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Control For a DC Micro grid Feeding Uncertain Loads in More Electric Aircraft

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1.Abstract

This project proposes an improved hybrid solar and wind with battery management system with specialized and accurate controllers developed using PID controller, the main concern of the project is developing an intelligent system which will work in synchronization with all other components of microgrid. The algorithm is developed in such a way that all sources should operate according to the variable load conditions. [1]We have proposed algorithm which is efficient in terms of making system reliable and stable, we have involved renewable resources as solar and wind energy for generation thus saving fuel consumption ultimately it affects economy of country. Simulation has been done which demonstrate the whole scenario of operation of all components of microgrid. Simulation model consists of model of renewable sources and battery with its controller grid and Load. To test the effectiveness of the system it is simulated on MATLAB. We can analyze the system effectiveness at different conditions namely as step changes in irradiance and several load condition.

2.Introduction

A microgrid is basically designed to overcome some challenges in distribution networks such as fuel consumption, reliability of system equipment, increment in emissions. A microgrid consists of renewable sources, battery, grid, load and control system for synchronization. Energy management system controller is developed using PID for better performance. We are using renewable resources

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as solar which are available in abundance. We have developed modules of both the resources to check their effectiveness in the proposed system. It is very important to design efficient energy management system because it provides stable power to electrical vehicle and other portable devices. [2] A battery management basically consists of charging and discharging strategies, SoC performance of the battery at different scenario, voltage balancing. The algorithm developed for energy management system is based on simple architecture that battery should be in charging mode when there is availability of solar power, battery comes in discharging mode when there is less availability of Pv power to compensate load.

[3]SOC estimations play very important role in whole energy management system, Soc estimation decides when battery should attain charging mode and discharging mode. It also ensures battery performance at different conditions. Advanced algorithm is implemented in the control system for a microgrid that can optimize the energy absorptions, save energy, as well as reduce costs ultimately energy management system. The main objective of the proposed system is to check the effectiveness of control strategies developed using PID controller in Microgrid for the purpose of energy management system. We have developed algorithm for the improvisation of energy management system in a Microgrid.

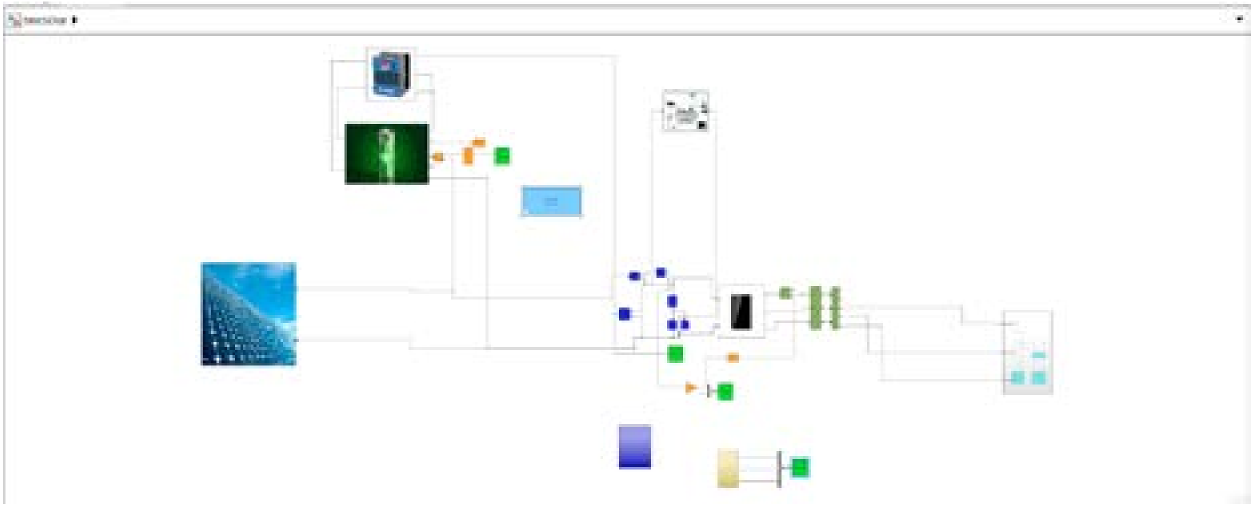


Figure 1: Proposed Simulink Model of the system

Renewable Resources of Energy

Solar energy is used as renewable source of energy for the system.

