PRINT ISSN 1119-8362
Electronic ISSN 2659-1502

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 26 (11) 1821-1826 November 2022

Development and Implementation of a Prototype Automatic Rain-Sensor Car Wiper System

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ABSTRACT: Various studies have been conducted over the years on how to reduce driver distractions while driving, but with little effort on the distraction that could be caused by manually operated wipers while driving whenever it rains. Drivers frequently take their hands off the steering to turn ON/OFF and adjust the wiper speed when driving during rain, which causes a loss of concentration and increases the risk of a car accident. This paper presents an automatic car wiper prototype system that adjusts the speed of the wiper based on the intensity of the rain. The system also includes an audio alert that warns the driver to stop driving during heavy rain. The rain sensor/intensity and servo motor; which regulates the wiper's speed, were interfaced by an ATMega328 (Arduino Uno A000066). It performed satisfactorily, with average response times of 0.78 seconds, 1.95 seconds, and 6 seconds for rain water detection, increasing rain intensity, and no rain detection respectively. The wiper speed was 15 rpm at moderate rain intensity and 32 rpm at heavy rain intensity. The wiper average response time and speed shows that it is a system that eliminate delay as compare to manually operated car wiper system. The developed system will reduce driver distractions while driving thereby reduces the risk of a car accident. As a result, this system can be combined with new technologies seen in contemporary vehicles.

DOI: https://dx.doi.org/10.4314/jasem.v26i11.13

Cite this paper as: AKANNI, J; OJO, A. O; ABDULWAHAB, A; ISA, A. A; OGUNBIYI, O (2022). Fabrication and Application of a Prototype Automatic Rain-Sensor Car Wiper System. *J. Appl. Sci. Environ. Manage.* 26 (11) 1821-1826

Keywords: Automatic rain-sensor car wiper; prototype; electronics; emerging technology; windshield; wiper

Early forms of land transportation such as horses, donkeys, wagons, horse-drawn carriages, etc. were crude means of transportation which were not designed to have a windshield to protect the driver or passengers or to act as a windbreak. However, with the introduction of engine-powered vehicles such as cars, aircraft, buses, etc., windshields were incorporated to serves as a means of protecting the vehicle drivers from flying debris, rainfall, etc (Pereverzev and Semenikhin, 2016; Tiwari *et al*., 2013). The windshield component included in engine-powered vehicles lacked a self-cleaning medium that resulted in the windshield being intermittently cleaned using brushes and clothing materials while driving especially during rainfall. This intermittent cleaning process was performed manually, requiring the driver to stretch his/her hand to the windshield outside the vehicle to clean the debris obstructing the driver's view. This act results in a reduction in concentration and increases accidental risk while driving. Windshield wipers are legal requirements that have made up a significant part of automobile systems (aircraft, watercraft, cars, trucks, buses, train locomotives, etc.) to remove rain, snow, and debris from its windshield in order to enhance drivers' visibility and safety (Elahi and Rahman, 2014). In the beginning, windshield wipers are made of a metal arm with a pivot at one end and a long rubber blade at the other. When manually powered, the arm moves the rubber blade back and forth over the windshield and pushing unwanted debris out of the way to improve visibility of the driver. Also, in 1903, Polish concert pianist Józef Hofmann and Mills Munitions were credited with inventing windshield wipers. This wiper

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was operated by a lever from within the vehicle, and it closely resembled the windshield wiper featured on many early car models (Rajarathnam *et al*., 2019; Windshield Wipers Atlanta GA 2017). This wiper was operated from within a vehicle via a lever and this version closely resembles the windshield wiper found on many early car models. From 1903 to the present date, when transportation is crucial for the movement of goods and services, windshield wipers have experienced a number of developments. Also, transportation helps humans traveling from place to place for leisure activities or exploring new opportunities. Automobiles like buses, cars, two-wheelers, etc. are utilized for day to day commutation by the masses. Of all the available automobiles, cars are the most frequently used in urban areas and its metropolis (Gavanas, 2019). According to the United State Department of Transportation, car accident cases have increased worldwide due to distraction caused by various means which includes the car wiping system, sound system etc (Warren, 1998). Most of the windshield wipers on vehicles (cars) are manually operated by drivers and this causes distraction which reduces concentration and increases risk of accident. In order to reduce car accident cases, there is a need for an automatic rain-sensing car wiping system which helps to reduce further distractions caused by the need to turn ON/OFF and also adjust car wiper speed in accordance with the intensity of rainfall.

