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Power Management Strategy for Hybrid Microgrid System under Islanded Condition using Adaptive Droop Control

Manasa Mythri Kodali[1*] and K. S. Srikanth[2]

Electrical and Electronics Engineering, KL University Greenfields, Vaddeswaram, Guntur District - 522502, Andhra Pradesh, India; manasamtech14@gmail.com, srikanth.dsd@gmail.com

Abstract

Background/Objectives: PV array systems are thought of to be a higher possibility among all non-conventional energy sources in distribution system with the features of increasing potency, high responsibility and low maintenance. This paper proposes the concept of energy management for grid connected hybrid system under islanding condition. **Methods/ Statistical Analysis:** Power management Control strategy used in this paper enables photovoltaic/battery unit as a primary supply that employs an adaptive droop control to share the load with alternative sources such as charging the battery. Additionally, this control technique is intended to switch the PV in operation to match the load demand autonomously whenever the available PV power is beyond the load and also the battery is totally charged. In addition with islanding microgrid conditions, such as voltage and frequency regulation and also power deficit circumstances the battery also provide operational functions with a separate storage unit. **Findings:** In this paper PV/battery unit is controlled using adaptive droop control to work as voltage supply, in contrast to the control strategy used in photovoltaic system from the literature wherever the Solar units are controlled to work as current controlled sources. Generally, in this system first the hybrid unit delivers power to load and stores in battery if there is any excess power generation. And consequently, in the second case, it will track and supply the most PV power to the microgrid provided that there's any deficit in load at microgrid. **Applications/Improvements:** The proposed control strategy is very useful for integration of hybrid power systems with the gird and to meet the upcoming future of the customers.

Keywords: Adaptive Droop, Control Strategy, Energy Management, Micro-Grid, PV System, State of Charge

1. Introduction

PV array systems are thought of to be a higher possibility among all non-conventional energy sources in distribution system with the features of increasing potency, high responsibility and low maintenance. From operation point of view, installation of PV systems are classified as either complete or grid interfaced[1-8]. Generally, in microgrid the PV systems behaves as a controlled current sources in order to inject suitable PV power to the microgrid[1-5]. In this paper, techniques for effective energy management is applied for microgrid under islanded condition. These methods need the effective power management system has access to the ability measurements at each unit and at node[1]. Therefore, all nodes across load should be equipped with power activity and communication modules, that don't seem to be sensible or promptly out there in most standard distribution networks. Additionally, consistent with the rule projected in, the battery and the electric cell are accustomed share the deficit load using droop control when the power from the PV and also the micro turbines[9-15]. This might exhaust the battery storage that is that the most important component under microgrid islanding conditions, and will lead to down the microgrid.

**Author for correspondence*

2. Configuration of Power Management Strategy

Figure 1 shows the simplified schematic diagram for an islanded based micro-grid system. Metric weight unit one could be a standard droop controlled unit, and metric weight unit a pair of Solar System/battery hybrid unit into account[16-19]. This paper proposed an operational functions and utilization of PV system for microgrid applications. Sodium molecule and P_{Bo} represent the power supplied from the battery storage system[2-14]. The dc-link interfaced battery is used in this system and it's controlled with bi-directional converter for both charging and discharging

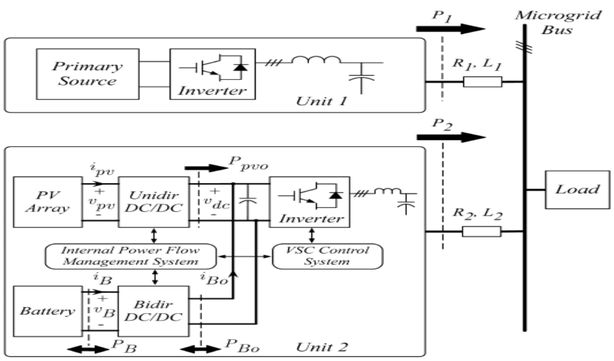


Figure 1. Basic architecture of Hybrid System.

