3 Waldo

3.1 Waldo input

3.1.1 Plan out what you are going to build. **Create and submit a dimensioned drawing of both input and output sides of your waldo system. A CAD drawing will work well here, but is not required. Pay attention to mounting details.**

I plan to make a 3 DOF robot. The 3D symbolic representation of the robot is shown as the figure below.

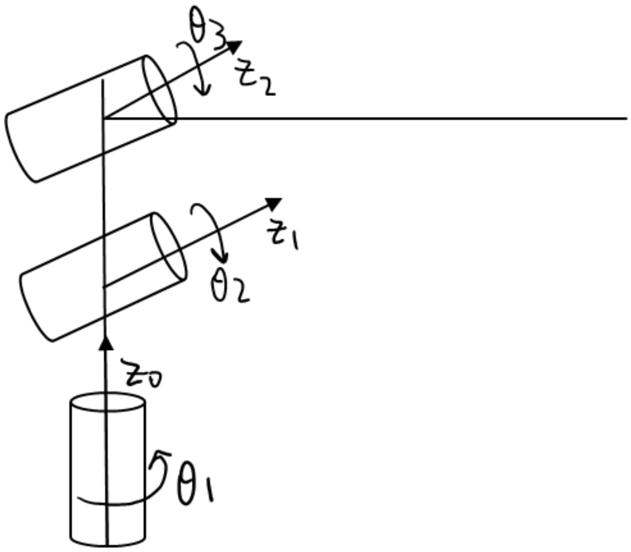

Figure 1 3D Symbolic Representation

The arms of the robot rotate around z_0, z_1, z_2 respectively, with angle θ_1, θ_2, θ_3. Obviously, the robot has 3DOF.

For the sensing part, each joint of the robot should be mounted with a potentialmeter to 'know' exactly how many angles does the arm rotate. In this case, each arm should be designed to an appropriate size to fit the potentialmeter. Meanwhile, the arm could not be too long. Otherwise, the torque rotating the potential meter may be too large, and decrease the sensitivity of the input side. Below is my design for the Waldo input side.

1- bass

2- potentialmeter

3- flange

4- joint 1

5- potentialmeter

6- flange

7- link 1

8- potentialmeter

9- link2

10- flange

Potentialmeter acts like a joint for the input side. For each link/bass, there is a square hole that totally fits the size of potentialmeter so that it could be fixed to the link. On the other side of the link, there is a hole that has the same shape as the potentialmeter's shaft, as well as the hole on the flange, so that the potential meter could rotate with the link/bass. Since the requirement for assembly is not so high for the sensing part, I plan to use superglue to attach each connection part. Please go to the CAD model for more details.

