

# Testbench Building Guide

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## 3D Prints

- Prusa XL 0.4mm nozzle
- 1.75 mm PLA
- 15% infill
- Support depending on .3mf file name in print folders.

All components are setup to be printed on Prusa XL with 1.75mm PLA filament.

Use the .3mf files in Print\_1 through Print\_8 to print all components needed to assemble the testbench. Each print folder contains its needed .stl files and are named whether they should be printed with or without support. This is because files containing belt links need to be printed without support for them to nest withing each other. The PLA should preferably be black for the belt, as this could affect how well the color sensor works, otherwise colors do not matter for the rest of the system.

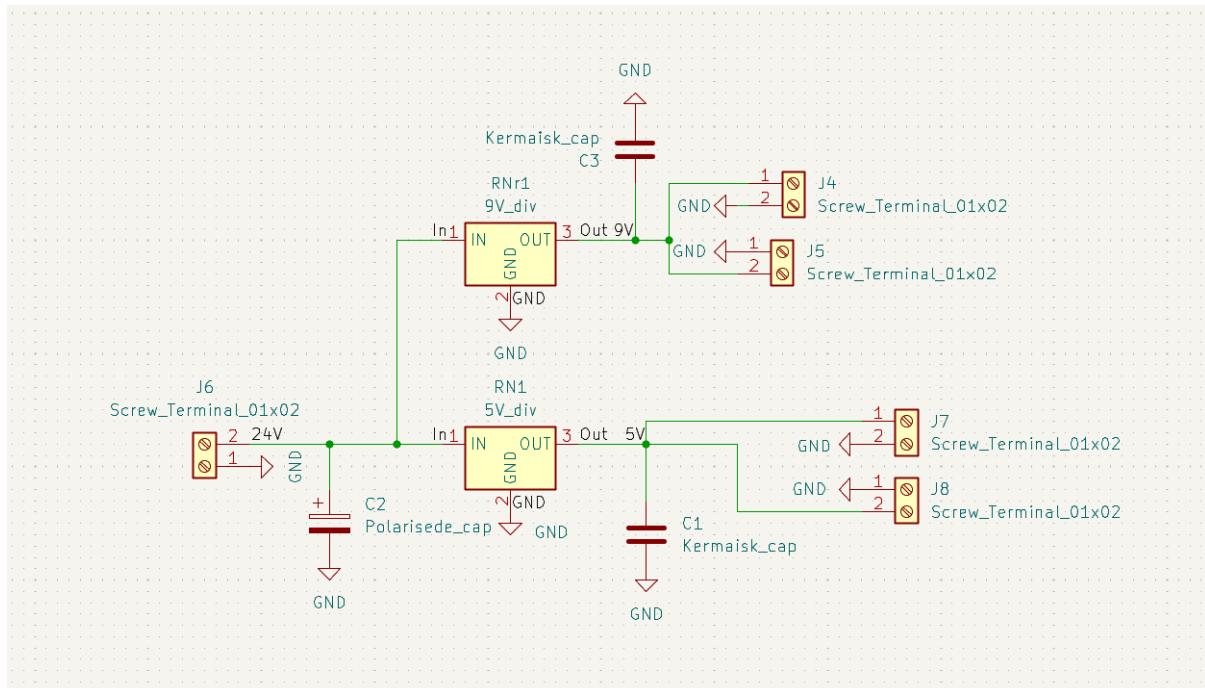
# PCB Building Guide

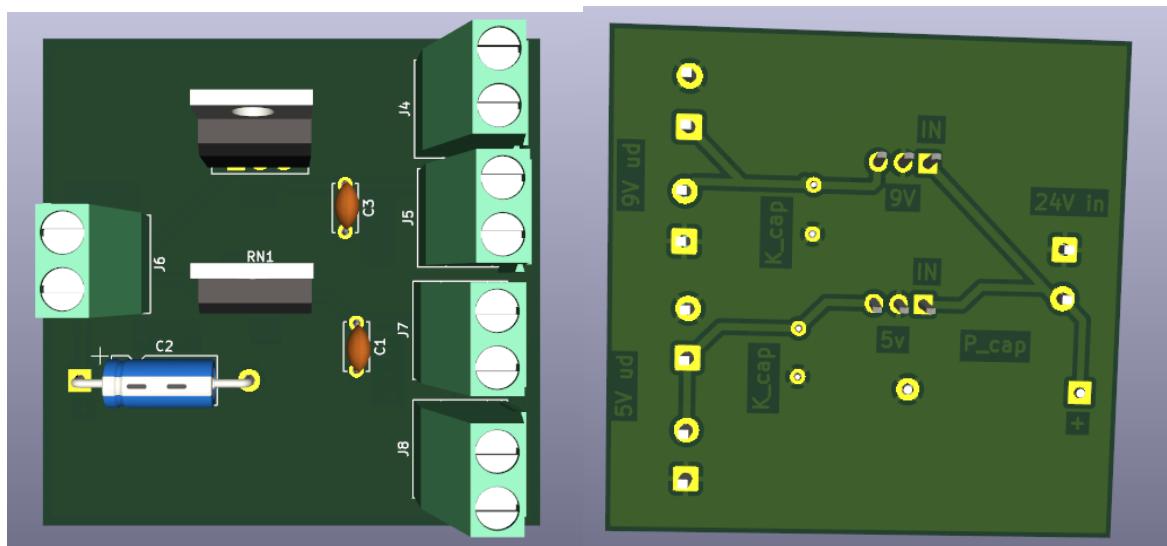
## Bill of Materials (BOM)

Item	Name	Amount
1	5V regulator MC7805ABT	4
2	9V regulator MC7809	1
3	12V regulator MC7812	1
4	BJT transistor TIP120G	7
5	Screw terminal 5.08 phoneix 2 terminal	5
6	Resistor 1.1K ohm	7
7	Resistor 1.5K ohm	7
8	Resistor 1.8k ohm	1
9	Resistor 2k ohm	2
10	Resistor 2.2k ohm	2
11	Resistor 3k ohm	7
12	Resistor 7.5k ohm	2
13	Resistor 13k ohm	7
14	Screw terminal 5.08 phoneix 3 terminal	22
15	Female 1x16 connecter	4
16	Capacitor keramisk 100 nF 50V	2
17	Capacitor Polariseded 100 $\mu$ F 100V	1
18	Capacitor keramisk 0.33 $\mu$ F	1
19	Capacitor keramisk 0.15 $\mu$ F	1
20	Potentiometer 10K Linear	1

For every PCB a schematic + both sides of the PCB are given + a the BOM for that specific PCB

