Project Deliverable E: Design Constraints and Prototype 2

GNG 2101 - INTO PROD DEV & MGMT FOR EN/CS

Winter 2023

Professor: Jason Foster

Group C3.1

Name of Authors:

Jordan Malench	*300246446*
Jeyason Jeyaparan	*300165084*
Ryan Dick	*300228675*
Joshua Labelle	*300185891*
Rabih Daoud	*300164191*

Submission date: March 22, 2023

Table of contents

Introduction

On March 1st 2023, we had the opportunity to meet with our client for the final time and present the prototypes that we have developed. During our meeting, we talked about the mobile app prototype and the CAD prototype that we created. Our client agreed with the functionality of the prototypes that we showed to her during our meeting.

After our final client interview, we worked on identifying two non-functional design constraints that play an important role in the development of our prototypes. The two non-functional design constraints that we identified is our design must be safe, and our design must be accessible. For the safety and accessibility design constraints, we described the changes that we had to make in our design to satisfy them. We also did research to demonstrate the effectiveness of our changes in satisfying the constraints. After we described our two non-functional design constraints, we defined the most critical product assumptions that we have not tested yet. We also developed our second set of prototypes. Our second prototypes are a circuit diagram created in TinkerCad, UML state diagram, and physical housing and frame. We also performed prototype testing as well, and evaluated the performance compared to the target specifications first developed in Project Deliverable B.

Non-functional constraints

Design for Safety

It was crucial that we put an emphasis on safety in our design as it would be used by children with physical disabilities. Some of the safety measures we will need to add to ensure that our design is safe are rubber stoppers at the bottom of the outer casing, an emergency stop button, a light that will turn on when the machine is running and a plastic casing in front of the LCD display.

The stoppers on the bottom of the outer casing are necessary as the machine is expected to be relatively heavy. The rubber stoppers on the bottom should help us avoid a situation in which the machine is knocked over and potentially hurting someone in the process.To determine the effectiveness of the rubber stoppers we performed some tests with the rubber stoppers and a stand in for the final t-shirt folder. We used a box and put mass in it to make it 3kg which was the same as our ideal mass for our t-shirt folder that we determined in our target specifications. We then put the stoppers on the bottom of the box and applied varied levels of force to the box. After some research online, we found that on average a human male can exert a force of 1000N[1]. We used this value and did some tests with the box and found that by using the rubber stoppers, we could prevent the box from moving when applying a force of 1000N.

The emergency stop button will completely shutdown the machine when pressed. This is an important safety measure for emergency situations such as when something gets caught in the machine. We did plenty of research on safety measures that we could implement in our design and one such feature that we found was the emergency stop button.

Another safety measure that we found during our research was the on light which will light up when the machine is active. This is an important safety feature that will let anyone know when the machine is active and to be careful when around the machine when they see that the light is on.

We will also add a plastic casing in front of the LCD display. We found through researching that an LCD display could be damaged or broken when hit with a large enough amount of force. In order to prevent this, we plan to install a plastic casing in front of the LCD display which should prevent the display from being damaged if any unintentional contact is made.

Design for Accessibility

It is crucial that we put an emphasis on accessibility in our design as it would be used by children with motor deficits, so we had to make sure that our t-shirt folder is able to be used by them. We need to make our t-shirt folder accessible to the children, by making sure that our design is made so that the children could easily activate the t-shirt folder with their hands. In order to do this, we made sure to do research on the kinds of special switches we could use to have the children interact with the t-shirt folder. We did our research by browsing through the products found on the Enabling Devices page. The three kinds of switches that we found on their website is the 4-in-1 joystick switch, the cushion grip switch, and the bright red switch. For the first kind of switch, we thought it would have been a good idea to use at first, because it would allow the child to have more control when folding the t-shirt folder. This is because for example, let's say the child wants the left flap to move only a little bit, the child simply has to move the joystick to the left a little bit. However, our team realized that this was a bad idea because the joystick is not big, so we thought that some of the children with more severe motor limitations would struggle when using it. After this, our team looked into the cushion grip switch. However, we didn't choose this kind of switch because it involves gripping which we thought that some of the children with severe motor limitations would struggle when using it. We finally thought of settling with the bright red switch, because it has a large target area, having a diameter of 5 inches in diameter. It also has an elevated height to make it more accessible on a table. Also, the switch lights up and vibrates when pressed, which is great to notify the child that he/she pressed the button to activate the t-shirt folder. [2]

