# Senior Design Manual

Bennett Petzold, Holly Grant, Hunter Marlette, Patrick Burke

Version 0.1 - April 2023

## Contents

# 1 Introduction

The ECE MakerSpace requires training for specific devices with complex or potentially dangerous methods of operation but has no way of enforcing this rule and preventing unauthorized users from accessing those devices. This device was designed to monitor and restrict that access while logging the data associated with each use of every device.

# 2 Bill of Materials

Full BOM and cost breakdown can be found here[1].

## 2.1 Main Components

| Item | Quantity | Link |
|---|---|---|
| Raspberry Pi Model 3B | 1 | Raspberry Pi Website[2] |
| Key Card Swipe Reader | 1 | Amazon Link[3] |
| Main PCB | 1 | N/A |
| Auxiliary PCB | 1 | N/A |
| Waveshare 4” HDMI Display | 1 | Amazon Link[4] |
| Enclosure Bottom Piece | 1 | 3D Printed |
| Enclosure Wall Piece | 1 | 3D Printed |
| Enclosure Top Plate | 1 | 3D Printed |
| Enclosure Buzzer Funnel | 1 | 3D Printed |
| 40mm Fan Filter | 2 | Digikey Link[5] |
| Buzzer | 1 | Mouser Link[6] |
| Relay Controller | 1 | N/A |

| Optional Item | Quantity | Link |
|---|---|---|
| 40mm 5v Fan | 1 | Amazon Link[7] |

## 2.2 PCB Components

### 2.2.1 Main PCB

| Item | Quantity | Link |
|---|---|---|
| TS3USB221RCR Multiplexor IC | 1 | Digikey Link[8] |
| LCA110 Opto Isolator | 3 | Digikey Link[9] |
| 0805 470Ω Resistor | 3 | Digikey Link[10] |
| 0805 0.1$\mu$f Capacitor | 1 | Digikey Link[11] |
| 2x20 Female GPIO Header | 1 | Mouser Link[12] |
| 2 pin 1.50mm JST-XH Right Angle Connector | 2 | Digikey Link[13] |
| 7 pin 1.50mm JST-XH Right Angle Connector | 1 | Digikey Link[14] |
| USB Type A Female Right Angle Connector | 1 | Digikey Link[15] |
| USB Type B Female Right Angle Connector | 1 | Digikey Link[16] |

| Optional Item | Quantity | Link |
|---|---|---|
| PCB Stencil | 1 | Highly Recommended! |
| 0805 LED Red | 1 | Digikey Link[17] |
| 0805 LED Blue | 2 | Digikey Link[18] |
| 0805 LED Green | 1 | Digikey Link[19] |
| 0805 0Ω Jumper Resistor | 4 | Digikey Link[20] |
| 0805 110Ω Resistor | 4 | Digikey Link[21] |
| 2 pin 1.50mm JST-XH Right Angle Connector | 2 | Digikey Link[22] |
| 2 pin 2.54mm JST-XH right angle connector | 1 | Digikey Link[23] |

### 2.2.2 Auxiliary PCB

| Item | Quantity | Link |
|---|---|---|
| 12mm Omicron Tactile Switch | 1 | Mouser Link[24] |
| Red Push Button Cap | 1 | Mouser Link[25] |
| Right Angle Tact Switch | 1 | Digikey Link[26] |
| 0805 LED Red | 1 | Digikey Link[27] |
| 0805 LED Blue | 2 | Digikey Link[28] |
| 0805 LED Green | 1 | Digikey Link[29] |
| 0805 110Ω Resistor | 4 | Digikey Link[30] |
| 7 pin 1.50mm JST-XH Right Angle Connector | 1 | Digikey Link[31] |

## 2.3 Relay Components

| Item | Quantity | Link |
|---|---|---|
| Solid State Relay | 1 | Amazon Link[32] |

## 2.4 Connecting Items

| Item | Quantity | Link |
|---|---|---|
| FPC Flat Flex HDMI Cable | 1 | Amazon Link[33] |
| Right angle USB connectors | 1 | Amazon Link[34] |
| Ethernet Cable | 1 | From Department |
| Micro USB Power Supply | 1 | From Department |
| Micro USB Male to USB Type A male Cable | 1 | From Department |
| USB Type B male to USB type A male cable | 2 | From Department |
| 7 pin male to male 1.50mm JST Cable | 1 | Digikey Link[35] |
| 2 pin male to male 1.50mm JST Cable | 2 | Digikey Link[36] |
| 4mm M2.5 screws | 4 | McMaster[37] |
| 12mm M2.5 screws | 8 | McMaster[38] |
| M2.5 hex standoffs | 2 | McMaster[39] |
| M2.5 Heat-Set inserts | 8 | McMaster[40] |
| M3 security screws | 8 | McMaster[41] |
| M3 Heat-Set inserts | 8 | McMaster[42] |

# 3 Raspberry Pi Setup

Full details for all scripts, including all required dependencies, are in the README[43]. A POSIX-like operating system is required for building the image and recommended for other the other steps.

## 3.1 Building the Raspberry Pi Image

### 3.1.1 GitHub Deploy Keys

GitHub deploy keys are permission-restricted SSH keys for specific repositories. We use a read-only deploy key to download and update the software on each Raspberry Pi. A file at `$HOME/.ssh/access_key` holds the credentials, and `$HOME/.ssh/config` is set to use it.

