International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

Management and Control of Photovoltaic Systems and Energy Storage in the DC Micro-Grid

[1] S. Rahimi
Dep. Electrical Engineering, Naragh branch,Islamic Azad University,Naragh, Iran

[2] S. M. Shariatmadar
Dep. Electrical Engineering, Islamic Azad University, Naragh branch,Naragh, Iran

[3] Mojtaba jamiati
Faculty Member
Department of Physics
Naragh branch, Islamic Azad University, Naragh, Iran

[4] A. Aliabbasi Jazi
Dep. Electrical Engineering, Islamic Azad University, Naragh branch,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.**

keyword—Micro-grid DC, Renewable energy, Photovoltaic ,Battery energy storage

I. 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. 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 are 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 [1]. Based on the simulation results of DC micro-grid, stable power delivery to a load is provided [2]. Another paper examines the SSR features of the system and proposes designing a new method for SSDC based on nonlinear optimization with damping torque specifications on a wide range of SSDC tensional frequencies using a reference and reaction signal [3]. 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 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 [4]. 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 [5]. 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 [6].

II. II. 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 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. Micro-grid structure and the proposed circuit

A Schematic diagram of DC micro-grid simulation is shown in Figure 1.

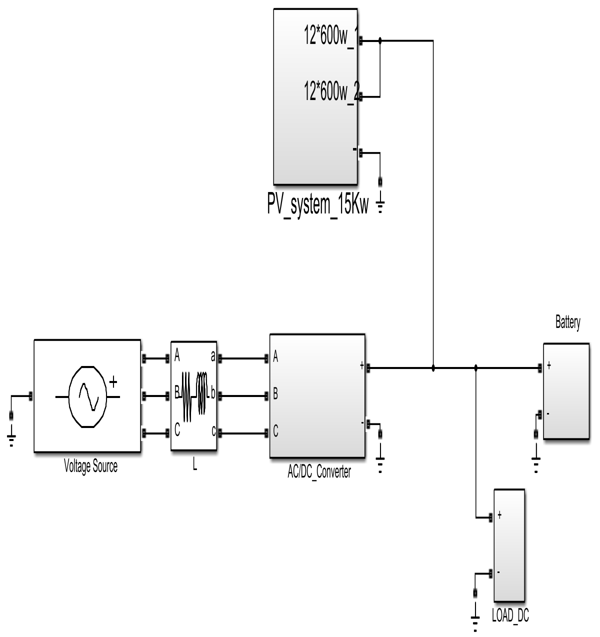

Figure 1. Schematic diagram of DC micro-grid simulations

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.

III. SYSTEM MODELING

A. Modeling Photovoltaic System

1) Modeling a photovoltaic array

Figure 2 has shown a photovoltaic model including a diode in parallel with the current source and a resistor RSh and a ***series resistor Rs***. [1]

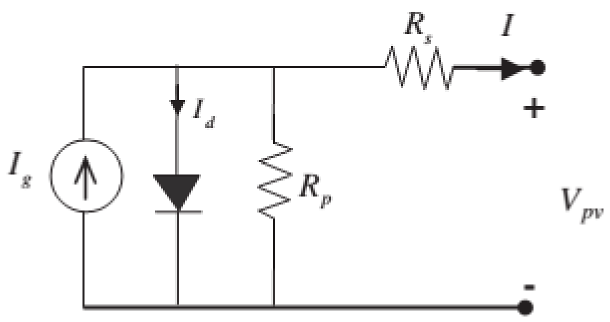

Figure 2: Equivalent circuit of a photovoltaic array

Characteristics Equation V-I of Photovoltaic array can be represented as Equation 1.

$$I_{PV}(V_{PV}) = I_g - I_o[\exp\left(\frac{v + R_S I}{aVt}\right) - 1] - \left(\frac{V_{PV} + R_s I_{PV}}{R_p}\right) \quad (1)$$

Ig and Io, 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

ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

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) RP and RS, are the equivalent parallel and series resistors and the equation (1) is extracted from the IV curve [7].
2) Photovoltaic system and the control algorithm
Circuit diagram and controlling topology of the photovoltaic system is represented in Figure3.

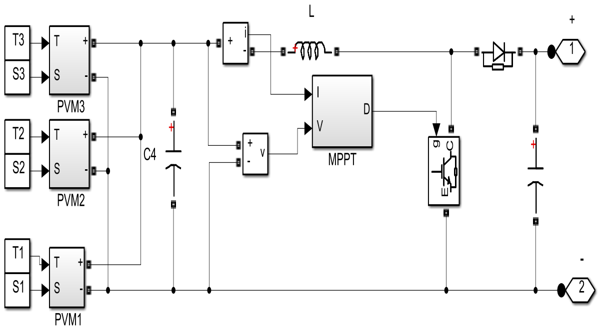

Figure 3 circuit diagram and topology control photovoltaic system

MPPT control system is used to control the output power of the photovoltaic system [9].
B. Battery Modeling

A. Battery Model

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 [1] which is shown in Figure 4.

