RPieces - TableTopXYZ

User and Assembly Manual

For Build Version 2.0

Written By: TGit-Tech (03/2018)

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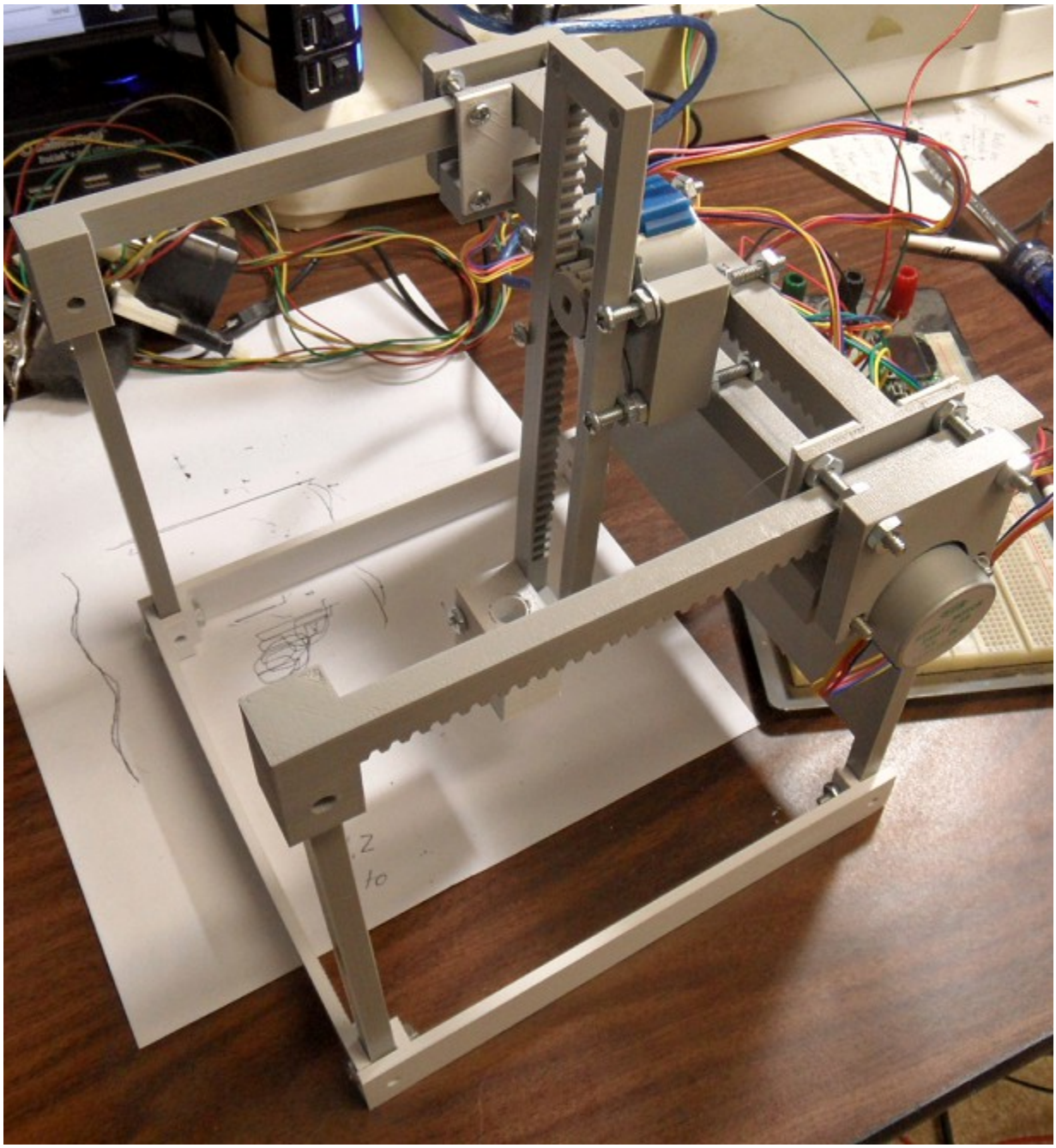
1. INTRODUCTION

