

ABYSSEXPLORER PROCESS ROUTER

Base

Process	Machine/Tool/Software	Comments
Cut the base main contour	CNC Router (ShopBot PRSalpha 96-48)	Use ¾" plywood. Follow ShopBot setup manual from the Machine Shop website. Import .dxf file into PartWorks and generate the toolpath. Zero Z-axis to ¾". Cut using a ¾" straight bit at 0.2 in/s feed rate.
Sand the outer and inner perimeter	Belt sander or spindle sander	Smooth rough edges on outer and inner cuts.
Drill holes for PLA leg inserts	Handheld drill with 5/32" drill bit.	Mark four holes aligned with the PLA legs mounting position along each of the two flat sides of the base. These align with the mounting points for the adjustable feet.
Install 3/16" threaded inserts	Allen key	Align the insert over the hole and hand-screw it in using a hex driver. Ensure the insert sits flush with the surface.
Drill holes for swivel foot inserts	Handheld drill with ¼" drill bit	Mark six equally spaced positions on the circular perimeter. Drill perpendicular to the surface.
Install M8 threaded inserts	Allen key.	Use a hex driver to install each M8 insert in the drilled holes. Ensure the insert sits flush with the surface.
Sand the inserts' area and surface chips	Handheld electric sander, 120 grit	Lightly sand around each insert to remove any raised edges or splintering caused by drilling or screwing.
Stain base	Brush, red walnut stain	Apply an even coat to all base surfaces. Allow to dry 24 hours before further handling. <i>Use appropriate PPE - wear an OV mask.</i>

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Legs

Process	Machine/Tool/Software	Comments
Convert .SLDPRT file to .stl file	Solidworks	Open the leg.SLDPRT file in SolidWorks and save it as a .stl file.
Layout and slicing	Orca Slicer (or equivalent slicer software)	Open two copies of the leg.stl file in Orca Slicer. Set the bottom of the legs to the build plate. Align the legs on the build plate (two prints may be needed if there is not enough space). The following print settings should be used: 1. Wall loops = 4 2. Supports = On 3. Support Type = Tree 4. Sparse Infill Density = 45% 5. Sparse Infill Pattern = Cubic 6. Layer thickness = 0.2mm Set temperature, nozzle, and other settings according to your printer and type of PLA. Slice the plate.
Printing	FDM 3D Printer (at least 9"x9"x9" build volume)	Send the G-code file to the printer and print using PLA.
Remove supports	Pliers	Carefully remove all tree supports from the legs.

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Axle

Process	Machine/Tool/Software	Comments
Face ends and cut to length	Cold saw or horizontal band saw and lathe with HSS tool	Cut off a small slice from one end of the steel rod to provide a roughly square surface. Face the rod to length.
Fixture rod in the lathe	Lathe, steady rest, fine tip marker, center drill	Fix the rod in the lathe with the steady rest. Insert the marker into the drill chuck on the lathe to draw circles on the end of the stock axle. Use these circles to adjust the steady rest in order to center the rod. Once the marker only draws a dot, use the centring drill's fine tip to make fine adjustments by eye.
Drill the rotary encoder hole	Lathe, center drill, drill bit	Drill the hole in one end of the stock according to the axle drawing. Go slowly and use lots of cutting fluid and lubricant, as the steel will heat up.
Fixture rod in mill	Mill, machinist's jacks, toe clamps, hex collet block, parallel	Place the rod inside a collet in the hex collet block and rest on a parallel in the vice with the rotary encoder hole end sticking out around 2 inches. Support each end of the rod with a machinist's jack. On the long end, use a toe clamp.
Drill set screw hole	Mill, drill chuck, center drill, drill bit	First, use the center drill to start the hole. Drill until the rotary encoder hole is reached.
Tap set screw hole	Mill, tap with handle and guide	Tap the set screw hole for a 6-32 set screw
Refix the rod in the mill	Mill, machinist's jacks, toe clamps, hex collet block, parallel	Repeat the fixturing step above, but switch the rod around. The new end should stick out around 3 inches.

