# Simulation and Implementation of Hybrid Micro Grid Based on DC-AC for Energy Management System using Power Electronics Transformer

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**Abstract -** *Now a day's intermediate output power and variable load voltage fluctuations and power mismatch tend to occur during AC/DC hybrid micro-grid operation. Therefore, a distributed energy coordination strategy is proposed in this project. This strategy can coordinate the power exchange between PET, AC micro-grid, DC micro-grid and energy storage to effectively suppress the fluctuation of DC bus voltage. At the same time, the proposed hybrid mode control method, only with on local information, can ensure the full utilisation of all subsystems and buffer the energy fluctuations of hybrid micro-grids. The simulation results show that the proposed control strategy can accurately control the bidirectional flow of power between the PET interfaces and regulate the power distribution between the main network, the AC micro-grid and the DC micro-grid to achieve the stable operation of the AC/DC hybrid micro-grid.*

***Key Words*: Power Electronics Transformer, Hybrid Micro-grid, Battery, Energy management control.**

## 1. INTRODUCTION

The main objective of the thesis is to develop a simulation and implementation of hybrid micro grid based on DC/AC for energy management system using power electronics transformer. To accomplish the task we have used a home industry and to connect the grid, an use the MATLAB software. Our circuit is very simple and easy to understand. It is compatible in almost all PC with operating system Microsoft Windows xp, windows vista or windows 7. The main goal of the project is to generate power is use on the home appliance and remaining power is to transfer on the grid. To use on the energy management system and power electronics transformer, also reduced on the harmonics.

Recently, the availability of power in India has not just increased but also improved, although the demand consistently rose more than the supply. That's why non-conventional sources have become the center of attraction. Wind energy is the cheapest form of renewable energy and PV offers added advantage over other renewable source because they produces no noise and require least maintenance. When any one of the system is shutdown the other can supply power.

## 1.1 OVERVIEW OF BLOCK DIAGRAM

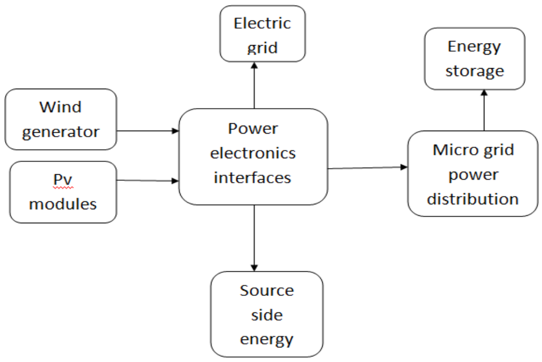


**Figure 1.1 Block diagram of proposed system**

Combined wind & PV hybrid generation system utilizes the solar and wind resources for electric power generation. Individual wind and solar renewable sources have unpredictable random behavior. Due to the earth terrains, bodies of water and vegetation the wind flow patterns are modified. Wind is highly unpredictable in nature as it can be here one moment and gone in another moment but it is capable of supplying large amount of power. Grid interface of hybrid generation system improves the system reliability.

## 2. PV SOLAR ENERGY SYSTEM

The sun is the largest energy source of life at the same time, it is the ultimate source of all energy (except power of geothermal). The sun radiates 174 trillion kWh of energy to the earth per hour. In other words, the earth receives 1.74 x $10^{17}$ watts of power from the sun. Characteristics of the sun is simplified as follows : mass $2\times10^{30}$ kg, beam length 700 km, age $5\times10^{9}$ years and estimated roughly 5 billion more years of life. The surface temperature of sun is approximately 5800 K while the internal temperature is approximately 15,000.000 K. The process of the nuclear fusion, which is characterized from the following reaction 4 H→4He+Energy is the result of the sun high temperature and the large amounts of energy emitted continuously.

$$J = \frac{P}{4\Pi d^2}$$

## 2.1 PHOTOVOLTAIC STRUCTURE

The photovoltaic cells structure is quite straightforward. It consists of 6 different layers of materials as shown in Figure 2.1. First of all, the efficiency of photons absorption is increasing due to the assistance of black cover glass surface, the glass is protecting the cell from the elements of atmosphere.

