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CONSTRUCTION AND PERFORMANCE TEST OF A RAIN SENSING AUTOMATED SLIDING WINDOW

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Abstract: *With the advancement of science and technology people are becoming more dependent on mechanical and electronic devices. The use of micro-controller and electronic devices can very easily fulfill this requirement. Applications include robotic controller, turning machine tools and other precise shaft positioning control environments etc. In the present work, the model of an automatically controlled window system using an Arduino UNO has been designed and constructed. A water sensor and mechanical control unit using a dc servo motor and belt-pulley arrangement is developed to control the motion of the window. Thus, an automated window control system sensed by rain water is developed. The significance of this system is automation of the window which can be customized according to the industrial, commercial or domestic requirements. After finishing the construction of the model, the performance test was carried out by spraying water on the window. The result showed that the system works satisfactory.*

Keywords: Automatic window, Arduino UNO, Motor controller IC, Water sensor.

1. INTRODUCTION

As a result of enhancement in the civilization and modernization, the human nature demands more comfort to his life. Man seeks ways to do things easily and comfortably which ultimately saves time. The remote sensing devices control things in daily life like switching on/off the lights, fans, TV, fridge and similar items. Automatic windows in modern building began to be used in the later years of the twentieth century. After 1990s, increasingly widespread application of the idea created a mass production of the same. Many large hotels, buildings and services adapted this technology to improve their grade level [1]. Opening and closing of doors using motion sensors is now a day a common practice in shopping malls or similar places in our country. Such a model infrared controlled automatic door was constructed using PIR sensors, dc motors, L293D motor controller and Arduino UNO microcontroller at KUET. It works by taking signal from the motion of human being. The performance of the model was satisfactorily [2]. Closing windows in houses is such a daily works which sometimes become cumbersome and irritating particularly in the rainy season. Sometimes we forgot to close the windows and left the room and suddenly it starts raining. Water enters into the room, thereby wetting the materials kept inside. That is why automation of such a window comes in daily life which will close the window automatically when rain water enters into the room. There are generally three ways to close or open the windows of a room. These are automatic windows with sliding, swinging and revolving. Every type has certain characteristics. In this paper only the sliding type automatic window is considered. Other types exist but are seen rarely in the residential building. Work was carried out to examine the primary operating characteristics of sliding window for a linear actuating system and remote controls by Sumit et. al. [3]. The theory was when the open button is pressed, a signal is send to the main circuit which allows current to pass through the window motor causing it to run and open the window. When the close button is pressed, the reverse motion is actuated. An automatic sliding window unit may employ either one or two sliding panels. But in domestic application in most cases the windows are divided into two panels.

An electronic control unit (ECU) has a huge application in any kind of control system. Any electronic circuit of a control system can be made simpler by using

microcontroller [4]. In this case just the application of limit switch, electronic circuit and motor control has been adopted. By the application of limit switch any kind of appliance can be controlled at certain length interval. It's wide applications can be adopted in an industry or domestic application to controlling door or window to prevent damage causes by rain. Besides this the window can be controlled by a belt and pulley assembly, using a motor controlled by microcontroller circuit. Depending on this concept a window can be opened and closed by utilizing this system using a rain sensing detector/sensor.

2. THEORETICAL ASPECTS

It is a common experience to have a sliding window in car or residence of developed country and to observe its rather smooth operation. By looking closely to the mechanism responsible for the motion of the window, it is noticed that it can be schematized by a relatively simple system, made of two pulleys and two material points. In order to adopt a simple model for the motion of sliding window, let us consider a the common way of mounting them on a slide, as shown in Fig. 1

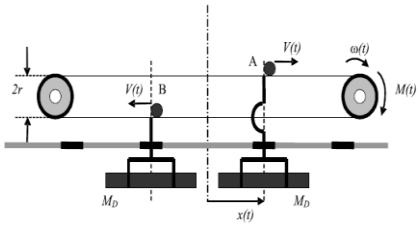

Fig 1: Representation of the mechanism of opening and closing sliding window.

