2024

Ultrasonic Radar Sensor Upgrade: Temperature Sensitive Radar Fan

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Development of ECE301
Circuits and Electromechanical Components
ECE301
December 5, 2024, Knoxville, TN, USA
Submitted to TRACE for Potential Publication

ECE301

ULTRASONIC RADAR SENSOR UPGRADE: TEMPERATURE SENSITIVE RADAR FAN

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ABSTRACT

This paper outlines the development and enhancement of a HC-SR04 Ultrasonic Radar to address challenges and improve daily life through simple automation. While small-scale ultrasonic radars hold significant potential, their applications in personalized and domestic contexts remain largely underutilized. This updated design integrates a small fan, a servo motor, and a DHT-11 temperature sensor to expand the device's functionality. The primary goal of this improvement is to streamline everyday tasks through efficient and user-friendly automation. By exploring engineering principles, Arduino-based assembly, and Python programming, multiple solutions have been developed to demonstrate the ability and versatility of an underutilized, highly powerful instrument.

NOMENCLATURE/KEYWORDS

HC-SR04	Ultrasonic Radar Sensor
DHT-11	Temperature and Humidity Sensor
Servo	Servo Motor used to pivot the HC-SR04
SRD-5VDC	5 Pin Relay

1. INTRODUCTION

Recognizing that Arduino controlled ultrasonic radars are underutilized in the personalized and domestic markets, our team set out to develop a solution and make improvements built upon radar detection. An Arudino controlled radar unit graphically displays data that can be used for a variety of purposes. These are purposes that we feel could be expanded into products for everyday users. Our solution to this was to combine an Arduino controlled ultrasonic radar, various sensors, and have it control a fan which a user could have for their own comfort. Based on the temperature in the room a user could sit down in front of radar, and a fan would automatically turn on and off based on that temperature. This report details the intricacies of our solution, how we developed the design, and future improvements of that design.

2. MATERIALS AND METHODS

2.1 Breakdown of Problem

To fully understand the necessity of the development of a solution we must first understand what the problem is described as. Starting the design process, we used the initial development of a radar that plotted and graphically displayed objects detected using the HC-SR04. From there we moved into what would be the next logical step for a design improvement. Using research from scholarly websites [1] and articles [2], we researched what had been novel ideas to understand what may be next on the market. Many of these designs focused on plotting and detecting multiple points but didn't focus on the end user. From our research, my colleague and I determined that we wanted to design a product that would positively impact the user of our product. My colleague and I defined the problem to face as a new solution to a hands off approach to cooling a specific point to a specified temperature. We determined that this would be an impactful problem to face as it could help those in a commercial setting that may require use of their hands at all times or those who may face mobility limitations and cant adjust a fan traditionally or who may face more obstacles to obtain the same result.

We determined that we wanted our design to have a few critical elements. It needed to be able to sense if an object was in a specified range, it needed to be programmable to a specific temperature that could be easily changed by the user, and we needed for there to be a responsive fan. These elements combined would provide a design that is versatile and scalable enough to be commercially viable, while still making an important impact that could be adapted as necessary. Utilizing the HC-SR04 Ultrasonic Radar Sensor as the base component of all design choices was critical to develop an ideal solution while keeping inside the given design parameters. The use of this component gives a common starting place for all designs while allowing our team to understand how this may economically impact our project choices. In addition to ensuring that we create an impactful design, we also wanted to create a design that could have room for future advancements and various models and modifications should the need arise.

Given the limitations of the arduino our team determined to develop two layouts that were going to be graded on 6 weighted criteria. The criteria were determined to be risk (weight 1), price point (weight 2), scalability (weight 2), complexity (weight 3), reliability (weight 4), and feasibility (weight 5). Using these design criteria based upon the problem requirements we were able to determine the optimal design for our solution.

2.2 Design 1

Using the above design requirements and criteria the first design that we built had a heavier focus on safety and reliability with the addition of the relay, as shown below in figure 1. The relay allows for a simpler fan as well as a lighter load on the fan to ensure the longevity of the part. Allowing for the fan to only have the 5V load when the temperature sensor is tripped at 72° F ensures that there is less of a chance for the fan to short out or overheat. This also ensures that there is an extra level of resistance when the product is scaled up ensuring that it is safer for commercial and residential uses.

