The DIY Smart Saw

How to Build a CNC Machine in an Afternoon Using Parts You Can Find at Any Store

Contents

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DIY SMART SAW

CHAPTER I : Introduction

First of all, thank you for your purchase of DIY Smart Saw plans. This manual and plans will provide you with a comprehensive set of instructions to complete your project and enjoy being productive with your CNC Machine – The DIY Smart Saw.

Whether you are building your DIY Smart Saw from scratch, I hope you find the process a creative and rewarding endeavor.

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What is a CNC Machine?

CNC stands for Computer Numeric Control and typically refers to a machine whose operation is controlled by a computer. The most common usage of CNC, and the one relevant to us, is the name given to devices that, under computer control are able to cut, etch, mill, engrave, build, turn and otherwise perform manufacturing operations on various materials.

Typically, a CNC machine has the ability to move a cutting or 3D printing head in 2 to 6 axes, meaning that it can position that tool head at a precise point in or on the material to create the cut or operation desired at that point. By moving the head through multiple points, the cutting head can cut or sculpt the design represented by a data stream of positioning points being sent by the PC.

By controlling a CNC machine through a PC it is possible for the user to design a product on-screen, convert it to CNC-readable code and then send that data to the CNC machine for it to produce a physical copy of the item designed.

The purpose of the DIY Smart Saw is to provide that powerful ability to go from concept design to physical product.

What is a DIY Smart Saw?

A DIY Smart Saw is a “personal” version of a CNC machine. It is controlled by your desktop computer and is designed for the hobbyist or enthusiast to create objects within a relatively compact space and at modest expense.

To that end, the DIY Smart Saw is designed to provide a resolution of one thousandth of an inch (0.001”) per step in each axis, and was intended to be accessible and buildable by the average DIY'er with non-specialist domestic tools.

This document will walk you through the building of a DIY Smart Saw from scratch. If you purchased, this manual will guide you through the assembly process and assist you in building a complete system. You also will find a comprehensive operator’s manual further on in this document.

Possibilities

The possible uses of the DIY Smart Saw are limited only by your imagination. Further on in this manual you will read how to expand the DIY Smart Saw to meet your larger format needs.

You can use a variety of end mills to suit whatever material your project requires. You can exchange the operational head unit to change over to PCB milling, laser etching or 3D printing. You can upgrade the spindle for more aggressive work. You can add coolant irrigation or vacuum for debris removal. The options are endless.

The DIY Smart Saw was designed from the outset to be versatile, expandable and generally hackable by the user. The website's photo and video gallery provides many examples of the type of applications that the DIY Smart Saw can be put to.

Limitations

The current design of the DIY Smart Saw is intended to provide a low cost precision CNC machine for the enthusiast but also provide a versatile platform for the developer to innovate and build upon.

The current system has a material workspace defined by the design. Therefore, without any expansion of the workspace, the basic limit to the size of a material object it can work on is 135mm (5 5/16") tall, by 385mm (1ft 3 5/32") wide, by 372mm (1ft 2 41/64") long. These dimensions represent the extents of a workspace allowed by clearance of the axes. In the modifications section of this manual, you will find directions for modifying this workspace within the existing design, as well as for expanding the workspace through expansion of the DIY Smart Saw chassis dimensions.

The design brief of the DIY Smart Saw had a target precision resolution of one thousandth of an inch (0.001”) to be delivered at low cost. To achieve this, the DIY Smart Saw Stepper Motor Driver Modules provide a relatively simple, low cost electronics design that operates in classic “full-step” mode. To attain the 0.001” resolution, the gearing of the DIY Smart Saw provides 20 revolutions of the drive screw for each inch of travel.

This low gearing produces the desired repeatable precision but results in relatively low travel speeds of the head. The current configuration has a top traversal speed of approximately 16 IPM (inches per minute). Given the size of the workspace, this is a respectable speed with which to traverse the table.

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CHAPTER II : Required Tools and Materials List

Chassis Build:

Welding Machine	
Hand Drill	
Drill	

Table Saw	
Professional CNC/Hammer and chisel(in case you don't have in the area a workshop with a professional CNC)	 
Grinder	
Circular Hand Saw	

Vise	
Tubular Wrench	
Hammer	
Screwdriver	

Marker	
Allen	
Carpenter Meter	
Depth Stop	

Calipers	
Elbow	
Brush	

Electronics Build:

Soldering Iron	
Rosin-Core Solder	
Wire Stripper	
Small Side Cutters (snips)	
Needle-Nose Pliers	

Mater List of Materials:

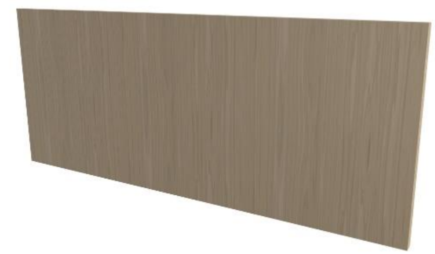
The purchase links provided are for reference only, you can choose to purchase the parts from other vendors, we will try to keep the list fresh, as some of the eBay listings might disappear in time, if you find any dead links, please contact the support, we are working on a mobile and web application to make this process easier in the future to find the needed parts, it's still under development and we will notify all the users once the app goes live

Nr. Crt.	***Description***	***Qty/Unit***	***Vendor***	***Images***
1	Front Base Frame (wood 740mm x 115mm x 50mm) (2ft 5 $^{9}/_{64}$” x 4 $^{17}/_{32}$” x 1 $^{31}/_{32}$”)	1	-	
2	Back Base Frame (wood 740mm x 115mm x 50mm) (2ft 5 $^{9}/_{64}$” x 4 $^{17}/_{32}$” x 1 $^{31}/_{32}$”)	1	-	

3	Side Base Frame (wood 1100mm x 115mm x 50mm) (3ft 7 $^{5}/_{16}$" x 4 $^{17}/_{32}$" x 1 $^{31}/_{32}$")	2	-	
4	Threaded Drive Rod, Motor Connection Board (wood 640mm x 115mm x 35mm) (2ft 1 $^{13}/_{64}$" x 4 $^{17}/_{32}$" x 1 $^{31}/_{32}$")	1	-	
5	Bottom Frame Cover (wood 1200mm x 740mm x 20mm) (3ft 11 $^{1}/_{4}$" x 2ft 5 $^{9}/_{64}$" x $^{25}/_{32}$")	1	-	

6	X Axis Support (Right Side) (wood 730mm x 170mm x 45mm) (2ft 4 $^{47}/_{64}$” x 6 $^{11}/_{16}$” x 1 $^{49}/_{64}$”)	1	-	
7	X Axis Support (Left Side) (wood 730mm x 170mm x 45mm) (2ft 4 $^{47}/_{64}$” x 6 $^{11}/_{16}$” x 1 $^{49}/_{64}$”)	1	-	
8	Y Axis Linear Guide Rails Support (wood 120mm x 50mm x 50mm) (4 $^{23}/_{32}$” x 1 $^{31}/_{32}$” x 1 $^{31}/_{32}$”)	2	-	

9	Y Axis Board (wood 635mm x 525mm x 16mm) (2ft 1” x 1ft 8 $^{43}/_{64}$” x $^{5}/_{8}$”)	1	-	
10	Y Axis Movement Guide (wood 380mm x 80mm x 50mm) (1ft 2 $^{61}/_{64}$” x 3 $^{5}/_{32}$” x 1 $^{31}/_{32}$”)	1	-	
11	X Axis Board (wood 400mm x 250mm x 16mm) (1ft 3 $^{3}/_{4}$” x 9 $^{27}/_{32}$” x $^{5}/_{8}$”)	1	-	

12	Z Axis Board (wood 395mm x 255mm x 16mm) (1ft 3 $^{35}/_{64}$” x 10 $^{3}/_{64}$” x $^{5}/_{8}$”)	1	-	
13	Back Cover X Axis Support (wood 740mm x 300mm x 16mm) (2ft 5 $^{9}/_{64}$” x 11 $^{13}/_{16}$” x $^{5}/_{8}$”)	1	-	
14	Upper Back Cover X Axis Support (wood 740mm x 110mm x 16mm) (2ft 5 $^{9}/_{64}$” x 4 $^{21}/_{64}$” x $^{5}/_{8}$”)	1	-	

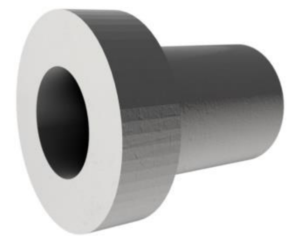
15	X Axis Support For The Motor (wood 140mm x 140mm x 55mm) (5 $^{33}/_{64}$”x 5 $^{33}/_{64}$”x 2 $^{11}/_{64}$”)	1	-	
16	Z Axis Support For The Motor (wood 250mm x 110mm x 48mm) (9 $^{27}/_{32}$” x 4 $^{21}/_{64}$” x 1 $^{57}/_{64}$”)	1	-	
17	Spindle Support (wood 252mm x 83mm x 71mm) (9 $^{59}/_{64}$” x 3 $^{17}/_{64}$” x 2 $^{51}/_{64}$”)	1	-	

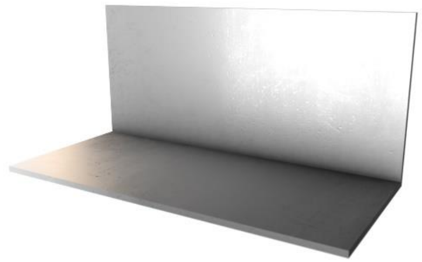
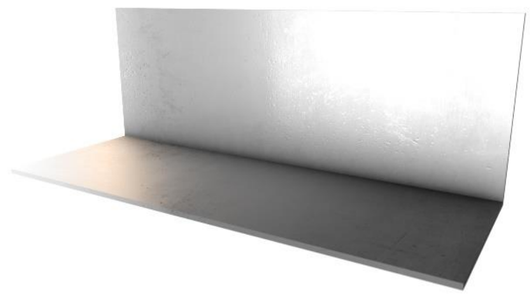
18	X Axis Movement Guide (wood 110mm x 70mm x 50mm) (4 $^{21}/_{64}$" x 2 $^{3}/_{4}$" x 1 $^{31}/_{32}$")	1	-	
19	Z Axis Threaded Drive Rod Ends (wood 113mm x 48mm x 48mm) (4 $^{29}/_{64}$" x 1 $^{57}/_{64}$" x 1 $^{57}/_{64}$")	2	-	
20	Up And Bottom Board Of The Drivers Enclosure (wood 350mm x 170mm x 16mm) (1ft 1 $^{25}/_{32}$" x 6 $^{11}/_{16}$" x $^{5}/_{8}$")	2	-	

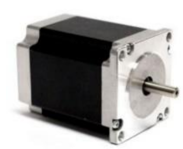
21	Left and Right Board Of The Drivers Enclosure (wood 400mm x 170mm x 16mm) (1ft 3 $^{3}/_{4}$” x 6 $^{11}/_{16}$” x $^{5}/_{8}$”)	2	-	
22	Back Board Of The Drivers Enclosure (wood 400mm x 350mm x 45mm) (1ft 3 $^{3}/$” x 1ft 1 $^{25}/_{32}$”” x 1 $^{49}/_{64}$”)	1	-	
23	Flexible Coupling Coil ø 5mm/6.35mm ($^{13}/_{64}$” / $^{1}/_{4}$”) Dimensions: ø30mm x 42mm (1$^{3}/_{16}$” x 1$^{21}/_{32}$”)	3	**eBay ->** **LINK**	
24	Precision Steel Rods ø25mm($^{63}/_{64}$”) 830mm(2ft 8 $^{43}/_{64}$”) Long	2	**AliExpress** **-> LINK**	

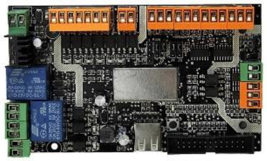
25	Precision Steel Rods ø20mm($^{25}/_{32}$”) 430mm(1ft 4 $^{59}/_{64}$”) Long	2	**Aliexpress -> [LINK]**	
26	Threaded Drive Rod Ø6mm at the ends x ø16mm Thickness ($^{5}/_{8}$”) 360mm(1ft 2 $^{11}/_{64}$”) Long	1	**Alibaba -> [LINK]**	
27	Threaded Drive Rod Ø6mm at the ends x ø16mm Thickness ($^{5}/_{8}$”) 1065mm(3ft 5 $^{59}/_{64}$”) Long	1	**Alibaba -> [LINK]**	
28	Threaded Drive Rod Ø6mm at the ends x ø16mm Thickness ($^{5}/_{8}$”) 770mm(2ft 6 $^{5}/_{16}$”) Long	1	**Alibaba -> [LINK]**	
29	End Shaft Support ø25mm($^{63}/_{64}$”) Dimensions : 70mm x 42mm x 25mm (2 $^{3}/_{4}$” x 1 $^{21}/_{32}$” x $^{63}/_{64}$”)	4	**eBay -> [LINK]**	
30	End Shaft Support ø20mm($^{25}/_{32}$”) Dimensions : 60mm x 51mm x 20mm (2 $^{23}/_{64}$” x 2 $^{1}/_{64}$” x $^{25}/_{32}$”)	4	**eBay -> [LINK]**	

31	Linear Motion Ball Bearing ø25mm(63/64”) Dimensions : 76mm x 51.5mm x 67mm (2 $^{63}/_{64}$” x 2 $^{1}/_{32}$” x 2 $^{41}/_{64}$”)	4	**eBay ->** **LINK**	
32	Linear Motion Ball Bearing ø20mm($^{25}/_{32}$”) Dimensions : 54mm x 50mm x 41mm (2 $^{1}/_{8}$” x 1 $^{31}/_{32}$” x 1 $^{39}/_{64}$”)	4	**eBay ->** **LINK**	
33	Linear Guide Rails 1000mm x 20mm x 20mm (3ft 3 $^{3}/_{8}$” x $^{25}/_{32}$” x $^{25}/_{32}$”)	2	**AliExpress -> LINK**	
34	Linear Guide Flange Blocks 77.5mm x 44mm x 30mm (3 $^{3}/_{64}$” x 1 $^{47}/_{64}$” x 1 $^{3}/_{16}$”)	4	**eBay ->** **LINK**	
34	Plastic Nuts ø16mm(5/8”) Dimensions: 31mm x 23.8mm x 23.8mm (1 $^{7}/_{32}$” x $^{15}/_{16}$” x $^{15}/_{16}$”)	6	**-**	

Plastic Bush Collar (Ø6mm Internal x 8mm Collar x 22mm Length)	2	-	
Copex Tube ø32mm(1 $^{17}/_{64}$”) 1000mm(3ft 3 $^{3}/_{8}$”)Long	1	**eBay ->** **LINK**	
Copex Tube ø20mm($^{25}/_{32}$”) 1000mm(3ft 3 $^{3}/_{8}$”)Long	1	**eBay ->** **LINK**	

38	Limitator Stop Piece (Steel) 44mm x 20mm x 2mm (1 $^{47}/_{64}$" x $^{25}/_{32}$" x $^{5}/_{64}$")	3	-	
39	Limitator Stop Piece L Shape (Steel) 69mm x 25mm x 2mm (2 $^{23}/_{32}$" x $^{63}/_{64}$" x $^{63}/_{64}$")	3	-	
40	Screws ø12mm(head) x ø6mm(thread) x 80mm(long) ($^{15}/_{32}$" x $^{15}/_{64}$" x 3 $^{5}/_{32}$")	100 pcs.	-	
41	Screws ø9.5mm(head) x ø4.75mm(thread) x 32mm(long) ($^{3}/_{8}$" x $^{3}/_{16}$" x 1 $^{17}/_{64}$")	100 pcs.	-	

42	Socket Head Cap Screws ø10mm(head) x ø5mm(thread) x 32mm(long) ($^{25}/_{64}$" x $^{13}/_{64}$" x 1 $^{17}/_{64}$")	45 pcs.	-	
43	Socket Head Cap Screws ø13mm(head) x ø6.5mm(thread) x 32mm(long) ($^{33}/_{64}$" x $^{1}/_{4}$" x 1 $^{17}/_{64}$")	25 pcs.	-	
44	Hex Head Cap Screws ø10mm(head) x ø5mm(thread) x 32mm(long) ($^{25}/_{64}$" x $^{13}/_{64}$" x 1 $^{17}/_{64}$")	32 pcs.	-	
45	Power Supply Mean Well SP-320-48	1	**eBay ->** LINK	
46	Stepper Motor Nema 34	3	**eBay ->** LINK	
47	Stepper Motor Drivers Power Step PSD8079-2P	3	**Alibaba** -> LINK	

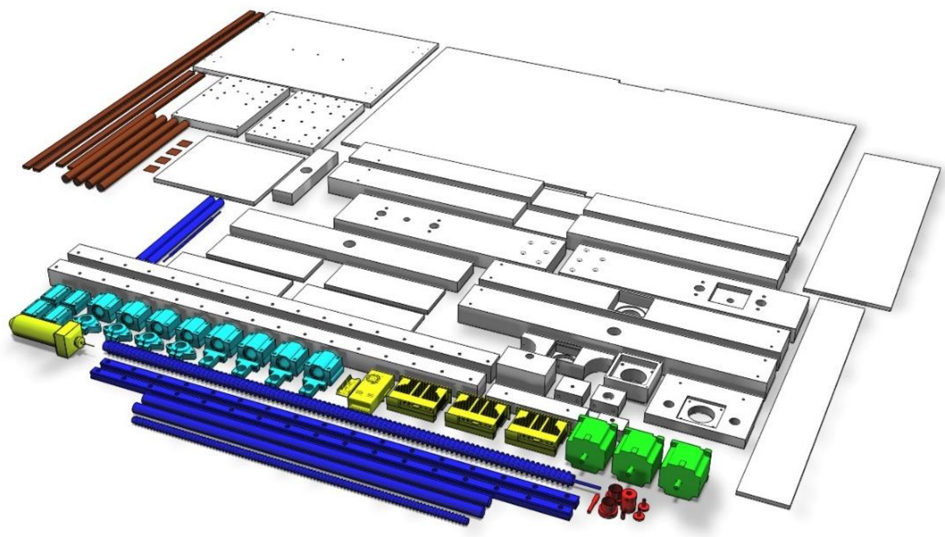
48	Cnc Breakout Board / Interface Board	1	**eBay ->** [LINK]	
49	Spindle Motor	1	**eBay ->** [LINK]	
50	Limit Switches (Optional)	6	**eBay ->** [LINK]	
51	Cable Connector	1	**eBay ->** [LINK]	
52	Emergency Stop Button	1	**eBay ->** [LINK]	

53	Pipes Tube (For Legs) ø38.11mm(1 $^{1}/_{2}$”) 800mm (2ft 7 $^{1}/_{2}$”)	4	-	
54	Rectangular Tubes (To Strengthen The Legs) 1050mm x 30mm x 21mm (3ft 5 $^{11}/_{32}$” x 1 $^{3}/_{16}$” x $^{53}/_{64}$”)	2	-	
55	Rectangular Tubes (To Strengthen The Legs) 60mm x 30mm x 21mm (2 $^{23}/_{64}$” x 1 $^{3}/_{16}$” x $^{53}/_{64}$”)	2	-	

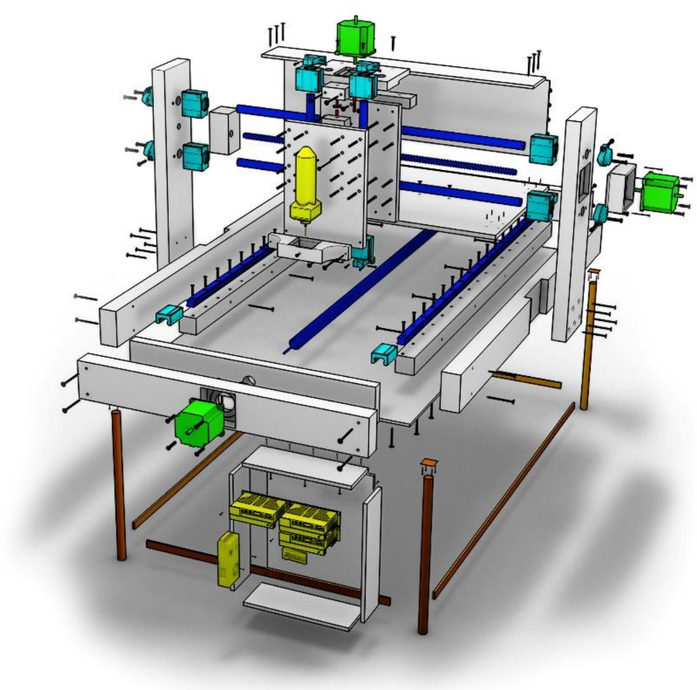
56	Rectangular Steel Sheet 97mm x 97mm x 2mm (3 $^{13}/_{16}$" x 3 $^{13}/_{16}$" x $^{5}/_{64}$")	4	-	

CHAPTER III : Plans

Exploded Views:



Complete Components



Exploded view of a complete DIY Smart SawE

Chassis Frame:

These plans include drawings and instructions for constructing a DIY Smart Saw with either a wooden or metal base. Both systems will have identical performance characteristics and the differences do not affect the specification or operation of other parts of the machine. The choice of a metal or wooden base is made by the builder and can be based upon the preference and/or comfort level the builder may have for one material over the other. The materials for the wooden base may cost less, but that price difference is an insignificant part of the overall cost of the project.

Wood:

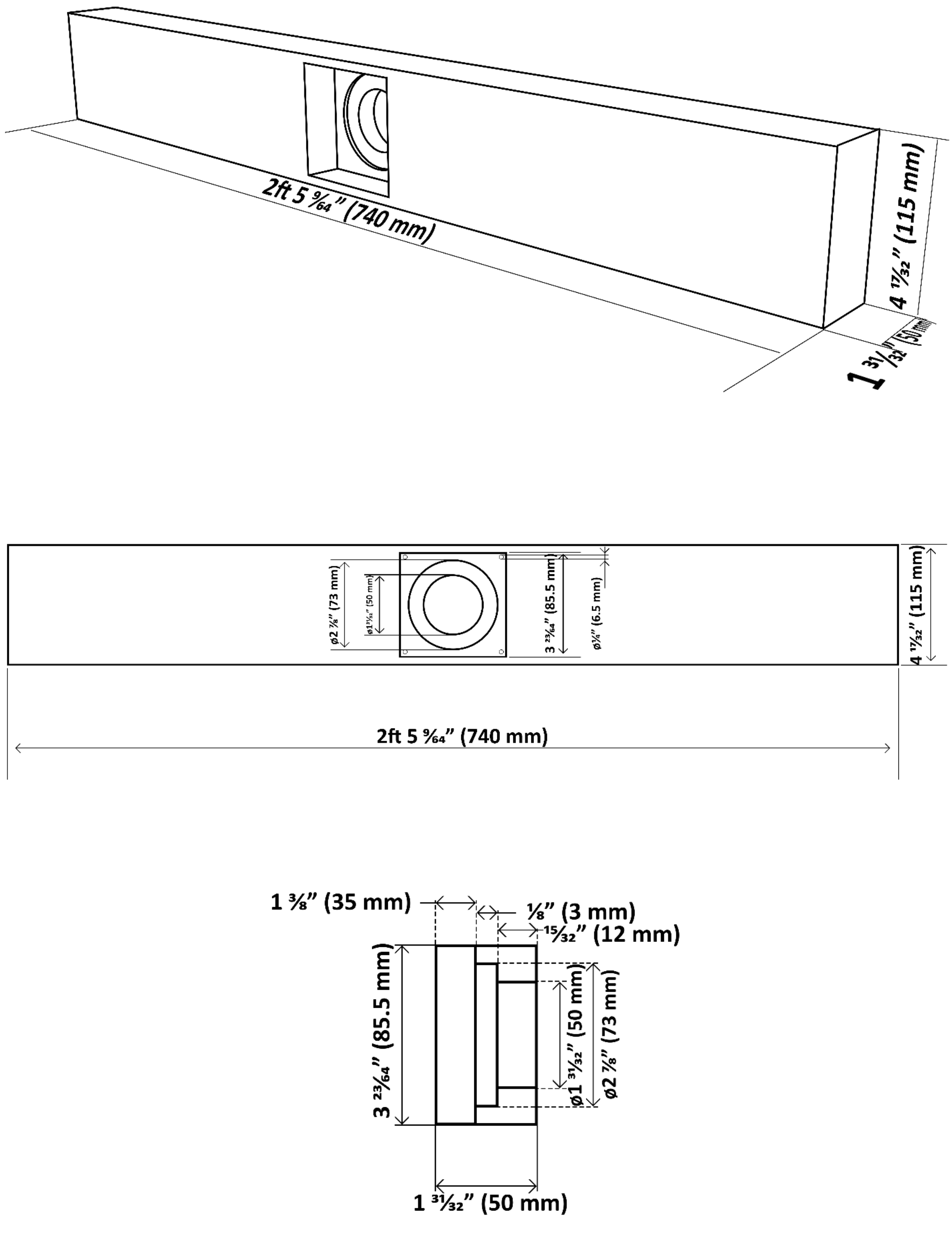
Whether you choose wood or metal for the base frame, the part dimensions and performance are identical. The wall thickness is not significant to the dimensions of the DIY Smart Saw as long as the space inside the tube is sufficient for the nut used to bolt the frame corners together. Whatever thickness of wood or metal is available, given that condition, should work fine.

Use a good wood or metal drill bit for drilling the required holes, preferably one with a pilot point. The chassis rails can be clamped (or in the absence of a clamp, tightly bound together with tape) to drill through pairs simultaneously.

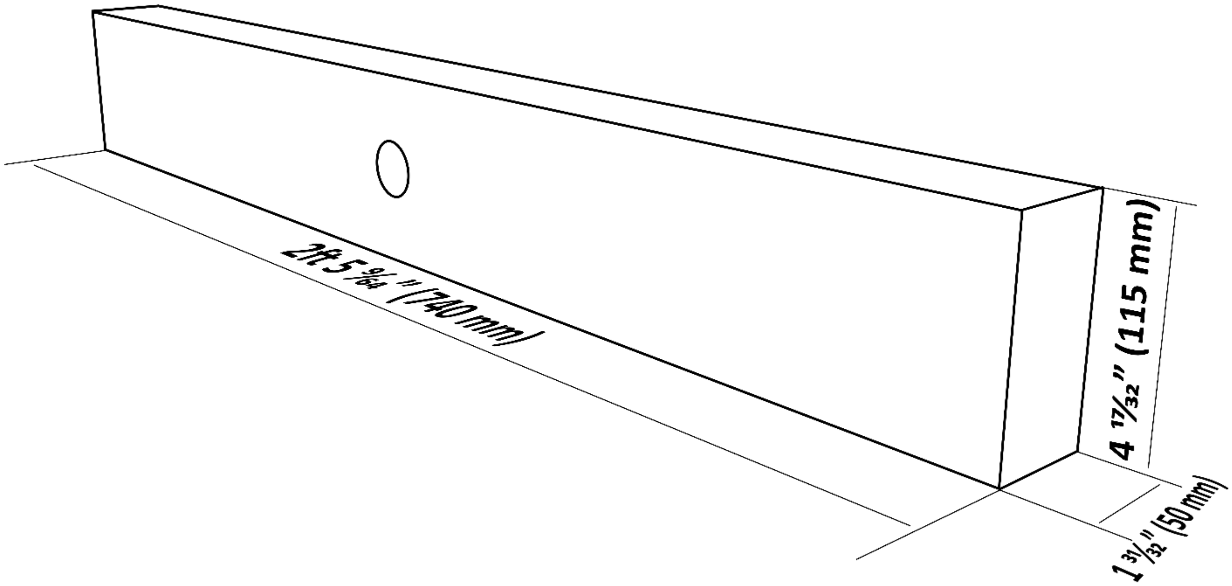
In this case you can use a Professional CNC for making bigger holes.

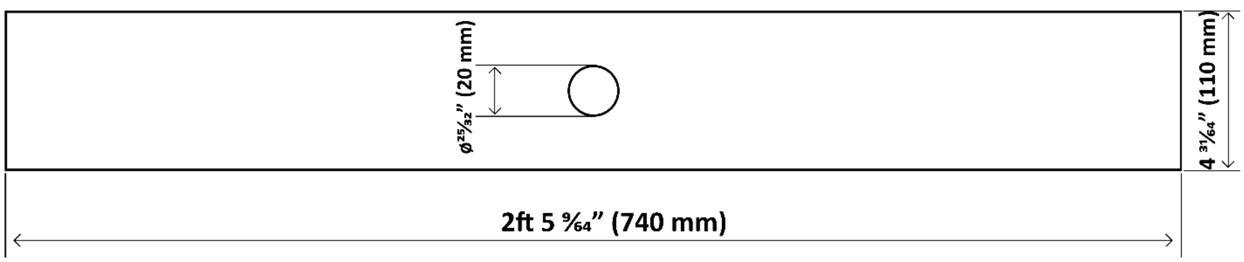
WARNING: Take care when cutting or drilling in metal to avoid getting cut on the sharp edges created. Use a file to de-burr sharp edges.

TIP: A drill press is particularly useful for this process to ensure that the holes are perpendicular to the rails and are perfectly aligned. If using a hand drill, take great care to drill at right angles to the rails.

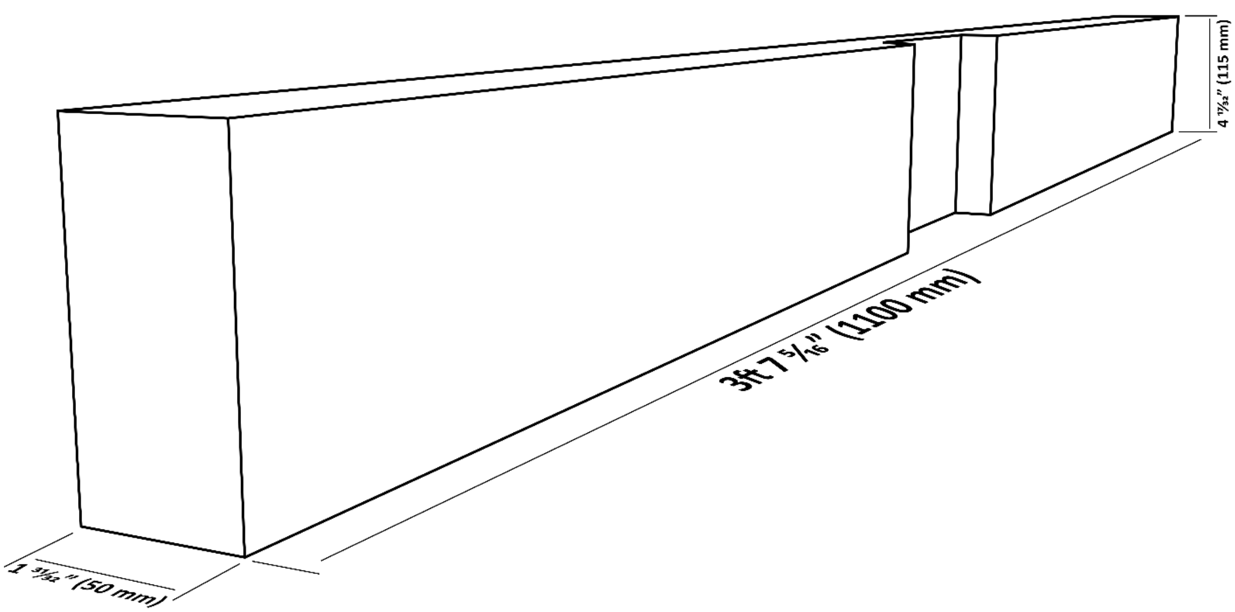


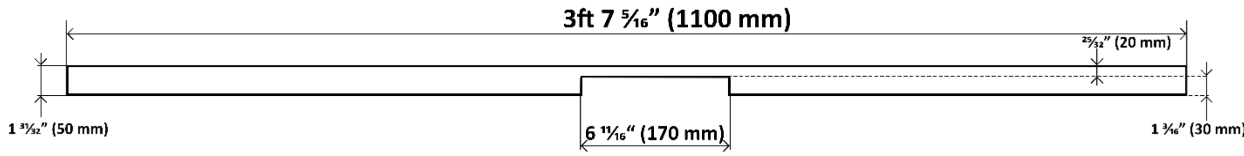
FRONT BASE FRAME



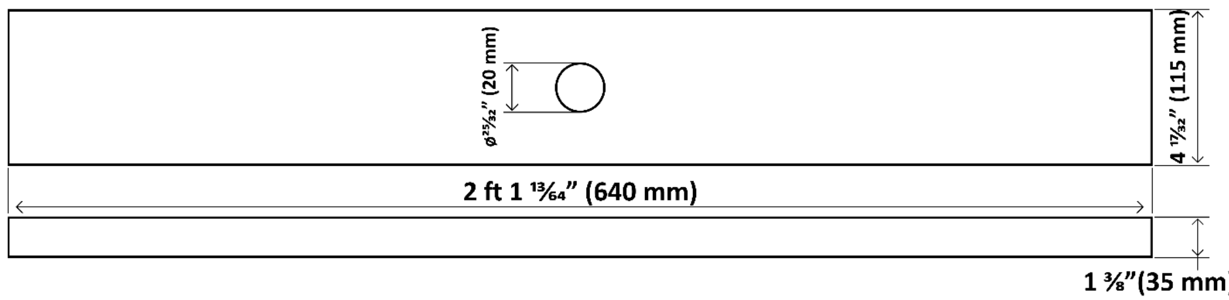


BACK BASE FRAME

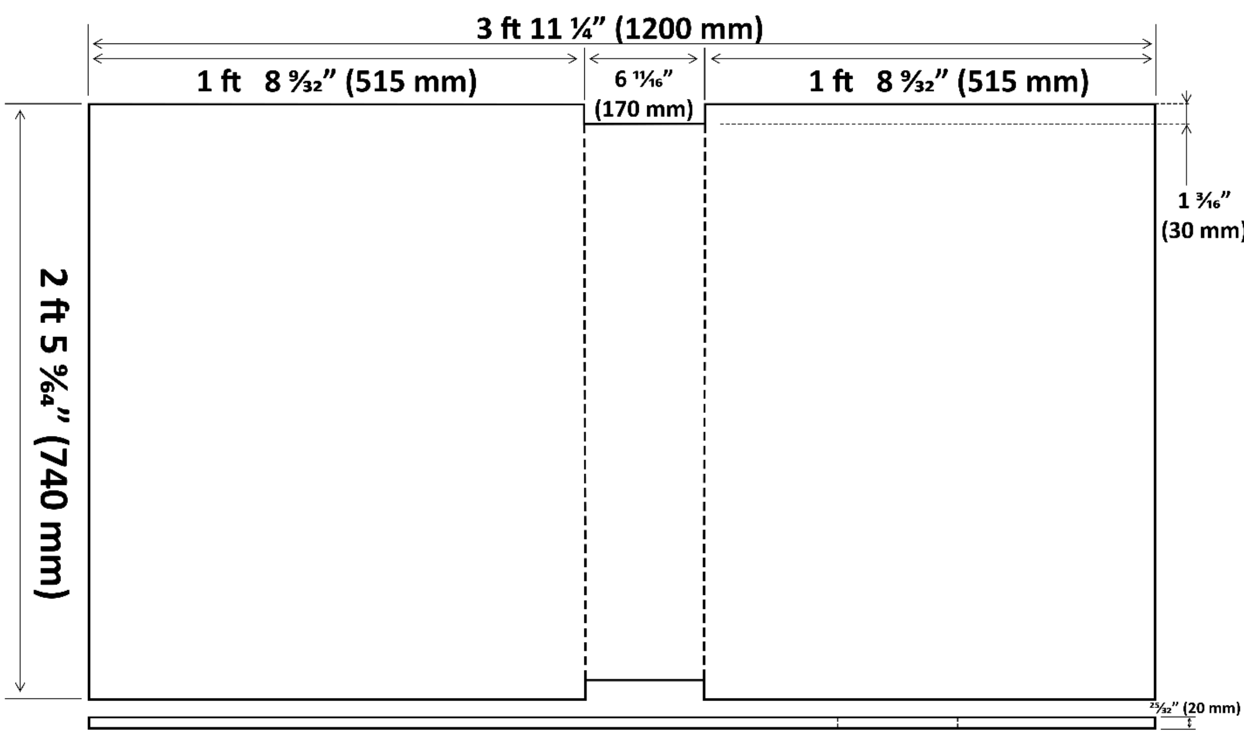




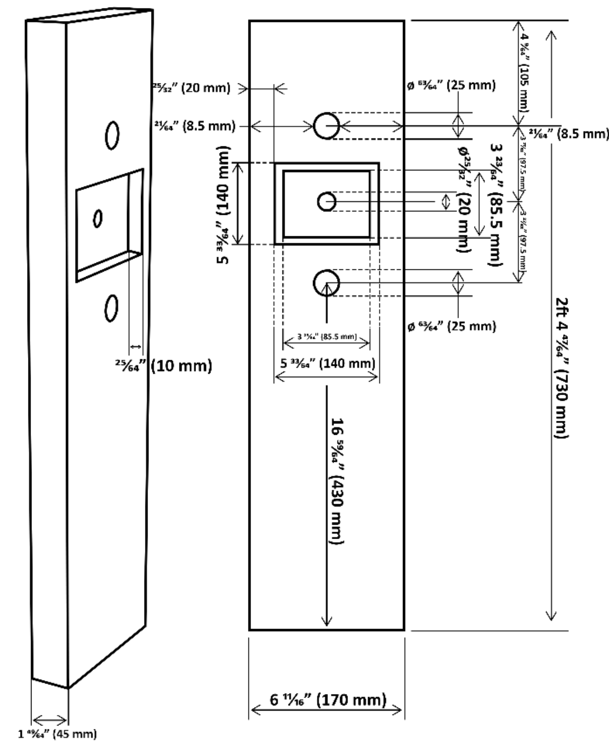
SIDE BASE FRAME



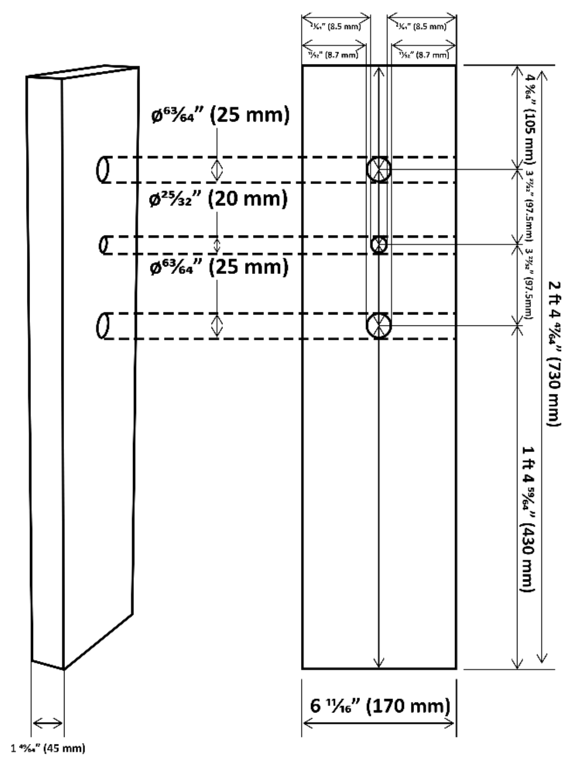
THREADED DRIVE ROD, MOTOR CONNECTION BOARD



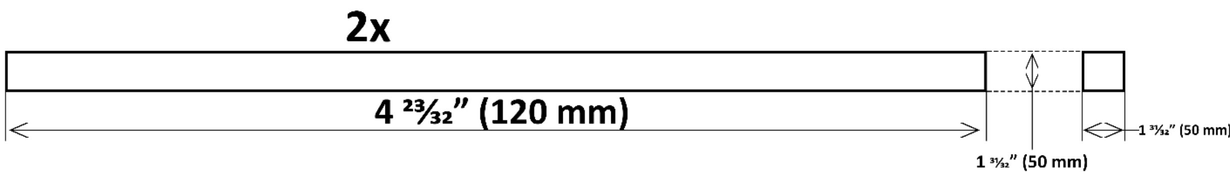
BOTTOM FRAME COVER



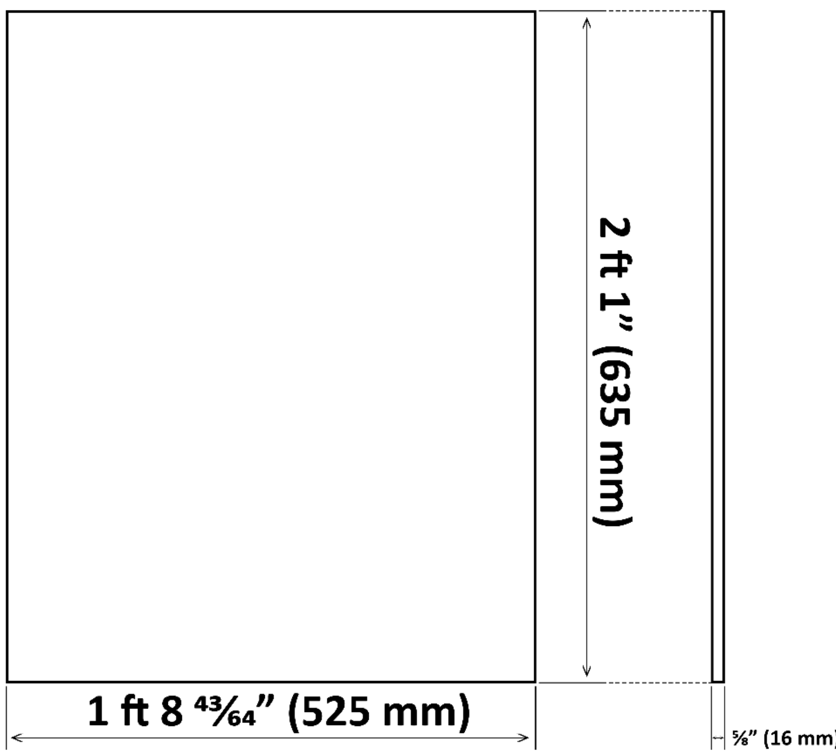
X AXIS SUPPORT (RIGHT SIDE)



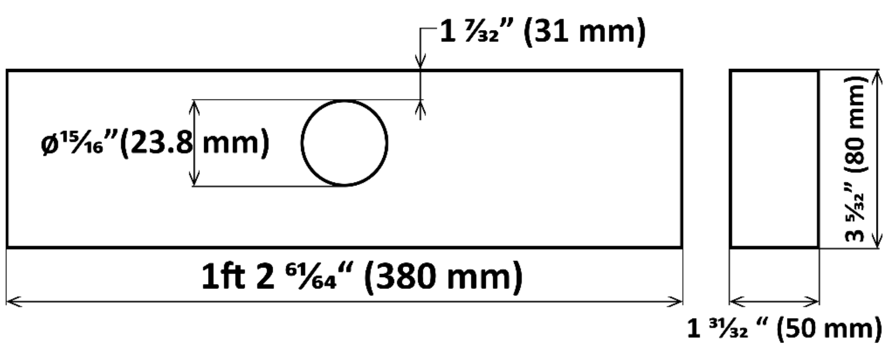
X AXIS SUPPORT (LEFT SIDE)



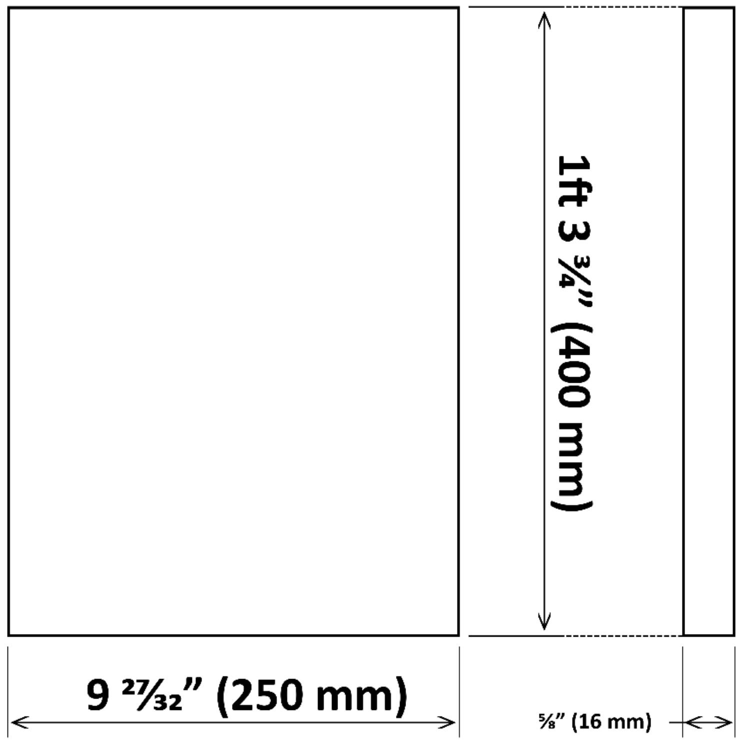
Y AXIS LINEAR GUIDE RAILS SUPPORT



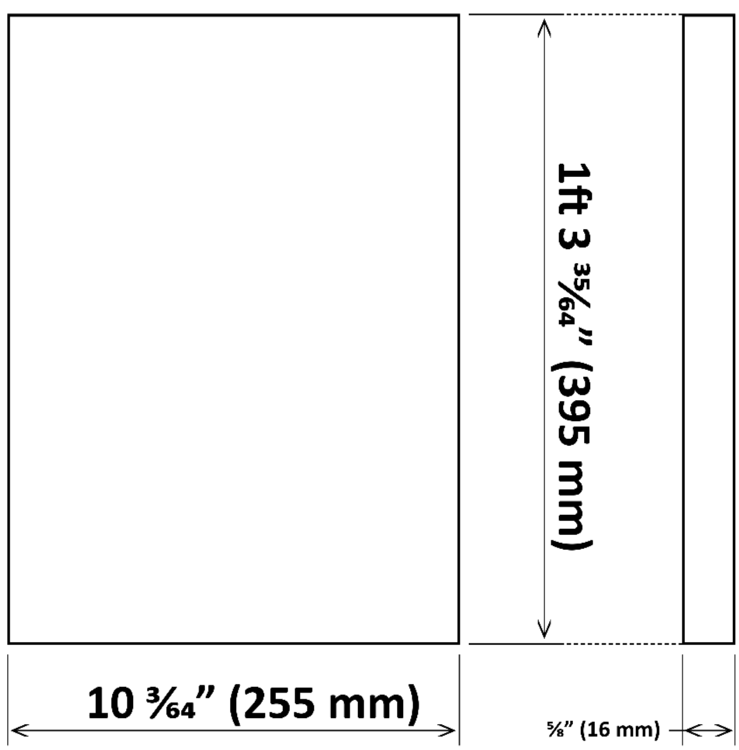
Y AXIS BOARD



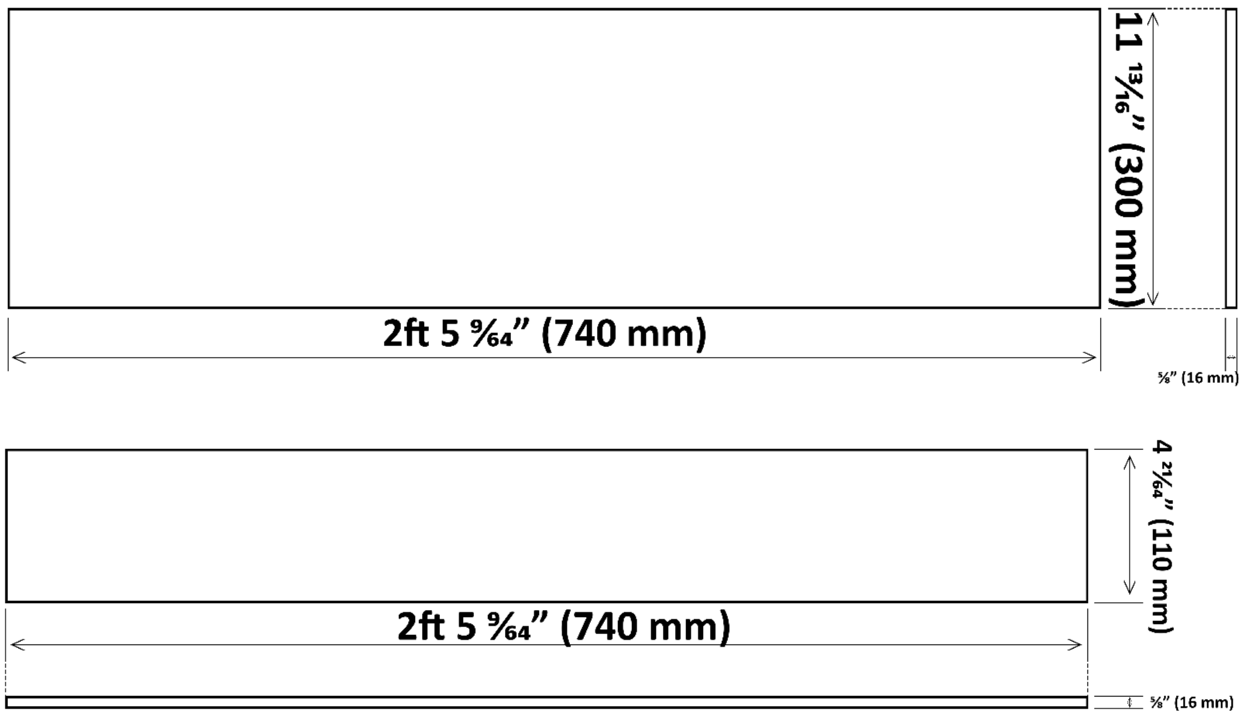
Y AXIS MOVEMENT GUIDE



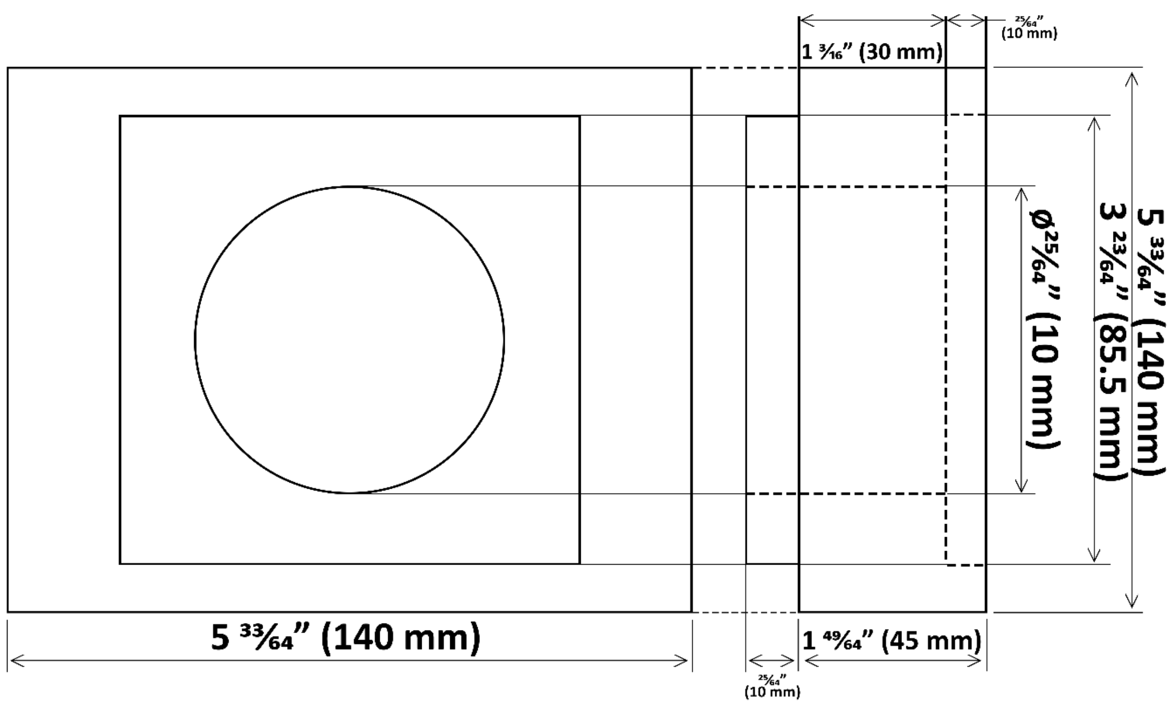
X AXIS BOARD



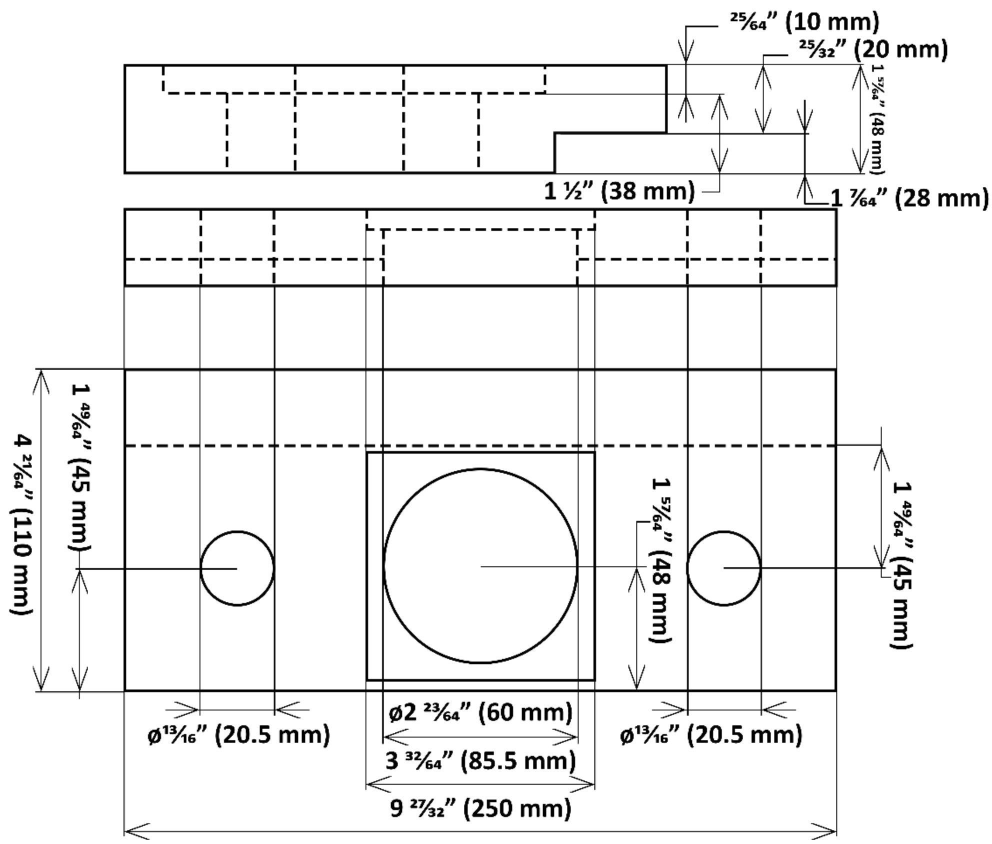
Z AXIS BOARD



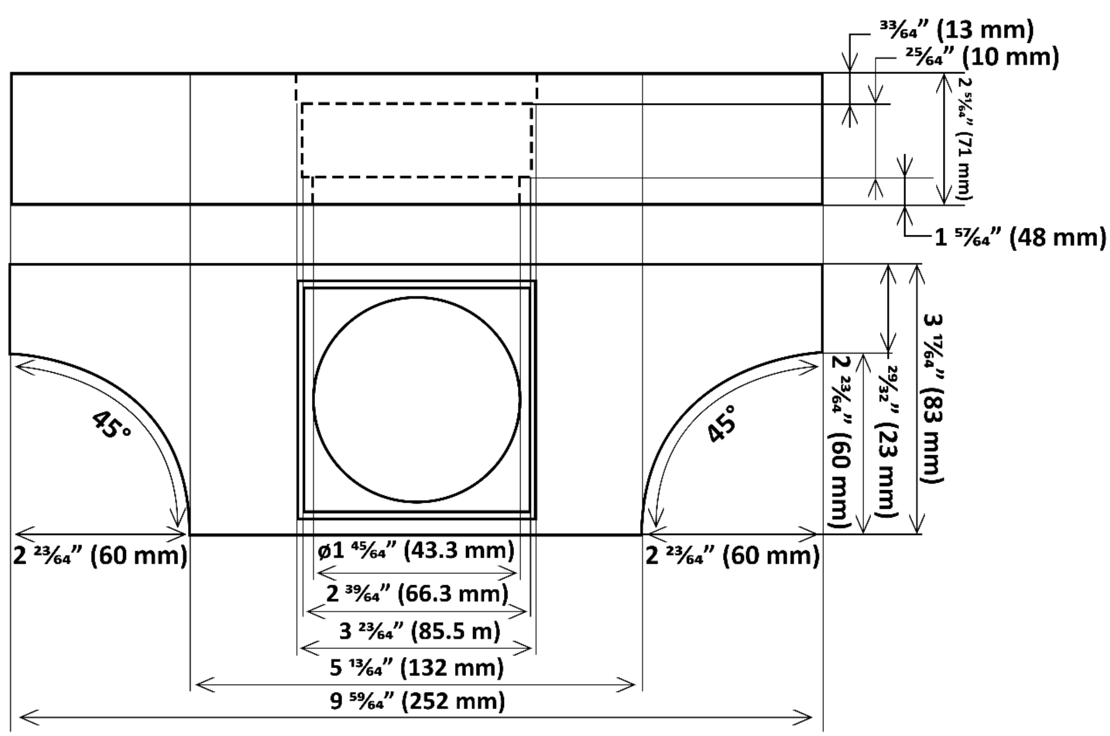
UP AND BACK ENCLOSURE FOR THE Z ANX X AXIS