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Mill flats for the handle	Mill, end mill	Mill each flat in passes, making sure to use lubricant. After milling along the rod, mill perpendicular to the rod at the end of the flat to make a right angle with the rest of the rod. Refix the part for each face as described above.
Deburr	Disk sander, grinding wheel, deburring tool	Use the disk sander and the grinding wheel to remove any burrs or sharp edges from the flats. Use the deburring tool to remove burrs from the rotary encoder hole.

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Spool Adapter

Process	Machine/Tool/Software	Comments
Convert .SLDPRT file to .stl file	SolidWorks	Open the spoolAdapter.SLDPRRT and spoolEndCap.SLDPRRT files in SolidWorks and save them as .stl files.
Layout and slicing	Orca Slicer (or equivalent slicer software)	Open the two .stl files in Orca Slicer. Orient the parts to avoid any supports. Arrange the parts on the build plate. The following settings should be used: 1. Sparse infill density = 30% 2. Layer thickness = 0.2mm 3. Wall loops = 4 Set temperature, nozzle, and other settings according to your printer and type of PLA. Slice the plate.
Printing	FDM 3D Printer	Send the G-code file to the printer and print using PLA.

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Rotary Encoder and Electronics Assemblies

Process	Machine/Tool/Software	Comments
Convert .SLDPRT file to .stl file	Solidworks	Open the rotaryHolder.SLDPRT file in SolidWorks and save it as a .stl file.
Layout and slicing	Orca Slicer (or equivalent slicer software)	Open the .stl file in Orca Slicer. Orient the part to avoid any supports. Arrange the part on the build plate. The following settings should be used: 1. Sparse infill density = 30% 2. Layer thickness = 0.2mm 3. Wall loops = 4 Set temperature, nozzle, and other settings according to your printer and type of PLA. Slice the plate.
Printing	FDM 3D Printer	Send the G-code file to the printer and print using PLA.
Mount the rotary encoder	Screw driver	Mount the rotary encoder into the 3D printed part using the provided screws, washers, and lock washers that come with the rotary encoder.
Solder header pins	Soldering iron, flux	Solder male header pins onto the Raspberry Pi Pico, OLED display, and logic level converter.
Prepare rotary encoder wires	Crimping tool	Crimp male Dupont connectors onto the ends of the four wires from the rotary encoder.
Wiring	Breadboard	Use Dupont jumper cables to wire the components on a breadboard according to

