



Telemetry Balkan doo Beograd

# ORA-8

## The Open Robotic Actuator Assembly Manual

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v 0.1.0

Beograd, Serbia  
2026-06-03



## Version History

| Version | Date       | Authors              | Description               |
|---------|------------|----------------------|---------------------------|
| 0.1.0   | 2026-04-30 | Sergei<br>Loshchilov | Original Document Started |
|         |            |                      |                           |
|         |            |                      |                           |
|         |            |                      |                           |
|         |            |                      |                           |
|         |            |                      |                           |
|         |            |                      |                           |
|         |            |                      |                           |



# Contents

|                                                                                                                |           |
|----------------------------------------------------------------------------------------------------------------|-----------|
| <b>Version History.....</b>                                                                                    | <b>2</b>  |
| <b>Contents.....</b>                                                                                           | <b>3</b>  |
| <b>1. Overview.....</b>                                                                                        | <b>5</b>  |
| <b>2. Bill of Materials.....</b>                                                                               | <b>6</b>  |
| 3D Printed Components.....                                                                                     | 6         |
| Mechanical Components.....                                                                                     | 7         |
| Electronic Components.....                                                                                     | 9         |
| <b>3. Mechanics Assembly.....</b>                                                                              | <b>10</b> |
| Print the 3D Printed Components.....                                                                           | 10        |
| Partially Disassemble DS51150.....                                                                             | 11        |
| Remove the back lid.....                                                                                       | 11        |
| Unsolder the PCB from the motor and the encoder.....                                                           | 12        |
| Remove the aluminium body.....                                                                                 | 13        |
| Replace the original long screws with M2.5x8.0 screws, to fixate the gearbox again.....                        | 14        |
| Install M4 Nuts into ORA-8 Body.....                                                                           | 14        |
| Install DS51150 Into ORA-8 Body.....                                                                           | 16        |
| Assembly ORA-8 Shaft.....                                                                                      | 17        |
| Install BTS7960, JST and Address Selector into ORA-8 Lid.....                                                  | 19        |
| Setup the Electronics.....                                                                                     | 20        |
| Install the wires protection tubes.....                                                                        | 21        |
| Mount ORA-8 Lid Into ORA-8 Body.....                                                                           | 22        |
| Set the DS51150 into a middle position.....                                                                    | 22        |
| Connect ORA-8 to the computer.....                                                                             | 22        |
| Connect to ORA-8 via Python.....                                                                               | 22        |
| Set the actuator position to the middle.....                                                                   | 23        |
| Mount 18T Arm on DS51150.....                                                                                  | 23        |
| Install ORA-8 Shaft into ORA-8 Body.....                                                                       | 24        |
| Push the shaft with the bearing into the body.....                                                             | 24        |
| Screw the 2 M3x12 screw with the washer and the grover washer in the middle and at the tip of the 18T arm..... | 25        |
| <b>4. Electronics Assembly.....</b>                                                                            | <b>26</b> |
| Schematics.....                                                                                                | 26        |
| DS51150 Servo Upgrade.....                                                                                     | 26        |
| Encoder <-> Arduino.....                                                                                       | 26        |
| Motor <-> BTS7960.....                                                                                         | 27        |
| BTS7960 <-> Arduino.....                                                                                       | 27        |
| Interfaces.....                                                                                                | 28        |
| COM1 (Left).....                                                                                               | 28        |
| Pinout.....                                                                                                    | 28        |



|                                           |           |
|-------------------------------------------|-----------|
| PCB.....                                  | 28        |
| COM2 (Right).....                         | 28        |
| Address Selector.....                     | 29        |
| Pinout.....                               | 29        |
| PCB.....                                  | 29        |
| <b>5. Connecting to the Computer.....</b> | <b>29</b> |
| OSP Controller.....                       | 29        |
| Connection Cable.....                     | 29        |
| Ring Topology.....                        | 30        |
| <b>6. Software.....</b>                   | <b>31</b> |
| Communication Protocol.....               | 31        |
| Arduino Firmware.....                     | 31        |
| Python SDK.....                           | 31        |
| Programming Example.....                  | 31        |
| Control the actuator angle.....           | 31        |
| <b>7. Conclusion.....</b>                 | <b>31</b> |



# 1. Overview

The ORA-8 (Open Robotic Actuator) is a modular, customizable robotic actuator designed for use in distributed robotic systems. It combines mechanical, electronic, and software components into a compact unit capable of precise position control and seamless integration into multi-node architectures.

This manual provides a complete guide to assembling the ORA-8 actuator, starting from the bill of materials and 3D-printed components, through mechanical and electronic assembly, and finishing with software setup and control. The actuator is based on a modified DS51150 servo, enhanced with an external motor driver (BTS7960), an Arduino Pro Mini controller, and an encoder interface to enable closed-loop control and communication over the OSP (Open Serial Peripheral) protocol.

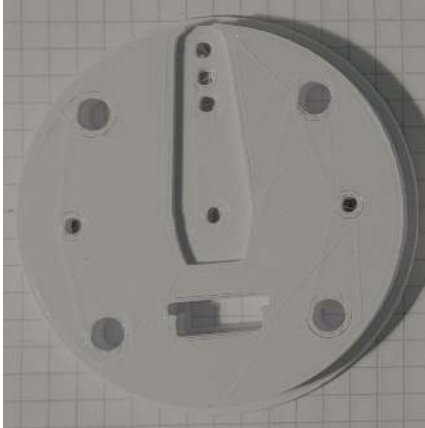
A key feature of the ORA-8 system is its support for ring topology, allowing multiple actuators to be daisy-chained and controlled via a single OSP controller. This makes it particularly suitable for scalable robotic systems such as manipulators, modular robots, and distributed motion platforms.

The document is intended for engineers, developers, and robotics enthusiasts who want to build, understand, and integrate ORA-series actuators into their systems.

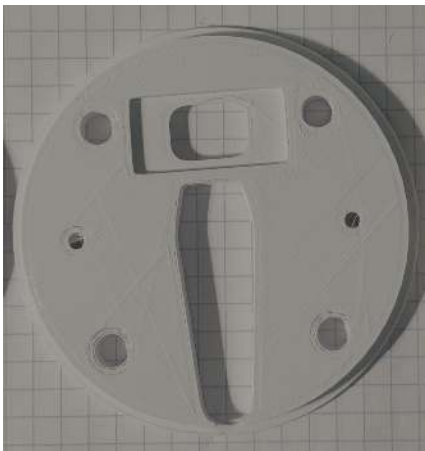
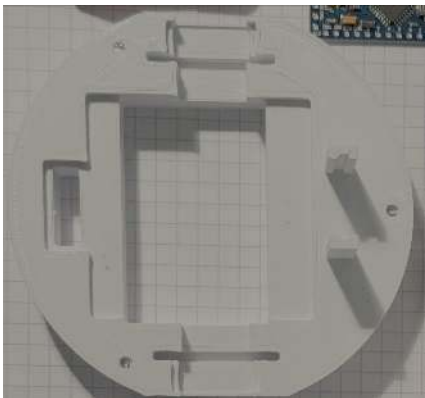
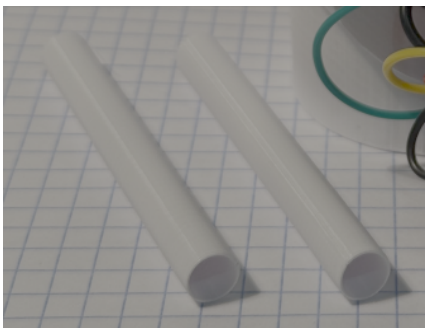


## 2. Bill of Materials

### 3D Printed Components

| Type                   | Quantity | Image                                                                                | Comments |
|------------------------|----------|--------------------------------------------------------------------------------------|----------|
| ORA-8 Body             | 1        |   |          |
| ORA-8 Shaft Upper Half | 1        |  |          |

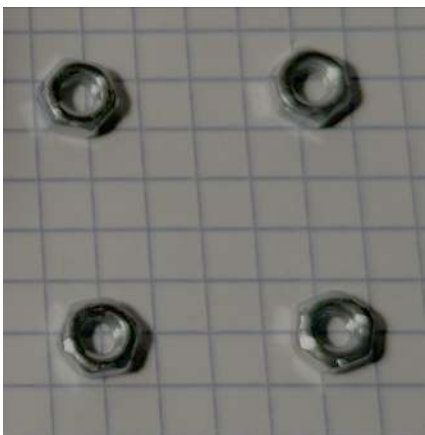
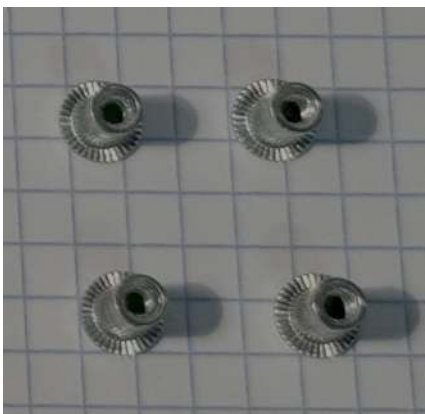


|                                             |   |                                                                                      |  |
|---------------------------------------------|---|--------------------------------------------------------------------------------------|--|
| ORA-8 Shaft Lower Half                      | 1 |    |  |
| ORA-8 Lid                                   | 1 |   |  |
| ORA-8 Schematics and Wires Protection Tubes | 2 |  |  |

## Mechanical Components

| Type | Quantity | Image | Comments |
|------|----------|-------|----------|
|------|----------|-------|----------|

