A Hybrid Renewable Energy System in Process Industries

Pardeep Rana (Engineering), Research Scholar, SunRise University, Alwar(Rajasthan)
Dr. Ram Mohan Singh Bhadoria (Engineering), Associate Professor, SunRise University, Alwar(Rajasthan)

ABSTRACT

The DC-link voltage loop of the controller is constructed using back stepping, the PI algorithm, and Fuzzy. The proposed Back Stepping Controller uses a supplementary switching loss estimator to compensate for losses. By using DSTF-pq theory in harmonic compensators instead of the more conventional LPF-pq theory, performance has been improved. Using a stability analysis based on the Barbalat lemma, we show that the system with BSC is stable across a wide range of values. The results of the simulations indicate that the grid-side current harmonics have been properly taken into account. Total harmonic distortion of the grid current managed by PI-DSTF, Fuzzy-DSTF, or BSC-DSTF is less than 5% under all steady-state situations. Clearly, this value is far lower than what is allowed by the IEEE standard. The suggested BSC-DSTF controller has superior speed than the PI-DSTF and Fuzzy-DSTF controllers, but the latter two have worse robustness and dynamic performance.The load and the HRES system, which was connected to the grid, were able to communicate with one another because of the connection that was made.

Keywords: Hybrid, Renewable Energy, Industries, Algorithm.

1. INTRODUCTION

The substantial increase in global demand for energy may be attributed to a number of causes, including rising population, higher rates of urbanisation, and higher volumes of international commerce. Consequently, governments everywhere have been forced to increase their reliance on fossil fuels. Coal, crude oil, and natural gas are all examples of conventional fuels that pose serious dangers to the local ecology if they are used indefinitely due to their limited availability and nonrenewable nature. Scientists have been prompted by the urgency of these problems to focus on developing green or renewable energy-based power-producing technologies that are less damaging to the environment and can be generated sustainably. In recent years, solar technology has advanced to the point where increasing PV panel arrays' power output is practical. However, the usage of renewable energy sources is limited. Production from wind and solar electricity, for example, may be greatly affected by weather conditions. Adding When using intermittent power sources like wind and solar, an energy storage system is essential to ensure a continuous flow of electricity to the grid. Using renewable energy sources like wind and sun is good for the environment, but we still need this backup system. The process of producing power from a variety of resources, as well as its transmission, storage, and control must all be included into the design of a reliable electrical power system that makes use of renewable energy.

2. HYBRID ENERGY SYSTEMS

Hybrid energy systems combine the advantages of renewable and nonrenewable power sources. When systems are integrated, changes to the way electricity is generated can have a greater overall effect (wind and solar). This kind of setup is referred to as a "hybrid system." Out in the field, where a steady stream of electricity is required all year round, applications that combine solar and wind power are put to use. Using a combination of different energy generation and storage methods, hybrid systems open up a lot of possibilities for how we get our power. Hydrocarbon, solar, wind, or a hybrid of these can all qualify as examples of acceptable sources. Photovoltaic cells and wind generators are not the primary focuses of this project, as one might expect; rather, they are essentially supplementary elements.

Renewable energy sources, such as solar panels and wind turbines, rely heavily on their physical context to function effectively. Therefore, we are not restricted to using only renewable sources of power like the sun and wind. Multiple renewable energy specialists have concluded that a good hybrid energy resource could be created by combining wind and solar electricity into one system. The sun's rays are strong enough to penetrate the atmosphere during the summer, so the wind is typically calmer then than at other times of the year. Wind speeds are typically highest in the winter, when there are fewer hours of daylight due to shorter days. Due to seasonal variations, the efficiency of various renewable energy sources varies throughout the year. The energy output of the system can only be maintained at a constant rate if the two systems are in equilibrium with one another.

2.1 Renewable energy hybrid systems have many benefits

The following are some broad advantages of using renewable energy hybrid systems:

- The ability of HRE systems to capitalize on the symbiotic interaction between various renewable energy sources benefits the system as a whole by improving power quality and reliability. As a result of the system as a whole effectiveness is enhanced.
- By maximising the use of renewable energy sources, HRE systems reduce emissions and cut down on the cost of generating electricity.
- When microgrids use hybrid renewable energy systems, all aspects of electricity delivery, including quality, reliability, and long-term viability, are improved.
- People have more options when it comes to making the most of the renewable resources at their disposal when they use high-renewable-energy systems.