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 - $29.77

2.1 Tools (N/A)

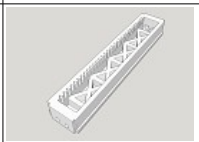
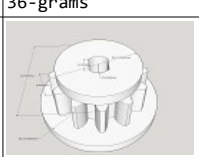
The following tools are required to build the project components

✓ 3D-Printer (With a 190mm x 190mm or larger XY Build Envelope)

✓ Phillips head screw driver and 5/16 nut driver or wrench

2.2 3D Parts & Fasteners ($9.17)

Below is the list of the Parts that needed to be printed by a 3D-Printer followed by significant notes about printing. They can be printed with any filament but PLA is highly suggested over ABS for it's non-curling and non-flexible (brittle) attributes. I've observed good solidity with ifun and PxMallion brand PLA filaments.

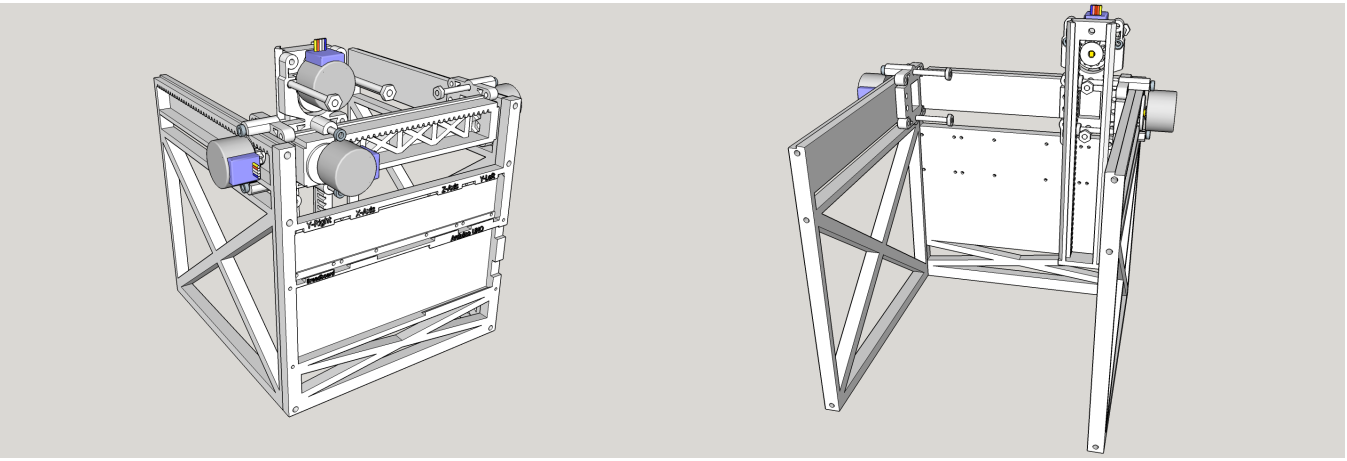
QTY	Part Picture Part Filename	Attach	Machine Screws (!Per-Part!)*QTY	Nuts (!Per-Part!)*QTY	Washers (!Per-Part!)*QTY	Est. Costs Per-Part PLA Cost @ $15/Kg roll www.boltdepot.com	Total Cost
2	 **Full-Side.stl** 115-grams	N/A See Below	N/A	N/A	N/A	$2.16 PLA	$4.32
1	 **BackSide.stl** 97-grams	(2)Full-Side	(2)#6-32 x 3/4” [$0.02/ea] (4)#6-32 x 1/2” ----OR even better... (2)#6 x 3/4” Sheet Metal Screws (4)#6 x 1/2” Sheet Metal Screws	N/A Threads Plastic	N/A	$1.82 PLA $0.12 Fasteners	$1.94
2	 **Y-Carriage.stl** 12-grams	X-Rack Full-Side Y-Motor	(2)#6-32 x 3/4” [$0.02/ea] (4)#6-32 x 1/2” [$0.02/ea] (2)#6-32 x 1” [$0.02/ea]	(2)#6 Nuts [$0.01/ea] N/A Threads Plastic (2)#6 Nuts [$0.01/ea]	N/A	$0.23 PLA $0.20 Fasteners	$0.43
1	 **XZ-Carriage.stl** 19-grams	X-Rack Z-Rack Z-Motor	(4)#6-32 x 1/2” [$0.02/ea] (4)#6-32 x 1/2” [$0.02/ea] (2)#6-32 x 1.5” [$0.03/ea]	N/A Threads Plastic N/A Threads Plastic (2)#6 Nuts [$0.01/ea]		$0.36 PLA $0.24 Fasteners	$0.60
1	 **X-Rack.stl** 51-grams	N/A	N/A See Y-Carriage	N/A	N/A	$0.96 PLA	$0.96
1	 **Z-Rack.stl** 36-grams	N/A	N/A See XZ-Carriage	N/A	N/A	$0.68 PLA	$0.68
4	 **MotorGear.stl** 3-grams	28BYJ-Motor	N/A - Pressed On	N/A	N/A	$0.06 PLA	$0.24

