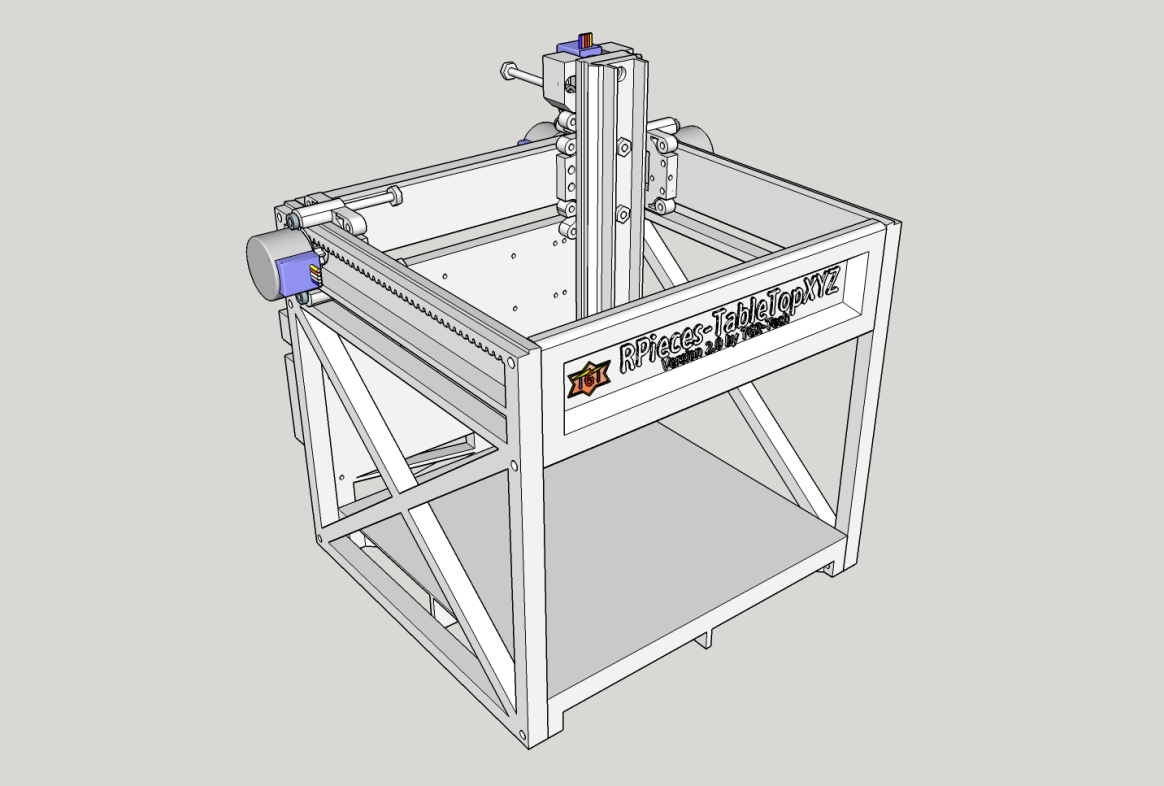
RPieces - TableTopXYZ

User and Assembly Manual

For Version 2.0

Written By: TGit-Tech (03/2018)



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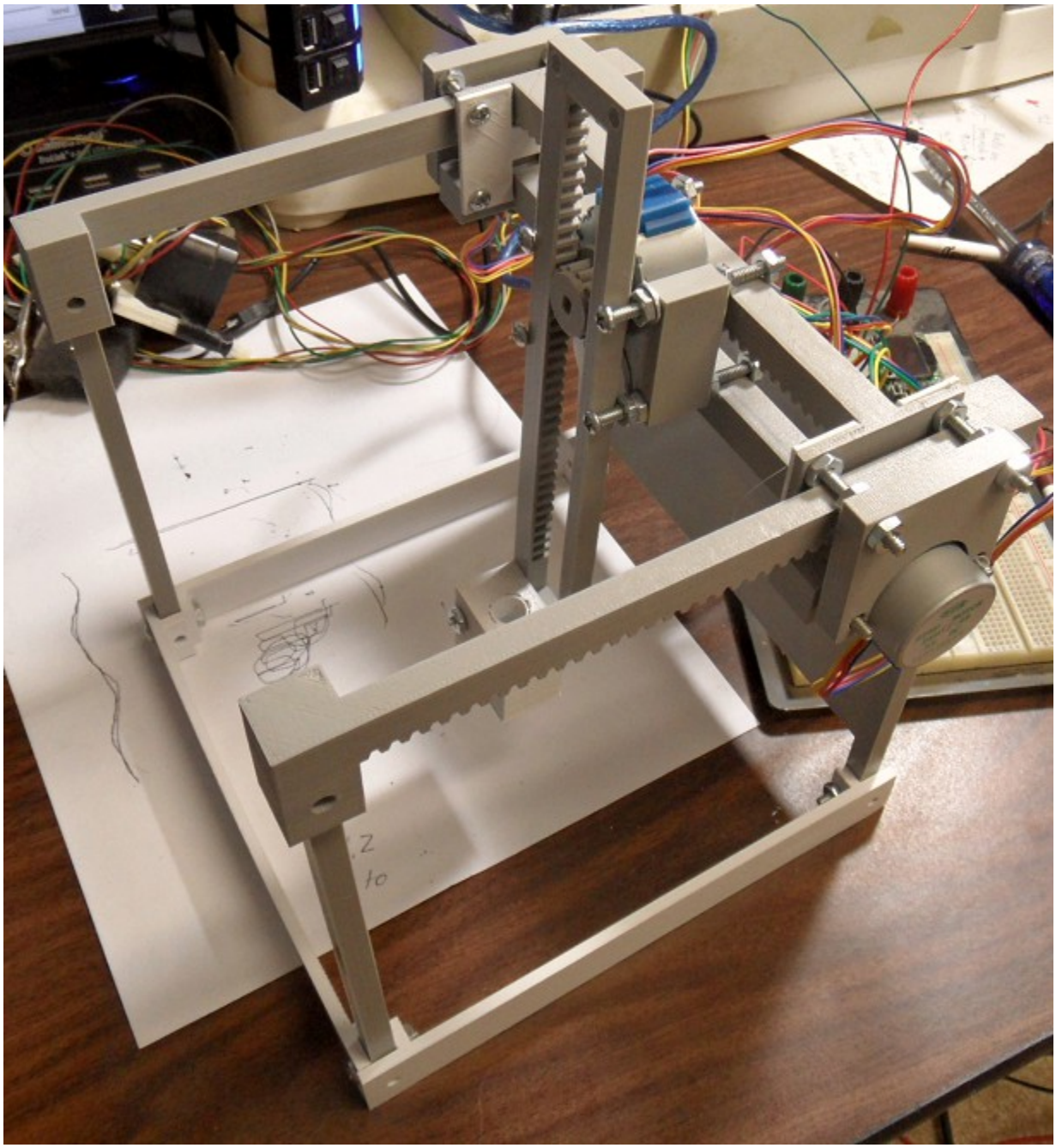
1. INTRODUCTION

The "***RPieces – TableTopXYZ"*** project's goal is to provide a simple and almost entirely printable motion frame for various usages. Possibly including 3d printing, plotting and minor milling. The platform can also be used in testing software, firmware or just testing model-creation on a physical unit before sending it to a much larger commercial unit.

The project is Open Source and Resides at: https://github.com/TGit-Tech/RPieces-TableTopXYZ
This documentation resides at: https://github.com/TGit-Tech/RPieces-TableTopXYZ/tree/master/docs



2. BILL OF MATERIALS - $33.93

2.1 Tools (N/A)

The following tools are required to build the project components

- ✓ 3D-Printer (With a 185mm x 185mm or larger XY Build Envelope)
- ✓ Phillips head screw driver and 5/16 nut driver or wrench

2.2 Power Supply ($2.15)

Illustration 1: 5Vdc Adapter

- ✓ (1) 5Vdc (Possibly up to 7Vdc – I'm using a 6Vdc 700mA) Power Adapter @ 400mA or greater ($2.15)
  - ○ https://www.aliexpress.com/item/1pcs-Universal-for-IC-Power-Adapter-AC-Charger-5V-2A-DC-2-5mm-US-for-Android/32581666097.html

2.3 Electronic Control ($18.45)

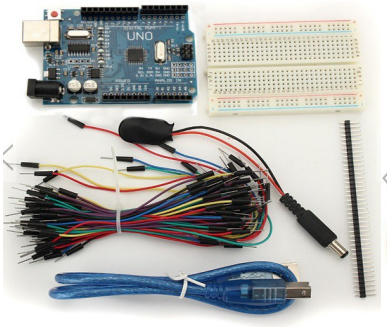


Illustration 2: (2) Arduino UNO R3

Illustration 3: LCD Keypad Shield

Illustration 4: M-F 20cm Dupont

- ✓ (1) UNO R3 or NANO Atmega328P Module, Mini Breadboard & Jumpers ($6.95/ea)
  - ○ https://www.aliexpress.com/item/Starter-Kit-for-Uno-R3-Bundle-of-5-Items-Uno-R3-Breadboard-Jumper-Wires-USB-Cable/32813470187.html

- ✓ (4) 28BYJ-48 5V DC Step Motor with ULN2003 Driver Board ($9.90/per5)
  - ○ https://www.aliexpress.com/item/NEW-5pcs-lot-Gear-Stepper-Motor-28BYJ-48-DC-5V-ULN2003-Driver-Test-Module-Board-For/32826285578.html
  - ○ Resources
    - ▪ 28BYJ Data-sheet http://www.sensors.co.nz/datasheet/28BYJ-48%20Stepper%20Motor.pdf
    - ▪ ULN2003 Data-sheet http://www.ti.com/lit/ds/symlink/uln2003a.pdf

- ✓ (~40) 20 cm Male to Female DuPont Jumpers ($1.60)
  - ○ https://www.aliexpress.com/item/Dupont-line-40pcs-20cm-male-to-female-jumper-wire-Banana-pro-Dupont-cable-support-Raspberry-pi/32393258299.html

2.4 3D Parts & Fasteners ($13.33)

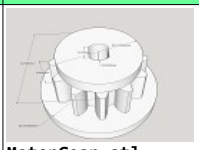
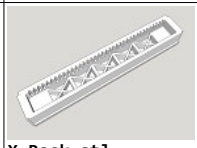
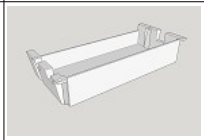
Below is the list of the Parts that need to be printed with a 3D-Printer in the order of assembly; so you can print them in the order shown and assemble them as they finish. Default printer settings are below; but check the per-part details below for any part-specific setting if one may exist .

