Journal of Information System and Technology Management JISTM
EISSN: 0128-1666

Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

JOURNAL OF INFORMATION SYSTEM AND TECHNOLOGY MANAGEMENT (JISTM)
www.jistm.com

IOT-ENABLED SMART LIGHTING SYSTEM WITH INTEGRATED PULLEY MECHANISM FOR HOME AUTOMATION

Nazhatul Hafizah Kamarudin[1*], Mohammad Arif Ilyas[2], Fadilla 'Atyka Nor Rashid[3], Fazlina Mohd Ali[4]

[1] Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Malaysia
Email: nazhatulhafizah@ukm.edu.my
[2] Faculty of Engineering & Built Environment, UCSI University, Malaysia
Email: mohammadarif@ucsiuniversity.edu.my
[3] Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Malaysia
Email: fadilla@ukm.edu.my
[4] Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Malaysia
Email: fazlina.mohali@ukm.edu.my
[*] Corresponding Author

Article Info:

Article history:
Received date: 02.10.2023
Revised date: 30.10.2023
Accepted date: 21.11.2023
Published date: 10.12.2023

To cite this document:

Kamarudin, N. H., Ilyas, M. A., Rashid, F. 'A. N., & Ali, F. M. (2023). IoT-Enabled Smart Lighting System With Integrated Pulley Mechanism For Home Automation. *Journal of Information System and Technology Management, 8* (33), 165-177.

DOI: 10.35631/JISTM.833013.

Abstract:

Lighting systems play a fundamental role in our daily life operations. However, the typical light bulb has a finite lifespan and is often installed in hard-to-reach locations, posing a challenge when it needs replacement. To address this issue, we've developed an IoT bulb holder equipped with a pulley mechanism designed to lower itself to a user-accessible height. This innovative system also features built-in light control functionality. Our solution integrates a microcontroller with a Wi-Fi module, a mechanical motor for the pulley mechanism, and an Android app. The Android app serves as the central control hub for the system. The microcontroller manages the DC motor's position and light control, responding to instructions from the app. Light control is achieved through a relay circuit, while the pulley mechanism is operated using a DC motor with a worm gearbox. The worm gearbox was chosen for its self-locking capabilities, eliminating the need for continuous power to maintain the light bulb at the desired height. 3D modeling software was utilized to create the casing and gearing components. Tests with two different microcontrollers: NodeMCU ESP8266 and ESP32 have been conducted. A comparative analysis revealed that the ESP32 is the superior choice for IoT projects due to its enhanced Wi-Fi efficiency and connectivity capabilities.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

Keywords:

Internet-of-Things, Home Automation, Bulb Holder, Pulley Mechanism

Introduction

In the contemporary world, there are certain essentials we cannot imagine our lives without, and at the core of these essentials lie the Internet and the electric light bulb. These two elements are integral in industrial or residential settings, providing illumination after sunset. However, while indispensable, the ubiquitous light bulb has a finite lifespan and is often positioned at heights that render replacement cumbersome.

As we continue to embrace the digital age, the Internet has become an inseparable part of our daily lives. The Internet of Things (IoT) has become prominent in recent years, offering many innovative applications. One such application is the evolution of smart lighting systems, capable of being controlled remotely over the internet from anywhere at any time.

In response to these evolving needs, the IoT bulb holder with an integrated pulley mechanism is introduced in this paper. Climbing stairs to change a light bulb can be hazardous, especially for elderly individuals.(Dymond, 2019; Farbman & McCoy, 2016) Therefore, this device replaces the traditional physical switch for activating and deactivating lights and streamlines the often-arduous task of light bulb replacement. By lowering itself to a user-accessible height, it ensures effortless maintenance and operation, bridging the gap between traditional illumination and the limitless possibilities of IoT technology.

Related Work

In today's rapidly evolving world, the Internet of Things (IoT) has ushered in a new era of connectivity and convenience, reshaping how we live. IoT applications, such as smart homes and smart cities, have garnered widespread attention and are becoming increasingly prevalent (Zhou et al., 2018). Utilizing microcontrollers like the NodeMCU V3 ESP8266 and ESP32 with integrated Wi-Fi chips has become instrumental in these IoT endeavors, enabling direct internet connectivity without additional gateways (Mesquita et al., 2018). The NodeMCU V3 ESP8266 and ESP32 microcontrollers can control the light bulb and pulley system and seamlessly integrate these functionalities into the IoT landscape.

