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Development of Automated Exhaust Fan for Modern Kitchen with IoT Notification System

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ABSTRACT

This project shows the development of an automated exhaust fan for a modern kitchen with an IoT notification system for a better air ventilation system with lower electrical consumption and cheaper installation costs. Utilizing an exhaust fan as the ventilation system will significantly lower the cost of installation and maintenance. The exhaust fan will carry the process of removing hot air from the kitchen so that cooler surrounding temperatures can be achieved. The application of an automated microcontroller system will allow higher energy efficiency for daily cooking appliance usage. Then, the application of the DHT22 temperature sensor as the input for the microcontroller which can detect the precise temperature of the surrounding air. The exhaust fan will automatically turn ON when it detects the surrounding temperature is increased from 33℃. However, a notification will be sent to the user through the Blynk Application when the temperature of the kitchen is increasing and achieved 37℃ while a buzzer will turn ON to alert people in the house. Next, the AC voltage controller will help regulate the speed of the fan according to the input temperature so that more energy can be saved during long daily usage. At the end of this project, the outcome product will become a microcontroller that can be used in various types of households that already have a wall-mounted exhaust fan. Moreover, more users will be able to install this whole ventilation system for their hot kitchen due to low installation and maintenance costs. Lastly, the electrical monthly bill can be reduced.

1. Introduction

The modern kitchen is mostly equipped with modern cooking appliances for various purposes to serve various kinds of meals. For example, modern appliances, such as Multi-Cooker, Electrical

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Steamers, Electrical Pressure-Cooker, Oven, Microwaves and Air Fryer. However, most cooking appliances have the highest contribution of heat to the modern kitchen as well as high electrical energy consumption upon usage [1,2]. Problems of high indoor temperature will affect the daily routine and bring discomfort to the family living inside [3]. High indoor temperatures can have a significant impact on the health and comfort of occupants, particularly the elderly [4,5]. A hot and, uncomfortable kitchen adds to sweating, uneasiness or any unneeded mishaps. So, the room temperature of the kitchen is also a vital factor, to note [6].

Modern homes and air ventilation systems are a perfect combination, especially after the COVID-19 pandemic which has changed most Malaysian citizens' routines, and home cooking activities have increased rapidly. Due to the high cooking activities inside most modern homes, the ventilation system is required the most to reduce the hot indoor temperature [7]. Almost all houses nowadays have already implemented various kinds of ventilation systems to solve this problem, based on the budget for installation and maintenance.

For example, the invention of the cooking hood ventilation system, which is installed directly above the stove, and acts as continuous heat suction when the fire is open during cooking activities. However, this system only focuses the heat from direct cooking on the stove while other electrical appliances contribute more heat to the kitchen surroundings. Moreover, these kitchen hood systems are more efficient for restaurant usage compared to homes because noise while running the system is quite uncomfortable for families with small kids around.

Apart from that, the implementation of an exhaust fan system with a wall-mounted design is more efficient for disposing of the heat covering more areas of the kitchen [8]. This system is reliable for removing the heat accumulated in the kitchen as well as the smoke during cooking on the stove. However, as usual, this system is not perfect enough from a technological view, because there are still some energy wastages while running continuously with the same rated speed. Also, Research has identified a significant issue with users forgetting to turn off gas stoves after cooking, leading to energy wastage [9,10]. This is part of a broader problem of energy wastage due to human behavior, such as leaving lights and equipment on in commercial buildings [11].

A range of studies have explored the development of automated safety systems for modern kitchens. [9] and [12] both focus on gas safety, with Alarm's system incorporating a gas valve mechanism and Pudugosula's using sensors to detect gas leakage and fire. a low-cost temperature control and exhaust system for an old age home kitchen has been presented by [13], while [14] introduces DeepSafe, a hybrid system that uses the Internet of Things (IoT) and deep learning to detect abnormal events and block gas sources. IoT is a concept of connecting, communicating, commanding and controlling the things by the human world with the help of Wi-Fi interfacing components [12,15]. The IoT is increasingly becoming an essential part of people's lives and its presence can be seen everywhere [16]. Whereas, a system that uses IoT for controlling and monitoring exhaust fans, with Fuada using an Android-based smartphone and Idrees employing edge computing for real-time data processing [17,18].

