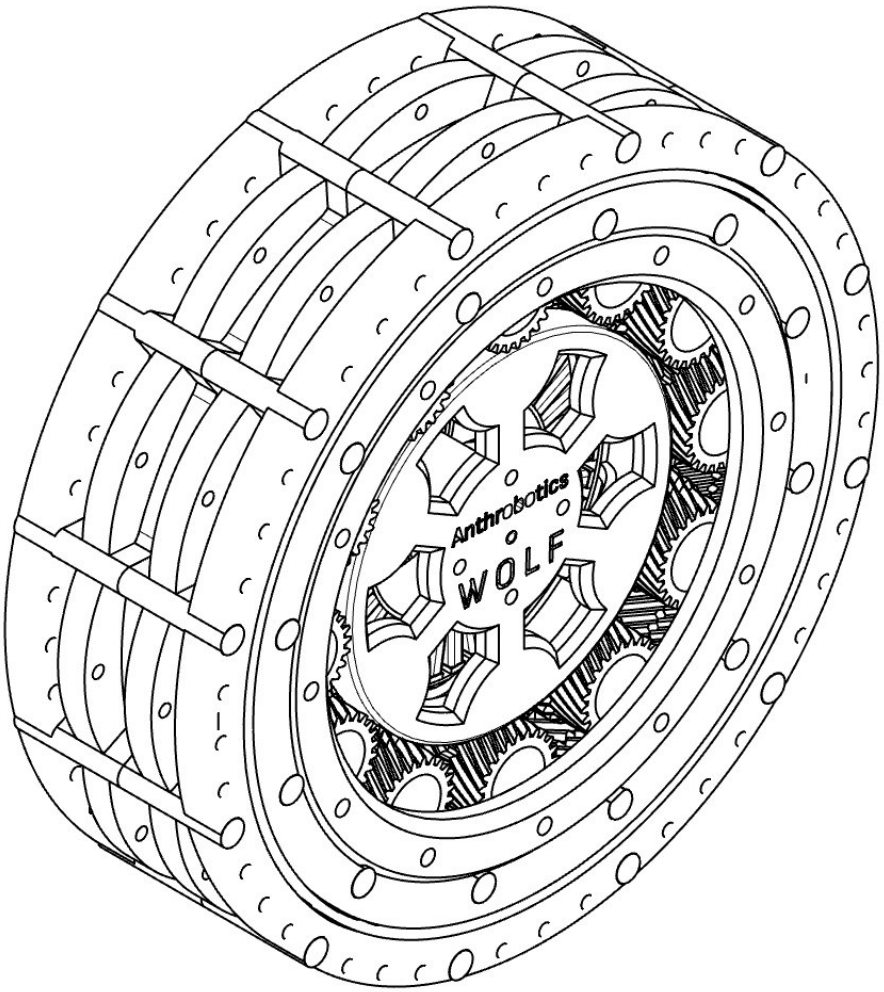
Anthrobotics

Robots for Everything™

WOLF Actuator



Assembly & Usage Guide

Version 1.1

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Changelog

This is the changelog for the WOLF actuator assembly & usage guide. All notable changes are documented here in reverse-chronological order, including unreleased changes for the next version, and what was added, changed, or removed. Record format is *[Version] - [Date]*. Date format is DD-MM-YYYY.

[1.1] - 23-07-2024

Unreleased

- Vendor list for purchasing COTS components
- WOLF-specific tuning guide and parameters for ODrive motor controller
- Assembly instructions and usage guidelines for V1.2
- Instructions and guidelines for making mounting adapters for driving axial and radial loads

Added

- Overview and specifications for V1.1
- Pointers to documentation for the modular bearing

Changed

- BOM to reflect V1.1
- 3D printing guide to reflect V1.1
- Assembly instructions to reflect V1.1
- Usage guidelines and recommendations to reflect V1.1

Removed

- Old documentation for V1.0 (see V1.0.5 release on GitHub for the docs)

[1.0] - 14-07-2024

Unreleased

- Assembly instructions and usage guidelines for the modular bearing
- Vendor list for purchasing COTS components
- WOLF-specific tuning guide and parameters for ODrive motor controller
- Assembly instructions and usage guidelines for V1.1
- Instructions and guidelines for making mounting adapters for driving axial and radial loads

Added

- Overview and specifications for V1.0
- BOM for V1.0
- 3D printing guide for V1.0, using Bambu Lab P1S
- Assembly instructions for V1.0
- Usage guidelines and recommendations for V1.0

Changed

- N/A

Removed

- N/A

Overview

The WOLF (wolfrom) actuator is a high-torque 3D-printable planetary robotic actuator. The design is based on the Wolfrom planetary gear train (PGT), and does not require a planet gear carrier or planet gear bearings. All planet gears are equally spaced, and provide a large contact area for both the sun gear and ring gears. All gears are replaceable for added modularity and easy maintenance. Modular crossed-roller bearings on both ends of the actuator provide WOLF with improved load-bearing capabilities, and smoother motion. The actuator is fully-backdriveable, and is capable of compliant control and force sensing. WOLF can be manufactured using a number of methods, including FDM and SLS 3D printing, and CNC machining.

Specifications

The specs of the WOLF actuator V1.1 are as follows:

- (Theoretical) Continuous Torque: 80 Nm
- (Theoretical) Peak Torque: 120 Nm
- Reduction: 34:1
- Weight: 1.2 Kg
- Max Operating Current: 58 A
- Operating Voltage Range: 24 VDC - 52 VDC
- Diameter: 202.3 mm
- Height: 67 mm
- Encoder: AS5047P

Bill of Materials (BOM)

You will need the following:

Printed components:

- 1x back plate
- 1x front plate
- 1x encoder magnet holder
- 1x encoder housing
- 2x internal ring gears
- 2x outer rings
- 12x planet gears
- 1x sun gear
- 2x modular bearings
- 1x planet gear alignment tool

NOTE: *Some printable parts are labeled as A or B. Print one of each.*

Commercial Off-the-shelf (COTS) components:

- 1x Eaglepower 8318 100KV brushless motor
- 1x AMS AS5047P (ABI/ABZ) encoder OR 1x AMS AS5048A (SPI) encoder
- 1x 6mmx2mm diametric encoder magnet
- 27x M3x5mm heat-set inserts, brass
- 12x M3x35mm bolts, socket head cap
- 12x M3x70mm bolts, socket head cap
- 12x M3x0.5mm hex nuts, 2mm height
- 3x M3x8mm bolts, countersunk
- 4x M2x6mm bolts, countersunk
- 12x M3x0.5mm nylock nuts, 4mm height
- 4x M4x12mm bolts, countersunk
- 4x M3x10mm bolts, countersunk

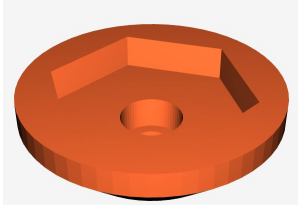
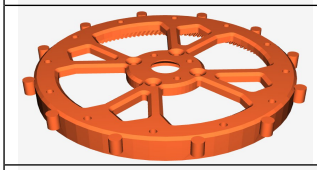
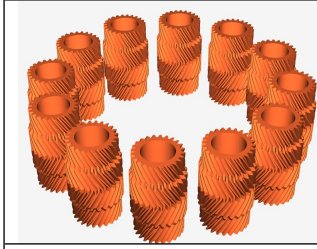
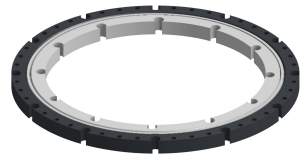
Tools:

