HARVESTING WIND POWER

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Abstract - Harvesting wind power has emerged as a pivotal strategy in transitioning towards sustainable energy sources due to its abundant availability and eco-friendly attributes. This paper presents an overview of various methodologies and technologies employed in the harvesting of wind power, encompassing both onshore and offshore applications. It discusses the fundamental principles governing wind energy conversion systems (WECS), including aerodynamics, turbine design, and power generation mechanisms. Furthermore, it explores the advancements in wind turbine technology, such as horizontal and vertical axis turbines, as well as emerging concepts like airborne wind energy systems. The integration of wind farms into existing power grids, along with associated challenges and solutions, is also addressed. Additionally, the environmental impacts and socio-economic considerations associated with wind power deployment are discussed, highlighting the importance of sustainable practices in the renewable energy sector. Finally, the paper concludes with insights into future trends and potential innovations in wind power harvesting, emphasizing the need for continued research and development to maximize its potential contribution to global energy demands while minimizing its environmental footprint.

Key Words: : Harvesting wind power; horizontal axis wind turbine (HAWT); vertical axis wind turbine (VAWT); maximum power point tracking; simulation; experimental setup. forecasting techniques; turbine technology; maximum power point tracking; hybrid systems and optimization.

1. INTRODUCTION –

For that reason, these systems require energy harvesting from the environment for long term operation. Together with solar and hydro systems, the wind is a renewable energy source mostly used in large-scale systems. Many works have been proposed for solar small-scale energy harvesting. These systems incorporate methods for maximum power point tracking (MPPT) to charge batteries or super capacitors. Several studies suggest the use of wind energy for small-scale systems, mainly with vertical axis wind turbines. Most part of this work is based on the evaluation of the Savonius turbine. However, there are few examples for wind energy harvesting which include the turbine, the generator and a maximum power transfer circuit. To compare various wind prototypes, it is defined the efficiency of the wind generator as the ratio of the generated output power and the maximum power available from the wind. The system in [12] used a commercial three-bladed turbine (16 cm radius), which provided 200 MW for a wind speed of 5.4 m/s (efficiency of 2.5%).

2. WIND OVERVIEW

Wind is used to produce electricity by converting the kinetic energy of air in motion into electricity. In modern wind turbines, wind rotates the rotor blades, which convert kinetic energy into rotational energy. This rotational energy is transferred by a shaft which to the generator, thereby producing electrical energy. Wind power has grown rapidly since 2000, driven by R&D, supportive policies and falling costs. Global installed wind generation capacity – both onshore and offshore – has increased by a factor of 98 in the past two decades, jumping from 7.5 GW in 1997 to some 733 GW by 2018 according to IRENA's data. Onshore wind capacity grew from 178 GW in 2010 to 699 GW in 2020, while offshore wind has grown proportionately more, but from a lower base, from 3.1 GW in 2010 to 34.4 GW in 2020. Production of wind power increased by a factor of 5.2 between 2009 and 2019 to reach 1412 TWh.Both onshore and offshore wind still have tremendous potential for greater deployment and improvement, globally.

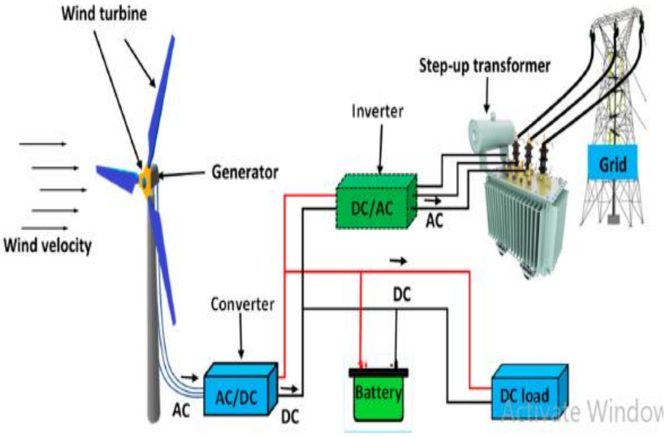

Fig -1: Grid-connected WEHS.