Other related research done by [19] proposes the creation of a monitoring and controlling system for indoor air quality based on IoT and fuzzy logic using PM10, CO2 sensors and exhaust fans as actuators. While, [20] presents a feedback system using a ventilation fan as an actuator, addressing issues of room pressure and aeration. Researcher in [21] introduces a prototype using a DHT11 temperature sensor to regulate fan operation based on room temperature and humidity. These studies collectively highlight the potential for advanced safety features in modern kitchen appliances.

With the new approach of implementing an automated or smart speed controller into the current exhaust fan, the system will be a new improvement with a low-cost budget. The smart control system is built with Arduino, some electronic components as well and system coding. This new Controller-based exhaust fan system is now able to control the speed of the fan according to surrounding requirements while continuously running state. Thus, more efficient usage can be applied to the system as well as reduce energy wastage. Finally, with the efficient usage of this system, users can save some money due to the reduction of energy used.

2. Methodology

The project methodology is divided into two parts which are hardware development and software implementation. The block diagram for this project is shown in Figure 1. The main component that acts as the brain for this project is a microcontroller or more specified is Arduino UNO R3. With the Arduino UNO R3, the exhaust fan speed and IoT data from Blynks can easily be controlled and recorded. Figure 2 shows the Circuit Diagram of this Project.