✓ 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



2.3 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

2.4 Electronic Control ($18.45)

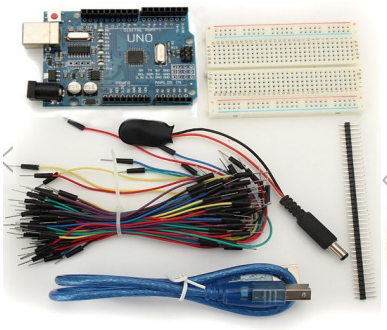


Illustration 2: (2) Arduino UNO R3

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

3. HARDWARE ASSEMBLY

3.1 X & Z-Rail / Tool-head

Note: The Z-Rail has been widened to fit on the other side of the machine XZ Motor Mount screws (It'll be apparent when assembling) so pictures of the Z-Rail won't be quit correct.

1. 3D Print the following files
   a) Pieces-STL/Z-Rail.stl
   b) Pieces-STL/XZ-MotorTie.stl
   c) ToolHeads-STL/ToolHead-PilotRazorPointPen.stl
   d) (2) Pieces-STL/MotorGear.stl

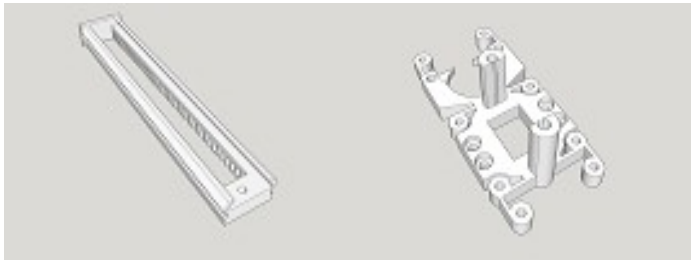


Illustration 5: (1) Z-Rail

Illustration 6: (2) MotorGear

2.