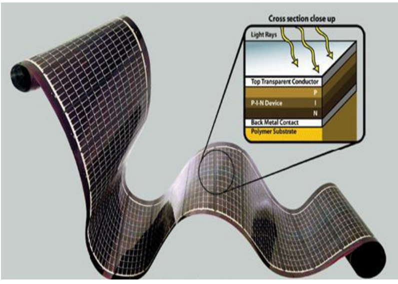


**Figure 2.1 Basic structure of a generic silicon PV cell**

The resistance between infinity and zero varies, the voltage and current will be determined to vary as well. Maximum power point (MPP) of Photovoltaic cell can be found in the figure 2.1

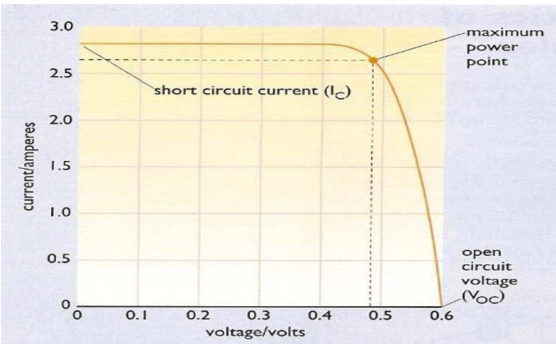


**Figure 2.2 I-V Curve of a typical silicon PV cell under standard test conditions**

Finally, international standard test conditions are established, in order to measure the power output of photovoltaic cells. The level of irradiance is defined as 1000 W/m², with the reference of air mass 1.5 solar spectral irradiance distributions and cell junction with temperature of 25°C.

## 2.3 MAIN PARTS OF A PHOTOVOLTAIC SYSTEM

In the figure 2.3, photovoltaic system is consisting of various devices. The complete photovoltaic system is constituted by inverter, charge controller and batteries.

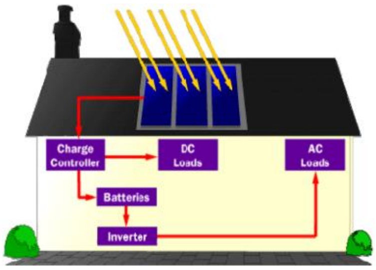


**Figure 2.3 General schematic of a residential PV system**

In this renewable energy system, the energy produced by Photovoltaic cell is stored in the batteries. Furthermore, Energy will be supplied to the system, it generally happens at nights, cloudy days and days which are required higher electrical demands. Charge controller is an important device for the battery life cycle. In the operation mode of charge controller, the life of battery will be reduced if overcharge occurs in the battery. The efficiency of the inverter is quite high and varies between 93% and 96%.

## 3. DC-DC CUK CONVERTER

The main applications of this circuit are in regulated dc power supplies, where a negative polarity output may be desired with respect to the common terminals of the input voltage and the average output is either higher or lower than the dc input voltage. The capacitor C1 acts as a primary means to store and transfer the power from input to output. The average output to input relations are similar to that of a buck-boost converter circuit. The output voltage is controlled by controlling the switch-duty cycle. The ratio of output voltage to input voltage is given by:

$$V_o / V_{in} = D*(1/1\text{-}D)$$
$$= I_{in} / I_{out}$$

## 4. WIND ENERGY SYSTEM

Wind is the continuous movement of atmospheric air masses and is determined by its speed and orientation. This movement derives from the changes and the different values of the atmospheric pressure while these values are the result of the solar heating of different parts of the earth's surface. Wind energy is the conversion of a small percentage, about 0.2%, of the solar radiation that reaches the surface of the earth. The wind power around the globe is estimated in 3.6×109 MW while, according to valid estimations of the world meteorology organization, the percentage which is available for energy exploitation in various parts of the world is only 1% and it is estimated around 0.6Q (175×1012 KWh).

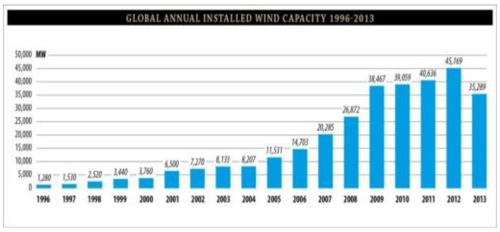


**Figure 4.1 Worldwide installed wind capacity the last 17 years**

## 4.1 VERTICAL AXIS WIND TURBINE (VAWT)

Vertical axis wind turbines are different from traditional wind turbines in that their main axis is perpendicular to the ground. Their configuration makes them ideal for both rural and urban settings and offers the owner an opportunity to offset the rising cost of electricity and to preserve the environment. VAWTs are not affected by the direction of the wind which is useful in areas where the wind changes direction frequently or quickly. VAWTs are better able to harvest turbulent air flow found around buildings and other obstacles.