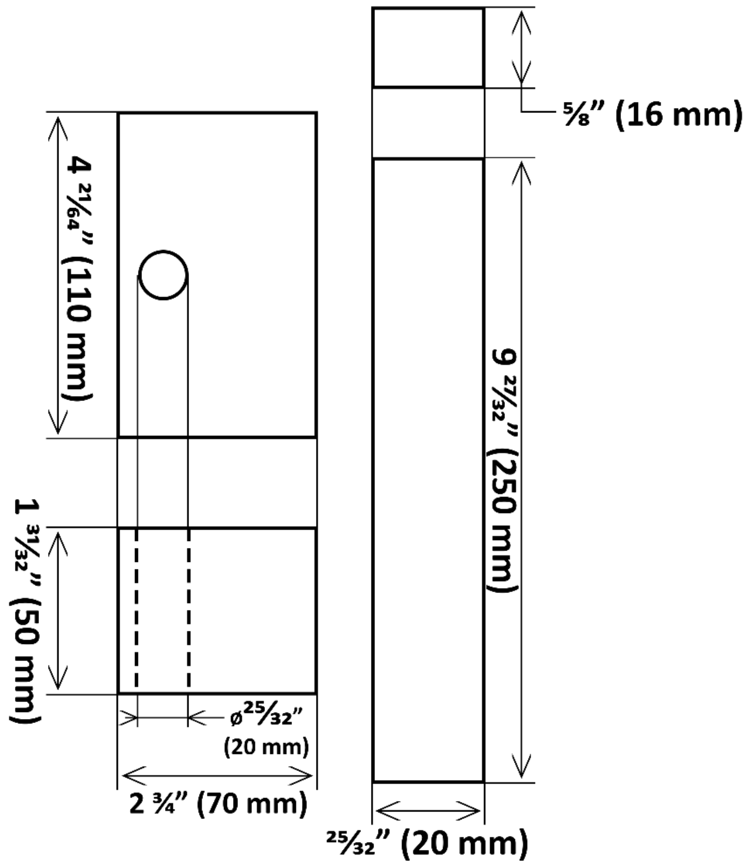
X AXIS SUPPORT FOR THE MOTOR



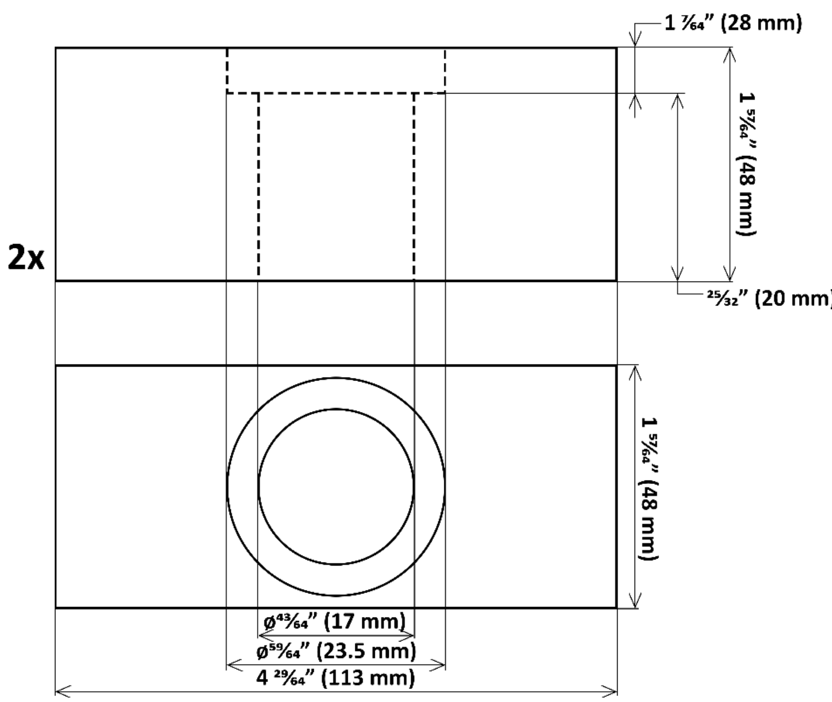
Z AXIS SUPPORT FOR THE MOTOR



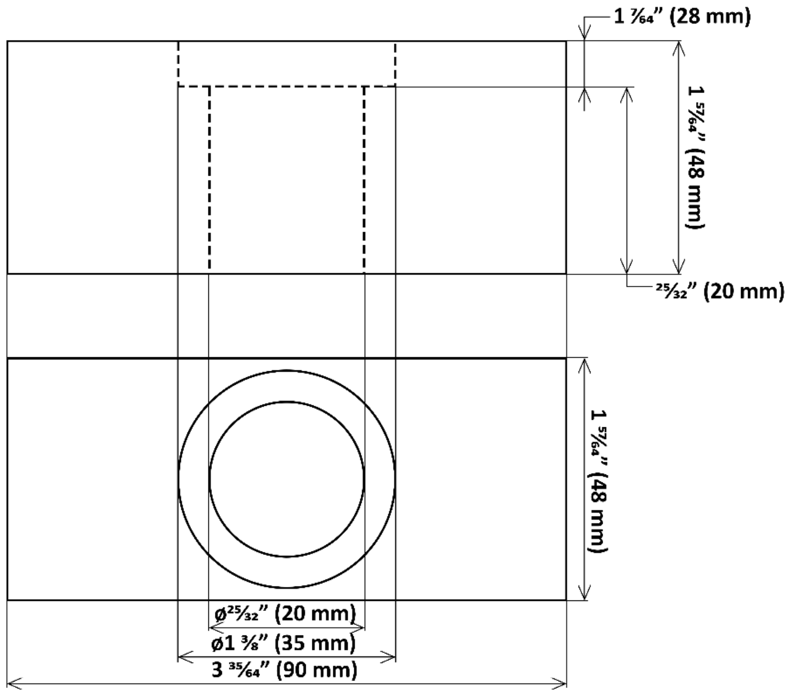
SPINDLE SUPPORT



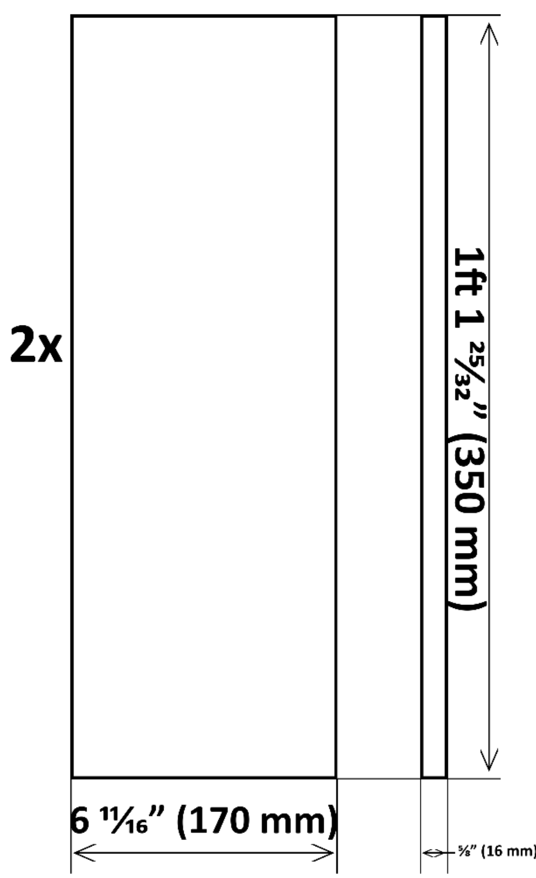
X AXIS MOVEMENT GUIDE



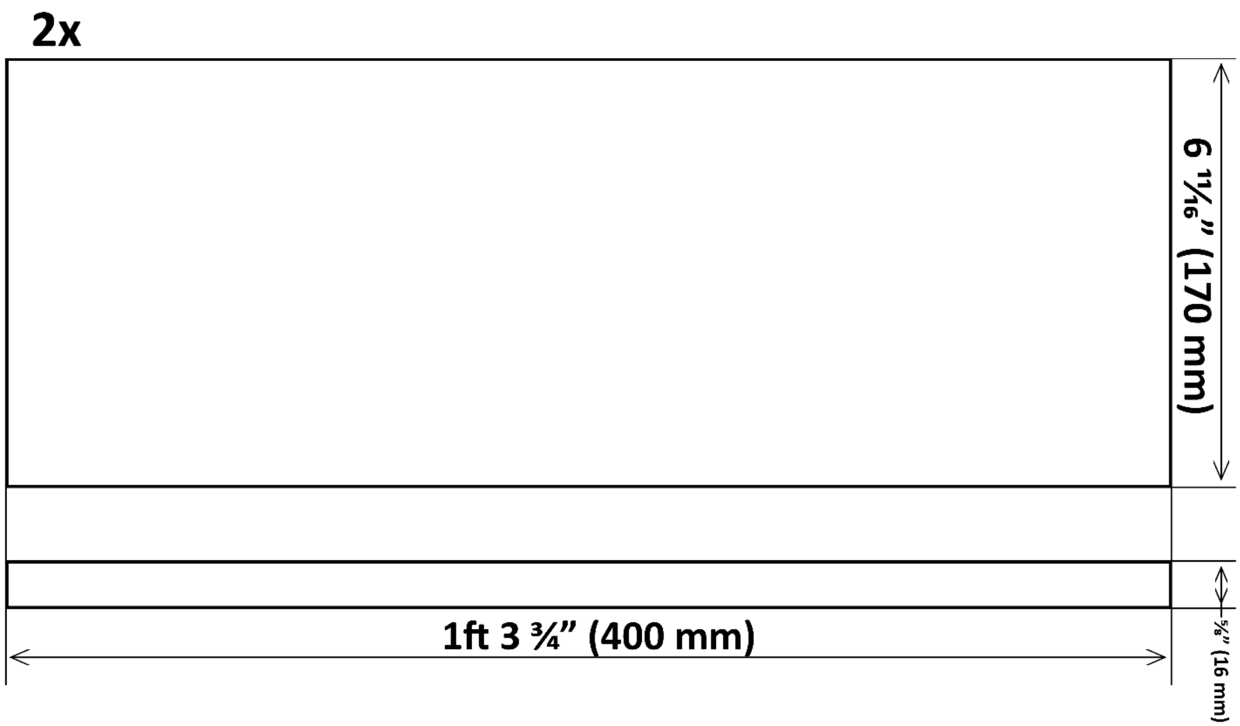
Z AXIS THREADED DRIVE ROD ENDS



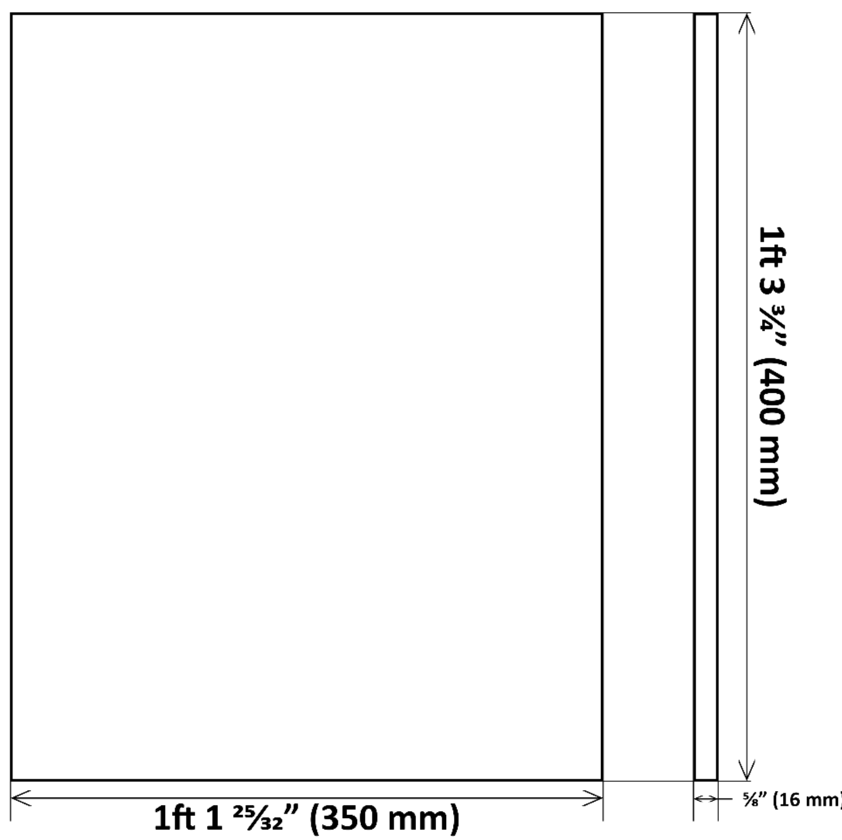
Z AXIS MOVEMENT GUIDE



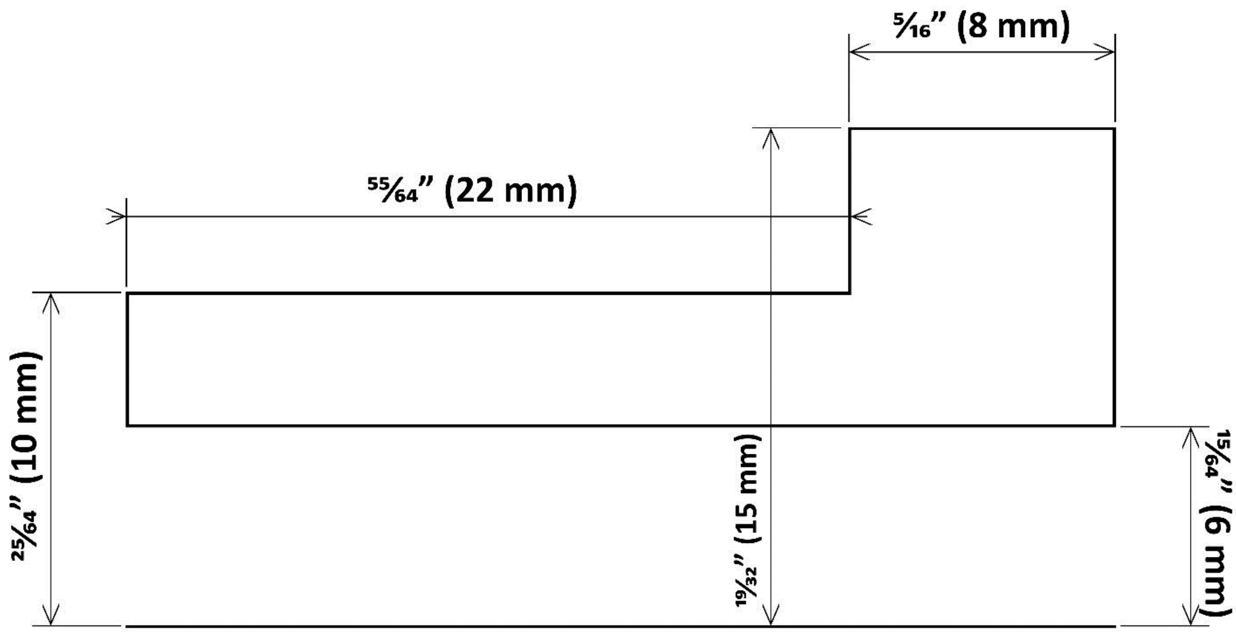
UP AND BOTTOM BOARD OF THE DRIVERS ENCLOSURE



LEFT AND RIGHT BOARD OF THE DRIVERS ENCLOSURE



BACK BOARD OF THE DRIVERS ENCLOSURE



PLASTIC BUSH COLLAR

Creating Your Parts:

Following the set of drawings provided for the DIY Smart Saw parts, cut and drill your chosen materials as directed, label each part and put to one side in preparation for later assembly. When parts are called for in pairs, they should be firmly clamped or taped together and drilled in pairs. This is essential for accurate alignment of rods and bearings which is critical for the smooth operation of your DIY Smart Saw.

1) Notes on precision cutting and drilling:

The DIY Smart Saw is a precision machine and requires a high level of accuracy in the fabrication work to create it. While a certain amount of tolerance is allowed for in the design, critical precision is required for:

- The relative positioning of the rods and bearings
- The relative positions of the axes to each other

2) Rods and bearings:

Rods must be perfectly parallel to either end. This means that the distance from outside edge of one rod to the other must be identical on both ends of their travel. Any variance greater than that will cause the carriage to bind up on the rails.

Likewise, the bearing holes in the bearing sub frames must be centered to the exact same dimension as the distance between centers of the rods. Precision in mounting the bearings on the correct matching centers to the rods is required to ensure a smooth-running axis.

As mentioned above, drilling matching parts in pairs is a simple and effective way to ensure alignment of holes between pieces. However, since the smooth operation of each carriage requires that rods must be parallel, and aligned accurately to the bearings, it is critical that care is taken to drill rod mounting holes and bearing mounting holes in the precise locations specified in the drawings.

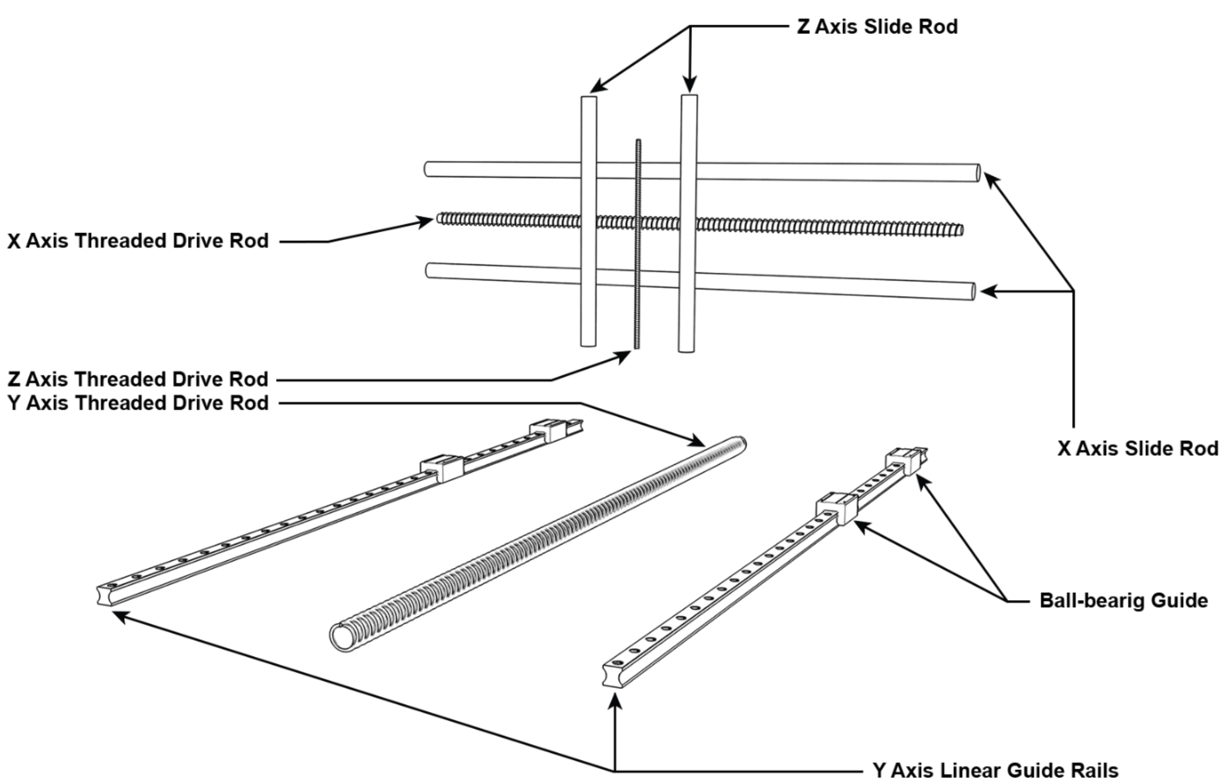
3) *Position of axes in relation to each other:*

The second-most critical requirement for precision is that the axes are aligned at exact right angles to each other. If not aligned, the work done by your DIY Smart Saw will also not be precise and aligned.

The Z depth may increase or decrease across your X table with no movement of the Z axis if your gantry and table are not completely square to each other. You may see work that should be square or rectangular be produced as a parallelogram if your Y axis is not aligned at exactly 90^{o} to the X axis.

This degree of alignment is achieved by taking great care and using a quality carpenter's or machinist's square at every step to ensure that right angles are maintained where required.

Before tightening down any chassis bolts or screws check for alignment and square. As long as the dimensions of the chassis holes on the metal chassis frame and the bottom cross-brace are accurate, it should be kept in square by the cross-brace.



CHAPTER IV : Building the Smart Saw

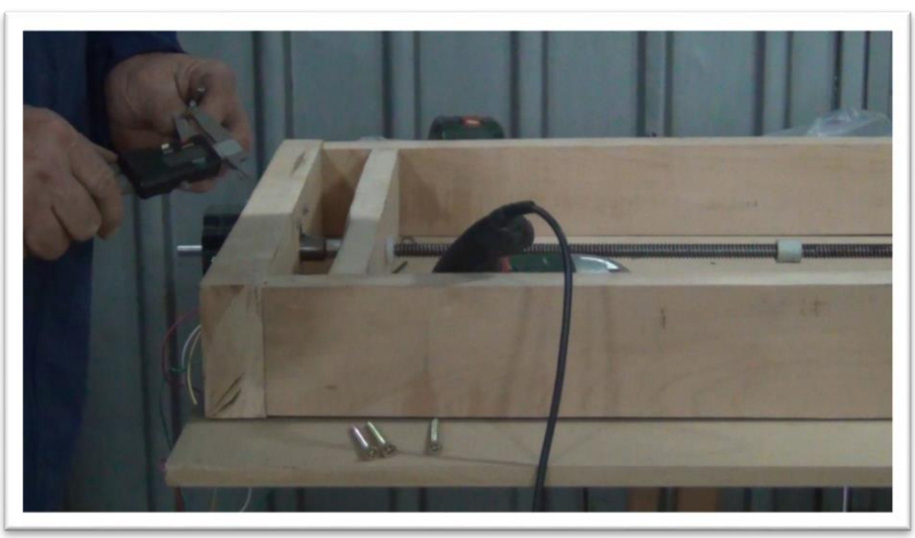
You will be building your DIY Smart Saw from scratch.

Chassis Frame:

For cutting the wood you can use a table saw and for making the holes for the motors and other pieces you can use a professional CNC MACHINE or a hammer and a chisels. Here is a link on how you can do this process: **LINK**

For the screwing holes you can use the drill.

For screwing the screws, you can use a power drill.



For measuring the screws and nuts so you can know the dimension/ diameter of the hole to drill you can use the caliper, as you can see in the previous picture. With the caliper you can make other measurements also.

For measuring and marking you can use a marker pen and carpenter meter.

For making the depth for the screws you can use a Depth Stop with the drill.

Here, in the pic below, you can see that I am using a homemade depth stop made by me from a cylinder wood piece. You can make one yourself.

For cutting other pieces/parts of wood I will also use the circular saw.

You can use the hammer for marking where to drill holes for the rails with a pointer.
For holding some wooden pieces in place you can use the vise.

You can use the hand vise to put 2 pieces together so you can drill and make holes in the same spot so that the alignment can be the same.

It can be used to tighten something else in place in the process.

For welding the frame and the legs which will be the base for the chassis you can use the welding machine.

For painting you can use a regular brush and I for my project used a metal silver-green paint.

Mechanical and Electrical Parts:

For this process you can use the tools used for chassis frame and add some screwdrivers, Allen's, soldering iron, Rosin-core solder, wire stripper, small side cutters (snips) and needle-nose pliers.

The Building Process in Drawings:

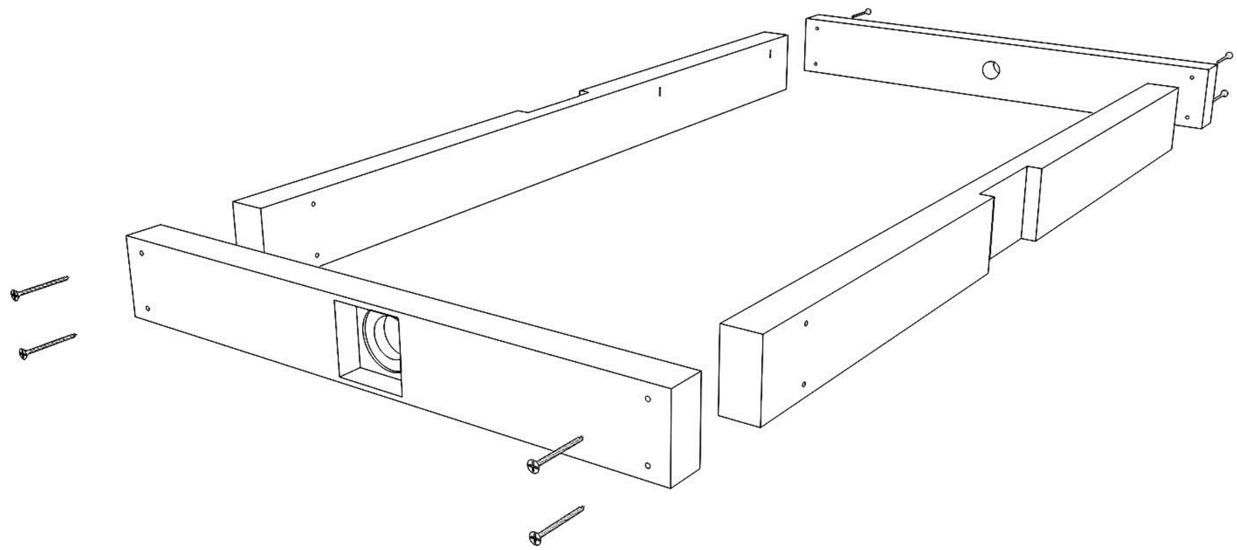


FIG. 1 (MOUNTING THE BASE FRAMES)

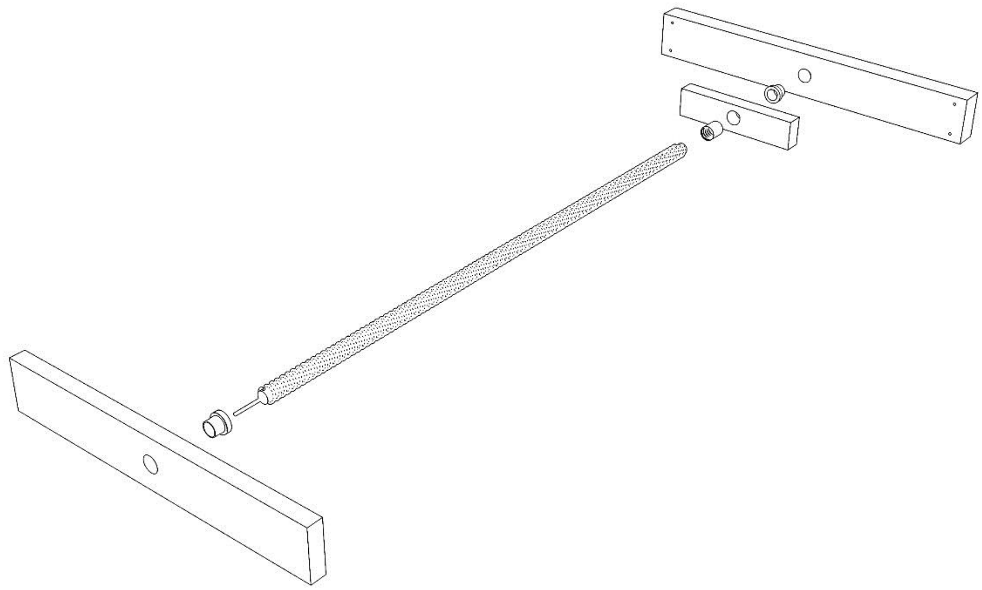


FIG. 2 (ADDING THE THREADED DRIVE ROD, MOTOR CONNECTION BOARD AND THE Y AXIS MOVEMENT GUIDE, USING FOR FASTEN IN PLACE 2 PLASTIC NUTS)

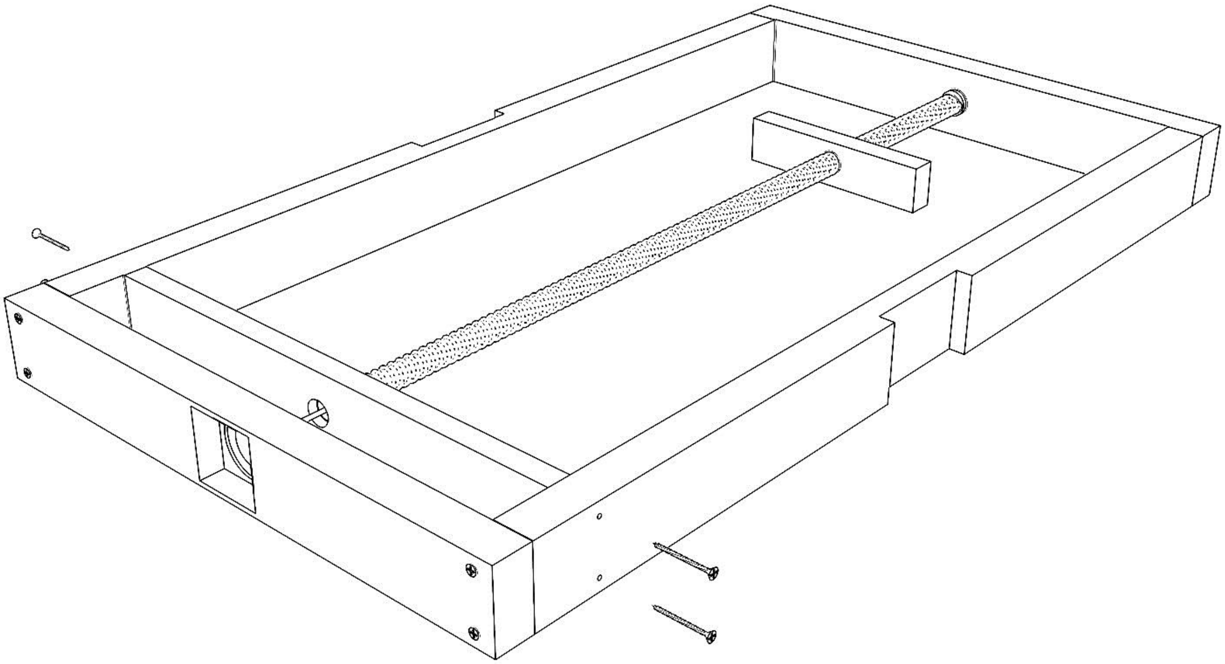


FIG. 3 (FIXING IT IN PLACE)

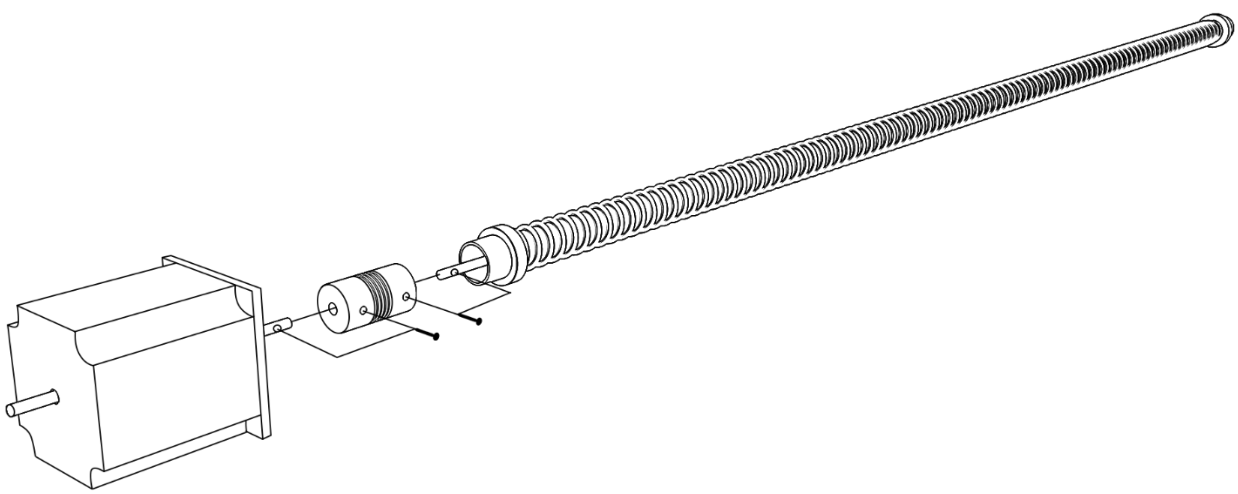


FIG. 4 (THE MOTOR, THREADED ROD CONNECTION)

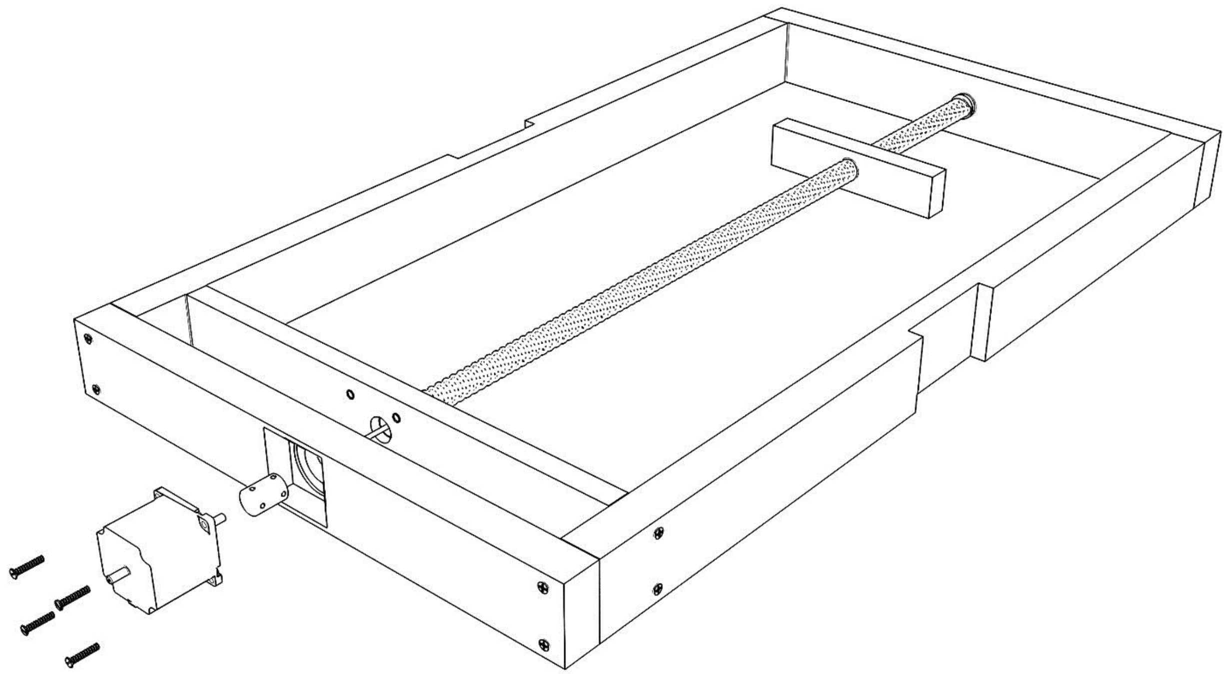


FIG. 5 (ADDING THE MOTOR AND CONNECTING IT TO THE THREADED ROD)

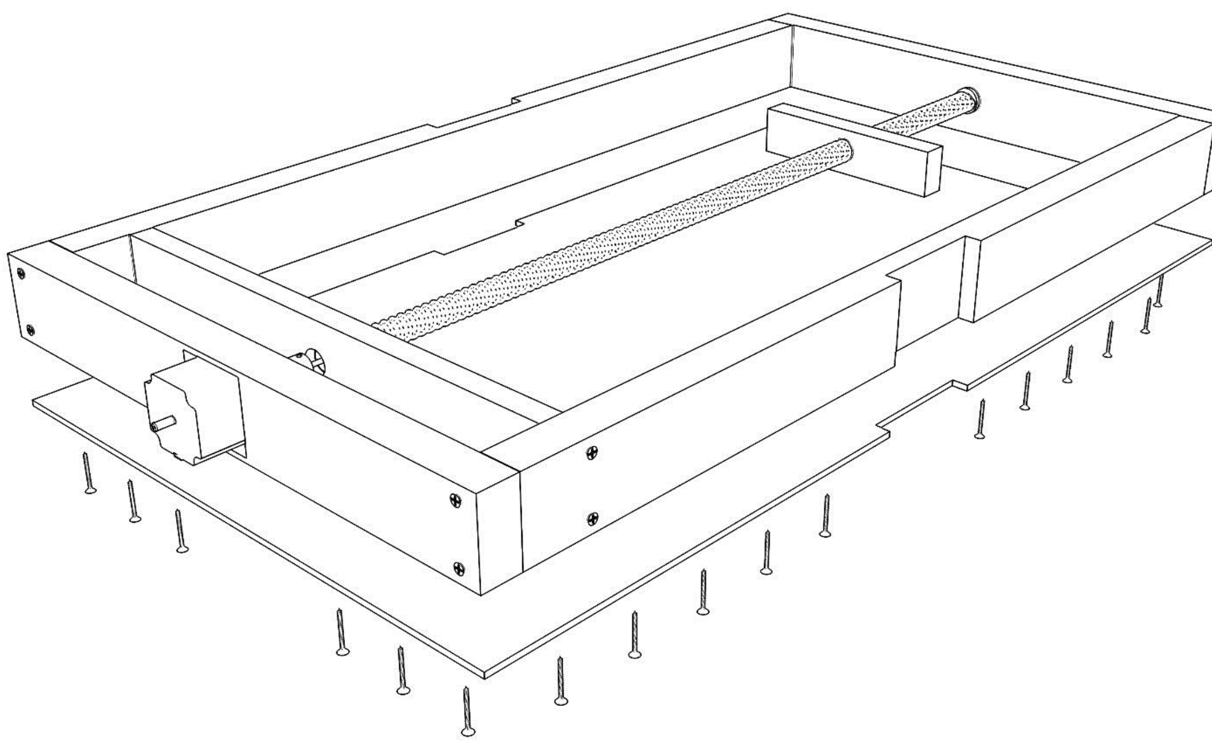


FIG. 6 (ADDING THE BOTTOM FRAME COVER)

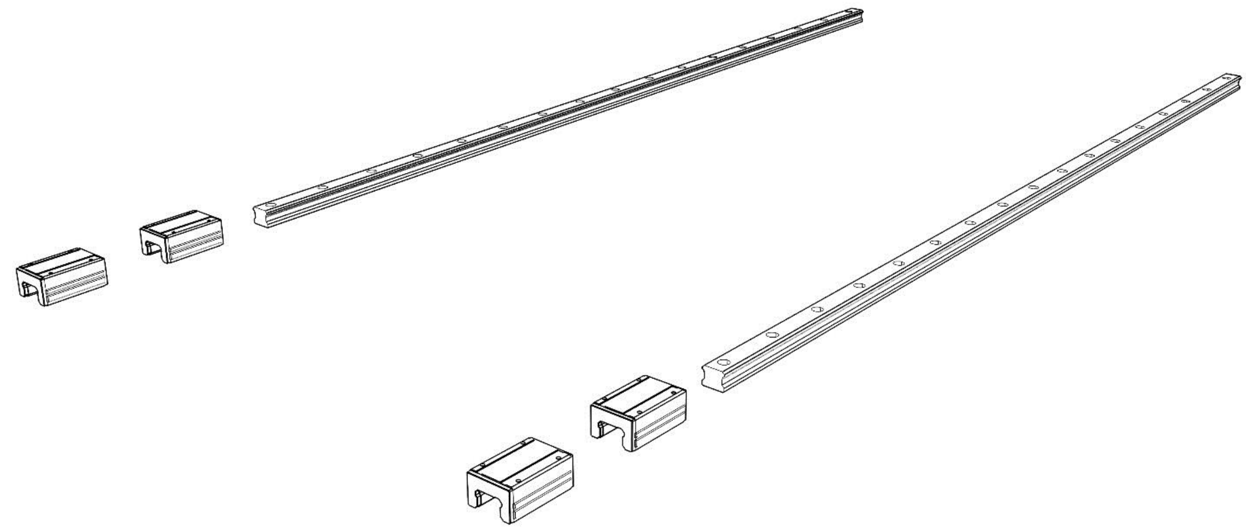


FIG. 7 (ADDING THE LINEAR RAIL BLOCK BEARING)

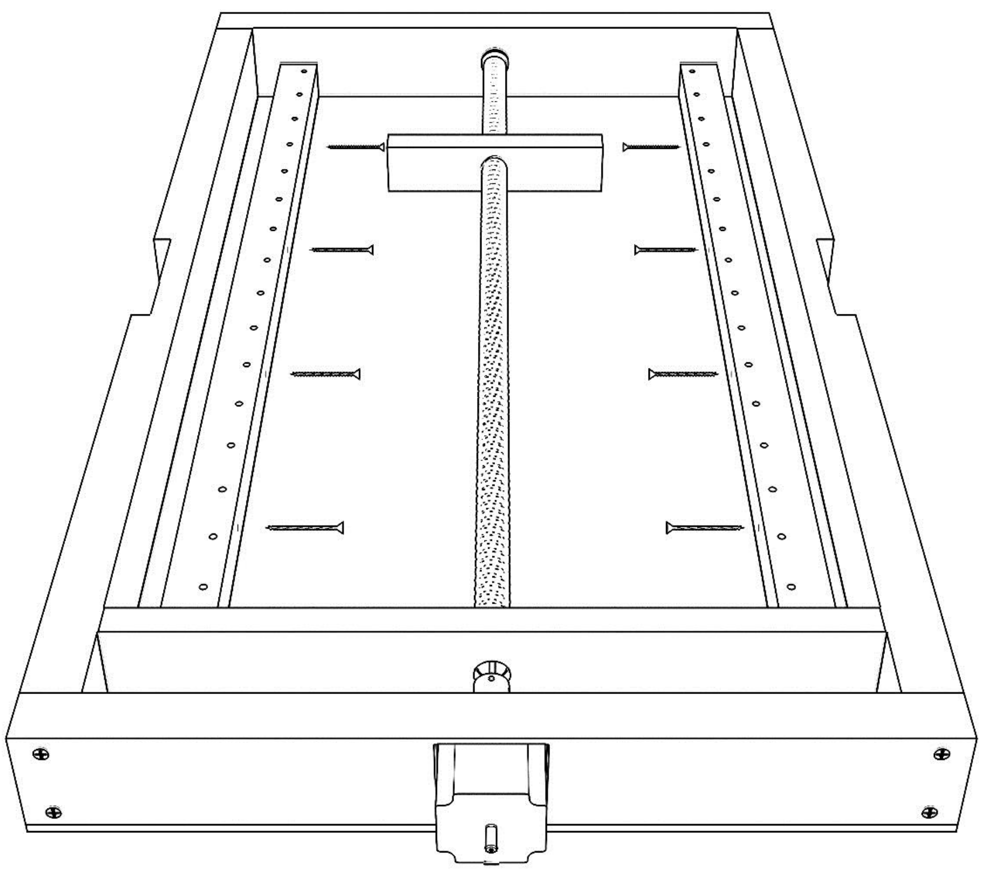


FIG. 8 MOUNTING THE Y AXIS LINEAR GUIDE RAILS SUPPORT)

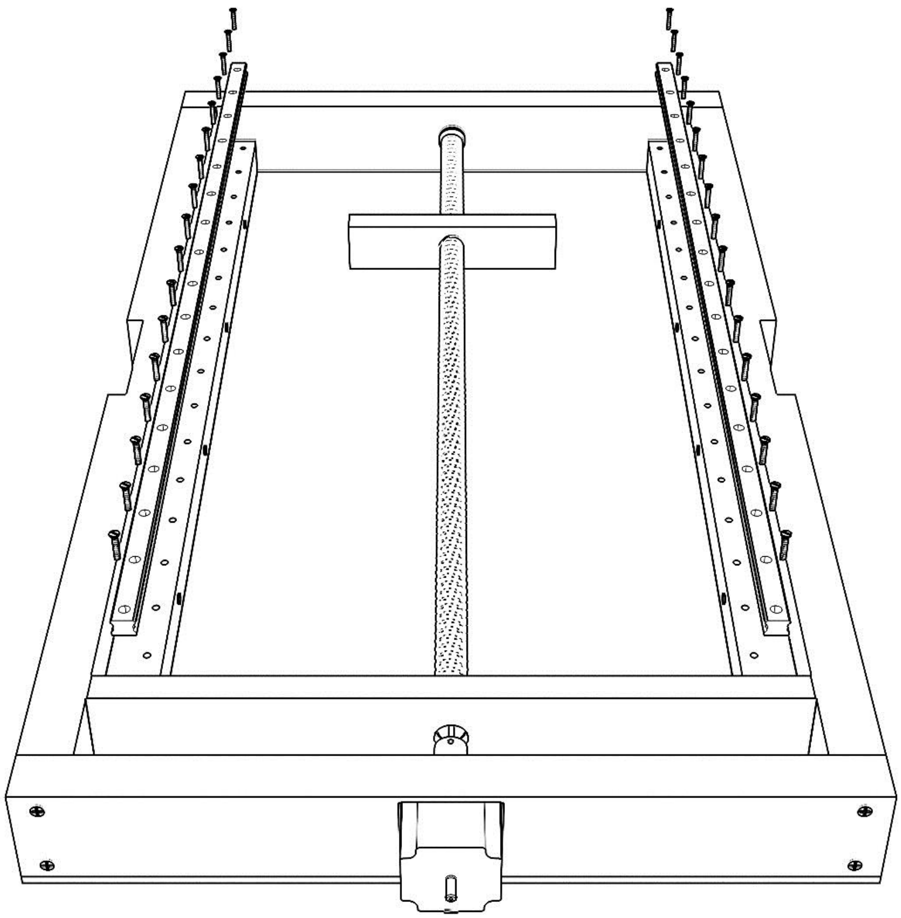


FIG. 9 (ADDING THE LINEAR GUIDE RAILS)

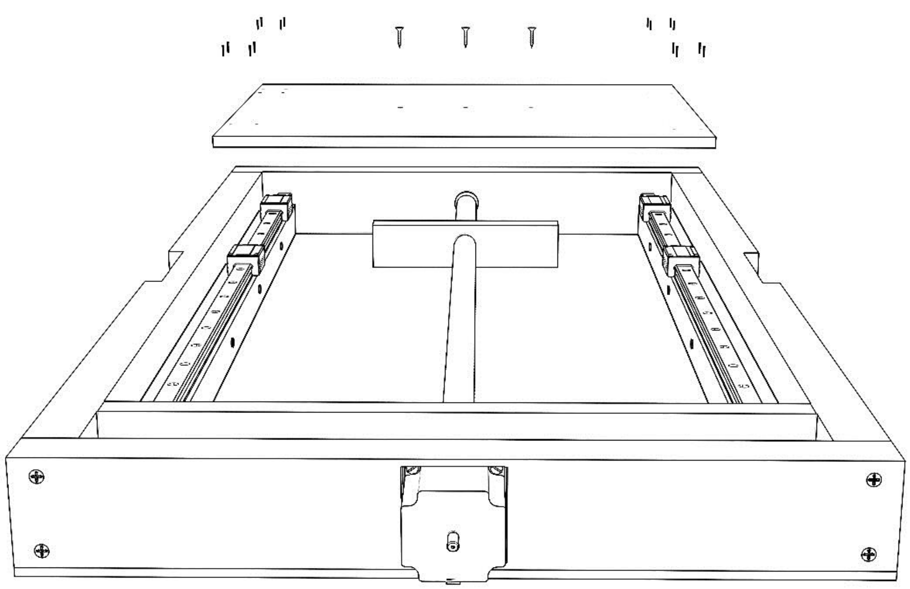


FIG. 10 (ADDING THE Y AXIS BOARD)

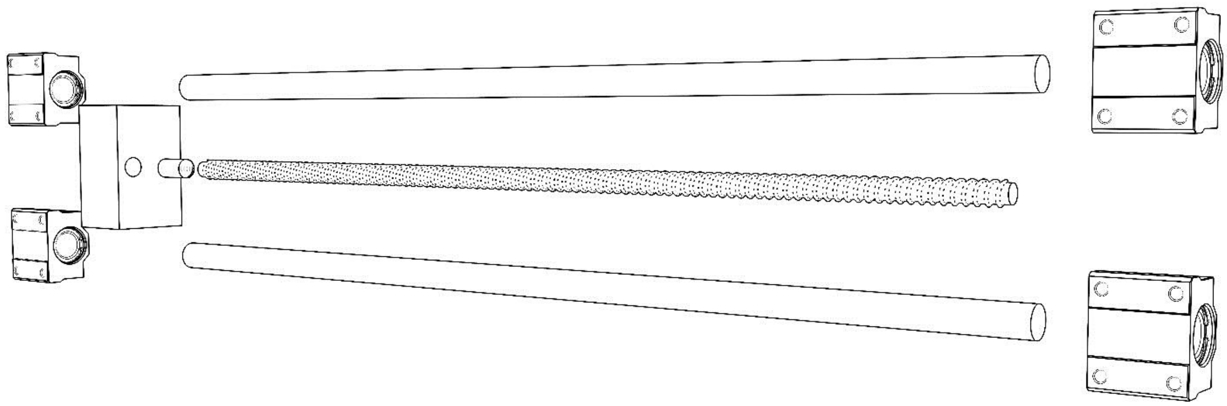


FIG. 11 (PUTTING TOGHETER THE PRECISION STEEL RODS, THE THREADED ROD, LINEAR MOTION BALL BEARINGS AND X AXIS MOVEMENT GUIDE)

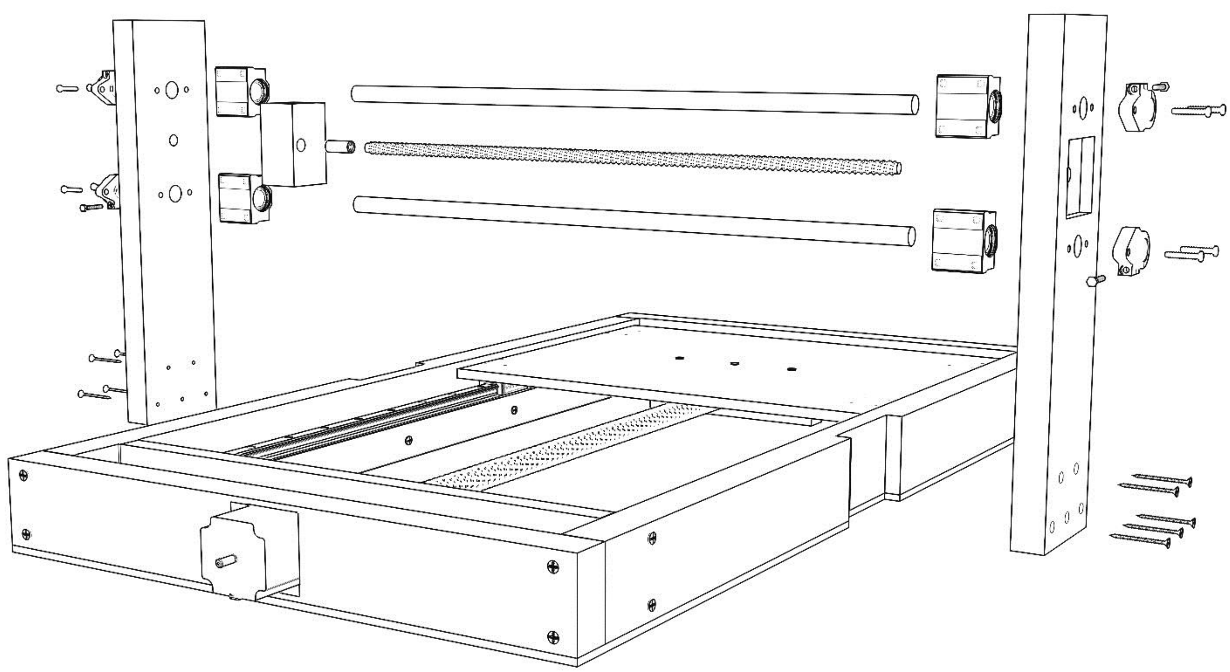


FIG. 12 (MOUNTING THE X AXIS SUPPORTS)

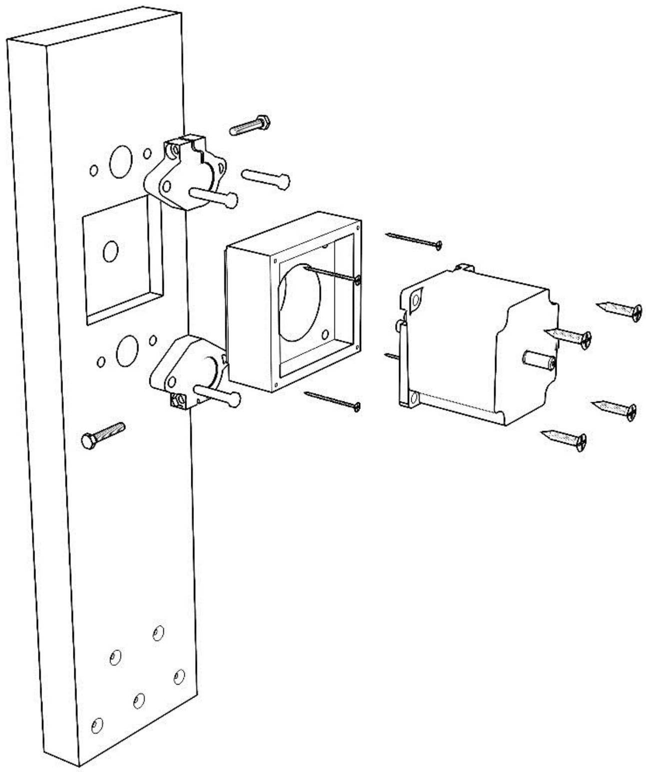


FIG. 13 (ADDING THE MOTOR SUPPORT AND MOUNT THE MOTOR)

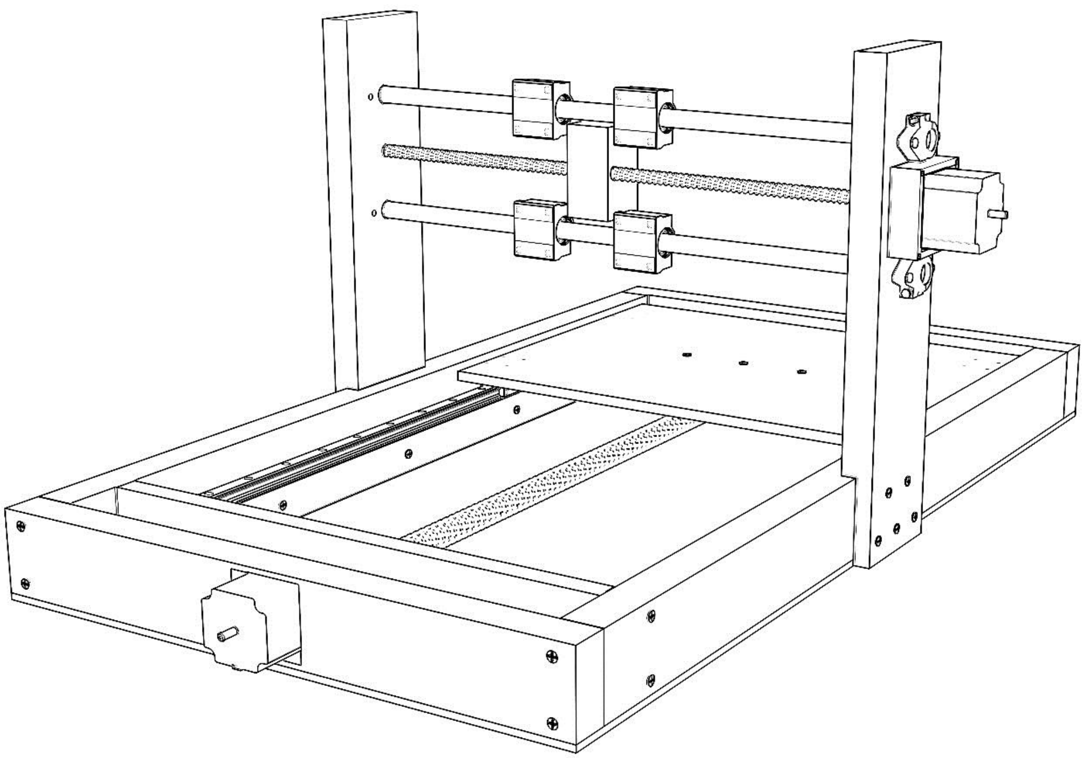


FIG. 14 (THE ASSEMBLY SO FAR)

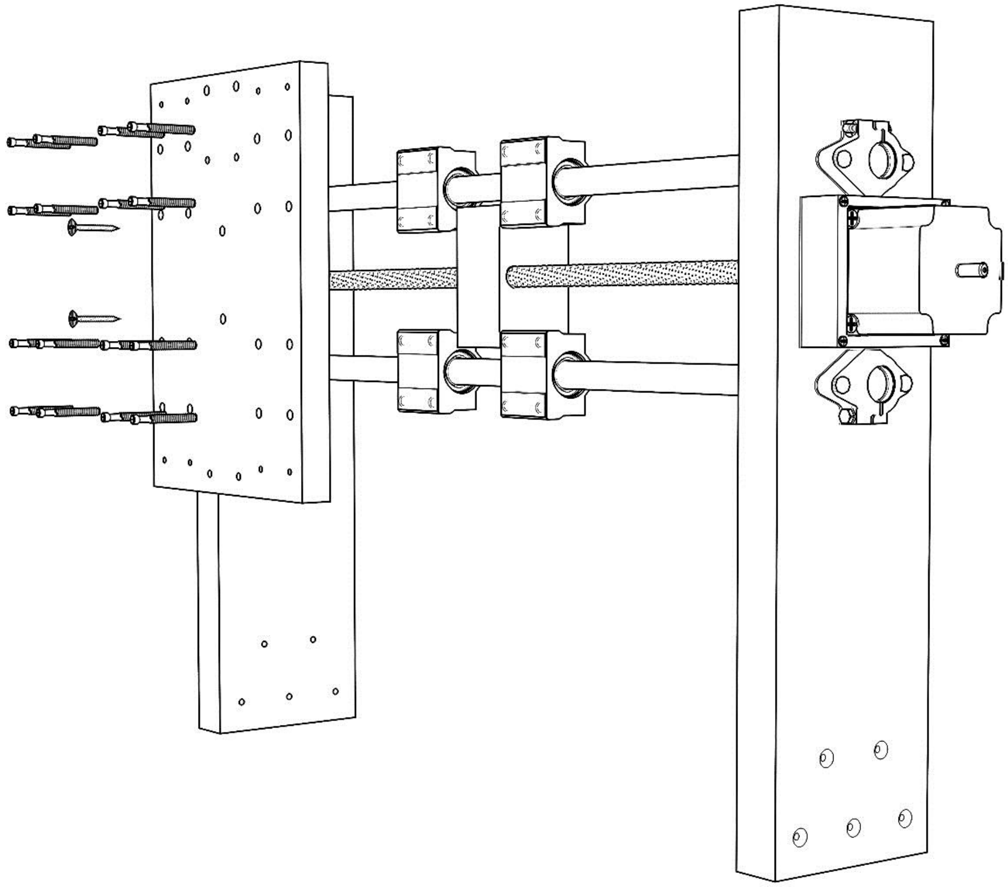


FIG. 15 (MOUNTING THE X AXIS BOARD)

