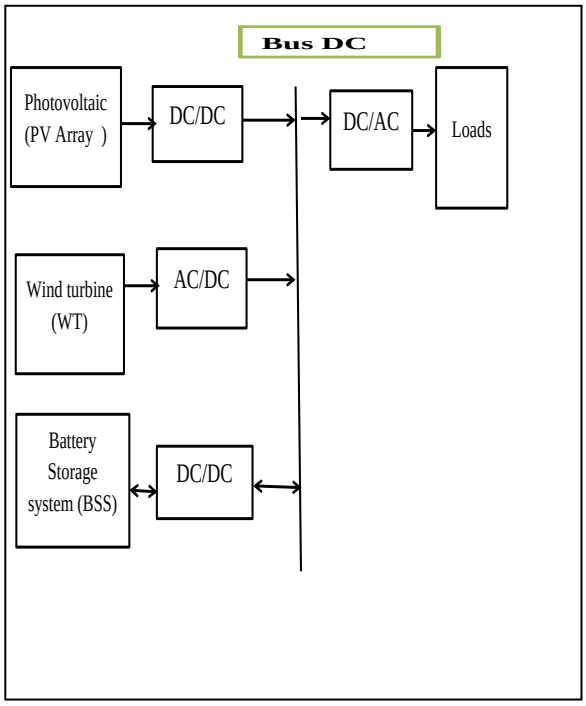

Fig1.Block diagram of the proposed system

The power produced in the maximum power distribution generations is considered the maximum power point tracker for photovoltaic generation (MPPT) is about 10 kW, the wind turbine is produced about 6.8 kW and the battery storage energy is discharged about 6 kW. The load consumption ranges between 10 and 14 kilowatts.

The table blow describe the value maximum power generation in the microgrid

Table. The value maximum power generation in microgrid

The type of source the energy	Value of maximum power generation
Photovoltaic energy	10 kw
Wind turbine energy	6.8 kw
Battery storage energy	6 kw
Load consumer energy	Fixe ;10kw and variable 4kw

II. Modeling and simulation of Microgrid system components

The components of the specified system are designed using Matlab/Simulink software.

III.1.Modeling of the proposed photovoltaic generation the system

The Simulink model is shown in this (Fig.2) and consists of two PV power generation models connected in parallel and connected to a single-phase protection diode with the addition of changing variable and fixed radiation.

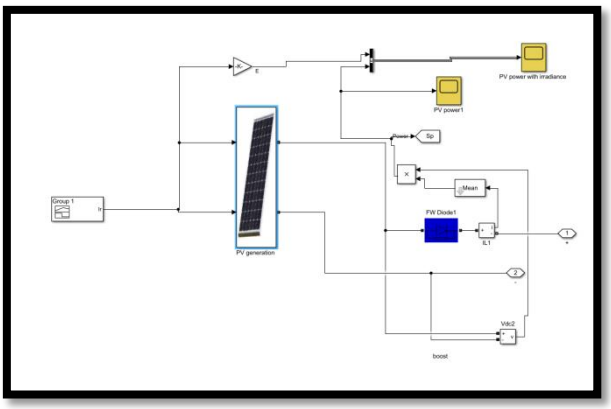

Fig .2.The proposed photovoltaic generation the system

III.2.Modeling of the proposed wind turbine generation the system

The wind turbine model is presented by group variables, where the input variable is the generator speed in unit and the controller is the blade pitch angle (beta) in degrees, and the wind speed in m/s. The variable output is the applied torque of the generator in per unit. Wind turbines convert kinetic energy into mechanical energy and thus produce mechanical energy according to a set of mathematical equations [12]. The permanent magnet synchronous generator (PMSG) relies on the output of high torque wind turbines, and there is a need to model and control the PMSG based on variable speed wind turbines [13]. The proposed model of a wind turbine at Simulink is shown here (Fig.3)

