Parking Sensor

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– ECE 09.321: Parking Sensor –

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1 Design Overview

The goal of this project is to build a parking sensor to detect how close the target vehicle is to another object while reversing. This is done by using an ultra sonic sensor to determine the distance from the nearest object and display this for the driver over UART. Along with this 5 sequential LEDs are lit up as the driver approaches the nearest object. These distances will be preset but can be altered by the user at anytime if desired via UART.

1.1 Design Features

This project has many different features all of which can be seen in the list below.

- Detects the vehicles distance from another car while reversing
- Displays the distance over UART for the user
- Lights 5 sequential LEDs to alert user they are nearing a vehicle
- User can set different values for the LEDs distance threshold over UART
- Brighter final LED (red) to alert user

1.2 Featured Applications

This project is intended to be used as a parking sensor for vehicles but can be applied for use in other applications as well. Below is a list of just a few applications this sensor could be used for.

- Parking Sensor
- Safe Driving distance sensor
- Home Alarm systems

1.3 Design Resources

Our code can be found on GitHub through the following link. GitHub Code

1.4 Block Diagram

A block diagram showing the connections can be seen in Figure 1.

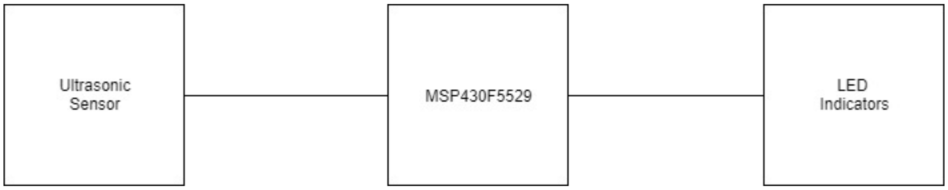

Figure 1: Block Diagram

1.5 Board Image

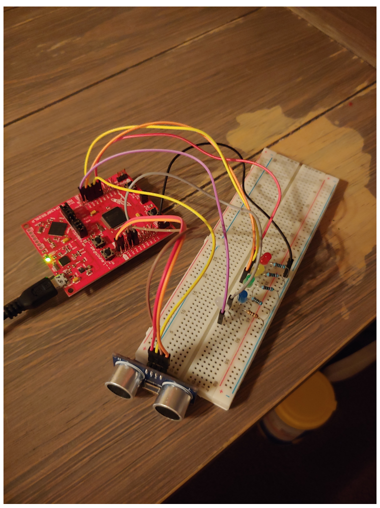

Figure 2: Bread Board Image

2 Key System Specifications

Below is the list of key system specifications including maximum and minimum input parameters.

PARAMETER	SPECIFICATIONS	DETAILS
Maximum Distance	2 meters	Maximum distance that the sensor can operate at.
Minimum Distance	2 centimeters	Minimum distance that the sensor can operate at.
Maximum Input Voltage for LED	14 Volts	The maximum input voltage that the LED indicators can take.
Reverse Voltage for LED	4 Volts	The maximum reverse voltage put across the LED indicators.

3 System Description

The goal of this system is to create a parking sensor that will alert the driver of how far they are from the nearest object behind them. The system as a whole uses an ultra sonic sensor which has its output converted into centimeters in order to be understood. The system also uses a breadboard with 5 LEDs which use the distance read from the other part of the system and compare it with a distance associated for each LED. When the measured distance is less than that of the distance for a certain LED it will become lit alerting the user. The final part of this system is UART which displays the distance in centimeters to the user and allows them to change the value each LED will turn on at if desired.

