www.idosr.org Eze *et al*
©IDOSR PUBLICATIONS
International Digital Organization for Scientific Research ISSN: 2550-794X
IDOSR JOURNAL OF SCIENTIFIC RESEARCH 8(2) 105-115, 2023.
https://doi.org/10.59298/IDOSR/2023/10.2.6008

# Design and Implementation of an Industrial Heat Detector and Cooling System Using Raspberry Pi

Eze Val Hyginus Udoka[1], Enerst Edozie[2], Turyahabwe Frank[2], Kalyankolo Umaru[2] and Wantimba Janat[2]

[1]Department of Publication and Extension, Kampala International University, Uganda.
[2]Department of Electrical Engineering, Kampala International University, Uganda.

## ABSTRACT

In this research paper an industrial heat detector and cooling system using Raspberry PI was successfully developed and implemented. The workspace/machine temperature is maintained and monitored continuously using the DHT11 temperature sensor with Raspberry Pi. This developed system triggers the cooling fan ON immediately the temperature is >25.99°C and triggers it OFF immediately the temperature range is <26.00°C and an email will be sent to the manger (user) when the machine or environment continues to heat above 30.00°C. Furthermore, if the machine continues to overheat up-to 40°C, the embedded software will automatically trigger OFF the machine indicating that something is wrong. The email will notify the manager (user) that the machine is getting overheated and needed an urgent attention. This research work has successfully achieved the aim of solving the problem of machine overheating by either cooling it or sending signal to the manager for immediate intervention which will help in reducing the cost of repairing and frequent maintenance.

**Keywords:** Heat detector, Cooling Fan, Raspberry, Sensor, Microcontroller, Solar Panel

## INTRODUCTION

There is everyday advancement in technology, artificial intelligent and smart electronic systems in the world. Demand for the accurate temperature control has conquered many of industrial domains. Automatic temperature control is important in order to maintain a comfortable environment. Automation system aims to further the cause of automation to achieve the goal of simplicity. Temperature can be controlled in an environment physically with either fan or AC. The major concern in the un-automation of electric fan has been a disturbance to the wellbeing of fan users. An electric fan is a device used to produce airflow for the purpose of creating comfort and ventilation. Electric fans are designed to create breeze and circulate air in a region [1]. The fan creates its cooling effect based on the speed at which its blades rotate; hence, the speed regulator is a very important part of a fan. Usually, the speed of the fan blades is controlled manually by the turning knob on the fan regulator [2][3]. Electric fan is one of the most popular electrical devices due to its cost effectiveness and low power consumption advantages. It is a common circuit and widely used in many applications [2][3]. So, an automatic temperature control system technology using microcontroller is needed for regulating the fan speed according to the temperature changes [4][5][6].

A heat detector monitors the air temperature and as the temperature varies within a preset temperature band above set point, the fan switch changes accordingly between ON and OFF values. Due to its advantages many research efforts had been focused on automatic temperature control system. A temperature controller is a closed loop control system which senses the temperature of the environment and compares it with a user-fed threshold temperature value and changes the speed of the fan accordingly [2]. In an automatic temperature-controlled system, the independent variable (temperature) is measured by a suitable sensor such as a thermocouple or thermistor and converts it to a signal acceptable by the controller. The controller compares the temperature signal to the desired temperature (set-point) and activates the final control device. The final control device alters the dependent variable (fan switch) to change the quantity of heat being taken or added to the process [1][2]. The automatic temperature-controlled fan can be effectively applied in a places like hospitals, homes of the handicapped peoples and elderly people, since it requires no human assistance [3].

The author in [4][5][6][7][8] worked on the ATmega8L microcontroller for Speed control of DC motor fed by a DC chopper and as well as the effect of input current and the receiver-transmitter distance on the voltage detected by infrared receiver. The chopper is driven by a high frequency PWM signal and the controlling PWM duty cycle is equivalent to that controlling the motor terminal voltage, which in turn adjusts the motor speed.

In [3] an automatic fan speed control system using Arduino Uno was design. The temperature is measured by the LM35 temperature sensor and Potentiometer was connected as a regulator to the microcontroller. The fan speed was displayed in the Revolution Per Minute (RPM) in the LCD.

