Grad Project Report

Description:

The objective was to design a digital distance measuring device used to measure the size of the room. This range is from 0.2 to 4m. We use an ultrasonic sensor and an input and display the calculated value on a seven-segment LED display. The display gives real-time values of the distance in meters.

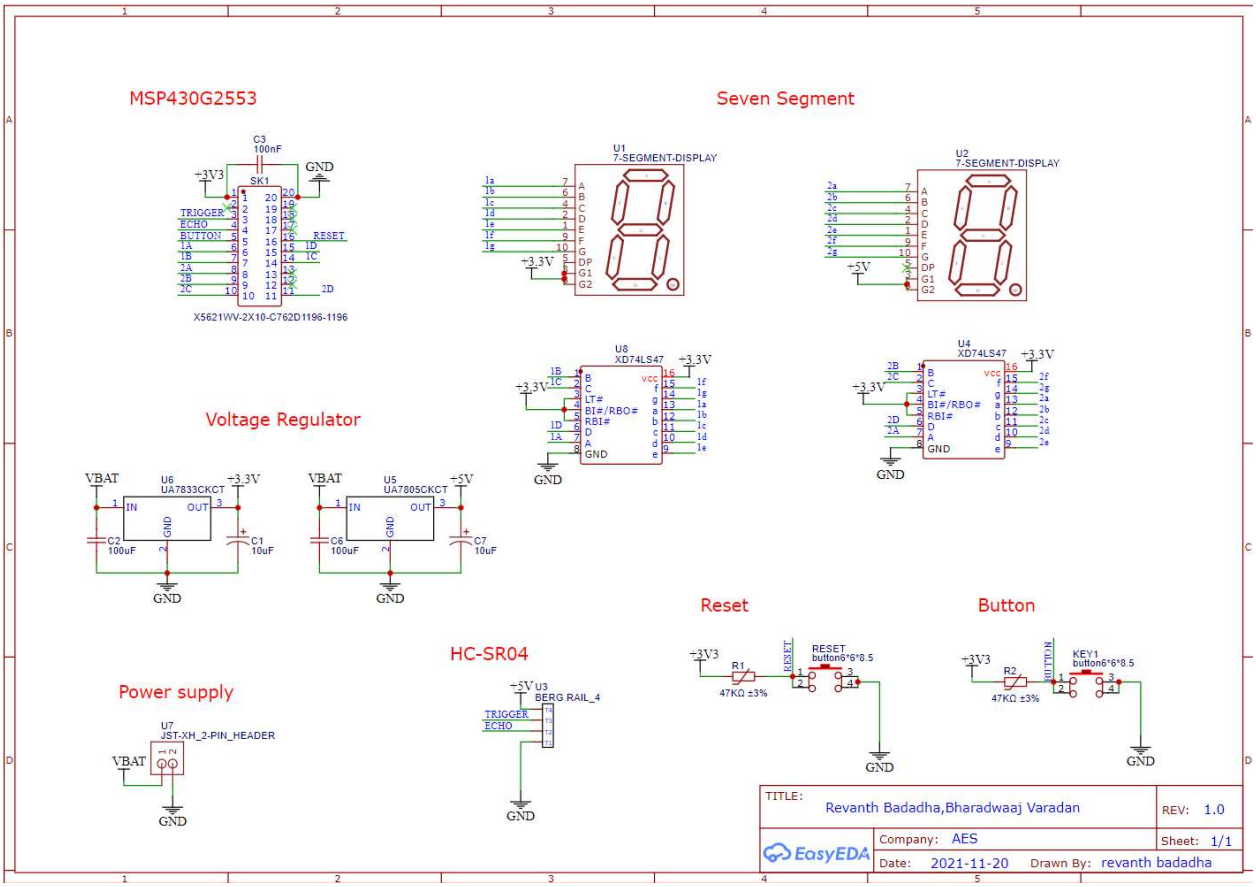
The MSP430 microcontroller is being used and mounted on a user-built perf board. (MSP430 Launchpad board not used). The MSP430G2553 is a 10 pin DIP chip with peripherals and a flexible system clock and it works on a 3.3V power supply. The mcu has 2 ports with 8 GPIO pins each. Since we need to connect 2 seven segment displays, which require 7 pins each thus leaving us no space on the mcu for connecting the sensor. To solve this issue, We used a 74LS47-BCD to seven segment decoder which only requires 4 pins to the microcontroller. The driver IC takes in a BCD(binary coded decimal) value and outputs the required led on a seven-segment. This method decreases the number of connections between the microcontroller and the seven segments thus allowing us the benefit of the remaining GPIO pins.