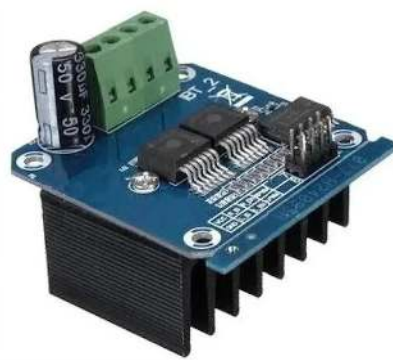


|                    |   |                                                                                      |                                                      |
|--------------------|---|--------------------------------------------------------------------------------------|------------------------------------------------------|
| 6814 Bearing       | 1 |    |                                                      |
| M4 Nut             | 4 |   |                                                      |
| M4x10 Screw        | 4 |                                                                                      |                                                      |
| M4 Threaded Rivets | 4 |  |                                                      |
| M2.5x8 Screws      | 4 |                                                                                      | To replace the original long screws of DS51150 servo |



|                                        |   |                                                                                    |                           |
|----------------------------------------|---|------------------------------------------------------------------------------------|---------------------------|
| DIN 7981 2.9x9.5<br>Self-Tapping Screw | 3 |  | To mount the ORA-8<br>lid |
|----------------------------------------|---|------------------------------------------------------------------------------------|---------------------------|

## Electronic Components

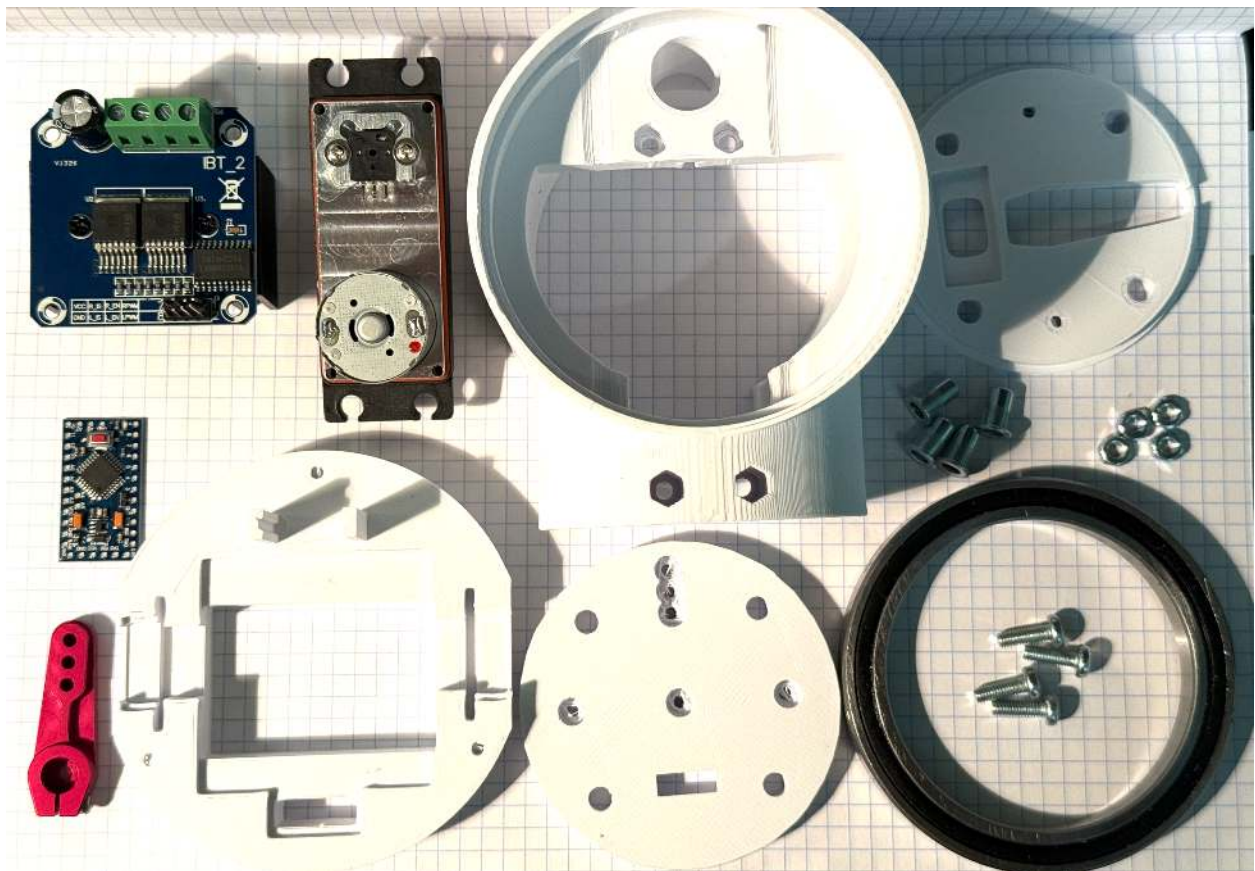
| Type                          | Quantity | Image                                                                                | Comments                                  |
|-------------------------------|----------|--------------------------------------------------------------------------------------|-------------------------------------------|
| DS51150 Servo                 | 1        |   | Needs to be modified                      |
| Arduino Pro Mini 5V<br>16 MHz | 1        |  | Make sure it is not<br>3.3V 8 MHz version |
| BTS7960 DC Motor<br>Driver    | 1        |  |                                           |



|                     |   |                                                                                    |                                                      |
|---------------------|---|------------------------------------------------------------------------------------|------------------------------------------------------|
| JST XH 6-Pin Female | 2 |  |                                                      |
| Wire AWG 22         |   |                                                                                    | To power up BTS7960 and connect BTS7960 to the motor |
| Wire AWG 28         |   |                                                                                    | To power up Arduino and connect the signal links     |

