Smart Toolbox

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1 Design Overview

The Smart Toolbox is a prototype meant for personal or industry use. The system allows the user to have the ability to monitor the amount of tools currently being used within their workshops. The Smart Toolbox could also determine whether specific tools are being distributed to workers or are simply missing. If any tool is missing from the toolbox, the name of this specific tool will appear on the attached LCD (Liquid Crystal Display) screen, to notify the user what tools are currently missing, without the need to actually look inside the toolbox themselves. In addition, the Smart Toolbox also contains a locking mechanism. In order for the toolbox to be unlocked and accessible, the user would need to enter the correct pass-code. If the user enters the incorrect pass-code, the toolbox will remain locked and its alarm system would activate.

1.1 Design Features

- Tool Detection System
- Display Tool Box Contents
- Pass-code Locking System
- Alarm System
- Bluetooth Speaker
- UART Transmissions

1.2 Featured Applications

- Personal Use
- Industry Use
- Tool Security

1.3 Design Resources

Github Repository:
https://github.com/Intro-To-Embedded-Systems-RU09342/final-project-g00nz/tree/master

1.4 Block Diagram

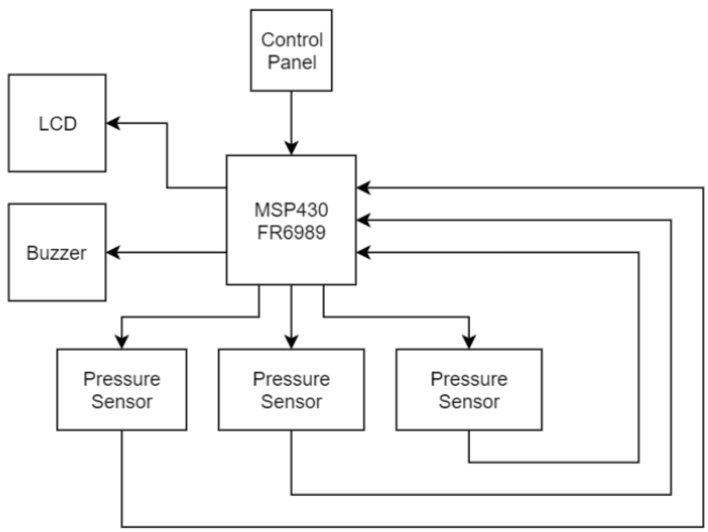


Figure 1: Block Diagram of the Smart Toolbox

1.5 Board Image

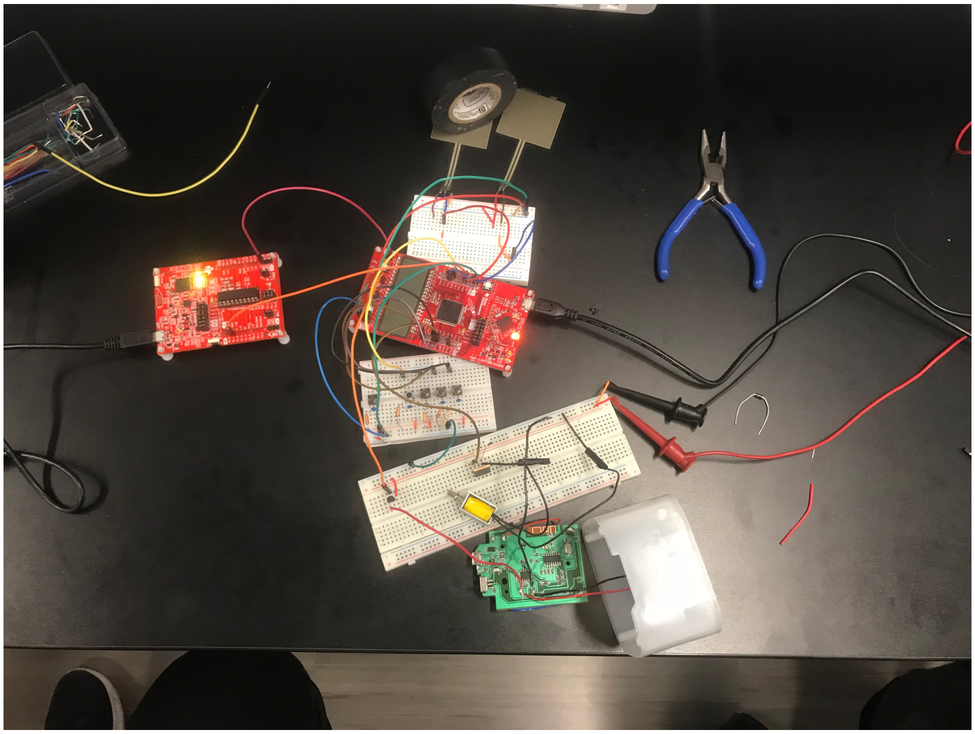


Figure 2: Board Image of the Smart Toolbox

2 Key System Specifications

Parameter	Specification	Detail
LCD	Allow the user to see which tools are missing from the toolbox	Currently using 42 segments, for the 6 separate 7-segment displays
Solenoid	Locking and unlocking the toolbox	Rated for 5V @ 35mA, the arm will pull when excited and push when not