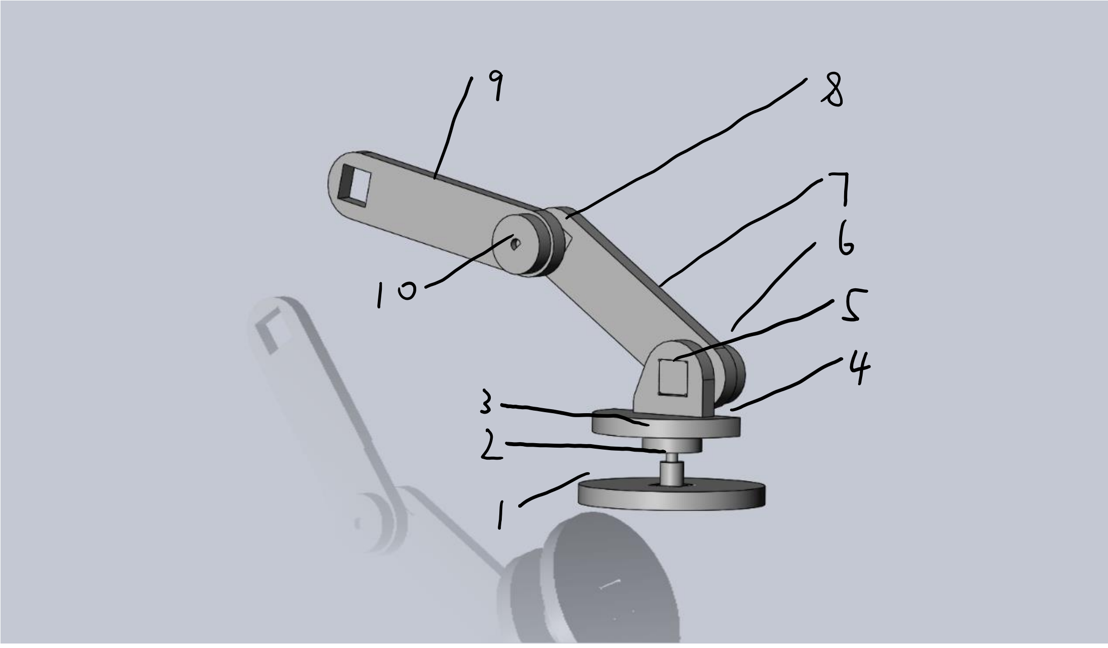

Figure 2 Draft of Sensing Part

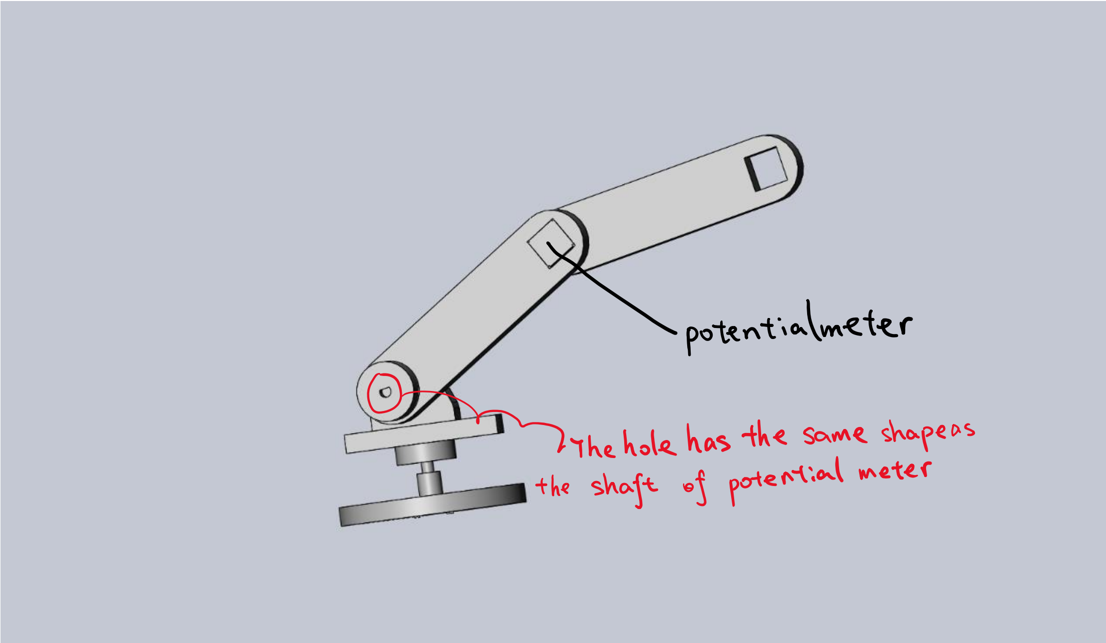

Figure 3 Draft of Sensing Part

The dimensioned drawing is shown in the figure below, which shows the mounting details and the overall dimension of the input side. Considering the tolerance of laser cutting and 3D printing, I plan to use superglue and hot melt for mounting the potentialmeter and links.