The control strategy for effective power management scheme is explained based on the figure shown in 2. In this the controller MPPT is used for controlling PV power with the help of latching signal rom SOC of battery. And second controller in figure 2 is used for controlling battery power[3]. If the SOC is minimum then MPPT controller is enabled so that it can be controlled with help of MPPT. In other way the reference voltage for PV controller is obtained directly from SOC controller if MPPT is disabled by latching signal from SOC controller[20-22].

3. Photovoltaic System

Operation of Photovoltaic system is to convert solar energy to electrical energy. Generally, solar panel is form of array structure. In this every cell is comparable to a diode with a tangency shaped. It produces current once lightweight absorbed at the junction, by PV system. Figure 4 shows the PV and IV characteristics of solar panel. And figure 3 shows[4,5] the electrical equivalent circuit for PV system which is used solar energy (i.e current) to electrical energy.

$$I = I_{ph} - I_D - I_{sh}$$
$$I = Iph - I_o [\exp (q V_D / nKT)] - (v_D / R_S)$$

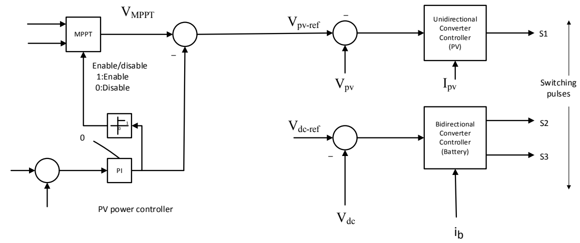


Figure 2. Control Strategy for Battery and PV Converter.

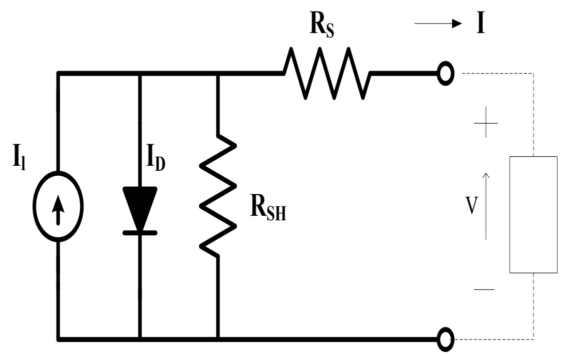


Figure 3. Electrical circuit of PV Module

The output power from the PV cell is expressed as P=VI.

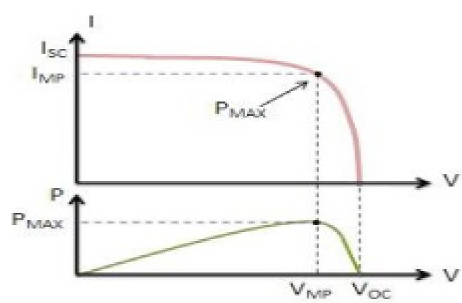


Figure 4. P-V & I-V Curves for Solar Panel

Figure 5 shows the Solar panel I-V characteristics with constant temperature and irradiance.

Figure 6 shows the characteristics of solar panel between Voltage and Power under different irradiance.

4. Battery Energy Storage System

The change of AC to DC is finished by Battery energy system, generally it's based on power electronic converters. Here the working of battery i.e. transformation of power into energy for putting away reason. By utilizing DC power Batteries may charges and in some cases releases. For this purpose Bi-directional power electronic converters[6-13] are required for controlling power flow from batteries to energy systems and vice-versa. In view of assortment of battery it's having fluctuated benefits and bad marks like value, weight, size, and power and vitality capacity[7-16].