3.1 Detailed Block Diagram

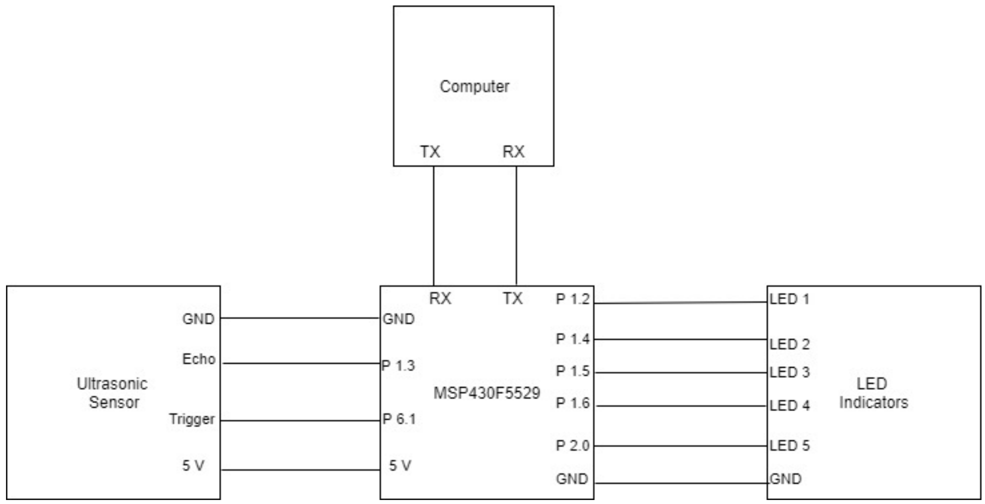

Figure 3: Detailed Block Diagram

3.2 Highlighted Devices

Below is a list of key components used in our system.

- MSP430F5529: Microcontroller used to control LED indicator lights.
- HC-SR04 Ultrasonic Sensor: Distance sensor used to determine the distance the system is from an object.

3.3 Device/IC 1: MSP430F5529

The MSP430F5529 is a microcontroller made by Texas Instruments. This processor has four timer modules, general purpose I/O pins, 12-bit ADC, and serial communication interfaces. Our system utilizes seven general purpose I/O pins, one for each LED indicator, one to trigger the distance sensor, and one to receive the distance echo from the distance sensor. The system also uses a serial communication interface for UART communication to send new distance values. The microcontroller is responsible for sending a trigger signal to the distance sensor, then calculating a distance from the echo signal received back from the distance sensor. It then must decide which LED indicators need to be lit depending on the distance. It is also responsible for setting which distances the LED indicators are lit for by receiving the distances as a package sent over UART.

3.4 Device/IC 2: HC-SR04 Ultrasonic Sensor

The HC-SR04 Ultrasonic Sensor is a distance sensor made by Mouser Electronics. The sensor takes a 5 Volt supply voltage and a trigger signal input that tells the sensor to start looking for the distance. The trigger input must be at least 10 microseconds long and can be up to 5 Volts. Once triggered, the sensor will send back an echo signal whose length is proportional to the distance an object is from the sensor. The sensor is responsible for calculating the distance and sending back an echo signal every 250 microseconds.

4 SYSTEM DESIGN THEORY

The overall operation of our design revolves around detecting distance using an ultrasonic sensor. The main components responsible for the device's operation are the MSP4305529 microcontroller and the HC-SR04 Ultrasonic sensor. The HC-SR04 uses ultrasonic waves to detect distance by transmitting a wave from one terminal and receiving the reflected wave back in the other. This allows for a fairly accurate distance reading for objects located in front of the sensor for up to 2 meters. Using the output of this device, the ADC on the microcontroller is able to convert the reading to a distance measurement (cm). Based on the distance detected, the five indicator LEDs illuminate accordingly so that the user can gauge the distance.

Each LED is assigned a distance value. Once the object in front of the sensor is equal to or less than the value, the respective LED lights up. UART was also utilized for this project. The UART transmit buffer displayed the distance readings in real time, which adjusted based on the distance detected. The receive buffer was also utilized in setting new distance values. For example, if the user wanted to change the distance thresholds for each LED, this could be done by sending a package of bytes through UART.

4.1 Design Requirement 1: Detect Distance up to Two Meters

This portion of the design included converting an analog signal from the ultrasonic sensor to a digital distance reading. After receiving a value using the sensor, the analog output was input into the ADC of the microcontroller. Converting to a distance measurement involved several things. For one, the value in the TA0CCR2 register had to be read and the last distance measurement was subtracted from it. After doing this, the value had to be scaled by a specific factor located in the data sheet in order to make the correct conversion to distance. Once the distance was correctly detected, it was output to the UART transmit buffer which displayed the readings in RealTerm.

4.2 Design Requirement 2: LED Indication

Five LEDs were connected to various output pins on the MSP430F5529. Each pin was responsible for driving an LED once the respective distance threshold was reached. The order of the LEDs were as follows, white, blue, green, yellow, and red. White indicated the farthest distance while red was the closest. Various thresholds were assigned to each LED, and based on the distance they would light up. These distances could be assigned over UART by sending a package of bytes. These values are stored in the receive buffer which then get assigned to the distance threshold variables. This would allow the user to set the thresholds to be any value, as long as they are within 2 meters, as that is the farthest distance the sensor can detect. The LEDs must remain in the proper order or else they will not function correctly.

5 Getting Started/How to use the device

This section covers the initialization and setup of the system from a mostly hardware standpoint. This section, along with its subsections, will provide instruction on how to configure and optimize the circuit, as well as how to use the overall system. The software aspect of this system is covered in Section 6.