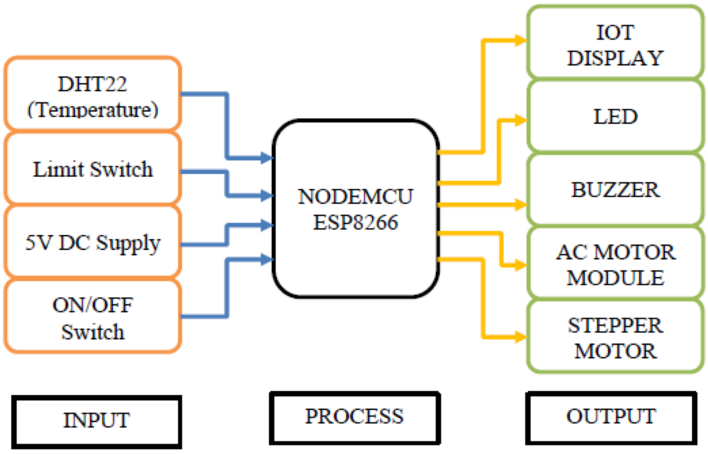

Fig. 1. Block Diagram of microcontroller process

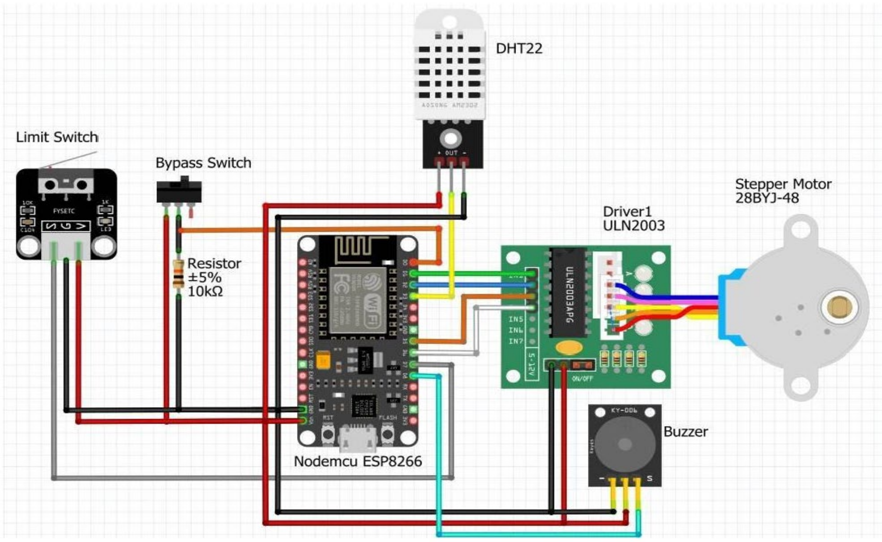

Fig. 2. Circuit Diagram of this Project

This project's flowchart begins with a high temperature recorded by the heat sensor detector, also known as DHT22. The process then continues with the signal being delivered to Arduino, and Arduino controlling the fan speed for cooling purposes. Furthermore, if the room temperature is too high, an LED light-up or buzzer sounds as a warning to the alert user or anybody in that house. The temperature value taken in the project is based on the previous research [13, 22]. Table 1 shows the system components and functionand Figure 3 shows the flowchart of the microcontroller.

Table 1
The system components and function

Component	Functions
Limit switch	The limit switch regulates the electrical circuit that controls the machine and its moving parts. These switches can be used as pilot devices for magnetic starter control circuits, allowing them to start, stop, slow down, or accelerate the functions of an electric motor.
Nodemcu ESP8266	The ESP 8266 is ideal for this project because it uses a limited number of sensor outputs and several device outputs and wireless signal transmission using wifi range to be sent to the Blynk application. It is beneficial to provide options for projects to remain simple because there will be sufficient resources
Temperature sensor DHT22	The DHT22 is a low-cost electronic temperature and humidity sensor with a simple design. It uses a capacitive humidity sensor and a thermistor to measure the ambient air temperature and calibrate a digital signal on the data pin. The equipment is straightforward to operate and offers a high level of dependability. It offers strong measurement stability and low inaccuracy. This sensor's operational voltage ranges from 3.3 to 5 volts, with an operating current of 0.3 mA and a standby current of 60 uA. The greatest temperature that this device can read is 80 degrees. It has a temperature reading accuracy of 0.5 percent, compared to merely 2 percent for the DHT22
Driver1 ULN2003	This module has a 5V to 12V DC input voltage supply and a 5-pin stepper motor output slot built in. Furthermore, this module includes four LED indicators for monitoring the four processes. The pins for incoming signals from the microcontroller are IN1, IN2, IN3, and IN4.
Buzzer	A buzzer is an electrical device that emits a beeping signal when electricity is supplied to it. It consists of a piezo core and a 2–4 kHz oscillator. When an electrical source is applied to a crystal form, the effect is called "piezoelectricity." The sound is produced by adjusting the frequency of the transmission. A transistor and a cable are included with the buzzer. This device will operate as an alert signal to the user as an alarm when the temperature is greater than 37℃.
Stepper Motor 28BYJ-48	The DC Stepper Motor required in this project is a 5V DC power supply to function properly. This stepper motor is attached to the system as an output for the microcontroller's speed control mechanism. Because the controller movement alternates between clockwise and anticlockwise directions, a stepper motor is the optimum choice for this system. The stepper model used is the 28BYJ-48 5V, which is a four-phase stepper with a low price and high market availability.