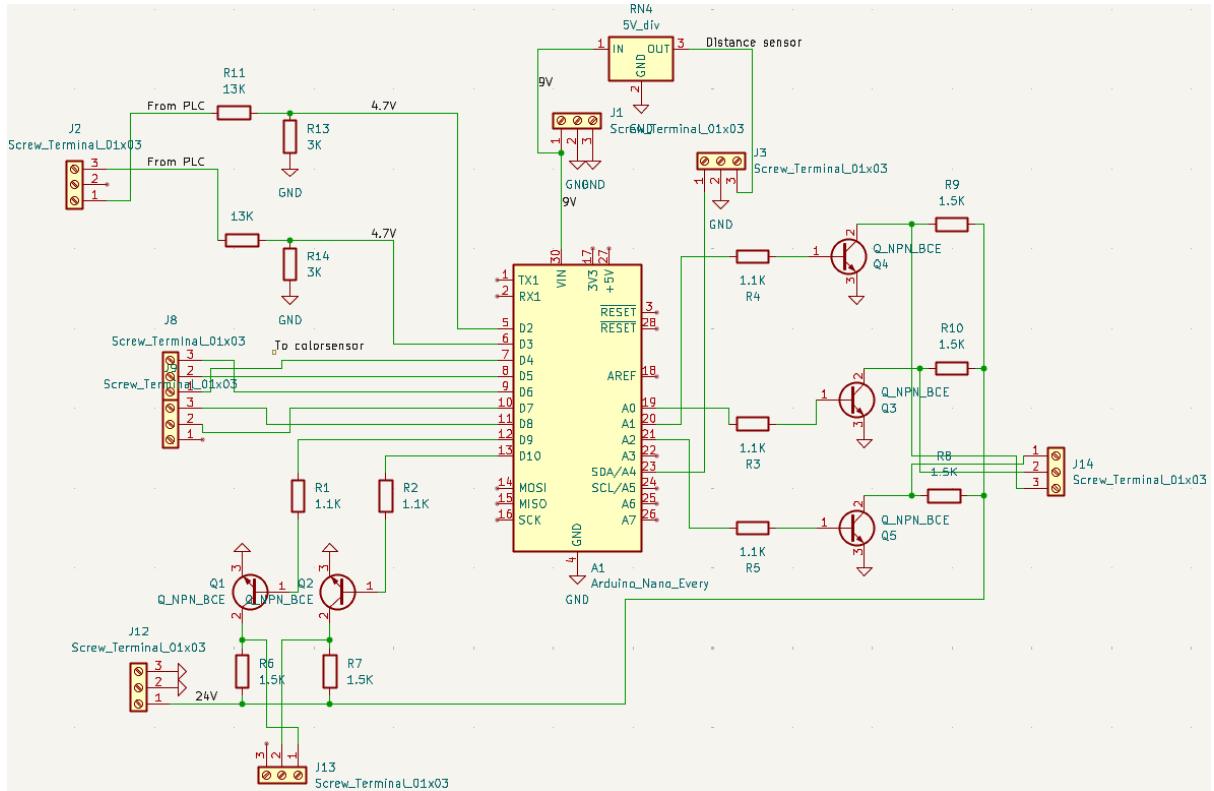
## PCB 1

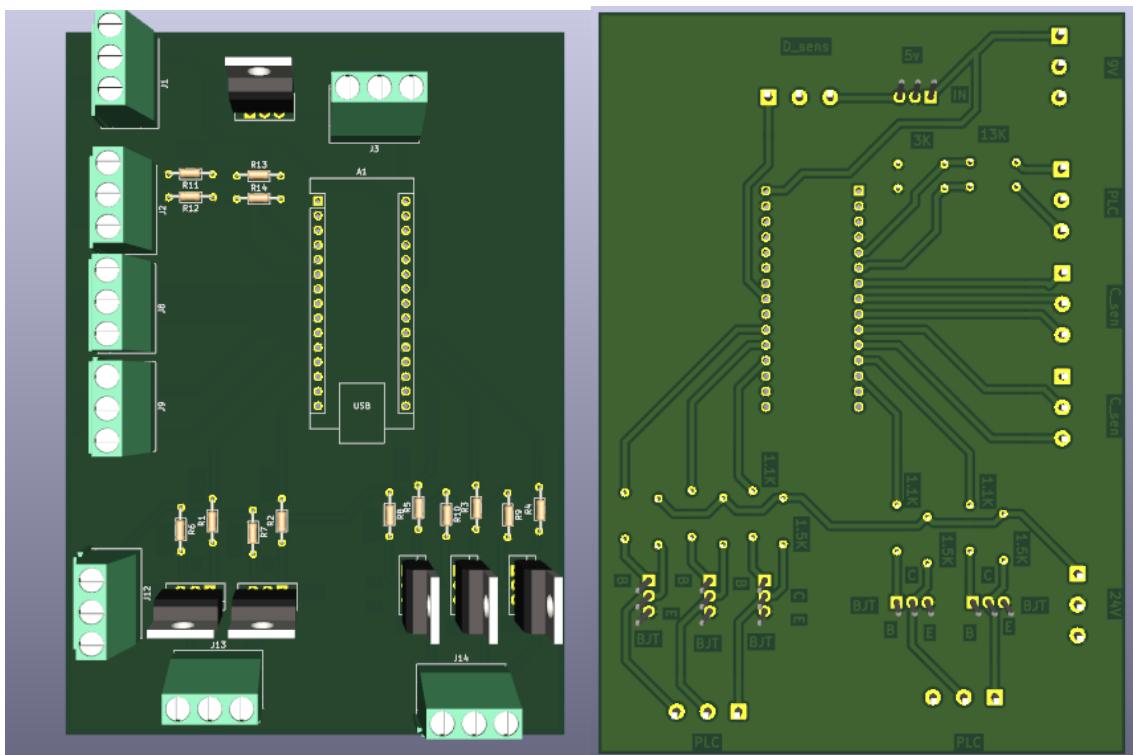




Item	Name	Amount
1	Screw terminal 5.08 phoneix 2 terminal	5
2	5V regulator MC7805ABT	1
3	9V regulator MC7809	1
4	Capacitor keramisk 100 nF 50V	2
5	Capacitor Polariseded 100 µF 100V	1