In 1905, Mary Anderson invented a wiping system which was popularly referred to as window cleaner (Olive III, 2019). The system consists of a rubber blade, a metal arm, and a lever. The system operating mechanism involves stretching of the drivers' hand towards the lever connected to the metal arm, resulting in the forth and back motion of the metal arm to which a rubber blade is attached, leading to the cleaning of the vehicle windshield. Although, her invention was standard, eliminating the need for drivers to stretch their hands through the window to clean the windshield with brushes or clothing materials while driving, the need for drivers' to manually operate the lever arm to clean the windshield while driving was still a form of distraction. The usage of an electric motor helps in moving a single metal arm with a long rubber blade forth and back across the car windshield was a solution to the manual operation of the lever arm. Dr. Ormond Wall created a semi-automatic wiping system for automobiles in 1917, which was executed by inserting an electric motor in the upper center of the windshield, causing the wiper to rise in a semicircular or rainbow form over the car's hood (Kulkarni and Holalad, 2012). Although this system operates the lever with an electric motor but the need for the driver to switch on the motor manually while driving was still a form of distraction. Hideki as cited in Viswanadh and Leela Krishna, 2015 developed an automated wiper with an optical rain sensor that detects rain drops. The system's operation is based on the optical sensors' use of light and the total internal refraction technique within the windshield. The disadvantage is that the system is expensive and sensitive to interferences. Pallavi as well as Shantanu developed an automatic wiper using piezoelectric material (Pallavi, 2016; Dharmadhikari *et al*., 2014). When raindrops press the piezoelectric material, energy is generated, which is then stored in a capacitor until a sufficient voltage is achieved to close the relay system and drive the wiper motor. The disadvantage is that the system is easily susceptible to false triggering. Also, Varshitha *et al*., 2018 work on improvement of auto wiper controller according to rain force. To detect rain and its intensity, they employed a combination of impedance and piezoelectric sensors. A microprocessor in the system receives data signals from sensors and regulates the movement of the windshield wipers based on the data signals. This system also has disadvantage of easily susceptible to false triggering. Ashik and Basavaraju, 2014 employed capacitive proximity sensing methods to detect rain. The research work is partially effective, but prone to stray electrical fields, and also the electronic component employed is rather expensive.

Kulkarni and Holalad, 2012 designed an automatic rain-sensing car wiper. This system was developed by using 8051 microprocessor and a cup sensor. The sensing device is basically a conical shape cup with a tray on the top of the cup to collect the maximum possible amount of water. When the water is collected in the tray, it moves into the cup which has different indication level and a discharge point where rainwater is drained. As the rainwater accumulates in the cup, the indicator levels are triggered and an output signal is sent to the microprocessor to increase or decrease the speed of the wiper motor. This model of semi-automatic rain-sensing wiping system has three different stages of rain intensity. However, the cup sensor does not last long and as different particles enters, the output signal is disturbed. Bluetooth automobile wipers were constructed by Mitra *et al*., 2017 and Minar and Tarique, 2012 integrating HC05 Bluetooth, Arduino, and servo motor. When the wiper detects a wireless Bluetooth signal from any mobile device, it starts operating. They developed a novel method of cleaning the windshield, however this equipment does not make driving distraction-free because it requires drivers to provide a Bluetooth signal before the wiper begins. Karande, *et al*., 2019 developed an automated automobile wiper system that switches on and off in response to rainfall. For control of the wiper system, Karande and his colleagues used a servo motor, rainfall detector, Arduino microcontroller, and liquid crystal display (LCD) module. When it rains, the rainfall detector detects it and transmits the information to the Arduino microcontroller, which analyses it before sending it to the servo motor to perform the required task. The information transmitted to the microcontroller is in responsible for adjusting the wiper speed depending on the intensity of the rain. This system's shortcoming is that it has only one speed and hence does not function as a rain intensity detector. Although different studies have been carried out towards improving vehicle wiping system however a car wiping system using rain detector and flow-rate meter has not been implemented. Hence, the objective of this paper is to fabricate and apply a prototype automatic rain-sensor car wiper system designed in this work.

MATERIALS AND METHOD

Modular design approach method was adopted in the development of the system; a number of modules/components were integrated together. The system was divided into two parts: The hardware and the software. Simulation of this system was first carried out in order to ensure that the system working principle conforms with the system circuit design correctly, accurately and functionally as expected. The system was then implemented with hardware.