5.1 Configuring the Circuit

The circuit consists of five LEDs each driven by an output pin on the microcontroller. Begin the circuit by connected the annode (long lead) of each LED to its respective output pin. The assignments are as follows:

- White LED - P2.0
- Blue LED - P1.6
- Green LED - P1.5
- Yellow LED - P1.4
- Red LED - P1.2

The cathode of each LED should be connected to ground using a resistor. For this circuit, 100 ohm resistors are recomennded as a minimum value. Depending on the LEDs utilized, the resistance value may need to be altered. After configuring the LEDs, the ultrasonic sensor is configured. The VCC and GND terminals are connected to the 5V and GND pins on the MSP430F5529. The trigger terminal is connected to P6.1 and the echo terminal is connected to P1.3. Ensure that the ground pin is connected to the LEDs as well. The circuit has now been configured correctly.

6 Getting Started Software/Firmware

Once the circuit is configured, the rest of the setup is done through software. The following sections will cover executing the code and setting and receiving the distances. A hierarchy chart of the system is also provided. On the software end, two programs are needed to interface with the system.

- Code Composer Studio 8.1.0
- RealTerm or PuTTY

Code Composer is used to run the code and send it to the microcontroller. Once the code is flashed to the controller, code composer is no longer needed as the program will be stored on the microcontroller until removed or overwritten. As for RealTerm, this is used to communicate with the system and provide the distances in real time as well as change them.

6.1 Hierarchy Chart

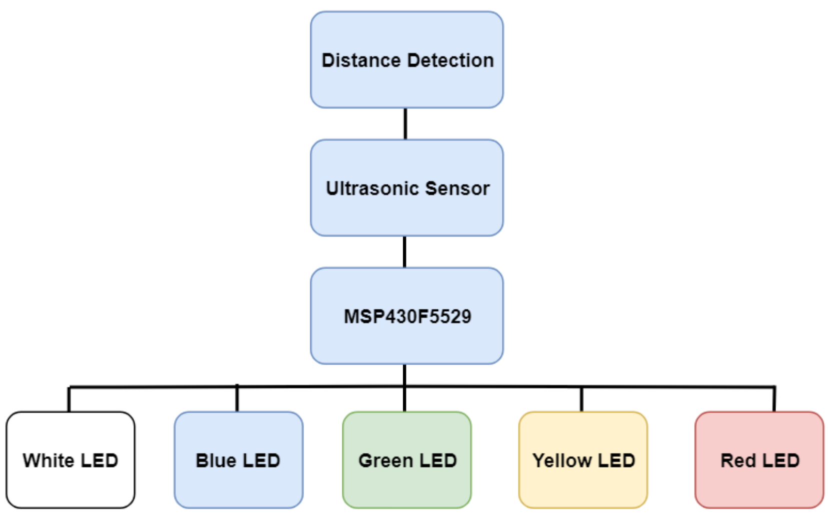

Figure 4: System Hierarchy Chart

6.2 Communicating with the Device

The parking sensor system is communicated with over UART. This can be done using any serial terminal including RealTerm or PuTTY. The serial terminal must be connected and set to the correct port where the microcontroller is connected. Now that the terminal is correctly set up, the distance at which each LED turns on can be set over UART. The distances can be set by sending them, separated by spaces, through the UART terminal.