Among the plethora of microcontrollers available in the market, three of the most prominent choices are the Arduino Uno R3, NodeMCU ESP8266, and ESP32. Their affordability has been a key driver behind their popularity, and their ease of programming and reprogramming makes them particularly appealing for IoT projects (Babiuch et al., 2019; Hussain et al., 2016). An insightful study indicates that the ESP32, equipped with a dual-core Tensilica Xtensa LX6 CPU, outperforms the ESP8266, which features a single-core Tensilica LX106 CPU (Babiuch et al., 2019; Maier et al., 2017). The ESP32's superior processing capabilities and a doubled clock speed compared to the ESP8266 result in smoother control, as outlined in Table 2.1. This table presents a comprehensive specification comparison for the Arduino Uno R3, NodeMCU V3 ESP8266, and ESP32.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013
In the context of this project, we aim to evaluate the ESP8266 and ESP32 microcontrollers regarding wireless connectivity, aligning with our objective to design an embedded Internet of Things (IoT) system. The NodeMCU V3 ESP8266 and ESP32 microcontrollers are under consideration due to their integrated Wi-Fi chips capable of connecting to 2.4 GHz Wi-Fi using IEEE 802.11, eliminating the need for gateways to access the internet (Mesquita et al., 2018). Another pivotal objective is creating a compact system, making the ESP32 microcontroller the preferred choice due to its superior size efficiency compared to the Arduino Uno R3 and NodeMCU V3 ESP8266. Table 1 details the specifications for Arduino Uno R3, NodeMCU V3 ESP8266, and NodeMCU ESP32.

Table 1: Arduino Uno R3, NodeMCU V3 ESP8266 and ESP32 specifications

	Arduino Uno R3	NodeMCU V3 ESP8266	NodeMCU ESP32
Microcontroller	ATmega328P	ESP8266 with Tensilica LX106 CPU	ESP32 with Tensilica Xtensa LX6 CPU
Clock Speed	16 MHz	80 MHz	160/240MHz
Analog Input Pins	6	1	18
Digital I/O Pins	14 (of which 6 provide PWM output)	16 (of which 16 provide PWM output)	32 (of which 16 provide PWM output)
Operating Voltage	5V	3.3V	3.3V
Wi-Fi chip onboard	No	Yes (2.4 GHz Wi-Fi using IEEE 802.11)	Yes (2.4 GHz Wi-Fi using IEEE 802.11)
Length	68.6 mm	58.0 mm	25.5 mm
Width	53.4 mm	31.0 mm	18.0 mm

(Arduino Uno R3,; Engr, 2020; Maier et al., 2017)

Optimizing Pulley Mechanisms: Motor Selection and Gearbox Type

The choice of motor and gearbox plays a pivotal role in determining their functionality and efficiency. These essential components effectively convert electrical energy into mechanical energy, and in most applications, DC motors are the go-to choice. Devices like computer fans, various household appliances, and even vibration motors (Pinto et al., 2020) predominantly employ DC motors due to their cost-effectiveness compared to pricier alternatives such as servo or stepper motors.

Table 2 comprehensively compares the characteristics of DC motors with Worm Gearboxes, Servo Motors, and Stepper Motors. One noteworthy advantage of a DC Motor with a Worm Gearbox is its self-locking ability. This means that the gear can rotate within the worm gear (on the motor side) while remaining immobile from the worm wheel (on the load side), as depicted in Figure 1 (Pinto et al., 2020). Integrating this worm gearbox with a DC motor adds a layer of reliability and control to various applications. When a DC voltage is applied to the motor, it facilitates clockwise or anti-clockwise rotation. What is particularly advantageous about a DC Motor with a Worm Gearbox is that its design does not necessitate a holding current

Journal of Information System and Technology Management JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013
to maintain the load at a specific height, contributing to energy efficiency(Grasso et al., 2018; Sri-Amphorn et al., 2020).