While opening the windows, an electric motor provides a moment *M(t)* to the system of two pulleys connected by a string to which the windows are connected in such a way that points A and B on the string move in opposite directions. Points A and B, on their turn, are connected, by means of rods, to the right and left siding windows, respectively, which follow the horizontal motion of these two points. The abscissa of point A is *x(t)* and corresponds to the abscissa of the middle point of the right sliding window whose mass is M_D. The velocity of point A is $V(t) = r\,\omega(t)$, where r is the radius of the pulley and $\omega(t)$ is its angular velocity. The reverse action will close the windows. Therefore, the motor should provide two directional movements.

3. DESIGN OF AN AUTOMATED WINDOW

For the development of the project a model window of 45 cm by 30 cm is considered. It is assumed that the model window will consist of two parts, so it will slide half the window length i.e., about 23 cm in the horizontal direction to open or close the window. As in most conventional office or residence buildings use aluminum frame window, the frame of the model window will also be made of aluminum weighing between 0.50 to 1.0 kg. The block diagram of the designed model shows the command flow of the entire working system. Most of the conventional automated window in our country would be larger in size and weight. So, if it can be proved that the designed model could satisfy the implementation of the idea then the system could be introduced for the larger windows as prototype in the future. The schematic diagram of the model window is shown in Fig. 2.

To construct the automated window control system sensed by rain sensing sensor, it would basically need to design three components, which will be attached to complete the ultimate construction of the window control system sensed by rain. They are briefly discussed in the following subsections.

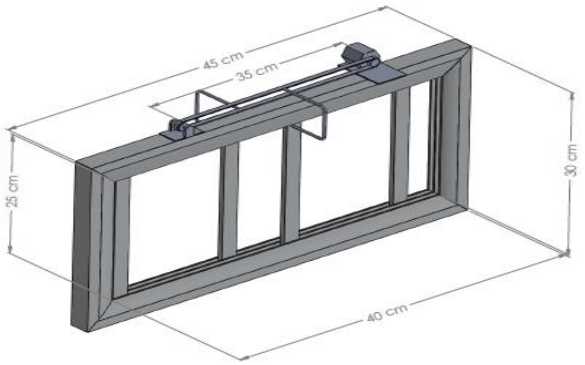

Fig. 2: The 3-D view of an automated window

3.1 Rain Detection System

The rain detection system would provide signal to the control unit to start the driving motors in the desired directions to open or close the window [5,6]. In fact if rain water falls directly on the sensor, it will sense and try to close the window, but it may happen that there is not much rain water that need closing the window. So, certain amount of water must be stored where the sensor will be dipped and send signal to the control unit. To construct the rain detection system a funnel, placed in front of the window, be used to collect rain water. It is assumed that a certain amount of water should store in the funnel and then the signal generates. The funnel is made such that the discharge rate of water from the funnel is lower than the collection rate, so that some water is stored in it. Thus, when it is raining, a little amount of water is stored in the funnel and when the rain stops the stored water is discharged slowly. It is known that the water has electric conductivity. As water sensor is placed into the funnel when it is partially submerged into water, the circuit would be completed and a signal will be generated. When the funnel is empty, the reverse will happen.

3.2 Arrangement to open and close the window

To convert electrical power into mechanical power which in turn will be used to close or open the window, a mechanical arrangement is required. An electrical motor will be utilized to convert such conversion. The power of the motor was calculated from the estimated load [7]. As the motor gives rotary motion and to open or close the window it is required a linear motion, so a belt-pulleys arrangement is used as shown in Fig. 2.

3.3 Electric Control Unit

To construct the electric control unit (ECU) a circuit diagram is made. The circuit has mainly two parts internally added; one is the amplifier part where the signal from the rain detection sensor is amplified and transferred; another is to control the motor to opening and closing the window. The schematic of the circuit diagram is shown in Fig. 3.