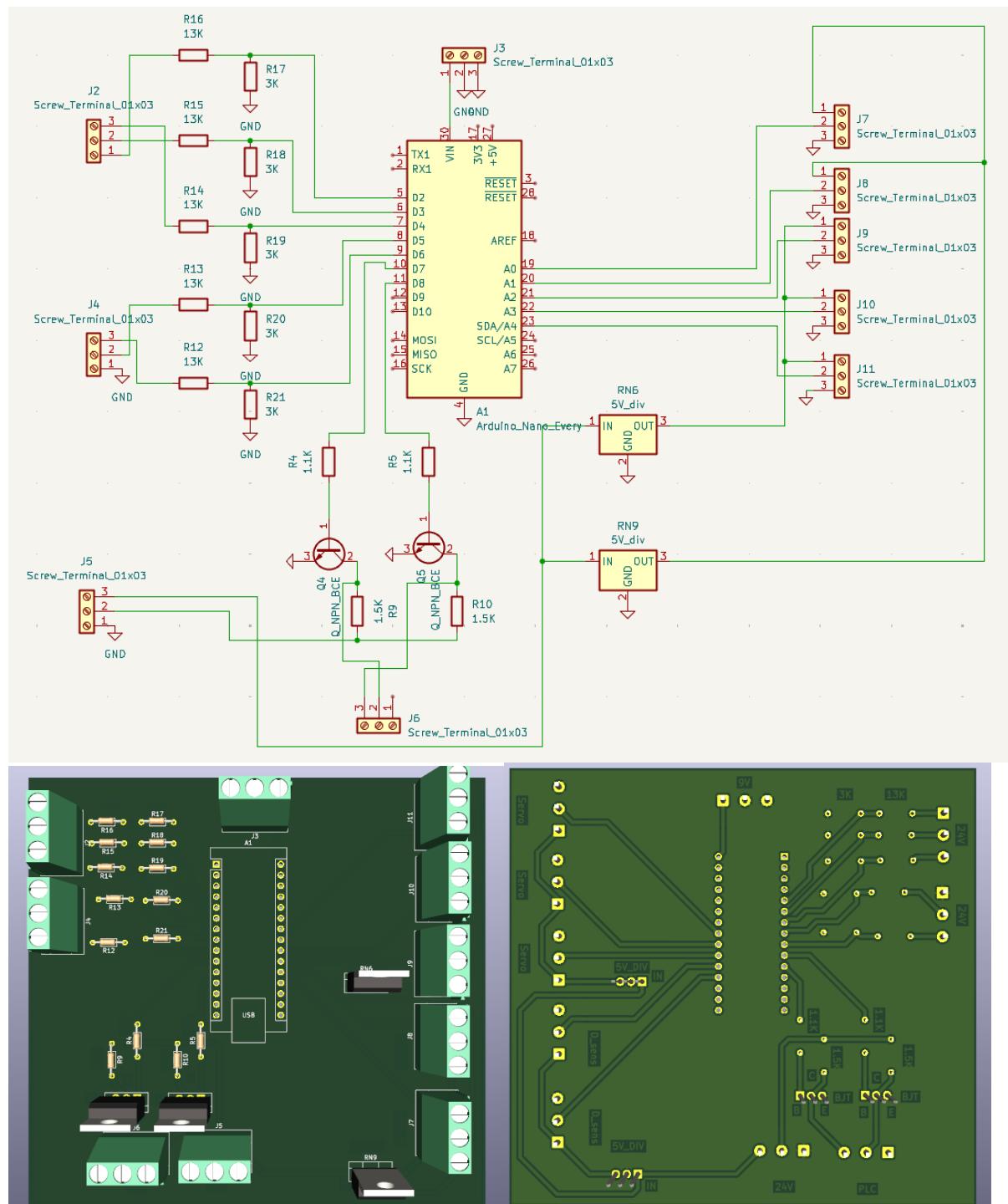
PCB 2





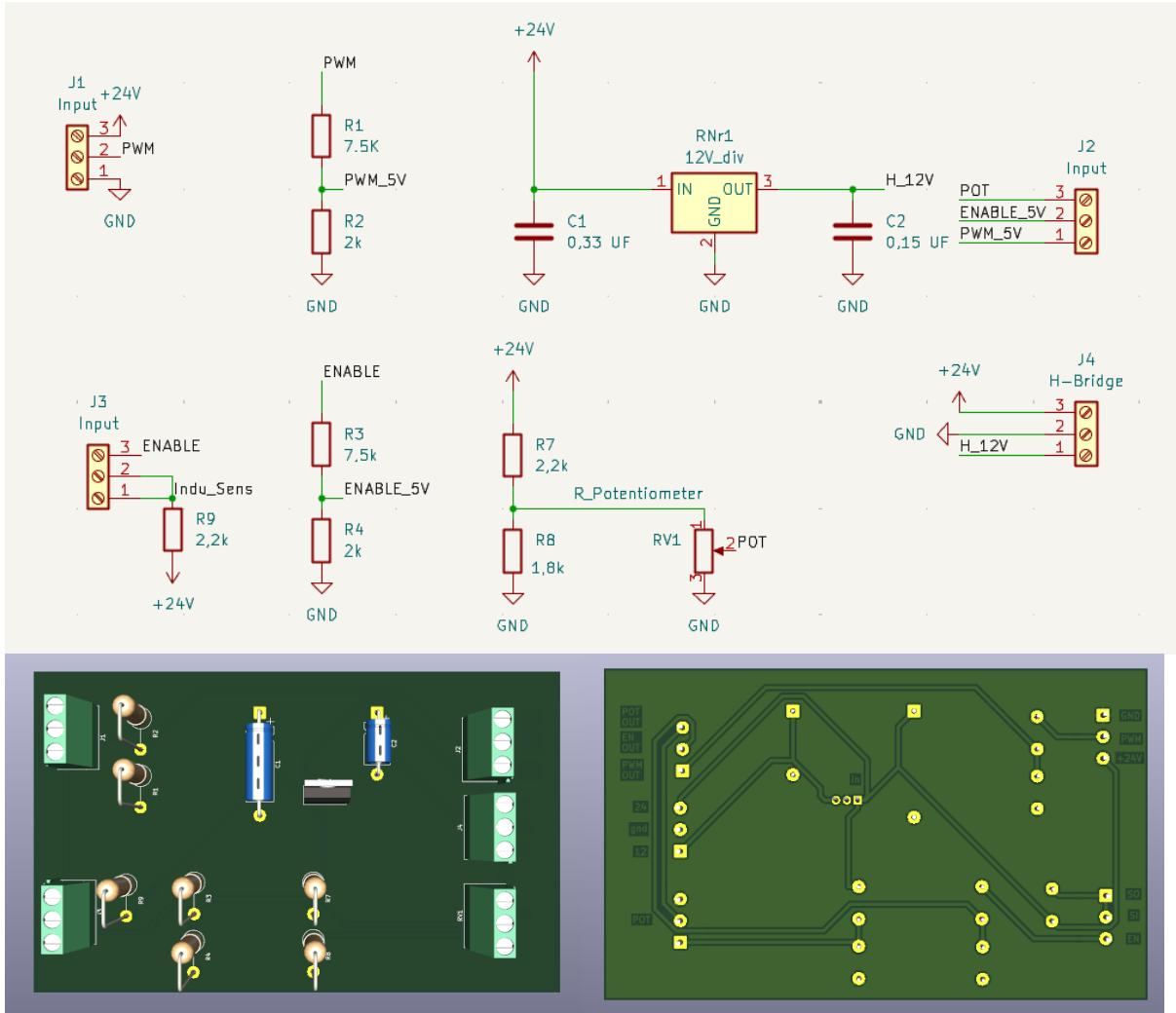
Item	Name	Amount
1	Screw terminal 5.08 phoneix 3 terminal	7
2	5V regulator MC7805ABT	1
3	Resistor 3k ohm	2
4	Resistor 13k ohm	2
5	Resistor 1.1K ohm	5
6	Resistor 1.3K ohm	5
7	BJT transistor TIP120G	5
8	Capacitor keramisk 0.33 µF	1
9	Capacitor keramisk 0.15 µF	1
10	Potentiometer 10K Linear	1

PCB 3



Item	Name	Amount
1	Screw terminal 5.08 phoneix 3 terminal	10
2	5V regulator MC7805ABT	5
3	Resistor 3k ohm	5
4	Resistor 13k ohm	2
5	Resistor 1.1K ohm	2
6	Resistor 1.3K ohm	2
7	BJT transistor TIP120G	2

## PCB 4



Item	Name	Amount
1	Screw terminal 5.08 phoneix 3 terminal	5
2	12V regulator MC7812	1
3	Resistor 1.8k ohm	1
4	Resistor 2k ohm	2
5	Resistor 2.2K ohm	2
6	Resistor 7.5K ohm	2
7	BJT transistor TIP120G	2

## Connection Guide

### PCB 1

Terminal J7 & J8 go to the color sensor

Terminal J4 & J5 go to PCB 2 and PCB 3 to power the arduinos

Terminal J6 gets power and ground from the power supply

### PCB 2

Terminal J1 is connected to J4 on PCB1

Terminal J2 is output from the PLC

Terminal J3 is to the distance sensor, The first position should be power to the sensor, second should be signal from the sensor, and third is ground.

Terminal J8 & J9 is to the color sensor. The first position should correspond to S0 and so on.

The last position should be OUT from the color sensor

Terminal J 12 is connected to the power supply

Terminal J14 & J13 is input to the PLC

### PCB 3

Terminal J2 & J4 is output from the PLC

Terminal J3 is connected to J5 on PCB1

Terminal J5 is connected to the power supply

Terminal J6 is input to the PLC

Terminal J7 & J8 is to the distance sensors, The first position should be power to the sensor, second should be signal from the sensor, and third is ground

Terminal J9 & J10 & J11 is connected to the servos The first position should be power to the servo, second should send signal to the servo, and third is ground

### PCB 4

Terminal J1 powers the circuit from power supply, and takes pwm signal from PLC

Terminal J3 takes the industry sensors output pulls it up and sends it back to the PLC to a digital input. It also takes an output from the PLC being Enable

Terminal J2 has output for PWM on motor control E, and POT OUTPUT that goes to the PLC analog input

Terminal J4 powers the motor controller, with 12V (VD) and GND and supplying the 24V(VS) to drive the motor.

# Linear Actuator Building Guide

## Bill of Materials (BOM)

Item	Name	Amount	Step
1	M8 x 60 Hex	1	4
2	M6 x 50 Hex	2	2
3	M5 x 20 Hex	1	5
4	M4 x 16 Sta	4	1
5	M2 x 10 Sta	8	3
6	M8 lock nut	3	4-5
7	M6 lock nut	2	2
8	M5 lock nut	1	5
9	M4 lock nut	4	1
10	M8 Plain Washer	2	4-5
11	M6 Plain Washer	4	2
12	M5 Plain Washer	3-5	5
13	M4 Plain Washer	4	1
14	M2 Plain Washer	8	3
15	Ball Bearing – 8 x 22 x 7	1	4
16	Parallax Standard Servo Motor SKU 900-00005	1	1

## Tools Required

- Torque Wrench
- 13mm Hex end fitting for M8 bolts
- 10mm Hex end fitting for M6 bolts
- If you have end fitting for M5 bolts it might get easier.
- Combination wrench for M8, M6 and M5 bolts and lock nuts
- Screwdriver for M4 and M2 Sta bolts.

## Assembly Steps

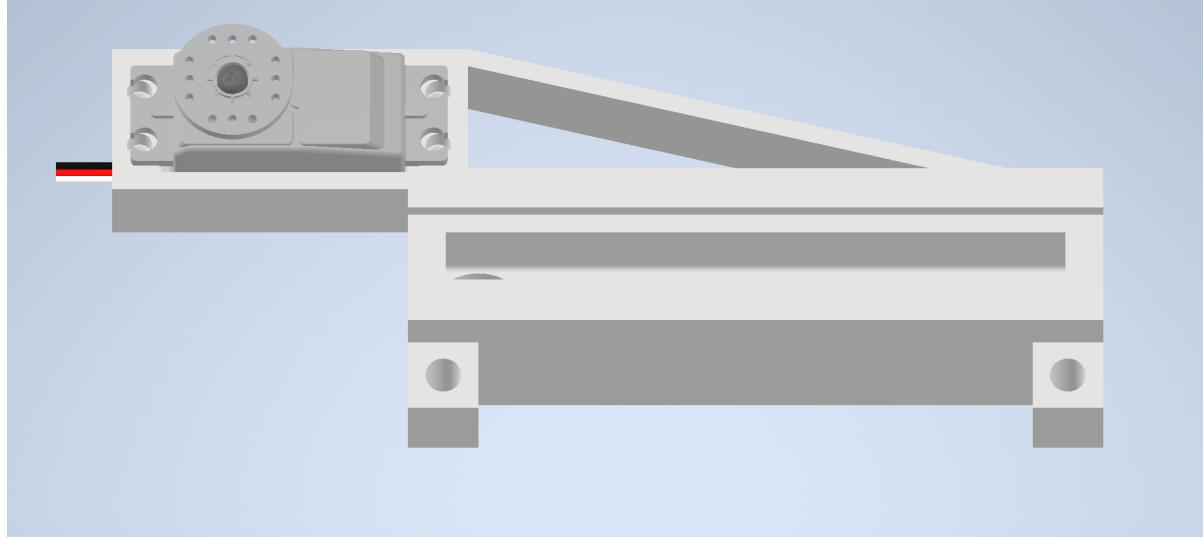
These steps assume that you have 3D printed all the necessary design parts for the Actuator.

### Step 1 - Installing the Servo motor

Looking at the BOM you find what you need for this step.

The first step is to install the servo motor into its designated slot in the housing of the actuator. The slot is designed with a tight fit around the motor and therefore might be difficult to install.

When installing it make sure the end of the motor with the cables, is inserted first and then try to squeeze it into place. You might worry about bending the cables which is fair so try to take care of them as much as possible. When you successfully installed the servo motor it should look like this.