Furthermore, the number of rotations a motor can achieve is a critical consideration. DC Motors with Worm Gearboxes and Stepper Motors can turn unlimited times, offering flexibility for various applications(Carmona et al., 2021; Singh, 2010). In contrast, Servo Motors are typically limited to a maximum of one full rotation. In applications that demand low speed and high torque, the incorporation of a mechanical gearbox becomes imperative. When coupled with a high-speed motor, this automated gearbox serves as both a torque amplifier and a speed reducer (Zhang, 2017), allowing for the precise tuning of mechanical power output in alignment with the application's unique requirements.

Table 2: Characteristics of Motor

	DC Motor with Worm Gearbox	Servo Motor	Stepper Motor
Self-Locking	Yes	No	No
Holding Current	No	Yes	Yes
Number of Rotation	Unlimited	1 cycle (0 ° - 360 °)	Unlimited
Operating Voltage	12 V	5 V	12 V

(“DC 12V Worm Gear Motor,”; Jason Poel, 2015; Zhang, 2017)

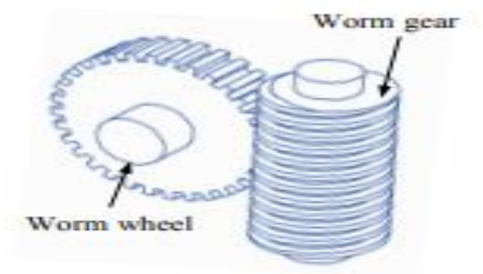

Figure 1: Worm Gearbox (Pinto et al., 2020)

Enhancing Pulley Mechanism Safety and Functionality

Figure 2 illustrates the fundamental operation of the pulley system, where the application of a DC voltage to the motor prompts it to rotate. Consequently, the rope either rolls up or unrolls, contingent on the polarity applied to the DC motor. While the design demonstrates functional feasibility, it is essential to address a safety concern that arises due to the choice of gearbox used, which needs to include the inherent safety features found in worm gearboxes associated with DC motors(Singh, 2010; Tanwar & L.M., 2019).

To rectify this safety issue, consider the adoption of a typical worm gearbox with a DC motor, as exemplified in Figure 3. This gearbox design offers an additional layer of safety and control, particularly in applications where stability and preventing unintended movements are paramount. Worm gearboxes exhibit self-locking characteristics, ensuring that the gear can rotate on the motor side while remaining fixed on the load side. This feature significantly

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013
minimizes the risk of accidental roll or unroll actions when the motor is not actively engaged, enhancing the overall safety of the pulley mechanism(Ritland, 2014).

By incorporating a worm gearbox with a DC motor, we can not only optimize safety but also bolster the reliability and performance of the pulley system, making it a more suitable choice for a wide array of applications where precision, stability, and safety are paramount considerations**.**

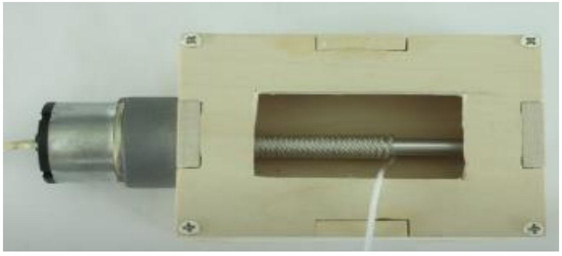

Figure 2: Pulley System [11]

Figure 3: DC Motor with Worm Gearbox
("DC 12V Worm Gear Motor," 2019)

Methodology
This section explains the operational approach to achieve the design objectives. While both NodeMCU ESP8266 and ESP32 offer Wi-Fi connectivity, the selection for this system centers on the NodeMCU ESP32 microcontroller. It is preferred due to its superior Wi-Fi efficiency, especially after continuous operation over 8 hours. NodeMCU ESP32 is harnessed to control the lighting system through a relay and orchestrate the pulley mechanism via a DC motor equipped with a worm gearbox. The comparative analysis between ESP8266 and ESP32 underscores the ESP32 as the more suitable choice for IoT projects, particularly in applications demanding prolonged connectivity and reliability.

