Team 5:
Keyless Entry Door Lock

MOHAMED GHONIM
IBRAHIM BINMAHFOOD
JOSHUA HOBBY
MOHAMED ASHKANANI

What are we making?

We are designing a digital door lock from scratch:

- buttons for the user to enter a pin code that gets stored in memory and the door only opens if the user enters the correct code the next time around.
- This device is useful in many cases such as the user wouldn't have to worry about what happens if they forget their keys for example.
- It is also helpful if they have other tenants staying with them temporarily (for example Airbnb, Coushsurfing, etc.) they can create temporary access pins which they can give to tenants without giving them a copy of their physical key.

Who are we targeting?

We are targeting houses and condos owners.
Especially those who offer services such as Airbnb and Couchsurfing since they usually need to set and rest multiple temporary pins for their tenants.

Problem and Need

- There are multiple door locks in the market, our goal is to make an affordable trustworthy design.
- We wanted our design to be modular, such that a basic LCD display could be used, or it could also be replaced with a fancier, colored OLED display. The end user could possibly swap these and add an alarm/speaker to the system, for example, by just connecting it to a pin header and installing firmware we would provide.
- Using the I2C control helps in achieving this modularity.
- When it comes to security related products, many people are more comfortable buying something locally designed, we are mainly targeting local customers.
- Affordability is also on top our list. The cost of our product should be under $50.

Motivation

- This is important because… Who doesn't need a cool, secure, modular, modern door lock made by cool broke capstone students?
- There are other keyless locks on the market, but they are usually expensive, or hard to find source codes or data for.
- There is always some worries that someone, somewhere might be storing that data or using the system to record/spy.
- Current keylock systems are usually not modular.

Concept of Operations

- The user sets a PIN code on an external keypad connected to the system (black box).
- The next time the user enters a PIN, the system checks if it's the correct pin or not. If it's the correct pin the microcontroller will communicate with the stepper motor board and the relay will move to the "open" position. If the wrong pin is entered, the motor will not work, and the door will not open.
- Once the door is open, there will be an option on the LCD to turn the lock off again.
- There is also an emergency access button on the board itself (not easily accessible by the user) for emergency situations (intrusive and requires opening the case).
- Our objective was to make a design and a working prototype.

Requirements

- The Design Must:

1. have one or more input sensors
2. have one or more outputs or transducers
3. have one or more microcontrollers/processing modules to control/generate the output.
4. Be safe.
5. Use components that can be hand-soldered.
6. Use two layers PCB.

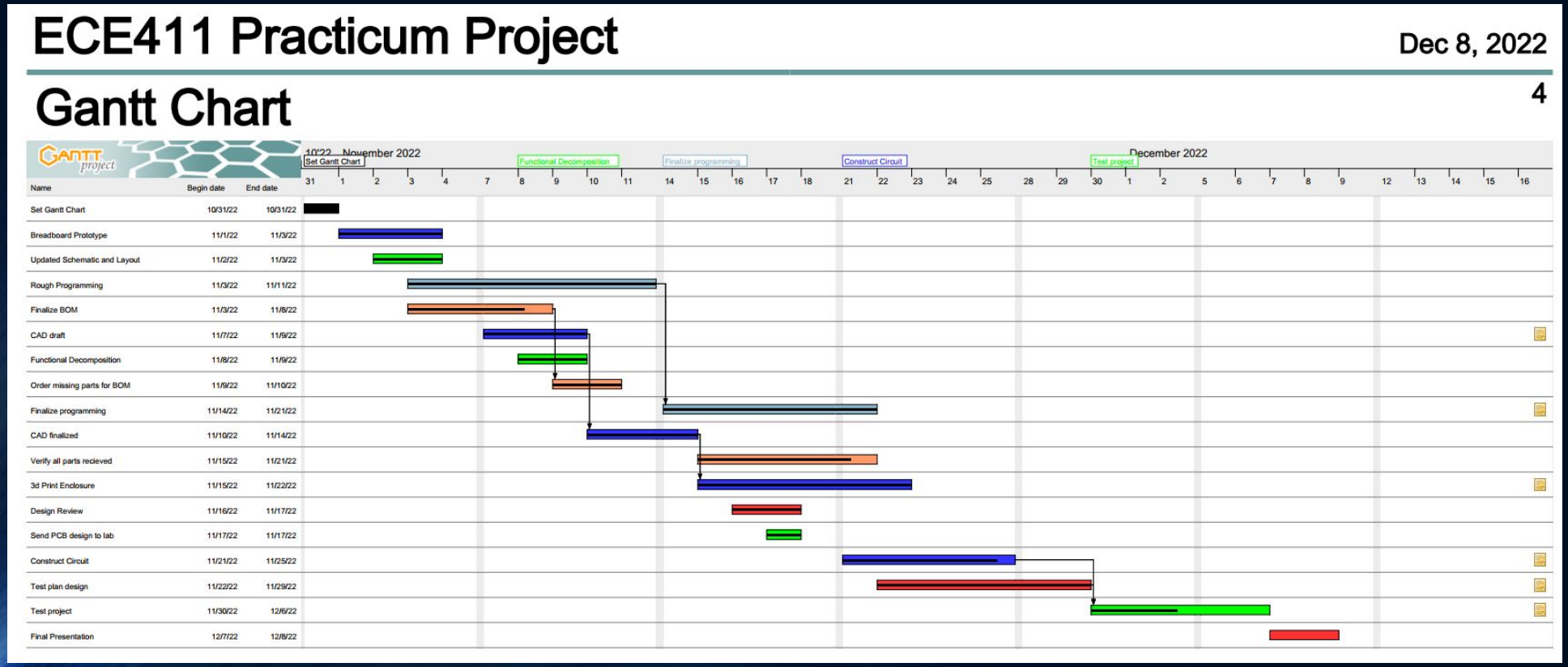
- The Design Should:

1. Be packaged in a 3D printed enclosure.
2. Be novel and add new features to current designs/competitors.
3. Be lightweight.
4. Be portable.

- The Design May:

1. Have an LCD display with a welcoming or error message.
2. Have a battery for operation if the power goes out.

Gantt Chart


ECE411 Practicum Project
Dec 8, 2022
Gantt Chart
4
10'22 November 2022
December 2022
Set Gantt Chart
Functional Decomposition
Finalize programming
Construct Circuit
Test project
Name
Begin date
End date
Set Gantt Chart 10/31/22 10/31/22
Breadboard Prototype 11/1/22 11/3/22
Updated Schematic and Layout 11/2/22 11/3/22
Rough Programming 11/3/22 11/11/22
Finalize BOM 11/3/22 11/8/22
CAD draft 11/7/22 11/9/22
Functional Decomposition 11/8/22 11/9/22
Order missing parts for BOM 11/9/22 11/10/22
Finalize programming 11/14/22 11/21/22
CAD finalized 11/10/22 11/14/22
Verify all parts recieved 11/15/22 11/21/22
3d Print Enclosure 11/15/22 11/22/22
Design Review 11/16/22 11/17/22
Send PCB design to lab 11/17/22 11/17/22
Construct Circuit 11/21/22 11/25/22
Test plan design 11/22/22 11/29/22
Test project 11/30/22 12/6/22
Final Presentation 12/7/22 12/8/22