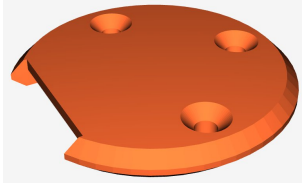
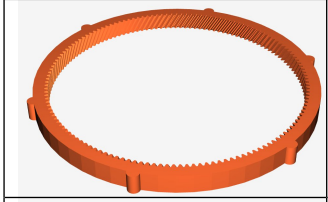
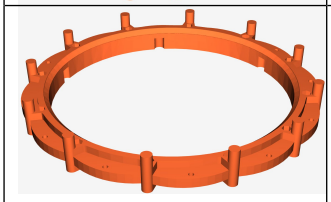
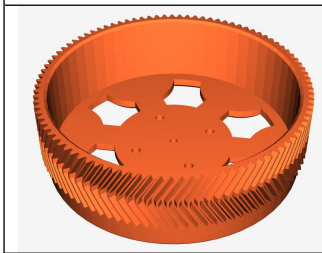
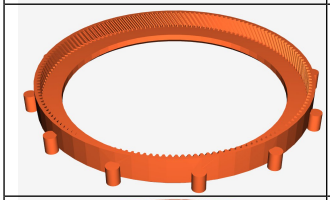
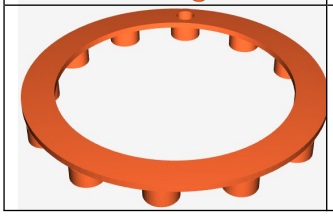
- 3D printer
- soldering iron w/ heat-set insert attachment
- Hex head drivers (M2, M3, M4)
- M3 wrench or compatible socket
- Tweezers
- PTFE lubricant (Super-Lube) for bearings and gears

3D Printing Guide

All parts were printed on a Bambu Lab P1S 3D printer in Polymaker PolySonic PLA. Global print settings are as follows:

- Quality:
  - Layer Height: 0.16 mm
  - Initial Layer Height: 0.2 mm
- Infill:
  - Density: 15%, unless otherwise noted
  - Pattern: Gyroid
  - Number of walls: 6
- Supports:
  - Support critical regions only
  - Thin tree supports
  - Threshold angle: 20°
- Other:
  - No bed adhesion
  - Z-seam: Random

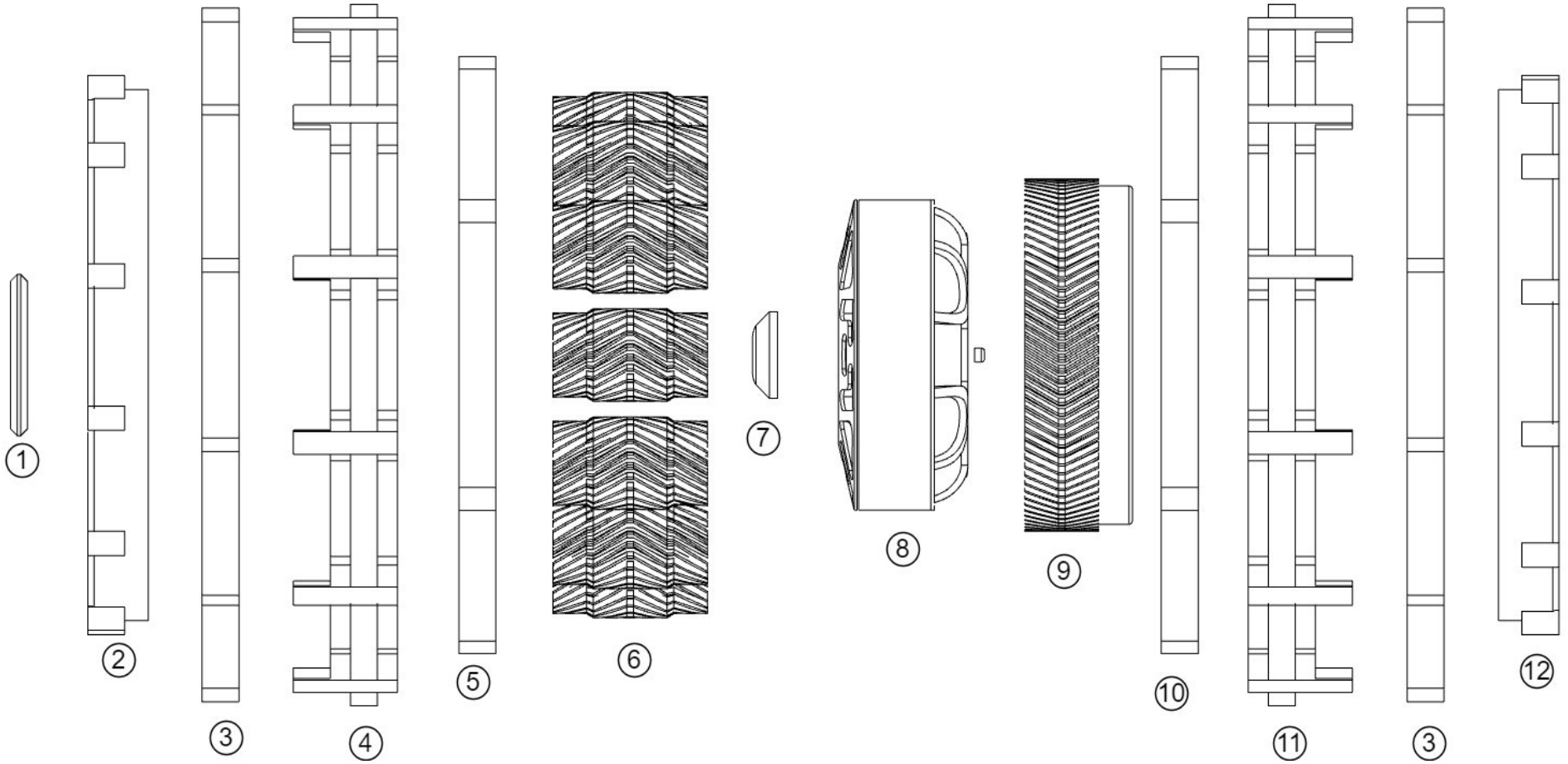
Image	File Name	Qty	Special notes
	encoder-magnet-holder.stl	1	print as-is
	back-plate.stl	1	rotate 180°
	planet-gears.stl	1	print as-is, 50% infill
	wolf-modular-bearing	2	print all separate components (see modular-bearing repo on GitHub)

	encoder-housing.stl	1	rotate 180°
	internal-ring-gear-A.stl	1	rotate 180°, 50% infill
	internal-ring-gear-B.stl	1	rotate 180°, 50% infill
	outer-ring-A.stl outer-ring-B.stl	1/EA	print with bearing alignment nubs facing up
	sun-gear.stl	1	print as-is, 50% infill
	front-plate.stl	1	print as-is
	planet-gear-alignment-tool.stl	1	rotate 180°

It is recommended to wipe the surface of the print bed with 70% isopropyl alcohol after every few prints to ensure prints adhere to the textured print bed. This is especially important for printing batches of small parts like the rollers.

Assembly Guide

An exploded view of the WOLF actuator’s mechanical components can be seen below:



From left to right:

(1) Encoder Housing

(2) Back plate

(3) Modular Bearing

(4) Outer Ring B

(5) Internal Ring Gear A

(6) Planet Gears (12x total)

