# MODELLING AND IMPLIMENTATION OF HYBRID AC/LVDC MICRO GRID

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**Abstract**— AC or DC micro grid consists of different renewable sources, converters and loads connected to the power system. These have multiple reverse connections. To overcome such problems we are going through hybrid micro grid. But power management, control over the grid, and function of the hybrid grid are further difficult than an independent ac or dc grid. A hybrid ac/dc micro grid consists of various operating modes. Each converter has its controlling technique to collect optimum power from renewable energy sources. These converters will reduce the power transformation among the networks, maintain the stable operation under different supply and demand conditions. This hybrid micro-grid is outlined to operate with renewable energy sources. And it is interconnection of large AC and LVDC networks, with a bi-directional AC/DC/AC converter. And this system has radial distribution among the networks. Here wind power and solar power are the renewable sources. In the wind power, we have a wind turbine along with DFIG, same as solar power has PV farm along with boost converter which is works on MPPT technique. The system has been simulated in Simulink. The result shows the effective operation of the grid with different sources.

***Keywords:*** PV Panel, MPPT Technique, Boost converter, LVC bus, Bi-directional converter, Wind based system, DFIG, AC/DC/AC converters.

## 1. LITARATURE SURVEY

We have many household items which are working on dc power. For this reason we have to convert ac power into dc power so we need to adopt another converter to convert ac to dc. Dc power utilizing drives has a problem of speed regulation. For this reason further ac/dc conversions are employed. Due to the increasing of these conversion stages, efficiency was decreased (ref 3) .To decrease these conversion stages, we have to install the small grids near by the load centers. It leads the concept of ac or dc micro grids (ref 4). AC micro grids feed the ac loads from the available ac or by converting available dc into ac (ref 4, 5). To feed the dc loads, we have to convert ac into dc which leads another conversion stages and dc power use drives has the problem of speed control so to compensate these problems we have to go through the concept of dc grids (Ref 6, 7). Due to the presence of ac loads in both cases (ac grids and dc grids), we have the problem of multiple conversions. To reduce these conversions we have to go through the concept of hybrid ac/dc micro grids. Ref (8, 9). The solution for this problem is we have to inter connect the separate ac and dc buses through a bidirectional problem to reduce the multiple conversions. The design of bidirectional converter with different control schemes was discussed in (ref 10). These all has various power quality issues those are discussed in (ref11). A main control technique is proposed to deal with the renewable energy sources (ref 16). A micro controller based controlling to balance the power in micro grid with renewable energy sources (ref 17). A hybrid ac-dc micro grid topology consists generally two sources. PV plant with battery store house and grid connected system was discussed in (ref 18). A new technique to manage PV-wind system was discussed in (ref 19). A hybrid ac-dc micro grid with different sources like diesel generator, wind farms, PV farms with battery banks was discussed in (ref 20). In case of optimization problems, hybrid ac-dc micro grid designed with the robust optimal power management system which is discussed in (ref 21). Later, low voltage concept is introduced. In case of household, office spaces and data centers usage of LVDC was increased. So for this purpose we are introduced the concept of LVDC micro grids discussed in (ref 22). These LVDC micro grids decrease the problem of multiple conversions by direct usage of the generated dc power. Household Appliances works on the voltage levels of 12v, 24v, 48v, this doesn't exceeds the level of 50v (ref 23, 24). But the concept of LVDC was extended to office appliances (ref 25).

For voltage drop analysis, different voltage levels such as 326v, 230v, 120v, 48v are done. From this detailed study we can know that 326v is more suitable for office appliances than 48v (ref 26). A hybrid grid means it is the connection of two different sources, with their controlling networks. These 2 sources are renewable energy sources like solar irradiation, fuel cell stack, battery etc. in dc side and wind speed, ultra capacitor, diesel generator etc. in ac side.

The major cause for going through renewable energy sources is:

Nowadays we are generating electricity using non renewable energy sources like natural gas, coal, and oil and so on, these have inordinate effect on the environment as it releases huge amount of carbon dioxide to the earth's atmosphere, it causes increased amount of temperature on earth's surface, which is named as greenhouse effect. Hence, by using advanced technology, no.of ways are developed to generate electricity using renewable energy sources such as the wind and solar etc. Coming to the representation of a hybrid grid, it has two types of sources. Dc source and ac source. These both are renewable sources. These sources are connected to loads along with their converters.

