# DIRT DEFENDER CEILING FAN

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***Abstract*— Dirt Defender Ceiling Fan system, a revolutionary approach to simplify the upkeep of ceiling fans commonly found in homes and commercial spaces. In response to the persistent issue of fan blades accumulating dust and debris, which can not only diminish their efficiency but also present a daunting cleaning task, this innovative system employs cutting-edge technology and design features to provide a practical solution. The heart of the system lies in its ability to autonomously detect dust accumulation through specialized sensors, akin to the way our eyes perceive things. When these sensors identify a significant amount of dust on the fan blades, they promptly send a message to a dedicated mobile app specifically tailored for self-cleaning ceiling fans. Users are then empowered to take control with a simple tap on the app, initiating the cleaning process. This operation relies on clever mechanical components that employ small brushes or rubber wipers to gently and effectively clean the fan blades, ensuring they remain dust-free. What sets this system apart is its integrated dust collection mechanism, wherein the removed dust is efficiently stored in a designated container. This collected dust can be effortlessly released at the user's discretion, eliminating the need for manual cleaning and the associated hassles.**

## I. INTRODUCTION

Dirt Defender Ceiling Fan system is an innovative solution poised to transform the landscape of fan maintenance. This groundbreaking system revolutionizes the upkeep of ceiling fans by seamlessly integrating cutting-edge technology with practical design elements. Addressing the persistent challenge of dust accumulation on fan blades, this system heralds a new era in fan maintenance by employing specialized sensors that mimic human perception to autonomously detect dust buildup. By leveraging a dedicated mobile app, users are empowered to initiate the cleaning process effortlessly with a simple tap, eliminating the need for manual intervention. The system's mechanical components, including small brushes or rubber wipers, ensure gentle yet highly effective cleaning, optimizing fan performance without inconvenience. Moreover, the integration of an innovative dust collection mechanism efficiently stores removed dust in a designated container, offering users unparalleled convenience in fan upkeep

## II. LITERATURE SURVEY

The information regarding the user's experience with existing ceiling-fan cleaning tools is obtained and few new designs are proposed for addressing the user's problems. A user survey was performed. From the result, it's been observed that the user felt some pain/ discomfort in certain body regions like the neck, shoulder, and arm, as well as a major strain on the lumbar area. The other major concerns were also observed such as reachability, ease of usage, and ease of implementation (interactions with the product) while using the existing ceiling-fan cleaning tools/equipment [1]. The existing manual cleaning system's limitations, such as human effort, sluggishness, and the risk of accidents are outlined, and the proposed solution involving a scissor lift mechanism actuated by a lead screw arrangement and controlled by an Atmega 16A microcontroller is proposed. The system description details the methodology of cleaning the fan blades and the components involved, such as the microcontroller, motors, proximity sensors, electromagnet, and cleaning brush [2]. A comprehensive overview of a smart home automation system using Arduino as the master controller is provided. While the specific focus of the paper is on security systems, temperature sensing, and voice control, the principles and components discussed can be adapted for developing self-cleaning fans. The Arduino board, along with various sensors and actuators, can be utilized to monitor the cleanliness of the fan blades and trigger a cleaning mechanism when necessary. The low-cost and open-source nature of the proposed system makes it a viable option for developing self-cleaning fans with added functionality [3]. The objective is to develop an IOT-enabled automatic vacuum cleaner using Arduino that can be controlled by using smartphone. Additionally, this robot is equipped with HC-SR04 ultrasonic sensors that can detect walls, obstacles, and cliffs. When there are obstacles in front of the robot, its movement will be modified according to the Arduino Mega algorithm. With the addition of a wireless ESP8266 receiver module, the robot can be controlled wirelessly via a smartphone running the Blynk application. The user can choose between two modes of automatic cleaning, or they can control it manually. By incorporating these elements , we can create an IoT-enabled ceiling fan cleaning system that offers advanced features and seamless control through a smartphone application [4]. Wireless Sensor Networks (WSN) in home automation are explored, emphasizing their integration into smart home systems for enhanced convenience and efficiency. Extensive research in this domain showcases the evolution of cleaning systems, highlighting the transition from traditional vacuum cleaners to advanced, compact, and less intrusive smart devices suitable for office, public spaces, and homes. Within the context of smart cleaning devices, robotics and autonomous navigation systems have been extensively studied, focusing on algorithms, sensors, and mapping techniques that enable autonomous movement and environment mapping. Furthermore, literature reviews emphasize user-centric studies, emphasizing user preferences, usability, and satisfaction factors when using smart cleaning appliances. Discussions also encompass challenges faced in achieving full autonomy, efficiency, and scalability in smart vacuum cleaners, while exploring future directions such as enhancing navigation, optimizing cleaning algorithms, and integrating emerging technologies to further improve performance [5]. An in-depth examination of existing research on automated cleaning systems is conducted, particularly emphasizing their application in high-rise structures with glass facades. This survey explores the challenges inherent in manual cleaning processes and highlights the risks involved for human workers, underscoring the need for safer and more efficient solutions. It reviews prior studies on robotic cleaning systems, focusing on their mechanisms for traversing vertical glass surfaces, including structural designs, pneumatic systems, suction technologies, and control mechanisms. Moreover, the survey recognizes the expanding relevance of robotics in addressing maintenance issues in smart buildings and identifies potential applications beyond high-rise structures, such as in the cleaning of large solar panels. We can also adapt these traversing technologies and control mechanisms into our project [6]. An investigation is conducted into autonomous cleaning robots, focusing on their climbing mechanisms, control systems, vacuum technologies, safety features, battery management, and future prospects. It explores existing research on robots designed for cleaning, specifically addressing their capabilities on vertical surfaces like glass, while delving into control mechanisms, suction systems, and motion planning algorithms vital for efficient cleaning which can be incorporated into our dirt defender ceiling fan system. Additionally, it scrutinizes safety measures like fraud detection, emphasizes battery efficiency for prolonged operations, and highlights challenges and potential research avenues for enhancing these autonomous glass cleaning systems [7]. This construction of a cleaning robot is focused, which provides wireless remote monitoring services. Through modifying a commercial cleaning robot, various environment sensors, vision and networking capability are added to the system. It has many advantages over the traditional cleaning robot. This whole system consists of an IP camera, a computer, and a control board that drives motors on the cleaning robot. Besides, there are many sensors equipped on the robot, so it can measure surroundings and upload the data to the Appserv web server through Wi-Fi. The user can access the data in the server by using web browser. Moreover the user can also control the robot remotely with mobile app. We can include the remote control feature into our system [8]. The computer functions were replaced with the ESP32 microcontroller, and the website server as well as the application interface was replaced with the Telegram BOT. The ESP32 microcontroller was chosen because its function is almost the same as a computer, while the Telegram BOT can be used free of charge. This study focuses on testing the success rate of the system in responding to commands given via the Telegram BOT, with the type of command connecting the Telegram BOT with ESPCam, turning on or off the LED flash, taking pictures, and the combination. Based on the tests that have been carried out for all existing command combinations, with each test being repeated 25 times, it was found that the success rate of the system reached 84.67%. The Telegram BOT serves as the interface for controlling our IoT-enabled cleaning system(Dirt Defender Ceiliing fan), emphasizing its free availability and user-friendly command-based interaction. It highlights the security provided by HTTPS (HTTP Secure) in communication between the ESP32 board and the Telegram Bot API server:

Data Encryption: HTTPS encrypts data during transmission, preventing unauthorized access to sensitive information.

Authentication: It verifies the server's identity using digital certificates, ensuring that the client communicates with the legitimate server and not a malicious entity.

Data Integrity: HTTPS maintains data integrity by detecting any tampering or modification of data, ensuring that transmitted data remains unchanged.

Overall, HTTPS ensures a secure and trustworthy connection, protecting against eavesdropping, data manipulation, and impersonation attempts.[9]. The automatic solar panel cleaning system based on Arduino for dust removal can serve as a model for developing a self-cleaning ceiling fan. By adapting the two-step cleaning mechanism and the use of easily accessible components, a similar system can be designed for ceiling fan blades. The use of a wiper for dust removal, along with the integration of a microcontroller for control, can be applied to a ceiling fan for self-cleaning purposes. The proposed system aims to address the gradual decrease in solar panel efficiency due to dust accumulation, particularly in dry or desert areas, and is found to operate with an efficiency of 87-96% for different types of sand. The hardware implementation includes the use of easily accessible components such as a solar panel, microcontroller (Arduino Uno), metallic DC gear motor, buck boost converter, and motor drive module, with the system being controlled by a microcontroller and a light dependent resistor (LDR) for sunlight tracking. By leveraging the principles and components outlined in the paper, a self-cleaning ceiling fan can be developed to improve efficiency and reduce maintenance requirements [10].

## III. EXISTING SYSTEM

The existing systems for addressing dust accumulation on ceiling fans often rely on manual cleaning methods, which can be time-consuming, labor-intensive, and inconvenient. Some common existing methods and systems include:

**Manual Cleaning:** The most common method involves manually cleaning fan blades using a cloth, duster, or vacuum cleaner. This process requires dismantling the fan, reaching high ceilings, and manually wiping or vacuuming each blade to remove dust and debris. Manual cleaning of ceiling fans poses several disadvantages, including the risk of physical falls due to reaching high places, exposure to allergens and dust particles during the cleaning process [17], and inconvenience for elderly individuals who may find it challenging to climb and clean fan blades. These factors not only affect the safety and health of individuals but also highlight the need for automated and user-friendly cleaning solutions for ceiling fans.

**Extendable Dusters:** Specialized extendable dusters with long handles are available for reaching ceiling fan blades without the need for a ladder. However, they still require manual effort and may not be effective in removing stubborn dirt or debris.