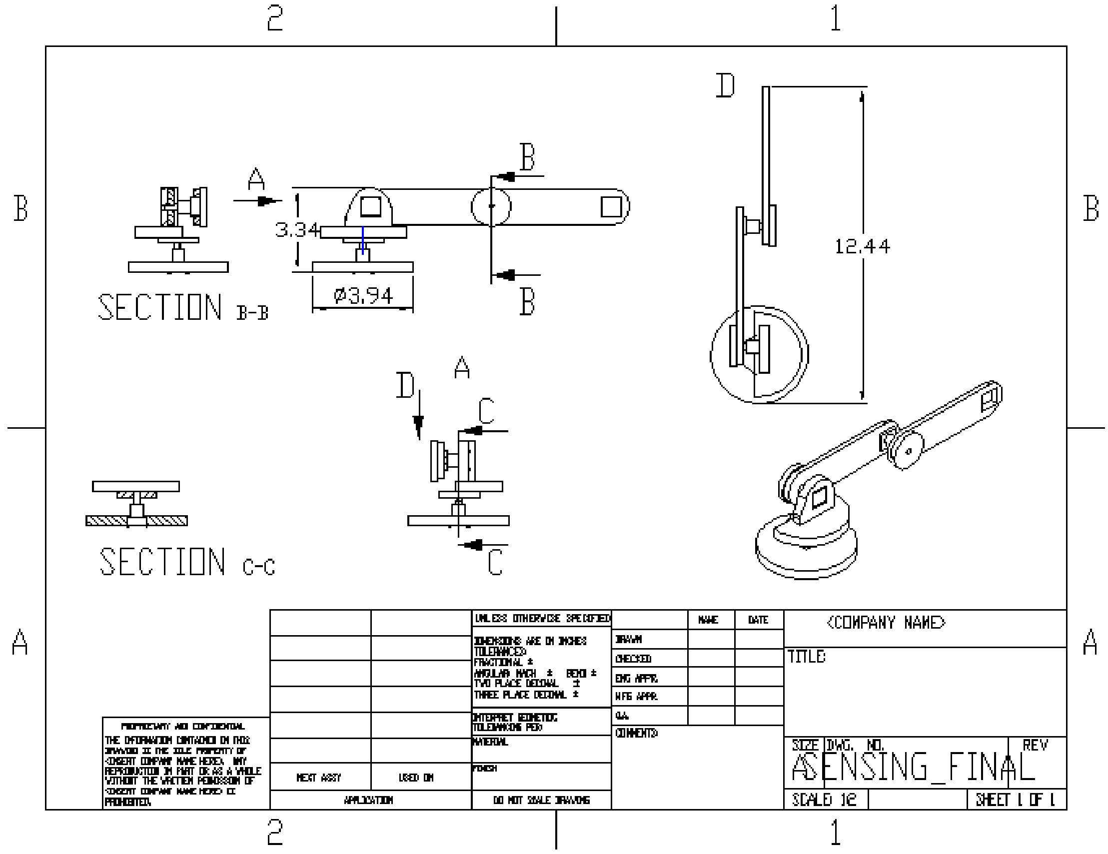

Figure 4 Assembling Drawing of input side

For more information, please refer to the CAD model in the folder below: (see sensing_final.SLDASM)

https://drive.google.com/drive/folders/1VoniyYa5j_mm-k41wf5KrpYcwojbFG7H?usp=sharing

For the output part, I adjust the dimension of input side. Most of the design part of the output side is quite similar to the sensing part. However, I replace the potentialmeter with servo motor. To make sure that the motor could be placed strength to each link, I enlarge the end of the link, and dig a hole that fix the size of motor so that the motor could be fully embedded into link. To fasten the motor to the link, I plan to use screws and nuts for connections. To connect the link to the shaft, I use a long flange, which is shown as the picture below, connected both to the shaft (there is a hub inside the flange in order to connect the motor and the flange itself) and the link(use superglue).The draft of output part is showed as below. For more details please refer to the CAD model of the output side.

