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IoT Based Solar Automatic Clothes Hanger System

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Abstract

A Laundry tasks are commonly performed as part of the daily routine, posing a challenge for individuals with time constraints, especially those engaged in busy daily schedules. This project endeavors to create an automated cloth hanger system that responds to weather changes, aiding users in managing laundry, particularly during rainy days. Controlled by the NodeMCU ESP32 microcontroller, the cloth hanger incorporates three sensors: a rain sensor, LDR, and DHT sensor. Additionally, a solar energy system is introduced to sustainably charge the lead-acid battery, powering the entire cloth hanging system with environmentally friendly technology. The DC motor's movement is guided by feedback signals from the sensors, detecting rain, low light levels, and high humidity. In response to any of these signals, the system automatically shelters the clothes. Through analysis, the prototype system accommodates a maximum of six clothes on the hanger and provides smartphone monitoring and notifications. A fully charged 12 V/7.2 Ah Sealed Lead Acid battery can support the maximum load under normal conditions for 24 hours without requiring recharging. In conclusion, the automated cloth hanger system has been successfully developed to streamline daily laundry tasks, incorporating green technology features.

1. Introduction

Clothes hanger is a useful tool for drying wet clothes after doing laundry at home. There is various type of cloth hanger design available today. Although they may differ in appearance, their functionality remains the same, to hang wet clothes. However, people often need to move the clothes from the hanger if it rains. Malaysia has a tropical weather where the annual temperature is 25.4 °C for years 1901-2021 and most likely most likely cloud cover during the afternoon or evening and just receives about six hours of direct sunlight per day [1]. Weather change can be unpredictable, it might be sunny in the morning, only to have the rain pouring down in the evening. This can pose a problem for individuals who wish to dry their wet clothes. Fortunately, with an automatic clothes hanger, individual do not need to worry about their laundry on rainy day, especially for those who work and have nobody at home to help them. With integration of IoT technology, automation, and renewable energy sources offer a promising solution for energy-efficient and smart clothes hanging systems.

The number of connected IoT devices has exceeded 12 billion, marking an 8% growth compared to 2021. This data comes from a report released in May 2022, indicating the continuous growth and adoption of IoT technology in various industries and sectors [2]. With implementation of IoT technology, this system transforms the clothes hanging process into more convenient and efficient experience. The focus of an IoT-based automatic clothes hanger system is to automate the process of hanging and retracting clothes. Traditional methods can be timeconsuming and require more effort. The hanger system will feature a motorized mechanism that can be controlled through a smartphone application. This will help users to control the time for hanging or retracting clothes automatically. The mobile application provides user with valuable information such as weather conditions and allow for operational control of the system. Users also can receive notifications or alerts regarding the system's operation, ensuring they stay informed.

The integration of solar power generation into the clothes hanger system allows it to harness renewable energy from the sun. This approach can reduce reliance on grid electricity, lower energy cost and decreased environmental pollution. Solar energy system convert sunlight into electricity directly by using photovoltaic (PV) panels or indirectly by using concentrated solar power (CSP) technology. Concentrated solar power systems have been installed with combined capacity of 5469 MW, representing approximately 1.13% of the total installed solar energy capacity worldwide. Solar energy possesses an estimated average power potential of 24W/m2 across the Earth's surface [3]. To ensure uninterrupted operation, the system incorporates battery storage for later use in the absence of sunlight or insufficient. The output power must be compatible with the operating load because insufficient power can damage battery storage and can decrease the lifespan of the battery.

This automatic clothes hanger system uses NodeMCU ESP32 microcontroller as the central control unit. It has built-in Wi-Fi and Bluetooth capabilities and can connect with other devices and facilitates data processing and communication. A light-dependent resistor (LDR) sensor measures ambient light level and digital humidity & temperature (DHT) sensor measure humidity and temperature. With the LDR reading, it determines whether it is sunny or rainy day. Based on the processed data, microcontroller send command to actuator of the clothes hanger system. With its automation capabilities and IoT connectivity, this system represents a significant advancement in optimizing the clothes hanging experience.