Hardware Components: The hardware consists of the rain drop detector module, rain intensity detector module, Arduino microcontroller module, an alarm module, UPS module and a servomotor. Figure 1 shows the block diagram of the automatic rain sensor car wiper system.

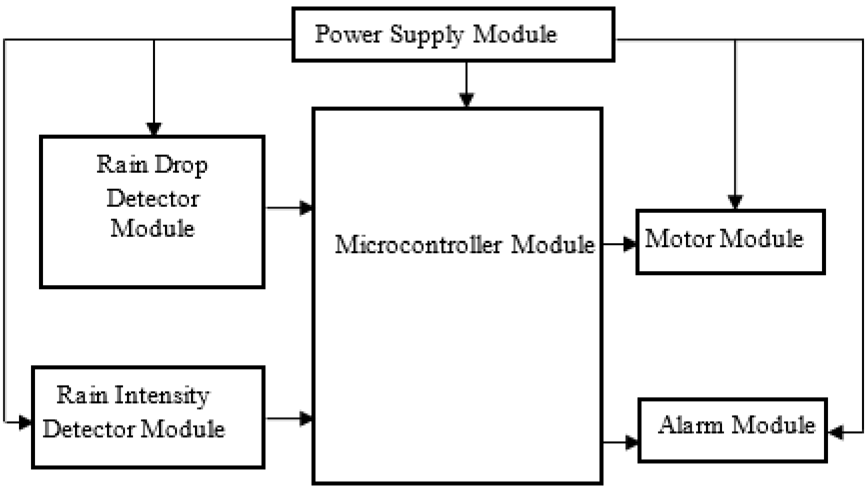

Fig 1: Block Diagram of the Automatic Rain sensor car wiper system

Rain Drop Detector Module: The rain drop sensor used is the FC-37 module. Figure 2 shows the picture of an FC-37 rain drop detector (sensing) module, it is made of copper line treated with nickel to protect the conduction line from rusting and increase its sensitivity of rainfall droplets.

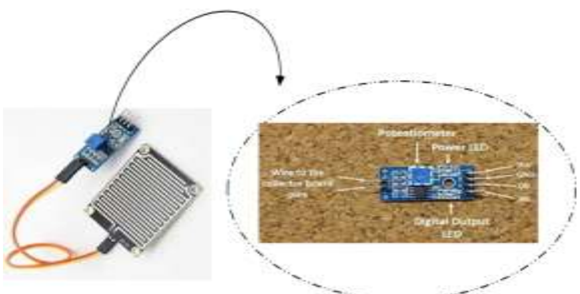

Fig 2: Picture of FC-37 Expanded part of Figure 2

Rain Intensity Detector Module: Studies revealed that the speed at which the rain water flows down the Windshield into a pipe that finally discharged the water away is proportional to the rain intensity and as a result, a sy201-f flow meter is incorporated into the system to keep real time tracking of the rain intensity. The frequency of the output signal depends on the velocity of the liquid flowing through the flow rate sensor (Laurantzon, 2010). Figure 3 shows the picture of sy201-f flow meter module.

Fig 3: The picture of the sy201-f meter flow module

Microcontroller Module: The microcontroller used is an Arduino Uno A000066, which was created by Arduino.cc in Italy and is based on the ATmega328p microprocessor. It is a compact, adaptable, and breadboard-compatible microcontroller. It is made of a physical programmable circuit board (commonly known as a microcontroller) and some software known as an IDE (Integrated Development Environment) that runs on a computer and is written in the C programming language (Akanni *et al.*, 2022). The picture of the Arduino Uno A000066 is shown in Figure 4.

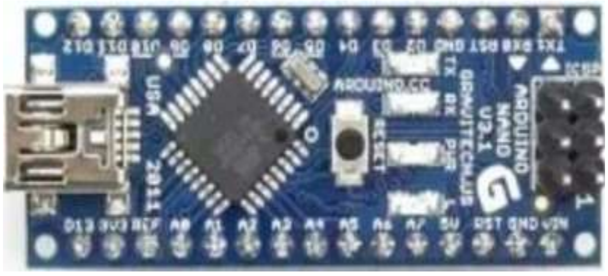

Fig 4: Picture of the Arduino Uno A000066

Power Supply and Servomotor Module: SPT5525LV-320 digital servomotor is used; it is a motor that provides exact control in terms of angular position, acceleration, and velocity capabilities that a standard motor does not. (Monjengue, 2019). The module works well with a DC input in the range 4.8 to 6.0 V, stall torque of 24kg.cm at 4.8 V and 26kg.cm at 6.0 V. Figure 5 shows the picture of an SPT5525LV-320 digital servomotor.

