SULTAN QABOOS UNIVERSITY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ECCE4227: EMBEDDED SYSTEMS

THE PROJECT

"AUTOMATIC WEATHER-SENSITIVE DOOR CLOSURE SYSTEM"

Project team: sec.20

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ABSTRACT

In this project, we developed an effective solution solving the challenging problem of the unpredictable weather in Oman. Starting from this basic understanding we built our system piece by piece with the desire for real development in this field. Our approach was to first understand the problem in detail. Preventing the rainwater in general from reaching the sensitive properties could help a lot. The rain is usually preceded by heavy wind and dark gloomy skies. We could, in theory, predict the rain by these two factors by using the widely available, and easy-to-source sensors of the force to detect the wind and the light intensity sensor to understand the outer environment lighting whether it is dark as in the night, or is it slightly dark as in the cloudy days. We wanted the system to get both analog values and decide if the situation needed interference or not. If the system detects a critical situation it should interfere. We decided that a motor shaft connected to a rope around it capable of pulling a door shut would be the right thing to do in such circumstances.

Problem description

The unpredictable weather Oman is facing is a very concerning problem that has led to catastrophic consequences. in the past cyclone alone the Sultanate's insurances incurred (162 million USD) in total property losses [1]. We believe that a considerable percentage of this figure could be avoided by implementing technologies that may prevent such losses. Starting from this basic understanding we wanted to build a system that closes the water entrances in the homes or offices to prevent damage. Our homes and working spaces are filled with very sensitive devices and components that could permanently be damaged by water. Forgetting the doors opened or the windows opened could lead to this, and this could be easily prevented by a system for detecting the rain and closing the doors. To sum things up, our goal was to develop an efficient system to detect bad weather in general and decide if it needs to interfere by closing water entrances like the doors or the windows to prevent damage to the properties and the sensitive devices and electrical components. This could be used in homes or offices ultimately saving property owners money and time.

INTRODUCTION

Imagine a world where doors automatically shut during rainstorms to protect our homes and to improve our lifestyle generally. This is no longer a science fiction thing but a reality with our project to develop a weather-triggered door-closing system that we developed successfully.

Design

The design of the system is shown in the simulation below. There are 2 analog sensors connected to (ADC0) and (ADC5). For both sensors, there is a resistance that's connected in series with them. One sensor senses force (FSR 406) and the other senses light (LDR). The output signal of PB.0 is connected to a transistor gate allowing -when it is set the attached motor -that's connected in series with a resistor-- to draw the mandatory current to drive it allowing it to ultimately rotate pulling the door shut. To detect the rain and the weather we developed a simple algorithm and simple mechanism. The mechanism is a pierced cup placed on top of the force sensor and a pulley system (to gain torque) connected to the motor shaft attached to a thread on one end and to the far side of the door on the other end. The algorithm keeps monitoring both the force and the light to decide the critical point where it should interfere. The algorithm is working in the daytime and nighttime and any other time in between. For the night, the system gets triggered by only the force regardless of the lighting conditions. In the gloomy Times of the day such as in cloudy times the algorithm checks both the light and the force and gets triggered with a lower force such as wind pushing the cup or even if it's raining slightly. By getting the force in grams we can get the precipitation rate in (ml). The motor needs to work **only once** in every storm, so we developed a code loop inside the loop that’s inside the main loop ordering the program to keep reading the analog weather values after triggering the system to prevent the motor damage.

the force sensor data sheet.