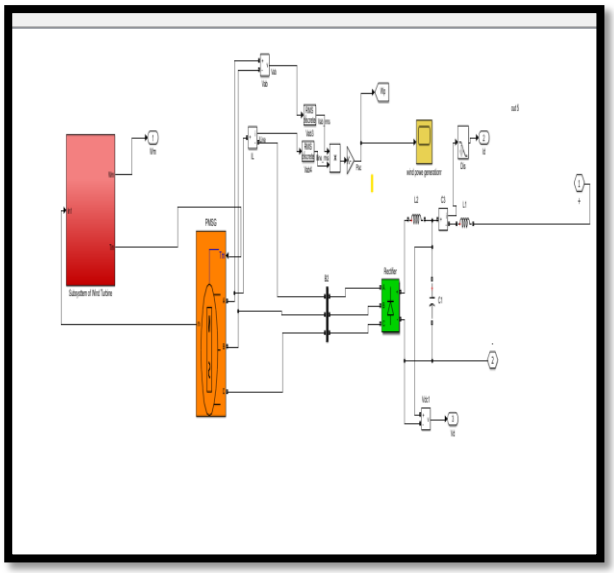

Fig 3.The proposed wind turbine generation the system

III.3. Modelling of the proposed battery energy system

Battery storage energy system is important in microgrid and we have introduced our Nicle Metale battery type system with parameter display of nominal voltage, rated capacity, battery response time and initial state-of charge. The battery change is charged and discharged by the flow energy source. The battery is connected to a bidirectional DC-DC converter. Battery energy storage system models Due to the stability of the microgrid, many models have been proposed in order to improve and stabilize the energy well in the microgrid, taking into account the stability of voltage, frequency, and total harmonic distortion [14]. In this (Fig. 4) details of the proposed battery power system are shown power system are shown

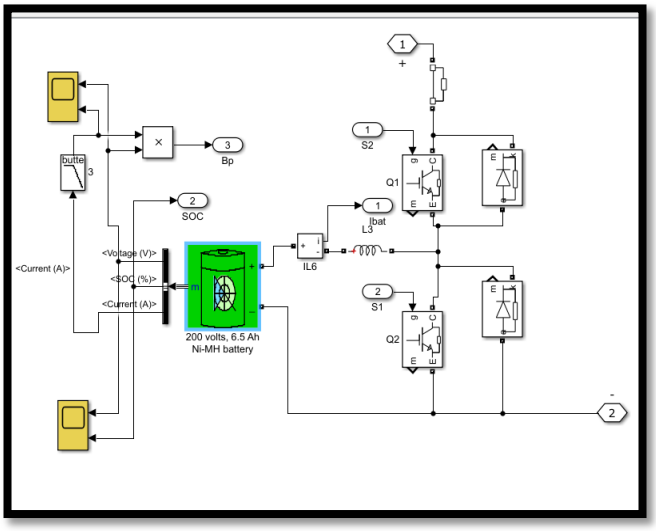

Fig .4. The proposed battery energy system

III.4.The Load proposed of the system

The loads in our system are divided into two parts: fixed load and variable load. The loads presented are considered three-phase in order to measure sinusoidal current and voltage. The loads are connected to the DC bus using a three-phase inverter (DC/AC).

III. Simulation results of the components of the Microgrid system

After the simulation of the components of microgrid We get different curves, which are: Photovoltaic power produced in shown (Fig.5) and the power generation of wind turbine in (Fig.6), the battery storage is charged and discharged in the form of current and output voltage curves for a battery shown in (Fig.7). The three-phase sinusoidal current and voltage profile for the loads is shown in (Fig.8 &Fig.9).

