



Energy Management in Photovoltaic Based Micro-Grid Systems

Mojtaba Jamiati

Department of Physics, Naragh Branch, Islamic Azad University, Naragh, Iran

Abstract

Using DC micro-grid to connect more efficiently with DC output has increased. The sources are photovoltaic and energy storage systems. The conversion losses of the sources for supplying the loads are reduced compared to the AC micro-grid. This method aims at combining the above methods to achieve maximum use of Renewable Energy and Energy Storage and enhancing the efficiency of the grid by using the Active power Filter and applying the DC to DC converter to boost the conversion efficiency and load management with having island inputs and the way to manage the inputs in the state of load disturbance and exit of one of the island inputs from the circuit is rapid injection of energy stored into the grid in the quickest time and the coordinated control between grid and photovoltaic system and battery have been studied in MATLAB/SIMULINK software. The amount of simulation time will be considered 0.5 seconds.

Keywords: Micro-grid DC, Renewable energy, Photovoltaic, Solar Cell, MATLAB SIMULINK

Article history: Received 28-Mar-2021; Revised 03-Apr-2021; Accepted 21-May-2021.

© 2020 IAUCTB-IJSEE Science. All rights reserved

1. Introduction

The first energy applied by human, was solar energy. Humans took a lot of gains of light and heat from the sun so that this energy became an integral part of the process of growing industries and has not lost its place even today. People who had access to free flows of water or lived in the windy territories used this kinetic energy and by transforming and curbing it raised their ability to do things bigger and harder. Out of different kind of renewable energy sources, the sun is an endless source of energy that can easily be converted into other types of energy such as thermal, electrical and chemical [1,2].

Micro-grid systems are in different shapes and sizes and can be connected to the main power grid or independently, to be exploited similar to the power systems available in natural islands. In other words, micro- grid system is assumed an accumulation of loads and sources that activate as a system only to create power and heat. Producers in micro-grid can be micro turbines, fuel and photovoltaic cells and reciprocating engines or any of the alternate power sources with Storage devices such as Fly Wheels, energy capacitors and batteries. It means they include renewable sources such as photovoltaic or windy manufacturers along with Fossil fuels producers that eliminate local heat requirements and create electricity.

Considering that the use of DC micro-grids is widely grown and these grids are effectively communicated with a variety of output sources such as photovoltaic systems and fuel cells and battery energy storage systems. Moreover, if the loads to be fed with DC power in these systems the need to convert and rectifying the resources compared with AC micro-grids will decrease. The paper offers some suggestions about strategic control and exploitation over the photovoltaic system and energy storage system in a DC micro-grid. About the ability to maximum use of renewable energies that act independently in the different factors process of this small grid some suggestions have been offered and this converter is located between the two methods. Also, extraordinary discussions are made about controlling the composition of the DC voltage and DC supply loads. When this system is balanced into autonomous grid during the normal operation and active power generation by an AC adapter, DC voltage is guaranteed constantly. Successful performance of the system in different situations will be reviewed by a coordinated strategy and about load management including load distribution and considering the battery state some proposals have been offered. Maximum power control and photovoltaic converter between the maximum power point and voltage control methods

can be observed. This battery is observed between charge and discharge states in the converter and in the grid, adapter is observed at the inversion phase and grid performance differences is characterized by the controlled methods. The bus voltage DC, acts as an information carrier that detects the different modes and also determines the switching modes [3]. Based on the simulation results of DC micro-grid, stable power delivery to a load is provided [4].