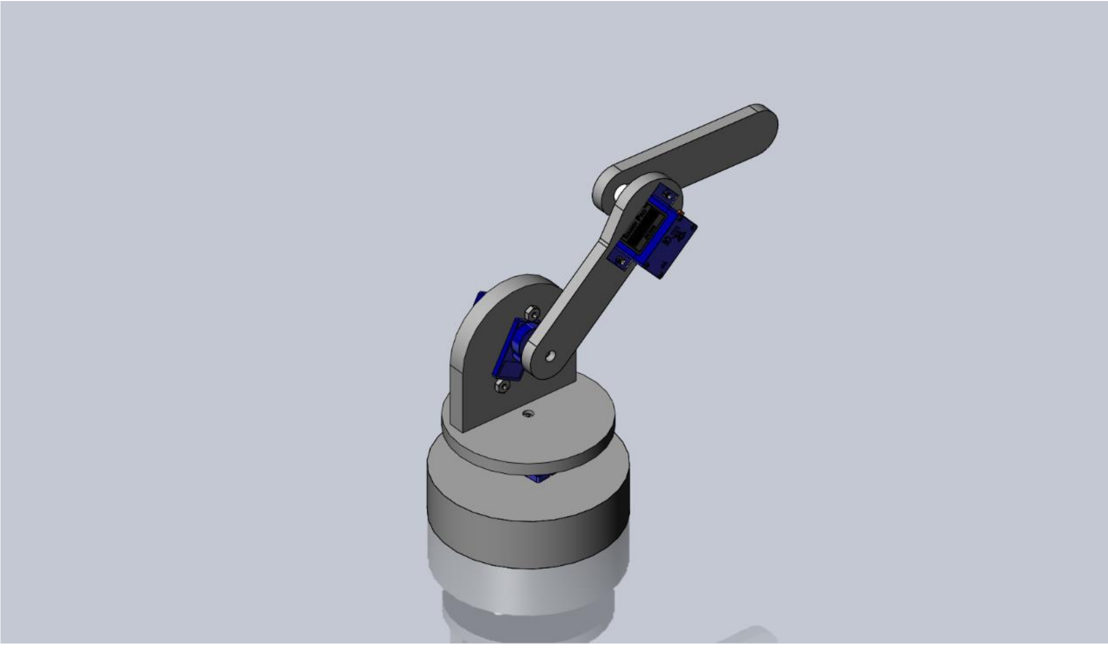

Figure 5 3D Sketch of output

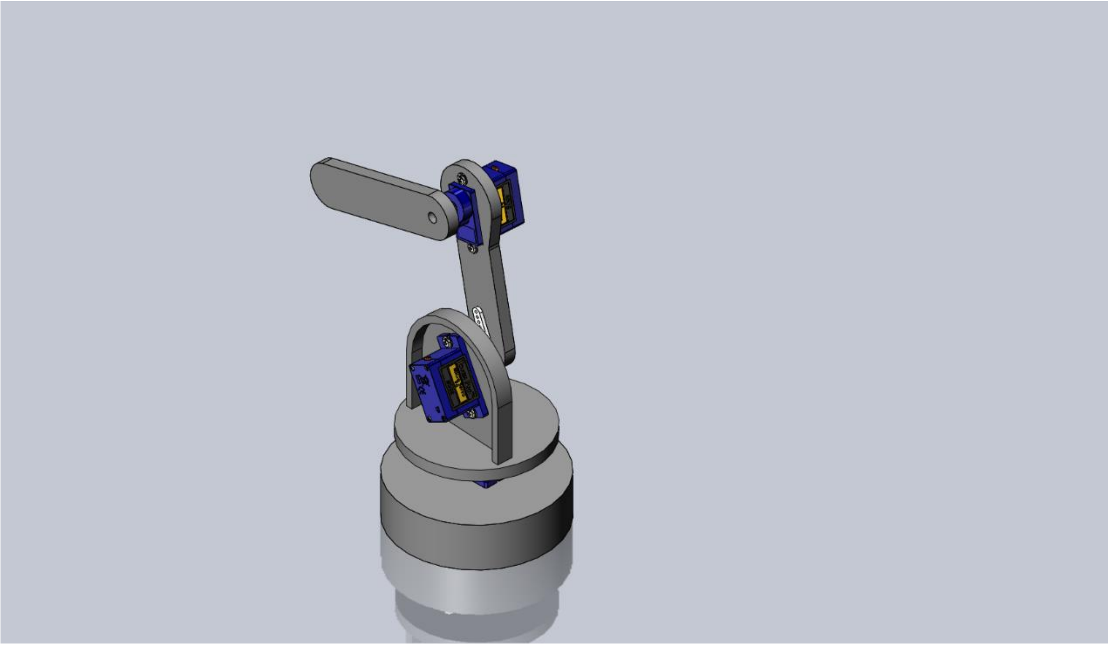

Figure 6 3D Sketch of Output

Below are the mounting details of the output part.