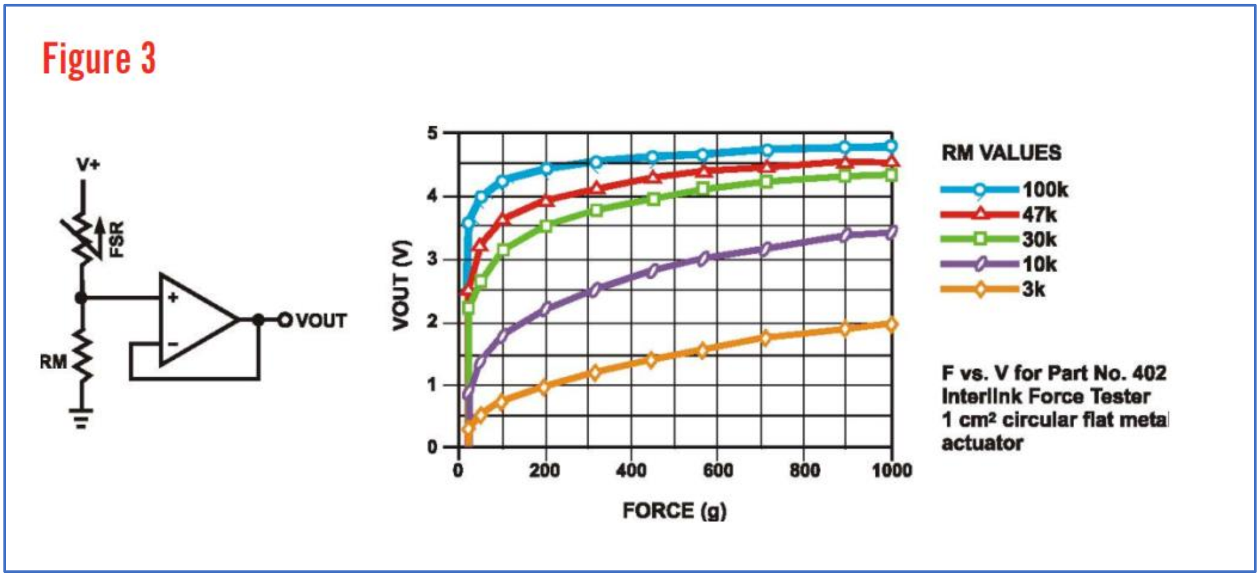

Figure 1: the force voltage characteristics [2]

We can calculate the slope of the graph to determine the conversion coefficient to approximate the amount of the precipitation rate and identify the amount of accumulated water on the Pierced cup placed on top of the force sensor.

$$m = \frac{v2 - v1}{force2 - force1} = \frac{2.4 - 1 \ \ (V)}{(200 - 10) * 10^{-3}(Kg)} = (7)\frac{V}{Kg} \ \ for\ short\ linier\ range\ only$$

So basically, to approximate the force we need to multiply by the factor of 7 which is implemented in the code to approximate the rain precipitation rate.

UBRR= $\frac{Xtal}{16*baud\ rate} - 1 = \frac{8M}{16*4800} - 1 = 103.17 = 103$ (calculations for the UBRR register setting communication rate)

Implementation

Figure 2 below shows the implemented circuit in our project, and it is designed to detect and respond to adverse weather conditions. As is clear, the circuit incorporated two analog sensors - one is force sensing resistor (FSR 406) and the other for measuring light intensity (LDR). These sensors provided crucial data inputs for weather condition analysis. The FSR measures the force applied to the surface of the contact, and its response range depends on the difference in its electrical resistance. As the pressure increase, the resistance of the force sensor decreases, then we measure the analog voltage at the point between variable resistor (FSR 406) and fixed resistor and we found that as pressure on the force sensor increase (low resistor), the voltage across the resistor increases that means the current flow also increases. The microcontroller served as the main control unit of the circuit. It received the digital signals from the ADC and executed the programmed instructions based on the detected weather conditions. We used a transistor gate to control the flow of current to the motor which is responsible for the mechanical action of pulling a door shut.

When testing the design in the laboratory, we found that it works as expected, when the LDR is completely covered with the hand (night time), we rely entirely on the force sensor, so we need to press the force sensor more, but when the hand is raised slightly upward, this represents the cloudy times of the day, so the process depends here on both sensors, but with a light press on the force sensor, the motor starts directly.