The key components required for this system encompass the NodeMCU ESP32 microcontroller, the NodeMCU ESP8266 microcontroller, an AC to DC converter, a DC-DC step-down converter, the L298N H bridge motor controller, the DC motor equipped with a worm gearbox, 1-channel 5V DC relay modules, a miniature slip ring, and a fuse. The cable size selection meets the AWG table standards, ensuring compatibility and safety.

Both the NodeMCU ESP32 and ESP8266 microcontrollers are instrumental in performance testing. They control the DC motor's rotational direction, facilitate clockwise or anticlockwise movement, and manage the light's power status, enabling ON or OFF control via the relay by modulating the live wire connected to the 240V AC light bulb. This comprehensive approach ensures that the project objectives are met while highlighting the efficiency and reliability of

Journal of Information System and Technology Management JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

the selected components, particularly the NodeMCU ESP32 microcontroller, in the context of continuous IoT applications.

Elevating Precision and Reliability: The Choice of Worm Gearbox with DC Motor

In this project, selecting a worm gearbox with a DC motor for the pulley system is deliberate and strategic, driven by its inherent self-locking characteristics. One of the key advantages of this combination is that it eliminates the need for a continuous power supply to maintain the load at a desired height. When the power supply to the motor is disengaged, the worm gearbox efficiently holds the load securely in position. This feature not only enhances safety but also ensures the stability and reliability of the pulley system.

Another noteworthy attribute of the worm gearbox with a DC motor is its ability to turn unlimited times. This endless rotation is essential for the worm wheel side (load side) to effectively roll or unroll the rope, facilitating the precise control of the height of the light, as depicted in Figure 2. This versatility and range of motion make the combination ideal for various applications where controlled movement is critical.

To bring this design to life, the utilization of a 3D printer becomes essential. It enables the fabrication of precise and customized components, such as a compact container and the pulley system attached to the DC worm gearbox. These components, intricately designed to accommodate a 24AWG wire for seamless control of the light's height, ensure that the system operates with the utmost precision, reliability, and efficiency. The 3D printing process empowers us to craft tailored solutions that align perfectly with the project's specific requirements, offering a cutting-edge approach to manufacturing and assembly.

Programming and Simulation Process

The project begins with utilizing the Arduino IDE, a software platform that simplifies the development and verification of C++ programs. These programs are created before being uploaded to the NodeMCU ESP8266 and ESP32 microcontrollers. To ensure a seamless workflow, selecting the appropriate port and installing the ESP8266 board and ESP32 board within the Arduino IDE is essential. Users have the flexibility to open built-in code within the Arduino IDE for added convenience.

The Blynk app, a mobile application tailored for IoT projects, is pivotal in designing user interfaces. It offers a variety of widgets to choose from, compatible with NodeMCU ESP8266 and ESP32. Users must register an account to harness the Blynk app's full potential. Once registered, they can initiate a new project by specifying a project name and microcontroller type, with the chosen connection being Wi-Fi.

After creating the project, users must copy the Auth token from the Blynk app and paste it into their Arduino program. A key feature of Blynk is the creation of widgets, such as buttons. Each button widget is assigned to an OUTPUT GPIO pin, with the option to select a digital pin. For instance, GP14 corresponds to D5 of the NodeMCU ESP8266 microcontroller, controlling the ON and OFF state of the light via a 5V 1 Channel Relay module. GP5 and GP4, connected to D1 and D2 of the NodeMCU ESP8266 microcontroller, dictate the worm gearbox DC motor's rotation direction (Clockwise and Anti-Clockwise). Similarly, GP21, GP22, and GP23, linked to D21, D22, and D23 of the NodeMCU ESP32 microcontroller, manage the light's state and the worm gearbox DC motor's rotation.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

A simulation is conducted using Proteus software to test the functionality of the L298N H bridge motor controller and the control of light through a relay. The simulation focuses on these aspects and employs an Arduino Uno as the microcontroller for its execution. Arduino pin 9 is connected to a 2N2222A transistor, as the output from microcontrollers typically lacks sufficient current to drive the relay coil. The RELAY NO is linked to the 240V AC input, and the COM is connected to the light bulb. Further connections include Arduino pins 10 and 11, which interface with the L298N H bridge motor controller at IN3 and IN4. The DC motor is connected to OUT3 and OUT4. The power supply for the L298N H bridge motor controller is +12V DC and GND, as depicted in Figure 4. Before the hardware implementation, this simulation phase is critical, ensuring the components' and control mechanisms' functionality and compatibility.