2. Material and Methods

2.1 Material

In this project the NodeMCU ESP32 microcontroller is used due to its capabilities and built-in Wi-Fi connectivity. It can use the Wi-Fi protocol to connect objects to the internet and enable data transfer [4]. It provides a reliable platform for integrating various sensors and connecting to the Blynk IoT platform for remote monitoring and control. By incorporating a DHT sensor, the system can monitor the environment inside the clothes hanger and ensure optimal conditions for drying clothes. It is capable of measuring temperature within a defined range, typically spanning from -40°C to 80°C, as well as humidity within a specific range of 0% to 100% [5]. The rain sensor can detect the presence of rain by measuring the conductive characteristics of rainwater or the water level on its surface [6]. This allows the system to avoid hanging clothes during rainy conditions, preventing wet clothes. A LDR (Light Dependent Resistor), is designed to detect and measure the brightness of light. When exposed to bright light, the sensor's resistance decreases, whereas it increases in darkness. This characteristic enables the sensor to determine light presence and provide appropriate output signals [7].

Next, A DC motor is use as an actuator. To control the movement of a DC motor, L298N motor driver is used, which has a capacity of managing currents up to 3A at 35V [8]. Additionally, the use of Solar Charge Controller is vital to controls the amount of charge that enters and leaves the battery, allowing it to operate at its best and most efficiently [9]. Blynk provides a user-friendly platform for IoT projects, enabling remote monitoring and control of connected devices. By connecting the ESP32 to the Blynk app, users can visualize sensor data, and receive notifications [10]. An improvements and new innovations from previous projects should be implemented so that the process of human life is simplified with the latest technology. All the material use in the project are:

- Solar panel
- Sealed Lead Acid Battery
- Solar Charge Controller
- L298N Motor Driver
- GL55 LDR
- DHT22
- Rain Sensor
- 12V DC Motor
- ESP32

2.2 Method

2.2.1 System Block Diagram

Figure 1 show the system block diagram. The automatic clothes hanger system utilizes solar energy by harnessing sunlight through photovoltaic (PV) panels to generate electricity. It incorporates battery storage to ensure uninterrupted operation even during periods of insufficient sunlight. At the heart of the system is the NodeMCU ESP32 microcontroller, which acts as the central control unit. Equipped with built-in Wi-Fi and Bluetooth capabilities it connected with Blynk, it enables seamless connectivity with other devices, facilitates data processing, and enables communication. The system employs an LDR sensor to measure the ambient light level and a DHT sensor to monitor humidity and temperature. Rain sensor will detect rain and give signal to ESP32. By analyzing the LDR reading, the system can determine whether it is a sunny or rainy day. Based on the processed data, the microcontroller sends commands to the clothes hanger system's actuator DC motor, enabling automated and optimized clothes hanging. This integration of automation capabilities and IoT connectivity represents a significant advancement in enhancing the clothes hanging experience.

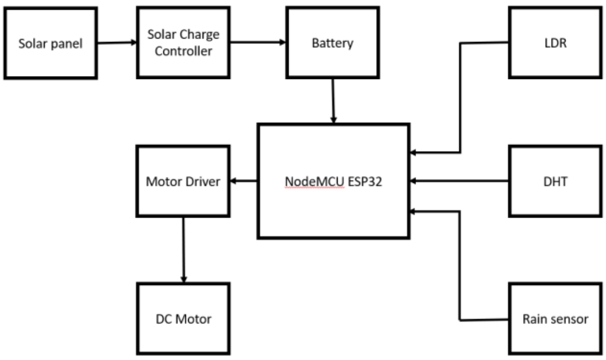

Fig. 1: *System Block Diagram*

2.2.2 System Circuit Diagram

The wiring diagram for all system hardware components is shown in Figure 2. The wiring diagram shows how the hardware is connected. The solar panel will collect energy from the sun, and it will charge the battery. Connect the GL55 LDR, DHT, and Rain sensor's OUT pin to any available digital pin of the ESP32. the IN1 and IN2 pins of the L298N motor driver is connected to any two digital pins of the ESP32. Connect the OUT1 and OUT2 pins of the L298N motor driver to the DC motor. All the sensors connect to ESP32 as input to make the DC motor moving. The DC motor connected to motor driver to control the DC motor speed.