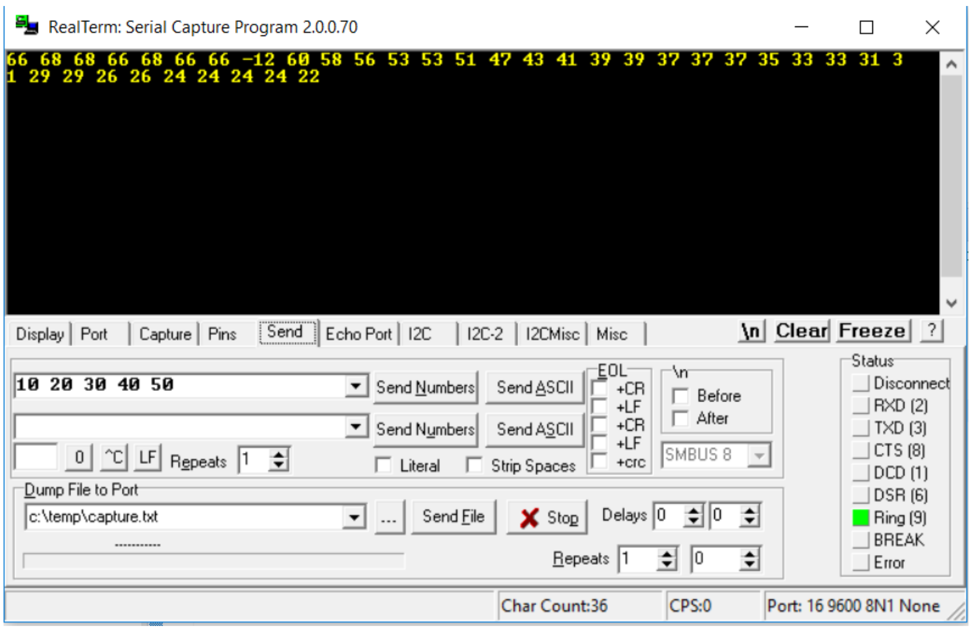

Figure 5: Example of Distances Sent Over UART

Figure 5 shows an example of setting the distances to 10, 20, 30, 40 and 50 centimeters using RealTerm. The distances will be set after the numbers have been sent using the send numbers button.

7 Test Setup

In order to test this device first the code must be compiled and transferred to the MSP430F5529. Once this is done the schematic seen in part 8 must also be constructed and have the correct pins connected to the LEDs. After that the ultra sonic sensor must be connected to the micro controller. On the ultra sonic sensor the Vcc pin is connected to 5V, the GND pin is connected to ground, the trigger pin is con-

nected to pin 6.1, and the echo pin must be connected to pin 1.3. Once this is completed the micro controller needs power and UART must be set up.
The UART setup for this is quite simple the baud rate must be set to 9600 and the port the micro controller is connected to must be selected. Finally set the output to integers and it will begin displaying the distance read from the sensor.

7.1 Test Data

The data for this project consists of the UART distance displayed and the LEDs lighting up in the proper order as the sensor nears and object. Figure 6 shows the UART displaying the sensors distance.

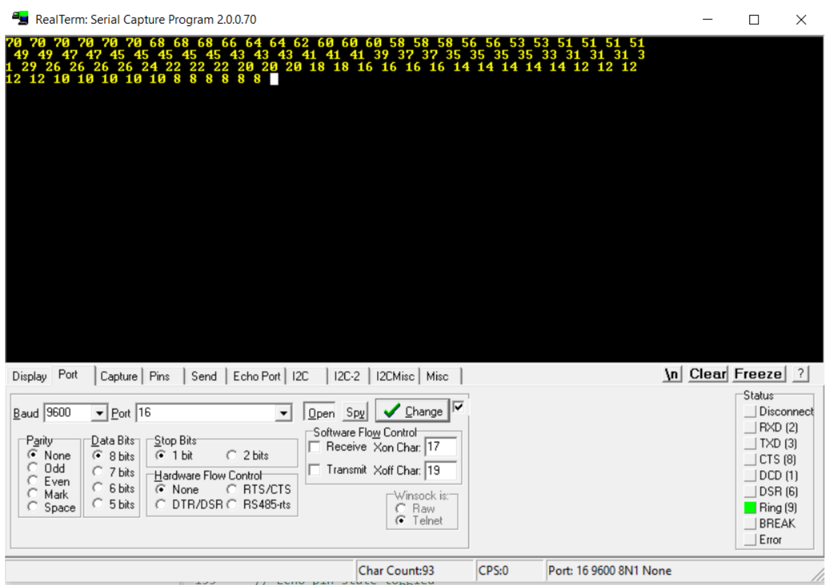

Figure 6: UART Distance Display

Along with the UART displaying distance the LEDs also began to light up which can be seen in Figure 7.