In [4] a fan speed controlling system using temperature and humidity sensor were designed using Arduino microcontroller as a regulator. This was design to work according to the environmental temperature whereas the fan speed is manually controlled. The temperature and humidity is measured by DHT22 Sensor and displayed in the LCD and the duty cycle of the temperature is already set as the reference temperature. The values of the duty cycle change the fan speed and also varies the temperature change.

In [9][10] designed a system that controls the room temperature using PT-100 and Pic microcontroller to regulate the speed of the fan. The PT100 temperature sensor was used in converting the temperature into equivalent voltage. The systematic design of low power supply, fixed voltage, subtraction and dimmer unit are designed and comparison among them in the devices were used for graphical representation. The pi microcontroller in [10][11] was programmed using MPLAB IDE and the input was given by the keypad to monitor the temperature value.

In [12] [13] the researcher proposed a system automatic temperature control system for electric fan using PIC microcontroller. The temperature is measured by the LM35 temperature sensor and LCD was used to display the temperature value results. Whenever the temperature increases beyond the set temperature reference value the fan triggers on and vice versa.

In [14][15][16][17][18][19] the researchers developed, fabricated and designed many solar photovoltaic models and detailed its advantages as one of the major sources of substituting conventional source of energy such as NEPA. The researchers also reviewed renewable energy as the only sources of energy that can cleanly substitute conventional sources of energy. For one to have steady power, the need to install solar photovoltaic panels in the building being it building integrated or stand alone is very necessary to avoid interruption in the cooling system. From this extensive review many drawbacks in the existing designs were encountered such as: (1) Industrially, many running machines over-heat up and got spoilt due to late detection and un-automated cooling system. This actually leads to unnecessary spending when the machines breakdown which would have been curtailed by an industrial heat detector and cooling system with instant email notification using raspberry pi. (2) There is no need of a person sitting/keeping around all the time to monitor the machines in terms of controlling their heating-cooling sessions hence reducing costs in terms of labor and also purchasing new machines or repairing the available ones due to the damages attained during the overheating process.

Due to all these drawbacks from the existing heating and cooling systems, it is necessary to develop an automatic temperature control electric fan that will have the capacity to automatically regulate the speed level of the fan according to temperature of the environment. Automatic temperature-controlled fan leverages the power of raspberry pi to provide an automatic control fan, regulates its speed by measuring the temperature of the environment, compare it, analyze it and sends notification to user instant. The Raspberry pi, Raspbian, Python, motor, jumper wires, sensors and other software tools were used to develop an automated fan which measures the surrounding temperature and adjusts the regulatory system of the fan accordingly in an automated manner [12][20][21][22][23].

The review from related works the idea behind this research work is to design & implement an industrial heat detector and a cooling system with instant email notification using raspberry pi that will control the speed of a fan based on the temperature of its environment with the help of a microcontroller. A temperature sensor has been used to measure the temperature of the workplace and the speed of the fan is varied according to the workplace temperature using PWM technique. The duty cycle is varied from 0 to 100 to control the fan speed depending upon the workplace temperature, which is displayed on Liquid Crystal Display. The main objective of this research work is to design and implement a smart device system using raspberry pi that will have the functional ability to detect heat, activate the fan for the cooling of the system and as well trigger email notification to the manager [24][25].

## MATERIALS AND METHODS

**Materials used for the research design**

**1. Temperature Sensor**: DHT11 temperature sensor was used due to its low-cost and also the ability to sense humidity. It was also used because it has the functionalities that makes it to be easily interfaced with any micro-controller such as Arduino, Raspberry Pi and so on to measure humidity and temperature instantaneously.


**Figure 1: DHT11 Temperature Sensor**

**2. Liquid Crystal Display:** The LCD is a dot matrix liquid crystal display that displays alphanumeric characters and symbols. The (16 X 2) LCD was used in this research work to display the room temperature value. The Liquid Crystal Display screen was used for this research work due its low cost, easily to interface, have no displaying limitations like seven segments.