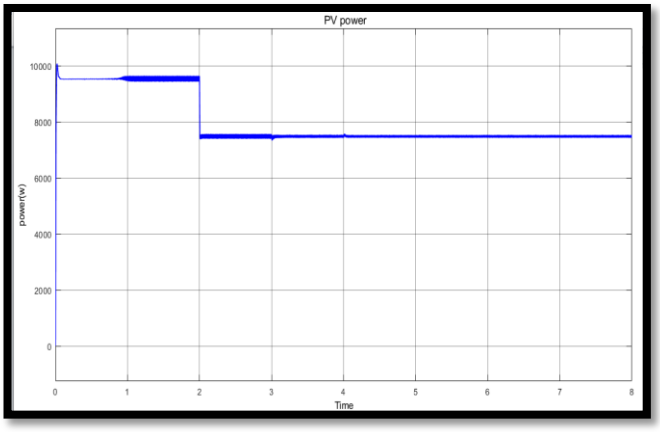

Fig.5. The output Power of photovoltaic

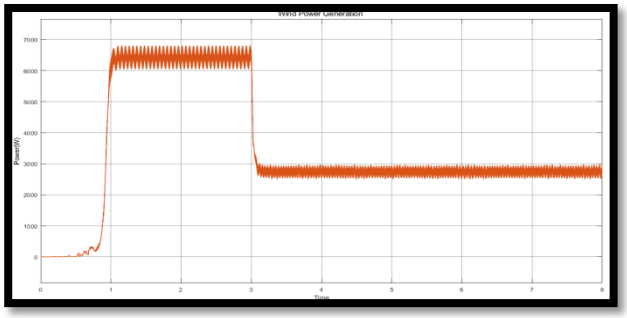

Fig.6.The output Power Wind Generation

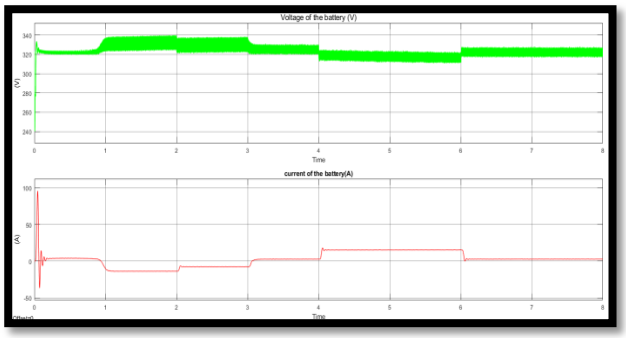

Fig.7.Current and voltage format for charging and discharging the Battery

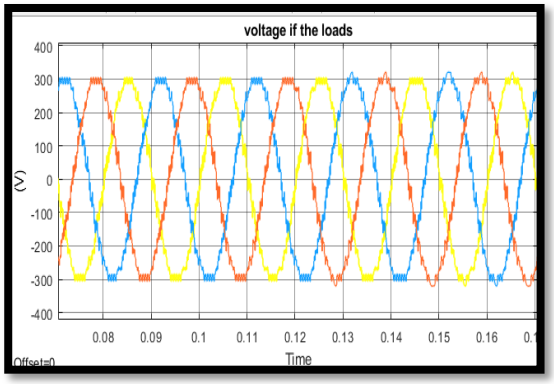

Fig.8 . The voltage of the loads

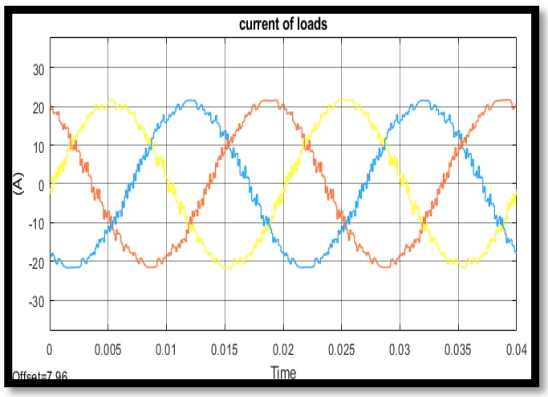

Fig.9. The current of the loads

V. Simulink model of the complete components of a small off-grid system

This model summarizes the entire components in off-grid mode. In this (Fig.10) the embedded components are designed using Matlab/Simulink. They include the integration of wind energy and photovoltaic energy in addition to this battery storage system to feed the loads.

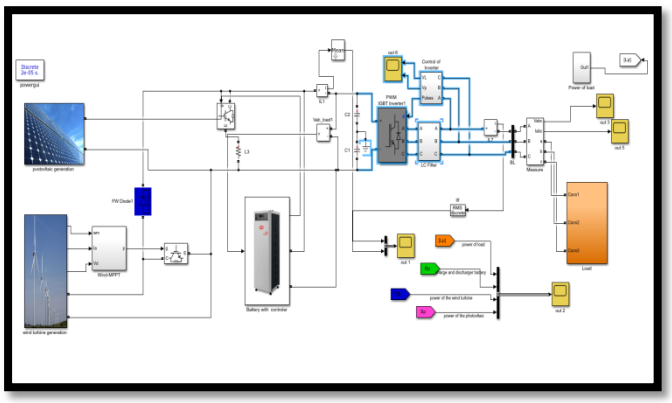

Fig.10. Microgrid hybrid energy model (wind turbines, photovoltaic and battery storage)

V.I. Discussed simulation result for microgrid

After the simulation the model microgrid –off grid the components the wind turbine and the solar photovoltaic generation is connect with battery storage and the load we get curves representing the value of the flowing power . The simulation results are divided into two parts

The first part is presented by the interval [0 4] .We noticed that the first load consumed about 10 kW with a significant increase of 8 kW and a significant decrease in the battery charge, which indicates that it has stored excess energy from other sources. Wind power reaches 6.8 kW, stabilizing with a slight decrease in PV power up to 8 kW.

The second part is presented by the interval of the [4 6] .Adding another load of 4 kilowatts. We observed an almost complete discharge in the storage battery at 5 kW, compensating for other sources such as photovoltaic energy which remained constant at 8 kW, with wind energy decreasing at 3 kW. The results are shown with (curves in detail in (Fig.11).

This change and distribution of energy is known as energy management system (EMS).

