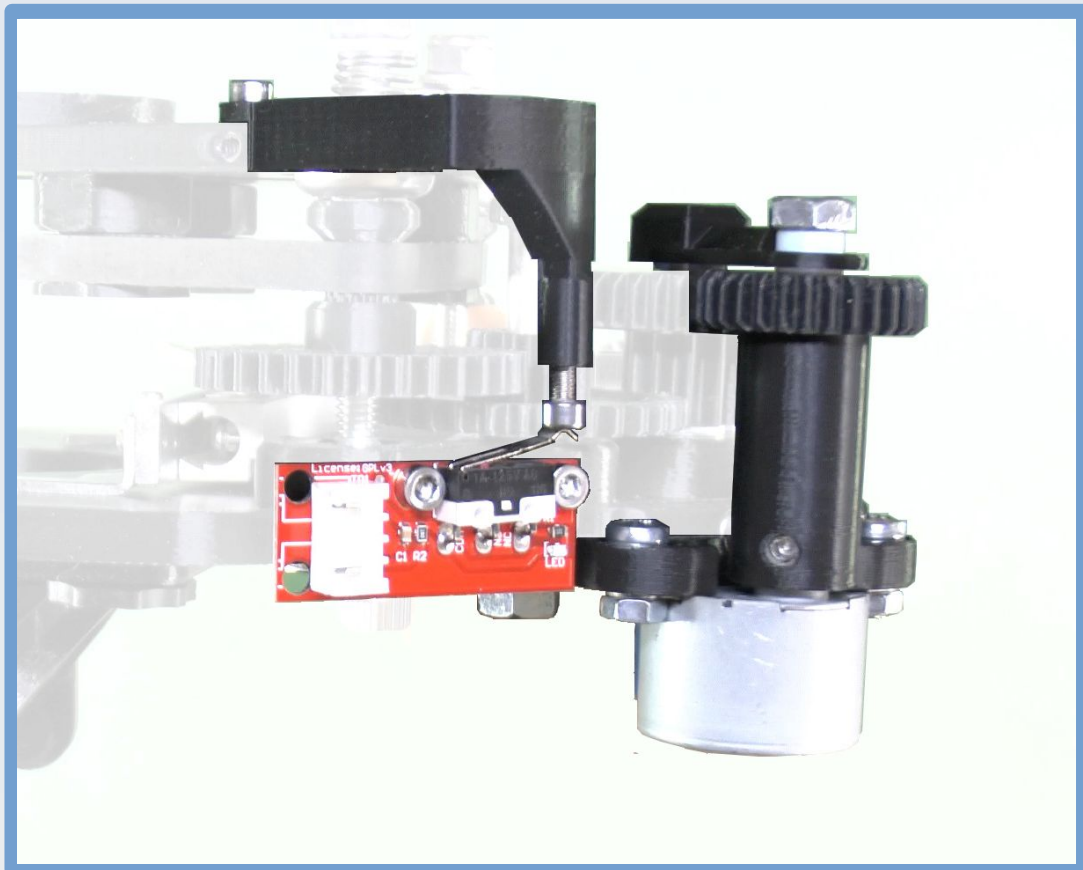




Z-Motor Upgrade

User's Manual

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Manual prepared by **OptArc** – Designers and manufacturers of custom optical and optoelectronic systems using 3D printing rapid prototyping and based in the UK. See optarc.co.uk for details.

Safety Information

Identification of risk

Throughout this manual please take heed of **warnings given in bold text and highlighted yellow** to avoid possible damage to equipment and/or harm to people.

Risk to vulnerable groups

PUMA microscopes and associated systems are not toys. They contain small parts which may come loose such as tiny metal screws and washers and glass components that may splinter or break or otherwise present a choking or sharp object hazard or chemical hazard (e.g. for batteries). **Please do not let babies or young children play with or gain access to any aspect of a PUMA system without close appropriate adult supervision. Likewise keep PUMA systems away from pets.**

Risk of damage to eyesight

When choosing and using a light source for a PUMA microscope, care must be taken to avoid the use of or exposure to light that could damage eyesight.