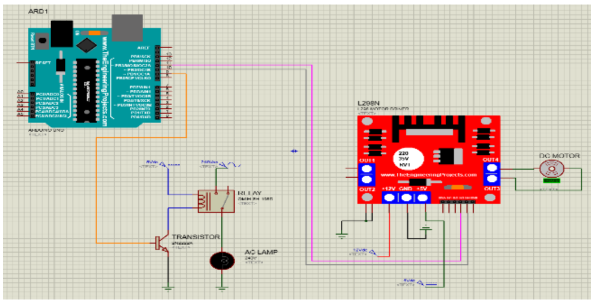

Figure 4: Schematic Diagram With Proteus Software Simulation.

The operation of our IoT bulb holder with a pulley mechanism hinges on the careful orchestration of code. This code is crafted within the Arduino IDE and uploaded to the NodeMCU ESP8266 and ESP32 microcontrollers. Once the code has been seamlessly integrated into these microcontrollers, they spring into action by automatically connecting to the Wi-Fi network, ensuring a swift and hassle-free setup.

The process begins when input data is dispatched from the Blynk app. This data is transmitted through the internet, reaching the NodeMCU ESP8266 and ESP32 microcontrollers for further processing. These microcontrollers become the heart of the operation, executing actions that determine the position of the DC motor and control the lighting based on the signals received from the Blynk app. The entire sequence of events is visually depicted in Figure 5, offering a comprehensive overview of the intricate process that unfolds to bring the IoT bulb holder with a pulley mechanism to life. This interconnected system seamlessly integrates the code, internet connectivity, and hardware components to deliver an innovative and efficient lighting solution.

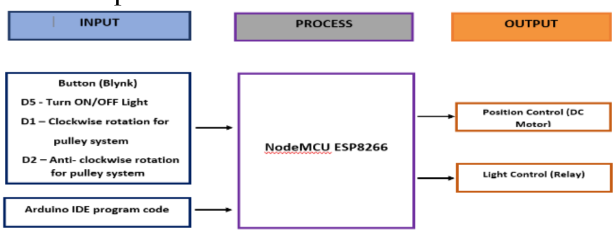

Figure 5: Overall Diagram of IOT-Enabled Smart Lighting With Pulley Mechanism.

Journal of Information System and Technology Management JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

Integrated Electrical Wiring for IoT Bulb Holder with Pulley Mechanism

Figure 6 offers an in-depth look at our IoT bulb holder's comprehensive electrical wiring configuration with a pulley mechanism employing the ESP8266 and ESP32 microcontrollers. The system is designed to seamlessly manage the lighting and pulley operation, orchestrating a harmonious blend of components and connections. The system's power input begins with the 240V AC supply, channeled through a 250V AC fuse rated at 0.5A. The fuse's other terminal is linked to the AC to DC converter's (L) input and the COM of the relay. The relay's NO (normally open) contact is then connected to the light bulb terminal, while the other terminal of the bulb is linked to the neutral.

A 12V DC output is directed to the buck converter and the H bridge motor controller from the AC to DC converter. The buck converter is tasked with converting the 12V DC to 5V DC, a crucial step to power up the NodeMCU microcontroller and the 1-channel 5V DC relay module. The buck converter's functionality can be fine-tuned using a variable resistor to regulate power. The connections for the ESP8266, as depicted in Figure 3.8, involve the 1-channel 5V relay module's IN pin, which is linked in series with a 2K resistor to the D5 pin of the NodeMCU ESP8266. This connection enables the control of the light's ON and OFF status.