The ultrasonic sensor measures the distance to an object using ultrasonic sound waves. The sensor determines the distance of an object by calculating the time lapse between the trigger pulse and the echo pulse. It works on a 5V power supply, hence we are using the LM7805 voltage regulator.

All the components are assembled on a perf board keeping in mind that the ultrasonic sensor is pointed towards the direction we want to measure the distance and the seven-segment display is placed towards the user along with a button to pause and reset the display. We are providing a 9V battery power supply. Voltage regulators are used for the sensor(9V to 5V) and msp430(9V to 3.3V).

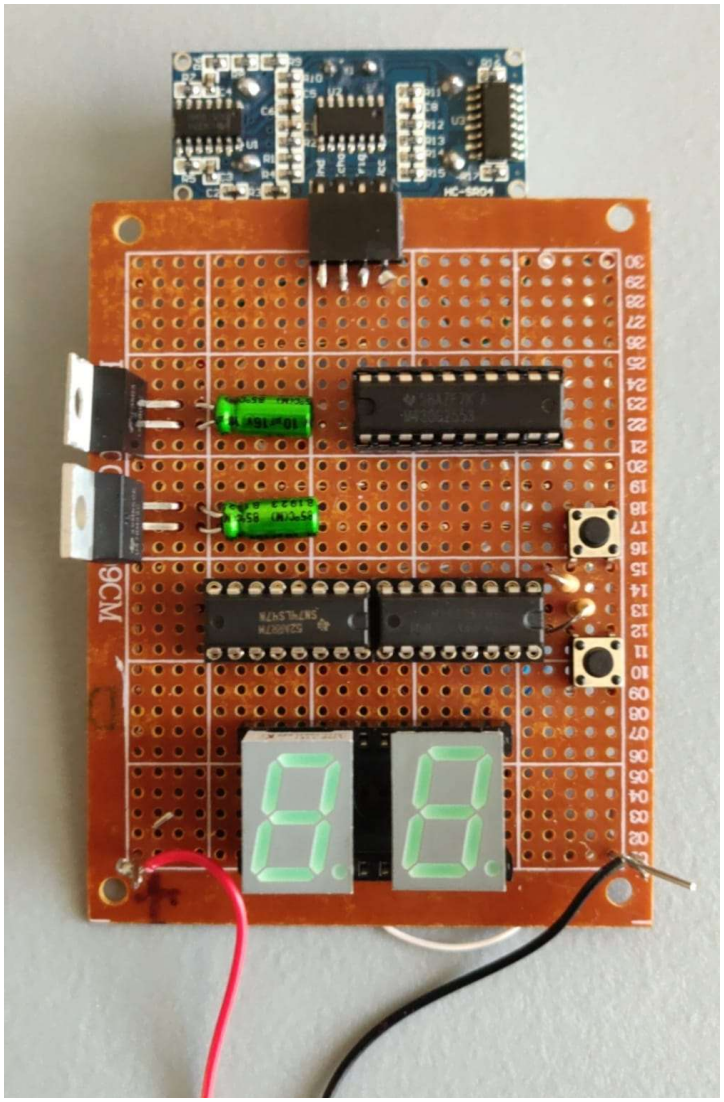
The approach to software was a step-by-step process.The program was written on Code composer studio. We performed unit testing and took time to understand the calculation required while converting the data obtained from the ultrasonic sensor to distance in meters. After successfully completing unit testing we moved onto integration testing.

