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# LOAD MANAGEMENT IN WIND SYSTEMS WITH FUZZY CONTROLLERS

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## ABSTRACT:

In this project, a fuzzy-logic based Maximum Power Point Tracking (MPPT) method for a standalone wind turbine system is proposed. Hill Climb Searching (HCS) method is used to achieve the MPPT of the Permanent Magnet Synchronous Generator (PMSG) driven wind turbine system. Simulation results will show the effectiveness of the proposed method in various operating conditions.

## I.INTRODUCTION

Wind poweris the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, wind mills for mechanical power, wind pumps for pumping water or drainage, or sails to propel ships. At the end of 2009, worldwide nameplate capacity of wind-powered generators was 159.2 gig watts (GW).Energy production was 340 TWh, which is about 2% of worldwide electricity usage; [1] [2] and has doubled in the past three years. Several countries have achieved relatively high levels of wind power penetration (with large governmental subsidies), such as 20% of stationary electricity production in Denmark, 14% in Ireland[3] andPortugal, 11% in Spain, and 8% in Germany in 2009.[4] As of May 2009, 80 countries around the world are using wind power on a commercial basis.[2] Large-scale wind farms are connected to the electric power transmission network; smaller facilities are used to provide electricity to isolated locations. Utility companies increasingly buy back surplus electricity produced by small domestic turbines.


Fig 1.1 A Modern wind turbine in rural scenery

### 1.1 Wind Energy

Wind energy, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, and produces no greenhouse gas emissions during operation. However, the construction of wind farms is not universally welcomed because of their visual impact and other effects on the environment. Wind power is non-dispatch able, meaning that for economic operation, all of the available output must be taken when it is available. Other resources, such as hydropower, and load management techniques must be used to match supply with demand. The intermittency of wind seldom creates problems when using wind power to supply a low proportion of total demand, but as the proportion rises, problems are created such as increased costs, the need to upgrade the grid, and a lowered ability to supplant conventional production. Power management techniques such as exporting excess power to neighboring areas or reducing demand when wind production is low, can mitigate these problems.

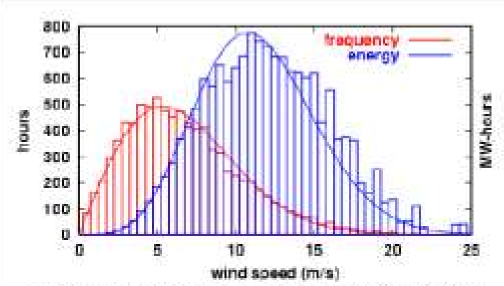
### Wind speeds:

• Cut-in wind speed (in the order of 3-5 m/s) and

• Nominal wind speed or rated wind speed: wind speed at which the nominal power of the turbine is reached (between 11 m/s and 16 m/s)

• cut-out wind speed : When the wind speed becomes very high, the energy contained in the airflow and the structural loads on the turbine become too high and the turbine is taken out of operation. Depending on whether the wind turbine is optimized for low or high wind speeds, (between 17 and 30 m/s).

• When the wind speed increases to levels above the nominal wind speed, the generated power cannot be increased further, because this would lead to overloading of the generator and/or, if present, the converter. Therefore, the aerodynamic efficiency of the rotor must be reduced, in order to limit the power extracted from the wind to the nominal power of the generating system.




Distribution of wind speed (red) and energy (blue) for all of 2002 at the Lee Ranch facility in Colorado. The histogram shows measured data, while the curve is the Rayleigh model distribution for the same average wind speed. Energy is the Betz limit through a 100 m (328 ft) diameter circle facing directly into the wind. Total energy for the year through that circle was 15.4 gigawatt-hours (GW·h).

Fig.1.4 waveform of wind speed

### Variable speed wind turbine model (DFIG):

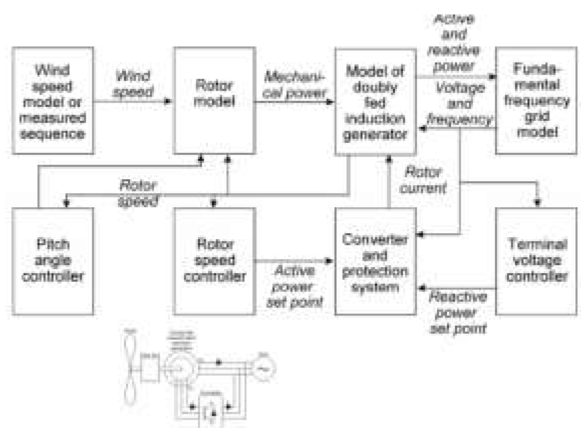



Fig. 1.5 Variable speed wind turbine model

### Features of wind power systems:

There are some distinctive energy end use features of wind power systems

i. Most wind power sites are in remote rural, island or marine areas. Energy requirements in such places are distinctive and do not require the high electrical power.

ii. A power system with mixed quality supplies can be a good match with total energy end use i.e. the supply of cheap variable voltage power for heating and expensive fixed voltage electricity for lights and motors.

iii. Rural grid systems are likely to be weak (low voltage 33 KV). Interfacing a Wind Energy Conversion System (WECS) in weak grids is difficult and detrimental to the workers' safety.

iv. There are always periods without wind. Thus, WECS must be linked energy storage or parallel generating system if supplies are to be maintained.