Solar Source-The solar source is used to generate power from the sun rays. A photovoltaic system makes use of some or more solar panels to convert the solar energy into electricity. It consists of various components which include the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output.

MATHEMATICAL MODELLING

1. PV Farm -

The equivalent circuit of a PV cell is shown in Fig. 1. The current source Iph represents the cell photocurrent. Rsh and Rs are the intrinsic shunt and series resistances of the cell, respectively. Usually, the value of Rsh is very large and that of Rs is very small, hence they may be neglected to simplify the analysis. Practically, PV cells are grouped in larger units called PV modules and these modules are connected in series or parallel to create PV arrays which are used to generate electricity in PV generation systems. The equivalent circuit for PV array is shown in Fig. 2.

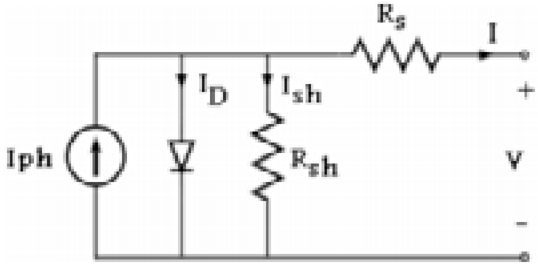


Fig. 1

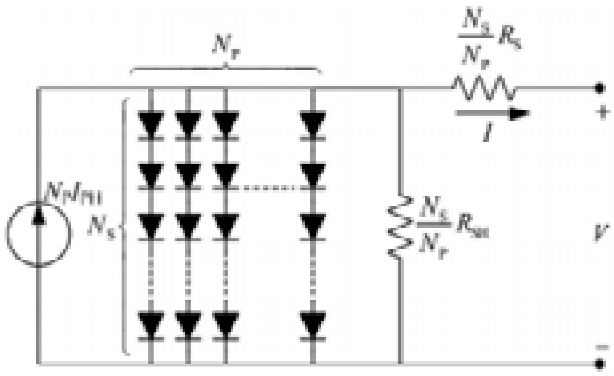


Fig.2

The voltage–current characteristic equation of a solar cell is provided: Module photo-current Iph:

$$I_{ph} = [I_{sc} + K_i(T - 298)] \times Ir/1000 \quad (1)$$

Here, Iph: photo-current (A); Isc: short circuit current (A) ;Ki: short-circuit current of cell at 25 °C and 1000 W/m2

T: operating temperature (K); Ir: solar irradiation (W/m2)

Module reverse saturation current Irs:

$$I_{rs} = I_{sc}/[\exp(qV_{OC}/NsknT) - 1] \quad (2)$$

Here, q: electron charge, = 1.6 × 10−19C; Voc: open circuit voltage (V); Ns: number of cells connected in series; n: the ideality factor of the diode; k: Boltzmann's constant, = 1.3805 × 10−23 J/K.

The module saturation current I0 varies with the cell temperature, which is given by:

$$I_0 = I_{rs}\left[\frac{T}{T_r}\right]^3 \exp\left[\frac{q \times E_{g0}}{nk}\left(\frac{1}{T} - \frac{1}{T_r}\right)\right] \quad (3)$$

Here, Tr: nominal temperature = 298.15 K; Eg0: band gap energy of the semiconductor, = 1.1 eV; The current output of PV module is:

$$I = N_P \times I_{ph} - N_P \times I_0 \times \left[\exp\left(\frac{V/N_S + I \times R_s/N_P}{n \times V_t}\right) - 1\right] - I_{sh} \quad (4)$$