Furthermore, the H bridge motor controller's Input 3 is connected in series with a 10K resistor to pin D1 of the NodeMCU ESP8266. In comparison, Input 4 of the H bridge motor controller is similarly connected in series with a 10K resistor to pin D2 of the NodeMCU ESP8266. The output from motor B of the H bridge motor controller is then seamlessly connected to the DC motor equipped with a worm gearbox. In the case of the ESP32, Figure 6 outlines the connections. The 1-channel 5V relay module's IN pin is linked in series with a 2K resistor to the D21 pin of the NodeMCU ESP32, facilitating control of the light's ON and OFF operation. Simultaneously, the H bridge motor controller's Input 3 is connected in series with a 10K resistor to the D23 pin of the NodeMCU ESP32. In comparison, Input 4 of the H bridge motor controller is likewise connected in series with a 10K resistor to the D22 pin of the NodeMCU ESP32. The output from motor B of the H bridge motor controller is intricately linked to the DC motor equipped with a worm gearbox, forming an integral part of the pulley mechanism.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

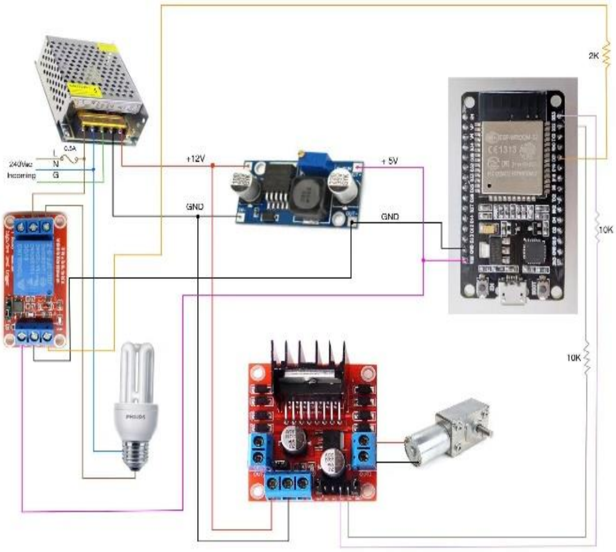

Figure 6: Integrated Electrical Wiring Diagram of IOT Bulb Holder with Pulley Mechanism using ESP8266 and ESP32

Result

Integrating 3D Model with Circuit Diagram for IoT Bulb Holder with Pulley Mechanism

Figure 7 presents the view of the IoT bulb holder with a pulley mechanism, combining the 3D printed model and the accompanying circuit diagram. This intricate integration ensures that all the elements work seamlessly together to deliver a functional and efficient lighting control system. The 3D printed model is meticulously designed to accommodate the various electronic components within distinct compartments:

1. Compartment A: This section is reserved for the AC to DC converter, serving as the initial step in the power supply chain.

2. Compartment B: Here, you will find the DC-DC step-down converter, the 1 Channel 5V Relay Module, and the NodeMCU ESP8266 microcontroller, collectively managing the intelligent control of the lighting system.

3. Compartment C: This compartment houses the H bridge motor controller and the DC motor with a worm gearbox. These components are instrumental in controlling the pulley mechanism.

4. Compartment D: This space is specifically designed for the roll and unroll mechanism of the wire, ensuring smooth operation.

The meticulous arrangement of these electronic components ensures a secure and organized placement, reducing clutter and facilitating efficient operation. Additionally, a printed gear design is meticulously attached to the shaft of the DC motor with the worm gearbox, enhancing the functionality of the pulley system.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013
The electrical circuit encompasses a well-structured power supply chain, commencing with the incoming 240V AC. This power source is meticulously safeguarded by a 250V AC fuse rated at 0.5A. The fuse's other terminal is connected to the AC to DC converter (L) and the relay COM. The relay's NO (normally open) contact is linked to a miniature slip ring, expertly accommodating red and black wires. Simultaneously, the other end of the tiny slip ring is utilized for the orange and brown wires, which are, in turn, connected to the light bulb terminal. The neutral terminal of the light bulb is securely linked to complete the circuit.

The 12V DC output from the AC to DC converter is routed to the buck converter and the H bridge motor controller. The buck converter plays a crucial role in transforming the 12V DC into 5V DC, and this adjustment can be fine-tuned using a variable resistor. The 1-channel 5V relay module is seamlessly integrated into the circuit, connected in series with a 2K resistor to the D21 pin of the NodeMCU ESP32, enabling precise control over the light's ON and OFF status. Furthermore, the H bridge motor controller's Input 3 is connected in series with a 10K resistor to the D23 pin of the NodeMCU ESP32. In comparison, Input 4 is similarly connected to a 10K resistor, this time to the D22 pin of the NodeMCU ESP32. The output from motor B of the H bridge motor controller is intricately linked to the DC motor equipped with a worm gearbox, completing the circuit.