This LCD has two registers known as Command and Data where the command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position and controlling display. The data register stores the data to be displayed on the LCD.


16x2
LCD

**Figure 2: Liquid Crystal Display**

**3. Raspberry Pi:** This is a credit card-sized computer that plugs into your TV or any other display which can be used to learn coding and to build electronics projects. The Raspberry Pi is being used by adults and children all over the world to learn programming and digital making. The original Pi had a single-core 700MHz CPU and just 256MB RAM, and the latest model has a quad-core 1.4GHz CPU with 1GB RAM. All over the world, people use Raspberry Pis to learn programming skills, build hardware projects, do home automation, and even use them in industrial applications. The Raspberry Pi is a very cheap computer that runs Linux and window but it also provides a set of GPIO (general purpose input/output) pins that allow you to control electronic components for physical computing and explore the Internet of Things (IoT).

**Figure 3: Raspberry Pi**

## METHODS

The microcontroller was programmed using C, Python, C# language in order to suit its designed features and as well to be loaded in Raspberry Pi. The Switch control of the DC Fan was used as PWM signal which manipulates the pulse width of the system and the temperature sensor was also reconfigured to suit the system design. The Temperature sensor was configured to senses the temperature of a room or workspace at a certain reference temperature range and feeds the microcontroller with the working signal. Furthermore, the relay switches OFF or ON the fan based on the interpreted temperature of the room or workspace and finally sends e-mail notification instantly to the manager. The block diagram, flow chart and circuit diagram of the system are shown as in figure 4, figure 5 and figure 6 respectively.

