POWER CONVERTER AND CONTROL OF WIND ENERGY CONVERSION SYSTEM FOR MAXIMUM POWER EXTRACTION

Sanket Kale, Student, Department of E&TC Engineering, PCET's Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, MH, India
Kapil Waghmare, Student, Department of E&TC Engineering, PCET's Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, MH, India
Kiran thorat, Student, Department of E&TC Engineering, PCET's Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, MH, India
Dr. Rahul G. Mapari, Professor, Department of E&TC Engineering, PCET's Pimpri Chinchwad College of Engineering and Research, Ravet, Pune, MH, India

Abstract:
In this paper the most emerging renewable energy source, wind energy, which by means of power electronics is changing from being a minor energy source to be acting as an important power source in the energy system and the standard power converter topologies from the simplest converters for starting up the turbine to advanced power converter topologies, where the whole power is flowing through the converter wind Energy conversion system is very predominant in generation of electrical power. The integration of Wind energy conversion system (WECS) with the grid is a challenging phenomenon in research areas. Several DC-DC converter control. strategies have been implemented in distributed renewable energy harnessing system for coping with the energy shortage and environmental crisis. Double-loop controls, one being with voltage in outer loop and current in inner loop and the other being current in outer loop and voltage in inner loop are presented and compared. Active and reactive power control is achieved independently via controlling q-axis and d-axis current components, respectively for the first scheme, whereas, active and reactive power control is achieved dependently via controlling modulation index of the PWM converter and duty ratio of the boost converter for the second scheme. The effective and powerful WECS is determined via the whole control system superiority and the system operation stability.

Keywords:
Wind Energy, Bidirectional Converter, Power electronics, Renewable Energy

I. Introduction

We know wind energy is one of the most promising renewable energy sources for producing electricity, due to its cost competitiveness compared to other conventional types of energy resources. Wind power penetration greatly increases in the electric power systems and it is anticipated to keep steady growth in the upcoming years. To convert wind energy into electrical energy we put a system to work between Wind Energy and Electrical energy. Wind Energy as an input and Electrical Energy is output. In wind energy conversion system power is converted from pulsating AC to pulsating DC and then DC is converted into AC. A wind turbine is a device that converts kinetic wind energy to electrical energy. Wind turbines are becoming into a more major source of intermittent renewable energy as a means of reducing energy costs and reducing reliance on fossil fuels. The generator, gearbox, and rotor are among the components of a wind turbine. An AC constant power supply is a power source that transmits alternating current (AC) electricity to a load. The two types of power input are AC and DC. The power needed by the load and the power supplied by the inverter and other power storage devices are usually mismatched. AC power supplies correct the electrical source's AC power to the device's necessary voltage, current, and frequency in order to address this problem. One of the most crucial components of a solar energy system is an inverter. It is a device that transforms solar panels produced direct current (DC) electricity into the alternating current (AC) electricity needed by the electrical grid. DC keeps the voltage of the electricity constant in one direction. As the voltage shifts from positive to negative in an AC circuit, electricity moves in both directions. One type of power electronics—a class of devices that control the flow of electrical power—includes inverters. A popular Pulse width modulation approach is sinusoidal Pulse width modulation (SPWM).

II. Research Background

A power converter is a device that converts the direct current (DC) output of the generator into alternating current (AC) which can be fed into the power grid. The power converter is also responsible for controlling the speed of the generator to maintain a constant output power despite variations in wind speed. This is accomplished using a control algorithm which monitors the power output and adjusts the generator speed accordingly. The control algorithm used for maximum power extraction from the WECS can be based on different control strategies. One popular approach is the maximum power point tracking (MPPT) algorithm, which continuously tracks the maximum power point of the WECS and adjusts the generator speed to maintain the maximum power output. Another approach is the droop control, which adjusts the generator speed based on the frequency deviation from a reference frequency.

Current Technology

Wind energy conversion systems (WECS) use power electronics converters to interface the variable frequency output of the wind turbine generator with the grid. The power converter and control system of a WECS are crucial components that ensure efficient and reliable operation of the system. The current technology for power converters in WECS is based on voltage source converters (VSCs) and current source converters (CSCs). VSCs use pulse width modulation (PWM) techniques to control the output voltage and frequency of the generator. CSCs, on the other hand, use PWM techniques to control the output current and voltage of the generator. The control strategy of a WECS aims to maximize the power extraction from the wind turbine by adjusting the generator torque and blade pitch angle. The control system uses feedback from sensors to adjust the generator torque and blade pitch angle in real-time.