In the build script directory, `.access_key` is copied into the image as a deploy key. If this is not in the directory (check with `ls -a`), copy the file in to the directory. If you do not have access to an existing key, generate one[44] and skip adding it to the ssh agent. Select "Add deploy key" in "MakerSpaceControl/RaspberryPiSoftware" → "Settings" → "Deploy keys" using the corresponding public key [fig. 1]. The public key is in `KEY_NAME.pub`, i.e. `$HOME/.ssh/access_key` has a public key at `$HOME/.ssh/access_key.pub` after generation.

To change deploy keys after build, mount the image file (`mount -o IMAGE.img MNT_DIR`) or the SD card (`mount IMAGE_PARTITION MNT_DIR`). Replace the key in the image (`cp KEY MNT_DIR/home/Project13/.ssh/access_key`). Then unmount the image file or SD card (`umount MNT_DIR`) before removing any media.

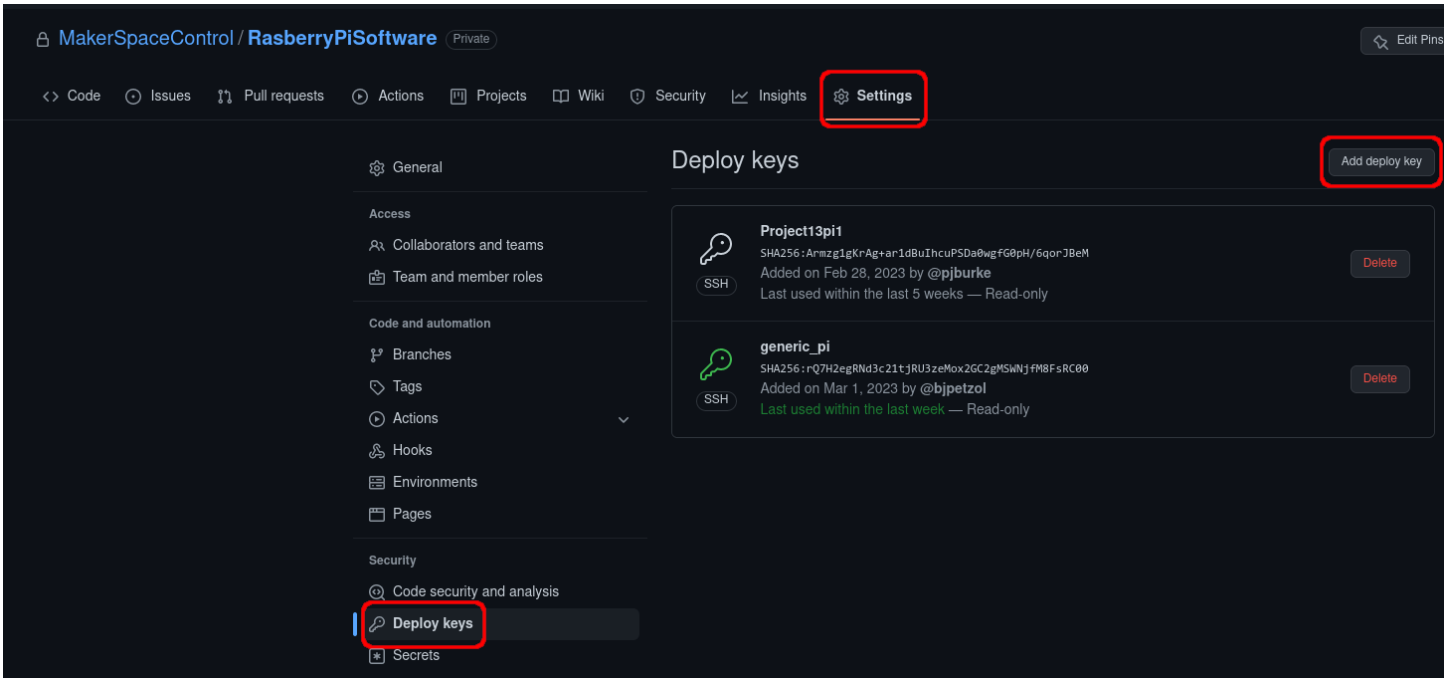



Figure 1: Adding a Deploy Key

### 3.1.2 User Settings

Two passwords are kept in the build script directory. The user password is in the plaintext `.password` and `.root_password` has the root password. All three identity files (`.password`, `.root_password`, and `.access_key`) are *deliberately* ignored by git for security. These files need to be copied to any new image build directories.

### 3.1.3 Running the Build Script

The build script is run with `./build.bash` and constructs an xz compressed image file. This script requires QEMU, sudo, and a user with sudo access to mount and build the image. Creating a new image takes at least half an hour, as the script needs to update and install many packages inside a virtual environment. The script needs to be given a superuser password after downloading a base image, but otherwise runs unattended. The output is tagged with the build date as per the build machine's clock.

## 3.2 Updating the Image

The update script is run with `./update.bash IMAGE.img` and constructs a new xz compressed image without destroying the provided base image. This requires the same permissions and tools as the build script, but is significantly faster. The script updates the image to have the latest packages and MakerSpace control code. The output is tagged with the build date as per the build machine's clock.

