ELEC 327 Final Report

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1 Introduction

For our final project, we wanted to design something that was both interesting and practical, so we decided to create a radar gun. We have always been fascinated on how the device worked, and thought it could be useful for our beer bike teams for them to measure the speed of the bikers. We designed the device to use ultrasonic sensor to measure the speed of the object, a LED display module to display the speed, and a buzzer plus LEDS to sound when it is above a certain speed. Finally, for the device we decided to use the components listed below:

2 Project Design

Bill of Materials:

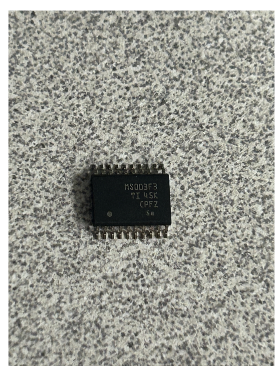
- Custom PCB

- HC-SR04 Ultrasonic Sensor (2 cm–450 cm)

- 10 $k\Omega$ Potentiometer

- 1602 LED Display Module

- MS0003F3 IC Board



- TDK PS1440PB02BT Through-hole Buzzer

- Multicolor LEDs

2.1 Special Sensor Used Breakdown

The only special sensor we decided to use was the ultrasonic sensor. Initially, we considered using two IR sensors over a certain distance, as they would measure the time it took to travel that distance, making both the concept and code implementation simpler. However, in the end, we decided to use the ultrasonic sensor as it allowed for a more flexible measurement of the object's speed rather than needing the object to move in a straight line. Additionally, it allowed us to measure the object at a further distance and with greater accuracy.

2.2 Design Process

2.2.1 Conceptual Design

To start off with designing and making a radar gun using only the supplies above caused us to have several design iterations of the device. One of our first designs of the circuit can be seen with **Figure 1** below:

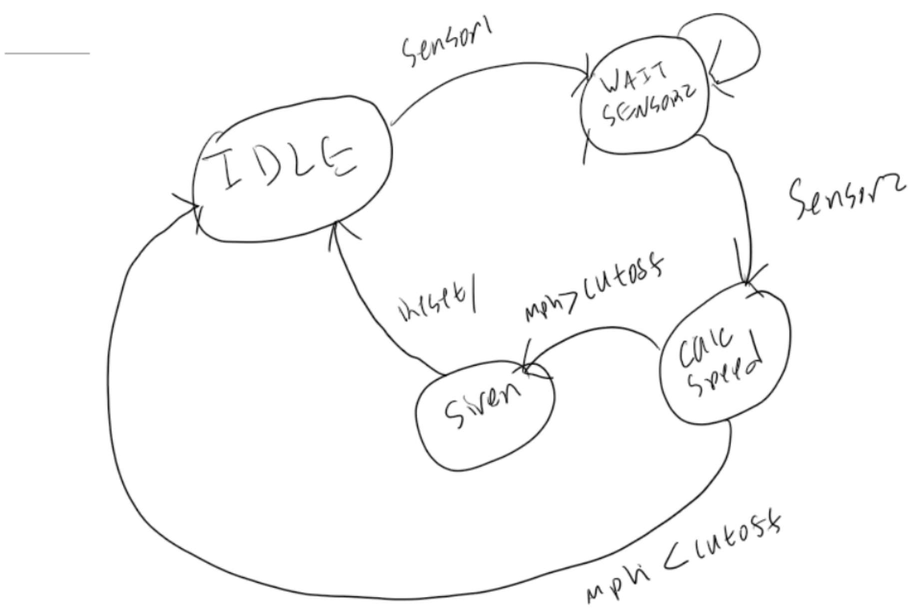


Figure 1: Conceptual Design of the Radar Gun Circuit

In the diagram we had four states of **Idle, Wait For Sensor, Calculate Speed, and Siren** and here is a breakdown of each phase:

- **Idle:** The system remains quiet with no active outputs until the first beam break (Sensor_1) is detected.
- **Wait for Sensor:** Upon activation of Sensor_1, the system records the initial timestamp t_1 and transitions to this state, awaiting the second beam break (Sensor_2).
- **Calculate Speed:** When Sensor_2 triggers, the system captures the second timestamp t_2, computes the elapsed time
$$\Delta t = t_2 - t_1,$$
and calculates the vehicle speed
$$v = \frac{d}{\Delta t},$$
where d is the known sensor spacing. The result is then converted to miles per hour.
- **Decision and Siren:** The calculated speed v is compared against the predefined threshold v_{cutoff}. If
$$v > v_{\text{cutoff}},$$
the FSM enters the *Siren* state, activating the buzzer and LED. After, it resets directly back to *Idle*.