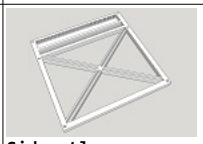
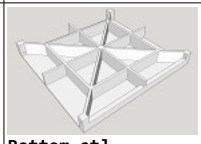
- ✓ Parts were printed on an Anet A8 3D-Printer using Cura with the following settings
  - ○ Layer Height = 0.2

- Shell Thickness = 1.6
- Fill Density = 100%
- Print Speed = 60
- Support = None

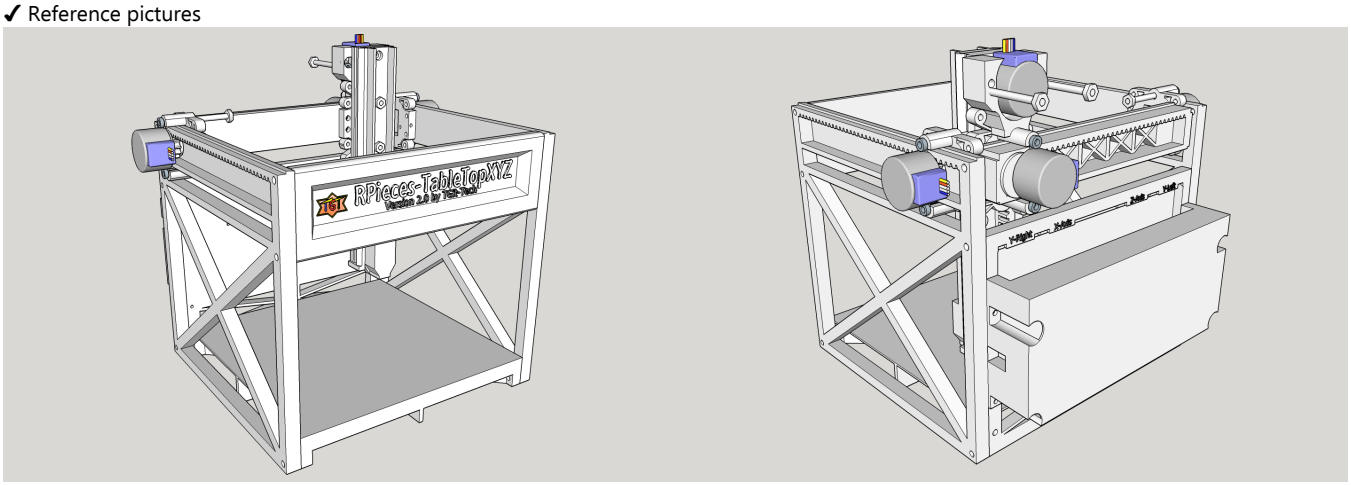
✓ Suggestions

- Bed leveling is extra important with any Rack-Gear containing prints -- to ensure a fairly consistent width across the entire tab-out.
- Use hairspray, tape or any preferred method that keeps large prints on the build plate – uneven builds will cause massive faults.
- Parts that hold structure are PLA preferred due to its non-curling and non-flexible (brittle) attributes.
  - I've especially been impressed with iFun and PxMallion for cheap structurally sound PLA filament brands
- Carriage parts are ABS preferred due to their flexible tension-ed slide screws but PLA should work fine.
  - eSun PLA+ filament makes a nice balance between PLA and ABS for such parts.
- Push all stepper motors towards the drive rail before tightening -- to make a snug gear to rail connection (reduces slop).

QTY	Part Picture Part Filename Grams of Filament	Attaches To	Fasteners (!Per-Part!)*QTY	Est. Costs Per-Part PLA Cost @ $15/Kg roll www.boltdepot.com @100-lots	Total Cost
4	 **MotorGear.stl** 3-grams PLA preferred	28BYJ-Motor	N/A – Pressed On	$0.04 Plastic	$0.18
1	 **X-Rack.stl** 58-grams PLA preferred	N/A	N/A See XZ & Y-Carriage	$0.87 Plastic	$0.87
1	 **XZ-Carriage.stl** 30-grams ABS preferred	X-Rack X-Motor Z-Rack Z-Motor	(4)#6 x 3/4” Sheet Metal Screws [$0.02/ea] (2)#6-32 x 1.5” [$0.03/ea] (4)#6-32 x 1/2” [$0.02/ea] (2)#6-32 x 3/4” [$0.02/ea]	$0.45 Plastic $0.26 Fasteners	$0.71
2	 **Y-Carriage.stl** 12-grams ABS preferred	X-Rack Full-Side Y-Motor	(2)#4 x 3/4” Sheet Metal Screws [$0.03/ea] (4)#6-32 x 1/2” Machine Screws [$0.02/ea] (2)#6-32 x 1” Machine Screws [$0.03/ea]	$0.18 Plastic $0.20 Fasteners	$0.76
Assembly Instructions for parts above @ #3.1.XZ-Carriage|outline					
1	 **Back.stl** 109-grams PLA preferred	(4)ULN2003 Arduino (2)Side	(16) #4 x 3/8” Sheet Metal Screws [$0.02/ea] [Optional] – Attaching ULN2003 with screws makes them much more stable but not required. N/A See Side for fasteners	$1.63 Plastic $0.32 Fasteners	$1.95
1	 **BackCover.stl** [!Optional Part!] 54-grams W/Supports!	Back	(4)#4 x 3/8” Sheet Metal Screws [$0.02/ea]	$0.81 Plastic $0.08 Fasteners	$0.89
Assembly Instructions for parts above @ #4.ELECTRONICS|outline					
1	 **Front.stl** 60-grams	(2)Side	N/A See Side for fasteners	$0.90 Plastic $0.08 Fasteners	$0.98

	PLA preferred				
2	 **Side.stl** 115-grams PLA preferred	Back Front Bottom	(2)#6 x 3/4” Sheet Metal Screws [$0.02/ea] (2)#6 x 3/4” Sheet Metal Screws [$0.02/ea] (1)#6 x 3/4” Sheet Metal Screw [$0.02/ea]	$1.72 Plastic $0.12 Fasteners	$3.68
1	 **Bottom.stl** 184-grams PLA preferred	Back (2)Side	(2)#6 x 3/4” Sheet Metal Screws [$0.02/ea] See Side for fasteners	$2.76 Plastic $0.04 Fasteners	$2.80
Assembly Instructions for parts above @ #3.2.Frame|outline					
1	 **Z-Rack.stl** 38-grams PLA preferred 206mm Long (angle)	N/A	N/A See XZ-Carriage	$0.57 Plastic	$0.57