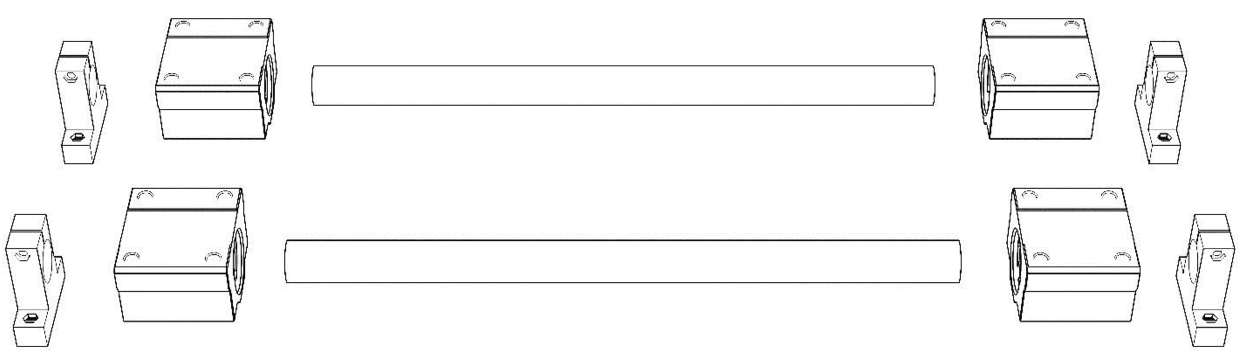


FIG. 16 (PUTTING TOGHETER THE PRECISION STEEL RODS, THE LINEAR MOTION BALL BEARINGS AND THE END SUPPORT)

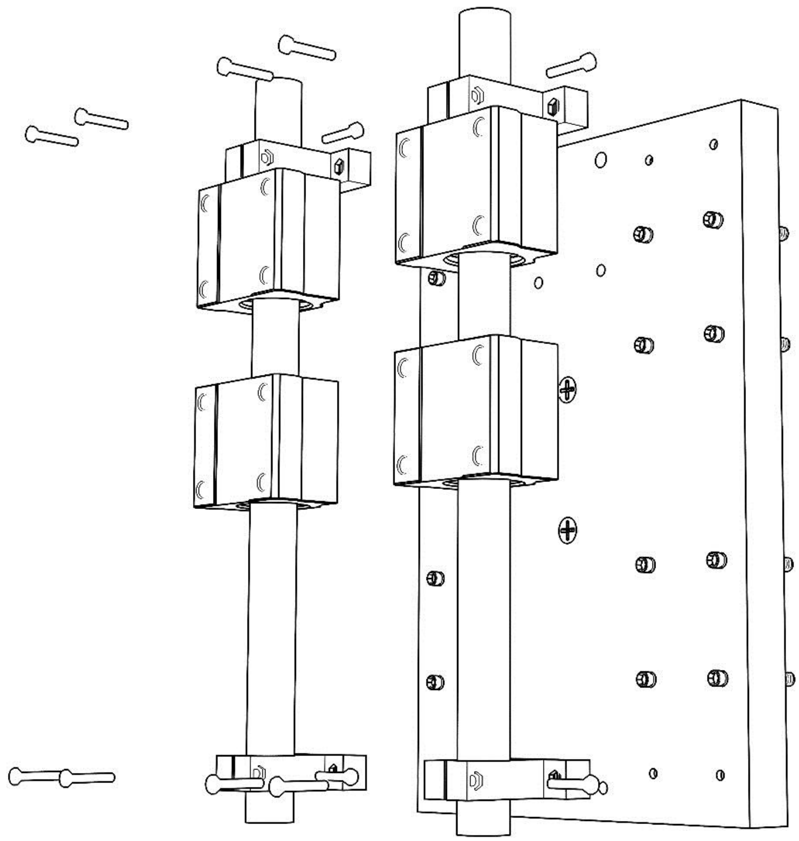


FIG. 17 (PUTTING IN PLACE THE ASSEMBLY IN FIG. 16)

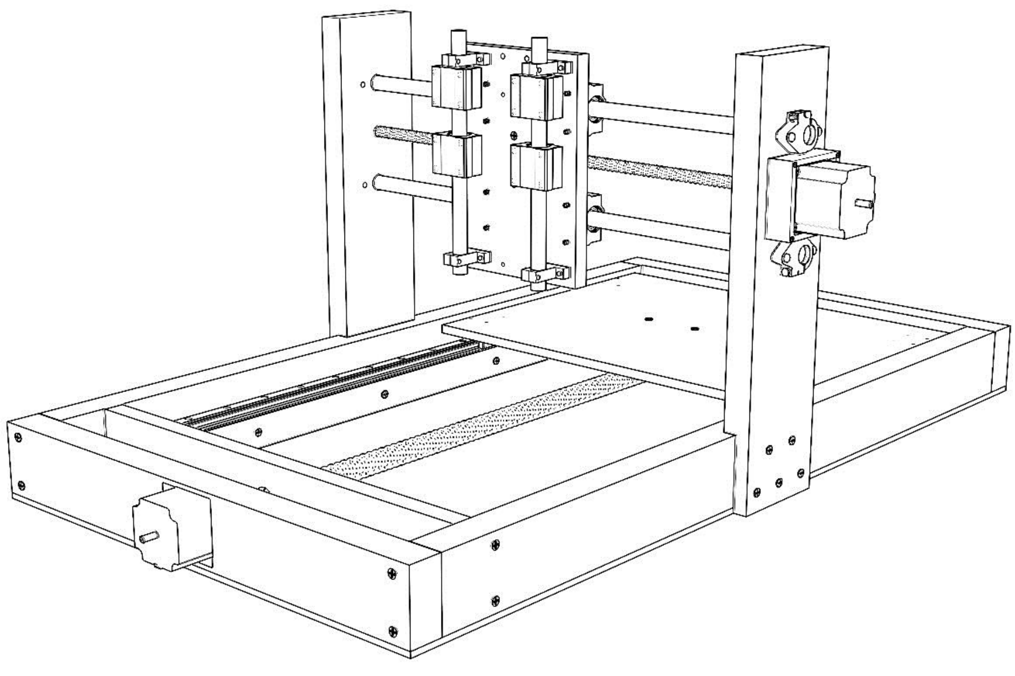


FIG. 18 (THE ASSEMBLY SO FAR)

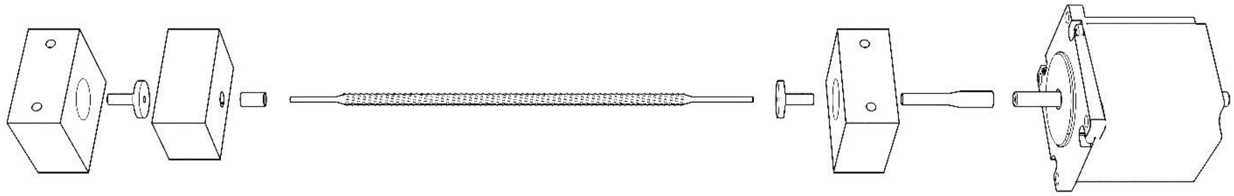


FIG. 19 (ADDING THE Z AXIS THREADED DRIVE ROD ENDS, THE Z AXIS MOVEMENT GUIDE AND THE Z AXIS THREADED DRIVE ROD ATTACHING TO THE MOTOR)

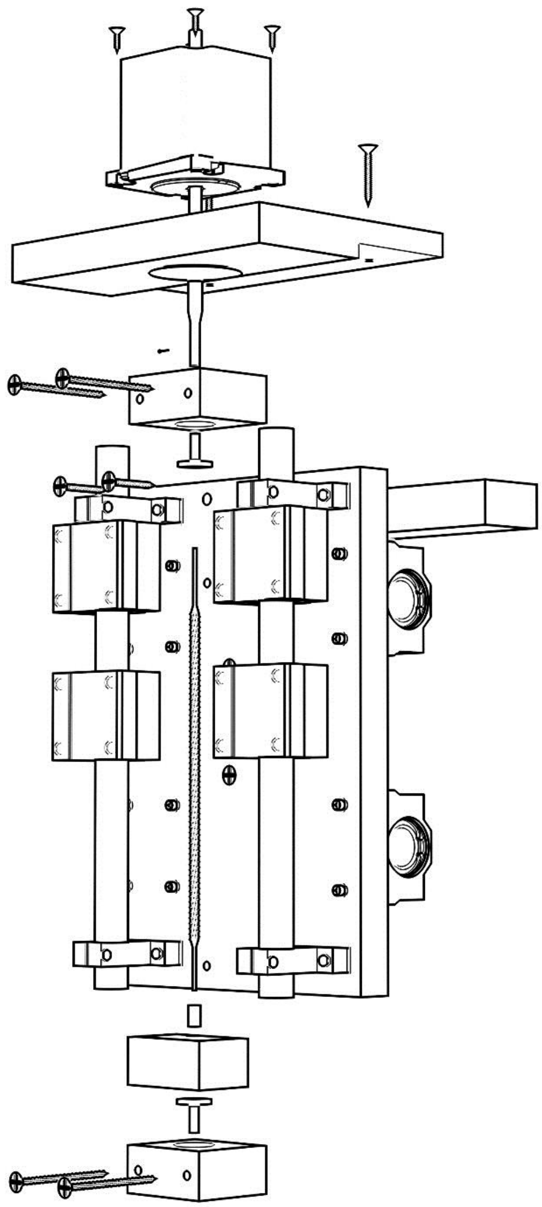


FIG. 20 (ADDING THE MOTOR SUPPORT AND THE ASSEMBLY IN FIG 19)

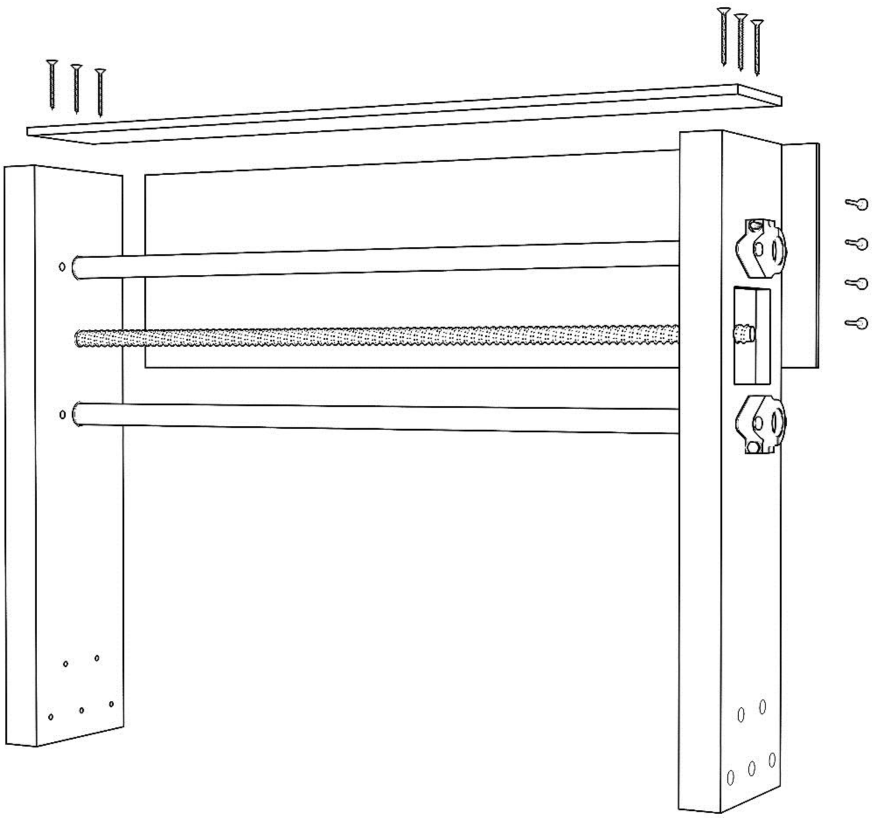


FIG. 21 (MOUNTING ENCLOSURE FOR THE Z ANX X AXIS)

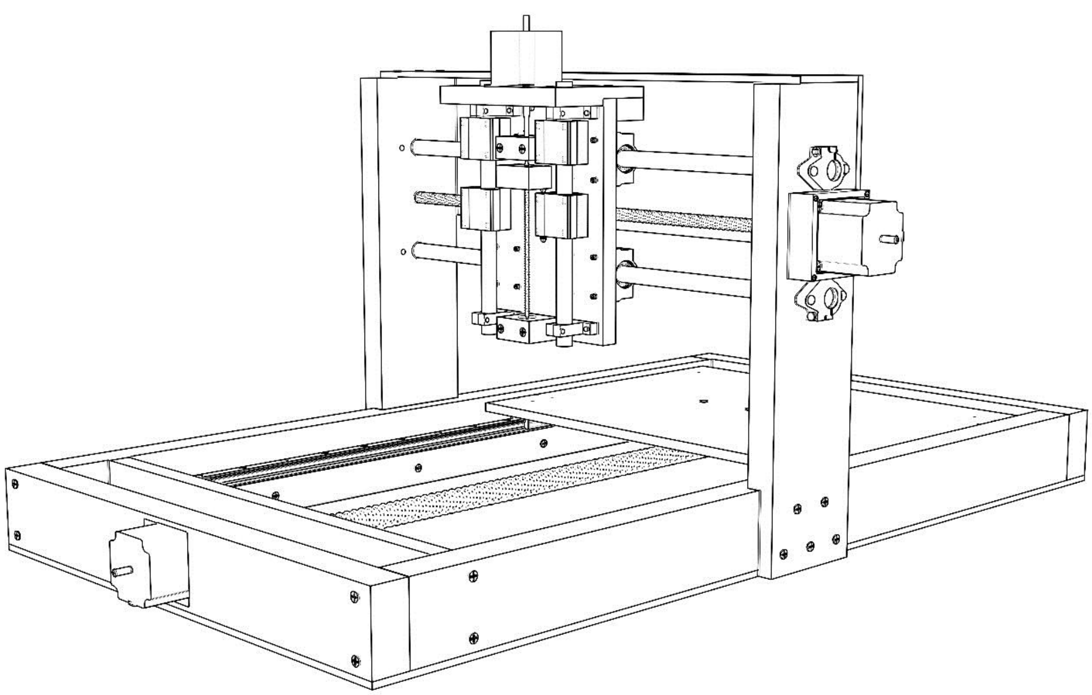


FIG. 22 (THE ASSEMBLY SO FAR)

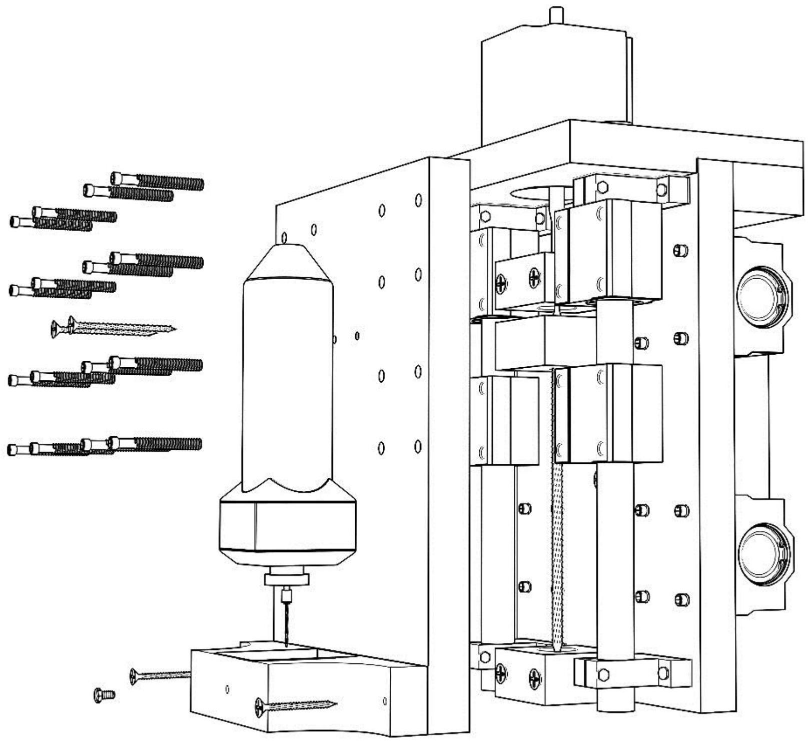


FIG. 23 (ADDING AND MOUNTING THE Z AXIS BOARD, THE SPINDLE SUPPORT AND THE SPINDLE)

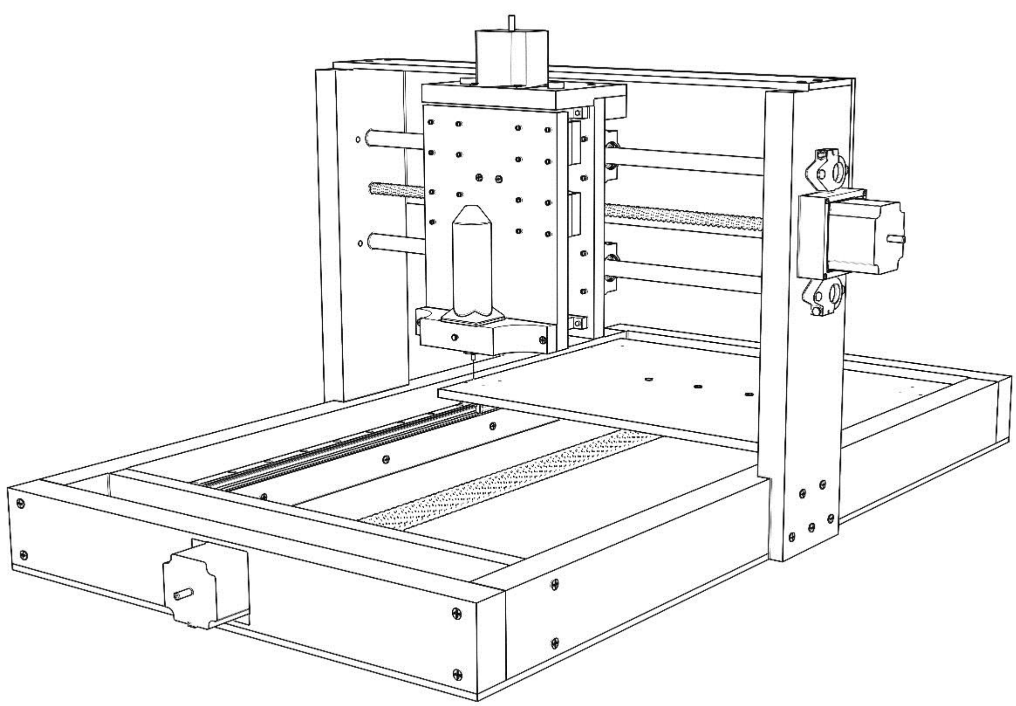


FIG. 24 (THE ASSEMBLY SO FAR)

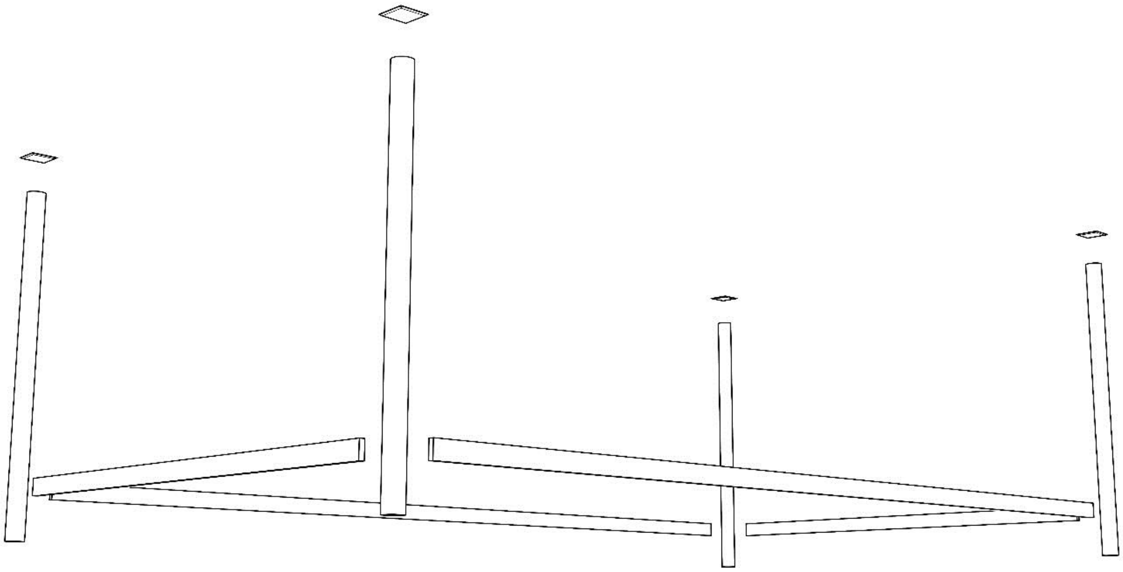


FIG. 25 (WELDING THE BASE FOR THE SUPPORT, ADDING THE LEGS)

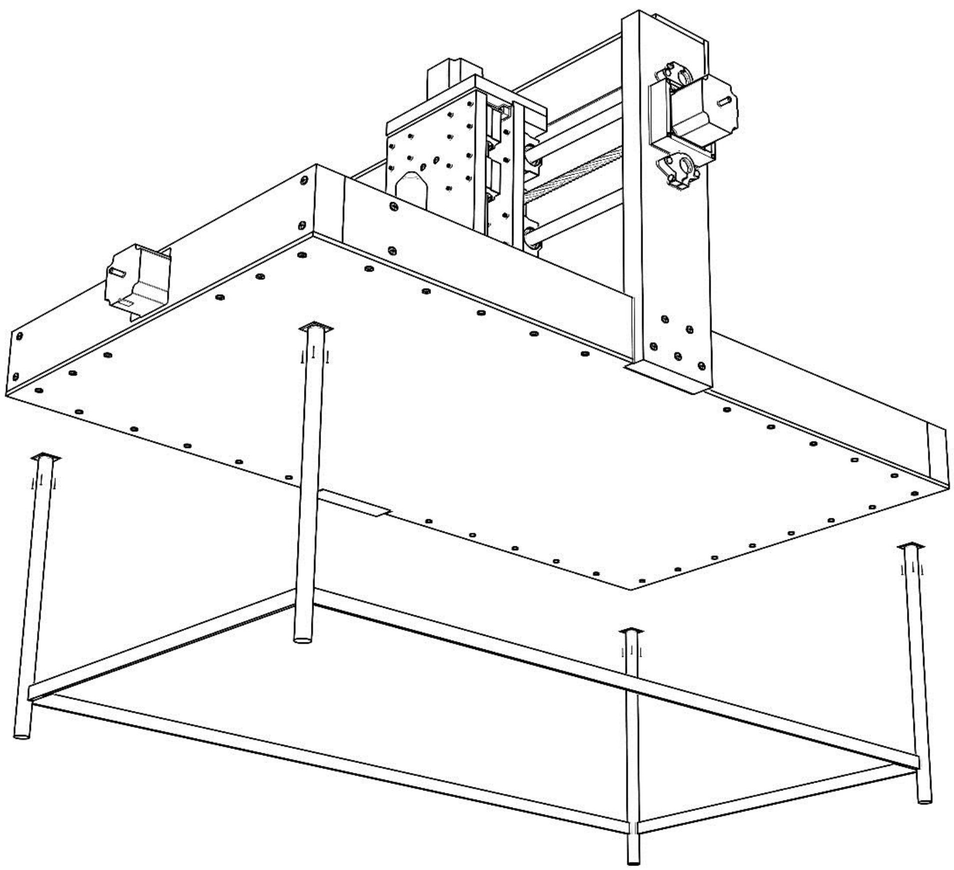


FIG. 26 (ADDING THE COUNTER TOP)

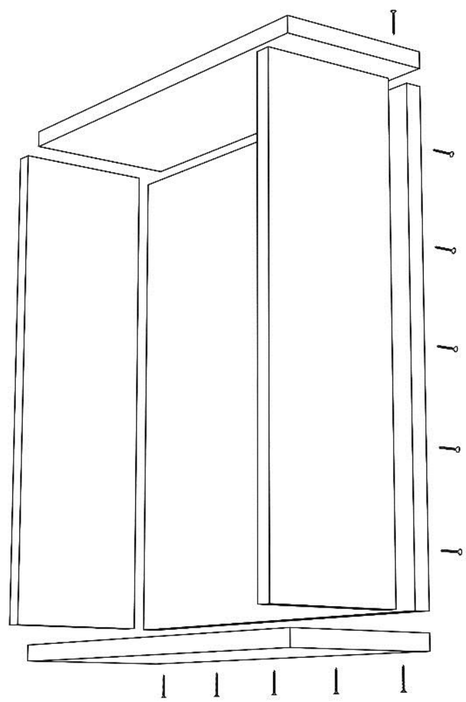


FIG. 27 (PUTTING TOGHETER THE ENCLOSURE)

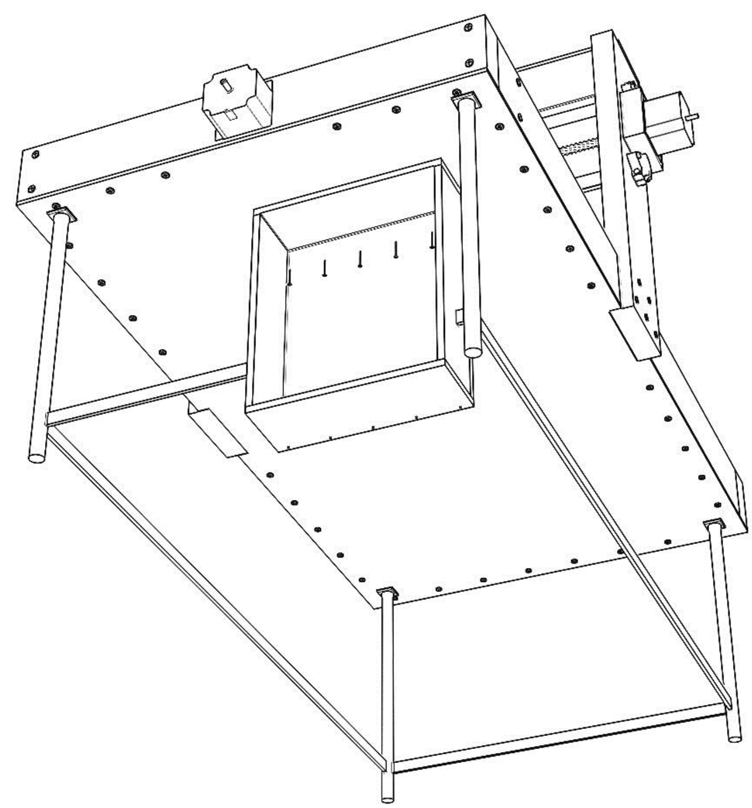


FIG. 28 (ADDING THE ENCLOSURE TO THE ASSEMBLY)

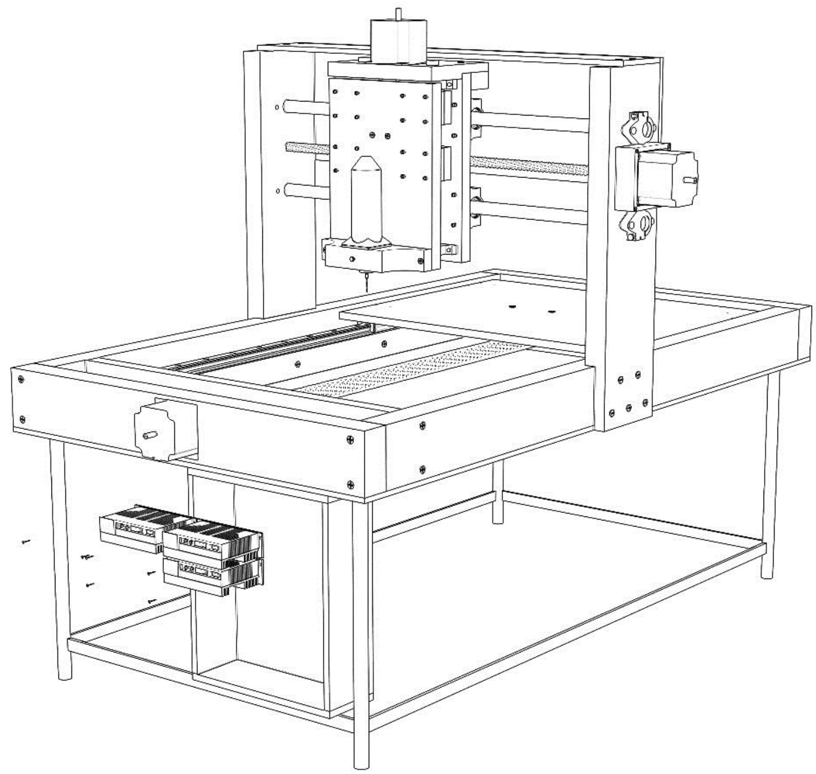


FIG. 29 (MOUNTING THE MOTOR DRIVERS)

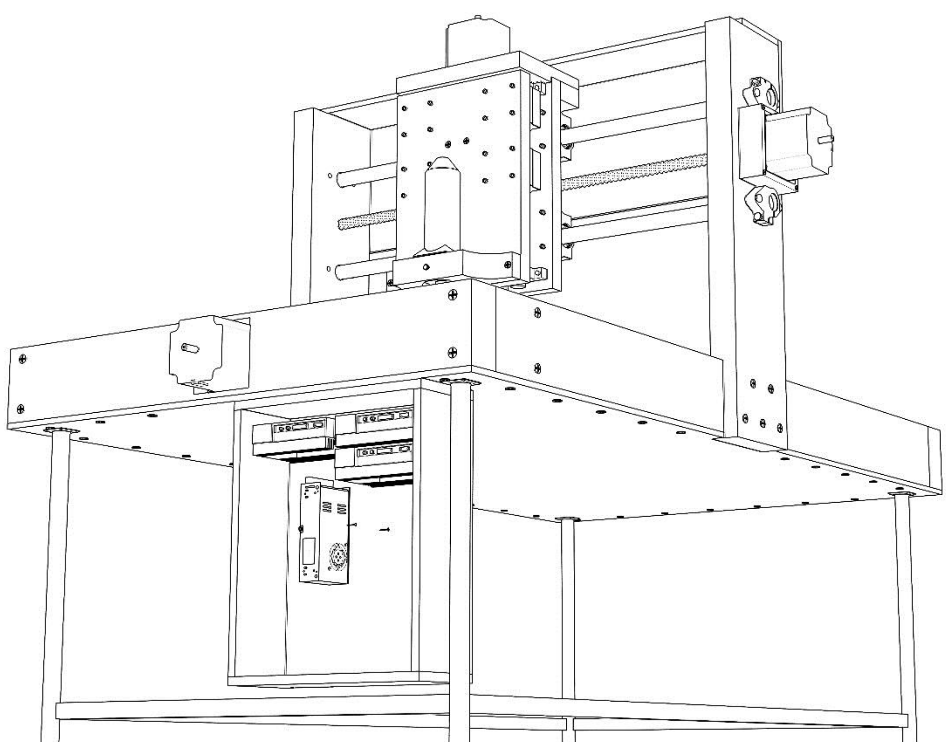


FIG. 30 (ADDING THE POWER SUPPLY)

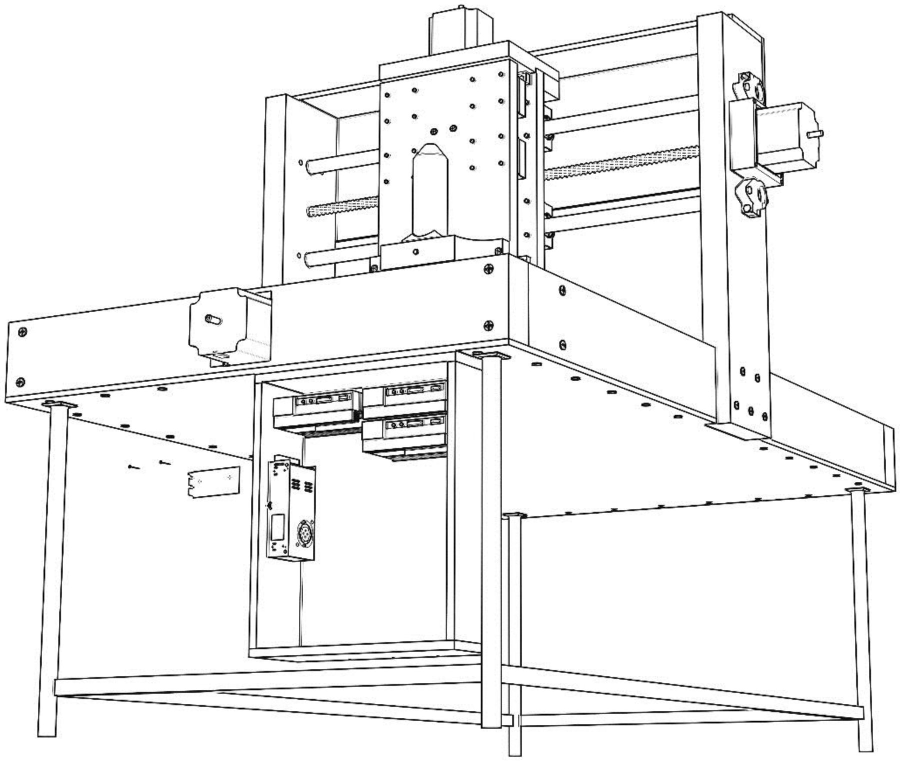


FIG. 31 (ADDING THE BREAKOUT BOARD)

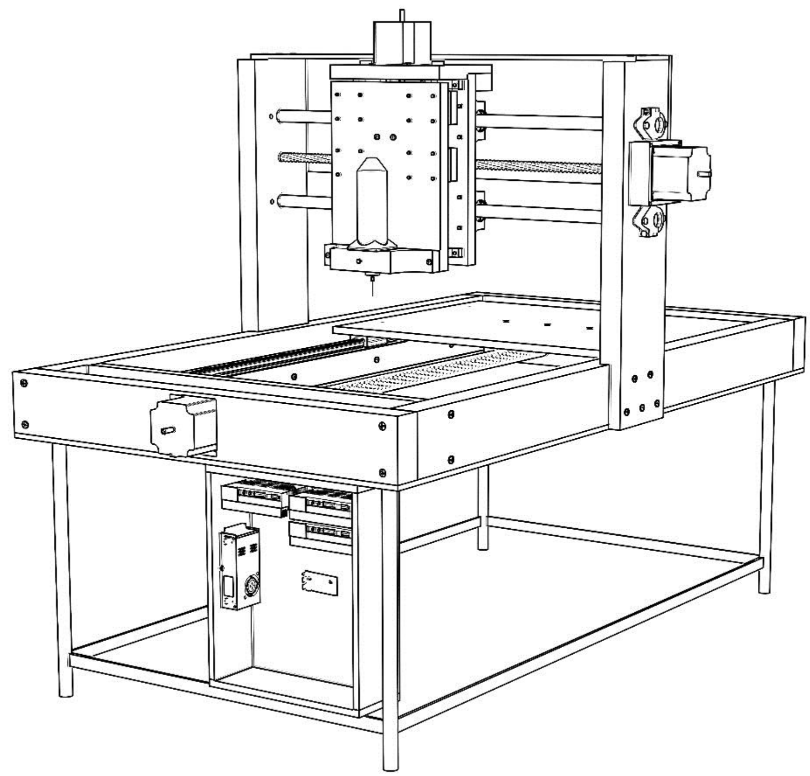


FIG. 32 (THE ENTIRE ASSEMBLY)

CHAPTER V : Additional Information

Stepper Motor Nema 34:

General Specifications:

Step Angle Accuracy	+5(full step, no load)
Temperature Rise	80°C (176°F) Max
Ambient Temperature	-10°C -- +50°C(14-122°F)
Insulation Resistance	100MΩ min. 500VDC
Dielectric Strength	500VAC for one minute
Shaft Radial Play	0.06 Max.(450g-load)
Shaft Axial Play	0.08 Max.(450g-load)

Electrical Specifications:

Model	Step Angle	Holding Torque	Current /Phase	Inductance /phase	Resistance /Phase	# of Leads	Rotor Inertia	Motor Weight	Motor Length
	(°)	Oz-In	A	mH	Ohm		g.cm²	lb	Inch
863S22	1.2	238	5	1.7	2.8	6	1200	4.63	2.87
863S42	1.2	566	5.0	1.35	4.5	6	2500	6.61	4.13
863S68H	1.2	960	3.5	1.7	20	6	3300	8.37	5.00

* ***Note:*** *although step angles for those 3-phase stepper motors are 1.2° degree, they will move 200 steps per resolution when driven by Leadshine 3-phase stepper drives, which I same as 2-phase 1.8° stepper motors. So there is no control system configuration between switch to 3-phase stepper motors from 2-phase stepper motors.*

Mechanical Specifications:

Dimensions are in mm and 1 inch=25.4mm

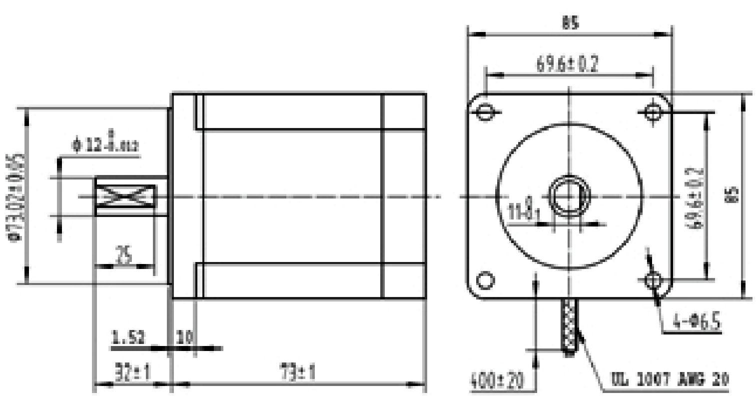


Figure 1 863S22 Mechanical Specifications

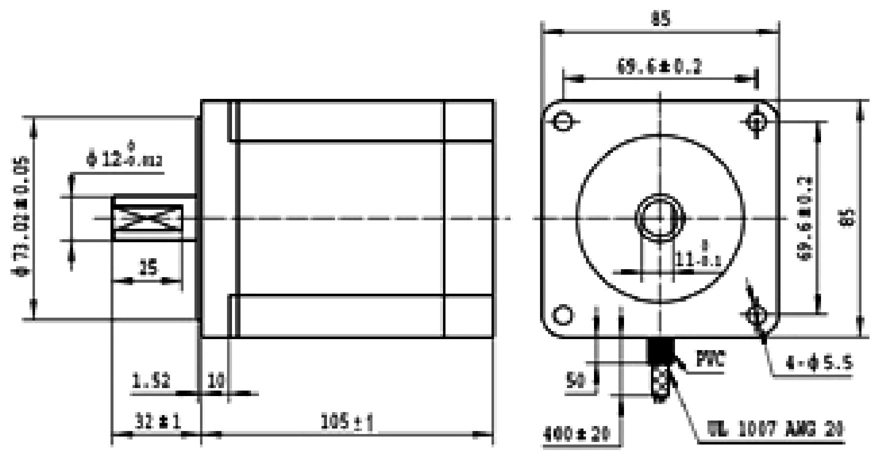


Figure 2 863S42 Mechanical Specifications

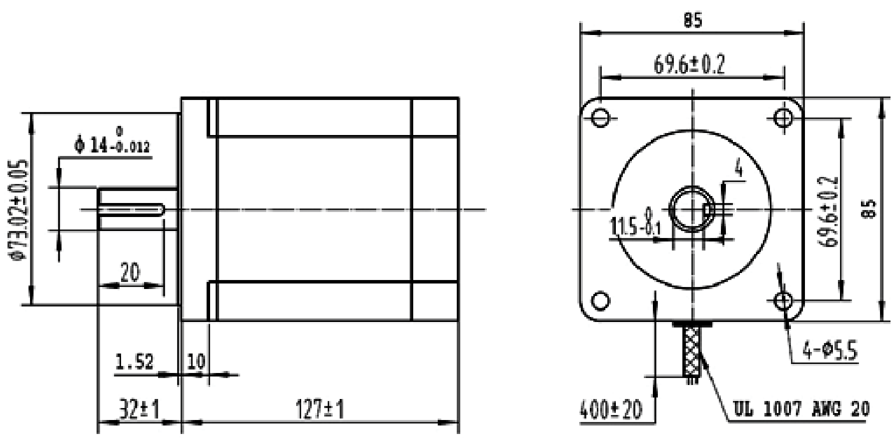


Figure 3 863S68H Mechanical Specifications

Stepper Motor Driver Power Step PSD8079-2P:

Electrical Specifications:

- 24 to 80VDC Supply Voltage
- H-Bridge, 2 Phase Bi-polar Micro-stepping Drive Suitable for 2-phase, 4, 6 and 8 leads step motors, with Nema size 23 to 42
- Output current selectable from 1.8 ~ 7.9A peak Current reduction by 50% automatically, when motor standstill mode is enabled
- Pulse Input frequency up to 200 kHz
- Optically isolated differential TTL inputs for Pulse, Direction and Enable signal inputs
- Selectable resolutions up to 12800 steps
- Over Voltage, Coil to Coil and Coil to Ground short circuit protection.

Introduction:

PSD8079-2P is a cost effective, high performance bi-polar two phase micro-stepping drive applying pure-sinusoidal current control technique. It is best suited for the applications that desired extreme low noise and heat. It operates well in an environment, where electricity supply experience instability and fluctuation.

The general pseudo-sinusoidal current control technology adopted by majority of the drive produced distorted sine wave, and current ripple, resulting in vibration, noise and motor heating. This results in motor degrading over time, reducing in motor performance and shortens the usage life.

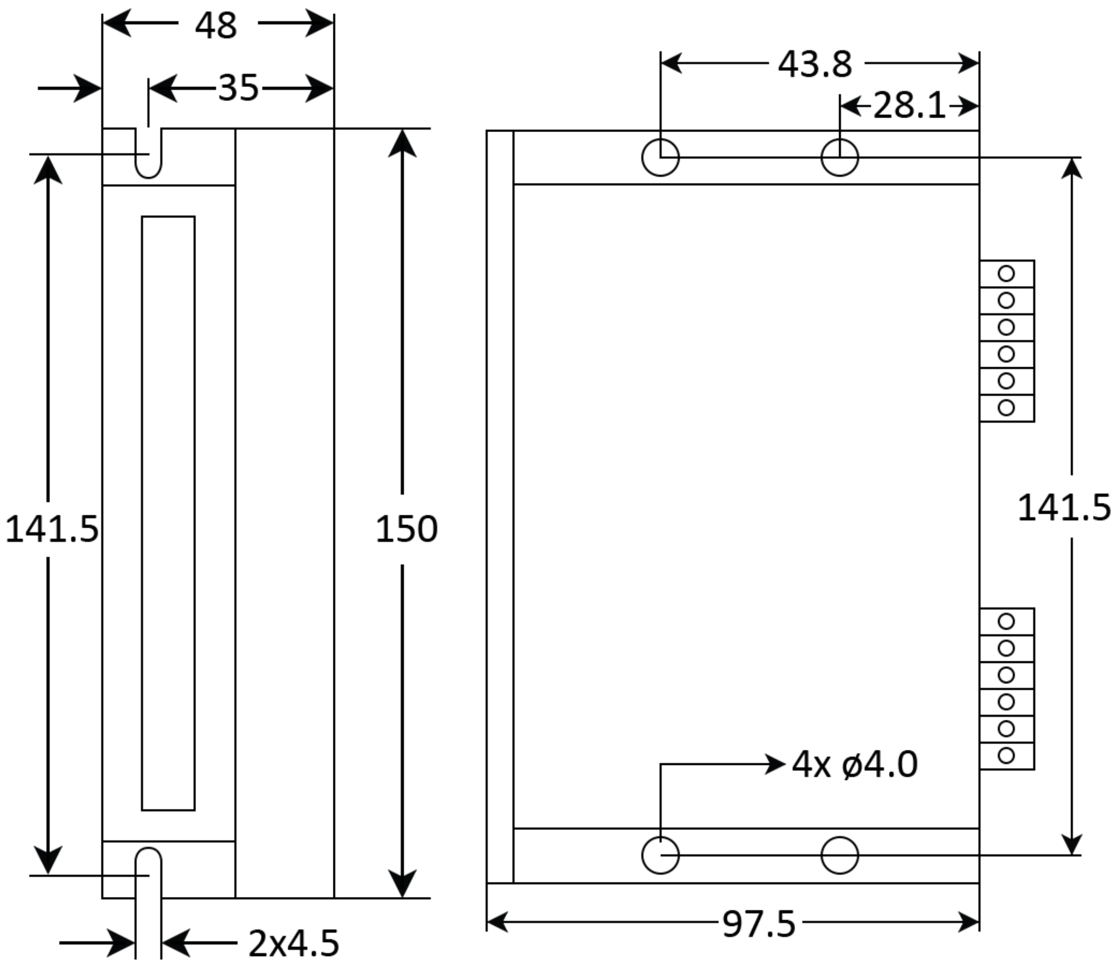
With an automatic optimization speed control technique, the PowerStep series drive output is very stable, with almost zero vibration and noise, performing close to a servo system, allowing the motor to operate smoothly. That helps to fulfill a design requirement of low noise, low heat and high performance.

Specifications:

Parameters	Min	Typical	Max	Unit
Output Current (Peak)	1.8	-	7.9	Amps
Supply Voltage	24	48	80	VDC
Logic Input Current	7	10	16	mA
Pulse Input Frequency	0	-	200	Khz
Low Level Time	2.5			μsec

Cooling	Natural Cooling or	Forced Convection
Environment	Space	Avoid dust, oil frost and corrosive gases
	Ambient Temperature	0°C - 50°C
	Humidity	40 – 80% RH
	Vibration	5.9m/s² Max
Storage Temp.		-10°C – 80°C
Weight		Approx. 500gram

Mechanical Dimensions (mm):



Current Setting:

Current Setting (A)	SW1	SW2	SW3
1.8	OFF	OFF	OFF
2.5	ON	OFF	OFF
3.5	OFF	ON	OFF
4.3	ON	ON	OFF
5.2	OFF	OFF	ON
6.0	ON	OFF	ON
7.0	OFF	ON	ON
7.8	ON	ON	ON

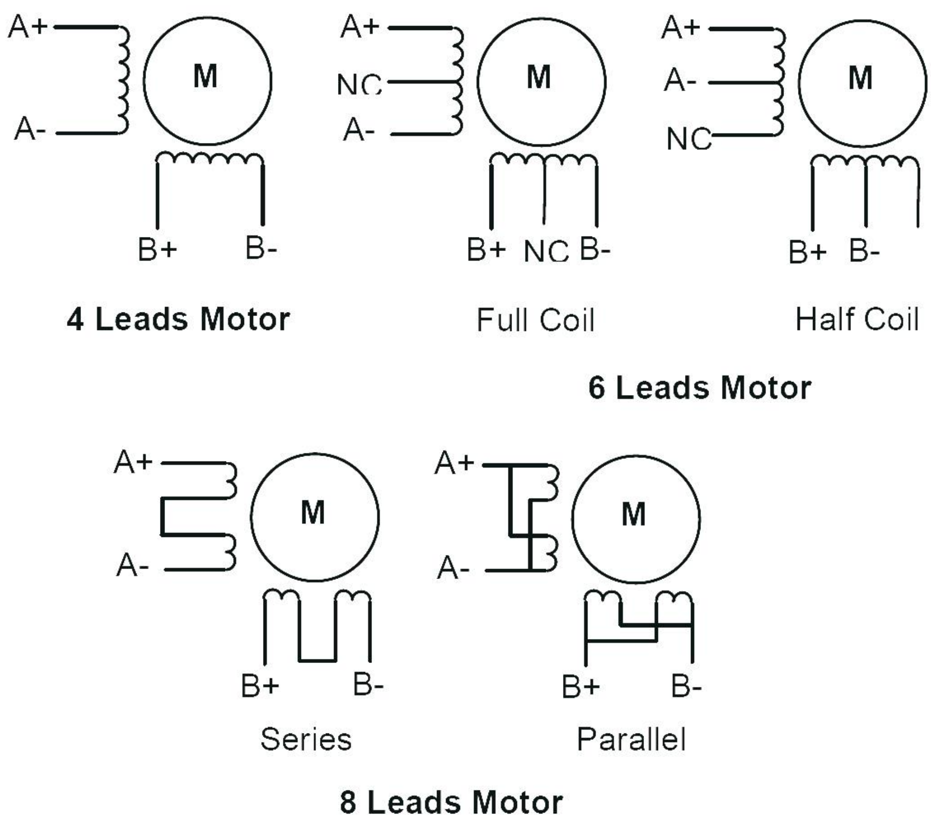
Microstep Setting:

Step/Rev	SW5	SW6	SW7	SW8
200	OFF	OFF	OFF	OFF
400	ON	OFF	OFF	OFF
500	OFF	ON	OFF	OFF
800	ON	ON	OFF	OFF
1000	OFF	OFF	ON	OFF
1250	ON	OFF	ON	OFF
1600	OFF	ON	ON	OFF
2000	ON	ON	ON	OFF
2500	OFF	OFF	OFF	ON
3200	ON	OFF	OFF	ON
4000	OFF	ON	OFF	ON
5000	ON	ON	OFF	ON
6400	OFF	OFF	ON	ON
8000	ON	OFF	ON	ON
10000	OFF	ON	ON	ON
12800	ON	ON	ON	ON

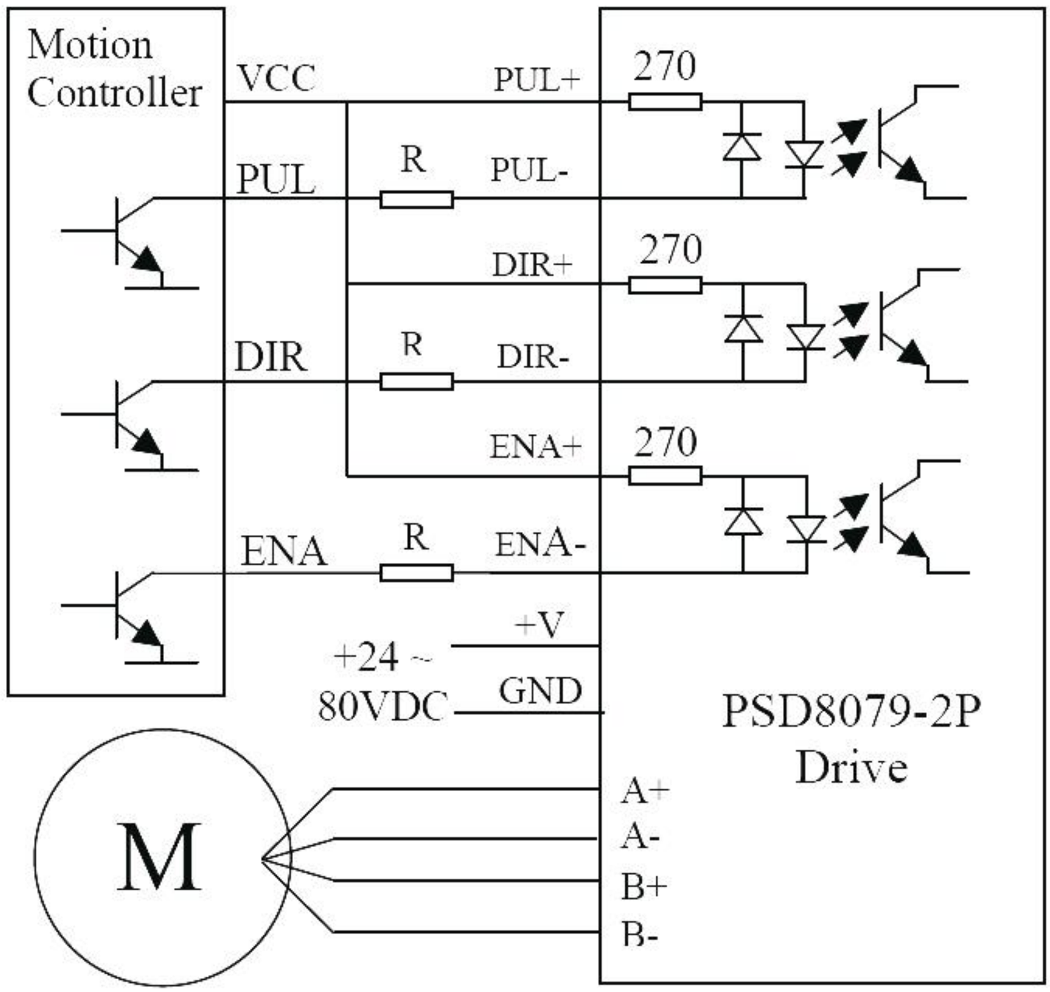
P1 Terminal Assignment:

Signal	Function and Description
PUL+ **PUL-**	Pulse or Step Input TTL differential input with high-going pulse, 1 µs width. For +12V OR+24V operation, a current limiting resistor had To be pull up or connected in series from the PUL+ to the VCC.
DIR+ **DIR-**	Director Input Logic High = positive (CW) rotation – 4.0 ~ 5.0V Logic Low = negative (CCW) rotation – 0 ~ 0.5V The DIR signal must be stable for at least 5ms before the drive receives the first pulse.
ENA+ **ENA-**	Enable Input Logic High = Drive Enabled Logic Low = Drive Disabled This input, if left unconnected, is recognized as Logic High By the drive, and it will be enabled.

P2 Terminal Assignment:

P2 Signal	Function and Description
GND	DC Power Ground
+V	DC Power Supply, +24VDC ~ +80VDC
A+,A-	
B+,B-	

Wiring:



R=0 if VCC=5V
R=1K(Power>0.125W) if VCC=12V;
R=2K(Power>0.125W) if VCC=24V;
R must be connected to control signal terminal.