With

$$V_t = \frac{k \times T}{q} \quad (5)$$

and

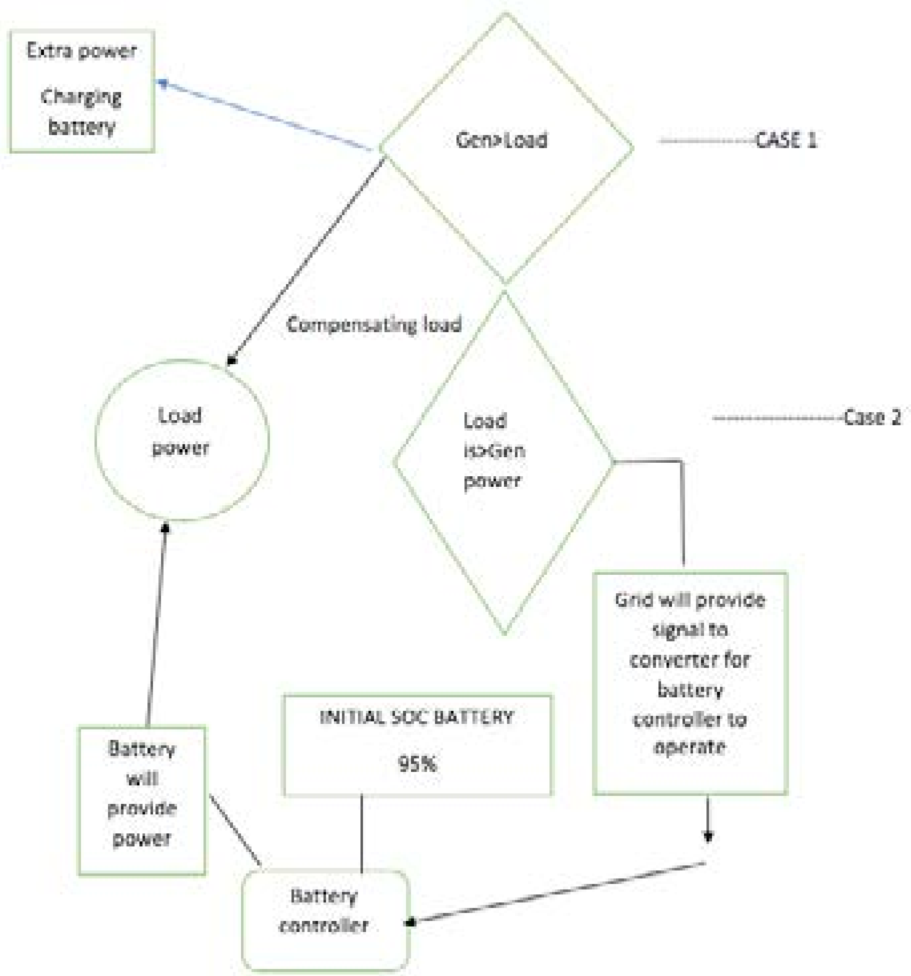
$$I_{sh} = \frac{V \times N_P/N_S + I \times R_S}{R_{sh}} \quad (6)$$

Here: Np: number of PV modules connected in parall; R s: series resistance (Ω); Rsh: shunt resistance (Ω);Vt: diode thermal voltage (V).

3. RESEARCH METHOD

An improvised control system is developed to improve microgrid stability and to increase performance efficiency at different scenarios. Proposed system consists of solar panels, grid, load and Nickel cadmium battery with its controller (initial soc of battery is set as 95%).

Overview of the algorithm is shown below which consists of two different cases-



CASE 1-

- If Generating power is more than the Load then extra power will be used in charging batteries and remaining will compensate load.