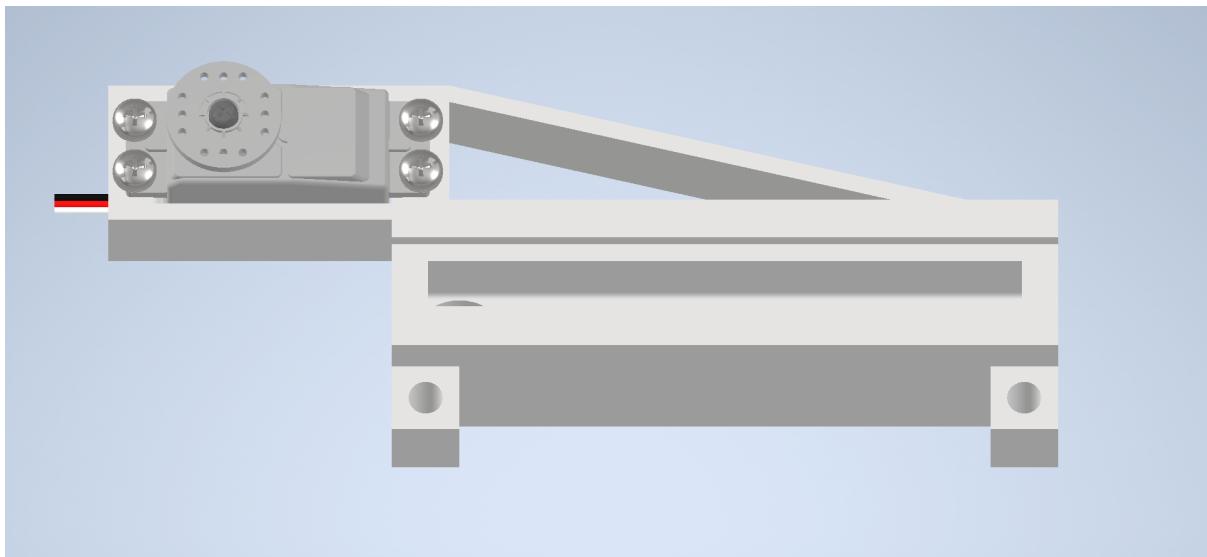


After installing the servo motor, you now make sure it is fixed in place. To do this you use the M4 sta. bolts, M4 lock nuts and M4 washers. Underneath the installed servo motor, you will see 4 hex formed slots made for the M4 lock nuts. You will insert a lock nut into one of the sockets and then using the screwdriver screw a M4 sta. bolt with a washer from the top into the lock nut and ultimately fastening the servo to the housing.

**Tip:** Make sure the lock nut is in its socket while screwing the bolt into it otherwise the lock nut will just screw around with the bolt and not get anywhere.....

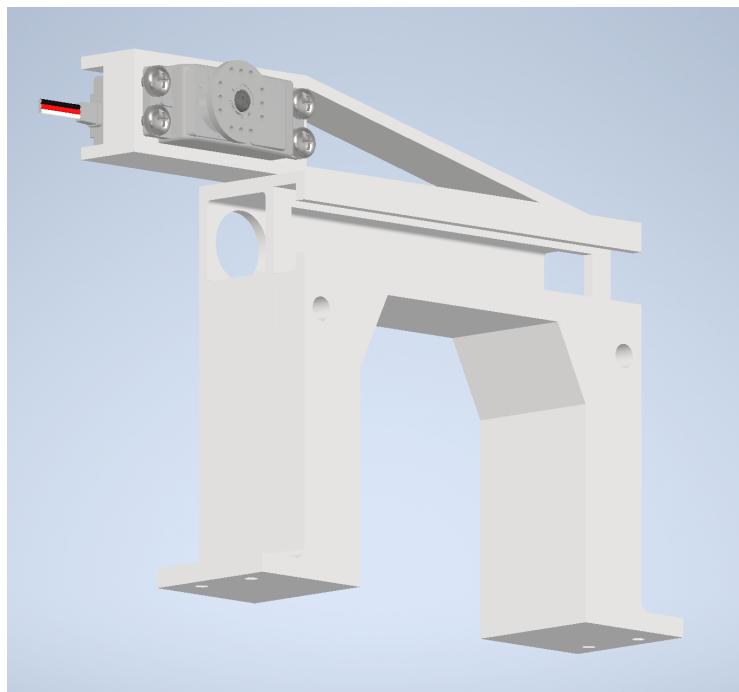


When all the M4 bolts are screwed into place it should look something like this.



### Step 2 – Mounting the legs

To attach the legs to the housing, you just fit them into place. It should be straightforward because of the fitted design. When attached it should look like this.

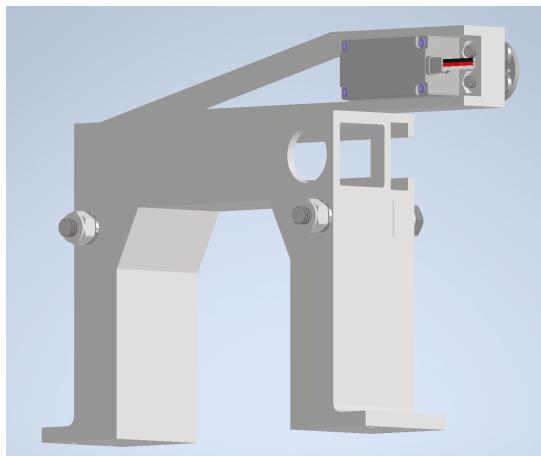
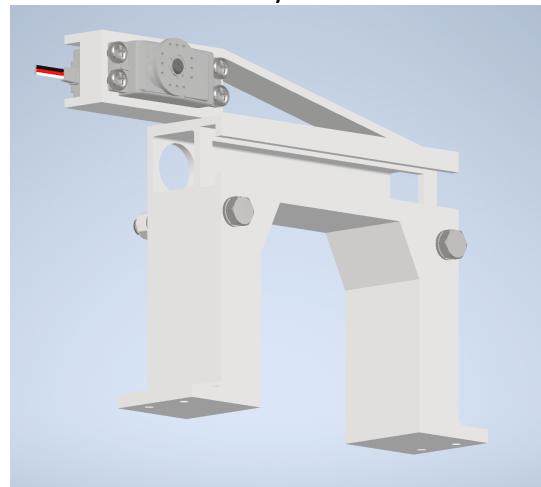


To then fasten the legs to the housing we use the materials given in BOM.

Firstly, you insert the M6 bolt with a M6 washer into the holes. Make sure the bolt head is on the same side as the rotating part of the servo motor. The holes might be tight, and you might need to use a torque wrench or combination wrench to screw it into place.

When they are into place you insert a M6 washer onto the bolt on the other side and screw a M6 lock nut on as much as possible with your fingers. When you can't anymore use the

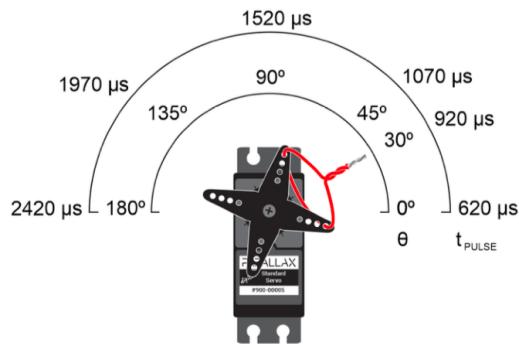
torque wrench to screw the lock nut the rest of the way, while holding the bolt head on the other side with a combination wrench. When you are done it should look like this.



Make sure that the lock nut isn't fasten too much so that the PLA doesn't bend and affect the design/mechanism.

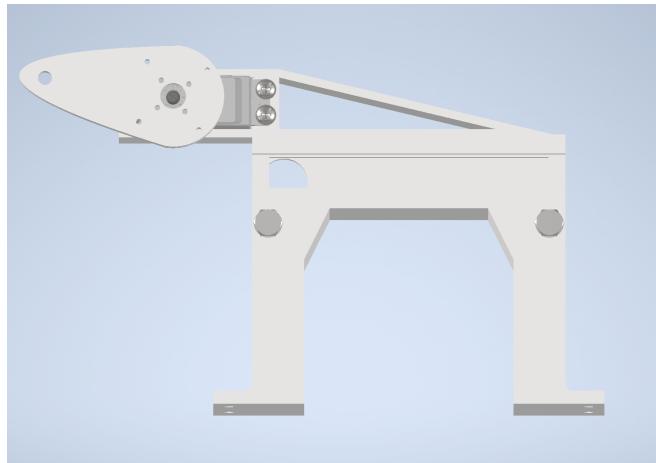
### Step 3 – Install the crank

To mount the crank onto the servo, you need to keep rotating the head of the servo towards 0 degrees until you hit a mechanical limit. Follow the angles shown underneath:

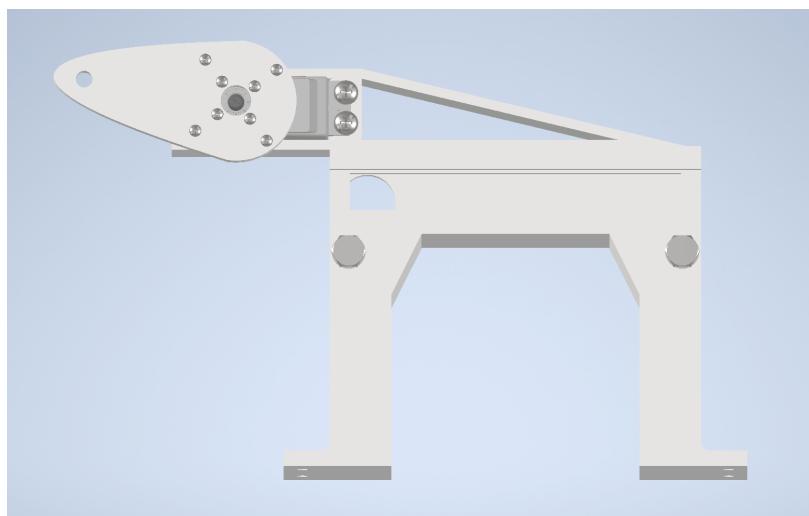


The crank was then aligned so that the coupler mounting hole pointed approximately at 90 degrees, as shown in. This configuration ensured correct orientation and maximized the effective stroke during servo rotation from 0 to 180 degrees.