Power Supply Mean Well SP-320-48:

Features:

·Universal AC input I Full range

·Built-in active PFC function, PF>0.95

·Protections: Short circuit I Overload I Over voltage I Over temperature

·Forced air cooling by built-in DC Fan

·Built-in fan speed control

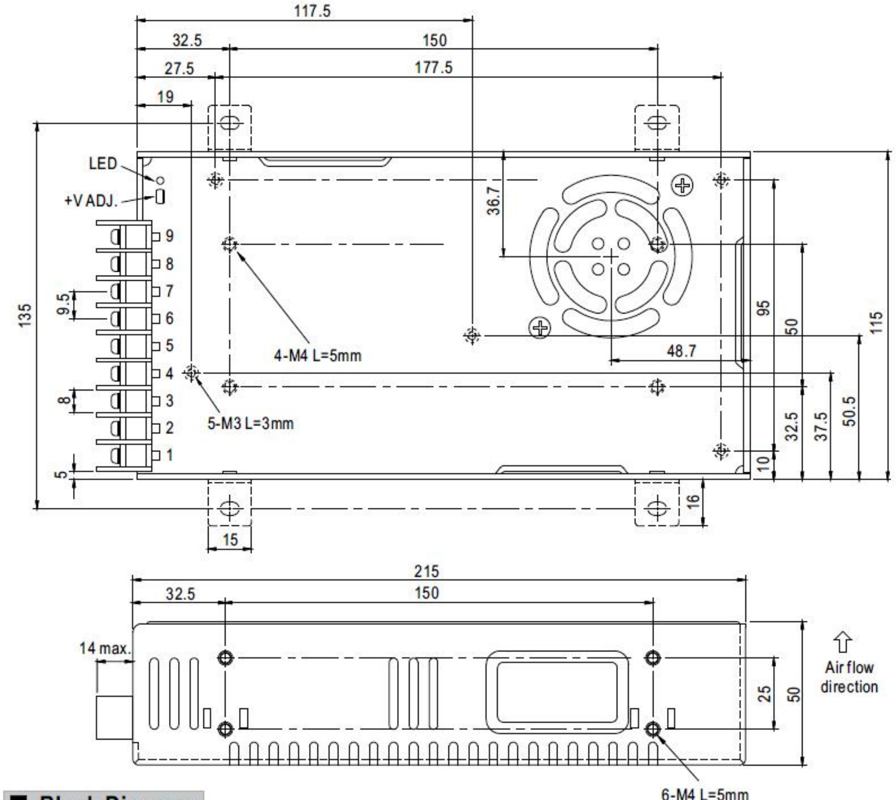
·Fixed switching frequency at 100 KHz

·3 years warranty

MODEL		SP-320-3.3	SP-320-5	SP-320-7.5	SP-320-12	SP-320-13.5	SP-320-15	SP-320-24	SP-320-27	SP-320-36	SP-320-48
OUTPUT	DC VOLTAGE	3.3V	5V	7.5V	12V	13.5V	15V	24V	27V	36V	48V
	RATED CURRENT	55A	55A	40A	25A	22A	20A	13A	11.7A	8.8A	6.7A
	CURRENT RANGE	0 ~ 60A	0 ~ 55A	0 ~ 40A	0 ~ 25A	0 ~ 22A	0 ~ 20A	0 ~ 13A	0 ~ 11.7A	0 ~ 8.8A	0 ~ 6.7A
	RATED POWER	181.5W	275W	300W	300W	297W	300W	312W	315.9W	316.8W	321.6W
	RIPPLE & NOISE (max.) Note.2	150mVp-p	150mVp-p	150mVp-p	150mVp-p	150mVp-p	150mVp-p	150mVp-p	200mVp-p	220mVp-p	240mVp-p
	VOLTAGE ADJ. RANGE	3.14 ~ 3.63V	4.5 ~ 5.5V	6 ~ 9V	10 ~ 13.2V	12 ~ 15V	13.5 ~ 18V	20 ~ 26.4V	26 ~ 31.5V	32.4 ~ 39.6V	41 ~ 56V
	VOLTAGE TOLERANCE Note.3	±1.0%	±2.0%	±2.0%	±1.0%	±1.0%	±1.0%	±1.0%	±1.0%	±1.0%	±1.0%
	LINE REGULATION	±0.5%	±0.5%	±0.5%	±0.3%	±0.3%	±0.3%	±0.2%	±0.2%	±0.2%	±0.2%
	LOAD REGULATION	±1.5%	±1.0%	±1.0%	±0.5%	±0.5%	±0.5%	±0.5%	±0.5%	±0.5%	±0.5%
	SETUP, RISE TIME	800ms, 50ms/230VAC 2500ms, 50ms/115VAC at full load									
	HOLD UP TIME (Typ.)	16ms/230VAC 16ms/115VAC at full load									
INPUT	VOLTAGE RANGE Note.5	88 ~ 264VAC 124 ~ 370VDC									
	FREQUENCY RANGE	47 ~ 63Hz									
	POWER FACTOR (Typ.)	PF>0.95/230VAC PF>0.98/115VAC at full load									
	EFFICIENCY (Typ.)	74%	79%	83%	86%	86%	86%	87%	88%	87%	89%
	AC CURRENT (Typ.) 115VAC	2.5A	5A								
	AC CURRENT (Typ.) 230VAC	1.5A	2.5A								
	INRUSH CURRENT (Typ.)	20A/115VAC 40A/230VAC									
	LEAKAGE CURRENT	<1mA / 240VAC									
PROTECTION	OVERLOAD	105 ~ 135% rated output power									
		Protection type : Hiccup mode, recovers automatically after fault condition is removed									
	OVER VOLTAGE	3.8 ~ 4.5V	5.75 ~ 6.75V	9.4 ~ 10.9V	13.8 ~ 16.2V	15.5 ~ 18.2V	18 ~ 21V	27.6 ~ 32.4V	33.7 ~ 39.2V	45 ~ 52.5V	57.6 ~ 67.2V
		Protection type : Shut down o/p voltage, re-power on to recover									
	OVER TEMPERATURE	Shut down o/p voltage, recovers automatically after temperature goes down									
ENVIRONMENT	WORKING TEMP.	-20 ~ +65℃ (Refer to "Derating Curve")									
	WORKING HUMIDITY	20 ~ 90% RH non-condensing									
	STORAGE TEMP., HUMIDITY	-40 ~ +85℃, 10 ~ 95% RH									
	TEMP. COEFFICIENT	±0.03%/℃ (0 ~ 50℃)									
	VIBRATION	10 ~ 500Hz, 2G 10min./1cycle, 60min. each along X, Y, Z axes									
SAFETY & EMC (Note 4)	SAFETY STANDARDS	UL60950-1, TUV EN60950-1, CCC GB4943(except for 3.3V, 36V) approved									
	WITHSTAND VOLTAGE	I/P-O/P:3KVAC I/P-FG:2KVAC O/P-FG:0.5KVAC									
	ISOLATION RESISTANCE	I/P-O/P, I/P-FG, O/P-FG:100M Ohms / 500VDC / 25℃/ 70% RH									
	EMC EMISSION	Compliance to EN55022 (CISPR22) Class B, EN61000-3-2,-3									
	EMC IMMUNITY	Compliance to EN61000-4-2,3,4,5,6,8,11, EN55024, light industry level, criteria A									
OTHERS	MTBF	207Khrs min. MIL-HDBK-217F (25℃)									
	DIMENSION	215*115*50mm (L*W*H)									
	PACKING	1.1Kg; 12pcs/14Kg/0.92CUFT									
NOTE	1. All parameters NOT specially mentioned are measured at 230VAC input, rated load and 25℃ of ambient temperature. 2. Ripple & noise are measured at 20MHz of bandwidth by using a 12" twisted pair-wire terminated with a 0.1uf & 47uf parallel capacitor. 3. Tolerance : includes set up tolerance, line regulation and load regulation. 4. The power supply is considered a component which will be installed into a final equipment. All the EMC tests are been executed by mounting the unit on a 360mm*360mm metal plate with 1mm of thickness. The final equipment must be re-confirmed that it still meets EMC directives. For guidance on how to perform these EMC tests, please refer to "EMI testing of component power supplies." (as available on http://www.meanwell.com) 5. Derating may be needed under low input voltages. Please check the derating curve for more details.										

■ Mechanical Specification

Case No. 912G Unit:mm

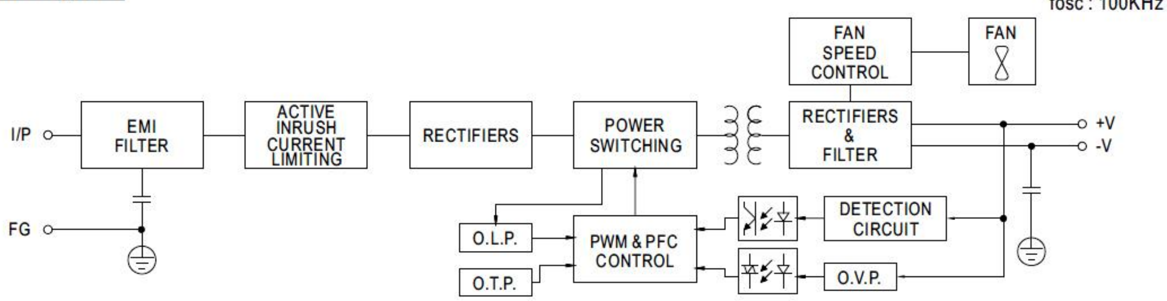


Terminal Pin No. Assignment :

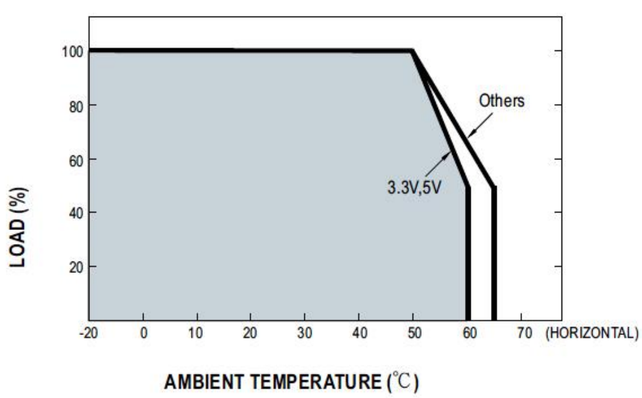
Pin No.	Assignment	Pin No.	Assignment
1	AC/L	4~6	DC OUTPUT -V
2	AC/N	7~9	DC OUTPUT +V
3	FG ⏚		

■ Block Diagram

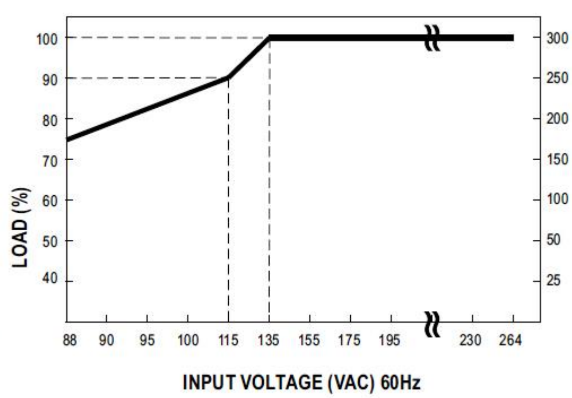
fosc : 100KHz



■ Derating Curve



■ Static Characteristics



Spindle Motor 400W ER11:

Description:

1. Application: Carving PCB, acrylic, Drilling
2. High speed and low noise
3. Suitable for DIY use or small-scale manufacturing

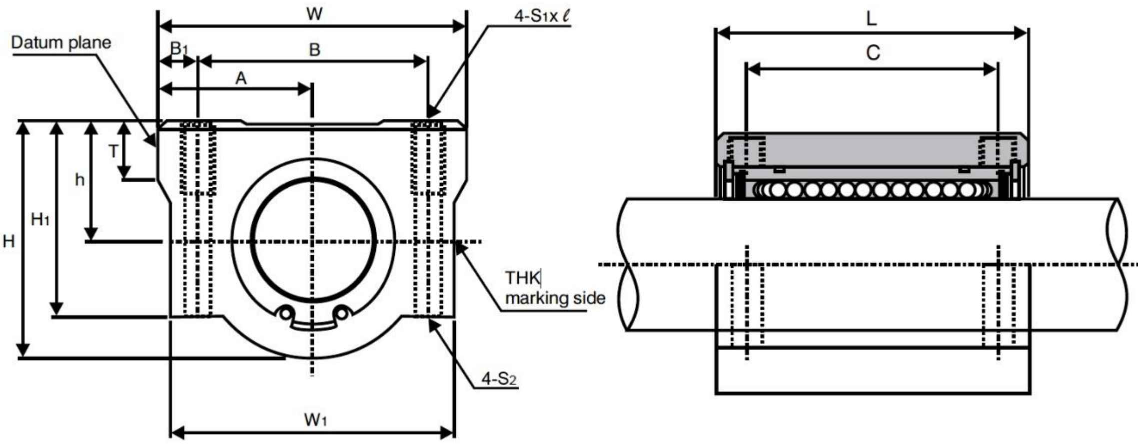
Parameter:

1. Spindle motor: New DC
2. Operating voltage: 12-48VDC
3. Power: 400W
4. Speed: 3000-12000r / min (12V-3000rpm, 24V-6000rpm, 36V-9000rpm, 48V-12000rpm)
5. Torque: 300mN.m
6. Insulation resistance :> 2 megohms
7. Dielectric strength: 400V
8. Diameter: 52mm
9. Chuck portion length: Arbor parts 35mm, (including the nut and sandwich 43mm)
10. Part chuck diameter: 16mm
11. Motor Overall Length: 140mm (comprising gripping parts and motor)
12. Spindle Weight: 0.7KG
13. Spindle radial runout: 0.01-0.03

14: Chuck Size:3.175mm

Linear Ball Bearings:

- Aluminum alloy housing
- Standard ball bushing
- Sealed



Dimensions in mm:

Part No.	Shaft size	Height	Width	Length	Mounting hole position			TAP		±0.02	±0.02				Basic load rating		Unit Weight
	ø	H	W	L	B	B_1	C	S_1x ℓ	S_2	h	A	H_1	W_1	T	Dyn. N	Static N	g
SC 12UU	12	29	42	36	30.5	5.75	26	M5x12	M4	15	21	25	39	8	412	598	102
SC 16UU	16	38.5	50	44	36	7	34	M5x12	M4	19	25	35	46	9	775	1180	189
SC 20UU	20	42	54	50	40	7	40	M6x12	M5	21	27	36	52	11	863	1370	237
SC 25UU	25	51.5	76	67	54	11	50	M8x18	M6	26	38	41	68	12	980	1570	555
SC 30UU	30	59.5	78	72	58	10	58	M8x18	M6	30	39	49	72	15	1570	2750	685
SC 40UU	40	78	102	90	80	11	60	M10x25	M8	40	51	62	96	20	2160	4020	1600
SC 50UU	50	102	122	110	100	11	80	M10x25	M8	52	61	80	116	25	3820	7940	3350

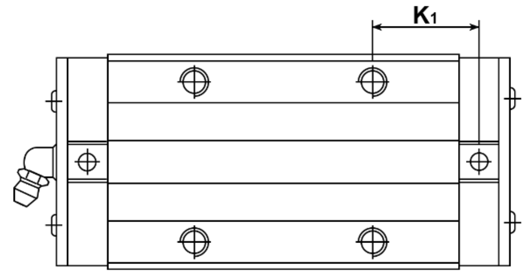
1N=0.102kgf

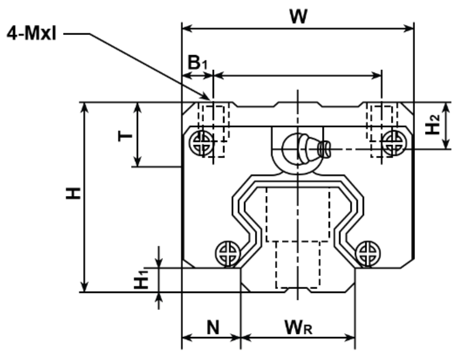
Linear Guide Flange Blocks:

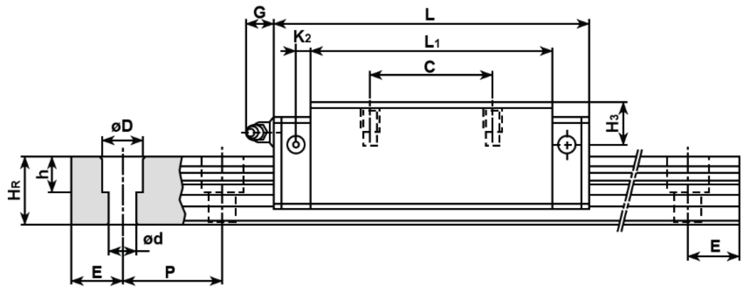
HG Series

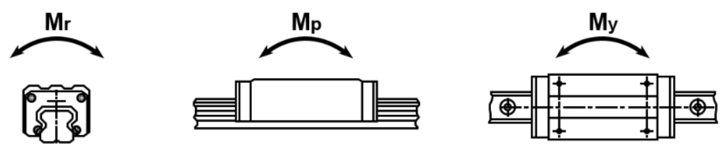
2-1-13 Dimensions for HIWIN HG series

HGH-CA / HGH-HA









Model No.	Dimensions of Assembly (mm)			Dimensions of Block (mm)														Dimensions of Rail (mm)							Mounting Bolt for Rail	Basic Dynamic Load Rating	Basic Static Load Rating	Static Rated Moment			Weight	
																												M_R	M_P	M_Y	Block	Rail
	H	H_1	N	W	B	B_1	C	L_1	L	K_1	K_2	G	M	T	T_1	H_2	H_3	W_R	H_R	D	h	d	P	E	(mm)	C(kN)	C_0(kN)	kN-m	kN-m	kN-m	kg	kg/m
HGW15CA	24	4.3	16	47	38	4.5	30	39.4	61.4	8	4.85	5.3	M5	6	8.9	3.95	3.7	15	15	7.5	5.3	4.5	60	20	M4x16	11.38	16.97	0.12	0.10	0.10	0.17	1.45
HGW20CA	30	4.6	21.5	63	53	5	40	50.5	77.5	10.25	6	12	M6	8	10	6	6	20	17.5	9.5	8.5	6	60	20	M5x16	17.75	27.76	0.27	0.20	0.20	0.40	2.21
HGW20HA								65.2	92.2	17.6																21.18	35.90	0.35	0.35	0.35	0.52	
HGW25CA	36	5.5	23.5	70	57	6.5	45	58	84	10.7	6	12	M8	8	14	6	5	23	22	11	9	7	60	20	M6x20	26.48	36.49	0.42	0.33	0.33	0.59	3.21
HGW25HA								78.6	104.6	21																32.75	49.44	0.56	0.57	0.57	0.80	
HGW30CA	42	6	31	90	72	9	52	70	97.4	14.25	6	12	M10	8.5	16	6.5	10.8	28	26	14	12	9	80	20	M8x25	38.74	52.19	0.66	0.53	0.53	1.09	4.47
HGW30HA								93	120.4	25.75																47.27	69.16	0.88	0.92	0.92	1.44	
HGW35CA	48	7.5	33	100	82	9	62	80	112.4	14.6	7	12	M10	10.1	18	9	12.6	34	29	14	12	9	80	20	M8x25	49.52	69.16	1.16	0.81	0.81	1.56	6.30
HGW35HA								105.8	138.2	27.5																60.21	91.63	1.54	1.40	1.40	2.06	
HGW45CA	60	9.5	37.5	120	100	10	80	97	139.4	13	10	12.9	M12	15.1	22	8.5	20.5	45	38	20	17	14	105	22.5	M12x35	77.57	102.71	1.98	1.55	1.55	2.79	10.41
HGW45HA								128.8	171.2	28.9																94.54	136.46	2.63	2.68	2.68	3.69	
HGW55CA	70	13	43.5	140	116	12	95	117.7	166.7	17.35	11	12.9	M14	17.5	26.5	12	19	53	44	23	20	16	120	30	M14x45	114.44	148.33	3.69	2.64	2.64	4.52	15.08
HGW55HA								155.8	204.8	36.4																139.35	196.20	4.88	4.57	4.57	5.96	
HGW65CA	90	15	53.5	170	142	14	110	144.2	200.2	23.1	14	12.9	M16	25	37.5	15	15	63	53	26	22	18	150	35	M16x50	163.63	215.33	6.65	4.27	4.27	9.17	21.18
HGW65HA								203.6	259.6	52.8																208.36	303.13	9.38	7.38	7.38	12.89	

Note : 1 kgf = 9.81 N

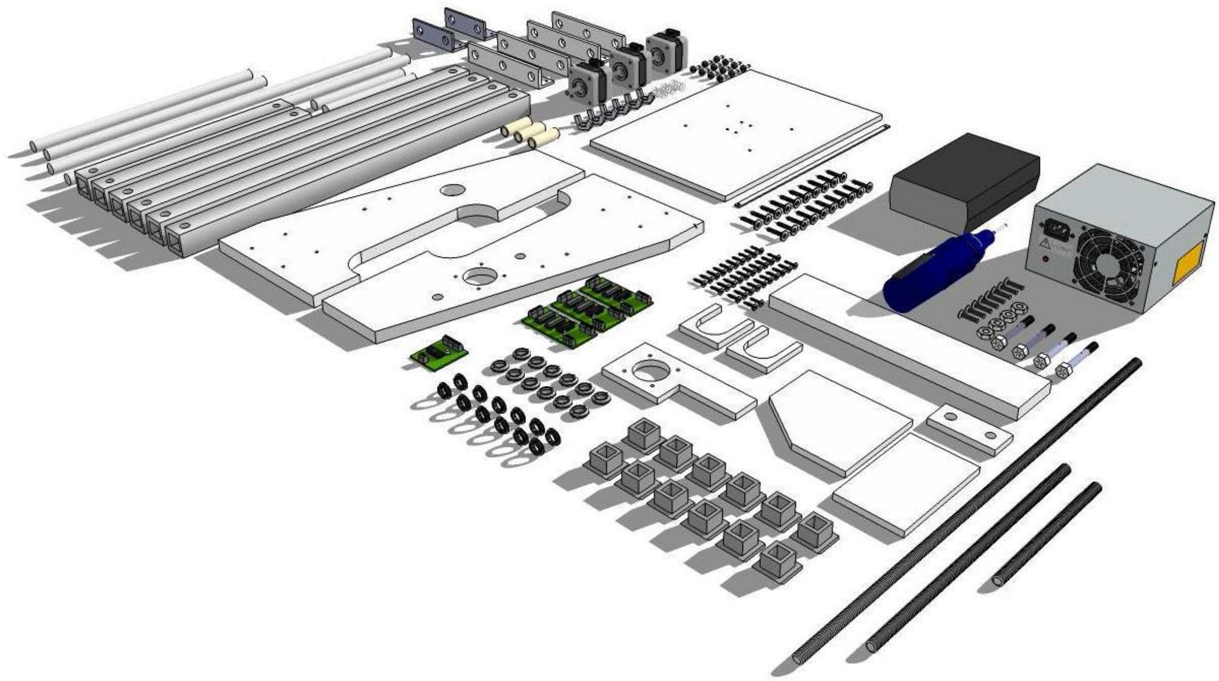
DIY SMART SAW – Desktop Version

Limitations:

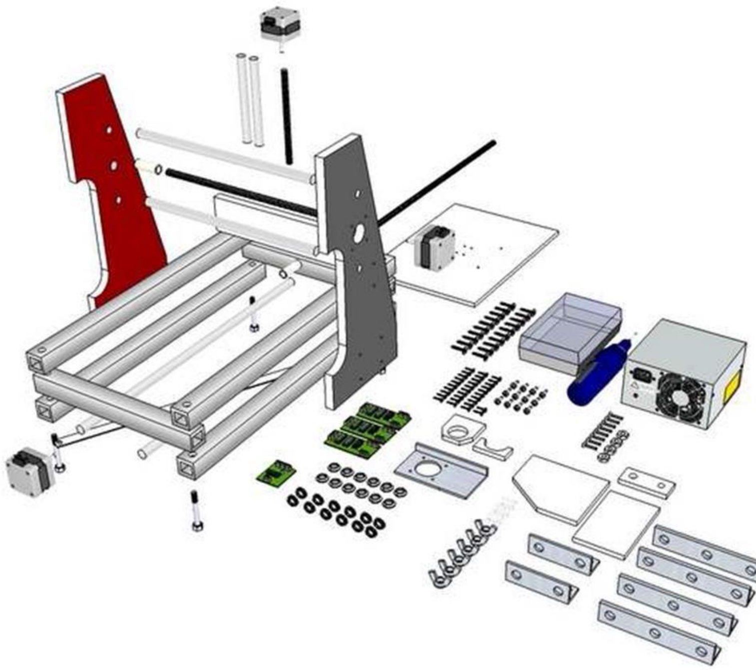
The current system has a material workspace defined by the design. Therefore, without any expansion of the workspace, the basic limit to the size of a material object it can work on is 76.2mm (3”) tall, by 190.5mm (7 1/2”) wide, by 215.9mm (8 1/2”) long. These dimensions represent the extents of a workspace allowed by clearance of the axes.

Chapter I : Plans

Exploded Views:



Complete Components



Explode view of a complete

DIY Smart Saw

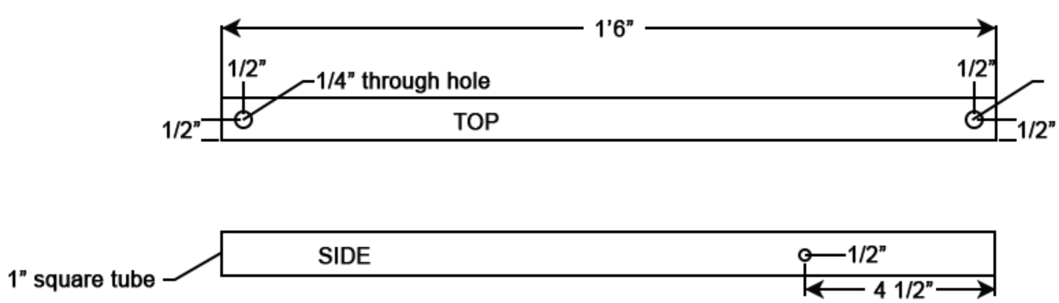
(DESKTOP VERSION)

Exploded Views:

These plans include drawings and instructions for constructing a DIY Smart Saw (Desktop Version) with either a wooden or metal base. Both systems will have identical performance characteristics and the differences do not affect the specification or operation of other parts of the machine. The choice of a metal or wooden base is made by the builder and can be based upon the preference and/or comfort level the builder may have for one material over the other. The materials for the wooden base may cost less, but that price difference is an insignificant part of the overall cost of the project.

Steel and Aluminum:

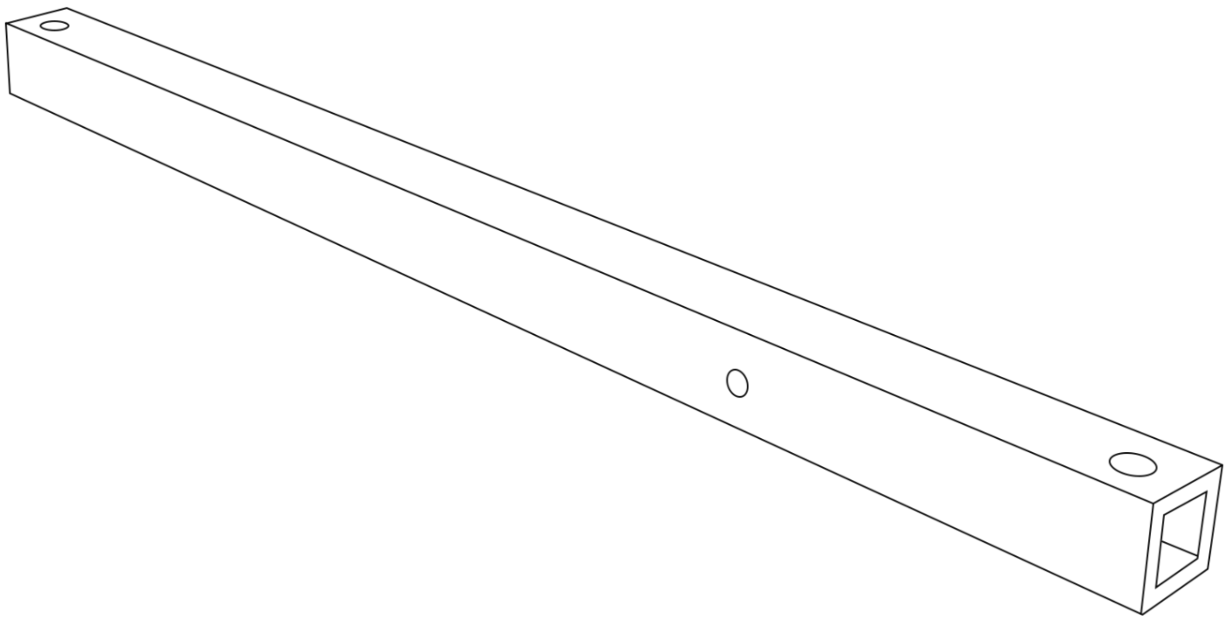
Whether you choose steel or aluminum 1" square tube for the metal base frame, the part dimensions and performance are identical. The wall thickness is not significant to the dimensions of the DIY Smart Saw (Desktop Version) as long as the space inside the tube is sufficient for the nut used to bolt the frame corners together. Whatever thickness of steel or aluminum is available, given that condition, should work fine. Use a good metal drill bit for drilling the required holes, preferably one with a pilot point. The chassis rails can be clamped (or in the absence of a clamp, tightly bound together with tape) to drill through pairs simultaneously.



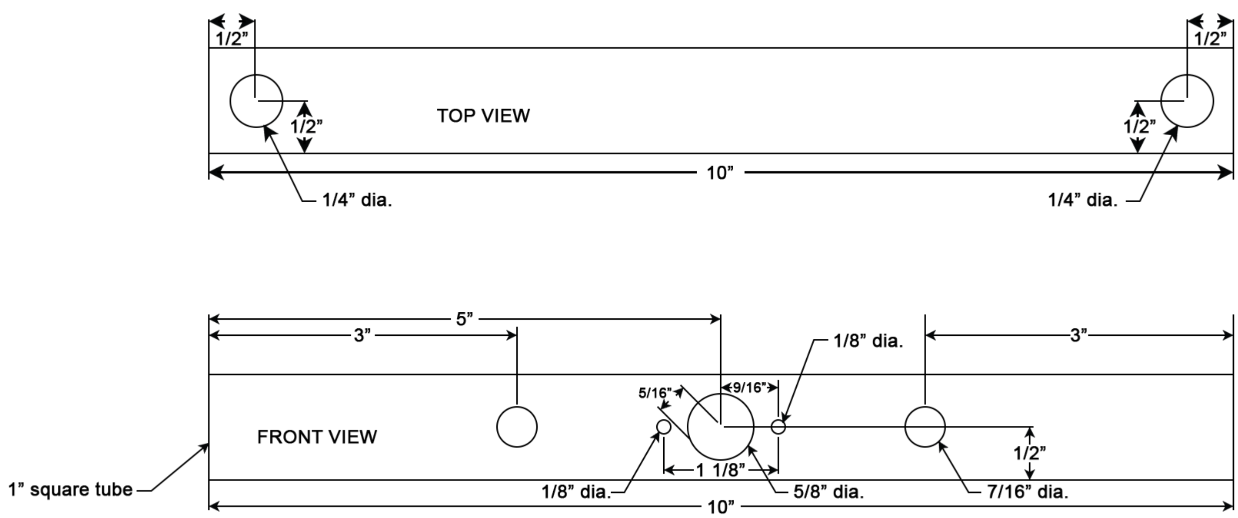
Chassis Side Rails (4 0ff)

Chassis Side Rails: Note only one mounting hole indicated. See alignment process for details about drilling remaining holes to obtain precise alignment.

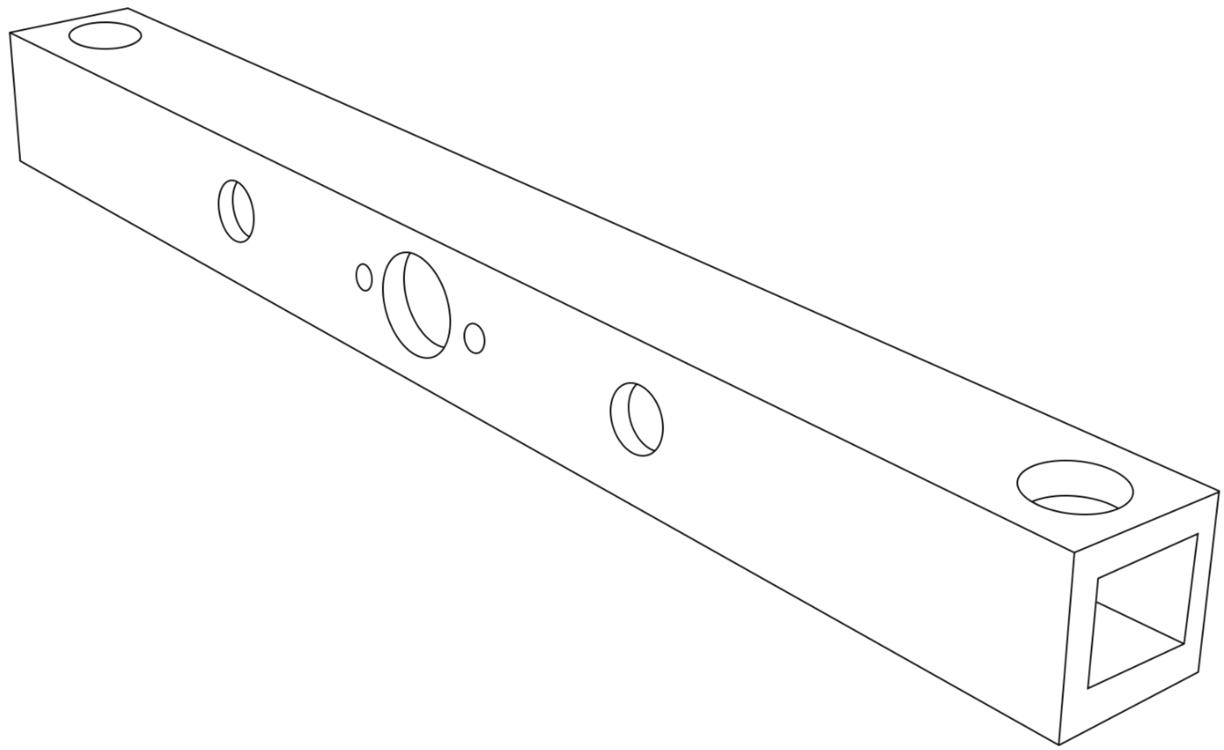
Chassis Side Rail, perspective view



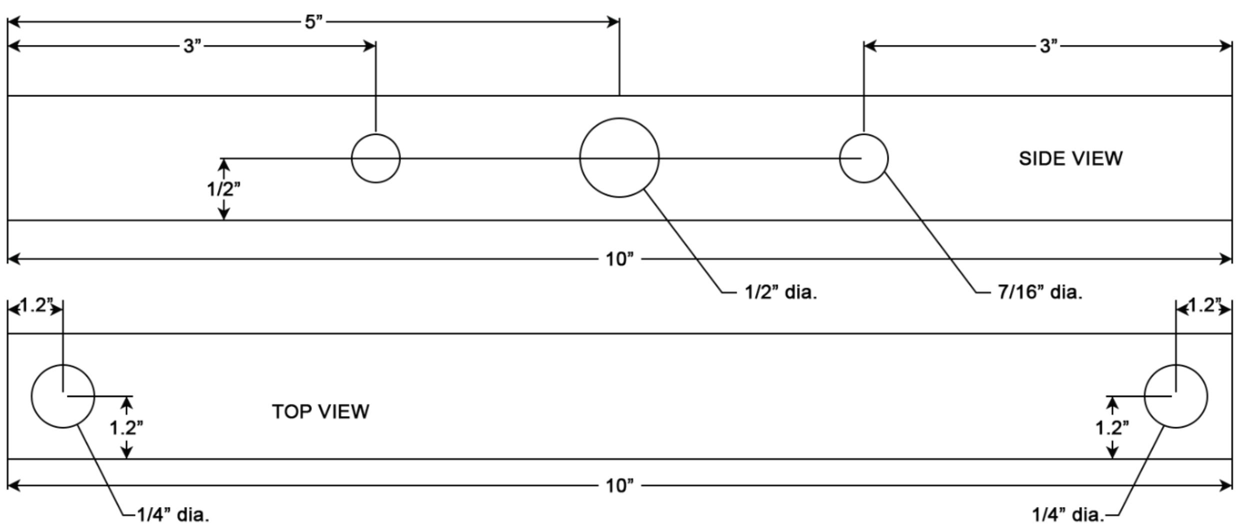
Front Chassis Cross Member (1 of 1)



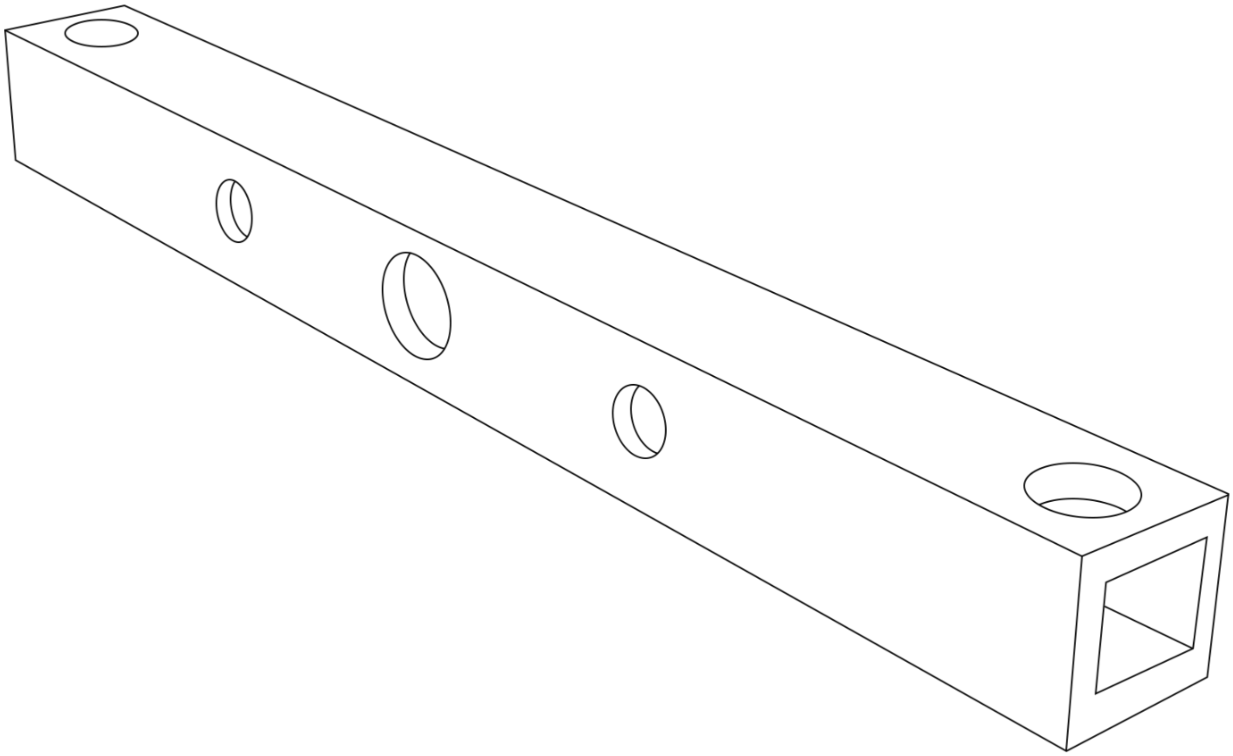
See page 176 Nema 17 motor mounting hole patter and dimension



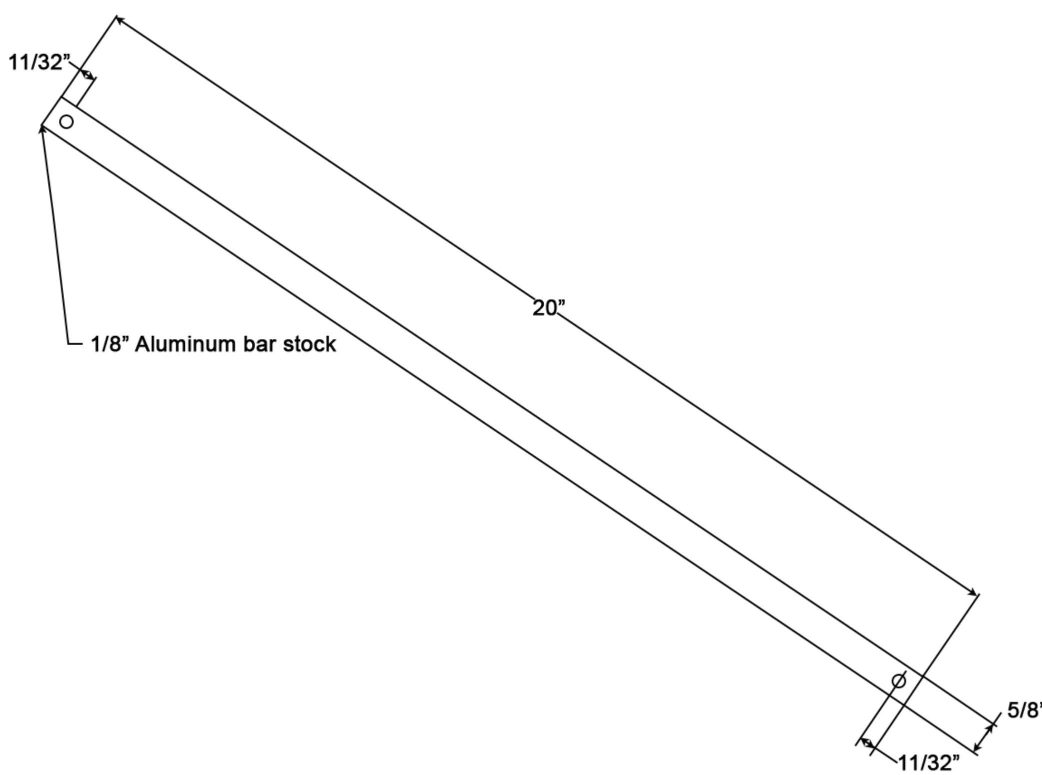
Front Chassis Cross Member, perspective view



Rear Chassis Cross Member (1 off)

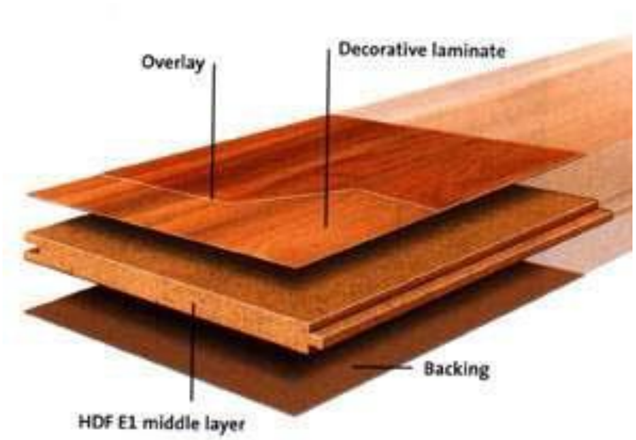


Rear Chassis Cross Member, perspective view



Wood:

The wooden base is comprised of four parts; two end plates and two side rails. The side rails are made of standard 2x4 lumber. Choose quality lumber with a fine grain. Be sure to make cuts exactly perpendicular to the length of the piece. Measure carefully and cut each piece to exactly 18” [457 mm] in length. The end plates and gantry support uprights are best made from a laminated composite, such as laminate flooring. This material can be purchased in most hardware and home improvement stores. Often they sell single boards and provide samples large enough to use upon request. Flooring companies frequently have cutoffs left over from flooring jobs.



Choose a laminate no thinner than 0.25 inches [6.4 mm] and no thicker than 0.4 inches [10 mm]. 3/8” to 1/2” Plywood or MDF may be substituted for the end plates if laminate is unavailable. For the gantry support uprights, use HDPE if laminate is unavailable.

Cut both the laminate end plate and gantry support uprights to size, align them carefully and clamp them together. In the absence of clamps, strong electrical tape or duct tape will suffice as long as the parts are perfectly aligned and bound tightly.

Drill holes for the 3/8” rails through both parts simultaneously as indicated in the drawings. Drill a 1/8” pilot hole through both plates in the center of the threaded rod hole/motor mount. Use this pilot hole to drill the larger holes for the threaded rod hole in the end plate and the motor axle hole in the front plate. Carefully measure and drill the four 1/8” holes for the NEMA 17 stepper motor mounting screws.

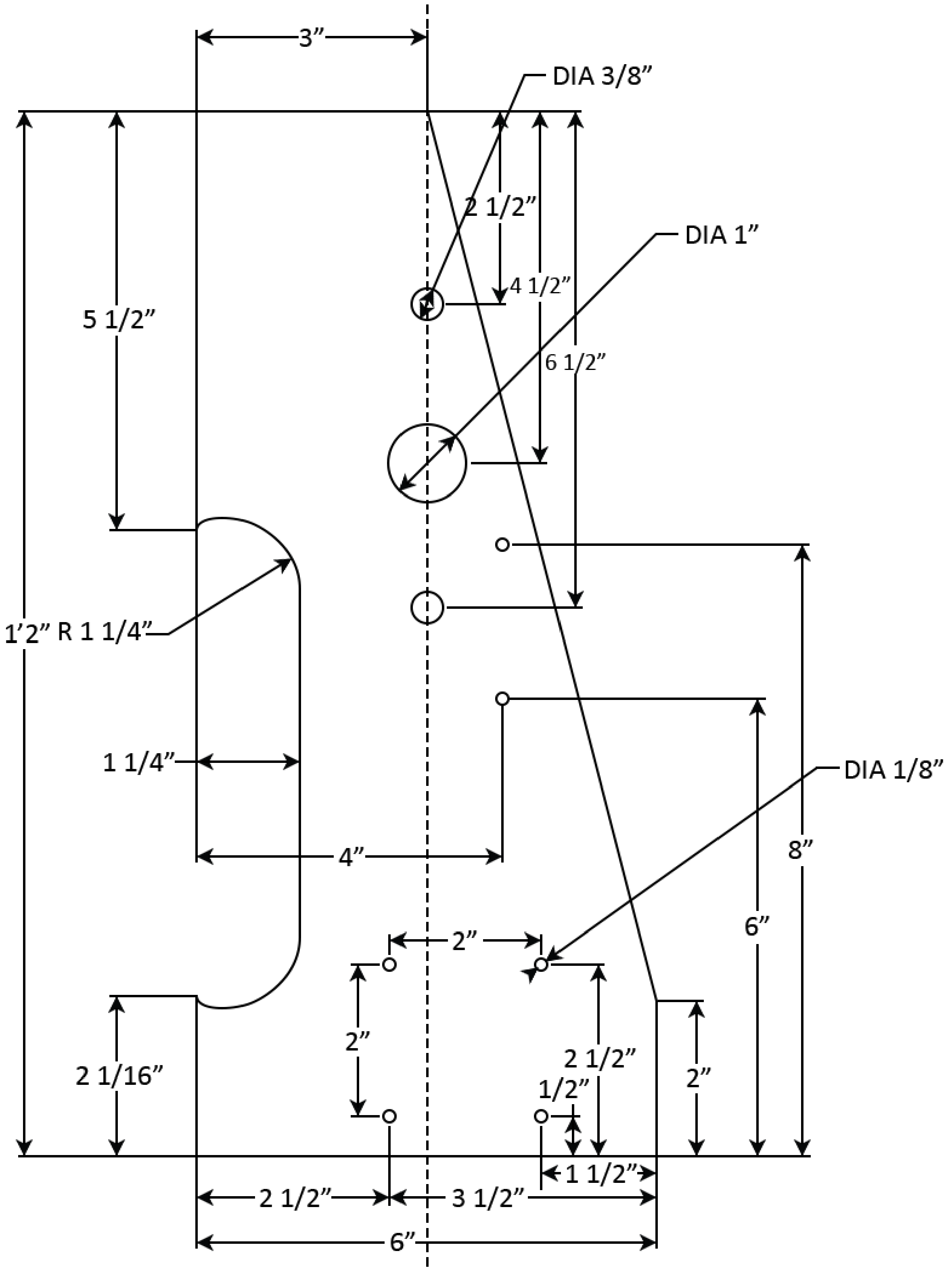
TIP: A drill press is particularly useful for this process to ensure that the holes are perpendicular to the rails and are perfectly aligned. If using a hand drill, take great care to drill at right angles to the boards.

Uprights and Gantry Brace:

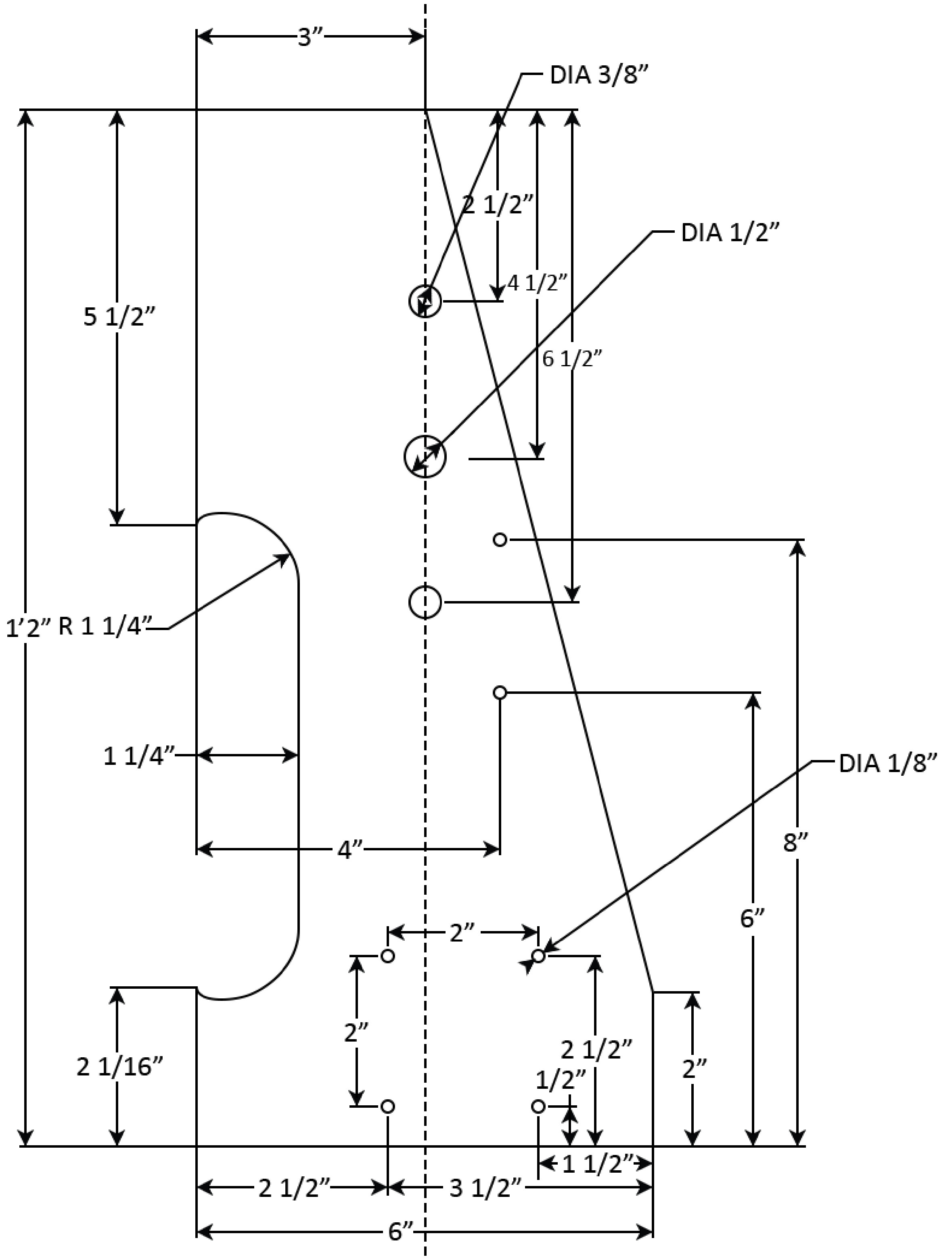
The gantry support uprights are best made from laminate as described in the section Wood above. In the absence of laminate, 3/8” HDPE or 1/2” quality plywood will provide a good substitute.

The following drawings provide dimensions for the creation of a left- and right-hand gantry support upright. See the appendices for the NEMA 17 motor mount hole dimensions. Note that with the exception of the motor mount holes, the uprights are exact mirror duplicates of each other.

TIP: It is best to cut and drill these parts simultaneosly while clamped togheter. This is especially beneficial when aligning the holes for the Y axis rods and the base mounting holes. By drilling through both pieces simultaneosly you ensure that both pieces are aligned to each other.



Left Gantry Support Upright (outside view). See appendix for motor mount holes.



Right Gantry Support Upright (inside view)

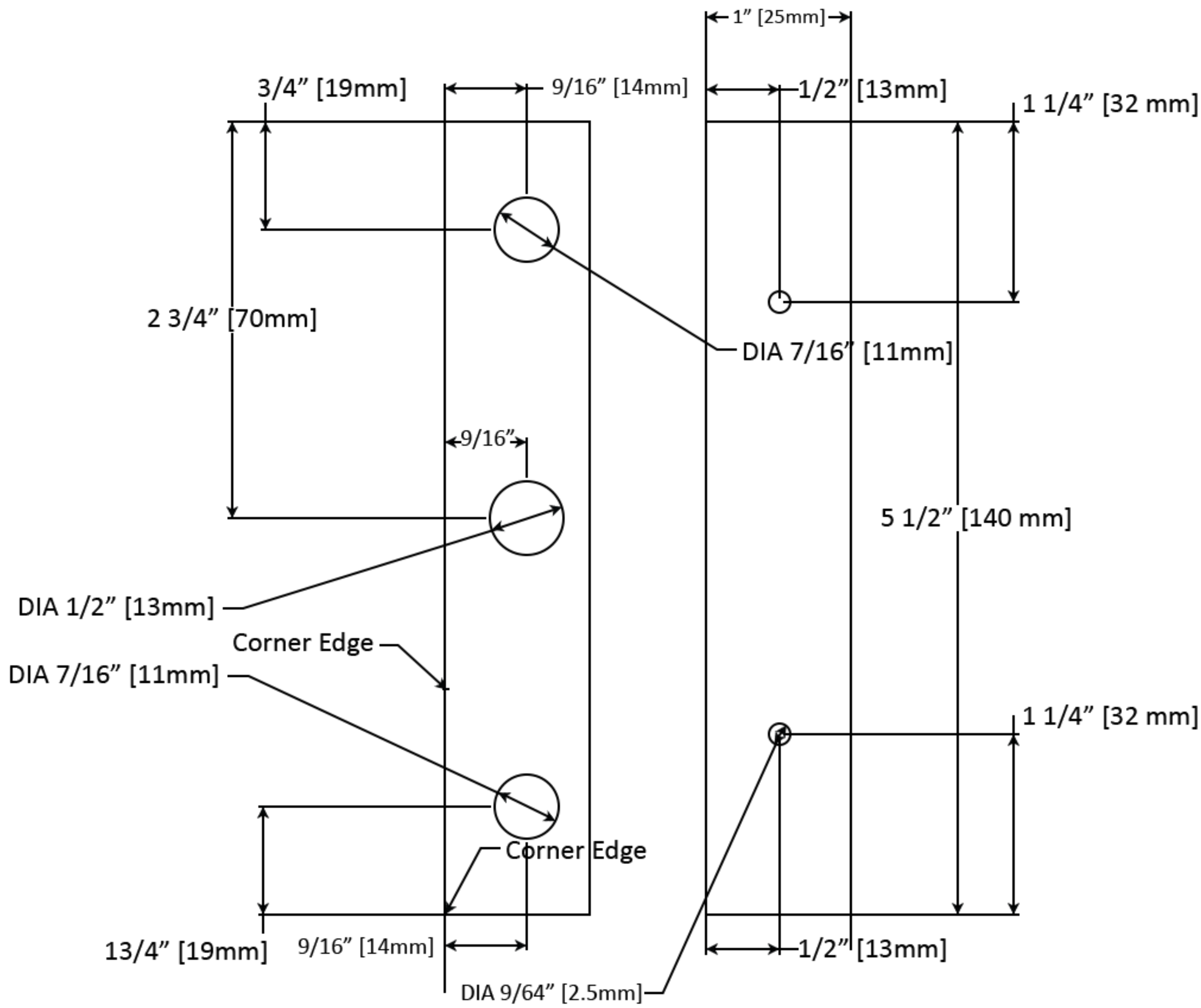
Bearings Sub Frames:

The bearings and sub frames are designed to be as simple and cost effective as possible while providing the performance and precision needed to meet the specification requirements.

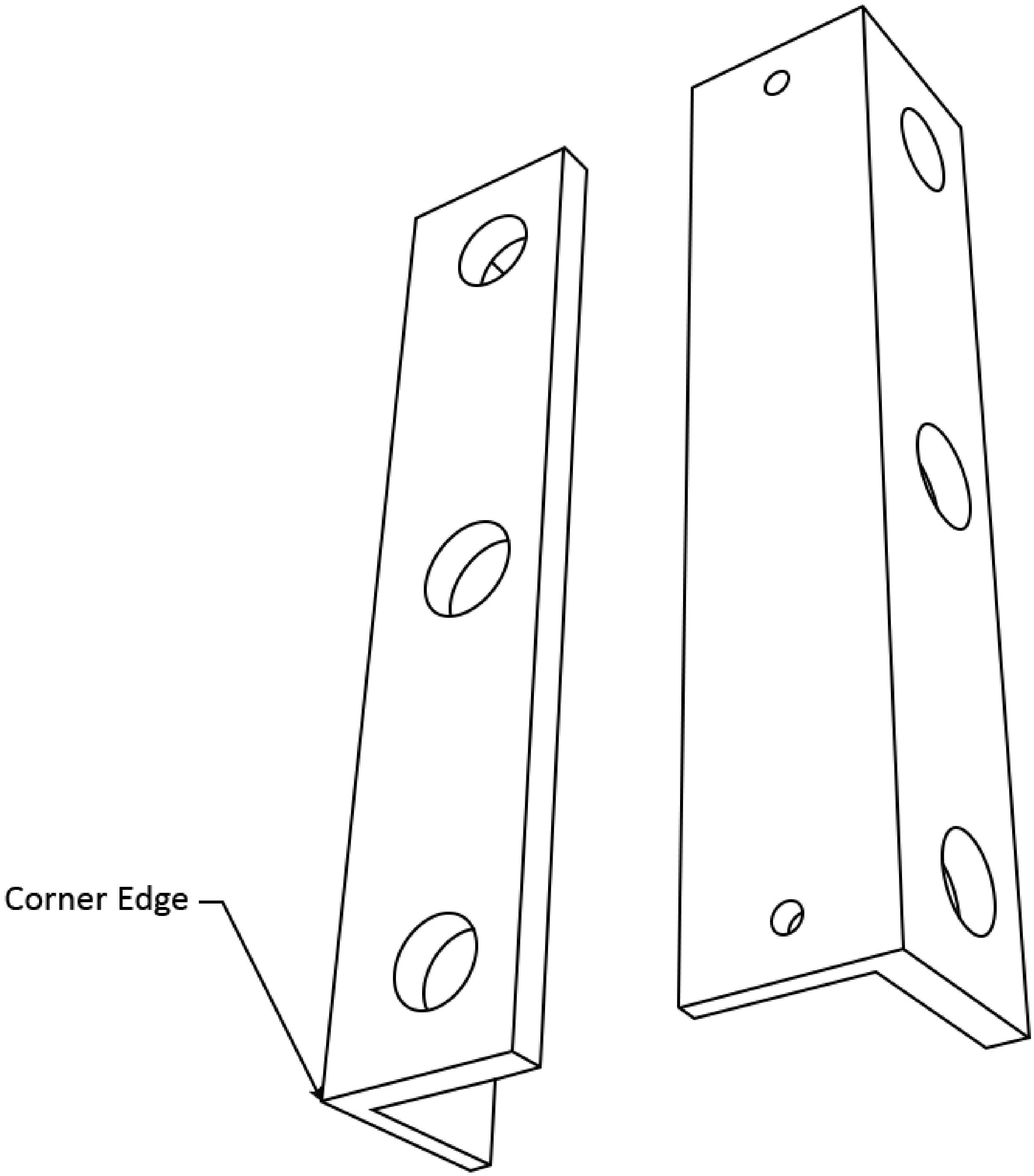
The sub frames used to support the bearings are made from 1" aluminum angle. They are used in pairs to transport the X axis table and the Y and Z axes carriages. Cut the bearing frames to length in pairs. Clamp each pair back to back, as shown in the illustration, ensuring that the pieces are perfectly aligned. Drill the 7/16" holes for the bearings and to clear the threaded rod as shown in the drawings. Mark each pair to keep them together and not mixed up with the other bearing sub frames.

Cut and drill one pair for each axis, as indicated in the drawings. The bearings are finger-pressed into their holes in the bearing sub-frames. Put them aside for later assembly to their respective carriage.