Proposed System

Wind energy conversion systems typically include a power converter and a control system that work together to extract the maximum possible power from the wind turbine. The power converter converts the variable-frequency AC power generated by the wind turbine into fixed-frequency AC power that can be fed into the grid. The control system regulates the power converter to ensure that the maximum amount of power is extracted from the wind turbine. Two commonly used modulation techniques for power converters are carrier-based pulse width modulation (CPWM) and space vector pulse width modulation (SPWM) CPWM involves generating a high-frequency carrier signal and varying the width of the pulses in the carrier signal to control the amplitude of the output waveform. In wind energy conversion systems, CPWM is typically used to control the output voltage of the power converter. SPWM involves generating a three-phase sinusoidal reference waveform and comparing it to a triangular carrier waveform to generate the pulse width modulation signal. SPWM is typically used to control the output current of the power converter. Both CPWM and SPWM have their advantages and disadvantages. CPWM is simpler to implement and has lower harmonic distortion, but it can result in higher switching losses and lower efficiency. SPWM is more complex to implement but offers better control of the output waveform and can result in higher efficiency.

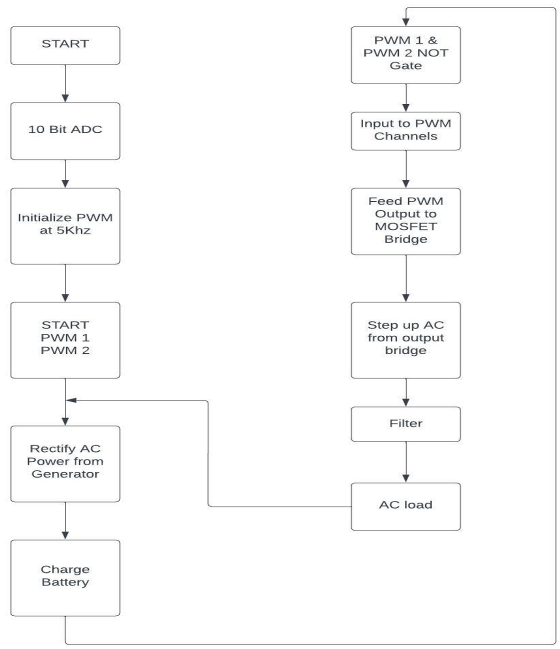


Fig 1: Flowchart of proposed system.

1. To start the working of wind turbine first step is to set up the wind turbine generator and its control system. It measures the wind speed and direction.
2. After initializing it convert the 10 bits into analog to digital. After this setup initialized the PWM techniques in proposed system of power converter and created the setup for AC/DC converter.
3. In the system of power converter two PWM techniques started working for rectifying continuous pulse width modulation is used.
4. The AC power is rectified from the generator and the energy that created from wind turbine is saved in the battery and the battery is charged.
5. PWM techniques which used in rectifying and inverting the current for better efficiency after they form waveforms for the current and voltage which is formed in the process of rectifying and inverting. It shows the waveform graph for the system.
6. Then it gives the input to PWM channels for the maximum power extraction from the wind turbine and then output is feed to the MOSFET bridge to inverting the current from DC to AC.
7. For maximize the power from given system step up AC output bridge is required and it filters the current and voltage and forms the stable AC load for the home appliances.

Key Technology

- Generator: This component converts the mechanical energy from the wind turbine into electrical energy.
- Power Converter: This component converts the direct current (DC) output of the generator into alternating current (AC) which can be fed into the power grid.
- Control Algorithm: This component is responsible for controlling the speed of the generator to maintain a constant output power despite variations in wind speed. The control algorithm can be based on different strategies such as maximum power point tracking (MPPT) or droop control. Overall, the proposed system for power converter and control of wind energy conversion systems for maximum power extraction is designed to ensure that the maximum

amount of energy is extracted from the wind and fed into the power grid, making wind energy a more viable source of renewable energy.

Block Diagram

Wind Turbine: A wind turbine is a device that converts the kinetic energy of wind into electrical energy. Wind turbines are an increasingly important source of intermittent renewable energy, and are used in many countries to lower energy costs and reduce reliance on fossil fuels. Wind Turbine contains some components which are Rotor, Gear box, Generator.

AC power supply(unstable): From wind turbine we get AC power supply and that AC power supply is not continuous with the help of CSPWM (continuous pulse width modulation) we stabilize that power. and further we sent it to the rectifier. Alternating current (AC) is the way electric power is transmitted from generating facilities to end users. It is used for power transportation because electricity needs to be transformed several times during the transportation process.

