

Energy Management and Control for Grid Connected Hybrid Energy Storage System under Different Operating Modes

SATHIYAMURTHI.K¹

**¹Assistant professor Department of EEE, Arignaranna institute of science and Technology.*

ABSTRACT- A hybrid micro grid-powered charging station reduces transmission losses with better power flow control in the modern power system. However, the control and energy management strategy between the renewable energy sources and the energy storages under different operating modes is a challenging task. In this paper, a new energy management format is proposed for the grid associated hybrid energy storage with the battery and the super capacitor under different operating modes. The main advantages of the proposed energy management scheme are effective power sharing between the different energy storage systems, faster DC link voltage regulation to generation and load disturbances, dynamic power sharing between the battery and the grid based on the battery state of charge, reduced rate of charge discharge of battery current during steady state and temporary power fluctuations, improved power quality features in AC grid and seamless mode transitions. The effectiveness of the proposed method is validated by both simulation and experimental studies.

KEYWORDS—series, energy management, HESS, DC coupled hybrid micro grid, super capacitor.

1. INTRODUCTION

Renewable energy systems such as photovoltaic (PV) and wind energy systems are widely designed grid connected or autonomous mode. This is a problem especially in small powerful system due to the restriction on the converter markets. Converters which are utilized in these kinds of energy systems operate on grid or off grid.

In this project, an optimal power management strategy has been developed by designing a wind-PV hybrid system to operate both as an autonomous system and as a grid-connected system. The converter used in this study has been designed to operate both on-grid and off-grid. Due to the continuous demand for energy, gel batteries can be used in the hybrid system to store the energy in an efficient manner.

The designed control Unit performs energy management for on grid and off grid wind/PV and battery hybrid systems by providing an effective energy transfer to batteries, loads and grid. So the designed control unit provided the opportunity to work more efficiently. Energy management is necessary in this present scenario.

Energy management helps in not only saving the energy but also in utilization of electrical energy in the efficient manner. So this project mainly focuses on Energy management of hybrid sources. The main purpose to focus on energy management system is due to the present energy scenario where the demand for energy is increasing rapidly. The use of renewable energy sources is rapidly increasing all over the world.

2. LITERATURE SURVEY

The PV panel and wind turbine generators are used as the main power generator in the system. Due to the continuous demand for energy, energy storage devices are required. Therefore, gel batteries can be used in the hybrid system. In order to operate hybrid system on grid and off grid the control unit was developed. With this control unit, the system can operate both on grid and off grid. By this means, the hybrid system could work more efficiently. The PV cell is formed by combining p and n type semiconductor material in a thin layer. Therefore, they are similar to diode in structure. The PV cell converts the solar radiation into electricity energy. Meanwhile, they fairly generate very low voltage in the high current density. Therefore, a PV cell shows a character of current source. In order to determine the behaviour of PV cell, many equivalent circuit structures are presented in the literature. The most commonly used is the one diode equivalent circuit.

The proposed control scheme uses the multi-agent based approach which is complex to design and requires large computational resources. The fuzzy logic rule based control approach will generate the significant error between the simulated and experimental results as it is sensitive to the change in system parameters.

The adaptive neural network (ANN) based control for hybrid AC/DC micro grid is presented. In the proposed method the ANN based control is applied to track the maximum power from the renewable source and to exchange power from the grid. The method is based on the online trained neural network controller which is too complex to model and requires large computational resources to get the optimal control parameters. The model predictive control (MPC) based EMS and control for the HESS. With the given control scheme, it is ensured that the battery and SC operate at preened SOC limits. As the proposed approach is based on the classical discrete MPC, it requires large computational resources. A unified EMS for grid-connected HESS.

The results presented show a better performance than the power management algorithm .interms of faster DC voltage regulation, execution time and charge/discharge rates of the battery system. However, the power sharing between the grid and the battery during different operating conditions is based on the SOC level of the battery which follows a discrete pattern.