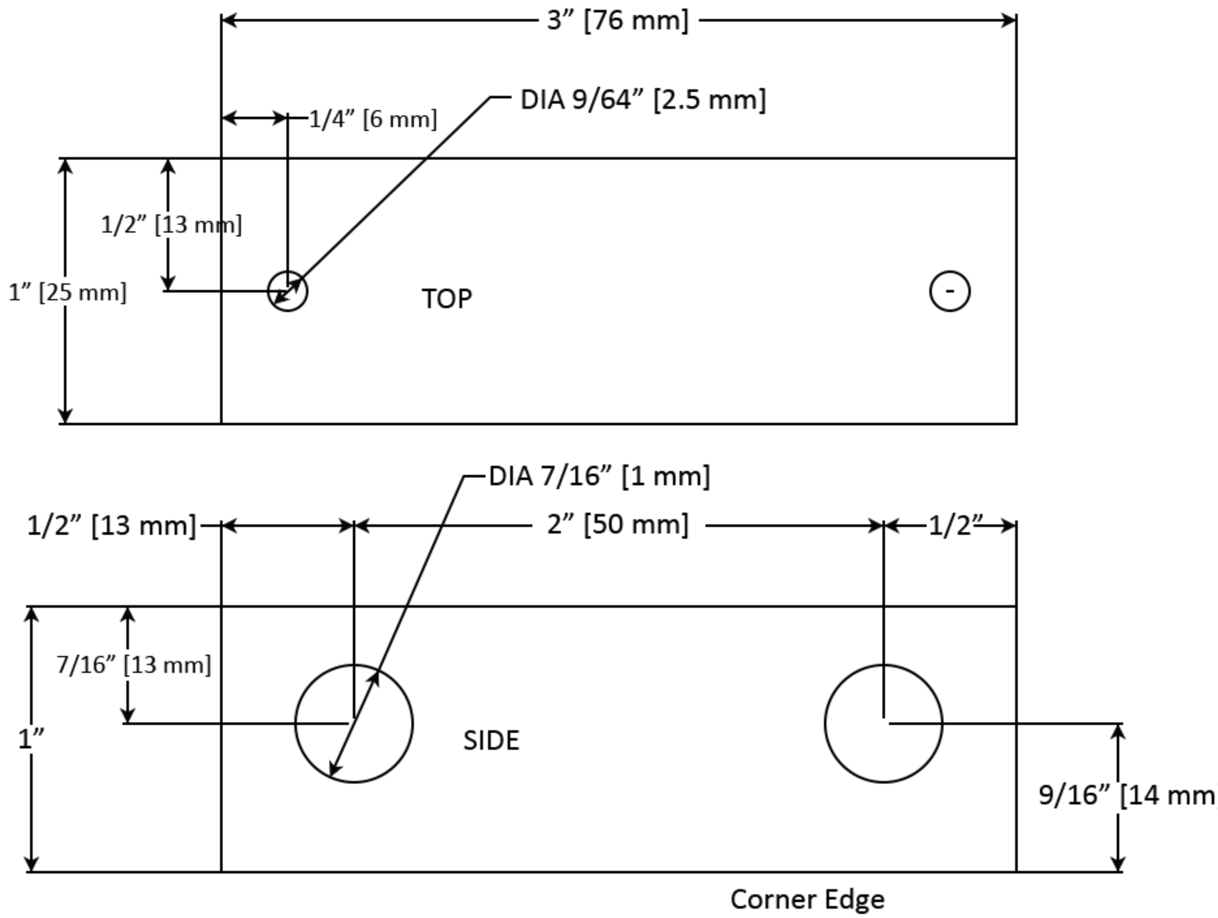
WARNING: Take care when cutting or drilling in metal to avoid getting cut on the sharp edges created. Use a file to de-burr sharp edges.



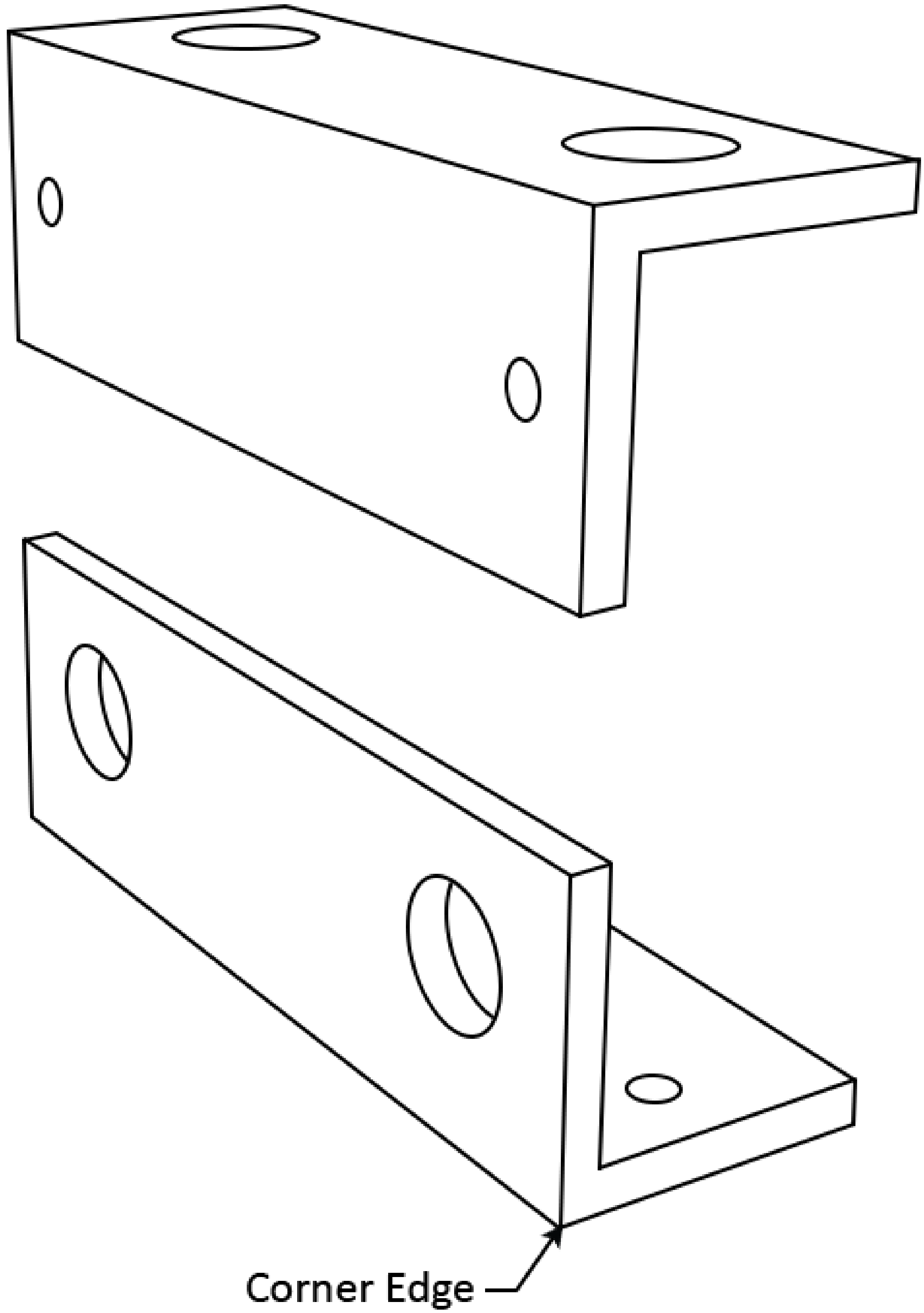
4 Required, 2 each for X AND Y axis. Note for X axis
small mounting holes change to 7/64” [2.8 mm]
X and Y Axes Bearings Support Sub-Frame



X and Y Axes Bearings Support Sub-Frame Perspective View



Z Axis Bearings Sub-Frame



Z Axis Bearings Sub-Frame, perspective view

Motors, Couplings, Rods and Screws:

The DIY Smart Saw (Desktop Version) is designed to use a 1/4”-20 threaded rod to provide the gearing necessary to produce the 0.001”-per-step resolution required. These rods are rotated by the stepper motors.

The rotation of the threaded rod moves a lead nut up and down the rod. The lead nut is attached to the corresponding carriage. When the lead nut moves so does the carriage. This arrangement constitutes the drivetrain for each axis. For simplicity and to meet the design specifications, each axis’ drivetrain is identical in all aspects except for its length. In the case of the DIY Smart Saw (Desktop Version) the unique lead nuts’ assembly is designed to provide anti-backlash characteristics to enhance the overall precision and repeatability of the machine. They are detailed in the next section.

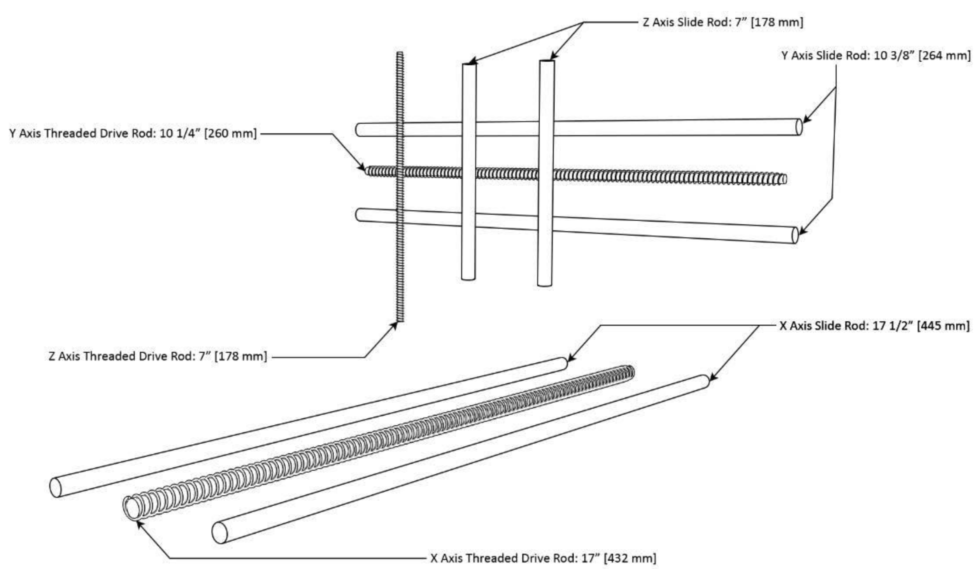
The threaded rods are attached to the stepper motor shafts by a 1 1/2” section of Polyethylene tubing. Tubing is used instead of a solid shaft coupling to allow the motor t “clutch” (slip when the force is too much) should the end mill become stuck in the work material. Should the motor continue to drive the drivetrain when the spindle head is stuck, the tubing will slip and give before serious damage occurs to the machine. On the Y and Z drivetrains the coupling tubing is clamped to the motor shaft and to the threaded rod using a double snap grip clamp.

The X axis motor mount does not allow sufficient clearance to use a snap grip clamp to secure the coupling tubing. Therefore, a pair of small zip ties is used for the X axis drivetrain. More details are provided in the Building your DIY Smart Saw (Desktop Version) section below. The DIY Smart Saw (Desktop Version) is designed to use NEMA 17 bipolar Stepper Motors. Stepper motors fall into two main categories; unipolar and bipolar. Bipolar stepper motors are more common and provide better torque than unipolar stepper motors. For this reason the DIY Smart Saw (Desktop Version) electronics were designed to drive bipolar stepper motors, and therefore if you will be building the electronics described in this manual, bipolar stepper motor are required.

The drawings provided show the mounting holes arrangement for NEMA 17 stepper motors. You will also require a set of four machine screws to mount each motor. They must match the threaded holes in your motors (for instance, the DIY Smart Saw (Desktop Version) motors use a metric thread, and therefore M3 machine screws are used) and are a length sufficient to reach through your mounting material and protrude about 4 mm into the body of the motor. Your local hardware store should carry suitable machine screws for this purpose.

Each axis travels on a pair of 3/8” precision steel rods. It is critical that these rods are smooth and without scratches or nicks as these marks will severely reduce the life of the bearings. Small imperfections may be removed carefully with every cloth or very fine sandpaper (600 grit or finer). Rods with any blemish that cannot be removed by fine sanding or polishing should be discarded and replaced.

Water-hardened steel drill rod is a suitable material, providing the precision required for the bearings at reasonable cost. Make sure that your vendor can supply you with unmarked blemish-free rods. Most hardware stores that sell this material stack multiple rods in a display case where they become damaged by customers repeatedly removing and replacing them in the display. You can talk with the store manager and ask that your order be taken off the top of their next shipment and carefully put to one side for you. Cut each pair of rods to length as indicated in the drawings.



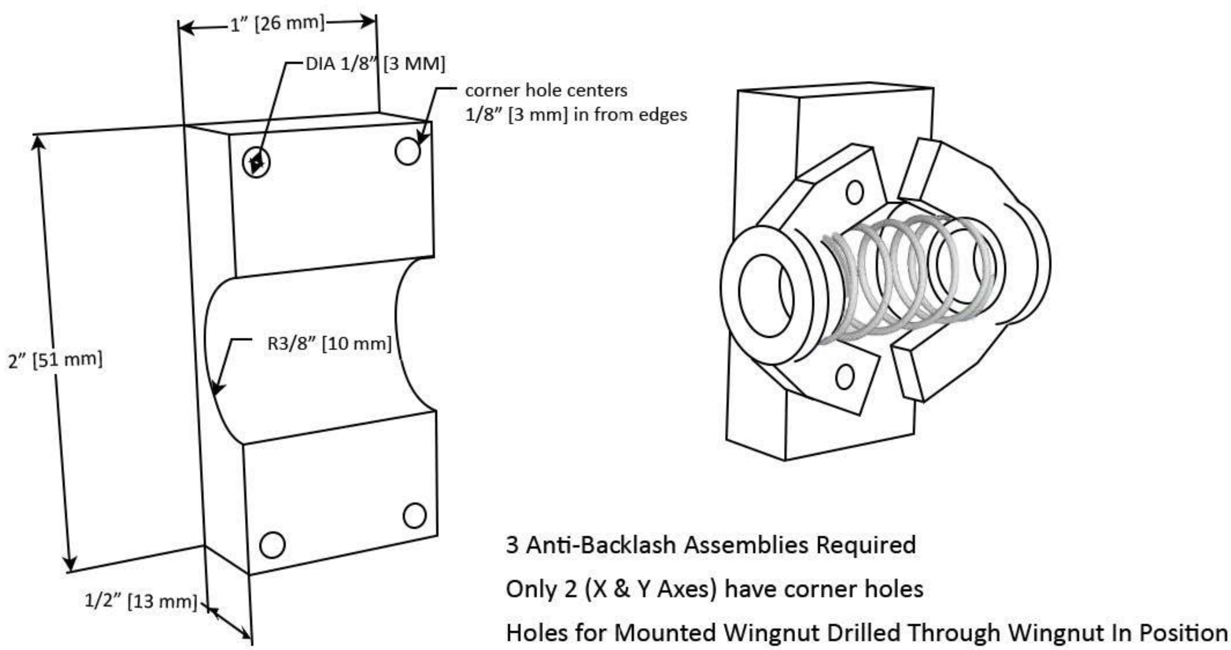
Cut Slide Rods and Threaded Drive Rods to Dimensions Shown

Anti-Backlash Lean Nuts:

“Backlash” is a term used to describe the slack or play between the lead nut and the driver screw. For CNC machines this can greatly reduce the accuracy and repeatability of the machine. Often this can be compensated for in software settings in the chosen CAM, but the best solution is to use anti-backlash lead nuts to eliminate it altogether.

The DIY Smart Saw (Desktop Version) incorporates anti-backlash lead nuts on all axes. A 1/4”-20 nylon wing nut is used as the main carrier, and a secondary nut is springloaded against the first, then mounted in such a way that the tension is maintained between both nuts. With both nuts pushing each other apart, there is constant contact between the nut threads and the threaded rods, eliminating the slack that causes backlash.

Three Anti-Backlash assemblies are required. The mounting block is cut to shape from 1/2” HDPE block. The center channel is a 1/4” deep semicircular cut, and is best done by clamping two blocks tightly together and drilling a 1/2” hole in the center between them, leaving a 1/4” semicircular channel in each block.



Anti-Backlash Mounting Block and Assembly

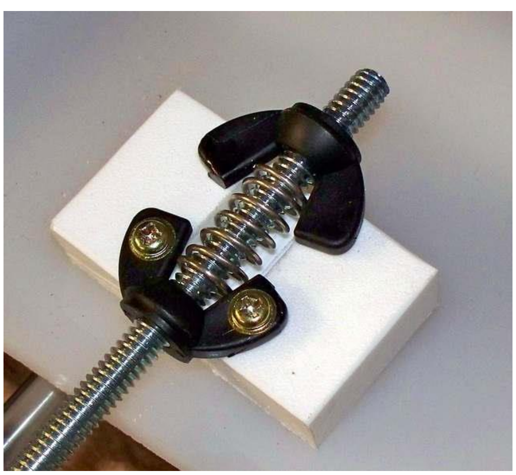
TIP: A drill press is particularly useful for this process to ensure that the holes are drilled straight through the blocks and are perfectly aligned. If using a hand drill, take great care to drill at right angles to the leading edge of the blocks.

Drill the four 1/8” [3 mm] mounting holes through the blocks in the corners of each block as shown in the drawing.

The 1/8” mounting holes through the wings of one of the two nuts are best drilled through the wings and into the mounting block in one operation. Taking one of your threaded rods, thread it through a wing nut with the wings pointing toward the near end of the threaded rod.

Slip a spring over the rod, followed by another wing nut with its wings pointing towards the other wing nut. You can see how these parts are arranged in the illustration.

TIP: Take a moment here to feel the lone wing nut on the threded rod. You can feel the degree of movement and slack in the nut as it moves on the threads of the rod. This is the slack that the anti-backlash lead nut meachanism will remove from your DIY Smart Saw (Desktop Version).



Turn the wing nuts so they put a small amount of tension on the spring. You want them close enough together and compressing the spring just enough to remove any play in the wing nuts, but not so tight that it becomes difficult to turn them on the rod.

Lay the threaded rod, two wing nuts and spring assembly on the mounting block. Position it so that the first wing nut wings rest on the block surface and the round body of the wing nut is firmly resting in the mouth of the channel. The wing nut should make contact around the curved open edge of the channel. If either wing of the wing nut is not lying flat on the surface of the block, the wing nut is likely too far into the channel. Back it out enough to allow the wings to rest flat on the block. See the illustration for reference.

The second unattached wing nut should also be resting in or near the mouth of the channel with both wings flat on the block surface.

Using a drill or rotary tool, drill a 1/8" hole through the fat part of each wing and into the mounting block as shown in the illustration. Attach the wing nut to the block with two #4 x 3/8" screws.

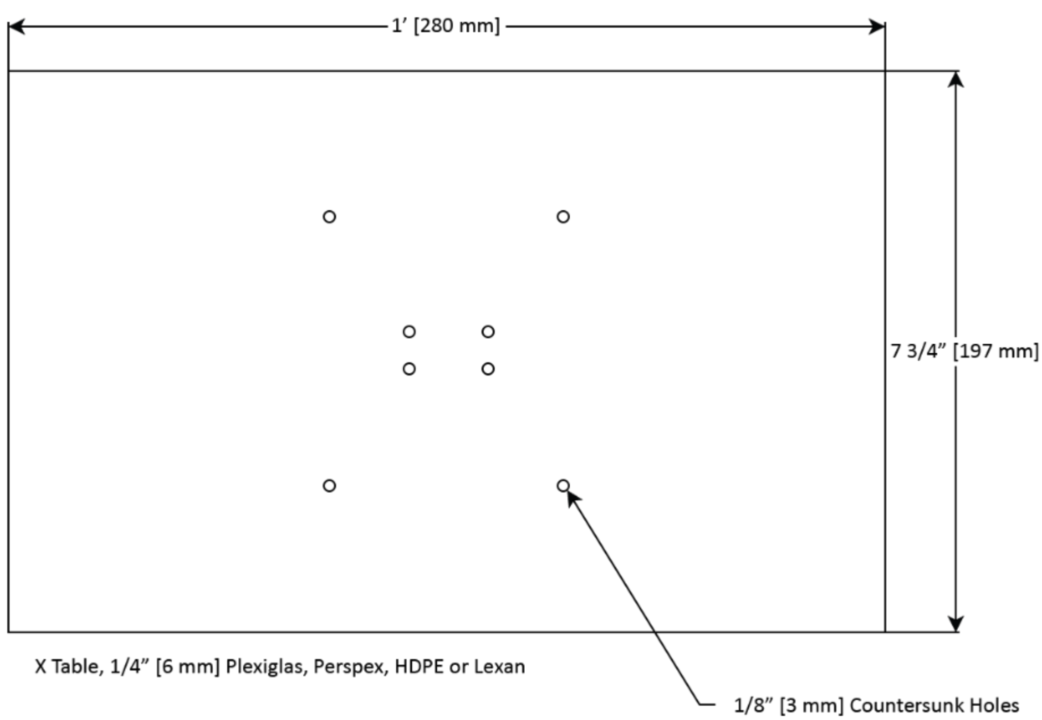
The completed anti-backlash lead nut assembly should allow the threaded rod to rotate freely, but without any slack or play when doing so.

Build three anti-backlash lead nut mechanisms and put them to one side for later attachment to the axes.

X Table:

The X Table is simply a piece of 1/4" HDPE or Plexiglas plate cut to the dimensions shown in the drawing. It is attached to the X axis bearing frames as described in the building section of the manual. The X axis anti-backlash lead nut assembly will be attached to the underside of the X axis table.

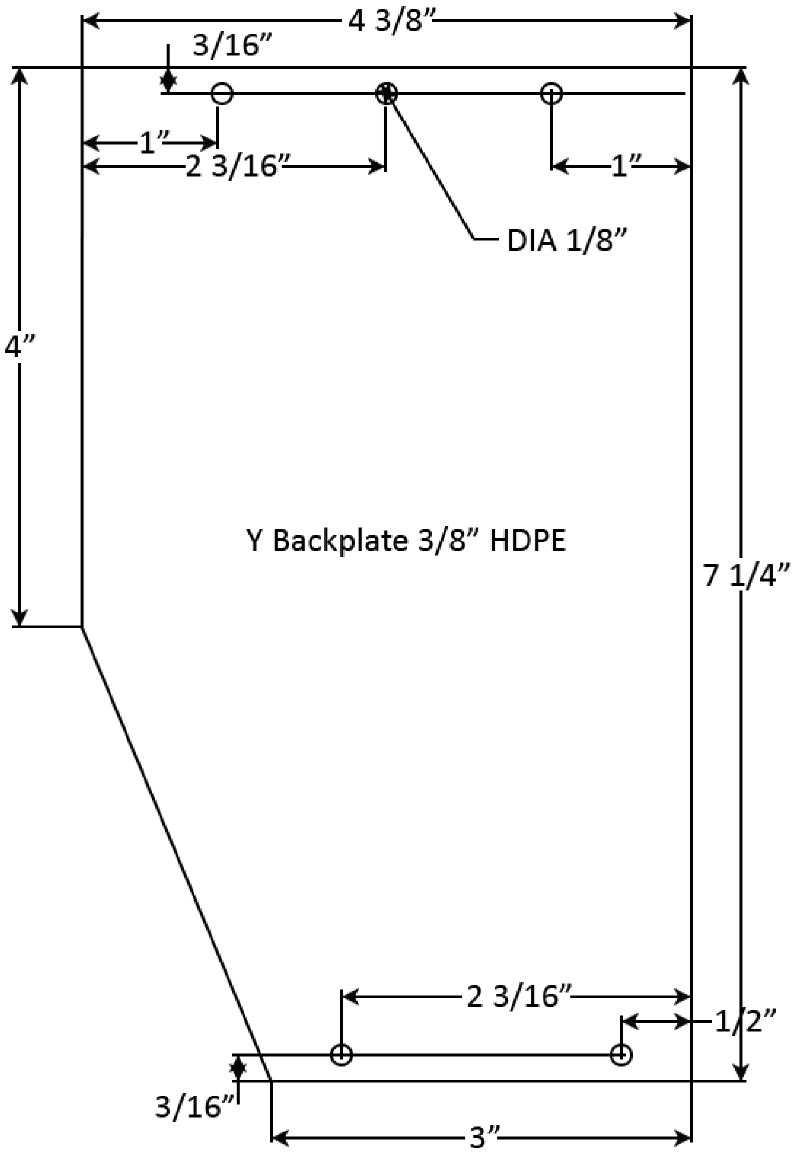
CAUTION: Great care must be given to ensuring that the bearings are perfectly aligned, as any missalignment will lead to poor performance and binding of the table. Details about how to achieve this alignment are given in the section Building Your DIY Smart Saw (Desktop Version) Bellow



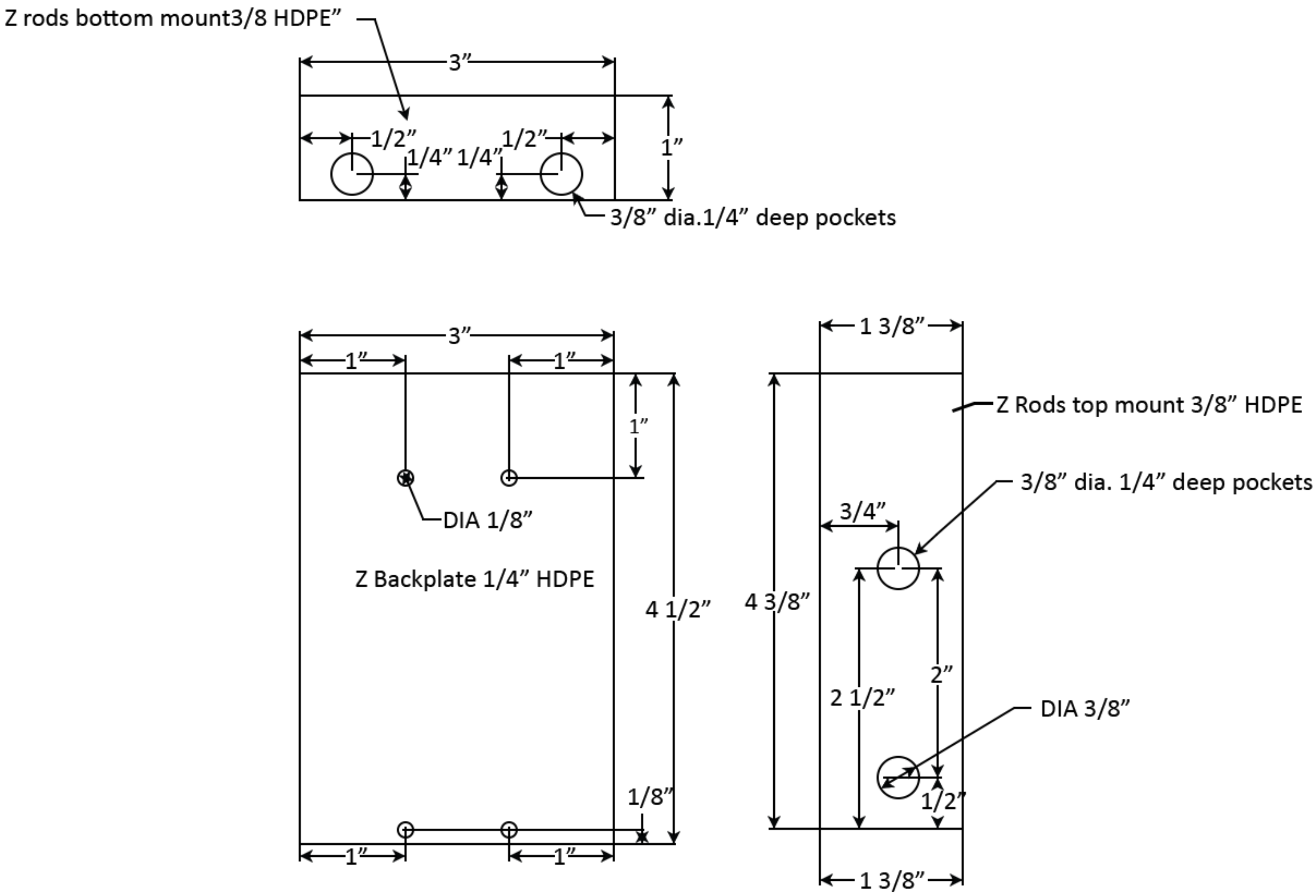
Y Table:

The Y carriage consists of a ¼" HDPE plate cut to the dimensions shown in the drawing. To this plate are attached the Y axis bearing sub frames, the Z motor mounting plate and the Z axis rod support blocks. The Y axis anti-backlash lead nut assembly will be attached to the rear side of the Y axis carriage.

As mentioned above, great care is needed to ensure the rods and bearings are perfectly aligned.



Y Carriage Backplate



Y Z Carriage Assembly

Z Table:

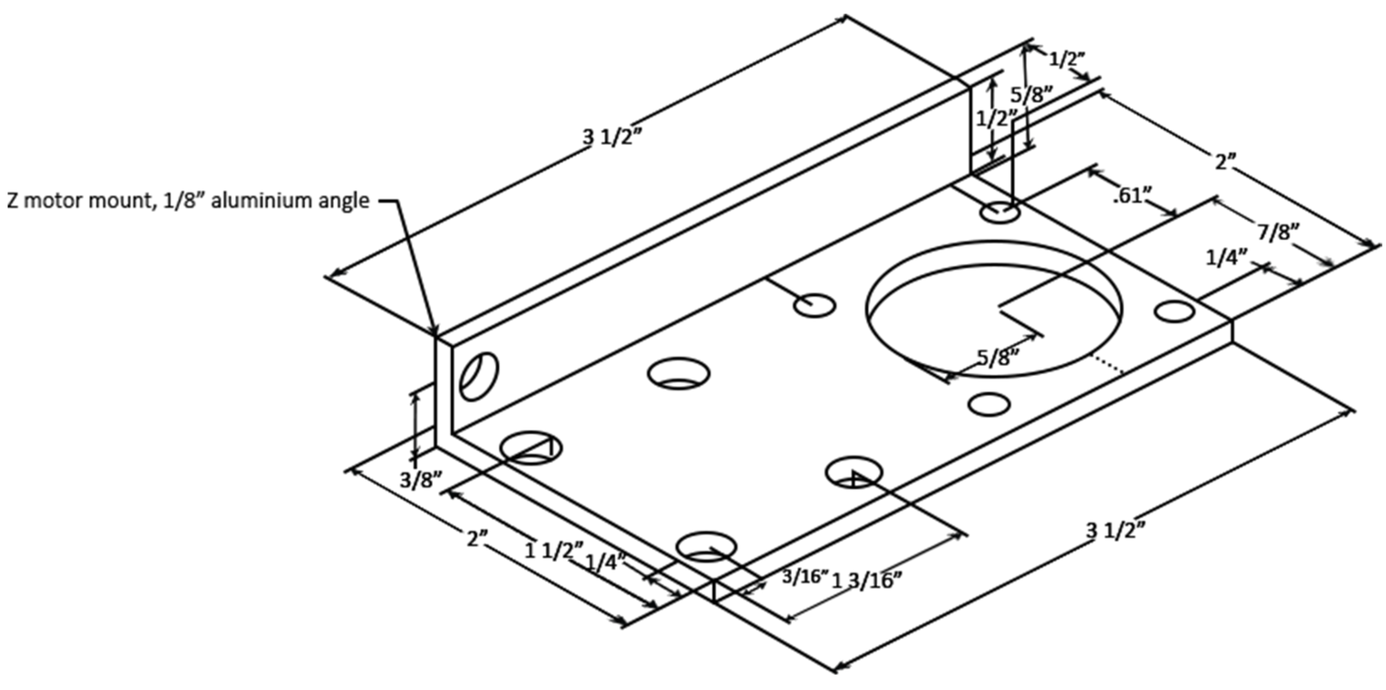
The Z carriage has several components designed to smoothly lower and raise the spindle to and from the X table surface – the working area. The Z carriage consists of a back plate, to which are connected the spindle cradle/mounts, the Z bearings sub frame and the Z axis anti-backlash lead nut assembly.

As mentioned above, great care is needed to ensure the rods and bearings are perfectly aligned. In addition, care must be given to the alignment of the Z axis drivetrain and the Z axis anti-backlash lead nut.

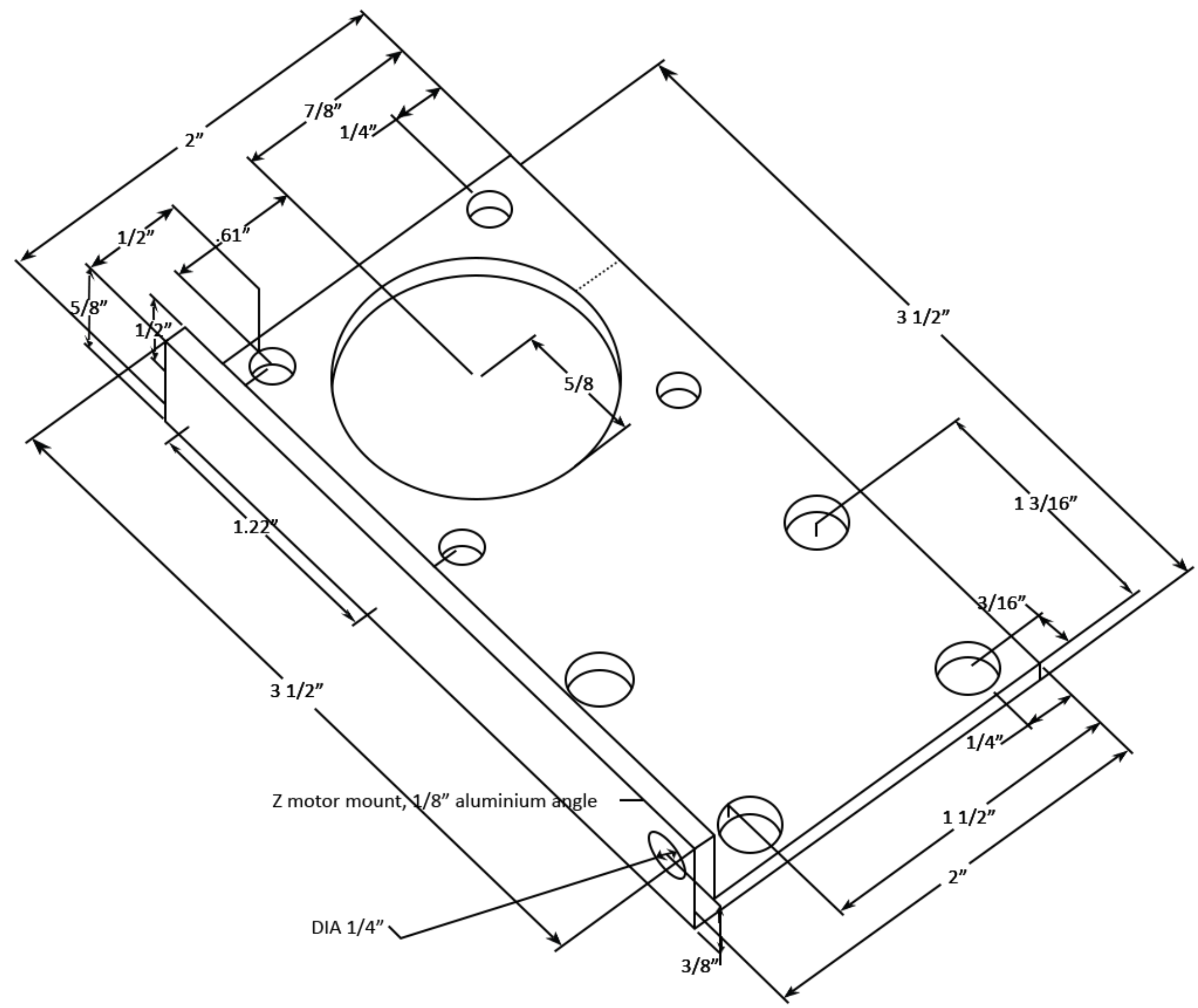
Z Motor Mount:

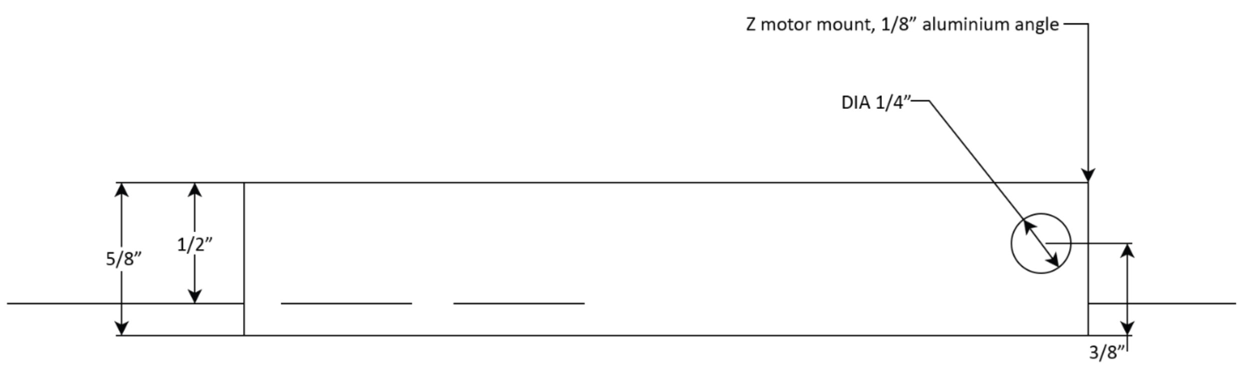
The Z motor mount is made from a section of 1/8” thickness 2” aluminum angle, cut down to provide a 2” x 1/2" angle, as shown In the drawings. Drill the mounting holes as indicated in the drawing, and use the NEMA 17 motor mounting diagram shown in the appendices to position the motor mounting holes around the center point indicated. Note that the holes through which this bracket is mounted to the HDPE Z carriage are 9/64”, slightly oversized. This is to allow the mounting screws to bite into the HDPE and not the aluminum, therefore pulling the aluminum tightly and securely into position. Two angle views are provided for clarity.

NOTE: If you use a motor coupling clamp you will need the 1 1/4” motor shaft clearance hole. If not, a 7/8” shaft clearance hole is recommended to match the raised flange on the motor face.

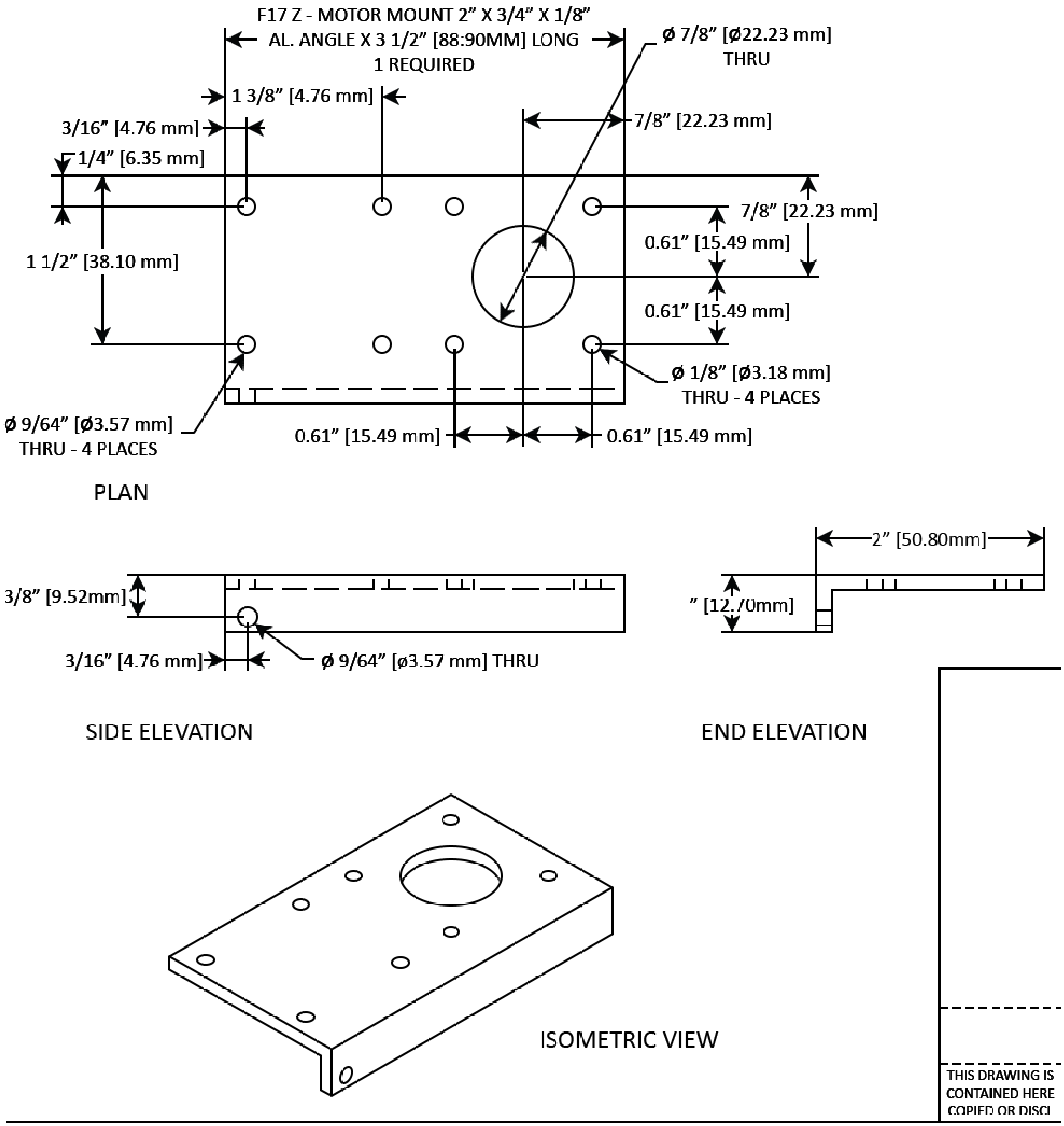


Z Motor Mount, 3D views





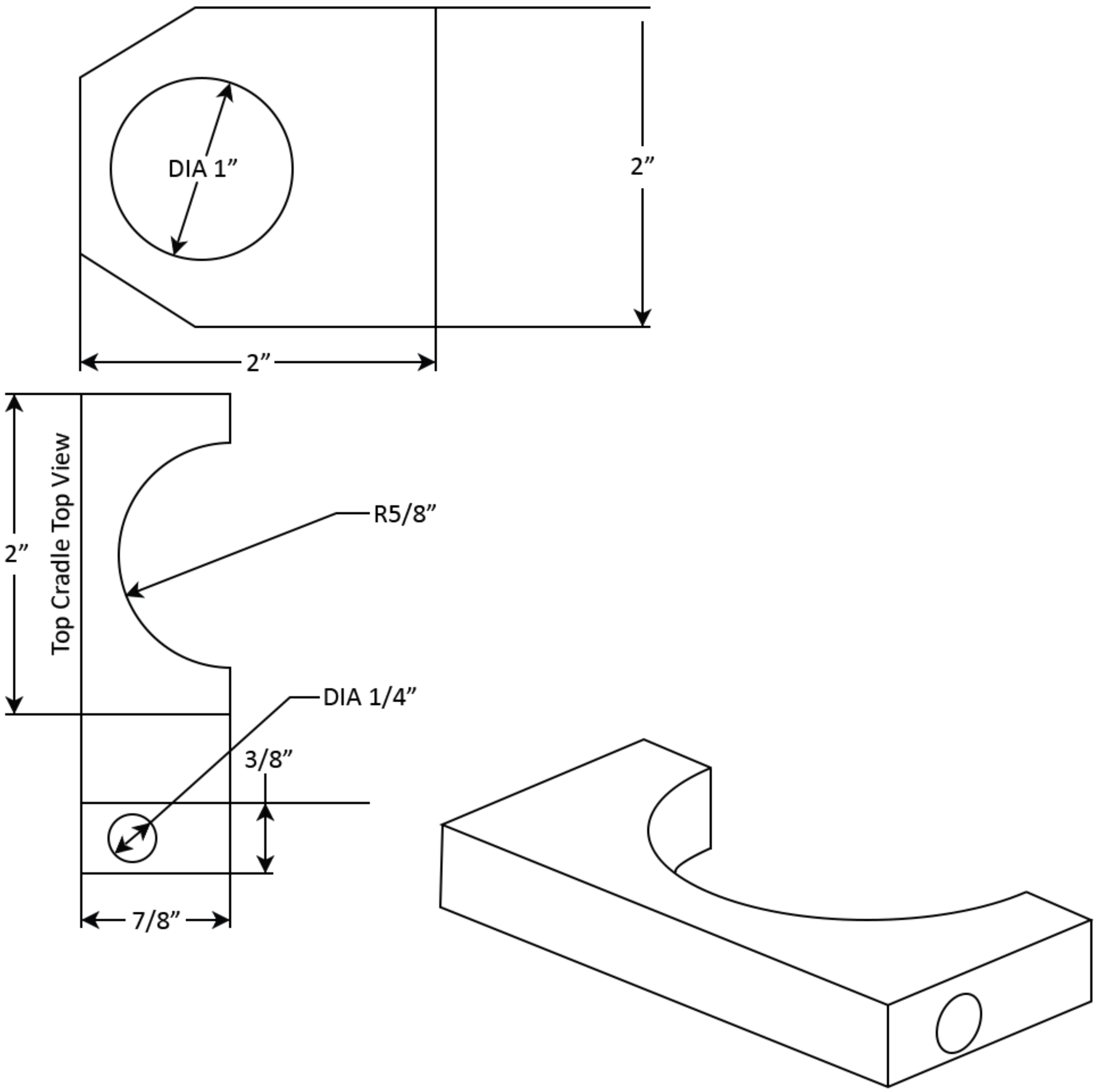
Z Motor Mount, edge view



Z Motor Mount Detail, showing optional 7/8” motor shaft clearance hole

(if coupling clamp not used).

Spindle Mount:



Spindle Mounts

The spindle mounts shown in the drawing provided are designed to mount the standard DIY Smart Saw (Desktop Version) spindle, and as shown in the following illustration on the right. To create the upper spindle cradle, start with a 2" x 2" block of HDPE and drill a 1 1/4" hole (or a diameter suitable for your choice of spindle) through the center of the square. Cut it in half and use one as the upper spindle cradle. Drill a 3/16" hole through the ends and the bottom of the semicircular notch as shown.

Of the two mounts, the top mount is designed to be a universal cradle, while the lower mount should be modified to match the diameter of your spindle/rotary tool of choice. For the standard DIY Smart Saw (Desktop Version) spindle, a 1" hole is used to match the diameter of the front end of the tool, and is positioned at a distance out from the Z axis back plate to provide a vertical alignment of the spindle when locked down in position.

The size and shape of the front (lowest) mount should be made to provide a tight and firm fit. Once cinched down in the upper cradle, the spindle should feel solidly fixed in position without any play or movement between the spindle and the Z carriage.

The illustration to the left shows the standard spindle mount on the DIY Smart Saw (Desktop Version) modified to mount an etching laser head. In this instance the upper spindle cradle is unused.

Wiring Diagram:

Wiring of the DIY Smart Saw (Desktop Version) has been greatly simplified for the hobbyist with the use of screw-down terminals. While this eliminates the need for soldering connections, It is still a good idea to solder tin the ends of the wires to be connected to help with good solid connections.

The DIY Smart Saw (Desktop Version) is designed to use a standard PC power supply. They are easilly available, inexpensive, offer the best power for the cost, provide a good universal standard color coding system, can be operated internationally in both 110V and 220V A/C countries and come with built-in cooling and protection against overheating and short circuits. Be sure to choose one with a power on/off switch.

Instructions on how to modify a PC power supply for use with a DIY Smart Saw (Desktop Version) are provided in the section Creating Your Parts below.

There are five main wiring tasks involved in setting up your DIY Smart Saw (Desktop Version)

electronics.

1. Wiring the DB-25 connector to the three DIY Smart Saw (Desktop Version) Universal bipolar Stepper Control Modules

2. Wiring the power supply to the three DIY Smart Saw (Desktop Version) Universal bipolar Stepper Control Modules

3. Wiring the three stepper motors to their respective DIY Smart Saw (Desktop Version) Universal bipolar

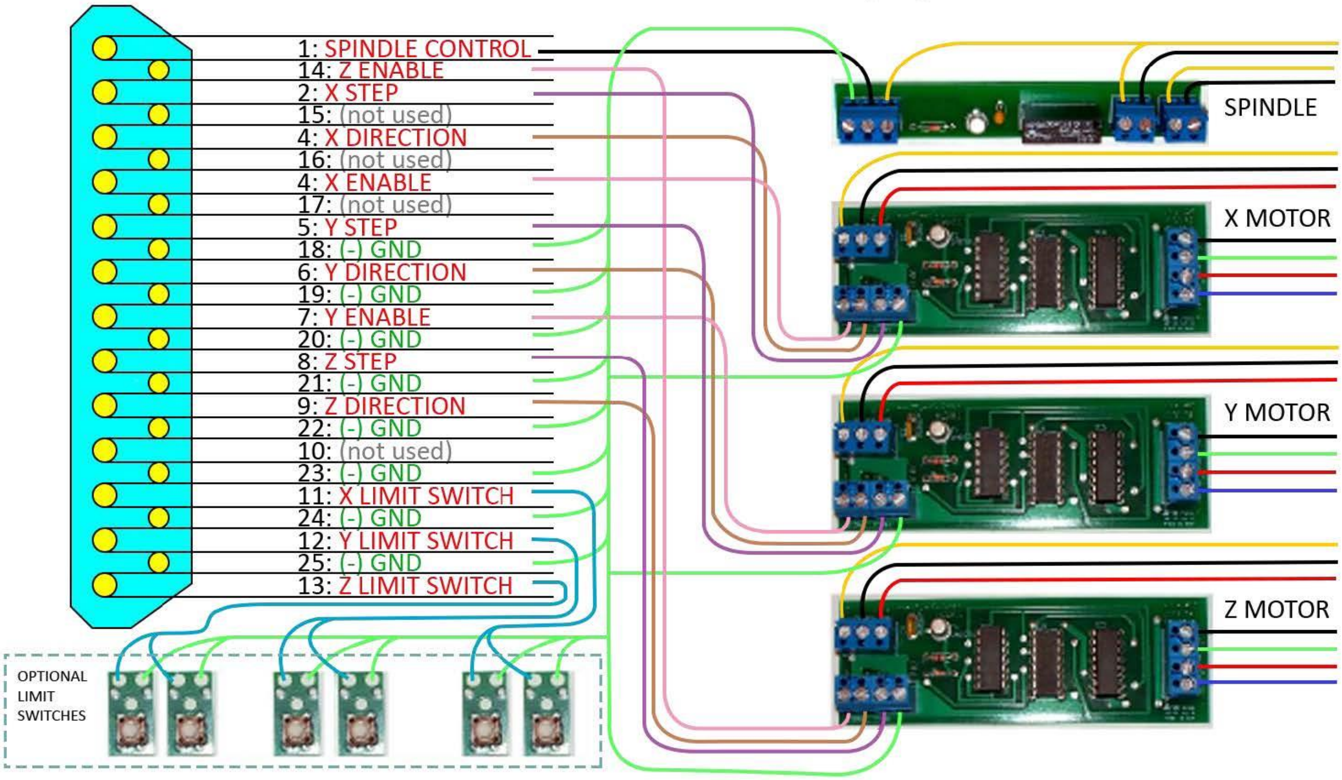
Stepper Control Modules

4. (Optional) wiring of the Spindle Control Modules to the power supply and spindle

5. (Optional) wiring of the Limit Switches

WARNING: Care must be taken to correctly connect the wires to the electronics, especially the power supply connections. The 12V, 5V and ground lines on the power supply are yellow, red and black respectively. Take great care not to mix these power lines up or connect the wrong line to the wrong terminal as serious damage may occur to your electronics.

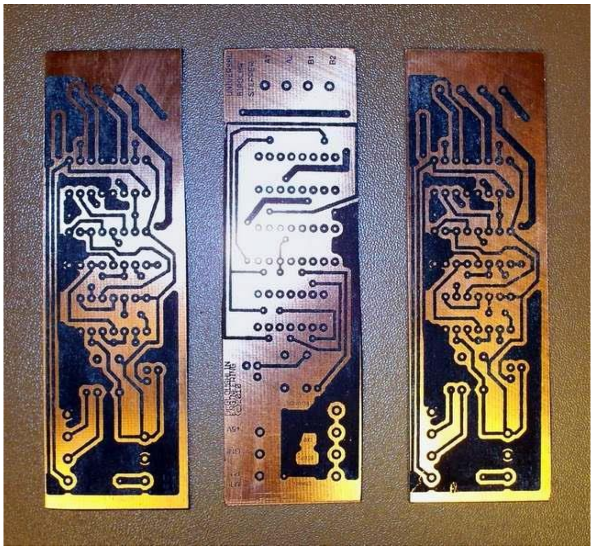
DIY Desktop CNC MACHINE Parallel Port Electronics Modules Connector
Pin-Outs and Wiring Diagram



Hardware:

The DIY Smart Saw (Desktop Version) uses a large number of hardware parts such as fasteners, springs, clamps, etc. The majority of these parts can be found at a well-stocked local hardware store. The parts bill of materials provides a detailed specification of each part to enable you to obtain the correct part for the task. In addition, the part numbers and websites of online suppliers of these parts are also provided. Outside of the US, use their online catalogs to provide you with manufacturer information and part numbers to help you search for local suppliers. See the appendix Master Bill of Materials for more details.

Electronics:

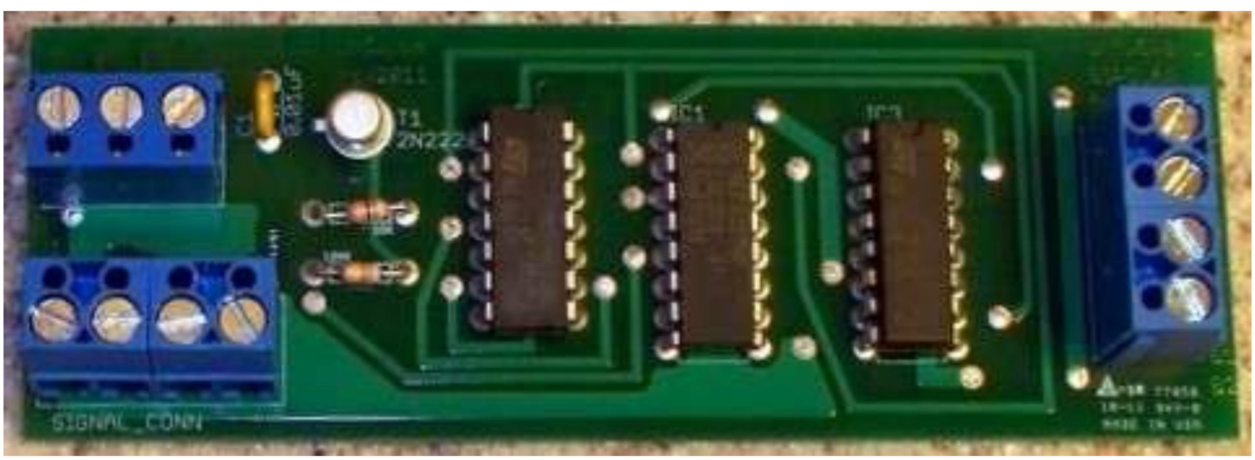


The DIY Smart Saw (Desktop Version)'s electronics and optional limit switch boards have been designed to be modular, simple, inexpensive and easy-to-make by the hobbyist. Circuit diagrams and PCB art are provided to create the electronics with either prototyping boards or home PCB etching.

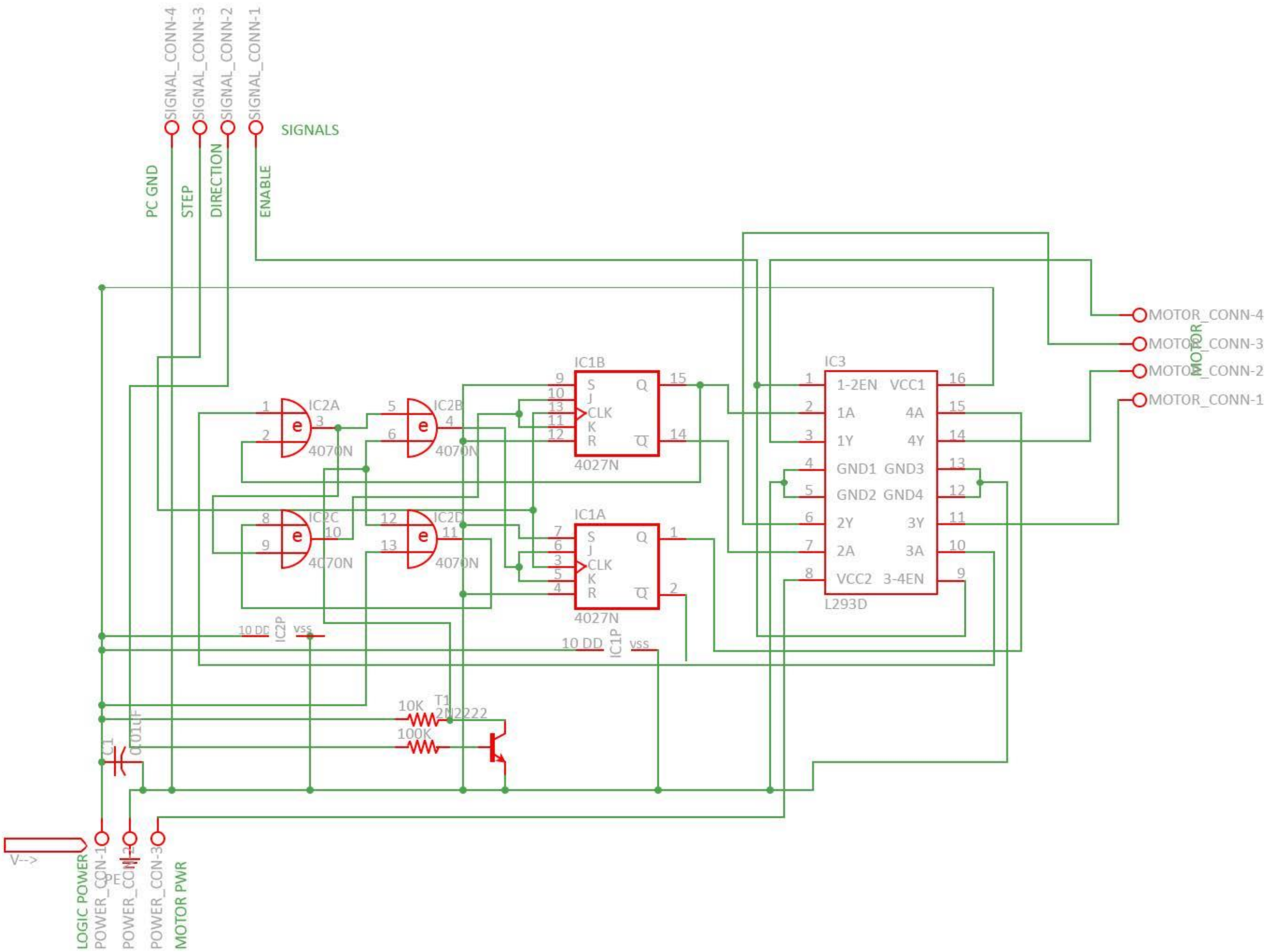
Stepper Controller Module:

1) *Specifications:*

Stepper Motor Type	4-wire bipolar
Motor Voltage	4.5 – 36 VDC
Circuit Voltage	5 VDC
Step Method	Full Step
Input Signals	ENABLE DIRECTION STEP
Motor Currect	1.2 A per channel (4)
Operating Temperature	0°C – 70°C
Connection Type	PCB-mount Screw Clamps
Thermal Shutdown	Yes
Electrostatic Discharge Protection	Internal
Dimensions	1.4” (35mm) x 4” (102mm)



2) Circuit Diagram:



The PCB required for the Stepper Control Module is double-sided. Great care must be taken to align the circuit on each side of the board when making your PCB.

