Journal of New Materials for Electrochemical Systems

Vol.25, No.2, April 2022, pp. 142-144

Journal homepage: http://iieta.org/journals/jnmes

SHORT COMMUNICATION

An intelligent cooling system based on predictive time domain algorithm with thermoelectric coolers for wind turbines

P. Vigneshwaran [1*], N. Padmavathi [2], G. Nirmala[3] and A. Sowmiya[4]

[1*]Assistant Professor, Department of Electrical and Electronics Engineering, K. Ramakrishnan College of Engineering, Trichy, Tamil Nadu, India.
[2]Assistant Professor, R.M.D. Engineering College, Kavaraipettai, India.
[3]Assistant Professor, R.M.D. Engineering College, Kavaraipettai, India.
[4]Assistant Professor, EIE, R.M.D. Engineering College, Kavaraipettai, India.

[1*]Corresponding Author Email:profpvigneshwaran@gmail.com

https://doi.org/10.14447/jnmes.v25i2.a08

Received: July-2021
Accepted: May 4-2022

Keywords:
Thermoelectric, Wind Turbine & Time Domain Algorithm.

ABSTRACT

Development of Power Electronics devices (PED) made renewable energy generation of power more feasible than that of traditional power plant generation. In India, Tamil Nadu the major source of renewable generation is come from Wind generation. Due to PED, heat generated is the Major issues in wind power generation, which consequence in terrible combustion accidents and disasters. Cooling system such as compressor based cooling scheme or two phases cooling is provided in addition to natural air cooling. The major disadvantages of the scheme are their volume, requirement of large power supplies and frequent chance to catch fire. Currently, using Thermo-electric coolers (TEC) called Peltier modules to provide cooling in wind power plant. Only after the system has reached massive temperature levels can it excavates the heat. The proposed method using predictive time domain algorithm the cooling process initiated in prepone manner. As soon as heat go up the system will detected and switched on cooling in predictive manner which can avoid the system to reach the maximum temperature. By using IoT, the system can monitor the temperature level and make use of predictive cooling technology over the surfaces without any delay time.

1. INTRODUCTION

The demand for generation is more than the available. Conventional generation leads to many harmful effects to the environment like increase in greenhouse gases, increase carbon rating. Non-conventional energy sources like Solar, Wind, Fuel cell and Biomass reduce the harmful effect [1]. Power electronics plays a major role in generation of renewable energy and to integrate it with grid. For generation of wind power the requirement of wind flow should be 16Km/hr [2,3]. Doubly Fed Induction generator or synchronous generator is used in generating the power. The intermittent energy is converted through AC-DC-AC converter. Major issues in wind power generation were heat generated due to PED which will consequence in terrible combustion accidents and disasters [4]. PED are fabricated by semiconductors which more efficient in operation but would dissipate more amount of heat energy. Dissipate heat will increase the temperature of Power Electronic Devices (PED) casting result in burning of switches. Therefore it is necessary to control the temperature by providing cooling [5,6]. Power Electronic Devices (PEDs) produce power, which can cause temperature fluctuations. When the temperature is too higher, there must be a way to dissipate heat from the components to the heat dissipation process, viz a liquid cooling plate, chassis or traditional heat sink. DFIG has extra hardware with components involve maximal costs, raised space requirements, weight, control complexity and design, decreased system reliability as there are several components are failure, raised maintenance, challenges and limitations inherent in such components, like requirements for heat dissipation, introduction of delays, measurement faults.

Electrochemical energy storage systems, particularly rechargeable batteries are broadly utilized as energy sources of power electronic devices. To fulfill the constant higher requirements of power electronic devices, the electrochemical performances of rechargeable batteries is considerably enhancement.

To address the heat dissipation problem, an efficient system is proposed with the surface of heat dissipate body. It predict the constant rise in temperature based upon the level cooling effect is initiated.

In literature, many proposals were presented for temperature control in wind turbine.

In [7], observed that the cooling of wind turbine system will reduce the levelized cost of energy.

In [8], investigated and compares the different cooling system.

In [9], design issues related the thermal and magnetic design of PMSM are highlighted.

In [10], discuss about the cryogenic cooling for offshore wind farm.

The Peltier effect has been deserted at its initial discovery. Recently, experiments have been made on new alloys to determine the feasibility of using the Peltier effect in a thermo-electric methodology. The cooler increases in the conditions of large temperature gradient were adjusted. It also signifies that Peltier module is noteworthy electronic factor for greater power storing. It contains lesser power with higher output. The steady temperature controller performs proficient in the process of testing, also fulfills the design necessities feasibly present novel thermo-electric converters based on the seebeck effect and show their scaling law, which is largely different from that of conventional TEC devices.

