Project 2 Final Report

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Introduction

The developed security system has made a large amount of progress since the previous report. Methods originally detailing a voltage divider circuit for a button pressing mechanism have been greatly refined into a digital serial bus capable of handling unlimited inputs. Sensors have been researched and were purchased for the goal of measuring IR 900nm waves for the purpose of directly detecting human black body radiation. As well, the original house design has been implemented via purchased materials and the proposed schematic. The security system installed in the house, is capable of handling a large amount of security features. As of the time of writing this, the security system works properly in accordance to the listed features.

Final Design

Main code:

The main code has five distinct features. Its first feature is the password input, which is handled by the button pressing mechanism. Once the password is placed, there is a control panel mechanism that follows with a selection process also handled by the keypad. This control panel has five selection modes.

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Control Panel
Note that changing any settings in the Control Panel will require the user to re-enter their password
Please enter one of they keyed inputs
1 for activating all alarm systems
2 for activating the inside alarm system
3 for activating the outside light system
Press 0 to change password
Press # to deactivate alarm
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Figure 1: Control panel feature list

After the control panel is activated, a user has the ability to activate a feature. Once a feature is selected, the control panel is cleared and the user is prompted to enter their password in order to return to the control panel. In order to change the password, the user is required to enter their password again before entering the new password. The flow chart works in the diagram shown

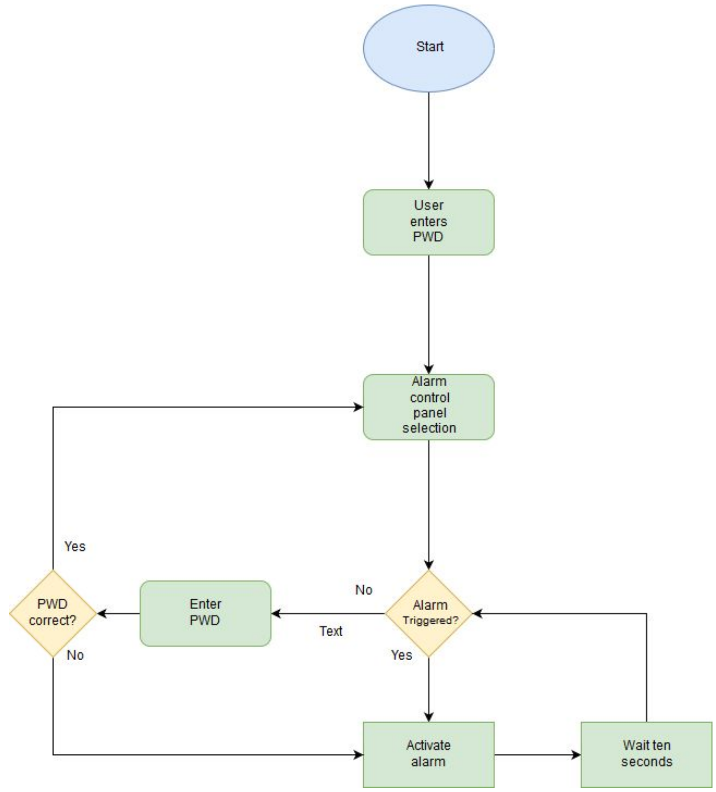

Figure 2: Simplified flow chart diagram of main code

Button pressing mechanism:

The proposed design for our button pressing mechanism was originally a voltage divider circuit based off of pressing buttons and measuring the voltage. However, with the implementation of a 12 digit keypad provided by the instructor, it was soon realized that a voltage divider was not going to be easily implemented. Instead, we elected towards converting the 10 input parallel bus that was provided with the keypad, into a 10 bit serial bus through a multiplexer circuit. This reduces the 10 inputs into 1 controlling input, 1 output bus capable of following distinct serial protocols. This is the current black box design program