## 2. System configuration

The system configuration was shown in below figure. It was connected with different ac and dc sources. Ac and dc loads are tied to its individual ac and dc systems. These converters are connected together with a bidirectional converter. Ac network have its corresponding sources, connected to its corresponding loads and energy storage elements. Same as dc network. In this suggested system, PV system connected to the boost converter which is works on P&O MPPT technique and it is tied to the dc bus to simulate dc source. A DFIG based wind system is tied along with their converters to ac bus to simulate ac sources. Solar irradiation and temperature, MPPT decides the output power of PV panel. A shunt capacitor is connected to PV terminals to decrease the high frequency ripples from the solar output. After this a dc-dc converter is present to boost up the low output obtain from the PV panel and now we have to maintain a dc link voltage. Three converters (boost converter, main converter, and bi-directional converter) connected to the common dc bus. Wind generating system consists of DFIG with back to back ac/dc/ac converter which is connected to a bus. These ac and dc networks are tied with a bidirectional converter to maintain the power flow between ac and dc sources.

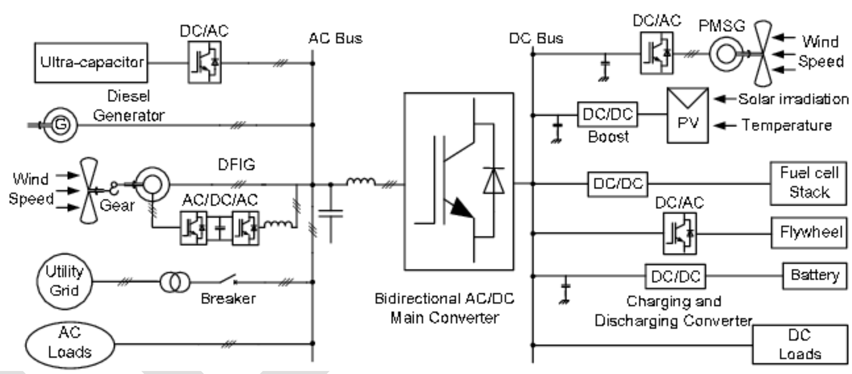


Fig.1 Proposed System

## 3. SYSTEM ODELLING AND DESIGNING

### 3.1. SOURCES:

#### A. Wind based system:

Wind is the main source of wind based system. Wind is caused by differences in the atmospheric pressure. Due to this differences wind moves from higher pressure to lower pressure areas. It causes different wind speeds. This system has wind turbines consisting of large no. of propellers. Propellers or blades turn around rotor due to the wind speed. Now the kinetic energy of wind is converter into rotational energy or mechanical energy. It was used to grinding grins or pumping water. The rotor was connected to the main shaft which spins the generator to generate electrical energy.

Power in the wind (P) = $\frac{1}{2}\rho\pi R^2 A V^3$

R =Radius of the blade ρ = Density of Air

A = Wind turbine rotor area V = average wind speed

**A.1. Modeling of DFIG based wind generator**

DFIG stator circuit directly connected to the transformer primary side and secondary side tied with the transmission line to make a common coupling point (PCC).DFIG rotor circuit tied to the ac-dc-ac converter. Here shunt capacitor to remove harmonics which are entering into the transmission system. Transformer is to provide voltage matching. DFIG based wind system has two converters. Rotor side converter and Grid side converter. Both are tied in parallel with dc link capacitor. Rotor side converter is to regulate the developed torque in DFIG by controlling the rotor current. However grid side connected converter prevents the dc bus voltage.