Fig 5: The picture of an SPT5525LV-320 digital servomotor

Software: Arduino IDE was used to provide the software development tools for the Arduino Uno A000066 microcontroller, write, debug and simulate embedded C-programming language. Figure 6 shows the flowchart of the operation of the system.

Hardware Implementation: The system prototype was not only simulated using computer-based simulation tools, it was also implemented into hardware. The step taken in hardware implementation involves arrangement of the modules/components on a breadboard, arrangement/connections/soldering of the modules/components on a Vero Board and system casing. Figure 7 shows the picture of the arrangement/connections/soldering of the modules/components on Vero Board. The system casing was specifically selected to factor in the issue of convenience as well as ruggedness. Figure 8 shows the picture of the system casing.

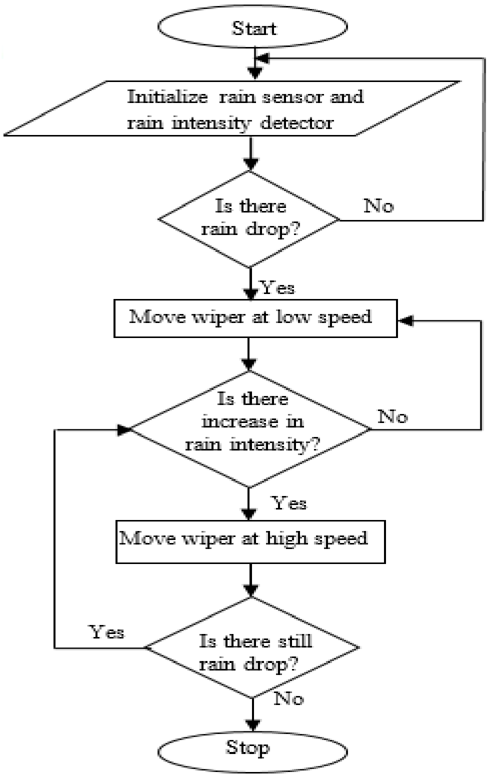

Fig 6: The flowchart for the operation of the system

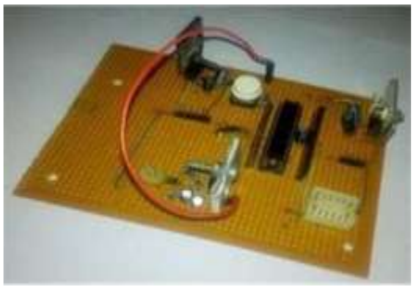

Fig 7: The picture of the arrangement/connections/soldering

Fig 8: The picture of the system casing

RESULT AND DISCUSSION

The various tests were carried out on the developed system to confirm the level of its performance and efficiency. The tests carried out includes: wiper average response time test and wiper average speed test. Table 1 shows the result of the wiper average response time test (wiper average response time of the system to detection of rainwater on the windshield, increase in rainwater intensity on the windshield and no rainwater on the windshield when the rain had stopped) while Table 2 shows the results of the wiper average speed test (average wiper's speed at moderate and heavy rain intensity). It was observed that the system performed satisfactorily, with average response times of 0.78 seconds, 1.95 seconds, and 6 seconds for rain water detection, increasing rain intensity, and no rain detection respectively. It was also observed that the wiper speed was 15 rpm at moderate rain intensity and 32 rpm at heavy rain intensity.

Table 1: wiper average response time test.

S/N	Test	Time response(s)
1	Response to the detection of rainwater on the windshield	0.78
2	Response to increase in rainwater intensity on the windshield	1.95
3	Response to no rainwater on the windshield	6.0

Table 2: wiper average speed test

S/N	TEST	SPEED (RPM)
1	Speed at moderate rain intensity	15
2	Speed at heavy rain intensity	32

Conclusion: An automatic car wiper prototype system that varies the speed of car wiper with respect to variation in rain intensity was developed. The wiper average response time and speed shows that it is a system that eliminate delay as compare to manually operated car wiper system. The developed system will reduce driver distractions while driving thereby reduces the risk of a car accident. As a result, this system can be combined with new technologies seen in contemporary vehicles.

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