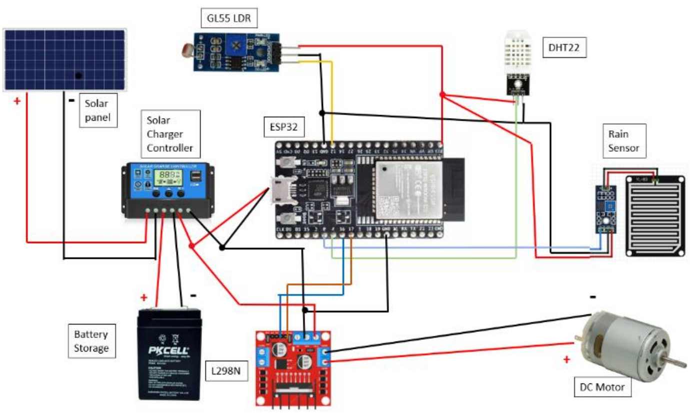

Fig. 2: *Circuit Diagram*

2.2.3 System Flowchart

Figure 3 show the system flowchart. The system initiation involves the NodeMCU ESP32 microcontroller connecting to the specified Wi-Fi network as defined in the program code. Following that, the microcontroller establishes a connection with the Blynk server. In high humidity conditions the cloth is inside the cover. If the humidity conditions are low, the cloth remains outside the cover until the rain sensor detects rainfall. When rain is detected by the rain sensor, the DC motor will bring the cloth inside the cover. Once the rain stop, DC motor will move the cloth outside the cover again. When no light is detected, DC motor will keep the cloth inside the cover for example during night-time.

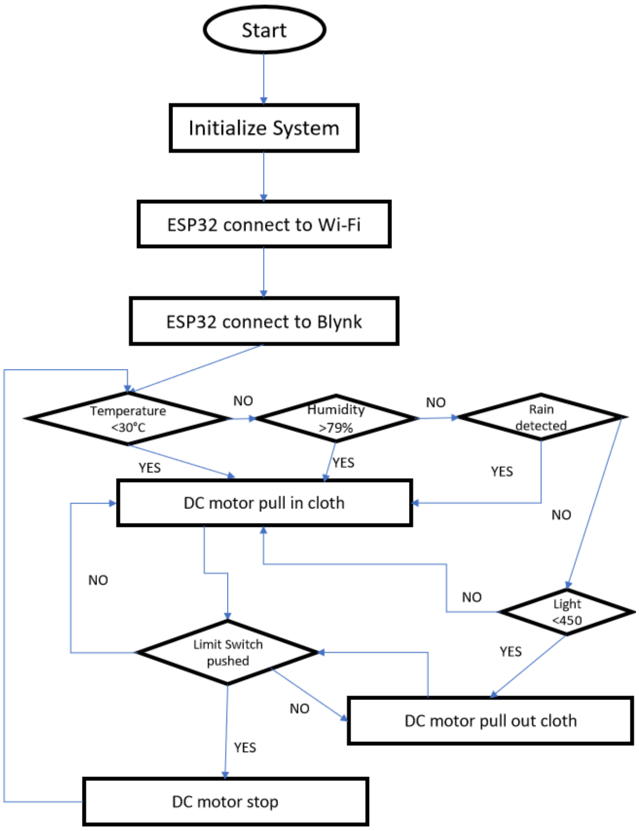

Fig. 3: *System Flowchart*

2.2.4 3D Layout Design

Figure 4 show the 3D design of the project. The length is 1.52 meter, and the height is 1.21 meter approximately. The box is the place for battery, sensors and ESP32 and the shelter for the cloth under it. The ladder like thing is the cloth hanger that can move in and out of the shelter according to sensor reading of weather conditions.