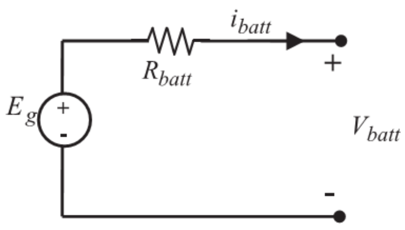

Figure 4: Equivalent circuit for the battery

And can be indicated by equation (2)

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

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.

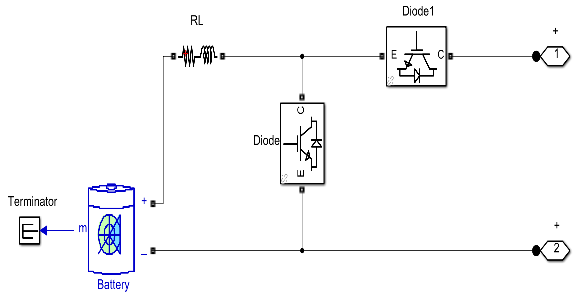

Figure 5: The circuit diagram of a battery storage system

B. The controlling circuit of the battery storage system

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 [8].

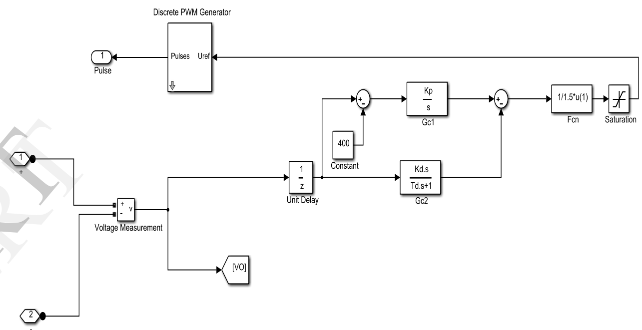

Figure 6. Block diagram of the proposed control battery storage system

Table 1. Photovoltaic system parameters

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

Table 2. shows the parameters of the battery storage system

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

Table 3. parameters of power system

Parameters	*Amount*
Voltage source	*600V*
Frequency	*50Hz*
Rs	*0.1mΩ*
Ls	*20µH*
Fs_AC/DC converter	*10khz*

IV. 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 $1000w/m^2$. 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.

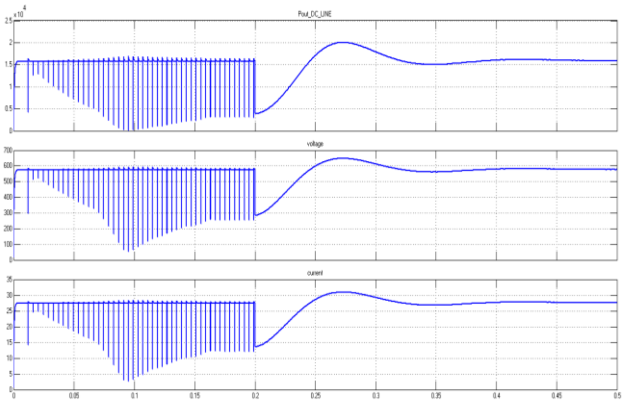

Figure 7, the power, voltage and load current for the first case

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 $1000w/m^2$. 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.

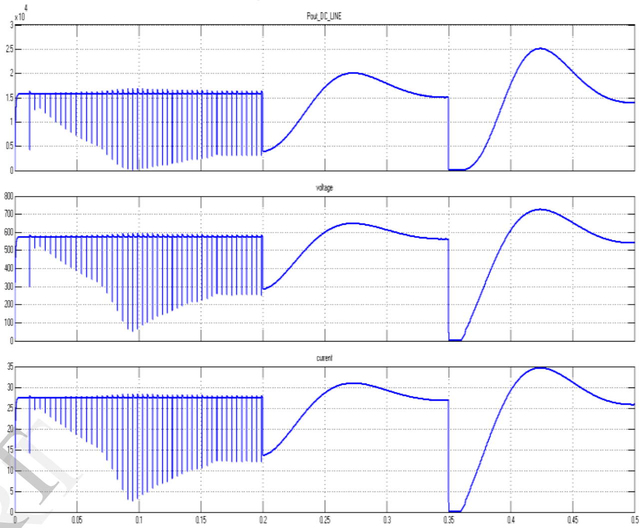

Figure 8. The Power, Voltage And Load Current For The Second Case

C. The third Case

The amount of simulation time will be considered 0.5 seconds and the amount of sunlight vary of $800w/m^2$ until $1000w/m^2$. At the time 0.05 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.

