Smart Electronic Component Organizer

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1. Introduction

1.1 Objective

As EE students, most of us have stored many electronic components such as resistors, capacitors and MOSFETs. Traditionally, we would store these components in storage organizers, a huge cabinet with many transparent plastic drawers. A small organizer may only have as few as 20 drawers. However, a larger one can have up to a hundred organizers. A big problem is that people usually cannot immediately locate the components they want. They have to look into the transparent boxes or at the tags one by one, wasting a lot of time.

We propose a solution to this problem by creating a logger with indicators for people to better store and find components. It would also consist of mechanical designs to push the drawers out from the back. People could use an App on their Android phones to connect to the organizer to find components, log new components, clear drawers and open the drawers by sending commands to the organizer using their App.

1.2 Background

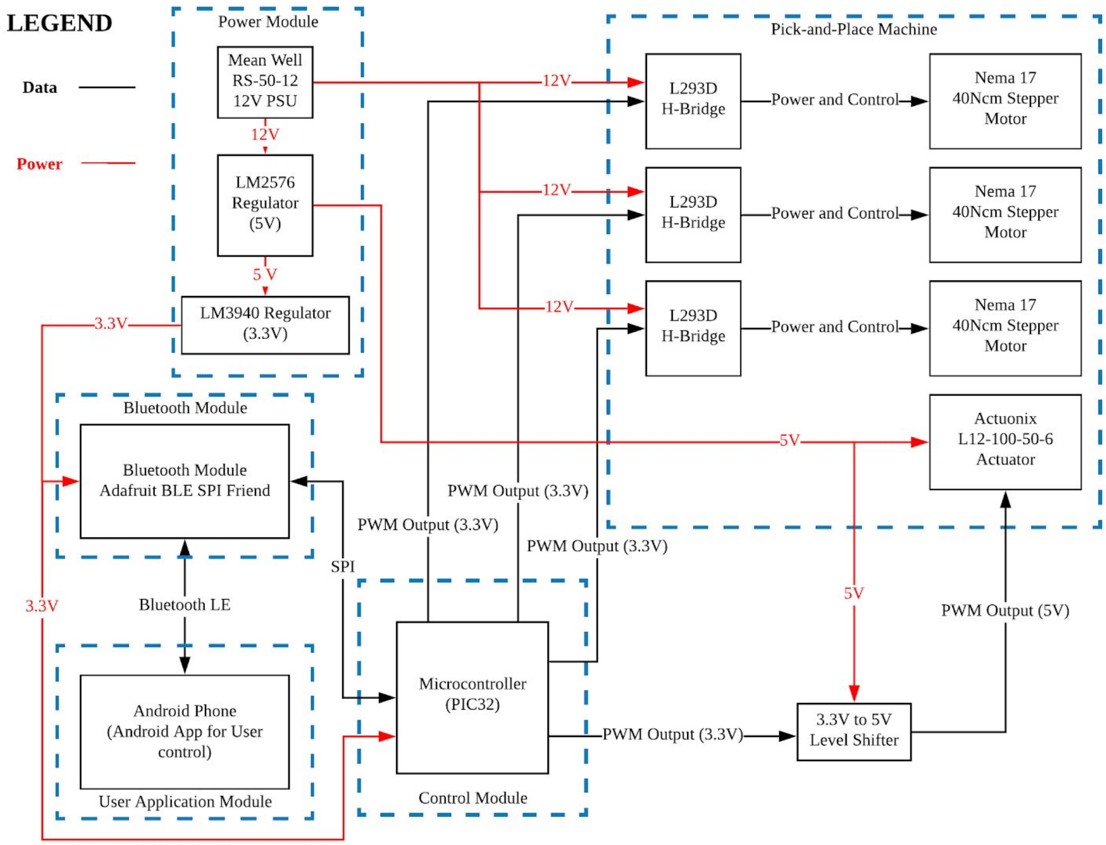
It is not a new idea to digitize boxes or lockers for better management. Though most of the lockers are accessed only by mechanical keys, many electronic lockers have been introduced to the market and deployed by mew department stores and apartments. However, hardly anyone considered bringing a digitized box management system to smaller instances, for example, an electronic components organizer. Although every experienced engineer would be used to find data in datasheets and lookup tables as well as to find a certain type of components out of hundreds of boxes, it would still waste much time. Because there are currently no widely-used and affordable digitized organizers on the market[1], the smart electronic components organizer is proposed to fill the white space.