(7) Encoder Magnet Holder

(8) Eaglepower 8318 Brushless Motor

(9) Sun Gear

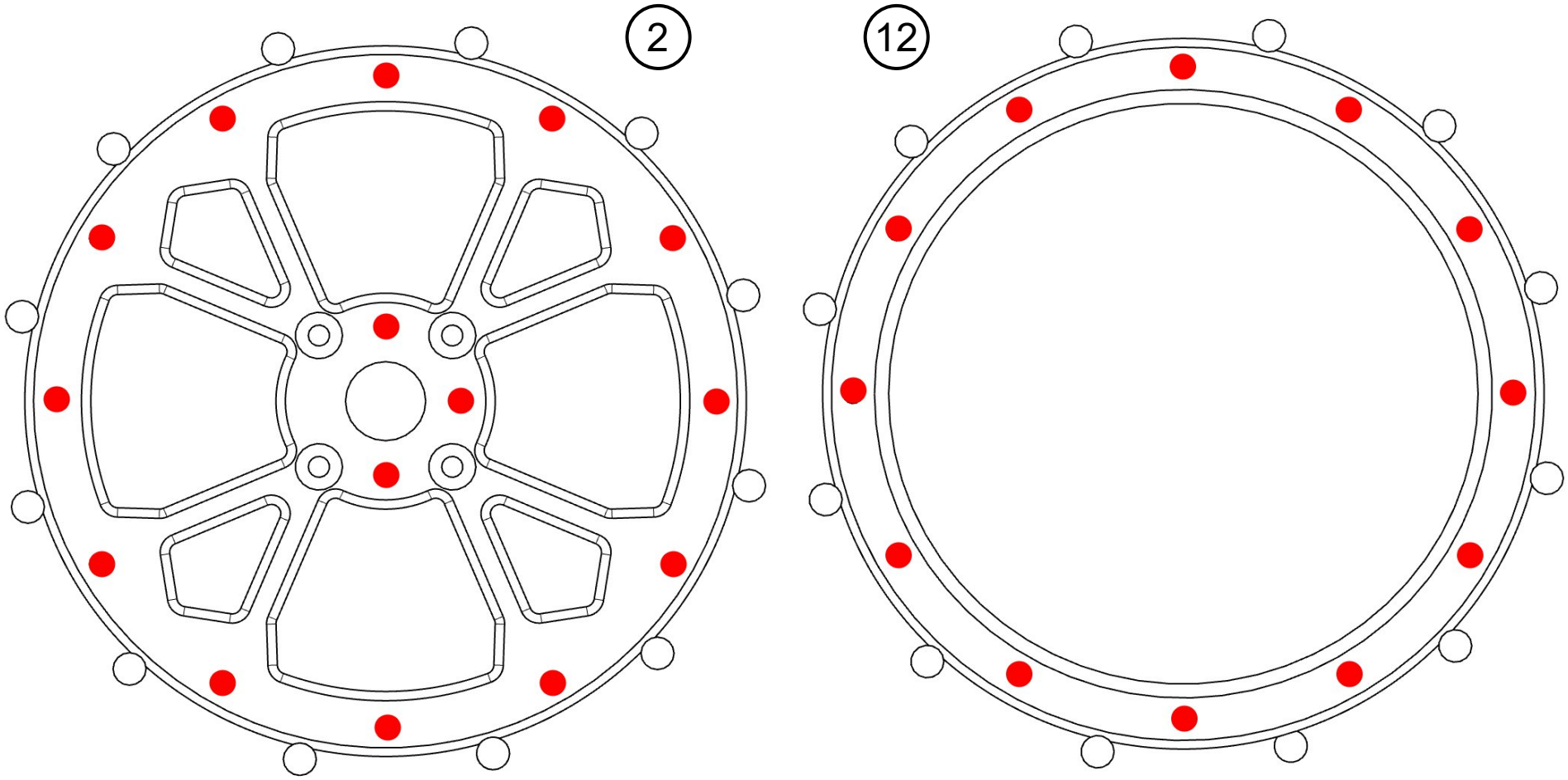
(10) Internal Ring Gear B

(11) Outer Ring A

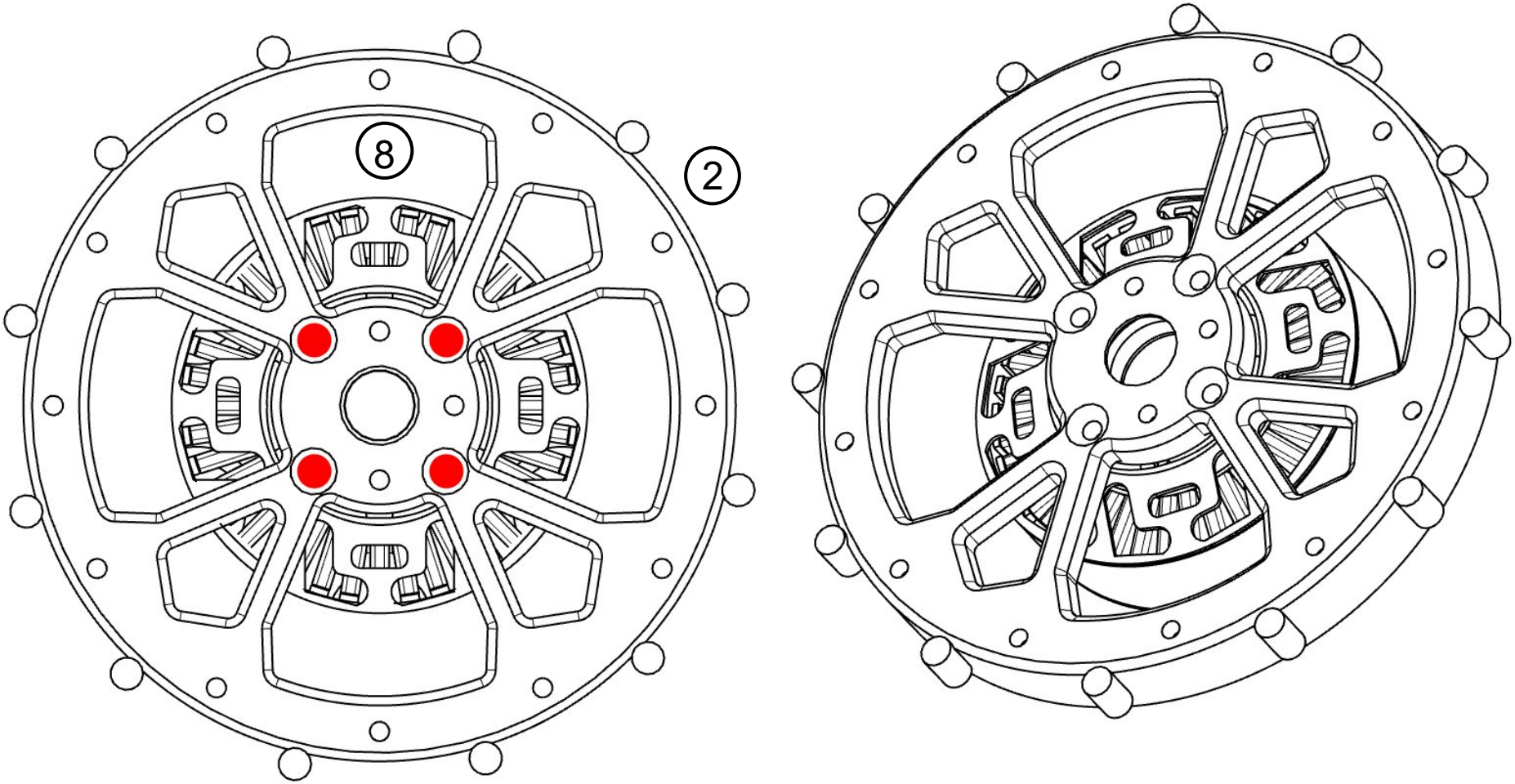
(3) Modular Bearing

(12) Front plate

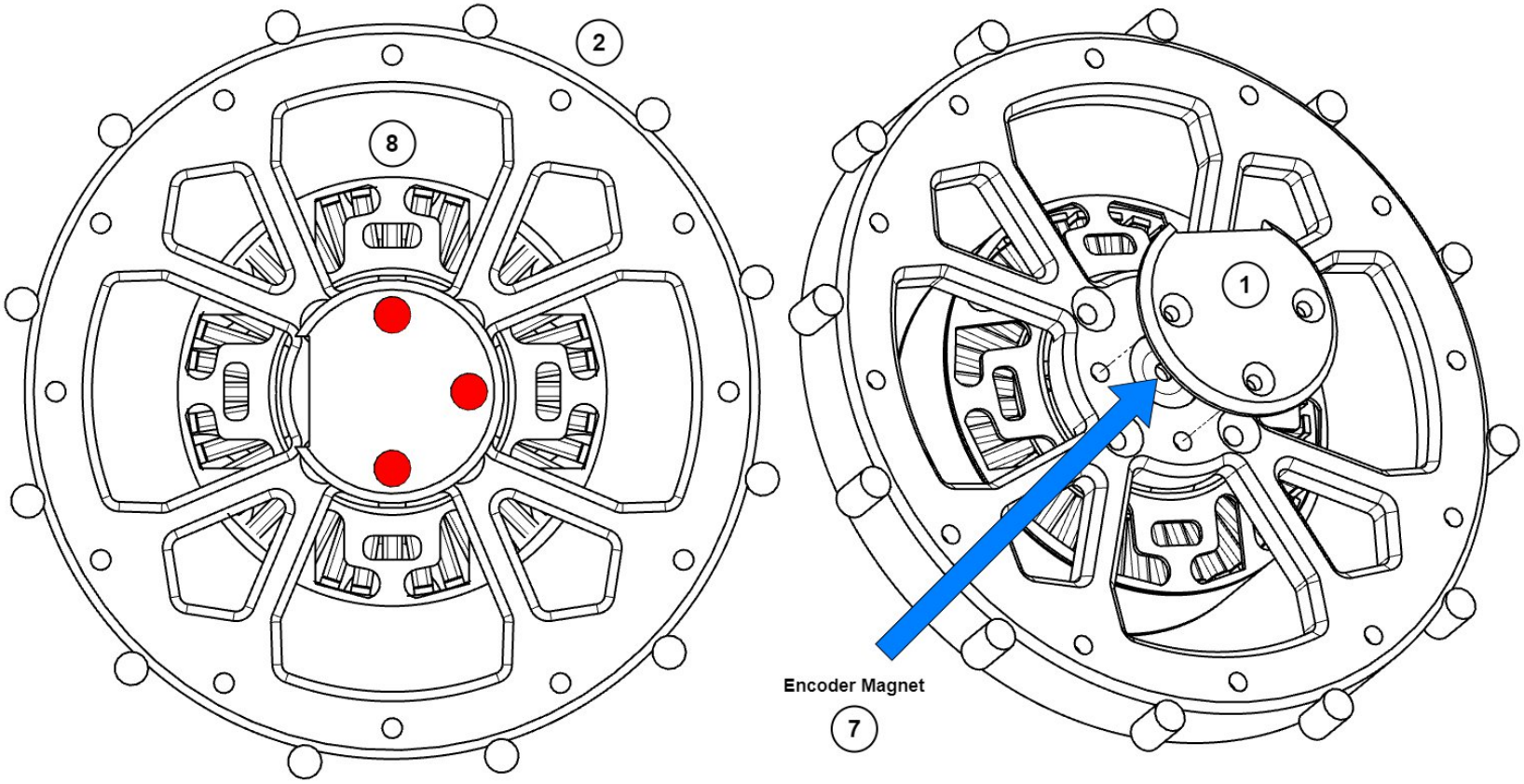
1. Insert 15x M3x5mm heat set inserts into the holes on the back plate (2), and 12x into the front plate (12) as highlighted in **RED**.



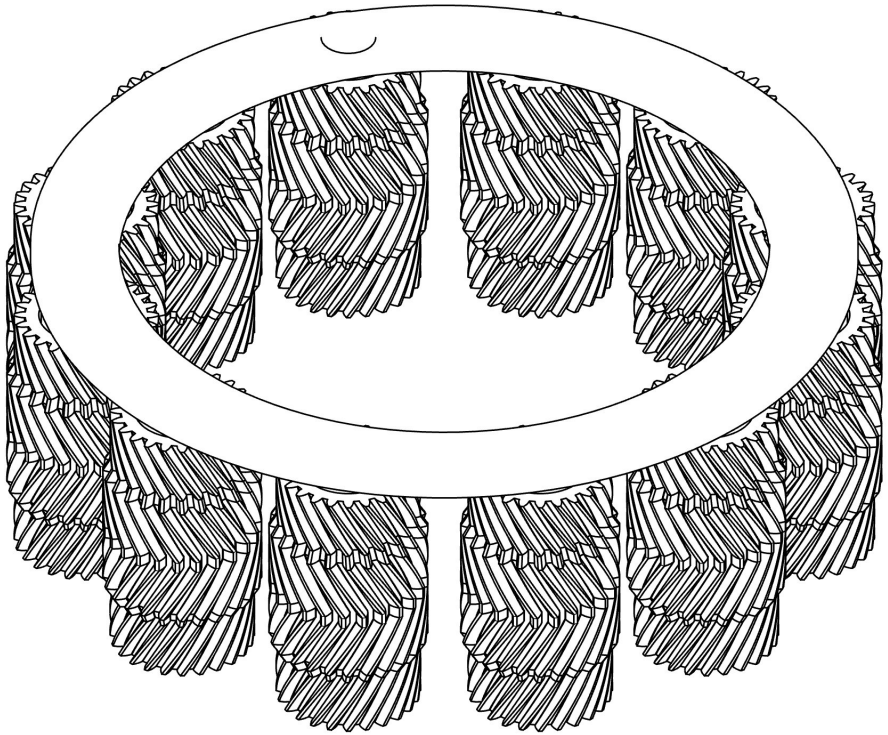