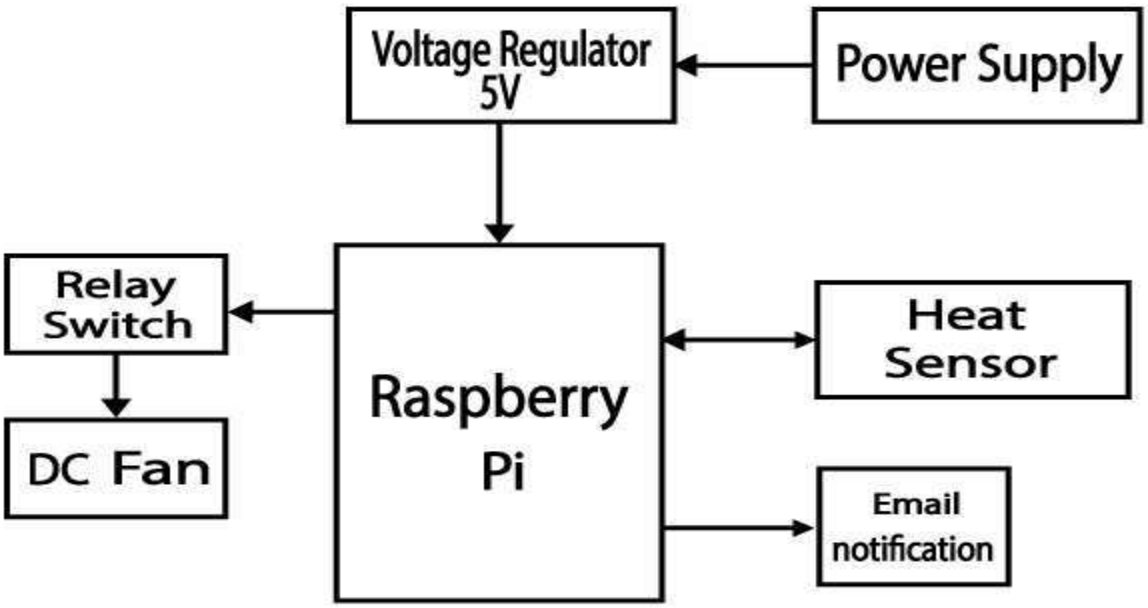


**Figure 4: Block Diagram of an Industrial Heat Detector and Cooling System.**

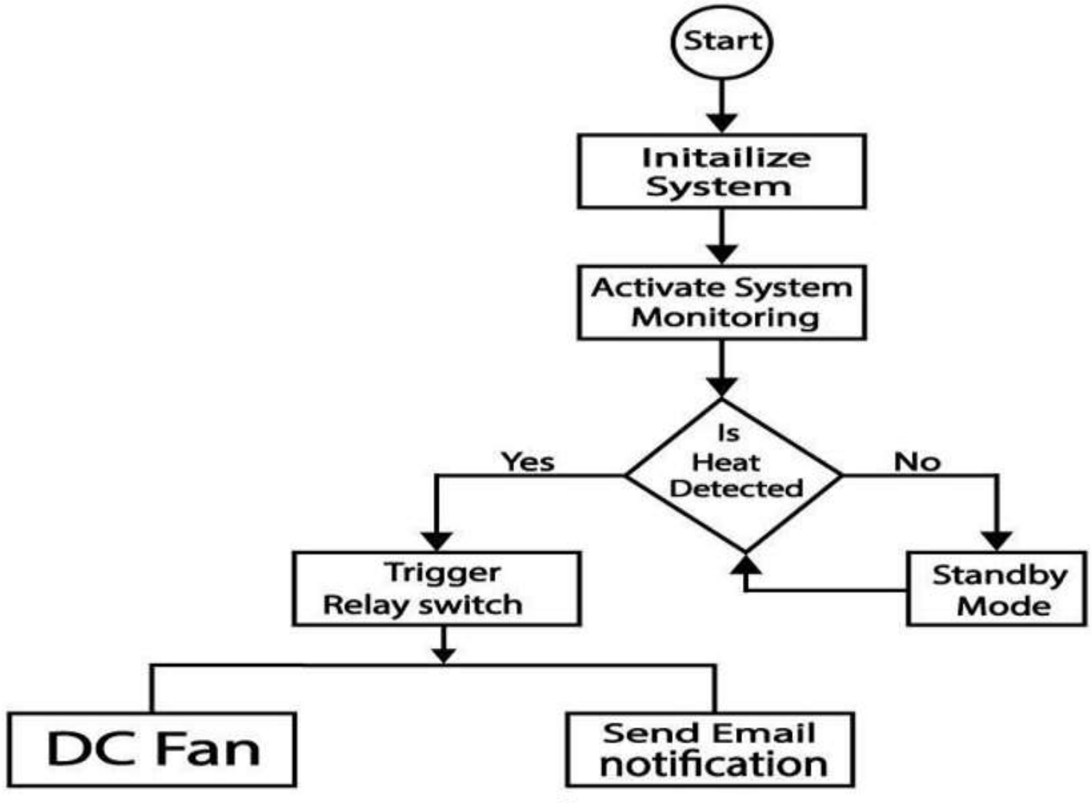


**Figure 5: Flowchart of an Industrial Heat Detector and Cooling System**

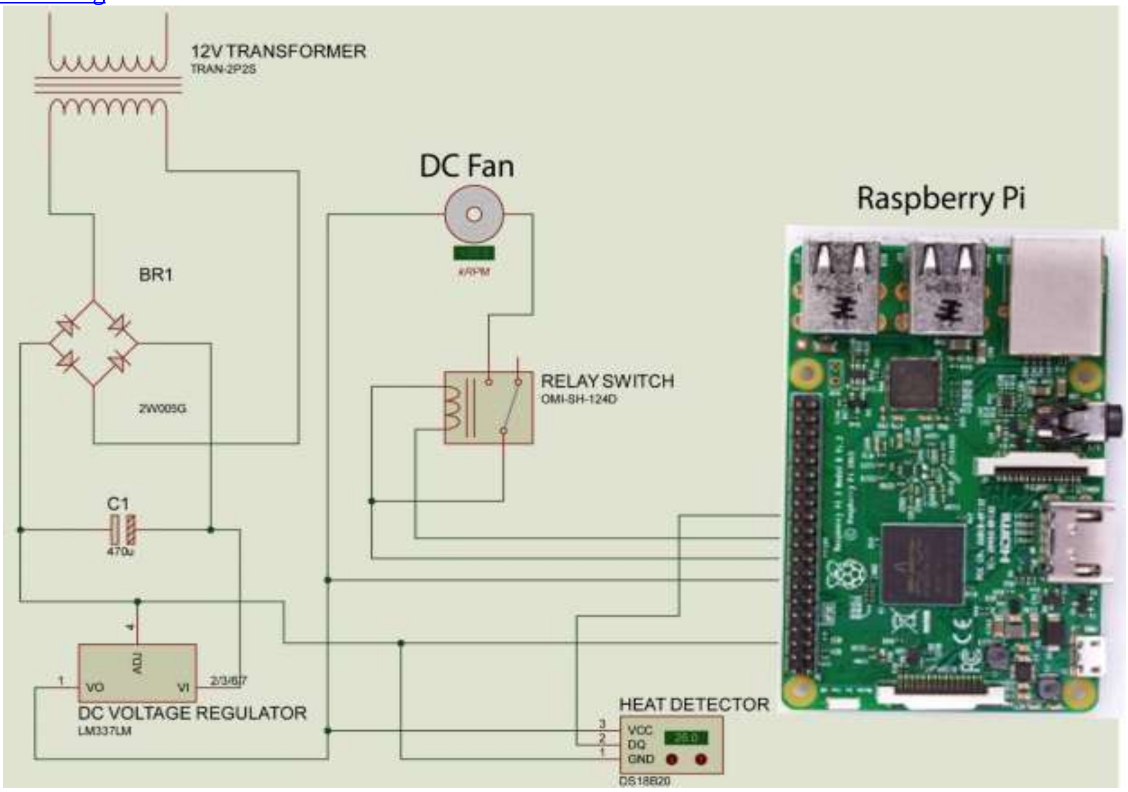


**Figure 6: Circuit Diagram of an Industrial Heat Detector and Cooling System**

DHT11 Sensor is used to measure the temperature and humidity. It consists of four pin: the first pin is connected to the VCC on the power supply (3.5 to 5 V), second pin is connected to the data and fourth pin is connected to the ground whereas third pin is free. The sensor is interface with Arduino and it consists of two electrodes which detects any resistance changes in the electrodes. Two channel opto-coupler relay are used to electrically control and activates the other devices according to the same electronic circuit. Raspberry Pi-3Model B runs on Raspbian OS and it is programmed using python 2.7.6. Raspbian's operating system was chosen because it runs on the Pi as OS has been optimized and ported to the Raspberry Pi ARM architecture. This OS has very good integration with the hardware and comes with pre- loaded GUI and development tools. The IP was edited to enable network interface files to accept commands from python. Simple Mail Transfer Protocol (SMTP) program was then used to deliver the email from the Raspberry Pi to the configured mail-hub. The program will be set to be resetting the sensor pin to LOW and recheck again the status after 2 seconds. This should return the program to the main loop and so on. Liquid Crystal Display is used to display the temperature and humidity results as output.

**RESULTS AND DISCUSSION**

This section of this research work details the reustls of this projrct work and as well discused the figures involved for more simplicity.