3. PROPOSED METHOD

The future of energy lies in the power of the wind. Advancements in wind turbine technology have unlocked the potential of harnessing clean, renewable energy on a larger scale. With larger and more powerful turbines, offshore and floating wind farms, improved energy storage, smart grid integration, and sustainable practices, wind power is driving us towards a greener, more sustainable tomorrow.

4. MODELING

The structural model of chair frame is created by using the Electrical Cad modeling software. The Harvesting Wind Power circuit diagram is shown below. It is used for charging batteries and therefore can be used in all those devices which run on battery. And we can add street light circuit diagram.

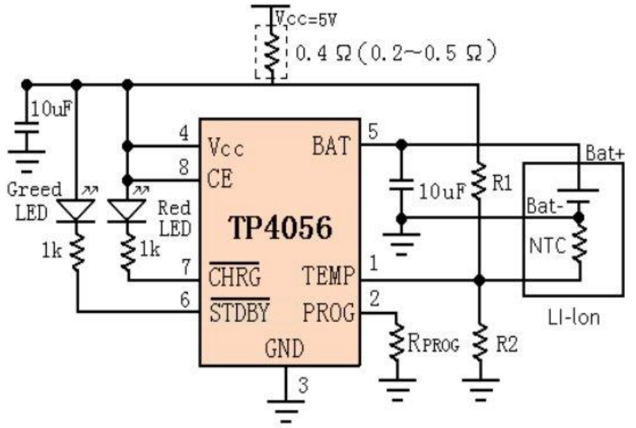

Fig-2: Charger Module Internal Circuit Diagram

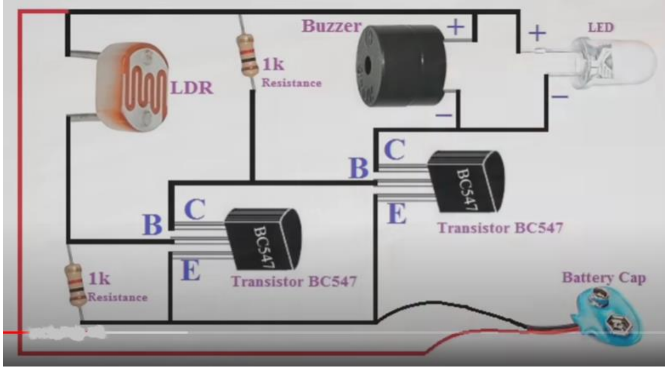

Fig -3: Automatic Street Light circuit diagram

4.1 MATERIAL

The properties of material used to manufacture are material used.

Wind Power Generation Circuit-
1- Battery Holder
2- 3.7 volt one cell
3- LEDs
4- Charger Module TP 4056
5- 12 volt Dc motor

Street Light Circuit Components-

1- Transistor BC547- 2
2- LDR one
3- Battery cap- 2
4- White LEDs- 10
5-1k Resistance- 2
6- Switch
7- Ten core wire one meter

5. ANALYSIS RESULT

In This Project We show when air come then windmill generate electricity and that electricity indication show by Red and Green LED bulb , And that electricity store in battery and we use there LDR Sensor for control Street Light On / Off For , So LDR On the Street Light Only Night Time So Our Electricity Power Save because Only Night Time Our Street Light Glow , and In This Project We show First Windmill and we show substation for store windmill generate power then that power step by step go to tower to DP Transformer and then go to street light , This is Best Project For transmission and distribution of electrical power.