More of Gantt Chart Tasks and Resources

ECE411 Practicum Project Dec 8, 2022

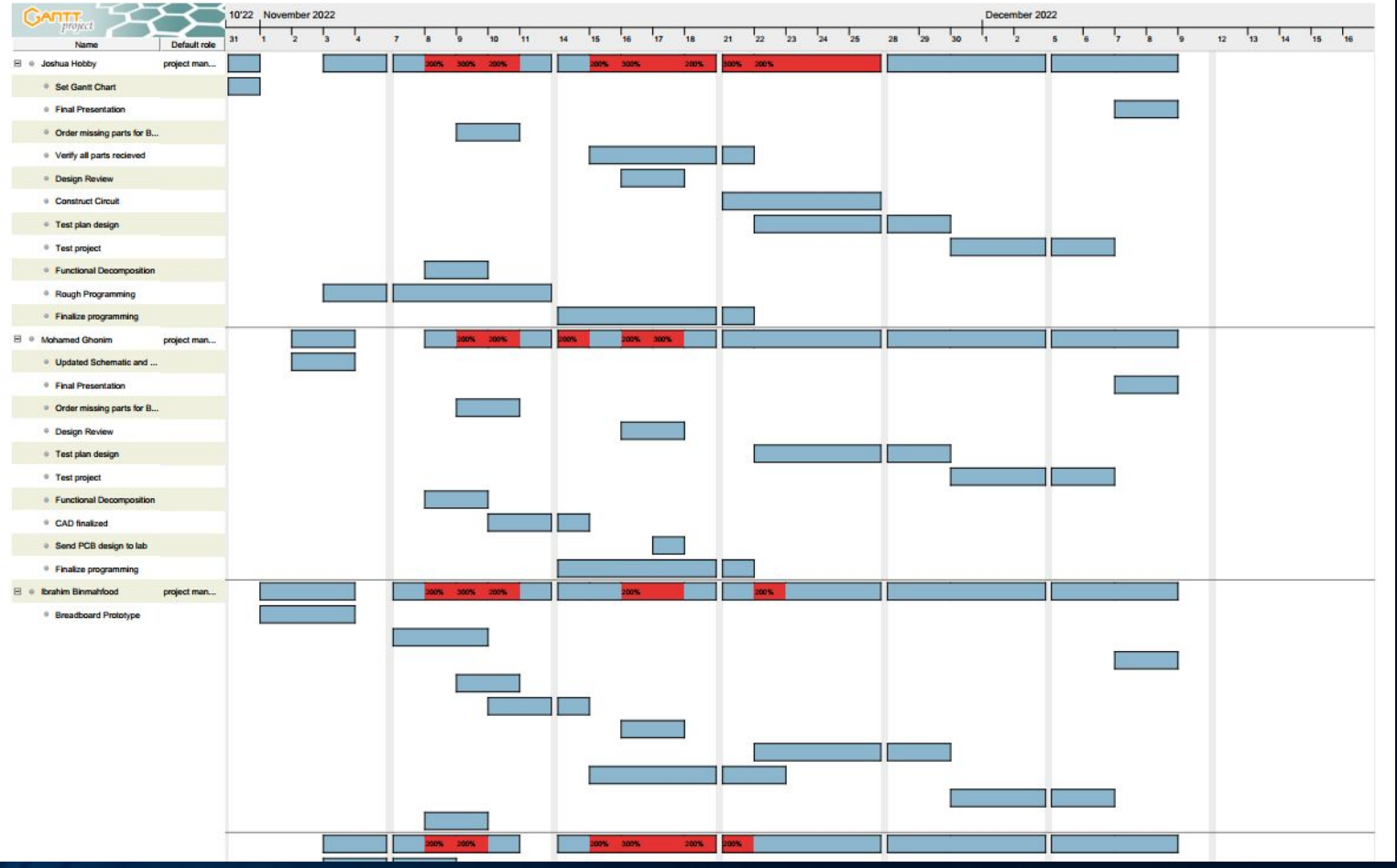
Tasks

Name	Begin date	End date
Set Gantt Chart	10/31/22	10/31/22
Breadboard Prototype	11/1/22	11/3/22
Updated Schematic and Layout	11/2/22	11/3/22
Rough Programming	11/3/22	11/11/22
Finalize BOM	11/3/22	11/8/22
CAD draft	11/7/22	11/9/22
Draft looks good. Design Review went well.		
Functional Decomposition	11/8/22	11/9/22
Order missing parts for BOM	11/9/22	11/10/22
Finalize programming	11/14/22	11/21/22
FInal code uploaded		
CAD finalized	11/10/22	11/14/22
Verify all parts recieved	11/15/22	11/21/22
3d Print Enclosure	11/15/22	11/22/22
Late. Got final print 12/6		
Design Review	11/16/22	11/17/22
Send PCB design to lab	11/17/22	11/17/22
Construct Circuit	11/21/22	11/25/22
PCB came in late. Could not start constructing on time. Issues with construction. Power supply adaptor missing.		
Test plan design	11/22/22	11/29/22
Documentation on Github for test plans		
Test project	11/30/22	12/6/22
Troubleshooting issues with implementing ATMega328 on PCB. MIcrocontroller works on Arduino,but does not transfer to board well.		
Final Presentation	12/7/22	12/8/22