CASE 2-

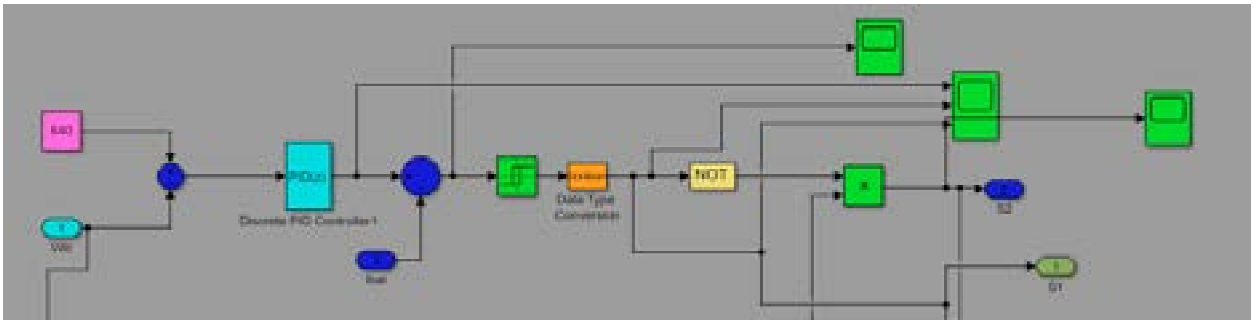
- If load is greater than generating power grid will provide signal to the converter for battery controller to operate, converter is designed with fuzzy logic control
- Charged battery will provide power to the load.

Control system

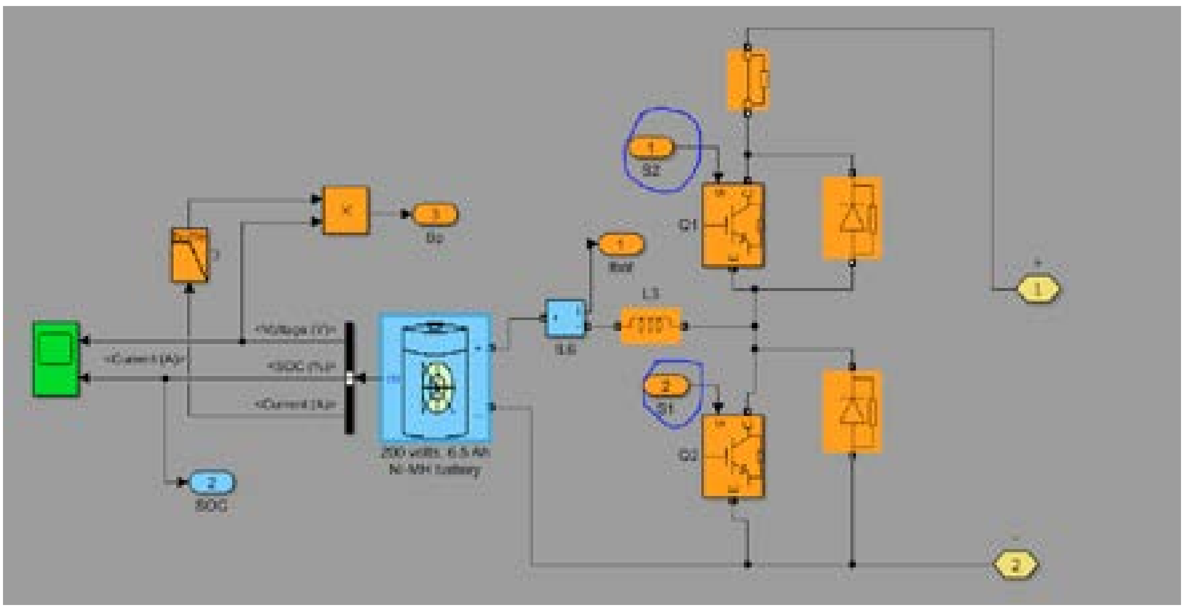
This is basic control system for switching process of battery to operate at different time according to the load and other resources.

Here, two parameters of battery are taken into consideration that are voltage and battery Soc,

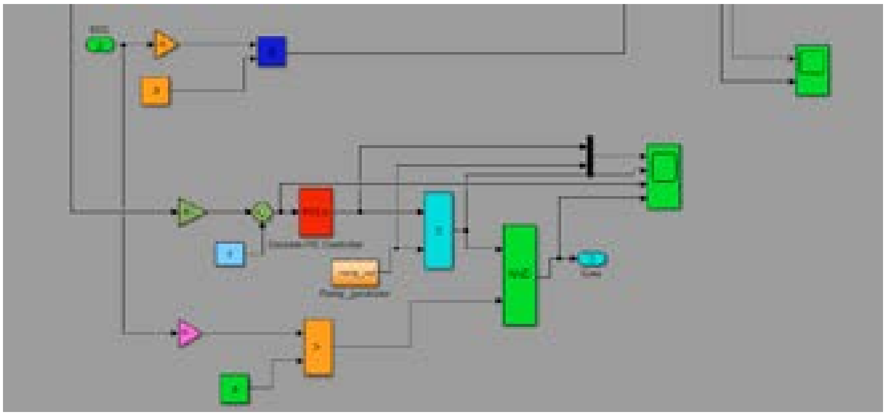
- Initial Soc of battery 95% and response time 30 second that means whenever soc reach to 90%, it indicates that battery is fully charged.