### PERMENANT MAGNET SYNCHRONOUS GENERATOR

Permanent Magnet Synchronous Generator is a type of Synchronous Generator which its excitation field is a permanent magnet instead of a coil.Synchronous Generators are the primary source of all electrical energy and commonly used to convert the mechanical power output of steam turbines, gas turbines, reciprocating engines, hydro turbines and wind turbines into electrical power for the grid. They are known as synchronous generators because they operate at synchronous speed. The speed of the rotor always matches supply frequency.

### 2.1Advantages of synchronous generator

They are more stable and secure during normal operation and they do not require an additional D.C supply for the excitation circuit.

- The permanent magnet synchronous generators avoid the use of slip rings, hence it is simpler and maintenance free.
- Higher power coefficient and efficiency.
- Synchronous generators are suitable for high capacities and asynchronous generators which consume more reactive power are suitable for smaller capacities.
- Voltage regulation is possible in synchronous generators where it is not possible in induction types.
- Condensers are not required for maintaining the power factor in Synchronous generators, as it is required in induction generators. closed gap induction

### MAXIMUM POWER POINT TRACKING

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a

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mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power.
The problem considered by MPPT methods is to automatically find the voltage VMPP or current IMPP at which a PV array delivers maximum power under a given temperature and irradiance. In this section, commonly used MPPT methods are introduced in an arbitrary order.

### 3.1 FRACTIONAL OPEN CIRCUIT VOLTAGE

The method is based on the observation that, the ratio between array voltage at maximum power VMPP to its open circuit voltage VOC is nearly constant.

$$V_{MPP} \approx k_1 V_{OC} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

This factor k1 has been reported to be between 0.71 and 0.78. Once the constant k1 is known,VMPP is computed by measuring VOC periodically. Although the implementation of this method is simple and cheap, its tracking efficiency is relatively low due to the utilization of inaccurate values of the constant k1 in the computation of VMMP.

### 3.2 FRACTIONAL SHORT CIRCUIT CURRENT

The method results from the fact that, the current at maximum power point IMPP is approximately linearly related to the short circuit current ISC of the PV array.

$$I_{MPP} \approx k_2 I_{SC} \quad \ldots\ldots\ldots\ldots (3.2)$$

Like in the fractional voltage method, k2 is not constant. It is found to be between 0.78 and 0.92. The accuracy of the method and tracking efficiency depends on the accuracy of K2 and periodic measurement of short circuit current.

## BOOST CONVERTER

A boost converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. It is a class of switching-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

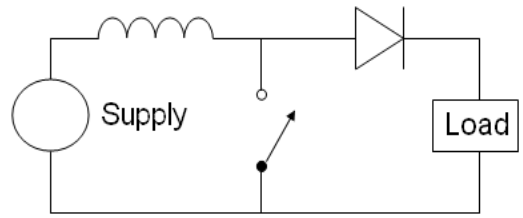



Fig 4.1 Circuit diagram of Boost Converter

Power can also come from DC sources such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion. A boost converter is a DC to DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it "steps up" the source voltage. Since power (*P* = *VI* or *P* = *UI* in Europe) must be conserved, the output current is lower than the source current.

A boost converter may also be referred to as a 'Joule thief'. This term is usually used only with very low power battery applications and is aimed at the ability of a boost converter to 'steal' the remaining energy in a battery. This energy would otherwise be wasted since a normal load wouldn't be able to handle the battery's low voltage. *

- This energy would otherwise remain untapped because in most low-frequency applications, currents will not flow through a load without a significant difference of potential between the two poles of the source (voltage).

**Block Diagram**

The basic building blocks of a boost converter circuit are shown in Fig.

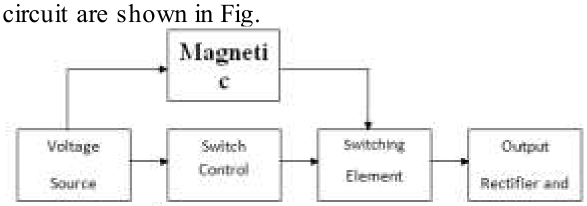



Fig 4.2Block diagram

The voltage source provides the input DC voltage to the switch control, and to the magnetic field storage element. The switch control directs the action of the switching element, while the output rectifier and filter deliver an acceptable DC voltage to the output.

