Door Counter

Patrick Wilk
Rowan University

December 21, 2018

1 Design Overview

The goal of this project was to solve a problem encountered at the Rowan Rec-Center. Upon entering the gym the receptionist must scan an ID walk over to a button and press on it in order to keep track of how many people entered. To count without the time waste, a design using a proximity sensor was created. When the sensor read a distance, using ultrasonic waves, below the set value it counted up. The distance reset and count transmitted to a device using UART.

1.1 Design Features

These are the design features:

- A distance value can be set to work in various sized pathways
- Counts the number of people crossing sensor
- Displays the count on the device over UART
- Uses LED to show when someone has crossed
- Can be reset by sending ”0” over UART

1.2 Featured Applications

This project was created to be used as a door-counter for areas that become crowded such as the gym. Other applications for the sensor are listed below:

- Motion sensor for security systems
- Large events for crowd counting
- Small businesses to know peak busyness times

1.3 Design Resources

My code can be found through this link:
https://github.com/RU09342-F18/intro-to-embedded-final-project-wilk/blob/master/Code

1.4 Block Diagram

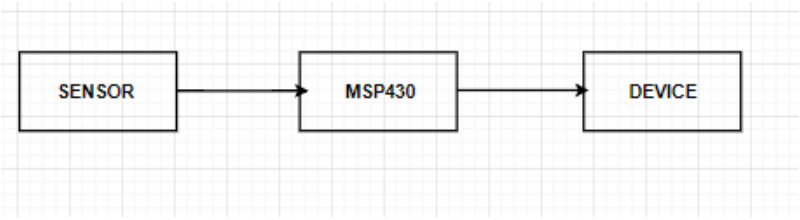

Figure 1: Block Diagram of Door Senor

1.5 Board Image

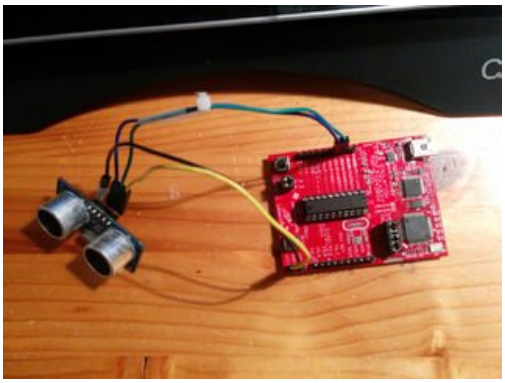

Figure 2: Board Circuit

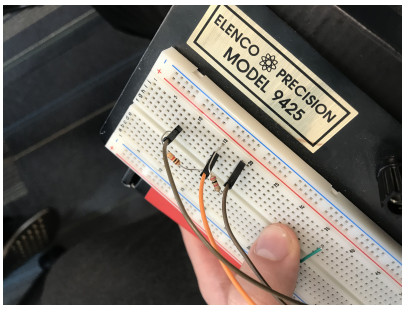

Figure 3: Board Voltage Divider

2 Key System Specifications

Below is the list of specifications for the device.

PARAMETER	SPECIFICATIONS	DETAILS
Maximum Sensor Voltage	5V	Maximum input voltage parameter
Maximum Distance	2 meters	Max distance the sensor can read
Minimum Distance	2 centimeters	Minimum distance the sensor can read parameter
Voltage divider	3.333V	1k and 2k resistor

3 System Description

The goal of this system is to count the number of people walking through a doorway. It would be attached about 2-3 feet off the ground onto the side of the door frame. The system uses an ultrasonic sensor which emits and receives sound waves. Using a simple equation of speed of sound and time for the waves to return it finds distance. If the distance of the sensor is set to be slightly smaller than the doorway, any distance smaller than the set value will alert the controller. A smaller distance means someone has passed and the count will increase by one. UART is used to display the count on a device, in this case a laptop. UART also allows the user to set different doorway distances and reset the system by sending ”0”.