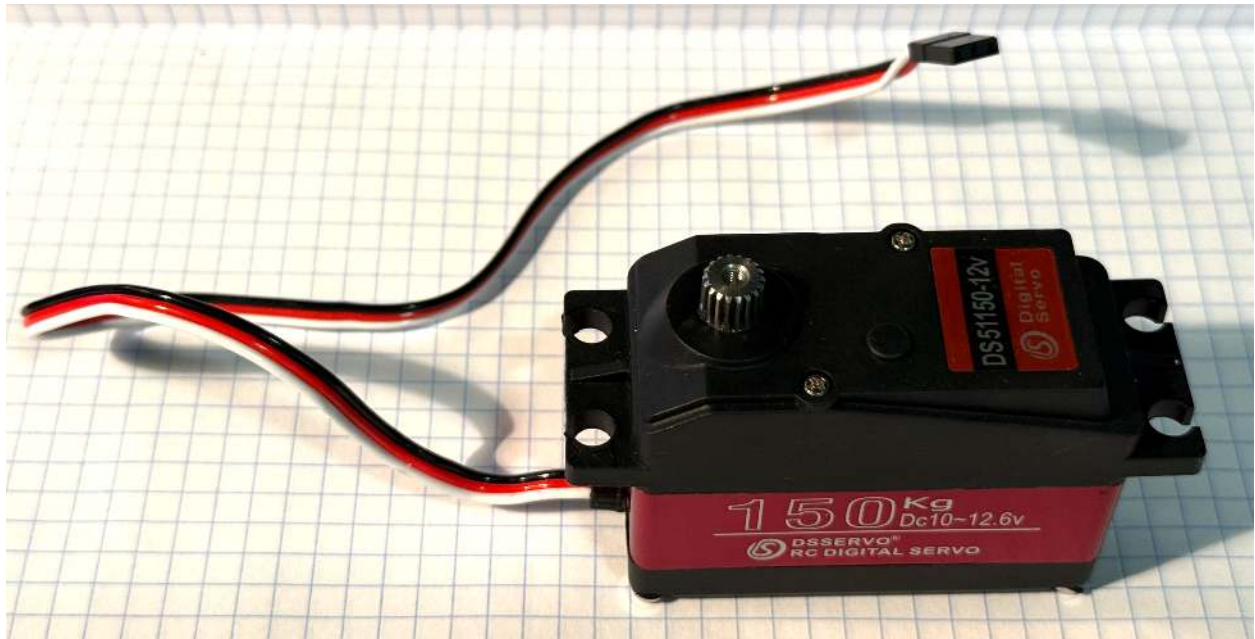
### 3. Mechanics Assembly

Print the 3D Printed Components

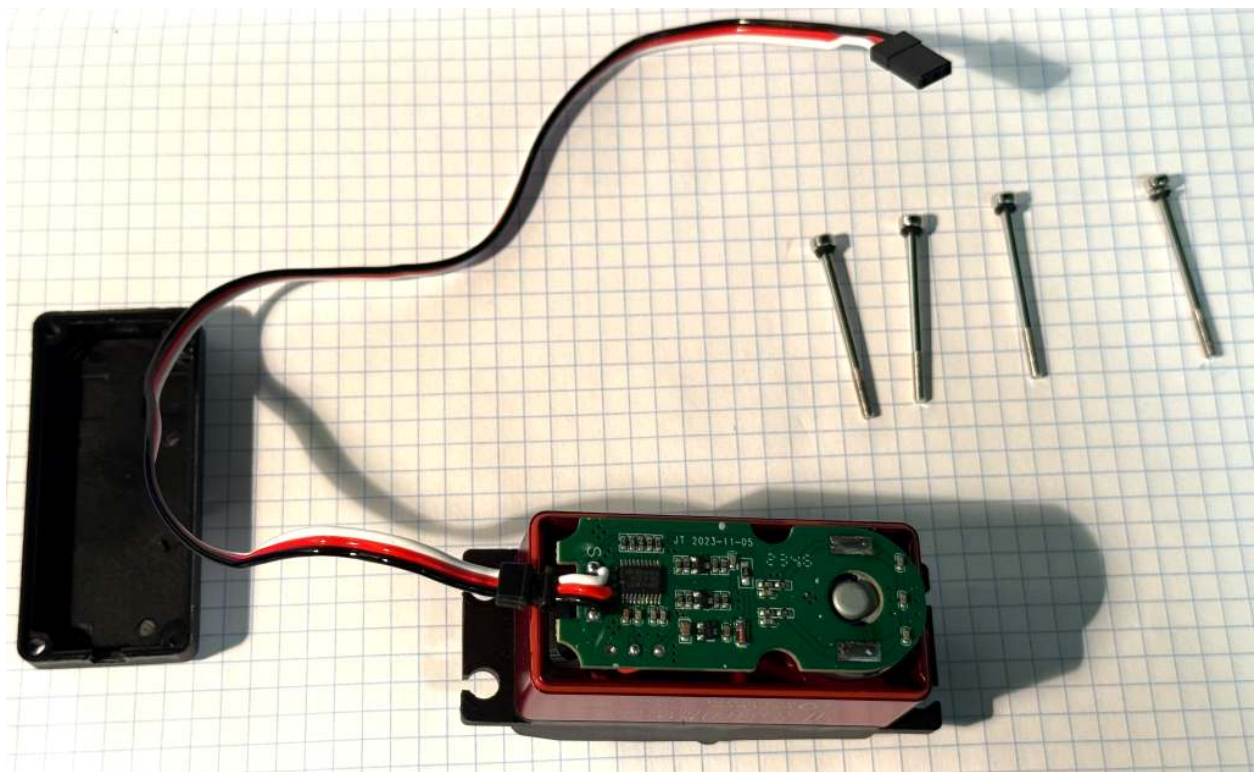




## Partially Disassemble DS51150

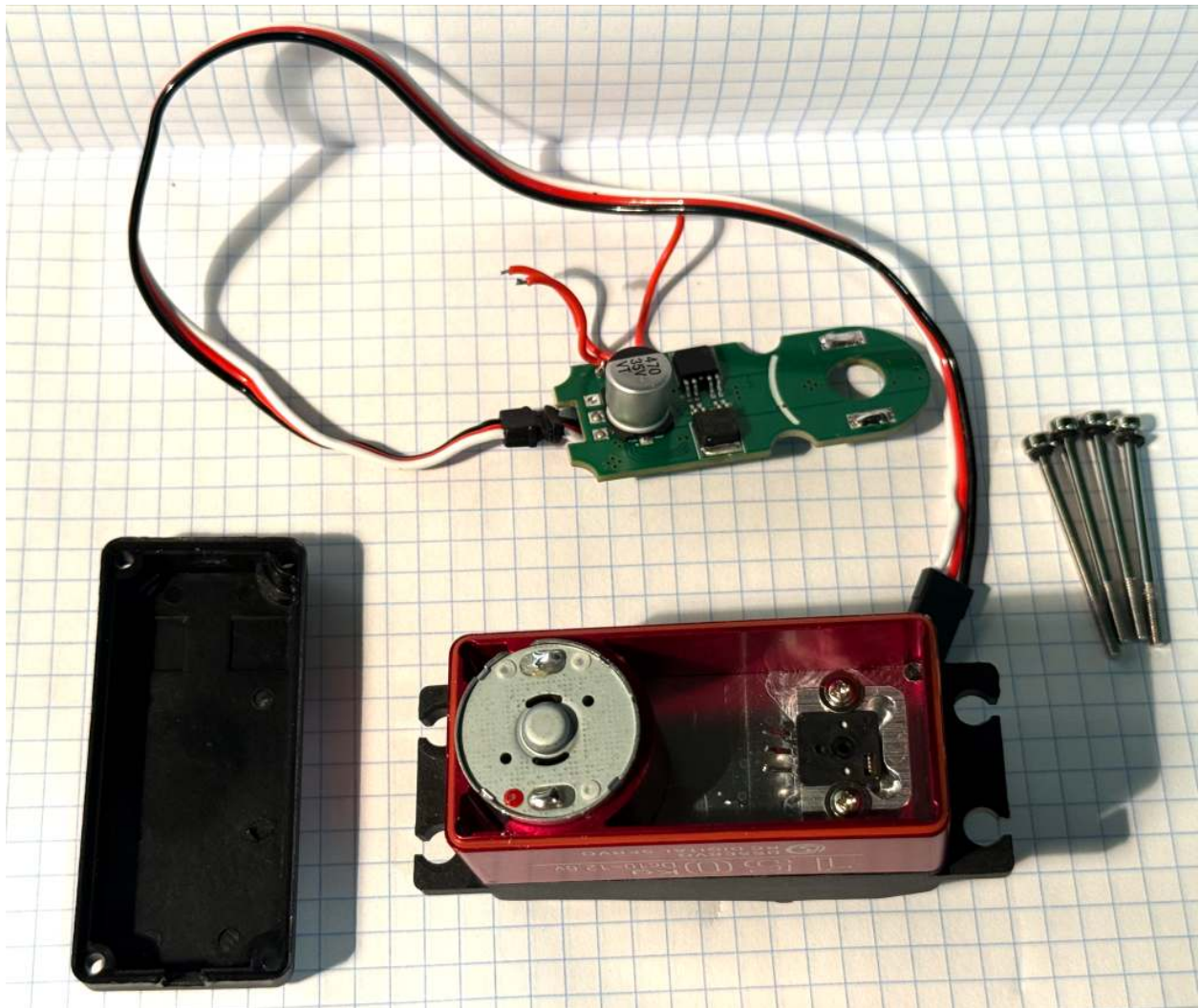


Remove the back lid



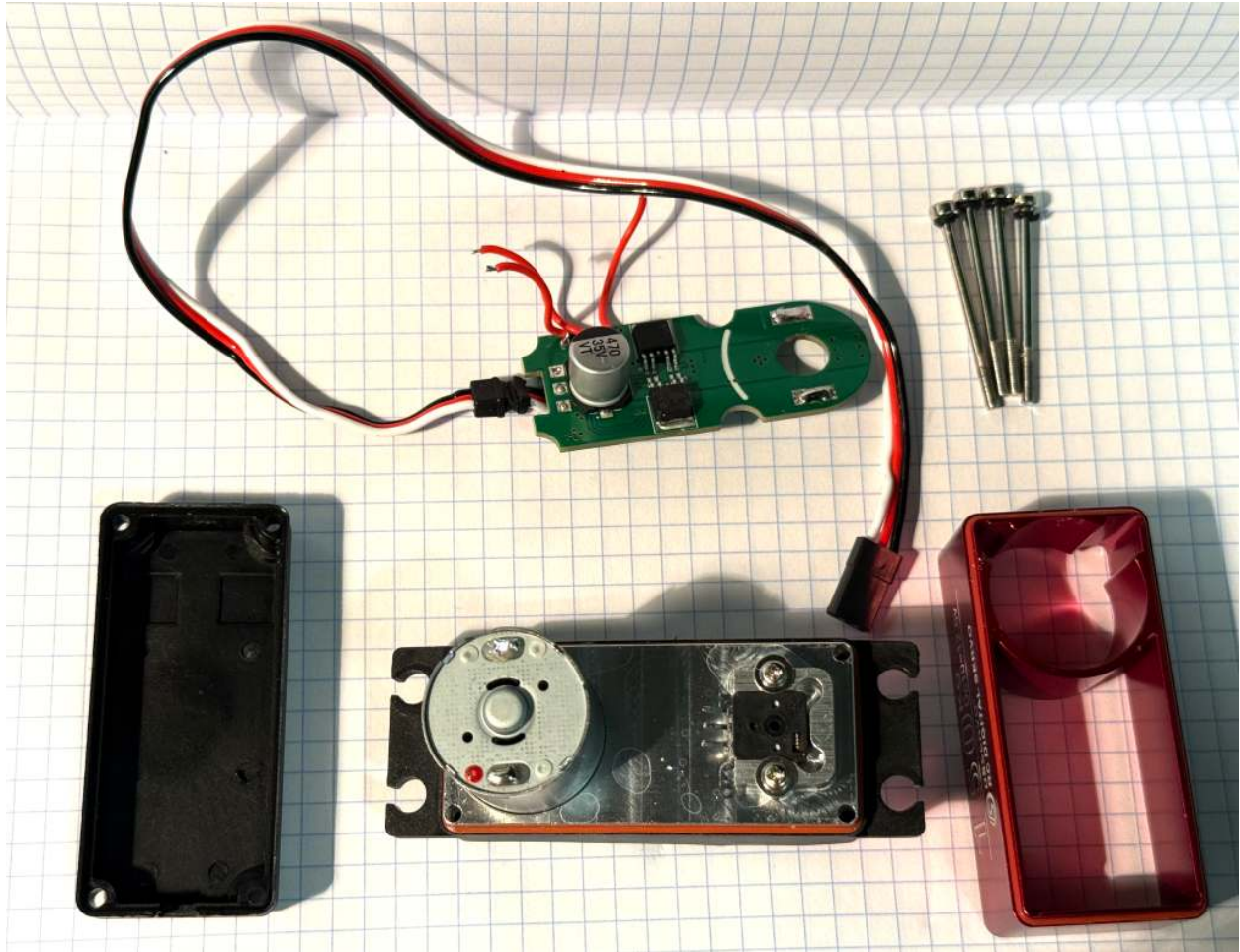


Unsolder the PCB from the motor and the encoder