2.2 Issues in Current HRE Systems

A hybrid system offers some advantages, but there are also some challenges and worries that must be addressed:

i. As a direct consequence of this, batteries are frequently used as one of the available storage options for hybrid systems. These batteries have a relatively short lifespan (a few years), which makes their upkeep and maintenance quite expensive. Additionally, they need to be checked frequently. It has been suggested that for hybrid systems to be cost-effective, the lifetime of their batteries should be increased to somewhere between years and decades.

ii. In a hybrid system, where some of the sources of power generation are renewable and all of them are subject to the effects of the weather, load sharing between the various sources used for power generation, the optimal power dispatch, and the determination of cost per unit generation are not simple tasks. These tasks require careful planning and execution.

iii. One way to ensure that there is a constant supply of electricity is to incorporate sources that are not affected by the weather, such as a fuel cell or diesel generator.

iv. That same spot presents a problem with the equilibrium. Because the power production from the various sources in a hybrid system is essentially comparable, a rapid change in the output power from any source or a rapid change in the demand may seriously compromise the system's stability.

v. The different sources that make up the hybrid system have to be operated at their most productive levels. In practise, this may not take place because load sharing is often unrelated to the capacity or ratings of the sources. A variety of factors, including the availability of fuel, the efficiency of each prospective energy source, the frequency with which they must be turned on and off, and the general dependability of each alternative, all play a role in the determination of how to load should be balanced.

3. MODELING OF WIND ENERGY CONVERSION SYSTEM (WECS)

Figure 1.1 provides a schematic representation of the wind energy conversion system that was put into use for this research. This setup allowed for the generation of mathematical models as well as simulation models. The core components of the WECS models are as follows:

- Model of a wind turbine
- Model of Drive Trains
- Theoretical Model of a Speed Limiter and
- Doubly - fed induction generator

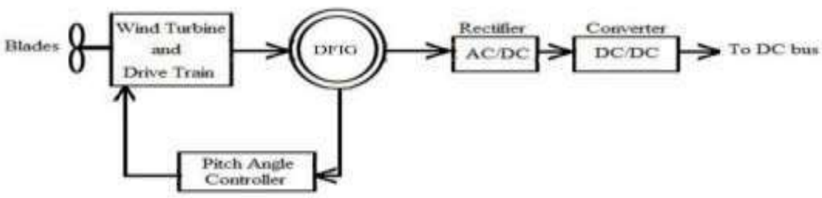


Figure 1.1: Global DFIG-based WECS configuration

3.1 Simulation of the Drive Train

The drive train of a wind turbine is comprised of the wind turbine, the generator, and the gear box. A turbine and a generator are the components that make up an inertia supply. The inertia of the gearbox is frequently ignored because the tooth wheels have such a negligible impact on the overall the inertial moment Means of Propulsion was modeled as a two-mass system here, and the connecting shaft that had inertia and shaft components was used to do so.

3.2 Speed Regulator Model

It is essential to make use of a model that features a speed regulator because there is the possibility that the wind speed will increase. Because of capacity constraints imposed by both the generator and the converters or inverters, the speed of the generator could not be regulated by increasing the amount of power that it produced. Because of this, the pitch angles of wind turbine blades can be adjusted to improve the rotor's aerodynamic efficiency. As a consequence of this, the rate of rotation of the rotor was able to be controlled. The power imbalance between output and wind energy input causes the generator's rotor speed to increase as the imbalance worsens.

Two subcomponents make up the speed regulator: the speed control component and the pitch control component. Input into the pitch control module comes in the form of an error signal that represents the voltage drop that occurred between the output the generator's output and the standard voltage. Pitch adjustments are made with the help of a controller that also operates the actuator for the blades. The rotor's blade pitch angle is adjusted by the control system when the actual wind speed is less than the rated speed. as efficient as possible.