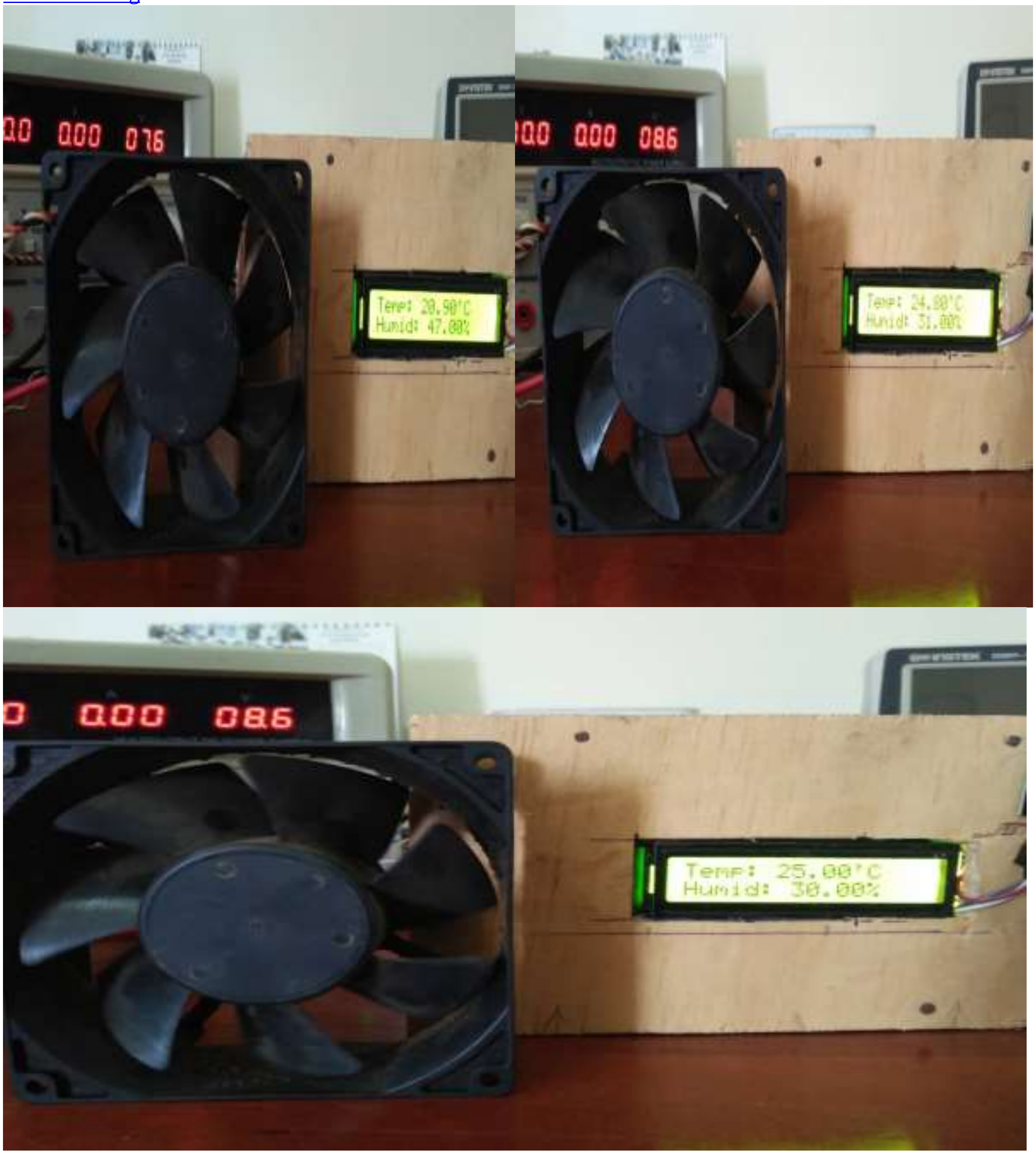


**Figure 7: The output of the design at temperature less than 25.99°C**

The diagram of figure 7, showed the output of the design from temperature range of 0.00°C to 25.99°C. It was observed from figure 7 that the accuracy of the designed system is reliable and durable as it maintained the perfect range for good system. The system triggers the cooling fan ON immediately the temperature is >25.99°C and triggers it OFF immediately the temperature range is <26.00°C. This working principle was adopted because from 0.00°C to 25,99°C the temperature ranges of a machines were meant to be ideally good but above that it will overheat and the cooling fan triggers ON to avoid overheating. From figure 7, it was observed that at temperature ranges of 24.80°C, 20.90°C, 25.00°C which are very close to the activating temperature

(26.00°C) the smart industrial heat detector and cooling system designed obviously never triggered ON because the temperature range of the machines or environment is still within the normal range.


**Figure 8: The Output of the Design at Temperature of 26.00°C and above**

The design showed that when temperature above 26.00°C is detected the cooling Fan triggers ON automatically as shown in figure 8. It was observed from figure 8 that the fan triggered ON immediately the temperature of the system or the environment is > 25.99°C which is the specified range for an ideal working system. This design system will trigger an email to the manger (user) when the machine or environment continues to overheat up to 30.00°C. Furthermore, if the machine continues to overheat up-to 40°C, the embedded software will automatically trigger OFF the machine indicating that something is faulty. The email will notify the manager (user) that the machine is getting overheated and needed an urgent attention and if the manger refuses to intervene immediately, the machine will automatically trigger OFF. From figure 8, it is observed that the accuracy and efficiency of this designed system is excellently and efficiently achieved at very low cost.