2. Secure the motor (8) to the back plate (2) using 4x M4x12mm countersunk bolts as highlighted in **RED**.



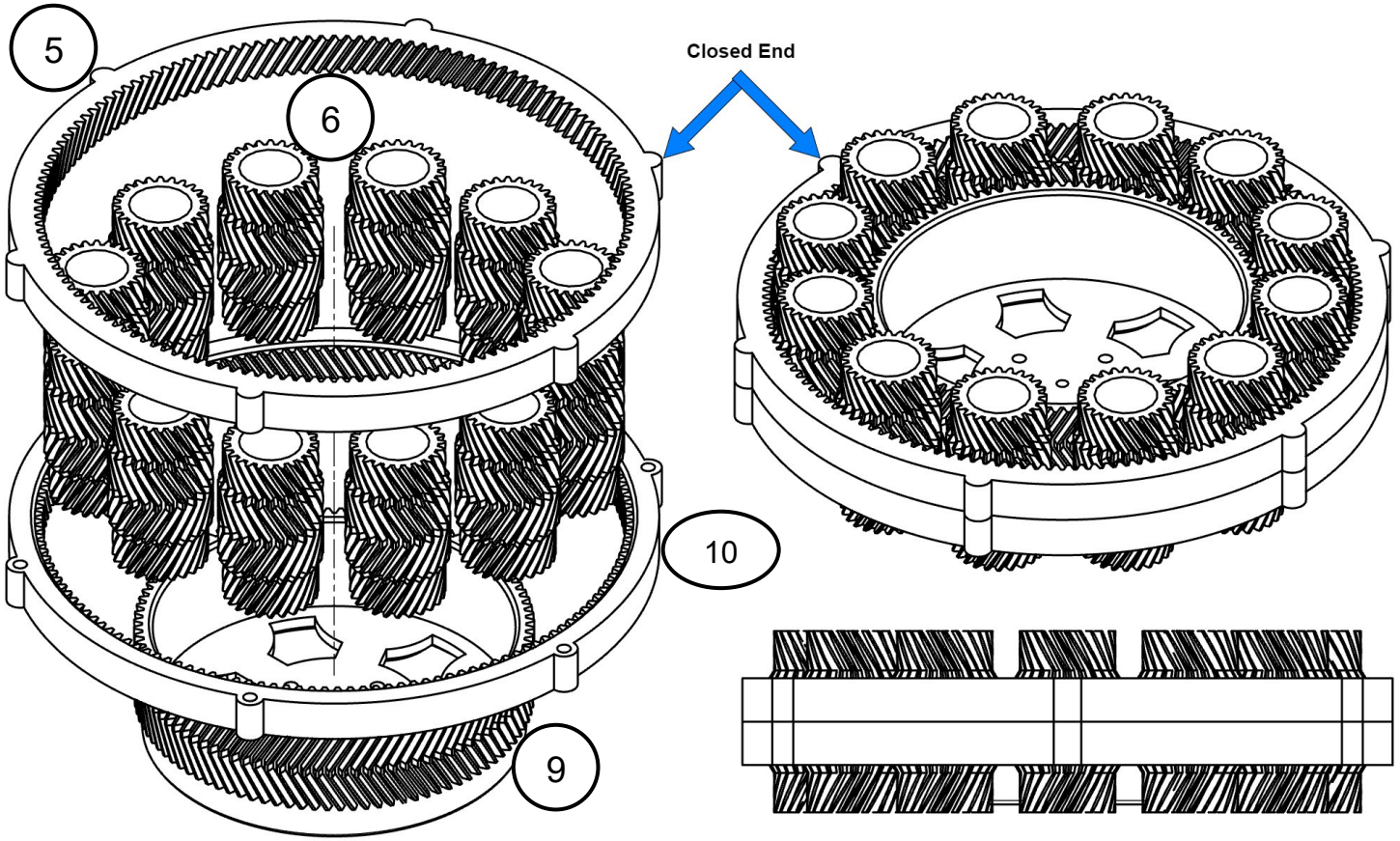
3. Press-fit a 6mmx2mm diametric magnet into the encoder magnet holder (7), and fit it to the rear hex nut on the motor (8) indicated by the **BLUE** arrow. Install the encoder into the encoder housing (1) using 4x M2x6mm countersunk bolts. Then secure the encoder housing to the back plate (2) with 3x M3x8mm countersunk bolts as highlighted in **RED**.