3.2 X-Rack / Carriage Assembly

Illustration 7: (1) X-Rack

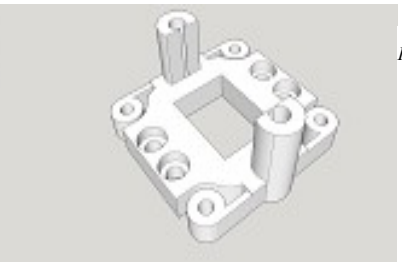


Illustration 8: (1) X-Guide

Illustration 9: (2) Motor Gear

3.3 Y-Rack Frame

3.4 Frame Sides & Electronics

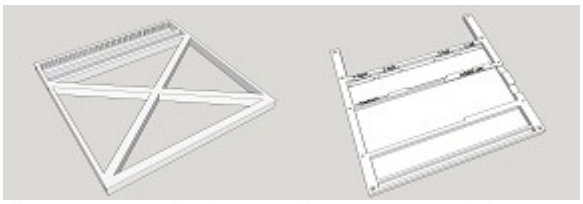


Illustration 10: (2) Full-Side

Illustration 11: (1)Backside 3D-Print

1. Install Electronics into Backside before attaching the (2) FULL-SIDE.STL pieces to BACKSIDE

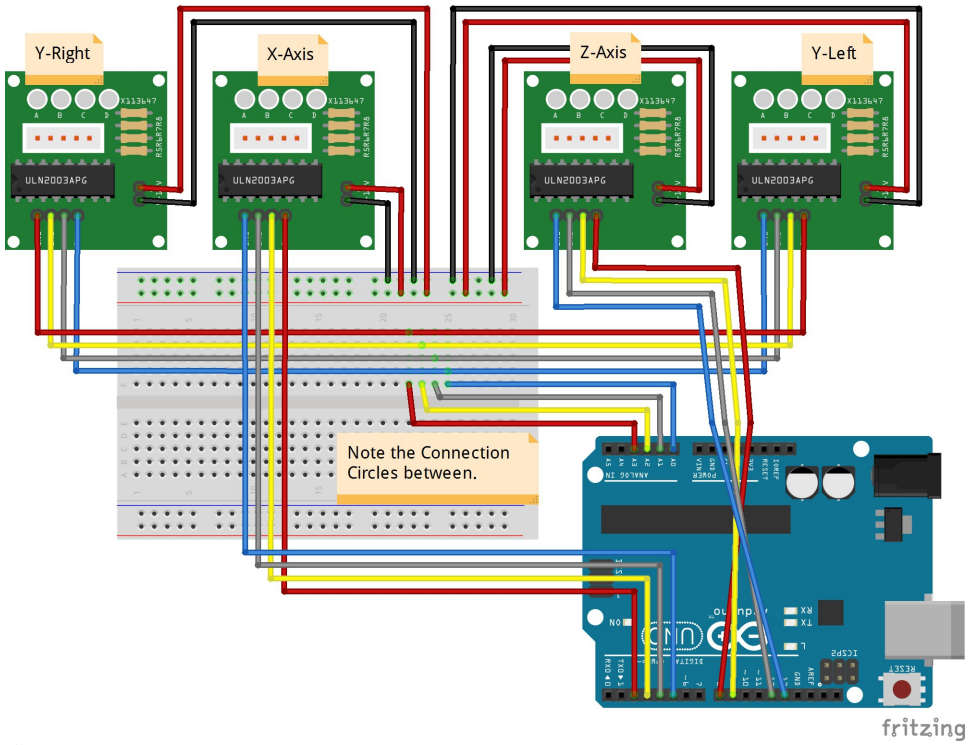
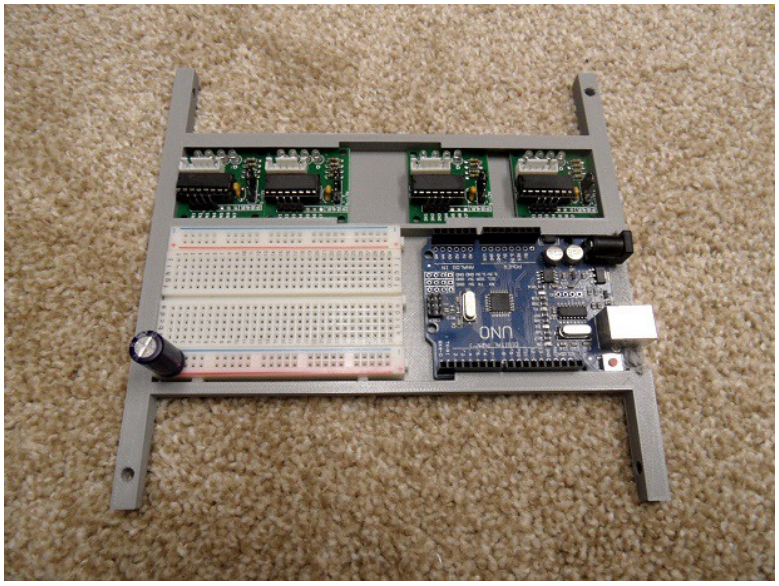