In particular **never allow direct or specular reflections of the sun to enter the microscope** through the illuminating mirror.

Also, **never allow laser light to enter the microscope through the illuminating mirror if any viewing is to be done by eye** (as opposed to recordings by a camera only).

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You can download the latest version of this User's Manual as a PDF file from the Support section of the OptArc website via this link:

<https://www.optarc.co.uk/support/>



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Legal information

Copyright

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Limitations of Use

The PUMA microscope and its associated systems do not have any certifications or regulatory approvals in any country for use in clinical diagnostics or treatment (human or veterinary).

The PUMA microscope and its associated systems are released to be used for research and educational purposes only.

Disclaimer

All PUMA project information including, without limitation, any CAD file or STL file and all documentation, advice and instruction (whether provided in video form, audible form, written form or otherwise) is provided 'as is' in good faith and is intended to be helpful but comes with no warranty whatsoever.

Anyone attempting to build or use a PUMA microscope or other PUMA-related material, accessory, module or derivative is hereby advised that there will be risk involved in 3D printing, post-print processing, assembly and usage of the resulting structures. This risk includes, without limitation, the risk of personal injury, damage and loss of resources.

Dr Paul J. Tadrous, TadPath and OptArc cannot accept any liability for any such injury, loss or other damages that may occur. All those who attempt to build or use any aspect of the PUMA project or derivatives thereof do so at their own risk.

Discrepancy in Appearance of Parts

The parts in your package may differ in exact appearance to the parts shown in this manual or in the associated videos or advertising materials because we always ship the latest versions of the scope and the manual and videos may have been prepared using earlier models. Functionality of the parts you receive will be the same or better than those illustrated in this manual and any associated video or advertising materials.

Abbreviations

Some common abbreviations used in this manual are listed below for convenience.

CAD Computer-aided design

JST Japan Solderless Terminal

PLA Poly-lactic acid

PTFE Poly-tetrafluoroethylene (plastic)

PUMA Portable Upgradeable Modular Affordable (3D printed microscopy system)

STL Stereolithography file format

ZM_ Terms that begin with this refer to CAD models for the PUMA Z-Motor system

Introduction

This manual pertains to the kit of parts supplied by OptArc that will enable you to upgrade the focus mechanism of a PUMA Foundation scope to work with a stepper motor.

This upgrade includes the all the required mechanical parts, two motors, a motor driver board and a limit switch but you will need to supply some other components for this upgrade to be fully functional. See below for detail.

For more information about the 3D printed parts used in this kit and, in particular if you would like to print any additional or replacement parts, please see the PUMA GitHub repository.

PUMA GitHub Page



<https://github.com/TadPath/PUMA>

Features of this condenser upgrade kit

This kit will enable you to get the benefits of smooth motor controlled focus motion that can be controlled by a computer or microcontroller once you have made it fully functional by supplying the additional parts required and making suitable connections.

More information about the required electronics and connections are provided on the PUMA GitHub repository and Z-Motor video on the PUMA Microscope YouTube channel.

What is not included in this upgrade kit

The stepper motors the ULN2003 driver board that come with this kit require a suitable power supply to run them and a computer or microcontroller to provide logic control pulse signals to the ULN2003 stepper motor driver board in order for the motor to work. **Never apply electrical power directly to the motor coils or you risk permanently damaging the motors.** Both motors supplied with this kit have been tested and demonstrated to be working prior to packing them.

While all the required mechanical coupling components are provided in this kit, a suitable power supply and microcontroller – and the connections from these devices to the motor – are not supplied. You will need to provide those yourself and make the required connections which may require additional cables and, possibly, soldering.

An example controller is the PUMA Control Console which is described on the PUMA GitHub repository and PUMA Microscope YouTube channel.

Tools: You will also need a 10 mm spanner or long nose pliers and Allen keys (2.0 and 2.5 mm) to complete the upgrade. These are not supplied.