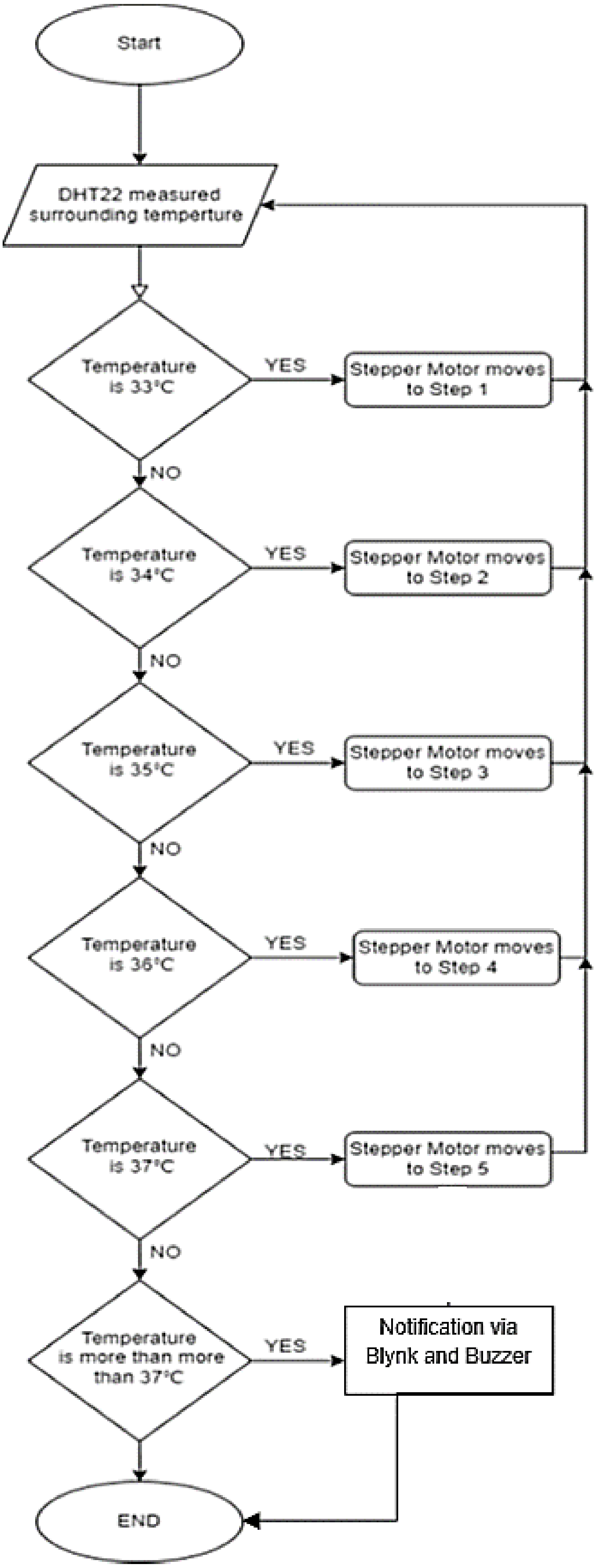

Fig. 3. Flowchart of the Microcontroller

3. Results
3.1 The Prototype

Figure 4 below shows the complete design and prototype of the automated exhaust fan for a modern kitchen with a safety fire detection system. The performance of the prototype has been set up and tested in a real modern kitchen household with moderated moderated-sized house as shown in Figure 5. Figure 6 shows the IoT Blynk setup.