✓ Reference pictures

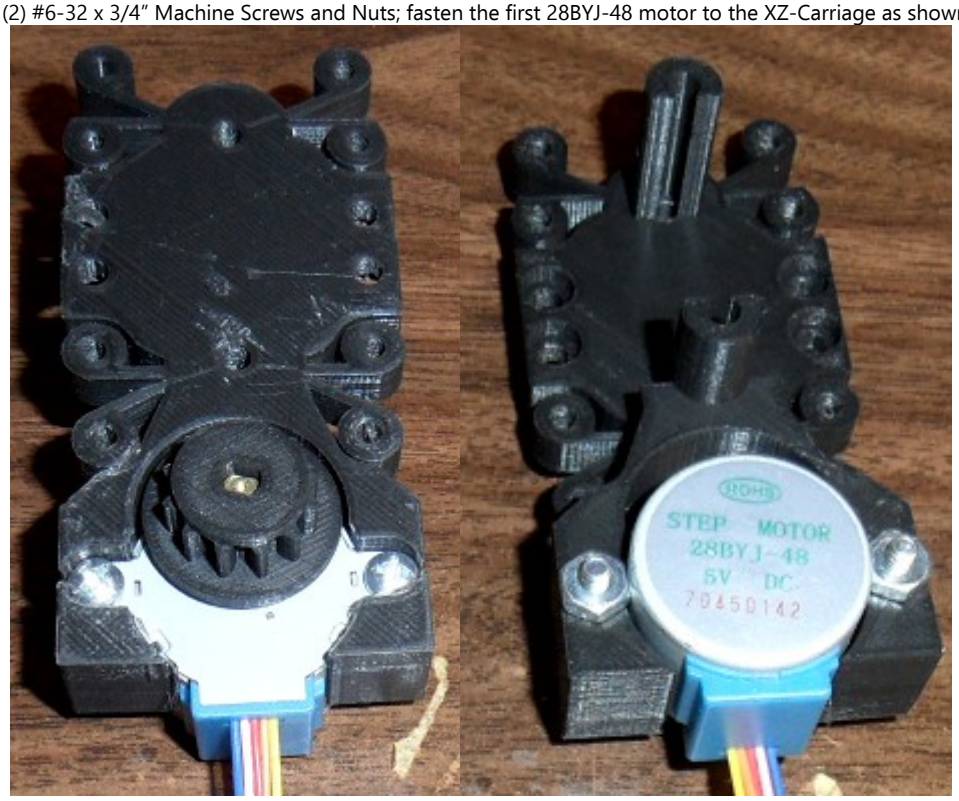


3. HARDWARE ASSEMBLY

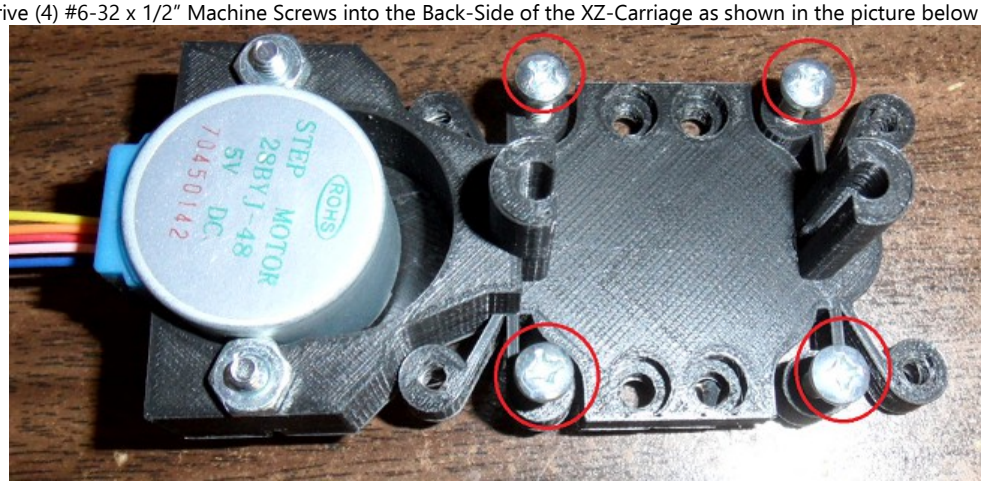
3.1 XZ-Carriage

1. Press (2) MotorGears onto (2) 28BYJ-48 Stepper Motor

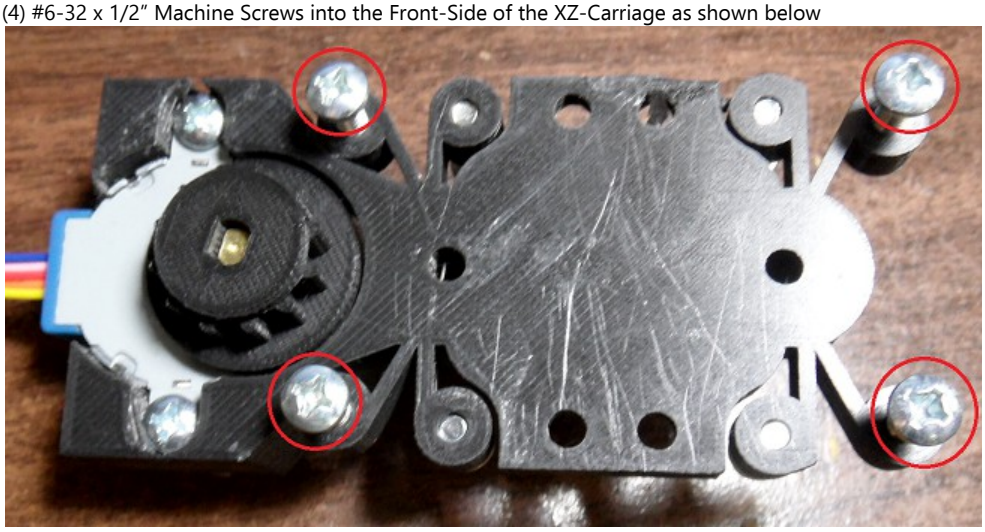
2. Using (2) #6-32 x 3/4" Machine Screws and Nuts; fasten the first 28BYJ-48 motor to the XZ-Carriage as shown below



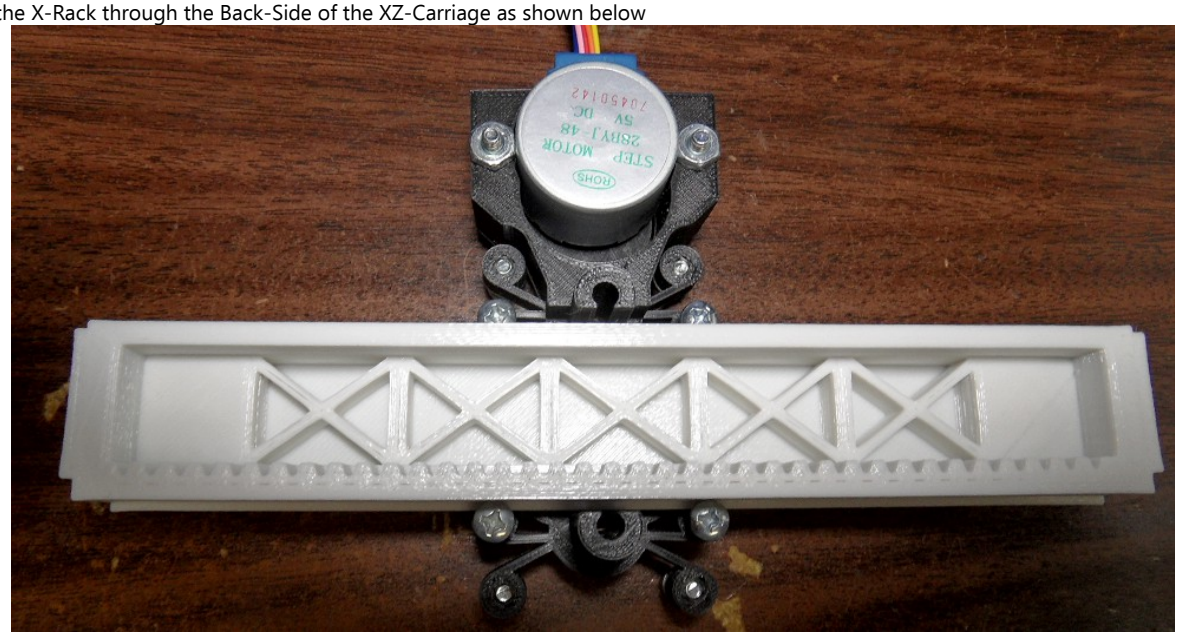
3. Drive (4) #6-32 x 1/2" Machine Screws into the Back-Side of the XZ-Carriage as shown in the picture below



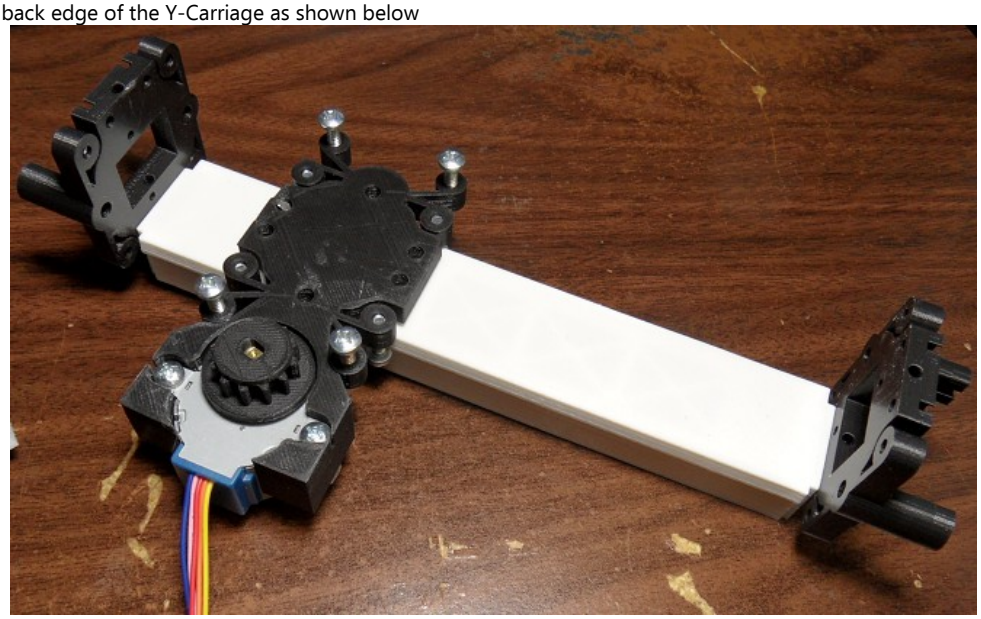
4. Drive (4) #6-32 x 1/2" Machine Screws into the Front-Side of the XZ-Carriage as shown below



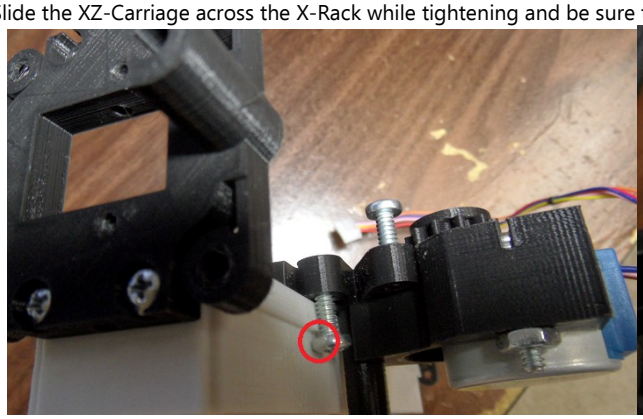
5. Slide the X-Rack through the Back-Side of the XZ-Carriage as shown below