1.3 High-level Requirement List

- The system should be able to keep track of different components. (names, values, quantities, and locations)
- The system should be about to register for new components as well as deleting unwanted components.
- After users have selected their electronic components using the application on their phones, the corresponding drawers should be opened.

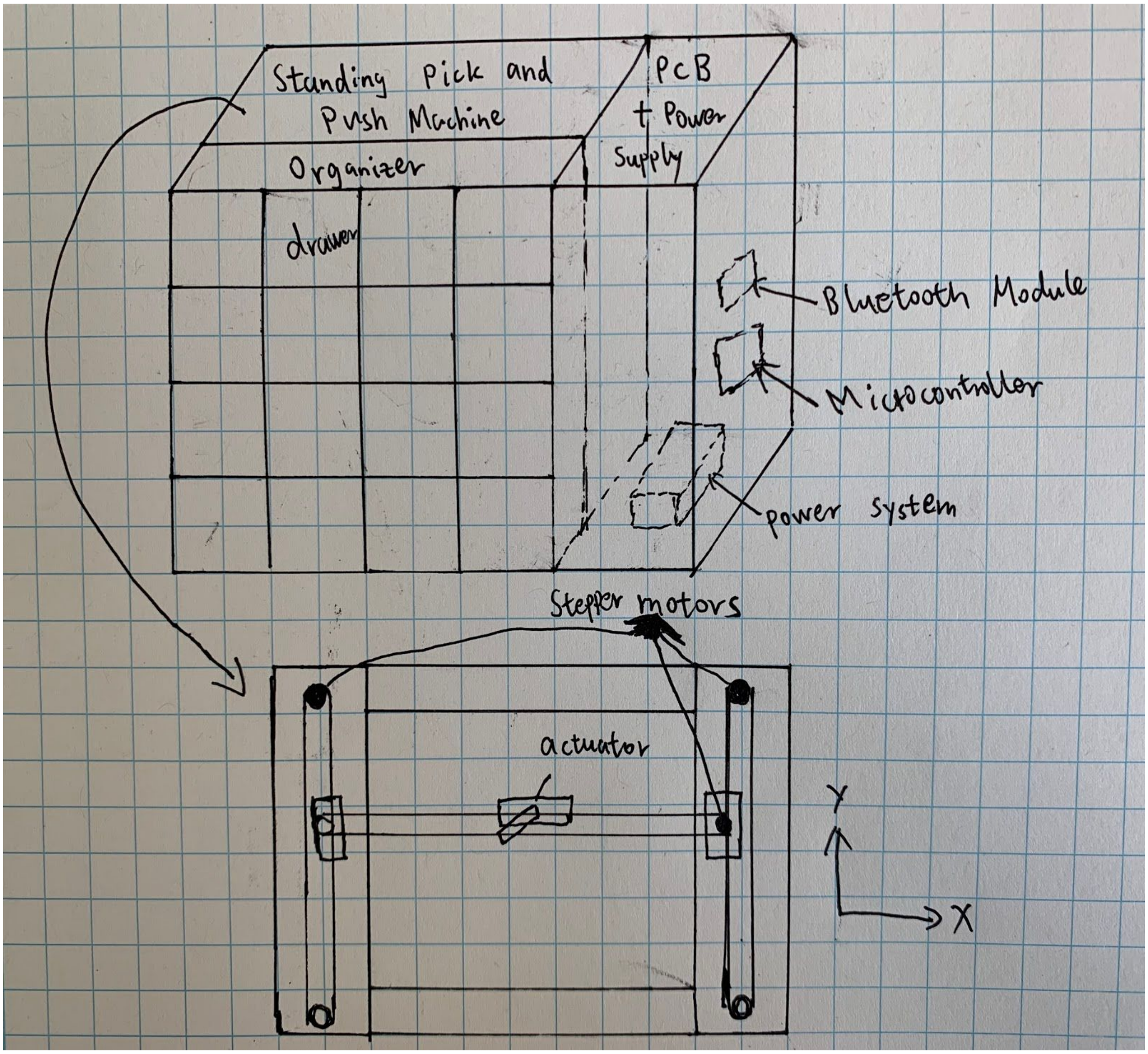
2. Design

2.1 Block Diagram



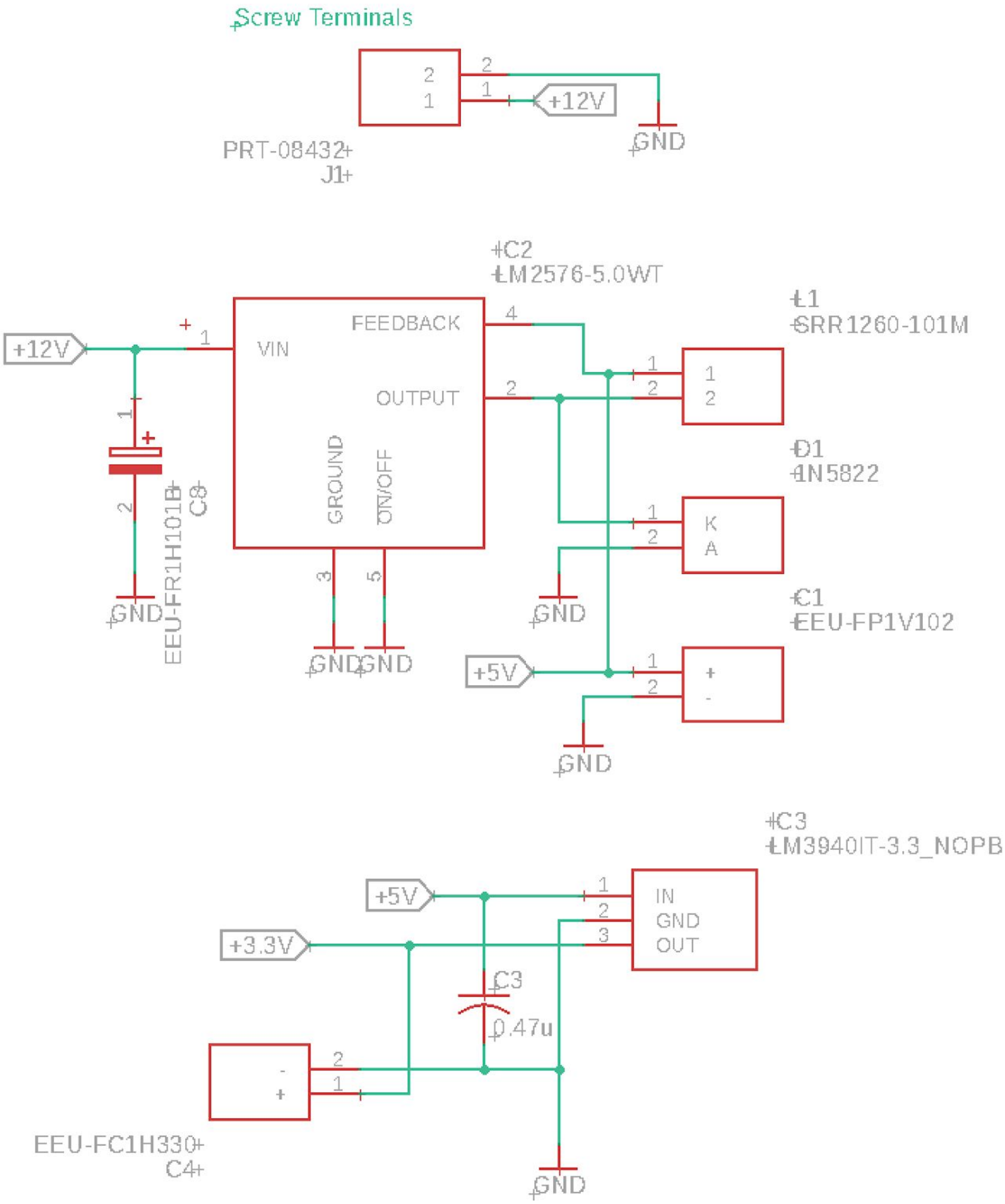
1. The user would enter the commands and information into their Android App, and the user inputs would be transmitted to the control module for further processing.
2. The user information is stored, processed and displayed in and on the user's Android phone.
3. All physical operations would be performed by the Pick-and-Place machine, the control signals will be sent to the machine by the control module.
4. All modules that require power will be powered by the power system.

2.2 Physical Design



This picture above shows the arrangement of different submodules in our project. The mechanical module is placed behind the organizer, and the control, bluetooth, and power submodules are placed adjacent to our organizer to keep the overall design compacted and safe.