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		Figure 1 below. Note that a perf board or custom PCB could be used for a more permanent and durable solution.
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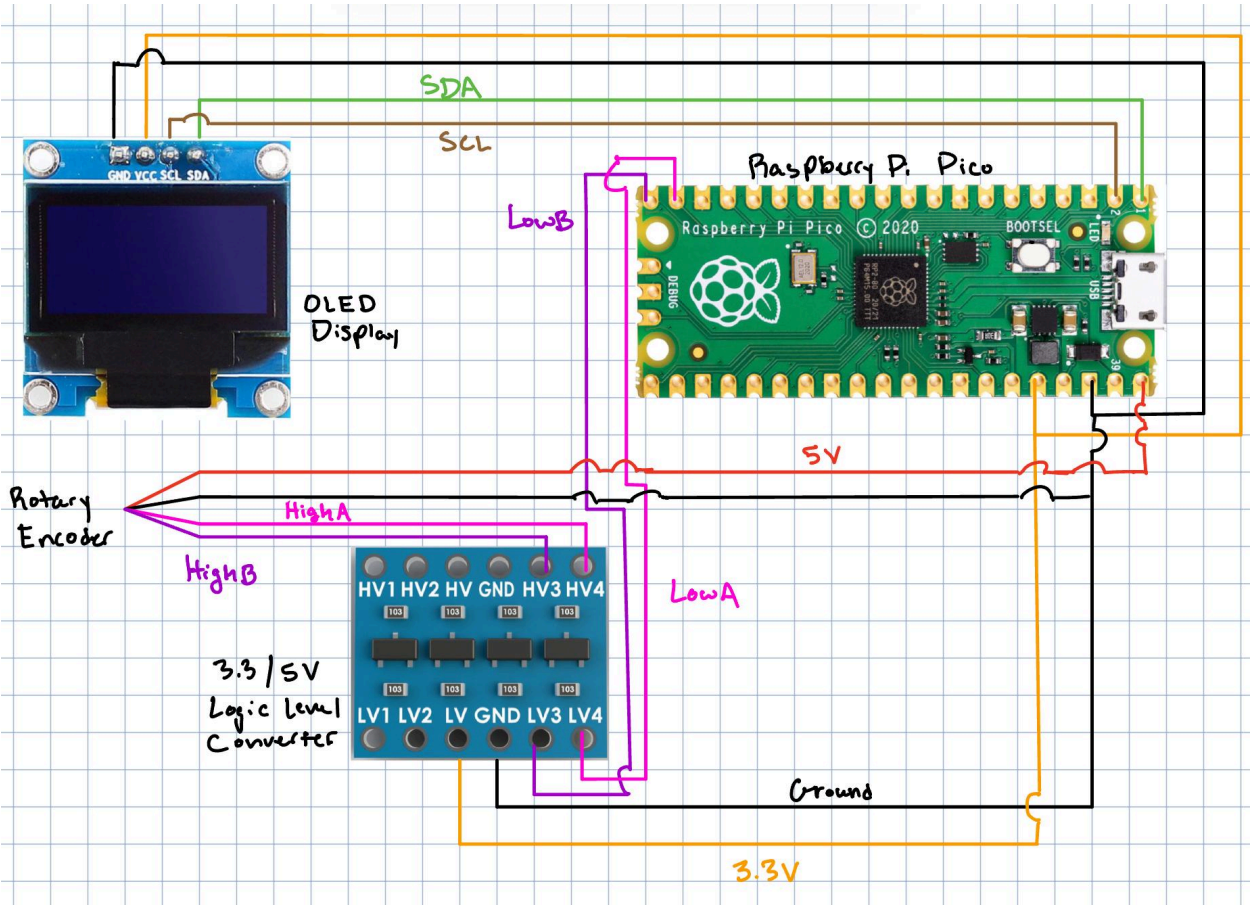


Figure 1: Wiring Diagram

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Payload (includes windows, attaching to cable)

Process	Machine/Tool/Software	Comments
Convert .SLDPRT files to .stl files	Solidworks	Open the payloadTop.SLDPRT file in SolidWorks and save it as a .stl file. Open the payloadBottom.SLDPRT file in SolidWorks and save it as a .stl file.
Layout and slicing	Orca Slicer (or equivalent slicer software)	Open one of each file in a new project in Orca Slicer. Arrange them on the build plate so they both fit without collisions (two separate prints may be needed if there is not enough space). The following print settings should be used: 1. Wall loops = 2 2. Supports = On 3. Support Type = Tree 4. Support Overhang Angle = 45° 5. Sparse Infill Density = 15% 6. Sparse Infill Pattern = Triangles 7. Layer thickness = 0.2mm Set temperature, nozzle, and other settings according to your printer and type of TPU 95A. Slice the plate and export as a .gcode file.
Print the payload top and bottom	FDM 3D Printer (at least 5.8" x 5.8" x 8.5" build volume)	Send the .gcode file to the printer and print using TPU 95A.
Remove supports	Pliers	Carefully remove all tree supports from the legs. Do not let the main print layers rip.

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Cut acrylic windows	CO2 Laser Cutter	Make a 3.529in diameter circle and a 1.4in length square in the laser cutter software. The following settings should be used: 1. Power = 100 2. Speed = 20 3. Current = 50 Place a clear acrylic sheet in the laser cutter and focus the laser. Run the laser cutter.
Attach the windows to the bottom payload piece	2-part Countertop Epoxy (or equivalent)	Prepare the epoxy according to the manufacturer's instructions. Spread a thin layer on the window sides and place them within their respective cutouts on the payload.
Smooth the payload's outside	2-part Countertop Epoxy (or equivalent)	Prepare the epoxy according to the manufacturer's instructions. Spread a thin layer all around the outside of the payload. Do not coat the locking mechanism with epoxy. Once fully cured, cut off any dried blobs with a knife.