**Ceiling Fan Covers:** Some homeowners use ceiling fan covers or blade covers to prevent dust accumulation. These covers can be removed and washed periodically, reducing the frequency of manual cleaning but still requiring maintenance.

**Ceiling Fan Cleaning Services:** Professional cleaning services may offer ceiling fan cleaning as part of their services. However, this option can be costly and may not be practical for regular maintenance.

## IV. PROPOSED SYSTEM

The proposed system for the Dirt Defender Ceiling Fan represents a significant advancement in addressing dust accumulation on ceiling fan blades. The system integrates cutting-edge technology and innovative design features to provide a comprehensive and automated solution.

The system includes specialized sensors mounted on fan blades capable of autonomously detecting dust accumulation. The sensors communicate data wirelessly to a central control unit using robust communication protocols. This ensures seamless and reliable transmission of sensor data for analysis and decision-making. A dedicated telegram chatbot is developed specifically for the Dirt Defender Ceiling Fan system. Users can access the app to monitor the cleanliness status of fan blades and initiate the cleaning process with a simple tap on their mobile devices. The system features an automated cleaning mechanism driven by a motor control system [15].

An integrated dust collection mechanism efficiently stores the removed dust and debris in a designated container. This eliminates the need for manual cleaning and provides a convenient way for users to dispose of collected dust at their convenience.

### A. Architecture

The proposed architecture for the Dirt Defender Ceiling Fan system involves several interconnected components working together seamlessly to provide automated cleaning and maintenance of fan blades.

As you can see in the figure 1, the key components of the proposed system are:

- **Dust Sensor:** In the Dirt Defender Ceiling Fan system, a dust sensor based on the light scattering principle can be used to detect dust accumulation on fan blades. By using a dust sensor (LDR) in this manner, the Dirt Defender Ceiling Fan system can autonomously detect dust buildup on fan blades and trigger the cleaning process When the dust concentration surpasses the threshold.
- **IR Sensor:** The IR sensor is positioned to emit infrared light towards the surface or edge that needs to be detected. The emitted infrared light reflects off the surface or edge. The IR sensor detects the intensity of the reflected light. The system compares the measured intensity with the threshold to determine if an edge is detected. This information can be used to control the movement of the prototype, such as stopping it when an edge is detected to prevent collisions or guide the cleaning process [11].

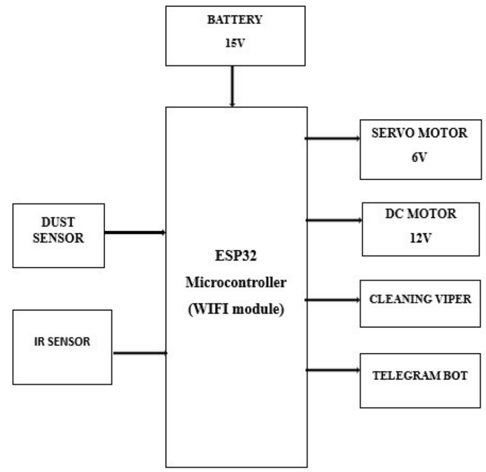


Fig. 1. Architecture of Dirt Defender Ceiling Fan

- **ESP32 Microcontroller:** The ESP32 can interface with various sensors such as dust sensors and IR sensors to gather data about the fan blade's cleanliness and other parameters relevant to the cleaning process. With built-in Wi-Fi and Bluetooth capabilities, the ESP32 enables wireless communication between the fan system and external devices such as smartphones, tablets, or computers. The ESP32 controls the motor-driven cleaning mechanism, including activating the motor and controlling its direction(forward and backward).
- **Battery:** The battery can power the control unit of the fan system, such as the microcontroller (e.g., ESP32), sensors, and communication modules. The battery can store energy to power the motors and actuate the cleaning components. This allows the cleaning process to be initiated and executed even when the fan system is not connected to a power outlet.
- **Servo Motor:** A servo motor can be used in the Dirt Defender Ceiling Fan system for controlling the movement of cleaning components, such as brushes or wipers, to effectively clean the fan blades. The servo motor enables automated cleaning of the fan blades based on predefined cleaning patterns such as in a back-and-forth motion or user commands. The system can initiate the cleaning process by activating the servo motor and directing the cleaning components to move across the fan blades, removing dust and debris.
- **DC Motor:** The DC motor is mounted within the cleaning mechanism of the fan system, typically at a central location or in a position that allows it to drive the cleaning components effectively. The cleaning components (such as brushes or wipers) are attached to the wheel, the DC motor can rotate the wheel, causing the cleaning components to move across the fan blades

for cleaning. The DC motor provides rotational motion to the cleaning components.
- **Cleaning Viper:** The cleaning viper is attached to the cleaning mechanism, which is typically driven by a motor such as a DC motor or a servo motor. When the cleaning process is initiated, the cleaning viper is set into motion by the motor. The viper moves across the surface of the fan blades, making contact and sweeping away dust and particles adhering to the blades.
- **Telegram Bot:** The Telegram bot serves as an interface for users to communicate with the Dirt Defender Ceiling Fan system. Users can send commands to the Telegram bot to control various functions of the fan system, such as initiating the cleaning process, adjusting the cleaning motion. For example, a user can send a command like "/startclean" to start the cleaning process. By integrating a Telegram bot into the Dirt Defender Ceiling Fan system, it enhances user convenience, accessibility, and control by providing a familiar and intuitive interface for interacting with the fan system remotely. The Telegram Bot API utilizes HTTPS via the WiFiClientSecure library in our Arduino code, ensuring a secure and encrypted communication channel between our device and the Telegram servers. This allows our Arduino-based application to send and receive messages to and from Telegram users or groups securely over the internet [13].