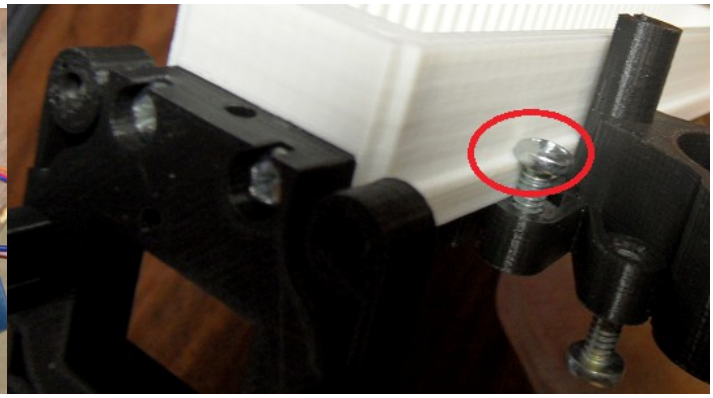


6. Using (4) #6 x 3/4" Sheet Metal Screws; attach (2) Y-Carriages to each end of the X-Rack with motor mounts pointing out and X-Rack hanging off the back edge of the Y-Carriage as shown below

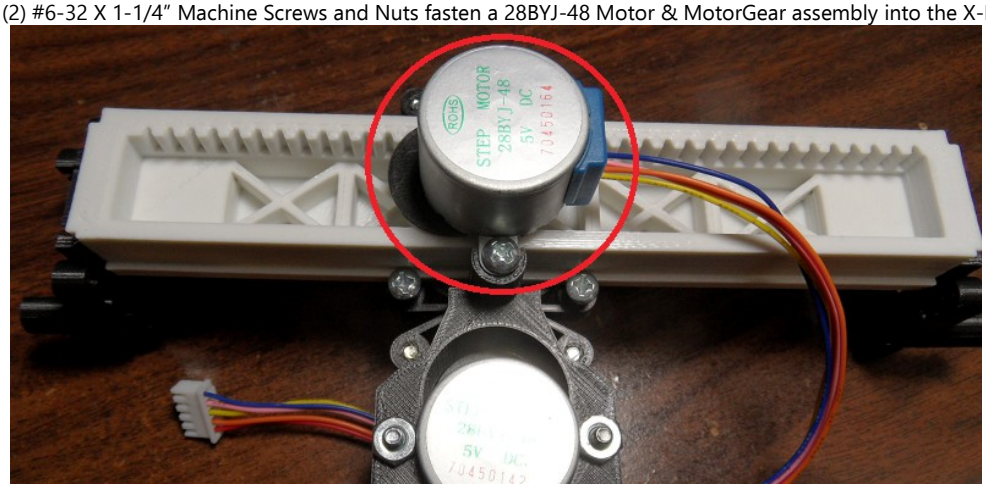


7. Adjust the (4) XZ-Carriage Rack Screws that hold the X-Rack so the screw touches the Tab-Out
   a) Press the X-Rack against the XZ-Carriage to determine how far to tighten
   b) Slide the XZ-Carriage across the X-Rack while tightening and be sure there isn't too much friction





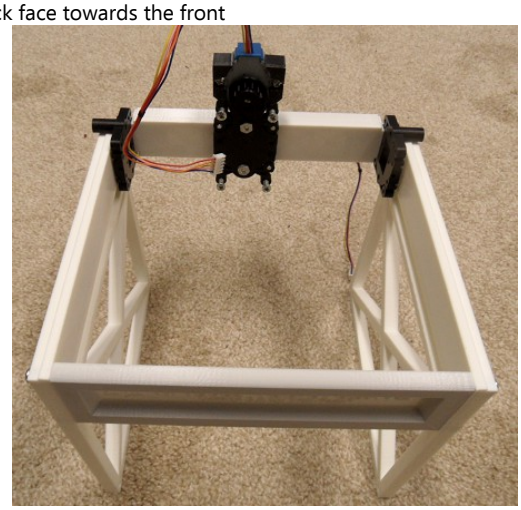
8. Using (2) #6-32 X 1-1/4" Machine Screws and Nuts fasten a 28BYJ-48 Motor & MotorGear assembly into the X-Rack as shown



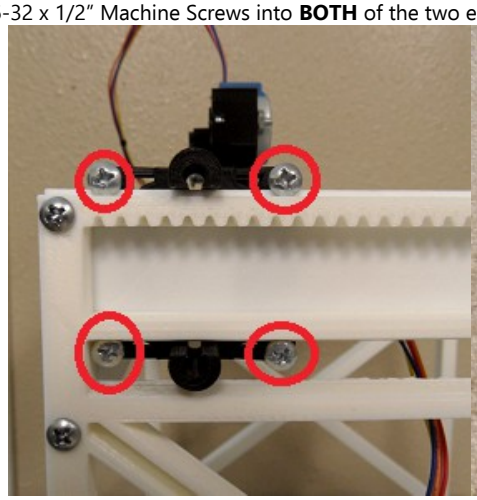
3.2 Frame

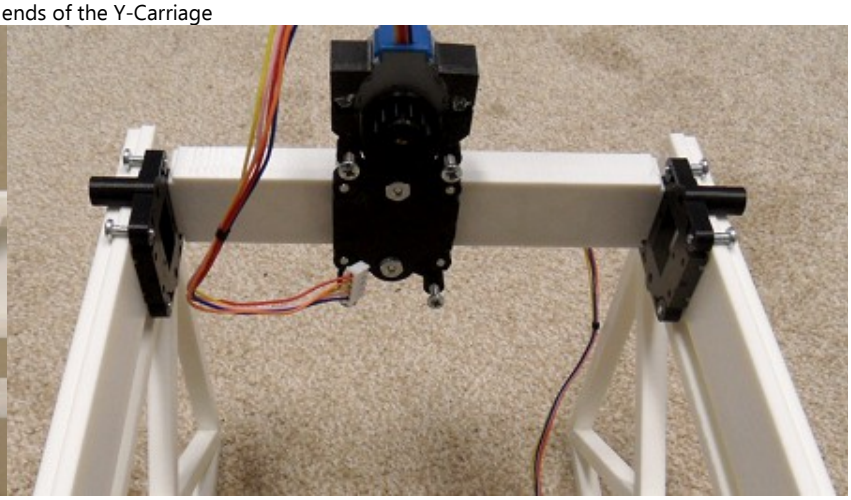
1. Using (4)#6 x 3/4" Sheet Metal Screws; attach the (2) Sides to the Top

2. Insert the XZ-Carriage/X-Rack Assembly into the (2) Sides
   a) Z-Motor facing upwards
   b) X-Rack face towards the front



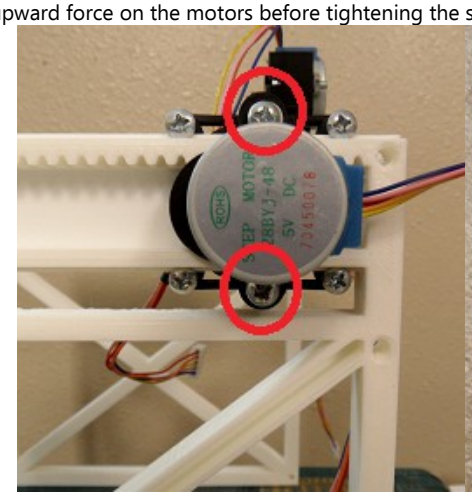
3. Drive (8) #6-32 x 1/2" Machine Screws into **BOTH** of the two ends of the Y-Carriage

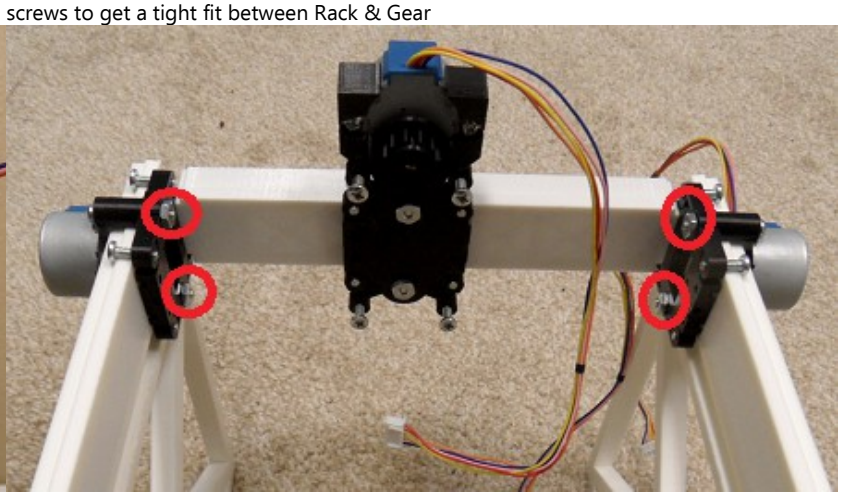




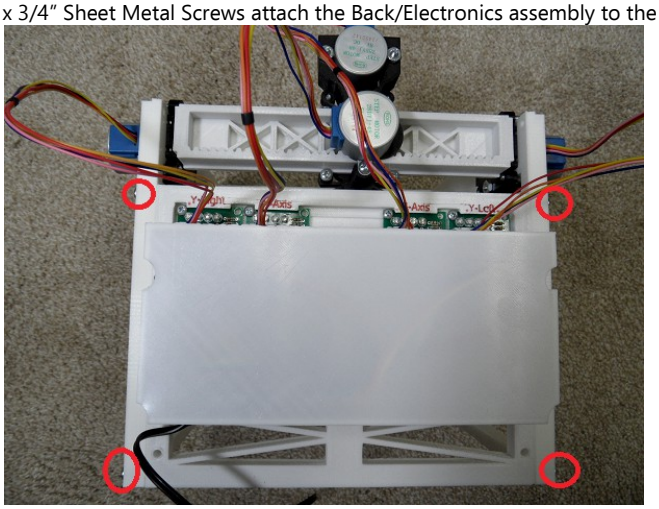
4. Press (2) MotorGear.stl onto (2) 28BYJ-48 Stepper Motors