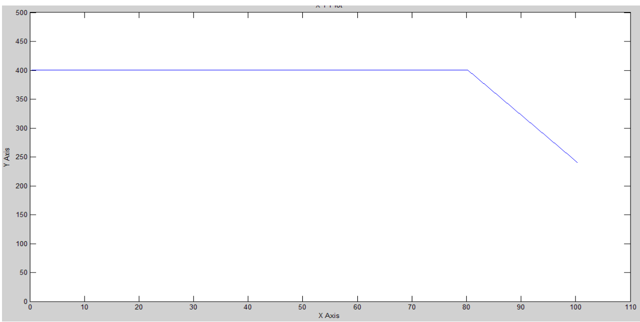


Figure 5. I-V Characteristics of Solar System

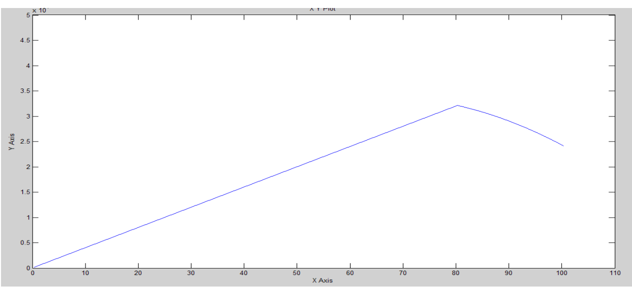


Figure 6. P-V Characteristics of Solar System

5. VSC control system

Figure 7 shows the control diagram for voltage source converter which is used for generating voltage and frequency reference signals. The power from the hybrid system is converted to w with the help of adaptive droop controller as shown in figure 8[7-8]. The effect of harmonics in power can be eliminated using first order filter.

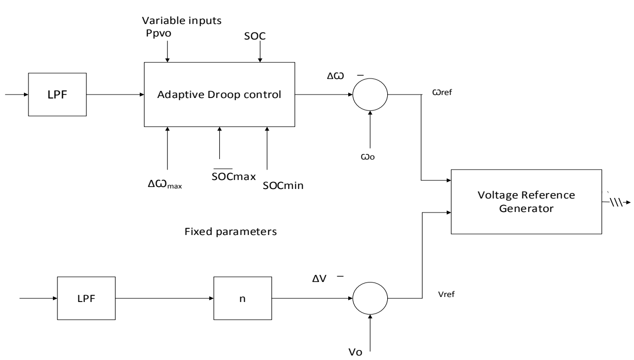


Figure 7. Closed Loop Control Diagram for VSC Converter.

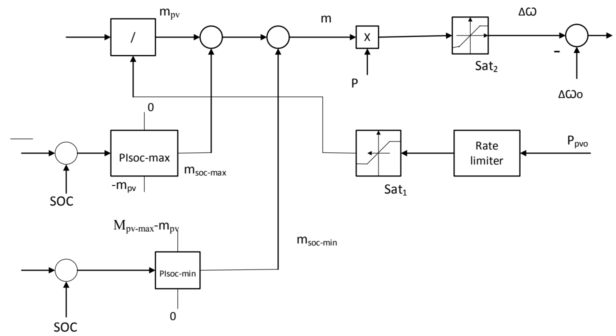


Figure 8. Adaptive Droop Control strategy.

Figure 7 shows the control structure which is used for implementation of operational scenario of adaptive droop control. In this, the slope of middle section is represented with 'm' in this droop curves. From figure 8, the slope 'm' is derived by considering the 3 slope variables such as m_{pv}, $m_{soc-max}$, and $m_{soc-min}$. As from the Figure 8, the saturation limits for two PI controllers are $PI_{soc-max}$ and $PI_{soc-min}$ area unit is considered[17,18] such that remain idle, i.e., each m soc-max and m soc-min equal zero, once SOCmin ≤ SOC ≤ SOCmax.

6. Power Sharing Scenario

Figure 9 shows the graphical representation between powers from the PV system to frequency which is called power sharing techniques. In this the minimum slope limits PV_{min} is taken by PV array power ratings and while the slope m_{pvmax} is chosen from 2 controller[9,10]. Suppose for example, the m_{pvmax} is calculated for 25% of PV power, therefore the battery can offer only 1/4[th] of solar power once all other units reach their rated limits[11-20].

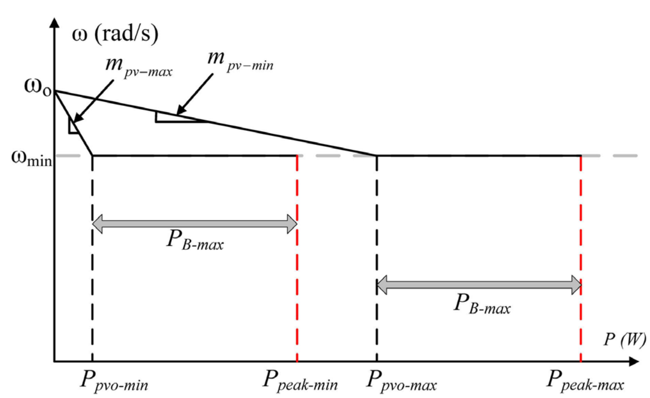


Figure 9. Droop slope limits based on Power.