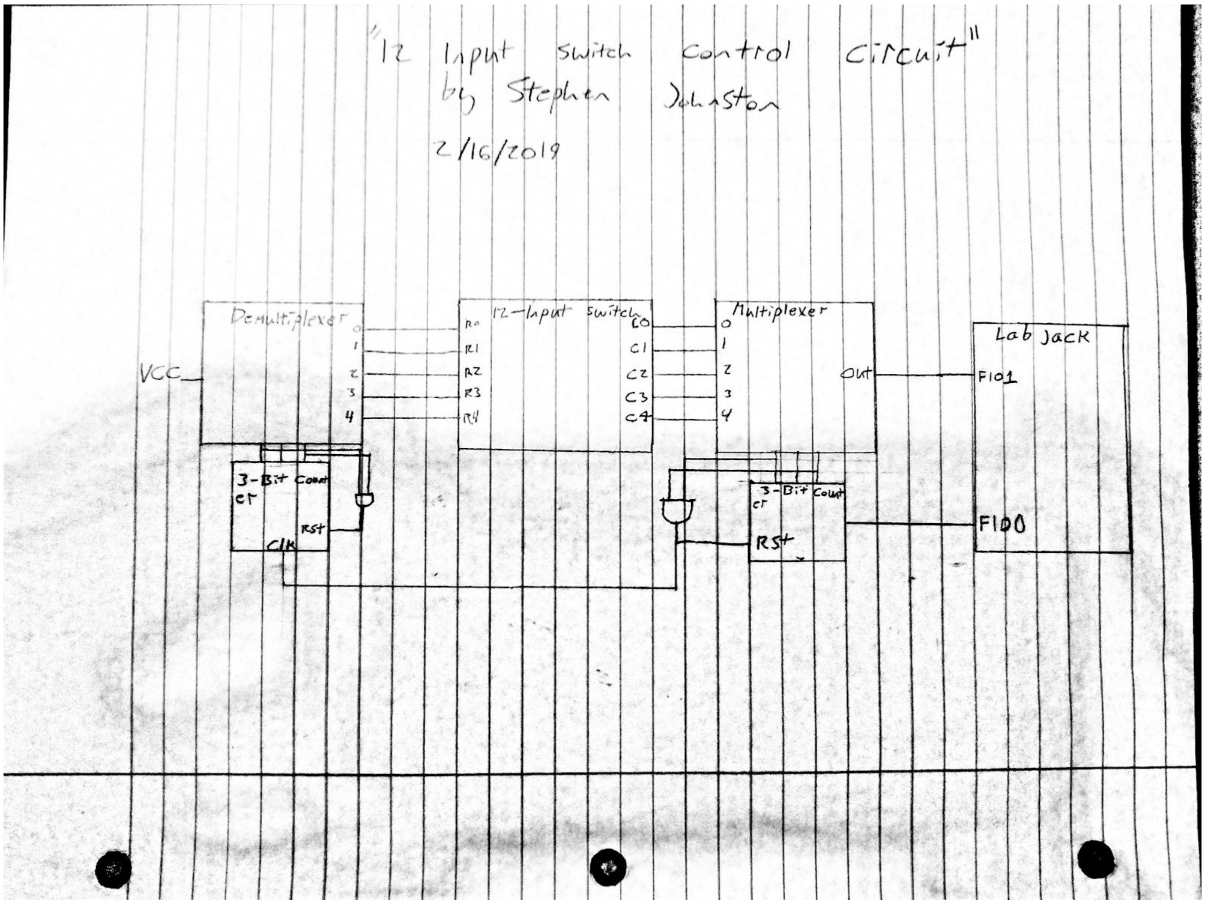

Figure 3: Black box diagram of button control circuit

IR Sensor

The IR sensor has also gained distinct progress, originally we've purchased a commercial
infrared filter to prevent waves outside the 900nm to 1030nm range from penetrating the material. The sensor itself was a photoresistor voltage division circuit that will trigger a binary (If greater than ~2V) input detection on the labjack. This sensor was placed on the outside of the house and will be used to trigger the lights. We also opted to use a commercial sensor that could provide more distinct features. These features were variable range and input delay. This sensor will be attached to the openings of doorways and windows such that any intruder will emit enough black body radiation to trigger the sensor and cause an alarm system to go off.