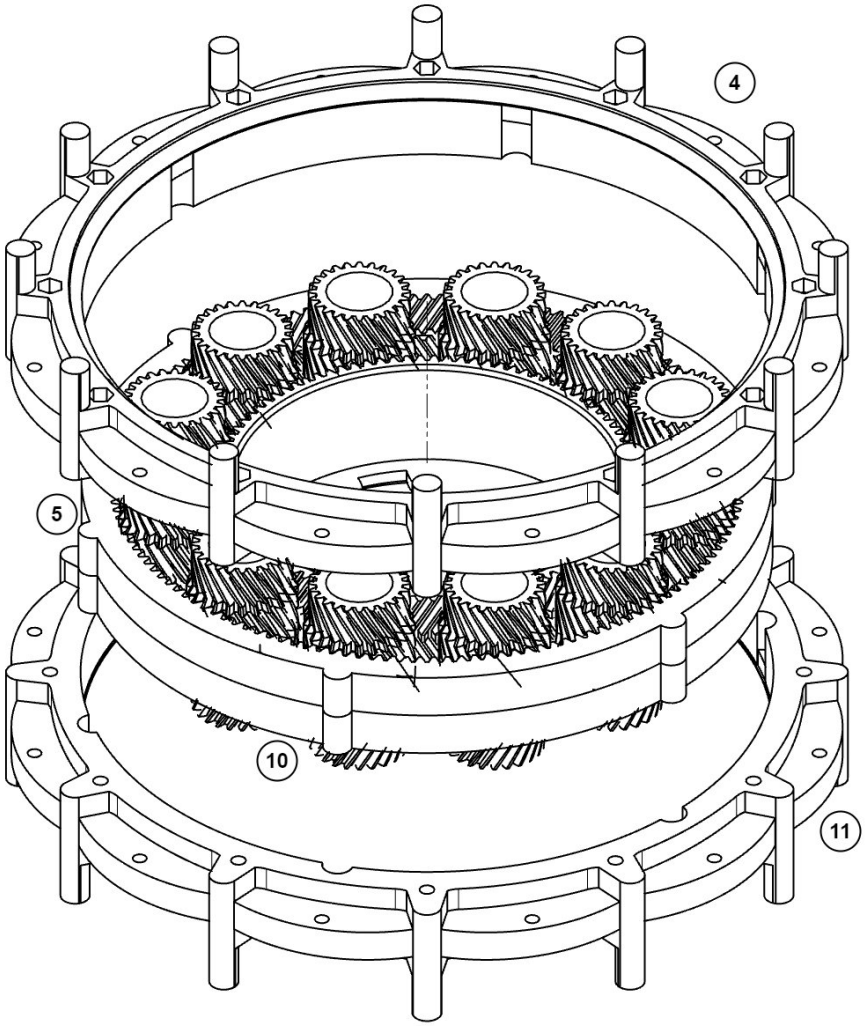
4. Arrange all 12x planetary gears (6) onto the planet gear alignment tool.

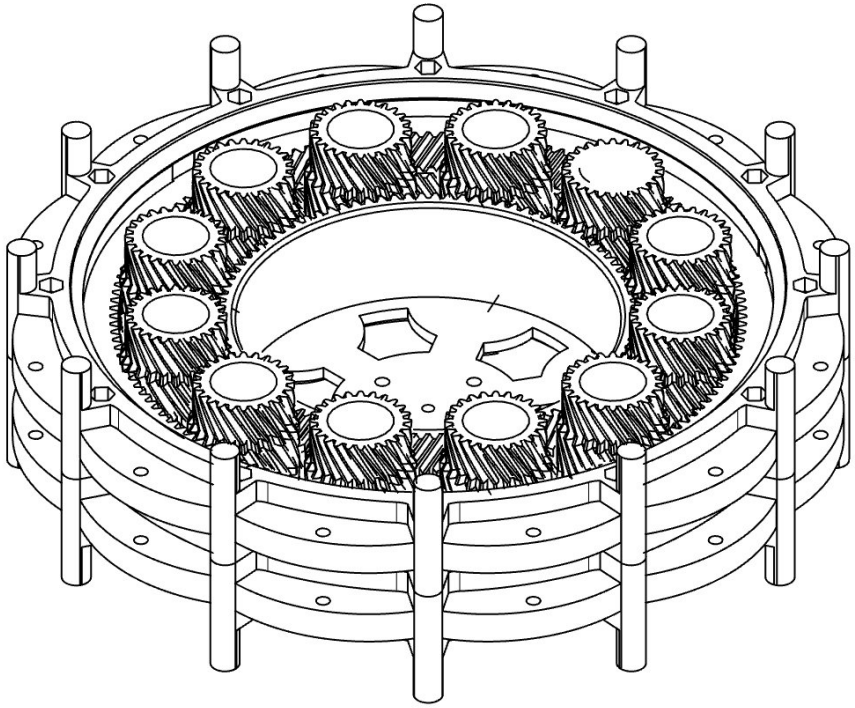


5. Place the internal ring gears A and B (5, 10) around the planet gears (6) so that they are located around the widest portion of the teeth. Insert the sun gear (9) into the center of the planet gears until the widest portion of teeth align. Ensure the closed end of ring gear A (indicated by the **BLUE** arrows) faces toward the rear of the actuator. Carefully remove the alignment tool from the planet gears.