## FUZZY LOGIC

### Description of Fuzzy Logic

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

## WIND ENERGY WITHOUT BATTERY

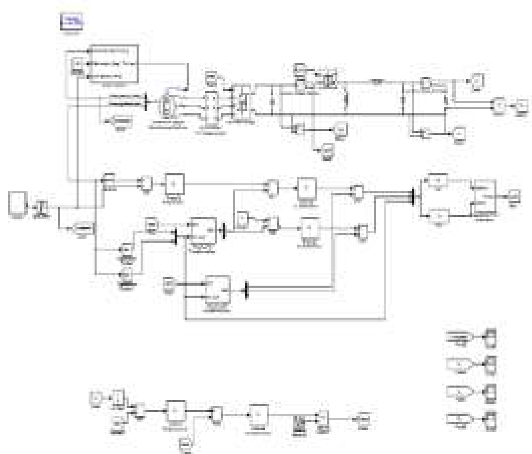
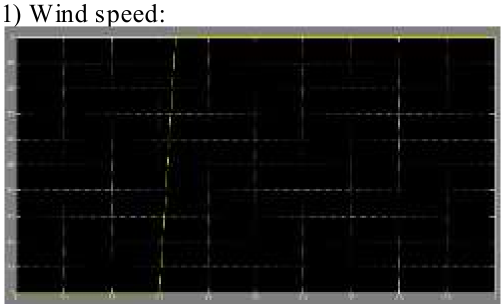


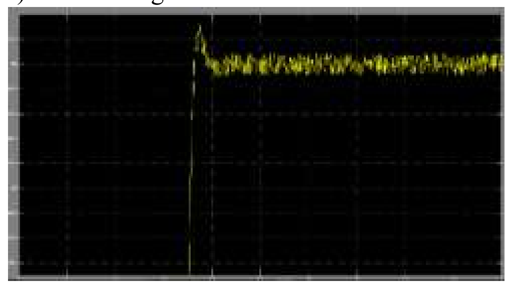
Fig 8.1: Wind energy without battery

### Output waveforms of WECS without Battery

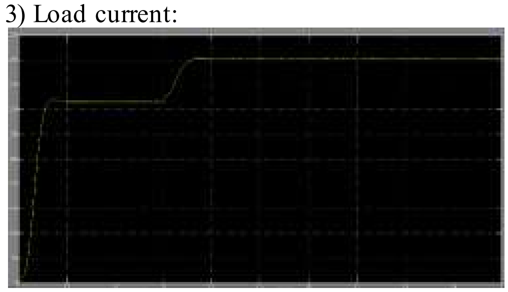
1) Wind speed:



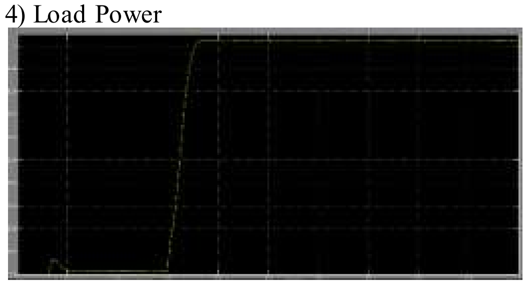
2) Load Voltage



3) Load current:



4) Load Power



## WIND ENERGY WITH BATTERY

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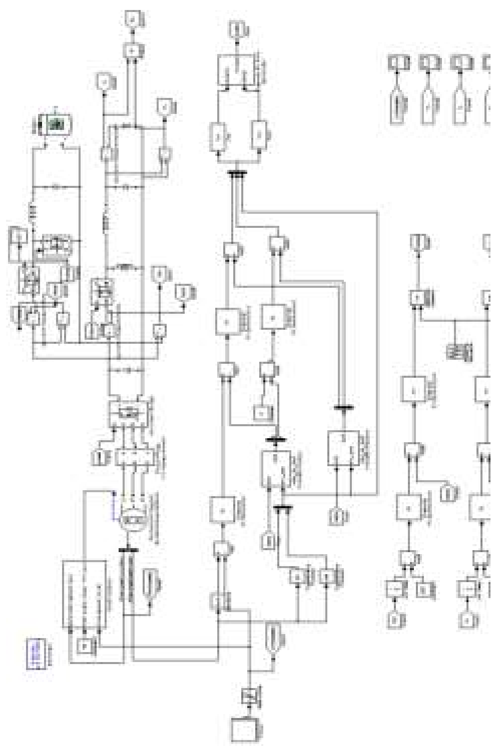
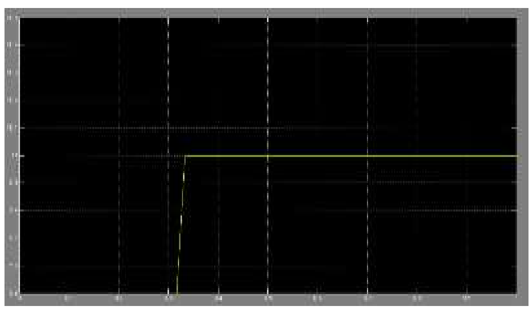