As referenced before, the goal of our product is to offer safety and accessibility to those in many environments while ensuring that a fair price could be met. This design has a cost of $38 dollars, where the most expensive component in the design is the relay. We believe this relay is a critical component, especially to keep the costs of external hardware, such as the fan to a lower price. We are able to use a less complex, and therefore cheaper fan, because we are adding the relay step in the product. Having the relay also boasts the ability to have a more customizable product with varying hardware sizes because the fan and the temperature sensors don't require internal relays and don't need to be connected.

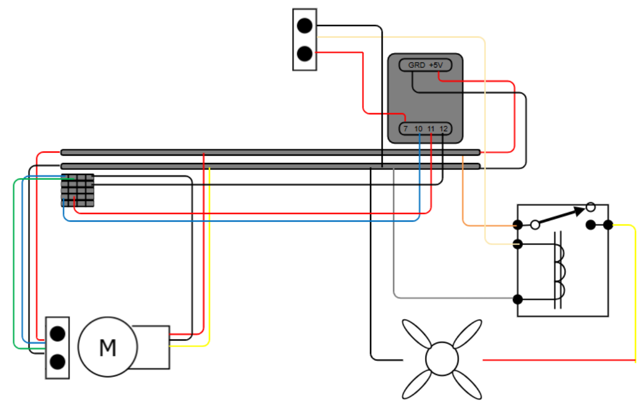
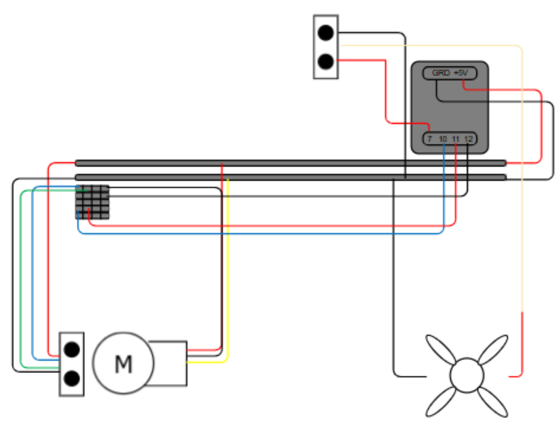


FIGURE 1: WIRING DIAGRAM OF DESIGN OPTION 1

2.3 Design 2

Conversely to design option 1 we wanted to develop a simpler and more cost effective option. With design 2 there is no relay, which saves around $6 per product unit. The simpler design costs around $32 per unit, however we believe that this would only be true at this size. Removal of the relay would require the fan to have a relay so that it isn't constantly energized and running, which at this size of production is not costly, however a larger design would be.

The lack of a relay also poses a slight safety issue in the fact that the fan is constantly taking the load from a battery with no resistor or safety measures between the two components and the design does not include fused circuits. We built and tested both designs and found that the completion of design 2, while requiring less wiring and parts, is more difficult because of the lack of relay.



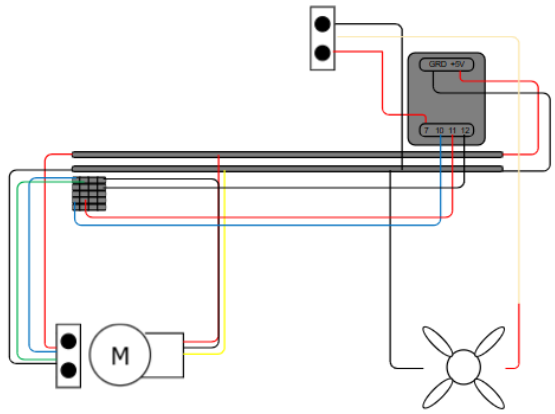


FIGURE 2: WIRING DIAGRAM OF DESIGN OPTION 2

3. RESULTS AND DISCUSSION

3.1 Current Design

The current design of our solution focuses on simplicity while introducing a safety factor to ensure longevity of the circuit. For a general recap of our solution, we engineered a fan circuit that energizes when signals are given that a) an object is in front of the radar sensor within 50 cm and b) the ambient temperature of the room is 72 degrees Fahrenheit or higher. When these conditions are met, a relay delivers power to the fan and completes the circuit. We will delve into the components of the entire circuit more. First is the servo motor. This motor uses three wires: power, ground, and a breadboard pin. Since the motor is constantly powered and grounded through bus bars, it starts to operate through communication with Arduino software. The trigger wire connects to pin 60a on the breadboard and software communication is done through jumping the breadboard connection to pin 12 on the Arduino.