When you know the correct orientation to mount the crank it should look something like this.

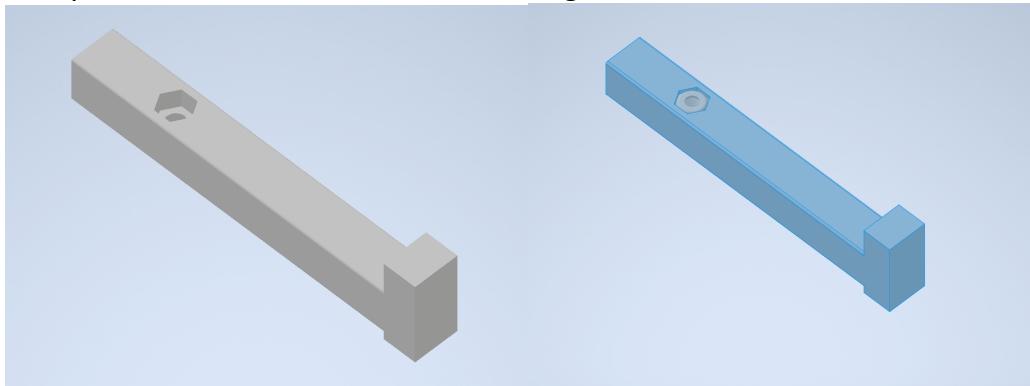


When you have it setup you fasten the crank to the head of the servo using the M2 bolts and washers with a screwdriver. When done it should look like this.

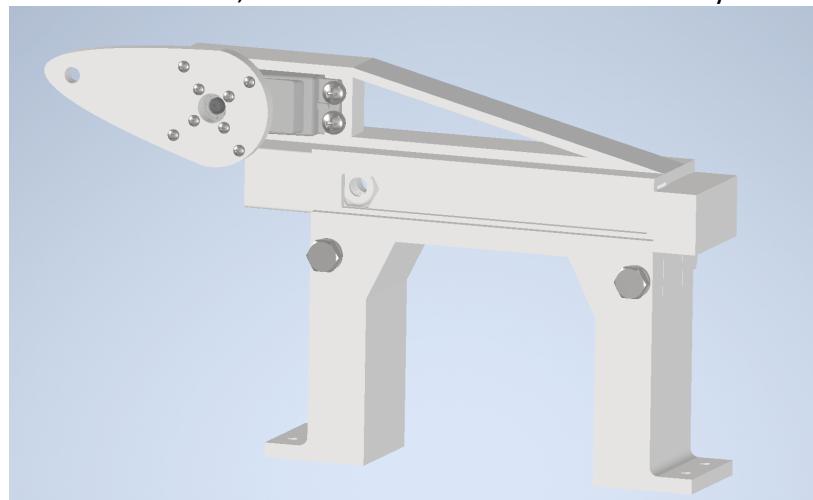


Step 4 – Install the slider shaft

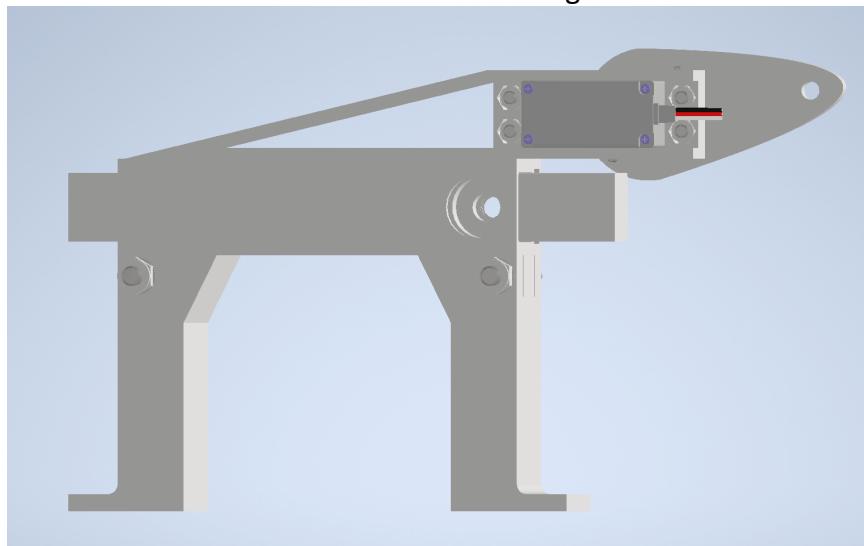
First you insert the M8 lock nut int the designated socket in the shaft.



Then you insert the shaft into the housing making sure that its all the way back. Make sure that the shaft is inserted like this, where the lock nut is visible this way:



Next you insert the M8 bolt from the back of the housing.

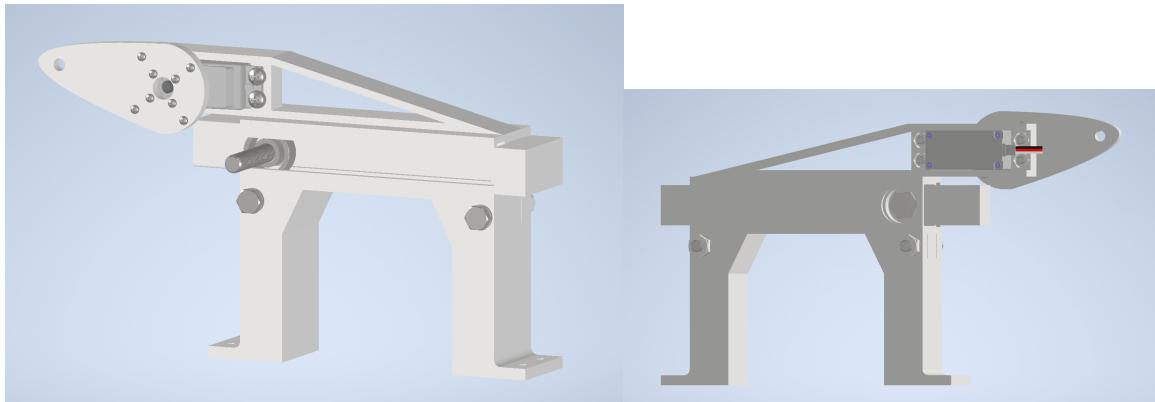


You then insert it though the shaft and screw it into the lock nut carefully with your hands until you can't anymore.

**When screwing the bolt though the lock nut makes sure that the lock nut stays fully in its socket!**

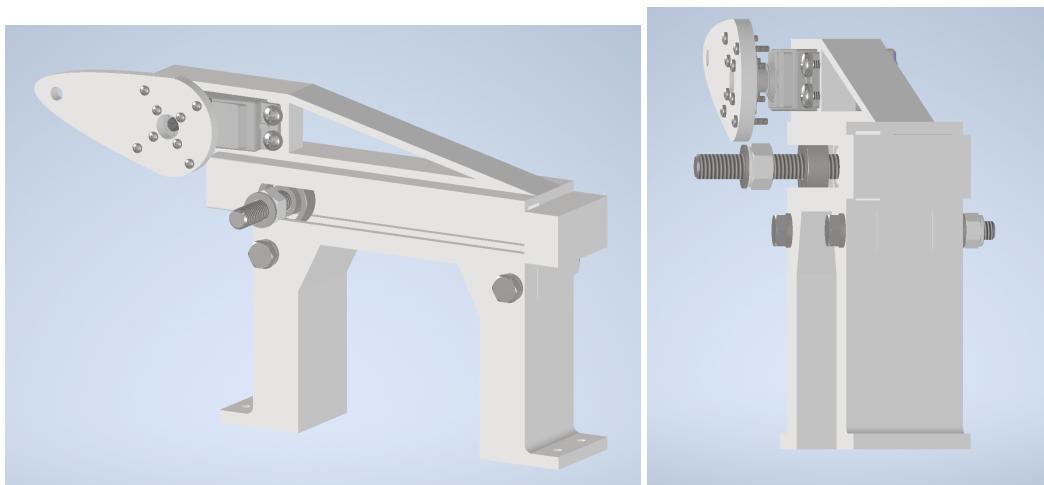
A way to solve the issue of the lock nut not staying in its place while screwing the bolt in, could be to heat insert it. Melting a bit of plastic around it to keep it in place.

Now the harder part. You must screw the bolt further through the lock nut but at the same time make sure that the bolt goes through a ball bearing you insert. When done it needs to look like this.