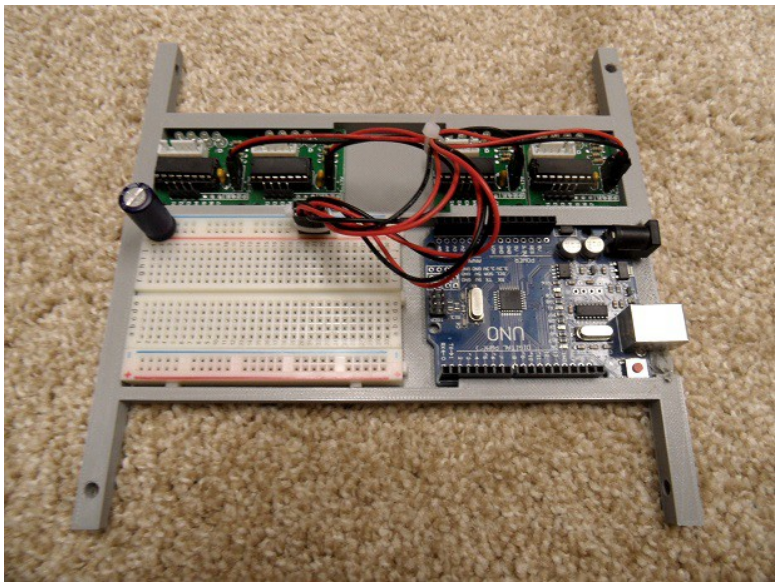
Illustration 12: Wiring Diagram

3.4.1 Electronics Assembly

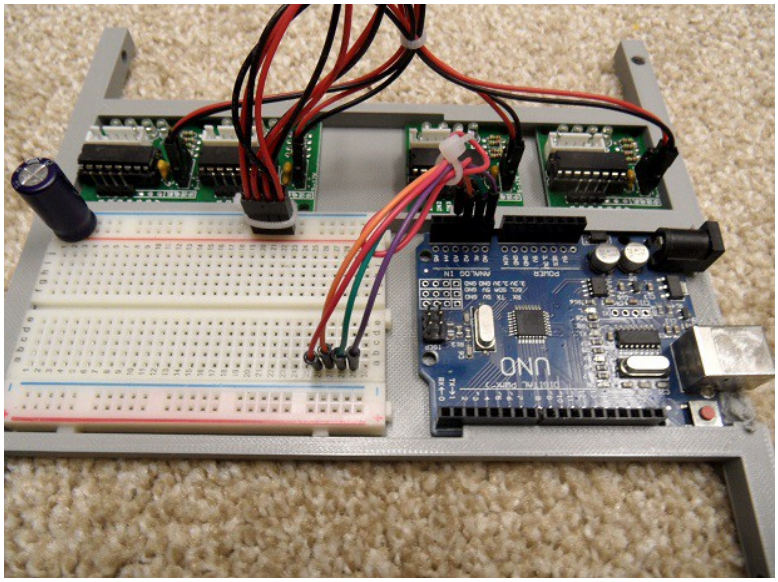
1. Place electronic assemblies inside the Backside Panel
   a) Place (4) ULN2003 driver boards - inserting them into the center and slide them to the edges
   b) Place (1) Arduino UNO - inserting on the left and sliding to the right
   c) Place a half-size bread board on the left.



2. Wire power to the ULN2003 driver boards
    a) Use Dupont Male to Female jumpers to wire the Positive (+) and Negative (-) pins on ALL the ULN2003 boards together on the BB power rail



3. Wire the Y-Axis Motor Control pins for splitting to BOTH Y-Axis motors (A0 → A3)
   a) Use breadboard jumper wires to route from the Arduino UNO → Breadboard or common point
   b) Diagram coloring order is:
      - A0 = Blue/Purple
      - A1 = Grey/Green
      - A2 = Yellow
      - A3 = Red



