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Smart Rain-sensitive Casement Window with Manual Switch Override

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***Abstract*: Rainfall, though beneficial can also be hurtful. When rain falls and windows are open, inlet of rain into houses or buildings can lead to the damage of properties ranging from electronics to furniture and even trigger electric shock. Besides the man-hour lost and loss of concentration in a large establishment in an attempt to shut windows when it is about to rain, hard-earned money is also affected if damage to properties occur. The need for comfort and convenience has prompted researchers to seek smart technological solutions to overcome the demanding traditional way of closing casement windows. This project, a smart rain-sensitive casement window conforms with the evolving quest to make life easy for man. It uses a resistive rain sensor to detect rain and triggers or activates a geared motor via an Arduino mini pro microcontroller to shut an open window. It also incorporates a manual pushbutton switch to manually close the window, without having to pull the window to a close. This process is achieved within a few milliseconds. Testing the device over a period of 3-days, showed it to be highly sensitive even to the smallest droplet of rain.**

***Keywords*: Smart, Casement window, Rain-sensitive, Arduino mini pro.**

1. Introduction

Traditionally, the windows of buildings or houses are operated manually by the occupants. Windows are closed manually when the need arises. It is not unusual for one to forget closing the window when we go out. When this happens, and it rains there is the likelihood of rain entering the room and causing unnecessary damage to the interior lighting appliances, furnishings and other items (Song et al, 2019). When it rains, it requires attention and it is more like a hectic chore. If the windows are not shut down when it is raining, it could lead to possible damage of property, like electronics, paintings and even cause electrical shocks. In a large office like a hospital or large shopping malls, moving around to close the windows during heavy downpour is tasking, time consuming and a waste of man hour. As technology steadily improves the quest for smart and intelligent homes have continually crept into the design and research space. Convenience in doing many things have become the order of the day. Thus, the need for smart systems that eases the way of doing things. Money is not easy to come by, hence protecting one's hard-earned valuables from damage by rainfall is of utmost importance. With the improvement of the quality of life, the perspective of intelligent home is gradually being realized (Qu & You, 2020). Home and buildings automation systems are now been adopted to large extent as a means of increasing comfort and achieving easy teleoperation tasks (Owojori et al., 2021). This design solves this problem by automatically closing the windows when water touches on the sensor, triggering the mechanism of a casement window.

2. Review of Related Literatures

(Sundara Siva Kumar & Nagesh, 2017) designed and implemented an automatic window closing system that activates in response to rain detection, using an AT89S52 microcontroller and a conduction-based rain sensor, Control Unit, stepper motor. The sensor was used to detect the rain or water flow. When it senses rain, the window closes automatically and opens when it is not in contact with rain or water flow. (Qu & You, 2020) went further to design an intelligent window system capable of automatically opening or closing based on environmental conditions, enhancing comfort, safety, and energy efficiency in homes. They utilized an STC series microcontroller as the control unit. The sensor integration were sensors for rain detection, temperature and humidity (dHT11), dust (GP2Y1010AU0F), and wind speed. A stepper motor was used for the actuation, to open or clow the window. (Stazi et al., 2017) designed and tested an automatic window-operating system in school classrooms that maintains both indoor air quality (IAQ) and thermal comfort by combining temperature and CO_2 levels into a control algorithm. (Song et al., 2019) designed an intelligent rainwater detection window based on STM32 single-chip microcomputer. The outdoor rain detection module detects rain, the signal is converted from digital signal to the single-chip microcomputer to make the circuit conductive. Driven by the deceleration motor under the control of the relay, the window is automatically turned off. The indoor temperature sensor detects that the single-chip microcomputer sends a signal to control the deceleration motor to close the window when the room temperature is too high. The device adopts a modular design, which is easy to install. The circuit part can be placed indoors, to prevent various losses caused by rain into the room. Furthermore, Okomba et al., 2017 designed a window which closes and opens and closely automatically during and after rainfall. The system design

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includes a PIC16F877A microcontroller which gets activated when a moisture detector sensor sends a high logic signal to it. The microcontroller executes its embedded program by activating the stepper motor through a ULN2003 current-dependent integrated circuit (IC) chip resulting in stepwise control of the window. Thus, the window is automatically closed when rainfall is detected but opens and remains open when no rain is detected.

(Owojori et al., 2021) designed an automatic sliding window which responds to system command via a Bluetooth developed App on a mobile phone. The design used an Arduino as its controller and HC-05 Bluetooth module as a communication link between the controller and mobile application which was developed on MIT Ai2 platform. An ultrasonic sensor was used to measure the distance of the sliding window to the edge of the wall by sending out and receiving pulses. A distance beyond or less than a threshold implies the system is closed or open and can be adjusted according to the user's preference using the mobile application. (Ou 2019) developed an intelligent opening and closing system for windows and doors. The system consists of three parts: door and window intelligent hoist, background data management center and mobile client. The Door and window intelligent hoist is an independent device separated from traditional Windows, with the ability to display indoor temperature and humidity in real time, air quality, automatically close Windows after rain, and adjust air quality and alarm. The background data management center conducts data interaction with the data server, checking the address, status, failure information and other functions of the intelligent door and window hoist.

3. System Design

A. Design Specification

The project design involves developing a cointegrated system where hardware and software components work together to achieve the project objectives. The hardware will be prototyped first, followed by the software development using the Arduino IDE to program and debug the hardware.