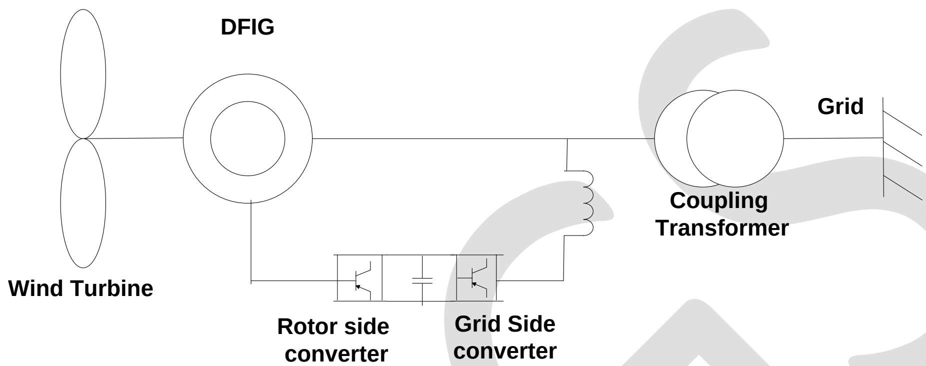


Fig.2.1 Wind Based generating station connected to the grid.

**B. Solar System**

Generally we have two types of technologies. Photovoltaic technology and thermal technology. Photovoltaic technology converts directly sun light into electricity. Thermal technology has dangerous amount of heat which is harmful. So here we are using photovoltaic technology. In this system we have solar panels which are connected to a converter. And Sun light is the main source. Each solar panel has no. Of PV cells and some are connected in series and some are in parallel. When sun light hits the panel, pv cells converts the solar energy into dc current. The converter is an inverter. This inverter will convert's dc power into ac power. The system can operate in two configurations – stand-alone mode and grid-connected mode. In the first method, Independent work of PV system was done that means it doesn't depends on any other power supply. And it feeds the loads by supplying electricity. So these are also called as autonomous systems. It has a storage ability (e.g. battery) it will store electricity to feed the loads during the night time or at times of poor sunlight levels and in second method, grid-connected PV system works along with the conventional distribution system. This combination is used to give electricity into grid or the loads which are connected to grid.

**B.1. Modelling of PV array**

Basic design of photovoltaic system consists of PV panel, dc-dc converter which is tied in series with the PV array, and a controller. This controller is used to trace the maximum power. It is essential ion photovoltaic system and it maximizes the output power and efficiency of PV system.

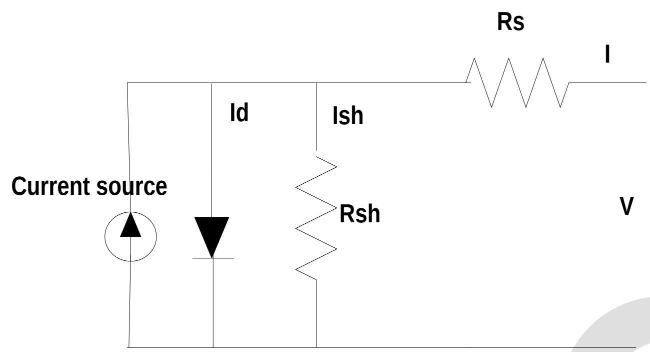


Fig.2.2.single diode PV array equivalent circuit

Basic equation to model PV array:

$$I_{PV} = I_{PH} - [I_S\left(exp\frac{q(V_{PV}+I_{PV}R_S)}{kT_CA}\right) - 1] - (V_{PV}+I_{PV}R_S)/R_P$$

We have many methods to mark out MPP. Here we are using P&O MPPT method to outline the maximum power.