What's included in the kit

This Z-Motor upgrade kit includes the following items only (quantities in brackets) – see figures 1 to 6:

- A 12V DC 28BYJ48 stepper motor with a JST PH female connector(1)
- A ZM_Motor_attachment plate (1)
- M4 Pozi-pan screws 10 mm long, M4 washers, M4 nuts (2 of each)
- A JST PH to JST XH gender changer adaptor connector (1)

Note: All the above components are pre-assembled for you into a single assembly and packaged in one bag (figure 1). **Never use this motor with a voltage supply higher than 12V or it will get dangerously hot and may cause burns injuries and melt and destroy the plastic gear of this kit and so cease to function as a focus motor. There is also the risk of fire.** Also do not use this motor with a 5V supply or it will not have the torque required to reliably turn the focus gears.

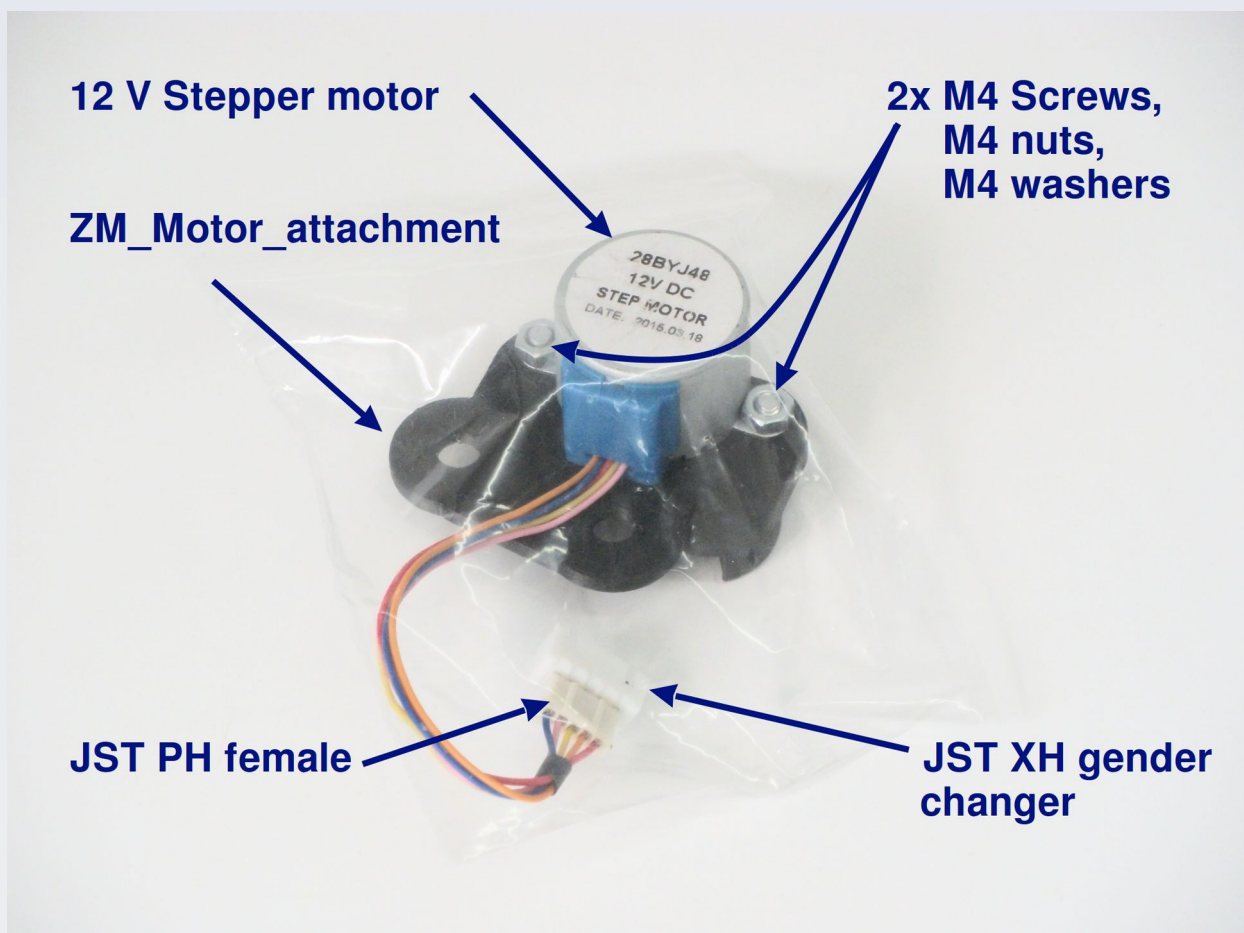


Figure 1. The bag containing the 12V stepper motor assembly.

- A 5V DC 28BYJ48 stepper motor with a JST XH female connector(1)