7. Simulation and Results

The performance of the grid interfaced hybrid system as shown in figure 1 is observed in Matlab/Simulink. It consist of PV structure, battery and also a VSI inverter which is used for grid interface purpose. The simulation results for this system is shown in two cases such as,

Case 1: Power Sharing & Balancing Scenario

Figure 10 shows the results for hybrid system during power sharing scenario. In this result we observed that the power shares form unit 1 to unit 2. And the change droop slope according power transfer rate limiter is shown in figure 11 and figure 12.

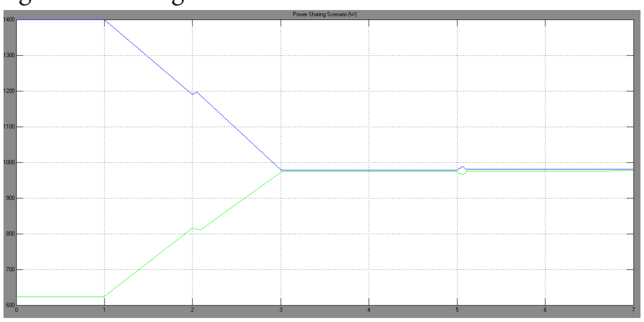


Figure 10. Result for performance of Hybrid System during Power Sharing Strategy.

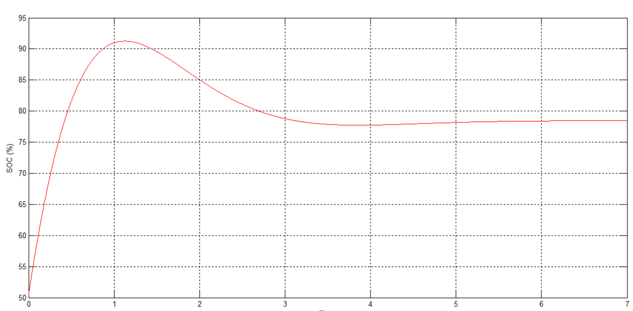


Figure 11. Simulation Result State of Charge.

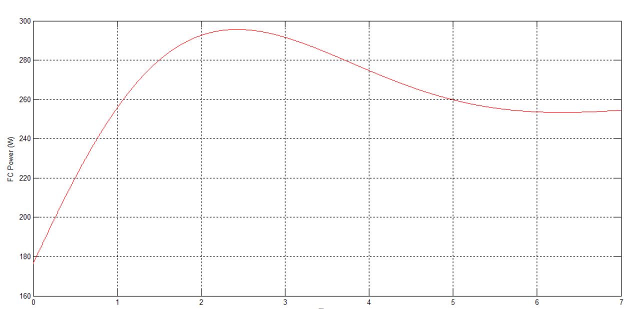


Figure 12. Simulation Result for Battery Power.

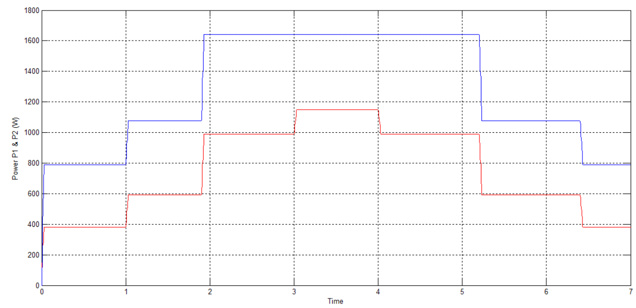


Figure 13. Result for performance of hybrid system under Power Balancing Condition.

The result in Figutt 13 shows that the power balancing conditions between Bus1 and Bus2.