This approach creates a sharp increase in the battery charge/discharge rates during transition which can reduce the battery operating lifetime.the sliding mode control technique is used to control the HESS. The proposed methods are supported by detail experimental results. However, the control approach mentioned is complex to design and depend on system parameters. Various power management algorithms for grid connected system . The studies presented in these literatures follow the discrete power sharing approach between the battery and the grid. The low complexity power management and control strategy for isolated DC micro grid . The energy management presented only deal with the isolated DC micro grid and neglect its connection with AC grid. a unified control and power management for PV-battery hybrid Micro grid for grid connected and islanding operation is presented.

3. METHODOLOGY

1.WIND TURBINE

A wind turbine, or alternatively referred to as a wind energy converter, is a device that converts the wind's kinetic energy into electrical energy.

The WT presents a rated power of 1.5 kW. It presents a two blade turbine coupled to a three-phase permanent magnet synchronous generator (PMSG). This WT is represented by a model with the following subsystems: turbine and generation system. The turbine model expresses the mechanical power extracted from the wind, which is a function of the wind speed and the blade tip speed ratio, as defined by the actuator disk theory. The generation system is composed of a three-phase

PMSG, ac-dc converter, and dc-dc converter, which are represented by models included in Sim Power Systems . The electrical and mechanical parts of the PMSG are represented by a second order state-space model.

The ac-dc and dc-dc converters are modeled by average-value equivalent models. The dc-dc power converter, which connects the WT to the hybrid system dc bus, is controlled by a torque reference-based maximum power point tracking (MPPT) control in order to extract the maximum available power from the WT. This MPPT control maintains the operating point of the WT on its maximum power coefficient for any wind speeds in the below-rated wind speed region, modifying the duty cycle of the WT dc-dc converter, which produces a variation of its rotational speed.

The maximum theoretical power output of a wind machine is thus 16/27 times the kinetic energy of the air passing through the effective disk area of the machine. If the effective area of the disk is A, and the wind velocity v, the maximum theoretical power output P is:

$$P = \frac{16}{27} \frac{1}{2} \rho v^3 A$$

where ρ is the air density.

2. PV PANELS

The PV system presents nine 0.180-kW PV panels, with a total rating of 1.6kW.Asingle-diodemodel, which is composed of a current source and a parallel diode (representing the ideal PV cell) with two resistances (series and parallel resistances), is used to represent each PV panel. This model presents suitable accuracy, and the parameters are easy to find in the commercial datasheets , which makes it perfect for the simulation of PV devices with power converters.

A dc-dc power converter controlled by a MPPT controller adapts the PV output voltage to the dc bus voltage. The MPPT controller generates the duty cycle of the PV converter to move the PV voltage to the voltage that corresponds to the maximum power point (MPP). In this work, the MPP voltage is defined as proportional to the PV open-circuit voltage . Thus, a fractional open-circuit voltage algorithm is used as MPPT algorithm to generate the duty cycle of the controller due to its simplicity.

3. HYDROGEN SUBSYSTEM

The hydrogen subsystem is composed of 0.48-kWPEM electrolyzer, 2280-liter hydrogen tank, and 1.2-kW PEM FC. PEM electrolyzer and PEM FC are highly efficient units that are suitable for autonomous and distribution operation . The PEM electrolyzer uses electrical energy to produce hydrogen from water. It is modeled by a

resistance, in which the power needed to produce hydrogen is consumed. Faraday's law is used to calculate the hydrogen produced depending on the electrical current in the resistance. The hydrogen produced by the electrolyzer is stored in the hydrogen tank. In the hydrogen tank model, the hydrogen available in the tank is obtained from the rate of incoming and outgoing hydrogen, taking into account the ideal gas equation. The PEM FC uses the hydrogen available in the tank in order to produce electrical energy. It is modelled by a reduced model of the complete model detailed.