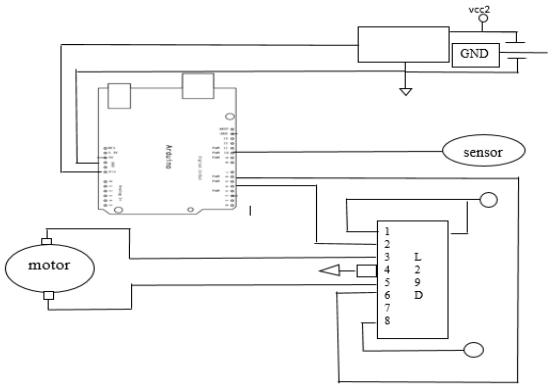

Fig. 3. Circuit diagram of ECU

4. Working Procedure of the Control System

The water sensor used in this project is to detect any water on the window. If it detects a certain quantity of water in the funnel then a signal will be sent to the Arduino. The Arduino would receive the signal and then send a signal to the motor controlling IC to start the motor and close the window. Two seconds after opening the window, the water sensor would again be activated to search for water and if any water is found than the window would stay closed. If no water is found then a signal would be sent to the motor controlling IC to open the door. A computer program would run the entire operation so that no human effort is necessary. The flow chart of the program is shown in Fig. 5.

5. Construction of Model Automated Window

The construction of the automated window control system is divided into the followings:

Frame: As described earlier, the size of the window was 45 cm in length and 30 cm in height and also 5cm in width. The frame was made from aluminum channel and the window panel is made of glass with aluminum. Each part of the window is of 23 cm in length, 30 cm in height and 2.5 cm in width placed inside the aluminum frame (rail) that travels on the wheel placed underneath them. The total frame is housed in another wooden casing.

Motor and pulley-belt: The motor and the pulley-belts are placed on the wooden casing and the belt is connected to the window with a liver arm. The liver arm is fastened such that when the belt moves, the window also moves. A 6 volt, 1 amp, 120 rpm (rated) dc motor is chosen for the work because of its easy availability in the market and reasonable price.

Battery: In this project a 6 volt, 1 amp, 3-cell battery is used which are connected internally with each other so that it may supply the necessary power and voltage.

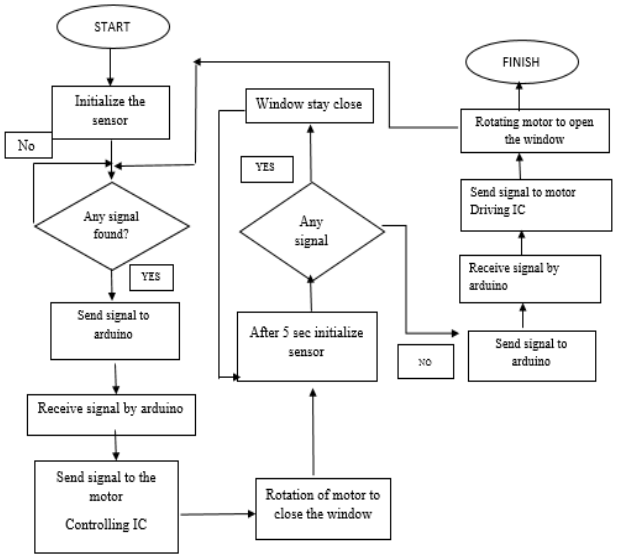

Fig.5. Flow Chart of the process

Motor driver: A L293D IC is used to drive the motor in this project. L293D is a motor driver integrated circuit which is used to drive dc motors rotating in either direction. It is a 16-pin IC which can control a set of two dc motors simultaneously. The L293D uses 5V for its own power and external power source is needed to drive the motors.

Sensors: In this project one water sensor is used which was placed inside the funnel. The funnel was placed in front of the window. The sensor, when it comes in contact with the rain accumulated in the funnel, it sends a signal to the electric control unit which thereby detects presence of rain and thus closes the window accordingly. This type of sensor is very simple, cost effective, and no alignment is necessary.

Arduino: The Arduino UNO is a microcontroller board based on the ATmega328. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The necessary program is stored

within this Arduino. The photographic view of the constructed model window is shown in Fig. 4.