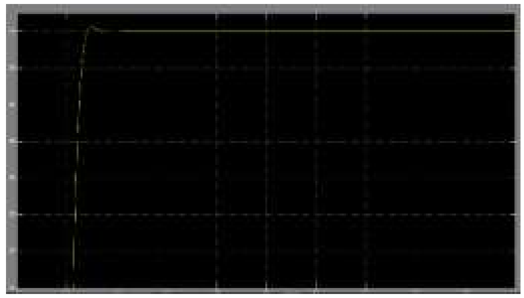
Fig 8.2 Wind energy with battery

**Output waveforms of WECS with Battery**

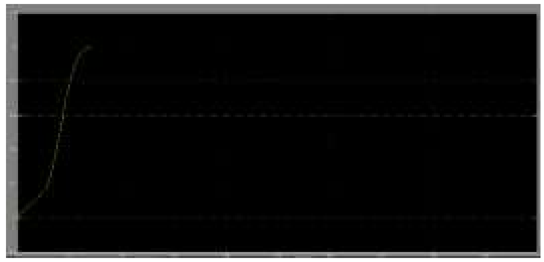
1)Wind speed



2) Load voltage



3) Load current



4) Load power

**8.3 WECS BY USING FUZZY LOGIC CONTROLLER**

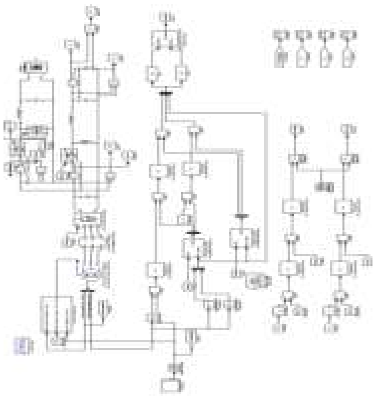
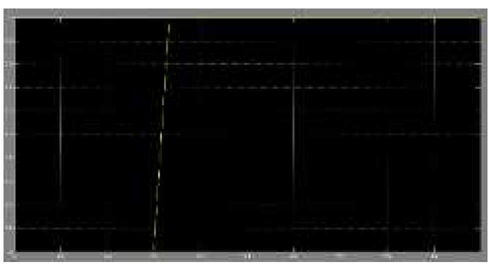


Fig 8.3 WECS by using Fuzzy logic controller

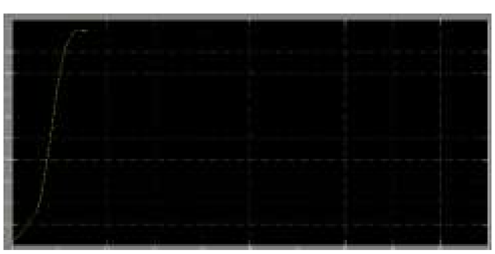
### 8.3.1 Output waveforms of WECS by using Fuzzy logic controller

1) Wind speed

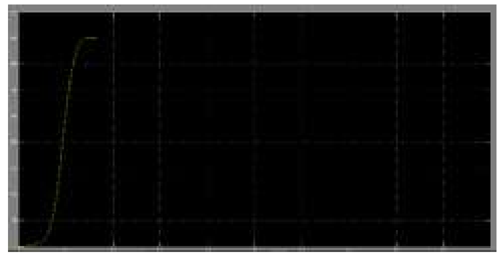


2) Load voltage

3) Load Current



4) Load power



## CONCLUSION:

This project proposes a WECS with battery storage for isolated load applications. A complete MATLAB/SIMULINK simulation is done for the proposed system. Thesimulation is validated for different wind speeds. Perturbation and observation method is implemented to track MPP. The system operates MPPT by varying boost converter duty ratio. Control of load power is accomplished with the help of bidirectional buck boost converter connected to battery bank. The excess power generated is used to charge the battery and it discharges when there is a shortage of power. Simulation is carried out for different wind speeds. Here in this project I have replaced PI Controllers with fuzzy logic controllers in order to obtain accurate results.

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