Figure 2. The 5V stepper motor.

Note (figure 2): This is provided as an alternative component to the 12V motor. If your power supply will be low voltage, you may remove the 12V motor from the motor attachment plate and replace it with this motor. Otherwise this motor may just be kept as a spare part. **Never use this 5V motor with a high voltage supply (only use it with a 5 volts supply) or it will get dangerously hot and may cause burns injuries and melt and destroy the plastic gear of this kit and so cease to function as a focus motor. There is also the risk of fire.**

- A ZM_Motor_gear (1)
- A ZM_Z_Yoke (1)
- M4 grub screws 5 mm long (2)
- A 16 mm long M6 hex bolt (1)
- A 5 mm long piece of PTFE tubing 8 mm outer diameter (1)

Note (figure 3): The above components are all pre-assembled for you into a single assembly and packaged in one bag.

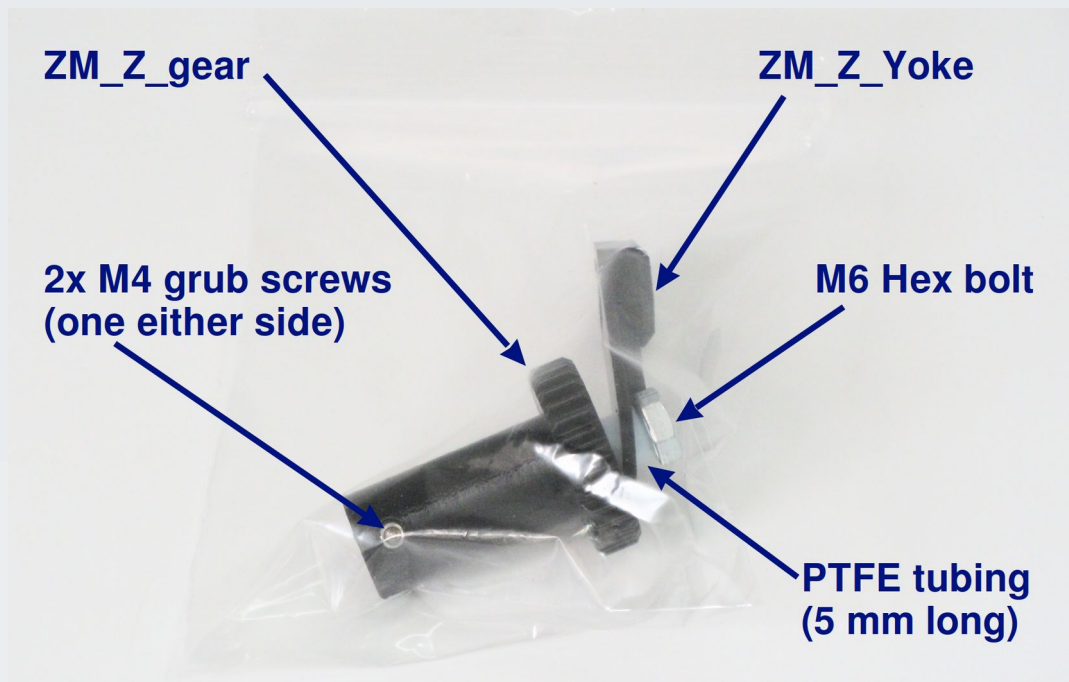


Figure 3. The bag with the Z motor gear and yoke assembly.