Fig.4. Photographic view of Constructed Model Window

5. Working Procedure of the Control System

The water sensor used in this project is to detect any water on the window. If it detects a certain quantity of water in the funnel then a signal will be sent to the Arduino. The Arduino would receive the signal and then send a signal to the motor controlling IC to start the motor and close the window. Two seconds after opening the window, the water sensor would again be activated to search for water and if any water is found than the window would stay closed. If no water is found then a signal would be sent to the motor controlling IC to open the door. A computer program would run the entire operation so that no human effort is necessary. The flow chart of the program is shown in Fig. 5.

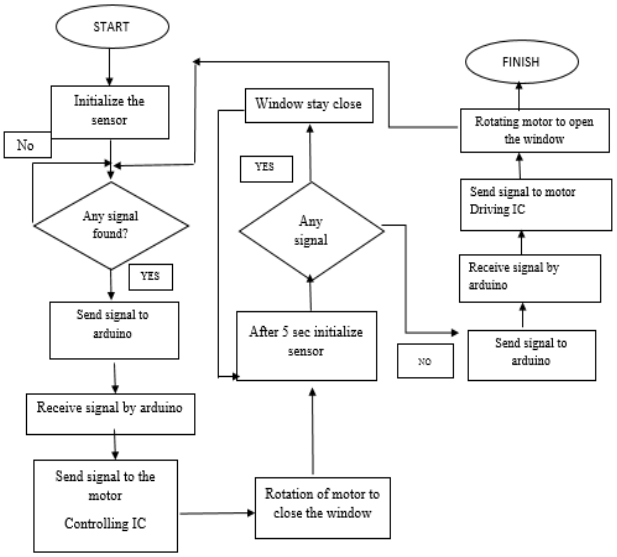

Fig.5. Flow Chart of the process

6. Performance Test

The constructed automated window model was tested to check its performance. During the test water was sprayed to the window to form artificial rain. The test results are shown in Table 1.

Table 1: The test results of automated window

No. of obser-vation	Water sprayed on window (ml)	Water collect-ed in funnel (ml)	Observation
1	8.0	2.0	Window stays open
	15.0	5.0	Window stays open
	23.0	6.5	Window closed
2	9.0	1.0	Window stays open
	16.0	4.0	Window stays open
	21.0	6.5	Window closed
3	8.0	2.0	Window stays open
	16.0	4.0	Window stays open
	24.0	6.5	Window closed
4	7.0	3.0	Window stays open
	14.0	6.0	Window stays open
	19.0	6.5	Window closed
5	8.0	2.0	Window stays open
	15.0	5.0	Window stays open
	24.0	6.5	Window closed

7. Results and Discussion

From the experimental results, it was observed that in every case when 6.5 ml water was stored in the funnel the sensor detected as rain and started the motor and closed the window. In this situation about 21-23 ml water was sprayed on the window. While in actual raining situation the system will work when 6.5 ml water will be accumulated in the funnel. How much water falls on the window is not a factor. As the model window is small in comparison to the real window so there will be no effect of sensing water and controlling the window to close it or open it.

The automated rain sensing window will reduce the human effort. It will be very helpful in residence or office when there is no person present to close the window. The reliability of the water sensor is sufficient. Four wheels are used to reduce the friction between window and the frame/rail. The motor is strong enough to supply the necessary power to carry the window. If the motor is weak there is a possibility to slip the belt over the pulley. As there is a drainage provision of water in the funnel, so water cannot be stored there for longer duration. So, after the rain stops, it takes the window to open position. The speed of the window closing and opening depends upon speed of the motor. To keep a constant speed, the supplied power must be constant. As seen in calculation the required power for opening or closing the window may be very small but a

slightly higher power motor than required may be used to increase its efficiency.

8. Conclusion

The automated sliding window was designed considering some factors such as economy, availability of components in the local markets, efficiency, compatibility and also durability. The performance of the system after test met design specifications. The general operation of the system and performance is dependent on the presence of the rain water on the sensor. The construction was made in such a way that it makes maintenance and repairs an easy task and affordable for the user. The model and the program can be modified according to the requirement and this project can be applied in industrial, commercial and domestic buildings.

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