The validity of the reduced model was demonstrated, where both the reduced and complete models were compared, showing similar responses, but with a considerable reduction of the computational time for the first one. Several control strategies for FC vehicles were evaluated by using this reduced model. In this reduced model, the FC voltage depends on the cell voltage and number of cells.

The cell voltage is determined as a function of the current density, temperature, and water, and hydrogen and oxygen partial pressures. The compressor, which controls the air flow in the cathode to keep constant the oxygen excess ratio, is represented by a first-order system. Finally, an ideal air cooler and humidifier are considered in the FC model.

4. BATTERIES

The hybrid system uses a 14.48-kWh lead-acid battery. This type of battery is usually the least expensive storage battery for any application, while still providing good performance and life characteristics. This battery is modelled by a conflict in series with a variable voltage source.

5. DC-DC CONVERTERS

Each energy source of the hybrid system provides a variable voltage, which depends on the current demand, at different ranges. Therefore, it uses a pulse-width modulated (PWM) dc-dc converter [6] to transfer the output power to the central dc bus. The output voltage of the WT rectifier is higher than the dc bus voltage. Thus, the WT plus rectifier system is connected to the dc bus by using a buck-type unidirectional converter. The connection of PV, FC, and electrolyzer to the dc bus is performed by using boost-type unidirectional converters. The PV and FC converters transfer power from the source to the dc bus, since both sources terminal voltages are lower than the dc bus voltage. The electrolyzer converter transfers power from the dc bus to the electrolyzer, whose terminal voltage is higher than the dc bus voltage. The battery uses a bidirectional converter, which allows the power flow from the battery

to the dc bus (boost-type) and vice versa (buck-type). Each dc-dc converter is modeled by using the two-quadrant chopper model included in SimPowerSystems. In this model, the chopper is represented by a simplified version of the converter containing an average-value equivalent model.