4. Connect control wires for the X, Y, and Z ULN2003 Control Boards

a) Right Side Y-Axis ULN2003

- A0 (Blue) → Breadboard → IN1
- A1 (Grey) → Breadboard → IN2
- A2 (Yellow) → Breadboard → IN3
- A3 (Red) → Breadboard → IN4

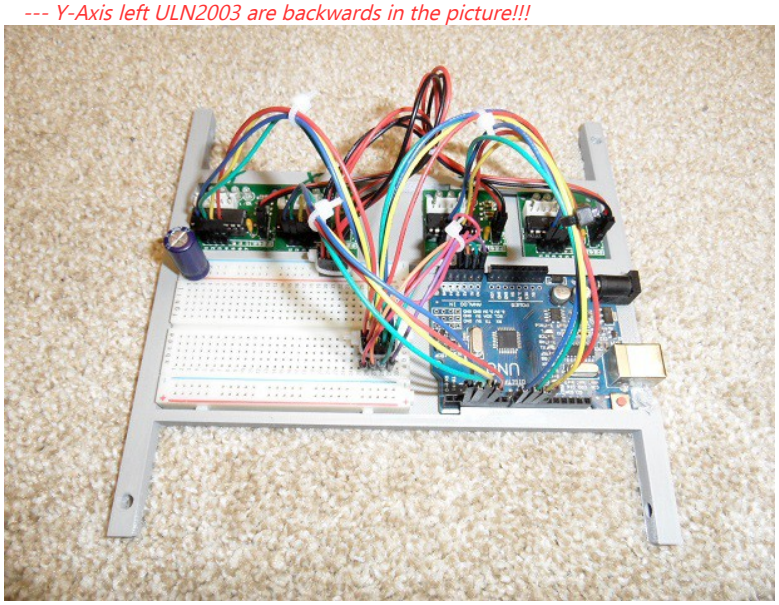
b) Left Side Y-Axis ULN2003 (**REVERSED WIRING**)

- A0 (Blue) → Breadboard → IN4
- A1 (Grey) → Breadboard → IN3
- A2 (Yellow) → Breadboard → IN2
- A3 (Red) → Breadboard → IN1

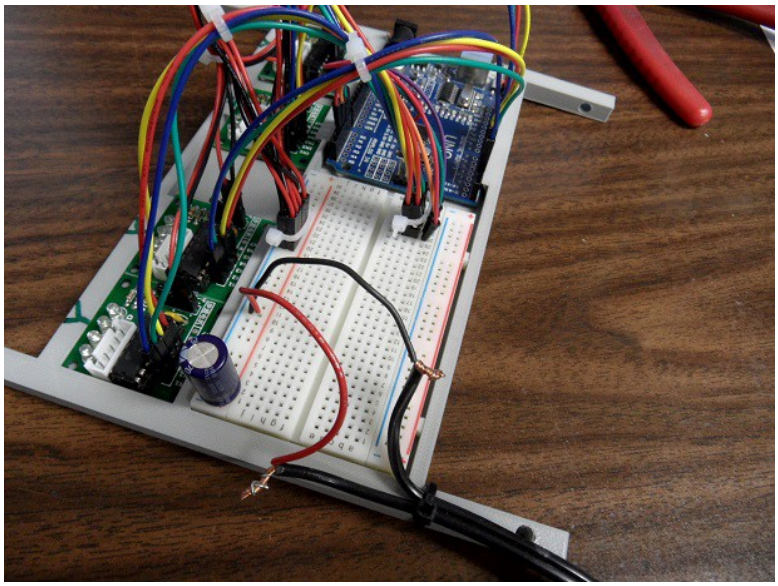
c) X-Axis ULN2003

- D5 (Blue) → IN1
- D4 (Grey) → IN2
- D3 (Yellow) → IN3
- D2 (Red) → IN4

Picture Has Errors!!! Following the Wiring Diagram or Text above.
--- D2...D5 are backwards on the Arduino in the picture!!!
--- Y-Axis left ULN2003 are backwards in the picture!!!