## 3.3 Flashing the Image

The image can be written to an SD card with `./install.bash IMAGE.img DISK...`, which provides convenience progress displays and automatically expands every partition to maximum size. Other image writing tools, such as Raspberry Pi Imager[45] or Balena Etcher[46] can also decompress and write the file with progress information. If using a third-party tool, this step does not require a POSIX-like machine. Make sure the SD card is fully written to before removing it. The tools should wait for a full write before showing as complete, but this can be verified on a POSIX-like machine by running

```
for device in /sys/block/*; do awk '{ print "$device: " $9 }' "${device}/stat"
```

and confirming that all sdX devices have a "0" status.

## 3.4 First Machine Boot

Once the SD card is written, it can be placed in the slot of the target Raspberry Pi. Assemble it with the rest of the physical system [section 7] and connect it to both ethernet and power. When the module is first powered on, and only when it is first powered on, it will display a MAC address for 30 seconds after booting. This MAC address is used as an identifier for management and communications with the remote server. Note it down and add the MAC address to the system. When the MAC address is added to the management database, the module will finish configuring itself and be fully functional without a reboot.

# 4 Printed Circuit Board Manufacturing

## 4.1 Ordering the Design Files

### 4.1.1 Accessing PCB documents

The PCB files were created using Autodesk Fusion 360. As of writing this document, April 2023, Fusion 360 has their own version control software called Fusion Teams.The folder entitled "Senior Design 13 - Makerspace Access Control" Contains all versions of the Circuit Board Designs and has been shared with the following:

| Name | Email | Role |
|---|---|---|
| Hunter Marlette | hemarlet@ncsu.edu | Administrator (Owner) |
| Patrick Burke | pjburke@ncsu.edu | Editor |
| Bennett Petzold | bjpetzol@ncsu.edu | Reader |
| Holly Grant | hmgrant@ncsu.edu | Reader |
| | | |
| Dzung Nguyen | dhnguye2@ncsu.edu | Editor |
| Dan Green | djgreen@ncsu.edu | Reader |
| Rachana Gupta | ragupta@ncsu.edu | Reader |
| Jeremy Edmondson | jedmond2@ncsu.edu | Reader |

The role permissions are as follows:

| Role | Permissions |
|---|---|
| Viewer | View online, Post and read comments |
| Reader | Viewer + open with desktop, download, copy and paste |
| Editor | Reader + edit, upload, rename, move, delete, and share |
| Manager | Editor + manage members and set access levels |
| Administrator | Manager + Permanently delete |

The PCB Documents are also located in the Hardware-Design[47] section of the GitHub Repository as well as in the Hardware Files[48] folder on the Google Drive. Both of these locations are shared with all of the above-mentioned users and associated email addresses.

### 4.1.2 Exporting the PCBs from Fusion 360 for manufacturing

There are four options for retrieving the files for printing the PCBs: using FUSION TEAMS online, using the Fusion 360 Desktop Application,retrieving the files from GitHub, and retrieving the already exported zip file from Google Drive. BY FAR the easiest way is to go to the Google Drive and getting the files already exported and zipped ready for use! They have all been listed below in case there is a reason one method is needed above the other. The first two options are the most complex, but will also be absolutely necessary for updating this design in the future using Fusion360 or if you need to export them in a different file format for use with a different manufacturer.

Option One: Open files from Fusion online

NOTE:

You are expected to have a Fusion 360 account that has one of the permissions listed above in order to have access to this method. You are also expected to have downloaded the desktop application of Fusion 360 in order for the following steps to work. Please see Autodesk's Website[49] for more details.

1. Open FUSION TEAM and access the project folder.
2. There are 6 folders within this directory. The only one necessary for reproducing this product is the last folder entitled "V6 - Consolidation". Open that folder and inside you will find two folders, one for each circuit board that must be manufactured for the system to function properly.

   **NOTE:** If you wish to make changes to the design, please create a new folder in this directory or export the files to a separate project. Do not make changes to the existing

finalized designs after May 2023 as they have been finalized by the team and reflect student work up to that date.

3. Open the folder corresponding to which board you are trying to export. Inside each folder you will find four files. One is the schematic file, one is the PCB document, one is the 3D CAD rendering, and one is the project header file that links the other three files together.
4. To open the whole project in the Fusion 360 desktop application, select the project header file in the online viewer. If there is any confusion over the labeling of the files, here is a description of the icons:
    - The schematic file, entitled "[name]_circuit", is a green rectangle with the schematic symbol for a light emitting diode inside the rectangle with a light grey background.
    - The PCB Design file looks almost like an Arduino, as it is supposed to most closely resemble how the PCB would look when printed. It in a solid dark green rectangle with one of the corners cut off and some smaller shapes on top resembling components.
    - The 3D render is simply an orange cube.
    - The Header file that you are going to want to access looks like you took the image for the schematic and placed it on top of the image of the PCB at a slight offset.
5. There should be a button in the top right corner of the window that reads "Open in Desktop"
6. After this opens in your desktop application, you should see four windows: a schematic in the top left, a PCB in the top right, and a top and bottom view of the 3D render on the bottom. There should also be a drop down menu on the left hand side with the name of the board you have opened. Click the triangle to expand that view and click on the PCB Design file as mentioned previously.
    - Alternately, if you see there is multiple tabs already opened, you can more easily click the PCB Design file there as well.
7. In the top menu click on "Manufacturing".
8. Find and open "CAM Processor" from the menu.
9. Check the box labeled "Export as ZIP" at the top of this window.
10. Disable extra silkscreening on the Main PCB:
    - Select "Silkscreen Top" from the list on the left hand side of the processor.
    - Click the "edit layers" icon that looks like three sheets of paper stacked on top of each other.
    - Deselect "tplace" and hit "OK".