2. DESIGN OF PROPOSED SYSTEM

Now-a-days the advanced cooling systems used in wind power systems are mostly mechanical systems like natural air, draught fan, coolant based cooling etc. Latest technology used in wind turbine for cooling the system is Pumped single storage system. Pumped single or 2 phase cooling is typically utilized to avert as well as dissipate heat from higher power heat sources, viz electronics, lasers, while thermal energy is transmitted a noteworthy variation amid the heat source and heat sink. Nowadays, pumped single phase cooling is broadly utilized in power electronics tool, there is no need for heat fluxes, temperature uniformity. Drawback of Pumped single storage system is it need frequent maintenance, profoundly toxic coolant, occupies more area and complicated installment. The proposed system block diagram is shown in Fig1.

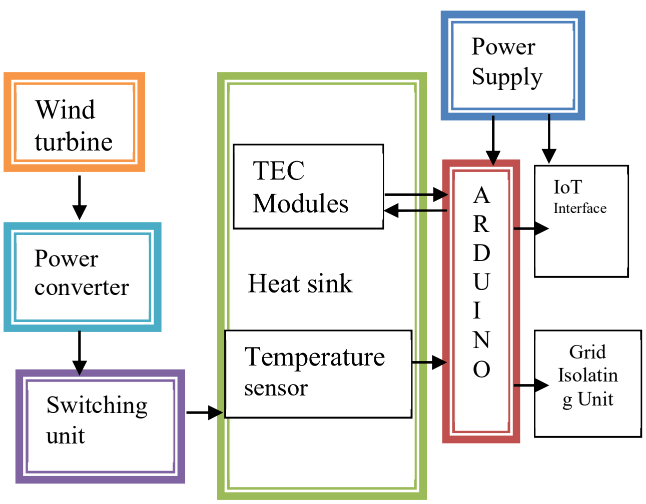

Figure 1. Proposed system block diagram

In our proposed method it is possible to predict the abnormal temperature by sampling and comparing strategy. The proposed system will reduce the heat level to reach the maximum temperature thereby reduce the dangerous effect happening due to beyond temperature rise. It monitors smartly with the help of IoT.

This system is also included with IoT based real-time data gathering and monitoring elements. Through which user can able to view the operating parameters via internet from anywhere. Thus it enhances the overall system efficiency.

Figure 2 represents the Proteus proposed simulation diagram.

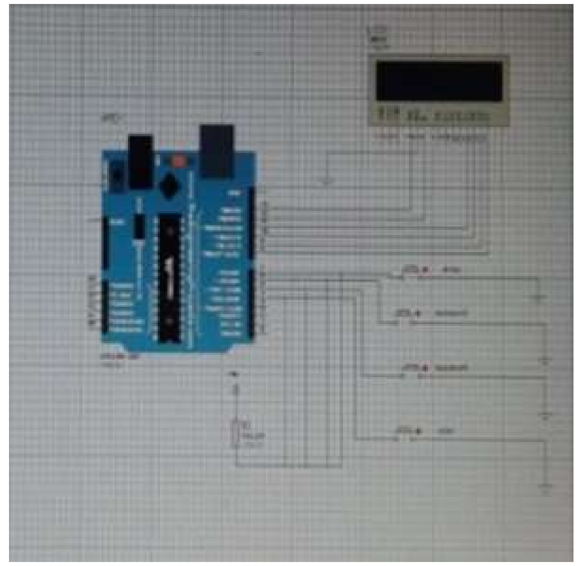

Figure 2. Proteus proposed simulation diagram

3. EXPERIMENTAL RESULTS AND ANALYSIS

The temperature sensor is heart actuator of the overall system. Here LM35 is used to sense the temperature. It gives output as an analog signal which is proportional to the instantaneous temperature input. That analog equivalent is given to the Arduino micro-controller. It considers the input to process further with respect to the user defined program and gives analog signals as output. By using transistor driven relays the output signal from Arduino tends to activate the respective cooling modules. Let us discuss about the conditions and logic of the program used for working with a predictive manner.

Role of input datum:

The input datum was taken into process by their assumed credentials with an interface depended tag names in program which can be given as follows.

Actual temperature (at): It is the analog value of real time temperature obtained by the temperature sensor placed on the surface of the device being protected.

Referance temperature (rt) : It is the numerical value of temperature described by the user for initiating the timer function for prediction process.

Operating temperature (ot) : It is the numerical value of temperature described by the user for initiating the cooling systems with respect to algorithm.

Mode a operating temperature (m_a): It is the numerical value of temperature described by the user. At this temperature the TEC module with “lower cooling capacity” has been activated.

Mode b operating temperature (m_b): It is the numerical value of temperature described by the user. At this temperature the TEC module with “higher cooling capacity” has been activated.

Mode c operating temperature (m_c): It is the numerical value of temperature described by the user. At this temperature both the TEC modules of "lower cooling capacity & higher cooling capacity" has been activated. Hardware set up is shown in Figure 3.