Integrating the 3D model and circuit diagram embodies the meticulous planning and precision required to create the IoT bulb holder with a pulley mechanism. The integration between hardware and electronics ensures a fully functional and efficient lighting control system.

Figure 7: Printed 3D Model with the Circuit Diagram of the IOT Bulb Holder with a Pulley Mechanism

Analyzing Wi-Fi Efficiency: ESP8266 vs. ESP32

In Tables 3 and 4, we present the results of a comprehensive analysis of Wi-Fi efficiency, mainly focusing on the performance after 8 hours of continuous usage and connectivity to the internet, as observed in both ESP8266 and ESP32 microcontrollers. The method employed for measurement involves assessing the strength of the internet connection by alternately pressing three buttons a total of 50 times.

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013
The initial experiment results for the Wi-Fi efficiency of the ESP8266 in the first test were marked by a 0% rating. This outcome signifies that users could not control the system through the Blynk app after 8 hours of continuous usage. This deficiency was attributed to the overloading of the processor's stack. When the processor becomes overloaded in this manner, the communication between the NodeMCU ESP8266 and the Wi-Fi router becomes compromised, ultimately leading to disconnection.

This starkly contrasts with the NodeMCU ESP32, boasting a clock speed of 160MHz in its processor. Compared to the NodeMCU ESP8266, which operates at a clock speed 80MHz, the significant difference in clock speed becomes evident. Notably, the enhanced clock speed of the ESP32 is a pivotal factor that significantly contributes to the marked improvement in Wi-Fi connectivity efficiency. Consequently, the Wi-Fi connectivity efficiency of the ESP module in the first test significantly improved from 0% to 100% after 8 hours of continuous usage for both the ESP8266 and ESP32, as demonstrated in Tables 3 and 4. This outcome underscores the positive impact of a higher clock speed on the performance of the ESP32, making it a more robust choice for prolonged IoT applications where continuous and reliable Wi-Fi connectivity is paramount.

Table 3: Efficiency of the ESP8266 Module

Results based on after 8 hours of using and when connected to the internet for ESP8266			
Number of tests	Number of times Button Press	Response on Light	Efficiency
First test	50	0	0 %
Second test	50	50	100 %
Third test	50	50	100 %

Table 4: Efficiency of the ESP32 Module

Results based on after 8 hours of using and when connected to the internet for ESP32			
Number of tests	Number of times Button Press	Response on Light	Efficiency
First test	50	50	100 %
Second test	50	50	100 %
Third test	50	50	100 %

Conclusion

This paper proposed an innovative IoT bulb holder with pulley mechanisms designed to simplify the task of light bulb replacement by lowering itself to a user-accessible height. The implementation leverages the NodeMCU ESP32, chosen for its superior Wi-Fi efficiency, ensuring robust internet connectivity for extended periods of use. The NodeMCU ESP32's ability to connect to Wi-Fi allows users to control the system globally, provided their mobile phones have internet connectivity. The selection of a higher voltage reduces the size of the copper wire employed in the system. Precision in 3D printing is crucial, with each machine exhibiting a printing tolerance of approximately 0.5 mm. Infill percentage plays a pivotal role in the structural integrity of printed components; 10% infill may result in incomplete printing

Journal of Information System and Technology Management JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

within spaces, while 80% infill ensures full printing, enhancing overall strength. Furthermore, the choice of material is a critical factor in the design. ABS material, selected for its ability to withstand higher temperatures, provides durability to the components. On the other hand, PLA material offers increased stiffness. This combination of innovative design, technology selection, and material considerations culminates in an efficient and user-friendly IoT bulb holder with pulley mechanisms.

Acknowledgments
The authors thank the Faculty of Information Science and Technology, University Kebangsaan Malaysia, for supporting this research under the GGPM-2023-070 grant. This research was also supported by UCSI University (UCSI REIG-FETBE-2021-042).

References
Arduino Uno R3. (n.d.). Retrieved November 12, 2023, from store. arduino.cc website: https://store.arduino.cc/usa/arduino-uno-rev3.