Control Panel	User control panel to lock or unlock device, or initiate tool box content display	5 buttons in total. Left most button is used to initiate content display, 4 right most buttons are used for pass-code input.
Force Sense Resistors	Tools are placed on top of these sensors in order to communicate which tools are present in the toolbox	Two sensors are currently in use for the prototype model to hold two separate tools, and communicate with the micro-controller.
Buzzer	Incorrect input for the pass-code will initiate a buzzing sound	The buzzer is a speaker with a PWM pin attached to it for the alarm system
Bluetooth Speaker	A module separate from our system that allows the user to play music over bluetooth	A separate board that has its own speaker and bluetooth chip, and can play media

3 System Description

The Smart Toolbox is a system built to create a more secure and user-friendly alternative for individuals. A vast majority of toolboxes today lack proper security features such that anybody could access anyone's toolbox without having to enter a specified pass-code to access the tools inside of it. The Smart Toolbox solves this problem as this system contains a pass-code feature to allow the user to create their own unique pass-code to keep their material inside safe and secure. The Smart Toolbox is a password protected system and in the event of the pass-code being entered incorrectly, an alarm system will activate automatically. Force sense resistors are utilized for tools to be placed on top of them, in order to display on the attached LCD screen to inform the user of what tools are currently present or missing from their toolbox.

3.1 Detailed Block Diagram

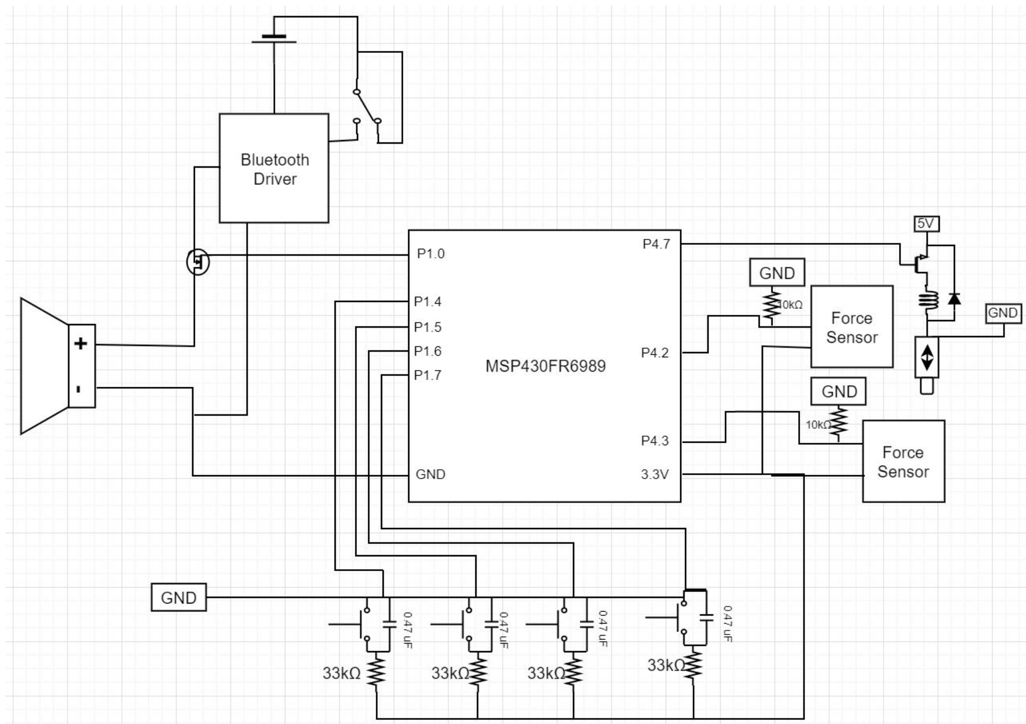


Figure 3: Detailed Block Diagram of the Smart Toolbox

3.2 Highlighted Devices

- MSP430FR6989

  This is the micro controller that is utilized to control the smart toolbox and display the tools that are currently in the toolbox.