House design

The house design changed since the previous report. We implemented the proposed design using wood and 3d printed materials. Though instead of two bedrooms we created one bedroom. Then we created an open living room with a small bathroom. We originally planned for two bedrooms, but our calculations made it so the hallway to the two bedrooms was very narrow. We decided against it to make it easier to put our hands in the house and easier to see the inside.

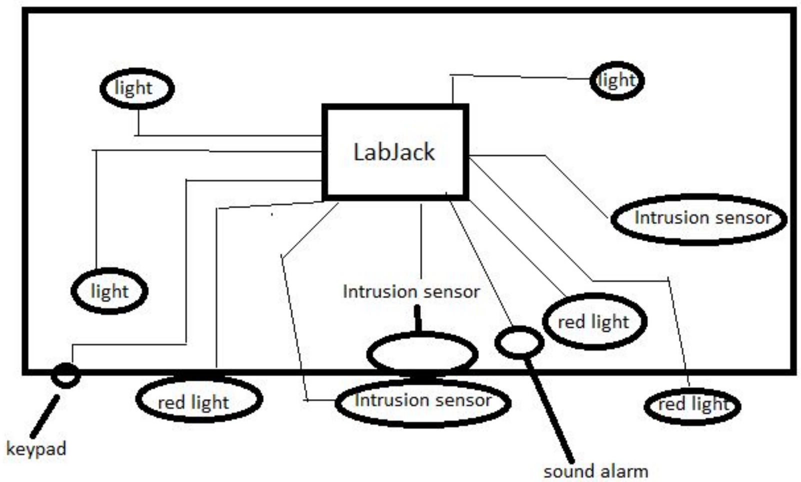

Figure 4: 2D-sketch of wiring for house.

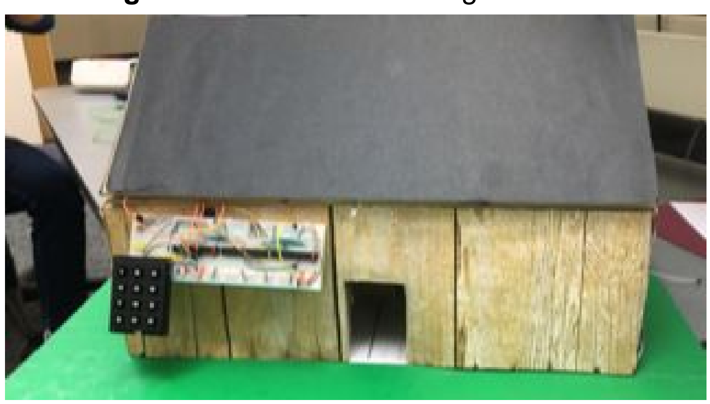

Figure 5: Construction of house with keypad attached.

Hardware

Hardware wise, the materials for all required components have been purchased and assembled As of right now, the bill of materials are as follows

Button pressing mechanism

Quantity Item Price

1 10 input button switch Provided by the teacher

1 4 input, 2 channel multiplexer, SN54HC153 $.75

1 4 input, 2 channel demultiplexer,SN54HC139 $.75

1 6 input inverter SN54HC04 $.75

1 4 input AND gate SN54HC08 $.75

2 4 bit counter SN54HC163 $.75

These components are connected such that the counter, which is controlled by a clock pulse, then selects the multiplexer channel. This then allows us to determine each input. The other components exist to overcome limitations created by the hardware, such as the SN54HC139 being active low output.There are two multiplexers, one being a demultiplexer, which powers a distinct row of the keypad, while another multiplexer selects each column. The reasoning behind this is because many buttons on the keypad are connected to the exact same output to save connection space but these same buttons have unique power sources. So if we power a distinct row of the keypad first, we can scan the same output without trouble. This is done by having an AND gate wired to the inputs characterising the number “3”, which corresponds to the fourth output. When this is turned on, a second counter is sent an ON clock pulse, triggering the counter at the next edge to move to the next number. This next number then is fed into a demultiplexer, which is wired to VCC. The demultiplexer then will select which row corresponds to which number, powering on only one row at a time.