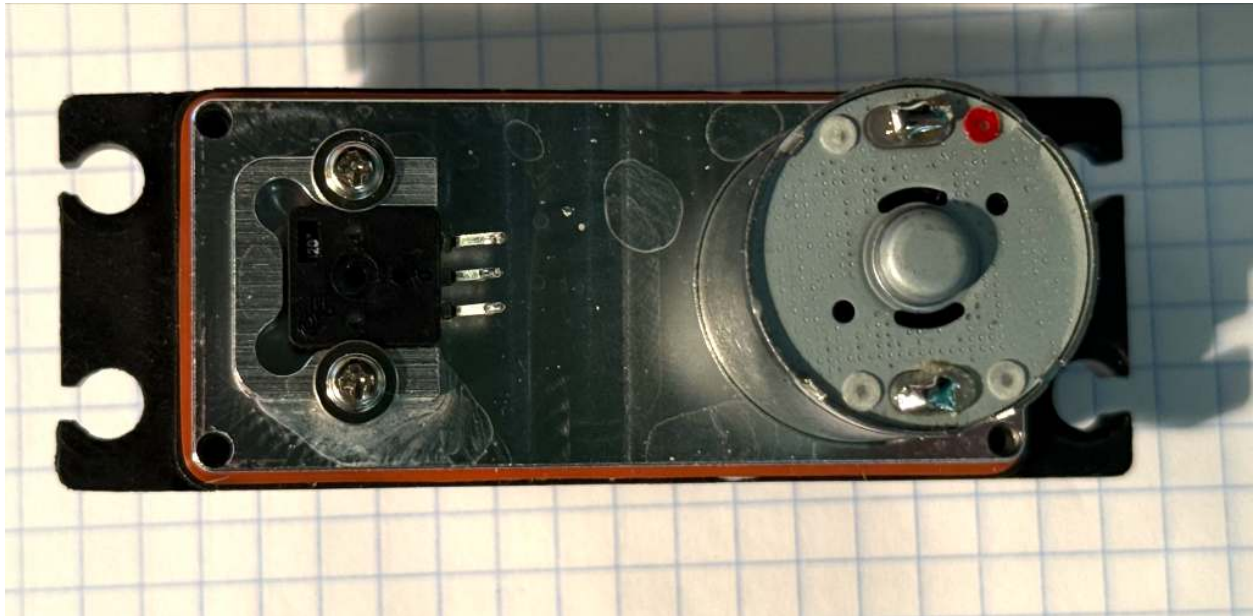
Remove the aluminium body



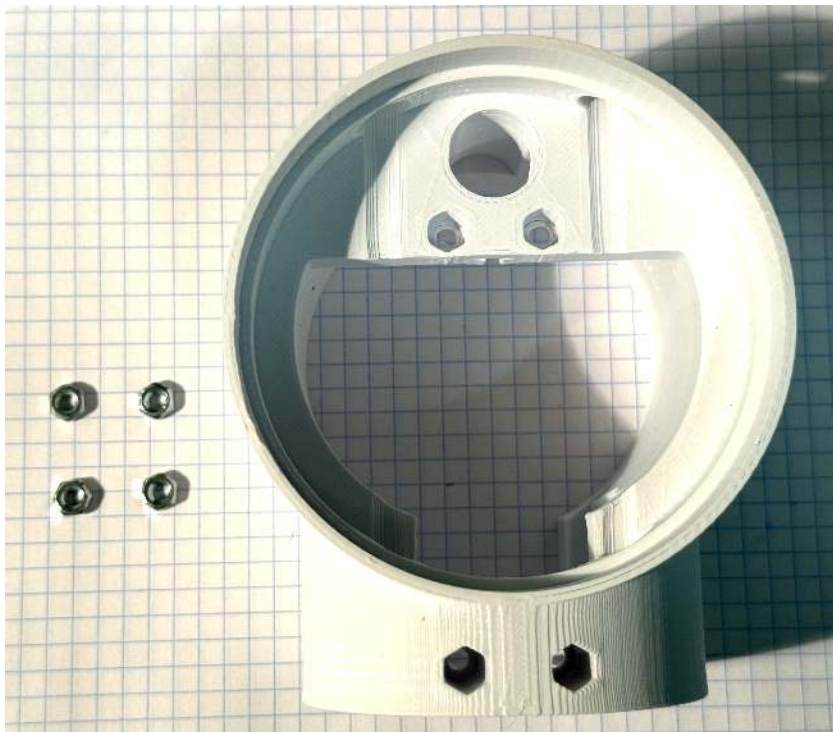
Note: be careful here. Try to remove it without opening the gearbox, as once the screws are unscrewed the gearbox is no longer fixed.

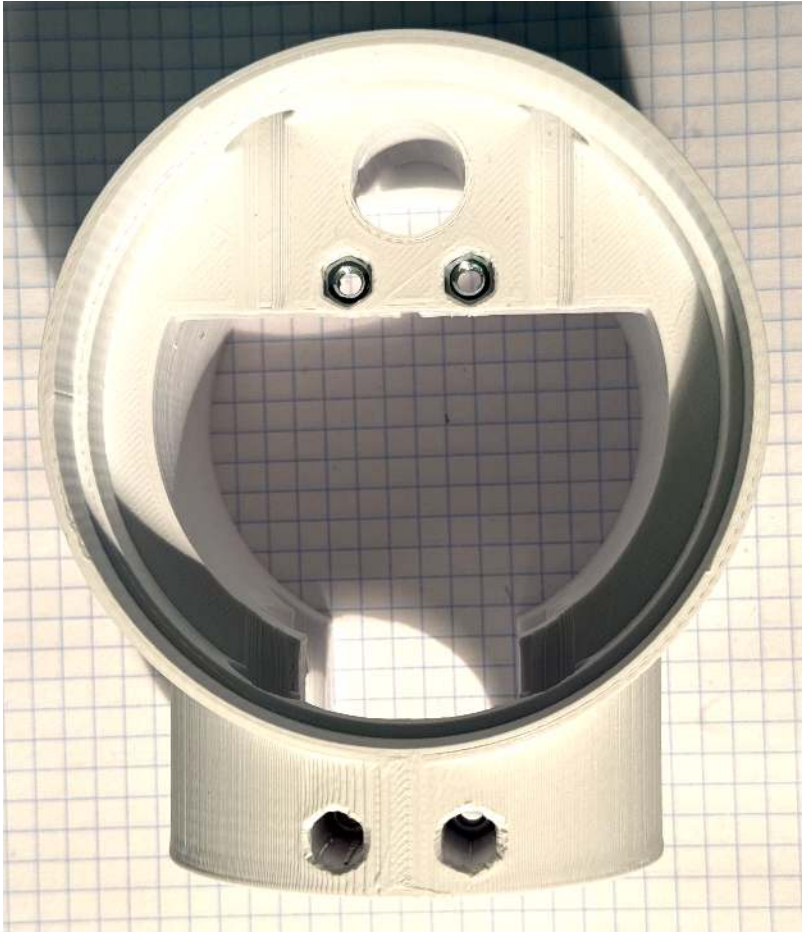


Replace the original long screws with M2.5x8.0 screws, to fixate the gearbox again