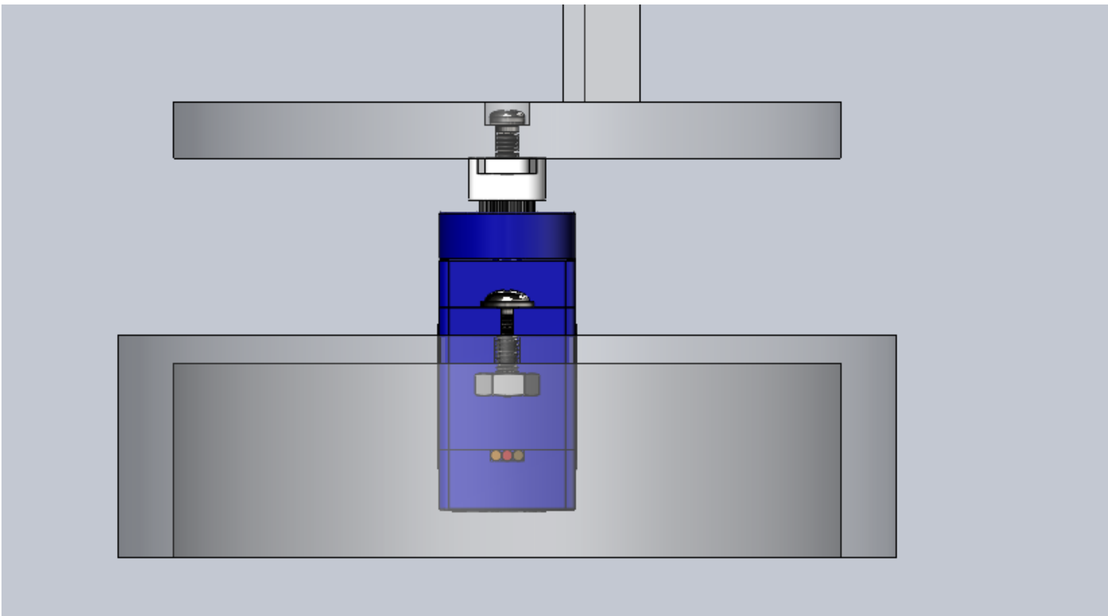

Figure 7 Mounting Details of Joint 1

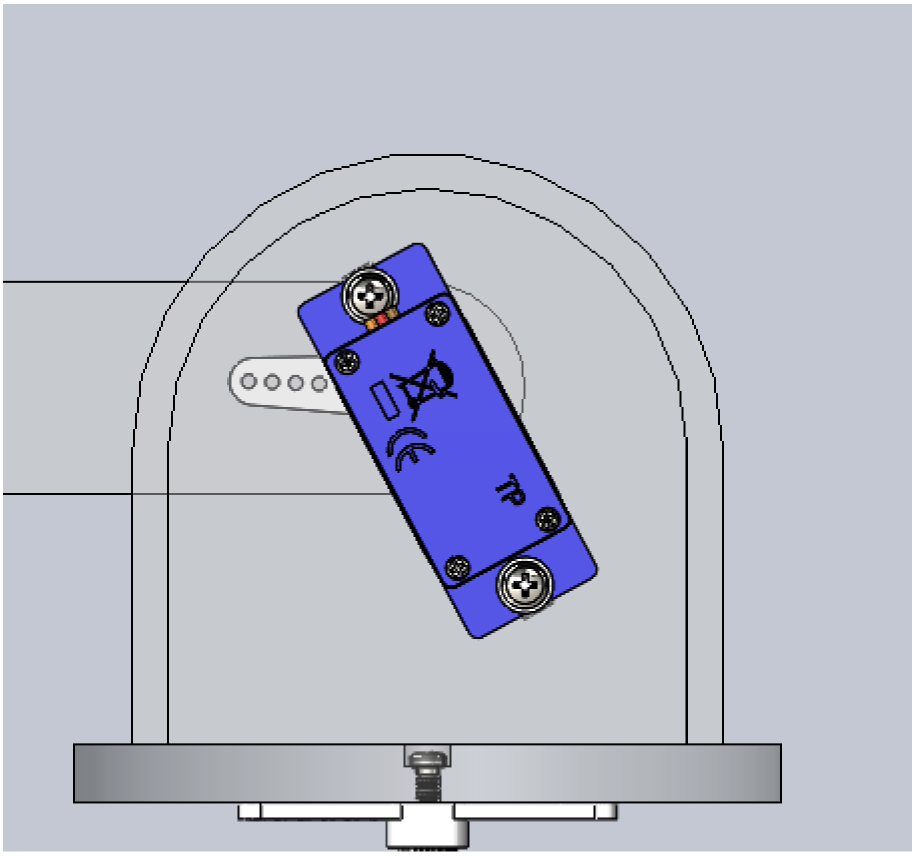

Figure 8 Mounting Details of Joint 2 (from the back)

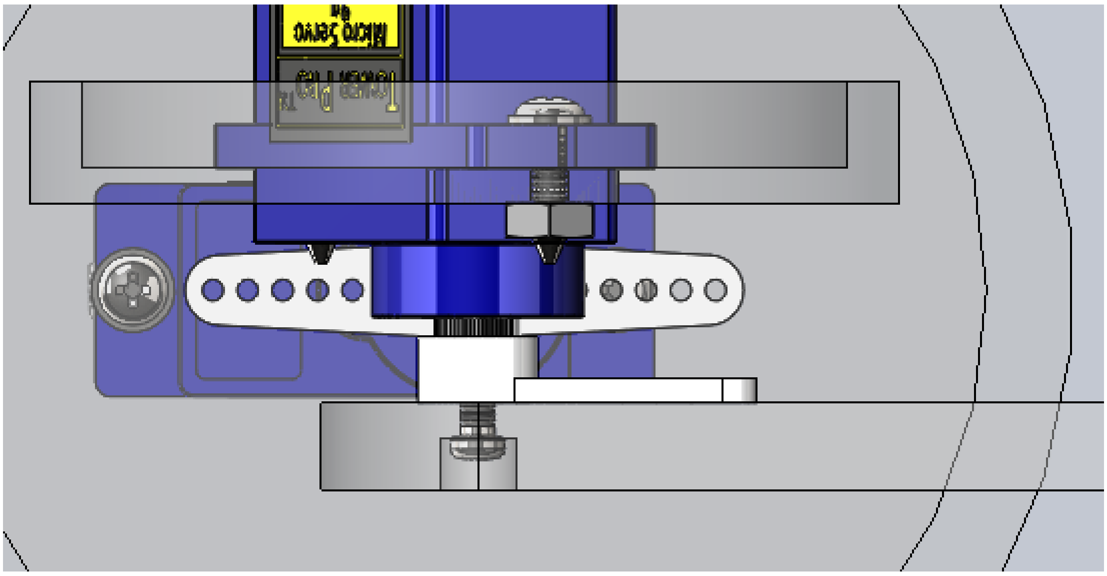

Figure 9 Mounting Details of Joint2 (from the top)