Assumed inputs for the input datum relative to variable declaration:
set reference temperature as "A"
set operating temperature as "G"
set Mode A actuating time as "S"
set Mode B actuating time as "R"
set Mode C actuating time as "L"
set Mode D actuating time as "V"
actual temperature from sensor will be "B"
rate of change in time be "M"

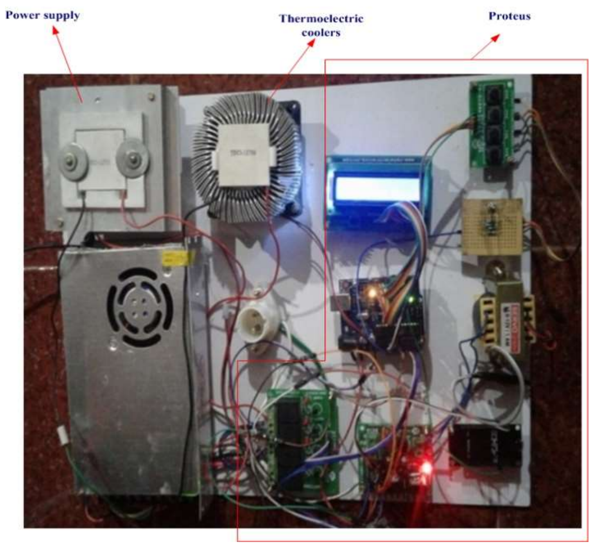

Figure 3. Hardware set up

Algorithm:-
When B>=A
Initiate timer
When B>G
Stop the timer and store its final value in "M"
If S<=M<=R ,Mode A
Relay 'i' will be ON (low cooling capacity)
If R<M<=L ,Mode B
Relay '2' will be ON(medium cooling)
If L<M<=V,Mode C
Both relay(1) and relay (2) will be ON (high cooling)
If B>V ,Mode D
Relay '3' will be ON(circuit trips)
If B<A

All the relays should be turned off and cooling system is ideal.

Because of incorporation of seebeck and Peltier effect it does not require any moving parts therefore less maintenance and reliability in operations. An advantage of proposed methodology was it can be easily incorporated with existing system. It also occupies less area and it's more compact. It can be smartly monitored and controlled with the help of IoT Technology.

4. CONCLUSION AND FUTURE WORK

Temperature monitoring is the important parameter in design any devices. The temperature raise in the power electronics are monitored by the proposed system and thus it is possible to predict the abnormal temperature by our sampling and comparing strategy. The predictive method will definitely reduce the fire accidents occur in wind turbine generation. This methodology is less toxic and compact compare to conventional heat sink method. This system is also including with IoT based real- time data gathering and monitoring elements. Through which user can able to view the operating parameters via internet from anywhere. Thus it enhances the overall system efficiency. In future this cooling system is implemented in real-time systems. Its application for other devices can be further developed. Need to consider the power quality while connecting the renewable energy source to the grid, because of nonlinear load, increase power electronic component.

REFERENCES

[1] Dhayalini K., Vigneshwaran P. (2020) Radio frequency identification system based automated public distribution system. In IOP Conference Series: Materials Science and Engineering 937(1):012041,

[2] Khalid A., Javaid N., Guizani M., Alhussein M., Aurangzeb K., Ilahi M. (2018) Towards dynamic coordination among home appliances using multi-objective energy optimization for demand side management in smart buildings. IEEE access. 6:19509-29.

[3] VigneshwaranPerumal, M.A. Madhumathi, G.,Nishanth, Madhumitha D., Sushmitha E.C. (2020) Photovoltaic brushless DC motor drive to pump water for irrigation using IoT, Journal of Critical reviews,7(10)

[4] Rajendran M., Perumal V. (2018) Saturation analysis on current transformer. International Journal of Pure and Applied Mathematics. 118(18):2169-76.

[5] Richard SP., Manivasagam R., Vigneshwaran P. (2020) Three-Level Topology for Shunt Active Power Filters. In IOP Conference Series: Materials Science and Engineering 937 (1):012002.

[6] Saranraj, R., Richard S.P. andVigneshwaran, P. (2020) Cyborg using Labview for temperature sensor handling,, International Journal of Engineering and advanced technology, 9(5)

[7] Zeichfüßl R., Oberneder M., Jöckel A. (2019) Open Air-Cooled Generators for the Use in Wind Turbines. In2019 Conference for Wind Power Drives (CWD)1-9,

[8] Zhou D, Blaabjerg F, Lau M, Tonnes M. (2013) Thermal profile analysis of doubly-fed induction generator based wind power converter with air and liquid cooling methods. In2013 15th European Conference on Power Electronics and Applications (EPE), 1-10.

[9] Ruuskanen V., Nerg J., Niemelä M., Pyrhönen J., Polinder H. (2013) Effect of radial cooling ducts on the electromagnetic performance of the permanent magnet synchronous generators with double radial forced air cooling for direct-driven wind turbines. IEEE transactions on magnetics. 49(6):2974-81.

[10] Stautner W., Fair R., Sivasubramaniam K., Amm K., Bray J, Laskaris ET., Weeber K., Douglass M, Fulton L., Hou S., Kim J. (2012) Large scale superconducting wind turbine cooling. IEEE transactions on applied superconductivity. 23(3):5200804.