Case 2: Experimental verification under SOC Upper Control limit

The performance results of the proposed grid interfaced hybrid system under SOC upper limit control is shown in figure 14 - 16. In this figure 14 shows the simulation results for power which is generated from PV and Battery system. Figure 15 shows the simulation results for power across bus 1 and bus2 and figure 16 shows the state of charge characteristics for battery under these considerations.

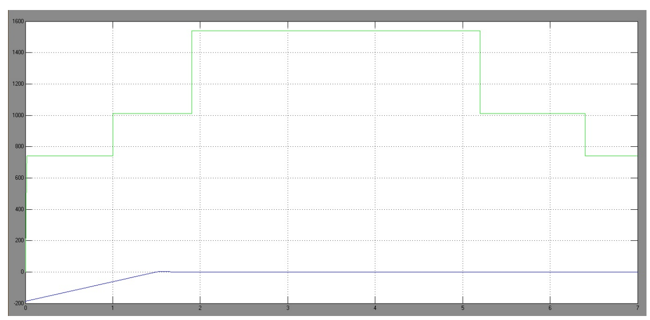


Figure 14. Simulation result for PV and Battery Powers under External SOC Controller.

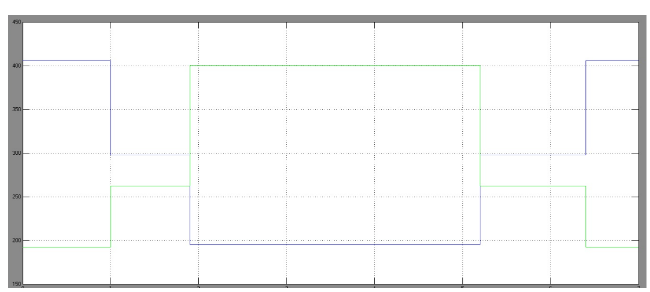


Figure 15. Simulation result for Bus1 & Bus 2 Power at load under External SOC Controller.

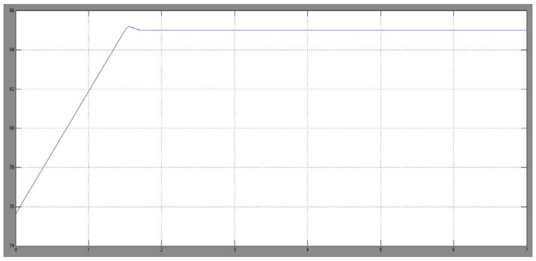


Figure 16. Simulation result for Battery State of charge under External SOC Controller.

The performance of the proposed grid interfaced microgrid under the condition of SOC reaches its maximum value. Figure 17-19 shows the simulation results for hybrid system. Figure 17 is output result for power across battery and PV system. Figure 18 is output result for power which is flows through load from bus 1 to bus 2. And figure 19 is battery state of charge conditions.

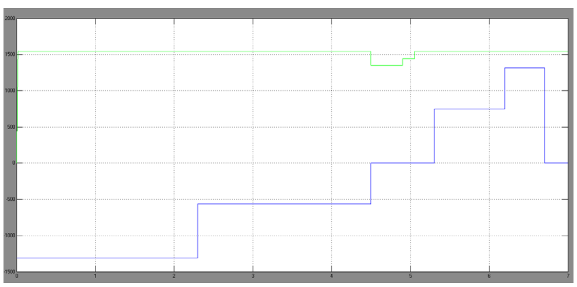
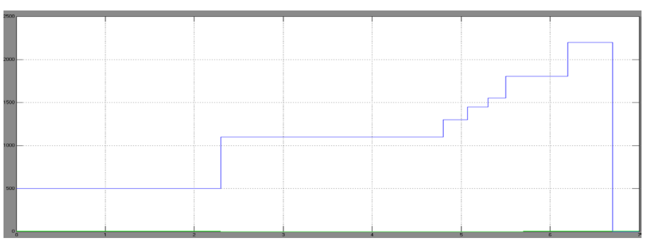
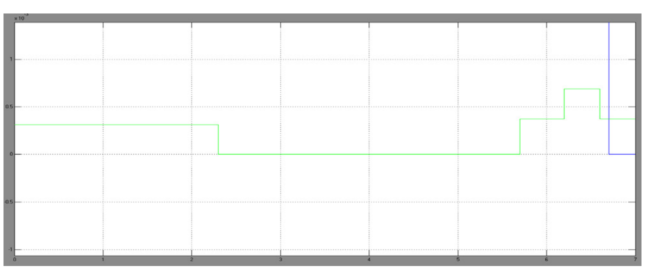


Figure 17. Simulation result for PV and Battery Powers under External SOC Controller.