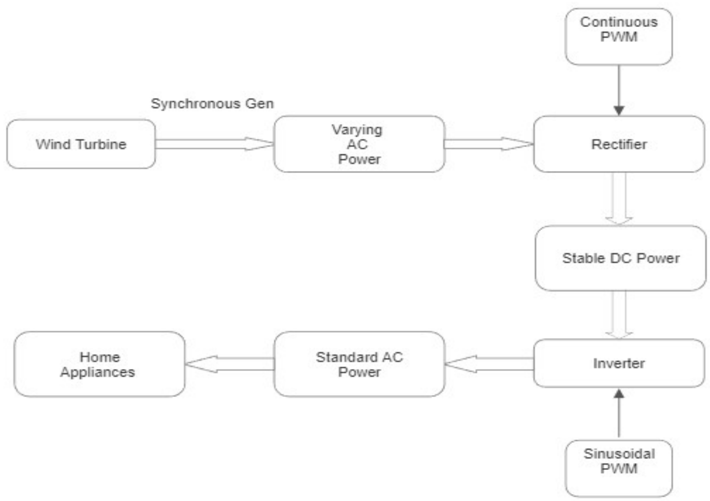


Fig 2: Block diagram of proposed system.

Rectifier (MOSFET): In energy harvesters, full wave rectifiers using diodes are frequently used. The traditional harvester circuit consists of an AC/DC rectifier with a full wave bridge and high voltage charges. These rectifier circuits based on diodes are not suited for obtaining current. In the typical circuit, diodes are replaced by n-channel switches to create a viable single- and double-stage energy harvesting module. An n channel MOSFET is added to the existing diode-based rectifier circuit in order to achieve the ideal voltage. The suggested MOSFET rectifier circuit is thought to be able to increase current and overcome voltage drop. A boost converter has been added to the energy harvesting circuit in order to double the voltage obtained at the rectifier's output. DC Power supply: From Rectifier we got Stabilize DC power and that DC power is supplied to the Inverter.

Inverter: An inverter is one of the most important pieces of equipment in a solar energy system. It is a device that converts direct current (DC) electricity, which is what a solar panel generates, to alternating current (AC) electricity, which the electrical grid uses. In DC, electricity is maintained at constant voltage in one direction.

AC power supply(stable): An AC stable power supply is a type of power supply used to supply alternating current (AC) power to a load. The power input may be in an AC or DC form. The power supplied from inverter and various power storage devices is oftentimes incompatible with the power needed by the load. To address this problem, AC power supplies transform and fine-tune AC power from the electrical source to the voltage, current, and frequency needed by the device. Home appliances: we can use that power for home appliance.

III. Applications

1. Electrical energy production: With wind turbines, the wind's kinetic energy can be transformed into mechanical energy and this, in turn, into electrical energy.
2. Pumping water: Wind energy can be used to extract water from the ground using wind pumps, which are turbines capable of pumping up to six hundred litters per hour, which is enough to meet the needs of a small farm.
3. Home appliances: We can use power for home appliance.
4. Renewable hydrogen: Wind energy is used to produce the continuous electrical current that the needed to produce renewable hydrogen. This type of hydrogen is used, for example, to produce synthetic fuels or eco-fuels.

IV. Results

Table 1: Analysis table.

Sr. No.	AC Generated	AC-DC (Loss 0.8 V)	Battery (Stabilize)	DC-AC (Loss 0.8 V)	Step-up AC
1	13.4	12.7	12 V	11.1	37.6 V
2	14.2	13.6	12 V	11.3	38.2 V
3	14.6	13.8	12 V	10.6	36.9 V
4	16.0	15,3	12 V	10.9	37.2 V
5	16.5	15.8	12 V	11.2	39.2 V

loss in v (expected - actual)		AC Connected
42-37.6 =	4.4	13.4
42-38.2 =	3.8	14.2
42-36.9 =	5.1	14.6
42-37.2 =	4.8	16
42-39.3 =	2.7	16.5