- A ZM_Z_Probe (1)
- ZM_Z_Limit_Sw_Mount (1)
- M3 Allen bolt socket cap 10 mm long (3)
- M3 M3 Allen bolt socket cap, 6 mm long (2)
- An M3 Allen bolt socket cap , 14 mm long (1)

Note (figure 4): All these are packaged in a single bag. One of the M3 Allen bolts (10 mm long) is already threaded into the Z-probe for you to a reasonable starting length but you will need to check and calibrate this length as described in the section on 'The upgrade procedure' below and Z-Motor YouTube video. Note that another of the M3 bolts in this pack is for use in providing additional securing of the ZM_Motor_attachment plate to the base plate of the microscope but this is optional so may be kept as a spare if you decide not to use it for that purpose. For more information see the section on 'The upgrade procedure' below.

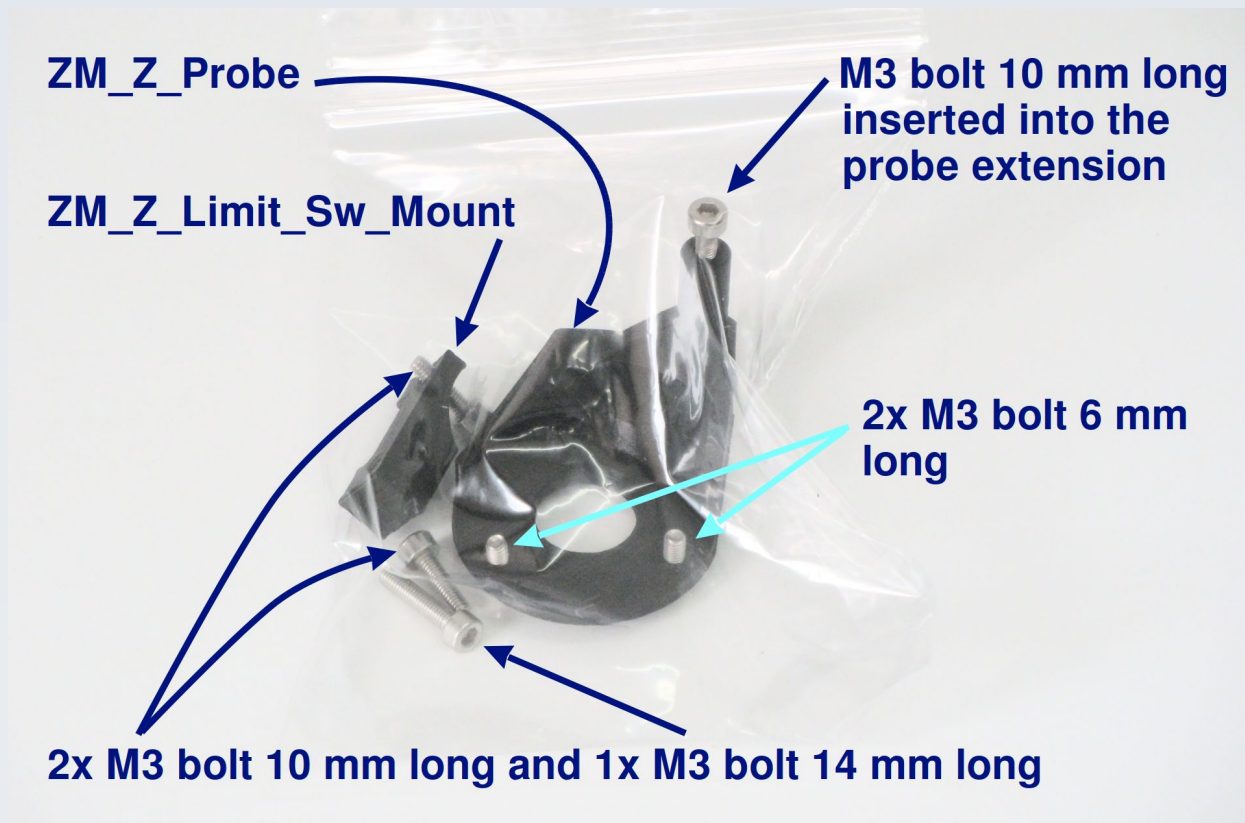


Figure 4. The bag with the Z probe and limit switch mount parts and 'extra' M3 10 mm bolt. Note that the M3 bolts may all be loose in the bag (except for the 10 mm bolt that is screwed into the Z-probe itself).

- An approximately 2 mm long piece of split PTFE tubing 8 mm outer diameter (1)
- A 5 pin JST XH PCB connector (1)
- A 5 pin JST XH cable (1)

Note (figure 5): The above components are all in one bag (with the two smaller components in their own smaller bag). **Note that the PTFE ring has been split for you – you must not attempt to split it again.**