Another paper examines the SSR features of the system and proposes designing a new method for damping effect is near the high-pressure turbine at the end of the shaft. Induction machine decreases the peak torques at the different parts of the shaft during the transient phase. Induction machine does not eliminate the torque boost but reduces it and so does not affect the dynamic response of the primary generator turbine and can only be detected after the interactive effect of the torsional oscillations is switched [6]. In another paper, a grid-connected photovoltaic system has been proposed. Based on accurate modeling of the system, the maximum power point tracking (MPPT) and error analysis has been studied. The control consists of a flow control strategy and voltage control strategy. The voltage control strategy enables the voltage DC regulation and power factor control. In addition, it is expected that the flow control strategy of photovoltaic system to have a good control against external fault and increase system reliability [7]. A technical review over the Unified Power Quality Conditioner (UPQC) is presented at the distribution grid. Although the main task of UPQC is minimizing the voltage of the grid and disorders associated with load flow along with reactive power and harmonic compensation of power but additional features such as pause offset voltage and active power load and the grid have been detected. Connecting method with them pros and cons are also explained. Recent advances in capacity expansion techniques and the future of using UPQC process have investigated by accepting the expansion of DG capacity [8].

2. System configuration

More DC loads such as light (LED) and electric vehicles lead to energy storage and reducing CO2 emissions compared to AC power systems. When power can be supplied entirely by renewable energy sources, high voltage transmission in long distance is no longer required. Micro-grid is proposed to facilitate the connection to renewable energy sources. The concept of intelligent grids is currently dominant in power industry. The purpose of making smart grids is reliable electricity delivery, with high-quality to digital communities with an environmentally friendly and sustainable method. Smart grids have an advanced structure and can facilitate the energy storage options and different loads AC and DC with the optimal

SSDC based on nonlinear optimization with damping torque specifications on a wide range of SSDC tensional frequencies using a reference and reaction signal [5].

It also, is used to eliminate the sub-synchronous oscillations in induction machine and coupled with the turbine shaft generator collection and also implements to check the site of induction machine that is used without help from any controller effectively. It has been found out that the best site for the damping unit of the induction machine to achieve the maximum utilization and efficiency of operations. To achieve these goals, electronic technology plays the most significant role as an interface for the resources and different loads in an intelligent grid. A Schematic diagram of DC micro-grid simulation is shown in Figure 1.

In the micro-grid under study a photovoltaic system and a battery have been used that are connected to the grid by AC / DC converter and details of the systems under study are shown in Table 1, 2 and 3.

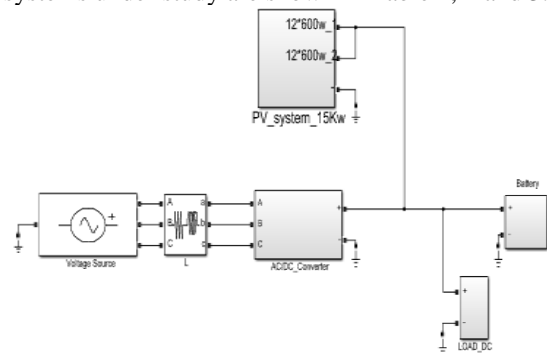


Fig. 1. Schematic diagram of DC micro-grid simulations [8].

Table.1.
Photovoltaic system parameters

Parameters	Amount
P_{nom}	14.4Kw
V_{nom}	500v
Q	$1.602 \times 10^{-19} C$
K	$1.38 \times 10^{-23} J/K$
I_{sc}	25.44A
V_{oc}	66V
T_r	25°
T	28°
S	0~1100
n_p	24*600w

Table.2.
Parameters of the battery storage system

Parameters	Amount
Battery type	Lead-acid
P_{nom}	15kw
V_{nom}	500v
Rating	30Ah
F_s	10kHz

Table.3.
Parameters of power system

Parameters	Amount
Voltage source	600V
Frequency	50Hz
R_s	0.1m Ω
L_s	20 μ H
F_s _AC/DC converter	10kHz

3. System modeling

A) Photovoltaic System

Modeling a photovoltaic array Figure 2 has shown a photovoltaic model including a diode in parallel with the current source and a resistor R_{sh} and a series resistor R_s . [3].

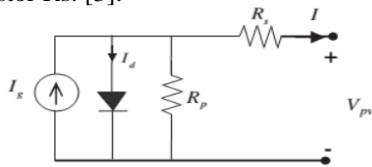


Fig. 2. Single-diode model of the theoretical photovoltaic cell [3].