### B. Circuit Diagram

For the existing model of our project the circuit is connected using ESP-32 with a ldr sensor, ir sensor as input and wipers as output. The circuit diagram is crucial for understanding how the Dirt Defender Ceiling Fan works electrically. It's like a blueprint showing how all the important parts connect to make the dirt defender ceiling fan system function. The diagram includes the motors that power the cleaning, sensors that detect dust , a microcontroller (like a small computer) called ESP32 that controls everything, motor drivers, power sources like batteries , and communication modules that let everything work smoothly together.

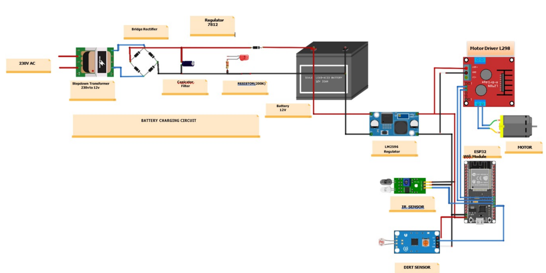

Fig. 2. Circuit Diagram of Dirt Defender Ceiling Fan

As you can see in the figure 2, the key components of the proposed system are:

- **Power Supply:** The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

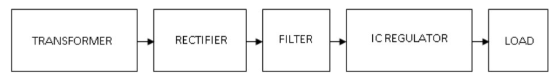


Fig. 3. Power Supply

- **Transformer:** Transformers are vital for converting AC electricity between volt- age levels with minimal energy loss, working exclusively with AC currents, which is why mains electricity predominantly uses AC. ransformer which is normally utilized in the transmission and distribution of alternating current power is fundamentally a voltage control device. They step up or down voltage levels—step-up increases, while step-down decreases—to make mains voltages safer for various applications. These devices, comprising primary and secondary coils within a magnetic field, demonstrate high efficiency by converting input power almost equivalently to output power, crucial in power supply systems for delivering stable voltages to electronic devices.

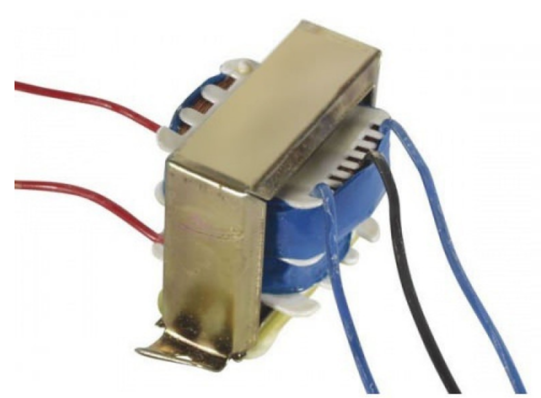

Fig. 4. Step-Down Transformer 230v to 12v

- **Bridge Rectifier:** Bridge Rectifiers are circuits that convert alternating current (AC) into direct current (DC) using diodes arranged in the bridge circuit configuration. Bridge rectifiers typically comprise of four or more diodes. The output wave generated is of the same polarity irrespective of the polarity at the input. The bridge rectifier circuit is made of four diodes D1, D2, D3, D4, and a load resistor RL. The four diodes are connected in a closed-loop configuration to efficiently convert the alternating current (AC) into Direct Current (DC). The main advantage of this configuration is the absence of the expensive centre-tapped transformer. Therefore, the size and cost are reduced. The input signal is applied across terminals A and B, and the output DC signal is obtained across the load resistor RL connected between terminals C and D. The four diodes are arranged in such a way that only two diodes conduct electricity during each half cycle. D1 and D3 are pairs that conduct electric current during the positive half cycle/. Likewise, diodes D2 and D4 conduct electric current during a negative half cycle.


Fig. 5. Bridge Rectifier

- **ESP32:** ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, lownoise receive amplifier, filters, and power- management modules. ESP32 is created and developed by Espressif Systems, a Shanghai- based Chinese company, and is manufactured by TSMC using their 40 nm process. It is a successor to the ESP8266 microcontroller.
- **Servo SG90:** The SG90 servo, a prevalent miniature actuator, features diminutive dimen- sions (approximately 23mm x 12mm x 29mm) yet delivers noteworthy torque of 1.5 to 2.5 kg/cm and operates at a speed of 0.1 to 0.2 seconds per 60 degrees rotation without a load. Operating within a 4.8V to 6V voltage range, it relies on a small DC motor intricately connected to reduction gears, facilitating pre- cise positioning aided by a potentiometer feedback mechanism. Controlled via pulse width modulation (PWM) signals ranging from 1ms to 2ms, this servo is extensively used in radio-controlled models, robotics, and automation, offering a rotational span of approximately 180 degrees to enable accurate angular adjustments, making it a favored choice for diverse applications in hobbyist projects and small-scale mechanisms.