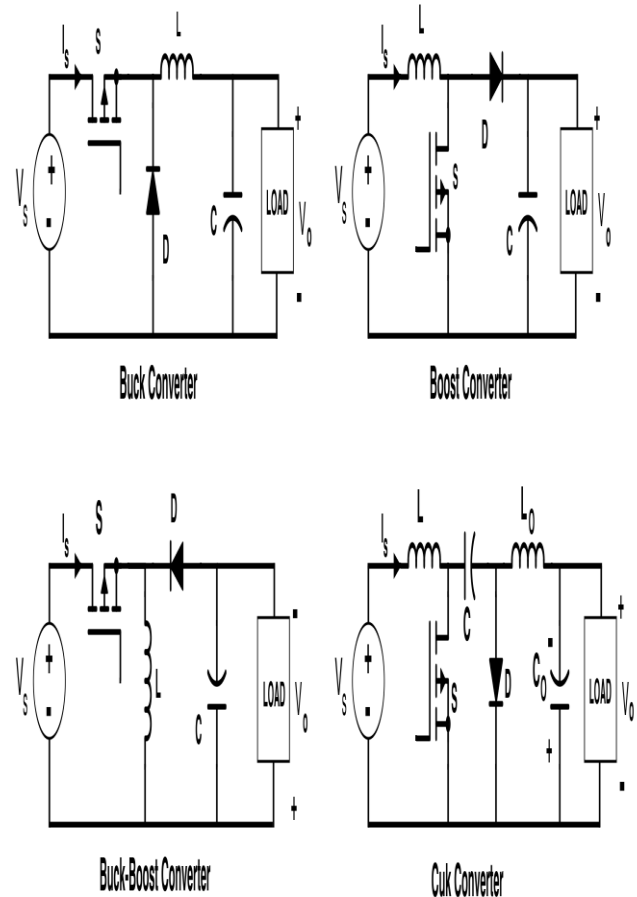


FIG1:PV and FC converter

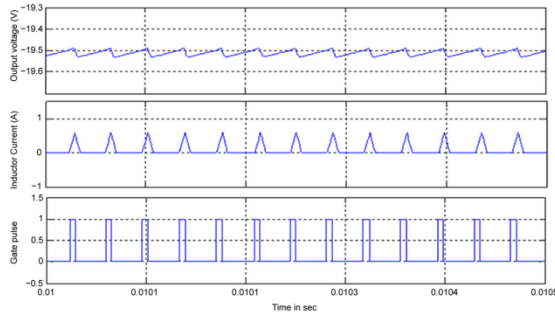
6. INVERTER

A three-phase IGBT inverter connects the dc bus of the hybrid system to grid. This inverter is represented by the model developed in. In this model, the snubber capacitor is eliminated, so that only the snubber resistance is taken into account. Furthermore, the forward voltages of the IGBTs and diodes are considered null. The inverter is PWM to produce the three-phase 50-Hz sinusoidal voltage. It uses hysteresis switching and controls the active and reactive power, as will be shown below.

5.SYSTEM MANAGEMENT & CONTROL

In renewable energy power systems, central control unit (supervisory controller), control the operation mode of the system and the flow of power also provides the optimum operation of control units which belongs to each energy source. Main decision factors for power

management strategy is power level supplied by wind turbines and solar panels and the battery power level of the state of charge. Supervisory controller must balance the power flow between system components. However, because power generation varies depending on atmospheric conditions, power management strategy can be very complex.

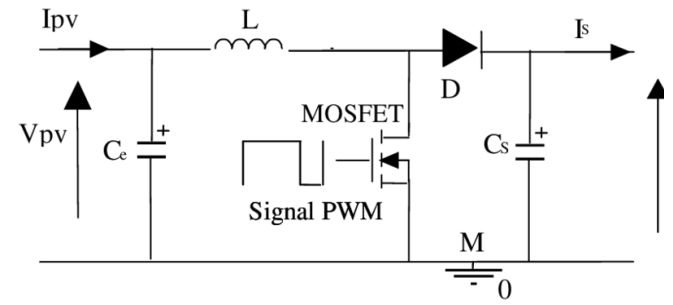


Control unit which is designed in this project, provides the operation of the hybrid system as autonomous and grid connected. The control unit's input terminals are output of PV panels, wind turbine output, battery, grid and autonomous loads. The output terminals are the switch between the DC/AC inverter and the grid, the DC/AC inverter and autonomous loads, grid and autonomous loads and the switch on the battery cable. PV generator is composed of fifty series cells and five parallel cells. PV array generates output voltage of 96.872v and wind power generates output voltage of 700v. DC/DC converter is used to stabilize the output voltage of solar and wind by using fuzzy logic controller. The FLC is designed with fuzzy logic toolbox in MATLAB

1.Dc/Dc Converter

A **DC/DC converter** is a power converter with an output DC voltage greater or lower than its input DC voltage. In this project DC/DC converter is controlled by using fuzzy logic controller to obtain a stable single phase 230v as a output from the DC/DC converter. The system components of DC/DC converter is described as follows, input voltage to the converter is from two sources (i.e.) solar and wind. Therefore total input voltage to the DC/DC converter will be around 500-700v. Since control unit is employed with fuzzy logic controller the output voltage of the converter is maintained to a constant voltage of 230v. In order to cross check the efficiency of the fuzzy logic controller, the same simulation is carried out with different controller for control unit (i.e.) PI controller. Corresponding scope of PI controller. It is observed that by using fuzzy logic controller the time taken to stabilize the voltage is very less when compared to the PI controller. So DC/DC converter with fuzzy logic controller results in efficient output when compared to DC/DC converter with PI controller. So this is efficient when compared the converter with PI controller. so in are they are adopting this controller, since it is more

efficient.