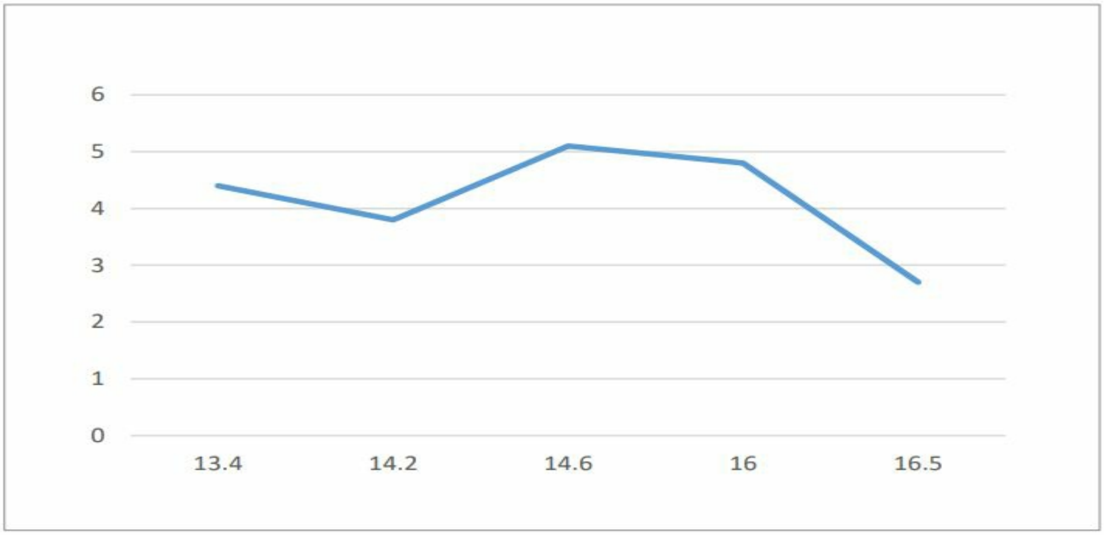


Fig 4: Graphical representation of analysis table.