## 4.2 PRINCIPLES OF SAVONIUS ROTOR WIND TURBINE

Savonius turbines are one of the simplest turbines. Aerodynamically, they are drag-type devices, consisting of two blades (vertical – half cylinders). A two blades savonius wind turbine would look like an "S" letter shape in cross section as shown in Figure 4.2. The lower blade (the concave half to the wind direction) caught the air wind and forces the blade to rotate around its central vertical shaft. Whereas, the upper blade (the convex half to wind direction) hits the blade and causes the air wind to be deflected sideway around it.

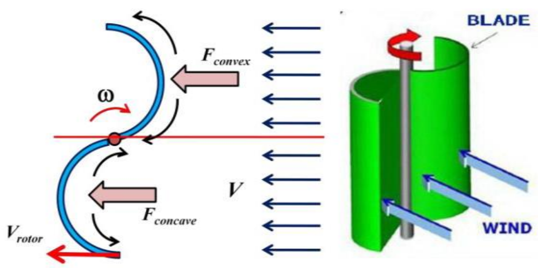


**Figure 4.2 Schematic drawing showing the drag forces exert on two blade Savonius.**

Because of the blades curvature, the blades experience less drag force ($F_{convex}$) when moving against the wind than the blades when moving with the wind ($F_{concave}$). Hence, the half cylinder with concave side facing texperience more drag force than the other cylinder, rotor to rotate. For this reason, Savonius turbines extract much less of the wind's power than other similarly sized lift type turbines because much of the power that might be captured has used up pushing the convex half, so savonius wind turbine has a lower efficiency.

## 4.3 ENERGY STORAGE SYSTEM

The two main types of batteries used in hybrid systems are nickel- cadmium and lead-acid. Nickel-cadmium batteries are restricted in use for few systems due to higher cost, lower energy efficiency and limited upper operating temperature. Lead–acid batteries are usually used for energy storage in hybrid systems to energy, to regulate system to supply load in insufficient solar radiation wind. Only 2 or 3 days of autonomy is required for batteries in wind–PV hybrid systems, while 5 to 6 days of autonomy are necessary in separate PV or wind systems.

## 5.1 POWER ELECTRONICS TRANSFORMER

Power Electronic Transformer (PET) is a new type of transformer, which realizes voltage transformation and performs power quality functions through modern power electronic converters. However, they have some disadvantages such as heavy weight, sensitivity to harmonics, voltage drop under load, (required) protection from system disruptions and overload, protection of system from problems arising at or beyond the transformer, environmental concerns regarding mineral oil, and low performance under dc-offset load unbalances.

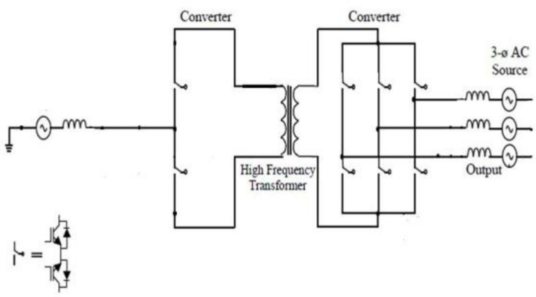


**Figure. 5.1 PET schematic diagram**

This capability is shown in Figure 5.1 where 3 series-output cells will supply a three-phase voltage source inverter and the remaining cells will supply individual loads. In this case, the input power fed to the series Half-bridges in switch would be different. Therefore, the HB rectifier should maintain voltage balance among the primary DC links and correct the input power factor.

## 6. MAXIMUM POWER POINT TRACTION (MPPT) CONTROL TECHNIQUES

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy.

Maximum power point tracking technique is used to improve the efficiency of the solar panel. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the thevenin impedance of the circuit (source impedance) matches with the load impedance.

## 6.1 Perturb and Observe (Hill climbing method)

Perturb & Observe (P&O) is the simplest method. In this we use only one sensor, that is the voltage sensor, to sense the PV array voltage and so the cost of implementation is less and hence easy to implement. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm.

## 6.2 PWM TECHNIQUES

Traditional solenoid driver electronics rely on linear control, which is the application of a constant voltage across a resistance to produce an output current that is directly proportional to the voltage. However, this scheme dissipates a lot of power as heat, and it is therefore very inefficient. A more efficient technique employs **Pulse Width Modulation** (PWM) to produce the constant current through the coil.