According to our client, the app needs to work for iPads because the client said that at the health center, they mainly have iPads. However, the client also mentioned that the health center also has Microsoft Surface Pros as well. So this means that our app needs to be compatible with both iPads and Microsoft Surface Pros because we want to make sure that a child could always access the t-shirt folder with a device in the health center, regardless of whether it's an iPad or a Microsoft Surface Pro. So to make sure that our app is compatible with both Microsoft Surface Pros and iPads, we did research into cross-platform mobile development. We learned that we could build apps for android, iOS and Windows devices using the Mobile Development with C++ workload, in Visual Studio. We learned that we could target Android, iOS and Windows in the same solution and share code between them using a cross-platform static or dynamic shared library. We also learned about Visual Studio Tools for Unity, which is an extension for Visual Studio that integrates Visual Studio's code editing, productivity and debugging tools with Unity. Unity is "a popular cross-platform gaming/graphics engine and development environment for immersive apps that target Windows, iOS, Android, and other platforms including the web." [3] Through using Visual Studio Tools for Unity (VSTU), you could use Visual Studio to write game and editor scripts in C#. [3] This could be used to build our app for the t-shirt folder. Also in terms of accessibility, our group thought about how there could be some children who are only stationed in one location in the hospital, so we need to find a way to have those children be able to access the t-shirt folder. So in order to do this, we researched bluetooth modules and the maximum range of the bluetooth modules. This is because we could connect the iPads or

Microsoft Surface Pros that the health center has to the t-shirt folder through Bluetooth. For example, we looked into the HC-06 Bluetooth module which is good for wireless communications of less than 100 meters. [4] So using this bluetooth module in our design would be a great idea, because children that are located less than 100 meters away from the t-shirt folder could still interact with it. Also, there should be accessibility in terms of taking into account patients that have visual or hearing impairments. Those that are visually impaired, could still access and use the t-shirt folder, because there is a Piezo buzzer that notifies the user when a t-shirt is finished folding. In addition, those that don't have good eyesight, could use the mobile app, where he/she could simply zoom into the words that are on the screen. Also, those that have hearing impairments could look at the LCD display to know the status of the t-shirt activated switch folder, and could look at the LED, to see if the t-shirt folder has completed folding, or if the t-shirt folder is on.

Summarize any new client feedback that you have received and clearly state what needs to be changed or improved in your design. Update your design accordingly.

With our third and final client meeting, we discussed the prototypes that we created. We made a mobile app prototype using Figma, and we also made a CAD prototype as well. After going through the app prototype, our client was perfectly fine with all of our transitions. She agreed with how the progress of our app will be displayed. She agreed with how the home page, settings page, and profile page looked. She especially enjoyed the cleaning reminders on our settings page, and she told us that idea was thoughtful, since it showed how we considered the maintenance of the T-shirt folder. We also showed to our client the CAD prototype, which is a physical representation of the mechanics behind our T-shirt folder. This included the folding linkage, between the flaps of the T-shirt folder. We also told our client, that the CAD model is not all of our T-shirt folder project, and mentioned that the folding linkages of the T-shirt folder will be hidden away in the Housing and Frame subsystem of our project. After going through the different views of the CAD model with our client, she said that she agreed with all of its details and had no problems with it. After this, we discussed with our client about our next steps within our project, which includes purchasing all of our materials and beginning the development of the button activated t-shirt folder. We also asked our client questions such as whether or not it was okay for a sound to play when the t-shirt folder is done folding. Our client said that a sound playing when the t-shirt folder finishes folding is perfectly fine. When we asked her about any kinds of improvements that we should make, she said that nothing needs to really be improved, and that everything looks great the way that it is.

Define the most critical product assumptions that you have not yet tested.

1) The Arduino Nano being able to actually control the servo motors.
2) The degree at which the servo motors turn.
3) HC-06 Bluetooth module being able to connect with React Native app.

Prototypes

For this deliverable, we created four different prototypes. The first is a UML State Diagram which shows the many states that the t-shirt folder will be in as well as how it will transition from one state to another. The second prototype is a TinkerCad circuit diagram that shows the many components in our t-shirt folder as well as the wiring that will be used to connect them together. The third prototype is a medium fidelity prototype of our mobile application with much of the front-end completed but minimal back-end completed. The final prototype is a physical prototype that is the housing and frame subsystem of the t-shirt folder.