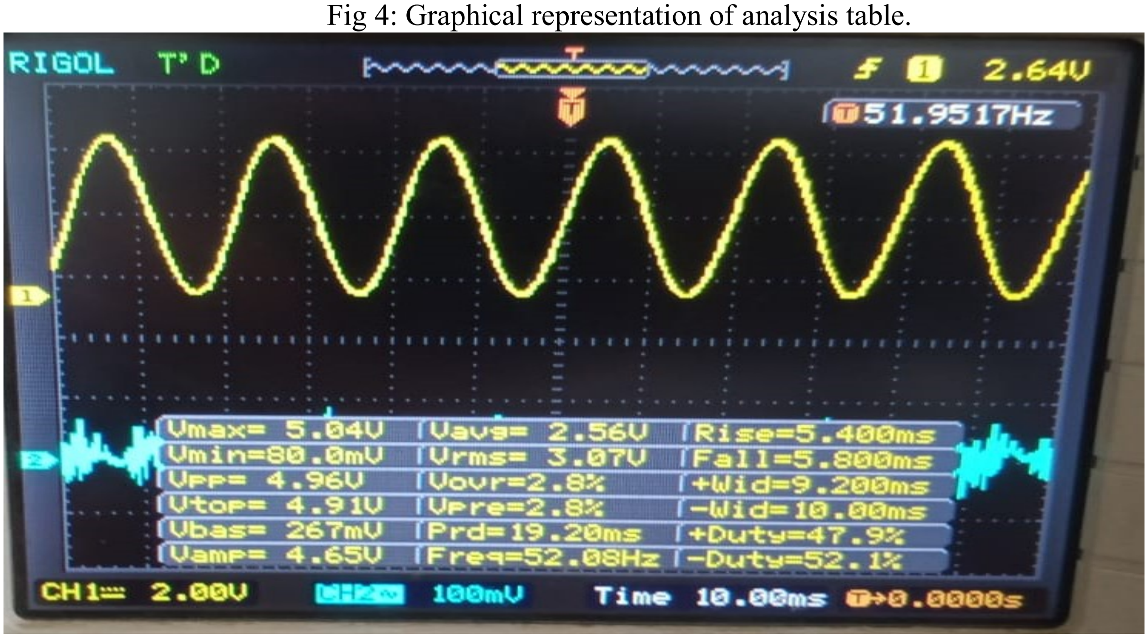
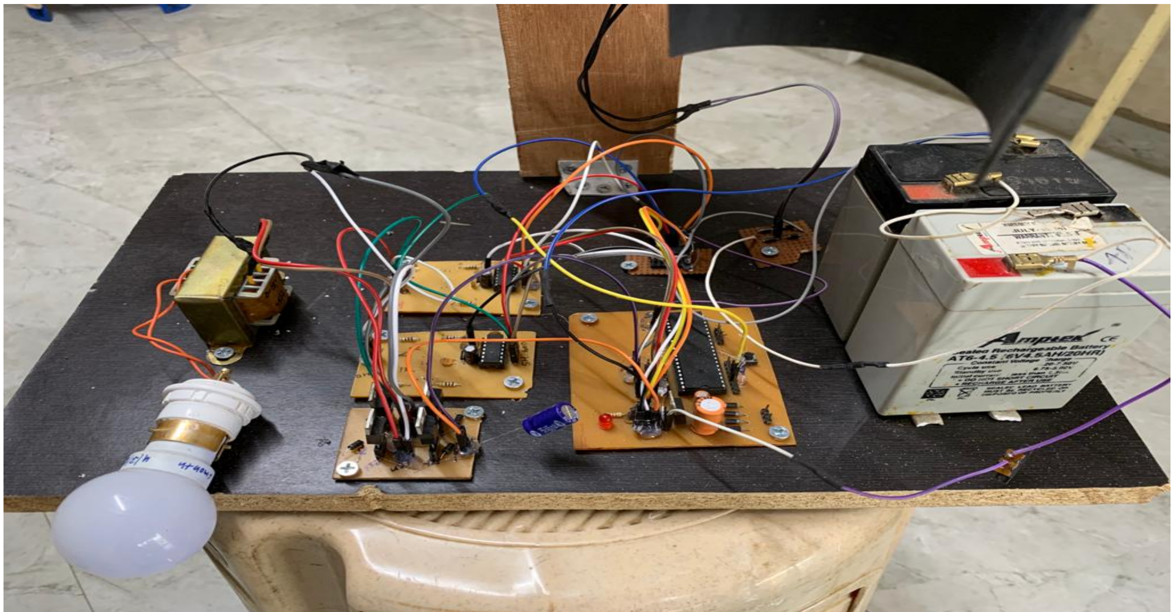
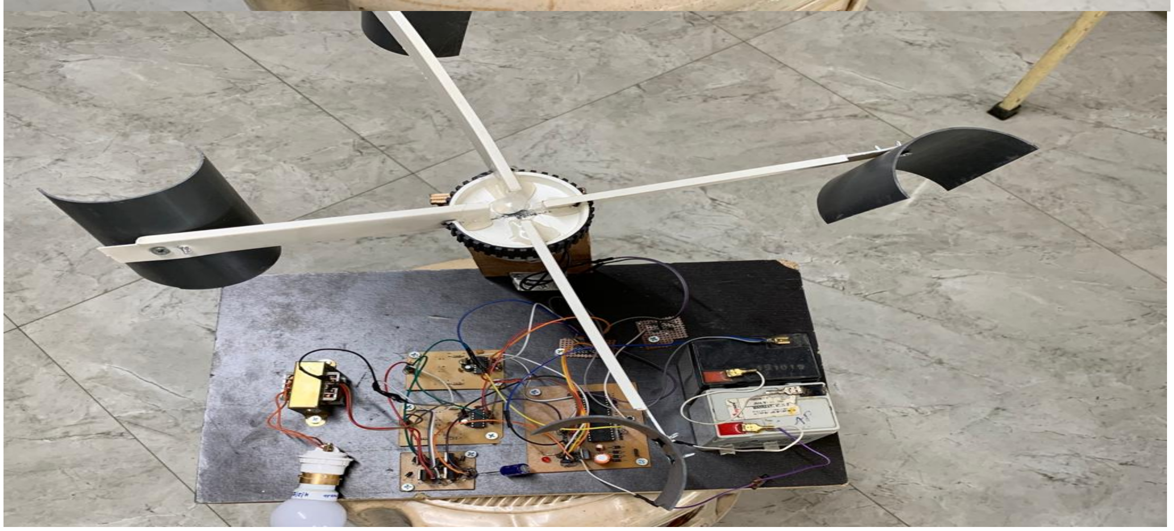


Fig 5: Readings in DSO

V. Conclusion

The DC-to-DC Conversion process is widely used in the power electronics. This paper proposes a method, which is for the maximum power extraction for wind turbine by using an CSPWM (Continuous Switching pulse width modulation) and SPWM (sinusoidal pulse width modulation). By using maximum power point tracking theorem and PWM techniques the power conversion and extraction of wind turbine is controlled. In rectifier and inverter using the methodology of continuous pulse width modulation (CSPWM) and sinusoidal pulse width modulation (SPWM) maximum power is extracted and stabilized efficiently. Wind energy system extracted maximum power by controlling the wind turbine rotational speed.





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