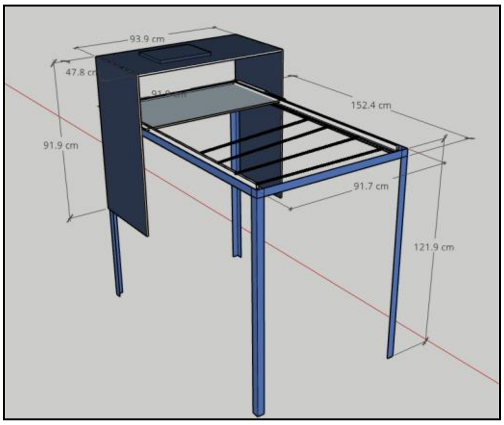

Fig. 4: *3D Layout Design*

3. Result and Discussion

3.1 Solar Power generation

To collect data of voltage generated by solar panels is by regularly measure the voltage produced by the solar panel. Figure 5 show the solar panel under sunlight to generate power. This data can be collected at different times of the day to understand the variations. The process is done starting from 8 a.m. to 7 p.m. and data is collected every one hour. The voltage generated by solar panel measured using multimeter and connected to solar panel negative and positive appropriately. Figure 6 show how to connect multimeter to solar panel appropriately and show the reading of solar panel generated voltage.

Fig. 5: *Solar panel under sunlight*

Fig. 6: *Measuring Voltage With Multimeter*

Figure 7 show the voltage generated by solar panel from 8 a.m. in the morning to 7 p.m. in the evening. The voltage generated 8 a.m. in the morning is 12.89 V. The highest voltage measure is at 10 a.m. which is 13.07 V while the lowest voltage measured is at 7 p.m. which is 2.66 V. The voltage drop occurred from 5 p.m. to 7 p.m.. The voltage at 10 a.m. is the highest.

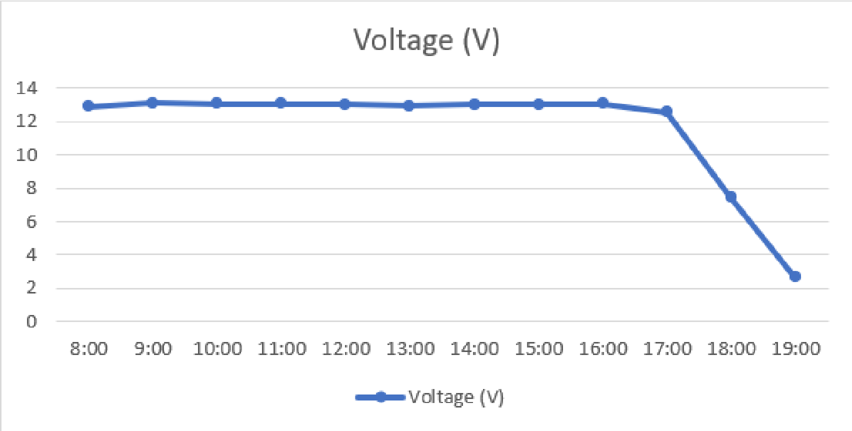

Fig. 7: *Solar Generated Voltage Graph*

From Figure 8 The observed increase in current from 0.25 A to 0.45 A between 8:00 and 11:00 is consistent with the expected behaviour of a solar panel. The peak current at 11:00 and 12:00 suggests that these hours experience the most intense sunlight, leading to the maximum current production by the solar panel. Subsequently, the observed gradual decrease in current from 0.44 A at 14:00 to 0.09 A at 19:00 is likely due to a decline in sunlight intensity as the day progresses towards evening. The lowest current measurement of 0.09 A at 19:00 indicates that the solar panel is receiving minimal sunlight at that time, likely marking the end of effective daylight for solar energy generation in this specific test.