- Select ”Silkscreen Bottom” from the list on the left hand side of the processor.
- Click the ”edit layers” icon.
- Deselect ”bplace” and hit ”OK”.

11. Disable extra silkscreening on the Auxiliary PCB:
    - Select ”Silkscreen Top” from the list on the left hand side of the processor.
    - Click the ”edit layers” icon that looks like three sheets of paper stacked on top of each other.
    - Deselect ”tdocu” and hit ”OK”.
    - Select ”Silkscreen Bottom” from the list on the left hand side of the processor.
    - Click the ”edit layers” icon.
    - Deselect ”bdocu” and hit ”OK”.

    NOTE: The extra steps above to disable the top and bottom placement silkscreen layers does not affect the performance of the board whatsoever and is purely cosmetic. Feel free to skip these steps if you wish.
12. Click ”Process Job”. Select the destination you wish to save the zip file and click ”Save”.

Option Two: Open files from Fusion Desktop App

1. Open Fusion 360 Desktop Application.
2. Click the icon in the top left of your window that looks like 9 squares arranged in a 3x3 grid.
3. Make sure that ”Hunter’s Team” is selected from the drop down menu in the top left.
4. This should open your library/team window that allows you to see all of the folders mentioned in option 1. Locate the correct folder and open the board files just like option 1.
5. Once opened, follow steps 7-12 exactly the same as option 1 to export your ZIP file correctly.

Option Three: Open files from Google Drive

1. Open the Senior Design Google Drive[50]
2. Navigate to ”home/Hardware Files/Final PCB Revisions/PCB Rev7” and locate the two ZIP files for each on the PCBs
    - You may also skip directly to the PCB Folder in the google drive here[51].
3. Download the necessary files to your computer to send to the manufacturer.

Option Four: Open files from GitHub Repository

1. Open the Hardware-Design folder of the GitHub repository[52]
2. Download the necessary files to your computer to send to the manufacturer.
   - You may view the README.md[53] file to navigate the repository.

## 4.2 Assembling Components onto the PCB

**IMPORTANT:** If you are assembling Revision 5 of the main PCB instead of Revision 6 (as printed on the front of the main PCB), you will need to connect pins 2 and 3 on OPTO 3. These are the middle left and bottom left pins when looking at the top of the board. You can simple bridge the pins with solder or use a 0Ω resistor to make the soldering easier. This has been fixed on the latest Fusion document file so if you have ordered new PCBs this will not be an issue.

**OPTIONAL:** The Green LED on the top of each section of LEDs can have it's corresponding resistor replaced with a lower value to make it brighter. There is 4.7 Ω resistors included in the assembly kit for this reason. This value most closely approximates the same brightness across all of the LEDs.

### 4.2.1 Main PCB

1. Firstly, locate the stencil for all of the surface mount components.
2. Align the stencil with the traces on the circuit board and secure both in place.
3. Using a squeegee, apply solder paste across the stencil making sure each trace is adequately covered.
4. Place all surface mount components in their corresponding locations. You may use the labels silk-screened onto the PCB as a guide but it is advisable to reference the Fusion file to make sure all components are installed correctly.
5. Set the reflow oven to Wave 3 (for the solder paste and reflow oven being used in the NCSU MakerSpace as of April 2023) This may change if a different reflow oven is being used, so figure out what temperature curve works with the solder paste and oven you are using currently.
6. Allow the reflow oven to run a complete cycle and let the board cool before proceeding to soldering the through-hole components. NOTE: At this point I would Recommend using a bench power supply to test that the surface mount LEDs and resistors are soldered in the correct locations and orientations.
7. Next solder each of the through hole components with a soldering iron and ensure for a secure connection.
8. Once all components are soldered onto the board, use a bench power supply and oscilloscope to test your connections. The USB Multiplexer may have to be connected to a Raspberry Pi to be able to be tested effectively.

#### 4.2.2 Auxiliary PCB

1. Repeat the same steps for the main board here except there are no extremely small surface-mount components besides the LEDs and resistors which can be easily reflowed without a stencil.
2. Once all components are soldered onto the board, use a bench power supply and multi-meter to test your connections. This boars is very easy to test with just a power supply and multi-meter and does not necessarily require a connection to the Raspberry Pi to confirm functionality.

# 5 Enclosure

## 5.1 Settings for 3D Printing

The Top requires PVA(polyvinyl alcohol) supports. No other components of the enclosure require supports.

All files are uploaded to the project GitHub in the Hardware Repository.