Characteristics Equation V-I of Photovoltaic array can be written as:

$$I_{pv}(V_{pv}) = I_g - I_0 \left[\exp\left(\frac{v + R_s I}{aV_t}\right) - 1 \right] - \frac{V_{pv} + R_s I_{pv}}{R_p} \quad (1)$$

Where, I_g and I_0 , are the photovoltaic currents and the saturated current of solar array, respectively. q is the electron charge, k Boltzmann's constant, T temperature of p-n bond in Kelvin scale, and a is the diode ideality constant. To increase the output voltage, the cells are connected in series arrangement in the solar modules. To increase the output, current the parallel combination will be applied. If a module is composed of NP parallel combinations in equation (1), R_p and R_s , are the equivalent parallel and series resistors and the equation (1) is extracted from the IV curve [9]. Circuit diagram and controlling topology of the photovoltaic system is represented in Figure 3. MPPT control system is used to control the output power of the photovoltaic system [10].

B) Battery

Considering the nonlinear characteristic of the battery, displaying it properly on a monitor is another challenge. Different models are available to simulate the behavior of the battery with different degrees of complexity and simulation behavior. The simplest model that is commonly used in a battery contains an ideal voltage source in series with a fixed internal resistance [3] which is shown in Figure 4.

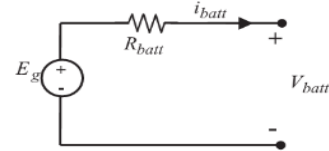


Fig. 3. Equivalent circuit for the battery [3].

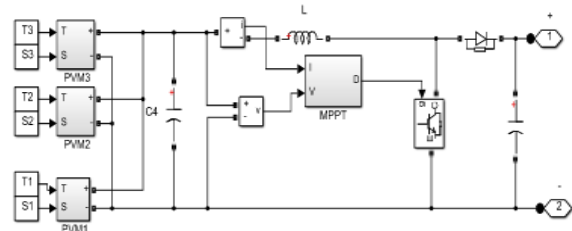


Fig. 4. circuit and topology control photovoltaic system [10].

And can be indicated by equation (2):

$$V_{batt} = E_g - i_{batt} R_{batt} \quad (2)$$

Besides, battery storage system circuit diagram is shown in Figure 5. Buck-Boost DC-DC converters in the circuit for different positions in the DC micro-grid are considered.

The controlling system of the battery storage system circuit uses pulse width modulation to control the IGBTs in the same way is shown in Figure 6 and by sampling the output voltage and passing through the PI controller gives command of turning off and on to IGBTs control pulse which has been extracted from [11].

4. Case studies and simulation results

In order to verify the proposed control methods for integrating Distributed photovoltaic (PV) system and storage of energy in a micro-grid DC the system simulation is performed using MATLAB SIMULINK and is examined in various modes.

A) The First Case

The amount of simulation time will be considered 0.5 seconds and the amount of sunlight changes will also be considered. At the time 0.05 seconds, the micro-grid disconnected from the grid continues to operate on itself and at other time from 0 to 0.2 seconds the photovoltaic system is out of the circuit and will be connected to the micro-grid after time 0.2 furthermore,

the battery storage system will stay in the circuit permanently and the results of the power, voltage, and the load current is as Figure 7.

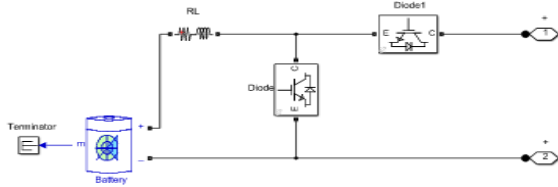


Fig. 5. The circuit diagram of a battery storage system[10].

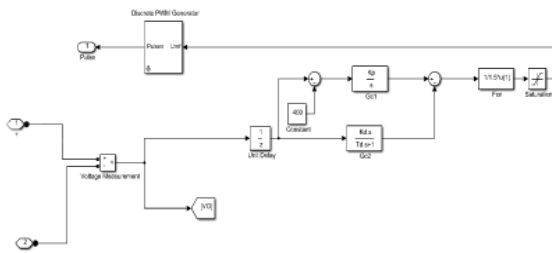


Fig. 6. Block diagram of the proposed control battery storage sys.