**Perturb & Observe MPPT technique**:

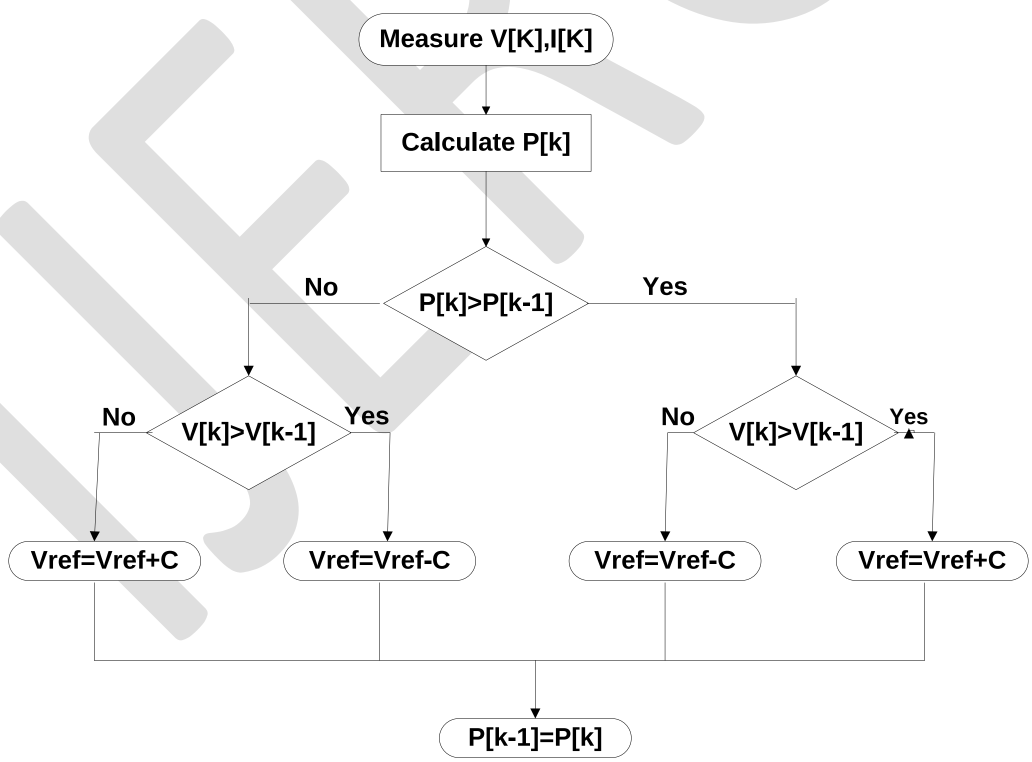


Fig.2.2 (a). P&O MPPT Technique Flow chart

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## 4. MODELLING OF CONVERTERS:

In this hybrid grid we have three types of converters. First one is boost converter which is coupled with the PV array to trace maximum power point. To inter connect DFIG with grid ac/dc/ac converter is used. And there is a bidirectional converter which is accountable for dc bus voltage in the grid.

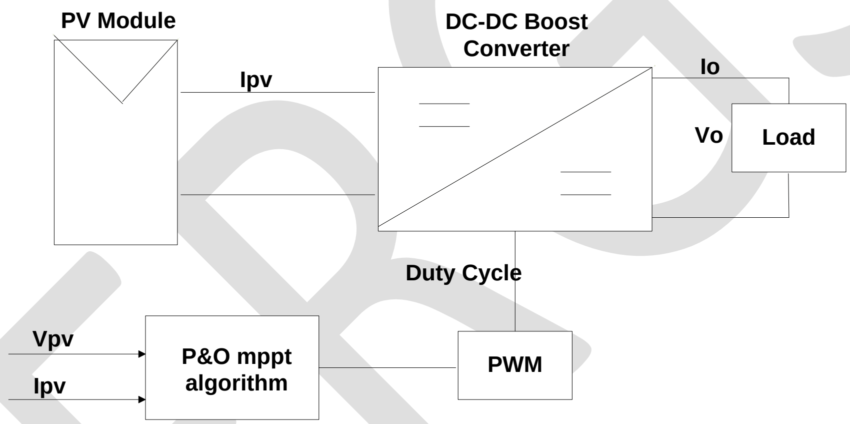
A. **Modelling of boost converter**: Commonly, in more cases boost converter is used as the MPPT converter. We may use this converter by using two control techniques. Direct duty cycle control (DDC) technique, current mode control (CMC) technique.