6. DISCUSSION

Wind power is considered a sustainable, renewable energy source, and has a much smaller impact on the environment compared to burning fossil fuels. Wind power is variable, so it needs energy storage or other dispatch able generation energy sources to attain a reliable supply of electricity. One method is to have a stator that can operate with two or more different number of poles. Thus, the machine can work with different mechanical speeds with respect to the different number of poles used; therefore, more energy can be produced. Another example of these control methods is to engage an electronically variable rotor resistance, so that the mechanical loads can be reduced, and the turbine can work with variable wind speeds. In addition, back-to-back converters or doubly fed topologies can be used for the control of variable speed wind turbines. Other developments in DFIG turbines are on overall system monitoring (Supervisory Control and Data Acquisition, SCADA) systems.

6.1 Developments in Machine Design

It is not possible to use conventional machines in wind turbine applications. Therefore different designs of induction, doubly fed, and synchronous PM machines are used in generation mode. Most of the mentioned machines need a gearbox that converts the mechanical speed of the rotor of the turbine (50–300 rpm) to mechanical speed of the rotor of the generator (750, 1000, or 1500 rpm). The 1.5 or 2MWgenerator has an outer diameter of about 4m, so that it can be transported by regular means. The 4.5MW generators with a diameter on the order of 10m are made in segments so that they can be transported separately. Another advantage of DD train generators is that they can be designed for high voltages. This does not improve the efficiency, but for high powers in the order of MW, when the voltage level is changed from 400 or 750V to 5 kV, the copper losses are reduced.

$$T_d = \frac{T}{((d_0^2\pi)/4)L_a},$$

Where *T* is the machine nominal torque (kN m), *T*d is the machine torque density (kNm/m3*)*, *d*0 is the stator outer diameter (active outer diameter only), and *L*a is the machine total axial length (active length only including stator end windings).

6.2 BLDC Machines

The waveform of the induced EMF from the stator winding is shown in Figure.20. The concentric winding of the machine and rectangular distribution of the magnetic flux in the air gap generate this no sinusoidal EMF. Due to this waveform, a BLDC generator has approximately 15% higher power density in comparison to a PMSG, which has a sinusoidal winding configuration and sinusoidal magnetic flux distribution in the air gap.

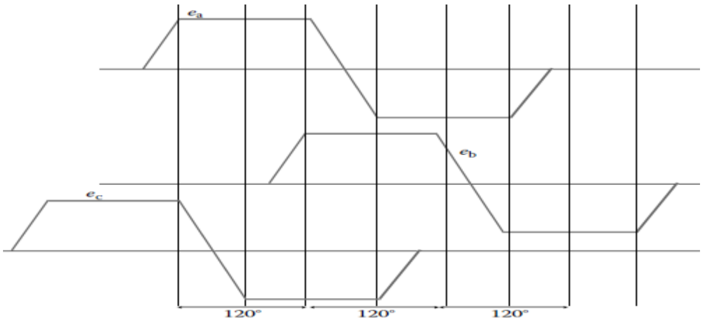

Fig -4: Induced EMF of a three-phase BLDC generator

6.3 Induction Machines

The DC bus voltage also reaches its steady-state value after the transient conditions and it is kept constant during the rest of the operation. The voltage measured across the terminals of a switch in the inverter is shown in Figure 5, which is the PWM chopped DC bus voltage. The output of the DC/AC inverter and line-to-line voltage after the transformer .This is a PWM sinusoidal voltage that can supply AC loads.

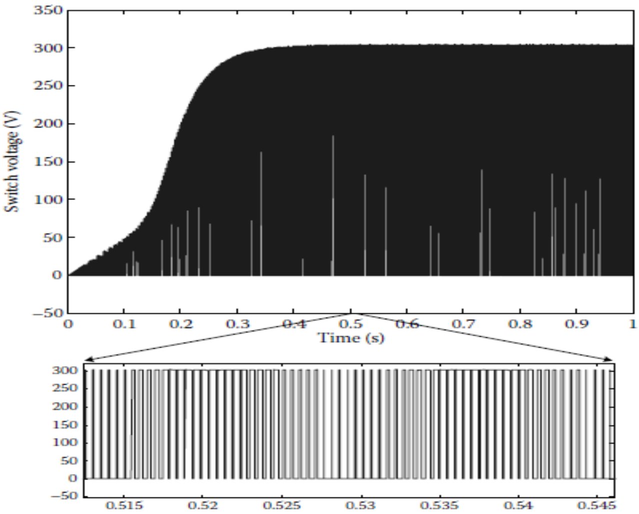

Fig -5: Voltage of the first switch of the inverter.