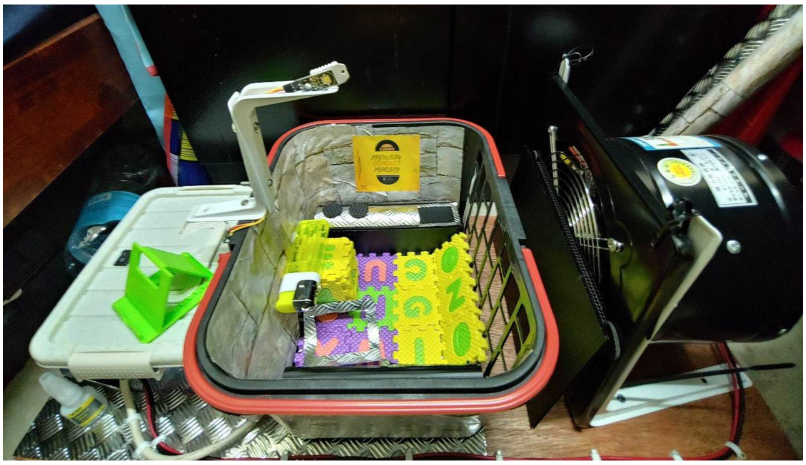

Fig. 4. Full automated exhaust fan prototype

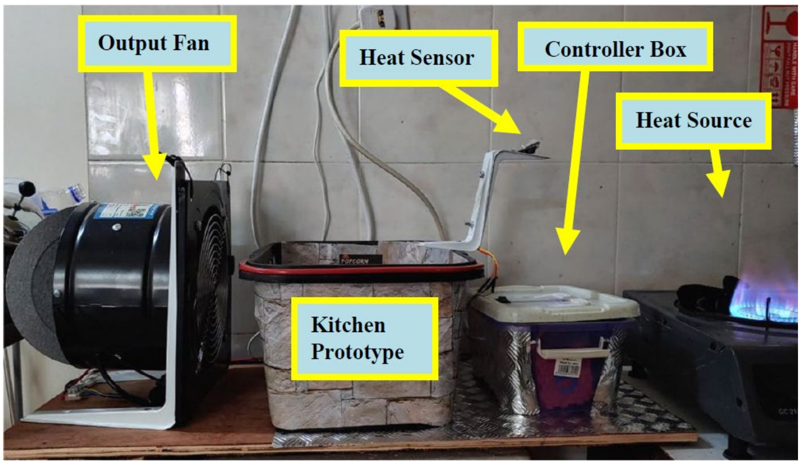

Fig. 5. Prototype setup for experimental

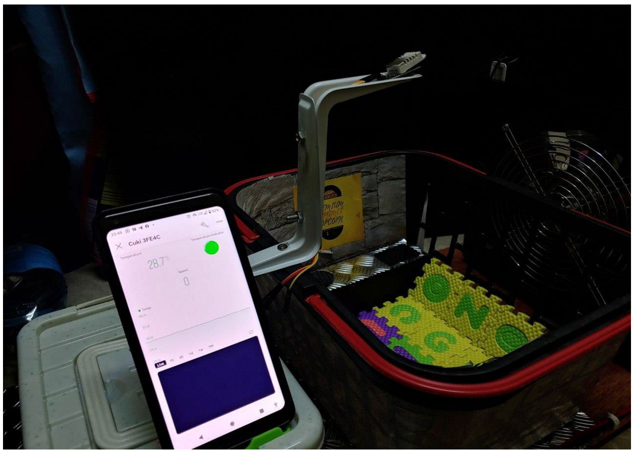

Fig. 6. IoT Blynk setup

3.1.1 Data from Blynks apps

Data provided in Table 2 is collected automatically from the Blynk application as shown in Figure 7. Table 2 shows the trend of the increases in speed of the fan starting from 33°C. Before 33°C, the speed of the fan will remain constant and then increase gradually until it reaches 37°C igniting the highest speed of the fan which is the 5th speed. Thus, the 5th speed is the limit of the system which is the rated normal working specification of the fan and as the increases of temperature more than 37°C will remain the same speed of the fan. Furthermore, the temperature limit is set for 60°C as the limit of the highest temperature can be detected by the DHT22 sensor.

Table 2
Fan Speed Vs Room Temperature

Angle of Stepper Motor	Room Temperature, °C	Fan Speed
0 °	0 – 32.9	0
150 °	33 – 33.9	1
176 °	34 – 34.9	2
203 °	35 – 35.9	3
229 °	36 – 36.9	4
255 °	37 – 60.0	5