**Direct duty cycle method:**

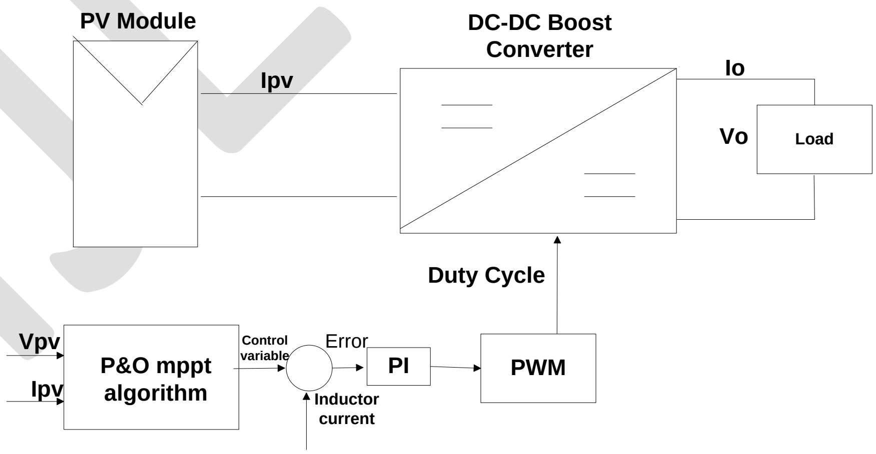
In these both cases some resistance is added as electrical load to examine the two methods. Duty cycle of the converter switch was calculated from the previous value of duty cycle. New value of duty cycle of the converter switch is calculated by adding or subtracting the previous value of the duty cycle with the help of perturb & observation technique.

**Current mode control method:**

In this control variable is current. And it is obtained from the P&O method. In this method also mppt based on previous perturb value. the previous perturb value moved towards or far from the point of maximum power and from this value we can discuss that operation.




(a) Direct duty cycle control technique




(b) Current mode control method

Fig. 3 Block diagram of P&O MPPT technique

Output voltage and current of boost converter:

$$V_0 = \frac{1}{(1-D)} V_{in}$$

$$I_0 = \frac{1}{(1-D)} I_{in}$$

Where,

$V_0$= boost converter output voltage

$I_0$ = boost converter output converter

D = Duty cycle

**B. Modelling of DFIG controllers:**

Wind turbine system has a generator named as doubly fed induction generator (DFIG). This DFIG secondary winding is tied to the secondary winding of three phase transformer. Rotor converter which is connected to the DFIG controls the rotor current which is present in stator flux reference frame. Direct current component and quadrature current component permit the decoupling effect of torque. Direct rotor current is used in such a way as field current in synchronous generator. Quadrature rotor current, controls the generator torque to get the desired rotational speed in fluctuated speed systems.

Supply side converter named as current controlled converter. It is used to deliver rotor power to the grid at synchronous speed .vector control of grid side converter allows reactive power compensation.

**C. Modelling of bi directional converter**

The major aim of bi-directional converter is to interconnect ac and dc networks of the micro grid. This converter is modeled in d-q reference frame for decoupling control effect. This converter has two control loops.

**Power control loop:**

After power invariant conversion in d-q reference, we have to calculate the real and reactive powers. This operation describes the decoupling control. From the decoupled equations, we can derive that real power and reactive powers which are controlled by q-axis and d-axis currents.

**Dc bus voltage control loop:**

A voltage loop is modeled for the modulation of dc-bus voltage to the reference value. And it has a constant dc link voltage throughout the process.