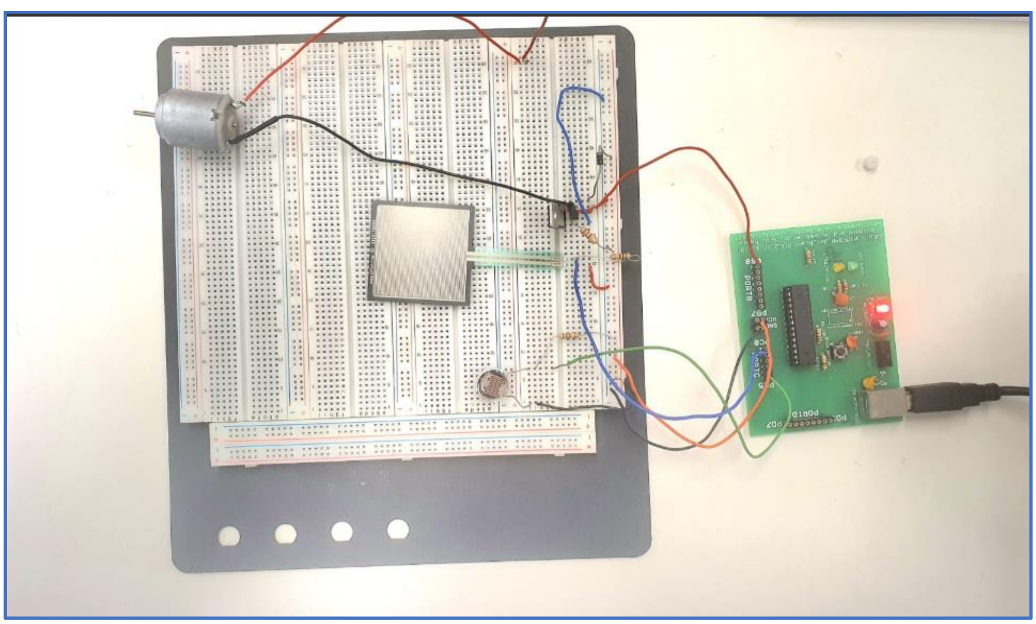

Figure 2: the implemented circuit

Simulation

The figure 3 shows the simulation of the project, based on the skills acquired from the Embedded Course Labs, the design succeeded and worked very well, but due to the unavailability of the force sensor (FSR 406) in the Proteus program, it was replaced with an LDR as per the instructor instructions. As is clear, we used two of them. The sensor connected to PC0 represents the force sensor, and the sensor connected to PC5 represents the light sensor, and we used an IRF540 transistor that acts as a high-side switch that controls the motor. At a specific voltage generated by the two analog sensors based on the light conditions and the force resulting from wind and rain, the current is allowed to flow through the motor, which turns closing the door.

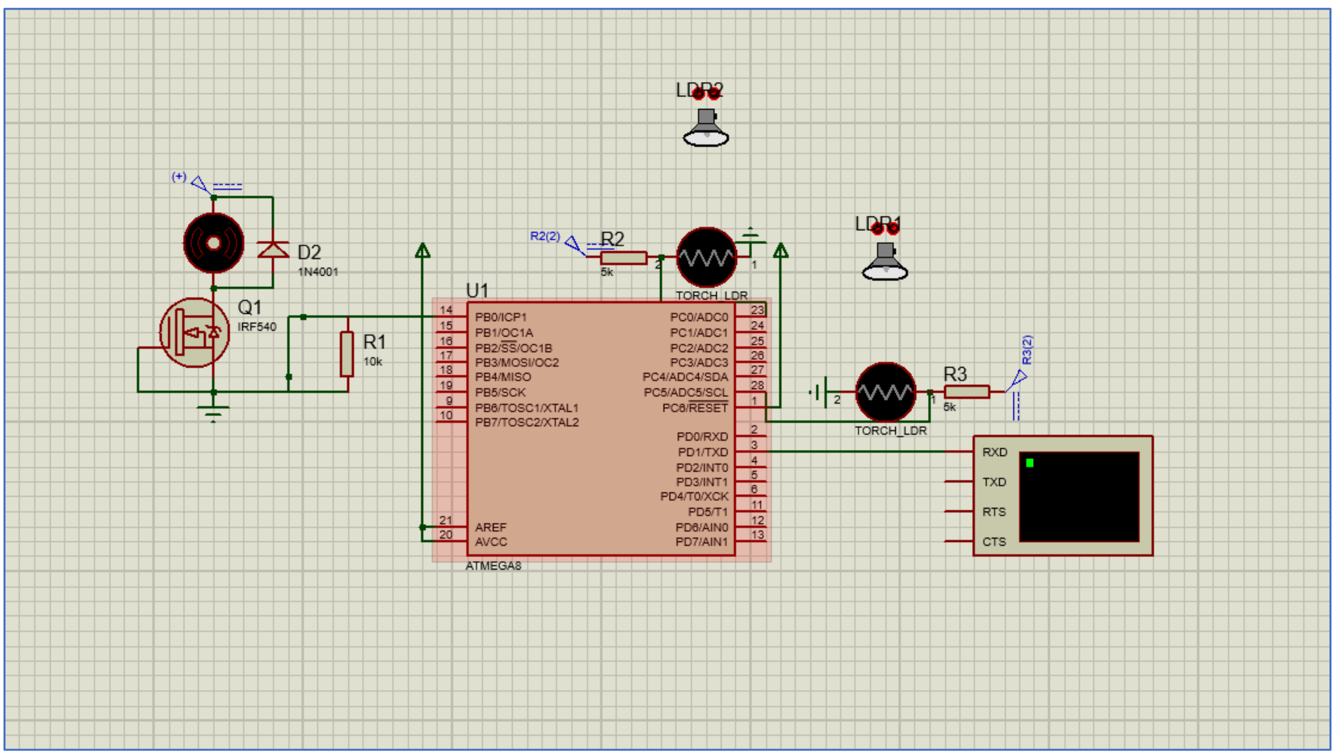

Figure3: the simulation

CONCLUSION

Describe the results expected from the project and why your approach will achieve those results.

In conclusion, our project succeeded in solving the problem for which it was built, through a system that can detect bad weather conditions in Oman, such as rain and strong winds, using sensor technology integrated with mechanical mechanisms. The project was simulated by using the Proteus program first and then implemented in the laboratory, where two types of analog sensors were used: sensor senses light (LDR) and force sensor (FSR 406) giving a command to the motor to close the door, and the response was fast and appropriate. A protective mechanism has been implemented in the code to prevent damage to the motor by continuously reading analog weather values and instructing the program to continue reading analog weather values after the system is powered on. The system succeeded in working daytime and nighttime and gloomy times of the day, regardless of the lighting conditions, which proves the possibility of real-world application.

REFERENCES

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