Hardware design:

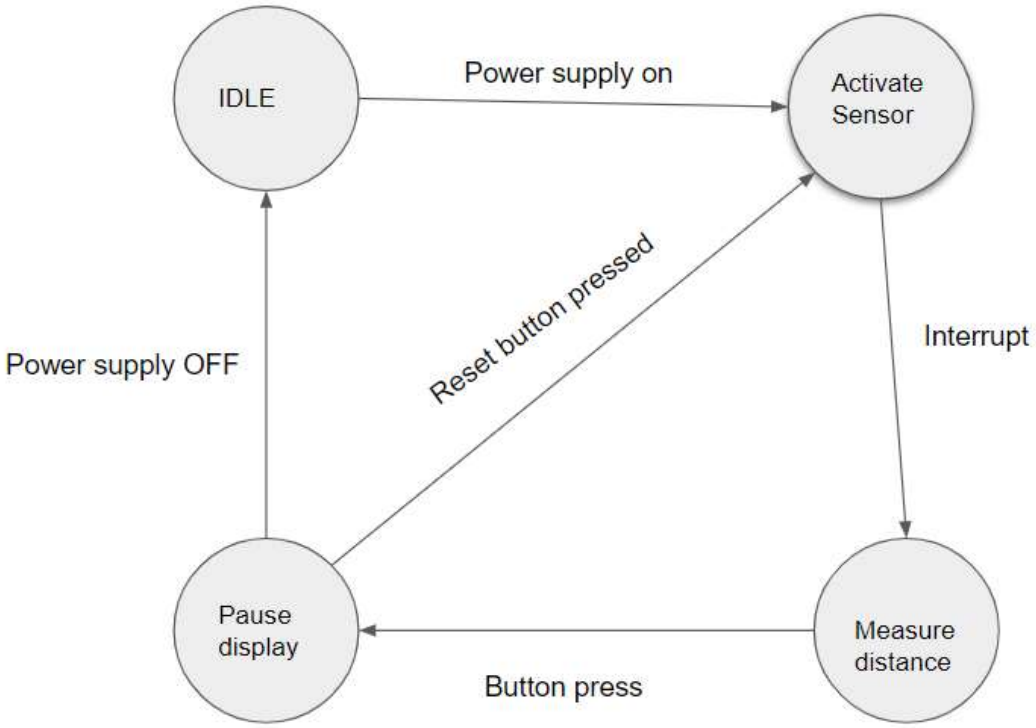


We designed our circuit on the EasyEda website which was a very flexible tool to use. The schematics contain all the required components and connections based on our requirements. The connections were all made by referring to the datasheets. There are some requirements that need to be met for a safe and efficient way of design. For example, a 100nF decoupling capacitor is placed between vcc and gnd of the microcontroller to suppress high-frequency noise in power supply signals and acts as a local power supply if the power supply drops the voltage temporarily. A 47K ohms is pulled up on the reset pin to ensure the voltage between Ground and Vcc is actively controlled when the switch is open.

Perf board design:



State Diagram:



The above diagram illustrates the working states of the design. The system will stay in idle state unless power supply is provided. Once that is given, the sensor is activated and sends a trigger pulse for 10us and waits for it to echo back which is received on echo pin. A timer is started while waiting for the echo. If it crosses 30us, the timer resets to 0 and the trigger pulse is sent again.when the echo pulse is receiver, it interrupts the microcontroller and calculates the time difference to measure the distance. If a button is pressed, an interrupt is triggered and the value on seven segments is paused which will reset after reset is pressed.

Algorithm

- The trigger pin is made high for 10us and turned OFF.
- The timer capture method is used to measure the time between echo high and echo low.
- An equation is used to calculate echo length where msec is the time between echo high and echo low.
- Then we divide the sensor value by 58 and depending on the distance value appropriate pins of MSP430 are made high which act as input for IC 7447
- Output pins of IC 7447 are connected to the seven-segment display.

Problems Encountered:

- There was a problem with the cost and delivery dates of PCBs which led us to solder our circuit on a perf board. It was a difficult task to accommodate all the components in a small space to fit our size.
- Wiring the circuit without shorting took a lot more time than expected. Even Though there were no wires shorted or mismatched, the board did not seem to work properly. We had to test continuity on each wiring and find the faulty wiring.
- The requirement of a switch when pressed to pause the display was difficult to implement. Even after trying different methods to implement it. It was an unsuccessful attempt.
- The sensor has its own limitations and that includes improper data when echoed back from uneven surfaces or angles.

Learnings:

It was fun designing a real-time embedded system with its own power supply. Though the process of soldering was tedious, It was worth it when the circuit worked. It provided an understanding of the complete approach and design of an embedded system going from designing, components selection, creating an overall BOM(Bill Of Materials), soldering and testing. This project helped in understanding the concepts of interrupts in real-time and other coding concepts that were taught in class.

Overall, This project gave a brief idea of the hardware and software aspects of real-time embedded system design.