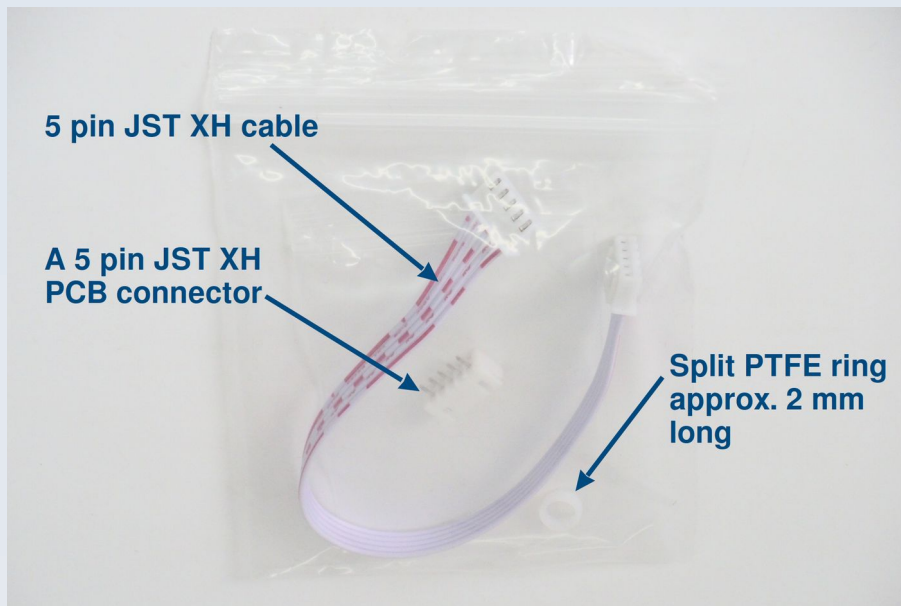


Figure 5. The bag with the JST XH cable, connector and split PTFE ring.

- An end stop limit switch with its cable (1)
- A ULN2003 stepper driver board (1)



Figure 6. The end stop limit switch and cable (left) and the ULN2003 stepper motor driver board (right) each come in separate packets.

No other parts are included.

The upgrade procedure

Important: Please ensure you read the notes in this chapter in addition to (and before) following the upgrade video because the notes contain information that may modify the procedures described in the video due to the fact that the parts in this kit are partially pre-assembled for you.

The main procedure is detailed in the Z-motor video on the PUMA microscope YouTube channel, link opposite:

The video also gives more general information about the Z-motor and using it so the part of the video that is most directly relevant to performing the upgrade starts at about time index 04:35 but you may find it helpful to see the overview of the system first which starts at about 02:55.

The time stamps in the following notes refer to times in this video.

Z-Motor video



<https://youtu.be/-lvkILM2m04>

Note: 04:47 – the motor gear has been prepared for you so you do not need to do this.