## CONCLUSION

In this research work, the workspace temperature is maintained and monitored continuously using the DHT11 temperature sensor with Raspberry Pi.

This designed system triggers the cooling fan ON immediately the temperature is >25.99°C and triggers it OFF immediately the temperature range is <26.00°C. The fan then triggers ON immediately the temperature of the system or the environment is > 25.99°C and an email sent to the manger (user) when the machine or environment continues heat above 30.00°C. Furthermore, if the machine continues to overheat up-to 40°C, the embedded software will automatically trigger OFF the machine indicating that something is wrong. The email will notify the manager (user) that the machine is getting overheated and an urgent attention is needed. This research work has successfully achieved the aim of solving the problem of machine overheating by either cooling it or sending signal to the manager for immediate intervention which will help in reducing the cost of repairing the machines.

**REFERENCES**

**[1].** Bai, Y. W., & Ku, Y. T. (2008). Automatic room light intensity detection and control using a microprocessor and light sensors. *IEEE Transactions on Consumer Electronics*, *54*(3), 1173-1176.

**[2].** Mustafa, S., Hossam, A., and Muammer, M. (2014). Automatic Fan Speed Control System Using Microcontroller. 6th Int'l Conference on Electrical, Electronics & Civil Engineering (ICEECE'2014), 27-28, 2014 Cape Town (South Africa)

**[3].** Nwankwo, N. P., Alumona, T., Onwuzulike, D. A., & Nwankwo, V. (2014). Design and implementation of microcontroller based automatic fan speed regulator (using temperature sensor). International Journal of Engineering Research and Management (IJERM), 01(05).

**[4].** Wong, K. K., Abu, S. N. A., Sahimi, M. S., & Othman, W. A. F. W. (2019). Development of Reverse Vending Machine using Recycled Materials and Arduino Microcontroller. International Journal of Engineering Creativity and Innovation, 1(1), 7-16.

**[5].** Fan, J. R., Abdi, R. M. S., Mohamad, M., & Othman, W. A. F. W. (2019). Energy Saving - Motion Activated Smart Fan Design and Implementation. International. Journal of Engineering Creativity and Innovation, 1(1), 24-32.

**[6].** Zairi, I. R. (2013). Design of an Automatic Temperature Control System for Smart Electric Fan Using PIC, International Journal of Science and Research(IJSR), 2(9).

**[7].** Eze, V. H. U., Olisa, S. C., Eze, M. C., Ibokette, B. O., & Ugwu, S. A. (2016). Effect of Input Current and The Receiver-Transmitter Distance on the Voltage Detected by Infrared Receiver. *International Journal of Scientific & Engineering Research*, vol. 7, no. 10, pp. 642–645.

**[8].** Eze, M. C., Eze, H. U., Chidebelu, N. O., Ugwu, S. A., Odo, J. I., & Odi, J. I. (2017). Novel Passive Negative and Positive Clamper Circuits Design for Electronic Systems. *International Journal of Scientific & Engineering Research*, vol. 8, no. 5, pp. 856–867.

**[9].** Vaibhav, B. (2014). Room Temperature based Fan Speed Control system using Pulse Width Modulation Technique, International Journal of Computer Applications, Volume 85- No 5,

**[10].** Amoo, A. L. (2014). Design and Implementation of a Room Temperature Control System: Microcontroller- Based, IEEE.

**[11].** Dilruba, Y. (2015). Automatic Room Temperature Controlled Fan Speed Controller Using PT-100, International Journal of Scientific and Engineering Research, 6(8).

**[12].** Kunalsingh, T. (2017). Automatic Fan Speed Control System using Arduino, International Journal of Novel Research and Development, Volume 2, Issue 4, April.

**[13].** Harshavar, T. G. (2017). Real Time-Based Temperature Control Using Arduino, International Journal of

Innovations in Engineering and Technology, Volume 8, Issue 2.