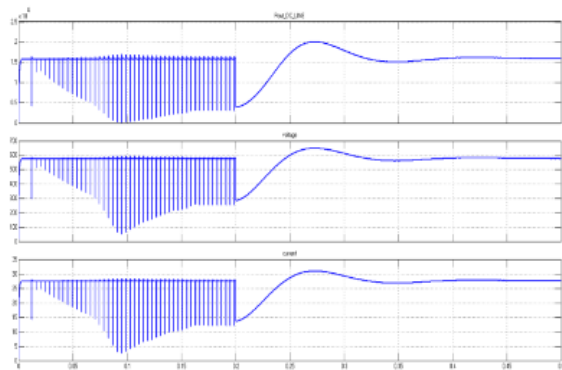


Fig. 7. The power- voltage and load current for the first case

B) The Second Case

The amount of simulation time will be considered 0.5 seconds and the amount of sunlight changes will also be considered. At the time 0.05 seconds, the micro-grid disconnected from the grid continues to operate on itself and at other time from 0 to 0.2 seconds the photovoltaic system is out of the circuit and will be connected to the micro-grid after time 0.2 furthermore, the battery storage system will stay in the circuit permanently ,only this state time from 0.35 to 0.36 Short-circuit in system Occurs and the results of the power, voltage, and the load current is as Figure 8.

C) The third Case

The amount of simulation time will be considered 0.5 seconds and the amount of sunlight vary of until. At the time0.05 seconds, the micro-grid disconnected from the grid continues to operate on itself and at other

time photovoltaic system and battery is connected to the micro-grid and the results of the power, voltage, and the load current is as Figure 9.

D) The fourth Case

The amount of simulation time will be considered 3 seconds and the amount of sunlight vary of untilwho Radiation changes in 1.25-1.5-2.25 seconds. At the time 0.05 seconds, the micro-grid disconnected from the grid continues to operate on itself and at other time the photovoltaic system is connected to the micro-grid and the battery storage system is disconnect all time and the results of the power, voltage, and the load current is as Figure 10.