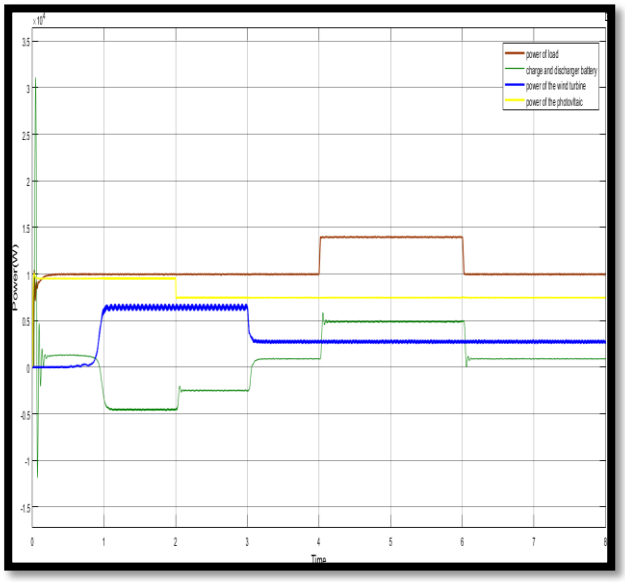

Fig.11. The curves power generation (wind turbine and photovoltaic with battery storage) and the loads.

V.II. Conclusion

Microgrid power system is an important source of distribution generation source. In this paper we model microgrid components in separate grid mode, which contain renewable energy provided by wind turbines, PV and battery storage with combined loads. We were presented with all models and summarized. The results were good in power distribution and microgrid power management system

Reference

[1] Rehmani, M. H., Reisslein, M., Rachedi, A., Erol-Kantarci, M., & Radenkovic, M. (2018). Integrating renewable energy resources into the smart grid: Recent developments in information and communication technologies. IEEE Transactions on Industrial Informatics, 14(7), 2814-2825.

[2] Badwawi, R. A., Abusara, M., & Mallick, T. (2015). A review of hybrid solar PV and wind energy system. Smart Science, 3(3), 127-138.

[3] Al-Dousari, A., Al-Nassar, W., Al-Hemoud, A., Alsaleh, A., Ramadan, A., Al-Dousari, N., & Ahmed, M. (2019). Solar and wind energy: Challenges and solutions in desert regions. Energy, 176, 184-194.

[6] Cetinkaya, U., & Bayindir, R. (2019, December). On&Off-Grid Hybrid Microgrid Design and Dynamic Analysis. In 2019 7th International Conference on Smart Grid (icSmartGrid) (pp. 132-136). IEEE.

[4] Muhtadi, A., & Saleque, A. M. (2017, August). Modeling and simulation of a microgrid consisting solar PV & DFIG based wind energy conversion system for St. Martin's island. In 2017 IEEE 3rd International Conference on Engineering Technologies and Social Sciences (ICETSS) (pp. 1-6). IEEE.

[5] Weitemeyer, S., Kleinhans, D., Vogt, T., & Agert, C. (2015). Integration of Renewable Energy Sources in future power systems: The role of storage. Renewable Energy, 75, 14-20.

[7] Sohn, J. M. (2016). Generation applications package for combined heat power in on-grid and off-grid microgrid energy management system. IEEE Access, 4, 3444-3453.

[8] Alzahrani, A., Ferdowsi, M., Shamsi, P., & Dagli, C. H. (2017). Modeling and simulation of microgrid. Procedia Computer Science, 114, 392-400.

[9] Egbue, O., & Uko, C. (2020). Multi-agent approach to modeling and simulation of microgrid operation with vehicle-to-grid system. The Electricity Journal, 33(3), 106714.

[10] Ding, F., Loparo, K. A., & Wang, C. (2012, July). Modeling and simulation of grid-connected hybrid AC/DC microgrid. In 2012 IEEE power and energy society general meeting (pp. 1-8). IEEE.

[11] Bhavsar, Y. S., Joshi, P. V., & Akolkar, S. M. (2015, October). Simulation of Microgrid with energy management system. In 2015 International Conference on Energy Systems and Applications (pp. 592-596). IEEE.

[12] Manyonge, A. W., Ochieng, R. M., Onyango, F. N., & Shichikha, J. M. (2012). Mathematical modelling of wind turbine in a wind energy conversion system: Power coefficient analysis.

[13] The permanent magnet synchronous generator (PMSG) depends on the output of high-torque wind turbines, and there is a need to model and control the PMSG based on variable speed wind turbines.

[14] Farrokhabadi, M., König, S., Cañizares, C. A., Bhattacharya, K., & Leibfried, T. (2017). Battery energy storage system models for microgrid stability analysis and dynamic simulation. IEEE Transactions on Power Systems, 33(2), 2301-2312.