Despite having only one output, we know exactly what pulse represents what button. We do this by counting the clock pulse in the program and mapping it to a distinct vector. We found this vector empirically, but it could have been predicted. The vector was mapped as

[0 1 3 5 0; 33 4 6 0 0; 0 0 9 8 0; 0 7 0 2 0]

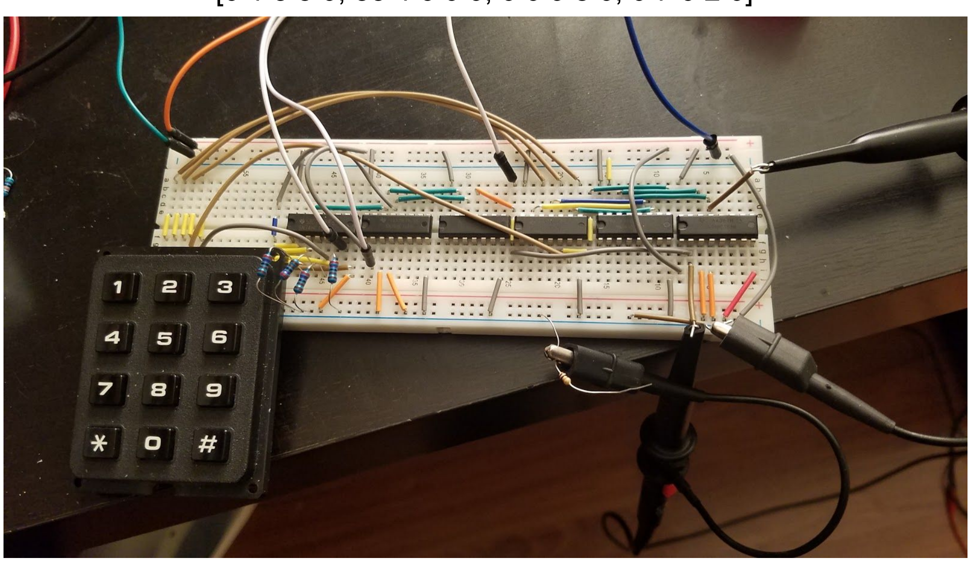

Figure 6: Parallel to serial converter with button output connected

IR sensor

This component is actually fairly simple, the IR sensor exists as a voltage divider circuit that measures a small response to different stimuli. Because we are using a very simple binary off/on measurement, the IR sensor is connected as the first resistor in this circuit, as described in the diagram above (figure -----) and in the photo below. This circuit will be active high. Due to time constraints, we were unable to encapsulate the IR sensor in 3d printed materials or attach an IR filter. Instead we calibrated the photo resistor for ambient light and a detection method for values substantially higher.

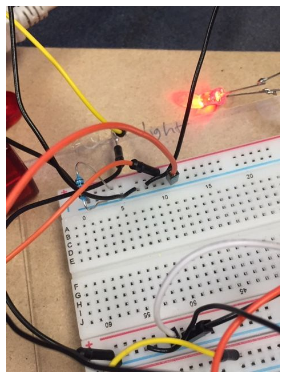

Figure 7: Breadboard under roof

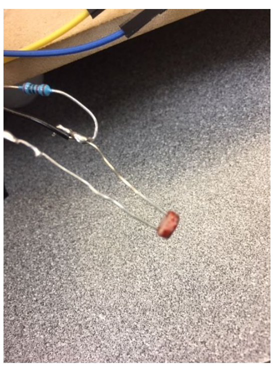

Figure 8: Photoresistor sensor

Figure 9: Infrared sensor

As of right now, the bill of materials are as follows

Quantity	Item	Price
1	Photoresistor	$.20
1	3000 ohm resistor	$.10
2	infrared sensor	$1.8