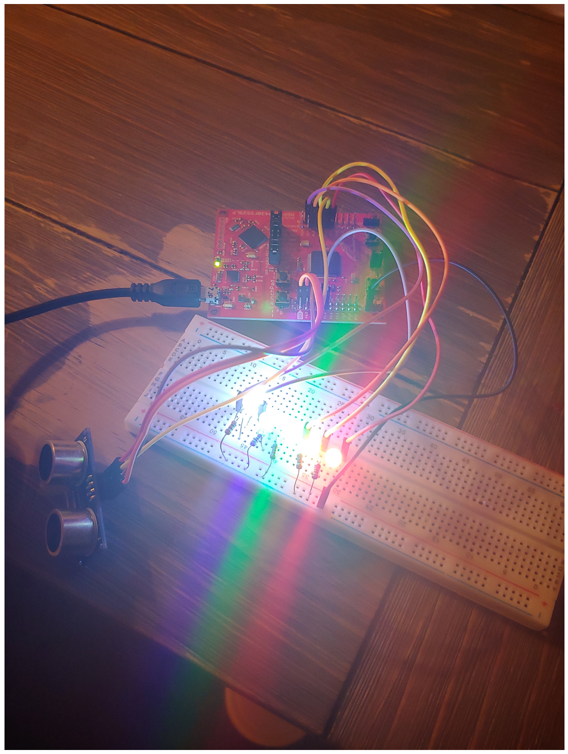

Figure 7: LED Test Data

8 Design Files

8.1 Schematics

This project only required one simple schematic to be built. The circuit does contain a convert-o-box on the red LED that will deliver increased current to make it brighter than the others. This was done as a final warning for the user. The schematic for this project can be seen in figure 8.

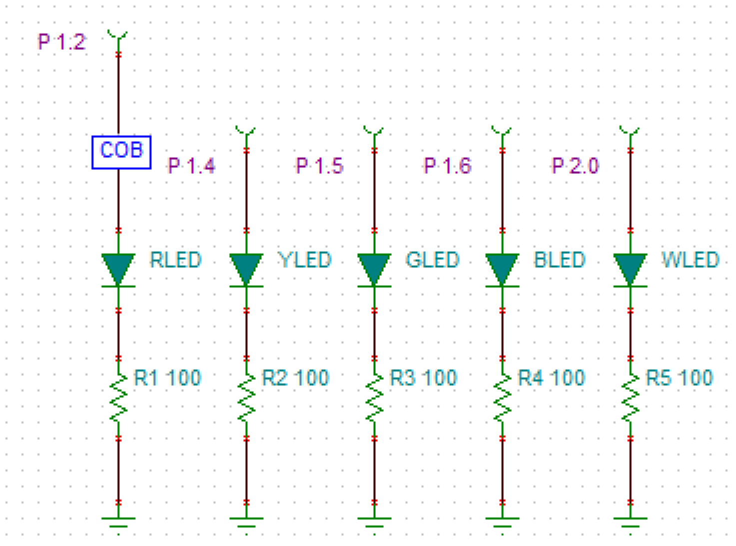

Figure 8: LED Schematic

Another schematic file was created to show how the ultrasonic sensor is connected. This also contains a convert-o-box as the value from the ultrasonic sensor is normally useless and needs to be converted to metric. This is the purpose of this COB and this schematic can be seen in Figure 9.

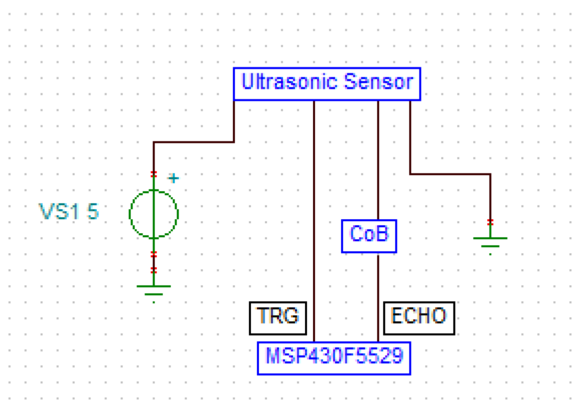

Figure 9: Sensor Schematic

8.2 Bill of Materials

- 1 MSP430F5529
- 5 100 Ohm resistors
- 5 LEDs ”preferably different colors”
- 1 HC-SR04 Ultra sonic sensor
- 1 Power supply

8.3 PCB Layout

This section contains the first draft of the PCB layout for this project. Further revision must be made on this PCB before it should be printed. Figure 10 shows this draft of the PCB.

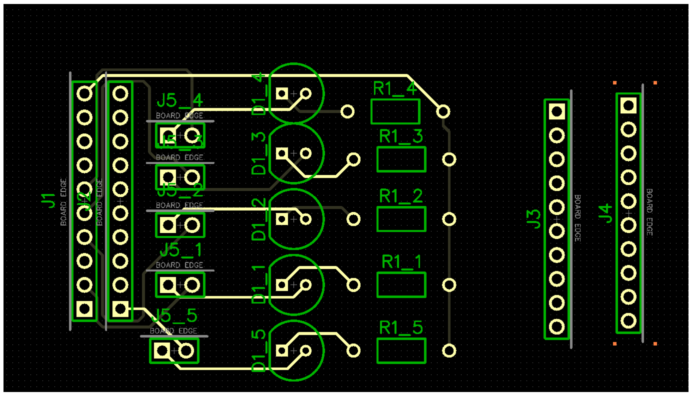

Figure 10: PCB layout