**[14].** Eze, V. H. U., Iloanusi, O. N., Eze, M. C., & Osuagwu, C. C. (2017) "Maximum power point tracking technique based on optimized adaptive differential conductance," *Cogent Engineering*, vol. 4, no. 1, pp. 1–13, doi: 10.1080/23311916.2017.1339336

**[15].** Eze, V. H. U., Eze, M. C., Chijindu, V., Chidinma, E., Samuel, E. U. A., & Chibuzo, O. C. (2022). Development of Improved Maximum Power Point Tracking Algorithm Based on Balancing Particle Swarm Optimization for Renewable Energy Generation. *International Digital Organization for Scientific Research of Applied Science*, vol. 7, no. 1, pp. 12–28.

**[16].** Eze, M. C. (2021). Solar Energy Materials and Solar Cells Optimum silver contact sputtering parameters for efficient perovskite solar cell fabrication. *Solar Energy Materials and Solar Cells*, vol. 230, no. 2020, p. 111185, doi: 10.1016/j.solmat.2021.111185.

**[17].** Eze, V. H. U., Oparaku, U. O., Ugwu, A. S., & Ogbonna, C. C. (2021). A Comprehensive Review on Recent Maximum Power Point Tracking of a Solar Photovoltaic Systems using Intelligent, Non-Intelligent and Hybrid based Techniques. *International Journal of Innovative Science and Research Technology*, vol. 6, no. 5, pp. 456–474.

**[18].** Eze, M. C. (2022). Improving the efficiency and stability of in-air fabricated perovskite solar cells using the mixed antisolvent of methyl acetate and chloroform. *Organic Electronics*, vol. 107, pp. 1–10,doi:10.1016/j.orgel.2022.106552.

**[19].** Eze, V. H. U., Eze, M. C., Ogbonna, C. C., Ugwu, S. A., Emeka, K., & Onyeke, C. A. (2021). Comprehensive Review of Recent Electric Vehicle Charging Stations. *Global Journal of Scientific and Research Publications*, vol. 1, no. 12, pp. 16–23.

**[20].** Edozie, E., Janat, W., Kalyankolo, Z., Adabara, I., & Ukagwu, K. J. (2020). Design and Analysis of a Lab IP Spy Camera and Alarm System using Raspberry Pi and ATMEGA328P. *System*, *4*(5), 16-20.

**[21].** Ibrahim, A., Kasiimbura, O., Enerst, E., Ginabel, O. O., Ouma, S., & Komujuni, S. (2019). Raspberry Pi 3 B+ Based War Field Spying Robot Using Wireless Camera. International Journal of Academic and Applied Research (IJAAR), Volume 3, Issue 7, Pages 49-53.

**[22].** Hassan, A. S., Adabara, I., Ronald, A., & Muteba, K. (2018). Design and Implementation of an Automatic Power Supply from Four Different Source Using Microcontroller. *vol*, *4*(5): 40-46.

**[23].** Edozie, E., & Vilaka, K. (2020). Design and Implementation of a Smart Sensor and RFID Door Lock Security System with Email Notification. *International Journal of Engineering and Information Systems (IJEAIS)*, *4*(7), 25-28.

**[24].** Hassan, A. S., Adabara, I., Ronald, A., & Muteba, K. (2018). Design and Implementation of an Automatic Power Supply from Four Different Source Using Microcontroller. *vol*, *4*(5): 40-46.

**[25].** Ibrahim, A., Abdurrahman, S., & Hassan, L. I. (2018). Design and Implementation of an Automatic Sun Tracking Solar Panel without Light Sensors. International Journal of Electrical and Electronic Science, Volume 5, Issue 3, Pages 77-83.

**CITE AS: Eze Val Hyginus Udoka, Enerst Edozie, Turyahabwe Frank, Kalyankolo Umaru, and Wantimba Janat (2023). Design and implementation of an industrial heat detector and cooling system using Raspberry Pi. *IDOSR Journal of Scientific Research* 8(2) 105-115, 2023. https://doi.org/10.59298/IDOSR/2023/10.2.6008**