This part is for voltage regulation of the battery this part will decide when voltage to increase and when to drop, whenever it senses load power is not compensated by other resources then it provides pulse to the switches s1 and s2. In this input to the PID is the comparison value of vdc and reference value.
PID works to achieve desired value. It provides switching pulses through s1 and s2 which in input to the mosfe



Battery management using soc control system here input is soc of the current situation. In next step, it is compared with some value of Soc, that whenever the soc reached its minimum it provides pulses to s1 and s2 for recharging of battery.



With the hybrid voltage and current mode control, the inverter is controlled as a current source to generate the reference power in the grid-tied mode. And its output power should be the sum of the power injected to the grid and the load demand P load + jQ load, which can be expressed as follows by assuming that the load is represented as a parallel RLC circuit:

$$P_{\text{load}} = \frac{3}{2} \cdot \frac{V_m^2}{R} \quad (1)$$

$$Q_{\text{load}} = \frac{3}{2} \cdot V_m^2 \cdot \left(\frac{1}{\omega L} - \omega C \right) \quad (2)$$

In the overall block diagram for the proposed unified control strategy, where the inductor current iLabc, the utility voltage vg abc, the load voltage cvarci, and the load current iLLabc are sensed. And the three phase inverter is controlled in the SRF, in which, three phase variable will be represented by dc quantity. The control diagram is mainly composed by the inductor current loop, the PLL, and the current reference generation module. In the inductor current loop, the PI compensator is employed in both D- and Q-axes, and a decoupling of the cross coupling denoted byω0Lf/k PWM is implemented in order to mitigate the couplings due to the inductor. The output of the inner current loop dd q, together with the decoupling of the capacitor voltage denoted by 1/k PWM, sets the reference for the standard space vector modulation that controls the switches of the three-phase inverter. It should be noted that k PWM denotes the voltage gain of the inverter, which equals to half of the dc voltage in this paper.

The PLL in the proposed control strategy is based on the SRF PLL, which is widely used in the three-phase power converter to estimate the utility frequency and phase. Furthermore, a limiter is inserted between the PI compensator GPL Land the integrator, in order to hold the frequency of the load voltage within the normal range in the islanded operation. In Fig., it can be found that the inductor current is regulated to follow the current reference iLrefdq, and the phase of the current is synchronized to the grid voltage vgabc. If the current reference is constant, the inverter is just controlled to be a current source, which is the same with the traditional grid-tied inverter. The new part in this paper is the current reference generation module shown in Fig, which regulates the current reference to guarantee the power match between the DG and the local load and enables the DG to operate in the islanded mode. Moreover, the unified load current feed forward, to deal with the nonlinear local load, is also implemented in this module.