- FSR406

  This is the force sense resistor that is utilized to determine whether or not there is a tool present in a specific position.

- Uxcell A14052800UX0914

  This is the solenoid that is utilized in order to lock and unlock the toolbox.

- IRL250

  This is the N-channel MOSFET that is utilized to isolate the micro controller from the higher amperage driving the solenoid.

- buzzer/speaker

  This is the device that is utilized to output a buzzing sound when an incorrect password is entered.

- MSP430G2553

  This micro controller is utilized to communicate with the MSP430FR6989 to display the UART function of this project.

3.3 Device/IC 1

The MSP430FR6989 micro-controller (Figure 4) would be utilized for the system and is primarily responsible for executing the implemented code, written in C, to allow the system to function accordingly. All implemented code for this system is programmed on the MSP430FR6989, allowing it to control the status of the system. The code for this system would include an ADC (Analog-to-Digital Converter) function to read the output voltage value of the point between the force sensor and pull-down resistor and convert the given analog value to a digital value. The micro-controller will register those values and depending on the weight or pressure that was placed, the LCD on the micro-controller will display if the pliers are in the toolbox or the tape. The code itself would also consist of a UART (Universal Asynchronous Receiver-Transmitter) function to allow Realterm, a software program to transmit and receive streams of data, to be utilized when the code is programmed on the micro-controller. Another function the code controls is the combination lock. By pressing certain buttons, the micro-controller will be able to register those buttons and initiate the buzzer to buzz or unlock the solenoid.

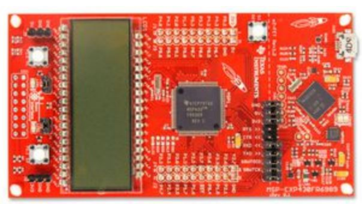
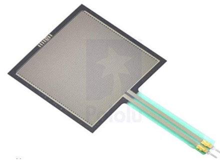


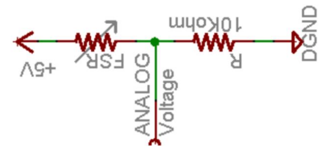
Figure 4: The MSP430FR6989 Micro-controller

3.4 Device/IC 2

A thin sensor that detects physical pressure. This device with a pull-down resistor enables us to determine if an object is on the sensor. The FSR406 (Figure 5) has one terminal connected to power and the other to a pull-down resistor connecting to ground. Then the point between the fixed pull-down resistor and the variable FSR406 resistor is connected to the analog input of the MSP430FR6989 micro-controller.



(a) The FSR406 Force Sensor



(b) Diagram

Figure 5: The Tool Detection

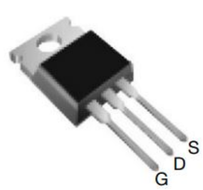
3.5 Device/IC 3

The Uxcell a14052800ux0914 solenoid (Figure 6) is used as a locking mechanism for our smart toolbox. This device is powered with 5V and about 0.83 A to use. It is connected with the micro-controller MSP430FR6989. When powered, the solenoid will retract its arm and then extend the arm when it is not powered.

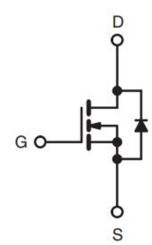
Figure 6: The Uxcell Solenoid Lock

3.6 Device/IC 4

The IRL250 (Figure 7) is the N-channel mosfet that is used to isolate the micro controller from the higher amperage driving the solenoid. Since the solenoid needs 1 A to work properly and must be controlled by the micro controller, a device was needed to ensure that the micro controller would not be exposed to the high current from the solenoid.



(a) IRL520



(b) N-Channel

Figure 7: The IRL520 N-Channel Power Mosfet

3.7 Device/IC 5

The Speaker and bluetooth chip (Figure 8) is used as a buzzer and entertainment center for our smart toolbox. This device is powered with 3.3V. It is connected with the micro-controller MSP430FR6989. The micro-controller is attached to the speaker, and by using a PWM (Pulse Width Modulation) signal, a frequency is generated and is audible from the speaker itself.