To screw the bolt further through the lock nut you insert and attach the 13 mm fitting for the torque wrench, onto the M8 bolt head. You keep using it until the 13 mm fitting goes into the housing hole and the M8 bolt is fasten to the shaft and its head does not touch the housing walls inside. **Again, when screwing the bolt though the lock nut makes sure that the lock nut stays fully in its socket!**

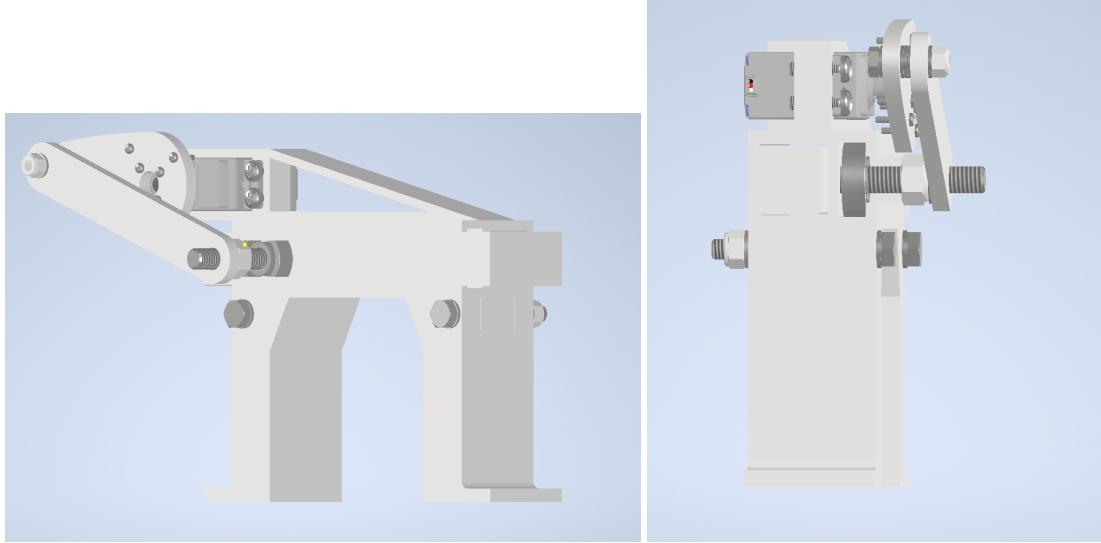
While still having the torque wrench attached to the bolt head and the M8 bolt is screwed into its place you screw another M8 lock nut onto the shaft with a washer. To do this you use a combination wrench to screw the lock nut into its place and the torque wrench to hold the bolt in its place. When done it should look like this.



How far you screw the lock nut onto the shaft will depend on the Coupler placement but one rule to follow is to make sure you don't screw it so far, that it will touch the housing.

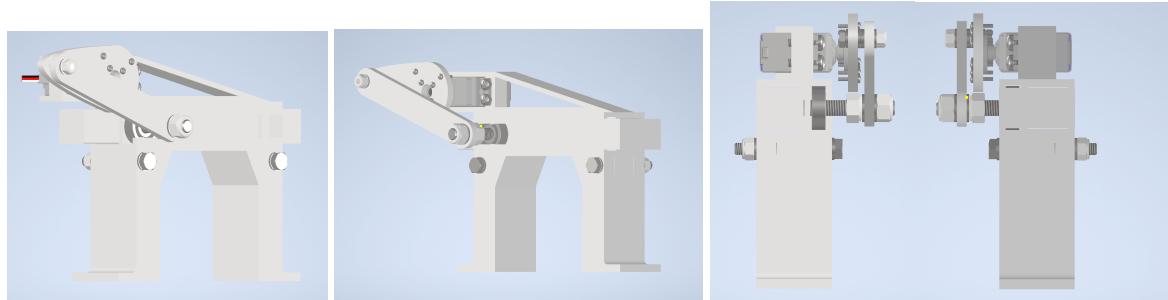
### Step 5 – Installing the coupler

To now attach the coupler to the system, which is the last part, you insert the M5 bolt from the back side of the crank through its end effector hole with a washer. On the other side you attach 2-3 washers depending on how many is needed to stay clear of the M2 bolts in the crank. Then you attach the coupler to the M5 bolt through its smaller and longer hole. At the same time, you can attach the coupler to the M8 bolt through its larger hole. To then fasten the coupler to the crank you attach a washer and a M5 lock nut to the M5 bolt. When done correctly the steps should look like this:



Make sure to not fasten the lock nut to much to the coupler. The washers need to be able to rotate and the M5 bolt needs to be able to move alittle inside the longer hole if needed.

To then finish it you must fasten the coupler to the M8 bolt. To do this you use a washer and a lock nut of the appropriate size. Again, you use the torque wrench to hold the M8 bolt on its head from the back side of the housing and a combination wrench to screw in the lock nut and washer. Make sure again that it's not fasten to much the washer needs to be able to rotate. When done correctly it should look like this.



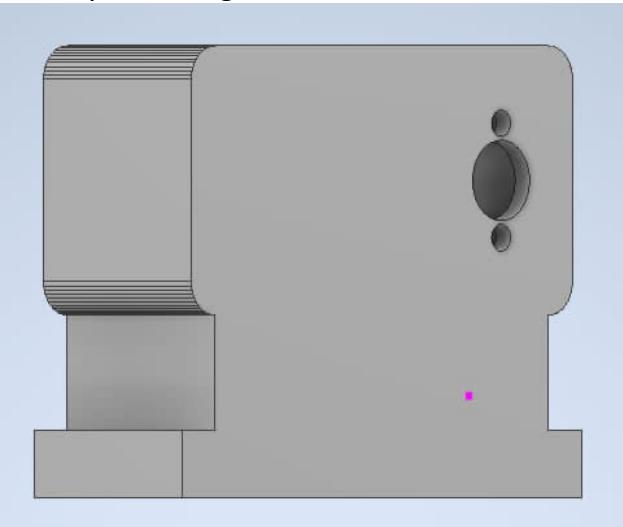
# System Construction guide

## Bill of Materials (BOM)

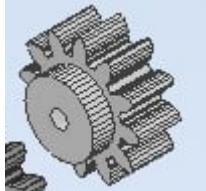
Item	Name	Amount
1	M4x20mm	2
2	M4 Nut	2
3	M4 Washer	4
4	M3x20mm	42
5	M3x12mm	2
6	M3 Nut	42
7	M3 Washer	94

### Step 1 – Gearbox

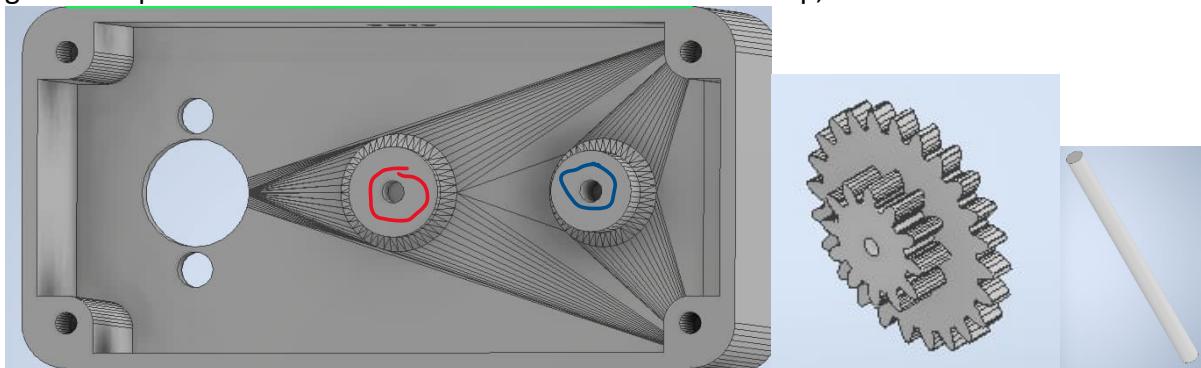
Start by mounting the motor on the back of the gearbox. With the two M3x12mm screws



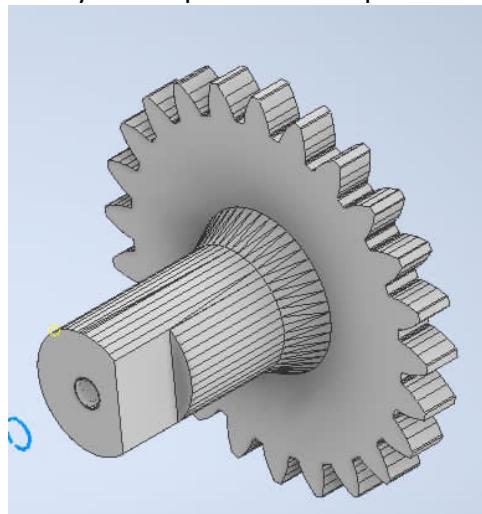
Place the small gear on the motor, with the gear part on top.