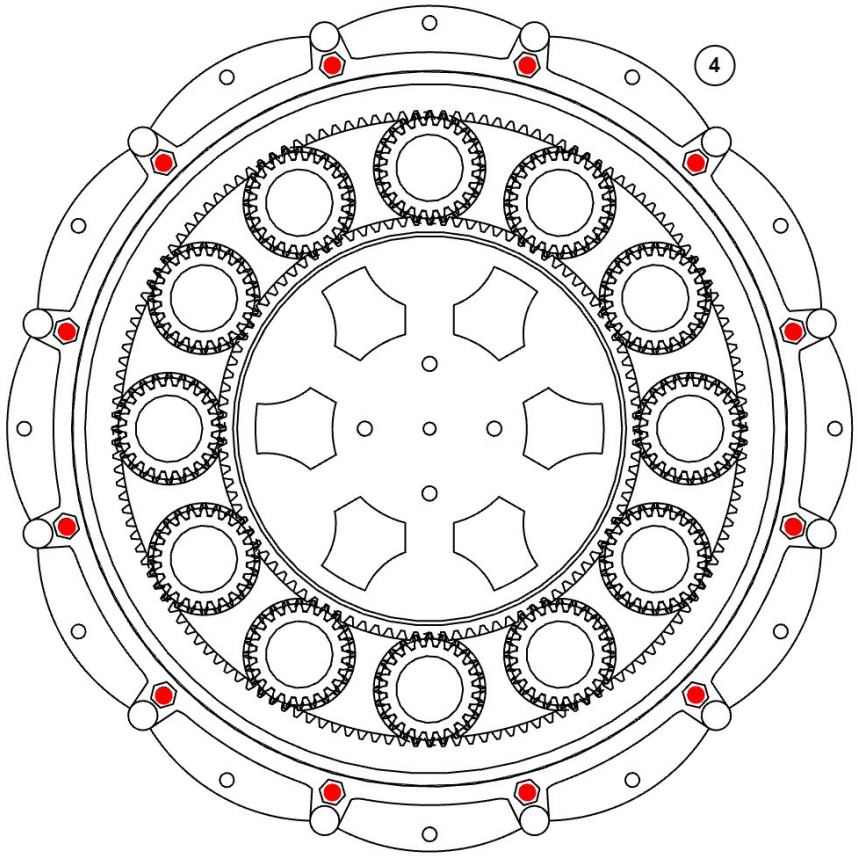


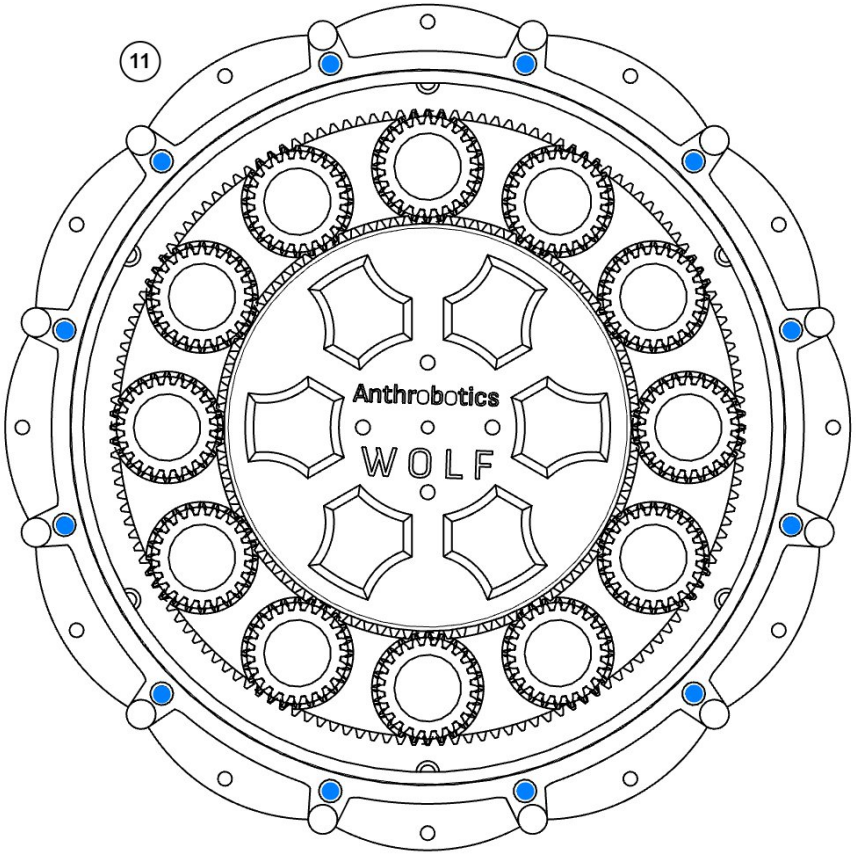
6. Install outer rings B and A (4, 11) around the inner ring gears (5, 10) by aligning the notches of the inner ring gears with the cutouts in the outer rings.





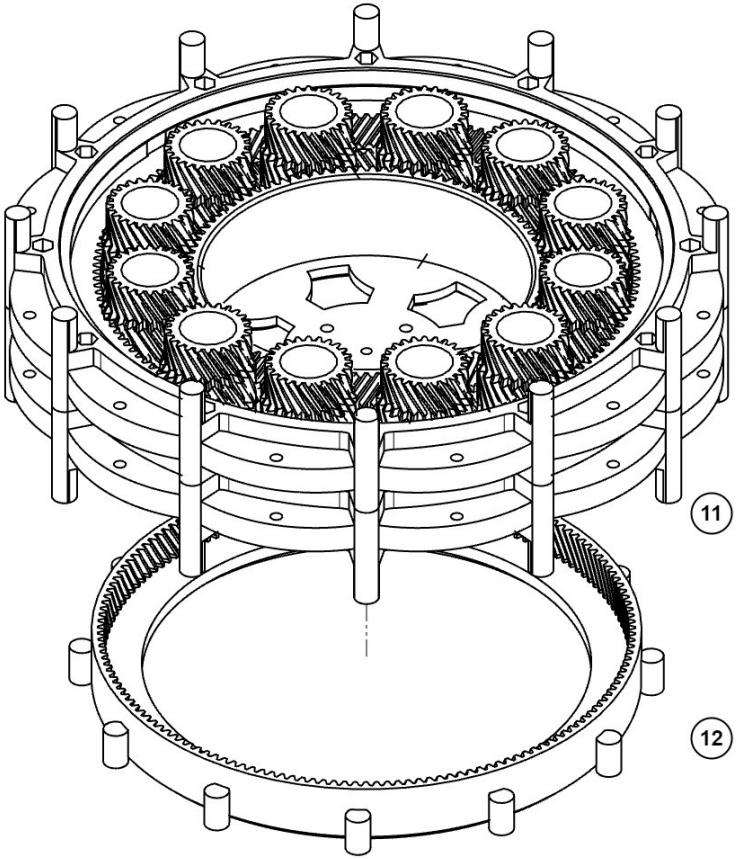
7. Insert 12x M3x35mm socket head cap bolts into outer ring A (11), highlighted in **BLUE**, and 12x M3x0.5mm hex nuts (2mm height) into outer ring B (4), highlighted in **RED**. Tighten the bolts to secure both rings together.

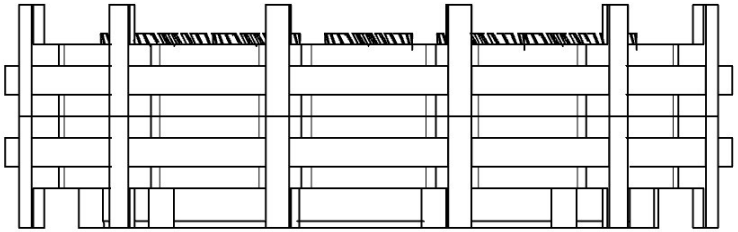




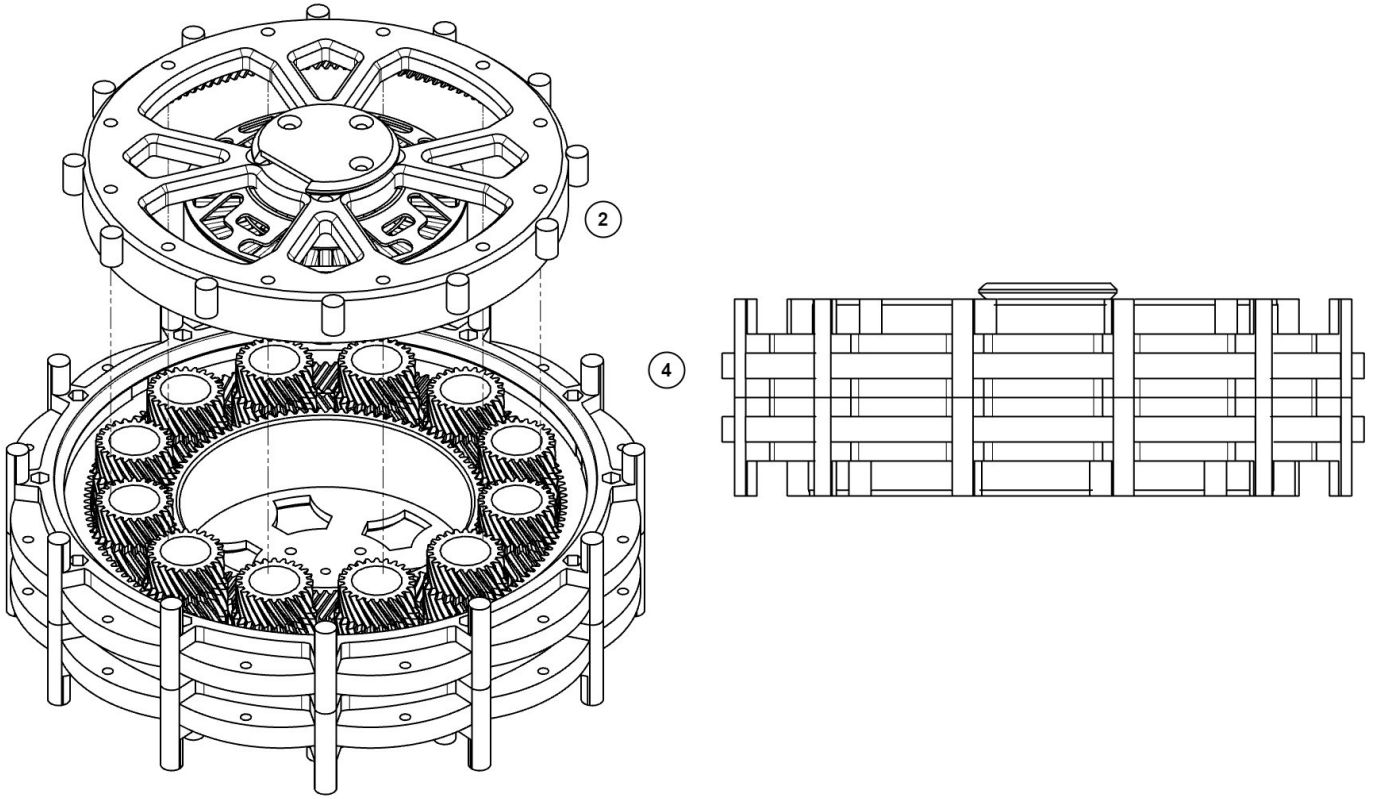
8. Apply a generous amount of PTFE lubricant to the planet gears, and rotate them several times. Ensure rotation is smooth, and that all gears spin freely.