UML State Diagram

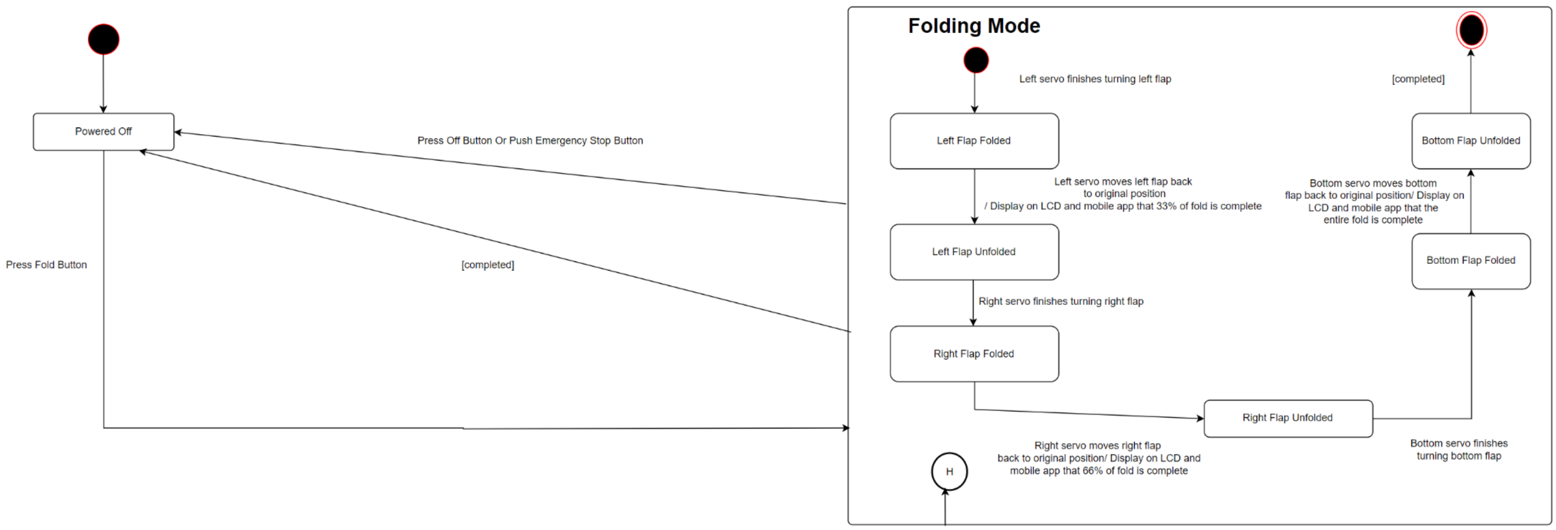

Figure 1: UML State Diagram of the t-shirt folder folding process

This state diagram illustrates the states that the system will be in throughout the folding process. The initial state in the state diagram occurs when the machine is turned on. The state diagram consists of a composite state which is represented in the state diagram by the states in the rectangle and is accessed when the Fold Button is pressed. The composite state consists of the folding process of the t-shirt folder and the corresponding states that will be displayed on the mobile application at the same time. The encircled H in the bottom left corner of the composite state indicates that the composite state keeps track of which t-shirt folding state it is in if the state is suddenly exited. What this means is that the folding state of the t-shirt folder will stay in place if the power is shut off or the emergency stop button is pressed. When the machine is turned back on, the t-shirt folder will continue to fold from the state that it left off on.