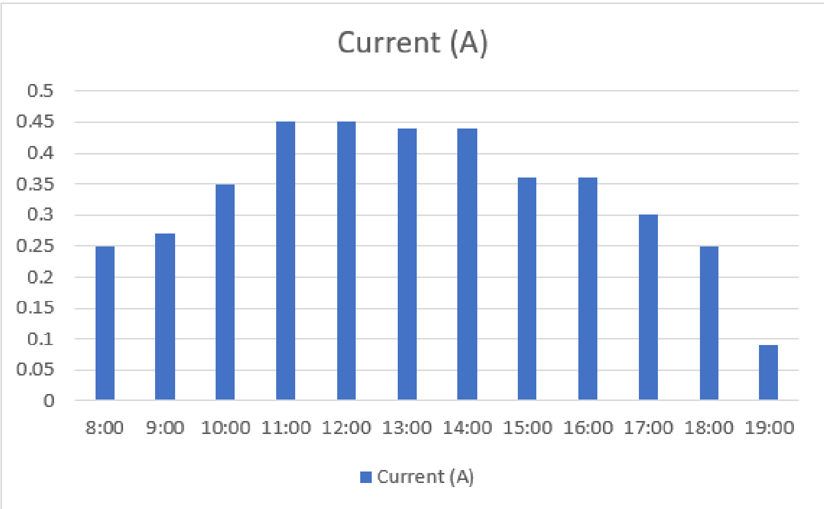

Fig. 8: *Solar Generated Current Graph*

3.2 DHT Temperature & Humidity Level Based on Weather Condition

This test is to collect data of humidity and temperature from DHT22 sensor. The data is used to set value range of temperature and humidity level based on weather conditions. This test is done for two days and start from 8 a.m. to 7 p.m.. Table 1 below shows a connection between the weather conditions and the recorded temperature and humidity levels. For example, elevated temperatures consistently align with "Sunny" weather, whereas lower temperatures are linked to "Partly Cloudy" and "Cloudy" conditions. Likewise, humidity levels exhibit fluctuations corresponding to the prevailing weather, with increased humidity frequently tied to "Cloudy" conditions. From the DHT22 data, a range can be set for as condition for system programming. The temperature ranges from 20 °C to 29 °C indicate cloudy weather with possible rain, while the range of 30 °C to 40 °C signifies partly cloudy weather with sunshine. Additionally, the humidity ranges from 50% to 79% correspond to partly cloudy and sunny weather, while the range of 80% to 90% indicates cloudy weather with possible rain. The data cannot determine the weather accurately, but it can help to determine next action in the system.

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Table 1 *DHT22 Reading*

Time	Temperature (°C)		Humidity (%)		Weather Condition	
	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
8:00	29	30	78	76	Partly Cloudy	Partly Cloudy
9:00	30	30	74	74	Partly Cloudy	Partly Cloudy
10:00	32	32	66	68	Sunny	Sunny
11:00	36	32	54	68	Sunny	Sunny
12:00	37	32	50	69	Sunny	Sunny
13:00	35	31	55	72	Sunny	Partly Cloudy
14:00	35	30	57	76	Sunny	Partly Cloudy
15:00	32	30	65	77	Sunny	Partly Cloudy
16:00	32	30	65	75	Sunny	Partly Cloudy
17:00	31	29	70	77	Partly Cloudy	Cloudy
18:00	30	29	75	83	Partly Cloudy	Cloudy
19;00	30	28	74	83	Cloudy/Sunset	Raining

3.3 GL55 LDR Reading Based on Weather Condition

Table 2 shows GL55 LDR reading based on weather conditions, starting from 8 a.m. in the morning to 8 p.m.. As light intensity increases, the resistance decreases, and vice versa. From the data, it shows that, when weather is sunny LDR reading is zero and when weather is partly cloudy or cloudy, LDR reading is increasing. This means 0 is high light intensity and 4095 is the lowest light intensity. From the data, a value can be set for sensing system where if the LDR reading is more than 450, the weather is cloudy. So, the cloth hanger will move cloth into the shelter when the value passed.