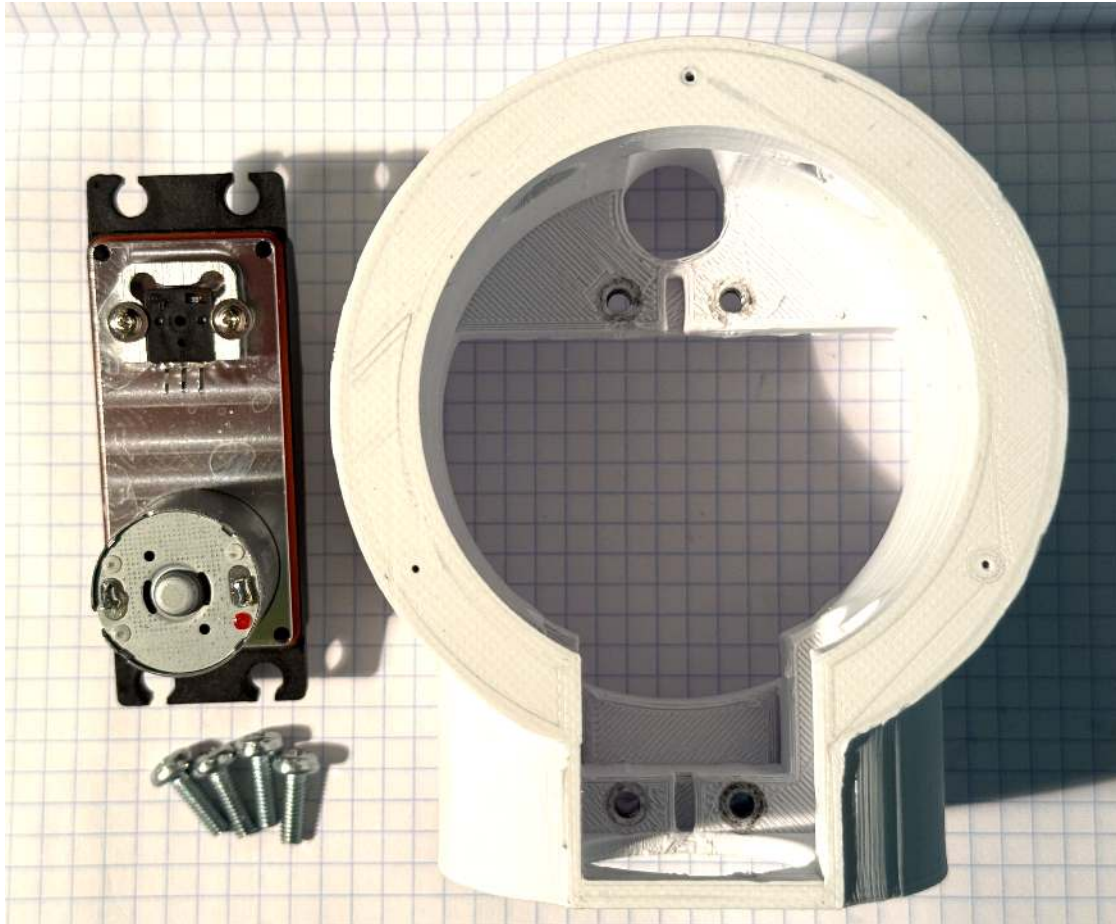
Install M4 Nuts into ORA-8 Body

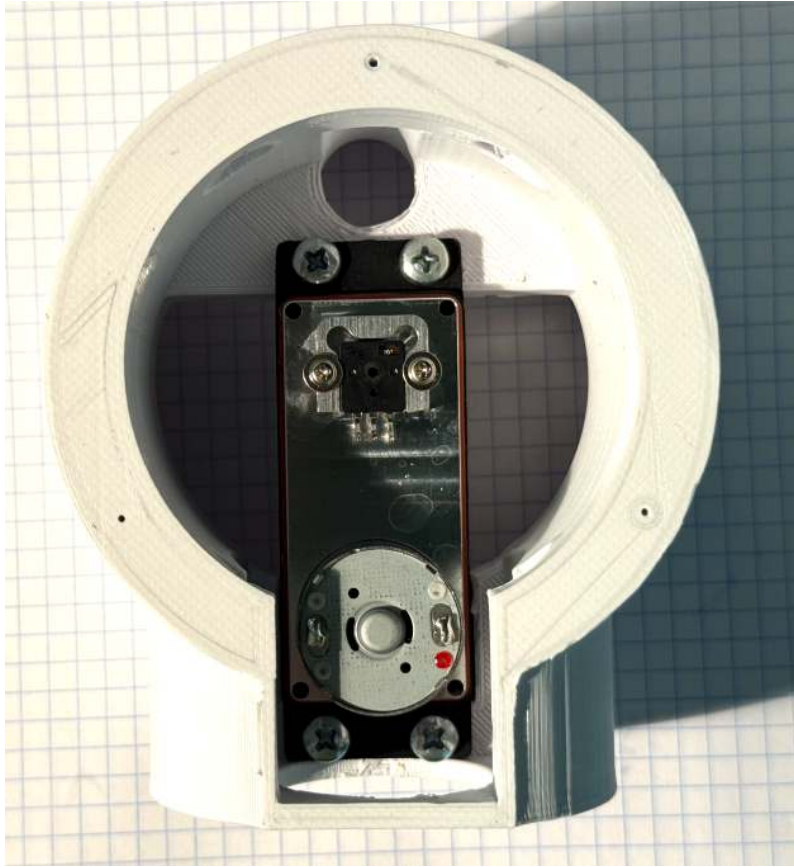




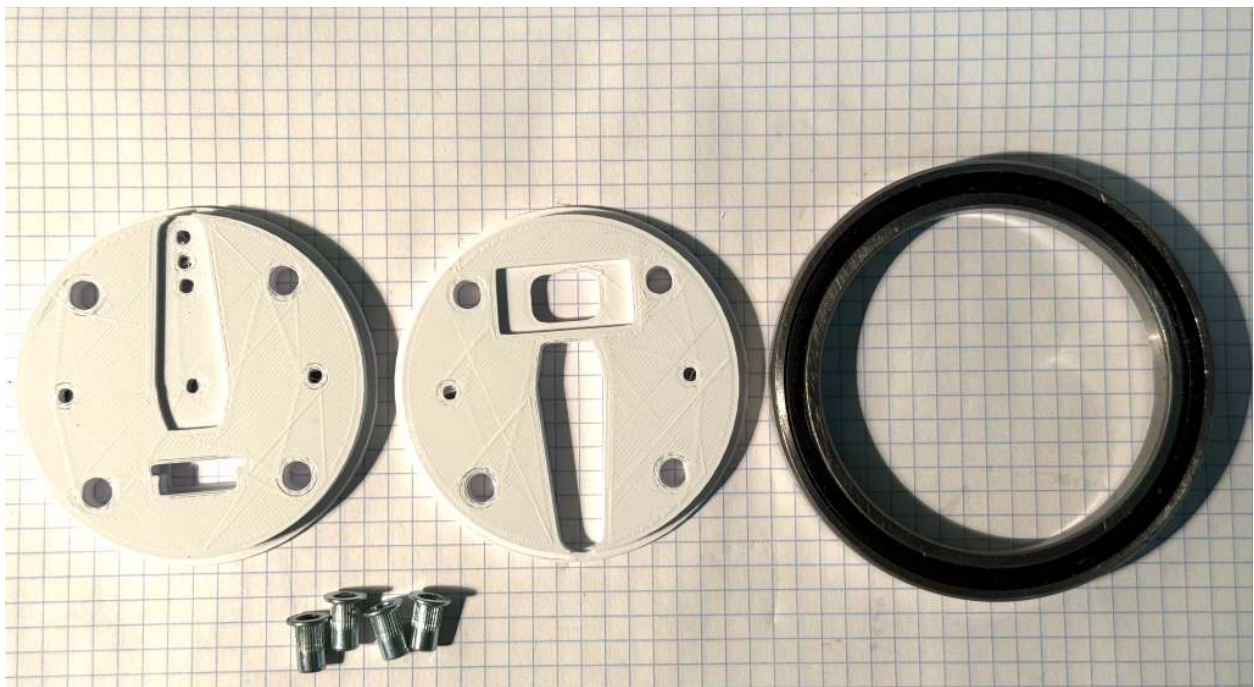


## Install DS51150 Into ORA-8 Body





Assembly ORA-8 Shaft





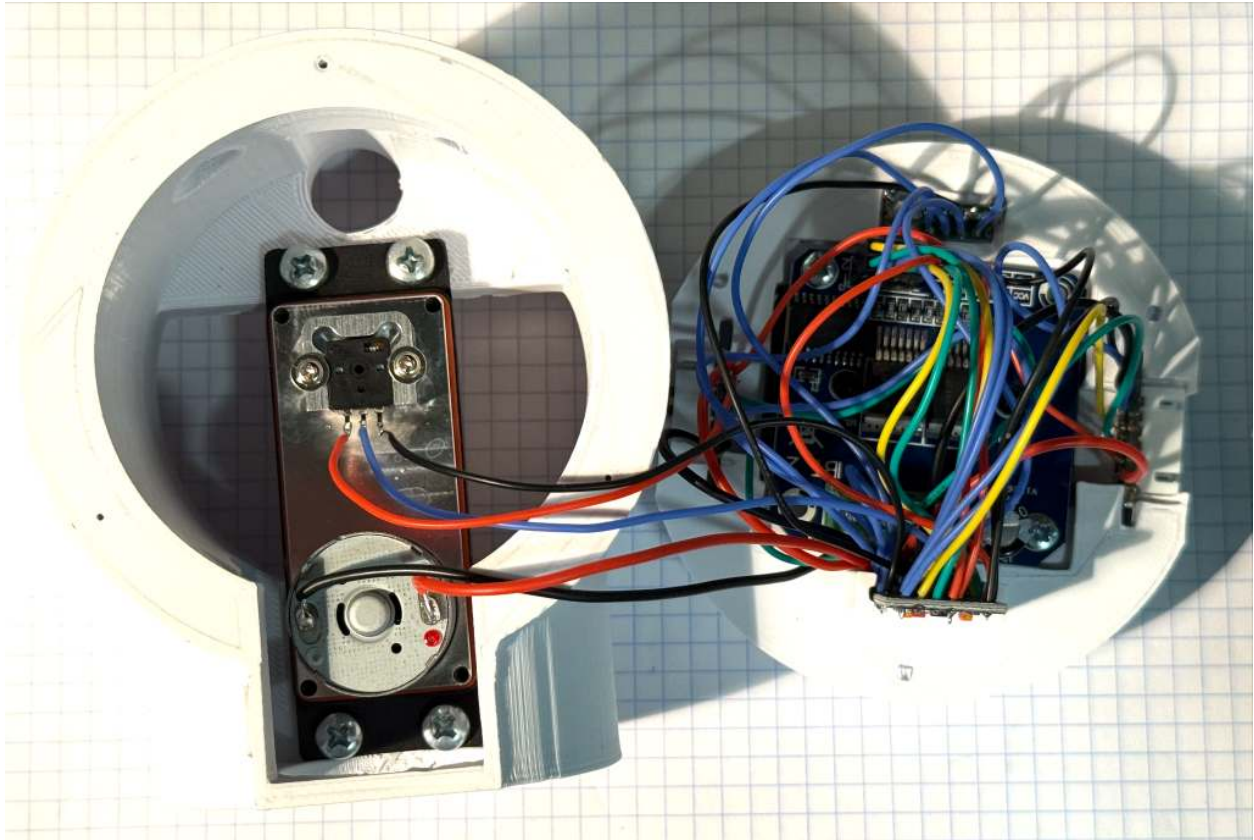


## Install BTS7960, JST and Address Selector into ORA-8 Lid





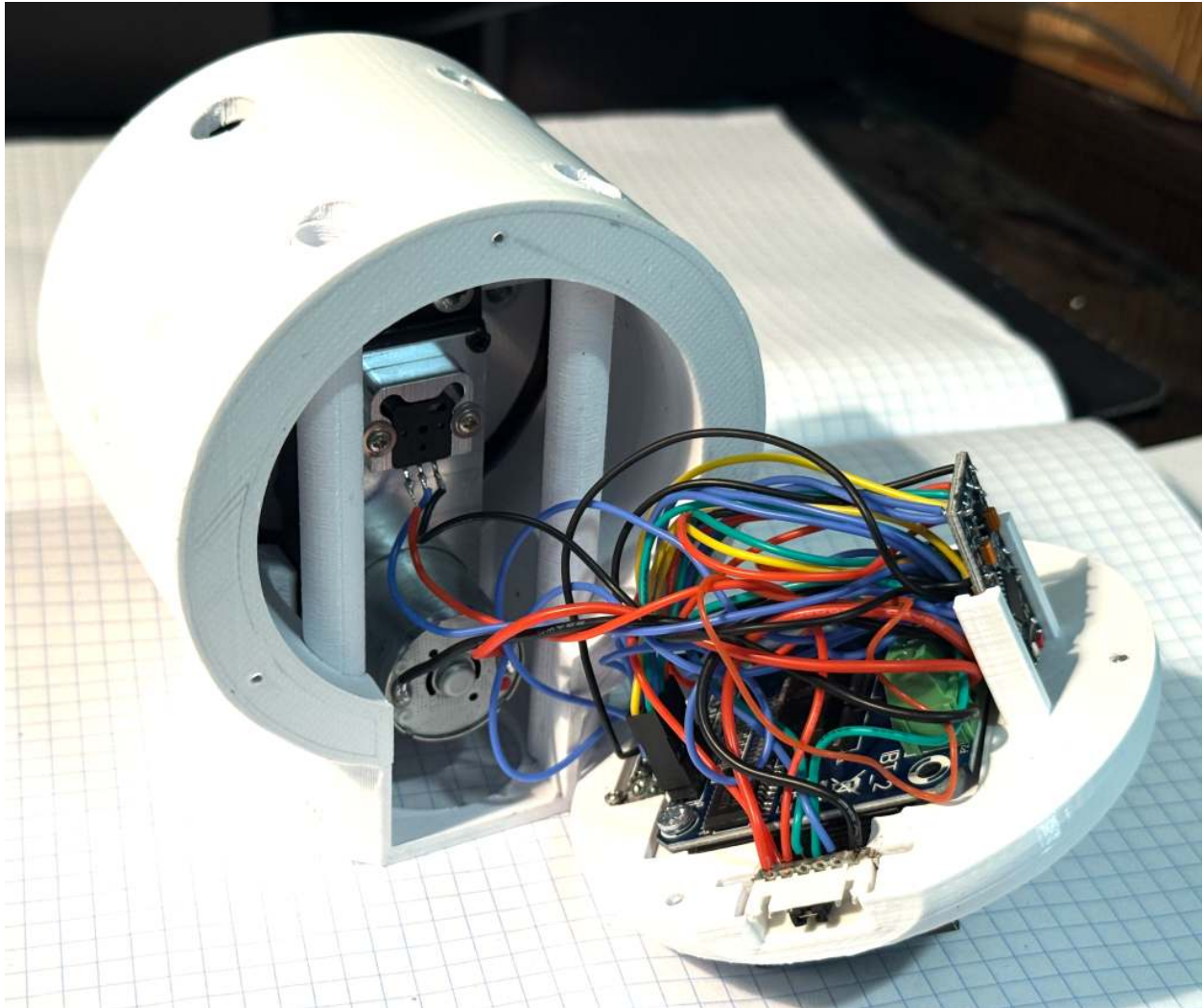