The second sensor was a commercial photo-sensor for infrared wavelengths

Software

Main

Our software was developed and worked accordingly. The button switch detection circuit was designed to be very easy to code. As of right now we have a serial 12 input detection vector that is mapped out to 16 different possible combinations, the unused combinations being left blank. With each clock pulse, an index is increased that associates the selected input with a number or character. After the program is finished (After all possible combinations have been attempted), a vector is returned with the buttons that were pressed.

GUI Diagnostics Code

There is one GUI to run diagnostics on the lighting and alarm system. The user runs the GUI which will open a window. They can check the alarm system which will go off on loop for 3 iterations. They can also check and uncheck the white LED house lights on and off to see if they work. The enter button closes the window. The overall purpose of the diagnostics mode to make sure the LEDs and sound alarm are working and are not burned out. Since the LEDs are in parallel, one burning out will not interfere with the others. If one is burned out then we can see which one needs to be replaced.

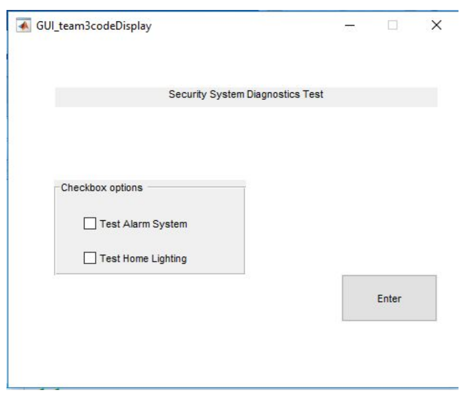

Figure 10: GUI display

Problems and solutions

Our largest problem was in the button detection circuit. The 74HC logic circuit was originally having problems with metastable states due to the lack of pull down resistors. This is resulted from some outputs of the 74HC logic outputting .5V as low without a load, while other inputs consider this as high. We replaced the input of the multiplexer with 500Ohm resistors to help counter this problem. As well the counter circuit was originally having trouble properly recording clock pulses, this was due to the two chip enable inputs on the counter being left floating. This was fixed by tying the chip enable inputs to VCC. Another odd interaction with the circuit was that the multiplexer selects different inputs depending on the input frequency. It was noticed that inputs below 60Hz had a totally different input selection process than inputs above 60Hz. The input selection process above 60Hz works at all frequencies above 60Hz. After mapping the output vector for all 11 button presses, the vectors appeared to be completely different. As shown below.

Below 60Hz Vector : [2 1 1 3 2;5 33 4 6 0;9 9 9 9 9;8 0 7 0 0]

Above 60Hz Vector :[0 1 3 5 0; 33 4 6 0 0; 0 0 9 8 0; 0 7 0 2 0]

The last peculiar error that the converter held was the issue of lost clock pulses on cables longer than 6 inches. Regardless of the frequency, the converter refused to count properly with clock pulses that were sent over wires longer than 6 inches. This is believed to be due to the attenuation that the cables create rather than any legitimate clock skew over the device.

Discussion

We've learned a lot during this second part, primarily from project management and allocating materials. Many different circuits that were discussed during either the current lectures or from lectures from other classes, were put to the test in such a way that enhances the learning experience.

Signature Paragraph

Team member contributions

Stephen Johnston: Parallel to serial bus hardware and software Implementation. Main code implementation

Nate Howard: House design and materials purchasing

Nick Sherbert: GUI diagnostic design and sensor implementation/Alarm Buzzer and Lighting

"All of the students listed at the top of this report have read it and agree with its content."

References:

"Microsoft Paint." *Wikipedia*, Wikimedia Foundation, 13 Mar. 2019, en.wikipedia.org/wiki/Microsoft_Paint.