5. Using (4)#6-32 x 1" Machine Screws and Nuts attach (2) Y-Motors
   a) Motor wires should face the Back-End (End without the Top which has already been attached)
   b) Put upward force on the motors before tightening the screws to get a tight fit between Rack & Gear

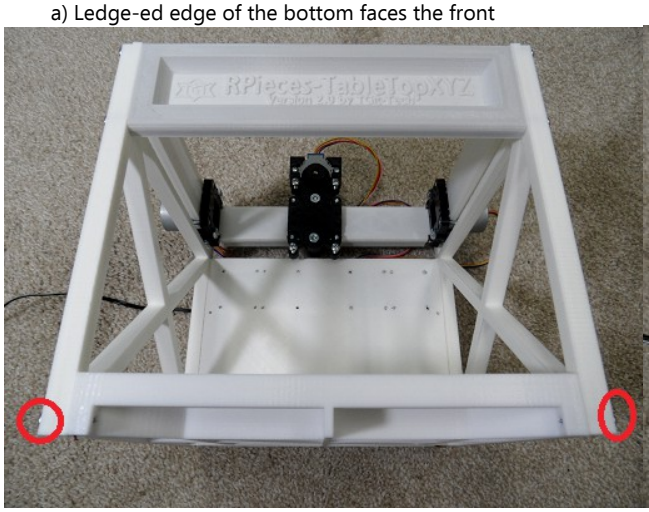


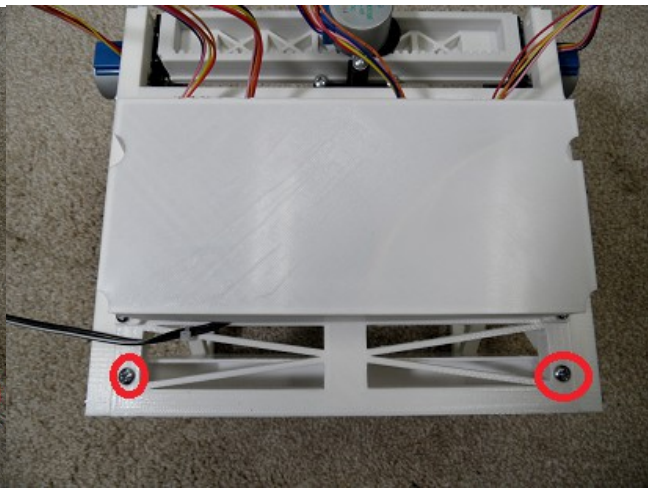


6. Using (4)#6 x 3/4" Sheet Metal Screws attach the Back/Electronics assembly to the Back



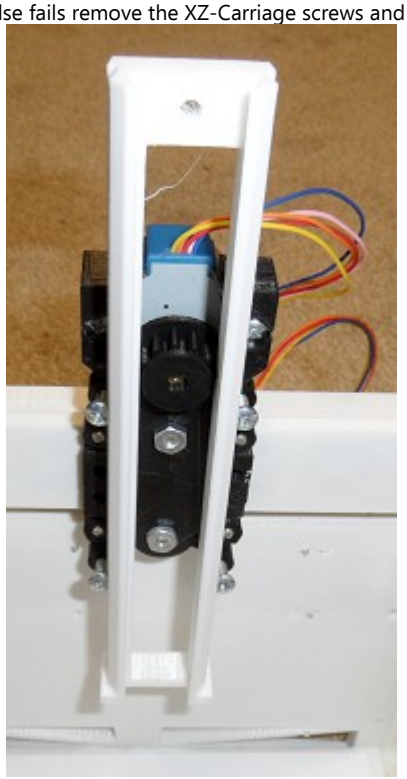
7. Using (4)#6 x 3/4" Sheet Metal Screws attach the Bottom to the sides and the Back
    a) Ledge-ed edge of the bottom faces the front





3.3 Z-Rack & Toolheads

1. Position the Z-Rack to center of the XZ-Carriage and attach
    a) Try pressing, wiggling or spreading the holding screws a little or pinching the Z-Rack
    b) If all else fails remove the XZ-Carriage screws and re-attach them with Z-Rack in place.

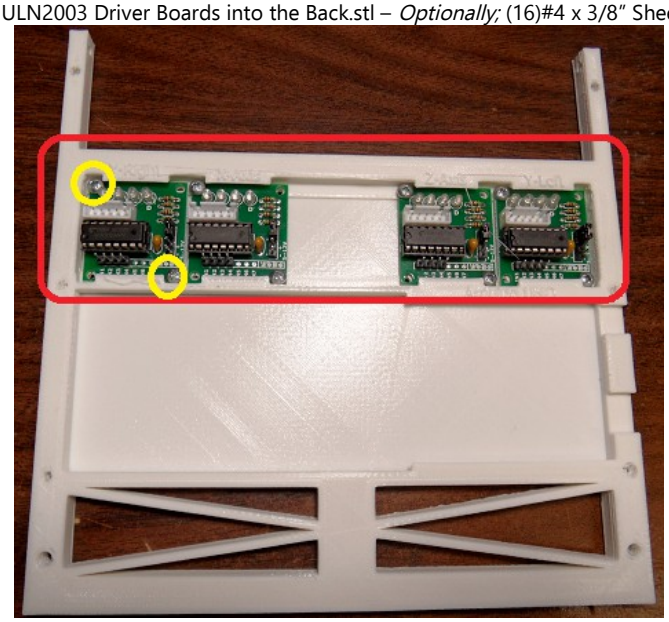


2. Proceed to pick a Tool-Head in section #6.TOOL-HEADS|outline and slide it into the Z-Rack and apply the (1) #6-32 x 1/2" machine screw and nut.

4. ELECTRONICS

4.1 Install Components

1. Install (4) ULN2003 Driver Boards into the Back.stl – *Optionally;* (16)#4 x 3/8" Sheet Metal Screws can be used for stability



2. Install the Arduino and Breadboard
    a) If using Arduino UNO; install the Arduino UNO first then the breadboard
    b) If using Arduino Nano; install breadboard first then the Nano positioned over center towards the top

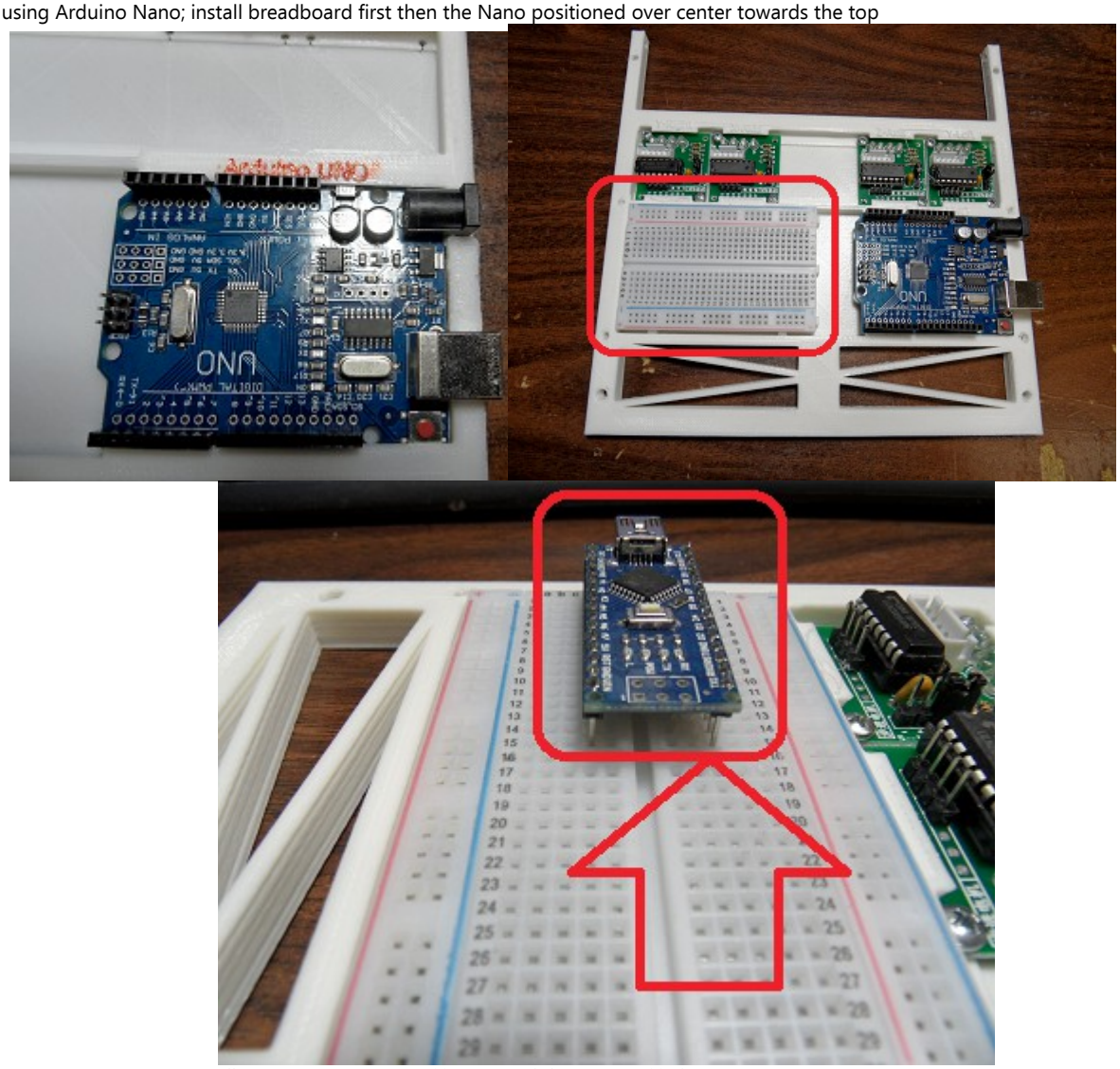
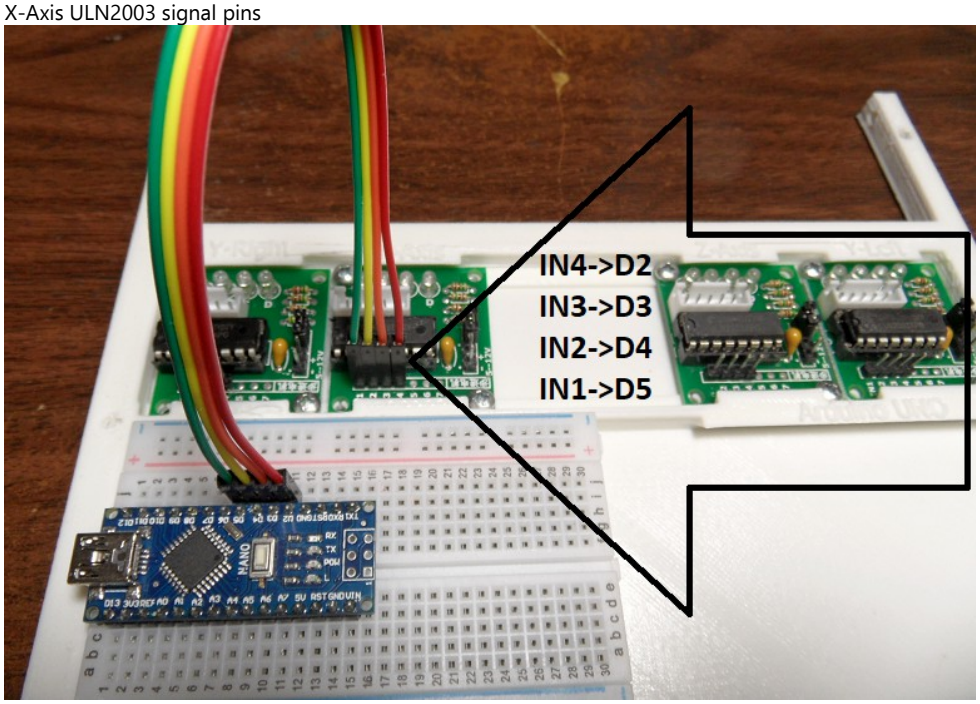