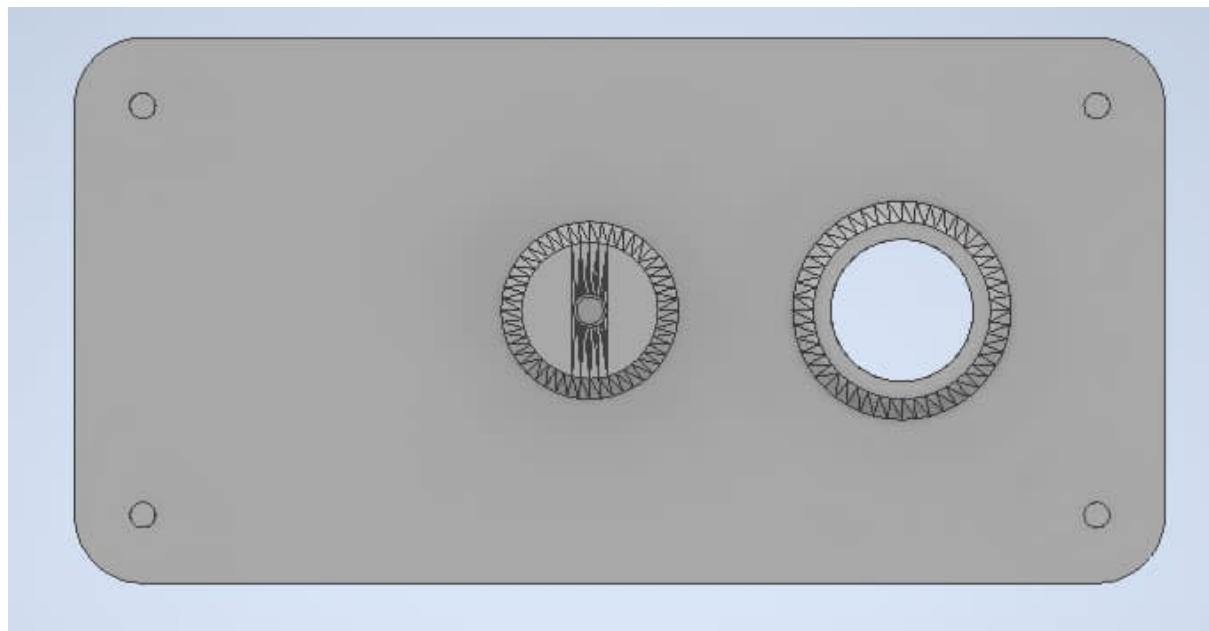
Place the first stick in the marked location(red) with 2 washers ontop and place the first big gear, with the small one at the top, and place the next stick with two washers and a big gear in same orientation on blue. Now place two washes ontop of both sticks and add the last big gear on top of the stick marked with red with 2 washers ontop, with the same orientation.



Now you can place the last piece onto the blue stick, this will be the output



Last thing to do is to place the lid onto the gearbox, remember to line up the holes in the lid with the sticks.



## Step 2 – Creating the testbench box

12 M3 Screws

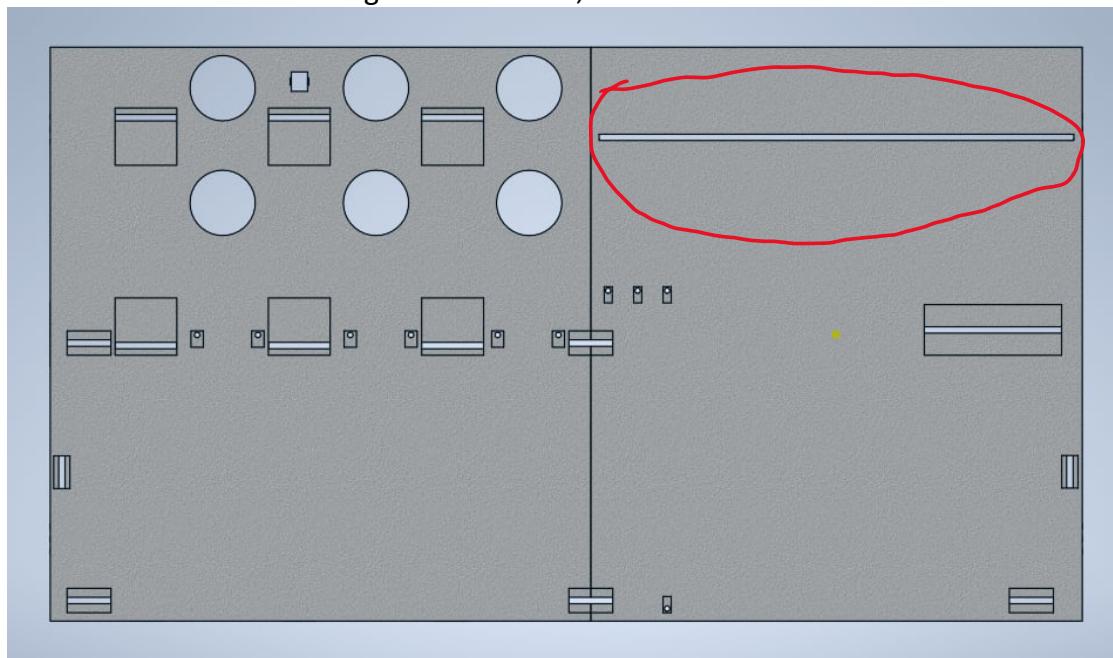
12 M3 nut

24 M3 washers

Turn the top left and top right part of the box on its head and push it together, screw together to make a single piece, and repeat the same with the bottom right and bottom left, you should now have an upper and a lower piece of the box

## Step 3 – Installing the PLC

Fasten the PLC bracket using the M4 screws, nuts and washers.

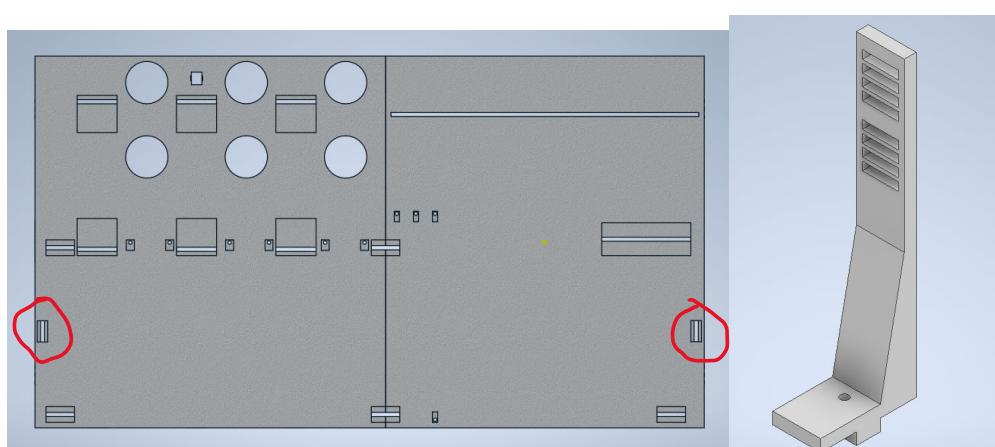


## Step 4

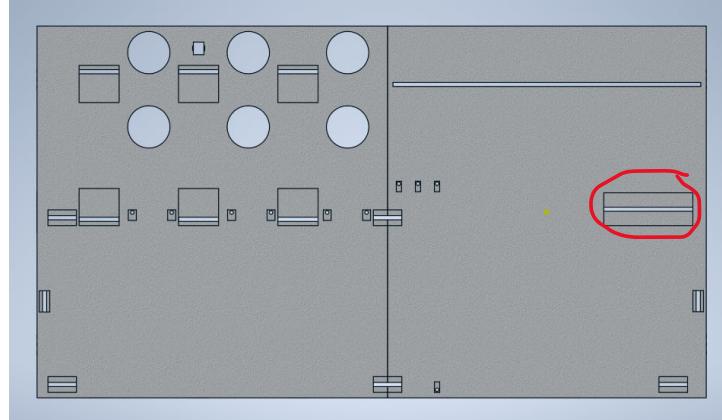
- Installing everything

Everything else should be installed using the M3

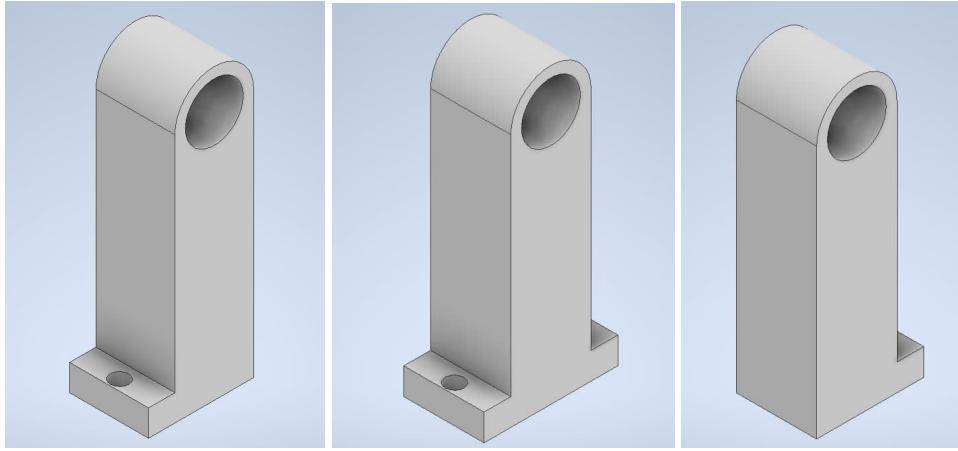
Install the industry sensors on their holders and place them on the marked location with the tall part going away from the box, remember to line them up.



Place the gearbox at the marked location pointing away from the PLC.