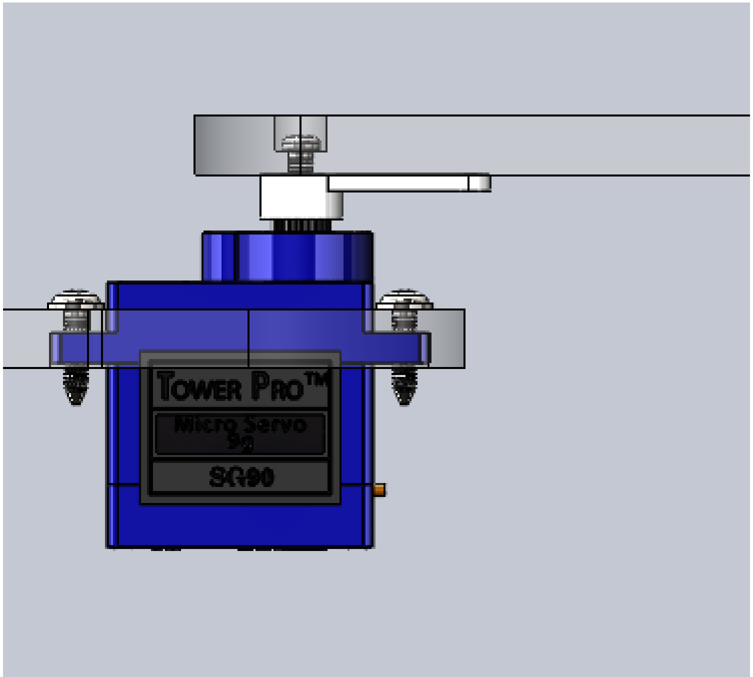

Figure 10 Mounting Details of Joint 3

Also, the dimensioned drawing below shows the overall and important dimensions of the output part.

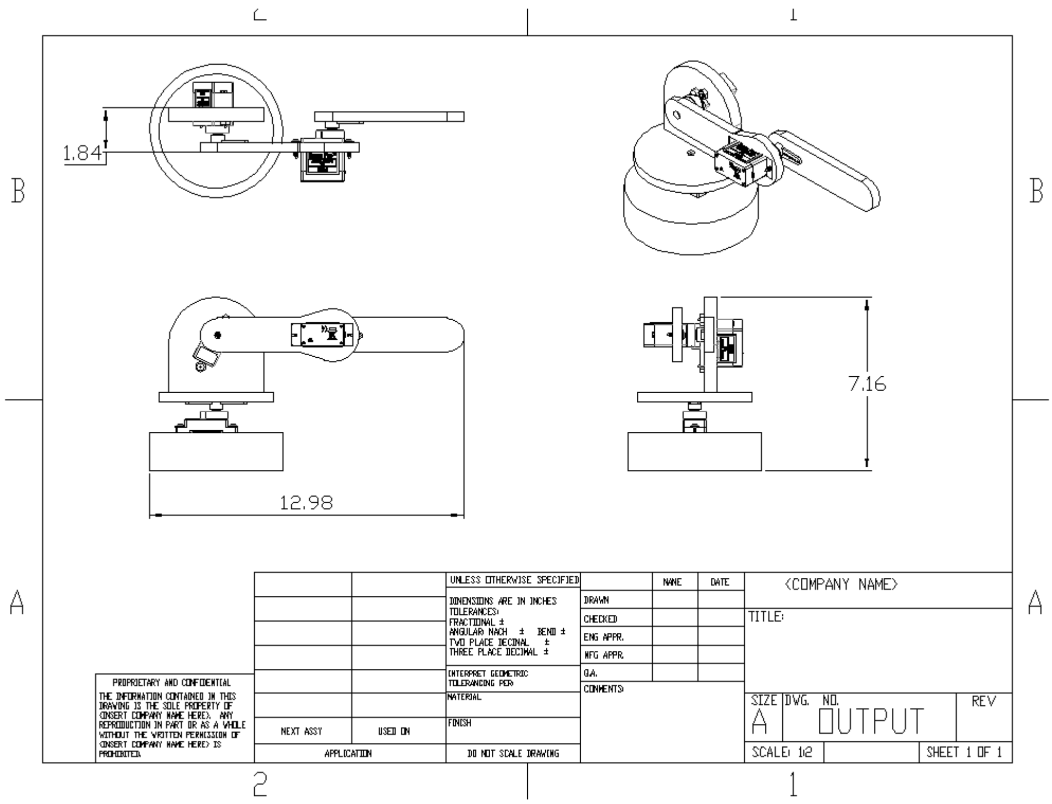

Figure 11 Dimension Drawing of Output Side

The CAD model of output side is in the link: (see output.SLDAMS)

https://drive.google.com/drive/folders/1VoniyYa5j_mm-k41wf5KrpYcwojbFG7H?usp=sharing

3.1.2 Now you need a way of reading two ADC channels continuously. Create two subroutines: one for setting up an ADC port, and one for reading the setup ADC port. **Submit your commented code.**

The code for this part is submitted separately on Canvas.