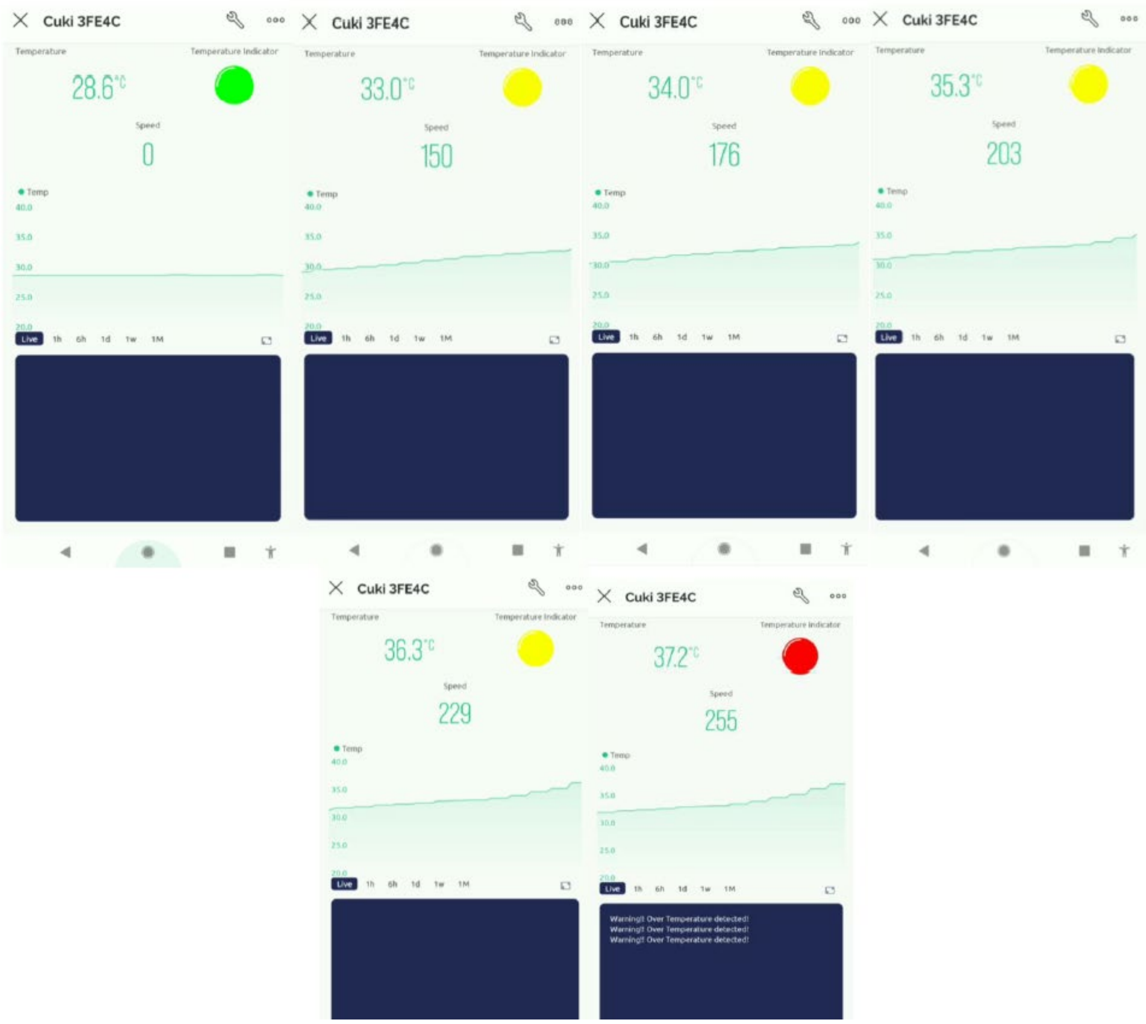

Fig. 7. Blynk data display

From the data that have been collected, it shows that the LED colour indicates the functionality mode of the system which is either green light for sleep mode, yellow light for working mode, or red light for emergency mode. Next, the temperature reading is shown at the top left of the Blynk app and it directly shows the measured temperature received by the DHT22 temperature sensor. Apart from that, the middle part of the app shows the speed of the fan which is represented by the angle of the stepper motor including 0°, 150°, 176°, 203°, 229° and 255°. Other than that, a live graph will be shown as the project runs and Blynk it is connected while a warning indication display at the bottom part of the application will pop up after 37.1℃ is detected.