Table 2 *GL55 LDR Reading*

Time	LDR Reading (0-4095)	Weather
08:00	62	Partly Cloudy
09:00	62	Partly Cloudy
10:00	0	Sunny
11:00	0	Sunny
12:00	0	Sunny
13:00	0	Sunny
14:00	0	Sunny
15:00	31	Sunny
16:00	50	Partly Cloudy
17:00	124	Partly Cloudy
18:00	234	Partly Cloudy
19:00	431	Cloudy
20:00	4095	Night

3.4 Blynk Monitoring

Figure 9, the Blynk web dashboard interface. The central panel constitutes the main dashboard area, showcasing widgets that display data and controls for interacting with the connected device. Notable widgets include gauges for temperature, humidity, light intensity, and rainfall, as well as buttons for controlling the direction of the DC motor. Additionally, the interface indicates that the device is currently "Offline" at the top, suggesting a lack of internet connectivity. At the bottom, values for internal parameters like "MF" and "MR" are displayed, which mean motor movement, forward and reverse is on or off. This comprehensive layout and functionality contribute to an intuitive and informative Blynk web dashboard experience.

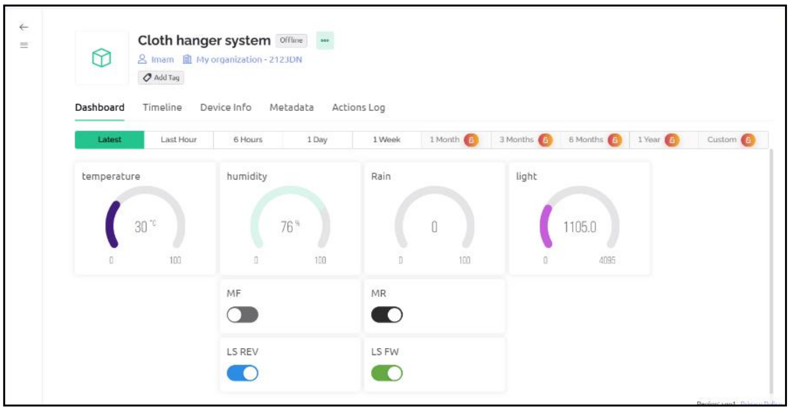

Fig. 9: *Blynk Web Dashboard*

3.5 Blynk Notification

Blynk notifications refer to alerts or messages sent through the Blynk platform to notify users about specific events or conditions in their IoT projects. Users can set up notifications to receive real-time information or alerts based on sensor readings, system states, or predefined triggers within their connected devices. These notifications serve as a crucial means of keeping users informed about the status and performance of their IoT applications, ensuring timely responses to important events or changes in the system. The Blynk notification system enhances user interaction and engagement with their projects, contributing to a more responsive and user-friendly IoT experience. Figure 10 show Blynk notification from this project. The notification is only when rain detected, rain stop, low light, and when each of limit switch pushed. The limit of notification setting is only 5 when using basic Blynk application. To setting up more than 5, paying for Blynk subscription is needed.