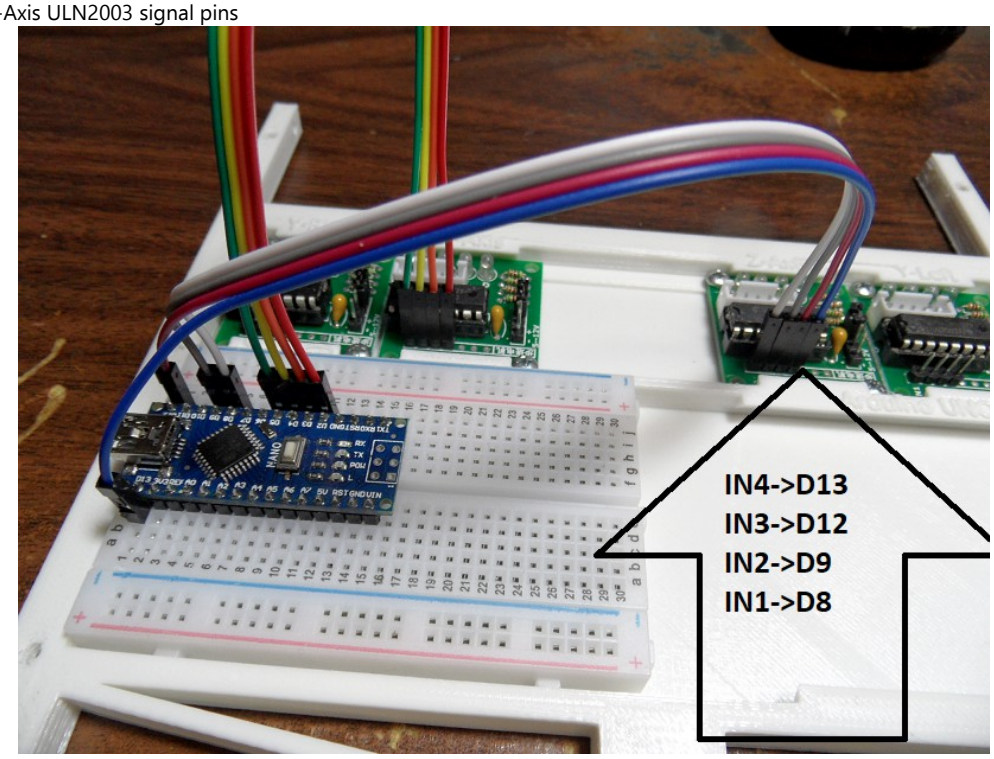
Illustration 5: Position Nano (1) empty row below center & (2) above

4.2 Wiring

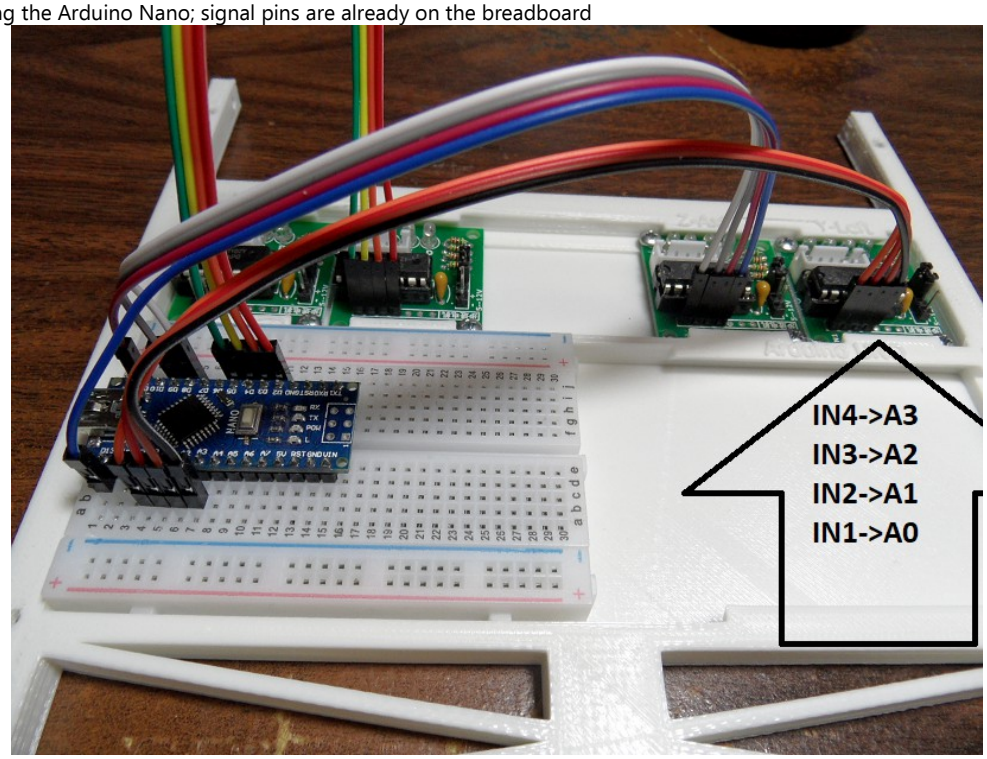
1. Wire up the X-Axis ULN2003 signal pins