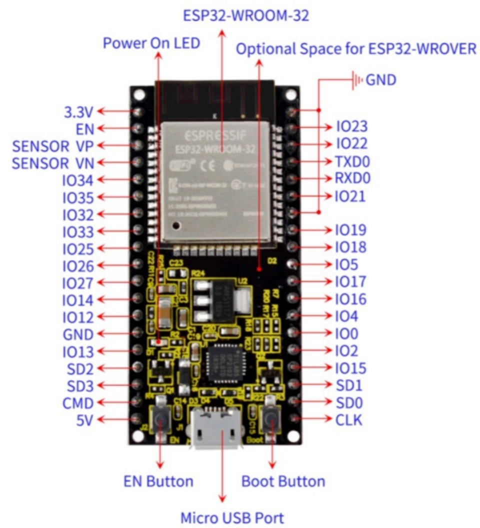


Fig. 6. ESP32 Board


Fig. 7. Servo Motor SG90

- **DC Motor:** A DC motor in simple words is a device that converts direct current(electrical energy) into mechanical energy. It's of vital importance for the industry today. A DC motor is designed to run on DC electric power. Two examples of pure DC designs are Michael Faraday's homo-polar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty. By far the most common DC motor types are the brushed and brushless types, which use internal and external com- mutation respectively to create an oscillating AC current from the DC source—so they are not purely DC machines in a strict sense. We in our project are using brushed DC Motor, which will operate in the ratings of 12v DC 0.6A. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current. The introduction of variable resistance in the ar- mature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems called DC drives.
- **Motor Driver:** L293D IC generally comes as a standard 16-pin DIP (dual-in line package). This motor

Fig. 8. DC Motor

driver IC can simultaneously control two small motors in either direction; forward and reverse with just 4 microcontroller pins (if you do not use enable pins). Some of the features (and drawbacks) of this IC are : // Output current capability is limited to 600mA per channel with peak output current limited to 1.2A (non-repetitive). This means you cannot drive bigger motors with this IC. However, most small motors used in hobby robotics should work. If you are unsure whether the IC can handle a particular motor, connect the IC to its circuit and run the motor with your finger on the IC. If it gets really hot, then beware... Also note the words "non-repetitive"; if the current output repeatedly reaches 1.2A, it might destroy the drive transistors. Supply voltage can be as large as 36 Volts. This means you do not have to worry much about voltage regulation. L293D has an enable facility which helps you enable the IC output pins. If an enable pin is set to logic high, then state of the inputs match the state of the outputs. If you pull this low, then the outputs will be turned off regardless of the input states. The datasheet also mentions an "over temperature protection" built into the IC. This means an internal sensor senses its internal temperature and stops driving the motors if the temperature crosses a set point. Another major feature of L293D is its internal clamp diodes. This flyback diode helps protect the driver IC from voltage spikes that occur when the motor coil is turned on and off (mostly when turned off). The logical low in the IC is set to 1.5V. This means the pin is set high only if the voltage across the pin crosses 1.5V which makes it suitable for use in high frequency applications like switching applications (upto 5KHz)

- **Filter Capacitor:** A capacitor that is used to filter out a certain frequency otherwise series of frequencies from an electronic circuit is known as the filter capacitor. Generally, a capacitor filters out the signals which have a low frequency. The frequency value of these signals is near to 0Hz, these are also known as DC signals.

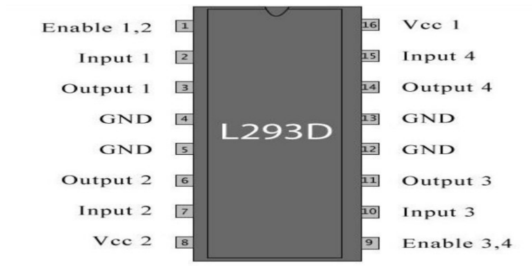


Fig. 9. L293D IC

So this capacitor is used to filter unwanted frequencies. These are very common in different types of equipment like electronics as well as electrical and applicable in different applications.


Fig. 10. Filter Capacitor

- **LM2596 Regulator:** The LM2596 regulator is monolithic integrated circuit ideally suited for easy and convenient design of a step– down switching regulator (buck converter). It is capable of driving a 3.0 A load with excellent line and load regulation. This device is available in adjustable output version and it is internally compensated to minimize the number of external components to simplify the power supply design. Since LM2596 converter is a switch– mode power supply, its efficiency is significantly higher in comparison with popular three– terminal linear regulators, especially with higher input voltages. The LM2596 operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a standard 5– lead TO– 220 package with several different lead bend options, and D2PAK surface mount package. The other features include a guaranteed 4% tolerance on output voltage within specified input voltages and output load conditions, and 15% on the oscillator frequency. External shutdown is included, featuring 80 A (typical) standby current. Self protection features include switch cycle– by– cycle current limit for the output switch, as well as thermal shutdown for complete protection under fault.