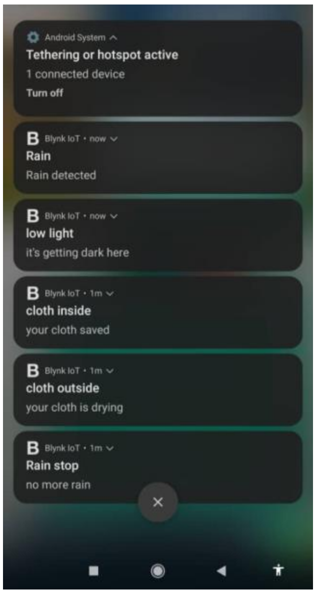

Fig. 10: *Blynk Notification*

3.6 DC Motor Output Based on Sensor Reading

The DC motor's movement in response to sensor input conditions and when a limit switch is triggered is depicted in the Table 3. Any sensor that picks up on low light, excessive humidity, low temperature, or precipitation will alert the microcontroller. Through programming, this signal is used to process conditions and produce the DC motor's output. It is indicated that the clothing is inside the shelter and out of the rain when the DC motor output is inverted. It indicates that the clothing is outside the shelter and exposed to sunlight when the DC motor output is forward, on the other hand. Only when strong light, low humidity, high temperature, and rain are detected by the sensors will the DC motor proceed forward. The DC motor will turn the other way when some other circumstances exist. To enhance the functionality of the cloth-hanging system, a feature has been incorporated to stop the DC motor when it reaches each end of the cloth hanger. Two limit switches are employed, one on each end, so that when either limit switch is activated, the DC motor comes to a halt. All these conditions collectively contribute to the automation of the cloth-hanging system.

Table 3 *DC Motor Output Condition*

Light intensity	Humidity	Temperature	Rain	DC motor	DC motor (Limit Switch Pushed)
Low	Low	Low	No rain detected	Reverse	Stop
Low	Low	Low	Rain detected	Reverse	Stop
Low	Low	High	No rain detected	Reverse	Stop
Low	High	Low	No rain detected	Reverse	Stop
High	Low	Low	No rain detected	Reverse	Stop
High	High	Low	No rain detected	Reverse	Stop
High	High	High	No rain detected	Reverse	Stop
High	High	High	Rain detected	Reverse	Stop
High	Low	High	No rain detected	Forward	Stop

3.7 DC motor strength test

This test is to assess how fast can DC motor to move the cloth. Table 4 summarizes the DC motor test, measuring its pulling speed with varying loads. The cloth used is thin cloth with average weight of 375 gram each. As the number of cloths the motor pulls increases from 1 to 6, the pulling time gradually increase from 3.35 seconds to 5.35 seconds. This demonstrates the motor's decreasing pulling speed with heavier loads, highlighting its limitations under increased resistance.

Table 4 *DC Motor Performance*

Number of cloths	Time complete movement
1	3.35 seconds
2	3.80 seconds
3	4.05 seconds
4	4.56 seconds
5	4.98 seconds
6	5.35 seconds

4. Conclusion

In conclusion, the IoT-Based Solar Automatic Cloth Hanger System presents a versatile and innovative solution for automating the cloth-hanging process while incorporating sustainable and efficient features. The key components and functionalities of the system include solar-powered operation, sensor integration for measuring humidity, temperature, and light levels, real-time monitoring through the Blynk application, and automated control of the DC motor.

The use of solar power not only aligns with eco-friendly practices but also ensures a continuous and sustainable energy source for the system. The integration of sensors, such as the DHT for weather conditions and the LDR for light levels, enhances the system's ability to respond to environmental changes and optimize cloth-hanging conditions. Real-time monitoring through the Blynk application provides users with instant access to sensor readings, allowing for informed decision-making and timely responses to system conditions. The inclusion of notifications further improves user engagement, alerting users when significant events like rain are detected. The DC motor's automated control based on system programming adds a layer of efficiency to the cloth-hanging process. Additionally, the incorporation of limit switches ensures the safety and proper functioning of the motor, preventing overextension. Despite the system's overall seamless operation, the test evaluating the DC motor's pulling speed with varying loads sheds light on its limitations under increased resistance, highlighting the importance of understanding performance characteristics.

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