Table 1
List of components and their specifications

S.No.	Components	Voltage	Current
1	Arduino pro mini	5V	20mA
2	Rain sensor	5V	10mA
3	Tact switch(button)	5V	20mA
4	Battery	12V	7.5A
5	Capacitor	35V	4A
6	Buck converter	5-80V	3A
7	Geared motor	12V	70mA
8	Relay	5V	70mA

4. Working Principles

On detecting rainfall, the rain sensor sent a signal to the Arduino Pro Mini, which in turn, activates the relay driver circuit to close the window via the DC motor. The manual open/close buttons allowed users to override the automatic operation, providing manual control when needed.

The system operated with a continuous power draw of approximately 7.5A from the 12V battery, ensuring reliable performance for the duration of the testing period. The battery was capable of supporting the system's operations, including the rain sensor, relay driver circuit, motor, and Arduino Pro Mini, without any significant voltage drops or power failures. Additionally, the buck converter effectively regulated voltage levels for the Arduino and motor, ensuring stable and efficient operation of all components. The feedback resistor provided real-time data on the motor's position, allowing the system to monitor and adjust the window's opening and closing range accurately. The relay driver circuit, aided by the NPN transistor and diodes, ensured smooth switching of the motor, protecting the system from potential damage caused by back electromotive force (EMF).

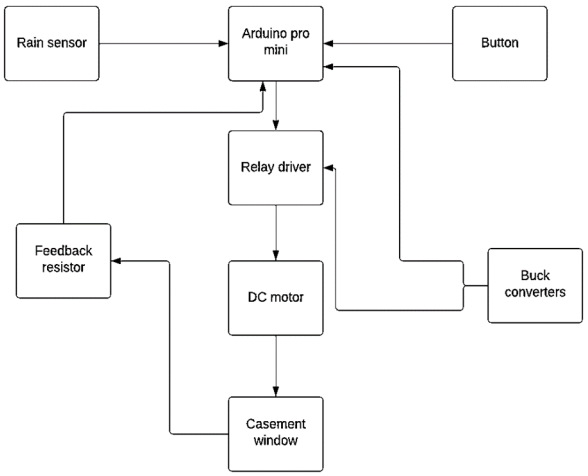

Fig. 1. System block diagram

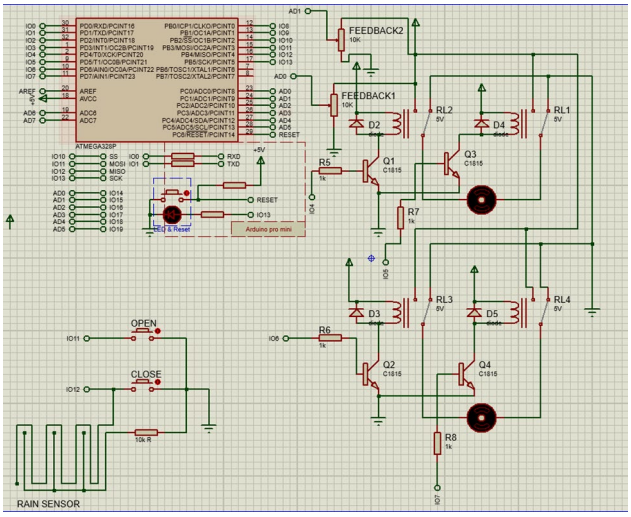

Fig. 2. Circuit diagram of the smart rain sensitive casement window

The smart rain-sensitive casement window system was successfully implemented, using only a 12V DC lead-acid battery as the primary power source for operation. The system's components were tested over a 3-day period, during which the rain sensor demonstrated high sensitivity, effectively detecting even small rain droplets.

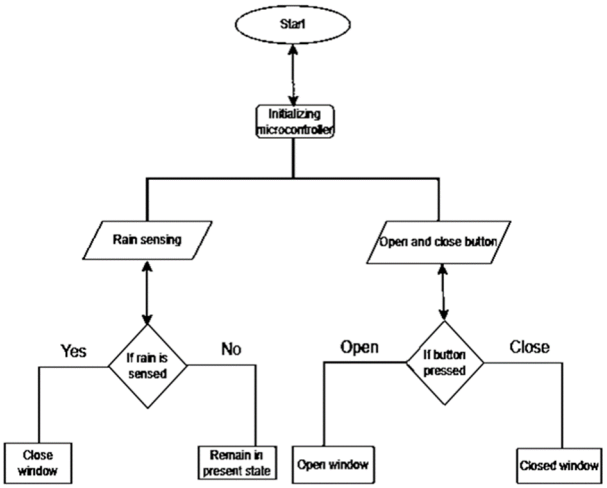

Fig. 3. System flow chart

5. Conclusion

Rainfall is natural and beneficial, however, when an unexpected rainfall happens and gets into our homes through our windows, because windows are not shut it can be devastating to our properties and even cause electrical shock as water is no friend to electricity. Besides, in a large establishment, it can be a herculean task to quickly shut all the windows especially when the rains come down expectedly and quickly. Thus, the need for a system that can take a proactive action to shut the windows even at the slightest detection of rain. This projects a smart rain-sensitive casement window comes in handy. It uses a rain sensor which detects the rainfall and sends a digital signal to the Arduino mini pro which is the Microcontroller. The Microcontroller processes the received signal and sends a message to the motor attached to the casement window to quickly shut window. A pushbutton switch is attached to operate the window manually without having to pull the window to a close. The process is achieved in a few milliseconds. Testing the device over a period of 3-days, showed it to be highly sensitive even to the smallest droplet of rain.

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