3.1 Detailed Block Diagram

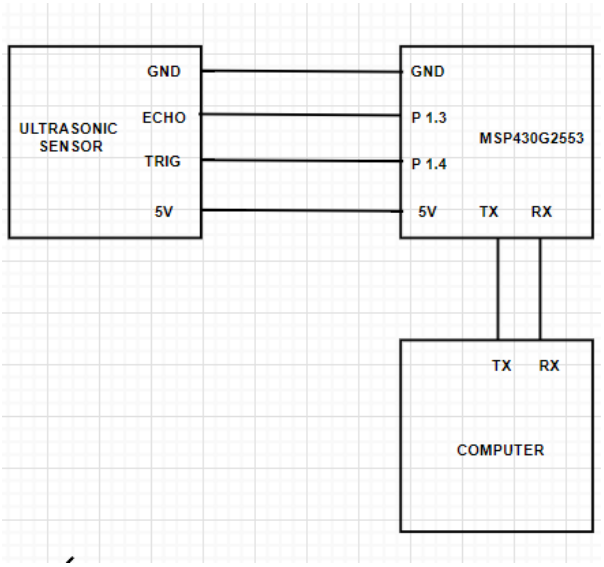

Figure 4: Detailed Block Diagram

3.2 Highlighted Devices

Below are the main components of the system

- MSP430G2553: Micro-controller used for inputs, outputs, and serial communication
- LM324 Ultrasonic Sensor: Proximity sensor for determining distance and movement

3.3 Device/IC 1: MSP430G2553

The MSP430G2553 is a micro-controller produced by Texas Instruments. The micro-controller has two 16-Bit Timer_A with three capture/compare registers, general purpose I/O Pins, Universal Serial Communication Interface (USCI). The door-counter system uses an output pin to trigger the sensor and an input pin to receive the echo from the sensor. The system uses UART to communicate the number of people that have walked by to the user, as well as allows the user to input a distance and reset the count. The micro-controller sends a signal to the trigger of the sensor and calculates the distance by analyzing the echo signal received. It then decides if the distance calculated is less than or greater than the set distance. If the distance is greater the sensor keeps looking for distance and once it is less it counts up. The micro-controller than displays the count on the device through UART.

3.4 Device/IC 2; LM324 Ultrasonic Sensor

The LM324 Ultrasonic Sensor or HC- SR04 is a proximity sensor which uses sound waves. The trigger must be high for at least 10us to send 8 40kHz and waits for a returning signal. The returning echo signal's length is proportional to the distance from the sensor to the object. The distance can be calculated by (high level time x velocity of sound (340M/s) /2. From the data-sheet equations can be found to find distance in centimeters or inches.

4 SYSTEM DESIGN THEORY

The purpose of the design was to detect movement using a change in distance through an ultrasonic sensor. Two main components were used to operate the system. The LM324 proximity sensor sends and receives ultrasonic waves and finds time. With time distance can be solved using velocity. This gives a fairly accurate distance reading for objects located near the sensor. The micro-controller takes the signal from the ECHO port on the sensor and converts the time of the signal to distance in centimeters. From the distances being calculated, the MSP430 can compare distances to see if movement has occurred. If there is change in distance there is movement.

If the movement occurs below the set distance UART is initialized. UART sends a count to the device (laptop) and is incremented each time detected movement occurs. The count is displayed in real time. The receive buffer was used to set different distance values depending on the wideness of the doorway and to reset the count by sending a "0".

4.1 Design Requirement 1: Detect Distance

The main design was to find a digital distance reading that can be understood, by converting an analog signal from the proximity sensor. The sensor sent a time value, which was an analog output into the ADC of the micro-controller. This value was then converted. CCR0 was set to 1000 so that timer counted up to 1000 at 1MHz. so 1 millisecond. Every time the timer counts to 1000 it triggers an interrupt. In interrupt, 1 was added to int milliseconds and there was a reset. So, when the interrupt occurred the signal has rising edge, and milliseconds are reset to 0. The program leaves the interrupt and waits for the falling edge while milliseconds are running. When interrupt occurs again, we have falling edge and use milliseconds as time between edges. This gave the length of the ECHO. Distance in centimeters was found by dividing by 58 or 148 for inches (from data sheet).