2.3 Functional Overview & Block Requirement
2.3.1 Power System



Schematic of the Power System

The power system is used to supply power for Control Module (MCU), Bluetooth LE module and Pick-and-Place Machine. The power system supplies 12 V to the h-bridge to drive three stepper motors for the Pick-and-Place Machine, 5V for H-Bridge enable pin and servo actuator, and 3.3V for MCU and Bluetooth module.
The power system consists of three parts: A 12 V DC power supply (Wall plug) to supply 12 V power, a LM2576 voltage regulator board to step down 12 V DC to 5V DC (with maximum load of 3A and efficiency of 77%), a LM3940 low dropout regulator board to convert 5 V DC to 3.3V DC (with maximum load of 1A).

The estimation of power required by the modules are listed below:

Components	Quantity	Voltage (V)	Power (W)	Powered By
PIC32 MCU [5]	1	3.3	1.5	LM3940 LDO Regulator
Adafruit BLE SPI module [6]	1	3.3	26.1m	LM3940 LDO Regulator
Actuonix L12-100-50-6 Actuator	1	5	460m * 5 = 2.3	LM2576 Step-down Voltage Regulator
NEMA 17 12V 0.4A/Phase bipolar Stepper Motor [7]	3	12	12 * 0.4 * 2 * 3 = 28.8	L293D 600mA Quadruple Half H-Bridge

The L293D H-Bridge directly source power from 12VDC power supply. Mean Well RS-50-12 12VDC 50W switching power supply would be sufficient.
LM2576 with maximum load of 5V at 3A would be enough to supply 2.3W actuator and LM3940 LDO regulator.
LM3940 LDO regulator with maximum load of 3.3V at 1A is capable of supplying the MCU and bluetooth module.
We estimate the total power consumption of our design to be around 35W.
The switching power supply model, Mean Well RS-50-12, which can supply up to 50W @ 12VDC is sufficient for supplying the power of our design.

Requirements	**Verification**
1. The switching power supply must be able to deliver a stable 12 VDC.	1. Use a digital multimeter to measure the output of the switching power

2. The regulator board must be able to step down the 12 V DC voltage and deliver a stable 5 V DC voltage with load of beyond 1A. 3. The linear regulator board must be able to step down the 5 V DC voltage and deliver a stable 3.3 V DC voltage with load beyond 0.6A.	supply to check whether the correct voltage has been generated. Connect KAL50FB3R00 3ohms 50W wirewound resistor between 12VDC and ground and test voltage across the resistor to see if the voltage drop below 12V. 2. Connect a wire wound resistor between 1.33 ohms and 5 ohms (KAL50FB3R00 3ohms 50W wirewound resistor) between ground and the regulator output. Test if the voltage across the wirewound resistor drops below 5VDC specified by the datasheet. 3. Connect a 810F5R0E 5ohms 10W wirewound resistor and test voltage across it to see if the voltage drops below 3.3V.