Note: 07:05 – the 2 mm long PTFE ring has been split for you so you do not need to do this.

Note: 07:32 – You can fix the motor assembly to the base plate of the microscope without removing the motor from its ZM_Motor_attachment plate if you choose not to use the extra 10 mm long M3 bolt to secure the motor attachment to the side of the microscope base plate. Use of this optional extra bolt is described from about 08:24 in the video. By avoiding this extra bolt you get the added convenience of not having to perform the awkward procedure of tightening the M4 screw and bolt (that hold the motor to its attachment plate) closest to the intermediate focus gear with a long thin screwdriver as is demonstrated from about 09:15 in the video. Also, if you choose not to use this additional M3 bolt you can get even more convenience by attaching the motor gear and Z-yoke assembly (figure 3) to the stepper motor – motor attachment assembly (figure 1) before fitting the whole lot to the microscope stage. The combined assembly will then look as shown in figure 7 and this whole assembly can be added to or removed from the scope in one go, making it quick and easy to add / remove / store the motor system as required (only the limit switch need be kept on the scope). Having said all this, it is generally advisable to leave the motor attached to the scope even when you are not using motor focussing because the motor adds additional ‘braking’ stability to the focus system even when using manual focus.

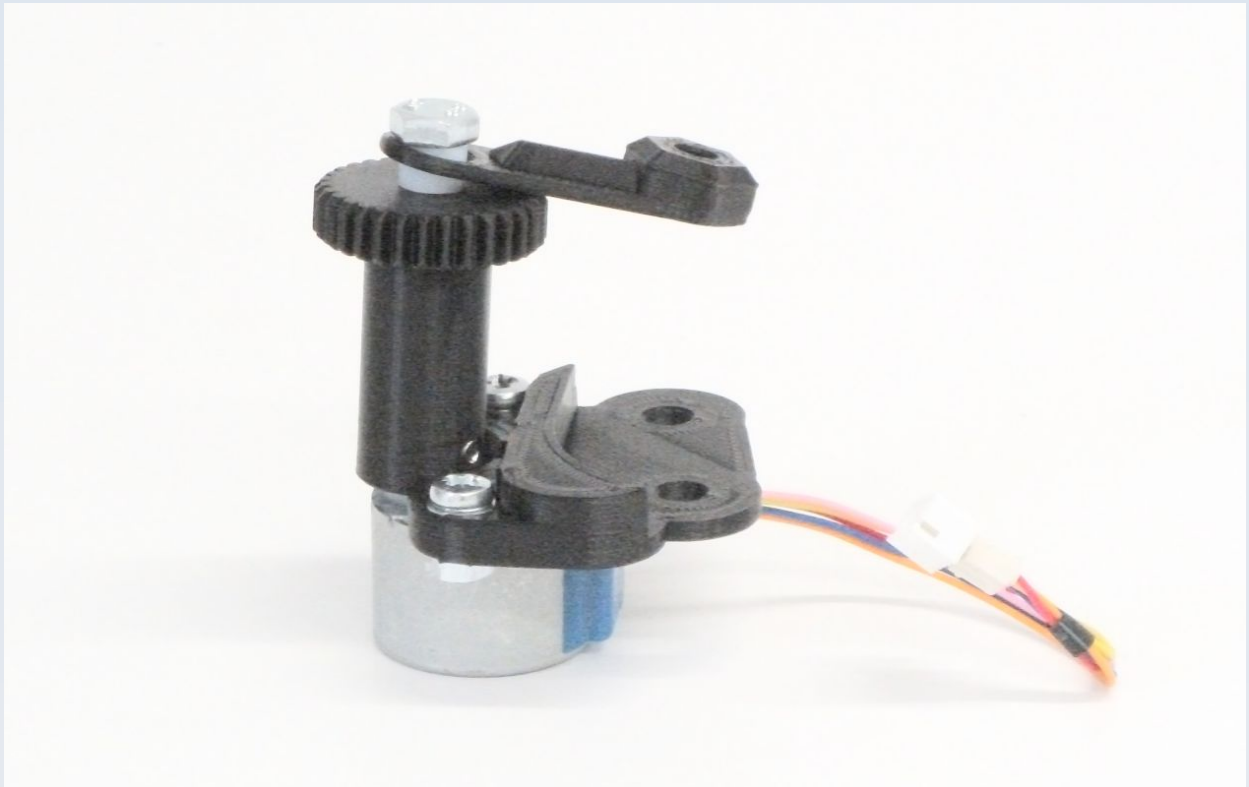


Figure 7. The combined motor, attachment plate, gear and yoke assembly. This may be kept together and fitted to / removed from the scope as a unit if you do not use the optional extra 10 mm long M3 side bolt. As mentioned in the video, **take great care not to over-tighten the M4 grub screws on the lower spindle of the motor gear or you will destroy the threads.**

Note: 14:55 – When adjusting the length of the Z-probe screw ensure the intermediate gear is not passively ‘riding high’ on its axle or this will result in a falsely narrower gap between the gears so the protruding length of the Z-probe screw you end up with will be too long and you may never be able to get the stage low enough (using motor control) to focus on any specimen.

The rest of the procedure for both fitting and using the Z-motor is as described in the Z-motor video and in the user manual of the PUMA Control software (available on the GitHub repository here: <https://github.com/TadPath/PUMA/tree/main/Software>)

Maintenance

This chapter discusses routine user maintenance. For details about how to fully take-apart your Z-motor fitments and re-assemble them see the PUMA Microscope YouTube channel videos.

Avoid excessive heat