TinkerCad Circuit Diagram

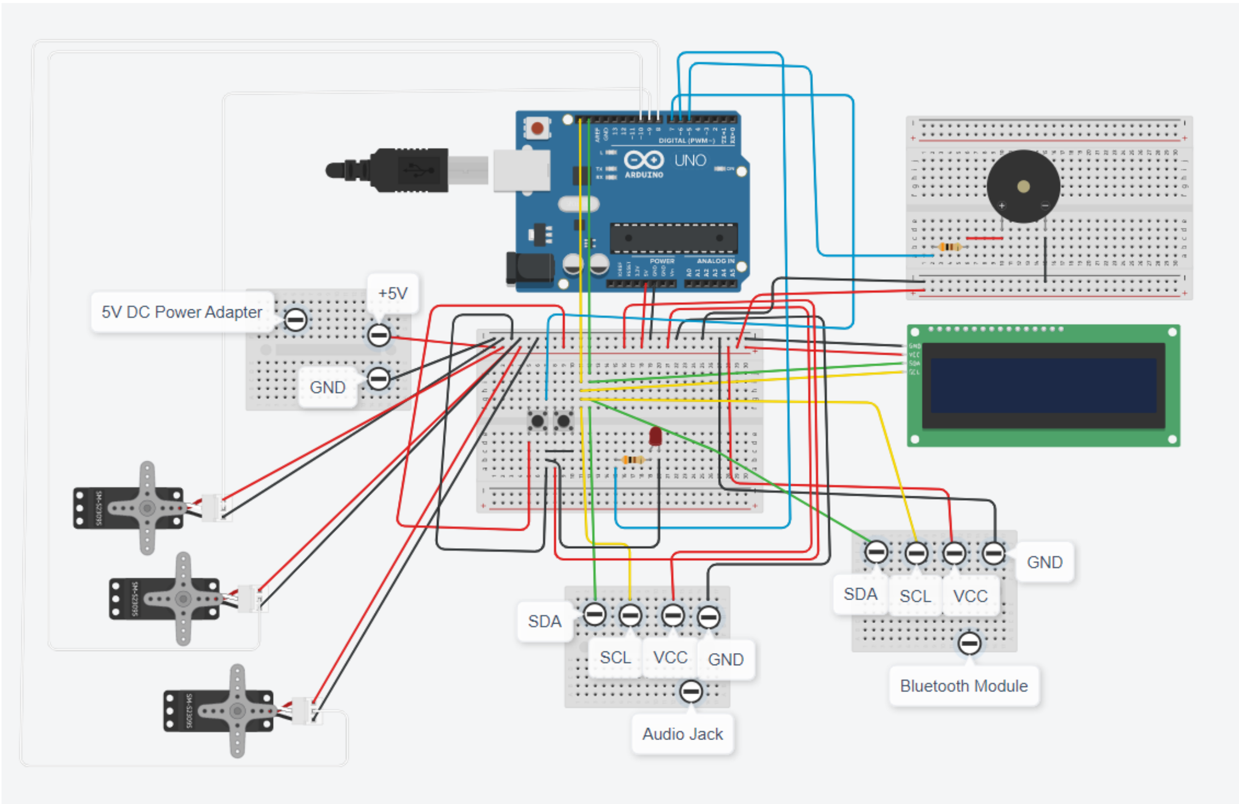

Figure 2: Tinkercad circuit diagram displaying the t-shirt folders circuitry and components

This tinkercad circuit diagram illustrates the circuitry and the components that we will use to make the automated t-shirt folder. The blue component in the middle at the top of the diagram is the Arduino. In this diagram, an Arduino Uno is used as a stand-in for the Arduino Nano which we will be using in our actual design. The Arduino is a microcontroller that we will be using to control all of the other components seen in the diagram. As you could see in the diagram, we also have the 3 DC Servo motors seen on the bottom left as well, which has its connections to the digital pins of the Arduino as well as to power and ground. In addition, we have the 5V DC Power Adapter that is represented as a small breadboard in our diagram. The 5V DC Power Adapter is used to power the Arduino, which powers all of the other technical components involved in our t-shirt folder. We also have the Audio Jack which is used to connect the button to the t-shirt folder. Then we have the LCD screen which is used to display the menu of the t-shirt folder, and the current states of the t-shirt folder. Then there is the HC-06 Bluetooth module which is used to connect the t-shirt folder to the mobile app. Then there is the Piezo buzzer, which is used to display a sound to the user, when the t-shirt folder is finished folding a t-shirt. Then there is the LED, which is used to visually show to the user that the t-shirt folder is finished folding. Then there is the two pushbuttons. One of the pushbuttons is used as an emergency stop button, and the other pushbutton is used to fold the flaps of the t-shirt folder.

Mobile App Prototype

(https://github.com/rabi3daoudd/t-shirt-folder)

Figure 3: Prototype of the iPad application built with React Native

The mobile app prototype created using React Native, essentially shows what will happen when the user presses the Fold button. When the user presses the Fold button and the Bluetooth is connected, a blue ring around the button representing the progress of the t-shirt folding appears, and when it makes a complete circle, the fold is complete. When the fold is complete, the # of t-shirts folded increments by 1. However, our prototype shows that if the Bluetooth is disconnected, then the button will not even be pressable.