## Setup the Electronics



Follow the Electronics Assembly to setup the electronics properly.

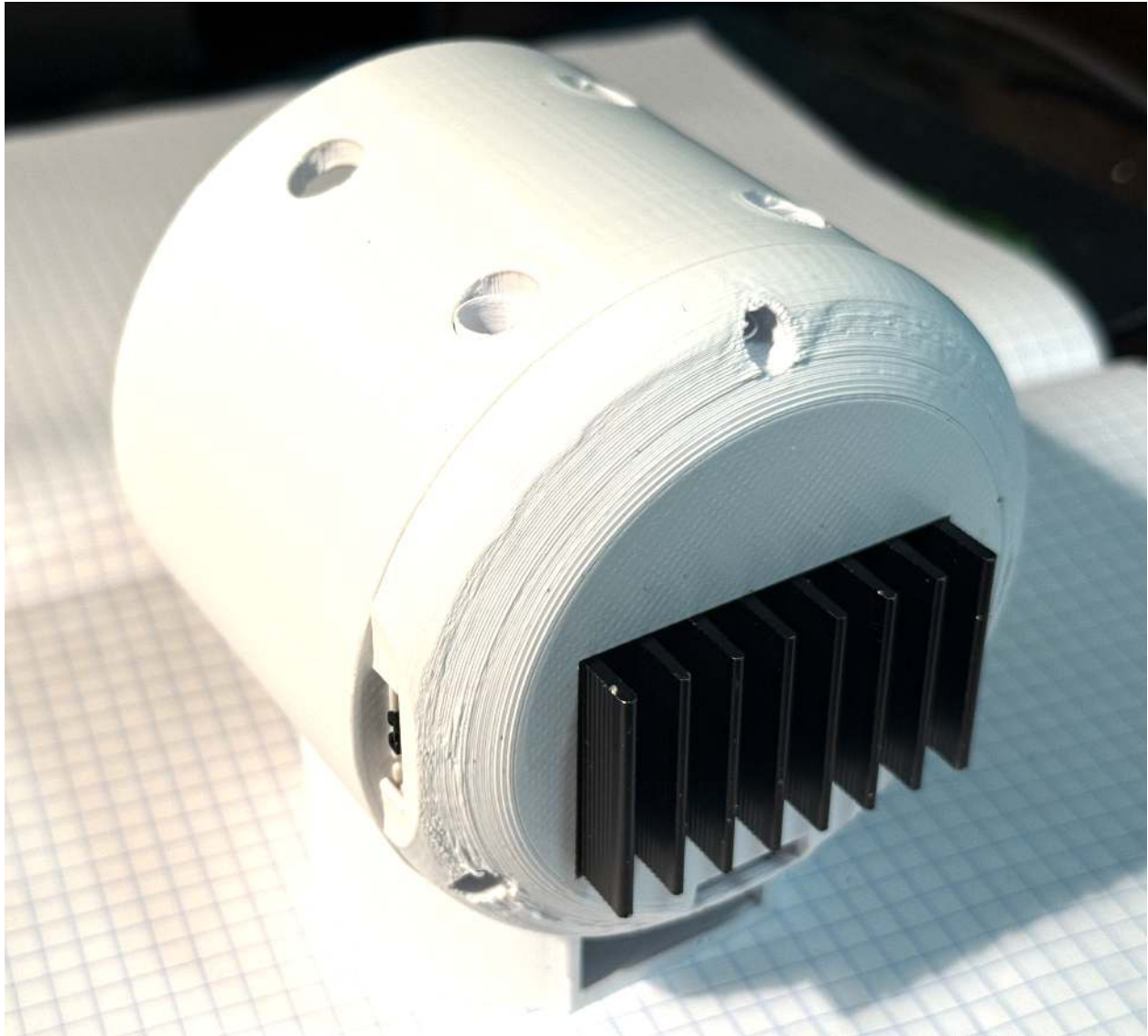


Install the wires protection tubes





## Mount ORA-8 Lid Into ORA-8 Body



Set the DS51150 into a middle position

Connect ORA-8 to the computer

See Connecting to the Computer section for more details.

Connect to ORA-8 via Python

```
from osp import OSP  
ora = OSP("/dev/cu.usbserial-AI20M8EA")
```