#### 5.1.1 Enclosure Lid settings

- Layout
  - set Rotate X =-78
  - set Rotate Y= 90
  - click On bed
  - Click Center
  - click Slice
- Extruder 1 (PLA)
  - Layer Height = 0.1 mm
  - Wall Thickness = 1.3 mm
  - Infill Density = 40 %
  - Printing Temperature =230 C
  - Build Plate Temp = 60 C
  - Adhesion Type = Skirt
  - Generate Supports = ON
  - Support Extruder = Extruder 2
- Extruder 2 (PVA)

  - Layer Height = 0.1 mm
  - Wall Thickness = 1 mm
  - Infill Density = 20 %
  - Printing Temperature =225 C
  - Build Plate Temp = 60 C
  - Adhesion Type = Skirt
- Expert Settings for Extruder 1
  - Goto Shell settings and set Top Surface Skin Layers = 2
  - Goto Shell settings and set Top/Bottom Pattern = Zig Zag
  - Goto Dual Extrusion and enable Prime Tower
  - set Prime Tower Size =15mm

#### 5.1.2 Enclosure Bottom & Top settings

- Layout
  - set Rotate X =-90 for top
  - set Rotate X = 90 for bottom
  - click On bed
  - Click Center
  - click Slice
- Extruder 1 (PLA)
  - Layer Height = 0.1 mm
  - Wall Thickness = 1.3 mm
  - Infill Density = 40 %
  - Printing Temperature =230 C
  - Build Plate Temp = 60 C
  - Adhesion Type = Skirt
  - Generate Supports = OFF

### 5.2 Preparing the printed pieces for installation

- Lid
  - Clean off supports I used the ultrasonic cleaner with water and no heat for 30-40 minutes
  - Clean up the large holes in the corners using a 3mm drill bit
- Middle Section
  - Clean up the holes on the top and bottom with a 3mm drill bit
- Bottom Plate
  - Clean up the large holes in the corners using a 3mm drill bit
  - clean up the Rasberry pi standoff holes in the middle with a 2.5mm drill bit

## 6 Relay Controller

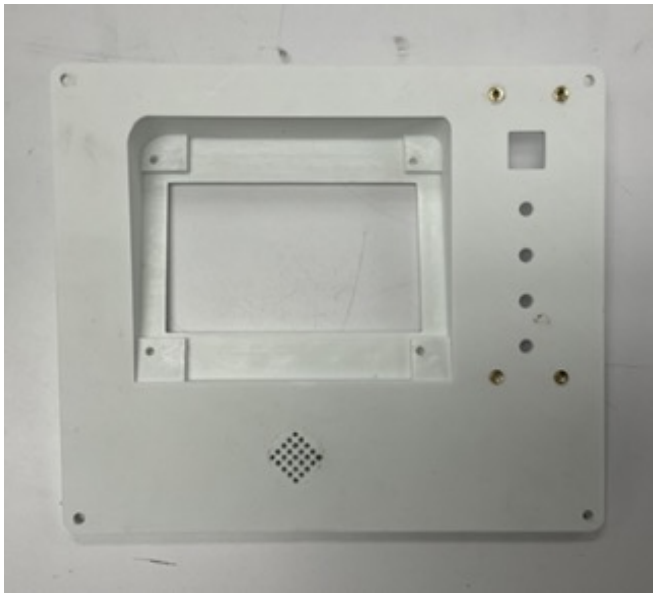
This will use 2 conductor wire (can be telephone or any other 22 gauge wire) and a Solid State relay.

Attach the 2 conductor wire to the relay on the control +- side, then add the 2pin JST connector used on our main board to the other end. Attach the controlled devices' power lines to the Load +- with the voltage source on the + and the device being supplied on the - side.

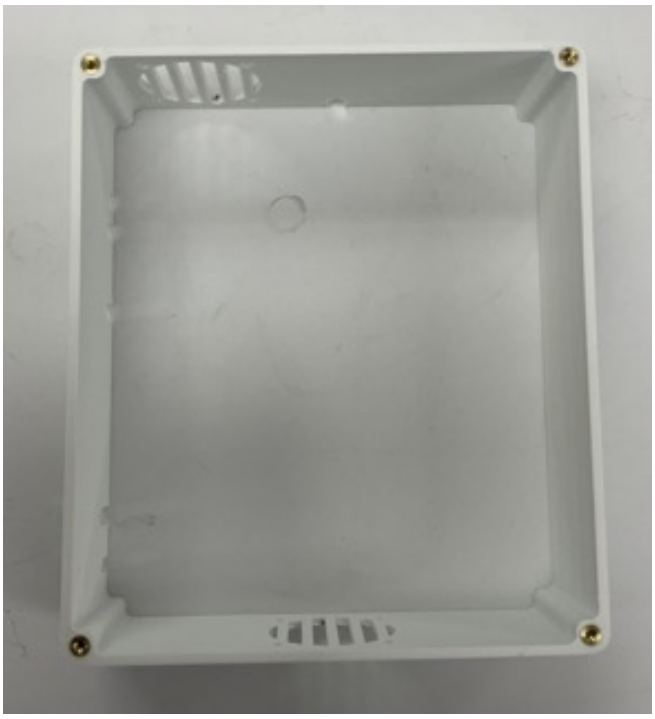
# 7 Final Assembly

## 7.1 Installing Heat Inserts

Begin by installing heat inserts in the holes on both the top and bottom of the enclosure walls and on the underside of the lid where the secondary board will be secured. Follow this tutorial[54] for using heat inserts and ensuring that no plastic from the enclosure coats the inside. Use the larger-sized(3mm) heat inserts for enclosure walls and the smaller-sized(2.5mm) inserts for the area on the lid where the auxiliary board with the button attaches.