3) Bill of Materials:

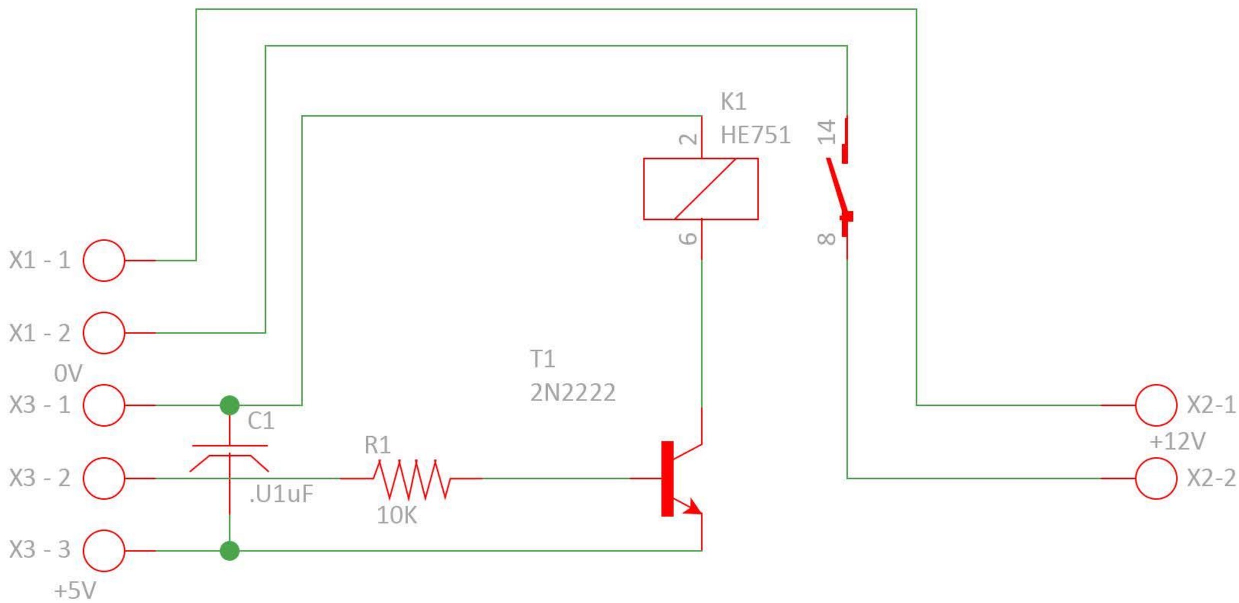
Component	Quantity Per Board
10K Resistor	1
100K Resistor	1
0.01uF Capacitator	1
4027N CMOS Logic, DIP	1
4070N CMOS Logic, DIP	1
L293D 4 Channel Motor Driver, DIP	1
2N2222 Transistor	1
W273-04P Screw Clamp Connector (or equiv.)	1
W273-3E Screw Clamp Connector (or equiv.)	2

Spindle Controller Module:

1) Specifications:

Operating Voltage	12 VDC
Logic Voltage	5 VDC
Spindle Voltage	3-24 VDC 110 VDC 220 VDC
Connection Type	PCB-mount Screw Clamps
Dimension	.5” x 4”

2) Circuit Diagram:

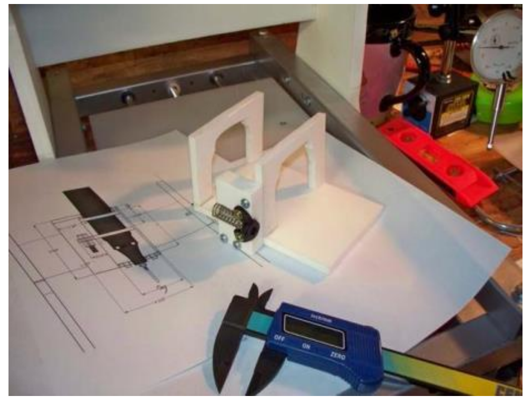


3) Bill of Materials:

Component	Quantity per Board
10K Resistor	1
2N2222 Transistor	1
893-202-1AC-F-S12VDC 5A 12VDC power relay	1
0.01Uf Capacitator	1
OSTTA030161 3-terminal screw clamp connector (or equiv.)	1
OSTTA020161 3-terminal screw clamp connector (or equiv.)	2

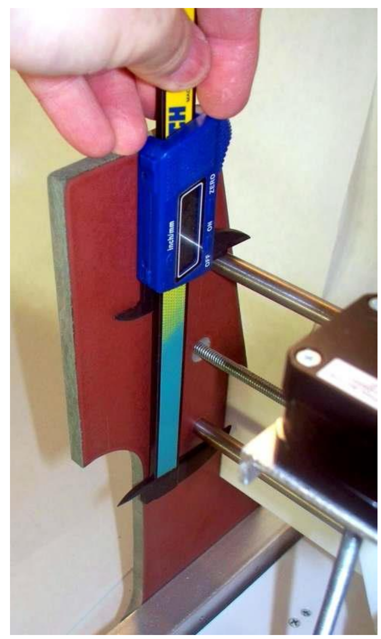
Creating Your Parts:

Following the set of drawings provided for the DIY Smart Saw (Desktop Version) parts, cut and drill your chosen materials as directed, label each part and put to one side in preparation for later assembly. When parts are called for in pairs, they should be firmly clamped or taped together and drilled in pairs. This is essential for accurate alignment of rods and bearings which is critical for the smooth operation of your DIY Smart Saw (Desktop Version).



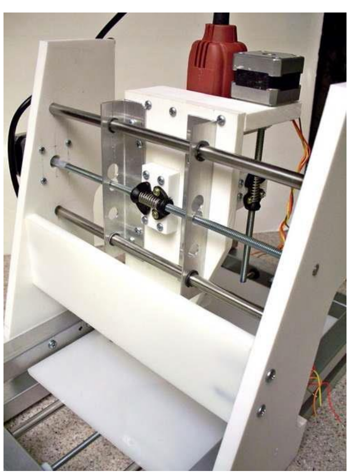
Notes and Precision Cutting and Drilling:

The DIY Smart Saw (Desktop Version) is a precision machine and requires a high level of accuracy in the fabrication work to create it. While a certain amount of tolerance is allowed for in the design, critical precision is required for



1. The relative positioning of the rods and bearings
2. The relative positions of the axes to each other

Rods and Bearings:



Rods must be perfectly parallel to within .01” on either end. This means that the distance from outside edge of one rod to the other must be identical on both ends of their travel to within one hundredth of an inch. Any variance greater than that will cause the carriage to bind up on the rails.

Likewise, the bearing holes in the bearing sub frames must be centered to the exact same dimension as the distance between centers of the rods. The Igus bearings allow for about .01” of tolerance when mounted in 7/16” holes, but precision in mounting

the bearings on the correct matching centers to the rods is required to ensure a smooth-running axis.
As mentioned above, drilling matching parts in pairs is a simple and effective way to ensure alignment of holes between pieces.

However, since the smooth operation of each carriage requires that rods must be parallel, and aligned accurately to the bearings, it is critical that care is taken to drill rod mounting holes and bearing mounting holes in the precise locations specified in the drawings.

Use the following diagram to determine how the bearing sub frames are mounted to their respective carriages to maintain the alignment of the through-drilled holes.

In the event that your holes do not align and you do experience binding of the axes carriages, see the Troubleshooting chapter towards the end of this manual for possible remedies and corrective measures.

Position of Axes in Relation to Each Other:

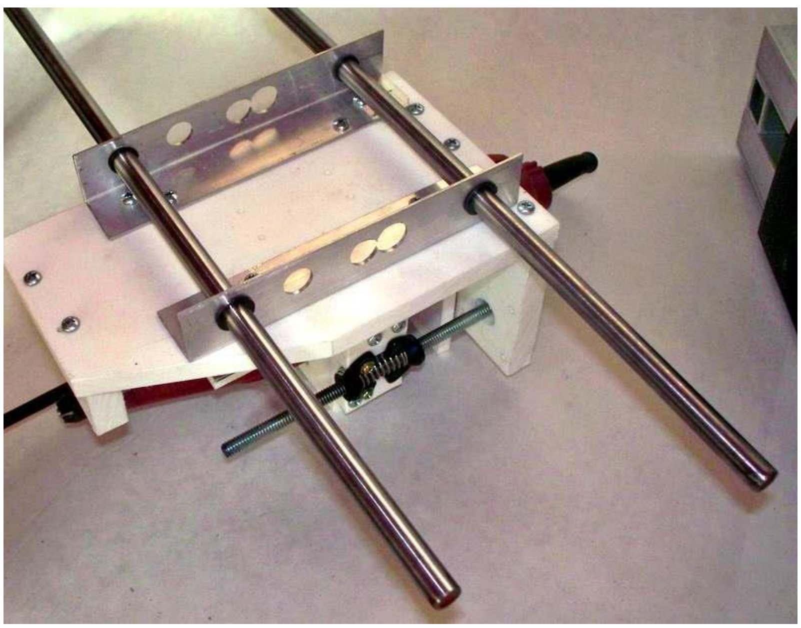
The second-most critical requirement for precision is that the axes are aligned at exact right-angles to each other. If not aligned, the work done by your DIY Smart Saw (Desktop Version) will also not be precise and aligned. The Z depth may increase or decrease across your X table with no movement of the Z axis if your gantry and table are not completely square to each other. You may see work that should be square or rectangular be produced as a parallelogram if your Y axis is not aligned at exactly 90o to the X axis.

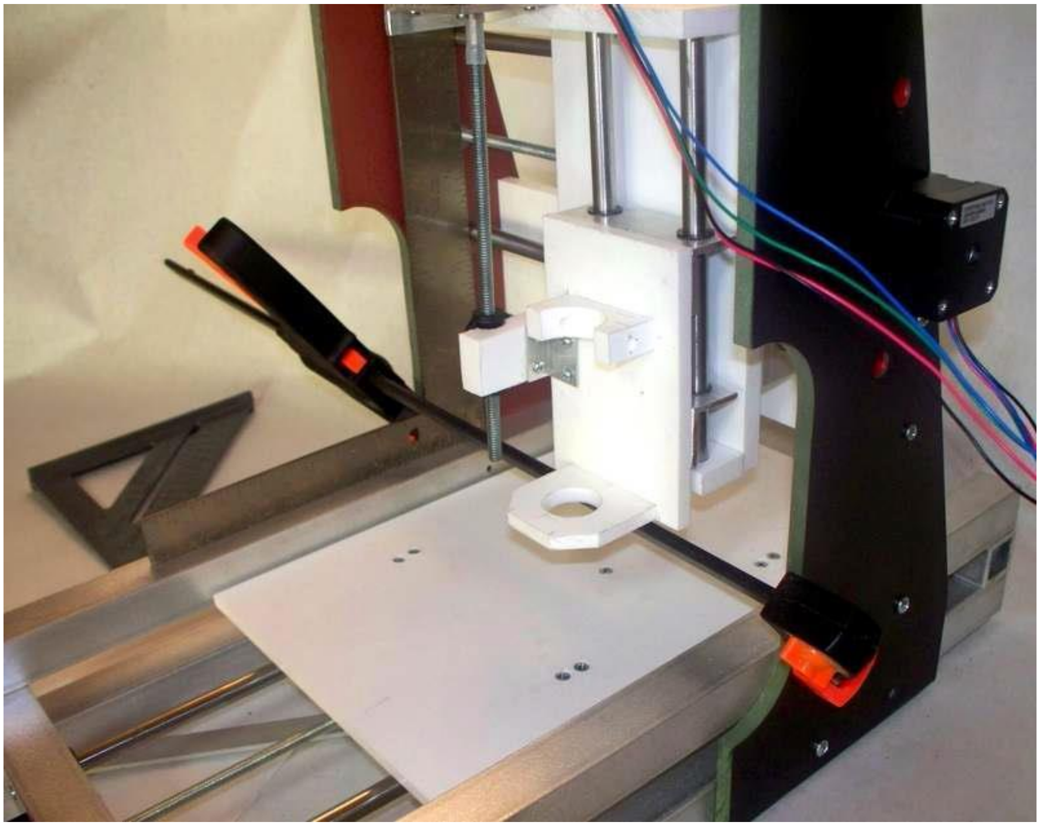
This degree of alignment is achieved by taking great care and using a quality carpenter's or machinist's square at every step to ensure that right angles are maintained where required. Before tightening down any chassis bolts or screws check for alignment and square. As long as the dimensions of the chassis holes on the metal chassis frame and the bottom cross-brace are accurate, it should be kept in square by the cross-brace.

To ensure that the Y axis is square to the X table, check for alignment first and tightly clamp the gantry support uprights in position against the outside edges of the frame as indicated in the drawings. At that point, once you are sure the gantry is square, use the mounting holes located in the bottom of the upright gantry supports as guides for drilling through into the metal frame, taking great care to drill perpendicularly into the metal.

Attach the upright gantry supports to the metal frame using #8 X 3/4" sheet metal screws, screwing them snugly in place, but do not tighten all the way down just yet. Measure again for squareness between the Y carriage gantry and the X table, adjust if necessary, and tighten down the screws.

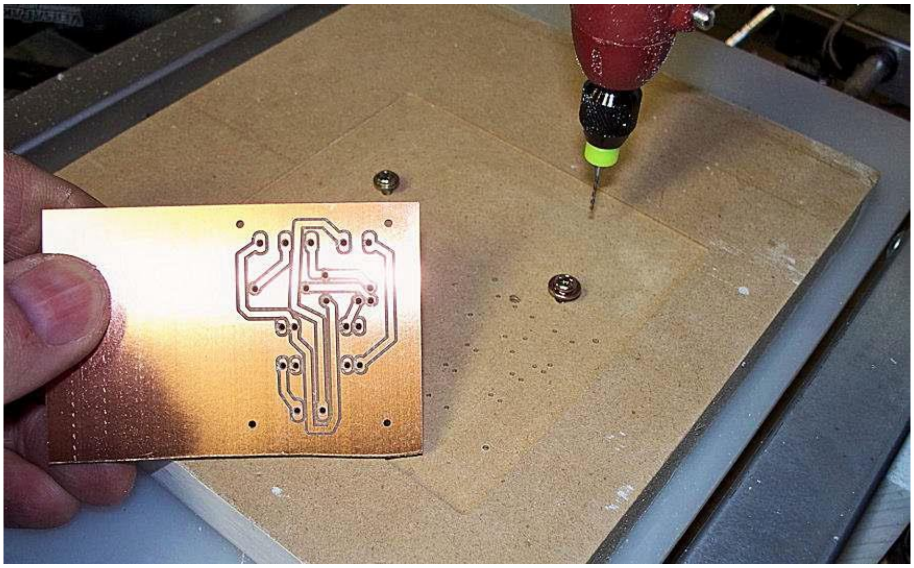
Check for squareness again to ensure that tightening the screws did not pull the Y axis gantry out of alignment. Once all the screws are tight, and the gantry remains square, only then should you remove your clamps.





Check for square before drilling and screwing gantry support uprights to chassis rails

(note use of carpenter's square)

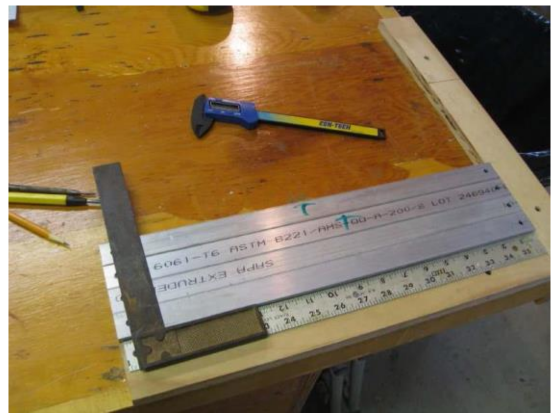


Ensuring that the axes are all exactly square to each other is particularly important for high precision work such as PCB isolation track milling. For such operations the slightest misalignment can render this process ineffective. This can cause milling of unequal depth across the board, resulting in various thicknesses of tracks, and components may not align with pads and through holes when attempting to assemble the final product.

Chapter II : Building the Smart Saw

(Desktop Version)

Chassis Frame:



The chassis frame calls for six pieces of 1” square aluminum tube which form the rails of the frame.

The chassis frame calls for six pieces of 1” square aluminum tube (see the section on material selection for information about steel and wooden base choices) which form the rails of the frame.

These pieces can be cut and drilled in pairs to help alignment accuracy from rail to rail. The most critical part of creating these rails is the alignment of the holes that support the X axis rods, and the holes in the ends of the rails that are used to bolt together the four corners of the chassis frame and the cross-brace.

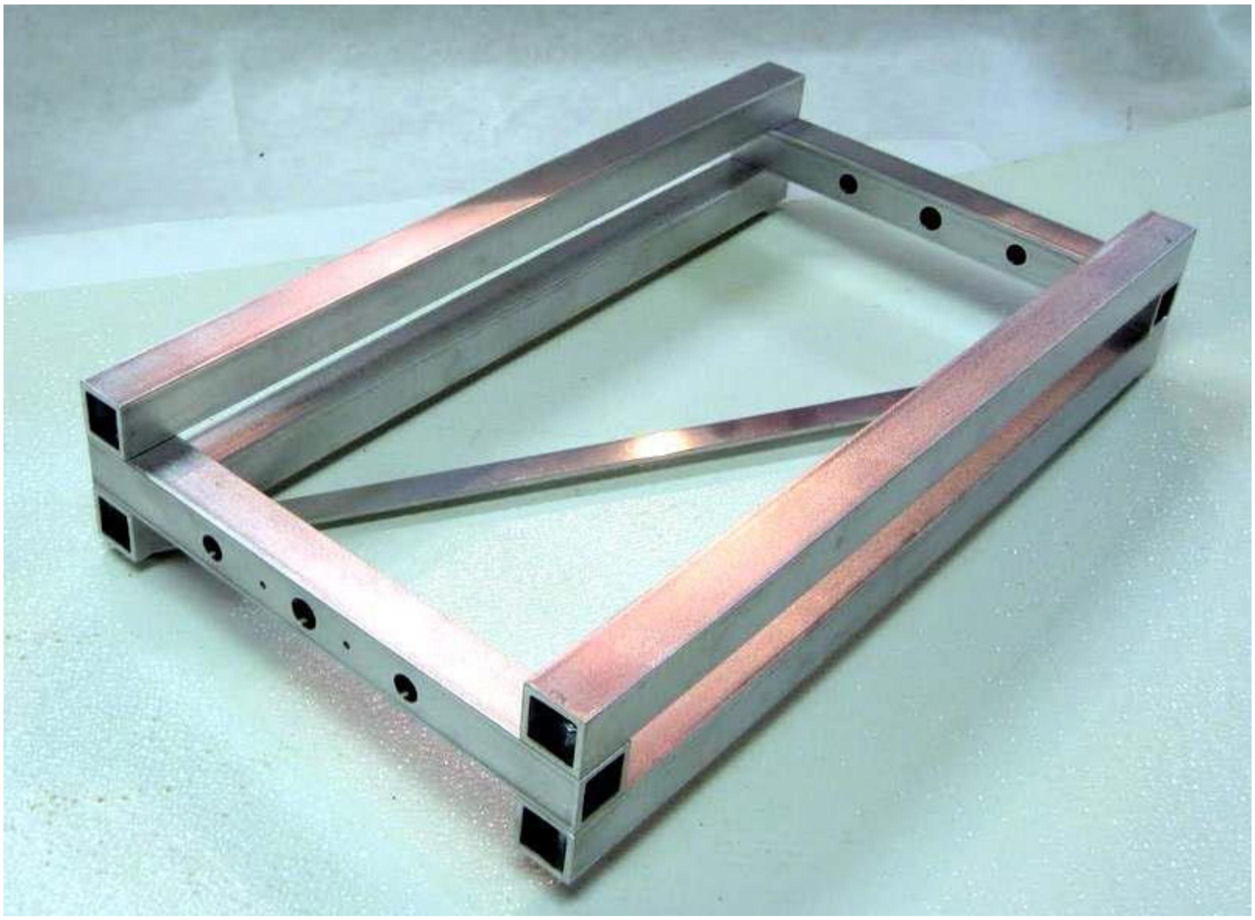
Drill the 10” end rails together. Clamp or tape them firmly together, carefully measure the location of the 7/16” holes for mounting the rods, and drill through both rails in one operation, taking great care to drill perpendicularly. Make sure the holes are drilled in the exact center point of the tube face. When they are drilled, use your calipers to make sure that the distance between the inside edge of a hole and the outside edge of the rail is exactly the same for both holes. This will ensure that the X table is level.

Separate the rails, and re-clamp them together so that they are stacked on top of each other and drilling down through the ends of the rails will create the corner bolting holes, as shown.

Clamp or tape together rail pairs for drilling to ensure alignment of holes

Once cut and drilled, assemble the chassis frame as indicated in the drawings, bolting the rails together through the corners as shown. Don't forget the cross-brace and the addition of washers on the bolts that do not go through the cross-brace. Check the frame for square as described above. Once square, tighten down the corner bolts, recheck for square, and you're done. Push the rubber grommets into the holes for the rods.

Your completed chassis frame should look like the one shown in the picture below.



Initial assembly of the chassis frame

Cutting and Preparing Rods and Leads Screw:

The hardened and threaded rods should be cut to the lengths prescribed in the drawings. This is best done with a hacksaw. If you have a metal band saw or chop saw available, this will make the cuts easier.

Note: A chop saw uses an abrasive blade, as opposed to a cutting blade. This may cause discoloration and bluing on the rod ends due to the high temperatures caused by the abrasive cutting. This is normal and purely cosmetic, and has no effect on your DIY Smart Saw (Desktop Version) performance.

Using a metal file or grinding wheel, chamfer the ends of each cut rod to remove any burrs and to bevel off the shoulder of the cut. This will make it easier to locate each rod in its hole/pocket/grommet without causing damage as the rod is inserted.

Gantry Support Uprights and Brace:

Next up is the gantry support uprights and cross-brace. The Gantry Support Uprights are cut to the dimensions provided in the drawings. They are cut from either 3/8" – 1/2" HDPE or from 10mm Laminated HDF. See the section Wood above for details on choosing the best material for your build.

The uprights are best clamped and drilled together. In the absence of a suitable clamp they may be bound together tightly with strong masking or duct tape. Great care must be given to preparation for this step to ensure that both pieces are perfectly aligned before drilling. Without this critical first step the holes, and therefore the Y axis rods, will not align which may cause binding and excess friction in the Y carriage. A drill press is strongly recommended for this step.

TIP: A drill press is particularly useful for this process to ensure that the holes are drilled straight through the uprights and are perfectly aligned. In addition, a drill press will allow for controlling the depth of the rod end pockets in the right-hand upright. If using a hand drill, take great care to drill at right angles to the leading edge of the blocks.

Once the gantry support uprights are completed, they are attached to the chassis frame. Align the mounting holes in one upright with its hole in the frame. This should position the rear edge of the upright 3” from the rear of the chassis rails. Make a note of this distance between the back edges of the gantry support upright and the end of the rail it attaches to. Carefully measure this distance from the rear of the chassis rail and, using your carpenter’s or machinist’s square, make a right-angled mark in pencil across both rails, indicating where the gantry support uprights should be located. Ensure that these marks, one on each side, align with each other and that they form a perpendicular line across that chassis. Align the gantry support uprights to this line and the bottom edge of the bottom rails, and clamp in place. See the above section Position of Axes in Relation to Each Other for the next step and how to ensure that your Y axis is square to the X table.

Once the gantry support uprights are attached and square, use a bar clamp to clamp the gantry cross-brace in place, making sure that the ends of the gantry cross support are centered over the holes you drilled in the gantry support uprights for this purpose. Using a 7/64” drill bit, drill pilot holes in the ends of the gantry cross brace using the holes you drilled in the gantry support uprights as guides. Using #6 x 3/4" sheet metal screws, screw the gantry cross-brace in place. Check again for square. At this stage, your progress should look like the one shown in the picture below.

Gantry support uprights attached to chassis

X Rods, Bearings and Table:

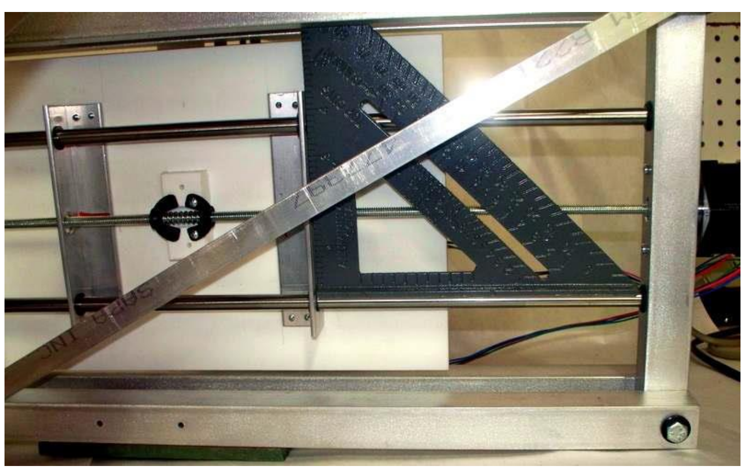
The next step is to attach the X axis bearings and bearing sub frames to the X table and mount it in the chassis.

Take the two X axis rods you prepared earlier and slide them through the front rail into the rubber grommets in the rod mounting holes. They should be a tight fit, but if they resist to the point that the rubber grommet is getting pulled out of the hole, apply a small amount of soap and water to the rod and try again. This will help slide them in. Once in place, use a paper towel to clean up the water and soap.

CAUTION: At this stage you should have checked that the distance between the rods is the same at all points along along their length, that they are the exact same distance in from the top of the support rails and have the same distance between centers as the bearings. If this is not clear, see the sections above on Precision Cutting and Drilling and Rods and Bearings.

Pull the rods back out of one end of the frame, and slide the X table bearing sub frames onto the rods. Make sure that the orientation of the bearing sub frames to each other is the same as when they were clamped together for drilling. Reinstall the rods into the grommets.

The bearing sub frames should slide back and forth freely on the rods when at right angles to them. Because they are loose (not yet attached to the table), they will have a tendency to skew and bind. Using a carpenter's or machinist's square, align them at right angles to the rods and use the square to keep them in this position while you slide them up and down. They should move freely and with little effort.



Use a machinist's or carpenter's square to ensure squareness between the rods and bearing support sub-frames

Flip the DIY Smart Saw (Desktop Version) upside down and support it such that the X axis bearing sub frames rest on the X table. The bearing sub frames must be at right angles to the X axis rods as described and the gap between the x table and the chassis side rails must be 1/8" at all points along each side. Once the bearing support sub-frames are aligned and in position, make a pencil line along the edge of the sub-frame for reference.

Using duct tape and, ensuring as detailed above that the bearing sub frames are at right angles to the rods, tape the bearing sub frames securely to the X table. With this temporary attachment, the table should slide easily back and forth on the rods. If movement is not smooth and easy, adjust the bearing sub frames until such time as the table moves freely. Using a 1/8" drill bit, use the small mounting holes in the bearing sub frames to drill pilot holes through the x table.

Flip the DIY Smart Saw (Desktop Version) back on to its feet, making sure that the tape is still secure and that the table still moves along the X axis freely. With a countersinking bit, countersink the holes sufficiently so that the heads of the table screws are below the working surface.

Using #6 x 1/2" flat head self-tapping countersunk screws, attach the X table to the bearing sub frames. Check again for free travel along the rods. Remove the duct tape.

1) Gantry and Carriages:

Before assembling the Y axis rods and drivetrain, the Y-Z carriage must be assembled.

2) Y-Z Assembly:

As shown in the diagram, the Y axis bearing sub frame is attached to the Y axis backplate. Insert the Y axis rods through the gantry support uprights and the Y axis bearing sub frames, taking care to keep the bearing subframes in the orientation and order they were through-drilled.

Use the technique described in the section X Rods, Bearings and Table above to ensure that the bearing support sub frames are at exact right angles to the rods. As with the X table, use duct tape to temporarily secure the bearing support sub frames to the Y axis backplate in the location indicated in the drawings once they are aligned correctly. Test for smooth motion along the rods.

Once they are correctly located, attach the bearing sub frames to the Y axis backplate with #4 x 3/8"screws. Retest for smooth motion along the full length of the Y axis rods. This assembly is the Y carriage.

Remove the temporary tape. Remove the Y carriage assembly from the Y axis rods and put to one side for later assembly and attachment of the Z axis.

The Z axis/carriage is perhaps the most complex part of the DIY Smart Saw (Desktop Version). Care must be taken to ensure that the Z axis is at exact right angles to the Y axis, and that movement of the Z carriage on the Z axis is smooth.

For the Z axis, the process assembly is slightly different than it was for the X and Y axes. Double-check that the top and bottom edges of the Z axis backplate are exactly parallel.

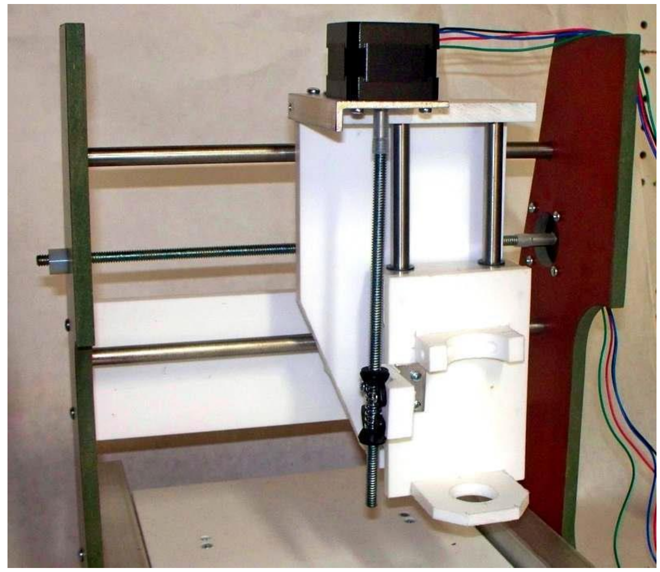
Carefully align the top bearing subframe to the top edge of the Z axis backplate, as shown in the diagram, and attach the bearing sub frame with #4 x 3/8” screws. Measure down from the top of the Z carriage backplate and make a mark at the location of the second bearing subframe. Do the same for the other side. Align the second bearing subframe to the marks and using your calipers, make sure that the distance between the bearing subframes is identical on both ends. Once aligned, screw it in place.

The Z axis backplate and the Z axis bearing subframes are the exact same width, so their edges on the sides should match up exactly as shown.

Attach the spindle mount cradle and spindle bottom mounting bracket as shown in the diagram. Attach the small aluminum Z axis anti-backlash lead nut assembly mounting bracket in the position indicated. The anti-backlash lead nut assembly will be attached later in the section Axes Drivetrains.

Take the Z axis top rod mounting block and attach it to the Y axis carriage, aligning it to the top of the Y carriage as shown. Next align the aluminum Z motor mount in position, and attach it in place with #6 x 3/8"screws on the top of the assembly only. Screws will only be attached to the top edge of the Y carriage backplate and to the Z axis top rod mounting block as shown. Do not attach the single corner screw on the return end of the angle where it aligns with the edge of the Y carriage backplate (as indicated in the drawing).

Using a carpenter’s or machinist’s square, make sure that the Z axis top rod mounting block is exactly at right angles to the Z axis backplate. Once correctly aligned, drill a 7/64"pilot hole for that corner screw using the hole in the aluminum bracket as a guide. Screw the corner screw to the Z carriage backplate to lock the Z axis top rod mounting block in place. Recheck for square.



Insert the Z axis rods through their bearings. Holding the Z carriage and Z axis rods as one assembly insert the rod ends into the pockets in the Z axis bottom rod mounting block, making

sure that they are aligned correctly as shown. The edge of the mounting block with the greater distance to the pockets is the side attached to the Y carriage backplate.

Holding the entire assembly of Z carriage, rods and bottom rod mounting block, insert the Z axis rods into the pockets in the Z axis top rod mounting blocks. Align the bottom rod mounting block so that the Z carriage travels smoothly up and down the Z rods. Using a bar clamp, secure it in position. Test again for smooth travel of the Z carriage. Once aligned correctly, fasten the Z rods lower mounting block with #6 x 3/4" screws.

You now have the complete Y-Z carriage assembly. Slide the Y bearings onto the Y axis rails. You'll be glad to know that as long as each of your axes slides freely on its rods, you've completed the most difficult and most precise part of building your DIY Smart Saw (Desktop Version).

Axes Drivetrains:

This next stage assembles and attaches the motors and drivetrains to each axis.

1) Motor Couplings:

The motor couplings are made from a 1.5” section of PVC tubing. The tubing will be a tight fit over the threaded rod and motor driveshaft, so some patience will be required with this step.

CAUTION: The DIY Smart Saw (Desktop Version) is supplied with a set of powerful stepper motors. They have the capability of seriously damaging the machine should they continue to rotate and drive the axis after it has either reached the end of the axis or has become stuck. The coupling tube that connects the threaded rod to the motor driveshaft is designed to provide a safety cluth for the drivetrain should the axis get stuck. This ability to slip should the torque on the coupling get too high is an important failsafe feature of your DIY Smart Saw (Desktop Version).
The clamps for this coupling should only be used if the coupling is too loose to operate under normal operational loads. Be aware that the clamps effectively dimish the ability to slip when necessary to do so.

Gloves will be helpful for this step, especially for the hand holding the threaded rod.

:: DO NOT USE ANY LUBRICANT ON THE DRIVETRAIN COUPLINGS ::

Soak the coupling in hot water for a few minutes to make it pliable. Holding the threaded rod firmly, screw the coupling over the end until the threaded rod is half way down the tube. You may need to wiggle the end of the coupling a bit at first to make it fit over the threaded rod, but once started it should thread on. It should take effort to thread the coupling but not so much that the coupling begins to twist and collapse. If it gets too difficult, warm the coupling tube again in hot water.

Make sure the coupling is dry before attaching the motor. Holding the threaded rod/coupling in one hand, push the motor driveshaft into the coupling until it reaches the end of the threaded rod. The coupling should reach the length of the driveshaft.

Repeat this process for all three drivetrains/motors.

TIP: If you built the Stepper Signal Exerciser provided in the Appendix, it can be used in this next step to rotate the stepper motors instead of rotating the drivetrain by hand. It will make this step go faster and easier.

2) Drivetrain Assembly:

Starting with the Y axis, place the motor assembly through the right-hand (when viewed from in front) gantry support upright and through the openings in the bearing support sub frames provided for drivetrain clearance. Taking one of the anti-backlash assemblies, place it between the two bearing support sub frames, roughly where it will be located, and thread the drivetrain threaded rod into the wingnut that is affixed to the mounting block. The anti-backlash assembly will not be attached to the Y carriage until a later step.

Once assembled, gently move the anti-backlash assembly back and forth along the threaded rod. There should be no looseness or play in the assembly. The rod should also rotate with minimal resistance. The anti-backlash assembly should be adjusted so that it eliminates play in the drivetrain without adding excessive resistance to the rotation of the

drivetrain. If you experience slack in the assembly it will need to be tightened, and if you experience difficulty in rotating the drivetrain, it
will have to be loosened. The anti-backlash assembly can be adjusted in half-turn (0.025") increments. See the Appendix on Adjusting the Anti-Backlash Lead Nuts for instructions on adjusting the assembly.

Continue to rotate the drivetrain through the anti-backlash assembly, keeping the Y carriage about half-way along the Y axis, until the motor reaches its mounting holes in the right-hand gantry support upright.

Repeat this process for the X and Z axes. In each case, do not attach the anti-backlash assembly yet to its respective carriage. For the Z axis, the anti-backlash mechanism is not between the bearing support subframes but the same assembly process applies.

3) Stepper Motor Mounting:

For each axis, align the motor's mounting holes with the corresponding holes in the motor mount, ensuring that the cable from each motor points downwards for the Y and X axes motors and points backwards for the Z axis motor. Using four correct length M3 machine screws for each axis, mount the stepper motors in position.

- The X motor uses 4 x 30mm M3 metric machine screws
- The Y motor uses 4 x 14mm M3 metric machine screws for 10mm laminate.
- Your choice of gantry support upright material will determine the screw length. The required length should be the thickness of the material plus 4mm
- The Z motor uses 4 x 8mm M3 metric machine screws

The screws should be snug, but not overtightened. When tightening the screws, tighten opposite corners in turn, ensuring that the motor is mounted flat against and perpendicular to the gantry support upright. Place the plastic bushing in the X and Y drivetrain hole in the rear chassis frame cross-member and the left-hand gantry support upright respectively. Your assembled Y axis should now look like the one shown in the picture below:

4) Test Your Axes:

Test your axes by rotating the drivetrain (manually or with the Stepper Signal Exerciser) to move the carriages along their rods.

At this stage your DIY Smart Saw (Desktop Version) should be full assembled. Now on the electronics.

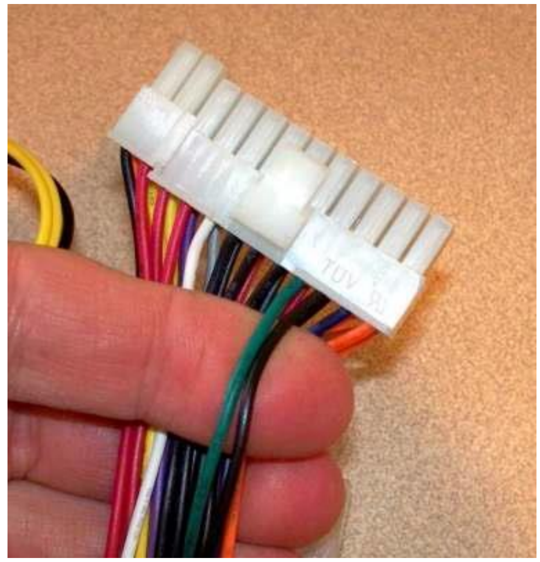
Power Supply and Enclosure:

This section describes how to prepare your power supply, how to attach your enclosure, and how to mount your electronics in preparation for wiring.

1) Modifying and Preparing your Power Supply:

The DIY Smart Saw (Desktop Version) uses a 200W or greater ATX computer power supply. The power supply will need to be modified for non-PC operation and the 5 VDC and 12 VDC power feeds required of the DIY Smart Saw (Desktop Version) will be tapped for use in driving the electronics and motors. The black (ground), red (5 VDC) and yellow (12 VDC) wires will be used and have to be separated from the rest of the harness, which is then tucked back into the power supply case.

WARNING : ELECTRICITY CAN BE DANGEROUS. To begin, make absolutely sure that the power cord is disconnected and that there is no power to the power supply. Failure to do sa may cause irreparable harm to the power supply and may also cause injury. at every step of these instructions, make sure to double-check connections to ensure that they are correct and well insulated.



Make sure that power is disconnected from the power supply by removing the power cord. Remove the four corner screws on the top of the power supply and remove the metal lid, revealing the power supply circuitry.

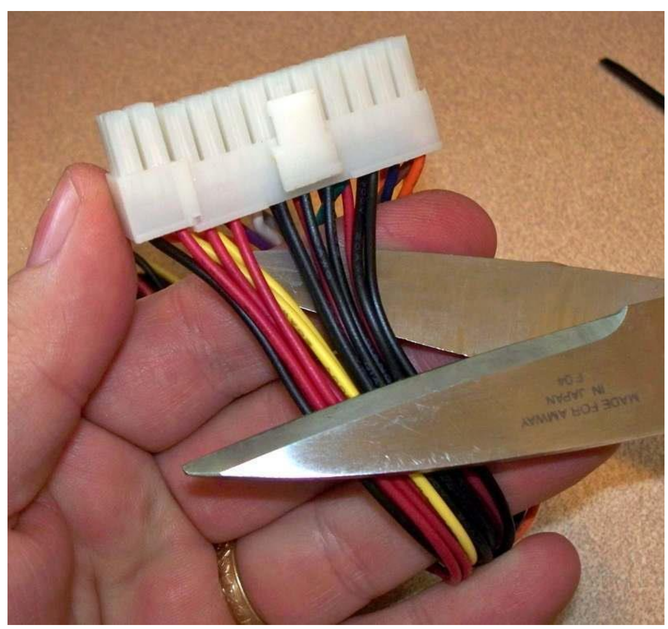
2) Mod for non-PC operation:

Your ATX power supply is usually turned on and off by the PC, but for our application we need it to turn on and off when you use the power switch on the case.

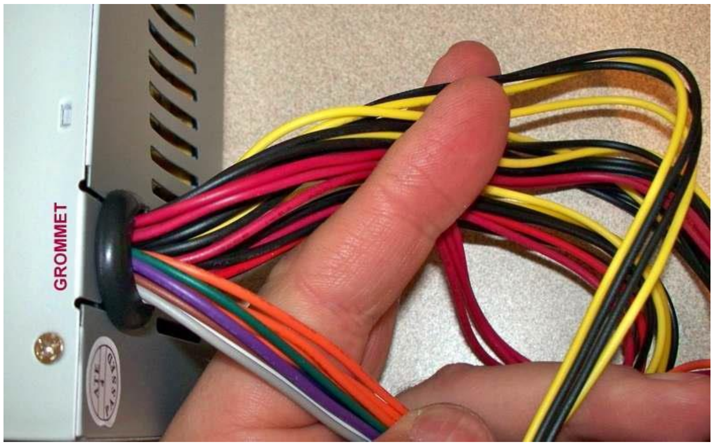
To achieve this find the green wire that goes to the largest connector and cut it and an adjacent black wire close to the connector. Strip back the insulation on both wires and twist them together. Using a wire nut or electrical tape, insulate this splice well as it will be pushed back into the power supply. Test your mod by reconnecting the power supply cord and turning it on. The fan should start indicating that the power supply can now function with the case switch and without a PC. If it works as expected, disconnect power and move to the next step. If not, disconnect power, recheck your connections, and test again.

3) Selecting the Required Power Feeds:

For the DIY Smart Saw (Desktop Version), you will need all of the black, red and yellow wires from the power supply's harness. Separate those wires from the others at the large connector end, and cut them close to the connector as shown. Cut the black, red and yellow wires that go to the disk drive power connectors so that you have the longest possible lengths when you snip off the connectors.



With all of the black, red and yellow wires separated from the harness, remove and open the strain relief grommet located around the wiring harness as it passes through the wall of the power supply (see illustration). Fold all the other unnecessary (nonblack, red or yellow) wires careful back into the power supply case. As long as you have a standard ATX PC power supply, there should be sufficient space to do this.



There should not be any loose wire ends put back into the case. With the exception of the green and black wire splice which you carefully insulated, the remaining wires will still be attached to the connector. If you have any loose wires or if in any doubt about the insulation of those wires, use electrical tape to ensure that no wires are exposed and could potentially short out inside of the power supply case.

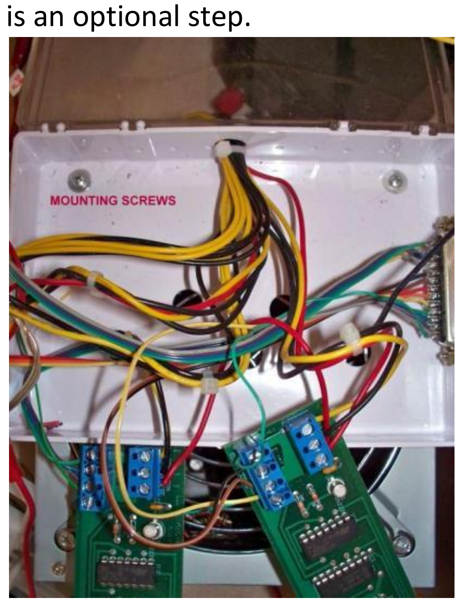
<u>Take care to not interfere with the cooling fan and keep all wires away from heat sinks.</u>

Replace the strain relief grommet around the bundle of black, red and yellow wires, replace it in its slot in the wall of the power supply enclosure, and check that the lid returns to its original position without obstruction. Do not replace the lid screws just yet.

4) Attaching the Electronics Enclosure (optional):

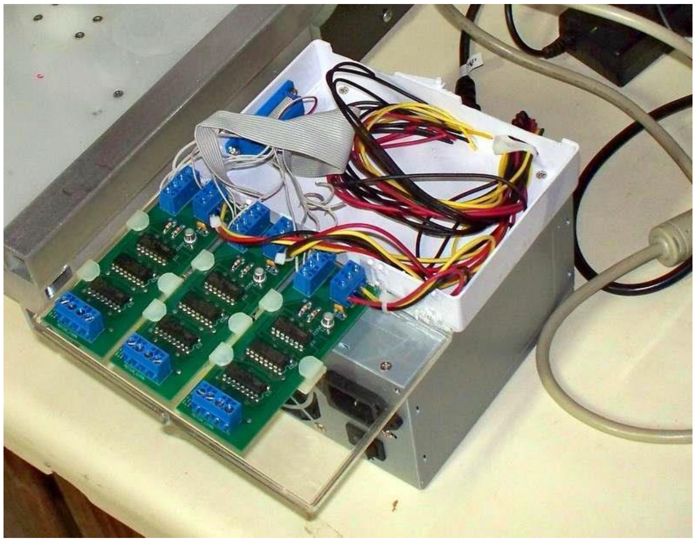
NOTE: Having the enclosure attached to your power supply will remove the possibility of movement in the wiring between the power supply an your electronics causing wires to come undone. It also keeps the distance between the power supply and your electronics as short as possible, and you can move this assembly around as one unit.

Attaching the electronics enclosure to the power supply case is an optional step.



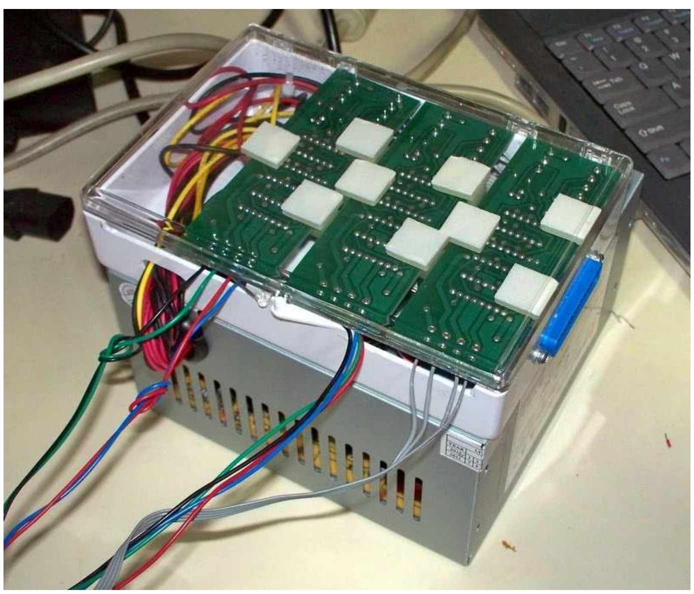
Unless you purchased a DIY Smart Saw (Desktop Version) prepared electronics enclosure you will need to make all the holes required in the case before mounting your enclosure to the power supply. These holes are necessary to locate the panel-mounted DB-25 connector, allow the power supply modified harness to enter the enclosure, and provide access for the motor wires to the connectors on the electronics boards.

Using the power supply lid as a template, mark and drill two holes through the bottom of your enclosure to align with the power supply lid screws. Replace the lid. Use the power supply lid screws to attach the enclosure to the power supply lid and the lid to the supply.



Note that if your power supply has its cooling fan on top, you will either have to drill ventilation holes in the bottom of your enclosure to allow for air flow, or consider not mounting your enclosure to that type of power supply. Note the ventilation holes in the example picture which shows a top-fan- mounted PC power supply.

The electronics boards are designed to be mounted in the enclosure using PCB edge standoffs. If using the DIY Smart Saw (Desktop Version) enclosure, the electronics boards are mounted to the lid of the enclosure as shown. This allows for greater access to the boards and wiring. You may choose to mount them otherwise if preferred.



Do a “dry-run” check before adhering the PCB edge standoffs to the lid, or enclosure.

Mount the electronics boards in the edge standoffs without removing the backing tape from the adhesive pads, and position them as desired. Once you are satisfied with their location, access and routing for the wiring, and access for removing the boards later should there be a need to do so, remove the backing tape and stick them in position.

At this stage your power supply should be ready for use with your DIY Smart Saw (Desktop Version).

Wiring Motors and Limit Switches:

There are two major wiring stages to setting up your DIY Smart Saw (Desktop Version); wiring the stepper motors and axes limit switches, and wiring of the electronics to the Power Supply and PC.

1) Stepper Motor Wiring:

Refer to the DIY Smart Saw (Desktop Version) master wiring diagram in the Appendices at the end of this manual.

DIY Smart Saw (Desktop Version)

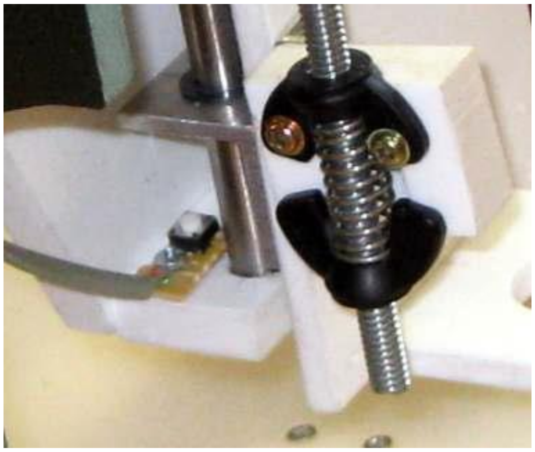
Reading from left to right, the colors should be blue, red, green and black, in that order.

Should you wish to connect other Stepper Motors, refer to the section Stepper Motor Upgrades for details on determining the correct connections for other stepper motors.

2) Limit Switches (optional):

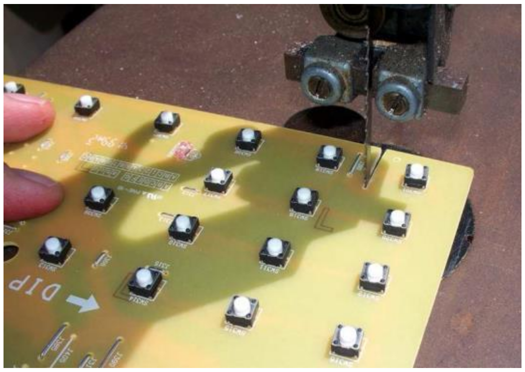
Limit switches are considered optional because most good CAM software applications provide for the specification of the table size and axes limits in its configuration. With proper configuration, your CNC application should not drive your axes further than their travel limits.

However, should a mistake be made in that configuration, or should the origin of the workspace (the point where the coordinates for the X, Y and Z axes are all 0) get reset to a position other than the true table origin point, then the CNC application could continue to drive the axis even though it has reached the end of its travel. If this should happen your DIY Smart Saw (Desktop Version) could be damaged. The drivetrain couplings should prevent serious damage, but at the very least they will be destroyed in the process.

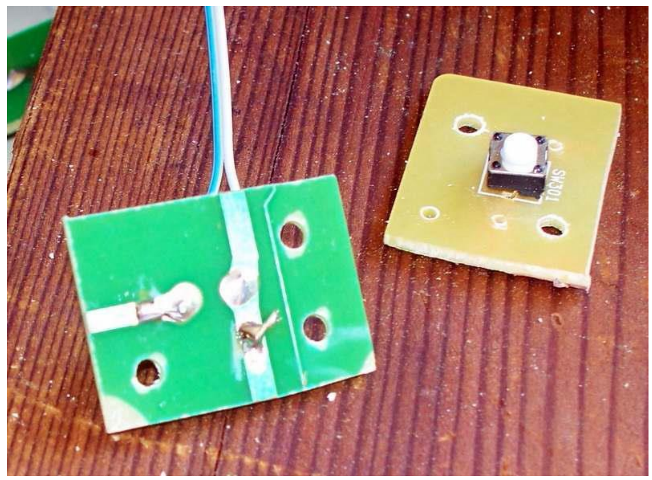


To prevent this from happening, your DIY Smart Saw (Desktop Version) can be outfitted with a limit switch at the end of each axis. Should the carriage travel to the end of its axis, the switch would be pressed, signaling that the end limit of the axis had been reached, and the DIY Smart Saw (Desktop Version) would be shut down by the CAM application before any damage could occur.

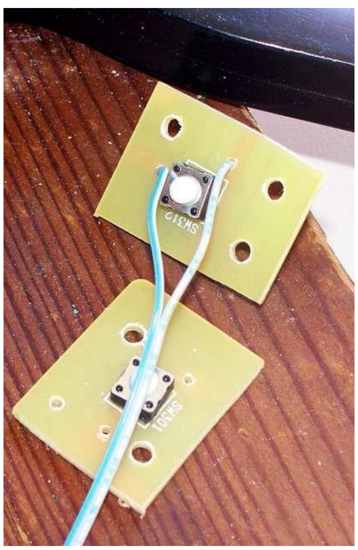
DIY Limit Switches



Any normally-open momentary switch can be located at the end of your axis' travel to become a limit switch. Probably the simplest way to make a set of limit switches is to use the button panel from a recycled piece of electronic equipment (as shown), such as a fax machine or a multifunction printer that uses a button panel.



These panels can be cut into smaller PCBs around the switches and the PCB tracks can be scraped back to expose a solder-able pad. Drill a small hole, about 1/16” through the top of the PCB into the track, and on the reverse side of the PCB, scrape back some exposed track to which to solder your wires. Push the tinned ends of your wires through the small hole, bend them over the exposed track and solder them in place. When cutting up the large panel PCB, be sure to leave enough PCB around the button to drill a mounting hole.



Alternatively, homemade limit switches can be made from push button switches and prototyping circuit board. Simply solder the switch to the PCB, solder the wires to the switch terminals, and drill a suitable mounting hole through the board. In the illustration, telephone cord is used and hot melt glue secures the cable to the board.

Wiring Limit Switches

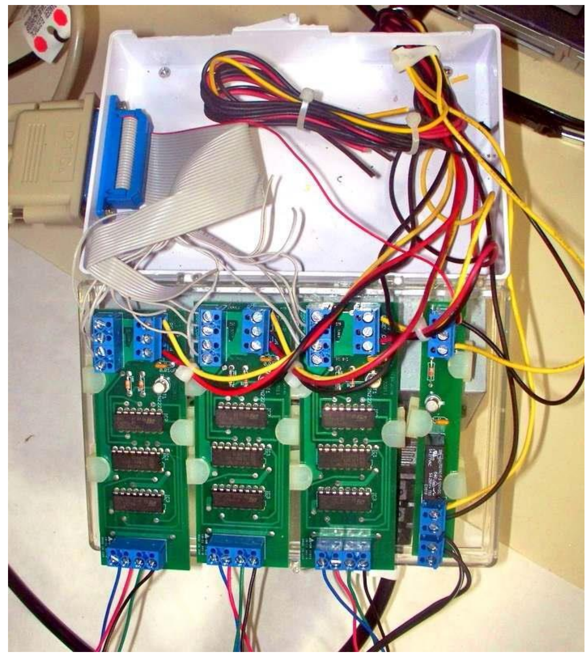
The limit switches for each axis are wired in parallel between ground and the input line for that axis on the parallel port. In this way, should either of the switches for an axis be pressed, the circuit will be closed and the limit emergency stop triggered.

Electronic Wiring:

This is probably the most complex of the wiring tasks for your DIY Smart Saw (Desktop Version).

1) Connecting a DB-25 male Connector:

For connecting to a PC parallel port, the DIY Smart Saw (Desktop Version) uses a male 25-pin D-type sub-miniature panel-mounted connector. These come in two major forms, as shown in the illustration below. They are; a less expensive connector with sockets in the back of the pins to which wires can be inserted and soldered individually, and a more-expensive ribbon cable version which can be crimped to a section of 25-way ribbon cable. The former requires that each of the 25 connections be individually soldered, while the latter version automatically connects the ribbon cores to the pins.



2) Wiring the PC Parallel Port Connector:

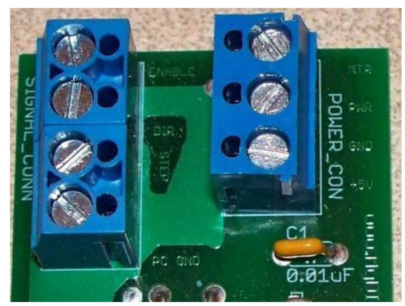
In both cases the pins, as numbered in the D-sub 25 connector, must connect to the correct connection on the electronics modules. The Wiring Diagram Appendix shows these connections. For the solder type connector, connect each individual pin to its corresponding connector on the electronics modules. For the ribbon cable, each strand of the cable connects to an individual pin on the D-sub 25 connector, but as indicated in the diagram, these strands are not numbered in sequence. When connecting the ribbon cable to the electronics, be careful to note the pin number for each strand before connecting to the electronics.