3.1.2 Cooling down experiment result

The method of analysis is to determine the time spent to cool down a kitchen room area temperature when the kitchen temperature is set to be more than 37℃. Five attempts are taken for testing purposes to determine the average time taken for cooling down the hot kitchen area with 5 different speeds of the exhaust fan. Next, this test data will be able to determine the efficiency of the system in real kitchen applications (Table 3).

Table 3
Time taken for cooling analysis

Initial Temperature	Time taken (minutes)				
	Speed 5	Speed 4	Speed 3	Speed 2	Speed 1
37.4 ℃	0.53	0.93	1.34	2.74	3.49
37.3 ℃	0.51	0.89	1.54	2.56	3.53
37.5 ℃	0.55	0.94	1.23	2.87	3.52
38 ℃	0.88	1.02	1.24	2.77	3.47
37.2 ℃	0.50	0.88	1.43	2.89	3.55

From the 5 attempts that have been taken, every trial has stated that the system needed approximately 3.5 minutes to cool down a hot room temperature of around 37℃ until the temperature measured is equal to or lesser than 33℃. Also, the speed of the exhaust fan will affect the time taken to cool down the kitchen area. In addition, the values of time measured are not very distant which implies that the system is efficient and has a low percentage of error.

3.1.3 Voltage and power operating

The author has done a comparison of a running exhaust fan manually and an automated system for cooling a hot kitchen. The result is shown in Figure 8 and Figure 9.

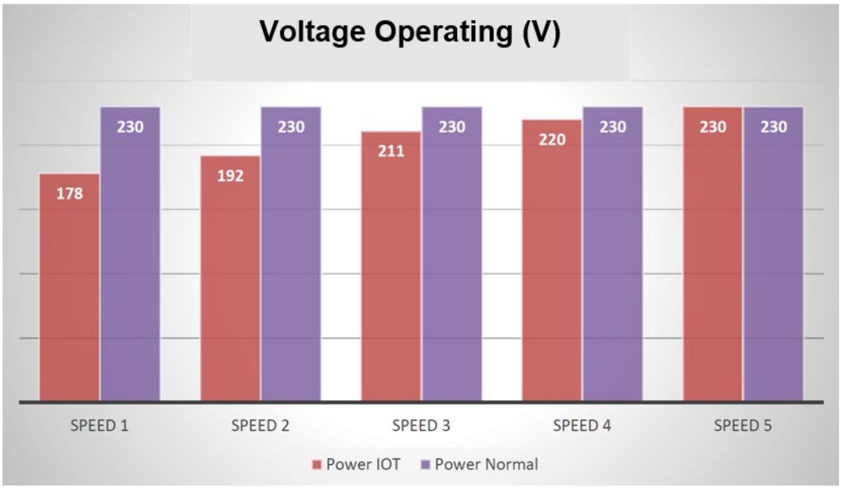

Fig. 8. Voltage operating comparison

Fig. 9. Power operating comparison

In comparison between those 2 graph data, exhaust fans that control with power IoT can be seen usage lower power consumption in total even though at full speed fans both normal and automated systems consume the same power operating value. Besides, human error in switching off when no usage with the normal system has to be considered an extra energy wastage.

4. Conclusions

The main reason for implementing the Automated exhaust fan system in this project is to provide more energy efficiency for daily consumption. The temperature sensor connected to the controller of the system acts as temperature monitoring as well as providing input data to the system. The older version or commonly used exhaust fan in many homes are connected directly to the power source and only have one speed. Besides the high power consumption, the user's careless mistakes in leaving the exhaust fan running more than needed lower the efficiency of the electrical power usage.

This project demonstrates how an automated exhaust fan system can work to reduce the temperature of a hot kitchen when it is needed in a short period as shown in the results section. This system can be used in any area of the house that needs to be cool and at the same time not consume so much energy. At the same time, with added safety features the system will give a notification to the house owner and turn on the alarm system.

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