PI OUTPUT VS FLC OUTPUT:

The **PI controller** is the most popular variation, even more than full **PID controllers**. The value of the **controller** output $u(t)$ is fed into the system as the manipulated variable input. A control system is an arrangement of physical components designed to alter another physical system so that this system exhibits certain desired characteristics. Following are some reasons of using Fuzzy Logic in Control Systems. While applying traditional control, one needs to know about the model and the objective function formulated in precise terms. This makes it very difficult to apply in many cases.

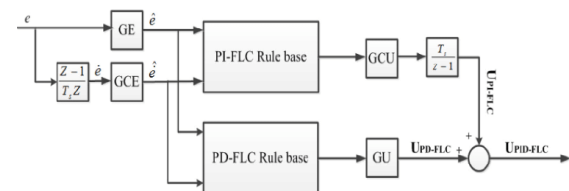


FIG 2: Dc/Dc Converter SIMULATION OUTPUT & DISCUSSION

Modes of operation:

Table 1. Operating modes Number of modes	Timing in seconds	S1	S2	S3	S4
1	0 - 0.5	1	0	0	1
2	0.5 - 1	0	0	1	0
3	<1	1	1	1	0

Where, S1= Battery switch, S2= Renewable sources to Grid switch, S3= Renewable sources to load switch, S4= Grid to load switch.

A. Mode 1

In mode 1 of operation, normal power supply to load occurs (i.e.) from grid power to load. During this operation of mode, power supply is not obtained from hybrid sources. So during this mode the voltage from the solar and wind sources is stored in the battery. According to the simulation, this mode is in operation from 0 sec to 0.5 sec.

B. Mode 2

In mode 2 of operation, power supply for load is obtained from solar and wind sources (i.e.) from renewable sources to load. During this operation of mode, power supply is not obtained from grid sources and also voltage from the

C. Mode 3

In mode 3 of operation, power supply for load and grid is obtained from hybrid sources (i.e.) from renewable sources plus battery to load and grid. During this operation of mode, stable power supply to load and grid is obtained from hybrid sources to overcome fluctuations if any.

The voltage from the solar and wind sources is stored in the battery as well to maintain the battery voltage. According to the simulation, this mode is in operation after 1sec.

4. CONCLUSION

The proposed system is based on fuzzy logic controller is found to be more compact and less complex. Within the context of developed control unit application, when the developer control unit is used, the power transferred to grid, batteries and/or autonomous loads are averagely more than the present scenario according the control unit is not used. By adopting this proposed method the power oscillations are reduced and steady state is reached at much faster rate. Results show excellent performance with FLC when compared to PI controller.

REFERENCE

- [1].Sarin, CR., Syam Nair., et al.: 'Load – source analysis and scheduling in hybrid smart grid using multilayer adaptive GNN algorithm' . Int.Conf.on Signal Processing, Communication, Power and Embedded System (SCOPE5), Paralakhemundi, India ,3-5 Oct. 2016, pp. 1900 – 1907.
- [2] Shaheen, N., Javaid, N., Iqbal, Z., et al.: 'A hybrid algorithm for energy management in smart grid'. 18th int.conf.on network-based information systems, Taipei, Taiwan, 2-4 Sept. 2015, pp. 58 – 63.
- [3] Wenlong Jing, Chean Hung Lai., et al.: 'Battery-Super capacitor Hybrid Energy Storage System in Standalone DC Micro grids: A Review'. IET Renewable Power Generation,2016.
- Luo, F. and Ye, H.H. (2003) Negative Output Super Lift Converters. IEEE Transactions on Power Electronics, 18, 1113-1121. <http://dx.doi.org/10.1109/TPEL.2003.816185>

[4] Ye Yang, Qing Ye, Leonard J. Tung, ., et al.: 'Integrated Size and Energy Management Design of Battery Storage to Enhance Grid Integration of Large-scale PV Power Plants'. IEEE Trans. Industrial Electronics, 2017, pp. 1 -1.

[5] The Future of Energy 2012 Results Book, Bloomberg New Energy Finance, New York, USA, BNEF, 2012.