Figure 8: Inexpensive Bluetooth Speaker

3.8 Device/IC 6

The MSP430G2553 (Figure 9) micro controller is used to receive the UART transmission from the MSP430FR6989. This transmission would have information about which tools are currently present in the toolbox.

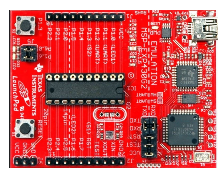


Figure 9: The MPS430G2553 micro controller

4 SYSTEM DESIGN THEORY

The design for the smart toolbox can be split into 3 parts; the locking system, the tool detection system, and the LCD and UART setup. Each of these systems control a main function of the smart toolbox as a whole, and the requirements of the project would not have been reached without each of these systems.

4.1 Design Requirement 1

The locking system would be required to unlock the toolbox when the correct combination of buttons was pressed. In addition to unlocking the toolbox, it would also have to lock the box again and play a buzzing noise when an incorrect combination was inputted. In order to accomplish the requirements, 4 buttons were set up with a capacitor and resistor so that each would output a 1 when not pressed and a 0 when depressed (Figure 10). Each of the buttons were then connected to a pin on the MSP430FR6989 and acted as an input to an if statement. This if statement was created so that when a button is pressed it would instantly check if it matched the password and would change the output of the system according to the result. If the input was incorrect, the system would output a 100% duty cycle PWM signal to be sent to the speaker. The PWM output would be sent to the gate of a 2N7000 MOSFET to drive the speaker and have it output a buzzing sound to indicate the password was incorrect. If the button input matched the set password, the system would output a 3.3 V signal to the IRL520 power MOSFET that would drive the solenoid. This solenoid would then retract when the micro controller outputs the 3.3 V. In order to prevent the solenoid from bouncing endlessly between retracting and extending, a diode is also used (Figure 11). After about 2 seconds, the micro controller would then output 0 volts to the power MOSFET which would then lock the system again.

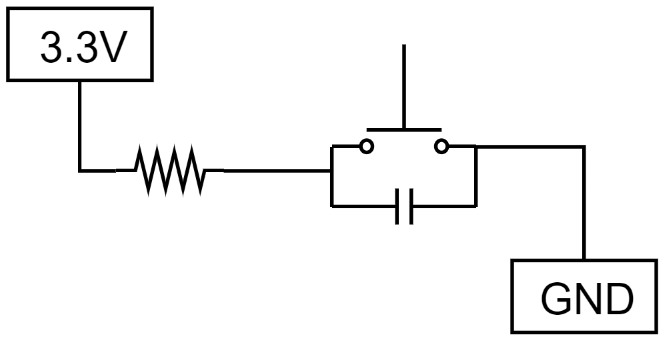


Figure 10: Button interfacing

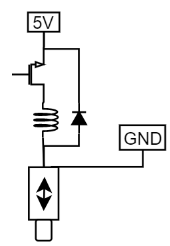


Figure 11: Solenoid interfacing

4.2 Design Requirement 2

The tool detection system would be required to determine which tools are present in the toolbox, without each tool having its own specified position. In order to achieve the requirements, force sense resistors would be used to determine the weight of the tool that is put in the toolbox. As seen in Figure 5 (b), the circuit was used to read the voltage across the 10kΩresistor, and this value would represent the weight of the tool that was on the force sense resistor. The voltage across the 10kΩresistor would then be inputted to a pin on the MSP430FR6989 that would read its value using the on-board ADC feature. This process would be repeated for another force sense resistor to be able to test multiple tools at the same time. The voltage value that was inputted into the ADC on the micro controller would then be compared to a predetermined set of ranges that would determine which tool was put inside of the toolbox. Depending on the outcome of these comparisons, different variables would change to tell the rest of the system information about the tools that are present.

4.3 Design Requirement 3

The LCD and UART setup would have to be able to display specific messages for specific inputs from the tool detection sensors. Therefore, using an outside driver library we are able to use a function called ”displayScrollText()” which allowed us, the developers to easily display any text on our LCD. Using conditional logic, we designed a function that will display four seperate messages ”Tape not here, Pliers not here”, ”Tape here, Pliers not here”, ”Tape not here, Pliers here”, and ”Tape here, Pliers here”. Thus, playing these specific messages when the values of the tool detection sensors ADC values are either above 750 and below 1700 (for pliers), or just above 1700(tape).