5. Wire Power Supply Adapter
    a) Cut and strip the ends of the 5Vdc Wall Power Adapter
    b) Wire-tie the end to the Backside leg
    c) Check the polarity of the power (+ / -)
    d) Attach power to the power rail wired in step #2 above
    e) OPTIONALLY an appropriate capacitor can be placed on this power rail.



4. SOFTWARE / FIRMWARE

4.1 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

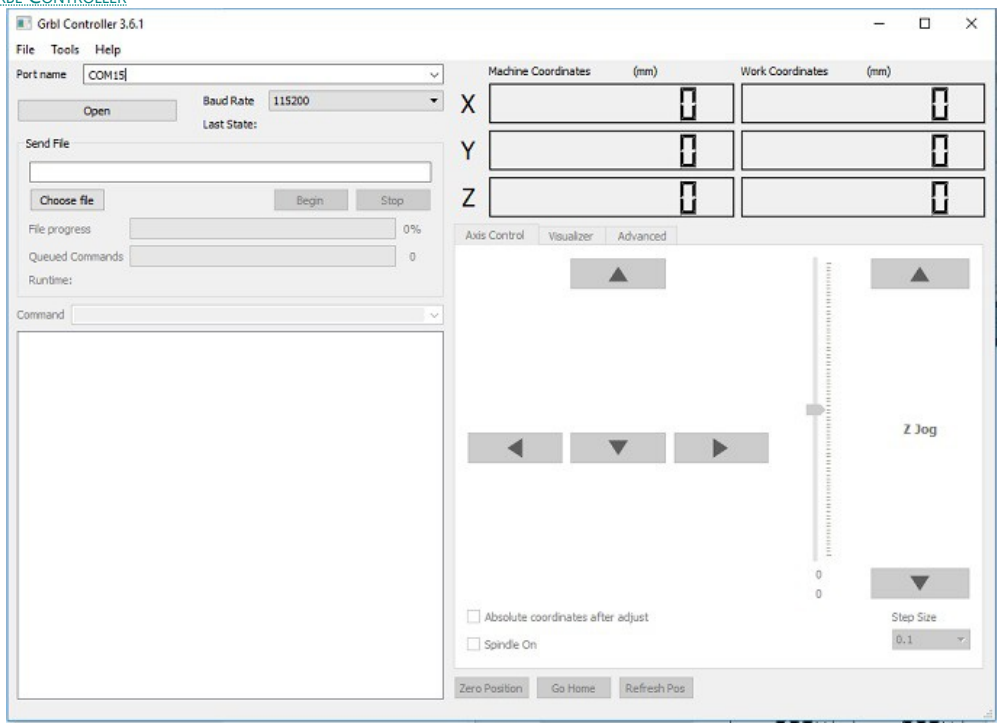
4. Now the unit is ready for operation.

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

4.2 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'.

4.3 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.

4.4 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

5. TOOL-HEADS

5.1 Pilot-Razor-Point-Pen

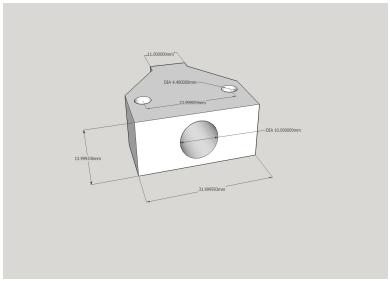


Illustration 13: ToolHead-PilotRazorPointPen.STL

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

✓ Mounting Hardware Required
- (2) #6-32 x 1-1/4" (or Longer) Machine Screws
- (2) Hex Nuts

5.2 Mini-Drill

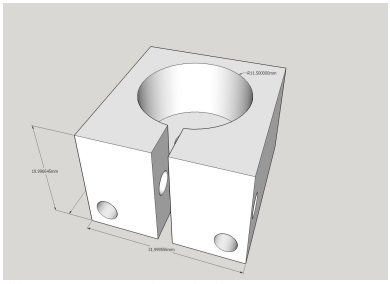


Illustration 14: ToolHead-PilotRazorPointPen.STL

✓ 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
- (3) #6 Hex Nuts