The 3D printed parts are made of PLA plastic which has a glass transition temperature of about 60 °C (140 °F). This means it will start to soften and may deform if allowed to get near that temperature. It is advisable to avoid exposing the microscope to temperatures in excess of 40 °C (104 °F).

Under no circumstances should the scope or the plastic parts of any module be placed on or near a room heater or radiator (e.g. to dry off if it gets wet or for any other reason).

Avoid keeping the scope or the plastic parts of any module in a vehicle on a sunny day or in a transparent closed cabinet exposed to the sun.

Moisture and condensation

The 3D printed parts are made of PLA plastic which can withstand moisture by water and many solvents but it is not completely solid or waterproof meaning that if submerged or exposed to excessive wetness that liquid might find its way into the air cells inside the plastic parts and take a long time to evaporate. Furthermore PLA plastic is biodegradable so having aqueous solutions stagnating inside its components could hasten degradation (although noticeable effects may take several years).

For these reasons please protect your components from the rain and do not immerse the parts in liquid. The correct use of immersion oil is fine but the oil must be removed after use with absorbent tissue and do not use excessive oil.

Motor care

Avoid using any voltage higher than the rated voltage for a motor or it may overheat, catch fire, cause burns injuries and / or permanently damage plastic attachments.

It is OK to rotate the motor gear by hand so long as the motor coils are not energised. Do not turn the motor gear by hand if the coils are energised because this may damage the gears in the motor as well as loosen the attachment of the 3D printed gear spindle to the motor.

Disposal and Recycling

The metal fixings are made of steel (either stainless steel or galvanised steel).

The 3D printed plastic parts are made with poly-lactic acid (PLA) plastic. The following advice is current as of 2021. Consult your local authorities for the latest situation.

Recycling of PLA Plastic in the UK

Most councils in the UK do not accept PLA plastic in green or food waste.

PLA can be recycled but only by a very few specialist facilities. Most councils in the UK will not accept PLA plastic in their recycle bin waste.

PLA should therefore be disposed of in general household waste or sent to a specific facility that will accept it for recycling. Those with the ability to do so may also grind used PLA and reform it into usable 3D printer filament.

Recycling of PLA Plastic outside the UK

Please consult with your local authorities for recycling advice.

Electronics

The motor and electronic connectors should only be disposed of in specialist electronic and electrical recycling facilities. Do not dispose of them as normal household waste or general recycling waste.

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