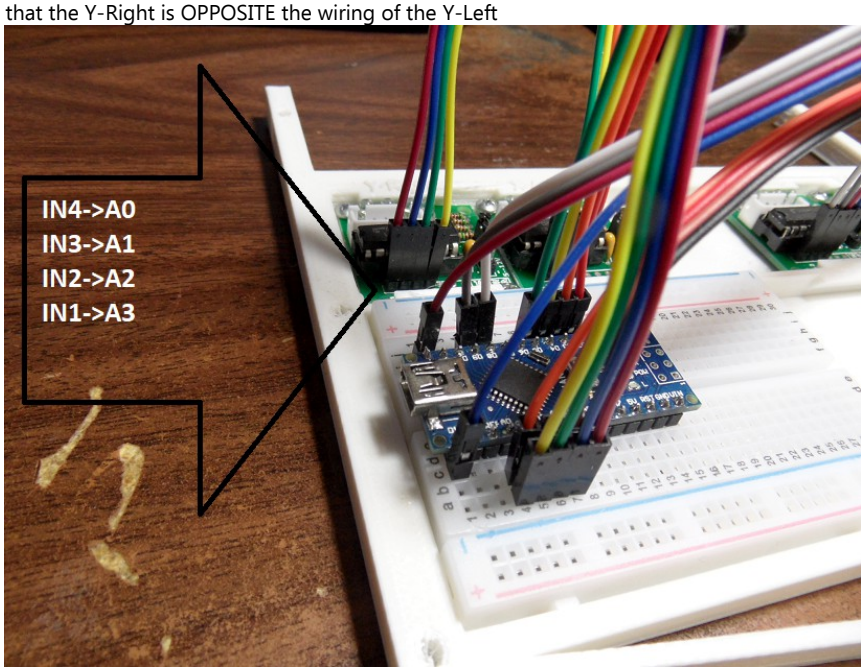
2. Wire up Z-Axis ULN2003 signal pins



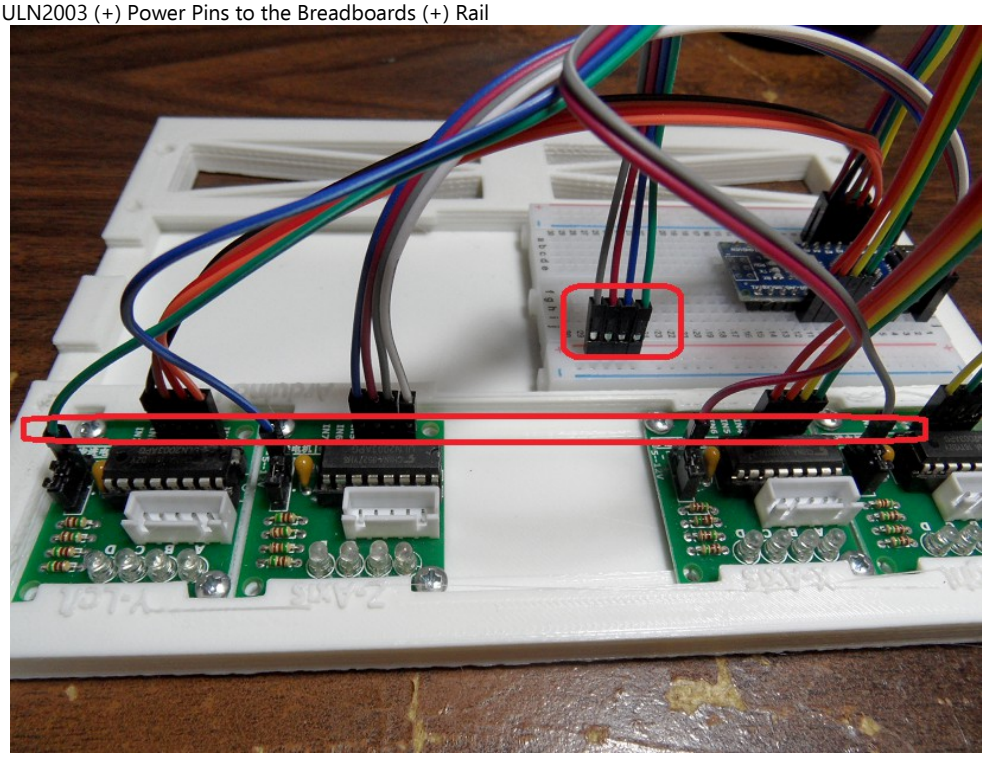
3. Wire up the Y-Left ULN2003 signal pins
    a) If using the Arduino UNO; signals must be jumped to the breadboard first so both Y-Axis's can use the same signals
    b) If using the Arduino Nano; signal pins are already on the breadboard



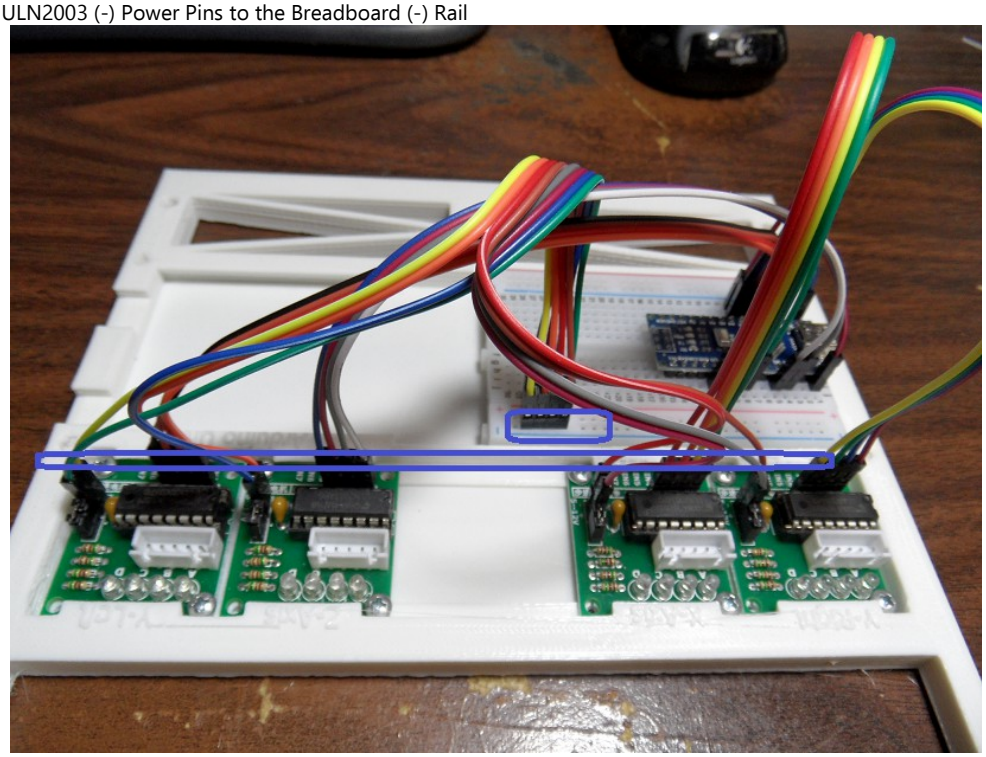
4. Wire up the Y-Right ULN2003 signal pins
    a) Notice that the Y-Right is OPPOSITE the wiring of the Y-Left



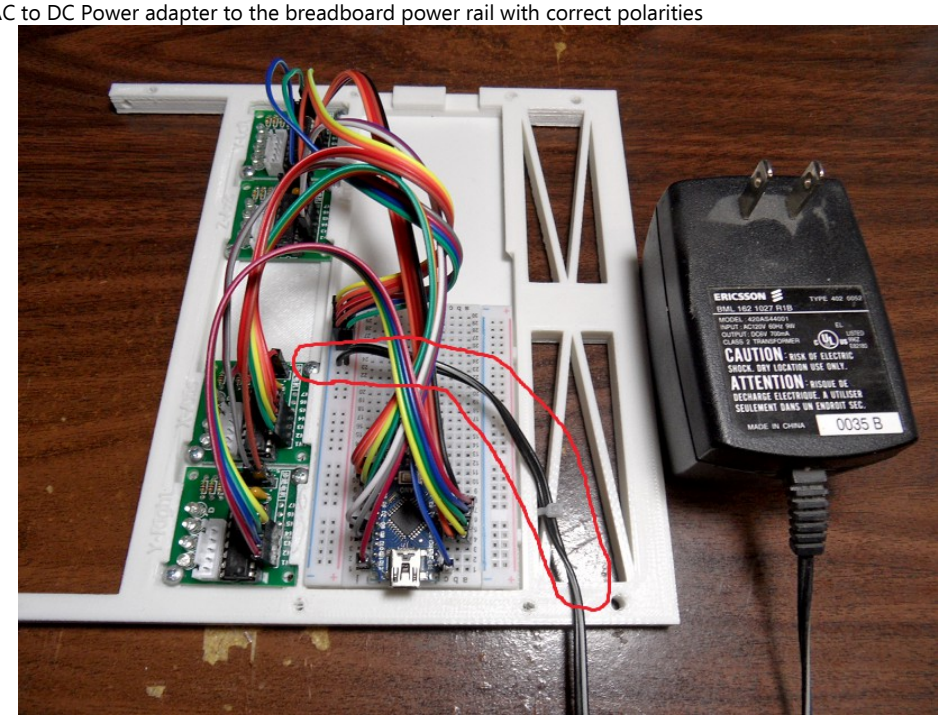
5. Wire all (4) ULN2003 (+) Power Pins to the Breadboards (+) Rail



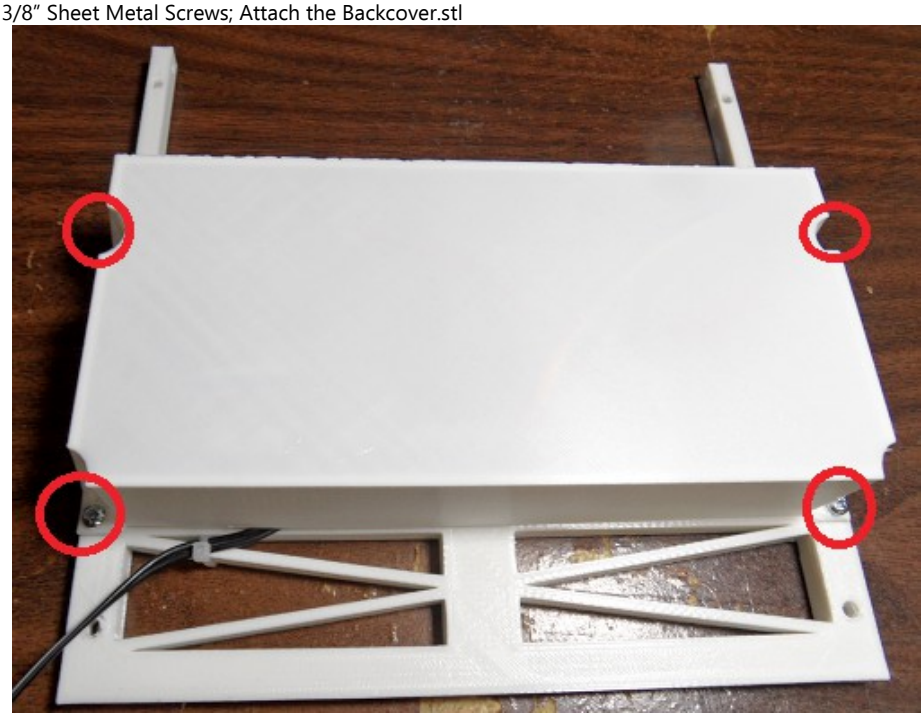
6. Wire all (4) ULN2003 (-) Power Pins to the Breadboard (-) Rail