2.3.2 Standing Pick and Push Machine

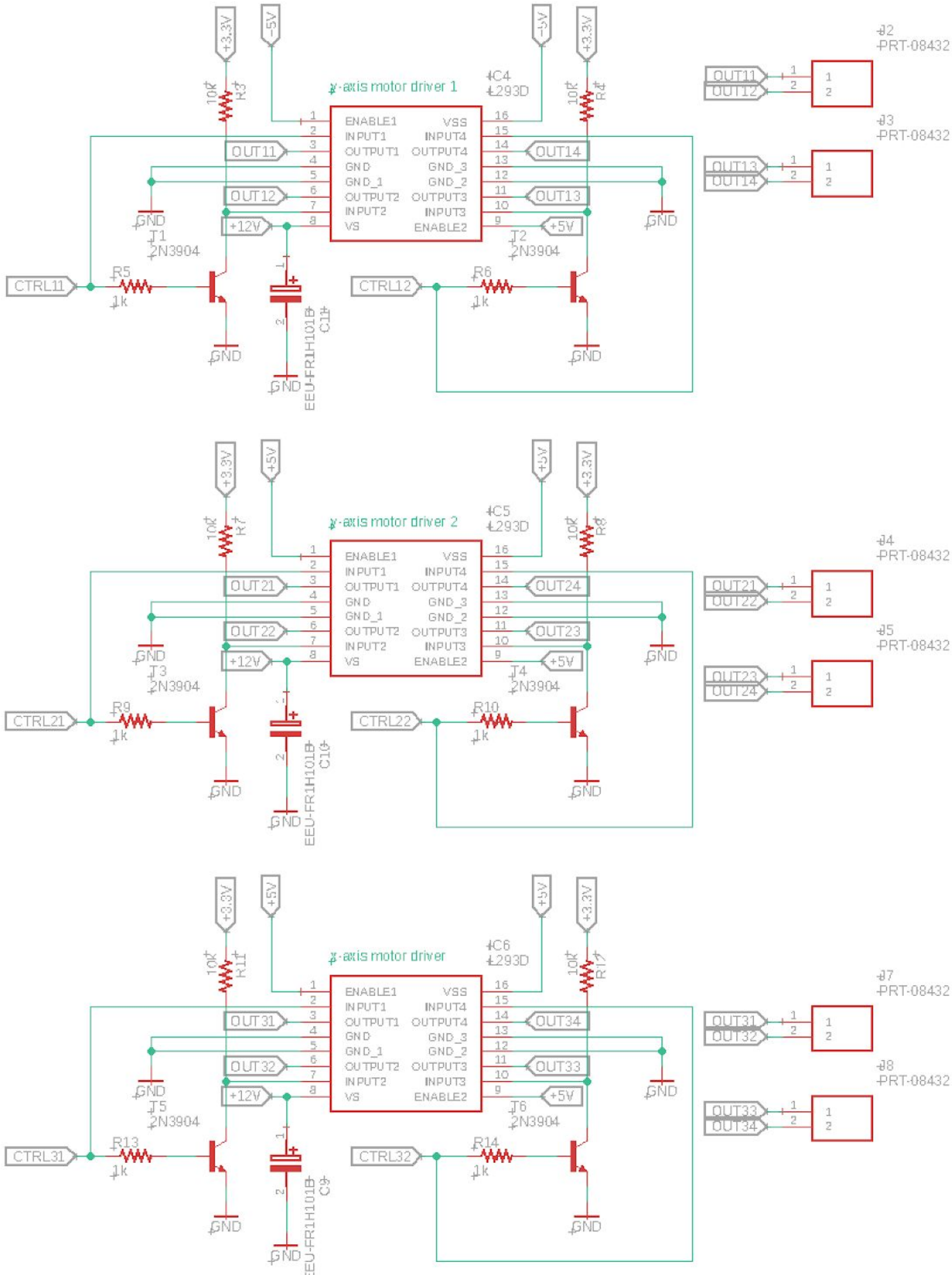


Diagram for Motor Driver circuit [8]

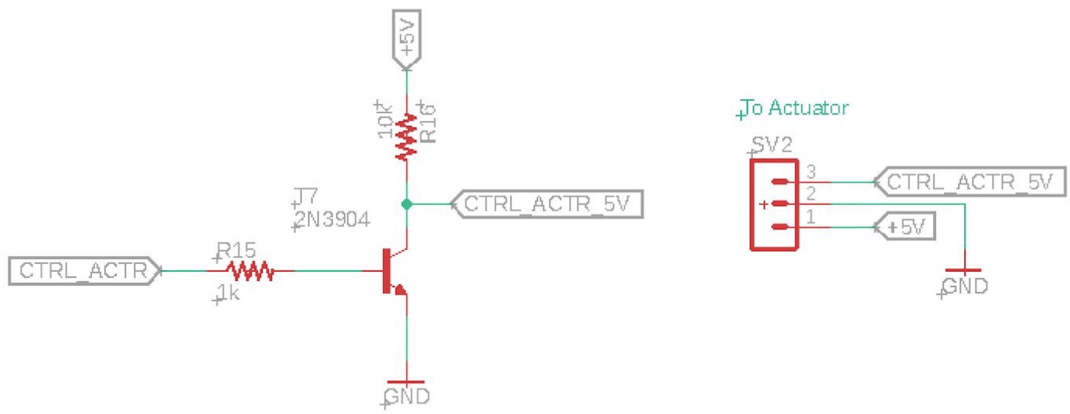


Diagram for Actuator Driver Circuit

The standing pick and push machine consists of three belt-driven linear sliders, an actuator, and three stepper motors. One stepper motor is used for the linear motion of the actuator in x direction and the other two motors are for lifting one belt-driven linear slider with actuator in y direction. The actuator, with a stroke length of 4 inches, is used to push open the drawer from its back. Each drawer is 2-⅛ inches wide, 1-½ inches tall, and 5-¼ inches long.

The 3 NEMA motors would be driven by 3 L293D quadruple half H-bridge with a supply of 12V. The MCU would control each H-bridge IC with 2 pins sending 3.3V (beyond low logic level of 2.3V) PWM. When controlling a bipolar stepper motor using full-step sequence, pin 1 and 2 as well as pin 3 and 4 are always inverted, only two pins from MCU are needed to control one motor since the inverted pin would be controlled by a NPN transistor as shown in the diagram.

