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Recent Trends in MPPT-Based Standalone Wind Energy Conversion Systems: Challenges and Future Prospects

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Abstract-Electricity in the modern time has become one of the most important need of the world. There are several sources of electricity present, such as petroleum, nuclear energy, and some natural resources, such as wind, tidal and solar energy. Electric power has become one of the most critical requirements in the modern society. Due to many constraints on natural sources of energy input in pollution and environmental damage, as well as lack of resources, there has been a demand in the last decade to employ renewable energy sources.

It is found that when a non linear load is connected with the wind connected Wound Rotor Induction Generator (WRIG) system then there is a large amount of harmonics present in the generated electricity.So the detection and mitigation of the harmonics is a compulsory part. MPPT system is used to track that point or value of wind turbine at which WRIG generates the maximum

electrical power. This article contains the information about the MPPT-Based Standalone Wind Energy Conversion System with Challenges and Future Prospects.

Keywords: Renewable Energy, Wind System, Hybrid Active Filter, Induction Generator

I. INTRODUCTION

This part details a brief study of background used for the proposed research work focused on reduction of harmonic reduction in wind connected WRIG system output. The detailed scope of proposed research work focused on the use of hybrid active filter to reduce harmonic in case on linear and nonlinear load is also presented in this part. At the end of this part, part wise organization of paper is presented.

1.1 Sources of Renewal Energy

Renewable Energy Trends across the Globe

Renewable energy has increased in popularity as a consequence of the current economic trend. The current contributions of various sources to our global energy over the past three years, revealing that 81% of our energy

is derived from fossil fuels. Recent advances in solar photovoltaic technology or the introduction of dependable projects in countries/regions such as Germany and Spain have resulted in a substantial expansion of the solar photovoltaic market.

There are numerous non-fossil fuel sources, including nuclear, hydro (dams with electrical turbines connected to the discharge), solar (both photovoltaic and solar thermal), and others. These non-fossil fuel sources account for approximately 19% of total energy today.

1.2 Different Sources of Renewable Energy

Wind Power

Wind is a significant renewable energy source. Since ancient times, wind energy has been frequently used in sailing ships and windmills. Wind possesses kinetic energy due to the movement of enormous quantities of air induced by the sun's differential heating of the atmosphere. This energy can be used to power mechanical and electrical devices. Wind turbines can be used to generate power, extract water from wells, and pump water directly. Wind farms can be built in places with high energy demands and large amounts of waste land.

Wind turbines can be used to harness the energy of airflow [3]. The daily output of turbines operated ranges between 600 KW and 5 MW [4]. Power generation is proportional to wind speed and grows as it does. Wind turbines have recently produced advances that are more resourceful and superior than aerodynamic construction.

Solar Energy

While touring through Africa, the British astronomer John Herschel [5] pioneered the use of solar collectors for heating meals. Solar energy has two applications. First, the recovered heat can be used to heat the atmosphere using solar energy. Another technique is to convert solar energy into electrical energy, the most important source of power. This can be accomplished using solar photovoltaic cells [6] or solar-powered power stations.

Solar panels are the medium through which solar energy is converted into electrical electricity. Solar panels can convert energy directly or use induced energy to heat water. PV (Photovoltaic) cells are constructed using semiconductor architectures similar to those used in computer systems. This substance absorbs sunlight and emits electrons from the atoms to which it is linked. This discharge causes a current to flow. Photovoltaic is defined as the process of converting absorbed light into electricity. With a guiding philosophy and distinct components.

Biomass

Biomass energy, obtained from organic matter, is a renewable and sustainable source of energy that may be used to generate electricity and other forms of power. Manure, forest debris, scrap lumber, mulch, sewage,

some crops, and various types of waste residue are examples of common resources that can be utilised to create biomass fuel. Photosynthesis is the process through which plants obtain energy from the sun. When these plants burn, they produce energy. As a result, biomass can be used as a natural battery to store solar energy and produce it when needed.

Geothermal

Geothermal energy is the heat energy stored in various layers of the earth [9]. This source can be used to heat water to produce very hot steam, which can then be utilised to power a gas turbine to generate electricity. Geothermal energy losses are frequently connected with sites near the tectonic plate border, notwithstanding recent technological advances [10].

II. Analysis of Wind Turbine System

A wind turbine is a rotating machine that converts kinetic energy into wind energy into mechanical energy. If mechanical energy is converted into electricity, the machine is called a wind generator, wind turbine, wind power unit (WPU), wind energy converter (WEC), or aero-generator. Wind turbines can be separated into two types according to the axis of rotation of the wind turbine. Horizontal axis and vertical axis wind turbine. Turbines that rotate around a horizontal axis are more common. Vertical axis turbines are less used.

Some special terms related to wind turbine are given below;

- Power factor: - The power factor is the ratio between the output power produced and the power available in the wind.
- Betz limit: - A wind turbine can convert only 59.3% of the kinetic energy of the wind into mechanical energy to rotate the rotor. This is theoretically the maximum power factor of any wind turbine.
- Peak speed ratio (λ): - The peak speed ratio, X or TSR for wind turbines, is the ratio between the tangential speed of a blade tip and the actual wind speed, the tip speed ratio is related to efficiency, the optimum varies depending on the design of the blade. For high efficient wind TSR is 6-7.