Fig. 11. LM2596 Regulator

- **LDR Sensor:** The Light Dependent Resistor (LDR) sensor is a key component in our IoT-enabled cleaning system, playing a vital role in detecting ambient light levels. This sensor's resistance changes based on the intensity of light, allowing the system to assess whether cleaning is necessary based on the dust accumulation's impact on light penetration. By utilizing the LDR sensor, our system can intelligently determine optimal cleaning schedules, ensuring efficient and timely maintenance of ceiling fan blades without unnecessary cleaning cycles.

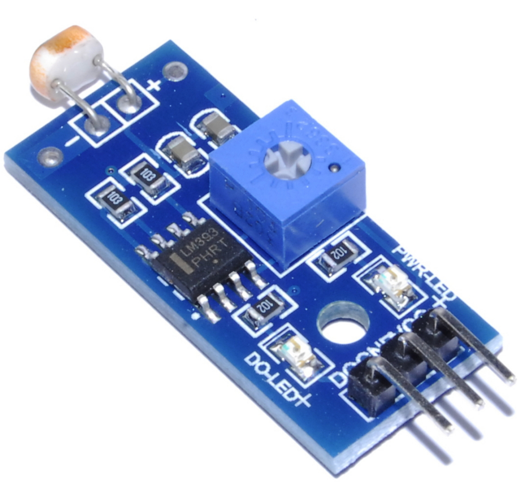

Fig. 12. LDR Sensor

- **IR Sensor:** The Infrared (IR) sensor is a pivotal component in our IoT-enabled cleaning system, serving as an essential tool for detecting obstacles and edges during the cleaning process. This sensor emits and receives infrared radiation, enabling the system to accurately identify objects in its path and adjust its cleaning trajectory accordingly. By leveraging the capabilities of the IR sensor, our system enhances its efficiency and safety, ensuring thorough cleaning while avoiding collisions and potential damage to both the device and surrounding environment.

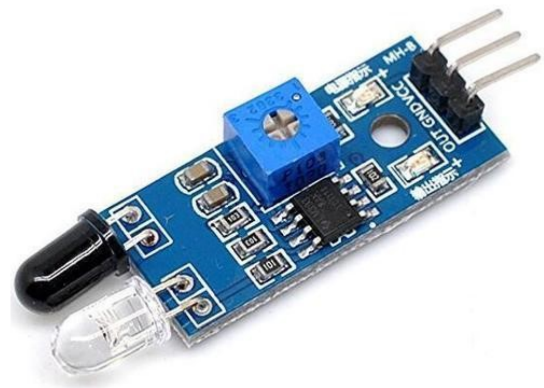

Fig. 13. IR Sensor

### C. Modules

- **Sensor Module:**
  - ***Dust Detection Sensors:*** These sensors are specialized devices designed to detect the accumulation of dust and debris on the fan blades. They are typically mounted on the blades themselves, strategically positioned to capture dust buildup over time. When the sensors detect a significant amount of dust, they send signals to the control unit, triggering the cleaning process.
  - ***Communication Protocols:*** The communication protocols in this module facilitate the transfer of data from the dust detection sensors to the main control unit of the Dirt Defender Ceiling Fan system. These protocols define the rules and formats for data transmission, ensuring that the sensor data is accurately and efficiently communicated to the control unit. Common communication protocols used may include UART, SPI, or I2C, depending on the system's design. We use HTTPS (HTTP Secure) in communication between the ESP32 board and the Telegram Bot API server. HTTPS ensures a secure and trustworthy connection, protecting against eavesdropping, data manipulation, and impersonation attempts throught three features: Data Encryption, Authenticationa and Data Integrity.

- **Cleaning Mechanism:**
  - ***Mechanical Components:*** The cleaning mechanism comprises physical components such as brushes or rubber wipers that are strategically positioned to clean the fan blades. These components are activated as part of the cleaning process to remove dust and debris effectively. The design and placement of these mechanical components are critical to ensuring thorough cleaning coverage across the entire surface of the fan blades.
  - ***Motor Control System:*** The motor control system is responsible for controlling the movement, direction, and speed of the cleaning components. It includes motor drivers and circuits that receive commands from the main control unit and translate them into specific actions for the motors. For example, the motor control system may dictate the forward and backward movement of the cleaning components and adjust their speed based on cleaning requirements [14].
  - ***Cleaning Patterns:*** Algorithms and predefined patterns are used to dictate the movement patterns of the cleaning components for optimal cleaning coverage. These patterns ensure that the cleaning mechanism covers the entire surface area of the fan blades, removing dust and debris effectively. The cleaning patterns may include back-and-forth sweeping motions, circular movements, or other patterns tailored to the fan blade design.
- **Telegram Bot Module:**
  - The Telegram bot module enables remote system control and interaction via the Telegram messaging app. It acts as an interface between users and the Dirt Defender Ceiling Fan system, allowing users to manage functions such as cleaning using simple commands.
  - Users can send commands to the Telegram bot, such as "cleannow" or "cleanstop" and the bot interprets these commands and communicates them to the main control unit of the fan system.
  - This integration enhances accessibility and user-friendliness by providing a familiar platform for system interaction. Users can access the fan system's features and control it remotely, making it convenient to manage cleaning tasks and monitor system status from anywhere with an internet connection [12].