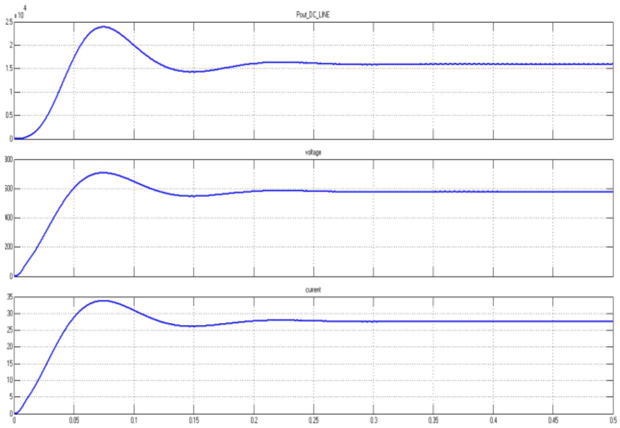

Figure 9. The power, voltage and load current for the third case

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

D. The fourth Case

The amount of simulation time will be considered 3 seconds and the amount of sunlight vary of $800w/m^2$ until $1000w/m^2$ who 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.

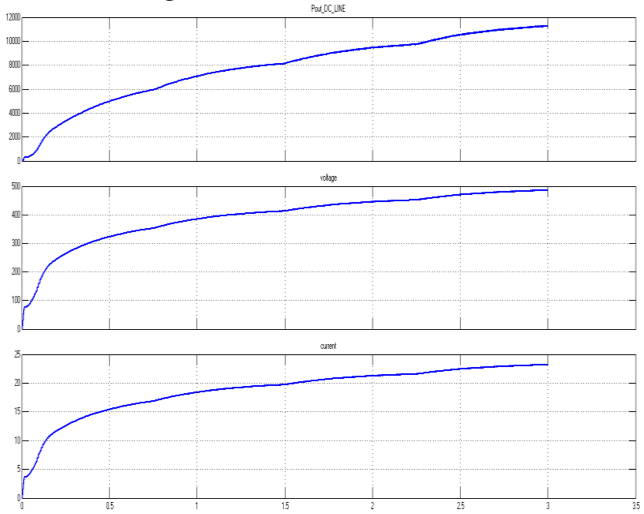

Figure 10. The power, voltage and load current for the fourth case

V. CONCLUSIONS

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] N.Eghtedarpour, and E. Farjah, "Control strategy for distributed integration of photovoltaic and energy storage systems in DC micro-grids"Elsevier, vol. 43, pp. 96–110, Sep. 2012.

[2] , J. Lee, B. Han, and N.Choi, "DC micro-grid operational analysis with detailed simulation model for distributed generation" Energy Conversion Congress and Exposition (ECCE), 2010 IEEE.

[3] K.R. Padiyar, and N. Prabhu, "Design and performance evaluation of subsynchronous damping controller with STATCOM" IEEE Transactions on, Power Delivery,vol. 21, no. 3, pp. 1398–1405, 2006.

[4] S.Purushothaman,and F. de Leon, "Eliminating Subsynchronous Oscillations With an Induction Machine Damping Unit (IMDU)" IEEE Transactions on, Power Systems, vol. 26, no. 1, pp. 225–232, 2011.

[5] K.Manohar,and P.Sobha Rani " Mppt and Simulation for a Grid-Connected Photovoltaic System and Fault Analysis " IJES ,vol.1,no.2,pp.158-166, 2012.

[6] Khadem, "UPQC for Power Quality Improvement in DG Integrated Smart Grid Network – A Review"International Journal of Emerging Electric Power Systems,vol 13, no.15,2012.

[7] S. Banitalebi Dehkordi , S. M. Shariatmadar , E. Shahmoradi Poor ,and S. S. Hatefinasab "Photovoltaic System in Term of the Variable Irradiation Connected To Micro-Grid DC" IJERT,vol. 3, no. 5, pp. 565–568,May 2014.

[8] A. Alias, N. A.Rahim, and M.Z. Husain, "A Single-Input Single-Output Aproach by using Minor-Lop Voltage Fedback Compensation with Modified SPWM Technique for Thre-Phase AC–DC Buck Converter" JPE,vol. 13, no. 5, pp. 829–839, 2013.

[9] W. Choi, and Ch. Lee "Photovoltaic panel integrated power conditioning system using a high efficiency step-up DCeDC converter" Elsevier, Renewable Energy,vol. 41, pp. 227-234,May 2012.