4.2 Design Requirement 2: Count Display

Using the distance, motion can be detected. The trigger sends a sound wave that returns or does not. If it does not return there is no object in front of the sensor or it is further than 2 meters away. Once, a reachable distance can be read the

sensor constantly calculates distance. The micro-controller continues to compare the distances to the set distance. If there is a change, this means that there was an interference between the set distance. The interference (someone walking by) sends a shorter echo which increments the count. This count increments with a one second delay every time the sensor reads a shorter distance. The delay is needed so the count does not jump to 20 or a high number, due to the sensor receiving multiple shorter distances in a short period of time. The count is then sent over UART, serial communication, to the laptop and is displayed.

5 Getting Started/How to use the device

This section covers how to build the system including the circuit, setting up pins, and powering the system.

5.1 Configuring Circuit

The circuit can be powered off of the MSP430. The MSP430 provides both a 5V supply and a ground. Of course the board is powered by a micro-USB 2.0. The 5V (Vcc) powers the ultrasonic sensor and uses the common ground. The Trig and Echo pin on the sensor are connected to the MSP430 as so:

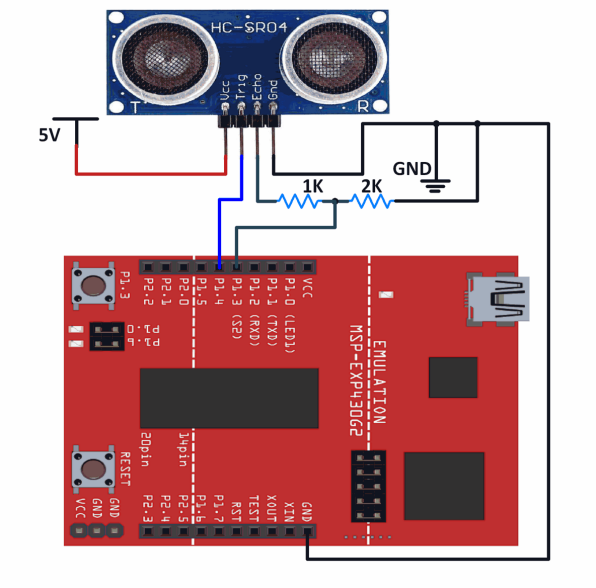

Figure 5: Picture Circuit Diagram

The 1k and 2k resistors were used to make a voltage divider. Since the Echo sends back a pulse of voltage that is 5V is must be converted back to 3.3. With the

voltage divider this was possible. Equation 1 was used to find resistance:

$$Vo = \frac{ViR1}{(R1 + R2)} \tag{1}$$

6 Getting Started Software/Firmware

Once the circuit is setup, the rest is completed through software. The following sections cover how to flash the code and receive count. Two programs are needed to make the system work:

- Code Composer Studio 8.1.0
- RealTerm

Code Composer is used to write the code and flash it to the micro-controller. Once the code is debugged and flashed, the micro-controller stores the instructions unless overwritten. RealTerm, is used to communicate with the system to display the count in real time, as well as to set distance and reset the count.

6.1 Hierarchy Chart

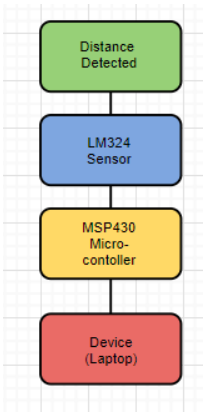

Figure 6: Detailed Block Diagram

6.2 Communicating with the Device

The Door Counter system is communicated with over UART. RealTerm, a serial terminal, was configured properly by setting the correct port and baud rate. The baud rate set in the code was 9600. In order to display integers ”int8” must be selected. Figure 7 shows the RealTerm display for configuration.