The wind farm controller‘s function is power management. It can initiate and shut down turbine operation as well as co- ordinate the operation of numerous wind turbines in response to environmental and operating conditions.

The wind turbine supervisory controller manages the individual turbine operation.

Including power production, low-wind shutdown, high-wind shutdown, high load limits, and orderly start-up and shut- down

Also provides control input to the dynamic controllers for r.p.m. control to maintain an optimum tip-speed-ratio, and blade pitch control.

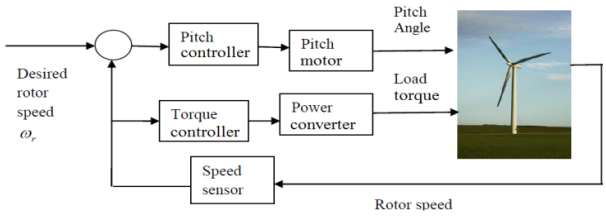

Fig.2 Block diagram of wind turbine closed loop control system

III. HYBRID ACTIVE FILTER AND CONTROLLERS

Hybrid Power Filters

Active power filters are the best solution to improve the quality of electrical power but require high conversion rates. So to overcome the above defect, hybrid power filters are used. The hybrid power filters are the combined device of active and passive filters. They have the advantage of both active and passive filters. There are different hybrid filters according to the composition and order of the circuit.

They are-

a. Shunt Active Power Filter and Series Active Power Filter
b. Shunt Active Power Filter and Shunt Passive Filter
c. Active Power Filter in series with Shunt Passive Filter
d. Series Active Power Filter with Shunt Passive Filter

Shunt APF and Series APF:

This filter is characterized by a coherent set of APFs, for example the elimination of the voltage and current harmonics. This combination can be found in Flexible AC Transmission Systems (FACTS). But the APF control is complex and this mixture contains two APFs, so controlling this filter configuration is more complex. Therefore, this series filters is not widely used.

A circuit diagram of shunt active power filter and series active power filter is show in following figure 3;

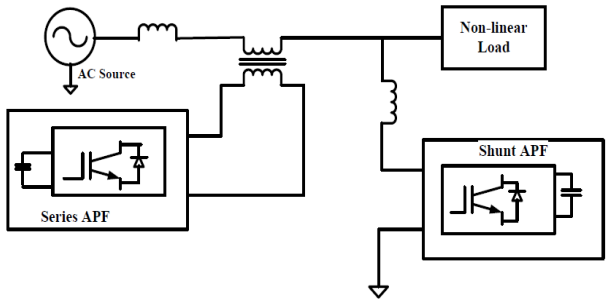

Fig.3 Shunt APF and Series APF

IV. Result and Discussion

The development of maximum power point tracking (MPPT) techniques for standalone wind conversion systems (WEC) has increased the efficiency and reliability of wind energy harvesting. Various traditional, soft data processing and hybrid MPPT methods have been detected, each with benefits and boundaries. While disturbances and inspections (P & O) and incremental cord

(INC) are widely used due to their simplicity, artificial intelligence (AI) -based and metaheuristic algorithms that advanced methods that metaheuristic algorithms provide

Despite these advances, many challenges, including sensor addiction, calculation complexity and lack of implementation of real -time. In addition, the integration of stable energy storage systems and hybrid renewable setup requires stable power distribution by stopping the wind energy. Future research should focus on improving the speed and accuracy of MPPT techniques and reducing the burden of calculating. The integration of AI, Internet of Things (IoT) and machine learning in MPPT strategies have promising capacity for autonomous and adaptive WECs. In addition, the progress of power electronics and battery management systems will increase viability to standalone wind power solutions.

Finally, while the MPPT-based standalone WEC has made significant advances, further innovation is needed to cross the existing boundaries and adopt a lot. By solving these challenges, wind power can play an important role in ever and efficient to meet global energy needs.

V. Future Scope

Many studies are being conducted to create filters that can reduce the amount of harmonics that are higher than the amount that hybrid lively electricity can filter out. Study on simulation and adaptation of maximum power extraction in standalone wind power systems opens several ways for future research and development. An important area is promoted by maximum power point tracking (MPPT) techniques using artificial intelligence and machine learning to increase the efficiency of dynamic wind conditions. The integration of hybrid renewable energy systems, such as a combination of air with solar or battery storage, can improve, reliability and stability. Implementation of real-time of the proposed customization methods through testing hardware-in-loop (HIL) and experimental verification can bridge the bridge between simulation and practical distribution. In addition, adaptive control strategies and future -state algorithms can be detected to optimize power extraction under separate environmental conditions. The ability to develop cost-effective solutions will make standalone wind systems more accessible, especially on remote and off sites. The inclusion of IoT-based smart monitoring can increase the performance of the system, leading to real-time data analysis and future maintenance. The viability of net-interactive standalone wind power systems can also be studied for better integration into microgrid. In addition, an intensive financial analysis will help to evaluate long -term benefits and strength to adapted wind energy solutions. Finally, advanced energy storage

technologies, such as super caps and next generation battery, can help improve research, power stability and storage capacity. These advances will contribute to the general development and efficiency of standalone wind power systems in the future.

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