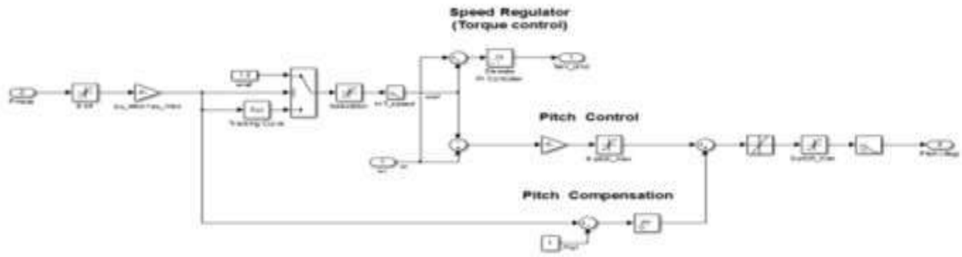


Figure 1.3: Model for a Speed Control Device

4. MAXIMUM POWER POINT TRACKING (MPPT) CONTROLLER

It is the job of the MPPT controller in a photovoltaic system to automatically find the voltage or current at which the solar array produces maximum power under a given set of conditions (temperature and irradiance). The array's maximum power point may be monitored to achieve this result. The existing MPPT methods, such as the Perturb and Observe method, the Fractional Open-Circuit Voltage method, the Incremental Conductance method, the Fuzzy Logic Control method, the Fractional Short-Circuit Current method, the Neural Network method, etc., all react to changes in irradiance and temperature. However, the P&O method and other MPPT techniques achieve their optimal performance when the temperature is kept as steady as feasible.

The P&O technique, which stands for "perturb and observe," is being used in the current study strategy. During this process, there was a minute adjustment made to the voltage that was produced by a solar array. To determine how the disturbance impacted the power output of the PV module, measurements were taken both before and after the event. If the disturbance causes an increase in power, this indicates that the voltage increased; if not, this indicates that the voltage decreased. The problem with the P & O technique is that it causes the MPP algorithm to oscillate toward the peak, which results in steady-state mistakes. We were able to circumvent the disadvantage of the P&O approach by decreasing the magnitude of the disturbances that happened while we were tracking. For this investigation, the MPPT (P&O) approach was built in Matlab, and the process for it is shown in Figure 1.4

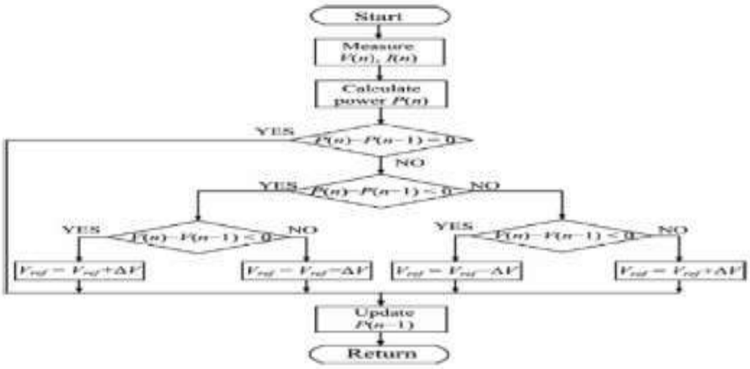


Figure 1.4: Using a P&O Algorithm

5. MODELLING OF FUZZY CONTROLLER

In order to govern the flow of power between the different modules of a hybrid power system, such a photovoltaic wind energy system fuel cell and energy storage components like a battery or an ultracapacitor, a fuzzy logic controller has been used in the study. To improve the overall performance of a hybrid system and its parts, a fuzzy logic controller was used in the present study. The controlling of the charging and discharging processes falls under the purview of this controller.

In the course of this research, a method known as twin peak detection was developed to ascertain the output voltage that is capable of reaching its greatest value. This program computed the steps that must be completed to determine the largest output that may be attained from renewable sources while still maintaining a connection to the grid.

- Voltage and current from solar and wind generators are being read.
- Comparison to a baseline value and subtraction of the associated renewable voltage source.
- Adjust the parameters to a normal value.
- Verify whether or not the values have reached their maximum potential.
- A grid-connected source without the highest possible peak and maximum parameters.
- Lessen the value of the storage system's adjusting parameter.