5 Test Setup

In order to test this device for proper function, first you must attach wires to their appropriate positions according to the block diagram. Then, properly testing the product requires using the control panel, to test which buttons unlock and lock the device/activate the solenoid. The code to unlock the device is pressing down the middle two buttons at the same time. If any other button or combination of buttons is pressed, then the buzzer will sound and the solenoid will not open the toolbox.

Next, properly testing the tool detection system, place the tools on the sensors and press the tool detection button. Then, to test the algorithm based in the software, continue to place the tape and pliers on the sensors in any and all combinations of ways that these tools can be placed, ie. pliers left pad, not placing the tape, then finally hitting the detect button for results. After each time the tool detection button is pressed, it sends various UART signals based on which tools are present and which ones are not. Therefore, a UART signal of 0x0010 would be sent to another micro-controller, MSP430G2553, and will be read from a register on that micro-controller. The possible combinations sent would be 0x0000, 0x0001, 0x0010, or 0x0011. This would be a representation of whether or not a tool is present on the FR6989’s end. The purpose of this is to simulate a control system that could potentially in the future control multiple tool boxes.

6 Design Files

6.1 Schematics

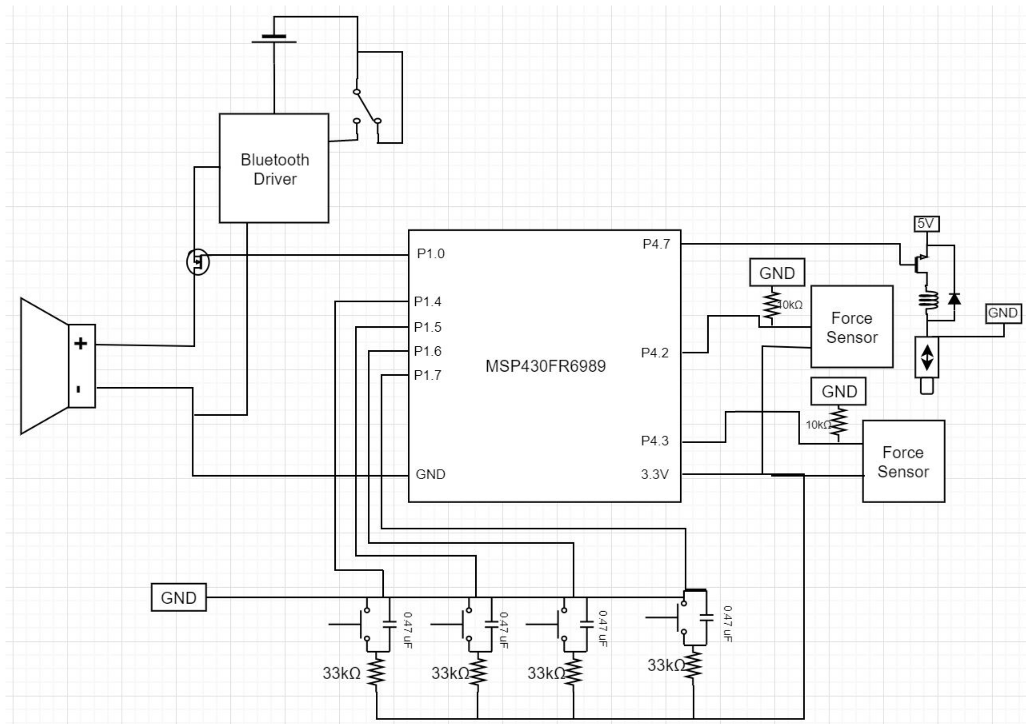


Figure 12: Schematic for the Smart Toolbox

6.2 Bill of Materials

Item Number	Description	Quantity
1	MSP430FR6989	1
2	MSP430G2553	1
3	Push Buttons	4
4	Force Sensors	2
5	Resistors 33k ohms	4
6	Reistors 10k ohms	2
7	Capacitors 0.47 uF	4
8	Solenoid Lock	1
9	Buzzer/speaker	1
10	IRL520	1
11	Diode (schottky)	1
12	2N7000 Mosfets	1