(a) Heat Inserts In the Lid



(b) Heat Inserts In the Walls

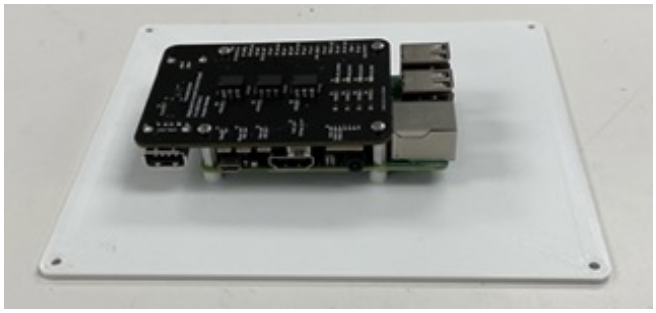
## 7.2 Attaching Key Card Reader

Due to the variance in screw hole placement on different brands of key card scanners, the holes must be manually marked and drilled for each assembly. First, place chosen scanner on a piece of paper and mark the screw hole placement by pushing a marker or pen through the paper and into the holes. Next, place the paper on the outside of the right enclosure wall (see photo) and mark the hole placement using the guide. Then drill out the holes with a bit corresponding with the size of the scanner's screws. Finally, screw the scanner into place on the outside of the enclosure walls with 3/8in 4/40 screws and with 2 washers on each screw, threading the screws from inside the wall through to the scanner.

Figure 3: Scanner Attached to Enclosure

## 7.3 Securing Internals

The main PCB will be placed on top of the Raspberry Pi by connecting the headers, with metal standoffs in between, placed at each of the screw holes. The 12mm M2.5 screws go through the holes on the bottom of the case and into the threaded standoffs in between the boards. M2.5 are inserted through the top of the main PCB and into the standoffs to secure both boards. The vent filters and fans can be attached to either vent on the inside of the enclosure walls using 4/40 screws, inserting the screw from outside the walls, through the fan and/or filter, and using a nut to secure. Then the fan's cable can be connected to the main PCB. Finally, connect all cables to their correct ports, add strain relief with plastic zip ties, and wrap and secure the excess cable from the scanner.



(a) Raspberry Pi and PCB Attached to Bottom Plate

(b) Fans and Filters Attached to Walls

## 7.4 Attaching Enclosure Walls

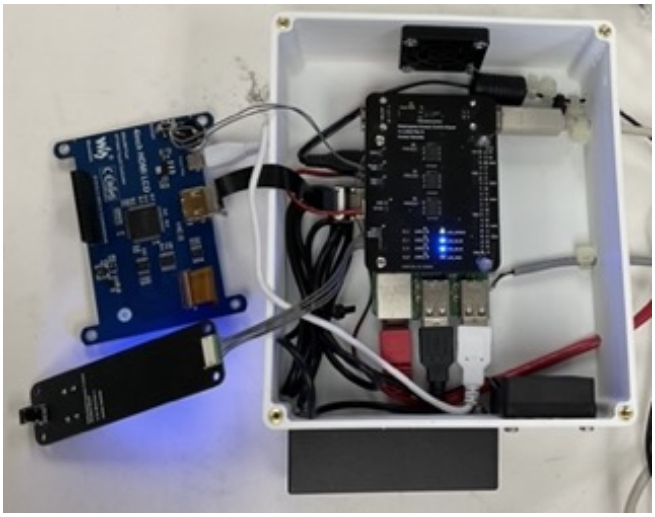
After the cables have been connected to the correct ports and properly managed, the enclosure walls can be placed on top, ensuring the cables thread through the notches. Using the correct screws(3mm), the bottom enclosure plate can be secured to the walls by inserting the screws up through the bottom and into the walls.

Figure 5: Cable Connections and Strain Relief

## 7.5 Securing Lid and Connections

The holes on the underside of the lid for the display must first be tapped using a 4-40 tap. Then the display can be screwed into place with the screws that come with them, ensuring the HDMI port is facing down. The secondary PCB can also be screwed into place on the underside of the lid with 4mm spacers in between the board and the lid to maintain the proper height. After both the HDMI cable and secondary board cable are connected to the main PCB and Raspberry Pi, the lid can be placed on top of the enclosure walls and secured in place with the 3mm security torx screws.

(a) Display and Secondary PCB Attached to Lid



(b) Cable Connections For All Internals

## 7.6 Connecting to device

Different devices will require different control methods. If it is a simple device that can just use USB then you just need to plug the USB line that plugs into the device into the controlling USB on the Main Board. If the device has a control line you will need the electrical schematic for that device and then find the door lines or another line that will pause the machine and then plug that line into our safety line control cable. If it is an AC-powered device then you will need to use a solid-state relay with a 3-5v control input voltage and then wire the power into that of whatever device you are trying to control as explained in section 6.

# 8 Database

## 8.1 Implementation

The databases are constructed using MariaDB[55]. The development version is constructed as a series of setup statements, collated from the `database` directory into `database_creation.sql` when `make` is run for the WebInterface respository. These setup statements are run inside a docker compose project, using the docker image for MariaDB version 10.9.4.

## 8.2 Databases and Access Control

There are three databases, cross-referenced in views, to clearly define access rules.