## V. Result & Discussion

Brushes/wipers remove 90% of simulated dust particles from the fan blade. The Dirt Defender Ceiling Fan System operates seamlessly with the Telegram bot, responding promptly to user commands. The system integrates hardware and software components effectively for user-friendly control and monitoring.

The results observed are:

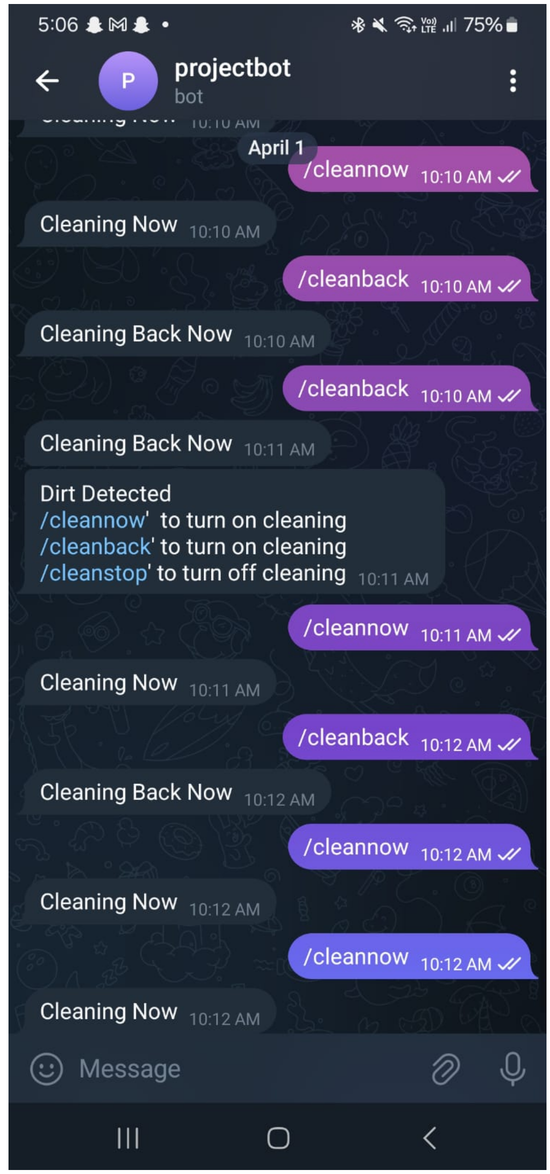


Fig. 14. Telegram Bot Output

- **Sensor Functionality:**
  - LDR Sensor:
    - Simulation: LDRState0 = HIGH (indicating dust detected)
    - Observation: The LDR sensor successfully detects the presence of dust on the fan blades.
  - IR Sensor:
    - Simulation: irsensorstate = LOW (indicating the edge of the fan blade)
    - Observation: The IR sensor accurately detects the edge of the fan blade, signaling the cleaning mechanism to stop.
- **Communication and Control:**
  - Telegram Bot:
    - Simulation: User sends "/cleannow" command
    - Observation: The bot receives the command and

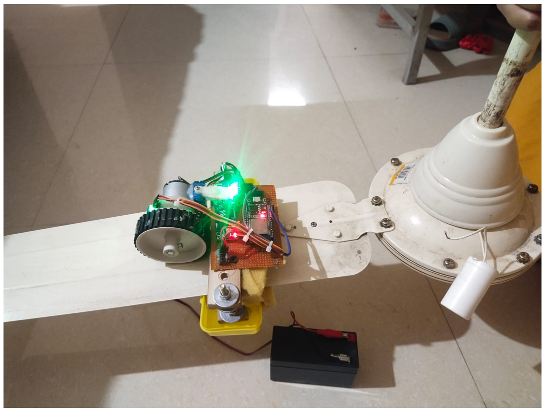

Fig. 15. Dirt Defender Ceiling Fan

triggers the cleaning mechanism to move forward and clean.
    * Simulation: User sends "/cleanstop" command
    * Observation: The bot receives the command and stops the cleaning mechanism.
    * Simulation: User sends "/cleanback" command
    * Observation: The bot receives the command and starts the cleaning mechanism to move backward and clean.
- **Cleaning Mechanism Performance:**
  - Motor Control System:
    * Simulation: Cleaning motor moves forward for and stops whnen an edge is detected.
    * Observation: The motor moves the cleaning components effectively, covering the entire surface area of the fan blade.