Set the actuator position to the middle

```
ora.ora_set_angle(0,8192)
```

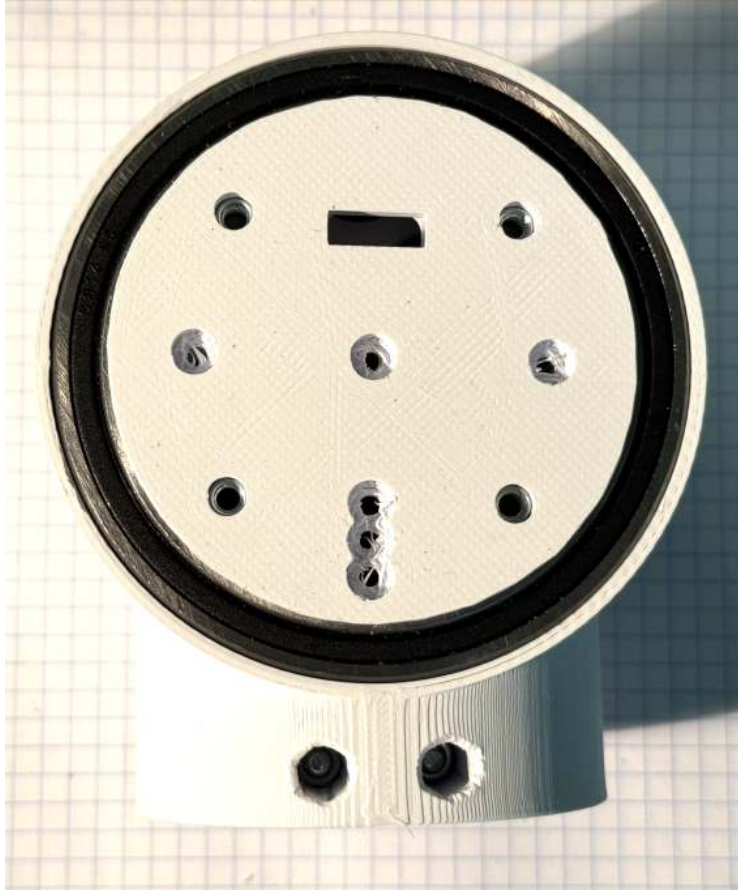
Mount 18T Arm on DS51150





## Install ORA-8 Shaft into ORA-8 Body

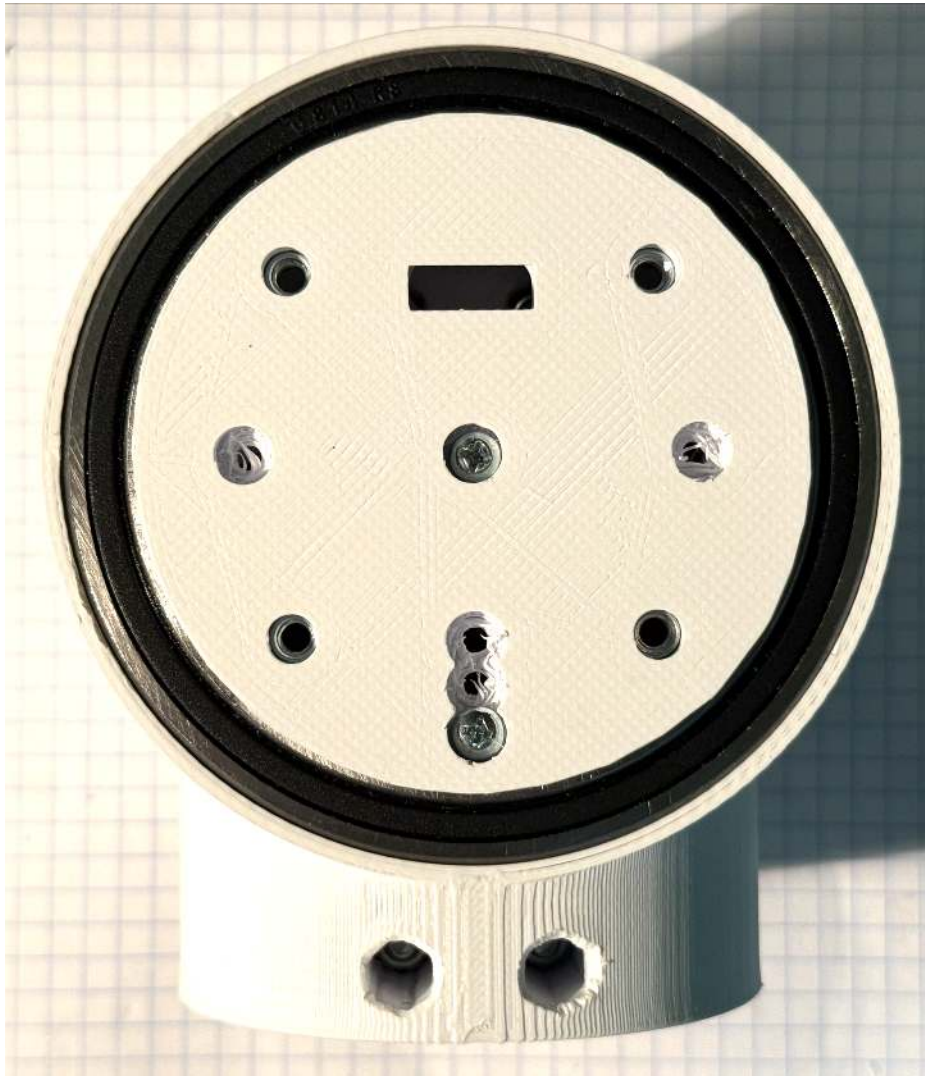
Push the shaft with the bearing into the body



Advise: Optionally apply the adhesive sealant to the body where it is touching the bearing.



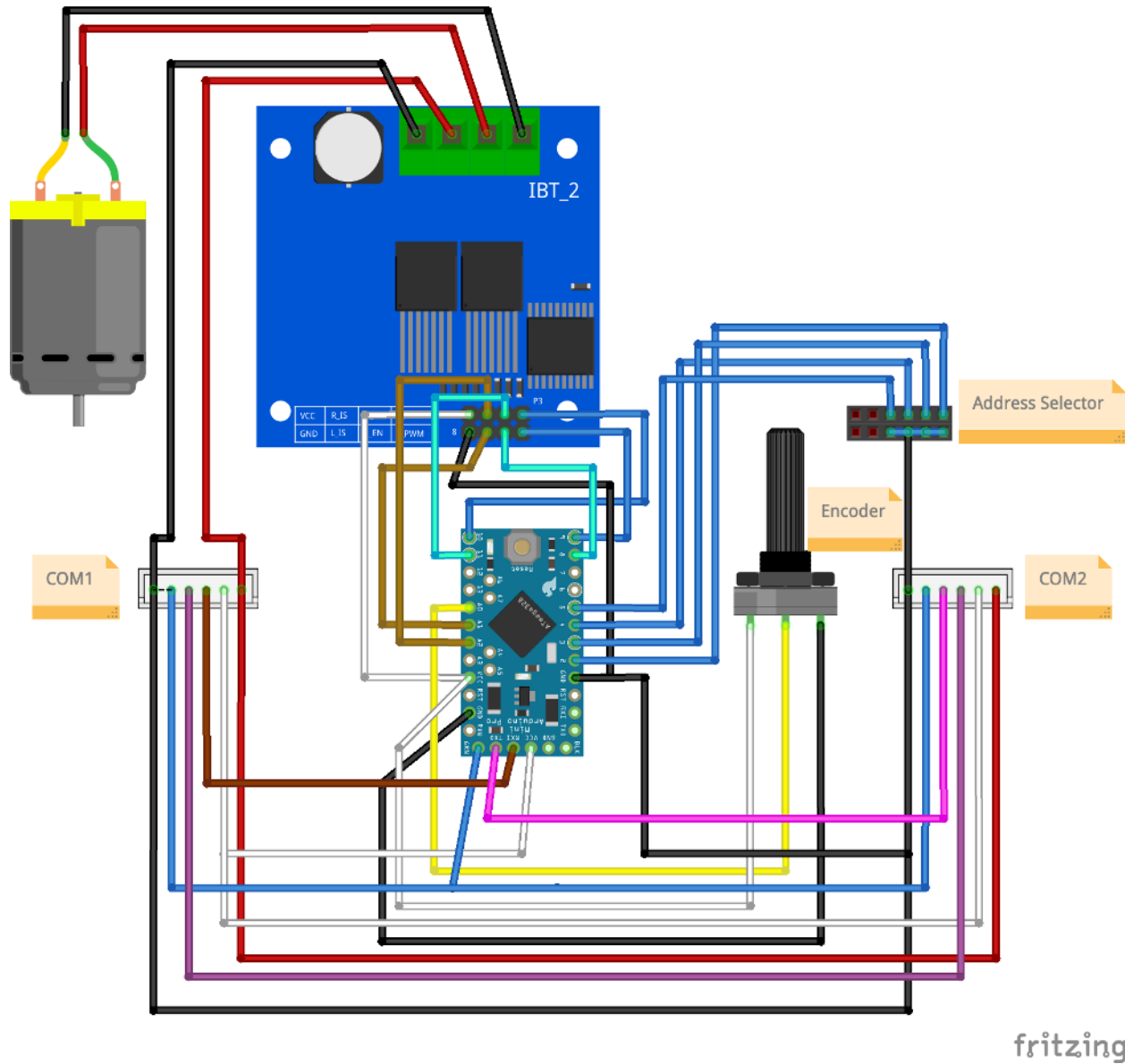
Screw the 2 M3x12 screw with the washer and the grover washer in the middle and at the tip of the 18T arm





## 4. Electronics Assembly

### Schematics

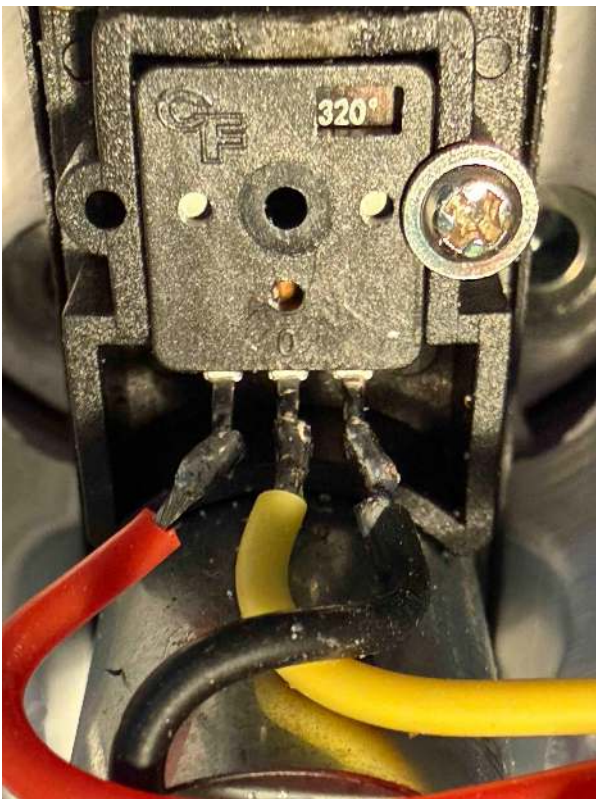
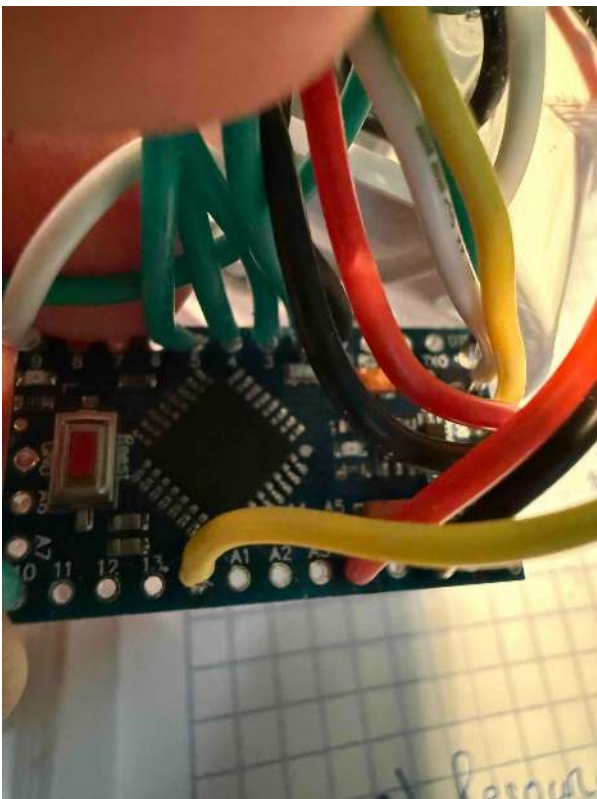