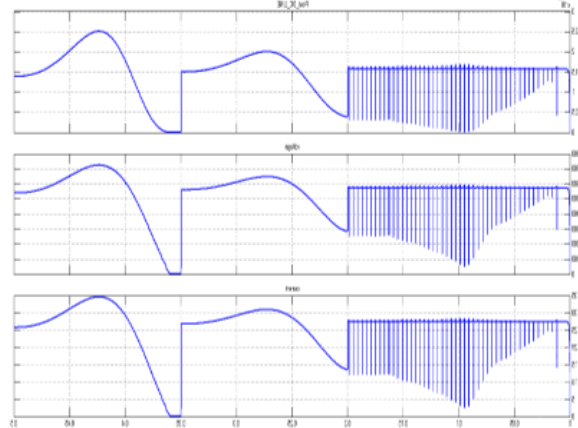


Fig. 8. The power, voltage and load current for the second case

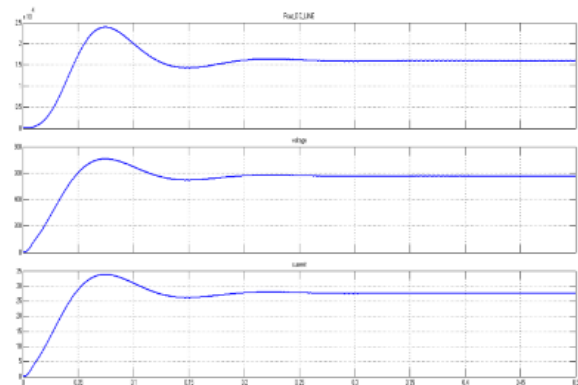


Fig. 9. The power, voltage and load current for the third case

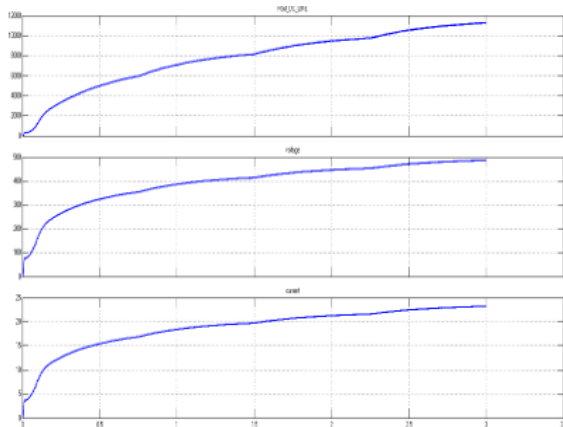


Fig. 10. The power, voltage and load current for the fourth case

5. Conclusion

In this paper, control and management of photovoltaic system and energy storage in the DC micro-grid system when the radiation changes have been regarded and the grid has been supposed to be working as an island so that the proposed controller provides the maximum photovoltaic power during different operating conditions in the micro-grid and sustainable transport with minimal disturbance between grid and island mode. The controller is used in DC voltage levels as a connecting line and coordinator of the sources and the battery storage system has been applied as a controlling input for switching mode and conducted after being approved in MATLAB/SIMULINK software.

References

- [1] Mirzaei Darian, M. M., Ghorreshi, A. M. and Hajatzadeh, M. J., 2020. Evaluation of Photovoltaic System Performance: A Case Study in East Azerbaijan. Iranian (Iranica) Journal of Energy & Environment, 11(1), pp. 75-78.
- [2] Firoozzadeh, M., Shiravi, A., and Shafiee, M., 2019. An experimental study on cooling the photovoltaic modules by fins to improve power generation: economic assessment. Iranian (Iranica) Journal of Energy & Environment, 10(2), pp. 80-84.
- [3] Eghtedarpour, N., Farjah, E., 2012. Control strategy for distributed integration of photovoltaic and energy storage systems in DC micro-grids. Elsevier, 43, pp. 96-110.
- [4] Lee, J., Han, B., Choi, N., 2010. DC micro-grid operational analysis with detailed simulation model for distributed generation. 2010 IEEE Energy Conversion Congress and Exposition, Atlanta, GA, USA, pp. 3153-3160.
- [5] Padiyar, K. R., Prabhu, N., 2006. Design and performance evaluation of subsynchronous damping controller with STATCOM. IEEE Transactions on, Power Delivery, Atlanta, GA, USA, 21(3), pp. 1398-1405.
- [6] Ahmed, M., Meegahapola, L., Vahidnia, A., Datta, M., 2019. Analysis and mitigation of low-frequency oscillations in hybrid AC/DC microgrids with dynamic loads. IET Generation, Transmission & Distribution, 13(9), pp. 1477-1488.
- [7] Manohar, K., Sobha Rani, P., 2012. Mppt and Simulation for a Grid-Connected Photovoltaic System and Fault Analysis. The International Journal of Engineering and Science (IJES), 1(2), pp. 158-166.

[8] BİRİCİK, S., 2018. Design of Unified Power Quality Conditioner for Power Quality Improvement in Distribution Network. Balkan Journal of Electrical and Computer Engineering, 6(1), pp. 47-52.

[9] El-Shahat, A., Sumaiya, S., 2019. DC-Microgrid System Design, Control, and Analysis. Electronics, 8(2), pp. 124-151.

[10] Choi, W. Y., Lee, C. G., 2012. Photovoltaic panel integrated power conditioning system using a high efficiency step-up DC-DC converter. Renewable Energy, 41(C), pp. 227-234.

[11] Alias A., A.Rahim, N., Husain, M. Z., 2013. A Single-Input Single-Output Approach by using Minor-Loop Voltage Feedback Compensation with Modified SPWM Technique for Three-Phase AC-DC Buck Converter. Journal of Power Electronics, 13(5), pp. 829-840.