3.1.3 Interface with the Teensy with two analog sensors (such as potentiometers) so their positions can be displayed to the USB serial port. Build the sensing side of your Waldo and submit a video of it moving with the position of the joints being moved and the angle being displayed in a serial window on a computer. **Submit a video of your device and the serial window showing the motion, include drawings, and any code used. Provide a short discussion of the sensitivity of your device (the number of ADC counts over the full range of motion, linearity and apparent noise**

sources.)

From the datasheet of potentialmeter, we know that the mechanical angle of it is 300°.

Mechanical Characteristics	
Stop Strength	5.65 N-cm (8 oz.-in.)
Mechanical Angle	300 ° nominal
Torque	
Starting	3.53 N-cm (5.0 oz.-in.) maximum
Running	3.53 N-cm (5.0 oz.-in.) maximum
Mounting (Torque on Bushing)	45 N-cm (4.0 lb.-in.) max [plastic bushing]; 79 N-cm (7.0 lb.-in.) max [metal bushing]
Weight (Single Section)	4.5 grams
(Each Additional Section)	2.5 grams
Terminals	Solderable pins
Soldering Condition	
Manual Soldering	96.5Sn/3.0Ag/0.5Cu solid wire or no-clean rosin cored wire; 370 °C (700 °F) max. for 3 seconds
Wave Soldering	96.5Sn/3.0Ag/0.5Cu solder with no-clean flux; 260 °C (500 °F) max. for 5 seconds
Wash Processes	For recommended wash processes, please refer to http://www.bourns.com/pdfs/sldclen.pdf
Marking	Manufacturer's trademark, model number, product code, terminal style, resistance code and date code
Ganging	2 cups maximum
Hardware	One lockwasher and one mounting nut is shipped with each potentiometer, except where noted in the part number.
Flammability	Conforms to UL94V-0
Epoxy	Conforms to UL 94V-1
IP Rating	IP67

Figure 12 Datasheet of 3310-9mm Potentialmeter

Therefore, we should convert the counts of ADC into angle. Since bits of ADC is $2^{10} - 1 = 1023$ times, by dividing $\frac{1023}{300} = 3.41$, we could make the digits displayed on the screen to be the angle of potentiometer.

The video is in the link below.

https://drive.google.com/file/d/1q41sg1w70nq10DE30ikrW1R9wOMesKXD/view?usp=sharing

The code is submitted separately on Canvas. The circuit diagram is shown in the figure below.

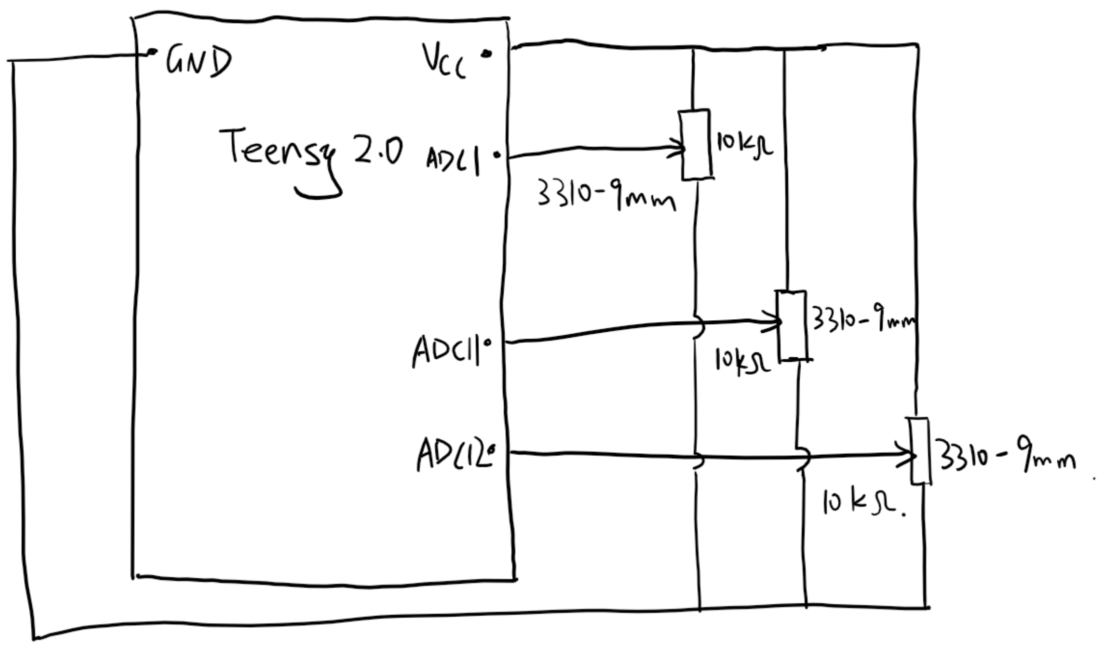

Figure 13 Circuit Diagram for Analog Input

One of my part should be produced by 3D printing. However, there is no TA in RPL during the fall break. For my input side, two of the potentiometers is connected directly to the link and one of the potentiometer is connected the base. So I confirmed with TA how to express the input side and made the input side for this problem looks like the video.