### DS51150 Servo Upgrade

Encoder <-> Arduino

| Encoder PIN | Arduino PIN |
|-------------|-------------|
|-------------|-------------|



|                                                                                    |                                                                                     |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Right                                                                              | GND                                                                                 |
| Middle                                                                             | A0                                                                                  |
| Left                                                                               | VCC                                                                                 |
|  |  |

Motor <-> BTS7960

| Motor PIN             | BTS7960 PIN |
|-----------------------|-------------|
| RIGHT (With RED Mark) | M+          |
| LEFT                  | M-          |

BTS7960 <-> Arduino

| BTS7960 | Arduino PIN |
|---------|-------------|
| PWM_L   | D9          |



|       |     |
|-------|-----|
| PWM_R | D10 |
| L_IS  | A1  |
| R_IS  | A2  |
| L_EN  | D8  |
| R_EN  | D11 |
| VCC   | VCC |
| GND   | GND |

## Interfaces

### COM1 (Left)

#### Pinout

| PIN0          | PIN1                               | PIN2                          | PIN3                                | PIN4              | PIN5                                |
|---------------|------------------------------------|-------------------------------|-------------------------------------|-------------------|-------------------------------------|
| GND           | DTR<br>Connected to<br>Arduino DTR | TX<br>Connected to<br>COM2 RX | RX<br>Connected<br>To Arduino<br>RX | Ctrl Power<br>+5V | Motor Power<br>+8.4 V or<br>+12.0 V |
| JST LOCK HERE |                                    |                               |                                     |                   |                                     |

#### PCB

Size: 20x8

### COM2 (Right)

| PIN0          | PIN1                               | PIN2                             | PIN3                          | PIN4              | PIN5                             |
|---------------|------------------------------------|----------------------------------|-------------------------------|-------------------|----------------------------------|
| GND           | DTR<br>Connected to<br>Arduino DTR | TX<br>Connected to<br>Arduino TX | RX<br>Connected to<br>COM1 TX | Ctrl Power<br>+5V | Motor Power<br>+8.4 V<br>+12.0 V |
| JST LOCK HERE |                                    |                                  |                               |                   |                                  |



## Address Selector

### Pinout

| <b>PIN 0</b> | <b>PIN 2</b> | <b>PIN4</b>      | <b>PIN6</b>      | <b>PIN8</b>      | <b>PIN10</b>     |
|--------------|--------------|------------------|------------------|------------------|------------------|
| reserved     | reserved     | ADR3<br>(Ard D5) | ADR2<br>(Ard D4) | ADR1<br>(Ard D3) | ADR0<br>(Ard D2) |
| reserved     | reserved     | GND              | GND              | GND              | GND              |
| <b>PIN1</b>  | <b>PIN3</b>  | <b>PIN5</b>      | <b>PIN7</b>      | <b>PIN9</b>      | <b>PIN11</b>     |

### PCB

Size: 18x8

## 5. Connecting to the Computer

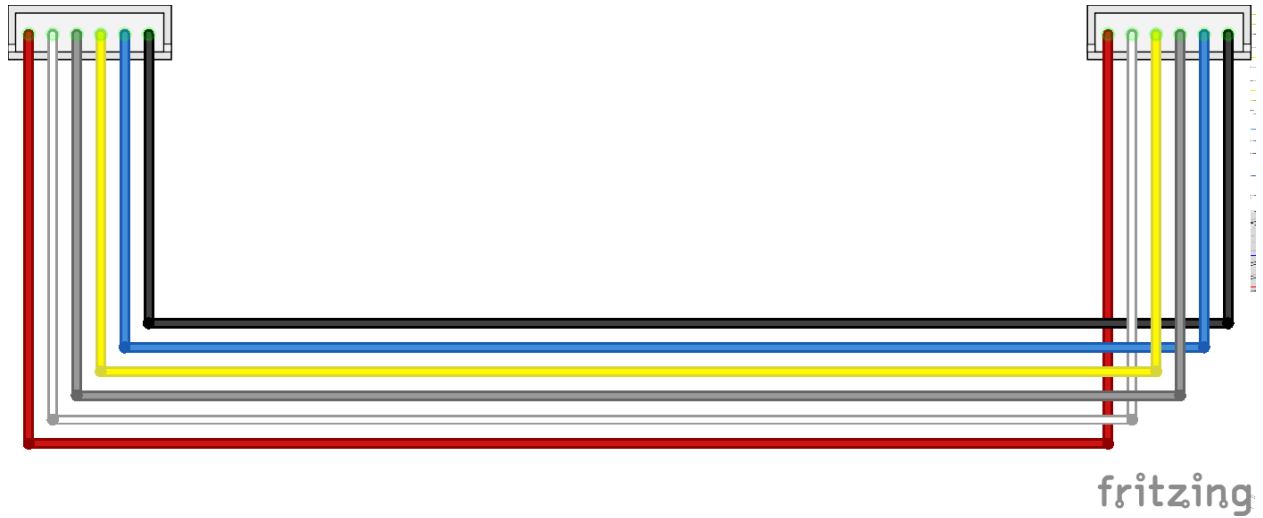
### OSP Controller

OSP Controller allows to connect the OSP-enabled devices like ORA-series actuators to the computer via USB port and to supply the power to those devices. The detailed information about the controller specs and the assembly instructions are available in OSP-Controller Assembly Manua available on ThingVerse:

<https://www.thingiverse.com/thing:7339429/files>

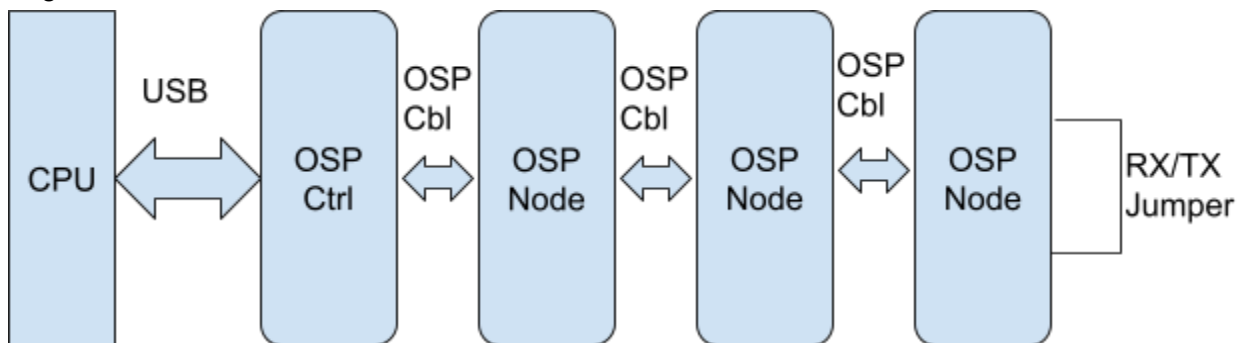
### Connection Cable

The OSP connection cable is JST XH Male <-> JST XH Male 6 wires cable.

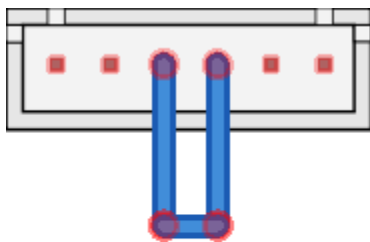


## Ring Topology

OSP protocol supports ring topology, allowing to connect multiple OSP-enabled devices to a single controller.



The last device must have the communication pins TX and RX connected with each other closing the loop and allowing the signal to run back to the controller.



fritzing



## 6. Software

### Communication Protocol

To control the ORA series actuators the OSP protocol is used. The documentation on this protocol is available at Telemetry Balkan doo website:

<https://www.telemetrybalkan.com/content/files/2023/02/Open-Serial-Peripheral.-Communication-Protocol.pdf>

### Arduino Firmware

Arduino firmware is available in ORA actuator repository in the src/arduino folder:

<https://github.com/sergei-nntu/ora/tree/main/src/arduino/sa>

### Python SDK

Python SDK with the code examples is available at src/python folder of ORA actuator repository:

<https://github.com/sergei-nntu/ora/tree/main/src/python>

## Programming Example

### Control the actuator angle

```
from osp import OSP

ora = OSP("/dev/cu.usbserial-A50285BI")
ora.ora_set_angle(0, 5000) # params (address, angle)
```

## 7. Conclusion

This document has walked the reader through the complete process of building the ORA-8 actuator, covering all essential aspects from mechanical preparation and hardware modification to electronics integration and software control. By following the outlined steps, the reader gains not only a working actuator but also a clear understanding of how each subsystem contributes to the overall functionality.

In particular, the manual demonstrated:

- How to modify a standard DS51150 servo into a controllable actuator platform
- How to assemble the mechanical structure using 3D-printed and standard components



- How to wire and integrate the electronics, including the Arduino controller, encoder, and motor driver
- How to interface the actuator using the OSP protocol and control it programmatically via Python
- How to connect multiple actuators in a scalable ring topology system

Beyond simple assembly instructions, this document provides insight into the design philosophy of the ORA system—modularity, extensibility, and openness. The reader is equipped not only to reproduce the ORA-8 actuator but also to modify, extend, and integrate it into more complex robotic applications.

The ORA-8 serves as a foundation for building distributed robotic systems, and this manual establishes the necessary knowledge to confidently work with both the hardware and software components of the platform.