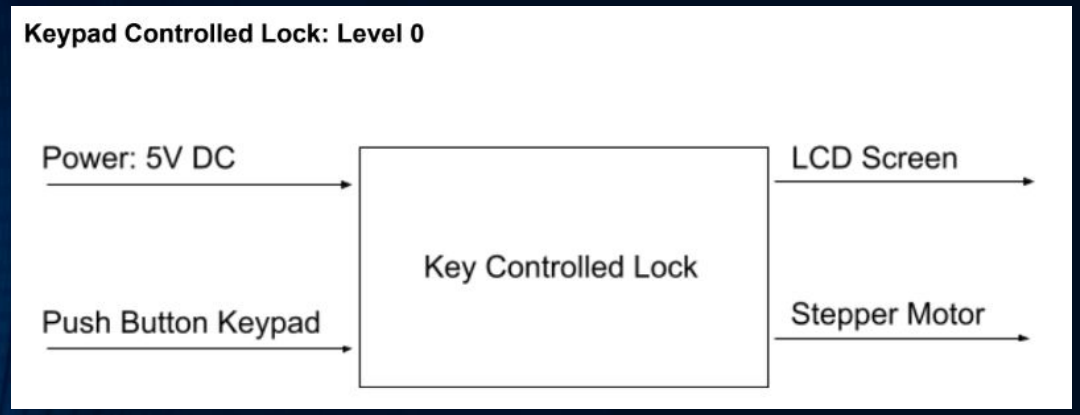
ECE411 Practicum Project Dec 8, 2022

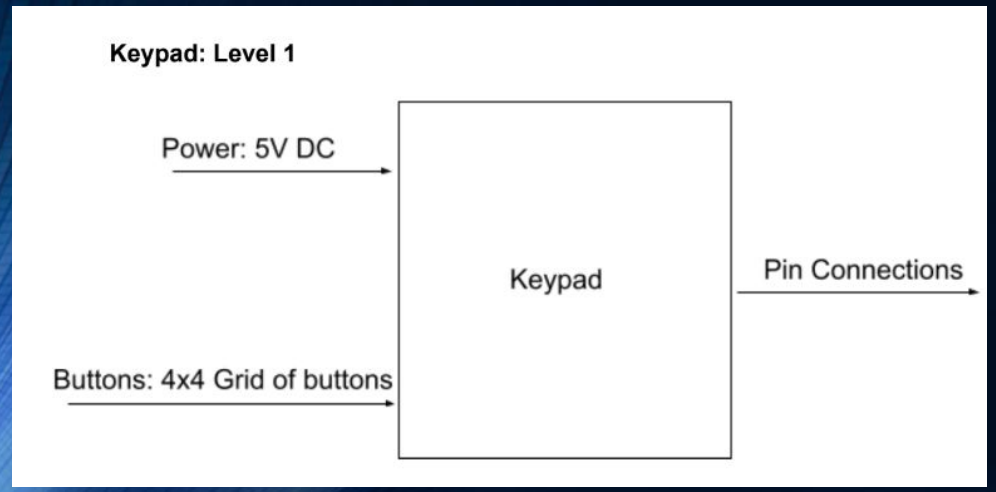
Resources Chart

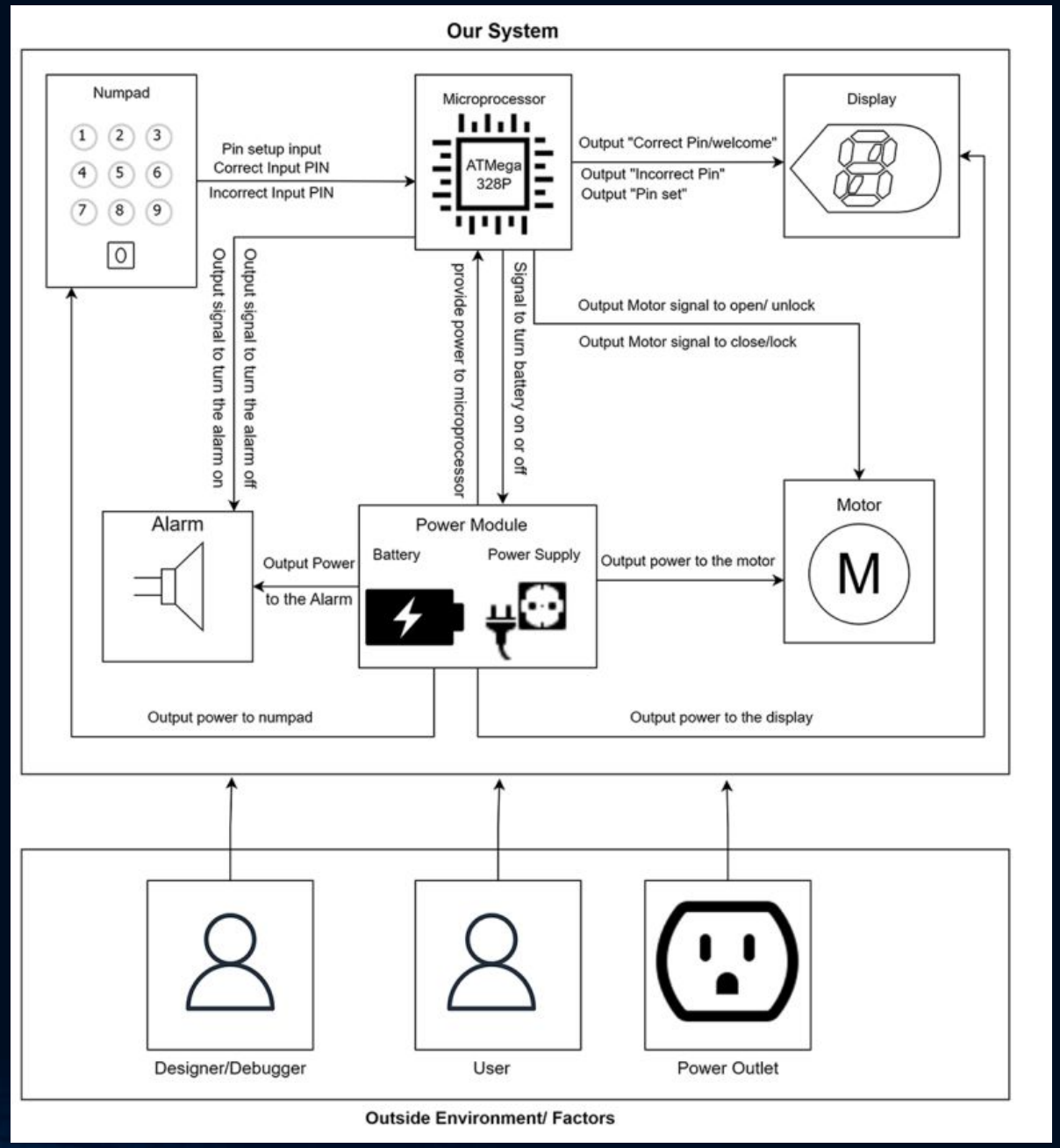
5



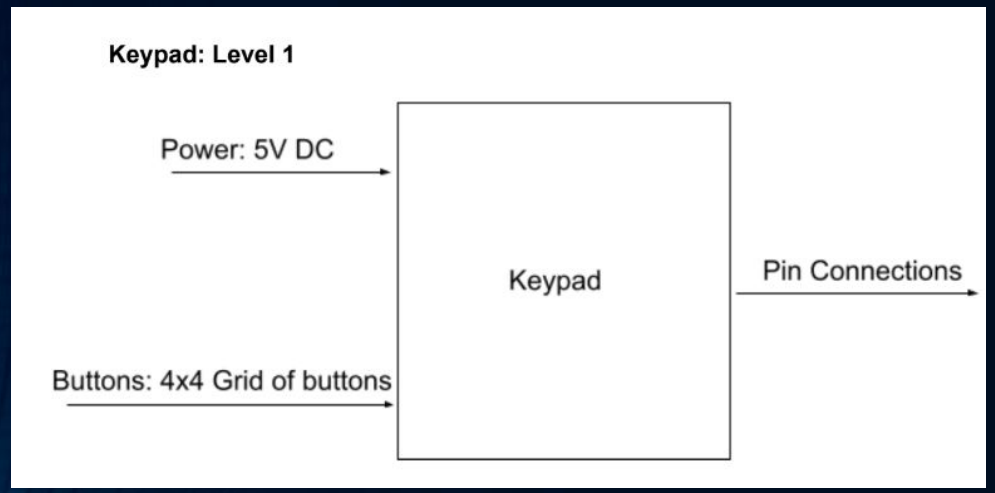
Design Overview

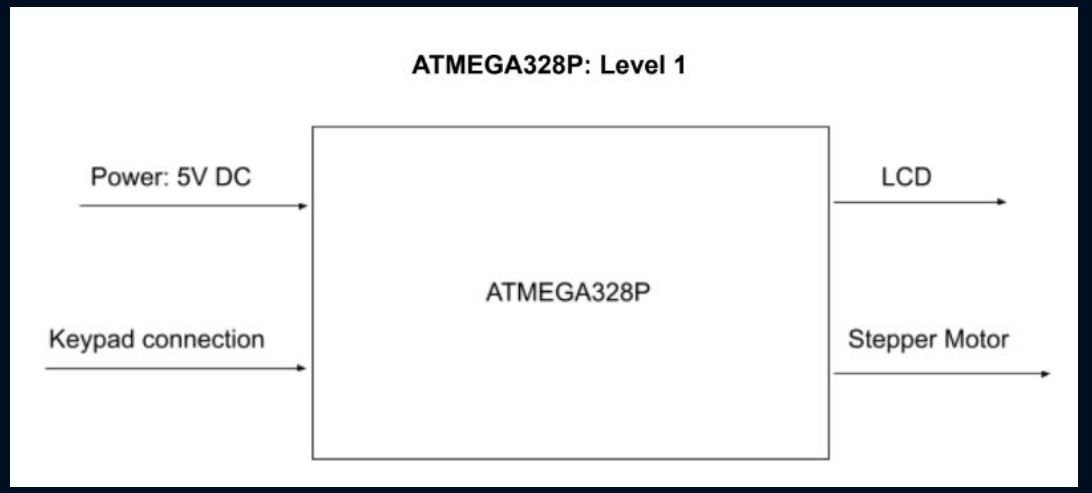


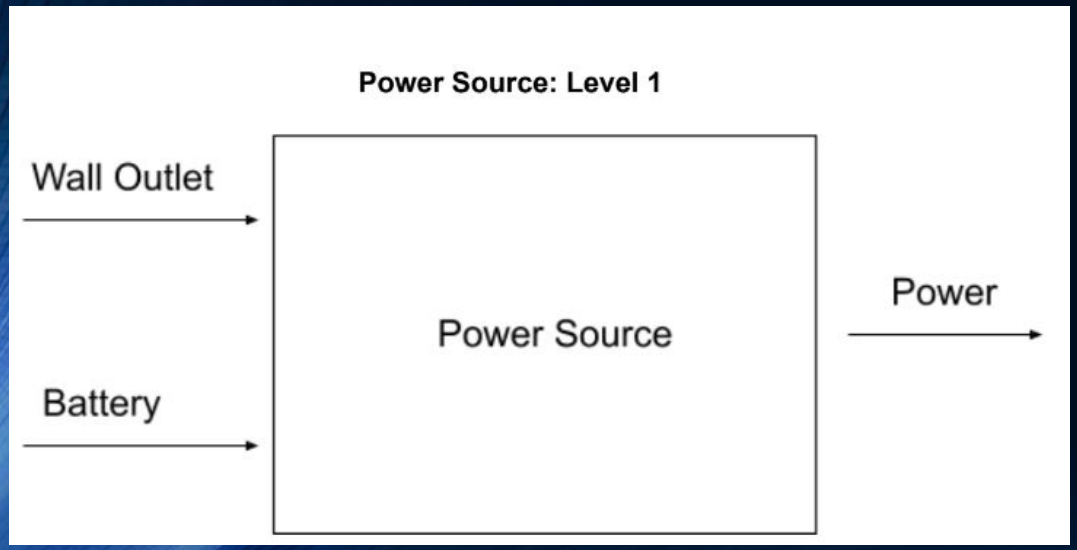


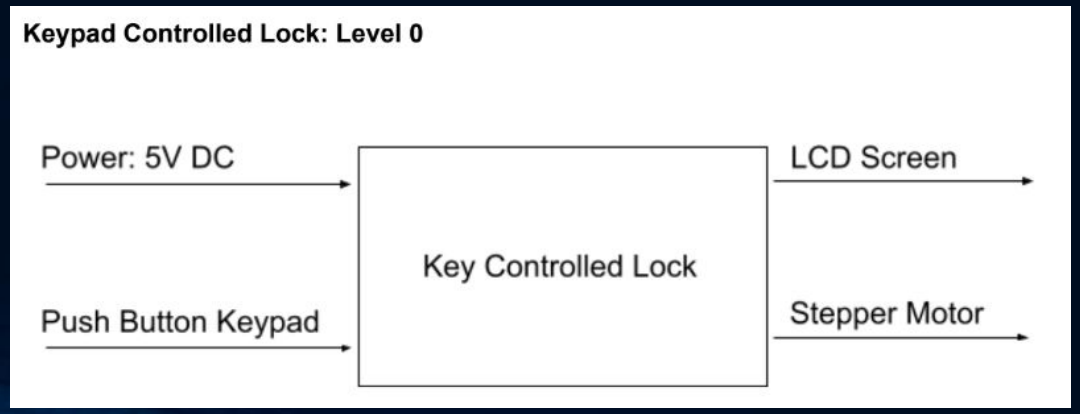