Each core in the ribbon cable can be peeled back as an individual wire. To do so, use a scissors or small side-cutters (snips) to nick the cable in between the cores to allow it to start tearing, and then peel back the individual core from the initial tear. Strip the end of the wire and tin it with solder.

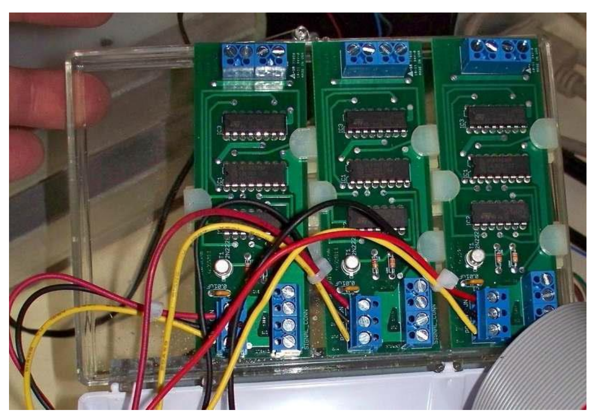
Once you have wired up the electronics modules as indicated in the Wiring Diagram, double check your connections before connecting to your PC. Using M3 metric screws and nuts, connect the D-sub 25 connector to the hole provided in the side of the DIY Smart Saw (Desktop Version) enclosure or to the hole you made for it in your own enclosure.

TIP: Tinning is very important as the ribbon cable cores are thin stranded wires and will not make good contact in the screw clamp connectors without the thickness of the additional solder.

Power Connections:



The power sources from the PC power supply you modified earlier connect to the electronics modules as indicated in the Wiring Diagram Appendix. Note that the ground (black) and 5 VDC (red) wires will always be connected as shown, regardless of what stepper motor is used. The DIY Smart Saw (Desktop Version) Stepper Driver Modules have labels on the board, as shown in the illustration, indicating the purpose of each connection. The DIY Smart Saw (Desktop Version) stepper motors use 12 VDC and therefore the 12 VDC (yellow) wires are connected to the motor power connector (MTR) on the DIY Smart Saw (Desktop Version) Stepper Driver Module.



The module can drive bipolar stepper motors rated from 3 VDC to 36 VDC so to use other stepper motors, the appropriate DC voltage source needs to be connected to this motor power terminal on the DIY Smart Saw (Desktop Version) Stepper Driver Module. Details about connecting other stepper motors are provided in the Chapter *Expanding Your* DIY Smart Saw (Desktop Version).

Chapter III : Configuring Your PC And CNC App

Your DIY Smart Saw (Desktop Version) is controlled by a CNC application that can process g-code (CNC instructions script) into a series of pulses that are used to control your machine connected to an output port (such as a parallel or USB port). Typically the g-code is generated by a Computer Aided Design (CAD) or Computer Aided Manufacturing (CAM) application that allows for the creation of a 2D or 3D design which can then be described by a g-code script. The CAD/CAM application saves the g-code for the design to an ASCII text file that can then be imported and processed by the CNC application.

The following CNC applications are recommended for controlling your DIY Smart Saw (Desktop Version). They are chosen to represent a range of operating systems and levels of sophistication, as well as varying costs to suit the user's budget. They all offer an ability to at least evaluate them for no initial cost.

Application	Website	Required OS	Interfaced Used	Free Trial?	Cost of Full App
KCam	www.kellyware.com	Win 98 Win XP	Parallel Port	Yes, limited time and then feature restrictions	US $105
EMC2	www.linuxcnc.org	Ubuntu (Linux)	Parallel Port Serial Port	Yes	Free
TurboCNC	www.dakeng.com	DOS or DOS-based Windows (Win 3.1, 95, 98)	Parallel Port	Yes	US $60
Mach3	www.machsupport.com	32-bit Windows (2000 or later)	Parallel Port Serial Port	Yes, limited to 500 Lines of g-code	US $175

General Setup:

This instruction manual will provide you with the details required to configure your CNC application to work with the DIY Smart Saw (Desktop Version) . There are many step-by-step setup tutorials and guides for each of these third-party software applications.

DIY Smart Saw (Desktop Version) Software Configuration Parameters:

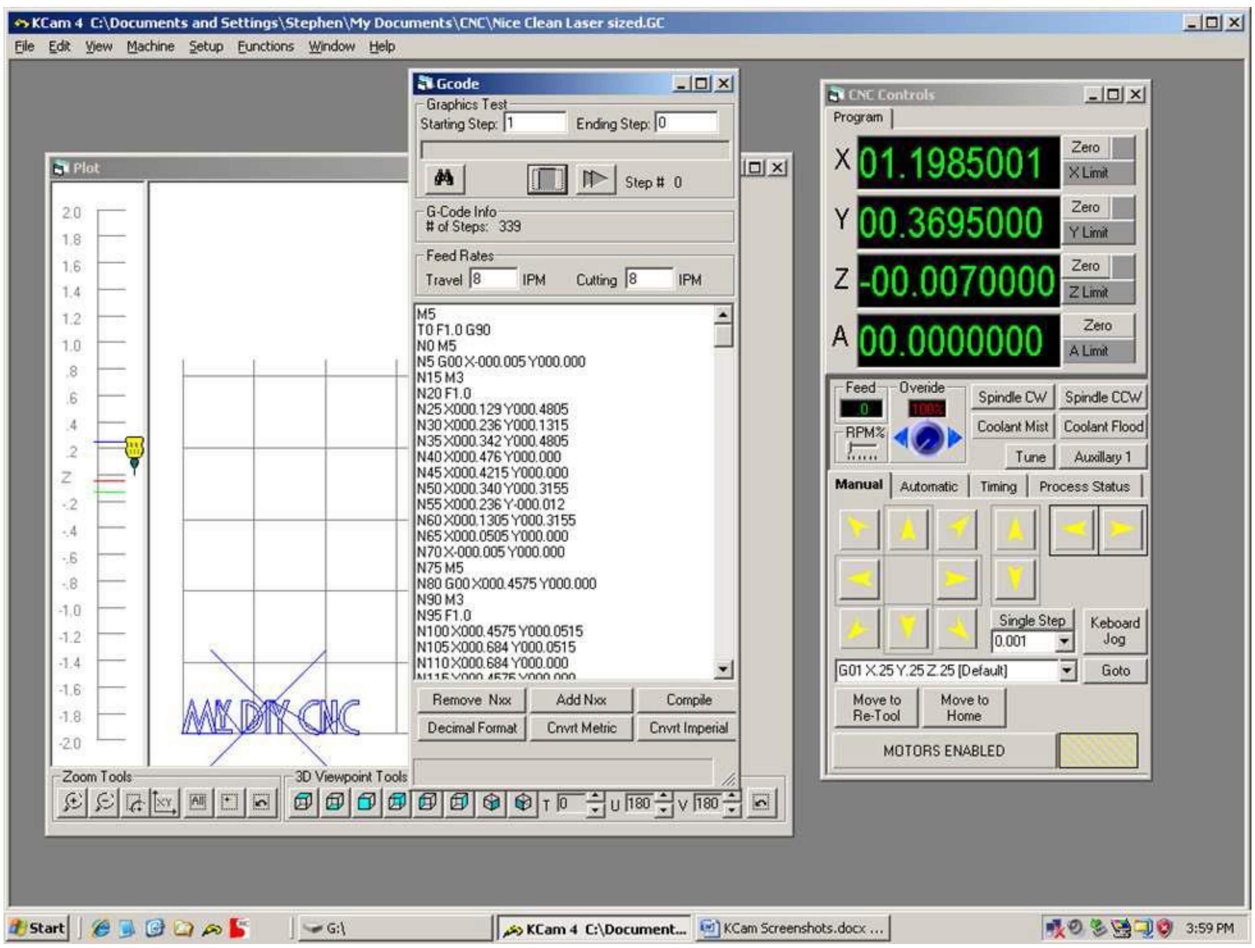
Table Dimensions	7 ¾" (197mm) x 11" (280mm)
Table Travel	9 ½" (241mm) Modifiable to max 15" (381mm)
Working Height Clearance	3" (76mm)
Max Spindle Height	5" (127mm)
Y axis travel	6" (152mm)
Z axis travel	4" (102mm)
Step Resolution	0.001" (0.0254mm)
Steps Per Revolution	50
Step Degrees	7.2
Distance per Step	0.001" (0.0254mm)
Step System	Full Step
Enable Required per Motor	Yes

The following sections provide specific settings for particular applications. Use the above general settings, along with the application's own tutorial and the software-specific information provided below, to configure your DIY Smart Saw (Desktop Version).

KCam (Windows XP/98):

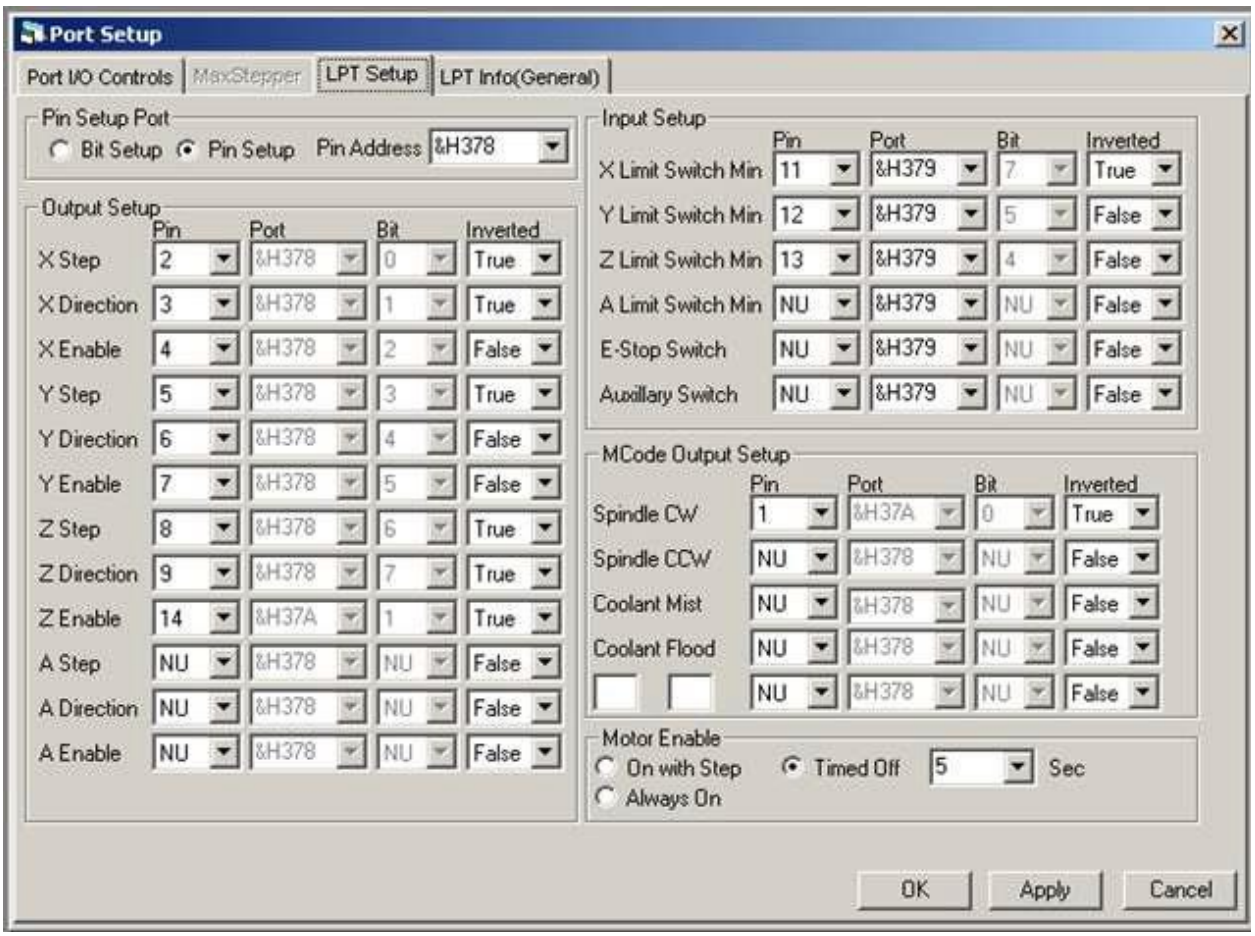
KCam is an excellent CNC application, and it performs very well with the DIY Smart Saw (Desktop Version).

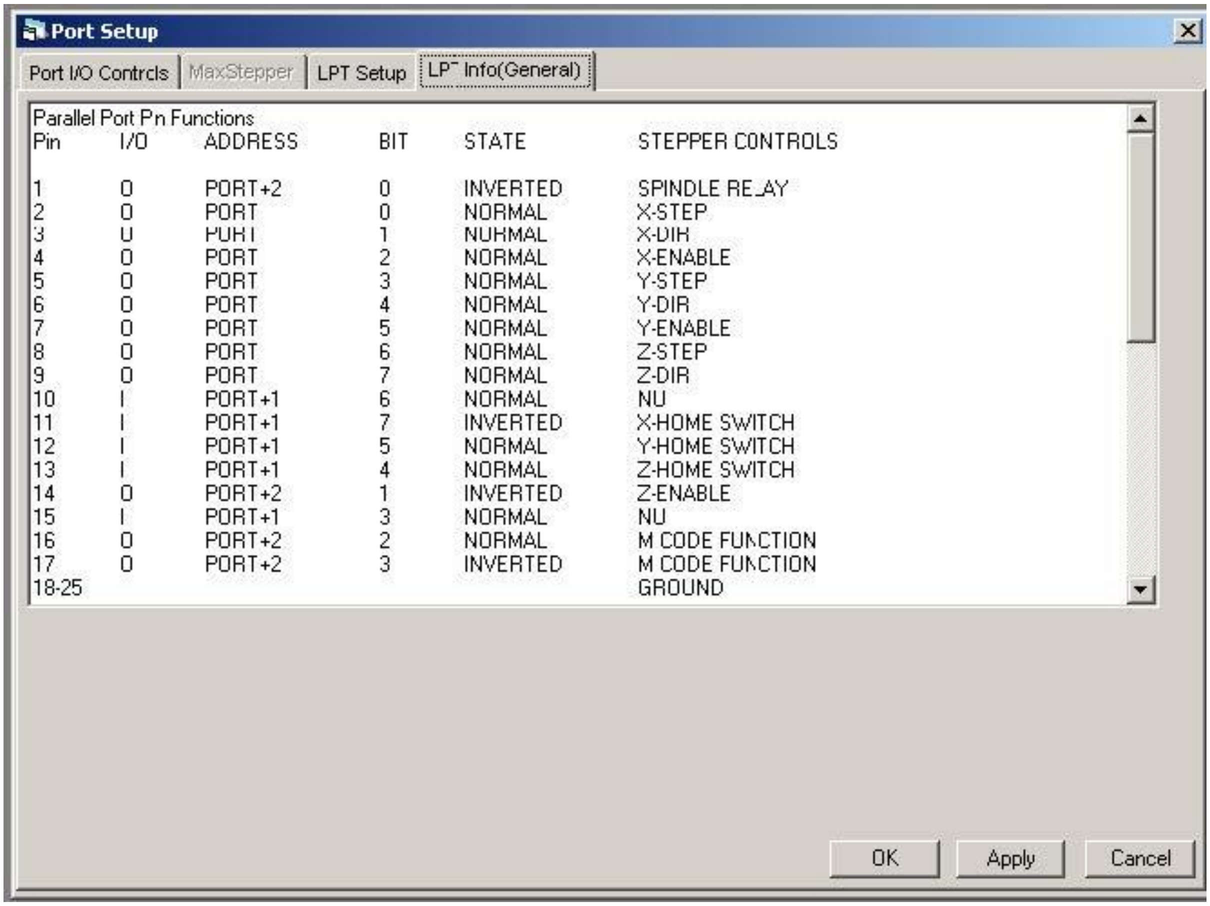
Use the following screenshots and notes to configure KCam to drive your DIY Smart Saw (Desktop Version).



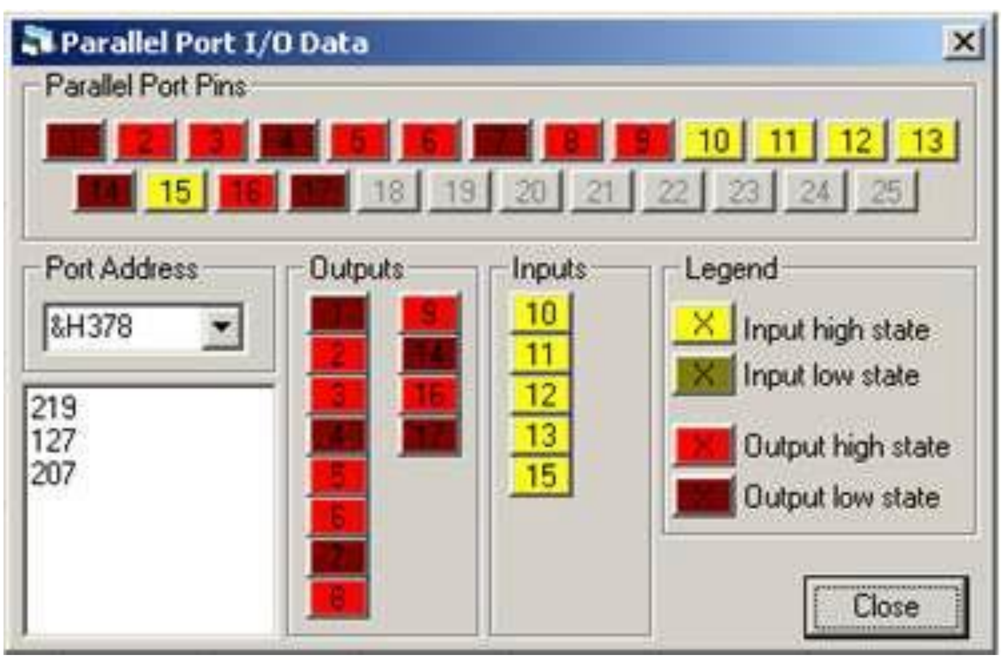
KCam interface screen, showing the Plot table, G-code and CNC Controls windows.

To configure KCam, ensure that your parallel port configuration matches the parallel port wiring to your electronics. The following screens show the standard KCam parallel port configurations. They match the DIY Smart Saw (Desktop Version) wiring diagrams and instructions. Use this screenshot and the DIY Smart Saw (Desktop Version) wiring diagrams to troubleshoot connection problems with KCam.

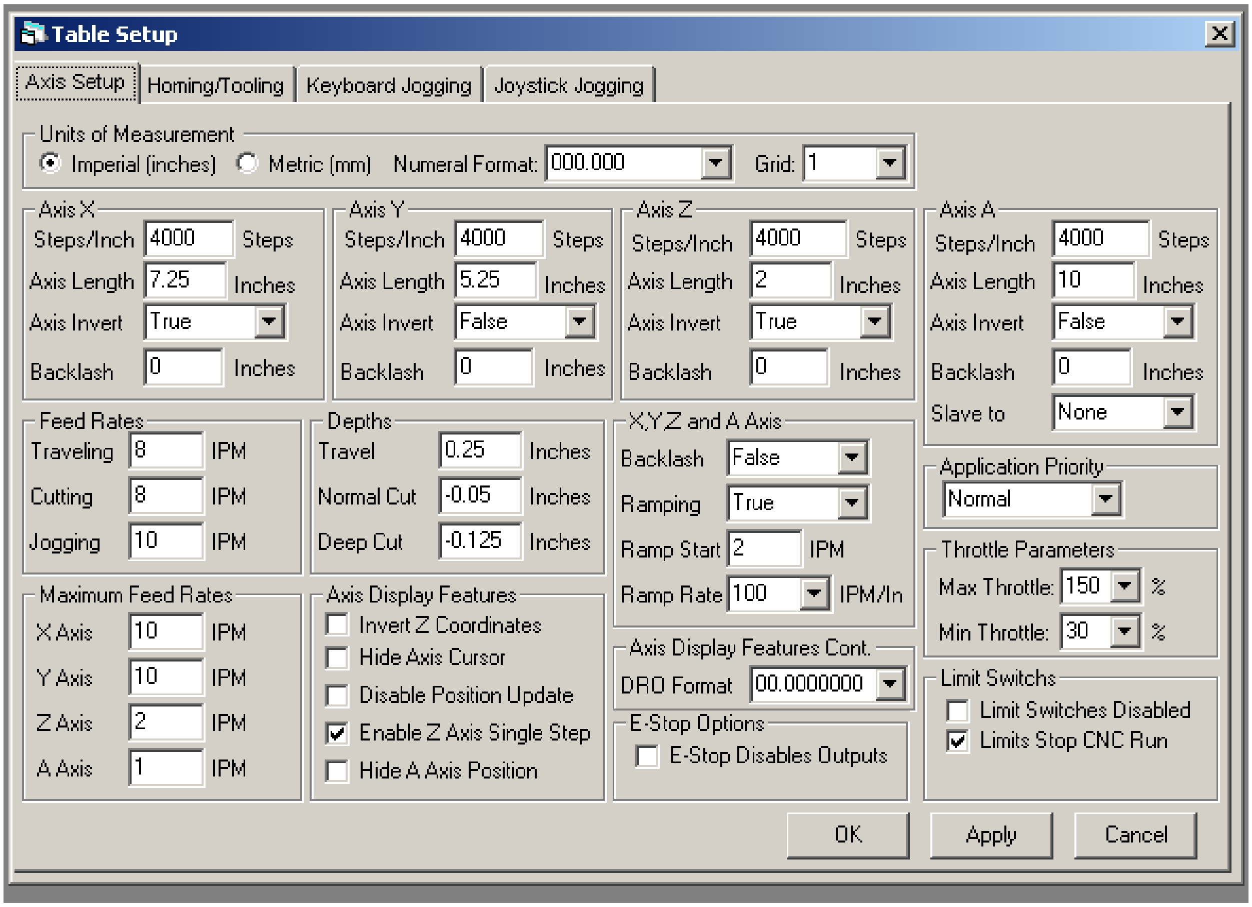




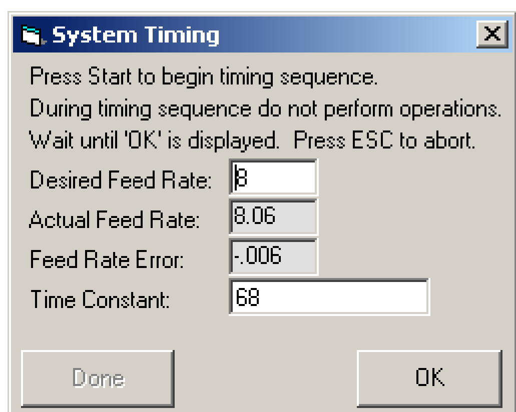
Once this configuration is set up correctly, use the Parallel Port I/O Data screen to monitor the parallel port channels. See that they correspond to your use of the CNC manual controls.



Probably the most important setup screen in KCam is the Table Setup screen. Use the parameters shown to configure your installation of KCam to your DIY Smart Saw (Desktop Version).

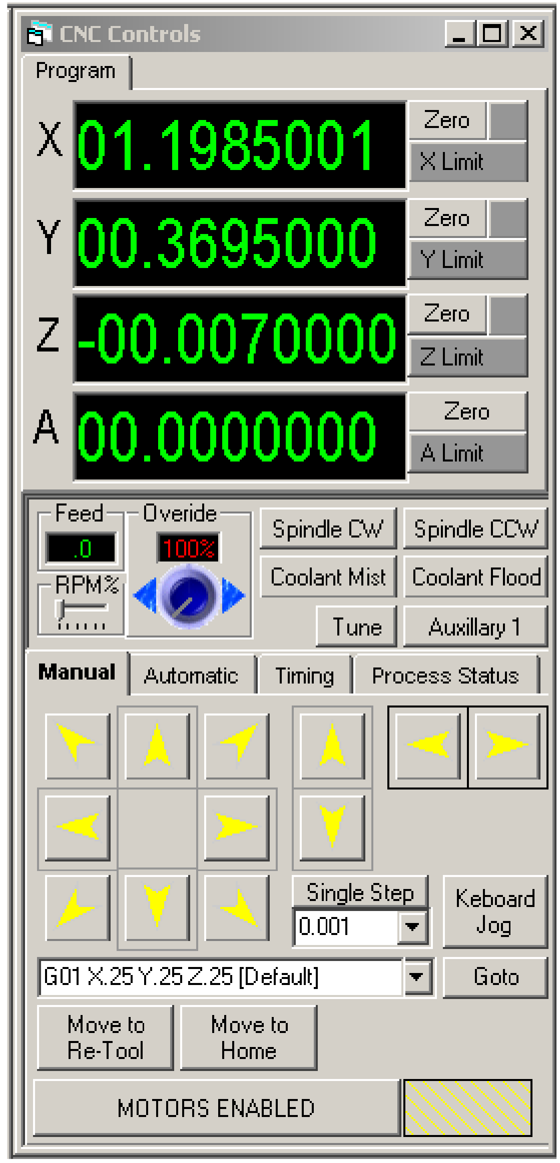


Note: Even though your DIY Smart Saw (Desktop Version) is a 1000-step-per-inch machine, KCam requiers a value of 4000 steps/inch to apply the correct scale to your DIY Smart Saw (Desktop Version).



Once your parameters are entered into KCam, perform a System Timing check (under Setup). This test will provide KCam with performance data on your PC which will allow it to optimize the communications with your DIY Smart Saw (Desktop Version).

Now that you have configured your DIY Smart Saw (Desktop Version) parameters in KCam, it's time to test its operation.



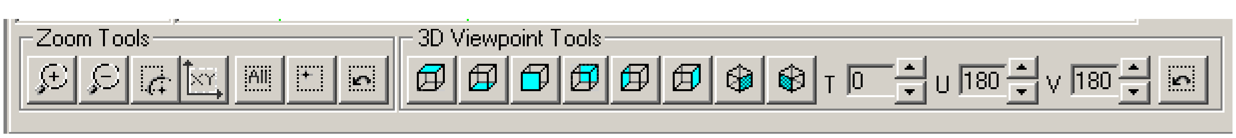
Use the CNC Controls window to jog the DIY Smart Saw (Desktop Version)'s axes back and forth.

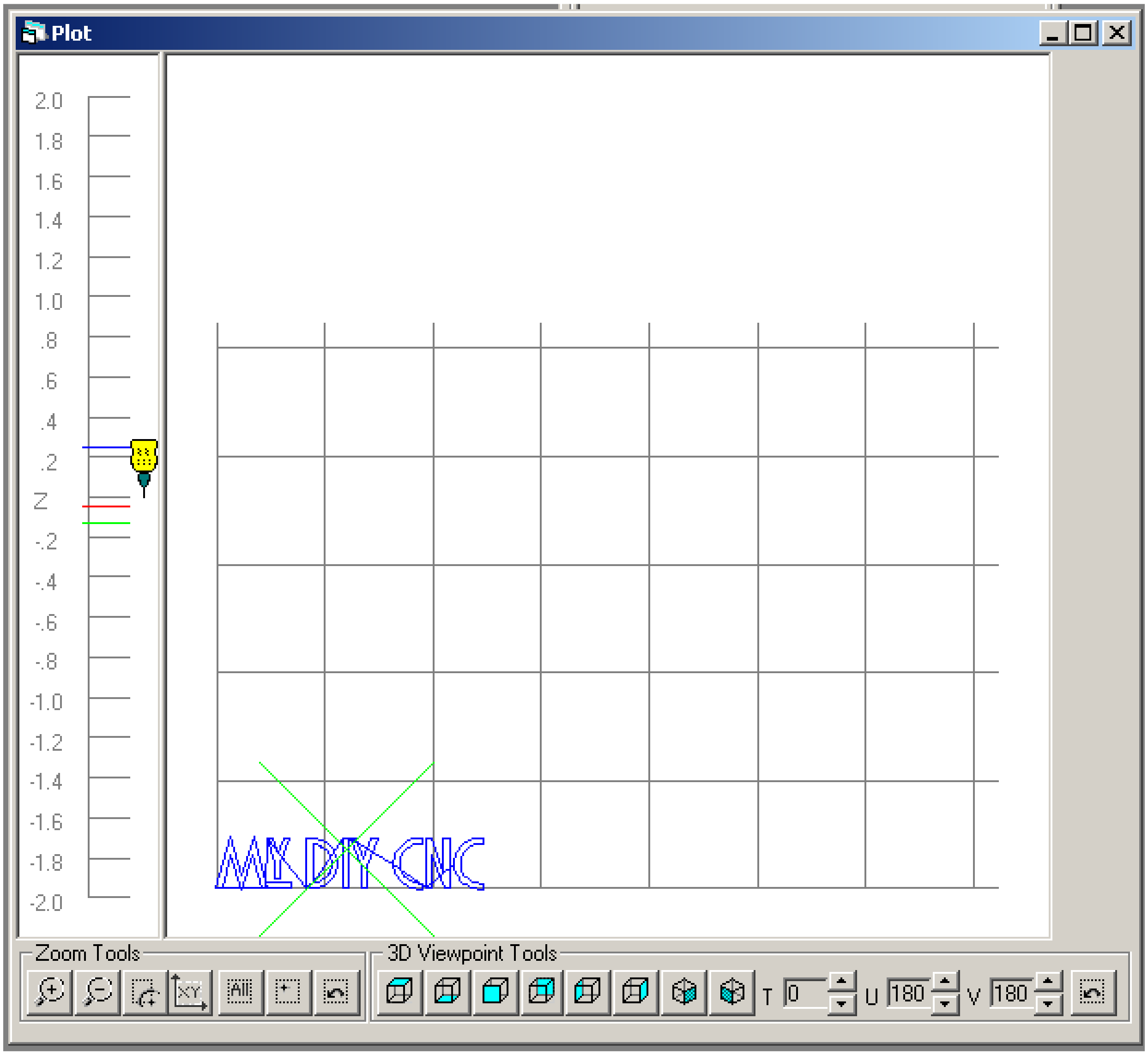
If you have limit switches installed, they should halt all operations when clicked and the button at the bottom of the CNC Controls screen will display MOTORS DISABLED against a red background.

Check what caused the issue. The limit button to the right of the axes coordinates display will be highlighted to indicate which axis triggered the limit switch. You should jog the offending carriage away click the red MOTORS DISABLED button to re-enable the motors.

Once configured and tested, load a g-code file into KCam and see how it plots on the Plot window. Use the Scale g-code and Offset g-code options (under Functions) to size and position the work within the limits of the DIY DIY Smart Saw (Desktop Version)'s table. The plot should display on the table diagram and give a good indication as to where it will be located on DIY Smart Saw (Desktop Version).

Use the zoom, pan, and view buttons at the bottom of the plot window to get the best view of your work as shown on the plot screen.





You should now be configured with KCam. However, take some time to learn this application and become proficient with it. You'll find its rich feature set very useful in your projects.

EMC2 (Linux):

EMC2 is a Linux CNC application. To be precise, it runs on Ubuntu, which is a very nice operating system. If you have had any trepidation about delving into Linux, you'll find Ubuntu very easy to use and feature rich. What better excuse to learn about Linux than while learning the ropes for EMC2?

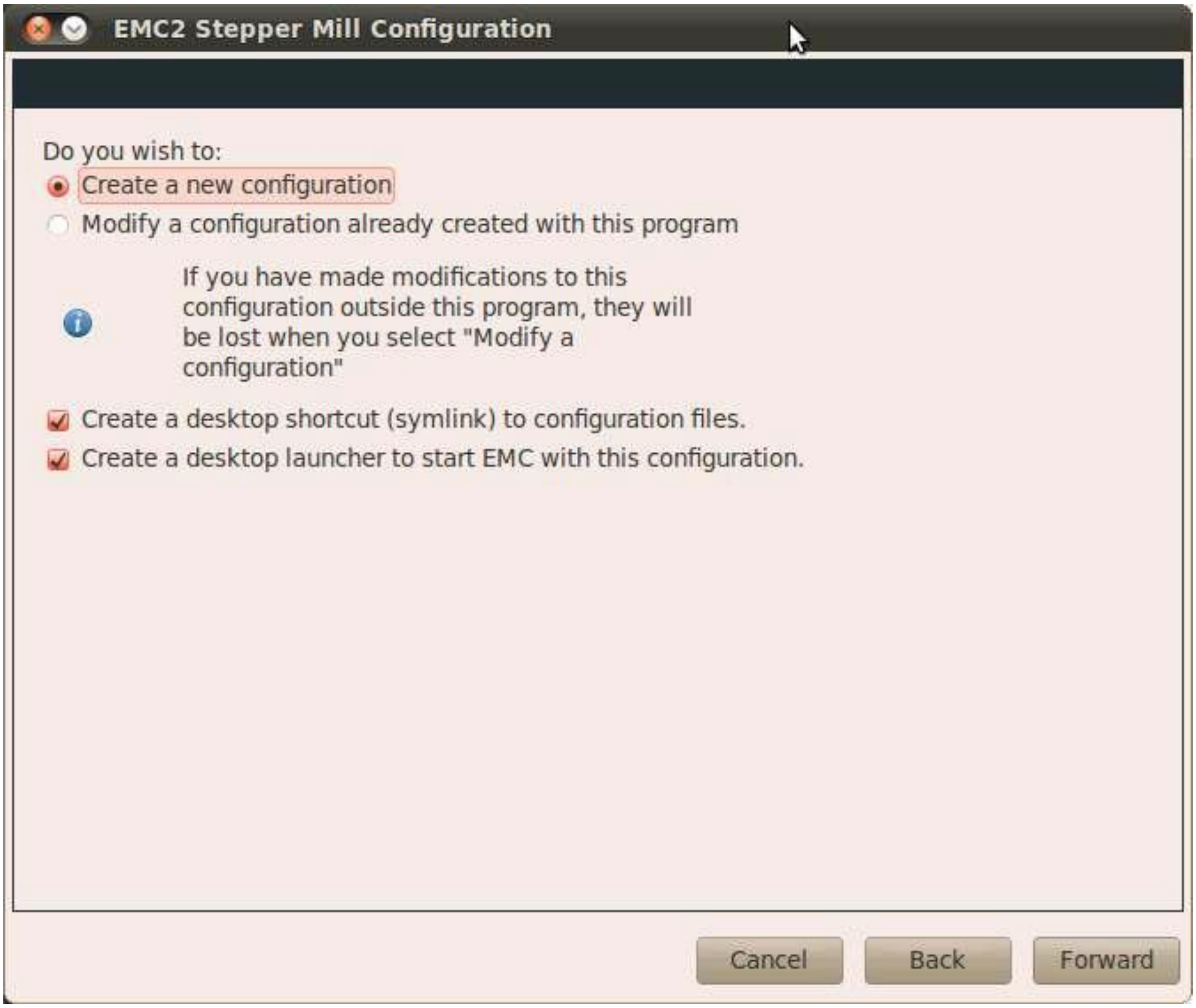
The folks at LinuxCNC.org provide you with a CD-ROM image that, once burned to disk, gives you a boot disk that will run Ubuntu without modifying your existing PC or its operating system. So if you're a Windows user you simply boot off the CD-ROM and your PC becomes an Ubuntu box with EMC2 already installed for you. Once you're done, shut down, remove the boot CDROM, and you're back to your original Windows PC without any modifications. This makes it very easy to try EMC2.

There are many great tutorials about setting up EMC2. EMC2 is configured using a utility called the StepConf Wizard. These instructions will walk you through configuring EMC2 using StepConf to run your DIY Smart Saw (Desktop Version).

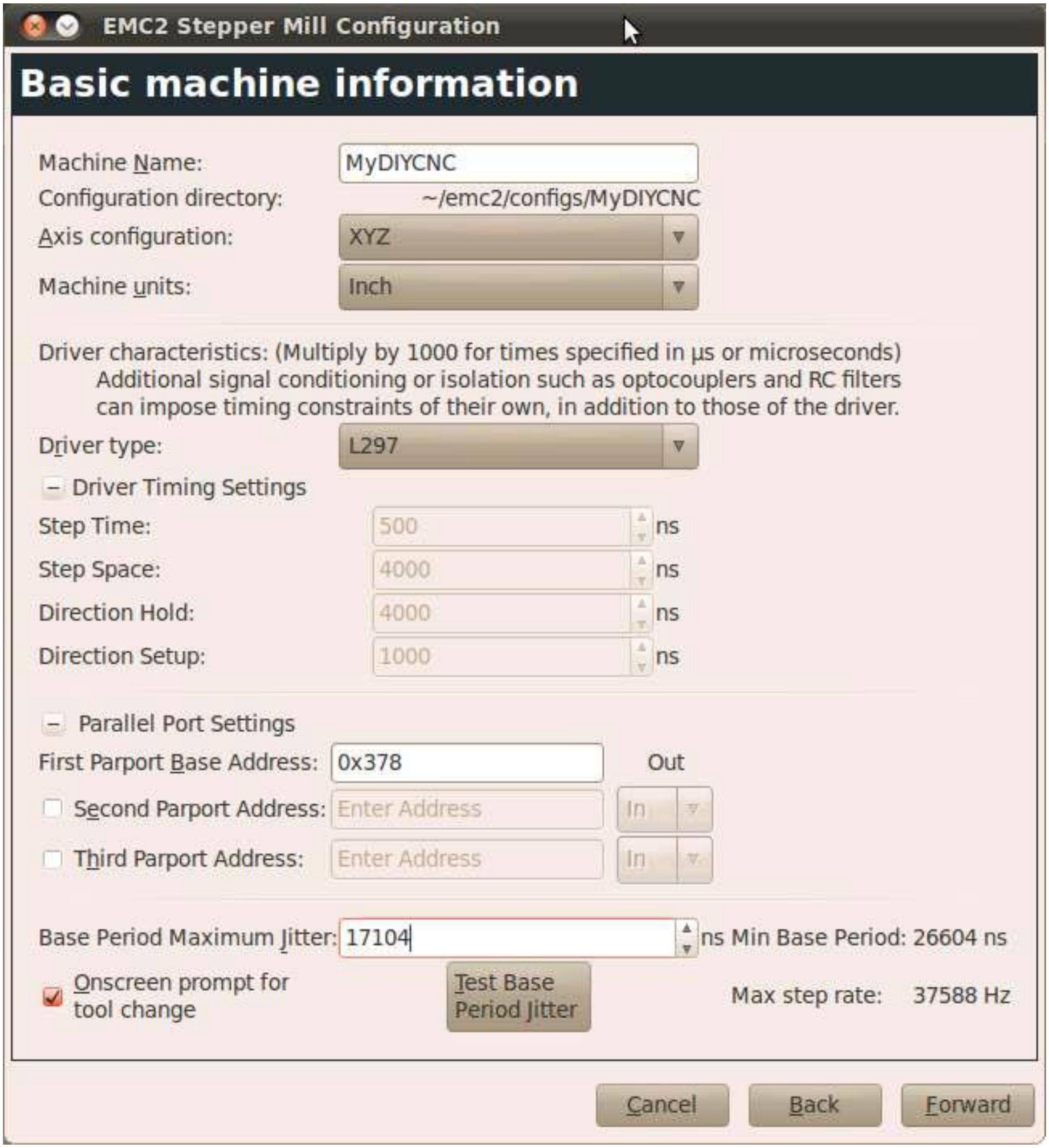
Be sure to read the EMC2 Getting Starded manual at www.linuxcnc.org/docs/EMC2_Getting _Started.pdf It's a good idea to print it out and refer to it as you set up your DIY Smart Saw (Desktop Version). It will provide a wealth of additional information regarding the setup of EMC2 on your PC.

Use the following screenshots and notes to configure EMC2 to drive your DIY Smart Saw (Desktop Version).

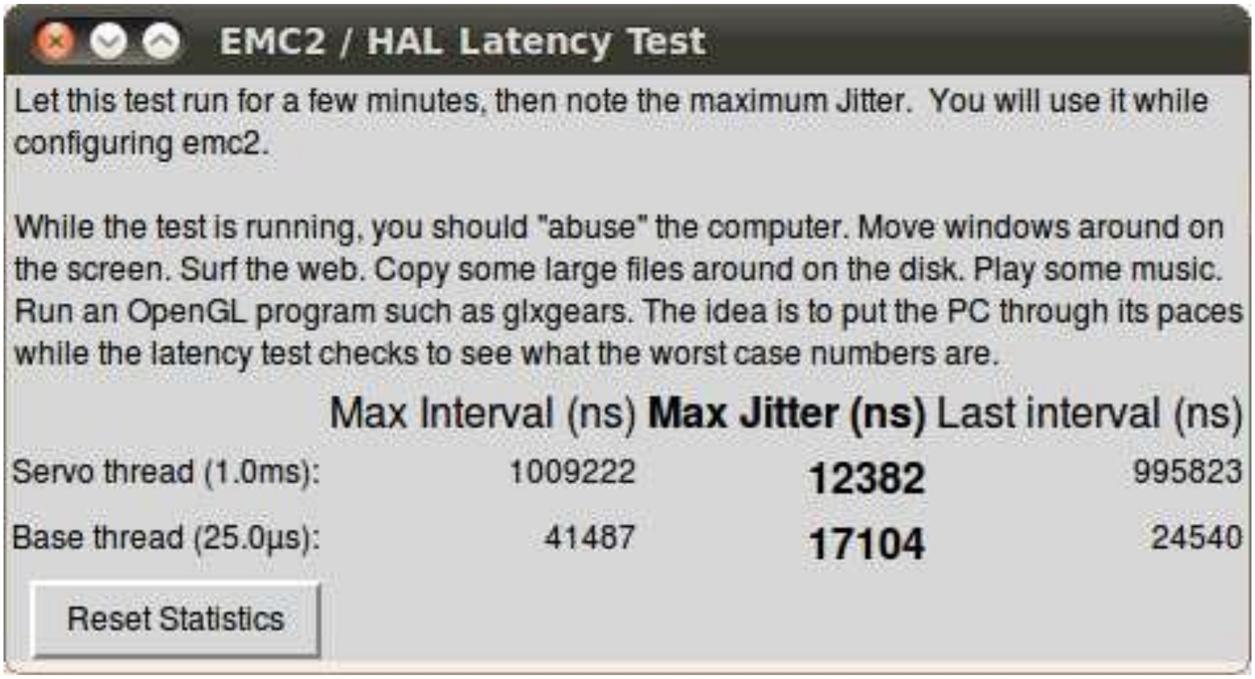
Launch the StepConf Wizard. You'll find it under the CNC applications group. Take note of the information given in each screen as you progress from screen to screen. Click the Forward button.



You are creating a new configuration file for your DIY Smart Saw (Desktop Version). Should you want to modify this configuration later, you would select the "Modify a configuration already created with this program" option and load your .conf file to review and edit.



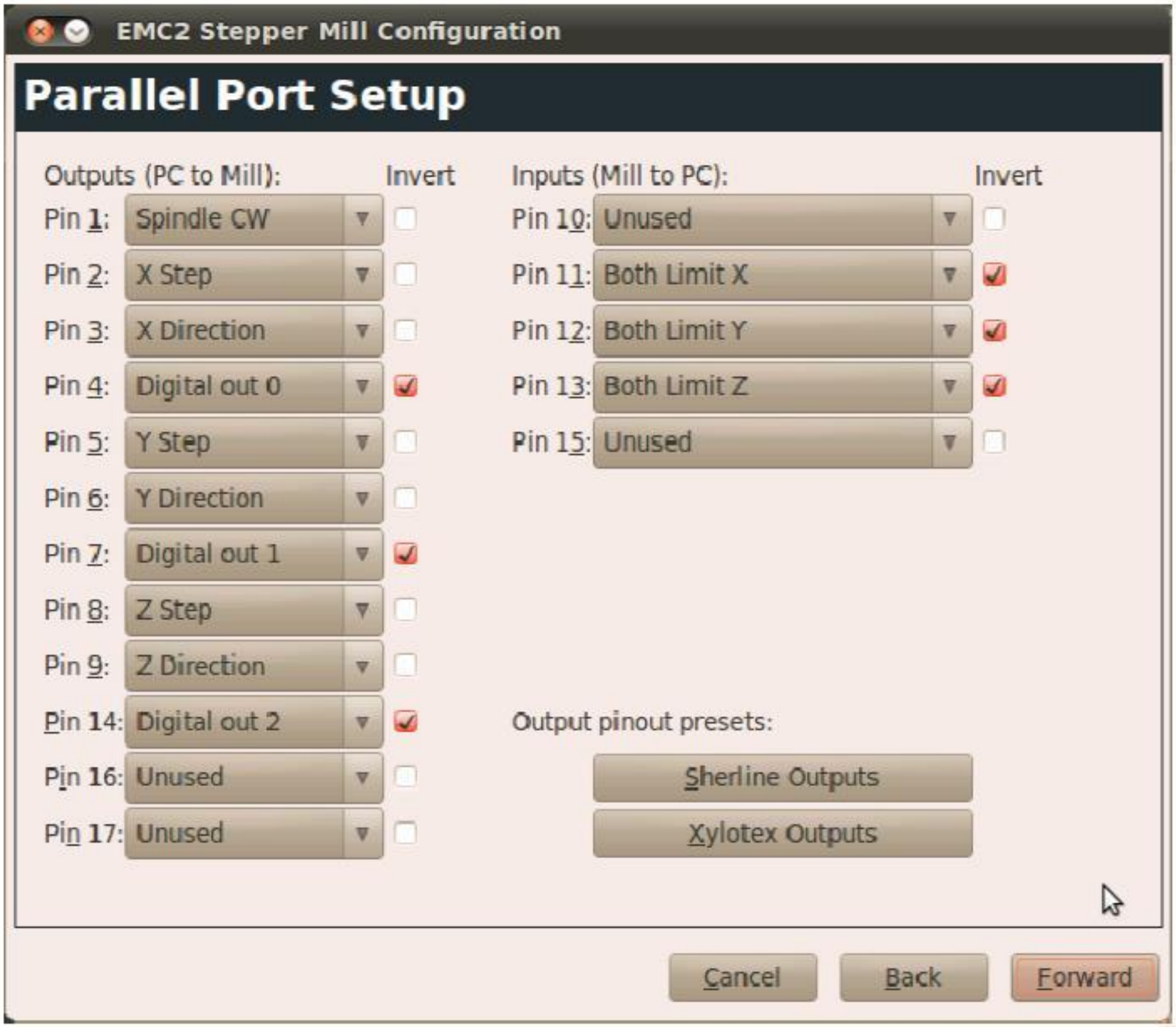
Enter the settings seen above in the Basic Machine Information screen. The value for Base Period Maximum Jitter is found by clicking the Test Base Period Jitter button, which evokes the Latency Test application. Once it has settled down (give it 5-10 minutes) closing this dialog box will insert the test result values into the appropriate Basic Machine Information fields.



The Latency Test application at work

The next step is the parallel port setup. Here you'll let EMC2 know what channels on the parallel port are used for what aspect of the DIY Smart Saw (Desktop Version). Enter the same values into your Parallel Port Setup window as seen below in this illustration.

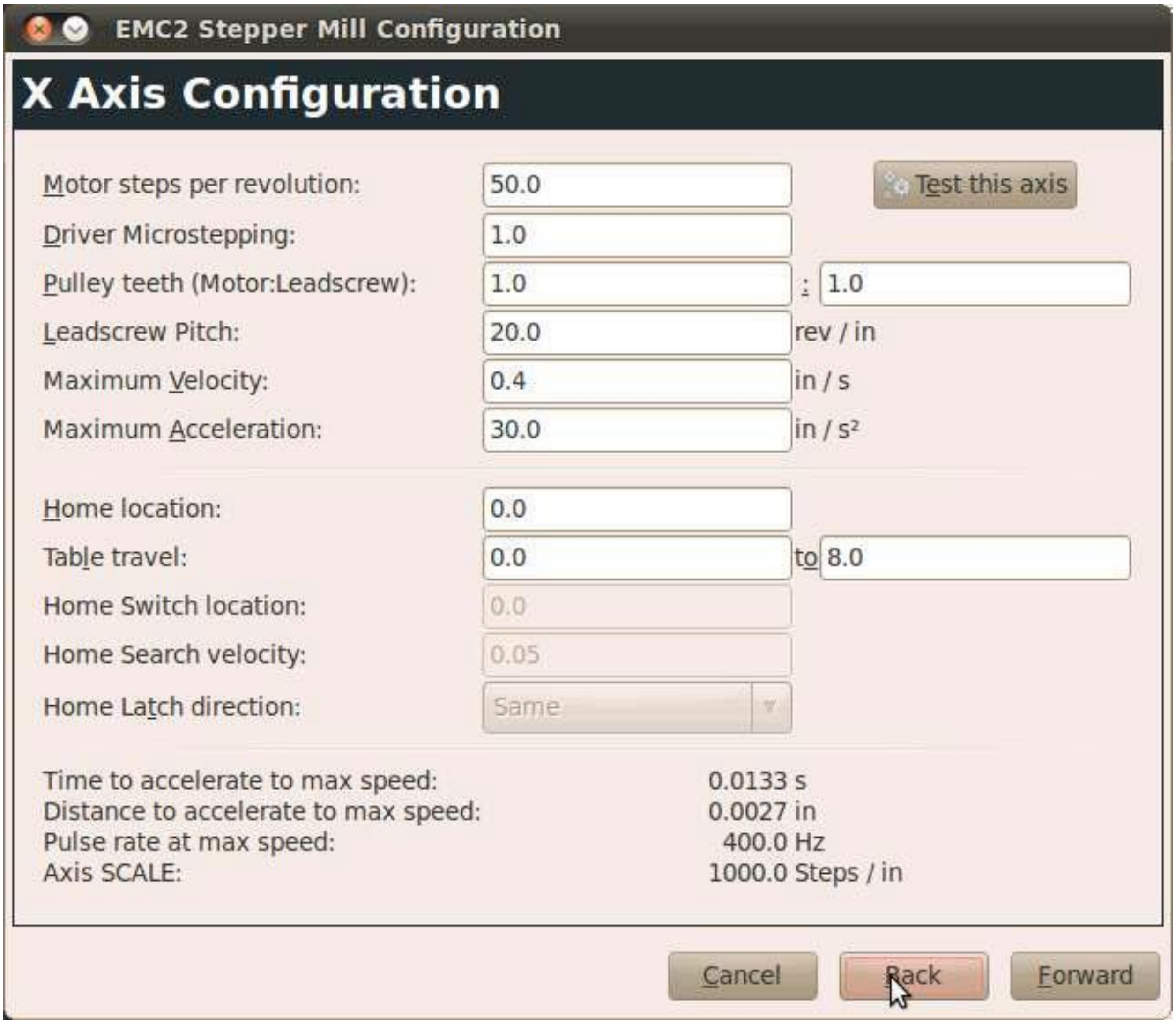
WARNING: Your DIY Smart Saw (Desktop Version) Stepper Driver Modules use step, direction and enable signals to control your DIY Smart Saw (Desktop Version) stepper motors. However EMC2 can only provide step and direction signals. The electronics require an "on" enable signal to function. For the electronics to receive an enable signal EMC2 must be configured to send an "on" signal out the appropiate port for wach axis, but it can only do so all the time rather than on demand. The net results is that the electronics are constantly enabled (as opposed to whenever they need to be in motion). This "always on" condition can cause the motor drivers to get quite hot. While they still stay within operating temperatures, when using EMC2 it will be necessary to run the DIY Smart Saw (Desktop Version) with the electronics enclosure opne to prevent heat buildup.



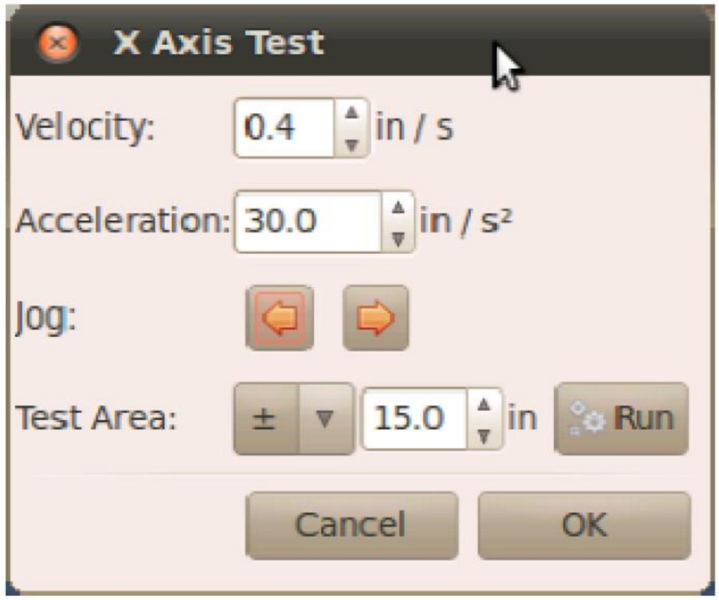
Note the pseudo-enable signals set for pins 4, 7 and 14

If you are using the optional limit switches, be sure to invert the signals on channels 11, 12 and 13 to accommodate the normally-open switches used in the DIY Smart Saw (Desktop Version) Limit Switch Modules. If you are not using limit switches, then make sure that pins 11, 12 and 13 are set as “Unused”.

Next, you will set up each axis’ parameters. For each axis use the “Test This Axis” button to jog the axis. This will confirm that you are configuring the correct axis on your DIY Smart Saw (Desktop Version) that EMC2 can control your axis and your step and direction connections are correct.



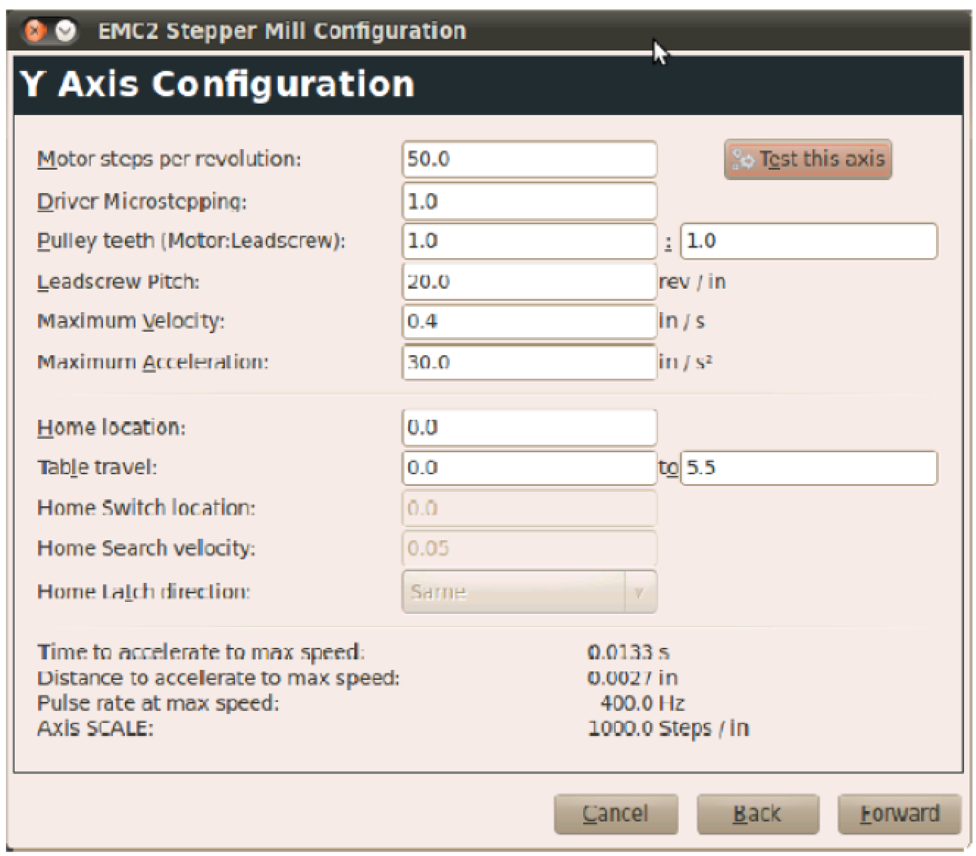
The axes settings shown should work fine for your DIY Smart Saw (Desktop Version) installation. However you should always use the "Test this axis" button to check the settings, and if necessary for your particular system, adjust for a more optimal setting.

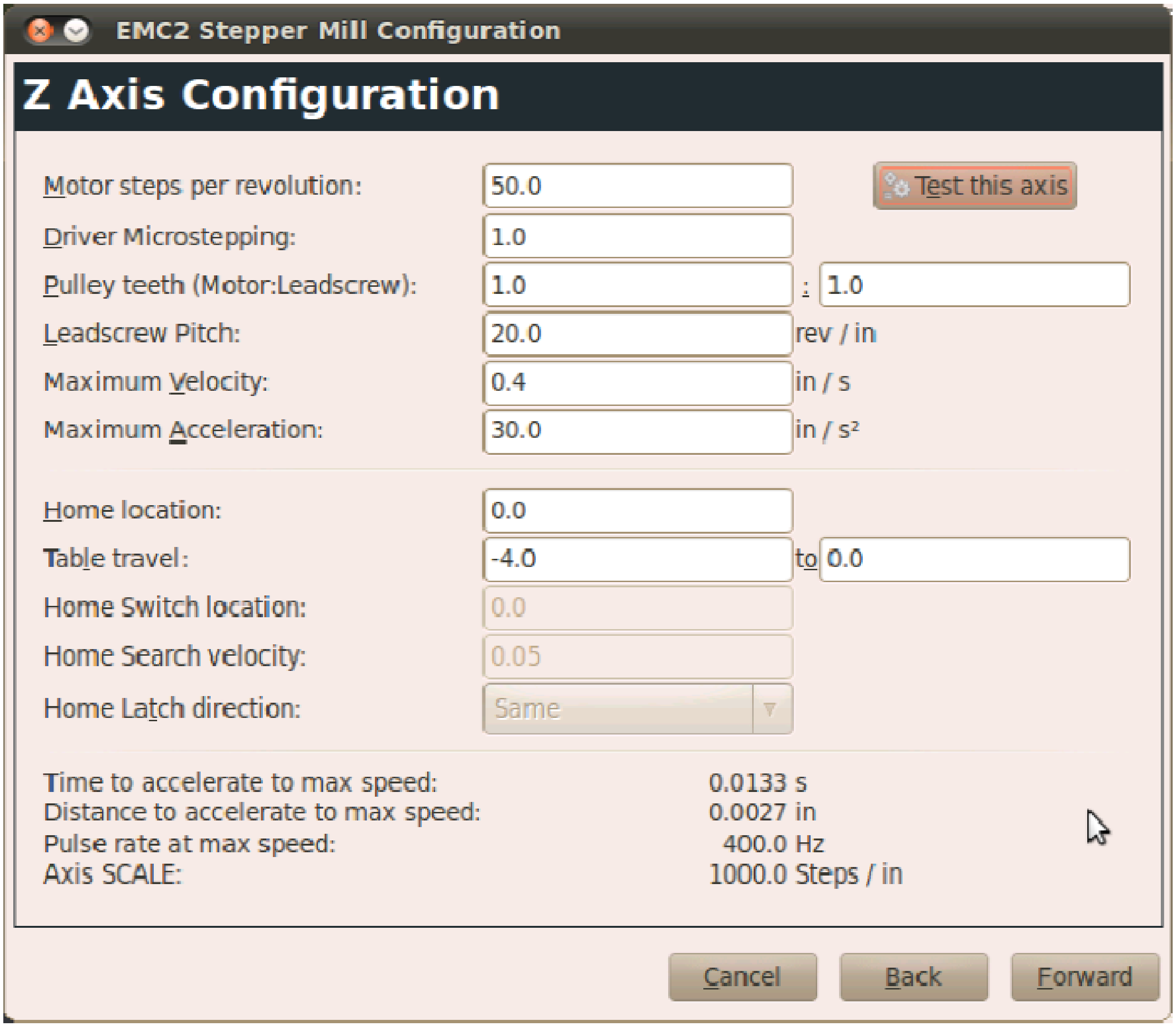


Using the Test Axis utility you may find better settings for your setup

Configure your Y and Z axes in the same way, making sure to test each one before progressing to the next step.