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Handle

Process	Machine/Tool/Software	Comments
Convert .SLDPRT file to .stl file	Solidworks	Open the handle.SLDPRT file in SolidWorks and save it as a .stl file.
Layout and slicing	Orca Slicer (or equivalent slicer software)	Open the .stl file in Orca Slicer. Orient the part to avoid any supports. Arrange the part on the build plate. The following settings should be used: 1. Sparse infill density = 30% 2. Layer thickness = 0.2mm 3. Wall loops = 4 Set temperature, nozzle, and other settings according to your printer and type of PLA. Slice the plate.
Printing	FDM 3D Printer	Send the G-code file to the printer and print using PLA.

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Final Assembly

Process	Tool/Part/Fastener	Comments
Attach adjustable feet to the base	Adjustable feet, M8 nuts, base, level	Thread the adjustable feet into the M8 inserts around the base. Adjust the feet to make the base flat by using a level. Tighten the nuts on top of the base to secure.
Attach legs to the base	Legs, base, 3/16" x 1" screws.	Insert the screws through the holes at the bottom of the legs and thread them through the inserts in the base. Tighten to secure. Make sure the bearing attachment holes at the top of the legs are aligned as seen in the assembly.
Prepare axle assembly parts for epoxy	Steel rod, spool adapter, spool end cap, 100-grit sandpaper, sandblaster, 100% acetone, >90% Isopropyl alcohol, clean microfiber rags	Sandblast the region where the spool adapter will contact the rod. Wipe the rod with acetone and let it dry. Lightly sand all points of contact on 3D-printed pieces. Wipe 3D-printed parts with isopropyl alcohol and let them dry.
Epoxy the axle assembly	Steel rod, spool adapter, spool end cap, cable spool, clean microfiber rags, epoxy, clean brush, marker, rubber mallet	Mark the length of the steel rod where the cable spool will sit. Spread epoxy on the outer diameter and inner face of the spool adapter and slide it into the spool. Spread epoxy on one face of the spool end cap and attach to the protruding section of the spool adapter on the cable spool's other face. Spread epoxy on the inner portion of the spool adapter and on the outer portion of the steel rod that will contact the spool adapter. Slide the rod through and align the spool with the marks on the rod. Use the mallet to position parts if

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		necessary. Leave to cure according to epoxy instructions.
Slide bearings on the axle assembly	Axle assembly (steel rod, spool adapter, spool end cap, and cable spool), pillow block bearings, rubber mallet, marker	Mark where the bearings should sit on the rod. Slide the bearings onto the rod and use the mallet to position them correctly.
Insert the rotary encoder shaft into the axle assembly	Rotary encoder assembly, axle assembly, rubber mallet, 6-32 x 0.25in set screw, allen key	Insert the rotary encoder shaft into the rotary encoder hole on the axle. Tap with a mallet lightly if needed. Secure with set screw.
Secure the axle assembly to the legs	Connected axle and rotary encoder assemblies, 7/16 SAE flat washers, #14 x 1" machine screws, screwdriver	Align the pillow block bearings with the holes on the top of the legs. Secure with screws and washers into the legs.
Secure electronics	Electronics assembly, duct tape	Remove the sticky backing from the breadboard and attach it to the top of the base. Tape down the rotary encoder cable
Attach handle	Handle, rest of assembly	Slide the handle onto the trapezoid shape protruding from one end of the axle
Connect payload	Payload assembly, rest of assembly, wire crimps, crimping tool	Slide the cable through the holes on the top of the payload. Secure the wire to itself using five crimps.
Power electronics	Battery with 5V output, USB A to Micro USB cable, duct tape	Plug the battery into the Raspberry Pi Pico and secure the cable and battery to the base with tape. The assembly is now complete.