Functional Decomposition

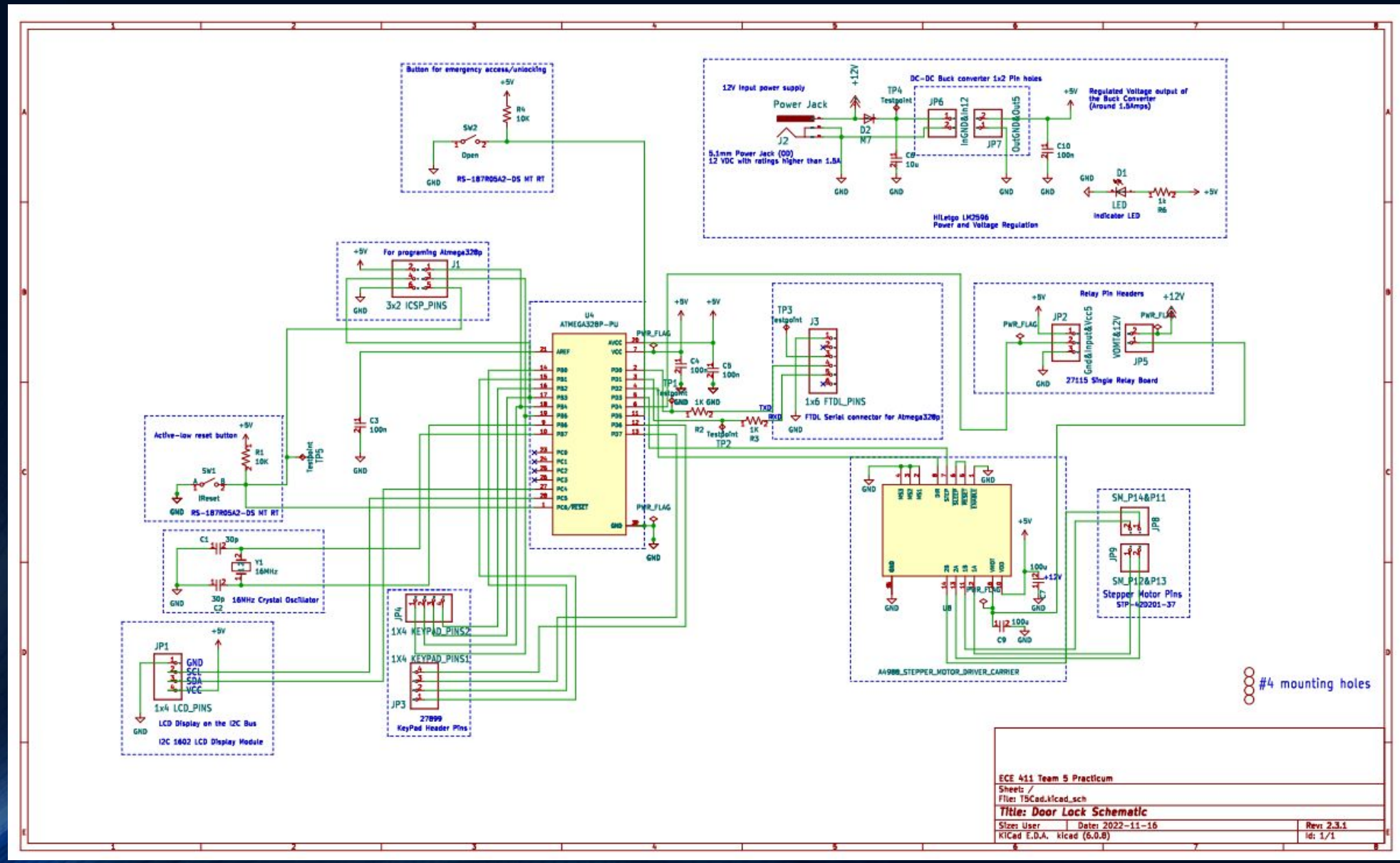




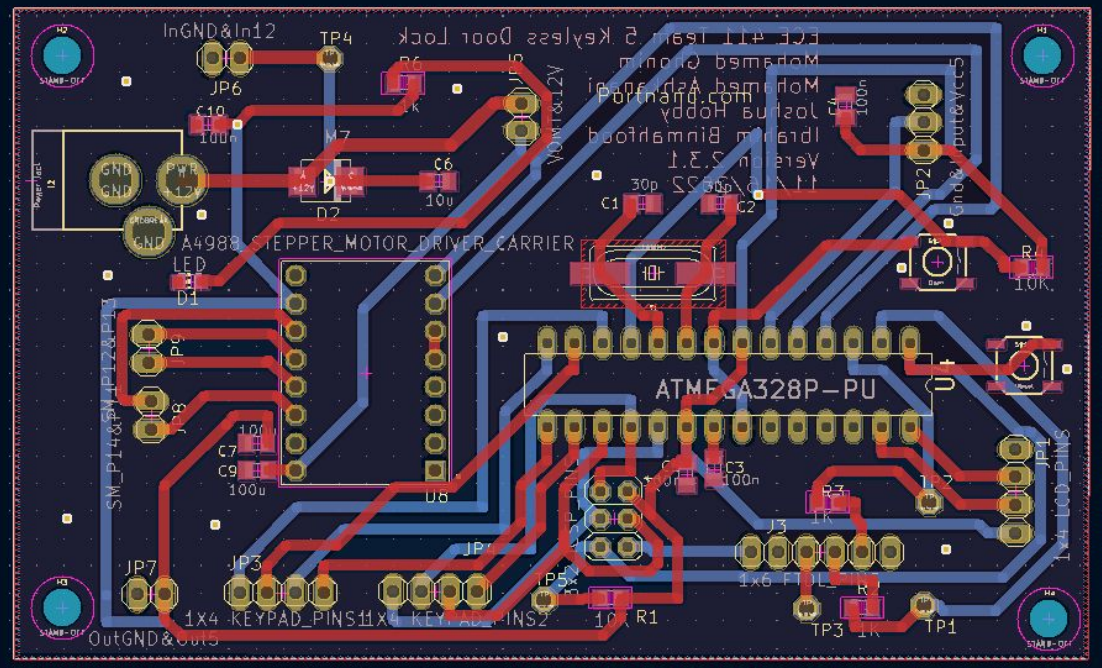


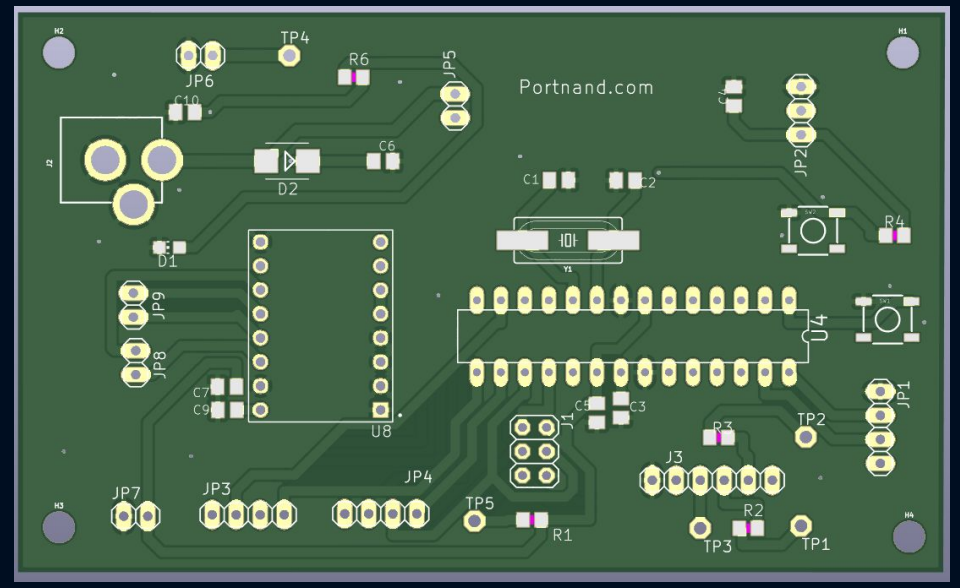


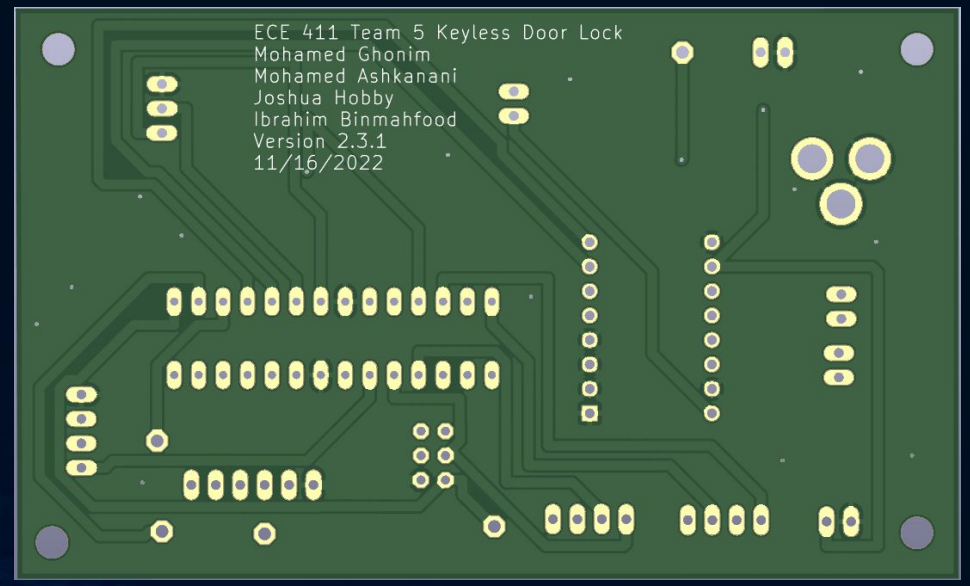
Implementation Details: KiCad Schematics



Implementation Details: Board Layout







ECE 411 Team 5 Practicum

Sheet:

File: T5Cad.kicad_pcb

Title: Keypad Door Lock PCB

Size: A4	Date: 2022-11-16	Rev: 2.3.1
KiCad E.D.A. kicad (6.0.8)		Id: 1/1

Tools Used

- KiCAD for the Schematics and PCB Design.
- Fusion360 for the PCB 3D enclosure Design.
- Arduino IDE.
- GanttProject for making the Gantt Chart.
- app.diagrams.net for making the block diagrams.
- GitHub for documentation and version control
- Discord, Whatsapp, etc.