7. Wind POWER Harvesting FORMULATION

Betz's law demonstrates the theoretical maximum power that can be extracted from the wind. The wind turbine extracts energy from the kinetic energy of the wind. Higher wind speeds result in higher extracted energy. The extracted power from the wind can be calculated using Equation.

$$P_{\text{extract}} = \frac{E_k}{t} = \frac{1}{2}\rho R^2\pi\frac{d}{t}(v_b^2 - v_a^2) = \frac{1}{2}\rho R^2\pi\frac{v_a + v_b}{2}(v_b^2 - v_a^2),$$

Where Pextract is the maximum extracted power from the wind, *V*a and *V*b are wind speeds after and before passing through the turbine, ρ is the air density, and *R* is the radius of the blades.

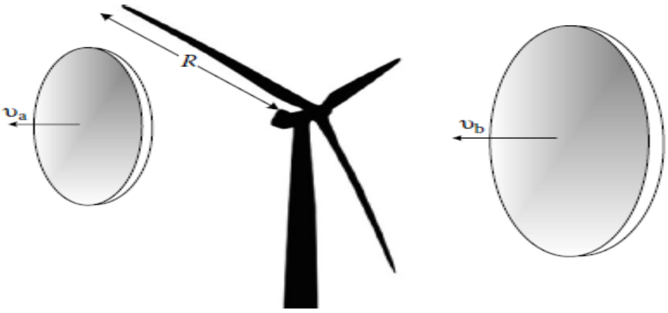

Figure -6: Wind speed before and after the turbine.

7.1 Winds

The wind is the phenomenon of air moving from the equatorial regions toward the poles, as light warm air rises toward the atmosphere, while heavier cool air descends toward the earth's surface. Therefore, cooler air moves from the North Pole toward the Equator and warms up on its way, while already warm air rises toward the North Pole and gets cooler and heavier, until it starts sinking back down toward the poles.

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}\rho V v^2 = \frac{1}{2}\rho A d v^2 = \frac{1}{2}\rho R^2 \pi d v^2,$$

Where *E*k is the wind kinetic energy, *m* is the wind mass, *v* is the wind speed, ρ is the air density, *A* is the rotor area, *R* is the blade length, and *d* is the thickness of the "air disc" Hence, the overall power of wind (*P*) is power.

$$P = \frac{E_k}{t} = \frac{1}{2}\rho R^2 \pi \frac{d}{t} v^2 = \frac{1}{2}\rho R^2 \pi v^3,$$

$$P = \frac{1}{2}\rho R^2 \pi v^3.$$

7.2 The RSC CONTROLLER

The RSC is used to control the wind turbine output power. This converter can also be used to regulate the voltage (or reactive power) measured at the grid terminals. The power is regulated to track the predefined power–speed characteristic of the wind turbine, and the mechanical power curve can be obtained for different wind speeds. The actual speed of the turbine (ωr) and power control loop are measured and the corresponding mechanical power is used as the reference power. The block diagram of the proposed RSC controller is depicted in Figure -7.