Given the background of the app being designed for children with special needs at a hospital and its function as a remote controller for an automatic t-shirt folder, the choice of React Native was made after careful consideration of the specific needs of the target users and devices. React Native's accessibility features and guidelines played a significant role in this decision, as they ensured that the app would be highly usable and accessible for the children with special needs. Additionally, React Native's ability to provide a seamless and consistent user experience across both iOS and Surface iPads/laptops was crucial, as the app needed to cater to different devices.

Furthermore, React Native's vast community support and extensive libraries enabled the rapid development of custom components, which would allow us to create an engaging and user-friendly interface tailored for the children's needs. While Flutter also offers cross-platform support, the familiarity with JavaScript and the ability to leverage existing knowledge and resources within the team contributed to the decision to use React Native. Overall, React Native was selected for its accessibility, cross-platform consistency, and the potential to create a highly customized and engaging user experience for the children with special needs at the hospital.

Check out the video which displays our prototype: https://share.cleanshot.com/MFfn6ybc

Mobile App Prototype Testing

In terms of price, it is + instead of -, because we don't have to pay to access React Native. However, for Ease of Use, it changed from a - to a +, because now a front end prototype of the app is developed, so we are able to see that the children are able to easily access it from an iPad. Not only that but because the app is connected to the t-shirt folder through Bluetooth, the children are able to access the t-shirt folder from a farther distance. In terms of availability, it is a +, because our mobile app could be accessed with people that have an iPad. In terms of reliability, it is a + instead of a 0, because when the Bluetooth is disconnected, the button cannot be activated.

Selection Criteria: Accessibility	Touchscreen (Deliverable B)	Touchscreen (Deliverable E)
Price	-	+
Ease of use (for kids)	-	+
Availability	0	+

Reliability	0	+

Housing and Frame Prototype

The housing and frame prototype is a physical prototype that shows the housing and frame subsystem of our project. It is stable and made with plastic bars,and the spaces between the frames will be filled with acrylic plates. The prototype also demonstrates the layout of some of the important exterior components for our design such as our emergency stop button and safety light. The technical and mechanical components of the project will be held within this prototype.