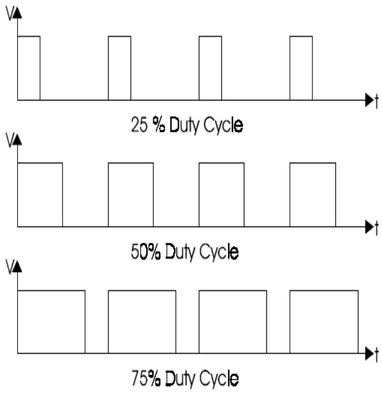


**Figure 6.1 Duty cycle**

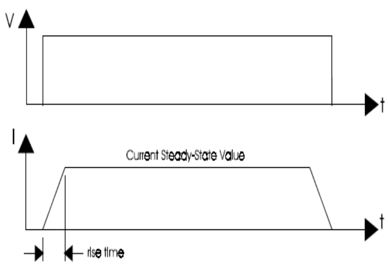


**Figure 6.2 Continuous voltage across the inductor**

## 6.3 LC FILTER

In grid synchronization due to the PWM inverter ripple current is injected to the grid to overcome this problem LC filter is used. Based on the current ripple the value of L is designed. Due to the lower switching smaller ripple result. The change in current is 10% to 15% of the rated value. In this system 10% of the rated current can be considered for the designed value of the inductor L. For reactive power supplied from the capacitor at fundamental frequency the capacitor C is designed.

## 7. RESULTS AND DISCUSSION

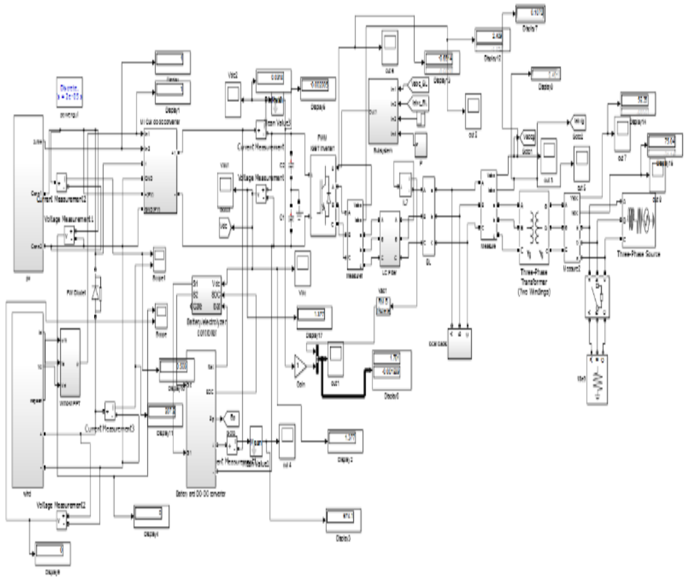

**Figure 7.1 Simulation of hybrid micro grid based on dc/ac for energy management system using power electronic transformer**