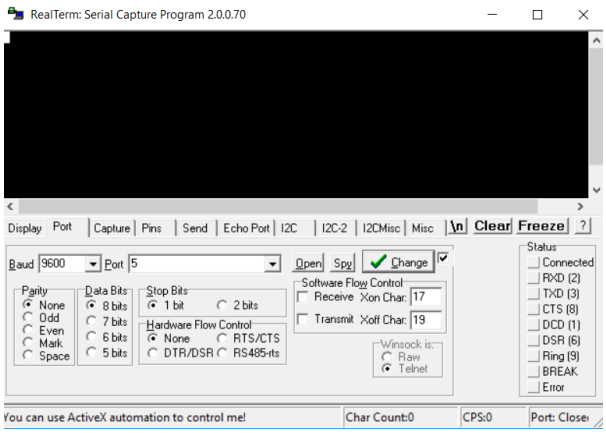

Figure 7: RealTerm UART

7 Test Setup

To test the Door Counter system the code on Code Composer was compiled which flashed it to the MSP430G2553, if it compiled successfully. After, the circuit from Figure 5 was constructed with the 5V from the controller connected to the sensor with all the grounds also connected to the controller. Next, UART must be setup through RealTerm. The port and baud rate must be set accordingly. The baud rate is always 9600 but the port may change and has to be checked in device manager. Finally, in the display tab int8 must be chosen to display integers for the count.

7.1 Test Data

The data of this system is to display the count of people walking past the sensor. Figure 8 shows the UART display of the count.

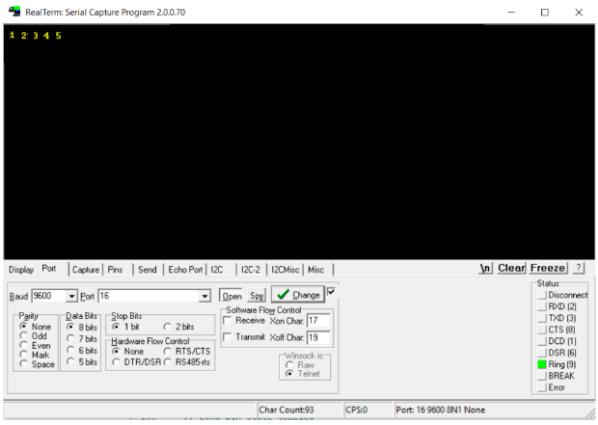

Figure 8: UART Count Display

8 Design Files

8.1 Schematics

This project required a simple circuit with all power coming from the MSP430 controller. The schematic for the system can be seen in Figure 9.

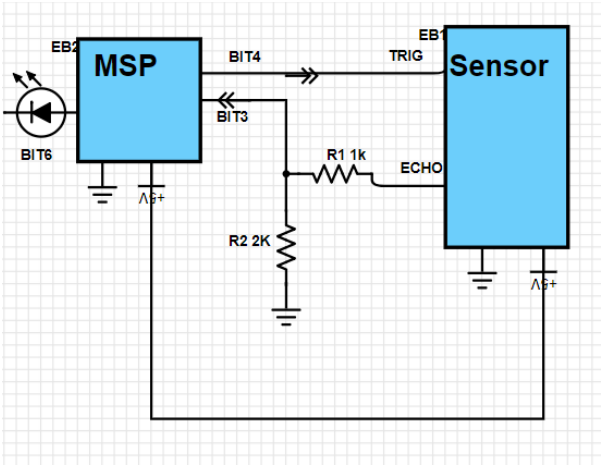

Figure 9: UART Count Display

8.2 Bill of Materials

- MSP430G2553 - $25

- 1,000 Resistor - 10 cents
- 2,000 Resistor - 10 cents
- LM324 Ultrasonic Sensor - $4
- Total = $ 29.20

9 References

- https://www.electronicwings.com/ti-launchpad/ultrasonic-sensor-hc-sr04-interfacing-with-msp-exp430g2-ti-launchpad
- https://www.digikey.com/schemeit/project/
- https://www.instructables.com/id/Ultrasonic-Sensor-with-MSP430-and-IARCCS/
- https://www.draw.io/
- http://www.ti.com/product/MSP430G2553
- https://www.mouser.com/datasheet/2/813/HCSR04-1022824.pdf