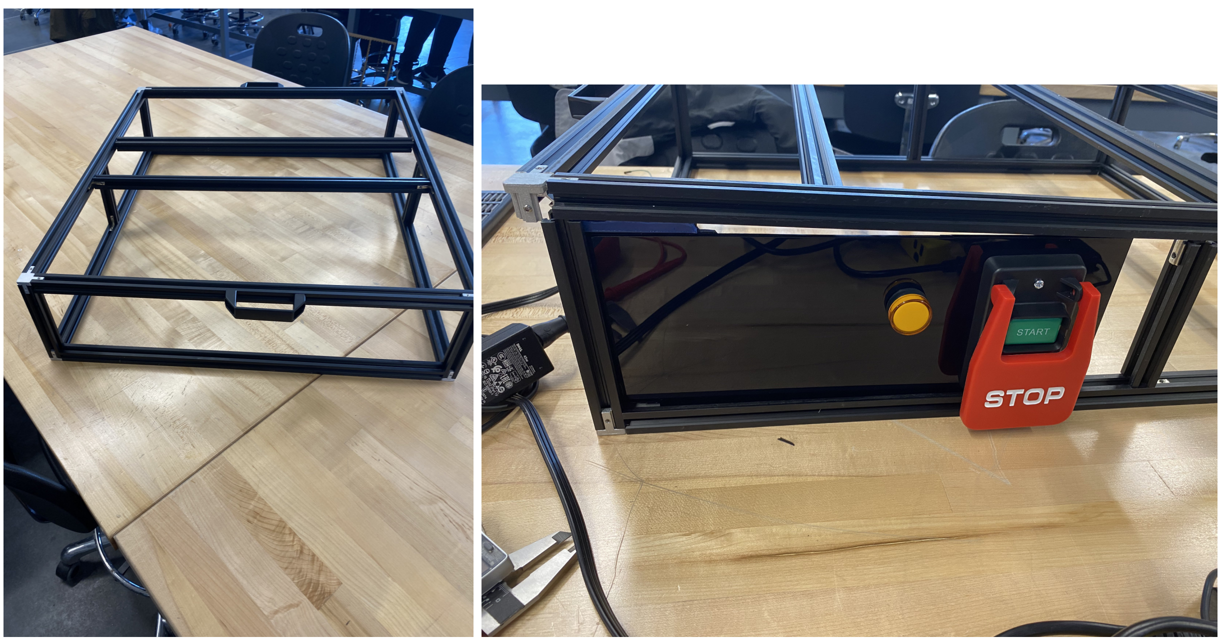

Figure 4: Prototype of the Housing and Frame Subsystem. T-shirt folder frame (left), T-shirt folder frame with acrylic plates, emergency stop and safety light (right)

Housing and Frame Prototype Testing

We tested the strength and stability of the housing and frame prototype by pressing as hard as we could on each of its bars, and the structure still remained intact. Because of this, we deemed that the strength and stability of the housing and frame subsystem is suitable for the t-shirt folder project. For the ease of assembly, we deemed that that was a + instead of 0, because the acrylic plates could easily slide into the gaps of the frames, and firmly hold its position. In terms of Ergonomics, we thought that it was a +, because we made sure that the box was easy to carry around, and it was built with smooth materials. In terms of safety, it is a +, because the plastic bars are very strong, and there will be acrylic plates around the housing and frame, to ensure that the user does not come into contact with the Arduino. We also did some testing by placing all of components in the frame, just to see if they all fit properly and they do. We also used a ruler to see if the T-shirt folder's 2 bar linkages would be able to fit in the t-shirt folder, without disturbing the positions of the other components. After doing this testing we were able to determine that the space given for mechanics is a + instead of a 0, because there is more than enough room to fit all of the technical and mechanical components of this project.

Selection Criteria: Frames	Contained box (Deliverable B)	Contained box (Deliverable E)
Stability	+	+
Ease of assembly	0	+
Ergonomics	+	+
Safety	+	+
Space given for mechanics	0	+

Closing remarks:

Conclusion

To conclude, the third client meeting confirmed to our team that the steps are going in the right direction in terms of our prototypes. This is because she agreed with the functionality of the mobile app prototype and the CAD model. Through extensive research and brainstorming, our team also came up with two non-functional constraints that must be taken into consideration when building our project, which is design for safety and design for accessibility. For example, in Design for Safety, we mentioned that we have to add a plastic casing in front of the LCD, to prevent the children from breaking the glass and injuring themselves. Another example, is in Design for Accessibility, making sure that mobile app is compatible with both Microsoft Surface Pros and iPads, because we want to make sure that the children could access the t-shirt folder with all the devices available to them in the health center. We also came up with our second prototypes, of the UML state diagram, TinkerCad circuit diagram, mobile prototype, and housing and frame prototype. For the mobile prototype and the housing and frame prototype, we carried out prototype testing and evaluated the performance compared to the updated target specifications first developed in Project Deliverable B. We showed our testing in the form of two different tables. We were also able to define the most critical product assumptions that we have not yet tested. For example, seeing if the Bluetooth module is able to connect to the React Native mobile app. Through working on this deliverable, our team learned more about the importance of creating more detailed prototypes, and non-functional constraints. The next step for deliverable F, is to determine our business model, and create a sustainability report, economics report, and intellectual property report for our t-shirt folder.

References

[1] Sage-Answers. (2021, May 14). *How many newtons of force can an average human exert?* Sage. Retrieved March 22, 2023, from https://sage-answers.com/how-many-newtons-of-force-can-an-average-human-exert/

[2] *Switches - Adaptive Archives*. Enabling Devices. (n.d.). Retrieved March 22, 2023, from https://enablingdevices.com/product-category/switches/

[3] Therealjohn. (n.d.). *Cross-platform Mobile Development in Visual studio*. Cross-Platform Mobile Development in Visual Studio | Microsoft Learn. Retrieved March 22, 2023, from https://learn.microsoft.com/en-us/visualstudio/cross-platform/cross-platform-mobile-development-in-visual-studio?view=vs-2022

[4] *HC-06 Bluetooth module*. Components101. (n.d.). Retrieved March 22, 2023, from https://components101.com/wireless/hc-06-bluetooth-module-pinout-datasheet