The radar sensor is physically attached to the servo motor as it requires movement to detect objects within 50cm. The radar uses four wires: a constant power and ground, and trigger and signal wires connected to pins 62a and 63a on the breadboard for communication with the software. With the radar having constant power and ground, the trigger sends a signal from the software to start operation and the signal sends timed voltages back when objects are detected to confirm where the object is in reference to the radar positioning. The breadboard pins are jumped with Arduino pins 10 and 11.

The temperature sensor uses three wires: a constant ground, power delivered from an Arduino pin and a signal wire. This sensor operates differently than previous components by not always being energized. When all other conditions are met within the code, the software delivers power to the sensor. With the constant ground, this makes the sensor operational. When 72 degrees Fahrenheit ambient temperature is met by the sensor, a signal is sent from the sensor to a relay.

In Design 2, this relay is bypassed and the signal wire delivers power straight to the fan. However, in Design 1, this is essential to power the fan and is included to protect the fan against sensor malfunction or shorting. The five pin relay is wired to only use four of the pins labeled by a constant power and ground, a trigger to energize the contacts on the inside of the relay, and a signal to send the constant power out of the relay, and into the fan. Power and ground are connected to bus bars on the breadboard. The trigger wire to switch inside contacts comes from the temperature sensor. The signal wire connectS to the power wire of the fan. To complete the fan circuit, the fan has constant ground.

Figure 3 provides a reasoning for why we chose to move forward with Design 1 over Design 2. It details a design matrix based on previously defined weighted criteria. These include from lowest to highest weight: feasibility, reliability, complexity, price point, scalability, and risk. Each criteria was given either a 1 or 2 rating based on how we felt the design fit into that category, 1 being less and 2 being more. At the end of rankings, the Design 1 ended up with the higher total, meaning that it fit our design criteria better than Design 2.

We determined that both designs are perfectly feasible with the components they require giving both a rank of 2. For reliability, Design 1 held the edge since it introduced a relay into the circuit, reducing the load on the fan and giving it a longer life. With this additional component, it also means Design 1 is more complex giving it a rank of 2 compared to Design 2. Since the relay was the most expensive part in the circuit it increased the total price of the solution higher than what Design 2 was. Therefore, we gave Design 2 the advantage. Also because of less numbers of parts, Design 2 came out on top in terms of scalability and future improvements. Our last criteria is risk. We determined that both designs with their differences presented the same amount of risk. As a result we decided to move forward with Design 1.

	Design 1	Design 2
Feasibility (5)	2	2
Reliability (4)	2	1
Complexity (3)	2	1
Price Point (2)	1	2
Scalability (2)	1	2
Risk (1)	1	1
Total	29	26

FIGURE 3: WEIGHTED CRITERIA DESIGN MATRIX

3.2 Future Advancements

As with any engineered solution, one must continually make improvements to a) make the solution competitive within the economic market and b) make the solution safer/cost effective for consumers. We have determined multiple options for future advancements that can accomplish these goals as well as lessen the financial impact of production. One option is to have the fan physically connected to a servo motor so that it turns the direction based on where the radar sensor detected an object was present. It adds some complexity to the overall circuit, but simplicity to the user. Another option is a fan the can be programmed to spin at different speeds based on either changing ambient temperatures or what the user might choose. Again, this makes the overall design more complex, but delivers a better experience for the user. Our last option is to include fusing within our circuits to protect against shorting and safety issues that arise with that.

4. CONCLUSIONS

Based on the above explanation of the materials and methods as well as the results and choosing design one we believe that this design could have a very beneficial impact on many lives. This simple automation can be scaled to many different sizes to impact many different sizes of commercial or residential buildings. The use of this technology in a smaller, yet no less impactful, way can open any doors to those with mobility limitations or those who simply require a hands off solution to comfort and cooling.

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