The sensitivity of the ADC input is determined by input range and resolution. Among them, input range is determined by Vref, which can be Vcc, 2.56V or AREF pin. For this problem, I set the Vref to Vcc. From the datasheet, we know that the bit of ADC is 10-bit. Therefore, in this case, the ADC counts $2^{10} - 1$ times, i.e. ADC counts 1023 times to let the output counts to 5V.


24. Analog to Digital Converter - ADC

24.1 Features
- **10/8-bit Resolution**

Figure 14 Screenshot from Datasheet of Teensy

However, the ADC is not strictly linear. The performance of ADC behaves like the figure below.

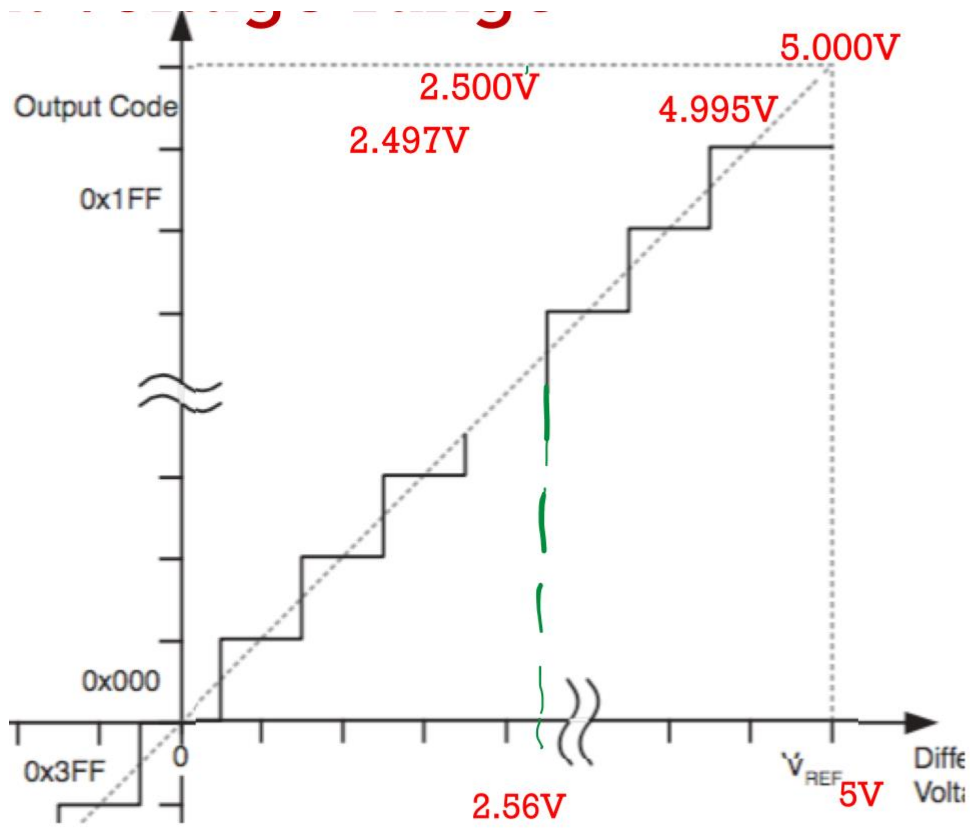

Figure 15 Output Code VS Vref

However, since the ADC counts 1023 times to Vref, which means that as the angle twists by 0.29°, the output code would add 1. In this case, we could consider the output code is linear with the voltage. In my circuit, the potentiometer acts like a voltage divider. It could change the voltage by turning it. Since we could consider the ADC as linear, the ADC does reflect the voltage of potentiometer.

Additionally, since the potentiometer of mine is connected directly to the links, the rotating angle of the link is exactly the same as that of the potentiometer. Therefore, my whole sensing part perform in a quite linear way.

The noise source mainly comes from the process of AC converting to DC. No matter of what kind of power supply (computer, voltage source, etc.), the power supply for the teensy is AC. However, teensy use 5V DC. In the US, the frequency of AC is always 60Hz. In the process of converting AC to DC, there is always a 60Hz noise, which would also perform in ADC.