Table 1: Database Users

| User | Scope |
|---|---|
| Controller_Read | API commands retrieving data |
| Controller_Write | API commands writing data |
| Admin_Read | Web management reading system status |
| Admin_Write | Web management database modifications |
| Root | Full permission base user |

Table 2: Overview of Databases

| Database | Write Users | Read Users | Purpose |
|---|---|---|---|
| Admin_Utility | Admin | Admin | System Configuration |
| Controller_Utility | Controllers | Controllers | Configuration Data |
| Logging | Controllers | Controllers, Admin | Usage Record |

## 8.3 Table Layout

**Admin_Utility**

| Table | Fields | Purpose |
|---|---|---|
| assignments | controller_id, device_id | Associate controllers with devices |
| blocked_users | id, time, administrator, reason | Block trained users from system access |
| devices | id, name, settings | Set configuration for each machine |
| users | allowed_device_id | Give users access to specific machines |

**Logging**

| Table | Fields | Purpose |
|---|---|---|
| log | time. controller_id, device_id, user, event | Record system usage and actions |

Table 3: Table Definitions

## 8.4 View Layout

**Admin_Utility**

| View | Databases Used | Purpose |
|---|---|---|
| auth_failures | Logging, Admin_Utility | Record of rejected accesses |
| recent_auth_failures | Admin_Utility | Rejected within past 24 hours |
| repeat_recent_auth_failures | Admin_Utility | Times rejected in past 24 hours |
| recent_events | Logging, Admin_Utility | Most recent event for per device |

**Controller_Utility**

| View | Databases Used | Purpose |
|---|---|---|
| allowed_users | Logging, Admin_Utility | User authorization testing |
| pi_settings | Admin_Utility | Getting setup for assigned device |

Table 4: View Definitions

# 9 API

## 9.1 Implementation

The API is built using Laravel[56]. The development version is an image inside a docker-compose project, referencing a database container. For deployment, the contents of `laravel_api/html` in the WebInterface repository can be copied to the target server.

## 9.2 Authentication

The API is meant exclusively for MakerSpace control unit access. Units give their MAC address in a "HTTP_MAC" header, and are only allowed to read and modify resources directly assigned to themselves. Any unit not assigned to a MakerSpace device inside the database will not be given access. If a machine's MAC address is compromised, the API access can be revoked by removing the MAC address from device assignments.

## 9.3 GET Requests

- config
  - Returns: JSON object of configuration settings
  - Side effect: Logs that the device is alive
- auth_user
  - Input: JSON array of user IDs
  - Returns: Boolean true or false for set of valid users
  - Side effect: logs authentication request
- user_admin
  - Input: JSON array of user IDs
  - Returns: Boolean true or false for set of admin users
  - Side effect: logs authentication request

## 9.4 POST Requests

- log
  - Input: JSON array of events
  - Effect: adds given events to the controller's log

# 10 Admin Website

## 10.1 Implementation

The website is constructed using PHP 8.1[57] on Apache[58], mysqli[59], and Google Charts[60] through JavaScript[61]. The development version is a docker image run inside the WebInterface docker compose project. The files in `server/html` in the WebInterface repository can be copied to a host for deployment.

## 10.2 Authentication

All website pages are protected by Shibboleth (the development version uses generic .htaccess files). Access to the database is controlled through locally stored credentials. It is assumed that any user with access to the underlying environment, or can log into the webpage, should be given full control of the system and access to all secrets. The two users constructed for interacting with the database are to protect against bugs, not to act as a protective measure.

## 10.3 Functionality

The website has full admin access to the database. All actions are built upon a consistent main display page that is meant for desktop use. Administrative changes (i.e. blocking a user) are performed through PHP form submissions. Live data graphs are constructed through continuous JavaScript actions. Any SQL commands outside of the prebuilt set should be performed with a separate MariaDB interactive client.

# 11 Troubleshooting/Debugging

## 11.1 Boot Issues

- System takes a long time to boot
  - Check that the SD card and power connector are properly seated.
  - Check if the SD card has a slow read speed – replace if so.
- Error in Raspberry Pi boot process
  - Check if the SD card is corrupted. Replace if it is.
  - Flash SD card with a known working image.
- System does not display UI fullscreen
  - Change the sleep time in i3-config (inside the build directory) to be longer and re-flash

## 11.2 Communication Issues

- System does not connect to USB/Ethernet/etc.
  - Re-seat all internal connectors.

  - Verify cords are fully functional.
  - Replace the Raspberry Pi.
- System is not communicating with API.
  - Check the system network connection.
  - SSH into the system and run `getmac` to confirm the address was properly copied.
  - Check for rejected communications in the admin interface, replace any incorrectly entered MAC address.
- Admin Interface is not communicating with database.
  - Check if the database is live.
  - Log into the database and check for rejected connections.
  - Update database user certifications.

### 11.3 Image Issues

- Image needs superuser permission to build/update/flash.
  - Use a system where you have superuser access.
- Image is corrupted on SD card.
  - Mount the SD card data partition and run `fsck -fy FILESYSTEM`
  - Decompress the latest image, loopback mount the data partition, and run `fsck -fy FILESYSTEM`
  - If the image has no issues, but the SD card is corrupted after writing it again, discard the SD card.
  - If the image has issues, go to an older image and check it. If it works, update the older image and reflash.
  - If no older issues work, rebuild an image from scratch.