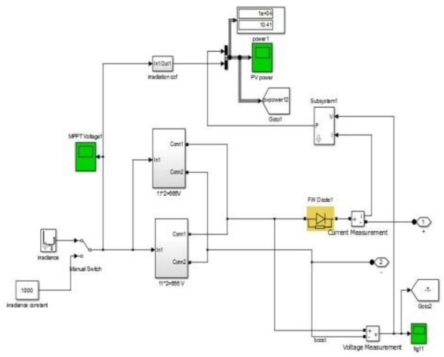

**Figure 7.2 Simulation of PV systems**

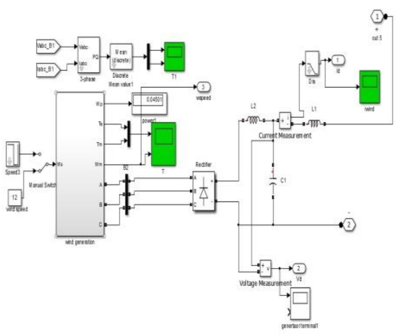

**Figure 7.3 Simulation of wind system**

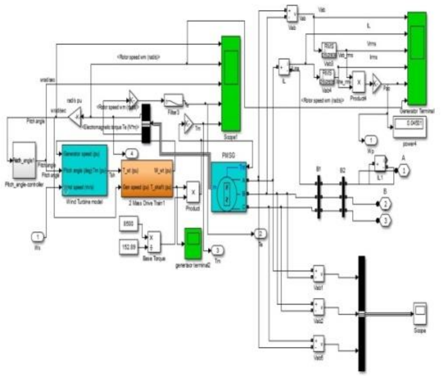

**Figure 7.4 Simulation of wind generator**

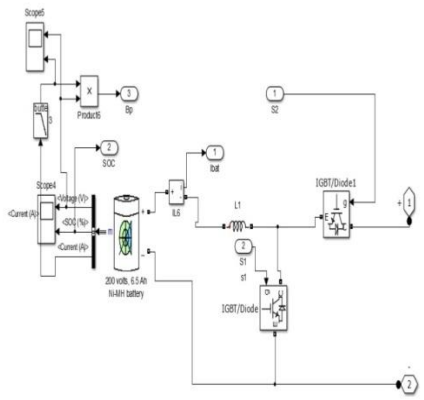

**Figure 7.5 Simulation of battery controller**

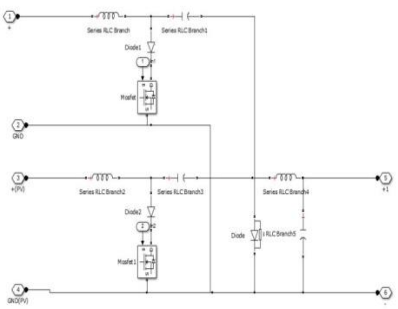

**Figure 7.6 Simulation of cuk converter**

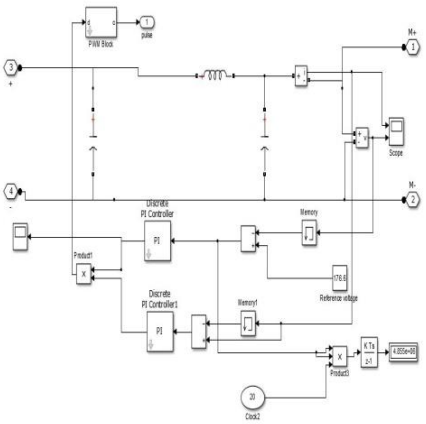

**Figure 7.7 Simulation of MPPT**

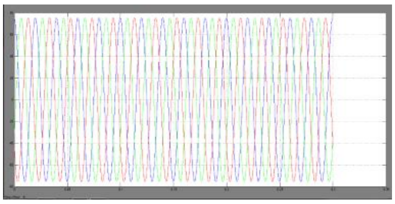

**Figure 7.8 Grid current**

Thus the simulation output voltage is finite in figure 7.8. The graph is grid connected of the output voltage is 80 volts at the time intervals; the simulation running time is 0.5.

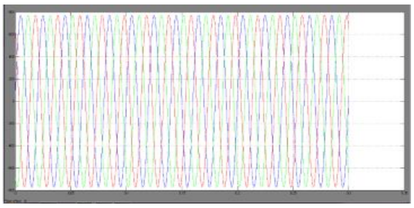

**Figure 7.9 Grid voltage**

Thus the simulation output current is finite in figure 7.9. The current is grid connected of the current. The output of the grid current is 800 amps at the time interval; then the simulation running time is 0.5.

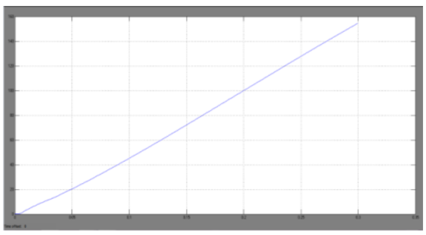

**Figure 7.10 Wind current**

The wind generator is generated on the current in 235.2 of the wind turbine in figure 7.10. In the current value is linearly increased.

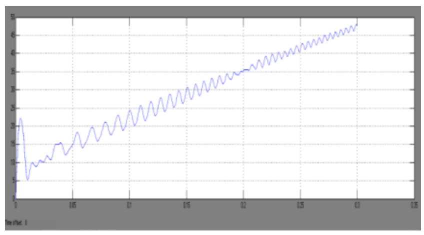

**Figure 7.11 Wind torque speed**

In this graph is identified on the starting torque is high an then torque is increased linearly in 60 above. The starting speed in the wind turbine is rotated on synchronous speed of the motor. The starting speed is 100 rpm above an then speed is increased linearly.

## CONCLUSION

A new reliable hybrid DG system based on PV and wind sources, with only a cuk converter followed by an inverter has been successfully implemented. The proposed hybrid system provides an elegant integration of PV system and wind source to extract maximum energy form the two sources. The proposed system aims to satisfy the load demand, manage the power flow from different sources, and inject the surplus power into the grid. The modified P & O is simulated in MATLAB simulink and its performance is verified using standard MPPT efficiency calculation and comparison studies on variation in $V_{ref}$ , with the modification made in the algorithm, the modified P & O method can track effectively for sudden changes in atmospheric conditions. Also, the modified P & O requires minimum algorithm steps when compared with standard P & O techniques.

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