2.2.2 Major Mistake

Despite working on the PCB together, our group forgot to add programming headers to our Speed Gun PCB. This caused us to have two options: either take three of the thinnest wires and solder them directly onto the pins we need access to, or reorder the PCBs and lose valuable time waiting for them to arrive. We spent a whole afternoon attempting the first option, but were not able to have it stick. Therefore, in addition for device stability, we decided to wait for the reordered PCB. In the meantime we decided to finish the code of our project, but we couldn't be sure as we couldn't even test if our code work because we didn't have the PCB. The PCB was able to arrive in time, but they arrived on the last day of class so we really had to rush to get our project done.

2.2.3 Final Design

For our final design, we simplified the circuit to only three stages of **Siren Off, Calculations, and Siren On**:

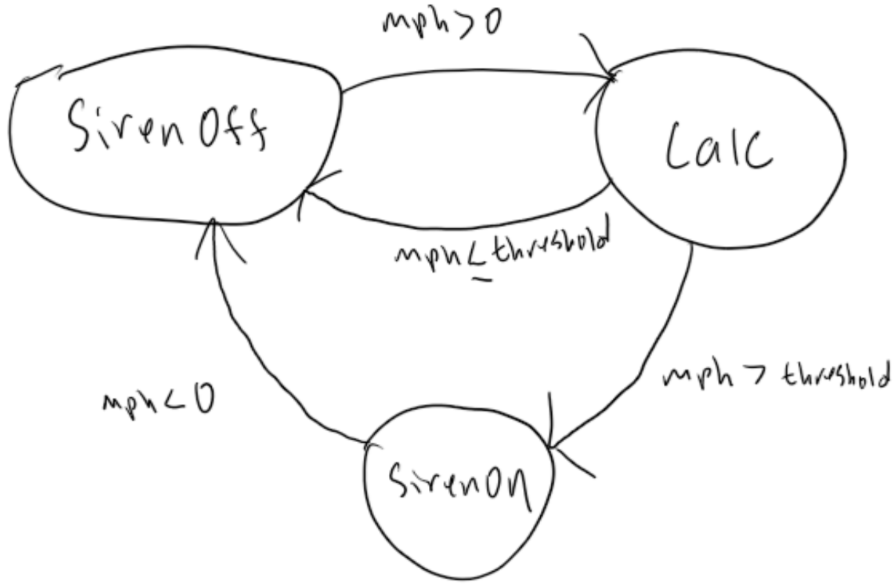


Figure 2: Final Design of the Radar Gun Circuit

Here's a breakdown of each stage:

- **Calculate (Calc):**
  - Compute v from the timestamps captured at Sensor_1 and Sensor_2.
  - If $v > v_{\text{th}}$, transition to `Siren On`.
  - Otherwise (i.e. $0 \leq v \leq v_{\text{th}}$), transition to `Siren Off`.
- **Siren On:**
  - Activate visual/auditory alerts.
  - As soon as $v < 0$ (object has passed beyond detection), transition to `Siren Off`.
- **Siren Off:**
  - Deactivate any alarms.
  - When $v > 0$ (new object detected), return to `Calculate`.

3 Code of Project

https://github.com/BrianoAden/RadarGun/tree/main

4 Conclusion

All in all, our final system worked really well with the sensors calulating the speed of the object with high accuracy. With further time, we could see future improvements such as adding a wireless aspect through adding bluetooth or Wifi modules or better user interface improvements such as adding a menu option for different modes. Through this project we were able to learn a lot of information from all aspects of electrical engineering from custom designing our PCB board to coding up the necessary algorithm for the project to function. This project was also great for us to see the real world application of all that we have learned in class and really put our knowledge to the test.