(a)



(b)

Figure 18 (a) & (b). Simulation result for Bus1 & Bus 2 Power at load under External SOC Controller.

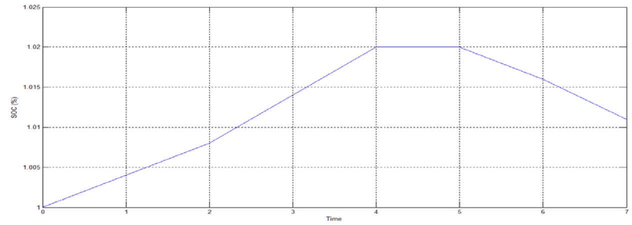


Figure 19. Simulation result for Battery State of charge under External SOC Controller.

Case 3: Battery Charging Priority Scenario

Figure 20-22 shows the performance result for hybrid system under battery charging priority.

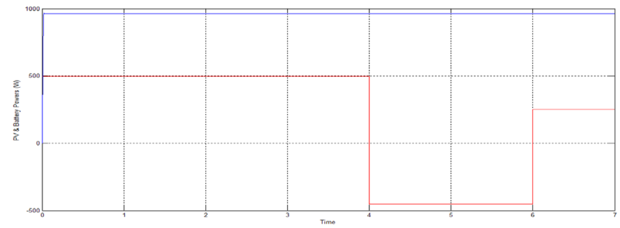


Figure 20. Simulation Result for PV & Battery Power.

Figure 20 shows the simulation result for PV and battery powers during battery cahrging prioriry. In this case the Power from the solar power is maintained constant and observe the charging performance of battery.

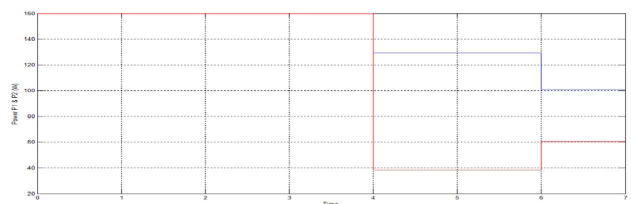


Figure 21. Simulation Result for Load Power under Bus 1 & Bus2.

Figure 21 shos the simulation result for Powers under bus 1 & bus 2 at laod terminals. And figure 22 shows the result of state of charge for battery.

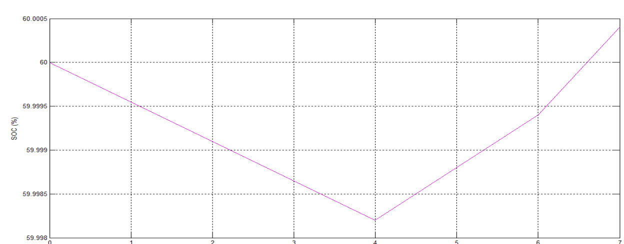


Figure 22. Simulation Result for State of Charge.

8. Conclusion

This paper gives conclusion about effective power management control strategy using adaptive droop control technique. In this paper PV/battery unit is controlled using adaptive droop control to work as voltage supply, in contrast to the control strategy used in photovoltaic system from the literature wherever the Solar units are controlled to work as current controlled sources. Generally, in this system first the hybrid unit delivers power to load and stores in battery if there is any excess power generation. And consequently, in the second case, it will track and supply the most PV power to the microgrid provided that there's any deficit in load at microgrid. On third case, the control strategy changes the operating scenario of PV power to follow the load once and in any case the load which is used at microgrid is less than available solar power at that case the battery starts charging, while in other situation the battery discharges its energy if the available PV power is less than load demand. The performance of system is observed in Matlab/Simulink and also verified the result.

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