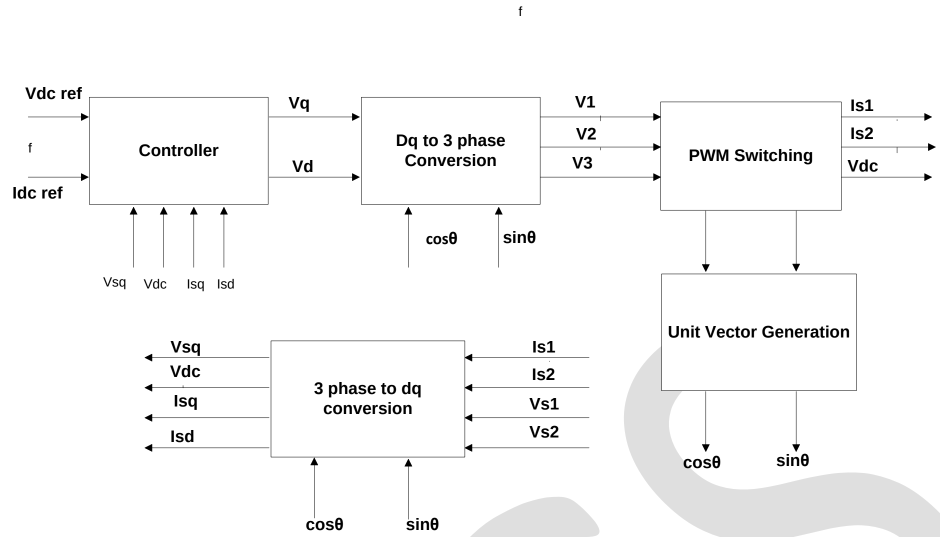
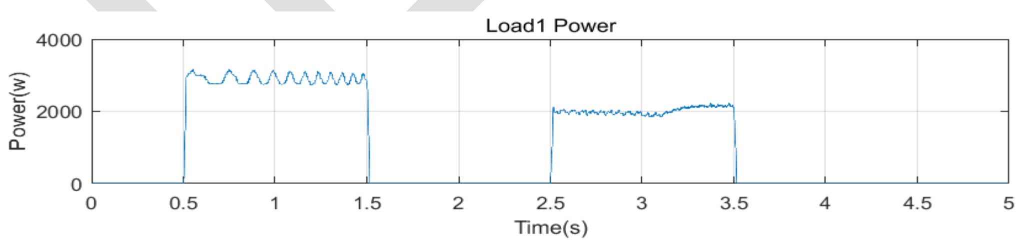



Fig.4 Block diagram of bi-directional converter

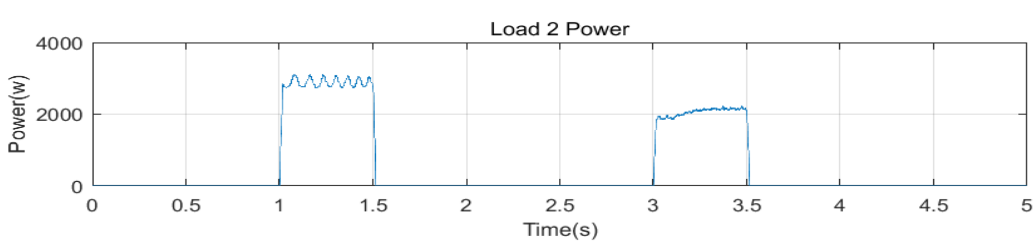
## 5. Simulation and results discussion:

A test system of hybrid micro grid design was done. Performance and simulation analysis of the system were studied. In this system ac network as well as dc networks are present. These both networks may have any no. of buses. Solar panel operating with the irradiance and temperature is 600w/ and c room temperature. Solar panel output graph was shown in Fig5.1 (a).From the boost converter we get the output as 850kw power shown in Fig 5.1(b). Finally after connect the LVDC bus finally from the dc side output is 8kw shown in fig 5.2(c).Ac side we have a wind turbine which is connected to the grid through DFIG and its converters. From the grid we get real power and reactive power. Here grid delivered 100kw power to the load shown in the fig5.2 (a). In this paper we have 2 loads operating from t=0 to t=5 sec. these 2 loads are single phase ac loads which are connected in parallel operating at the voltage of 200v. Load 1 and load 2 consuming the power of 3kw and 2 KW at different times. 2 loads are tie up with the grid through transformers shown in Fig 5.3(a), 5.3(b).

Now the designed mat lab file was simulated. First load operate from t=0.5sec to t=1.5sec with consuming power of 30kw. And t=2.5sec to t=3.5sec consuming the power of 20kw. Second load operate from t=1 sec to t=1.5 sec with consuming power of 30kw. And t=3sec to t=3.5sec with the power of 20kw. These two loads are operated by giving the gate signals. Solar was continuously in operating mode. Sometimes it will give the power to battery and sometimes feed the load.




(a)




(b)

Fig 5.3. a. load 1 power.   b. load 2 power

**6. Conclusion**

Thus, a smart hybrid AC/LVDC micro grid was considered in this paper. In the test system the design was simulated. Results are executed; verified the concept of proposed system operation and controlling. The achievement of such type of hybrid micro grids gives the more importance for the development of renewable generating systems. This paper explains complete design of sources with their controllers, and modeling of boost converter, bi directional converter with their control techniques.

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