To control the actuator, the 3.3V PWM from MCU is translated to 5V using a NPN transistor.

Requirements	**Verifications**
1. When the draw is open, it is able to move forward for at least ¾ of its length. This is 4 inches. 2. The actuator is able to fully extend (100 mm) to push out the drawer and retract back to the initial location. 3. The actuator should be able to point at the center of a chosen drawer within ±20% error. 4. The actuator is able to move horizontally or vertically at least 2	1. Use a ruler to make a measurement of the distance between the drawer front and the edge of the top of the organizer. 2. Use a ruler to measure the stroke length after the actuator stops extending and compare this length with when it is at its initial position. 3. Measure and compare the positions of where the actuator point to and the center of the drawer

cm/s.	4. Use Arduino to monitor the frequency of stepping signals and measure the length of the actuator traveled in 1 second

2.3.3 Bluetooth Module

The Bluetooth Module consists of an Adafruit Bluetooth LE SPI board. The Bluetooth Module connects to the control module through SPI interface and connects to the user's Android phone through Bluetooth 4.0 protocol.

The Bluetooth Module receives the user command sent from the Android phone using an Android application, then it sends the command data to the control module through SPI interface. It could also receive data packets from the control module, then send them to the user's mobile phone to be read and processed by the Android application.

Requirement	Verification
1. The Bluetooth module must be able to connect to the control module through SPI. a. The control module could send data packets to the Bluetooth module b. The control module could receive data packets correctly to the Bluetooth module 2. The Bluetooth module must be able to connect to the user's Android phone through Bluetooth 4.0 LE. a. The bluetooth module could send data packets previously received from the control module to the user's phone. b. The bluetooth module could send	1. Verify that bluetooth module is correctly setup, initialized and connected to the control module by checking the contents in the control registers of the bluetooth module. 2. Verify that bluetooth module is able to receive or send data packets from or to the control module by sending test data packets from control module and route back to the control module again. 3. Verify that the bluetooth module is able to send data packets to the Android phone by sending test data packets from the control module and check whether the phone can receive the test data packets. 4. Verify that the bluetooth module is able to receive the data packets from the Android phone by sending test data packets to the bluetooth module and check whether the control module can receive the test data packets.

2.3.4 Control Module

Diagram for Control Module Circuit (MCU)

The control module consists of a PIC32MX270 MCU. The control module connects to the mechanical components (Pick-and-place machine) and the bluetooth module.

The control module receives the data packets from the Android phone by reading from the Bluetooth module. Then, it processes these data into control signals to the mechanical components. It could also report its internal status, such as the status of current task, values of status registers, etc. to the android phone by sending data packets to the Bluetooth module.

Requirement	Verification
1. The control module must be able to correctly control the mechanical components. 2. The control module must be able to receive commands from an Android phone and process them properly. 3. The control module must be able to report its own status, such as task status.	1. Write unit test codes to test the control module's ability to control mechanical components, including stepper motor and actuator. 2. Send test data packets to the control module and see whether it receives the data and handles them properly. 3. Write unit test codes to test the self-report functions of the control module.

2.3.5 Android Application

The Android Application is a software inside the user's Android phone. The application takes the user inputs and either sends commands to the control module or updates its internal data respectively.

The application also displays the current status of the storage drawers and mechanical components, including the contents in each drawer, the location of empty drawers and current location of the actuator in the pick-and-place machine.

The application communicates with the control module through a bluetooth module using Bluetooth 4.0 protocol, it could either send the user commands to the control module or receive the status feedback from the control module for further processing.