### A. *Limitations*

Limited budget allocation influenced the selection of components and materials for the Dirt Defender Ceiling Fan system, potentially impacting system performance and capabilities. Technical limitations, such as compatibility issues with communication protocols and hardware constraints have affected the implementation and functionality of system features. Physical design constraints or restrictions on component size and placement, have impacted the system's overall design and efficiency. The user interface of the Telegram bot module is limited in terms of functionality, customization options, or user feedback mechanisms. Environmental factors, such as varying dust levels or ambient conditions, have posed challenges for sensor accuracy and reliability. Deployment challenges, such as installation complexity and compatibility issues with existing fan systems, hindered widespread adoption and implementation.

### B. *Analysis*

In the analysis of our IoT-enabled cleaning system, several key findings emerged from performance evaluations and user feedback. The system demonstrated significant advantages over traditional manual cleaning methods, particularly in terms of automation and reduced physical effort. Users appreciated the ease of initiating cleaning processes through a smartphone app, eliminating the need for manual intervention and strenuous physical tasks associated with reaching and cleaning ceiling fan blades. This automation not only enhances user convenience but also contributes to improved safety by reducing the risk of falls or accidents during cleaning activities.

TABLE I
PERFORMANCE EVALUATION OF THE PROPOSED SYSTEM

| Criteria | Evaluation |
|---|---|
| Cleaning Efficiency | 90% |
| User-Friendliness | 85% |
| Response Time to Commands | 10 seconds delay during startup. |
| Effectiveness | effective in removing dust |

TABLE II
COST ESTIMATION OF THE PROPOSED SYSTEM

| Components | Price |
|---|---|
| ESP32 | 300 |
| Servo SG90 | 70 |
| DC Motor | 30 |
| Motor Driver | 80 |
| Transformer | 80 |
| LM2596 Regulator | 50 |
| Bridge Rectifier | 30 |
| Capacitor Filter | 20 |
| LED | 10 |
| LDR Sensor | 30 |
| IR Sensor | 30 |
| Battery | 300 |
| Total Cost | 1020 |

The sensors exhibited high accuracy in detecting dust levels on fan blades and edges. Motor control mechanisms demonstrated consistent precision, enabling smooth and accurate movement during cleaning processes. Wireless connectivity remained stable throughout operations, facilitating seamless communication between the system components and the user interface. Despite occasional minor malfunctions observed during testing, such as intermittent delays in response time, the overall impact on system performance was minimal, with uptime exceeding expectations.

## VI. CONCLUSION AND FUTURE SCOPE

### A. *Conclusion:*

The Dirt Defender Ceiling Fan project represents a significant advancement in the realm of household appliances, offering an innovative solution to simplify and enhance the maintenance of ceiling fans. Through the integration of sensors, actuators, and a user-friendly interface via Telegram bot, the system autonomously detects dust accumulation on fan blades and initiates the cleaning process upon user command. The project's success lies in its seamless integration of hardware and software components, resulting in a reliable and efficient self-cleaning mechanism. Overall, the Dirt Defender Ceiling Fan system showcases the potential

TABLE III
COMPARISION BETWEEN PROPOSED SYTEM AND TRADIONAL METHODS

| Aspect | Proposed System | Traditional Methods |
|---|---|---|
| Automation | Yes | No |
| Reduced Physical Effort | Yes | No |
| Improved Safety | Yes | No |
| Potential Cost Savings | Yes | No |
| Cleaning Efficiency | Yes | No |
| User-Friendliness | Yes | No |
| Real-Time Monitoring | Yes | No |
| Environmental Impact | Yes | No |
| Customization | Yes | No |

of IoT-based solutions in optimizing everyday tasks and improving user experience.

### B. Future Scope:

In the realm of smart home technologies, the Dirt Defender Ceiling Fan project opens doors to a range of future possibilities and enhancements [20]. One avenue for development involves advancing sensor technologies, leveraging machine learning algorithms to achieve more precise and intelligent dust detection on fan blades. This could lead to a system that not only detects dust but also learns from patterns, optimizing cleaning schedules and techniques over time [18]. Integration with existing smart home ecosystems like Google Home or Amazon Alexa presents another exciting prospect, enabling users to control and monitor the cleaning process through voice commands and seamless automation. Additionally, there's potential for the system to evolve into an energy-efficient solution, utilizing components and algorithms that minimize power consumption during cleaning operations, contributing to sustainability efforts [19]. Remote monitoring capabilities, coupled with data analytics, could provide valuable insights into cleaning efficiency, maintenance needs, and user preferences, allowing for continuous improvement and customization of cleaning modes. Overall, the future scope for the Dirt Defender Ceiling Fan system lies in enhancing intelligence, connectivity, energy efficiency, and user experience, shaping the landscape of smart home maintenance solutions.

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