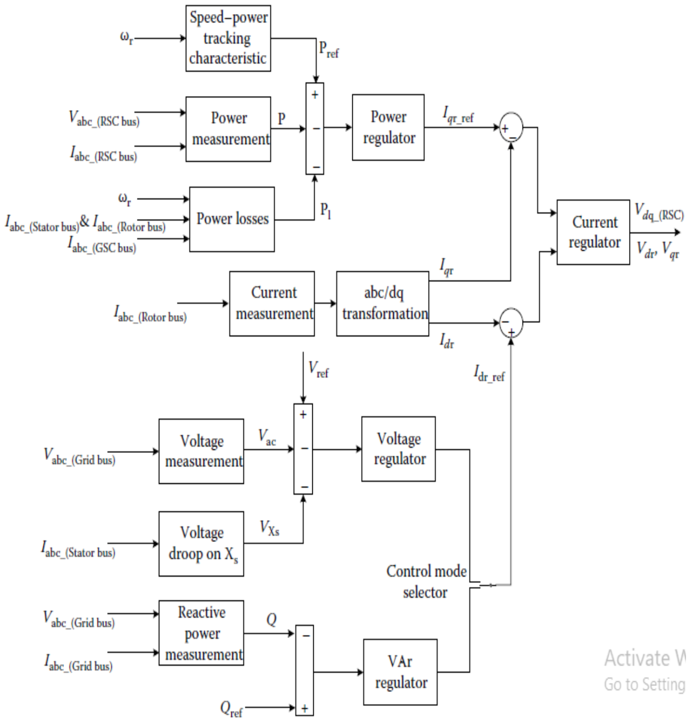

Fig -7: Block diagram of the RSC controller

8. GENTERTOR-SIDE CONVERTER RESULTS

For this experiment, adjustable DC power supply has been used rather than the grid-side converter. A diode is used is series in order to protect the DC supply as this structure is irreversible. The DFIG should be operated only on sub-synchronous mode, i.e. _*M* ≤ _*s*, with _*s* = 1500 rpm is the synchronous speed. The control algorithm is implemented using Dspace hardware/software. A picture of the experimental setup for generator-side converter control validation is given by Fig.8.

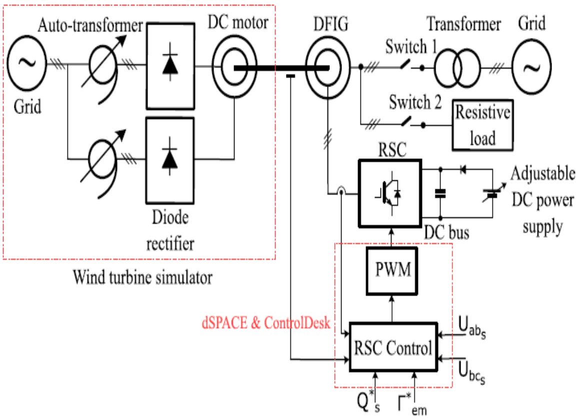

Fig -8: Rotor-side converter control.

9. CONCLUSION

One solution for such problems is to build hybrid systems of wind turbines and solar panels, or diesel generators with long- and short-term energy storage devices. Therefore, during the daytime, solar panels can be used as the prime energy generator, and the diesel generator can be turned on if additional power is needed (during peak time). On the other hand, during the night, wind might be strong enough to use solely the wind turbines. This concept needs energy storage units (batteries, ultra capacitors, or flywheels) and has an increased system cost; however it is highly reliable. In conclusion, hybrid topologies for renewable energy technologies offer sustained power production and satisfy sustained load demands. The proposed digital control strategy has been successfully implemented on dSPACE board using Embedded Coder from Matlab/Simulink. Specifically, the control strategy has been implemented and experimentally validated for each subsystem, namely: grid-side converter, rotor-side converter, and grid-connection. In this context, a labscale experimental platform has been designed and realized.

10. FUTURE WORKS

Future works should be investigating the implementation of permanent magnet synchronous generators-based wind energy conversion, then highlighting the clear ability of the developed platform to emulate both wind and tidal turbines whatever the used generator topology.

Significant funds are invested in various research and development projects of wind energy harvesting. The research and development efforts in wind energy harvesting can be categorized into three different areas: (a) developments in control systems, (b) developments in electrical machine design, and (c) developments in distribution and grid-connected topologies.

11. REFERENCES

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