9. Install front plate (12) by meshing with the planet gears on the side of outer ring A (11).

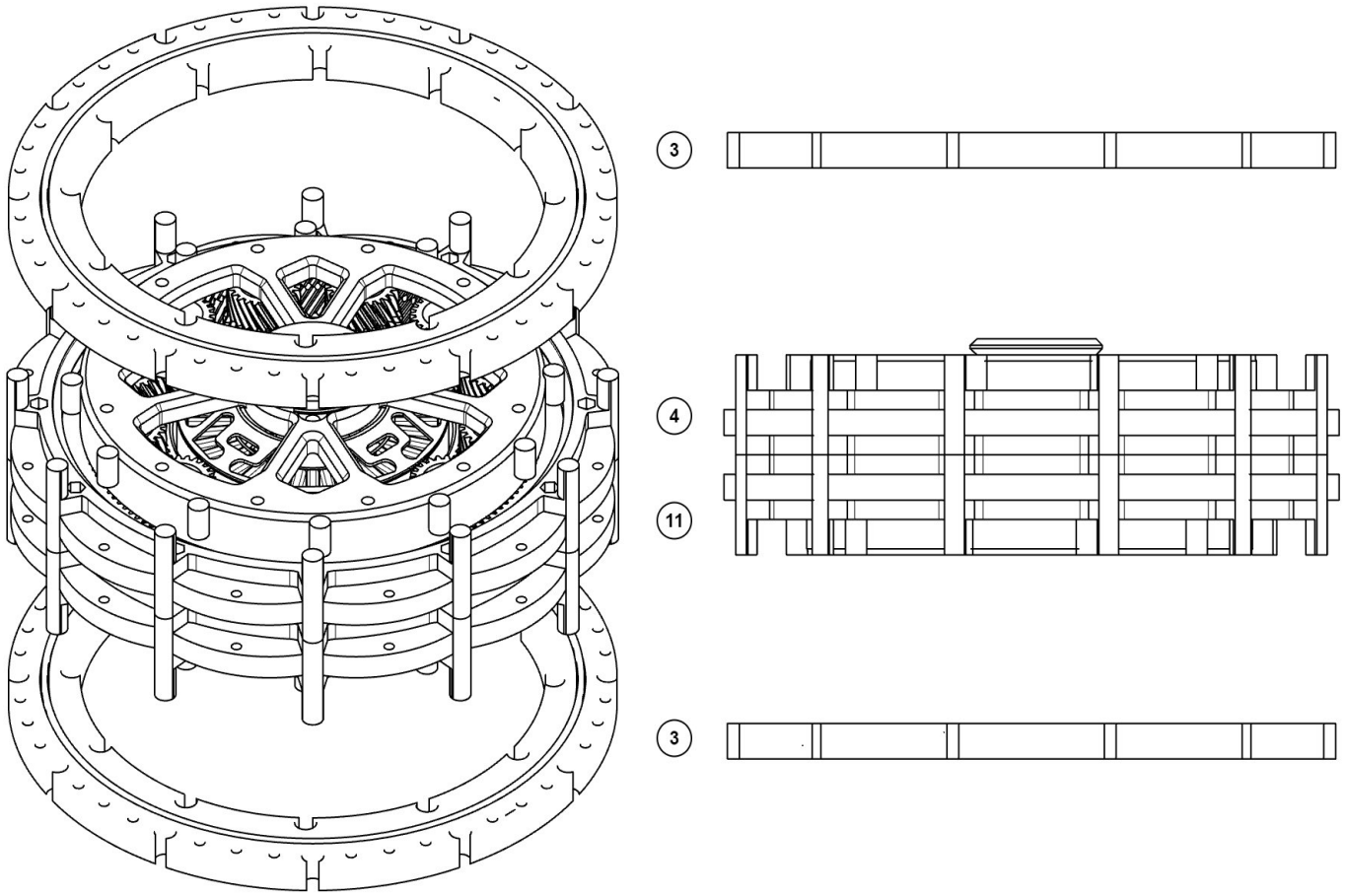




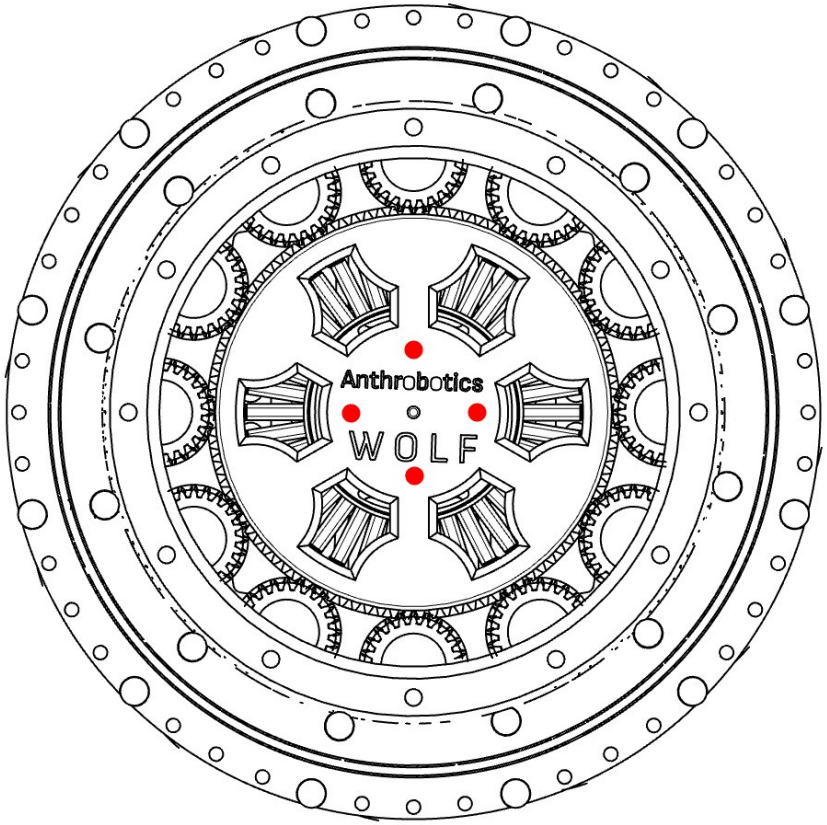
10. Install the back plate assembly (2) by meshing with the planet gears on the side of outer ring B (4). Ensure that the heat set inserts line up with those on the front plate. This will ensure that the actuator can be *mounted symmetrically* on both sides.