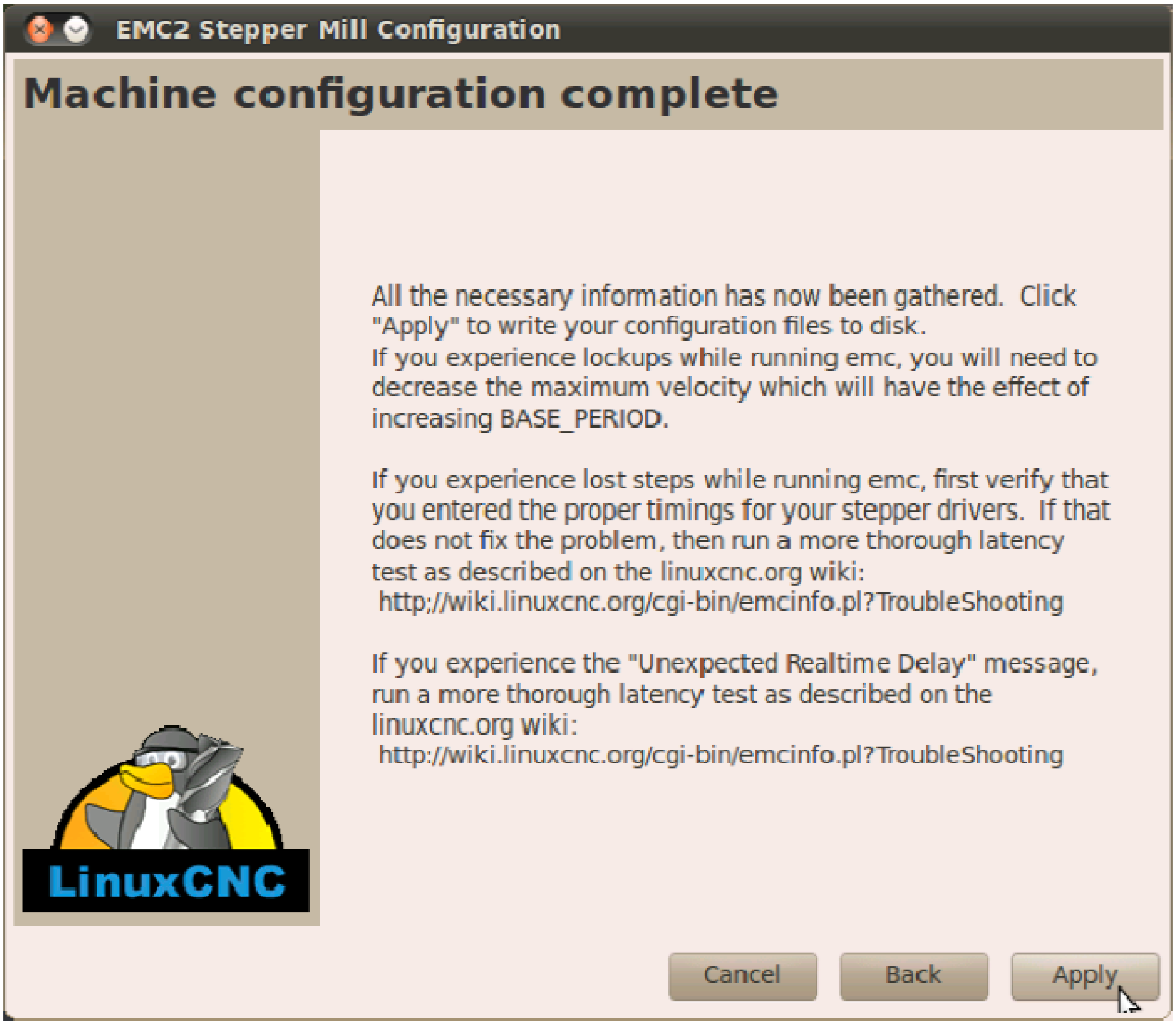
Y Axis configuration ->





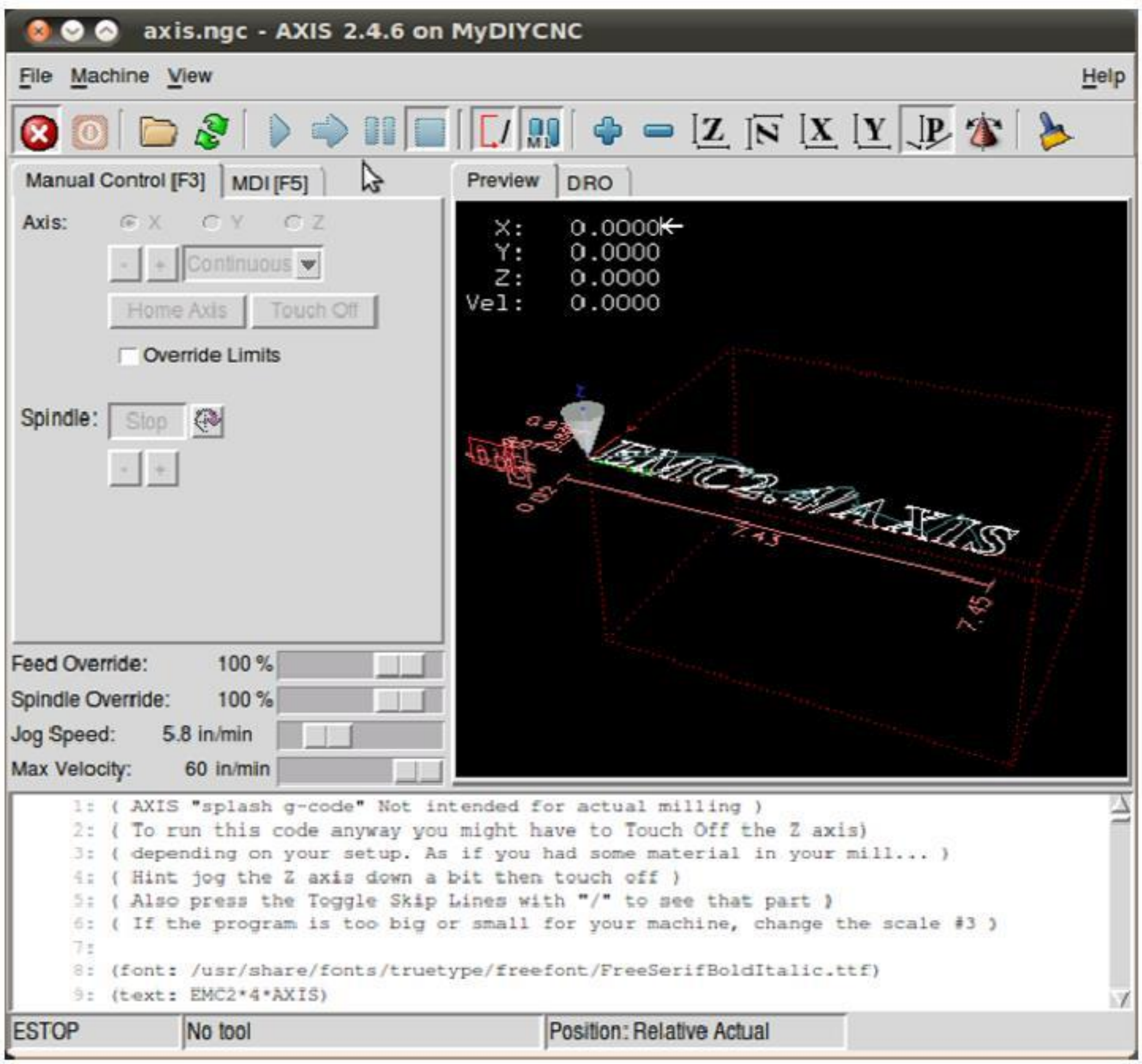
Z Axis Configuration. Note the table travel values are negative
as the Z axis travels away from the table.

That's it. You should see the following confirmation screen once you reach the end of the configuration. The StepConf Wizard will save a .stepconf file containing all of your settings. Pay careful attention to the final messages provided on this screen.



All done! If you see this confirmation screen, you've setup your DIY Smart Saw (Desktop Version)

You should now be good to go with EMC2 and your DIY Smart Saw (Desktop Version). Double-clicking on the new desktop icon for your configuration file should launch EMC2 with your new settings.



Use the EMC2 User Guide (http://www.linuxcnc.org/docview/html/) to learn how to use EMC2 with your DIY Smart Saw (Desktop Version)

Other CNC Application (Mach 3, Turbo CNC, ETC.):

Your DIY Smart Saw (Desktop Version) will work with any of the other CNC applications that use a discreet enable/step/direction signal set to control the CNC axes steppers.

The following link is a good overview of CNC applications and where they fit in the design-to-product cycle. This page also provides links to additional information about these applications.
http://www.probotix.com/cnc_software/

Chapter IV : Expanding Your DIY Smart Saw (Desktop Version)

Workspace Dimensions:

To expand the physical workspace of your DIY Smart Saw (Desktop Version) requires the uniform lengthening of the machine's frame members aligned to the axis being stretched. For instance, to expand the X axis to 24" instead of 18", simply add an additional 6 inches to all parts aligned to that axis. For the X axis they would be:

• All 4 side rails

• Both rods

• The drivetrain threaded rod

All other dimensions can remain the same. For the side rails, the additional length should be added such that the front vertical edge of the gantry support uprights is aligned with the center point of the rails.

The table/workspace definitions in your CNC application will have to be changed to accommodate the longer axis.

Use this same procedure to lengthen any/all of the axes. In the case of the Z axis, the length of the gantry support uprights can be increased without any changes to the Z axis itself to allow a larger clearance beneath the spindle. Be sure to also raise the gantry support cross-brace to allow clearance of your work piece as it travels the length of the x axis.

Your DIY Smart Saw (Desktop Version) electronics and stepper motors need not be changed at all to accommodate the new dimensions.

Table Travel Mod:

There is a simple modification you can make to the standard DIY Smart Saw (Desktop Version) to extend the travel of the X axis. The X axis stepper motor obstructs the table travel. Cut a 1 1/4" [32 mm] x **up to** 4" [102 mm] notch in the center leading edge of the table to allow for clearance around the motor. Note that the longer the slot the more flex you will have in the table, so this modification has a trade-off you should consider when deciding how much additional travel you want to have. The following drawing shows the dimensions and position of this notch. Using your spindle as a handheld rotary tool, the notch can be easily cut from the table in-situ. The slot should not extend further into the table than to the first bearings support sub-frame. Be sure to update your table travel configuration in your CNC application.

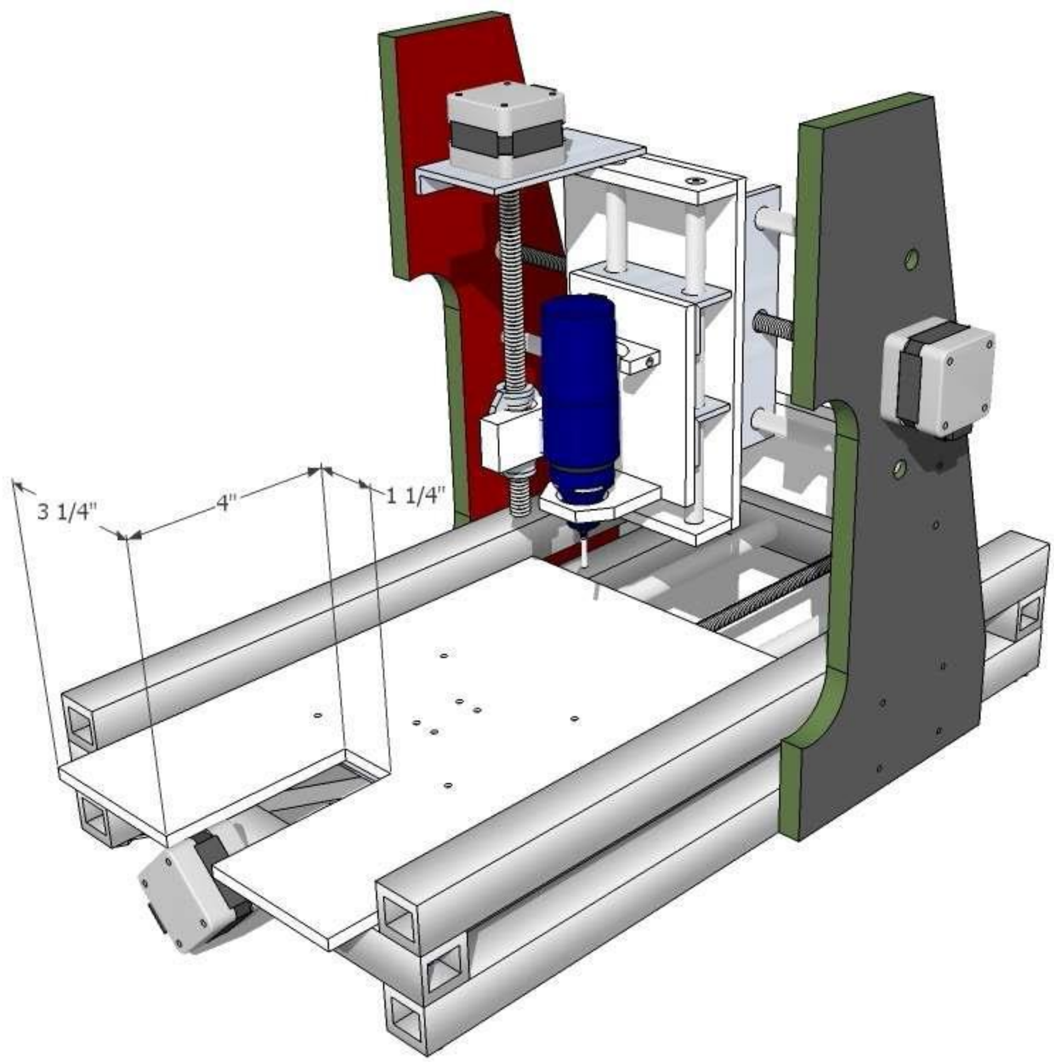


Table modification to allow more X axis travel

Spindle Upgrades:

Your DIY Smart Saw (Desktop Version), if you purchased a version that includes a spindle, comes with a 12V 16,000 RPM rotary tool. You may upgrade to another rotary tool or alternative machine head, such as a laser or 3D printing head, simply by adjusting the spindle mounts to suit. The universal spindle mount described in this manual should prove suitable for any spindle up to approximately 1 3/4" [44.5 mm] in body diameter and approximately 1" in nose diameter.

In addition you will be able to download g-code files to use with your DIY Smart Saw (Desktop Version) to cut out new spindle mounting blocks for a variety of standard and commonly-available rotary tools.

The DIY Smart Saw (Desktop Version) Spindle Control Module has the ability to switch on and off the power to any corded rotary tool correctly wired to its power terminals.

WARNING: Never use a cordless rotary tool as a spindle on your DIY Smart Saw (Desktop Version). As the battery runs out the tool will lose rotary speed and torque, causing it to bind up and likely get stuck in the material. Your DIY Smart Saw (Desktop Version) may damage itself severly in trying to continue with the operation when the spindle is stuck in the work piece.

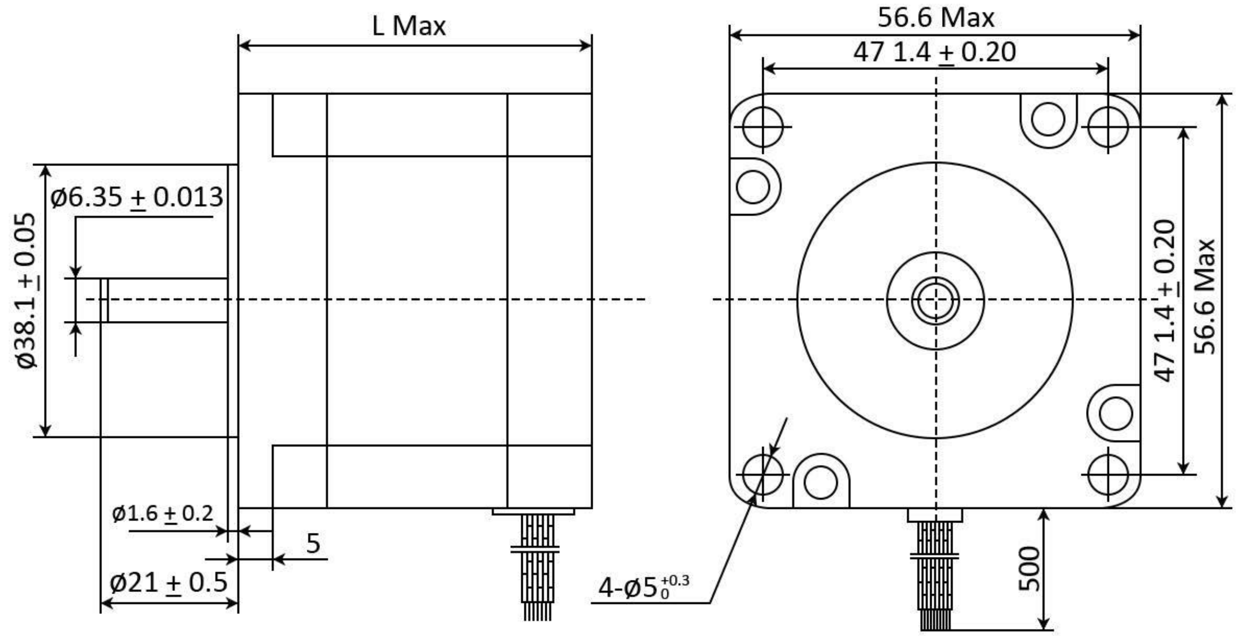
Stepper Motor Upgrades:

1) Larger Stepper Motors:

The DIY Smart Saw (Desktop Version) is designed to use NEMA 17 standard bipolar stepper motors. The optimum voltage for the stepper motors is 12V as this is easily available from your host power supply.

Any unipolar stepper motor can be "converted" to a bipolar stepper motor by, in most cases, ignoring the center trap of the motor coils and wiring across the coils as if it were a bipolar stepper motor.

However, you should be able to easily accommodate a wide range of different stepper motors to meet your specific needs. The DIY Smart Saw (Desktop Version) Stepper Motor Driver Modules can drive any bipolar (or modified unipolar) stepper motor from 3 VDC up to 36 VDC and 1.2 A per channel. Keep in mind however, if you choose a stepper motor that requires more than 12 VDC you will have to provide an additional power supply for it. The mounting holes for the stepper motors on each axis can be modified to support different stepper motor sizes, such as NEMA 23. The dimensions for a NEMA 23 mount are shown below.



Standard NEMA 23 Stepper Motor mounting dimensions (in mm)

If you are expanding the workspace dimensions of the DIY Smart Saw (Desktop Version) beyond 2x the design dimensions you may want to consider upgrading to NEMA 23 motors to provide greater torque for moving larger carriages and work pieces, and for greater speed traversing a larger table.

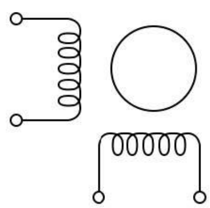
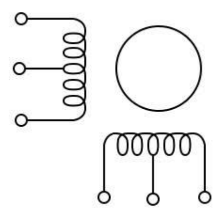
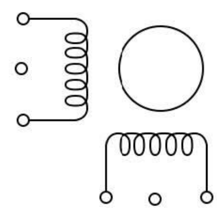
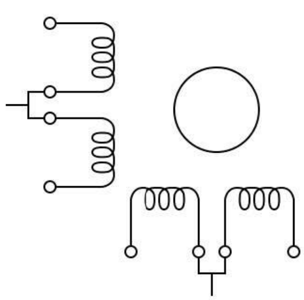
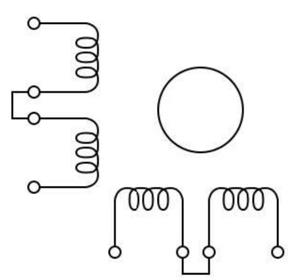
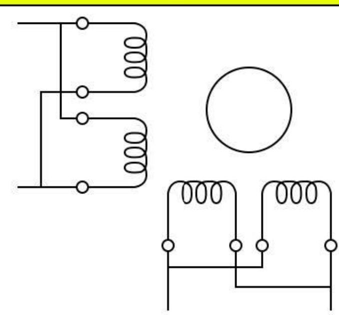
2) Salvaged and Recycled Motors:

Old electronic equipment, such as printers, fax machines, scanners, copiers and floppy disk drives are great sources of stepper motors. Often they can be found for free from websites such as Craigslist and Freecycle.org and from your local e-waste recycle center. Your local municipal dump is usually happy to have someone take away and make use of their “toxic” electronic equipment waste. With a little research you should be able to collect a nice inventory of stepper motors for your DIY Smart Saw (Desktop Version) and similar projects.

If you can identify the stepper motor from its markings, find its datasheet online and use that data to determine how to connect it to your driver electronics.

In the absence of a datasheet, first determine if the stepper motor is unipolar or bipolar. Bipolar motors will have four wires, while unipolar stepper motors have more (typically 5, 6 or 8). Most unipolar stepper motors can be converted to bipolar by wiring them in such a way as to create a two-coil stepper motor (see chart).

Wire Connection Diagrams

4 Lead Bipolar Connection	6 Lead Unipolar Connection	6 Lead Bipolar (Series) Connection
		
8 Lead Unipolar Connection	8 Lead Bipolar (Series) Connection	8 Lead Bipolar (Parallel) Connection
		

Using an ohmmeter you can check for continuity across the coils of a bipolar stepper motor to determine which pair of wires connects to the ends of each coil. If a pair of wires shares a resistance value, then they are connected through the coil. If there is no connection (infinite resistance) between them, then those wires are connected to different coils. Through this process of elimination you can determine the coil connections.

For a unipolar stepper motor, the fifth and sixth wires are connected to the center point of the coil, and therefore the resistance will read half that of the full coil. The pairs of wires with the larger resistance value are the ends of the coils, while the wire(s) with half that value between the identified ends is the center tap. Following the chart above you should be able to "convert" your unipolar stepper motor to a bipolar configuration for use with the DIY Smart Saw (Desktop Version) Stepper Motor Driver Modules.

Once you have identified the coil leads, you need to identify the positive from negative ends of the coils to determine the winding sequence. If the wires are not connected in the correct sequence, the motor will not respond or will twitch or rotate with a jerky motion. This is done by connecting the wires to your DIY Smart Saw (Desktop Version) Stepper Motor Driver Module and proceeding through the following steps until the motor rotates smoothly.

1. Connect the four wires to ports A1, A2, B1 and B2 in any order.
2. If the motor does not rotate, reverse A1 and A2.
3. If the motor still does not rotate, reverse B1 and B2
4. If the motor sill does not rotate, reverse A2 and B1
5. If the motor still does not rotate, reverse A1 and A2

By step 5 you should have found the correct wiring sequence for full smooth rotation.

Taking apart old equipment can be great family fun

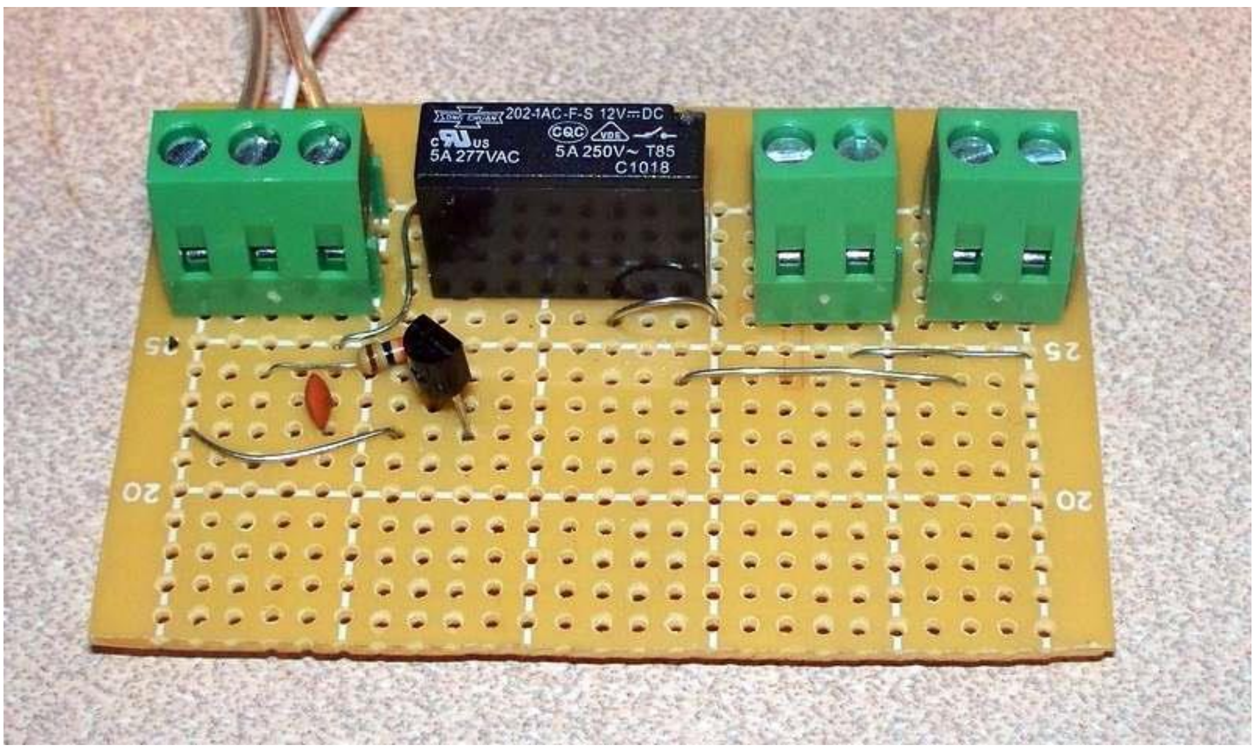
Once you have determined the settings of your stepper motors, be sure to enter these values into your CNC application's configuration settings.

Electronic Upgrades:

In addition to the DIY Smart Saw (Desktop Version) electronics to drive the DIY Smart Saw (Desktop Version)'s stepper motors you may wish to upgrade to a Spindle Control Module and Limit Switch Modules to round out your machine.

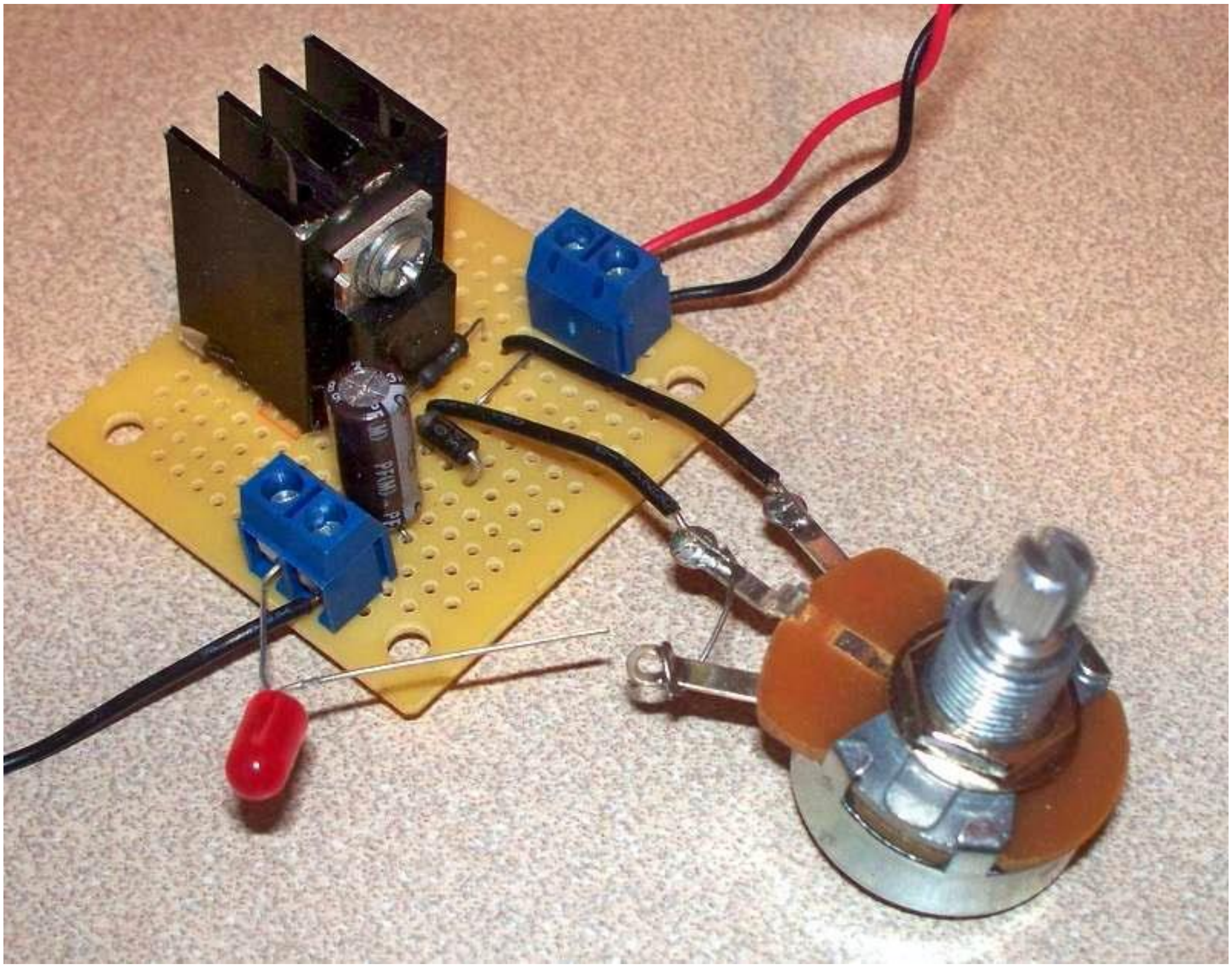
1) The Spindle Control Module:

The Spindle Control Module will allow your spindle to be controlled by your CNC application and from g-code being processed by the application. This will save you from manually turning on and off your spindle. However, there are also many other uses for this versatile module.



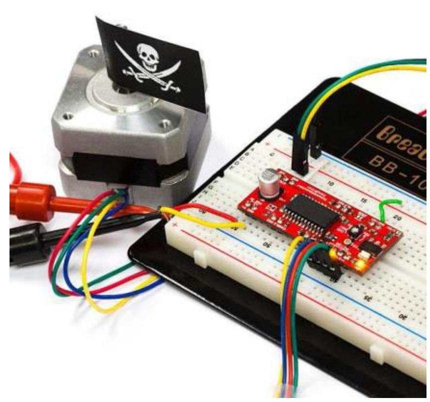
DIY Spindle Control Module made from the circuit diagram provided in this manual

The Spindle Control Module can be used to turn on and off any power source/object with a signal from your PC. If you decide, for instance, to mill hard metals and require irrigation to cool your end mill, then the Spindle Control Module is used to **turn the coolant pump on and off** on command from the CNC application. Should you upgrade to a **3D printing head** or **laser head** then this module becomes more essential, as it can be used in those applications to turn on and off the material dispensing of the 3D printing head or the laser in the case of the laser head. Since a laser will continue to burn anything in its path while on, it is critical to provide machine control to the laser power to allow the laser to be turned off while travelling from one etching/cutting point to another.



DIY Laser Driver Module, also controlled by a Spindle Control Modules

2) *The Spindle Control Module:*



The DIY Smart Saw (Desktop Version) Stepper Driver Modules were designed to provide simple, reliable, easy to home-build, inexpensive electronics to drive a range of stepper motors. Their intended application was to provide one thousandth of an inch (0.001") precision with the DIY Smart Saw (Desktop Version). In addition, there are many other options for CNC/Stepper Motor Driver electronics. You may wish to drive unmodified unipolar stepper motors, or use micro-stepping to increase the precision and resolution of your DIY Smart Saw (Desktop Version).

There are many online vendors such as Jameco (www.jameco.com), Spark Fun (their EasyDriver shown in picture) (www.sparkfun.com) and Solarbotics (www.solarbotics.com) who offer stepper motor drivers and controllers for various applications, capabilities and costs. A careful read through their product specifications and datasheets where available will help you determine the best upgrade boards for your application within your budget.

3) Future DIY Smart Saw (Desktop Version):

At the time of writing this manual, DIY Smart Saw (Desktop Version) has several exciting development projects on the drawing board for the DIY Smart Saw (Desktop Version). This includes USB controllers, a 3D printing head, laser head options and more- powerful stepper motor drivers that incorporate micro stepping and other features. As ever, we will pursue our philosophy of capability and precision at low cost through innovative design.

Chapter V : Troubleshooting

Before requesting technical support, please use the following Troubleshooting Matrix to determine an initial solution to your issue.

Troubleshooting Matrix

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
DIY Smart Saw (Desktop Version) Unresponsive to the host PC	No power	Power supply not connected to wall. Connect. Fan not running in power supply. Check power supply is getting electricity. Connect power supply. Replace if still unresponsive.
	PC not connected	Check connections to PC. Check connections between PC DB-25 connector and electronics modules. Check for good ground between PC connections and electronics modules.
	PC not running application properly	Check CNC application is running as expected. Check the CNC application is addressing the correct port. Check that the CNC application is sending the correct signals to the port (use the app's port monitor). Reboot CNC application and/or PC.

One axis is unresponsive	Bad connection to stepper motor	Check the stepper motor cables are making good contact in the Stepper Driver Module's terminals. Be sure to solder tin the stepper motor wires to allow good contact in the terminals. Double-check the wiring sequence. Make sure that the stepper wires are connected in the correct order.
	Bad connections to Stepper Driver Module	Check all connections to the Stepper Driver Module. Check for good ground to Stepper Driver module. Check that signal connections from the PC/Db-25 connection to the Stepper Driver Module are correct and solid. Check that the Stepper Driver Module enable signal is connected and getting a high (+5 VDC) signal.
	Axis limit switch triggered	Check limit switches to if any are either depressed, faulty or shorted out. Make sure that the screw used to mount the limit switch modules is insulated (with a plastic washer) from the board. Check CNC application to see if it is receiving a triggered limit switch signal.

		In EMC2 check that the parallel port limit switch channels are inverted.
One Axis is "Jittering"	Stepper Motor not connected correctly	Recheck that all connections are solid between the stepper motor and the Stepper Motor Driver module. Check that the stepper motor wires are connected in the correct order. Check that the correct voltage is connected to the motor power terminal.
	CNC application misconfigured	Check that the speed settings for the axis are correct in the CNC application.
	Axis, drivetrain or carriage is binding or obstructed	Check that the axis is not binding up or is being obstructed. Check that the anti-backlash leadscrew is not obstructed or fouled with debris. With power off, check that the drivetrain threaded rod can rotate freely. If not, determine why and remedy. Apply light machine oil to the Igus bearings (air tool oil is a good lubricant for this). Check alignment of axis and correct as necessary.
Axis movement is difficult towards one end of travel	Axis rods misaligned	Check for alignment of the rods to each other, and for squareness as described in the manual. Loosen connecting screws for that axis, realign and test for smooth travel, then tighten down.

		If having correcting alignment, testing for free travel, and then after retightening the connecting screws the misalignment returns, determine which screws pull the axis out of alignment when tightened down: remove that screw, oversize (ream) the hole with a drill bit one fractional size larger. Replace the screw, test again for alignment and free travel, then tighten down.
	Rods damaged	Inspect the axis rods around the area of difficulty visually and by touch. If any damage is found to the rod surface it may be repairable if it is a minor blemish. Move the carriage out of the way, clean the rod thoroughly, and with fine emery paper, rub the blemish until it is smooth and smooth travel is restored. Thoroughly clean the rod to remove all abrasive and metal dust before allowing the carriage to travel again on the rod. Failure to do so may damage your Igus bearings. If the blemish/damage cannot be removed, replace the rod before any further use.
	Binding is minor	The Igus bearings can be run dry or lubricated. Lubricate the rods and anti- backlash assembly with light machine oil, such as air tool oil. Run the axis back and forth across the difficult section of travel.

		If the binding does not improve, check for alignment and/or damage.
Spindle does not operate	No power	Check the power supply to the spindle. Check that the spindle is turned on. Check that the Spindle Control Module is correctly connected.
	Spindle Control Module faulty	Check that the Spindle Control Module is functioning. The onboard relay should “click” when the board is activated. If faulty, replace board or swap out faulty relay or transistor.
	CNC application incorrectly configured	Check that the CNC application is sending the correct “on” signal to the Spindle Control Module.
Spindle turns off when it should turn on	CNC application incorrectly configured	Check the CNC application’s port configuration. Invert the signal to the spindle control channel.
Output product from the DIY Smart Saw (Desktop Version) is not aligned correctly/ is skewed/ is not rectangular as expected (if outputting a square shape/form)	Axes out of square to each other	Thoroughly check all axes for squareness to the chassis and each other. Correct for squareness as described in the manual.
	One axis is exhibiting backlash	Check the anti-backlash assembly. Check that it is adjusted correctly as described in the manual. Check that the spring is holding tension when adjusted. Replace if necessary. Check for dirt or debris fouling the lead screws.

	Axis is "loose"	Check for excessive wear in the lead screws. Replace with new wing nuts. Check that the mounting block is securely fastened to the carriage. Tighten if necessary. Check for play in the axes mounts, rods, bearings and/or bearing support sub- frames. Correct as necessary.
Travel on one axis stops in mid operation, while other axes continue to move as expected.	Drivetrain coupling failure	Check that the coupling between the motor shaft and the threaded rod is secure. Check for either part spinning inside the coupling. Replace coupling. Check for coupling damage. Replace coupling.
	Motor failure	Check the stepper motor by swapping its connections with another axis, and testing. If the motor operates, then check the Stepper Driver Module. If the motor still does not function, but the swapped motor does function when reconnected to that Stepper Driver Module, replace the stepper motor.
	Axis failure	See section *troubleshooting a non- responsive axis* above.
Depth of cutting increases/decreases across the table	Table not level	Either: a) Level the table by following the instructions in the manual on how to check the table for squareness or alignment. b) Mill a new surface into an MDF board attached to the table.

PCB tracks not parallel or "fuzzy"	Incorrect end mill	Use an end mill specifically for PCB milling.
	Spindle/collet/end mill loose	Check to see if the rotating end mill oscillates or vibrates. It should spin with a clearly defined point visible. Remove the collet and end mill. Make sure that the correct collet is used for your diameter end mill. Ensure that the end mill/collet is centered and tightened down in the spindle. Check the spindle bearings. With the spindle off and the collet removed, feel the spindle shaft for any play, slack or sideways movement. Identify the source of the movement and remedy. If the play is from wear in the spindle bearings, replace the spindle. Check the spindle mounts for any play. The spindle should be held firm without any play or movement. If play is found, identify the cause and remedy such that the spindle is firmly held in the cradle.

Chapter VI : Appendices

DIY Smart Saw (Desktop Version) Master bill of Materials:

The following is the recommended bill of materials for the DIY Smart Saw (Desktop Version). Bill of materials for the electronics modules are provided separately. Items and suppliers are recommended, equivalents may be substituted.

Description	Qty/ Unit	Vendor
NEMA 17 12V Stepper Motor	3	Various
Stepper Controller Module	3	Various
Optional Limit Switch Module	6	Various
Optional Spindle Control Module	1	Various
200W or greater ATX PC Power Supply	1	Various
25 pin D-Type, Ribbon	1	Jameco
Ribbon cable, 25-core, 6”	1	Jameco
Metal Base Long 18”, 1” square tube	4	Various
Metal Base width 10”, 1” square tube	2	Various
Chassis Corner Bolt: Hex Head Cap Screw 1/4"-20 Thread, 2-1/2"	4	McMaster
Chassis Corner Nut: Nylon-Insert Hex Locknut 1/4"-20	4	McMaster
Back Brace Screw Zinc-Plated Steel, NO 6 Size, 3/4"	4	McMaster
Flat Washer 1/4" Screw Size, 5/8" OD	2	McMaster
Uprights Screws Screw Zinc-Plated Steel, NO 8 Size, 3/4"	8	McMaster
Table Flat Head Phil Sheet Metal Screw NO 6 Size, 1/2"	12	McMaster
Z motor mount, Spindle mount: #6 Size, 1/2" screws	10	McMaster
Z Carriage: #6 Size, 3/4" screws	9	McMaster
Wingnuts, Z mount: #4, Size, 3/8" screws	26	McMaster
Anti Backlash Assembly screws, NO 4 Size, 3/8”	10	McMaster
Anti Backlash Assembly Y mount, NO 6 Size, 3/4”	4	McMaster
Machine Screws: M3 Size, 30mm	4	McMaster
Machine Screws: M3 Size, 14mm Length	4	McMaster
Machine Screws: M3 Size, 8mm Length	4	MSC
10mm Laminated HDF uprights	2	Simple Floors
HDPE 10”x3” Gantry Brace, 3/8” HDPE	1	TAP Plastics
1/4”-20 threaded Rod 17 1/2” **	1	MSC
1/4”-20 threaded Rod 10” **	1	MSC
1/4”-20 threaded Rod 7” **	1	MSC
3/8 precision steel rod 18” **	2	MSC

3/8 precision steel rod 11” **	2	MSC
3/8 precision steel rod 7” **	2	MSC
Grommet 3/8" ID, 5/8" OD, 3/32"	4	McMaster
Igus linear bearings	12	Igus
X table, 7 ¾” [197 mm] x 12” [305 mm] 1/4” HDPE	1	TAP Plastics
1/4”-20 Nylon wing nuts	6	McMaster
Anti backlash spring	3	McMaster
1/2” HDPE anti-backlash assembly mounting blocks	6	TAP Plastics
Two core cable for limit switches, 2' pieces	6	Jameco
1” x 1/8” Aluminum Angle bearing support sub-frames, 5.5”	4	Various
1” x 1/8” Aluminum Angle bearing support sub-frames, 3”	2	Various
Aluminum flat rod 5/8"W X 20"L X .125" thick	1	Various
Aluminum Z Motor Mount, 1/2” x 2” angle, .125”thick	1	Various
Aluminum Z Anti-backlash Mount, 3/4” x 3/4” angle, .062 thick	1	Various
Standard Spindle	1	Various
1/4” x 2” x 2” HDPE Spindle Bottom Mount	1	TAP Plastics
1/2” x 2” x 1” HDPE Spindle Top Cradle	1	TAP Plastics
Drivetrain couplings: 1.5” x 1/4” Polyethylene tube	3	Home Depot
Optional Mini Hose Clamps (snap grip)	4	McMaster
Electronics Housing	1	TAP Plastics
1/2” Nylon Spacer Tube	2	Lowe’s (The Hillman Group)
PCB Edge Mounts	12	Various

** The rod dimensions shown in the Bill of Materials are different from the drawing. Those that differ are okay, in that they just mean the rod ends protrude a fraction more. This has no effect on functionality but perhaps is an aesthetic consideration (you may think it looks better, or not so much). So for reference, the following are the dimensions we use in-house for our product build:

1/4”-20 threaded Rod 17” Qty 1 MSC 6050108
1/4”-20 threaded Rod 10 1/4” Qty 1 MSC 6050108
1/4”-20 threaded Rod 7” Qty 1 MSC 6050108
3/8 precision steel rod 17 1/2” Qty 2 MSC 6010243
3/8 precision steel rod 10 3/8” Qty 2 MSC 6010243
3/8 precision steel rod 7” Qty 2 MSC 6010243

DIY Smart Saw (Desktop Version) Stepper Driver Module Bill of Materials:

The following is the recommended bill of materials for the DIY Smart Saw (Desktop Version). Bill of materials for the electronics modules are provided separately. Items and suppliers are recommended, equivalents may be substituted.

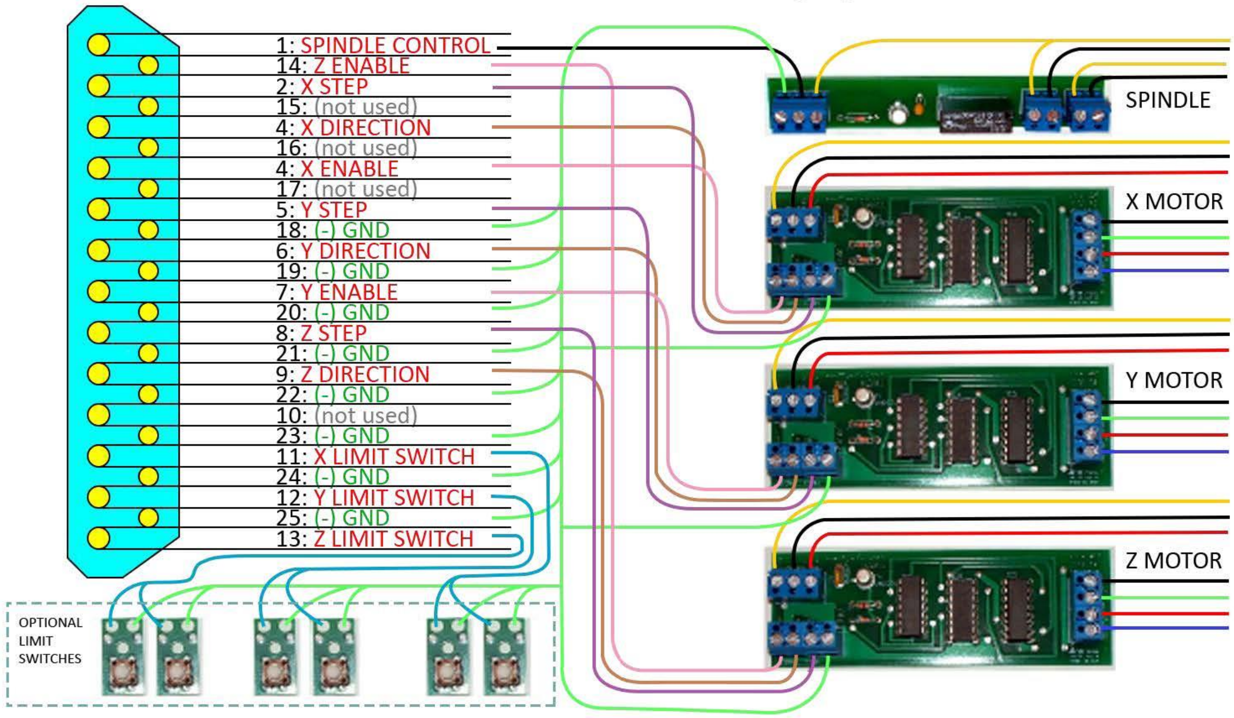
Description	Qty/Unit	Vendor
Bare PCB	1	Various
10K Resistor	1	Jameco
100K Resistor	1	Jameco
0.01uF Capacitor	1	Jameco
4027N	1	DigiKey
4070N	1	DigiKey
L293D	1	DigiKey
16 DIP heatsink (optional)	1	Jameco
2N2222 Transistor	1	DigiKey
W237-04P connector 4 terminal	2	Jameco
W237-3E connector 3 terminal	1	Jameco

DIY Smart Saw (Desktop Version) Spindle Control Module Bill of Materials:

Description	Qty/Unit	Vendor
Bare PCB	1	Various
Micro Power Relay	1	Mouser
2N2222 Transistor	1	DigiKey
Resistor A	1	Jameco
Resistor B	1	Jameco
0.01uF Capacitor	1	Jameco
W237-2 connector 2 terminal	2	Jameco
W237-04P connector 4 terminal	1	Jameco

Wiring Diagram:

DIY Desktop CNC MACHINE Parallel Port Electronics Modules Connector
Pin-Outs and Wiring Diagram



DIY Smart Saw (Desktop Version) Wiring Diagram color codes

Power to electronics modules

BLACK: Ground

RED: +5 VDC

YELLOW: +12 VDC

Stepper motor connections

BLACK: A1

GREEN: A2

RED: B1

BLUE: B2

Connections to PC

GREEN: Ground

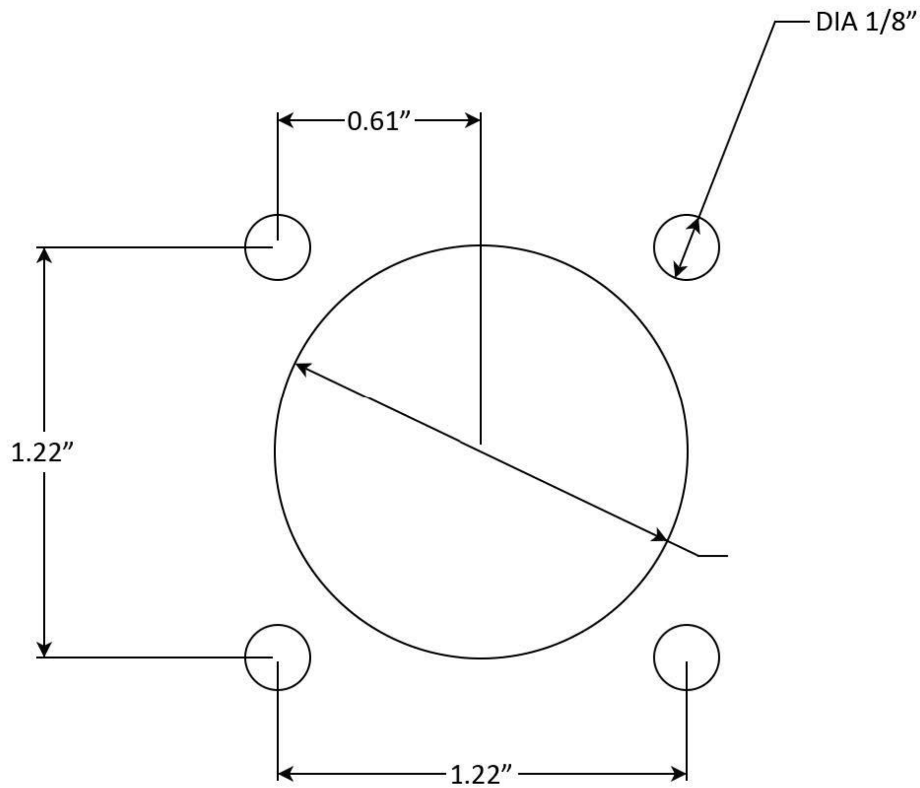
PURPLE: Step Signal

BROWN: Direction Signal

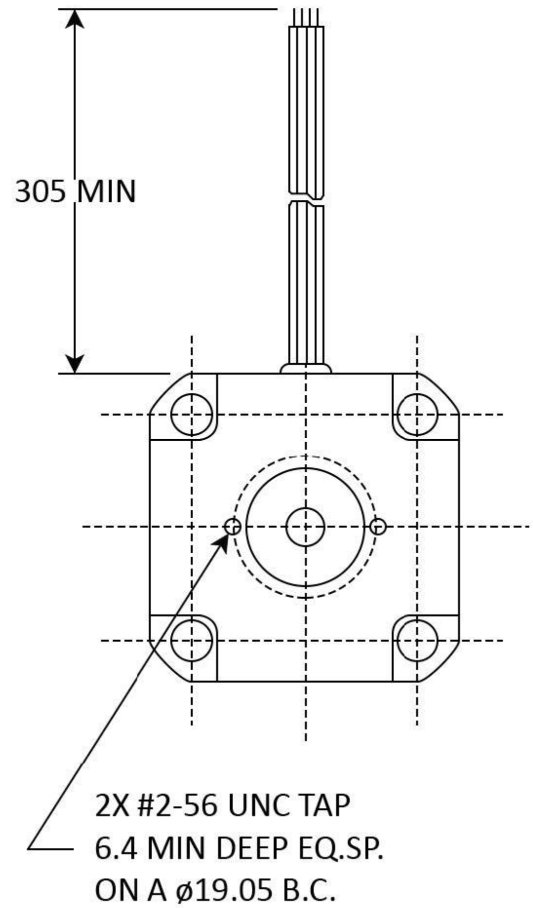
PINK: Enable Signal

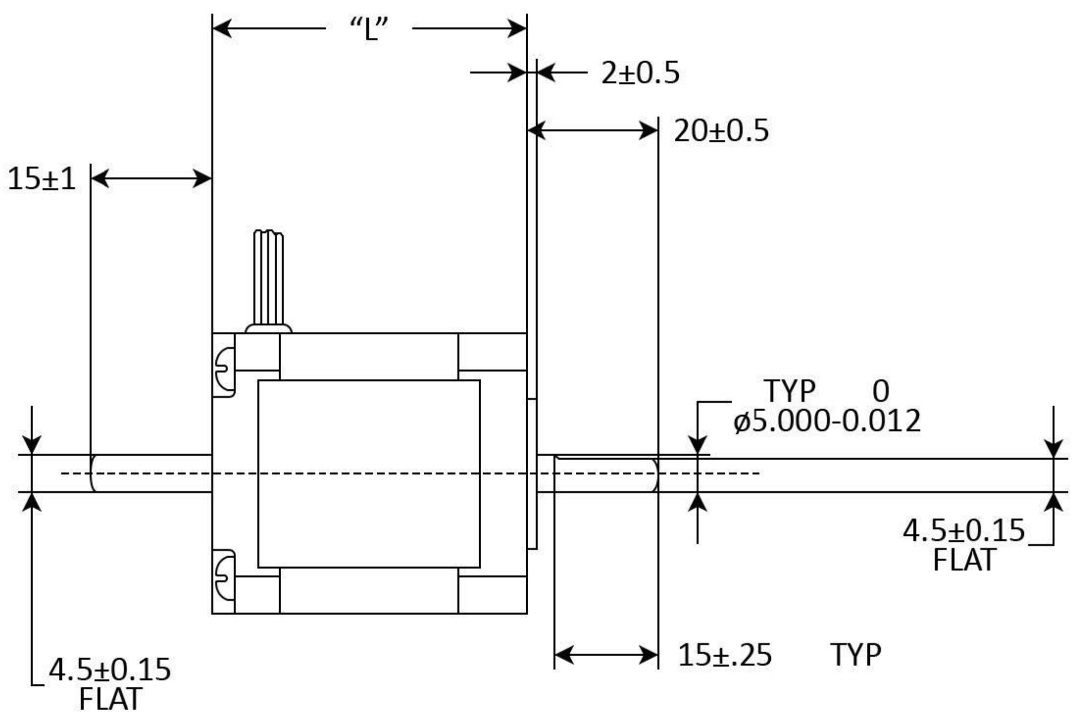
TEAL: Limit Switch +

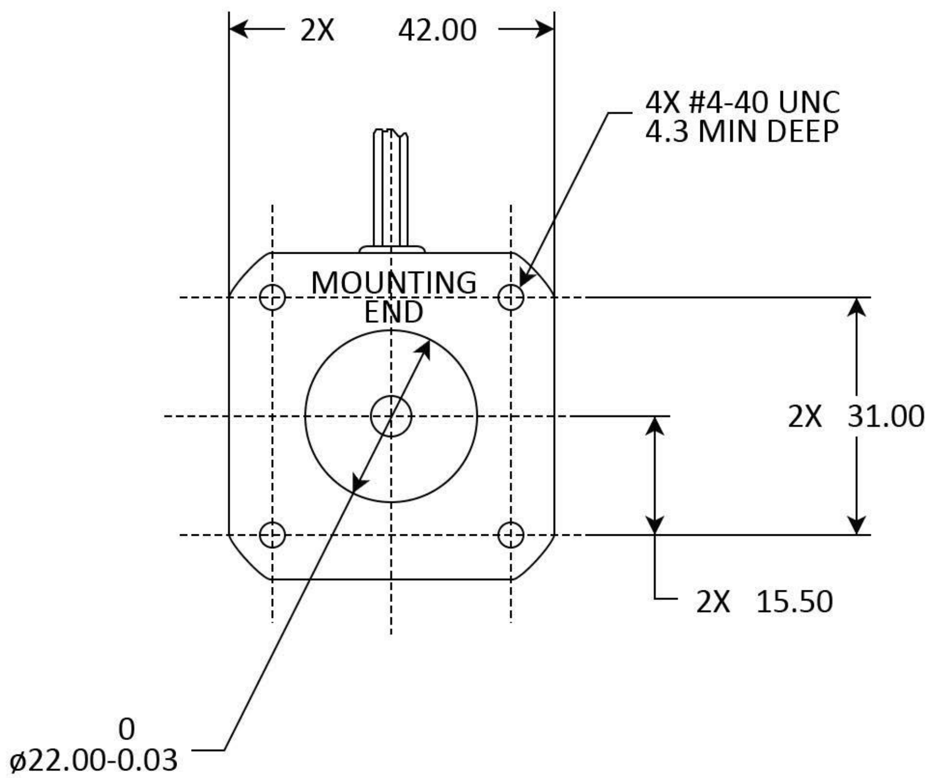
Stepper Motor Mount Holes (NEMA 17):



Nema 17 Motor Mounts







NEMA 17 Motor Metric Mounting Dimensions