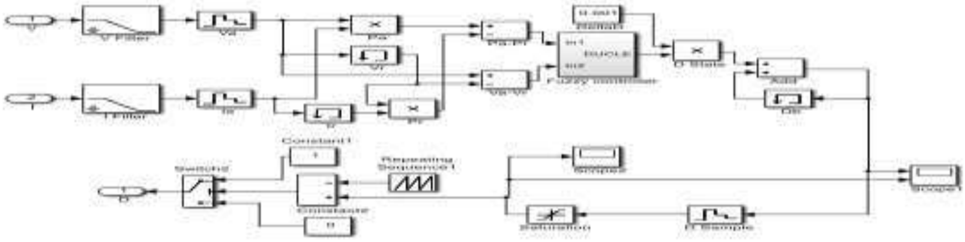


Figure 1.5: The Fuzzy Controller Modeling Simulation

6. ENERGY TRANSITIONS

The progression of industrial society can be interpreted as a chronicle of shifts in how energy is viewed and used. People living in less developed countries that rely heavily on agriculture can meet their fundamental caloric requirements through the practise of simple forms of agriculture, which are nothing more than methods of capturing the sun's energy for human consumption. It is possible to use solar energy that has been stored in firewood or other forms of biomass energy to heat and cook food in one's home.

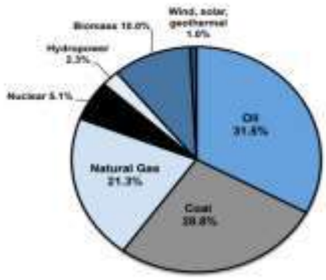
The complexity and growth of economies both lead to a dramatic increase in the amount of energy that is required. Since firewood and other forms of biomass energy were found to be insufficient to power expanding economies in Europe and the United States during the nineteenth and twentieth centuries, a shift toward the use of hydropower and coal in the earlier centuries was prompted. The 1950s marked the beginning of the process of incorporating nuclear power into the overall energy system. (Ichinokura, O, 2011)

Following each period of rapid economic growth, the dominant energy source shifted. Energy sources like coal, oil, and natural gas are driving global market growth because they are widely used in developed countries. Contrarily, in the twenty-first century, the next major transition away from fossil fuels and toward renewable energy sources is already well underway. Factors like price increases, scarcity of fossil fuels, and technological advances may all play a role in this shift.

Given the scarcity of fossil fuels and the sluggish geological pace at which they are generated, the transition to renewable energy sources is unavoidable. Given this information, the question that has to be asked is not if or whether society will transition to renewable energy, but when. Although improvements in fossil fuel extraction methods may postpone resource depletion, there is a far greater urgency in addressing the issue of mitigating the worst consequences of climate change. By switching to renewable energy while most fossil carbon is still underground, we may be able to mitigate some of the worst impacts of global warming and climate change.. (Kang, X 2012)

7. CAPITAL INTENSITY

The price of electricity that is produced by the combustion of fossil fuels such as natural gas is disproportionately high because the gas needs to be purchased in large quantities and utilized over a considerable amount of time.



If the discount rate is 5%, the present value of one dollar's worth of gas that is purchased in year 50 for a gas-fired plant that has a lifespan of 50 years is only $0.09. It is not necessary to take out a loan to purchase gas to generate electricity in the years to come.

The requisite generating facilities have been built, and the yearly cost of producing power from renewable sources such as solar and wind is quite low. Although this offers a few operational advantages over fossil fuels, it demands a greater investment, to begin with. The construction of an energy plant that runs on renewable resources is analogous to the construction of an energy plant that runs on fossil fuels, in addition to the purchase of all of the fuel that the fossil plant would need during its lifetime. There aren't that many homes that would buy a gas furnace and then proceed to buy all of the gas the furnace would use for its lifetime at the same time. Nevertheless, this is the case with renewable energy since it is inherent to the nature of the resource.