Bill Of Materials:

Bill Of Materials for: [Practicum Group 5] [TEAM NAME]
Last modified: [12/08/2022]
PCB version: [PCB VERSION #4]
BOM revision: [BOM REV P/NP = Place/Not Place (components marked NP are not stuffed on the board)

Cnt	Part References	P/NP	Mfg	Device	Mfg PN	Description	Dist	Dist Part Number	Cost Ea.	Cost Tota
1	U4	P	Microchip	ATMEGA328P-PU	ATMEGA328P-PU	MICROCONTROLLER	Amazon	N/A	$13.50	$13.50
1	U1	P	JOYNANO	Stepper motor	N/A	JoyNano Nema 17 Stepper Motor Integrated 310mm T8 Lead Screw	Amazon	M42SH40-1684A	$12.99	$12.99
1	U2	P	Pololu	A4988_STEPPER_MOTOR_DRIVER_CARRIER	1182	Stepper motor controler; IC: A4988; 1A; Uin mot: 8÷35V	Pololu	1182	$14.45	$14.45
1	U4	P	Parallax	Single Relay Board	27115	Single Relay Board	Mouser	619-27115	$9.99	$9.99
2	IC1, IC2	P	Texas Instruments	LM7805S/NOPB	LM7805S/NOPB	IC REG LINEAR 5V 1.5A	Digi-key	296-49741-ND	$2.27	$4.54
1	U2	P	GeeekPi	16x2 White on Blue Character LCD	N/A	16x2 White on Blue Character LCD	Amazon	N/A	$10.99	$10.99
1	U3	P	Parallax	KEYPAD4X4	27899	SWITCH KEYPAD 16 KEY NON-ILLUM	Crystalfontz	CFAH1602B-TMI-JT	$7.95	$7.95
1	D2	P	Würth Elektronik	LEDCHIP-LED0805	150080GS75000	LED	Mouser	710-150080GS75000	$0.19	$0.19
1	SW1	P	C&K	SWITCH-MOMENTARY-2SMD	RS-187R05A2-DS MT RT	Various NO switches- pushbuttons, reed, etc	Digi-key	CKN10361TR-ND	$0.64	$0.64
1	SW2	P	C&K	SWITCH-MOMENTARY-2SMD	RS-187R05A2-DS MT RT	Various NO switches- pushbuttons, reed, etc	Digi-key	CKN10361TR-ND	$0.64	$0.64
1	X1	P	ECS	CRYSTALSMD-HC49UP	ECS-160-18-5PX-TR	Crystals (Generic)	Digi-key	XC2081TR-ND	$0.45	$0.45
2	R1, R2	P	Yageo	R-US_R0805	RC0805FR-0710KL	10 kOhms ±1% 0.125W, 1/8W Chip Resistor 0805 (2012 Metric) Moisture Resistant	Digi-key	311-10.0KCRTR-ND	$0.10	$0.20
3	R3, R4, R5	P	Yageo	R-US_R0805	RC0805FR-071KL	RES 1K OHM 1% 1/8W 0805	Digi-key	311-1.00KCRTR-ND	$0.10	$0.30
4	C1, C2, C3, C4	P	Samsung Electro-Mechanics	C-EUC0805K	CL21B104KBCNNNC	CAP CER 100nF 50V X7R 0805	Digi-key	1276-1003-2-ND	$0.10	$0.40
2	C5, C6	P	Samsung Electro-Mechanics	C-EUC0805K	CL32Z107MQV6PNE	CAPACITOR, European symbol	Digi-key	1276-CL32Z107MQV6PNETR-ND	$0.10	$0.20
1	C7	P	Samsung Electro-Mechanics	C-EUC0805K	CL31B106KLHNNNE	10 µF ±10% 35V Ceramic Capacitor X7R 1206 (3216 Metric)	Digi-key	1276-3103-2-ND	$0.66	$0.66
2	C8, C9	P	Samsung Electro-Mechanics	C-EUC0805K	CL21C300JBANNNC	CAP CER 30PF 50V C0G/NP0 0805	Digi-key	1276-1130-2-ND	$0.10	$0.20
1	J1	P	Harwin	PINHD-2X3	M20-9980345	PIN HEADER	Digi-key	952-2120-ND	$0.34	$0.34
1	J2	P	Sullins	PINHD-1X6	PRPC006SAAN-RC	PIN HEADER	Digi-key	S1011EC-06-ND	$0.19	$0.19
1	J1	P	HiLetgo	LM2596 Adjustable DC-DC Step Down Buck Power Conver	N/A	Power Converter Module 4.0-40V to 1.25-37V LED Voltemeter	Amazon	N/A	$5.25	$5.25
1	J3	P	HiLetgo	AVR ISP	N/A	USBTiny USBtinyISP AVR ISP Programmer 6/10 Pin Bootloader for Arduino UNO MEGA	Amazon	N/A	$9.19	$9.19
1	Exterior	P	EPL	3D printed eterior for the device	N/A	A small 3D printed device with hole for the getting power and the LCD display	EPL	N/A	$8.00	$8.00
									Sum	$93.26

VERSION INFO

Rev	Date	Notes
1.0r3	2022-12-08	Add some new components to the list
1.0r2	2022-11-20	Update some wrong components
1.0r1	2022-11-10	Cleaned up parts, fixed mistakes, rough draft of board
1.0r0	2022-10-31	Initial BOM, an simple list of all the components required. Dist Part Number and cost were not determined

IP License and prior work.

The license we used for our project is: GNU General Public License v3.0

We referenced multiple Arduino libraries and KiCAD schematics and Libraries.
Programming an AVR ATmega328P with an Arduino:
https://www.brennantymrak.com/articles/programming-avr-with-arduino

Arduino 16×2 LCD Tutorial – Everything You Need to Know:
https://howtomechatronics.com/tutorials/arduino/lcd-tutorial/

Control Stepper Motor with A4988 Driver Module & Arduino:
https://lastminuteengineers.com/a4988-stepper-motor-driver-arduino-tutorial/

Designing PCB with KiCad:
https://ezcontents.org/designing-pcb-kicad

Test plan

Test Writer : Team 5						
Test Case Name:	Stepper Motor Parametric Test #1				Test ID#	STMP-01
Description:	Test the stepper motor movement for locking and unlocking the door by measuring the rotation of the stepper motor. We need to measure the direction as well as the angle of rotation using a protractor.				Type:	
Test Information						
	Name of Tester:				Date:	
Hardware Ver:	2.3.1				Time:	
Setup:	**Materials:** Hardware/Equipment: Project BOM + Protractor Software: Source code at https://github.com/ECE411T5/Practicum/tree/main/src **Note:** The initial starting condition is with the system locked, and the stepper motor in the lock position.					
Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Enter "1234"	Screen Displays "Unlocked: Welcome"				
2	Wait	Stepper Motor turns 180 degrees CW to unlock position				
3	Press Lock Button	Stepper Motor turns 180degrees CCW to the lock position.				
4	Enter Wrong code	Clear the LCD Screen, Motor is in lock position.				
Overall Test Result:						