7. Wire the AC to DC Power adapter to the breadboard power rail with correct polarities



8. Using #6 x 3/8" Sheet Metal Screws; Attach the Backcover.stl



4.3 Wiring Diagram

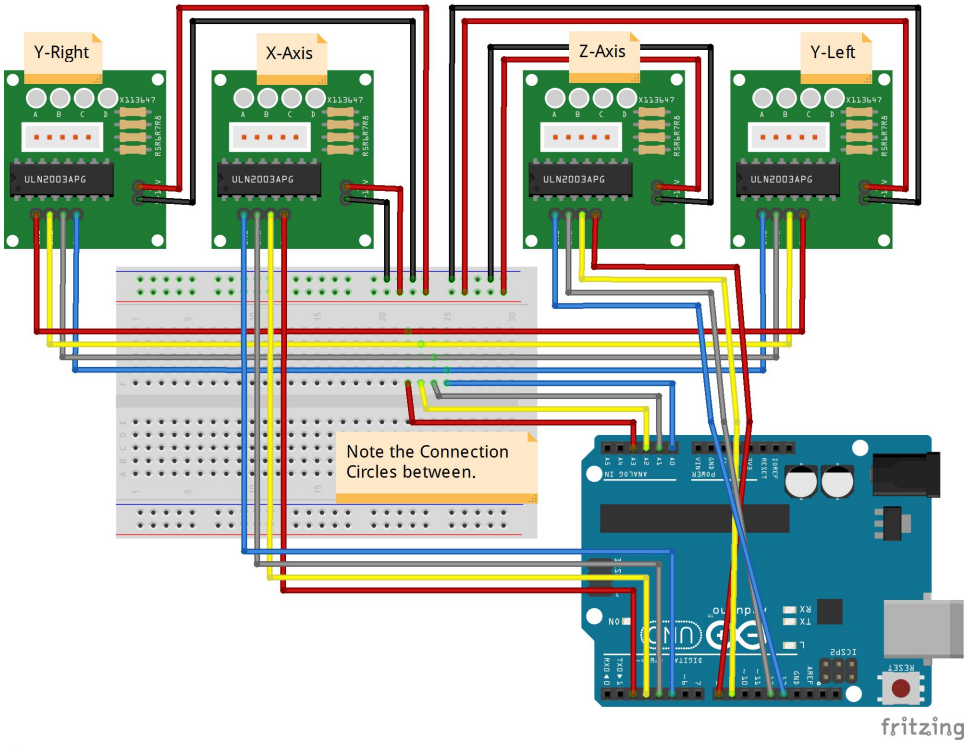


Illustration 6: Wiring Diagram

5. SOFTWARE / FIRMWARE

5.1 Firmware Upload

1. Install Arduino Sketch IDE https://www.arduino.cc/en/Main/Software

2. Install the modified GRB-28BYJ-48 Firmware
   a) In a web-browser; go to https://github.com/tgit23/GRBL-28byj-48
   b) Click on the file GRBL.ZIP
   c) Click on the DOWNLOAD button on the lower-right next to "History" and Save to a place you'll remember – like Documents or Desktop
   d) Run the Arduino Sketch IDE
   e) Choose Menu Item SKETCH → INCLUDE LIBRARY → ADD .ZIP LIBRARY
   f) Select the GRBL.ZIP Library file saved in step 'c' above

3. Upload the Firmware
   a) Inside any running Arduino Sketch IDE
   b) Choose FILE → EXAMPLES → GRBL → GRBLUPLOAD
   c) Select the Port the Arduino UNO is connected to; in Sketch menu TOOLS → PORT
   d) Select the Board; Sketch menu TOOLS → BOARD → ARDUINO/GENUINO UNO
   e) Press the Up-Arrow in the Top-Left Corner to upload the firmware onto the Arduino UNO board

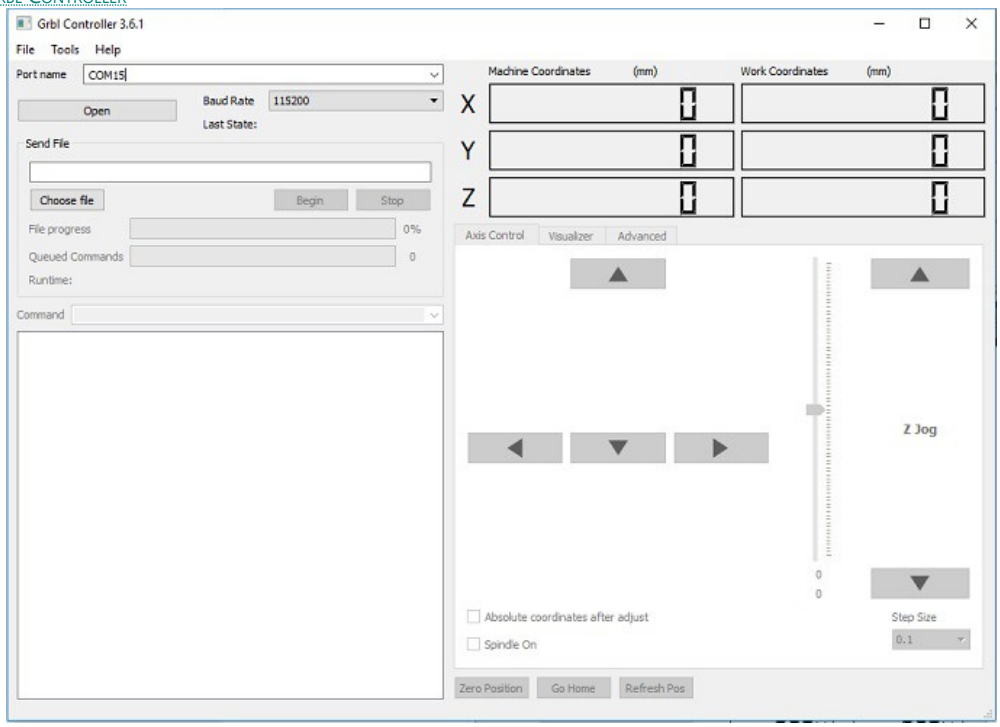
4. Now the unit is ready for operation.

✓ More Information
- GRBL Wiki @ https://github.com/gnea/grbl/wiki
-

5.2 Controller Install / Initial Settings

1. Download and install GRBL CONTROLLER located @ http://zapmaker.org/projects/grbl-controller-3-0/

2. Run GRBL CONTROLLER



3. Pick the Port on which the Arduino UNO is connected and click 'Open'

4. Enter GRBL Settings for the Machine (**First Time Only**)

a) $0=3 ; Step pulse, microseconds
b) $1=1 ; Step idle delay, microseconds (shuts off motors)

c) $100=100 ; X steps/mm
d) $101=100 ; Y steps/mm
e) $102=100 ; Z steps/mm

f) $110=550 ; Max rate X, mm/min
g) $111=550 ; Max rate Y, mm/min
h) $112=550 ; Max rate Z, mm/min

i) $120=100 ; X Acceleration, mm/sec^2
j) $121=100 ; Y Acceleration, mm/sec^2
k) $122=100 ; Z Acceleration, mm/sec^2

GRBL will store these values in the Arduino UNO EEPROM thus retain them during during power off and uploads.

✓ In 3d printer terms the GUI Controller example would be 'pronterface'.

5.3 Running a design file

1. Run GRBL CONTROLLER

2. Pick the Port on which the Arduino UNO (Machine) is connected and click 'Open'

3. On Tab 'Axis Control' select 'Step Size' 10 and then click the up-arrow on Z-Jog.

4. Using the 'Axis Control' to operate the machine motion; position the 'head' at a point that will be represented as coordinate 0,0

5. Click 'Zero Position'

6. Under 'Send File' click 'Choose File' and select the design file (.nc) to run

a) Example files can be gotten @ https://github.com/tgit23/RPieces-TableTopXYZ/tree/master/nc-examples

7. Click 'Begin' to start executing.

5.4 Design Software

Design Software for GRBL often includes the G-Code generator (In 3d printer terms – slic3r).

✓ Common free GRBL design software (the signifying difference being CAM or CAD)
- FreeMill w/ VisualCAM (also free)
- SketchUCam plug-in for Google Sketchup
- pyCam

✓ Milling or drilling PCB
- KiCad
- FlatCAM

6. TOOL-HEADS

6.1 Pilot-Razor-Point-Pen

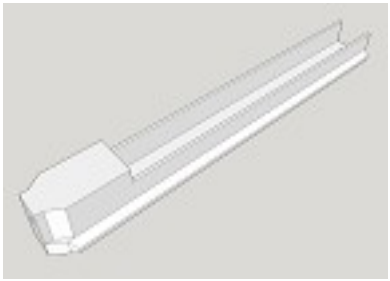


Illustration 7: ToolHead-PilotRazorPointPen.STL

✓ Example of the Pen @ http://www.staples.com/Pilot-Razor-Point-Pens/product_SS110064

✓ Mounting Hardware Required
- (1) #6-32 x 1/2" Machine Screw & Nut

6.2 Mini-Drill

** Not yet ready for Version 2.0 – Updates will come soon **

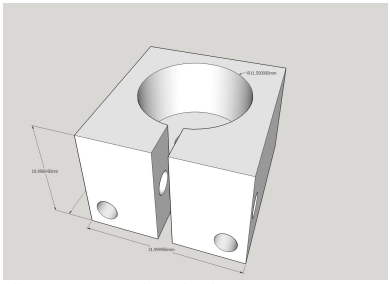


Illustration 8: ToolHead-PilotRazorPointPen.STL

✓ Example of Mini-Drill @ https://www.amazon.com/Lemonbest-Micro-Electric-Drill-1-5mm/dp/B01301L2L6/ref=pd_sim_60_3
- Full Description Line — Mini DIY Micro Electric Hand Drill for PCB 0.7 to 1.5mm Craft Drill Chuck Tools with US Plug
- Item Weight — 2.7 ounces
- Product Dimensions — 5.1 x 1 x 1 inches
- Wattage — 18 watts

✓ Mounting Hardware Required
- (3) #6-32 x 1-1/2" (or Longer) Machine Screws