8. CONCLUSION

The solar photovoltaic system model built in Matlab/Simulink ran well in the simulation. Solar radiation, current draw, the voltage at open circuit, and GIS data output are all examples of such variables. In addition, a mathematical model of a PEMFC fuel cell was created and simulated for this research. The fuel cell was modelled as a closed system with a constant channel pressure. The fuel supply rate was automatically adjusted based on the power use. The Matlab/Simulink PEMFC model performed well in simulated tests. The mathematical model for a wind power system, including energy storage and an Ultracapacitor, is presented in this article. Using D-q transformation has improved the DC power quality. Once connected to the grid, a voltage source inverter transformed the DC power into three-phase AC. Most importantly, this study contributes to the literature by modeling and developing grid-connected renewable power-generating systems as a practical response to the growing dependence on conventional power plants. Different renewable energy sources, such as wind energy systems, solar arrays, and fuel cell systems, may be integrated effectively into the suggested three-phase microgrid framework.

9. REFERENCES

1. Akagi, H. (2015). The state-of-the-art of active filters for power conditioning. In Power Electronics and Applications, 2005 European Conference on, pages 1–15.
2. Rajaei, A., and Rahideh, A. (2016). Detection of grid voltage fundamental and harmonic components using Kalman filter and generalized averaging method. IEEE Transactions on Power Electronics, 31(2):1064–1073.
3. Akagi, H., Watanabe, E., and Aredes, M. (2017). Shunt Active Filters, chapter 4, pages 111–236. Wiley-Blackwell.

4. Golea, A., Srairi, K., and Benbouzid, M. E. H. (2015). Implementation of adaptive fuzzy logic and pi controllers to regulate the dc bus voltage of the shunt active power filter. Applied soft computing, 28:125–131.
5. Ali, S., Chauhan, Y. K., and Kumar, B. (2018). Study amp; amp; performance of DVR for voltage quality enhancement. In 2013 International Conference on Energy Efficient Technologies for Sustainability, pages 983–988
6. Anderson, P. M., and Bose, A. (2019). Stability simulation of wind turbine systems. IEEE Transactions on Power Apparatus and Systems, PAS-102(12):3791–3795.
7. Khadem, S. K., and Basu, M. (2015). Real-time control of shunt active power filter under distorted grid voltage and unbalanced load condition using self-tuning filter. IET Power Electronics, 7(7):1895–1905.
8. Mousavi, M. S., and Jalilian, A. (2016). Sliding mode control of dc-link capacitors voltages of an NPC 4-wire shunt active power filter with selective harmonic extraction method. In 2016 7th Power Electronics and Drive Systems Technologies Conference (PEDSTC), pages 273–278
9. Teodorescu, R., and Chen, Z. (2016). Power electronics in renewable energy systems. In 2006 12th International Power Electronics and Motion Control Conference pages 1–17
10. Boehringer, A. F. (2016). Self-adapting dc converter for solar spacecraft power supply. IEEE Transactions on Aerospace and Electronic Systems, AES-4(1):102–111.
11. Leon, J. I., and Moreno-Alfonso, N. (2016). Power-electronic systems for the grid integration of renewable energy sources: A survey. IEEE Transactions on Industrial Electronics, 53(4):1002–1016.
12. Charles, S. and Vivekanandan, C. (2015). An efficient FPGA-based real-time implementation shunts active power filter for current harmonic elimination and reactive power compensation. Journal of Electrical Engineering and Technology, 4(4).
13. Parisini, T., and Hui, S. Y. R. (2017). A fast-convergent modulation integral observer for online detection of the fundamentals and harmonics in grid-connected power electronics systems. IEEE Transactions on Power Electronics, 32(4):2596–2607.
14. Chen, S. and Joos, G. (2015). Rating issues of unified power quality conditioners for load bus voltage control in distribution systems. In 2001 IEEE Power Engineering Society Winter Meeting. Conference Proceedings (Cat. No.01CH37194), volume 2, pages 944–949
15. Chen, Y.-M., Cheng, C.-S., and Wu, H.-C. (2016). Grid-connected hybrid PV/wind power generation system with improved dc bus voltage regulation strategy. In Twenty-First Annual IEEE Applied Power Electronics Conference and Exposition, 2006. APEC ’06., pages 7 pp