<table>
<tr><th>Requirement</th><th>Verification</th></tr>
<tr><td>
1. The application must be able to correctly store user data into their phone and retrieve the data upon application start.
User data includes:
a. The contents of each drawer.
b. The locations of empty drawers.
c. User's previous search history for components.
d. Username
e. The bluetooth device ID and name of the bluetooth module
2. The application must be able to accept user commands, including:
a. Finding a specific component. If the component exists, the corresponding drawer will be shown to the user.
b. Opening a drawer either by location, component name or previous search result.
c. Store one or more components into one or several drawers. If there are no empty drawers, the application would notify the user and cancel. If the component already exists in one of the drawers, the application will notify the user of the location of such drawer.
</td><td>
1. Test the user data storage capability by inputting random user commands and restarting the application.
2. Test the communication between the phone and the Bluetooth and control modules by sending random commands to the control module or requesting status from the control module.
3. Test the correct execution of user commands by observing the behavior after executing each user command and match them with the expected behavior.
4. Test the robustness of the application by running for a prolonged period of time and observe whether the application runs properly or has crashed. (e.g. 4 hours - 8 hours)
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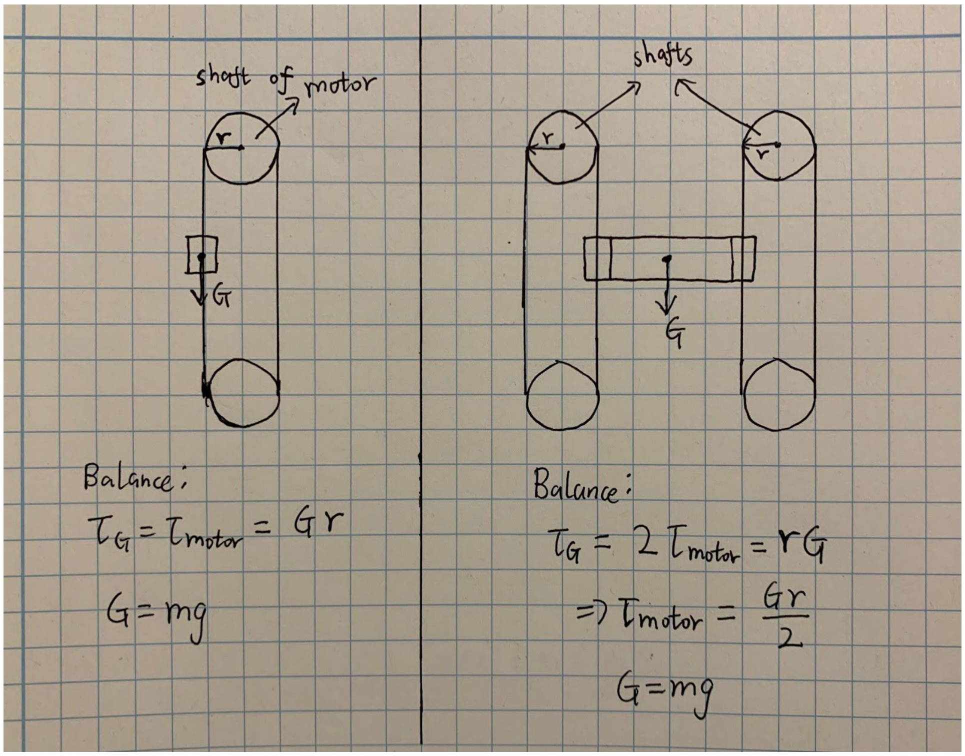
d. Remove one or more components from one of several drawers. 3. The application must be able to communicate with the Bluetooth module and control module properly. The possible data in the communication are: a. Commands that should be interpreted by the control module to control mechanical components. b. Status messages generated by the control module to be read and processed by the application.	

2.4 Tolerance Analysis

The crucial part of our project would be opening the drawer for the chosen electronic component. We have to select suitable a actuator and three stepper motors. The structure for picking a drawer and pushing it is similar to a pick and place machine, except that it has to be standing vertically. This means we have to lift up or lower a horizontal belt-driven rail attached with an actuator in the y-direction. So here we consider simple pulley systems.



When there is an object attached to the belt, the torque of the motor must equal to the torque of this object exerted on this motor in order for the system to be at balance. Similarly, if we use two stepper motors to lift the same object, half of the torque from each motor is required. In our case, the object is a belt, an actuator, and another motor that would be moving upward or downward. The total of their mass is less than 0.45kg, so the torque of a stepper motor is

$$= mgr/2 = 0.45\ kg * 9.81 m/s^2 * 0.225\ cm\ /2 = 0.5\ N * cm$$

Therefore, we have to choose stepper motors that have holding torque 2 times greater than 0.5 N*cm. This would leave enough margin for frictions and any necessary adjustments.

In order to push the drawer (assuming it is filled with electronic components such that the total mass is 0.3kg), the required force is (μ is the friction coefficient of plastic to plastic[9]),

$$F = \mu mg = 0.4 * 0.3\ kg * 9.81 m/s^2 = 1.18N$$

We need to multiply this quantity by two as well to ensure enough initial acceleration since there are imperfect plastic rails under the drawers. This is the necessary parameter for actuator selection.