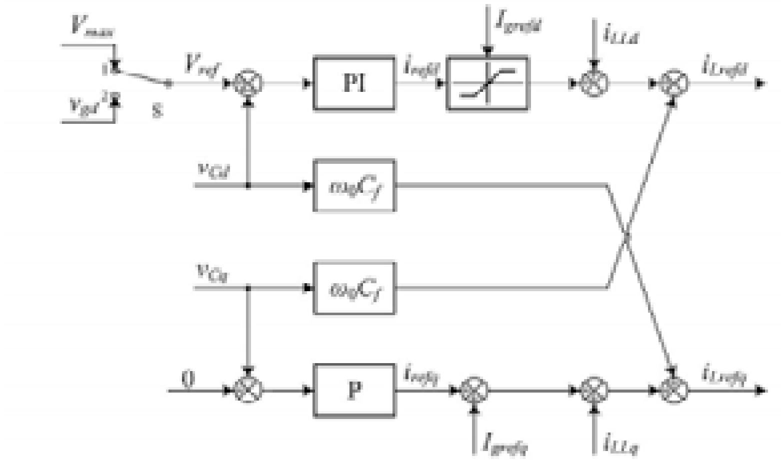
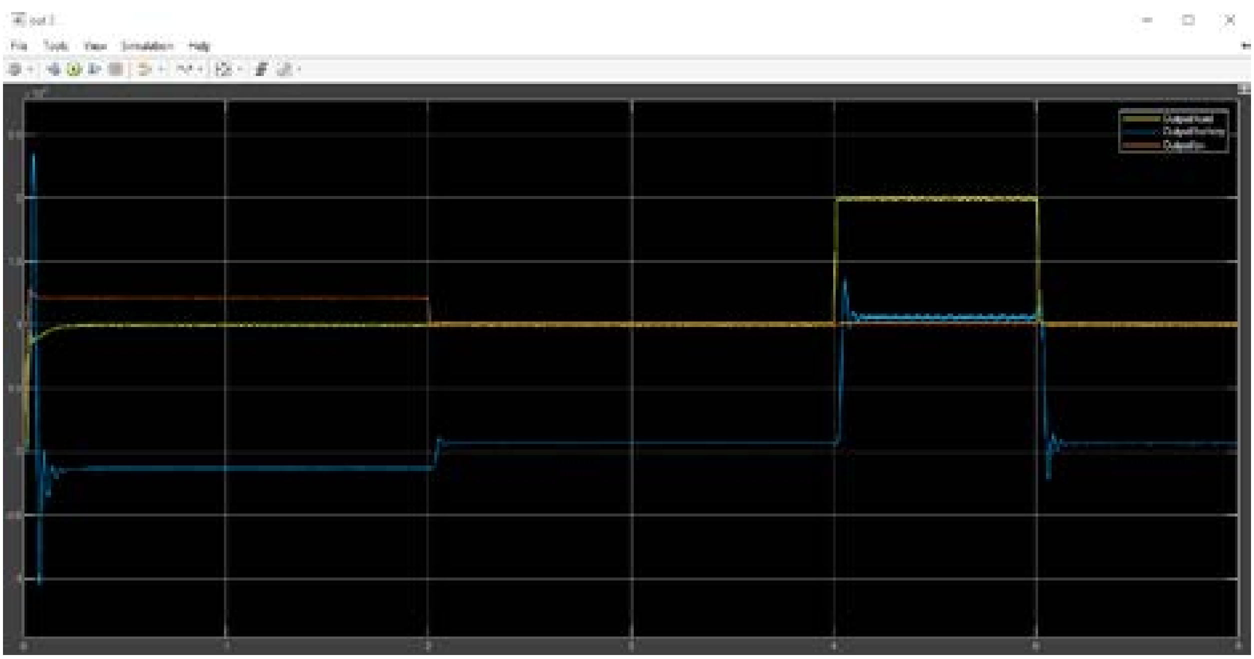


Fig. Black diagram of the current generation module

Results



Above From the graph we can see charged battery is providing power to load and battery is charged by the renewable resources that is solar. Extra power is transferred to the grid sometimes it takes power from other sources. At starting the solar power is very less this is because of solar data i.e. irradiance data has small values at starting time.

Here is the output of all pV, load and battery. Here, controller performed battery management, we can observe at starting battery is charging mode since load is compensated by PV power, but after sometime when we load increases the battery comes in discharging mode at time 4 sec to 5 sec after that again it gets stable.

Initially, battery is charged so it is providing enough power to compensate the load, whenever others resources provide enough power to load, battery comes into charging mode.

Conclusion

Modeling of each components of Microgrid is presented and focused on EMS with pid controller. We have used Nickel-Metal hydride type battery because of its high-power capability. Performance of the proposed system has been evaluated at different electrical conditions.

Control structure is designed in such a way that it can perform good at any sudden changes in load and disturbance. Simulation results show effectiveness and the credibility of control system designed using PID controller.

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