Babiuch, M., Foltynek, P., & Smutný, P. (2019). *Using the ESP32 Microcontroller for Data Processing*. https://doi.org/10.1109/CarpathianCC.2019.8765944

Carmona, E., Antequera-Barroso, J., & Cardeñoso, J. (2021). Future Teachers' Perception Of The Usefulness Of Sketchup For Understanding The Space And Geometry Domain. *Heliyon*, *7*, e08206. https://doi.org/10.1016/j.heliyon.2021.e08206

DC 12V Worm Gear Motor. (n.d.). Retrieved November 11, 2023, from Cytron website: https://my.cytron.io/p-dc-12v-worm-gear-motor-200rpm.

Dymond, M. (2019). *Glass transition temperatures, melting temperatures, water contact angles and dimensional precision of simple fused deposition model 3D prints and 3D printed channels constructed from a range of commercially available filaments*. https://doi.org/10.1016/j.cdc.2019.100244

Engr, F. (2020). NODEMCU ESP8266 VS ARDUINO UNO'. Retrieved November 12, 2023, from electroniclinic website: https://www.electroniclinic.com/nodemcu-esp8266-vs-arduino-uno/.

Farbman, D., & McCoy, C. (2016). *Materials Testing of 3D Printed ABS and PLA Samples to Guide Mechanical Design*. https://doi.org/10.1115/MSEC2016-8668

Grasso, M., Azzouz, L., Ruiz-Hincapie, P., Zarrelli, M., & Ren, G. (2018). Effect of temperature on the mechanical properties of 3D-printed PLA tensile specimens. *Rapid Prototyping Journal*, *24*. https://doi.org/10.1108/RPJ-04-2017-0055

Hussain, A., Hamad, M., Hafeez, K., & Zaibnab, T. (2016). Programming a Microcontroller. *International Journal of Computer Applications*, *155*, 21–26. https://doi.org/10.5120/ijca2016912310

Jason Poel, S. (2015). Build a Motorized System for Raising and Lowering Hanging Plants. Retrieved November 11, 2023, from Make website: https://makezine.com/projects/motorized-system-raising-lowering-hanging-plants

Maier, A., Sharp, A., & Vagapov, Y. (2017). *Comparative Analysis and Practical Implementation of the ESP32 Microcontroller Module for the Internet of Things*. https://doi.org/10.1109/ITECHA.2017.8101926

Mesquita, J., Guimarães, D., Pereira, C., Santos, F., & Almeida, L. (2018). *Assessing the ESP8266 Wi-Fi module for the Internet of Things*. https://doi.org/10.1109/ETFA.2018.8502562

Pinto, V., Gonçalves, J., & Costa, P. (2020). *Model of a DC Motor with Worm Gearbox*. https://doi.org/10.1007/978-3-030-58653-9_61

Journal of Information System and Technology Management
JISTM
EISSN: 0128-1666
Volume 8 Issue 33 (December 2023) PP. 165-177
DOI: 10.35631/JISTM.833013

Ritland, M. (2014). *3D printing with SketchUp*. Birmingham: Packt Publishing Ltd.

Singh, S. (2010). *Beginning Google SketchUp for 3D Printing*. https://doi.org/10.1007/978-1-4302-3362-6

Sri-Amphorn, P., Abeykoon, C., & Fernando, A. (2020). Optimization of Fused Deposition Modeling Parameters for Improved PLA and ABS 3D Printed Structures. *International Journal of Lightweight Materials and Manufacture, 3*. https://doi.org/10.1016/j.ijlmm.2020.03.003

Tanwar, S., & L.M., M. (2019). *Energy Conservation for IoT Devices: Concepts, Paradigms and Solutions*.

Zhang. (2017). *Aalborg Universitet Design and Analysis of Magnetic-Geared Transmission Devices for Low-Speed High-Torque Application*. Retrieved from https://api.semanticscholar.org/CorpusID:52992682

Zhou, W., Zhang, Y., & Liu, P. (2018). The Effect of IoT New Features on Security and Privacy: New Threats, Existing Solutions, and Challenges Yet to Be Solved. *IEEE Internet of Things Journal, PP*. https://doi.org/10.1109/JIOT.2018.2847733