3. Cost and Schedule

3.1 Cost Analysis

The average hourly wage for an Electrical Engineer in the United States is $34/hr [4]. There are 16 weeks in a semester. We have 3 people working on the development of this project, and each of us works about 15 hours per week.
Estimate hours = 3 x 16 x 15 hours = 720 hours
Estimate cost of labor = $34/hour x 720 hours x 2.5 = $61,200

Component	Cost
PIC32MX270F256B MCU	$4.32
Akro-Mils 10116 16 Drawer Plastic Parts Storage Hardware and Craft Cabinet, 10.5-Inch x 8.5-Inch x 6.5-Inch, Black	$13.66
L12-R Micro Linear Servos for RC & Arduino	$70.00
Adafruit Bluefruit LE SPI Friend - Bluetooth Low Energy (BLE)	$17.50
STEPPERONLINE Stepper Motor Nema 17 Bipolar 40mm 64oz.in(45Ncm) 2A 4 Lead 3D Printer Hobby CNC	$12.99 (x3)
Screw Terminals 5mm Pitch (2-Pin)	$0.95(x6)
LM2576-5.0WT	$1.91
LM3940IT-3.3/NOPB	$1.82
SRR1260-101M	$1.25
2N3904	$0.25*4
EEU-FP1V102	$1.61
EEU-FR1H101B	$0.50*4
L293D	$3.91(x3)
SMD Ceramic Capacitors and SMD Resistors	$20.00

Estimate cost of parts = $191.47
Total cost = $61,200 + $191.47= $61,391.47

3.2 Schedule

Week	Kaiwen	Canlin	Yihao
3/2	Test power circuit submodule and relay polarity inverter circuit with actuator on breadboard.	Write codes for BLE module initialization, MCU - BLE module communication. Learn basics of Android Development.	Communicate with Machine shop about the mechanical design, make adjustments if necessary
3/9	Design first version of PCB including power, MCU and motor controlling submodules	Write the skeleton of Android App for Phone - BLE module communication. Write code in MCU to control the BLE module to send/receive data packets from phone.	Write commands to test actuator and motors to find correct parameters for signal input and to make sure there is enough input power
3/16	Finish and order first version of PCB from Oshpark	Continue developing the Android App to allow user inputs. Write code to enable MCU to receive and process data packets sent from the phone.	Complete the mechanical submodule and start testing it with previously written commands associated with potential user input
3/23	Communicate with other group member over software and mechanical module development	Starting to test the integration of the control module and mechanical components. Test basic functions to command the actuator and stepper motor.	Assist teammate on the integration of mechanical submodule and control module and test function on software
3/30	Solder components on PCB and test	Continue to develop the App. Starting to test integration of phone - BLE - control module -	Help teammate mount components onto PCB and start testing

		mechanical component.	
4/6	Integrate the PCB with bluetooth module and mechanical submodule	Continue developing the App to allow the user to send commands to control the mechanical components.	Assist teammates with final integration of all submodules
4/13	Debug and optimize design	Debugging	Debugging with teammates
4/20	Mock Demo & debugging	Mock Demo & Debugging	Mock Demo & debugging
4/27	Demonstration & Mock Presentation	Demonstration & Mock Presentation	Demonstration & Mock Presentation
5/4	Presentation	Presentation	Presentation

4. Ethics and Safety

One safety issue might occur in our project is handling the wall supply that supplies for all of the other modules. We need to carefully determine the power consumption of each module, dedicate to safely distribute power in our power management design, and decide the working conditions of our organizer as a reference to our users.

Another potential safety issue is there is a possibility that the actuator pushes one of the drawers too far so that the whole organizer might fall on the user. This could be prevented by setting a maximum current or voltage applied on the mechanical structure, conducting a series of testing about the force exerted by the actuator when opening the drawer, and making adjustments to the position of the actuator correspondingly.

Coming up with solutions for both of the statements above are to uphold the IEEE Code of Ethics #1, by disclosing any safety issues and also trying to prevent them during the development stage[3]. As a team of three people, we aim to collaborate with each other, support each other's idea, and make the best use of each one's strength as well as learn from each other. This would reflect the IEEE Code of Ethics #10[3].

Along the way to the completion of this project and to the future, staying active and positive to respond to any supportive criticism is essential to the development of our product. Making immediate modifications based on feedback and correcting mistakes without any delay is necessary for any project development. This is suggested by IEEE Code of Ethics #7[3].

5. Citations

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