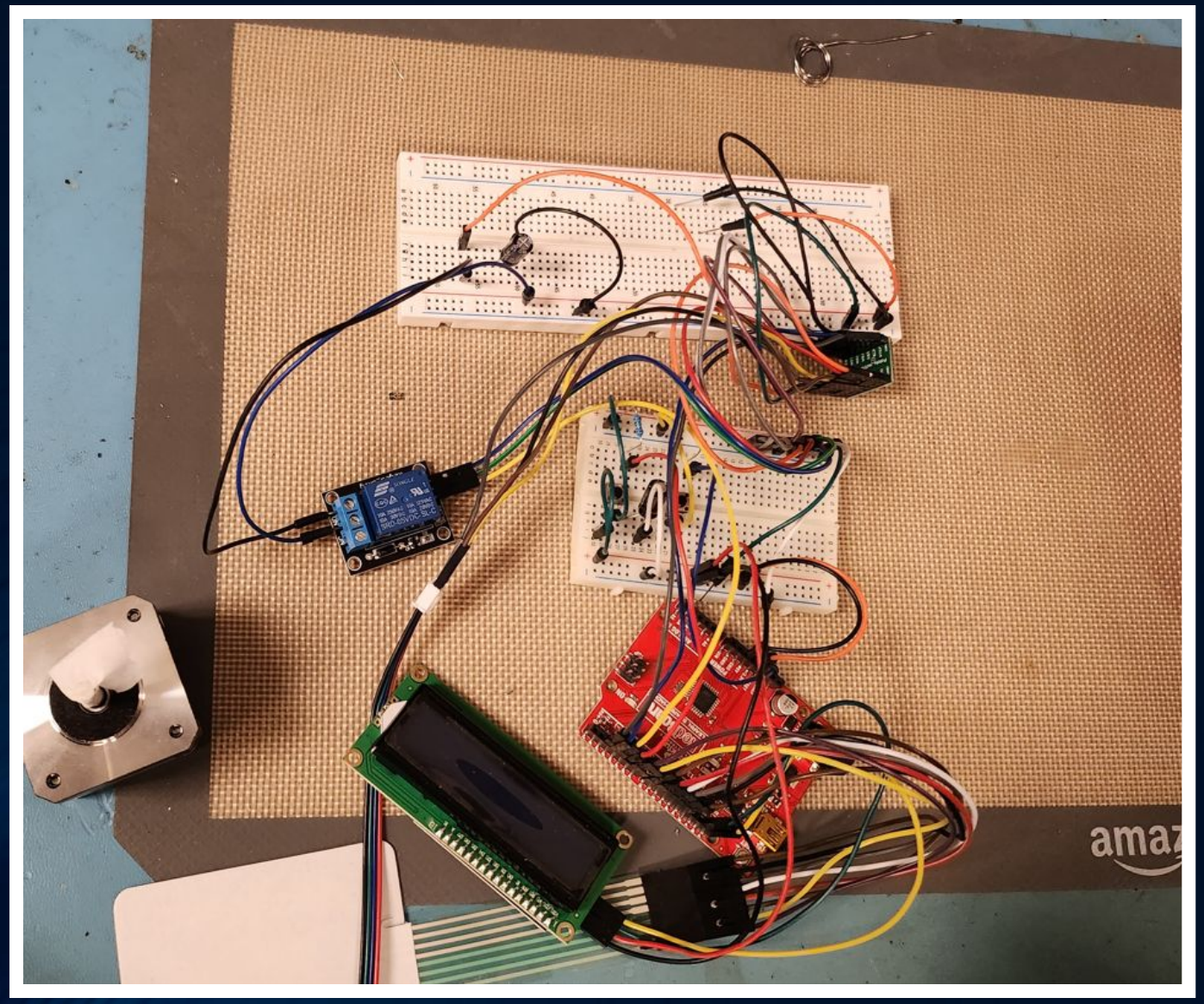
Test Writer : Team 5						
Test Case Name:	LCD Display and Keypad integration test #1				Test ID#	LCDKPI-01
Description:	Verify that the user input on the Keypad is displaying correctly on the LCD Display				Type:	
Test Information						
	Name of Tester:				Date:	
Hardware Ver:	2.3.1				Time:	
Setup:	**Materials:** Hardware/Equipment: Projects BOM. Software: Source code at https://github.com/ECE411T5/Practicum/tree/main/src **Note:-** We need to make sure all the components are appropriately connected first and that our code compiles with no issues. We need to make sure that the display is cleared if the button "C" is pushed, and that the display will show whether or not the entered code is correct or incurred.					
Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Enter any random pin/code	The entered pin or code is displayed on the LCD display correctly and is not overwritten or cropped, etc.				
2	Enter an incorrect pin	LCD message saying "Incorrect Pin" then "C" clears the pin.				
3	Enter the correct pin	LCD message saying "Correct Pin" then "C" clears the pin.				
4	Enter any pin then "C"	The LCD displays that pin then the code gets cleared quickly				
Overall Test Result						

Testing

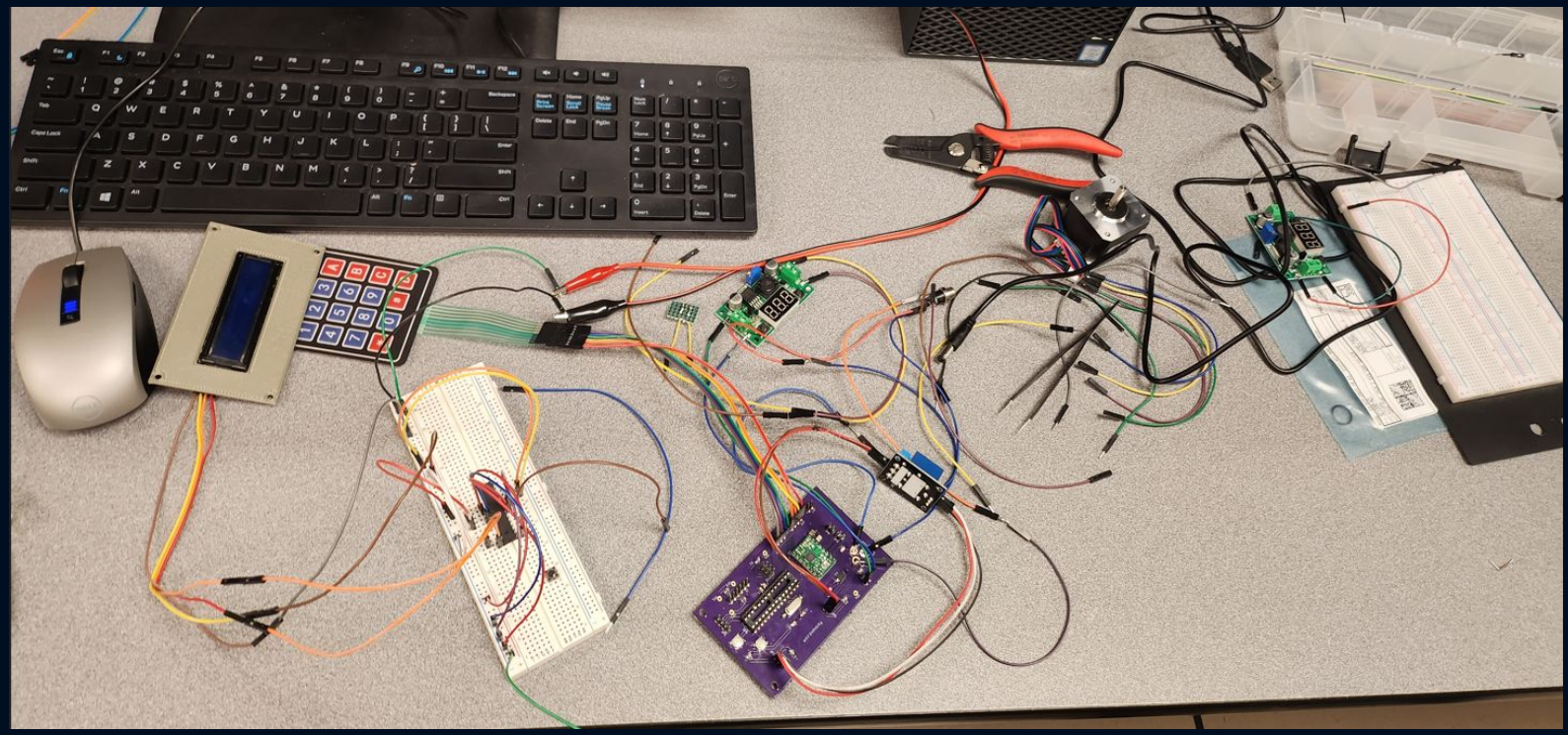
We initially built our whole design on breadboards. To test the breadboard design, we connected each module separately first.