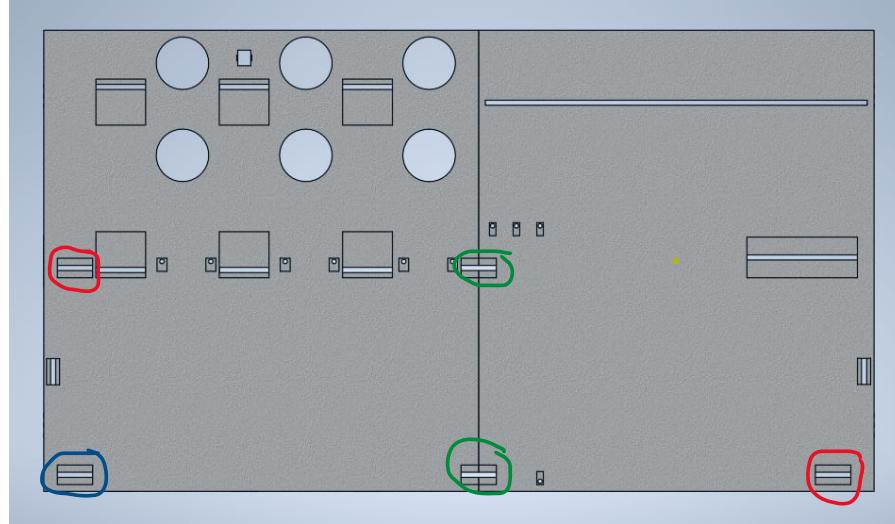
Place support holders on marked locations, so their holes face inwards, so they can hold the rollers. Don't screw anything in, until rollers/drive are placed between supports.



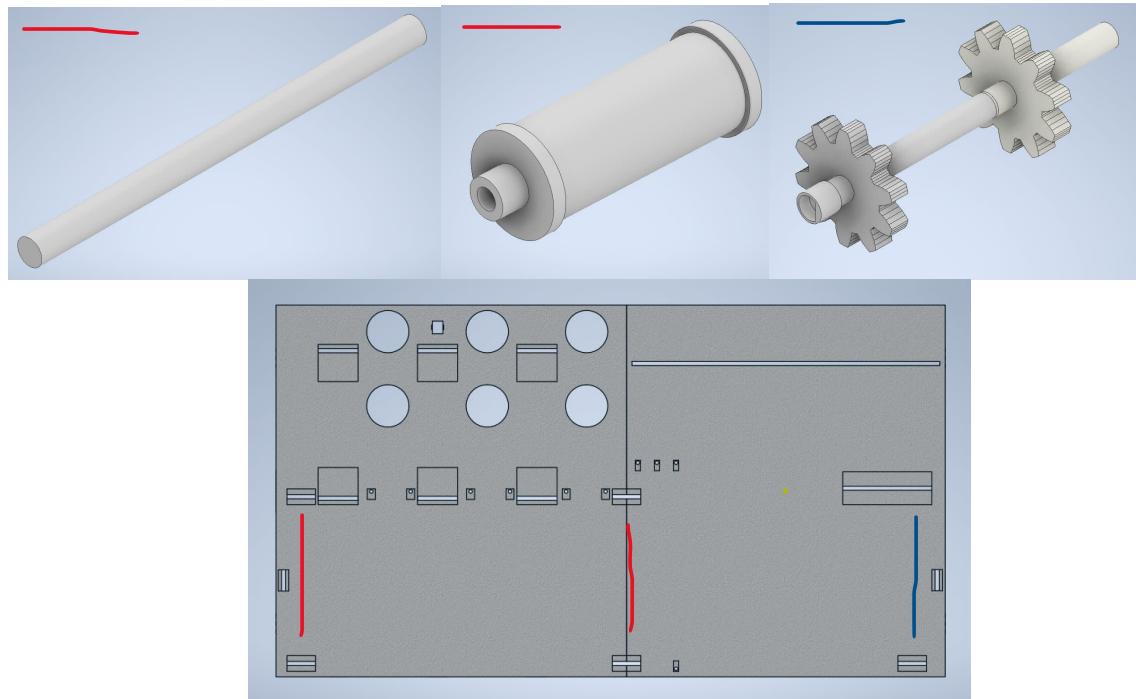
RED

GREEN

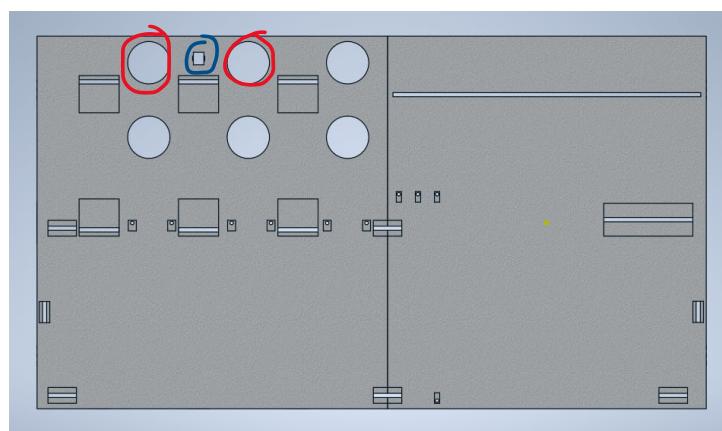
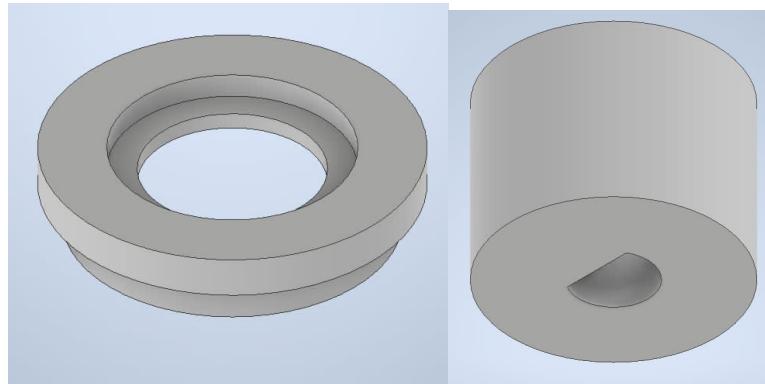
BLUE



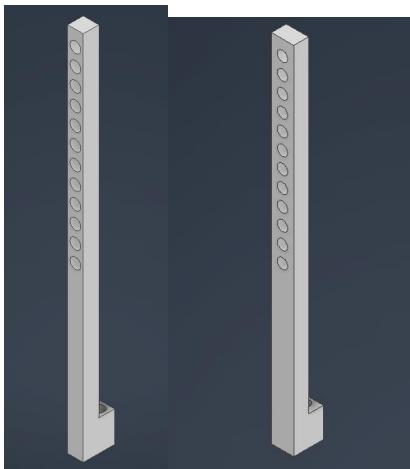
Place the stick inside the rollers, and place them between marked(red) support locations, with the longest side of the roller pointing downwards. And place the band drive on the gearbox and its support(Blue). After this the supports can be screwed in place



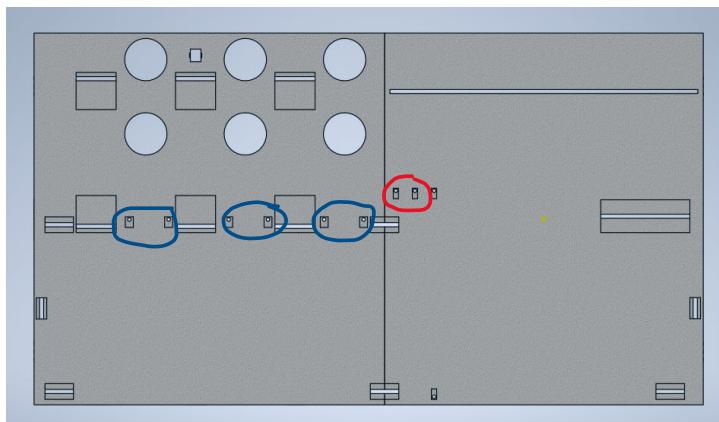
Place the button holders inside the marked holes(red) and the potentiometer with its cap.(Blue)



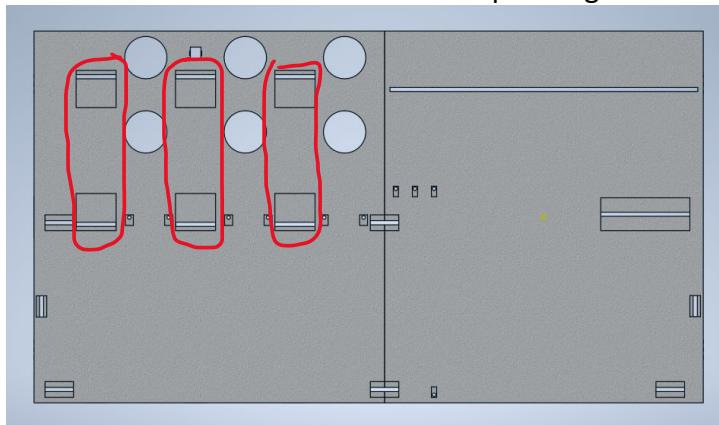
Place the two 5 mm sensor holders marked red  
Place the six 7.5 mm sensor holders marked blue



Align with the holes beneath



Place the assembled actuators on the marked locations pointing towards the conveyor belt



Lastly connect the 4 belt links into one big piece and secure it around the rollers and the band drive from thee gearbox