## 12 External Links

1. https://docs.google.com/spreadsheets/d/1I3pgFnPUj8xgdaECBA7j94ydT4JwhcCwujzxo4dt6PY/edit#gid=97521878

2. https://www.raspberrypi.com/products/raspberry-pi-3-model-b-plus/

3. https://www.amazon.com/dp/B0BHYXL8VB

4. https://www.amazon.com/HDMI-LCD-Resolution-Resistive-Screen/dp/B07P5H2315/

5. https://www.digikey.com/en/products/detail/orion-fans/GRM40-30/2621295
6. https://www.mouser.com/ProductDetail/CUI-Devices/CCG-1206
7. https://www.amazon.com/WINSINN-Brushless-Cooling-Extruder-Makerbot/dp/B07KRSJVP7
8. https://www.digikey.com/en/products/detail/texas-instruments/TS3USB221DRCR/1258254
9. https://www.digikey.com/en/products/detail/ixys-integrated-circuits-division/LCA110/203107
10. https://www.digikey.com/en/products/detail/bourns-inc/CR0805-JW-471ELF/3785327
11. https://www.digikey.com/en/products/detail/nextgen-components/0805B104K500BD/15776052
12. https://www.mouser.com/ProductDetail/Adafruit/2222
13. https://www.digikey.com/en/products/detail/jst-sales-america-inc/S2B-ZR-LF-SN/926576
14. https://www.digikey.com/en/products/detail/jst-sales-america-inc/S7B-ZR-LF-SN/926581
15. https://www.digikey.com/en/products/detail/allied-components-international/AUSB1-4600/14321121
16. https://www.digikey.com/en/products/detail/switchcraft-inc/RAHPCUB20/17372468
17. https://www.digikey.com/en/products/detail/osram-opto-ams-osram/LS-R976-NR-1/1227987
18. https://www.digikey.com/en/products/detail/liteon/LTST-C170TBKT/388527
19. https://www.digikey.com/en/products/detail/liteon/LTST-C171GKT/386793
20. https://www.digikey.com/en/products/detail/stackpole-electronics-inc/RMCF0805ZT0R00/1756901
21. https://www.digikey.com/en/products/detail/bourns-inc/CR0805-JW-111ELF/3785219
22. https://www.digikey.com/en/products/detail/jst-sales-america-inc/S2B-ZR-LF-SN/926576
23. https://www.digikey.com/en/products/detail/jst-sales-america-inc/S2B-XH-A-1-LF-SN/9961922
24. https://www.mouser.com/ProductDetail/Omron-Electronics/B3F-5050
25. https://www.mouser.com/ProductDetail/Omron-Electronics/B32-1380
26. https://www.digikey.com/en/products/detail/e-switch/TL1105VF160Q/378974
27. https://www.digikey.com/en/products/detail/osram-opto-ams-osram/LS-R976-NR-1/1227987

28. https://www.digikey.com/en/products/detail/liteon/LTST-C170TBKT/388527

29. https://www.digikey.com/en/products/detail/liteon/LTST-C171GKT/386793

30. https://www.digikey.com/en/products/detail/bourns-inc/CR0805-JW-111ELF/3785219

31. https://www.digikey.com/en/products/detail/jst-sales-america-inc/S7B-ZR-LF-SN/926581

32. https://www.amazon.com/SSR-25DD-3-32VDC-Output-5-240VDC-Plastic/dp/B08GNSPCND

33. https://www.amazon.com/Cablecc-Angled-Multicopter-Aerial-Photography/dp/B07R6CWPH1/

34. https://www.amazon.com/gp/product/B073GTBQ8V/

35. https://www.digikey.com/en/products/detail/jst-sales-america-inc/A07ZR07ZR28H102A/9972189

36. https://www.digikey.com/en/products/detail/jst-sales-america-inc/A02ZR02ZR28H305B/6009417

37. https://www.mcmaster.com/92000A102

38. https://www.mcmaster.com/92005A075/

39. https://www.mcmaster.com/95947A007

40. https://www.mcmaster.com/94180A321

41. https://www.mcmaster.com/91870A306/

42. https://www.mcmaster.com/94180A333

43. https://github.ncsu.edu/MakerSpaceControl/RaspberryPiBuild/blob/main/README.md

44. https://docs.github.com/en/authentication/connecting-to-github-with-ssh/generating-a-new-ssh-key-and-adding-it-to-the-ssh-agent

45. https://www.raspberrypi.com/software/

46. https://www.balena.io/etcher

47. https://github.ncsu.edu/MakerSpaceControl/Hardware-Design

48. https://drive.google.com/drive/folders/1XmkZzzdNFWirSOfwTD2oHMQbwkMx24IF

49. https://www.autodesk.com/support/technical/article/caas/sfdcarticles/sfdcarticles/How-does-Fusion-360-get-installed.html

50. https://drive.google.com/drive/u/0/folders/16LREA6uZIBmt0r77SXmVdAlndRQpoMT1

51. https://drive.google.com/drive/folders/1qATTFgdaTWc2hBvAnFWY5WV3vpXczItH?usp=share$_{l}ink$

52. https://github.ncsu.edu/MakerSpaceControl/Hardware-Design

53. https://github.ncsu.edu/MakerSpaceControl/Hardware-Design/blob/main/README.md

54. https://www.youtube.com/watch?v=GP1qrN-ONTA

55. https://mariadb.org/

56. https://laravel.com/

57. https://www.php.net/

58. https://httpd.apache.org/

59. https://www.php.net/manual/en/book.mysqli.php

60. https://developers.google.com/chart/

61. https://developer.mozilla.org/en-US/docs/Web/JavaScript