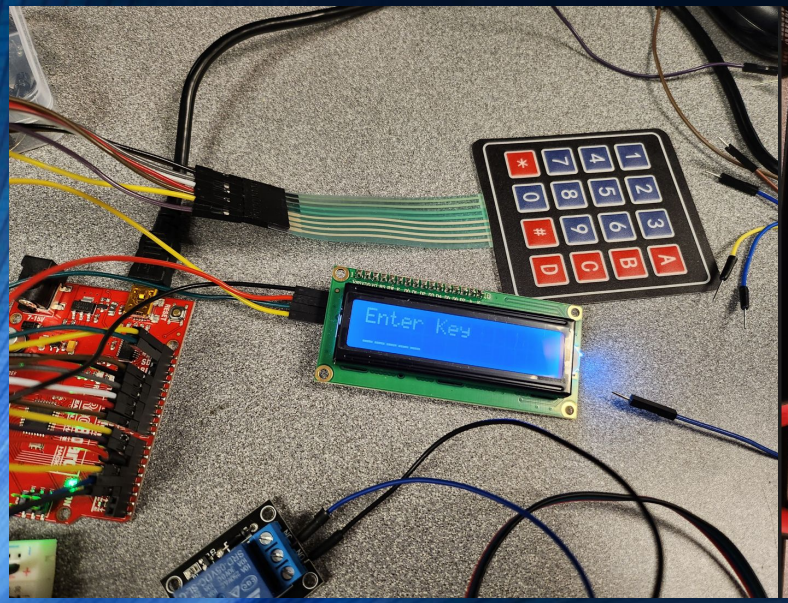
- We tested, debugged, and fixed the issues with our LCD Display, until we made sure it's working as expected.

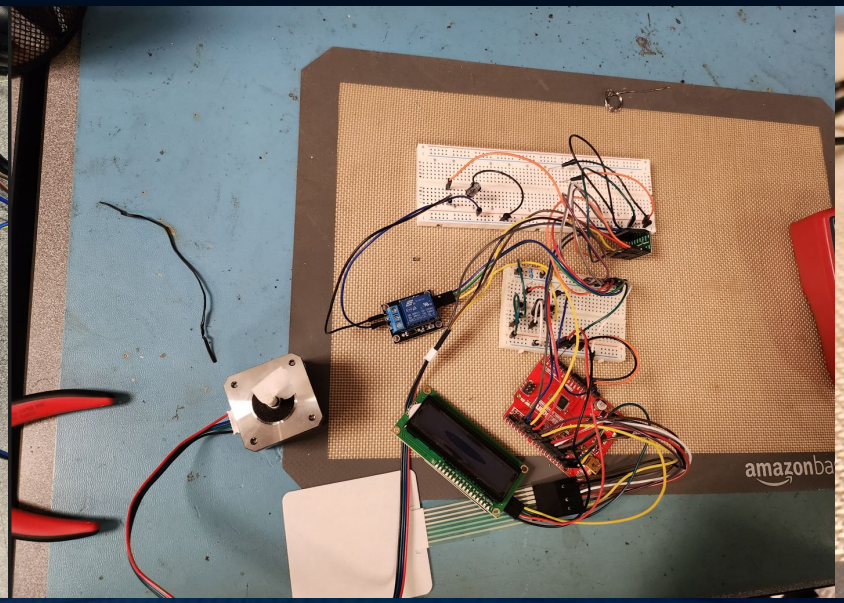
- We did this with all the components. Motor, Relay, Keypad, etc.
- Finally, we put the system together and we got it to work on our breadboard.

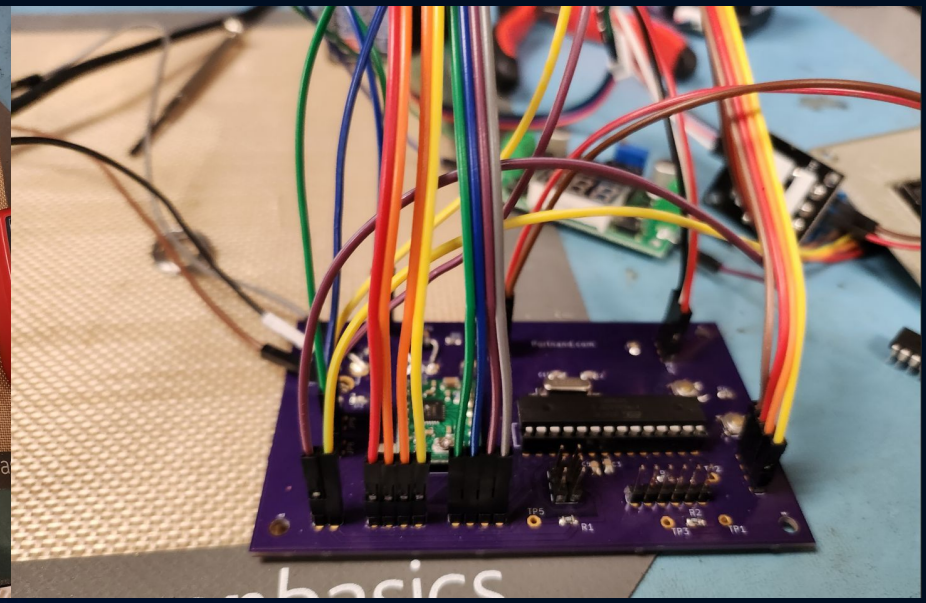


Testing & Putting things together









Results

- The final prototype breadboard is working properly.
- The PCB board didn’t work, but the breadboard prototype ended up working and all the functions and requirements were accordingly.
- The design was for the ATMEGA328P-PU, but we ended up actually using the arduino uno for this design.

Contributions

Mohamed Ghonim
- KiCAD, Schematics, PCB board

Ibrahim Binmahfood:
- Breadboard Prototype, Coding

Joshua Hobby:
- Soldering, documentation

Mohamed Ashkanani:
- Soldering, documentation

Lessons Learned

-Always check the orientation of components before soldering
-Test one board before setting up another
-Surface mounted components should have extra space on pad for hand soldering
-Helpful for prototype to have more space than necessary and be ready to scale down for production
-Buy back-up components (supplies don't always come quickly)
-Check compatibility of components
-Take into consideration wires when designing enclosure (They take up space too!)
-Calibrate components before soldering when possible
-Make sure that there is one neutral ground on the PCB board
-May need separate voltage rail (successful on breadboard, but had issues on PCB). Use another buck converter to supply the ATMEGA328P with 5V
-Check schematic wiring of components
- Make sure the stepper motor actually fits the lock that is opened and closed.

Real"ish" Customer Reviews

-1 out of 5 stars

Product came to me in pieces and did not fit in case. Installed on front door. Was robbed that night. Will not purchase again.

-5 out of 5 stars

Did not work, but the homeless person who entered my home was my long lost brother! Wouldn't have reconnected otherwise!