11. Install the modular bearings (3) by aligning the inner and outer mounting holes with the nubs on the outer rings (4, 11), and the front and back plates. Press fit the bearings into place.



12. Secure the sun gear to the motor with 4x M3x10mm countersunk bolts, highlighted in **RED**.



Congratulations! Your WOLF actuator is now assembled!

Usage Guidelines

The WOLF actuator can be used to drive loads and provide rotary motion in a number of applications, including, but not limited to:

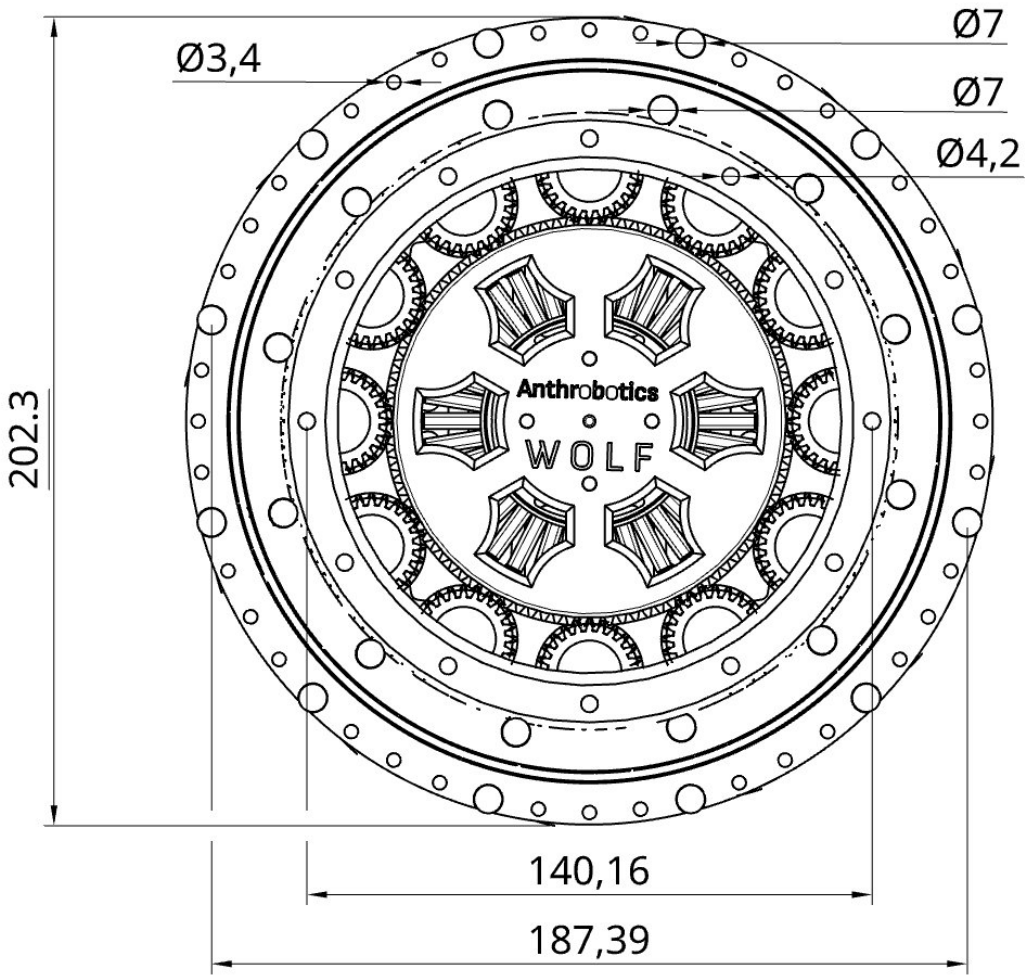
- Humanoid robots
- Large quadruped robots
- 3-Axis motion systems
- Unmanned Ground Vehicles (UGV)

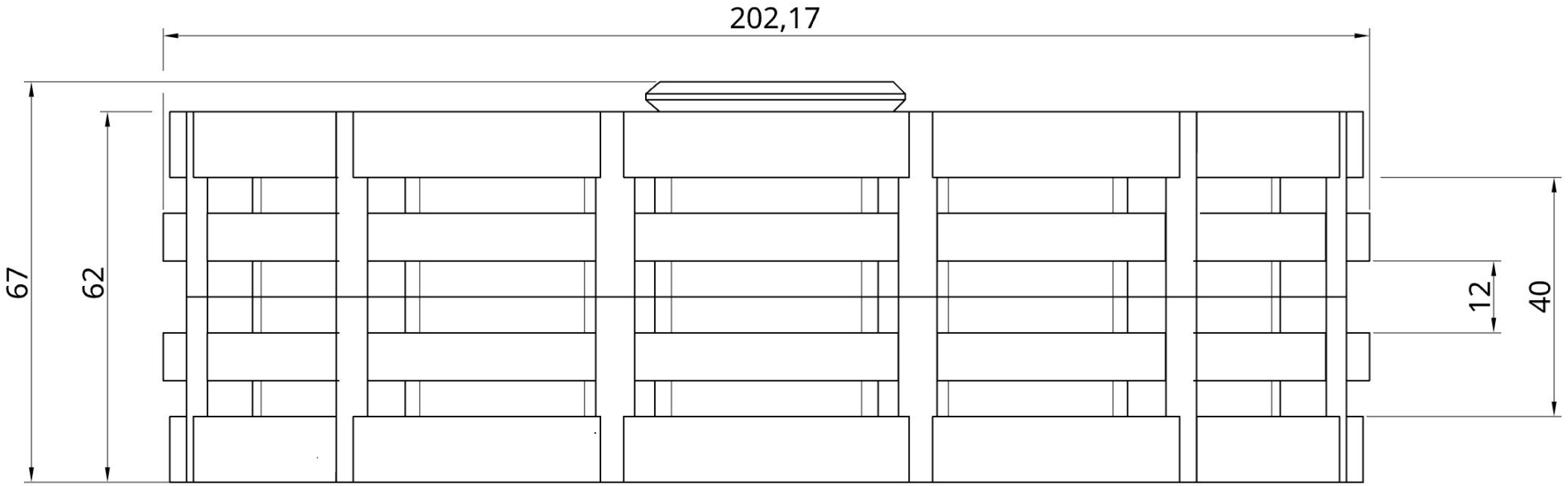
It is recommended to use the mounting pattern and dimensions on the next page to integrate WOLF into your own designs. A few notes on integration:

- To attach an axial load to WOLF on *one side*, it is recommended to use the outer ring closest to the front plate. This makes it easier to access the mounting bolts, as the motor/encoder lead side will typically be toward the inside of a robot or other device.
- To attach a radial load to WOLF (both sides of the outer rings), it is recommended to create an adapter to facilitate mounting additional structure (i.e. 2020 aluminum extrusion).
- To mount radial loads onto WOLF, use 12x M3x70mm bolts. These are installed through the secondary outer holes on the modular bearing. Secure with 12x M3x0.5mm nylock hex nuts (4mm height) on the opposite bearing. Alternatively, use threaded holes in your radially-attached component.
- M4 and M5 mounting options will be available in V1.3
- It is recommended secure the actuator using mounting holes on both the front and back plates to avoid uneven distribution of weight. While this is not always possible when driving axial loads requiring infinite rotation (i.e. wheels on a robot, slewing base for motion platforms, etc.), it will prolong the lifespan of the bearings when used to drive radial loads (i.e. inline arms or legs for robots).

Mounting Pattern and Dimensions

All measurements are in mm





Feedback and Contributions

We welcome all feedback from the community that can help improve this project along with its documentation! If you have helpful feedback for us, or would like to discuss the project, please let us know through the following:

- Opening an issue on GitHub, tagged as [feedback]
- Discuss on GitHub in the Feedback and Ideas section
- Opening a thread in the *Anthro Army Chat* on Substack
- Sending us a DM on Twitter / X
- The *#feedback-forum* in the Anthrobotics Discord server
- By sending us an email: support@anthrobotics.ca

We also welcome contributions from the community! If you would like to get involved, reach out to us!

We made it our mission to make humanoid robots for everything - accessible to everyone. If you share the same vision, we'd be happy to have you join our team.